Quasonix

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Installation and Operation Manual

Compact RDMS™ Telemetry Receiver

Quasonix, Inc.
6025 Schumacher Park Dr.
West Chester, OH 45069
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Revision 2.2.1

Specifications subject to change without notice.
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1 Introduction

1.1 Description

This document describes the installation and operation of the Quasonix Compact RDMS™ Telemetry Receiver. The RDMS™ (Receiver / DeModulator / bit Synchronizer) is designed to demodulate RF signals in several formats:

- PCM/FM (ARTM Tier 0)
- SOQPSK-TG (ARTM Tier I)
- Multi-h CPM (ARTM Tier II or ARTM CPM)
- Legacy (PSK) suite, including
  - BPSK
  - QPSK
  - Asymmetric QPSK (AQPSK) *Requires -37 option*
  - Asymmetric Unbalanced QPSK (AUQPSK) *Requires -37 option*
  - Offset QPSK (OQPSK)
  - Unbalanced QPSK (UQPSK)
  - Digital PM

The RDMS™ provides true trellis demodulation in ARTM Tier 0, Tier I, and Tier II modes, delivering BER performance within 0.2 dB of theory. It also provides a clock signal (two clock signals in the AQPSK and AUQPSK modes), obviating the need for any outboard bit synchronizer.

The RDMS™ is manufactured by:

Quasonix, Inc.
6025 Schumacher Park Drive
West Chester, OH 45069
CAGE code: 3CJA9

1.2 Nomenclature

The RDMS™ is available in a number of variations, depending on the options specified at the time of order. The features and modes installed in each unit are identified in the model number, as depicted in Figure 1.

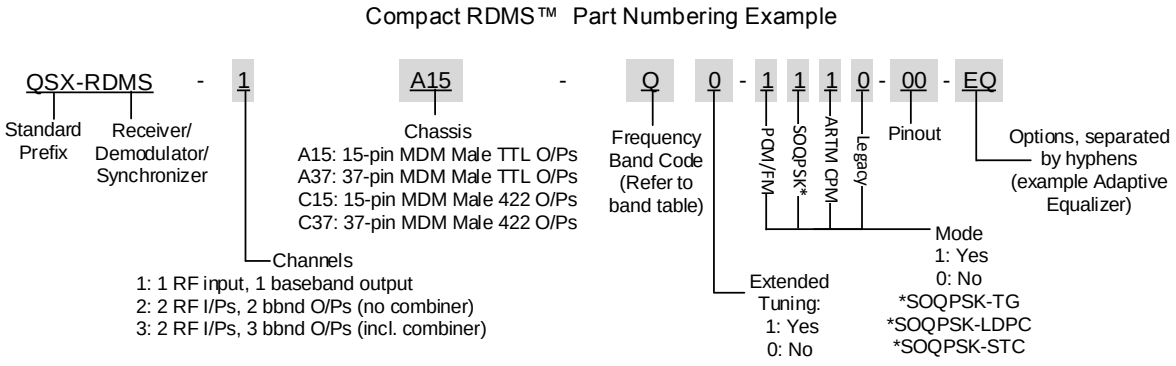


Figure 1: Receiver Types and Options

1.2.1 Options

The available options include:

- 14 14 SAW filter option (Adds 70 kHz, 1.4, 3, 6, 14, and 28 MHz filters)
- 8F Eight-way clock and data multiplexer (requires 37-pin connector)
- DR Double rate SOQPSK-TG (46 Mbps)
- EN Ethernet Payload
- EQ Adaptive Equalizer
- ET Extended temperature range (-40°C to +85°C)
- K7 K7 Viterbi Decoder (k=7, rate 1/2)
- WV Wide voltage operating range (15 VDC - 35 VDC)

For example, a model QSX-RDMS-1-A15-Q0-1110-00-EQ is configured as follows:

Table 1: Model Configuration Example

Identifiers	Description
QSX	Quasonix product
R	Receiver / Demodulator / Bit Synchronizer
DMS	Demodulator / Bit Synchronizer
1	Channels
A15	15-pin MDM Male TTL Outputs
Q	Frequency band code
0	No Extended Tuning
1110	Tier 0 present, Tier I present, Tier II present, Legacy (PSK) absent
00	Pinout
EQ	Adaptive Equalizer option

1.2.2 Detailed Option Descriptions

1.2.2.1 SAW Filter Option – 14

This option adds additional SAW filters, for a total of 14. Additional filters are 70 kHz, and 1.4, 3, 6, 14, and 28 MHz.

1.2.2.2 Eight-way Clock and Data Multiplexer – 8F

Normally, the three clock and data streams available on the MDM-37 are Clock and Data A (the primary), Clock and Data B (the secondary for asynchronous PSK modulations), and Clock and Data C (what would normally be the primary for the combiner channel in a rack mount configuration).

The 8F option allows the user to designate what information comes out on these pins by way of an eight-way multiplexer (MUX). (Though there are a total of four pairs of clock and data, there are only enough pins to allow access to three pairs in the compact configuration.) This makes it possible for the information from the primary Clock and Data to be copied to the secondary and tertiary set of outputs, giving the user three simultaneous copies of the information.

The 8F option also requires the -37 option to be installed on the receiver.

1.2.2.3 Double Rate - DR

The DR option provides double-speed SOQPSK-TG (46 Mbps). This option extends the standard upper bit rate limit from 23 Mbps to 46 Mbps

1.2.2.4 Ethernet Payload - EN

When the EN option is enabled, all transmitted clock and data signals are serialized Ethernet packets.

1.2.2.5 Adaptive Equalizer - EQ

The Adaptive Equalizer option in the Quasonix receiver improves reception in multipath channels by using digital signal processing to compensate for the signal distortion due to multipath. This option is compatible with standard telemetry applications and installations and it works with any brand of transmitter.

Multipath fading can seriously degrade the quality of wireless telemetry data. Radio transmissions can reflect off of the airframe or other objects and arrive at the receiving antenna with different time delays, carrier phases, and relative strengths. The sum of these multiple transmission paths can produce serious distortion and signal fading resulting in poor data quality and long periods of data outage. Contrary to most situations, increasing the transmit power will not improve the link quality and may actually make the situation worse. Narrowing the beamwidth of the antenna may help eliminate some of the reflections and reduce the overall fading and distortion, but constraints on dish size and antenna tracking performance impose beamwidth limits.

Another solution is to mitigate the effects of the multipath channel by applying a filtering operation at the receiver that effectively undoes the distortion caused by the channel, thereby 'equalizing' the received signal. Since the transmitter is typically moving relative to the receiver, the RF propagation environment dynamically changes over time requiring the equalizer to 'adapt' to continually combat the perceived channel distortion. The 'adaptive equalizer' automatically calculates and applies a compensating filter to the received signal that restores its ability to be recovered by a traditional telemetry detector.

1.2.2.6 Extended Temperature - ET

The ET option specifies an extended operating temperature range (-40°C to +85°C).

1.2.2.7 Viterbi Decoder (for Legacy PSK Only) - K7

The K7 option (k=7, rate 1/2) enables Viterbi decoding of a convolutionally encoded data stream, which converts it back to the original (uncoded) source data stream.

Convolutional encoding adds redundant information to the transmitted data stream to help detect and correct bit errors that may occur, particularly due to predominantly Gaussian noise. Use of convolutional encoding requires a matching Viterbi decoder in the receiver to extract the source data. The decoded data rate is half the encoded data rate.

The receiver has two independent decoders, one for in-phase ("I") data and one for quadrature ("Q") data. For BPSK, only a single decoder is used. Each decoder is compatible with the convolutional encoding described in the "Consultative Committee for Space Data Systems, Recommendation for Space Data System Standards, TM Synchronization and Channel Coding, CCSDS 131.0-B-1, Blue Book, September 2003, Section 3."

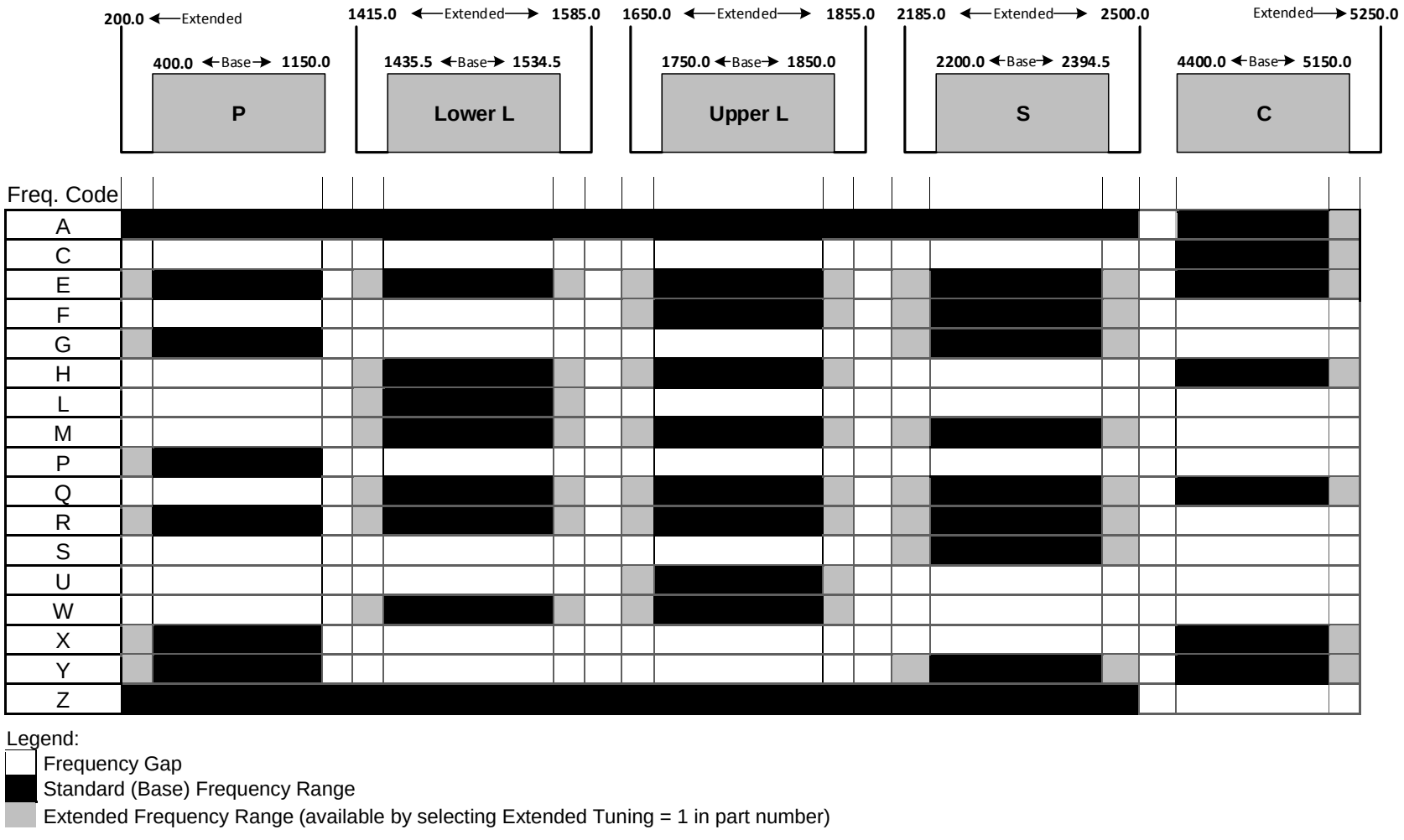
1.2.2.8 Wide Voltage – WV

This option specifies a wide voltage operating range (15 VDC - 35 VDC).

1.2.3 Band Configurations

Band configuration codes are listed in Table 2. Two additional band codes are described in section 1.2.3.1.

Table 2: Band Configuration Codes



1.2.3.1 Additional Band Codes

Two additional band codes are available:

- Band Code 7: 70 MHz standard range, 0.5 MHz-20 MHz, 70 MHz extended range
- Band Code T: 2025.0 MHz to 2110.0 MHz standard range

2 Specifications

Characteristic	Specification
Receiver Section	
Type	Dual-conversion superheterodyne
Input RF Frequency	Refer to Table 2
Tuning resolution	Tunes in 62.5 kHz increments, to the 70 MHz IF output, after the 70 MHz IF output, receiver tunes in increments of less than 1 Hz
Frequency stability	1 ppm over temperature 1 ppm per year aging
Reference oscillator	20 MHz
Noise figure	3.5 dB (typical), 5 dB (maximum)
LO phase noise, measured at 70 MHz IF output	-115 dBc/Hz @ 1 MHz offset
Maximum RF input	+20 dBm (+10 dBm for C-band)
Available gain (to 70 MHz IF output)	114 dB
Gain control	128 dB control range; User selectable: AGC or MGC (AGC freeze)
AGC time constant	Adjustable, 0.1 ms to 1000 ms
First IF bandwidth	60 MHz (nominal)
IF rejection	> 90 dB
Image rejection	70 dB
RF input impedance	50 ohms
Second IF Section	
IF frequency	70 MHz
IF output level	0 dBm nominal (AGC mode)
IF output impedance	50 ohms
IF bandwidths	250 kHz, 500 kHz, 1 MHz, 2 MHz, 4.5 MHz, 10 MHz, 20 MHz, 40 MHz. Automatic selection based on data rate, with manual override Optional: 70 kHz, 1.4 MHz, 3 MHz, 6 MHz, 14 MHz, 28 MHz

Demodulator Section	
Demodulator type	ARTM Tier 0 (PCM/FM), ARTM Tier I (SOQPSK-TG), ARTM Tier II (Multi-h CPM) Legacy suite: Analog FM, BPSK, QPSK, Offset QPSK (OQPSK), Asymmetric QPSK (AQPSK), Unbalanced QPSK (UQPSK), Asymmetric Unbalanced QPSK (AUQPSK), Digital PM
Bit Rates	Tier 0: 24 kbps to 23 Mbps in 1 bps steps Tier I: 100 kbps to 46 Mbps in 1 bps steps Tier II: 1 Mbps to 46 Mbps in 1 bps steps Legacy: 25 kbps to 20 Mbps in Analog FM, 50 kbps to 10 Mbps in BPSK, 50 kbps to 20 Mbps in QPSK in 1 bps steps
Synchronization time(Average, at BER = 1e-5)	Tier 0: 250 bits, Tier I: 385 bits, Tier II: 2,800 bits
Synchronization threshold	Tier 0: -8.0 dB Eb/N0; RF Input (dBm): -118.0 (1 Mbps), -108.0 (10 Mbps) Tier I: -6.0 dB Eb/N0; RF Input (dBm): -116.0 (1 Mbps), -106.0 (10 Mbps) Tier II: -7.0 dB Eb/N0; RF Input (dBm): -117.0 (1 Mbps), -107.0 (10 Mbps)
Sensitivity (BER = 1e-5)	Tier 0: 8.6 dB Eb/N0; RF Input (dBm): -101.4 (1 Mbps), -91.4 (10 Mbps) Tier I: 11.2 dB Eb/N0; RF Input (dBm): -98.8 (1 Mbps), -88.8 (10 Mbps) Tier II: 13.0 dB Eb/N0; RF Input (dBm): -97.0 (1 Mbps), -87.0 (10 Mbps)
Bit Synchronizer Section	
Input codes	NRZ-L/M/S, BIΦ-L/M/S
Output codes	NRZ-L/M/S, BIΦ-L/M/S
Data and clock out	TTL or RS-422
Lock detector out	TTL
RSSI	Single 0 – 3.3 VDC, 2 MHz bandwidth (-37 option required)
Video out	Dual wideband outputs, DC to 35 MHz (-37 option required)
Environmental Section	
Operating Temperature	-20°C to +70°C
Non-operating Temperature	-40°C to +85°C
Operating Humidity	0 to 95% (non-condensing)
Vibration	20 G, 5 Hz to 2 kHz (all axes)
Acceleration	100 G (all axes)
Shock	100 G pk, half-sine, 5 ms (all axes)
Altitude	Up to 100,000 ft.
Physical Section	
Size / Weight	4.00” x 3.00” x 1.00” / 11 oz.
Connectors	RF input: SMA female IF output: SMA female Baseband: MDM-15 or MDM-37 (-37 option)
Power	28 VDC ± 4 VDC, 750 mA typical

3 Installation Instructions

3.1 Mechanical

The Compact RDMS™ is designed to be mounted by eight (8) 6-32 screws through the holes along the front and back edges, as depicted in Figure 2 on the following page.

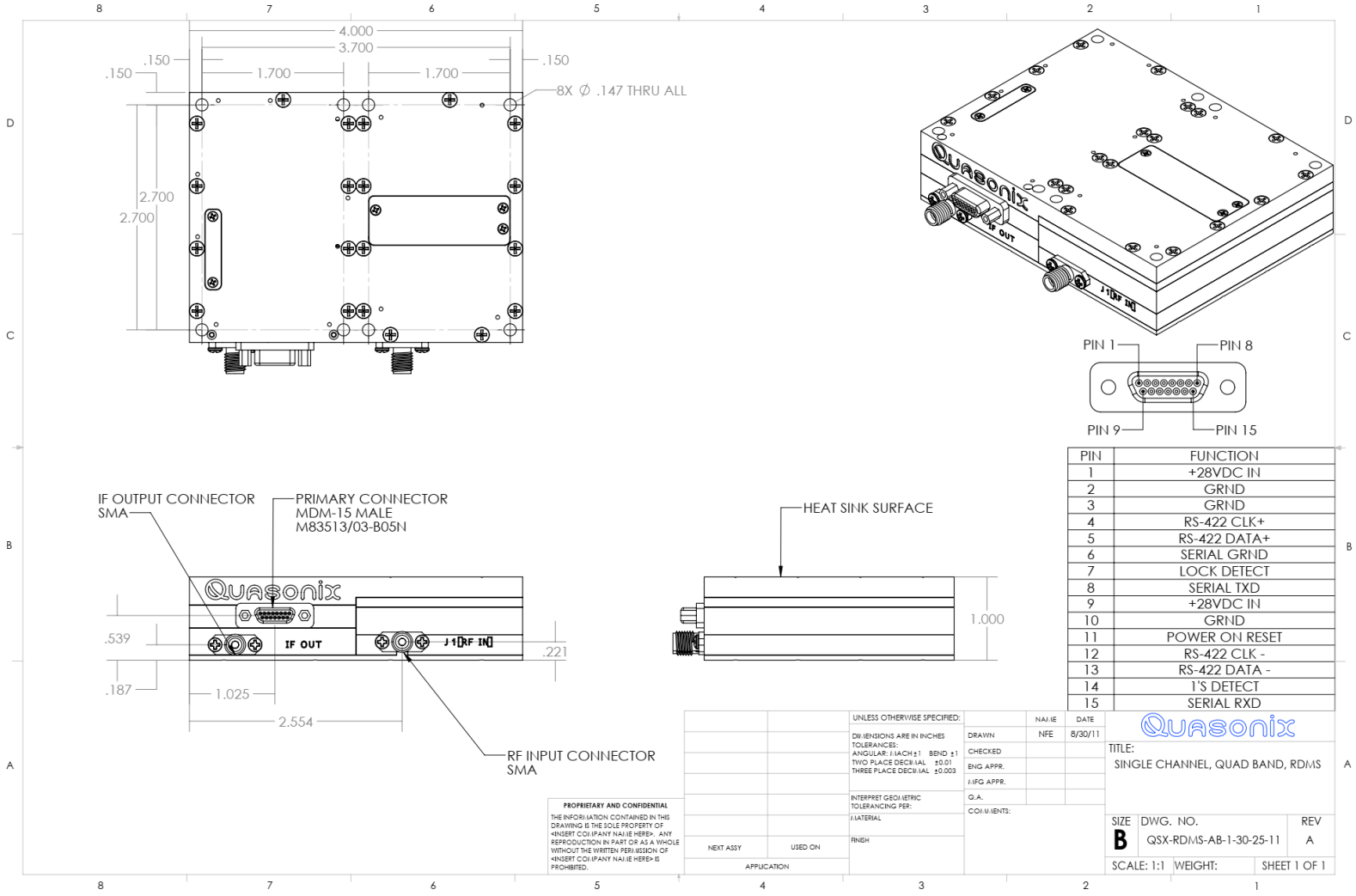


Figure 2: RDMS™ in 4.00” x 3.00” x 1.00” Compact Housing

3.2 Thermal

It is important that the RDMS™ be kept within its specified operating range of -40°C to +70°C. At maximum bit rates, the unit dissipates approximately 20 watts. At normal ambient room temperatures, a small fan blowing across the top cover is adequate. Higher ambient temperatures will require more airflow and/or a finned heat sink on the cover.

3.3 Electrical

The RDMS™ has three external connectors, an MDM-15 male for all baseband interfaces, a female SMA connector for the RF input, and a second female SMA connector for an IF output. Note that first generation hardware did not include the IF output. The pin numbering and wiring for the MDM-15 male connector is shown in Figure 3. Refer to Appendix B for optional 37 pin information.

Figure 3: MDM-15 Pin Numbers

Table 3: MDM-15 Pin Assignments

Position	Signal	Description
1	+28 VDC	Primary 28 VDC power to module
2	Ground	Primary power return, 2 amps maximum; Internally tied to pins 3, 6, and 10
3	Ground	Primary power return, 2 amps maximum; Internally tied to pins 2, 6, and 10
4	Clock Out	Primary LVTTL clock output, Clock+ for RS 422 output
5	Data Out	Primary LVTTL data output, Data+ for RS 422 output
6	232 Ground	Ground return for RS-232 control lines; Internally tied to pins 2, 3, and 10
7	Demod Lock Out	3.3 volt TTL lock detector output for all modes

Position	Signal	Description
8	RS 232 Tx Output	RS-232 responses to host controller
9	+28 VDC	Primary 28 VDC power to module
10	Ground	Secondary power return, 2 amps maximum; Internally tied to pins 2, 3, and 6
11	Power ON	Power on reset pin; Temporarily grounding this pin is equivalent to power cycling the module
12	Clock Return	Ground for LVTTL outputs, Clock- for RS 422 outputs
13	Data Return	Ground for LVTTL outputs, Data- for RS 422 outputs
14	Ones Detect	LVTTL signal use for sync time testing
15	RS 232 Rx Input	RS-232 commands from host controller

By default, the output data is valid on the falling edge of the clock, as shown in Figure 4. The polarity of the output clock may be inverted by use of the “CP 1” command described below.

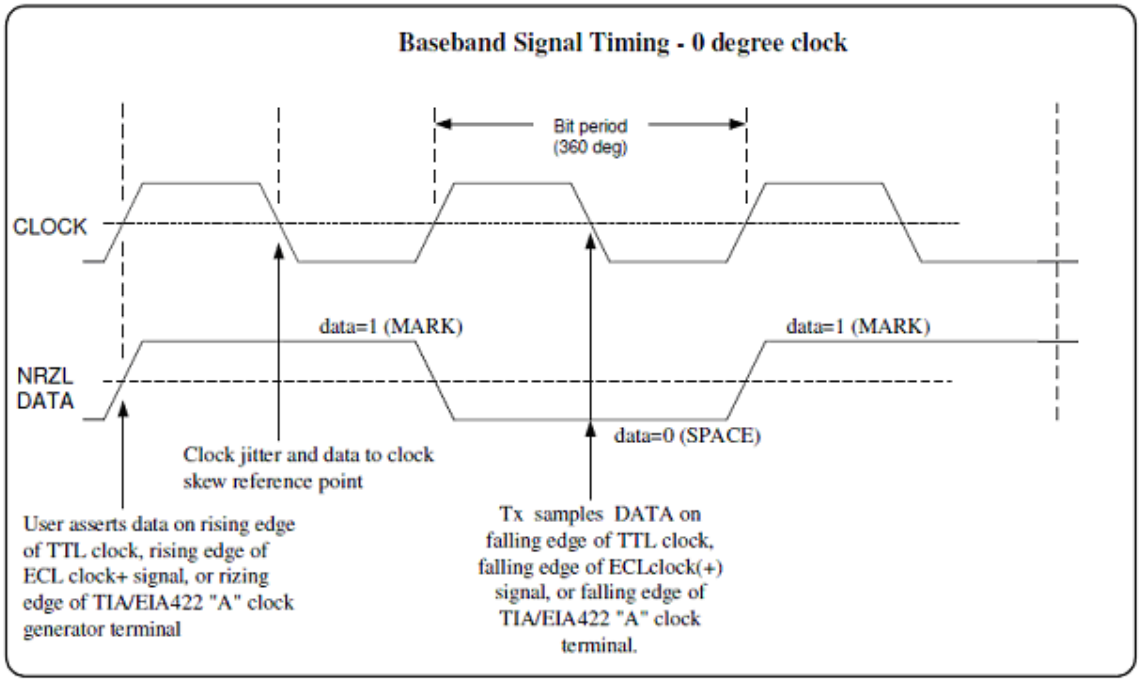


Figure 4: Baseband Signal Timing

The 70 MHz IF output on the second SMA connector, labeled “IF OUT”, is provided for troubleshooting purposes. The IF is resistively coupled from the input of the demodulator. Therefore, the signal level on the IF output should be within 2 dB of the demodulator’s input.

The IF output must have a 50-ohm load at all times. Therefore, if it is not connected to external test equipment, then the 50-ohm terminator that comes installed on the port must remain attached.

4 Operating Instructions

4.1 Power-on Operation

When the receiver is powered up, the integral demodulator defaults to a particular modulation mode, which is based on the configuration of the unit. The modulation mode priority is outlined in Table 4.

Table 4: Default Modulation Start Up

Startup Order	Modulation
1	Legacy PSK
2	PCM/FM (Tier 0)
3	SOQPSK (Tier I)
4	Multi-h CPM (Tier II)

4.2 Stored Parameters

The following parameters are stored in the unit's nonvolatile flash memory. The descriptions and default values are listed in Table 5. As with the Quasonix part number ordering method, parameters are typically stored in binary format. That is, "1" designates the feature is enabled, "0" designates the feature is disabled.

Table 5: Stored Parameters

Parameter Name	Description	Default Value
Bit Rate	24 kbps - 40 Mbps depending on mode	1 Mbps
Clock Polarity	1 or 0, denoting clock polarity inverted or not, respectively	0 (inversion OFF)
Data Polarity	1 or 0, denoting data polarity inverted or not, respectively	0 (inversion OFF)
De-Randomizer	1 or 0, denoting derandomizer ON or OFF, respectively	0 (de-randomizer OFF)
Differential Decoding	1 or 0, depending on whether differential decoding is ON This is only meaningful for SOQPSK-TG modulation. Note: IRIG 106-04 stipulates the use of differential encoding, so operation without differential encoding is only possible with a demodulator operating in a "non-IRIG 106" mode.	1 (differential decoding ON)

Parameter Name	Description	Default Value
Frequency	This is the desired frequency of the receiver in MHz.	1450.5 MHz, 1800.5 MHz, or 2370.5 MHz for Lower-L band, Upper-L band, or S band, respectively 1450.5 MHz for tri band 4675.0 MHz for C band
Modulation	This is the modulation method used. Value of 0-10 Options are: 0 - PCM/FM 1- SOQPSK 2 - MHCPM 3 - BPSK 4 - QPSK 5 - AQPSK 6- AUQPSK 7 - OQPSK 8 - UQPSK 9 - DPM 10 - FM	QPSK, if it exists If not, then PCM/FM If not, then SOQPSK If not, then MHCPM
Modulation Index Tracking*	In PCM/FM mode only Allows Trellis demodulator to automatically detect and adjust to Modulation Indices not at ideal 0.7	A (Auto Tracking)

***Note:** If the user cannot guarantee that the transmit source is a new generation, digitally synthesized transmitter, the receiver should be left in Tracking mode. Failure to do so will cause the receiver to fail to acquire improperly deviated signals altogether. All tracking loops are already optimized for fastest synchronization, and should not be adjusted in any way.

If the user knows for sure that the transmit source is digitally synthesized, the tracking should be set to Off, for the minimum acquisition time.

4.3 RDMS Serial Control Protocol

The Compact RDMS™ is controlled via a simple three-wire serial interface (transmit, receive, and ground). Configure your controller's serial port to the following settings:

- Baud rate of 115,200
- 8 bits
- No parity
- 1 stop bit

For setup and configuration via a standard Windows-based PC, Quasonix recommends the application called *Terminal*, a flexible, full-featured control interface that is included in the RDMS Product CD. Otherwise, one can use HyperTerminal, included with the standard Windows installation (Start -> All Programs -> Accessories -> Communications -> HyperTerminal).

When power is applied to the receiver, the welcome message, shown in Figure 5, displays.

```
Initializing...
downconverter init...
Quasonix Demod/Receiver Interface
IRIG-106 Release 07
6025 Schumacher Park Drive
West Chester, Oh 45069
(513) 942-1287
www.Quasonix.com <http://www.Quasonix.com>
CAGE CODE: 3CJA9
FPGA Revision: 0x3132 0x0000
PSK FW Revision: 2.0.043 7/29/2008
PSK>
```

Figure 5: RDMS™ Welcome Message

All commands are one or two alphabetic characters, followed by 0, 1, or 2 arguments. If the command is issued with arguments, there must be a space after the alphabetic characters. The commands are not case sensitive.

All commands generate a response of one or more lines. The length of the response depends on the verbosity level (set by the VL command). The last response line is always the currently selected mode (PCM/FM, SOQPSK, CPM, or PSK), followed by the character "+" or ">", depending on the version of the firmware. This prompt signifies that the RDMS is ready to accept new characters.

4.3.1 Tier 0 (PCM/FM), Tier I (SOQPSK-TG), and Tier II (Multi-h CPM) Commands

The following table describes all receiver user commands. Listed are the command code, name, description of the command, whether specific options must be ordered or the command is standard on all receivers, basic or advanced command, and whether the command is restricted to specific waveform modes.

Note: If a user issues a command that does not apply to a given mode, an "Invalid Command" message is displayed. Any command that is valid in a mode but is disabled due to the option not being installed, returns an "Option Not Installed" message.

Table 6: Standard and Optional User Commands

Mnemonic	Name	Description	Option (s) Required	Basic or Advanced Command	Mode Restriction
?	Help Message	Displays abbreviated list of available commands	Standard	Basic	None
AD	Downconvert Antenna	AD Report the downconvert antenna state AD 0 Set downconvert antenna state to OFF (Disabled) AD 1 Set downconvert antenna state to ON (Enabled) **Downconverting antenna control only available when using a 5-band downconverter AND P and C bands are available on the unit. (applies to customers using downconverting antennas for C-band)	**Standard	Basic	None
AE	AGC Enable	Enable or Disable Automatic Gain Control (AGC) Examples: AE Report AGC state AE 0 Set AGC state to OFF (Disabled) AE 1 Set AGC state to ON (Enabled)	Standard	Basic	None

Mnemonic	Name	Description	Option (s) Required	Basic or Advanced Command	Mode Restriction
AV	Manual Attenuator Control	Report or set the value of the input attenuator Valid range is 0 to 124 dB Examples: AV Report the input attenuator setting AV 0 Set input attenuator to 0 dB AV 124 Set input attenuator to 124 dB	Standard	Basic	None
BE	Bit Error Rate	For Bit Error Rate commands and information, refer to Appendix A, Bit Error Rate Testing.	Standard	Advanced Command	None
BL	Break Lock	Breaks false locks No additional parameters	Standard	Basic	PSK (legacy)
BM	Bit Rate Measurement	Report bit rate measurement	Standard	Basic	PSK (legacy)
BR	Bit Rate	Report or set baseband bit rate Examples: BR Report the bit rate setting BR 5 Set bit rate to 5 Mbps BR 0.6 Set bit rate to 600 Kbps	Standard	Basic	For Asynch PSK (legacy) modes, BR A and BR B must be specified separately
CC	Convolutional Decoder Enable	Enables or disables the convolutional decoder Examples CC Report convolutional decoder state CC 0 Set the convolutional decoder to Disabled CC 1 Set the convolutional decoder to Enabled	K7	Basic	PSK (legacy)

Mnemonic	Name	Description	Option (s) Required	Basic or Advanced Command	Mode Restriction
CP	Clock Polarity	Report or set clock polarity inversion state Examples: CP Report the clock source state CP 0 Set clock inversion OFF CP 1 Set clock inversion ON	Standard	Basic	For Asynch PSK (legacy) modes, CP A and CP B must be specified separately
DE	Differential Decoder Enable	Report or set differential decoding Examples: DE Report the differential decoding setting DE 0 Set differential decoding OFF DE 1 Set differential decoding ON	Standard	Basic	SOQPSK
DP	Data Polarity	Report or set data polarity inversion state Examples: DP Display the current data polarity DP 0 Set data polarity to NOT inverted (OFF) DP 1 Set data polarity to inverted (ON)	Standard	Basic	For Asynch PSK (legacy) modes, DP A and DP B must be specified separately
FL	Force Lock Indication	Diagnostic tool to force the system to indicate locked or unlocked status; primarily used to verify wiring setup Examples: FL Show the force lock state FL 1 Force lock to ON FL 0 Force lock to Normal FL -1 Force lock to OFF	Standard	Advanced Command	None

Mnemonic	Name	Description	Option (s) Required	Basic or Advanced Command	Mode Restriction
FR	Frequency	Report or set receiver center frequency Examples: FR Report the frequency setting FR 2200.5 Set modulation to 2200.5 MHz	Standard	Basic	None
FS	IF Filter Select	Report or set the current IF filter in the receiver FS Display the current IF filter FS A Set IF filter to automatic FS (0-7) Manually set IF filter (not recommended)	Standard -14 option permits 7 additional filters	Basic	None
GO	Start/Restart	Apply changes then reset demodulator. Initiate demodulation with current parameters. This command is required when setting both the modulation and the bit rate. GO command is issued any time the bit rate is changed. This forces the demodulator to rescale all of its loop parameters and digital filtering so they are set properly for the bit rate.	Standard	Basic	None
HX	eXtended Help	Displays a full list of available commands	Standard	Basic	None

Mnemonic	Name	Description	Option (s) Required	Basic or Advanced Command	Mode Restriction
LD	LDPC Decode Enable	Enable, disable, or show the current state of the Forward Error Correction (FEC) / Low Density Parity Check (LDPC) decoder Examples: LD Show the current decoder state LD 1 Enable the LDPC decoder LD 0 Disable the LDPC decoder	LD	Advanced Command	PSK (legacy) Select mode 7 (OQPSK)
LP	Lock Output Polarity	Report or set the active level of the lock indication to active high or active low Examples: LP Show the current lock output polarity LP 1 Set the active level to high LP 0 Set the active level to low	Standard	Advanced Command	None
MA	Modulations Allowed	Report the available waveform modes (modulations) available for this unit	Standard	Basic	None

Mnemonic	Name	Description	Option (s) Required	Basic or Advanced Command	Mode Restriction
MI	Modulation Index	Report or Set Modulation Index Tracking or Acquire Examples MI Report Mod Index Track Status MI O Disable Mod Index Tracking (Set to h=0.7) MI A Acquire mode enable MI A D Sets the maximum delta h (indicates a change in h defaults to 0.005) MI A S Sets the delta h settling time defaults to 500 ms MI H Hold Mod Index Tracking at current position MI I Sets Trellis Index MI T Tracking mode enable MI T H x Sets the Tracking Hold threshold	Standard	Basic	PCM/FM

Mnemonic	Name	Description	Option (s) Required	Basic or Advanced Command	Mode Restriction
MO	Modulation	Report or set modulation setting Examples: MO Report the modulation setting MO 0 Set modulation to PCM/FM MO 1 Set modulation to SOQPSK-TG MO 2 Set modulation to Multi-h CPM MO 3 Set modulation to BPSK MO 4 Set modulation to QPSK MO 5 Set modulation to AQPSK MO 6 Set modulation to AUQPSK MO 7 Set modulation to OQPSK MO 8 Set modulation to UQPSK MO 9 Set modulation to Digital PM (DPM)	Standard	Basic	Limited to modes installed
NZ	NRZ Encoding	Report or set the non-return to zero (NRZ) value used by the receiver Examples: NZ Show the current NRZ value NZ L Set the NRZ to Level NZ M Set the NRZ to Mark (1) NZ S Set the NRZ to Space	Standard	Advanced Command	PCM/FM and PSK (legacy)

Mnemonic	Name	Description	Option (s) Required	Basic or Advanced Command	Mode Restriction
OC	Output Control	Report or set the channel source values Examples: OC Show current OC settings OC D Set the default outputs OC c s Set the channel and clock source For detailed syntax information, refer to Appendix C	8F and -37	Basic	None
OM	Output Muting	Report or set the operation of clock and data output muting; clock and data outputs can be disabled after some period of time without lock Examples: OM Show the output muting state OM 0 Disables output muting OM 1 Enables output muting OM T x Sets the delay between loss of lock and muted outputs in milliseconds from 0 to 46016	Standard	Advanced Command	None
PA	Reset Stored Configuration	Resets ALL parameters in ALL waveform modes to the factory default state and sets the receiver to the lowest default mode and lowest bit rate Refer to Appendix E for a list of factory default values by mode	Standard	Basic	None

Mnemonic	Name	Description	Option (s) Required	Basic or Advanced Command	Mode Restriction
PL	Input Power Level	Reports or sets the current input power level setting Examples: PL Report the current input power level information tracking state PL 0 Set the current power level information tracking display to OFF PL 1 Set the current power level information tracking display to ON PL reports the Input signal level of the receiver, the signal level into the demod, the digitally scaled signal level, the SNR, and eb/N0	Standard	Advanced Command	None
PN	Phase Noise Compensation	Report or set phase noise compensation state Examples: PN Report the phase noise compensation state PN 0 Set phase noise compensation to OFF PN 1 Set phase noise compensation to ON	Standard	Basic	PCM/FM
PR	Reset Defaults for Currently Selected Mode	Restores factory default parameters for the currently selected mode on the unit Refer to Appendix E for a list of factory default values by mode	Standard	Advanced Command	None
QT	Query Temperature	Report the temperature in degrees Celsius	Standard	Basic	None

Mnemonic	Name	Description	Option (s) Required	Basic or Advanced Command	Mode Restriction
RN	Derandomizer State	Report or set the derandomizer state Examples: RN Report the derandomizer state RN 0 Set the derandomizer OFF RN 1 Set the derandomizer ON	Standard	Basic	None
SN	Show Serial Number	Report the serial number for the unit	Standard	Basic	None
SV	Save Parameters	Saves the current parameters in non-volatile memory, including frequency, modulation, bit rate, data polarity, clock polarity, AGC state, verbosity level, etc.	Standard	Basic	None

Mnemonic	Name	Description	Option (s) Required	Basic or Advanced Command	Mode Restriction
SY	System Status Tracking	Displays the system status of the receiver The first argument specifies the period, in milliseconds, between status updates. Zero (0) disables continuous monitoring. The second argument specifies the number of status lines between header output. Examples: SY Displays current status report settings SY 5 Sets status output period to 5 milliseconds SY 5 100 Sets status header output once every 100 status updates The SY command reports system status information about the timing and frequency tracking loops, as well as mod scaling, lock indication and eb/n0 data. This command is very effective for troubleshooting link issues.	Standard	Advanced Command	Available for all EXCEPT PSK (legacy)
TO	Tape Output	Displays the status of the Tape Output option Example: TO Displays current tape output status settings (enabled/disabled and output frequency)	37	Advanced Command	PCM/FM

Mnemonic	Name	Description	Option (s) Required	Basic or Advanced Command	Mode Restriction
TO F	Tape Output Frequency	Sets the carrier frequency of the pre-detection complex Tape Output Examples: TO F 0 Sets the Tape Output Frequency to Off (carrier frequency = 0 MHz) TO F 1 Sets the Tape Output Frequency to a specific frequency number Value range is 0.000 to 20.000 MHz	37	Advanced Command	PCM/FM
TO T	Tape Output Source	Sets the test output to a Tape source; Enables or Disables the pre-detection complex baseband as the tape output source When enabled (T=1), pre-detection complex baseband is selected as the source of data to send on I and Q analog outputs When disabled (T=0), the I and Q analog outputs (frequency/phase information) are restored to their normal defaults which vary by mode Examples: TO T 0 Sets the Tape Output Source to disabled TO T 1 Sets the Tape Output Source to enabled	37	Advanced Command	PCM/FM
VE	Version	Report the current Firmware (software) version information for the receiver	Standard	Basic	None

Mnemonic	Name	Description	Option (s) Required	Basic or Advanced Command	Mode Restriction
*VF	Viterbi Forget Factor	Report or set the Viterbi forget factor, on a scale from 0.01 – 0.99 Examples: VF Report the Viterbi forget factor VF 0.04 Set the Viterbi forget factor to 0.04 VF 0.62 Set the Viterbi forget factor to 0.62	Standard	Advanced Command	PCM/FM
VL	Verbosity Level	Report or set verbosity level, on a scale of 0 – 9 Examples: VL Report the verbosity level VL 0 Set the verbosity level to 0 VL 5 Set the verbosity level to 5	Standard	Advanced Command	None
ZZ	Show Options	Displays the current hardware configuration and options on the receiver	Standard	Advanced Command	None

***Note regarding VF command:** The VF command sets the observation window for the Viterbi decoder in the trellis demod. The longer the window, the more coding gain. The smaller the window, the more resistant to phase noise. Quasonix recommends NOT manually changing this value. The Phase Noise Compensation mode automatically adjusts this as needed.

5 Performance Specifications

5.1 DC Input

The Compact RDMS™ operates from a nominal 28 VDC, +/- 4 VDC with a current consumption of no more than 25 Watts.

5.2 RF Frequency Error

By default, the Compact RDMS™ is capable of acquiring a signal with a frequency error of up to ±100 kHz.

5.3 Bit Error Rate

The RDMS™ meets the following BER limits, when tested with a signal source, which complies with IRIG 106-05.

Table 7: RDMS BER Specifications

BER	Maximum E_b/N_0 (dB)		
	PCM/FM, Tier 0	SOQPSK-TG, Tier I	Multi-h CPM, Tier II
10^{-3}	7.5	9.5	11.0
10^{-4}	9.0	11.5	12.5
10^{-5}	10.0	13.0	13.5
10^{-6}	11.0	14.5	14.5

Typical BER performance, plotted in Figure 6, is significantly superior to that tabulated above.

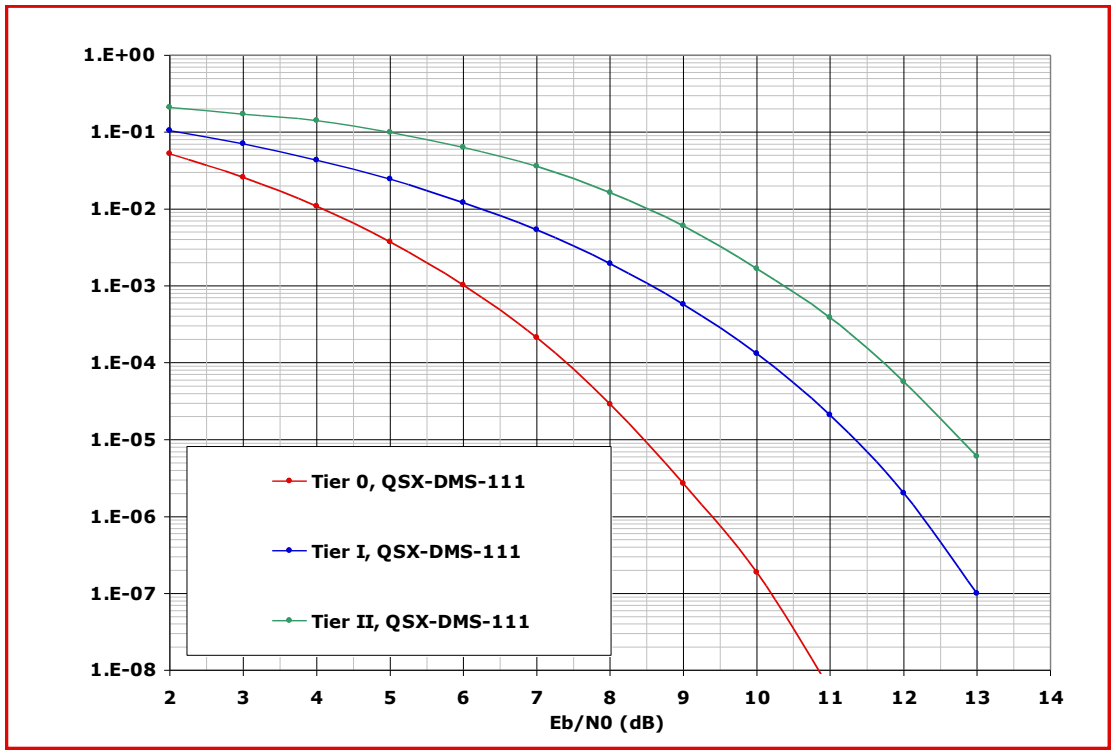


Figure 6: BER Performance for Tier 0, I, and II

5.4 Synchronization

The Compact RDMS™ offers very fast, reliable acquisition, even at very low signal to noise ratio. Synchronization time is a function of modulation type and IF frequency error. Typical SOQPSK results (from 10,000 synchronization trials) are shown in Figure 7.

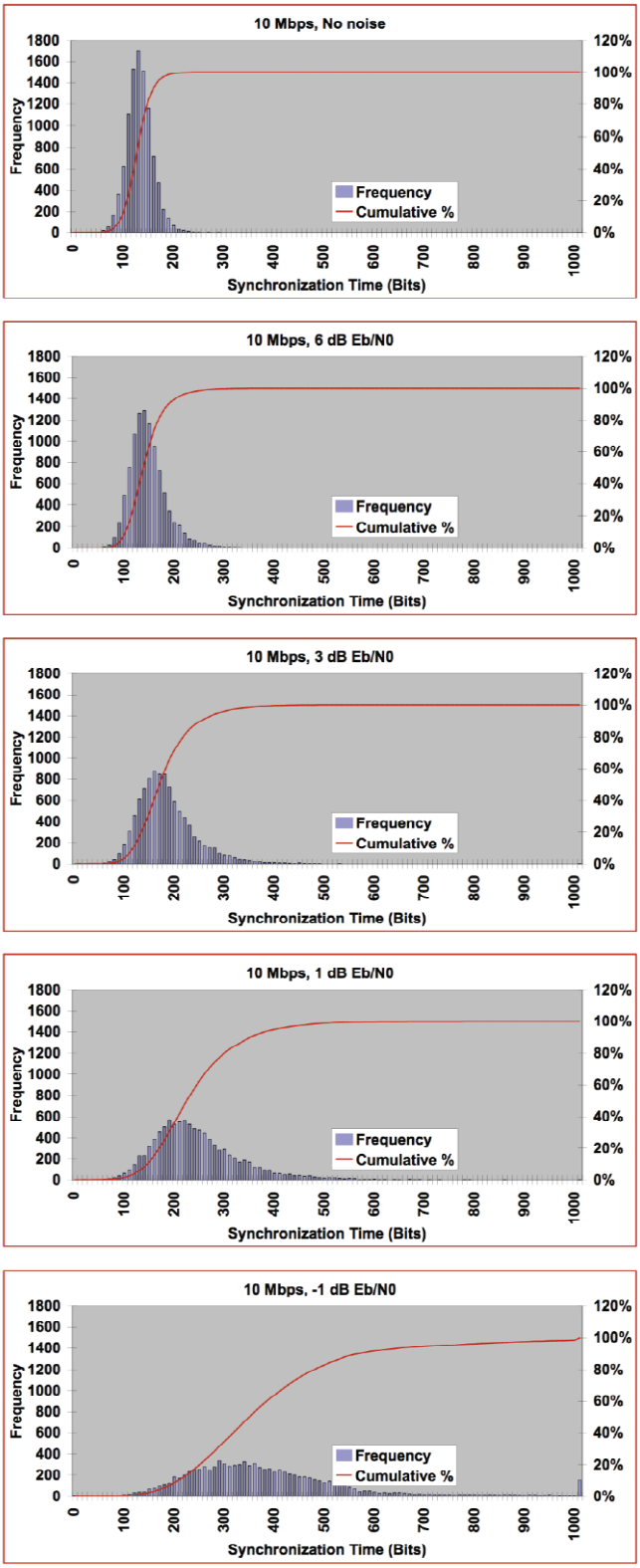
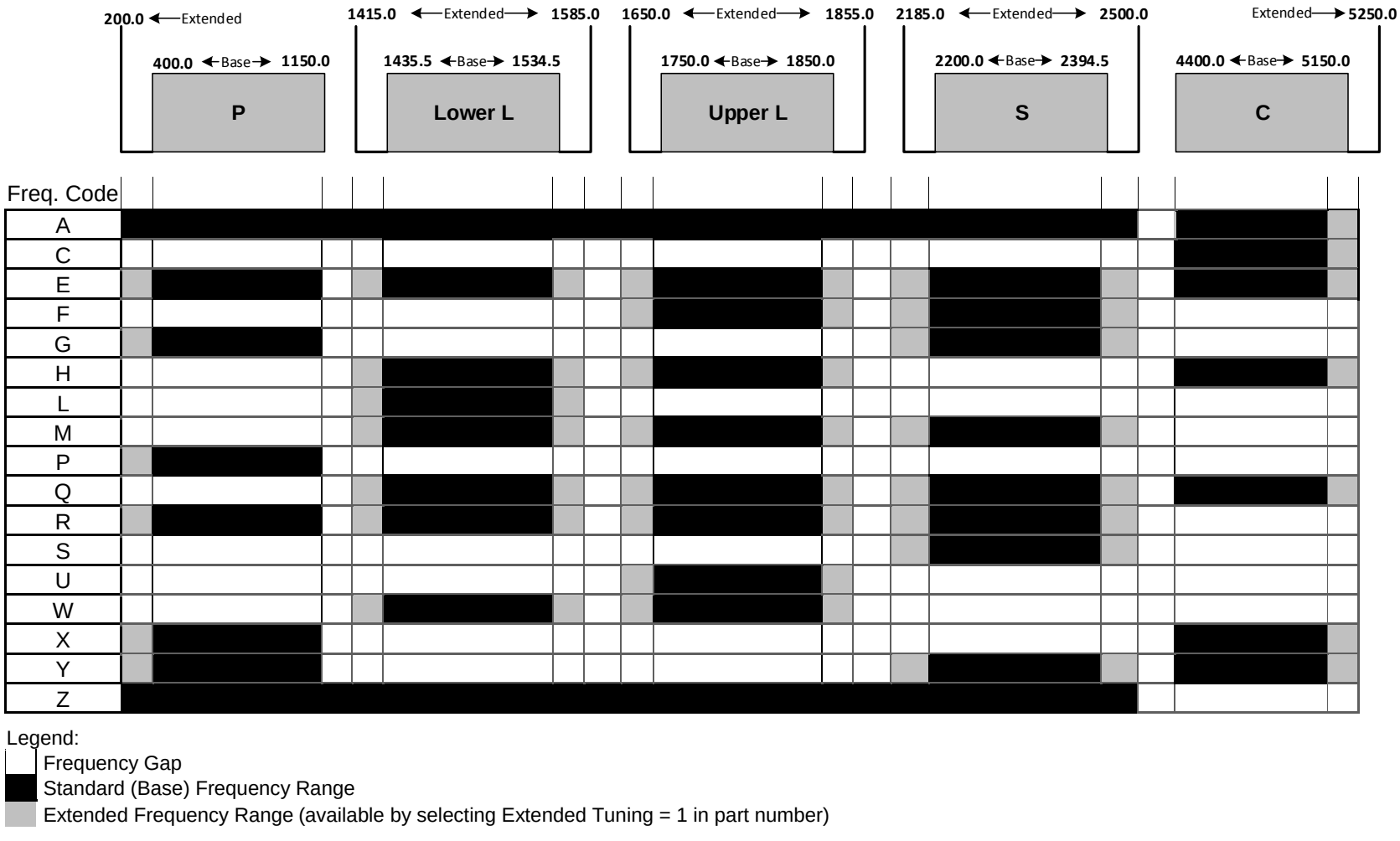


Figure 7: Synchronization Time at Various Signal-to-Noise Ratios

5.4.1 RF Input

The Compact RDMS™ is available in frequency bands shown in Table 8. Two additional band codes are described in section 5.4.1.1. The input impedance is 50 ohms.

Table 8: Band Configuration Codes



5.4.1.1 Additional Band Codes

Two additional band codes are available:

- Band Code 7: 70 MHz standard range, 0.5 MHz-20 MHz, 70 MHz extended range
- Band Code T: 2025.0 MHz to 2110.0 MHz standard range

6 IF Module

The receiver's integrated IF filter module, shown in Figure 8, includes eight (8) SAW filters, ranging in bandwidth from 250 kHz to 40 MHz in approximately one octave steps. The standard eight filters are 250 kHz, 500 kHz, 1 MHz, 2 MHz, 4.5 MHz, 10 MHz, 20 MHz, and 40 MHz. These filters serve as anti-aliasing filters ahead of the A/D converter in the demodulator itself. In addition, they can provide an added measure of adjacent channel interference rejection. The measured responses of the eight filters are shown in Figure 9 and Figure 10 (note the change of horizontal scale between the two figures).

Six additional filters are available allowing for a total of 14. The optional filters are 70 kHz, 1.4 MHz, 3 MHz, 6 MHz, 14 MHz, and 28 MHz. The measured responses of the optional filters are shown in Figure 11 and Figure 12. Contact Quasonix for information about the optional filters.

Based on the receiver's high level of integration, the proper IF filter is automatically selected based on the current mode and bit rate settings of the demodulator. Although manual filter selection is available, it is not recommended.

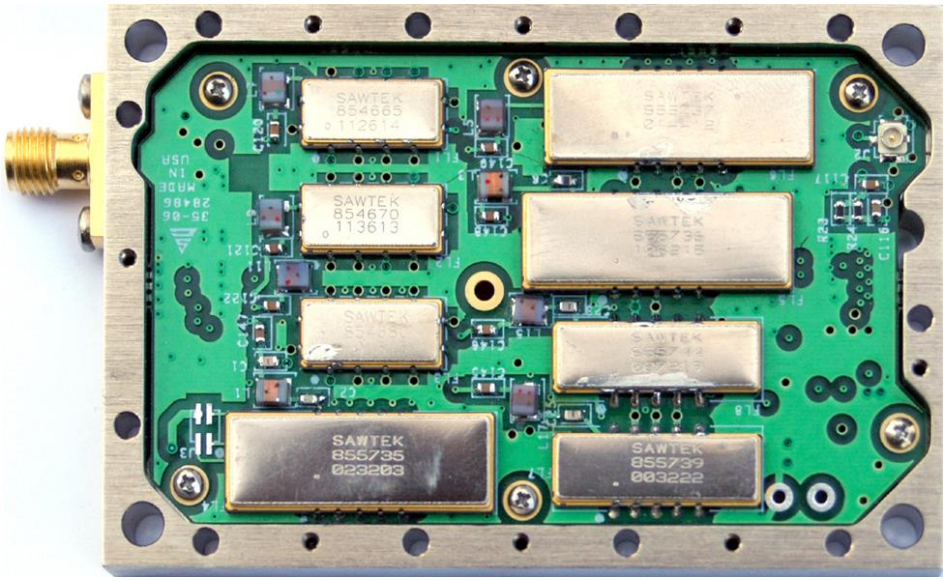


Figure 8: 70 MHz IF Module in 2" x 3" Chassis

The IF module attaches directly to the demod modules.

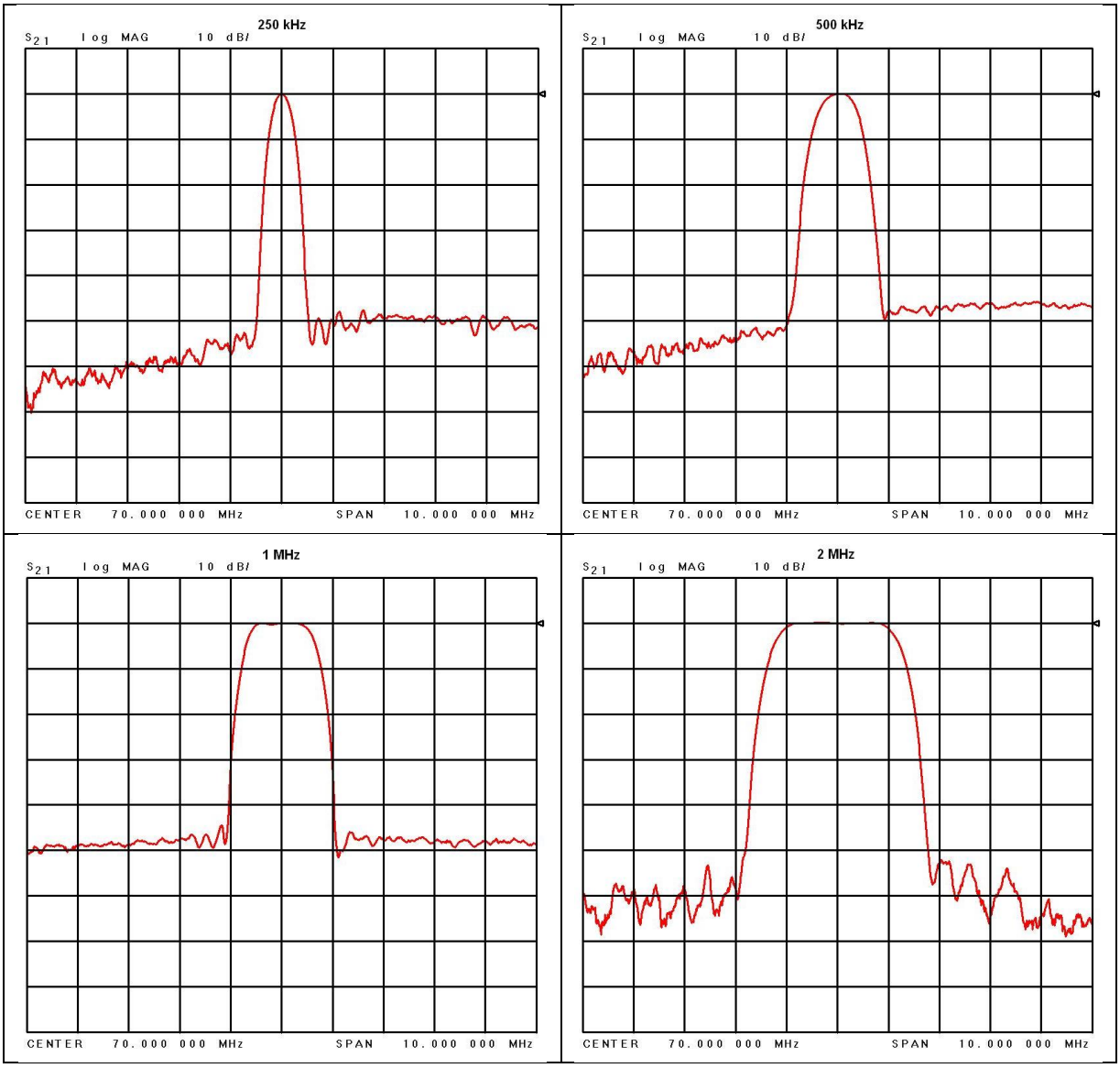


Figure 9: 70 MHz IF Module in 2” x 3” Chassis SAW Filter Responses, Narrow Group (10 MHz Span)

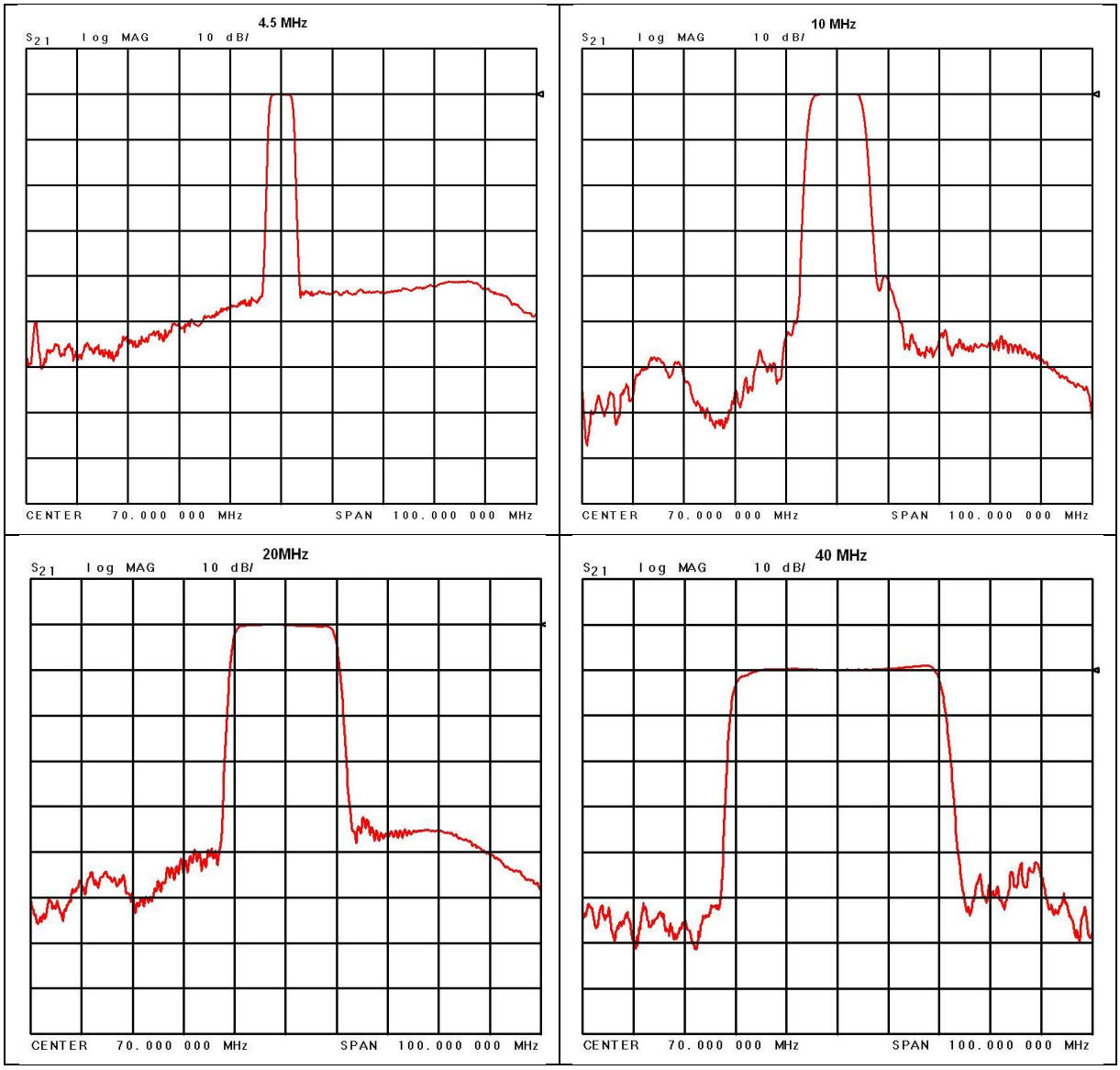


Figure 10: SAW Filter Responses, Wide Group (Plotted on 100 MHz Span)

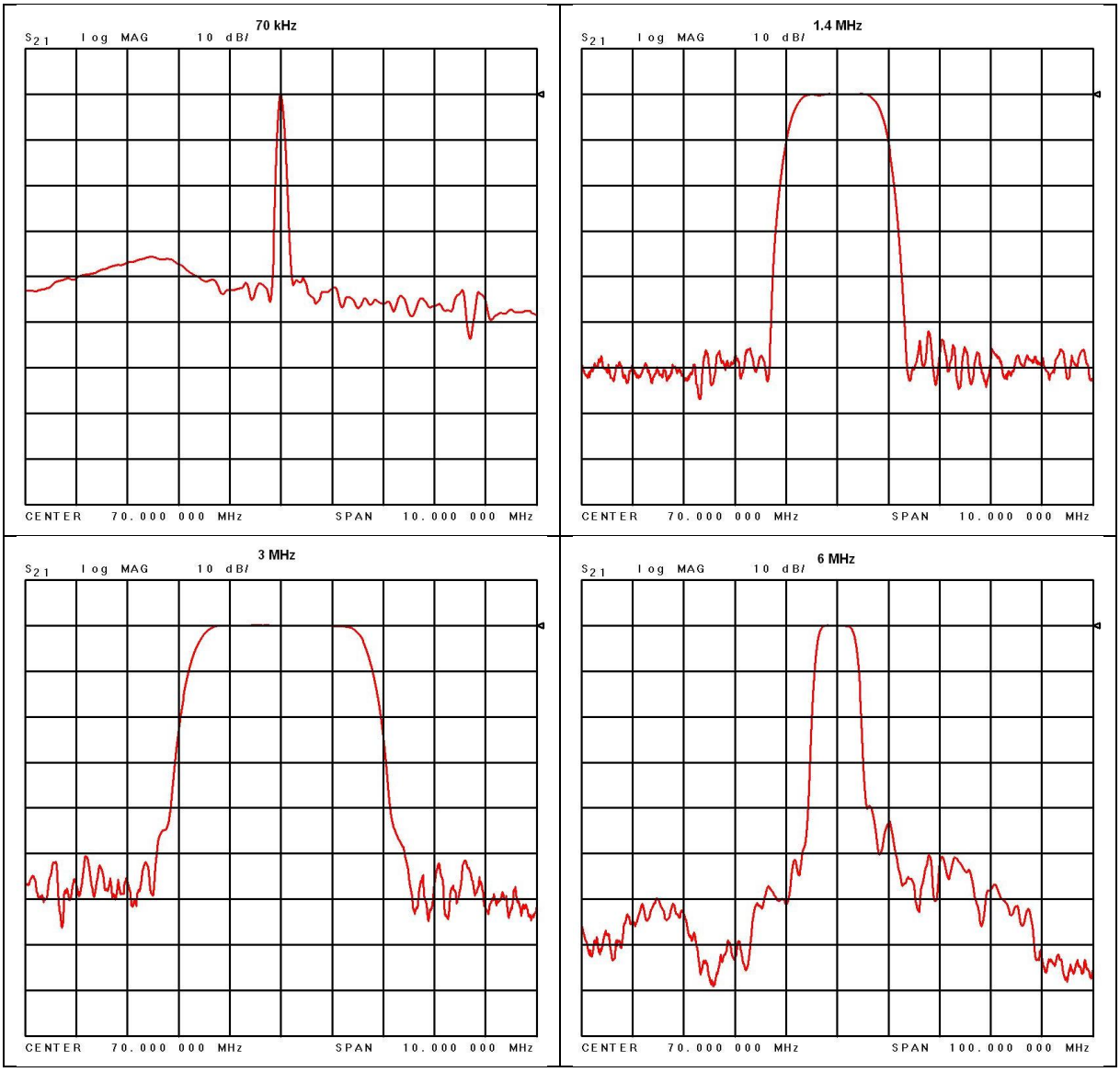


Figure 11: Optional SAW Filter Responses for 70 kHz to 6 MHz

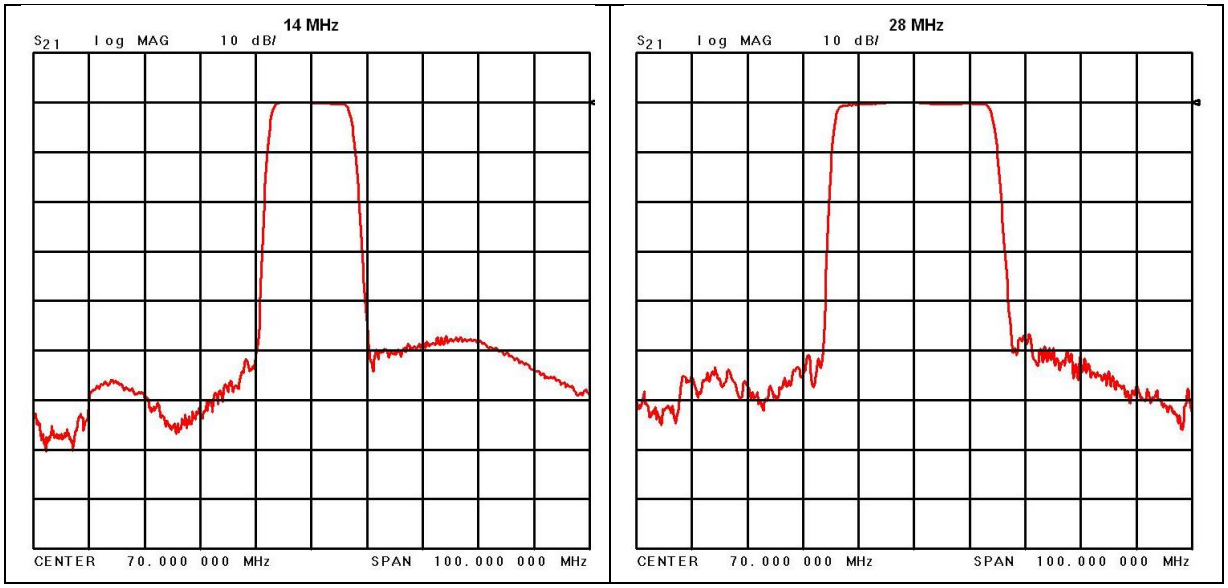


Figure 12: Optional SAW Filter Responses for 14 MHz and 28 MHz

7 Maintenance Instructions

The Compact RDMS™ requires no regular maintenance, and there are no user-serviceable parts inside.

8 Product Warranty

The Compact RDMS™ carries a standard parts and labor warranty of one (1) year from the date of delivery.

8.1 Quasonix Limited Warranty Statement

This Limited Warranty Statement (this "Limited Warranty") applies to all hardware and software products and internal components of such products (the "Products") sold by Quasonix, or its representatives, authorized resellers, or country distributors (collectively referred to herein as "Quasonix"). EXCEPT AS EXPRESSLY SET FORTH IN THIS LIMITED WARRANTY, QUASONIX MAKES NO OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO ANY PRODUCTS SOLD BY IT. Quasonix expressly disclaims all warranties and conditions not stated in this limited warranty. There are no warranties which extend beyond the description on the face hereof. Capitalized terms not otherwise defined herein shall have the meaning set forth in those certain General Terms and Conditions of Sale for Standard Product, as amended from time to time.

Quasonix warrants to customer that for one (1) year from the date of shipment of the Products by Quasonix (the "Warranty Period"), such Products purchased from Quasonix or its authorized affiliate will materially conform to the specifications set forth in the applicable Quasonix Specifications, if any, and are free from defects in materials and workmanship under normal use during the Warranty Period. As used herein, "normal use" means the intended use of the Products for which it was designed by Quasonix.

This Limited Warranty extends only to the original purchaser of the Products and is not transferable to anyone who obtains ownership of the Products from the original purchaser.

Quasonix's software, whether incorporated into the Products or sold separately, is warranted solely to the extent that problems or "bugs" are found in the software and affect the functional operation of the Products. At no time shall requests for changes in the software architecture or visual esthetics be considered a warranty item.

The Products are manufactured using new materials only. Replacement parts may be new or equivalent to new. Replacement parts are warranted to be free from defects in material or workmanship for thirty (30) days or for the remainder of the Warranty Period of the Products in which they are installed, whichever is longer.

During the Warranty Period, Quasonix will repair or replace the defective Products. All components or hardware products removed from the Products under this Limited Warranty become the property of Quasonix. All warranties are limited to the repair or replacement of the Products.

In no event shall Quasonix be liable for any special, consequential, incidental or indirect damages of any kind, including, without limitation, loss of profits, loss of data, "down-time," loss of use or damage to other equipment, or personal injury or death, whether or not Quasonix has been advised of the possibility of such loss.

Notwithstanding anything to the contrary herein, Quasonix's entire liability hereunder from any cause whatsoever and regardless of the form of action shall be limited to the amount actually received by Quasonix.

Quasonix shall not be liable for a breach of the warranty set forth in this Limited Warranty unless: (i) the customer gives written notice of the defect, reasonably described, to Quasonix's Contracts Administrator within thirty (30) days of the time when customer discovers or ought to have discovered the defect and obtains a Return Materials Authorizations ("RMA") number; (ii) Quasonix is given a reasonable opportunity after receiving the notice to examine such Products and customer (if requested to do so by Quasonix) returns such Products to Quasonix's facility in Moorpark, CA, unless otherwise approved by Quasonix; and (iii) Quasonix reasonably verifies customer's claim that the Products are defective.

Subject to the foregoing, with respect to any such Products during the Warranty Period, Quasonix shall, in its sole discretion, either: (i) repair or replace such Products (or the defective part) or (ii) credit or refund the price of such

Products at the pro rata contract rate provided that, if Quasonix so requests, customer shall, at Quasonix's expense, return such Products to Quasonix.

The customer is responsible for all costs associated with packaging and shipping of the defective Products to Quasonix's facility and clearly marking or affixing the given RMA number on the shipping label. Quasonix is not responsible for any loss or damage during shipment to Quasonix's facility. Following repair or replacement of covered Products, Quasonix will assume responsibility for the costs associated with the return of the material to the customer to an address provided by the customer. Notwithstanding the foregoing, items returned to Quasonix's facility and found to be operational or otherwise not covered by this Limited Warranty shall be returned to the customer at the customer's expense.

This Limited Warranty does not apply to expendable parts, such as cables, lamps, fuses, connectors, etc. This Limited Warranty does not extend to any Products which have been damaged or rendered defective (a) as a result of accident, misuse, abuse, or external causes; (b) by operation outside the usage parameters stated in the user documentation that shipped with the Products; (c) as a result of a failure to follow the instructions in the Operations & Maintenance Manual (d) by the use of parts not manufactured or sold by Quasonix; or (e) by modification or service by anyone other than (i) Quasonix, (ii) an Quasonix authorized service provider, or (iii) your own installation of end-user replaceable Quasonix or Quasonix approved parts if available for the Products in the servicing country.

THE TERMS OF THE WARRANTIES CONTAINED HEREIN DO NOT IN ANY WAY EXTEND TO ANY PRODUCT OR PART THEREOF OR SOFTWARE MATERIALS WHICH WERE NOT MANUFACTURED BY SELLER OR PREPARED BY SELLER OR ANY OF ITS AFFILIATES.

These terms and conditions constitute the complete and exclusive warranty agreement between the customer and Quasonix regarding the Products purchased. This Limited Warranty is applicable in all countries and may be enforced in any country where Quasonix or its authorized affiliates offer warranty service subject to the terms and conditions set forth in this Limited Warranty.

These terms and conditions supersede any prior agreements or representations (including representations made in Quasonix sales literature or advice given to the customer by Quasonix or an agent or employee of Quasonix) that may have been made in connection with the purchase of the Products. No change to the conditions of this Limited Warranty is valid unless it is made in writing and signed by an authorized representative of Quasonix.

8.1.1 Extended Warranties

Extended warranties or extra coverage are available upon request. Please contact Quasonix for details and pricing.

THE REMEDIES SET FORTH IN THIS LIMITED WARRANTY STATEMENT SHALL BE THE BUYER'S SOLE AND EXCLUSIVE REMEDY AND SELLER'S ENTIRE LIABILITY FOR ANY BREACH OF THE LIMITED WARRANTY SET FORTH HEREIN.

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9 Technical Support and RMA Requests

In the event of a product issue, customers should contact Quasonix via phone (1-513-942-1287) or e-mail (support@quasonix.com) to seek technical support. If the Quasonix representative determines that the product issue must be addressed at Quasonix, a returned materials authorization (RMA) number will be provided for return shipment.

Authorized return shipments must be addressed in the following manner:

Quasonix, Inc.
ATTN: Repair, RMA #
6025 Schumacher Park Drive
West Chester, OH 45069

To ensure that your shipment is processed most efficiently, please include the following information with your product return:

- Ship To – Company name, address, zip code, and internal mail-drop, if applicable
- Attention/Contact person – Name, Title, Department, Phone number, email address
- Purchase Order Number – If applicable
- RMA Number – provided by the Quasonix representative

Please note that Quasonix reserves the right to refuse shipments that arrive without RMA numbers.

10 Appendix A – Bit Error Rate Testing

There is a separate BERT for each data path in the receiver (0 main channel, 1 combiner channel). By default all commands are targeted to the current "tracking channel" (TC command), 0 or 1. If the tracking channel is set to 2 (tracking both channels), then the channel must be explicitly specified.

The results of the test can be displayed using the BE command with no parameters or a continuous display can be produced using BE D 1. BE D 0 turns off the continuous display.

Table 9: Bit Error Rate Serial Commands

Mnemonic	Name	Description
BE ?	Bit Error Rate Help	Provides help for using the bit error rate commands
BE [c]	Bit Error Rate Status	Report bit error rate status [c] is optional and indicates channel 0 or 1 If channel is omitted, the current tracking channel (TC) is used If TC is 2, a channel number is required Examples: BE Show the bit error rate status BE 1 Show the status of channel 1
BE D	Bit Error Rate Status Continuous	Report a continuous display of bit error rate status Examples: BE D 0 Show continuous bit error rate status is OFF BE D 1 Show continuous bit error rate status is ON
BE [c] P n	Set Bit Error Test Pattern	Sets bit error test pattern [c] is optional and indicates channel 0 or 1 If channel is omitted, the current tracking channel (TC) is used If TC is 2, a channel number is required P indicates a preset or fixed pattern length where 'n' is one of: PN6, PN9, PN11, PN15, PN17, PN20, PN23, PN31 or, for a fixed pattern length of 2 to 32 (fixed patterns are automatically determined)

Mnemonic	Name	Description
BE [c] T n	Set Bit Error Measurement Type	Sets bit error measurement type The test type can be configured to run continuously or stop when either a time limit, bit count, or error count has been reached. The error count limit guarantees a minimum number of errors. [c] is optional and indicates channel 0 or 1 If channel is omitted, the current tracking channel (TC) is used If TC is 2, a channel number is required T indicates type where 'n' is one of the following: C = continuous (clears limits) T x = time limit where 'x' is between 0 and 4.29497E+06 seconds B x = bit limit where 'x' is between 0 and 9.3825E+13 E x = error limit where 'x' is between 0 and 3.1275E+13
BE G n	Set Bit Error Measurement Gating	Sets bit error measurement gating The test can be configured to make a single measurement or, when a time limit, bit count, or error count is set, automatically repeat the test. Examples: BE G S S indicates Single BE G R R indicates Repeat

Mnemonic	Name	Description
BE [c] M	Measurement Enable	Starts or stops bit error measurement (toggle command) If a time limit, bit count, or error count limit is set and the limit has been reached (enabled but not running) the BERT is restarted. [c] is optional and indicates channel 0 or 1 If channel is omitted, the current tracking channel (TC) is used If TC is 2, a channel number is required Examples: BE M Enter command once to Start bit error measurement, current tracking channel BE M Enter command again to Stop bit error measurement current tracking channel BE 1 M Enter command once to Start bit error measurement, for channel 1
BE [c] R	Hardware Bit Error Register Display	Reports the bit error register status [c] is optional and indicates channel 0 or 1 If channel is omitted, the current tracking channel (TC) is used If TC is 2, a channel number is required Example: BE 1 R Report bit register state for channel 1
BE [c] W reg value	Set Hardware Bit Error Register	Sets hardware bit error register 'reg' to 'value' [c] is optional and indicates channel 0 or 1 If channel is omitted, the current tracking channel (TC) is used If TC is 2, a channel number is required 'reg' is hex register index 00 to 0a 'value' is 32 bit hex value to write to register

The Hardware Bit Error Register Display reports the current status of the bit error rate test (BERT).

A column header is displayed every ten rows.

The 'E' column indicates the BERT is enabled by displaying a pound sign '#'. If the BERT is not enabled, this column is blank.

The 'R' column indicates the BERT is actually running and making a measurement by displaying a '!'. If the BERT is not running, this column is blank.

The BERT can be enabled, but not running, in the case of a time, bit, or error count limit.

An asterisk '*' after the error rate column indicates that the data is inverted. If the display is continuous and a time, bit, or error limit is set with repeating gating, the display shows the end of the test by displaying '>>>' in the first three columns.

The following shows an example display with a five (5) second repeating test.

```
 E R             Time        Bit Count      Error Count       Error Rate
# !   0:00:00:03.772        3.773e+07                2        5.301e-08*
# !   0:00:00:04.023        4.023e+07                2        4.971e-08*
# !   0:00:00:04.276        4.276e+07                2        4.677e-08*
# !   0:00:00:04.527        4.528e+07                2        4.417e-08*
# !   0:00:00:04.779        4.780e+07                2        4.184e-08*
>>>   0:00:00:05.000        5.000e+07                2        4.000e-08*
# !   0:00:00:00.251        2.512e+06                0        0.000e+00*
# !   0:00:00:00.503        5.032e+06                0        0.000e+00*
# !   0:00:00:00.757        7.574e+06                2        2.641e-07*
# !   0:00:00:01.011        1.011e+07                2        1.978e-07*
# !   0:00:00:01.263        1.264e+07                2        1.582e-07*
```

11 Appendix B – Pinouts for Optional 37 Pin Connector

The optional 37-pin connector provides three sets of clock and data, two high-speed analog outputs, and one low-speed analog output. Pin numbering for the optional connector is shown in Figure 13. Pin assignments are listed in Table 10.

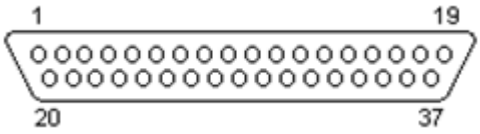

Figure 13: Optional 37-Pin Numbers

Table 10: Optional 37-Pin Assignments

Position	Signal	Description
1	DAC A	Analog output (+/- 5VDC)
2	DAC B	Analog output (+/- 5VDC)
3	RSSI	Received Signal Strength Indication (0-3.3VDC)
4	Data C +	Clock and Data pairs
5	DNC	Factory use only – Do Not Connect
6	DNC	Factory use only – Do Not Connect
7	+28 VDC In	System power
8	Ground	System power
9	Ground	System power
10	Clock A +	Clock and Data pairs
11	Data A +	Clock and Data pairs
12	Serial Ground	RS232 Serial Connection - Ground
13	Lock Detect	LVTTL Indicator Line
14	Serial TXD	RS232 Serial Connection - Transmit
15	Clock C +	Clock and Data pairs
16	Clock B +	Clock and Data pairs
17	Data B +	Clock and Data pairs
18	DNC	Factory use only – Do Not Connect
19	DNC	Factory use only – Do Not Connect

Position	Signal	Description
20	DAC Ground	Analog output (GND)
21	DNC	Factory use only – Do Not Connect
22	Data C -	Clock and Data pairs
23	DNC	Factory use only – Do Not Connect
24	DNC	Factory use only – Do Not Connect
25	SDI	Signal Degradation Indication (RF Networks 2241)
26	+28 VDC In	System power
27	Ground	System power
28	Power on Reset	
29	Clock A -	Clock and Data pairs
30	Data A -	Clock and Data pairs
31	Ones Detect	LVTTL Indicator Line
32	Serial RXD	RS232 Serial Connection - Received
33	Clock C -	Clock and Data pairs
34	Clock B -	Clock and Data pairs
35	Data B -	Clock and Data pairs
36	DNC	Factory use only – Do Not Connect
37	DNC	Factory use only – Do Not Connect

12 Appendix C – Detailed Output Control (OC) Command Settings

The Output Control command, as described in Table 6, is used to report or set the channel source values.

Note: The state settings use the alpha O, not a number zero (0).

Mnemonic	Name	Description
OC ?	Help Message	Displays abbreviated list of available commands
OC	Current Settings	(This is an example - current settings will vary.) O_0 = CLK_I0 O_1 = DATA_I0 O_2 = CLK_Q0 O_3 = DATA_Q0 O_4 = CLK_I1 O_5 = DATA_I1 O_6 = CLK_Q1 O_7 = DATA_Q1
OC D	Set Default Outputs	O_0 = CLK_I0 O_1 = DATA_I0 O_2 = CLK_Q0 O_3 = DATA_Q0 O_4 = CLK_I1 O_5 = DATA_I1 O_6 = CLK_Q1 O_7 = DATA_Q1

Mnemonic	Name	Description
OC c s	Set Channel and Source	where c is channel: O_0, O_1, O_2, O_3, O_4, O_5, O_6, O_7 where s is source: CLK_I0, DATA_I0, CLK_Q0, DATA_Q0, CLK_I1, DATA_I1, CLK_Q1, DATA_Q1, CLK_T, DATA_T, OFF When the outputs return the value above, this says the outputs are routed to the default settings. If anything is changes, an asterisk (*) appears before the changed parameter. For example, changing the secondary Clock and Data to match the primary commands are: OC O_2 CLK_I0 OC O_3 DATA_I0 When the changes are made, the list displays as follows: OC O_0 = CLK_I0 O_1 = DATA_I0 *O_2 = CLK_I0 *O_3 = DATA_I0 O_4 = CLK_I1 O_5 = DATA_I1 O_6 = CLK_Q1 O_7 = DATA_Q1 Now the user has the clock and data I0 (the letter I and the number 0), on both the primary (A channel) and secondary (B channel) outputs. These settings can be saved with the SV command, but are only saved per mode. If the user changes modes (using the MO command), they must repeat the settings for the other mode.

13 Appendix D – Phase Noise Compensation

13.1 Trellis Demodulation Basics

Legacy Single-Symbol Detection:

- Uses basic Limiter-Discriminator operation
- Frequency in this bit above nominal → data = 1
- Frequency in this bit below nominal → data = 0
- Makes no use of adjacent symbols for error correction

Trellis Detection:

- Uses the phase tree for data detection
- Uses adjacent symbols to help decide on "iffy" bits
- Improves BER performance by 3.5 to 5.0 dB

The Phase Tree shown in Figure 14, shows all of the possible paths the phase trajectory can take over a period of seven bits. Figure 15 shows the two unique paths, based on whether the second bit is a 1 or 0.

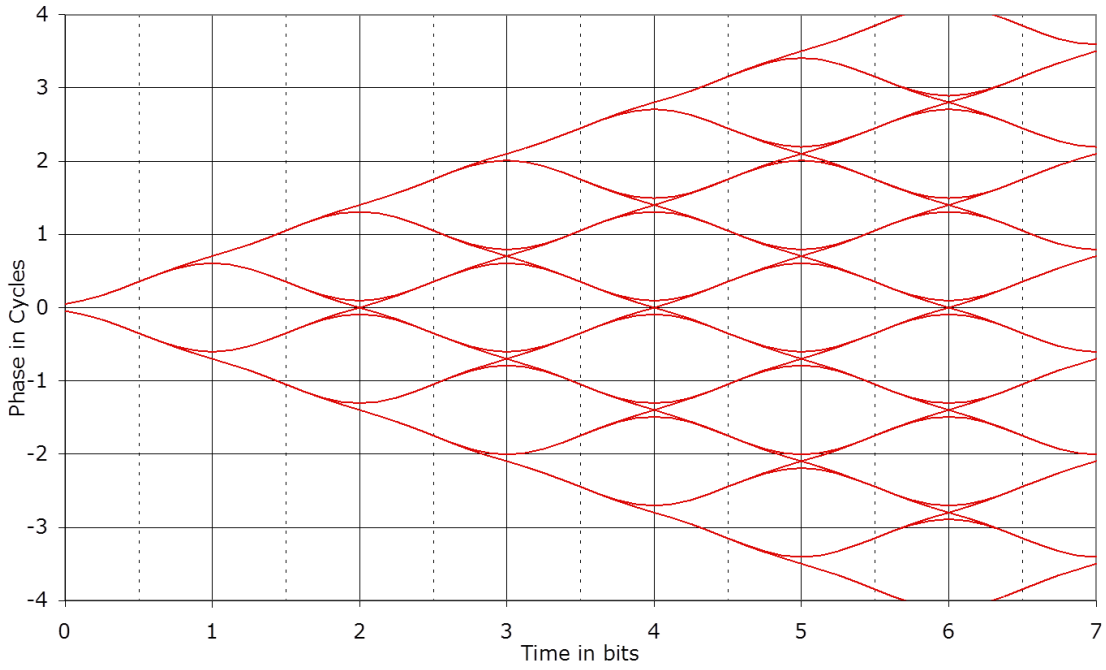

Figure 14: Ideal PCM/FM Phase Tree (h = 0.7)

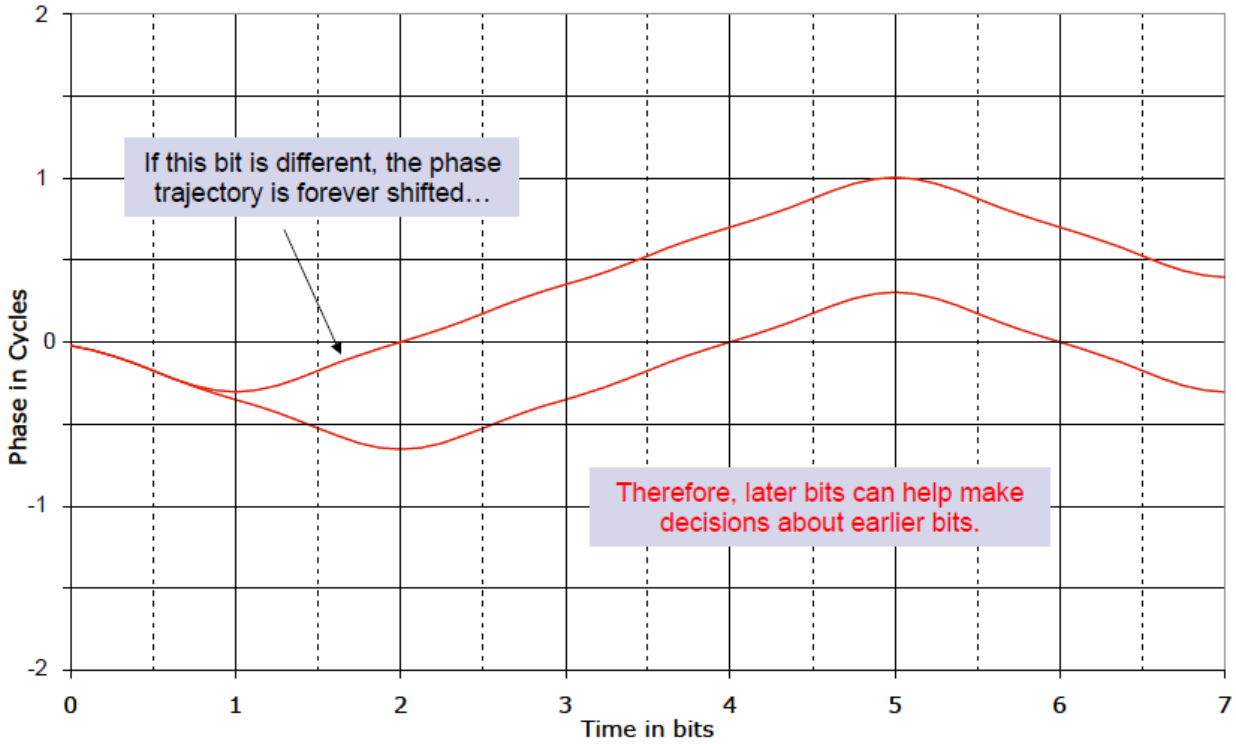

Figure 15: Phase Trajectory Never Forgets

13.1.1 Trellis Demodulation Summary

The basic premise of trellis demodulation is that the signal from the transmitter follows a known path through the phase tree. When the demodulator knows this, it can use a sequence of several symbols to help make better decisions about each individual bit. This process improves BER performance by about 3.5 to 5 dB over conventional FM detection. However, this assumes that the transmitter is really following the "known" and "correct" phase tree, and this assumption is NOT always true.

High phase noise can reduce the trellis detection gain because phase noise corrupts the tree. The following figures illustrate the differences in trellis detection gain depending on the amount of phase noise introduced.

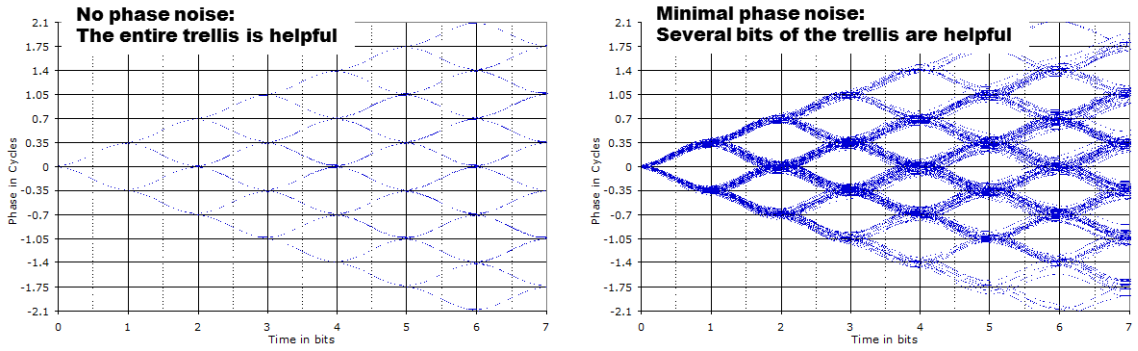

Figure 16: Trellis Detection Gain with Zero to Minimum Phase Noise

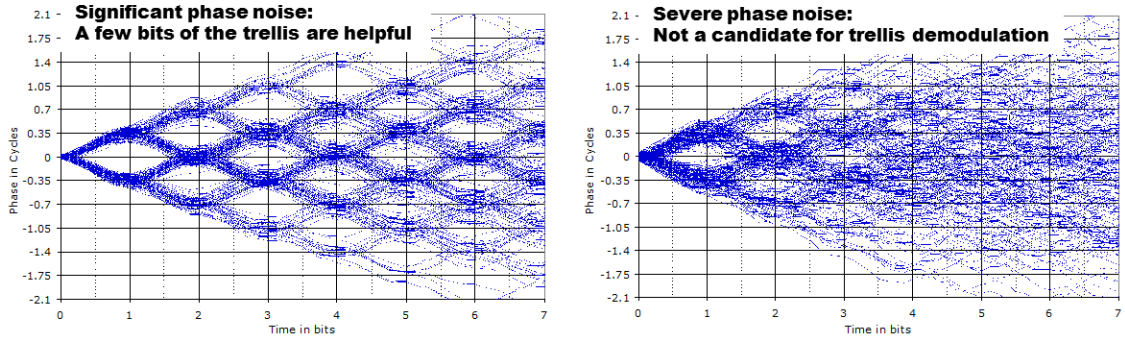

Figure 17: Trellis Detection Gain with Significant to Severe Phase Noise

13.2 Phase Noise Impact

Trellis demodulation is based on the assumption that the signal is following a predictable path through the trellis. If this is not true (due to high phase noise), then a trellis demodulator cannot provide the expected performance gain.

- Many legacy analog transmitters (a simple modulated VCO) have high phase noise.
- Vibration often further increases phase noise.
- Phase noise is generally more damaging at low bit rates.
- Phase Noise Compensation (PNC) gives back some of the trellis detection gain, by shortening the trellis observation span.

13.3 Clock Jitter Impact

Many older PCM encoders are susceptible to large inaccuracies in clock rate or have clock stability issues, especially under harsh vibration conditions. While the RDMS is capable of tracking static clock rate errors as large as 1000 ppM, excessive jitter causes the integrated bit sync to lose lock. Enabling the PNC mode opens the tracking loop bandwidth to accommodate for these issues. This increase in bandwidth does have a tradeoff. A wider tracking range allows the RDMS to deal with the additional jitter, but it may also increase synchronization times slightly, and slightly increase the minimum SNR at which the RDMS declares lock.

13.4 When to Use PNC

There is no bullet-proof test for whether PNC is needed, but there are good indicators. Turn on PNC if:

- The demodulator is struggling to lock, even with good Signal to Noise Ratio (SNR). ("Good" SNR means the Quality bar is above one-quarter height.)
- The eye pattern NEVER looks “clean,” as in Figure 18
- Symptoms get worse when the transmitter is under vibration
- Symptoms get worse at low bit rates

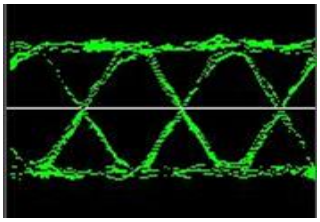

Figure 18: "Clean" Eye Pattern

13.5 Know Your Transmitter

If you know the brand and type of transmitter, these tips can help determine when to use PNC.

If your transmitter was manufactured by these companies, PNC should be OFF:

- Quasonix – guaranteed
- Nova Engineering – highly likely
- L3 – probably, but digital transmitters only

If the transmitter was manufactured by the companies below, PNC should be ON:

- Microwave Innovations
- Emhiser
- Southern California Microwave
- L3 (analog transmitters)

14 Appendix E – Factory Reset Values

When a reset command is activated, the frequency defaults to the lowest valid frequency for the lowest authorized band on the unit. The reset priority is:

1. QPSK
2. PCM/FM
3. SOQPSK
4. Multi-h CPM

Reset values for each mode are listed in the following tables.

Table 11: QPSK Factory Reset Values

Parameter	Reset State
Bit Rate	1
Modulation Scaling	N/A
Clock Polarity	Normal
Data Polarity	Normal
Derandomizer	Disabled
Differential Decoder	N/A
IF Filter	Auto
Downconvert Antenna	Disabled
AGC	Enabled
Convolutional Decoder	Disabled
Lock Output Polarity	Active High
NRZ Encoding	NRZ-L
Output Control	Default
Output Muting	Disabled
Phase Noise Compensation	Disabled
Tape Output	Disabled

Table 12: PCM/FM Factory Reset Values

Parameter	Reset State
Bit Rate	1
Modulation Scaling	Tracking
Clock Polarity	Normal
Data Polarity	Normal
Derandomizer	Disabled
Differential Decoder	N/A
IF Filter	Auto
Downconvert Antenna	Disabled
AGC	Enabled
Convolutional Decoder	Disabled
Lock Output Polarity	Active High
NRZ Encoding	NRZ-L
Output Control	Default
Output Muting	Disabled
Phase Noise Compensation	Disabled
Tape Output	Disabled

Table 13: SOQPSK Factory Reset Values

Parameter	Reset State
Bit Rate	1
Modulation Scaling	N/A
Clock Polarity	Normal
Data Polarity	Normal
Derandomizer	Disabled
Differential Decoder	Enabled
IF Filter	Auto
Downconvert Antenna	Disabled
AGC	Enabled
Convolutional Decoder	N/A
Lock Output Polarity	Active High
NRZ Encoding	N/A
Output Control	Default
Output Muting	Disabled
Phase Noise Compensation	Disabled
Tape Output	Disabled

Table 14: Multi-h CPM Factory Reset Values

Parameter	Reset State
Bit Rate	1
Modulation Scaling	N/A
Clock Polarity	Normal
Data Polarity	Normal
Derandomizer	Disabled
Differential Decoder	N/A
IF Filter	Auto
Downconvert Antenna	Disabled
AGC	Enabled
Convolutional Decoder	N/A
Lock Output Polarity	Active High
NRZ Encoding	N/A
Output Control	Default
Output Muting	Disabled
Phase Noise Compensation	Disabled
Tape Output	Disabled

15 Appendix F – Acronym List

Acronym	Description
AGC	Automatic Gain Control
AM	Amplitude Modulation
AQPSK	Variant of Quadrature Phase Shift Keying
ARTM	Advanced Range Telemetry
AUQPSK	Variant of Quadrature Phase Shift Keying
BER	Bit Error Rate
BNC	Bayonet Neill-Concelman Connector (RF Connector)
BPSK	Binary Phase Shift Keying
CD	Compact Disk
CPM	Continuous Phase Modulation
DB-9	D-subminiature 9 pin Serial Connector
DC	Diversity Combiner
DHCP	Dynamic Host Configuration Protocol
DPM	Digital Phase Modulation
FPGA	Field Programmable Gate Array
IF	Intermediate Frequency
IP	Internet Protocol
kbps	Kilobits per second
KHz	Kilohertz
LCD	Liquid Crystal Display
Mbps	Megabits per second
MCX	Snap on subminiature connector
MHCPM	multi-h Continuous Phase Modulation
MHz	Megahertz
N	(connector type) Threaded RF connector
OQPSK	Offset Quadrature Phase Shift Keying
PCMFM	Pulse Code Modulation/Frequency Modulation
PM	Phase Modulation

Acronym	Description
PSK	Phase Shift Keying
QPSK	Offset Quadrature Phase Shift Keying
RDMS	Receiver DeModulator Synchronizer
RF	Radio Frequency
RJ-45	Ethernet Connection Jack
RM	Rack Mount
RRC	Remote RDMS Client
RS-232	Recommended Standard 232 (Serial Communications)
SAW	Surface Acoustic Wave
SDI	System Degradation Indication
SOQPSK	Shaped Offset Quadrature Phase Shift Keying
SOQPSK-TG	Shaped Offset Quadrature Phase Shift Keying –Telemetry Group
TRL	Tracking Loop
TTL	Transistor Transistor Logic
UDP	User Datagram Protocol
UQPSK	Unbalanced Quadrature Phase Shift Keying
USB	Universal Serial Bus
VAC	Voltage Alternating Current
VDC	Voltage, Direct Current
WAN	Wide Area Network