

User Manual

Tektronix

**2715
Spectrum Analyzer**

070-9115-05

This document supports
firmware version 2.14.97 and above.



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General Safety Summary

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it. To avoid potential hazards, use this product only as specified.

Only qualified personnel should perform service procedures.

While using this product, you may need to access other parts of the system. Read the *General Safety Summary* in other system manuals for warnings and cautions related to operating the system.

To Avoid Fire or Personal Injury

Use Proper Power Cord. Use only the power cord specified for this product and certified for the country of use.

Connect and Disconnect Properly. Do not connect or disconnect probes or test leads while they are connected to a voltage source.

Ground the Product. This product is grounded through the grounding conductor of the power cord. To avoid electric shock, the grounding conductor must be connected to earth ground. Before making connections to the input or output terminals of the product, ensure that the product is properly grounded.

Observe All Terminal Ratings. To avoid fire or shock hazard, observe all ratings and marking on the product. Consult the product manual for further ratings information before making connections to the product.

The common terminal is at ground potential. Do not connect the common terminal to elevated voltages.

Do not apply a potential to any terminal, including the common terminal, that exceeds the maximum rating of that terminal.

Do Not Operate Without Covers. Do not operate this product with covers or panels removed.

Use Proper Fuse. Use only the fuse type and rating specified for this product.

Avoid Exposed Circuitry. Do not touch exposed connections and components when power is present.

Wear Eye Protection. Wear eye protection if exposure to high-intensity rays or laser radiation exists.

Do Not Operate With Suspected Failures. If you suspect there is damage to this product, have it inspected by qualified service personnel.

Do Not Operate in Wet/Damp Conditions.

Do Not Operate in an Explosive Atmosphere.

Keep Product Surfaces Clean and Dry.

Provide Proper Ventilation. Refer to the manual's installation instructions for details on installing the product so it has proper ventilation.

Symbols and Terms

Terms in this Manual. These terms may appear in this manual:



WARNING. Warning statements identify conditions or practices that could result in injury or loss of life.



CAUTION. Caution statements identify conditions or practices that could result in damage to this product or other property.

Terms on the Product. These terms may appear on the product:

DANGER indicates an injury hazard immediately accessible as you read the marking.

WARNING indicates an injury hazard not immediately accessible as you read the marking.

CAUTION indicates a hazard to property including the product.

Symbols on the Product. The following symbols may appear on the product:



WARNING
High Voltage



Protective Ground
(Earth) Terminal



CAUTION
Refer to Manual



Double
Insulated

Preface

This manual contains operating information for the Tektronix 2715 Spectrum Analyzer and includes menus and operating features. The following manuals also support the Tektronix 2715 Spectrum Analyzer:

- *2714 & 2715 Spectrum Analyzer Programmer*
- *2714 & 2715 Spectrum Analyzer Reference*
- *2715 Spectrum Analyzer Service*
- *Cable TV RF Measurements Software User*

For manual ordering information, refer to *Appendix F: Accessories & Options* or contact your local Tektronix Field Office or representative.

Who Should Use This Manual?

This manual is intended for electronic technicians with experience in making cable television-related measurements.

Standards and Conventions Used

Most terminology is consistent with standards adapted by IEEE and IEC. Abbreviations used in the instrument and in the documentation are consistent with ANSI Y1.1–1972. Copies of the ANSI and IEEE standards can be ordered from the Institute of Electrical and Electronic Engineers Inc.

Change/History Information

Changes to the 2715 may occur or manual errors may be found that make some of the information in the manual inaccurate. When this happens, *Manual Change Information* notices containing the corrected information are inserted at the rear of the manual. This ensures that the manual contains the latest and most accurate information available when the product is sold.

Contact any Tektronix Service Center for information.

Manual Organization

General Sections 1 through 3 contain material that enables the beginning or experienced operator to safely power up and initially normalize the spectrum analyzer.

Sections 4 through 6 provide detailed explanations and some measurement examples that may be especially useful. The examples should be read while interactively using the spectrum analyzer and carrying out the instructions. In this way, you quickly acquire the knowledge and skills necessary to make accurate measurements. The end of one example and start of the next are indicated by a settings box that looks like this:

8.75MHZ	(AUTO SWEEP)	M 11.45 MHZ
23.5DBMV		M 13.8 DBMV
600KHZ		10 DB/
300KHZ RBW		STD CH 2

The box shows what the control settings of the spectrum analyzer should be to continue with the example that follows it. The contents of the box resemble the spectrum analyzer's on-screen data readouts. Each example begins with the sweep control in AUTO mode. To remind you of this, (AUTO SWEEP) is shown in the top center of the box. The parentheses mean the enclosed item is not part of the normal on-screen readouts.

Six appendices, a glossary, and an index contain information about a number of topics useful, but not essential, to spectrum analyzer operation.

Specific *Introduction* contains a brief description of spectrum analysis and reviews the characteristics of the Tektronix 2715 Cable TV Spectrum Analyzer.

Getting Started enables you to safely apply power and signals to the spectrum analyzer. You become acquainted with the fundamental controls of the instrument and make your first measurements using a firmware-based CATV measurement routine and the built-in calibration signal.

Operating Basics provides most of the information needed for routine operation.

Dedicated Controls explains the features of the spectrum analyzer and the benefits you gain from each control and menu option as you go through examples. You learn to easily obtain accurate spectral and time-domain measurements.

CATV Measurements describes CATV requirements and offers step-by-step procedures to conduct automated measurement routines.

Spectrum Analyzer Menus describes the 2715 menu-selectable, firmware-driven features.

Appendix A: Specification lists the 2715 electrical, physical, and environmental specifications.

Appendix B: Broadcast AM, FM & TV Signal Sources describes connecting the 2715 to various signal sources to do the examples shown in the manual.

Appendix C: System Messages describes abnormal instrument operating situations and the recommended resolution or correction.

Appendix D: Global Resets provides the definitions, descriptions, and categories of the various reset procedures for the instrument settings.

Appendix E: External Input and Output explains the procedure to get signals in and out of the back panel of your spectrum analyzer. Configurations for interconnect cables are also discussed.

Appendix F: Accessories & Options describes all standard and optional accessories and options currently available for the 2715.

If you are already familiar with the spectrum analyzer, this manual can serve as a “how to” reference. Check the index or table of contents for the location of the subject of interest. Then set the spectrum analyzer according to the corresponding settings box, and refresh your memory by carrying out the example following the box.



Introduction

Introduction

This section introduces you to the basic concepts of an RF spectrum analyzer and its uses. This section also briefly describes the features of the 2715 Cable TV Spectrum Analyzer.

What is a Spectrum Analyzer?

There are several types of spectrum analyzers, but we will describe only the heterodyne, or scanning, spectrum analyzer. A scanning RF spectrum analyzer is essentially a radio receiver.

Tune a conventional FM broadcast receiver from one end of the band to the other. As you tune, plot the reading of the signal level meter versus frequency. The graph you produce is a frequency domain representation, or spectrum, of the FM broadcast band. The graph tells you at which frequencies the signals occur and how strong they are. If stations are too close together, you will not be able to get an independent meter reading for each individual station, and you will hear them simultaneously. This is because the intermediate frequency (IF) filter of the receiver has a bandwidth that is too wide to separate (resolve) the stations.

What you have just done is tune or scan the FM broadcast band with a resolution bandwidth equal to the bandwidth of the IF filter in your receiver. If you plot your measurements on graph paper with one centimeter divisions, making each division equal 1 MHz, the span/division of the resulting plot is 1 MHz/division.

If you stop tuning, the receiver no longer spans a range of frequencies, but is fixed at the currently selected frequency; it is in zero span mode. The output of the receiver depends on the signal coming through the IF filter at the selected frequency. If you plot the amplitude of the signal as a function of time (or view it on an oscilloscope-type display) you create a time-domain representation (signal amplitude versus time).

A spectrum analyzer performs similarly to the receiver except that the scanning is usually performed automatically (and faster than you do it manually) and there is a selection of IF bandwidths or resolution bandwidths to choose from. Multiple resolution bandwidths are needed because in some cases you may want to separate closely-spaced, narrow-band signals, while in others you may want to examine signals with larger bandwidths. There is a maximum speed at which a band can be accurately scanned with a resolution bandwidth of a given width (generally, the smaller the resolution bandwidth, the slower the speed). The spectrum analyzer can automatically select the fastest speed for you.

You can find additional information about basic spectrum analyzer concepts and definitions in Tektronix application note 26W-7037-1, *Spectrum Analyzer Fundamentals*.

What Can You Do With a Spectrum Analyzer?

Spectrum analyzers measure how the power in an input signal is distributed in frequency. You can use spectrum analyzers to determine signal amplitudes and frequencies, noise power, carrier-to-noise ratios, signal or filter bandwidths, distortion (harmonic and intermodulation), FM deviation, and percent modulation. Also, you can use spectrum analyzers to detect spurious signals, align transmitters and receivers, and check specifications.

About the 2715

The Tektronix 2715 Cable TV Spectrum Analyzer is a portable, cable TV, radio frequency (RF), scanning spectrum analyzer for use in the field or in the shop. It weighs less than 22 lbs (9.5 kg) and can be equipped with a battery and inverter for use in locations without AC power.

The user interface is simple enough for the beginner but versatile enough to satisfy an expert. Fundamental cable TV (CATV) measurement parameters, such as center frequency, span/division, and reference level, are automatically set when you select a channel table and channel. In nonCATV mode, measurement parameters can be controlled directly with dedicated keys. You can display a spectrum by using only three controls. Call-up menus enable you to automate operations, such as bandwidth or carrier-to-noise ratio measurements, and to directly enter front-panel control settings. Measurement parameters and results are displayed on-screen.

To increase measurement flexibility, the 2715 Cable TV Spectrum Analyzer has the following standard features:

- Automated CATV measurements, including in-service measurements of carrier-to-noise (C/N), composite second order (CSO), and in-channel response (ICR)
- Frequency-corrected YIG oscillator for high frequency accuracy; you can change the default oscillator settling delay time to optimize settling time for your particular use; the 2715 stores the new value
- True analog display (in addition to digital storage) with 1 μ s/div sweep speed that lets you see beats down in the noise
- Low input signal sensitivity with the built-in preamplifier activated
- Signals as large as 70 dBmV (+20 dBm) can be accommodated
- Automatic selection of both sweep speed and resolution bandwidth
- Digital and time-domain functions
- AM/FM detection
- User-definable modes
- 300 Hz to 5 MHz resolution bandwidths

Post-detection digital sampling and storage is used with a unique max/min display mode that provides a close approximation of analog displays. Peak detection is also provided. It is possible to display up to four traces simultaneously and to perform ensemble statistics. A continuously updated “waterfall” display mode can be used to compare the four most recent spectral sweeps. 124 Kbytes of nonvolatile random access memory (NVRAM) is provided to enable saving front-panel configurations and spectral sweeps for later review or operation. The exact storage capability depends on what else you are storing in the instrument (such as user-defined keystroke sequences).

You may improve the center frequency setting time in some applications by changing the YIG oscillator settling delay time from the factory default value. The new setting value is saved automatically. See *Changing the YIG Settle Delay* on page 6–78 for more information.

NOTE. *The stability and frequency accuracy specifications of the spectrum analyzer are guaranteed only for the factory default YIG settling delay time.*

In-service measurement capability includes measurement of C/N, CSO, and ICR (on NTSC and PAL signals only). Gating hardware in the 2715 Spectrum Analyzer allows these measurements to be made on normal modulated TV signals without disruption to the TV program in progress.

Since gated-measurement techniques have advantages and disadvantages, the 2715 Spectrum Analyzer is designed so that you always have a choice of whether or not you use gated (in-service) measurement techniques. If you follow the In-Service menu selections for C/N, CSO, or ICR, you will be making a gated measurement; otherwise you will be making a measurement in the conventional way without gating. For more information about in-service measurements refer to *In-Service Measurement Capability* on page 5–18.

The instrument is very durable, but rough handling, or liquids, dust, or other contaminants inside the case can cause damage. The optional Travel Line package provides additional protection during transportation.

Optional capabilities result in even greater performance. Refer to *Appendix F: Accessories and Options*, for information on options currently available for the 2715 Cable TV Spectrum Analyzer.



Getting Started

Getting Started

This section describes the procedure you should follow when your new 2715 arrives from the factory. Observe the indicated precautions to prevent damage to the instrument during initial checkout and subsequent use.

Receiving and Unpacking

The spectrum analyzer and its standard accessories are carefully packed at the factory using a specially designed shipping container to prevent damage during transit.

If, upon receipt, damage to the shipping container is evident, notify the shipper. Tektronix, Inc. is not responsible for damage caused during shipping.

If you have not already done so, carefully remove the spectrum analyzer and its accessories from the shipping container and inspect them for damage. Do not destroy the shipping container. Test spectrum analyzer operation using the *System Checkout* procedure on page 2–4. If damage or defects are discovered, or if components are missing, notify your local Tektronix field office or representative.

Packaging and Storing

In the event that the equipment must be returned to a Tektronix Service Center, carefully package it in the original shipping container. Use the vinyl vapor barrier, and insert the original foam blocks in the same fashion they were received. If the original shipping materials are not available, use a container of equivalent strength and dimensions. Wrap the instrument in a vinyl vapor barrier, and cushion the instrument on all sides with foam or other suitable packing material.

Attach a tag to the instrument clearly showing:

- Owner's name and address
- Name of the person at your location who may be contacted
- Instrument model and serial number
- Description of the problem and service expected

The 2715 can be stored up to 90 days in an environment that meets the nonoperating specifications. It is suggested that you provide a dust cover. For longer periods, the 2715 should be enclosed in a vapor barrier containing appropriate desiccant material and stored in an environment that meets the nonoperating specifications. The original shipping material can be used and is also useful for protecting the equipment if it must be moved.

Installation

The 2715 is designed for table-top operation in any orientation and requires no special installation. However, the handle can be positioned at several angles to serve as a convenient tilt stand. To position the handle, pull out at both pivot points on the sides of the instrument, and simultaneously rotate the handle to the desired position.

Tektronix, Inc. provides an optional rackmount adapter kit (Option 30) that requires 5.25 in (133.4 mm) vertical clearance and a cradle mount adapter (Option 34) that requires 7 in (177.9 mm). Contact your local Tektronix field office or representative for additional information.

The 2715 is equipped with a plastic front panel cover to protect it from mechanical damage. The cover should always be used when transporting the 2715. To remove the cover, place the 2715 on its back feet, then simultaneously pull out and up slightly on each side of the cover.

Regardless of where the spectrum analyzer is used or installed, always provide at least 50.80 mm (2 in.) clearance adjacent to the cooling vents at the sides, bottom, and back of the spectrum analyzer.

See *Appendix A: Specifications* for input power requirements.

NOTE. See the *Getting Started* section of your 2715 Cable TV System Software Manual for setup instructions needed to connect the 2715 to a personal computer.

Precautions

The spectrum analyzer is tough but not indestructible. It can be damaged unless the following cautions are observed:

- Do not apply too large a signal to the input

Never apply signals to the RF INPUT connector if their combined amplitude is greater than +70 dBmV (+20 dBm), or if there is a DC component greater than 100 V. If you exceed these input ratings, you can permanently damage the spectrum analyzer.

If necessary, use an external attenuator first. Further, to prevent damage by transients, use maximum RF attenuation when connecting a signal with a DC component. Then remove attenuation as needed to make the measurement. Also, be aware that the 2715 is optimized for a -30 dBm input to the first mixer. A larger input signal may lead to nonlinear operation and inaccurate results.

DO NOT connect a CATV trunk carrying AC power directly to the RF INPUT. The 1st mixer can be overloaded making accurate measurements impossible. Also, a power surge might raise the peak AC voltage above the maximum safe input level.



CAUTION. *The maximum safe RF and DC input levels are clearly printed near the signal input jack (RF INPUT).*

- Do not apply incorrect AC input power

The 2715 will accept mains power up to $250 \text{ VAC}_{\text{RMS}}$ (refer to *Appendix A: Specifications* for additional information). It is unlikely that you will apply incorrect power while using standard plugs and receptacles in the normal working environment. However, in the field or during abnormal conditions, you might have to connect temporary power. Be certain that any power source connected to the 2715 applies less than $250 \text{ VAC}_{\text{RMS}}$ between conductors or between either conductor and ground. To avoid damage to the source, ensure that it is rated for at least 120 W operation.

- Do not allow moisture, dust, or other contaminants inside the case

Electronic circuits do not mix well with water, chemicals, dust, or grit. The case is not water tight or air tight, so avoid exposing your instrument to these or other contaminants. Do not place liquid containers on or near the spectrum analyzer where they can be spilled into it. Use the Travel Line rain cover (Option 33), or other suitable covering, when transporting the spectrum analyzer outside in inclement weather.

- Do not handle the spectrum analyzer with undue roughness

Do not physically abuse the spectrum analyzer. It can withstand a fair amount of rough handling but dropping it off a workbench or bouncing it around the trunk of a car or the back of a truck may cause damage. Protect the instrument while transporting it, and use it where it cannot be accidentally hit, kicked, or dropped.

- Provide proper ventilation



CAUTION. To prevent damage from over heating, you must ensure that the clearance provided by the feet is maintained on the bottom and that there are at least 2 in (50.80 mm) of clearance around the other sides. **DO NOT** block the air intake areas on the sides, bottom, or the exhaust area at the rear. Never operate the instrument inside a carrying case.

System Checkout

After you have observed the foregoing precautions, you are ready to perform the initial system checkout. Checkout consists of “normalizing” the spectrum analyzer and then measuring the frequency and amplitude of the built-in calibration source. In the process, you will become acquainted with the front panel and the display.

Turning On the Spectrum Analyzer

Before applying power, make sure there is no signal source connected to the spectrum analyzer.

1. Plug in the power cord.
2. Press the **POWER** switch.

The green LED adjacent to the power switch lights indicating that power is turned on. The LED indicators flash and you hear a few beeps as the 2715 performs its power-up self test.

When power is applied to the 2715, it initializes its front-panel controls to settings stored in memory. If the instrument has been used before, those settings may be user-defined (see *User-Defined Power-Up Settings* on page 6–62). If no user-defined settings exist, the 2715 defaults to the factory power-up settings that are permanently stored in initialized RAM (random access memory). The only exception is that the default channel table and channel are replaced by the last selected channel table and channel before power-down.

A display appears on screen almost immediately. You may see the following message:

WARMUP TIME 15 MIN

When the factory-default power-up settings are being used, it is possible to make general observations immediately after the power is turned on. If user-defined power-up settings are implemented, the message **WAITING FOR USER DEFINED POWERUP** appears briefly. The 2715 front panel is locked out while the message is displayed. After the message disappears, the factory-default settings are replaced by the user-defined settings, and you can proceed with your observations.

Whichever settings are used, the WARMUP message is displayed. It disappears after a few seconds. Remember, however, that the spectrum analyzer may require a full 15 minutes to be operating within specification. Consequently, measurement errors and system messages can occur within the warm-up period, particularly if you switch the spectrum analyzer to a narrow span or resolution bandwidth (BW) filter.

You may also see the following phrase during warmup:

NORMALIZATION SUGGESTED

Initial Normalization

Normalization is a process by which the 2715 measures and stores its own calibration parameters using a built-in reference. When this message appears, the instrument is reporting that its self-test feature has determined that its performance no longer matches that predicted by the previous normalization. It is not unusual for the message to appear during the warm-up period, especially if a narrow resolution bandwidth filter is called for by user-defined power-up settings, or if the ambient temperature is different than that at which the previous normalization was performed. If the message remains (or reappears) after the warm-up period, a new normalization should be carried out. Normalization ensures the utmost accuracy when making measurements. We suggest that, whenever maximum accuracy is required, you allow your instrument to reach a stable operating temperature in the environment in which the measurements will be carried out and then perform a normalization before making the measurements.

Perform a normalization to ensure the calibration of the 2715 and to verify its operational status. Additional information about normalization may be found in *Normalizing the 2715* on page 6–65.

1. To do an initial normalization of the 2715, ensure that no external signals are connected to the 2715.
2. Press [UTIL] and [3].

This calls up a menu that offers you a choice of normalization processes.

3. Select ALL PARAMETERS by pressing [0].

Normalization should begin immediately and continue without interruption until it is completed.

Normalizing all parameters requires several minutes. During the process, you will see various displays and messages which keep you informed of progress, but do not require action. The process ends with an audible beep and the message NORMALIZATION COMPLETE, indicating satisfactory operation. If you receive any other message terminating this initial normalization, repeat the procedure. If the message persists, contact your Tektronix Service Center.

Restoring the Factory Default Settings

To ensure a common starting point for the calibration signal measurement, you must restore the factory-default power-up settings.

4. Press [UTIL] [1] [1].

This restores the factory-default settings whenever the 2715 is in normal spectral display mode (and most other modes). It is a handy method of returning to a fixed set of conditions if you get lost.

The Initial Display

Figure 2–1 shows what the spectrum analyzer screen looks like after initializing the instrument settings.

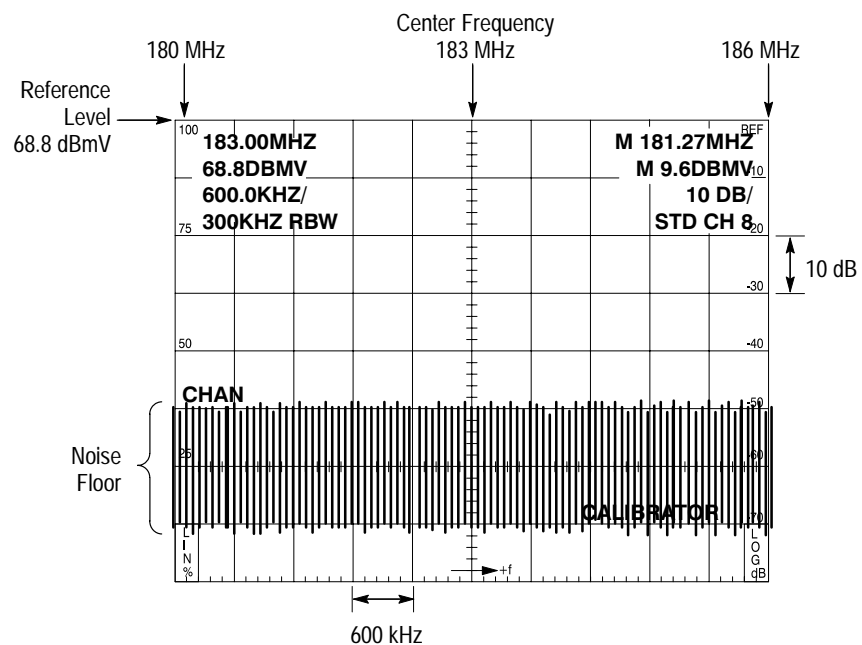


Figure 2-1: Display with Factory Default Power-Up Settings

The displayed spectrum represents the noise floor of the spectrum analyzer. The noise floor is the amplitude of the noise generated internally by the spectrum analyzer itself and passed through the resolution bandwidth filter. Narrowing the resolution bandwidth lowers the noise floor, because noise power is directly proportional to the resolution bandwidth.

The noise appears as a thick, irregular band across the bottom portion of the screen. To achieve this appearance, digital display storage is used. The unique max/min display shown here is designed to resemble the analog spectra that the spectrum analyzer inherently produces.

5. Press **[D]** to see the analog display.

This turns off the D storage register (the only one currently enabled). When all registers are turned off, the analog display appears.

6. Repeatedly press **[D]** to toggle the D register on and off several times. Notice the similarity between displays.
7. Turn the D register on.

To obtain the max/min display, the maximum and minimum amplitudes of the analog spectrum are each sampled at 256 points. Plotting the two interleaved sets of 256 points produces the 512 point graph of the spectrum that you see. This display not only imitates the analog spectrum, but can also assist in detecting low-level signals by more effectively showing the characteristic void they produce under the noise floor.

The spectral display is overlaid by a 32-character wide by 16-character high text screen. Not all of the text fields are displayed all the time, and you can turn the text screen on and off by pressing **[READOUT]**.

The top portion of the text screen contains two data readout columns that are present whenever the text screen is turned on. The readouts show spectrum analyzer settings or measurement results. Figure 2–2 shows the data normally displayed in the readout columns.

Center frequency	Marker frequency
Reference level	Marker amplitude
Horizontal scale factor	Vertical scale factor
Resolution bandwidth	Channel table and number
(Various messages may appear as needed below the data readout columns)	

Figure 2–2: Normal On-Screen Data Readouts

With the spectrum analyzer in the MAX SPAN mode (indicated by MAX following the horizontal scale factor), the resulting spectrum spans the entire input frequency range. In this mode, the first item in the left column lists the frequency at the location of the frequency marker (the intensified spot on the display).



The types of information in the right column may change depending on operating mode. You will learn when to expect alternate information as we discuss the various modes. Below the readout columns, messages and indicators appear as warranted, and numeric instrument settings can be entered.

Control Panel Basics

The control panel has several characteristics included to make it easy and convenient to operate:

- Controls with related functions are generally grouped together — the groupings (Function Blocks) are defined by the borders or background color surrounding the controls
- Dedicated controls permit quick selection of important measurement functions — the controls are defined by background color
- Arrow keys directly increase and decrease critical control settings
- Menu keys located in the MENUS function block call up lists of operator-selectable features
- A numeric keypad permits selection of menu options and entering of critical measurement parameters
- Terminator buttons in the keypad block designate the units for numeric entries with a single keystroke
- An immediate entry mode that enables you to enter arbitrary values for the channel/frequency, span, and reference level directly from the keypad
- Red LED function status indicators adjacent to certain buttons indicate when the functions are active
- Green LED register status indicators illuminate when any storage register contains a saved waveform

The controls most fundamental to spectrum measurements (**[CHAN/FREQ]**, **[SPAN/DIV]**, and **[REF LEVEL]**) are located in a single central function block with a dark gray background. These controls can be conveniently set using either the arrow keys or immediate entry mode.

The arrow keys enable you to instantly change control settings. [] and [] move according to the channel table selection. The arrow keys are active whenever the spectrum analyzer is in the spectral display mode.

In immediate entry mode, you press the key corresponding to the parameter you wish to set ([**CHAN/FREQ**], [**SPAN/DIV**], or [**REF LEVEL**]), type the parameter value on the keypad, and press the appropriate terminator key to complete the entry. The value appears on screen as you type.

Each of the terminators ([**W**], [**X**], [**Y**], and [**Z**]) can represent more than one unit as indicated by the legend to the right of each key; however, the keys are context sensitive. If an entry represents a frequency, the indicated frequency unit is selected automatically when you press the key. If dBs are required, the indicated dB unit is selected, and so on for all of the units.

Many keys are toggle-action. The ability to undo an action, including menu selection, by pushing the same button or sequence of buttons that carried out the action is typical of operations performed on the 2715.

8. Press [**VID FLTR**] to observe the toggle action.

The red video filter LED illuminates, and the trace shrinks vertically as the filter turns on and averages the noise.

9. Press [**VID FLTR**] again.

The noise spectrum expands to its original size as the filter is turned off, and the LED goes out.

Sounds The 2715 can emit tones under the following conditions:

- During power-on self test
- When an abnormal condition occurs
- When a message appears
- When a key is pressed

The instrument emitted self-test beeps when it was powered up. The beep can be set to sound when an error occurs, when a key is pressed, when either happens, or it can be set to never sound.

If the error alert is turned on and an abnormal condition exists, such as a request to extend a measurement parameter beyond its range, the 2715 emits a high-level beep. A message is simultaneously displayed on-screen describing the abnormal condition.

The 2715 is equipped with AM and FM demodulator circuits that extract the audio signals on amplitude or frequency modulated RF signals. The demodulated audio is reproduced on the built-in speaker. This feature can be used to identify most voice channels based on their content or call signs and can help to identify others by enabling you to determine the type of modulation (frequency shift keying, pulsed CW). For better quality audio or private listening, use the headphone jack on the right side of the 2715. The AM/FM demodulators are discussed in detail in *DEMODO* on page 6–56.

The Built-In Calibrator

The 2715 is equipped with a built-in calibration source. The calibrator for the 2715 has no external “Cal Signal” output. Instead, the calibrator resides in the 2715 and can be “connected” to the input path without the need for external cabling by selecting the proper Input Menu option.

10. Press the **MAX SPAN** key (located below the REF LEVEL key).

11. Press the **AUTO RES BW** key.

12. Press [**INPUT**] to call up the Input Menu.

Item 9 specifies a CAL SIG @ 100MHz 18.8DBMV. The calibrator is a CW signal with a fundamental frequency of 100 MHz at an amplitude of 18.8 dBmV (–30 dBm). Higher order harmonics at lower levels are also present. Item 9 toggles the calibrator on and off.

13. Press [**9**] to turn the calibrator on.

The screen reverts immediately to the spectral display. The word CALIBRATOR now appears near the bottom right of the screen signifying that the calibrator is enabled. You should see a few signal peaks towards the left of the display. These are the fundamental and harmonics of the calibrator signal. If you do not see them, it is because the amplitudes of the harmonics may be lower than the noise floor of the 2715.

NOTE. When the calibrator is enabled, the normal RF input is disconnected internally from the input attenuator and cannot be viewed.

14. Press [**INPUT**] [**9**] to disable the calibrator.

Making Your First Measurement

The following two types of measurements can be made with the 2715:

- CATV measurements
- NonCATV measurements

Selecting a Channel Table

The factory defaults set the 2715 in the normal (CATV) mode.

The resolution bandwidth (RES BW) is set to 300 kHz, allowing you to see most of the detail in the channel band.

1. Connect a cable TV feed to the RF INPUT.
2. Press [**CATV/APPL**] [**8**] [**1**] to call up a menu of channel tables.

Initially, there are three factory-installed tables in this menu. You may choose to add other tables to this menu using the PC-based software that comes with the 2715.

3. Press [**0**] to select the standard (STD) table.

The reference level is then set so the peak of the visual carrier is approximately one division down from the top graticule line, and the center frequency and span are set so the channel band is centered on the screen horizontally.

4. Press any menu button to return to the spectral display.

The abbreviation CHAN appears at left center of the screen. The CHAN indicator tells you that you can enter the channel number directly from the keypad. This is done by keying in a permissible number followed by the [**W**] terminator key (labeled **CHAN**).

Select an active channel (channel 8 for this exercise).

5. Press keypad numbers corresponding to the desired channel.

The numbers you press appear on screen to the right of CHAN. If you make a mistake, you can correct it by repeatedly pressing the backspace key until the incorrect number disappears and then entering the correct number.

6. Press [**W**] after the channel number has been entered.

This key can represent units of CHAN, GHz, SEC, or V. Because you selected an entry mode that requires a channel, the 2715 correctly interprets the currently displayed entry as STD CH 8.

Direct frequency entry capability is available from the front panel. However, the 1 GHz terminator is not available in the normal mode, because it is reserved for channel selection.

You are now ready to perform a CATV measurement.

Typical CATV Measurement

This example is one of several CATV measurements and allows you to measure the visual and aural carrier levels over the selected channel. Note that the following are the only actions needed to make a measurement:

- Select a channel table
- Select a measurement channel
- Select a measurement
- Run the measurement

The channel table and measurement channel selected at power down will be remembered when power is reapplied to the 2715. Therefore, the only thing that needs to be selected after that is the type of measurement.

Items 1 through 4 on the second page of the CATV MEASUREMENTS menu are toggle-type functions. For example, if you select VIEW MODULATION (LINE) with [CATV/APPL] [9] [2], you get a preselected VITS line. You must make the same selection or select another measurement to disable the line display.

7. Press [CATV/APPL] [1] to call up the CARRIER LEVELS menu.
8. Press [0] to select/run the Carrier Levels.

The 2715 starts the measurement routine (much like performing a center measure on the visual and aural carriers). When the measurement is finished, the 2715 returns to the spectral display. Two lines near center screen display the measurement results. One line displays the visual carrier amplitude and frequency in absolute values, and the second line displays aural carrier amplitude and frequency as offsets from the visual carrier values.

9. Press [CATV/APPL] to recall the CARRIER LEVELS measurement menu.
10. Press [1] to store the measurement results.
11. Press [2] to display the measurement results. See Figure 2-3 for a typical display.
12. Press [W] to display the last stored results (if they exist).
13. Press [3] to print the measurement results. (The spectrum analyzer must be connected to a printer that is capable of printing text.)
14. Press [4] to print the stored measurement results.
15. Press [9] to deselect the CARRIER LEVELS measurement.
16. Disconnect the cable TV feed from the RF INPUT.

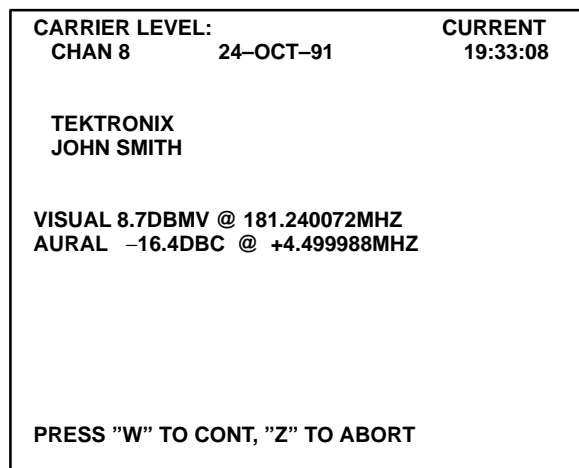


Figure 2-3: Typical Measurement Result Display

Making Your First NonCATV Measurement

This procedure shows you how to verify the frequency and amplitude of the calibration signal. Although the calibration signal is used, the measurement technique is the same for any continuous signal. In the process, you will learn to use three of the most important controls on the spectrum analyzer and to confirm that the major functions of the spectrum analyzer are operating correctly.

1. Press [UTIL] [1] [1] to recall FACTORY DEFAULT POWER-UP settings.

The factory defaults set the RF attenuation to 50 dB. This affords the most protection to the spectrum analyzer, because any signal at the input undergoes maximum attenuation before reaching the power-sensitive mixer circuit. We recommend that you use this setting when connecting unknown signals to the spectrum analyzer.

2. Press [CATV/APPL] [8] [0] to disable the CATV mode.
3. Press [MAX] then [AUTO] (in the RES BW block) to enable maximum span and AUTO RES BW.

The span goes to 180 MHz per division, and the resolution bandwidth goes to 5 MHz. This is maximum span and is indicated by the word MAX in the span readout. This is the safe setting for introducing new signals. It enables you to view the entire measurement range (1.8 GHz) of the spectrum analyzer. If a smaller span is used, large signals can be present off-screen.



CAUTION. The total signal power (that is, all signals on-screen or off added together), not just the signal of interest, must remain below +70 dBmV. With a small span, it is also possible to reduce the attenuation to view a low level, on-screen signal while inadvertently allowing an off-screen, high-level signal to saturate the mixer, causing spurious responses and possibly even damaging the mixer.

4. Press [INPUT] [9] to turn on the built-in calibrator.

NOTE. The amplitude of the internal calibrator is 18.8 dBmV. This places the peak level at the top graticule line with the reference level set at 18.8 dBmV and 0 dB internal attenuation.

To measure the calibration signal, you are going to use the three primary controls on the spectrum analyzer. These are located in the central dark gray function block and are shown in Figure 2–4. The three primary controls and the **FREQ/MKRS** knob to the left are the controls you will use most often. In general, you can make most measurements with only these controls, although you will find that other controls and menu features enable you to make many measurements more quickly and conveniently.

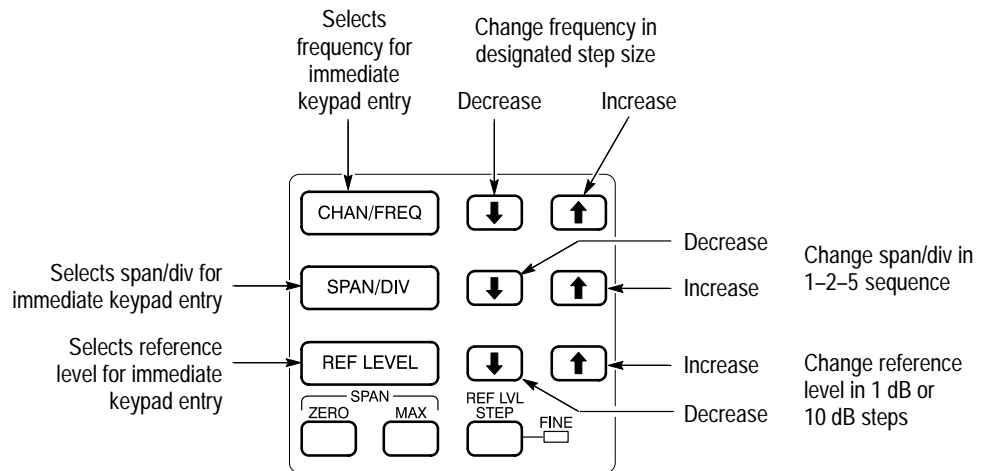


Figure 2–4: The Primary Controls

First, raise the displayed signal height by reducing the reference level. The reference level represents the signal power needed to deflect the displayed spectrum to the top graticule line. The 2715 provides several methods of directly changing the reference level. The most convenient method is to press the arrow keys.

- Press [\blacktriangledown] to the right of [REF LEVEL] three times to reduce the reference level 30 dB.

For numeric entry, the W key terminates any channel number; whereas, the X, Y, or Z keys terminate channel/frequency entry. On channel/frequency, the 2715 selects the channel closest to the new channel/frequency.

Figure 2–5 shows what the resulting display should look like, although some of the signal peaks on your spectrum analyzer may have slightly different amplitudes than those shown. Notice that both the reference level and RF attenuation readouts have decreased 30 dB (the reference level is 38.8 dBmV and the RF attenuation is 20 dB).

Normally the arrow keys change the reference level 10 dB per press, but in FINE mode the value changes 1 dB per press. Another method is to set the reference level to 20.8 dBmV, less than half a division above the expected signal amplitude. We choose this value for the following reasons:

- Signal amplitudes are read out and displayed most accurately when they are near the reference level.
- 2 dB provides a small amount of “headroom” in case the signal should be slightly larger than anticipated.

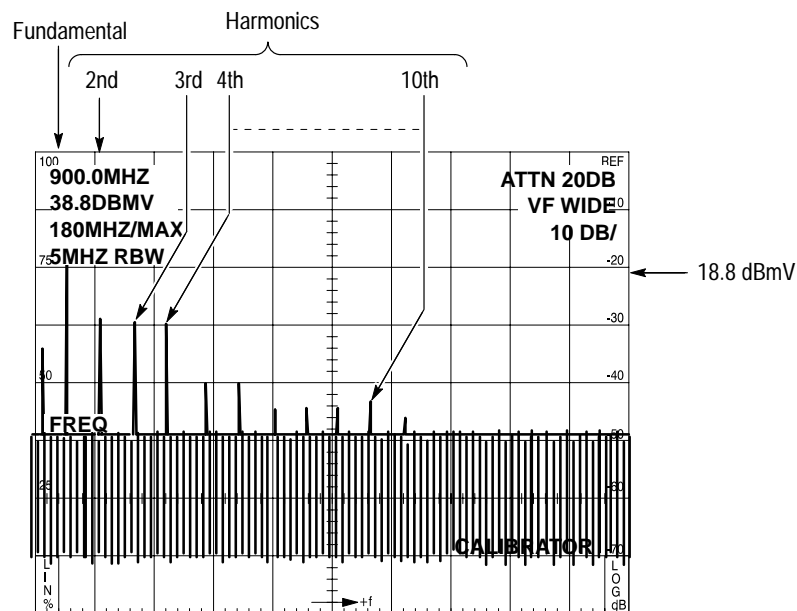


Figure 2–5: Calibrator Signal and Harmonics

To specify a predetermined value, press **[REF LEVEL]** to place the reference level in the immediate entry mode. The abbreviation REFL will appear at left center of the screen.

The REFL indicator tells you that you can enter the reference level directly from the keypad by typing a value followed by an appropriate terminator key.

NOTE. *In the spectral display mode, the abbreviation for the control last placed in the immediate entry mode remains on screen until another control is chosen. When a control is in the immediate entry mode, repeated settings for that control can be entered without having to press **[CHAN/FREQ]**, **[SPAN/DIV]**, or **[REF LEVEL]** again. Only primary controls can be placed in immediate entry mode.*

6. Press **[2] [0] [.] [8]** to set the reference level to 20.8 dBmV.

The numbers you type appear on screen to the right of REFL. If you make a mistake, you can correct it by repeatedly pressing **[BKSP]** (the backspace key) until the incorrect number disappears and then entering the correct value.

7. Press **[Y]** after the correct number has been entered.

The Y key can represent units of kHz or +dB. Because you selected an entry mode (immediate reference level entry) that requires decibels, and because the factory-default unit is dBmV, the spectrum analyzer correctly interprets the currently displayed entry as 20.8 dBmV. If the currently selected reference level units had been dBm or dBW, the 2715 would have interpreted your entry correctly when you pressed the terminator key.

The RF attenuation is reduced to 2 dB and the reference level readout indicates the desired 20.8 dBmV. For the parameters established for this example, this entry method enabled you to specify a reference level that could not be achieved with the arrow keys unless you switched to the FINE mode. You can also enter fractional reference levels to the nearest 0.1 dB with this method.

The spectrum analyzer is still in the MAX SPAN mode, which means that the harmonics of the calibrator signal are barely more than one half division apart. Spread them out by reducing the span/div. As in the case of the reference level, the spectrum analyzer provides two direct entry methods.

8. Press **[↵]** to the right of **[SPAN/DIV]** twice to reduce the span to 50 MHz/division.

Notice that the readout now indicates 50 MHz/, and the harmonics are two divisions apart.

Suppose that you want to view just a single harmonic and the 30 MHz band to either side of it. You can do this by setting the span to 6 MHz/division. This is not a value obtainable with the arrow keys, but you can get it in the immediate entry mode.

9. To set the span/division to a predetermined value, first press **[SPAN/DIV]** to place span in the immediate entry mode.

Notice that the abbreviation SPAN appears at the left center of the screen.

The SPAN indicator tells you that you can enter the span/div directly from the keypad. This is done by keying in a permissible value followed by an appropriate terminator key.

10. Press **[6]** to set the span/div to 6 MHz.

Any number you type appears on screen to the right of SPAN. If you make a mistake, you can correct it by repeatedly pressing **[BKSP]** (the backspace key) until the incorrect number disappears and then entering the correct value.

11. Press **[X]** after the correct number has been entered.

This key can represent units of MHz, ms, or mV. Because you selected an entry mode that requires a frequency, the 2715 correctly interprets the currently displayed entry as 6 MHz. If a time or voltage unit had been required, the 2715 would have interpreted your entry as 6 ms or 6 mV, respectively.

The span now is set to 6 MHz, and the ninth harmonic of the calibrator signal is centered on screen at 900 MHz. You may have noticed that the resolution bandwidth changed to 1 MHz. This demonstrates the AUTO resolution bandwidth selection mode of the 2715. The spectrum analyzer reduces its resolution bandwidth as you reduce the span/div, so the resolving power of the instrument automatically increases as you look at the spectrum more closely.

To look at the calibrator signal fundamental, you must change the center frequency. The spectrum analyzer provides three direct methods of doing so, each appropriate under different circumstances.

12. Press **[▼]** to the right of **[CHAN/FREQ]** twice.

Notice that the center frequency readout now indicates approximately 894.0 MHz. The frequency arrow keys change the center or start frequency by the same as the span/div, but you can change the tuning rate. See *Selecting the Tuning Increment* on page 6–21. You could continue pressing **[▼]** until the correct frequency is reached, but this would require a large number of presses.

This method of changing frequency is very useful for scanning relatively small bands. To change by larger amounts, use the immediate entry mode to set the center or start frequency to a predetermined value.

13. Press [**CHAN/FREQ**] to place the center or start frequency in the immediate entry mode.

Notice that the abbreviation **FREQ** appears at left center of the screen.

The **FREQ** indicator tells you that you can enter the center frequency directly from the keypad by keying in a permissible value followed by an appropriate terminator key.

14. Press [**1**] [**0**] [**1**] to set the center frequency to 101 MHz.

The numbers you press appear on screen to the right of **FREQ**. If you make a mistake, you can correct it by repeatedly pressing the backspace key until the incorrect number disappears and then entering the correct value.

15. Press [**X**] after the correct number has been entered.

This key can represent units of MHz, ms, or mV. Had you wanted to set the frequency to 101 kHz, you would have pressed [**Y**].

This method of changing center or start frequency is most useful when large changes are required or if you know ahead of time exactly what frequency is required.

The span is now set to 6 MHz and the fundamental of the calibrator signal is not quite centered on screen. Center the calibrator signal with the **FREQ/MKRS** knob.

16. Turn the **FREQ/MKRS** knob several clicks counterclockwise to reduce the center or start frequency.

Each click reduces the frequency by the currently selected tuning increment (0.02 times the span/div, or 0.12 MHz in this case). The control functions as the “fine” frequency adjustment. Rotating the knob clockwise increases the frequency at the same rate.

17. Continue turning the knob in either direction until the signal is centered.

Your screen should now resemble Figure 2–6.

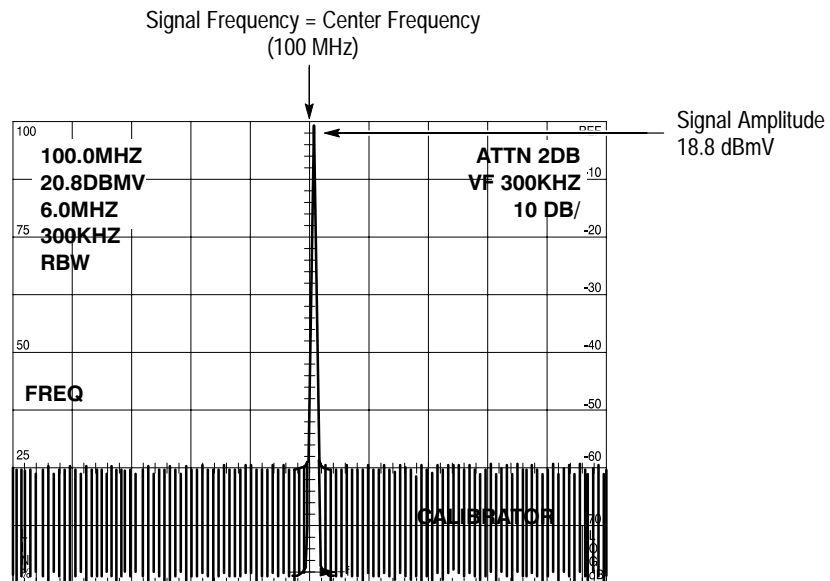


Figure 2–6: Calibrator Signal Fundamental

The signal frequency is 100 MHz and the signal peak is 0.2 division below the reference level so its amplitude is 18.8 dBmV as shown in the following equation:

$$20.8 \text{ dBmV ref level} - 0.2 \text{ div} \times 10 \text{ dB/div} = 18.8 \text{ dBmV}$$

Using only the frequency, span, and reference level controls you have verified the basic operation of the 2715, and determined the frequency and amplitude of its calibrator signal.



Operating Basics

Operating Basics

This section provides an overview of the spectrum analyzer display, menus, controls, and connectors. The experienced spectrum analyzer user will find it a handy guide.

Display Screen

The spectrum analyzer display consists of an 8 division high by 10 division wide graphical sweep screen with a 16 row by 32 character text screen overlay. In the spectral display mode, both the graphic and text data are normally present, although the text screen can be toggled on and off by pressing [READOUT]. In the menu display mode, only the text screen is normally present, but the sweep display can be turned on (see *The Spectral Display in Menus* on page 6–74).

The entire screen area is available for the sweep display, but contents of the text screen are placed in predetermined locations. Figure 3–1 shows the text screen layout used in the spectral display mode. When the optional Display Title line is not used, rows 2 through 11 and rows 13, 14, and 15 move up one.

LINE #	SCREEN CONTENT
1	Display Title (optional)
2	Center Freq/Start Freq RF Atten/Mkr Freq/Counter Freq
3	Reference Level Vid Fltr BW/Marker amplitude*
4	Horizontal Scale "TRKG" Indicator Vert Scale*
5	Resolution BW Blank/TV Channel/Video Line
6	"UNCAL" Indicator Single Sweep Messages
7	Error Message
8	User Defined Program Title
9	Displayed Message
10	UDP Status
11	Keypad entry/WFM to Save
12	Real-time Clock Display
13	
14	
15	"CALIBRATOR" Indicator
16	"WARMUP TIME 15 MIN" Message/GPIB & RS-232 Status

* May also contain C/N, NOISE NORM'D, BW, & OBW results.

Figure 3–1: Layout of the Text Screen in the Spectral Display Mode

Figure 3–2 shows the text screen for the menu display mode. The menu footer area contains prompts, general information, and additional data entries shown below:

- Which key to press to return to the spectral display
- Which key to press to back up one menu level
- Which menu key was pressed to enter this menu
- What data to enter
- Data that has already been entered
- Which terminator key to press

LINE #	SCREEN CONTENT
1	Menu Title
2	
3	
4	Up To 10
5	Items (0–9) Displayed
6	Here
7	:
8	:
9	:
10	:
11	:
12	:
13	Error Message
14	Data Entry
15	Footer area containing prompts
16	general information, and data entries.

Figure 3–2: Layout of the Text Screen in the Menu Display Mode

Connectors, Controls, and Menus

Most of the spectrum analyzer front-panel controls are located in function blocks that are denoted by their borders or background colors. Each block contains related controls. The central gray-colored block contains the fundamental channel, center (or start) frequency, span, and reference level controls. For convenience, one function block is dedicated exclusively to menu display. The control panel and its major functional areas are shown in Figures 3–3 through 3–8. The *Dedicated Controls* section contains detailed discussions of the controls.

Trace alignment controls and various input/output connectors are located at the rear panel. Figure 3–9 on page 3–10 shows the spectrum analyzer back panel and its connectors. The alignment controls are discussed in *Miscellaneous Controls* on page 4–33, and the connector terminations are described in *Appendix E: External Input and Output*.

The menu structures are shown starting on page 3–11. Some menu items are not present because they either are not available at the current menu level, are intended primarily for factory calibration and troubleshooting, or they apply to instrument options not currently installed.

A brief description of the function of each of the listed menu selections is given. The functions of the menu selections are discussed in greater detail in the *CATV Measurements* and *Spectrum Analyzer Menus* sections.

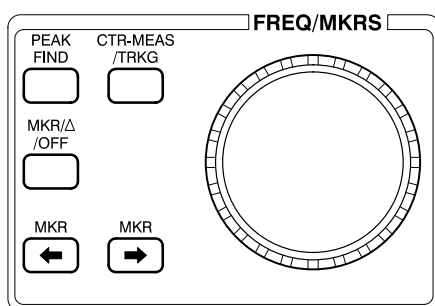


Figure 3–3: The Frequency/Marker Function Block

FREQ/MKRS

In the normal spectral display mode, the knob changes the center, or start, frequency by 0.02 of the span/div per click. In programmed or tabular tuning modes frequency is changed by the designated tuning increment per click. In ZERO SPAN frequency is changed by a percent of the resolution BW per click (see *Selecting the Tuning Increment* on page 6–21). In other modes, the knob may control marker horizontal position or video line number.

CTR-MEAS/TRKG

One press initiates a center measure. The frequency of the signal nearest center screen (or nearest the marker, if active) is measured and made the new center frequency. Signal frequency and amplitude are displayed at the upper right of the screen. Two quick presses enter the signal track mode (continuously repeated center measures, enabling a drifting signal to be tracked); signal frequency readout is optional in this mode and is enabled by pressing [MKR/FREQ] [9] [1]. A third press returns to normal operation.

PEAK FIND The marker is moved to the highest on-screen signal peak (turns the marker on if it is not active) independent of the detection threshold.

MKR/ Δ /OFF The first press turns on a single marker at center screen; its position is controllable with the **FREQ/MKRS** knob. A second press fixes the position of the first marker and turns on a second marker (delta marker mode); its position is controllable with the **FREQ/MKRS** knob. A third press turns off both markers.

MKR [\blacktriangleleft] [\blacktriangleright] Keys Each key, respectively, jumps the moveable marker from its current position to the next on-screen signal peak to the left or right. Signals must be above the detection threshold (see *Setting the Signal Threshold* on page 6–22).

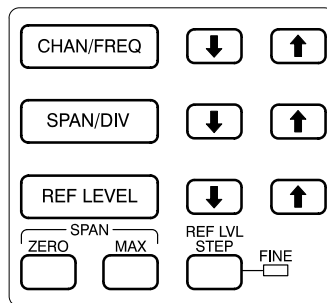


Figure 3–4: Fundamental Analyzer Controls

CHAN/FREQ Selects the channel number immediate entry mode when CATV mode is active. CHAN appears on the screen at left center. Enter the desired channel from the keypad; terminate with [W]. In nonCATV mode, it selects the center, or start, frequency for immediate entry mode. FREQ appears on the screen at left center. Enter the desired frequency from the keypad; terminate with [Hz], [kHz], [MHz], or [GHz] key.

Range: 0 Hz to 1.8 GHz

SPAN/DIV Selects the span per division for the immediate entry mode. SPAN appears on the screen at left center. Enter the desired span/div from the keypad; terminate with [Hz], [kHz], [MHz], or [GHz] key.

Range: 1 kHz to 180 MHz

REF LEVEL	<p>Selects the reference level for the immediate entry mode. REFL appears on the screen at left center. Enter the desired reference level from the keypad; terminate with [+dBx] or [-dBx] key.</p> <p>Range: +68.8 to -21.2 dBmV (or equivalent in other units)</p>
REF LEVEL [▲] [▼] Keys	<p>The arrow buttons increase ▲ or decrease ▼ the FREQUENCY, SPAN/DIV, and REF LEVEL by a specified amount. They are always active in the spectral display mode, even if the parameter is not selected for immediate entry.</p> <p>CHAN Change (CATV mode): changes by one channel in the channel table, skipping the SKIPPED channels</p> <p>FREQUENCY change: equivalent of 50 knob clicks or 1 major division in the AUTO tuning increment mode, and by the designated tuning increment in other modes</p> <p>SPAN/DIV change: in a 1-2-5 sequence from 1 kHz to 180 MHz</p> <p>REF LEVEL change: 1 dB or 10 dB per step depending on REF LVL STEP setting</p>
ZERO and MAX Keys	<p>Shortcuts, respectively, to the zero span and maximum span settings. The keys are toggles; one press activates the setting, the second returns to the span used prior to the first press.</p> <p>ZERO SPAN: no frequency sweep, horizontal axis calibrated in time/div, and the display is a time domain representation of the signal at the indicated center, or start, frequency</p> <p>MAX SPAN: 180 MHz/div (often used to view full input range of 0-1.8 GHz)</p>
REF LVL STEP	<p>Toggles the amount by which the REF LEVEL arrow keys change the reference level between 1 dB and 10 dB per press. The adjacent FINE indicator is illuminated when 1 dB is selected.</p>

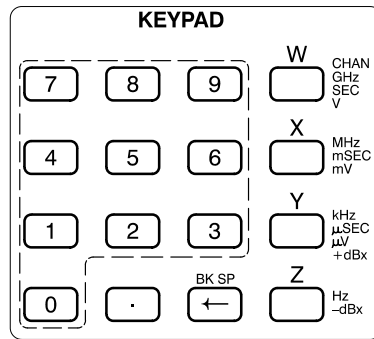


Figure 3-5: The Keypad

Numeric Keys (0-9) Numeric keys are used to enter numerical values in the immediate entry mode or in response to menu prompts. They are also used to select the numbered items from menus.

Terminator Keys (W, X, Y, Z) The terminator keys signify the end of an entry, and supply the appropriate units for the entry. They are context sensitive; if you press [X], the spectrum analyzer automatically interprets it as MHz, ms, or mV depending on the parameter being entered.

Dot Key (•) The dot key supplies the decimal point in numeric entries, and can be used as a period in label and title entries.

BKSP Key The backspace key erases the last character pressed in data entry modes and backs up one menu level when menus are active.

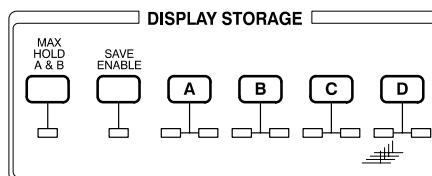


Figure 3-6: Display Register Control

Register Select and Save Keys (A, B, C, D) Pressing [A], [B], [C], or [D] when SAVE ENABLE is not armed turns its respective register on and off for display. When the register is displaying data (saved or current), the red LED to the lower right of the key is lighted.

When SAVE ENABLE is armed, press [A], [B], or [C] to store the current sweep if the register is cleared, or clear the register if it contains saved data.

The saving or clearing action occurs whether the register is displaying data or not. The green LED to the lower left of the key lights when the register contains saved data.

Pressing **[D]** when SAVE ENABLE is armed toggles the spectrum analyzer in and out of waterfall display mode. All registers must first be cleared. Individual sweeps cannot be saved in D.

SAVE ENABLE Arms the save (clear) function. Press **[SAVE ENABLE]** and then press the key corresponding to the register to be saved (cleared). The LED below the key lights when SAVE ENABLE is armed.

MAX HOLD A&B Enables max hold mode. When MAX HOLD is enabled, the A and B registers retain the largest signal observed (unless they contain saved waveforms). The LED below the key lights when MAX HOLD is active.

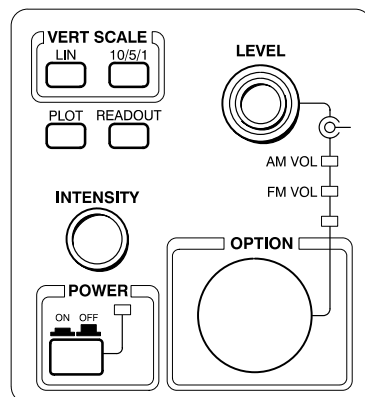


Figure 3–7: Vertical Scale and Other Controls

VERT SCALE This area of the front panel contains the following controls:

10/5/1. Press repeatedly to cycle the vertical scale in a 10–5–1–10... sequence in LOG (logarithmic) display mode.

LIN. Toggles the vertical display mode from LOG (logarithmic) to LIN (linear) and back again. Scale factor is controlled by the reference level controls in the LIN mode and by **[10/5/1]** in the LOG mode.

PLOT Initiates a screen plot on an optional printer or plotter. Plotter and interface must be correctly configured (see *System Configuration* on page 6–67).

- READOUT** Toggles the on-screen readouts on and off. Use when readouts overlay data, or to eliminate blanking intervals in analog display.
- POWER** Toggles spectrum analyzer power on and off. Green LED next to key is illuminated when power is on.
- INTENSITY** Turning the knob clockwise increases CRT brightness.
- LEVEL** The inner knob sets trigger level in INT, EXT, and (AC) LINE trigger modes (as on a conventional oscilloscope), horizontal position in manual scan mode, and picture framing in video monitor mode.
Outer knob controls volume of the AM and FM demodulators.
- AM VOL and FM VOL** Lights when the AM or FM demodulators are active to indicate that the outer knob of the LEVEL control sets the audio volume. See DEMOD on page 6–56.
- VID FLTR** Normally the spectrum analyzer smooths the detected signal with a video filter having a bandwidth equal to the resolution bandwidth. The filter bandwidth is indicated in the right-hand readout column. However, pressing [VID FLTR] (see Figure 3–8) toggles an alternate, automatically selected or user-designated video filter on and off. Its bandwidth replaces the normal video filter readout.

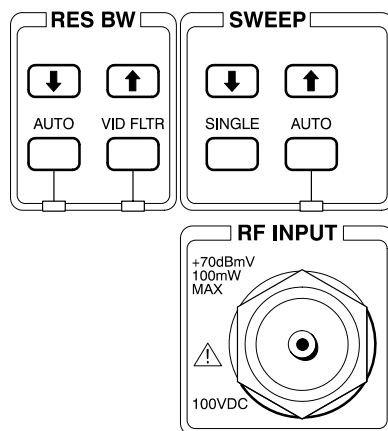






Figure 3–8: Resolution BW and Sweep Control

You can designate the video filter bandwidth using the UTIL Menu (see *Menu-Entered Control Settings* on page 6–60).

Automatic Selection: 1/100 of the resolution BW
 Fixed Range: 3 Hz to 300 kHz and WIDE in a 1–3 sequence

SINGLE Press [**SINGLE**] to place the 2715 in a single sweep mode similar to a conventional oscilloscope. SGLSWP MODE appears on the screen. With the 2715's sweep in free run mode (default), press the key again to start a sweep. In other trigger modes, the sweep begins with the first trigger signal following entry into single sweep. SGLSWP ARM appears briefly at the start of each sweep. Pressing [**AUTO**] in the SWEEP function block exits the single sweep mode, but preserves the current auto or manual sweep rate selection mode.

AUTO The AUTO keys in the RES BW and SWEEP function blocks toggle the spectrum analyzer into and out of automatic resolution bandwidth and sweep rate selection modes, respectively. Pressing **SWEEP [AUTO]** also exits single sweep mode (but preserves the sweep rate selection mode). The LEDs below the keys are lit when the automatic mode is selected. When toggling out of the automatic mode, the resolution BW and sweep rate remain as they were until manually changed. When toggling into the automatic mode, the spectrum analyzer selects the resolution bandwidth and sweep rate appropriate to the currently selected span.

[] [] The RES BW and SWEEP arrow keys increase [] and decrease [] the resolution bandwidth and sweep rate (time/div) in a specified sequence. They are always active in the spectral display mode, but using either disables automatic resolution BW or sweep rate selection, respectively.

RES BW: sequences through the installed filters 300 Hz, 1 kHz, 3 kHz, 10 kHz, 30 kHz, 100 kHz, 300 kHz, 1 MHz, 5 MHz

SWEEP: follows 1–2–5 sequence from 2 s/div to 1 μs/div. Rates <100 μs/div are useable only in the analog display mode



CAUTION. The spectrum analyzer RF signal input is an F-type 75 Ω connector. **Observe Maximum Input Ratings.**

Input signal:

Maximum Amplitude: <+70 dBmV

Maximum DC: 100 Volts

Frequency Range: 9 kHz to 1.8 GHz

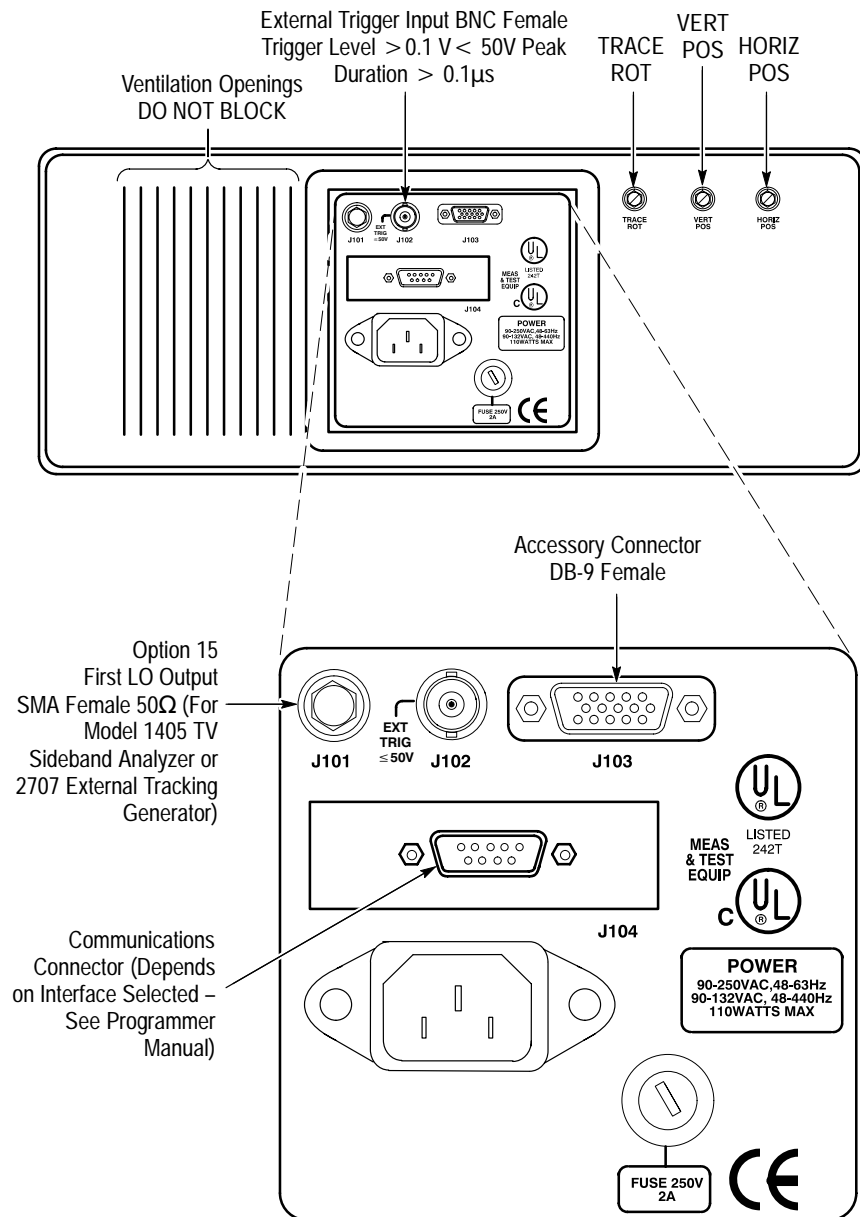
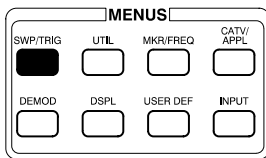


Figure 3-9: The 2715 Back Panel

The remainder of this section shows structure of the menus and submenus displayed by pressing the following keys in the MENUS block:

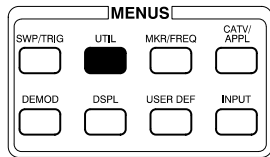
- SWP/TRIG
- UTIL
- MKR/FREQ
- CATV/APPL
- DEMOD
- DISPL
- USER DEF
- INPUT

Some of the submenus are used for servicing; information about these submenus is in the optional *2715 Spectrum Analyzer Service Manual*. Refer to *Table F-2: Optional Accessories* on page F-1 for the part number of the service manual.

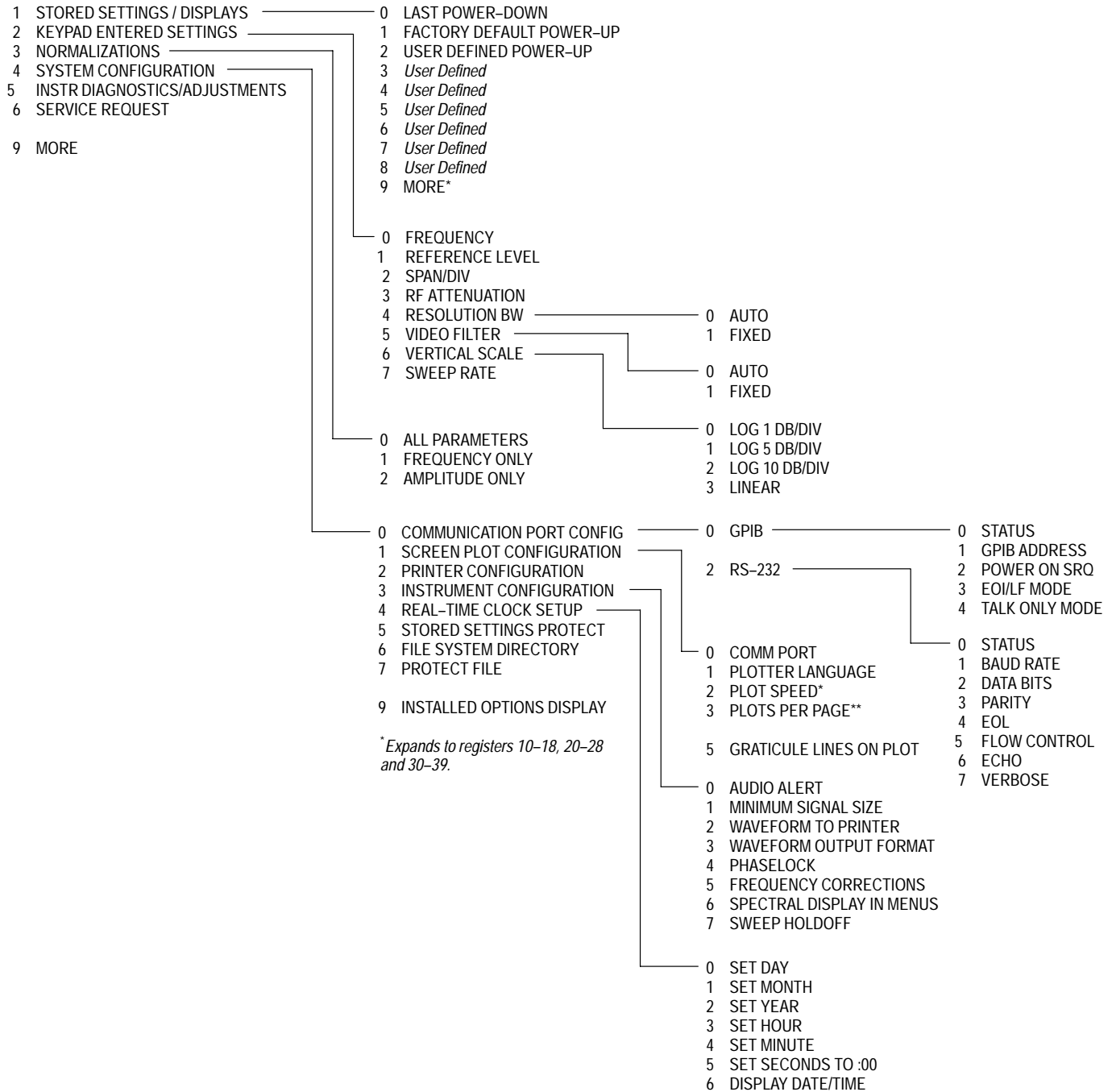


SWP/TRG Menu Structure

- 0 FREE RUN
- 1 INTERNAL
- 2 EXTERNAL
- 3 LINE
- 4 TV LINE
- 5 TV FIELD
- SWEEP MENU
- 6 SWEEP RATE
- 7 MANUAL SCAN
- 8 SYNC POLARITY
- 9 SETUP TABLE ————— HORIZONTAL LINE TRIGGERING
 - 0 CONTINUOUS
 - 1 KNOB SELECTABLE
 - 2 KEYPAD ENTERED LINE
 - 3 KEYPAD ENTRY
 - 4 TV LINE STANDARD

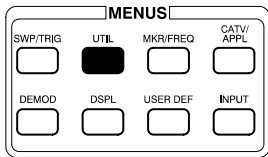


UTIL Menu Structure (1 of 2)

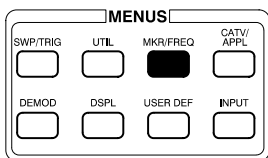
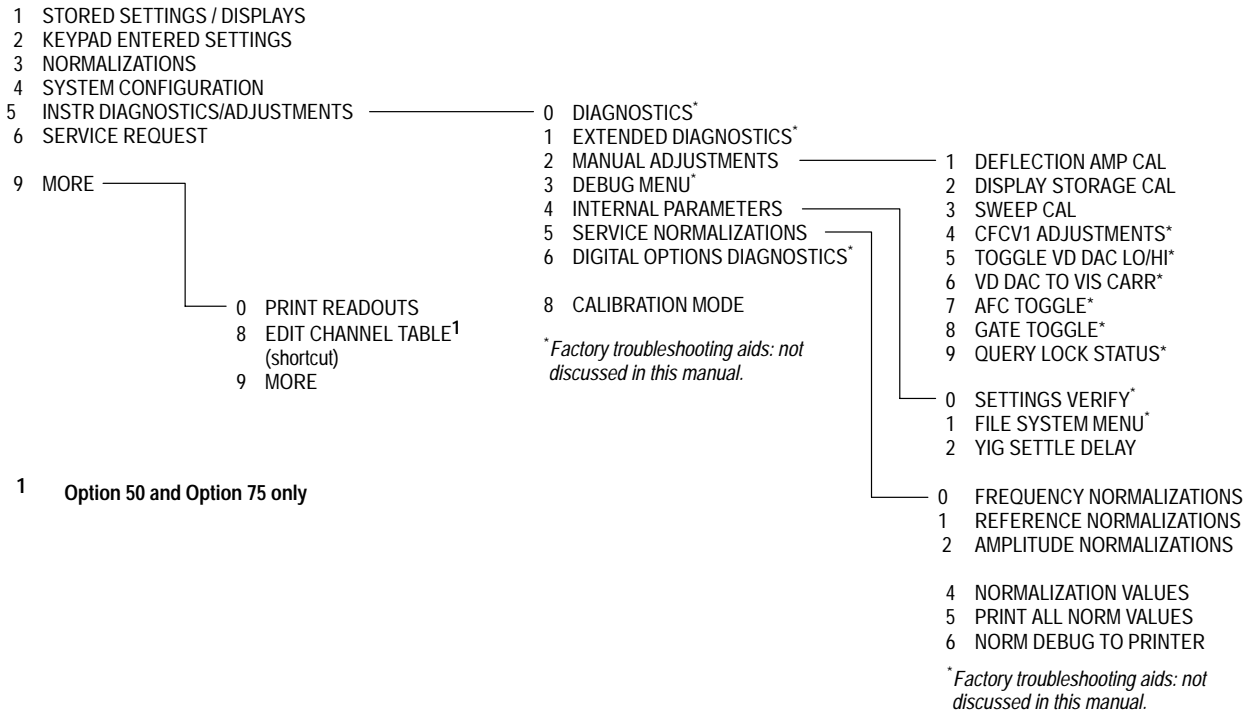


*Expands to registers 10-18, 20-28 and 30-39.

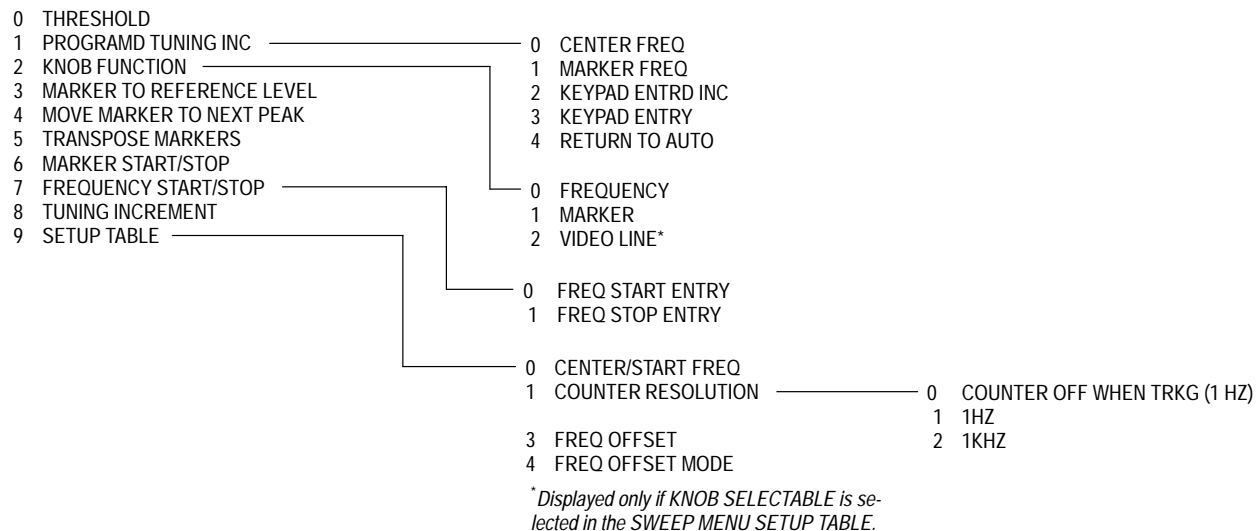
**Displayed when selected plotter language is HPGL.

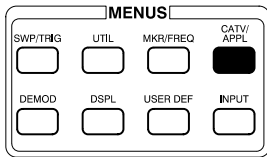


UTIL Menu Structure (2 of 2)

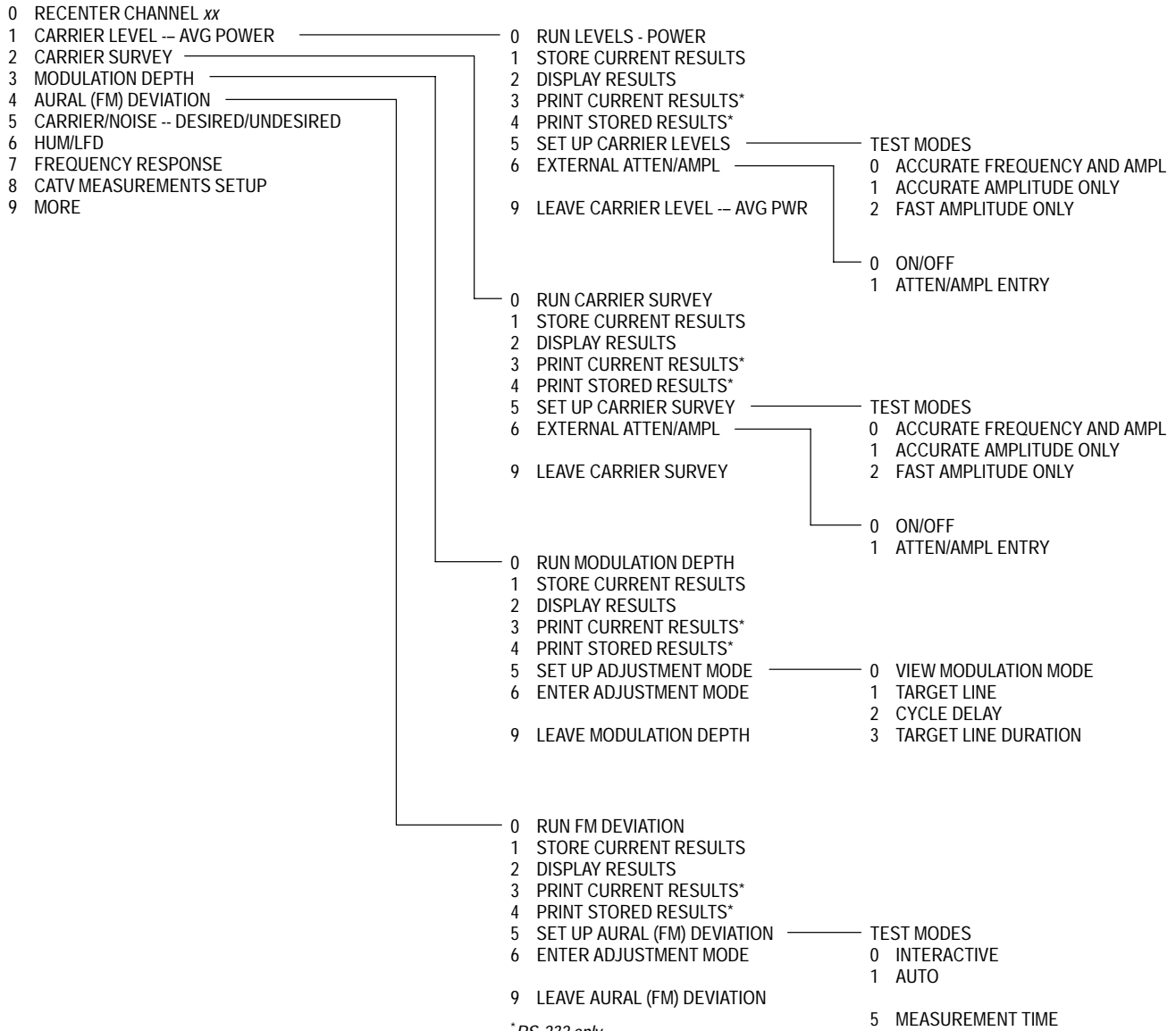


MRK/FREQ Menu Structure

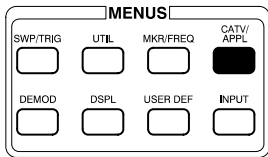




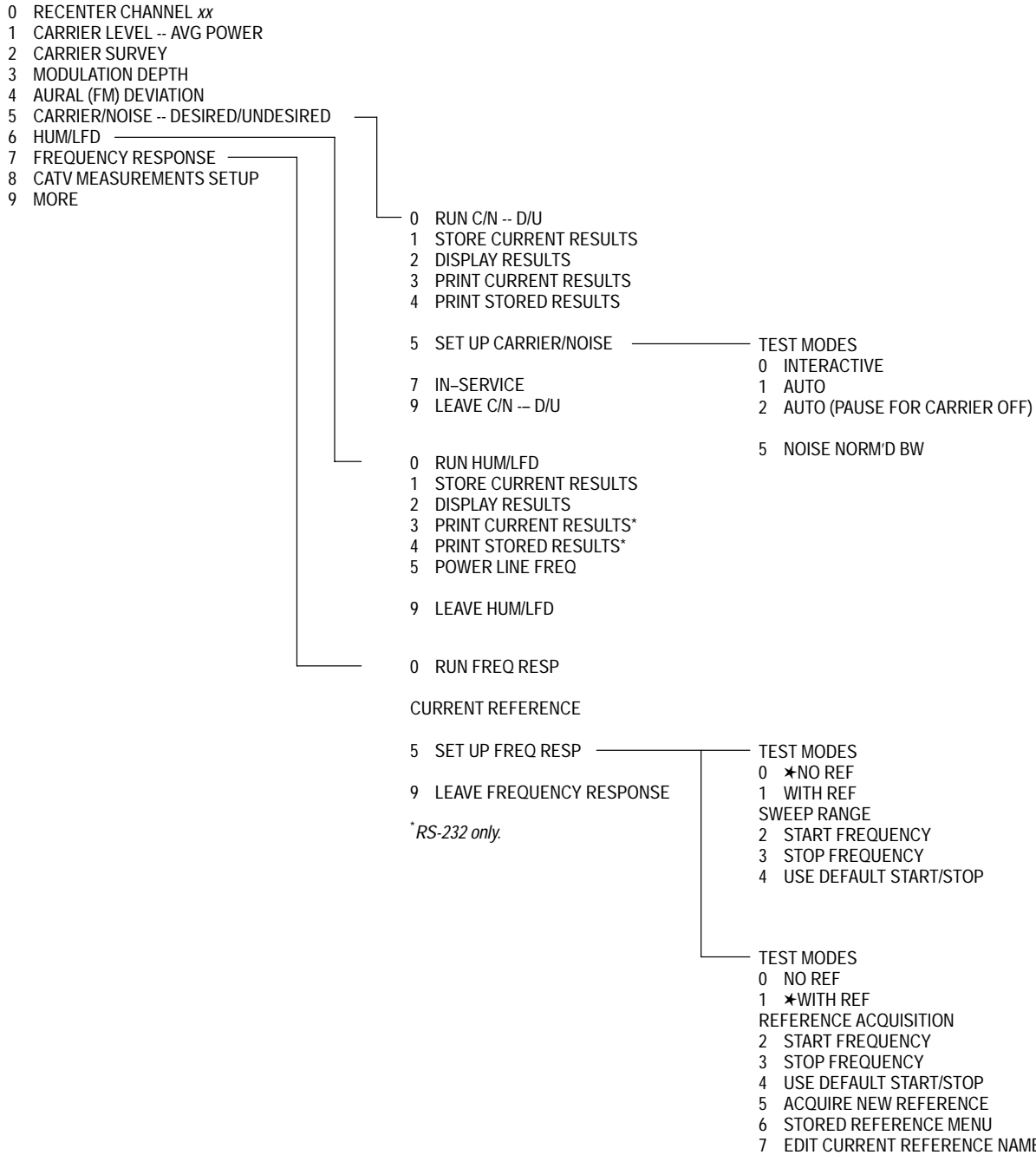
CATV/APPL CATV Measurements Page 1 Menu Structure (1 of 3)



*RS-232 only.

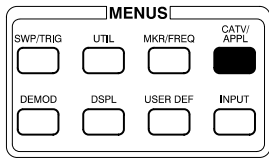


CATV/APPL CATV Measurements Page 1 Menu Structure (2 of 3)



*RS-232 only.

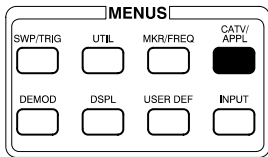
**Displayed only if a reference has been acquired.



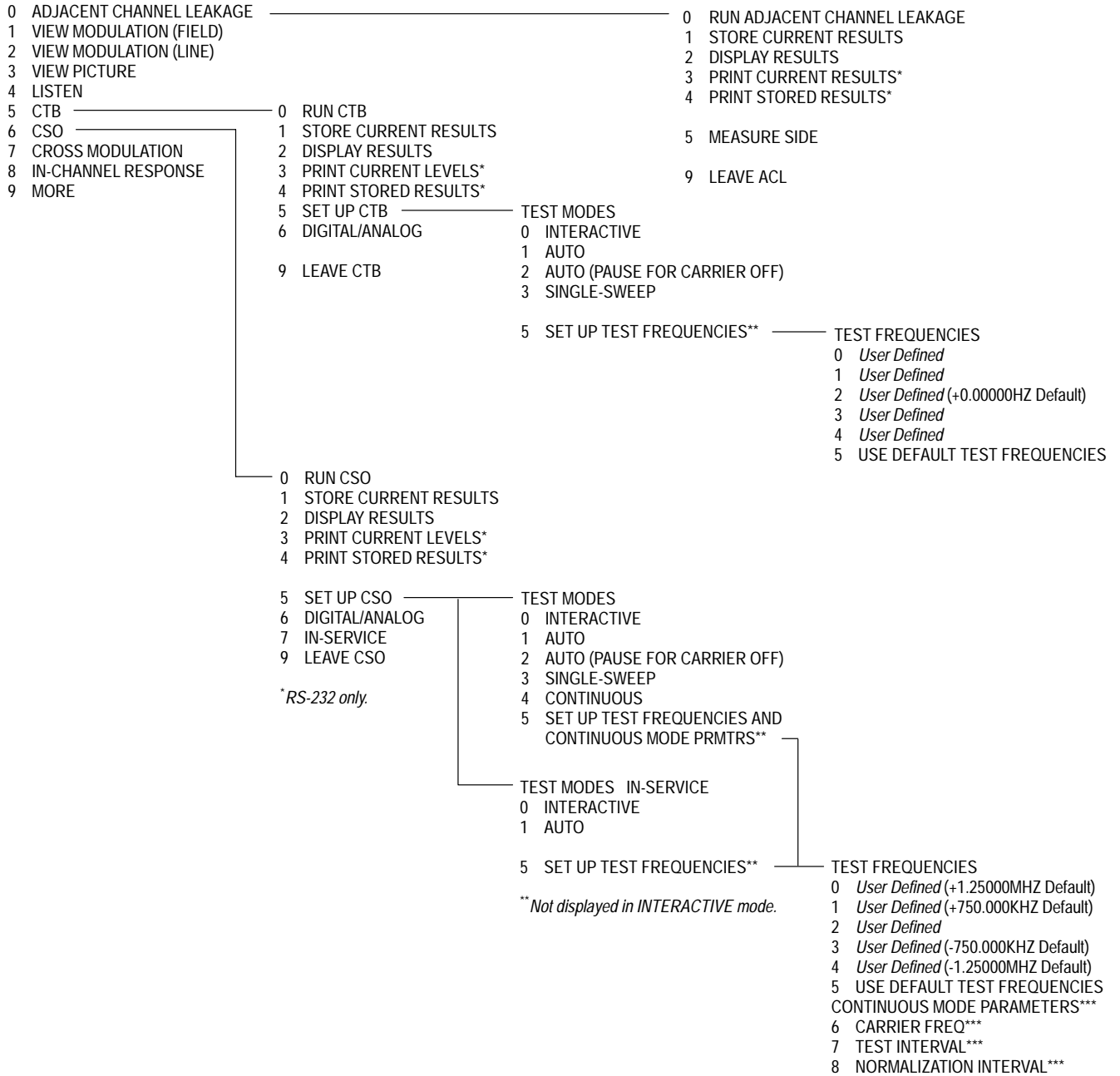
CATV/APPL CATV Measurements Page 1 Menu Structure (3 of 3)

- | | | | |
|---|------------------------------------|---|----------------------------------|
| 0 | RECENTER CHANNEL xx | | |
| 1 | CARRIER LEVEL -- AVG POWER | | |
| 2 | CARRIER SURVEY | | |
| 3 | MODULATION DEPTH | | |
| 4 | AURAL (FM) DEVIATION | | |
| 5 | CARRIER/NOISE -- DESIRED/UNDESIRED | | |
| 6 | HUM/LFD | | |
| 7 | FREQUENCY RESPONSE | | |
| 8 | CATV MEASUREMENTS SETUP | 0 | EXIT CATV MEASUREMENT MODE |
| 9 | MORE | 1 | CHANNEL TABLE |
| | | 2 | SKIP CHANNEL |
| | | 3 | ALL CHANNELS |
| | | 4 | SITE |
| | | 5 | OPERATOR |
| | | 6 | REF LEVEL UNIT |
| | | 7 | EDIT CHANNEL TABLES ² |
| | | 8 | REMOVE ALL STORED RESULTS |
| | | 9 | LEAVE CATV MEASUREMENTS SETUP |
| | | 0 | STD |
| | | 1 | HRC |
| | | 2 | IRC |
| | | 3 | <i>User Defined</i> |
| | | 4 | <i>User Defined</i> |
| | | 5 | <i>User Defined</i> |
| | | 6 | <i>User Defined</i> |
| | | 7 | <i>User Defined</i> |
| | | 8 | <i>User Defined</i> |
| | | 9 | <i>User Defined</i> |
- To CATV/APPL
CATV Measurements Page 2

2 Option 50 and Option 75 only



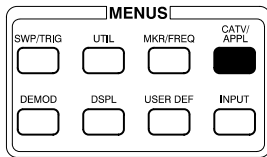
CATV/APPL CATV Measurements Page 2 Menu Structure (1 of 2)



*RS-232 only.

**Not displayed in INTERACTIVE mode.

***Displayed only if CONTINUOUS mode is selected.



CATV/APPL CATV Measurements Page 2 Menu Structure (2 of 2)

- 0 ADJACENT CHANNEL LEAKAGE
- 1 VIEW MODULATION (FIELD)
- 2 VIEW MODULATION (LINE)
- 3 VIEW PICTURE
- 4 LISTEN
- 5 CTB
- 6 CSO
- 7 CROSS MODULATION
- 8 IN-CHANNEL RESPONSE
- 9 MORE

To CATV/APPL
CATV Measurements Page 1

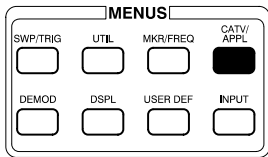
- 0 RUN CROSS MODULATION
- 1 STORE CURRENT RESULTS
- 2 DISPLAY RESULTS
- 3 PRINT CURRENT RESULTS*
- 4 PRINT STORED RESULTS*
- 5 METHOD (FREQUENCY DOMAIN or TIME DOMAIN (NCTA))
- 9 LEAVE CROSS MODULATION

- 0 RUN IN-CHAN RESP
- 1 STORE CURRENT RESULTS
- 2 DISPLAY RESULTS
- 3 PRINT CURRENT RESULTS*
- 4 PRINT STORED RESULTS*
- 5 SET UP IN-CHAN RESP
- 6 TEST SIGNAL LINE NUMBER**
- 7 IN-SERVICE
- 9 LEAVE IN-CHAN RESP

*RS-232 only.
**Displayed only when IN-SERVICE is On.

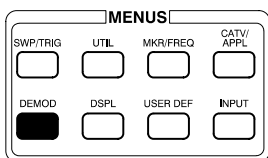
- TEST MODES
- 0 INTERACTIVE
- 1 AUTO (PAUSE FOR SIGNAL ON)
- TEST FREQUENCIES
- 2 User Defined (-500.000KHZ Default)
- 3 User Defined (+500.000KHZ Default)
- 4 User Defined (+1.25000MHZ Default)
- 5 User Defined (+2.00000MHZ Default)
- 6 User Defined (+3.00000MHZ Default)
- 7 User Defined (+3.75000MHZ Default)
- 8 USE DEFAULT TEST FREQUENCIES

- TEST MODES IN-SERVICE
- 0 INTERACTIVE
- 1 AUTO
- TEST FREQUENCIES
- 2 User Defined (-500.000KHZ Default)
- 3 User Defined (+500.000KHZ Default)
- 4 User Defined (+1.25000MHZ Default)
- 5 User Defined (+2.00000MHZ Default)
- 6 User Defined (+3.00000MHZ Default)
- 7 User Defined (+3.75000MHZ Default)
- 8 USE DEFAULT TEST FREQUENCIES



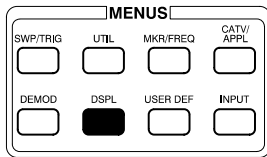
CATV/APPL Applications Menu Structure

- 0 BANDWIDTH MODE
- 1 CARRIER TO NOISE
- 2 NOISE NORM'D
- 3 SIGNAL SEARCH MENU ————— 0 BEGIN FREQ
- 4 OCCUPIED BW ————— 1 END FREQ
- 7 FM DEVIATION MODE
- 8 CATV MEASUREMENT MODE
- 9 SETUP TABLE ————— 2 START TEST
- 3 DISPLAY RESULTS
- 0 DB DOWN FOR BW MODE
- 1 NORM BW FOR C/N
- 2 NOISE NORM'D BW
- 3 PERCENT OCCUPIED BW



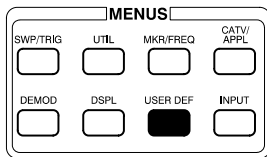
DEMODO Menu Structure

- 0 OFF
- 1 AM DEMODULATOR
- 2 FM DEMODULATOR
- 3 BROADCAST (AM) VIDEO
- 9 VIDEO MONITOR SETUP ————— 0 VIDEO DETECT MODE
- 1 SYNC POLARITY
- 2 VIDEO POLARITY



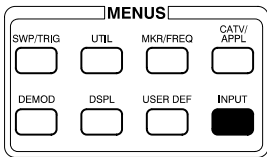
DSPL Menu Structure

- | | | |
|--------------------------|-------|---------------------------|
| 0 DIGITAL/ANALOG | | 1 INITIATE AVERAGING |
| 1 ENSEMBLE AVERAGING | ————— | 2 TERMINATE AVERAGING |
| 2 B, C MINUS A | | 3 MAX |
| 3 B, C MINUS A OFFSET TO | | 4 MEAN |
| 4 ACQUISITION MODE | | 5 MIN |
| 5 TITLE MODE | ————— | 6 MAX/MIN |
| 6 GRATICULE ILLUMINATION | | 7 NUMBER OF AVERAGES |
| 7 DISPLAY SOURCE (AM) | | 8 SAVE RESULTS IN DISPLAY |
| 8 DISPLAY LINE | ————— | |
| 9 MIN HOLD | | |
-
- | | | |
|--|--|----------------------|
| | | 1 TITLE MODE |
| | | 2 TITLE MODE EDIT |
| | | 3 PLOT LABELING |
| | | 4 PLOT LABELING EDIT |
-
- | | | |
|--|--|--------------------------|
| | | 1 ON/OFF |
| | | 2 VALUE ENTRY |
| | | 3 DISPLAY LINE TO MARKER |
| | | 4 LIMIT DETECTOR |

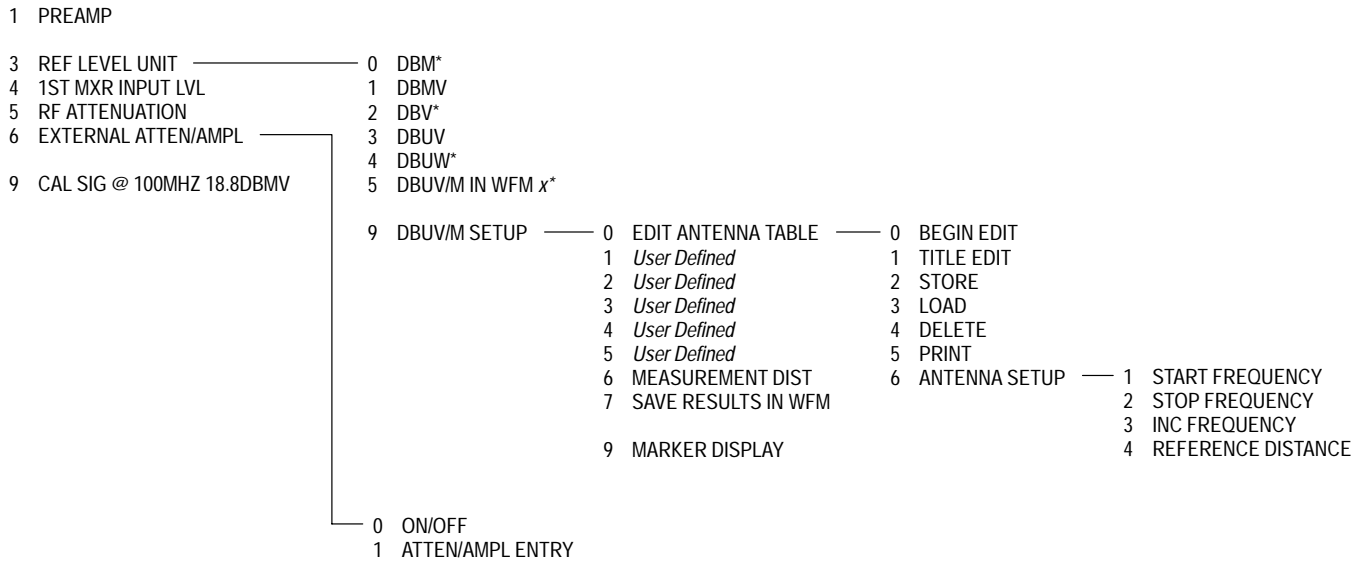


USER DEF Menu Structure

- | | | |
|------------------------------|-------|--|
| 0 <i>User Defined</i> | | |
| 1 <i>User Defined</i> | | |
| 2 <i>User Defined</i> | | |
| 3 <i>User Defined</i> | | |
| 4 <i>User Defined</i> | | |
| 5 <i>User Defined</i> | | |
| 6 <i>User Defined</i> | | |
| 7 <i>User Defined</i> | | |
| 8 <i>User Defined</i> | | |
| 9 USER DEF PROGRAM UTILITIES | ————— | |
-
- | | | |
|--|--|----------------------------|
| | | 0 ACQUIRE KEY STROKES |
| | | 1 TITLE EDIT |
| | | 2 WAIT FOR END OF SWEEP |
| | | 3 DISPLAY MESSAGE |
| | | 4 PAUSE FOR "USER DEF" KEY |
| | | 5 CONTINUOUS EXECUTION |
| | | 6 STORE |
| | | 7 DELETE |
| | | 8 PROTECT |
| | | 9 TIME DELAY SETUP |
-
- | | | |
|--|-------|-------------------|
| | ————— | 0 SET DAY |
| | | 1 SET HOUR |
| | | 2 SET MINUTE |
| | | 3 REPEAT INTERVAL |
| | | 4 RUN N TIMES |
| | | 5 CLEAR TIME |



INPUT Menu Structure



**Not available in CATV Measurements Mode.*



Dedicated Controls

Dedicated Controls

This section describes in detail the dedicated controls of the 2715. All of the dedicated controls are on the 2715 front panel except the trace alignment controls, which are on the back. These dedicated controls are used to carry out the most common and general spectrum analyzer operations without the need to call up the menus. The first part of the section covers the controls that initiate frequently performed actions. Included in this category are all the operating increment and decrement functions of span, channel entry, frequency, and reference level. The second part of the section covers the enhanced versatility controls that increase your ability to make accurate spectral measurements easily and conveniently.

Fundamental Operations

Getting Started described the amplitude and frequency measurement of a continuous narrow-band signal (the calibration signal) using only three controls. This section will repeat the initial measurement, but this time with the [CHAN/FREQ], [SPAN/DIV], [REF LEVEL], and associated controls contained in the gray-colored central function block. These controls are fundamental to most spectrum analyzer operations. You can perform a majority of spectral measurements with only these controls.

First set the 2715 controls to the values shown in the following settings box:

<i>Frequency</i>	(AUTO SWEEP)	ATT 50DB
38.8DBMV		VF 300KHZ
600.0KHz/ MAX		10 DB/
300KHz RBW		<i>Channel Table Name</i> CH <i>nn</i> CALIBRATOR

Frequency = Center of default power-up channel, center of currently selected channel, or selected frequency

nn = *Channel number*

This is most easily done by pressing [UTIL] [1] [1] to recall the factory default settings.

SPAN/DIV The span controls change the total display frequency span range symmetrically about the center frequency, select channel table entries, and set the 2715 in the maximum span or zero span modes.

1. Press **[INPUT] [9]** to turn on the calibration signal.
2. Press **[MKR/Δ/OFF]** twice to turn off the markers.
3. Press **[CHAN/FREQ] [4] [0] [0] [X]** to set the 2715 center frequency to 400 MHz.
4. Press **[MAX]** and **[AUTO] RES BW**. Remember that in MAX SPAN the marker changes position and not the frequency at screen center.
5. Press **[REF LEVEL] [3] [8] [•] [8] [Y]** to set the reference level to 38.8 dBmV.

Arrow Keys. The arrow keys to the right of **[SPAN/DIV]** change the frequency span represented by one horizontal division on the screen. The arrows directly increase or decrease the span per division.

6. Beginning with maximum span, press **[▼]** to the right of **[SPAN/DIV]** several times to decrease the span/div to 20 MHz¹.

This causes the 2715 to zoom in on the spectral display.

7. Now press **[▲]** until the span/div increases to 180 MHz.

Watch the spectral display zoom out just as though it was moving away from you.

The up arrow increases the span/div, compressing or squeezing the spectrum together. The down arrow decreases the span/div and expands or stretches the spectrum. The arrow keys are active whenever the 2715 is in the spectral display mode. Experiment by pressing each arrow key until the span/div no longer changes. You will notice two characteristics of the 2715:

- Span/div changes in a 1–2–5 sequence between 1 kHz and 100 MHz, plus 180 MHz/div in maximum span
- Resolution BW changes automatically as the span changes (later, we show how this can be changed)

¹ If you request a narrow span before the 2715 is completely warmed up, you may get a **NORMALIZATION SUGGESTED** message. This message should not appear after the 2715 warms up.

Keypad Entry. The preset span/div values are sufficient for most measurement needs. However, other span/div settings can be specified to the nearest tenth of a unit. To set the span/div to an arbitrary value do the following steps:

8. Press **[SPAN/DIV]** to place span in the immediate entry mode.

Notice that the word SPAN appears at left center of the 2715 screen. The word SPAN indicates that you can enter the span/div directly from the keypad (immediate entry mode) by keying in a permissible value followed by an appropriate terminator key. Any value from 1 kHz/div to 180 MHz/div is acceptable. You can enter up to 25 characters, but the 2715 rounds the value to three decimal points and stores it. In the spectral display, the value is shown rounded to one decimal point (to see the stored value, press **[UTIL] [2]**).

9. Press **[3] [3] [•] [3] [X]** to set the span/division to 33.3 MHz.

The numbers you type appear on screen to the right of SPAN. If you make a mistake, you can correct it any time prior to pressing **[X]** by repeatedly pressing **[BKSP]** (the backspace key) until the incorrect entry disappears and then entering the correct value.

Pressing a terminator button (**[W]**, **[X]**, **[Y]**, or **[Z]**) determines the units and enters the data. **[X]** can represent units of MHz, ms, or mV. Because the immediate span/div entry mode requires a frequency, the 2715 correctly interprets the currently displayed value as 33.3 MHz when you press **[X]**. If a time or voltage unit had been required, the 2715 would have interpreted your entry as 33.3 ms or 33.3 mV, respectively, when you pressed **[X]**. On the other hand, had you wanted the entry to represent a span/div of 33.3 kHz, you would have pressed **[Y]** instead of **[X]**.

10. Press **[▼]**.

The span/div changes to 20 MHz; the nearest span/div value in the downward direction in the normal 1–2–5 sequence. Had you pressed **[▲]**, the span/div would have changed to 50 MHz; the nearest value in the upward direction.

The span readout now indicates 20MHz/ and the 4th harmonic of the calibration signal is at the center frequency of 400 MHz.

MAX. There is often a need to view the entire input frequency range of the 2715, such as when connecting new signals to the 2715 input. In this mode, the 2715 is in MAX SPAN. The dedicated front-panel key is provided to conveniently enter and exit this mode.

11. Press **[MAX]** to obtain the largest span available on the 2715.

The span/div readout now indicates 180MHz/MAX.

12. Press [**MAX**] a second time to return to 20KHZ/.

Many of the keys on the 2715 are toggle action. The ability to undo an action by pushing the same button that carried out the action is typical. MAX is a toggle-action key taking you from the current span/div to 180 MHz/div and back.

ZERO. The following example demonstrates the effects of using zero span.

13. Set the center frequency to 100 MHz.

Notice that the calibration signal is centered in the display.

14. Press [**ZERO**].

The signal is a straight, horizontal line.

In the zero span mode, the 2715 remains at a fixed frequency. What you see is the variation in time of the signal power coming through the RBW filter at that frequency. Since the calibration signal has constant amplitude, the display is constant.

15. Turn the **FREQ/MKRS** knob to slowly increase the center frequency.

The signal amplitude decreases and the noise increases as you tune away from the calibration signal. The noise generated internally by the 2715 has a time-varying random amplitude.

In the zero span mode, the 2715 does not sweep the frequency spectrum. Rather, the local oscillator remains at a fixed frequency so that the resolution bandwidth filter brackets the designated center frequency. Because the display screen is still swept, the span readout indicates sweep speed (time per division rather than frequency per division). The word ZSPAN follows the sweep speed to denote zero span operation. In a sense, you have turned your spectrum analyzer into an oscilloscope.

16. Press [**ZERO**] to return to 20 MHz/div span.

Channel Entry

The following procedures demonstrate two methods of entering a channel selection.

Arrow Keys. This procedure uses the arrow keys to select a channel from a selected channel table:

1. Press [**UTIL**] [**1**] [**1**] to restore the factory defaults.
2. Press [**▲**] adjacent to [**CHAN/FREQ**].

The channel selection steps to the next channel in the selected channel table.



3. Press [] adjacent to [CHAN/FREQ].

The channel selection steps to the previous channel.

The up arrow selects the next higher channel in the channel table, whereas the down arrow selects the previous channel. If you step past the end of the channel table, the display wraps to the start of the table (and vice versa). The keys remain active whenever the 2715 is in the spectral display mode.

Keypad Entry. CHAN/FREQ defaults to CHAN whenever the CATV mode is active. The abbreviation CHAN appears at left center of the 2715 screen. CHAN indicates that you can enter the channel number directly from the keypad. This is done by keying in a permissible channel number (according to the selected channel table) followed by [W]. Enter the desired channel number with the front-panel keypad to select a channel.

***NOTE.** In the CATV mode, frequency can be entered by terminating the entry with the [X], [Y], or [Z].*

In the nonCATV mode, [CHAN/FREQ], the associated [] and [], and all the terminator keys exclusively control frequency. The nonCATV mode is enabled by pressing [CATV/APPL] [8] [0].

For instance, to select channel 8 in the specified table, do the following steps:

4. Press [8] [W].

The numbers appear on the screen to the right of CHAN. If you make a mistake, correct it any time prior to pressing [W] by repeatedly pressing [BKSP] (the backspace key) until the incorrect number disappears and then type the correct number. Pressing [W] ends the entry, and the 2715 interprets the currently displayed value as Channel 8.

The other terminators are used for channel frequency entry. For example, if you enter a certain frequency, the displayed channel number defaults to the channel within whose limits the entry falls.

Frequency Entry (Normal Mode)

The frequency controls set the 2715 normal center or start frequency in the normal or CATV mode.

FREQ/MKRS. This procedure shows how to adjust the center frequency using the FREQ/MKRS knob.

1. Press [INPUT] [9] to turn on the calibration signal.
2. Press [1] [0] [0] [X] to set the center frequency to 100 MHz.

3. Press **[SPAN/DIV] [1] [0] [0] [X]** to set the span to 100 MHz/div.
4. Press **[REF LEVEL] [3] [8] [•] [8] [Y]** to set the reference level to 38.8 dBmV.
5. Press **RES BW [AUTO]**.
6. Turn the **FREQ/MKRS** knob a few clicks clockwise.

Each click of the knob increases the center frequency by 2.0 MHz.

7. Turn the **FREQ/MKRS** knob counterclockwise, and the center frequency decreases by the same amount.
8. Reduce the span to 20 MHz/div.
9. Turn the **FREQ/MKRS** knob a few clicks clockwise.

The spectral display appears to move sideways at about the same rate as it originally did. However, it is now moving only 0.4 MHz per click. We call this visual behavior constant rate tuning. It occurs because the knob normally changes the center frequency at 0.02 of the span/div per click.² Obviously, it would take 250 clicks to change the frequency by 100 MHz at 20 MHz/div.

The knob remains active whenever the 2715 is in the spectral display mode.

Arrow Keys. The arrow keys can also be used to change the normal center or start frequency as discussed in the following example:

10. Press **[▲]** adjacent to **[CHAN/FREQ]**.

The frequency changes by channel allocation width of the currently selected channel table (6 MHz for the STD, HRC, and IRC channel tables).

If you had previously selected a channel by entering a frequency value that is not centered about the channel allocation width, the first increment will move the center frequency to the center of the next channel. Subsequent increments then default to the channel allocation width.

The up arrow selects the next channel, and the down arrow selects the previous channel. This means that even though the 2715 is in the CATV mode, you can increase and lower the center frequency by the channel allocation width using the up and down arrows. You can then fine-tune the center frequency using the **FREQ/MKRS** knob.

The keys remain active whenever the 2715 is in the spectral display mode.

² In MAX SPAN the indicated frequency changes alternately by 3 or 4 MHz and as a percent of the Resolution BW in ZERO SPAN. See *Selecting the Tuning Increment* on page 6–21 for a description of how you can change the tuning rate.

Keypad Entry. For very large frequency changes, or to preset a known center or start frequency, the direct entry mode is faster. To set the center or start frequency to a predetermined value, do the following steps:

11. Press **[CHAN/FREQ]** to place the center or start frequency in the immediate entry mode.

Even though the word CHAN appears at left center of the 2715 screen, you can enter the center frequency directly from the keypad (immediate entry mode) by keying in a permissible value followed by an appropriate terminator key (**[X]**, **[Y]**, or **[Z]**). You can enter any value from 0 Hz to 1800 MHz, even though the 2715 low-frequency specification is 9 kHz. Your entry can contain up to 25 characters, but regardless of how many you enter, the 2715 attempts to control frequency to the nearest hertz. The frequency is displayed at the top of the left-hand data column to 1% of the span/div.

12. Press **[1] [•] [2] [5] [X]** to set the center frequency to 1.25 MHz.

The numbers you type appear on-screen to the right of CHAN. If you make a mistake, correct it any time prior to pressing the MHz terminator by repeatedly pressing **[BKSP]** until the incorrect number disappears, and then enter the correct value.

Pressing a terminator key (**[X]**, **[Y]**, **[Z]**) determines the units and enters the data. **[X]** can represent units of MHz, ms, or mV. Because the frequency immediate entry mode requires a frequency, the 2715 interprets the currently displayed value as 1.25 MHz when you press **[X]**. If a time or voltage unit had been required, the 2715 would have interpreted your entry as 1.25 ms or 1.25 mV, respectively, when you pressed **[X]**³. On the other hand, had you wanted the entry to represent a frequency of 1.25 GHz, you would have pressed **[1] [2] [5] [0] [X]**. (Use the correct multiple and **[X]** to select GHz while the 2715 is in the CATV mode.)

Now use the direct entry method to set the center frequency to 100 MHz:

13. Press **[CHAN/FREQ] [1] [0] [0] [X]**.

Frequency Entry (NonCATV Mode)

The following procedures demonstrate how to change the frequency when operating in the nonCATV mode.

Arrow Keys. You can adjust the frequency using the arrow keys as shown in the following procedure:

1. Press **[CATV/APPL] [8] [0]** to exit CATV mode.
2. Press **[1] [0]**.

³ However, neither is a permissible value at this menu level, and your entry would have been rounded to the nearest allowable value.

3. Press [▲] adjacent to [CHAN/FREQ].

The frequency changes by 10 MHz. (It would take ten presses of the arrow key to change the frequency by 100 MHz.)

The frequency arrow keys change the frequency by one division.

4. Change the span/div to 100 MHz.
5. Press [▼] adjacent to [CHAN/FREQ].

The frequency changes by one division (100 MHz). At large span/div settings, the arrow keys can change the frequency very rapidly.

Keypad Entry. For very large frequency changes, or to preset a known center or start frequency, the direct entry mode using the keypad is faster. To set the center or start frequency to a predetermined value, press [CHAN/FREQ] to place the center or start frequency in immediate entry mode. The abbreviation **FREQ** appears at left center of the 2715 screen.

The abbreviation **FREQ** indicates that you can enter the center frequency directly from the keypad. This is done by keying in a permissible value followed by an appropriate terminator key. You can enter any value from 0 Hz to 1.8 GHz, even though the 2715 low-frequency specification is 9 kHz. Your entry can contain up to 25 characters, but regardless of how many you enter, the 2715 attempts to control frequency to the nearest hertz, and the frequency is displayed at the top of the left-hand data column to 1% of the span/div.

6. Press [CHAN/FREQ] to enter the immediate entry mode.
7. Press [1] [•] [2] [5] [X] to set the center frequency to 1.25 MHz.

The numbers you type appear on screen to the right of **FREQ**. If you make a mistake, correct it any time prior to pressing **MHz** by repeatedly pressing [BKSP] until the incorrect number disappears, and then enter the correct value.

Pressing a terminator key ([W], [X], [Y], [Z]) determines the units and enters the data. [X] can represent units of MHz, ms, or mV. Because the frequency immediate entry mode requires a frequency, the 2715 interprets the currently displayed value as 1.25 MHz when you press [X]. If a time or voltage unit had been required, the 2715 would have interpreted your entry as 1.25 ms or 1.25 mV, respectively, when you pressed [X]. On the other hand, had you wanted the entry to represent a frequency of 1.25 GHz, you would have pressed [W] instead of [X].

8. Press [CATV/APPL] [8] to return the 2715 to CATV mode.
9. Press [INPUT] [9] to turn on the calibrator.

10. Press [**REF LEVEL**] [**3**] [**8**] [**•**] [**8**] [**Y**] to set the reference level to 38.8 dBmV.
11. Press [**MKR/Δ/OFF**] twice to turn off markers.
12. Press [**CHAN/FREQ**] [**1**] [**0**] [**0**] [**X**] to use the direct entry method to set the center frequency to 100 MHz.

REF LEVEL

The Ref Level controls adjust the reference level of the display and increment and decrement the reference level step size. Following is a review of the reference level adjustment.

Arrow Keys. You can adjust the reference level using the arrow keys as shown in the following procedure:

1. Notice the height of the signal peak and then press [**▼**] adjacent to [**REF LEVEL**].

The signal peak appears to increase 10 dB when you press the key. Actually, the calibration signal amplitude does not change when you change the reference level. Instead, the reference level decreases (changes in the direction indicated by the arrow key) to 28.8 dBmV and the attenuation to 10 dB. The signal only appears larger because the reference level has been lowered 10 dB and now represents a signal level of 28.8 dBmV, 10 dB or one division greater than the calibration signal.

2. Press [**▲**] adjacent to [**REF LEVEL**] to reduce the on-screen signal height one division.

The reference level readout increases 10 dB to 38.8 dBmV (changes in the direction indicated by the arrow) and RF attenuation changes to 20 dB. The signal peak drops one division, but its amplitude is still 18.8 dBmV.

The up arrow increases the reference level, and the down arrow lowers it. The keys remain active whenever the 2715 is in the spectral display mode.

NOTE. *The direction of the arrows always represents the direction of change of the 2715 setting. ([**▲**] adjacent to [**REF LEVEL**] increases the reference level and lowers the displayed signal height.)*

Keypad Entry. As with frequency and span/div, you can directly enter the reference level from the keypad. This feature is especially handy when you have a good estimate ahead of time of what the signal amplitude is, or when you are simply interested in how much below a given amplitude a particular signal is. For instance, you might want to preset the reference level to +15 dBmV to examine cable TV signals at a customer drop.

The following procedure shows you how to set the reference level to a predetermined value:

3. Press [**REF LEVEL**] to place the reference level in the immediate entry mode.

Notice that the abbreviation REFL has appeared at left center of the 2715 screen.

The REFL notation indicates that you can enter the reference level directly from the keypad. This is done by keying in a permissible value followed by an appropriate terminator key. You can enter any value from -21.2 to $+68.8$ dBmV (or the equivalent in other units). You can enter up to 25 characters, but regardless of how many you enter, the 2715 rounds and displays the reference level to a tenth of a dB.

4. Press [**2**] [**1**] [**•**] [**3**] [**Y**] to set the reference level to 21.3 dBmV.

The numbers you type appear on screen to the right of REFL. If you make a mistake, you can correct it any time prior to pressing [**Y**] by repeatedly pressing [**BKSP**] until the incorrect number disappears, and then typing the correct value.

Pressing a terminator key (only [**Y**] or [**Z**] in this case) determines the units. The [**Y**] key can represent units of kHz, μ SEC, μ V, or +dBx. Because the reference level immediate entry mode requires decibels, and because the reference level unit is dBmV, the 2715 correctly interprets the currently displayed value as 21.3 dBmV when you press [**Y**]. If a frequency unit had been required, the 2715 would have interpreted your entry as 21.3 kHz when you pressed [**Y**]. On the other hand, had you wanted to enter a negative reference level, you would have pressed [**Z**] for -dBx. The 2715 ignores the [**W**] or [**X**] terminator keys because they do not represent acceptable reference level units.

REF LVL STEP. The calibration signal peak is now less than one division below the reference level.

5. Press [**REF LVL STEP**].

Nothing happened on screen, but the red LED next to the key is illuminated. This indicates that the rate at which the reference level arrow keys change the on-screen signal height and reference level is now 1 dB per press rather than 10 dB.

6. Press [\blacktriangledown] three times.

The signal peak rises until it is just above the reference level, and the readout indicates 18.3 dBmV. You cannot get the signal peak closer to the reference level without entering a new reference level in the immediate entry mode.

7. Press [\blacktriangle] ten times.

The signal peak should drop to almost one division below the reference level. The reference level readout should indicate 28.3 dBmV.

8. Press [REF LVL STEP] again.

REF LVL STEP is another toggle-action key. The LED goes out indicating that the reference level is back in 10 dB per press mode.

9. Press [\blacktriangledown].

Confirm that the reference level returns to 18.3 dBmV.

10. Reset the reference level to 38.8 dBmV.

Enhanced Versatility

The first part of this section covered the fundamental controls of the 2715. This second part covers the remaining controls and how they enhance your ability to make accurate spectral measurements easily and conveniently. We cover how to control the resolution bandwidth, vertical scale factor, and sweep speed. We show how to use display storage and marker controls to quickly measure signal amplitude and frequency with maximum accuracy; and we show how to make direct spectral comparisons and to save important results for future reference in nonvolatile RAM (NVRAM).

Res BW

100.0MHz	(AUTO SWEEP)	ATTN 20DB
38.8DBMV		VF WIDE
20.0MHz/		10 DB/
5MHz RBW (AUTO)		<i>Channel Table Name</i> CH <i>nn</i> CALIBRATOR

The Res BW controls select the 2715 resolution bandwidths of 300 Hz to 5 MHz and allow time to be automatically selected to match the selected bandwidth.

Set the 2715 parameters as follows to match the preceding settings box:

1. Press [UTIL] [1] [1] to recall factory default settings.
2. Press [CHAN/FREQ] [1] [0] [0] [X] to set the center frequency to 100 MHz.
3. Press [SPAN/DIV] [2] [0] [X] to set the span/div to 20 MHz.
4. Press [REF LEVEL] [3] [8] [.] [8] [Y] to set the reference level to 38.8 dBmV.
5. Press [INPUT] [9] to enable the calibrator.
6. Press [AUTO] to set the resolution bandwidth to 5 MHz.
7. Press [MKR/Δ/OFF] twice to disable the markers.

Arrow Keys. Until now, resolution bandwidth has been left in the AUTO mode, which enables you to make measurements without worrying about where the resolution bandwidth is set. The 2715's default is a fixed resolution bandwidth of 300 kHz. AUTO mode is available, but it is not the normal operating mode. There are circumstances in which you will want to control the resolution bandwidth yourself. For instance, if you look at the time domain representation of a TV video signal using zero span, you will want to use the 5 MHz (maximum bandwidth) filter to ensure enough bandwidth for the video signal. In other cases, you may want to select a very narrow resolution bandwidth in order to resolve signal sidebands or intermodulation distortion products. The RES BW arrow keys enable you to select resolution bandwidths of 300 Hz, 1 kHz, 3 kHz, 10 kHz, 30 kHz, 100 kHz, 300 kHz, 1 MHz, and 5 MHz in the 2715.

It is important to know how far signals must be separated before we can see them as separate. The answer depends on the particular filters, bandwidths, signal levels and other factors, but the following rules apply:


- If the signal amplitudes are less than 3 dB different, they are resolved when their frequency separation equals the resolution bandwidth.
- For signals more widely separated in amplitude and frequency, let A be the amplitude difference. Then:

$$F = \left(1 + \frac{A}{22}\right) \times \text{resolution BW}$$

where F is the required frequency separation. This rule is based on the fact that the 2715's 60 dB filter bandwidths tend to be approximately 7 times the 6 dB bandwidth and assumes the filter roll-off is approximately linear in dB. Using this condition, if the signals are 30 dB different in amplitude (A), then they have to be separated by approximately $2.4 \times$ resolution BW.

8. Set the span to 2.0 MHz/div.


The resolution bandwidth readout indicates 300 kHz.

9. Press [] in the RES BW function block to change the resolution bandwidth.

Notice that the noise floor increases approximately 12 dB as you switch from 300 kHz resolution bandwidth to 5 MHz. The reason for this rise in the noise floor is that the noise coming through a filter is proportional to the filter bandwidth. A wide filter passes more white noise components (frequencies) than a narrow filter. Consequently, more noise comes through a 5 MHz filter than through a 300 kHz filter.

The LED below the RES BW AUTO key went out indicating that the resolution bandwidth is no longer being automatically selected, and the resolution bandwidth readout indicates 5 MHz. The calibration signal now appears to be 5 MHz wide. Theoretically, the calibration signal should be infinitely narrow — a spike at 100 MHz.

To understand what has happened, you must recall the process going on within the 2715. It is sweeping a narrow-band signal (the calibration signal) past a broadband filter (the 5 MHz resolution filter). As the signal is moved past the filter, it maps the shape of the resolution filter. What you see is the spectral shape of the filter rather than that of the calibration signal. This means that on unmodulated signals a resolution bandwidth filter that is too wide can artificially broaden the displayed spectrum (although the signal peak remains accurate).

10. Repeatedly press [] in the RES BW function block to narrow the resolution bandwidth until the on-screen readout indicates 3 kHz.

There is a high-level beep and the message UNCAL (if there is no beep, check that the audio alert is set to ERROR ONLY or BOTH — see *The Audio Alert* on page 6–71).

The 2715 is now sweeping the calibration signal past the resolution filter too quickly for the filter output to rise to its steady-state value before the signal is no longer present at the filter input. This can result in low amplitude and skewed frequency readings. This means that a resolution bandwidth that is too narrow can result in incorrect amplitude and skewed frequency measurements. Measurement accuracy is compromised when the UNCAL message is present.

AUTO. Pressing [AUTO] in the RES BW function block toggles between manual and automatic selection of the resolution bandwidth. When the resolution bandwidth is selected automatically by the 2715, the LED below the key is illuminated.

11. Press [**AUTO**] to place the resolution bandwidth in the automatic mode.

The red LED lights. You can take the 2715 out of AUTO mode by pressing a **RES BW** arrow key or by pressing [**AUTO**].

12. Set the span/div to 50 MHz.
13. Note the indicated resolution bandwidth.
14. Press [**↔**] in the **RES BW** function block.

The LED turns off, and the resolution bandwidth goes to 300 kHz.

15. Press [**AUTO**].

The LED lights, and the resolution bandwidth is switched back to 5 MHz.

16. Press [**AUTO**] again.

The LED turns off, but the resolution bandwidth is still 5 MHz. Toggling out of the AUTO mode with [**AUTO**] maintains the automatically selected resolution bandwidth until you change it with a **RES BW** arrow key.

Video Filter

700.0MHz	(AUTO SWEEP)	ATTN 20DB
28.8DBMV		VF WIDE
50.0MHz/		10 DB/
5MHz RBW (AUTO)		<i>Channel Name</i> CH <i>nn</i> CALIBRATOR

A video filter is a postdetection filter (sometimes referred to as a noise-averaging filter) used to reduce noise in the displayed spectrum to its average value, making low-level signals more easily detectable. Normally, the 2715 uses a video filter about as wide as the resolution bandwidth. This limits postdetection noise, but does not significantly alter the displayed amplitude of narrow-band signals. However, if you must measure very wideband or pulse-like signals, you may wish to use a filter somewhat wider than that automatically selected by the 2715. See *Menu-Entered Control Settings* on page 6–60.

The video filter width is indicated in the on-screen readouts by VF bandwidth, where bandwidth is equal to the bandwidth of the video filter being used. This is true except in the case of the 5 MHz or the 1 MHz filter where the WIDE video filter is automatically selected. You can select WIDE video filter for any resolution bandwidth.

When you press [**VID FLTR**], the 2715 automatically selects a narrower video filter bandwidth approximately 1/100 of the resolution BW (specifying particular filter bandwidth using the **UTIL** menu is described later in this section). The narrow video filter dramatically reduces the noise and enhances the visibility of narrow-band signals. Care must be taken, though, because it will also reduce the indicated amplitudes of wideband signals such as video modulation and short duration pulses.

The following steps demonstrate the effects of the video filter:

1. Ensure that the 2715 is set as in the settings box on page 4–14, and note if the signal peaks at 700 MHz, 800 MHz, and 900 MHz are visible.
2. Press [**VID FLTR**].

The red LED below the key lights, indicating that a narrow video filter is being used, and the bandwidth of the filter is indicated on screen.

Notice how much less noisy the lower portion of the spectral display appears. By filtering the noise, it is sometimes possible to reveal low-level signals that are in the noise. This is the primary reason for using a video filter. The signal peaks at 700 MHz, 800 MHz, and 900 MHz (the seventh, eighth, and ninth harmonics of the calibration signal) should now be visible. There are small differences from instrument to instrument, but you should be able to spot the peaks above the noise.

Video filtering works well for continuous wave and other narrow-band signals, but when examining pulsed or wideband signals such as television video (especially the sync pulses), a video filter may prevent you from accurately seeing signal characteristics in much the same way that using a resolution bandwidth that is too narrow does.

Although it may not have been apparent, the sweep speed also decreased in order to accommodate the longer time constant of the video filter. Just as with the resolution bandwidth filter, a signal needs more time to reach its peak amplitude when propagating through a narrow video filter.

3. Press [**VID FLTR**] again to toggle the video filter off.

Vert Scale The Vert Scale controls select from the available logarithmic vertical scale factors or convert to the linear mode.

100.0MHz	(AUTO SWEEP)	ATTN 6DB
23.8DBMV		VF WIDE
20.0MHz/		10 DB/
5MHz RBW (AUTO)		<i>Channel Name</i> CH <i>nn</i>
		CALIBRATOR

10/5/1. The VERT SCALE function block contains a three-way toggle key labeled 10/5/1. This label expresses the three logarithmic vertical scale factors available on the 2715: 10, 5 and 1 decibels per major vertical division. Press the key to cycle the vertical scale factor through the three values in a 10 dB –5 dB –1 dB –10 dB... sequence.

1. Press [**10/5/1**].

The signal peak is now one division down from the reference level. Also, the vertical scale factor readout now indicates 5dB/. The noise also seems to have disappeared; the signal-to-noise difference is the same, but the scale factor change has moved the noise below the bottom of the screen.

2. Press [**10/5/1**] again.

The signal peak is now five divisions down and the readout says 1 dB/. The primary use for this feature is to more accurately read displayed signal peaks.

3. Press [**10/5/1**] once again to restore the 10dB/ setting.

LIN. The second key in the VERT SCALE function block is also toggle-action. It converts the vertical scale from logarithmic to linear and back again.

4. Ensure that the calibration signal is centered and the reference level is set to 23.8 dBmV.

5. Press [**LIN**].

The vertical scale readout now indicates 1.94MV/. When the LIN mode is initially selected, the 2715 converts the vertical scale so the bottom graticule line is 0 V and the scale factor is converted from dB to volts. The display is similar to what you see on an oscilloscope. Thereafter, the REF LEVEL arrow keys change the scale factor in a 1-2-5 sequence. Consequently, the reference level changes by 6 or 8 dB when changing scale factors. If the FINE reference level step size is selected while in the LIN mode, the arrow keys change the scale factor at a rate of approximately 0.02 division per step and the corresponding reference level changes approximately 0.2 dB.

6. Press [**LIN**] to toggle back to logarithmic mode.

When switching back to logarithmic from linear, the last selected log scale is implemented.

Sweep

100.0MHz	(AUTO SWEEP)	ATTN 0DB
-21.2DBMV		VF 3KHz
50.0KHz/		10 DB/
10KHz RBW (AUTO)		

The Sweep function block controls the 2715 normal sweep rate, auto sweep, and single sweep feature (other trigger modes are discussed in *SWP/TRIG* on page 6–83). The rate at which the CRT beam sweeps across the screen is known as the sweep rate. It is also the rate at which the displayed spectrum is swept.

Arrow Keys. Normally, sweep rate is automatically selected by the 2715. However, in some cases, such as when looking at the time domain representation of a signal in zero span, you may want to vary the sweep rate for a better view of the signal:

1. Ensure that the calibrator is turned off, and enter the zero span mode.

The currently selected sweep rate is displayed on screen as the horizontal scale factor in zero span mode and has units of time/division (in the spectral mode, view the sweep rate by pressing [**SWP/TRIG**]). The sweep rate readout indicates 50MS/ZSPAN (50 ms/div in zero span) and the internal noise is displayed.

2. Press [**▼**].

The LED below AUTO in the SWEEP function block turns off, indicating the sweep rate is no longer being automatically selected.

3. Press [**▼**] continuously until the sweep rate readout changes to 1MS/ZSPAN.

The SWEEP down arrow key decreases the sweep rate in a 1-2-5 sequence.

The noise on the trace is no longer visible. Variations in the noise waveform can be seen occurring in a millisecond or less. Even faster sweep rates are possible (1 μ s/div) with display storage disabled.

4. Press [▲] several times.

The noise is compressed to a grass-like appearance and the indicated sweep rate increases. The SWEEP [▲] key increases the sweep rate in a 1-2-5 sequence.

The [▼] and [▲] keys perform reciprocal actions; they decrease or increase the time required to sweep one division. Pressing either key removes the 2715 from the automatic sweep rate selection mode, and [▲] or [▼] thereafter function like the sweep rate selector on a conventional oscilloscope.

***NOTE.** Because sweep rate is the inverse of sweep speed, decreasing sweep rate increases sweep speed.*

5. Reset the sweep rate to 50 ms/div and the span/div to 50 kHz.
6. Set the reference level to 38.8 dBmV, and turn on the calibrator.
7. Press [▼] repeatedly to reduce the time/div.

A beep sounds and the word UNCAL appears.

8. Continue to press [▼] to increase the sweep speed, and notice the signal peak decrease and shift to the right.

This condition occurs when sweeping too fast for a given resolution BW and demonstrates how measurement errors can occur. The resolution filter is sweeping so fast that its output does not have time to reach steady-state.

9. Reselect **ZERO SPAN**.

The UNCAL message disappears, because in the zero span mode the filter is not being swept at all.

10. Reset the displayed sweep speed to 1 ms/div.

AUTO. The AUTO key in the SWEEP function block serves two purposes. First, it is used in much the same way as the AUTO key in the RES BW function block — as a toggle-action key that switches the 2715 between automatic and manual selection of sweep rate. When AUTO sweep rate selection is active, the sweep rate selected by the 2715 depends on the span/div, resolution bandwidth, and video filter in use. Second, pressing the SWEEP AUTO key when the 2715 is in the single sweep mode exits from that mode.



11. Press [**ZERO**] to exit the zero span mode.

Notice how distorted the calibration signal is.

12. Press **[AUTO]** in the SWEEP function block.

The LED below the key lights, indicating that the sweep rate is being automatically selected by the 2715. The sweep rate is now 50 ms/div, the UNCAL message has disappeared, and the calibration signal is correctly indicated as 18.8 dBmV at 100 MHz.

13. Press **[AUTO]** again in the SWEEP function block.

The LED turns off but the display does not change. Toggling out of the AUTO mode maintains the automatically selected rate until you change it with [] or [].

14. Reactivate the AUTO sweep mode.

SINGLE SWEEP

100.0MHz	(AUTO SWEEP)	ATTN 20DB
38.8DBM		VF 300KHz
1.0MHz/		10 DB/
300KHz RBW (AUTO)		

The 2715 is equipped with a single-sweep feature. When activated by pressing **[SINGLE]**, the 2715 makes only one sweep. Other controls (except **AUTO** in the SWEEP function block) operate normally, and signals at the input to the 2715 are treated just as they would be otherwise. Pressing **[AUTO]** in the SWEEP function block exits from the single sweep mode.

When a sweep begins will depend on how the 2715 is triggered. The factory default mode is free run; this is the mode the 2715 currently should be in.

15. Set the resolution BW to 3 kHz.

The sweep now takes two seconds.

16. At midsweep, press **[SINGLE]**.

The current sweep is aborted and the message SGLSWP MODE appears on screen under the right readout column. The message means the sweep circuit is in the single sweep mode and halted.

17. Press **[SINGLE]** again.

This prepares the sweep to begin as soon as it receives the next trigger signal (which occurs automatically in the free-run mode). A message reading SGLSWP ARM momentarily appears and a single sweep is carried out. The sweep will progress across the screen as a new spectral display is created.

When the sweep is completed, the SGLSWP MODE message reappears indicating the 2715 has completed the sweep and is ready to be rearmed.

If the 2715 is not in the free-run trigger mode (see *SWP/TRIG* on page 6–83 to change modes), behavior is much the same.

Pressing [**SINGLE**] causes the current sweep to abort and the SGLSWP MODE message to appear. If you press the key again, the SGLSWP ARM message appears. This time, however, the 2715 waits for the first designated trigger signal; when detected, a single sweep begins. After the sweep is complete, the SGLSWP MODE message reappears.

You can start a new single sweep in any trigger mode as often as you wish by pressing [**SINGLE**] after the SGLSWP MODE message appears.

18. Press [**AUTO**] in the SWEEP function block to exit from the single-sweep mode.

The single-sweep mode is useful when you want to prevent a succeeding sweep from overwriting a trace you just acquired or to capture the characteristics of intermittent signals.

Level There is a dual, concentric-shaft LEVEL control below the **FREQ/MKRS** knob. The inner knob controls the triggering level when the 2715 is in internal, external, or line trigger modes, just as the equivalent control does on a conventional oscilloscope. It also controls the horizontal sweep position in the manual scan mode. It has no effect in the other trigger modes.

The outer knob controls the volume of the AM and FM demodulators and picture framing in video monitor mode.

Alternate uses of the LEVEL control are discussed under *DEMODO* on page 6–56 and *Manually Scanning* on page 6–89.

Display Storage The 2715 can display an analog spectrum of up to four sampled and stored digital spectra. A major advantage of display storage is that it results in a flicker-free sweep.

100.0MHz	(AUTO SWEEP)	ATTN 20DB
38.8DBM		VF 300KHz
5.0MHz/		10 DB/
300KHz RBW (AUTO)		CALIBRATOR

Display Registers. The digital display storage registers are named A, B, C, and D. Their status is controlled by the **[A]**, **[B]**, **[C]**, and **[D]** keys; the red and green LEDs below each key indicate the status of the corresponding register. When a red LED is illuminated, the contents of the corresponding register are displayed. The contents of a register can be either the measurement currently being carried out or previously saved data.

When only a red LED is illuminated, the register contents are the result of the 2715's current activity. Current results are updated from the signal at the 2715 input during each sweep. The present control settings are used for the update.

When an A, B, or C green LED is illuminated, the corresponding register contains a saved sweep (the on-screen readouts are saved along with the sweep). A saved sweep cannot be erased, modified, or updated without operator interaction.

When the D green LED is lighted, the 2715 is in the "waterfall" mode.

[A], **[B]**, **[C]**, and **[D]** are toggle-action keys that activate and deactivate the display registers. A register's contents are displayed only when it is active (red LED lighted), although it still contains saved data as long as its green LED is lighted.

1. Press **[C]** to turn on the C register.

The only change that might be apparent is an increase in intensity, since the 2715 is now displaying the C trace on top of the D trace.

2. Press **[A]** and **[B]** to turn on the A and B registers.

There may be an increase in intensity, but the shape of the spectral display should not change because each register contains exactly the same information.

3. Press **[B]**, **[C]**, and **[D]** to deactivate the B, C, and D registers.

This display is no different than the D register waveform. Verify this by turning on the D register and turning off A (press **[D]** and then **[A]**). Verify that this is true of the other registers by alternately switching a new one on and the previous one off.

Deactivate all registers to display the analog output of the 2715.

Note its similarity to the MAX/MIN display.

Any time all four red LEDs are extinguished, the analog output of the 2715's detector is displayed. The digitizer is still working; you have just disabled all the display registers. The analog display can be very useful for viewing time-varying modulation such as television video signals.

It is also useful if you are used to a spectrum analyzer that may not have digital display capabilities; since it provides a display you are familiar with and allows you to see the similarity between the MAX/MIN display and the analog signal. You can usually obtain a sharper analog display, especially at higher sweep speeds, by varying the intensity (see *INTENSITY* on page 4–35) and/or turning off the on-screen readouts.

4. Activate the D register.

SAVE ENABLE, A, B, C Registers. The SAVE ENABLE key modifies the function of the [A], [B], [C], and [D] keys. When used with [A], [B] or [C] key, it enables you to save the current digitizer output in the corresponding register.

NOTE. The CATV mode assumes full control of the waveform storage registers. Therefore, waveforms stored manually will be erased when CATV mode is activated at power-up, during a reboot cycle ([UTIL] [5] [0] [9]), or when it is reactivated after having been disabled.

5. Press [SAVE ENABLE] to manually save a waveform.

The red LED below SAVE ENABLE lights. This indicates that the SAVE function is armed.

6. Press [A] to save into the A register what is presently being displayed.

The green LED below [A] lights, but observe that the A register was turned off and remains turned off.

7. Press [D] to turn off the D register.

8. Press [A] to turn on the A register.

Notice that the display does not change with time. The contents of the A register are not being updated. You are viewing a saved sweep.

9. Now save a waveform into the B register.

10. Activate the B register and ensure the A register is turned off.

11. Set the resolution bandwidth to 30 kHz.

12. Press [SAVE ENABLE] [B].

The current sweep is saved and the B green LED lights. The register remains active, but because it is now saved, it is no longer updated.

NOTE. Status of the red LED is not changed by the save operation.

13. Deactivate all registers (all red LEDs extinguished).

14. Set the resolution bandwidth to 5 MHz.

15. Press **[SAVE ENABLE] [C]**.

The green C LED lights.

16. Activate the C register.

The digitized and saved version of the analog sweep is displayed. The digitizer is continuously updated, whether it is being displayed or not. Further, it is always the current digitizer output that is saved. You cannot, for instance, save one register into another. However, nonvolatile RAM does make it possible to permanently save the contents of the display registers by transferring them to stored settings registers (see *Other User-Defined Settings* on page 6–63).

17. Press **[SAVE ENABLE] [A]** to deactivate the C register and activate A.

The A green LED turns off, indicating there is nothing stored in the A register. The register remains active, but the displayed spectrum is now updated during each sweep.

The on-screen readouts are stored along with the sweep. Since the 2715 displays only one group of readouts at a time, the readouts for the highest priority register are displayed when multiple registers are active. Register priority is shown in the following chart.

Priority	Register
Highest	D-register, current waveform
:	C-register, current waveform
:	B-register, current waveform
:	A-register, current waveform
:	D-register, saved waveform
:	C-register, saved waveform
:	B-register, saved waveform
Lowest	A-register, saved waveform

To see how register priority works, view some spectra:

18. Turn off A, turn on B, and note the on-screen readouts.

The indicated resolution bandwidth should read 30 kHz.


19. Turn on C.

The resolution bandwidth should read 5 MHz (C has a higher priority than B, so its readouts are displayed).

20. Turn on the A register and set the resolution bandwidth to **AUTO**.

Notice the **RBW** readout change. Any register containing a current sweep has a higher priority than a register containing a saved sweep, so the A-register readouts are now displayed.

21. Clear and deactivate the B and C registers. Leave only the D register active.

The SAVE ENABLE key changes the function of the D key. [**SAVE ENABLE**] [**D**] places the 2715 in the waterfall mode (symbolized by the  icon below the D key). This waterfall display is more effective in peak acquisition mode (discussed under *DSPL* on page 6–27).

100.0MHz	(AUTO SWEEP)	ATTN 40DB
58.8DBM		VF 300KHz
5.0MHz/		10 DB/
300KHz RBW (AUTO)		CALIBRATOR

22. Press [**DSPL**] [**4**] to enter the peak acquisition mode.

23. Press [**SAVE ENABLE**] [**D**] to enter the waterfall mode.

All eight of the register status LEDs light and four traces appear. Registers A, B, and C must be cleared before the 2715 allows you to enter the waterfall mode, because the waterfall mode uses all four registers. This is a safeguard to prevent accidental overwriting of previously saved data. If you attempt to enter this mode without first clearing the registers, you receive an error message.

Look at Figure 4–1. D is the bottom waveform and A the top. Each waveform is displaced upwards one division from the preceding waveform and shifted 1/2 division to the right. The current sweep is in the D register, the previous sweep in C, the next previous in B, and so on. At the end of each sweep, the waveforms are all shifted up one register. This display can be used to watch slowly varying spectra evolve or to obtain a feel for the variability of signals. Waterfall can also be useful for catching an event that occurs quickly. In the present case of the calibration signal, you will observe that there is virtually no variation.

24. Create a small signal shift by slightly changing the center frequency.

Notice how the waterfall mode records the shift.

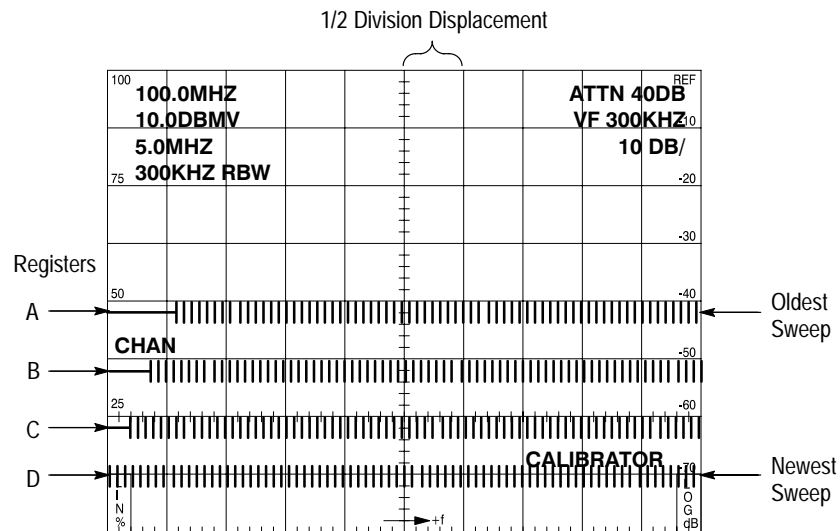


Figure 4-1: Example of a Waterfall Display

25. Press [**SINGLE**] in the SWEEP function block to halt the waterfall action.

Thereafter, each time you press [**SINGLE**] the waterfall will advance one trace.

26. Press [**AUTO**] in the Sweep function block to exit from the single sweep mode and continue the waterfall display.

You do not have to view all the traces.

27. Turn off the A and C registers.

28. Turn off B and D registers.

29. Turn A and C registers back on.

You can view any, all, or none of the registers. Turn them all off and the analog display reappears. However, the 2715 is still in waterfall mode. You cannot selectively erase a register or store new data in it without first exiting from the waterfall mode.

30. Turn on all registers.

31. Press [**SAVE ENABLE**] [**D**] to exit from the waterfall display mode.

All LEDs except the red D turn off, and the waterfall display collapses to a single D register trace.

32. Reset the center frequency to 100 MHz.

33. Press [**DSPL**] [**4**] to return to the MAX/MIN acquisition mode.

MAX HOLD A & B. The A and B registers can be used in the MAX HOLD mode to save the peak values of measured spectra. The register must be cleared before you can use it in the MAX HOLD mode.

The MAX HOLD feature compares the amplitude of the current sweep, point for point, with the stored maximum value of previous sweeps. If the current amplitude is greater, the current value becomes the new stored maximum; if not, the previous value is retained.

34. Deactivate the D register.

35. Make sure the A register is cleared and activated, then press **[MAX HOLD A & B]**.

The red LED below the MAX HOLD A & B key lights signifying that you have entered the MAX HOLD mode. The spectral display, especially the noise, is much smoother. After several minutes, the noise floor appears to drift upwards a couple of dB. Because the calibration signal is constant, there is no noticeable change in it. The upward drift of the noise floor slows and stops as the most likely maximum values are observed and stored. Now only an occasional noise peak exceeds the previously stored values.

36. Activate the D register.

Note that the waveform in the D register (waveform without MAX HOLD) is always less than the A register waveform. Recording the peak signal excursions observed during a large number of sweeps using the MAX HOLD feature yields an estimate of the maximum signal values. It can also be very useful for determining maximum signal amplitude during transient conditions or for making low-level fluctuating signals more apparent by saving their peak value. You can observe as many sweeps as you wish. You could equally as well have used the B register for MAX HOLD.

37. Press **[MAX HOLD A & B]** when you are ready to exit the MAX HOLD mode.

The red LED goes out, and only the D register sweep remains.

A feature called MIN HOLD, similar to MAX HOLD and activated by pressing **[DSPL] [9]**, saves the minimum signal values. Using both MIN HOLD and MAX HOLD, you can measure a signal's total excursion.

Freq/Mkrs

The Freq Mkrs controls select single and delta markers, select center measure tracking, and control the marker peak find features.

MKR/ Δ /OFF. The MKR/ Δ /OFF key is a three-way toggle that enables you to control one, or a pair, of markers. A marker is a bright spot that appears on the digitized waveform. Markers can be used only with the digital display. When the

marker mode is turned off, the spot on the display indicates either the center or starting frequency of the display. When a single marker is turned on, it can be moved to any point along the displayed waveform using the **FREQ/MKRS** knob. The corresponding signal amplitude and frequency are displayed on screen. The marker amplitude readout represents the most accurate method for determining signal amplitude with the 2715 (unless a separate, extremely precise signal is used for direct comparison). In general, amplitude accuracy is further enhanced if the signal being measured is first moved to within one division of the top graticule line using the **REF LEVEL** controls.

In delta (Δ) marker mode, two markers designate the points on the waveform between which the differences in signal amplitudes and frequencies are measured and displayed. It is not possible to display one marker on a particular trace while displaying the second marker on another trace. More than one register can be displayed, but the markers appear only on the highest priority waveform.

1. Press [**MKR/ Δ /OFF**] to activate the marker.

The sweep does not change, but the RF attenuation and video filter readouts have been replaced by approximate marker frequency and amplitude readouts such as the following:

M 100.0MHZ

M 18.8DBMV

The M preceding the readouts represent the amplitude and frequency of the signal at the marker position.

2. Turn the **FREQ/MKRS** knob several clicks clockwise.

The marker moves to the right and the readout tracks it. The knob now controls the marker position rather than the center frequency.

3. Turn the **FREQ/MKRS** knob to move the marker into the noise.

Notice that the marker actually moves up and down between the max and min noise values on alternate clicks of the knob. This is because each click of the knob moves the marker to the next bit in the digital waveform memory, thus tracking the stored max and min values.

4. Turn the **FREQ/MKRS** knob counterclockwise and the marker moves left.

Again, the readout tracks the signal amplitude and frequency at the marker position.

Be aware that the marker frequency accuracy is not as good as the center frequency accuracy because it includes a span nonlinearity component (see *CTR-MEAS/TRKG* on page 4-29 for a discussion of frequency measurement accuracies).

If you attempt to move the marker past either edge of the display, the spectrum will move towards the opposite edge while the marker remains stationary. If you move the marker past the right edge, the signal peak moves to the left.

5. Turn the **FREQ/MKRS** knob a few clicks counterclockwise.

The marker moves to the left but the spectrum will not move back towards its original position until you attempt to move the marker past the other edge of the display.

6. Recenter the calibration signal peak by trying to move the marker past the left edge of the display.

7. Ensure the marker and the calibration signal peak are centered, and press **[MKR/Δ/OFF]** again.

The spectral display did not change, but the marker frequency and amplitude readouts now read something like the following:

D 0KHZ
D 0.0DB

The delta-marker mode is turned on.

8. Turn the tuning knob clockwise.

Now you can see both markers. One remains at the original marker position while the position of the second is controlled by the knob. The right column indicates the difference (denoted by the letter D preceding the readouts) in frequency and amplitude between the two marker positions.

9. Increase the span to 50 MHz/div.
10. Use the tuning knob to place the movable marker at the top of the first signal peak to the right of center (the calibration signal second harmonic).

The right column now reads as follows:

D 100MHz
D -13.0 DB

NOTE. *The values displayed by your instrument may not exactly match those illustrated.*

You are measuring the difference in frequency and amplitude between the fundamental and second harmonic of the calibration signal. Your instrument may not read these values exactly, but it should be close.

If you attempt to move the movable marker past the edge of the display, you will see that the spectral display behaves almost the same as it did for the single

marker. The difference is that the stationary marker remains fixed with respect to the spectrum. You can even force the stationary marker off screen and the readout will continue to indicate the difference between the two marker positions. In this way you can make difference measurements across the whole input range of the 2715.

11. Turn the tuning knob clockwise until the readout indicates the movable marker is 900 MHz to the right of the stationary marker.
12. Turn on the video filter if the sixth or seventh harmonics of the calibration signal near center screen are not visible.

The peaks should now be visible.

13. Place the moveable marker on either peak to measure its difference in amplitude and frequency relative to the fundamental.
14. Press [**MKR/Δ/OFF**] (one press if in Δ-marker mode, two if in single-marker mode) to exit the marker mode and return to the normal RF attenuation and video filter readouts.
15. Turn off the video filter.

CTR-MEAS/TRKG.

140.0MHz	(AUTO SWEEP)	ATTN 40DB
28.8DBMV		VF WIDE
50.0MHz/		10 DB/
5MHz RBW (AUTO)		CALIBRATOR

The center measure feature detects the signal peak nearest the marker and above a preset amplitude threshold (changing the threshold is discussed in *MKR/FREQ* on page 6–17). When the marker is turned off, the signal peak nearest center screen is used. The 2715 then measures the signal frequency and makes it the new center frequency.

This feature allows you to bypass tuning to measure a signal frequency; just place the marker close to the signal of interest and press [**CTR-MEAS/TRKG**]. Press the key twice to enable the signal track feature to keep drifting signals centered by continuously repeating the center measure feature.

NOTE. *CTR-MEAS/TRKG provides the easiest and most accurate method of determining a signal's frequency.*

16. Press [**MKR/Δ/OFF**] to activate the marker.

17. Use the **FREQ/MKRS** knob to place the marker near the calibration signal. (In general, place the marker near the signal of interest. If you do not turn on the marker, the signal nearest center screen is measured.)

18. Set the reference level so the signal peak is within one division of the top graticule line.

19. Press [**CTR-MEAS/TRKG**].

The calibration signal is recentered, and the amplitude and frequency of the centered signal are read out at the upper right of the screen preceded by a C (counter).

The counter readout provides the most accurate frequency determination available on the 2715, and its resolution can be set to 1 Hz if desired. The counter readings disappear when a control setting is altered.

The marker and counter amplitude readouts are equally accurate. However, the signal amplitude indicated by the position of the marker relative to the graticule may differ slightly from the readout. The readout is more accurate because it contains no display nonlinearities.

The center frequency and counter measurements are also equally accurate, but in general the counter readout is more precise.

20. To look closely at the calibration signal third harmonic, place the marker near the third harmonic (approximately 280 MHz).

21. Press [**CTR-MEAS/TRKG**].

The calibration signal third harmonic is now the new center frequency and its frequency and amplitude are displayed at the top of the right-hand readouts.

22. Press [**MKR/ Δ /OFF**] to enter the delta-marker mode.

23. Place the movable marker near the calibration signal fundamental (at 100 MHz).

24. Press [**CTR MEAS/TRKG**].

This mode of operation centers the signal peak nearest the movable marker and measures the difference between the centered signal and the signal at the fixed marker. In this case, the fundamental is recentered, and the markers appear on top of it and the third harmonic. Readings of approximately 200 MHz and 12 dB appear at the top of the left column preceded by the letters DC (delta-counter). The center measure feature with the delta marker mode provides a convenient method of determining precise signal differences without manual tuning or interpolation of graphical data.

25. Turn off the markers.

The center measure feature can perform still another function. When center measure is used in the zero span mode, the counter measures the frequency at the output of the 2715 detector. Because the output varies only if the signal is modulated, the counter is actually measuring the frequency of the modulation (if none is present, you receive a message saying so). Normally, AM detection is used, but you can select FM detection. Whichever detector is selected, the center measure feature provides a quick method of determining the frequency of the modulating signal. Of course, the modulation frequency must fall within the bandwidth of the resolution bandwidth filter and any video filter that is active (and the FM discriminator when FM detection is selected).

Reset the 2715 controls according to the following settings box:

100.0MHz	(AUTO SWEEP)	ATTN 10DB
28.8DBM		VF WIDE
20.0MHz/		10 DB/
5MHz RBW (AUTO)		CALIBRATOR

The signal track feature of the 2715 continuously repeats the center measure operation. On each sweep the signal nearest midscreen is remeasured and recentered. This is useful for keeping a slowly varying or jittering signal centered for close observation.

26. Press [CTR MEAS/TRKG] twice to activate signal track.

The term TRKG appears in center screen indicating that the 2715 is in the signal track mode.

If you turn the tuning knob while a sweep is underway, the signal will be displaced a bit during the next sweep. On the following sweep the signal is recentered. The frequency readouts change because the tracking mode continuously repeats the center measure feature.

If the signal being tracked falls below a preset threshold (see *Setting the Signal Threshold* on page 6–22), tracking halts and the message NO SIGNAL FOUND ABOVE THRESHOLD is displayed. The message is accompanied by a beep. When the signal rises back above threshold, signal track automatically resumes.

27. Simulate signal loss and recovery by turning the calibrator off and then back on again.

The audible beep makes this signal track mode useful as an amplitude threshold detector.

You can also obtain continuous counter readings in the signal track mode.

28. Press [**MKR/FREQ**] [**9**] [**1**] [**2**] to turn on the counter (see *Counter Resolution* on page 6–23 for additional information).

The following steps show how to continuously monitor a frequency difference:

29. Press [**CTR MEAS/TRKG**] again to exit from tracking mode.
30. Reset the span to 50 MHz/div.
31. Enter the delta-marker mode.
32. Place the movable marker near the third harmonic.
33. Reenter the tracking mode.

You are using the delta-counter feature in the signal track mode. The third harmonic is centered and the frequency difference between the fundamental and third harmonic is being constantly monitored.

34. Exit from the tracking mode and turn off the markers.

Arrow Keys. You can use the arrow keys to move the marker from one peak to another:

35. Center the calibration signal.
36. Turn on the marker.
37. Press [**MKR**] [**▶**].

The marker jumps to the second harmonic peak.

38. Press [**▶**] again.
39. The marker jumps to the third harmonic.
40. Now press [**MKR**] [**◀**].

The marker jumps in the other direction.

[**MKR**] [**◀**] and [**MKR**] [**▶**] move the marker to the next signal peak in the indicated direction and above the preset threshold, but they will not go beyond the edge of the display or lower than 0 Hz. Further, the readouts and center measure/tracking behave as if you had manually moved the marker.

41. Enter the delta-marker mode and press the arrow keys.

The movable marker jumps in the direction of the arrows just as the single marker did, and the readouts behave as if you had manually moved the marker.

PEAK FIND. You can use PEAK FIND to automatically position a marker on the highest signal on screen.

42. Ensure that the markers are turned off.

43. Set the center frequency to 275 MHz.

44. Press [**PEAK FIND**].

The marker is automatically turned on and jumped to the peak of the calibration signal at 100 MHz. The 2715 detected the highest signal on screen and automatically moved the marker to it. After the move, the 2715 behaves exactly as if you had moved the marker there manually.

45. Press [**MKR**] [**◆**] to move the marker to the peak of the third harmonic.

46. Press [**PEAK FIND**] again.

The marker moves back to the fundamental; the marker peak find feature always locates the highest peak on screen.

Miscellaneous Controls

We have discussed and experimented with all the 2715 functions except the menu keys and a few miscellaneous controls. The menu keys are covered thoroughly in *Operating Basics* section, and the remaining, miscellaneous controls will be covered briefly here.

NOTE. Any control settings can be used.

PLOT. Immediately below the VERT SCALE function block is a PLOT button that causes an optional printer or plotter to draw an image of the screen. The on-screen readouts are plotted on the drawing in the border area so they do not interfere with the waveform. If you wish to have graticule lines on the printout, you must turn them on by pressing [**UTIL**] [**4**] [**1**] [**5**]. You can also add labels to the plot (see *Adding Titles and Labels* on page 6–36).

Before attempting to create a screen plot, ensure that the communications port is correctly configured (see *System Configuration* on page 6–67).

To make a plot of the screen, check that your printer or plotter is powered up, on line, and that the paper is in correct registry. Then, with the 2715 displaying the desired trace(s), press [**PLOT**].

The printer or plotter quickly begins to draw the trace. Because the printer or plotter output data is sent to a temporary buffer, the 2715 returns to the spectral display and is ready to accept additional commands before printing or plotting ends. A typical plot is shown in Figure 4–2.

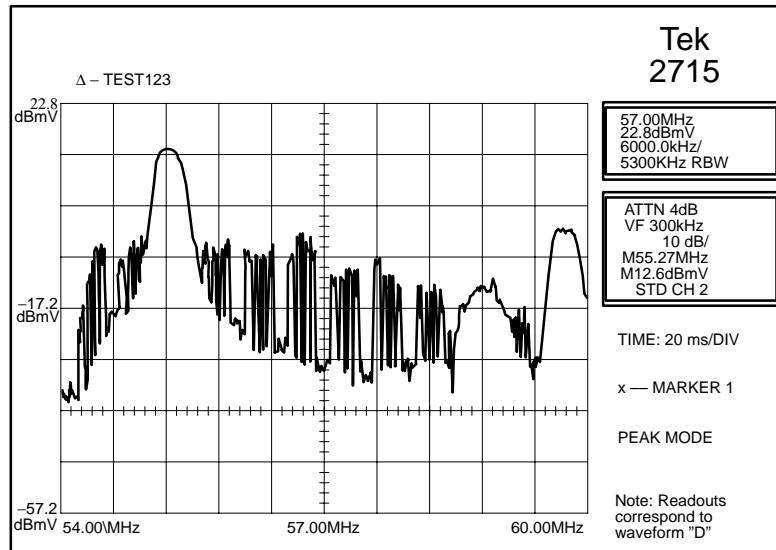


Figure 4-2: Typical Plotter Output Showing TV Channel Spectrum

NOTE. Plotting time can be reduced by choosing peak acquisition mode, or using the video filter, to reduce noise variations. Noise variations do not affect printing time when using a dot-matrix printer.

READOUT. You can toggle the standard on-screen readouts on and off. There are two reasons for doing so. First, it prevents the readouts from overlapping the signal spectrum.

The following steps illustrate the second reason:

1. Initialize the 2715 to the factory power-up defaults.
2. Enter the analog display mode.
3. Press [SWEEP] [▲].

Notice the regularly spaced dark areas in the sweep.

4. Press [READOUT] below the VERT SCALE function block to turn off the readouts.

The dark areas are gone now.

The dark areas represent time when the CRT beam is writing the on-screen readouts. Their appearance changes with sweep speed. By eliminating the readouts, you eliminate the dark areas. You will also notice that the trace has intensified. This is because the 2715 does not have to take time out from each sweep to write the on-screen data.

5. Press [**READOUT**], activate register D, and press [**AUTO**] in the SWEEP function block to turn the data readouts back on.

INTENSITY. The intensity control is a rotary knob that works exactly like any oscilloscope intensity control. Twist the INTENSITY knob slowly back and forth. Notice the display grow brighter and dimmer as you turn the control. Leave the intensity set to a level sufficient for good contrast in your ambient light conditions. If you have to turn it to full intensity, try reducing the ambient light or shielding the display. If the 2715 is used in direct sunlight, a contrast-enhancing light filter is recommended (part of the Travel Line Package, Option 33).

Rear Panel Trace Adjustments. There are three controls (TRACE ROTation, VERTical POSition, and HORIZontal POSition) at the upper right of the 2715 rear panel that are used with a built-in test display to adjust trace alignment. The control shafts are recessed within hexagonal nuts that attach the controls to the 2715 chassis. Do not attempt to turn the hexagonal nuts and do not use excessive force when turning the control shafts. A plastic adjustment tool is recommended instead of a screwdriver.



CATV Measurements

CATV Measurements

Firmware-based CATV measurement routines allow technicians to easily make frequency domain and baseband measurements. Without these automated routines, making these measurements would require a high degree of technical expertise, require a long setup time, and be subject to error.

CATV Preliminary Information

This section provides information on input power limitations for CATV operation, an overview of CATV preparatory information, and specific 2715 CATV applications.

CATV measurements and capabilities include the following:

- Carrier level and frequency measurement
- Averaged power measurement
- Survey of system analog visual and aural carrier levels and frequencies measurement plus digital channel averaged-power measurement
- Depth of modulation measurement
- Aural carrier deviation measurement
- Visual carrier-to-noise ratio measurement
- Desired-to-Undesired signal ratio measurement on digital channels
- Hum/low frequency disturbance measurement
- System frequency response measurement
- Adjacent channel leakage measurement on digital channels
- Viewing demodulated video and baseband modulation
- Viewing picture
- Listen mode (aural carrier demodulation)
- Composite triple beat (CTB) measurements on analog and digital channels
- Composite second order beat (CSO) measurements on analog and digital channels
- In-Channel response measurement
- Cross modulation measurement

Be sure that the input power limitation is not exceeded before connecting a cable feed to the RF INPUT. Read the information in *Input Power Limitations* below.

Input Power Limitations



CAUTION. To prevent damage, the safe maximum total RF input power for the 2715 is +70 dBmV. DC input voltage is limited to 100 VDC maximum.

Total input power above the rated maximum can cause damage to the instrument and voids the factory warranty. For a number of equal amplitude signals, the total power is approximately:

$$\text{Total Signal} = \text{Single Signal} + 10 \log (\text{Number of Signals})$$

Thus, the safe maximum amplitude per signal is given in Table 5–1.

Table 5–1: Safe Maximum Signal Levels

Number of Signals Input to Spectrum Analyzer	Safe Maximum Amplitude per Signal (dBmV)
1	+70.0
10	+60.0
30	+55.2
50	+53.0
70	+51.5
100	+50.0

Remember, two 68 dBmV signals total more than 70 dBmV. Higher signal levels should be externally attenuated.

With the exception of Adjacent Channel Leakage (ACL), these tests are characterized for use in a multichannel environment (no preselector) or in a single-channel environment (preselector used). ACL is characterized for the single-channel environment only, since it is used only at the head end prior to the system combiner.

In the multichannel environment, digital signals are typically 10 dB lower in level than analog TV signals on the same system. In this case, the maximum safe input level per channel may be unexpectedly far below the maximum safe total power for the attenuator (+70 dBmV). For example, in a 150-channel flat system dominated by analog TV signals, the maximum safe input level for a digital signal 10 dB below the analog levels is only about +37 dBmV.

For this reason, the maximum signal input level for the digital tests (except for ACL) is depicted as +37 dBmV for the multichannel environment. In specific cases, the safe limit may be higher, but it is your responsibility to correctly make that determination based on your specific circumstances (number of analog channels on the system and how far down the digital signal is from the general level of the analog channels).

Note that even when the preselector is used, the maximum signal level input for most of the digital tests is depicted as being below the +70 dBmV burnout limit. This is because of specific measurement-dependent hardware limits of the instrument. Violating the depicted limit can result in inaccurate measurement results.



CAUTION. To avoid overloading the 2715 and possibly damaging it, do not place AC or DC power supply voltages on the input of the 2715.

Initial Setup

At power-up, the 2715 comes up in the CATV mode tuned to the default power-up channel. The power-up channel is the last active channel when power was turned off or channel T-7 (labeled 907 in STD Table 5-4) if NVRAM was erased before the last power-down.

Upon entering the CATV MEASUREMENT MODE, the instrument software searches for the visual carrier signal associated with the default power-up channel and places a marker at the visual carrier peak. The instrument then configures itself as follows.

Frequency	Center of default power-up Channel Band ¹
Reference Level	+68.8 dBmV
Span/Div	Channel Band — 10
RF Attenuation	50 dB
Resolution Bandwidth	300 kHz
Sync & Video Polarity	From current channel table
Vertical Mode	Log
Vertical Scale	10 dB/div
Sweep	Auto
Trigger	Free Run
Marker	On
Marker Frequency	Apparent Visual Carrier Position

¹ Channel Band = Channel limits defined in the current channel table. If the last selected channel does not exist, such as when NVRAM has been erased, the default channel becomes Channel T-7 (labeled 907 on the display) — the first channel in the first channel table.

The CATV MEASUREMENT MODE will remain active until it is explicitly disabled by pressing [CATV/APPL] [8] [0].

General (CATV) 2715 Mode

If the 2715 is in the CATV mode, press [CATV/APPL] and the CATV mode comes up on the screen. If the 2715 is not already in the CATV mode, press [CATV/APPL] [8] [0] from the spectral display.

The firmware centers the channel on the screen, then displays the top level (PG 1) of the CATV MEASUREMENTS menu. The menu resides on two pages. You can toggle between the menu pages by pressing [9] from either page. See Figure 5-1.

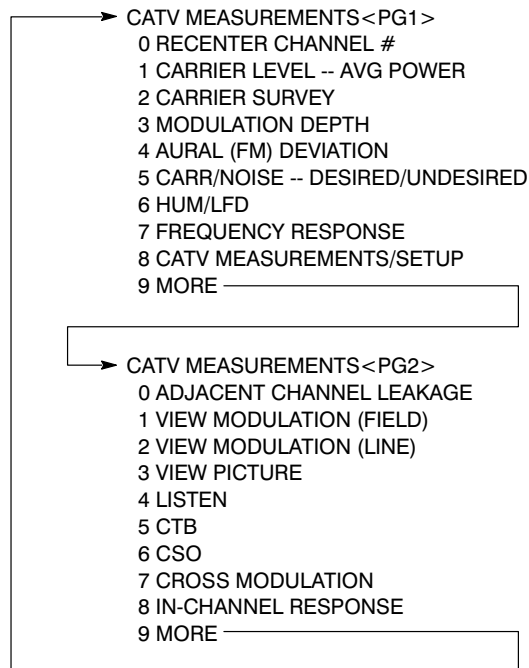


Figure 5-1: CATV MEASUREMENTS Menu

Signal Types

The 2715 is capable of making certain measurements on TV, FM, Pilot, and Digital signals in the CATV mode.

NOTE. Previous versions of Cable TV RF Measurements Software allowed you to use a Data signal type. The new Cable TV RF Measurements Software for Windows replaces the Data signal type with a Digital signal type. If desired, you can use the FM signal type to simulate a Data signal type with the new software.

Table 5–2 shows the measurements that can be made on each signal type.

Table 5–2: Signal Type Measurements

Measurements	Signal Types			
	TV	FM	Pilot	Digital
Carrier Level	X	X	X	
Avg Power				X
Carrier Survey	X	X	X	X
Modulation Depth	X			
Aural (FM) Deviation	X	X		
Carrier To Noise	X	X	X	
Desired/Undesired				X
Hum/LFD	X	X	X	
Frequency Response	X	X	X	X
View Field Modulation	X			
View Line Modulation	X			
View Picture	X			
Listen	X	X		
CTB	X	X	X	X
CSO	X	X	X	X
Cross Modulation	X	X	X	
Adjacent Channel Leakage				X

Channel Tables

Channel tables are the central data that controls the actions of the measurements. The 2715 uses channel tables to tune to different channels in any one CATV system. Thus, the resident firmware provides three commonly used (factory-loaded) channel tables: STD, HRC, and IRC.

In addition, you can create your own customized channel table(s) using the *Cable TV RF Measurements Software for Windows* and an IBM-compatible PC or you may choose to modify any of the channel tables directly from the 2715 front panel. These two features; creating and editing customized channel tables, allows the technician to accommodate all nonstandard channel frequencies and operating conditions in a unique system.²

The following defaults are common to all channels in the factory-loaded channel tables:

Color System	NTSC
Channel Allocation Width	6 MHz
Aural Carrier Offset	4.5 MHz
Channel Edge	(Visual Carrier -1.25 MHz)
Signal Type	TV
Video Polarity	Negative
Sync Polarity	Positive
Skip Status	False
Scrambling Status	False
VITS	None

Channels 907 through 913 in the STD factory-loaded channel table (Table 5-4) represent channels T-7 through T-13.

There are a number of different television standards worldwide that differ in video modulation polarity. In negative video modulation, maximum carrier power occurs during the sync tips. In positive video modulation, maximum carrier power occurs during white program material. All defined systems use negative modulation except for the A, C, E, and L systems, which use positive modulation. When modifying or creating a channel table, be sure to select the correct video polarity for your system. (The sync polarity will always be the opposite of the video polarity.)

In defined systems, if the video polarity is positive, the aural modulation type is AM instead of FM. The 2715 automatically selects AM aural modulation for any channel that uses positive video polarity.

² Frequencies above 1.8 GHz are not supported by the Cable TV RF Measurements Software. The 2715 Spectrum Analyzer with either Option 50 or Option 75 installed is capable of frequencies up to 2.15 GHz. For frequencies above 1.8 GHz you are limited to the 2715 front panel to create and edit the channel tables.

Selecting a Channel Table

There are two sources of channel tables; one source is the three default tables, (STD, HRC, and IRC), and the other source is the unlimited user defined tables. Up to seven of these user defined tables can be stored in NVRAM in the 2715. Press [CATV/APPL] [8] [1] to call up the channel table menu then press a number corresponding to the desired channel table to select the table. Press any menu button to return to the spectral display.

Editing a Channel Table (Opt 50 and Opt 75 Only)

Press [CATV/APPL] [8] [7] or shortcut [UTIL] [9] [8] to call up the channel table edit function. Press the number(s) corresponding to the desired channel table to select a table for edit. Figure 5–2 shows the STD table with SCRAMBLED element selected. Select the element to be edited by turning the FREQ/MKRS knob and incrementing through each field until the desired element is highlighted (reverse video).

NOTE. If you assign a channel frequency above 1.8 GHz the channel table will be unusable by the Cable TV RF Measurements Software.

Use the front panel buttons to make the changes and back space button (BK SP) to remove the changes one character at a time. Use <ABORT ALL> to undo all changes back to when <FINISH> was last executed and use <UNDO CHAN> to undo all changes back to when the channel was selected.

NOTE. The FINISH selection and the ABORT ALL selection ends the editing session and goes back to the CATV MEASUREMENTS SETUP menu.

```

EDIT CHANNEL TABLE: STD

CHANNEL: 2          TYPE: CATV
VISUAL FREQ : 55.25000MHZ
CHAN WIDTH  : 6.000000MHZ
CHAN EDGE   : -1.25000MHZ
2ND OFFSET  : NONE
SCRAMBLED   : NO           SKIP: NO
QUIET LINE  : AUTO
ICR LINE    : 19
WHITE LINE  : NONE
POLARITY, VIDEO/SYNC: NEG/POS
warnings, errors, messages
<FINISH> <UNDO CHAN> <ABORT ALL>
USE KNOB TO SELECT PARAMETER.
USE MARKER ARROWS TO EDIT.

```

Figure 5–2: Channel 2 of the STD channel table selected for edit with menu set to change SCRAMBLED (toggles between YES/NO)

Table 5–3 shows the element selected, selection options if applicable, and front panel key assignments for making changes.

Table 5–3: Menu Selections

Element Selected	Selection Options	Edit Keys ³
CHANNEL	All Channels	USE KEYPAD, CHAN/FREQ ARROWS TO EDIT
TYPE	CATV, PILOT, DIGITAL, and FM ⁴	USE MKR ARROWS TO EDIT
VISUAL FREQ	N/A	USE KEYPAD TO EDIT
CENTER FREQ	N/A	
CHAN WIDTH	N/A	
CHAN EDGE	N/A	
2ND OFFSET	NONE, offset frequency	USE KEYPAD TO EDIT. 0=NONE
SCRAMBLED	YES, NO	USE MKR ARROWS TO EDIT
SKIP		
QUIET LINE	AUTO, any line number	USE KEYPAD. W=ENTER Z=AUTO
ICR LINE	NONE, any video line number	USE KEYPAD. W=ENTER Z=NONE
WHITE LINE	NONE, any video line number	USE KEYPAD. W=ENTER Z=NONE
POLARITY, VIDEO/SYNC	NEG/NEG, NEG/POS, POS/NEG, POS/POS	USE MKR ARROWS TO EDIT ⁵
<FINISH>	N/A	X=STORE TABLE AND EXIT
<UNDO CHAN>	N/A	Y=UNDO CHANNEL CHANGES
<ABORT ALL>	W=CONFIRM ABORT Z=CANCEL	Z=ABORT ALL TABLE CHANGES

³ The last line of text on the screen identifies the front panel button used for editing the selected element.

⁴ If the channel TYPE selected is CATV or PILOT, the next line reads VISUAL FREQ. If the channel TYPE selected is DIGITAL or FM, the next line reads CENTER FREQ.

⁵ The right MKR arrow toggles the SYNC polarity and the left MKR arrow toggles the VIDEO polarity.

Figure 5–3 shows a channel with the menu set to store the changes and exit the menu (<FINISH>). It has a second aural carrier 4.7MHz above the video carrier.

```
EDIT CHANNEL TABLE: ED'S TV
CHANNEL: 907S      TYPE: CATV
CENTER FREQ: 7.25000MHZ
CHAN WIDTH : 3.00000MHZ
CHAN EDGE  : -1.50000MHZ
2ND OFFSET : 4.70000MHZ
SCRAMBLED  : NO           SKIP: NO
QUIET LINE : 15
ICR LINE   : 19
WHITE LINE : 14
POLARITY, VIDEO/SYNC: NEG/POS
warnings, errors, messages
<FINISH> <UNDO CHAN> <ABORT ALL>
USE KNOB TO SELECT PARAMETER.
X = STORE TABLE AND EXIT
```

Figure 5–3: Channel with FINISH selected

The <FINISH> selection (shown in Figure 5–3) ends the editing session and goes back to the CATV MEASUREMENTS SETUP menu. The table of edited data is copied into NVRAM and becomes the master copy. Upon returning to the spectral display, if the channel displayed currently was edited during the session, the screen will reflect the changes.

The <UNDO CHAN> selection repaints the screen with all the values that were there before the channel was selected, and the CHANNEL element is automatically selected for further editing.

The <ABORT ALL> selection copies the original table from NVRAM back to RAM, the channel table reverts to its original state, and the parent menu is displayed. A confirmation prompt is displayed before this complete loss of all edits can occur.

Selecting a Test Channel

While in the spectral display, enter the desired test channel by pressing keypad numbers corresponding to the channel and terminate the entry by pressing **[W]**, or enter any frequency within the channel band of the channel and terminate with **[X]**, **[Y]**, or **[Z]**. Refer to Tables 5–4 through 5–6 for factory-loaded channel tables.

Table 5–4: STD

Channel	Visual Carrier	Aural Carrier
907	7.00	11.5
908	13.00	17.5
909	19.00	23.5
910	25.00	29.5
911	31.00	35.5
912	37.00	41.5
913	43.00	47.5
2	55.25	59.75
3	61.25	65.75
4	67.25	71.75
5	77.25	81.75
6	83.25	87.75
95	91.25	95.75
96	97.25	101.75
97	103.25	107.75
98	109.25	113.75
99	115.25	119.75
14	121.25	125.75
15	127.25	131.75
16	133.25	137.75
17	139.25	143.75
18	145.25	149.75
19	151.25	155.75
20	157.25	161.75
21	163.25	167.76
22	169.25	173.75
7	175.25	179.75
8	181.25	185.75
9	187.25	191.75
10	193.25	197.75
11	199.25	203.75
12	205.25	209.75
13	211.25	215.75
23	217.25	221.75
24	223.25	227.75
25	229.25	233.75
26	235.25	239.75
27	241.25	245.75
28	247.25	251.75
29	253.25	257.75

Table 5-4: STD (Cont.)

Channel	Visual Carrier	Aural Carrier
30	259.25	263.75
31	265.25	269.75
32	271.25	275.75
33	277.25	281.75
34	283.25	287.75
35	289.25	293.75
36	295.25	299.75
37	301.25	305.75
38	307.25	311.75
39	313.25	317.75
40	319.25	323.75
41	325.25	329.75
42	331.25	335.75
43	337.25	341.75
44	343.25	347.75
45	349.25	353.75
46	355.25	359.75
47	361.25	365.75
48	367.25	371.75
49	373.25	377.75
50	379.25	383.75
51	385.25	389.75
52	391.25	395.75
53	397.25	401.75
54	403.25	407.75
55	409.25	413.75
56	415.25	419.75
57	421.25	425.75
58	427.25	431.75
59	433.25	437.75
60	439.25	443.75
61	445.25	449.75
62	451.25	455.75
63	457.25	461.75
64	463.25	467.75
65	469.25	473.75
66	475.25	479.75
67	481.25	485.75
68	487.25	491.75
69	493.25	497.75
70	499.25	503.75
71	505.25	509.75

Table 5-4: STD (Cont.)

Channel	Visual Carrier	Aural Carrier
72	511.25	515.75
73	517.25	521.75
74	523.25	527.75
75	529.25	533.75
76	535.25	539.75
77	541.25	545.75
78	547.25	551.75
79	553.25	557.75
80	559.25	563.75
81	565.25	569.75
82	571.25	575.75
83	577.25	581.75
84	583.25	587.75
85	589.25	593.75
86	595.25	599.75
87	601.25	605.75
88	607.25	611.75
89	613.25	617.75
90	619.25	623.75
91	625.25	629.75
92	631.25	635.75
93	637.25	641.75
94	643.25	647.75

Table 5-5: HRC

Channel	Visual Carrier	Aural Carrier
2	54.00	58.5
3	60.00	64.5
4	66.00	70.5
1	72.00	76.5
5	78.00	82.5
6	84.00	88.5
95	90.00	94.50
96	96.00	100.50
97	102.00	106.50
98	108.00	112.50
99	114.00	118.50

Table 5-5: HRC (Cont.)

Channel	Visual Carrier	Aural Carrier
14	120.00	124.50
15	126.00	130.50
16	132.00	136.50
17	138.00	142.50
18	144.00	148.50
19	150.00	154.50
20	156.00	160.50
21	162.00	166.50
22	168.00	172.50
7	174.00	178.50
8	180.00	184.50
9	186.00	190.50
10	192.00	196.50
11	198.00	202.50
12	204.00	208.50
13	210.00	214.50
23	216.00	220.50
24	222.00	226.50
25	228.00	232.50
26	234.00	238.50
27	240.00	244.50
28	246.00	250.50
29	252.00	256.50
30	258.00	262.50
31	264.00	268.50
32	270.00	274.50
33	276.00	280.50
34	282.00	286.50
35	288.00	292.50
36	294.00	298.50
37	300.00	304.50
38	306.00	310.50
39	312.00	316.50
40	318.00	322.50
35	288.00	292.50
36	294.00	298.50
37	300.00	304.50
38	306.00	310.50
39	312.00	316.50
40	318.00	322.50
41	324.00	328.50
42	330.00	334.50
43	336.00	340.50
44	342.00	346.50
45	348.00	352.50
46	354.00	358.50

Table 5-5: HRC (Cont.)

Channel	Visual Carrier	Aural Carrier
47	360.00	364.50
48	366.00	370.50
49	372.00	376.50
50	378.00	382.50
51	384.00	388.50
52	390.00	394.50
53	396.00	400.50
54	402.00	406.50
55	408.00	412.50
56	414.00	418.50
57	420.00	424.50
58	426.00	430.50
59	432.00	436.50
60	438.00	442.50
61	444.00	448.50
62	450.00	454.50
63	456.00	460.50
64	462.00	466.50
65	468.00	472.50
66	474.00	478.50
67	480.00	484.50
68	486.00	490.50
69	492.00	496.50
70	498.00	502.50
71	504.00	508.50
72	510.00	514.50
73	516.00	520.50
74	522.00	526.50
75	528.00	632.50
76	534.00	538.50
77	540.00	544.50
78	546.00	550.50
79	552.00	556.50
80	558.00	562.50
81	564.00	568.50
82	570.00	574.50

Table 5-5: HRC (Cont.)

Channel	Visual Carrier	Aural Carrier
83	576.00	580.50
84	582.00	586.50
85	588.00	592.50
86	594.00	598.50
87	600.00	604.50
88	606.00	610.50
89	612.00	616.50
90	618.00	622.50
91	624.00	628.50
92	630.00	634.50
93	636.00	640.50
94	642.00	646.50

Table 5-6: IRC

Channel	Visual Carrier	Aural Carrier
2	55.25	59.75
3	61.25	65.75
4	67.25	71.75
1	73.25	77.75
5	79.25	83.75
6	85.25	89.75
2	55.25	59.75
3	61.25	65.75
4	67.25	71.75
1	73.25	77.75
5	79.25	83.75
6	85.25	89.75
95	91.25	95.75
96	97.25	101.75
97	103.25	107.75
98	109.25	113.75
99	115.25	119.75
14	121.25	125.75
15	127.25	131.75
16	133.25	137.75
17	139.25	143.75
18	145.25	149.75
19	151.25	155.75
20	157.25	161.75
21	163.25	167.75
22	169.25	173.75

Table 5-6: IRC (Cont.)

Channel	Visual Carrier	Aural Carrier
7	175.25	179.75
8	181.25	185.75
9	187.25	191.75
10	193.25	197.75
11	199.25	203.75
12	205.25	209.75
13	211.25	215.75
23	217.25	221.75
24	223.25	227.75
25	229.25	233.75
26	235.25	239.75
27	241.25	245.75
28	247.25	251.75
29	253.25	257.75
30	259.25	263.75
31	265.25	269.75
32	271.25	275.75
33	277.25	281.75
34	283.25	287.75
35	289.25	293.75
36	295.25	299.75
37	301.25	305.75
38	307.25	311.75
39	313.25	317.75
40	319.25	323.75
41	325.25	329.75
42	331.25	335.75
43	337.25	341.75
44	343.25	347.75
45	349.25	353.75
46	355.25	359.75
47	361.25	365.75
48	367.25	371.75
49	373.25	377.75
50	379.25	383.75
51	385.25	389.75
52	391.25	395.75
53	397.25	401.75
54	403.25	407.75
55	409.25	413.75
56	415.25	419.75
57	421.25	425.75
58	427.25	431.75

Table 5-6: IRC (Cont.)

Channel	Visual Carrier	Aural Carrier
59	433.25	437.75
60	439.25	443.75
61	445.25	449.75
62	451.25	455.75
63	457.25	461.75
64	463.25	467.75
65	469.25	473.75
66	475.25	479.75
67	481.25	485.75
68	487.25	491.75
69	493.25	497.75
70	499.25	503.75
71	505.25	509.75
72	511.25	515.75
73	517.25	521.75
74	523.25	527.75
75	529.25	533.75
76	535.25	539.75
77	541.25	545.75
78	547.25	551.75
79	553.25	557.75
80	559.25	563.75
81	565.25	569.75
82	571.25	575.75
83	577.25	581.75
84	583.25	587.75
85	589.25	593.75
86	595.25	599.75
87	601.25	605.75
88	607.25	611.75
89	613.25	617.75
90	619.25	623.75
91	625.25	629.75
92	631.25	635.75
93	637.25	641.75
94	643.25	647.75

**In-Service Measurement
Capability**

In-service measurement capability includes measurement of C/N, CSO, and ICR (on negative modulation polarity signals only). Gating hardware in the 2715 Spectrum Analyzer allows these measurements to be made on normal modulated TV signals without disruption of programming. This is done by interrupting the signal processing path of the spectrum analyzer during times when active video and/or undesired test signals would interfere with the measurement.

The advantage of using gating techniques is that you can perform more measurements without interrupting service to your subscribers. Also, carrier-to-noise may be measured within the video band of the channel, which allows you to make meaningful measurements through a set-top converter without using extra equipment or complicated procedures.

NOTE. *In-service measurements are not available when measuring digital channels.*

Note the following limitations that apply when using gated measurements:

- Gated measurements are not generally available on scrambled channels, since the gate timing hardware depends on normal horizontal and vertical sync pulse structure for its operation.
- Measurement speed is reduced in some cases, since it takes longer to obtain trace filling and/or averaging when the gate is open so little of the time (typically less than 1%).
- Selection of beat frequencies is more difficult in interactive CSO mode because the gating is not compatible with ordinary video filtering. Visually, the dominant feature of the resulting screen display is the collection of noise peaks (as opposed to the average noise level viewed with appropriate video filtering). A technique for minimizing the impact of this effect is suggested in the section on CSO measurement details; however, there will always be some loss in the ability to see weak CSO components. This does NOT impact the accuracy or dynamic range of the earnest CSO measurement taken once you have defined the frequencies to be checked.
- Since the channel is active during in-service measurements, it is possible for the measurement accuracy to be affected adversely by residual or inaccurate video content in the line(s) being measured. For example, if a noisy video signal is applied to the modulator at the head end, the resulting noise sideband power will be indistinguishable from noise introduced by the distribution system. Noisy video can limit the sensitivity for both C/N and CSO measurements taken in-service. When measuring ICR, noise is not a concern, but the 2715 assumes that the test signal in the specified line is spectrally flat at the head end. If this is not true, the 2715's flatness will be misstated. A technique for assessing flatness and compensating for a nonflat video source is suggested in the section on ICR measurement details.

The successful application of gated measurements, therefore, depends on good quality video signals. In particular, you should avoid attempting to make in-service measurements on channels carrying video from low quality sources such as consumer grade VCRs and camcorders. In addition to the noise and flatness problems, most low quality video sources produce head switching glitches or other disturbances which tend to disrupt the timing of the 2715's gate operation. Such disruptions may cause measurement errors ranging from subtle to dramatic.

When performing in-service tests, the instrument routine checks for quiet lines at lines 10 through 20 and 272 through 282 on NTSC systems or at lines 6 through 20 and 318 through 332 on PAL systems. If the only quiet lines available are beyond this range, then you must specify the quiet line in the channel table, using the *Cable TV RF Measurements Software for Windows* provided with your instrument. In this case, the in-service test is run on the specified line, even though it is outside the normal range, but there is no verification that the line is still quiet after the test.

The 2715 firmware includes an algorithm which automatically sets the RF attenuator and RF preamplifier states to values based on a measurement of the signal levels on the system throughout the frequency range. This is done for the same reason that the overall operating level in a CATV system needs to be controlled — to make a suitable compromise between noise and distortion.

In some instances, this may cause an unexpected result. The gating hardware used for some of the in-service measurements needs a strong signal to perform reliably. In a nonflat system, weaker signals on the system may fail to meet this requirement because the optimum RF attenuator and preamplifier settings are based on the levels of the stronger signals present, causing the weaker signals to have excessively low levels at the 1st mixer of the 2715. In this case, the 2715 automatically increases the 1st mixer input level (by the minimum amount required). However, increasing the 1st mixer input level may cause the measurement to be corrupted by instrument-generated distortion products. Although this technique will sometimes give an inaccurate test result, the error is in the conservative direction. That is, if the test result reports that the CATV system passes, it most likely has passed by a greater margin than indicated by the measurement result. Note that whenever the 1st mixer input level has to be increased, the test result is flagged by adding 2000 to its magnitude (see individual test descriptions for more details).

If a measurement is flagged by adding 2000 to its magnitude, you must decide whether or not to accept the measurement. If the numerical result is acceptable, no further action is necessary. If you want a more accurate measurement, you should consider using preselection in front of the 2715 (either use a CATV preselector or make the measurement through a set top converter, if applicable). Alternatively, use a nongated measurement, which will not need to make the 1st mixer level readjustment.

The 2715 is designed so that you will always have a choice of whether or not you use gated (in-service) measurement techniques. If you follow the In-Service menu selections for C/N, CSO, or ICR, you will be making a gated measurement; otherwise you will be making a measurement in the conventional way without gating.

CARRIER LEVEL and AVERAGED POWER Measurement

The 2715 can take measurements on negative and positive video modulation, scrambled video channels, dual aural carrier video channels, AM or FM aural modulation, and digital channels. Aural measurements are only made on analog video channels (2715 TV signal type). Refer to Table 5–2 on page 5–5.

The CARRIER LEVELS measurement records and displays the following parameters for the current channel:

- Peak visual carrier level (averaged power if measuring a digital channel)
- Visual carrier frequency (not available when measuring a digital channel)
- Intercarrier frequency (not available when measuring a digital channel)
- Visual-to-aural carrier amplitude ratio (not available when measuring a digital channel)

Three measurement modes allow you to select the trade-off between measurement time and accuracy that best fits your needs:

- **FREQ/AMPL** — accurately measures carrier frequencies and amplitudes
- **ACCUR AMPL** — accurately measures carrier amplitude, but does not measure carrier frequency
- **FAST AMPL** — less accurately measures carrier amplitude and does not measure carrier frequency

NOTE. When measuring a digital channel, all measurements are made in a mode similar to **ACCUR AMPL**.

In conjunction with the CARRIER LEVELS measurement, you can set up the 2715 so that the above parameters are measured for a second aural carrier for the current channel. These measurements are also recorded and displayed.

CARRIER LEVEL

When the CARRIER LEVELS measurement is initiated on an analog channel, the 2715 performs the following steps that are common to all CARRIER LEVELS measurement modes:

- Recalls base settings, if necessary. Base settings are the standard settings from which each test is run; equivalent to selecting [0] (RECENTER CHANNEL xx) from the CATV Measurements menu (page one)
- Sets sweep to single-sweep mode, acquisition mode to peak detect, and selects 5 MHz video filter bandwidth
- Sets span/div so that the screen covers one channel width (or 50 KHz/div for FM channels)
- Sets the resolution bandwidth to 100 KHz for FM channels, otherwise sets it to 300 KHz
- Sets the time/div based on measurement mode, video modulation polarity, channel scrambled status, and span/div
- Tunes to the center of the channel, takes a sweep, and adjusts the reference level up in 10 dB steps if max signal is off the top of the screen
- If the channel is not a dual aural carrier TV channel, identifies and measures all carriers in 10 dB/div; if the channel is a dual aural carrier TV channel, sets span to 50 kHz/div

If you select FAST AMPL measurement mode, the 2715 executes the preceding common steps followed by these steps for each carrier in turn:

- If a dual aural carrier TV channel, tunes to the carrier in 50 KHz/div and 100 KHz resolution bandwidth. Identifies the carrier and measures amplitude in 10dB/div
- Adds flatness correction to the amplitude (or amplitude relative to visual carrier) values measured in 10 dB/div and stores results

If you select ACCUR AMPL measurement mode, the 2715 executes the common steps listed earlier followed by these steps for each carrier in turn:

- If a dual aural carrier TV channel, tunes to the carrier in 50 KHz/div and 100 KHz resolution bandwidth. Identifies the carrier and measures amplitude in 10dB/div
- If the carrier was identified in 10 dB/div, measures amplitude more accurately as follows:
 - Sets the reference level to 1 dB above the carrier level measured in 10 dB/div, sets to 1dB/div, takes a sweep, and adjusts the reference level up in 1 dB steps if carrier peak is off the top of the screen

- If the aural carrier has AM modulation, increments the reference level 2 dB, switches to LIN vertical display mode, and averages 25 sweeps
- Adds flatness correction and stores the resulting amplitude (from 1 dB or the averaged LIN waveform) as a visual or FM carrier amplitude, or stores the amplitude relative to visual carrier if this is an aural carrier

If you select **FREQ/AMPL** measurement mode, the 2715 executes the common steps listed earlier followed by these steps for each carrier:

- Tunes to the carrier if in 50 KHz/div. If carrier is one from a dual aural carrier TV channel, attempts to identify the carrier in 10 dB/div. If the carrier is identified, counts the carrier, and sets span to 50 KHz/div. Then measures amplitude more accurately, as described earlier in second bullet item under **ACCUR AMPL** measurement mode
- Stores the resulting frequency as a visual or FM carrier frequency, or if an aural carrier, stores the frequency relative to the visual carrier

AVERAGED POWER

If you measure a digital channel, the 2715 executes these steps for each carrier:

- Recalls base settings, if necessary. Base settings are the standard settings from which each test is run; equivalent to selecting **[0]** (**RECENTER CHANNEL xx**) from the **CATV Measurements** menu (page one)
- Sets sweep to single-sweep mode, acquisition mode to sample detect, and selects 30 Hz video filter bandwidth
- Sets the resolution bandwidth to 100 KHz in channels wider than 4 MHz, otherwise sets it to 30 KHz
- Sets span/div so that the screen covers 15 % more than one channel width
- Sets time/div to **AUTO** mode
- Takes a sweep and adjusts the reference level up in 10 dB steps if max signal is off the top of the screen
- Finds the edges of the signal
- Integrates the power spectral density of all screen locations between the edges of the signal
- Stores the resulting amplitude as an averaged power amplitude

NOTE. *If the preselector is used, you should allow or correct for its insertion loss. The input level limit (with preselector) can be extended to +62 dBmV, but this can cause significant additional inaccuracy.*

Enable CARRIER LEVELS Measurement

You use the CATV MEASUREMENTS menu to access the CARRIER LEVEL -- AVG POWER measurement menu. The CATV MEASUREMENTS menu resides on two pages (see Figure 5-1 on page 5-4). You can toggle between the pages by pressing [9].

1. Press [CATV/APPL] to display the CATV MEASUREMENTS menu.
2. Press [1] to select the CARRIER LEVEL -- AVG POWER measurement menu.
3. This gives you the following options:

- 0 RUN LEVELS-POWER FREQ/AMPL
- 1 STORE CURRENT RESULTS
- 2 DISPLAY RESULTS
- 3 PRINT CURRENT RESULTS (*RS-232 Only*)
- 4 PRINT STORED RESULTS (*RS-232 Only*)
- 5 SET UP CARRIER LEVELS
- 6 EXTERNAL ATTEN/AMPL
- 9 LEAVE CARRIER LEVEL -- AVG PWR

In this example, the accurate amplitude measurement mode (ACCUR AMPL) is selected (see menu item 0).

4. Press [5] to select a different measurement mode.

This displays the SET UP CARRIER LEVELS submenu with the following menu choices:

- 0 ACCURATE FREQUENCY AND AMPL
- 1 *ACCURATE AMPLITUDE ONLY
- 2 FAST AMPLITUDE ONLY

5. Press [0] to select ACCURATE FREQUENCY AND AMPL .

Note that the asterisk (*) moves to that selection in the menu, indicating that it is the current selection.

6. Press [BKSP] to return to the CARRIER LEVEL -- AVG POWER measurement menu.
7. Press [0] to run the Carrier Levels measurement, using the accurate frequency and amplitude mode.

After completing the measurement, the instrument displays the current results superimposed on the spectral display.

8. Press [CATV/APPL] to again display the CARRIER LEVEL -- AVG POWER menu.

9. Press [1] to store the results of the last measurement along with the channel table, channel number, time, date, site, and operator information.

After a short period, the message RESULTS STORAGE COMPLETE is displayed.

10. Press [2] to display the results of the last measurement performed.

A display resembling Figure 5-4 is displayed.

CARR LEVEL:		CURRENT
CHAN 8	05-JAN-94	12:00:00
STD		
VISUAL	13.2 DBMV @ 181.239780MHZ	
AURAL	-16.8DBC @ +4.500001MHZ	
PRESS "W" TO CONT, "Z" TO ABORT		

Figure 5-4: Carrier Level, Averaged Power Measurement Results

The word CURRENT appearing at the upper right corner of the display means that you are looking at the result of the most recent measurement performed.

The word STORED appearing at the upper right corner of the display means that you are looking at a stored result for the particular measurement. Stored results are displayed in sequence starting with the most recently stored result.

At this point you can choose to either go ahead and view other previously stored results by pressing [W], or stop viewing the results by pressing [Z].

11. If you have not already done so, press [Z] to return to the CARRIER LEVELS menu.

NOTE. You can print measurement results only when the RS-232 interface is installed in the 2715. The GPIB interface does not support the print function.

Be sure to select handshaking ([UTIL] [4] [0] [2] [5]) to match that expected by the printer or long jobs may not print completely.

12. Press [3] to print the results of the last measurement performed. A printer must be connected to the 2715.
13. Press [4] to print all stored results of the measurement. A printer must be connected to the 2715.
14. Press [9] to return to the CATV MEASUREMENTS menu.

CARRIER SURVEY Measurement

The CARRIER SURVEY measurement makes a carrier levels measurement on all active (unskipped) channels in the current channel table, and makes a record of the following parameters:

- Peak visual carrier amplitude (or averaged power if measuring a digital channel)
- Visual carrier frequency (not available when measuring a digital channel)
- Intercarrier frequency (not available when measuring a digital channel)
- Visual-to-aural carrier amplitude ratio (not available when measuring a digital channel)

When the CARRIER SURVEY measurement is initiated, the 2715 performs the following steps:

- Advances to the next unskipped channel in the channel table
- Executes a CARRIER LEVELS measurement (refer to *Carrier Levels Measurement* on page 5–20), using the measurement mode selected for CARRIER SURVEY measurement (execute AVG PWR if measuring a digital channel).
- Sets RF attenuation mode back to auto and vertical mode back to 10 dB/div before measuring the next channel

Enable CARRIER SURVEY Measurement

To make a CARRIER SURVEY measurement, do the following steps:

1. Press [CATV/APPL] to call up the CATV MEASUREMENTS menu. See Figure 5–1 on page 5–4.
2. Press [2] to select the CARRIER SURVEY measurement menu.

4. If you have skipped channels, press **[BKSP] [2]** to return to the CARRIER SURVEY menu.

5. Press **[0]** to run the CARRIER SURVEY measurement.

After the measurement is complete, the instrument displays the message RESULTS AVAILABLE VIA “DISPLAY” IN THE CARRIER SURVEY MENU.

6. Press **[CATV/APPL]** to display the CARRIER SURVEY menu.

7. Press **[1]** to store the results of the last measurement.

After a short period, the message RESULTS STORAGE COMPLETE is displayed.

8. Press **[2]** to display the results of the last measurement performed.

A display resembling Figure 5–5 comes up.

```

CARR SURVEY:                CURRENT
CHAN 8          06-JAN-94    12:00:00
STD

----- CHANNEL 2 -----
VISUAL 10.5 DBMV @ 55.250000MHZ
AURAL  -15.8DBC @ +4.500000MHZ
----- CHANNEL 3 -----
VISUAL  9.8 DBMV @ 61.250000MHZ
AURAL  -15.4DBC @ +4.500000MHZ
----- CHANNEL 4 -----
VISUAL  9.5 DBMV @ 67.250000MHZ
AURAL  -15.1DBC @ +4.500000MHZ

"W" CONT,          "Y" NEXT,          "Z" ABORT

```

Figure 5–5: Typical Carrier Survey Report Screen

You can choose to either go ahead and page through all the stored results for the last measurement by repeatedly pressing **[W]**, or stop viewing the results by pressing **[Z]**.

After all of the current results have been displayed (as you continue pressing **[W]** or if you press **[Z]**), the 2715 starts displaying stored results for the Carrier Survey measurement beginning with the last stored results.

After all the results have been displayed, the 2715 reverts to the CARRIER SURVEY menu.

9. Press [3] to print results of the last measurement performed. A printer must be connected to the 2715.

NOTE. You can print measurement results only when the RS-232 interface is installed in the 2715. The GPIB interface does not support the print function.

Be sure to select handshaking ([UTIL] [4] [0] [2] [5]) to match that expected by the printer or long jobs may not print completely.

10. Press [4] to print all stored results of the measurement. A printer must be connected to the 2715.
11. Press [9] to leave the Carrier Survey measurement and return to the CATV MEASUREMENTS menu.

MODULATION DEPTH Measurement

The MODULATION DEPTH measurement records and displays the depth of modulation for the current channel. Test results can be displayed and stored. Stored or current results can be printed if you have an RS-232 interface installed in the 2715. You make selections and run the modulation depth test using the CATV MEASUREMENTS submenu, MODULATION DEPTH, which provides the following choices:

- 0 RUN MODULATION DEPTH
- 1 STORE CURRENT RESULTS
- 2 DISPLAY RESULTS
- 3 PRINT CURRENT RESULTS (*RS-232 Only*)
- 4 PRINT STORED RESULTS (*RS-232 Only*)
- 5 SET UP ADJUSTMENT MODE
- 6 ENTER ADJUSTMENT MODE
- 9 LEAVE MODULATION DEPTH

When you initiate the MODULATION DEPTH measurement, the 2715 performs the following:

1. Tunes to the carrier frequency, finds the peak value, and moves the signal to top of screen. The 2715 then enables zero span, linear vertical scale, and 1 MHz RBW filter.
2. If VITS is present in the selected channel table data for this channel, the 2715 uses the VITS line to determine depth of modulation. (The VITS line must include a 100% white signal for this method to work.) In this case, the sweep time is set to 100 μ s/div and the trigger mode to TV line trigger.

The VITS line is defined in the channel table using the IBM-compatible PC software.

If VITS is not present, the sweep time is set to 2 ms/div and the trigger mode to FREE RUN.

In either case (VITS or no VITS), 10 sweeps are taken and modulation depth is computed for each sweep. The final result is the average of all 10 sweeps. For each sweep, modulation depth is computed as follows:

$$\frac{\text{max}}{\text{max} - \text{min}} \times 100\%$$

NOTE. This measurement does not work well on a scrambled channel where the sync tip is not present.

Enable MODULATION DEPTH Measurement

The following procedure shows how to make a modulation depth measurement:

1. Press [**CATV/APPL**] to call up the CATV MEASUREMENTS menu. See Figure 5-1 on page 5-4.
2. Press [**3**] to select the MODULATION DEPTH measurement menu.
3. This gives you the following options:

- 0** **RUN MODULATION DEPTH**
- 1** **STORE CURRENT RESULTS**
- 2** **DISPLAY RESULTS**
- 3** **PRINT CURRENT RESULTS (RS-232 Only)**
- 4** **PRINT STORED RESULTS (RS-232 Only)**
- 5** **SET UP ADJUSTMENT MODE**
- 6** **ENTER ADJUSTMENT MODE**
- 9** **LEAVE MODULATION DEPTH**

4. Press [**0**] to run the Modulation Depth measurement.

After the measurement is complete, the instrument displays the current results superimposed on the spectral display.

5. Press [**CATV/APPL**] to display the MODULATION DEPTH menu.
6. Press [**1**] to store the results of the last measurement.

After a short period, the RESULTS STORAGE COMPLETE is displayed.

7. Press [**2**] to display results of the last measurement performed.

A display resembling Figure 5-4 on page 5-24 shows the percent modulation. Now you can choose to either view other previously stored results for this measurement by pressing [**W**], or stop viewing the results by pressing [**Z**].

8. Press [**Z**] to return to the MODULATION DEPTH menu.

9. Press [3] to print the results of the last measurement performed. A printer must be connected to the 2715.

NOTE. You can print measurement results only when the RS-232 interface is installed in the 2715. The GPIB interface does not support the print function.

Be sure to select handshaking ([UTIL] [4] [0] [2] [5]) to match that expected by the printer or long jobs may not print completely.

10. Press [4] to print all stored results of the measurement. A printer must be connected to the 2715.

11. Press [9] to leave the Modulation Depth measurement and return to the CATV MEASUREMENTS menu.

ADJUSTMENT MODE

The modulation depth adjustment mode allows you to make real-time adjustments of modulation depth. You select SET UP ADJUSTMENT MODE to display the SET UP MOD DPTH ADJ MODE menu. Using this menu, you can select whether or not you view a full field or a single line. You also use this menu to set the target line, cycle delay, and target line duration. The SET UP MOD DPTH ADJ MODE menu choices are listed below.

0	VIEW MODULATION MODE	FIELD (LINE)
1	TARGET LINE	87.5%
2	CYCLE DELAY	1000MSEC
3	TARGET LINE DURATION	30.0%

The VIEW MODULATION MODE provides two choices: FIELD or LINE. If you select FIELD, you view a full field; if you select LINE, you will view line #17 unless you have specified a VITS line for the channel in the channel table.

With TARGET LINE selected, you can set the target line to the depth of modulation for which you want to adjust. The target line can be set to represent values from 0% to 100%, with 87.5% the default setting.

With CYCLE DELAY selected, you can change the duration of the adjustment cycle. The adjustment cycle consists of a display of the channel field (or line) that alternates with a display of the target line and its associated readouts.

You can use the cycle delay with the target line duration (discussed in the following text) to adjust the display times for comfortable viewing. The cycle delay values can range from 0 ms to 30,000 ms.

With TARGET LINE DURATION selected, you can adjust how much of the cycle delay is used to display the target line and its associated readouts. You can use the target line duration with the cycle delay (discussed in the previous text) to adjust the display times for comfortable viewing. The target line duration values can range from 0% to 100%.

Table 5–7 shows examples of the interactions between cycle delay time, target line duration, and the display times for the target line and channel field or line displays.

Table 5–7: Examples of Cycle Delay/Target Line Duration Interaction

Cycle Delay	Target Line Duration	Additional Target Line Display Time	Additional Channel Field/Line Display Time
1000 ms	95%	950 ms	50 ms
1000 ms	50%	500 ms	500 ms
1000 ms	30%	300 ms	700 ms
500 ms	95%	475 ms	25 ms
500 ms	50%	250 ms	250 ms
500 ms	30%	150 ms	350 ms

When you select ENTER ADJUSTMENT MODE from the MODULATION DEPTH menu, the following is displayed:

- Target Line—appears at the position representing the selected target line percentage value (0% to 100%). The position of the target line is relative to the top of the screen, which is 0%.
- Target line percentage—value appears in the lower right hand corner of the screen.
- Current Sync Tip Voltage—value appears in the upper left hand corner of the display. If the sync tip voltage varies during the adjustment process, the 2715 automatically adjusts the reference level to keep the sync tips at the top of the screen and displays the new sync tip voltage value.
- User Prompt—instructions on how to quit the adjustment mode (“W” or “Z” To Quit) appear in the lower left hand corner of the screen.
- Error Message—Out Of Range appears in the center of the screen if the input voltage is outside the reference level ranges for the 2715.

To use the adjustment mode, adjust the modulator so that the peak white level extends down into the displayed target line.

Some differences may occur in the measured modulation depth values, depending upon the exact point to which you adjust the peak white level. If you adjust the peak white level to the top or bottom edge of the target line, you may find a 0.4% to 0.8% difference in the measured value. It is best to adjust the peak white level to the center of the target line.

AURAL (FM) DEVIATION Measurement

The aural (FM) deviation measurement records and displays the peak frequency deviation of the aural carrier on the current channel. There are two user-selectable measurement modes: interactive and auto. Both modes require that you select a measurement time from 10 seconds to 24 hours (in minutes). The mode and the measurement time defaults to the last values used if you do not select new values. Test results can be displayed and stored. Stored or current results can be printed if you have an RS-232 interface installed in the 2715.

NOTE. *This measurement has no meaning for channels in which the aural carrier uses AM modulation.*

You make selections and run tests using the CATV MEASUREMENTS submenu, AURAL (FM) DEVIATION, which provides the following choices:

- 0 RUN FM DEVIATION INTERACTIVE**
- 1 STORE CURRENT RESULTS**
- 2 DISPLAY RESULTS**
- 3 PRINT CURRENT RESULTS (RS-232 Only)**
- 4 PRINT STORED RESULTS (RS-232 Only)**
- 5 SET UP AURAL (FM) DEVIATION**
- 6 ENTER ADJUSTMENT MODE**

- 9 LEAVE AURAL (FM) DEVIATION**

Note that the RUN FM DEVIATION selection indicates the measurement mode (in this example, interactive is selected).

You use the SET UP AURAL (FM) DEVIATION selection in the above menu to do the following:

- Change measurement modes
- View or change the selected measurement time

The SET UP AURAL (FM) DEVIATION submenu provides the following choices:

- 0 *INTERACTIVE (RESUME/ACCEPT)**
- 1 AUTO**

- 5 MEASUREMENT TIME 0.17MIN**

When you select MEASUREMENT TIME, you are prompted to enter a new value for the measurement time. Use the keypad to enter the new time in minutes (0.17 minutes to 1440 minutes). If the value you enter is outside the range, an OUT OF RANGE message displays, and the measurement time is set to the closest limit.

Auto Mode Auto mode runs until the user-selected measurement time elapses (or you terminate or abort it) and then terminates with the measurement results displayed. This mode can be used in System Test Programs, since it does not require user interaction.

When you initiate an auto FM deviation measurement, the 2715 does the following:

1. Checks if the channel table specifies this channel as TV or FM. If the channel is specified other than TV or FM, the measurement is aborted.
2. Tunes to the aural carrier of the current channel as specified in the channel table and places a marker at the aural carrier location.
3. Sets the RBW and VF to 100 kHz.
4. Performs a center measure to count and recenter the aural carrier.
5. Enables ZERO SPAN, selects FM Deviation, sets sweep time to 100 ms/div, enables waveform C as the MIN HOLD destination, and turns on min hold.
6. Continues to sweep while waveform C accumulates peak deviation until one of the following occurs:
 - You press [W] (terminates test and saves results)
 - You press [Z] (aborts test and does not save results)
 - A GPIB Device Clear Command (DCL) is received (aborts test and does not save the results)
 - The user-selected time limit is reached
7. Computes the result as a mean peak deviation after rejecting widely deviating readings. It computes the mean and standard deviations of all the data in waveform C, discards the data more than two standard deviations from the mean, and computes a new mean from the remaining data.
8. Displays the cumulative aural (FM) deviation.

Interactive Mode Interactive mode runs until the user-selected time elapses (or you terminate or abort it) and then displays the measurement results and a prompt for the operator to resume or accept the current measurement.

When you initiate an interactive aural (FM) deviation measurement (and do not terminate or abort it), the 2715 performs the following:

1. Executes step 1 through step 8 as discussed earlier in *Auto Mode*.
2. Loads Waveform B with a straight line halfway across the screen (horizontally) to mark the position of the completed mean.

3. Prompts you to either resume or accept the current measurement. If you select RESUME, the 2715 makes another measurement. The min hold register is not cleared between measurements to allow further accumulation of the peak deviation.

Adjustment Mode

When you select ENTER ADJUSTMENT MODE from the AURAL (FM) DEVIATION submenu, the 2715 computes and displays the instantaneous aural (FM) deviation for each sweep. This allows you to use a constant test tone to adjust the level of modulation on a sweep by sweep or real-time basis. No measurement results are stored in this mode.

Enable AURAL (FM) DEVIATION Measurement

The following procedure shows how to make an aural (FM) deviation measurement:

1. Press [**CATV/APPL**] to display the CATV MEASUREMENTS menu. See Figure 5-1.
2. Press [**4**] to select the AURAL (FM) DEVIATION measurement menu.
3. Press [**5**] to select SET UP AURAL (FM) DEVIATION.
4. Press [**0**] to select interactive mode (if not already selected as indicated by an asterisk).
5. Press [**5**] and use the keypad to enter “.” and “5”.
6. Press [**W**] to enter selected time (sets the measurement time to 0.50 minutes).
7. Press [**BKSP**] to return to the AURAL (FM) DEVIATION measurement menu.
8. Press [**0**] to run the interactive aural (FM) deviation measurement.

After the measurement is complete, the instrument displays the current results and the message

RESUME OR ACCEPT CURRENT MEAS
 “W” TO RESUME, “Z” TO ACCEPT

9. Press [**W**] to run the measurement again or [**Z**] to accept the current measurement.

If you press [**W**] to run the measurement again, waveform C continues to accumulate peak deviation data for the measurement time you selected (30 seconds).

10. Press [**CATV/APPL**] to display the AURAL (FM) DEVIATION menu.

11. Press [1] to store the results of the last measurement.

After a short period of time, the message RESULTS STORAGE COMPLETE is displayed.

12. Press [2] to display results of the last measurement performed.

A display resembling Figure 5–4 on page 5–24 appears showing FM deviation. At this point you can choose to either go ahead and view other previously stored results for this measurement by pressing [W] or stop viewing the results by pressing [Z].

13. Press [Z] to return to the AURAL (FM) DEVIATION menu.

14. Press [3] to print the results of the last measurement performed. A printer must be connected to the 2715.

NOTE. You can print measurement results only when the RS-232 interface is installed in the 2715. The GPIB interface does not support the print function.

Be sure to select handshaking ([UTIL] [4] [0] [2] [5]) to match that expected by the printer or long jobs may not print completely.

15. Press [4] to print all stored results of the measurement. A printer must be connected to the 2715.

16. Press [9] to leave the AURAL (FM) DEVIATION measurement and return to the CATV MEASUREMENTS menu.

CARRIER-TO-NOISE, DESIRED-to-UNDESIRED Measurement

The CARRIER-TO-NOISE, DESIRED-to-UNDESIRED measurement records and displays the visual carrier-to-noise ratio for the current analog channel or the desired-to-undesired ratio for digital channels. The desired-to-undesired ratio is the measurement of averaged power in the selected channel with the desired signal applied compared to the measurement of averaged power in the selected channel without the desired signal.

If the in-service basis is selected (not available in positive modulation systems or when measuring a digital channel), this measurement is made during gated slices in the vertical retrace interval. This permits the carrier-to-noise measurement to be performed within the normal video frequency band (excluding the region within about 1 MHz of the visual carrier) while normal program material is being broadcast.

CARRIER-TO-NOISE

When the CARRIER-TO-NOISE measurement is initiated on an analog channel, the 2715 performs the following:

NOTE. *When you are measuring C/N on an in-service basis at a test frequency within the video band, the useful sensitivity may be limited by noise on the video signal being carried.*

1. If in-service basis is selected, finds a group of quiet lines (if none are specified in the channel table).
2. Tunes to the visual carrier frequency and sets the following: RBW to 300 kHz with no video filter, span to 200 kHz/div, sweep speed to 50 ms/div (200 ms/div if the modulation polarity is positive as in the French L system). The 2715 makes a single sweep, and then does a peak search with the marker and records the marker value as the carrier level.
3. Performs one of the following (unless in auto in-service basis):
 - a. If normal basis (in-service not selected), returns to frequency and span settings that display the whole channel across the screen. Selects 30 kHz RBW and turns the video filter on. Initially places the marker on the minimum point of the waveform, and if necessary, changes the reference level setting so that the low point is at least 10 dB above the bottom of the screen.
 - b. If interactive in-service basis is selected, returns to frequency and span settings that display the whole channel across the screen. Selects 100 kHz RBW and turns the video filter off. Enables gating and peak acquisition mode. Initially places the marker at 2 MHz above the visual carrier, and if necessary, changes the reference level setting so that the low point of the trace is at least 10 dB above the bottom of the screen.
4. If in interactive mode, prompts the user to adjust the marker to the desired position for the noise measurement. If in auto mode with pause-for-carrier-off, prompts the user to turn off the carrier.
5. Measures the noise at the location shown in Table 5–8 using the applicable built-in noise measurement routine, which applies the noise measurement corrections for filter BW, detector errors, and instrument noise floor proximity. If measuring on the in-service basis, the routine includes switching to zero span and averaging for a substantial number of TV vertical sweep periods.

Table 5–8: Locations of Noise Measurement

Mode	Measurement Location
In-service interactive	At marker
In-service auto	At +2.7 MHz above carrier
Interactive	At marker
Auto	At lowest channel edge
Pause	At +2.7 MHz above carrier
Digital	Average whole channel

6. Subtracts the noise level from the previously measured carrier level (both expressed in log (dB) units) and displays the result as C/N in dB.
7. If in-service basis is selected, verifies that the quiet lines measured are still quiet. Turns preamp on or off as needed. Stores measured waveform in Display Register A.

NOTE. *The Carrier-to-Noise test result may be marked with an asterisk (*). This indicates that the measured noise level is within 2 dB of the 2715's calculated noise level. Under these conditions, the inaccuracy is always on the conservative side; the actual Carrier-To-Noise ratio will be better than the measured value.*

The gated Carrier-to-Noise test result may also have 1000, 2000, or 3000 added to it. This indicates that events occurred during the measurement which may cause an inaccurate result. If so, the inaccuracy is always on the conservative side; the actual Carrier-To-Noise ratio will be better than the measured value.

If 1000 is added to the result, the instrument detected that one or more of the quiet lines found at the start of the test were not quiet at the end of the test.

If 2000 is added to the result, the instrument increased the signal level at the 1st mixer input above optimum to ensure adequate signal level for accurately-timed gating control. For Carrier-to-Noise measurements, this should occur only on channels that are substantially weaker than the general system level.

If 3000 is added to the result, both of the above events occurred.

When performing in-service tests, the instrument checks for quiet lines at lines 10 through 20 and 272 through 282 on NTSC systems or at lines 6 through 20 and 318 through 332 on PAL systems. If the only quiet lines available are beyond this range, then you must specify the quiet line in the channel table, using the Cable TV RF Measurements Software for Windows. In this case, the in-service test is run on the specified line, even though it is outside the normal range, but there is no verification that the line is still quiet after the test.

DESIRED-to-UNDESIRED

When the DESIRED-to-UNDESIRED measurement is initiated, the 2715 performs the following:

1. Average power measurements as is done as described in the CARRIER LEVEL -- AVG POWER menu on page 5–23.
2. The user is prompted to turn the channel under test off.
3. Then the Resolution Bandwidth is set to 30 kHz and the Video Bandwidth to 30 Hz.
4. A sweep is initiated.
5. Any coherent distortion signals are identified and the value of the most powerful one is recorded.
6. The power spectral density of all screen locations is integrated between the edges of the channel and is calculated.

NOTE. A correction for the instrument noise floor is made and the power in any signals found in step 5 is included in this calculation.

7. The results of the calculation done in step 6 is stored as a desired-to-undesired ratio. The frequency limits that the power was measured within are stored as the signal bandwidth. The largest coherent signal found in the undesired measurement is also reported, but not stored.

**Enable CARR/NOISE --
DESIRED/UNDESIRED
Measurement**

The following procedure shows how to make a CARRIER-TO-NOISE or DESIRED-to-UNDESIRED measurement:

1. Press [CATV/APPL] to call up the CATV MEASUREMENTS menu. See Figure 5–1.
2. Press [5] to select the CARR/NOISE -- DESIRED/UNDESIRED measurement menu.

This displays the following options:

- 0 **RUN C/N -- D/U**
- 1 **STORE CURRENT RESULTS**
- 2 **DISPLAY RESULTS**
- 3 **PRINT CURRENT RESULTS (RS-232 Only)**
- 4 **PRINT STORED RESULTS (RS-232 Only)**
- 5 **SET UP CARRIER/NOISE**
- 7 **IN-SERVICE**
- 9 **LEAVE C/N -- D/U**

3. Press [7] to toggle between normal or in-service basis.

4. Press **[5]** to call up the CARRIER/NOISE setup menu (test modes).

This gives you the following options:

- 0** **INTERACTIVE**
- 1** **AUTO**
- 2** **AUTO with (PAUSE FOR CARRIER OFF)**
- 5** **NOISE NORM'D BW**

***NOTE.** Option 2 is not available if IN-SERVICE is selected in the CARRIER-TO-NOISE menu. If the channel to be measured is digital, the measurement is made with option 2 no matter which mode you selected.*

In Interactive Test Mode, you will be prompted to place the marker on the noise floor at some time during the measurement.

***NOTE.** When measuring Carrier-to-Noise on an in-service basis in interactive mode, the apparent noise level displayed will be higher than the true noise level. This is because the gating is not compatible with video filtering, and, visually, the dominant feature of the screen display is the collection of noise peaks. This does not affect the accuracy of the earnest measurement, nor does it affect your ability to locate a low-amplitude region for the earnest measurement. In this particular situation, there is no need for concern when the visual noise level appears to be excessively high.*

In Auto Test Mode, you will not be required to do any settings.

In Auto with Pause-for-Carrier-Off Test Mode, you will be prompted to turn off the carrier at some time during the measurement. If measuring an analog channel, the spectrum analyzer then measures the noise at 2.7 MHz above the video carrier. If measuring a digital channel, the spectrum analyzer measures the undesired power across the whole channel.

In addition to the three test modes, you are given the option of resetting the normalized noise bandwidth. The default bandwidth is 4 MHz. (This is not used for digital channels.)

5. Press **[BKSP]** to return to the CARR/NOISE -- DESIRED/UNDESIRED measurement menu.
6. Press **[0]** to run the CARR/NOISE -- DESIRED/UNDESIRED measurement.

After the measurement is complete, the instrument displays the current results, the offset frequency (from the carrier) at which the noise was measured, and the normalization bandwidth superimposed on the spectral display.

7. Press [**CATV/APPL**] to display the CARR/NOISE -- DESIRED/UNDESIRED menu.

8. Press [**1**] to store the results of the last measurement.

After a short period of time, the message RESULTS STORAGE COMPLETE is displayed.

9. Press [**2**] to display results of the last measurement performed.

A display resembling Figure 5–4 on page 5–24 comes up showing current results and the normalization bandwidth. You can either go ahead and view other previously stored results for this measurement by pressing [**W**], or stop viewing the results by pressing [**Z**].

10. Press [**3**] to print the results of the last measurement performed. A printer must be connected to the 2715.

***NOTE.** You can print measurement results only when the RS-232 interface is installed in the 2715. The GPIB interface does not support the print function.*

*Be sure to select handshaking ([**UTIL**] [**4**] [**0**] [**2**] [**5**]) to match that expected by the printer or long jobs may not print completely.*

11. Press [**4**] to print all stored results of the measurement. A printer must be connected to the 2715.

12. Press [**9**] to leave the CARR/NOISE -- DESIRED/UNDESIRED menu and return to the CATV MEASUREMENTS menu.

HUM/LFD Measurement

The HUM/LFD measurement records and displays the peak-to-peak HUM/LFD parameters for the currently selected channel. HUM is measured on an unmodulated carrier and includes the power line fundamental and 2nd harmonic. LFD is measured on a modulated carrier and may include some video-related energy. Measurements on modulated carriers may not give accurate results if the video polarity is positive (for example, the French L system).

When the HUM/LFD measurement is initiated, the firmware configures the 2715 as follows:

- Sweep triggering: Free run, single sweep
- Center Frequency: Visual carrier of the currently selected channel
- Span/div: 600 kHz/div

- Resolution bandwidth: 300 kHz
- Video filter: Off
- Acquisition mode: Peak
- Reference level: Signal peak is at top of screen
- Vertical mode: Linear
- Span: Zero Span
- Sweep speed: 20 ms/div

A time domain (ZERO SPAN) waveform is acquired. This waveform is converted to the frequency domain using a Fast Fourier Transform (FFT) calculation so that the percent hum for the power line fundamental and 1st harmonic can be measured. The hum values are calculated from the FFT result as follows.

$$4 \times 100 \times \frac{\text{Power Line Frequency Component}}{\text{Visual Carrier Component}}$$

The factor of four (4) comes from the following two sources:

- The two-sided nature of the FFT requires that the apparent levels of each harmonic be doubled
- The result must be doubled again to obtain the peak-to-peak harmonic levels since the FFT finds only the peak value of each harmonic component

The hum data values are shown in the two readout lines as follows:

ZZ.Z% TOTAL HUM
XX.X% @ F₀ YY.Y% @ F₁

where F₀ is the power line fundamental (50 Hz or 60 Hz)
and F₁ is the power line 1st harmonic (100 Hz or 120 Hz).

The time domain data is displayed in waveform B.

Enable HUM/LFD Measurement

The following procedure shows how to make a HUM/LFD measurement:

1. Press [CATV/APPL] to call up the CATV MEASUREMENTS menu. See Figure 5-1.
2. Press [6] to select the HUM/LFD measurement menu.

This gives you the following options:

- 0** **RUN HUM/LFD**
- 1** **STORE CURRENT RESULTS**
- 2** **DISPLAY RESULTS**
- 3** **PRINT CURRENT RESULTS (RS-232 Only)**
- 4** **PRINT STORED RESULTS (RS-232 Only)**
- 5** **POWER LINE FREQ**
- 9** **LEAVE HUM/LFD**

3. Press [**5**] to select the desired power line frequency (60 Hz or 50 Hz). The [**5**] key toggles between the two line frequencies.

4. Press [**0**] to run the Hum/LFD measurement.

After the measurement is complete, the instrument displays the measured hum at the selected power line frequency and the time domain waveform in waveform B.

5. Press [**CATV/APPL**] to display the HUM/LFD menu.

6. Press [**1**] to store the results of the last measurement.

After a short period of time, the message RESULTS STORAGE COMPLETE is displayed.

7. Press [**2**] to display the results of the last measurement performed.

A display resembling Figure 5-4 appears showing the current result. You can press [**W**] to view other previously stored results for this measurement, or press [**Z**] to stop viewing the results.

8. Press [**3**] to print the results of the last measurement performed. A printer must be connected to the 2715.

NOTE. You can print measurement results only when the RS-232 interface is installed in the 2715. The GPIB interface does not support the print function.

Be sure to select handshaking ([**UTIL**] [**4**] [**0**] [**2**] [**5**]) to match that expected by the printer or long jobs may not print completely.

9. Press [**4**] to print all stored results of the measurement. Again a printer must be connected to the 2715.

10. Press [**9**] to leave the HUM/LFD measurement and return to the CATV MEASUREMENTS menu.

FREQUENCY RESPONSE

The FREQUENCY RESPONSE test displays the difference between spectra taken at different times or places in the system (mode 1), or a raw spectrum of the entire channel table (mode 2). The modes are selectable from the FREQ RESP SETUP menu.

A mode 1 frequency response test has two parts. The first part is acquisition of the reference and the second is comparing the current spectrum with the stored reference spectrum. The reference may be acquired either by measurement or by recalling a previously stored reference from NVRAM.

A mode 2 frequency response test sets the instrument up into a mode that sweeps between specified frequency limits in a 5 MHz resolution bandwidth.

When the FREQUENCY RESPONSE test is initiated, the start and stop frequency limits default to the minimum and maximum frequencies in the selected channel table.

If a mode 1 test has been selected, a reference must be acquired. A reference is acquired by using the ACQUIRE A REFERENCE selection in the FREQ RESP SETUP menu. The default start and stop frequency limits may be changed prior to acquiring the reference, if desired. (Whenever the start or stop frequencies are changed, the current reference is marked as invalid.) The instrument will sweep between the start and stop limits specified in this menu, apply a digital filter to the resultant sweep, and retain the resultant waveform and instrument setup. The digital filter is used to smooth the reference to reduce sensitivity to slight frequency errors and differences in program material between the reference sweep and the subsequent frequency response peaks.

During reference acquisition, the reference name is assigned by linking the site name, current date, the start frequency, and the stop frequency. The name may be changed with the EDIT CURRENT REFERENCE NAME selection. This selection can only be used if there is a currently valid reference.

The reference is acquired with the 5 MHz RBW filter. The goal is to capture the video carrier peaks throughout the frequency range.

Running The Mode 1 Test

If a valid reference exists, the mode 1 test (WITH REF) may be run. The first step is to recall the reference settings into the 2715 hardware. Then after each sweep, the raw sweep data is filtered using the identical digital filter used to filter the reference data. The reference waveform is then subtracted from the current waveform and the difference written into the C register for display on the screen. This process continues until the user terminates the test by pressing [W] or [Z]. At termination, the last difference waveform is left saved in the C display.

Running The Mode 2 Test

If mode 2 (NO REF) is selected, the instrument is set up to sweep between the specified frequency limits. The 5 MHz RBW is selected, and the peak acquisition mode is installed. The start and stop frequencies of the sweep are taken from the start and stop frequencies currently defined for the reference. These default to the lowest and highest frequencies found in the channel table, but can be changed by the user in the **FREQ RESP SETUP** menu. The instrument then simply displays the raw sweep as it sweeps between those limits.

Enable FREQUENCY RESPONSE

The following procedure shows how to make a frequency response measurement:

1. Press [**CATV/APPL**] to call up the **CATV MEASUREMENTS** menu. See Figure 5–1.
2. Press [**7**] to select the **FREQUENCY RESPONSE** measurement menu.

This gives you the following three options and displays the current frequency response reference if one exists.

**0 RUN FREQUENCY RESPONSE
CURRENT REFERENCE:**

Site Name, Date, Start Frequency, Stop Frequency, user-defined name, or <NONE>. The reference name appears only if the test mode **WITH REF** is selected. The string <SITE NAME>, <DATE>, <START>, <STOP> is the default reference name assigned when the reference is acquired. You can modify the reference name by selecting item 7 (**EDIT CURRENT REFERENCE NAME**) in the **FREQ RESP SETUP** menu, shown below.

- 5 FREQ RESP SETUP**
- TEST MODES**
- 0 NO REF**
- 1 *WITH REF**
- 2 START FREQUENCY**
- 3 STOP FREQUENCY**
- 4 USE DEFAULT START/STOP²**
- 5 ACQUIRE NEW REFERENCE**
- 6 STORED REFERENCE MENU**
- 7 EDIT CURRENT REFERENCE NAME**
- 9 LEAVE FREQUENCY RESPONSE**

3. Press [**5**] [**0**] [**BKSP**] [**0**] to run the frequency response measurement without a reference.

The instrument sets the 2715 to sweep between the specified start and stop frequencies with a 5 MHz resolution bandwidth and returns to normal user control. The instrument shows a display similar to that shown in Figure 5–6.

² Lowest and highest frequencies in the selected channel table.

You can then modify the display by various means (for example, changing the reference level, changing vertical sensitivity, or using MARKER START/STOP to zoom in on any portion of the display).

A line drawn through the peaks of the waveform shown in Figure 5–6 represents the frequency response. The slope of this line suggests that the higher frequency channels have been provided with a little more gain compensation than the lower frequency channels to compensate for frequency-dependent losses in the transmission line. This display is useful only when frequency-dependent losses in the transmission line are known.

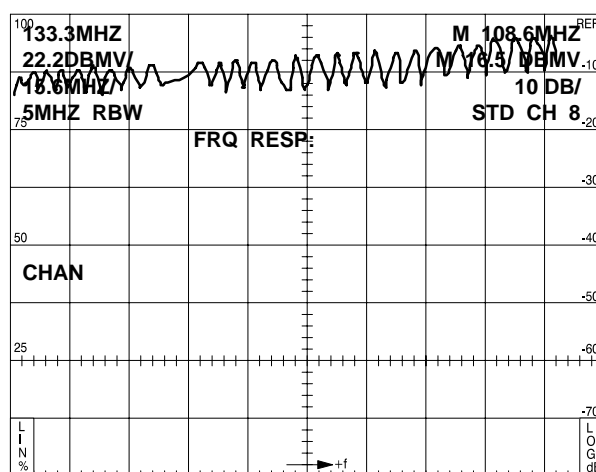


Figure 5–6: Typical Frequency Response Display Without Reference

The instrument returns to the spectral display. Note that the FREQUENCY RESPONSE menu is still active. If you press [CATV/APPL], the FREQUENCY RESPONSE menu will be displayed.

A more definitive display is acquired by comparing the result to a known reference. Item 5 in the FREQUENCY RESPONSE menu lets you acquire this reference.

A reference may be taken at the head end and stored to compare with data taken at any point along the transmission line. Storing this data also allows periodic checks over time at the same point.

To acquire a frequency response reference, perform the following steps:

1. Press [CATV/APPL] [5] to call up the FREQ RESP SETUP menu.
2. Press [1] to select the “WITH REF” test mode.

3. Enter the start and stop frequencies as follows. Note that the default start frequency is the visual carrier for the lowest unskipped channel in the selected channel table, and the default stop frequency is the visual carrier for the highest unskipped channel in the selected channel table.
 - a. If the default start/stop frequency range is adequate for your measurements, press [4] to select it and go directly to step 4.
 - b. Press [2] and enter a start frequency with the keypad.
 - c. Press [3] and enter a stop frequency with the keypad.
4. Press [5] to acquire a reference.

When the reference acquisition is complete, the instrument reverts to the spectral display and displays the message REFERENCE ACQUIRED.

If you want to rename the new reference, press [CATV/APPL] [5] [7] [W] and follow the on-screen instructions. After renaming the new reference, press [6] [n] [X] (where n is a number from 0 to 9 representing a storage register) to save it. Press [CATV/APPL] [0] to run the frequency response measurement.

If you want to save the new reference without renaming it, press [CATV/APPL] [5] [6] [n] [X] (where n is a number from 0 to 9). Press [CATV/APPL] [0] to run the frequency response measurement.

The measurement runs continuously while the instrument shows a display similar to that shown in Figure 5–7.

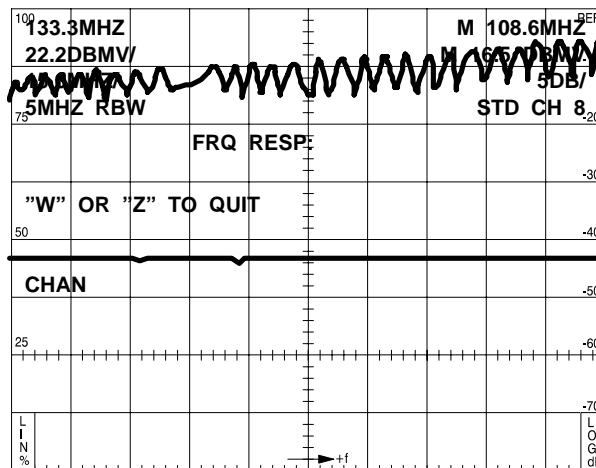


Figure 5–7: Typical Frequency Response Display With Reference

The top trace in Figure 5–7 is the raw trace. That portion of the reference where it breaks up might be a group of scrambled channels. In this case, it is the FM band. The reference was taken with the start frequency set at 55.25 MHz and the stop frequency set at 211.25 MHz (CH 2 to CH 13). The trace at center screen is the frequency response.

ADJACENT CHANNEL LEAKAGE Measurements

Adjacent channel leakage (ACL) measures the average power in the channel under test, and then measures the average power in the adjacent channels. The results is a ratio of these two numbers. The adjacent channels must not be active during the measurement.

The adjacent channel leakage measurements only run on digital channels. The measurements should be made at the output of the modulator at the head end. At this location, the adjacent channels cannot be seen so the ACL can run without requiring that you turn adjacent channels off. ACL measurements may be made beyond the combiner, but four channels, the two adjacent channels on each side of the channel under test, must be turned off before the measurement is made.

ACL measurements may be selected in the menu to occur on either the lower side, upper side or both sides of the channel under test. Only the worst ACL encountered is reported.

If any coherent spurious signals are found in the adjacent channels, the largest is reported to the instrument screen, but is not stored as part of the results.

The 2715 assumes that the adjacent channel is of the same type as the channel under test.

Both the measurements of the average power level of the channel under test (desired) and the average power level of the adjacent channel (undesired) are performed as described in *DESIRED-to-UNDESIRED* on page 5–38.

Enable Adjacent Channel Leakage Measurement

The following procedure shows how to make an adjacent channel leakage measurement:

1. Press [**CATV/APPL**] to call up the CATV MEASUREMENTS menu. See Figure 5–1.
2. Press [**9**] to select MORE, which displays the second page of the CATV MEASUREMENTS menu.
3. Press [**0**] to select ADJACENT CHANNEL LEAKAGE.

This gives you the following options:

- 0** **RUN ADJACENT CHANNEL LEAKAGE**
- 1** **STORE CURRENT RESULTS**
- 2** **DISPLAY RESULTS**
- 3** **PRINT CURRENT RESULTS (RS-232 Only)**
- 4** **PRINT STORED RESULTS (RS-232 Only)**
- 5** **MEASURE SIDE** **BOTH**
- 9** **LEAVE ACL**

- 4.** Press [**5**] to select the frequency channel on which you want the test to run — the upper frequency channel (UPPER), the lower frequency channel (LOWER), or both the upper and lower frequency channels (BOTH).

- 5.** Press [**0**] to run the adjacent channel leakage measurement.

After the measurement is complete, the instrument displays the measured adjacent channel leakage.

- 6.** Press [**CATV/APPL**] to display the ADJACENT CHANNEL LEAKAGE menu.

- 7.** Press [**1**] to store the results of the last measurement.

After a short period of time, the message RESULTS STORAGE COMPLETE is displayed.

- 8.** Press [**2**] to display the results of the last measurement performed.

A display resembling Figure 5–4 appears showing the current result. You can press [**W**] to view other previously stored results for this measurement, or press [**Z**] to stop viewing the results.

- 9.** Press [**3**] to print the results of the last measurement performed. A printer must be connected to the 2715.

NOTE. You can print measurement results only when the RS-232 interface is installed in the 2715. The GPIB interface does not support the print function.

Be sure to select handshaking ([**UTIL**] [**4**] [**0**] [**2**] [**5**]) to match that expected by the printer or long jobs may not print completely.

- 10.** Press [**4**] to print all stored results of the measurement. Again a printer must be connected to the 2715.

- 11.** Press [**9**] to leave the adjacent channel leakage (ACL) measurement and return to the CATV MEASUREMENTS menu.

CTB and CSO Measurements

The methods to make these measurements are: Interactive, Automatic, Automatic with Pause-for-Carrier-Off, Single Sweep, and (for CSO only) Continuous. Also, some of the CSO measurement methods can be performed on an in-service basis. Interactive mode helps you search for beats. The automatic modes let you measure beats when you already know where they occur. For the Automatic, Automatic with Pause-For-Carrier-Off, and Single-Sweep modes, CSO is usually measured at offsets of ± 0.75 MHz and at ± 1.25 MHz for NTSC (National Television Systems Committee) systems. CTB is measured at zero offset. A CTB may also be viewed between channels 4 and 5 for a standard channel plan.

Regardless of the mode selected, the first step is to measure the peak level of the visual carrier in the current channel. When operated in Continuous mode, the carrier frequency measured is that specified in the Setup menu. This measurement is the reference level that all subsequent measurements are referred to. Up to 5 beats are measured. The results are presented in terms of dBc relative to the carrier level measured at the beginning.

When the CTB and CSO measurement is done on a digital channel, the average channel power is measured. The Interactive mode and Automatic with Pause modes are used to perform the measurement. This measurement is not available in the in-service mode.

NOTE. *The CTB or CSO test result may be marked with an asterisk (*). This indicates when a beat signal is within 2 dB of the 2715's noise level. Under these conditions, the displayed dBc value may be lower than the actual value (that is, the beats may have a smaller amplitude than the displayed value).*

The gated CSO test result may also have 1000, 2000, or 3000 added to its magnitude. This indicates that certain events occurred during the measurement which may cause an inaccurate result. If so, the inaccuracy is on the conservative side; the actual CSO will be weaker than the measured value.

If 1000 is added to the result, the instrument detected that one or more of the quiet lines found at the start of the test were no longer quiet at the end of the test. This can occur only on gated measurements.

If 2000 is added to the result, the instrument increased the signal level at the 1st mixer input above optimum to ensure adequate signal level for accurately-timed gating control. For CSO measurements, this normally occurs on channels that are only a few dB weaker than the general system level.

If 3000 is added to the result, both of the above events occurred.

Interactive Mode

First, the instrument measures the peak of the video carrier on the current channel.

You are prompted to move the marker to the first beat to be measured. You may make any required changes to the instrument setup to help locate beats. For example, you can use menu choice [6] to select the analog display.

If you are using the in-service basis, the instrument first finds quiet lines, if none were specified in the channel table. Then the algorithm that performs the earnest beat amplitude measurements will reset the RF attenuator/preamp combination to appropriate settings. The algorithm has its own means of adequate averaging for the measurement.

To measure the beat, the instrument returns to the specified frequency, sets the instrument to NCTA-recommended settings (span at 50 kHz/div, RBW to 30 kHz, and video filter to 10 Hz). The 2715 may adjust the reference level so that the reading is at least one division from the bottom of the screen to minimize logging errors. It then searches for the maximum value within two divisions (100 kHz) of the specified frequency and returns this as the measurement (normal basis).

When earnestly measuring each CSO product on an in-service basis, the instrument moves to slightly below the selected beat frequency, sets 30 kHz RBW, and turns the video filter off. The instrument begins gating the signal path so that the path is on only during quiet lines in the vertical interval. It then internally acquires and averages a reasonable number of readings during gate on times, for each of a series of closely spaced frequencies bracketing the selected beat frequency. The highest reading for the collection of averaged submeasurements is reported as the amplitude of the selected beat. The 2715 then verifies the quiet lines.

After the measurement has been made, or [Z] is pressed, the instrument returns to the spectral display.

Automatic Mode

In the Automatic mode, the instrument measures the level of the signals at frequencies specified in the setup table. Up to five (5) frequencies can be specified. For each table entry, the instrument measures the beat using the same settings as specified for the interactive case.

Automatic With Pause Mode

The Automatic With Pause mode is identical to the Automatic mode except that after measuring the video carrier, the instrument pauses and prompts you to turn off the carrier. The Automatic With Pause mode is not available when in-service basis is selected.

Single-Sweep Mode

The Single-Sweep mode is designed to minimize the time that the carrier must be turned off. The Single-Sweep mode is not available when in-service basis is selected.

First, the instrument measures the peak of the video carrier on the current channel, then pauses and prompts you to turn off the carrier.

In this mode, the instrument scans the signals at frequencies specified in the setup table relative to the carrier frequency. Absolute frequencies are ignored. If no frequencies are specified, the instrument uses the default frequencies. From these it creates a single-sweep test table. It then computes sweep limits that include all the frequencies found in the single-sweep table (with 250 kHz of oversweep at each end). It takes a single sweep using a 30 kHz RBW and no video filter. It checks each of the frequencies in the single-sweep test table to see that the signals there are neither too near the bottom of the screen nor too near the top for a safe measurement. If necessary, it adjusts the reference level to ensure that the measurement can be made accurately. It then turns on the 100 Hz video filter and sweeps again. It now prompts you to turn the carrier back on and proceeds to measure all the beats specified in the single-sweep test table using the single sweep data.

Press [CATV/APPL] to call up the CATV MEASUREMENTS menu. See Figure 5-1.

Continuous Mode

The Continuous mode is designed to run CSO tests repeatedly for 24 hours. It assumes that the carrier of the channel-under-test has been turned off and will remain off for the duration of the test. The Continuous mode is not available when in-service basis is selected.

The frequency of the reference carrier is selectable either as an absolute frequency, or as a frequency relative to the carrier of the channel-under-test. The default is -6 MHz relative. The carrier is assumed to be stable in frequency to within ± 200 kHz.

The frequencies of the beats may be specified only relative to the carrier of the channel-under-test. At least one beat frequency must be specified for the test to run. The beats are assumed to be within ± 50 kHz of the specified frequencies.

The interval at which the continuous CSO repeats is selectable from 15 seconds (default) to 21600 seconds (6 hours) in one second increments.

The 2715 periodically runs a subset of normalizations throughout the test. These normalizations take about 3 minutes. The interval is selectable from 1 hour (default) to 24 hours in one hour increments. Selecting 24 hours has the effect of turning the periodic normalization off.

When the continuous CSO is activated, the 2715 runs full normalizations before any CSO measurements are done. The initial normalizations take about 12 minutes. The 24 hour clock that times the test doesn't start until after the initial normalizations are complete.

The actual CSO test consists of tuning to the selected reference carrier frequency, setting the span to 50 kHz/div, resolution bandwidth to 300 kHz, video bandwidth to 300 kHz, and sweep speed to 20 ms/div. Then, it sweeps the carrier frequency and measures the amplitude. Beat frequencies are then measured by setting the span to 300 kHz/div, resolution bandwidth to 30 kHz, video bandwidth to 300 Hz, and sweep speed to 200 ms/div. After these settings are complete, it sweeps the frequency and measures the beat amplitude.

After one cycle of the test is complete, it waits for the test interval to expire, then repeats the test.

During the test, the 2715 display shows the current time, the time when the next cycle will start, the time when the complete test will finish, and the time the next normalization will occur.

The test may be stopped at any time by pushing the [W] or [Z] key. When the test is stopped all results data, acquired to that time, is retained.

The results may only be viewed on an external computer. The 2715 display shows how many beats were measured, how many times they were measured, the interval between measurements, and if the DISPLAY RESULTS button was pushed, the amplitude of the measurement floor. The measurement floor is the absolute amplitude below which the instrument noise floor is interfering with the measurement to such an extent that accurate amplitude corrections are not possible.

Enable CTB or CSO Measurement

The following procedure shows how to make a CTB or CSO measurement:

1. Press [9] [5] (or [9] [6]) to select the CTB or CSO measurement menu.

This gives you the following options:

- 0** RUN CTB (or CSO)
- 1** STORE CURRENT RESULTS
- 2** DISPLAY RESULTS
- 3** PRINT CURRENT RESULTS (*RS-232 Only*)
- 4** PRINT STORED RESULTS (*RS-232 Only*)
- 5** SET UP CTB (or CSO)
- 6** DIGITAL/ANALOG
- 7** IN-SERVICE (CSO ONLY)
- 9** LEAVE CTB (or CSO)

To run the CTB or CSO measurement in the Interactive mode, follow these steps:

2. If you are making a CSO measurement, press [7] to toggle IN-SERVICE basis on or off, as desired.
3. Press [5] [0] to select the Interactive mode.
4. Press [BKSP] [0] to run the measurement.

The instrument measures the visual carrier peak, then prompts you to move the marker to the first beat.

If you are using the CSO in-service basis in the interactive mode, the instrument first finds quiet lines, if none were specified in the channel table. Then the algorithm that performs the earnest beat amplitude measurements will reset the RF attenuator/preamp combination to appropriate settings. The algorithm has its own means of adequate averaging for the measurement.

5. Press [CATV/APPL] [6] to enable the Analog display with short holdoff, since it might be easier to visually detect beats in the analog mode.
6. Turn the **FREQ/MKRS** knob to place the first beat on a graticule line. Make a note of this graticule line.
7. Press [CATV/APPL] [6] to enable the Digital display, and move the marker to the graticule line noted in the preceding step.
8. Press [W] to continue with the measurement.

At the end of the measurement, the instrument displays the results and prompts you to move the marker to the second beat.

9. Repeat steps 4 through 7 for the second, third, fourth, and fifth beats, or press [Z] to quit at any prompt.

NOTE. *If you decide to quit in the middle of the measurement, all measurement results up to that point will be retained in a temporary buffer.*

You can then decide to save those results using the STORE CURRENT RESULTS selection or ignore (discard) them.

You can also view those results with the DISPLAY RESULTS selection.

Each time a measurement is made, the instrument displays the worst case result up to that point.

10. Press [CATV/APPL] to display the CTB or CSO menu.

11. Press [1] to store the results of the last measurement.

After a short period of time, the message RESULTS STORAGE COMPLETE is displayed.

12. Press [2] to display the results of the last measurement performed.

A display resembling Figure 5–8 comes up. At this point you can choose to either go ahead and view other previously stored results by pressing [W], or stop viewing the results by pressing [Z].

13. Press [3] to print the results of the last measurement performed. A printer must be connected to the 2715.

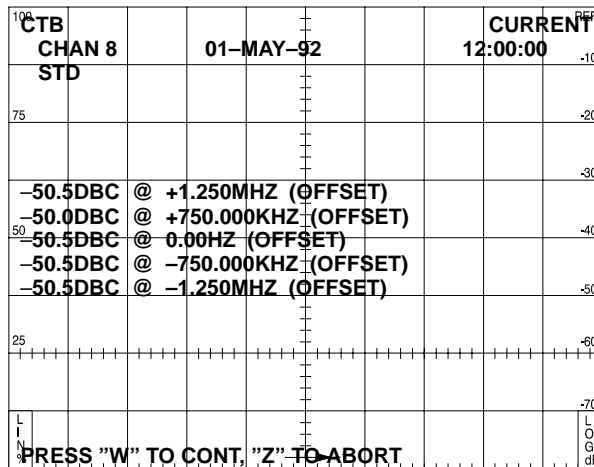


Figure 5–8: Typical CTB (or CSO) Measurement Results Display

NOTE. You can print measurement results only when the RS-232 interface is installed in the 2715. The GPIB interface does not support the print function.

Be sure to select handshaking ([UTIL] [4] [0] [2] [5]) to match that expected by the printer or long jobs may not print completely.

14. Press [4] to print the all results of the measurement. A printer must be connected to the 2715.

15. Press [9] to exit this mode or continue to the next measurement mode.

To run the CTB or CSO measurement in the Automatic mode, follow these steps:

1. If you are taking a CSO measurement, press [7] to toggle IN-SERVICE basis on or off, as desired.

2. Press **[6] [1]** to select Automatic mode.

SET UP TEST FREQUENCIES menu (item 5) is added to the menu. These frequencies represent points where beats are expected to occur relative to the visual carrier.

3. Press **[0]** and enter the first beat frequency either as an offset from the visual carrier or as an absolute frequency.
4. Press **[1]** and enter the second beat frequency.
5. Press **[2]** and enter the third beat frequency.
6. Press **[3]** and enter the fourth beat frequency.
7. Press **[4]** and enter the fifth beat frequency.
8. Press **[5]** to use the default frequencies.
9. Press **[BKSP] [BKSP] [0]** to run the measurement.

The instrument measures the visual carrier peak for a reference, then sets the span/div setting such that the measurements are made over a 100 kHz span on either side of the frequency position. The instrument measures the first, second, third, fourth, and fifth beats. After the measurement is complete, or after the routine is aborted, the worst case result is displayed in the spectral display.

10. Press **[CATV/APPL]** to display the CTB or CSO menu.
11. Press **[1]** to store the results of the last measurement.

After a short period of time, the message RESULTS STORAGE COMPLETE is displayed.

12. Press **[2]** to display results of the last measurement performed.

A display resembling Figure 5–8 comes up. You can either view other stored results by pressing **[W]**, or stop viewing the results by pressing **[Z]**.

13. Press **[3]** to print the results of the last measurement performed. A printer must be connected to the 2715.

NOTE. You can print measurement results only when the RS-232 interface is installed in the 2715. The GPIB interface does not support the print function.

Be sure to select handshaking (**[UTIL] [4] [0] [2] [5]**) to match that expected by the printer or long jobs may not print completely.

14. Press **[4]** to print all stored results of the measurement. A printer must be connected to the 2715.

To run the CTB or CSO measurement in the Automatic mode with Pause for Carrier Off, follow these steps:

***NOTE.** Automatic mode with Pause for Carrier off is not available if the in-service CSO measurement basis is selected.*

1. Press **[5] [2]** to select the Automatic mode with Pause for Carrier Off.

The SET UP TEST FREQUENCIES menu (item 5) is added to the menu. These frequencies represent points where beats are expected to occur relative to the visual carrier.

2. Press **[0]** and enter the first beat frequency either as an offset from the visual carrier or as an absolute frequency.
3. Press **[1]** and enter the second beat frequency.
4. Press **[2]** and enter the third beat frequency.
5. Press **[3]** and enter the fourth beat frequency.
6. Press **[4]** and enter the fifth beat frequency.
7. Press **[5]** to use default frequencies.
8. Press **[BKSP] [BKSP] [0]** to run the measurement.

The instrument measures the visual carrier peak for a reference, then prompts you to turn off the carrier.

9. Turn off the carrier and press **[W]** to continue (or **[Z]** to abort) the measurement over the spectral display.

The instrument measures the beats within 100 kHz on either side of each frequency, then displays the worst case result with the spectral display.

10. Press **[CATV/APPL]** to display the CTB or CSO menu.
11. Press **[1]** to store the results of the last measurement.

After a short period of time, the message RESULTS STORAGE COMPLETE is displayed.

12. Press **[2]** to display results of the last measurement performed.

A display resembling Figure 5–8 comes up. You can either view other previously stored results by pressing **[W]**, or stop viewing the results by pressing **[Z]**.

13. Press **[3]** to print the results of the last measurement performed. A printer must be connected to the 2715.

NOTE. You can print measurement results only when the RS-232 interface is installed in the 2715. The GPIB interface does not support the print function.

Be sure to select handshaking ([UTIL] [4] [0] [2] [5]) to match that expected by the printer or long jobs may not print completely.

14. Press [4] to print all stored results of the measurement. A printer must be connected to the 2715.

15. Press [9] to exit this mode or continue to the next measurement mode.

To run the CTB or CSO measurement in Single-Sweep mode, follow these steps:

NOTE. Single-Sweep mode is not available if the in-service CSO measurement basis is selected.

1. Press [5] [3] to select the Single-Sweep mode.

The SET UP TEST FREQUENCIES menu (item 5) is added to the menu. These frequencies represent points where beats are expected to occur relative to the visual carrier.

2. Press [0] and enter the first beat frequency as an offset (only) from the visual carrier.

3. Press [1] and enter the second beat frequency.

4. Press [2] and enter the third beat frequency.

5. Press [3] and enter the fourth beat frequency.

6. Press [4] and enter the fifth beat frequency.

7. Press [5] to use default frequencies.

8. Press [BKSP] [BKSP] [0] to run the measurement.

The instrument measures the visual carrier peak for a reference, then prompts you to turn off the carrier.

9. Turn off the carrier and press [W] to continue (or press [Z] to abort) the measurement.

Single-Sweep mode searches the Auto Test table for the lowest and highest frequencies relative to the visual carrier, and sets the instrument's span/div and center frequency to sweep from 0.25 MHz below the lowest frequency to 0.25 MHz above the highest frequency. The instrument then makes a sweep within these constraints, and prompts you to turn on the carrier.

10. Turn on the carrier and press **[W]** to continue (or **[Z]** to abort) the measurement.

The instrument searches the single-sweep record for beats within ± 50 kHz of offset locations specified in the test table and displays the worst case result.

To run the CSO measurement in Continuous mode, follow these steps:

NOTE. *Continuous mode is not available if the in-service CSO measurement basis is selected.*

1. Press **[5]** **[4]** to select the Continuous mode.

The SET UP TEST FREQUENCIES AND CONTINUOUS MODE PARAMETERS menu (item 5) is added to the menu.

2. Press **[5]** and enter the SET UP TEST FREQUENCY menu.
3. Press **[0]** and enter the first beat frequency as an offset from the visual carrier.
4. Press **[1]** and enter the second beat frequency.
5. Press **[2]** and enter the third beat frequency.
6. Press **[3]** and enter the fourth beat frequency.
7. Press **[4]** and enter the fifth beat frequency.
8. Press **[5]** to use default frequencies.
9. Press **[6]** to specify the frequency of the carrier to be measured. This is usually the next channel down (in frequency).
10. Press **[7]** to enter the test interval. Minimum interval (and default) is 15 seconds. The maximum test interval is 21600 seconds (6 hours).
11. Press **[8]** to enter how often the instrument normalization will be run. Minimum interval (and default) is 1 hour and the maximum interval is 24 hours.
12. Press **[BKSP]** **[BKSP]** **[0]** to run the measurement.

The instrument normalizes itself for about 12 minutes. It then measures the specified carrier frequency within 200 kHz on either side for a peak to use as an amplitude reference. Next it measures the amplitudes of the beats within 50 kHz on either side of the specified beat frequencies. It then waits for the interval to expire so the cycle can be repeated.

13. Press [W] or [Z] to stop the test. It will stop when the current cycle finishes.

When the measurement is complete it displays the number of beats that were measured, the number of times they were measured, and the number of seconds between measurements.

14. Press [CATV/APPL] to display the CSO menu.

15. Press [1] to store the results of the last measurement.

After a short period of time, the message RESULTS STORAGE COMPLETE is displayed.

16. Press [2] to display information concerning the tests performed.

A display resembling Figure 5–9 comes up. To view other previously stored results, press [W] or to stop viewing, press [Z].

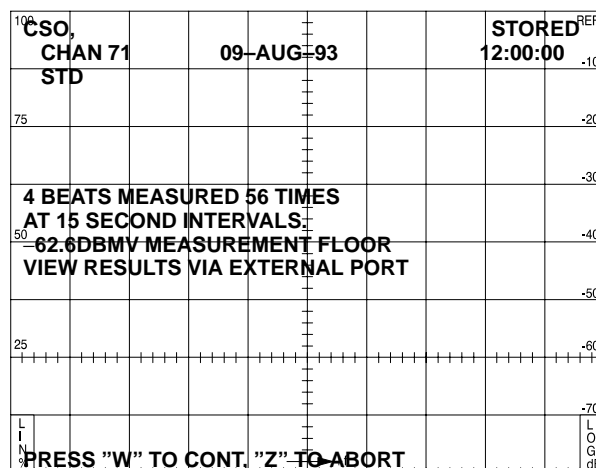


Figure 5–9: Typical Continuous Mode Results Display

17. Press [3] to print the results of the last measurement performed. A printer must be connected to the 2715.

NOTE. You can print measurement results only when the RS-232 interface is installed in the 2715. The GPIB interface does not support the print function.

Be sure to select handshaking ([UTIL] [4] [0] [2] [5]) to match that expected by the printer or long jobs may not print completely.

18. Press [4] to print all stored results of the measurement. A printer must be connected to the 2715.

19. Press [9] to exit this mode or continue to the next measurement mode.

CROSS MODULATION Measurement

The spectrum analyzer has two methods for measuring cross modulation: Time Domain NCTA (National Cable Television Association) and Frequency Domain. You can select the method from the CROSS MODULATION measurement menu (refer to *Enable CROSS MODULATION Measurement* on page 5–61).

Both methods measure and record the cross modulation in the current channel. For meaningful calibration, both methods require using the system stimulation recommended by the NCTA. This stimulation requires the following:

- All carriers (except the channel under test) must be synchronously modulated 100% with a horizontal rate square wave.
- The channel under test must carry an unmodulated CW carrier.

The two methods measure cross-modulation effects on the CW carrier in fundamentally different ways.

The Time Domain (NCTA) method tunes the spectrum analyzer to the visual carrier frequency, sets ZERO SPAN, and then detects any modulation with an envelope detector. A Fourier analysis is performed on the output of the detector to assess the amplitude of the modulation at the horizontal rate. The result is scaled and reported in units of dBc.

The Time Domain (NCTA) method closely conforms to the recommended NCTA procedure. This method is often thought to most accurately reflect the level of visible picture impairment. However, this may not be the best method for measuring sideband amplitudes, since cross modulation can also occur as phase modulation, which the envelope detector used by this method does not detect.

Therefore, the cross modulation sidebands can have significantly higher amplitudes than indicated by the Time Domain measurement result. This may result in picture impairment arising from phase modulation to amplitude modulation conversion in the asymmetric IF filter of the TV receiver, and may lead to failure to detect coherent disturbances in excess of legal limits.

NOTE. *The Frequency Domain method is sensitive to the accuracy of the frequency of the visual carrier when the frequency is defined in the channel table (refer to Channel Tables on page 5–6). If the channel under test has an aeronautical offset of 12.5 kHz and the offset is not accounted for in the channel table, then the cross modulation measurement may not find the 15.73 kHz sidebands. If the sidebands are not found, the measurement will abort.*

The Frequency Domain method reliably detects sidebands arising from either amplitude modulation or phase modulation (or a combination of both). Also, the useful measurement range of the Frequency Domain method is significantly greater than that of the Time Domain method.

The Frequency Domain method measures the carrier peak with a wide-resolution filter and then directly measures sideband amplitudes using a narrow resolution filter. However, the result is scaled to produce readings conforming to the NCTA method for the case of pure amplitude modulation (as is assumed by the Time Domain method). This is done to preserve continuity with previous history. So, the indicated cross modulation reading is 9.9 dB worse than the sideband amplitude that produced it. For example, if sidebands are found at -60 dBc, an equivalent cross modulation level of -50.1 dBc is displayed and stored.

For another example, suppose the test carrier is cross modulated such that the carrier amplitude varies 1% peak to peak. Both the Time Domain and Frequency Domain methods would report a cross modulation level of -40 dBc. The closest-in sidebands would then be 49.9 dB below the carrier.

As a final example, suppose that instead of being amplitude modulated the test carrier is phase modulated to an extent that produces closest-in sidebands 65 dB down from the carrier. The Frequency Domain method would report a cross modulation level of -55.1 dBc, but the Time Domain method would detect no cross modulation and would display $\text{CROSS MOD} < -48$ DBC, indicating that the cross modulation level was below its measurement limit.

If the cross modulation is the result of amplitude and phase effects, the sidebands will be unequal in amplitude. The Frequency Domain method reports the higher of the two sideband amplitudes to ensure the most conservative result with respect to compliance with legal limits on coherent disturbances.

Enable CROSS MODULATION Measurement

The following procedure shows how to take a cross modulation measurement:

1. Press [**CATV/APPL**] to call up the CATV MEASUREMENTS menu. See Figure 5-1.
2. Press [**7**] to display the CROSS MODULATION measurement menu shown below.
 - 0 **RUN CROSS MODULATION**
 - 1 **STORE CURRENT RESULTS**
 - 2 **DISPLAY RESULTS**
 - 3 **PRINT CURRENT RESULTS (RS-232 Only)**
 - 4 **PRINT STORED RESULTS (RS-232 Only)**
 - 5 **METHOD (FREQUENCY DOMAIN or TIME DOMAIN (NCTA))**
 - 9 **LEAVE CROSS MODULATION**
3. Press [**5**] to select the method for measuring the cross modulation. (Refer to *CROSS MODULATION Measurement* on page 5-60 for information about the measurement methods.)

4. Press [0] to run the Cross Modulation measurement.

The instrument prompts you to turn off the modulation.

5. Turn off the modulation and press [W] to continue (or [Z] to abort) the measurement.

The instrument measures the Cross Modulation and displays the result.

6. Press [CATV/APPL] to display the CROSS MODULATION menu.

7. Press [1] to store the results of the last measurement.

The message RESULTS STORAGE COMPLETE is displayed.

8. Press [2] to display results of the last measurement performed.

You can either view other previously stored results for this measurement by pressing [W], or stop viewing the results by pressing [Z].

9. Press [3] to print the results of the last measurement performed. A printer must be connected to the 2715.

NOTE. You can print measurement results only when the RS-232 interface is installed in the 2715. The GPIB interface does not support the print function.

Be sure to select handshaking ([UTIL] [4] [0] [2] [5]) to match that expected by the printer or long jobs may not print completely.

10. Press [4] to print the last stored results of the measurement. A printer must be connected to the 2715.

11. Press [9] to leave the Cross Modulation measurement and return to the CATV MEASUREMENTS menu.

In-Channel Response Measurement

You can measure the in-channel response interactively or automatically. There are two types of automatic mode. If the in-service basis is not selected, Auto (Pause for Signal On) mode is used. If in-service basis is selected, Auto mode is used.

With in-service basis selected, the measurement is made using a specific test signal (multiburst, line sweep, or ghost-cancelling) embedded in the vertical retrace interval. The measurement basis is selected from the main IN-CHANNEL RESPONSE menu, item [7]. You also need to specify the TV line number containing the desired test signal by selecting choice [6] in that menu.

The test signal line number is the number of the field line on which the test signal is inserted for in-service testing. For television systems using the National Television System Committee (NTSC) standard, this typically is on line 10 through line 20 of field 1 and line 9 through line 19 of field 2. However, the 2715 counts field lines consecutively from 1 to 525. Therefore, the range of potentially valid line numbers for the test signal will be 10 through 20 (for odd-numbered fields) or 272 through 282 (for even-numbered fields). For systems using the Phase Alternation Line (PAL) standard, the test signal line number is typically line 6 through line 20 and line 318 through line 332.

NOTE. *If the only quiet lines available are beyond the ranges listed above, then you must specify the quiet line in the channel table, using the Cable TV RF Measurements Software for Windows provided with your instrument. In this case, the in-service test is run on the specified line, even though it is outside the normal range, but there is no verification that the line is still quiet after the test.*

Select the measurement mode from the IN-CHAN RESP SETUP menu before initiating the test. The Interactive mode assists you in selecting a pair of measurement points. The Automatic mode allows measurement levels at up to five locations that are entered using the IN-CHAN RESP SETUP menu. If you did not choose the in-service basis, you will be prompted to replace the modulated signal with a test signal for either interactive or automatic modes.

NOTE. *When doing the In-Channel Response test in-service and if the channel under test has a carrier level of -2 dBmV or less, it is necessary to turn on the preamp and select an RF attenuation setting such that a 1st mixer input level of -2 dBmV or greater is maintained.*

When the measurement is initiated, the instrument does the following:

- Enables peak acquisition mode
- Sets the reference level so that the peaks of the detected test signal are placed in the top major division while the instrument is in the 10 dB/div mode
- Sets the vertical mode to 1 dB/div
- If measuring on in-service basis, enables gating on the specified TV line and performs a slow sweep
- In interactive mode, the instrument prompts you to move the marker to the first location (for example, the lowest detected burst packet in a Multiburst signal) and press **[W]** to make the first measurement. Then the instrument prompts you to move the marker to the second location (for example, the highest detected burst packet) and press **[W]** to make the second measurement. The instrument then calculates the difference between the two

measurements, divides the difference by two, and presents the quotient as the measurement result.

The previous example used a Multiburst test signal. If the test signal is Line Sweep, the procedure is the same, with the marker positioned on the highest point in the detected sweep and then on the lowest point (or vice versa).

Interactive Mode

For this mode, the IN-CHANNEL RESPONSE is measured at two locations that are chosen by placing a marker at the lowest point in the channel response and taking a measurement, then moving the marker to the highest point in the response and taking another measurement. The 2715 then divides the difference between these measurements by two and presents the quotient as the measurement result.

Automatic Mode

For this mode the IN-CHANNEL RESPONSE is usually measured at six frequencies (which commonly correspond to burst frequencies of a test generator). The default test locations are -0.5 MHz, $+0.5$ MHz, $+1$ MHz, $+2$ MHz, $+3$ MHz, and $+3.75$ MHz, all relative to the visual carrier.

NOTE. *Statutory proof-of-performance tests may require test frequencies other than the default values.*

Frequencies entered into the 2715's IN-CHANNEL RESP SETUP menu (items 2 through 7) must match the frequencies actually produced by your test generator. If a sweep generator is used, you may enter any frequency that is within the generator's range. However, do not enter frequencies that are closer than 500 kHz to the visual carrier.

When using a multiburst generator, you must enter the frequencies that it actually produces. If you are not sure which frequencies your generator produces, consult your generator manual, or use the 2715 to measure them. Do not use the 2715 count function to measure the multiburst frequencies. It may not produce accurate results on burst and pulsed signals.

NOTE. *The "Out Of Range" message may appear after running an In-Channel Response measurement. This message indicates one of these conditions.*

- *IN-CHANNEL RESP SETUP menu test locations do not match generator output*
 - *Flatness response of modulator or other cable TV system components is not within ± 3.5 dB*
-

To achieve the best amplitude measurement accuracy, your test generator must produce a signal whose spectral density is the same at each test frequency. Ideally, all signals should have equal amplitude and burst duration (for multi-burst signals) or uniform sweep rate (for swept signals).

Many generators do not meet standards for flat spectral density. Further, test signals carried on program video may not be flat. Therefore, if in-channel response measurements yield excessive response deviations, check the flatness of the test signal being used (if possible). This might be done either at RF or at baseband (depending on circumstances) at the head end of the cable system. If such a check reveals a problem, it is reasonable to use the head end data to compensate the field data for the in-channels errors measured at the head end.

Running the Interactive Measurement

The following procedure shows how to make an interactive in-channel response measurement.

1. Press CATV/APPL to call up the CATV MEASUREMENTS menu. See Figure 5-1.
2. Press [9] [7] to select the IN-CHANNEL RESPONSE measurement menu.

This gives you the following options:

- 0 RUN IN-CHAN RESP
- 1 STORE CURRENT RESULTS
- 2 DISPLAY RESULTS
- 3 PRINT CURRENT RESULTS (*RS-232 Only*)
- 4 PRINT STORED RESULTS (*RS-232 Only*)
- 5 IN-CHAN RESP SETUP
- 6 TEST SIGNAL LINE NUMBER
- 7 IN-SERVICE
- 9 LEAVE IN-CHAN RESP

NOTE. If you attempt the in-channel response measurement based on VITS or ghost-cancelling signals carried on the program video, strong, periodic signals in the video waveform may corrupt the measurement. Choose the in-service basis with menu item [7] to resolve this problem.

If you are not measuring in-service, it is recommended that you have a test signal generator warmed up and connected to the on-line switcher.

3. Press [5] [0] to select the Interactive mode.
4. Press [BKSP] [0] to run the measurement.

If you are not running the test in-service, the instrument pauses and prompts you to enable a full-field test signal (Multiburst or Line Sweep).

5. If not running this test as in-service, replace the modulating video source with a full-field multiburst signal or a full-field line sweep signal and press **[W]** to continue with the measurement.

The instrument measures the visual carrier peak, then prompts you to move the marker to the first test location.

6. Use the **FREQ/MKRS** knob to move the marker to the first test location.
7. Press **[W]** to continue with the measurement.

The instrument measures the amplitude of the test signal at the marker location, then prompts you to move the marker to the second test location.

8. Press **[W]** to continue with the measurement.
9. Press **[CATV/APPL]** to display the **IN-CHANNEL RESPONSE** menu.
10. Press **[1]** to store the results of the last measurement.

After a short period of time, the message **RESULTS STORAGE COMPLETE** is displayed.

11. Press **[2]** to display the results of the last measurement performed.

A display resembling Figure 5–8 on page 5–54 comes up. At this point you can choose to either go ahead and view other previously stored results by pressing **[W]** or stop viewing the results by pressing **[Z]**.

NOTE. You can print measurement results only when the RS-232 interface is installed in the 2715. The GPIB interface does not support the print function.

Be sure to select handshaking (**[UTIL] [4] [0] [2] [5]**) to match that expected by the printer.

12. Press **[3]** to print the results of the last measurement performed. A printer must be connected to the 2715.
13. Press **[4]** to print all the results of the measurement. Again a printer must be connected to the 2715.
14. Press **[9]** to exit this measurement.

Running The Automatic Measurement

When taking an In-Channel Response measurement in Auto mode, you have a choice between using the in-service basis or the normal basis; use menu item [7] to choose the basis. If you choose in-service, you must also use item [6] to specify the TV line number containing the desired test signal.

1. Press [5][1] to select Auto mode.

Auto Test Locations (items 2 through 8) are added to the menu. These locations are points relative to the visual carrier where measurements are to be made.

2. Press [2] and enter the first measurement location.
3. Press [3] and enter the second measurement location.
4. Press [4] and enter the third measurement location.
5. Press [5] and enter the fourth measurement location.
6. Press [6] and enter the fifth measurement location.
7. Press [7] and enter the sixth measurement location.
8. Press [BKSP] [0] to run the measurement.

If measuring in-service, the instrument measures the visual carrier peak for a reference, then enables gating on the specified TV line and measures the test signal amplitudes at the specified frequencies.

If measuring on the normal basis, the instrument pauses and prompts you to switch to the appropriate full-field test signal before continuing. It then measures the visual carrier peak and the test signal amplitudes.

9. Press [CATV/APPL] to display the IN-CHANNEL RESPONSE menu.
10. Press [1] to store the results of the last measurement.

After a short period of time, the message RESULTS STORAGE COMPLETE is displayed.

11. Press [2] to display the results of the last measurement performed.

A display resembling Figure 5-8 on page 5-54 appears. You can view other previously stored results by pressing [W] or stop viewing the results by pressing [Z].

NOTE. You can print measurement results only when the RS-232 interface is installed in the 2715. The GPIB interface does not support the print function.

Be sure to select handshaking ([UTIL] [4] [0] [2] [5]) to match that expected by the printer.

12. Press [3] to print results of the last measurement performed. A printer must be connected to the 2715.
13. Press [4] to print all stored results of the measurement; a printer must be connected to the 2715.

Auxiliary Operations

The following auxiliary operations involve viewing a display. Each selection toggles the desired display on and off.

Press [9] repeatedly until page 2 of the CATV MEASUREMENTS menu [CATV MEASUREMENTS (PG 2)] is displayed. Note the following items in the menu:

- 1 **VIEW MODULATION (FIELD)**
- 2 **VIEW MODULATION (LINE)**
- 3 **VIEW PICTURE**
- 4 **LISTEN**

These features are selected by pressing the number that applies to each, and deselected by pressing the same number or pressing a number that applies to another feature.

View Modulation (Field)

This operation allows you to view a full field of baseband modulation in the analog mode.

This operation is not available for FM, DATA, and PILOT signals.

If this current channel has scrambling on (as specified in the channel table), you are prompted to turn off scrambling before proceeding. The needed trigger modes will not work with scrambling.

When the operation is invoked, the 2715 tunes to the visual carrier and enables the 1 MHz resolution bandwidth filter and zero span.

The 2715 then finds and centers the peak of the visual carrier and places it at the reference level. The display storage and readouts are turned off, and short holdoff is selected for an analog display.

The 2715 sets the sweep time to 2 ms/div and the trigger mode to TV Field trigger.

To view field modulation, press [1]. The center frequency is set to the visual carrier frequency of the selected channel, zero span is enabled, the sweep rate is set to 2 ms/division, the resolution bandwidth is set to 1 MHz, and the readouts are turned off.

You should see at least one field of the video signal.

Line Modulation

This operation allows you to view one line of demodulated video for the current channel in the analog mode.

The setup is the same as for field modulation except that the 2715 sets the sweep time to 10 μ s/div and the trigger mode to TV Line trigger.

The line to trigger on is set to the VITS line specified in the channel table. If no VITS line is specified, then line 17 is selected.

The **FREQ/MKRS** knob is assigned to video line. This lets you select the line to trigger on. Thus you can display any line in the field for viewing by using the knob.

To view line modulation, press [**CATV/APPL**] [2]. The center frequency is set to the visual carrier frequency of the selected channel, zero span is enabled, the sweep rate is set to 10 μ s/division, the resolution bandwidth is set to 5 MHz, and the readouts are turned off.

If a VITS line is specified in the channel table, you should see that VITS line. If a VITS line is not specified, then you should see line 17 of the video signal. If you wish to change the displayed line, press [**READOUT**] and turn the **FREQ/MKRS** knob to select the desired line; then turn off the readouts.

View Picture

View Picture provides demodulation of the video carrier on the current channel.

The instrument sets up for the video demodulation mode on the current channel with the following settings:

Frequency	1.5 MHz above Visual Carrier
Reference Level	Set for viewable picture
Span/Div	Zero Span
Sweep Time	5 μ s/Div
Resolution Bandwidth	5 MHz

Both NTSC and PAL video channels are supported. The instrument stays in this mode until the mode is deselected, the channel is changed, or another test is run.

Item 3 in the DEMOD menu (BROADCAST <AM> VIDEO) is displayed as ON any time VIEW PICTURE is enabled.

To view the video picture, press **[CATV/APPL] [3]**. Video monitor mode is automatically enabled. Turn the outer LEVEL knob to obtain a full-size and locked picture. Also, you can change the reference level to obtain the best contrast.

To disable the VIEW PICTURE mode, press **[CATV/APPL] [3]** again or **[DEMODO] [3]**.

Listen This operation turns on either the FM or the AM demodulator, according to the type of modulation on the channel. If the channel type is FM, FM modulation is always used. If the channel type is TV, the modulation type depends on the video polarity as described in *Channel Tables* on page 5–6.

To listen to channel audio, press **[CATV/APPL] [4]**. Use the outer LEVEL knob to set the audio level.

When the carrier has FM modulation, the display shows the instantaneous FM deviation:

Top-Screen	=	0 kHz
Deflection Factor	=	10 kHz/division

The other bright trace (waveform C) accumulates the peak deviation in MIN HOLD mode.

When the carrier has AM modulation, the display shows the demodulated audio.

You can disable the LISTEN mode by pressing **[CATV/APPL] [4]** again or **[DEMODO] [0]**. However, if you use the **[DEMODO] [0]** selection to disable LISTEN mode, the active channel will not be recentered on the screen — you merely turn off demodulation.



Spectrum Analyzer Menus

Spectrum Analyzer Menus

This section describes the menu-selected, firmware-driven features of the 2715. The menus provide a high degree of sophistication without a complicated control panel.

Press any key in the front-panel MENU function block to cause a menu to be displayed on the screen. The menus enable you to perform a variety of tasks (as listed below), some of which are not convenient using the front-panel dedicated controls.

- Displaying and centering TV channel signals
- Automating measurements
- Controlling 2715 operational modes
- Changing control increments and settings
- Storing and recalling control settings
- Normalizing the 2715
- Executing diagnostic routines

Each menu is a list of numbered items. Choosing an item often results in a submenu being displayed. Some infrequently-used items from the sub-menu may call up a secondary sub-menu. A few items from the menus are neither listed nor explained in the following discussions: these represent factory troubleshooting and calibration aids not intended for general operator use. Some items discussed may not appear in your instrument because of the installed options.

An overview of the menus is included in *Operating Basics*. The overview should provide all the information you need to use the menus, once you become familiar with the menu features.

Using the Menus

From the spectral display mode, first press the appropriate menu key in the MENUS function block, then press the number key on the keypad corresponding to the desired selection. If you are in a menu, a menu key just takes you back to the spectral display mode.

A feature status indicator on the right side of the menu item shows the present value or condition of that parameter or feature. See Figure 6–1 as an example. The status indicator is updated as you make selections or alter parameters.

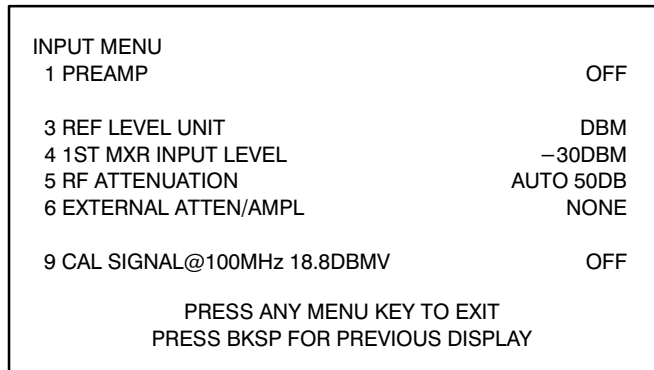


Figure 6-1: The INPUT Menu

Depending on the parameter or feature, there are three ways the status may be changed; each uses the numeric keypad:

- When only two or three values or conditions are permitted, pressing the keypad key corresponding to the item number cycles through the acceptable values. At each step, the new status appears at the end of the line.
- If the 2715 accepts a smaller range of values, it presents a secondary menu consisting of a list of the values that may be selected by pressing their corresponding keypad keys.
- If a parameter can have a wide range of numerical values, two things happen. First, the selected item number is preceded by an asterisk (to ensure there is no confusion about which item was selected). Then you are prompted to enter the new value. This is illustrated in Figure 6-2 where item 6 from the SWP/TRIG menu has been selected.

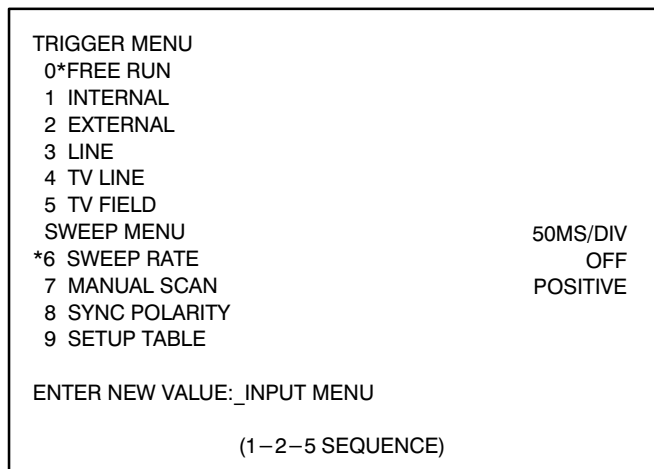


Figure 6-2: Sweep/Trigger Menu with SWEEP RATE Selection Chosen

To enter a setting or parameter value, press the sequence of number keys representing the numerical value, and then press the appropriate terminator key. The numbers appear on screen as you type them, but they are not entered until you press the terminator key.

If you make a mistake, you can correct it any time prior to pressing a terminator by repeatedly pressing [BKSP] (the backspace key) until the incorrect number disappears and then typing the correct value.

The terminator keys ([W], [X], [Y], and [Z]) determine the units and enter the data. Each key can represent several units, but they are context-sensitive, and the 2715 will determine the intended unit based on the parameter or setting you are attempting to modify. For instance, [X] can represent MHz, ms, or mV, and if you are attempting to enter a sweep rate, the 2715 will correctly interpret the units as msec when you press [X].

To enter a value of 20 milliseconds, press [2] [0] [X].

Whereas, to enter 20 microseconds, press [2] [0] [Y].

Entering a value for the sweep rate also removes the sweep rate parameter from automatic selection. To return to automatic selection, you press [AUTO] in the SWEEP function block on the front panel.

There are three ways to exit from a menu:

- Many selections cause the 2715 to revert automatically to the measurement mode it was in before calling up the menu. In some cases a small delay is provided between making the selection and reverting to the spectral display to enable you to see the status indicator at the end of the menu line change. However, the change is also reflected in the on-screen readouts in many cases, or by the nature of the spectral display itself.

The following prompt is displayed at the bottom of all menus prior to making a selection:

**PRESS ANY MENU KEY TO EXIT
PRESS BKSP FOR PREVIOUS DISPLAY**

- Simply pressing a menu key returns instantly to the spectral display. You can use this technique if you decide not to make a selection.
- Pressing the backspace key, [BKSP], returns to the previous menu. If there is no previous menu, you return to the spectral display. The backspace key can, therefore, be used to return to a previous menu to alter a selection, or to back entirely out of a menu and return to the spectral display.

In general, menus are not reproduced here. It is intended that you call up menus on the 2715 and follow along with the examples in this section as they are described. For a handy reference, consult *Operating Basics*.

To view the attenuation and video filter screen readouts, turn the markers off during these menu descriptions (menus are turned on by default).

Input

100.0MHz	(AUTO SWEEP)	ATTN 12DB
28.8DBMV		VF WIDE
600MHz/		10 DB/
300KHz RBW (AUTO)		

The Input menu (see Figure 6–1) controls parameters that alter signal sensitivity, change measurement amplitude units, and turn the calibration signal on and off.

Turning the Calibrator On and Off

The following procedure shows how to turn the calibrator on and off.

1. Press **[INPUT]** to call up the Input menu.

The word OFF following item 9 of the INPUT menu indicates the calibrator signal is turned off.

2. Press **[9]** to turn on the calibrator signal.

The spectral display appears and the word CALIBRATOR is now displayed at the lower right of the screen, indicating the calibrator signal is on. The calibrator signal is the peak at center screen. Turning on the calibrator also internally disconnects the RF input path from the RF Attenuator and prevents viewing external signals.

3. Press **[INPUT]** again.

The word following item 9 now is ON. In this way, the menu enables you to toggle between the two possible settings and displays the current setting.

4. Press **[9]** again to turn the calibrator off.

You get the spectral display back but without the word CALIBRATOR displayed.

5. Press **[INPUT] [9]** once again to turn the calibrator back on.

Setting RF Attenuation

The following steps show how to set the RF attenuation.

6. Press **[REF LEVEL] [4] [8] [•] [8] [Y]** to set the reference level to 48.8 dBmV.

7. Press [**▼**] to the right of [REF LEVEL] twice.

Notice that the signal peak rises but the noise floor does not. This is because the RF attenuation decreased each time you pressed the key. The increased signal height is achieved by reducing attenuation. However, the noise floor is generated after the RF attenuator, so it is not affected.

8. Reset the reference level to 48.8 dBmV and select the INPUT menu.

Item 5 indicates that the RF attenuation is 30 dB and that it is selected automatically by the 2715. We can control the RF attenuation so that it remains at a fixed value.

9. Press [5], and this prompt appears:

ENTER NEW VALUE OR "W": __
(0 TO 50 IN 2 DB STEPS)
W = AUTO

10. Press [3] [0] [Y] to enter a fixed value of 30 dB.

The display returns unchanged.

11. Press [**▼**] twice.

Now the signal peak and the noise floor both rise. This is because pressing [**▼**] twice increased the 2715 IF gain by 20 dB to lower the reference level, but the RF attenuation is unchanged.

12. Press [INPUT] [5] [W] to place the RF attenuation back in the automatic mode.

Changing Reference Level Units

The following steps show how to change reference level units:

13. Press **CATV/APPL** to select the APPL menu.

14. Press [8] to select CATV MEASUREMENTS SETUP.

15. Press [6] to select REF LEVEL UNIT.

Item 6 toggles between DBUV and DBMV, as indicated on the right side of the screen.

There is an alternate method to change reference level units from the INPUT menu.

16. Press [INPUT] to select the Input menu.

17. Press **[3]** to select REF LEVEL UNIT.

Six selections are shown. Item 1, DBMV, and item 3, DBUV, are the only available selections; all others are selectable only in the nonCATV mode. If items 0, 2, 4, or 5 are selected, error message FUNC NOT AVAILABLE IN CURRENT MODE will appear; these items are available only after exiting from the CATV mode, which is described below.

18. Press **[CATV/APPL] [8] [0]** to disable the CATV mode.

19. Press **[INPUT]** to call up the Input menu.

20. Ensure the reference level is set to 18.8 dBmV, and then press **[3]**.

A list of six possible units appears. Select item 2, dBV. The spectral display is restored, but the reference level now reads -41.2 dBV because 1 mV is 60 dB below a 1 V reference. Only the units change, not the 2715 gain, attenuation, or input impedance. Therefore, the displayed spectrum is unchanged.

21. Change the units back to dBm and turn off the calibrator.

Each of the six units except the DBUV/M (dB relative to a $\mu\text{V}/\text{m}$) represents a simple change of scale. Be aware that the 2715 always measures the voltage at its input across its $75\ \Omega$ input impedance, and then scales the result according to the selected units. Because the DBUV/M is not just a simple unit conversion, it is discussed separately in *Using the DBUV/M* on page 6–10.

Accommodating External Amplification/Attenuation

When you want to measure a high amplitude signal, it is possible that you will have to attenuate the signal before inputting it to the 2715. (Remember, the maximum total signal power at the input to the 2715 should not exceed +70 dBmV, or 100 mW.) On the other hand, if you have a very weak signal, you may need to amplify it.

22. Press **[CATV/APPL]** to enable the CATV mode.

23. Ensure the calibrator is turned off.

24. Press **[INPUT]** to call up the Input menu.

Item 6 indicates that there is presently no external attenuation or amplification.

25. Press **[6]** to call up the external attenuation and amplification selections.

26. Press **[1]** to allow you to input an attenuation value.

Suppose you have attenuated an RF transmitter output 40 dB prior to measuring it.

27. Following the on-screen prompts, press **[4] [0] [Z]**.

This procedure enters an external attenuation value of 40 dB. The spectral display does not change, but the reference level now indicates 58 dBmV and is followed by the term OFST. This indicates that the reference level has been offset, in this case by 40 dB. Any reference level now entered is offset automatically by the external attenuation or gain.

28. Press [INPUT] [6].

Item 0 indicates that the offset is turned on.

29. Press [0] to turn off the offset.

The spectral display will reappear, but OFST is gone.

30. Press [INPUT] [6] [0] to toggle the offset back on without reentering the external attenuation value.

31. Turn off the offset.

32. Enter a value of 0 dB for external attenuation.

Accommodating a 50 Ω Source

The 2715 has a 75 Ω input impedance and expects a 75 Ω signal source impedance. However, a 50 Ω source impedance is typically associated with some applications that use dBm as a standard amplitude measurement unit. The 2715 provides two ways to make 50 Ω measurements:

- When making narrowband measurements (for example, carrier-to-noise ratios, relative amplitudes of signals close together in frequency, interference levels relative to a nearby signal), you can generally connect the 2715 directly to a 50 Ω source. If a 50 Ω source is connected to the input of a 50 Ω instrument, the voltage will be 1.6 dB lower than it is with the same source connected to the 75 Ω input of the 2715. We can also calculate that 0 dBmV dissipated in 75 Ω is equal to -48.8 dBm across 50 Ω . The total difference is, therefore, -50.4 dB.

For these cases, use item 6 of the INPUT menu (EXTERNAL ATTEN/AMPL) to enter a 1.6 dB offset to the reference level. See *Accommodating External Amplification/Attenuation* on page 6-6.

- When making broadband measurements or measurements of absolute amplitude (for example, antenna, system, or amplifier sweeps; absolute carrier amplitude; comparison of signals widely separated in frequency), you may want to present a matched load to the source to provide maximum flatness and to minimize standing wave ratios. You can do so by inserting the matching minimum loss pad shown in Figure 6-3 between the source and the 2715. To obtain correct dBm readings, set the INPUT menu measurement parameters as follows:

Item 3:	REF LEVEL UNIT	DBM
Item 6:	EXTERNAL ATTEN/AMPL	-4

In this case, you select the dBm unit via **[INPUT] [3] [0]** and the 50 Ω source because the 2715 is matched to the 75 Ω side of the minimum loss pad and the signal really is being terminated in a 50 Ω impedance. Further, it is the attenuation of the pad that is entered under item 6 and not its insertion loss. The 7.5 dB accounts for both the insertion loss and the fact that the signal at the input to the minimum loss pad is 1.9 dB less than it would be if the 50 Ω source were connected directly to the 2715.

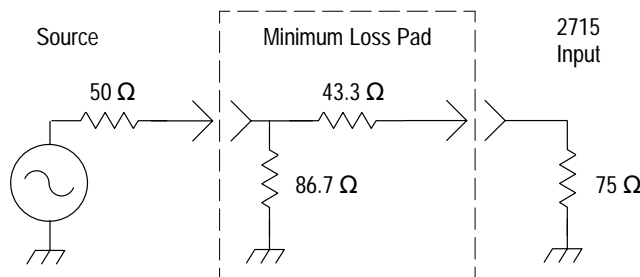


Figure 6–3: 75/50 Ω Matching Minimum Loss Pad

If in doubt whether the pad is needed, compare a measurement with the pad to the same measurement without the pad. If there is no significant difference, omit the pad. In some cases, such as carrier-to-noise measurements, the use of a pad may drop your system noise level below the 2715 noise floor. In such cases, the pad cannot be used. Removing the pad typically does not distort carrier-to-noise measurements.

When a 50 Ω source is frequently used, you can store the settings above in one of the **STORED SETTINGS** registers (see the **UTIL** menu discussion on page 6–60); then you merely have to recall the settings each time a 50 Ω source is used with the 2715.

Setting the First Mixer Input Level

Overdriving the 2715's first mixer circuit can generate spurious signals and cause inaccurate measurements. As the signal amplitude increases past the maximum linear range of the circuit, its output amplitude becomes less than it should be. This creates lower-than-actual amplitude measurements. On the other hand, if the signal amplitude at the mixer is too low, signals may become lost in the 2715's internal noise. An optimum compromise is achieved within the 2715 by making the top graticule line represent a –30 dBm level at the input to the first mixer.

However, in cases where total signal energy is large, it may be beneficial to restrict the input to the mixer to a smaller value. By resetting the first mixer input level to, say, –40 dBm, you increase the RF attenuation by 10 dB while simultaneously increasing the IF gain 10 dB. This provides additional protection to the first mixer. In other cases, you may want to examine a low-level signal adjacent to a high-level signal. A –20 dBm level at the first mixer input allows

you to get an additional 10 dB of sensitivity by reducing the RF attenuation 10 dB and decreasing the IF gain 10 dB to compensate. The danger is that internally generated distortion products may become more noticeable.

To change the signal level at the mixer, press **[INPUT]** [4].

You are prompted to enter a new mixer input level. You can enter values from -50 dBm to -20 dBm in 2 dB steps. Try -20 dBm and -40 dBm while observing the level of the noise. Because the RF attenuation is increased by the same amount the first mixer input is decreased, and the noise floor rises as the mixer level is reduced. When you are done experimenting, set the mixer input level back to -30 dBm.

Turning the Preamplifier ON/OFF

100.0MHz	(AUTO SWEEP)	ATTN 0DB
0.0DBMV		VF 300KHz
5MHz/		10 DB/
300KHz RBW (AUTO)		

The 2715 is equipped with an internal preamplifier. The preamplifier can be very useful when measuring cable TV noise (see *Measuring Carrier-to-Noise Ratios* on page 6–46) or other signals near or below the normal 2715 noise floor. It is also useful for increasing the sensitivity of radiated RF energy measurements (leakage, etc.). The nominal gain in sensitivity using the preamplifier is 12 dB. Above 600 MHz the preamplifier remains usable and useful, but its flatness rolls off somewhat and is not specified. To be effective, the preamplifier must be used with no RF attenuation. The preamplifier is not normally turned on, because it can easily result in overdriving the first mixer. The signal amplitude at the first mixer with the preamplifier on and no RF attenuation is equal to the input signal level plus approximately 18 dB (that is, a 10 dBmV signal would probably overdrive the first mixer). Total signal amplitude greater than 0 dBmV at the input to the 2715 with the preamplifier turned on may create spurious signal components and produce unreliable amplitude measurements.

Note the level of the noise floor and then press **[INPUT]** [1].

Item 1 of the INPUT menu toggles the preamplifier on and off. The preamplifier is now turned on as indicated by the term PRE following the reference level readout.

Again note the noise floor. It should be approximately 12 dB lower than before. The 2715 has automatically reduced its internal gain (thus lowering the normal noise floor) to compensate for the added gain of the preamplifier. The result is that you can now see signals that are up to 12 dB below the normal 2715 noise floor. Toggle the preamplifier off.

Using the DBUVM

The decibel relative to a microvolt per meter (dB μ V/m) is an electric field strength unit that characterizes the intensity of radiated RF energy. Typically, the radiated signal amplitude is measured at the terminals of a calibrated antenna to determine the field strength.

With most spectrum analyzers, you then correct the measured signal amplitude for any external gain or attenuation, convert signal amplitude to radiated intensity using the antenna factor (often referred to as the K-factor) for your antenna, and scale the field strength for the difference between the measurement distance and the required reference distance.

However, the 2715 performs the correction, conversion and scaling for you. Input the external gain or attenuation, antenna factor, and measurement distance using the INPUT menu. Then, select the dB μ V/m reference unit and the 2715 does the rest. The signal intensity is read out on screen using the marker and corrected for distance, in either dB μ V/m or V/m. Using the DISPLAY menu, you can have the 2715 sound an alert if the measured signal exceeds a threshold that you set. This feature facilitates go/no-go or present/absent tests.

Figure 6–4 shows how to set up your equipment. A balun can be included as part of your antenna. The filter and external matching network are optional. The filter is intended primarily to prevent off-the-air signals, such as radio and television, from swamping the 2715. The matching network may be necessary for maximum accuracy. If in doubt, try the measurement with and without the network. If there is no difference, omit the network for maximum sensitivity.

The following formula relates the radiated field strength in dB relative to a microvolt per meter (dB μ V/m) to the measured signal amplitude in dB relative to a millivolt (dBmV), and scales the result measured at a distance d_{meas} to a reference distance, d_{ref} . (The reference distance is often specified by the regulatory agencies.)

$$P_{\text{dB}\mu\text{V}/\text{m}} = P_{\text{dBmV}} + 13 + 20 \log \left[\frac{d_{\text{meas}}}{d_{\text{ref}}} \right] - A + K$$

d_{meas} = distance from radiation source at which the measurement is carried out

d_{ref} = reference distance at which the intensity is desired

A = attenuation or gain between antenna and 2715. If the filter is used, its gain or attenuation should be included in this number. If balun losses are not included in the antenna factor, they should be included here. Cable loss, if significant, can also be included here.

K = antenna factor; supplied by manufacturer or calculated as follows:

$$K = 20 \log f - G - 10 \log (19 \times R_{\text{ant}})$$

G = antenna gain as a function of frequency

f = frequency of signal in MHz

R_{ant} = output resistance of the antenna or the balun, if the balun is treated as part of the antenna

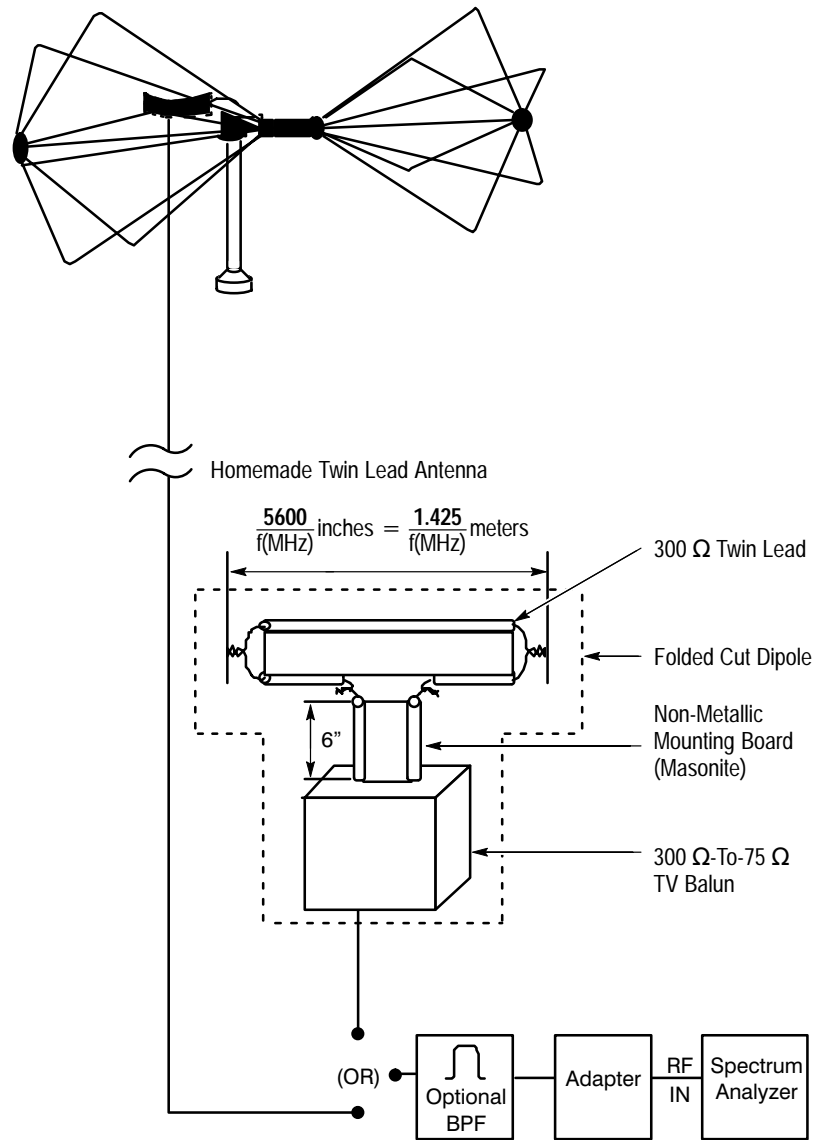


Figure 6-4: Equipment Setup for Field Strength Measurements

With the 2715, you enter the attenuation using the EXTERNAL ATTEN/AMPL feature from the INPUT menu and the antenna factor, measurement distance, and reference distance using the DBUV/M SETUP under the REFERENCE LEVEL UNITS of the INPUT menu. Note that many commercial antenna suppliers include the balun losses in the antenna factor. For the most accurate results, use an antenna calibrated at the specified reference distance and perform the measurement at that distance. If possible, measure the return loss of the antenna to make certain it is properly tuned to the desired frequency. See Tektronix application note 26W-7037-1, *Spectrum Analyzer Fundamentals*, concerning return loss measurements.

To use the dB μ V/m, follow this procedure:

1. Press [**INPUT**] to call up the INPUT menu.
2. Press [**3**] to select REF LEVEL UNIT from the INPUT menu.
3. Press [**9**] to select DBUV/M SETUP from the REFERENCE LEVEL UNIT submenu.
4. Press [**6**] to select MEASUREMENT DISTANCE from the DBUV/M SETUP.
5. Enter the distance at which the measurement will actually be carried out (default distance is 3.0 m).

You can enter distances in feet, meters, kilometers, or miles, but the 2715 converts them to meters or kilometers before displaying them.

6. Repeatedly press [**7**], SAVE RESULTS IN WFMx, until the indicated register (A, B, C) is the one in which you want the resulting measurement to appear.

The waveforms are repeatedly saved, deleted, saved, and so on until you terminate the dB μ V/m mode. At that point, the last sweep is retained in the selected register.

Item 9, MARKER DISPLAY, controls whether the on-screen marker amplitude reads out in decibels relative to a microvolt per meter (DBUV/M) or directly in volts per meter (V/m). The reference unit does not change; only the marker amplitude readout changes.

7. Toggle item 9 to select the units you prefer.

Table 6–1 lists equivalent voltage and decibel values in 4 dB steps. Interpolate between values if closer results are required.

Table 6–1: Equivalent Decibel — Voltage Values

dB μ V/M	0	4	8	12	16	
0	1	1.58	2.51	3.98	6.31	microvolt per meter
20	10	15.8	25.1	39.8	63.1	
40	100	158	251	398	631	
60	1	1.58	2.51	3.98	6.31	millivolt per meter
80	10	15.8	25.1	39.8	63.1	
100	0.1	0.158	0.251	0.398	0.631	volt per meter
120	1	1.58	2.51	3.98	6.31	

8. Select the antenna number (1 through 5) that matches the antenna you are using.
9. Press [**◆**] to return to REFERENCE LEVEL UNITS.
10. Press [**5**] to select DBUV/M IN WFM *x*.
11. Press [**INPUT**] [**6**] and enter any external gain or attenuation (skip this step if none is present).

This number should include the gain or attenuation of any external amplifier or filter, and the losses of any balun that are not included in the manufacturers K factor table for your antenna.

12. Connect your antenna and proceed with your measurement. To obtain a measure of the maximum signal strength, save the measurement in the A or B register and select MAX HOLD. Rotate the antenna until the maximum reading is obtained.
13. Turn on the marker and use it to read out the field strength directly in dB μ V/m or V/m.

While using the dB μ V/m unit, you cannot unsave the destination register or use the LIN, FM DEMODULATOR, or EXTERNAL SOURCE features (you also cannot select the dB μ V/m unit while using these features). Attempting to do so will result in an error message.

If you turn off the destination register while using dB μ V/m, the message DBUV/M MEASUREMENT MODE IDLE is displayed.

The dB μ V/m measurement is not made while idling, and you still cannot unsave the destination register or use the LIN, FM DEMODULATOR, or EXTERNAL SOURCE features.

To disable the dB μ V/m measurement mode, select any other reference unit.

If you are using an antenna for the first time, you need to create an antenna table. From time to time you may also need to alter an existing table. Whether creating new antenna tables or changing old tables, all editing takes place in the local buffer or editing buffer using the EDIT ANTENNA TABLE selection from the DBUV/M SETUP on the Input menu. New antenna data is written directly to the buffer prior to permanent storage; old data is loaded into the buffer prior to editing and restorage. If you wish to enter new antenna data or change old data, use the following procedure:

1. Press [**INPUT**] to call up the Input menu.
2. Press [**9**] to select DBUV/M SETUP from the INPUT menu.
3. Press [**0**] to select item EDIT ANTENNA TABLE.

4. To create a new antenna entry, press [**6**] ANTENNA SETUP. Enter the start, stop, and frequency steps at which measurements will be made. Enter the reference distance.

The reference distance is the distance to which you want the field strength referred. For maximum accuracy your antenna should be calibrated at the reference distance and your measurement made at that distance. However, if you require another distance, enter it here. For instance, if you are making measurements at 10 meters, but want the field strength at 3 meters, then enter 3 meters.

5. Press [**◆**] to return to EDIT ANTENNA TABLE.

Item 0 will continue to indicate EMPTY at the end of the line because there are still no antenna factors in the local buffer.

6. To edit an old antenna entry, press [**3**] LOAD from the EDIT ANTENNA TABLE and choose the antenna you want to edit.

If there is already something in the local buffer, you are given the choice:

W = OVERWRITE LOCAL BUFFER
Z = ABORT

7. If you need the data currently in the local buffer, abort the procedure and store it. Otherwise, press [**W**].

After the antenna is loaded, its name (if it has one) or number is shown at the end of the first line of EDIT ANTENNA TABLE indicating that the antenna factors for that antenna have been loaded into the local buffer.

If you attempt to change the frequencies at which you plan to use an antenna, whether it is a newly created antenna or an old one, you must delete the local buffer and start over as though it is a new antenna. To delete the local buffer, select item 4, DELETE from EDIT ANTENNA TABLE and then select item 6, EDITING BUFFER. Confirm the deletion by pressing [**Y**] and proceed as though you are creating a new antenna table.

8. After you have loaded an old antenna table or established the frequency range and calibration distance for a new one, press [**0**] from EDIT ANTENNA TABLE.

A list of frequencies beginning with the start frequency and ending with the stop frequency appears. The numbers to the right of the frequencies are the antenna factors, or K-factors. When creating antenna tables, the 2715 supplies default values of zero for the K-factors.

9. To begin changing the antenna factors, press [**W**] and enter the appropriate factor.

The asterisk indicates which factor is to be edited.

After you enter a value for a factor, the asterisk moves to the next frequency. If you do not want to change the antenna factor at the indicated frequency, turn the **FREQ/MKRS** knob to move the asterisk to the desired frequency.

For instance, suppose an antenna manufacturer specifies the antenna factors for his antenna as follows:

f	k	f	k	f	k
—	—	55.0	2.7	60.0	3.5
51.0	2.1	56.0	2.9	61.0	3.6
52.0	2.3	57.0	3.0	62.0	3.8
53.0	2.4	58.0	3.2	63.0	3.9
54.0	2.5	59.0	3.3	—	—

Then to make measurements from 55 to 60 MHz, the entries in the antenna table should look like this:

```

1>      55.000000 :      2.7
2>      56.000000 :      2.9
3>      57.000000 :      3.0
4>      58.000000 :      3.2
5>      59.000000 :      3.3
6>      60.000000 :      3.5

```

- 10.** If you are creating a new antenna table, press **[Z]** to exit (return to **EDIT ANTENNA TABLE**) after the last entry has been completed. If you are editing an existing table, press **[W]** after your last entry. Then press **[Z]** to return to **EDIT ANTENNA TABLE**.

Naming antennas is not required, but names can provide quick reminders of the purpose of each antenna. The following steps show how to name an antenna:

- 11.** Press **[1]** to select **TITLE EDIT**.

- 12.** Press **[W]** to begin editing.

If an old antenna table is being modified, its name appears at the upper left with an underscore cursor beneath the first letter. If the antenna table is new, only the cursor appears.

- 13.** Press **[Y]** to delete an old name entirely. (You can press **[Z]** to abort the title editing process without changes.)

- 14.** Turn the **FREQ/MKRS** knob to select letters to change the title.

- 15.** Use **MKR [↵]** or **MKR [⬅]** to move the cursor back and forth.

16. Press [X] when the title is complete.

17. Press [2] to select STORE.

18. Choose any unused antenna number.

The new or modified antenna table will be stored under that number. Its name is displayed adjacent to the number. If you do not name the antenna, it is given a name of ANTENNA #. If all five antenna tables are already in use, you will have to delete an existing antenna before you can store the new or modified table. For instance, suppose you have modified an existing antenna table and wish to store the modified version in the place of the original table using the same antenna name. Even though the name and location are the same, you must first delete the original antenna table. Deleting the original antenna from the antenna list does not delete the edited version in the local buffer. After you delete the original, store the edited version in the original location.

You can print the antenna data if your 2715 is equipped with an optional communications port and appropriate printer.

19. To print the antenna data, select item 5, PRINT, from EDIT ANTENNA TABLE.

20. Choose the antenna data you want to print from the resulting list.

The DISPLAY LINE feature ([DSPL] [8]) can be used with the dB μ V/m for making vehicular surveys of leakage from cable TV installations, or in other applications where an audible alert is useful whenever a signal amplitude crosses a preset threshold. To sound a high-level alert whenever the measured RF field strength exceeds the threshold, set the DISPLAY LINE at the desired threshold. See *The Display Line and Limit Detector* on page 6–40 for complete details.

To look for very low amplitude RF energy, turn on the 2715's preamplifier. Actual sensitivity depends on the antenna used and losses in cabling and coupling to the 2715. With minimum cable losses and an antenna that matches the 75 Ω 2715 impedance, you should be able to see signals ranging from approximately 2 dB μ V/m (1.3 μ V/m) at 55 MHz to 14 dB μ V/m (5 μ V/m) at 216 MHz.

If greater sensitivity is required, the following three options are possible:

- Provide an external preamplifier
- Use a higher-gain antenna; sensitivity increases directly as antenna gain
- If the signal being measured is narrowband, reduce the RBW to the narrowest setting still capable of passing the signal; for instance, the 3 kHz filter increases sensitivity by a further 20 dB over the 300 kHz filter

MKR/FREQ

100.0MHz	(AUTO SWEEP)	ATTN 12DB
28.8DBMV		VF WIDE
20.0MHz/		10 DB/
5MHz RBW (AUTO)		CALIBRATOR

With the Marker/Frequency menu you can directly affect the frequency characteristics of the spectral display and control the markers in ways not available from the front panel.

Setting Start and Stop Frequencies

Perhaps you would prefer to directly specify the beginning and ending frequencies of the display rather than its center frequency and span. The 2715 enables you to do so as follows:

1. Press **[MKR/FREQ] [7]** to call up the Marker/Frequency menu.
2. Press **[7]** to select FREQUENCY START/STOP.

A submenu appears enabling you to specify start and stop frequencies for the spectral display.

3. Press **[0]**.
4. Press **[1] [7] [5] [X]** to specify a start frequency of 175 MHz.
Note that the indicated start frequency has changed.
5. Press **[1]**.
6. Press **[4] [2] [5] [X]** to enter a value of 425 MHz for the stop frequency.
7. Press any menu button to return to the spectral display.

The span is 25 MHz/division, making the start and stop frequencies 175 MHz and 425 MHz respectively. If you make the start frequency greater than the stop frequency, the 2715 enters ZERO SPAN mode tuned to the start frequency.

Using Markers to Set Start and Stop Frequencies

You can also set the start and stop frequencies with the markers. This method provides a visually intuitive approach to span control, enabling you to designate only that portion of the displayed spectrum that is of particular interest.

8. Turn on the marker and place it just to the left of the calibration signal harmonic at 300 MHz.

9. Enter the delta-marker mode and place the active marker just to the right of the harmonic at 400 MHz.

10. Select item 6, MARKER START/STOP, from the Marker/Frequency menu.

The spectral display reappears and brackets the calibration signal third and fourth harmonics. The marker start/stop selection automatically adjusts the starting frequency of the display and the span/div so that what is displayed is what was between the markers. If you are not in the delta-marker mode when you select MARKER START/STOP, the 2715 will enter zero span at the current center or marker frequency.

11. Turn off the markers. Notice that the resolution BW has also changed in response to the changed span/div, because RES BW was in AUTO mode.

Transposing Markers

300.0MHz	(AUTO SWEEP)	ATTN 12DB
28.8DBMV		VF WIDE
50.0MHz/		10 DB/
5MHz RBW (AUTO)		CALIBRATOR

Suppose you want to measure the difference in frequency between the peaks at 300 MHz and 500 MHz and between 500 MHz and 200 MHz. The following steps show how to make these measurements:

12. Enter marker mode, and position the marker on the 300 MHz peak.

13. Enter delta-marker mode and place the active marker on the 500 MHz peak.

The difference is 200 MHz.

14. Select item 5, TRANSPOSE MARKERS, from the Marker/Frequency menu.

15. Turn the **FREQ/MKRS** knob.

The movable marker has become the reference and the old reference is now the movable marker.

16. Move the marker to the 200 MHz peak and note the frequency difference.

17. Exit from delta-marker mode.

Changing the Knob Function

100.0MHz	(AUTO SWEEP)	ATTN 12DB
28.8DBMV		VF WIDE
20.0MHz/		10 DB/
5MHZ RBW (AUTO)		CALIBRATOR

The knob is normally used to vary the center/start frequency, marker position, or the video line selection.

The following procedure describes how to measure the frequency difference between the calibrator signal and each of its harmonics, but you could use the same procedure to measure any series of signals across the whole range of the 2715.

1. Enter the delta-marker mode with both markers at the calibrator signal peak.
2. Call up the Marker/Frequency menu.
3. Select item 2, KNOB FUNCTION.

The Knob Function menu appears. Currently, the knob is controlling the markers, as you would expect in delta-marker mode.

4. Select item 0 from the Knob Function menu to change to frequency control.
5. Press [**MKR/FREQ**].

The spectral display reappears.

6. Rotate the **FREQ/MKRS** knob several clicks clockwise.

Notice how the center frequency increases and the spectrum slides to the left. One marker remains fixed on top of the cal signal peak while the other remains fixed at center scale. Consequently, the difference frequency also increases.

7. Continue turning the knob until the second harmonic approaches center scale.
8. Press [**CTR MEAS/TRKG**].

The second harmonic is automatically centered. The amplitude and frequency difference between the fundamental and the harmonic are displayed at the top of the right column preceded by DC (delta count).

9. Repeat this procedure for the third harmonic.

Notice that although the reference peak (the cal signal fundamental) is now far off-screen to the left, you are still accurately measuring the difference frequency.

10. Continue this process all the way to 1.8 GHz.

11. Exit from this mode by turning off the markers.

This feature is particularly useful when you want to measure the differences between two or more signals so widely separated in frequency that they do not fit on screen at the span/division at which you wish to view them. If you are already using the Marker/Frequency menu, item 2 also conveniently turns on the marker mode when it is set to MKR.

If you trigger the 2715 with a TV video sync pulse by choosing KNOB SELECTABLE from the Sweep/Trigger menu Setup Table, the Knob Function menu offers another choice: VIDEO LINE. Selecting VIDEO LINE lets you use the FREQ/MKRS knob to control which TV line triggers the sweep. Selecting FREQUENCY or MARKER continues to let you control the center or marker frequency. This feature enables you to conveniently flip between frequency and TV line control. This can be very useful when viewing multiple TV channels. You can select FREQUENCY for changing channels and then go to VIDEO LINE for choosing the line number. For a complete explanation of TV LINE trigger mode, see *TV Line Trigger* on page 6–85.

Moving the Marker to the Next Higher or Lower Peak

300.0MHZ	(AUTO SWEEP)	ATTN 10DB
28.8DBMV		VF WIDE
50.0MHZ/		10 DB/
5MHZ RBW (AUTO)		CALIBRATOR

The front-panel controls enable you to move the marker to the next signal peak to the left or right, but the Marker/Frequency menu enables you to jump the marker from peak to peak in ascending order of amplitude, and then jump down again in descending order.

1. Turn on the single marker and place it in the noise — it does not matter where.
2. Select item 4 from the Marker/Frequency menu.
3. Press [W].

The marker is now on top of the lowest of the calibration signal harmonics.

4. Select item 4 and press [W] again.

The marker is now on top of the second lowest peak.

5. Repeat this process until the marker reaches the highest peak (the fundamental).

6. After the marker is on the highest peak, select item 4 and press [X].
7. Repeat this process several times and watch the marker jump to progressively lower peaks.

If you try to jump the marker above the highest peak or below the lowest, the message NO SIGNAL FOUND ABOVE THRESHOLD is displayed. You cannot jump the marker to off-screen signals.

Marker to the Reference Level

MARKER TO REFERENCE LEVEL is an item on the MKR/FREQ menu that can be used to quickly and easily determine signal amplitudes.

8. Using any method, (for instance, the MOVE MARKER TO NEXT PEAK feature), place the marker on top of the signal to be measured.

In this case, use the calibration signal fundamental.

9. With the marker at the signal peak, press [MKR/FREQ] [3].

The reference level is changed to the signal amplitude to place signals at the reference level to make relative measurements. It is also a convenient method of setting the video carrier to the reference level when using the video monitor option.

10. When you are finished, turn off the marker.

NOTE. Signal amplitudes are always determined most accurately when the signal is within one division of the reference level.

Selecting the Tuning Increment

300.0MHz	(AUTO SWEEP)	ATTN 10DB
28.8DBMV		VF WIDE
50.0MHZ/		10 DB/
5MHZ RBW (AUTO)		CALIBRATOR

The instrument tuning increment (amount per click by which the tuning knob changes frequency) is 0.02 of the span/division. The following steps show how to change the tuning increment:

1. Call up the Marker/Frequency menu.

Item 8 is a two-way toggle function indicating that the tuning increment is presently being automatically selected by the 2715. In AUTO mode, the tuning increment is as shown in Table 6-2.

Table 6–2: AUTO Tuning Increment

Span/div	Resolution Bandwidth Filter	Tuning Increment
Zero span	300 Hz, 3 kHz, and 30 kHz	0.033 of RBW
	1 kHz, 10 kHz, 100 kHz, and 1 MHz	0.05 of RBW
	300 kHz	20 kHz
	5 MHz	200 kHz
All Others		0.02 of span/div ¹

¹ Because of the readout resolution, this appears as 3 and 4 MHz on alternate clicks of the knob in MAX SPAN.

- Slowly press [8] twice.

The tuning increment progresses from AUTO to PROGRMD (programmed) and back to AUTO again. If programmed tuning is selected (see *Programmed Tuning* on page 6–24), you can specify whether the center frequency, marker frequency, or keypad entered frequency increment will be used as the tuning increment.

Center or Start Frequency

The following steps show how to toggle between Center or Start Frequency:

- Choose item 9 from the Marker/Frequency menu to bring up the setup table.

The first item toggles frequency control between center and start frequency. When start frequency is selected, the **FREQ/MKRS** knob controls the frequency at the left edge of the display rather than the frequency at the center.

- Choose item 0 from the setup table.

The spectral display reappears but the center frequency bright spot is now moved to the left edge of the screen, and the frequency readout is preceded by the letters SF (as in SF 300MHz) indicating that the start frequency is now 300 MHz. Some users prefer to run the 2715 in this mode. This feature can be useful for viewing sidebands or performing harmonic distortion measurements.

- Toggle back to center frequency control by pressing [**MKR/FREQ**] [9] [0].

Setting the Signal Threshold

As discussed earlier, there is a threshold below which the 2715 will not automatically detect signal peaks. Normally the 2715 estimates the peak amplitude of the minimum displayed signal (which usually represents the noise floor) and sets the threshold one division higher. However, when the displayed signal is greater everywhere than the noise, the 2715 sets the threshold in proportion to the signal peaks rather than the noise floor. The threshold is then

artificially high and may result in other signals being ignored that rise only slightly above the threshold. Item 0 of the MKR/FREQ menu enables you to set the threshold to a fixed amplitude suitable for detecting the signals present in your particular application. The fixed threshold is also handy when you simply want to exclude low-level signals while jumping the marker among high-level peaks.

The following steps show how to set the threshold:

6. Choose Item 0 from the MKR/FREQ menu.
7. Enter a value of -45 dBm, following the prompts.
8. Press any menu button to return to the spectral display.
9. Using either the MOVE MARKER selection from the MKR/FREQ menu or the marker arrow keys, attempt to move the marker from peak to peak.

It will only jump to the peaks above -45 dBm in amplitude.

10. Turn off the marker.
11. Press **[MKR/FREQ] [0] [Z]** to restore automatic threshold selection.
12. Press any menu button to return to the spectral display.

Counter Resolution

The 2715 enables you to change the resolution of its built-in counter. It is possible to specify its resolution as 1 kHz or 1 Hz, or to turn off the counter when the Signal Track mode is in use. Be aware that this feature only changes the counter resolution to 1 Hz, not the accuracy.

13. Press **[MKR/FREQ] [9] [1]**.
14. Under COUNTER RESOLUTION, select item 0, COUNTER OFF WHEN TRKG.
15. Press **[CTR MEAS/TRKG]** and notice the counter reads out to 1 Hz.
16. Enter the TRKG mode and note that there is no counter reading.
17. Return to COUNTER RESOLUTION and select 1 kHz.

Notice the counter is now reading in TRKG mode. When you select items 1 or 2, the counter reads out to the indicated resolution in either CTR MEAS or TRKG. Because it takes longer to update the display when the counter is reading out, turning it off speeds up the signal tracking capability.

18. Reselect item 0 from COUNTER RESOLUTION, and then turn off the TRKG mode.

Programmed Tuning

300.0MHz	(AUTO SWEEP)	ATTN 12DB
28.8DBMV		VF WIDE
50MHz/		10 DB/
5MHz RBW (AUTO)		CALIBRATOR

1. Choose item 1 from the MKR/FREQ menu.

The Programmed Tuning Increment menu appears. Programmed tuning increments can be designated by the center or start frequency, the marker or delta-marker frequency, or numeric keypad entries.

The current center frequency is approximately 300 MHz (as would be the start frequency if you placed the 2715 in that mode).

2. Press [0] to select the center frequency as the tuning increment.

The spectral display reappears.

3. Turn the **FREQ/MKRS** knob one click clockwise.

The frequency is changed 300 MHz.

4. Reset the center frequency to 300 MHz.

5. Turn on the marker.

6. Position the marker at 150 MHz.

7. Select item 1 from the MKR/FREQ menu.

8. Now choose item 1, currently MARKER FREQ, from the Programmed Tuning Increment menu to select the marker frequency as the tuning increment.

9. Turn off the marker, and turn the **FREQ/MKRS** knob one click.

10. The frequency should change 150 MHz.

11. Reset the frequency to approximately 300 MHz.

12. Turn on the marker, and position it on the calibration signal fundamental at 100 MHz.

13. Enter the delta-marker mode and place the movable marker on the second harmonic at 200 MHz.

14. From the Programmed Tuning Increment menu, select item 1, which now reads DELTA MKR FREQ.

- 15.** Turn off the markers and turn the **FREQ/MKRS** knob one click.

The frequency now changes by one harmonic (100 MHz) per click. When making distortion measurements, this is one way to look at positions where harmonics should be present. In fact, any time your measurements require you to look at multiples of a frequency difference, but you do not want to be bothered with actually entering the frequency, the delta-marker tuning increment mode provides a quick, convenient way of doing it.

- 16.** Return to the Programmed Tuning Increment menu to specify a particular tuning increment.

- 17.** Choose item 3, **KEYPAD ENTRY**, and enter a value of 7 MHz.

The spectral display reappears.

- 18.** Turn the **FREQ/MKRS** knob.

The frequency changes by 7 MHz per click, a value not otherwise available. Entering a keypad tuning increment automatically places the 2715 in programmed tuning mode.

- 19.** There are two ways to turn off any programmed increment, including the keypad entered increment:

- a.** First, toggle item 8 on the Marker/Frequency menu to read **AUTO**.

This turns off the keypad value and restores automatic selection of the tuning increment.

- b.** Second, select the programmed tuning increment from the **MKR/FREQ** menu and choose item **[4]**, **RETURN TO AUTO** from the Programmed Tuning Increment menu.

This also turns off the keypad value and restores automatic selection of the tuning increment.

- 20.** Turn the keypad increment back on by reselecting **PROGRMD TUNING INC** from the **MKR/FREQ** menu, and choosing item 2, **KEYPAD ENTRD INC**.

- 21.** Now turn off the keypad selected increment.

Frequency Offsets
(not available in CATV
mode)

300.0MHz	(AUTO SWEEP)	ATTN 12DB
28.8DBMV		VF WIDE
20.0MHz/		10 DB/
5MHz RBW (AUTO)		CALIBRATOR

The Marker/Frequency Setup Table also enables you to offset the on-screen center frequency readout. The center frequency itself is not actually changed, and the counter readout still indicates the true frequency rather than the offset value. This feature is intended to allow the output frequencies of block down converters (LNB's) used in video communications and other industries to be correctly indicated. However, it can be used any time a signal has been shifted in frequency by a known amount and you want to display its frequency prior to shifting.

For example, if the signal to be viewed is the output of a down converter with a 5.15 GHz local oscillator, perform the following steps:

1. Press [**MKR/FREQ**] to call up the Marker/Frequency menu.
2. Press [**9**] to select SETUP TABLE.
3. Press [**3**] to select FREQ OFFSET.
4. Enter an offset of 5.15 GHz (ignore the CALIBRATOR DOESN'T MATCH READOUT warning).

Notice that the status of item 4, FREQ OFFSET MODE, changed from OFF to ON PLUS.

5. Press [**4**] several times.

The status of the frequency offset cycles through OFF – ON PLUS – ON MINUS.

6. Leave the offset set to ON PLUS and return to the spectral display.

The center frequency is now indicated as 5450.0 MHz (300 MHz + 5150 MHz offset).

7. Press [**CTR MEAS/TRKG**].

The counter readout still indicates the true center frequency.

8. Turn on the marker and turn the **FREQ/MKRS** knob clockwise.

The marker frequency is also increased by 5.15 GHz.

9. Press [**MKR/FREQ**] to call up the Marker/Frequency menu.

10. Press [**9**] to select the SETUP TABLE.

11. Press [4] to toggle FREQUENCY OFFSET MODE to ON MINUS.

12. Return to the spectral display.

The center frequency now reads 4850.0 MHz and the marker reads progressively lower frequencies as it moves to the right.

The frequency axis appears reversed because any time the local oscillator in the frequency converter is above the frequency of the original signal, the output frequencies are reversed. That is, the higher the input signal frequency, the lower the output frequency. This is exactly the process that occurs in C-band block down converters. Therefore, you use ON MINUS when viewing their output. Ku-band converters, on the other hand, have local oscillator frequencies below the input signal frequency, and you use ON PLUS when viewing their output signals.

DSPL

300.0MHz	(AUTO SWEEP)	ATTN 12DB
8.8DBMV		VF WIDE
20.0MHz/		10 DB/
5MHz RBW (AUTO)		CALIBRATOR

The Display menu enables you to change the appearance of the display screen and the signals presented on it. From the Display menu, you can do the following:

- Switch between analog and digital display modes
- Ensemble average spectra
- Directly subtract a stored trace from an active trace
- Switch between MAX/MIN and PEAK signal acquisition modes
- Title and label displays and plots
- Turn the graticule lights on and off
- Change the source of the display from an internal to an external signal
- Control an on-screen reference line to simplify amplitude measurements and establish alarm thresholds
- Enable and disable the Min Hold feature

Changing the Display Mode

You can place the 2715 in the analog display mode by turning off all the display registers using [A], [B], [C], and [D] (see *Display Storage* on page 4–20). However, a more convenient method when two or more registers are active, is to use item 0 on the Display menu. Item 0 is a toggle that switches the 2715 between analog and digital display modes. If the 2715 is in the digital display mode, pressing item 0 turns off all display registers (enters analog display mode). When in the analog mode, pressing item 0 performs one of two actions:

- If analog mode was entered using item 0, the register configuration prior to entering analog mode is restored.
- If analog mode was entered by manually turning off all registers with [A], [B], [C], and [D], the last register turned off is reactivated.

13. Ensure the C and D display registers are active. Save the C register and change the center frequency to 280 MHz so you can distinguish the two active traces.

14. Press [DSPL] [0].

Notice that only the analog signal remains.

15. Press [DSPL] [0] again.

Both the saved C digital display and the current D digital display return (the same register configuration that was in use prior to entering the analog mode by selecting item 0).

16. Turn on the B register, and then turn off all registers in the order D, C, B.

17. Press [DSPL] [0].

Notice that the B register, the last one turned off, is the only one reactivated.

18. Reset the center frequency to 300 MHz and turn on only the D register.

Ensemble Averaging

In general, ensemble averaging techniques are used for the same reason as filters, to enhance the desired signal-to-noise ratio. Narrow resolution BW or video filters reduce the noise by reducing the 2715's bandwidth. Unfortunately, they also require slower sweep speeds, and in the cases of broadband signals, the filters may limit the signal energy. For these applications, we can use ensemble averaging. However, if ensemble averaging is used with pulsed waveforms without taking special care to synchronize the 2715 to the signal, erroneous measurements result. This is because of the way scanning spectrum analyzers determine the spectrum of pulsed signals. See Tektronix application note 26W-7037-1, *Spectrum Analyzer Fundamentals*, for more information about pulse measurements.

Ensemble averaging computes the average value of some parameter (peak, mean, minimum, etc.) of a number of signal spectra. If the nature of the signal does not change during the period over which the average is compiled, the parameter being averaged rapidly approaches its mean value. This results in an enhancement of the signal-to-noise ratio without reducing the bandwidth or slowing the sweep speed. This does not mean you cannot ensemble average continuous narrowband signals. However, in those cases you can also use video filtering, which may prove faster and more convenient.

The result of the ensemble average is an estimate of the mean value of the parameter being averaged. Successive estimates, or averages, will vary from each other in a random fashion. The larger the number of sweeps averaged, the more accurate an estimate of the spectral characteristic that is obtained.

19. Select ENSEMBLE AVERAGING by pressing [DSPL] [1].

The Ensemble Averaging menu appears. Items 1 and 2 start and stop the averaging process. The remaining items specify which values to average, how many sweeps to average, and where to store the result.

If you are going to store just the one ensemble average, it makes little difference where you put it. You can use registers A, B, or C, but you cannot store the average in a register that already contains data. Register D is not available, because it always contains the current trace. If you plan to use the stored average as a reference and perhaps intend to subtract it from other spectra, you must store it in register A. Whichever register is used, it must be cleared before you attempt to store new data in it or you will receive an error message.

Item 8 of the ENSEMBLE AVERAGING sub-menu is a three-way toggle that switches among registers in the sequence A, B, C, A

20. Ensure that register A is clear and then repeatedly press [8] until the last character on the line is A.

You can average a fixed number of spectra or choose continuous averaging. Continuous averages are used when the mean value of the signal you are viewing can change slowly with time, when you want to watch a mean value estimate change in real time, or when you simply wish to continuously monitor a process.

If you select a fixed ensemble size, you can average up to 1024 sweeps. The parameter being averaged can be the maximum, minimum, max/min, or mean of the spectral display. Averaging begins when item 1 is selected from the Ensemble Averaging menu and ends when the Nth sweep has been completed. You can also stop the averaging by selecting item 2 from the menu.

Continuous averaging weights older sweeps so that they have a progressively smaller effect on the average. Each step back in time reduces the impact of a sweep to 90 per cent of its previous value.

The factory default setting is a 16-sweep fixed average. Do the following steps to change the number of averages to 24:

21. Press [7] from the Ensemble Averaging menu.

22. Press [2] [4] [W].

Item 7 will update as you press [W].

You are now ready to compile a parameter average. There are four choices. Begin with the max/min display.

23. Press [6] MAX/MIN from the Ensemble Averaging menu.

The asterisk moves down to indicate MAX/MIN is selected.

24. Press [1] to start averaging.

The spectral display reappears and both status indicators for register A light. At the bottom of the right-hand readout column, the number of sweeps averaged is displayed (displayed only when the 2715 is in the non-CATV mode). When all 24 sweeps have been included in the average, the readout stops indicating the number unless the A register is the only one turned on.

25. Turn the D register on and off several times and note the difference.

Most of the sweep-to-sweep variations in the noise have disappeared.

Now we will repeat the experiment, this time storing the MAX average in register B. In this case, only the 256 maximum values of each max/min sweep are averaged and stored.

26. Press [DSPL] [1] [3] to select MAX.

27. Press [8] repeatedly to select register B.

28. Press [1] to start the averaging process.

Both status indicators for register B light, the average peak value almost coincides with the upper edge of the MAX/MIN average.

29. Turn off the A register to see the average maximum by itself.

30. Turn the A register back on.

31. To store the MIN average in register C, press [DSPL] [1] [5] [8].

32. Press [1] from the ENSEMBLE AVERAGING submenu to start averaging.

Both status indicators for register C light. Here, too, we see that the average minimum coincides closely with the lower edge of the MAX/MIN average. In computing the average MIN, the 256 minimum points from each max/min sweep are used.

33. To store the MEAN value of the spectrum in register A, press **[DSPL] [1] [4] [8]**.
34. Press **[1]** from the ENSEMBLE AVERAGING submenu to start averaging.
35. At the prompt, press **[W]** to overwrite the previously stored max/min average.

Again, the mean value of the noise appears to be halfway between the max and min values. The average MEAN is what you get if you add successive maximum and minimum values in dB from the MAX/MIN display, divide by two, and average the results. The MEAN average is a visual mean, not a true mean, that can be very useful in making weak signals visible.

36. Turn on the D register to see the current sweep with its visual mean and average maximum and minimum values superimposed.

The mean along with the max and min values provide an estimate of the variability of the signal.

The signal peak does not appear to have changed because the calibration signal is essentially constant (little or no variability), so its min, max, and mean amplitude are all about the same. This can be used to advantage.

37. Turn off the A, B, and C registers.
38. Set the reference level to +58.8 dBmV.

The calibration signal third harmonic is almost lost in the noise.

39. Now ensemble average the spectrum MEAN values and store the result in A.

The mean spectrum leaves little doubt as to the presence or location of the signal peak. Sometimes you can achieve even better results using the average minimum.

40. Experiment if you like before proceeding, then clear the A, B, and C registers and leave only the D register active.

Subtracting Stored Signals

400.0MHz	(AUTO SWEEP)	ATTN 12DB
28.8DBMV		VF WIDE
100MHz/		10 DB/
5MHz RBW (AUTO)		CALIBRATOR

The B,C MINUS A feature of the Display menu enables you to subtract a sweep stored in register A from an active sweep in registers B or C. You can use it to flatten a noise spectrum, get rid of unwanted signals, easily detect signal changes, and so forth.

Observe the current sweep, especially the zero-frequency and calibration signal peaks. In your instrument the noise floor may rise slightly with increasing frequency.

1. Perform a 24 sweep MAX/MIN ensemble average and store the result in A.

The average indicator is displayed only when the 2715 is in the non-CATV mode.

2. Wait until the ensemble average is complete.
3. Ensure item 3 of the Display menu reads B,C MINUS A OFFSET TO CENTER. (If it does not, select item 3 once.)
4. Press [DSPL] [2] to activate the B,C MINUS A mode.
5. Turn on the B register and turn off A and D.

The display now consists of a much-reduced and totally flat noise floor and some intermittent peaks similar to Figure 6–5. The zero-frequency and calibration signal peaks have almost disappeared. You have subtracted the average max/min spectrum stored in the A register from the active sweep in the B register (you can also use the C register), and are displaying the result that consists only of the sweep-by-sweep variations. The vertical center of the screen represents zero amplitude difference between the waveforms.

Waveform subtraction can be used as a sensitive detector of signal changes. Suppose you were trying to measure a weak signal, which you could turn on and off, in the presence of interfering noise and signals. You could turn the signal off, compile the ensemble average and subtract it as above. Then, when you turn the weak signal back on, it would show up because it was not part of the stored average.

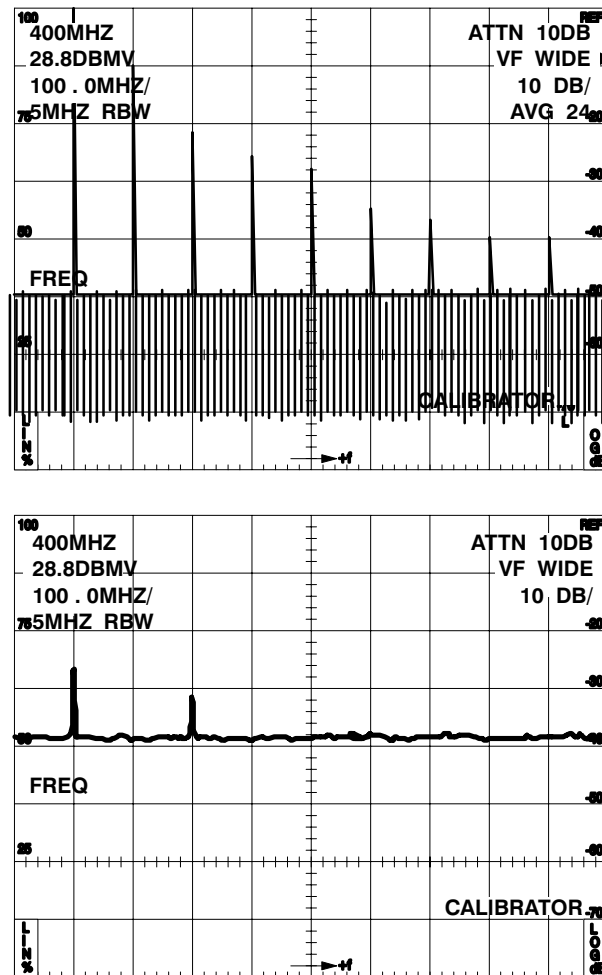


Figure 6-5: Average Signal Plus Noise and Average Signal-Plus-Noise Subtracted from the Current Sweep

- Decrease the reference level 10 dB.

The calibration signal peaks appear.

- Increase the reference level 20 dB.

The technique works no matter the direction of the signal change.

- Reset the reference level to 18.8 dBmV and change the center frequency slightly.

Again the calibration signal peaks appear. Any change from the average, either amplitude or frequency, becomes obvious.

If the waveform in B gets so much larger than that in A that the result goes off-screen, subtract the average MEAN noise from the MAX HOLD signal plus noise. This provides a measure of the maximum signal variations about the mean noise level.

9. Press [DSPL] [2] to disable B, C MINUS A mode.
10. Ensure the center frequency is set to 400 MHz and the reference level to 18.8 dBmV.
11. Turn off the calibrator and store a 24 sweep MEAN average of the noise in register A (you need to overwrite the display currently stored in register A).
12. After the average is complete, turn the calibrator back on and activate MAX HOLD in register B.

The resulting traces are shown in Figure 6–6.

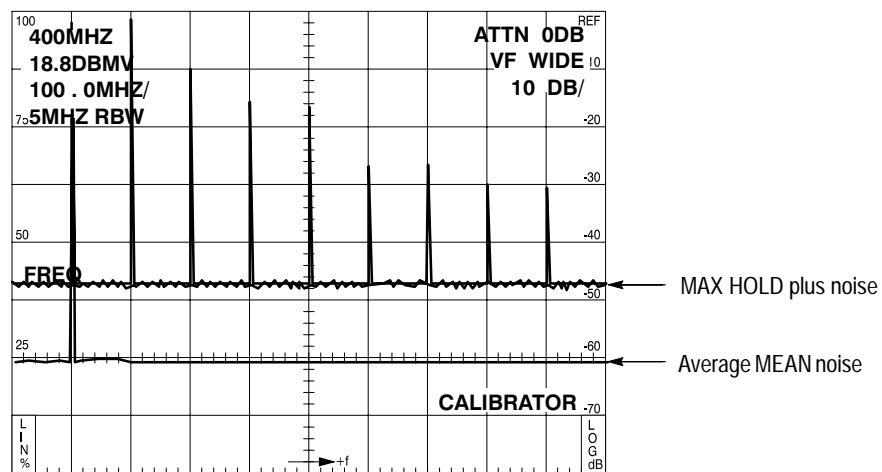


Figure 6–6: Average MEAN Noise and MAX HOLD Signal-Plus-Noise

13. Turn off the A register.
14. Press [DSPL] [2] to enter the B, C MINUS A mode.

The resulting noise floor is approximately two divisions down from the reference level, but some of the calibration signal peaks fold over and point downward. See Figure 6–7.

15. Press [DSPL] [3].

The waveform is now nearer the bottom of the screen where you can see it more clearly.

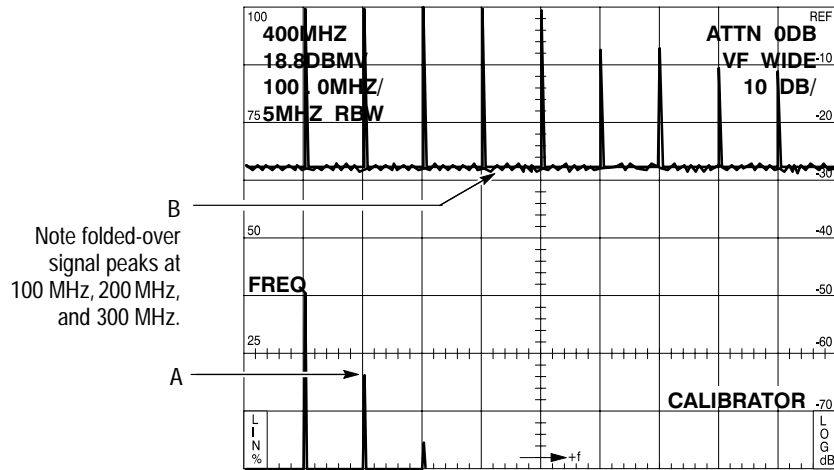


Figure 6-7: B, C Minus A Offset to Center

You have offset the difference between the B and A register waveforms, which is always greater than zero, to the top of the screen (zero difference is at the reference level). However, values above the reference level appear at the bottom of the screen. See Figure 6-8. The points labeled A and B in Figures 6-7 and 6-8 have exactly the same value in each figure. Imagine that the screen curves backwards at the top and bottom until it joins itself, forming a cylinder.

All points of zero difference lie along the joint. Now cut the joint and uncurl the cylinder, allowing it to become a flat screen again. Both the top and bottom of the screen represent zero difference, with negative signal peaks descending from the top of the screen and positive peaks rising from the bottom.

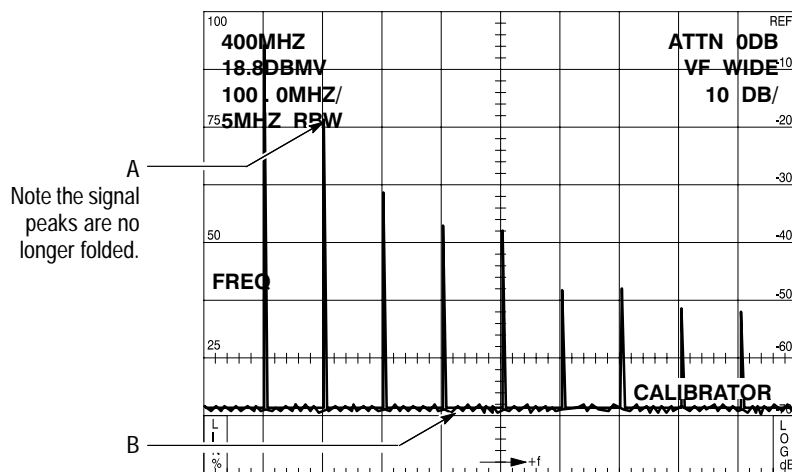


Figure 6-8: B, C Minus A Offset to Top

Changing Acquisition Mode

100.0MHz	(AUTO SWEEP)	ATTN 20DB
+18.8DBMV		VF WIDE
20.0MHz/		10 DB/
5MHz RBW (AUTO)		CALIBRATOR

Item 4 on the Display menu toggles between MAX/MIN and PEAK signal acquisition modes.

1. Press [DSPL] [4] to change acquisition modes.
2. Toggle back and forth between MAX/MIN and PEAK several times.

Notice that the display PEAK is essentially the top of the MAX/MIN display.

The 2715 produces an analog spectrum. In the MAX/MIN acquisition mode, the maximum and minimum amplitudes of this spectrum are alternately sampled at 512 successive points. Plotting the two interleaved sets, of 256 points each, produces the analog-like MAX/MIN spectrum that you see. In the PEAK acquisition mode, the maximum amplitude only is sampled and displayed at all 512 points. The Max/Min mode has the advantage of bearing some semblance to the analog signal and readily revealing pulsed versus constant carrier signals. Pulsed signals cause the signal peaks to be filled in.

3. Leave the display in the MAX/MIN mode.

Adding Titles and Labels

175.0MHz	(AUTO SWEEP)	ATTN 2DB
18.8DBMV		VF WIDE
20.0MHz/		10 DB/
5MHz RBW (AUTO)		CALIBRATOR

If you want to permanently store a spectral display, either by photographing the screen or by plotting the display, you can first title the display. If you are plotting the display, you can also label significant points.

1. Ensure that only the D register is active.
2. Press [DSPL] [5] to select title mode.

Item 2 reads TITLE MODE EDIT if one or more registers contain a current sweep (as now) or TITLE MODE EDIT WFM X if only saved data is displayed (saving a waveform also saves its title).

In either case, the title to be edited is always associated with the highest priority displayed waveform (see register priority chart on page 4–23). This means, for instance, that to create a title for the B waveform, the C and D registers must be turned off; or to edit the title of a saved waveform in the C register, all registers containing a current sweep must be turned off. Although you can edit the title of a saved waveform for display or plotting, only the originally saved waveform title is retained. You can circumvent this restriction by saving the waveform and its new title as part of a stored settings group (see *Save and Recall Settings and Displays* on page 6–62); the edited title is then retained as part of the newly saved settings/waveform, and you can delete the original or not as you choose.

When performing a screen plot, the title being edited is attached to the highest priority waveform (even if it has a previously saved title). However, if lower priority saved waveforms exist, their titles are correctly attached to them.

The title can be up to 31 characters on a single line, and you can only title one display at a time. When the title mode is turned on, the left-hand readouts move down one row to accommodate the title, even if the title field is blank. Select item 2 to edit an existing title or to enter a new title. If the display is already titled, the title appears in the upper left with an underscore cursor beneath the first letter. If the display is untitled, just the cursor appears.

The characters that can be used in the title are listed below the title in three lines arranged as follows:

- Alphabetic characters
- Numbers
- Punctuation and special characters

The selected character appears in reverse video in the list and also appears above the cursor. (In the list, <SP> indicates the space or blank character.)

To enter or edit a title, use the **FREQ/MKRS** knob to select a character. As you turn the knob, the selected character moves through the list, wrapping between the end of one line and the start of the next and between the end of the last line and the beginning of the first.

Move the cursor left or right to a new character position with the **MKR [◀]** and **MKR [▶]** buttons. When done editing, leave the cursor in its last position to avoid an unwanted character. Delete the character to the left of the cursor by pressing the **BKSP** button on the keypad. Delete the entire line by pressing **[Y]**.

As an example, the following procedure creates a new title, *TEST123*:

3. Press **[2]** to start the title mode edit.
4. Rotate the **FREQ/MKRS** knob until the letter T appears.
5. Press **MKR [▶]** to move the cursor one place to the right.

6. Rotate the **FREQ/MKRS** knob until E appears.

7. Continue this process until you have spelled TEST.

You can enter numbers and advance the cursor automatically without rotating the knob by using the numeric keypad.

8. Press [**1**] [**2**] [**3**] to complete the title.

9. Press [**X**] to store the result in the display title buffer.

You can also exit from the title edit mode without saving the title or any changes by pressing [**Z**].

The following steps show how to make the title visible on screen or on a plot:

10. Press [**1**] to toggle on TITLE MODE. (Pressing [**1**] again turns off the title.).

11. Leave the title on, and return to the spectral display.

Your title is visible in the upper left corner of the screen.

At this point, the title is associated with the highest priority waveform. Permanently attach it to a waveform C.

12. Press [**SAVE ENABLE**] and [**C**].

13. Press [**DSPL**] [**5**] [**2**] [**Y**] to delete the title from the display title buffer.

14. Return to the spectral display.

The title is gone, but the readouts are displaced downward one line because TITLE MODE is still enabled.

15. Turn off the D register and turn on C.

The title is back; it has become part of the saved waveform in C. The title will vanish from the screen if any register is turned on that contains a current sweep, but will remain in storage register C until waveform C is unsaved with [**SAVE ENABLE**] [**C**].

There are several other title or text information entry functions available. In each case, with the exception of plot labeling, text is entered just the same as for title editing. Plot labeling is similar.

16. Press [**DSPL**] [**5**] [**4**] to select PLOT LABELING EDIT.

Since plot labels can use all 16 display lines instead of just one, most of the instructions are on a separate screen so that they do not cover the label being entered.

The buttons and the **FREQ/MKRS** knob work the same as for other text editing. In addition, any of the up or down arrow buttons move the cursor vertically between lines. Labeling information may be entered on any or all lines. As the cursor moves between lines, the list of available characters shifts so that the line being edited is always visible.

- 17.** Press **[W]** to display the label editing screen.

The **W** button toggles between the label editing screen and the instruction screen.

The editing screen displays the label being edited (if any exists), the cursor, and the display of available characters. This screen also displays the waveform so that you can see how the label will plot with respect to the waveform.

- 18.** Move the cursor one division to the right of center screen and two divisions down from the reference level.

- 19.** Enter the characters **2ND HARMONIC**.

- 20.** Move the cursor to the peak at the left of the screen; label it **FUNDAMENTAL**.

The labels denote the calibrator signal and its second harmonic.

- 21.** Press **[X]** to store the label(s). (Pressing **[Z]** exits from the procedure without any changes.)

- 22.** Press **[3]** from the Title Mode menu to make labels appear on your plot.

Item 3 is a toggle which turns the labels on and off.

- 23.** Press **[DSPL]** to return to the spectral display.

NOTE. Labels only appear on the hard copy device, not on the screen.

See Figure 6–9 for an example of what the plot should look like.

- 24.** Turn off the title and plot labels.

Turning Graticule Illumination On and Off

Item 6 on the Display menu is a simple toggle that turns the graticule illumination on and off. Press **[DSPL]** **[6]** several times to see the graticule illumination change states.

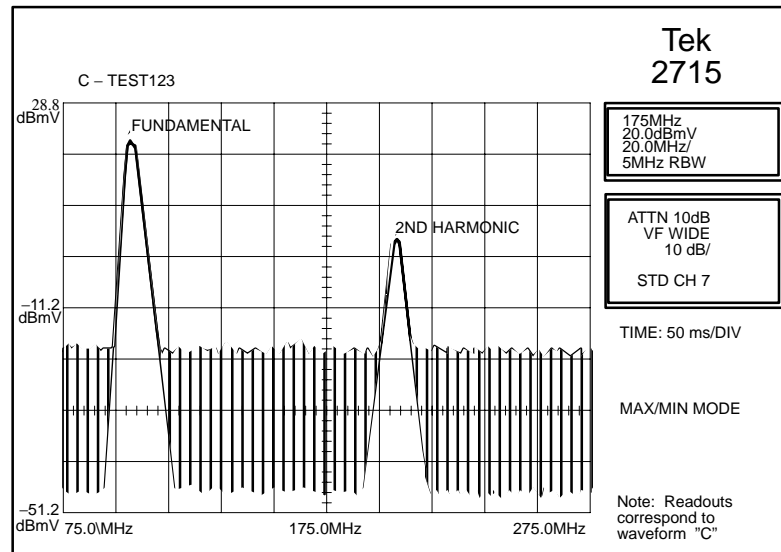


Figure 6-9: 2715 Plot with Title and Plot Labels

Displaying an External Source

Item 7, DISPLAY SOURCE, in the Display menu enables you to substitute an external, low-pass signal for the normally displayed spectrum. The signal must be input to the 2715 on pin 1 of the rear panel Accessory Connector J103, and must be in the range of 0 to 1.4 V with a 3 dB bandwidth of 50 kHz or less. DISPLAY STORAGE, VERT SCALE 10 /5 /1, SWEEP RATE, and some VID FLTR selections (10 Hz, 1 kHz, 10 kHz, 100 kHz) remain active and can be used to process the external signal. Refer to J103 — Accessory Connector on page E-2 in Appendix E: External Input and Output for additional details.

The Display Line and Limit Detector

100.0MHz	(AUTO SWEEP)	ATTN 0DB
18.8DBMV		VF WIDE
50.0MHz/		10 DB/
5MHz RBW (AUTO)		CALIBRATOR

The 2715 provides a convenient method to determine whether a signal peak is higher or lower than some particular level, or whether it falls within a specified range. The DISPLAY LINE feature displays a horizontal line at the level you specify. You can visually compare signal amplitudes to the line or set the 2715 to sound an alarm if a signal crosses the line.

1. Press [DSPL] [8] to select the DISPLAY LINE feature.
2. Press [2] to select VALUE ENTRY.

3. Press **[2] [•] [2] [Z]** to enter -2.2 dBmV.

The 2715 reverts automatically to the spectral display that now contains a horizontal line two divisions down (-2.2 dBmV). You will notice the A register red LED is lit. When you display the line, you cannot display the contents of the A register. Data stored in A is not destroyed, but you cannot see it until you turn off the line.

The following steps show another way to set the level of the line:

4. Turn on the marker and set it at the peak of the calibration signal third harmonic.
5. Press **[DSPL] [8]**.
6. Press **[3]** to select DISPLAY LINE TO MARKER.

The spectral display reappears with a horizontal line at the marker position. This provides a convenient way to identify all signals greater or less than another signal. If the marker is not turned on when item 3 is selected, you receive an error message.

7. Press **[DSPL] [8]**.
8. Press **[4]** to select LIMIT DETECTOR.

The end-of-line status indicator changes to OVER; the display line has been made an upper limit. If an on-screen signal goes over the limit, the audio alarm sounds.

9. Press **[DSPL]** to return to the spectral display.

The alarm should be sounding. When the limit detector and the display line are both selected, the marker automatically turns on and moves to the highest signal peak on screen. This feature enables you to quickly read the amplitude of the largest signal after the alarm alerts you that the limit has been exceeded.

10. Press **[DSPL] [8]**.
11. Press **[2]** and enter a new value of 23.8 dBmV for the display line.

The alarm should stop because all signals are now below the limit.

12. Press **[DSPL] [8] [4]**.

The status indicator changes to UNDER. The display line has now changed to a lower limit; the alarm will sound when all signals on screen are under the limit.

13. Press **[DSPL]** to return to the spectral display. The alarm should be sounding.

14. Select the LIMIT DETECTOR once again.

The status indicator changes to OVER-UNDER. The display line becomes an upper limit and the threshold set using the [MKR/FREQ] [0] becomes a lower limit.

15. Press [DSPL] to return to the spectral display.

The limits are indicated by the broken horizontal line. If signals are within the limits, no alarm sounds. The alarm will sound if all signals fall below the lower limit or if one signal exceeds the upper limit.

The limit detecting features are very useful for go/no-go or yes/no type tests. They are especially useful for doing vehicular leakage surveys of cable television facilities. Set the display line to the desired number of dB μ V/m, and when the alarm sounds, note the location and magnitude (using the marker readout) of the leak for later investigation and correction.

Further, the display line/limit detector feature converts the user-definable command WAIT FOR END OF SWEEP to a WAIT FOR LIMIT command (see *USER DEF* on page 6–89). This is a handy way to halt the execution of a user-defined routine until the alarm condition has been satisfied.

If you change the reference level while using the display line/limit detector feature, the line changes position on screen to track the new reference level. Press [▼] next to [REF LEVEL] to observe this. However, the line cannot be moved off-screen. Continue pressing [▼] until the line reaches the top of the screen. You will receive the message DISPLAY LINE OUT OF RANGE.

Lower the line and the message will disappear.

16. Press [DSPL] [8] [4] to turn off the limit detector.

17. Press [1] to turn off the display line.

Activating Minimum Hold

400.0MHz	(AUTO SWEEP)	ATTN 0DB
8.8DBMV		VF WIDE
20MHz/		10 DB/
5MHz RBW (AUTO)		CALIBRATOR

The following procedure describes how to determine the approximate upper and lower bounds on a spectrum by using the MIN HOLD and MAX HOLD features. While MAX HOLD is accessible by dedicated key, MIN HOLD can be accessed only from the Display menu.

1. Press **[DSPL] [9]**.

You will be offered a choice of storage registers for the result of the MIN HOLD process.

2. Press **[W]** to simultaneously start the MIN HOLD process and select the A register for the result (pressing **[X]** or **[Y]** would select the B or C register, respectively, for the result).

This feature is analogous to the MAX HOLD function. Minimum hold compares the amplitude of the current sweep, point for point, with the stored minimum value of previous sweeps. If the current amplitude is less, the current value becomes the new stored minimum.

3. Press **[MAX HOLD] [B]** to accumulate the maximum spectrum amplitude in register B.

With the A, B, and D registers displayed, you have an upper and lower bound on the real-time signal in D. As time passes, you will notice that the upper and lower bounds no longer change, because the probability of new random spectral peaks exceeding those already observed becomes very small.

4. Press **[DSPL] [9]** to turn off the minimum hold feature.

Reselecting MIN HOLD when it is already on toggles the feature off.

5. Press **[MAX HOLD]** to turn maximum hold feature off.

6. Clear and turn off the A and B registers.

APPL

100.0MHz	(AUTO SWEEP)	ATTN 0DB
18.8DBMV		VF 30 KHz
100.0KHz/		10 DB/
30KHz RBW (AUTO)		CALIBRATOR

This menu is not accessible when the 2715 is in the CATV mode. (When the 2715 is in the CATV mode and **[CATV/APPL]** is pressed, the CATV Measurements pages come up on the screen.) Disable the CATV mode by pressing **[CATV/APPL] [8] [0]**.

The Applications menu automates some routine but time-consuming spectral measurements. It enables you to quickly determine the following:

- Signal bandwidths
- Normalized noise amplitudes
- Carrier-to-noise ratios
- Occupied bandwidth
- FM deviation
- Search for signals in a specified frequency range


Most of the items in this menu are toggles that turn the indicated measurement mode on and off. However, you can specify certain measurement parameters using item 9, **SETUP TABLE**. Because several of the measurement modes make use of the markers, you can also exit from those modes by turning off the markers.

One of the items (**SIGNAL SEARCH**) enables the 2715 to automatically detect and catalog any signals within a specified frequency range and above a designated threshold. The signal amplitudes and frequencies are measured, and the results can be displayed on-screen or, if you have a RS-232 port, sent to a printer.

Measuring Signal Bandwidths

The 2715 measures signal bandwidth by detecting the signal peak, and then finding the frequency points on the signal spectrum that are a designated number of dB down from the peak. You specify the number of dB using the Application menu Setup Table. The difference between the frequency points is the bandwidth. Optimum resolution is obtained by spreading the signal across as large a portion of the screen as possible (resolution is essentially plus or minus one frequency cell or 1/512 of the total span in **PEAK** acquisition mode).

For the following example on how to measure signal bandwidths, you need to first change the resolution BW to 300 kHz. This provides a simulated signal several divisions wide and equal to the width of the resolution BW filter.

1. Press **RES BW** [] until RBW readout is 300 kHz.
2. Press [**CATV/APPL**].

Item 0 indicates **BANDWIDTH MODE @ -3 DB**, which means that by selecting this item, the 2715 will measure the bandwidth of a displayed signal at points 3 dB down from its peak amplitude.

To measure the bandwidth at a point other than 3 dB down, do the following steps:

3. Press [**9**] to select **SETUP TABLE** from the Applications menu.

4. Press **[0]** from the Setup Table to display the prompt for a new value.
5. Press **[6] [Z]** to enter a value of -6 dB.
6. Press **[BKSP]** to return to the Applications menu.
7. Press **[0]** to implement BANDWIDTH MODE.

The 2715 returns automatically to the spectral display after you press **[0]**. The delta markers have been activated and bracket the calibration signal peak. If the signal peak is not centered, the 2715 selects the peak nearest center screen.

The first two items in the right on-screen column read as follows:

BW 300KHZ
@ -6DBC

You are measuring the bandwidth of the resolution bandwidth filter. The indicated bandwidth will not be exactly 300 kHz; it will vary slightly about 300 kHz.

8. Press **[▼]** next to **[SPAN/DIV]** until the span readout is 10.0KHZ.
9. Press **RES BW [▼]** until RBW readout is 30KHZ.

The bandwidth should now read approximately 30 kHz.

The 2715 remains in bandwidth mode until you call up the Applications menu and toggle it off, make an alternate selection, or until you turn off the markers.

10. Press **[APPL] [0]** to turn off bandwidth mode.

Measuring Average Noise

100.0MHz	(AUTO SWEEP)	ATTN 0DB
18.8DBMV		VF WIDE
20.0MHz/		10 DB/
5MHz RBW (AUTO)		

Item 2 of the Applications menu causes the 2715 to measure the average noise at the marker location and normalize it to a specified bandwidth. The default bandwidth is 4 MHz, but you can change it to suit your application.

For this example, you need to change the bandwidth to 5 MHz to obtain an approximation of the 2715's noise floor.

1. Press **[CATV/APPL] [9] [2]**.
2. Press **[5] [X]** to enter a value of 5 MHz.

3. Press [**BKSP**] to return to the Applications menu.
4. Press [**2**] again.

The spectral display reappears and the marker is turned on. The first two items in the right on-screen column read approximately as follows.

N-44.2DBMV
@ 5.0MHZ

The reading may vary somewhat, and is the average internal noise in a 5 MHz band at the marker frequency. You may also receive the following warning.

NOISE LEVEL LESS THAN 2DB

This is because the 2715 recognizes when the noise it is measuring approaches its own noise floor. It knows that it cannot accurately measure external signals too close to that value.

5. Press [**DSPL**] and ensure that item 4 is set to MAX/MIN display mode.
6. Press [**DSPL**] to return to the spectral display.
7. Turn the **FREQ/MKRS** knob to reposition the marker at the bottom of the displayed noise.

Notice that the noise amplitude readout does not change significantly.

The noise amplitude appears to be approximately halfway between the maximum and minimum values of the spectral display. This is because the 2715 does not compute the arithmetic mean of the minimum and maximum values using decibels (that yields an incorrect answer). The display does not change, but you may notice a pause while the 2715 carries out the noise measuring algorithm. First, the 2715 measures the average noise power in ZERO SPAN using a narrow bandwidth video filter (see a better approximation of the average noise by pressing [**VID FLTR**]). It then corrects the measured value for the difference between average and RMS amplitudes. More corrections are added for the effects of log amplification and to account for the equivalent noise bandwidth of the resolution bandwidth filter not being exactly 5 MHz. The resulting noise is then normalized to the specified bandwidth.

8. Turn off the markers and the video filter.

Measuring Carrier-to-Noise Ratios

To demonstrate the carrier-to-noise (C/N) ratio feature of the 2715, we will measure the calibrator-to-2715-noise-floor ratio in a 5 MHz bandwidth. However, you are more likely to measure a carrier peak to system noise ratio, but the technique is the same.

9. Press [**INPUT**] [**9**] to turn on the calibrator.
10. Press [**CATV/APPL**] to call up the Applications menu.

11. Press [9] to select the Setup Table.
12. Press [1] to select NORM BW FOR C/N.
13. Press [5] [X] to enter 5 MHz for the noise bandwidth for the carrier-to-noise (C/N) measurement.
14. Press [BKSP] to return to the Applications menu.
15. Press [1] to turn on the C/N feature.

The spectral display reappears with the fixed marker on top of the 100 MHz signal peak (the 2715 places the fixed marker on the signal peak nearest the center of the screen in the C/N mode). The moveable marker appears 1 division from the left screen edge.

16. Reposition the moveable marker 50 MHz above the signal.

***NOTE.** The moveable marker is initially positioned only to clearly separate it from the fixed marker. You must place the noise marker at the frequency where you want the noise measured.*

The first two items in the right on-screen column read approximately as follows:

**C/N 63.0DB
@ 5.0MHZ**

The reading may vary slightly. You will also receive the NOISE LEVEL LESS THAN 2DB warning.

The C/N reading is the ratio of the signal power at the fixed marker's position to the average noise power at the movable marker position. The noise reading is corrected as indicated in the normalized noise measurement section. Since the noise level measured earlier was approximately -44.2 dBmV and the signal peak is 18.8 dBmV, the ratio should be approximately 63 dB.

The preamplifier discussed with the INPUT menu in this section can be very important when making noise or C/N measurements in broadband networks. For instance, in the U.S., good cable television operating practice requires that the video signal be at least 0 dBmV while picture quality requires the noise to be approximately 43 dB lower, or approximately -43 dBmV in a 4 MHz band.

17. Press [CATV/APPL] to call up the Applications menu.
18. Press [9] to select the Setup Table.
19. Press [1] to select NORM BW FOR C/N.

- 20. Press [4] [X] to reset the noise bandwidth to 4 MHz for the carrier-to-noise (C/N) measurement.
- 21. Press [BKSP] to return to the Applications menu.
- 22. Press [2] to turn on the NOISE NORM'D feature.

Notice the measured noise is approximately -42 dBmV.

If we connected the 2715 to a cable television tap with a 0 dBmV video signal and a 43 dB C/N, we would be unable to measure the noise or C/N because the cable noise (-43 dBmV in this example) is below the normal 2715 noise floor.

- 23. Press [INPUT] [9] to turn off the calibrator.
- 24. Press [INPUT] [1] to turn on the preamplifier.
- 25. Press [INPUT] [5] [0] [y] to set the RF attenuation to zero.

Notice that the 2715 noise floor has been reduced by over 12 dB to approximately -55 dBmV, making it possible to measure both noise and C/N on our hypothetical cable.

- 26. Turn off the preamp and noise measurement mode.
- 27. Press [UTIL] [1] [1] to reinitialize the 2715 to the factory default power-up settings.

NOTE. If the 2715 is in the PEAK acquisition mode, it reverts to MAX/MIN mode whenever the normalized noise or carrier-to-noise features are activated. You can return it to PEAK mode by pressing [DSPL] [4].

Searching for Signals

900.0MHz	(AUTO SWEEP)	ATTN 50DB
68.8DBMV		VF WIDE
180MHz/		10 DB/
5MHz RBW (AUTO)		

The 2715 provides a signal search feature that enables you to detect signal peaks over a wide frequency range while still using a narrow span and/or resolution BW. The 2715 sequentially implements a series of searches using the marker peak find capability and the span and resolution BW that you specify using the Signal Search menu. Each search range is equal to 10 times the specified span/div, but each search range except the first overlaps the previous range by one division.

The first search starts at the beginning frequency and the last stops at, or overlaps, the end frequency as indicated in Figure 6–10. Although the last search range may overlap the end frequency, no signals are reported above the end frequency. A verification process looks at the entire range twice and reports only those signals which are present both times.

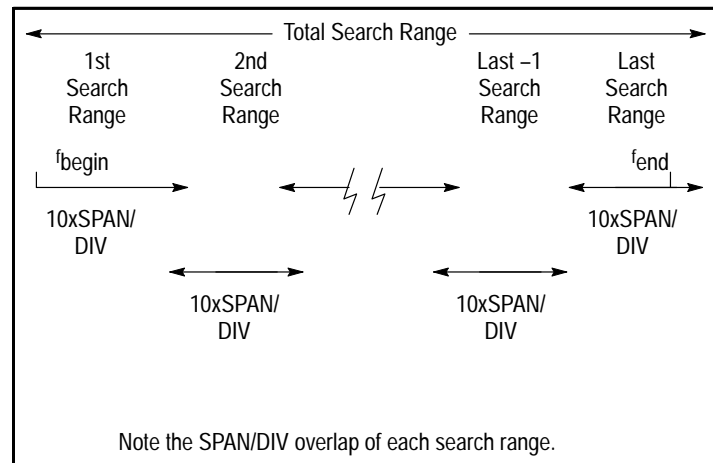


Figure 6–10: The SIGNAL SEARCH Frequency Range

To see how SIGNAL SEARCH works, reset the following 2715 controls to search the frequency range from 55 to 550 MHz.

SPAN/DIV	5.0MHz
RESOLUTION BW	300.0KHz
REFERENCE LEVEL	28.8DBMV
VIDEO FILTER	300.0KHz

1. Press **[INPUT] [9]** to turn on the calibrator.
2. Press **[CATV/APPL]** twice.
3. If in CATV MEASUREMENTS mode, press **[8] [0]**.
4. Press **[CATV/APPL] [3]** to select the SIGNAL SEARCH menu.
5. Press **[0]** to select BEGIN FREQ.
6. Press **[5] [5] [X]** to enter 55 MHz.
7. Press **[1]** to select END FREQ.

8. Press [5] [5] [0] [X] to enter 550 MHz.

The frequency and amplitude of all signals within the specified frequency range that are below the reference level but above the threshold will be stored. The threshold is normally set by the 2715 at approximately one division above the lowest signal peaks (usually noise), but you can reset it manually if desired with [MKR/FREQ] [0]. See *Setting the Signal Threshold* on page 6–22 for details.

9. Press [2] to start the test.

The measurement parameters change, and the message SIGNAL SEARCH IN PROCESS is displayed while the search is occurring. The center frequency will change as each search range is completed. When the search is complete, the message disappears and the 2715 is reset to its original measurement parameters.

10. Press [UTIL] [4] [2] to select PRINTER CONFIGURATION from the SYSTEM CONFIGURATION menu.

11. Press [0] until the status indicator reads CRT (this feature is explained in the UTIL discussion on page 6–60).

12. Press [UTIL].

13. Press [CATV/APPL] [3] to reselect the SIGNAL SEARCH MENU from the Application menu.

Notice that the number of signals detected is displayed at the end of item 3, DISPLAY RESULTS.

14. Press [3].

The SIGNAL SEARCH RESULTS table appears. Five signals are listed (the calibration signal fundamental and its first four harmonics). The amplitude and frequency of each are indicated.

15. Press [CATV/APPL] twice to return to the spectral display.

Measuring Occupied Bandwidths (OBW)

900.0MHz	(AUTO SWEEP)	ATTN 50DB
68.8DBMV		VF WIDE
180MHz/MAX		10 DB/
5MHz RBW (AUTO)		

Measuring occupied bandwidths is similar to measuring signal bandwidths, except that the 2715 determines the bandwidth that contains n% of the signal's energy rather than the bandwidth enclosed by the x dB down points.

To determine the occupied bandwidth, the 2715 first sums the signal power in all 512 frequency cells of the displayed spectrum, ignoring any contributions more than 40 dB below the signal peak. (This is the total displayed signal power, P_t .) It then sums the power in the cells starting at the left-hand edge of the screen until the accumulated power equals or exceeds the following:

$$P_t \times \frac{1}{2} \left(1 - \frac{n}{100}\right)$$

P_t = total signal power

n = percentage of signal power within the occupied BW

It then performs a similar calculation starting at the right-hand screen edge. That is, it finds the frequency cells, both above and below the signal, beyond which half the power not-in-the-occupied bandwidth resides. The frequency difference between the upper and lower cells is the $n\%$ occupied bandwidth.

For instance, if you specify the 90% occupied bandwidth, the 2715 first computes the total signal power. Next, it sums the signal power in the cells starting at the left-hand edge until it accumulates 5% of the total. (The percent signal power not-in-the-occupied bandwidth is $(100\% - 90\%) = 10\%$, and half of it is below, and half above, the occupied BW). See Figure 6–11.

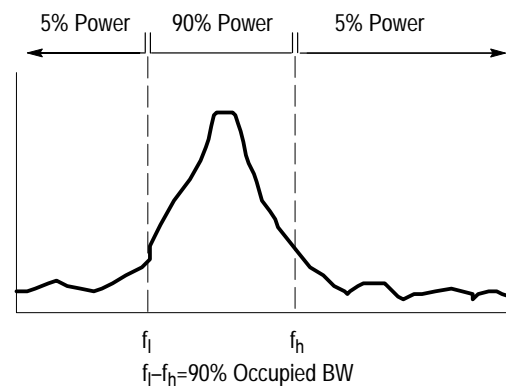


Figure 6–11: Illustration of Occupied BW Measurement

If the accumulated power does not precisely equal half the power not-in-the-occupied bandwidth (the usual case), the 2715 linearly interpolates between frequency cells to arrive at better frequency estimates.

NOTE. The occupied bandwidth mode always works on the digitally sampled signal. Therefore, different results can be obtained in PEAK and MAX/MIN modes unless video filtering is used to minimize post-detection noise.

You can demonstrate occupied bandwidth mode using a broadcast signal:

1. Connect a short antenna or CATV tap to the 2715 input as outlined in *Appendix B: Broadcast AM, FM, and TV Signal Sources*.
2. Ensure that the calibrator is turned off.
3. Adjust the reference level until you can see individual FM broadcast or TV sound carrier signal peaks.
4. Tune the 2715 until a strong signal is centered. Your display might resemble Figure 6–12.

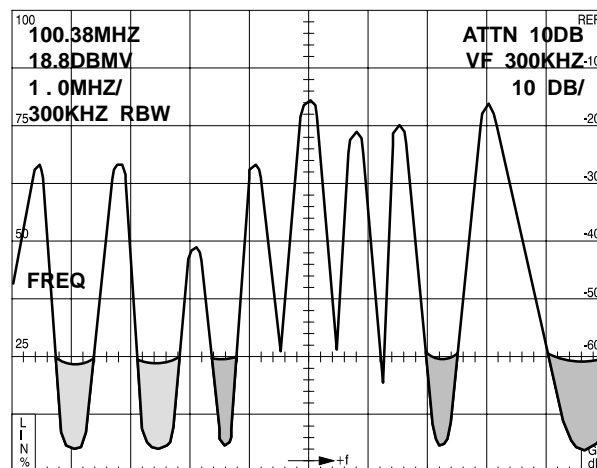


Figure 6–12: Portion of U.S. Broadcast FM Band

5. Press [CATV/APPL] to return to the Applications menu.
6. Press [4] to select OCCUPIED BW.
The spectral display reappears with both markers active.
7. Set the span to 25 kHz/div, and recenter the signal, if necessary.
The right-hand data column will display something similar to the following.

**OBW 57.36KHZ
@ 90%**

Because the signal varies considerably from sweep to sweep, the markers jump around the screen and you will not get a consistent occupied BW reading.

8. Activate MAX HOLD in register B and turn off register D.

Remember that the markers are present only on the highest priority waveform. In a short time a broad spectral peak develops, and the OBW reading begins to settle to a constant value. Figure 6–13 shows a typical MAX HOLD waveform from an FM stereo broadcast. The relatively sharp skirts near ± 70 kHz denote the upper and lower limits of frequency deviation.

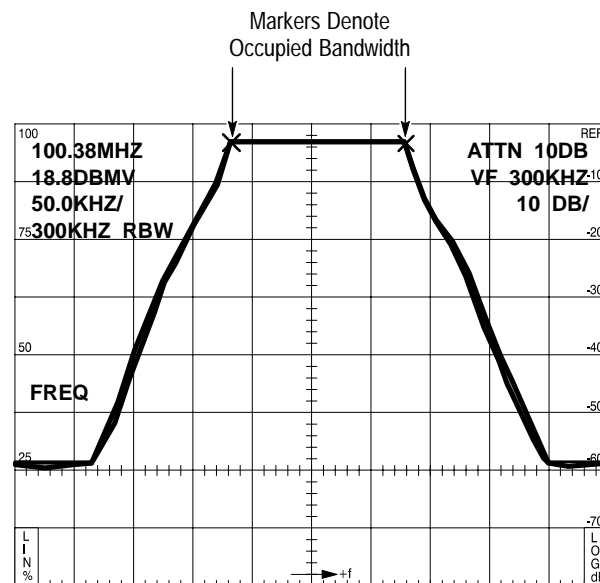


Figure 6–13: OCCUPIED BW Mode with MAX HOLD

To obtain best frequency accuracy when making occupied BW measurements, as with signal bandwidth measurements, use small spans/division (spread the signal over as much of the screen as possible) subject to the following limitations:

- The signal spectrum at the edges of the screen should be down at least 40 dB from its peak
- The signal peak should be at least 40 dB greater than the displayed noise
- The resolution bandwidth filter must be 1/5 or less of the occupied bandwidth — a resolution bandwidth filter that is too wide will artificially broaden the occupied bandwidth (remember how the 5 MHz resolution bandwidth filter made the calibrator signal look like it is 5 MHz wide)
- Only vertical scales of 5 or 10 dB/div can be used

- There should be no signal on-screen except the desired signal; other signals, including the zero hertz spur, will contribute some inaccuracy

For optimum amplitude accuracy, keep the signal peak near the reference level.

9. Press [**APPL**] [**4**] to turn off OCCUPIED BW (or turn off all display registers).
10. Turn off MAX HOLD A & B and register B.
11. Turn register D back on.

Viewing Instantaneous Frequency Deviation

100.0MHz	(AUTO SWEEP)	ATTN 0DB
18.8DBMV		VF 300KHz
1.0MHz/		10 DB/
300KHz RBW (AUTO)		

Normally, the display you see on the 2715 represents the input signal after it has been AM detected. The result is a conventional spectral display of signal power vs. frequency. However, by selecting FM DEVIATION MODE, you can view instantaneous frequency variations vs. time.

1. Connect a short antenna or CATV tap to the 2715 input as outlined in *Appendix B: Broadcast AM, FM, and TV Signal Sources*.
2. Ensure that the calibrator is turned off.
3. Adjust the reference level until you can see individual FM broadcast or TV sound carrier signal peaks.
4. Tune the 2715 until a strong signal is centered.

Your display might resemble Figure 6–12 on page 6–52.

5. Press [**SPAN/DIV**] [**1**] [**0**] [**0**] [**Y**] to change the span to 100 kHz/div.
6. Press [**CATV/APPL**] [**7**] to select FM DEVIATION MODE from the Applications menu.

The 2715 reverts to a waveform display mode in zero span. The bottom line of the right column reads as shown below:

FM 10 KHz/

This indicates that FM demodulation is now being used and that the vertical scale factor has changed to 10 kHz/division. The vertical axis now measures frequency deviation. The sweep being displayed should resemble the upper trace in Figure 6–14. It is an approximate indication of the instantaneous frequency deviation.

The vertical scale can be changed in a 10-5-1 kHz/div sequence.

7. Repeatedly press [10/5/1] to cycle through the frequency deviation scales; set the vertical scale to 10 kHz/div.
8. Press [DSPL] [9] [W] to select MIN HOLD IN WFM A.

Let the data accumulate for two to three minutes. A ragged horizontal waveform develops indicating the maximum frequency excursions during the observation period.

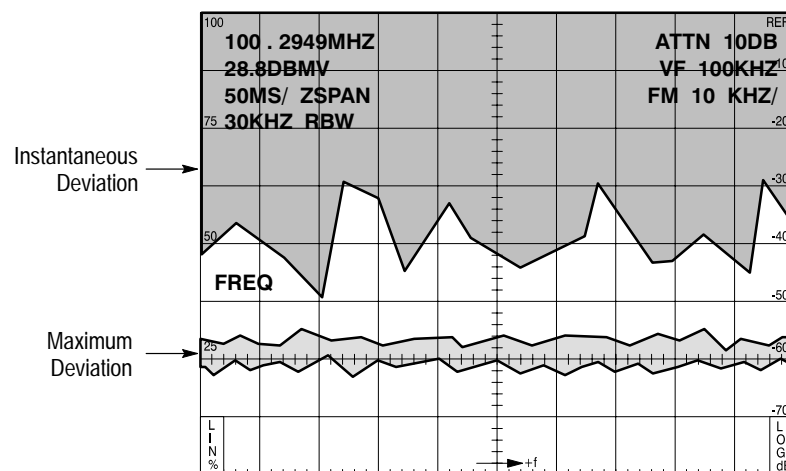


Figure 6–14: Instantaneous Frequency Deviation and Maximum Observed Deviation

The following steps show how to read out the frequency deviation with the marker:

9. Press [MKR/Δ/OFF] to turn the marker on.
10. Turn off all registers except register A.
11. Use the **FREQ/MKRS** knob to move the marker to the point where you want the measurement.

NOTE. Because of the FM demodulator bandwidth, the modulating signal used in the deviation monitor mode should consist of normal program material or a single tone in the audio frequency range.

The foregoing technique provides a quick look at unidirectional frequency deviation. The carrier frequency is at the reference level, and a downward excursion represents a deviation below the carrier. If the FM spectrum is symmetrical, the peak-to-peak deviation is twice the unidirectional amount. In the example above, 7 divisions is 70 kHz (at 10 kHz/div), and the peak-to-peak deviation is approximately 140 kHz.

To see the deviation in both directions, try the MAX HOLD technique outlined in *Measuring Occupied Bandwidths* on page 6–50. For extremely accurate deviation measurements, the Bessel null approach should be used; see Tektronix application note 26W-7037-1, *Spectrum Analyzer Fundamentals*.

DEMODO

100.0MHz	(AUTO SWEEP)	ATTN 0DB
18.8DBMV		VF 300KHz
1.0MHz/		10 DB/
300KHz RBW (AUTO)		

The DEMODO menu provides a means of listening to AM or FM modulation on the signals being analyzed and activating the video monitor mode.

Listening to FM Transmissions

Listening to signals often helps to identify the source. A built-in speaker is provided, but if higher fidelity is needed, or if you are using the 2715 in a noisy location, headphones can be used. A 1/8 inch miniature phone jack is located near the front of the right side of the 2715.

1. Connect a short antenna or CATV tap to the 2715 input as outlined in *Appendix B: Broadcast AM, FM, and TV Signal Sources*.
2. Ensure that the calibrator is turned off.
3. If necessary, adjust the reference level until you can see individual signal peaks in the 88 to 108 MHz FM broadcast band.

If you do not have broadcast FM in your area, you can tune to a TV station audio carrier.

4. Tune the 2715 until a strong signal is centered.

5. Press [**DEMOD**].
The DEMOD/TG menu appears.
6. Press [**2**] to select FM DEMODULATOR.
The LED adjacent to FM VOL on the front panel lights, the spectral display reappears, and you may hear the 2715 sweeping.
7. If you hear nothing, turn the outer barrel of the **LEVEL** control clockwise to increase the volume.
8. Press [**ZERO SPAN**] to hear whatever is being transmitted by the station.
9. Leave the 2715 in zero span, and turn the **FREQ/MKRS** knob to tune it as you would a radio receiver. The signal level rises as you tune in stations and falls to the noise floor when no station is present.
10. Press [**DEMOD**] [**0**] to turn off the FM demodulator.
11. Press [**ZERO SPAN**] to return to the normal spectral display.

Listening to AM Transmissions

To listen to AM transmissions, connect an antenna to the 2715 as outlined in *Appendix B: Broadcast AM, FM, and TV Signal Sources*. The antenna will probably need to be much longer than for FM.

12. Press [**CHAN/FREQ**] [**1**] [**X**] to set the center frequency to 1 MHz.
13. Press [**SPAN/DIV**] [**1**] [**0**] [**Y**] to set span to 10 kHz/div.
14. Ensure **RES BW** and **SWEEP** are set to **AUTO**.
15. Ensure that the calibrator is turned off.
16. If necessary, adjust the reference level until you can see signal peaks in the 500 kHz to 1.6 MHz area (this is the medium-wave broadcast band).
17. Tune the 2715 until a strong signal is centered.
18. Press [**DEMOD**].
The DEMOD/TG menu appears.
19. Press [**1**] to select AM DEMODULATOR.
The LED adjacent to AM VOL on the front panel lights, and the spectral display reappears.
20. Press [**ZERO SPAN**] and adjust the **LEVEL** control as needed until you hear whatever is being transmitted by the station.

21. Leave the 2715 in zero span, and turn the **FREQ/MKRS** knob to tune it as you would a radio receiver. The signal level rises as you tune in stations and falls to the noise floor when no station is present.
22. Press [**DEMOD**] [**0**] to turn off the FM demodulator.
23. Press [**ZERO SPAN**] to return to the normal spectral display.

Listening to AM or FM Transmissions

To hear AM and FM stations, select AM DEMODULATOR and FM DEMODULATOR simultaneously (both AM VOL and FM VOL LEDs will light). This approach is convenient if you do not know whether the signal is AM or FM, or for simply finding audio modulated signals and then switching on only the AM or FM demodulator to determine which type of modulation is being used.

Video Demodulation

100.0MHz	(AUTO SWEEP)	ATTN 0DB
18.8DBMV		VF 300KHz
1.0MHz/		10 DB/
300KHz RBW (AUTO)		

The video demodulator enables you to view broadcast or satellite video transmissions. This is useful for identifying signals and determining the nature of interference.

1. Press [**DEMOD**] to call up the DEMOD/TG menu.

Item 3 is an on/off toggle that may indicate BROADCAST (AM) VIDEO or SATELLITE (FM) VIDEO, depending on the mode that was last selected. The BROADCAST mode is used for off-air or cable TV signals; SATELLITE is used, for example, when viewing FM video signals at the output of a block down converter (LNB). In the following example we will use the AM monitor mode to view an off-air or cable TV signal. First, here is some information to keep in mind:

- The carrier-to-noise ratio must be sufficiently large (at least 30 dB in a 4 MHz bandwidth in BROADCAST mode, 10 dB in a 30 MHz bandwidth in SATELLITE mode), but it is possible to get a poor quality display at slightly lower C/N's
- You will not be able to satisfactorily monitor scrambled or sync-less signals in either mode
- The video carrier in either mode should be placed at the reference level for satisfactory operation
- Energy dispersal dithering is generally not a problem in the SATELLITE mode

2. Press [9] to select VIDEO MONITOR SETUP from the DEMOD/TG menu.
3. Press [0] to toggle VIDEO DETECT MODE to BROADCAST.
4. Toggle items 1 and 2 to the proper polarities. If you do not know the polarity, set SYNC POLARITY to POSITIVE and VIDEO POLARITY to NEGATIVE.

These are the standards for normal U.S. broadcast television. You can change them later to accommodate other standards if the video is inverted or sync cannot be achieved.

5. Press [DEMOD] to return to the spectral display.
6. Ensure that the calibrator is turned off.
7. Connect a short antenna or CATV tap to the 2715 input as outlined in *Appendix B: Broadcast AM, FM, and TV Signal Sources*.
8. Tune to a strong video carrier (choose an unscrambled channel).
9. Adjust the reference level until the signal peak is at the top line. The signal level is very important for proper performance³ and must also be well above the noise floor.
10. Press [DEMOD] [3] to select BROADCAST (AM) VIDEO.

When item 3 is activated, the 2715 presets a number of measurement parameters in order to generate a TV picture. You may be able to obtain a slightly better picture by changing some settings.

11. Experiment with the following controls:
 - **REF LEVEL** (use the 1 dB step size) — adjust for best display
 - **INTENSITY** — adjusts contrast
 - **LEVEL** (outer knob) — changes vertical size and adjusts for a flicker-free display
 - **SWEEP** arrow keys — changes horizontal size

12. Press [DEMOD] [3] to turn off the BROADCAST (AM) VIDEO.

When the monitor is disabled, the settings used prior to entering monitor mode are restored; any changes you have made while using the video monitor are overwritten.

13. Press [UTIL] [1] [1] to initialize your instrument.

³ This can be conveniently done by placing the marker on top of the video carrier and selecting item 3, **MARKER TO REFERENCE LEVEL**, from the MKR/FREQ menu.

UTIL

The Utility menu provides access to system configuration and initialization features, front-panel settings and waveform storage facilities, instrument normalization and diagnostics, and miscellaneous other functions. Some of the selections within the Utility menu and its submenus are used by service personnel to troubleshoot the 2715. Therefore, not all selections are discussed here.

If the instrument is not already initialized to factory settings, press **[UTIL] [1] [1]**.

Menu-Entered Control Settings

900.0MHz	(AUTO SWEEP)	ATTN 50DB
68.8DBMV		VF WIDE
180MHz/MAX		10 DB/
5MHz RBW (AUTO)		

Although the 2715 controls are most conveniently activated or set using the dedicated front-panel controls, the Utility menu provides a method of setting all the major control functions from a single submenu. This feature is especially useful when you are setting up a new measurement and know ahead of time how the 2715 is to be configured. The following example uses the Utility menu to reset the center frequency, reference level, and span. You could also set the resolution BW, video filter, vertical scale, and sweep rate.

1. Press **[INPUT] [9]** to turn on the calibrator.
2. Press **[UTIL] [2]** to select the KEYPAD ENTERED SETTINGS from the Utility menu.

This item enables you to set instrument controls to specific values from a single menu without having to use the front-panel controls.

3. Press **[0]** to select FREQUENCY.
4. Press **[1] [0] [0] [X]** to enter a value of 100.000 MHz for the center frequency.

The Keypad Entered Settings menu shows the frequency to three decimal places, whereas the on-screen readout displays the specified frequency from zero to four decimal places depending on the span. Both values are truncated figures, but the 2715 still controls the frequency to the nearest hertz specified. The number of decimal places in the on-screen readout is commensurate with the screen resolution at the selected span.

You can also enter decimal values for the reference level and span.

5. Press **[1]** to select REFERENCE LEVEL.

6. Press **[2] [4] [.] [5] [2] [Y]** to enter 24.52 dBmV.

The 2715 rounds and stores the reference level to one decimal place (0.1 dB).

7. Press **[2]** to select SPAN/DIV.

8. Press **[2] [2] [.] [6] [8] [3] [2] [X]** to enter 22.6832 MHz/division.

The span is rounded and stored to three decimal places, but in the spectral display the span is shown rounded to one place.

Leave the remaining parameters set as they are, but note the following settings:

- RF attenuation can be set to AUTO (the default), or fixed from 0 to 50 dB in 2 dB step
 - The resolution bandwidth can be set to AUTO (the default), 300 Hz, 1 kHz, 3 kHz, 10 kHz, 30 kHz, 100 kHz, 300 kHz, 1 MHz, or 5 MHz — if you enter another value, the 2715 will convert it to the nearest available value
 - This menu provides the only method of manually setting the video filter bandwidth. The video filter bandwidth can be set to AUTO (in which case it is 1/100 of the resolution bandwidth in normal mode) or fixed from 3 Hz to 300 kHz in a 1–3 sequence (3 Hz, 10 Hz, ...100 kHz, 300 kHz); other values will be converted to the nearest allowable values
 - Selecting item 6, VERTICAL SCALE, calls up another menu that enables you to select any of the normal values of 10 dB/div, 5 dB/div, 1 dB/div, or Linear
 - Sweep rate can be set from 1 μ s/div to 2 s/div in a 1–2–5 sequence. Other values will be converted to the nearest allowable value. Rates faster than 100 μ s/div can be used only with analog displays (that is, with display storage turned off)
9. Press **[UTIL]** to return to the spectral display and view the screen you have created.
10. Press **[UTIL] [2]** to return to the KEYPAD ENTERED SETTINGS menu.
11. Press **[2] [2] [0] [X]** to enter a span/div of 20 MHz.
12. Press **[1] [2] [8] [.] [8] [Y]** to enter a reference level of 28.8 dBmV.
13. Press any menu button to restore the spectral display.

Save and Recall Settings and Displays

The 2715 enables you to save and recall up to 36 sets of control settings and any saved displays that accompany them. These are in addition to the factory default power-up settings that are permanently stored in the instrument. The 2715 also automatically saves the settings/displays in use (in location 0) when it is powered down. You can manually save up to 35 additional setting/display groups, and designate one group as the power-up settings.

A general word of caution: the 2715 will not allow you to destroy a display currently saved in registers A, B, or C. If you attempt to recall settings (with or without corresponding displays), you will receive the message CANNOT OVERWRITE SAVED DISPLAY.

The settings will be recalled along with any displays saved in registers A, B, or C that are not currently saved, but currently saved registers will not be overwritten. To recall a previously saved display, first unsave its destination register.

Recall Last Power-Down Settings

The following example demonstrates the ability the 2715 has to recall the last settings in effect before the power was turned off:

14. Turn off the 2715 and then turn it on again.
15. Press [UTIL] call up the Utility menu.
16. Press [1] to select STORED SETTINGS/DISPLAYS.
17. Press [0] to select LAST POWER-DOWN.
18. The settings that were in effect the last time power to the 2715 was turned off are immediately recalled.

User-Defined Power-Up Settings

100.0MHz	(AUTO SWEEP)	ATTN 0DB
18.8DBMV		VF WIDE
20.0MHz/		10 DB/
5MHz RBW (AUTO)		CALIBRATOR

The following examples describe using the user-defined power-up settings:

1. Press [UTIL] to call up the Utility menu.
2. Press [1] to select STORED SETTINGS/DISPLAYS.
3. Press [2] to select USER DEFINED POWER-UP.
4. Following the prompt, press [X] to store the current settings.

You are warned if other settings are already stored as the user-defined power-up. If there are old settings, you must delete them before you can store the current settings.

- a. To delete old settings, press **[Y]**, and then **[W]** to confirm the deletion. Then store the current settings.

5. Turn the instrument power off and back on.

During the standby period, the factory default power-up settings are displayed, but immediately afterwards the settings you just stored are automatically implemented.

At power-up the 2715 restores the user-defined power-up settings, if they exist, following the standby period. If they do not exist, it uses the factory default settings. If the user-defined power-up settings include a narrow span, the NORMALIZATION SUGGESTED message may appear. The message should disappear following warmup as soon as you use a control.

Other User-Defined Settings

The remaining items on the Stored Settings/Displays menu can be used exactly as you used USER DEFINED POWER-UP SETTINGS. The difference is that they are not automatically implemented at power-up time, or by the initialization selection; they must be recalled from the Stored Settings/Displays menu.

6. Press **[INPUT] [9]** to turn on the calibrator.
7. Press **[CHAN/FREQ] [9] [0] [X]** to change the frequency to 90 MHz.
8. Press **[REF LEVEL] [3] [8] [.] [8] [Y]** to set the reference level to 38.8 dBmV.
9. Press **[DSPL] [1]** to select ENSEMBLE AVERAGING.
10. Press **[4]** to select MEAN.
11. If the number of averages is not set to 16, press **[7]** and set number to 16.
12. Press **[8]** repeatedly until A register is selected.
13. Press **[1]** to save a 16 sweep ensemble mean in register A.
14. Press **[MAX HOLD] [B]**.
15. Press **[SAVE ENABLE] [B]** to save the max hold values in register B.
16. Press **[INPUT] [9]** to turn off the calibrator.
17. Press **[UTIL]** to call up the Utility menu.
18. Press **[1]** to select STORED SETTINGS/DISPLAYS.

Notice that settings 3 through 8 are blank⁴, and item 9 indicates MORE.

There are, in fact, 34 fields (in addition to last power-down and user-defined power-up) contained on 4 menu pages in which you can save stored settings and displays.

19. Repeatedly press [9] to advance to page 4.

20. Press [BKSP] three times to back up to the first page.

The register locations currently being displayed are indicated at the top right of each page (R00–R08, R10–R18, R20–R28, R30–R39).

21. Press [3] [X] to store the settings you entered earlier in the register 3 location (if there is a setting already present, delete it or use another location).

22. Unsave the A and B registers, and turn them off. (If you do not, the CANNOT OVERWRITE SAVED DISPLAY message is displayed when you try to recall settings.)

23. Press [MAX HOLD] to turn it off.

24. Press [UTIL] [1] [2] [W] to reinitialize the 2715 to your user-defined power-up settings.

25. Press [UTIL] [1]. Item 3 reads as follows:

AB 90MHZ 38.8DBMV 20MHZ

This message shows the primary control settings that are saved in that location and tells you register A and B waveforms are saved along with the settings.

26. Press [3] [W].

The control settings and the saved waveforms are both restored. Whenever you save settings (including LAST POWER-DOWN and USER DEFINED POWER-UP), you also store the contents of digital storage registers A, B, and C.

You can store up to 108 waveforms as well as 36 groups of settings (actual numbers depend on what else, such as user-defined programs, is being stored). Furthermore, this information is saved even after the power is turned off. You can do things like record waveforms in the field and bring them back to the lab with you for further analysis or permanent recording, or store reference waveforms in the lab for comparison in the field.

⁴ If your instrument has been used previously, you may find that some or all of the items already contain saved settings and displays.

You can also store settings and waveforms by title as follows:

1. Using the Display menu, create a title for the current display (see *Adding Titles and Labels* on page 6–36). Call it MY SETTINGS. Turn on title mode and return to the spectral display.

2. Press [UTIL] [1] [4] [X].

This saves the settings under item 4 of the Stored Settings/Displays menu.

3. Press [UTIL] [1].

Item 4 on the menu is now MY SETTINGS. The settings are recalled like any other, but the title often helps remind you what the settings are used for.

Normalizing the 2715

NOTE. Any control settings can be used.

Normalization is a set of procedures contained in ROM that calculate gain and frequency characteristics of the circuits in the 2715 based on the built-in 100 MHz, 18.8 dBmV calibrator signal. The characteristics must be accurately known to correctly scale and display the analyzed signal. The normalization values are stored in non-volatile memory (NVRAM). Using external signals to achieve even greater measurement accuracy, or to renormalize the reference if NVRAM should ever be lost is described later in *Service Normalizations* on page 6–80.

If the 2715 self-test routine detects that the present 2715 gain or frequency characteristics differ significantly from those determined during the previous normalization, the NORMALIZATION SUGGESTED message is displayed on the screen. You should then perform a normalization, although the 2715 remains useable for relative measurements. The NORMALIZATION SUGGESTED message may also appear while the 2715 is warming up, especially if the user-defined power-up settings include a narrow span. This is normal, and you need not perform a normalization unless the message persists beyond the warm-up period. Any time you require the utmost accuracy, we recommend a normalization first.

Normalization may be required because of any of the following:

- Circuit or component variation with time (drift)
- Large temperature difference from that at which previous normalization was carried out
- Nonvolatile memory (NVRAM) is lost for any reason

Always perform the normalizations in environments, especially temperatures, like those in which the subsequent measurements will be carried out. Also, remove any input signals from the 2715 before performing amplitude or frequency normalizations. Although we recommend that you wait a full 15 minutes after power-up before making measurements with the 2715 (it is within advertised specifications by then), it is possible to make them shortly after power-up. If you must make measurements immediately after the instrument is turned on and the NORMALIZATION SUGGESTED message is on screen, carry out a normalization directly. Note, however, that if you do so, the 2715 may require renormalization after it is fully warmed up.

1. Press [UTIL] to call up the Utility menu.
2. Press [3] to select NORMALIZATIONS.

The Normalizations menu enables you to normalize amplitude parameters (AMPLITUDE ONLY), the frequency parameters (FREQUENCY ONLY), or both (ALL PARAMETERS). It takes longer for amplitude normalization than for frequency normalization, and several minutes for both. Routinely select ALL PARAMETERS to ensure the 2715 measures amplitude and frequency as accurately as possible, but if you are in a hurry, you can select only the parameters that are most important to your measurements.

3. Disconnect all signals from the 2715 input.
4. Press [0] to select ALL PARAMETERS.

Typically, you will see a number of changing waveforms and messages on screen telling you which normalizations are being carried out. However, if NVRAM is ever lost, the factory reference normalizations are lost with it (see *If You Lose NVRAM* on page 6–81). Then, regardless of which normalizations you are carrying out, you will receive the following message.

**** ONE OR MORE REFERENCE NORMALIZATIONS HAS NOT BEEN PERFORMED.**

**** FOR OPTIMUM ACCURACY, REFERENCE NORMALIZATIONS MUST BE DONE**

**** CONSULT MANUAL FOR PROCEDURE**

PRESS “W” TO CONTINUE

PRESS “Z” TO ABORT

5. If you have facilities to carry out the reference normalizations (see *Service Normalizations* on page 6–80), abort this process and perform the reference normalizations before continuing. Otherwise, press [W] to continue.

A recently normalized instrument is more accurate than one that is not normalized, even if the references have not been normalized.

The normalization process completes without further operator intervention. When it is complete, a beep sounds if the audio alert is enabled (see *The Audio Alert* on page 6–71) and the following message appears:

NORMALIZATION COMPLETE

If you receive a message that either frequency or amplitude normalization failed, try the procedure again. The spectral display reappears automatically upon completion of normalization. In case of repeated failures, contact your local Tektronix Service Center or representative.

System Configuration

All configuration settings selected in the UTIL menu are retained in NVRAM until you change them. The System Configuration menu offers nine choices.

1. Press [UTIL] to call up the Utility menu.
2. Press [4] to select SYSTEM CONFIGURATION.

Configuring the Communications Port

The 2715 is provided with a digital communications port to exchange data and commands with an external instrument controller or a printer/plotter. Either an RS-232 Interface (Option 08) or an IEEE 488 General Purpose Interface Bus (GPIB) port (Option 03) is available. The RS-232 port is modem compatible and makes possible remote operation via a telephone line. Port connectors are located on the rear panel. See *Appendix E: External Input and Output*.

The accompanying Programmer Manual contains additional information about setting up and configuring the 2715 for remote or automated operations and complete explanations of the commands that are used. See the Programmer Manual for additional information.

3. Press [0] to select COMMUNICATION PORT CONFIG.

COMMUNICATION PORT CONFIG displays both GPIB and RS-232 selections regardless of which is installed. You must select whichever one is currently installed in your instrument (check the physical configuration of J104 at the rear panel), See Figures E–3 and E–4 in *Appendix E: External Input and Output* for GPIB and RS-232 connector configurations.

The menu shows the following:

0 GPIB	OFFLINE/ADDR #
2 RS-232	OFFLINE/BAUD RATE

If the GPIB port is currently active, its GPIB address (0 through 30) is displayed at the end of the line. Otherwise, the line ends with OFFLINE.

If the RS-232 port is currently active, its baud rate is displayed at the end of the line (for example, 9600). Otherwise, the line ends with OFFLINE.

RS-232 Configuration.

4. Press [2] to select RS-232 from the COMMUNICATION PORT CONFIG menu.

Several choices are offered; in all cases the 2715 settings must match those used by the controller or printer/plotter.

- Item 0, STATUS, enables you to toggle the RS-232 port on and off line. The port must be on-line to communicate with any other device.
- Item 1, BAUD RATE, cycles through the baud rate of the port. Possible baud rates are:

110	600	4800
150	1200	9600
300	2400	

Normally, you set this parameter to as large a value as possible to speed up data transfer. However, the controller, or the printer/plotter, must support data transfers at the same rate. When 110 is chosen, two stop bits are automatically selected; for any other value, 1 stop bit is automatically selected. The default value is 9600.

- Item 2, DATA BITS, determines the number of data bits per word. The default is 8 bits and is required for binary data transfers. Seven bits can be used for ASCII character transfers.
- Item 3, PARITY, cycles between NONE, ODD, and EVEN. The default is NONE.
- Item 4, EOL, sets the end-of-message designator when a message is sent by the 2715. When a message is transmitted over RS-232, the instrument sending the message signifies that the message has been completed. Item 4 enables you to select CR (carriage return), LF (line feed), or CR LF (both) used to terminate messages sent to the 2715. The default is CR.
- Item 5, FLOW CONTROL, specifies the type of handshaking that will be used. The following three choices are possible (see the Programmer manual for expanded information on these selections):

HARD (RTS/CTS) — The RTS, CTS, DTR lines are used. The DCD and DSR lines are ignored. This mode facilitates binary transfers.

SOFT (XON/XOFF) — XON/XOFF (CTRL Q/CTRL S) protocol is used. Only transmit and receive lines are needed, but RTS and DTR must be forced true. Suitable for use with a modem. However, code conflicts make binary transfers unreliable.

NONE — No flow control is used, but RTS and DTR must be forced true. This is suitable for use with a modem. However, the user is responsible to ensure that data buffers do not overflow.

The default is NONE.

- Item 6, ECHO, is a toggle intended for use with unsophisticated terminals. When ECHO is ON, the 2715 sends the character it has just received back to the terminal screen. CTRL Q and CTRL S are not echoed. The default is OFF.
- Item 7, VERBOSE, is an on/off toggle. When VERBOSE is ON, a response is returned to the controller following each command or query. The response may be an event code, the correct query response, or a simple OK for a completed command not normally requiring a response. When VERBOSE is OFF, only responses to queries are generated. The default is OFF.

GPIB Configuration.

5. Press **[0]** to select GPIB from the COMMUNICATION PORT CONFIG menu. The GPIB Port Configuration menu appears.

Several choices are offered; in all cases the 2715 settings must match those used by the controller or printer/plotter.

- Item 0, STATUS, enables you to toggle the GPIB port on and off line. The port must be on-line to communicate with any other device.
- Item 1, GPIB ADDRESS, specifies the primary address (the 2715 does not support secondary addresses), that can be any value from 0 to 30. When the 2715 is used with a system controller, the value must match that used to configure the controller. Address 0 is usually reserved for the controller itself. When the 2715 is used in the TALK ONLY mode with a plotter, any address can be used. The address you set is read immediately by the 2715 and retained in NVRAM until you change it.
- Item 2, POWER ON SRQ, determines whether a service request (SRQ) is generated at power up. Because there normally is no need for a SRQ at power up, the default setting of item 2, POWER ON SRQ, is OFF. However, in some cases you may want to sense that power has been turned on before continuing your test. For those cases you can toggle the POWER ON SRQ to ON by pressing **[2]**.

- Item 3, EOI/LF MODE, sets the end-of-message designator. When a message is transmitted over the GPIB, the instrument sending the message signifies to other instruments on the bus (including the system controller) that the message has been completed. This can be done in two ways:

The interface management line named End Or Identify (EOI) is asserted (brought to its low state) simultaneously with the last data byte that is transmitted.

The ASCII codes for carriage return (CR) and line feed (LF) are appended to the message; EOI is still asserted simultaneously with the transmission of LF.

All Tektronix instruments and controllers use EOI to terminate messages. You should, therefore, toggle item 3 until the end of the line indicates EOI. The EOI/LF MODE option is included for controllers that do not use the EOI signal line.

- Item 4, TALK ONLY MODE, must be set to OFF when the 2715 is used with a controller, because the controller determines whether the 2715 is talking or listening. If you normally use the 2715 with a controller, set the TALK ONLY MODE to OFF.

However, to send screen plot data directly to a GPIB plotter without a controller, set the TALK ONLY MODE to ON, and disconnect all instruments except the 2715 and the plotter from the bus. Place the plotter in the listen only mode (usually done with controls on the plotter). You can then send screen data from the 2715 to the plotter by pressing **[PLOT]**.

Selecting the Screen Plotter Configuration

Whichever communications port is installed in your 2715, the spectral display and its attendant information can be sent to a printer or plotter by pressing **[PLOT]**, but you must first correctly configure the interface.

To configure the port in your 2715 for use with your particular printer or plotter, select item 1 of the System Configuration menu, SCREEN PLOT CONFIGURATION.

- Item 0, COMM PORT, on the Screen Plot Configuration menu indicates to which communications port the plot is sent. Make the choice based on whether RS-232 or GPIB is installed. See *Configuring the Communications Port* on page 6–67 for more information. However, your print/plot device must also be equipped with a corresponding interface (GPIB or RS-232).
- Item 1, PLOTTER LANGUAGE, cycles through the supported printer and plotter models. Repeatedly select item 1 from the menu. Each time you press **[1]**, the printer or plotter displayed at the end of the line changes. EPSON FX (the default) refers to FX-series printers produced by Epson, and HPGL stands for Hewlett Packard Graphics Language. Stop when the model of your printer/plotter (or the one yours emulates) is displayed.

- Item 2, PLOT SPEED, only appears if a plotter is selected for item 1. Repeatedly select item 2, PLOT SPEED, to cycle through the available speeds of FAST, FASTER, FASTEST, SLOW, and NORMAL (the default). Try the various speeds with your plotter to see which produces the most satisfactory results. Printers do not support these options.
- Item 3, PLOTS PER PAGE, only appears if a plotter is selected for item 1. Repeatedly select item 3 to cycle through the available plots per page.
- Item 4, PLOT POSITION, only appears if 4 PLOTS PER PAGE is selected for item 3. This option enables you to select the quadrant of the paper on which the current plot will be placed. Repeatedly select item 4, PLOT POSITION, to cycle through the available positions.
- Item 5 on the SCREEN PLOT CONFIGURATION menu determines whether or not graticule lines are printed on the hard copy output. Status of the plotted graticule lines is independent of whether the on-screen graticule illumination is on or off. Press [5] to toggle the GRATICULE LINES ON PLOT between ON and OFF.

Selecting the Printer Configuration

All CATV measurements enable you to send ASCII character strings to the CRT or to the optional RS-232 port, if it is installed. You cannot send these strings to a GPIB device.

1. Press [UTIL] [4] to return to the SYSTEM CONFIGURATION menu.
2. Press [2] to select PRINTER CONFIGURATION.
3. Press [0] to select PRINTER DEVICE.

The PRINTER DEVICE will toggle between TTY00 and CRT (TTY00 is functional only if an RS-232 interface is installed in your instrument). If the GPIB option is installed, CRT is always displayed. Select CRT if you want results that would normally be sent to a printer to be displayed on the 2715 screen instead. On-screen display is sometimes not satisfactory if there is more than one screen of data, because only the last screen remains visible.

Instrument Configuration

Item 3, INSTRUMENT CONFIGURATION, of the System Configuration menu enables you to reset internal parameters and conditions. Some of the more useful ones are described in the following subsections.

The Audio Alert

Item 0, AUDIO ALERT, of the Instrument Configuration menu is a four-step sequencer whose status is indicated at the end of the line. You can choose one of the following features:

- OFF — The 2715 creates no audible beeps.
- KEYCLICK ONLY — The 2715 emits a short beep when a key is pressed.

- **ERROR ONLY** — This is the factory default. A beep occurs only when the 2715 issues an alarm, error, or warning message. The alert sounds only once, even if the condition repeats and a displayed message is repeated.
- **KEYCLICK & ERROR** — Combination of **KEYCLICK ONLY** and **ERROR ONLY** modes.

Switch the audio alert to the setting of your choice.

Setting the Minimum Signal Size

Minimum signal size is the smallest amplitude difference that must exist between signal peaks for them to be recognized as separate peaks during Next Higher and Next Lower or Marker arrow operations. It is expressed in bits; full scale being 255 bits. The minimum value is 2 bits; factory default is 20 bits or approximately 8% of full scale (three minor divisions).

1. Press [**1**] to select **MINIMUM SIGNAL SIZE** from the Instrument Configuration menu.
2. Type a new value and enter it by pressing [**W**].
The new value appears at the end of item 1.
3. Experiment if you want, then restore the factory default value.

Sending Waveforms to a Computer

***NOTE.** This feature is used primarily for certain procedures at the factory; we recommend that you leave **WAVEFORM TO PRINTER** turned off.*

Item 2 of the **INSTRUMENT CONFIGURATION** menu, **WAVEFORM TO PRINTER** (**[UTIL] [4] [3] [2]**), sends a binary or ASCII representation of the displayed waveform to the serial port following each sweep. The 2715 must have the RS-232 port installed, and **PRINTER CONFIGURATION** must be set to **TTY00** (**[UTIL] [4] [2] [0]**).

Item 2 toggles data transmission **ON** and **OFF**, and item 3 toggles the data format between **ASCII** and **binary**.

Turning Phaselock On and Off

100.0000MHz	(AUTO SWEEP)	ATTN 12DB
28.8DBMV		VF 3KHz
20.0KHz/		10 DB/
3KHz RBW (AUTO)		CALIBRATOR

The 2715 uses internal reference oscillators to analyze the input signal. At wide spans, a slight amount of drift in an internal oscillator is not noticeable. However, as the span is reduced to a few kHz/div or less, any internal oscillator jitter becomes apparent. The on-screen indication is phase noise close to the base

of a signal and/or an apparently drifting signal. Therefore, the oscillators in the 2715 are typically phaselocked to a stable reference when operating at narrow spans. This happens automatically when the span is 20 kHz/div or less. Phaselock minimizes the amplitude of the noise pedestal close to a signal, but may actually increase it slightly at frequencies farther away. Therefore, phaselock may be turned off when desired.

Toggle phaselock between AUTO and OFF using item 4, PHASELOCK, from the Instrument Configuration menu. Return to the spectral display to see the effects. Leave PHASELOCK in AUTO when you are done.

Frequency Corrections On and Off

300.0MHz	(AUTO SWEEP)	ATTN 10DB
28.8DBMV		VF WIDE
50.0MHz/		10 DB/
5MHz RBW (AUTO)		CALIBRATOR

During normal operation, the 2715 periodically computes frequency corrections (to compensate for short-term drift within the 2715 itself) and applies them to the displayed trace. It does this between sweeps. You can shorten the intersweep interval by disabling the frequency corrections, although some high-frequency accuracy may be sacrificed, and the signal may drift off screen at small spans/div.

***NOTE.** Short Holdoff mode reduces the intersweep interval even further, but also disables most marker measurement modes.*

1. Observe the spectral display for a few sweeps.

There is a slight pause about every fourth sweep. This is the period during which the corrections are computed and implemented.

2. Press **[SPAN/DIV] [5] [0] [Y]** to reduce the span to 50.0 kHz/div. Watch the signal peak for several minutes.

Notice how the signal peak drifts relative to screen center and then is recentered as the 2715 computes and implements the corrections.

3. Press **[UTIL] [4] [3]** to call up the INSTRUMENT CONFIGURATION menu.

FREQUENCY CORRECTIONS, from the Instrument Configuration menu is a toggle that enables you to turn the corrections off and on.

4. Press **[5]** to turn off the frequency corrections feature.
5. Press **[UTIL]** to return to the spectral display.

Notice how the signal now drifts continuously.

6. Press [UTIL] [4] [3] [5] again to turn the frequency corrections back on.
7. Press [UTIL] to return to the spectral display.

Note that the signal is again centered.

The Spectral Display in Menus

Some people prefer to have the display present when working with menus, others do not.

8. Press [UTIL] [4] [3] to activate the INSTRUMENT CONFIGURATION menu.
9. Repeatedly press [6] to toggle SPECTRAL DISPLAY IN MENUS off and on.

Note how the spectral display is superimposed on the menu.

10. For now, leave the display turned on.

Changing the Sweep Holdoff

There is a holdoff period between the end of one sweep and the start of the next to give the internal circuits time to stabilize. For faster response time when continuous observation of signals is necessary, the delay can be minimized by entering the short holdoff mode. When using short holdoff in the AUTO sweep mode, a fictitious signal sometimes appears at the left edge of the screen.

NOTE. Turning on *SHORT HOLDOFF* disables frequency corrections and most marker measurement modes.

11. Ensure the spectral display is turned on.
12. Press [7] to select SWEEP HOLDOFF from the INSTRUMENT CONFIGURATION menu.

Messages appear to indicate which features are sacrificed when using short holdoff.

13. Read the messages and press [W] to continue.

The SWEEP HOLDOFF status switches from NORMAL to SHORT HOLDOFF and a signal peak may appear at the left edge of the screen.

14. Press [7] to reset the sweep holdoff to NORMAL.
15. Press [6] to turn off SPECTRAL DISPLAY IN MENUS.

Setting the Date and Time

The 2715 contains a real-time clock with battery backup power. The clock is used to display the date and time stamp on measurement results. The clock is also used to trigger user-defined programs and to label printer/plotter outputs.

The following steps show how to set the real-time clock:

1. Press **[UTIL]** **[4]** select the System Configuration menu.
2. Press **[4]** to select REAL-TIME CLOCK SETUP.
3. Select items 0 through 5 to update the clock. Terminate each entry by pressing **[W]**.
4. Press **[6]** to toggle the clock display on or off in the menu, the spectral display, and printer/plotter outputs.
5. Press **[UTIL]** to return to the spectral display.

Protecting Stored Settings

You can protect your stored settings so that they are not accidentally deleted.

1. Press **[UTIL]** **[4]** to call up the SYSTEM CONFIGURATION menu.
2. Press **[5]** to toggle item STORED SETTINGS PROTECT to ON.
3. Press **[BKSP]** to return to the UTILITY menu.
4. Press **[1]** to select STORED SETTINGS/DISPLAYS.
5. Attempt to delete any stored setting.

The message ONLY WAVEFORMS DELETED appears. When STORED SETTINGS PROTECT is turned on, you cannot delete the stored settings, but waveforms stored along with them will be deleted.

6. Press **[BKSP]** **[4]** to return to the SYSTEM CONFIGURATION menu.
7. Press **[5]** to turn off STORED SETTINGS PROTECT.
8. Press **[UTIL]** to return to the spectral display.

The File System

The 2715 stores settings, waveforms and other data in a system of files in NVRAM. Normally you will not alter those files. Press **[UTIL]** **[4]** **[6]** to view a directory of existing file names.

File names are established by the firmware. Table 6–3 and Table 6–4 list the file names and describe their contents. Files are created only as required. That is, you will not find a BSET03 settings file unless you have previously saved the B-register settings in the third storage location.

Several other files representing system parameters may also be present, including the following.

Table 6–3: The File System

Settings Files:	Each file saves the control settings for a particular register (A, B, C, D) in a designated location (00–39). BSET03 saves B-register settings in the number 3 location.		
Curve Files:	Each file saves curve data from register A, B, or C in a designated location (00–39). D-register curves are never saved. AWF04 saves the A-register curve in location 4.		
User-Defined Program (UDP) Files:	Each file saves a keystroke sequence representing a particular UDP in a designated location (0–8). UDP1 is the second user-defined program.		
Channel Table Files:	Each file saves the channel table in a designated location (0–9) representing channel table data for a particular table. CHTBL3 saves the channel table information in location 3.		
CATV Measurement Results Files:	Each file saves the CATV measurement results in a designated location (1–4). RSLT3 saves the CATV measurement results in the number 3 location.		
Flatness Correction Data Files:	Flatness files save the data generated by running the flatness correction procedure.		
Antenna Table Files:	Each file saves the antenna table in a designated location (1–5) representing antenna data for a particular antenna. ACF3 saves the antenna information in location 3.		
Normalization Files:	Normalization files save the data generated by normalizing the Spectrum Analyzer, including reference normalization.		
File Names			
Curves n=A,B,C	Settings n=A,B,C,D	User-Defined Programs	Antenna Tables
nWFM00 – nWFM39	nSET00 – nSET39	UDP0 – UDP8	ACF1 – ACF5
Channel Tables	CATV Measurement Results	Flatness Corrections	Normalizations
CHTB0 – CHTBL9	RSLTX	FCOR	NORM

Table 6–4: Additional File System

Name	Description
12.88	Version
SEARCH	Signal search configuration
SETUP	Instrument configuration
S_CATV	CATV configuration
S_GPIB	GPIB configuration
S_PLOT	Plotter configuration
S_RTC	Real-time clock configuration
S_TTYx	RS-232 configuration

DSET00 and SET0BU are special files. They are created automatically by the 2715 and contain the D-register settings used when the 2715 was last turned off. SET0BU is a backup in case DSET00 is corrupted during a power-down or power-up cycle.

Other temporary files may also be created by the 2715 for internal purposes.

Protecting Files

Files you wish to preserve such as waveform, settings, or UDP files can be protected from accidental erasure in several ways. UDP files can be selectively protected from the USERDEF menu, while all settings files can be protected by pressing [UTIL] [4] [5].

However, to protect an individual file in the file system, first determine its file number by viewing the file directory by pressing [UTIL] [4] [6]. The number is listed under the FID column in the directory. Return to the System Configuration menu and select item 7, PROTECT FILE. Following the on-screen prompt, enter the number of the file you want to protect. Confirm your selection by pressing [W]. It is now impossible to delete the file without first unprotecting it.

Repeat the foregoing process to unprotect a previously protected file. The process constitutes a toggle that alternately protects and unprotects the designated file.

NOTE. *Unless you have specific reasons for doing otherwise, do not protect system parameter and normalization files (see Table 5–6 on page 5–15). Doing so may prevent the 2715 from carrying out its normal functions or updating data.*

Confirming Installed Options

If you are in doubt as to which options are installed in your instrument, press [UTIL] [4] [9].

The resulting display begins by listing the instrument's firmware version and the Tektronix copyright. Below that, two columns list the options installed in your 2715. You will see a readout similar to the following:

```

NVM 1 12.88  NVM 2 12.88
GPIB          RS-232

```

The number following NVM (nonvolatile memory) is for internal Tektronix use only and of no value to the user. The list will vary according to the options actually installed in your instrument.

GPIB and RS-232 both appear regardless of which is physically installed in the 2715. See *Configuring the Communications Port* on page 6–67 for additional information.

Diagnostics and Adjustments

NOTE. Any control settings can be used.

Many of the items on the Utility menu are intended for servicing of the 2715. However, we will describe a few used to verify instrument performance. Items not discussed are reserved for service personnel or for use under factory supervision.

Aligning the Display

NOTE. This procedure will overwrite saved waveforms without warning.

1. Press [**UTIL**] to call up the UTILITY menu.
2. Press [**5**] to select INSTR DIAGNOSTICS/ADJUSTMENTS.
3. Press [**2**] to select MANUAL ADJUSTMENTS.
4. Press [**2**] to select DISPLAY STORAGE CAL.

This selection creates a checkerboard display used to adjust trace position and rotation. The trace rotation, vertical, and horizontal alignment controls are located on the back of the 2715 (see *Miscellaneous Controls* on page 4–33).

5. Turn the **TRACE ROT** control until the checkerboard test pattern is rotationally aligned with the graticule.
6. Adjust the **VERT POS** control until the the top line of the pattern coincides with the top graticule line.
7. Last, turn the **HORIZ POS** control until the vertical center line of the display coincides with the center vertical line of the graticule.
8. After completing the alignment, repeatedly press [**UTIL**] until the spectral display reappears.

Changing the YIG Settle Delay

You may improve the center frequency setting time in some applications by changing the YIG oscillator settling delay time from the factory default value. The factory YIG oscillator settling delay time default is 5000 ms. The indicated YIG oscillator settling time (for example, the default of 5000 ms) represents the longest delay that will occur. Typically, most operations of the spectrum analyzer will result in shorter delay times. The default settling time was chosen to ensure compliance with published specifications for all instruments over a variety of conditions such as temperature, aging, wide frequency steps, calibration variations, YIG oscillator variations, and other component variations.

All 2715 spectrum analyzer stability and frequency accuracy specifications are guaranteed only at the 5000 ms setting. However, in many applications, faster settling delay time may be successfully used. Determination of the suitability of

settings other than the factory default of 5000 ms must be made by the user of the specific 2715 spectrum analyzer. The best way to verify operation is to compare measurement results using the factory-default YIG oscillator settling delay time and your reset time. You may then choose to use and store the reset time.

The minimum acceptable settling time may vary from instrument to instrument as well as application to application. You are encouraged to verify acceptable performance on an instrument by instrument basis when changing the default settling time.

NOTE. *If the YIG oscillator settling delay time has been reset from the factory default of 5000 ms and any error messages occur as the center frequency or span/div is being reset (such as NORMALIZATION SUGGESTED) or if any aspect of frequency-related performance of your instrument appears to be inappropriate, the YIG oscillator settling delay time should be increased or returned to 5000 ms.*

If the YIG oscillator settling time is changed from the factory default, a message indicating this case is displayed during instrument power-up. This is a reminder to you that the factory default value is no longer being used.

Instruments returned to Tektronix for repair and/or calibration will have the YIG oscillator settling time returned to the factory default value (5000 ms) and the factory default value will be used during repair and calibration. Any repair involving replacing or repairing the YIG oscillator may result in acceptable settling times different from those originally selected.

To change the YIG oscillator settling delay time, do the following steps:

1. Press **[UTIL]** to call up the UTILITY menu.
2. Press **[5]** to select INSTR DIAGNOSTICS/ADJUSTMENTS.
3. Press **[4]** to select INTERNAL PARAMETERS.
4. Press **[2]** to select YIG SETTLE DELAY.
5. Use the keypad to enter the new delay value in milliseconds, press **[X]** to terminate the entry.

You now have changed the YIG oscillator settling delay time from the factory default value of 5000 ms to the value you entered. This value is permanently stored until you change it using the above procedure.

Service Normalizations

The 2715 contains a set of frequency and amplitude normalization values when it is shipped from the factory. The normalizations are based on reference values, called reference normalizations, determined at the time of manufacture. The reference normalizations specify the 2715 gain step sizes and the frequency and amplitude of the internal calibrator signal. The references are determined by comparison with an accurate external attenuator and signal source. If NVRAM is ever lost (for instance, because the battery runs down), the factory reference normalizations are lost with it, and you must perform a service reference normalization to achieve maximum accuracy from the 2715. If you have signal sources available that are more precise than the on-board calibration signal, they can be used to achieve added accuracy when normalizing the 2715.

Using the REFERENCE NORMALIZATIONS selection from the Service Normalizations menu, you can measure new reference values for the on-board calibration signal and attenuator with respect to more precisely known alternate sources. The alternate sources must exceed the following specifications:

frequency: 5 parts in 10⁷, ±10 Hz

amplitude: -18.8, ±0.1 dBmV @ 100, ±1 MHz

attenuation (gain step): ±10 0.5 dB @ 100, ±1 MHz

We will not give examples for all reference normalizations, but we will show you how to determine a new frequency reference:

1. Connect an external frequency source to the 2715 input meeting the frequency specification given above.

Various sources are available (for example, WWV in the U.S., some broadcast television carriers, assorted frequency standards). A frequency of 100 to 500 MHz would be very good, but signals as low as 5 MHz can be used.

2. Return to the spectral display and perform a center measure to ensure the external reference is centered.
3. Press [UTIL] [5] [5] to select SERVICE NORMALIZATIONS.
4. Press [1] to select REFERENCE NORMALIZATIONS.
5. Press [1] to select INTERNAL REF FREQ from the resulting Reference Normalizations menu.

On-screen prompts appear for each of the reference normalizations.

6. Press [1] to select EXTERNAL FREQ, and enter the frequency of the external source.

7. Press [2] to select CONNECTED, MEASURE and press [W] when you are ready to have the 2715 determine the new reference.

After a few seconds you will receive a NORMALIZATION COMPLETE message.

8. Determining new gain step and amplitude references is done in a similar fashion (follow the prompts).
9. Press [UTIL] [3] [0] to complete the process of optimizing the 2715's accuracy by performing a complete normalization.

The remaining items on the Service Normalizations menu are normally used only by service personnel. However, menu item 4 can be used to view selected normalization values, and item 5 sends the normalization values to a printer. These can be handy for future reference. Item 6 sends any messages that occur during normalization to the printer.

If your 2715 has RS-232 installed, you can obtain a hard copy of the normalization values by doing the following:

10. Place your Epson FX-compatible printer on-line (a plotter will not work unless it can emulate an FX-series printer) with the paper in the correct position.
11. Select item 5 from the Service Normalizations menu. Printing starts immediately. Control of the 2715 is returned following printout.

If You Lose NVRAM

NOTE. *If NVRAM is lost, the flatness correction data will also be lost. This data can be reloaded by a Tektronix service center or by using the procedure described in the 2715 Service Manual.*

The NVRAM in the 2715 is powered by lithium batteries. Battery life is limited to a few years.



WARNING. *Handling and disposing of lithium cells can be hazardous. Refer all battery maintenance to a Tektronix service center.*

When the batteries run down, NVRAM and all of its contents are lost. All stored settings, tables, and waveforms disappear, as well as all normalization data. To prevent inadvertent loss of the reference normalizations, routinely return your 2715 to Tektronix for battery replacement. When a Tektronix service center replaces your battery, it also renormalizes the references, ensuring that your instrument will operate within its specifications.

If NVRAM is ever lost in the field, you may have to renormalize the 2715.

1. Press [UTIL] [3] [1] to carry out a frequency normalization.

The 2715 will use default reference values from internal EPROM's or DIP switches. The default values will not result in optimum accuracy, but they will enable you to make approximate measurements. More importantly, they will enable you to carry out the reference normalizations required to ensure that the 2715 is fully within its specification and operating at maximum accuracy.

2. Follow the instructions in *Service Normalizations* on page 6–80 and the resulting on-screen prompts to perform the service reference normalizations.
3. After the reference normalizations are complete, press [UTIL] [3] [0] to complete the frequency and amplitude normalizations.

If external reference sources are not available, simply perform the frequency and amplitude normalizations with [UTIL] [3] [0]. The 2715 will be useable, but the references should be renormalized at the earliest opportunity. If the battery is worn out, you will have to renormalize the 2715 each time it is used until the battery can be replaced.

Generating a Service Request

NOTE. Any control settings can be used.

Utility menu item 6, SERVICE REQUEST, enables you to manually generate a service request (SRQ) whenever required for testing or other purposes. See the *2714 & 2715 Programmer Manual* for detailed information about SRQs and their uses.

To generate a SRQ, press [UTIL] [6]. If the communications port is on line, the request is generated immediately and reflected on-screen by the message REQUEST at bottom center (if the port is off line, nothing happens). The message remains on screen until serviced by the controller, or until the communications port is cycled on and off line using [UTIL] [4] [0] [0] [0] (GPIB) or [UTIL] [4] [0] [2] [0] (RS-232).

NOTE. The techniques for reporting the event causing an SRQ are different for RS-232 and GPIB. See the *2714 & 2715 Programmer Manual*.

Printing the On-Screen Readouts

The Utility menu also enables you to print the on-screen readouts on an FX-series printer. The 2715 must be equipped with the RS-232 port, and the printer must be connected directly to the port. Each on-screen line is terminated with a linefeed regardless of the terminator selected from the RS-232 configuration menu. Further, the RS-232 port must be on line to use this feature.

Printing the on-screen readouts can be handy if you wish to print results during a user-defined program (UDP) sequence. For instance, suppose that you perform a marker peak find function during the UDP. The frequency and amplitude of the signal are displayed at the upper right of the screen (the normal marker readouts).

To have the 2715 print the readouts through the RS-232 port, ensure your printer is powered up, on line and ready.

1. Press **[UTIL] [4] [0] [2] [0]** to place the RS-232 port on line.
2. Press **[BKSP]** three times to return to the UTILITY menu.
3. Press **[9]** to select MORE.
4. Press **[0]** to select the PRINT READOUTS option. Printing begins immediately.

SWP/TRIG

100.0MHz	(AUTO SWEEP)	ATTN 12DB
28.8DBMV		VF 300KHz
1.0MHz/		10 DB/
300KHz RBW (AUTO)		

The Sweep/Trigger menu enables you to select the 2715 trigger mode. During normal operation of the 2715, the sweep generator is free running. A new sweep begins as soon as possible after the end of the previous sweep. However, when dealing with time domain analysis or pulsed signals, it may be advantageous to trigger the sweep from some characteristic of the input signal, or from another signal related in a fixed way to the input signal. The Sweep/Trigger menu also enables you to specify the sweep rate and enter the manual scan mode.

Free Running the Sweep Generator

Press **[SWP/TRIG]** to call up the Sweep/Trigger menu.

Press **[0]** to select FREE RUN to place the 2715 sweep generator in the free running, or continuous, mode. This is the default setting, and is usually satisfactory for analyzing continuous signals. It is also a good mode for examining the time domain representation of CW and noise-like signals.

Oscilloscope Trigger Modes

Just as on a conventional oscilloscope you can choose the input signal, an external signal applied at the back panel of the 2715, or the AC power line as the trigger source. You do this by selecting INTERNAL, EXTERNAL, or LINE trigger from the SWP/TRIG menu.

The INTERNAL, EXTERNAL, and LINE trigger modes cause the sweep generator to start a new sweep when the trigger signal amplitude crosses a threshold determined by the setting of the LEVEL control (inner knob to the left of SWP/TRIG). If the 2715 is placed in zero span and linear amplitude mode, the resulting waveforms resemble those that you would see on an oscilloscope (detected signal amplitude vs. time).

Internal triggering requires the signal to be at least one division in amplitude, and is most often used for time domain analysis. If internal triggering is used for spectral analysis, the triggering signal must be tuned to the left edge of the spectral display.

The LEVEL control adjusts a threshold so that the sweep begins when the amplitude of the input signal crosses that threshold.

1. Connect a short antenna or CATV tap to the 2715 input as outlined in *Appendix B: Broadcast AM, FM, and TV Signal Sources*.
2. Tune to a strong television video carrier and adjust the signal height to near the reference level.
3. Set the 2715 to LIN mode, zero span, and 5 MHz resolution bandwidth.
4. Set the sweep rate to 2 msec/div, and deactivate all storage registers.
5. The screen displays one field of video information. The dark vertical spaces in the waveform are caused by the time taken to write the on-screen readouts.
6. Turn off the readouts.

The waveform on screen should resemble Figure 6–15, except it will be sliding across the screen because the sweep generator is free running.

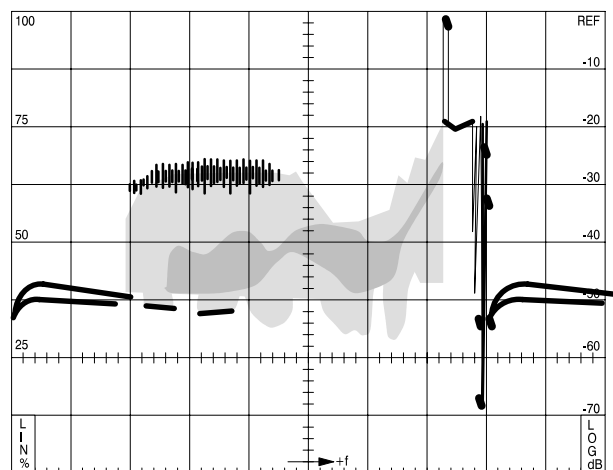


Figure 6–15: Video Field Using Internal or TV Field Triggering

7. Select item 1, INTERNAL, from the SWP/TRIG menu.
8. Slowly rotate the LEVEL control until the display is stationary.

The sweep is now being triggered by the vertical sync pulse.

External triggering is usually chosen for pulsed signal analysis when there is an externally available gate signal signifying that the signal to be examined is present at the 2715 input (for example, the keying signal from an RF transmitter or the squelch signal in a receiver — if the gating signal is not available, you might trigger internally). The External trigger signal is applied through a BNC connector (J102) on the back of the 2715; its amplitude can be from 100 mV to 50 V. See *Appendix E: External Input and Output* for additional information.

9. Without changing any other control settings, select item 3, LINE, from the SWP/TRIG menu.

10. If the screen goes blank, readjust the LEVEL control.

The sweep is triggering on a sample of the AC power line voltage. The display may be slowly drifting or stationary. TV sweep rates are nearly harmonically related to line frequency, but small, fractional hertz differences create the slow drift.

11. Turn on the readouts.

TV Line Trigger

100.0MHz	(AUTO SWEEP)	ATTN 12DB
28.8DBMV		VF 300KHz
1.0MHz/		10 DB/
300KHz RBW (AUTO)		

Item 4, TV LINE, of the Sweep/Trigger menu is one of two internal triggering modes that are particularly useful for time-domain analysis of television signals. A horizontal sync pulse begins each TV line. You can designate the TV line standard in use (NTSC, PAL, SECAM, or OPEN) and how the line is selected using item 9, SETUP TABLE. When CONTINUOUS line triggering is selected, any sync pulse will trigger the sweep. KNOB SELECTABLE and KEYPAD ENTRY modes enable you to select a particular horizontal sync pulse as the trigger signal. The selected line is displayed at the bottom of the right on-screen readout column. Choosing any HORIZONTAL LINE TRIGGERING mode from the SETUP TABLE also selects the TV LINE trigger mode.

The following steps show how TV line triggering works:

1. Connect a short antenna or CATV tap to the 2715 input as outlined in *Appendix B: Broadcast AM, FM, and TV Signal Sources*.

2. Change the resolution BW to 5 MHz.
3. Tune to a strong TV video carrier. Ensure the signal peak is close to the reference level.
4. Call up the Sweep/Trigger menu and select SETUP TABLE, item 9.
5. Repeatedly select item 4, TV LINE STANDARD, until the TV line standard appropriate to your signal appears. Use the OPEN (1024 line) setting for nonstandard systems.

Items 0 through 3 of the SETUP TABLE determine which sync pulse(s) is used. Choosing any of them also selects item 4, TV LINE mode, from the Sweep/Trigger menu.

6. Select item 0, CONTINUOUS, and then return to the spectral display.
7. Turn off digital storage and select zero span.
8. Enter LIN mode, and change the sweep rate to 20 $\mu\text{sec}/\text{div}$ (sweep rate is indicated in the left-hand readout column).

The screen should resemble Figure 6–16. In CONTINUOUS mode, the sweep generator is triggered by the first pulse that occurs after the 2715 enters the ready-to-be-triggered state. In other words, after the 2715 completes the current sweep, it enters the ready-to-be-triggered state, and is retriggered by the first horizontal sync pulse that comes along. Thus, a different sync pulse generally triggers each sweep. The video signals following each sync pulse are not quite the same, but are nevertheless displayed on top of each other. The result is an intense, but fuzzy, display.

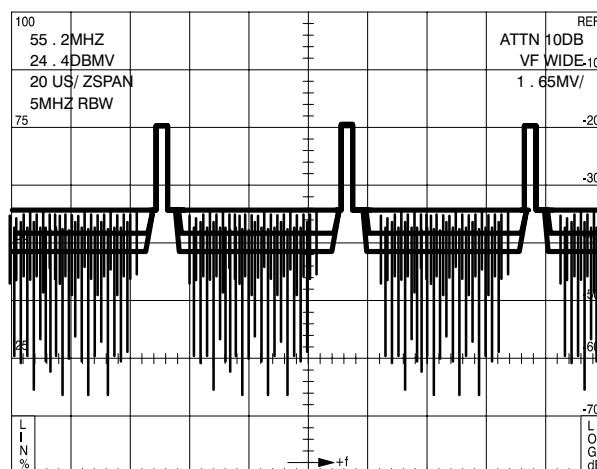


Figure 6–16: Video Signal Using Continuous Horizontal Line Triggering

9. Call up the SETUP TABLE again and choose item 1, KNOB SELECTION TABLE.
10. Return to the spectral display.

The tuning knob now controls which pulse is used.

Pulses are numbered from 1 to 1023. The current line number (horizontal video line number and sync pulse number are the same) is displayed at the bottom of the right on-screen column. If more than one sync pulse is displayed, the number is that of the pulse nearest the left edge of the screen.

Turning the knob clockwise increases the line number and counter-clockwise decreases it.

11. Turn to about line 17 to view several lines including the vertical interval test signal (VITS).

This signal is usually present between lines 15–20 in the U.S. (see Figure 6–17). The display is not as bright as it was in the CONTINUOUS mode, because the 2715 is triggering on, and displaying, only one horizontal line out of every 525. If the display is too dim, adjust the INTENSITY control.

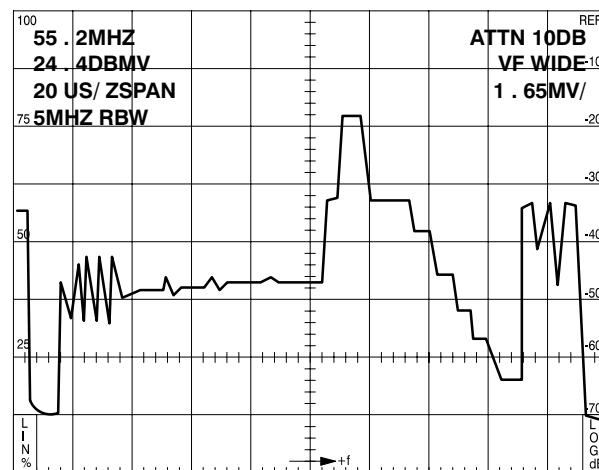


Figure 6–17: Video Signal Using Knob-Selectable Horizontal Line Triggering (VITS Visible)

When knob-selectable TV line triggering is active, pressing **[MKR/FREQ] [2]** allows the knob function to be changed from frequency control to marker control or video line selection. This is a great convenience if you want to change TV channels. See *Changing the Knob Function* on page 6–19 for more information.

12. Call up the SETUP TABLE from the SWEEP/TRIGGER menu.

If you select item 2, KEYPAD ENTERED LINE, the sync pulse indicated at the end of the line will be used as the trigger.

13. Select item 3, KEYPAD ENTRY, and enter number 279 from the numeric keypad.

The number you enter appears at the end of the KEYPAD ENTERED LINE. This number also changes when you operate in the knob-selectable mode; it shows the number of the sync pulse last used as the trigger.

14. Press [2] and return to the waveform display.

On most U.S. NTSC stations you now see the VITS for the second picture field.

When using the keypad-entered lines, the tuning knob controls frequency instead of the line number.

SWP/TRTV Video Field Triggering

Item 5, TV FIELD, of the Sweep/Trigger menu is the second of two internal triggering modes that are particularly useful for time domain analysis of television signals. Call up the Sweep/Trigger menu and choose item 5. The display is now being triggered by the TV vertical sync pulse that occurs near the beginning of each field. Using the SWEEP arrow keys, slow the sweep rate to 2 ms/div. The display resembles Figure 6-15 on page 6-84. You can now see an entire frame of video information with the start of the frame at the left of the display. The frame does not slip sideways as it does in the LINE trigger mode, because the sweep generator is locked to the displayed signal itself.

You can eliminate the dark vertical spaces in the display by turning off the readouts.

Setting the Sweep Rate

Slow the sweep rate without using SWEEP [▲] and [▼]:

15. Call up the Sweep/Trigger menu and choose item 6, SWEEP RATE.

16. Following the prompt, enter 5 ms/div.

The 2715 reverts immediately to the display mode and you can see three whole video frames. This feature enables you to conveniently set sweep rate when you are already working in the Sweep/Trigger menu and may have turned off the readouts.

17. Return to the FREE RUN mode by pressing [SWP/TRIG] [0].

Manually Scanning

100.0MHz	(AUTO SWEEP)	ATTN 12DB
28.8DBMV		VF 300KHz
1.0MHz/		10 DB/
300KHz RBW (AUTO)		

1. Center a strong video carrier.
2. Call up the Sweep/Trigger menu and select item 7, MANUAL SCAN.
The spectral display reappears, but it does not appear to be updating.
3. Turn the inner **LEVEL** control knob and watch the screen carefully.
A portion of the display updates as you turn the knob. In this mode, the knob controls the horizontal sweep position.
4. Turn the inner **LEVEL** control knob slowly from fully counter-clockwise to fully clockwise, and watch the screen update.

This feature enables you to carefully examine a small portion of the spectrum. It is also convenient for manually scanning a broadcast or communications band while listening to demodulated signals — the 2715 acts like a radio receiver. The operator can stop at any station since the sweep is being manually controlled.

5. Toggle the manual scan mode off by selecting item 7 again.

USER DEF

100.0MHz	(AUTO SWEEP)	ATTN 12DB
28.8DBMV		VF WIDE
20MHz/		10 DB/
5MHz RBW (AUTO)		

The User-Definable menu enables you to store and execute user-definable sequences of keystrokes called routines or programs. The routines are intended to permit a series of operations to be carried out with only two keystrokes. Press the USER DEF menu button and select the routine you want to run. This feature is particularly useful when you have to make a series of repetitious measurements.

Before you can use routines they must be created, and each routine must have a well-defined starting point. One good way to ensure the routine starts with the correct instrument settings is to begin by recalling a specific group of settings.

Another way is to start with a known group of settings (for example, the factory or user-defined power-ups) and manually change them to the configuration at which your routine begins (this can be done within the routine, but it uses up additional memory).

In the following example, we shall create a user-defined routine to perform CARRIER LEVELS measurements on 10 channels at six-hour intervals. The resultant UDP will execute a 24-hour test.

The result over 24 hours will be five sets of 10 stored results representing a set for each time the UDP is repeated and the set stored when the UDP was first created.

To create the user-defined routine:

1. Press [**USER DEF**] and select item 9, **USER DEF PROG UTILITIES**. Select item 1, **TITLE EDIT**, and press [**W**] to begin editing. Enter a title of **24-HOUR LEVELS**. The procedure is the same used to title a display (see **Adding Titles and Labels** in this section). The title can be up to 28 characters long. Remember to press [**X**] to store the title. Titling the routine is not mandatory (if you do not supply a title, the routine is named **PROGRAM #** by default) but does help you to recall what a routine is supposed to do.
2. Select item 0, **ACQUIRE/EXIT KEYSTROKES**, from the **USER DEF PROG UTILITIES**. This begins the accumulation of keystrokes. The spectral display reappears with the routine name superimposed and the following message:

ACQUIRE KEY STROKES 0 BYTES

Each key that you press will now be recorded in the order in which it was pressed. This sequence of key strokes constitutes the bulk of the user-defined routines. The function of that key is also carried out as you watch. You can return to the **USER DEF PROGRAM UTILITIES** at any time by pressing [**USER DEF**].

3. Press [**UTIL**] [**1**] [**1**] to recall the **FACTORY DEFAULT POWER-UP**.
4. Select a channel table.
5. Select a channel.
6. Run a **CARRIER LEVELS** measurement on the selected channel.
7. Store the current **CARRIER LEVELS** measurement results in **NVRAM**.
8. Repeat steps 4 through 7 for the other nine channels.
9. Press [**USER DEF**] [**9**] [**9**] to select **TIME DELAY SETUP**.

10. Set the following:
 - Day of the week on which you want the UDP to run; the [0] key cycles through the days of the week
 - Time (hour and minute) when the first measurement will start
 - Set REPEAT INTERVAL to 6 HRS (UDP will repeat after every six hours)
 - Set RUN N TIMES to 5 (the number of times you want the UDP to repeat over a 24-hour period)
11. Store the routine in one of nine locations (registers) by pressing [USER DEF] [6] and selecting a storage location. For this exercise, assume that no UDP has already been stored in Slot 3. Store the routine in Slot 3. You cannot store a routine in a location in which another routine is already stored. You must first delete the prior routine.
12. To prevent your routine from accidental erasure, press [USER DEF] [9] and select item 8, PROTECT, and then press [3]. Select item 7, DELETE, and notice the # next to your routine indicating that it is protected. Press [3] [W]. The following message appears:

REMOVE PROTECTION FIRST

To remove the protection, press [BKSP] [8] [3]. You can now delete the routine if you wish.

13. To execute the UDP, press [USER DEF] [3]. The display will return to the spectral display and also display the message:

**WAITING FOR *Date Time* PROG 3
PRESS USER DEF TO ABORT**

NOTE. In creating the UDP, you actually stored data from each measurement as the UDP was being defined. If you want to retain only the data from the 24-hour test, be sure to remove all stored results prior to executing the UDP. Also, the SITE and OPERATOR NAMES should be defined prior to the UDP execution so the stored data will be properly nomenclated.



Appendices

Appendix A: Specifications

This section lists the electrical, physical, and environmental characteristics of the spectrum analyzer, specifies the performance requirements for those characteristics, and provides supplementary information.

Electrical Characteristics

Unless otherwise stated, the following tables of electrical characteristics and features apply to the spectrum analyzer after a 15 minute warm-up period (within the environmental limits) and after all normalization procedures have been carried out.

Information in the Performance Requirement column of Tables A-2 through A-8 is guaranteed and verifiable unless otherwise noted. Supplemental Information is intended to further explain a characteristic, its performance requirement, or to describe characteristic performance that is impractical to verify. Supplemental Information is not guaranteed and may not be supported by a performance check procedure.

Changes to a characteristic because of the addition of an option are included in Table A-7.

Table A-1: CATV Characteristics

Characteristic	Description
Input Configuration	
All except Option 50	75 Ω Female F connector
Option 50	50 Ω Type N connector
Channel Selection	The visual and aural carriers are displayed when the channel number is entered, or either [\blacktriangle] or [\blacktriangledown] next to [CHAN/FREQ] is pressed
Tune Configuration	STD (73.603), HRC (73.605), IRC (73.612), and Custom ¹
Channel Range	0 to 999 ¹
Frequency Range (except Opt 50 and Opt 75)	1 MHz to 1.8 GHz ² , Preamp limited to 600 MHz
Frequency Range (Opt 50 and Opt 75)	1 MHz to 2.15 GHz ² , Preamp limited to 600 MHz
Visual Carrier Frequency Measurement	Accuracy is dependent on the accuracy of the spectrum analyzer — see Frequency Accuracy in Table A-2.
Method	Internal Counter
Resolution	1 Hz
Accuracy	$5 \times 10^{-7} \times \text{Carrier Frequency} \pm 10 \text{ Hz}$, ± 1 Least Significant Digit @ 55.25 MHz (Ch 2) worst case is $\pm 38 \text{ Hz}$ @ 325.25 MHz (Ch 41) worst case is $\pm 173 \text{ Hz}$ @ 643.25 MHz (Ch 94) worst case is $\pm 332 \text{ Hz}$
Visual-to-Aural Carrier Frequency Measurement	Aural carrier measured relative to the visual carrier
Method	Internal Counter
Difference Range	1 MHz to 10 MHz ³ for an amplitude difference of $\leq 30 \text{ dB}$ and aural C/N $\geq 15 \text{ dB}$ (300 kHz RBW)
Resolution	1 Hz
Accuracy	$\pm 15 \text{ Hz}$ for visual-to-aural carrier difference $\leq 8 \text{ MHz}$
Visual Carrier Peak Level Measurement	Absolute peak amplitude of visual carrier measured with PREAMP OFF
Accurate Frequency and Amplitude	Visual carrier frequency measurement Visual-to-aural carrier frequency measurement Visual carrier peak level measurement Visual-to-aural carrier level difference measurement
Accurate Amplitude Only	Visual carrier peak level measurement Visual-to-aural carrier level difference measurement
Fast Amplitude Only	Carrier amplitudes are measured using marker values in 10 dB/div vertical scale
Amplitude Range	-18 dBmV to +58.8 dBmV ⁴ for visual C/N $\geq 30 \text{ dB}$ (300 kHz RBW)

¹ Configured using Cable TV RF Measurements Software.

² Dependent on selected channel table. Frequencies above 1.8 GHz are not supported by the Cable TV RF Measurements Software.

³ Dependent on selected channel table.

⁴ Total input power (all signals included) cannot exceed +70 dBmV.

Table A-1: CATV Characteristics (Cont.)

Characteristic	Description
Frequency Range	15 to 1015 MHz
Resolution	0.1 dB
Absolute Accuracy	± 2.5 dB for visual C/N ≥ 30 dB (300 kHz RBW) and for FM signal C/N ≥ 33 dB (100 kHz RBW) assumes flatness corrections are present
Relative Accuracy	± 0.5 dB relative to adjacent channel ± 1.2 dB relative to all other channels
Visual-to-Aural Carrier Level Difference Measurement	Aural carrier level measured relative to the visual carrier
Difference Range	0 to 30 dB for aural C/N ≥ 15 dB (300 kHz RBW)
Resolution	0.1 dB
Accuracy	± 0.75 dB for aural C/N ≥ 15 dB (300 kHz RBW)
Averaged Power (Typical)	Averaged amplitude measured with preamp off
Accuracy	± 2.5 dB for input levels above -30 dBmV, up to $+37$ dBmV (multichannel) or $+52$ dBmV (preselector in use)
Resolution	0.1 dB
Modulation Depth Measurement (Typical)	Percent AM measured from sync tip to lowest white level found in 10 sweeps (the VITS line is used if it is defined in the channel table)
AM Range	50% to 95%
Resolution	0.1%
Accuracy	$\pm 2\%$ for visual C/N ≥ 40 dB (300 kHz RBW)
HUM/LFD Measurement (Typical)	Power line frequency is measured on an unmodulated visual carrier, and low frequency disturbance (LFD) is measured on the modulated carrier
AM Range	1% to 10% peak-to-peak
Resolution	0.1%
Accuracy	$\pm 1\%$ for Hum $\leq 5\%$ and visual C/N ≥ 25 dB (300 kHz RBW) $\pm 2\%$ for Hum $< 10\%$ and visual C/N ≥ 25 dB (300 kHz RBW)
Carrier-to-Noise (C/N) Measurement (Typical)	Default noise floor is a normalized 4 MHz bandwidth measured relative to the visual carrier peak
Optimum Input Range	See Figure A-1 on page A-7
Maximum Range	See Figure A-1 on page A-7
Resolution	0.3 dB
Accuracy	See Figure A-1 on page A-7
In-Service C/N (typical)	Noise density is measured at 2 MHz offset (by default) from visual carrier during quiet lines in the vertical interval, then normalized to 4 MHz BW and expressed as dBc
Optimum Input Range	See Figure A-1 on page A-7
Maximum Range	See Figure A-1 on page A-7
Resolution	0.3 dB

Table A-1: CATV Characteristics (Cont.)

Characteristic	Description
Accuracy	See Figure A-1 on page A-7
Desired-to-Undesired Ratio (Typical)	Channel averaged power is divided by total noise plus distortion in the channel
Resolution	0.1 dB
Accuracy	± 2 dB within the limits shown in Figure A-6 on page A-9
CTB Measurement (Typical)	Composite triple beat (CTB) is measured relative to the visual carrier peak according to the NCTA recommended spectrum analyzer settings — SINGLE-SWEEP mode does not use all the NCTA recommended settings
Maximum Range	See Figure A-2 on page A-7
Resolution	0.3 dB
Accuracy	See Figure A-2 on page A-7
Digital Channel CTB (Typical)	Measured relative to the averaged power of the test channel
Resolution	0.3 dB
Accuracy	± 2 dB within the limits shown in Figure A-8 on page A-10
CSO Measurement (Typical)	Composite second order (CSO) is measured relative to the visual carrier peak according to the NCTA recommended spectrum analyzer settings — SINGLE-SWEEP and CONTINUOUS modes do not use all the NCTA recommended settings
Optimum Input Range	See Figure A-3 on page A-8
Maximum Range	See Figure A-3 on page A-8
Resolution	0.3 dB
Accuracy	See Figure A-3 on page A-8
In-Service CSO (Typical)	CSO products are measured per NCTA recommendations during quiet lines in the vertical interval, then expressed as dBc
Optimum Input Range	See Figure A-4 on page A-8
Maximum Range	See Figure A-4 on page A-8
Resolution	0.3 dB
Accuracy	See Figure A-4 on page A-8
Digital Channel CSO (Typical)	Measured relative to the averaged power of the test channel
Resolution	0.3 dB
Accuracy	± 2.0 dB within the limits shown in Figure A-7 on page A-10
Frequency Response Measurement (Typical)	For fixed-amplitude scrambling or no scrambling, system amplitude variations (flatness) are measured relative to a reference trace (stored during the frequency response reference setup)
Reference Trace Storage (Nonvolatile)	Up to 10 traces with spectrum analyzer states
Range	5 dB/div, fixed
Resolution	0.2 dB
Trace Flatness Accuracy	± 0.75 dB

Table A-1: CATV Characteristics (Cont.)

Characteristic	Description
Carrier Survey	Absolute peak amplitude of each visual carrier measured and each associated aural carrier level measured relative to the measured visual carrier for the selected channels — characteristics are identical to the frequency (visual and aural) and level measurements (frequency is counted only if ACCURATE FREQUENCY AND AMPL is on)
Accurate Frequency and Amplitude	Visual carrier frequency measurement Visual-to-aural carrier frequency measurement Visual carrier peak level measurement Visual-to-aural carrier level difference measurement
Accurate Amplitude Only	Visual carrier peak level measurement Visual-to-aural carrier level difference measurement
Fast Amplitude Only	Carrier amplitudes are measured using marker values in 10 dB/div vertical scale
Visual Carrier	
Amplitude Range	-18 dBmV to +58.8 dBmV ⁵ for C/N ≤30 dB (300 kHz RBW)
Frequency Range	15 MHz to 1015 MHz
Resolution	0.3 dB
Absolute Accuracy	±2.7 dB for visual C/N ≥30 dB (300 kHz RBW) and for FM signal C/N ≥33 dB (100 kHz RBW) assumes flatness corrections are present
Relative Accuracy	±0.8 dB relative to adjacent channel ±1.5 dB relative to all other channels
Aural Carrier	
Difference Range	0 to 30 dB for C/N ≥15 dB (300 kHz RBW)
Resolution	0.3 dB
Accuracy	±1.1 dB for C/N ≥15 dB (300 kHz RBW)
Aural <FM> Deviation (Typical)	Peak FM deviation measured for the selected channel
Range	10 kHz to 50 kHz, usable to 80 kHz
Accuracy	±4 kHz
Cross Modulation (Typical)	The third order distortion at the horizontal sync frequency (AM) measured on the unmodulated visual carrier, as corrected to the NCTA recommended synchronous square wave modulation procedure
Range	48 dB
Resolution	0.1 dB
Accuracy	±2 dB for cross modulation < 36 dB ±3 dB for cross modulation < 48 dB
Listen (Typical)	The aural carrier for the selected channel is demodulated
Output	Speaker or headphones with volume control
Demodulation Type	FM
Sweep	Displays instantaneous peak FM deviation

⁵ Total input power (all signals included) cannot exceed +70 dBmV.

Table A-1: CATV Characteristics (Cont.)

Characteristic	Description
View Picture (Typical)	The visual carrier, NTSC or PAL format depending on the selected channel, is demodulated
View Modulation (Field) (Typical)	One video field of the selected channel video is displayed
View Modulation (Line) (Typical)	The VITS line is displayed — if no VITS line is specified in the channel table, line 17 is displayed
TV Line Selection	Selectable using the FREQ/MKRS knob during View Line Modulation function
Line Format	NTSC or PAL
Line Range	1 to 525 (NTSC), 1 to 625 (PAL)
Sweep Time	10 μ s/div
In-Channel Response	
Range	± 3 dB (the auto test is run in 1 dB/div)
Resolution	0.1 dB
Accuracy	± 0.5 dB, Auto mode ± 0.8 dB, Interactive mode
Adjacent Channel Leakage (Typical)	Averaged power in adjacent channel(s) is divided by averaged power for the test channel
Resolution	0.1 dB
Accuracy	± 2.0 dB within limits shown in Figure A-5 on page A-9
In-Service In-Channel Response (Typical)	Standard vertical interval test signal (line sweep, ghost-canceller, multiburst) is measured within gate which excludes active video; result is expressed as dB P-P
Resolution	0.2 dB
Accuracy	± 0.5 dB assuming test signal is flat at head end

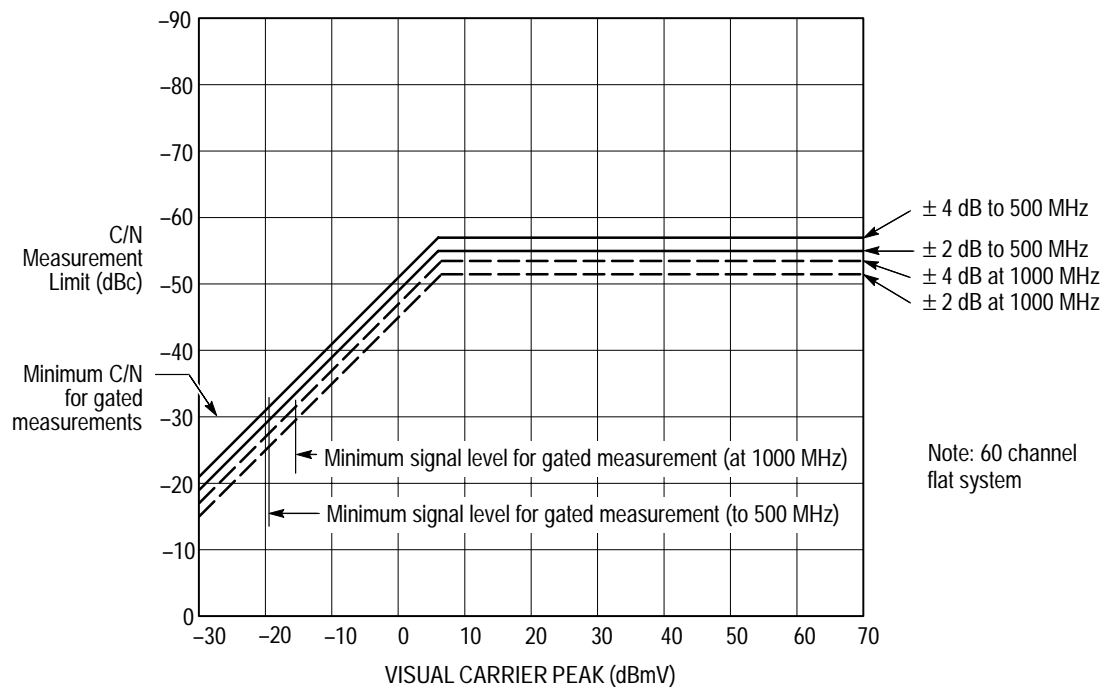


Figure A-1: Typical Accuracy Limits for Carrier-to-Noise Measurement

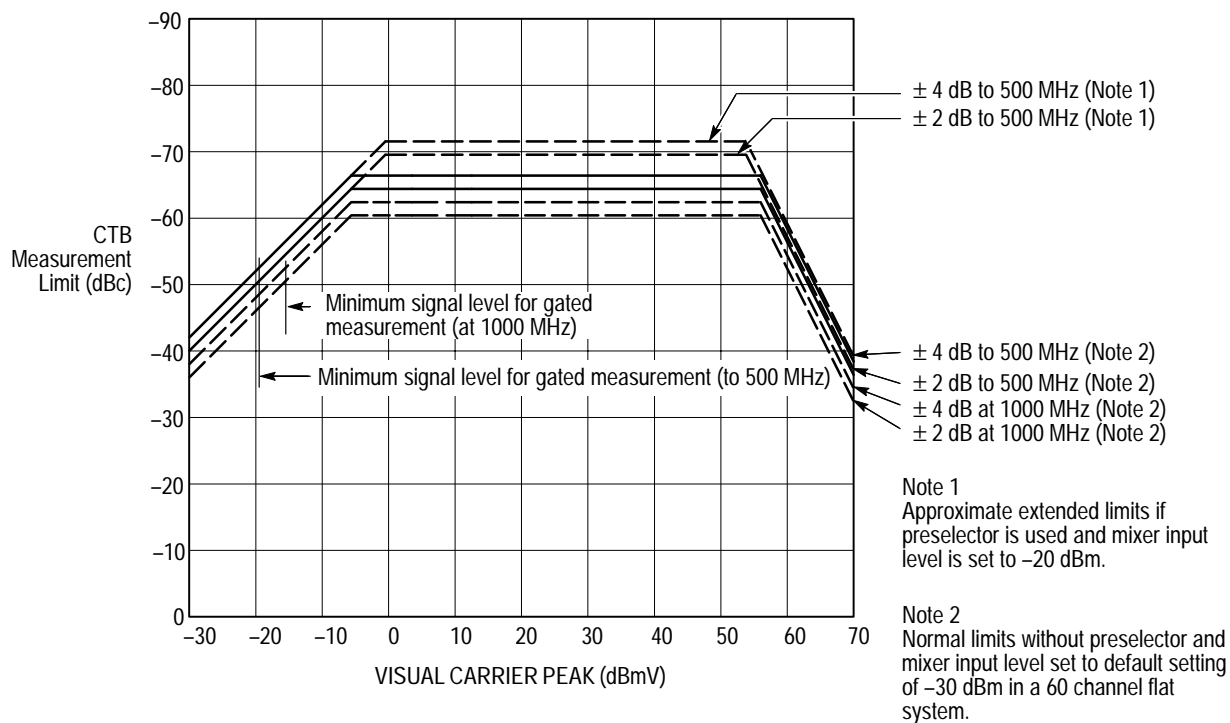


Figure A-2: Typical Accuracy Limits for CTB Measurement

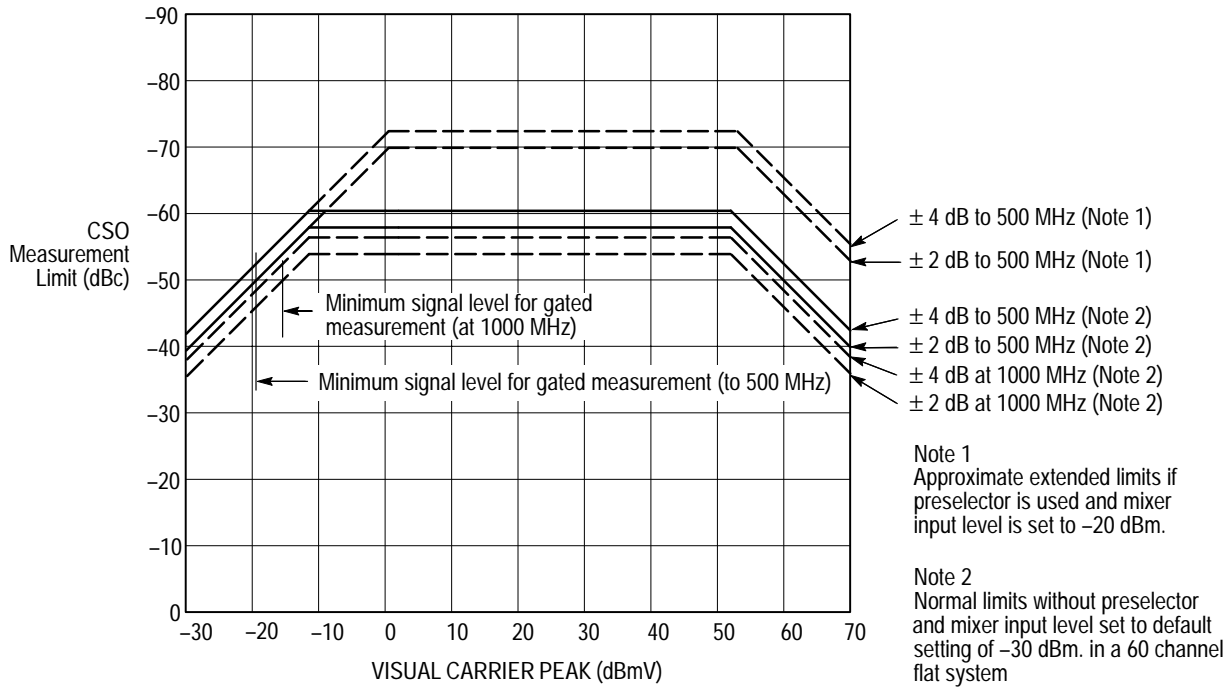


Figure A-3: Typical Accuracy Limits for Nongated CSO Measurement

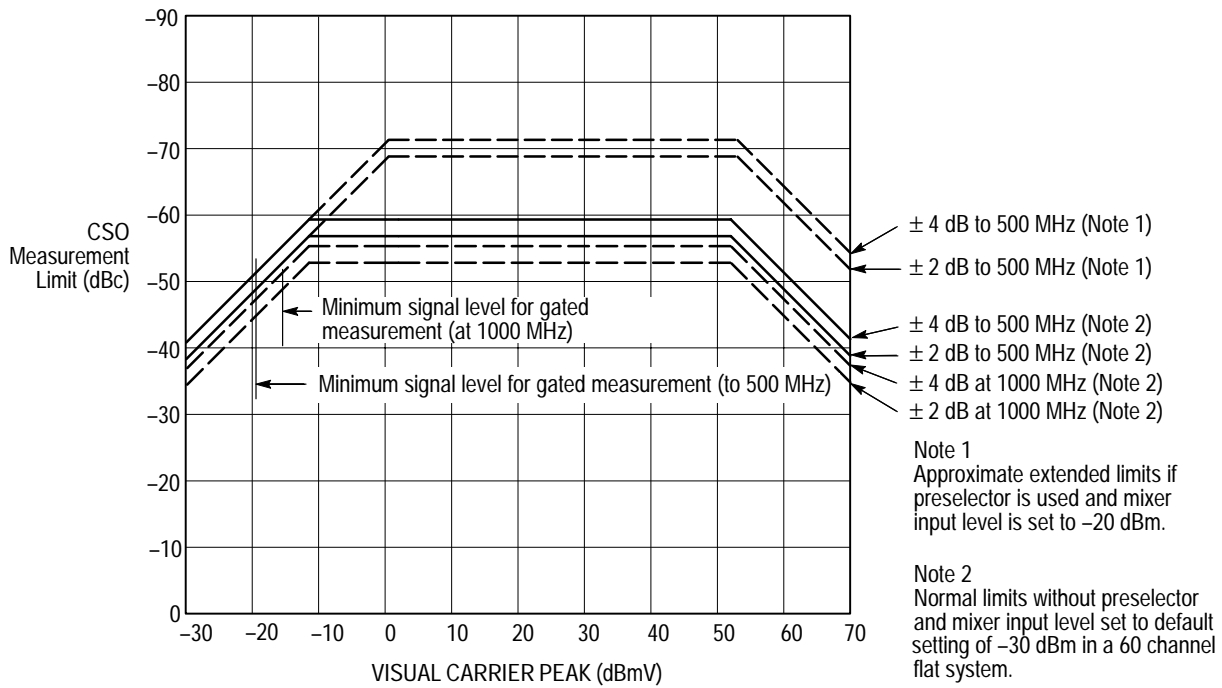


Figure A-4: Typical Accuracy Limits for Gated CSO Measurement

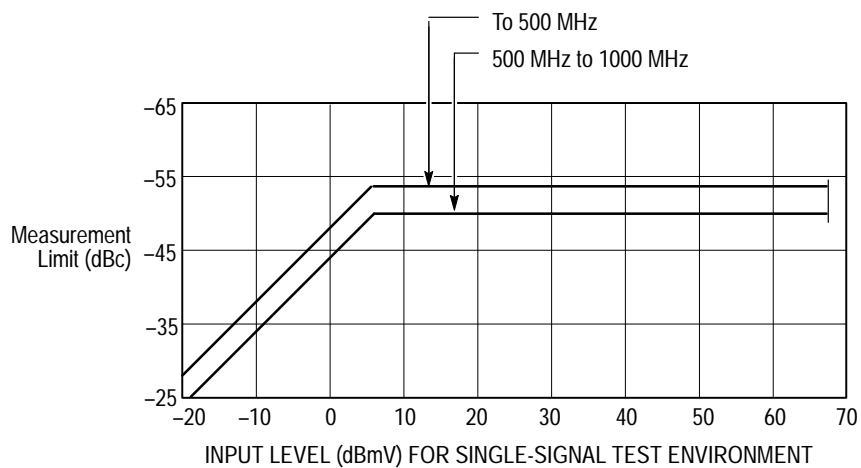


Figure A-5: Typical ACL Measurement Limits for 2 dB Accuracy

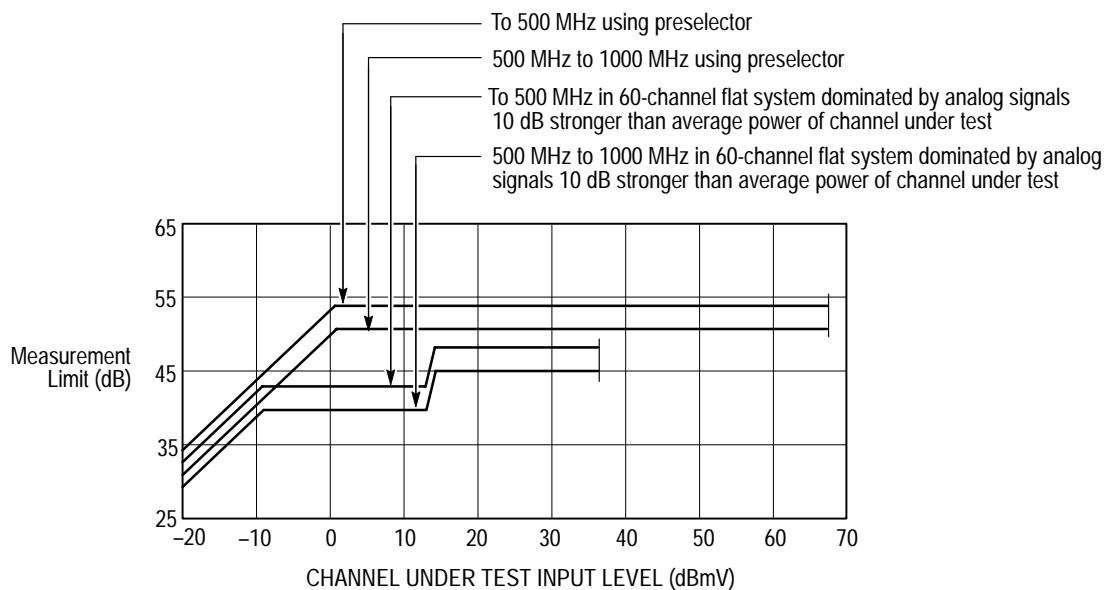


Figure A-6: Typical D/U Measurement Range Limits for 2 dB Accuracy

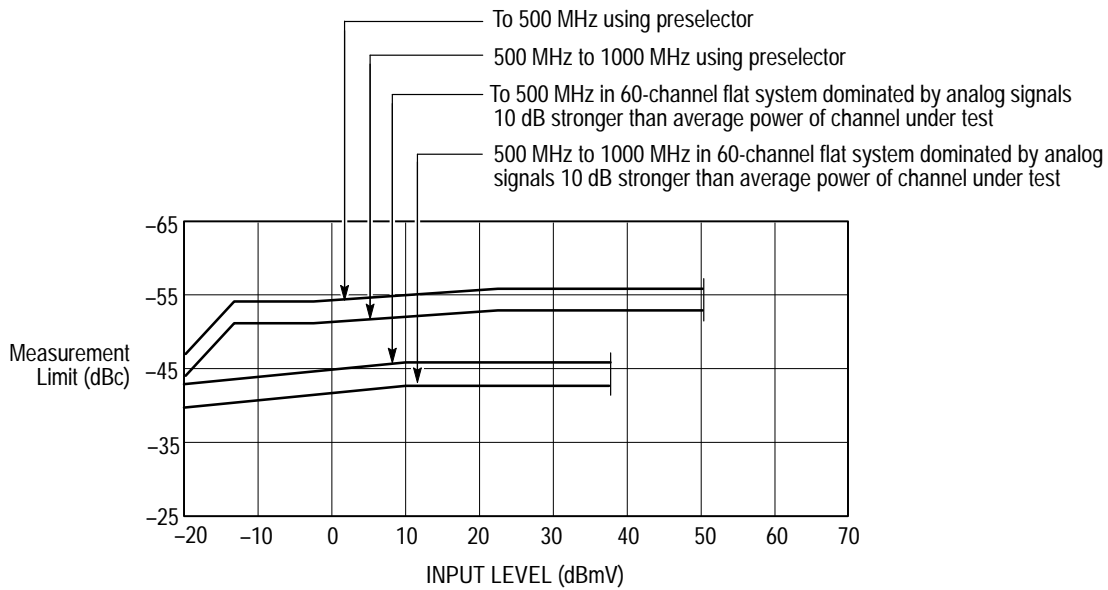


Figure A-7: Typical Digital Signal CSO Measurement Range Limit for 2 dB Accuracy

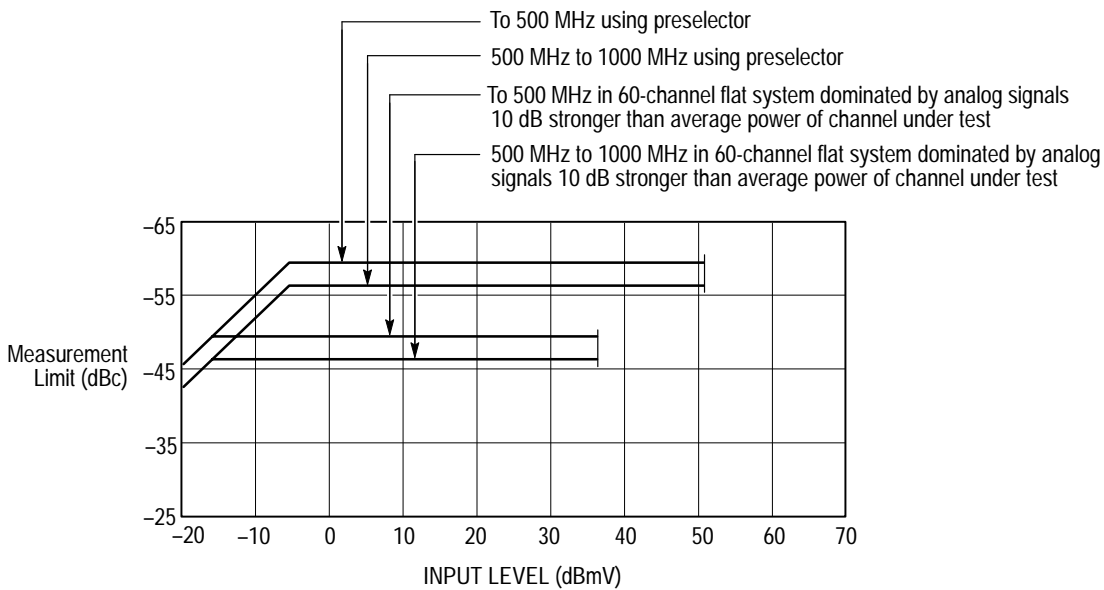


Figure A-8: Typical Digital Signal CTB Measurement Range Limit for 2 dB Accuracy

Table A-2: Frequency-Related Characteristics

Characteristic	Performance Requirement	Supplemental Information
Channel		Tuned with keypad, [CHAN/FREQ] [▲], or [CHAN/FREQ] [▼], according to the selected channel table
Frequency Range	All except Option 50 and Option 75: 9 kHz to 1.8 GHz Option 50 and Option 75: 9 kHz to 2.15 GHz	Tuned with keypad, [CHAN/FREQ] [▲], [CHAN/FREQ] [▼], FREQ/MARKERS knob, UTIL menu, or MKR/FREQ menu
Accuracy	5×10^{-7} of center frequency ± 10 Hz ± 1 least significant digit	Assumes zero drift since last normalization procedure
Drift Long Term (One Year)		± 2 PPM/year
Short Term (SPAN/DIV ≤ 20 kHz)	All except Option 50 and Option 75: ≤ 400 Hz up to 1.8 GHz Option 50 and Option 75: 500 Hz above 1.8 GHz	With frequency corrections enabled
Readout Resolution		1 kHz or 1 Hz (counter readout), menu selectable
Frequency Span/Div Range		Using [SPAN/DIV] [▲] and [SPAN/DIV] [▼] buttons, selections in a 1-2-5 sequence Using the keypad or UTIL menu, select any value from 100 MHz/div to 1 kHz/div. In MAXSPAN, 180 MHz/div (All except Option 50 and Option 75) or 215 MHz/div (Option 50 and Option 75) In ZERO SPAN, 0 Hz/div
Accuracy/Linearity	Within 3%	Measured over the center 8 divisions
Flatness (Relative to the Reference Level at 100 MHz)	All instruments: ± 2 dB 9 KHz to 1.8 GHz Option 50 and Option 75: ± 3 dB above 1.8 GHz	Measured with 10 dB of RF Attenuation and PREAMP off Flatness is affected by: <ul style="list-style-type: none"> ■ Input voltage standing-wave ratio (VSWR) ■ Gain variation ■ Mixer conversion

Table A-2: Frequency-Related Characteristics (Cont.)

Characteristic	Performance Requirement	Supplemental Information
Residual FM With SPAN/DIV ≤ 20 kHz	All except Option 50 and Option 75: ≤ 100 Hz peak-to-peak total excursion in 20 ms up to 1.8 GHz Option 50 and Option 75: ≤ 120 Hz peak-to-peak total excursion in 20 ms (above 1.8 GHz)	Short term, after 1 hr warm-up, and with PHASELOCK in AUTO mode
With SPAN/DIV > 20 kHz	All except Option 50 and Option 75: ≤ 2 kHz peak-to-peak total excursion in 20 ms up to 1.8 GHz Option 50 and Option 75: ≤ 2.4 KHz peak-to-peak total excursion in 20 ms above 1.8 GHz	
Resolution Bandwidth (6 dB down)		Resolution bandwidth selections are: 5 MHz, 1 MHz, 300 kHz, 100 kHz, 30 kHz, 10 kHz, 3 kHz, 1 kHz, and 300 Hz for the spectrum analyzer
Shape Factor (60 dB/6 dB)	7:1 or less for all resolution bandwidths ≤ 1 MHz	
Noise Sidebands	All except Option 50 and Option 75: ≤ -70 dBc at 30X Resolution Bandwidth for all resolution bandwidths ≤ 100 kHz Option 50 and Option 75: ≤ -69 dBc at 30X Resolution Bandwidth for all resolution bandwidths ≤ 100 kHz	
Video Filter		Reduces video bandwidth to about 1% of the selected resolution bandwidth; or one of 12 video filters (3 Hz, 10 Hz, 30 Hz, 100 Hz, 300 Hz, 1 kHz, 3 kHz, 10 kHz, 30 kHz, 100 kHz, 300 kHz, or WIDE) can be selected from the UTIL menu

Table A-2: Frequency-Related Characteristics (Cont.)

Characteristic	Performance Requirement	Supplemental Information
Resolution Bandwidth (6 dB down)		Resolution bandwidth selections are: 5 MHz, 1 MHz, 300 kHz, 100 kHz, 30 kHz, 10 kHz, 3 kHz, 1 kHz, and 300 Hz for the spectrum analyzer
Shape Factor (60 dB/6 dB)	7:1 or less for all resolution bandwidths ≤1 MHz	
Noise Sidebands	≤-70 dBc at 30X Resolution Bandwidth for all resolution bandwidths ≤100 kHz	
Video Filter		Reduces video bandwidth to about 1% of the selected resolution bandwidth; or one of 12 video filters (3 Hz, 10 Hz, 30 Hz, 100 Hz, 300 Hz, 1 kHz, 3 kHz, 10 kHz, 30 kHz, 100 kHz, 300 kHz, or WIDE) can be selected from the UTIL menu

Table A-3: Frequency/Amplitude Related Characteristics

Characteristic	Performance Requirement	Supplemental Information
Marker		The frequency and amplitude values of the marker position are displayed and are preceded by the letter M [MKR] [▶] and [MKR] [◀] position the marker to the next right or left signal peak, respectively
Accuracy		
Frequency		Same as SPAN/DIV
Amplitude		A function of the reference level, vertical scale factor, and normalizations (see <i>Display Dynamic Range</i> on page A-15) Also, flatness corrections while in CATV mode for range of 15 MHz to 1.105 GHz
Delta Marker	When activated, a second marker is displayed at the same frequency as the first marker. This is the "Reference Marker"	The FREQ/MARKERS control may be used to position the first marker; the frequency and amplitude differences between markers are readouts preceded by the letter D
Accuracy		
Frequency	1 PPM ±10 Hz of the higher marker frequency	With both signals counted
Amplitude		Same as Marker

Table A-3: Frequency/Amplitude Related Characteristics (Cont.)

Characteristic	Performance Requirement	Supplemental Information
Center Measure		When activated, the signal nearest center screen (or nearest marker if marker is on) and above a preset threshold level, is moved to center screen The frequency and amplitude values are preceded by the letter C
Readout Resolution	1 kHz or 1 Hz	Readout resolution is selectable
Signal Tracking		When activated, the centered signal is held at center screen Signal tracking requires a signal strength greater than the threshold level If the strength of a signal being tracked decreases below the threshold level, the instrument displays the message NO SIGNAL FOUND ABOVE THRESHOLD

Table A-4: Amplitude-Related Characteristics

Characteristic	Performance Requirement	Supplemental Information
Vertical Display Mode		10 dB/div, 5 dB/div, 1 dB/div, and Linear
Reference Level		
Range		Top of graticule
Log Mode		-21.2 dBmV to +68.8 dBmV (-41.2 dBmV to +48.8 dBmV with the PREAMP enabled)
Linear Mode		10.83 μ V/div to 342.33 mV/div (1.08 nV div to 34.23 mV/div with the PREAMP enabled)
Steps		
Log Mode		1 dB or 10 dB
Linear Mode		1-2-5 sequence: 10.83 μ V/div to 342.33 mV/div
FINE REF LVL STEP Activated		≥ 0.2 division per increment
Accuracy		Dependent on: <ul style="list-style-type: none"> ■ Normalizations ■ Calibrator accuracy ■ Frequency response

Table A-4: Amplitude-Related Characteristics (Cont.)

Characteristic	Performance Requirement	Supplemental Information																				
Display Dynamic Range	All except Option 50 and Option 75: 80 dB maximum (Log) 8 divisions (Linear)	Log Mode Display Dynamic Range is dependent upon the selected Resolution Bandwidth. The accuracy specifications apply for amplitude measurements done with the marker only, since marker measurements are corrected for logging errors. Option 50 and Option 75: Baseline will rise to indicated value, typically 10 dB to 20 dB below signal level applied near frequency of 2.11 GHz. Display Dynamic Range is reduced if there is signal energy at or near 2.11 GHz.																				
Accuracy 10 dB/div Mode	± 1.0 dB/10 dB to a maximum cumulative error of ± 2.0 dB over the 70 dB range and a maximum cumulative error of ± 4.0 dB over the 80 dB range	10 dB/div accuracy and range is affected by the signal-to-noise ratio of the selected Resolution Bandwidth filter. See following table for maximum specified range.																				
		<table border="1"> <thead> <tr> <th>Resolution Bandwidth</th> <th>dB Down</th> </tr> </thead> <tbody> <tr> <td>5 MHz</td> <td>40</td> </tr> <tr> <td>1 MHz</td> <td>40</td> </tr> <tr> <td>300 kHz</td> <td>50</td> </tr> <tr> <td>100 kHz</td> <td>50</td> </tr> <tr> <td>30 kHz</td> <td>60</td> </tr> <tr> <td>10 kHz</td> <td>60</td> </tr> <tr> <td>3 kHz</td> <td>80</td> </tr> <tr> <td>1 kHz</td> <td>80</td> </tr> <tr> <td>300 Hz</td> <td>80</td> </tr> </tbody> </table>	Resolution Bandwidth	dB Down	5 MHz	40	1 MHz	40	300 kHz	50	100 kHz	50	30 kHz	60	10 kHz	60	3 kHz	80	1 kHz	80	300 Hz	80
Resolution Bandwidth	dB Down																					
5 MHz	40																					
1 MHz	40																					
300 kHz	50																					
100 kHz	50																					
30 kHz	60																					
10 kHz	60																					
3 kHz	80																					
1 kHz	80																					
300 Hz	80																					
5 dB/div Mode	± 1.0 dB/10 dB to a maximum cumulative error of ± 2.0 dB over the 40 dB range																					
1 dB/div Mode	± 1 dB maximum error over the 8 dB range																					
Linear Mode	$\pm 5\%$ of full scale																					
RF Attenuator Range		0 to 50 dB in 2 dB steps																				

Table A-4: Amplitude-Related Characteristics (Cont.)

Characteristic	Performance Requirement			Supplemental Information
Sensitivity without Preamp				Equivalent maximum input noise for each resolution bandwidth.
Resolution Bandwidth	@110 MHz	@ 1.8 GHz	@ 2.15 GHz*	
5 MHz	-36 dBmV (-85 dBm)	-28 dBmV (-77 dBm)	-26 dBmV (-75 dBm)	*Performance measurements above 1.8 GHz refer to the Option 50 and Option 75 instruments only.
1 MHz	-43 dBmV (-92 dBm)	-35 dBmV (-84 dBm)	-33 dBmV (-82 dBm)	Sensitivity decreases linearly approximately 8 dB from 9 KHz to 1.8 GHz. Above 1.8 GHz sensitivity decreases linearly approximately 10 dB.
300 kHz	-48 dBmV (-97 dBm)	-40 dBmV (-89 dBm)	-38 dBmV (-87 dBm)	NOTE: Sensitivity degrades as the FREQUENCY setting is decreased from approximately 10 MHz to 9 kHz. Maximum loss in sensitivity is approximately 20 dB.
100 kHz	-53 dBmV (-102 dBm)	-45 dBmV (-94 dBm)	-43 dBmV (-92 dBm)	
30 kHz	-58 dBmV (-107 dBm)	-50 dBmV (-99 dBm)	-48 dBmV (-97 dBm)	
10 kHz	-63 dBmV (-112 dBm)	-55 dBmV (-104 dBm)	-53 dBmV (-102 dBm)	
3 kHz	-68 dBmV (-117 dBm)	-60 dBmV (-109 dBm)	-58 dBmV (-107 dBm)	
1 kHz	-73 dBmV (-122 dBm)	-65 dBmV (-114 dBm)	-63 dBmV (-112 dBm)	
300 Hz	-78 dBmV (-127 dBm)	-70 dBmV (-119 dBm)	-68 dBmV (-117 dBm)	
Sensitivity with Preamp				NOTE. Sensitivity with the Preamp enabled is not specified above 600 MHz.
Resolution Bandwidth	@110 MHz	@ 1.8 GHz and 2.15 GHz		
5 MHz	-48 dBmV (-95 dBm)	Not Specified		
1 MHz	-55 dBmV (-104 dBm)	Not Specified		
300 kHz	-60 dBmV (-109 dBm)	Not Specified		
100 kHz	-65 dBmV (-114 dBm)	Not Specified		
30 kHz	-70 dBmV (-119 dBm)	Not Specified		
10 kHz	-75 dBmV (-124 dBm)	Not Specified		
3 kHz	-80 dBmV (-129 dBm)	Not Specified		
1 kHz	-85 dBmV (-134 dBm)	Not Specified		
300 Hz	-90 dBmV (-139 dBm)	Not Specified		

Table A-4: Amplitude-Related Characteristics (Cont.)

Characteristic	Performance Requirement	Supplemental Information
Spurious Responses Residual (no input signal)	All except Option 50 and Option 75: ≤ -51 dBmV (≤ -100 dBm) except at 1780 MHz where the spurious response is ≤ -41 dBmV (≤ -90 dBm). Option 50 and Option 75: ≤ -26 dBmV (≤ -75 dBm) at 2.0 GHz.	With 0 dB RF attenuation
3 rd Order IM (Intermodulation) Products	All except Option 50 and Option 75: ≤ -70 dBc up to 1.8 GHz	From any two on-screen signals within any frequency span Option 50 and Option 75: Typically ≤ -65 dBc at 2.15 GHz
Zero Frequency Spur	$\leq +39$ dBmV (≤ -10 dBm)	Referenced to input with 0 dB RF attenuation
2 nd Harmonic Distortion	≤ -66 dBc	Measured with 1 st mixer input level of $\leq +9$ dBmV
LO (Local Oscillator) Emission	All except Option 50 and Option 75: ≤ -21 dBmV (≤ -70 dBm)	With 0 dB RF attenuation and preamp off. Option 50 and Option 75: When frequency is below 90 MHz: Typically $< +29$ dBmV (-20 dBm) When frequency is above 350 MHz: Typically ≤ -21 dBmV (≤ -70 dBm)

Table A-5: Input/Output Signal Characteristics

Characteristic	Performance Requirement	Supplemental Information
RF Input		Type F male connector or type N female connector
VSWR with RF Attenuation ≥ 10 dB	1.5:1 maximum	Checked to 1 GHz
VSWR with 0 dB RF Attenuation	All except Option 50 and Option 75: 2:1 maximum up to 1 GHz 3.5:1 maximum up to 1.8 GHz Option 50 and Option 75: 4:1 maximum up to 2.15 GHz	
Maximum Safe Input		+70 dBmV (0.1 W or 2.2 V) continuous peak 100 VDC blocking capacitor Caution: Do not apply more than 100 VDC or 100V peak AC to the RF Input
1 dB Compression Point (minimum)	+34 dBmV (-15 dBm)	With no RF Attenuation and 1 st mixer at +19 dBmV (-30 dBm)

Table A-5: Input/Output Signal Characteristics (Cont.)

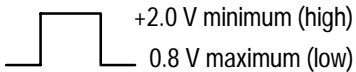
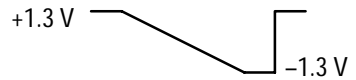
Characteristic	Performance Requirement	Supplemental Information
Ext Trig (J102)		BNC connector, 10 k Ω , DC coupled for external trigger signals
Voltage Range		
Minimum		Typically at least 100 mV _{peak} , 15 Hz to 1 MHz
Maximum		50 V (DC + peak AC)
Pulse Width		0.1 μ s minimum
Accessory Connector (J103)		DB-15 female connector
Pin 1: External Video Input		Typically 100 ohm, DC coupled, 0 - 50 kHz, 0 - 1.6 V (200 mV/div) signal input for vertical deflection of the CRT beam. The signal is processed through the video filters and the 1 dB, 5 dB, and 10 dB scale factor circuits on the Log board. Display storage may be by-passed.
Pin 2: Sweep Gate		TTL-compatible signal that goes to a logic high level while the CRT beam is sweeping.
Pin 3: Chassis and Signal Ground		
Pin 4: Sweep Output		Provides a nominal +1.3 V to -1.3 V negative-going ramp, proportional to the horizontal sweep (output impedance \leq 50 Ω).
Pin 5: Log Video Output		Provides 0 V to +1.6 V of video signal, inversely proportional to the vertical display amplitude. 0 V is the top of the screen. Impedance is 1 k Ω .
Pin 6: CLK0 Output		Clock output to Option 05 (External Tracking Generator). CMOS logic levels typically +3.5 V high, +1.5 V low.
Pin 7: Data I Input		Data input from Option 05 (External Tracking Generator). Typically +5 V high, +0.1 V low.
Pin 8: Data O Output		Data output to Option 05 (External Tracking Generator). CMOS logic levels, typically +3.5 V high, +1.5 V low.
Pin 9: ~EXTGLATCH		Logic output to Option 05 (External Tracking Generator). CMOS logic levels, typically +3.5 V high, +1.5 V low.
Pin 10: 26.38 MHz Input		Input from Option 05 (External Tracking Generator); typically a 0.5 V _{p-p} sine wave centered at +3.7 VDC.

Table A-5: Input/Output Signal Characteristics (Cont.)

Characteristic	Performance Requirement	Supplemental Information
Pin 11: VLVL Output		DC output to Option 05 (External Tracking Generator); typically ± 9.5 V with TG level set to ON.
Pin 12: SWPSLOPE Output		Negative going ramp output to Option 05 (External Tracking Generator); typically ± 5 V with analyzer set to max span.
Pins 13 through 15		Not used
Digital Communications Port (J104)		RS-232 or GPIB connector

Table A-6: Power Requirements

Characteristic	Performance Requirement	Supplemental Information
Input Voltage		
Line Voltage Range	90 VAC to 250 VAC	
Line Frequency Range	48 Hz to 63 Hz	
Line Voltage Range	90 VAC to 132 VAC	
Line Frequency Range	48 Hz to 440 Hz	
Line Fuse	2 A Slow-Blow	
Input Power	90 W (1.2 A) for standard instrument 105 W (1.4 A) maximum with options (115 W maximum at 90 V and 440 Hz)	At 115 V and 60 Hz
Leakage Current		3.5 mA _{RMS} maximum or 5 mA _{peak} maximum

Table A-7: Supplementary Characteristics Due to Options

Characteristic	Performance Requirement	Supplemental Information
Option 03		Provides a GPIB interface port at J104 to replace RS-232
Option 08		Provides a RS-232 serial interface port at J104 to replace GPIB
Option 15		Add a 1 st LO output
1 st LO Output Level	$\geq +48.8$ dBmV (≥ 0.0 dBm)	At spectrum analyzer frequencies ≥ 100 kHz

Table A-8: General Characteristics

Characteristic	Performance Requirement	Supplemental Information
Sweep		Normal, Single Sweep, and Manual Scan
Sweep Rate	1 $\mu\text{s}/\text{div}$ to 2 s/div in a 1–2–5 sequence	
Accuracy	$\pm 10\%$ over the center 8 divisions	
Triggering		Free Run, Internal, External, Line, TV Line, and TV Field
Internal Trigger Level	1 division or more of signal	
External Trigger Level		See EXT TRIG in Table A-5
Nonvolatile Memory (Battery-Backed Up)		Instrument settings, waveforms, and normalization results are stored in NVRAM
Battery Life (Lithium)		
At +55° C Ambient Temperature		1 to 2 years
At +25° C Ambient Temperature		At least 5 years
Temperature Range for Retaining Data		-10° C to +75° C
Internal Calibrator		Provides 100 MHz marker for amplitude calibration and comb of 100 MHz markers for frequency and span calibration
Amplitude and Accuracy	+18.8 dBmV (-30 dBm), ± 0.3 dB, at 100 MHz, ± 2 kHz	
Drift	± 2 PPM/year	
IF Gate Rise and Fall Times		7 μs nominal
Off Isolation		> 60 dB

Table A-9: Environmental Characteristics

Characteristic	Description
<i>The Description column describes how most characteristics were derived and a description of the characteristic. This instrument meets MIL-T-28800E, Type III, Class 5, Style C Specifications.</i>	
Electromagnetic Interference (EMI)	
Emissions: EN50081-1	Radiated Emissions, 30 MHz-1 GHz EN55022 Class B (CISPR 22B) Conducted Emissions, 150 kHz-30 MHz EN55022 Class B (CISPR 22B) Conducted Emissions, Power Line Harmonics, 0-2 kHz IEC 555-2/3
Immunity: EN50082-1	Electrostatic Discharge, 8 kV IEC 801-2 Radiated Immunity, 27 MHz-500 MHz IEC 801-3 Performance Requirement: No responses above -90 dBm in a 3 V/meter field Fast Transients, Capacitive Clamp, 1 kV Power Leads, 500 V Control Leads IEC 801-4 Power Line Surge, 1 kV Differential Mode, 2 kV common mode IEC 801-5
Temperature	
Operating	0° C to +50° C
Nonoperating ¹	-55° C to +75° C ²
Humidity	
Operating	95% RH ± 5% + 30° C and below 75% RH ± 5% + 31° C through + 40° C 45% RH ± 5% + 41° C through + 50° C
Nonoperating	Five cycles (120 hours) in accordance with MIL-STD-28800E, class 5
Altitude	
Operating	15,000 ft (4.57 km)
Nonoperating	50,000 ft (15.24 km)

¹ After storage at temperatures below -15° C, the instrument may not reset when power is first turned on. If this happens, allow the instrument to warm up for at least 15 minutes, then turn power off for 5 seconds and back on.

² NVRAM is lost below -10° C.

Table A–9: Environmental Characteristics (Cont.)

Characteristic	Description
Vibration Operating (Instrument secured to a vibration platform during test)	MIL-T-28800E, Method 514 Procedure X (modified) 15 minutes along each of 3 major axes at a total displacement of 0.015 in (0.38 mm) peak-to-peak (2.4 g at 55 Hz), with frequency varied from 10 Hz to 55 Hz in 1-minute sweeps Hold for 10 minutes at 55 Hz All major resonances must be above 55 Hz (resonance is defined as an excursion greater than 2X the input displacement)
Shock (Operating and Nonoperating)	Three guillotine-type shocks of 30 g, one-half sine, 11 ms duration each direction along each major axis, total of 18 shocks; no drops allowed on the front surface and front corners
Transit Drop (Free Fall)	8 in (203.2 mm), one per each of 5 faces and 4 corners (instrument is tested and meets drop height of 12 in (304.8 mm))

Table A–10: Physical Characteristics

Characteristic	Performance Requirement
Weight	
With Standard Accessories	25 lbs (11.34 kg)
Without Standard Accessories	22.5 lbs (10.21 kg)
Dimensions	
Height with Feet and Handle	5.4 in (137.16 mm)
Width	
With Handle	14.2 in (360.68 mm)
Without Handle	12.9 in (327.66 mm)
Depth	
With Front Panel Cover	17.5 in (444.50 mm)
Without Front Panel Cover	16.85 in (427.99 mm)
With Handle Extended	20.1 in (510.54 mm)

Table A-11: Certifications and Compliances

Category	Description
EC Declaration of Conformity – EMC	<p>Meets intent of Directive 89/336/EEC for Electromagnetic Compatibility. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Communities:</p> <p>EN 50081-1 Emissions: EN 55022 Class B Radiated and Conducted Emissions EN 60555-2 AC Power Line Harmonic Emissions</p> <p>EN 50082-1 Immunity: IEC 801-2 Electrostatic Discharge Immunity IEC 801-3 RF Electromagnetic Field Immunity IEC 801-4 Electrical Fast Transient/Burst Immunity IEC 801-5 Power Line Surge Immunity</p>
EC Declaration of Conformity – Low Voltage	<p>Compliance was demonstrated to the following specification as listed in the Official Journal of the European Communities:</p> <p>Low Voltage Directive 73/23/EEC</p> <p>EN 61010-1:1993 Safety requirements for electrical equipment for measurement, control, and laboratory use</p>
Approvals	<p>UL1244 – Standard for Electrical and Electronic Measuring and Testing Equipment</p> <p>CAN/CSA C22.2 No. 231 – Safety Requirements for Electrical and Electronic Measuring and Testing Equipment</p>
Installation Category Descriptions	<p>Terminals on this product may have different installation category designations. The installation categories are:</p> <p>CAT III Distribution-level mains (usually permanently connected). Equipment at this level is typically in a fixed industrial location</p> <p>CAT II Local-level mains (wall sockets). Equipment at this level includes appliances, portable tools, and similar products. Equipment is usually cord-connected</p> <p>CAT I Secondary (signal level) or battery operated circuits of electronic equipment</p>

Table A-12: Safety Certification Compliance

Category	Description
Temperature (operating)	+5° C to +50° C
Altitude (maximum operating)	2000 meters (6562 ft.)
Relative Humidity (maximum operating)	80% for temperatures up to 31° C, decreasing linearly to 50% at 40° C
Equipment Type	Test and Measuring
Safety Class	Class I (as defined in IEC 1010-1, Annex H)—grounded product
Overvoltage Category	Overvoltage Category II (as defined in IEC 1010-1, Annex J)
Pollution Degree	Pollution Degree 2 (as defined in IEC 1010-1) Note: Rated for indoor use only.

Table A-13: Safety Standards

Category	Standards
U.S. Nationally Recognized Testing Laboratory Listing	UL1244 – Standard for Electrical and Electronic Measuring and Testing Equipment
Canadian Certification	CAN/CSA C22.2 No. 231 – Safety Requirements for Electrical and Electronic Measuring and Test Equipment
European Union Compliance	Low Voltage Directive 73/23/EEC, as Amended by 93/68/EEC EN61010-1/A1 – Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use
Additional Compliance	UL3111-1 – Standard for Electrical Measuring and Test Equipment IEC1010-1 – Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use

Appendix B: Broadcast AM, FM, and TV Signal Sources



CAUTION. To prevent damage when connecting signal sources to the 2715, be certain the total signal strength is less than +70 dBmV. If in doubt, check with a broadband RF wattmeter or voltmeter.

For some of the experiments in this manual, you need AM or FM modulated signals. The most readily available signals are AM and FM broadcasts. To receive AM or FM broadcast radio stations, you can plug a piece of wire directly into the center terminal of the input connector and hang the other end out a nearby window. If your building is not metal-framed, you can probably use a length of wire that fits within the same room as the spectrum analyzer. The required length of wire will depend on the strength, location, and frequency of the transmitter, among other variables; 50 kW FM stations 40 miles distant have been received with a wire paper clip, straightened and inserted directly into the input connector.



CAUTION. The spectrum analyzer can be damaged by static discharge or high-level signals. Remove any static charge before connecting a wire or antenna to the spectrum analyzer.

Remove any static charge by first momentarily grounding the wire to the case of the instrument. If the wire may be carrying AC or DC power, measure it with a high-impedance voltmeter or oscilloscope to be sure that it does not exceed the DC input rating of the spectrum analyzer. If you are close to a transmitter, be sure to set a reasonably high value of RF attenuation before connecting the wire or antenna to the spectrum analyzer. Use the spectrum analyzer to measure the signal amplitude at the frequency of the transmitter before going to lower attenuator settings. If you have an accessible antenna (such as a wire or whip) connected, ground yourself to the case of the instrument to dissipate body static charge before touching the antenna.

Appendix C: System Messages

The 2715 will display messages under the following conditions:

- Self-check routines detect abnormalities
- Incorrect information is entered
- An improper operation is attempted
- It is necessary to alert you to an operation in progress

The messages that may be displayed are contained in the following list. Their causes and corrections are indicated immediately below the message. If you are unable to correct an abnormal situation, contact your local Tektronix Service Center and report the message.

1ST MEASUREMENT COMPLETE

Go to the next step in the procedure.

2ND MUST BE W/IN CHAN BW

The second aural carrier must be within the channel bandwidth.

2ND MUST BE W/IN RANGE OF 1ST

The second aural carrier must be 200 kHz to 2.550 MHz greater than the first aural carrier.

300HZ FILTER NOT INSTALLED

2715 cannot detect presence of 300 Hz filter.

ADDITIONAL NVRAM NOT INSTALLED

Occurs when accessing a file located in extended NVRAM if the 2715 cannot detect the presence of the extended NVRAM.

AMPL NORM SUGGESTED (VR PIN DAC)

Perform amplitude normalization. Contact your local Tektronix service center or representative if message persists.

AMPL OUT OF RANGE (NORMALIZATIONS)

Perform amplitude normalization again. Contact your local Tektronix service center or representative if message persists.

AMPLITUDE NORMALIZATION FAILED

Perform amplitude normalization again. Contact your local Tektronix service center or representative if message persists.

AMPLITUDE OUT OF CALIBRATION

The spectrum analyzer amplitude may be out of calibration. This message may be generated by the auto sweep rate measurement routine.

AVERAGE NOISE TOO LOW

The average noise level in the Carrier-to-Noise or Noise Normalization measurement is below the bottom of the screen and cannot be digitized. To correct the problem, reduce the reference level to bring the noise level onto the screen.

AVERAGE IN PROCESS

An ensemble average (not CONTINUOUS) is in process. Used to report event over GPIB.

CALIBRATOR DOESN'T MATCH READOUT

The calibrator is enabled and an external attenuation or external frequency offset is enabled.

CAN'T COUNT WITH CORRECTIONS OFF

Turn Frequency Corrections ON. The location of this selection is [UTIL] [4] [3].

CANNOT CALC. VERT. SENSITIVITY

Perform amplitude normalization. Contact your local Tektronix service center or representative if message persists.

CANNOT COUNT (VCO IF)

Perform frequency normalization. Either the VCO counter input or the IF counter input failure can cause this error to occur. Contact your local Tektronix service center or representative if message persists.

CANNOT COUNT BEAT FREQUENCY

Perform frequency normalization. Contact your local Tektronix service center or representative if message persists.

CANNOT DELETE FILE WHILE IN USE

Occurs when attempting to delete a file that is in use.

CANNOT NORMALIZE PLL VCO

Perform frequency normalization. Contact your local Tektronix service center or representative if message persists.

CANNOT OVERWRITE SAVED DISPLAY

Old data must be deleted or transferred to STORED SETTINGS before new data can be saved.

CANNOT OVERWRITE STORED REF

An attempt was made to overwrite a stored reference.

CANNOT OVERWRITE STORED SETTING

An instrument setting is already stored in this register. Old setting must be deleted first.

CANNOT OVERWRITE STORED WAVEFORM

A waveform is already stored in this register. Old waveform(s) must be deleted first.

CANNOT STORE — NV MEMORY FULL

Must delete other settings if further storage is desired.

CATV MEASUREMENT FAILURE

A CATV measurement function failed.

CHAN DOESN'T EXIST IN CHAN TABLE

A channel has been selected that does not exist in the current channel table.

CNTR SIGNAL OUT OF IF PASSBAND

The signal in zero span is not above the threshold. Perform CTR MEAS again or use a wider resolution bandwidth filter. Performing a frequency normalization may also facilitate a count. Because of span and display storage inaccuracies, the signal may not be exactly centered in the digital display.

COMM PORT NOT INSTALLED

2715 cannot detect the presence of the communications port.

COMMAND NOT IMPLEMENTED

Feature not installed on this instrument.

COUNTER FREQUENCY UNSTABLE

Perform normalizations again. Frequency counter or input to it is unreliable. Contact your local Tektronix service center or representative if message persists.

COUNTER NOT INSTALLED

2715 cannot detect the presence of the counter.

DATA ERROR IN FILE

Firmware/hardware error. Contact your local Tektronix service center or representative if message persists.

DBUV/M MEASUREMENT MODE IDLE

Destination waveform for DBUV/M is not being displayed and the correction calculation is disabled. The mode can be restarted by turning on the destination waveform register.

DEFAULT DATA LOADED

Since a file could not be read to load a data structure, the default values were loaded into the file and into the data structure.

DELETE EDITING BUFFER FIRST

The editing buffer must be deleted before the desired function or entry can be accomplished.

DELETE EXISTING PROGRAM FIRST

A user-defined program already exists in this register. It must be deleted before the new one can be stored.

DELETE EXISTING TABLE FIRST

An attempt was made to store an antenna correction factor table in a file position that is already used. You must delete the file with the table deletion menu prior to attempting to store the new file.

DESTINATION WAVEFORM CONFLICT

An attempt was made to enable two functions that use the same destination waveform. The display line, ensemble average, min hold, dBmV/M and waterfall mode use destination waveforms.

DIRECTORY ERROR IN FILE

Firmware/hardware error. Contact your local Tektronix service center or representative if message persists.

DISCONNECT INPUT SIGNAL

Input signal needs to be removed in following step.

DISPLAY LINE OFF SCREEN

The display line is out of range either at the top or bottom of the CRT display.

EDITING BUFFER IS EMPTY

The local editing buffer for either the UDP or antenna tables is empty. If you are attempting to delete the editing buffer, the error message is simply to inform the you that the selected action is invalid.

END OF FILE

Firmware/hardware error. Contact your local Tektronix service center or representative if message persists.

ENSEMBLE AVERAGE COMPLETE

Signifies completion of an ensemble average process.

ERROR

Firmware error. Contact your local Tektronix service center or representative if message persists.

FATAL ERROR IN FILE

Firmware/hardware error. Contact your local Tektronix service center or representative if message persists.

FILE NOT FOUND

Occurs when attempting to access a file that does not exist.

FILE SIZE ERROR

Occurs when attempting to create a new file in NVRAM and the size of the new file is not the same as the size of the existing file. The most probable cause is that there is a version mismatch between the file system and the current firmware.

FILE SYSTEM DIRECTORY FULL

Occurs when attempting to store a file in the NVRAM and there are no more directory entries available.

FILE SYSTEM FULL

Occurs when attempting to store a file in the NVRAM and there is no more room to store the file.

FIRST STEP MUST BE DONE FIRST

Preceding step must be performed prior to selected one. Part of the reference normalizations are order-dependent.

FLATNESS CORRECTION NOT AVAIL

An attempt to access the measurement-specific flatness correction failed. A value of 0.0 is used on failure to access correction data. This failure is usually due to a corrupted or missing flatness correction data file.

FORMATTING PLOT

Downloading plot file to hardcopy device.

FREQ OUT OF RANGE (NORMALIZATIONS)

Perform frequency normalization again. Contact your local Tektronix service center or representative if message persists.

FREQ NORM SUGGESTED (1ST LO)

Perform frequency normalization. Contact your local Tektronix service center or representative if message persists.

FREQ NORM SUGGESTED (FIND SIDE)

Perform frequency normalization. Contact your local Tektronix service center or representative if message persists.

FREQ NORM SUGGESTED (INNER PLL)

Perform frequency normalization. Contact your local Tektronix service center or representative if message persists.

FREQ NORM SUGGESTED (SET BEAT)

Perform frequency normalization. Contact your local Tektronix service center or representative if message persists.

FREQ NORM SUGGESTED (SET VCO)

Perform frequency normalization. Contact your local Tektronix service center or representative if message persists.

FREQ NORM SUGGESTED (SPAN DAC)

Perform frequency normalization. Contact your local Tektronix service center or representative if message persists.

FREQUENCY NORMALIZATION FAILED

Perform frequency normalization again. Contact your local Tektronix service center or representative if message persists.

FUNC NOT AVAIL IN DBUV/M MODE

Selected function is not available with the dB μ V/m measurement mode enabled. Functions not available include LIN vertical mode, FM and EXTERNAL display sources, and attempting to unsave the selected destination waveform. Choose new reference units to enable the selected operation.

FUNC NOT AVAIL IN CURRENT MODE

Refer to manual for proper instrument settings. This error message may appear, for instance, upon the invocation of instrument functions such as carrier to noise, noise normalized bandwidth, and antenna correction factors while in linear scaling mode. In these particular cases the vertical scaling mode would have to be changed to logarithmic before invoking the functions. Another case would be the invocation of a user-defined routine while in the user-defined routine acquisition mode. The acquisition mode must be exited before any routine can be activated.

FUNC NOT AVAIL ON THIS CHAN TYPE

A function was invoked on a signal which the channel table thinks is of an inappropriate type to be performed on this signal.

FUNCTION NOT AVAIL IN LIN MODE

Switch to LOG mode vertical scale to obtain proper functioning. This error message may appear upon the invocation of instrument functions such as carrier to noise, noise normalized bandwidth, and antenna correction factors.

FUNCTION NOT AVAIL IN MAX SPAN

Signal track mode incompatible with MAX SPAN. Try smaller span.

ILLEGAL COMMAND

Firmware error. Contact your local Tektronix service center or representative if message persists.

ILLEGAL PARAMETER PASSED

Firmware error. Contact your local Tektronix service center or representative if message persists.

ILLEGAL START/STOP/INC VALUES

Illegal Start, Stop, or Increment values are present for the antenna correction factor table the user is attempting to edit. Either the initial non-usable values are present (the user has not attempted to enter his own values) or the values entered have some inconsistency, such as the start value being greater than the stop value.

INACTIVE MARKER OFF SCREEN

The frequency value of the inactive marker has been retained. The marker itself is out of the range of the display and is not visible.

INSUFFICIENT MEMORY AVAILABLE

Not enough memory (NVRAM) is available for the operation.

INTERNAL REF AMPL TOO INACCURATE

Perform reference amplitude normalization again, checking for the presence of the correct external reference frequency and amplitude. Contact your local Tektronix service center or representative if message persists.

INTERNAL REF FREQ TOO INACCURATE

Perform reference frequency normalization again, checking for the presence of the correct external reference frequency and its correct entry from the keypad. Contact your local Tektronix service center or representative if message persists.

INTERRUPT FAULT AT FF

Firmware/hardware error. Contact your local Tektronix service center or representative if message persists.

INTERRUPT FAULT

Firmware/hardware error. Contact your local Tektronix service center or representative if message persists.

INVALID DEVICE NUMBER

Firmware/hardware error. Contact your local Tektronix service center or representative if message persists.

INVALID FILE NUMBER

Firmware/hardware error. Contact your local Tektronix service center or representative if message persists.

LAST PWR DOWN REG CHECKSUM ERR

Last power down settings bad; defaults used. Contact your local Tektronix service center or representative if message persists.

LEAVE INTERACTIVE MODE FIRST

An attempt was made to do something illegal in interactive mode or carrier-to-noise mode, such as run another CATV test or try to invoke a UDP.

MALLOC: RAN OUT OF MEMORY

Memory allocation firmware/hardware error. Contact your local Tektronix service center or representative if message persists.

MARKERS ARE OFF

Marker(s) must be turned on to obtain desired function.

MARKER WOULD OVERWRITE NOISE VALUE

Enabling the marker would overwrite the saved Carrier-to-Noise or Normalized Noise value. Markers cannot be placed on a display saved with Carrier-to-Noise or Noise Norm'd modes enabled.

MUST BE IN DELTA MARKER MODE

Turn on Delta Markers to obtain desired function.

NO CSO BEATS ARE DEFINED

This message appears when a continuous CSO test terminates because no beats were specified in the CSO setup menu.

NO LISTENER

A screen plot front-panel operation was attempted to the GPIB port but no listen addressed devices were available. Place a listen-addressed device on the bus and reselect the operation.

NO MODULATION ON SIGNAL

Occurs in zero span when CTR MEAS is attempted and there is no constant frequency modulation on the carrier.

NO QUIET VIDEO LINES FOUND

Quiet lines are retrace lines where no modulation is present. The Carrier-to-Noise and Composite Second Order tests use quiet lines to take in-service measurements. The 2715 was unable to automatically find quiet lines to use for the tests.

NO REFERENCE DEFINED

A function was invoked which requires a valid current reference, but no such reference exists.

NO SIGNAL (NORMALIZATIONS)

Perform normalizations again. Contact your local Tektronix service center or representative if message persists.

NO SIGNAL FOUND ABOVE THRESHOLD

There is no displayed signal exceeding the marker threshold value. Threshold can be reset using the MKR/FREQ menu.

NO SIGNAL AT CENTER OF DISPLAY

Firmware/hardware error. Contact service center if message displays repeatedly.

NO SIGNAL AT COUNTER INPUT

Perform normalizations again. Contact your local Tektronix service center or representative if message persists.

NO TEST LINE NUMBER SPECIFIED

An in-service measurement of the in-channel response was attempted without entering a test signal line number. Enter a test signal line number at the menu prompt and then take the in-service in-channel response measurement.

NOISE LEVEL LESS THAN 2DB

Measured system noise level is less than 2 dB above the 2715 noise floor. Noise power correction has been made by NOISE NORM'D or C/N mode algorithms in the 2715.

NON-COMPATIBLE NVM FORMAT

The firmware version was not compatible with the non-volatile memory. Consequently the NVM was re-initialized. Contact service center if message displays repeatedly.

NONE OF THE TRACES ARE ACTIVE

A digitized waveform must be on to employ desired function.

NORMALIZATION COMPLETE

Normalization routine successfully finished.

NORMALIZATION SUGGESTED

Frequency normalization needed. Contact your local Tektronix service center or representative if message persists.

NORMALIZED RESULT OUT OF RANGE

Perform normalizations again. Contact your local Tektronix service center or representative if message persists.

NORMALIZING

Normalization routine running.

NOT AVAILABLE WITH DBUV/M IDLE

The selected function is not available with DBUV/M mode idled. Select new reference unit to enable operation.

NOT AVAIL IN SHORT HOLDOFF MODE

Certain functions that require end-of-sweep processing are not available when in the Short Holdoff mode.

NOT AVAIL IN WATERFALL MODE

The selected function is not available in waterfall mode.

NOT AVAIL W/DISPLAY STORAGE ON

Function not compatible with digital display. Use analog display.

NOT INSTALLED

Feature not installed on this instrument.

NVM CHECKSUM ERROR

Nonvolatile memory has been corrupted and consequently re-initialized. Contact the local Tektronix service center or representative if message persists.

NVM FRAGMENTATION ERR

Firmware/hardware error. Contact your local Tektronix service center or representative if message persists.

NVM SEGMENTATION ERROR

Firmware/hardware error. Contact your local Tektronix service center or representative if message persists.

NVM VERSION MIS-MATCH

Firmware/hardware error. Contact your local Tektronix service center or representative if message persists.

ONLY WAVEFORMS DELETED

When settings you are attempting to delete are protected, only the saved waveforms are deleted.

ONLY WAVEFORMS SAVED

When saving settings in a location containing previously protected settings, only the waveforms are saved.

OUT OF RANGE

A value has been entered that is outside the permitted range. The instrument will default to the closest permissible value. If the message appears at times other than data entry, a firmware/hardware error is probable. Contact your local Tektronix service center or representative if message persists.

PLOT ABORTED

A new plot request has caused the currently running plot to be aborted. A new plot must be requested again in order to restart plot process.

PLOT COMPLETE

A plot operation has been finished.

PLOT IN PROCESS

Signifies (for GPIB reporting) that a plot is in progress.

POLYNOMIAL HAS NO SOLUTION

Firmware/hardware error. Contact your local Tektronix service center or representative if message persists.

PORT OFFLINE

Select ONLINE in proper port configuration submenu.

PRINTER ERROR

Check the printer. Some printers return Printer Error for all conditions that need attention (offline, out of paper, etc.); refer to the printer manual.

PRINTER IS NOT CONNECTED

Connect printer to appropriate port. Check printer cable.

PRINTER OUT OF PAPER

Reload printer paper.

PROGRAM NOT EXECUTABLE

The selected user-defined program is corrupted or too big to fit into available internal memory. Delete and resave the affected program.

PROTECTED FILE

Occurs when attempting to delete a file that is protected.

QUERY NOT AVAILABLE

Query attempted on function for which there is no query response.

QUIET LINE VERIFICATION FAILED

The 2715 was unable to find the quiet line used to take in-service Carrier-to-Noise and Composite Second Order measurements.

REAL TIME CLOCK HW FAILURE

Firmware/hardware error. Contact your local Tektronix service center or representative if message persists.

REAL TIME CLOCK NOT INSTALLED

2715 cannot detect presence of real-time clock.

REFERENCE LEVEL HAS NEW RANGE LIMITS

The reference level range limits have changed because the preamp or external ATTEN/AMPL mode is activated. The reference level itself does not change.

REFERENCE NORMALIZATION FAILED

Perform the reference normalization again, checking for the presence of the correct external reference frequency and its correct entry from the keypad, if required. Contact your local Tektronix service center or representative if message persists.

REGISTER VALUE NOT ALLOWED

A storage register value was utilized that is not legal for the requested function. For example, the register value 1 was used with the GPIB command STORe. This attempts to store settings in the factory default power-up register, a reserved register.

REMOVE PROTECTION FIRST

The selected user-defined program cannot be deleted until its file protection is removed.

RUNTASK: CANNOT START PROCESS

Firmware error. Contact your local Tektronix service center or representative if message persists.

SATELLITE VIDEO MNTR NOT INSTLD

2715 cannot sense presence of optional satellite (FM) video detector.

SEARCH TERMINATED, MAX SIGNALS

Signal search is terminated if it detects more than 50 signals.

SELECT TALK ONLY MODE FIRST

Screen plot front-panel operation requires the GPIB address mode to be talk only when the plot port is set to GPIB.

SELECTED PROGRAM IS EMPTY

The selected user defined program is empty. No action is taken.

SELECTED STORED SETTING IS EMPTY

Setting must be stored before it can be recalled.

SELECTED TABLE IS EMPTY

The selected antenna correction factor table is empty.

SETTING CORRUPTED

Requested stored setting has been deleted because of a corrupted data value. This message may also occur in general instrument operation if Settings Verify [UTIL] [5] [4] is turned ON. This selection checks all data transactions involving the instrument settings. No deletions occur in the general operation. Contact your local Tektronix service center or representative if message persists.

SHORT HOLDOFF MODE NOT INSTLD

2715 cannot detect presence of Short Holdoff feature.

SHORT YIG DELAY. GO TO UTIL/5/4

The YIG oscillator settling delay time has been changed from the factory default setting of 5000 ms. Use the Utility Menu ([UTIL] [5] [4] [2]) to change the YIG oscillator settling delay time, if desired. Settings less than 5000 ms may affect instrument compliance with published specifications.

SIGNAL CANNOT BE SET PROPERLY

Perform normalizations again. Contact your local Tektronix service center or representative if message persists.

SIGNAL OUT OF IF PASSBAND

Frequency to be counted is not within one resolution bandwidth of the center frequency. Repeat CTR MEAS or use a wider resolution bandwidth filter. Performing a frequency normalization may also facilitate a count. Because of span and display storage inaccuracies, the signal may not be exactly centered in the digital display.

The message may also be displayed in Signal Track mode with the Frequency Counter enabled when tracking a rapidly moving signal. Disabling the Frequency Counter may correct the problem. The instrument may also try to count random noise on the filter skirts resulting in this error message. Turning on the Video Filter or raising the Signal Threshold corrects the problem.

SIGNAL OVER RANGE

The signal peak is above the top of the CRT display. Lower the reference level.

SINGLE SWEEP ARMED

Instrument armed for single sweep.

SINGLE SWEEP MODE

Instrument in single sweep mode.

SINGLE SWEEP TRIGGER

Single sweep has been triggered.

SIGNAL SEARCH COMPLETE

Firmware routine finished.

SIGNAL SEARCH IN PROCESS

Firmware routine running.

STAND BY

A delay is required in the use of the instrument until this message disappears.

START FREQUENCY CHANGED

A change in the stop frequency necessitated a change in the start frequency.

STOP FREQUENCY CHANGED

Change in start frequency necessitated a change in stop frequency.

STORAGE REGISTER EMPTY

No data yet stored in the register accessed.

TABLE CURRENTLY IN USE

The table is currently in use, but the user may still delete it if desired.

TABLE IS TOO LARGE TO EDIT

The current combination of start/stop/increment setup frequencies results in a correction table with too many elements.

TIMER INTERRUPT FAULT

Firmware/hardware error. Possible malfunction of interrupt timer on processor board indicated. Contact your local Tektronix service center or representative if message persists after normalization.

TOO MANY FILES OPEN

Firmware/hardware error. Indicates that the maximum number of files is already open. Cannot open any more files at this time. Contact your local Tektronix service center or representative if message persists after normalization.

UNCAL

Indicates the 2715 is operating in an uncalibrated state. Occurs under the following conditions:

- Sweep speed is too fast for a specified resolution BW, video filter, and span combination
- One or more critical normalizations have not been completed successfully

UNCAL OFF

A change-of-state indicator briefly displayed when an uncalibrated state has been corrected and exited.

UNCAL ON

A change-of-state indicator briefly displayed when an uncalibrated state has been entered.

UNDEFINED ERROR CODE

Firmware/hardware error. Returned error code has overrun established limits. Contact your local Tektronix service center or representative if message persists.

UNDEFINED EVENT CODE

Firmware/hardware error. Returned error code has overrun established limits. Contact your local Tektronix service center or representative if message persists.

USE ANTENNA SETUP MENU FIRST

The antenna start/stop/increment frequencies must be set prior to editing the correction table.

USER DEFINED PROGRAM IN PROCESS

A UDP is in progress. Reported primarily for GPIB purposes.

USER DEFINED PROGRAM COMPLETE

A UDP has finished.

USER REQUEST

A user request SRQ has been initiated.

VERT MODE/SCALE MISMATCH ON DIFF

B minus A function attempted with mixed vertical modes (LOG/LIN display, AM/FM demodulator) or mixed scales (10/5/1 dB/, 10/5/1 kHz/, 17.5/87.5/175 MV/). Reset the vertical modes or scales to be consistent. Amplitude mode/scale choices are found with **[UTIL] [2] [6]** with scale choices also available from the front panel VERT SCALE function block. Demodulator choices are found with **[DEMODO] [1]** and **[DEMODO] [2]**.

WAIT ABORTED SWEEP NOT ARMED

Requested WAIT FOR END OF SWEEP was aborted immediately to avoid an endless wait loop. This error occurs if WAIT is requested while in single sweep mode with the sweep not armed.

WARNING: USING EMPTY ANT TABLE

The table called for is empty. The function is still being performed but with values of zero for each increment of the table.

ZERO SPAN ENTERED

Instrument is now in zero span.

Appendix D: Global Resets

Settings on the 2715 can be reset in many ways. Some instrument settings are always reset, while others are never reset, and still others are reset during certain reset cycles only. This appendix includes a description of which settings are in each category, and when each category of settings is reset.

Definitions

These definitions are included to make the following explanations more clear.

Reset

To restore a setting to a previous state. This is what happens to the center frequency, for example, when power is removed and re-applied. The center frequency setting is RESET.

Reset Category

Each setting belongs to one RESET CATEGORY, such as center frequency belongs to the fragile reset category. The categories are described later in this appendix.

Reset Cycle

An operation that causes one of the RESET CATEGORIES to be operated on.

Retain

The opposite of RESET. A setting is RETAINED for a particular RESET CYCLE if its value can be set to any allowable value and remains at that value after the RESET CYCLE completes.

Reset Cycle Description

Following is a list of all the possible reset cycles:

POWER DOWN/UP CYCLE

Invoked by powering the instrument down and back up again.

INITIALIZE INSTRUMENT SETTINGS CYCLE

Invoked with [UTIL] [0].

RECALL LAST POWER DOWN CYCLE

Invoked with [UTIL] [1] [0].

RECALL FACTORY DEFAULT POWER-UP CYCLE

Invoked with [UTIL] [1] [1].

RECALL USER DEFINED POWER-UP CYCLE

Invoked with [UTIL] [1] [2] [W].

RECALL NUMBERED SETTINGS CYCLE

Invoked with [UTIL] [1] xx [W]. xx is one of a selection of stored settings designated by numerals 0-9 on 4 successive screens.

POWER-UP DIAG AND REBOOT CYCLE

Invoked with [UTIL] [5] [0] [9].

Reset Categories

The 2715 has several distinct settings categories.

Precious Settings

Precious settings are not reset by any reset cycle. The settings in this class can only be changed by manually setting each to its desired value. The following are precious settings:

- Measurement Channel
- Saved Waveforms
- Plot Configuration (including Comm Port, Plot Language, and Plot Speed)
- GPIB or RS-232 configuration
- Real-Time Clock Configuration
- Audio Alert Setting
- Settings Protect Mode
- Signal Search Parameters

Mode-related Settings

These are settings that are reset during some cycles and retained during others. The settings are reset as follows:

- During an INITIALIZE INSTRUMENT SETTINGS cycle, settings are reset to the values retained at the last physical power down.
- During a POWER DOWN/UP cycle, settings are reset to the values retained at the last physical power down, unless a User-Defined Power-up exists — in that case, settings are reset to those stored in the User-Defined Power-up setting.
- During a POWER-UP DIAG AND REBOOT cycle, settings are reset the same as during a POWER DOWN/UP cycle, but instead of the values resetting to those retained at the last physical power down, they reset as if a physical power down had just occurred.

- During all other cycles, settings are not reset.

The following are mode-related settings:

- Utility Menu Items
 - Spectral Display in Menus
- Marker/Freq Menu Items
 - Frequency Reference Mode (CENTER/START)
 - Counter Resolution
 - Frequency Tuning Mode (AUTO and TABULAR only; others revert to AUTO)
 - Entered Frequency Tuning Increment
 - Tabular Tuning Table
 - Frequency Offset
 - Frequency Offset Mode (ON/OFF)
- Input Menu Items
 - Input Impedance
 - Reference Level Units
 - External Gain/Attenuation
 - External Gain/Attenuation Mode (ON/OFF)
 - dB μ V/M Measurement Distance
 - dB μ V/M Antenna Table
 - dB μ V/M Target Waveform
- Sweep/Trigger Menu Items
 - Video Sync Polarity
 - Video Line Triggering Mode (CONTINUOUS/KNOB/ENTERED)
 - Video Line Triggering Standard (NTSC/SECAM/PAL/OPEN)
- Display Menu Items
 - Ensemble Averaging Destination Waveform
 - MIN HOLD Destination Waveform

- Ensemble Averaging Mode
- Ensemble Averaging Number-of-Sweeps
- B,C Minus A Offset Mode, Display Acquisition Mode (PEAK/MAX-MIN)
- Display Line Value
- CATV/Applications Menu Items
 - Bandwidth Display dBc Value
 - Occupied BW percent
 - Carrier-to-Noise Reference Bandwidth
 - Normalized Noise Reference Bandwidth
- Demod Menu Items
 - Video Monitor Mode (BROADCAST/SATELLITE)
 Sync Polarity
 Video Polarity

Fragile Settings

Fragile settings are those that are reset during any reset cycle. Any settings not covered by the previous categories are fragile. Resets occur as follows:

- During POWER DOWN/UP, INITIALIZE INSTRUMENT SETTINGS, and POWER-UP DIAG AND REBOOT cycles, settings are reset to user-defined power-up (if it exists) — otherwise, settings are reset to default values.
- During RECALL LAST POWER DOWN cycle, settings are reset to last power-down settings.
- During RECALL FACTORY DEFAULT POWER-UP, settings are reset to the factory default settings.
- During RECALL USER DEFINED POWER-UP and RECALL NUMBERED SETTINGS cycles, settings are reset to the specified settings storage register.

Normalization Values

The normalization values are modified by executing some or all of the normalizations. These values are only lost in the case of certain NVRAM failures. The values being used by the instrument may be set to default values with the service menus. Normalization values for the last executed (passed) normalizations are always restored during the POWER DOWN/UP and the POWER-UP DIAG AND REBOOT cycles. The other cycles do not affect the normalization values.

Appendix E: External Input and Output

The rear panel of the 2715 contains several input and output (I/O) connectors. One or more may not be used on your instrument, depending on which options you have installed.

Mains Power

For safety, be sure to use a 3-wire, AC power cord, and be certain the ground conductor is properly connected. Adjacent to the power receptacle is the mains fuse with its size marked. If the fuse repeatedly blows, it is likely you have a hardware problem. If you suspect a problem, contact your local Tektronix Field Office or representative.

J101 — TV Sideband Analyzer and External Tracking Generator Interface

This output connector provides the first local oscillator (1st LO) signal to the Tektronix 1405 TV Sideband Analyzer or the 2707 External Tracking Generator. The connector is provided as part of Option 15. The 1405 is designed for testing video modulators, transmitters, and CATV head ends. The sideband analyzer provides standard video signals to the input of the modulator, whose output is accurately measured using the 2715. The 2707 External Tracking Generator allows you to make swept frequency measurements on devices such as filters. Simply insert an SMA-to-SMA cable between the LO IN connector on the rear of the 1405 (or J101 IN on the rear of the 2207) and J101 on the rear of the 2715.

You can also superimpose frequency markers generated by the 1405 on the sweep produced by the 2715. The markers consist of variable width “dips” in the 2715 sweep and are in addition to the intensified frequency markers internally generated by the 2715. To superimpose the markers, connect the Z AXIS OUT signal from the 1405 to the 2715 external video input (pin 1 of accessory connector J103; use pin 3 of J103 for signal ground). Turn the markers on or off with the push-buttons on the 1405, and control their width and depth using the WIDTH and INTEN controls on the 1405 front panel. Consult the *1405 User Manual* or Tektronix publication 26W-7043 *Antenna To Tap...No Loose Ends*, for instructions on making measurements with the 1405/271x combination (treat the 2715 as though it is a 2710).

J102 — External Trigger

The shell of this BNC input connector is at chassis ground. If you plan to use an external trigger (see SWP/TRIG in *Spectrum Analyzer Menus*), this is where the trigger signal is input to the 2715. The trigger signal must be positive-going and rise above 100 mV for at least 0.1 μ s.



CAUTION. To avoid damaging the 2715, combined AC plus DC trigger signal levels must not exceed 50 V peak.

An external trigger signal starts a new sweep each time it rises above a threshold established by the setting of the LEVEL control, providing the previous sweep is completed and item 2, EXTERNAL, is selected from the Sweep/Trigger menu.

A typical external trigger signal might be a +5 V pulse signifying that a transmitter has been keyed on, or that a receiver has detected a signal that rises above its squelch setting. For instance, to determine the spectrum of a gated CW signal, you could apply the gated CW to the 2715 input while triggering externally with the gating signal. The 2715 would then perform a spectral sweep only when the CW signal was present at its input.

To trigger the 2715 externally, connect the external trigger signal to the EXT TRIG connector and select item 2, EXTERNAL, from the Sweep/Trigger menu. Turn the LEVEL control fully counter-clockwise and then rotate it slowly clockwise until a sweep occurs. If the external trigger is pulsing, the 2715 sweep should now remain in sync with it (if not, you may have to adjust the LEVEL control a bit more).

When you are finished, reselect the FREE RUN trigger mode.

J103 — Accessory Connector

The accessory connector, J103, is a 15-pin D connector, (not RS-232 compatible). The connector provides an interface for video I/O, the 2715's sweep gate, and the sweep ramp signals. The connector also provides signals used by the Tektronix 2707 External Tracking Generator. Terminations are shown in Figure E-1. The following signals are discussed in detail:

- External Video Input (pin 1)
- Sweep Gate (pin 2)
- Chassis and Signal Ground (pin 3)
- Sweep Ramp (pin 4)
- Video Output (pin 5)

The remaining signals (see Figure E-1) are used by the 2707 External Tracking Generator and are not discussed in this manual. Refer to the *2707 External Tracking Generator Instruction Manual* if you need more information about these signals.

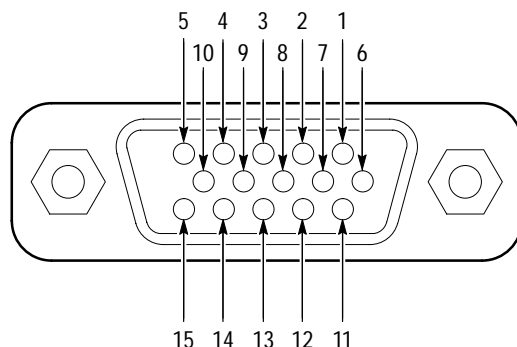


Figure E-1: Accessory Connector (J103)

Pin	Signal
1	External Video Input
2	Sweep Gate
3	Chassis/Signal Ground
4	Sweep Ramp
5	Video Out
6	CLK0 Input
7	DATA1 Output
8	DATA0 Input
9	~EXTGLATCH Input
10	23.38 MHz Output
11	VLVL Input
12	SWPSLOPE Input
13	Not Used
14	Not Used
15	Not Used

Bulleted instructions in the signal discussions guide you through applications using the Accessory Connector signals. The instructions are designed to be used consecutively, as provided. The signals are discussed in logical sequence, not in pin-number order.

100.0MHZ	(AUTO SWEEP)	ATTN 10DB
28.8DBMV		VF WIDE
20.0MHZ/		10 DB/
5MHZ RBW (AUTO)		CALIBRATOR

Pin 1 — External Video Input

Pin 1 enables you to introduce an external video signal to the 2715, in effect giving it limited oscilloscope capabilities. It is also used to introduce the frequency markers from the 1405 TV Sideband Analyzer (see the previous discussion of J101 on page E-1).

The video signal can be any signal limited to a 0–50 kHz band and an amplitude range of 0–1.4 V. The 2715 preamplifier, RF attenuator, mixer, resolution bandwidth filter, and log amplifier circuits are bypassed. The sweep rate and vertical scale circuits are utilized.

Since the digital storage remains active, you can use the 2715 to store images of external signals for comparison purposes, or compile statistical estimates of their parameters using ensemble averaging.

To experiment, you need a signal meeting the external input amplitude and frequency limits. Various signal generators can be used.

- Connect the signal source to pin 1 of the Accessory Connector and its ground lead to pin 3. Toggle DSPL menu item 7, DISPLAY SOURCE, to EXTERNAL.

The 2715 reverts to the display mode in zero span (there is no need to sweep the signal past the resolution bandwidth filter since these circuits are bypassed). The top graticule line is 0 V. The only information in the left on-screen readout that is meaningful is the sweep speed. The sweep speed is initially the speed in effect before you switched to EXTERNAL source; in this case, 50 ms/division. The only information in the right readout that is meaningful is the bottom line (EXT 175MV/) indicating that the external (EXT) input is being used with a vertical scale factor of 175 mV/div.

- Press [10/5/1] three times and notice that the scale changes to 87.5MV/, 17.5MV/, and back to 175MV/. Turn off all registers to view the analog signal, and then turn the D register back on.

The VERT SCALE and DISPLAY STORAGE function blocks remain operational. You can alter the display scaling, view analog or digital signals, compile ensemble statistics, or select other items from the DSPL menu.

Pin 3 — Chassis and Signal Ground

Pin 3 of the Accessory Connector is chassis and signal ground.

100.0MHz	(AUTO SWEEP)	ATTN 10DB
28.8DBMV		VF WIDE
20.0MHZ/		10 DB/
5MHZ RBW (AUTO)		CALIBRATOR

Pin 5 — Video Output

Pin 5 of the Accessory Connector is the analog video output from the 2715. The analog video output is a 0 to 1.6 V signal representing the vertical deflection of the display on the 2715 with all registers turned off. 0 volts is the top graticule line and +1.6 V is the bottom line. The output signal range remains constant

regardless of reference level, attenuation, and vertical scale. The signal can be used to drive an external oscilloscope or other video display unit. For example, in certain applications a device with a low- or high-persistence phosphor may be particularly useful.

- Connect pin 5 to an input channel of an oscilloscope. At the oscilloscope, select 0.2 V/div and 50 ms/div scale factors, invert the input, and trigger internally.

You may have trouble triggering because of the multiple signal peaks and blanking period of the video signal, but there should be a spectrum on the oscilloscope similar to the one on the 2715. If not, adjust your oscilloscope trigger and vertical position controls.

Pin 2— Sweep Gate

Pin 2 of the Accessory Connector contains the sweep gate. The sweep gate is a +5 V pulse whose leading edge is synchronous with the start of the 2715's sweep. The trailing edge marks the end of sweep. See Figure E-2. The signal is usually used in conjunction with the video output (pin 5) to indicate when a new sweep is beginning.

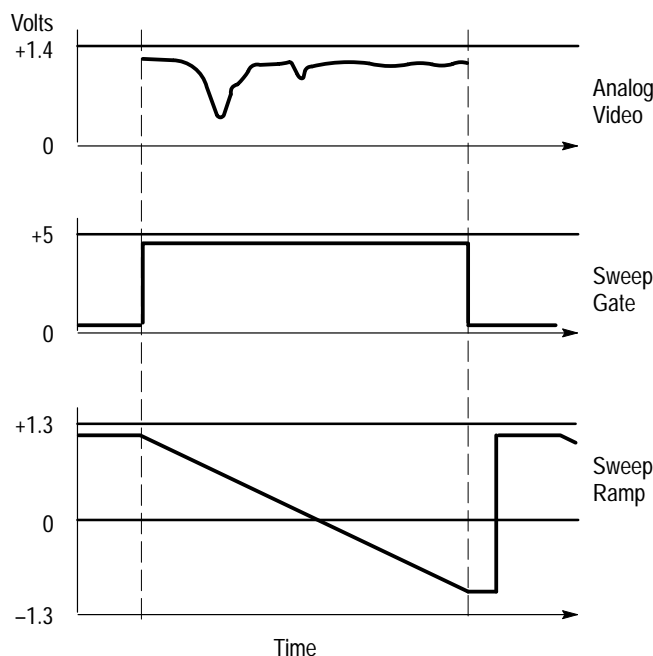


Figure E-2: Sweep Gate and Ramp Timing

- Continuing with the setup from the video output discussion, connect pin 2 to the external trigger input of your oscilloscope and select the external trigger mode positive slope. Adjust the oscilloscope trigger level control until the spectral display locks in place. Now turn off all the analyzer's registers. Compare the spectrum analyzer and oscilloscope displays.

If the image is as desired, follow the next step (this can be especially important when you are trying to view time-varying analog spectra).

- Turn on MAX HOLD in all the 2715 registers. Notice the analog trace is still displayed on the oscilloscope.

By using the video output to view the analog display, all four registers remain available for digital storage and display. You can have an analog display and four (different) digital traces.

- If your oscilloscope has a sweep magnifier or delayed sweep facility, use either one to obtain an enhanced view of the central signal peak on the oscilloscope without altering the spectrum analyzer settings.

The oscilloscope horizontal scale factor equals the 2715 span/division times the ratio of the 2715 and oscilloscope sweep speeds.

Pin 4 — Sweep Ramp

Pin 4 of the Accessory Connector is the sweep ramp. The sweep ramp varies linearly from +1.3 V to -1.3 V and is proportional to the horizontal position of the sweep as it crosses the screen. The start of the ramp is synchronous with the start of the 2715 sweep. The bottom of the ramp marks the end of sweep; see Figure E-2. The signal is usually used in conjunction with the video output to generate the horizontal deflection for an external video unit such as an XY oscilloscope or recorder.

- Continuing with the setup from the Sweep Gate paragraph, connect pin 4 to the X-axis input of your oscilloscope and the video output to the Y-axis. Place the oscilloscope in XY mode. Adjust the X-axis gain on the oscilloscope until the sweep just fills the screen. If the sweep is backwards, invert the X-axis input to reverse it.

The advantage in using the ramp to control the oscilloscope is that there is no difference in the time bases used by the 2715 and the oscilloscope. The disadvantage is that you cannot control the oscilloscope time base independently of the 2715.

J104 — Digital Communications Port

The 2715 is equipped with a digital communications connector, labeled J104. The type of connector on your instrument depends on the communications option selected when the 2715 was purchased.

GPIB If Option 03 (GPIB) is installed, J104 is a 24-pin IEEE Standard 488 GPIB connector. The pin-outs for the GPIB connector are shown in Figure E-3. Signal levels, handshaking, protocols, and other matters of importance to digital communications are detailed in the *2714 & 2715 Programmer Manual* and the pertinent standards.

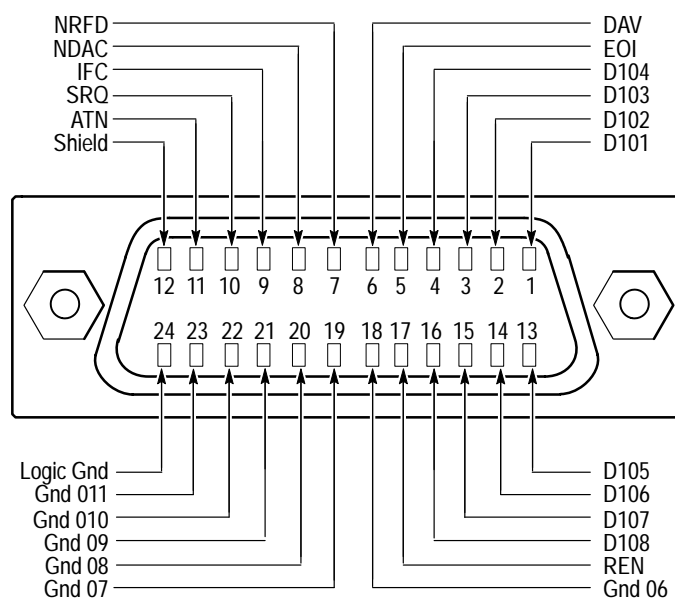


Figure E-3: IEEE Standard 488 (GPIB) Connector Pin Assignments

GPIB Cable. GPIB cable connectors are consistent. The following two interconnect cables are available from Tektronix (see *Appendix F: Accessories and Options* for more information):

- GPIB cable, 1 meter long
- GPIB cable, 2 meters long

RS-232 If Option 08 (RS-232) is installed, J104 is a 9-pin male D connector. The pin-outs for the RS-232 connector are shown in Figure E-4. Signal levels, handshaking, protocols, and other matters of importance to digital communications are detailed in the *2714 & 2715 Programmer Manual* and the pertinent standards.

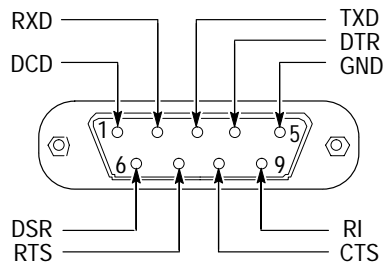


Figure E-4: RS-232-C Connector Pin Assignments

The RS-232 connector (J104) on the 2715 is typically used to connect the 2715 to a PC that is running the *Cable TV RF Measurements Software*. The RS-232 connector on the PC interface card may be one of three types:

- 9-pin female.
- 25-pin female
- 25-pin male

Check which type of connector your PC interface card has and refer to the following tables and illustrations to determine which cable you need.

9-Pin female to 9-Pin Female Null Modem Cable.

Table E–1 and Figure E–5 show the wiring configuration for this type of cable. A cable with this configuration is available as an optional accessory. Refer to *Appendix F: Accessories and Options* for the part number.

NOTE. Pins 1 and 8 are connected together on each 9-pin female connector. Both pins connect to pin 7 on the opposite 9-pin connector.

Table E–1: 9-Pin Female to 9-Pin Female Null-Modem Cable

9-Pin Female	to	9-Pin Female
Pin (signal)		Pin (signal)
1,8 (DCD, CTS)	to	7 (RTS)
2 (RXD)	to	3 (TXD)
3 (TXD)	to	2 (RXD)
4 (DTR)	to	6 (DSR)
5 (GND)	to	5 (GND)
6 (DSR)	to	4 (DTR)
7 (RTS)	to	1,8 (DCD, CTS)
8 (see pin 1)		
9 (not used)		

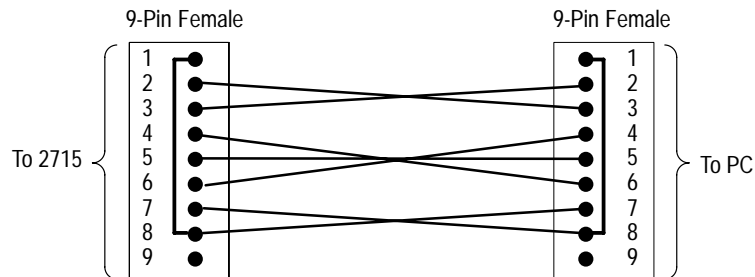


Figure E–5: 9-Pin Female to 9-Pin Female Null-Modem Cable

9-Pin Female to 25-Pin female Null-Modem Cable

Table E–2 and Figure E–6 show the wiring configuration for this type of cable. A cable with this configuration is available as an optional accessory. Refer to *Appendix F: Accessories and Options* for the part number.

NOTE. Pins 1 and 8 are connected together on the 9-pin female connector; these connect to pin 4 on the 25-pin female connector. Pins 5 and 8 are connected together on the 25-pin female connector; these connect to pin 7 on the 9-pin female connector.

Table E-2: 9-Pin Female to 25-Pin Female Null-Modem Cable

9-Pin Female	to	25-Pin Female
Pin (signal)		Pin (signal)
1,8 (DCD, CTS)	to	4 (RTS)
2 (RXD)	to	2 (TXD)
3 (TXD)	to	3 (RXD)
4 (DTR)	to	6 (DSR)
5 (GND)	to	7 (GND)
6 (DSR)	to	20 (DTR)
7 (RTS)	to	5, 8 (CTS, DCD)
8 (see pin 1)		
9 (not used)		

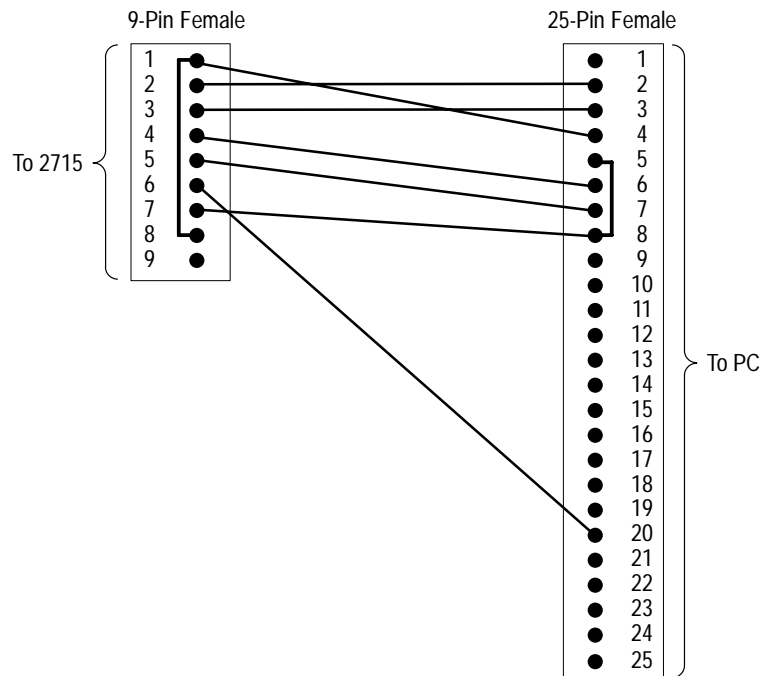


Figure E-6: 9-Pin Female to 25-Pin Female Null-Modem Cable

9-Pin Female to 25-Pin Male Extension Cable.

Table E-3 and Figure E-7 show the connections for this type of cable. A cable with this configuration is available as an optional accessory. Refer to *Appendix F: Accessories and Options* for the part number.

Table E-3: 9-Pin Female to 25-Pin Male Extension Cable

9-Pin Female	to	25-Pin Male
Pin (signal)		Pin (signal)
1 (DCD)	to	8 (DCD)
2 (RXD)	to	3 (RXD)
3 (TXD)	to	2 (TXD)
4 (DTR)	to	20 (DTR)
5 (GND)	to	7 (GND)
6 (DSR)	to	6 (DSR)
7 (RTS)	to	4 (RTS)
8 (CTS)	to	5 (CTS)
9 (not used)		

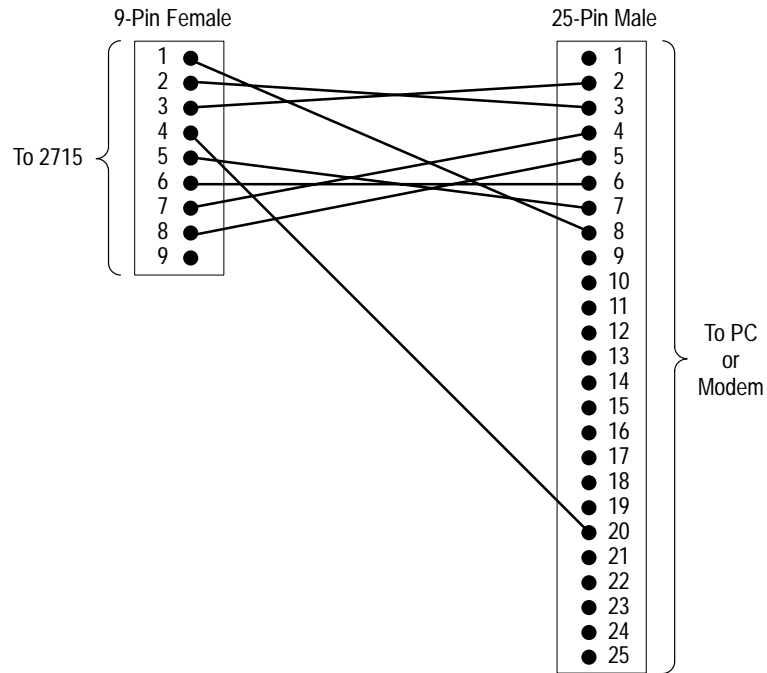


Figure E-7: 9-Pin Female to 25-Pin Male Extension Cable

Appendix F: Accessories and Options

Accessories

The 2715 is shipped with the standard accessories listed in Table F-1. Optional accessories are listed in Table F-2. Also, optional AC mains power cords are available meeting various international standards (see Table F-3).

Table F-1: Standard Accessories

Tektronix Part Number	Description
070-9115-XX	User Manual, 2715
070-8533-XX	Programmer Manual, 2714 & 2715
070-8535-XX	Pocket Reference, 2714 & 2715
070-9611-XX	User Manual, Cable TV RF Measurements Software
161-0104-00	U.S. Power Cord
200-2520-00	Front Cover
103-0045-00	Adapter, Connector, N Male to BNC Female, 50 Ω
103-0301-00	Adapter, 75 Ω Female F-to-Female BNC
103-0310-00	Adapter, 75 Ω Female-to-Female F

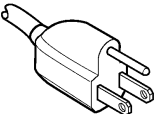
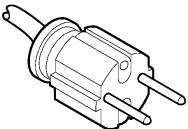
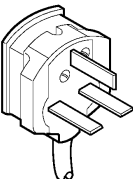
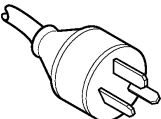
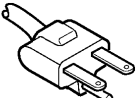
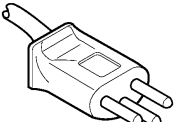
Table F-2: Optional Accessories

Tektronix Part Number	Description
012-1339-00	Coaxial cable, 75 Ω BNC-to-BNC, 24 in (609.6 mm)
012-0074-00	Coaxial cable, 75 Ω BNC-to-BNC, 42 in (1066.8 mm)
012-0057-01	Coaxial cable, 50 Ω BNC-to-BNC, 42 in (1066.8 mm)
012-0991-01	GPIB cable, 39.4 in (1 m)
012-0991-00	GPIB cable, 78.8 in (2 m)
012-1380-00	RS-232 cable, 9-pin female-to-25-pin female, 76 in (1930 mm)
012-1379-00	RS-232 cable, 9-pin female-to-9-pin female, 76 in (1930 mm)
012-1241-00	RS-232 cable, 9-pin female-to-25-pin male, 180 in (4572 mm)
016-0848-00	Rain Cover
016-0677-03	Accessory Pouch
016-0566-00	Viewing Hood
346-0199-00	Carrying Strap

Table F-2: Optional Accessories (Cont.)

Tektronix Part Number	Description
606-0110-02	Service Kit
337-2775-01	CRT Light Filter (clear)
337-2775-02	CRT Light Filter (gray)
070-9096-00	Service Manual
016-0792-02	Transit Case

Table F-3: Power Cord Identification

Plug Configuration	Normal Usage	Option Number
	North America 125 V	Standard
	Europe 230 V	A1
	United Kingdom 230 V	A2
	Australia 230 V	A3
	North America 230 V	A4
	Switzerland 230 V	A5

Options

This section describes the options for the 2715. All options are factory installed.

Options B1 and B2

Option B1. This option adds a service manual for the Spectrum Analyzer.

Option B2. This option adds a reference manual, a user manual, a programmer manual, and a service manual for the Spectrum Analyzer.

Option M1 — Option M3 (Extended Service and Warranty Options)

There are three extended service and warranty options offered for the 2715 that go beyond the basic one-year coverage. Contact your local Tektronix Field Office or representative for details.

- Option M1 — Two routine calibrations to published specifications in years two and three, respectively, of warranty coverage, plus two years remedial service.
- Option M2 — Four years remedial service.
- Option M3 — Four routine calibrations to published specifications in years two, three, four, and five, respectively, of product ownership, plus four years of remedial service.

Option 03 (GPIB Communications Port)

Option 03 supplies a GPIB communications port that conforms to the IEEE Standard 488 General Purpose Interface Bus. It also supplies a Programmer Manual. The port is activated and configured with the UTIL menu. The 24-pin port connector is located on the rear panel of the 2715.

Connector terminations can be found in *Appendix E: External Input and Output* or in the Programmer Manual. For programming instructions, refer to the Programmer Manual. To configure the GPIB port, see *System Configuration* in Section 6 of this manual.

Option 05 (External Tracking Generator)

Option 05 supplies a Tektronix 2707 Tracking Generator for swept measurements from 100 Hz to 1.8 GHz and at least 100dB dynamic range to see filter, ultimate rejection, or circuit isolation characteristics.

Option 07 (Inverter/Battery Pack)

Option 07 supplies a Tektronix 2704 DC-to-AC Inverter, 2705 Battery Pack, Instruction Manual, and necessary mounting hardware. This option allows operation of the 2715 in locations where AC power is not available. The 2705 provides approximately one hour of operation when used with the 2704 Inverter and 2715. Operating time can be extended by using additional 2705 Battery Packs, or alternate 12 VDC sources. The Inverter also contains a charger and an auxiliary 18 VDC output to power external devices such as Low Noise Block Down Converters (LNB) used in satellite downlink applications.

- Option 08
(RS-232 Communications Port)** Option 08 provides an RS-232 serial communications port and a Programmer Manual. This port conforms closely to the IEEE P1174.232 Draft Standard that defines the features and functions of the RS-232 interface as it applies to instrument systems. However, it does not necessarily comply with the three-level protocol. The port is activated and configured with the UTIL Menu. The port connector is located on the rear panel of the 2715.
- Connector terminations can be found in *Appendix E: External Input and Output* or in the Programmer Manual. For programming instructions, refer to the Programmer Manual. To configure the RS-232 port, see *System Configuration* in Section 6 of this manual.
- Option 15
(TV Sideband Analyzer/External Tracking Generator Interface)** Option 15 provides an interface for the Tektronix 1405 TV Sideband Analyzer and the 2707 External Tracking Generator. The 1st LO is buffered, routed to J101 on the 2715 rear panel, and terminated in 50 Ω . The 2715/1405 combination enables you to measure TV modulator/transmitter frequency responses. The 2715/2707 combination allows you to take swept frequency measurements on devices such as filters.
- Option 30
(Rackmount Adapter)** Option 30 provides the hardware for installing the 2715 in a standard 19 in (426.6 mm) rack. The rackmount adapter requires minimum vertical space of 5.25 in (133.35 mm). (An alternate cradle-mount adapter is also available — see Option 34.) The 2715 meets all electrical and environmental specifications when it is mounted according to the procedures accompanying Option 30.
- Option 33
(Travel Line Package)** Option 33 is a Travel Line package that includes a rain cover, accessory pouch, gray CRT filter, and carrying strap.
- Option 34
(Cradle Type Rackmount Adapter)** Option 34 consists of a front panel mask and rack mounting cradle which adapts the 2715 to a standard 19 in (482.6 mm) rack. The adapter requires 7 in (177.8 mm) vertical rack space.
- This option preserves the portability of the 2715. Slide assemblies are provided for front access to, and easy removal of, the 2715.
- Option 50** This option provides a 50 Ω input, frequency range of 9 KHz to 2.15 GHz, and channel table editing from the front panel of the 2715.
- Option 75** This option provides a 75 Ω input, frequency range of 9 KHz to 2.15 GHz, and channel table editing from the front panel of the 2715.



Glossary and Index

Glossary

Active Trace

Live trace or the B-SAVE A trace (a trace recalled into B is not an active trace).

Amplitude

The magnitude of an electrical signal.

Amplitude Modulation (AM)

The process, or result of a process, in which the amplitude of a sine wave (the carrier) is varied in accordance with the instantaneous voltage of a second electrical signal (the modulating signal).

Aural Carrier Level

The RMS voltage of a channel's aural (sound) carrier measured across a termination impedance which matches the internal impedance of the system.

Baseline Clipper (Intensifier)

A means of increasing the brightness of the signal relative to the baseline portion of the display.

Calibrator

A signal generator producing a specified output used for calibration purposes.

Carrier, Carrier Signal

The electrical signal, typically a sine wave, upon which modulation is impressed.

Carrier Frequency

The frequency of the carrier signal.

Carrier-to-Noise Ratio (C/N)

The ratio of carrier signal power to average noise power in a given bandwidth surrounding the carrier; usually expressed in decibels.

Center Frequency

That frequency which corresponds to the center of a frequency span, expressed in hertz.

Clear (Erase)

Presets memory to a prescribed state, usually that denoting zero.

Composite Second Order (CSO)

Second order distortion products generated by the direct addition or subtraction of fundamental visual carrier frequencies.

Composite Triple Beat (CTB)

Cross modulation third order distortion product resulting from the addition and subtraction of fundamental visual carriers with the co-channel interference harmonic of other visual carriers, or the addition and subtraction of a combination of three visual carriers.

dBc

Decibels referenced to carrier level.

dBm

A unit of expressed power level in decibels referenced to 1 milliwatt.

dBmV

A unit to express voltage levels in decibels referenced to 1 millivolt.

dB μ V

A unit to express voltage levels in decibels referenced to 1 microvolt.

Decibel (dB)

Ten times the logarithm of the ratio of one electrical power to another.

Deflection Coefficient

The ratio of the input signal magnitude to the resultant output indication. The ratio may be expressed in terms of volts (rms) per division, decibels per division, watts per division, or any other specified factor.

Depth of Modulation

The difference between the maximum and the minimum of the RF envelope amplitude expressed as a percentage of the maximum RF envelope level.

Digitally Averaged Display

A display of the average value of digitized data computed by combining serial samples.

Digitally Stored Display

A display method whereby the displayed function is held in a digital memory. The display is generated by reading the data out of memory.

Display Frequency

The input frequency as indicated by the spectrum analyzer and expressed in hertz.

Display Dynamic Range

The maximum ratio of the levels of two nonharmonically related sinusoidal signals, each of which can be simultaneously measured on the screen to a specified accuracy.

Display Flatness

The unwanted variation of the displayed amplitude over a specified frequency span, expressed in decibels.

NOTE. Display flatness is closely related to frequency response. The main difference is that the spectrum display is not moved to center screen.

Display Law

The mathematical law that defines the input-output function of the instrument. The following cases apply:

Linear

A display in which the scale divisions are a linear function of the input signal voltage.

Square Law (Power)

A display in which the scale divisions are a linear function of the input signal power.

Logarithmic

A display in which the scale divisions are a logarithmic function of the input signal voltage.

Display Reference Level

A designated vertical position representing a specified input level. The level may be expressed in dBm, volts, or any other units.

Distortion

Degradation of a signal, often a result of nonlinear operations, resulting in unwanted signal components. Harmonic and intermodulation distortion are common types.

Dynamic Range

The maximum ratio of the levels of two signals simultaneously present at the input which can be measured to a specified accuracy.

Effective Frequency Range

That range of frequency over which the instrument performance is specified. The lower and upper limits are expressed in hertz.

Envelope

The limits of an electrical signal or its parameters. For instance, the modulation envelope limits the amplitude of an AM carrier.

Envelope Display

The display produced on a spectrum analyzer when the resolution bandwidth is greater than the spacing of the individual frequency components.

Filter

A circuit which separates electrical signals or signal components based on their frequencies.

Frequency

The rate at which a signal oscillates, or changes polarity, expressed as hertz or number of cycles per second.

Frequency Band

The continuous range of frequencies extending between two limiting frequencies, expressed in hertz.

Frequency Domain Representation

The portrayal of a signal in the frequency domain; representing a signal by displaying its sine wave components; the signal spectrum.

Frequency Drift

Gradual shift or change in displayed frequency over the specified time due to internal changes in the spectrum analyzer, where other conditions remain constant. Expressed in hertz per second.

Frequency Linearity Error

The error of the relationship between the frequency of the input signal and the frequency displayed (expressed as a ratio).

Frequency Marker

An intensified or otherwise distinguished spot on a spectrum analyzer display indicating a specified frequency point.

Frequency Modulation (FM)

The process, or result of a process, in which the frequency of an electrical signal (the carrier) is varied in accordance with some characteristic of a second electrical signal (the modulating signal or modulation).

Frequency Range

That range of frequencies over which the performance of the instrument is specified.

Frequency Response

The unwanted variation in the displayed amplitude over a specified center frequency range, measured at the center frequency expressed in decibels.

Frequency Response (Cable TV System Related)

The overall gain variation of a system as a function of frequency. Normally measured in dB p-p (sometimes called peak-to valley) or as \pm dB (half the peak-to-peak value).

Frequency Span (Dispersion)

The magnitude of the frequency band displayed; expressed in hertz or hertz per division.

Full Span (Maximum Span)

A mode of operation in which the spectrum analyzer scans an entire frequency band.

Gain Compression

Effect seen at an input level where the analyzer circuits have less gain than their small signal values. This is usually specified at the 1 dB compression point in terms of the input level required to reduce the gain by 1 dB.

Graticule

The calibrated grid overlaying the display screen of spectrum analyzers, oscilloscopes, and other test instruments.

Harmonic Distortion

The distortion that results when a signal interacts with itself, often because of nonlinearities in the equipment, to produce sidebands at multiples, or harmonics, of the frequency components of the original signal.

Harmonics

Frequency components of a signal occurring at multiples of the signal's fundamental frequency.

Heterodyne Spectrum Analyzer

A type of spectrum analyzer which scans the input signal by sweeping the incoming frequency band past one of a set of fixed RBW filters and measuring the signal level at the output of the filter.

Hum Modulation

Modulation distortion at power frequencies (hum) is the amplitude distortion of the desired signal caused by the modulation of these signals at the frequency of the power source.

Hum Sidebands

Undesirable responses created within the spectrum analyzer, appearing on the display, that are separated from the desired response by the fundamental or harmonic of the power line frequency.

Impulse Bandwidth

The displayed spectral level of an applied pulse divided by its spectral voltage density level assumed to be flat within the pass-band.

Inactive Trace

SAVE A trace or a trace recalled into the B display before the sweep is started.

Input Impedance

The impedance at the desired input terminal. Usually expressed in terms of VSWR, return loss, or other related terms for low impedance devices and resistance-capacitance parameters for high impedance devices.

Intermediate Frequency (IF)

In a heterodyne process, the sum or difference frequency at the output of a mixer stage which will be used for further signal processing.

Intermodulation Spurious Response (Intermodulation Distortion — IMD)

An unwanted spectrum analyzer response resulting from the mixing of the n^{th} order frequencies, due to nonlinear elements of the spectrum analyzer. The resultant unwanted response is displayed.

Line Display

The display produced on a spectrum analyzer when the resolution bandwidth is less than the spacing of the signal amplitudes of the individual frequency components.

Line Spectrum

A spectrum composed of signal amplitudes of the discrete frequency components.

Live Trace

Any combination of the A trace and/or the B trace when SAVE A is off.

Local Oscillator (LO)

An oscillator which produces the internal signal that is mixed with an incoming signal to produce the IF signal.

Markers

The instrument uses three types of markers:

Update Marker

Marks the current sweep position in a digital storage display as the display is being updated.

Video Markers

Marker signals applied to the external VID|MARKER input from a Tektronix 1405 Television Sideband Analyzer. The Video Markers mark frequencies of interest on the television signal.

Waveform Markers

When the Marker function is enabled, it provides a movable cursor with readout of frequency and amplitude at the marker position. When the delta marker mode is enabled, a second marker allows operations and readout between the two marker positions.

MAX HOLD (Peak Mode)

Digitally stored display mode which, at each frequency address, compares the incoming signal level to the stored level and retains the greater. In this mode, the display indicates the peak level at each frequency after several successive sweeps.

MAX/MIN

A display mode on the spectrum analyzer that shows the maximum and minimum signal levels at alternate frequency points; its advantage is its resemblance to an analog display.

MIN HOLD

A spectrum analyzer feature which captures the minimum signal amplitude at all displayed frequencies over a series of sweeps.

Modulate

To regulate or vary a characteristic of a signal.

Modulating Signal

The signal which modulates a carrier. The signal which varies or regulates some characteristic of another signal.

Modulation

The process of varying some characteristic of a signal with a second signal.

Modulation Envelope

The curve limiting the carrier amplitude of an AM signal.

Multiple Display Memory

A digitally stored display having multiple memory sections which can be displayed separately or simultaneously.

Noise

Unwanted random disturbances superimposed on a signal which tend to obscure it.

Noise Floor

The self-noise of an instrument or system that represents the minimum limit at which input signals can be observed. The spectrum analyzer noise floor appears as a “grassy” baseline in the display, even when no signal is present.

Noise Sidebands

Undesired response caused by noise internal to the spectrum analyzer appearing on the display around a desired response.

Nonvolatile RAM (NVRAM)

A type of random access memory (RAM) which does not lose its contents when power is switched off.

Oscilloscope

An instrument for displaying a time domain representation of an electrical signal; displays the amplitude of an input signal as a function of time.

Peak Detection

A detection scheme wherein the peak amplitude of a signal is measured and displayed. In spectrum analysis, 20 log (peak) is often displayed.

Phase Lock

The control of an oscillator or signal generator so as to operate at a constant phase angle relative to a stable reference signal source. Used to ensure frequency stability in spectrum analyzers.

Primary Controls

Those controls of fundamental importance to spectrum analyzer operation: frequency control, span/div, and reference level.

Primary Marker

The marker displayed in the Single Marker mode whose frequency and/or position is changed when tuning with the CENTER/MARKER FREQUENCY control. When two markers are displayed, the brightest marker is the primary marker.

Pulsed Carrier Waveforms

Signal types wherein the carrier is turned on and off, or pulsed, as in radar, sonar, and continuous wave (CW) code.

Pulse Stretcher

A pulse shaper that produces an output pulse, whose duration is greater than that of the input pulse, and whose amplitude is proportional to that of the peak amplitude of the input pulse.

Reference Level

The signal level required to deflect the CRT display to the top graticule line.

Relative Display Flatness

The display flatness measured relative to the display amplitude at a fixed frequency within the frequency span, expressed in decibels.

Residual FM (Incidental FM)

Short term displayed frequency instability or jitter due to instability in the spectrum analyzer local oscillators. Given in terms of peak-to-peak frequency deviation and expressed in hertz or percent of the displayed frequency.

Residual Response

A spurious response in the absence of an input signal. (Noise and zero pip are excluded.)

Resolution Bandwidth (RBW)

The width of the narrowest filter in the IF stages of a spectrum analyzer. The RBW determines how well the analyzer can resolve or separate two or more closely spaced signal components.

Save

A function which inhibits storage update, saving existing data in a section of multiple memory (for example, Save A).

Scanning Spectrum Analyzer

See heterodyne spectrum analyzer.

Scanning Velocity

Frequency span divided by sweep time and expressed in hertz per second.

Secondary Marker

The “second” marker displayed only in the Delta Marker mode.

Sensitivity

Measure of a spectrum analyzer’s ability to display minimum level signals, expressed in volts or decibels. Internal frequency (IF) bandwidth, display mode, and any other influencing factors must be given.

Shape Factor (Skirt Selectivity)

The ratio of the frequency separation of the two (60 dB/6 dB) down points on the response curve to the static resolution bandwidth.

Single Sweep

Operating mode in which the sweep generator must be reset for each sweep. Especially useful for obtaining single examples of a signal spectrum.

Signal Identifier

A means to identify the spectrum of the input signal when spurious responses are possible.

Span Per Division, Span/Div

Frequency difference represented by each major horizontal division of the graticule.

Spectrum

The frequency domain representation of a signal wherein it is represented by displaying its frequency distribution.

Spectrum Analysis

The technique or process of determining the frequency distribution of a signal.

Spectrum Analyzer

A device for determining the frequency components of a signal.

Spurious Response

A response to a spectrum analyzer wherein the displayed frequency is not related to the input frequency.

Static (Amplifier) Resolution Bandwidth

The specified bandwidth of the spectrum analyzer's response to a continuous wave (CW) signal, if sweep time is kept substantially long. This bandwidth is the frequency separation of two points on the response curve, usually 6 dB down, if it is measured either by manual scan (true static method) or by using a very low speed sweep (quasi-static method).

Sweep Speed, Sweep Rate

The speed or rate, expressed in time per horizontal division, at which the electron beam of the CRT sweeps the screen.

Vertical Scale Factor, Vertical Display Factor

The number of dB, volts, etc., represented by one vertical division of a spectrum analyzer display screen.

Video

The term is used here generally to mean a signal after the detector stage. It can also be used more specifically to mean a base-band (zero carrier frequency) television signal.

Video Filter

A postdetection low-pass filter.

View (Display)

Enables viewing of contents of the chosen memory section (e.g., "View A" displays the contents of memory a; "View B" displays the contents of memory B).

Visual Carrier Level

The rms voltage of a channel's visual (picture) carrier, considered as a sine-wave, at the peak of the modulation envelope, measured across a termination impedance which matches the internal impedance of the system.

Volatile/Nonvolatile Storage

A volatile storage system is one where any total loss of power to the system will result in a loss of stored information. Nonvolatile memory is not subject to the instrument power supply for its storage.

Waveform Subtraction

A process wherein a saved waveform can be subtracted from a second, active waveform.

Zero Pit (Response)

An output indication which corresponds to zero input frequency.

Zero Span

An operating mode in which the frequency span is reduced to zero.

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