



LS-28-DRSM Multi-Mode Modular Receiver

User's Manual



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Acronyms

AEQ – Adaptive Equalization
AGC - Automatic Gain Control
AM - Amplitude Modulation
ASCII – American Standard Code for Information Interchange
AUQPSK - Asymmetric Unbalanced Quadrature Shift Keying
BCD – Binary Coded Decimal
BER - Bit Error Rate
BERT - Bit Error Rate Test
BNC - Bayonet Neill–Concelman (connector)
BPSK - Binary Phase Shift Keying
BSC – Best Source Combining
BW – Bandwidth
dB – Decibel
dBm – Decibel milliwatts
CF – Control Functions
CH10 – IRIG-106 Chapter 10
CLK – Clock
DAT - Data
DHCP – Dynamic Host Configuration Protocol
DRSM – Dual Receiver System Modular
DSP - Digital Signal Processor or Digital Signal Processing
Eb/No - Energy per bit/Noise Energy
EGC – Equal Gain Combining
EOF – End-of-File
FAC - Frame Alternate Complement
FCC - Frame Code Complement
FEC - Forward Error Correction
FFID – Frame Format Identification
FM - Frequency Modulation
FPGA – Field Programmable Gate Array
GB - Gigabyte
GHz - Giga Hertz
GUI – Graphical User Interface
Hz - Hertz
ICD - Interface Control Document
IF - Intermediate Frequency
INV - Invert
IP - Internet Protocol
IRIG - Inter-Range Instrumentation Group
KB – Kilobyte

Acronyms (continued)

kHz - KiloHertz
LBW - Loop Bandwidth
LDPC - Low Density Parity Coding
LDPS - Lumistar Data Processing System
LED - Light Emitting Diode
LSB - Least Significant Bit
Mbps - Mega Bits Per Second
Msps - Mega Symbols per Second
MH-CPM - Multi-H Constant Phase Modulation
MHz - Mega Hertz
MRC - Maximum Ratio Combining
MSB - Most Significant Bit
MS-PCMFM - Mutli-Symbol Pulse Code Modulation Frequency Modulation
NTSC - National Television System Committee
OQPSK - Offset Quadrature Phase Shift Keying
OS - Operating System
OSI - Open System Interconnect
PAL - Phase Alternating Line
PCM - Pulse Code Modulation
PLL - Phase Lock Loop
PM - Phase Modulation
PSK - Phase Shift Keying
PTP - Precision Time Protocol (IEEE-1588)
QPSK - Quadrature Phase Shift Keying
RF - Radio Frequency
RX - Receive
SBS - Straight Binay Seconds
SE - Single-Ended
SFID - Sub Frame Identification
SMA - Subminiature Version A
SMB - Subminiature Version B
SOQPSK-MIL - Shapped Offset Quadrature Shift Keying - Military
SOQPSK-TG - Shapped Offset Quadrature Shift Keying - Task Group
SOY - Seconds of Year
SRRC - Square-Root Rasied Cosine
SS-PCMFM - Single Symbol Pulse Code Modulated Frequency Modulation
STC - Space Time Code
TCP - Transmisson Control Protocol
TOY - Time of Year

Acronyms (continued)

TX - Transmit

URC - Unique Recycling Code

USB - Universal Serial Bus

1PPS – One Pulse Per Second

1 Introduction

1.1 General

The following document contains information on the Lumistar LS-28-DRSM multi-mode modular receiver product designed and manufactured by Lumistar Inc. The intent is to familiarize the user with the device's mechanical, electrical, and interconnection aspects as well as introduce and train the user in the operations of the supplied software control applications provided as part of the device delivery.

This document is not intended to define and illustrate the detailed communications protocol of the LS-28-DRSM necessary for independent software development. This information can be found in the device **Interface Control Document** (ICD). The document number is DOC-28M-01-ICD-xx where the -xx is the documentation revision number.

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-28-DRSM design
- Section 2 provides information on hardware interfaces
- Section 3 provides information related to device communications
- Section 4 provides documentation of the LS28M Network Interface User Application
- Section 5 provides documentation of the LS28M Serial User Application

The document will occasionally utilize document flags to highlight important factors. These flags can appear in any location and relate to any topic. A document flag will always be placed in close proximity to pertinent information. Document flag examples appear in Figure 1-1.

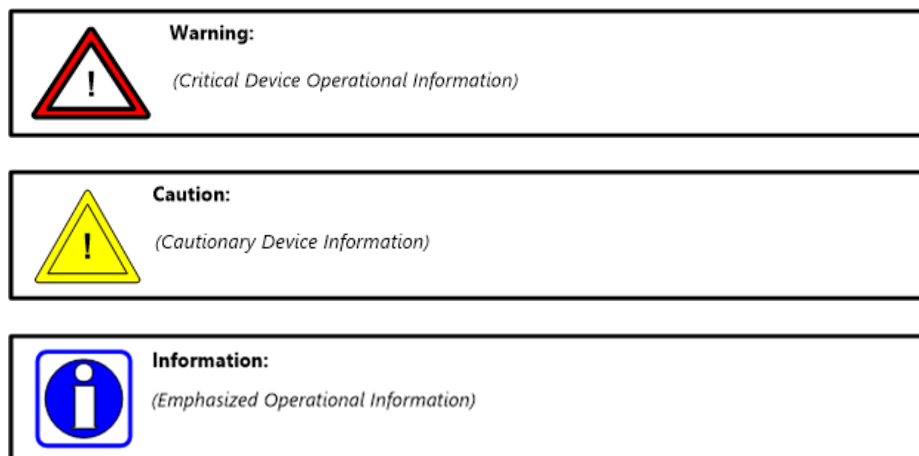


Figure 1-1 Document Flag Formats

1.3 List of Referenced Documents

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

- Lumistar LS-28M Interface Control Document: (DOC-28M-01-ICD-09)
- Lumistar LS-28M Alternate Control Interface Document: (DOC-28M-01-ACI-03)
- Lumistar LS-28M Field Support Manual: (DOC-28M-01-FSM-02)
- Telemetry Standards: (IRIG-106-2015)
- IRIG Serial Time Code Formats: (IRIG-200-2016)
- Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems: (IEEE-1588-2008)
- User Datagram Protocol (RFC 768)

1.4 Device Brief

The LS-28-DRSM is a sophisticated data receiver that includes all the traditional functions of a full rack mount telemetry processing station in the approximate footprint of a 3 ½ inch host computer hard drive. Standard capabilities include two independent digital multi-band RF receiver channels, each supporting multiple digital demodulation formats, bit synchronization, forward error correction, data recording, decommutation, graphical displays, baseband data acquisition, and Ethernet data distribution. The flexibility of the design architecture allows adaptability too many other applications, such as Spectrum Monitoring, Command Verification Receivers, and traditional Data Acquisition applications with minor modifications to the device's firmware personality. A general LS-28-DRSM block diagram is shown in Figure 1-2.

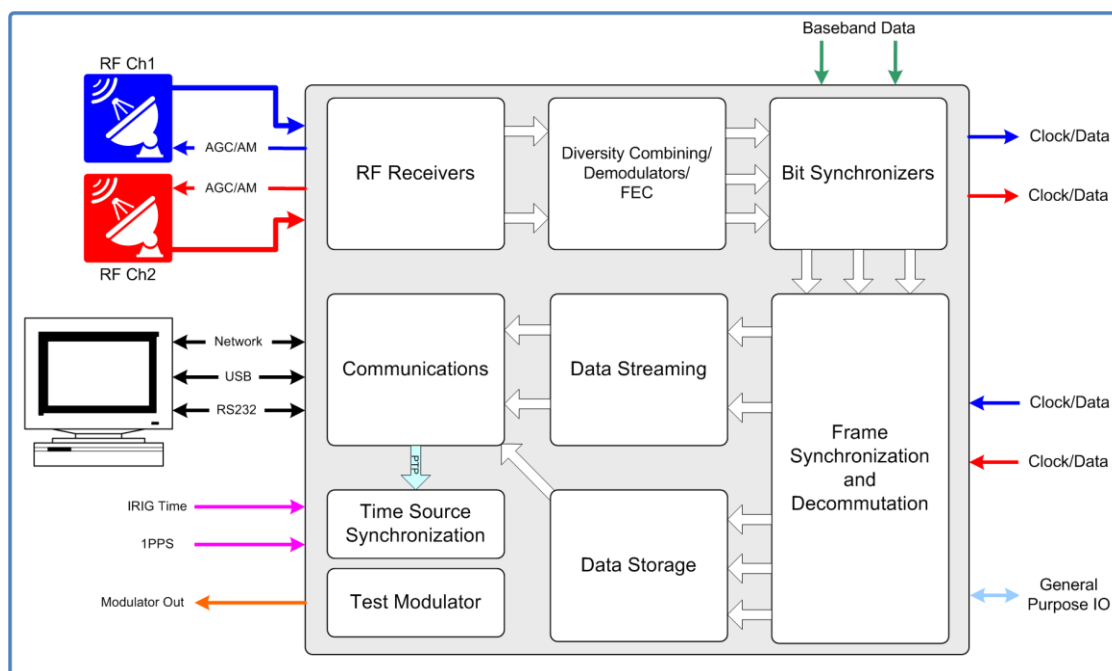


Figure 1-2 General Block Diagram of the LS-28-DRSM

Some of the primary design objectives of the LS-28-DRSM 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 1000/100/10Mbps Ethernet interface with alternate controls being provided by USB and RS-232. 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 multi-core DSP Engine that can take on up to twelve "personalities". 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. Operational firmware loads, or "personalities", are retained internal to the device for quick switching between operational requirements. 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 traditional Range Telemetry Receiver/Combiner, the LS-28-DRSM 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, diversity combining, multi-mode demodulation, bit synchronization, IQ video output, Eb/No monitoring, Spectral and Constellation displays with other data quality indicators are provided. Various non-standard options include the addition of up to 64 GB per channel data recording at the bit level and UDP data broadcasting of the received telemetry. The receiver can be configured to support Multi-symbol PCM/FM, SOQPSK, GMSK, Analog FM Video with or without NTSC de-emphasis, BPSK, QPSK, OQPSK, AUQPSK, PCM/PM, and Multi-H CPM. Data rate support is up to 30 Msps (60 Mbps for quadrature modulation techniques). The unit has a very flexible and useful internal Data/IF Modulator and Bit Error Reader/Frame Synchronizer Lock indicator for use in system Loop-Back Tests. 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.

If the User wants to convert from receiver mode to a dual channel bit synchronizer personality, that change can be commanded via software. The unit will be converted to a dual-channel bit sync while the GUI is transformed for that operational mode. The bit sync function can operate to 30 Mbps and provides numerous options for PCM code conversion.

The LS-28-DRSM provides the capability to decommutate the data from any input source (RF, IF, baseband). The framed data is then broadcast via UDP packets. These packets can be brought in via a network "Auxiliary Input" to the Lumistar Data Processing Software (LDPS) suite of tools for real time display, archive, playback and simulation of flight test data. A diagram illustrating the use of a LS-28-DRSM in a network configuration is shown in Figure 1-3.

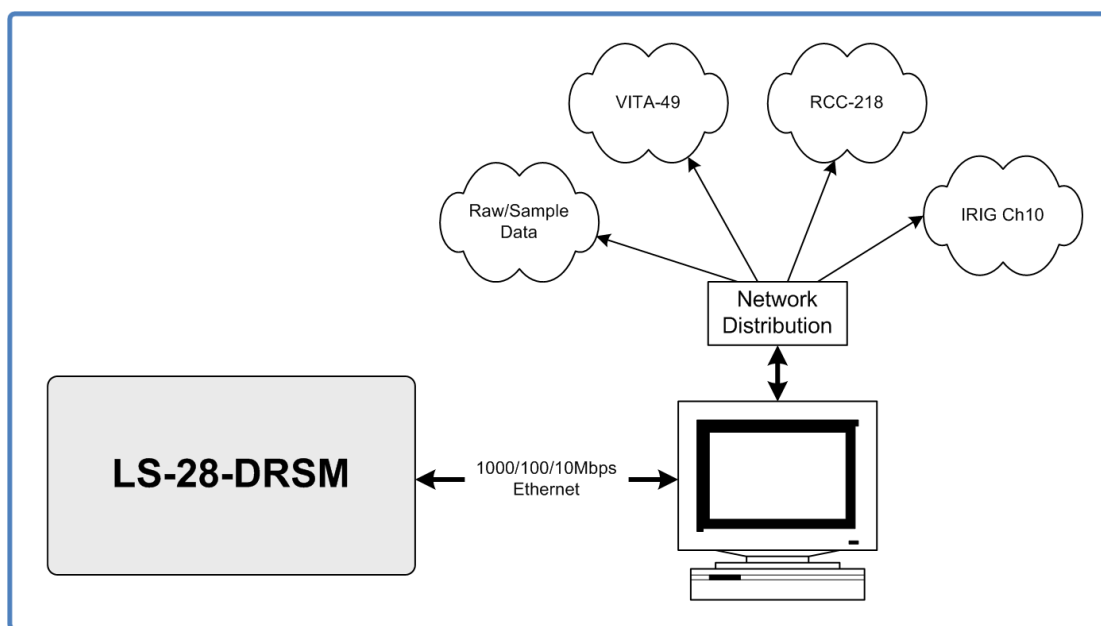


Figure 1-3 The LS-28-DRSM as part of a network data distribution design

The LS-28-DRSM is capable of handling many modern coding and digital link enhancement schemes, such as Viterbi, Reed-Solomon, LDPC, Space Time Coding, and Adaptive Equalization. Each of these has its own special niche, applications and merits (as well as demerits) in modern Telemetry Flight Test and Space Telemetry Applications.

Field Upgrade capabilities for the LS-28-DRSM units began in units with serial numbers of 5000 and higher. Field Upgrades are a very powerful capability to install updates, fixes and enhancements in units previously delivered. Performing field updates requires a very strict adherence to the steps necessary to perform this task. If the steps are interrupted, or performed in the incorrect sequence, failures can result in the unit being unable to operate requiring the unit to be returned for repair. It is beyond the scope of this document to outline the procedures and precautions related to field upgrades. The *Lumistar LS-28M Field Support Manual (DOC-28M-01-FSM-02)* manual outlines the field upgrade process.

Device "slice" detail block diagrams are shown in Figure 1-4 through Figure 1-7. Device specifications for the LS-28-DRSM as a standalone entity are listed in Table 1-1. Device specifications for the LS-28-DRSM mounted in the desktop chassis are listed in Table 1-2. Device specifications for the LS-28-DRSM mounted in the 1U Rackmount 12" Deep chassis are listed in Table 1-3. Device specifications for the LS-28-DRSM mounted in the 1U Rackmount 22" Deep chassis are listed in Table 1-4. Device specifications for the LS-28-DRSM mounted in the Ruggedized Transport case are listed in Table 1-5.

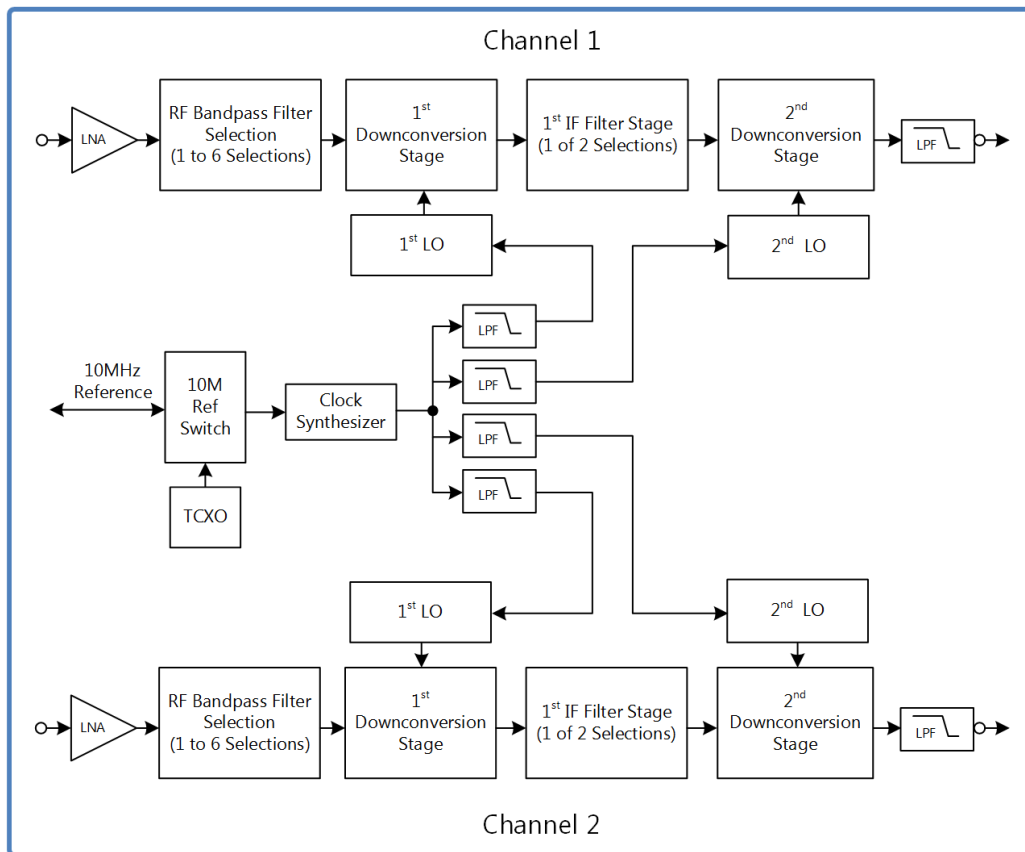


Figure 1-4 Block Diagram: Slice 1 - RF to IF Downconversion

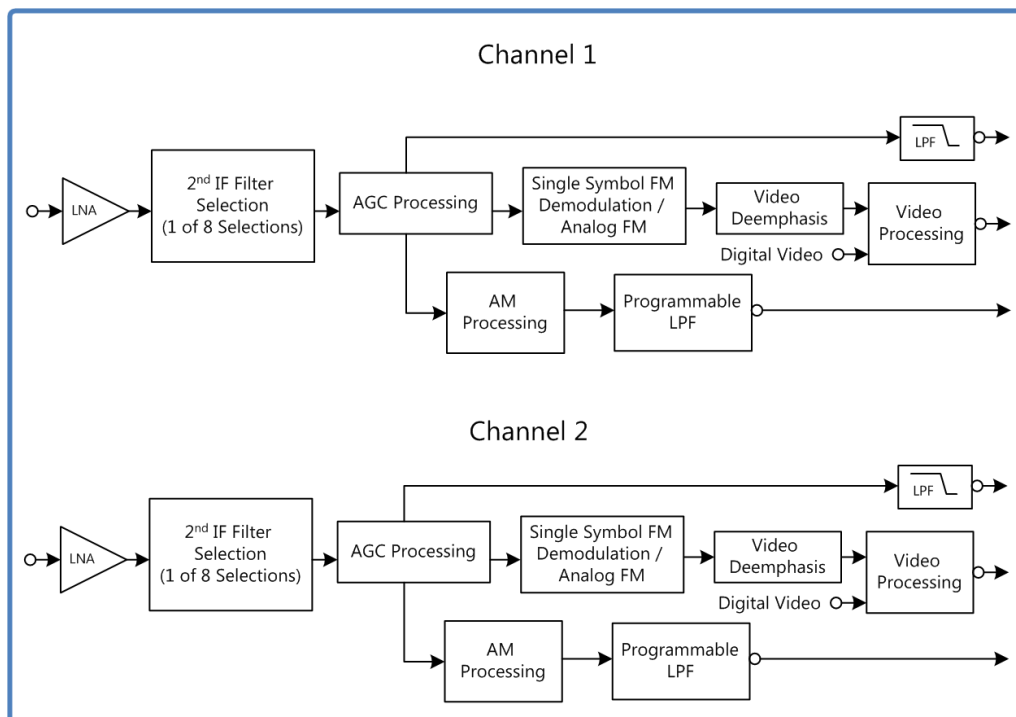


Figure 1-5 Block Diagram: Slice 2 - 2nd IF and Analog Processing

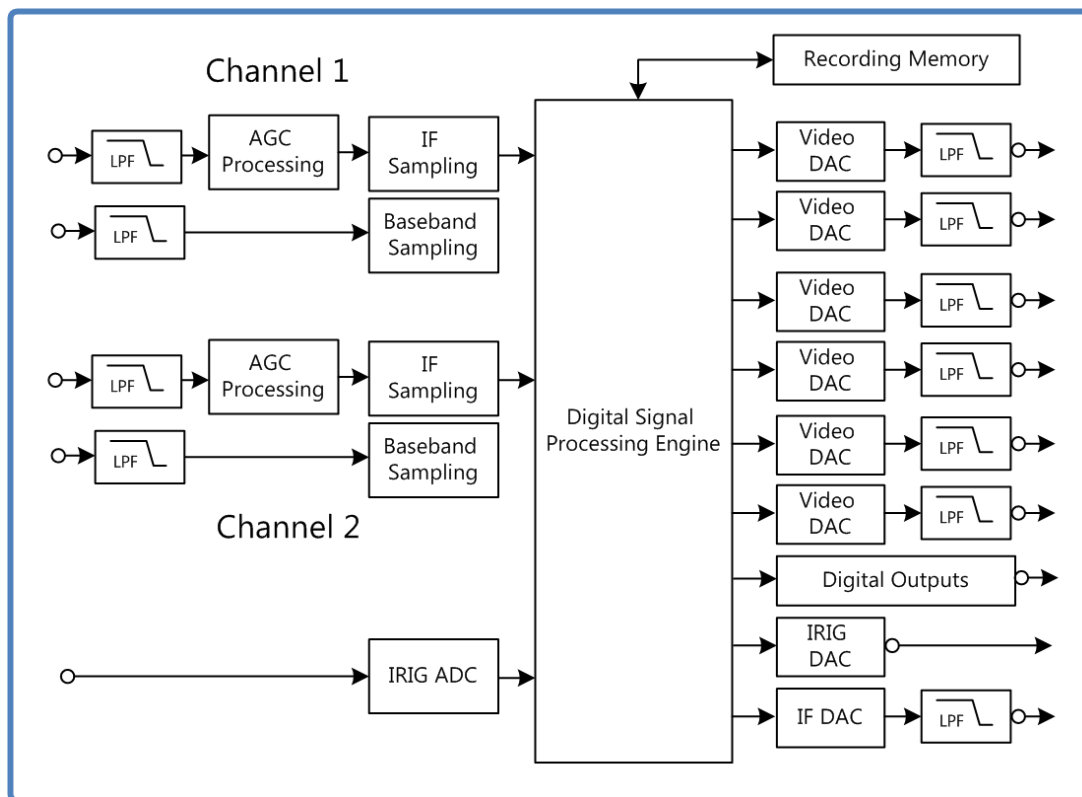


Figure 1-6 Block Diagram: Slice 3 - Digital Signal Processing

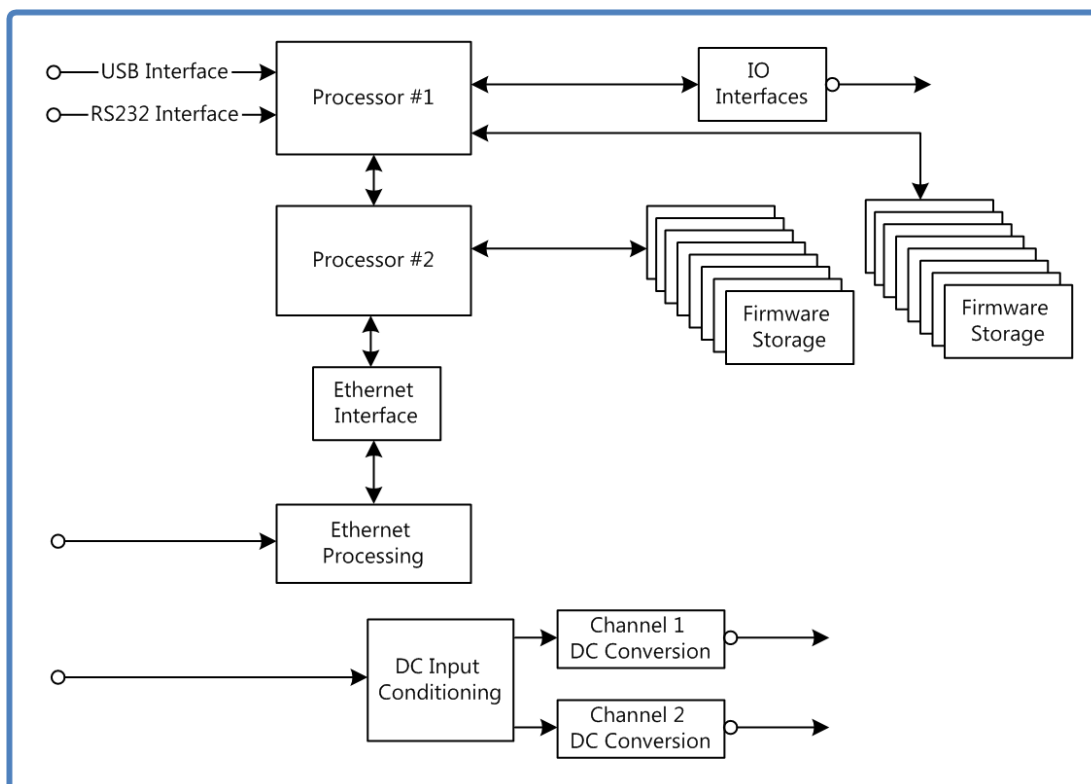


Figure 1-7 Block Diagram: Slice 4 – Processing, Storage and DC Power Conversion

Category:	Specifications:	Details:
Mechanical	Envelope Dimensions ins. (mm.)	6.00 (152.4) L x 4.00 (101.6) W x 1.672 (42.47) H
	Form Factor	Modular Brick
	Weight oz. (kgs)	~ 32oz. (~0.91kgs.)
Electrical	Individual power requirements	9-42VDC
		Nom. +24VDC @ 2.875A
	Total Power (both Channels)	~ 46 to 52 Watts (mode and data rate dependent)
Performance		
<i>RF Tuner</i>	RF Input Bands	Typ. Config. up to 5 Bands plus 70MHz
		Band range: 70MHz – 6.2GHz
		Alt. Config. allows up to 6 RF Bands (<i>future</i>)
	Tuner Resolution	50kHz (Typical); 2Hz minimum
	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 Phase Noise @ 1kHz	<= -84.2dBc (typical)
	70MHz Phase Noise @ 10kHz	<= -97.8dBc (typical)
	70MHz Phase Noise @ 100kHz	<= -105.5dBc (typical)
	70MHz Phase Noise @ 1MHz	<= -124.5dBc (typical)
	Receiver OIP ₃	> +15dBm (typical)
	70MHz Output Level	Typ. 0 dBm (+/- 1dBm); Adjustable
	SAW IF 3dB Bandwidths Available (used for Adjacent Channel Rejection)	250kHz, 500kHz, 1MHz, 2MHz, 5MHz, 10MHz, 20MHz, 40MHz
<i>Demodulation</i>	Types	Analog AM, Video FM, SS-PCMF, MS-PCMF, BPSK, QPSK, OQPSK, AUQPSK, AQPSK, UQPSK, Direct PM, MH-CPM, Sub-Carrier PM w/BPSK/QPSK
	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
<i>Frame Sync/Decom</i>	Number Available	3; Stream up to 2 Real-time feeds; Class I and II
	Frame Sync Pattern Length	Up to 64 bits
<i>Recoding</i>	SFID/URC/FCC Support	Yes
	Number of Channels	3
<i>Time</i>	Recording Depth/Channel	Up to 64GB
	Source	Data; Samples
<i>FEC</i>	IRIG Time	A, B, G; Reader/Generator; 1PPS Input and Output
	IEEE-1588 PTP	Yes; Reader only
<i>Connectors</i>	LDPC	1024 and 4096 Block Sizes; Rates: 4/5, 2/3, 1/2
	Viterbi	K = 7; Rate 1/2 (<i>Future 3/4, 7/8</i>)
<i>Environmental</i>	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
	Digital I/O Connector	(3) MicroDSub-25 Plug
	Power/Digital I/O Connector	(1) MicroDSub-25 Receptacle
	Temperature, Operational	-40° to 85° Celsius (Industrial)
<i>Connectors</i>	Temperature, Storage	-40° to 125° Celsius
	Humidity, non-condensing	<40° C 0-90%, >40° C 0-75%

Table 1-1 General LS-28-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)	~ 54 to 60 Watts (mode and data rate dependent)
Performance	All Receiver Performance Parameters	(Same as that of the LS-28-DRSM shown in Table 1-1 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
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
	Digital I/O Connector	(3) MicroDSUB-25 Plug
	Power/Digital I/O Connector	(1) MicroDSUB-25 Receptacle
	Chassis Power	(1) 5.5mmx2.5mm DC power Jack
		(1) Switchcraft 62GB8FX 8-Pin DIN Connector (<i>alternate</i>) Pins 1,2,4,6: +VDC In Pins 3,5,7,8: +VDC Return
		(1) Amphenol PT02A-8-4P(025) (<i>alternate</i>) Pins A, C: +VDC In Pins B, D: +VDC Return
Environmental	Temperature, Operational	-40° to 85° Celsius (Industrial)
	Temperature, Storage	-40° to 125° Celsius
	Humidity, non-condensing	<40° C 0-90%, >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 2 nd and 3 rd Edition

Table 1-2 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)	~ 75 Watts (mode and data rate dependent)
Performance	All Receiver Performance Parameters	(Same as that of the LS-28-DRSM shown in Table 1-1)
Connectors	External Reference In/Out	(1) SMA Jack
	RF Signal Input	(2) N-Style Receptacle
	IF Signal Output	(2) BNC F Jack Receptacle, (1) SMA IF/IF Modulator Out
	Analog I/O Connector	(12) BNC F Jack Receptacle
	Digital I/O Connector	(6) BNC F Jack Receptacle
	Auxiliary Digital/Analog IO	(3) MicroDSub-25 Receptacle (See Section Error! Reference source not found.)
	USB 2.0 Interface	(1) USB-B Receptacle
	Chassis Power	(1) IEC320-C14 AC Inlet
Environmental		(1) Amphenol PT02A-8-4P (025) (alternate – custom order) Pins A, C: +24VDC In Pins B, D: +24VDC Return
	Temperature, Operational	-40° to 85° Celsius (Industrial)
	Temperature, Storage	-40° to 125° Celsius
	Humidity, non-condensing	<40° C 0-90%, >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 1-3 1U Rackmount Chassis (Short) - Device Specifications Table

Category:	Specifications:	Details:
Mechanical	Envelope Dimensions in. (mm.)	22.0 (558.8) L x 18.94 (481) W x 1.732 (44.0) H [BNC Excursion]
	Unboxed Weight lbs. (kgs.)	19.6lbs. (8.89kgs.)
Electrical	Power Input Range	90-264VAC / 47-63Hz
	Total Power (both Channels)	~ 150 Watts (mode and data rate dependent)
Performance	All Receiver Performance Parameters	(Same as that of the LS-28-DRSM shown in Table 1-1)
Connectors	External Reference In/Out	(1) SMA Jack
	RF Signal Input	(2) N-Style Receptacle
	IF Signal Output	(2) BNC F Jack Receptacle, (1) SMA IF/IF Modulator Out
	Analog I/O Connector	(12) BNC F Jack Receptacle
	Digital I/O Connector	(6) BNC F Jack Receptacle
	Auxiliary Digital/Analog IO	(3) MicroDSub-25 Receptacle (See Section Error! Reference source not found.)
	Chassis Power	(1) IEC320-C14 AC Inlet
	Serial Controls	Micro-DB15 (Amphenol MDM-15PH003B) Pin 7: RS232RX, Pin 8: RS232RX, Pin 12: RS232RTN
Environmental	Temperature, Operational	-40° to 50° Celsius (Industrial)
	Temperature, Storage	-40° to 85° Celsius
	Humidity, non-condensing	<40° C 0-90%, >40° C 0-75%
Safety and EMC	EMI	EN55011 Class B, FCC Part 15 Class B; CSPP22 Class B
	Safety	UL60950-1; EN60950-1; IEC60950-1

Table 1-4 1U Rackmount Chassis (Long) - Device Specifications Table

Category:	Specifications:	Details:
Mechanical	Envelope Dimensions in. (mm.)	16.44 (417.6) L x 13.00 (330.2) W x 6.82 (173.2) H
	Unboxed Weight lbs. (kgs.)	16.0 lbs. (7.26 kgs.)
Electrical	Power Input Range (AC)	85-264VAC / 47-63Hz
	Alt. Power Input Range (DC)	10.8-32VDC
	Total Power (both Channels)	~ 70 Watts (mode and data rate dependent)
	Power Preference/Selection	Automatically switched; no interruption when switching between sources; AC power favored over DC input
	Portable Battery Power Bag (<i>Optional</i>)	LiFePO ₄ 50AH battery; Includes AC charger (100-120VAC 50/60Hz); Weight ~ 16 lbs; Run-time Estimate: 8 hours
Performance	All Receiver Performance Parameters	(Same as that of the LS-28-DRSM shown in Table 1-1)
Connectors	External Reference In/Out	(1) SMA Jack
	RF Signal Input	(2) N-Style Receptacle
	IF Signal Output	(2) BNC F Jack Receptacle, (1) SMA IF/IF Modulator Out
	Analog I/O Connector	(12) BNC F Jack Receptacle
	Digital I/O Connector	(6) BNC F Jack Receptacle
	Auxiliary Digital/Analog IO	(3) MicroDSub-25 Receptacle (See Section Error! Reference source not found.)
	Chassis Power	(1) IEC320-C14 AC Inlet
		(1) Amphenol PT02A-8-4P (025) Pins A, C: +VDC In Pins B, D: +VDC Return
	GPS Antenna	(1) SMA Jack (<i>optional</i>)
Environmental	Temperature, Operational	-40° to 50° Celsius (<i>Industrial</i>)
	Temperature, Storage	-40° to 85° Celsius
	Humidity, non-condensing	<40° C 0-90%, >40° C 0-75%
Safety and EMC	EMI	EN55011 Class B, FCC Part 15 Class B; CSPR11 Class B
	Immunity	EN61000-4-2 thru 6, -8, -11
	Safety	UL60601-1; IEC60601-1

Table 1-5 Ruggedized Portable Case - Device Specifications Table

2 Hardware Interface

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-28-DRSM is delivered.

2.1 Mechanical Outline – Basic Receiver

The LS-28-DRSM is described as a “brick” configuration having the same traditional footprint as a standard 3.5” host computer hard disk drive. Figure 2-1 provides a diagram of the top view of the device. Figure 2-2 illustrates the various front-view configurations available. Of the front-views shown, the most common is the -001 “4-Slice” version.

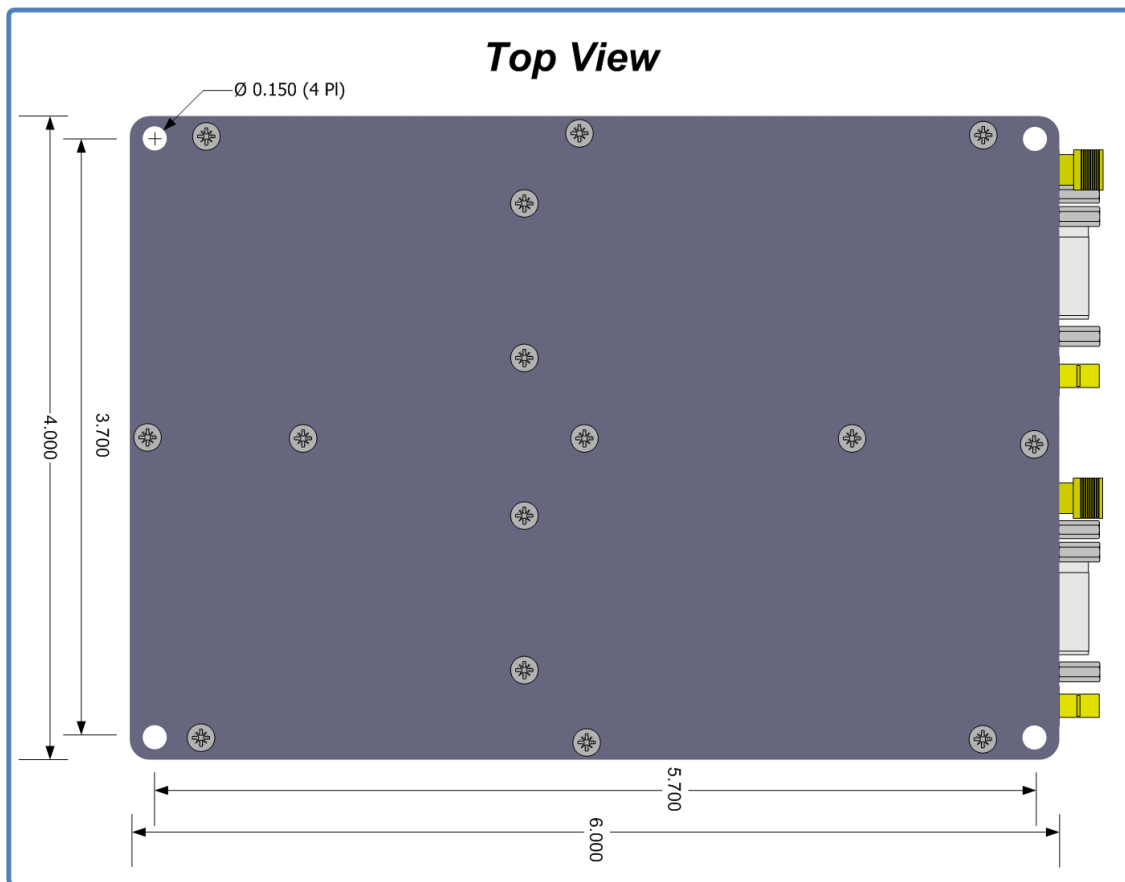


Figure 2-1 Representative Top View of the LS-28-DRSM brick assembly



Information:

Some hardware versions of the LS-28-DRSM contain top and bottom covers which are not anodized in a blue color but rather are coated in a RoHS compliant (clear) chem film.

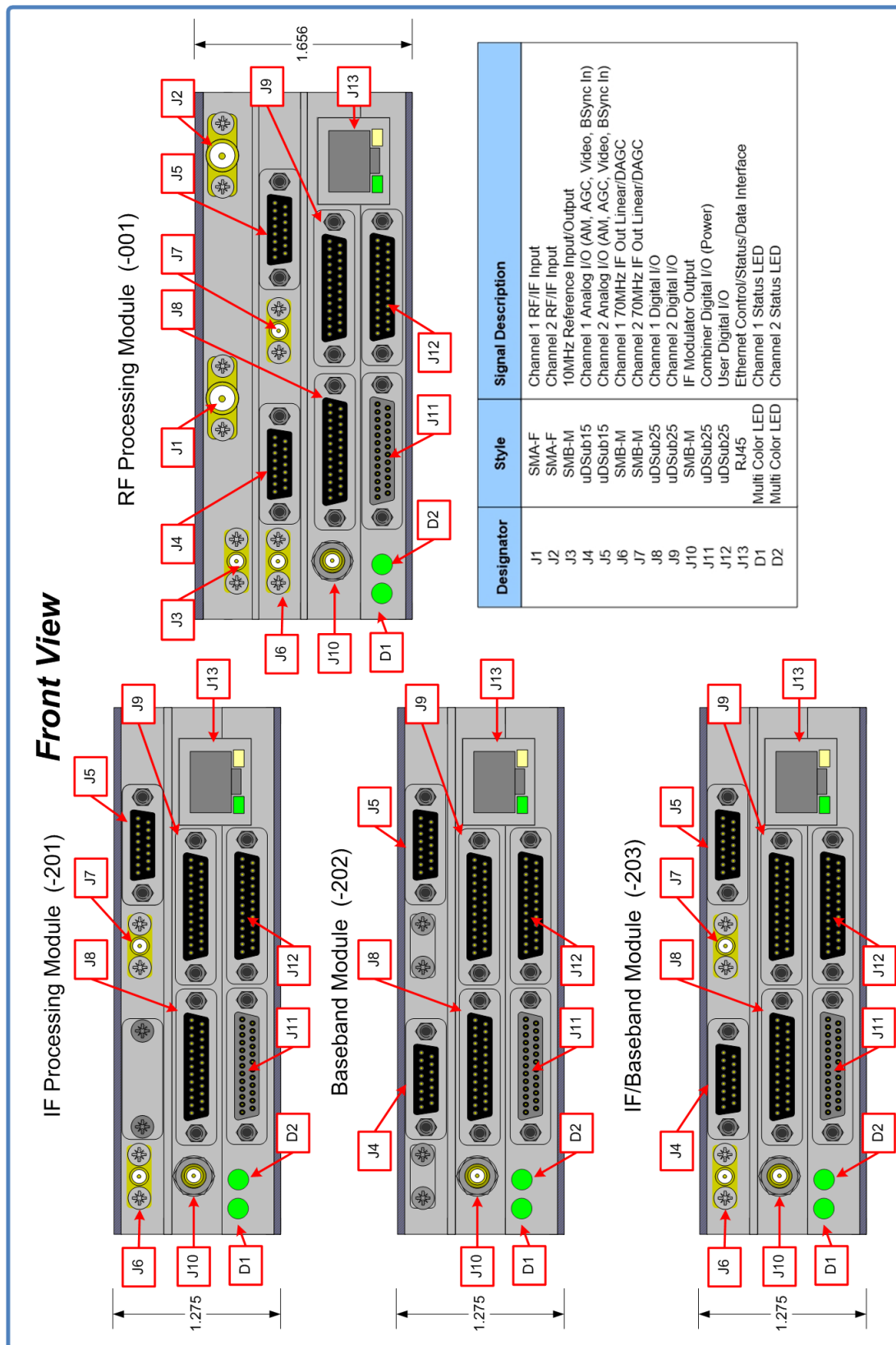


Figure 2-2 Various Front-Views of the LS-28-DRSM brick assembly

The device can be mounted using four UNC6-32 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.

The LS-28-DRSM 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*.

2.2 Interface Signals: Micro-D Sub Pin-outs

Figure 2-2 presents a front-view of the LS-28-DRSM. This figure contains a reference table of LS-28-DRSM interface connectors. This table makes reference to four Micro-D-Sub connectors. Figure 2-3 and Figure 2-4 provide detailed interface pin-outs of the Micro-D connections of the LS-28-DRSM that matches the revision 2 cabling. Figure 2-5 and Figure 2-6 provide detailed interface pin-outs of the Micro-D connections of the LS-28-DRSM that matches the revision 3 cabling.

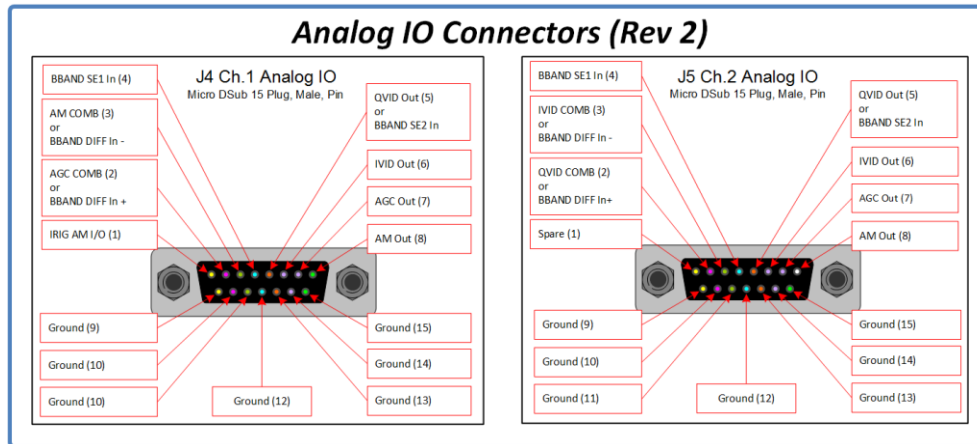


Figure 2-3 Revision 2 Cable: LS-28-DRSM J4 and J5 Connector Pin-out Details

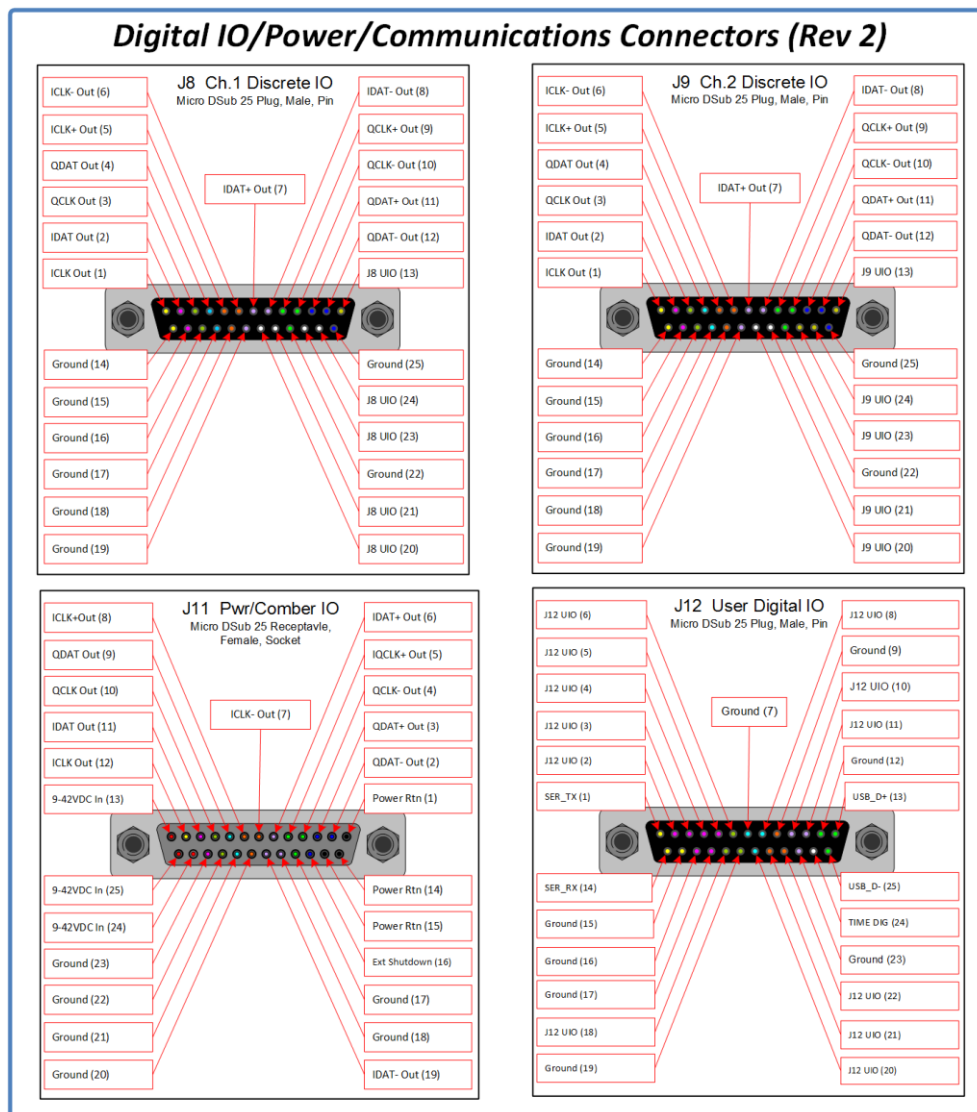


Figure 2-4 Revision 2 Cable: LS-28-DRSM J8, J9, J11 and J12 Connector Pin-out Details

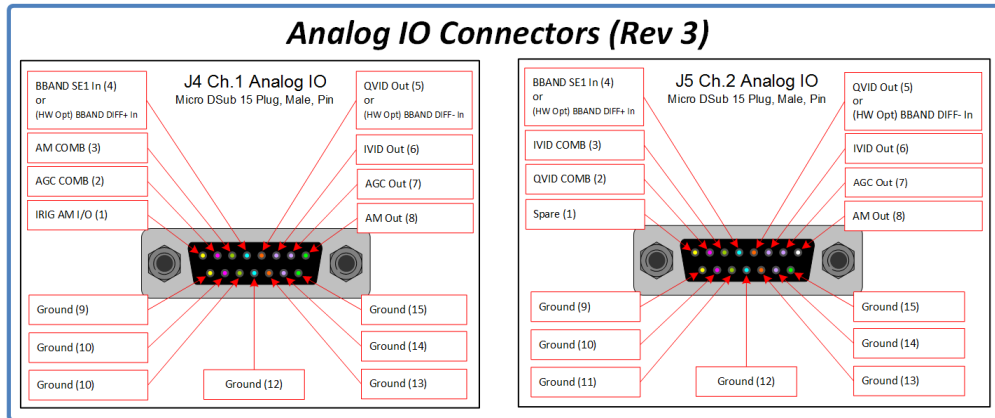


Figure 2-5 Revision 3 Cable: LS-28-DRSM J4 and J5 Connector Pin-out Details

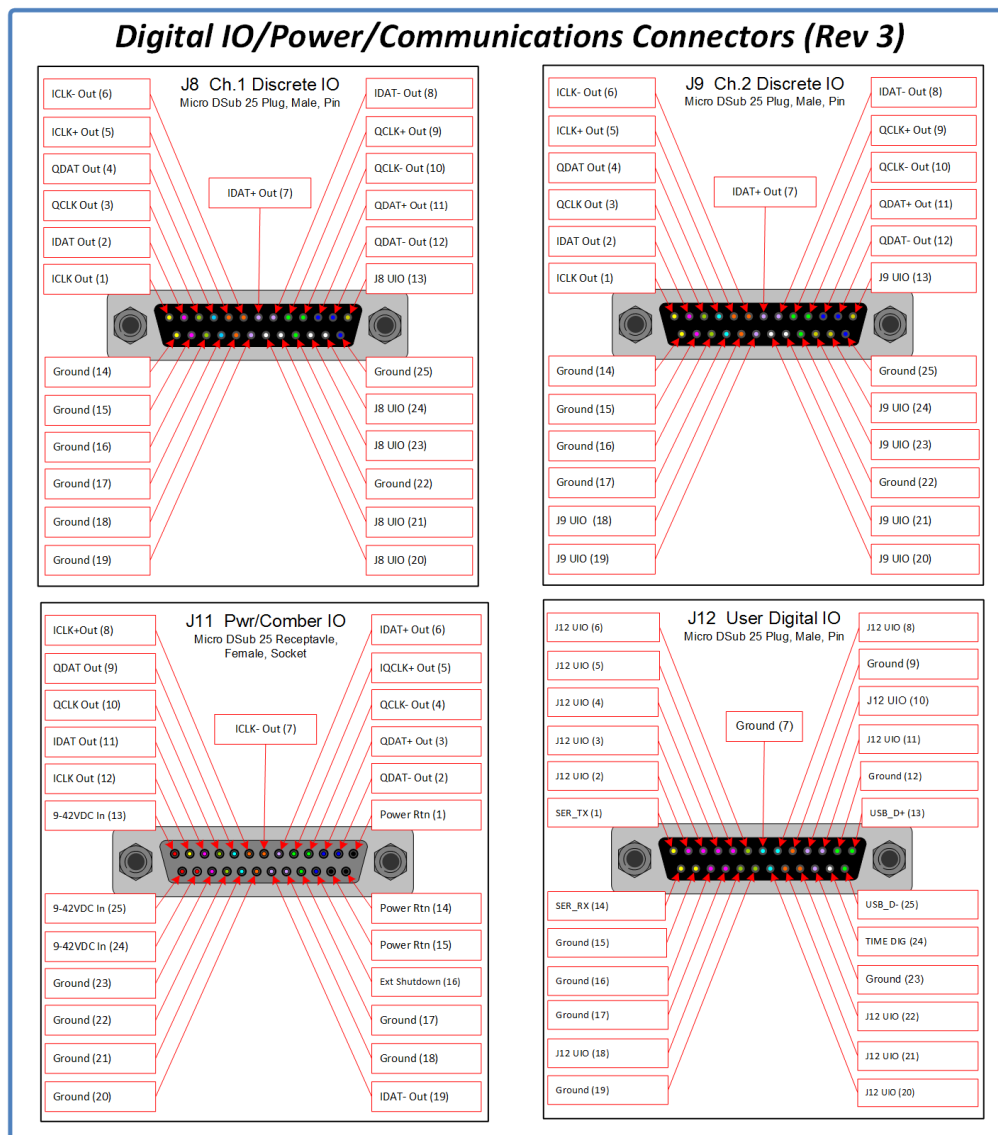


Figure 2-6 Revision 3 Cable: LS-28-DRSM J8, J9, J11 and J12 Connector Pin-out Details

2.3 Interface Signals: Electrical Definitions/Characteristics

The interface signals of the LS-28-DRSM vary in type and electrical complexity. There are several different types of signals deployed as detailed in Table 2-1. The "User IO" can be configured in various manners to provide additional functionality. The list of user IO is shown in Table 2-1 and Table 2-2.

Signal Name	Interface Direction	Interface Type	Input Voltage Range	Input Ω	Output Voltage	Output Ω	See Note
IRIG AM IO	I/O	Analog	2Vp-p	100 Ω /10k Ω	2Vp-p	100 Ω /10k Ω	1
IVID Out	O	Analog Video			0-4Vp-p	75 Ω	2
QVID Out	O	Analog Video			0-4Vp-p	75 Ω	2
IVID Comb	O	Analog Video			0-4Vp-p	75 Ω	2
QVID Comb	O	Analog Video			0-4Vp-p	75 Ω	2
BBAND SE In	I	Analog Video	+/-10V	50/75/100/1k Ω			3
BBAND Diff In +/-	I	Differential	+/-4V	100 Ω /5k Ω			4
AGC Out	O	Analog			+/-5V	50 Ω	5
AGC Comb	O	Analog			+/-5V	50 Ω	5
AM Out	O	Analog			0-6Vp-p	20 Ω	6
AM Comb	O	Analog			0-6Vp-p	20 Ω	6
ICLK Out	O	Digital			5V		7
IDAT Out	O	Digital			5V		7
QCLK Out	O	Digital			5V		7
QDAT Out	O	Digital			5V		7
ICLK +/- Out	O	RS422			3.4V Diff	100 Ω	8
IDAT +/- Out	O	RS422			3.4V Diff	100 Ω	8
QCLK +/- Out	O	RS422			3.4V Diff	100 Ω	8
QDAT +/- Out	O	RS422			3.4V Diff	100 Ω	8
9-42VDC In	PWR	Power	9-42VDC				9
Pwr Rtn	PWR	Power	GND				9
Ext Shut Down	I	Digital	GND				10
SER TX/RX	I/O	RS232					11
USB_D+/-	I/O	USB 2.0					12
TIME_DIG	I/O	Digital	5V		5V		1,7

Notes:

- 1.) Signal direction is based on the utilization of the IRIG time generator.
- 2.) Analog video output levels are software adjustable.
- 3.) Bit sync single-ended input impedances are software selectable.
- 4.) Bit sync differential input impedance is software selectable. 100mV differential input requirement.
- 5.) Output voltage is software selectable in terms of ranges and slopes.
- 6.) Bipolar analog signal. Output voltage is software selectable in terms of output gain. Output voltage level varies as a function of AM index.
- 7.) Transceiver: SN74LVC2T45. 5V outputs can drive 50 ohm loads at >3.8V logic switching levels. Output voltage can be 3.3V. Consult factory for availability.
- 8.) Transceiver: ISL3259E prior to HW Rev 10, MAX22501 in HW Rev 10+; 100-110 ohm differential termination
- 9.) DC input voltage can vary from 9V-42V. Per pin current limit is 3A.
- 10.) 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.
- 11.) RS232 transceiver: SN75C3221E. This device is capable of 1Mbps transactions. Firmware limits the BAUD rate to 250kbps. RS232 interface is active simultaneously with USB2.0 and Ethernet interfaces.
- 12.) USB2.0 operation only. USB interface is active simultaneously with RS232 and Ethernet interfaces.

Table 2-1 Primary IO Signal Electrical Definitions

Connector-Pin	Signal ID	Interface Direction	Direction Control	Speed	Output Voltage	See Note
J8-13	J8 EPGIO1	O	Hardware	Low	Open Collector	1,2
J8-20	J8 UIO1	I	Hardware	High	5V	3,4
J8-21	J8 UIO2	I	Hardware	High	5V	3,4
J8-23	J8 UIO3	I	Hardware	High	5V	3,4
J8-24	J8 UIO4	I	Hardware	High	5V	3,4
J9-13	J9 EPGIO1	O	Hardware	Low	Open Collector	1,2
J9-20	J9 UIO1	I	Hardware	High	5V	3,4
J9-21	J9 UIO2	I	Hardware	High	5V	3,4
J9-23	J9 UIO3	O	Hardware	High	5V	3,4
J9-24	J9 UIO4	O	Hardware	High	5V	3,4
J12-2	J12 UIO1	O/I	Software	High	5V	3,4,5
J12-3	J12 UIO2	O/I	Software	High	5V	3,4,5
J12-4	J12 UIO3	O/I	Software	High	5V	3,4,5
J12-5	J12 UIO4	O/I	Software	High	5V	3,4,5
J12-6	J12 UIO5	O/I	Software	High	Diff+	5,6
J12-18	J12 UIO5	O/I	Software	High	Diff -	5,6
J12-8	J12 UIO7	O/I	Software	High	Diff+	5,6
J12-20	J12 UIO7	O/I	Software	High	Diff -	5,6
J12-21	J12 UIO9	O/I	Software	High	Diff+	5,6
J12-22	J12 UIO9	O/I	Software	High	Diff -	5,6
J12-10	J12 UIO11	O/I	Software	High	Diff+	5,6
J12-11	J12 UIO11	O/I	Software	High	Diff -	5,6

- 1.) Open-collector output capable of sinking 500mA. 50V breakdown voltage.
- 2.) Low speed interfaces have a maximum 50Hz operational rate.
- 3.) Transceiver: SN74LVC2T45. 5V outputs can drive 50 ohm loads at >3.8V logic switching levels. Output voltage can be 3.3V. Consult factory for availability.
- 4.) High speed interfaces can maintain signaling rates up to 60MHz.
- 5.) Interface direction is software definable in groups of two pins at a time.
- 6.) Transceiver: ISL3259E prior to HW Rev 10, MAX22501 in HW Rev 10+; 100-110 ohm differential termination

Table 2-2 User IO Signal Electrical Definitions

2.4 Desktop chassis Cabling Interfaces

The LS-28-DRSM in the Desktop chassis assembly is typically delivered with a set of six 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.

There are two generations of cables that have been issued. Cables shipped prior to approximately March of 2019 are revision 2 cables and are defined in detail in Figure 2-7 thru Figure 2-12 that follow. Cables shipped after that date are revision 3 cables and are defined in detail in Figure 2-13 thru Figure 2-18 that follow. Revision information is clearly marked on the cable assemblies. There are several cable and cabling options that are available. Consult your Lumistar sales representative for available options.

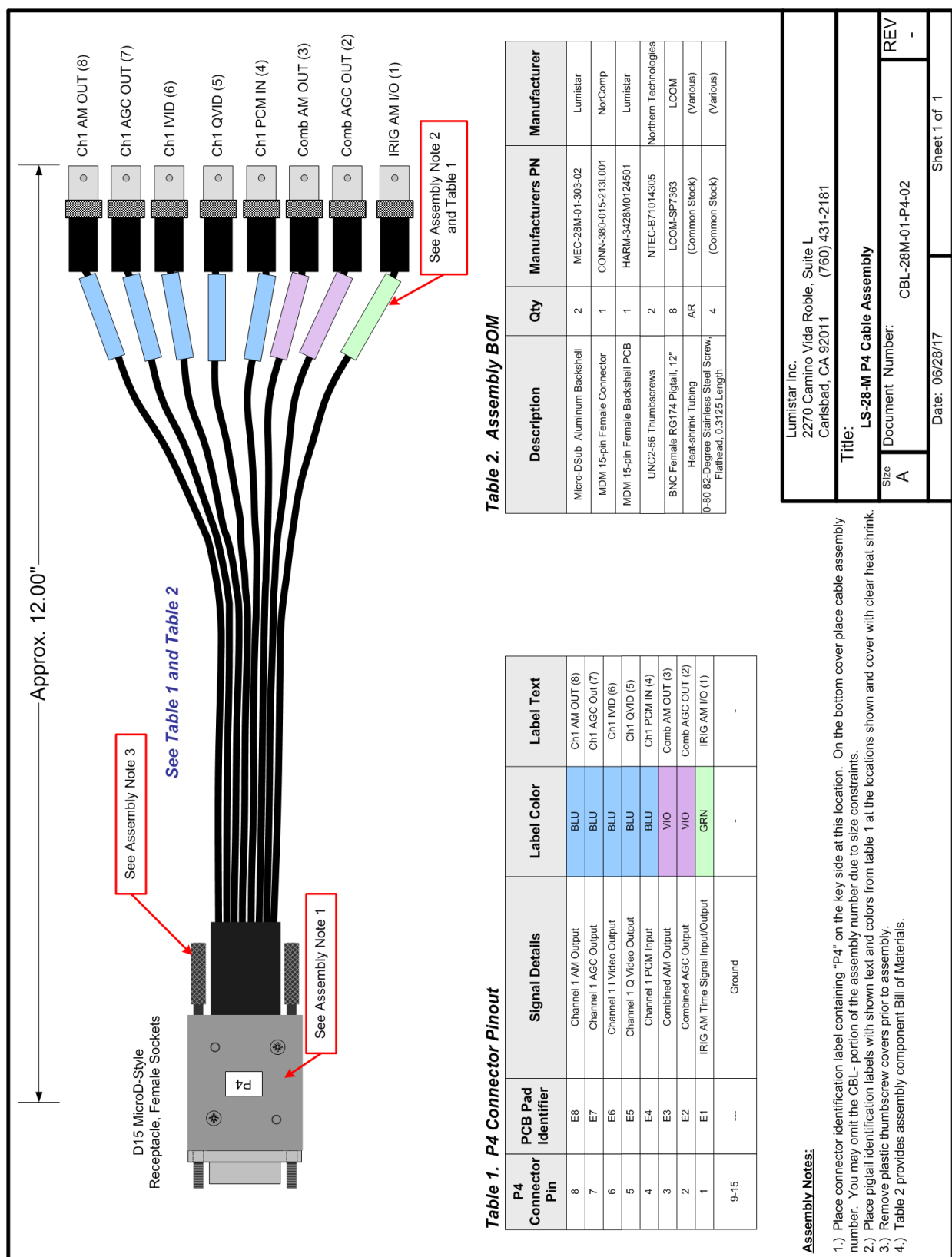


Figure 2-7 Revision 2: P4 User Interface Cable

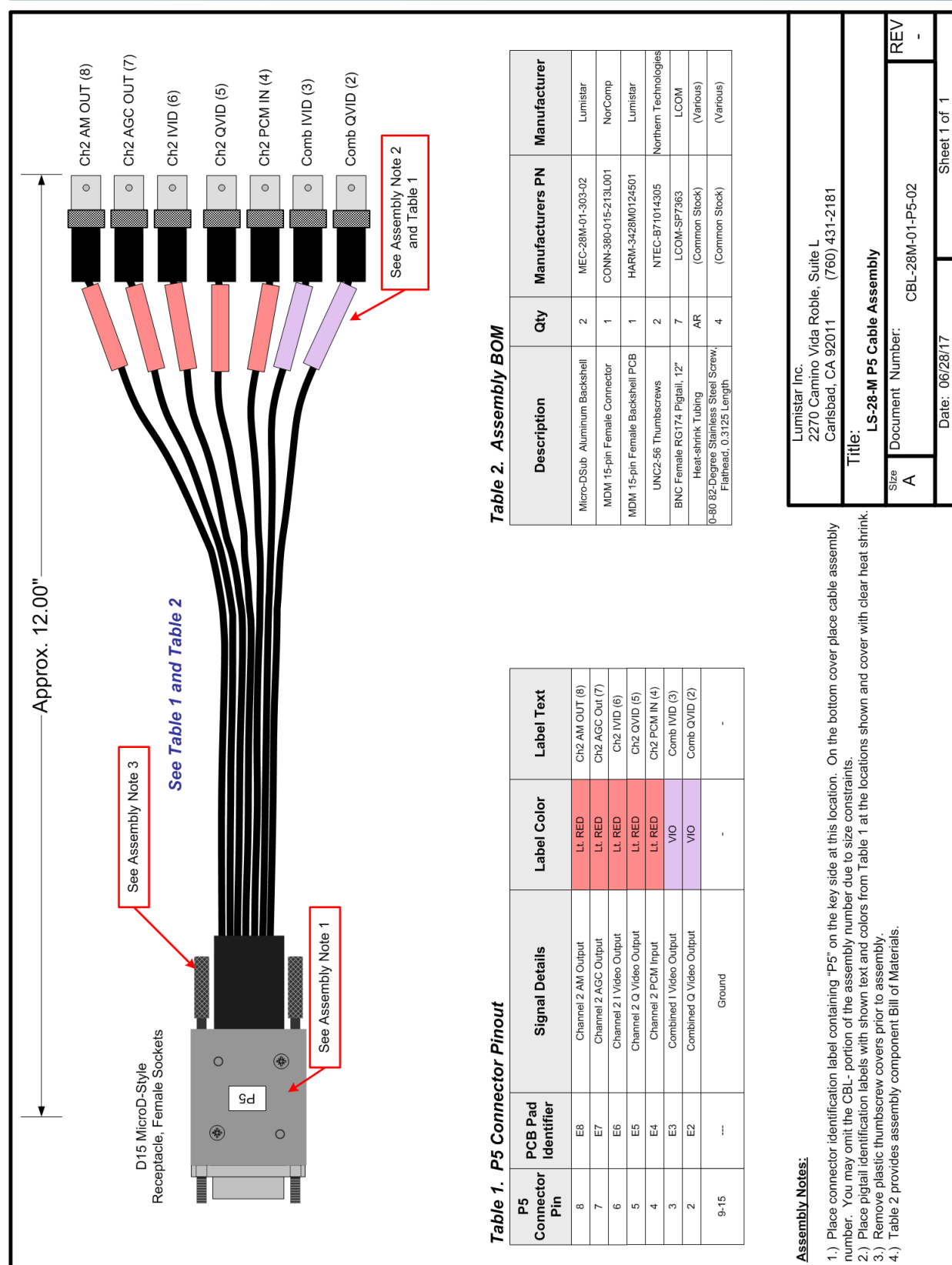


Figure 2-8 Revision 2: P5 User Interface Cable

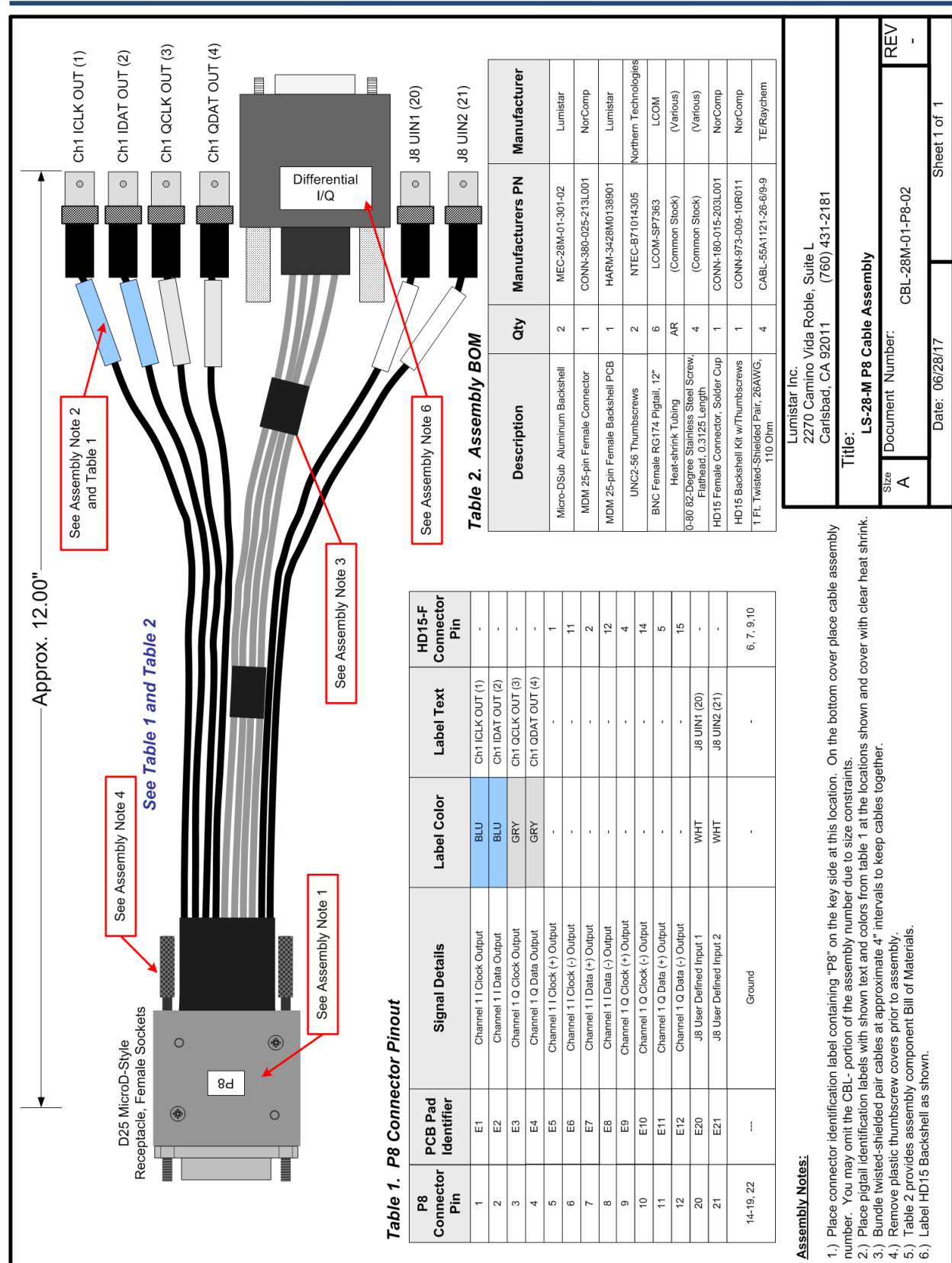


Figure 2-9 Revision 2: P8 User Interface Cable

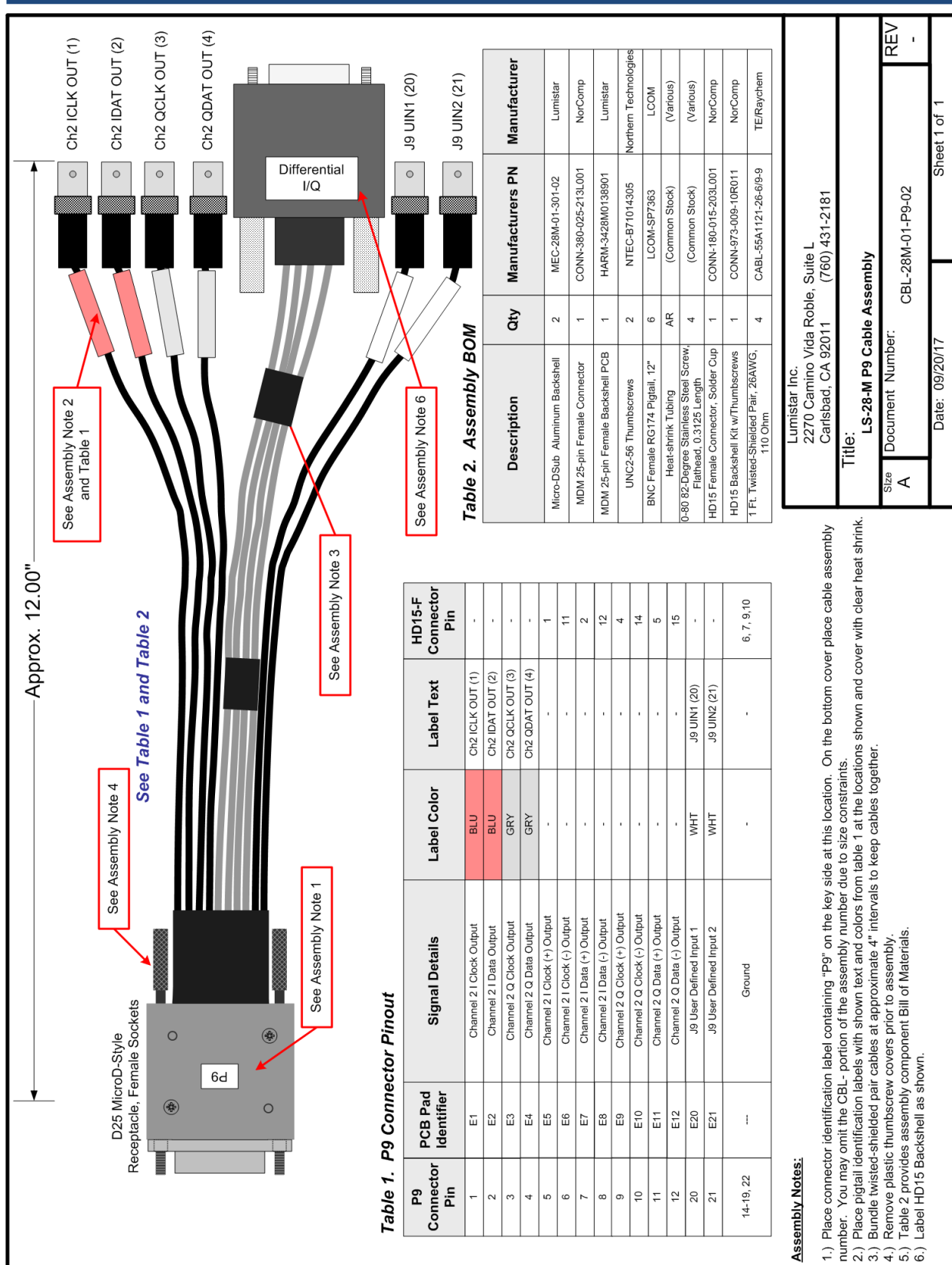


Figure 2-10 Revision 2: P9 User Interface Cable

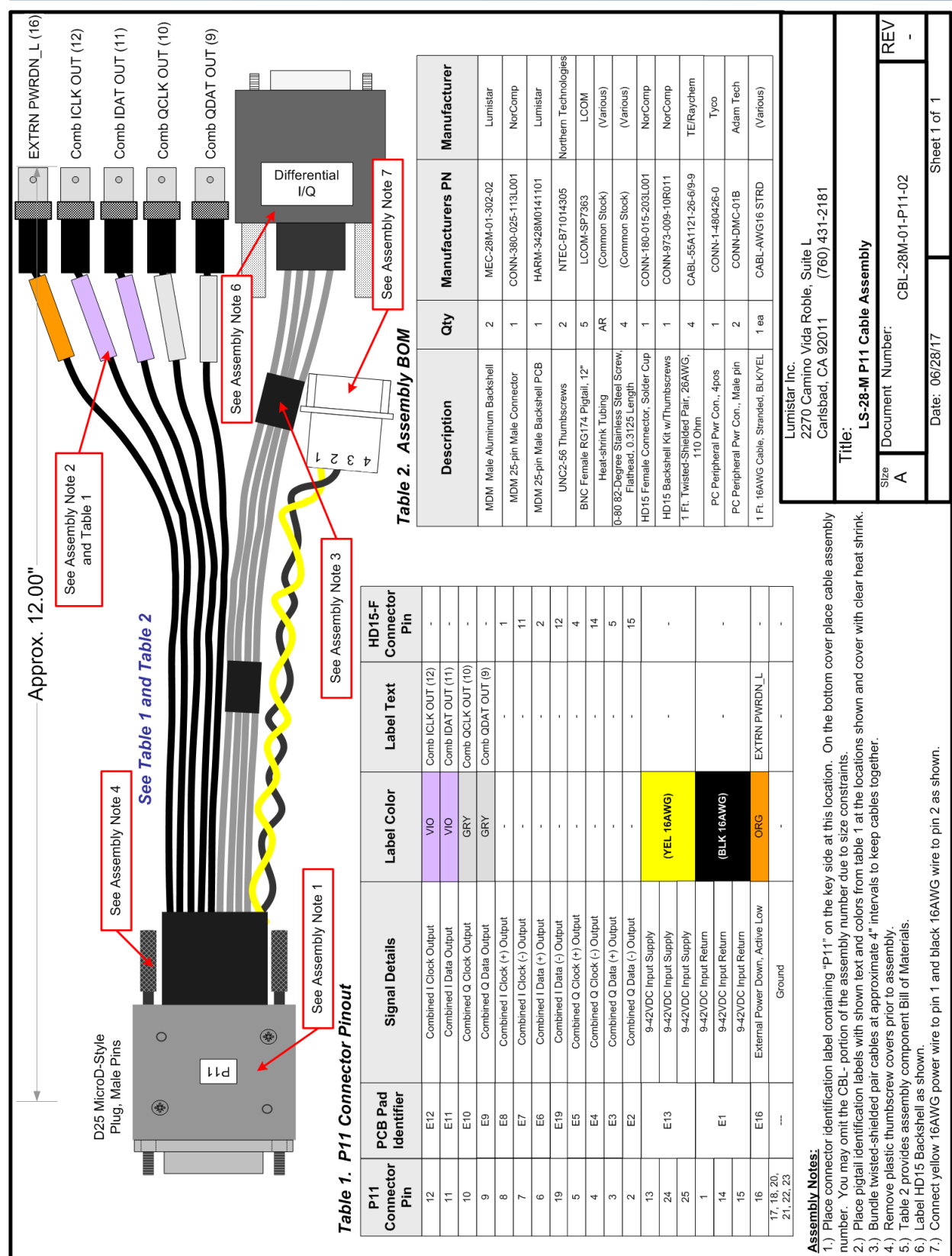


Figure 2-11 Revision 2: P11 User Interface Cable

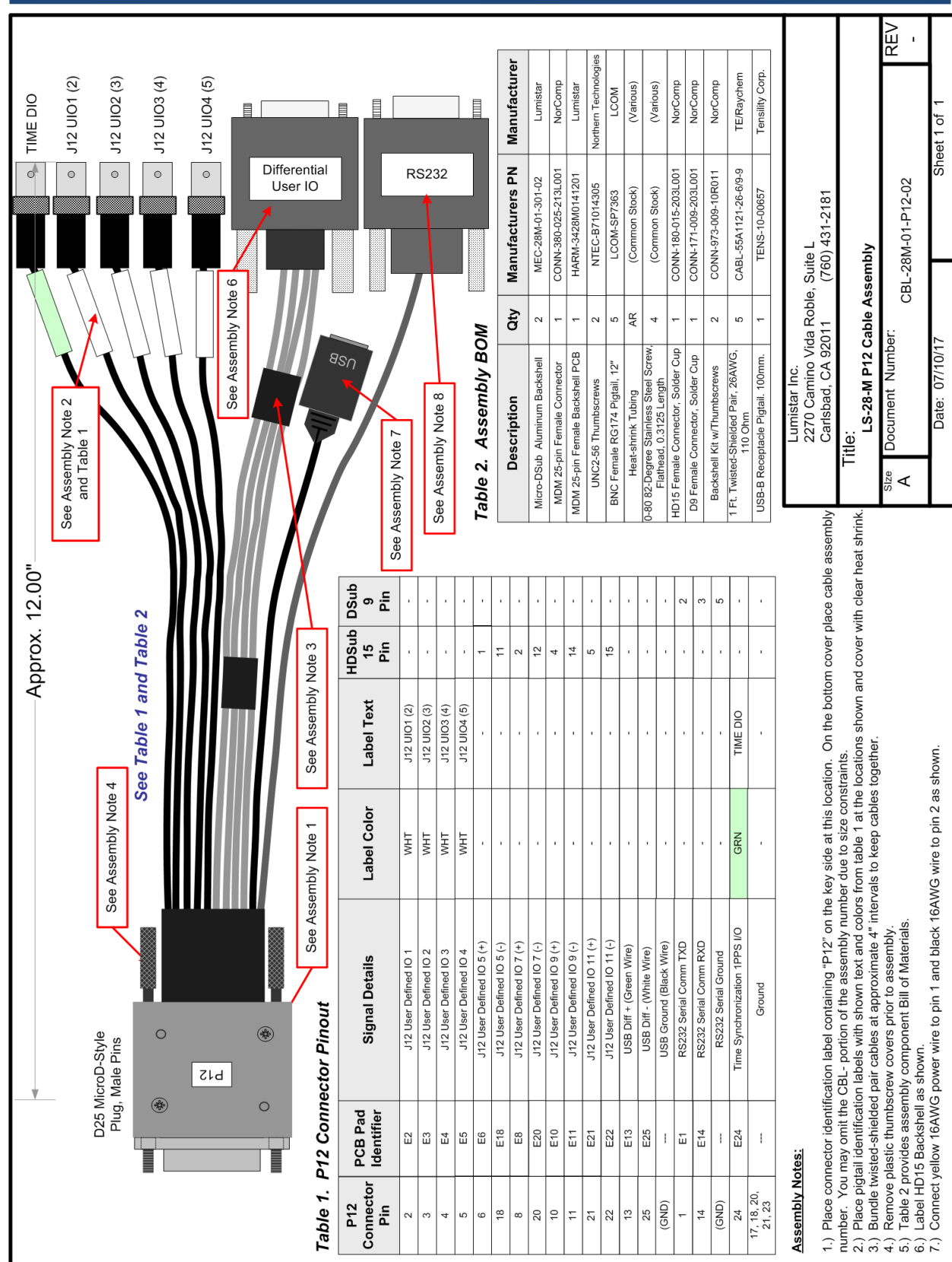


Figure 2-12 Revision 2: P12 User Interface Cable

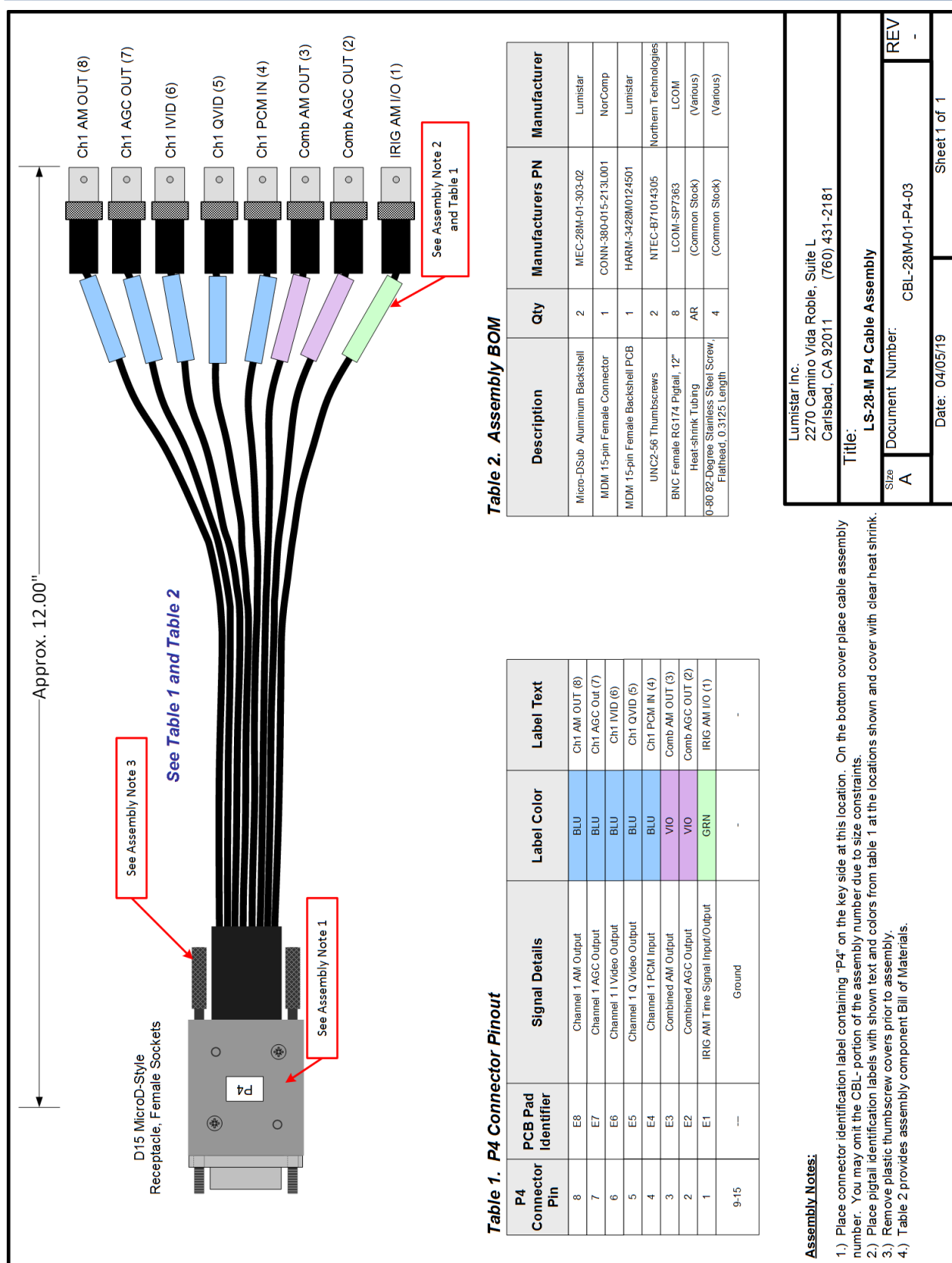


Figure 2-13 Revision 3: P4 User Interface Cable

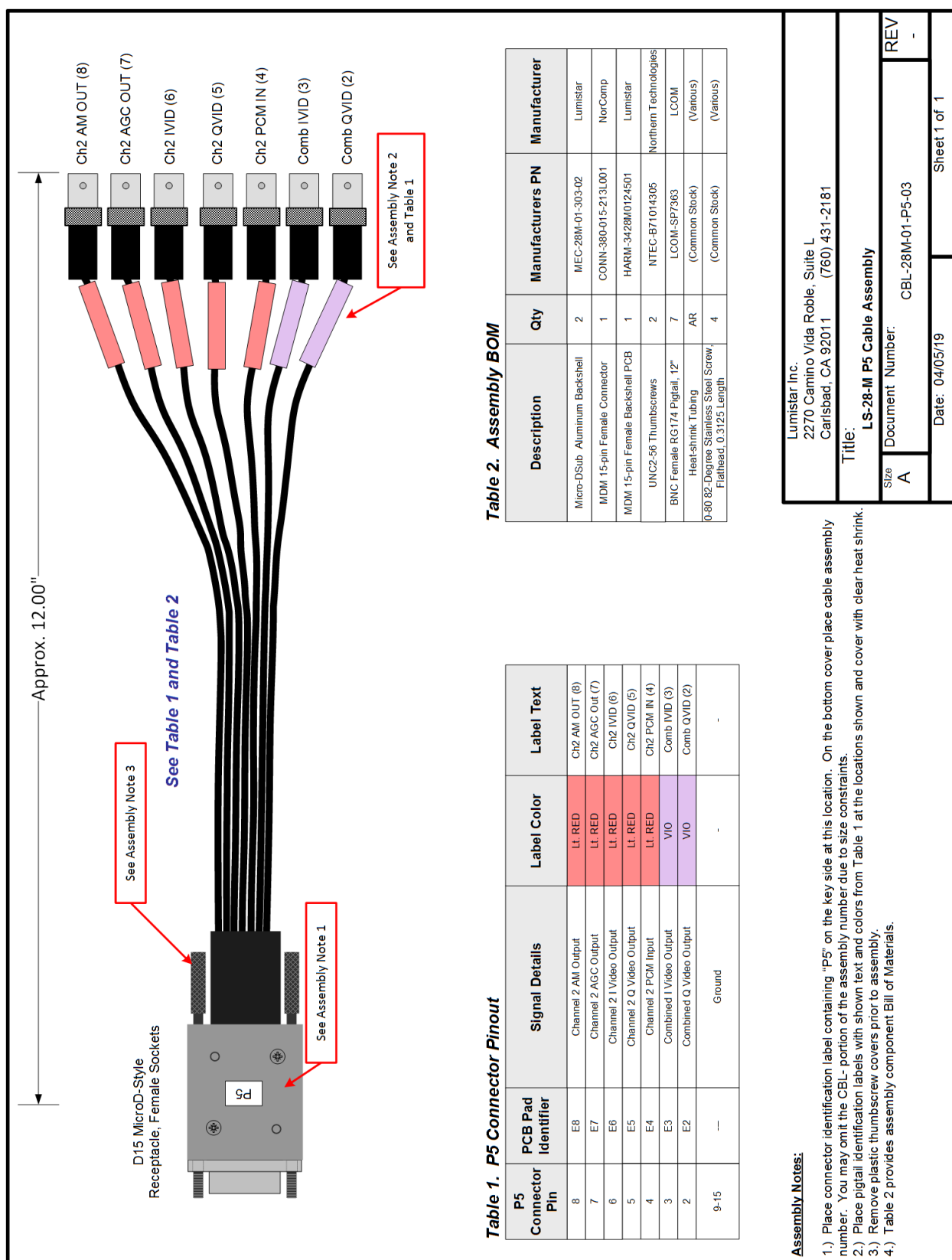


Figure 2-14 Revision 3: P5 User Interface Cable

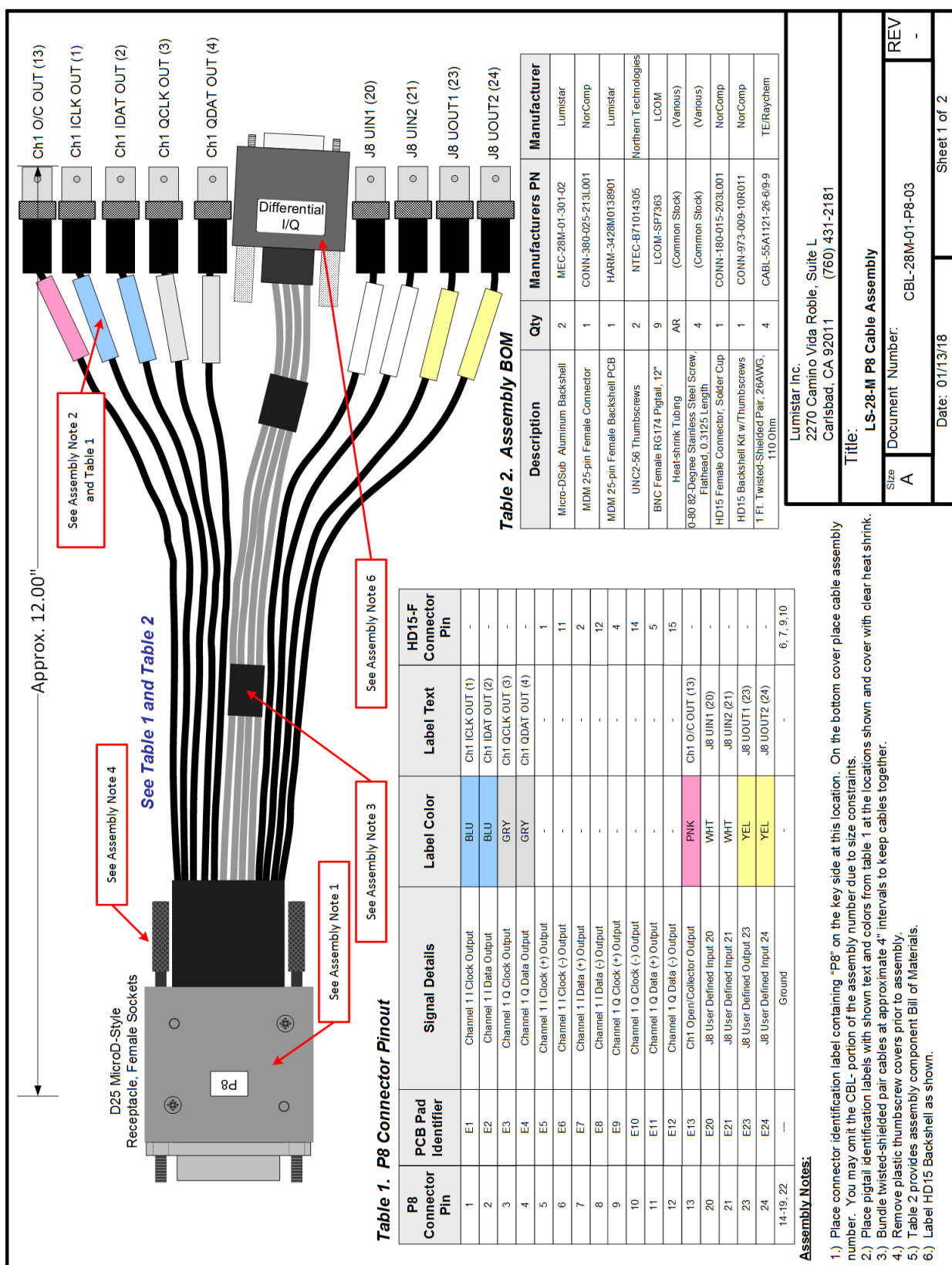


Figure 2-15 Revision 3: P8 User Interface Cable

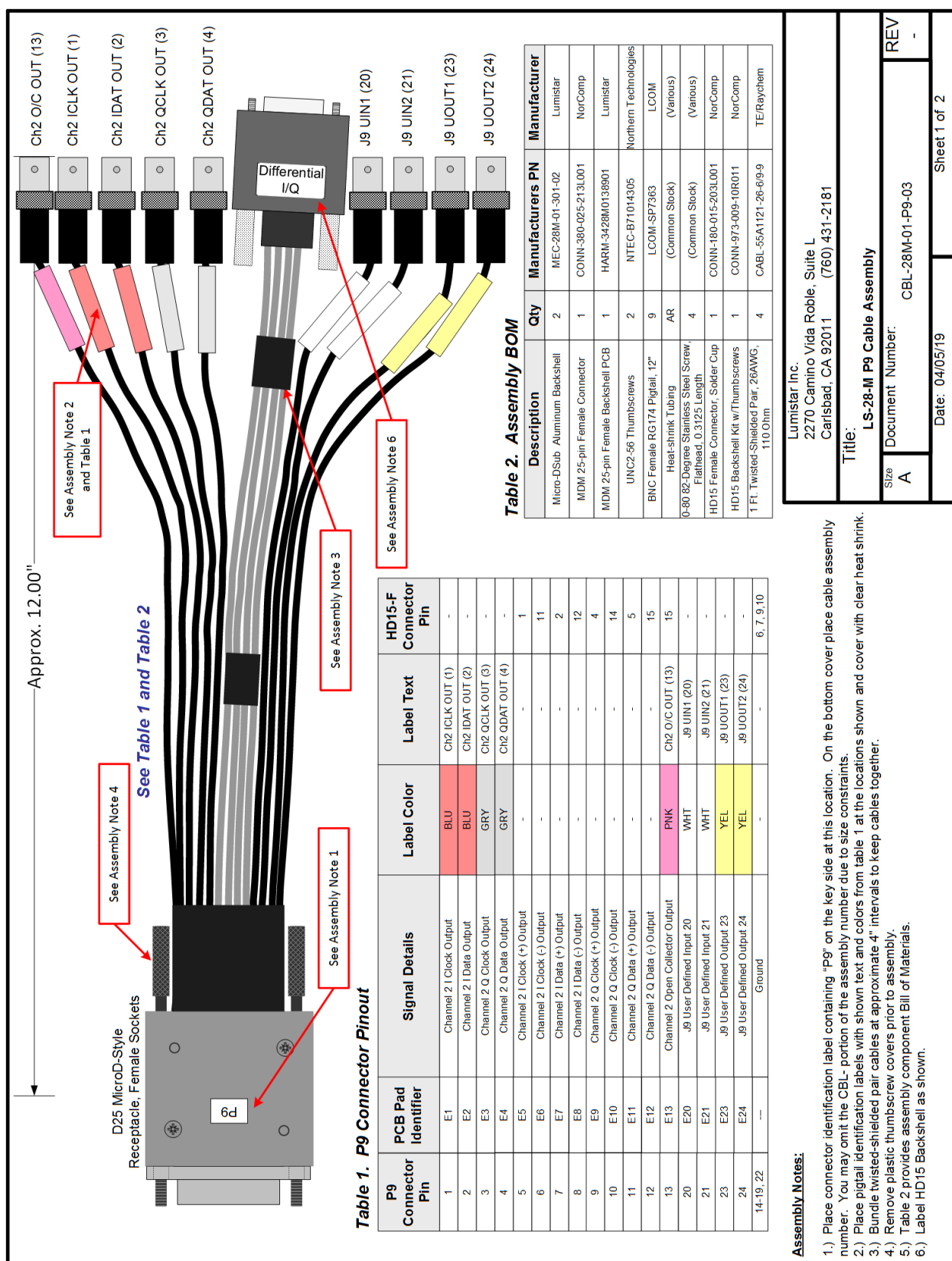


Figure 2-16 Revision 3: P9 User Interface Cable

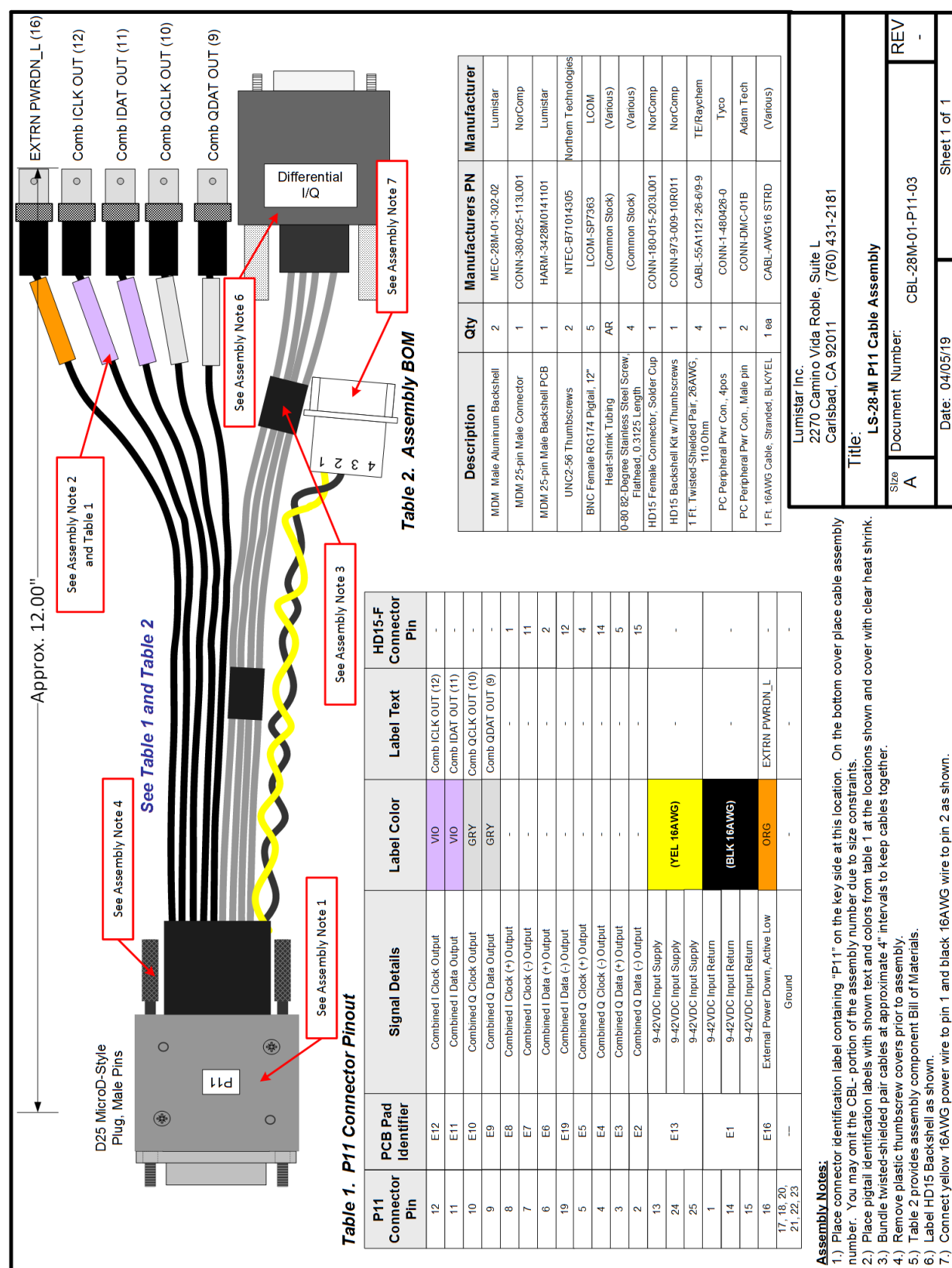


Figure 2-17 Revision 3: P11 User Interface Cable

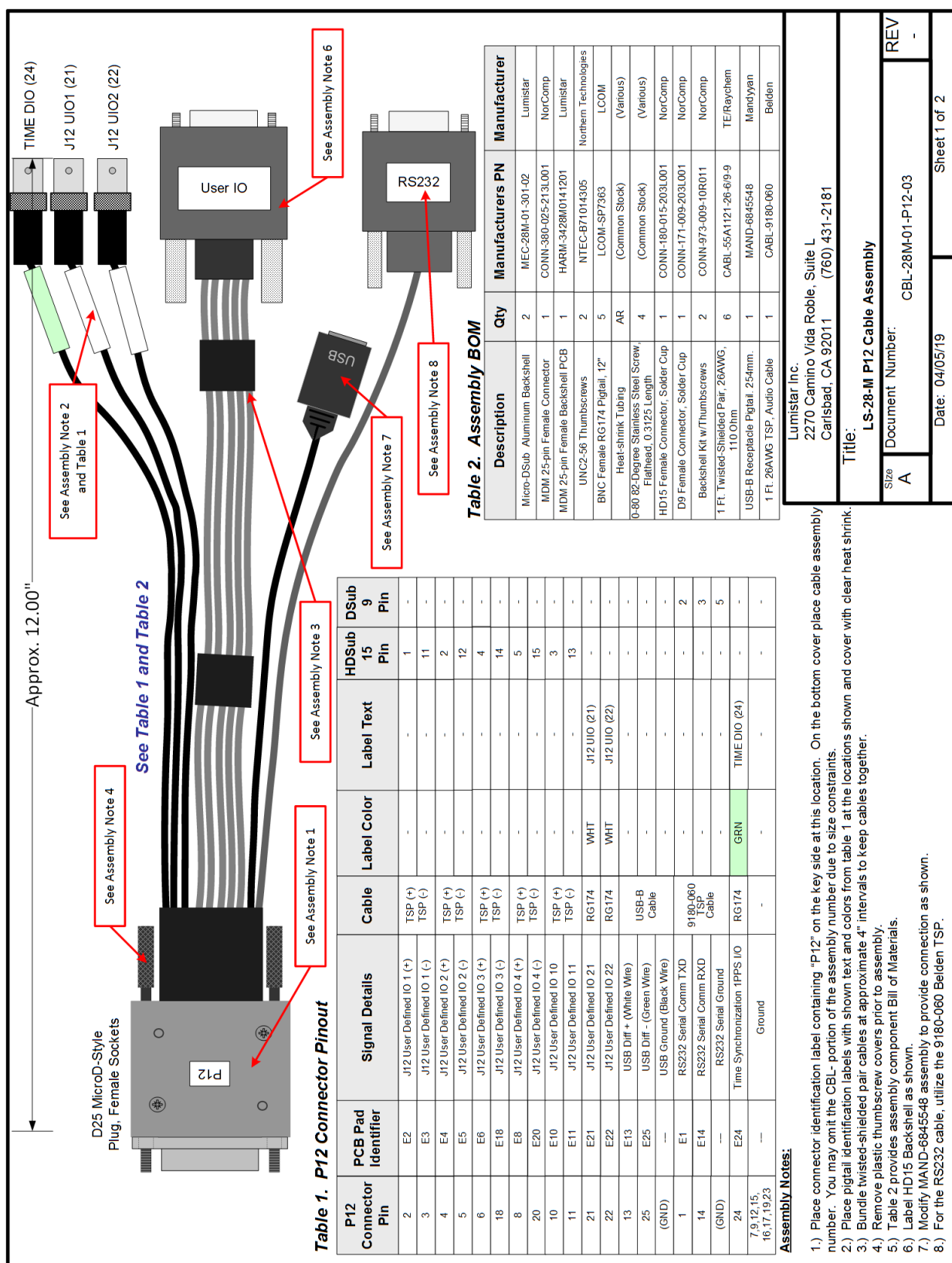


Figure 2-18 Revision 3: P12 User Interface Cable

2.5 Chassis/Case Options

Lumistar offers an array of delivery options for the LS-28-DRSM. 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.
- 1U 19" Rackmount Chassis (Long) – 22" depth solution for rack mounting. Includes host PC.
- Portable Ruggedized Case – Pelican 1450 series case with cooling and dual power capabilities.
- 2U 22" Rackmount Chassis – Contains one to four LS-28-DRSM dual channel units (*near future*)

2.5.1 Desktop Chassis

Lumistar offers an optional LS-28-DRSM desktop chassis that provides mounting, power cabling provisions, and cooling functions for the LS-28-DRSM. The fixture comes with a desktop AC to DC power converter.

There are now two generations of the desktop chassis. The diagram in Figure 2-19 shows the mechanical outline of the Generation 1 fixture which is no longer being shipped as of the date of this document.

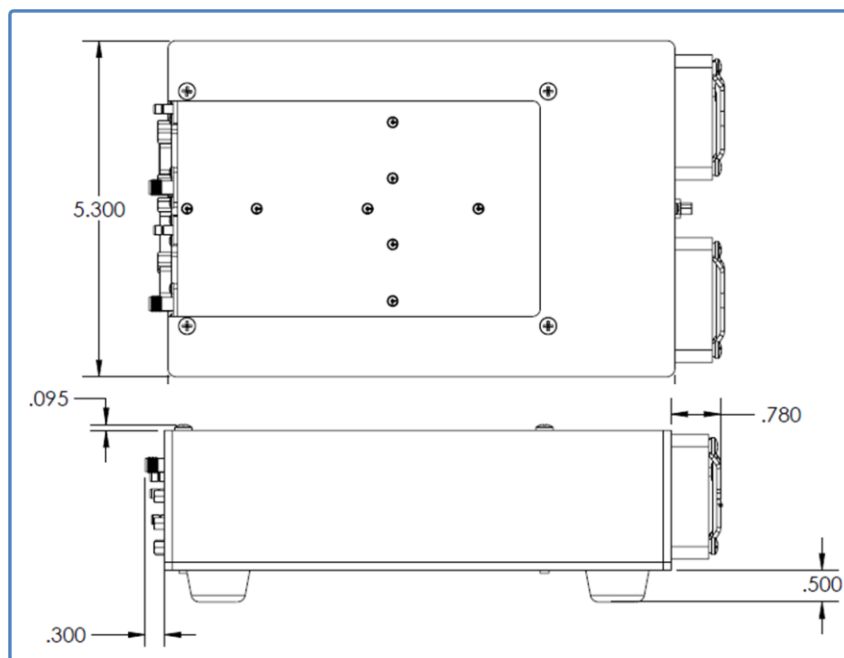


Figure 2-19 LS-28-DRSM Generation 1 Desktop chassis

The fixture comes with removable rubber feet. Often, this fixture is used directly as a basis for customer mounting. The feet are removable and the resulting hole locations can be used as direct mount points either by using the provided UNC6-32 threads or by counter-sinking mount points at these locations. Figure 2-20 contains a drawing locating these mount-hole locations.

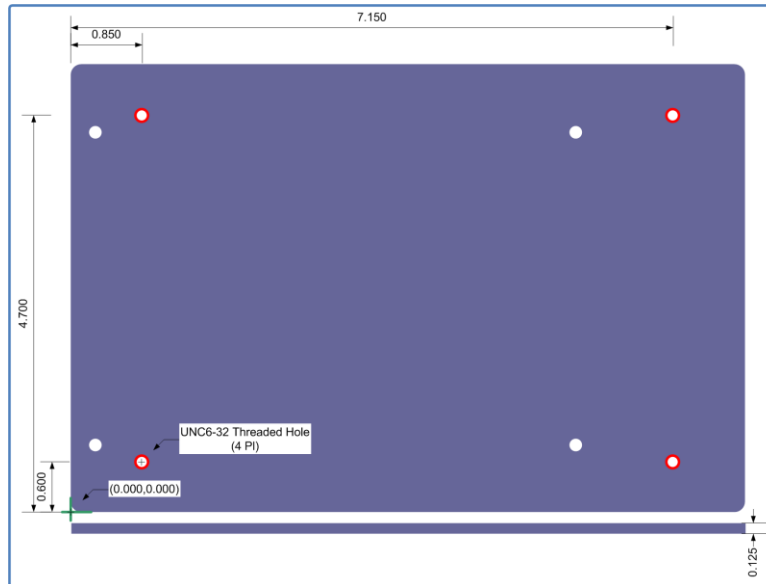


Figure 2-20 LS-28-DRSM Desktop chassis – Generation 1 Mounting Plate Dimensions

A lighter and more capable Generation 2 desktop chassis is presently being shipped. This unit is shown in Figure 2-21. This fixture has added capabilities versus the Generation 1 fixtures. While the Generation 1 desktop chassis were designed to operate on 24VDC only, the generation 2 fixture can be operated on input voltages between 9 and 36VDC. In addition, the Generation 2 fixtures can be stacked and mounted together as shown in Figure 2-22. The overall mechanical dimensions of the generation 2 desktop chassis are shown in Figure 2-23. Mounting dimensions for the lower section of the housing are provided in Figure 2-24.

Three options for power connections are available for the desktop chassis. The unit has primarily been delivered with a 5.5mm x 2.5mm power connector. However, future deliveries will be via an 8-pin DIN connector which offer keying and better power transfer. Additionally, there is an option to have a MIL-DTL-26482 Series bayonet connector option. Consult Lumistar sales for ordering options.



Figure 2-21 LS-28-DRSM Desktop chassis – Generation 2 ISO view



Figure 2-22 LS-28-DRSM Desktop chassis – Generation 2 Stacked ISO view

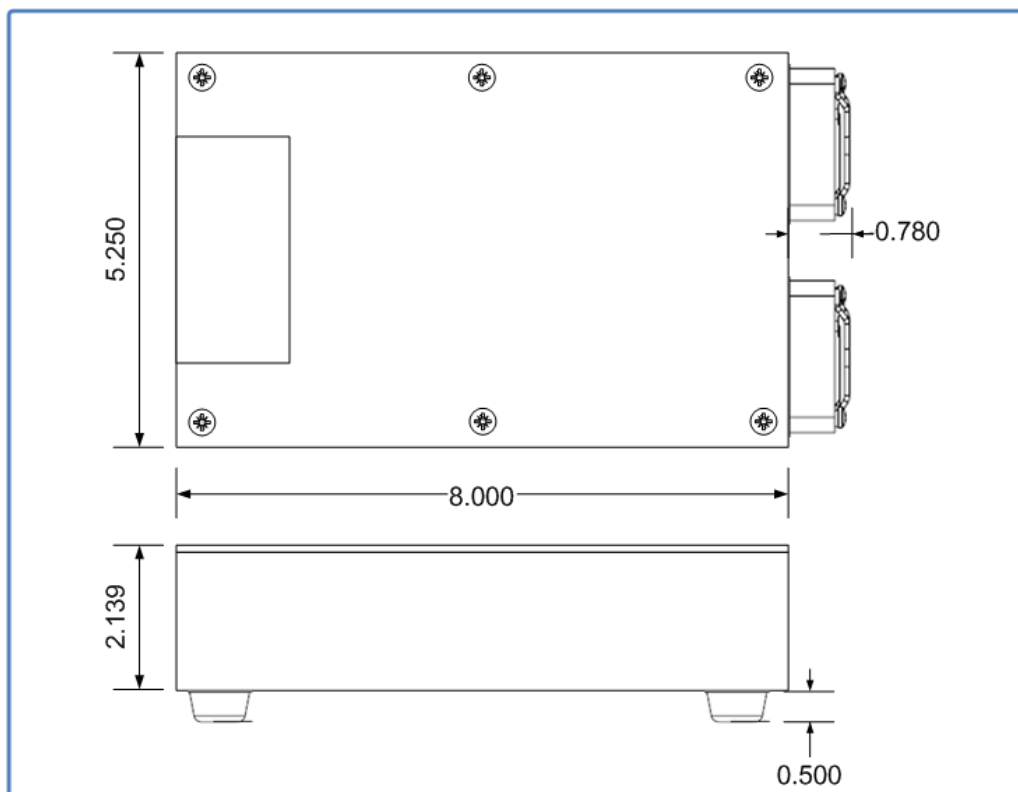


Figure 2-23 LS-28-DRSM Desktop chassis – Generation 2 Overall Dimensions



2.5.2 1U 12" and 1U 22" LS-28-DRSM Chassis'

Lumistar offers two different LS-28-DRSM designs in 19" 1U rackmount configurations: one that is 12" deep and one unit that is 22" deep. Figure 2-25 shows the front and rear panels of both chassis'.

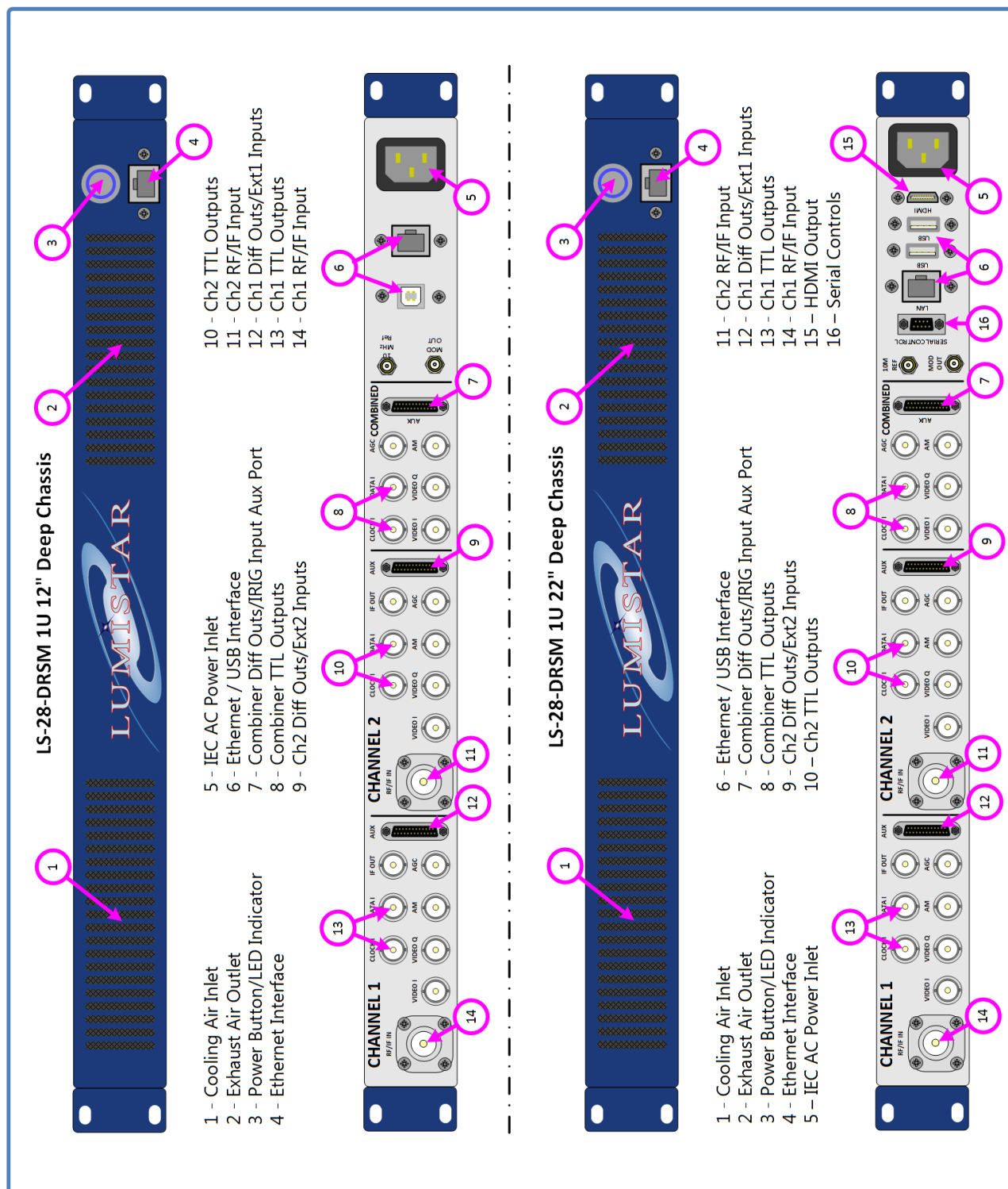


Figure 2-25 LS-28-DRSM 1U 12" and 22" Chassis Front and Rear Panels

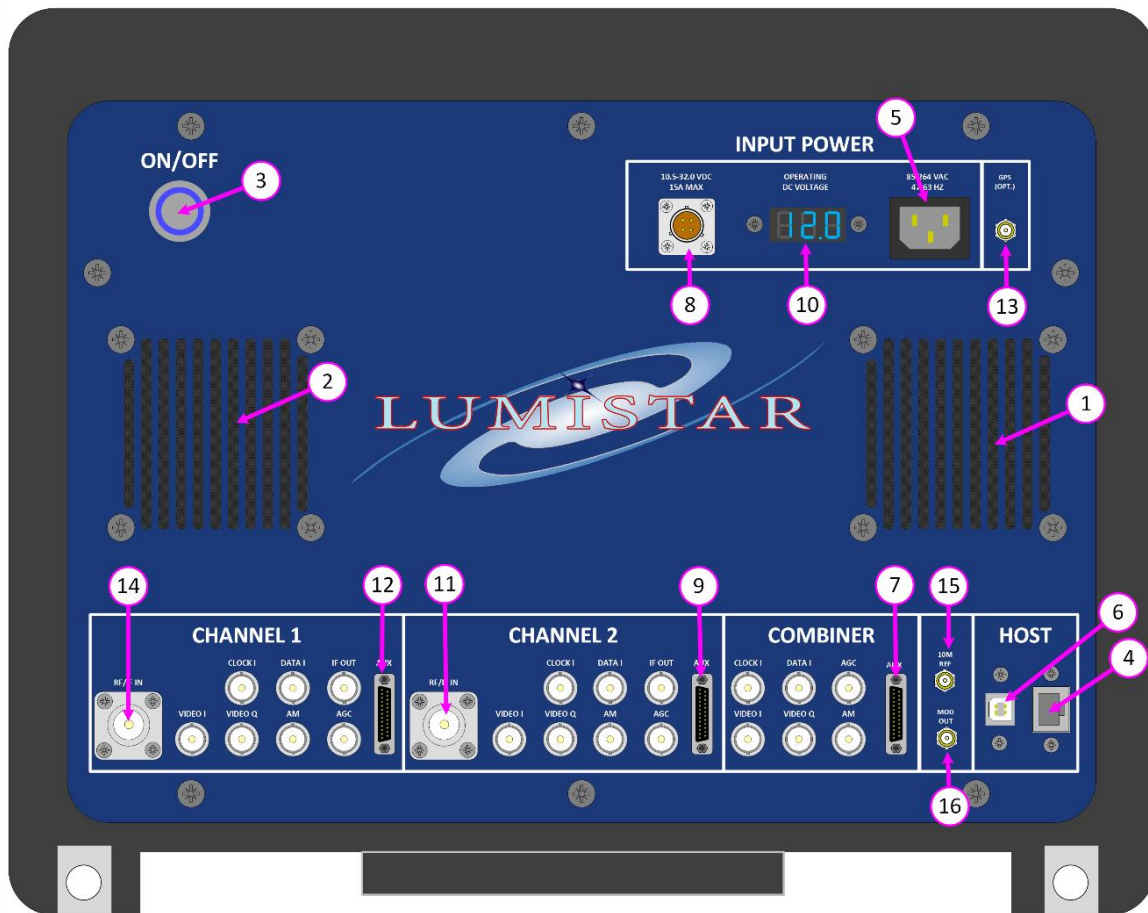
The two 1U chassis offerings vary in capabilities.

The 12" deep 1U LS-28-DRSM chassis requires an external host PC to run the LS-28-DRSM application software to control and status the LS-28-DRSM. The chassis contains the receiver and all power and cooling provisions. The chassis also contains an unmanaged 1Gbps 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 delivered with the three required Auxiliary interface cables, and an AC power cord. Overall specifications and the pin connections of the DC connector are listed in Table 1-3.

The 22" deep 1U LS-28-DRSM chassis contains an internal PC running the Microsoft Windows 10 Pro operating system and hosting the LS28_App control software. Some custom options related to the internal PC of the 22" chassis may be available. Consult Lumistar sales for further details. The 22" chassis does not contain an internal Ethernet switch. Instead, the chassis contains three independent Ethernet networks attached to the internal PC. One of the available networks is setup statically and attached to the internal receiver. The network interface connections on the exterior of the chassis are setup in DHCP mode and may be connected to the customer network. If there is a desire to merge the networks within the chassis, the customer should bridge the available networks as directed by the customers IT professionals. This unit is delivered with the three required Auxiliary interface cables, and an AC power cord. Overall specifications and the pin connections of the serial control connector are listed in Table 1-4.

2.5.3 Portable Ruggedized Case (Pelican 1450 Case)

Lumistar offers a LS-28-DRSM mounted inside of a portable case for ultra-portable and rugged field applications. All power and cooling provisions are included. An external host PC, such as a laptop computer (not included but can be ordered as an option) must be provided if active control interactions and status are required with the unit. Figure 2-26 contains the top view, ISO closed case view of the unit. This figure also contains a picture of the optional Battery Bag with shoulder harness for cases where DC field battery power is desired. This unit is delivered with the three required Auxiliary interface cables, and an AC power cord. Optionally, the unit can be delivered with a portable LiFEPO⁴ battery for field DC operations. Overall specifications and the pin connections of the DC power connectors are listed in Table 1-5.



- 1 - Cooling Air Inlet
- 2 - Exhaust Air Outlet
- 3 - Power Button/LED Indicator
- 4 - Ethernet Interface
- 5 - IEC AC Power Inlet

- 6 - USB Interface
- 7 - Combiner Diff Outs/IRIG Input Aux Port
- 8 - DC Power Input
- 9 - Ch2 Diff Outs/Ext2 Inputs
- 10 - DC Power Voltmeter

- 11 - Ch2 RF/IF Input
- 12 - Ch1 Diff Outs/Ext1 Inputs
- 13 - GPS Antenna Port (optional)
- 14 - Ch1 RF/IF Input
- 15 - 10M Reference I/O
- 16 - Comb IF/Modulator IF Out



Portable Battery Case w/Shoulder Strap
(Optional)

Figure 2-26 LS-28-P Ruggedized Portable Case (Pelican)

2.5.4 Auxiliary (AUX) I/O Connectors

Primary IO interfaces are provided by BNCs and RF connectors on both 19-inch 1U rack mount chassis' as well as the Ruggedized Portable Case. On these units, secondary IO is provided by three Micro D-Sub 25-pin connectors.

Products requiring Auxiliary connectors delivered prior to approximately June of 2019 utilize the revision 1 auxiliary cables. These are depicted in Figure 2-27, Figure 2-28 and Figure 2-29. After June of 2019, Revision 2 auxiliary cables were standardized for delivery. These revisions are depicted in Figure 2-30, Figure 2-31, and Figure 2-32. Versions are clearly marked on auxiliary cables.

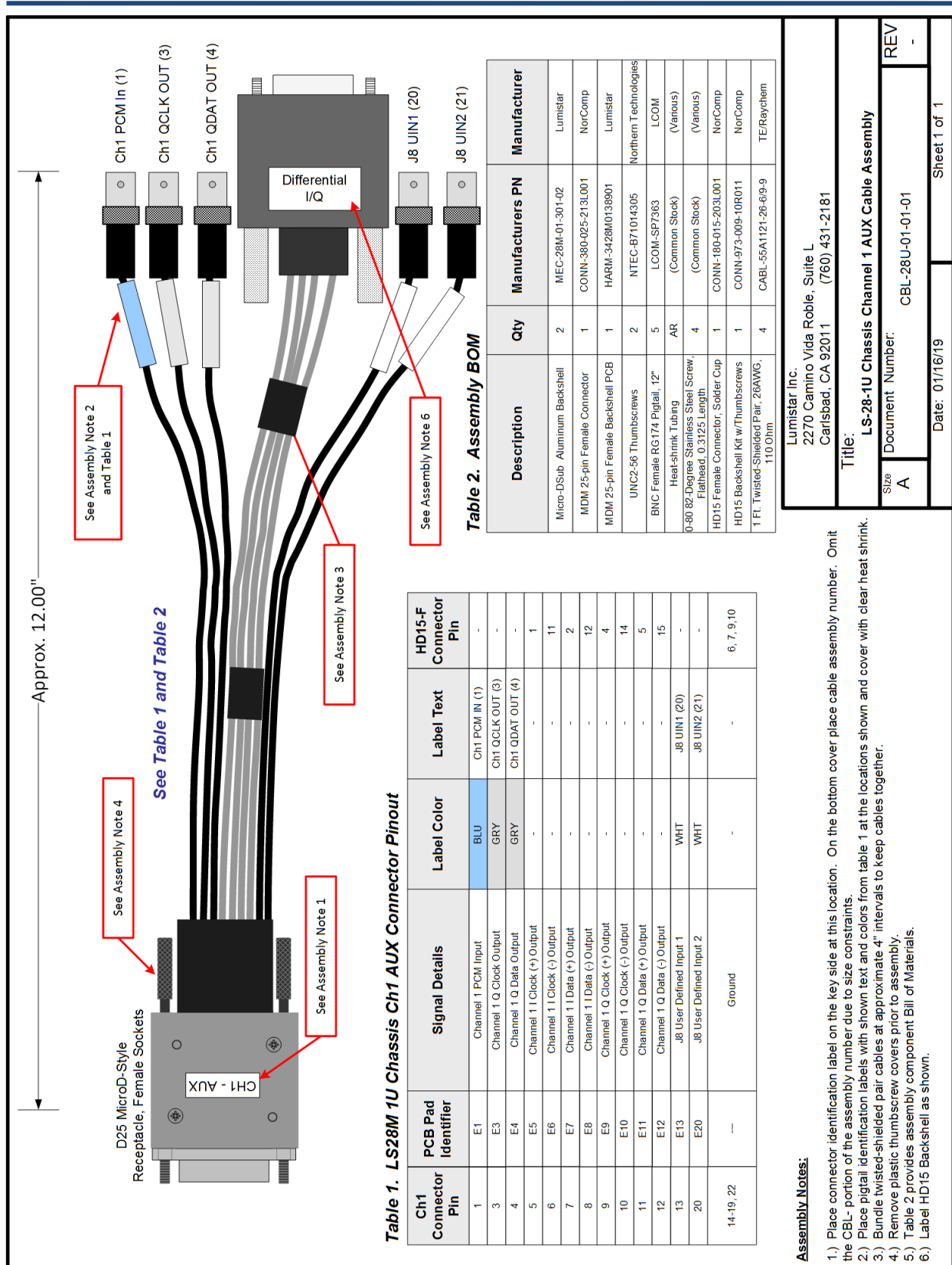


Figure 2-27 Revision 1 Cable: LS-28-DRSM 1U Chassis AUX1 Cable

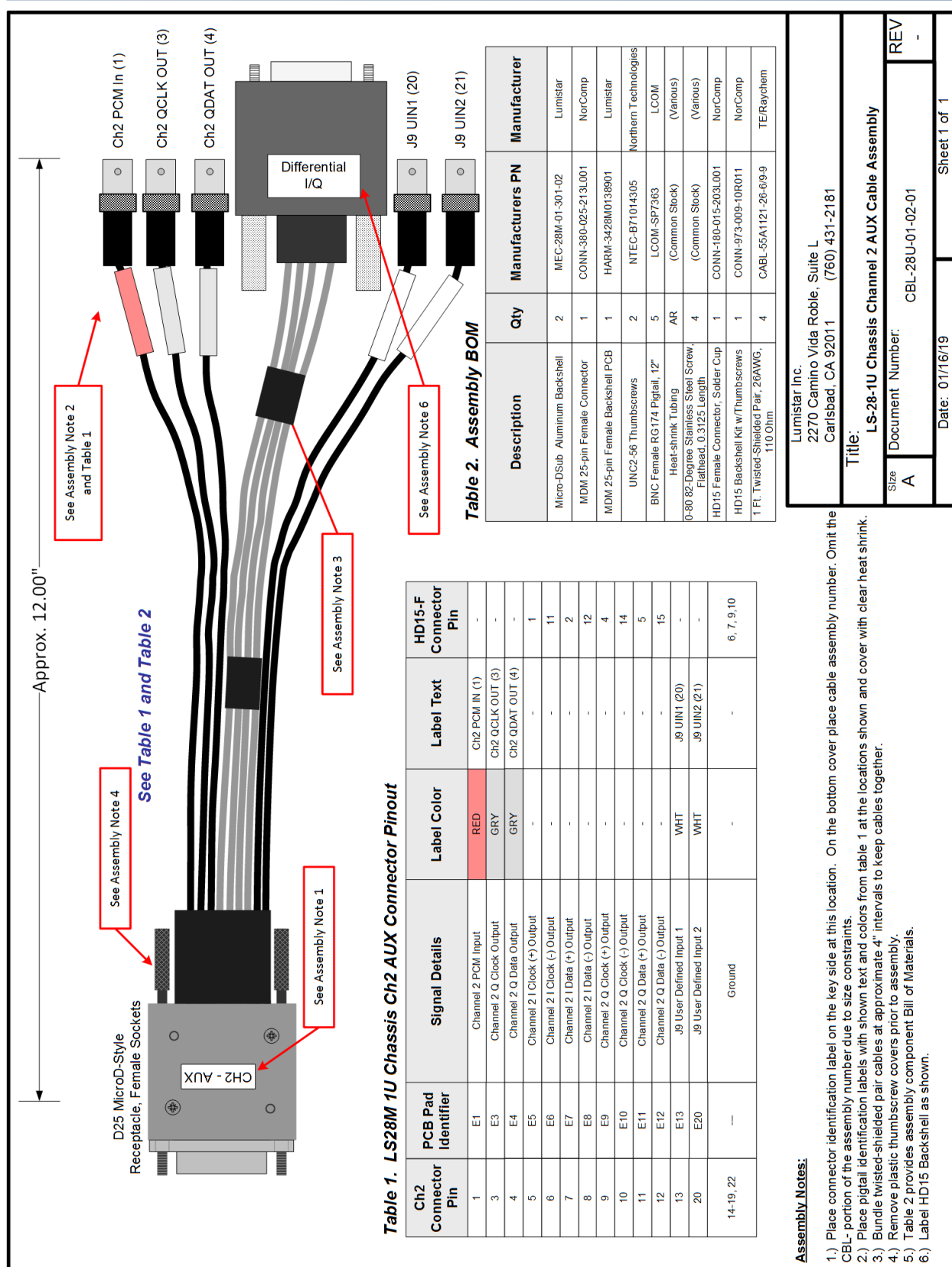


Figure 2-28 Revision 1 Cable: LS-28-DRSM 1U Chassis AUX2 Cable

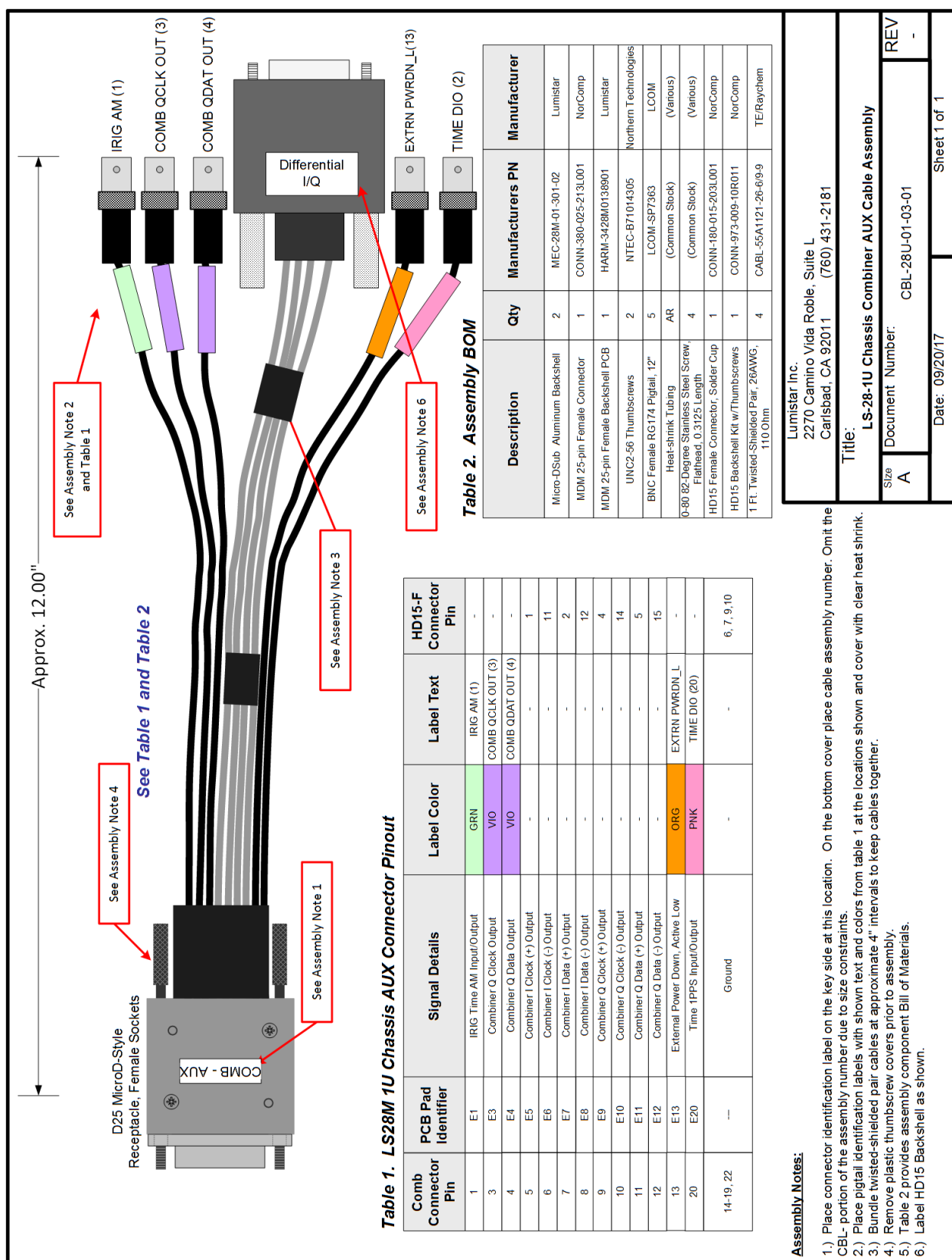


Figure 2-29 Revision 1 Cable: LS-28-DRSM 1U Chassis AUX3 Cable

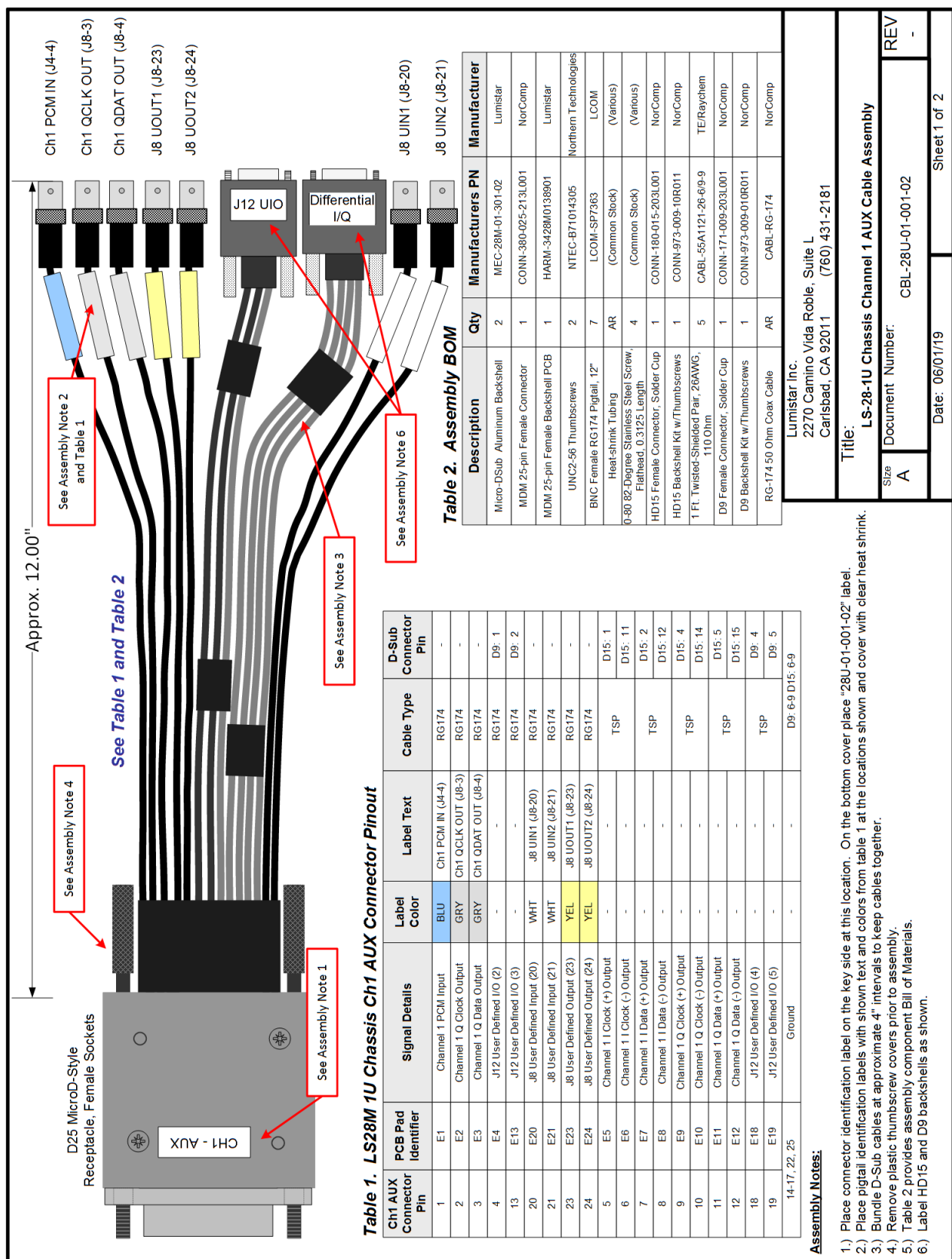


Figure 2-30 Revision 2 Cable: LS-28-DRSM 1U Chassis AUX1 Cable

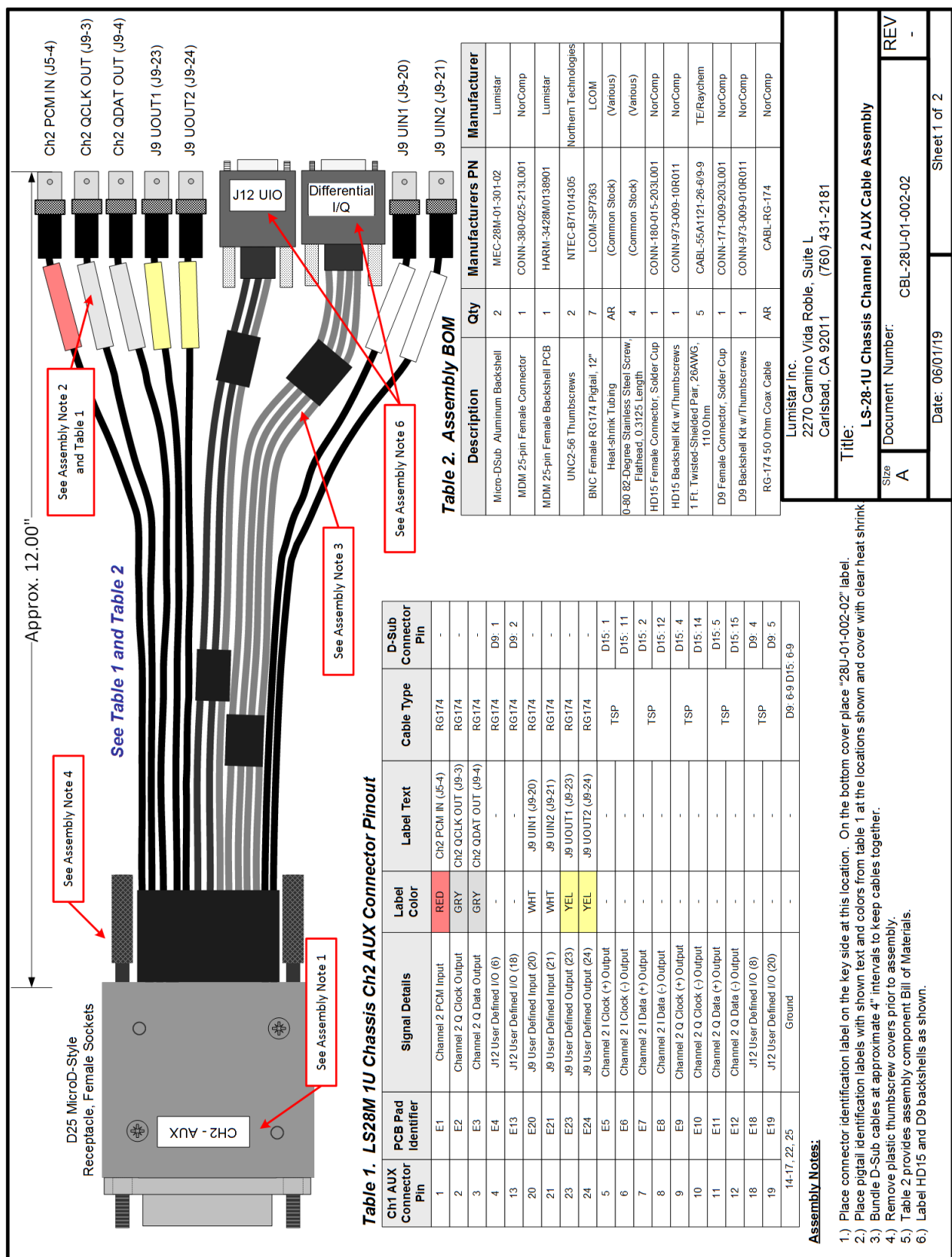


Figure 2-31 Revision 2 Cable: LS-28-DRSM 1U Chassis AUX2 Cable

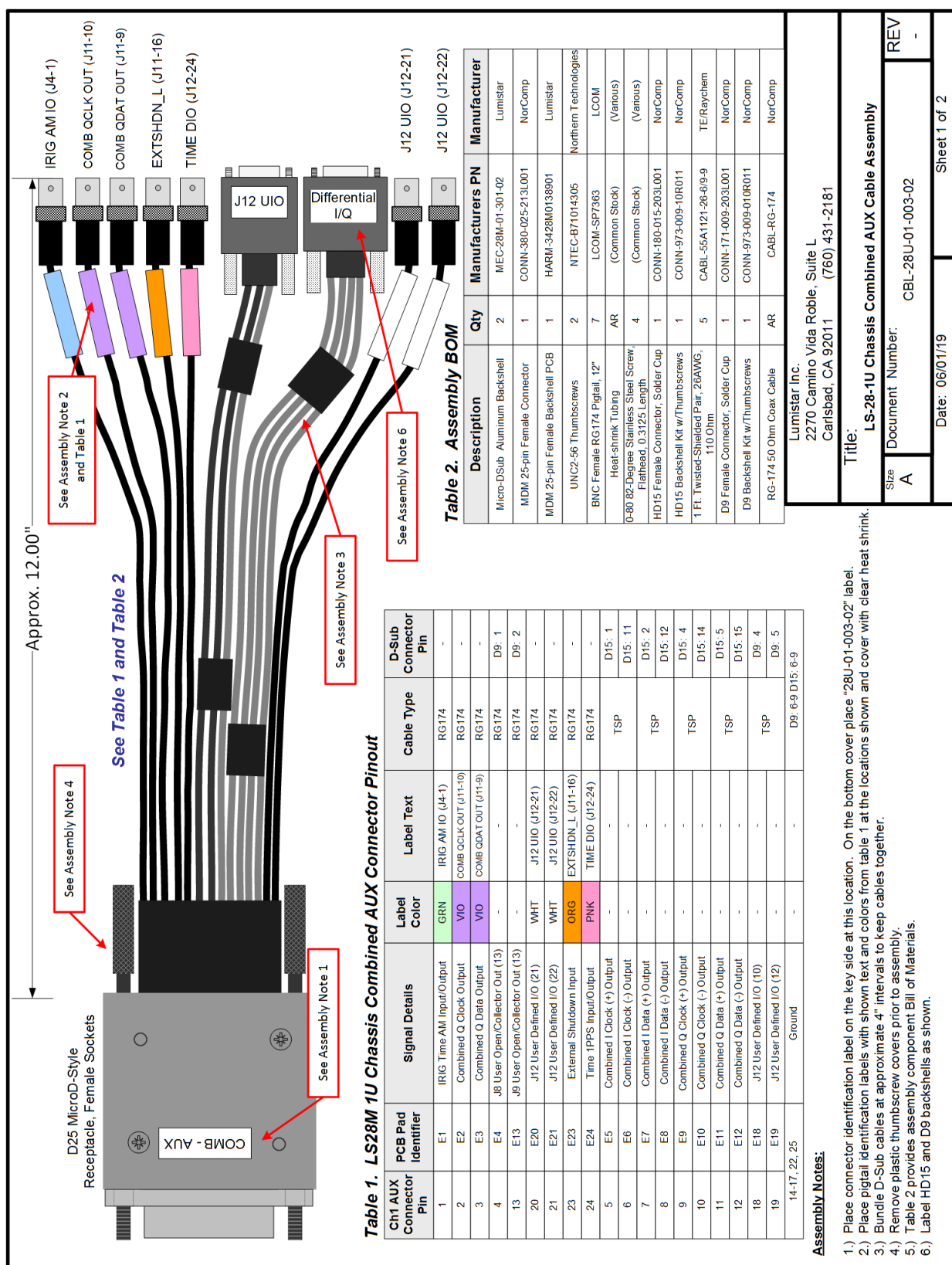


Figure 2-32 Revision 2 Cable: LS-28-DRSM 1U Chassis AUX3 Cable

2.6 Cooling and Thermal Conditioning

The LS-28-DRSM 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 45 to 52 Watts. This load can and will vary based on operating mode. The actual calculation of the total heat load of the system is quite complex due to many factors involved which include:

- Operational mode
- Programmed data rate
- The use of video outputs

Generally speaking, the design utilizes CMOS logic. The higher the processing rate, the more power the device will consume. Auxiliary items that are purely analog in nature consume even greater amounts of power and thus increase the heat load of the device. The use of all six video outputs can add up to 6 Watts of additional heat load. The design employs the ability to shut down unnecessary functions such as the video output channels to conserve system power. However, these controls are under the user's direction and thus conservation of system power is as well.

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.

**Caution:**

Forced air cooling is required for the majority of LS-28-DRSM applications. It is suggested to use greater than 40 CFM of cooling air routed around that sides of the unit.

**Caution:**

Video Outputs require analog amplification and analog signal distribution which consumes a great deal of power and generates additional heat. The video outputs should be disabled when not in use.

3 Communications Interface

The LS-28-DRSM can communicate through one of three physical interface paths. The three interfaces include: an RS-232 serial interface, a USB 2.0 serial interface, and a 10/100/1000Mbps Ethernet serial interface. Each of these interface's function at all times. Simultaneously operation is allowed.


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-28-DRSM.


Caution:

No serial interface is provided priority over any other.

There are functional limitations that are imposed based on the interface method utilized. Figure 3-1 provides a matrix of system functions that are available via the available interfaces.

	Receiver System Commands	Receiver System Status	Receiver Eb/No Status (UDP)	Receiver Spectrum Display (UDP)	Receiver Eye Pattern Display (UDP)	Receiver Constellation Display (UDP)	Field Firmware Upgrades
Ethernet Interface	Y	Y	Y	Y	Y	Y	Y
USB 2.0 Interface	Y	Y	N	N	N	N	Y
RS232 Interface	Y	Y	N	N	N	N	Y

Figure 3-1 Interface Capabilities Matrix

3.1 Serial/USB Interface

The LS-28-DRSM 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. This interface is capable of being used as a secondary interface for field upgrades of on-board firmware sources, as a control and status interface, and as a debug port. Real-time data and graphics interfaces cannot be provided thru this interface due to its limited bandwidth. Serial communications on this port are limited to 250K BAUD. Starting with revision 5 of the hardware design, this interface can support up to 921.6K BAUD. Consult Lumistar support if rates higher than 250K BAUD are desired.

The LS-28-DRSM provides a USB 2.0 serial interface. Included with the delivery is a driver installation that converts the USB serial interface into a standard COM port for several different operating systems,

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.

3.2 Ethernet Network Interface

The LS-28-DRSM provides a 10/100/1000Mbps 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, and non real-time data transfers from the device. The UDP protocol is used to receive real-time packet data from the device such as display content for spectral, eye and constellation displays as well as streamed data.

The Ethernet interface packet size is defined by the networking maximum transmission unit (MTU) of 1500 bytes. Both TCP and UDP transmissions are limited to this packet size.

Ethernet port assignments are defaulted as shown in Table 3-1.

Ethernet Default Port Assignments		
Port#	Port Data	Protocol
5000	Command and Status	TCP
5001	Spectral Display Data Ch1	UDP
5002	Spectral Display Data Ch2	UDP
5003	Decom Streaming Data Ch1	UDP
5004	Decom Streaming Data Ch2	UDP
5005	Recording Memory Download	TCP
5006	(Unassigned)	----
5007	Constellation Display Data Ch1	UDP
5008	Constellation Display Data Ch2	UDP
5009	Constellation Display Data Ch3	UDP
5010	Eye Pattern Display Ch1	UDP
5011	Eye Pattern Display Ch2	UDP
5012	Eye Pattern Display Ch3	UDP
5013	Consolidated Status Data	UDP
5014	(Unassigned)	----
5015	Test Socket - <i>Factory Use</i>	UDP

Table 3-1 Ethernet Port Assignments Table

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

The LS-28-DRSM is delivered configured with a **Static IP Address**. The primary default address is **192.168.16.220**. 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: 192.168.16.220

Unit 2 IP Address: 192.168.16.225

Unit 3 IP Address: 192.168.16.230

Unit 4 IP Address: 192.168.16.235

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. An example of how to configure a common Windows network Host Controller to operate in either Static mode which is necessary to change the delivered mode of operation is described in section 3.2.1.1. An example of how to set a Windows network host to DHCP mode follows in section 3.2.1.2.

**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.

3.2.1.1 Modification of a Windows Host controller to Static IP mode

To modify the controlling host's network configuration to static IP mode, perform the following steps:

Step 1: Connect the LS-28-DRSM to the target host machine either directly with a Ethernet crossover cable or by connecting both the device and the host to an Ethernet switch using standard Ethernet cables.

Step 2: On the target host application machine, access the Windows Control Panel.

Step 3: From Windows Control Panel, select the Network and Sharing Center.

Step 4: From Network and Sharing Center, select the "Change adapter settings" option from the left-hand menu. See Figure 3-2.

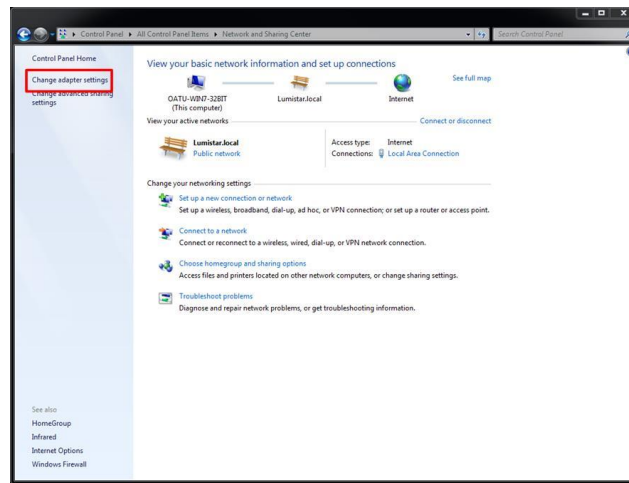


Figure 3-2 Windows Network and Sharing Page

Step 5: The Network Connections window shows the available connections the target host can use. Right-click on the local area connection attached to the LS-28-DRSM and select "Properties". See Figure 3-3.

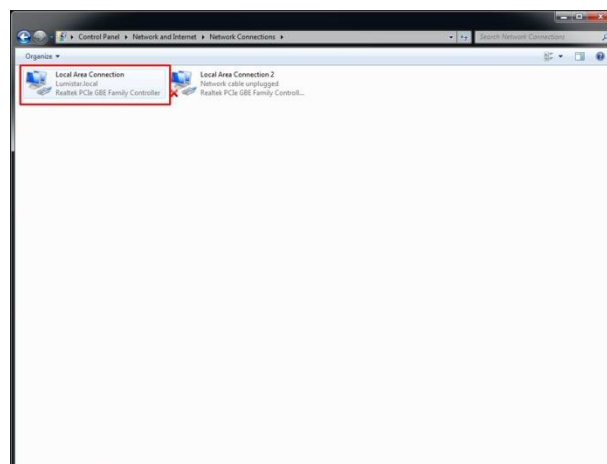


Figure 3-3 Windows Network Connections Page

Step 6: From the Local Area connection Properties window, double-click on "Internet Protocol Version 4 (TCP/IPv4)". See Figure 3-4.

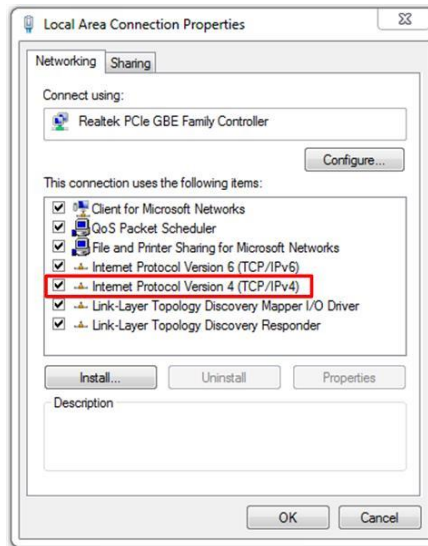


Figure 3-4 Windows Network Connections properties page

Step 7: To set the unit to a static IP address, select the "Use the following IP address:" option. Then enter the desired IP address in the designated field. A suggestion is to use the IP address 192.168.16.200 as shown below. Once the IP address is filled, the Subnet mask field will automatically populate. See Figure 3-5.



Warning:

The static IP address of the host machine cannot be set identically to any device on the connected network.

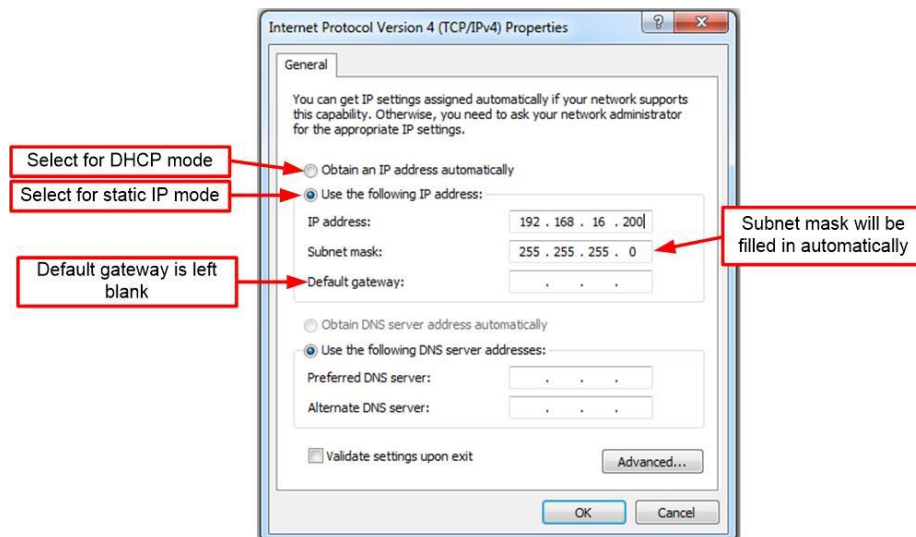


Figure 3-5 Windows Network Connections IPv4 properties page –Static IP

Step 8: From the Internet Protocol Version 4 (TCP/IPv4) Properties window, click "OK".

Step 9: From the Local Area Connection Properties window, click "OK".

3.2.1.2 Modification of a Windows Host controller to DHCP Mode

To modify the controlling host's to the DHCP network configuration, perform the following steps:

Step 1: Connect the target host to a DHCP enabled network.

Step 2: On the target host application machine, access the Windows Control Panel.

Step 3: From Windows Control Panel, select the Network and Sharing Center.

Step 4: From Network and Sharing Center, select the "Change adapter settings" option from the left-hand menu. See Figure 3-2.

Step 5: The Network Connections window shows the available connections the target host can use. Right-click on the local area connection connected to the DHCP enabled network and select "Properties". See figure 3-3.

Step 6: From the Local Area connection Properties window, double-click on "Internet Protocol Version 4 (TCP/IPv4)". See Figure 3-4.

Step 7: To set the unit to DHCP mode, select the "Obtain an IP address automatically" option. See Figure 3-6.

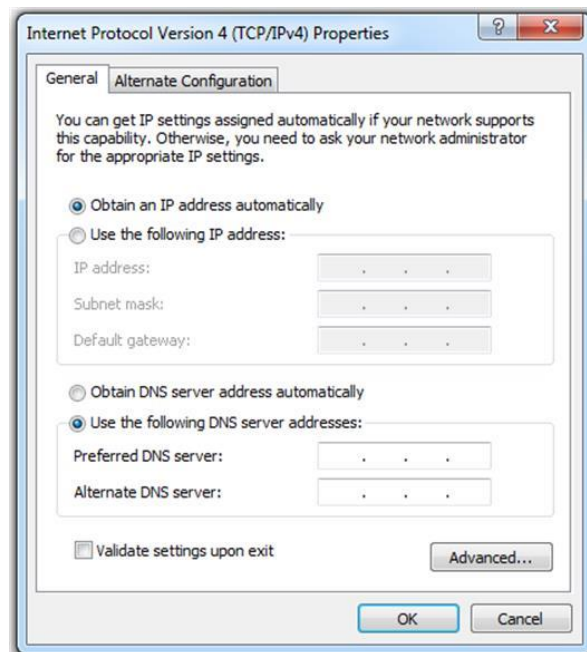


Figure 3-6 Windows Network Connections IPv4 properties page - DHCP

Step 7: From the Internet Protocol Version 4 (TCP/IPv4) Properties window, click "OK".

Step 8: From the Local Area Connection Properties window, click "OK".

3.2.2 Modification of the network configuration from the factory defaults

To modify the LS-28-DRSM to any other network configuration from the factory set static IP address, perform the following steps:

Step 1: Perform the steps to create a Windows network host controller with subnet mask access to 192.168.16.220 as described in section 3.2.1.1.

Step 2: Interconnect a standard RJ45 network cable between the Windows network host and the LS-28-DRSM unit.

**Information:**

On network hosts which contain 1000Mbps (1Gbps) Ethernet connections, direct RJ45 cabling is possible due to a feature included with all "Fast Ethernet" controllers called MDI-X (Medium Dependent Interface - Crossover) which provides the necessary auto-detection signal support.

**Caution:**

If the network host contains a 100Mbps network interface, **who use is strongly discouraged**, cabling between the host and the LS-28-DRSM will likely require the use of a cross-over style Ethernet cable. Consult the manufacturer of the host device for the presence of MDI-X capabilities in the Ethernet adapter.

Step 3: Ensure that both the host platform and the LS-28-DRSM are powered and allow the unit to enter the fully operational state which is indicated by both LEDS flashing Green at a 1Hz rate.

Step 4: On a host machine connected to the same network as the LS-28-DRSM, launch a web browser window and enter the IP address in the address bar of the browser. The factory default IP address is **192.168.16.220**. This will result in web browser page display similar to the one shown in Figure 3-7. The tab provides network information to the user (as indicated) and the ability to administrative access controls. To set an administrative password, enter a password in the indicated box, select the ENABLE check box and click the UPDATE button at the bottom of the page.

**Warning:**

If the administrator password for the LS-28-DRSM is set and then forgotten, the unit will require return to the Lumistar factory for repair.

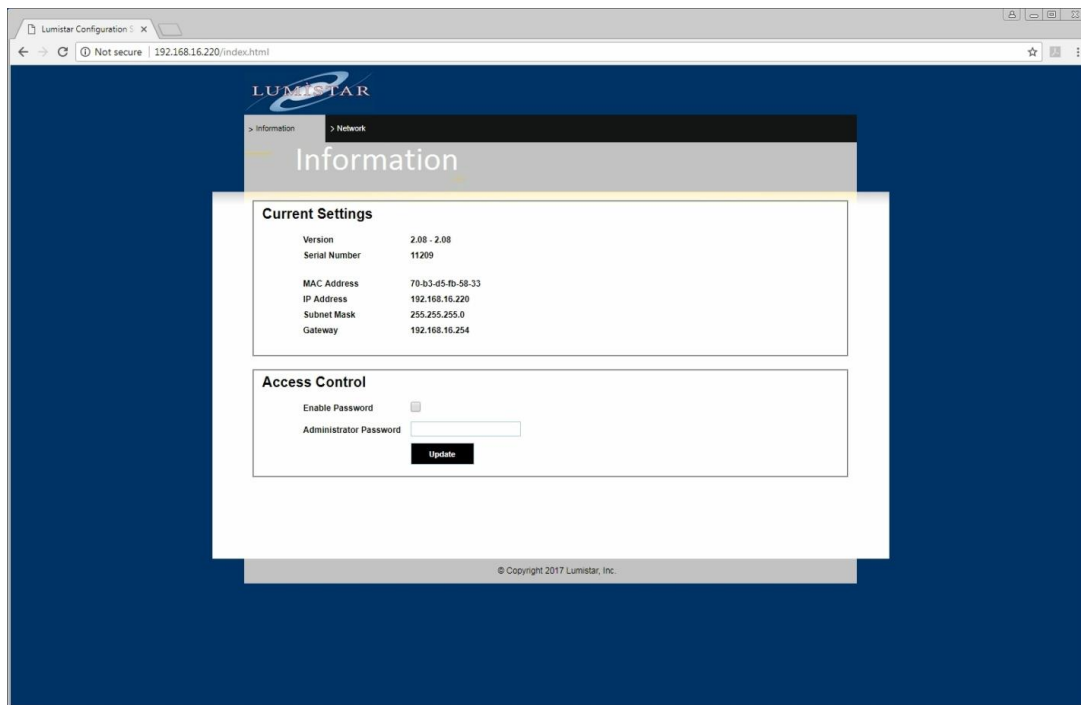


Figure 3-7 LS-28-DRSM Network Setup: Web Browser Information Setup Tab

Step 5: To change any of a number of other network parameters, select the NETWORK tab on the web browser page. This will bring up web page similar to the one shown in Figure 3-8.

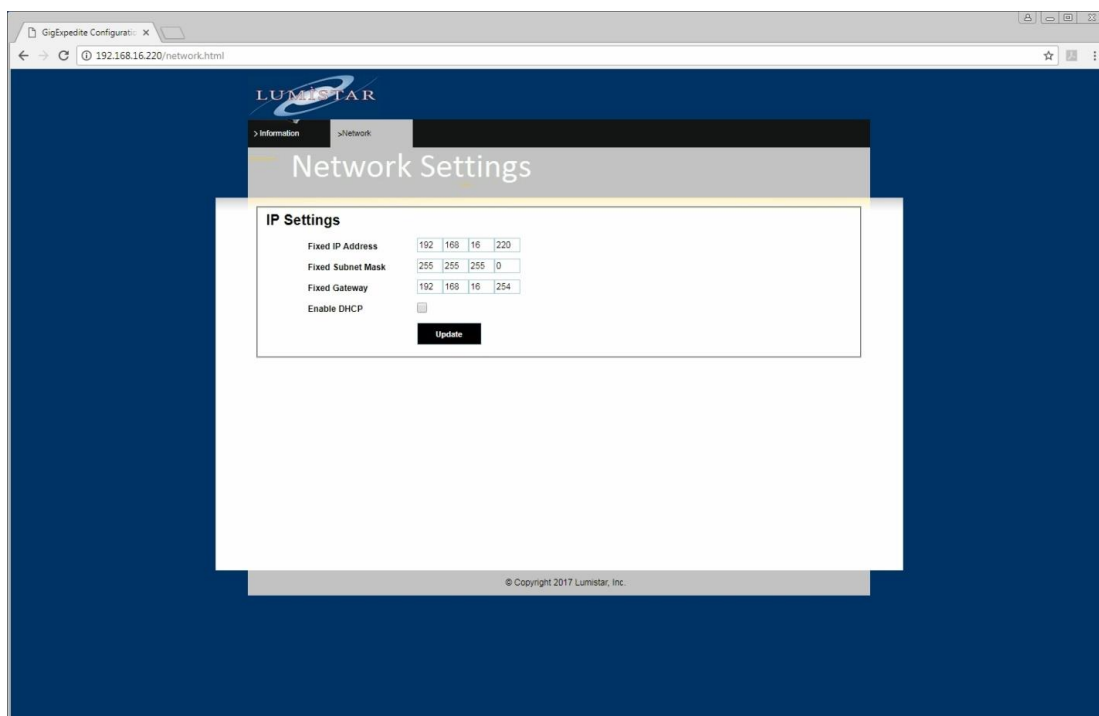


Figure 3-8 LS-28-DRSM Network Setup: Web Browser Network Setup Tab

Settings can be entered in the provided spaces and then updated by clicking the UPDATE button.

The DHCP check-box allows the DHCP mode to be enabled and disabled. If the DHCP mode is enabled, the fixed IP address fields will be ignored and addressing will be assigned by another controlling network source. If no such host is available to assign the unit an address, all network functions will be prohibited.

Deselecting the DHCP box will place the device in static IP mode using the address field setting set on this tab. Be sure to press the UPDATE button prior to closing this page to make the settings active. Settings will be retained between power cycles.

**Warning:**

If the DHCP mode is selected, the unit will not contain an IP address, subnet or gateway setting. If set to this mode, a DHCP network controller **MUST** be present to assign network interface settings. If the unit is set to DHCP mode, the **ONLY** means to change network control settings is to attach the unit to a network which contains a DHCP controller.

3.2.3 Modification of Windows Firewall Settings

The supplied user application requires access to several ports as well as the ability to receive UDP packets. Primary Windows Firewall settings, as a general rule, allow the TCP connections and block the UDP transactions. To allow the standard Windows 7 or Windows 10 operating system installs to receive UDP transactions, firewall settings typically need to be altered.

**Caution:**

Without the proper firewall privileges for the UDP transactions, no graphic instrumentation displays will be available and no streaming data will be provided by the LS-28-DRSM

There are two means of modifying the firewall settings: using an application provided by Lumistar, or by setting the system firewall settings manually. To simplify the firewall requirements, Lumistar provides an application to open the firewall for the necessary functions. You can find the **OpenFirewall(ADMIN).exe** file in the main application installation directory. To run this application, you will need to have administrative privileges on the machine containing the application installation. Consult your IT administration personnel if you do not. To launch the application in administrative mode, right-click the application title in the LS28 installation directory and select the "Run As Administrator" from the Windows menu. Upon completion, the application will provide a note with status on its success.

To configure the firewall settings manually, perform the following steps:

Step 1: On the target host application machine, access the Windows Control Panel.

Step 2: From Windows Control Panel, select the Windows Firewall control.

Step 3: From Windows Firewall control, select the "Advanced Settings" option from the left-hand menu. See Figure 3-9.

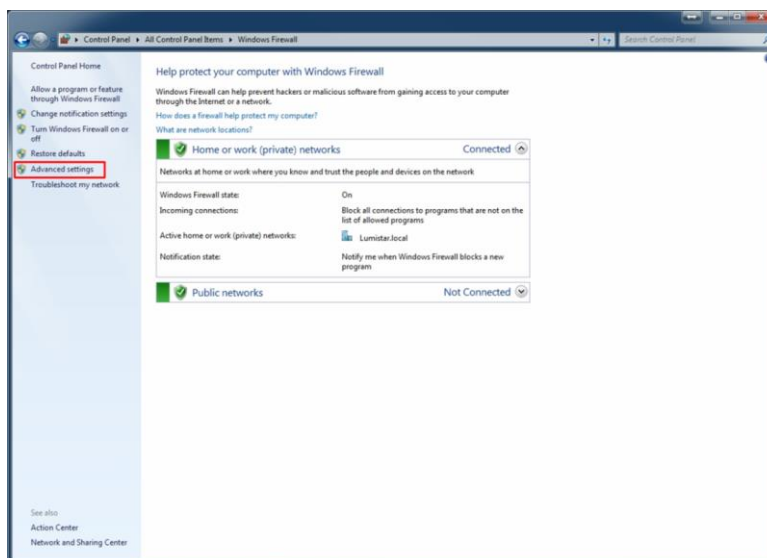


Figure 3-9 Windows Firewall – Advanced Setting Tab

Step 4: From the window shown in Figure 3-10, select the "Inbound Rules" from the left-hand menu.

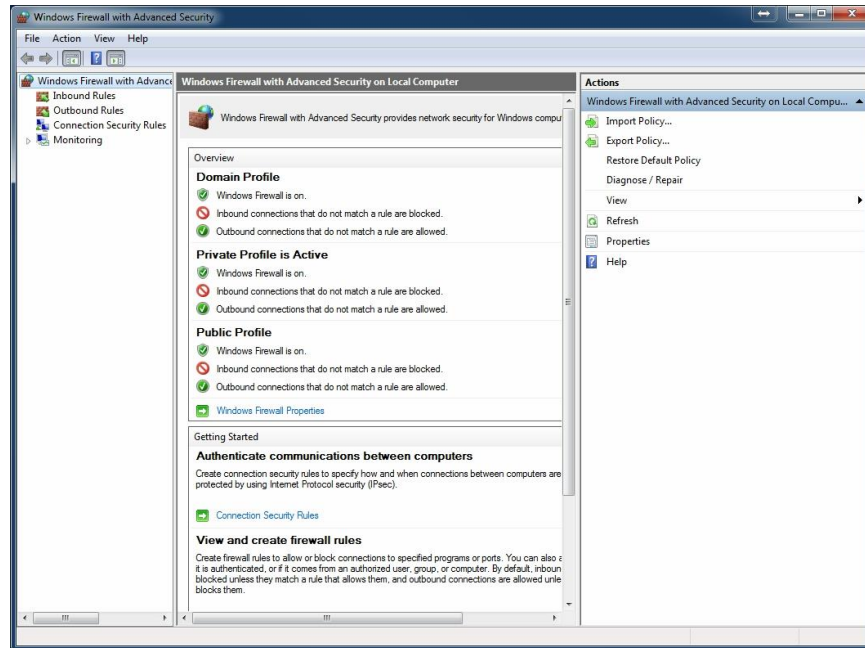


Figure 3-10 Windows Firewall – Advanced Security Inbound Rules

Step 5: From the window below, select the "New Rule" option under the ACTIONS window pane on the right. Refer to Figure 3-11.

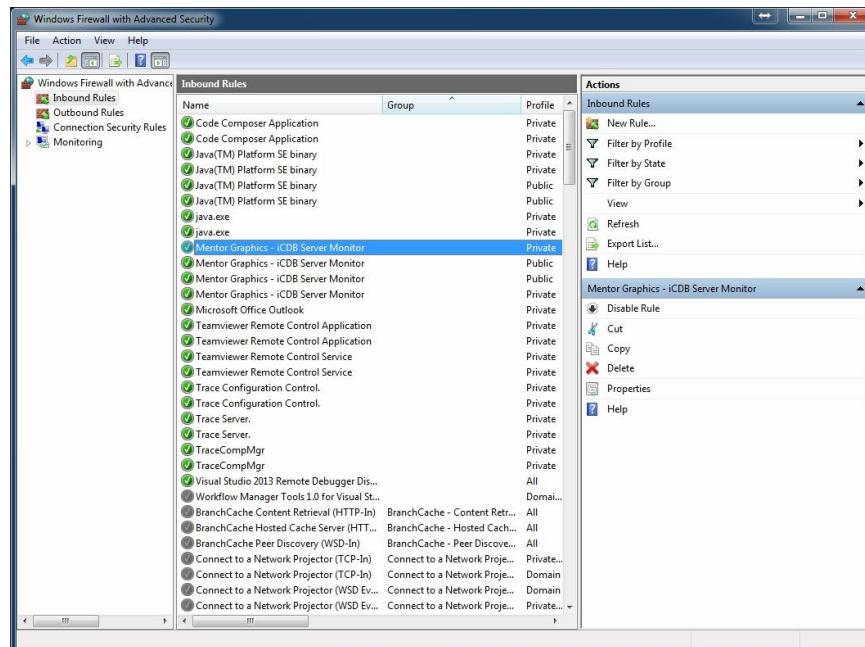


Figure 3-11 Windows Firewall – Advanced Security New Rule

Step 6: The "New Rule" process will begin with the RULE TYPE menu as shown in Figure 3-12.

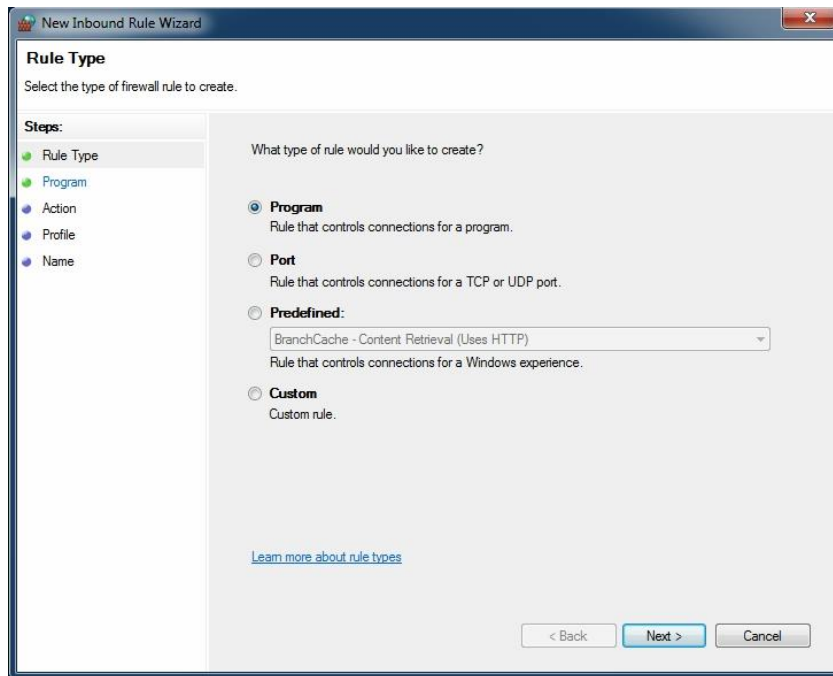


Figure 3-12 Windows Firewall – Advanced Security New Rule: Type

Step 7: The “New Rule” process will continue with the PROGRAM menu, browse to the route of the LS-28-DRSM installation and select the EXE file that is found there. The application will typically be located as shown in the following Figure 3-13.

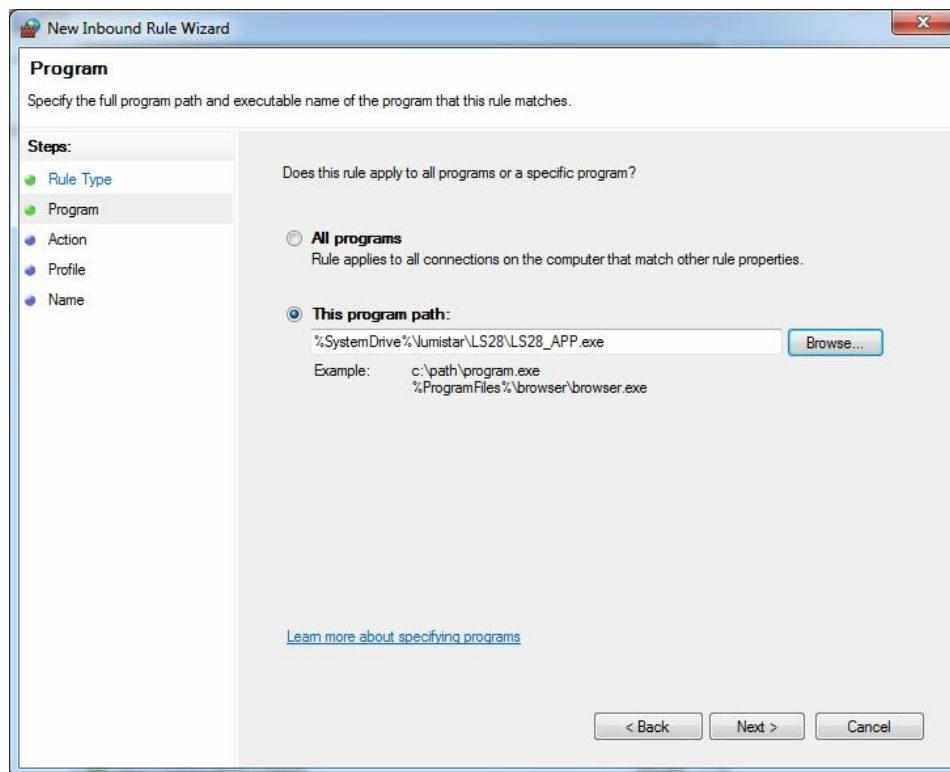


Figure 3-13 Windows Firewall – Advanced Security New Rule: Program

Step 8: On the ACTION menu, select "Allow the connection". Consult Figure 3-14.

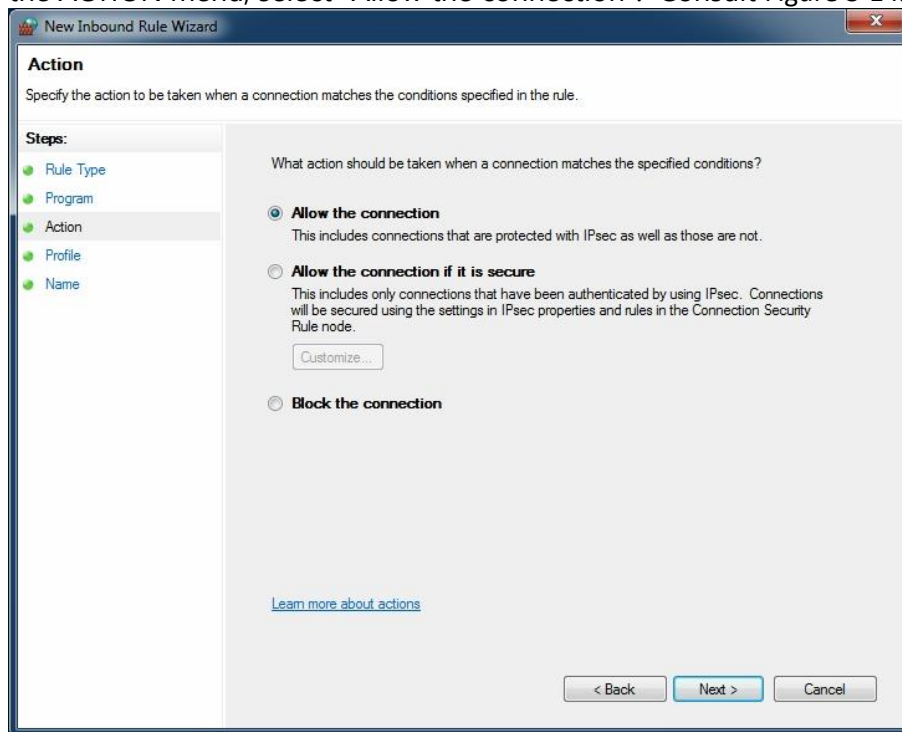


Figure 3-14 Windows Firewall – Advanced Security New Rule: Allow Connections

Step 9: On the PROFILE menu, select the domains that the rule will apply to as shown in Figure 3-15.

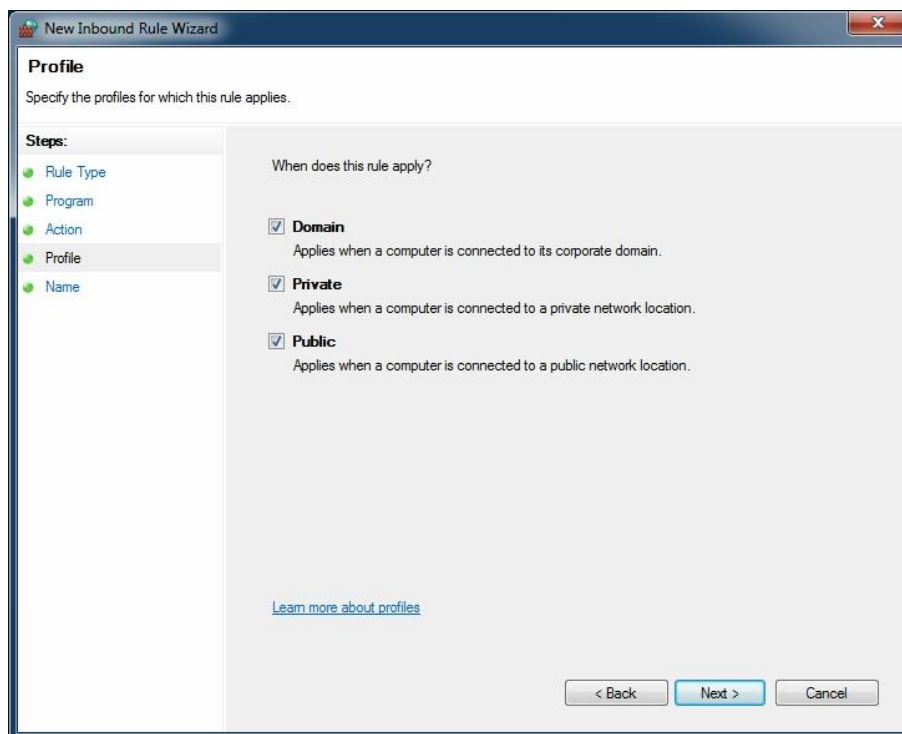


Figure 3-15 Windows Firewall – Advanced Security New Rule: Domains

Step 10: Finally, name the rule for easy identification and select the FINISH button as shown in Figure 3-16.

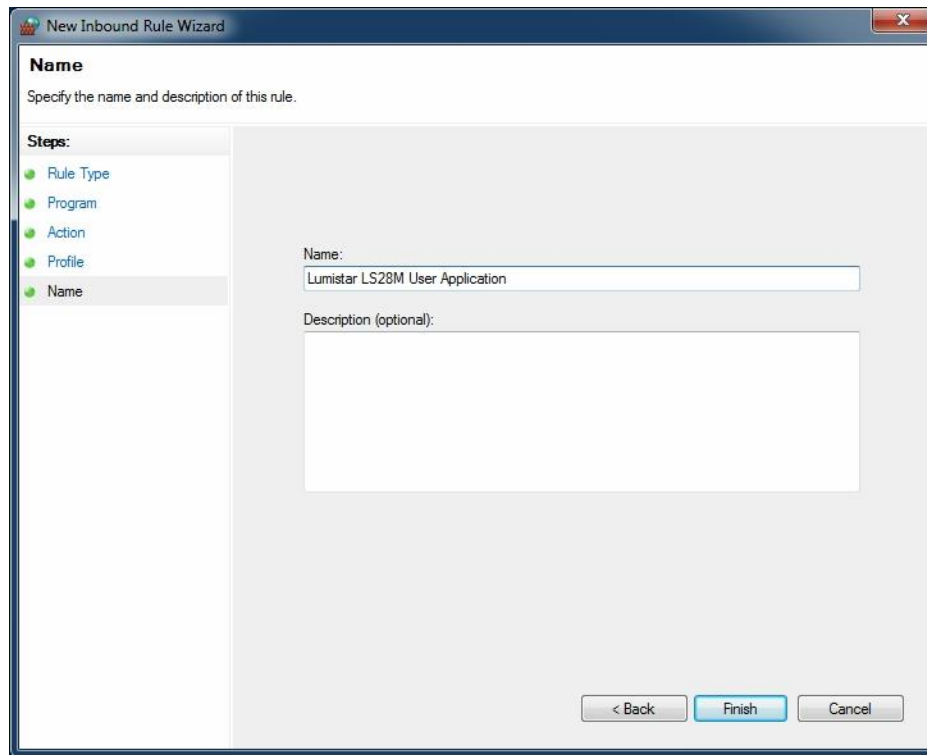


Figure 3-16 Windows Firewall – Advanced Security New Rule: Name

4 Software Application – Network Interface

The LS28 Network Application (Ls28_APP) is the primary software deliverable for the LS-28-DRSM. This application provides a user interface to all functions of the device that can be run on most Windows platforms. A list of supported Windows platforms is shown in Figure 4-1.

Supported Operating Systems:	
Windows 7 x86/x64	Windows Server 2008
Windows 8 x86/x64	Windows Server 2008 R2
Windows 8.1 x86/x64	Windows Server 2012
Windows 10 x86/x64	Windows Server 2012 R2
	Windows Server 2016

Figure 4-1 Network User Application – Supported Operating Systems

The LS28 Network Application software is processor intensive. Lumistar suggests that the user install the application on modern processor platforms with a minimum of 4GB (16GB for Windows 10 Pro) of high-speed RAM, 100GB of free disk space, hardware graphics acceleration, and a minimum of a 4th generation Intel i7 processor. Use of the application on lower end host platforms can result in poor response of graphic displays as well as unusual application behavior and stalling.

4.1 General Application Operations

There are several aspects of the user network application that are considered general in operational nature. These aspects will be described in paragraphs that follow.

4.1.1 Communications Setup Launch Window

When the application is launched, the window to appear will be a Communications Setup window as shown in Figure 4-2.

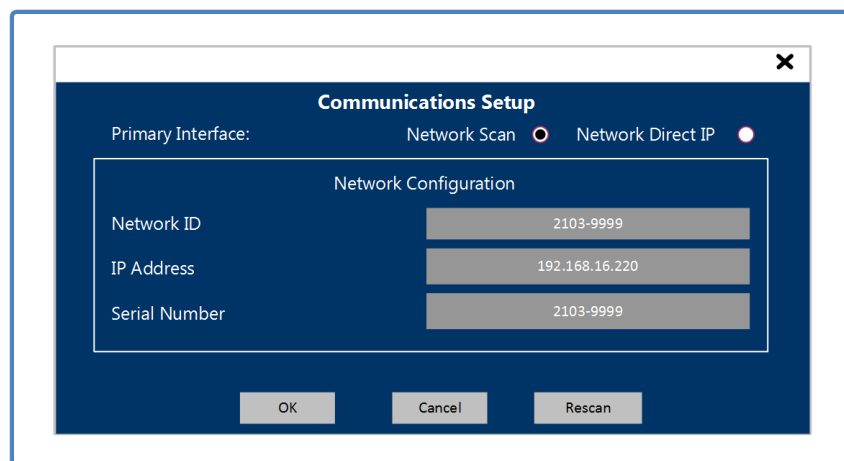


Figure 4-2 General Application Operations – Communications Setup Menu

The command options for this control are described as follows:

Primary Interface: This radio button provides a selection for the primary in interface communications interface source. If *Network Scan* is selected, the *Network Configuration* controls become active. In the event that direct IP addresses need to be entered, the *Network Direct IP* option can be selected which allows the user the ability to directly enter an IP address. If communications cannot be established with the user entered IP address, the communication menu will return for the user to try another entry. Consult with your IT administrators for assistance.

Network ID: This *Network Configuration* control allows the user to select the device to be communicated with via an assigned network name. The user has the ability to assign a 16-character name to the device as a familiar reference to a particular unit. A drop-down list of all available LS-28-DRSM units discovered on the network will be presented to the user.

IP Address: This *Network Configuration* control allows the user to select the device to be communicated with via network IP address. A drop-down list of all available LS-28-DRSM units discovered on the network will be presented to the user.

Serial Number: This *Network Configuration* control allows the user to select the device to be communicated with by its assigned serial number. A drop-down list of all available LS-28-DRSM units discovered on the network will be presented to the user.

OK/Cancel/Rescan: These three buttons allow the user to control the responses of the Communications Setup window. *OK* selects the desired assignments and attempts further communication based on user inputs. *Cancel* rejects any changes and exits the control window. *Rescan* allows the user to rescan the network to find recently added LS-28-DRSM units that may have joined a network.

The Communications Setup window will only discover LS-28-DRSM hardware units on a given network. To be discovered, the unit must reside within the allowed network subnet masks, be powered, and have completed its boot-up configurations. This state will be signaled by the status LEDs on the front of the unit (reference D1 and D2 in Figure 2-2) blinking green at approximately 0.5 Hz. The user does not need to maintain visual contact with the device LEDs. Communications attempts prior to a full boot cycle completion will not be successful.

In the case that the user only has a single unit on a given network, automatic launch of this control window could become unnecessary and thus eliminated. Refer to the system menu documentation that follows for further details.

4.1.2 Application Layout

After successful attaching via the network connection, the network application will open and to the home tab. The general layout of the applications is defined in Figure 4-3. The network application employs extensive use of tool-tips to assist the user with quick references related to system controls and status.

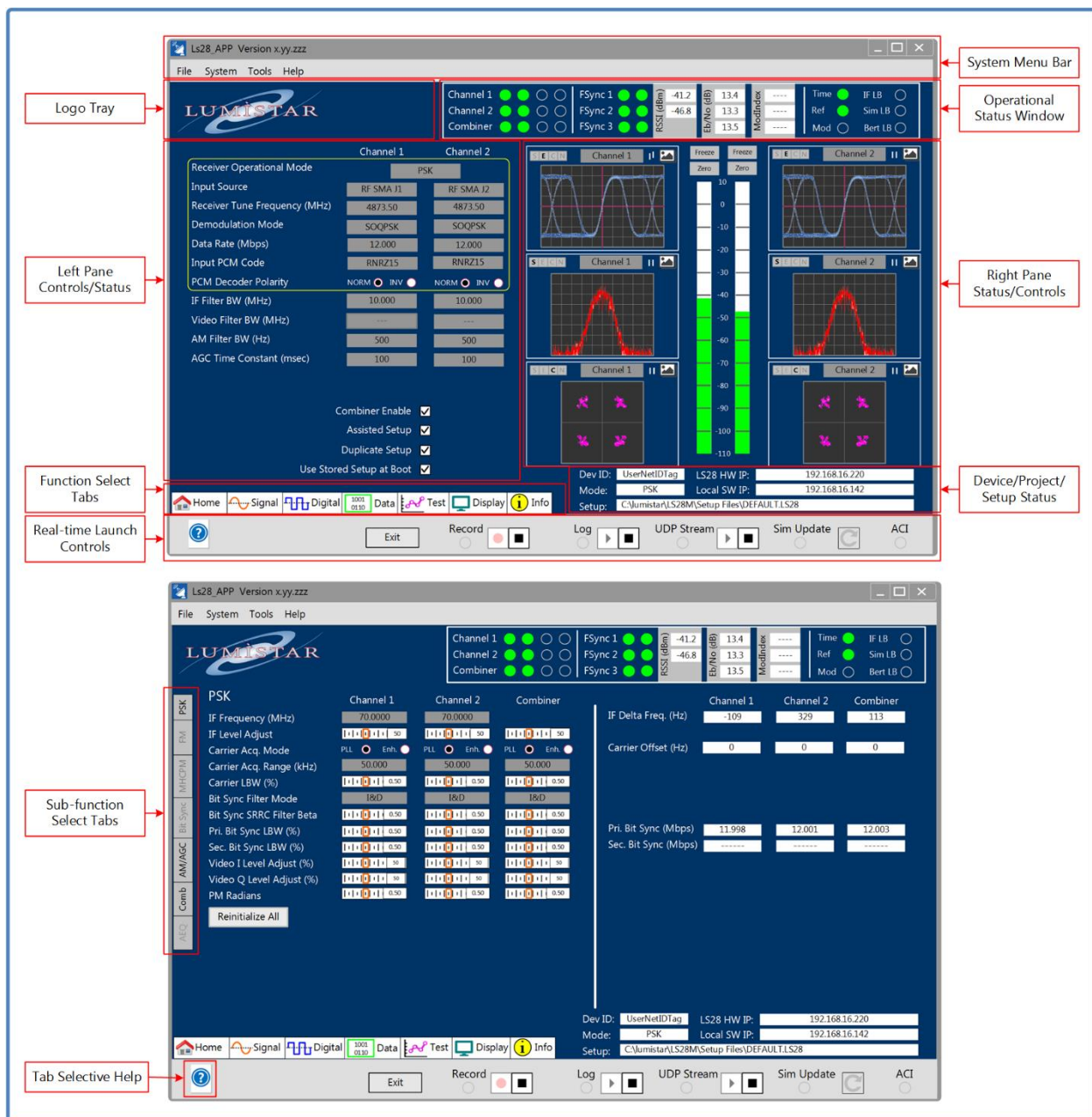


Figure 4-3 Network User Application – General Screen Layout

The application layout sections are defined as follows:

Function Select Tabs: Towards the lower left corner of the application, a series of horizontal selection tabs breaks the command and status functions for the LS-28-DRSM application into signal path components. These tabs are what the user will select to move to various functions within the user application. All function select tabs are visible regardless of the active function select tab selected.

Logo Tray: This area of the application provides a company logo display area. The application provides the user the ability to add custom logos in this area. To do so, follow the procedure outlined below:

- 1.) Custom logos can be any pixel density but must be in JPG format.
- 2.) The custom logo must be named "StartupLogo.jpg" to be incorporated into the application at startup.
- 3.) The custom logo must reside in the \Lumistar\LS28\System\Images directory.
- 4.) The custom logo should be presented in a 3.275:1 (L:H) aspect ratio. If the logo is not in the aspect ratio, it will be stretched to this aspect ratio.
- 5.) To prevent a custom logo from being stretched, place the logo in a 1:1 aspect ratio on a box filled with the RGB color of (1, 51, 102).

The logo tray is visible regardless of the active function select tab selected.

Left Pane Controls/Status: The left half of the screen below the logo tray contains an area for functional setup entry. The pane contains controls associated with the function or sub-function tab that is selected. The pane is used primarily for command control entry but may secondarily contain status.

System Menu Bar: This bar contains typical Windows application menu functions and controls. The upper right corner of this area contains typical windows minimize, maximize, and exit buttons. The minimize button will shrink the application to the toolbar. The maximize button does nothing because the actual size of the application on the host desktop is scaled by a different process which will be described in future paragraphs. The exit button operates in standard windows fashion.

The upper left-hand side displays the application name and version information. Version information has taken two formats since the applications inception. Early versions of the application were in the format of **X.YYY** where **X** was always "1" and the **YYY** function was either two numbers indicating the release or two numbers and a release subversion letter. Present and future version numbers follow the format **XX.YY.ZZZ**. In this configuration, the **XX** field represents the generational release number of the application. The **YY** field represents a major release of the software. Changes in this field often indicate the need for updated DLLs and may indicate that firmware updates are also required. The **ZZZ** field represents a minor release of the software. Most changes in this field do not require any firmware updates and are indications of application enhancements and/or repairs of discovered issues.

The main menu item bars are detailed in Figure 4-4.

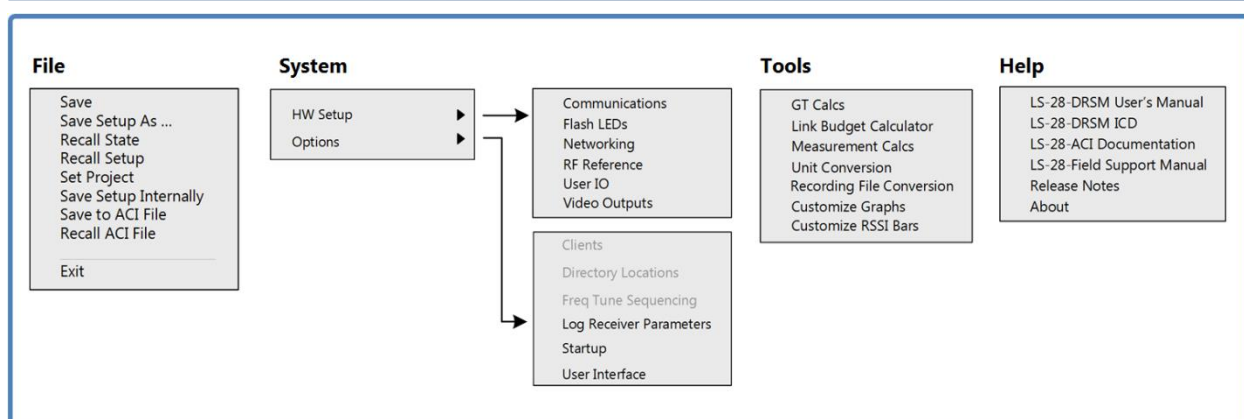


Figure 4-4 Menu Bar – File Drop-Down List

1.) **File:**

- a. Save – This menu option allows the user to save the present setups directly, overwriting the present saved values with the same given name. Be cautious when using this command. Once overwritten, the saved file prior to saving cannot be recovered.
- b. Save Setup As - This menu option allows the user to select and save a setup under a user defined name.
- c. Recall State – This menu option allows the user to select the last LS-28-DRSM operational state. Each time the application is run, at the time the application is exited, a "state" file is saved. This state file represents the very last setup regardless of whether the user has saved the last operational setup or not.

There are some caveats to this recovery. If the user has configured via the SYSTEM-STARTUP menu to launch the application with either a certain setup file or a default file, no state data can be recovered.

- d. Recall Setup - This menu option allows the user to recover and load a previously stored setup.
- e. Save Setup As - This menu option allows the user to select and save a setup under a user defined name.
- f. Set Project - This menu option allows the user to setup a project related folder on the host computer. In doing so, all saved setup files and hardcopy files will be saved to this folder.
- g. Save Setup Internally – This menu option allows the user to store a group of LS-28-DRSM settings in internal non-volatile memory for recover at power up. This menu option is only functional if the unit has this option installed. See section 4.2.1 for additional details.
- h. Save to ACI File – This menu option allows the user to store a group of LS-28-DRSM settings associated with the "Auxiliary Control Interface". Files stored in this fashion will have .ACI file extensions. See the ACI Interface section of this manual for additional details.

-
- i. Recall ACI File – This menu option allows the user to recall a previously stored group of LS-28-DRSM settings associated with the “Auxiliary Control Interface”. See the ACI Interface section of this manual for additional details.
 - j. Exit - Allows the user to exit the application.
- 2.) **System:**
- a. HW Setup – This menu contains items that associated with common LS-28-DRSM hardware controls and setup. The menu selection contains multiple options that can be accessed by using the horizontal pull-out menu.
 - i. *Communications* - This is an application level menu similar to the one that is typically provided during application launch. Refer to paragraph 4.1.1 for complete details.
 - ii. *Flash LEDs* – If this function is selected, the LEDs on the front view of the LS-28-DRSM will alternate **RED** and **BLUE** at a 1Hz rate for approximately 8 seconds. This function allows and easy means of verifying communication and location.
 - iii. *Networking* – This menu option allows the user to setup and control the network features of the LS-28-DRSM. The LS-28-DRSM contains a powerful network interface. There are a number of data sources that are streamed from the device to client applications, including the very Ls28_APP control application. In addition, there are special interfaces built into the application software that allow ease of external application development. To better cover this expansive subject, refer to details and figures included in section 4.10 of this document.
 - iv. *RF Reference* - Selection of this item allows the user to setup the RF synthesizer input source. Refer to the Figure 4-5. The LS-28-DRSM contains an internal 260ppb temperature compensated 10MHz reference source for this purpose. However, the design also allows the user the ability to select an external 10MHz source to synchronize the RF synthesizers with either a common reference source or to synchronize multiple receivers. This process is occasionally required for very narrow bandwidth, low data rate reception.

There are three operational points of emphasis in terms of RF Reference sources. The first point of emphasis is that in order for the LS-28-DRSM to tune in RF mode, a reference source must be present. Either an external source must be present or the internal source must be present. The second point of emphasis is that the reference selection mode is stored within the device and recovered at power up. The final point of emphasis is that if a reference source selection of “Internal” has been made, the reference interface port (refer to J3 in Figure 2-2) becomes an output. If an external source is applied to this connector while the unit is set to internal, the unit may experience erratic behavior or potential damage.

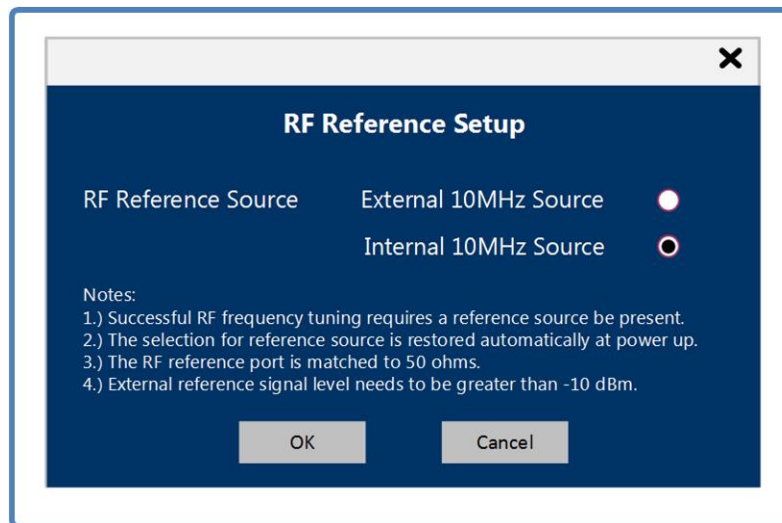


Figure 4-5 HW Setup – RF Reference Setup Dialog Window



Warning:

If the internal reference source is disabled, an external source must be applied for RF tuning to be functional.



Warning:

If the internal reference is enabled, the reference connector on the unit operates as an output. Connecting another external input source will cause erratic operational behavior and potential device damage.

- v. *User IO* – Selection of this hardware menu option allows the user to select various user IO signals. Refer to the Figure 4-6 below for User IO Selection screens.

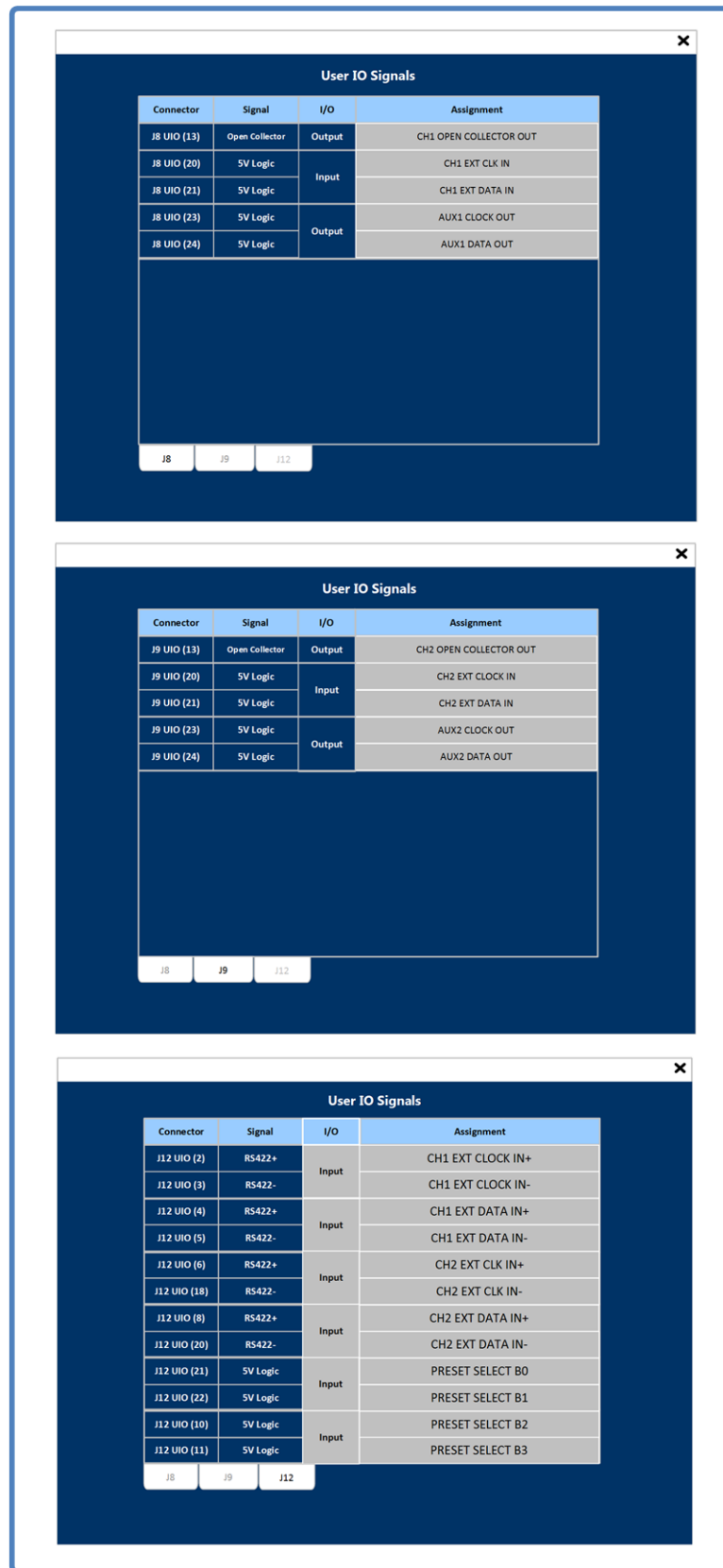


Figure 4-6 User IO Setup GUI

The selections of UIO are shown in the Figure 4-7.

Pin	Digital Output Assignment	Pin	Digital Output Assignment	Pin	Digital Input Assignment	Digital Output Assignment	Pin	Digital Input Assignment	Digital Output Assignment
J8-13	CH1 OPEN COLLECTOR OUT	J9-13	CH2 OPEN COLLECTOR OUT	J12-2	CH1 EXT CLK IN+	CH1 CLK OUT +	J12-8	CH2 EXT DAT IN+	CH2 DAT OUT +
Pin	Digital Input Assignment	Pin	Digital Input Assignment		PCM ENCODER1 CLK IN+	PCM SIM1 CLK OUT+		PCM ENCODER2 DAT IN+	PCM SIM2 DAT OUT+
J8-20	CH1 EXT CLK IN	J9-20	CH2 EXT CLK IN		TRIGGER1 IN+	SLV1 CLK OUT+		TRIGGER4 IN+	SLV2 DAT OUT+
	PCM ENCODER1 CLK IN		PCM ENCODER2 CLK IN		AUX1 CLK IN+	COMB CLK OUT+		AUX2 DAT IN+	COMB DAT OUT+
	TRIGGER1 IN		TRIGGER3 IN	Pin	Digital Input Assignment	Digital Output Assignment	Pin	Digital Input Assignment	Digital Output Assignment
	AUX1 CLK IN		AUX2 CLK IN	J12-3	CH1 EXT CLK IN-	CH1 CLK OUT -	J12-20	CH2 EXT DAT IN-	CH2 DAT OUT-
Pin	Digital Input Assignment	Pin	Digital Input Assignment		PCM ENCODER1 CLK IN-	PCM SIM1 CLK OUT-		PCM ENCODER2 DAT IN-	PCM SIM2 DAT OUT-
J8-21	CH1 EXT DAT IN	J9-21	CH2 EXT DAT IN		TRIGGER1 IN-	SLV1 CLK OUT-		TRIGGER4 IN-	SLV2 DAT OUT-
	PCM ENCODER1 DAT IN		PCM ENCODER2 DAT IN		AUX1 CLK IN-	COMB CLK OUT-		AUX2 DAT IN-	COMB DAT OUT-
	TRIGGER4 IN		TRIGGER4 IN	Pin	Digital Input Assignment	Digital Output Assignment	Pin	Digital Input Assignment	Digital Output Assignment
	AUX2 DAT IN		AUX2 DAT IN	J12-4	CH1 EXT DAT IN+	CH1 DAT OUT +	J12-21	PRESET SELECT B0	CH1 CARRIER LOCK
Pin	Digital Output Assignment	Pin	Digital Output Assignment		PCM ENCODER1 DAT IN+	PCM SIM1 DAT OUT+		EXT STATUS TRIGGER1	CH1 BSYNC LOCK
J8-23	COMB CLK OUT	J9-23	COMB CLK OUT		TRIGGER2 IN+	SLV1 DAT OUT+			CH1 SIG QUALITY LOCK
	PCM SIM1 CLK OUT		PCM SIM2 CLK OUT		AUX1 DAT IN+	COMB DAT OUT+			STREAM1 LOCK
	SLV1 CLK OUT		SLV2 CLK OUT	Pin	Digital Input Assignment	Digital Output Assignment	Pin	Digital Input Assignment	Digital Output Assignment
	AUX1 CLK OUT		AUX2 CLK OUT	J12-5	CH1 EXT DAT IN-	CH1 DAT OUT -	J12-22	PRESET SELECT B1	CH2 CARRIER LOCK
Pin	Digital Output Assignment	Pin	Digital Output Assignment		PCM ENCODER1 DAT IN-	PCM SIM1 DAT OUT-		EXT STATUS TRIGGER2	CH2 BSYNC LOCK
J8-24	COMB DAT OUT	J9-24	COMB DAT OUT		TRIGGER2 IN-	SLV1 DAT OUT-			CH2 SIG QUALITY LOCK
	PCM SIM1 DAT OUT		PCM SIM2 DAT OUT		AUX1 DAT IN-	COMB DAT OUT-			STREAM2 LOCK
	SLV1 DAT OUT		SLV2 DAT OUT	Pin	Digital Input Assignment	Digital Output Assignment	Pin	Digital Input Assignment	Digital Output Assignment
	AUX1 DAT OUT		AUX2 DAT OUT	J12-6	CH2 EXT CLK IN+	CH2 CLK OUT +	J12-10	PRESET SELECT B2	COMB CARRIER LOCK
					PCM ENCODER2 CLK IN+	PCM SIM2 CLK OUT+		EXT STATUS TRIGGER3	COMB BSYNC LOCK
					TRIGGER3 IN+	SLV2 CLK OUT+			COMB SIG QUALITY LOCK
					AUX2 CLK IN+	COMB CLK OUT+			STREAM3 LOCK
Pin	Digital Input Assignment	Pin	Digital Input Assignment	Pin	Digital Input Assignment	Digital Output Assignment	Pin	Digital Input Assignment	Digital Output Assignment
J12-18	CH2 EXT CLK IN-	J12-11	PRESET SELECT B3	J12-11	PRESET SELECT B3	EXT STATUS TRIGGER4			TIME LOCK
	PCM ENCODER2 CLK IN-								REF LOCK
	TRIGGER3 IN-								STREAM1 LOCK
	AUX2 CLK IN-								STREAM2 LOCK

Figure 4-7 User IO Selection Tables

Programmable user IO or "UIO" is a very powerful feature of the LS-28-DRSM. It allows the user to duplicate certain inputs and outputs or select specialized functions. Each control tab is associated with the related panel connector. Identification of connector pin numbers are provided on each tab along with the logic level or signal interface level associated with the UIO. Cells that are displayed in gray allow for user selection. For signals on J12, along with the signal assignment, the direction of the signal is also programmable. If IO levels not listed on these tabs are required, consult factory support.

There are two special UIO signals designated as pins J8-13 and J9-13 which are special "open-collector" signals which are triggered by receiver signal strength measurements. Selecting these two signals will display a pop-up menu that allows the user to programming the signal levels at which these signals become active and the interval rate for monitoring of signal strength. The Figure 4-8 below illustrates theses controls.

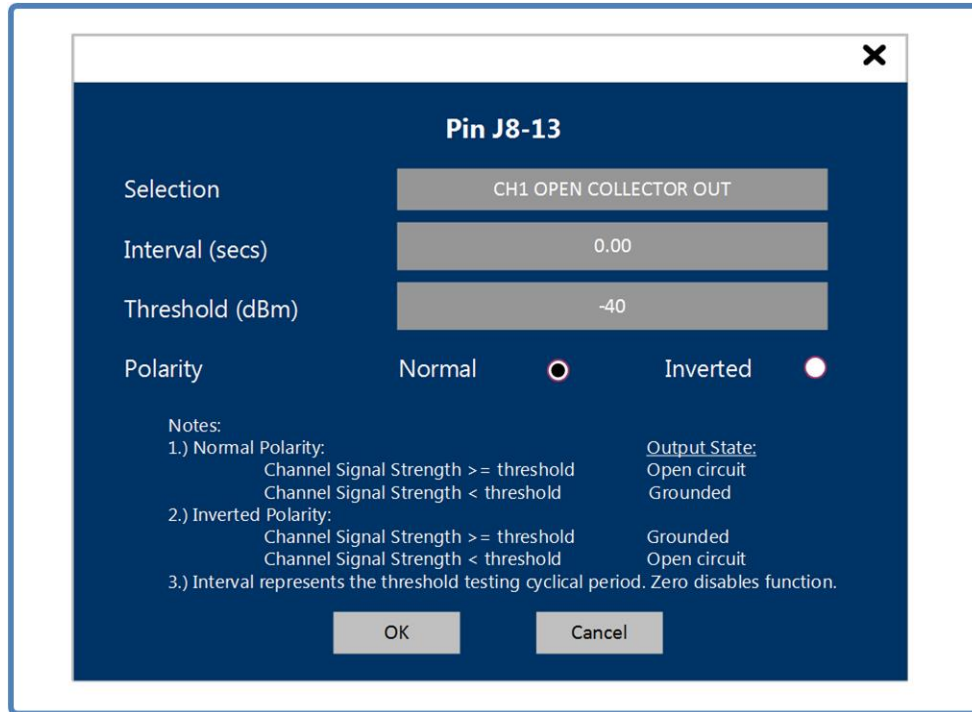


Figure 4-8 Open Collector Setup Controls

- vi. *Video Outputs* – Selection of this item allows the user to enable and disable the video output ports of the LS-28-DRSM. By default, the video outputs will be disabled to reduce power consumption. The use of video outputs should be based purely on need since use of all six available video outputs will result in the unit consuming up to 6 additional watts of power. Refer to Figure 4-9.

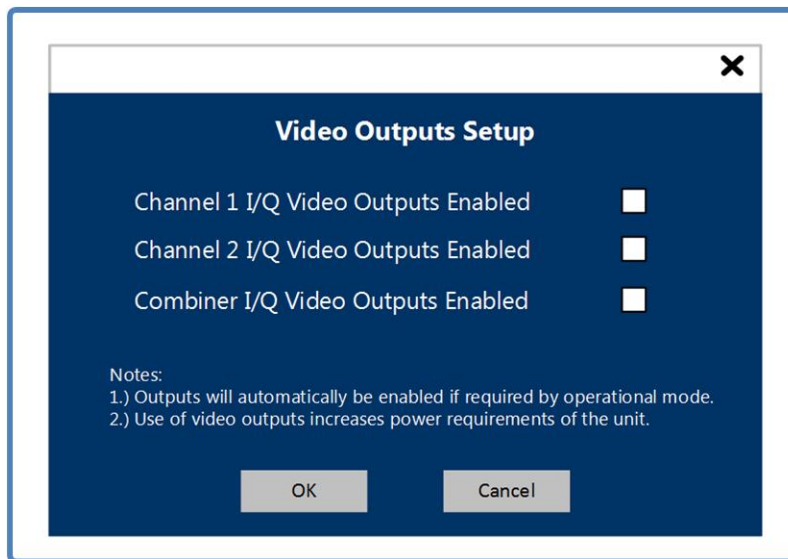


Figure 4-9 HW Setup – Video Outputs Setup Dialog Window

**Caution:**

Video Outputs require analog amplification and analog signal distribution which consumes a great deal of power and generates additional heat. The video outputs should be disabled when not in use.

- b. Options – This menu contains items that associated with common LS-28-DRSM controls and setups that are software related. These options include GUI controls, and software monitoring functions. The menu selection contains multiple options that can be accessed by using the horizontal pull-out menu.
 - i. *Log Receiver Parameters* – The LS-28-DRSM provides a means of logging various receiver parameters to a host file during active operations. For logging functions to begin, a set of parameters to be logged must be selected by the user. Some parameters are operational mode dependent and cannot be selected in certain operation conditions. The user can select which channel or channels will be logged, at what rate the logging will take place, and any of up to one dozen logging parameters.

Once channels have been enabled, the real-time logging controls will become active (refer to Figure 4-10). The user starts and stops logging from these controls. When active, the LED on the Real-time controls panel will be green. Once logging has been halted, a file will be stored on the host processor with a time related to the completion of that file. Parameter data will contain a header line and all data will be presented in a comma separated value format.

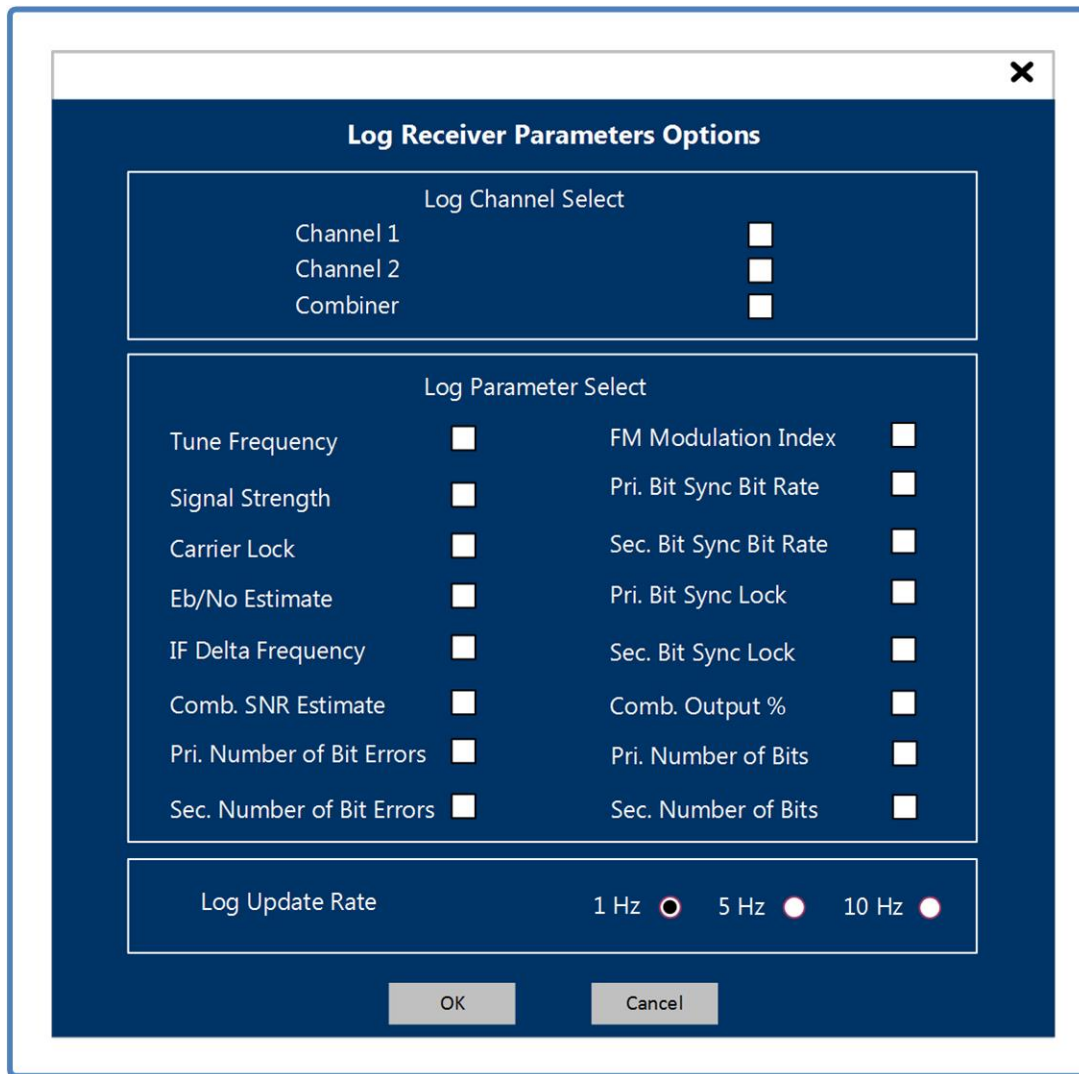


Figure 4-10 Options – Log Receiver Parameters Dialog Window

- ii. *Startup* – The LS-28-DRSM provides a means for the user to set certain launch criteria related to the user network application. Refer to Figure 4-11. The criteria include the type of file to load at initialization, whether the user desires a full network scan at each application start, and whether the user always would like to launch to the primary HOME tab. Use of this dialog box is password protected. At each launch of the application, a password will need to be entered to change any of these settings. Once entered, the password will keep the menu option unlocked for the duration the application is active.

The software application install will create a default password. Taking the lead from the brilliance of our government leaders, Lumistar has set the default application (case sensitive) password to the following: **password**.

Startup options include the following controls:

Load at Startup – Three options exist for startup of the software application. The user can elect the select the last setup files used during application execution on the previous launch. The user can opt to load the last operational state. The operational state does not necessarily relate to a given setup file. State data is data that reflects any unsaved setup changes that were present at the last application execution. The user can also direct that startup conditions always return to a given default setup file. The name of the setup files can be entered below the radio button selections in the *Default Setup Files* window.

Launch To Home Page – This selection box drives the LS28_App to always return to the HOME tab during startup.

Launch with Communications Setup – Selecting this box to drives the LS28_App to always launch the Communications network scan window, shown in Figure 4-2 at boot time. If this box is deselected, the LS28_App will automatically attempt to login to the last known good IP address at startup. If this attempt fails, the communications network scan window will automatically appear to assist the customer.

Launch with Stored Modulator Enables – Selecting this box allows saved modulator setups to be returned at application boot. By default, it is risky to have the on-board modulator settings be recovered at boot time because the settings could result in unexpected behavior resulting in the user being unsure of the source of signals and data. If this box is deselected, the LS28_App will automatically attempt to recover these setting at startup.



Caution:

The ***Launch with Stored Modulator Enable*** does not enable the modulator settings to be recover at boot time based on internal setups. This selection only relates to controls via the Network Control Application.

Reestablish TCP Connection – If the user network communications becomes unreliable or suffers interrupted or sporadic behavior for whatever reason, selection of this box will allow that application software to test for the return of proper communications paths and then automatically reestablish the main application TCP control/status connections. It should be noted that once this application option is selected, the connection attachments may be reattached automatically when the customer does not actual want reattachment.

Record at Boot – It is possible to have the unit power up and begin recording, if the unit contains on-board recording capabilities. If the unit contains the

recording option, the control boxes shown must be enabled for each recording channel that is desired to begin at power up. Setting these boxes will allow the internal firmware to start a recording file name and begin recording in accordance with settings on the DATA tab.

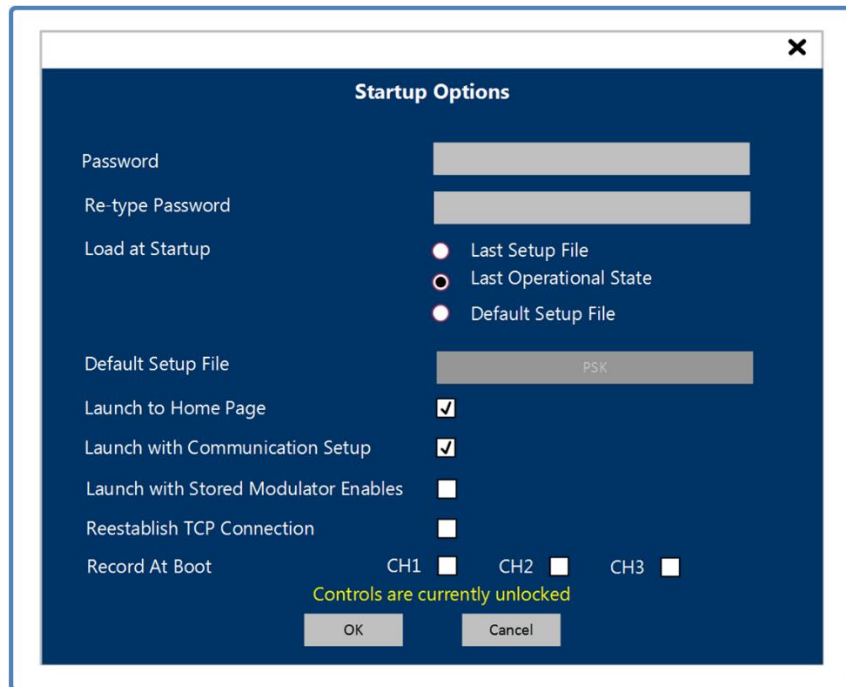


Figure 4-11 Options – Startup Options Dialog Window

- iii. *User Interface* – The LS-28-DRSM user interface has several controls that apply generically to the entire application. These are shown in the Figure 4-12.

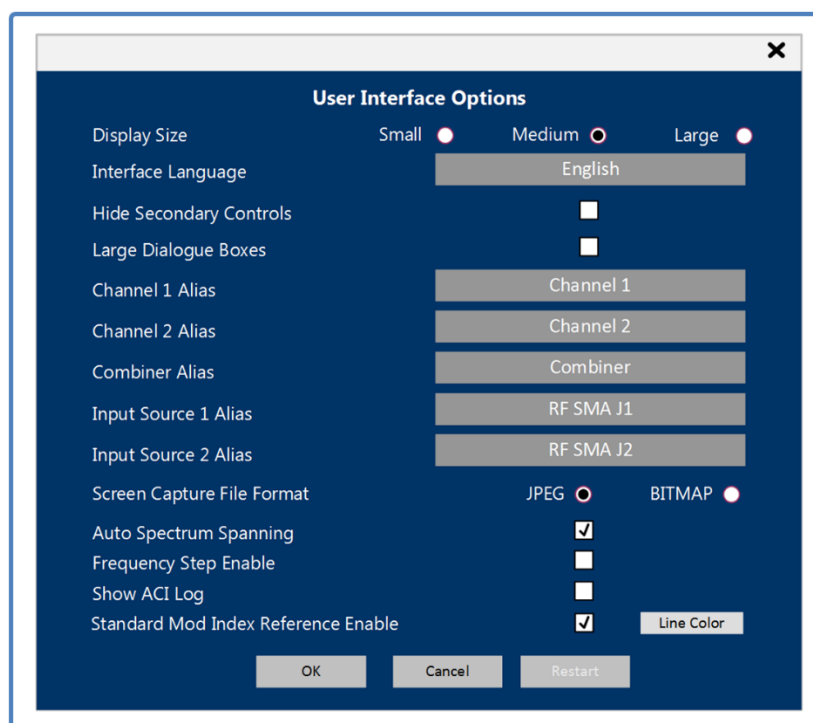


Figure 4-12 Options – User Interface Dialog Window

Display Size allows the user to select from three application window sizes. These sizes are meant to provide a means of sizing the application to fit a wide cross section of available display sizes. These include the following: Small = 1015 (h) x 611 (v), Medium = 1179 (h) x 785 (v), and Large = 1518 (h) x 954 (v). The application is not intended to fill the entire operational screen but selections may need to be altered based on the resolution of the host screen.

Interface Language is a rather unique application offering that makes the use of alternate languages possible. Most application text items can be altered via a text file. The standard text file is found in the C:\lumistar\LS28\System\LANGUAGES directory. Modifying the text in this file will result in different label text and tool-tips appearing in the application. Consult the factory for an application note on how to make these changes.

Hide Secondary Controls allows the user to eliminate all but the most necessary HOME tab data entry items.

Large Dialog Boxes allows the user interface to have enlarged application dialog interface boxes for ease of readability.

Channel Alias entry boxes allow the user to modify the names of channels to better reflect their application use. The user can modify references such as

channel to any value of 16 characters or less. These alias labels will appear in all tabs of the application.

Input Source Alias entry boxes allow the user to modify the names of Input source channels to better reflect their application use. The user can modify references such as channel to any value of 16 characters or less. These alias labels will appear in the home tab of the application only. This alias only applies to the Input source for the receiver.

Screen Capture Format allows the user to select in screen capture formats. Both BMP and JPG formats are allowed.

Auto Spectrum Spanning provides the spectrum analyzer graphs span selections based on the input setup. Calculations will be made based on data rate settings, demodulation settings, and input PCM code settings that will adjust the spectrums frequency spans so that the maximum resolution of will be maintained. Disabling this selection means that the controls revert to those of the DISPLAY tab.

Frequency Step Enable allows the user to implement a frequency tune step function on the main Home tab GUI interface. Once selected, the interface allows the user to enter frequency tuning steps in kilo Hertz steps to be added or subtracted from the tune frequency. Values can be entered between 0.01 and 5000 kHz. Buttons are provided in the user interface to increment and decrement the tune steps by the amount programmed. If the Home menu "Duplicate Setup" button is selected, steps will be supplied to both channels as programmed simultaneously. If the "Duplicate Setup" button is deselected, individual channel tune controls are provided and must be operated separately.

When Frequency Step functionality is selected, the Home tab controls will be changed as shown in the Figure 4-13.

Show ACI Log allows to add a small LOG icon next to the ACI activity indicator on the Real-Time Launch Control banner to be used while debugging ACI interface controls. Selecting this icon will present a Log script window that will list ACI commands as they are being received and responded to.

Standard Mod Index Reference Enabled allows the user to modify the Eye Pattern Displays of the LS28 GUI during PCMFm operational modes to add a line indicating deviation levels of received symbols. This line will be added at a location that represents a modulation index of 0.35 (peak) per the suggestions

for proper PCMFM modulation found in the IRIG 106 specifications. This index line will only appear during MS-PCMFM and SS-PCMFM modulation modes.

Line Color allows the user to change the color of the modulation Index reference when enabled.

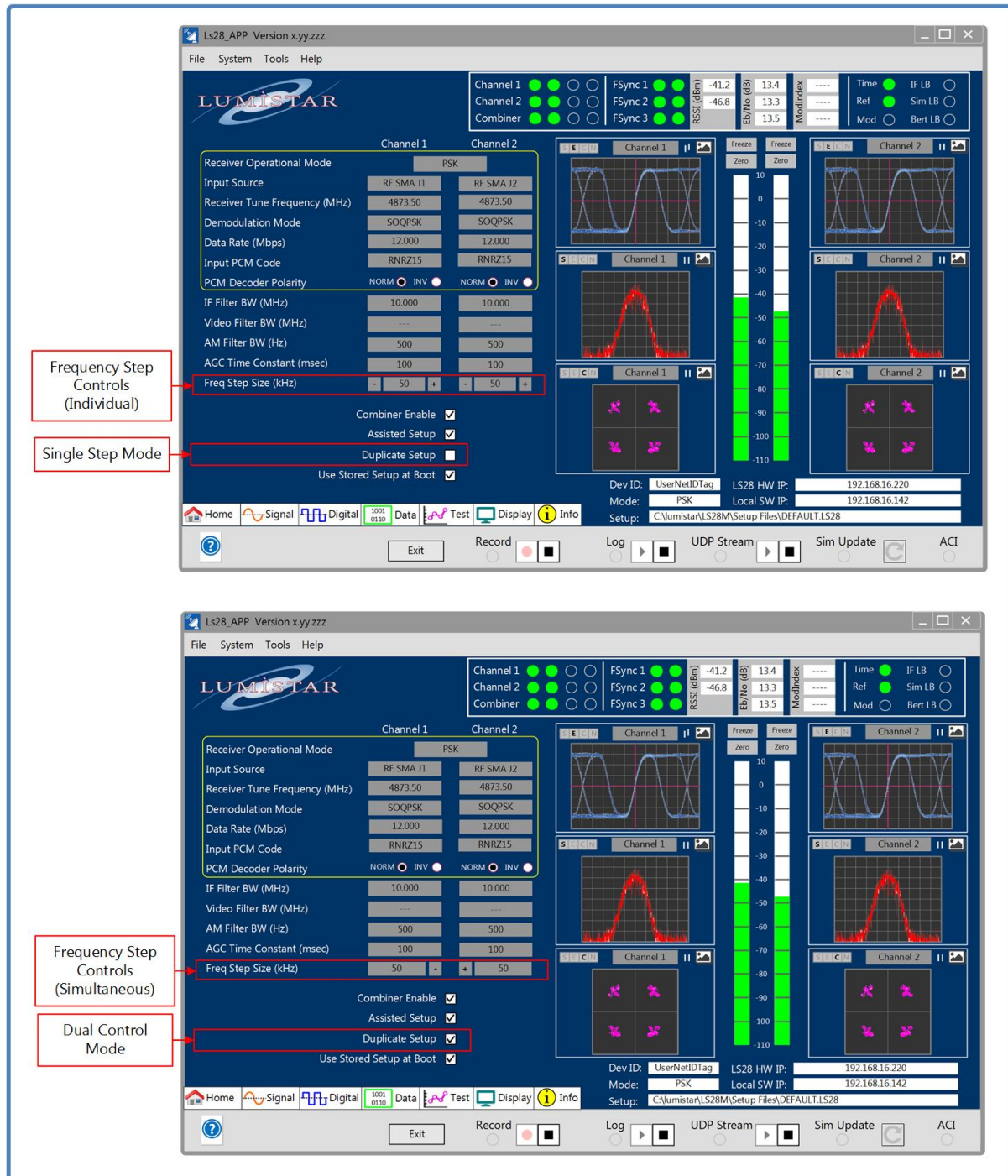


Figure 4-13 Options – Frequency Step Home Tab Controls

3.) **Tools:**

- a. G/T Calcs - This utility provides added functionality to the use of LS-28-DRSM resources. The utility allows the user to perform solar flux calculations including antenna gain and system noise temperature. These are referred to as G/T calculations. Figure 4-14 illustrates the G/T utility dialog window.

G/T Calculations

Channel 1 Enabled ☒ Channel 2 Enabled ☒

Receiver

Freq (MHz): 2280.5
IF BW (MHz): 2.000
RF Level (dBm): -87.2

Antenna

Diameter (meters): 2.4
Beam Width (deg): 5.0

Point Antenna at Cold Sky
Ready

Point Antenna at Hot Sky
Ready

NOAA Solar Flux Density
Updated: 000:00:00.0000

Freq (MHz)	Flux
410	53.0
610	77.0
1415	115.0
2695	131.0
4995	173.0
8800	285.0

Save Recall Hardcopy

Calculate

Results

Channel 1		Channel 2	
Y Factor:	9.679	Y Factor:	9.679
Cold Sky (dBm):	-87.9	Cold Sky (dBm):	-87.9
Hot Sky (dBm):	-82.1	Hot Sky (dBm):	-82.1
G/T (dB/K):	11.2	G/T (dB/K):	11.2

Close

Figure 4-14 Tools – G/T Solar Flux Calculations Utility

- i. Receiver Setup – This area allows the user to enter the tune frequency and the IF bandwidth value for testing.
- ii. Antenna – To perform the G/T calculations, the user must enter information pertaining to the antenna. This includes the diameter of the antenna. The diameter will automatically calculate a beam width based on the tune frequency and diameter entries.
- iii. NOAA Solar Flux Density – NOAA takes solar flux measurements at several locations around the world multiple times a day. The data is available at <http://www.swpc.noaa.gov>. The user should pick the geographic location closest to their operational location and then fill in the table values for the flux measurements. These values are used in the G/T calculations based on the tune frequency.
- iv. Point Antenna at Cold Sky – This button is used to make observations of “Cold Sky” measurements. The user should point the antenna to a location 180 degrees away from the direction of the intended source of “Warm Sky”.

Pressing this button will cause multiple measurements to be made in the "Cold Sky" direction.

- v. Point Antenna at Warm Sky – This button is used to make observations of "Warm Sky" measurements. The user should point the antenna to a location in the sky that has the highest interference source. This is usually done by pointing the antenna at the Sun or the Moon. Pressing this button will cause multiple measurements to be made in the "Warm Sky" direction.
 - vi. Calculate - Selecting this button after the Cold and Warm sky data has been sampled will result in a calculation of G/T values. Results will be displayed in the associated status fields.
- b. Link Budget Calculator - This utility, shown in Figure 4-15 performs standard telemetry performance calculations for RF data transmissions over a given distance. The user will need to enter certain criteria into the calculator to perform the calculations. The result will be a probability of communications success.

LinkBudget Ver 2.10

Hardcopy About Help

Main Factors

Range: 10.0 Miles
 Frequency: 2250.0 MHz
 Tx Power: 5.0 Watts
 Bit Rate: 1000.0 kbps
 Minimum Eb/No Desired or Minimum BEP Desired: 15.0 dB / 1.0E-7

Noise Factors

LNA Noise Figure: 0.1 dB
 LNA Gain: 6.0 dB
 Rx Noise Figure: 0.1 dB

Antenna Factors

Tx Feed Loss: 1.0 dB
 Tx Ant Gain: 1.10 dBi
 Weather: 0.1 dB
 Polarization: 0.1 dB
 Rx Ant Gain: 10.0 dBi
 Rx Feed Loss: 0.1 dB

Link Budget

Calculation Results

Free Space Attenuation	-123.6 dB
Tx Power	37.0 dBm
Bit Rate	60.0 dB
Noise Temp 290 deg K	-173.9 dBm/Hz
Noise pwr/bit No	-173.8 dB
Rx pwr/bit Eb	-136.9 dB
Received Eb/No	36.9 dB
Fade Margin	21.9 dB
Link Reliability	99.4 Percent

Figure 4-15 Tools – Link Budget Calculator Utility

- c. Measurement Calcs - This utility provides calculations that are associated with telemetry values. These include RF measurements of many types, calculation of telemetry data such as date and time formats, frame rates, and other useful data. See Figure 4-16.

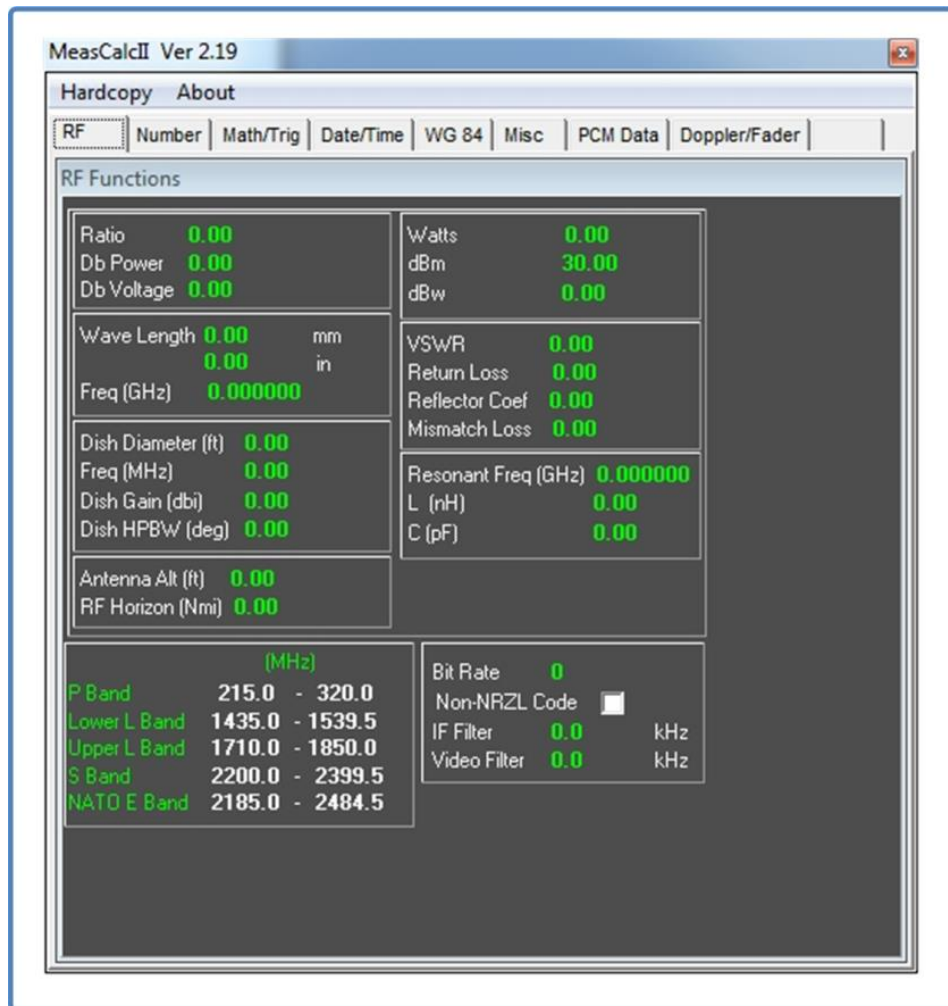


Figure 4-16 Tools – Measurements Calculator II Utility

- d. Unit Conversions - This is a general-purpose utility for converting values from one measurement unit to a different measurement unit. A number of conversion formats are provided. Figure 4-17 illustrates the various types of conversions available.

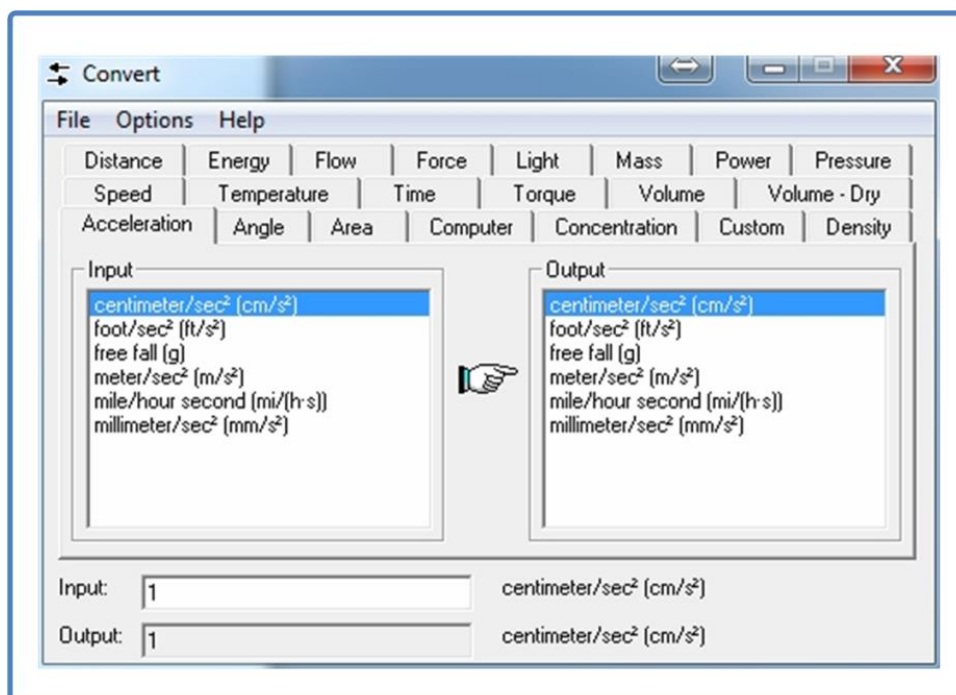


Figure 4-17 Tools – Unit Conversions Calculator Utility

- e. Recording File Conversion Utility – This conversion utility allows the user to convert the LS-28-DRSM recording files to a format referred to as the TM1 format. This format allows for playback of the contents in the Lumistar LDPS_8x and LDPS_10x application software. Figure 4-18 illustrates the utility control window.

Users should select the directory containing the source file to convert, select the file to be converted via the "Please Choose a file" button, select the source file, enter a converted file name in the "Converter File Name" field, and then select "Start Conversion". Once selected, the LED next to the conversion button will be illuminated and a bar gauge showing the progress of the conversion process. Once completed, the activity LED will be extinguished, and the bar gauge will be removed.

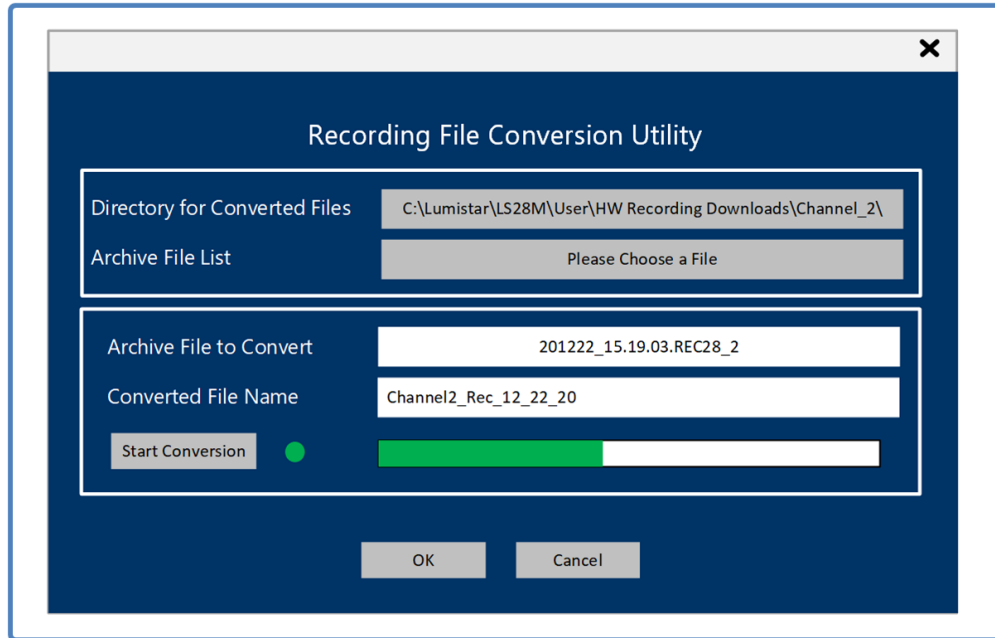


Figure 4-18 Tools – Recording File Conversion Utility

- f. Customize Graphs - This tool allows the user the ability to customize the graph features of the LS-28-DRSM application to better meet their individual needs. Customization includes the ability to select any color for the graph backgrounds and measurement line colors. Selecting the *Set Default Colors* will return the graphs to the predefined defaults that were present during installation. Figure 4-19 below illustrates the control interface for customizing graph colors.

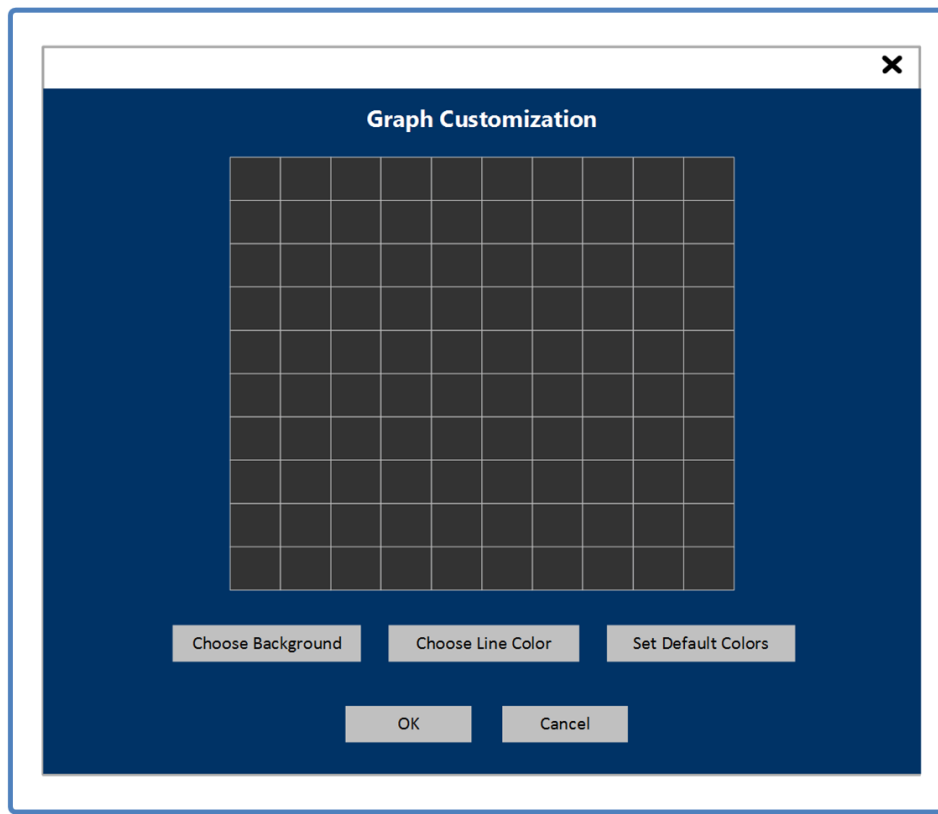


Figure 4-19 Tools – Customize Graph Color Controls

- g. Customize RSSI Bars – This tool allows the user with the ability to customize the RSSI bar graphs to indicate various receiver signal levels. If enabled, three different colors will be displayed for the individual receiver channel bars based on two different user selected threshold settings. Colors are selectable for and upper, nominal, and lower threshold levels. Threshold breakpoints are entered as dBm levels for only the upper and lower levels. Figure 4-20 illustrates the control interface for customizing RSSI display bars.

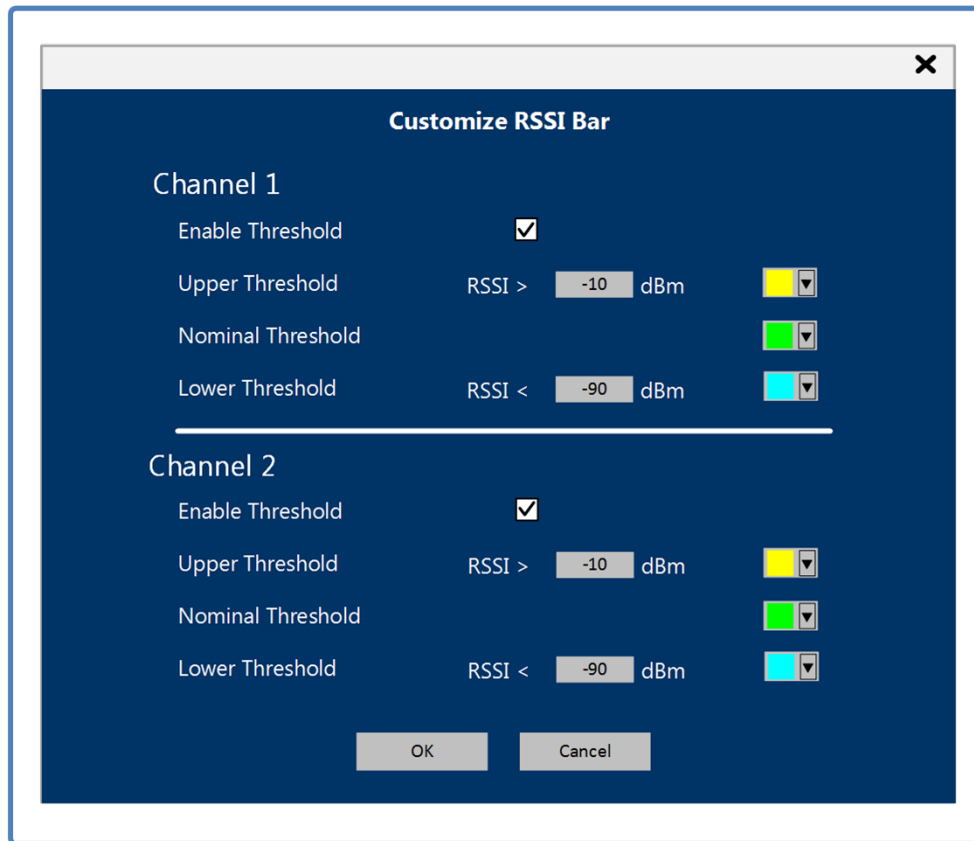


Figure 4-20 Tools – Customize RSSI Bar Color Controls

4.) **Help:**

- a. User's Manual – This menu selection will launch a host PC's PDF viewer and display a full copy of this manual.
- b. About – The window will pop up information concerning the application version, the company address, phone number, cage code, and web site address.

The System menu bar is visible in all function select tabs.

Operational Status Window: In the upper right-hand corner of the active application window is the operational status window. This area contains status related to the channel operations and lock states of the functions within the LS-28-DRSM.

The status is presented in a stacked row format. Each horizontal row contains status for an individual channel. Status beyond the right-hand vertical line relates to general system status. Figure 4-21 defines each status indicator.

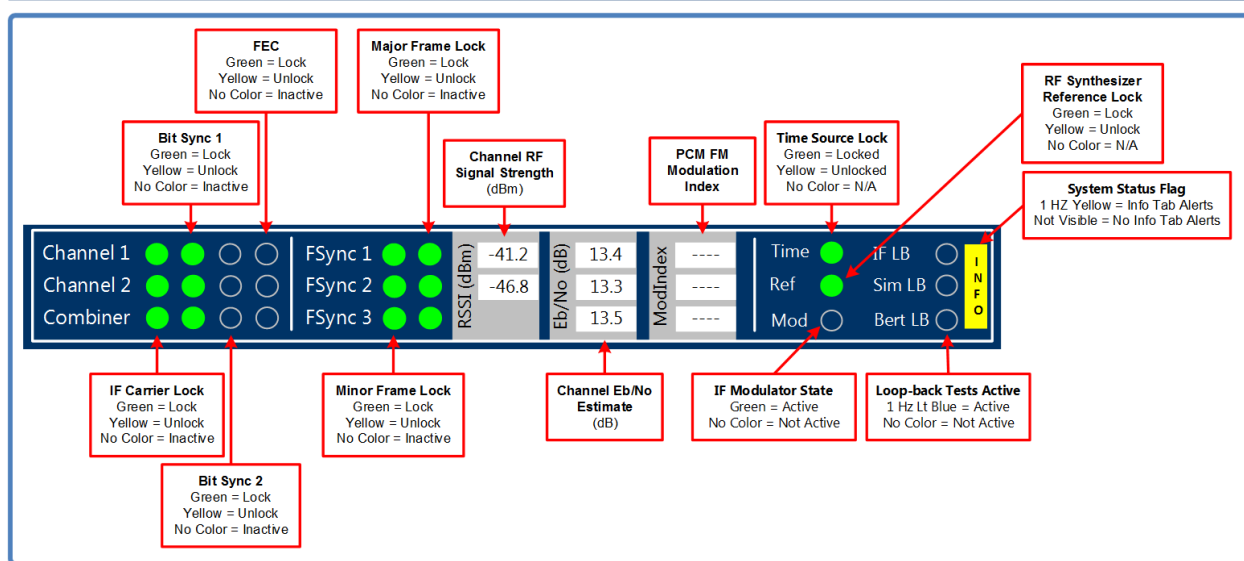


Figure 4-21 Network User Application – Status Window Definitions

It is important to note that some of these indicators are licensed features. If these licensed features are inactive, the status indications will not be active. Some indications are operational mode dependent. The PCM FM Modulation Index indication is an example of operational mode dependent status.

Right Pane Status/Controls: The right half of the screen below the operational status window contains an area for functional status related to the selected function or sub-function tab. The right pane is used primarily for functional status but secondarily can provide command controls.

Device/Project/Setup Status: In the lower right-hand half of the screen is an area which indicates that device operational mode that has been selected, project related data, and loaded setup file information. This area is visible in all function select tabs. This area includes the hardware IP address of the connected LS-28-DRSM as well as the IP address of the host that is connected and providing the Network User Application (LS28_App).

Real-time Launch Controls/Status: To start and stop real-time logging, recording, and streaming functions, buttons to start, stop and status these functions are included along the bottom strip of the application window. In addition, a control is provided for updating PCM simulator downloads as well as an LED indicating that this needs to be performed. The LED indicates when any of these processes are active when they are green, or in the case of the Sim Update control, a green LED indicates that a simulator changes have been made and not updated. In addition to the Sim Update LED, the Sim Update control button will also be changed from gray to orange. When the status LEDs are gray, the real-time function is not active or the simulator does not require updates. The control buttons toggle between the start and stop processing of these functions. In addition, there is an activity LED for the Alternate Control Interface (ACI). This LED will be clear if the functionality is disabled, yellow if the functionality is enabled and no external client is attached and green when the mode is active and attached to an external client. For full documentation on the use of the Alternate Control Interface, consult the following document: *Lumistar LS-28M Alternate Control Interface Document: (DOC-28M-01-ACI-02)*.

Sub-function Select Tabs: On several of the function select tabs, a series of vertical sub-selection tabs provide the operator the ability to address specific functions within the primary tab function. These vertical tabs redefine the page layouts to detail controls and status for the requested specialized tab sub-function. Only sub-function tabs associated with the operational mode that is active are enabled while vertical tabs that are not associated with the operational mode or are not licensed are disabled.

Tab Selective Help: Selecting this button on any given tab will automatically launch the Adobe Acrobat Reader to the tab related page in this manual. This function requires the use of the Adobe Acrobat application installed on the controlling host PC. This installation is provided with the install of the Network User Application in the *UserTools* directory. The installation of this application will be automatically installed with the installation of the user software. If after install, the user elects to remove the application, tab selective help will cease functioning.

4.2 Function Select Tab – Home

The Home tab is one of the seven function select tabs and likely the most utilized. From this tab, most users can setup all the primary functions of the receiver as well as view status on the operations of all aspects of the receiver system. The Home tab is shown in Figure 4-22.

Figure 4-23 illustrates the ties between the LS28_App HOME tab controls and the operational block diagram of the internal components of the LS-28-DRSM.

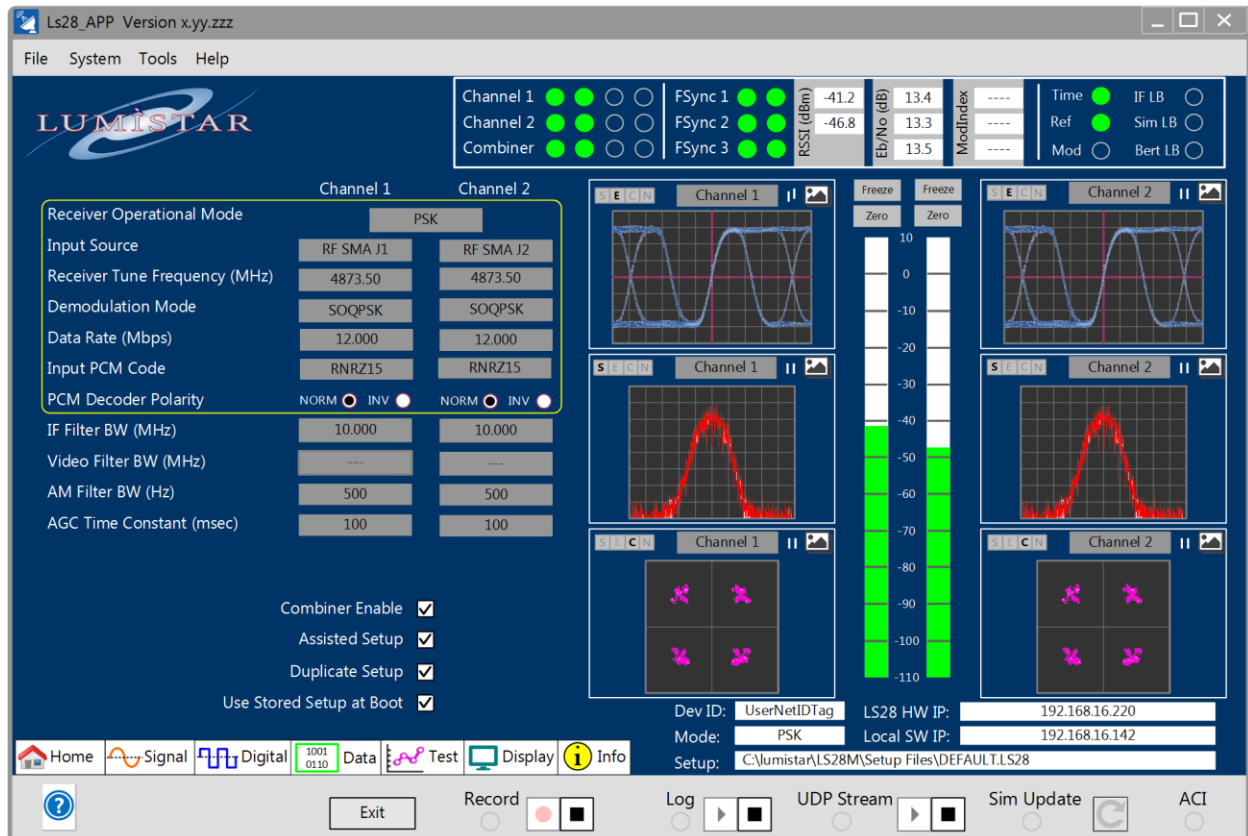


Figure 4-22 Network User Application – Home Function Select Tab

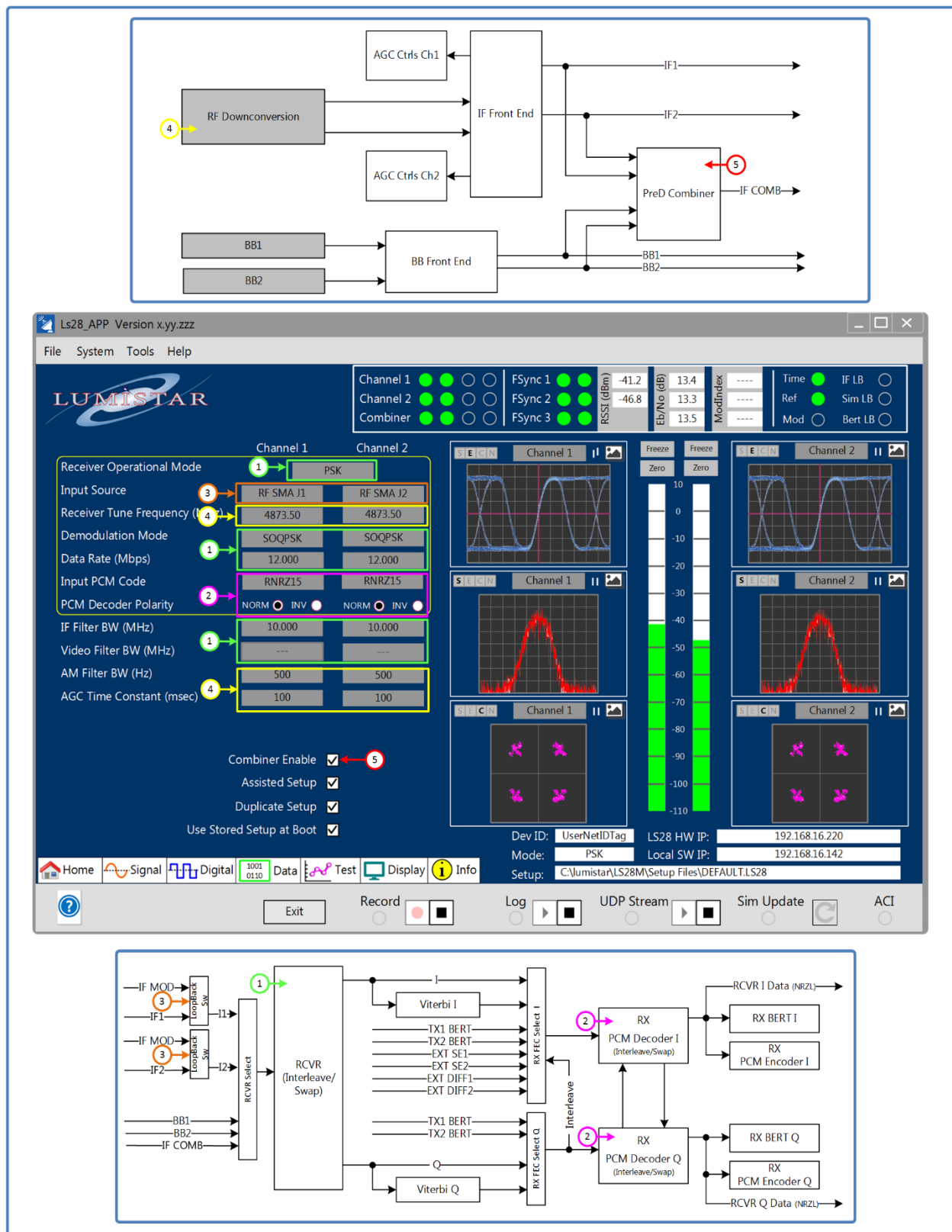


Figure 4-23 Network User Application - Receiver Input Processing Converter Block Diagram

4.2.1 Home Tab – Left Pane

Receiver Operational Mode: This application control allows the user to select between the major functional "personalities" or operational modes of the LS-28-DRSM. The user should select the primary operation mode first and then set other settings based on signal requirements. The main operational modes at the time of the writing of this document the following operational modes include: PSK, MS-PCMFm, SS-PCMFm/Video FM, MH-CPM and Bit Sync. Other modes such as LDPC modes may be listed in this drop-down based on licensing options.

Input Source: The input source control allows the user to select input sources if multiple sources are available. The input sources will be controlled internally by the LS-28-DRSM firmware based on licensed options and operational mode selections.

While the unit operation mode is other than the bit sync, most hardware configurations provide two selection options: Channel \times RF (where \times is the channel number) and Loopback IF. When in the RF channel selection state, the source of signal is the related RF downconversion channel, according to its user settings. When the Loopback IF is selected, the source of data into the demodulation engine is connected internally to the IF test modulator. Consult Figure 4-26 for further routing details.



Warning:

Loopback IF mode does not route the IF Test modulator to the analog downconversion stages of the design. When in Loopback IF mode, Network User Application RF signal strength will not be active. The AGC and AM outputs will not be active during this mode.



Information:

Loopback IF mode is provided by internal switching networks. No external cabling is required for operation.

No baseband loopback hardware switching is provided.

When in Bit Sync mode, the only options available are SE1 and SE2. However, for most hardware versions of the LS-28-DRSM, SE1 is the only valid selection form bit sync inputs. There are no built-in loopback test provisions for baseband sources to the bit synchronizer.

Receiver Tuning Frequency: The RF tune frequency for each of the RF input ports, identified as J1 and J2 of Figure 2-2 are set by this control. Entries will result in a dialog box that provides the users with a list of installed RF bands to choose from. Values will be listed as ranges of values in MHz. Attempts to tune outside the values listed will be disregarded.

Demodulation Mode: This control is active only in PSK mode. PSK mode has several demodulation modes to select from. When the operational mode is set to PSK and more than one PSK sub-mode is licensed, the user will be presented with a list of PSK demodulation options. These may include BPSK, QPSK, OQPSK,

SOQPSK-TG, SOQPSK-MIL, UQPSK, UAQPSK, and Direct PM. Selections are made on a per-channel basis but must be identical between channels if diversity combining is being utilized.

For all non-PSK operation modes, this field will be filled automatically and non-selectable.

Data Rate: This command control dialog box allows the user to enter the desired data rate for each channel. If the operational mode and demodulation mode selected requires two separate entries for I and Q data rates, the user will be prompted for both data rates.

Input PCM Code: This control provides the user the ability to select from a number of PCM decoder values. Users should select a code that is the same as the modulation or data source. The decoder selections are shown in Table 4-1.

PCM Input Decoder Selections	
NRZ-L	Non Return To Zero - Level
NRZ-M	Non Return To Zero - Mark
NRZ-S	Non Return To Zero - Space
RNRZ11-L	PRN11 Randomized Non Return To Zero - Level
RNRZ11-M	PRN11 Randomized Non Return To Zero - Mark
RNRZ11-S	PRN11 Randomized Non Return To Zero - Space
RNRZ15-L	PRN15 Randomized Non Return To Zero - Level
RNRZ15-M	PRN15 Randomized Non Return To Zero - Mark
RNRZ15-S	PRN15 Randomized Non Return To Zero - Space
RNRZ17-L	PRN17 Randomized Non Return To Zero - Level
RNRZ17-M	PRN17 Randomized Non Return To Zero - Mark
RNRZ17-S	PRN17 Randomized Non Return To Zero - Space
RNRZ23-L	PRN23 Randomized Non Return To Zero - Level
RNRZ23-M	PRN23 Randomized Non Return To Zero - Mark
RNRZ23-S	PRN23 Randomized Non Return To Zero - Space
BIO-L	Bi Phase - Level
BIO-M	Bi Phase - Mark
BIO-S	Bi Phase - Space
RZ	Return To Zero
DM-M	Delay Modulation (Miller Code) - Mark
DM-S	Delay Modulation (Miller Code) - Space
DBIO-M	Differential Bi Phase - Mark
DBIO-S	Differential Bi Phase - Space
MDM-M	Modified Delay Modulation (Miller Code) - Mark
MDM-S	Modified Delay Modulation (Miller Code) - Space

Table 4-1 Input PCM Decoder Selection Table

PCM Decoder Polarity: These radio button controls provide the user the ability to invert any of the selected Input PCM Decoder selections, essentially doubling the number of PCM decoder selections. Once INV is selected, the data polarity is inverted for the selection made in the Input PCM Decode selection.

IF Filter BW: The user can select IF filter bandwidths for the modulation, PCM code, and data rates programmed on the home tab. There are two mechanisms for selecting an IF filter bandwidth: manual mode or assisted setup mode. In manual mode, selected when the Assisted Setup option is deselected (see below), allows the user to select from one of 32 filter bandwidths. The bandwidth selections provided cover

all data rate options allowed by the demodulation engine. Table 4-2 lists all manual selectable IF filter bandwidths.

Input Filters Table			
No.	IF Filter Bandwidth (MHz)	Video Filter Bandwidth (kHz)	AM Filter Bandwidth (Hz)
1	0.025	125	50
2	0.050	250	100
3	0.100	500	200
4	0.125	1000	300
5	0.175	1500	400
6	0.250	2000	500
7	0.300	2500	600
8	0.500	3000	700
9	0.750	4000	800
10	1.000	4200	900
11	1.500	6000	1000
12	2.000	8000	1100
13	2.400	10000	1200
14	2.500	12000	1300
15	3.000	15000	1400
16	3.300	20000	1500
17	3.500		1600
18	4.000		1700
19	5.000		1800
20	6.000		1900
21	8.000		2000
22	10.000		3000
23	12.000		4000
24	15.000		5000
25	16.000		6000
26	18.000		7000
27	20.000		8000
28	24.000		9000
29	28.000		10000
30	30.000		15000
31	35.000		20000
32	40.000		50000

Table 4-2 Input Filter Selection Bandwidth Tables

Video Filter BW: The Single-Symbol PCMFM demodulation section of the receiver design provides 16 selectable output low-pass filters video filters. These filters allow FM response with targeted bandwidth selections for improved bit synchronization processing. This tab control allows the user to select the filter setting only in SS-PCMFM/Video FM operational mode. In all other operation modes video filter is performed in the digital domain and no user selections are required. Table 4-2 contains the FM filter selections provided.

AM Filter BW: The AM demodulation section of the receiver design provides 32 selectable output low-pass filters. These filters allow AM response with very targeted bandwidth selections for improved antenna tracking functions. This tab control allows the user to select the filter setting. Table 4-2 contains the AM filter selections provided.

AGC Time Constant: The LS-28-DRSM provides a control to adjust the AGC output signal time constant. Eight time constant values are provided as follows: 100usec, 1msec, 5msec, 10msec, 50msec, 100msec, 500msec, and 1 second. These values are typically used for antenna tracking purposes. This AGC time constant will not be applied to the IF output unless the Digital AGC mode is selected. See information related to this mode in the function select Signal sections of this manual.

Combiner Enable: This selection box enables and disables the Diversity Combiner functions within the LS-28-DRSM if this option is licensed. For combiner settings to be loaded, this box must be selected. If disabled, no combiner values will be loaded and on most GUI menu items will be disabled that are related to the combiner.

Assisted Setup: This selection box switches filter selections for IF and video filter bandwidths from manual mode to automatic mode. In automatic mode, firmware within the LS-28-DRSM takes all signal information provided to the device into account and programs the filters selections automatically. These values are calculated based on formulas shown in the Figure 4-24 and Figure 4-25.

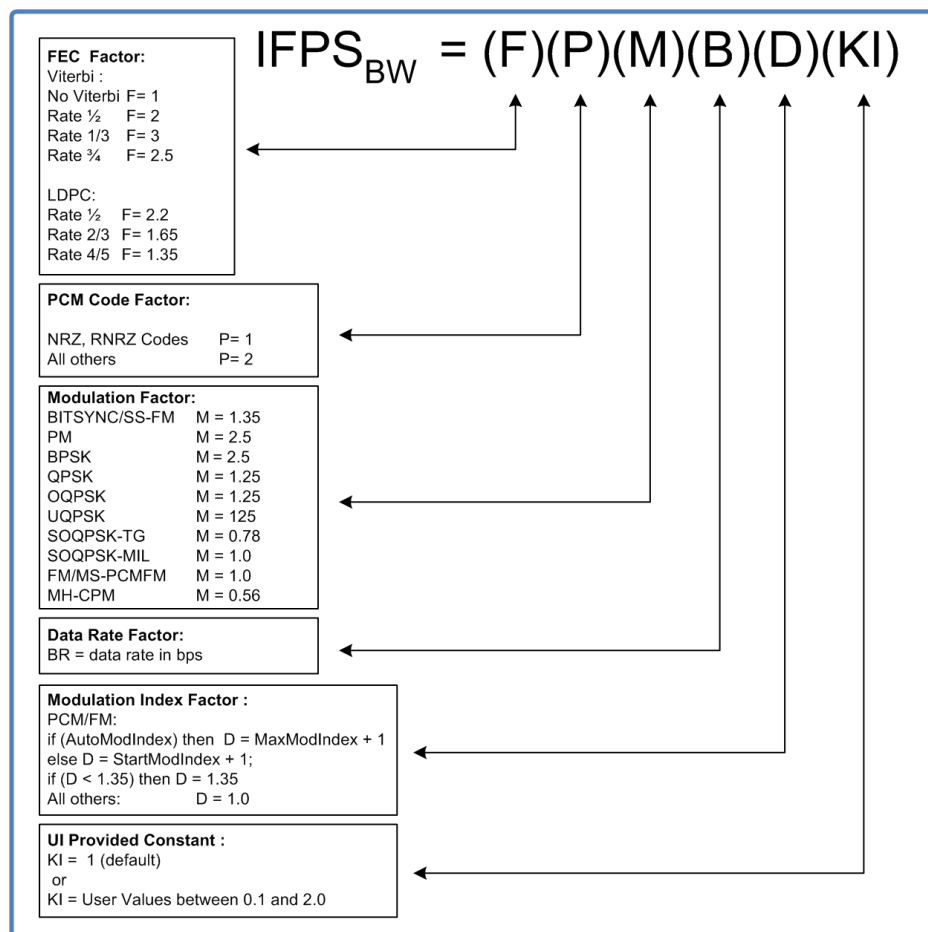


Figure 4-24 Network User Application – IF Pre-Select Filter Bandwidth Select Formulas

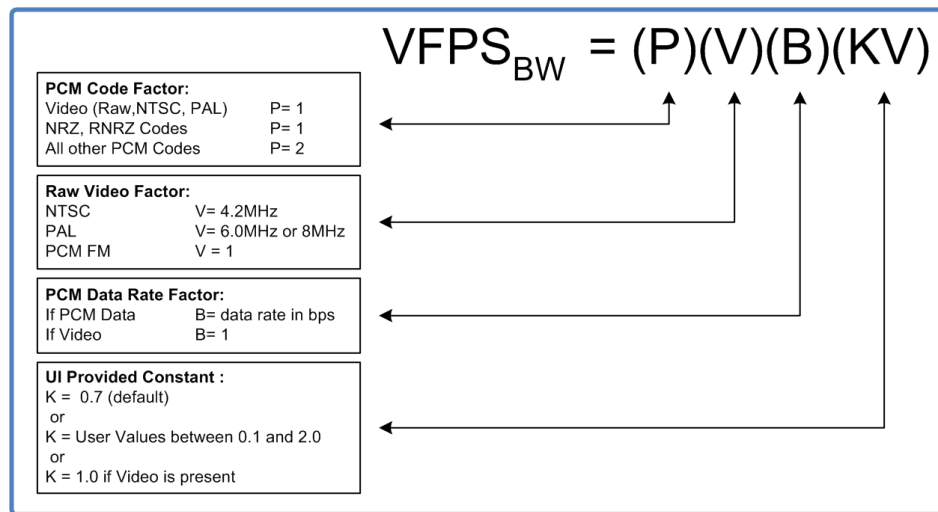


Figure 4-25 Network User Application – FM Video Pre-Select Filter Bandwidth Select Formulas

Duplicate Setup: To ease user setup, the application software provides a setup duplication utility. When selected, all settings applied to one channel will be copied to the alternate channel and the combiner. The only item not copied from one channel to the other through this function is the RF tune frequency.

Use Stored Setup at Boot: This home page selection will ONLY be present if the connected device has the feature enabled. If the device has not been configured with this option, this screen option will NOT be presented on the HOME tab.



Warning:

The "Use Stored Setups at Boot Time" functionality does potentially have security related implications. This option is NOT provided as a default feature to eliminated any potential security concerns.



Caution:

The "Use Stored Setups at Boot Time" functionality is provided as a default feature on units that have internal recording memory options installed.



Information:

If the device has been delivered with the "Use Stored Setups at Boot Time" functionality disabled but it is desired that the functionality be enabled, contact Lumistar Customer Service for assistance.

If enabled, the LS-28-DRSM can store its last general operating settings to internal non-volatile memory and then recall this setup state at power up. The operational settings contain nearly all options that can be set by user interaction via the Network User Application. However, stored setups do have limitations. Most

notable, **the unit will not boot up streaming real-time data**. The main issue with doing so is the configuration of the boot-time destination IP addresses and port numbers. These port numbers are most often assigned by the Operating System of the host system receiving the streamed data and are often different between socket connections.

**Warning:**

The "Use Stored Setups at Boot Time" functionality does not automatically provide initiation and reattachment of IP connections associated with real-time data streaming.

To utilize this functionality, three sequential steps are required. First and foremost, this option must be installed at the time of order. If this option is not installed, internally stored setups are prohibited. If the unit has this option enabled, the user should setup the receiver and data processing as desired and then select from the FILE menu the option *Save Setup Internally*. Once selected, all state information will be transferred to the internal non-volatile memory for recovery at power up. Storage of setup changes is **NOT** an automatic function. The user must initiate a *Save Setup Internally* each time setup parameters are changed. Once a stored setup has been internally stored, the final step to make the setup active at the next power up cycle is for the user to select the "Used Stored Setup at Boot" option on the HOME tab.

**Warning:**

If "Use Stored Setups at Boot Time" functionality is enabled and the user makes changes to setup parameters and does not elect to store them internally, these changes will not be recalled during subsequent boot cycles. No automatic storage of settings is provided.

**Caution:**

As long as the "Use Stored Setups at Boot Time" functionality is enabled, the unit will boot to the last stored settings at each boot. To disable this cyclical action, deselect the "Use Stored Setups at Boot Time" menu selection.

4.2.2 Home Tab – Right Pane

For this section, refer to Figure 4-22

Display Control - S: This right pane graphic control enables the spectral display functions for a selected display.

Display Control - E: This right pane graphic control enables the eye-pattern display functions for a selected display.

Display Control - C: This right pane graphic control enables the constellation display functions for a selected display.

Display Control – N: This right pane graphic control disables all display functions for a selected display.

Display Control – Channel Select Button: This graphic control for channels allows the user to toggle through all available channel selections for a graphic display allowing the user to arrange displays as desired.

Display Control – Pause/Run Button: This graphic control allows a graphic display to be paused or run continuously.

Display Control – Screen Capture Button: This graphic control allows the user to make a capture of a selected display in either bit map or JPEG format. These files will be located in the project hardcopy folder.

Freeze/Zero Buttons: The right pane contains two AGC control buttons. When the AGC freeze button is selected, the gain controls for the AGC output signal are frozen in their present state. This makes the AGC output gain response linear until the freeze condition is removed by user input. When the zero command is selected, the AGC values will enter a relative measurement mode providing a delta value in the signal response window. The RSSI value will maintain the actual signal level being received but to two bar graph status displays will provide measurement relative to the signal value at the time the zero state was engaged.

Signal Strength Status Bar Graph: The center left status pane contains a dual bar gauge providing the user with a graphical representation of the RF channel signal strength. This input signal level is also provided in the system status window.

4.3 Function Select Tab - Signal

The Signal select tab provides the user with received signal processing controls and associated status. This tab, along with the HOME tab hosts primary controls of the receiver, demodulator and bit synchronizer stages of the design. Refer to Figure 4-26 for the block diagram of these sections.

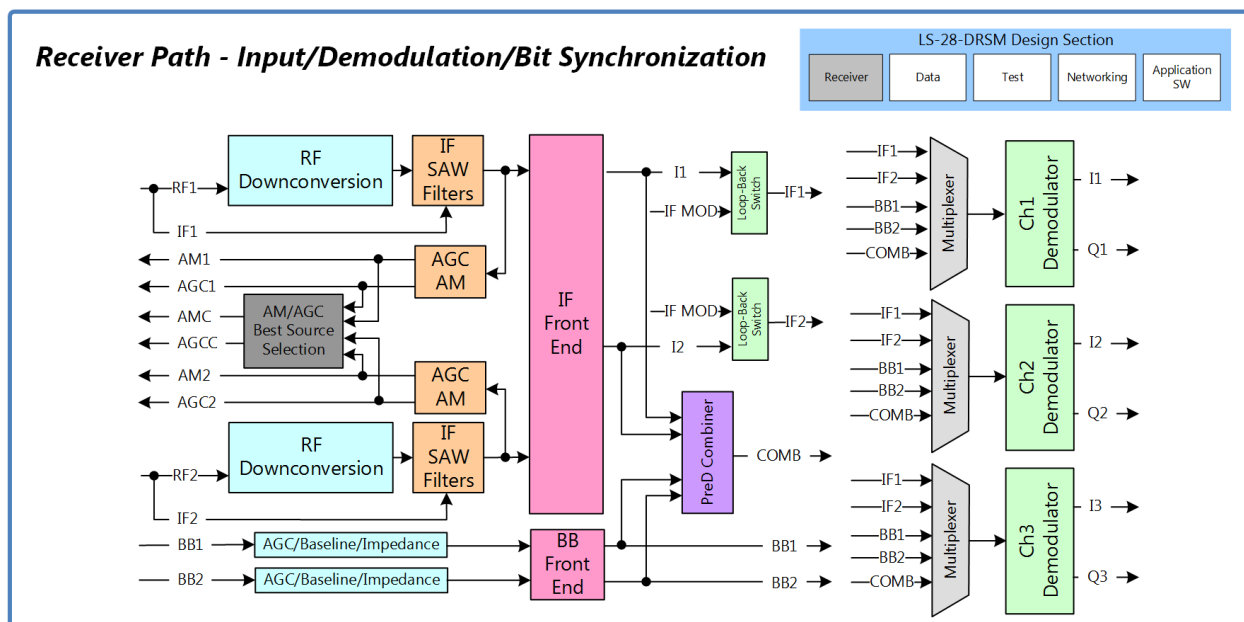


Figure 4-26 Receiver, Demodulator and Bit Synchronizer Block Diagram

These controls are a mixture of purely analog signal controls as well as initial digital processing stages of signal processing. Provided controls and status relate to the signal prior to digital data and clock output processing. Controls and status are split between seven sub-function tabs: PSK, FM, MH-CPM, Bit Sync, AM/AGC, Combiner, and AEQ.

4.3.1 Signal Sub-function Select Tab - PSK Tab

If the unit is licensed to support the PSK demodulation mode and the operational mode setting on the Home tab is set to PSK, this tab will be active. See Figure 4-27 for tab layout.

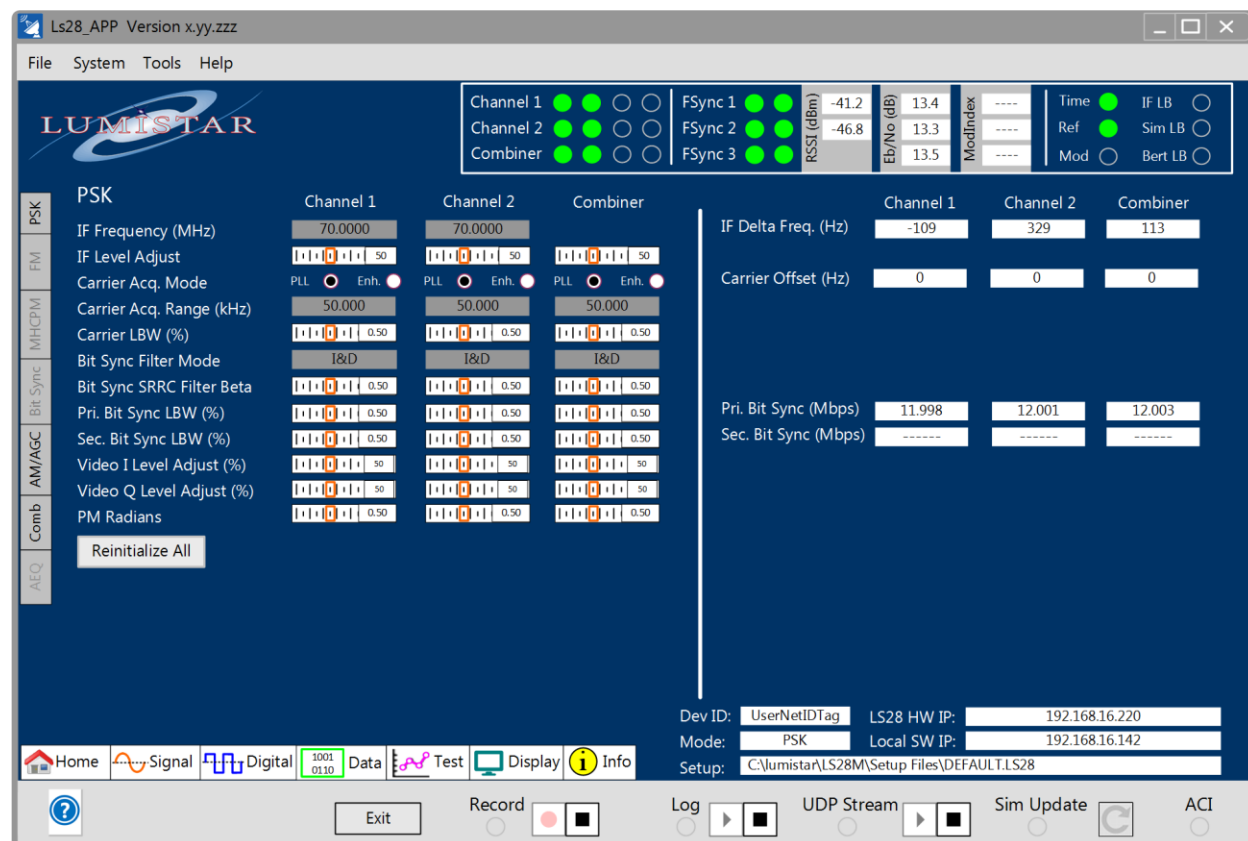


Figure 4-27 Network User Application – Signal Sub-function Select: PSK

4.3.1.1 Signal PSK Tab – Left Pane

IF Frequency: This control entry box allows the user to set the IF center frequency of the digitization section of the design. Normally, this entry should be set to 70MHz. If the RF downconversion stage is part of the configuration, this setting should always be set to 70MHz. However, there may cases where different center frequency settings are desirable. The range of this setting is 1 to 100MHz.

IF Level Adjust: The LS-28-DRSM contains three IF output ports. These ports are identified as J6, J7 and J10 in Figure 2-2. The output level can be adjusted via the slider bar provided or by selecting the numeric box and entering a number. The control provides percentage of maximum output power control and not a specific output value. It should be noted that settings of 0% do not entirely eliminate the IF output signal.

Carrier Acquisition Mode: Once the RF downconversion process is complete, the resulting intermediate frequency (IF) must be tracked prior to signal demodulation. There are two user level controls associated with this process. This radio button allows the user to change modes associated with acquiring the IF carrier in the case where the carrier may be varying due to frequency offsets or actively moving due to Doppler

effects. The standard operational mode is the "PLL" selection. In this mode the standard IF tracking phase lock loop is utilized.

In the standard PLL mode, the receiver can only lock to signals where the carrier acquisition range is less than the symbol rate. In circumstances where the carrier acquisition range is greater than the symbol rate, the enhanced "ENH" carrier tracking mode may be desirable. Enhanced mode uses a phase discriminator on a baseband converted signal with a low-pass filter bandwidth to obtain a carrier frequency estimate. It then uses this estimate to program the receiver carrier frequency to adjust the kick logic routines used in tracking. Enhanced mode works best when the symbol rate is low relative to the Carrier Acquisition Range. This mode is not recommended for very noisy environments since the methodology used allows acquisition range bandwidths, which can be large, into the estimate of the carrier frequency. It should also only be used in demodulation modes that do not cross the I/Q origin such as MH-CPM, MS-PCMFM, SOQPSK, and OQPSK.

Carrier Acquisition Range: The carrier acquisition range setting allows the user to select the desired positive and negative sweep range of the carrier acquisition tracking. For example, a setting of 50kHz allows the frequency tracking loop to vary +/- 50kHz. The larger the acquisition range, the larger the IF offset that can be tracked. In typical applications where Doppler effects are small, acquisition ranges in the +/-50kHz range are appropriate.

The suggested acquisition range for various symbol rates for the PSK operational mode are shown in Table 4-3.

Carrier Loop Bandwidth (LBW): The IF carrier is tracked within the receiver by a phase lock loop (PLL). This is a closed loop feedback system that contains associated correction rate coefficients. These coefficients are referred to as the carrier loop-bandwidth (LBW). Loop bandwidths values are typically provided as a percentage of a given factor. For the carrier, this is a percentage of the symbol data rate programmed by the user.

Generally, as loop bandwidth values increase, lock times decrease but higher bandwidths can increase loop related errors such as jitter and noise. Narrow loop bandwidths increase lock time and decrease noise and jitter. Trade-offs may need to be made based on the signal channel characteristics.

Table 4-3 contains the ranges appropriate for a given symbol rate. These values can either be entered in the associated slider box or by adjusting the slider itself.

Bit Sync Filter Mode: Similar to carrier tracking, the bit synchronization process within the LS-28-DRSM provides multiple filter modes. The default mode contains the standard Integrate and Dump (I&D) PLL tracking filter. A secondary Square-Root Raised Cosine tracking filter is also provided as a matched filter for situations where inter-symbol interference is prevalent. This is the case in some transmission channels and under heavily filtered modulation formats.

Typical operations should utilize the standard PLL loop filter. The bit sync filter mode setting applies to both primary and secondary bit syncs.

Bit Sync Square-Root Raised Cosine (SRRC) Filter Beta: The SRRC filter has a programmable roll-off factor referred to as the filter Beta. This value for baseband processing abides by the following formula:

$$BW = 1 + B/2T_s \text{ where}$$

BW = Filter Bandwidth

B = Beta value

T_s = Symbol period

Beta values between 0 and 1 can be entered in the associated slider box or by adjusting the slider itself. The bit sync SRRC filter mode setting applies to both primary and secondary bit syncs. This value has no meaning if the bit sync filter mode is set to I&D mode.

Primary Bit Sync Loop Bandwidth (LBW): Bits within the bit synchronizer function of the receiver are tracked by a phase lock loop (PLL). This is a closed loop feedback system that contains associated correction rate coefficients. These coefficients are referred to as the bit sync loop-bandwidth (LBW). Loop bandwidths values are typically provided as a percentage of a given factor. For the bit synchronizer, this is a percentage of the symbol rate programmed by the user.

Generally, as loop bandwidth values increase, lock times decrease but higher bandwidths can increase loop related errors such as jitter and noise. Narrow loop bandwidths increase lock time and decrease noise and jitter. Trade-offs may need to be made based on the signal channel characteristics.

The primary bit sync loop bandwidth controls the settings to the first bit synchronizer of each channels two provided bit synchronizers.

Table 4-3 contains the ranges appropriate for a given symbol rates. These values can either be entered in the associated slider box or by adjusting the slider itself.

Secondary Bit Sync Loop Bandwidth (LBW): Similar to the primary bit sync loop bandwidth setting, the secondary bit sync loop bandwidth controls the settings to the second bit synchronizer of each channel two provided bit synchronizers. This bit synchronizer is only utilized in a few PSK sub-modes such as AQPSK and UAQPSK.

Table 4-3 contains the ranges appropriate for a given symbol rates. These values can either be entered in the associated slider box or by adjusting the slider itself.

Video I Level Adjust: The LS-28-DRSM provides two video output ports for video reconstruction of the demodulated symbols. These video outputs can be adjusted in level. This slider control adjusts the I video output signal level for the selected channel. Values entered in the available box or adjusted using the slider are percentages of the maximum output available. These values can either be entered in the associated slider box or by adjusting the slider itself.

Video Q Level Adjust: The LS-28-DRSM provides two video output ports for video reconstruction of the demodulated symbols. These video outputs can be adjusted in level. This slider control adjusts the video output with the Q video signal level. Values entered in the available box or adjusted using the slider are percentages of the maximum output available. These values can either be entered in the associated slider box or by adjusting the slider itself.



Caution:

The video output reconstruction is made directly after baseband downconversion within the FPGA. At this point in the signal processing chain I and Q determination may still contain modulation ambiguity. Therefore, assignments of which video output is the actual I and which is Q can not be made with total confidence.

Symbol Rate (SR)	Carrier Acq. +/- Range Min. (Hz)	Carrier Acq. +/- Range Max. (Hz)	Carrier Acq. +/- Range Default (Hz)	Carrier Acq. +/- LBW Min. (%)	Carrier Acq. +/- LBW Max. (%)	Carrier Acq. +/- LBW Default (%)	Data LBW +/- Min. (%)	Data LBW +/- Max. (%)	Data LBW +/- Default (%)
1K<SR<50K	500	400K	SR/2.1	0.05	2.55	2.00	0.05	2.55	2.00
50K<SR<5M	500	400K	SR/2.1 to 200K	0.05	2.55	1.00	0.05	2.55	1.00
5M<SR<30 M	500	400K	200K	0.05	2.55	0.50	0.05	2.55	0.50

Table 4-3 PSK Operational Mode Range and LBW Table

PM Radians: The LS-28-DRSM PSK mode can provide a sub-mode of direct PM. This sub-mode allows the user to set the expected radians exposed to the demodulation engine. The user can select values between 0.01 radians and 2.55 radians. These values can either be entered in the associated slider box or by adjusting the slider itself.

Reinitialize All: This button acts to reload and reinitialize all tabs controls as presently indicated.

4.3.1.2 Signal PSK Tab – Right Pane

IF Delta Frequency: This status window provides feedback to the user of the IF frequency difference between what has been set in the demodulation control versus the present tracking value of the demodulation engine. Values provided will be displayed in Hertz and will be a signed value. Negative values indicate that the tracked IF frequency is lower than that programmed. Positive values indicate the frequency is greater than that programmed.

Carrier Offset: This status window provides feedback to the user of the carrier offset when using the "ENH" carrier acquisition mode. Carrier offset will be provided as a signed integer in Hertz. The window will be inactive in the PLL mode.

Primary Bit Sync: Similar to the IF frequency feedback, the LS-28-DRSM bit synchronizer functions provides a feedback to the user on the actual PLL clock bit rate for a given bit synchronizer. This field provides bit clock rates for the primary bit synchronizer of each channel.

Secondary Bit Sync: For demodulation schemes that require separate I and Q data streams, the LS-28-DRSM bit synchronizer functions provides a feedback to the user on the actual PLL clock bit rate for the

secondary bit synchronizer. This field provides bit clock rates for the secondary bit synchronizer of each channel.

4.3.2 Signal Sub-function Select Tab – FM

This sub-function select tab will only be active if the operational mode setting on the Home tab is set to Multi-symbol PCMFM (MS-PCMFM) or Single-Symbol-PCMFM/Video FM. Because there are two operational modes the signal Sub-function tab is dependent upon which of the two operational modes is active.

4.3.2.1 MS-PCMFM Mode

If the unit is licensed to support the MS-PCMFM demodulation mode and the operational mode setting on the Home tab is set to MS-PCMFM, this tab will be active. See Figure 4-28 for tab layout.

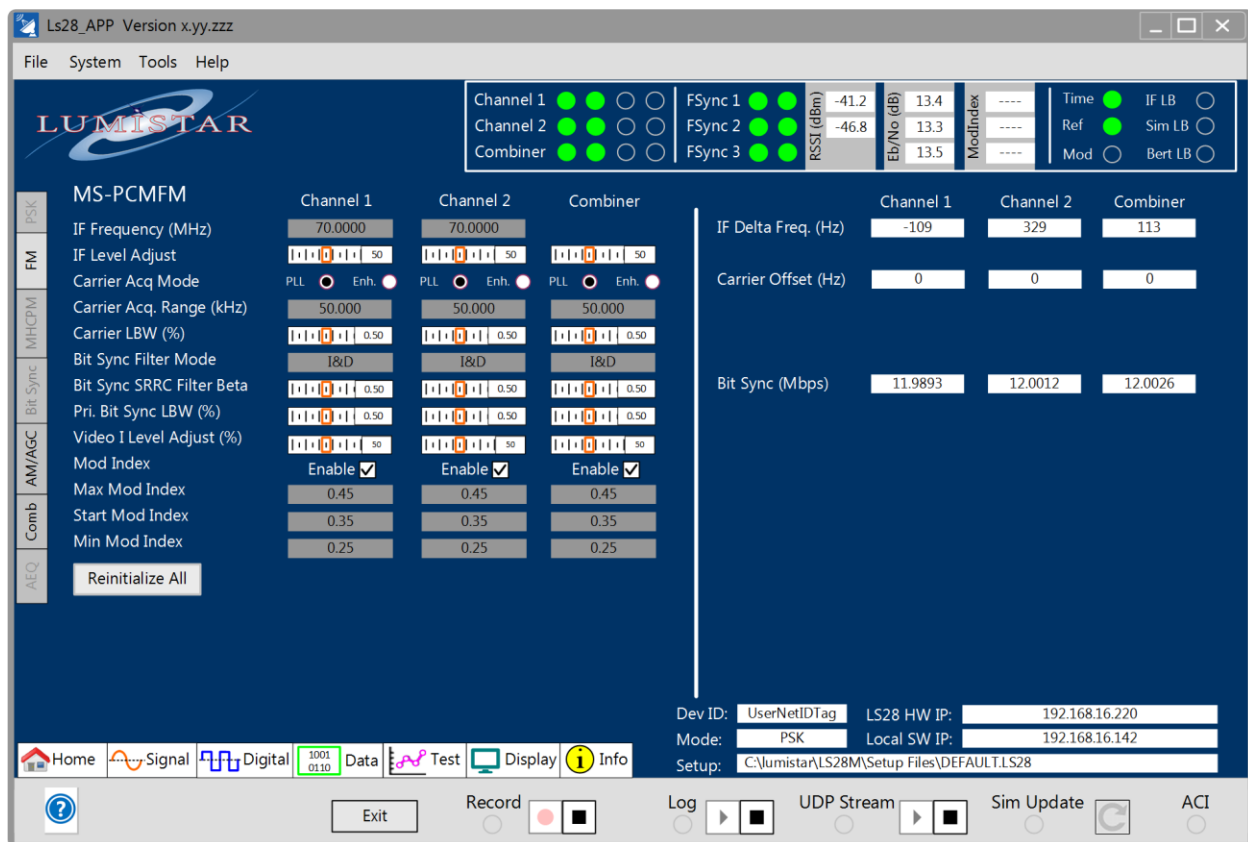


Figure 4-28 Network User Application – Signal Sub-function Select: MS-PCMFM

4.3.2.1.1 Signal MS-PCMFM Tab – Left Pane

IF Frequency: This control entry box allows the user to set the IF center frequency of the digitization section of the design. Normally, this entry should be set to 70MHz. If the RF downconversion stage is part of the configuration, this setting should always be set to 70MHz. However, there may cases where different center frequency settings are desirable. The range of this setting is 1 to 100MHz.

IF Level Adjust: The LS-28-DRSM contains three IF output ports. These ports are identified as J6, J7 and J10 in Figure 2-2. The output level can be adjusted via the slider bar provided or by selecting the numeric box and entering a number. The control provides percentage of maximum output power control and not a specific output value. It should be noted that settings of 0% do not entirely eliminate the IF output signal.

Carrier Acquisition Mode: Once the RF downconversion process is complete, the resulting intermediate frequency (IF) must be tracked prior to signal demodulation. There are two user level controls associated with this process. This radio button allows the user to change modes associated with acquiring the IF carrier in the case where the carrier may be varying due to frequency offsets or actively moving due to Doppler effects. The standard operational mode is the "PLL" selection. In this mode the standard IF tracking phase lock loop is utilized.

In the standard PLL mode, the receiver can only lock to signals where the carrier acquisition range is less than the symbol rate. In circumstances where the carrier acquisition range is greater than the symbol rate, the enhanced "ENH" carrier tracking mode may be desirable. Enhanced mode uses a phase discriminator on a baseband converted signal with a low-pass filter bandwidth to obtain a carrier frequency estimate. It then uses this estimate to program the receiver carrier frequency to adjust the kick logic routines used in tracking. Enhanced mode works best when the symbol rate is low relative to the Carrier Acquisition Range. This mode is not recommended for very noisy environments since the methodology used allows acquisition range bandwidths, which can be large, into the estimate of the carrier frequency. It should also only be used in demodulation modes that do not cross the I/Q origin such as MH-CPM, MS-PCMFM, SOQPSK, and OQPSK.

Carrier Acquisition Range: The carrier acquisition range setting allows the user to select the desired positive and negative sweep range of the carrier acquisition tracking. Since MS-PCMFM modulation requires frequency sweeping, this PLL allows for wider carrier acquisition ranges than PSK modes.

If the acquisition setting of 500kHz is programmed, this allows the frequency tracking loop to vary +/- 500kHz. The larger the acquisition range, the larger the IF offset that can be tracked. In typical applications where Doppler effects are small, acquisition ranges in the +/-100kHz to 2000kHz range are appropriate for MS-PCMFM.

The suggested acquisition ranges based on symbol rate for the MS-PCMFM operational mode are shown in Table 4-4.

Carrier Loop Bandwidth (LBW): The IF carrier is tracked within the receiver by a phase lock loop (PLL). This is a closed loop feedback system that contains associated correction rate coefficients. These coefficients are referred to as the carrier loop-bandwidth (LBW). Loop bandwidths values are typically provided as a percentage of a given factor. For the carrier, this is a percentage of the symbol data rate programmed by the user.

Generally, as loop bandwidth values increase, lock times decrease but higher bandwidths can increase loop related errors such as jitter and noise. Narrow loop bandwidths increase lock time and decrease noise and jitter. Trade-offs may need to be made based on the signal channel characteristics.

Table 4-4 contains the ranges appropriate for a given symbol rate. These values can either be entered in the associated slider box or by adjusting the slider itself.

Bit Sync Filter Mode: Similar to carrier tracking, the bit synchronization process within the LS-28-DRSM provides multiple filter modes. The default mode contains the standard Integrate and Dump (I&D) PLL tracking filter. However, a secondary Square-Root Raised Cosine tracking filter is also provided as a matched filter for situations where inter-symbol interference is prevalent. This is the case in some transmission channels and under heavily filtered modulation formats.

Typical operations should utilize the standard PLL loop filter. The bit sync filter mode setting applies to both primary and secondary bit syncs.

Bit Sync Square-Root Raised Cosine (SRRC) Filter Beta: The SRRC filter has a programmable roll-off factor referred to as the filter Beta. This value for baseband processing abides by the following formula:

$$BW = 1 + B/2T_s \text{ where}$$

BW = Filter Bandwidth

B = Beta value

T_s = Symbol period

Beta values between 0 and 1 can be entered in the associated slider box or by adjusting the slider itself. This value has no meaning if the bit sync filter mode is set to I&D mode.

Primary Bit Sync Loop Bandwidth (LBW): Bits within the bit synchronizer function of the receiver are tracked by a phase lock loop (PLL). This is a closed loop feedback system that contains associated correction rate coefficients. These coefficients are referred to as the bit sync loop-bandwidth (LBW). Loop bandwidths values are typically provided as a percentage of a given factor. For the bit synchronizer, this is a percentage of the symbol rate programmed by the user.

Generally, as loop bandwidth values increase, lock times decrease but higher bandwidths can increase loop related errors such as jitter and noise. Narrow loop bandwidths increase lock time and decrease noise and jitter. Trade-offs may need to be made based on the signal channel characteristics.

The primary bit sync loop bandwidth controls the settings to the first bit synchronizer of each channels two provided bit synchronizers.

Table 4-4 contains the ranges appropriate for a given symbol rates. These values can either be entered in the associated slider box or by adjusting the slider itself.

Video I Level Adjust: The LS-28-DRSM provides two video output ports for video reconstruction of the demodulated symbols. These video outputs can be adjusted in level. This slider control adjusts the I video signal level. Values entered in the available box or adjusted using the slider are percentages of the maximum output available. These values can either be entered in the associated slider box or by adjusting the slider itself.

Mod Index Enabled: This checkbox enables custom FM modulation index controls for the MS-PCMFM demodulation and bit synchronization. If the checkbox is selected, the controls of Max Mod Index, Start Mod Index and Min Mod Index become active. If the box is not checked, the MS-PCMFM FM modulation index will be assumed to be within the stated IRIG standards of 0.35. The FM modulation index ranges will extend down to 0.30 and up to 0.40 but will not seek modulation index values beyond these settings.

For digital modulation sources, custom Mod index settings should not be necessary. For analog FM modulation sources where deviation controls are less strict, especially for FM sources that are AC coupled, custom modulation index settings may be required.

For sources that have anticipated FM sources that are under or over deviated beyond the typical 0.35 IRIG suggested value, the custom value settings have been provided. There are some operational impacts to the use of the custom modulation index values. Modulation index search values that are wider than the standard 0.3 to 0.4 values increase the acquisition time. The more the custom settings can be set to what the actual signal path requires, the faster acquisition and tracking times can be shortened.

**Caution:**

Lumistar suggests that if custom modulation index values need to be utilized that the user identify the range needed and then narrow the customized settings to best match these ranges to improve acquisition and performance factors.

**Caution:**

Lumistar strongly discourages the use of very wide settings for custom modulation index entries for all PCM FM sources. The use of the custom modulation index values should be configured for specific applications and not used as a general operating procedure.

Max Mod Index: The Max Mod Index setting allows the user to enter the maximum FM modulation index to extend to when demodulating FM sources. Values up to 2.55 may be entered but values below 1.80 are suggested.

Start Mod Index: The Start Mod Index instructs the demodulation engine where to expect the FM modulation index to reside. From this set point, the demodulation engine will start the search for the appropriate demodulation index value.

Min Mod Index: The Min Mod Index setting allows the user to enter the minimum FM modulation index to extend to when demodulating FM sources. Values up down to 0.01 may be entered but values greater than 0.10 are suggested.

Symbol Rate (SR)	Carrier Acq. +/- Range Min. (Hz)	Carrier Acq. +/- Range Max. (Hz)	Carrier Acq. +/- Range Default (Hz)	Carrier Acq. +/- LBW Min. (%)	Carrier Acq. +/- LBW Max. (%)	Carrier Acq. +/- LBW Default t (%)	Data LBW +/- Min. (%)	Data LBW +/- Max. (%)	Data LBW +/- Default (%)
1K<SR<50K	1000	1M	100K	0.0001	0.1	0.0005	0.05	2.55	2.00
50K<SR<5M	1000	1M	200K	0.0001	0.1	0.0005	0.05	2.55	1.00
5M<SR<30 M	1000	1M	500K	0.0001	0.1	0.0005	0.05	2.55	0.50

Table 4-4 MS-PCMFM Operational Mode Range and LBW Table

Reinitialize All: This button acts to reload and reinitialize all tabs controls as presently indicated.

4.3.2.1.2 Signal MS-PCMFM Tab – Right Pane

IF Delta Frequency: This status window provides feedback to the user of the IF frequency difference between what has been set in the demodulation control versus the present tracking value of the demodulation engine. Values provided will be displayed in Hertz and will be a signed value. Negative values indicate that the tracked IF frequency is lower than that programmed. Positive values indicate the frequency is greater than that programmed.

Carrier Offset: This status window provides feedback to the user of the carrier offset when using the “ENH” carrier acquisition mode. Carrier offset will be provided as a signed integer in Hertz. The window will be inactive in the PLL mode.

Bit Sync: Similar to the IF frequency feedback, the LS-28-DRSM bit synchronizer functions provides a feedback to the user on the actual PLL clock bit rate for a given bit synchronizer. This field provides bit clock rates for the bit synchronizer of each channel.

4.3.2.2 SS-PCMFM/FM Video Mode

If the unit is licensed to support the SS-PCMFM demodulation mode and the operational mode setting on the Home tab is set to SS-PCMFM, this tab will be active. See Figure 4-29 for tab layout.

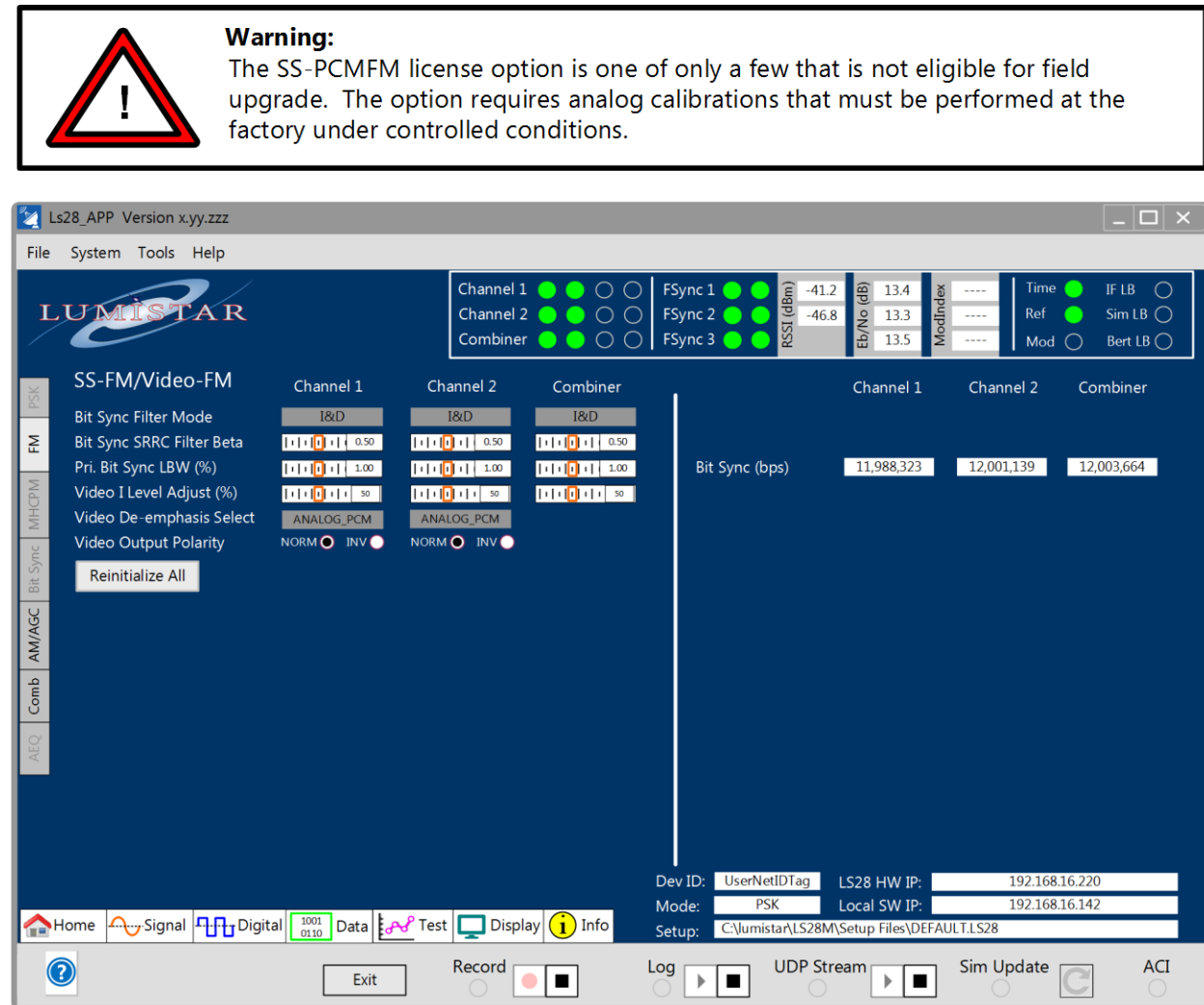


Figure 4-29 Network User Application – Signal Sub-function Select: SS-FM/Video-FM

4.3.2.2.1 Signal SS-PCMFM/FM Video Tab – Left Pane

Bit Sync Filter Mode: The bit synchronization process within the LS-28-DRSM provides multiple filter modes. The default mode contains the standard Integrate and Dump (I&D) PLL tracking filter. A secondary Square-Root Raised Cosine tracking filter is also provided as a matched filter for situations where inter-symbol interference is prevalent. This is the case in some transmission channels and under heavily filtered modulation formats.

Typical operations should utilize the standard PLL loop filter. The bit sync filter mode setting applies to both primary and secondary bit syncs.

Bit Sync Square-Root Raised Cosine (SRRC) Filter Beta: The SRRC filter has a programmable roll-off factor referred to as the filter Beta. This value for baseband processing abides by the following formula:

$$BW = 1 + B/2T_s \text{ where}$$

BW = Filter Bandwidth

B = Beta value

T_s = Symbol period

Beta values between 0 and 1 can be entered in the associated slider box or by adjusting the slider itself. This value has no meaning if the bit sync filter mode is set to I&D mode.

Primary Bit Sync Loop Bandwidth (LBW): Bits within the bit synchronizer function of the receiver are tracked by a phase lock loop (PLL). This is a closed loop feedback system that contains associated correction rate coefficients. These coefficients are referred to as the bit sync loop-bandwidth (LBW). Loop bandwidths values are typically provided as a percentage of a given factor. For the bit synchronizer, this is a percentage of the symbol rate programmed by the user.

Generally, as loop bandwidth values increase, lock times decrease but higher bandwidths can increase loop related errors such as jitter and noise. Narrow loop bandwidths increase lock time and decrease noise and jitter. Trade-offs may need to be made based on the signal channel characteristics.

The primary bit sync loop bandwidth controls the settings to the first bit synchronizer of each channels two provided bit synchronizers.

Table 4-4 contains the ranges appropriate for a given symbol rates. These values can either be entered in the associated slider box or by adjusting the slider itself.

Video I Level Adjust: The LS-28-DRSM provides two video output ports for video reconstruction of the demodulated symbols. These video outputs can be adjusted in level. This slider control adjusts the I video signal level. Values entered in the available box or adjusted using the slider are percentages of the maximum output available. These values can either be entered in the associated slider box or by adjusting the slider itself.

Video De-emphasis Select: If the FM source is legacy analog video sources standardized by the National Television System Committee (NTSC) or the standard for Phase Alternating Line (PAL) video. These two standards allow for a process of pre-emphasis to equalize the transmitted signal in frequency ranges that are most susceptible to noise. This process must then be de-emphasized when received to remove this equalization. The LS-28-DRSM contains provisions for both video formats. It also provides a means of bypassing this de-emphasis process and provide specific filter for single-symbol PCM FM.

Video Output Polarity: For analog output sources, this selection allows the user to invert the analog output polarity.

Reinitialize All: This button acts to reload and reinitialize all tab controls as presently indicated.

4.3.2.2.2 Signal SS-PCMFM Tab – Right Pane

Bit Sync: The LS-28-DRSM bit synchronizer functions provides a feedback to the user on the actual PLL clock bit rate for a given bit synchronizer. This field provides bit clock rates for the bit synchronizer of each channel.

4.3.3 Signal Sub-function Select Tab – MH-CPM

If the unit is licensed to support the MH-CPM demodulation mode and the operational mode setting on the Home tab is set to MH-CPM, this tab will be active. See Figure 4-30 for tab layout.

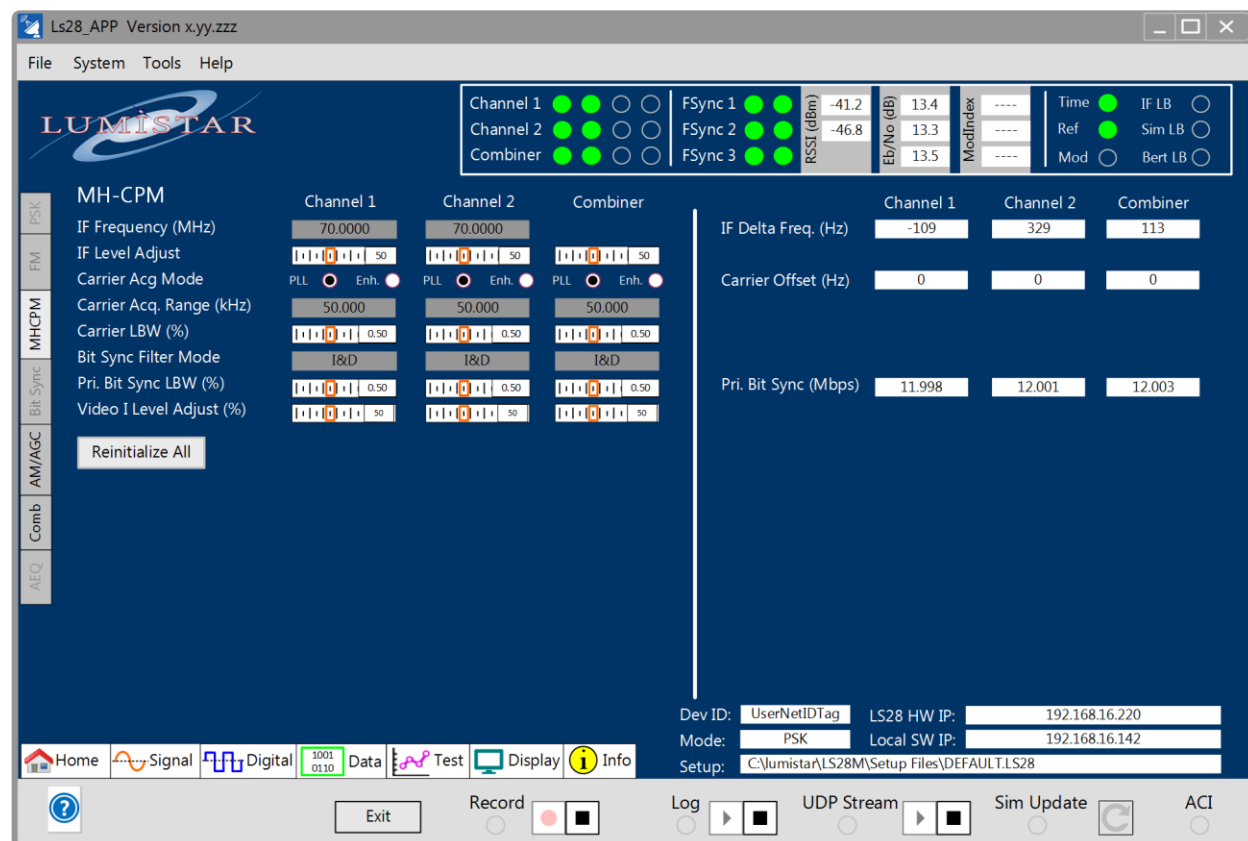


Figure 4-30 Network User Application – Signal Sub-function Select: MH-CPM

4.3.3.1 Signal MH-CPM Tab – Left Pane

IF Frequency: This control entry box allows the user to set the IF center frequency of the digitization section of the design. Normally, this entry should be set to 70MHz. If the RF downconversion stage is part of the configuration, this setting should always be set to 70MHz. However, there may cases where different center frequency settings are desirable. The range of this setting is 1 to 100MHz.

IF Level Adjust: The LS-28-DRSM contains three IF output ports. These ports are identified as J6, J7 and J10 in Figure 2-2. The output level can be adjusted via the slider bar provided or by selecting the numeric box and entering a number. The control provides percentage of maximum output power control and not a specific output value. It should be noted that settings of 0% do not entirely eliminate the IF output signal.

Carrier Acquisition Mode: Once the RF downconversion process is complete, the resulting intermediate frequency (IF) must be tracked prior to signal demodulation. There are two user level controls associated with this process. This radio button allows the user to change modes associated with acquiring the IF carrier in the case where the carrier may be varying due to frequency offsets or actively moving due to Doppler

effects. The standard operational mode is the "PLL" selection. In this mode the standard IF tracking phase lock loop is utilized.

In the standard PLL mode, the receiver can only lock to signals where the carrier acquisition range is less than the symbol rate. In circumstances where the carrier acquisition range is greater than the symbol rate, the enhanced "ENH" carrier tracking mode may be desirable. Enhanced mode uses a phase discriminator on a baseband converted signal with a low-pass filter bandwidth to obtain a carrier frequency estimate. It then uses this estimate to program the receiver carrier frequency to adjust the kick logic routines used in tracking. Enhanced mode works best when the symbol rate is low relative to the Carrier Acquisition Range. This mode is not recommended for very noisy environments since the methodology used allows acquisition range bandwidths, which can be large, into the estimate of the carrier frequency. It should also only be used in demodulation modes that do not cross the I/Q origin such as MH-CPM, MS-PCMFM, SOQPSK, and OQPSK.

Carrier Acquisition Range: The carrier acquisition range setting allows the user to select the desired positive and negative sweep range of the carrier acquisition tracking. For MH-CPM carrier acquisition ranges should be set in the same manner as they are for PSK mode. These values can be found in Table 4-3.

If the acquisition setting of 500kHz is programmed, this allows the frequency tracking loop to vary +/- 500kHz. The larger the acquisition range, the larger the IF offset that can be tracked. In typical applications where Doppler effects are small, acquisition ranges in the +/-50kHz to 500kHz range are appropriate for MH-CPM.

Carrier Loop Bandwidth (LBW): The IF carrier is tracked within the receiver by a phase lock loop (PLL). This is a closed loop feedback system that contains associated correction rate coefficients. These coefficients are referred to as the carrier loop-bandwidth (LBW). Loop bandwidths values are typically provided as a percentage of a given factor. For the carrier, this is a percentage of the symbol data rate programmed by the user.

Generally, as loop bandwidth values increase, lock times decrease but higher bandwidths can increase loop related errors such as jitter and noise. Narrow loop bandwidths increase lock time and decrease noise and jitter. Trade-offs may need to be made based on the signal channel characteristics.

Table 4-3 contains the ranges appropriate for a given symbol rate for PSK modes. These can be used for MH-CPM mode as well. These values can either be entered in the associated slider box or by adjusting the slider itself.

Bit Sync Filter Mode: For the MH-CPM mode, the bit sync filter mode is fixed in the Integrate and Dump (I&D) filter mode.

Primary Bit Sync Loop Bandwidth (LBW): Bits within the bit synchronizer function of the receiver are tracked by a phase lock loop (PLL). This is a closed loop feedback system that contains associated correction rate coefficients. These coefficients are referred to as the bit sync loop-bandwidth (LBW). Loop bandwidths

values are typically provided as a percentage of a given factor. For the bit synchronizer, this is a percentage of the symbol rate programmed by the user.

Generally, as loop bandwidth values increase, lock times decrease but higher bandwidths can increase loop related errors such as jitter and noise. Narrow loop bandwidths increase lock time and decrease noise and jitter. Trade-offs may need to be made based on the signal channel characteristics.

The primary bit sync loop bandwidth controls the settings to the first bit synchronizer of each channels two provided bit synchronizers.

Table 4-3 contains the ranges appropriate for a given symbol rates. These values can either be entered in the associated slider box or by adjusting the slider itself.

Video I Level Adjust: The LS-28-DRSM provides two video output ports for video reconstruction of the demodulated symbols. These video outputs can be adjusted in level. This slider control adjusts the I video signal level. Values entered in the available box or adjusted using the slider are percentages of the maximum output available. These values can either be entered in the associated slider box or by adjusting the slider itself.

Reinitialize All: This button acts to reload and reinitialize all tab controls as presently indicated.

4.3.3.2 Signal MH-CPM Tab – Right Pane

IF Delta Frequency: This status window provides feedback to the user of the IF frequency difference between what has been set in the demodulation control versus the present tracking value of the demodulation engine. Values provided will be displayed in Hertz and will be a signed value. Negative values indicate that the tracked IF frequency is lower than that programmed. Positive values indicate the frequency is greater than that programmed.

Carrier Offset: This status window provides feedback to the user of the carrier offset when using the "ENH" carrier acquisition mode. Carrier offset will be provided as a signed integer in Hertz. The window will be inactive in the PLL mode.

Primary Bit Sync: Similar to the IF frequency feedback, the LS-28-DRSM bit synchronizer functions provides a feedback to the user on the actual PLL clock bit rate for a given bit synchronizer. This field provides bit clock rates for the primary bit synchronizer of each channel.

4.3.4 Signal Sub-function Select Tab - Bit Sync

If the unit is licensed to support the stand-alone Bit Sync mode and the operational mode setting on the Home tab is set to Bit Sync, this tab will be active. See Figure 4-31 for tab layout.

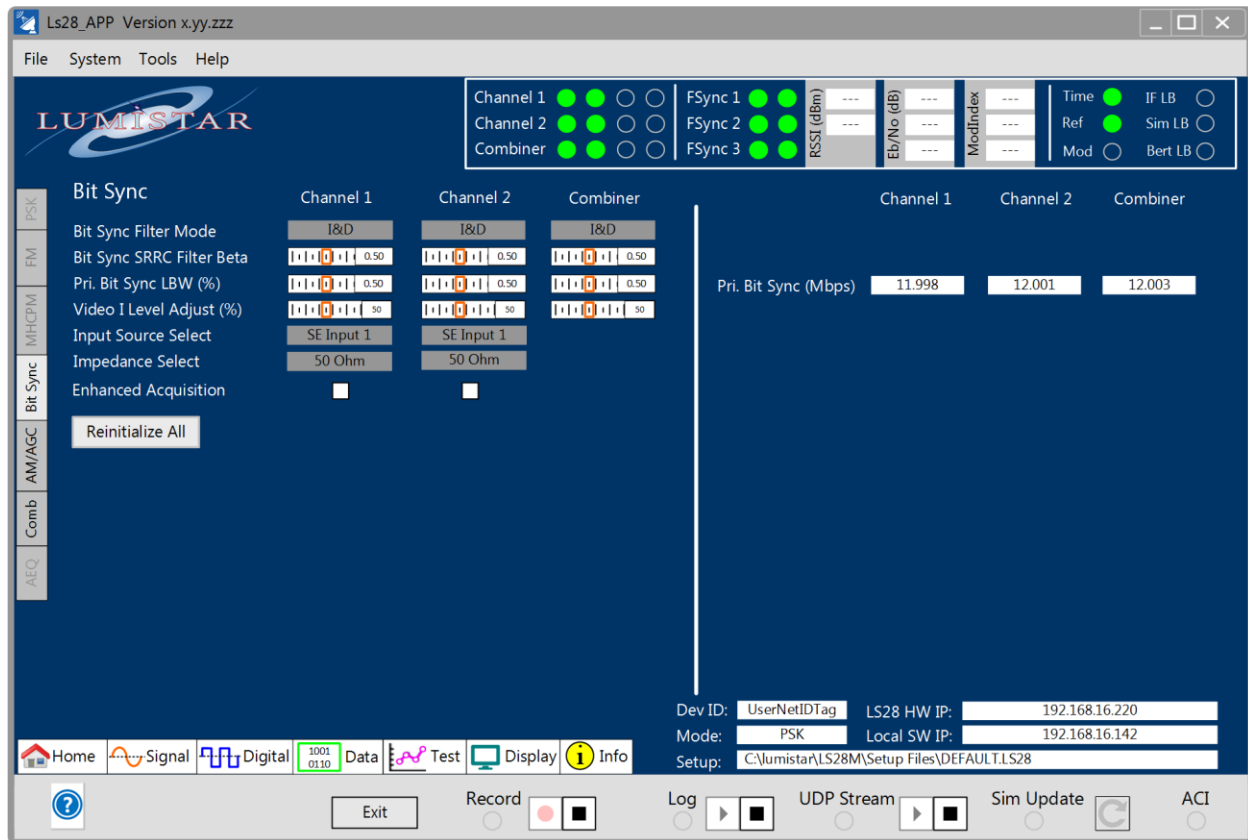


Figure 4-31 Network User Application – Signal Sub-function Select: Bit Sync

4.3.4.1 Signal Bit Sync Tab – Left Pane

Bit Sync Filter Mode: The bit synchronization process within the LS-28-DRSM provides multiple filter modes. The default mode contains the standard Integrate and Dump (I&D) PLL tracking filter. A secondary Square-Root Raised Cosine tracking filter is also provided as a matched filter for situations where inter-symbol interference is prevalent. This is the case in some transmission channels and under heavily filtered modulation formats.

Typical operations should utilize the standard PLL loop filter. The bit sync filter mode setting applies to both primary and secondary bit syncs.

Bit Sync Square-Root Raised Cosine (SRRC) Filter Beta: The SRRC filter has a programmable roll-off factor referred to as the filter Beta. This value for baseband processing abides by the following formula:

$$BW = 1 + B/2T_s \text{ where}$$

BW = Filter Bandwidth

B = Beta value

T_s = Symbol period

Beta values between 0 and 1 can be entered in the associated slider box or by adjusting the slider itself. The bit sync SRRC filter mode setting applies to both primary and secondary bit syncs. This value has no meaning if the bit sync filter mode is set to I&D mode.

Primary Bit Sync Loop Bandwidth (LBW): Bits within the bit synchronizer function of the receiver are tracked by a phase lock loop (PLL). This is a closed loop feedback system that contains associated correction rate coefficients. These coefficients are referred to as the bit sync loop-bandwidth (LBW). Loop bandwidths values are typically provided as a percentage of a given factor. For the bit synchronizer, this is a percentage of the symbol rate programmed by the user.

Generally, as loop bandwidth values increase, lock times decrease but higher bandwidths can increase loop related errors such as jitter and noise. Narrow loop bandwidths increase lock time and decrease noise and jitter. Trade-offs may need to be made based on the signal channel characteristics.

The primary bit sync loop bandwidth controls the settings to the first bit synchronizer of each channels two provided bit synchronizers.

Table 4-3 contains the ranges appropriate for a given symbol rates for PSK. These values apply to the PCM Bit Synchronizer mode also. These values can either be entered in the associated slider box or by adjusting the slider itself.

Video I Level Adjust: The LS-28-DRSM in bit synchronizer mode provides a video output ports for video reconstruction of the PCM input signal. The video outputs can be adjusted in peak-to-peak voltage level. This slider control adjusts the I video output signal level. Values entered in the available box or adjusted using the slider are percentages of the maximum output available. These values can either be entered in the associated slider box or by adjusting the slider itself.

Input Source Select: The LS-28-DRSM in bit synchronizer mode provides a number of input source selections. Differences in hardware builds affect the types and numbers of inputs. Channel selections can include two Single-End (SE) and one differential input options for selection. This control drop-down list allows the user to select between the options available in a given build.

Impedance Select: Each of the bit sync input channels has selectable input impedances. If differential mode is available, selections between 120 ohms and 5K ohms are provided. In single-ended mode, the impedance selections typically offered can include 50, 75, 100, and 1K ohms. Differences in hardware builds can affect the number of selections available.

Enhanced Acquisition: During certain bit sync phases where data is dropping and returning in a sporadic fashion, or when NRZ data content has low numbers of transitions, a special mode has been developed that tailors the PLL operations of the bit sync to slow AGC and Baseline cycles so that the lock maintenance and signal reacquisition times are improved. This is a "trained" mode requiring that the bit rate be entered to start a training cycle and create a hysteresis of signal parameters to initialize the mode.

Reinitialize All: This button acts to reload and reinitialize all tab controls as presently indicated.

4.3.4.2 Signal Bit Sync Tab – Right Pane

Primary Bit Sync: Similar to the IF frequency feedback, the LS-28-DRSM bit synchronizer functions provides a feedback to the user on the actual PLL clock bit rate for a given bit synchronizer. This field provides bit clock rates for the primary bit synchronizer of each channel.

4.3.5 Signal Sub-function Select Tab - AM/AGC

This sub-function select tab will be active in all receiver operational mode settings on the Home tab with the exception of the stand-alone bit sync mode. See Figure 4-32 for tab layout.

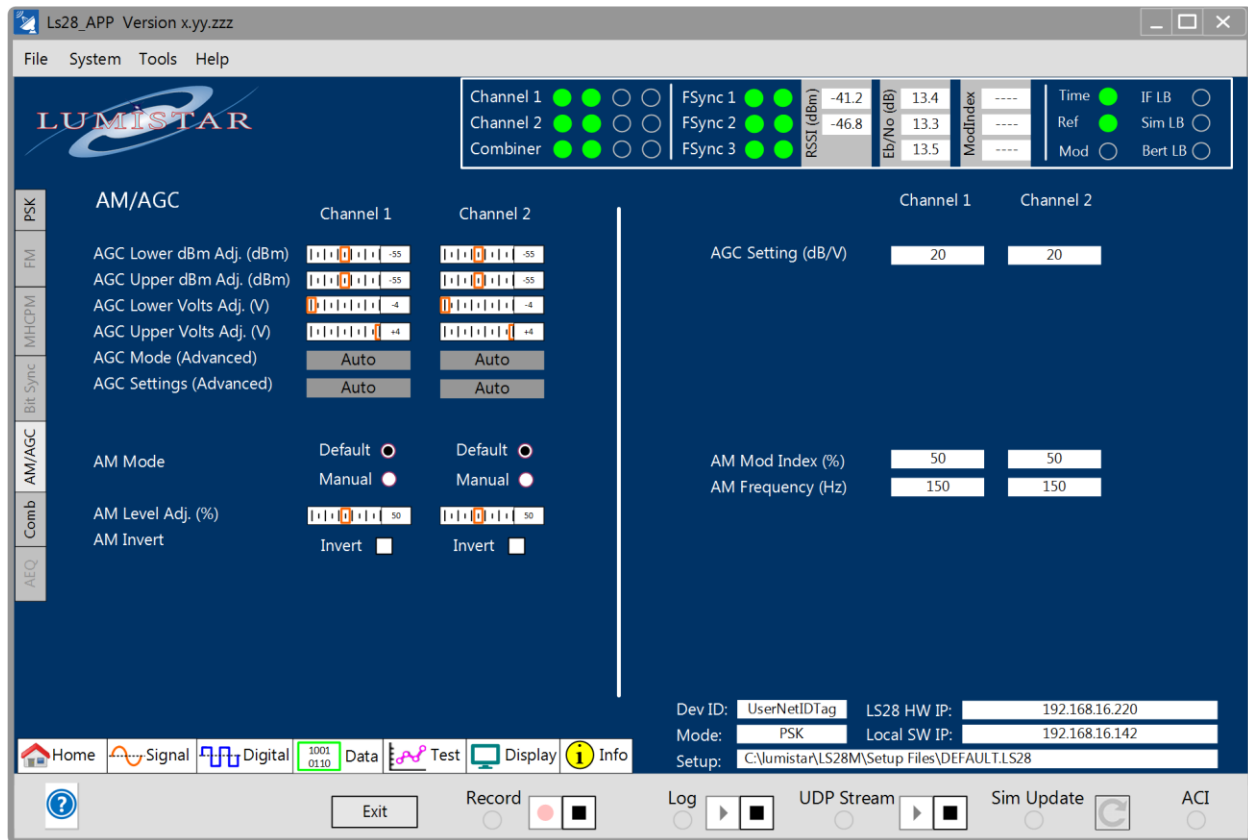


Figure 4-32 Network User Application – Signal Sub-function Select: AM/AGC

4.3.5.1 Signal AM/AGC Tab – Left Pane

AGC Mode: This control entry allows the user the ability to swap between Standard and DAGC modes. If DAGC mode is selected, the linear AGC operating mode will be initiated. The typical operating mode is the standard AGC mode.

AGC Lower dBm Adj. (dBm): This control allows the user to select the lower RF receiver input level that will be associated with the lower voltage adjust range.

AGC Upper dBm Adj. (dBm): This control allows the user to select the upper RF receiver input level that will be associated with the upper voltage adjust range.

AGC Lower Volts Adj. (V): This control allows the user to select the lower RF receiver input level related AGC output voltage level.

AGC Upper Volts Adj. (V): This control allows the user to select the upper RF receiver input level related AGC output voltage level.

AGC Mode (Advanced): This control entry box allows advanced AGC mode capabilities. Consult factory for information on how to initiate these controls.

AGC Settings (Advanced): This control entry box allows advanced AGC mode capabilities. Consult factory for information on how to initiate these controls.

AM Mode: This radio button allows the user to alternate between the factory default calibrated AM output setting of 4Vp-p into 75 ohms at 50% AM index and manual AM output level control. Typical applications would utilize the automatic mode.

Manual mode may be necessary to adjust output levels for various load requirements. Regardless of which AM mode is selected, output voltage values will be directly related to measured AM index values.

AM Level Adj. (%): The AM Level Adjust control only functions when the AM mode is set to Manual mode. Slider or box entry controls are provided. The control provides percentage adjustment in terms of maximum adjustment voltage levels. A value of 0% does not necessarily result in a zero output voltage level. Overdriving the output can result in distorted waveform shapes. All AM output levels are bipolar in nature.

AM Invert: In some applications, the need to invert the polarity of the AM output response may be required. This check-box control allows the user to invert the AM output signal.

4.3.5.2 Signal AM/AGC Tab – Right Pane

AGC Setting (dB/V): This status calculation provides the user with a dB/Volt slope value related to AGC dBm and Voltage settings in the left pane.

AM Mod Index (%): This status provides an AM modulation index measurement value. This value is relatively accurate for AM index values between 6 and 66%. Values of AM index past 66% are more closely related to pulsed RF transmissions versus continuous carrier transmissions. AM Filter settings from the Home function select tab will have an effect on this estimated value.

AM Frequency (Hz): This status box provides an estimated AM frequency for the AM output. The estimate is affected in accuracy based on AM index level, AM filter settings, wave shape, and noise values.

4.3.6 Signal Sub-function Select Tab – Comb (Combiner)

If the unit is licensed to support the IF Combiner mode and the Combiner Enabled check box on the Home tab is selected, this tab will be active. See Figure 4-33 for tab layout.

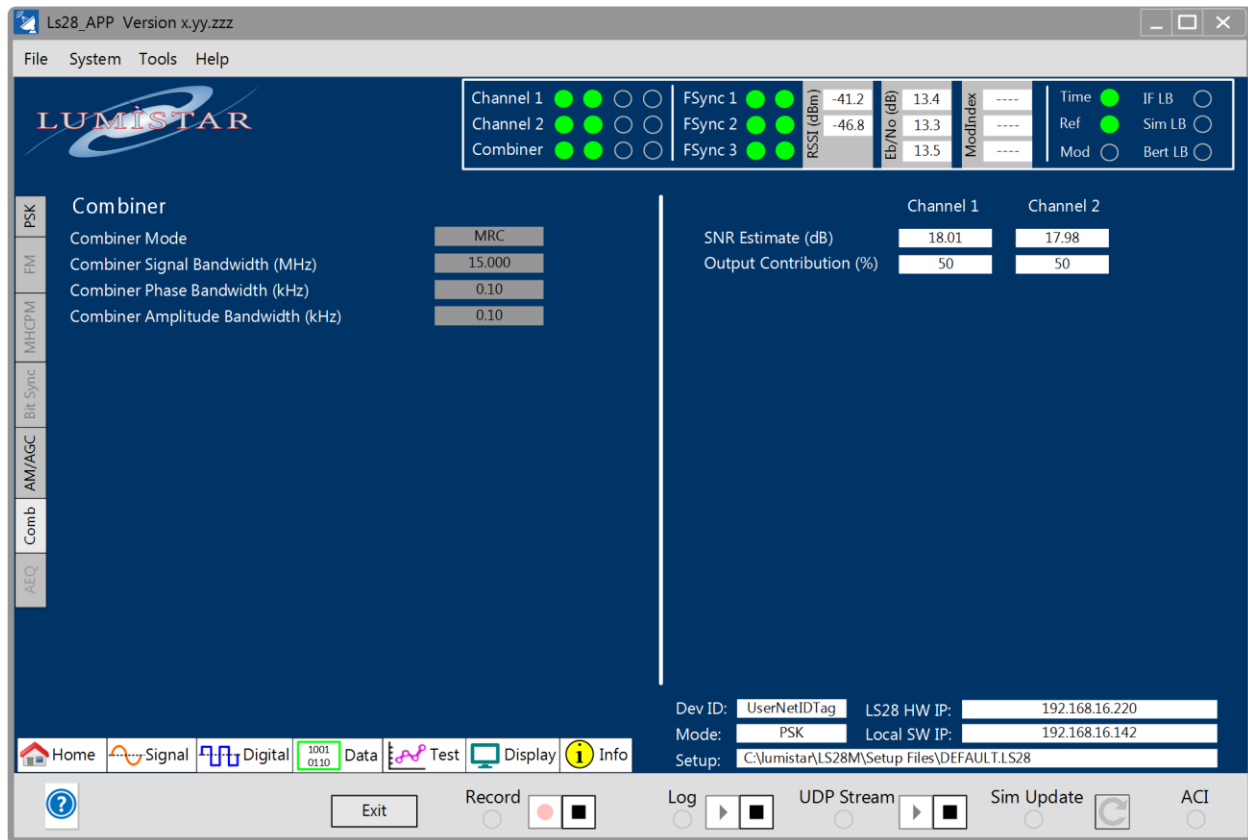


Figure 4-33 Network User Application – Signal Sub-function Select: Combiner

4.3.6.1 Signal COMB Tab – Left Pane

Combiner Mode: This left pane control allows the selection of the available modes of the diversity combiner if licensed and enabled. Five combiner operational modes are provided: Maximal-Ratio Combining (MRC), Equal Gain Combining (EGC), and Best Source Combining (BSC), CH1 Only, CH2 Only.

The LS-28-DRSM employs a pre-detection, maximal-ratio diversity combiner. It accepts two IF inputs (typically 70 MHz) with independent or complementary fading, usually from separate polarizations or separate antennas. The most significant performance improvement from a diversity combiner occurs in a fading environment when the two channels fade independently. When one channel is in a fade, there is a good chance that the other channel will not be in a fade, and so the effect of the fade is completely mitigated. Only when both channels fade does the combined signal fade. A diversity combiner provides the additional performance advantage of providing gain by phase aligning and optimally combining the two signals. Combining prior to demodulation (pre-detection) makes that gain available to the receiver's tracking process and significantly reduces the chances of the receiver losing lock.

The LS-28-DRSM combiner measures the relative phase of the two signals and the Signal-to-Noise Ratio (SNR) estimate of each channel. The phase of the weaker signal is adjusted to match the stronger signal. In a multi-path environment, rapid phase fluctuations occur in the deepest part of the fade. By adjusting the phase of the weak signal to that of the strong signal, the rapid phase fluctuations are mitigated. The amplitudes are adjusted based on the ratio of the two SNR measurements to provide a maximal ratio combining. This means that if the two signals have different SNRs, then the signal with the lower SNR will be attenuated relative to the signal with the stronger SNR, ensuring that weak or faded signals do not negatively affect the combined signal. Signals with the same SNR will be combined with equal strength.

Equal Gain combining is used for very fast fade rate environments where fades in excess of 10kHz are expected. This scenario may exist when the signal is transmitted through a vehicles exhaust plume. The EGC operational mode should only be used in these extreme situations.

Best source combining removes the theoretical gain aspects of the combiner. It simply selects the channel with the best SNR estimate at a given time. Lumistar suggests the typical use of the MRC combining mode.

The CH1 and CH2 only modes directs the combiner output to be selected based on channel.

Combiner Signal Bandwidth (MHz): This bandwidth setting is automatically selected based on the input settings provided to the two channels on the Home function select tab. Even though the value is automatically calculated in all modes, the user retains the ability to adjust the combiner IF bandwidth with this control. Settings are entered as MHz bandwidth values.

Combiner Phase Bandwidth (kHz): In combining the two signals being received, both signals are converted to baseband prior to being combined. Once the signal is converted to baseband, the weaker of the two signals is rotated to match phases with the strongest of the received signals. This process is a form of phase filtering. If this setting is too narrow, then frequency offsets cannot be managed in the case that the signals are provided in a frequency diversity mode. If the setting is too large performance of the overall combining functionality is impaired. Lumistar suggests that the most appropriate setting for this phase bandwidth setting is 20kHz.

Combiner Amplitude Bandwidth (kHz): In combining the two received signals contain different power levels, or more accurately Signal to Noise Ratios (SNR). The SNR estimates of each channel are performed continuously. The amplitude bandwidth affects these estimates. If settings are too narrow, then fast signal fading cannot be accommodated and if the settings are too wide then the accuracy of the SNR estimates is jeopardized. Lumistar suggests that the most appropriate setting for this amplitude bandwidth setting is 20kHz.

4.3.6.2 Signal COMB Tab – Right Pane

SNR Estimate (dB): This right pane status window provides the user with a metric on the individual signals being received in terms of a Signal to Noise Receive estimates being calculated by the combiner functions.

Output Contribution (%): This right pane status window provides the user with a metric on the percentage of each channel that is adding contributions to the final combined product. These calculations are based on the associated SNR estimates being displayed.

4.3.7 Signal Sub-function Select Tab – AEQ

This sub-function tab is provided for future Adaptive Equalization functions. Consult the factory for availability.

4.4 Function Select Tab – Digital

The Digital select tab provides the user digital data output PCM encoding, routing and Forward Error Correction (FEC) processing controls and status. Controls and status are split between three sub-function tabs: PCM Encoder, Routing, and FEC.

4.4.1 Digital Sub-function Select Tab - PCM Encoder

This sub-function select tab provides controls related to the output PCM encoders for the LS-28-DRSM. There are six PCM output encoders in the design. See Figure 4-34 for tab layout.

The LS-28-DRSM contains a large number of PCM encoders and decoders throughout the design. To help in the understanding of where the encoders and decoders are located within the overall design, a block diagram of the locations and inter-relations between these PCM code conversion units is shown in Figure 4-35.

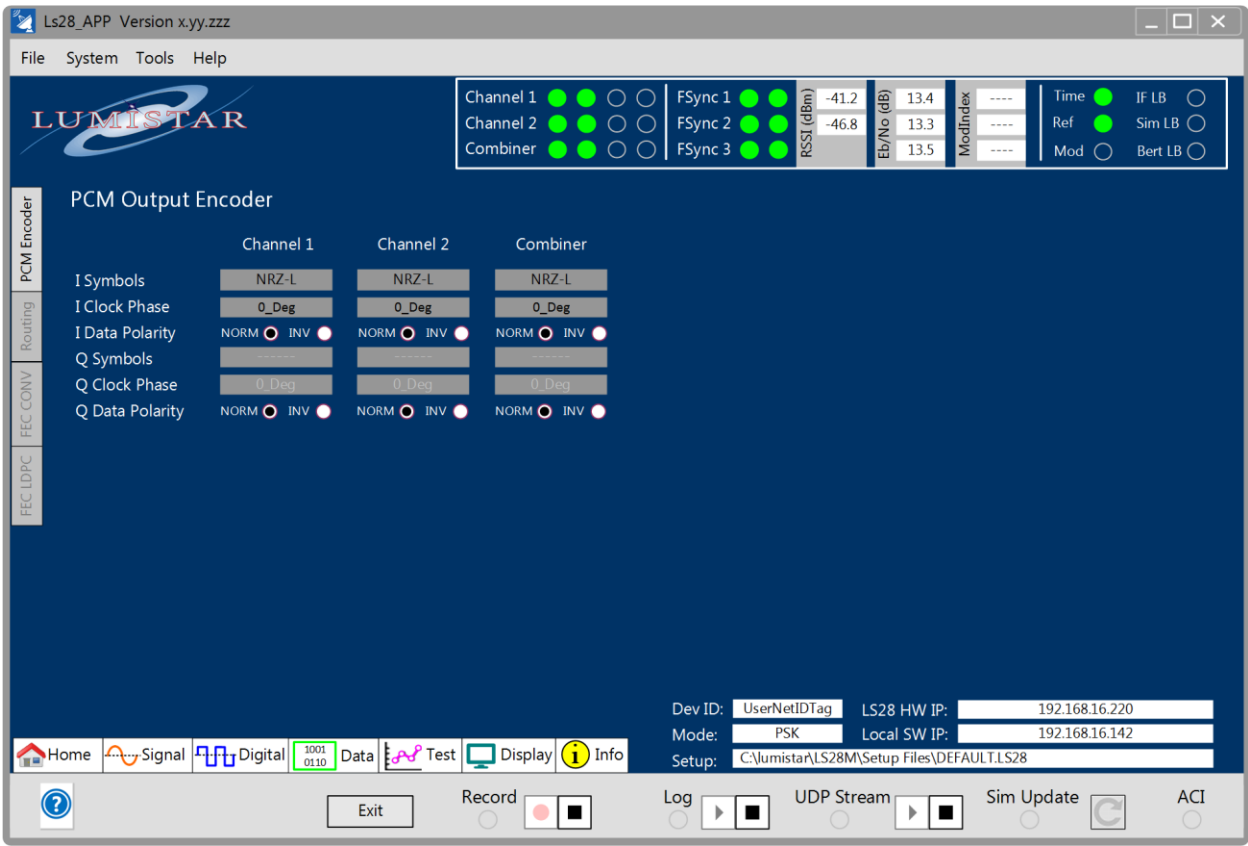


Figure 4-34 Network User Application – Digital Sub-function Select: PCM Output Encoder



4.4.1.1 Digital PCM Encoder Sub Tab – Left Pane

I Symbols: This left pane control allows the user to encode the output symbols from the bit synchronizer function into a PCM format as they desire. This may match that of the input PCM decoding or differ entirely. Table 4-5 lists all PCM encoder modes that are available.

PCM Output Encoder Selections	
NRZ-L	Non Return To Zero - Level
NRZ-M	Non Return To Zero - Mark
NRZ-S	Non Return To Zero - Space
RNRZ11-L	PRN11 Randomized Non Return To Zero - Level
RNRZ11-M	PRN11 Randomized Non Return To Zero - Mark
RNRZ11-S	PRN11 Randomized Non Return To Zero - Space
RNRZ15-L	PRN15 Randomized Non Return To Zero - Level
RNRZ15-M	PRN15 Randomized Non Return To Zero - Mark
RNRZ15-S	PRN15 Randomized Non Return To Zero - Space
RNRZ17-L	PRN17 Randomized Non Return To Zero - Level
RNRZ17-M	PRN17 Randomized Non Return To Zero - Mark
RNRZ17-S	PRN17 Randomized Non Return To Zero - Space
RNRZ23-L	PRN23 Randomized Non Return To Zero - Level
RNRZ23-M	PRN23 Randomized Non Return To Zero - Mark
RNRZ23-S	PRN23 Randomized Non Return To Zero - Space
BIO-L	Bi Phase - Level
BIO-M	Bi Phase - Mark
BIO-S	Bi Phase - Space
RZ	Return To Zero
DM-M	Delay Modulation (Miller Code) - Mark
DM-S	Delay Modulation (Miller Code) - Space
DBIO-M	Differential Bi Phase - Mark
DBIO-S	Differential Bi Phase - Space
MDM-M	Modified Delay Modulation (Miller Code) - Mark
MDM-S	Modified Delay Modulation (Miller Code) - Space

Table 4-5 Output PCM Encoder Selection Table

I Clock Phase: Along with the output data from the bit synchronizer is a correlated clock. The phase of the output clock in relationship to the data is user selectable via this left pane control. The phase numbers are associated with the rising edge of the clock versus the bit period. Settings include 0-degree, 90-degree, 180-degree and 270-degrees. To make this clearer these associations are illustrated in Figure 4-36.

The 0-degree clock phase is the default setting. Some sampling systems may perform better based on alternate phase settings.

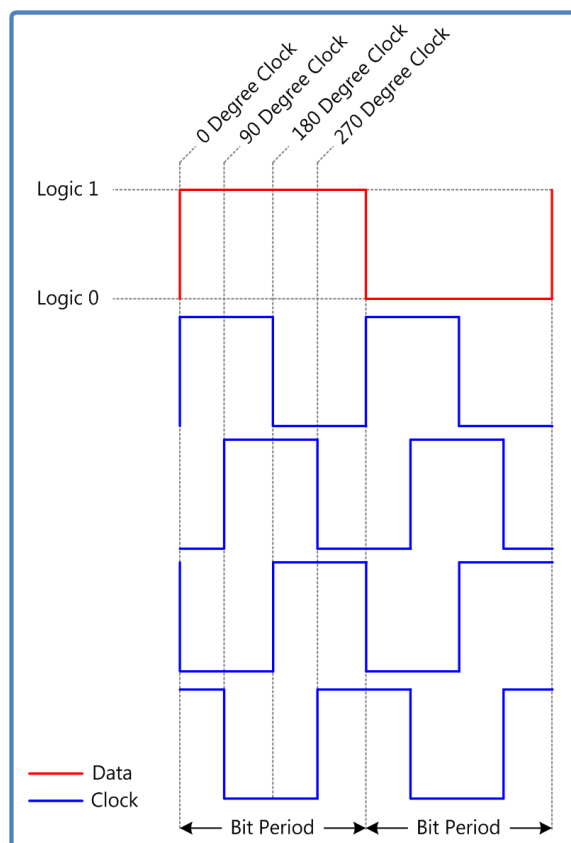


Figure 4-36 PCM Output Data and Clock Phase Configurations

I Data Polarity: This control radio-button sets the PCM encoder output polarity. The NORM (normal) setting is the default setting. The INV setting inverts the output data stream.

Q Symbols: This left pane control allows the user to encode the Q output symbols from the bit synchronizer function into a PCM format as they desire. This may match that of the input PCM decoding or differ entirely. Table 4-5 lists all PCM encoder modes that are available.

The Q symbol controls are only available in applicable modes which are AUQPSK, and AQPSK.

Q Clock Phase: Along with the Q output data from the bit synchronizer is a correlated clock. The phase of the output clock in relationship to the data is user selectable via this left pane control. The phase numbers are associated with the rising edge of the clock versus the bit period. Settings include 0-degree, 90-degree, 180-degree and 270-degrees. To make this clearer these associations are illustrated in Figure 4-36.

The Q symbol controls are only available in applicable modes which are AUQPSK, and AQPSK.

Q Data Polarity: This control radio-button sets the Q PCM encoder output polarity. The NORM (normal) setting is the default setting. The INV setting inverts the output data stream.

The Q symbol controls are only available in applicable modes which are AUQPSK, and AQPSK.

4.4.2 Digital Sub-function Select Tab – Routing

This sub-function select tab provides controls related to the signal routing for the LS-28-DRSM. See Figure 4-37 for tab layout. For further illustration of the control locations presented on the routing tab, refer to Figure 4-38.

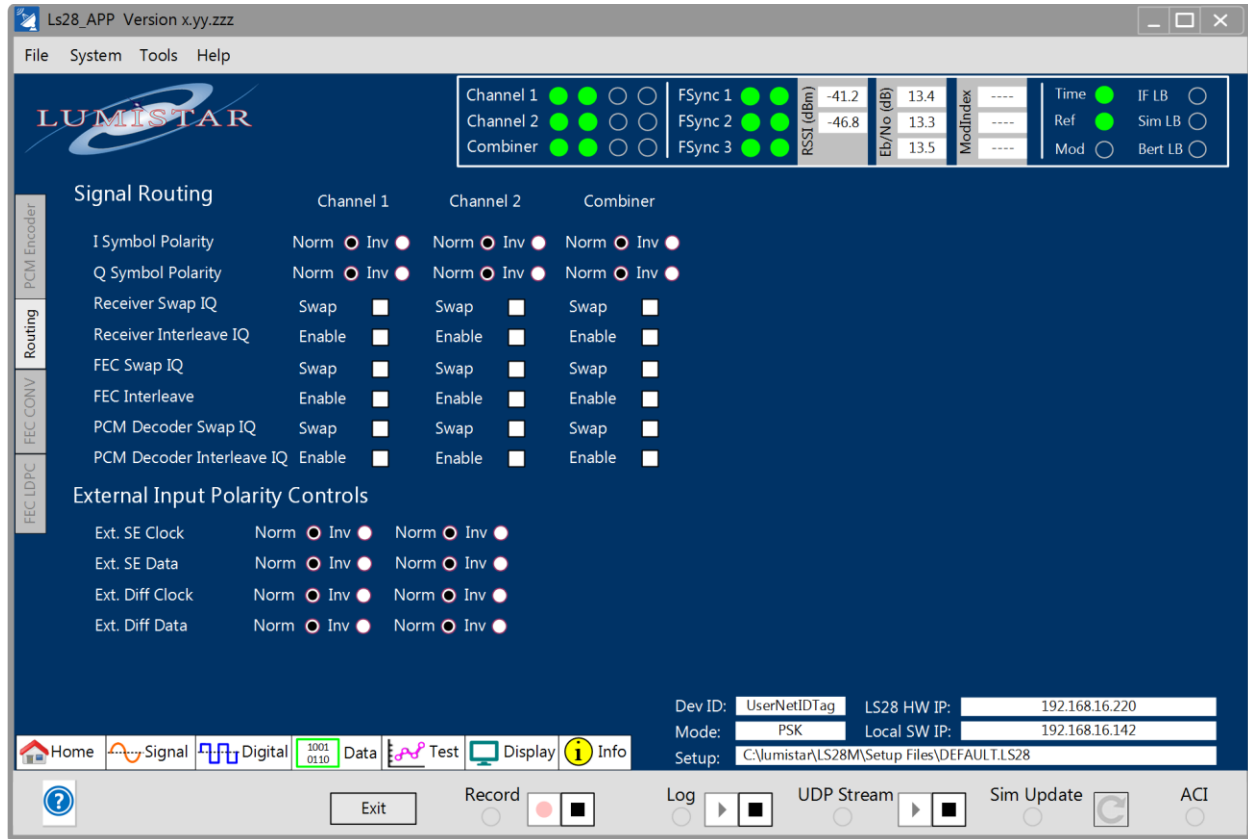


Figure 4-37 Network User Application – Digital Sub-function Select: Digital Routing

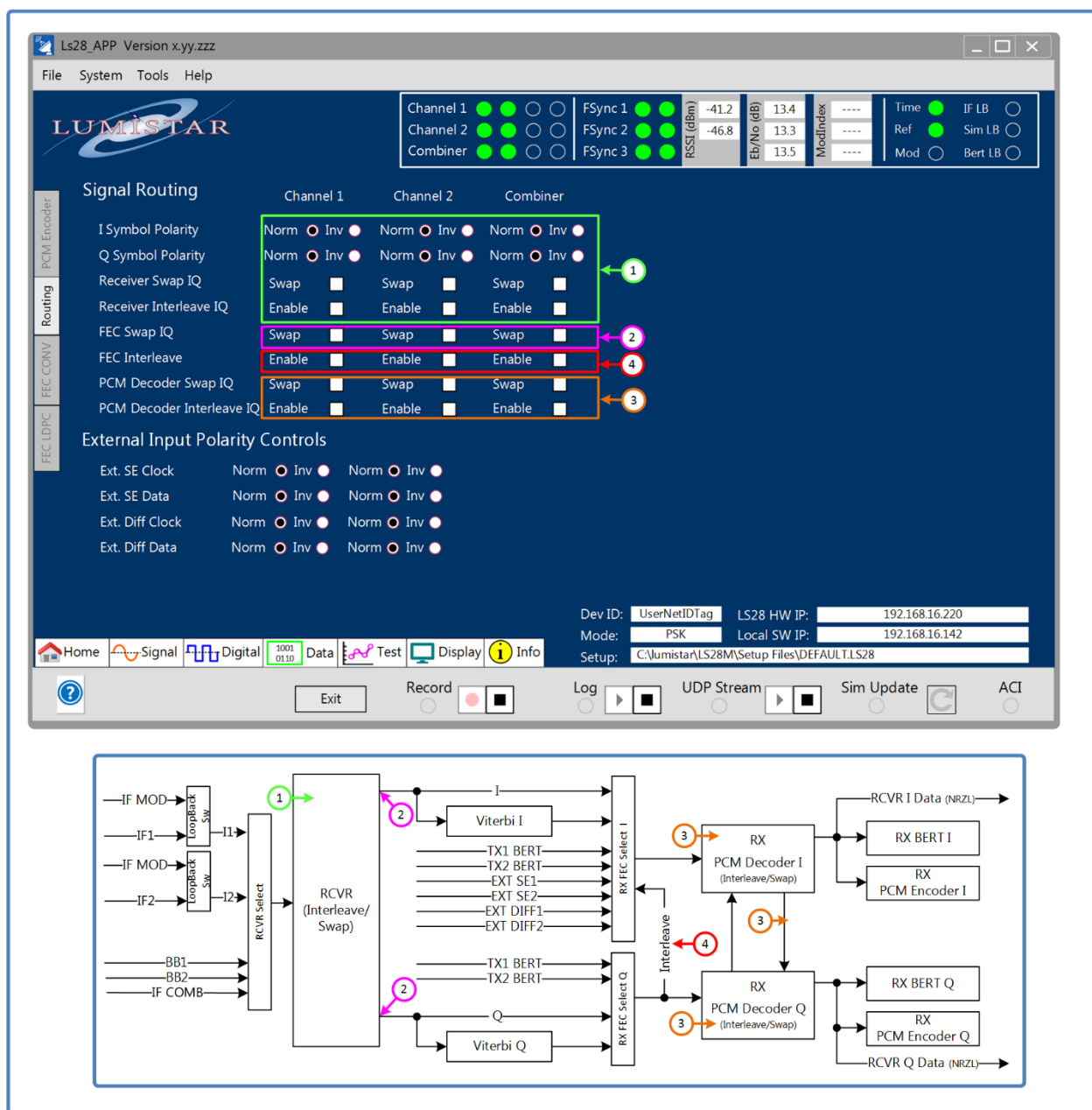


Figure 4-38 Network User Application – Routing Block Diagram

4.4.2.1 Digital Routing Tab – Left Pane

In some PSK modulation formats, ambiguity is encountered when receiving data. These include QPSK formats as well as more simplistic BPSK. These ambiguities are integral to the modulation itself and must be resolved by some means. In quadrature modulation formats, ambiguities on whether a received symbol is an I symbol or a Q symbol and the polarity of these symbols creates a cases where there are up to 8 possible solutions. There are methods to eliminate these ambiguities such as the use of differential encoding and decoding. However, these methods cannot always be utilized. In these cases, this tab provides the user with controls to eliminate these undesired effects.

I Symbol Polarity: This control radio-button sets the PCM encoder output polarity. The NORM (normal) setting is the default setting. The INV setting inverts the I symbol data stream.

Q Symbol Polarity: This control radio-button sets the PCM encoder output polarity. The NORM (normal) setting is the default setting. The INV setting inverts the Q symbol data stream.

Receiver Swap IQ: This control check box allows the I and Q data streams to be swapped within the receiver in cases where the received signal has been assigned by the receiver in IQ swapped manner. The Receiver represents the beginning of the digital processing chain.

Receiver IQ Interleave: If I and Q data streams require re-interleaving into a single stream, this check box controls allows this functionality within the receiver. The Receiver represents the beginning of the digital processing chain.

FEC Swap IQ: This control check box allows the I and Q data streams to be swapped within the FEC decoder in cases where the symbols have been assigned in an IQ swapped manner. The FEC decoder is optional and not used in all processing formats.

FEC IQ Interleave: If I and Q data streams require re-interleaving into a single stream, this check box controls allows this functionality within the FEC decoder. The FEC decoder is optional and not used in all processing formats.

PCM Decoder Swap IQ: This control check box allows the I and Q data streams to be swapped within the PCM decoder in cases where the symbols have been assigned in an IQ swapped manner. The PCM Decoder is at the end of the digital processing chain.

PCM Decoder IQ Interleave: If I and Q data streams require re-interleaving into a single stream, this check box controls allows this functionality within the PCM decoder. The PCM Decoder is at the end of the digital processing chain.

Ext SE Clock: This control radio-button sets the external clock polarity for the respective digital single-ended (SE) input stream. The NORM (normal) setting is the default setting. The INV setting inverts the polarity of the incoming clock.

Ext SE Data: This control radio-button sets the external data polarity for the respective digital single-ended input stream. The NORM (normal) setting is the default setting. The INV setting inverts the polarity of the incoming data.

Ext Diff Clock: This control radio-button sets the external clock polarity for the respective digital differential (DIFF) input stream. The NORM (normal) setting is the default setting. The INV setting inverts the polarity of the incoming clock.

Ext Diff Data: This control radio-button sets the external data polarity for the respective digital differential (DIFF) input stream. The NORM (normal) setting is the default setting. The INV setting inverts the polarity of the incoming data.

4.4.3 Digital Sub-function Select Tab – FEC CONV

If the unit is licensed to support the Viterbi FEC operational mode, this tab will be active. This sub-function tab provides controls and status associated with Viterbi convolutional formats of Forward Error Correction (FEC). Consult the factory for additional information on other LS-28-DRSM FEC options.

Figure 4-39 illustrates the controls and status of the convolution decoder option.

Convolutional coding is a bit-level encoding technique rather than block-level techniques such as Reed-Solomon and LDPC coding. Advantages of convolutional codes over block-level codes include gradual degradation of Eb/No gain as error rates increase, decoding after an arbitrary length of data, and bit-level encoding techniques do not require synchronization. Convolutional decoding is not particularly efficient at correcting burst errors but are adept at handling errors spread out over time.

Viterbi Forward Error Correction is a licensed option for the LS-28-DRSM that decodes convolutionally encoder data and is used to obtain a posteriori probability estimate of the most likely sequence of hidden states, referred to as the Viterbi path. Viterbi decoding can contain variable constraint lengths between 3 and 15 and variable rates. Lumistar Viterbi decoding utilizes a constraint length fixed at seven ($k=7$) and supports a rate of 1/2. Other rates may be available. Consult Lumistar Sales for further details.

Lumistar Viterbi decoding is based on soft-bit decisions and is performed in an iterative manner. There are two polynomials assigned to the output bit combinations: the G0 and G1 polynomials. These polynomials can be inverted and their orders can be swapped.

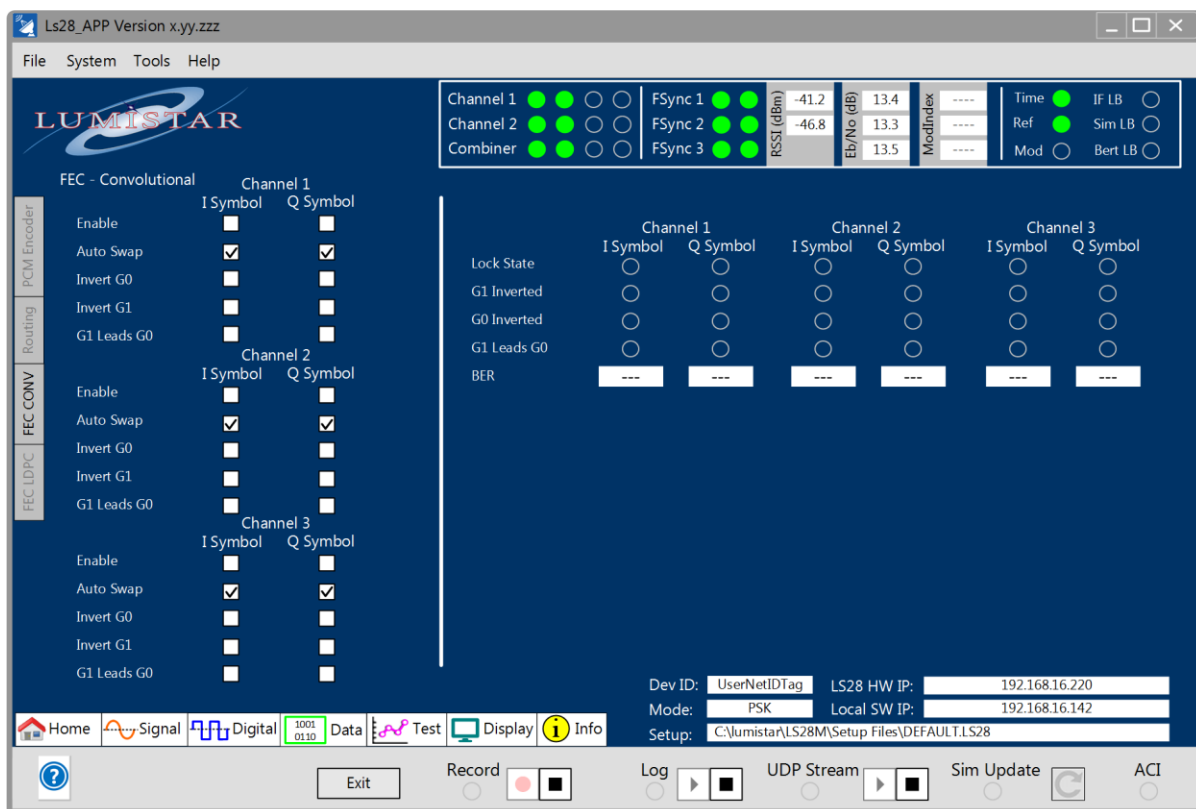


Figure 4-39 Network User Application – Digital Sub-function Select: FEC Convolutional

4.4.3.1 Digital FEC CONV Tab – Left Pane

The Convolutional FEC decoder controls are defined as follows:

Enable: This control box enabled the I and Q symbol decoding for each channel. It is possible to have only the I Symbol enabled while having the Q channel disabled as would be the case for modulation formats that do not have a quadrature symbol. If this selection has not been enabled, all decoding is disabled for the channel.

Auto Swap: This control box allows the convolutional decoder to automatic detect the G0 and G1 polarity and G1 versus G0 order. Selecting this option disables the controls for Invert G0, Invert G1, and G1 leads G0. If manual selection of the Invert G0, Invert G1, and G1 leads G0 are desired, the Auto Swap selection must be disabled. It is recommended to utilize this mode during all convolutional decoding operations.

Invert G0: This control box allows the convolutional decoder to manually invert the G0 polynomial. This control can only be utilized if the Auto Swap selection for the symbol and channel is disabled.

Invert G1: This control box allows the convolutional decoder to manually invert the G1 polynomial. This control can only be utilized if the Auto Swap selection for the symbol and channel is disabled.

G1 Leads G0: This control box allows the convolutional decoder to manually force the G1 polynomial to lead the G0 polynomial. This control can only be utilized if the Auto Swap selection for the symbol and channel is disabled.

4.4.3.2 Digital FEC CONV Tab – Right Pane

The Convolutional FEC decoder status window includes the following status displays:

Lock State: This status LED indicator provides lock state information. If the indicator is Green, the state of decoding is enabled and locked. If the indicator is yellow, the state of decoding is enabled but unlocked. When the indicator is transparent, this means that convolutional decoding is disabled.

G1 Inverted: Convolution decoding must be enabled for this indicator to be active. This status LED indicator provides G1 polynomial polarity status. If the indicator is transparent this means that the G1 polarity is normal. A yellow indicator means that the polarity is inverted.

G0 Inverted: Convolution decoding must be enabled for this indicator to be active. This status LED indicator provides G1 polynomial polarity status. If the indicator is transparent this means that the G1 polarity is normal. A yellow indicator means that the polarity is inverted.

G1 Leads G0: Convolution decoding must be enabled for this indicator to be active. This status LED indicator provides G1 versus G0 polynomial order status. If the indicator is transparent this means that the G0 polynomial leads the G1 polynomial. A yellow indicator means that the G1 polynomial leads the G0 polynomial.

BER: Convolution decoding must be enabled for this reading to be active. The BER window indicates the approximate BER value of the decoding output based on the metrics coming from the Viterbi decoding process.

4.4.4 Digital Sub-function Select Tab – FEC LDPC

If the unit is licensed to support the LDPC FEC operational mode, this tab will be active. This sub-function tab is provided for controls and status associated with Low Density Parity Coding (LDPC) formats of Forward Error Correction (FEC). Consult the factory for additional information on other FEC options. Refer to section 4.9 of this document for all information on LDPC.

4.5 Function Select Tab – Data

The Data select tab provides the user with post data reception/decoding functionality including frame synchronization, time tagging, recording, decommutation, and data streaming. Controls and status are split between six sub-function tabs: Frame Sync, Decom, DecomWdAttr, Recording, Stream, and Time.

It is important to understand the underlying architecture of the data processing, recording and streaming engine of the LS-28-DRSM. To assist in these discussions, Figure 4-40 illustrates the interconnections of the system.

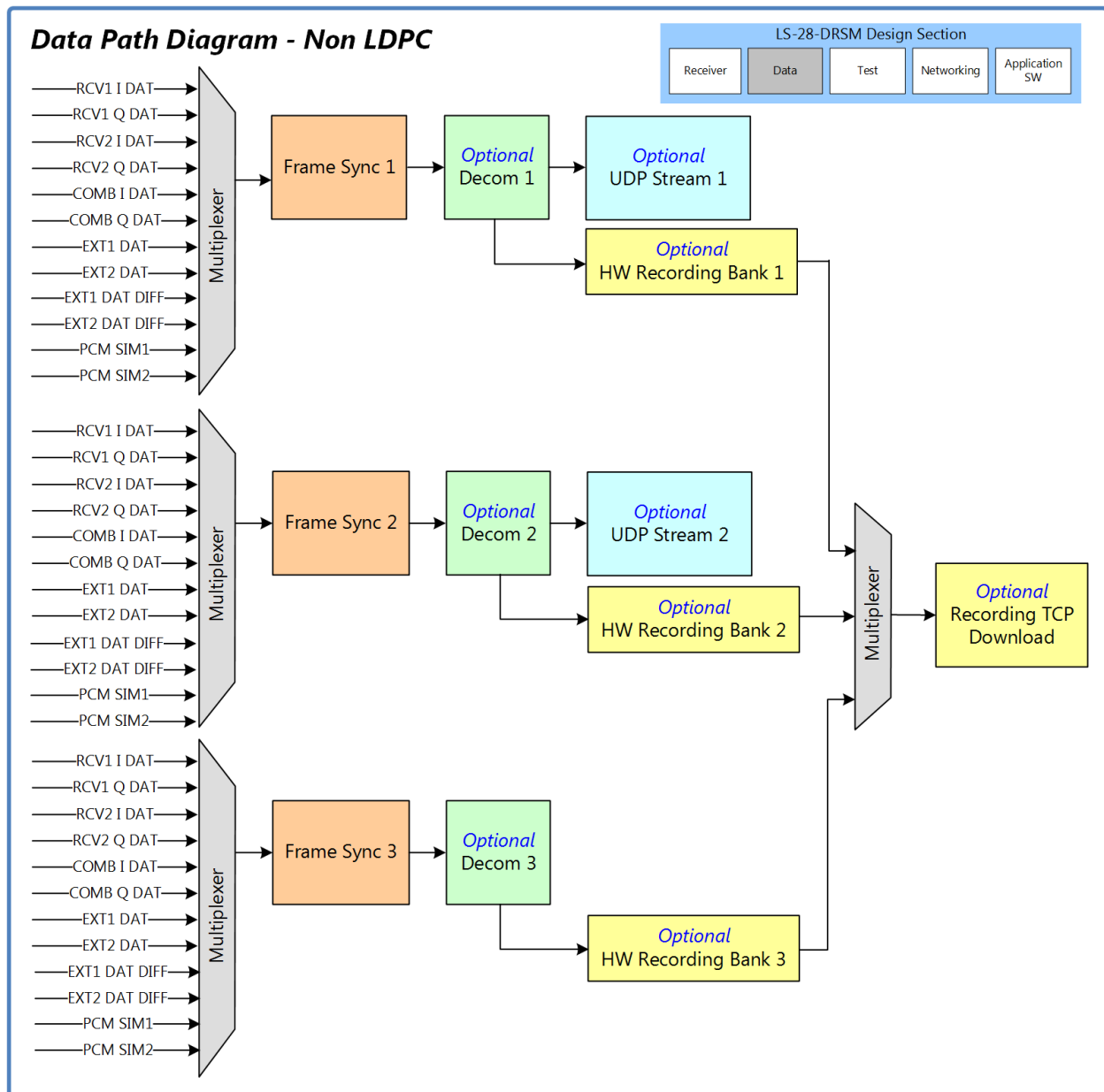


Figure 4-40 Non-LDPC Data Frame Sync/Decom/Recording/Data Streaming Engine Blk Diagram

As shown in Figure 4-40, all data inputs from the receiver are multiplexed through three 8:1 muxes and applied to one of three frame synchronizers. Each frame synchronizer subsequently feeds an associated decommutator. Outputs from the decommutator can be supplied to both recording memory and, in the case of decommutator 1 and 2, can feed to one of data streaming sources.

Frame synchronizers are provided as standard items if the Bit Sync option is licensed or any time any of the following are licensed: decommutation, data recording, or data streaming. In the case where bit synchronization is selected as the stand-alone operational mode, frame synchronization allows the user to setup an frame synchronize data being received which allows one additional confirmation tool pertaining to the state and validity of the incoming data. If data that is being received is encrypted, this process requires the use of an external decrypter. For these feeds, external inputs allow the data to be sent back to the unit for streaming.

Recording and streaming requires the presence of a decommutator. However, this does not mean that these two options require true frame synchronization. Data can be frame synchronized, decommutated as defined in chapter 4 of the IRIG standard, and then be recorded and streamed. Equally, data can be recorded and streamed with no frame synchronization or decommutation in a raw format. Regardless, each of these processed must be configured and defined. The following sections will outline these processes.

4.5.1 Data Sub-function Select Tab - Frame Sync

This Data Frame Sync sub-function select tab provides controls and status related to the Frame synchronizer functions of the LS-28-DRSM. See Figure 4-41 for tab layout.

As shown in Figure 4-41, frame synchronization is the initial process block in the LS-28-DRSM data processing engine. The responsibility of this feature is to attempt to synchronize a stream of data. In this sub-function tab, the user should load information related to synchronization processing.

In telemetry data, the use of a frame sync pattern is the typical means of representing the presence of a frame of data. This frame sync pattern can vary in size and location within the frame. The IRIG standards body group has defined appropriate frame sync patterns of lengths from 7 bits to 33 bits in length.



Figure 4-41 Network User Application – Data Sub-function Select: Data Frame Synchronizer

4.5.1.1 Data Frame Synchronizer Tab – Left Pane

The Data Frame Synchronizer left tab contains controls for the three frame synchronizers of the LS-28-DRSM.

Frame Sync Enabled: To enable the frame synchronizer functions for a selected frame synchronizer, enable this check-box supply.

Frame Sync Data Source: To route data from the receiver functions to the frame synchronizer, the user must select from one of eight data sources. This control drop-down list provides a means of selecting one

of the following sources: Channel 1 I Data, Channel 1 Q Data, Channel 2 I Data, Channel 2 Q Data, Combiner I Data, Combiner Q Data, External Ch1 Clock/Data, and External Ch2 Clock/Data. It should be noted that external sources require both a clock and a data source.

Frame Sync Input PCM Code: This control dialog box provides the user selections to the PCM input decoder at the front of the frame sync input. The user can select from the PCM input codes shown in

Table 4-6. This decoder provides an opportunity to decode any frame sync input source that may contain data that may be something other than NRZ-L format.

PCM Input Decoder Selections	
NRZ-L	Non Return To Zero - Level
NRZ-M	Non Return To Zero - Mark
NRZ-S	Non Return To Zero - Space
RNRZ11-L	PRN11 Randomized Non Return To Zero - Level
RNRZ11-M	PRN11 Randomized Non Return To Zero - Mark
RNRZ11-S	PRN11 Randomized Non Return To Zero - Space
RNRZ15-L	PRN15 Randomized Non Return To Zero - Level
RNRZ15-M	PRN15 Randomized Non Return To Zero - Mark
RNRZ15-S	PRN15 Randomized Non Return To Zero - Space
RNRZ17-L	PRN17 Randomized Non Return To Zero - Level
RNRZ17-M	PRN17 Randomized Non Return To Zero - Mark
RNRZ17-S	PRN17 Randomized Non Return To Zero - Space
RNRZ23-L	PRN23 Randomized Non Return To Zero - Level
RNRZ23-M	PRN23 Randomized Non Return To Zero - Mark
RNRZ23-S	PRN23 Randomized Non Return To Zero - Space
BIO-L	Bi Phase - Level
BIO-M	Bi Phase - Mark
BIO-S	Bi Phase - Space
RZ	Return To Zero
DM-M	Delay Modulation (Miller Code) - Mark
DM-S	Delay Modulation (Miller Code) - Space
DBIO-M	Differential Bi Phase - Mark
DBIO-S	Differential Bi Phase - Space
MDM-M	Modified Delay Modulation (Miller Code) - Mark
MDM-S	Modified Delay Modulation (Miller Code) - Space

Table 4-6 Input PCM Decoder Selection Table

FS PCM Decoder Polarity Invert: This check box control provides the user the ability to invert any of the selected Frame Sync Input PCM Decoder selections, essentially doubling the number of PCM decoder selections. Once INV is selected, the data polarity is inverted for the selection made in the Frame Sync Input PCM Decode selection.

Frame Sync Pattern Length: This control dialog box allows the user to enter the length of the frame sync pattern as a value between 7 and 64 bits. When values are entered between 7 and 32 bits, the standard IRIG Frame sync pattern will automatically be loaded into the Frame Sync Pattern field on this tab.

Frame Sync Pattern: The frame sync pattern control window allows the user to enter values for the frame sync pattern. Entry of the frame sync pattern length will automatically fill this field with the IRIG defined

optimal frame synchronization pattern. The user can alter the pattern to one of their choosing. Entries should be right justified. It is highly recommended to use the patterns in Table 4-7.

Optimum Frame Synchronization Patterns for PCM Telemetry (IRIG Barker Codes)					
Pattern Length	Pattern	Pattern Length	Pattern	Pattern Length	Pattern
7	0x58	16	0xEB90	25	0x1F2DC40
8	0xB8	17	0x1E6A0	26	0x3E9AC40
9	0x170	18	0x3CD40	27	0x7D69980
10	0x370	19	0x7CCA0	28	0xF5E5980
11	0x5B8	20	0xEDE20	29	0x1EBCCD00
12	0xB60	21	0x1DD2C0	30	0x3EBCCD00
13	0x1D60	22	0x3CDA80	31	0x7F37D420
14	0x39A0	23	0x7AE680	32	0xFE6B2840
15	0x7650	24	0xFAF320	33	0x1F74E9498

Table 4-7 Optimal Frame Synchronizer Patterns



Information:

The frame synchronization patterns specified in the Appendix C of the IRIG specification are based on principles related to methods used in asynchronous PCM bit synchronization. The goal of the pattern selected is to have the maximum likelihood of proper detection and the least likely hood of false detection under all channel conditions. Robert Barker was one of the fathers of these types of studies in the 1950's. His works helped define patterns that offered the greatest autocorrelation factors and therefore the smallest impulse response side-lobe power. These data patterns, when received by bit synchronizers circuitry, have the greatest propensity to achieve a stable phase lock condition, including in noisy conditions, and thus render correct bit sliced decisions. Since Barker pattern lengths end at 13, there have been several studies to extend these codes above that number. Extensions were sometimes achieved by nesting Barker sequences, maximum length sequences, and via other longer sequence autocorrelation studies. All of these studies have been compiled in one manner or another but Barker codes are always a part of any table of values. Barker codes are used in IEEE803.11 wireless transmissions today. In IRIG terms, sequences up to 33-bits are defined. All of these patterns meet the maximum autocorrelation guidelines. Patterns above 13 bits may offer diminishing returns in terms of autocorrelation improvements, but do add to abilities in overall synchronization strategy.

Frame Sync Pattern Mask: Along with the frame sync pattern, the user can set certain frame sync pattern bits as "don't cares". A mask is applied to each frame sync pattern applied. If the user wishes to make certain bits "don't cares", simply set the corresponding bit (or bits) in the Frame Sync Pattern Mask to zero and the frame synchronizer will disregard received values at these locations in determining lock.

Frame Sync Polarity: This pull-down control allows the user to set one of four frame sync polarity choices. These include: NORMAL, INVERT, NORMAL & INVERT (FAC) and AUTO. NORMAL settings will only synchronize to the pattern as shown in the Frame Sync Pattern control entry box. INVERT will only synchronize to the opposite polarity of the value shown in the Frame Sync Pattern control entry box. NORMAL & INVERT will sync to the frame sync pattern and the opposite of the frame sync pattern. The AUTO setting will synchronize to the frame sync pattern regardless of polarity and change all the resulting minor frame data along with the frame sync pattern into the NORMAL polarity mode.

Frame Sync Clock Invert: This check box control provides the user the ability to invert any of the selected Frame Sync Input PCM Decoder clock selections.

Frame Sync Window: The Frame Sync Window control allows the user to allow the minor frame synchronization window to be longer or shorter than defined. The window can be programmed for periods of bit slips (fewer bits than expected) or bit stuffs (more bits than expected). Up to three bit slips or stuffs can be programmed. Positive numbers indicate bit stuff programming. Negative numbers indicate bit slip programming.

Frame Sync BER Tolerance: When the data channel quality becomes poor, all data in the stream will be affected including the frame sync pattern. This control dialog box allows the user to program how many of the bits in the frame sync pattern can be in error prior to declaring that the frame sync pattern does not match. Values from 0 to 32 can be programmed in this field.

This setting has to correlate with the assigned frame sync pattern length as well as general overall BER concerns. For most applications, only small values should be assigned. For example, if the frame sync pattern is 32 bits in length and the BER tolerance is set to 16, this relates to one of every two bits being in error and the pattern still qualify as LOCKED. BER performance of 1 in 2 would result in the demodulation engine being completely unable to maintain lock. As a more practical matter, in the example of a 32-bit frame sync pattern, if 1 of those bits experience bit errors, this represents a BER value of $3.125e-2$. This BER performance is still quite poor and would likely result in the demodulation engine being unlocked but is at least a more practical programmed figure. This value is commonly set to zero.

Frame Sync Verify->Lock: When data is being synchronized, data goes through three phases: SEARCH, VERIFY, LOCK, and CHECK. These modes are related to what is referred to as "Synchronization Strategy".

In most applications, synchronization strategy requires the successful reception of two or more contiguous frame sync patterns to declare lock. Ensuring two successful pattern matches virtually eliminates that a frame sync pattern was not falsely found in the payload data and is a genuine a frame sync pattern. When data is unlocked the frame sync is considered to be in SEARCH mode. Once the first frame sync pattern is detected the state moves to VERIFY. This control allows the user to set the number of subsequent patterns that need to be matched to declare a LOCK state.

Frame Sync Check->Search: When data is being synchronized, data goes through three phases: SEARCH, VERIFY, LOCK, and CHECK.

Once the frame sync is considered to be in LOCK mode if the frame sync detection fails to match two sequential patterns, the LOCK state is switched to the CHECK which indicates that the frame sync may be in the process of unlocking and returning to the SEARCH state. This control allows the user to set the number of subsequent patterns that need to remain unmatched prior to moving from the CHECK state to the SEARCH mode.

4.5.1.2 Data Frame Synchronizer Tab – Right Pane

The Data Frame Synchronizer right tab contains status for the three frame synchronizers of the LS-28-DRSM.

Sync State: This right pane indicator will provide the user with an indication of the frame synchronizer lock state. This indication will be one of the following: SEARCH, VERIFY, LOCK or CHECK.

Bit Rate: This right pane status pane contains the present channel bit rate status.

Frame Count: A running count of the minor frame synchronization patterns received will be provided in this right pane status window.

Bit Slips Count: A running count of the minor frame bit slips detected will be provided in this right pane status window.

Bit Stuffs Count: A running count of the minor frame bit stuffs detected will be provided in this right pane status window.

Ext Clock Status: This indicator is only active if the left pane setting for the Frame Sync Data Source is set to an external source. This indicator will be yellow if no clock is present from the external source or green if the clock is present. External sources must provide both data and clock to the LS-28-DRSM. If the Frame Sync data source is not selected as an external source, the indicator will be transparent.

4.5.2 Data Sub-function Select Tab – Decom

If the unit is licensed for the Decom function or the recording function, this tab will be active. This Data Decom sub-function select tab provides controls and status related to the Decommutator (often shortened to Decom) functions of the LS-28-DRSM. See Figure 4-42 for tab layout.

Decommutation is the process that occurs after frame synchronization. It is a process of collecting measurands from a data stream, possibly with different data rates that have been combined into a frame-based transmission. There are numerous frame formats that can be defined based on user needs. The IRIG standards body has classified these PCM frame formats into two classes: Class I and Class II. Class I formats are considered to be the most common and most simplistic of the two. Class II format distinctions include the following:

- 1.) Bit Rates in excess of 5Mbps
- 2.) Word Lengths in excess of 16 bits.
- 3.) Fragmented words
- 4.) More than 8192 bits or 1024 words per minor frame
- 5.) Unevenly spaced super commutation
- 6.) Format changes
- 7.) Asynchronous embedded formats
- 8.) Tagged data formats
- 9.) Formats with content that uses something other than unsigned straight binary, discrete, or complimentary arithmetic representation for negative numbers
- 10.) Asynchronous data transmission
- 11.) Merger of multiple format types

In reality, the lines between Class I and Class II formats have blurred over the years. Class I formats commonly cross the 5Mbps boundary and occasionally contain more than 1024 words or 8192 bits per minor frame. The decommutators of the LS-28-DRSM provide support for both format classes.

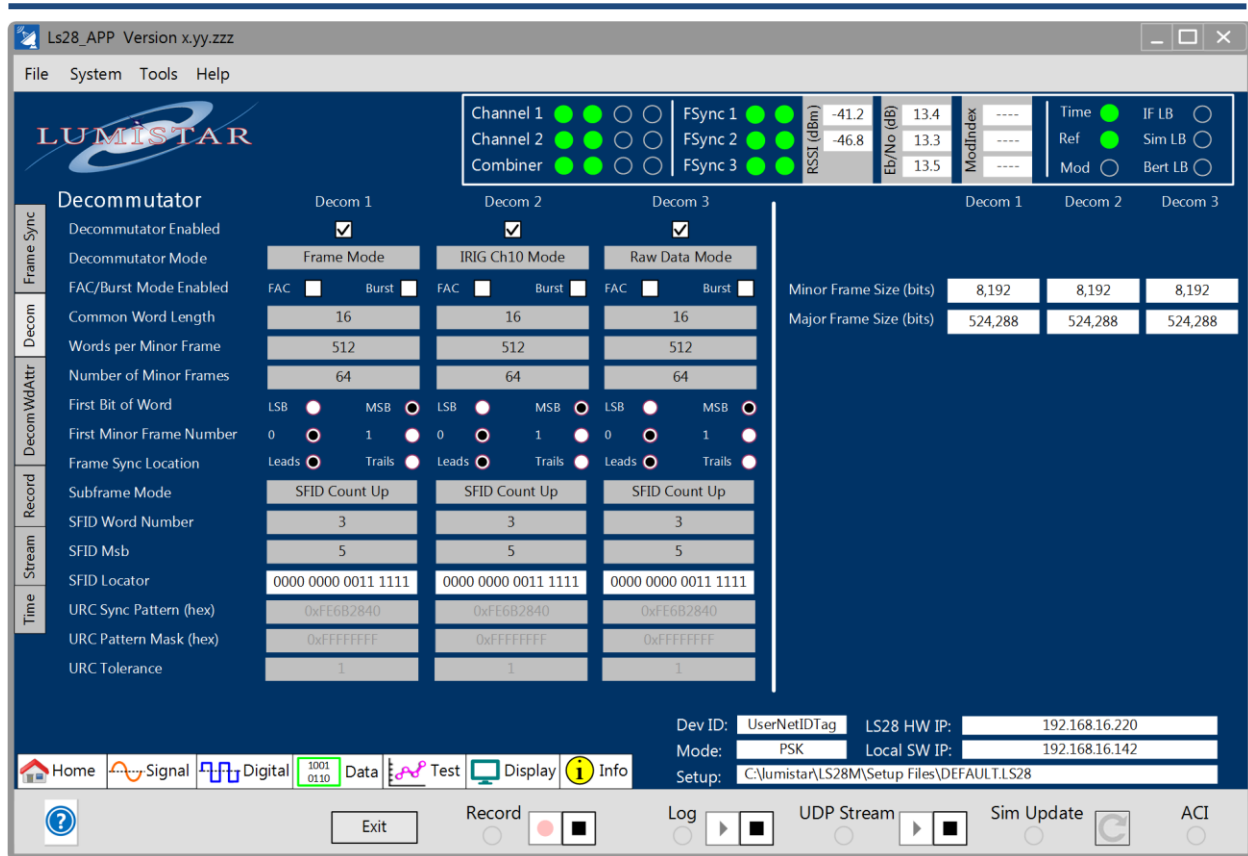


Figure 4-42 Network User Application – Data Sub-function Select: Decom

4.5.2.1 Data Decommutator Tab – Left Pane

The Data Decommutator left pane area contains controls for the three LS-28-DRSM Decommutators.

Decommutator Enabled: To enable a selected decommutator, this check-box control is provided. This control must be enabled to utilize the associated decommutator functionality.

Decommutator Mode: This control drop-down list includes the following operational mode options: Frame Mode, Flywheel Mode, Raw Data Mode, and External Sync Mode.

In Frame mode, the decommutator will be looking to synchronize on a programmed Frame Sync pattern given the requirements programmed on the Frame Sync tab. In Flywheel mode, the decommutator will continuously cycle through received data until it finds a frame sync pattern as defined on the Frame Sync tab. Once a frame sync pattern matches the sync criteria outlined, buffered data will continue to fill out the defined real-time transport buffer. This partial buffer will contain misaligned and useless data but the data provided in the subsequent buffers will be correct. Refer to additional information in the LS-28-DRSM Interface Control Document for additional details. In Raw mode, the decommutator will not look for a frame sync pattern. It will simply buffer up data as directed on this page and then transfer when that number of bits has arrived. External sync mode connects the decommutator to the external sync pulse via the GPIO interface.

FAC/Burst Mode Enabled: This row in the left pane allows for two controls. The Frame Alternate Compliment (FAC) mode is a less commonly used variant of FCC subframe mode. In this mode, the frame synchronization pattern is alternated with the complement of the frame synchronization pattern for each minor frame. Figure 4-43 illustrates the FAC mode. Selecting this check-box control enables FAC mode.

Burst mode automatically overrides the frame sync slip and stuff bit settings to capture the frame sync pattern as quickly as possible. This can be set in any mode. Selecting this check-box control enables burst mode.

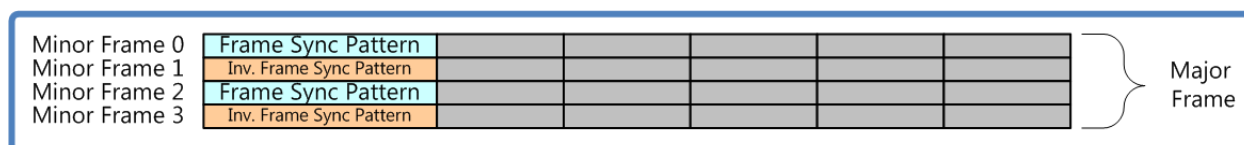


Figure 4-43 Subframe FAC Mode

Common Word Length: To enter the anticipated common word length of the data in a particular frame, this control dialog box allows the user to enter the most commonly available word length in the minor frame data. The common word length defines the length in bits of the *majority* of words that make up a minor frame. Note, not all words in a minor frame need be of the same length. For example, the majority of the words in a minor frame could be 8-bits in length, and thus the common word length would be 8. However, several of the words might be 14 or 16 bits in length and would be individually specified using the detailed decommutator word attributes which will be outlined in following section. Values between 3 and 16 are provided in accordance with IRIG standards for framed telemetry.

Words per Minor Frame: The user defines the minor frame length by invoking the Words Per Minor Frame control. Here, the user enters the number of words (of length specified by common word length) that make up a minor frame. The minor frame length on the LS-28-DRSM may be between 3 and 65536 words.

Number of Minor Frames: This control dialog box allows the user to enter the number of minor frames in a major frame. Values can be entered between 1 and 65536.

First Bit of Word: This radio button control allows the user to set up the meaning of the first bit in a given word. Selection of Most Significant Bit (MSB) and Least Significant Bit (LSB) are provided.

First Minor Fame Number: Minor frames can be numbered starting with 0 or 1. This radio button control allows the user to select the number of the first frame.

Frame Sync Location: The user specifies the location of the frame sync pattern within the frame by the use of this radio button. If the frame sync pattern is at the front of the frame the user should select LEADS. Conversely, if the frame sync pattern is at the end of the data transmission the user should select the TRAILS option. Reference Figure 4-44.

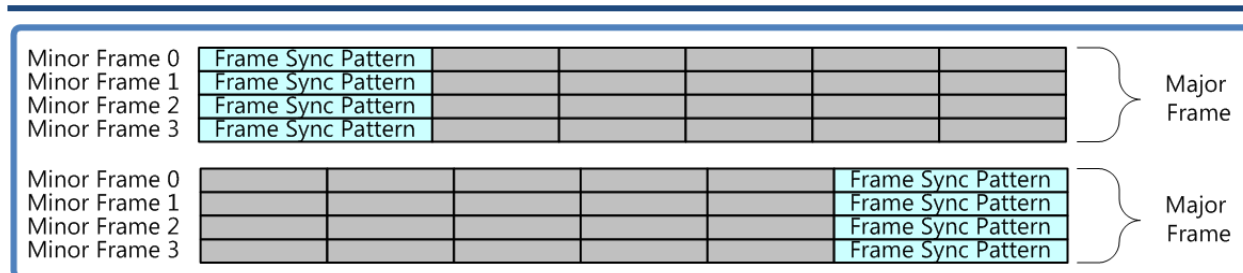


Figure 4-44 Frame Sync Pattern Position Diagram

Subframe Mode: To implement a subframe synchronization scheme, telemetry designers often add one or more “special” words to each minor frame. The frame synchronizer then uses the special words to establish the location of the first minor frame in the major frame. The LS-28-DRSM supports five options in terms of subframe synchronization modes: None, SFID Counting Up, SFID Counting Down, FCC, and URC.

When NONE is select, the decommutator will consider that no sub-frame mode is implemented.

When SFID Counting Up is selected, the decommutator will assume that the unit is utilizing a Subframe ID (SFID) Counter that is counting up in value. The count will start from 0 or 1 as directed by the First Minor Frame Number setting.

When SFID Counting Down is selected, the decommutator will assume that the unit is utilizing a Subframe ID (SFID) Counter that is counting down in value. The count will terminate in either 0 or 1 as directed by the First Minor Frame Number setting.

SFID use is illustrated in Figure 4-45.

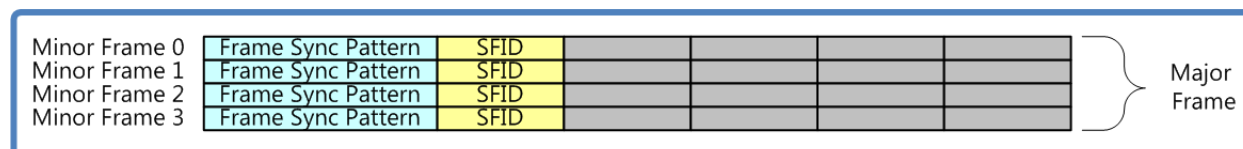


Figure 4-45 Frame Sync SFID Diagram

Frame Code Complement (FCC) mode is a method where the complement (inverted) synchronization pattern is placed in the FSP location in minor frame 0. All other frame sync patterns are not inverted. Because the complement of the frame synchronization pattern exhibits the same correlation properties as the true pattern, frame sync lock will not be compromised. Minimum sync overhead is attained using this method, although it requires longer subframe acquisition time than the SFID method. FCC is illustrated in Figure 4-46.

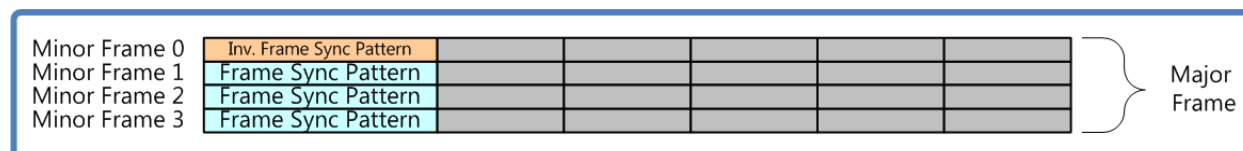


Figure 4-46 FCC Mode Illustration

Unique Recycling Code (URC) mode is a variation of FCC mode. For URC, a unique word is added anywhere in the first minor frame. A unique synchronization pattern *not* related to the primary synchronization pattern is used. This can replace the frame sync pattern or be at a different location in the first minor frame. URC is illustrated in Figure 4-47.

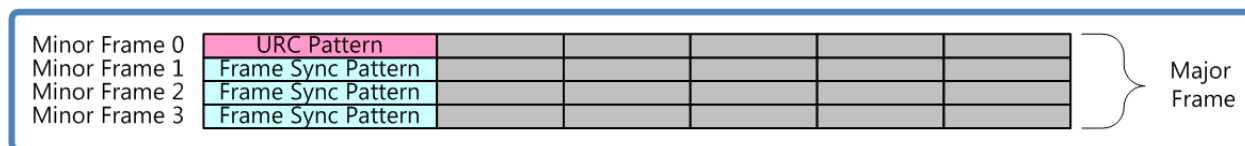


Figure 4-47 URC Mode Illustration

SFID Word Number: The location of the subframe identification (SFID) word(s) is arbitrary within the minor frame and may be specified by the user with this left pane control dialog box. As the LS-28-DRSM can support up to 65,536 words per minor frame, the user may thus locate the SFID word anywhere within this range, provided it does not overlap or coincide with the frame synchronization pattern location.

SFID MSB: The SFID acts as a frame counter, but it is not always the case that all of the bits in the SFID word are used for this purpose. For example, the SFID word might be 16-bits in length, but there might only be 512 minor frames in the major frame. In this scenario, a 9-bit counter ($2^9 = 512$) would be required. The user would specify the location of the counter within the larger 16-bit word by setting the Sync ID most significant bit (MSB) command and selecting the appropriate bit position for the most significant bit of the SFID counter.

SFID Locator: The SFID Locator is a status display that graphically illustrates where the Subframe Sync ID MSB is located within the minor frame SFID word.

URC Sync Pattern (hex): If the URC mode has been selected in the Subframe Mode control list, the URC pattern must be defined. Up to a 64-bit URC pattern can be defined by the user.

URC Pattern Mask (hex): In a similar manner as the frame sync pattern definition on the frame sync tab, the URC provides a mask setting that allows any bits within the URC mask to be identified as “don’t cares”. If the user wishes to make certain bits “don’t cares”, simply set the corresponding bit (or bits) in the URC Pattern Mask to zero and the correlator will disregard received values at these locations in determining lock.

URC Tolerance: When the data channel quality becomes poor, all data in the stream will be affected including the URC pattern. This control dialog box allows the user to program how many of the bits in the URC pattern can be in error prior to declaring that the URC pattern does not match. Values from 0 to 32 can be programmed in this field.

This setting has to correlate with the assigned URC pattern length as well as general overall BER concerns. For most applications, only small values should be assigned. For example, if the URC pattern is 32 bits in length and the BER tolerance is set to 16, this relates to one of every two bits being in error and the pattern still qualify as LOCKED. BER performance of 1 in 2 would result in the demodulation engine being completely unable to maintain lock. As a more practical matter, in the example of a 32-bit URC pattern, if 1 of those bits experience bit errors, this represents a BER value of 3.125×10^{-2} . This BER performance is still

quite poor and would likely result is the demodulation engine being unlocked but is at least a more practical programmed figure. This value is commonly set to zero.

4.5.2.2 Data Decommutator Tab – Right Pane

The Data Decommutator right pane area contains status for the three LS-28-DRSM Decommutators.

Minor Frame Size (bits): This right pane status window provides a calculated minor frame size in bits. This size will take into word attribute settings when calculating this value.

Major Frame Size (bits): This right pane status window provides a calculated major frame size taking into account the word attribute settings.

4.5.3 Data Sub-function Select Tab – DecomWdAttr

The Data DecomWdAttr sub-function select tab provides controls and status related to the Decommutator detailed word attributes. See Figure 4-48 for tab layout.

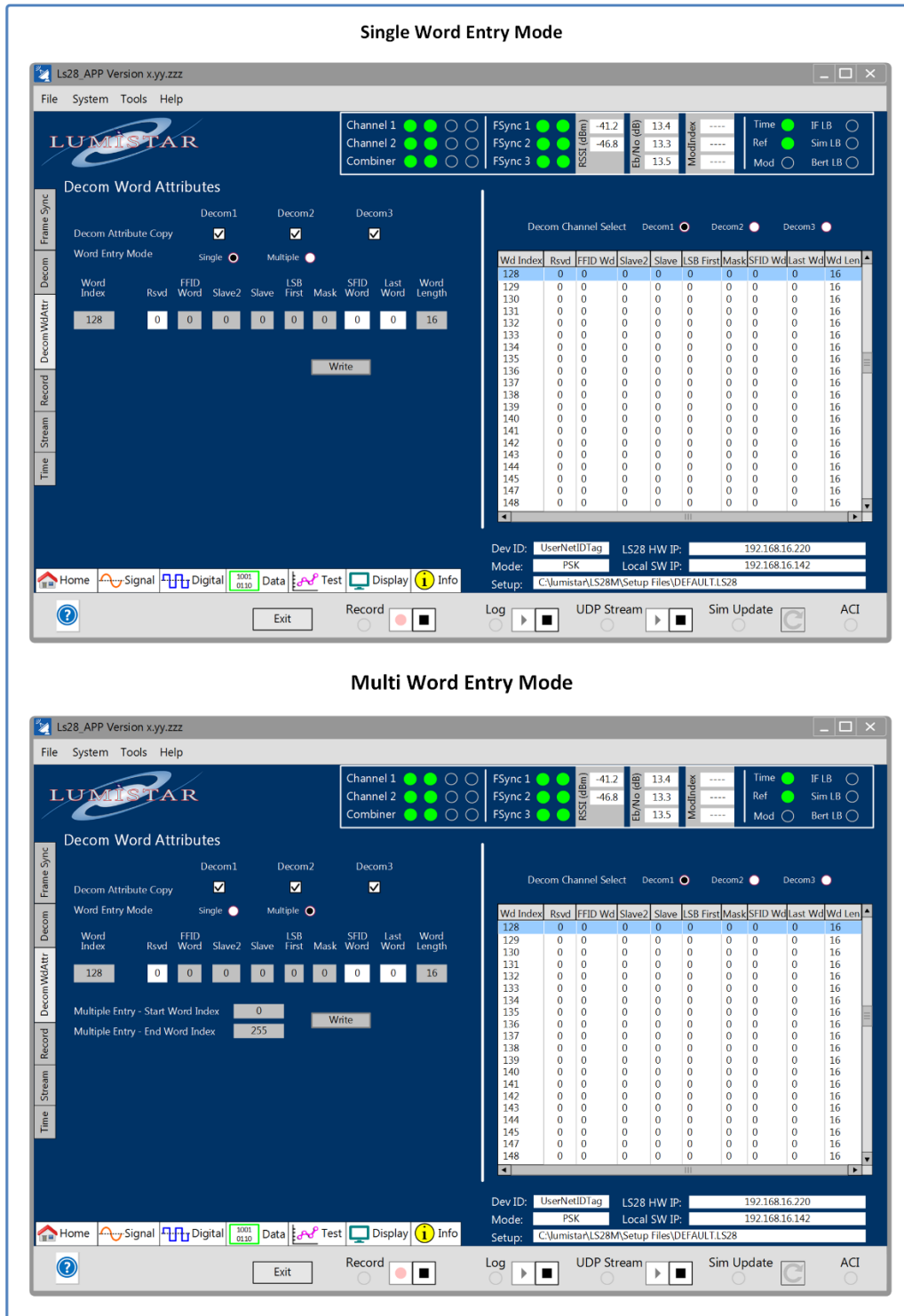


Figure 4-48 Network User Application – Data Sub-function Select: DecomWdAttr

4.5.3.1 Data DecomWdAttr Tab – Left Pane

The Data DecomWdAttr left tab pane contains the controls for the decommutator detailed word attribute entries.

Decom Channel Select: There are three decommutator select check-box controls on this row of the left pane. Each enables one of three decommutator word attribute tables. Entry of word attribute values can be done individually for each decommutator or by selecting all three, word attributes can be applied to all three decommutators simultaneously.

Word Entry Mode: To simplify the entry of values into the word attributes storage, word entries can either be made individually or the process can be streamlined by entering multiple values at one. This radio-button control allows the user to select between the two entry modes.

The controls in this pane work in conjunction with the status display of the left pane. Single word entry mode modifications are selected in the right pane and modified in the left pane. See the description in paragraph 4.5.3.2 for additional details.

If SINGLE is selected, values that appear in the attribute entry controls are selected by clicking the appropriate word in the right pane word attribute scrolling list. Once selected, the word index to be modified will be highlighted in the right pane and values will automatically be filled into the fields in the left pane for modification. Any changes made to a word's attributes are applied directly. The Write button is not necessary in this mode.

If MULTIPLE is selected, a group of words can be modified to all have the same contents at the same time. This mode requires the use of the Multiple Entry Start and End words and the Write button. See further details in paragraphs to follow.

Word Index: This is a status display of the selected word number that is being modified. The Up/Down arrow keys next to this status word allow the user to single out any give word that they choose. This index will not apply when the Word Entry Mode is MULTIPLE.

Rsvd: This attribute entry control is unused at this point and is reserved for future use. No entries are allowed in this field.

FFID: This attribute entry control is unused to indicate that the selected word is a Frame Format Identification (FFID) word for IRIG Class II multi-format provisions. Set this bit to a 1 to indicate that this is a FFID word.

Slave2: This attribute entry control indicates that this is a second level slave word value designating it further slave processing. This slave processing can be performed by another decommutator. Set this bit to a 1 to indicate that this is a Slave2 word.

Slave: This attribute entry control indicates that this is a first level slave word value designating it further slave processing. This slave processing can be performed by another decommutator. Set this bit to a 1 to indicate that this is a Slave word.

LSB First: This attribute entry control sets the Least Significant Bit (LSB) first for a specific data word. If this is set to 1, the selected word or words will be configured to have the first bit be the LSB. If set to 0, the word will be considered Most Significant Bit (MSB) first.

Mask: This attribute entry control allows the word to be masked. If enabled (logic 1) the word will be ignored in the frame. It will not appear in the frame data that is streamed or recorded.

SFID/URC Word: This attribute entry control marks the specified word as a SFID word or as a URC word. This field is filled in automatically based on the settings of the Decom Subfunction select tab. Values that are indicated by a logic 1 are designated as SFID or URC words.

Last Word: This attribute entry control marks the specified word as the last word in the minor frame and is set automatically based on settings within the Decom Subfunction select tab. The indicated value will be set to 1 for the last word in the frame.

Word Length: This attribute entry control sets the word length in bits for the specified word. Values between 3 and 16 are valid.

Multiple Entry – Start Word Index: This control will only be visible when the Word Entry Mode is set to MULTIPLE. Using this mode, a start word must be specified. This value must be greater than the Multiple Entry Index - End Word entry. Values can be from 1 to 65536.

Multiple Entry – End Word Index: This control will only be visible when the Word Entry Mode is set to MULTIPLE. Using this mode, an end word must be specified. This value must be less than the Multiple Entry Index - Start Word entry.

Write: Once the Start and End words have been specified in the MULTIPLE Word Entry Mode and the attribute entry controls have been set as desired, pressing this button will cause the values to be written to all specified words.

4.5.3.2 Data DecomWdAttr Tab – Right Pane

The Data DecomWdAttr right tab pane contains the status of the decommutator detailed word attribute entries.

Decom Channel Select: This three-position radio button allows the user to select which set of decommutator word attributes to read. Only one set of decommutator word attributes may be read at a time.

Read: This right pane control button will cause the selected decommutator word attributes to be read into the Word attribute scrolling display window. This button must be selected to update the contents of the display window.

Word Attribute Scrolling List: This scrolling display window displays the results of the last Word Attributes Read. It is also used to select the Word Index for the left pane single Word Entry Mode modification controls. To select the value to modify in this mode, select along any attribute in that word, the line will highlight and the control widows in the left pane will be filled with the contents for modification.

4.5.4 Data Sub-function Select Tab – Record

If the unit is licensed for the recording option, and the recording FLASH memory is physically installed, this tab will become active. This Data Record sub-function select tab provides controls and status related to the Recording features of the LS-28-DRSM. See Figure 4-49 for tab layout.

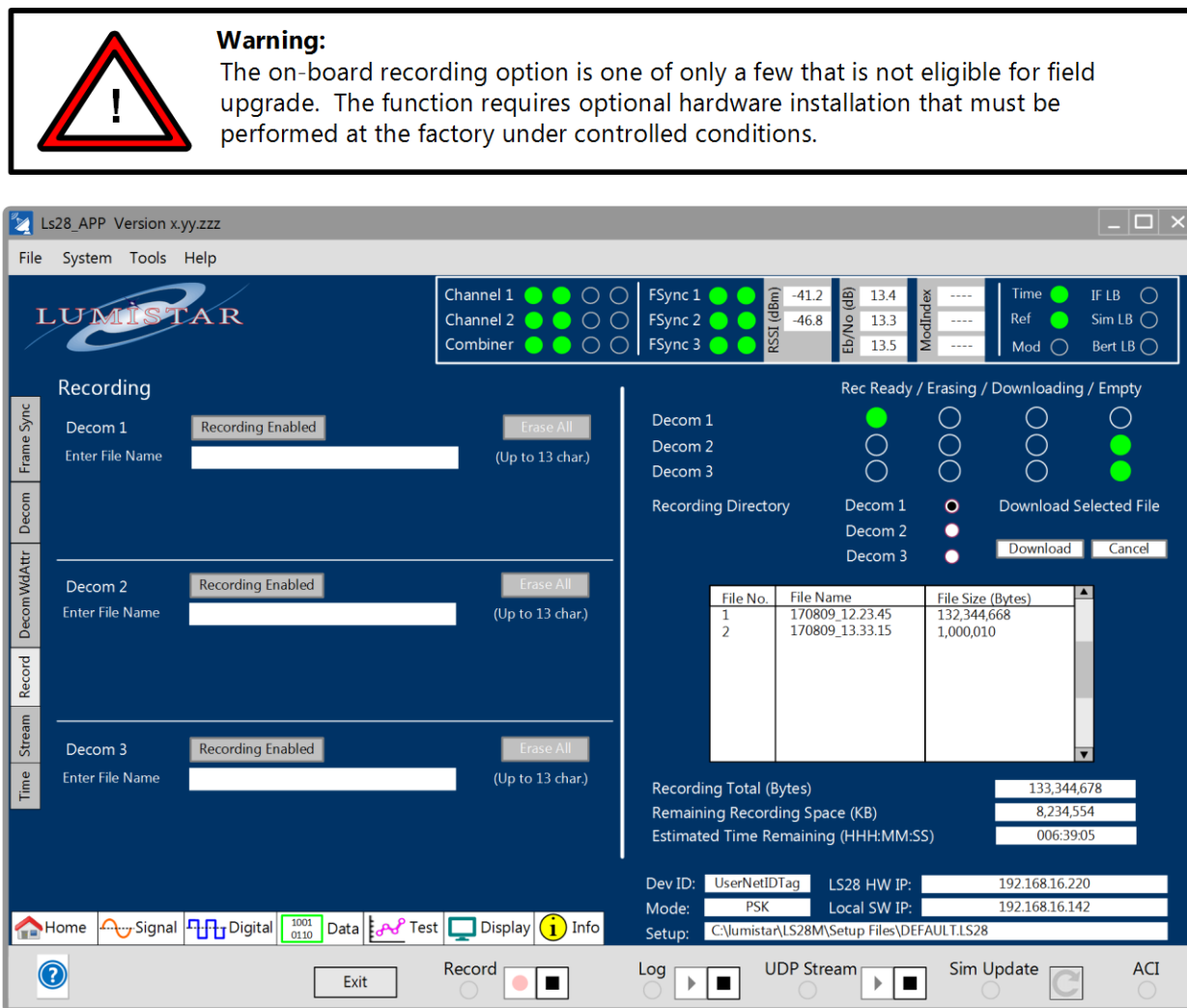


Figure 4-49 Network User Application – Data Sub-function Select: Record

4.5.4.1 Data Record Tab – Left Pane

The Data Record left tab pane contains the primary setup controls for the LS-28-DRSM recording functions.

Recording Enabled: This left pane control button sets the recording function for the selected channel in an enabled state. This will not start the recording process but rather indicate that the process should be started once the real-time RECORD launch control was activated. With each recording run, a new file will be created and assigned a name related to the calendar date and time when the run occurred in accordance with host time.

Erase All: This left pane control button initiates the erase feature of a given channel. This selection will result in another dialog box warning that you are about to erase all recorded channel contents. This process, once started, cannot be halted and is permanent. Exercise caution prior to utilizing this function. There are no provisions for single file erasing within a recording set.

**Warning:**

Prior to selecting the ERASE ALL feature for a channel, download all recording files that need to be retained. Once the ERASE ALL function is complete, contents can not be restored.

**Information:**

The recording process stores data in FLASH memory in sequential order. There is no means of deleting individual files once recorded. All files must be deleted for a given channel.

**Warning:**

Erasing of recording memory is performed to all memory for a given channel. This process requires approximately 58 seconds per channel. During the erase period, responses from the Network User's Application software may result in "No response" warnings until complete.

**Information:**

Listings of recording memory capacities between channels when empty may vary due to differences between bad-block tables between devices.

Enter File Name: This left pane control line allows the user to enter a file name for the recording file. If the user leaves this location blank, an automatic file naming process will be initiated.

4.5.4.2 Data Record Tab – Right Pane

The Data Record right tab pane contains LS-28-DRSM recording status and various post-recording download controls.

Rec Ready: This right pane indicator will illuminate green if recording is enabled for a specific channel. If this indicator is extinguished, then no data will be recorded for that channel. Recording runs are initiated and halted from the RECORD real-time control along the lower tray of the network application GUI. Once at least one channel has been initiated for recording, the real-time RECORD button on the lower tray will become active as shown in Figure 4-49. The real-time control affects recording for all channels enabled.

Erasing: This right pane indicator will illuminate green during the Erase All function for a specific channel. The indicator will be green during the erase process and be extinguished once the process is complete.

Downloading: This right pane indicator will illuminate green during the download process and extinguish once the process is complete. Recording download data formats will be dictated by the frame synchronizer and decommutator section definitions and setups. An example of a download packet from the recording channel is provided in section 4.5.5.

Empty: This right pane indicator will illuminate after all data has been erased for a selected channel. Once data has been stored internally, the LED will be extinguished.

Recording Directory: All files recorded for a specific channel will be displayed in the recording directory. This directory listing is local to the LS-28-DRSM and is not a reflection of a directory on the connected host computer. A new file will be started on each consecutive recording run. Each will be named in the following format: **YYMMDD_hh.mm.ss** where **YY** is the last two digits of the year, **MM** is the month, **DD** is the day, **hh** is the hour, **mm** is the minute and **ss** is the second that the file was stored. Each file will be listed by name along with an assigned number and the corresponding file size in Kilobytes (KB). Files to be downloaded are selected from this directory prior to download.

Channel Select: This three-position radio button allows the user to change the channel for which right pane controls are applied. Only one channel may be active at a time.

Download Selected File: Once the file to be downloaded has been selected in the recording directory, this control button allows the user to initiate the download. Only one file from one channel can be downloaded at a time. Downloading of files is prohibited while recording is active.

**Warning:**

Downloading of recorded data will likely impact the performance of live data streaming. Refrain from performing download operations while streaming is active.

**Information:**

Recording and downloading are mutually exclusive to each other and thus can not be performed simultaneously.

Recording Total (KB): Upon Download Channel Select changes, the total of all recorded files for that channel will be displayed in this status window in Kilobytes.

Remaining Recording Space (KB): Upon Download Channel Select changes, the total of all recorded files for that channel will be subtracted from the total amount of recording room per channel and displayed in this status window in Kilobytes.

Estimated Time Remaining (HHH:MM:SS): An estimate of the remaining recording time available is provided to via this status window. This estimate is based on the present recording data format and data rate. Changes to either of these parameters will result in a change in the estimated time remaining.

4.5.5 Additional Recording Information

Additional data concerning recording is provided in the following paragraphs.

4.5.5.1 Recording Fundamentals

The on-board recording option provides a means of directly recording digital data that has been received, demodulated, and framed. To more fully understand this functionality, the following recording capabilities list has been created:

The On-Board Recording option **IS**, **CAN** or **DOES**:

- **IS** a hardware related option that must be physical installed for use
- **CAN** be used simultaneously with data being streamed in a real-time fashion
- **CAN** record digital data that has been received and demodulated into a digital format
- **CAN** record data that contains a defined frame and subframe format
- **CAN** record data that is just grouped as a set of bits with no defined frame attributes
- **CAN** record encrypted data
- **CAN** provided time stamping based on IRIG-A, B or G formats or IEEE-1588 Precision Time Protocol
- **CAN** provide up to 64GB per channel of recording
- **DOES** record data in a compact format with a 24-byte time and status header
- **CAN** provide files that can be converted to IRIG CH10 format via a LDPS_10x utility
- **CAN** provide files for play-back via LDPS_10x and TDynaSim
- **CAN** record with no Network User Application running
- **CAN** automatically start recording at power-up

The On-Board Recording option **IS NOT**, **CAN NOT** or **DOES NOT**:

- **IS NOT** available as a "license file" upgrade. The unit must be returned for memory installation.
- **DOES NOT** provide removable recording memory
- **DOES NOT** record the I/Q symbol samples of the incoming RF or IF signal
- **DOES NOT** record the RSSI of the received signal
- **DOES NOT** record the AM of the received signal
- **DOES NOT** allow the deletion of a single file from the recording archive
- **DOES NOT** record data while in frame mode if the frame lock is not present
- **DOES NOT** record files in native IRIG CH10 format
- **CAN NOT** record in a format that is different than the defined real-time streaming format

The recorded data is Reed-Solomon encoded prior to being stored in the internal FLASH memory. This encoding is required to prevent bit errors that may occur due to the storage media. In addition, recording is performed on page boundaries within the FLASH memory. These two factors contribute to a small, but unavoidable, amount of memory consumption associated with the recording process itself.

It is highly recommended that recording processes are started and stopped via proper software controls. Using these controls is the only method to ensure recording integrity.

It is also not recommended to purposely remove device power while actively recording. The engineers at Lumistar understand that there are unavoidable situations where power may be inadvertently lost while recording is active. When this occurs a previously started recording file can get stranded in memory without a proper End-of-File (EOF) recording record. In addition, data that was received and buffered for storage but had not been encoded prior to FLASH memory writes, or data that was in-process of being written to FLASH memory but fell short of a full page, will either be lost or rendered unusable. At power up boot, if a recording file is located which lacks an EOF record, the LS-28-DRSM firmware will attempt to repair this recording file. Since the file recordings for the LS-28-DRSM are always sequentially placed in memory, and the FLASH erase process is based on the entire memory contents for a channel, the process of finding the EOF location for an improperly closed file is conducted by looking for the first page of memory within the entire recording memory that is easily identifiable as free from recorded content. A portion of the unwritten file page is taken into account and the recording record for the file is repaired so that the file may be downloaded. This file will contain erroneous or blank data at the very end of the file but data prior to the power disruption will be valid. It is the user's responsibility to locate the boundary of useable data.

When the user selects a file to download, the firmware within the LS-28-DRSM inserts the 256-byte User Data header at the top of the download file and the data within the FLASH memory is cycled thru Reed-Solomon decoding to remove the recording encoding. Data is provided to the user using TCP protocol to ensure packet sequence order and reception.

4.5.5.2 Recording User Data Header

The Network User Application will automatically add a directory record to the top of each recorded file that provides information shown in Table 4-8. The content for the payload of the header comes from application entries shown in Figure 4-50.

Data presented in this header is provided as ASCII characters, as described in Table 4-8. This header is not stored in the active real-time recording memory but instead is stored in non-volatile memory within the LS-28-DRSM recording directory. Once the user selects a file for download, the user data header is inserted at the top of the recorded content to transfer.

User Data	Header Data (ASCII)	Overhead Bytes	Min. Payload Bytes	Max. Payload Bytes	Ref Diagram	See Note
Start of File Descriptor	[Telemetry Archive] <CR> <LF>	21	0	0		3
Frame Sync Pattern (FSP)	Sync=(FSP in Hex) <CR> <LF>	7	1	16	A	
Recording Header Time Stamp	TimeStamp=048:18:22:23.670001 <CR> <LF>	12	19	19		1
Recording Device Source	DecomType=LS28 <CR> <LF>	7	4	4		3
Bit Rate in Bits-per-Second	BPS=(4 to 8 characters) <CR> <LF>	6	4	8	B	
Common Word Length	BitsPerWord=(1 to 2 characters) <CR> <LF>	14	1	2	C	
Words per Frame	WordsPerFrame=(1 to 6 characters) <CR> <LF>	16	1	6	D	
First Minor Frame Number	FirstFrame=(1 characters) <CR> <LF>	13	1	1	E	
Last Minor Frame Number	LastFrame=(1 to 5 characters) <CR> <LF>	12	1	5	F	2
Word Alignment	WordAlignment=RIGHT <CR> <LF>	16	5	5		3
Frames Per Interrupt	DmaBlockCount=(1 to 3 characters) <CR> <LF>	16	1	3	G	
SFID Word Number	SubFrameIdWord=(1 to 5 characters) <CR> <LF>	17	1	5	H	
FSP Location	Loc=LEADS or TRAILS <CR> <LF>	6	5	6	I	
Bit Order	BOrd=LSB or MSB	5	3	3	J	
Spare	(up to 38 ASCII spaces)	3				
End of File Descriptor	<CR> <LF> <Ctrl Z>					3
Totals		171	47	83		

Notes:

- 1.) The time placed in this header location should be the Julian time, as presented in the time of the controlling host. The degree of precision of this time value is not critical and may be a different format from "first frame data time tag value."
- 2.) The last frame value is dependent upon the first frame value. If the value of the first frame is zero, the last frame value will be one less than set in the "Number of Minor Frames" setting.
- 3.) These values are fixed and do not change.

Table 4-8 Recording File 256-Byte ASCII Directory Record

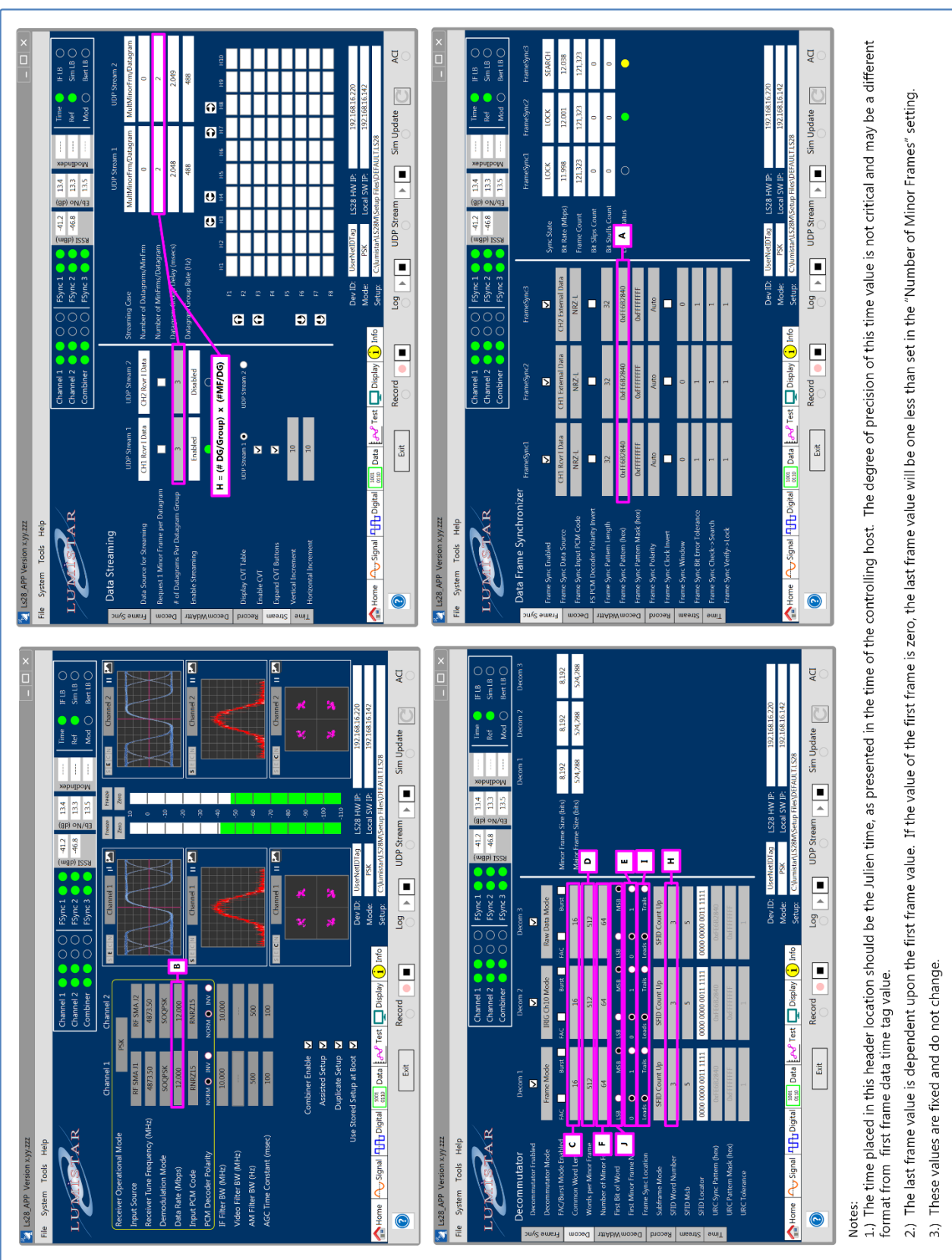


Figure 4-50 Network User Application – Recording Header Content Diagram

4.5.5.3 Automatic Recording at Boot Time

As described in Section 4.1.2 and Figure 4-11, the LS-28-DRSM allows the automatic recording at power up. In the case that these elections have been made, it is most common to also have the selection for recalling previously stored setups at power up. Assuming this to be the case, recording file names have to be assigned internally by the LS-28-DRSM. Since time synchronization may not also be possible, file names will be assigned as follows: CHx_tttttttt where x = the channel being recorded and tttttttt = the number 50usec intervals since the unit was started last.

Upon LS28_App launch and connection to a unit in this state, the Power-Up Boot Control Screen will be presented as shown in Figure 4-51. At this control screen, the user has three options:

- 1.) Exit the control window by selecting the EXIT button.
- 2.) Select the CONTINUE button on the bottom of the control window which will close all recordings that are active properly and continue with the LS28_App startup.
- 3.) Select individual recordings to halt by selecting the button to the right of each channel sub-window, choosing to continue others, and then exit the control window by selecting the EXIT button.

The screenshot displays a 'Recording Status' window with a dark blue background and white text. It contains three sub-windows for Channel 1, Channel 2, and Channel 3. Each sub-window lists recording details and has a 'Stop Rec.' button. At the bottom of the main window are 'Continue' and 'Exit' buttons.

Recording Status	
Channel 1	
File Name	CH1_121E518B
File Size (Bytes)	300,126,879
Remaining Capacity (Bytes)	33,813,013,248
Time Remaining	014:33:41
Channel 2	
File Name	CH2_121E518B
File Size (Bytes)	299,446,584
Remaining Capacity (Bytes)	33,811,723,008
Time Remaining	014:32:11
Channel 3	
File Name	CH3_121E518B
File Size (Bytes)	298,899,376
Remaining Capacity (Bytes)	33,822,802,944
Time Remaining	014:34:05

Figure 4-51 Network User Application – Power-Up Boot with Recording Active Control Screen

4.5.5.4 Recording File Format:

Recording file formats are provided to the user in a slightly different format than the real-time streaming data packets. There are two different formats of the recording packets: BCD Time Format, and SOY Time format. These formats are illustrated in Figure 4-52 and Figure 4-53.

The differences in the download formats versus the real-time streaming data consists of two deltas: the location of the related frame header, and the user data header.

For recording data, the first frame header is considered a "remnant" and does not reflect the time of the actual first bit of the frame data. This frame header appears in gray in the figures that follow. The first valid frame header actually is appended to the bottom of the valid frame data which immediately proceeds it. The opposite of this is true for real-time streamlining data.

The user data header, defined above in section 4.5.5.2, is only provided for downloaded recordings. There is no equivalent for real-time streaming data.

TCP Recording Packet (BCD Time Format)											
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0			
Frame Int Hdr Length = 256	User/Comment Data Byte 0									User Data	User Data Field
	User/Comment Data Byte 1										
	User/Comment Data Byte 2..253										
	User/Comment Data Byte 254										
	User/Comment Data Byte 255										
Data Type <15:8>										Frame Header	Data Type Field
Data Type <7:0>											Time Type Field
Time Reserved								TSLCK			Time Stamp Field (BCD)
Fly Wheel	BCD Out En	1PPS En	IRIG En		1PPS Type		IRIG Type				
BCD 1's Years					BCD 100's Days						
BCD 10's Days					BCD 1's Days						
BCD 10's Hours			BCD 1's Hours								
Minor	BCD 10's Minutes				BCD 1's Minutes						
Frame	BCD 10's Seconds				BCD 1's secs						
Footer	BCD 100's msec					BCD 10's msec					
Length=24	BCD 1's msec					BCD 100's usec					
BCD 10's usec					BCD 1's usec						
Reserved			Carrier Lock	Bitsync Lock	Channel						Channel Field
Channel Reserved											
Channel Reserved											
Channel Reserved											
Reserved			Reserved								Frame Sync Field
Reserved	Frame Sync Error Count <6:0>										
Dead Clock	FS Invert	FS Normal	FS Lock	Frame Sync State		Bit Stuff	Bit Slip				
Reserved		Number Bit Stuffs		Reserved		Number Bit Slips					
Decom Reserved					Major Frame State		Major Lock	Right Align			Decom Field
Decom Subframe Mode		Decom Sync Mode			FFID Status						
Minor Frame Count <15:8>											
Minor Frame Count <7:0>											
Minor Frame Data (Variable)	Minor Frame Data Byte 0									Frame Data	Frame Data (Variable Size based on Decom Setup up to 128K Bytes)
	Minor Frame Data Byte 1										
	Minor Frame Data Byte 2										
	Minor Frame Data Bytes 3...131,070										
	Minor Frame Data Bytes 131071										
	Minor Frame Data Bytes 131072										
Data Type <15:8>										Frame Header	Data Type Field
Data Type <7:0>											Time Type Field
Time Reserved								TSLCK			Time Stamp Field (BCD)
Fly Wheel	BCD Out En	1PPS En	IRIG En		1PPS Type		IRIG Type				
BCD 1's Years					BCD 100's Days						
BCD 10's Days					BCD 1's Days						
BCD 10's Hours					BCD 1's Hours						
BCD 10's Minutes					BCD 1's Minutes						
Minor	BCD 10's Seconds				BCD 1's Seconds						
Frame	BCD 100's Milliseconds				BCD 10's Milliseconds						
Footer	BCD 1's Milliseconds				BCD 100's Microseconds						
Length=24	BCD 10's Microseconds				BCD 1's Microseconds						
Reserved			Carrier Lock	Bitsync Lock	Channel						Channel Field
Channel Reserved											
Channel Reserved											
Channel Reserved											
Reserved			Reserved								Frame Sync Field
Reserved	Frame Sync Error Count <6:0>										
Dead Clock	FS Invert	FS Normal	FS Lock	Frame Sync State		Bit Stuff	Bit Slip				
Reserved		Number Bit Stuffs		Reserved		Number Bit Slips					
Decom Reserved					Major Frame State		Major Lock	Right Align			Decom Field
Decom Subframe Mode		Decom Sync Mode			FFID Status						
Minor Frame Count <15:8>											
Minor Frame Count <7:0>											

Figure 4-52 Network User Application – Recording Packet Format (BCD)

TCP Recording Packet (SOY Time Format)													
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0					
Frame Int Hdr Length = 256	User/Comment Data Byte 0								User Data	User Data Field			
	User/Comment Data Byte 1												
	User/Comment Data Byte 2..253												
	User/Comment Data Byte 254												
	User/Comment Data Byte 255												
Minor Frame Footer Length=24	Data Type <15:8>								Frame Header	Data Type Field			
	Data Type <7:0>									Time Type Field			
	Time Reserved							TSLCK		Time Stamp Field (SOY)			
	Fly Wheel	BCD Out En	1PPS En	IRIG En	1PPS Type		IRIG Type						
	IRIG MSW (seconds) <31:16>												
	IRIG MSW (seconds) <23:16>												
	IRIG MSW (seconds) <15:8>												
	IRIG MSW (seconds) <7:0>												
	IRIG LSW (nanoseconds) <31:24>												
	IRIG LSW (nanoseconds) <23:16>												
	IRIG LSW (nanoseconds) <15:8>												
	IRIG LSW (nanoseconds) <7:0>												
	Reserved		Carrier Lock	Bitsync Lock	Channel					Channel Field			
	Channel Reserved												
	Channel Reserved												
	Channel Reserved												
	Reserved									Frame Sync Field			
	Reserved	Frame Sync Error Count <6:0>											
	Dead Clock	FS Invert	FS Normal	FS Lock	Frame Sync State		Bit Stuff	Bit Slip					
	Reserved		Number Bit Stuffs		Reserved		Number Bit Slips						
	Decom Reserved				Major Frame State		Major Lock	Right Align		Decom Field			
	Decom Subframe Mode	Decom Sync Mode		FFID Status									
	Minor Frame Count <15:8>												
	Minor Frame Count <7:0>												
Minor Frame Data (Variable)	Minor Frame Data Byte 0								Frame Data	Frame Data (Variable Size based on Decom Setup up to 128K Bytes)			
	Minor Frame Data Byte 1												
	Minor Frame Data Byte 2												
	Minor Frame Data Bytes 3...131,070												
	Minor Frame Data Bytes 131071												
	Minor Frame Data Bytes 131072												
Minor Frame Footer Length=24	Data Type <15:8>								Frame Header	Data Type Field			
	Data Type <7:0>									Time Type Field			
	Time Reserved							TSLCK		Time Stamp Field (SOY)			
	Fly Wheel	BCD Out En	1PPS En	IRIG En	1PPS Type		IRIG Type						
	IRIG MSW (years)							IRIGSec<24>					
	IRIG MSW (seconds) <23:16>												
	IRIG MSW (seconds) <15:8>												
	IRIG MSW (seconds) <7:0>												
	IRIG LSW (nanoseconds) <31:24>												
	IRIG LSW (nanoseconds) <23:16>												
	IRIG LSW (nanoseconds) <15:8>												
	IRIG LSW (nanoseconds) <7:0>												
	Reserved		Carrier Lock	Bitsync Lock	Channel					Channel Field			
	Channel Reserved												
	Channel Reserved												
	Channel Reserved												
	Reserved									Frame Sync Field			
	Reserved	Frame Sync Error Count <6:0>											
	Dead Clock	FS Invert	FS Normal	FS Lock	Frame Sync State		Bit Stuff	Bit Slip					
	Reserved		Number Bit Stuffs		Reserved		Number Bit Slips						
	Decom Reserved				Major Frame State		Major Lock	Right Align		Decom Field			
	Decom Subframe Mode	Decom Sync Mode		FFID Status									
	Minor Frame Count <15:8>												
	Minor Frame Count <7:0>												

Figure 4-53 Network User Application – Recording Packet Format (SOY)

4.5.6 Data Sub-function Select Tab – Stream

This Data sub-function Stream select tab is present if the Frame Sync and Decom functions are licensed. The tab provides controls and status related to the data streaming features of the LS-28-DRSM. See Figure 4-54 for tab layout.

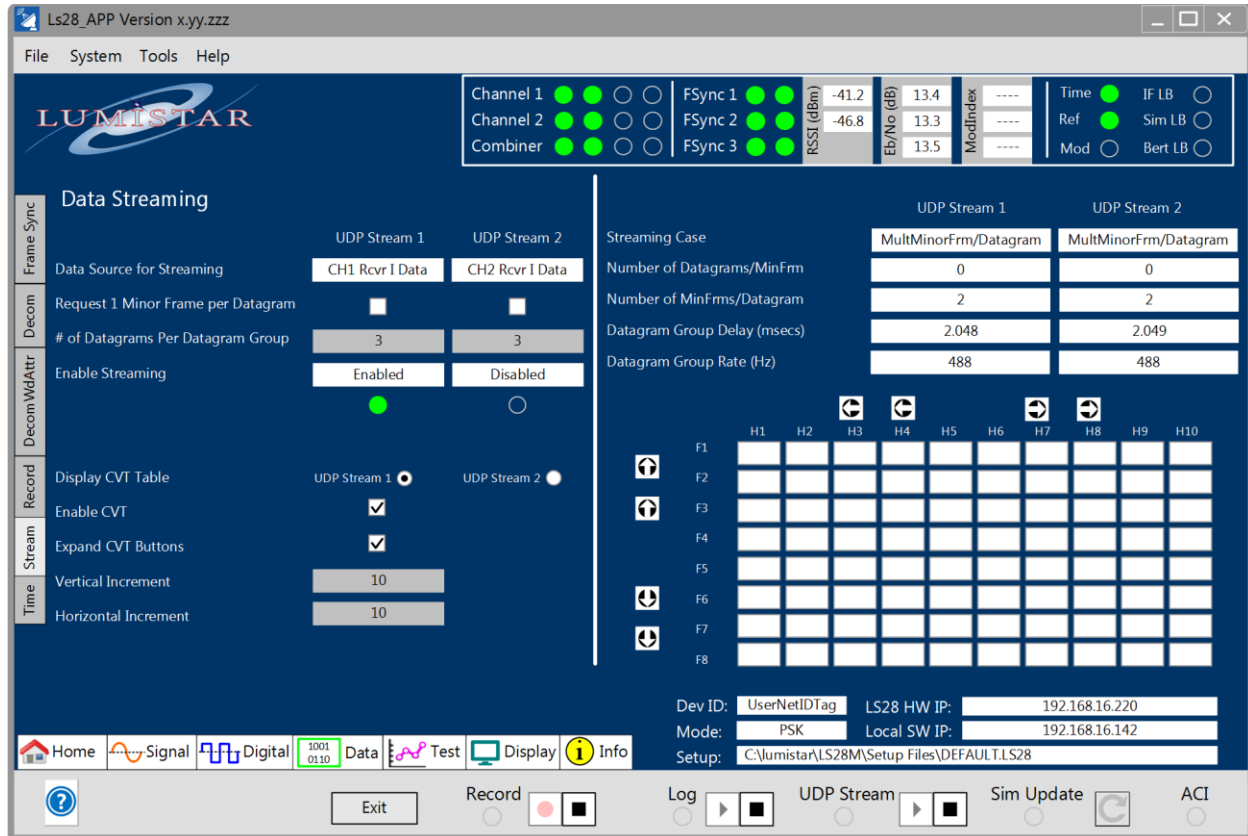


Figure 4-54 Network User Application – Data Sub-function Select: Stream

Streaming data is a complex function. Datagram network packets are limited in size and PCM frames take many different formats. For these reasons, there are several different organizations (cases) that are possible for transmissions. To help clarify the packet formats and streaming organizations, Figure 4-55 thru Figure 4-59 illustrate the details of the streaming frame.

UDP Streaming Packet (BCD Time Format)													
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0					
Datagram Header Length=8	Device ID (0x28)								Datagram Header	Datagram Header			
								MADG					
	Datagram Sequence Number <15:8>												
	Datagram Sequence Number <7:0>												
	Sequence Number												
	# Minor Frames per Datagram												
	# of Datagrams per Minor Frame												
	Datagram Number												
Minor Frame Header Length=24	Data Type <15:8>								Frame Header	Data Type Field			
	Data Type <7:0>									Time Type Field			
	Time Reserved							TSCLK		Time Stamp Field (BCD)			
	Flywheel	BCD Out En	1PPS En	IRIG En	1PPS Type		IRIG Type						
	BCD Years				BCD 100's Days								
	BCD 10's Days				BCD 1's Days								
	BCD 10's Hours				BCD 1's Hours								
	BCD 10's Minutes				BCD 1's Minutes								
	BCD 10's Seconds				BCD 1's secs								
	BCD 100's Milliseconds				BCD 10's msec								
	BCD 1's Milliseconds				BCD 100's Microseconds								
	BCD 10's Microseconds				BCD 1's Microseconds								
	Reserved		Carrier Lock	Bitsync Lock	Channel								
	Channel Reserved									Channel Field			
	Channel Reserved												
	Channel Reserved												
	Reserved									Frame Sync Field			
	Reserved	Frame Sync Error Count <6:0>											
	Dead Clock	FS Invert	FS Normal	FS Lock	Frame Sync State		Bit Stuff	Bit Slip					
	Reserved		Number Bit Stuffs		Reserved		Number Bit Slips						
	Decom Reserved				Major Frame State		Major Lock	Right Align		Decom Field			
	Decom Subframe Mode		Decom Sync Mode		FFID Status								
	Minor Frame Count <15:8>												
Minor Frame Count <7:0>								Frame Data	Frame Data				
Frame Data	Minor Frame Data Byte 0												
	Minor Frame Data Byte 1												
	Minor Frame Data Byte 2												
	Minor Frame Data Bytes 3...1382												
	Minor Frame Data Bytes 1383												
	Minor Frame Data Bytes 1384												

Figure 4-55 Data Streaming: Packet Format with BCD Time

UDP Streaming Packet (SOY Time Format)											
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0			
Datagram Header Length=8	Device ID (0x28)								Datagram Header	Datagram Header	
							MADG				
	Datagram Sequence Number <15:8>										
	Datagram Sequence Number <7:0>										
	Sequence Number										
	# Minor Frames per Datagram										
	# of Datagrams per Minor Frame										
Minor Frame Header Length=24	Datagram Number								Frame Header	Data Type Field	
	Data Type <15:8>										
	Data Type <7:0>										Time Type Field
	Time Reserved							TSCLK			
	Flywheel	BCD Out En	1PPS En	IRIG En	1PPS Type		IRIG Type			Time Stamp Field (SOY)	
	IRIG MSW (years)							IRIGSec<24>			
	IRIG MSW (seconds) <23:16>										
	IRIG MSW (seconds) <15:8>										
	IRIG MSW (seconds) <7:0>										
	IRIG LSW (nanoseconds) <31:24>										
	IRIG LSW (nanoseconds) <23:16>										
	IRIG LSW (nanoseconds) <15:8>										
	IRIG LSW (nanoseconds) <7:0>										
	Reserved		Carrier Lock	Bitsync Lock	Channel						Channel Field
	Channel Reserved										
	Channel Reserved										
	Channel Reserved										
	Reserved										Frame Sync Field
	Reserved	Frame Sync Error Count <6:0>									
	Dead Clock	FS Invert	FS Normal	FS Lock	Frame Sync State		Bit Stuff	Bit Slip			
	Reserved		Number Bit Stuffs		Reserved		Number Bit Slips				
	Decom Reserved				Major Frame State		Major Lock	Right Align		Decom Field	
	Decom Subframe Mode		Decom Sync Mode		FFID Status						
	Minor Frame Count <15:8>										
Minor Frame Count <7:0>											
Frame Data	Minor Frame Data Byte 0								Frame Data	Frame Data	
	Minor Frame Data Byte 1										
	Minor Frame Data Byte 2										
	Minor Frame Data Bytes 3...1382										
	Minor Frame Data Bytes 1383										
	Minor Frame Data Bytes 1384										

Figure 4-56 Data Streaming: Packet Format with SOY Time

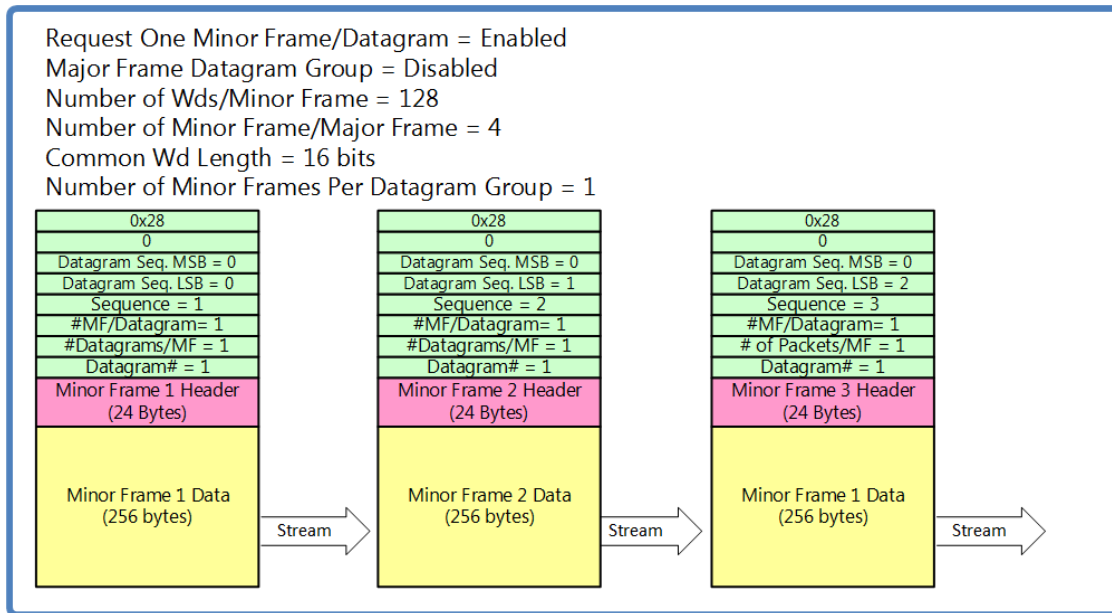


Figure 4-57 Data Streaming: Case 1 - Single Minor Frame per Datagram

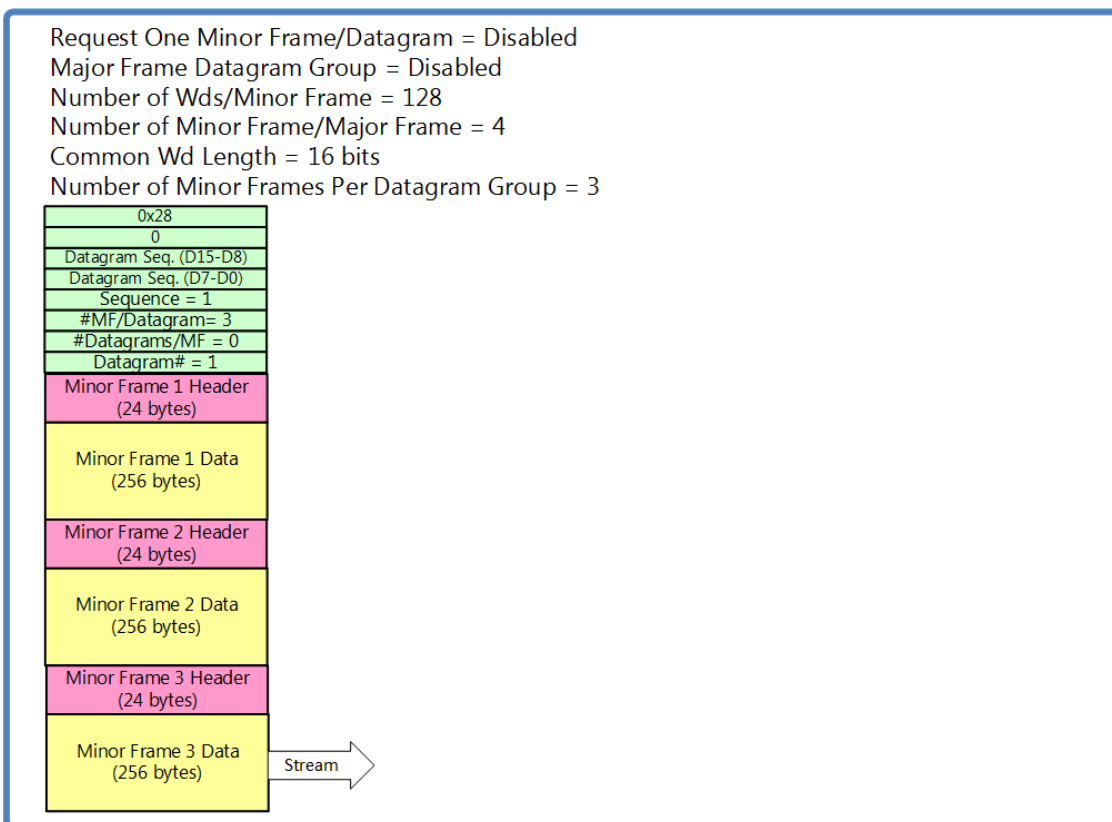


Figure 4-58 Data Streaming: Case 2 - Multi Minor Frame per Datagram

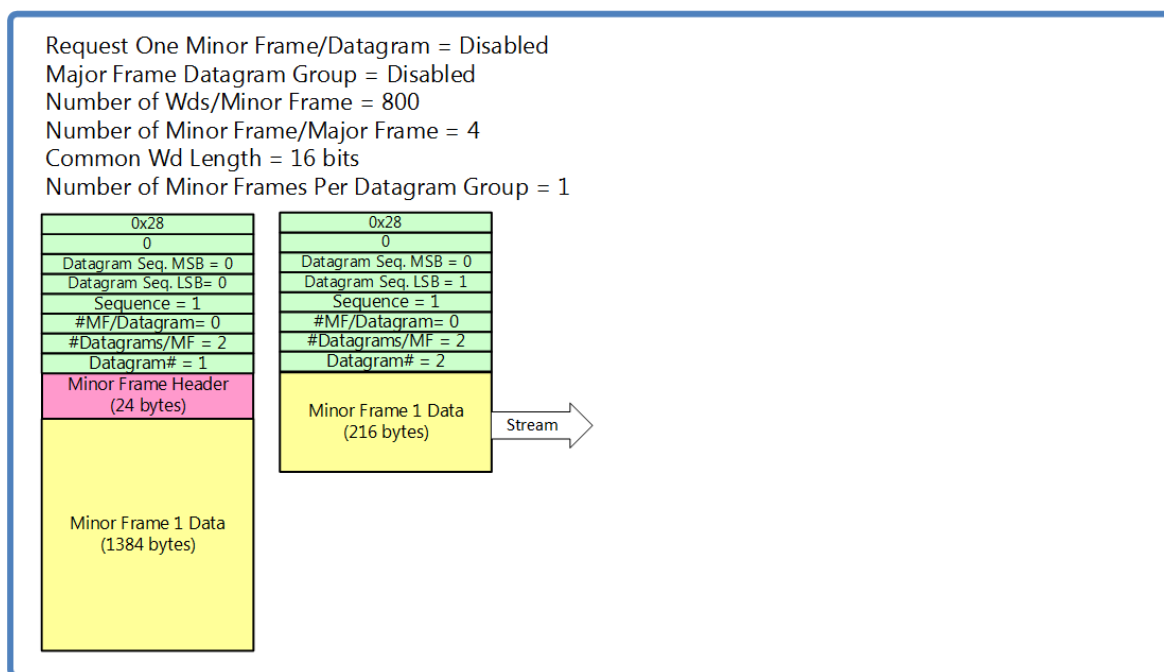


Figure 4-59 Data Streaming: Case 3 - Multiple Datagrams per Minor Frame

Streaming data content is defined in greater detail in the *Lumistar LS-28M Interface Control Document* (DOC-28M-01-ICD-09).

4.5.6.1 Data Streaming Tab – Left Pane

The Data Streaming left pane area contains controls for the two streaming channels provided by the LS-28-DRSM design.

Data Source for Streaming: This status window provides information to the user as to which source has been set for data for streaming for the given port. This setting is actual set on the FrameSync Subfunction select tab. On that tab, eight selections are available from a drop-down list. These sources include: Ch1 I Data, Ch1 Q Data, Ch2 I Data, Ch2 Q Data, Combiner I Data, Combiner Q Data, External Clk/Data 1, External Clk/Dat 2, External Clk/Data 1 Diff, External Clk/Data 2 Diff, PCM SIM1 and PCM SIM2. Refer to the diagram in Figure 4-40.

Request 1 Minor Frame per Datagram: If the minor frame is smaller than 1384 bytes, which describes most frames, the user can select an option to send every minor frame in an individual datagram. There are implications for this selection in terms of performance. If the frequency of datagram groups exceeds 2000 Hz, data can be lost during streaming.

of Datagrams Per Datagram Group: This control allows the user to select the number of datagrams to group in a datagram group. This control only applies to streaming real-time data and not to graphical data packages.

Streamed real-time data always occurs in groups. Each datagram group is composed of up to 1384 bytes of frame data along with additional headers as shown in Figure 4-57 thru Figure 4-59. Datagram grouping has to be carefully considered in the setup of streaming real-time data. Values as small as 1 can be

programmed in this control. However, if the frequency of datagram group rate exceeds 1000 Hz, the internal processing engine may experience overburdened processing. For optimal sustained performance, it is best to keep the datagram group rate as low as possible, optimally 100Hz or less. To illustrate the effects of datagram groups refer to Figure 4-60.

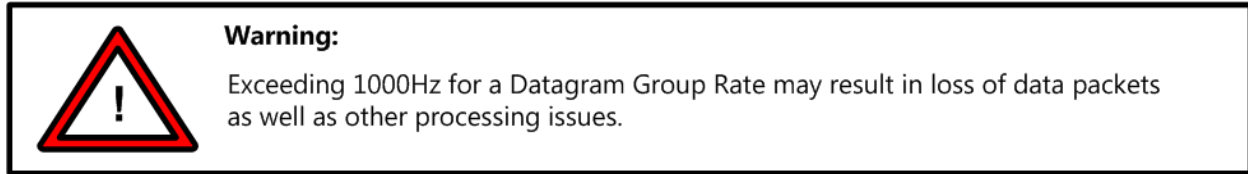
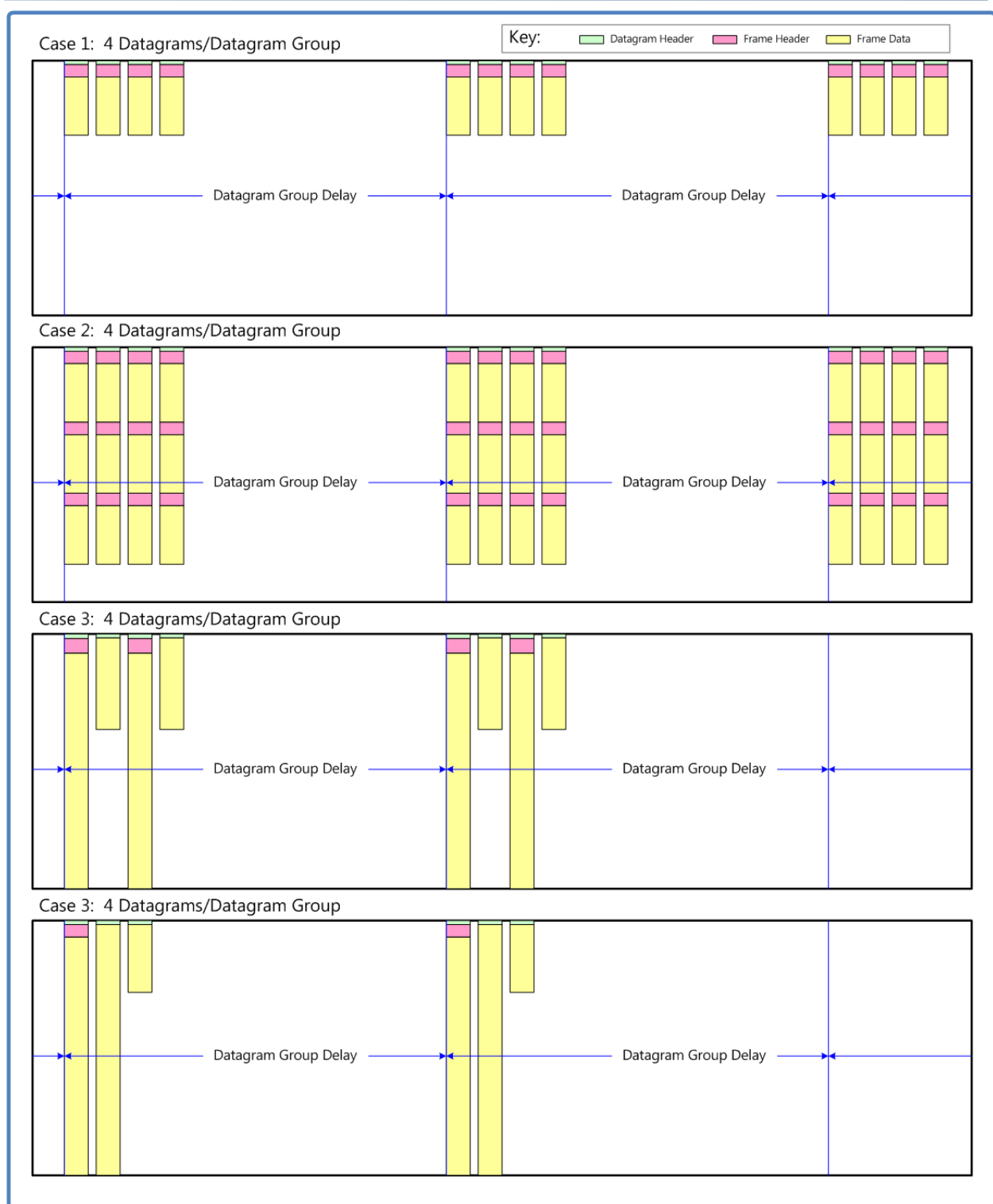


Figure 4-60 shows that message cases grouped according to the setting in this control. Messages within a group will be transmitted one after another until the entire group has been transferred. This will be followed by a null period where no transmissions occur. Once the number of datagrams in a programmed group has been received within the LS-28-DRSM the next group of transmissions occurs. The figure contains two case 3 examples. The first shows that a single received message that is large enough that it requires 3 datagrams for complete transmission. Since the datagrams per group programming is set to 4, a calculation is performed on the number of datagrams per message versus the programmed datagram grouping size to see if it will fit evenly. If it does not, the programmed setting is rounded down to the closest number which matches the value programmed. If the value programmed is less than that of a complete message, the value will be rounded up. The final Case 3 example requires only two datagrams per message which means that two messages can be grouped together.

**Figure 4-60** Streaming Illustration – Datagram Transmission Grouping

Enable Streaming: This control allows the user to select whether a channel has been enabled for streaming or functions. If either or both channels have been enabled for streaming, the real-time streaming controls in the lower tray become active as shown in Figure 4-61. Once enabled, the LED below each channel column will be Green if active and contain no color when inactive.

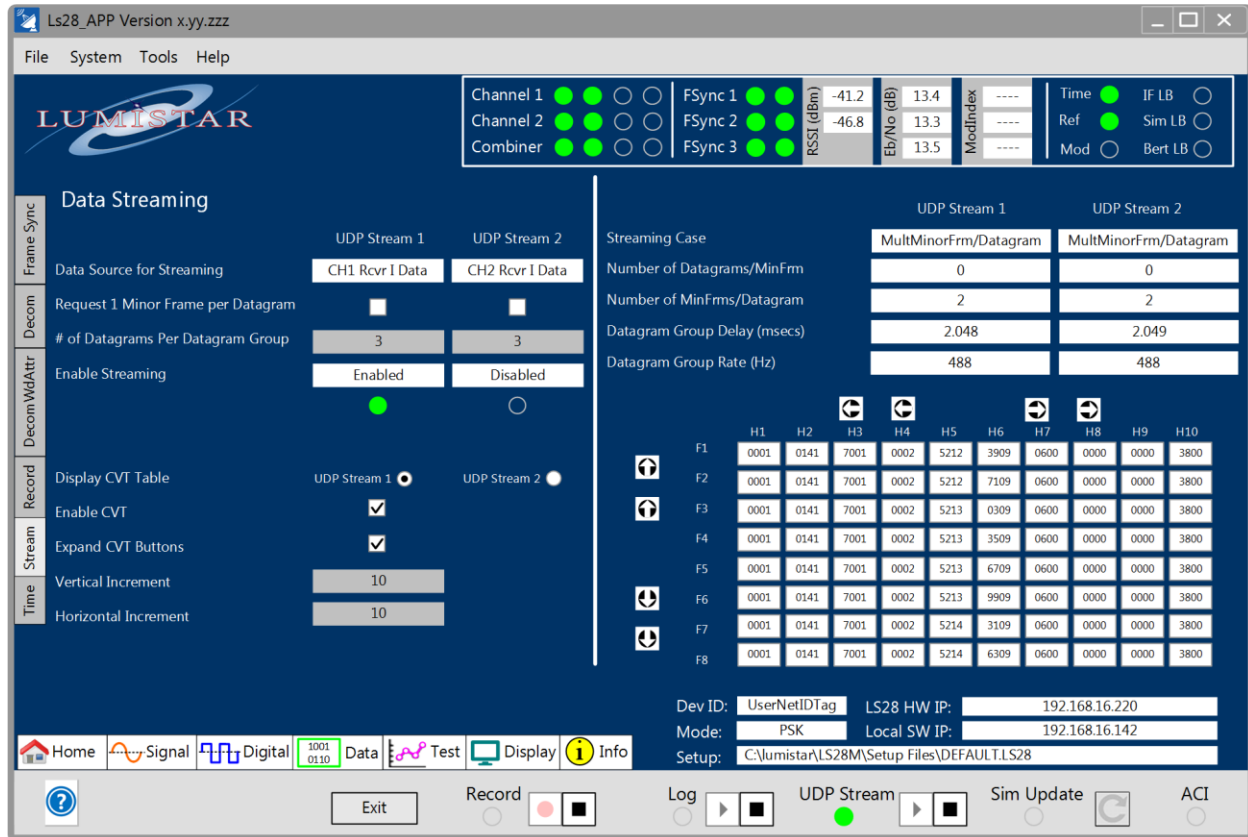


Figure 4-61 Network User Application – Data Sub Function Select: Streaming Active

Display CVT Table: This control allows the user to select which of the two potential streams will be displayed in the right status pane of the Streaming tab. Once data is streaming only one source can be displayed in the status tab CVT. Data will only be displayed in this tab if data streaming is enabled and the streaming data has been started.

Enable CVT: To enable the status CVT client display in the right status pane, the user must select this check box.

Expand CVT Buttons: To browser larger frames more efficiently, selecting this menu option allows the user to program a second, outer set of CVT control buttons. These arrows in both the horizontal and vertical axis allowing step sizes based on the programmed Vertical and Horizontal increments.

Vertical Increment: This value is the outer arrow "Expanded CVT Button" step size for the vertical axis controls.

Horizontal Increment: This value is the outer arrow "Expanded CVT Button" step size for the horizontal axis controls.

4.5.6.2 Data Streaming Tab – Right Pane

The Data Streaming right pane area contains status for the two streaming channels provided by the LS-28-DRSM design.

Streaming Case: There are three streaming cases that can occur: a single minor frame per datagram, multiple minor frames per datagram, and multiple datagrams per minor frame. This status window displays the present streaming case as configured.

Number of Datagrams/MinorFrm: This status window provides the user with the number of datagrams per minor frame. The reported values are integer numbers.

Number of MinorFrms/Datagram: This status window provides the user with the number of minor frames in each datagram. The reported values are integer numbers.

Datagram Group Delays (msec): This status window provides the user with calculated average periodic delay between the transmission of datagram groups.

Datagram Group Rate (Hz): This status window provides the user with calculated average periodic frequency of the transmission of datagram groups.

CVT Table: Directly below the frame display status is an 80-element Current Value Table (CVT) client display. This table allows the user to examine streaming data in a row and column arrangement. Only one stream's data can be displayed. The control arrows above and to the left of the CVT allow the user to scroll data to view within the frame. The CVT client requires that data streaming be enabled and active, and that data be present via a locked data frame or in raw data mode.

4.5.7 Data Sub-function Select Tab – Time

In most cases, the Time Data sub-function select tab is present by default. However, the time functions are associated with time tagging data that is being packaged for streaming from the frame sync and decom functions. When these functions are not licensed, there is really no purpose for the on-board time synchronization and thus the option may not be provided. If the time function is not licensed, the Time sub-tab will not be present. This Data sub-function select tab provides controls and status related to the time generator and reader features of the LS-28-DRSM. See Figure 4-62 for tab layout.

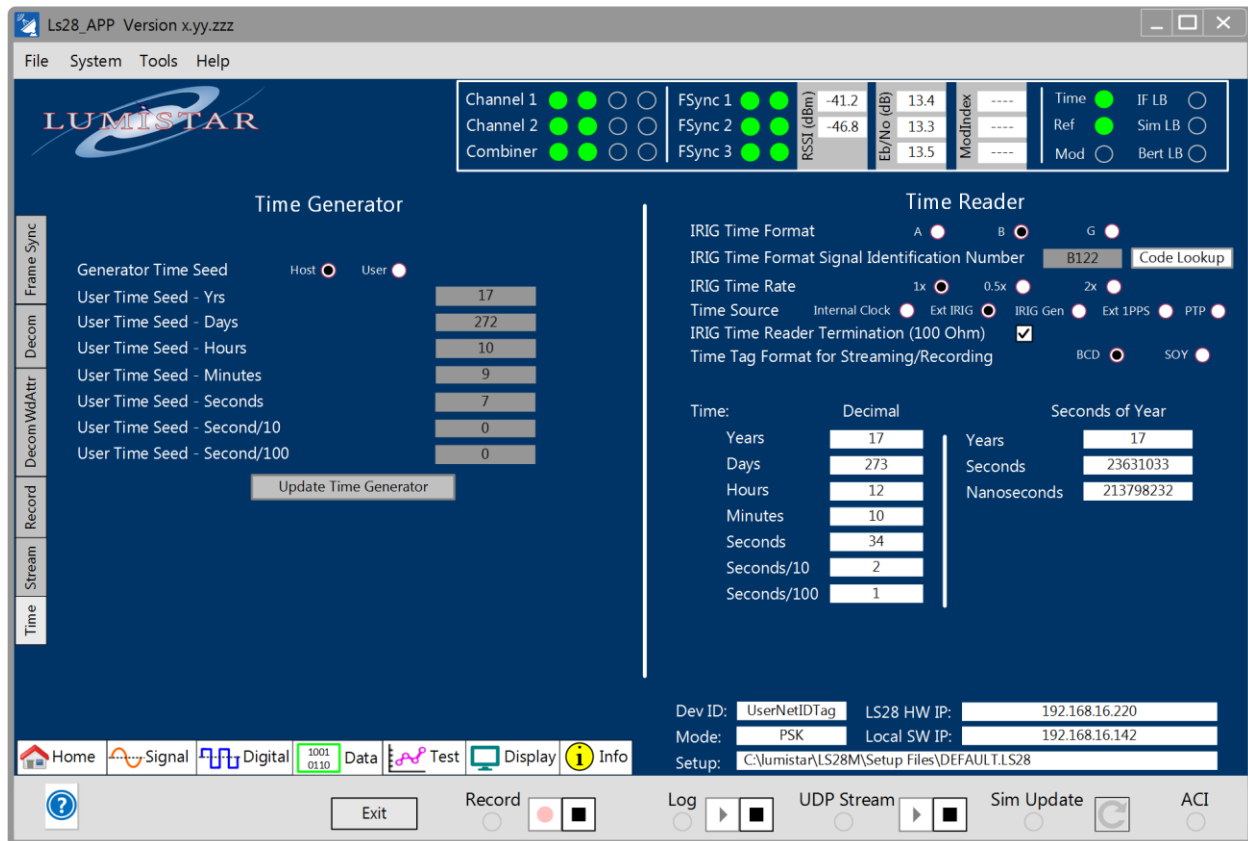


Figure 4-62 Network User Application – Data Sub-function Select: Time

4.5.7.1 Data Time Tab – Left Pane

The left pane of the Data Time sub-function tab contains controls for the setup of the LS-28-DRSM time generator.

Generator Time Seed: This left pane radio-button allows the user to select from two time generator seed sources: the host source time or user entered time. If the user time seed is selected, the user must fill in all of the time values defined. Either selection mode requires depressing the Update Time Generator button to seed the time.

User Time Seed - Yrs: This control entry box allows the user to enter time generator year seed values from 0 to 99.

User Time Seed - Days: This control entry box allows the user to enter time generator day seed values from 0 to 366.

User Time Seed - Hours: This control entry box allows the user to enter time generator hour seed values from 0 to 23.

User Time Seed - Minutes: This control entry box allows the user to enter time generator minutes seed values from 0 to 59.

User Time Seed - Seconds: This control entry box allows the user to enter time generator seconds seed values from 0 to 59.

User Time Seed – Second/10: This control entry box allows the user to enter time generator tenths of seconds seed values from 0 to 9.

User Time Seed – Second/100: This control entry box allows the user to enter time generator hundredths of seconds seed values from 0 to 9.

Update Time Generator: This control button applies the user seeded time values to the time generator.

4.5.7.2 Test BERT Tab – Right Pane

The right pane of the Data Time sub-function tab contains controls for the setup of the LS-28-DRSM time reader as well as status of the present reader time.

IRIG Time Format: This three-position radio button allows the user to select the IRIG-200 time format as one of three choices: IRIG A, IRIG B or IRIG G. IRIG time format selections will automatically be assigned to the IRIG time generator.

These formats are the most commonly used but other formats are available. Consult the factory for availability.

IRIG Time Format Signal Identification Number: The IRIG-200 specification has a complex time format signal identification scheme outlined within the specification. This identification scheme composes 38 several time signal criteria into an identification number. Time format signal selections will automatically be assigned to the IRIG time generator. Figure 4-63 outlines the assignment number scheme.

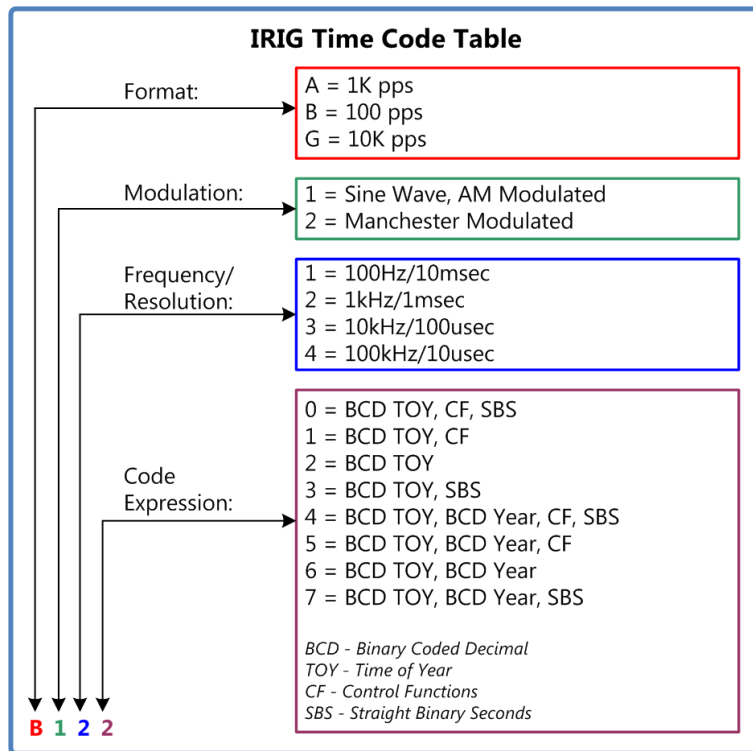


Figure 4-63 IRIG Time Identification Codes

This drop-down list right-pane control allows the user to select from a number of provided IRIG time formats. For each IRIG time format selected by the IRIG Time Format radio buttons, the list will change.

Code Lookup: This button provides the user with the contents shown in Figure 4-63 as reference for simple correlation of identification number parameters.

IRIG Time Rate: The IRIG time reader can accept time at rates that are $\frac{1}{2}$ normal rate or twice normal rate for certain functions. This three-position radio button allows the user to select for normal rates or any of the other provided time rates. Time rate selections will automatically be assigned to the IRIG time generator.

Time Source: There are five selections for the time reader source: Internal Clock, External IRIG input, IRIG generator, External 1PPS or PTP. When in Internal Mode, the time reader is connected to the time source from with the FPGA which is uncorrelated with external time.

When External IRIG mode is selected, the time source will flywheel based on internal clock values and will wait for a signal from the time input port of J4 Pin1. If one does not exist, the time values will increment based on internal time clocks until a source provides a time to which it can synchronize at which time it will use that applied time.

If the IRIG generator is selected, the IRIG source will come from the on-board generator. With this selection, the IRIG AM port on J4 will be switched to an output port as will the IRIG digital time port on J12. Ensure that these connections do not contain driving sources prior to making this selection.

**Warning:**

Do not select the on-board IRIG generator as a time source if other sources are connected to the IRIG AM I/O port of J4 or the TIME DIO signal of J12. Doing so may damage the output drivers of the LS-28-DRSM or the connected devices.

If the external 1PPS source is selected, the time will synchronize to a one pulse-per-second (1PPS) source provided to the LS-28-DRSM. This source may be applied to the J12 TIME DIO port. With this selection, the IRIG AM port on J4 will be switched to an input port as will the IRIG digital time port on J12.

If a network based PTP time source is available, and the PTP licensing option is enabled, the PTP button will become active. Selecting this button will use the PTP time source as synchronized time. This time source is almost always the most accurate time source available. If no PTP network source is detected by the LS-28-DRSM, this selection will be disabled.

1PPS Source: This selection control is used in conjunction with the Time Source selection being placed in the External 1PPS mode. When this mode is active, this control switches between two different 1PPS sources: an external 1PPS source on TIME DIO of J12, or an internal 1PPS source from the Ethernet network hardware.

IRIG Time Reader Termination (100 Ohm): On many occasions, it may be desirable to terminate the IRIG time signal to maintain signal integrity. The LS-28-DRSM time reader provides a software selectable 100 ohm termination to ground at the time reader input. Normally, this termination is enabled but based on different user applications, it may be necessary to disable this termination.

Time Tag Format for Streaming/Recording: There are two formats of time for the streamed and recorded data: Binary Coded Decimal (BCD) or Seconds of Year (SOY). Both formats offer different capabilities. BCD formatted data offers better readability when data is being examined using standard tools since time has been encoded essentially in Decimal format. SOY provides time stamps with a much finer resolution than that achievable in standard IRIG formats. Time increments in SOY mode in 8 nanosecond increments opposed to the 10 microsecond resolution of IRIG G. Reference section 5 of the *LS-28M Interface Control Document* for additional time source format information.

Time – Decimal Years: This right pane status update field will display the current year information if the time format selected provides for year related transfers. Values between 0 and 99 may be displayed.

Time – Decimal Days: This right pane status update field will display the current day information from the time reader registers. Values between 0 and 366 may be displayed.

Time – Decimal Hours: This right pane status update field will display the current hour information from the time reader registers. Values between 0 and 23 may be displayed.

Time – Decimal Minutes: This right pane status update field will display the current minute information from the time reader registers. Values between 0 and 59 may be displayed.

Time – Decimal Seconds: This right pane status update field will display the current second's information from the time reader registers. Values between 0 and 59 may be displayed.

Time – Decimal Seconds/10: This right pane status update field will display the current tenths of seconds information from the time reader registers. Values between 0 and 9 may be displayed.

Time – Decimal Seconds/100: This right pane status update field will display the current hundredths of seconds information from the time reader registers. Values between 0 and 9 may be displayed.

Time – Seconds of Year Year: This right pane status update field will display the current year information if the time format selected provides for year related transfers. Values between 0 and 99 may be displayed.

Time – Seconds of Year Seconds: This right pane status update field will display the current year time value in seconds. Values between 0 and 31,622,400 may be displayed.

Time – Seconds of Year Nanoseconds: This right pane status update field will display the current nanosecond time value. In reality, this time window value increments in 8 nanosecond increments making this the smallest measurable increment of the LS-28-DRSM

4.6 Function Select Tab – Test

The Test select tab provides the user with a number of system test functions including transmit and receive Bit Error Rate Testers (BERT), and an IF test modulator. The function select tab contains three sub-function tabs: BERT, Modulator, and PCM ENC.

4.6.1 Test Sub-function Select Tab – BERT

This sub-function tab is provided for Bit Error Rate Testing (BERT) functions. The LS-28-DRSM provides up to six receiver BERTs, referred to as RX BERTs, and two transmission BERTs, referred to as TX BERTs. Refer to Figure 4-64 for tab layout.

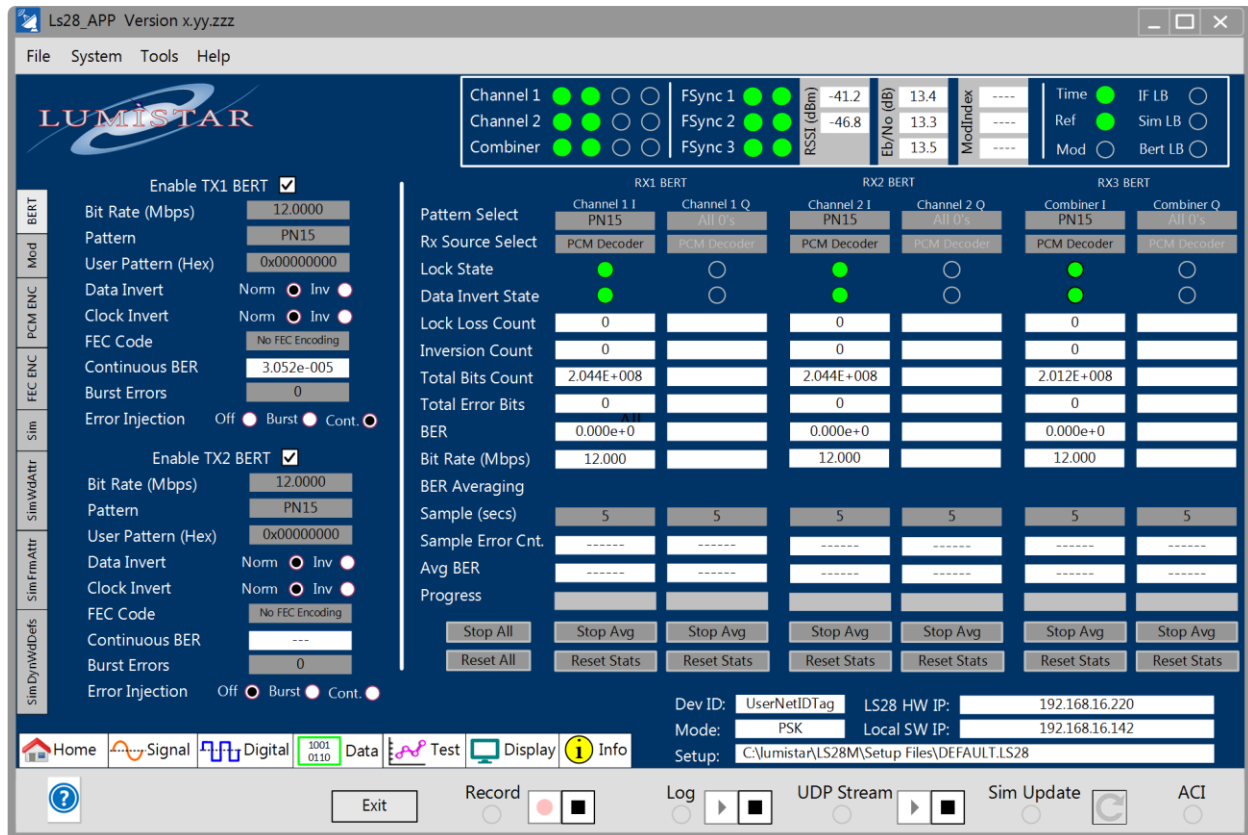


Figure 4-64 Network User Application – Test Sub-function Select: BERT

4.6.1.1 Test BERT Tab – Left Pane

The Test BERT left pane area contains controls for the two LS-28-DRSM TX BERTs.

Enable TX1/TX2 BERT: This check-box control enables the functions of the respective transmit (TX) BERT. Deselecting this control will disable the functions of the respective TX BERT.

Bit Rate (Mbps): Entry of the TX BERT bit rate is done via this dialog box. Entry of values between 1000 and 60Mbps are allowed.

Pattern Select: Data patterns for the TX BERT can be selected from this drop-down list. Pattern options include pseudo-random sequences, repetitive patterns and user patterns. The list is as follows: All 0's, All 1's, Alternating 0's and 1's, PN3, PN4, PN5, PN6, PN7, PN9, PN10, PN11, PN15, PN17, PN18, PN20, PN21, PN22, PN23 and a selectable User Pattern.

User Pattern (Hex): A user defined pattern of up to 31 bits can be entered in hexadecimal in this dialog box. For this pattern to be active, the Data Pattern window must be set to "User Pattern".

Data Invert: The TX BERT data pattern polarity can be altered via this left pane control radio button.

Clock Invert: The TX BERT clock polarity can be altered via this left pane control radio button.

FEC Code: This entry box allows the user to select the Forward Error Correction Code to apply to the test data source.

Continuous BER: This status box will contain the resulting calculated BER value that will be expected when the Error Injection selection is "Continuous". Values will appear in scientific notation.

Burst Errors: This control box allows the user to enter from 1 to 64 errors to burst into the TX BERT output stream. Burst errors are, by definition, patterns which are inverted from their normal polarity state. Patterns longer than 64 bits will be re-correlated and redefined by typical RX BERTS as locked in an inverted state.

Error Injection: This set of radio buttons select the TX BERT error injection mode. Three options are provided: OFF, BURST, and CONT (continuous). When the OFF option is selected, no TX BERT errors will be injected. When the BURST mode is selected, a BURST button will be presented directly to the left of the Burst Error Control box. Each time the button is selected, a burst of the number of errors indicted in the Burst Error control box will be inserted in the output of the TX BERT data stream. If the CONT button is selected, a single bit error will be injected in each pattern cycle. This will result in a continuous BER rate as indicated in the "Continuous BER" status pane.

4.6.1.2 Test BERT Tab – Right Pane

The Test BERR right pane occupies the majority of the tab display area and contains the results of the RX BERT functions.

Pattern Select: Data patterns for the receive (RX) BERT can be selected from this drop-down list. Pattern options include pseudo-random sequences, repetitive patterns and user patterns. The list is as follows: All 0's, All 1's, Alternating 0's and 1's, PN3, PN4, PN5, PN6, PN7, PN9, PN10, PN11, PN15, PN17, PN18, PN20, PN21, PN22, PN23 and a selectable User Pattern.

RX Source Select: This drop-down menu allows the user to select the source for the RX BERT channel being controlled. Options include: PCM Decoder, Ext SE1 Input, Ext SE2 Input, Ext DIFF1 Input, Ext DIFF2 Input, Loopback. The PCM decoder is the main receiver PCM decoder in the LS-28-DRSM receiver. The selections of Ext SE1, Ext SE2, Ext DIFF1, and Ext DIFF2 allow the user to direct external sources to the RX BERT inputs. Loopback is an internal connection between the TX1 or TX 2 BERT and the six RX BERTs. In

loopback mode, TX1 BERT is connected to the I-Channel RX BERT channels. In loopback mode, TX2 BERT is connected to the Q-Channel RX BERT channels.

Lock State: This LED indicator provides the present state of the RX BERT pattern correlator. A green indication indicates that the receive correlator is locked to the selected pattern. If the indicator is yellow, the correlator is unable to establish lock.

Data Invert State: This LED indicator provides the present status as to whether the data that the RX correlator is receiving is presently polarity inverted or non-inverted. In the inverted state, the LED indicator will be yellow. If the pattern is not inverted, the LED will contain no color.

Lock Loss Count: This status box contains a count of the number of times the RX BERT has lost lock since the last reset.

Inversion Count: This status box contains a count of the number of times the RX BERT has detected a pattern inversion since the last reset. This count includes all inversion counts including one to an inverted state and from an inverted state.

Total Bit Count: This status box contains the total number of bits that the RX BERT has counted since the last reset condition.

Total Error Count: This status box contains the total number of error bits that the RX BERT has counted since the last reset condition.

Calculated BER: This status box contains a calculation of the Bit Error Rate (BER). For this status box, the BER calculation takes the total number of errors counted and divides that number by the total number of bits counted. This calculated value is not a time-averaged value but a long-term trend calculation.

Bit Rate (Mbps): This status box provides the present bit rate being received for the specified channel. Values are provided in Mbps.

Loopback: Selection of this check box internally loops the TX BERT to the RX BERT channels. TX1 BERT will be looped back to RX1 BERT. TX2 BERT will be looped back to both the RX2 and RX3 BERTs.

Sample (Secs): The lower area of the right pane contains an averaged BER calculation section. Each channel can setup a sample period and calculate the average BER over a given period. To set the averaging period, enter a value in seconds between 2 and 86400 (1 day) in the resulting dialog box.

Avg Errors: The number of errors per second over the averaged period will be displayed in this status box.

Avg BER: The calculated average BER figure will be displayed in this status box. This will be a calculation of the number of bit errors accumulated in the Sample period divided by the number of bits counted in the averaging period.

Progress: The progress status bar provides a visual feedback of the progress on averaging process. As the process progresses, a bar will fill from the left to the right of the display area.

Stop/Start Avg: This toggle button is used to initiate and halt the averaged BER calculations for a selected RX BERT channel.

Reset Stats: This toggle button is used to clear the bit error and clock counts used for BER calculations on a selected RX BERT channel. Only active channels apply to this button.

Stop/Start All: This toggle button is used to initiate and halt the averaged BER calculations for all six RX BERT channels. Only active channels apply to this button.

Reset All: This toggle button is used to clear the bit error and clock counts used for all BER calculations for all six RX BERT channels. Only active channels apply to this button.

4.6.2 Test Sub-function Select Tab – Modulator

If the IF modulator is licensed on the unit, and the unit is of a supporting hardware version, this sub-function tab will be active. This Test sub-function tab is provided for IF Test Modulator functions. Refer to Figure 4-65 for tab layout.

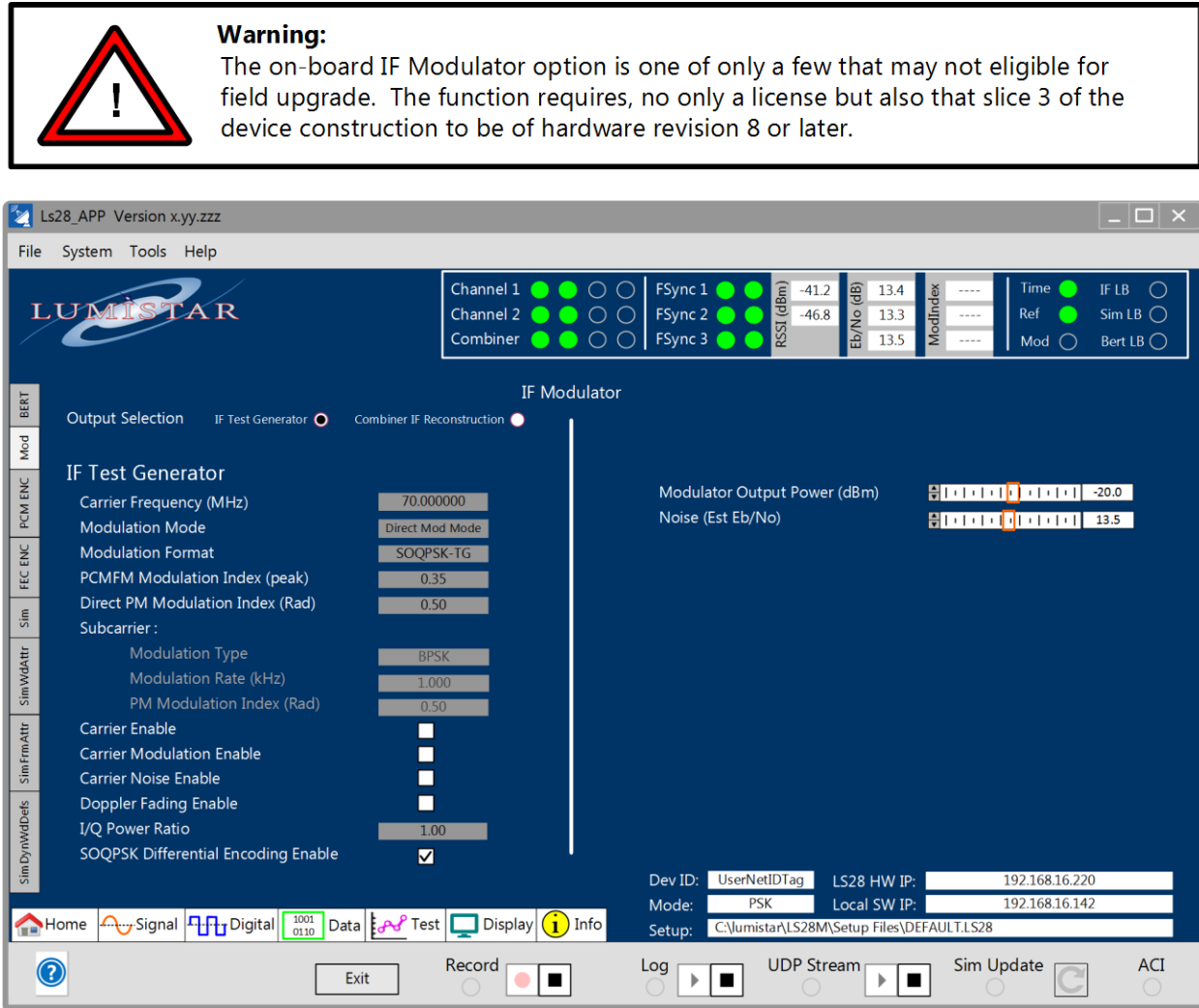


Figure 4-65 Network User Application – Test Sub-function Select: Modulator

4.6.2.1 Test Modulator Tab – Left Pane

The Test Modulator left pane area contains controls for the LS-28-DRSM on-board modulator source.

Output Selection: These radio buttons allow the user to direct the use of the IF output modulator. Two selections are provided: IF Test Generator and Combiner IF Reconstruction.

To use the IF modulator output as a reconstructed combiner IF output, the right-hand radio button should be selected. When selected, the video I/Q baseband signals from the output of the internal IF combiner are automatically routed to the IF modulator and then up-converted to be centered at 70MHz. Signals that are

routed have been filter and processed by the signal processing engine prior to the upconversion process. When this mode is selected, the defined operations disable the majority of controls on the left-hand tab.

To use the IF modulator output as a test output, the left-hand radio button should be selected. When selected, the sources of data to the modulator are controlled by the TEST- PCM ENC sub-tab. To utilize the IF modulator as a test or stimulation source for the receiver, loop-back controls must be engaged on the HOME tab along with the carrier and modulation being enabled on this tab. See section 4.2.1 for additional details.

Carrier Frequency (MHz): This control dialog box allows the user to enter the on-board IF modulator center frequency. Typically, this value is set to 70MHz. The range of acceptable carrier frequency entries is 1MHz to 100MHz.

Modulator Mode: This dialog box allows the user to control the modulator's operational mode. There are two operational modes provided: Direct Modulation and Subcarrier Modulation mode. Most of the modulation formats offered fall into the direct modulation mode. Subcarrier mode is for PM/BPSK, PM/QPSK and PM/OQPSK. When the mode is selected as subcarrier mode, the subcarrier related controls will become active.

Modulation Format: To select the modulation type, the user can select the IF modulation format from a drop-down list that contains the following selections: BPSK, QPSK, OQPSK, UQPSK, UAQPSK, PM-Direct, SOQPSK-TG, SOQPSK-MIL, MHCPC, PCMF, and AQPSK.

PCMF Modulation Index (peak): When the PCMF modulation mode is selected, this control setting allows the user to adjust the FM modulation index for values between 0.1 and 4.0. The default and normal setting is 0.35.

Direct PM Modulation Index (Rad): When the Direct PM modulation mode is selected, this control setting allows the user to adjust the PM modulation index between 0.00001 and 3.14159 radians. Nominal settings are 0.500 radians.

Subcarrier - Modulation: When the modulation mode is selected as Subcarrier PM/PSK, this value allows the user to select between the BPSK, QPSK and OQPSK subcarrier modes.

Subcarrier – Modulation Rate (MHz): To select the Sub-carrier modulation rate, this control box allows the user to set the rate from 0.001 and 10MHz.

Subcarrier – PM Modulation Index (Rad): When the Subcarrier PM Modulation mode is selected, this control setting allows the user to adjust the PM modulation index between 0.00001 and 3.14159 radians. Nominal settings are 0.500 radians.

Carrier Enable: To enable the IF modulator carrier, this control check-box is provided. Enabling the carrier will initiate transmissions from the IF modulator but will not modulate that carrier. This control is typically disabled each time the application is started to prevent the user from falsely interpreting a signal seen in the HOME tab graphs as a signal that has been received.

Carrier Modulation Enable: To enable the IF modulator carrier modulation, this control check-box is provided.

**Information:**

The **Carrier Enable** and the **Carrier Modulation Enable** will be automatically disabled at power up and between setup loads to prevent confusion between real and test signals. This can be overridden in SYSTEM – OPTIONS – STARTUP menu.

Carrier Noise Enable: The IF modulator contains an on-board Average White Gaussian (AWG) noise source which can be mixed directly into the modulator output. This control check-box is provided to enable and disable the AWGN source. *(Future option. Details of this operation will be provided at the time of implementation.)*

Doppler Fading Enable: This check box engages the doppler fading provisions of the IF test modulator. *(Future option. Details of this operation will be provided at the time of implementation.)*

I/Q Power Ratio: This control entry box allows the user to adjust the I/Q power ratios in the AUQPSK and AQPSK modes. The ratio of I signal power to Q signal power can be set between 0.00001 and 100. The nominal power setting ratio is 1.00.

SOQPSK Differential Encoding Enable: This check box allows the enabling and disabling of the differential encoding provided by the IF Test modulator. The LDPC mode requires that SOQPSK differential encoding be disabled. Standard SOQPSK-TG and SOQPSK-MIL require that differential encoding be enabled.

4.6.2.2 Test Modulators Tab – Right Pane

Modulator Output Power (dBm): This slide bar and dialog box allows the user to adjust the modulator's IF output level over a range from -2dBm to -90dBm.

Noise (Est. Eb/No dB): This slide bar and dialog box allows the user to adjust the modulator's carrier additive noise output level. *(This function will be available in the future.)*

4.6.3 Test Sub-function Select Tab - PCM ENC

This Test sub-function tab provides controls for test data source encoding functions. Refer to Figure 4-66 for tab layout.

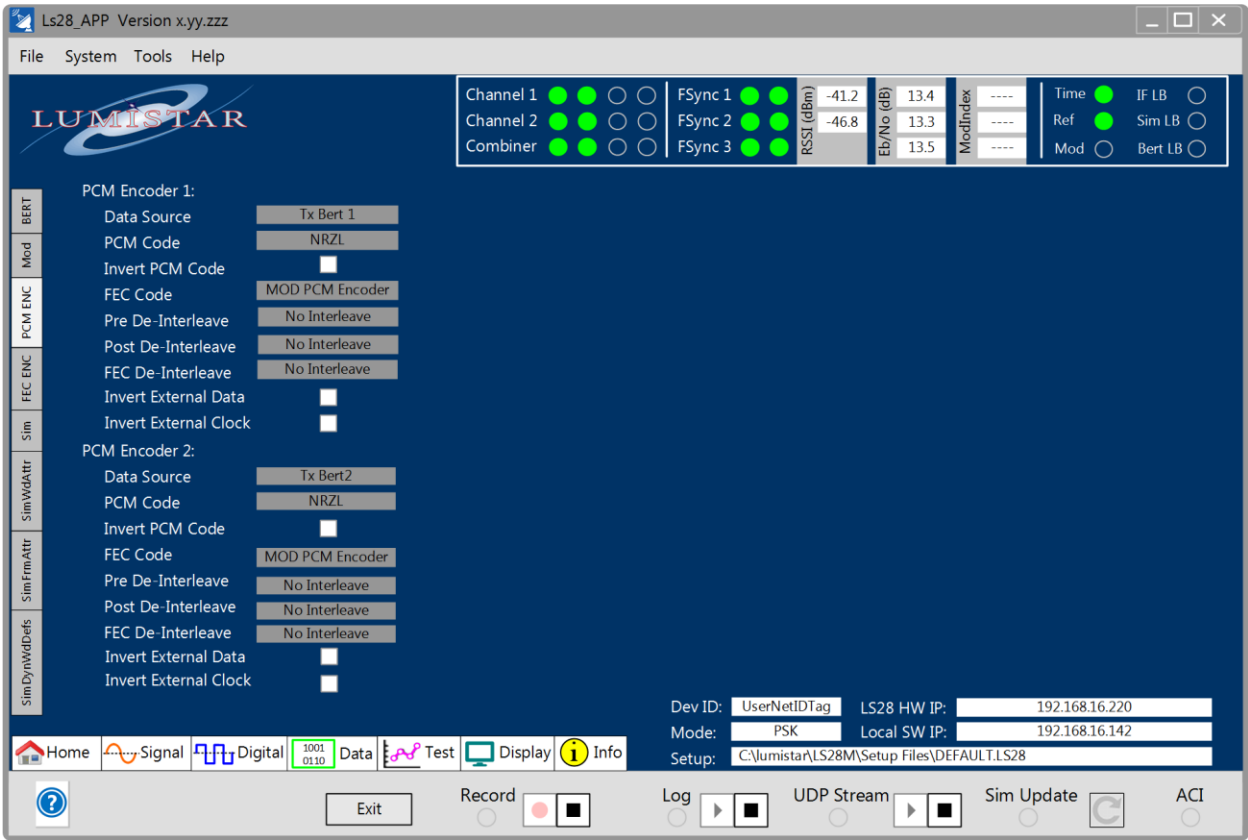


Figure 4-66 Network User Application – Test Sub-function Select: PCM Encoder

4.6.3.1 Test PCM ENC Tab – Left Pane

The Test PCM ENC left pane area contains controls for the LS-28-DRSM on-board modulator PCM Encoders.

PCM Encoder – Data Source: The data source for the PCM encoder to the LS-28-DRSM includes several sources. This control drop-down list allows the user to select the source from one of the following sources: TX BERT1, TX BERT2, PCM Simulator 1, and PCM Simulator 2. Future enhancements include the ability to utilize external clock and data sources.



Information:

External input selections for the PCM Encoder sources are presently disconnected. These selections will be available in future releases.

PCM Encoder – PCM Code: The source of the PCM is provided in a given format. The modulator must be programmed to the PCM code in which data is provided. Table 4-1 contains a list of the PCM code provisions of the LS-28-DRSM. The user must select one of these formats.

PCM Encoder – Invert PCM Code: This check box inverts the PCM polarity selected in the PCM Code control window.

PCM Encoder – FEC Code: The LS-28-DRSM can be licensed for various FEC encoding schemes. Three selections are provided: MOD PCM Encoder, Convolutional Enc, and LDPC Encoder. If no FEC encoding is required, the MOD PCM Encoder selection should be selected. If the Convolutional Enc option is selected, the Viterbi (convolutional) encoding selections as directed by settings in the TEST – FEC ENC sub-tab. If LDPC encoding is selected, settings in the TEST – FEC ENC sub-tab will be used to change output encoding.

Pre De-Interleave: The user may opt to deinterleave the input prior to the PCM encoder(s). The default for this setting is No Interleave. This command allows the FEC encoder to separately encode the I and Q streams independently of each other. Other options include: Internal Deinterleave, External Deinterleave.

Post De-Interleave: The user may opt to deinterleave the input after the PCM encoder(s). The default for this setting is No Interleave. This command allows the FEC encoder to separately encode the I and Q streams independently of each other. Other options include: Internal Deinterleave, External Deinterleave.

FEC De-Interleave: The user may opt to deinterleave the input within the FEC encoder. The default for this setting is No Interleave. This command allows the FEC encoder to separately encode the I and Q streams independently of each other. Other options include: Internal Deinterleave, External Deinterleave.

Invert External Data: This selection allows the user to invert the external data input.

Invert External Clock: This selection allows the user to invert the external clock input.

4.6.4 Test Sub-function Select Tab – FEC ENC

This Test sub-function tab provides controls and status for FEC Encoding of Test data sources. Refer to Figure 4-67 for tab layout.

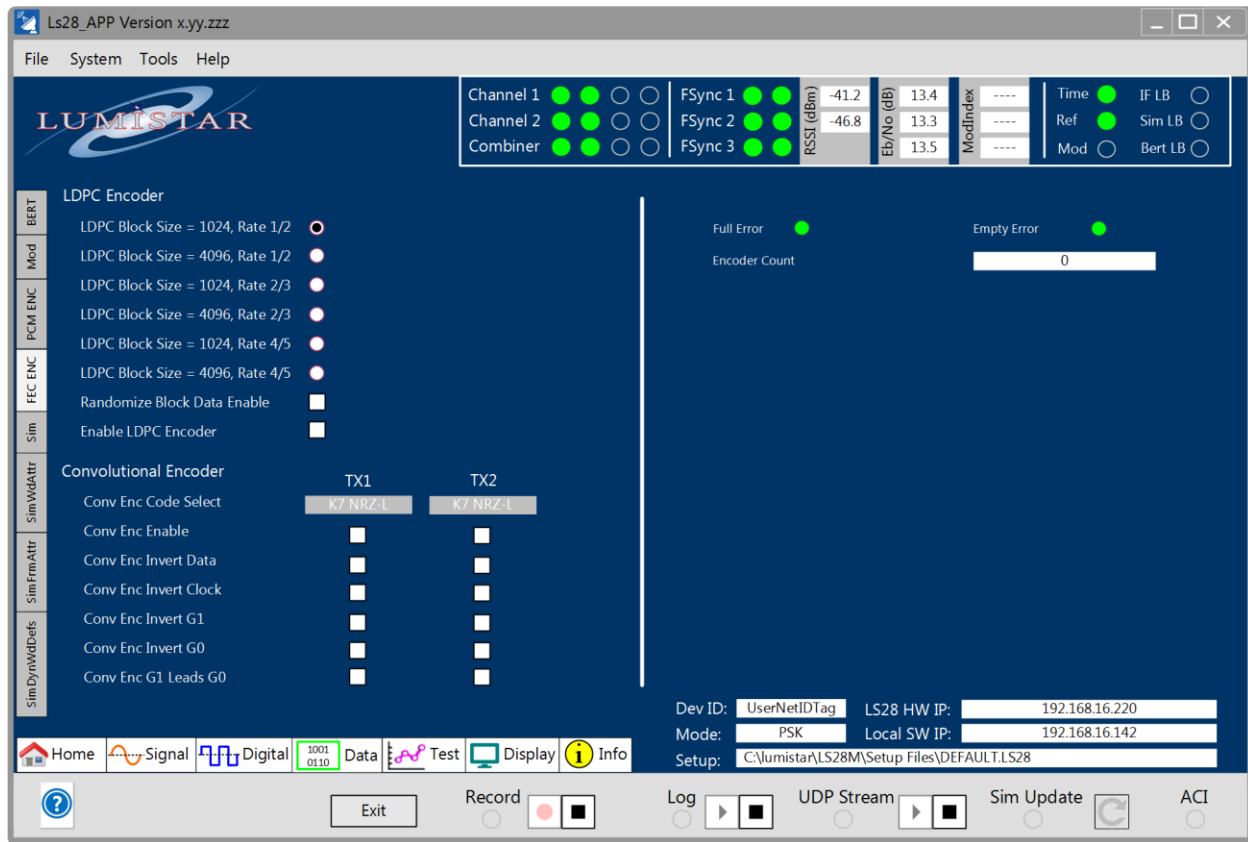


Figure 4-67 Network User Application – Test Sub-function Select: FEC ENC

4.6.4.1 Test FEC ENC Tab – Left Pane

The Test FEC ENC left pane area contains controls for the LS-28-DRSM on-board modulator FEC Encoders.

LDPC Encoder – LDPC Block Size/Rate Selections: LDPC Encoding is a Block Encoding method. Block encoding requires inputs to the encoding for data block size and the encoding rate. Six radio buttons are provided to select the combinations of block and rate settings that are matched with the decoding options that are provided in the receive chain. These block/rate combinations are based on the combinations defined by IRIG-106 specifications.

Selections include: Block Size = 1024/Rate = 1/2, Block Size = 4096/Rate = 1/2, Block Size = 1024/Rate = 2/3, Block Size = 4096/Rate = 2/3, Block Size = 1024/Rate = 4/5, Block Size = 4096/Rate = 4/5.

LDPC Encoder – Randomize Block Data Enable: The selection box allows the randomization of the block data with the LDPC encoding packages. If deselected, randomization is not performed.

LDPC Encoder – Enable LDPC Encoder: This selection box allows the LDPC encoder to be enabled and disabled. If the box is checked, the LDPC encoder is enabled. If deselected, the LDPC encoder will be disabled.

Convolutional Encoder – Conv Enc Code Select: This drop-down menu allows the user to select the convolutional encoder PCM code and constraint setup. There are four allowed selections implemented: $K=7/\text{NRZ-L}$, $K=7/\text{NRZ-M}$, $K=4/\text{NRZ-L}$, and $K=4/\text{NRZ-M}$. It is worth noting that the constraint length of the Viterbi decoder in the LS-28-DRSM is fixed at $K=7$.

Convolutional Encoder – Conv Enc Enable: This selection box allows the convolutional encoder to be enabled and disabled. If the box is checked, the convolutional encoder is enabled. If deselected, the convolutional encoder will be disabled.

Convolutional Encoder – Conv Enc Invert Data: This selection box allows the convolutional encoder's data output polarity to be altered. If the box is checked, the convolutional encoder data output will be inverted. If deselected, the convolutional encoder data output will be normal polarity.

Convolutional Encoder – Conv Enc Invert Clock: This selection box allows the convolutional encoder's clock output polarity to be altered. If the box is checked, the convolutional encoder clock output will be inverted. If deselected, the convolutional encoder clock output will be normal polarity.

Convolutional Encoder – Conv Enc Invert G1/G0: This selection box allows the convolutional encoder's G0 and G1 polynomial output polarities to be altered. If the box is checked, the convolutional encoder polynomial output polarity will be inverted. If deselected, the convolutional encoder polynomial output polarity will be normal.

Convolutional Encoder – Conv Enc G1 leads G0: This selection box allows the convolutional encoder's G1 and G0 polynomial output orders to be altered. If the box is checked, the convolutional encoder polynomial G1 will lead the G0 output. If deselected, the convolutional encoder G0 will lead the G1 output.

4.6.4.2 Test FEC ENC Tab – Right Pane

The Test PCM ENC left pane area contains controls for the LS-28-DRSM on-board modulator PCM Encoders.

FEC Encoder – Full Error: The full error LED will be yellow if there is an error condition during the encoding process associated with the data FIFO. This LED status will be pertinent only when using external sources for encoding streams. This LED will be Green normally.

FEC Encoder – Empty Error: The full error LED will be yellow if there is an error condition during the encoding process associated with the data FIFO. This LED status will be pertinent only when using external sources for encoding streams. This LED will be Green normally.

FEC Encoder – Encoder Count: This status box shows the count of the number of LDPC packets that have been packaged by the internal LDPC encoder. This count will increment over time.

4.6.5 Test Sub-function Select Tab – SIM

This Test sub-function tab provides controls for test PCM Simulator. PCM Simulators will be provided whenever the licensing of decommutation functions is enabled. Refer to Figure 4-68 for tab layout.

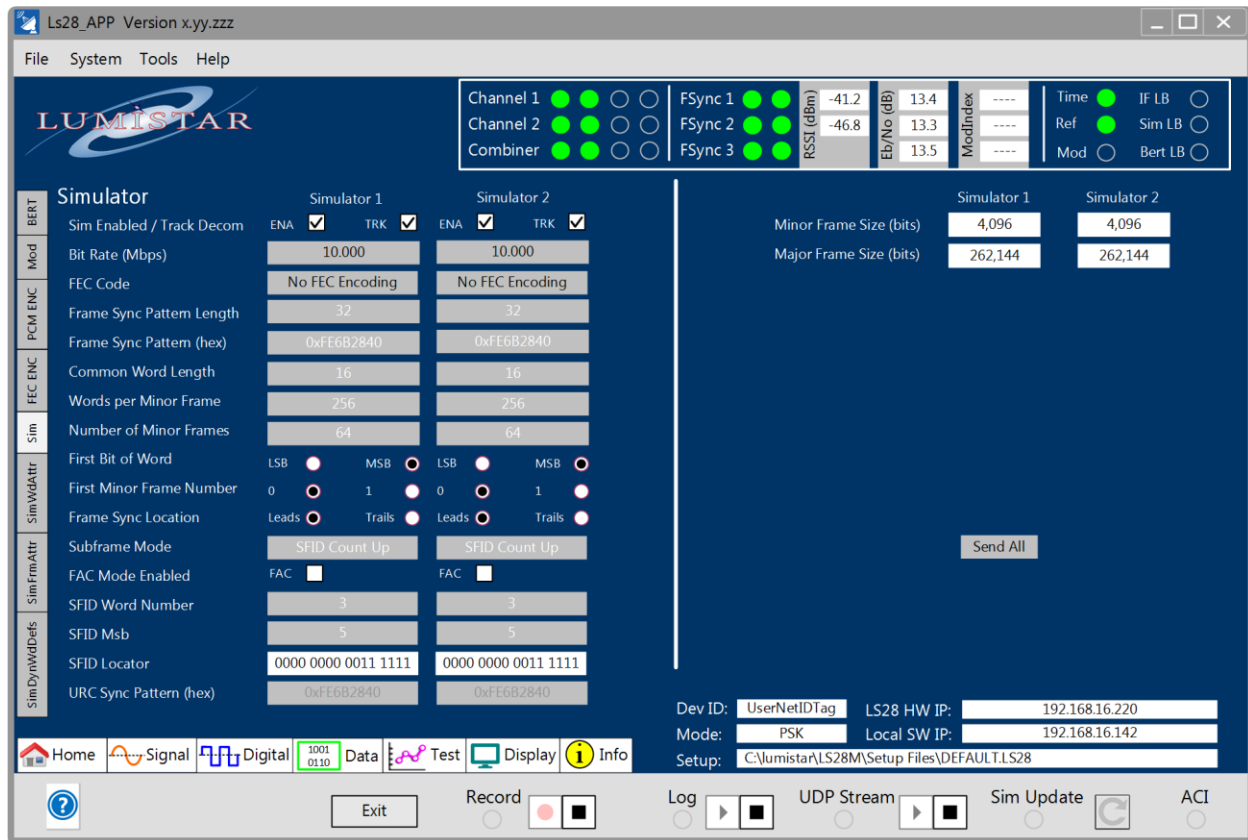


Figure 4-68 Network User Application – Test Sub-function Select: SIM

4.6.5.1 Test SIM Tab – Left Pane

The Test SIM left pane area contains controls for the LS-28-DRSM on-board PCM Simulators. There are two independent and autonomous PCM simulators provided. Control definitions below apply to each of the simulators.

Simulator – Sim Enabled/Track Decom: The SIM ENA check box allows the user to enable and disable the simulator functions on the LS-28-DRSM for each simulator. When the box is checked, the simulator is active. When unchecked, the simulator is disabled.

Setting the associated parameters for the simulator is a tedious process that can become frustrating when attempting to synchronize the simulator with an associated decom setup. The TRK check box allows the user to have the setup of the decom setup copied directly to the simulator. This is referred to as “tracking the decom”. Checking this box enables this automatic process. If the box is unchecked, simulator settings can be set at will.

There are some items that are either unknown or require further definition even when the TRK box is selected. These include, but are not limited to, the desired bit rate, and the simulator word content.

When the TRK mode is enabled, many of the tab controls will become disabled and will only be able to be changed by changes set on the DATA-FRAME SYNC and DATA – DECOM tabs.

Simulator – Bit Rate: This control box allows the user to set the desired PCM simulator bit rate. Values from 1Kbps to 60Mbps are allowed.

Simulator – FEC Code: This drop-down menu box allows the user to select the FEC encoding style desired for the PCM Simulator data stream. The menu selections include:

No FEC Encoding

LDPC K1024 R12 (Block Size = 1024, Rate = 1/2)

LDPC K4096 R12 (Block Size = 4096, Rate = 1/2)

LDPC K1024 R23 (Block Size = 1024, Rate = 2/3)

LDPC K4096 R23 (Block Size = 4096, Rate = 2/3)

LDPC K1024 R45 (Block Size = 1024, Rate = 4/5)

LDPC K4096 R45 (Block Size = 4096, Rate = 4/5)

Convolutional R1/2 (Constraint Length = 7, Rate = 1/2)

Reed/Solomon

Simulator – Frame Sync Pattern Length: This control box allows the user to set the desired PCM Simulator Frame Sync pattern length. Values from 7 to 64 are supported. Values set in this window will cause the Frame Sync Pattern controls to be automatically filled with the IRIG-106 defined Barker code. However, this value can be altered manually by the user if desired.

Simulator – Frame Sync Pattern: This control box allows the user to set a specific Simulator Frame Sync pattern as defined by the Frame Sync Pattern Length control. As indicated, this value will be automatically filled with the IRIG-106 specified Barker code based on the Frame Sync Pattern length entry. However, it is possible for the user to alter this pattern if desired.

Simulator – Common Word Length: This control box allows the user to set a specific a Simulator Common Word Length. Values from 3 to 16 bits may be entered.

Simulator – Words Per Minor Frame: This control box allows the user to set the number of words defined in a minor frame. Values from 3 to 65536 words may be entered.

Simulator – Number of Minor Frames: This control box allows the user to set the number of minor frames that make up a major frame. Values from 1 to 65536 words may be entered.

Simulator - First Bit of Word: This radio button control allows the user to set up the meaning of the first bit in a given word. Selections of Most Significant Bit (MSB) and Least Significant Bit (LSB) are provided.

Simulator - First Minor Fame Number: Simulator minor frames can be numbered starting with 0 or 1. This radio button control allows the user to select the number of the first frame.

Simulator - Frame Sync Location: The user can specify the location of the frame sync pattern within the simulation frame by the use of this radio button. If the frame sync pattern is at the front of the frame the user should select LEADS. Conversely, if the frame sync pattern is at the end of the data transmission the user should select the TRAILS option. Reference Figure 4-44 for illustration.

Simulator - Subframe Mode: To implement a Simulation subframe synchronization scheme, telemetry designers often add one or more "special" words to each minor frame. The frame synchronizer then uses the special words to establish the location of the first minor frame in the major frame. The LS-28-DRSM simulator supports five options in terms of subframe synchronization modes: None, SFID Counting Up, SFID Counting Down, FCC, and URC.

When NONE is select, the PCM simulator will consider that no sub-frame mode is implemented.

When SFID Counting Up is selected, the simulator will assume that the unit is utilizing a Subframe ID (SFID) Counter that is counting up in value. The count will start from 0 or 1 as directed by the First Minor Frame Number setting.

When SFID Counting Down is selected, the simulator will assume that the unit is utilizing a Subframe ID (SFID) Counter that is counting down in value. The count will terminate in either 0 or 1 as directed by the First Minor Frame Number setting.

SFID use is illustrated in Figure 4-45.

Frame Code Complement (FCC) mode is a method where the complement (inverted) synchronization pattern is placed in the FSP location in minor frame 0 by the PCM simulator. All other frame sync patterns are not inverted. Because the complement of the frame synchronization pattern exhibits the same correlation properties as the true pattern, frame sync lock will not be compromised. Minimum sync overhead is attained using this method, although it requires longer subframe acquisition time than the SFID method. FCC is illustrated in Figure 4-46.

Unique Recycling Code (URC) mode is a variation of FCC mode. For URC, a unique word is added anywhere in the first minor frame. A unique synchronization pattern *not* related to the primary synchronization pattern is used. This can replace the frame sync pattern or be at a different location in the first minor frame. URC is illustrated in Figure 4-47.

Simulator – FAC Mode Enabled: This simulator control places the PCM simulator in FAC mode. If this box is selected, the FAC mode is enabled. Deselecting this box disables the FAC mode.

Simulator - SFID Word Number: The location of the subframe identification (SFID) word(s) is arbitrary within the simulation minor frame and may be specified by the user with this control dialog box. As the LS-28-DRSM can support up to 65,536 words per minor frame, the user may thus locate the SFID word anywhere within this range, provided it does not overlap or coincide with the simulator frame synchronization pattern location.

Simulator - SFID MSB: The PCM Simulator SFID acts as a frame counter, but it is not always the case that all of the bits in the SFID word are used for this purpose. For example, the SFID word might be 16-bits in length, but there might only be 512 minor frames in the major frame. In this scenario, a 9-bit counter ($2^9 = 512$) would be required. The user would specify the location of the counter within the larger 16-bit word by setting the Sync ID most significant bit (MSB) command and selecting the appropriate bit position for the most significant bit of the SFID counter.

Simulator - SFID Locator: The Simulator SFID Locator is a status display that graphically illustrates where the Subframe Sync ID MSB is located within the minor frame SFID word.

Simulator - URC Sync Pattern (hex): If the Simulator URC mode has been selected in the Subframe Mode control list, the URC pattern must be defined. Up to a 64-bit URC pattern can be defined by the user.

4.6.5.2 Test SIM Tab – Right Pane

The Test PCM Simulator left pane area contains status for the LS-28-DRSM internal PCM Simulator and a "Send All" control button.

Simulator – Minor Frame Size (bits): This status window provides a calculation of the simulator's minor frame size in bits.

Simulator – Major Frame Size (bits): This status window provides a calculation of the simulator's major frame size in bits.

Simulator – Send All: This control button is used to send all related Simulator setup parameters to the internal firmware for setup. If a change has been made, a message is placed in the left pane stating "Changes have been made that need to be sent". At the same time the Sim Updates LED on the Real-time Controls banner will be illuminated green and the Sim Update button will be colored orange.

4.6.6 Test Sub-function Select Tab – SimWdAttr

This Test sub-function tab provides controls for setting simulator word attributes. Refer to Figure 4-69 for tab layout.

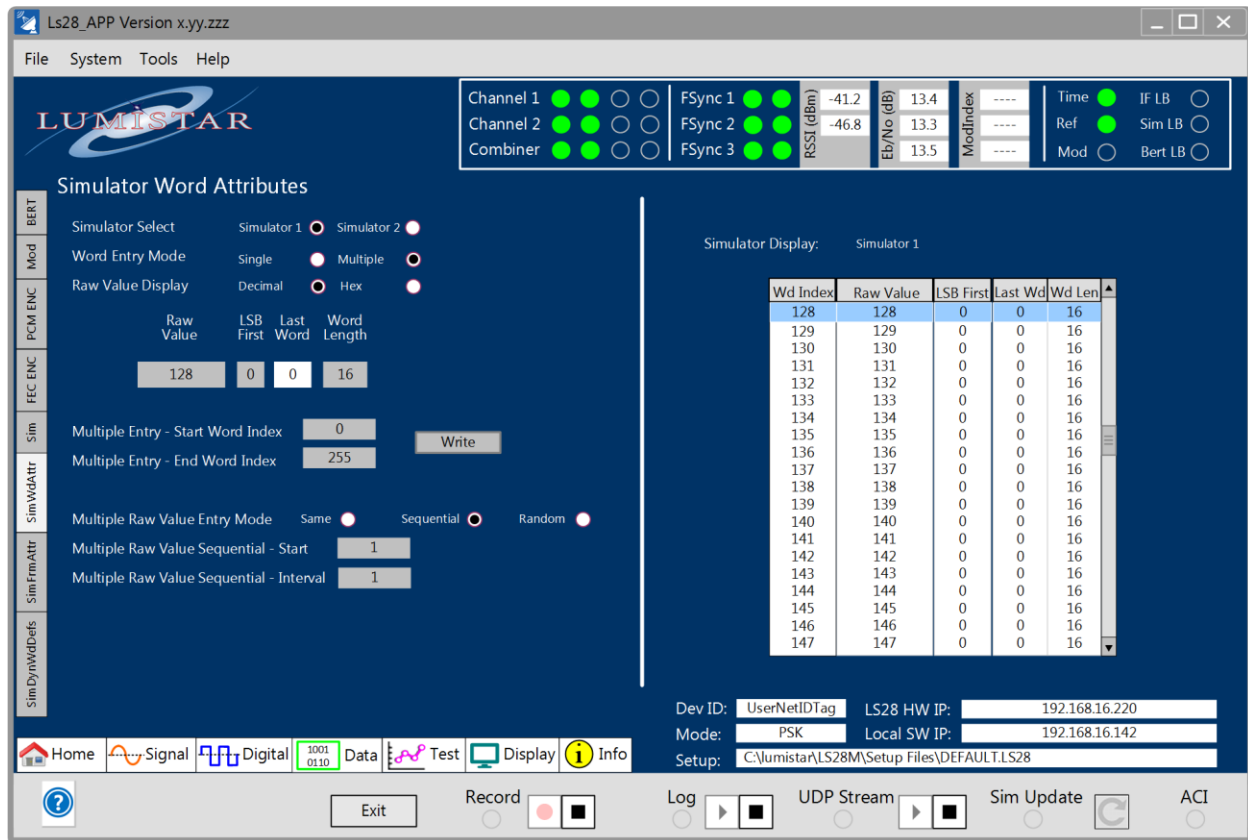


Figure 4-69 Network User Application – Test Sub-function Select: SimWdAttr

4.6.6.1 Test SimWdAttr Tab – Left Pane

The Test Simulator Word Attributes left pane area contains controls for the LS-28-DRSM.

Simulator Select: These radio button controls allow the user to select which PCM Simulator is being setup. Only one PCM Simulator can be setup at a time.

Word Entry Mode: These radio button controls allow the user to select whether the word entry mode is a single word at a time or multiple words will be setup at a given write.

Raw Value Display: These radio button controls allow the user to select whether data is displayed in the right pane Simulator Display as a hexadecimal or decimal values.

Raw Value: When a word index position within the Simulator Display window is selected, the control line Raw Value entry window will be filled. This value can then be modified, as desired, based on the word length.

LSB First: Upon selection of a word index position within the Simulator Display window, the control line LSB First entry window will appear. Setting the value of this control to 1 sets the associated word to LSB First configuration. If this value is set to 0, the bit orientation is MSB first configuration.

Last Word: Upon selection of a word index position within the Simulator Display window, a control line Last Word status window will appear. A value of 1 within this status window indicates that value selected is marked as the last word in the frame. A value of 0 within the status window indicates that the value selected is not the last word of the frame.

Word Length: Upon selection of a word index position within the Simulator Display window, the control line Word Length control window will appear. This window allows the user to set the number of bits allowed for the selected word index. Values between 3 and 16 can be entered. This entry box allows the user to set simulator word lengths that vary from the simulator common word length definition.

Multi Entry – Start Word Index: This control window allows the user to select the simulator frame index location to start multi entry updates.

Multi Entry – Stop Word Index: This control window allows the user to select the simulator frame index location to end multi entry updates.

Multiple Raw Value Entry Mode: These radio buttons select the simulator Multiple Entry mode. There are three selectable sub modes. The SAME mode allows a user to program a set of word values to the same value as provided in the Raw Value setting from the start to stop word index. The SEQUENTIAL mode allows the user to program a sequential sequence of values with a given interval from the start to stop word index. The RANDOM mode allows the user to program values to be set with random values from the start to stop word index.

Multiple Raw Value Sequential – Start: This control window entry box allows the sequential start location used for simulator word entry during sequential entry mode.

Multiple Raw Value Sequential – Interval: This control window entry box allows the sequential step values used for simulator word entry during sequential entry mode.

Write: This control button allows the user to initiate the selected programming sequence of minor frame contents.

4.6.6.2 Test SimWdAttr Tab – Right Pane

The Test SimWdAttr right tab provides a status window that shows the contents of the PCM Simulator frame. Word Index, Raw Value, LSB First, Last Wd and Word Length are provided in a scrolling window. This window is also used to select word index positions for the left control pane. Selection of a word index can be made by selecting an entry line. The line selected will be highlighted (blue) once selected and the contents will be loaded in the left pane control window.

4.6.7 Test Sub-function Select Tab – SimFrmAttr

This Test sub-function tab provides controls and status for the Simulator Frame Attributes. Refer to Figure 4-70 for tab layout.

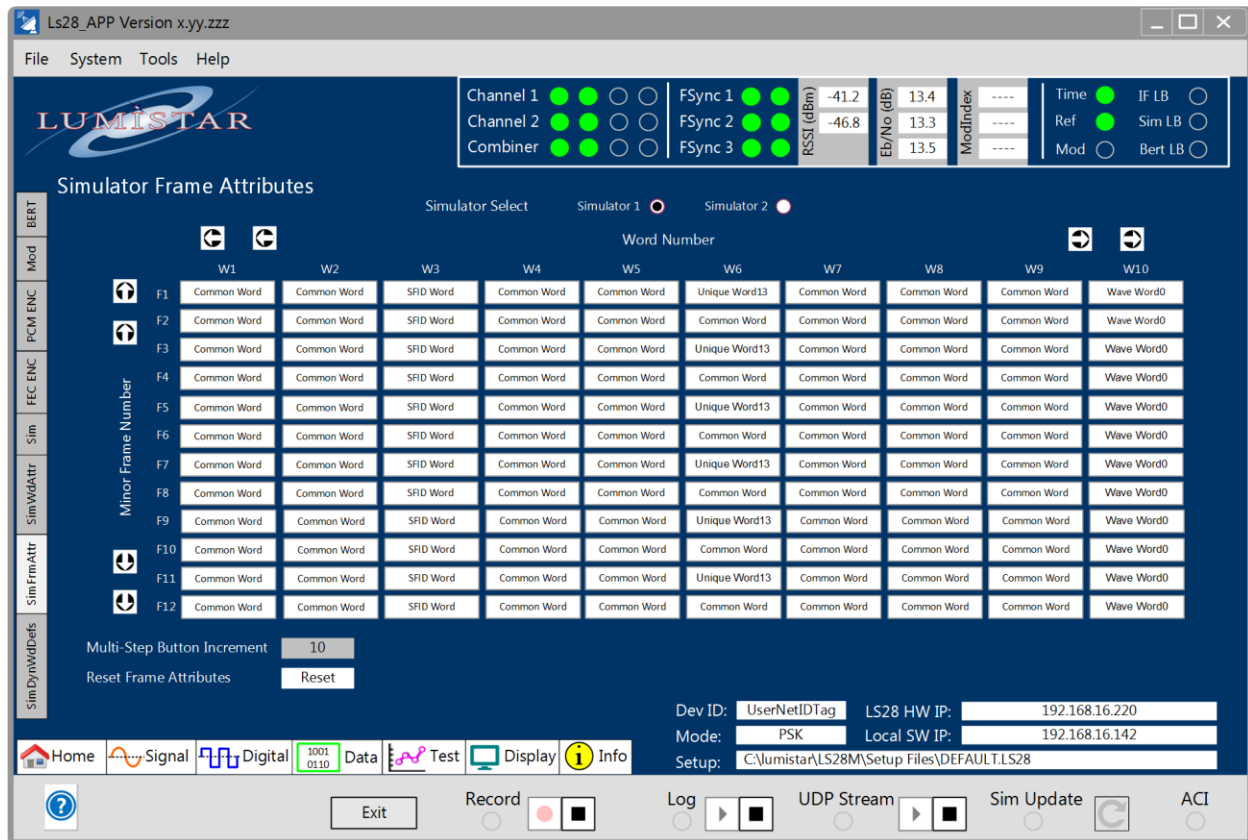


Figure 4-70 Network User Application – Test Sub-function Select: SimFrmAttr

Simulator Select: The radio button control allows the user to select between PCM Simulator 1 and PCM Simulator 2 PCM.

Multi-Step Button Increment: This control window allows the user an entry dialogue box to set the Multi-Step button control. Values can be set between 1 and 1000.

Reset Frame Attributes: This control allows the user to reset all frame attributes to “Common Word”.

Simulator Frame Attributes Array: Each of the boxes in the Simulator Frame Attributes array can be selected and will bring up controls for that word position within a frame. An example of the controls is illustrated in Figure 4-71.

The figure displays three sequential screenshots of the 'Word Definitions' dialog box, which is used for configuring test parameters for the SimFrmAttr Array. Each dialog box features a title bar with a close button (X) and a dark blue background.

Dialog 1 (Top):

- Word Definitions:**
- PRN1 Pattern:** ☒ (Selected)
- PRN2 Pattern:** ☐
- Wave Word:** ☐
- Unique Word:** ☐
- Common Word:** ☐
- Do For A Single Entry:** ☐
- Use Word and Frame Stop:** ☐
- PRN Pattern:** PN15
- Word Start:** 1
- Word Interval:** 0
- Frame Start:** 1
- Frame Interval:** 0
- Buttons:** OK, Cancel

Dialog 2 (Middle):

- Word Definitions:**
- PRN1 Pattern:** ☐
- PRN2 Pattern:** ☐
- Wave Word:** ☒ (Selected)
- Unique Word:** ☐
- Common Word:** ☐
- Do For A Single Entry:** ☐
- Use Word and Frame Stop:** ☐
- Wave Word Number:** Wave Word 1
- Word Start:** 1
- Word Interval:** 0
- Frame Start:** 1
- Frame Interval:** 0
- Buttons:** OK, Cancel

Dialog 3 (Bottom):

- Word Definitions:**
- PRN1 Pattern:** ☐
- PRN2 Pattern:** ☐
- Wave Word:** ☐
- Unique Word:** ☒ (Selected)
- Common Word:** ☐
- Do For A Single Entry:** ☐
- Use Word and Frame Stop:** ☐
- Unique Word Number:** Unique Word 1
- Word Start:** 1
- Word Interval:** 0
- Frame Start:** 1
- Frame Interval:** 0
- Buttons:** OK, Cancel

Figure 4-71 Network User Application – Test Sub-function SimFrmAttr Array - Controls

PRN1/ PRN2: The radio button control allows the user to select between two potential PRN simulation streams for a given major frame word location: PRN1 and PRN2. The PRN pattern assignment is made via the control window in the upper right portion of the control window. Just for clarification, these PRN injections are not related to the TX BERT settings from the Test BERT Tab.

Wave Word : This radio button allows the user to select a predefined wave word for a given common word location within a major frame. There are six wave words that can be defined. When this selection is made, select the desired wave word in the upper right-hand portion of the control window.

Unique Word: This radio button allows the user to select a predefined unique word for a given common word location within a major frame. There are 56 unique words that can be defined. When this selection is made, select the desired unique word in the upper right-hand portion of the control window.

Common Word: This radio button allows the user to select that a word for a given location within a major frame revert to the common word definition as defined in the SimWdAttr tab.

Do for A Single Entry: This selection box sets the entry mode to a single value at a time. When this box is selected, word interval, word stop, frame interval and frame stop entry boxes will be removed from the right half of the control window.

Use Word and Frame Stop: This selection box sets the entry mode to be a multiple setup. When this box is checked, the entry can be placed in the word and frame based on start, stop and interval settings in the right half of the control window.

4.6.8 Test Sub-function Select Tab – SimDynWdDefs

This Test sub-function tab provides controls for the PCM Simulator Dynamic Word Definitions. Refer to Figure 4-72 for tab layout.

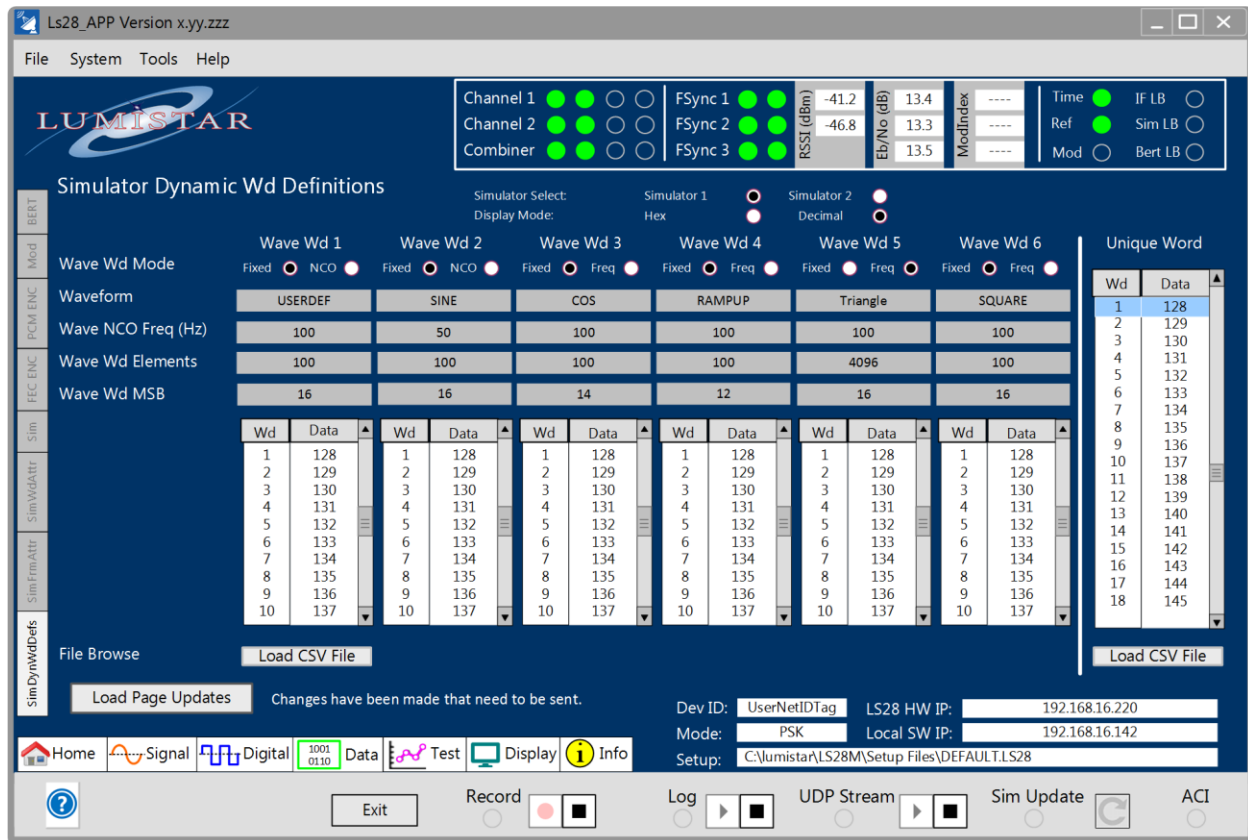


Figure 4-72 Network User Application – Test Sub-function Select: SimDynWdDefs

Simulator Select: The radio button control allows the user to select between PCM Simulator 1 and PCM Simulator 2 PCM.

Display Mode: The radio button control allows the user to select between hexadecimal and decimal displays in the control matrix of the tab.

Wave Wd Mode: The radio button control allows the user to select between the fixed and NCO modes of Wave Word data output control. In fixed mode, the data contents of the wave word definitions are provided based on the fixed rate as derived from the frame definitions. The NCO mode outputs data values based on a specifically programmed data rate and thus relieve the confinement to frame parameters and rates. Values for the NCO are limited from 0 to 63 Hertz.

Waveform: The drop-down menu allows the user to select between nine different predefined waveform selections: NOTHING, SINE, COSINE, SQUARE, TRIANGLE, RAMP UP, RAMP DOWN, RANDOM, and USERDEF. NOTHING setting disables the wave word. Six mathematical functions are provided as well as

random data values can be selected. In addition, using the USERDEF selection, a custom waveform can be defined via a comma separated file that the user can load. Up to 4096 values can be entered.

Wave NCO Freq (Hz): This control box allows the user to set the NCO frequency rate for use in NCO waveform mode. Frequencies between 0 and 63 Hertz can be programmed.

Wave Wd Elements: This control window allows the user to enter the number of elements being used to define the specific waveform. Values between 1 and 4096 can be entered in this window.

Wave Wd MSB: The control window allows the user to define the MSB position of the data being used in the waveform definition. Values between 3 and 16 can be set.

Scrolling Word Entry Window: This screen area allows the user to scroll through wave word indices and values. The user can select individual data values and modify them locally.

Scrolling Unique Word Window: This screen area allows the user to scroll through wave word indices and values. The user can select individual data values and modify them locally.

Load CSV File: Waveforms and Unique Word values can be loaded via common separated files. These files are flat and can be held in any directory locations.

Load Page Updates: After changes have been made on this tab, the changes are not automatically load. This button is required to be selected to upload any changes that have been made on this tab.



Warning:

The **Load Page Updates** button must be selected to perform the loading of changes on this tab. This will be denoted by the label *"Changes have been made that need to be sent"* that will be located right next to the button.

4.7 Function Select Tab – Display

The Display select tab provides the user with the ability to setup graph responses to best fit viewing requirements based on their signal processing needs. Refer to Figure 4-73 for tab layout.

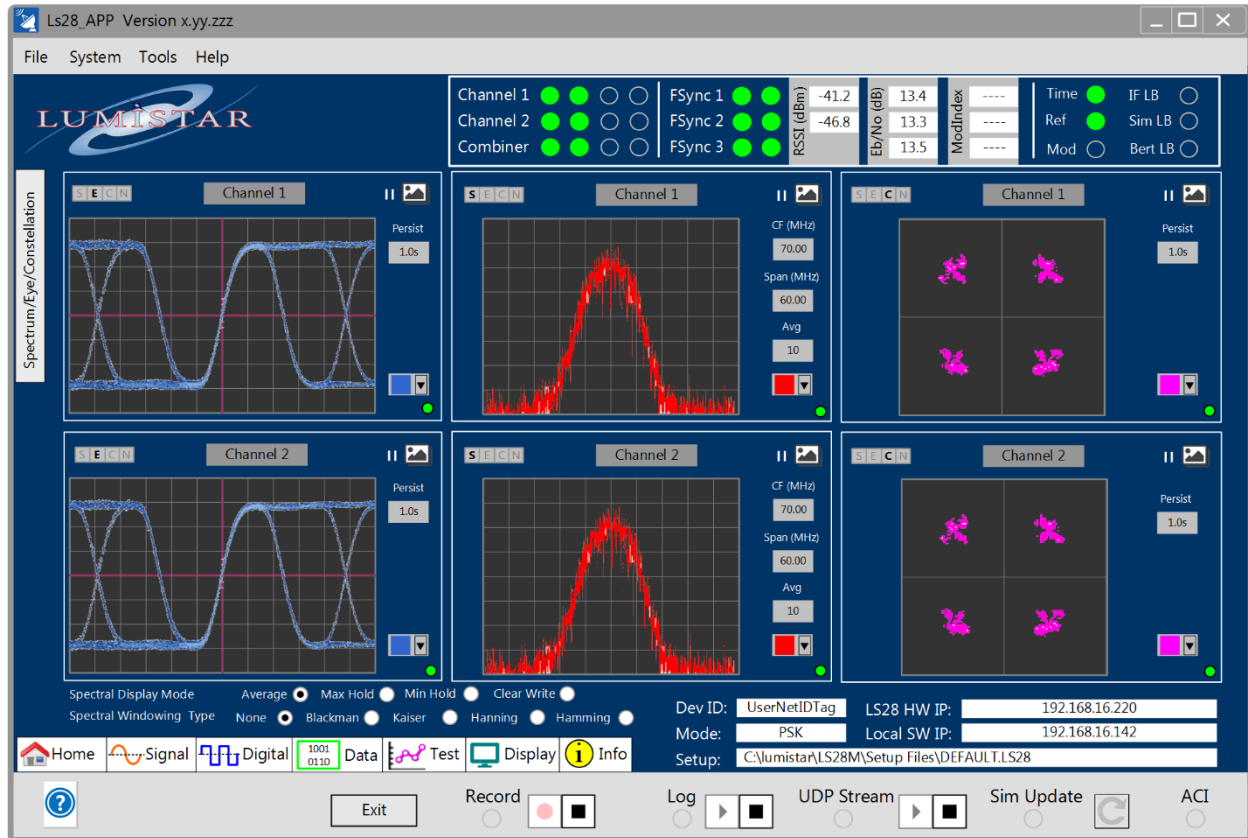


Figure 4-73 Network User Application – Display Select Tab

Display Control - S: This graphic control enables the spectral display functions for a selected display. Selections will be applicable to the related displays on the Home function select tab.

Display Control - E: This graphic control enables the eye-pattern display functions for a selected display. Selections will be applicable to the related displays on the Home function select tab.

Display Control - C: This graphic control enables the constellation display functions for a selected display. Selections will be applicable to the related displays on the Home function select tab.

Display Control – N: This graphic control disables all display functions for a selected display. Selections will be applicable to the related displays on the Home function select tab.

Display Control – Channel Select Button: This graphic control allows the user to toggle through all available channel selections for a graphic display allowing the user to arrange displays as desired. Selections will be applicable to the related displays on the Home function select tab.

Display Control – Pause/Run Button: This graphic control allows the graphic display to be paused or run continuously.

Display Control – Color Button: This graphic control allows the user to select custom colors for the graphic displays. Selecting the drop-down button provides a palette of 20 colors as well as a button that exposes the entire host color palette of options. Color selections will be applicable to the related displays on the Home function select tab.

Display Control – CF (MHz): This graphic control only applies to the spectral displays. It allows the user to program the center frequency of the spectral display. The control is limited to values between 40 and 100MHz. Selections will be applicable to the related displays on the Home function select tab.

Display Control – Span (MHz): This graphic control only applies to the spectral displays. It allows the user to program the frequency span of the spectral display. The control is limited to values between 1 and 60MHz. Selections will be applicable to the related displays on the Home function select tab.

Display Control – Avg: This graphic control only applies to the spectral displays. It allows the user to program the number of spectral plots updates to sum, average and then display. Spectral updates occur at an approximate 5Hz rate.

Display Control – Pers: This graphic control allows the user to program graphics persistence values. This functionality causes displayed data to overlay over multiple cycles and thus provide a more averaged display response. Control settings are in seconds and vary in 0.5 second increments from 0 to 1.0 seconds. A setting for 1 second would build up samples for 1 second and then start replacing the oldest sampled data with more recent samples. Selections will be applicable to the related displays on the Home function select tab.

Display Data Status: In the lower right hand corner of each graphic display is an indicator that provides status on the UDP stream for a given display. A green indicator provides status that UDP communications for this graphic display is active. A red indicator provides status that the UDP communications for that display is presently stalled or disconnected.

Display Control – Spectral Display Mode: The spectral display mode selection allows the user to select one of four operational modes. If *Average* is selected, the spectral displays will display the averaged value of the number of samples that are programmed in the Avg menu entry. Averaging can be selecting between 1 and 10 samples. The *Max Hold* selection allows the display to continuously update the display with only the largest sampled values. The *Min Hold* selection allows the display to continuously update the display with only the smallest sampled values. The *Clear Write* selection allows the display to update completely on smallest sampled values.

Display Control – Spectral Windowing Type: This graphic control only applies to the spectral displays. Selection of various spectral windowing techniques allow the user to program the display tapering equations based on different mathematical windowing techniques. This is sometime helpful in filtering or adjusting display content to emphasis or de-emphasis certain frequency response characteristics. It is beyond the scope of this documentation to explain the differences between these windowing functions. Instead, we would refer you to the following link for further study on the topic:

https://en.wikipedia.org/wiki/Window_function. The windowing techniques offered for selection include: None, Blackman, Kaiser, Hanning, and Hamming.

**Warning:**

Depending on the host PC processing capabilities, persistence settings on the Eye Pattern displays and the Constellation displays can consume a large amount of processing power making other system status responses slow or halt. If this occurs, lower the persistence values until responses improve.

4.8 Function Select Tab – Info

The Info select tab provides the user primarily with status on operating conditions and device configuration information. Controls and status are split between two sub-function tabs: ENV and License.

4.8.1 Info Sub-function Select Tab - ENV

The ENV sub-function tab provides the user value information concerning real-time operations as well as information pertaining to communications setups and firmware versions. Refer to Figure 4-74 for tab layout.

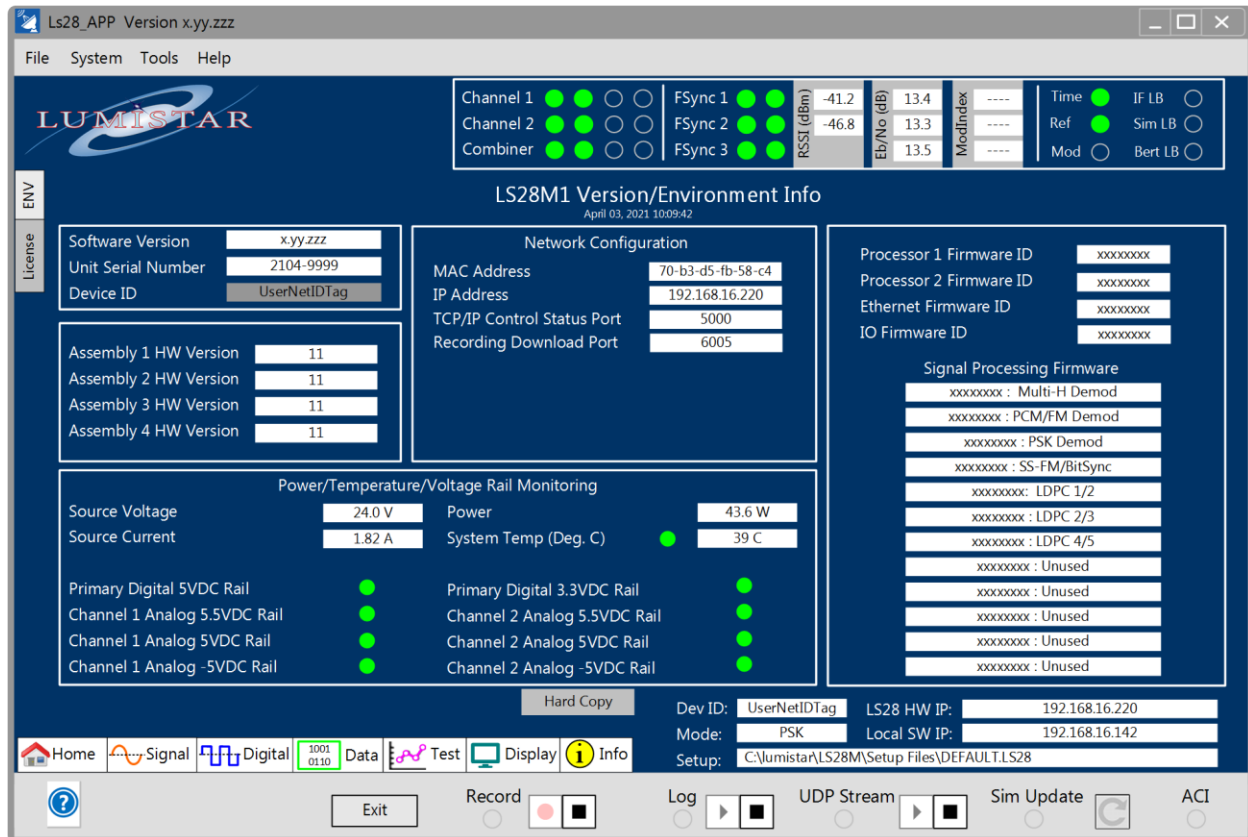


Figure 4-74 Network User Application – Info Sub-function Select: ENV

Device ID: In the upper left-hand box of this tab is a control entry entitled device ID. This control allows the user to enter up to 16 ASCII characters to identify the device on a network by name. The ID is stored within the device's non-volatile memory and is presented in the communications window upon request.

The upper left status box provides information on the device's assigned serial number. This number is typically formatted with the number on the left-hand side of the hyphen representing the month and year of the hardware assembly. The numbers on the right side of the hyphen indicate the primary engine hardware version number followed by three digits that indicate the sequence serial number.

The center left hand status box indicates what hardware board revision is assigned to each physical slice of the LS-28-DRSM.

The lower left hand status window provides electrical and thermal status related to various voltage rails within the unit and the source supply to the unit. Present operating temperature is provided in degrees Celsius. LED colors indicate proper tolerance of these values. Yellow indicates that the value is outside the desired functional range. A green LED indicates that the operational value is within nominal operating range. If the operational temperature value is above approximately 70 degrees Celsius or any of the various voltages ranges are beyond tolerance, the INFO flag on the main status window will flash at an approximate ½ Hz rate. Consult Figure 4-21.

**Warning:**

If the unit temperature exceeds 70 degree Celsius, the INFO tab will be displayed. Steps should be taken to provide properly cooling to ensure continued operation.

The upper center status box provides information pertaining to the present network configuration. Data will be supplied on the MAC address of the unit, the IP Address setting, the TCP Control port number, and the Recording download TCP port number.

The upper right-hand status box provides firmware dates for all of the active firmware within the design. The firmware versions listed include both DSP1 and DSP2, the Ethernet FPGA, the IO FPGA, and all available signal processing firmware files. Firmware versions are expressed in YYYY:MM:DD format.

4.8.2 Info Sub-function Select Tab - License

The License sub-function tab provides the user value information concerning information on what license options are active and which ones are available. Refer to Figure 4-75 for tab layout.

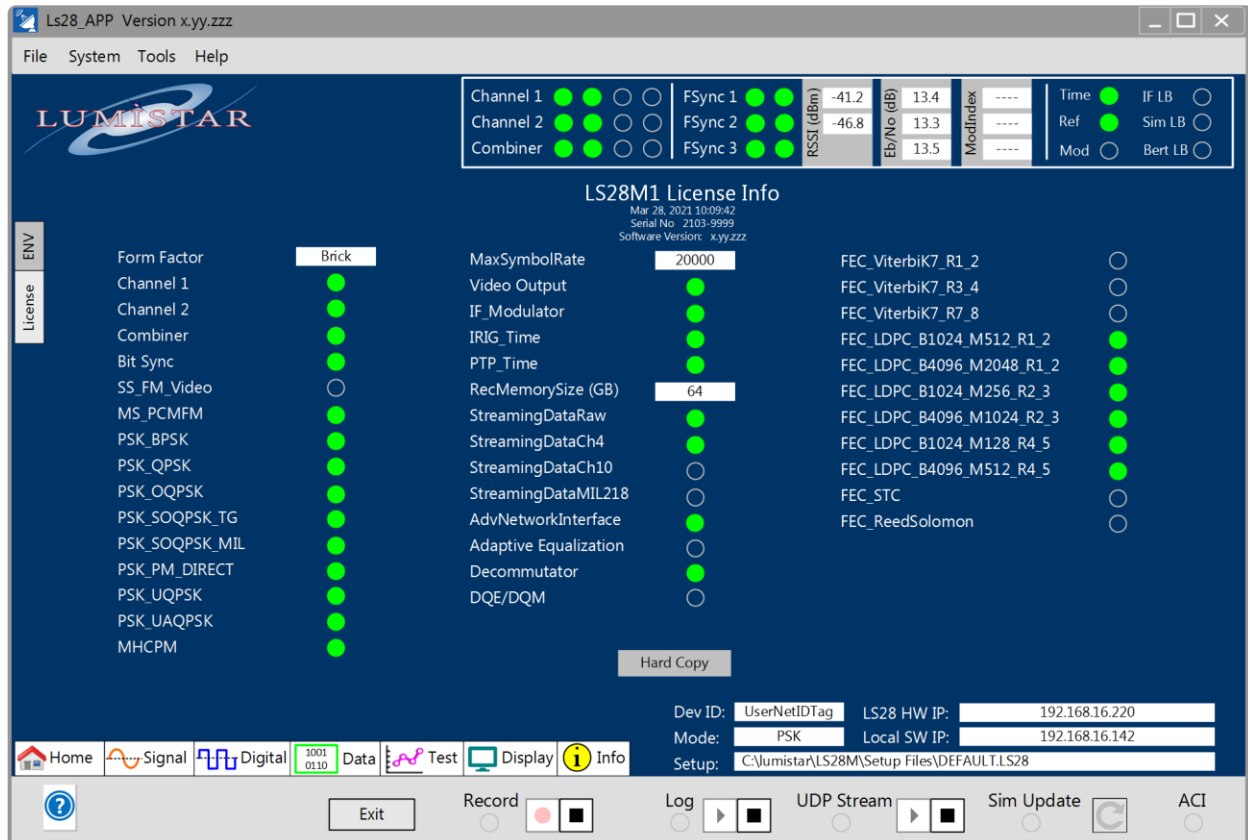


Figure 4-75 Network User Application – Info Sub-function Select: License

Active license functions are indicated by green LEDs. LED indicators that are blank indicate that a function may be available but not licensed. There are license options that are dependent upon hardware configurations and revision levels.

Three fields provide information concerning device form-factor, indications of the maximum symbol rate setting, and the amount of recording memory installed in the device. A figure of 0GB of recording memory indicates that no recording memory is present.



Warning:

LEDs on the license tab that appear clear are indications that the license option is not installed. The LED may be clear due to other factors such as hardware configurations of the attached device or general availability of the option. Clear license LEDs do not necessary indicate that an option is available for the connected device.



Information:

Most, but not all, license options can be added via field upgrade. Consult Lumistar customer service for more details.

4.9 Low Density Parity Coding (LDPC)

4.9.1 General Information on LDPC

To better understand the differences between the operations of the LS-28-DRSM in the Low Density Parity Coding (LDPC) mode and the non-LDPC modes, a brief explanation of LDPC may be helpful.

Low Density Parity Coding (LDPC) is a linear error correction block code format. Like other forward error correction methods, LDPC encoding adds redundancy to the data payload so that the receiving agent can both detect and correct errors that occur during transmission. The benefit of this encoding is to create a "near" Shannon channel capacity in noisy transmission environments.

LDPC packet encoding is composed of three different parts: an Attached Synchronization Marker (or ASM), an information block which contains the data payload, and a parity code block at the end of the sequence. Although there are a number of different LDPC formats used in industry, Appendix R of the IRIG-106 specification narrows the field to a set of six block codes containing three different code block rates and two different information block sizes. Figure 4-76 illustrates the specifics of LDPC message composition. Figure 4-77 illustrates LDPC messages decoding sequences once received.

As stated before, LDPC allows reception and correction of transmitted data at very low E_b/N_0 s which is its primary benefit. Unfortunately, as always, there are also "costs" of various types associated with using this encoding method. Both of the LDPC figures illustrate some interesting aspects of this encoding method. One of the aspects shown in Figure 4-76 is the growth of total transmitted data due to the various encoding options. This added data requirement has a negative effect in terms of the required bandwidth for data transmission. To provide exact figures, Table 4-9 lists the six IRIG-106 specified LDPC formats and their impacts on the data transmission requirements. It is important to realize the impact of the encoding on the demodulator bandwidth. As an example, if the LDPC encoded SOQPSK data was in format $R=1/2$ and the maximum symbol rate of the receiver was licensed for 20Msps, then the maximum supported LDPC data rate would be $(20\text{Msps} \times 2)/2.0625 = 19.39\text{Mbps}$.

The second interesting aspect is shown in Figure 4-77. This figure shows that the LDPC decoding adds additional delays prior to unencoded data being available to the user. It is important to note that since this is a block decoding scheme, decoding cannot begin until the entire package of parity bits have arrived. Once all package bits are present, the decoding process is iterative and may take multiple passes through the decoder for proper rendering of results. The decoder uses the clock derived from the incoming stream and will wait until the beginning of the next received block until it provides decoded bits from the previous decoding pass. This means that in the case of $K=4096$, $R=4/5$ LDPC encoded packets, data received by the system may not be available for in excess of 10,000 bit periods. Once data is produced, it will be clocked at the originating data rate but only for a period related to the original payload content. Thus the resulting clock and data will be non-contiguous. Overall, it will average the rate of the original unencoded data rate. It is also important to note that data contained in a LDPC package that is incomplete cannot be recovered. Each package must contain all data and the parity package to be properly decoded.

LDPC Data Package Sizes		
Rate	Data Block Size	Encoded Bit Rate Multiplier
4/5	1024	1.3125
4/5	4096	1.3125
2/3	1024	1.5625
2/3	4096	1.5625
1/2	1024	2.0625
1/2	4096	2.0625

Table 4-9 LDPC Data Package Multiplier Table

The LS-28-DRSM contains three operational modes associated with LDPC, one for each LDPC rate supported. Each operational mode can support either block size thus offering all six IRIG supported LDPC formats. The user selects the LDPC code that they want and the appropriate LDPC decoder is loaded into the interface for operation. Once loaded, a single LDPC decoder processing path is present. LDPC mode is supported for all PSK modes including SOQPSK. There are no changes associated with LDPC in the RF and IF receiving path. There are changes to the data processing path. The data processing path requires special dual frame-synchronizers (automatically controlled based on selected mode) for LDPC decoding. The mode also limits some of the recording and decommutation stages. Figure 4-77 outlines the data decoding engine implications for the LDPC processing mode.

It may be questioned why there are not three LDPC decoders implemented in the design, one for each channel. There are two logical responses to this question. First, each of the LDPC decoders takes a large amount of FPGA processing resources. In certain configurations, sufficient resources for more than one decoder engine do not exist. Secondly, in the very common case where a combiner is used, more than one LDPC decoder actually makes no sense. Combiners are a standard feature of the LS-28-DRSM. Since LDPC decoding is close to the theoretical limit of the channel capacity, the performance curve is rather sharp in slope. This means that there are either no errors or there are many errors. This aspect is common among FEC methods. To have multiple LDPC decoders would yield nearly identical results.

In LDPC mode, all clock and data outputs of the LS-28-DRSM are connected to the LDPC decoder, regardless of the channel selected to decode. Thus, all channels are duplicates.

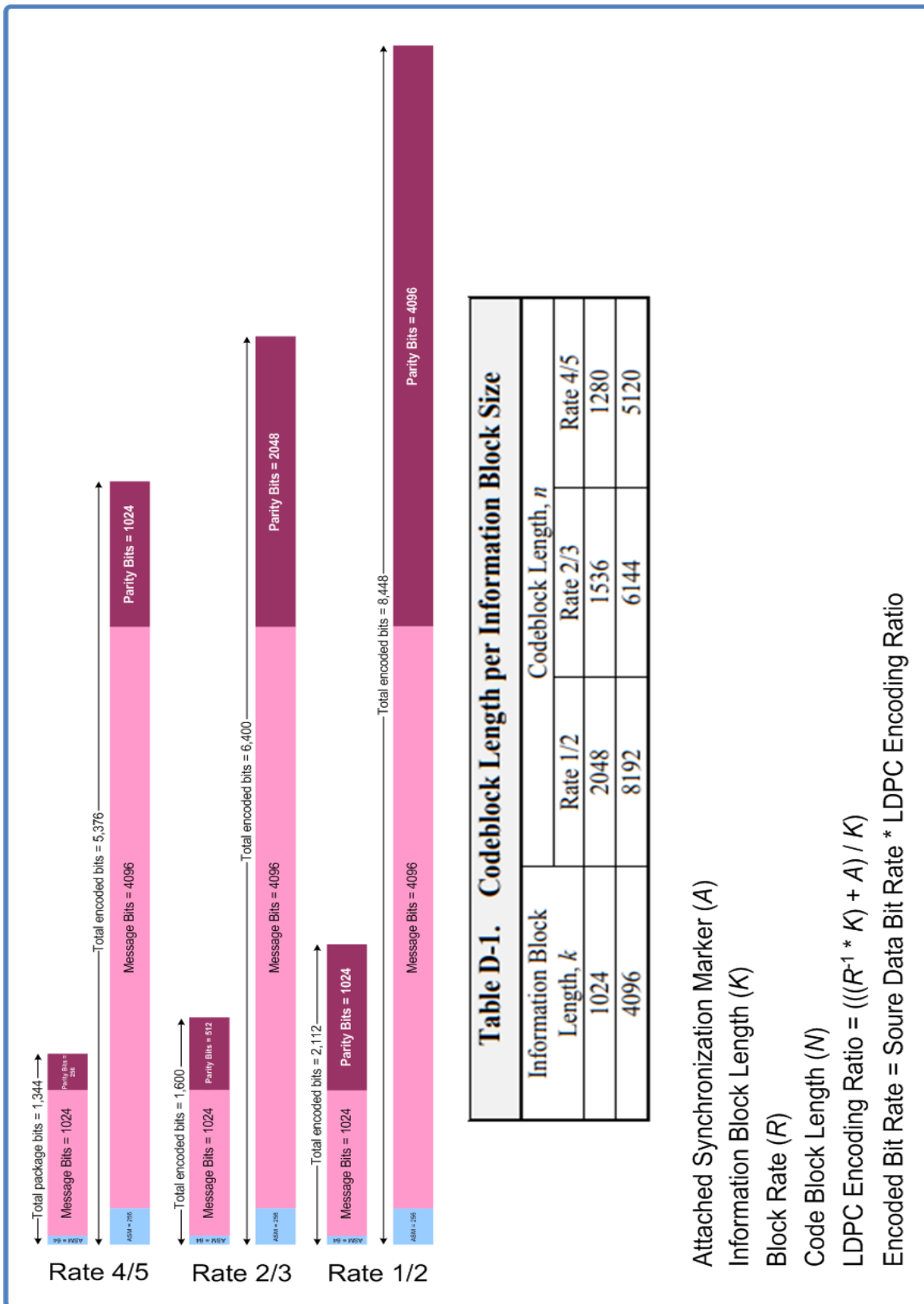


Figure 4-76 LDPC – Message Composition

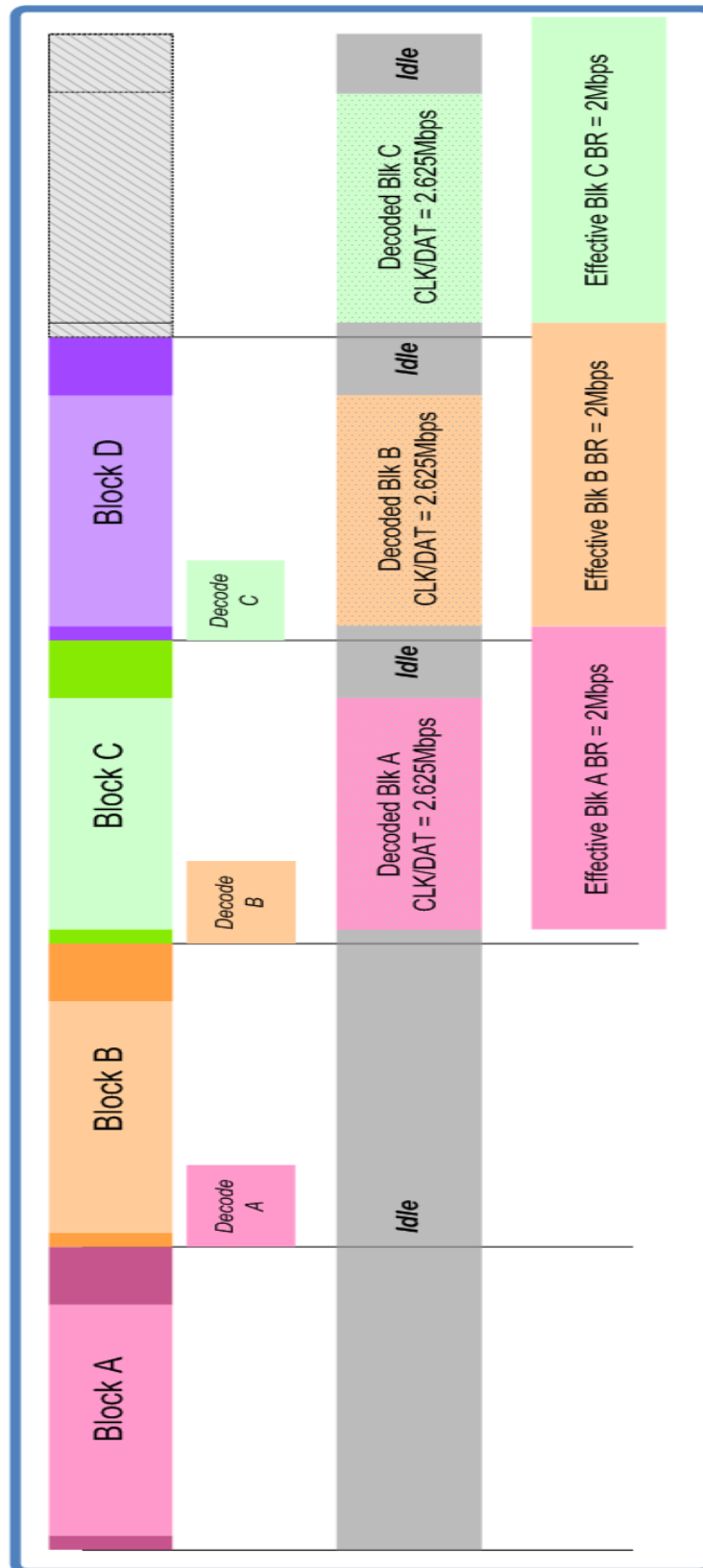


Figure 4-77 LDPC – Message Transmission/Decoding Cycles

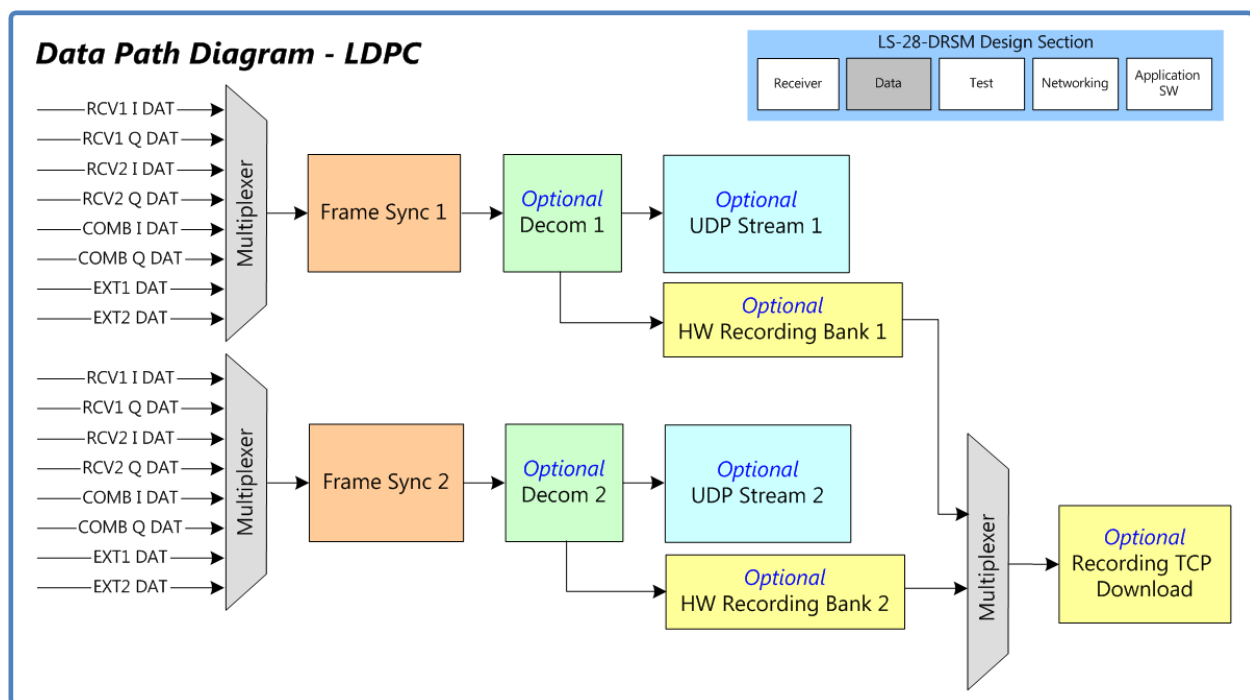


Figure 4-78 LDPC Data Frame Sync/Decom/Recording/Data Streaming Engine Blk Diagram

4.9.2 LDPC Mode Specific GUI Interfaces

If the LS-28-DRSM is licensed to operate in LPDC operational mode, the format of several of the operational tabs changes to reflect firmware changes. Not all tabs change. Only tabs containing LDPC specific changes to controls or status are provided in the following sections. Controls that are unchanged are included in the documentation that proceeds this section and will not be repeated in the following.

4.9.2.1 LDPC – Home Tab

The Home tab is one of the seven function select tabs and likely the most utilized. From this tab, most users can setup all of the primary functions of the receiver as well as view status on the operations of all aspects of the receiver system. The LDPC Home tab is shown in Figure 4-79. In LDPC mode changes include the fact that there is only a single demodulator to configure.

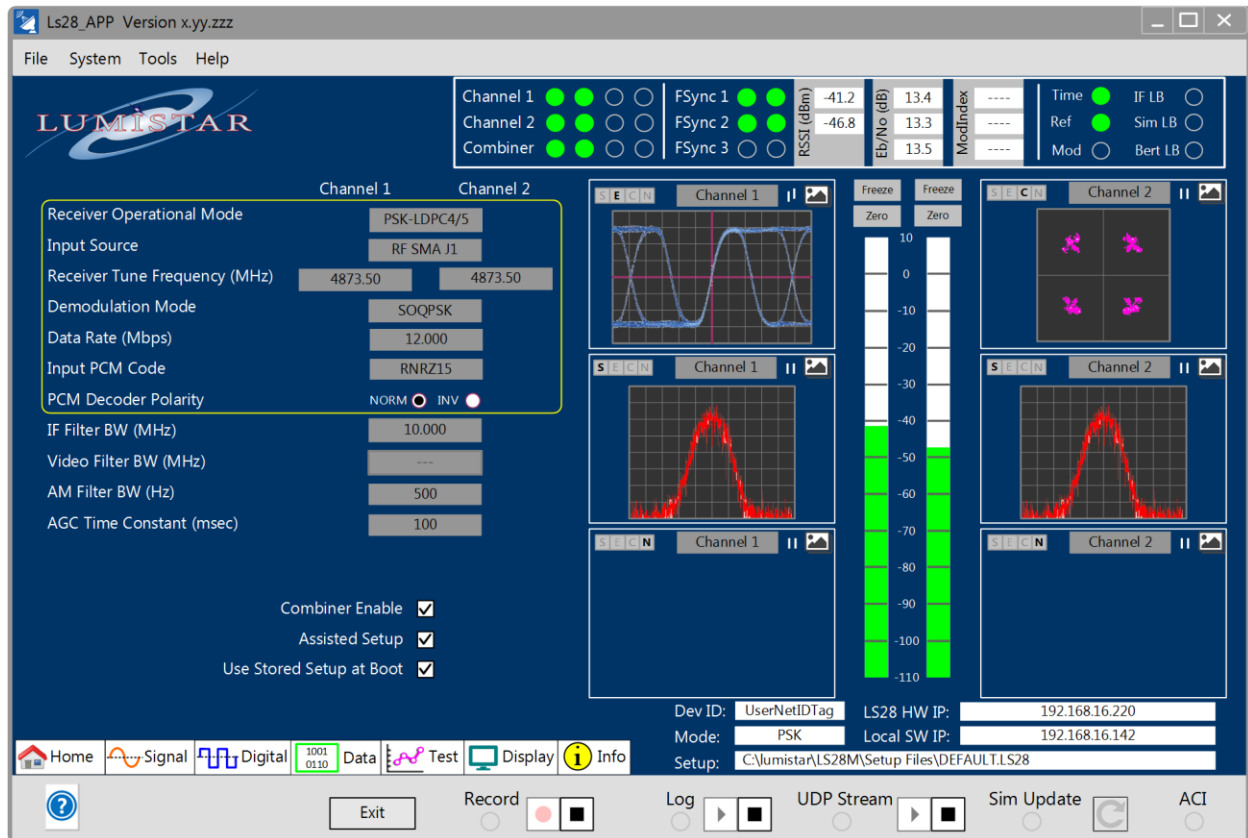


Figure 4-79 Network User Application – LDPC Home Function Select Tab

4.9.2.1.1 LDPC Home Tab – Left Pane

Receiver Operational Mode: This application control allows the user to select between the major functional "personalities" or operational modes of the LS-28-DRSM. The user should select the primary operation mode first and then set other settings based on signal requirements. Figure 4-79 shows the typical LDPC format regardless of LDPC mode selected.

Input Source: The input source control allows the user to select input sources if multiple sources are available. The input sources will be controlled internally by the LS-28-DRSM firmware based on licensed options and operational mode selections. Options include Receiver CH1, Receiver CH2, RF Combiner, Loopback CH1 and Loopback CH2.

Receiver Tuning Frequency: The RF tune frequency for each of the RF input ports, identified as J1 and J2 of Figure 2-2 are set by this control. Entries will result in a dialog box that provides the users with a list of

installed RF bands to choose from. Values will be listed as ranges of values in MHz. Attempts to tune outside the values listed will be disregarded.

Demodulation Mode: This control is active only in PSK mode. PSK mode has several demodulation modes to select from. When the operational mode is set to PSK and more than one PSK sub-mode is licensed, the user will be presented with a list of PSK demodulation options. These may include BPSK, QPSK, OQPSK, SOQPSK-TG, SOQPSK-MIL, UQPSK, UAQPSK, and Direct PM. Selections are made on a per-channel basis but must be identical between channels if diversity combining is being utilized.

Data Rate: This command control dialog box allows the user to enter the desired data rate for each channel. If the operational mode and demodulation mode selected requires two separate entries for I and Q data rates, the user will be prompted for both data rates.

Input PCM Code: This control provides the user the ability to select from a number of PCM decoder values. Users should select a code that is the same as the modulation or data source. The decoder selections are shown in Table 4-1.

PCM Decoder Polarity: These radio button controls provide the user the ability to invert any of the selected Input PCM Decoder selections, essentially doubling the number of PCM decoder selections. Once INV is selected, the data polarity is inverted for the selection made in the Input PCM Decode selection.

IF Filter BW: The user can select IF filter bandwidths for the modulation, PCM code, and data rates programmed on the home tab. There are two mechanisms for selecting an IF filter bandwidth: manual mode or assisted setup mode. In manual mode, selected when the Assisted Setup option is deselected (see below), allows the user to select from one of 32 filter bandwidths. The bandwidth selections provided cover all data rate options allowed by the demodulation engine. Table 4-2 lists all manual selectable IF filter bandwidths.

Video Filter BW: The Single-Symbol PCMFM demodulation section of the receiver design provides 16 selectable output low-pass filters video filters. These filters allow FM response with targeted bandwidth selections for improved bit synchronization processing. This tab control allows the user to select the filter setting only in SS-PCMFM/Video FM operational mode. In all other operation modes video filter is performed in the digital domain and no user selections are required. Table 4-2 contains the FM filter selections provided.

AM Filter BW: The AM demodulation section of the receiver design provides 32 selectable output low-pass filters. These filters allow AM response with very targeted bandwidth selections for improved antenna tracking functions. This tab control allows the user to select the filter setting. Table 4-2 contains the AM filter selections provided.

AGC Time Constant: The LS-28-DRSM provides a control to adjust the AGC output signal time constant. Eight time constant values are provided as follows: 100usec, 1msec, 5msec, 10msec, 50msec, 100msec, 500msec, and 1 second. These values are typically used for antenna tracking purposes. This AGC time constant will not be applied to the IF output unless the Digital AGC mode is selected. See information related to this mode in the function select Signal sections of this manual.

Combiner Enable: This selection box enables and disables the Diversity Combiner functions within the LS-28-DRSM if this option is licensed. For combiner settings to be loaded, this box must be selected. If disabled, no combiner values will be loaded and on most GUI menu items will be disabled that are related to the combiner.

Assisted Setup: This selection box switches filter selections for IF and video filter bandwidths from manual mode to automatic mode. In automatic mode, firmware within the LS-28-DRSM takes all signal information provided to the device into account and programs the filters selections automatically. These values are calculated based on formulas shown in the Figure 4-24 and Figure 4-25.

Use Stored Setup at Boot: The LS-28-DRSM has the ability to store its last setup internally and then recall this setup state at power up. To utilize this functionality, three sequential steps are required. First and foremost, this option must be installed at the time of order. If this option is not installed, internally stored setups are prohibited. If the unit has this option enabled, the user should setup the receiver and data processing as desired and then select from the FILE menu the option *Save Setup Internally*. Once selected, all state information will be transferred to the internal non-volatile memory for recovery at power up. This is **NOT** an automatically updating function. The user must initiate a *Save Setup Internally* each time a setup refresh is desired. Once a stored setup has been internally stored, the final step to make the setup active at the next power up cycle is for the user to select the "Used Stored Setup at Boot" option on the HOME tab.



Information:

Some security requirements will not allow internal storage of setups. This option must be physically installed at the time the unit is ordered.

4.9.2.1.2 LDPC Home Tab – Right Pane

For this section, refer to Figure 4-22 and Figure 4-79.

Display Control - S: This right pane graphic control enables the spectral display functions for a selected display.

Display Control - E: This right pane graphic control enables the eye-pattern display functions for a selected display.

Display Control - C: This right pane graphic control enables the constellation display functions for a selected display.

Display Control – N: This right pane graphic control disables all display functions for a selected display.

Display Control – Channel Select Button: For LDPC mode, no channel selections are allowed. All selections are related to a fixed set based on the LDPC mode selection.

Display Control – Pause/Run Button: This graphic control allows a graphic display to be paused or run continuously.

Display Control – Screen Capture Button: This graphic control allows the user to make a capture of a selected display in either bit map or JPEG format. These files will be located in the project hardcopy folder.

Freeze/Zero Buttons: The right pane contains two AGC control buttons. When the AGC freeze button is selected, the gain controls for the AGC output signal are frozen in their present state. This makes the AGC output gain response linear until the freeze condition is removed by user input. When the zero command is selected, the AGC values will enter a relative measurement mode providing a delta value in the signal response window. The RSSI value will maintain the actual signal level being received but to two bar graph status displays will provide measurement relative to the signal value at the time the zero state was engaged.

Signal Strength Status Bar Graph: The two center-left pane bar gauges provide the user with a graphical representation of the RF channel signal strength. This input signal level is also provided in the system status window.

4.9.2.2 LDPC – Signal PSK Tab

The LDPC Signal PSK tab is shown in Figure 4-80. In LDPC mode changes include the fact that there is only a single demodulator to configure. The source selected in the LDPC Home tab will be listed above the controls and the status.

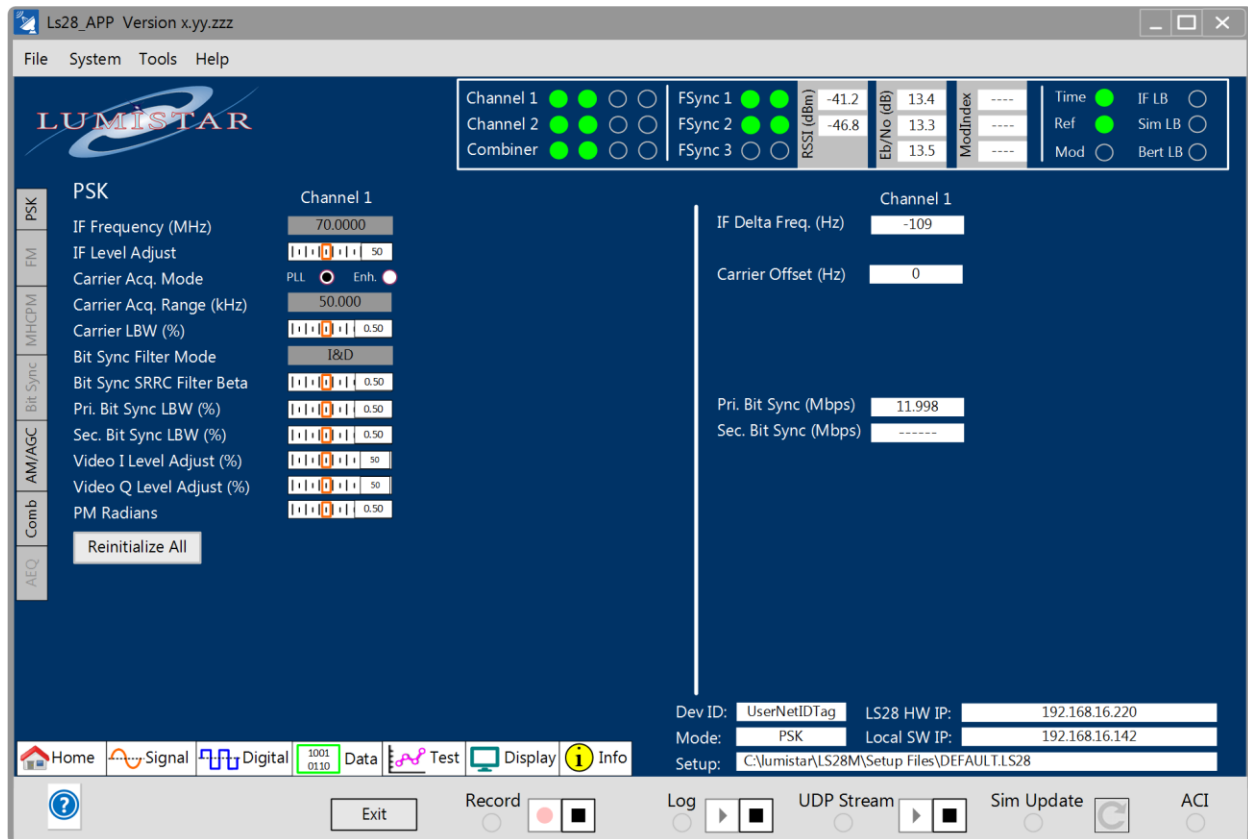


Figure 4-80 Network User Application – LDPC Signal Tab - PSK

4.9.2.2.1 LDPC Signal PSK Tab – Left Pane

IF Frequency: This control entry box allows the user to set the IF center frequency of the digitization section of the design. Normally, this entry should be set to 70MHz. If the RF downconversion stage is part of the configuration, this setting should always be set to 70MHz. However, there may cases where different center frequency settings are desirable. The range of this setting is 1 to 100MHz.

IF Level Adjust: The LS-28-DRSM contains three IF output ports. These ports are identified as J6, J7 and J10 in Figure 2-2. The output level can be adjusted via the slider bar provided or by selecting the numeric box and entering a number. The control provides percentage of maximum output power control and not a specific output value. It should be noted that settings of 0% do not entirely eliminate the IF output signal.

Carrier Acquisition Mode: Once the RF downconversion process is complete, the resulting intermediate frequency (IF) must be tracked prior to signal demodulation. There are two user level controls associated with this process. This radio button allows the user to change modes associated with acquiring the IF carrier in the case where the carrier may be varying due to frequency offsets or actively moving due to Doppler

effects. The standard operational mode is the "PLL" selection. In this mode the standard IF tracking phase lock loop is utilized.

In the standard PLL mode, the receiver can only lock to signals where the carrier acquisition range is less than the symbol rate. In circumstances where the carrier acquisition range is greater than the symbol rate, the enhanced "ENH" carrier tracking mode may be desirable. Enhanced mode uses a phase discriminator on a baseband converted signal with a low-pass filter bandwidth to obtain a carrier frequency estimate. It then uses this estimate to program the receiver carrier frequency to adjust the kick logic routines used in tracking. Enhanced mode works best when the symbol rate is low relative to the Carrier Acquisition Range. This mode is not recommended for very noisy environments since the methodology used allows acquisition range bandwidths, which can be large, into the estimate of the carrier frequency. It should also only be used in demodulation modes that do not cross the I/Q origin such as MH-CPM, MS-PCMFM, SOQPSK, and OQPSK.

Carrier Acquisition Range: The carrier acquisition range setting allows the user to select the desired positive and negative sweep range of the carrier acquisition tracking. For example, a setting of 50kHz allows the frequency tracking loop to vary +/- 50kHz. The larger the acquisition range, the larger the IF offset that can be tracked. In typical applications where Doppler effects are small, acquisition ranges in the +/-50kHz range are appropriate.

The suggested acquisition range for various symbol rates for the PSK operational mode are shown in Table 4-3.

Carrier Loop Bandwidth (LBW): The IF carrier is tracked within the receiver by a phase lock loop (PLL). This is a closed loop feedback system that contains associated correction rate coefficients. These coefficients are referred to as the carrier loop-bandwidth (LBW). Loop bandwidths values are typically provided as a percentage of a given factor. For the carrier, this is a percentage of the symbol data rate programmed by the user.

Generally, as loop bandwidth values increase, lock times decrease but higher bandwidths can increase loop related errors such as jitter and noise. Narrow loop bandwidths increase lock time and decrease noise and jitter. Trade-offs may need to be made based on the signal channel characteristics.

Table 4-3 contains the ranges appropriate for a given symbol rate. These values can either be entered in the associated slider box or by adjusting the slider itself.

Bit Sync Filter Mode: Similar to carrier tracking, the bit synchronization process within the LS-28-DRSM provides multiple filter modes. The default mode contains the standard Integrate and Dump (I&D) PLL tracking filter. A secondary Square-Root Raised Cosine tracking filter is also provided as a matched filter for situations where inter-symbol interference is prevalent. This is the case in some transmission channels and under heavily filtered modulation formats.

Typical operations should utilize the standard PLL loop filter. The bit sync filter mode setting applies to both primary and secondary bit syncs.

Bit Sync Square-Root Raised Cosine (SRRC) Filter Beta: The SRRC filter has a programmable roll-off factor referred to as the filter Beta. This value for baseband processing abides by the following formula:

$$BW = 1 + B/2T_s \text{ where}$$

BW = Filter Bandwidth

B = Beta value

T_s = Symbol period

Beta values between 0 and 1 can be entered in the associated slider box or by adjusting the slider itself. The bit sync SRRC filter mode setting applies to both primary and secondary bit syncs. This value has no meaning if the bit sync filter mode is set to I&D mode.

Primary Bit Sync Loop Bandwidth (LBW): Bits within the bit synchronizer function of the receiver are tracked by a phase lock loop (PLL). This is a closed loop feedback system that contains associated correction rate coefficients. These coefficients are referred to as the bit sync loop-bandwidth (LBW). Loop bandwidths values are typically provided as a percentage of a given factor. For the bit synchronizer, this is a percentage of the symbol rate programmed by the user.

Generally, as loop bandwidth values increase, lock times decrease but higher bandwidths can increase loop related errors such as jitter and noise. Narrow loop bandwidths increase lock time and decrease noise and jitter. Trade-offs may need to be made based on the signal channel characteristics.

The primary bit sync loop bandwidth controls the settings to the first bit synchronizer of each channels two provided bit synchronizers.

Table 4-3 contains the ranges appropriate for a given symbol rates. These values can either be entered in the associated slider box or by adjusting the slider itself.

Secondary Bit Sync Loop Bandwidth (LBW): Similar to the primary bit sync loop bandwidth setting, the secondary bit sync loop bandwidth controls the settings to the second bit synchronizer of each channel two provided bit synchronizers. This bit synchronizer is only utilized in a few PSK sub-modes such as AQPSK and UAQPSK.

Table 4-3 contains the ranges appropriate for a given symbol rates. These values can either be entered in the associated slider box or by adjusting the slider itself.

Video I Level Adjust: The LS-28-DRSM provides two video output ports for video reconstruction of the demodulated symbols. These video outputs can be adjusted in level. This slider control adjusts the I video output signal level for the selected channel. Values entered in the available box or adjusted using the slider are percentages of the maximum output available. These values can either be entered in the associated slider box or by adjusting the slider itself.

Video Q Level Adjust: The LS-28-DRSM provides two video output ports for video reconstruction of the demodulated symbols. These video outputs can be adjusted in level. This slider control adjusts the video output with the Q video signal level. Values entered in the available box or adjusted using the slider are

percentages of the maximum output available. These values can either be entered in the associated slider box or by adjusting the slider itself.

**Caution:**

The video output reconstruction is made directly after baseband downconversion within the FPGA. At this point in the signal processing chain I and Q determination may still contain modulation ambiguity. Therefore, assignments of which video output is the actual I and which is Q can not be made with total confidence.

PM Radians: The LS-28-DRSM PSK mode can provide a sub-mode of direct PM. This sub-mode allows the user to set the expected radians exposed to the demodulation engine. The user can select values between 0.01 radians and 2.55 radians. These values can either be entered in the associated slider box or by adjusting the slider itself.

Reinitialize All: This button acts to reload and reinitialize all tabs controls as presently indicated.

4.9.2.2.2 LDPC Signal PSK Tab – Right Pane

IF Delta Frequency: This status window provides feedback to the user of the IF frequency difference between what has been set in the demodulation control versus the present tracking value of the demodulation engine. Values provided will be displayed in Hertz and will be a signed value. Negative values indicate that the tracked IF frequency is lower than that programmed. Positive values indicate the frequency is greater than that programmed.

Carrier Offset: This status window provides feedback to the user of the carrier offset when using the “ENH” carrier acquisition mode. Carrier offset will be provided as a signed integer in Hertz. The window will be inactive in the PLL mode.

Primary Bit Sync: Similar to the IF frequency feedback, the LS-28-DRSM bit synchronizer functions provides a feedback to the user on the actual PLL clock bit rate for a given bit synchronizer. This field provides bit clock rates for the primary bit synchronizer of each channel.

Secondary Bit Sync: For demodulation schemes that require separate I and Q data streams, the LS-28-DRSM bit synchronizer functions provides a feedback to the user on the actual PLL clock bit rate for the secondary bit synchronizer. This field provides bit clock rates for the secondary bit synchronizer of each channel.

4.9.2.3 LDPC – Signal PCM Encoder Tab

This sub-function select tab provides controls related to the output PCM encoders for the LS-28-DRSM in LDPC mode. There are six PCM output encoders in the design. All will be set the same. See Figure 4-81 for tab layout.

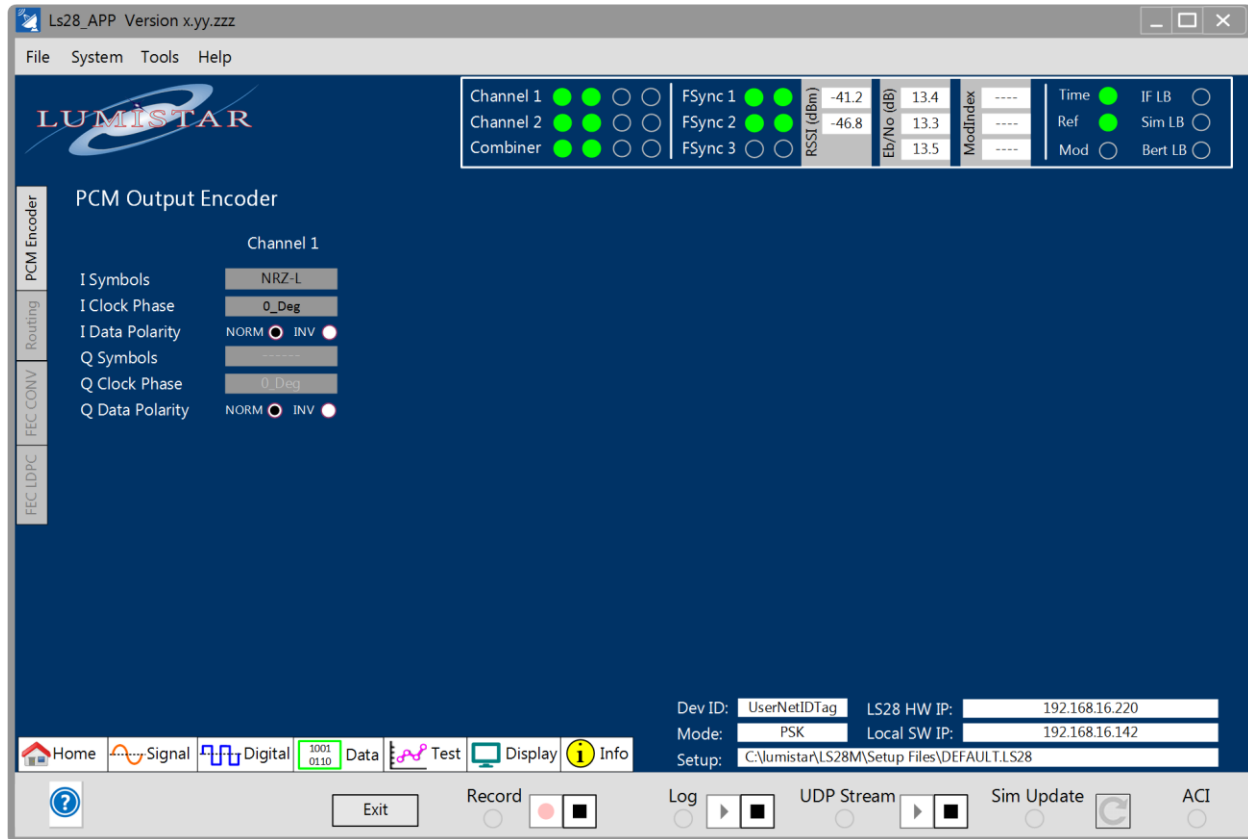


Figure 4-81 Network User Application – LDPC Signal Tab – PSK PCM Encoder

4.9.2.3.1 LDPC Signal PCM Encoder Tab – Left Pane

I Symbols: This left pane control allows the user to encode the output symbols from the bit synchronizer function into a PCM format as they desire. This may match that of the input PCM decoding or differ entirely. Table 4-5 lists all PCM encoder modes that are available.

I Clock Phase: Along with the output data from the bit synchronizer is a correlated clock. The phase of the output clock in relationship to the data is user selectable via this left pane control. The phase numbers are associated with the rising edge of the clock versus the bit period. Settings include 0-degree, 90-degree, 180-degree and 270-degrees. To make this clearer these associations are illustrated in Figure 4-36.

The 0-degree clock phase is the default setting. Some sampling systems may perform better based on alternate phase settings.

I Data Polarity: This control radio-button sets the PCM encoder output polarity. The NORM (normal setting is the default setting. The INV setting inverts the output data stream.

Q Symbols: This left pane control allows the user to encode the Q output symbols from the bit synchronizer function into a PCM format as they desire. This may match that of the input PCM decoding or differ entirely. Table 4-5 lists all PCM encoder modes that are available.

The Q symbol controls are only available in applicable modes which are AUQPSK, and AQPSK.

Q Clock Phase: Along with the Q output data from the bit synchronizer is a correlated clock. The phase of the output clock in relationship to the data is user selectable via this left pane control. The phase numbers are associated with the rising edge of the clock versus the bit period. Settings include 0-degree, 90-degree, 180-degree and 270-degrees. To make this clearer these associations are illustrated in Figure 4-36.

The Q symbol controls are only available in applicable modes which are AUQPSK, and AQPSK.

Q Data Polarity: This control radio-button sets the Q PCM encoder output polarity. The NORM (normal) setting is the default setting. The INV setting inverts the output data stream.

The Q symbol controls are only available in applicable modes which are AUQPSK, and AQPSK.

4.9.2.4 LDPC – Signal PCM Digital Routing Tab

This LDPC sub-function select tab provides controls related to the signal routing for the LS-28-DRSM. See Figure 4-82 for tab layout.

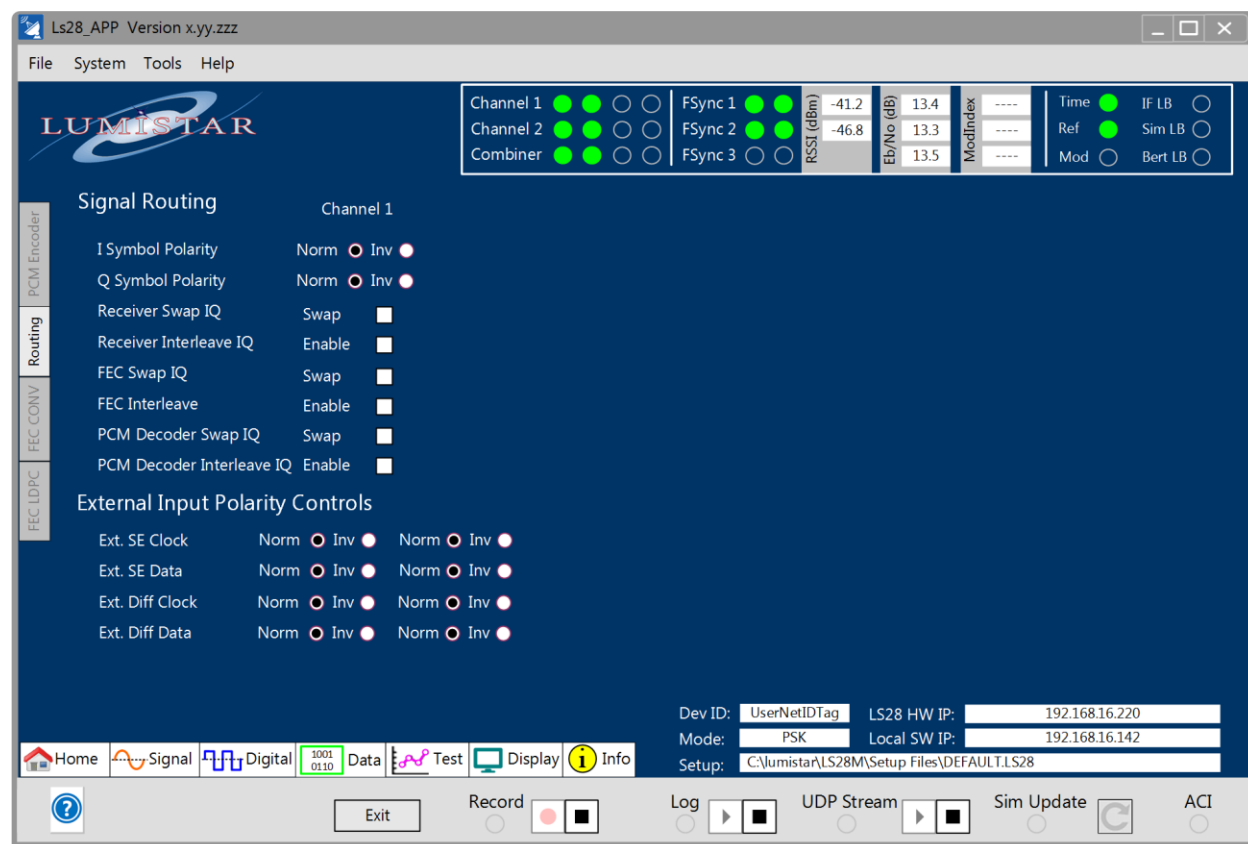


Figure 4-82 Network User Application – LDPC Signal Tab – Digital Routing

4.9.2.4.1 LDPC Signal Digital Routing Tab – Left Pane

In some PSK modulation formats, ambiguity is encountered when receiving data. These include QPSK formats as well as more simplistic BPSK. These ambiguities are integral to the modulation itself and must be resolved by some means. In quadrature modulation formats, ambiguities on whether a received symbol is an I symbol or a Q symbol and the polarity of these symbols creates a cases where there are up to 8 possible solutions. There are methods to eliminate these ambiguities such as the use of differential encoding and decoding. However, these methods cannot always be utilized. In these cases, this tab provides the user with controls to eliminate these undesired effects.

I Symbol Polarity: This control radio-button sets the PCM encoder output polarity. The NORM (normal) setting is the default setting. The INV setting inverts the I symbol data stream.

Q Symbol Polarity: This control radio-button sets the PCM encoder output polarity. The NORM (normal) setting is the default setting. The INV setting inverts the Q symbol data stream.

Receiver Swap IQ: This control check box allows the I and Q data streams to be swapped within the receiver in cases where the received signal has been assigned by the receiver in an IQ swapped manner. The Receiver represents the beginning of the digital processing chain.

Receiver IQ Interleave: If I and Q data streams require re-interleaving into a single stream, this check box controls allows this functionality within the receiver. The Receiver represents the beginning of the digital processing chain.

FEC Swap IQ: This control check box allows the I and Q data streams to be swapped within the FEC decoder in cases where the symbols have been assigned in an IQ swapped manner. The FEC decoder is optional and not used in all processing formats.

FEC IQ Interleave: If I and Q data streams require re-interleaving into a single stream, this check box controls allows this functionality within the FEC decoder. The FEC decoder is optional and not used in all processing formats.

PCM Decoder Swap IQ: This control check box allows the I and Q data streams to be swapped within the PCM decoder in cases where the symbols have been assigned in an IQ swapped manner. The PCM Decoder is at the end of the digital processing chain.

PCM Decoder IQ Interleave: If I and Q data streams require re-interleaving into a single stream, this check box controls allows this functionality within the PCM decoder. The PCM Decoder is at the end of the digital processing chain.

Ext SE Clock: This control radio-button sets the external clock polarity for the respective digital single-ended (SE) input stream. The NORM (normal) setting is the default setting. The INV setting inverts the polarity of the incoming clock.

Ext SE Data: This control radio-button sets the external data polarity for the respective digital single-ended input stream. The NORM (normal) setting is the default setting. The INV setting inverts the polarity of the incoming data.

Ext Diff Clock: This control radio-button sets the external clock polarity for the respective digital differential (DIFF) input stream. The NORM (normal) setting is the default setting. The INV setting inverts the polarity of the incoming clock.

Ext Diff Data: This control radio-button sets the external data polarity for the respective digital differential (DIFF) input stream. The NORM (normal) setting is the default setting. The INV setting inverts the polarity of the incoming data.

4.9.2.5 LDPC – Data Frame Sync Tab

This LDPC Data Frame Sync sub-function select tab provides controls and status related to the Frame synchronizer functions of the LS-28-DRSM. See Figure 4-83 for tab layout.

As shown in Figure 4-78, frame synchronization is the initial process block in the LS-28-DRSM data processing engine. The responsibility of this feature is to attempt to synchronize a stream of data. In this sub-function tab, the user should load information related to synchronization processing. Only two frame synchronizers are available in the LDPC decoding method.

In telemetry data, the use of a frame sync pattern is the typical means of representing the presence of a frame of data. This frame sync pattern can vary in size and location within the frame. The IRIG standards body group has defined appropriate frame sync patterns of lengths from 7 bits to 33 bits in length.

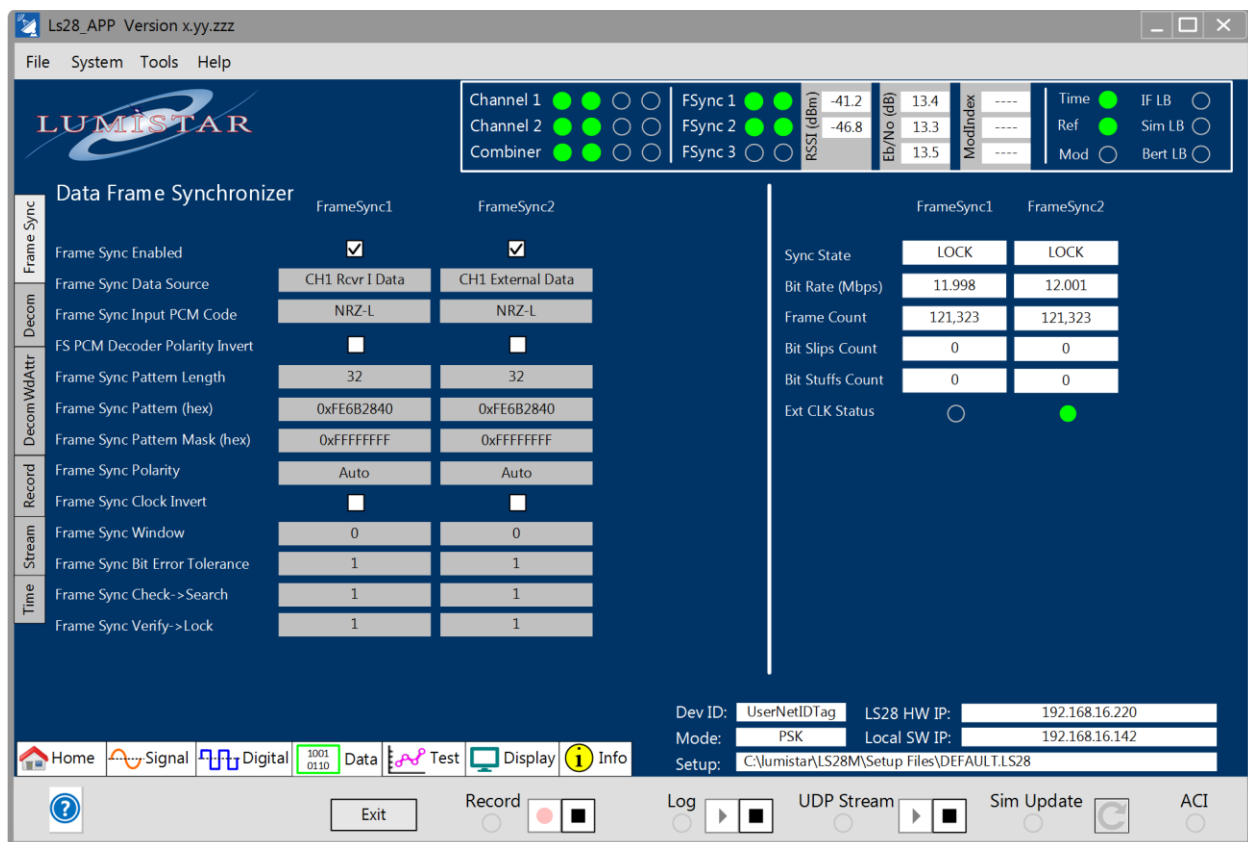


Figure 4-83 Network User Application – LDPC Data – Frame Sync

4.9.2.5.1 LDPC Data Frame Sync Tab – Left Pane

The LDPC Data Frame Synchronizer left tab contains controls for the two frame synchronizers of the LS-28-DRSM.

Frame Sync Enabled: To enable the frame synchronizer functions for a selected frame synchronizer, enable this check-box supply.

Frame Sync Data Source: To route data from the receiver functions to the frame synchronizer, the user must select from one of eight data sources. This control drop-down list provides a means of selecting one of the following sources: Channel 1 I Data, Channel 1 Q Data, Channel 2 I Data, Channel 2 Q Data, Combiner I Data, Combiner Q Data, External Ch1 Clock/Data, and External Ch2 Clock/Data. It should be noted that external sources require both a clock and a data source.

Frame Sync Input PCM Code: This control dialog box provides the user selections to the PCM input decoder at the front of the frame sync input. The user can select from the PCM input codes shown in

Table 4-6. This decoder provides an opportunity to decode any frame sync input source that may contain data that may be something other than NRZ-L format.

FS PCM Decoder Polarity Invert: This check box control provides the user the ability to invert any of the selected Frame Sync Input PCM Decoder selections, essentially doubling the number of PCM decoder selections. Once INV is selected, the data polarity is inverted for the selection made in the Frame Sync Input PCM Decode selection.

Frame Sync Pattern Length: This control dialog box allows the user to enter the length of the frame sync pattern as a value between 7 and 64 bits. When values are entered between 7 and 32 bits, the standard IRIG Frame sync pattern will automatically be loaded into the Frame Sync Pattern field on this tab.

Frame Sync Pattern: The frame sync pattern control window allows the user to enter values for the frame sync pattern. Entry of the frame sync pattern length will automatically fill this field with the IRIG defined optimal frame synchronization pattern. The user is allowed to alter the pattern to one of their choosing. Entries should be right justified. It is highly recommended to use the patterns in Table 4-7.

Frame Sync Pattern Mask: Along with the frame sync pattern, the user can set certain frame sync pattern bits as "don't cares". A mask is applied to each frame sync pattern applied. If the user wishes to make certain bits "don't cares", simply set the corresponding bit (or bits) in the Frame Sync Pattern Mask to zero and the frame synchronizer will disregard received values at these locations in determining lock.

Frame Sync Polarity: This pull-down control allows the user to set one of four frame sync polarity choices. These include: NORMAL, INVERT, NORMAL & INVERT (FAC) and AUTO. NORMAL settings will only synchronize to the pattern as shown in the Frame Sync Pattern control entry box. INVERT will only synchronize to the opposite polarity of the value shown in the Frame Sync Pattern control entry box. NORMAL & INVERT will sync to the frame sync pattern and the opposite of the frame sync pattern. The AUTO setting will synchronize to the frame sync pattern regardless of polarity and change all the resulting minor frame data along with the frame sync pattern into the NORMAL polarity mode.

Frame Sync Clock Invert: This check box control provides the user the ability to invert any of the selected Frame Sync Input PCM Decoder clock selections.

Frame Sync Window: The Frame Sync Window control allows the user to allow the minor frame synchronization window to be longer or shorter than defined. The window can be programmed for periods

of bit slips (fewer bits than expected) or bit stuffs (more bits than expected). Up to three bit slips or stuffs can be programmed. Positive numbers indicate bit stuff programming. Negative numbers indicate bit slip programming.

Frame Sync BER Tolerance: When the data channel quality becomes poor, all data in the stream will be affected including the frame sync pattern. This control dialog box allows the user to program how many of the bits in the frame sync pattern can be in error prior to declaring that the frame sync pattern does not match. Values from 0 to 32 can be programmed in this field.

This setting has to correlate with the assigned frame sync pattern length as well as general overall BER concerns. For most applications, only small values should be assigned. For example, if the frame sync pattern is 32 bits in length and the BER tolerance is set to 16, this relates to one of every two bits being in error and the pattern still qualify as LOCKED. BER performance of 1 in 2 would result in the demodulation engine being completely unable to maintain lock. As a more practical matter, in the example of a 32-bit frame sync pattern, if 1 of those bits experience bit errors, this represents a BER value of $3.125e-2$. This BER performance is still quite poor and would likely result in the demodulation engine being unlocked but is at least a more practical programmed figure. This value is commonly set to zero.

Frame Sync Verify->Lock: When data is being synchronized, data goes through three phases: SEARCH, VERIFY, LOCK, and CHECK. These modes are related to what is referred to as "Synchronization Strategy".

In most applications, synchronization strategy requires the successful reception of two or more contiguous frame sync patterns to declare lock. Ensuring two successful pattern matches virtually eliminates that a frame sync pattern was not falsely found in the payload data and is a genuine a frame sync pattern. When data is unlocked the frame sync is considered to be in SEARCH mode. Once the first frame sync pattern is detected the state moves to VERIFY. This control allows the user to set the number of subsequent patterns that need to be matched to declare a LOCK state.

Frame Sync Check->Search: When data is being synchronized, data goes through three phases: SEARCH, VERIFY, LOCK, and CHECK.

Once the frame sync is considered to be in LOCK mode if the frame sync detection fails to match two sequential patterns, the LOCK state is switched to the CHECK which indicates that two frame sync may be in the process of unlocking and returning to the SEARCH state. This control allows the user to set the number of subsequent patterns that need to remain unmatched prior to moving from the CHECK state to the SEARCH mode.

4.9.2.5.2 LDPC Data Frame Sync Tab – Right Pane

The LDPC Data Frame Synchronizer right tab contains status for the three frame synchronizers of the LS-28-DRSM.

Sync State: This right pane indicator will provide the user with an indication of the frame synchronizer lock state. This indication will be one of the following: SEARCH, VERIFY, LOCK or CHECK.

Bit Rate: This right pane status pane contains the present channel bit rate status.

Frame Count: A running count of the minor frame synchronization patterns received will be provided in this right pane status window.

Bit Slips Count: A running count of the minor frame bit slips detected will be provided in this right pane status window.

Bit Stuffs Count: A running count of the minor frame bit stuffs detected will be provided in this right pane status window.

Ext Clock Dead: This indicator is only active if the left pane setting for the Frame Sync Data Source is set to an external source. This indicator will be yellow if no clock is present from the external source or green if the clock is present. External sources must provide both data and clock to the LS-28-DRSM. If the Frame Sync data source is not selected as an external source, the indicator will be transparent.

4.9.2.6 LDPC – Data Decom Tab

This LDPC Data Decom sub-function select tab provides controls and status related to the Decommutator (often shortened to Decom) functions of the LS-28-DRSM. See Figure 4-84 for tab layout.

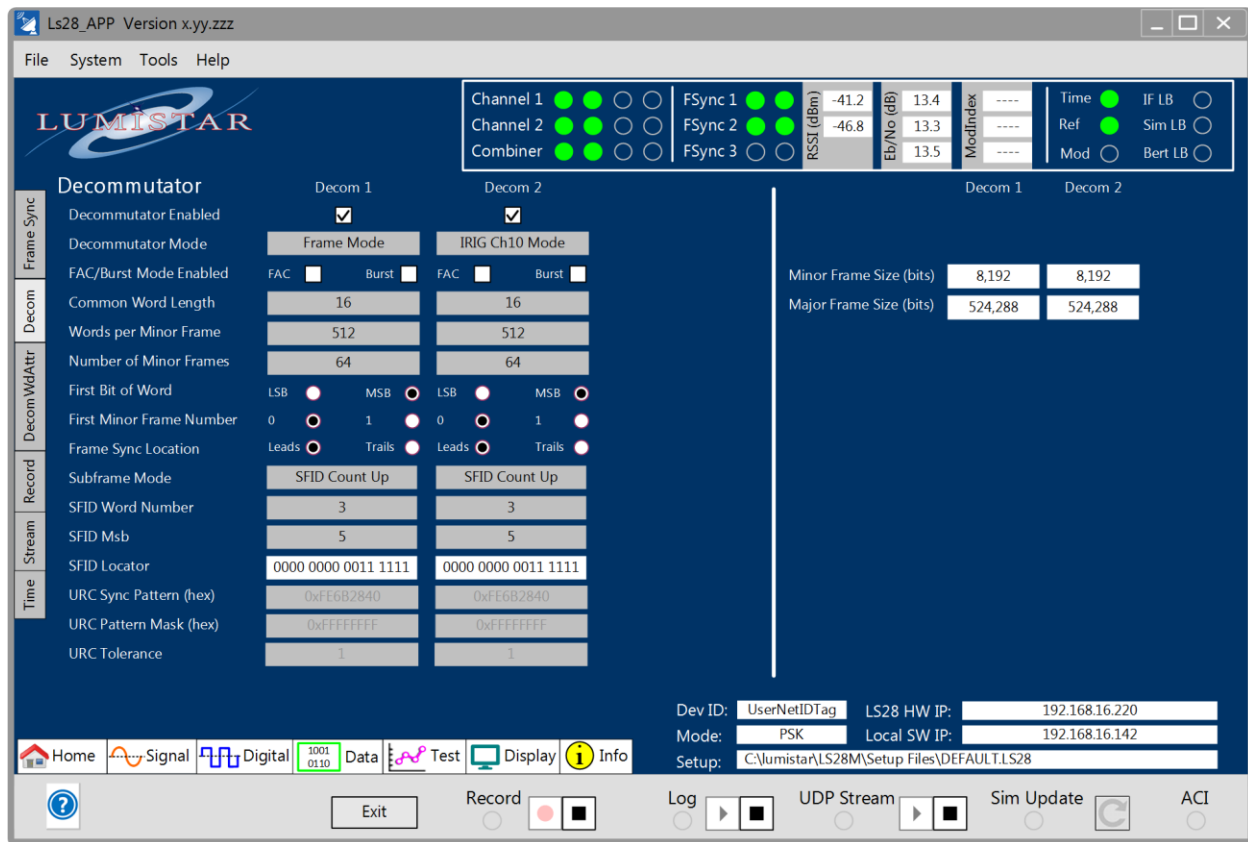


Figure 4-84 Network User Application – LDPC Data – Decom

4.9.2.6.1 LDPC Data Decom Tab – Left Pane

The LDPC Data Decommutator left pane area contains controls for the two LS-28-DRSM Decommutators.

Decommutator Enabled: To enable a selected decommutator, this check-box control is provided. This control must be enabled to utilize the associated decommutator functionality.

Decommutator Mode: This control drop-down list includes the following operational mode options: Frame Mode, Flywheel Mode, Raw Data Mode, and External Sync Mode.

In Frame mode, the decommutator will be looking to synchronize on a programmed Frame Sync pattern given the requirements programmed on the Frame Sync tab. In Flywheel mode, the decommutator will continuously cycle through received data until it finds a frame sync pattern as defined on the Frame Sync tab. Once a frame sync pattern matches the sync criteria outlined, any buffered data will be transferred and a new buffer will be created based on the synchronized data. In Raw mode, the decommutator will not look for a frame sync pattern. It will simply buffer up data as directed on this page and then transfer when that number of bits has arrived. External sync mode connects the decommutator to the external sync pulse via the GPIO interface.

FAC/Burst Mode Enabled: This row in the left pane allows for two controls. The Frame Alternate Compliment (FAC) mode is a less commonly used variant of FCC subframe mode. In this mode, the frame synchronization pattern is alternated with the complement of the frame synchronization pattern for each minor frame. Figure 4-43 illustrates the FAC mode. Selecting this check-box control enables FAC mode.

Burst mode automatically overrides the frame sync slip and stuff bit settings to capture the frame sync pattern as quickly as possible. This can be set in any mode. Selecting this check-box control enables burst mode.

Common Word Length: To enter the anticipated common word length of the data in a particular frame, this control dialog box allows the user to enter the most commonly available word length in the minor frame data. The common word length defines the length in bits of the *majority* of words that make up a minor frame. Note, not all words in a minor frame need be of the same length. For example, the majority of the words in a minor frame could be 8-bits in length, and thus the common word length would be 8. However, several of the words might be 14 or 16 bits in length and would be individually specified using the detailed decommutator word attributes which will be outlined in following section. Values between 3 and 16 are provided in accordance with IRIG standards for framed telemetry.

Words per Minor Frame: The user defines the minor frame length by invoking the Words Per Minor Frame control. Here, the user enters the number of words (of length specified by common word length) that make up a minor frame. The minor frame length on the LS-28-DRSM may be between 3 and 65536 words.

Number of Minor Frames: This control dialog box allows the user to enter the number of minor frames in a major frame. Values can be entered between 1 and 65536.

First Bit of Word: This radio button control allows the user to set up the meaning of the first bit in a given word. Selection of Most Significant Bit (MSB) and Least Significant Bit (LSB) are provided.

First Minor Fame Number: Minor frames can be numbered starting with 0 or 1. This radio button control allows the user to select the number of the first frame.

Frame Sync Location: The user specifies the location of the frame sync pattern within the frame by the use of this radio button. If the frame sync pattern is at the front of the frame the user should select LEADS. Conversely, if the frame sync pattern is at the end of the data transmission the user should select the TRAILS option. Reference Figure 4-44.

Subframe Mode: To implement a subframe synchronization scheme, telemetry designers often add one or more "special" words to each minor frame. The frame synchronizer then uses the special words to establish the location of the first minor frame in the major frame. The LS-28-DRSM supports five options in terms of subframe synchronization modes: None, SFID Counting Up, SFID Counting Down, FCC, and URC.

When NONE is select, the decommutator will consider that no sub-frame mode is implemented.

When SFID Counting Up is selected, the decommutator will assume that the unit is utilizing a Subframe ID (SFID) Counter that is counting up in value. The count will start from 0 or 1 as directed by the First Minor Frame Number setting.

When SFID Counting Down is selected, the decommutator will assume that the unit is utilizing a Subframe ID (SFID) Counter that is counting down in value. The count will terminate in either 0 or 1 as directed by the First Minor Frame Number setting.

SFID use is illustrated in Figure 4-45.

Frame Code Compliment (FCC) mode is a method where the complement (inverted) synchronization pattern is placed in the FSP location in minor frame 0. All other frame sync patterns are not inverted. Because the complement of the frame synchronization pattern exhibits the same correlation properties as the true pattern, frame sync lock will not be compromised. Minimum sync overhead is attained using this method, although it requires longer subframe acquisition time than the SFID method. FCC is illustrated in Figure 4-46.

Unique Recycling Code (URC) mode is a variation of FCC mode. For URC, a unique word is added anywhere in the first minor frame. A unique synchronization pattern *not* related to the primary synchronization pattern is used. This can replace the frame sync pattern or be at a different location in the first minor frame. URC is illustrated in Figure 4-47.

SFID Word Number: The location of the subframe identification (SFID) word(s) is arbitrary within the minor frame and may be specified by the user with this left pane control dialog box. As the LS-28-DRSM can support up to 65,536 words per minor frame, the user may thus locate the SFID word anywhere within this range, provided it does not overlap or coincide with the frame synchronization pattern location.

SFID MSB: The SFID acts as a frame counter, but it is not always the case that all of the bits in the SFID word are used for this purpose. For example, the SFID word might be 16-bits in length, but there might only be 512 minor frames in the major frame. In this scenario, a 9-bit counter ($2^9 = 512$) would be required. The user would specify the location of the counter within the larger 16-bit word by setting the Sync ID most significant bit (MSB) command and selecting the appropriate bit position for the most significant bit of the SFID counter.

SFID Locator: The SFID Locator is a status display that graphically illustrates where the Subframe Sync ID MSB is located within the minor frame SFID word.

URC Sync Pattern (hex): If the URC mode has been selected in the Subframe Mode control list, the URC pattern must be defined. Up to a 64-bit URC pattern can be defined by the user.

URC Pattern Mask (hex): In a similar manner as the frame sync pattern definition on the frame sync tab, the URC provides a mask setting that allows any bits within the URC mask to be identified as "don't cares". If the user wishes to make certain bits "don't cares", simply set the corresponding bit (or bits) in the URC Pattern Mask to zero and the correlator will disregard received values at these locations in determining lock.

URC Tolerance: When the data channel quality becomes poor, all data in the stream will be affected including the URC pattern. This control dialog box allows the user to program how many of the bits in the URC pattern can be in error prior to declaring that the URC pattern does not match. Values from 0 to 32 can be programmed in this field.

This setting has to correlate with the assigned URC pattern length as well as general overall BER concerns. For most applications, only small values should be assigned. For example, if the URC pattern is 32 bits in length and the BER tolerance is set to 16, this relates to one of every two bits being in error and the pattern still qualify as LOCKED. BER performance of 1 in 2 would result in the demodulation engine being completely unable to maintain lock. As a more practical matter, in the example of a 32-bit URC pattern, if 1 of those bits experience bit errors, this represents a BER value of 3.125×10^{-2} . This BER performance is still quite poor and would likely result in the demodulation engine being unlocked but is at least a more practical programmed figure. This value is commonly set to zero.

4.9.2.6.2 LDPC Data Decom Tab – Right Pane

The LDC Data Decommutator right pane area contains status for the three LS-28-DRSM Decommutators.

Major Frame Lock: This right pane status will indicate if a major frame lock has occurred within the parameters programmed by the user.

Minor Frame Size (bits): This right pane status window provides a calculated minor frame size in bits. This size will take into word attribute settings when calculating this value.

Major Frame Size (bits): This right pane status window provides a calculated major frame size taking into account the word attribute settings.

4.9.2.7 LDPC – Data Record Tab

This LDPC Data Record sub-function select tab provides controls and status related to the Recording features of the LS-28-DRSM. See Figure 4-85 for tab layout.

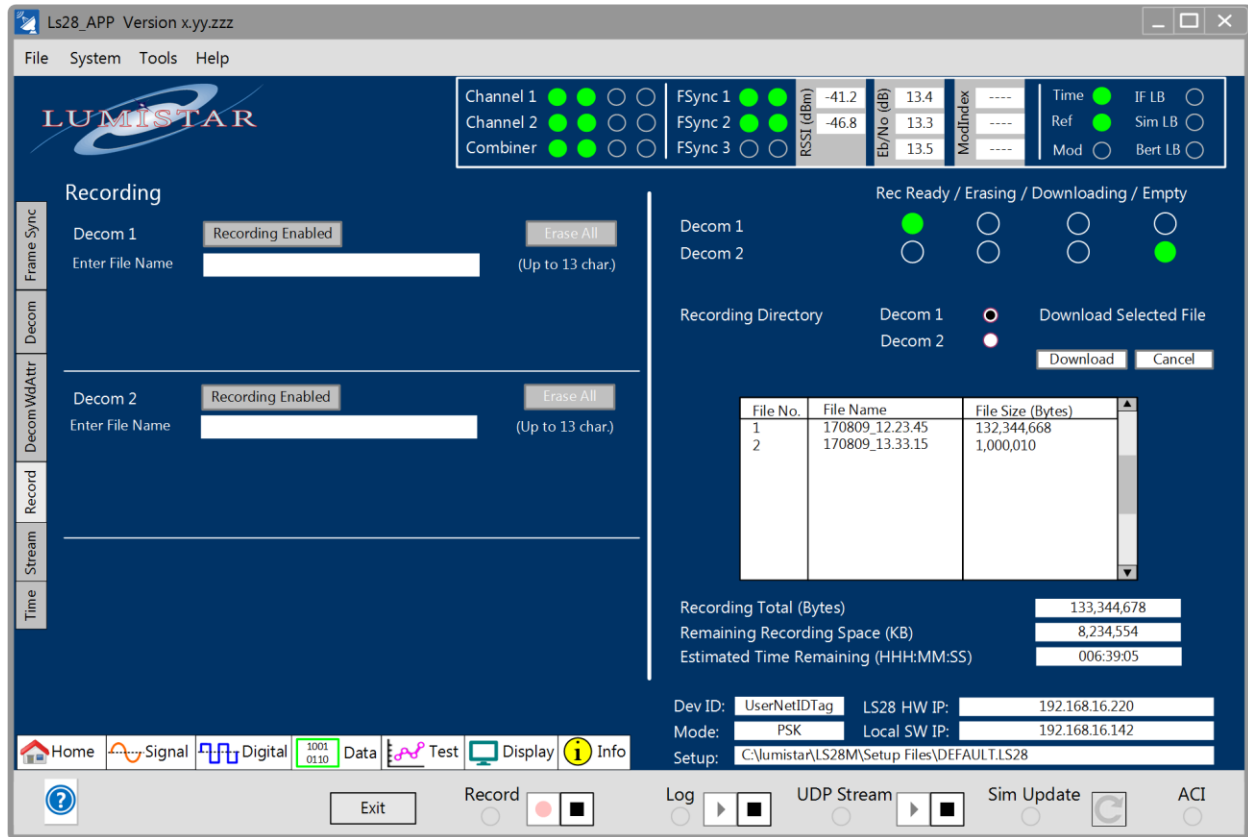


Figure 4-85 Network User Application – LDPC Data – Record

4.9.2.7.1 LDPC Data Record Tab – Left Pane

The LDPC Data Record left tab pane contains the primary setup controls for the LS-28-DRSM recording functions.

Recording Enabled: This left pane control button sets the recording function for the selected channel in an enabled state. This will not start the recording process but rather indicate that the process should be started once the real-time RECORD launch control was activated. With each recording run, a new file will be created and assigned a name related to the calendar date and time when the run occurred in accordance with host time.

Erase All: This left pane control button initiates the erase feature of a given channel. This selection will result in another dialog box warning that you are about to erase all recorded channel contents. This process, once started, cannot be halted and is permanent. Exercise caution prior to utilizing this function. There are no provisions for single file erasing within a recording set.

**Warning:**

Prior to selecting the ERASE ALL feature for a channel, download all recording files that need to be retained. Once the ERASE ALL function is complete, contents can not be restored.

**Information:**

The recording process stores data in FLASH memory in sequential order. There is no means of deleting individual files once recorded. All files must be deleted for a given channel.

**Warning:**

Erasing of recording memory is performed to all memory for a given channel. This process requires approximately 58 seconds per channel. During the erase period, responses from the Network User's Application software may result in "No response" warnings until complete.

**Information:**

Listings of recording memory capacities between channels when empty may vary due to differences between bad-block tables between devices.

Enter File Name: This left pane control line allows the user to enter a file name for the recording file. If the user leaves this location blank, an automatic file naming process will be initiated.

4.9.2.7.2 LDPC Data Record Tab – Right Pane

The LDPC Data Record right tab pane contains LS-28-DRSM recording status and various post-recording download controls.

Rec Ready: This right pane indicator will illuminate green if recording is enabled for a specific channel. If this indicator is extinguished, then no data will be recorded for that channel. Recording runs are initiated and halted from the RECORD real-time control along the lower tray of the network application GUI. Once at least one channel has been initiated for recording, the real-time RECORD button on the lower tray will become active as shown in Figure 4-85. The real-time control affects recording for all channels enabled.

Erasing: This right pane indicator will illuminate green during the Erase All function for a specific channel. The indicator will be green during the erase process and be extinguished once the process is complete.

Downloading: This right pane indicator will illuminate green during the download process and extinguish once the process is complete. Recording download data formats will be dictated by the frame synchronizer and decommutator section definitions and setups. An example of a download packet from the recording channel is provided in Figure 4-52 and Figure 4-53. It is important to note that the download process is performed using the TCP protocol. There are IPv4 MTU limits for each package of data sent but these are different than those imposed on UDP transmissions from the LS-28-DRSM.

4.9.2.8 LDPC – Test BER Tab

This BERT Test sub-function tab is provided for Bit Error Rate Testing (BERT) functions. The LS-28-DRSM LDPC modes provide two receiver BERTs, referred to as RX BERTs, and two transmission BERTs, referred to as TX BERTs. Refer to Figure 4-86 for tab layout.

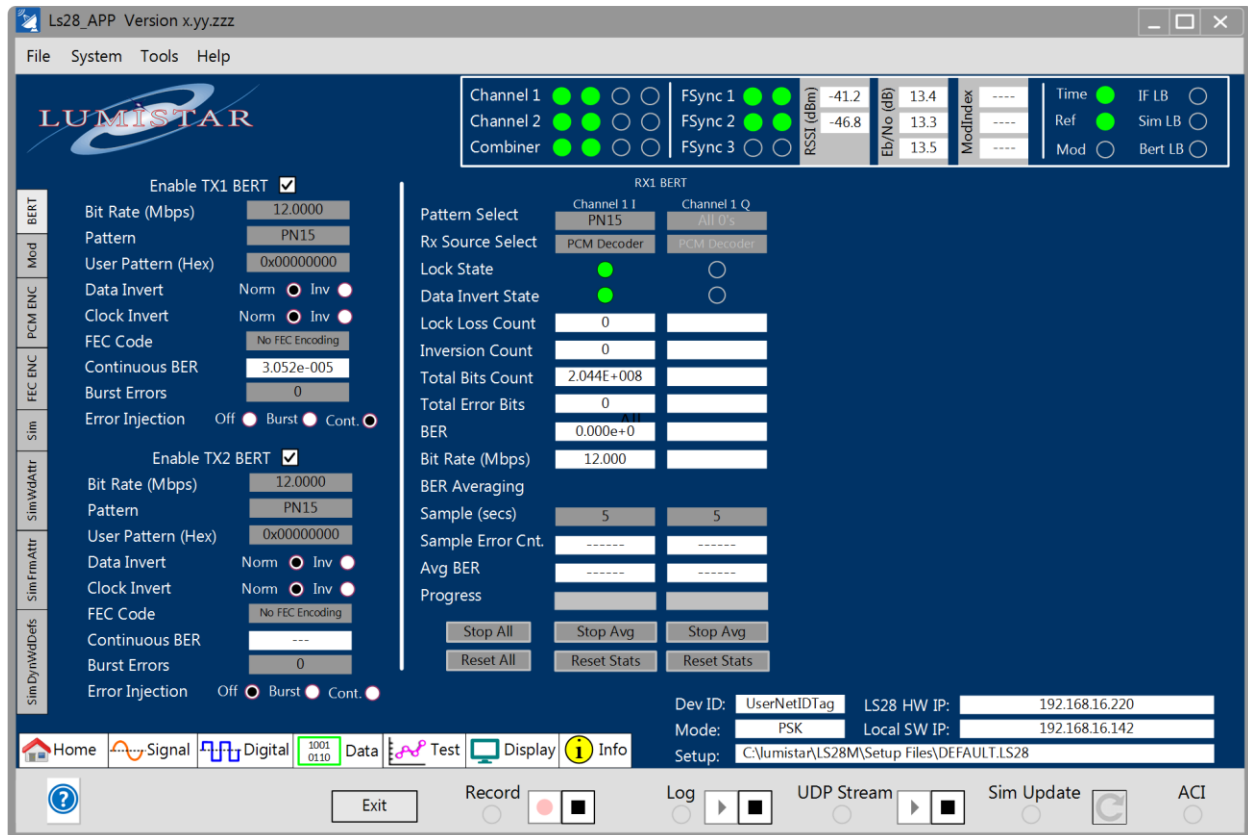


Figure 4-86 Network User Application – LDPC Test – BER

4.9.2.8.1 LDPC Test BER Tab – Left Pane

The Test BERT left pane area contains controls for the two LS-28-DRSM TX BERTs.

Enable TX1/TX2 BERT: This check-box control enables the functions of the respective transmit (TX) BERT. Deselecting this control will disable the functions of the respective TX BERT.

Bit Rate (Mbps): Entry of the TX BERT bit rate is done via this dialog box. Entry of values between 1000 and 60Mbps are allowed.

Pattern Select: Data patterns for the TX BERT can be selected from this drop-down list. Pattern options include pseudo-random sequences, repetitive patterns and user patterns. The list is as follows: All 0's, All 1's, Alternating 0's and 1's, PN3, PN4, PN5, PN6, PN7, PN9, PN10, PN11, PN15, PN17, PN18, PN20, PN21, PN22, PN23 and a selectable User Pattern.

User Pattern (Hex): A user defined pattern of up to 31 bits can be entered in hexadecimal in this dialog box. For this pattern to be active, the Data Pattern window must be set to "User Pattern".

Data Invert: The TX BERT data pattern polarity can be altered via this left pane control radio button.

Clock Invert: The TX BERT clock polarity can be altered via this left pane control radio button.

FEC Code: This entry box allows the user to select the Forward Error Correction Code to apply to the test data source.

Continuous BER: This status box will contain the resulting calculated BER value that will be expected when the Error Injection selection is "Continuous". Values will appear in scientific notation.

Burst Errors: This control box allows the user to enter from 1 to 64 errors to burst into the TX BERT output stream. Burst errors are, by definition, patterns which are inverted from their normal polarity state. Patterns longer than 64 bits will be re-correlated and redefined by typical RX BERTS as locked in an inverted state.

Error Injection: This set of radio buttons select the TX BERT error injection mode. Three options are provided: OFF, BURST, and CONT (continuous). When the OFF option is selected, no TX BERT errors will be injected. When the BURST mode is selected, a BURST button will be presented directly to the left of the Burst Error Control box. Each time the button is selected, a burst of the number of errors indicated in the Burst Error control box will be inserted in the output of the TX BERT data stream. If the CONT button is selected, a single bit error will be injected in each pattern cycle. This will result in a continuous BER rate as indicated in the "Continuous BER" status pane.

4.9.2.8.2 LDPC Test BER Tab – Right Pane

The Test BERR right pane occupies the majority of the tab display area and contains the results of the RX BERT functions.

Pattern Select: Data patterns for the receive (RX) BERT can be selected from this drop-down list. Pattern options include pseudo-random sequences, repetitive patterns and user patterns. The list is as follows: All 0's, All 1's, Alternating 0's and 1's, PN3, PN4, PN5, PN6, PN7, PN9, PN10, PN11, PN15, PN17, PN18, PN20, PN21, PN22, PN23 and a selectable User Pattern.

RX Source Select: This drop-down menu allows the user to select the source for the RX BERT channel being controlled. Options include: PCM Decoder, Ext SE1 Input, Ext SE2 Input, Ext DIFF1 Input, Ext DIFF2 Input, Loopback. The PCM decoder is the main receiver PCM decoder in the LS-28-DRSM receiver. The selections of Ext SE1, Ext SE2, Ext DIFF1, and Ext DIFF2 allow the user to direct external sources to the RX BERT inputs. Loopback is an internal connection between the TX1 or TX 2 BERT and the six RX BERTs. In loopback mode, TX1 BERT is connected to the I-Channel RX BERT channels. In loopback mode, TX2 BERT is connected to the Q-Channel RX BERT channels.

Lock State: This LED indicator provides the present state of the RX BERT pattern correlator. A green indication indicates that the receive correlator is locked to the selected pattern. If the indicator is yellow, the correlator is unable to establish lock.

Data Invert State: This LED indicator provides the present status as to whether the data that the RX correlator is receiving is presently polarity inverted or non-inverted. In the inverted state, the LED indicator will be yellow. If the pattern is not inverted, the LED will contain no color.

Lock Loss Count: This status box contains a count of the number of times the RX BERT has lost lock since the last reset.

Inversion Count: This status box contains a count of the number of times the RX BERT has detected a pattern inversion since the last reset. This count includes all inversion counts including one to an inverted state and from an inverted state.

Total Bit Count: This status box contains the total number of bits that the RX BERT has counted since the last reset condition.

Total Error Count: This status box contains the total number of error bits that the RX BERT has counted since the last reset condition.

Calculated BER: This status box contains a calculation of the Bit Error Rate (BER). For this status box, the BER calculation takes the total number of errors counted and divides that number by the total number of bits counted. This calculated value is not a time-averaged value but a long-term trend calculation.

Bit Rate (Mbps): This status box provides the present bit rate being received for the specified channel. Values are provided in Mbps.

Loopback: Selection of this check box internally loops the TX BERT to the RX BERT channels. TX1 BERT will be looped back to RX1 BERT. TX2 BERT will be looped back to both the RX2 and RX3 BERTs.

Sample (Secs): The lower area of the right pane contains an averaged BER calculation section. Each channel can setup a sample period and calculate the average BER over a given period. To set the averaging period, enter a value in seconds between 2 and 86400 (1 day) in the resulting dialog box.

Avg Errors: The number of errors per second over the averaged period will be displayed in this status box.

Avg BER: The calculated average BER figure will be displayed in this status box. This will be a calculation of the number of bit errors accumulated in the Sample period divided by the number of bits counted in the averaging period.

Progress: The progress status bar provides a visual feedback of the progress on averaging process. As the process progresses, a bar will fill from the left to the right of the display area.

Stop/Start Avg: This toggle button is used to initiate and halt the averaged BER calculations for a selected RX BERT channel.

Reset Stats: This toggle button is used to clear the bit error and clock counts used for BER calculations on a selected RX BERT channel. Only active channels apply to this button.

Stop/Start All: This toggle button is used to initiate and halt the averaged BER calculations for all six RX BERT channels. Only active channels apply to this button.

Reset All: This toggle button is used to clear the bit error and clock counts used for all BER calculations for all six RX BERT channels. Only active channels apply to this button.

4.10 Networking Controls

The LS-28-DRSM device is purposely designed as a network centric device. The power of this primary design attribute is expansive on several levels. To understand the network capabilities more fully, a brief primer on network interfaces will be provided in section 4.10.1. Controls for the network operations of the LS-28-DRSM are included in section 4.10.3.

4.10.1 General Network Primer

The LS-28-DRSM utilizes an Ethernet network interface based of the IEEE 802.3 10/100/1000BASE-T network standard. The network interface allows for up to 16 defined ports or “connections” for delivery of various types of data. These ports are analogous to lanes of “data traffic” and allow multiple application connections forming a virtual *multilane highway* of data. The ports allow for segregating certain data types into a given connection socket. Ports can be individually assigned by protocol type. Table 3-1 lists the assigned ports and protocol types for the LS-28-DRSM.

Network communications operate using a layered protocol approach. This is commonly referred to as the Open System Interconnect (OSI) model. The model contains 7 layers as defined in Figure 4-87.

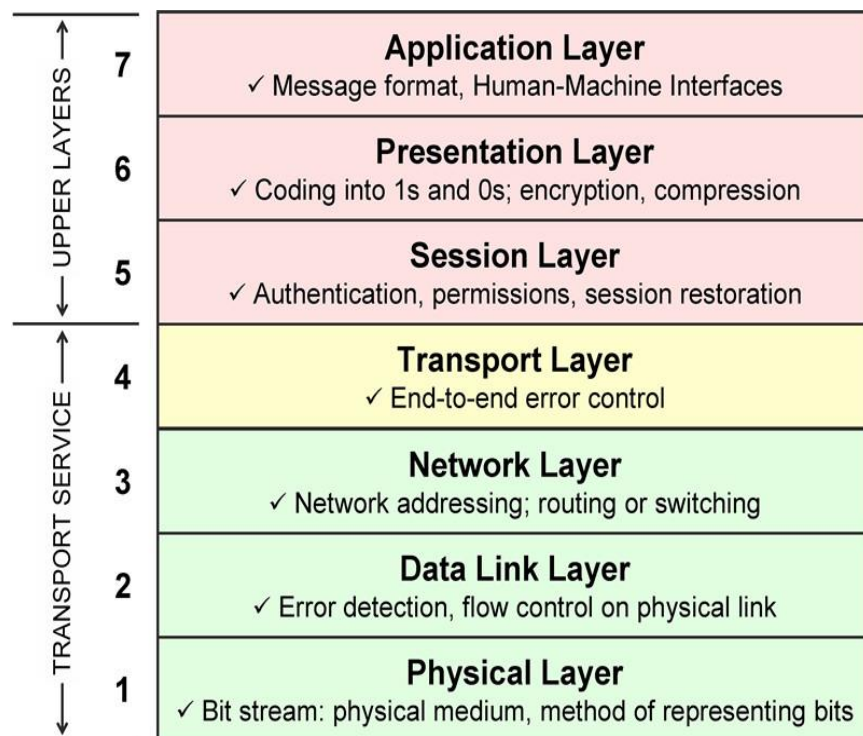


Figure 4-87 Network OSI Layer Diagram

Some of the layers of the OSI communications model are controlled at the hardware level, some are a combination of both hardware and software, and those beyond layer four are almost exclusively in the software domain.

The LS-28-DRSM communicates based on the specifications of Internet Protocol Version 4 (IPv4). The device utilizes both the TCP and UDP protocol for communications. TCP ports are more likely to be used for critical data delivery when guaranteed packet delivery is required. This protocol is used when timing delays are of a lower consequence. UDP protocols are used for streaming unidirectional data with minimal overhead. Most "real-time" data is sent via this protocol. UDP communications are considered "connectionless" because the data source transmits data to a given location but lacks status as to whether any device is receiving this data or the success of the physical transmission. For the primary command and status interface, the LS-28-DRSM utilizes the TCP protocol. For decommutated and data associated with display graphs, data is transmitted via the UDP protocol.

By definition, traffic that occurs on the network will experience some level of transmission delay. These delays are not totally within the control of the device itself but are dependent on network access times, bandwidth availability and software translation times. Lumistar highly recommends that the device be utilized on a 1Gbps network to limit the network transport delays as much as possible.

4.10.2 Network Connection Schemes

Network communications are made via routing schemes. Figure 4-88 illustrates three primary routing methods.

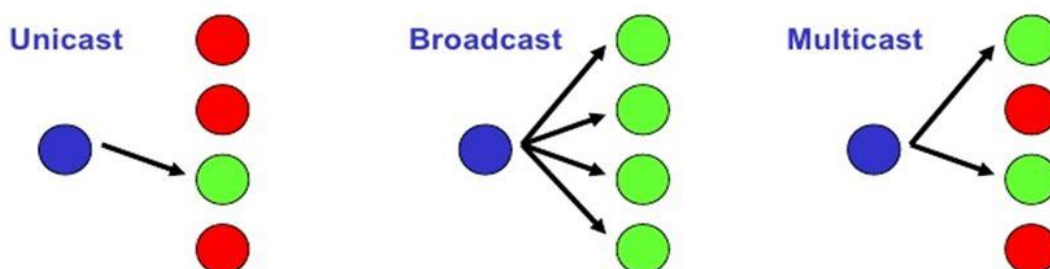


Figure 4-88 Network Routing methods

4.10.2.1 Unicast Connections

Unicast routing is considered to have a one-to-one association between the sender and the destination. The majority of client-server applications utilize unicast routing to some extent. Once communications channels are established in unicast mode, the connected applications have complete and exclusive access to this socket connection at the exclusion of other terminals on the network.

4.10.2.2 Broadcast Connections

Broadcast routing is considered to have a one-to-all association between the sender and all destinations. Broadcast communications are most often used in IPv4 for general network management and maintenance and not typically used by application level software. Multicast routing, available only using the UDP protocol, is considered to have a one-to-many association between the sender and selected or "subscribed" destinations. All Ethernet terminals that utilize TCP and UDP protocols require communications via all three routing methods for proper operations.

4.10.2.3 Multicast Connections

In the LS-28-DRSM design, special emphasis is placed on multicast routing capabilities. Multicast is important because it provides "real-time" streaming of received data as well as graphical data to multiple clients. Multicast is a form of broadcast but only to specified or "subscribed" clients. Clients subscribed to multicast addresses and ports eliminate the need for directed transmission or multiple transmissions of the same data content to different unicast addresses.

Multicast sources such as the LS-28-DRSM rely on multicast enabled routers to forward traffic to clients that are subscribed to receive the transmissions. More importantly, the multicast capable routers do not send data to addresses that have not requested it.

4.10.2.3.1 IGMP - Internet Group Management Protocol

IGMP is a communications protocol used between Multicast Sources and adjacent routers on IPv4 networks. This protocol provides the basic interchange "subscription" to a specific multicast transmission. IGMP operates in the network layer and requires a single IGMP querier per subnet (often an equipped router) to perform this function.

When a multicast transmission is initiated within the LS-28-DRSM, the network section of the design performs the necessary IGMP requests associated with the address and port automatically. When received by the network IGMP querier, the querier will then begin requesting updates from the initiating host on a periodic basis (typically every 120 seconds) to maintain the multicast connection.

4.10.2.3.2 Layer 3 Routers and Multilayer Switches

Layer 3 routers and some multilayer network switches often offer multicast capabilities. These devices typically run as an IGMP Proxy or PIM (Protocol Independent Multicast). These devices act as the IGMP querier which keeps track of "subscription" requests by network hosts to a specific multicast address and port.

4.10.2.3.3 Layer 2 Switches

Layer 2 switches typically do not provide IGMP querier functions. Many offer a function called "IGMP snooping" which is a process where the switch will listen to the IGMP query commands and then only route transmissions to hosts that match the query. Note, IGMP snooping requires an IGMP Querier function be present somewhere on the network branch.

Standard layer 2 switches, are not set up by default to handle multicast transmissions. In these cases, and cases where there is no IGMP querier, switches will send all multicast traffic to all attached ports, a condition referred to as "flooding". Network flooding consumes network resources and bandwidth and can result in the network being overwhelmed to the point where no transmission bandwidth on the network can be obtained. When this occurs, all network traffic can be disrupted.

For example. Let's assume that there are two 20Mbps real-time data streams connected to switches that contain only layer 2 switches and that there are no IGMP Querier on the network. However, the switch is connected to other switches within the network that contain a total of 18 connected hosts. With overhead, the 20Mbps streams will be approximately 24Mbps each. Therefore, 48Mbps for the two streams, essentially

broadcast to all hosts turns into 840Mbps, nearly the limit of the 1Gbps network. This illustrates just how essential proper network setup for Multicast transmissions can be.

**Warning:**

Multicast networks require an IGMP Querier for proper operation. The lack of one can cause network disruptions and network flooding.

4.10.3 Network Control Tab

The network control tab provides the primary user interface for the LS-28-DRSM network setup. See Figure 4-89 for tab layout.

Networking

UDP Stream	Destination IP Address	Destination Port No	Multi Cast	Enable
Spectral Display Ch 1	192 . 168 . 16 . 100	12001	<input type="checkbox"/>	<input type="checkbox"/>
Spectral Display Ch 2	192 . 168 . 16 . 100	12002	<input type="checkbox"/>	<input type="checkbox"/>
Constellation Display Ch 1	192 . 168 . 16 . 100	12007	<input type="checkbox"/>	<input type="checkbox"/>
Constellation Display Ch 2	192 . 168 . 16 . 100	12008	<input type="checkbox"/>	<input type="checkbox"/>
Constellation Display Ch 3	192 . 168 . 16 . 100	12009	<input type="checkbox"/>	<input type="checkbox"/>
Eye Display Ch 1	192 . 168 . 16 . 100	12010	<input type="checkbox"/>	<input type="checkbox"/>
Eye Display Ch 2	192 . 168 . 16 . 100	12011	<input type="checkbox"/>	<input type="checkbox"/>
Eye Display Ch 3	192 . 168 . 16 . 100	12012	<input type="checkbox"/>	<input type="checkbox"/>
Status Data	192 . 168 . 16 . 100	32770	<input type="checkbox"/>	<input type="checkbox"/>
Streaming Data Ch 1	192 . 168 . 16 . 100	32768	<input type="checkbox"/>	<input type="checkbox"/>
Streaming Data Ch 2	192 . 168 . 16 . 100	32769	<input type="checkbox"/>	<input type="checkbox"/>

Close UDP Streams on Exit (90 sec Max.) ☐ UDP Stream Time-out Enable/Disable

Enable Network Settings ☐ Multiple Entry

Enable Alternate Control Interface (ACI) ☐ Master Network Enable/Disable

TCP Address of Controlling Agent 192 . 168 . 16 . 100 Local Listening Port 33000

Path Address of shared file C:\Lumistar\LS28_App\User\ACIFile.cfg

OK Cancel

Multiple Entry

Destination IP Address	Destination Port No.	Port Number Increment	Multi Cast	Enable
230 . 0 . 0 . 0	50000	1	<input type="checkbox"/>	<input type="checkbox"/>

OK Cancel

Figure 4-89 Network User Application – System | Network setup tab

Destination IP Address: There are eleven potential UDP sources provided by the LS-28-DRSM. Each source requires that a destination address be provided for its data stream reception. This field allows the user to program these IP addresses. There is no checking of the IP addresses for validity. Many addresses

are reserved for special purposes. The Internet Assigned Numbers Authority (IANA) is responsible for maintaining the official assignments of IP addresses for specific uses. IANA provides a list of registered IP address ranges which can be found at the following link: <https://www.iana.org/assignments/ipv4-address-space/ipv4-address-space.xhtml>

Destination Port Number: Each of the eleven UDP IP addresses requires a defined network port number. These controls allow the user to set the UDP destination port number. There is no checking of port assignment validity other than a range check for values between 0 and 65,535. Many of these are reserved for privileged services. The Internet Assigned Numbers Authority (IANA) is responsible for maintaining the official assignments of port numbers for specific uses. IANA provides a list of registered port numbers which can be found at the following link: <https://www.iana.org/assignments/service-names-port-numbers/service-names-port-numbers.xhtml>

Multicast: This selection control signals the LS28_APP when the user has entered an IP address considered a multicast address. The control application will then connect to these addresses using multicast socket connections. Enabling this option does not cause a validity check of the programmed IP address but rather only changes the format of the socket connection made. When this option is deselected, the socket connections are considered to be unicast addresses. The device being controlled must be licensed with the *AdvNetworkInterface* for this selection to be available. Consult the factory for licensing details.

Enable: This control allows for individual inclusion or exclusion of particular UDP streams for control via this tab. If this selection is disabled, the Ls28_APP will control the stream of data and automatically route the data stream back to the control application for use. If this selection is enabled, then the specified control settings will only be active once the "Enable UDP Network Settings" control is enabled.

Close UDP Streams on Exit : This control allows the user to select the behavior of the UDP streaming data upon the close of the Ls28_APP application. If it is desired that the UDP streaming data sources automatically be halted at the close of the application, then select this option. If selected, during the normal closing of the application, all open streaming sources will be properly closed upon exit. If something unexpected happens in the execution of the controlling application software or to the OS of the hosting platform that interrupts normal software operations, selecting this option will instruct the LS-28-DRSM server to halt these channels on its own within 90 seconds of the application or OS anomaly even in cases where the software is no longer in control.

Enable UDP Network Settings: This is a master control for all individual UDP stream control definitions. The intended implementation is to have the user set controls for all desired UDP streams via the other tab controls. Once all controls are set, enabling this selection will make the control settings active. Conversely, deselecting this control will revert to direct internal application control of all UDP streams.

Multiple Entry: This control makes the entry of network addresses and ports in the Networking Control window very simple. Selecting this button will launch a multiple entry control window as shown at the bottom of Figure 4-89. To set all of the address and ports in the control window at the same time, simply enter the IP address, port number, and the port number interval desired. If the address entered is a multi-

cast address, select the Multicast check box. The user can then set all of the port entry enables by selecting the Enable check box. Once the OK button is selected, the entries will be initiated.

Enable Alternate Control Interface: This selection enabled and disabled the Alternate Control Interface of the LS28_APP. This interface allows for an external client to control and status all of the aspects of the LS-28-DRSM through a shared file interface and a private TCP connection between the control application and the client application. It is beyond the scope of this documentation to describe the details of this interface. Refer to the document *Lumistar LS-28M Alternate Control Interface Document (DOC-28M-01-ACI-03)* for full details. The device being controlled must be licensed with the [AdvNetworkInterface](#) for this selection to be available. Consult the factory for licensing details. Once enabled, the ACI LED on the Real-time Launch Controls/Status section of the LS28_APP will become active. When disabled, the ACI LED will be shown as transparent.

TCP Address of Controlling Agent: To provide a level of security and control, ACI interface activity will only be allowed from designated IP addresses. If the ACI interface is active, this control window allows the user to program the designated IP address of the external controlling client. The LS28_APP will only allow connections from this designated IP address.

Local Listening Port: This control allows the user to program the local listening port for the ACI interface. Port values must be in the range of 0 and 65,535.

Path Address of Shared File: As described in the ACI documentation, the ACI interface requires the sharing of a control file. This field allows the user to program the path address of the shared file. Both the user client application and the LS28_APP control application must have access to this file for ACI operation success.

5 LS28M Software Application

Lumistar provides the user a secondary Windows-based LS-28-DRSM control and status application. This application can operate in the following Windows operating system releases: Windows 7 x86, Windows 8 x64, Windows 10 x86, and Windows 10 x64. This application provides reduced functionality versus the LS-28-DRSM Network Interface application. It was initially design primarily for use with the non-network RS-232 or USB interfaces but was expanded over time to additionally provide network interfaces.

**Information:**

Most controls and status in Section 5 of this document are similar or identical to previously described details. This section makes exclusive use of data from prior sections and refers to many tables and figures from earlier sections rather than creating them for a second time.

This application serves different purposes than the Network Interface application. Where the source code for the Network Application Software is not available to the user, the entire code set of the LS28M application is available as a Microsoft Visual C++ 2013 project. The application does not provide visual UDP streaming of graphics displays such as the spectrum displays, constellation displays, or eye patterns nor does it provide all Network Interface application controls. The application also provides a means of updating the Digital Signal Processors firmware as well as the Demodulator FPGA firmware.

**Warning:**

The LS28M software application requires access to the Windows registry to save parameters between successive executions of the application. This requires the application be run in Administrator mode. Consult your IT administrator for necessary access.

5.1 LS28M General Application Layout

To understand the LS28M application further, the general layout of the application is shown in Figure 5-1 below.

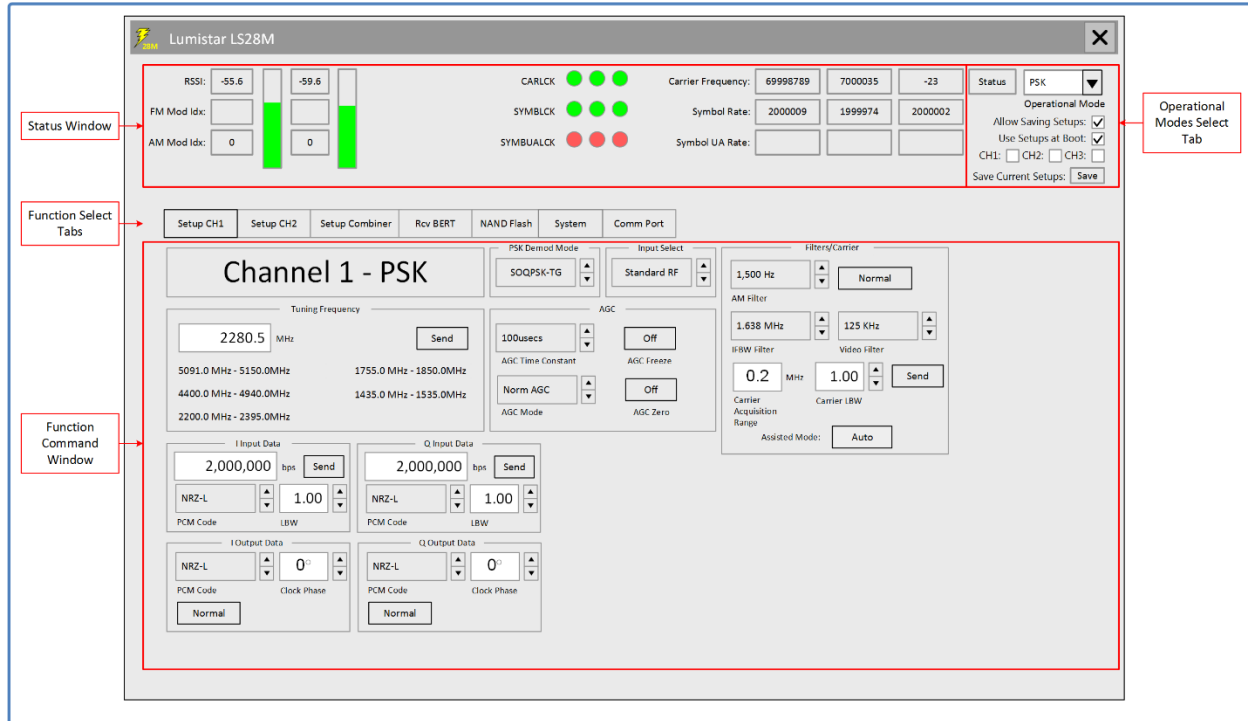


Figure 5-1 LS28M User Application – General GUI Layout

The application layout sections are defined as follows:

Status Window: The upper area of the application contains an operational status area to provide the user information pertaining to the incoming RF signal and demodulation status of the LS-28-DRSM receiver. Consult Figure 5-2 for details.

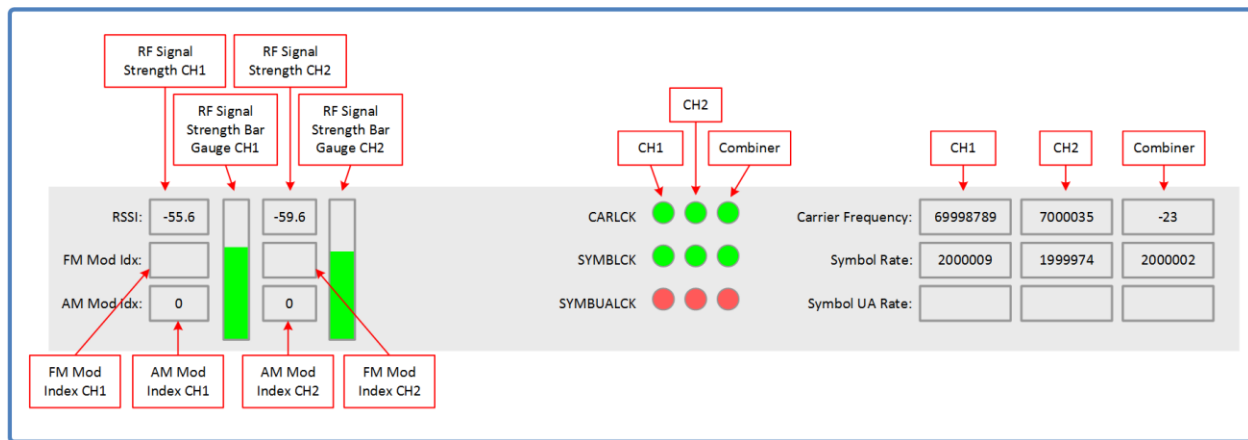


Figure 5-2 LS28M User Application – Status Window Details

- 1.) **RF Signal Strength CH1 (CH2):** These status boxes provide the user with the signal input measurement of both LS-28-DRSM RF inputs. Values are displayed in dBm and are updated at an approximate 5 Hz rate.
- 2.) **RF Signal Strength Bar CH1 (CH2):** These two bar graphs provide a visual representation of the RF signal strength. These bars provide a simple means of comparing signal strengths between the channels. The more filled the bar gauge reading the larger the input signal level.
- 3.) **FM Mod Index CH1 (CH2):** These status boxes provide the user with the signal input measurement of both LS-28-DRSM FM Demodulation Indices. These status updates are only available if the operational mode of the unit is PCM/FM or SS-PCMFM. Values are unit-less and are within the range of 0.1 and 2.55 and updated at an approximate 5 Hz rate when active.
- 4.) **AM Mod Index CH1 (CH2):** These status boxes provide the user with the signal input measurement of both LS-28-DRSM AM Demodulation Indices. Values are percentages and are more accurate at values below 66%. Values are updated at an approximate 5 Hz rate when active.
- 5.) **Status LEDs:** For each channel, there are three status LEDs to indicate lock conditions of the following: IF carrier lock, Bit Sync lock for the I channel, and Bit Sync lock for the Q channel. When each of these status' are unlocked the LED will be red. A green LED indicates a lock condition. The SYMBUALCK LED will only be green if the UAQPSK mode is active and the Q channel bit synchronizer is locked.
- 6.) **Numeric Status Windows:** For each channel, there are three numeric status windows to provide the user with numeric status related to the following: IF carrier frequency, Bit Sync I channel bit rate, and Bit Sync Q channel bit rate. The IF frequencies of CH1 and CH2 are direct carrier frequency measurements of the tracked 70MHz carrier. The combiner IF frequency will be reported in terms of the frequency delta from an original value of 70MHz. This value can be negative in value.

Function Select Tab: To select between functional operations in the LS28M application tabs are provided to change the related function control window.

Function Command Window: The major portion of the GUI is reserved for command entries related to the selected function tab. Users will enter primary controls in this region of the application.

Operational Mode Select Tab: The main operational mode selection for the LS-28-DRSM are selected via this drop-down menu. The items in the drop-down selection list will depend on the licensed functions of the attached unit. Options may be as follows: PCM/FM, PSK, MHCPM, SS-PCMFM, and Bit Sync. This area of the screen also contains controls for the recall setups at boot time and the record at boot time options of the LS-28-DRSM.

5.1.1 Comm Port Function Select Tab

This tab is typically the first tab that the user encounters. The tab provides the user with the ability to select between the serial interface connection or the Ethernet connection as a means of communicating with the LS-28-DRSM. See Figure 5-3 for tab layout.

The screenshot displays the 'Lumistar LS28M' application window. The 'Comm Port' tab is active, showing a navigation bar with tabs: Setup CH1, Setup CH2, Setup Combiner, Rcv BERT, NAND Flash, System, and Comm Port. The main area is divided into two sections: 'Serial Port Connection' and 'Ethernet Connection'. In the 'Serial Port Connection' section, the 'Comm Port' is set to 'COM9' and the 'BAUD Rate' is '57600'. There is a 'Test' button with a green indicator light and a 'Use Serial Port Connection' button. The 'Ethernet Connection' section shows a 'Remote IP Address' of '192.168.16.220' and a 'Save' button, with a 'Use Ethernet Connection' button below it. The top of the window contains various status and configuration fields, including RSSI (-55.6, -59.6), FM Mod Idx, AM Mod Idx (0), Carrier Frequency (69998789, 7000035, -23), Symbol Rate (2000009, 1999974, 2000002), and Symbol UA Rate. It also includes a 'Status' dropdown (PSK) and checkboxes for 'Operational Mode' (Allow Saving Setups, Use Setups at Boot, CH1, CH2, CH3) and a 'Save Current Setups' button.

Figure 5-3 LS28M User Application – Function Select: Comm Port

Serial Port Connection - Comm Port: Under the Serial Port Connection window, which will only be active if the serial port is selected as the device communications interface, this scroll button control allows the user to select the host COM port that the device is connected to. This interface may be a true RS-232 interface port or a virtual port COM port associated with the LS-28-DRSMs USB interface.

The application software installation provides the user with a USB COM port driver. The present release is found in the [PL2303_Prolific_DriverInstaller_v1190.zip](#) file. The driver, once installed on the host platform, will appear in the Windows device manager. Figure 5-4 illustrates a typical installation. COM port assigned numbers will be dependent upon other COM ports already present on the host. The [Prolific USB-to-Serial Comm Port](#) tag will identify the installed port assignment.

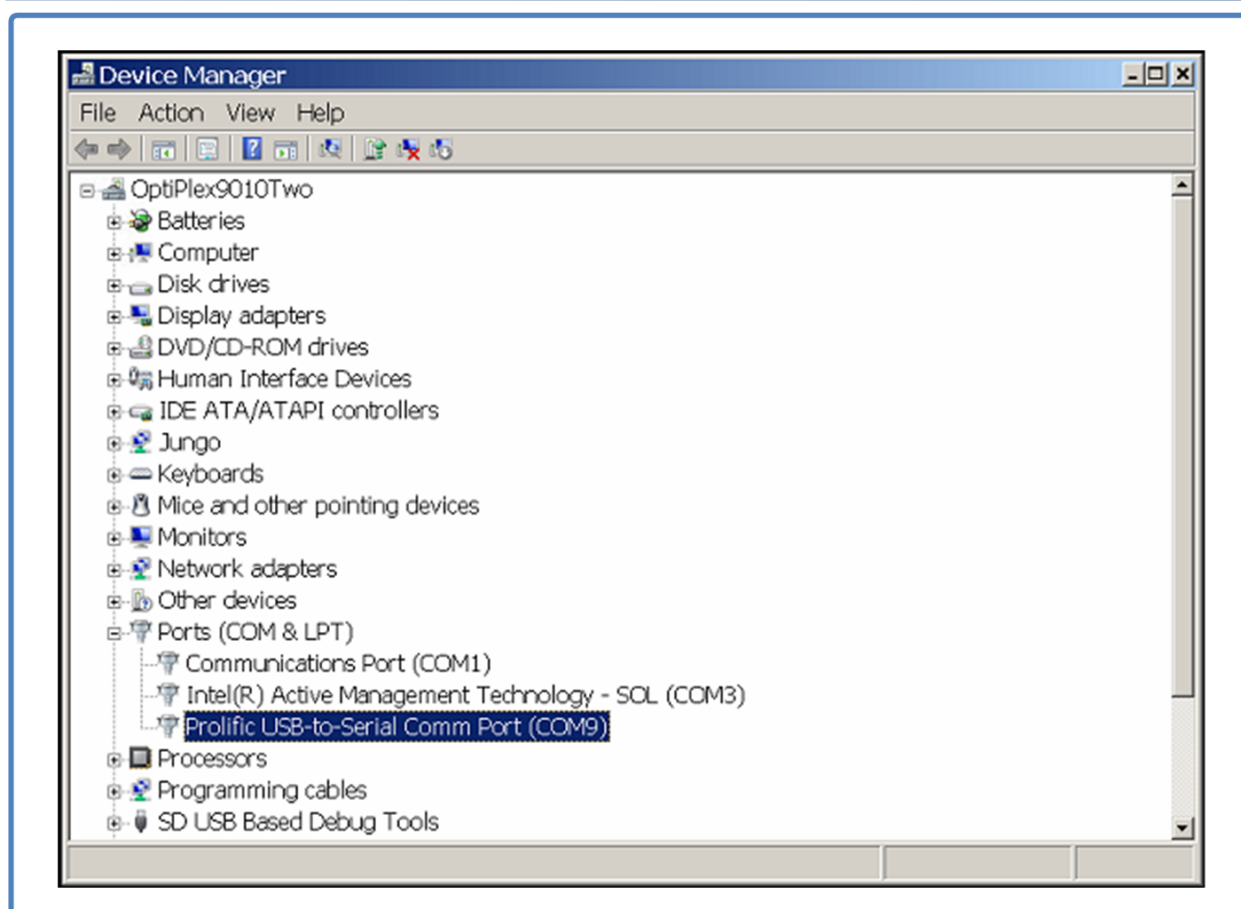


Figure 5-4 LS28M User Application – USB Prolific COM driver installation

Serial Port Connection - BAUD Rate: This control entry box allows the user to set a BAUD rate for the serial connection to the LS-28-DRSM. The default rate is 57,600 bps. This rate should not be changed unless directed by Lumistar support personnel.

Serial Port Connection - Test: Once the user has set the appropriate COM port, depressing the Test button will perform a test of the serial communications path. If the path communications is successful, the small indicator next to the button will be green. If communications fails, the indicator will be red.

Serial Port Connection - Use Serial Port Connection: This control button allows the user to select the RS-232 or USB as a communications channel for the LS28M User application. If this button is selected, the Ethernet connection controls will be disabled. Once selected and the COM port has been selected and tested, the application will need to be restarted to use this setting.

Ethernet Connection - Remote IP Address: When the Ethernet connection has been selected as the communication channel, the user should enter the IP address assigned to the unit in this control entry box. If the IP address is unknown, the Network Interface application can be utilized to scan all available LS-28-DRSM units and detect the IP addresses available.

Ethernet Connection - Save: Once the IP address has been set, the Save button provides a means of saving this address for future application runs. Once this setting is made, the application will require a restart for the setting to become active.

Ethernet Connection - Use Ethernet Connection: This control button allows the user to select the Ethernet as a communications channel for the LS28M User application. If this button is selected, the Serial Port connection controls will be disabled. Once selected and the IP address has been set and saved, the application will need to be restarted to use this setting.

5.1.2 Setup Combiner Function Select Tab

This tab provides the user with the ability to set and control the combiner setups. This tab will only function in the serial interface mode. See Figure 5-5 for tab layout.

Figure 5-5 LS28M User Application – Function Select: Setup Combiner

Tuning Frequency - Signal Bandwidth: This setting is used to program the combiner IF bandwidth. Unlike the Network User Application, all settings are manually programmed in the LS-28M. Settings are entered as Hz bandwidth values.

Tuning Frequency - SNR Filter Bandwidth: In combining the two received signals contain different power levels, or more accurately Signal to Noise Ratios (SNR). The SNR estimates of each channel are performed continuously. The amplitude bandwidth affects these estimates. If settings are too narrow, then fast signal fading cannot be accommodated and if the settings are too wide then the accuracy of the SNR estimates is jeopardized. Lumistar suggests that the most appropriate setting for this SNR bandwidth setting is 20kHz.

Tuning Frequency - Phase Filter: In combining the two signals being received, both signals are converted to baseband prior to being combined. Once the signal is converted to baseband, the weaker of the two signals is rotated to match phases with the strongest of the received signals. This process is a form of phase filtering. If this setting is too narrow, then frequency offsets cannot be managed in the case that the signals are provided in a frequency diversity mode. If the setting is too large performance of the overall

combining functionality is impaired. Lumistar suggests that the most appropriate setting for this phase bandwidth setting is 20kHz.

Tuning Frequency - Combiner Type: There are two types of combining selectable for the LS-28-DRSM: Complex and Baseband. Complex is used for the combining of two signals that are modulated and combined at 70MHz. The other combining mode is for baseband signals.

Tuning Frequency - Reconstruction Upsample: This control allows the user to select the combined output to be upconverted and then output via the modulator output.

Tuning Frequency - Combiner Type: This control allows the selection of the available modes of the diversity combiner if licensed and enabled. Five combiner operational modes are provided: Maximal-Ratio Combining (MRC), Equal Gain Combining (EGC), and Best Source Combining (BSC), CH1 Only, CH2 Only.

The LS-28-DRSM employs a pre-detection, maximal-ratio diversity combiner. It accepts two IF inputs (typically 70 MHz) with independent or complementary fading, usually from separate polarizations or separate antennas. The most significant performance improvement from a diversity combiner occurs in a fading environment when the two channels fade independently. When one channel is in a fade, there is a good chance that the other channel will not be in a fade, and so the effect of the fade is completely mitigated. Only when both channels fade does the combined signal fade. A diversity combiner provides the additional performance advantage of providing gain by phase aligning and optimally combining the two signals. Combining prior to demodulation (pre-detection) makes that gain available to the receiver's tracking process and significantly reduces the chances of the receiver losing lock.

The LS-28-DRSM combiner measures the relative phase of the two signals and the Signal-to-Noise Ratio (SNR) estimate of each channel. The phase of the weaker signal is adjusted to match the stronger signal. In a multi-path environment, rapid phase fluctuations occur in the deepest part of the fade. By adjusting the phase of the weak signal to that of the strong signal, the rapid phase fluctuations are mitigated. The amplitudes are adjusted based on the ratio of the two SNR measurements to provide a maximal ratio combining. This means that if the two signals have different SNRs, then the signal with the lower SNR will be attenuated relative to the signal with the stronger SNR, ensuring that weak or faded signals do not negatively affect the combined signal. Signals with the same SNR will be combined with equal strength.

Equal Gain combining is used for very fast fade rate environments where fades in excess of 10kHz are expected. This scenario may exist when the signal is transmitted through a vehicles exhaust plume. The EGC operational mode should only be used in these extreme situations.

Best source combining removes the theoretical gain aspects of the combiner. It simply selects the channel with the best SNR estimate at a given time. Lumistar suggests the typical use of the MRC combining mode.

The CH1 and CH2 only modes directs the combiner output to be selected based on channel.

Tuning Frequency - Send: This button allows the user to send all setting changes associated with the Tuning Frequency box.

I Input Data – Data Rate (bps): This control window allows the user to set the combiner's I data rate in bits-per-second.

I Input Data – PCM Code: This control drop-down list allows the user to select the combiner's I PCM Input decoding format. Table 4-6 provides a list of Input PCM Codes that can be selected.

I Input Data – LBW: Bits within the bit synchronizer function of the receiver are tracked by a phase lock loop (PLL). This is a closed loop feedback system that contains associated correction rate coefficients. These coefficients are referred to as the bit sync loop-bandwidth (LBW). Loop bandwidths values are typically provided as a percentage of a given factor. For the bit synchronizer, this is a percentage of the symbol rate programmed by the user.

Generally, as loop bandwidth values increase, lock times decrease but higher bandwidths can increase loop related errors such as jitter and noise. Narrow loop bandwidths increase lock time and decrease noise and jitter. Trade-offs may need to be made based on the signal channel characteristics.

The I Input bit sync loop bandwidth controls the settings to the first bit synchronizer of each channels two provided bit synchronizers.

Table 4-3 contains the ranges appropriate for a given symbol rates. These values can either be entered in the associated slider box or by adjusting the slider itself.

I Input Data – Send: This button allows the user to send all setting changes associated with the I Input box.

I Output Data – PCM Code: This control drop-down list allows the user to select the combiner's I PCM Output decoding format. Table 4-5 provides a list of Output PCM Codes that can be selected.

I Output Data – Clock Phase: This control allows the user to select one of four output clock phases for the combiners I Output clock. The selections allowed are: 0-degrees, 90-degrees, 180-degrees, and 270-degrees.

I Output Data – Normal: This button is used to set the I Output Data Polarity. The Polarity can be toggled between Normal and Inverted.

Q Input Data – Data Rate (bps): This control window allows the user to set the combiner's Q data rate in bits-per-second.

Q Input Data – PCM Code: This control drop-down list allows the user to select the combiner's Q PCM Input decoding format. Table 4-6 provides a list of Input PCM Codes that can be selected.

Q Input Data – LBW: This control allows the user to program the combiner's I channel bit synchronizer Loop Bandwidth settings.

Q Input Data – Send: This button allows the user to send all setting changes associated with the Q Input box.

Q Output Data – PCM Code: This control drop-down list allows the user to select the combiner's Q PCM Output decoding format. Table 4-5 provides a list of Output PCM Codes that can be selected.

Q Output Data – Clock Phase: This control allows the user to select one of four output clock phases for the combiners Q Output clock. The selections allowed are: 0-degrees, 90-degrees, 180-degrees, and 270-degrees.

Q Output Data – Normal: This button is used to set the Q Output Data Polarity. The Polarity can be toggled between Normal and Inverted.

Filters/Carrier – IF Filter BW: This control allows the user to select the 70MHz IF filter bandwidth settings.

Filters/Carrier – Carrier Acquisition Range: This control allows the user to select the IF carrier acquisition range settings for the combiner functions.

Filters/Carrier – Carrier LBW: This control allows the user to select the IF carrier loop bandwidth settings for the combiner functions.

Filters/Carrier – Assisted Mode: This allows the Filters and Carrier settings to be switched between Assisted (Automatic) and Manual Settings mode.

Filters/Carrier – Send: This button allows the user to send all setting changes associated with the Filters/Carrier box.

5.1.3 Rcvr BERT Function Select Tab

This tab provides the user with the ability to control and status the RX BERT on the LS-28-DRSM. This tab will only function in the serial interface mode. See Figure 5-6 for tab layout.

The screenshot displays the 'Lumistar LS28M' application window. At the top, there are status indicators for RSSI (-55.6, -59.6), FM Mod Idx, and AM Mod Idx (0). To the right, there are status LEDs for CARLCK, SYMBLCK, and SYMBUALCK, along with frequency and rate settings (Carrier Frequency: 69998789, 7000035, -23; Symbol Rate: 2000009, 1999974, 2000002; Symbol UA Rate). Below these are checkboxes for 'Operational Mode' (Allow Saving Setups, Use Setups at Boot) and 'Save Current Setups' (Save).

The main section of the interface is divided into three columns, each representing a different BERT setup: 'Rcv BERT Channel 1 Setup', 'Rcv BERT Channel 2 Setup', and 'Rcv BERT Combiner Setup'. Each column contains a 'Setup' tab and a 'Status' tab. The 'Setup' tabs include 'Enabled' and 'Normal' buttons, 'Enable BERT' and 'Invert Clock' checkboxes, and a 'PRN Pattern' dropdown menu (set to PN15). The 'Status' tabs show 'Locked' and 'Normal' LEDs, 'Bit Error Count', 'Bit Count', 'Calculated BER', 'Bit Rate', and 'Out of Lock Count' fields, along with a 'Reset Rcvr BERT' button.

Figure 5-6 LS28M User Application – Function Select: Rcvr BERT

Rcv BERT – Enable BERT: This button enables the respective RX BERT. When this button is toggled to disabled, all BERT status will be halted.

Rcv BERT – Invert Clock: This toggle button will change the polarity of the BERT clock. The state toggles between normal and inverted.

Rcv BERT - PRN Pattern: This is a drop-down control that allows the user to select the RX BERT PRN pattern for correlation. The list is as follows: All 0's, All 1's, Alternating 0's and 1's, PN3, PN4, PN5, PN6, PN7, PN9, PN10, PN11, PN15, PN17, PN18, PN20, PN21, PN22, PN23 and a selectable User Pattern.

Rcv BERT - Locked: This RX BERT status LED indicates the correlator state. If the unit is locked, the LED will be Green. If unlocked, the LED will be Yellow.

Rcv BERT - Normal: This RX BERT status LED indicates the correlator state polarity state. If the unit detects normal polarity, the LED will be Green. If inverted, the LED will be Yellow.

Rcv BERT – Bit Error Count: This status field contains the number of bit errors that have been detected since the last RX BERT reset. This is a cumulative figure.

Rcv BERT – Bit Count: This status field contains the number of bits that have been counted since the last RX BERT reset. This is a cumulative figure.

Rcv BERT – Calculated BER: This status field contains a calculated BER since the last reset. To get this figure, the number of errors counted is divided into the number of bits counted.

Rcv BERT – Bit Rate: This status field contains the detected bit rate in bits-per-second.

Rcv BERT – Out of Lock Count: This status field contains a count of each occurrence when lock has been lost.

Rcv BERT – Reset Rcvr BERT: This button resets the metrics that have been accumulated in the RX BERT status windows.

5.1.4 NAND Flash Function Select Tab

The tab provides the user with the ability to download and repair internally recorded files. This tab requires the Ethernet connection for download. See Figure 5-7 for tab layout.

The screenshot displays the 'NAND Flash' tab in the Lumistar LS28M application. At the top, there are status indicators for RSSI, FM Mod Idx, AM Mod Idx, and carrier frequency. Below these are buttons for 'Setup CH1', 'Setup CH2', 'Setup Combiner', 'Rcv BERT', 'NAND Flash', 'System', and 'Comm Port'. The 'NAND Flash' tab is selected, showing a table of file numbers, names, and lengths for CH1. To the right of the table are buttons for 'Read File Directory', 'Remaining Capacity', and 'Repair Last File'.

File Number	File Name	File Length
0	210415_11.43.18	1,930,308
1	210415_11.46.49	5,678,142
2	210415_11.48.17	4,532,224
3	210415_11.53.03	1,064,704
4	210415_11.56.17	2,778,068
5	210415_11.58.33	1,313,024
6	210415_12.06.14	6,109,322
7	210415_12.13.02	2,274,304
8	210414_12.22.07	5,885,652

Figure 5-7 LS28M User Application – Function Select: NAND Flash

NAND Flash - CHx: These three buttons select the recording channel for control and status.

NAND Flash – Read File Directory: This button will cause the recording file list held on the LS-28-DRSM to be downloaded to the file directory listing status window. It will also update the recording area remaining storage capacity.

NAND Flash – Repair Last File: This button allows for the repair of the last file in a recording directory. This is used if the last file does not contain an end-of-file directory listing. This button will operate in USB and serial interface mode.

NAND Flash – Remaining Capacity Status: This status box displays the remaining storage capacity in bytes of the channel selected.

NAND Flash – File Directory Listing: This status window lists the file numbers, file names, and file sizes of the recording directory. This area is filled and updated by the "Read File Directory" button.

5.1.5 System Function Select Tab

The tab provides the user with the ability to perform DSP and FPGA updates, provides status on the firmware versions loaded to the LS-28-DRSM, provides hardware version information, controls the internal reference clock, and provides utility control buttons. See Figure 5-8 for tab layout.

Figure 5-8 LS28M User Application – Function Select: System

System – Reference Clock: This control button enables and disables the internal RF reference clock. If the reference clock is disabled, an external 10MHz reference must be applied to provide RF downconversion processing.

System – EEPROM Bulk Erase Status: Part of the procedure for updating firmware is to erase the FLASH memory before re-writing. This bar gauge provides a visual status of the erase process. The *Lumistar LS-28M Field Support Manual (DOC-28M-01-FSM-02)* contains great detail of the use of these controls. Please consult this document for additional information.

System - Page Prgm Status: Once the programming process has begun, this bar gauge provides the user with a visual indication of the process and how near completion the action is. The *Lumistar LS-28M Field Support Manual (DOC-28M-01-FSM-02)* contains great detail of the use of these controls. Please consult this document for additional information.

System - Update Byte Count Status: The FPGA firmware update process is a rather long and involved. These two windows provide a byte count of the update process activity. Using the network interface, the process will pace at approximately 1MB per minute. The *Lumistar LS-28M Field Support Manual (DOC-28M-01-FSM-02)* contains great detail of the use of these controls. Please consult this document for additional information.

System – DSP1/DSP2 File Load: This area contains the file browse and load functions associated with the update of the DSP firmware. The *Lumistar LS-28M Field Support Manual (DOC-28M-01-FSM-02)* contains great detail of the use of these controls. Please consult this document for additional information.

System – Demodulator FPGA Configuration Update File Load/Status: This area contains the file browse and load functions associated with the update of the signal processing FPGA firmware. The *Lumistar LS-28M Field Support Manual (DOC-28M-01-FSM-02)* contains great detail of the use of these controls. Please consult this document for additional information.

System – Versions Read: This button requests that all system page status be updated from the LS-28-DRSM. After being depress, all firmware version dates will be current.

System – DHCP: This check box provides status on the present state of the Network DHCP setting. If DHCP is enabled, this box will be checked. The box does not control the DHCP mode of the network setting.

System – Upload License File to Device: This control button allows the user to browse for a command file that Lumistar Customer support has provided to perform a license update. Once completed, the unit will contain a new license capability after the unit is rebooted.

System – Run Encrypted Command on Device: This utility control button allows the user to browse for a command file that Lumistar Customer support has provided to perform a specific update or corrective activity. The files will contain commands to be run internally after the download is complete.

System – Turn Off Consolidated Status: This utility control button provides a means of disabling the UDP consolidated status message stream.

System – Turn Off All Graphs: This utility control button allows the user to disable all graph UDP streams that are active on the network connection.

System – Ping: This utility control button allows the user to perform a PING command (0x0000) via the USB, Serial and Ethernet interfaces.