LS-27-M Modular RF Downconverter/Receiver

User's Manual

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Acronyms

AGC - Automatic Gain Control
AM - Amplitude Modulation
BNC - Bayonet Neill–Concelman (connector)
BSC – Best Source Combining
BW – Bandwdith
dB – Decibel
dBm – Decibel milliwatts
DHCP – Dynamic Host Configuration Protocol
DSP - Digital Signal Processor or Digtial Signal Processing
FM - Frequency Modulation
FPGA – Field Programmable Gate Array
GHz - Giga Hertz
GUI – Graphical User Interface
Hz - Hertz
ICD - Interface Control Document
IF - Intermediate Frequency
INV - Invert
IP - Internet Protocol
KB – Kilobyte
kHz - KiloHertz
LED - Light Emitting Diode
Mbps - Mega Bits Per Second
MHz - Mega Hertz
NTSC - National Televison System Committee
OS - Operating System
PAL - Phase Alternating Line
PLL - Phase Lock Loop
RF - Radio Frequency
RX – Receive
SE - Single-Ended
SMA - Subminature Version A
SMB - Subminature Version B
SS-PCMFM - Single Symbol Pulse Code Modulated Frequency Modulation
TCP - Transmisson Control Protocol
TX - Transmit
USB - Universial Serial Bus
1PPS – One Pulse Per Second

1 Introduction

1.1 General

This document is the User's Manual for the Lumistar LS27M Modular RF Downconverter/Receiver. This product represents Lumistar's 4th generation of the LS27 Series of RF Downconverters. In addition to RF downconversion functions, 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 3 1/2 hard-disk format. The product provides two independent and autonomous multi-band downconversion stages. Each channel provides the conversion of up to five 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 LS27M product. A block diagram of the product design is shown in Figure 1-2.

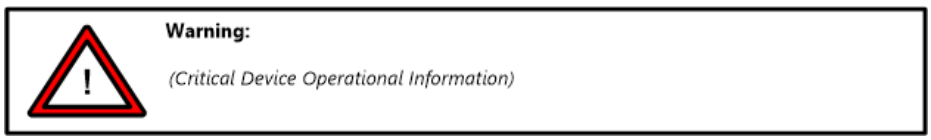
Consult the web site for the most recent release of all related product documentation.

1.2 Document Outline

This document contains the following sections:

- Section 1 provides a document overview as well as a brief on the LS-27-M design
- Section 2 provides receiver theory of operation
- Section 3 provides hardware, cabling and opeational instructions
- Section 4 provides communications and 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 in Figure 1-1.



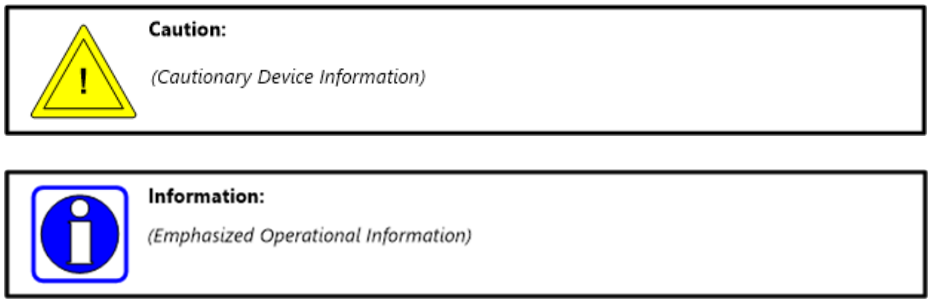


Figure 1-1 Document Flag Formats

1.3 List of Referenced Documents

A number of documents are referenced within this document. A list of these documents follows:

- Telemetry Standards: (IRIG-106-2015)
- User Datagram Protocol (RFC 768)

2 Theory of Operation

2.1 Device Brief

The LS-27-M is a sophisticated RF Downconverter that Track Receiver with FM Discrimination options. The device is hosted in the approximate footprint of a 3 ½ inch host computer hard drive. Standard capabilities include two independent digital multi-band RF receiver channels, AM demodulation and filtering, extensive AGC processing and scaling programmability, Automatic Frequency Control (AFC) *(future option)*.

Some of the primary design objectives of the LS-27-M product line were to reduce the platform size, to provide an "OS-less" environment by eliminating product use of commercial software operating systems for functional processing, to provide easy and flexible field upgrade/enhancements capabilities, and to provide a network appliance for device control and data transport. The unit is controlled and monitored using a 100/10Mbps Ethernet interface with alternate controls being provided by USB, RS-232, and RS422 4-Wire interfaces. Using provided documentation of several sources, the customer can develop their own interface GUI, or chose to utilize the provided Lumistar network application.

At the heart of the modular design is a flexible and extensible DSP Engine. The device construction is via up to four hardware sections, referred to as "slices": RF, IF, Signal Processing and a Control Processing Engine. The slices can be configured as a whole set or as a subset to perform targeted functionality. New firmware personalities and/or control processing revisions are easily updated in the field. No need to return the unit for most modifications.

When configured as a tracking receiver the LS-27-M is capable of handling up to six frequency bands per channel anywhere from 70 MHz to greater than 6 GHz. All standard RF receiver functions, such as antenna tracking using AM demodulation and AGC feedback, downconversion, and best source AGC and AM selection. The unit constantly performs maintenance monitoring of various environmental parameters and alert the user to out of boundary conditions. The software logs the user settings and important receiver performance parameters as a function of time.

Device "slice" detail block diagrams are shown in Figure 2-1through **Error! Reference source not found.** Device specifications for the LS-27-M as a standalone entity are listed in Table 2-1. Device specifications for the LS-27-M mounted in the desktop chassis are listed in Table 2-2. Device specifications for the LS-27-M mounted in the 1U Rackmount 12" Deep chassis are listed in Table 3-1.

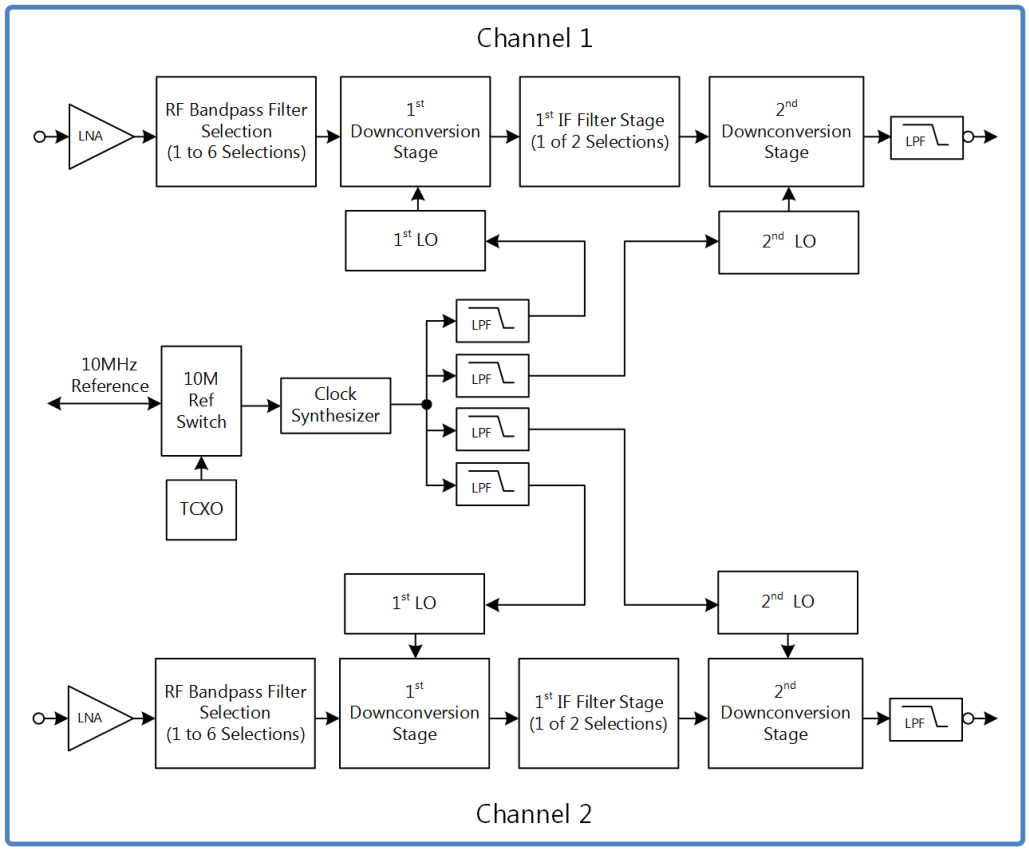


Figure 2-1 Block Diagram: Slice 1 - RF to IF Downconversion

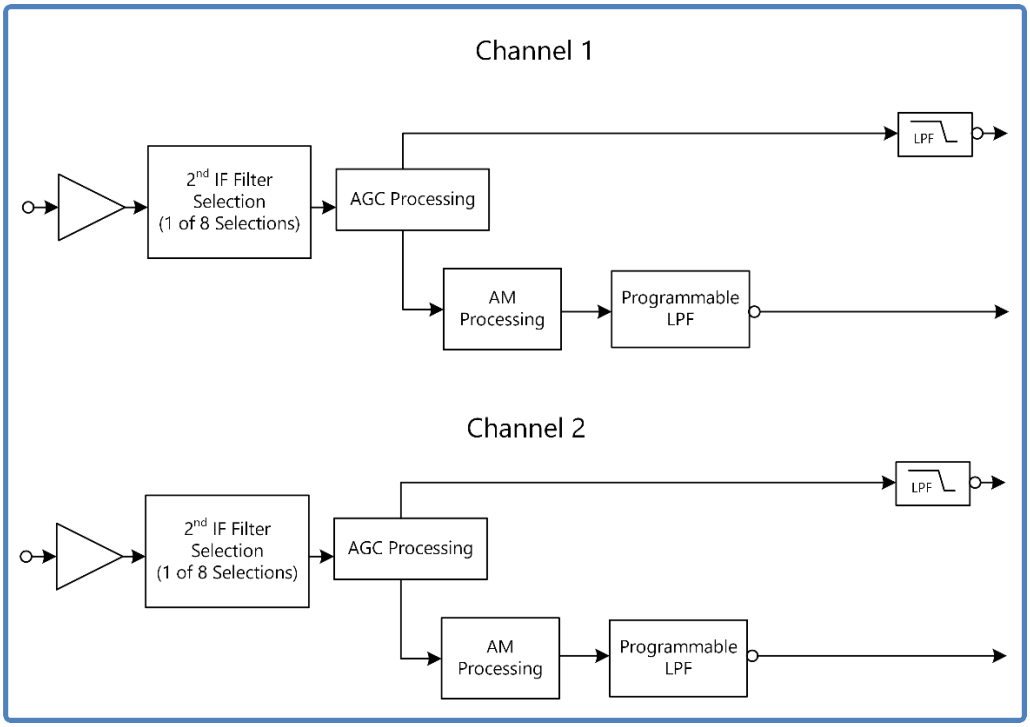


Figure 2-2 Block Diagram: Slice 2 - 2nd IF and Analog Processing

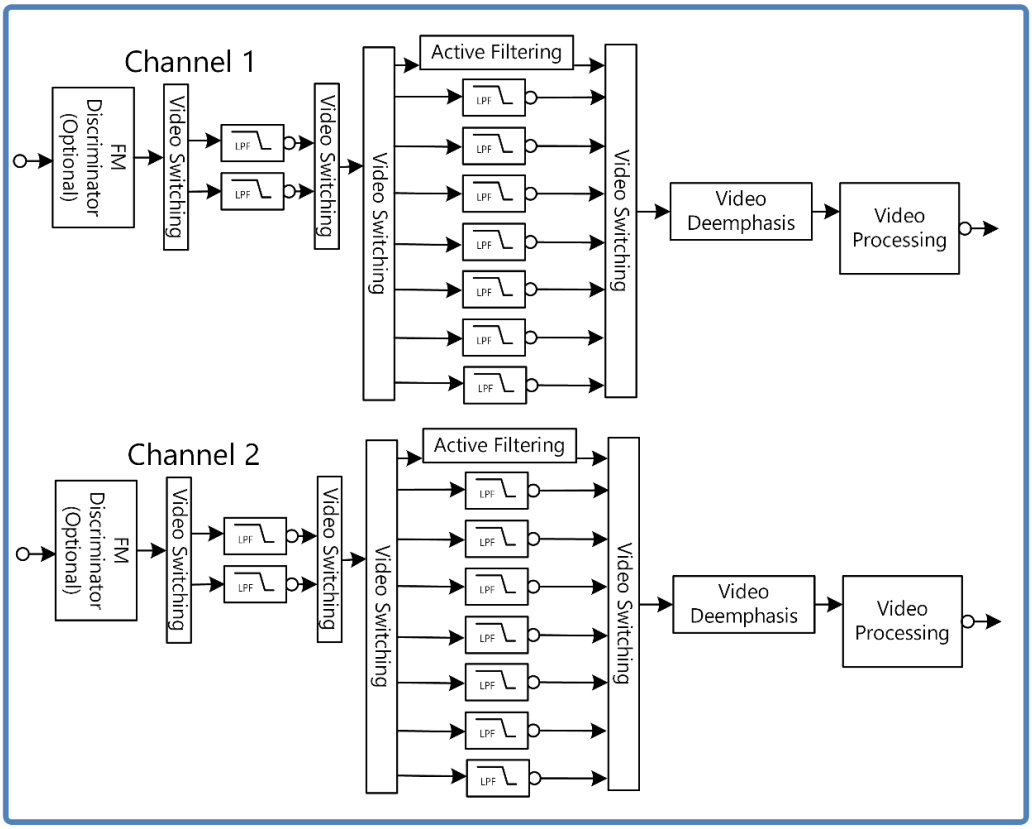


Figure 2-3 Block Diagram: Slice 3 – FM Video Discrimination and Processing

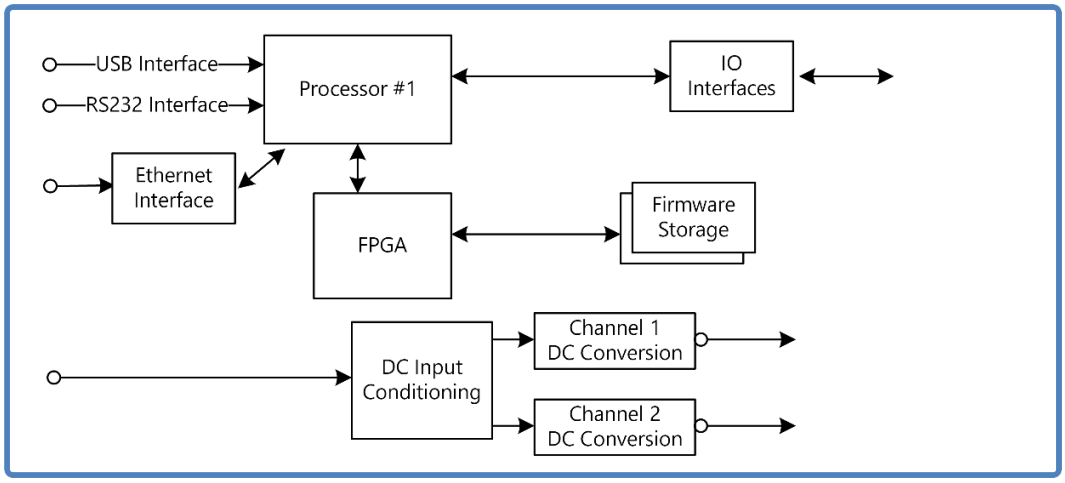


Figure 2-4 Block Diagram: Slice 4 – Processing, and DC Power Conversion

Category:	***Specifications:***	***Details:***
Mechanical	Envelope Dimensions ins. (mm.)	6.00 (152.4) L x 4.00 (101.6) W x 1.656 (42.06) H
	Form Factor	Modular Brick
	Weight oz. (kgs)	~ 32oz. (~0.91kgs.)
Electrical	Individual power requirements	9-42VDC
	Total Power (both Channels)	~ 26 to 36 Watts (mode dependent)
MTBF	Calculated MIL-217F Notice 2; Parts Count Method	38,405 hours, Ground Fixed Environment, 50 degrees C nominal operating temperature;
Performance		
RF Tuner	RF Input Bands	Typ. Config. up to 5 Bands plus 70MHz
		Band range: 70MHz – 6.2GHz
	Tuner Resolution	50kHz (Typical); 2Hz minimum
	VSWR	1.5:1 Typical
	Frequency Accuracy	0.002% (Max.) 0.001% (Typical)
	RF Input AGC Range	+10dBm to –110dBm
	Input Level without Damage	+28dBm
	Receiver Input P_{1dB}	+10dBm (typical)
	Receiver Noise Figure	<= 5dB (typical @ threshold)
	70MHz Output Level	Typ. 0 dBm (+/- 1dBm); Adjustable
	SAW IF 3dB Bandwidths Available Data: Typical Antenna Tracking:	250kHz, 500kHz, 1MHz, 2MHz, 5MHz, 10MHz, 20MHz, 40MHz 120kHz, 250kHz, 500kHz, 1MHz, 1.5MHz, 2MHz, 5MHz, 8MHz
Demodulation	Types	Analog AM, Video FM, SS-PCMFM' 14MHz FM BW
	Video FM De-emphasis	Bypass, NTSC, PAL
	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
	AM Output	2Vp-p @ 50% AM Index; 50 ohms; User adjustable
	Video Filtering 3dB Bandwidth (FM Option Required)	125K, 250K, 500K, 1M, 1.5M, 2M, 2.5M, 3M, 4.2M, 6M, 8M, 12M, 15M, 20M Hz
Receiver AGC	Range	+5V/-5V; unipolar and bipolar; user programmable slope and range
Connectors	External Reference In/Out	(1) SMB Jack
	RF Signal Input	(2) SMA Jack Receptacle
	IF Signal Output	(3) SMB Jack Receptacle
	Analog I/O Connector	(2) MicroDSub-15 Plug
	Power/Digital I/O Connector	(1) MicroDSub-25 Receptacle/Plug
Environmental	Temperature, Operational	-20° to 70° Celsius
	Temperature, Storage	-40° to 85° Celsius
	Humidity, non-condensing	<40° C 10-90%, >40° C 0-75%

Table 2-1 General LS-27-M Device Specifications Table

Category:	*Specifications:*	*Details:*
Mechanical	Envelope Dimensions in. (mm.)	8.00 (203.2) L x 5.25 (133.4) W x 2.639 (67.0) H [Including Feet]
	Unboxed Weight lbs. (kgs.)	3lbs. (1.36kgs.)
Electrical	Power Input Range	9-36VDC
	Total Power (both Channels)	~ 30 Watts
Performance	All Receiver Performance Parameters	(Same as that of the LS-27-M shown in **Error! Reference source not found.**)
DC Power Supply	Desktop mount in. (mm.)	8.20 (208) x 2.90 (73) x 1.6 (39)
	Manufacturer/Model	Inventus MWA220024A-12A
	Input Power	85-264VAC/47-63Hz; Auto Switching
	Weight lbs. (kgs.)	2.1 (0.95)
	Output Power	24VDC @ 9.2A or 18V @ 8.33A
Connectors	External Reference In/Out	(1) SMB Jack
	RF Signal Input	(2) SMA Jack Receptacle
	IF Signal Output	(2) SMB Jack Receptacle
	Analog I/O Connector	(2) MicroDSub-15 Plug
	Digital I/O Connector	(1) MicroDSub-25 Plug
	Power/Digital I/O Connector	(1) MicroDSub-25 Receptacle
	Chassis Power	(1) Switchcraft 62GB8FX 8-Pin DIN Connector *(alternate)* Pins 1,2,4,6: +VDC In Pins 3,5,7,8: +VDC Return
		(1) Amphenol PT02A-8-4P(025) *(alternate)* Pins A, C: +VDC In Pins B, D: +VDC Return
Environmental	Temperature, Operational	-20° to 70° Celsius
	Temperature, Storage	-40° to 85° Celsius
	Humidity, non-condensing	<40° C 10-90%, >40° C 0-75%
Safety and EMC	Emissions	EN55011 Class B, FCC Part 15; IEC-61000-3-2, 3; IEC61000-4-2 thru 6, 8, 11
	Immunity	EN61000-3-2, -3; EN6100-4-2 thru 6, 8, and 11
	Safety	UL 60601-1, IEC60601-1 2nd and 3rd Edition

Table 2-2 Desktop Rackmount Chassis - Device Specifications Table

Category:	*Specifications:*	*Details:*
Mechanical	Envelope Dimensions in. (mm.)	12.5 (317.5) L x 18.94 (481) W x 1.732 (44.0) H [BNC Excursion]
	Unboxed Weight lbs. (kgs.)	12.2lbs. (5.53kgs.)
Electrical	Power Input Range	90-264VAC / 47-63Hz
	Total Power (both Channels)	~ 50 Watts (mode and data rate dependent)
Performance	All Receiver Performance Parameters	(Same as that of the LS-27-M shown in **Error! Reference source not found.**)
Connectors	RF Signal Input	(2) N-Style Receptacle
	IF Signal Output	(2) BNC F Jack Receptacle
	Analog I/O Connector	(4) BNC F Jack Receptacle
	Auxiliary Digital/Analog IO	(1) HDSub-15 Receptacle (See Section **Error! Reference source not found.**)
	Serial Communications	(1) HDSub-15 Receptacle
	USB 2.0 Interface	(1) USB-B Receptacle
	Chassis Power	(1) IEC320-C14 AC Inlet
		(1) Amphenol PT02A-8-4P (025) *(alternate – custom order)* Pins A, C: +24VDC In Pins B, D: +24VDC Return
Environmental	Temperature, Operational	-40° to 70° Celsius
	Temperature, Storage	-40° to 85° Celsius
	Humidity, non-condensing	<40° C 10-90%, >40° C 0-75%
Safety and EMC	Emissions and Immunity	EN55011 Class B, FCC CFR 47 Part 18; IEC-61000-3-2, 3; IEC61000-4-2 thru 6, 8, 11
	Safety	IEC60601-1: 2005+A1: 2012, EN60601-1:2006+A11:2011+A1+A12, UL ANSI/AAMI ES60601-1

Table 2-3 1U Rackmount Chassis (12" Depth) - Device Specifications Table

3 Hardware Specifications, Cabling and Operations

This document section will examine hardware design aspects including physical mounting of the device, electrical interface standards involved with the user connections, power and cooling of the device, and cabling options. This section will also provide specifications for various mechanical enclosures that the LS-27-M is delivered.

3.1 Mechanical Outline – Basic Receiver

The LS-27-M is described as a "brick" configuration having the same traditional footprint as a standard 3.5" host computer hard disk drive. Figure 3-1 provides a diagram of the top view of the device. Figure 3-2 illustrates the various front-view configurations available.

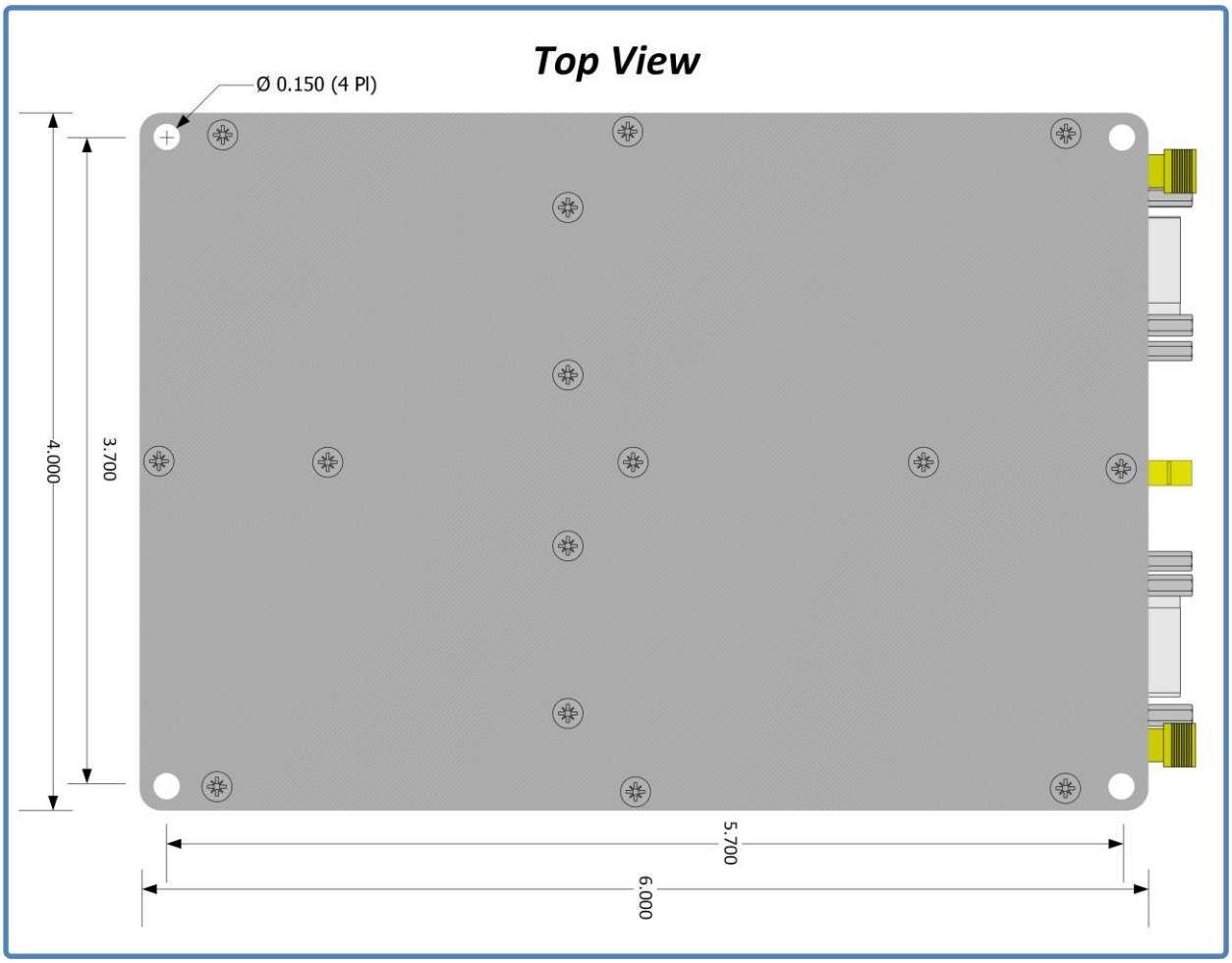
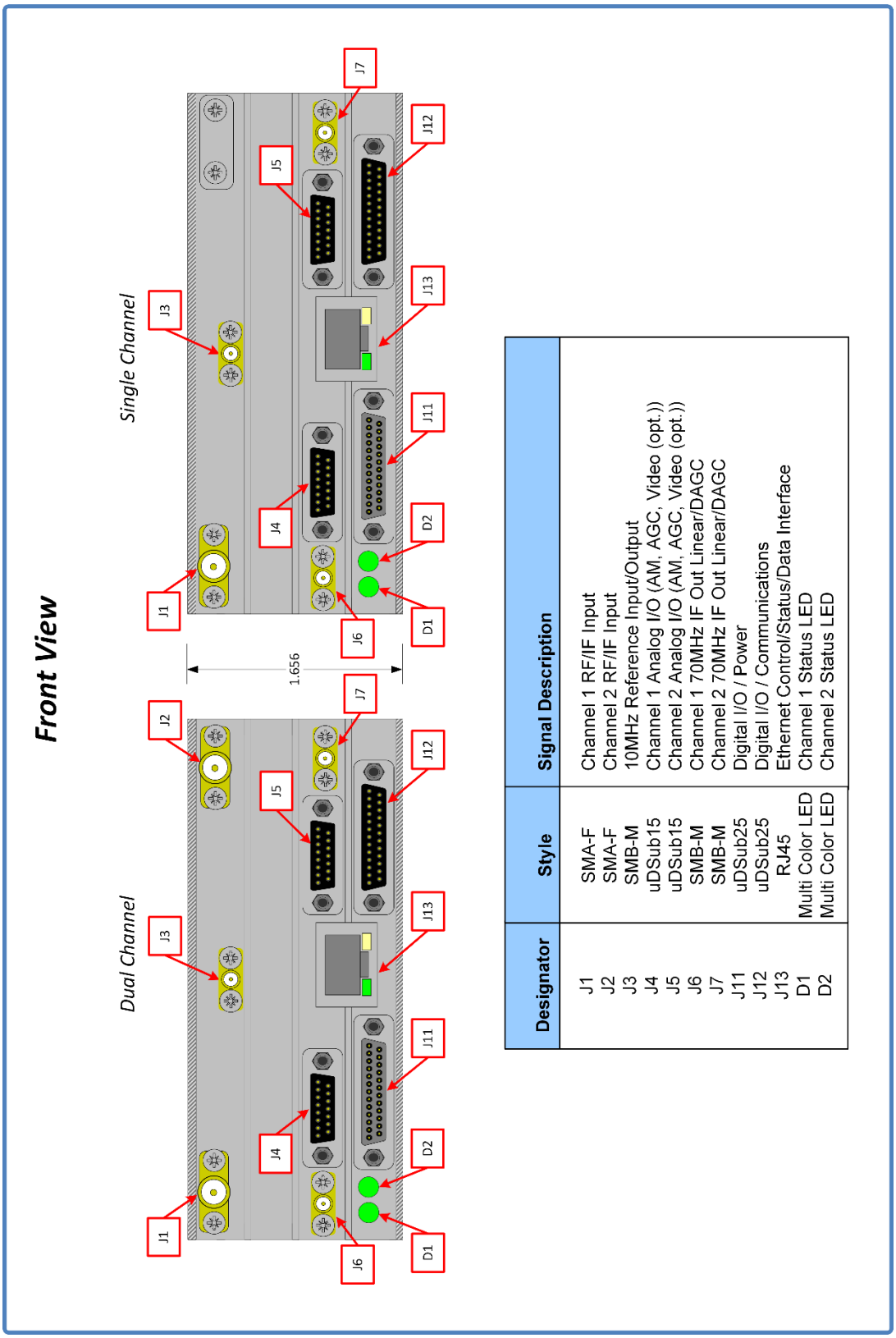


Figure 3-1 Representative Top View of the LS-27-M brick assembly



Designator	Style	Signal Description
J1	SMA-F	Channel 1 RF/IF Input
J2	SMA-F	Channel 2 RF/IF Input
J3	SMB-M	10MHz Reference Input/Output
J4	uDSub15	Channel 1 Analog I/O (AM, AGC, Video (opt.))
J5	uDSub15	Channel 2 Analog I/O (AM, AGC, Video (opt.))
J6	SMB-M	Channel 1 70MHz IF Out Linear/DAGC
J7	SMB-M	Channel 2 70MHz IF Out Linear/DAGC
J11	uDSub25	Digital I/O / Power
J12	uDSub25	Digital I/O / Communications
J13	RJ45	Ethernet Control/Status/Data Interface
D1	Multi Color LED	Channel 1 Status LED
D2	Multi Color LED	Channel 2 Status LED

Figure 3-2 Various Front-Views of the LS-27-M brick assembly

The device can be mounted using four UNC 6-32 or Metric 3 or 3.5mm machine screws. Total device height does not exceed 1.656 inches (42.06mm) so the length of the mounting screw will only depend on the desired number of mounting threads. UNC 6-32 Helicoils can be inserted into any of the mounting holes at the corner of the device which allows for flush mounting of the device from the bottom or top of the device.

The LS-27-M contains two multi-color status LEDs on the front of the device. These are shown in figure 2-2 and referenced as D1 and D2. The LEDs provide high-level functional status to the user and can be used in physical location of a particular device in the case that multiple devices have been deployed.

The LEDs are tri-color: RED, GREEN, BLUE. During normal operations, the front LEDS will blink BLUE at a very rapid pace directly after application of power. The LED will then proceed to pause on BLUE for an additional period. During this period of BLUE LED activity which last less than 10 seconds, no communications with the unit is possible. Once both LEDs start alternating between GREEN and off with each state being active for a 1 second period, the unit has full communications ability.

There is a FLASH LED function call that is available that will toggle the LEDS between a RED and BLUE state for an approximate 8-second period via the application software. This is useful in verifying communications with the device and locating a specific unit.

If the unit D1/D2 LEDs are both toggling RED after boot, or after a change in operational mode is attempted, this indicates that the signal processing FPGAs were not successfully loaded leaving the unit non-functional from a signal processing standpoint. If this happens, the user should power the unit down for 120-seconds and then re-apply unit power. If after this power cycle the LEDs are still toggle RED, change operational modes and then re-attempt the 120-second power cycle. If the flashing red LEDs persist, contact customer service *for additional support.*

3.2 Interface Signals: Micro-D Sub Pin-outs

Figure 3-2 presents a front-view of the LS-27-M. This figure contains a reference table of LS-27-M interface connectors. This table makes reference to four Micro-D-Sub connectors. Figure 3-3 and Figure 3-4 provide detailed interface pinouts of the Micro-D connections of the LS-27-M.

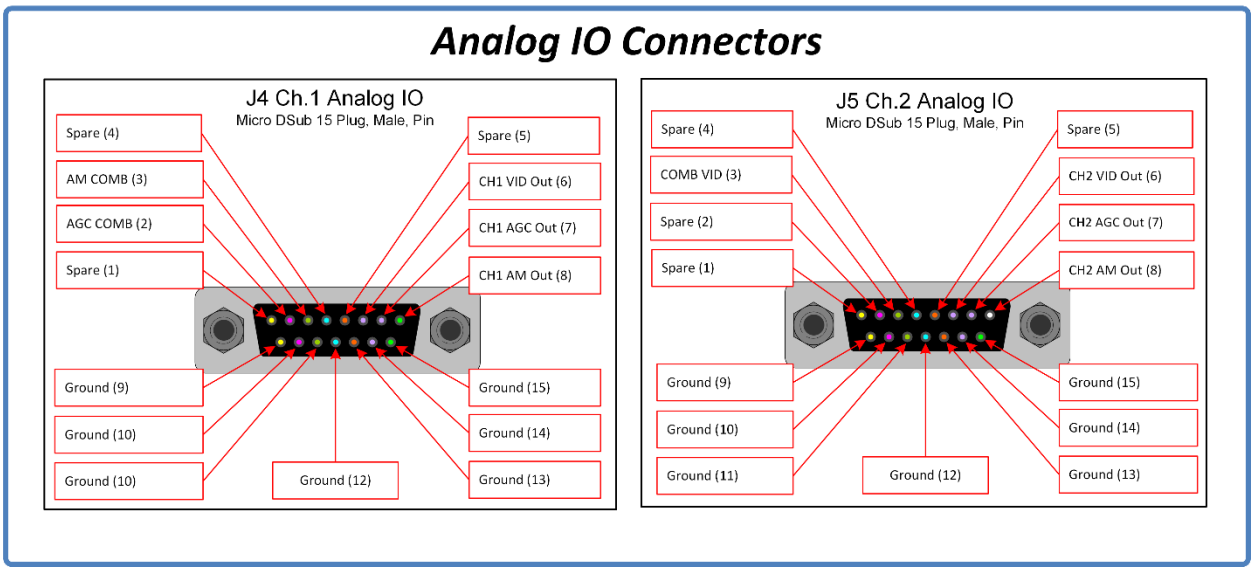


Figure 3-3 Revision 2 Cable: LS-27-M J4 and J5 Connector Pin-out Details

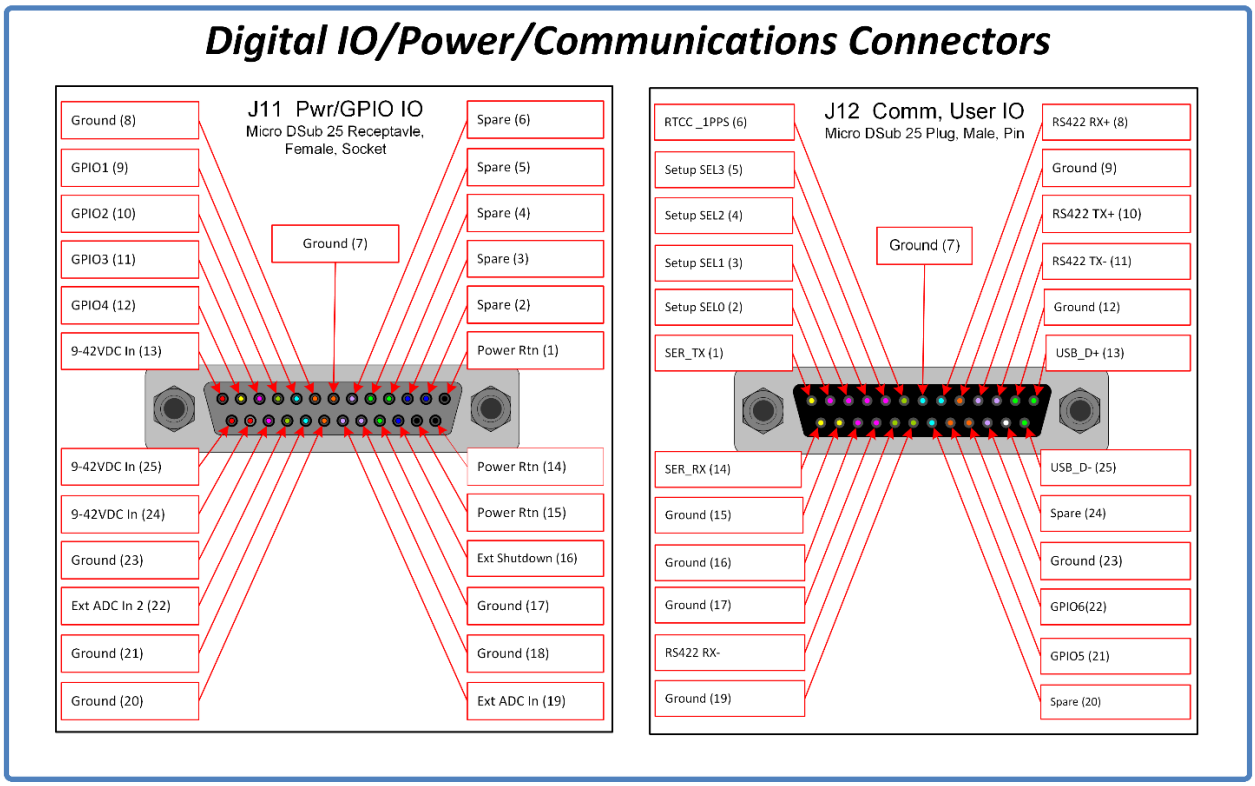


Figure 3-4 Revision 2 Cable: LS-27-M J11 and J12 Connector Pin-out Details

3.3 Interface Signals: Electrical Definitions/Characteristics

The interface signals of the LS-27-M vary in type and electrical complexity. There are several different types of signals deployed as detailed in Table 3-1.

Signal Name	Interface Direction	Interface Type	Input Voltage Range	Input Ω	Output Voltage	Output Ω	See Note
VID Out	O	Analog Video			0-4Vp-p	75Ω	1
VID Comb	O	Analog Video			0-4Vp-p	75Ω	1
AGC Out	O	Analog			+/-5V	50Ω	2
AGC Comb	O	Analog			+/-5V	50Ω	2
AM Out	O	Analog			0-6Vp-p	20Ω	3
AM Comb	O	Analog			0-6Vp-p	20Ω	3
9-42VDC In	PWR	Power	9-42VDC				4
Pwr Rtn	PWR	Power	GND				4
Ext Shut Down	I	Digital	Open/GND				5
SER TX/RX	I/O	RS232 or RS422/RS485					6
USB_D+/-	I/O	USB 2.0					7

Notes:

1.) Analog video output levels are software adjustable.
2.) Output voltage is software selectable in terms of ranges and slopes.
3.) Bipolar analog signal. Output voltage is software selectable in terms of output gain. Output voltage level varies as a function of AM index.
4.) DC input voltage can vary from 9V-42V. Per pin current limit is 3A.
5.) Pull below 2.2V for shutdown. Leave unconnected or pull-up for normal operation. Ground or pull low for shutdown. Input tolerance: -40V to 100V.
6.) Serial communications transceiver is SW selectable. Default is RS232. Four-wire RS422/485 is also available. Only one transceiver is active at a time
7.) USB2.0 operation only. USB interface is active simultaneously with Serial and Ethernet interfaces.

Table 3-1 Primary IO Signal Electrical Definitions

3.4 Desktop chassis Cabling Interfaces

The LS-27-M in the Desktop chassis assembly is typically delivered with a set of four interface cables. These cables interface connections on the Micro D-Sub connections to more commonly available interface connections such as BNC, USB-B, DSub9 and HD15 connections.

Cables are not typically provided for the Ethernet interface, the SMA RF connections, or the SMB IF connections. Consult the Lumistar Factory if you are interested in the purchase of any of these cables.

Cables shipped are defined in detail in Figure 3-5 thru Figure 3-8 that follow. There are several cable and cabling options available. Consult your Lumistar sales representative for details.

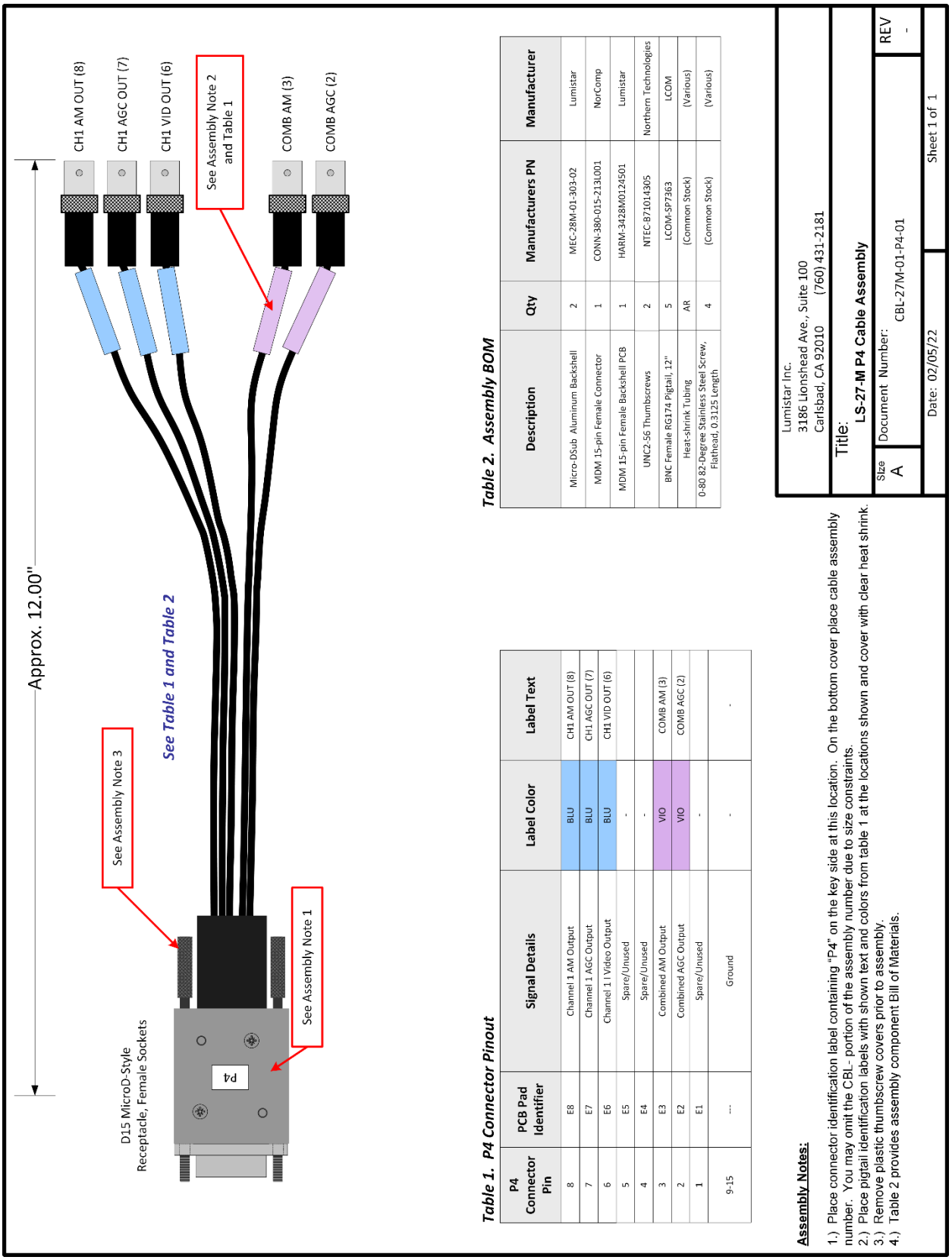


Table 1. P4 Connector Pinout

P4 Connector Pin	PCB Pad Identifier	Signal Details	Label Color	Label Text
8	E8	Channel 1 AM Output	BLU	CH1 AM OUT (8)
7	E7	Channel 1 AGC Output	BLU	CH1 AGC OUT (7)
6	E6	Channel 1 Video Output	BLU	CH1 VID OUT (6)
5	E5	Spare/Unused	-	
4	E4	Spare/Unused	-	
3	E3	Combined AM Output	VIO	COMB AM (3)
2	E2	Combined AGC Output	VIO	COMB AGC (2)
1	E1	Spare/Unused	-	
9-15	---	Ground	-	-

Table 2. Assembly BOM

Description	Qty	Manufacturers PN	Manufacturer
Micro-DSub Aluminum Backshell	2	MEC-28M-01-303-02	Lumistar
MDM 15-pin Female Connector	1	CONN-380-015-213L001	NorComp
MDM 15-pin Female Backshell PCB	1	HARM-3428M0124501	Lumistar
UNC2-56 Thumbscrews	2	NTEC-B71014305	Northern Technologies
BNC Female RG174 Pigtail, 12"	5	LCOM-SP7363	LCOM
Heat-shrink Tubing	AR	(Common Stock)	(Various)
0-80 82-Degree Stainless Steel Screw, Flathead, 0.3125 Length	4	(Common Stock)	(Various)

Assembly Notes:

1.) Place connector identification label containing "P4" on the key side at this location. On the bottom cover place cable assembly number. You may omit the CBL- portion of the assembly number due to size constraints.
2.) Place pigtail identification labels with shown text and colors from table 1 at the locations shown and cover with clear heat shrink.
3.) Remove plastic thumbscrew covers prior to assembly.
4.) Table 2 provides assembly component Bill of Materials.

Lumistar Inc.
3186 Lionshead Ave., Suite 100
Carlsbad, CA 92010 (760) 431-2181

Title: LS-27-M P4 Cable Assembly

Size A | Document Number: CBL-27M-01-P4-01 | REV -

Date: 02/05/22 | Sheet 1 of 1

Figure 3-5 P4 User Interface Cable

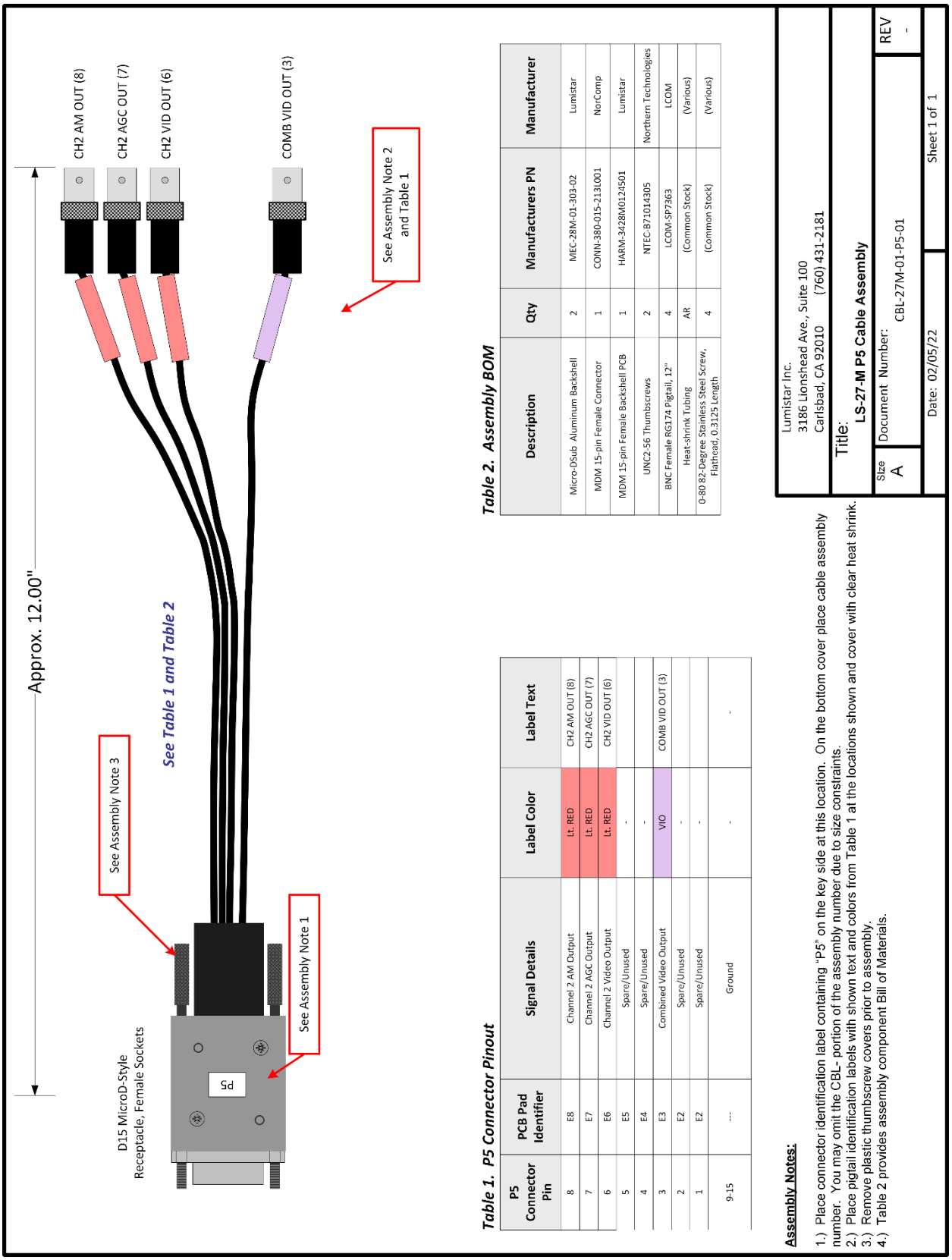


Table 2. Assembly BOM

Description	Qty	Manufacturers PN	Manufacturer
Micro-DSub Aluminum Backshell	2	MEC-28M-01-303-02	Lumistar
MDM 15-pin Female Connector	1	CONN-380-015-213L001	NorComp
MDM 15-pin Female Backshell PCB	1	HARM-3428M0124501	Lumistar
UNC2-56 Thumbscrews	2	NTEC-B71014305	Northern Technologies
BNC Female RG174 Pigtail, 12"	4	LCOM-SP7363	LCOM
Heat-shrink Tubing	AR	(Common Stock)	(Various)
0-80 82-Degree Stainless Steel Screw, Flathead, 0.3125 Length	4	(Common Stock)	(Various)

Table 1. P5 Connector Pinout

P5 Connector Pin	PCB Pad Identifier	Signal Details	Label Color	Label Text
8	E8	Channel 2 AM Output	Lt. RED	CH2 AM OUT (8)
7	E7	Channel 2 AGC Output	Lt. RED	CH2 AGC OUT (7)
6	E6	Channel 2 Video Output	Lt. RED	CH2 VID OUT (6)
5	E5	Spare/Unused	-	
4	E4	Spare/Unused	-	
3	E3	Combined Video Output	VIO	COMB VID OUT (3)
2	E2	Spare/Unused	-	
1	E2	Spare/Unused	-	
9-15	---	Ground	-	-

Assembly Notes:

1.) Place connector identification label containing "P5" on the key side at this location. On the bottom cover place cable assembly number. You may omit the CBL- portion of the assembly number due to size constraints.
2.) Place pigtail identification labels with shown text and colors from Table 1 at the locations shown and cover with clear heat shrink.
3.) Remove plastic thumbscrew covers prior to assembly.
4.) Table 2 provides assembly component Bill of Materials.

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Carlsbad, CA 92010 (760) 431-2181

Title:
LS-27-M P5 Cable Assembly

Size A | Document Number: CBL-27M-01-P5-01 | REV -

Date: 02/05/22 | Sheet 1 of 1

Figure 3-6 P5 User Interface Cable

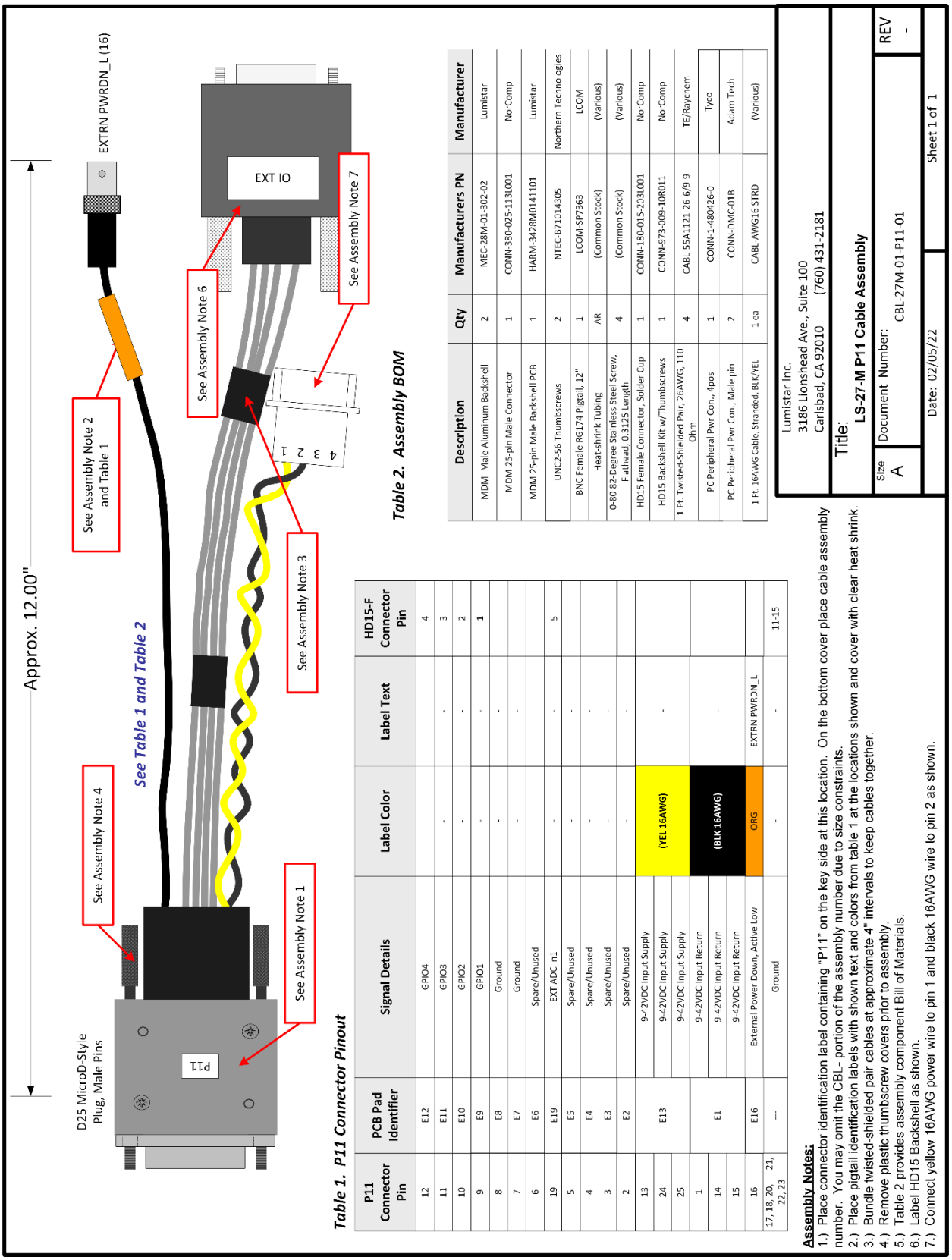

Table 1. P11 Connector Pinout

P11 Connector Pin	PCB Pad Identifier	Signal Details	Label Color	Label Text	HD15-F Connector Pin
12	E12	GPIO4	-	-	4
11	E11	GPIO3	-	-	3
10	E10	GPIO2	-	-	2
9	E9	GPIO1	-	-	1
8	E8	Ground	-	-	
7	E7	Ground	-	-	
6	E6	Spare/Unused	-	-	
19	E19	EXT ADC In1	-	-	5
5	E5	Spare/Unused	-	-	
4	E4	Spare/Unused	-	-	
3	E3	Spare/Unused	-	-	
2	E2	Spare/Unused	-	-	
13	E13	9-42VDC Input Supply	(YEL 16AWG)	-	
24		9-42VDC Input Supply			
25		9-42VDC Input Supply			
1	E1	9-42VDC Input Return	(BLK 16AWG)	-	
14		9-42VDC Input Return			
15		9-42VDC Input Return			
16	E16	External Power Down, Active Low	ORG	EXTRN PWRDN_L	
17, 18, 20, 21, 22, 23	---	Ground	-	-	11-15

Table 2. Assembly BOM

Description	Qty	Manufacturers PN	Manufacturer
MDM Male Aluminum Backshell	2	MEC-28M-01-302-02	Lumistar
MDM 25-pin Male Connector	1	CONN-380-025-113L001	NorComp
MDM 25-pin Male Backshell PCB	1	HARM-3428M0141101	Lumistar
UNC2-56 Thumbscrews	2	NTEC-871014305	Northern Technologies
BNC Female RG174 Pigtail, 12"	1	LCOM-SP7363	LCOM
Heat-shrink Tubing	AR	(Common Stock)	(Various)
0-80 82-Degree Stainless Steel Screw, Flathead, 0.3125 Length	4	(Common Stock)	(Various)
HD15 Female Connector, Solder Cup	1	CONN-180-015-203L001	NorComp
HD15 Backshell Kit w/Thumbscrews	1	CONN-973-009-10R011	NorComp
1 Ft. Twisted-Shielded Pair, 26AWG, 110 Ohm	4	CABL-55A1121-26-6/9-9	TE/Raychem
PC Peripheral Pwr Con., 4pos	1	CONN-1-480426-0	Tyco
PC Peripheral Pwr Con., Male pin	2	CONN-DMC-01B	Adam Tech
1 Ft. 16AWG Cable, Stranded, BLK/YEL	1 ea	CABL-AWG16 STRD	(Various)

Assembly Notes:

1.) Place connector identification label containing "P11" on the key side at this location. On the bottom cover place cable assembly number. You may omit the CBL- portion of the assembly number due to size constraints.
2.) Place pigtail identification labels with shown text and colors from table 1 at the locations shown and cover with clear heat shrink.
3.) Bundle twisted-shielded pair cables at approximate 4" intervals to keep cables together.
4.) Remove plastic thumbscrew covers prior to assembly.
5.) Table 2 provides assembly component Bill of Materials.
6.) Label HD15 Backshell as shown.
7.) Connect yellow 16AWG power wire to pin 1 and black 16AWG wire to pin 2 as shown.

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Title: LS-27-M P11 Cable Assembly

Size A | Document Number: CBL-27M-01-P11-01 | REV -

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Figure 3-7 P11 User Interface Cable

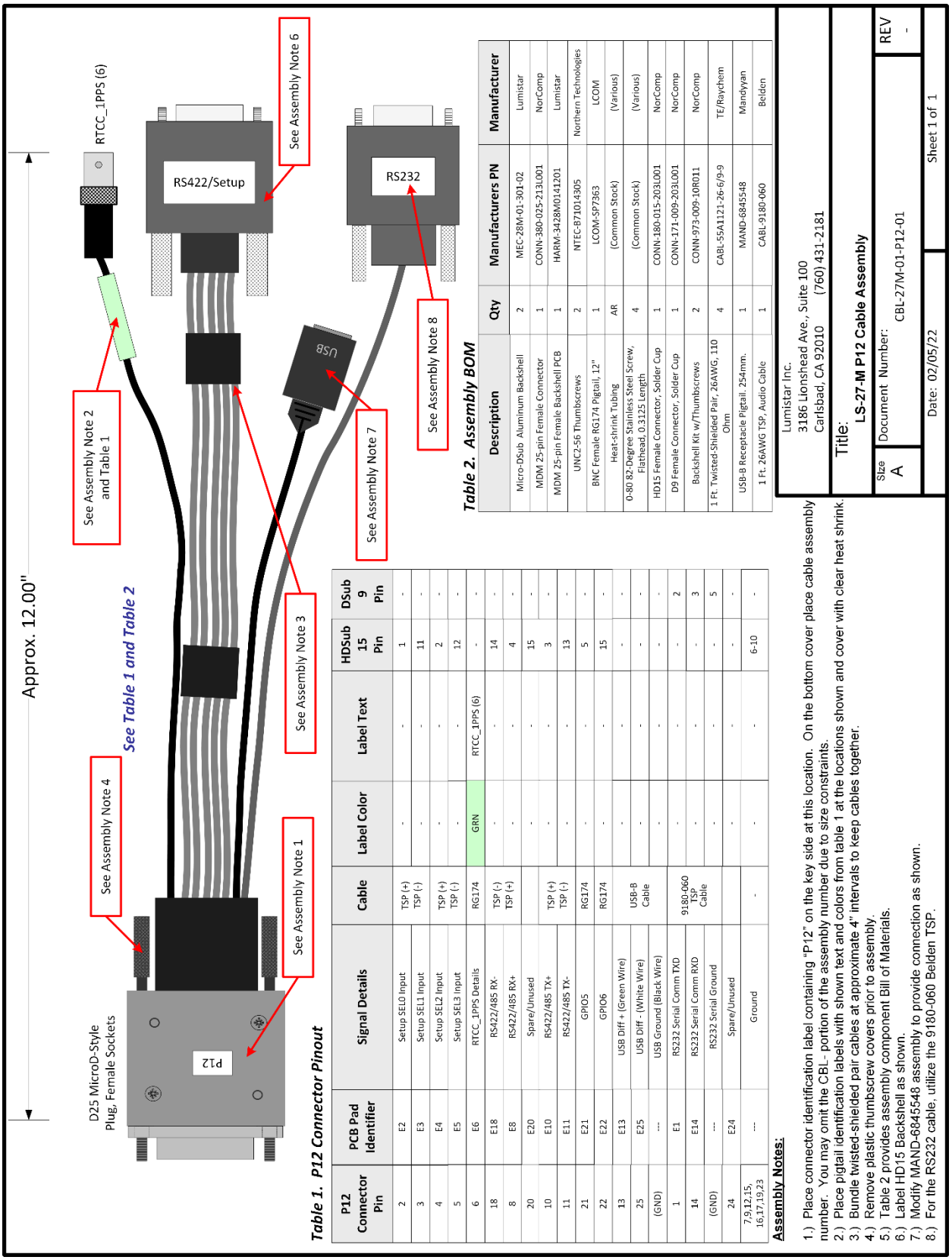

Table 1. P12 Connector Pinout

P12 Connector Pin	PCB Pad Identifier	Signal Details	Cable	Label Color	Label Text	HDSub 15 Pin	DSub 9 Pin
2	E2	Setup SEL0 Input	TSP (+)	-	-	1	-
3	E3	Setup SEL1 Input	TSP (-)	-	-	11	-
4	E4	Setup SEL2 Input	TSP (+)	-	-	2	-
5	E5	Setup SEL3 Input	TSP (-)	-	-	12	-
6	E6	RTCC_1PPS Details	RG174	GRN	RTCC_1PPS (6)	-	-
18	E18	RS422/485 RX-	TSP (-)	-	-	14	-
8	E8	RS422/485 RX+	TSP (+)	-	-	4	-
20	E20	Spare/Unused		-	-	15	-
10	E10	RS422/485 TX+	TSP (+)	-	-	3	-
11	E11	RS422/485 TX-	TSP (-)	-	-	13	-
21	E21	GPIO5	RG174	-	-	5	-
22	E22	GPIO6	RG174	-	-	15	-
13	E13	USB Diff + (Green Wire)	USB-B Cable	-	-	-	-
25	E25	USB Diff - (White Wire)		-	-	-	-
(GND)	---	USB Ground (Black Wire)		-	-	-	-
1	E1	RS232 Serial Comm TXD	9180-060 TSP Cable	-	-	-	2
14	E14	RS232 Serial Comm RXD		-	-	-	3
(GND)	---	RS232 Serial Ground		-	-	-	5
24	E24	Spare/Unused		-	-	-	-
7,9,12,15, 16,17,19,23	---	Ground	-	-	-	6-10	-

Table 2. Assembly BOM

Description	Qty	Manufacturers PN	Manufacturer
Micro-DSub Aluminum Backshell	2	MEC-28M-01-301-02	Lumistar
MDM 25-pin Female Connector	1	CONN-380-025-213L001	NorComp
MDM 25-pin Female Backshell PCB	1	HARM-3428M0141201	Lumistar
UNC2-56 Thumbscrews	2	NTEC-871014305	Northern Technologies
BNC Female RG174 Pigtail, 12"	1	LCOM-SP7363	LCOM
Heat-shrink Tubing	AR	(Common Stock)	(Various)
0-80 82-Degree Stainless Steel Screw, Flathead, 0.3125 Length	4	(Common Stock)	(Various)
HD15 Female Connector, Solder Cup	1	CONN-180-015-203L001	NorComp
D9 Female Connector, Solder Cup	1	CONN-171-009-203L001	NorComp
Backshell Kit w/Thumbscrews	2	CONN-973-009-10R011	NorComp
1 Ft. Twisted-Shielded Pair, 26AWG, 110 Ohm	4	CABL-55A1121-26-6/9-9	TE/Raychem
USB-B Receptacle Pigtail. 254mm.	1	MAND-6845548	Mandyan
1 Ft. 26AWG TSP, Audio Cable	1	CABL-9180-060	Belden

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Title: **LS-27-M P12 Cable Assembly**

Size A | Document Number: CBL-27M-01-P12-01 | REV -

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Assembly Notes:

1.) Place connector identification label containing "P12" on the key side at this location. On the bottom cover place cable assembly number. You may omit the CBL- portion of the assembly number due to size constraints.
2.) Place pigtail identification labels with shown text and colors from table 1 at the locations shown and cover with clear heat shrink.
3.) Bundle twisted-shielded pair cables at approximate 4" intervals to keep cables together.
4.) Remove plastic thumbscrew covers prior to assembly.
5.) Table 2 provides assembly component Bill of Materials.
6.) Label HD15 Backshell as shown.
7.) Modify MAND-6845548 assembly to provide connection as shown.
8.) For the RS232 cable, utilize the 9180-060 Belden TSP.

Figure 3-8 P12 User Interface Cable

3.5 Chassis/Case Options

Lumistar offers an array of delivery options for the LS-27-M. These include:

- Desktop Chassis – Compact desktop arrangement with force air cooling. Includes desktop power supply.
- 1U 19" Rackmount Chassis (Short) – 12" depth solution for rack mounting.

3.5.1 Desktop Chassis

Lumistar offers an optional LS-27-M desktop chassis that provides mounting, power cabling provisions, and cooling functions for the LS-27-M. The fixture comes with a desktop AC to DC power converter.

This unit is shown in Figure 3-9. The fixture can be operated on input voltages between 9 and 36VDC. In addition, fixtures can be stacked and mounted together as shown in Figure 3-10. The overall mechanical dimensions of the desktop chassis are shown in Figure 3-11. Mounting dimensions for the lower section of the housing are provided in Figure 3-12.

Power interface is provided via two connector styles: an 8-pin DIN connector or a MIL-DTL-26482 4-pin bayonet twist-lock connector. Consult Lumistar sales for ordering options.

Figure 3-9 LS-27-M Desktop chassis –ISO view

Figure 3-10 LS-27-M Desktop chassis – Stacked ISO view

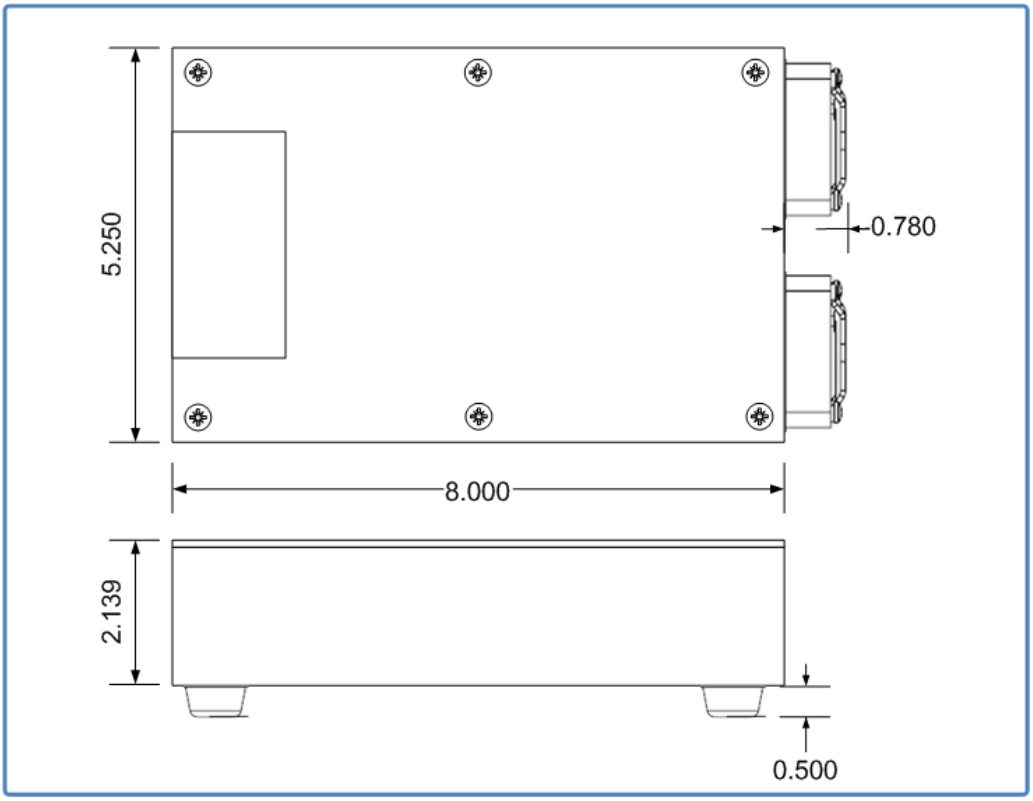


Figure 3-11 LS-27-M Desktop chassis – Envelope Dimensions

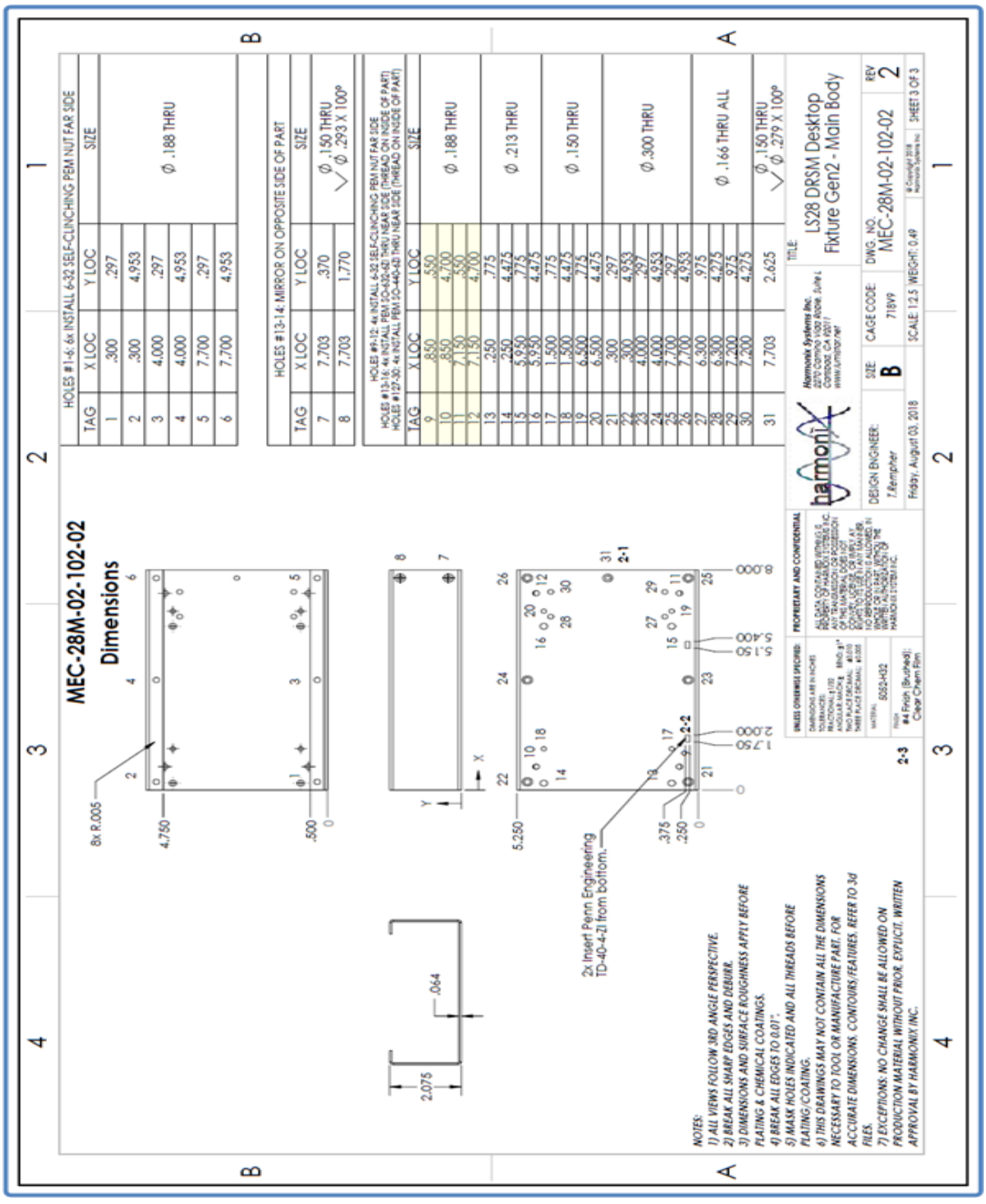
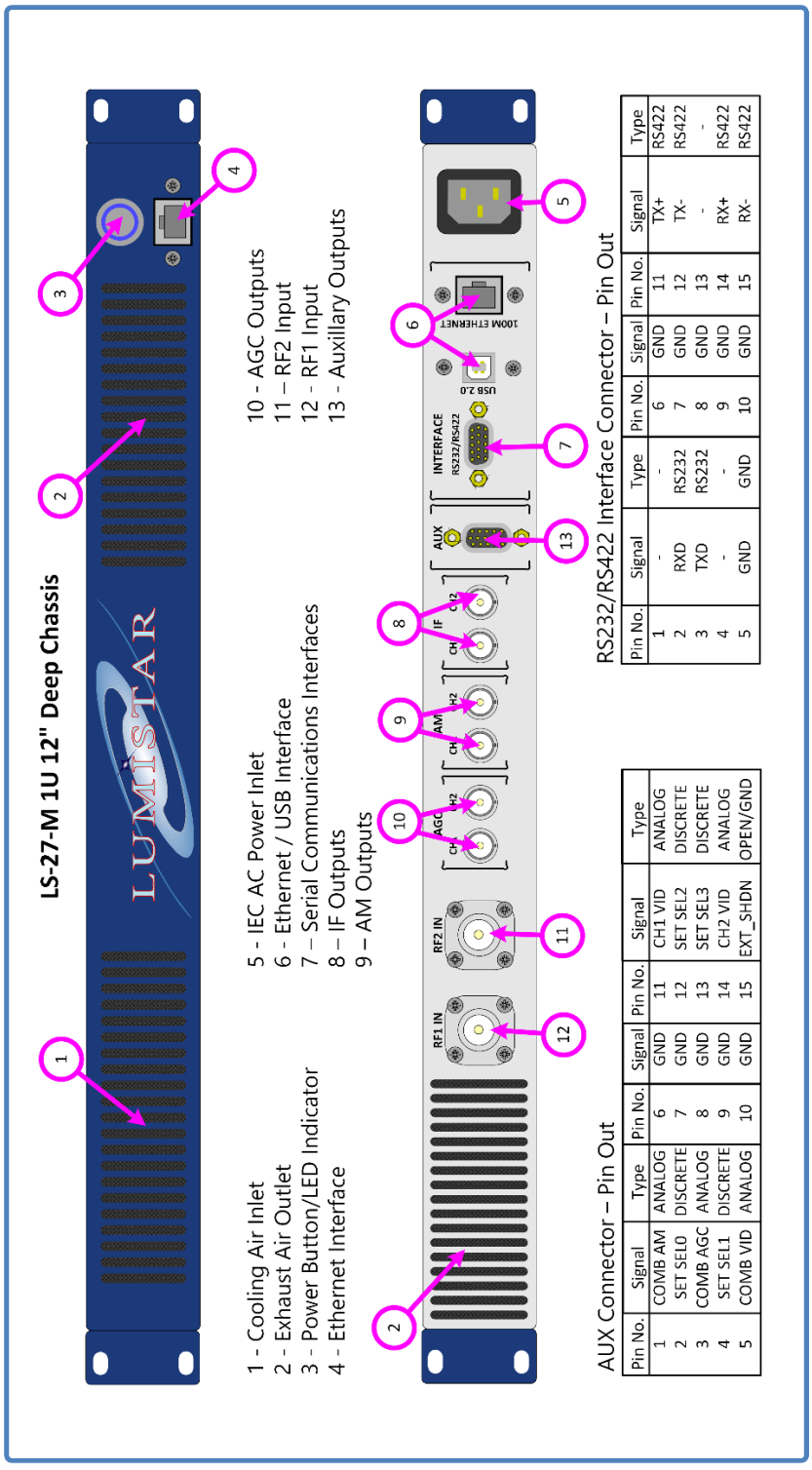


Figure 3-12 LS-27-M Desktop chassis – Lower Housing Mounting Points

3.5.2 1U 12" LS-27-M Chassis

Lumistar offers the LS-27-M designs in 19" 1U rackmount configuration.



Pin No.	Signal	Type	Pin No.	Signal	Pin No.	Signal	Type
1	COMB AM	ANALOG	6	GND	11	CH1 VID	ANALOG
2	SET SEL0	DISCRETE	7	GND	12	SET SEL2	DISCRETE
3	COMB AGC	ANALOG	8	GND	13	SET SEL3	DISCRETE
4	SET SEL1	DISCRETE	9	GND	14	CH2 VID	ANALOG
5	COMB VID	ANALOG	10	GND	15	EXT_SHDN	OPEN/GND

Pin No.	Signal	Type	Pin No.	Signal	Pin No.	Signal	Type
1	-	-	6	GND	11	TX+	RS422
2	RXD	RS232	7	GND	12	TX-	RS422
3	TXD	RS232	8	GND	13	-	-
4	-	-	9	GND	14	RX+	RS422
5	GND	GND	10	GND	15	RX-	RS422

Figure 3-13 LS-27-M 1U 12" Chassis Front and Rear Panels

The 12" deep 1U LS-27-M chassis requires an external host PC to run the application software to control and status the LS-27-M. The chassis contains the receiver and all power and cooling provisions. The chassis also contains an unmanaged 100/10Mbps Ethernet 5-Port Switch (model: Netgear GS305-100PAS) for network connections between the internal receiver and the front and rear panel mounted Ethernet connectors. The 12" version of the chassis can be offered with optional DC power input. Consult with the Lumistar sales for availability. In the case that DC power provision is elected, the AC power connector on the rear of the chassis is replaced with an Amphenol PT02A-8-4P (025) bayonet power connector. This unit is **not** delivered with an auxiliary (AUX) interface cable or an interface connection to the serial connector. If these are required, consult Lumistar Sales for availability. Overall specifications and the pin connections of the DC connector are listed in Table 2-3.

3.6 Cooling and Thermal Conditioning

The LS-27-M must maintain a satisfactory operating temperature range to ensure sustainable functionality. It is **highly recommended** that provisions for forced air are used to cool the device during operation. The unit itself provides a significant heat load during typical operations which typically reaches 24 to 26 Watts.

Auxiliary items that are purely analog in nature consume even greater amounts of power and thus increase the heat load of the device.

The design is constructed from aluminum which is where all generated heat is directed. The sides of the unit are the primary heat sinking area. Although the top and bottom surfaces of the device will dissipate heat, they act in a secondary role to the sides of the device. This fact is what drives the design of our desktop chassis. In this fixture, we provide approximately 40.6 Cubic Feet per Minute (CFM) of airflow which is directed around the sides of the chassis.

Of course, ambient temperature of the applied forced air is also a factor. In general, the maximum operating temperature of **the unit should not exceed 70 degrees C for extended periods**. Its optimal operational temperature should be maintained in the 40-60 degree C range.

The user must maintain awareness of the ambient ingested air. Conditions such as barometric pressure, the amount of moisture in the air, and air temperature will affect the cooling capacity of inlet air. If the ambient air temperature is already 40 degrees Celsius, the cooling efficiency of this input air is very limited.

Warning:

If the unit temperature exceeds 70 degree Celsius, degraded operation may occur. Steps should be taken to provide properly cooling to ensure continued operation.

4 Communications and Programming Interface

The LS-27-M can communicate through one of three physical interface paths. The three interfaces include: an RS-232 (or selectable RS-422/485 4-Wire) serial interface, a USB 2.0 serial interface, and a 10/100 Ethernet serial interface. Each of these interfaces function simultaneously.

Information:

In the event that there is simultaneous communications on more than one serial interface, the last commanding interface would control the operating state of the LS-27-M.

Caution:

No command and control interface is provided priority over any other.

4.1 Serial/USB Interface

The LS-27-M provides a simple RS-232 serial interface. The asynchronous interface lacks flow-control and thus operates as a three-wire (transmit, receive, and ground) physical connection. As delivered, the interface operates at 57.6K BAUD using 8 data bits, 1 start bit, 1 stop bit and no parity.

The LS-27-M provides a USB 2.0 serial interface. Included with the delivery is a driver installation that converts the USB serial interface into a standard MS Windows or Linux COM port for simplifying the interface. As delivered, the interface typically communicates at 57.6K BAUD using 8 data bits, 1 start bit, 1 stop bit and no parity. The speed can be increased dramatically to a maximum of 921.6K BAUD. This interface is capable of being used as a secondary interface for field upgrades of on-board firmware sources, as a control and status port, and as a debug interface. Lumistar provides a USB driver interface installation package to support the USB port. This package is located on the software installation disk and must be installed on the host platform prior to use of the USB interface.

4.2 Ethernet Network Interface

The LS-27-M provides a 10/100Mbps Ethernet interface. This interface is considered the "primary" and the most capable device interface.

The interface data speed is automatically detected and switched by the interface hardware. Communications is provided via the Internet Protocol (IP) [IPv4] suite via two transport layer communications protocols: Transmission Control Protocol (TCP), and User Datagram Protocol (UDP). The TCP protocol is utilized for commanding, general status from the device. The UDP protocol is used in the device "discovery" process. Typical Port assignments are port 5000. The unit allows for IP address selection, static and DHCP address assignments, subnet mask assignment, and gateway assignments.

4.2.1 Initial setup of the Network Interface for the LS-28-DRSM

The LS-27-M is delivered configured with a **Static IP Address**. The primary default address is **192.168.16.227**. If the user desires that the unit be switched to a different static IP address, or to Dynamic Host Configuration Protocol (DHCP) mode, a controlling host set to the same sub-net mask will be required so the setup can be completed.

In cases where Lumistar has been made aware ahead of time that unit deliveries are to be used on the same network subnet in a multiple-unit configuration, the units will be assembled and tested prior to delivery in a mock configuration. In these cases, IP addressing becomes more complicated than single unit deliveries because the same static IP address cannot be used for each device. In multi-unit deliveries, the last octet of the IP address will often be configured in steps of five. For example, in a multi-unit delivery of four units that are to be used simultaneously, the IP assignments upon delivery would be as follows:

Unit 1 IP Address: 192.168.16.227

Unit 2 IP Address: 192.168.16.232

Unit 3 IP Address: 192.168.16.237

Unit 4 IP Address: 192.168.16.242

Configuring hosts communication between various network configurations is operating system dependent and will be generally outlined below. Slight operating system variations in functional screens may exist and will be up to the user to interpret.

Information:
Network configuration, connection and security typically require consent and access privileges from a network system administrator. The sections that follow attempt to describe the necessary steps that need to be taken in a rather "Open" network environment. Specific requirements in terms of network security and connection routing are the user's responsibility. Please contact your system administrator before going further.

4.3 Protocol and Messaging

This chapter provides interface protocol information for the LS-27-M receiver. The product is offered in single channel format in which case only the channel 1 commands will be responded to.

4.3.1 Protocol

The LS-27-M supports the traditional protocol of all existing LS-27B product families as well as optional "extended" LS27M series commands. By default, the LS27 protocol is backwards compatible with all previous generations of the LS27B product generations. The LS27M series of commands will be additions to the existing set of commands added in the future to address some of the enhanced features that exist in the

LS-27-M generation of hardware that were not available in the previous generations. The release of this document only covers the LS27 protocol until further definition exists on the LS27M enhanced commands are developed.

4.3.1.1 Command and Status Messaging – LS27 Protocol

Interface to the LS-27-M is via command-response messaging. For every command sent from the host, the receiver will respond to indicate that the command was received, at a minimum. If commands are sent requesting status additional bytes of data will also be returned in the response. 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 4-1 contains a diagram of the message header for the interface 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.

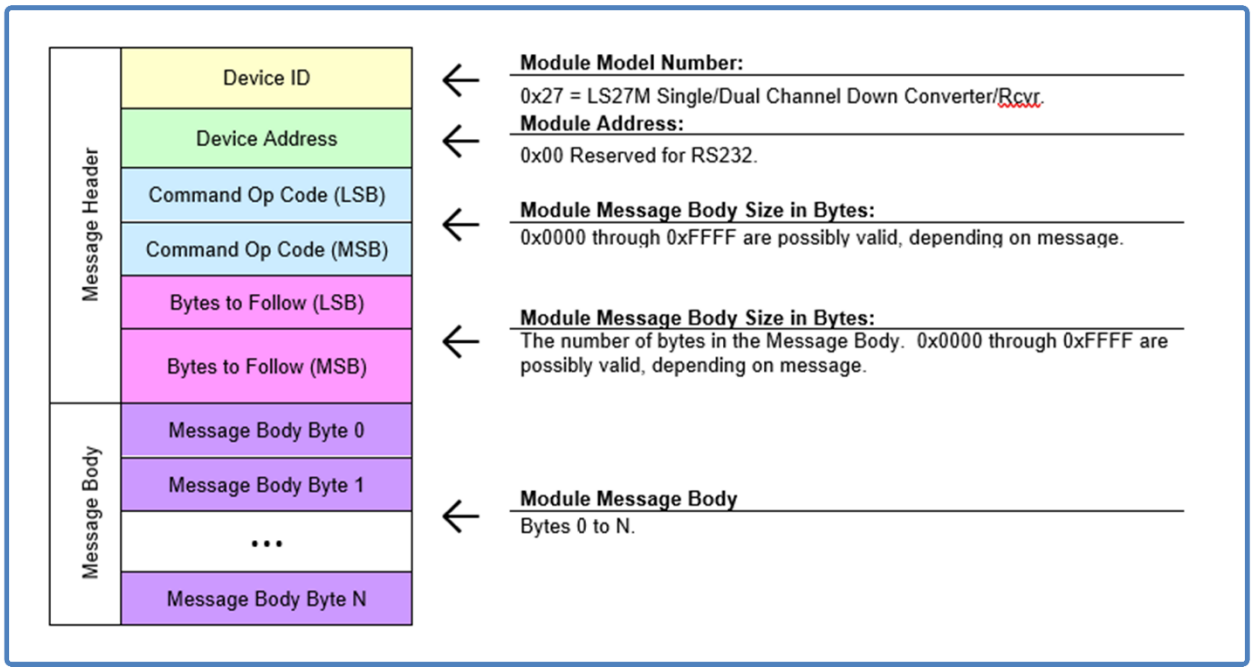


Figure 4-1 Message Header – LS-27 Protocol

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 4-2 indicates the general configuration of the host and terminal message transactions.

There are five message types: a "Ping" message, a "Primary Setup" message, a "Secondary Setup" message, a "General Status" message, and a "EEPROM Page Read" message.

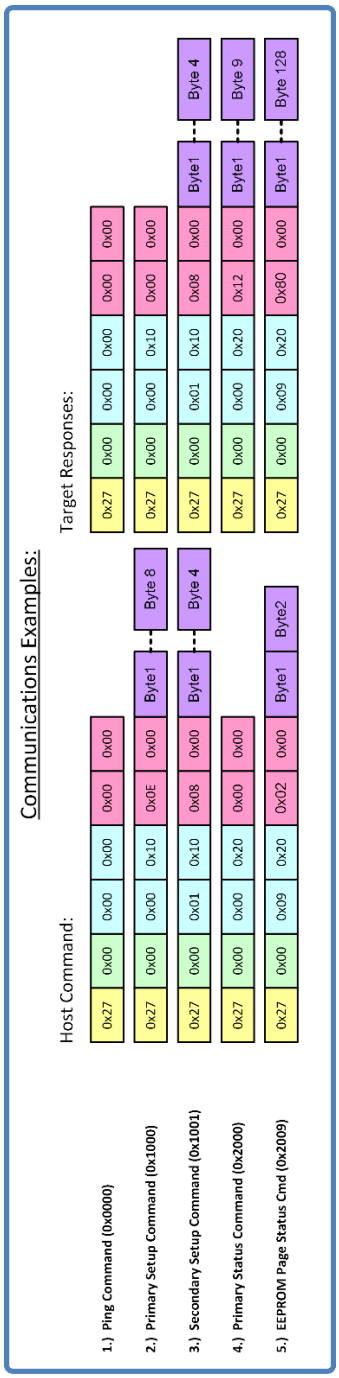


Figure 4-2 Message Transaction Examples – LS27 Protocol

4.3.1.1.1 Ping Command Messaging – 0x0000 Message ID

The "Ping" command is used as to determine the health and 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. The message format appears in Figure 4-3.

Ping Command Content (Message ID = 0x0000)

Header Byte	D7	D6	D5	D4	D3	D2	D1	D0	Notes:
0	Device ID								0x00 or 0x27
1	Device Address								0x00
2	Command Op Code LSB								0x00
3	Command Op Code MSB								0x00
4	Bytes to Follow LSB								0x00
5	Bytes to Follow MSB								0x00
Body Byte	**D7**	**D6**	**D5**	**D4**	**D3**	**D2**	**D1**	**D0**	**Notes:**
(none)									

Ping Command Response

Header Byte	D7	D6	D5	D4	D3	D2	D1	D0	Notes:
0	Device ID								0x27
1	Device Address								0x00
2	Command Op Code LSB								0x00
3	Command Op Code MSB								0x00
4	Bytes to Follow LSB								0x00
5	Bytes to Follow MSB								0x00
Body Byte	**D7**	**D6**	**D5**	**D4**	**D3**	**D2**	**D1**	**D0**	Notes:
(none)									

Figure 4-3 Ping Message Construction – LS-27 Protocol

4.3.1.1.2 Primary Setup Command/Response Message – 0x1000 Message ID

The "Primary Setup" message provides fundamental control information to the receiver channel. The message header is followed by eight (8) data bytes as defined in Figure 4-4. Bit definitions are also defined below.

Setup Command Content (Message ID = 0x1000)

Header Byte		D7	D6	D5	D4	D3	D2	D1	D0	Notes:
0		Device ID								0x27
1		Device Address								0x00
2		Command Op Code LSB								0x00
3		Command Op Code MSB								0x10
4		Bytes to Follow LSB								0x08
5		Bytes to Follow MSB								0x00
Body Byte		**D7**	**D6**	**D5**	**D4**	**D3**	**D2**	**D1**	**D0**	**Notes:**
0	6	-	XDOUT	DAT POL	SETUP_NUMBER				DCx	
1	7	INTREF	-	-	-	-	-	-	-	
2	8	LIM	AGCZERO	BANDOFPREF		FRZ	AGCTC			
3	9	AFC*	IFBW			DEEMPHFIL	VFLT			
4	10	AMINV	-	-	AMFIL					
5	11	TUNE1 (Fc *mod* 1MHz / 10kHz)								
6	12	TUNE2 (Fc *mod* 256MHz / 1MHz)								
7	13	TUNE3 (Fc / 256MHz)								

* - AFC is only available on future versions of the LS27M version.

Setup Command Response

Header Byte	D7	D6	D5	D4	D3	D2	D1	D0	Notes:
0	Device ID								0x27
1	Device Address								0x00
2	Command Op Code LSB								0x00
3	Command Op Code MSB								0x10
4	Bytes to Follow LSB								0x00
5	Bytes to Follow MSB								0x00
Body Byte	**D7**	**D6**	**D5**	**D4**	**D3**	**D2**	**D1**	**D0**	Notes:
(none)									

Figure 4-4 Primary Setup Message Construction – LS-27 Protocol

Bit Definitions for the Primary Setup command are shown in Figure 4-5.

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
AFC	Automatic Frequency Control	0 =Disabled, 1 = Enabled *(Future LS27M Option)*
INTREF	Internal/External Reference Clock Selection	0=Select External Reference Clock, 1=Select Internal Reference Clock
XDOUT	External Discrete Output (for RF FE Switch)	1 = RF Input A, 0 = RF Input B
DAT POL	FM Demodulator Output Polarity	0=Normal Polarity, 1=Inverse Polarity. (FM Demod Option Required)
LIM	Hardware Limited Mode	0=LIM mode is off, 1=LIM mode is on.
AGCZERO	AGC Zero Mode	0=AGC Zero mode is off, 1=AGC Zero mode is on.
BANDOFPREF	Band Of Preference	Selects the band to start looking for the Center Frequency.
FRZ	AGC Freeze	0=Freeze DAGC Discrete Out Processing. 1=Enable DAGC Discrete Out Processing.
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. (FM Demod Option Required)
DEEMPHFIL	DeEmphasis Filter Selection	0=DeEmphasis Disabled, 1= DeEmphasis Enabled. (FM Demod Option Required)
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 Hertz.
TUNE1	Receiver Tune Center Frequency Wd 1	Wd1 Receiver Center Frequency (MHz) (Fc mod 1MHz)/10kHz
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/256MHz
SNUM	Setup Number	Save the current setup to one of 16 possible storage locations.

Figure 4-5 Primary Setup Message Construction Bit Definitions – LS-27 Protocol

4.3.1.1.3 Secondary Setup Command/Response Message – 0x1001 Message ID

The Secondary Setup command 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 4-6. Mode command definitions are shown in Figure 4-7. Mode command response definitions are shown in Figure 4-8. For special Mode Command "Get Setup Info", responses are shown in Figure 4-9.

Mode Command Content (Message ID = 0x1001)

Header Byte		D7	D6	D5	D4	D3	D2	D1	D0	Notes:
0		Device ID								0x27
1		Device Address								0x00
2		Command Op Code LSB								0x01
3		Command Op Code MSB								0x10
4		Bytes to Follow LSB								0x04
5		Bytes to Follow MSB								0x00
Body Byte		**D7**	**D6**	**D5**	**D4**	**D3**	**D2**	**D1**	**D0**	**Notes:**
0	6	MODE					-	-	DCx	
1	7	CMD1								
2	8	CMD2								
3	9	CMD3								

Mode Command Response

Header Byte		D7	D6	D5	D4	D3	D2	D1	D0	Notes:
0		Device ID								0x27
1		Device Address								0x00
2		Command Op Code LSB								0x01
3		Command Op Code MSB								0x10
4		Bytes to Follow LSB								0x04
5		Bytes to Follow MSB								0x00
Body Byte		**D7**	**D6**	**D5**	**D4**	**D3**	**D2**	**D1**	**D0**	**Notes:**
0	6	MODE					-	-	DCx	
1	7	STAT1								
2	8	STAT2								
3	9	STAT3								

Figure 4-6 Secondary Setup Message Construction – LS-27 Protocol

Mode	Definition	CMD1	CMD2	CMD3
0x02	EEPROM Mode	EEPROM Sub Mode: 000ppppb = 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 = (Reserved) 0x03 = (Reserved)	(Unused)	(Unused)
0x06	Read AM LPF Table	(Unused)	Table Index (0 to 31)	(Unused)
0x07	Read AM Freq Value	(Unused)	(Unused)	(Unused)
0x09	Read SW2 Mode Cmd	0x00=Read, 0x80=Write	If Write, 0x40=Prefer To Use EEPROM	If Write, GPSTAT1 (SW2) Values
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 DAGC 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)
0x0C	Implementation A Override (for development use only)	| 5 4 3 2 1 0| 5 4 3 2 1 0| 5 4 3 2 1 0| 5 4 3 2 1 0| | VGA2 | ATTN2 | VGA1 | ATTN1 | |23 22 21 20 19 18|17 16|15 14 13 12|11 10 09 08|07 06|05 04 03 02 01 00| | CMD3 | CMD2 | CMD1 | | 7 6 5 4 3 2 1 0| 7 6 5 4 3 2 1 0| 7 6 5 4 3 2 1 0|		
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)
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	Host RSSI Averaging Mode	0=No Averaging, 1=Filtered Averaging	0=Write CMD1 Value, 1=Read Only	(Unused)
0x18	Front End Attenuator Control Mode	| 7 | 6 |5|4|3|2|1|0| DC1: |Wrt|Fra|Atten Value|	| 7 | 6 |5|4|3|2|1|0| DC2: |Wrt|Fra|Atten Value|	DC1&|7|6|5|4|3|2| 1 | 0 | DC2: | |Wrt|On At Boot|
0x19	Rd Stored Environment Values	0 = Max Temp °C, 1 = Min Temp °C 2 = Max Voltage, 3 = Min Voltage 4 = Max Amperage, 5 = Min Amperage, 6 = Current Temp °C, 7 = Current Voltage, 8 = Current Amperage	(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 4-7 Secondary Setup Message Mode Command Definitions – LS-27 Protocol

Mode	Functional_Mode	STAT1	STAT2	STAT3
0x02	EEPROM Mode: Read	Page_Offset	8 LSBs of EEPROM Read Value	8 MSBs of EEPROM Read Value
0x02	EEPROM Mode: Pg Set	Page Number	(Unused = 0)	(Unused = 0)
0x03	Tune Mode	Fc Mod 1MHz/10Khz	Fc MOD 256MHz/1MHz	Fc/256MHz
0x04	DAGC Control Mode	DAGC Control Mode Commanded	(Unused = 0)	(Unused = 0)
0x06	Read AM LPF Table	Index Value	8 LSBs of AM LPF Fc Frequency	8 MSBs of AM LPF Fc Frequency
0x07	Read AM Freq Counter	8 LSBs of AM Counter Frequency	8 Mid-SBs of AM Counter Frequency	1 MSB of AM Counter_Frequency
0x09	Read SW2	BIT7=0, Device is LS27B BIT7=1, Device is LS27P3 BIT6=1, No Physical Switch exists BIT5=1, Prefer to use EEPROM instead of Physical Switch	LS27B: SW2 Values (0x00 to 0xFF) LS27P3: SW2 Values (0x00 to 0x0F)	LS27B: Ext. Disc. Lines (0x00-0x1F) LS27P3: Unused, 0x00
0x0A	Program Custom Time Constants	Custom Time Constant Number (Values between 1 and 3)	8 LSBs of 100 usec Tconstant Multiple	8 MSBs of 100 usec Tconstant Multiple
0x0B	Select DAGC Output Range	(Unused = 0)	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 = 0)
0x0D	Program Digipot Mode		Current Digipot Setting (0 – 99)	
0x0E	Programmable AGC Out dBm Range	Lower dBm value in 2's complement format.	Upper dBm value in 2's complement format.	(Unused = 0)
0x0F	Programmable AGC Out Voltage Range	Starting voltage value * 10 in 2's complement value.	Ending voltage value * 10 in 2's complement format.	(Unused = 0)
0x10	DAC Adjust Mode	DAC Selection Value	8 LSBs of the DAC Setting	6 MSBs of the DAC Setting
0x12	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.	| 7 | 6 |5|4| 3 |2|1| 0 | |LIM|AGCZERO|-|-|FRZ|-|-| - | Fc Mod 1MHz/10Khz AGC Time Constant value in 100 usec LSB Lower dBm value in 2's comp format Start voltage value * 10 in 2's comp |POL|AGCTC Index| VFIL |CAL| External RSSI Correction MSB External Compression Point MSB	|7|6|5|4| 3 |2| 1 | 0 | |-| IFBW|DEEMP|-|BANDOFPREF| Fc MOD 256MHz/1MHz AGC Time Constant value in 100 usec 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	| 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)
0x17	Host RSSI Averaging	0=No Averaging, 1=Filtered Averaging	(Unused = 0)	(Unused = 0)
0x18	Front End Attenuator Control Mode	|7| 6 |5|4|3|2|1|0| DC1:| |Frz|Atten Value|	|7| 6 |5|4|3|2|1|0| DC2:| |Frz|Atten Value|	DC1&|7|6|5|4|3|2|1| 0 | DC2:| |On At Boot|
0x19	Rd Stored Environment Values	0 = Max Temp °C, 1 = Min Temp °C, 2 = Max Voltage, 3 = Min Voltage, 4 = Max Amperage, 5 = Min Amperage, 6 = Current Temp °C, 7 = Current Voltage, 8 = Current Amperage.	8 LSBs of Temp Value (Signed Int16) 8 LSBs of Voltage 8 LSBs of Current	8 MSBs of Temp Value (Signed Int16) 8 MSBs of Voltage 8 MSBs of Current
0x1F	Serial Channel Control Mode	(Unused = 0)	(Unused = 0)	(Unused = 0)

Figure 4-8 Secondary Setup Message Mode Command Responses – LS-27 Protocol

Get Setup Info Mode Table:

Get DCxCTRL124 Values		7	6	5	4	3	2	1	0
Submode= 0x00	STAT1	LIM	AGCZERO	-		FRZ	-		
	STAT2	-	IFBW Filter Index			DEEMP	-	Band of Preference	
	STAT3	AM Inverse	-		AM Filter Index				

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	AGC Time Constant Value in 100 µsecs LSB							
	STAT2	AGC Time Constant Value in 100 µsecs MSB							
	STAT3	-				Host RSSI Averaging		DAGC Control Mode	

Get AGC Out dBm Range		7	6	5	4	3	2	1	0
Submode= 0x03	STAT1	Lower dBm Value							
	STAT2	Upper dBm Value							
	STAT3	DAGC Output Range							

Get AGC Out Voltage Range		7	6	5	4	3	2	1	0
Submode= 0x04	STAT1	Lower Voltage Value (x10)							
	STAT2	Upper Voltage Value (x10)							
	STAT3	DAGC Output Range							

Get Miscellaneous Values		7	6	5	4	3	2	1	0
Submode= 0x05	STAT1	FM Demod Polarity	AGC Time Constant Index			Video Filter Index			DAGC Cal Mode
	STAT2	-							
	STAT3	-							

Get External RSSI Correction		7	6	5	4	3	2	1	0
Submode= 0x06	STAT1	External RSSI Correction MSB							
	STAT2	External RSSI Correction LSB							
	STAT3	-							

Get Ext. Compression Point		7	6	5	4	3	2	1	0
Submode= 0x07	STAT1	External Compression Point MSB							
	STAT2	External Compression Point LSB							
	STAT3	-							

Figure 4-9 Secondary Setup Message Mode Command Get Setup Info Responses – LS-27 Protocol

4.3.1.1.4 General Status Command/Response Message – 0x2000 Message ID

The General Status command provides receiver operational status such as signal strength, deviation amounts, AM index values, and certain lock states. The message definition is shown in Figure 4-10. Bit definitions for the command are shown in Figure 4-11.

General Status Command Content (Message ID = 0x2000)

Header Byte	D7	D6	D5	D4	D3	D2	D1	D0	Notes:
0	Device ID								0x27
1	Device Address								0x00
2	Command Op Code LSB								0x00
3	Command Op Code MSB								0x20
4	Bytes to Follow LSB								0x00
5	Bytes to Follow MSB								0x00
Body Byte	**D7**	**D6**	**D5**	**D4**	**D3**	**D2**	**D1**	**D0**	**Notes:**
(none)									

General Status Command Response

Header Byte		D7	D6	D5	D4	D3	D2	D1	D0	Notes:
0		Device ID								0x27
1		Device Address								0x00
2		Command Op Code LSB								0x00
3		Command Op Code MSB								0x20
4		Bytes to Follow LSB								0x09
5		Bytes to Follow MSB								0x00
Body Byte		**D7**	**D6**	**D5**	**D4**	**D3**	**D2**	**D1**	**D0**	**Notes:**
0	6	REFSTATE	PLLSYNC	-	-	-	-	-	-	
1	7	DC1RSSILO								
2	8	DC1COMPWARN	DC1ZEROSTAT	DC1LO2STAT	DC1LO1STAT	DC1RSSIHI				
3	9	DC1XDIN	DC1AMINDX							
4	10	-	DC1FMDEV							
5	11	DC2RSSILO								
6	12	DC2COMPWARN	DC2ZEROSTAT	DC2LO2STAT	DC2LO1STAT	DC2RSSIHI				
7	13	DC2XDIN	DC2AMINDX							
8	14	-	DC2FMDEV							

Figure 4-10 General Status Message Construction – LS-27 Protocol

Response Mnemonic	Description/Definition	Logic State/Explanation
REFSTATE	Present state of the Internal/External Reference Select	1 = Internal Reference Selected, 0 = External Reference Selected
PLLSYNC	Internal Synthesizer Reference Synchronization Status	1 = PLL Synchronized, 0 = PLL Unsynchronized
DCxRSSILO	DCx Received Signal Strength (8 LSBs)	Lower 8 bits of RSSI level
DCxRSSIHI	DCx Received Signal Strength (4 MSBs)	Upper 4 bits of RSSI level
DCxCOMPWARN	DCx Compression Warning	0 = Not in compression, 1 = May be in compression.
DCxAMINDX	DCx Measured AM Index	AM Index Measurement (Range 0-127)
DCxLO1STAT	DCx LO1 Status	1 = Locked, 0 = Unlocked
DcxLO2STAT	DCx LO2 Status	1 = Locked, 0 = Unlocked
DCxXDIN	DCx External Discrete Input (PIN4)	1 = Logic High State, 0 = Logic Low State
DCxFMDEV	DCx FM Deviation in Percent	Valid range is from 0% – 127%.
DCxZEROSTAT	DCx AGC Zero State	1=In AGC Zero Mode, 0=Not in AGC Zero Mode.

Figure 4-11 General Status Message Bit Definitions– LS-27 Protocol

4.3.1.1.5 EEPROM Page Read Command/Response Message – 0x2009 Message ID

The primary receiver configuration information, used to drive software GUIs and 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 Page read Message structure is shown in Figure 4-12. Bit definitions for the message are shown in Figure 4-13. An example of the EEPROM contents is shown in Figure 4-14.

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

Header Byte	D7	D6	D5	D4	D3	D2	D1	D0	Notes:
0	Device ID								0x27
1	Device Address								0x00
2	Command Op Code LSB								0x09
3	Command Op Code MSB								0x20
4	Bytes to Follow LSB								0x02
5	Bytes to Follow MSB								0x00
Body Byte	**D7**	**D6**	**D5**	**D4**	**D3**	**D2**	**D1**	**D0**	**Notes:**
0	6	-	-	-	-	-	-	DCx	
1	7	-	-	-	PAGE				

EEPROM Page Status Command Response

Header Byte	D7	D6	D5	D4	D3	D2	D1	D0	Notes:
0	Device ID								0x27
1	Device Address								0x00
2	Command Op Code LSB								0x09
3	Command Op Code MSB								0x20
4	Bytes to Follow LSB								0x80
5	Bytes to Follow MSB								0x00
Body Byte	**D7**	**D6**	**D5**	**D4**	**D3**	**D2**	**D1**	**D0**	**Notes:**
0	6	LOC0_LSB							
1	7	LOC0_MSB							
2-125	8-131	...							
126	132	LOC63_LSB							
127	133	LOC63_MSB							

Figure 4-12 EEPROM Page Read Message Construction – LS-27 Protocol

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 4-13 EEPROM Page Read Message Bit Definitions – LS-27 Protocol

LS27M1 Configuration EEPROM Map – Pg Address 0

EEPROM Address Offset (Hex)	EEPROM Address Offset (Dec)	Register Contents	LS27M1 Downconverter #1 (Decimal [*])	LS27BM1 Downconverter #2 (Decimal [*])
0x00	0	IFBW0 (kHz):	250[*]	250[*]
0x01	1	IFBW1 (kHz):	500[*]	500[*]
0x02	2	IFBW2 (kHz):	1000[*]	1000[*]
0x03	3	IFBW3 (kHz):	2000[*]	2000[*]
0x04	4	IFBW4 (kHz):	5000[*]	5000 [*]
0x05	5	IFBW5 (kHz):	10000[*]	10000[*]
0x06	6	IFBW6 (kHz):	20000[*]	20000[*]
0x07	7	IFBW7 (kHz):	40000[*]	40000[*]
0x08	8	MSB: Averaging Function enumeration value, LSB:# of LOG samples taken in the RSSI Calc.	0x0003	0x0003
0x09	9	DAGC Limited Mode Target in dBm.	0	0
0x0A	10	AGC Time Constant 0 (100 µSec Updates):	1 (0.1msec)	1 (0.1msec)
0x0B	11	AGC Time Constant 1 (100 µSec Updates):	10 (1msec)	10 (1msec)
0x0C	12	AGC Time Constant 2 (100 µSec Updates):	100 (10msec)	100 (10msec)
0x0D	13	AGC Time Constant 3 (100 µSec Updates):	1000 (100msec)	1000 (100msec)
0x0E	14	AGC Time Constant 4 (100 µSec Updates):	10000 (1sec)	10000 (1sec)
0x0F	15	AGC Custom Time Constant 1	50 [*] (5msec)	50 [*] (5msec)
0x10	16	AGC Custom Time Constant 2	500 [*] (50msec)	500 [*] (50msec)
0x11	17	AGC Custom Time Constant 3	5000 [*] (500msec)	5000 [*] (500msec)
0x12	18	FE Attenuator Hysterious in ½ dBm Steps	4	4
0x13	19	Band 0 Start Freq (MHz):	2200 [*]	2200 [*]
0x14	20	Band 0 Stop Freq (MHz):	2400[*]	2400[*]
0x15	21	Band 1 Start Freq (MHz):	1710[*]	1710[*]
0x16	22	Band 1 Stop Freq (MHz):	1850[*]	1850[*]
0x17	23	Band 2 Start Freq (MHz):	1435[*]	1435[*]
0x18	24	Band 2 Stop Freq (MHz):	1540[*]	1540[*]
0x19	25	Band 3 Start Freq (MHz):	70[*]	70[*]
0x1A	26	Band 3 Stop Freq (MHz):	70[*]	70[*]
0x1B	27	Tuning Step: Band1 (LSByte = Step x 5kHz) Band2 (LSByte = Step x 5kHz)	0x0A0A	0x0A0A
0x1C	28	Tuning Step: Band3 (LSByte = Step x 5kHz) Band4 (LSByte = Step x 5kHz)	0x0A00	0x0A00
0x1D	29	Band 0 RSSI M Scale: (x10000)	293	293
0x1E	30	Band 0 RSSI B Scale: (x10)	-1100	-1100
0x1F	31	Band 1 RSSI M Scale: (x10000)	293	293
0x20	32	Band 1 RSSI B Scale: (x10)	-1100	-1100
0x21	33	Band 2 RSSI M Scale: (x10000)	293	293
0x22	34	Band 2 RSSI B Scale: (x10)	-1100	-1100
0x23	35	Band 3 RSSI M Scale: (x10000)	293	293
0x24	36	Band 3 RSSI B Scale: (x10)	-1100	-1100
0x26	37	Video Filter 0 BW (kHz)	125[*]	125[*]
0x26	38	Video Filter 1 BW (kHz)	250[*]	250[*]
0x27	39	Video Filter 2 BW (kHz)	500[*]	500[*]
0x28	40	Video Filter 3 BW (kHz)	1000[*]	1000[*]
0x29	41	Video Filter 4 BW (kHz)	2500[*]	2500[*]
0x2A	42	Video Filter 5 BW (kHz)	4200[*]	4200[*]
0x2B	43	Video Filter 6 BW (kHz)	10000[*]	10000[*]
0x2C	44	Video Filter 7 BW (kHz)	15000[*]	15000[*]
0x2D	45	Serial Channel BAUD (Rate/100)	576[*]	576[*]
0x2E	46	Serial Channel Format (#bits, pe, parity, #stop bits)	0x0080	Select SCIA Comm Type
0x2F	47	DeEmphasis Filter value in number of lines	525	525
0x30	48	FPGA Firmware Version / Invert PLL Lock Indication	0	*Unused/Spare*
0x31	49	DSP Firmware Version ID MSW:	0x0209	*Unused/Spare*
0x32	50	DSP Firmware Version ID LSW:	0x2009	*Unused/Spare*
0x33	51	RF/IF Hardware Port Configuration	0x0015	0x0015
0x34	52	Board Serial Number MSW	0x2700	(Highest Record Temp)
0x35	53	Board Serial Number LSW	0x0001	(Lowest Record Temp)
0x36	54	External Reference Input Frequency Setting (MHz)	10	(GPSTAT1 Replacement)
0x37	55	RF Input Switch Available	0	0
0x38	56	Board ID ASCII Character 0:	'L' (76)	(Highest Record Voltage)
0x39	57	Board ID ASCII Character 1:	'S' (83)	(Lowest Record Voltage)
0x3A	58	Board ID ASCII Character 2:	'2' (50)	(Highest Record Current)
0x3B	59	Board ID ASCII Character 3:	'7' (57)	(Lowest Record Current)
0x3C	60	Board ID ASCII Character 4:	'M' (77)	*Unused/Spare*
0x3D	61	Board ID ASCII Character 5:	'1' (49)	*Unused/Spare*
0x3E	62	Board ID ASCII Character 6:	0 *(ASCII 'null')*	*Unused/Spare*
0x3F	63	Board ID ASCII Character 7:	0 *(ASCII 'null')*	*Unused/Spare*

[*] = Values may be different based on User configurations

Figure 4-14 EEPROM Page Read of Primary Page 0