TEGAM INC.

MODEL M-1011A and M-1012A

AC RATIO STANDARD

Instruction Manual

PN# M-1011A-840-01
Publication Date: June 2008
REV. A

TEGAM INC.

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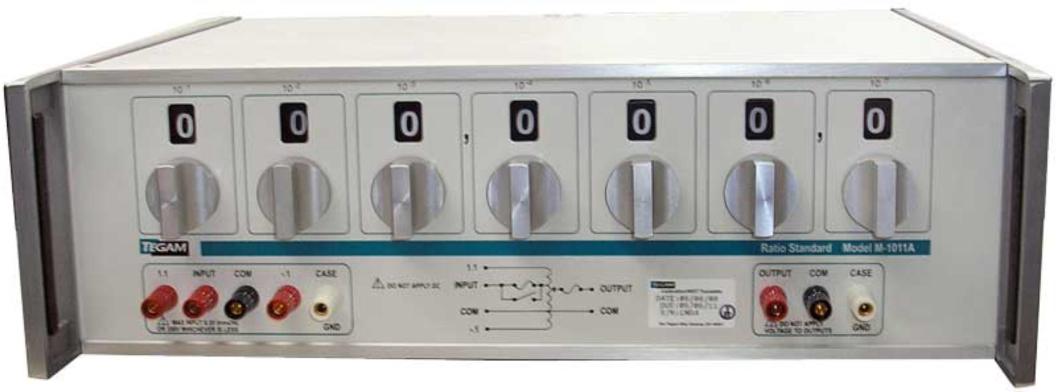

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NOTE: This user's manual was as current as possible when this product was manufactured. However, products are constantly being updated and improved. Because of this, some differences may occur between the description in this manual and the product received.

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ILLUSTRATIONS

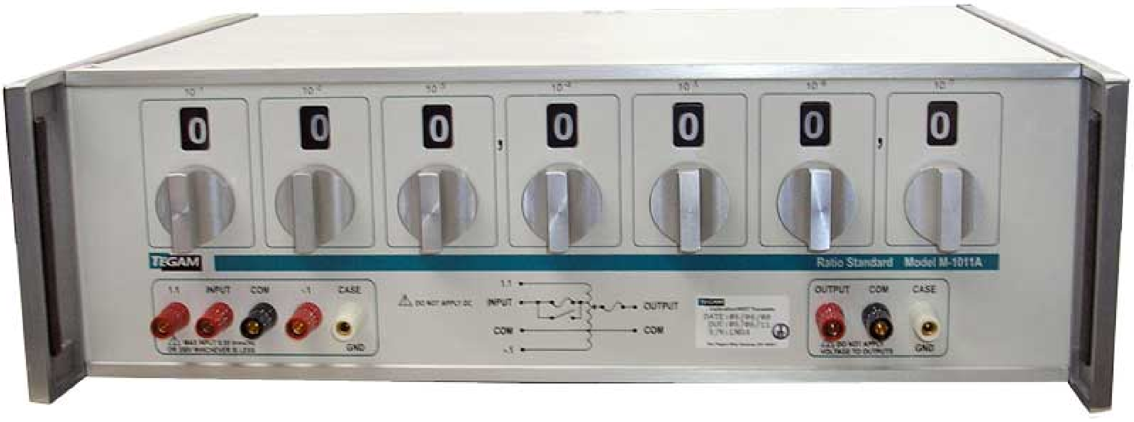


Figure 1-1. Model M-1011A or M-1012A AC Ratio Standard

Section I
GENERAL DESCRIPTION

1.1 PURPOSE

The AC ratio standards are inductive voltage dividers providing an output voltage which is in a precise ratio to an input voltage. The standard can be used to measure the output voltage of a unit under test or to duplicate the voltage ratio output required of a unit under test.

1.2 DESCRIPTION

The AC ratio standard is a completely contained test unit which only requires connection to an input voltage for operation. The Model M-1011A is a precision voltage divider that is designed specifically for the 50 Hz to 10 kHz frequency range, providing high input impedance and optimum performance thoughout this range. The ratio accuracy, which is traceable to the National Institute of Standards and Technology, is a based on the use of a toroidal transformer and is not affected by age or environmental conditions. The Model M-1012A is identical to the Model M-1011A except it is designed specifically for the 30 Hz to 1000 Hz frequency range.

The AC ratio standard consists of seven tapped windings. Portions of the input voltage are selected from the tapped windings by rotary switches. These portions are added together to form the output voltage.

All ratio standard controls and connection points are mounted on the front panel. An additional set of connection points are mounted on the back panel. Both input and output circuits are fused with the fuse holders mounted on the back panel. Switching transients are virtually eliminated by resistors which maintain continuity between steps while settings are being changed.

The AC ratio standard provides maximum ratios up to 1.111111 and minimum ratios as low as -0.0111111 with seven place resolution. Additional terminals provide ratio taps of 1.1 and -0.1.

The ratio accuracy of the standard is based upon the use of a toroidal autotransformer which is not affected by age or environmental conditions. Accuracy is traceable to the National Institute of Standards and Technology.

1.3 OPTIONAL ACCESSORIES

Option 11 (TEGAM part number -OPT-11) is a rack mount adapter for "A" models, refer to Paragraph 4.3.

Section II
SPECIFICATIONS

2.1 INTRODUCTION

This section contains specification information for the AC Ratio Standard Models M-1011A and M-1012A.

2.2 MAINTENANCE TOOLS

1 - Phillips Head Screwdriver

2 - Contact Cleaner

2.3 SPECIFICATIONS

Refer to Tables 2-1 and 2-2.

Table 2-1. Model M-1011A Specifications

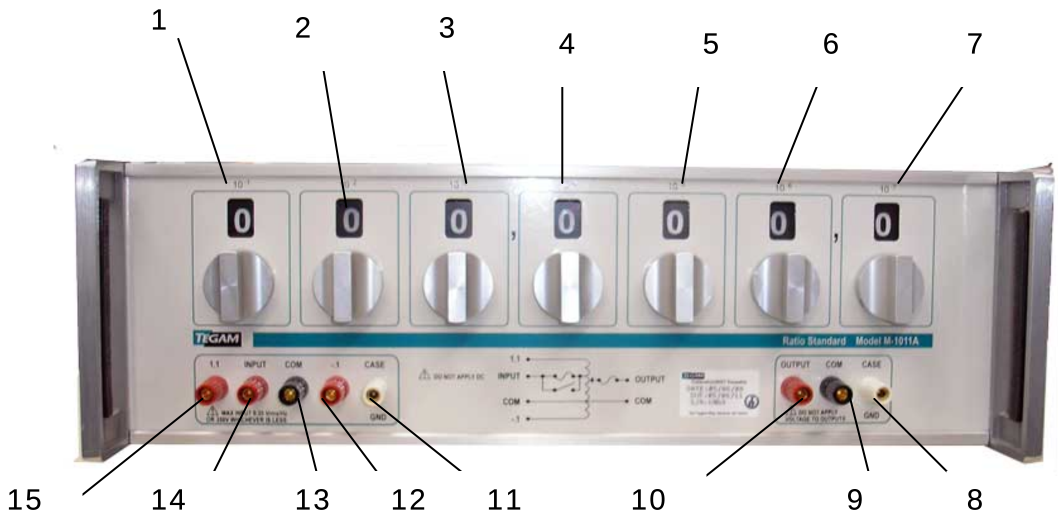
CHARACTERISTIC	SPECIFICATIONS
Frequency Range:	50 to 10,000 Hz
Maximum rms Input Voltage:	0.35 f (f in Hz) or 350 volts whichever is less.
Ratio Range: Maximum Minimum	 1.111111 -0.0111111
Resolution:	0.00001%
Accuracy of Indicated Ratio: 50 to 1,000 Hz Above 1 kHz	 $\pm\left(0.0001 + \frac{0.000025}{\text{Ratio}}\right)\%$ $\pm\left(0.0001\% + \frac{0.000025}{\text{Ratio}}\right) \times F^2$ where F is in kHz
Terminal Linearity:	0.0001% (1ppm) or better (above 1 kHz, multiply by F^2 in kHz)

Table 2-1. Specifications (Cont.)

CHARACTERISTIC	SPECIFICATIONS
Maximum Effective Series Output Impedance:	R: 3.5 ohms L: 75 µH
Input Impedance at 20 V and 400 Hz:	200 K minimum
Dimensions:	
Bench Operation:	43.2 cm (17") wide, 14.9 cm (5-7/8") high 42.8 cm (16-7/8") deep, (including feet and handles)
Rack Mounted:	48.3 cm (19") wide, 13.3 cm (5-1/4") high 38.4 cm (15-1/8") deep, (depth from back of rack mounting ears to end of back panel terminals).
Weight:	18 lbs.

Table 2-2. Model M-1012A Specifications

CHARACTERISTIC	SPECIFICATIONS
Frequency Range:	30 to 1,000 Hz
Maximum rms Input Voltage:	2.5 f (f in Hz) or 350 volts, whicheverr is less.
Ratio Range: Maximum Minimum Resolution:	 1.111111 -0.0111111 0.00001%
Accuracy of Indicated Ratio: 30 to 400 Hz	 $(0.0001\% + \frac{0.00005\%}{\text{Ratio}})$
Terminal Linearity:	0.0001% (1 ppm) or better
Maximum Effective Series Output Impedance	R: 5 ohms, L: 350 µH
Input Impedance at 20 V and 60 Hz	200 K minimum
Dimensions Bench Operation: Rack Mounted:	 43.2 cm (17") wide, 14.9 cm (5-7/8") high 42.8 cm (16-7/8") deep, (including feet and handles) 48.3 cm (19") wide, 13.3 cm (5-1/4") high 38.4 cm (15-1/8") deep, (depth from back of rack mounting ears to end of back panel terminals).
Weight:	26 lbs.



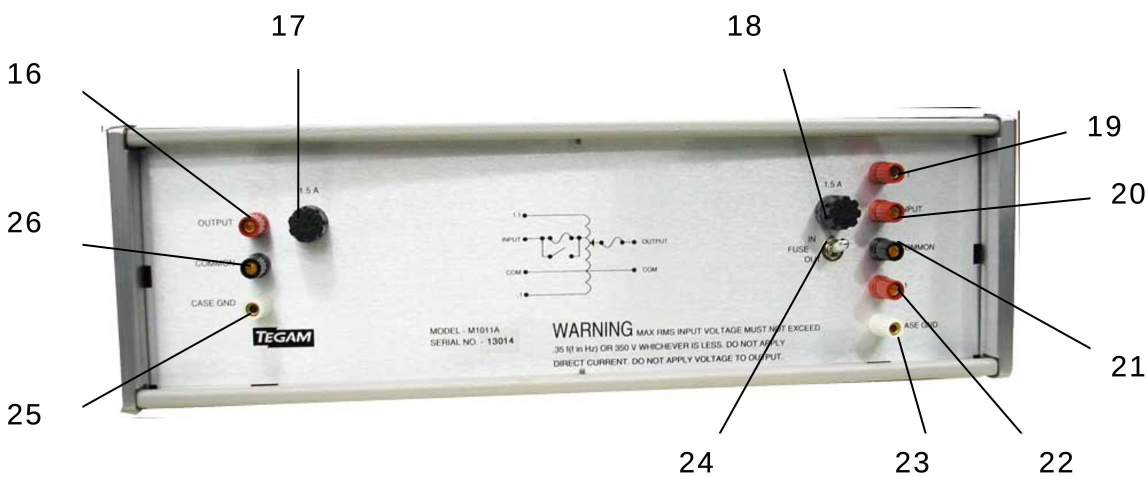


Figure 3-1.

Operating Controls, Switches, and Terminals, Model M-1011A or M-1012A

Section III

CONTROLS, SWITCHES, AND TERMINALS

3.1 INTRODUCTION

This section contains functional descriptions of all Model M-1011A and Model M-1012A controls, switches, and terminals. The location and purpose of the controls, switches and terminals are the same for the two AC ratio standard instruments.

3.2 CONTROLS, SWITCHES, AND TERMINALS

All external controls, switches, and terminals of the Model M-1011A and M-1012A are located on the front and back panels. Their location is identified by numbers in Figure 3-1, and their function described in Table 3-1.

Table 3-1. Controls, Switches, and Terminals

KEY	PANEL/DIAL MARKING	REFERENCE DESIGNATOR	FUNCTION
1	0 TO X	S1	Decade switch that provides 1 X 10-1 voltage ratio steps from 0 to 10 X 10^{-1} (x) (11 positions).
2	-1 TO X	S2	Decade switch that provides 1 x 10^{-2} voltage ratio steps from -1 to 10 x 10^{-2} (x) (12 positions).
3	-1 TO X	S3	Decade switch that provides 1 x 10-3 voltage ratio steps from -1 to 10 x 10^{-3} (x) (12 positions).

Table 3-1. Controls, Switches, and Terminals (Cont.)

KEY	PANEL/DIAL MARKING	REFERENCE DESIGNATOR	FUNCTION
4	-1 TO X	S4	Decade switch that provides 1 X 10^{-4} voltage ratio steps from -1 to 10 x 10^{-4} (x) (12 positions).
5	-1 TO X	S5	Decade switch that provides 1 x 10^{-5} voltage ratio steps from -1 to 10 x 10^{-5} (x) (12 positions).
6	-1 TO X	S6	Decade switch that provides 1 x 10^{-6} voltage ratio steps from -1 to 10 x 10^{-6} (x) (12 positions).
7	-1 TO X	S7	Decade switch that provides 1 x 10^{-7} voltage ratio steps from -1 to 10 x 10^{-7} (x) (12 positions).
8	CASE GND		Chassis (case) grounding terminal.
9	COM		Common output circuit terminal (zero output voltage reference).
10	OUTPUT		Voltage output terminal
11	CASE GND		Chassis (case) grounding terminal.
12	-.1		0.1 ratio tap terminal (output).
13	COM		Common input circuit terminal (zero input voltage reference).
14	INPUT		Voltage input terminal.
15	1.1		1.1 ratio tap terminal (output).

Table 3-1. Controls, Switches, and Terminals (Cont.)

KEY	PANEL/DIAL MARKING	REFERENCE DESIGNATOR	FUNCTION
16	OUTPUT		Voltage output terminal.
17	1.5 A	F2	Fuse, in series with OUTPUT terminal.
18	1.5 A	F1	Fuse, in series with INPUT terminal.
19	1.1		1.1 ratio tap terminal.
20	INPUT		Voltage input terminal.
21	COMMON		Common input circuit terminal (zero input voltage reference).
22	-0.1		-0.1 ratio tap terminal.
23	CASE GND		Chassis (case) grounding terminal.
24	FUSE IN OUT	S8	Shorting toggle switch for removing INPUT FUSE F1 from the input circuit (OUT position)
25	CASE GND		Chassis (case) grounding terminal.
26	COMMON		Common output circuit terminal (zero output voltage reference).

Section IV

INSTALLATION

4.1 UNPACKING

No special handling or unpacking procedures are required. After unpacking, inspect units for any evidence of damage.

4.2 BENCH OPERATION

The AC ratio standard is shipped ready for use as a bench-operated instrument. A folding support that is attached to the feet under the front of the instrument may be pulled down to elevate the front of the instrument for ease of operation.

4.3 RACK MOUNTING

Rack mounting, option 11, (TEGAM part number OPT-11) is available at extra cost. Option 11 consists of a set of adapter brackets and attaching screws that permits mounting the AC ratio standard into a standard 19 inch rack. To prepare the instrument for rack mounting, proceed as follows:

a. Remove the six screws that attach the four feet and folding support to the bottom of the instrument. Retain the screws, feet and support for future use.

b. Attach one rack mounting bracket (Part No. 964729-003-1) to each side of the instrument using two 10-32 X 3/8” flat head screws (Part No. 964064-263) and three 6-32 x 3/8” flat head screws (Part No. 964064-028) in each bracket. Note that you will need to remove the two 6-32 screws securing the side frame to the front panel to install the new 6-32x3/8” flat head screw.

4.4 OPERATING POWER

No operating power is required, however, excitation voltage is required during operation, refer to Tables 2-1 and 2-2.

Section V

OPERATION

5.1 INTRODUCTION

Instructions for operating the AC ratio standard models are presented in this section. Refer to Section III for descriptions of the operating controls, switches, and terminals. Refer to Section IV for installation information.

5.2 CONNECTING TO THE AC RATIO STANDARD

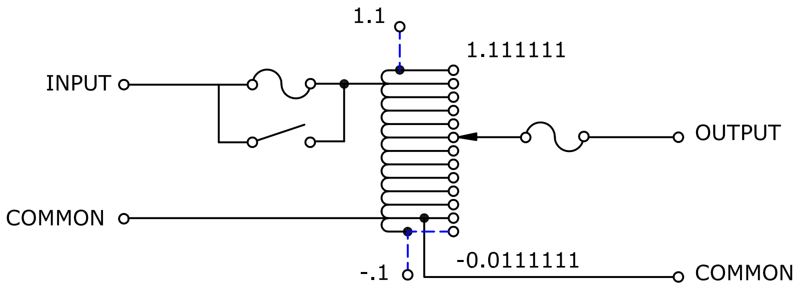
Three output circuit configurations are available to the user. All configurations have the same direct input connection and provide in-phase output voltage. Choice of output circuit is controlled by which terminals are used. Refer to Figure 5-1 for abbreviated schematics of the three Ratio Standard configurations.

5.3 OPERATION

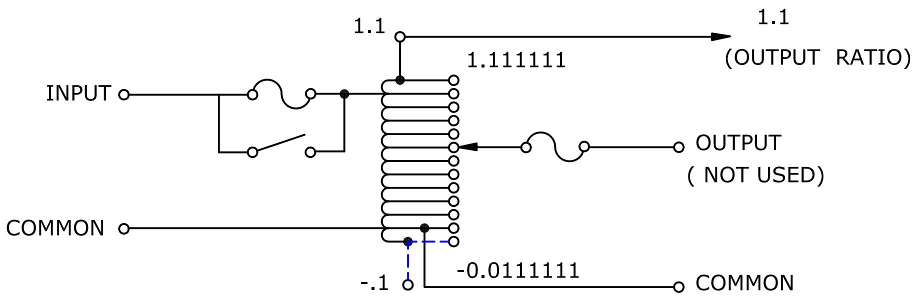
5.3.1 General

A typical application of the Ratio Standard is shown in Figure 5-2. The output of the Ratio Standard is compared to the output of the unit under test using a phase-sensitive null indicator such as a phase angle voltmeter, TEGAM Model PAV-4. When the in-phase components of the two outputs are exactly equal, the phase angle voltmeter indicates a null. The input-to-output voltage ratio of the unit under test may then be read from the settings of the Ratio Standard.

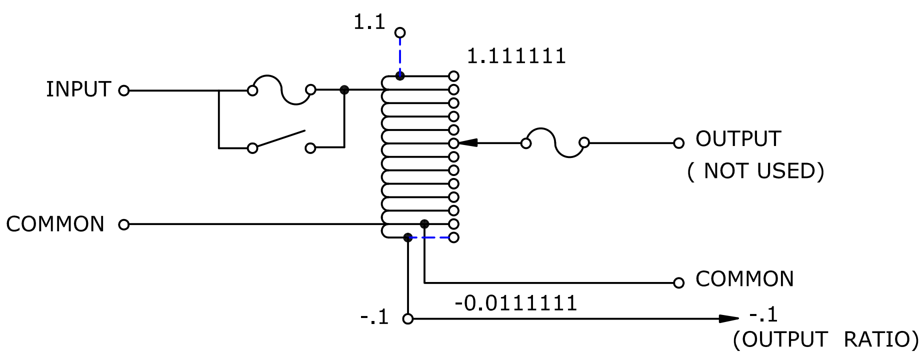
Additional applications are available from the factory.



STANDARD CONNECTION



1.1 RATIO VOLTAGE CONNECTION



-.1 RATIO VOLTAGE CONNECTION

Figure 5-1. Ratio Standard Configurations

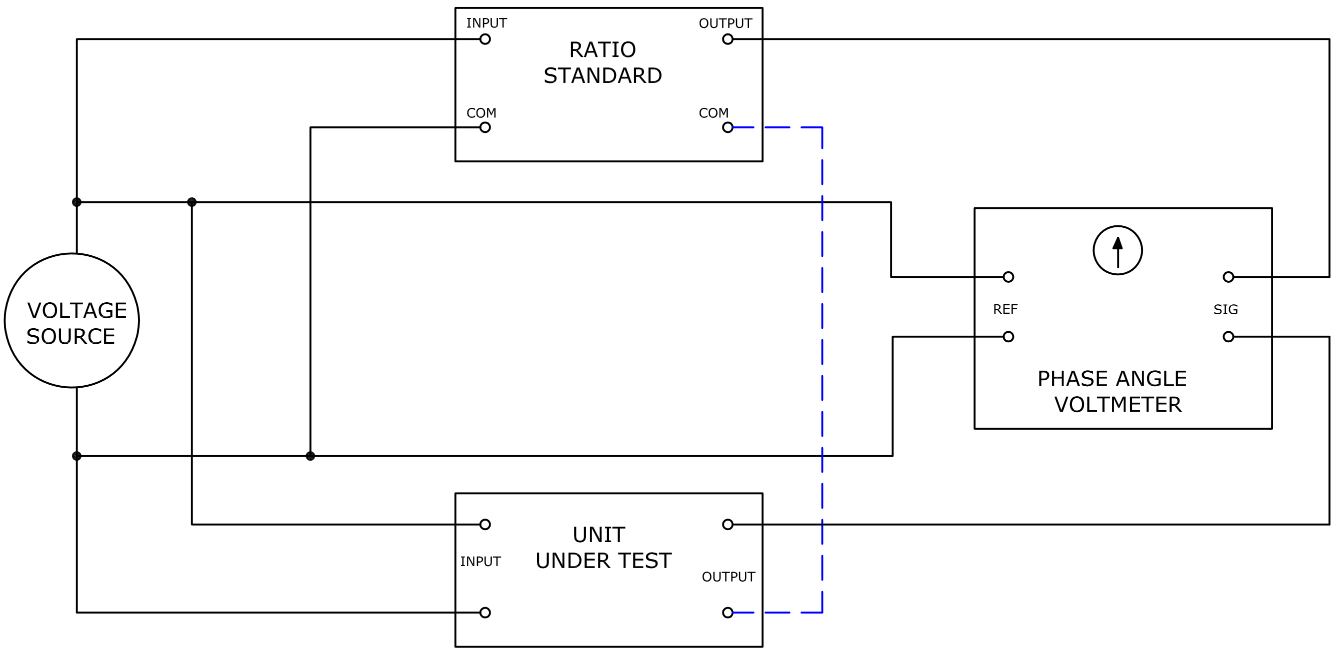


Figure 5-2 Typical Application

5.3.2 **Operation**

To operate the AC Ratio Standard, proceed as follows:

a. Throw the back panel mounted FUSE toggle switch to IN position.

WARNING

A shock hazard exists on the instrument's input terminals when voltage levels exceed 30V rms or 42.2V peak.

b. Connect input or reference voltage source to the INPUT and adjacent COMMON terminals. Make certain the input voltage is less than 0.35 time the frequency in Hz for the M-1011A (or 2.5 time the frequency in Hz for the M-1012A) of the input signal or 350 volts, whichever is less. Refer to Paragraph 5.5 for information of excessive voltage.

CAUTION

Make certain the input voltage does not contain a dc component. DC currents of more than a few microamperes will cause saturation of the input winding. If dc voltage is accidentally applied to the unit, degauss the unit as outlined in the maintenance section, Paragraph 7.3.

c. Make connections to the OUTPUT and COMMON terminals. Refer to Figure 5-1, "Standard Configuration".

CAUTION

Do not apply voltage across the output terminals.

d. Turn the input voltage source ON.

e. Set the standard controls to the desired ratio or to the setting required to obtain a null. When a null has been obtained, the FUSE toggle switch may be thrown to the OUT position to provide a more accurate null measurement.

f. When a final null is obtained, the input-to-output voltage ratio of the unit under test may then be read from the switch settings of the standard.

CAUTION

After the ratio reading has been recorded, the FUSE toggle switch should be returned to the IN position for input circuit protection.

Example

Assume the following AC Ratio Standard switch positions at null.

10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}
6	3	1	2	7	8	5

The input to output voltage ratio would be:

0.6312785

g. To obtain a 1.1 ratio voltage, connect the output to the 1.1 and COMMON terminals. Refer to Figure 5-1, "1.1 Ratio Voltage Connection".

h. To obtain a -.1 ratio voltage, connectd the output to the -.1 and COMMON terminals. Refer to Figure 5-1, "-.1 Ratio Voltage Connection".

5.4 ACCURACY UNDER LOAD CONDITIONS

5.4.1 General

While the Ratio Transformer is designed for maxium accuracy in the unloaded condition, reasonable loads may be applied. The resulting accuracy is a function of the load and the output impedance of the transformer. With reference to the equivalent circuit, Figure 5-3, we see an "ideal" transformer with a series impedance (R_S and L_S) inserted in the output arm. The series impedance is due to leakage inductance, wiring resistance, switch resistance, potentiometer resistance and other stray circuit elements. R_S and L_S vary with the ratio setting, but only the maximum value is specified, refer to Table 2-1, Maximum Effective Series Output Impedance. From R_S and L_S, the effect of loading upon the transformer accuracy can be calculated, see Paragraph 5.4.2. The resulting loading error must be added to the no load ratio accuracy of the "ideal" transformer to obtain the accuracy at the output terminals.

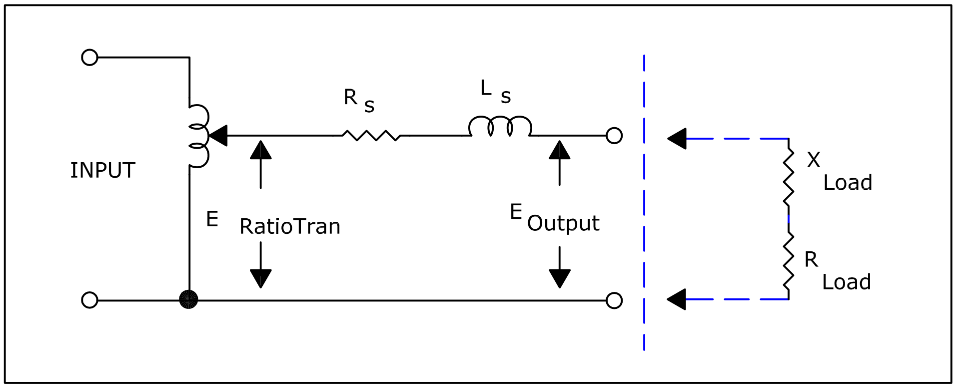


Figure 5-3. Equivalent Circuit, Direct Connection

5.4.2 Loading Error Computations

Referring to Figure 5-3, E_{output} equals $E_{Ratiotran}$ when the output is unloaded. When a load is added, the current flow through $R_s L_s$ develops a voltage drop and an E_{output} error. The following formula may be used in determining the output voltage error.

$$|Z_L| = \sqrt{R_{load}^2 + X_{load}^2} = \text{Load Impedance}$$

$$R_T = R_{load} + R_s = \text{Total Resistance}$$

$$X_T = X_{load} + 2\pi f L_s = \text{Total Reactance}$$

$$|Z_T| = \sqrt{R_T^2 + jX_T^2} = \text{Total Impedance}$$

$$E_{output} = \frac{|Z_L|}{|Z_T|} \times E_{RatioTran}$$

$$\%\ \text{Load Error} = \frac{E_{Ratio\ Tran} - E_{out}}{E_{Ratio\ Tran}} \times 100\%$$

% Total Error = % Load Error + no load ratio accuracy

Example:

Assume 100 V applied to a Model M-1011A with a ratio setting of 0.820000. Determine the total percent error at a test freqency of 5 kHz, an R_{load} = 10,000 ohms, and an X_{load} = +j31.41 ohms (1.0 mH) where the unloaded error is 0.003262% (see accuracy of indicated ratio, Table 2-1).

$$|Z_L| = \sqrt{(10{,}000)^2 + x(31.41)^2} = 10{,}000.049$$

From Table 2-1, Maximum Effective Series Output Impedance is 3.5 ohms and 75 µH.

$$R_T = 10{,}000 \text{ ohms} + 3.5 \text{ ohms} = 10{,}003.5 \text{ ohms}$$

$$X_T = +j31.41 \text{ ohms} + j2\pi\ (5 \times 10^3) \times 0.075 \times 10^{-3} = +j33.766 \text{ ohms}$$

$$Z_T = \sqrt{(10{,}003.5)^2 + (j33.766)^2} = 10{,}003.557 \text{ ohms}$$

$$E_{output} = \frac{10{,}000.049}{10{,}003.557} \times 82.00 = 81.971 \text{ V}$$

$$\% \text{ Load Error} = \frac{82.00 - 81.971 \text{ V}}{82.00} \times 100\% = 0.03536\%$$

% Total Error = 0.03536 + 0.003262 = 0.03862%

NOTE:

The example gives a loaded error 11.8 times greater than the unloaded error. However, this is not an indeterminate error. By correcting the Model M-1011A dial setting indication by the computed difference of E_{output}, the 0.003262% unloaded accuracy is substantially returned.

5.5 EFFECTS OF EXCESSIVE INPUT VOLTAGE

The maximum rms input voltage rating must be observed in order to prevent core saturation. Input voltage in excess of rating will cause core saturation, resulting in the permeability of the core material to drop sharply to almost zero. The input impedence will drop correspondingly, resulting in excess input current. If driven by a low impedance source, the input fuse will blow, thereby protecting the transformer windings. No adverse effects result from saturation once the input voltage is reduced to within rating.

Section VI

THEORY OF OPERATION

6.1 GENERAL

The AC Ratio Standard consists of seven tapped transformer windings and seven rotary switches. Refer to the Schematic Diagram, Figure 9-1. A portion of the input voltage is selected from each tapped winding and these portions are added together to form the output voltage.

The full input voltage is applied across the INPUT and COMMON terminals and thus across the decade portion of the input (10^{-1}) winding. The 10^{-1} winding and each of the remaining windings (10^{-2} through 10^{-7}) are precisely tapped to provide 12 equal subwindings that will provide 12 precise voltage outputs. S1 has eleven positions. The lower wiper arm of S1 can select any of eleven voltages from 0 to 1.0 volts in precise 0.1 input voltage ratio steps. The two wiper arms of switch S1, separated by one position, applies precise 0.1 voltage portions of the 10^{-1} winding across the decade portion of the 10^{-2} winding. The lower wiper arm of S2, which has 12 positions, selects a -0.01 to 0.1 portion of the input voltage selected by switch S1. The process continues through the seven windings until the final and smallest portion is selected by switch S7.

The input winding between the INPUT terminal and the 1.1 terminal provides a precise 0.1 step-up on the input voltage. The total voltage between the 1.1 terminal and the COMMON terminal is precisely 1.1 times the input voltage. The input winding between the COMMON terminal and the -.1 terminal supplies a voltage with an amplitude precisely 0.1 times the input voltage and 180 degrees out of phase. The voltage between the COMMON terminal and the -.1 terminal is therefore -0.1 times the input voltage.

The seven transformer windings are included in two transformers. The first transformer (T1) contains three windings (10^{-1}, 10^{-2}, and 10^{-3}) on a common toroid core. The second transformer (T2) contains three windings (10^{-4}, 10^{-5}, and 10^{-6}) on one common core and the final 10^{-7} winding on a separate core. Switching transients are virtually eliminated by resistors R1, R3, R5, R7, R9 and R11 (Model M-1011A), and R1 through R20 (Model M-1012A), which maintain continuity between voltage steps while settings are being changed.

The switch contacts are multileaf type that have very low contact resistance. Additionally, each switch has four decks that are paired and wired in parallel to further reduce contact resistance.

6.2 THEORETICAL ANALYSIS OF ACCURACY

Theoretical analysis of a perfect autotransformer used for stepdown purposes shows that if leakage inductances and winding resistance are uniformly distributed and the turns can be accurately tapped, the accuracy as a voltage divider for no load is perfect.

Consider first the effects of leakage inductance. The most symmetrical configuration in so far as flux is concerned, is the uniformly wound toroid. By suitably interleaving the windings and carefully maintaining uniformity, the total leakage inductances can be kept to under 10% of the air core inductance. Since the air core inductance is approximately $1/\mu$ times the inductance with iron core, where μ is the permeability of the core material, the total leakage inductance to coupled inductance ratio is $1/10\mu$. The core material used in the transformers is supermalloy which has a guaranteed initial permeability of 100,000. The leakage to coupled inductance ratio is therefore approximately .0001%. Since this figure represents the ratio of voltage dropped in the leakage inductance to total voltage, the error in the transformer due to non-distributed leakage inductance will not exceed this, if the leakage inductance per turn does not vary by more than ±100%. This condition can be met with suitable techniques of interleaving the windings.

Non-distributed winding resistance has much the same effect as non-distributed leakage inductance. If the effects of winding capacities are neglected, the winding resistance is most important at low frequencies since the exciting impedance of the transformer is directly proportional to frequency. Since the exciting impedance is fairly reactive, the voltage dropped in the winding resistance will be almost in quadrature with the input and consequently any non-distributed resistance will cause some phase error as well as magnitude error. The fact that this error voltage is in quadrature makes the magnitude error extremely small and for all practical purposes negligible. Typical figures might be .000001% for small ratios and even less for larger ratios. Phase angles from this cause would be approximately .01 milliradians at low frequencies and small ratios, decreasing for larger ratios.

At higher frequencies distributed capacitance becomes important. It causes voltage drops in the leakage inductance and winding resistance which are not uniformly distributed due to the transformer action. Like the effects of winding resistance, the errors caused by the capacitance are mainly in quadrature and so cause phase shift at low ratios. Typical values for this phase shift are:

> Less than .05 milliradians for frequencies below 1 kHz and
> Ratios above .1 for low voltage – high frequency units.
>
> Less than .05 milliradians for frequencies below 200 Hz and
> ratios above .1 for high voltage low frequency units.

Phase angle due to this cause is almost directly proportional to frequency for any particular ratio down to frequencies where the non-distributed resistance takes over.

Another source of error is voltage drop due to exciting current in the leads to the transformer. This effect may be minimized by using heavy connecting leads or treating the transformer as a four terminal impedance. The internal wiring of the transformers contributes to this error. These effects are worst at higher frequencies, above the self-resonant frequencies of the transformers.

6.3 AC RATIO STANDARD ACCURACY

The AC Ratio Standard accuracy is presented in two ways. The first is called Terminal Linearity, the same term used for describing potentiometer accuracy. The usual definition of terminal linearity is "error in the output divided by the total input":

$$\text{Terminal Linearity} = \frac{\triangle E_o}{E_{in}},$$

where:

$\triangle E_o$ is the actual error voltage in the output and

E_{in} is the total input voltage.

The second way that accuracy is presented is in terms of output voltage. It is called "Ratio Accuracy" or "Accuracy of Indicated Ratio".

$$\text{Ratio Linearity} = \frac{\triangle E_o}{E_o},$$

where:

$\triangle E_o$ is the actual error voltage in the output and

E_o is the total output voltage.

The second accuracy approach is specified by a formula which gives the maximum error which could be expected in the indicated ratio. This gives the error as a percentage of the output if the input is perfectly known. This accuracy is applicable to a bridge circuit, since the source voltage is common to both branches of the bridge circuit, and variations of source voltage cause no error (see Paragraph 7.4.2 which describes use of a bridge circuit when performing an accuracy test).

Section VII

MAINTENANCE

7.1 GENERAL

Since AC Ratio Standards are passive devices, a minimum maintenance is required. With the exception of cleaning switch contacts, no maintenance on a regularly scheduled basis is required. Moving parts are lubricated at the factory and should require no further lubrication.

7.2 SWITCH CONTACTS

During Calibration Intervals, clean switch contacts with a good grade of solvent such as alcohol or acetone. Relubricate contacts with a small amount of light lubricant.

7.3 DEGAUSSING

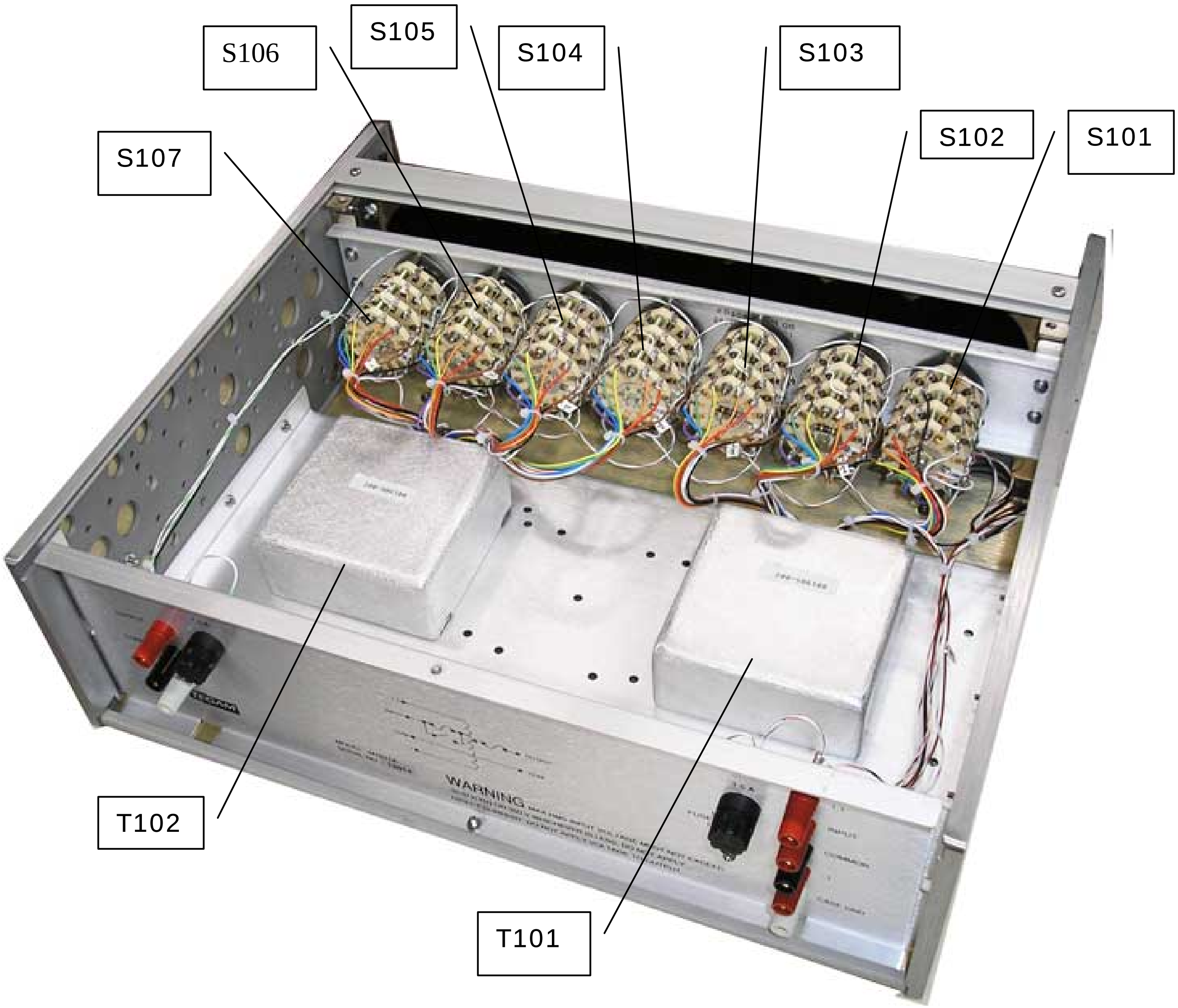
If dc voltage is accidently applied to the input terminals, degauss the unit as follows:

a. Connect a 1K resistor in series with the INPUT terminal.

b. By means of a variac or other suitable voltage control, apply a 60 Hz signal between the open end of the 1K resistor and the COM terminal.

c. Starting with the voltage control at zero, increase voltage to 40 V rms.

d. Slowly decrease the voltage to zero. The period of time to reduce the voltage from 40 V rms to zero should be between 10 to 15 seconds.



NOTE: The Model M-1012A is the same except for the size of T1 and T2 and the model number.

Figure 7-1. Location Of Components, Model M-1011A (Top View)

7.4 CALIBRATION CHECK

Provided that the AC Ratio Standard is kept in a normal laboratory environment, the unit should only require a calibration check every three years. Under more severe conditions, the calibration period must be shortened.

This section includes two tests: an input impedance test and a simplified ratio accuracy test. Refer to Table 7-1 for a list of test equipment required.

Table 7-1 Test Equipment Required

NOMENCLATURE	PART NUMBER OR MODEL	APPLICATION	RANGE	ACCURACY
AC Ratio Standard	Model M-1011A or Model M-1012A	Provides comparison standard for ratio test.	1.111111 to -0.111111 ratios	Per National Institute of Standards Calibration Test
Bridge Transformer	Model ST248 (TEGAM)	Provides signal isolation.	120 Vac, 400 cps (maximum)	
Null Indicator	Model PAV-4 or equivalent	Provides means of comparing output voltage.		
Decade Resistance Box		Provides voltage divider network.	1 megohm range	±0.5%
DVM		Measuring voltages		2%
Switch		Check voltage divider network.	SPDT	
Audio Oscillator		AC Voltage Source	20 Hz to 20KHz 0 to 45 VRMS	

7.4.1 Impedance Check

To check input impedance, proceed as follows:

a. Connect unit into test setup as shown in Figure 7-2.

b. Set input frequency to 400 Hz (M-1011A) and 60 Hz (M-1012A).

c. Adjust voltage source until DVM V1 indicates twice the desired voltage through the unit under test.

d. Adjust decade resistance box until DVM V2 shows equal indications with switch SW-1 in either position A or B.

e. Read input impedance from the decade resistance box. The input impedance shall be 200 kilohm or more.

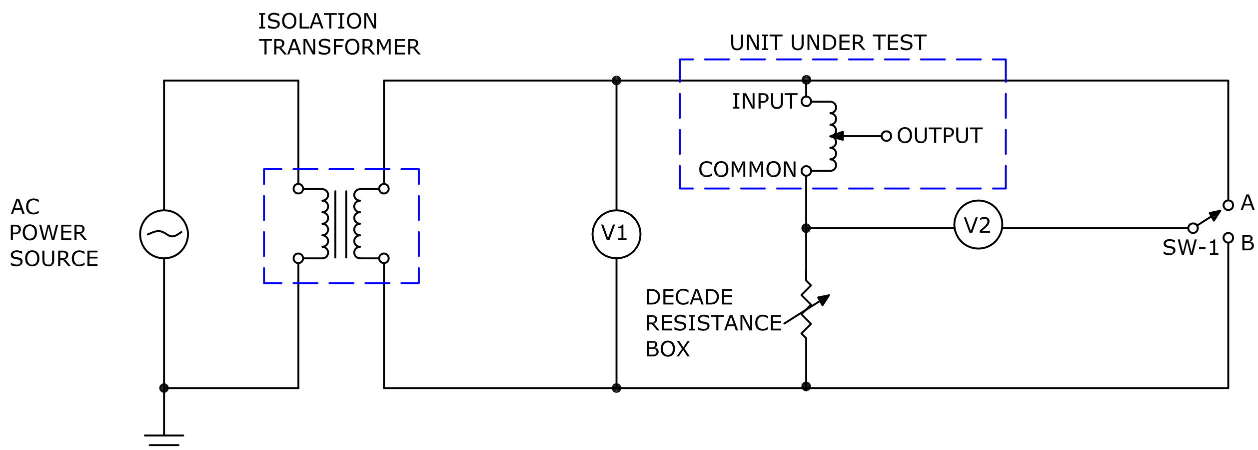


Figure 7-2. Impedance Test Setup

7.4.2 Ratio Accuracy Test

This procedure uses a Model M-1011A or M-1012A AC Ratio Standard as a reference. To test the ratio accuracy proceed as follows:

a. Use test setup shown in Figure 7-3.

b. Set input signal frequency to 400 Hz.

c. Apply an input voltage of 10 V AC as indicated on Voltmeter V1.

d. Set the Model M-1011A or M-1012A AC Ratio Standard reference controls for an output reading of 0.0000000.

e. Adjust unit under test controls until the Null Indicator indicates a null.

f. Compare the ratio indicated by the unit under test against the ratio indicated by the reference standard. The two ratios shall agree within the “Accuracy of Indicated Ratio” listed in Table 2-1.

g. Repeat steps “e” through “f” for each switch position of the reference Standard (0.1111111, 0.2222222, etc.).

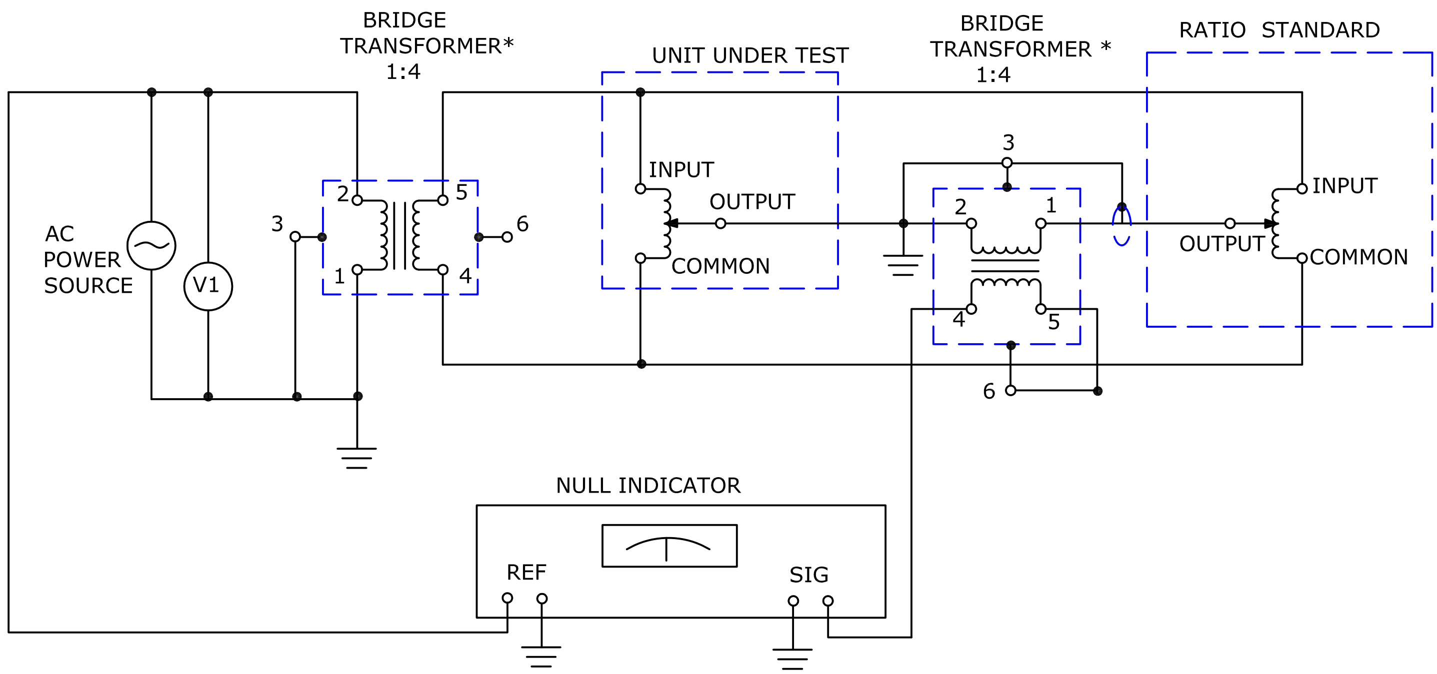


Figure 7-3. Ratio Accuracy Test Setup

* Not required if a PAV-4B or PAV-4C null indicator is used. Bridge transformers are part of the PAV-4B and PAV-4C instruments.

Section VIII

REPLACEABLE PARTS

8.1 INTRODUCTION

This section includes all pertinent data necessary to locate, identify, and procure additional parts for the equipment. Parts are listed alpha-numerically by reference symbol and include all replaceable electronic items. Satisfactory replacement may be made with either the listed component or an exact replacement of the parts (s) removed from the equipment.

8.2 ORDERING INFORMATION

The following instructions will aid in ordering parts:

a. Address all inquires or orders to:
CUSTOMER SERVICE DEPARTMENT
TEGAM, Inc.
10 Tegam Way,
Geneva, Ohio 44041

b. Include the following information:
1. Model and Serial Number of instrument.
2. Assembly Reference Symbol Number (i.e. A1A1).
3. Reference Designation Number (i.e. C1).
4. TEGAM Part Number.
5. Description (as shown on Parts List).

c. Packing
No special handling or packing procedures are required. It is suggested you pack the instrument in a crash resistant box.

8.3 PARTS LIST USE

The Table of Contents at the front of the manual lists the Parts List Tables, related assemblies, and location. The following paragraphs describe the use and meaning of the four columns included in the Parts List starting with Table 8-3.

a. Reference Designation, Column 1

   The Reference Designation column contains an alpha-numeric listing of parts as they appear on the equipment chassis, illustration, or schematic. The reference designation identifies the parts as to their component function in the instrument. Refer to Table 8-1.

b. TEGAM Part Number, Column 2

   The TEGAM Part Number column contains the part number as designated by TEGAM.

c. Description, Column 3

   The Description column contains the identification of component parts, including all pertinent specifications. When the description column is used for a reference symbol for which no part exists, “NOT USED”, is placed in the column. In these instances, column 2 is left blank. Refer to Table 8-2 on abbreviations that are used in the Parts List.

d. Total Quantity, Column 4

   The total quantity used of each Part Number listed.

TABLE 8-1. Reference Symbols

A	Assembly	R	Resistor
C	Capacitor	S	Switch
F	Fuse	T	Transformer
K	Relay	W	Cable
L	Inductor	XF	Fuse Holder

TABLE 8-2. Abbreviations

A	Ampere	mH	Millihenry
AC	Alternating Current	No.	Number
Desig.	Designator	Ref.	Reference
Hz	Hertz	V	Volts
k	Thousand (10^3)	W	Watts
Mfr	Manufacturer	%	±% if sign not shown

TABLE 8-3. Parts List for Model M-1011A

Ref. Desig.	TEGAM Part No.	Description	Total Qty.
	104561-001	Bezel	2
	203052-001	Chassis	1
	203076-001	Bracket, Cover	2
	203077-001	Cover, Slide	2
	203078-001	Cover, Top	1
	203192-001	Trim	2
	404444-001	Dial	7
	404499-001	Knob	7
	966050-001	Frame, Side	2
	964003-028	Screw, Mach. PH 6-63X3/8	4
	964003-045	Screw, Mach. PH 8-32X1/2	8
	964006-005	Hex Nut 6-32	3
	964025-005	Washer .312 OD	7
	964025-006	Washer .375	8
	964064-028	Screw, Mach. 6-32x3/8	26
	964066-004	Washer, Lock #6	7
	964066-005	Washer, Lock #8	8
	6093-001	Rear Panel Sub. Assy.	1
	100564-001	Washer	2
	203040-001	Rear Panel	1
F1, F2	924000-022	Fuse, 1.5 amphere	2
XF1, XF2	924001-001	Fuse Holder	2
	941018-001	Binding Post, Red	4
	941018-002	Binding Post, White	2
	941018-003	Binding Post, Black	2
S8	951036-027	Toggle Switch	1
	6113-002	Bottom Cover Assy.	1
	203079-001	Bottom Cover	1
	964003-028	Screw, Mach. PH 6-32x3/8	2
	964003-029	Screw, Mach. PH 6-32x7/16	4
	964024-005	Screw, Mach. FH 4-40x7/16	6

TABLE 8-3. Parts List for Model M-1011A (continued)

Ref. Desig.	TEGAM Part No.	Description	Total Qty.
	964025-005	Washer Flat .312 ID	6
	964066-004	Washer, Spring Lock #6	6
	964118-104	Tilt Bail	1
	006148-001	Switch Sub. Assy.	1
T1	1985-002	Transformer, Toroid	1
T2	1986-002	Transformer, Toroid	1
	203044-001	Switch Bracket	1
S1 thru S7	402180-001	Rotary Switch	7
R5, R7	945001-021	Resistor, Composition	4
R9, R11		47 ohms, 10%, 1/2W	
R1, R3	945001-041	Resistor, Composition	2
		2.2K ohms, 10%, 1/2W	
	964005-009	Lockwasher 3/8 Int. Tooth	7
	964006-011	Hex Nut 3/8-32	7
	6115-001	Front Panel Assy.	1
	100564-001	Washer	2
	104556-001	Front Panel	1
	203002-001	Bracket	2
	203053-001	Window	7
	941018-001	Binding Post, Red	4
	941018-002	Binding Post, White	2
	941018-003	Binding Post, Black	2
	964006-006	Hex Nut 8-32	4
	964025-006	Washer, Flat .375OD	4
	964066-005	Washer, Spring Lock #8	4

TABLE 8-4. Parts List for Model M-1012A

Ref. Desig.	TEGAM Part No.	Description	Total Qty.
	104561-001	Bezel	2
	203052-001	Chassis	1
	203076-001	Bracket, Cover	2
	203077-001	Cover, Slide	2
	203078-001	Cover, Top	1
	203192-001	Trim	2
	404444-001	Dial	7
	404499-001	Knob	7
	966050-001	Frame, Side	2
	964003-028	Screw, Mach. PH 6-63X3/8	4
	964003-045	Screw, Mach. PH 8-32X1/2	8
	964006-005	Hex Nut 6-32	3
	964025-005	Washer .312 OD	7
	964025-006	Washer .375	8
	964064-028	Screw, Mach. 6-32x3/8	26
	964066-004	Washer, Lock #6	7
	964066-005	Washer, Lock #8	8
	6093-001	Rear Panel Sub. Assy.	1
	100564-001	Washer	2
	203040-001	Rear Panel	1
F1, F2	924000-022	Fuse, 1.5 amphere	2
XF1, XF2	924001-001	Fuse Holder	2
	941018-001	Binding Post, Red	4
	941018-002	Binding Post, White	2
	941018-003	Binding Post, Black	2
S8	951036-027	Toggle Switch	1
	6113-002	Bottom Cover Assy.	1
	203079-001	Bottom Cover	1
	964003-028	Screw, Mach. PH 6-32x3/8	2
	964003-029	Screw, Mach. PH 6-32x7/16	4
	964024-005	Screw, Mach. FH 4-40x7/16	6

TABLE 8-4. Parts List for Model M-1012A (continued)

Ref. Desig.	TEGAM Part No.	Description	Total Qty.
	964025-005	Washer Flat .312 ID	6
	964066-004	Washer, Spring Lock #6	6
	964118-104	Tilt Bail	1
	006144-001	Switch Sub. Assy.	1
T1	1859-001	Transformer, Toroid	1
T2	1860-001	Transformer, Toroid	1
	203044-001	Switch Bracket	1
S1 thru S7	402180-001	Rotary Switch	7
R5, R7	945001-021	Resistor, Composition	4
R9, R11		47 ohms, 10%, 1/2W	
R1, R3	945001-041	Resistor, Composition	2
		2.2K ohms, 10%, 1/2W	
	964005-009	Lockwasher 3/8 Int. Tooth	2
	964006-011	Hex Nut 3/8-32	7
	M-1012A-051	Front Panel Assy.	1
	100564-001	Washer	2
	M-1012A-330	Front Panel	1
	203002-001	Bracket	2
	203053-001	Window	7
	941018-001	Binding Post, Red	4
	941018-002	Binding Post, White	2
	941018-003	Binding Post, Black	2
	964006-006	Hex Nut 8-32	4
	964025-006	Washer, Flat .375 OD	4
	964066-005	Washer, Spring Lock #8	4

Section IX

SCHEMATIC DIAGRAMS

9.1 INTRODUCTION

Section IX contains a Schematic Diagram for the Models M-1011A and M-1012A AC Ratio Standard instruments.

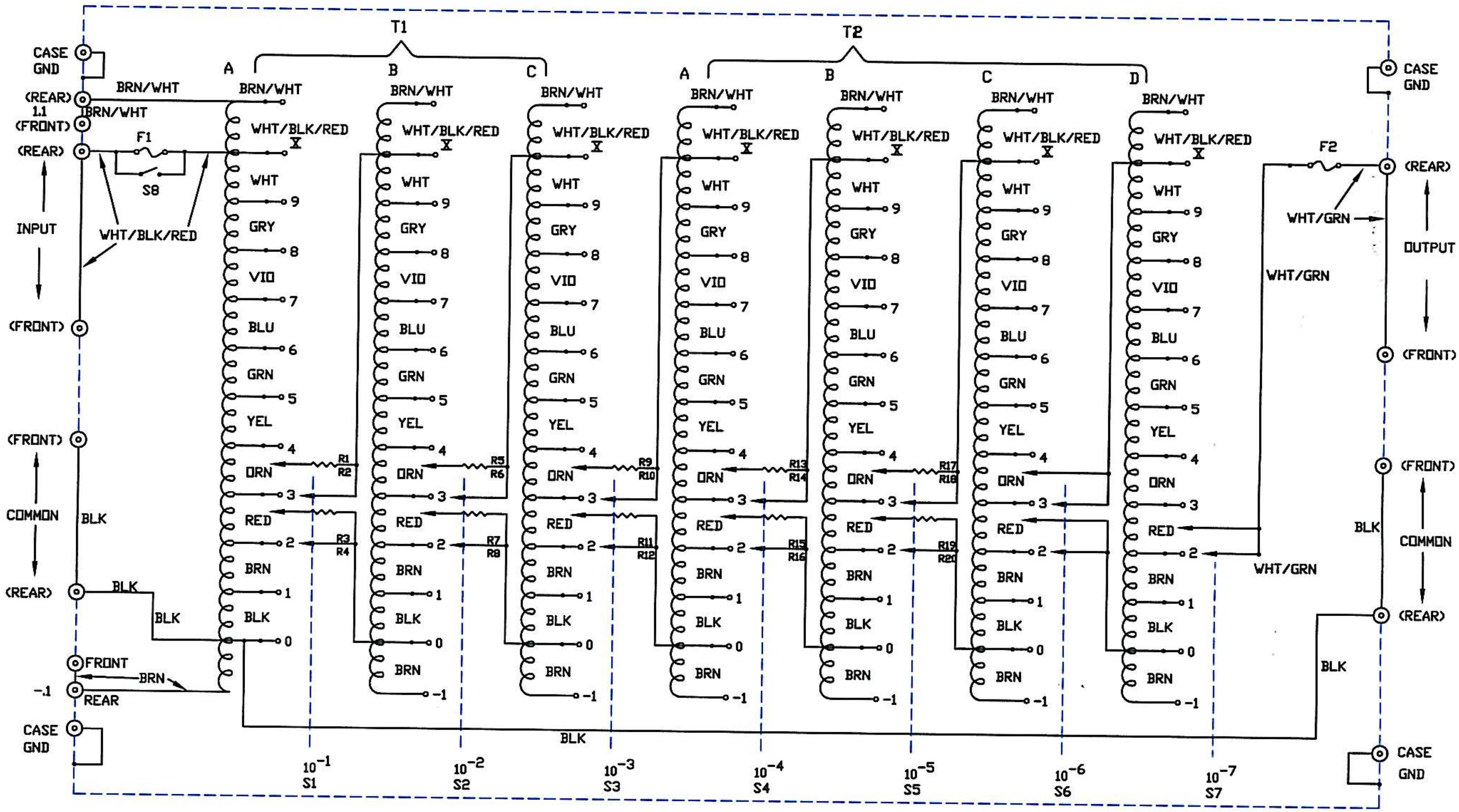


FIGURE 9-1. SCHEMATIC DIAGRAM, MODELS M-1011A OR M-1012A