LS27B Hardware User's Manual

Dual channel Multi-Band RF Downconverter
with AM and FM Demodulation

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1 Introduction

1.1 General

This document is the Hardware User's Manual for the Lumistar LS27B Dual Channel Multi-band RF Downconverter. This product represents Lumistar's 3rd generation of the LS27 Series of Dual Channel RF Downconverters. In addition to the functionalities of the Lumistar LS27P3 PCI downconverter, this product also provides and optional FM demodulation stage for each input channel. Figure 1-1 contains detailed model number construction. This document applies to all model combinations indicated by this figure.

The intent of this document is to provide physical, functional, and operational information for the end user including hardware configuration, interconnection and software interfaces for the device.

The design implements a Digital Signal Processor Engine (DSPE) controlled superhetrodyne downconverter with AM demodulation and optional FM demodulation. This receiver is in the physical format and size similar to a standard 5 3/4" CD or DVD drive format. The product provides two independent and autonomous multi-band downconversion stages. Each channel provides the conversion of up to four RF pass-bands to a 70MHz Intermediate Frequency (IF) output while providing AM demodulation of the input signal. The product's standard configuration provides eight software selectable IF bandwidth filters, roughly placed at octave intervals (or as ordered by the customer), to reduce channel noise bandwidth and improve adjacent channel rejection. The product line can optionally be equipped with an FM demodulation stage and eight video filters.

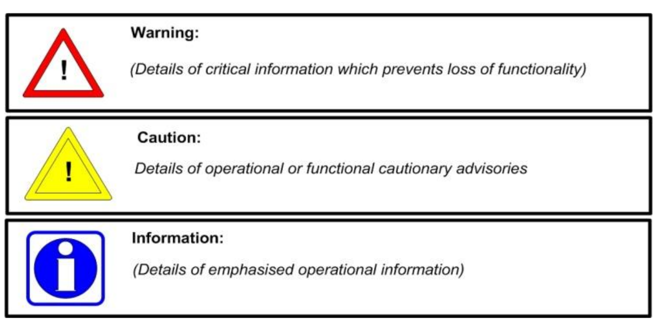
Table 1-1 provides specifications for electrical, mechanical, and operational characteristics of the LS27B product. A block diagram of the product design is shown in Figure 1-2.

1.2 Manual Format and Conventions

This manual contains the following sections:

- Chapter 1 provides a brief product overview and technical specifications
- Chapter 2 provides receiver theory of operation
- Chapter 3 provides installation and configuration instructions
- Chapter 4 provides programming information

Throughout this document, several document flags will be utilized to emphasis warnings or other important data. These flags come in three different formats: Warnings, Cautions, and Information. Examples of these flags appear below.



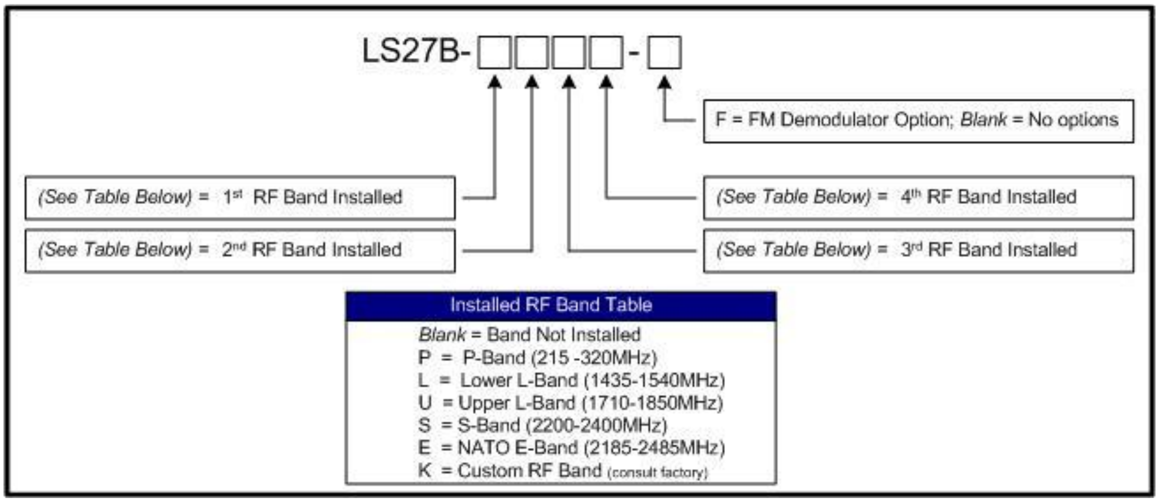


Figure 1-1 LS27B Model Number Construction Details

Category:	Specifications:	Details:
Mechanical		
	Envelope Dimensions	7.00"(L) x 5.75"(W) x 1.625" (H)
	Form Factor	5 3/4" CD/DVD Drive Size
	Weight	~ 30oz.
Electrical		
	Individual power requirements	+12VDC @ 2A (nominal); 11-36VDC input
	Total Power (both Channels)	~ 22Watts (nominal), ~26Watts (max.)
Performance		
RF Tuner	RF Input Bands	2185.5 - 2485.5 MHz (E-Band)
		2200.5 - 2399.5 MHz (S-Band)
		1710.5 - 1849.5 MHz (Upper L-Band)
		1435.5 - 1539.5 MHz (Lower L-Band)
		215.5 - 319.5 MHz (P-Band)
		Custom (Consult Factory)
	Tuner Resolution	50kHz (Typical)
	Frequency Accuracy	0.002% (Max.) 0.001% (Typical)
	RF Input AGC Range	+10dBm to –100dBm
	Input Level without Damage	+28dBm
	Receiver Input P_{1dB}	+10dBm (typical)
	Receiver Noise Figure	5dB (typical @ threshold)
	70MHz Phase Noise @ 100kHz	Less than -110dBc (typical)
	Receiver OIP_3	> +15dBm (typical)
	70MHz Output Level	-20dBm (+/- 1dBm)
	2^{nd} IF 3dB Bandwidths Available (typical)	250kHz, 500kHz, 1MHz, 2MHz, 5MHz, 10MHz, 20MHz, 40MHz
Demodulation	Types	AM, FM (optional)
	AM -3dB Frequency Response	50kHz (AM Low-pass Bypass Mode)
	AM Low-pass Filters	32 Software Selectable
	AM -3dB Bandwidths	50, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1K, 1.1K, 1.2K, 1.3K, 1.4K, 1.5K, 1.6K, 1.7K, 1.8K, 1.9K, 2K, 3K, 4K, 5K, 6K, 7K, 8K, 9K, 10K, 15K, 20K, 50K Hz
	FM Video Filters (typical)	125kHz, 250kHz, 500kHz, 1MHz, 2.5MHz, 4.6MHz, 10MHz, 15MHz.
Connectors		
	External Reference Input/Output	(1) SMA Jack, Female
	RF Signal Input	(2) SMA Jack, Female
	IF Signal Output	(2) SMA Jack, Female
	Output Connector	(1) 2x8 0.100 Shrouded Header, keyed
	DC Power Connector	(1) 1x4 0.200 Shrouded Header, keyed
	Serial Interface, DI Connector	(1) 2x10 0.100 Shrouded Header, keyed
Environmental		
	Temperature, Operational	-40° to 85° C (Industrial)
	Temperature, Storage	-20° to 90° C
	Humidity, non-condensing	<40° C 0-90%, >40° C 0-75%

Table 1-1 Specifications for the LS27B

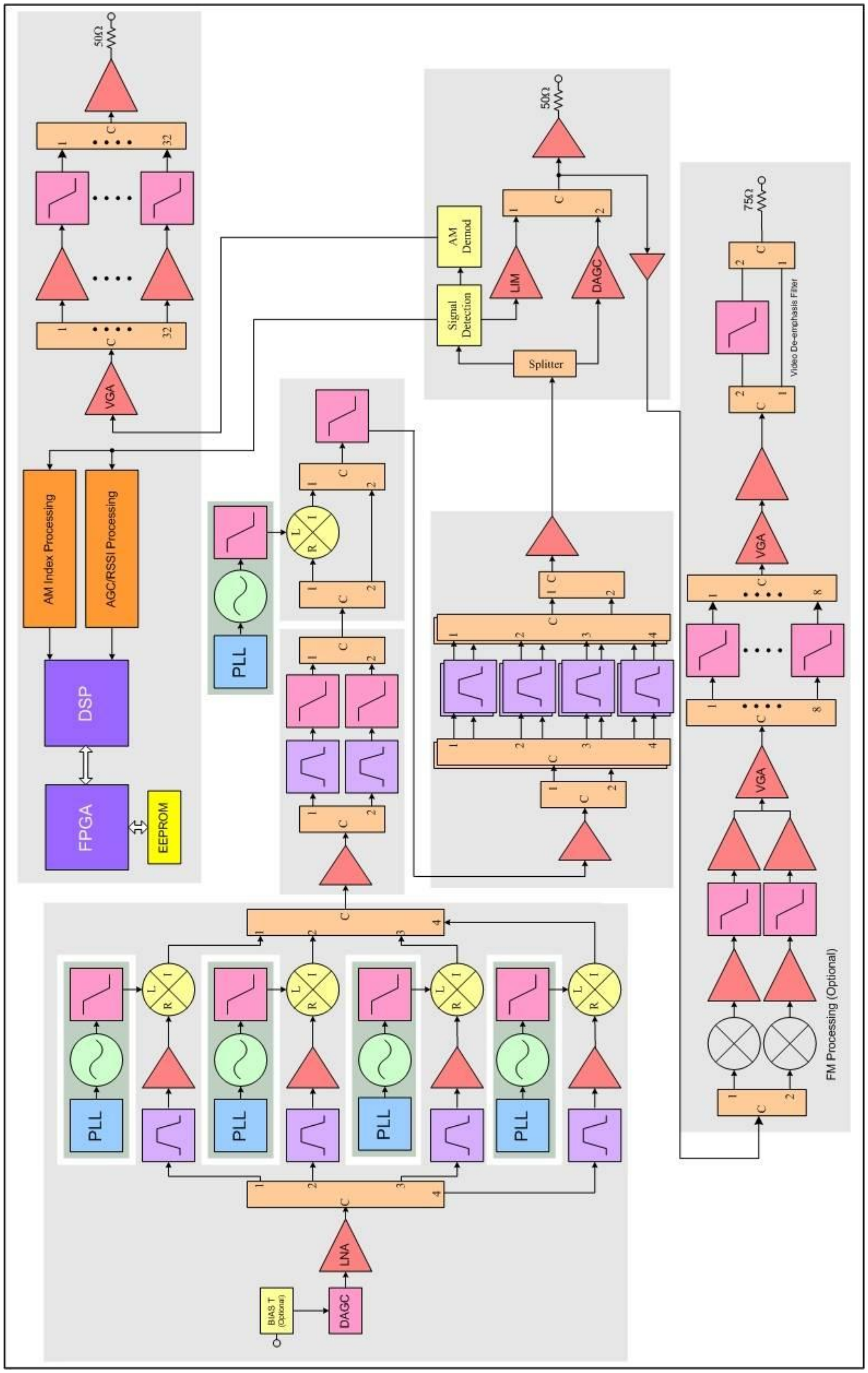


Figure 1-2 Block Diagram of LS27B Series Multi-band Receiver

2 Theory of Operation

In order to more clearly understand the operation of the receiver, this section will detail the various stages of the receiver design. These stages are as follows:

- 1st Downconversion
- 1st IF Band-pass Filter
- 1st Local Oscillator
- 2nd Downconversion
- 2nd Local Oscillator
- 2nd IF Filter
- Limiting Amplifier/AM Demodulation/Digital AGC (DAGC)
- Digital Signal Processing Engine (DSPE)
- FM Demodulation Stage (Optional)

With the exception of the DSPE, each of these sections are physically shielded and isolated from one another to facilitate the greatest EMI/RFI ingress and egress protection allowing the receiver exceptional performance.

For the following sections, refer to the block diagram of Figure 1-2.

2.1 1st Downconversion

The RF input is applied to the 1st Downconversion stage. The stage may optionally contain a bias-T which can be used to power an external LNA through the RF interface port. (Contact the factory for further details on this option.) A DAGC section is next in the signal chain for very high level signal protection and compression compensation. This is followed by a low-noise amplifier (LNA) to provide a large amount of gain while maintaining a very low noise figure enhancing the receiver's overall sensitivity. Selectable RF band-pass filters follow the LNA. The RF signal is then mixed with the first local oscillator (LO) which converted to the 1st IF frequency.

2.2 1st IF Band-pass Filter

The output of the 1st Downconversion stage is send through one of two1st IF filter paths based on the selection of high-side or low side conversion. To eliminate images and limit the overall noise bandwidth to the remaining receiver sections, a 50MHz band-pass filter is switched into the signal path.

2.3 1st Local Oscillator

In a superhetrodyne design, local oscillators (LOs) are utilized to convert high frequencies to lower, "intermediate" frequencies. The first LO is injected into the mixer of the first Downconversion stage to accomplish this task. Mixers can either utilize a sum or difference frequency component to produce IF frequencies. For example, if an RF frequency of 2,200 MHz was to be converted to an intermediate frequency of 250MHz, a difference component of 1,950MHz could injected to the mixer or a sum frequency component of 2,450MHz could be applied. The difference component LO application is referred to a "low-side" conversion. The sum component application is referred to as "high-side" conversion. Both methods are equally valid and each has its own benefits. The LS27B design has the ability to utilize either approach and actually switch between the methods when necessary for performance reasons.

2.4 2nd Downconversion

The receiver designs contain a switchable 2nd Downconversion stage. Similar to the 1st Downconversion stage, it contains a mixer to convert the 1st IF frequency to a second IF frequency of 70MHz. If the RF frequency band is relatively low, as is the case for P-Band inputs, the on-board processor can bypass the 2nd Downconversion stage switching to a single superhetrodyne process. In either case, a low-pass filter is applied to the signal path at the output of this stage to reduce harmonics and low frequency noise from being applied to subsequent stages.

2.5 2nd Local Oscillator

The second LO is injected into the mixer of the 2nd Downconversion stage to provide the second IF frequency of 70MHz. Like the first conversion stage, the second LO utilizes low-side injection for this conversion. A low-pass filter is applied to the LO output to minimize spurious and harmonic signals from being converted in the 2nd Downconversion stage. The 2nd LO is automatically disabled for RF bands that employ a single super heterodyne process.

2.6 2nd IF Filter

From the output of the 2nd conversion stage, the resulting intermediate frequency is then applied to a group of bandpass filters to minimize noise bandwidth and improve adjacent channel rejection. The 2nd IF stage contains eight IF (SAW) filters centered at 70MHz and varying in bandwidth from 250kHz to 40MHz in approximately octave steps.

2.7 Digital AGC/Limiting Amplification/AM Demodulation

Outputs from the 2nd IF Filter Stage are routed to the final signal detection, AM demodulation, and gain stage in the receiver. The output stage combines both a limiting amplifier and digital AGC (DACG) section. Included in the design is an AM demodulation stage for antenna tracking applications. The main system gain element provides for 90 to 110dB of signal gain. Signal level detection is utilized in DAGC controls.

2.8 Digital Signal Processing Engine (DSPE)

The LS27B design contains a highly integrated digital signal processing engine (DSPE) which is utilized for linearization, filtering and control applications. This engine is composed of a digital signal processor, FPGA resources, ADCs, DACs and localized memory used to process the signal path parameters. Each of the channels is controlled and statused as an autonomous receiver. The engine performs “real-time” tasks as well as user software interfaces.

2.9 FM Demodulation Stage (Optional)

The LS27B design may optionally contain an FM demodulation stage for each channel. The stage is split between a narrow-band and wide-band demodulator to optimize processing of each signal characteristic. The output of the FM demodulation is software switched between one of eight video filters. The output can also be switched, in addition to the video filter, thru a video de-emphasis network for true analog video signals. The unit is comes standard with NTSC de-emphasis but other formats are available. The demodulation stage has a software adjustable output level.

3 Installation and Configuration

Chapter 3 provides installation and configuration information. This chapter will familiarize the user with the layout of the device, and provide information on the proper installation and interconnection of the hardware.

3.1 Product Outline Diagrams

Figure 3-1 contains an outline diagram of the top and bottom sides of the product. Connector locations and switch positions are indicated. The model number, serial number, revision information and product options are denoted on the RF enclosure label.

3.2 Hardware Configuration

The receiver design contains configuration switches to control various functions. Figure 3-2 contains a diagram of the configuration switches along with the default factory positions for these switches.

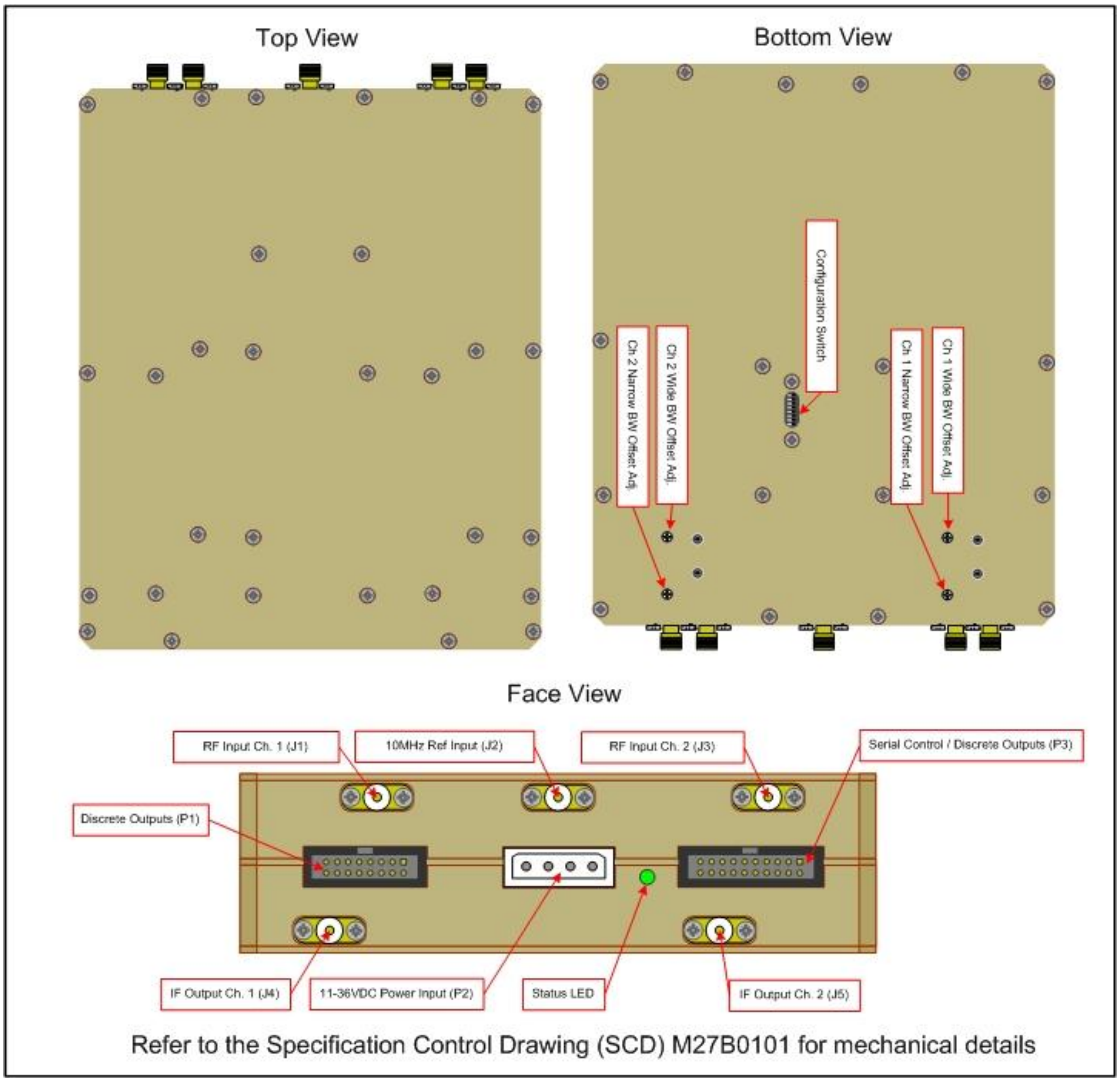


Figure 3-1 LS27B Mechanical Outline Drawing

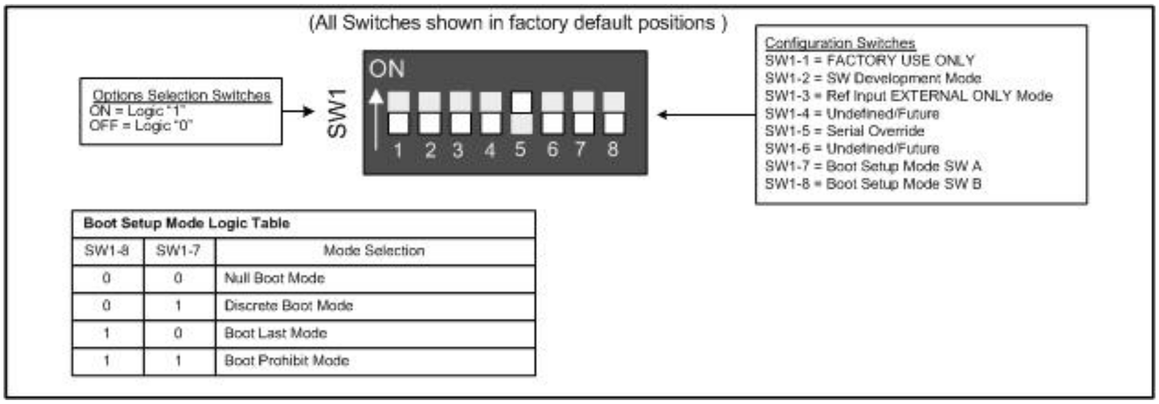


Figure 3-2 Receiver Configuration Switch SW1

The configuration switches in Figure 3-2 have the following functions:

1.) The SW1-1 is defined as FACTORY USE and should remain in the OFF state as shown.

> **Warning:**
> SW1-1 is defined as FACTORY USE ONLY. In order to facilitate proper operation this switch MUST remain in the OFF position.

2.) The SW1-2 switch sets the LS27B to SW Development mode. When the switch is in the ON position, the serial status messages will contain dynamic data. The intent of this switch is to aid the development of user software without the necessity of having any inputs to the unit.

> **Warning:**
> If SW1-2 is in the ON position, the serial status will not reflect the actual input conditions. During normal operations, this switch MUST be in the OFF position.

3.) J2 allows for either an external reference source to be supplied to the receiver for synchronization to external RF hardware, or for the output of an on-board 10MHz reference to synchronize other external items to the unit's synthesizer reference source. SW1-3 controls the operation of the synthesizer reference clock distribution and PLL at boot-time. When SW1-3 is in the OFF position, the J2 connection is in an automatic sense mode. In this mode, at boot-time, the clock distribution system monitors for the presence of an external reference at port J2 (see Figures 3-1). If there is no external reference present at J2 (10MHz @ +4dBm) within 250msecs of boot-time, the unit will automatically switch the J2 input port to an output mode, enable on on-board 10MHz TCXO (+/- 3ppm stability minimum), and the route the 10MHz TCXO source to both the J2 output (at +2 to -2dBm @ 50 ohms) and use it to synchronize the internal synthesizers. When SW1-3 is in the ON position, the internal LS27B 10MHz reference clock will be disabled and the J2 connector will be switched to be a dedicated input. In this mode, the unit will presume the presence of an external 10MHz reference source.

Warning:

SW1-3 switch is set to ON, the reference input is in the "EXTERNAL ONLY" mode. If no external reference is supplied (10MHz @ >=4dBm), the unit will lack synthesizer synchronization which will affect the overall performance of the unit.

4.) Switch SW1-5 initiates the serial override mode. When in the ON position, the serial interface is automatically set to 57.6K BAUD for each serial communications channel. When in the OFF position, commands to alter the serial data rate can be issued.

5.) Switches SW1-7 and SW1-8 define the LS27B power-up boot configuration selection. This combination of switches allows the user to select pre-stored configuration setups by various methods. The description of these methods follows:

a. **NULL Boot Mode** – In this mode, the LS27B receivers will not tune to any stored setups that may have been previously stored in the unit's internal non-volatile memory. When commanded via one of the appropriate serial interfaces, it will tune the receiver as commanded. In this mode, storage of setup parameters are stored in internal non-volatile memory.

b. **Discrete Boot Mode –** In this mode, the LS27B receiver will be setups will be selected via the state of the external discrete lines on P3-7 thru P3-10. These discrete lines will determine a four bit number from zero to fifteen. At boot time, the LS27B will tune both receivers to the setup whose number is defined by the values of the discrete lines. Note that each receiver may still be tuned to a different frequency and setup, since each receiver has a separate list of 16 setups. Subsequent serial setup commands will override the boot setup and save that setup in non-volatile memory.

c. **Boot Last Mode –** In this mode LS27B will program the receivers with the last valid setup. Subsequent setup commands will override the boot setup and replace the setup as directed by the user.

d. **Boot Prohibit Mode** - This mode is designed for security conscious requirements. In this state the LS27B will not tune to any setup at power-up. Any serial commands will setup the receivers as usual, but no information will be retained internally in non-volatile memory. In addition, at boot time any existing setup information in any of the sixteen possible setup locations in non-volatile memory will be deleted.

6.) Switches defined as "Undefined/Future" have no implementation and thus their state is irrelevant.

3.3 Physical Installation

To install the receiver in the target computer system, the following procedure should be followed:

1. Perform a normal system shutdown of the target host system and remove the primary power plug.

2. Install the receiver in an unobstructed DVD/CD drive bay or in mounting rails. PCs vary in their mechanical configurations so it may be necessary to remove additional PC hardware to properly install the unit.

3. For mounting hardware locations, reference the Specification Control Drawing for the product (Doc. Number: M27B0101).

4. It is recommended that at least four 4-40UNC mounting screws (provided) be used in the mounting of the unit. This accommodates higher vibration and shock environments. Ensure that the installation provides room for the RF and I/O connections.

5. Airflow across the unit is strongly recommended to prevent long-term heat related damage. Multiple sets of mounting holes have been provided to allow for some rear fan clearances.

6. Connect the serial control interface to an available RS/EIA-232 interface via the P3 connector.

7. Connect the user I/O as desired via the P1 connector (refer to Figure 3-3).

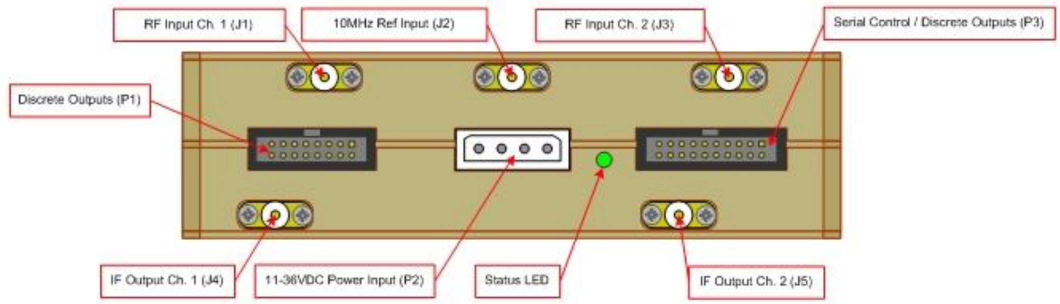
8. Connect the required RF and IF connections via the J-numbered connectors (refer to Figure 3-3).

9. Re-apply power to the unit and initiate the user software to communicate via the serial interface.

3.4 Interconnection

The receiver platforms provide multiple interface connectors. Figure 3-3 provides interface pin-outs and mating connector information for all connectors. Lumistar can provide an optional BNC style interface panel as shown in Figure 3-4 to ease the facilitation of user interfaces. Consult the factory for further details.

A communication harness is provided with the delivered unit. This harness is shown in Figure 3-5.



J1 Connector	
RF Signal Input Ch. 1	SMA Female

J2 Connector	
10MHz Reference Input	SMA Female

J3 Connector	
RF Signal Input Ch. 2	SMA Female

J4 Connector	
IF Signal Output Ch. 1	SMA Female

J5 Connector	
IF Signal Output Ch. 2	SMA Female

P1 Connector	Tyco PN:5103310-3
Pin 1	Ch. 1 AGC Output
Pin 2	Ground
Pin 3	Ch. 1 AM Output
Pin 4	Ground
Pin 5	Ch. 1 PCM Output #1
Pin 6	Ground
Pin 7	Ch. 1 Optional Bias-T Vin
Pin 8	Ground
Pin 9	Ch. 2 AGC Output
Pin 10	Ground
Pin 11	Ch. 2 AM Output
Pin 12	Ground
Pin 13	Ch. 2 PCM Output #1
Pin 14	Ground
Pin 15	Ch. 2 Optional Bias-T Vin
Pin 16	Ground

P2 Connector	Molex PN:53109-0410
Pin 1	+11-36VDC Power
Pin 2	Power Return
Pin 3	Power Return
Pin 4	(Unused)

P3 Connector	Tyco PN:5103310-5
Pin 1	SERIAL RDXA
Pin 2	SERIAL TXDA
Pin 3	SERIAL RTNC
Pin 4	------
Pin 5	------
Pin 6	------
Pin 7	DIO1
Pin 8	DIO2
Pin 9	DIO3
Pin 10	DIO4
Pin 11	DIO5
Pin 12	DIO RTN
Pin 13	SERIAL RXDB
Pin 14	SERIAL TXDB
Pin 15	SERIAL RTNB
Pin 16	------
Pin 17	SERIAL RXDC
Pin 18	SERIAL TXDC
Pin 19	SERIAL RTNC
Pin 20	------

Figure 3-3 LS27B Pin-outs and Connector Identification

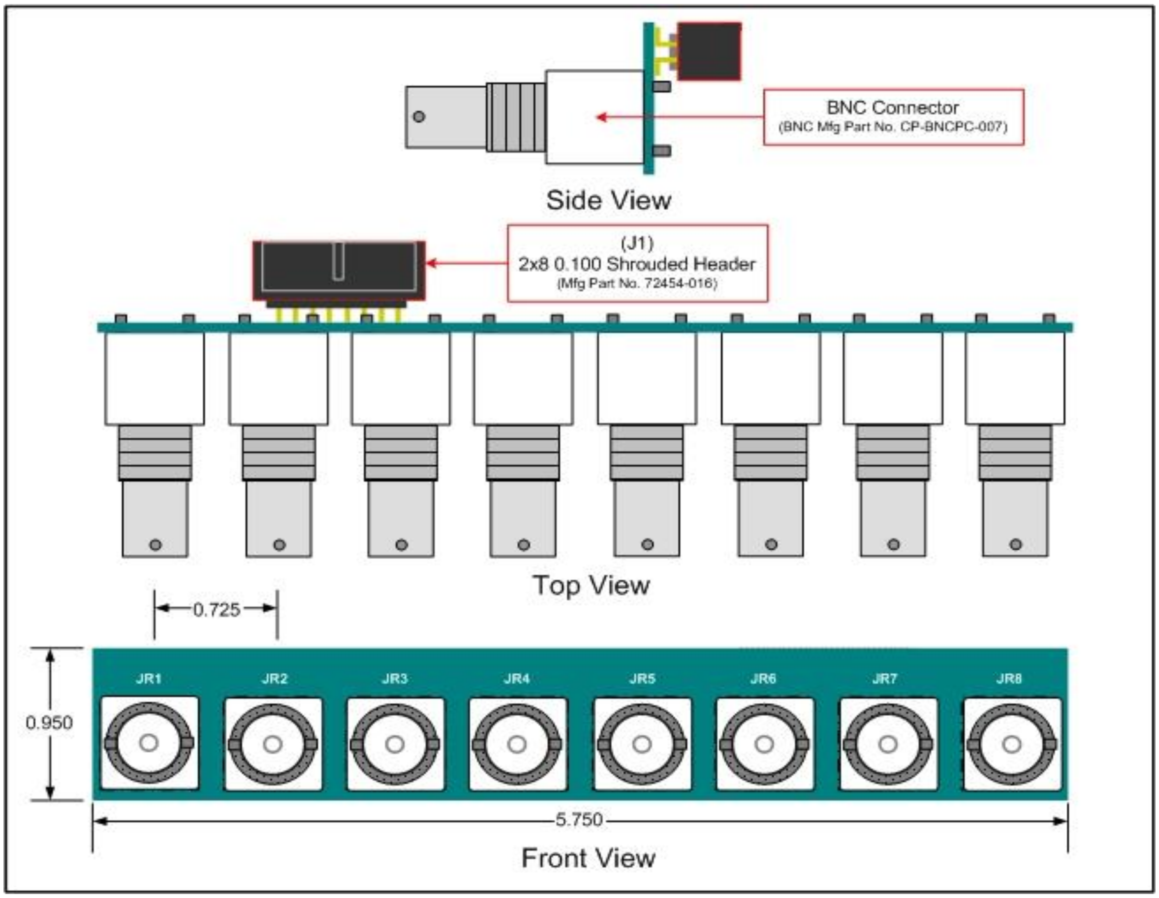


Figure 3-4 LS27B Optional User Interface Panel

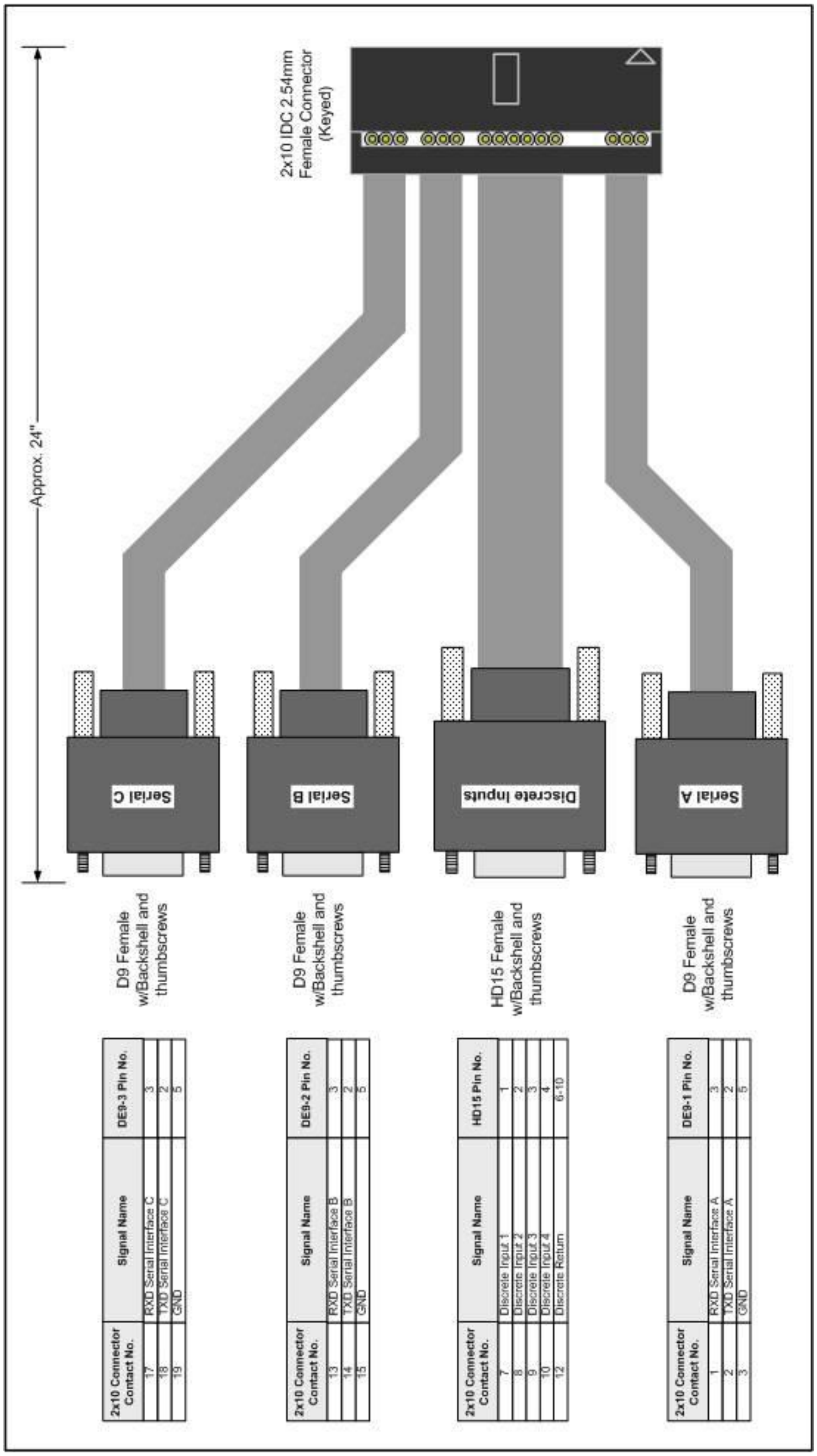


Figure 3-5 LS27B Communication Interface Cable (C27B0001)

3.5 External Setup Discretes

As shown in Figure 3-3, connector P3 contains five discrete selection inputs (four of which are active). These bits are used to select previously stored user setups for the LS27B without the use of a serial host interface.

Each of the LS27B input channels allows the storage of up to sixteen (16) receiver setups. Using the serial interface, the user can program particular configurations for the receiver channels, and then select a corresponding storage number. The operation of these discretes is based on the boot-time mode selection switches of SW1-7 and SW1-8. (Refer to section 3.2 for the proper setting of the configuration switches to enable the use of the external setup discretes.)

The discrete inputs will function as the main controls until serial communications to the unit takes place. At that point, the discrete interfaces are ignored and control of the unit is switched to the serial interface.

Selection of the discrete (logic 1) is made by connecting the desired discrete input to P3-13 pin. If the discrete input is left disconnected, the input will be considered logic 0.

DIO 4-0 Setting	Format Selected
0000_b	Programmed Setup 0
0001_b	Programmed Setup 1
0010_b	Programmed Setup 2
0011_b	Programmed Setup 3
0100_b	Programmed Setup 4
0101_b	Programmed Setup 5
0110_b	Programmed Setup 6
0111_b	Programmed Setup 7
1000_b	Programmed Setup 8
1001_b	Programmed Setup 9
1010_b	Programmed Setup 10
1011_b	Programmed Setup 11
1100_b	Programmed Setup 12
1101_b	Programmed Setup 13
1110_b	Programmed Setup 14
1111_b	Programmed Setup 15

Table 3-1 LS27B External Discrete Setup Selection Table

4 Communications

This chapter provides communications interface information pertaining to the LS27B drive bay dual receiver.

4.1 Serial Bus Interface

The LS27B is controlled and statused via a standard RS/EIA-232 asynchronous, 3-wire, serial interface method. The interface is capable of being run at rates between 9.6k BAUD and 115.2k BAUD with a default rate of 57.6k BAUD. The unit is shipped with SW1-5 position in the ON position. In this position, the unit will only communicate at 57.6k BAUD. (See programming section for details on how to alter the serial communication BAUD rate.)

The host communication channel should be setup in the following configuration:

Number of bits:	8
Parity:	None
Stop Bits:	1
Flow Control:	None

The design contains three serial interface channels, operating via two different protocols: "single receiver protocol" and "dual receiver protocol". Refer to Figure 3-3 for pin-out assignments.

4.1.1 Serial Bus Interface – Dual Receiver Interface Protocol

The Serial "A" bus, contained on P3 pins 1 thru 3, communicates via the "Dual Receiver Interface Protocol" defined in chapter 5. This protocol is "enhanced" from the existing "LS25B" protocol and provides for controls for both receiver channels via a single physical interface.

Information:
The "dual receiver" interface protocol provides some expanded functional capabilities that are not available via the previous LS25B "single receiver" interface protocol.

4.1.2 Serial Bus Interface – Single Receiver Interface Protocol

The Serial "B" bus, contained on P3 pins 14 thru 16, and Serial "C" bus, contained on P3 pins 18 thru 20, communicates via the existing LS25B Single Receiver Interface Protocol defined in chapter 5. The Serial "B" control/status interface is dedicated to the Channel 1 receiver. The Serial "C" bus control/status interface is dedicated to Channel 2 receiver.

Warning:
Only utilize one interface protocol at a time. Do not communicate on all three interfaces simulatenously.

5 Communications

This chapter provides interface protocol information for the LS27B drive bay dual receiver.

The LS27B product provides a dual protocol interface method. It supports a "single receiver protocol" which is operational compatible with the previous Lumistar generation of LS25B drive-bay receiver. It also supports an enhanced "dual receiver protocol" which provides some additional functional capabilities.

5.1 Single Receiver Protocol

Single receiver protocol is active on serial interface B which controls receiver number one of the device, and serial interface C, which controls receiver number two. The two receiver interfaces can be operated simultaneously and autonomously. All command/status information contained in the following sections relates to single channel operation but the format is identical between channels.

5.1.1 Single Receiver Protocol - Command and Status Messaging

Interface using the single receiver protocol is via command-response messaging. For every command sent from the host, the receiver will respond to indicate that the command was received. Commands from the host are grouped in two categories: primary commands and secondary commands. Primary commands are used to control the basic tuning and setup of the receiver. Secondary commands are used to set various "lower-priority" operational modes and to obtain secondary status. Secondary host commands occasionally require that the host send two commands: a first command followed by a status request message.

All host messages require a message header of six (6) bytes. If the host command requires additional data be transferred to the host, the data will immediately follow the command header. Figure 5-1 contains a diagram of the message header for the single receiver protocol.

The first byte of the message header contains a device identification flag of 0x25. The second byte indicates the module address being commanded. For RS-232 communications, this should always be set to 0x00. Bytes 3 and 4 contain the message identification. Message identification informs the type and format of data that will follow the header, if any. Bytes 5 and 6 of the message header indicate the number of command related bytes that follow the message header.

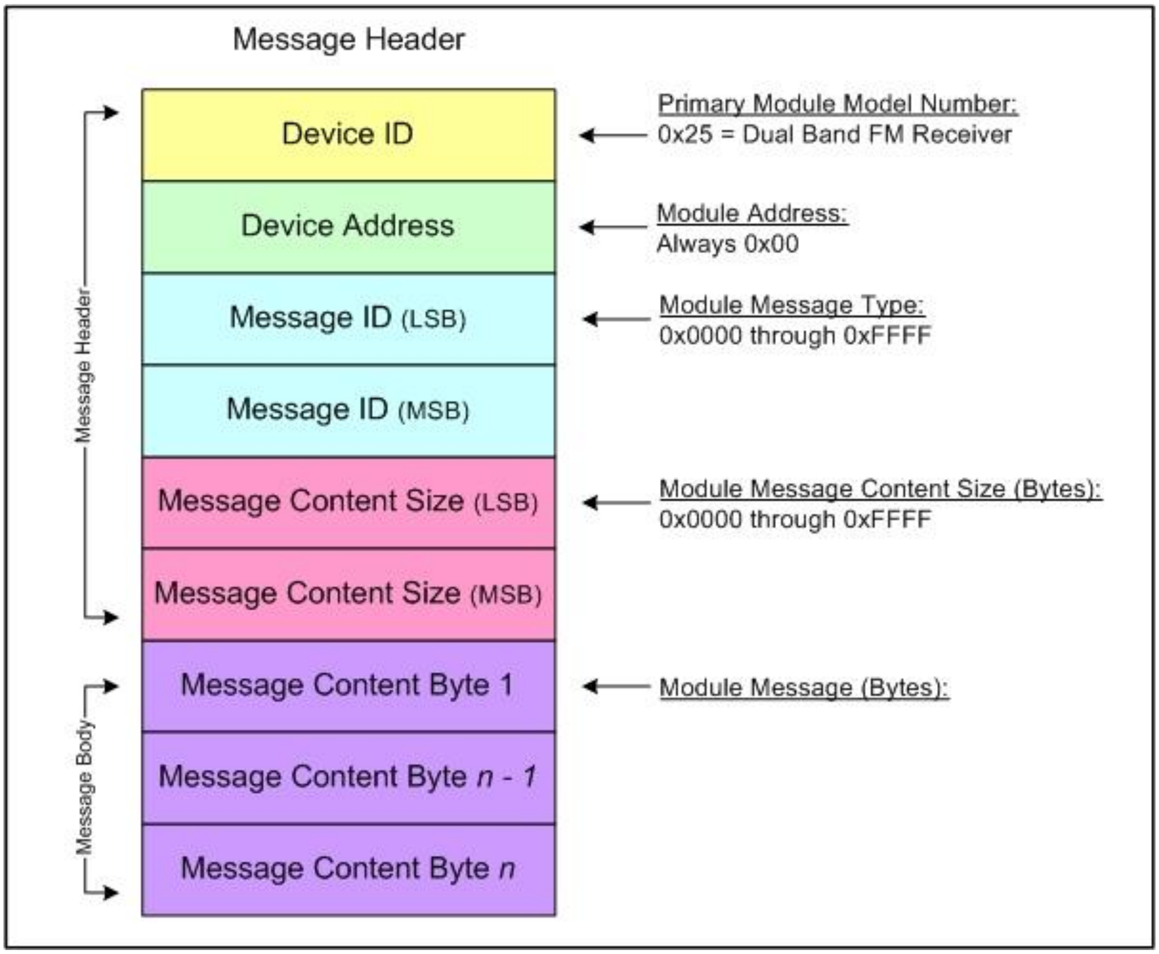


Figure 5-1 **Single Receiver Protocol Message Format**

In response to any host command, the protocol will respond with a minimum of an echoed message header. If additional information is to be conveyed to the host, the data will immediately follow the echoed header. Figure 5-2 indicates the general configuration of the host and terminal responses.

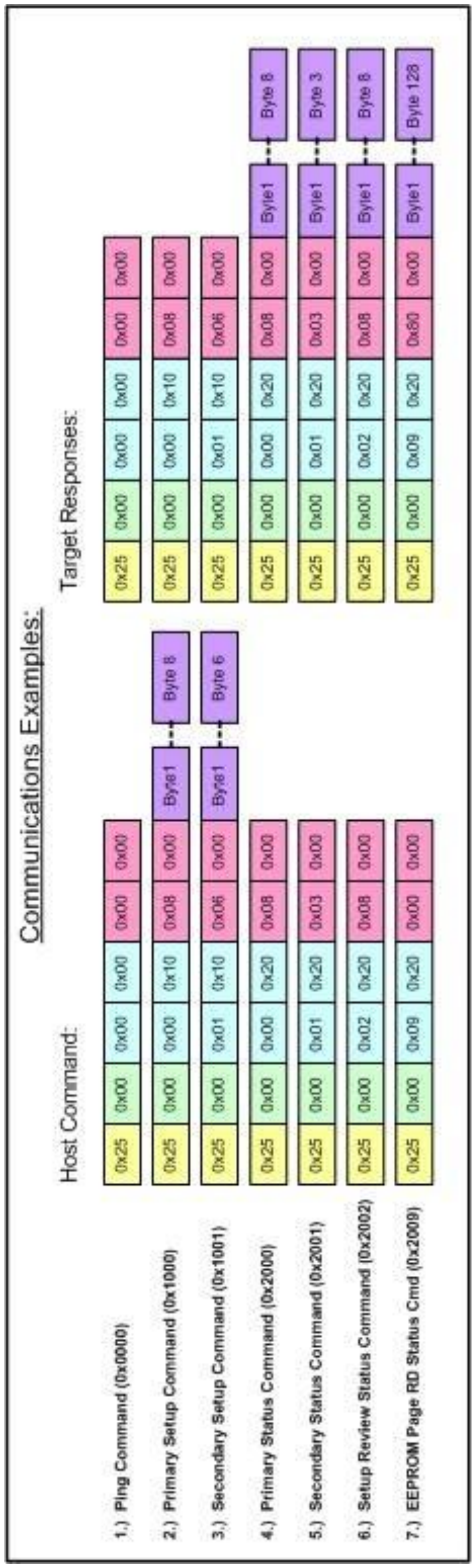


Figure 5-2 **Single Receiver Protocol Messaging Configurations**

5.1.1.1 Single Receiver Protocol - Command Messaging

There are three command message types: a "Ping" command, a "Primary Setup" command, and a "Secondary Setup" command.

5.1.1.1.1 Single Receiver Protocol - PING Command

The "Ping" command is used as to determine the health/presence of the communications channel between the host and the receiver. In response to the "Ping" command, the receiver will echo the received message header back to the host.

5.1.1.1.2 Single Receiver Protocol - Primary Setup Command

The "Primary Setup" command is provides fundamental control information to the receiver channel. The message header is followed by eight (8) data bytes as defined in Figure 5-3.

Primary Command Message Content (Message ID = 0x1000)

Content Byte	D7	D6	D5	D4	D3	D2	D1	D0	Notes:
1	TLM2DEMP	POLARITY	AMINV	REF	-	LINEAR	TCONST		
2	DO3	DO2	DO1	DO0	-	-	-	-	
3	VFILT				IFFILT				
4	-	-	-	-	AMFILT		-	RFBAND	
5	TUNE1 (Fc /256MHz)								
6	TUNE2 (Fc *mod* 256MHz/1MHz)								
7	TUNE3 (Fc *mod* 1MHz/10kHz)								
8	SNUM								

Figure 5-3 **Single Receiver Protocol Primary Message Command Structure**

Caution:

Only 8 IF Filter bandwidths and 8 Video Filter bandwidths are available in the LS27B configuration. Selections of bandwidths are above this number will be ignored.

5.1.1.1.3 Single Receiver Protocol - Secondary Setup Command

The "Secondary Setup" command is provides non-critical control information to the receiver channel and requests that internal status from the controlled channel. The message header is followed by six (6) data bytes as defined in Figure 5-4.

Secondary Command Message Content (Message ID = 0x1001)

Content Byte	D7	D6	D5	D4	D3	D2	D1	D0	Notes:
1	MODE								
2	CMD1								
3	CMD2								
4	CMD3								
5	CMD4								
6	CMD5								

Figure 5-4 **Single Receiver Protocol Secondary Message Command Structure**

5.1.1.2 Single Receiver Protocol - Command Bit/Byte Definitions

Figure 5-5 contains the bit and bit pairing definitions for the primary and the secondary messages. Figure 5-6 contains the definition for the secondary message mode byte.

Command Mnemonic	Description/Definition	Logic State/Explanation
TLM2DEMP	TLM2 Out De-emphasis video filter selection	0 = Disabled; 1 = Enabled
POLARITY	Demodulator Polarity Invert	0 = Normal Polarity, 1 = Inverted Polarity
AMINV	AM Output Inversion	0 = Normal Polarity, 1 = Inverted Polarity
REF	Reference Source Select	0 = Internal 10MHz Reference Osc. Select; 1 = External Reference Osc. Select
LINEAR	Linear Output Select	0 = Linear Output Disabled; 1 = Linear Output Enabled
TCONST	AGC Time Constant Select	00 = Shortest Time Constant 01= Next to Longest Time Constant 10 = Next to Shortest Time Constant 11= Longest Time Constant
VFILT	Video Filter Select	0000 = Video Filt.0 0100 = Video Filt.4 1000 = Video Filt.8 11xx = (Unused) 0001 = Video Filt.1 0101 = Video Filt.5 1001 = Video Filt.9 0010 = Video Filt.2 0110 = Video Filt.6 1010 = Video Filt.10 0011 = Video Filt.3 0111 = Video Filt.7 1011 = Video Filt.11
IFFILT	IF Filter Select	0000 = IF Filt.0 0100 = IF Filt.4 1000 = IF Filt.8 11xx = (Unused) 0001 = IF Filt.1 0101 = IF Filt.5 1001 = IF Filt.9 0010 = IF Filt.2 0110 = IF Filt.6 1010 = IF Filt.10 0011 = IF Filt.3 0111 = IF Filt.7 1011 = IF Filt.11
RFBAND	RF Band Select	0 = Highest Frequency Band Enabled; 1 = Lowest Frequency Band Enabled
AMFILT	AM Low-Pass Filter Cutoff Select	00 = EEPROM Contents 39 01 = EEPROM Contents 40 10 = EEPROM Contents 41 11 = EEPROM Contents 42
TUNE1	Receiver Tune Center Frequency Wd 1	Wd1 Receive Center Frequency (MHz) Fc/256MHz
TUNE2	Receiver Tune Center Frequency Wd 2	Wd2 Receiver Center Frequency (MHz) (Fc mod 256MHz)/1MHz
TUNE3	Receiver Tune Center Frequency Wd 3	Wd3 Receiver Center Frequency (MHz) (Fc mod 1MHz)/10kHz
SNUM	Setup storage Number	Value between 0 and 15
MODE	Secondary Operations Mode Command	[See Operational Mode Table]
CMD1	Secondary Command Wd 1	[See Operational Mode Table]
CMD2	Secondary Command Wd 2	[See Operational Mode Table]
CMD3	Secondary Command Wd 3	[See Operational Mode Table]
CMD4	Secondary Command Wd 4	[See Operational Mode Table]
CMD5	Secondary Command Wd 5	[See Operational Mode Table]

Figure 5-5 **Single Receiver Protocol Command Bit Grouping Definitions**

Mode	Definition	CMD5	CMD 4	CMD3	CMD2	CMD1
0x02	Digipot Mode	(Unused)	(Unused)	*Digipot Select:* 0x01 = AGC Slope 0x02 = AM Gain 0x04 = LOG Level	*Digipot Preset Value:* 0-99 Digipot Setting	*Digipot Instruction:* 0x01 = Decrement Digitpot 0x02 = Increment Digipot 0x03 = Set Digipot to Preset Value 0x04 = Query Digipot Setting
0x03	DAC Mode	(Unused)	(Unused)	*DAC Data:* 6 MSBs of DAC Setting	*DAC Data:* 8 LSBs of DAC Setting	*DAC Selection:* 0x01 = TLM Gain 0x02 = RF Attn Control
0x04	Ext. Ref. Mode	(Unused)	(Unused)	(Unused)	(Unused)	Ext. Reference Freq. (MHz)
0x05	Stored Setup Review	(Unused)	(Unused)	(Unused)	(Unused)	*Stored setup number:* Value between 0-15
0x07	EEPROM Mode	*PROM Write Data:* 8MSBs of Write Data	*PROM Write Data:* 8LSBs of Write Data	*PROM Line:* Value Between 0-63 or 255 For page response (see information below)	*PROM Page:* Value Between 0-15	*Mode:* 0x00 = RD PROM 0 (Primary) 0x01 = WR PROM 0 (Primary) 0x10 = RD PROM 1 (Secondary) 0x11 = WR PROM 1 (Secondary)
0x1F	Serial Channel Control Mode	(Unused)	(Unused)	3 MSBits of (BAUD Rate/100).	8 LSBits of (BAUD Rate/100).	0x00 = Serial Baudrate Select Submode.

Figure 5-6 **Single Receiver Protocol Secondary Command Mode Definitions**

5.1.1.3 Single Receiver Protocol - Status Messaging

There are four (4) status message types: primary status response, secondary status response, stored setup status response, and the EEPROM Page read status response.

5.1.1.3.1 Single Receiver Protocol - Primary Status Response

The primary status response provides the host with fundamental receiver status such as the received signal strength, FM deviation measurement, AM index value, and the detected AM frequency. Figure 5-7 depicts the primary status message content.

Primary Status Response Content (Message ID = 0x2000)

Content Byte	D7	D6	D5	D4	D3	D2	D1	D0	Notes:
1	-	-	-	-	MODID				
2	RSSI7	RSSII6	RSSI5	RSSI4	RSSI3	RSSI2	RSSI1	RSSI0	
3	-	-	-	-	-	-	RSSI9	RSSI8	
4	DEV								
5	AMI								
6	AMFREQ1								
7	AMFREQ2								
8	SNUM								

Figure 5-7 **Single Receiver Protocol Primary Status Message Structure**

5.1.1.3.2 Single Receiver Protocol - Secondary Status Response

The secondary status response provides the receiver with configuration information and provides information relates to mode commands. Figure 5-8 depicts the secondary status message content.

Secondary Status Response Content (Message ID = 0x2001)

Content Byte	D7	D6	D5	D4	D3	D2	D1	D0	Notes:
1	MODE								
2	RTN1								
3	RTN2								

Figure 5-8 **Single Receiver Protocol Secondary Status Message Structure**

5.1.1.4 Single Receiver Protocol - Stored Setup Status Response

A total of sixteen (16) receiver setups can be stored in the receiver's internal memory and then be recalled by simply providing an index value. (Future provisions will allow these setups to be activated via discrete interaction.) These configurations can be reviewed using secondary mode commands. The stored setup status response message structure is shown in Figure 5-9.

Stored Setup Status Response Content (Message ID = 0x2002)

Content Byte	D7	D6	D5	D4	D3	D2	D1	D0	Notes:
1	TLM2DEMP	POLARITY	AMINV	REF	-	LINEAR	TCONST		
2	-	-	-	-	MODID				
3	VFILT				IFFILT				
4	-	-	-	-	AMFILT		-	RFBAND	
5	TUNE1 (Fc /256MHz)								
6	TUNE2 (Fc *mod* 256MHz/1MHz)								
7	TUNE3 (Fc *mod* 1MHz/10kHz)								
8	SNUM								

Figure 5-9 **Single Receiver Protocol Stored Setup Status Message Structure**

5.1.1.5 Single Receiver Protocol - EEPROM Page Read Status Response

The primary receiver configuration information, used to drive software controls, is found in the first page (indexed from 0) of the receivers primary internal EEPROM. Information contained in this EEPROM includes the bandwidths installed in the receiver, associated IF and video filter bandwidths, along with various other configuration information. This information can be accessed via an EEPROM read mode command. The resulting status message contents are shown in the Figure 5-10. An example of the EEPROM contents is shown in Figure 5-12.

EEPROM Page Read Response Content (Message ID = 0x2009)

Content Byte	D7	D6	D5	D4	D3	D2	D1	D0	Notes:
1	LOC0_LSB								
2	LOC0_MSB								
…	…								More bytes
127	LOC63_LSB								
128	LOC63_MSB								

Figure 5-10 **Single Receiver Protocol EEPROM Page Read Status Message Structure**

5.1.1.6 Single Receiver Protocol - Status Bit/Byte Definitions

Figure 5-11 contains the bit and bit pairing definitions for the status messages.

Status Mnemonic	Description/Definition	Logic State/Explanation
MODID	Module Serial ID	Value between 0 and 15; RS232 indicated by address 0
RSSI0-9	RSSI Signal Strength	Value between 0 and 1024 (Linear dBm = (0.0782 x Value) - 100.0; Limited dBm = (0.1075 x Value) - 100.0)
DEV	FM Deviation Estimate	Value between 0 and 120
AMI	AM Index Estimate	Value between 0 and 100
AMFREQ1	AM Frequency Wd 1	8 MSBs of the AM Frequency Counter
AMFREQ2	AM Frequency Wd 2	8 LSBs of the AM Frequency Counter
TLM2DEMP	TLM2 Out De-emphasis video filter selection	0 = Disabled; 1 = Enabled
POLARITY	Demodulator Polarity Invert	0 = Normal Polarity; 1 = Inverted Polarity
AMINV	AM Output Inversion	0 = Normal Polarity, 1 = Inverted Polarity
REF	Reference Source Select	0 = Internal 10MHz Reference Osc. Select; 1 = External Reference Osc. Select
LINEAR	Linear Output Select	0 = Linear Output Disabled; 1 = Linear Output Enabled
TCONST	AGC Time Constant Select	00 = Shortest Time Constant 01= Next to Longest Time Constant 10 = Next to Shortest Time Constant 11= Longest Time Constant
VFILT	Video Filter Select	0000 = Video Filt.0 0100 = Video Filt.4 1xxx = (Unused) 0001 = Video Filt.1 0101 = Video Filt.5 0010 = Video Filt.2 0110 = Video Filt.6 0011 = Video Filt.3 0111 = Video Filt.7
IFFILT	IF Filter Select	0000 = IF Filt.0 0100 = IF Filt.4 1xxx = (Unused) 0001 = IF Filt.1 0101 = IF Filt.5 0010 = IF Filt.2 0110 = IF Filt.6 0011 = IF Filt.3 0111 = IF Filt.7
RFBAND	RF Band Select	0 = Highest Frequency Band Enabled; 1 = Lowest Frequency Band Enabled
AMFILT	AM Low-Pass Filter Select	00 = Lowest Fcutoff 01 = Next to Lowest Fcutoff 10 = Next to highest Fcutoff 11 = Highest Fcutoff
TUNE1	Receiver Tune Center Frequency Wd 1	Wd1 Receive Center Frequency (MHz) Fc/256MHz
TUNE2	Receiver Tune Center Frequency Wd 2	Wd2 Receiver Center Frequency (MHz) (Fc mod 256MHz)/1MHz
TUNE3	Receiver Tune Center Frequency Wd 3	Wd3 Receiver Center Frequency (MHz) (Fc mod 1MHz)/10kHz
SNUM	Setup storage Number	Value between 0 and 15
MODE	Secondary Operations Mode Command	[See Operational Mode Table]
RTN1	Secondary Status Wd 1	[See Operational Mode Table]
RTN2	Secondary Status Wd 2	[See Operational Mode Table]
LOC0_LSB	EEPROM Contents – LSB	EEPROM Page Content Data Byte
LOC0_MSB	EEPROM Contents – MSB	EEPROM Page Content Data Byte
LOC63_LSB	EEPROM Contents – LSB	EEPROM Page Content Data Byte
LOC63_MSB	EEPROM Contents – MSB	EEPROM Page Content Data Byte

Figure 5-11 **Single Receiver Protocol Status Response Bit Grouping Definitions**

EEPROM Map		
Offset	**Contents**	**Description/ Information**
0	Signal Bandwidth IF Filter 0 (kHz)	IF Filter Bandwidth (Hz) = Value x1000 Hz
1	Signal Bandwidth IF Filter 1 (kHz)	
2	Signal Bandwidth IF Filter 2 (kHz)	
3	Signal Bandwidth IF Filter 3 (kHz)	
4	Signal Bandwidth IF Filter 4 (kHz)	
5	Signal Bandwidth IF Filter 5 (kHz)	
6	Signal Bandwidth IF Filter 6 (kHz)	
7	Signal Bandwidth IF Filter 7 (kHz)	
8	*(Unused / Spare)*	
9	*(Unused / Spare)*	
10	*(Unused / Spare)*	
11	*(Unused / Spare)*	
12	Signal Bandwidth Video Filter 0 (kHz)	Video Filter Bandwidth (Hz) = Value x1000 Hz
13	Signal Bandwidth Video Filter 1 (kHz)	
14	Signal Bandwidth Video Filter 2 (kHz)	
15	Signal Bandwidth Video Filter 3 (kHz)	
16	Signal Bandwidth Video Filter 4 (kHz)	
17	Signal Bandwidth Video Filter 5 (kHz)	
18	Signal Bandwidth Video Filter 6 (kHz)	
19	Signal Bandwidth Video Filter 7 (kHz)	
20	*(Unused / Spare)*	
21	*(Unused / Spare)*	
22	*(Unused / Spare)*	
23	*(Unused / Spare)*	
24	RF Input Attenuator Set Point	
25	*(Unused / Spare)*	
26	RF Band 0 Start Frequency (MHz)	RF Band Edge = Value x 1MHz
27	RF Band 0 Stop Frequency (MHz)	
28	RF Band 1 Start Frequency (MHz)	
29	RF Band 1 Stop Frequency (MHz)	
30	RF Band 0 Linear Output Compression	Linear Output Compression Point (RSSI Count)
31	RF Band 1 Linear Output Compression	
32	AGC Time Constant Count #0	AGC Time Constant (msec) = Constant Count x 0.1msec
33	AGC Time Constant Count #1	
34	AGC Time Constant Count #2	
35	AGC Time Constant Count #3	
36	*(Unused / Spare)*	
37	*(Unused / Spare)*	
38	AM LPF Filter #0	AM Low-pass filter Bandwidth = Value x 1Hz
39	AM LPF Filter #1	
40	AM LPF Filter #2	
41	AM LPF Filter #3	
42	De-emphasis Filter Line Count	Video Line Count: 525 = NTSC
43	*(Unused / Spare)*	
44	Max Preset Value	Maximum number of User Presets (Indexed from 0)
45	Active Setup Value	Preset Number at Boot-time
46	*(Unused / Spare)*	
47	*(Unused / Spare)*	
48	FPGA Firmware ID	FPGA Firmware Number
49	DSP Firmware ID1	DSP Firmware Date: MSB = Month in Hex, LSB = Day in Hex
50	DSP Firmware ID2	DSP Firmware Date: Two Bytes = Year in Hex
51	Board Serial Number MSW	Device Serial Number in Hex.
52	Board Serial Number LSW	
53	Primary Configuration ID	ASCII Representation Of Device ID (Always 0x25)
54	Options #1	ASCII Representation Of Device Options (Future Use)
55	Options #2	
56	*(Unused / Spare)*	
57	Serial Channel Baud Rate	Serial Channel BAUD/100
58	Serial Channel Format	Serial Channel Signaling Level = 232
59	*(Unused / Spare)*	
60	*(Unused / Spare)*	
61	Ext. Ref. Input Freq. Multiplier	External Reference Input Frequency = Multiplier x 1MHz
62	*(Unused / Spare)*	
63	*(Unused / Spare)*	

Figure 5-12 **Single Receiver Protocol - EEPROM Contents**

5.2 Dual Receiver Protocol

Dual receiver protocol is active on serial interface A only. This interface controls both internal receivers using the same serial interface channel. Each receivers operations are autonomous.

5.2.1 Dual Receiver Protocol - Command and Status Messaging

Interface using the dual receiver protocol is via command-response messaging. For every command sent from the host, the receiver will respond to indicate that the command was received. Commands from the host are grouped in two categories: primary commands and secondary commands. Primary commands are used to control the basic tuning and setup of the receiver. Secondary commands are used to set various "lower-priority" operational modes and to obtain secondary status. Secondary host commands occasionally require that the host send two commands: a first command followed by a status request message.

All host messages require a message header of six (6) bytes. If the host command requires additional data be transferred to the host, the data will immediately follow the command header. Figure 5-13 contains a diagram of the message header for the dual receiver protocol.

The first byte of the message header contains a device identification flag of 0x27. The second byte indicates the module address being commanded which should always be set to 0x00. Bytes 3 and 4 contain the message identification. Message identification informs the type and format of data that will follow the header, if any. Bytes 5 and 6 of the message header indicate the number of command related bytes that follow the message header.

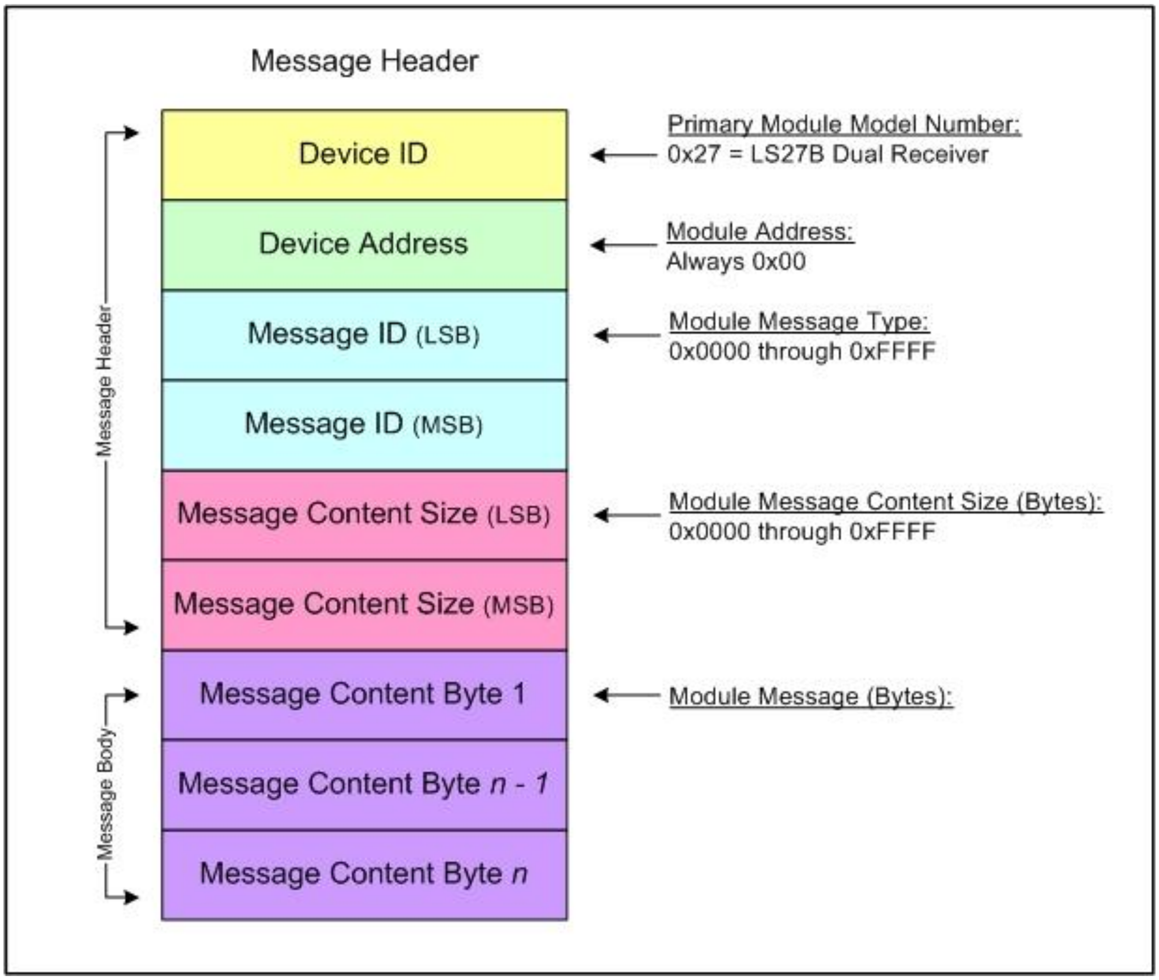


Figure 5-13 **Dual Receiver Protocol Message Format**

In response to any host command, the protocol will respond with a minimum of an echoed message header. If additional information is to be conveyed to the host, the data will immediately follow the echoed header. Figure 5-14 indicates the general configuration of the host and terminal responses.

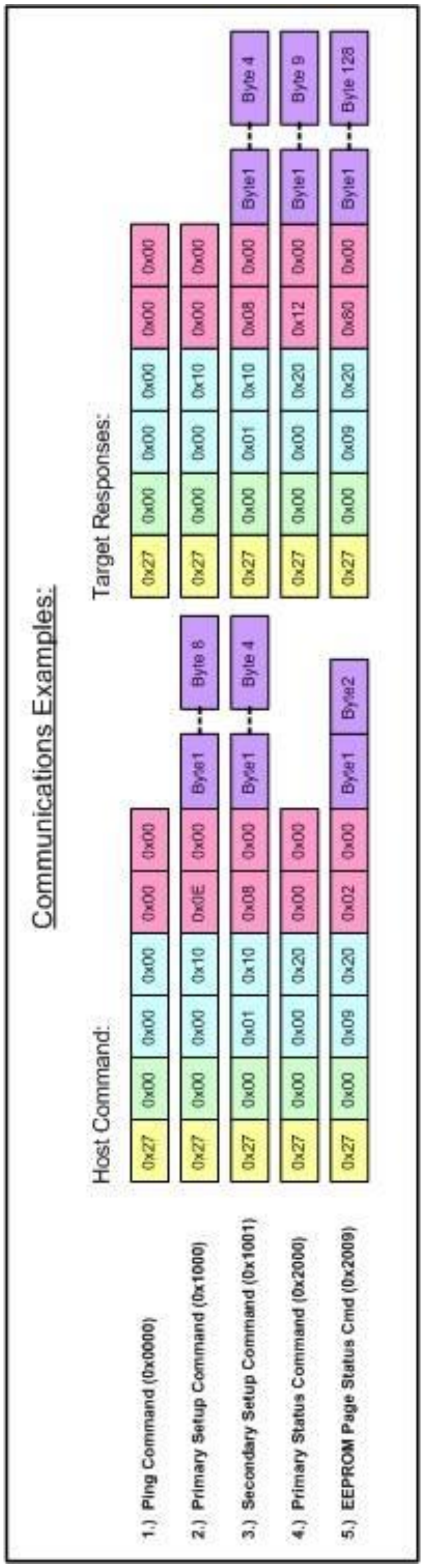


Figure 5-14 **Dual Receiver Protocol Messaging Configurations**

5.2.1.1 *Dual Receiver Protocol - Command Messaging*

There are four command message types: a "Ping" command, a "Primary Setup" command, a "Secondary Setup" command, and a "Append Flash File Section" command.

5.2.1.1.1 *Dual Receiver Protocol - PING Command*

The "Ping" command is used as to determine the health/presence of the communications channel between the host and the receiver. In response to the "Ping" command, the receiver will echo the received message header back to the host.

5.2.1.1.2 *Dual Receiver Protocol - Primary Setup Command*

The "Primary Setup" command is provides fundamental control information to the receiver channel. The message header is followed by eight (8) data bytes as defined in Figure 5-3.

Primary Command Message Content (Message ID = 0x1000)

Content Byte	D7	D6	D5	D4	D3	D2	D1	D0	Notes:
1	-	-	POLARITY	SNUM				CHx	
2	INTREF	-	-	-	-	-	-	-	
3	LIM				FRZ	AGCTC			
4	-	IFBW			DEMP	VFILT			
5	AMINV			AMFIL					
6	TUNE1 (Fc /256MHz)								
7	TUNE2 (Fc *mod* 256MHz/1MHz)								
8	TUNE3 (Fc *mod* 1MHz/10kHz)								

Figure 5-15 **Dual Receiver Primary Protocol Message Command Structure**

5.2.1.1.3 *Dual Receiver Protocol - Secondary Setup Command*

The "Secondary Setup" command is provides control information to the receiver channel commanded and requests that internal status from the controlled channel. The message header is followed by four (4) data bytes as defined in Figure 5-15.

Secondary Command Message Content (Message ID = 0x1001)

Content Byte	D7	D6	D5	D4	D3	D2	D1	D0	Notes:
1	MODE					-	-	CHx	
2	CMD1								
3	CMD2								
4	CMD3								

Figure 5-15 **Dual Receiver Protocol Secondary Message Command Structure**

5.2.1.1.4 Dual Receiver Protocol – Append Flash File Section Command

This command can be used to program the DSP with a successor flash file. This process is analogous to updating the BIOS on a personal computer. Contact Lumistar, Inc. for further information and to receive the latest DSP flash file. The DSP flash file can be divided into 128 byte sections and loaded into the DSP's onboard memory with multiple 0x1020 commands. The last 0x1020 command may have a body less than 128 bytes long to accommodate the different possible lengths of the DSP flash file. In that case, the "Bytes to Follow" value in the command header section should be set to the actual number of bytes in the command body. After the last flash file section has been delivered to the DSP, send a 0x1001 Secondary Setup command with a 0x13 value in the Mode field and a 0xFF value in the CMD1 field. When the DSP receives this command it will use the reconstructed flash file that it has retained in local memory and write this file into the flash RAM. Depending on the current DSP flash file version, it may load the file and then begin blinking the LED at about 1 Hz. The LS27B will then need to be power cycled before any further commands are sent to it. More recent DSP versions will reboot after the successor file has been fully written to DSP flash RAM.

5.2.1.2 Dual Receiver Protocol - Command Bit/Byte Definitions

Figure 5-16 contains the bit and bit pairing definitions for the primary and the secondary messages. Figure 5-17 contains the definition for the secondary message mode byte. Figure 5-18 contains the definitions for the secondary message mode responses.

Command Mnemonic	Description/Definition	Logic State/Explanation
CHx	Radio Selection Number	0=Radio 1 or Down Converter 1, 1=Radio 2 or Down Converter 2
INTREF	Internal/External Reference Clock Selection	0=Select External Reference Clock, 1=Select Internal Reference Clock
POLARITY	FM Demodulator Output Polarity	0=Normal Polarity, 1=Inverse Polarity
LIM	Hardware Limited Mode	0=LIM mode is off, 1=LIM mode is on.
FRZ	AGC Freeze	0=Freeze AGC (infinite AGCTC), 1=Use selected AGCTC .
AGCTC	AGC Time Constant Selection	0=0.1 msec, 1=1 msec, 2=10 msec, 3=100 msec, 4=1 sec, 5=CustomTC1 , 6=CustomTC2, 7=CustomTC3
IFBW	IFBW Filter Selection	0=Filter 1, 1=Filter 2, 2=Filter 3, 3=Filter 4, 4=Filter 5, 5=Filter 6, 6=Filter 7, 7=Filter 8
VFLT	Video Filter Selection	0=Filter 1, 1=Filter 2, 2=Filter 3, 3=Filter 4, 4=Filter 5, 5=Filter 6, 6=Filter 7, 7=Filter 8
DEMP	DeEmphasis Filter Selection	0=Don't use DeEmphasis Filter, 1=Use DeEmphasis Filter.
AMINV	AM Inverse	0=AM is normal, 1=AM is inverted.
AMFIL	AM Filter Selection	0=50, 1=100, 2=200, 3=300, 4=400, 5=500, 6=600, 7=700, 8=800, 9=900, 10=1000, 11=1100, 12=1200, 13=1300, 14=1400, 15=1500, 16=1600, 17=1700, 18=1800, 19=1900, 20=2000, 21=3000, 22=4000, 23=5000, 24=6000, 25=7000, 26=8000, 27=9000, 28=10000, 29=15000, 30=20000, 31=50000
TUNE1	Receiver Tune Center Frequency Wd 1	Wd1 Receiver Center Frequency (MHz) Fc/256MHz
TUNE2	Receiver Tune Center Frequency Wd 2	Wd2 Receiver Center Frequency (MHz) (Fc mod 256MHz)/1MHz
TUNE3	Receiver Tune Center Frequency Wd 3	Wd3 Receiver Center Frequency (MHz) (Fc mod 1MHz)/10kHz
SNUM	Setup Number	Save the current setup to one of 16 possible storage locations.

Figure 5-16 **Dual Receiver Protocol Command Bit Grouping Definitions**

Mode	Definition	CMD1	CMD2	CMD3
0x02	EEPROM Mode	EEPROM Sub Mode: 000pppppb = PROM Page No. 01aaaaaab = RD Offset Pg Address (LSB is returned on STAT2, MSB is returned on STAT3).	(Unused) (Unused)	(Unused) (Unused)
0x03	Tune Mode	Fc Mod 1MHz/10Khz	Fc MOD 256MHz/1MHz	Fc/256MHz
0x04	DAGC Control Mode	0x00 = LINEAR 0x01 = LIMITED 0x02 = COMBINER (Not implemented) 0x03 = RESERVED (Not implemented)	(Unused)	(Unused)
0x06	Read AM LPF Table	(Unused)	Table Index (0 to 31)	(Unused)
0x07	Read AM Freq Value	(Unused)	(Unused)	(Unused)
0x08	Program Ext Ref Freq	(Unused)	Allowable: 5, 10, 20, 25 MHz	(Unused)
0x09	Read SW2 Mode Cmd	(Unused)	(Unused)	(Unused)
0x0A	Program Custom Time Constants	Custom Time Constant Number (Values between 1 and 3)	8 LSBs of 100uSec TConstant Multiple	8 MSBs of 100uSec TConstant Multiple
0x0B	Select AGC Out Range	(Unused)	0x00 = -4V to 0V, 0x08 = 0V to -4V, 0x01 = -2V to 0V, 0x09 = 0V to -2V, 0x02 = 0V to +2V, 0x0A = 2V to 0V, 0x03 = 0V to +4V, 0x0B = 4V to 0V, 0x04 = -2V to +2V, 0x0C = 2V to -2V, 0x05 = -4V to +4V, 0x0D = 4V to -4V, All others undefined.	(Unused)
0x0D	Program Digipot Mode	Digipot Instruction: 0x01 = Decrement Digipot 0x02 = Increment Digipot 0x03 = Set Digipot to Preset Value 0x04 = Query Digipot Setting 0x05 = Set Digipot to Default Value	Digipot Preset Value: 0-99	Digipot Select: 0x00 = AM Gain
0x0E	Programmable AGC Out dBm Range	Lower dBm value in 2's complement format. Valid range is from -110 to 10. Granularity is 1 dBm.	Upper dBm value in 2's complement format. Valid range is from -110 to 10. Granularity is 1 dBm.	(Unused)
0x0F	Programmable AGC Out Voltage Range	Starting voltage value * 10 in 2's complement format. Valid range is from 40 (4.0 V) to -40 (-4.0 V). Granularity is 0.1 V.	Ending voltage value * 10 in 2's complement format. Valid range is from 40 (4.0 V) to -40 (-4.0 V). Granularity is 0.1 V.	(Unused)
0x10	DAC Adjust Mode	DAC Selection: 0x01 = Video Output Adjust	8 LSBs of DAC Setting	6 MSBs of DAC Setting
0x12	Get Setup Info Mode	0x00 = Get DCxCTRL124 Submode. 0x01 = Get Tune Freq Submode. 0x02 = Get DAGC Values Submode. 0x03 = Get AGC Out dBm Range. 0x04 = Get AGC Out Voltage Range. 0x05 = Get Miscellaneous Values.	(Unused)	(Unused)
0x13	DSP Flash Update Mode	DSP Flash Update SubMode: 0x00 = Append Flash Value 0xFF = Write Stored Values	LSB of Flash Value Word (Unused)	MSB of Flash Value Word (Unused)
0x14	External Values Mode	External Values Submode: 0x00 = RSSI Correction Submode. 0x01 = Compression Point Submode.	RSSI Correction MSB Compression Point MSB	RSSI Correction LSB Compression Point MSB
0x17	RSSI Averaging Mode	RSSI Averaging Submode. 0x00 = Set Number of RSSI Samples. 0x01 = Set RSSI Averaging Function. 0x02 = Enter AFRZ Mode. 0x03 = Exit AFRZ Mode.	Value from 2 to 50. 0=Simple Average, 1=Filtered Average. (Unused) (Unused)	(Unused) (Unused) (Unused) (Unused)
0x1F	Serial Channel Control Mode	0x00 = Serial Baudrate Select Submode.	8 LSBits of (BAUD Rate/100).	3 MSBits of (BAUD Rate/100).

Figure 5-17 **Dual Receiver Protocol Secondary Command Mode Definitions**

<table>
<tr><th>Mode</th><th>Functional Mode</th><th>STAT1</th><th>STAT2</th><th>STAT3</th></tr>
<tr><td>0x02</td><td>EEPROM Mode: Read</td><td>Page Offset</td><td>8 LSBs of EEPROM Read Value</td><td>8 MSBs of EEPROM Read Value</td></tr>
<tr><td>0x02</td><td>EEPROM Mode: Pg Set</td><td>Page Number</td><td>(Unused = 0)</td><td>(Unused = 0)</td></tr>
<tr><td>0x03</td><td>Tune Mode</td><td>Fc Mod 1MHz/10Khz</td><td>Fc MOD 256MHz/1MHz</td><td>Fc/256MHz</td></tr>
<tr><td>0x04</td><td>DAGC Control Mode</td><td>DAGC Control Mode Commanded</td><td>(Unused = 0)</td><td>(Unused = 0)</td></tr>
<tr><td>0x06</td><td>Read AM LPF Table</td><td>Index Value</td><td>8 LSBs of AM LPF Fc Frequency</td><td>8 MSBs of AM LPF Fc Frequency</td></tr>
<tr><td>0x07</td><td>Read AM Freq Counter</td><td>8 LSBs of AM Counter Frequency</td><td>8 Mid-SBs of AM Counter Frequency</td><td>1 MSB of AM Counter Frequency</td></tr>
<tr><td>0x08</td><td>Program Ext Ref Freq</td><td>(Unused = 0)</td><td>Ext Ref Frequency in MHz (5,10,20,25)</td><td>(Unused = 0)</td></tr>
<tr><td>0x09</td><td>Read SW2</td><td>0x00=LS27B
0x80=LS27P3</td><td>LS27B: SW2 Values (0x00 to 0xFF)
LS27P3: SW2 Values (0x00 to 0x0F)</td><td>LS27B3 Ext. Disc. Lines (0x00-0x1F)
LS27P3: Unused, 0x00</td></tr>
<tr><td>0x0A</td><td>Program Custom Time Constants</td><td>Custom Time Constant Number (Values between 1 and 3)</td><td>8 LSBs of 100 µsec Tconstant Multiple</td><td>8 MSBs of 100 µsec Tconstant Multiple</td></tr>
<tr><td>0x0B</td><td>Select AGC Output Range</td><td>(Unused = 0)</td><td>0x00 = -4V to 0V, 0x08 = 0V to -4V,
0x01 = -2V to 0V, 0x09 = 0V to -2V,
0x02 = 0V to +2V, 0x0A = 2V to 0V,
0x03 = 0V to +4V, 0x0B = 4V to 0V,
0x04 = -2V to +2V, 0x0C = 2V to -2V,
0x05 = -4V to +4V, 0x0D = 4V to -4V,
All others undefined.</td><td>(Unused = 0)</td></tr>
<tr><td>0x0D</td><td>Program Digipot Mode</td><td></td><td>Current Digipot Setting (0 – 99)</td><td></td></tr>
<tr><td>0x0E</td><td>Programmable AGC Out dBm Range</td><td>Lower dBm value in 2's complement format.</td><td>Upper dBm value in 2's complement format.</td><td>(Unused = 0)</td></tr>
<tr><td>0x0F</td><td>Programmable AGC Out Voltage Range</td><td>Starting voltage value * 10 in 2's complement value.</td><td>Ending voltage value * 10 in 2's complement format.</td><td>(Unused = 0)</td></tr>
<tr><td>0x10</td><td>DAC Adjust Mode</td><td>DAC Selection Value</td><td>8 LSBs of the DAC Setting</td><td>6 MSBs of the DAC Setting</td></tr>
<tr><td>0x12</td><td>Get Setup Info Submodes:
0x00=Get DCxCTRL124 Submode.
0x01=Get Tune Freq Submode.
0x02=Get DAGC Values Submode.
0x03=Get AGC Out dBm Range.
0x04=Get AGC Out Voltage Range.
0x05=Get Miscellaneous Values.
0x06=Get External RSSI Correction
0x07=Get External Compression Pt.</td><td>| 7 | 6 |5|4| 3 |2|1| 0 |
| LIM|AGCZERO|-|-|FRZ|-|-| - |
Fc Mod 1MHz/10Khz
DAGC Time Const in µsec LSB
Lower dBm value in 2's comp format
Start voltage value * 10 in 2's comp
|AFRZ|RSSIAVEFUNC| VFIL |CAL|
External RSSI Correction MSB
External Compression Point MSB</td><td>|7|6|5|4| 3 |2| 1 | 0 |
|-| IFBW|DEEMP|-|BANDOFPREF|
Fc MOD 256MHz/1MHz
DAGC Time Const in µsec MSB
Upper dBm value in 2's comp format
End voltage * 10 in 2's comp format
Number of RSSI Samples MSB
External RSSI Correction LSB
External Compression Point LSB</td><td>| 7 |6|5|4|3|2|1|0|
|AMINV|-|-| AMFLT |
Fc/256MHz
DAGC Control Mode
(Unused = 0)
(Unused = 0)
Number of RSSI Samples LSB
(Unused = 0)
(Unused = 0)</td></tr>
<tr><td>0x13</td><td>DSP Flash Update Mode</td><td>If Submode=0x00, STAT1=0
If Submode=0xFF DSP will reboot.</td><td>If Submode=0x00, STAT2=0
If Submode=0xFF DSP will reboot.</td><td>If Submode=0x00, STAT3=0
If Submode=0xFF DSP will reboot.</td></tr>
<tr><td>0x14</td><td>External Values Mode</td><td>(Unused = 0)</td><td>(Unused = 0)</td><td>(Unused = 0)</td></tr>
<tr><td>0x1F</td><td>Serial Channel Control Mode</td><td>(Unused = 0)</td><td>(Unused = 0)</td><td>(Unused = 0)</td></tr>
</table>

Figure 5-18 **Dual Receiver Protocol Secondary Command Mode Responses**

Get DCxCTRL124		7	6	5	4	3	2	1	0
Submode=0x00	STAT1	LIM	AGCZERO	-	FRZ	-			
	STAT2	-	IFBW		(DEEMP)	-		BANDOFPREF	
	STAT3	AMINV	-	AMFIL					
Get Tune Frequency		**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Submode=0x01	STAT1	Fc Mod 1MHz/10Khz							
	STAT2	Fc MOD 256MHz/1MHz							
	STAT3	Fc/256MHz							
Get DAGC Values		**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Submode=0x02	STAT1	AGCTC LSB							
	STAT2	AGCTC MSB							
	STAT3							DAGC CTRL MODE	
Get AGC Out dBm Rng.		**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Submode=0x03	STAT1	Lower dBm Value							
	STAT2	Upper dBm Value							
	STAT3	-							
Get AGC Out Volt Rng.		**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Submode=0x04	STAT1	Lower Voltage Value (x10)							
	STAT2	Upper Voltage Value (x10)							
	STAT3	-							
Get Misc. Values		**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Submode=0x05	STAT1	AFRZ	RSSI Averaging Function			VFIL			DAGC Cal Mode
	STAT2	Number of RSSI Samples MSB							
	STAT3	Number of RSSI Samples LSB							
Get Ext. RSSI Correction		**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Submode=0x06	STAT1	External RSSI Correction MSB							
	STAT2	External RSSI Correction LSB							
	STAT3	-							
Get External Comp. Pt.		**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Submode=0x07	STAT1	External Compression Point MSB							
	STAT2	External Compression Point LSB							
	STAT3	-							

Figure 5-19 **Dual Receiver Protocol Get Setup Info Mode Table**

5.2.1.3 Dual Receiver Protocol - Status Messaging

There are two (2) status message types: primary status response, and the EEPROM Page read status response.

5.2.1.3.1 Dual Receiver Protocol - Primary Status Response

The primary status response provides the host with fundamental receiver status such as the received signal strength, FM deviation measurement, AM index value, and the detected AM frequency. Figure 5-20 depicts the primary status message content.

Primary Status Response Content (Message ID = 0x2000)

Content Byte	D7	D6	D5	D4	D3	D2	D1	D0	Notes:
1	REF	PLL	-	-	-	-	-	-	
2	CH1RSSIL								
3	CH1COMP	-	CH1LO2	CH1LO1	CH1RSSIH				
4	-	CH1AMINDX							
5	-	CH1FMDEV							
6	CH2RSSIL								
7	CH2COMP	-	CH2LO2	CH2LO1	CH2RSSIH				
8	-	CH2AMINDX							
9	-	CH2FMDEV							

Figure 5-20 **Dual Receiver Protocol Primary Status Message Structure**

5.2.1.3.2 Dual Receiver Protocol - EEPROM Page Read Status Response

The primary receiver configuration information, used to drive software controls, is found in the first page (indexed from 0) of the receivers primary internal EEPROM. Information contained in this EEPROM includes the bandwidths installed in the receiver, associated IF and video filter bandwidths, along with various other configuration information. This information can be accessed via an EEPROM read mode command. The EEPROM read status command structure is shown in Figure 5-21. The resulting status message contents are shown in the Figure 5-22. An example of the EEPROM contents is shown in Figure 5-23.

EEPROM Page Read Command Content (Message ID = 0x2009)

Content Byte	D7	D6	D5	D4	D3	D2	D1	D0	Notes:
1	-	-	-	-	-	-	-	CHx	
2	-	-	-	PAGE					

Figure 5-21 **Dual Receiver Protocol EEPROM Page Read Status Command Structure**

EEPROM Page Read Response Content (Message ID = 0x2009)

Content Byte	D7	D6	D5	D4	D3	D2	D1	D0	Notes:
1	LOC0_LSB								
2	LOC0_MSB								
…	…								More bytes
127	LOC63_LSB								
128	LOC63_MSB								

Figure 5-22 **Dual Receiver Protocol EEPROM Page Read Status Message Structure**

EEPROM Map			
Offset	**CH1**	**CH2**	**Description/ Information**
0	Signal Bandwidth Filter 0 (kHz)	Signal Bandwidth Filter 0 (kHz)	IF Filter Bandwidth (Hz) = Value x1000 Hz
1	Signal Bandwidth Filter 1 (kHz)	Signal Bandwidth Filter 1 (kHz)	
2	Signal Bandwidth Filter 2 (kHz)	Signal Bandwidth Filter 2 (kHz)	
3	Signal Bandwidth Filter 3 (kHz)	Signal Bandwidth Filter 3 (kHz)	
4	Signal Bandwidth Filter 4 (kHz)	Signal Bandwidth Filter 4 (kHz)	
5	Signal Bandwidth Filter 5 (kHz)	Signal Bandwidth Filter 5 (kHz)	
6	Signal Bandwidth Filter 6 (kHz)	Signal Bandwidth Filter 6 (kHz)	
7	Signal Bandwidth Filter 7 (kHz)	Signal Bandwidth Filter 7 (kHz)	
8	*(Unused / Spare)*	*(Unused / Spare)*	
9	*(Unused / Spare)*	*(Unused / Spare)*	
10	AGC Time Constant Count #0	AGC Time Constant Count #0	AGC Time Constant (msec) = Constant Count x 0.1msec
11	AGC Time Constant Count #1	AGC Time Constant Count #1	
12	AGC Time Constant Count #2	AGC Time Constant Count #2	
13	AGC Time Constant Count #3	AGC Time Constant Count #3	
14	AGC Time Constant Count #4	AGC Time Constant Count #4	
15	User AGC Time Constant Count #5	User AGC Time Constant Count #5	
16	User AGC Time Constant Count #6	User AGC Time Constant Count #6	
17	User AGC Time Constant Count #7	User AGC Time Constant Count #7	
18	*(Unused / Spare)*	*(Unused / Spare)*	
19	RF Band 1 Start Frequency (MHz)	RF Band 1 Start Frequency (MHz)	RF Band Edge = Value x 1MHz
20	RF Band 1 Stop Frequency (MHz)	RF Band 1 Stop Frequency (MHz)	
21	RF Band 2 Start Frequency (MHz)	RF Band 2 Start Frequency (MHz)	
22	RF Band 2 Stop Frequency (MHz)	RF Band 2 Stop Frequency (MHz)	
23	RF Band 3 Start Frequency (MHz)	RF Band 3 Start Frequency (MHz)	
24	RF Band 3 Stop Frequency (MHz)	RF Band 3 Stop Frequency (MHz)	
25	RF Band 4 Start Frequency (MHz)	RF Band 4 Start Frequency (MHz)	
26	RF Band 4 Stop Frequency (MHz)	RF Band 4 Stop Frequency (MHz)	
27	*(Unused / Spare)*	*(Unused / Spare)*	
28	*(Unused / Spare)*	*(Unused / Spare)*	
29	RF Band 1 RSSI M Scale Factor	RF Band 1 RSSI M Scale Factor	RSSI (dBm) = ((RSSI Reg Value) x (M/10000)) + (B/10)
30	RF Band 1 RSSI B Scale Factor	RF Band 1 RSSI B Scale Factor	
31	RF Band 2 RSSI M Scale Factor	RF Band 2 RSSI M Scale Factor	
32	RF Band 2 RSSI B Scale Factor	RF Band 2 RSSI B Scale Factor	
33	RF Band 3 RSSI M Scale Factor	RF Band 3 RSSI M Scale Factor	
34	RF Band 3 RSSI B Scale Factor	RF Band 3 RSSI B Scale Factor	
35	RF Band 4 RSSI M Scale Factor	RF Band 4 RSSI M Scale Factor	
36	RF Band 4 RSSI B Scale Factor	RF Band 4 RSSI B Scale Factor	
37	Signal Bandwidth Video Filter 0 (kHz)	Signal Bandwidth Video Filter 0 (kHz)	Video Filter Bandwidth (Hz) = Value x1000 Hz
38	Signal Bandwidth Video Filter 1 (kHz)	Signal Bandwidth Video Filter 1 (kHz)	
39	Signal Bandwidth Video Filter 2 (kHz)	Signal Bandwidth Video Filter 2 (kHz)	
40	Signal Bandwidth Video Filter 3 (kHz)	Signal Bandwidth Video Filter 3 (kHz)	
41	Signal Bandwidth Video Filter 4 (kHz)	Signal Bandwidth Video Filter 4 (kHz)	
42	Signal Bandwidth Video Filter 5 (kHz)	Signal Bandwidth Video Filter 5 (kHz)	
43	Signal Bandwidth Video Filter 6 (kHz)	Signal Bandwidth Video Filter 6 (kHz)	
44	Signal Bandwidth Video Filter 7 (kHz)	Signal Bandwidth Video Filter 7 (kHz)	
45	Serial Channel Baud Rate	*(Future Use)*	Serial Channel BAUD/100
46	Serial Channel Format	*(Future Use)*	No. Bits/PE/Parity/Stop Bits
47	*(Unused / Spare)*	*(Unused / Spare)*	
48	*(Unused / Spare)*	*(Unused / Spare)*	
49	DSP Firmware ID MSW	*(Unused / Spare)*	DSP Firmware Date: MSB = Month in Hex, LSB = Day in Hex
50	DSP Firmware ID LSW	*(Unused / Spare)*	DSP Firmware Date: Two Bytes = Year in Hex
51	RF/IF Hardware Port Configuration	RF/IF Hardware Port Configuration	(Future Use)
52	Board Serial Number MSW	*(Unused / Spare)*	Device Serial Number in Hex.
53	Board Serial Number LSW	*(Unused / Spare)*	
54	Ext. Ref. Input Freq. Multiplier (MHz)	*(Unused / Spare)*	External Reference Input Frequency = Multiplier x 1MHz
55	*(Unused / Spare)*	*(Unused / Spare)*	
56	Board ID ASCII Character 1	*(Unused / Spare)*	ASCII Representation Of Device ID
57	Board ID ASCII Character 2	*(Unused / Spare)*	
58	Board ID ASCII Character 3	*(Unused / Spare)*	
59	Board ID ASCII Character 4	*(Unused / Spare)*	
60	Board ID ASCII Character 5	*(Unused / Spare)*	
61	Board ID ASCII Character 6	*(Unused / Spare)*	
62	Board ID ASCII Character 7	*(Unused / Spare)*	
63	Board ID ASCII Character 8	*(Unused / Spare)*	

Figure 5-23 **Dual Receiver Protocol EEPROM Contents**

5.2.1.4 Dual Receiver Protocol - Status Bit/Byte Definitions

Figure 5-24 contains the bit and bit pairing definitions for the status messages.

Response Mnemonic	Description/Definition	Logic State/Explanation
REF	Present state of the Internal/External Reference Select	1 = Internal Reference Selected, 0 = External Reference Selected
PLL	Internal Synthesizer Reference Synchronization Status	1 = PLL Synchronized, 0 = PLL Unsynchronized
CHxRSSIL	CHx Received Signal Strength (8 LSBs)	Lower 8 bits of RSSI level
CHxRSSIH	CHx Received Signal Strength (4 MSBs)	Upper 4 bits of RSSI level
CHxCOMP	CHx Compression Warning	0 = Not in compression, 1 = May be in compression.
CHxAMINDX	CHx Measured AM Index	AM Index Measurement (Range 0-127)
CHxLO1STAT	CHx LO1 Status	1 = Locked, 0 = Unlocked
CHxLO2STAT	CHx LO2 Status	1 = Locked, 0 = Unlocked
CHxFMDEV	CHx FM Deviation in Percent	Valid range is from 0% – 127%.

Command Mnemonic	Description/Definition	Logic State/Explanation
DCx	Radio Selection Number	0=Radio 1 or Down Converter 1, 1=Radio 2 or Down Converter 2
PAGE	EEPROM Page Number Selection	0 – 31 are valid page numbers.

Figure 5-24 **Dual Receiver Protocol Status Cmd/Response Bit Grouping Definitions**