Third-Generation RDMS™ Compact Receiver-Combiner

MADE IN USA

The Industry's Premier Receiver Takes to The Air

The highest-performing telemetry receiver on the market is now available in a compact, flight-ready package. Experience the industry's fastest synchronization, best SOQPSK-TG detection, premier Best-Channel Selector and Adaptive Equalizer, and all the advantages of diversity combining - anywhere your test article takes you. Quasonix is... Reinventing Telemetry™.

Complete Receiver – RF to Bits — A single-box solution that accepts RF signals and delivers baseband clock and data. No external add-ons required.

Rugged, Space-Efficient Design — Ultra-compact 52 cubic-inch chassis affords flexibility with system integration.

Space-Time Coding (STC) with SOQPSK Mode — Space-Time Coding (STC) operates with Quasonix STC-enabled transmitters to eliminate the dropouts caused by transmit antenna pattern nulls due to inter-antenna interference.

Low-Density Parity Check (LDPC) with SOQPSK Mode — Low-Density Parity Check coding operates with Quasonix LDPC- enabled transmitters to improve link margin by up to 9 dB, while still using 22% less bandwidth than PCM/FM at the same payload data rate; fully integrated forward error correction system.

Data Quality Encapsulation (DQE)/Data Quality Metric (DQM) — Data Quality Encapsulation (DQE) is a process of bundling Data Quality Metric words with payload data, including a sync word to aid BSS time alignment; built-in real-time DQM display via the browser interface.

Best-Channel Selector (BCS) — Combiner data output seamlessly selects the best channel (Ch1, Ch2, or Pre-Detection Diversity Combiner) based on DQM.

Pre-Detection Multi-Mode Diversity Combiner — Provides Maximal Ratio Combining with gain virtually indistinguishable from theory. Also features a revolutionary dynamic time alignment function which increases the allowable time skew between channels by over 1300 nanoseconds.

Built-In Integrated Three-Channel Spectrum Analyzer — Spectrum analyzer shows frequency domain view for up to three channels simultaneously, via the browser interface

Modulation Index Tracking* for PCM/FM — Maintains superior BER performance even if the received signal's modulation index varies by as much as 500%, a breakthrough for tracking legacy analog transmitters (*patented).

Phase Noise Compensation — Optimizes demodulator performance for use with legacy TM packs and transmitters with excessive phase noise.

Best SOQPSK-TG Detection in the Industry — RDMS's trellis detection for SOQPSK-TG yields improvements of 2 dB or more over the competition's single-symbol detectors.

Easy Field Updates — Software and firmware updates - free for the lifetime of your receiver - can now be installed by the customer on site.

Future-Proofing Simplified — Upgrades such as new DSP and GUI features can be added with a simple file download while your receiver is still in the test article.

True Trellis Demodulation in All ARTM Modes — Provides true multi-symbol trellis detection in all three ARTM modes for optimal demodulation.

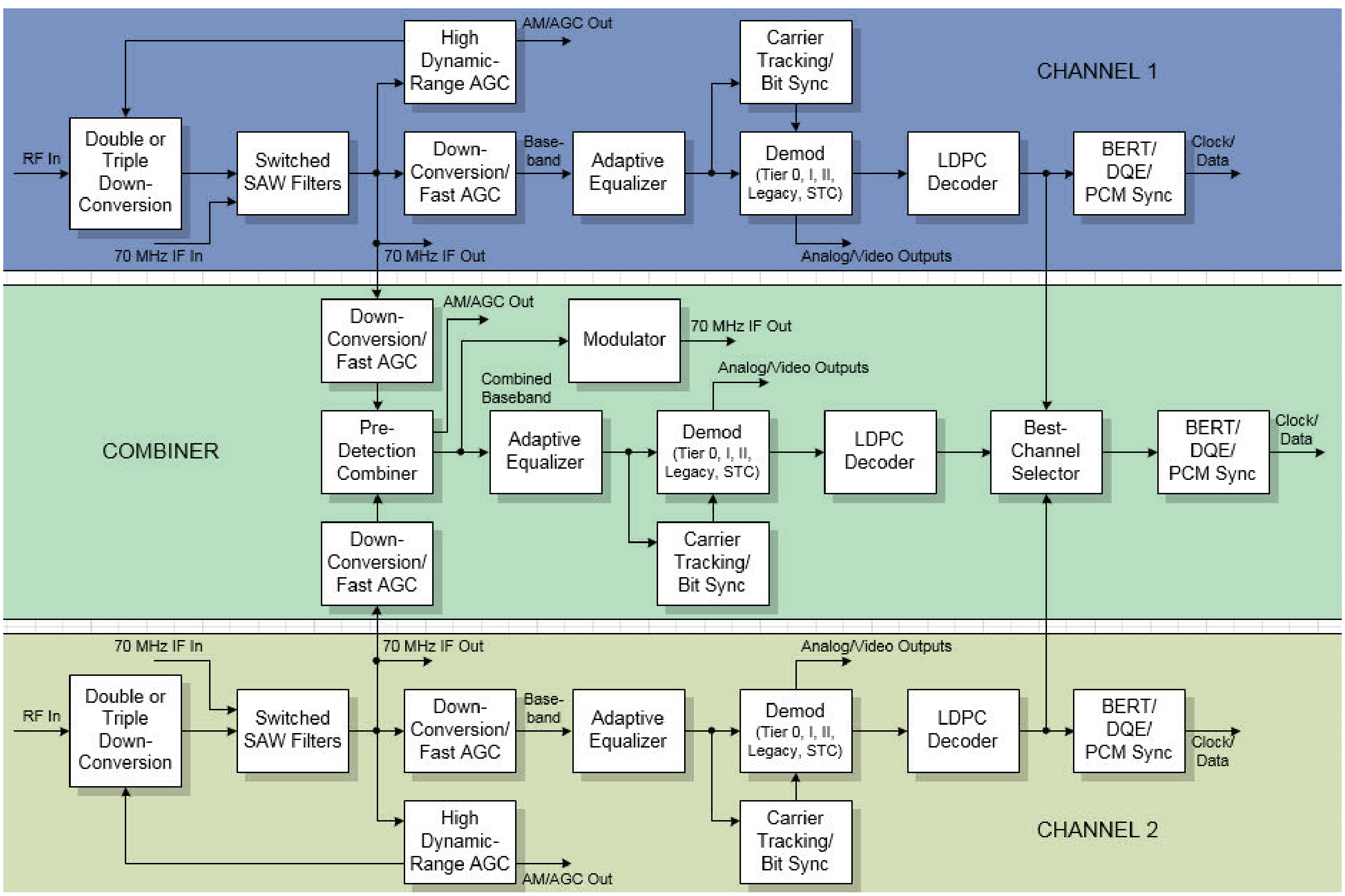
3.5 to 5 dB Improvement in PCM/FM Performance — Improves BER performance by 3.5 to 5 dB over the best single-symbol demodulators, to within 0.2 dB of the theoretical limit.

Lowest Noise Figure — Typical 3.5 dB noise figure bests all other ARTM receivers on the market, hands down.

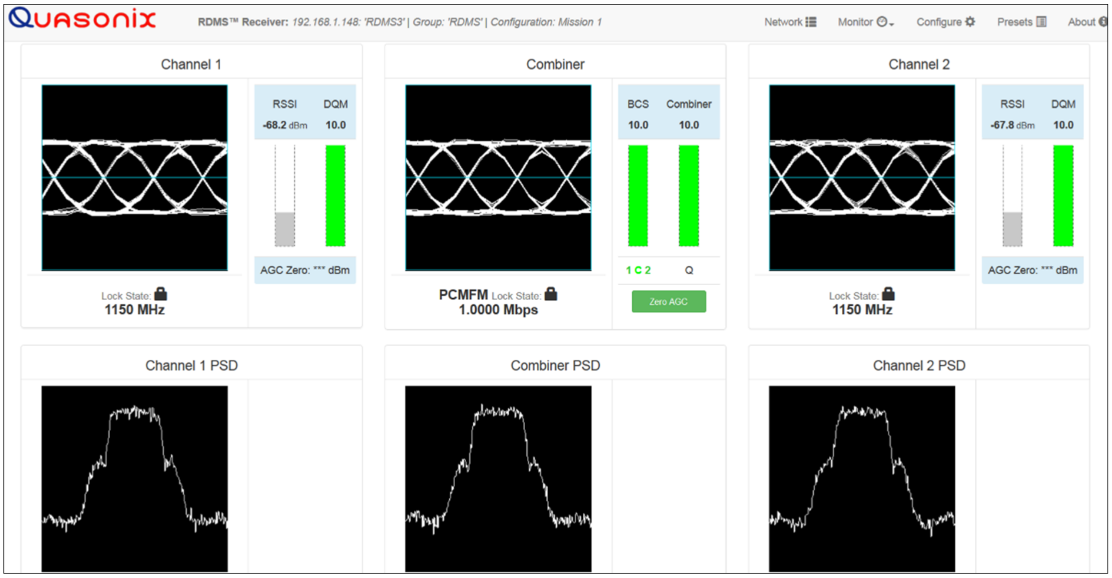
Rapid Synchronization — Synchronizes up to 100 times faster – and maintains sync at lower signal-to-noise ratios – than any other ARTM demodulator.

Available with Adaptive Equalization — Powerful decision-directed equalizer mitigates multipath distortion; reduces dropouts caused by multipath reflections.

Simplified Block Diagram

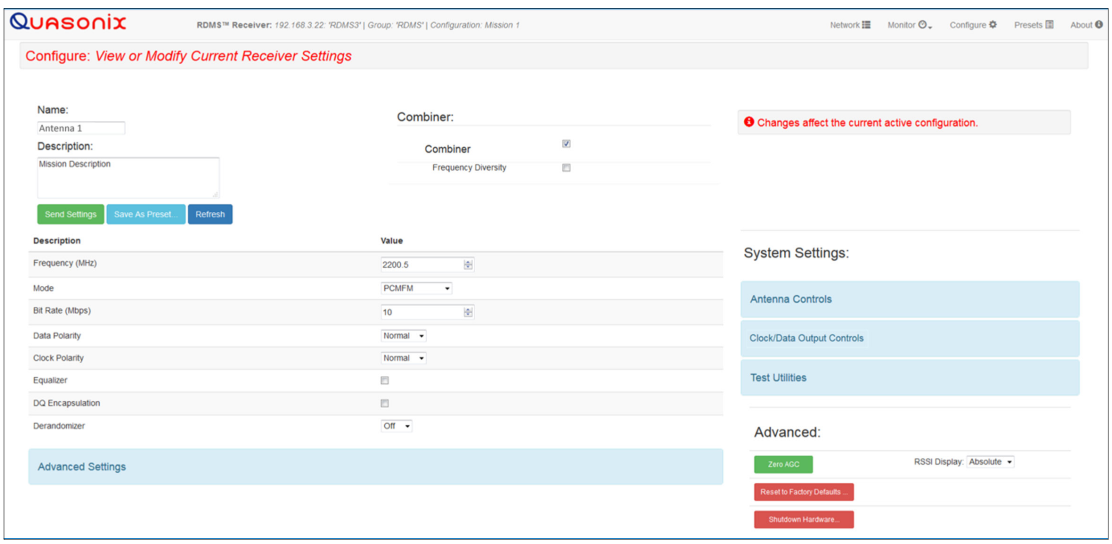


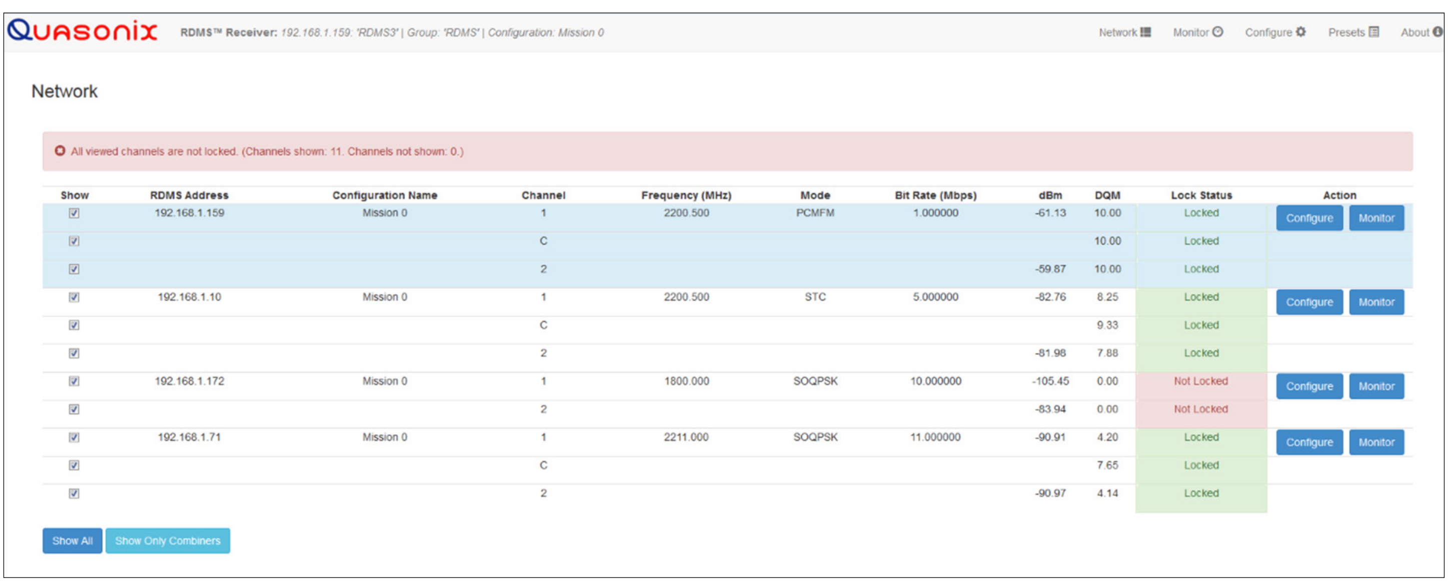
Remote RDMS Client



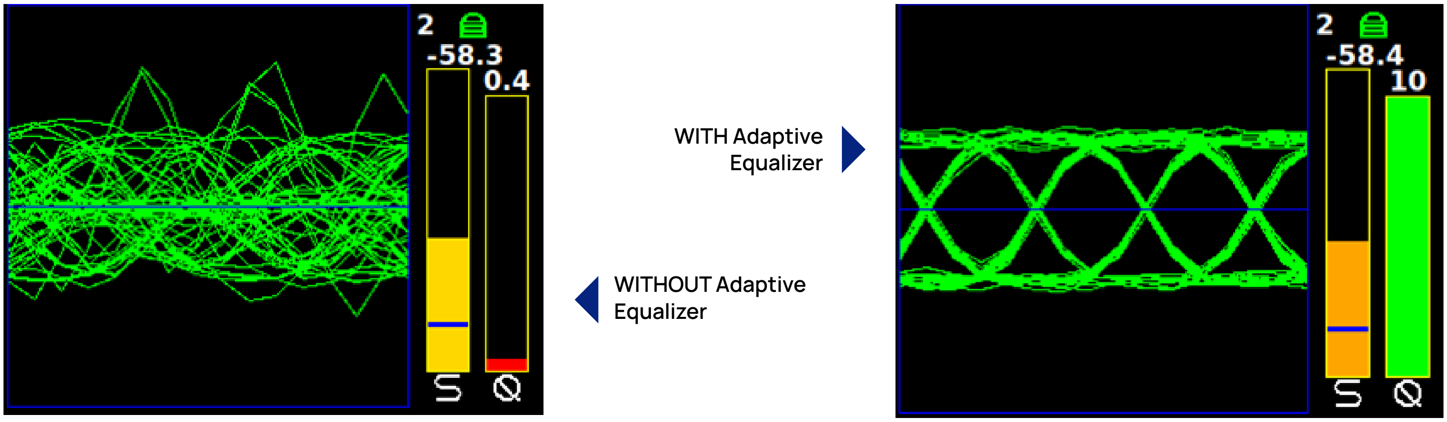
Features

- Browser-based interface—works with common web browsers
- Intuitive layout with all primary control and monitoring functionality for Channel 1, Channel 2, and Combined Channel in one window





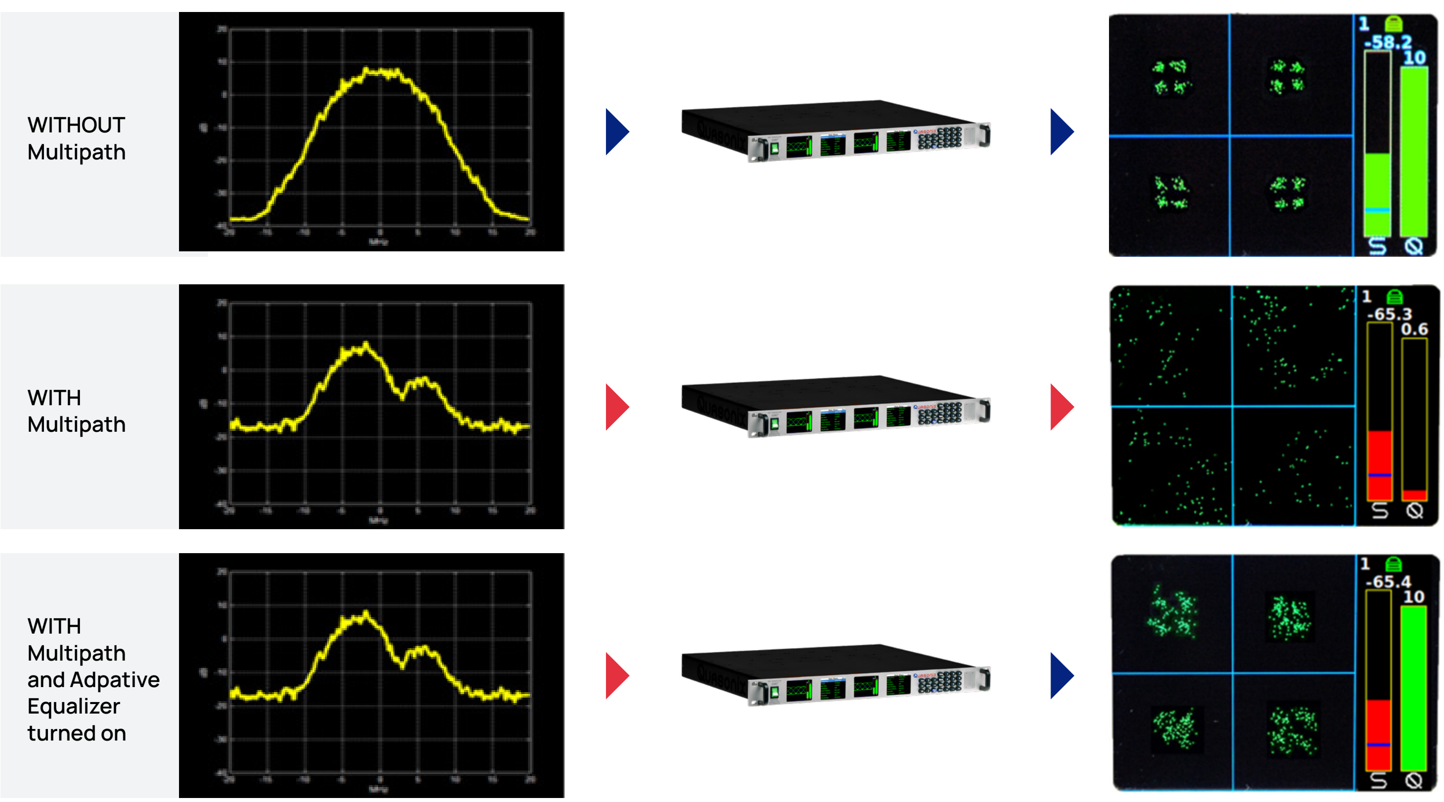
Adaptive Equalizer Option for RDMS Telemetry Receivers



Improves Reception in Multipath Channels

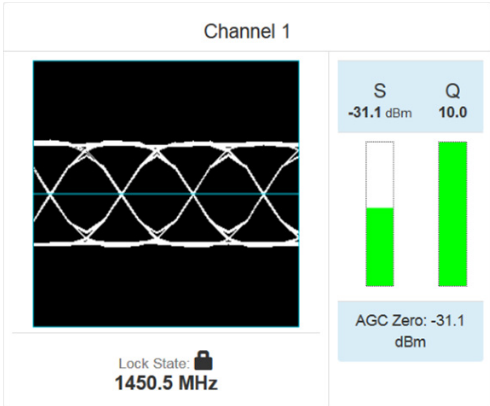
- Adaptive Equalizer combats Multipath Fading with Digital Signal Processing.
- NEW! Uses decision-directed feedback to tackle harsh channels and provide cleaner results.
- Available in Tier 0 (PCM/FM), Tier 1 (SOQPSK-TG), Tier 2 (ARTM CPM/Multi-h CPM), BPSK, QPSK, OQPSK, DPM, and SOQPSK/LDPC modes of operation.
- Works with your existing transmitter, no matter what brand it is.

Available as a programming upgrade to most Quasonix RDMS Telemetry Receivers



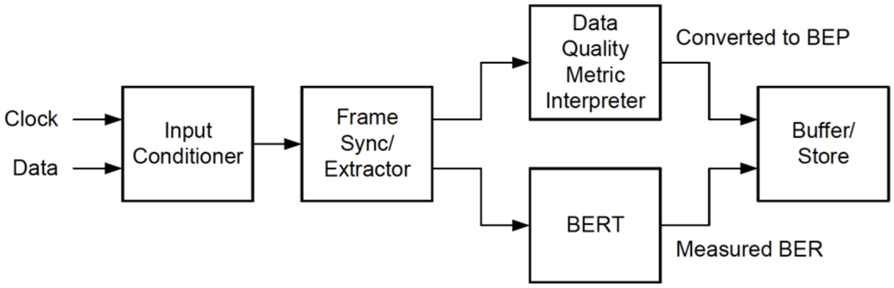
Data Quality Metric (DQM) with Real-Time Display

DQM is a measure of received signal quality that is embedded in the PCM stream and based on statistics developed deep inside the demodulator. DQM encodes an estimate of bit error probability (BEP) in a form optimally usable by best source selectors (BSS) such as the Quasonix Maximum Likelihood Stream Combiner™ (MLSC™).



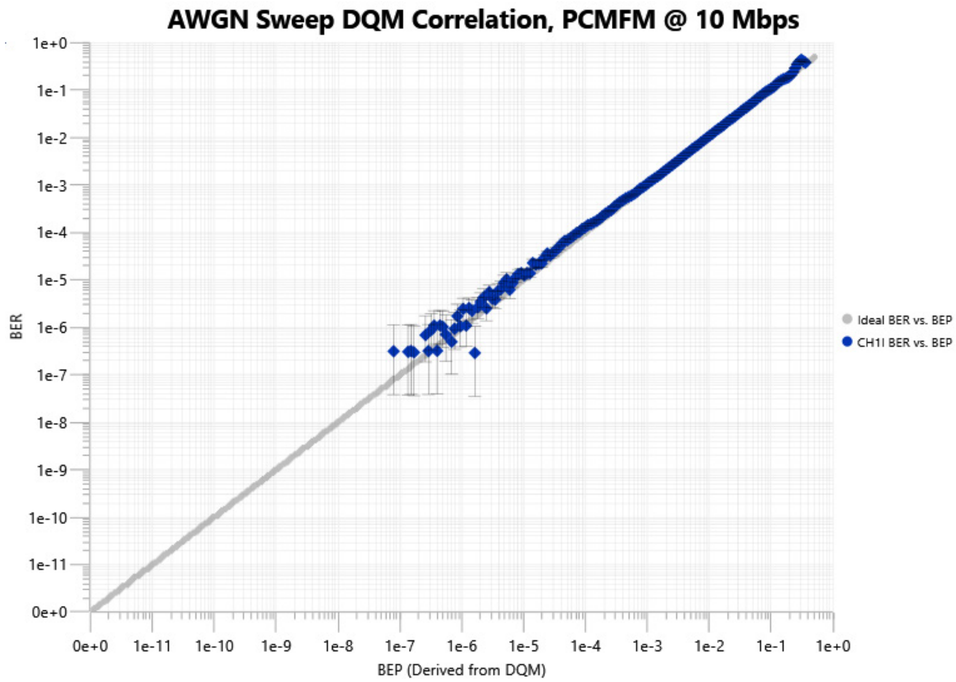
The displayed DQM value (Q on the Signal Graph) ranges from zero to ten. A zero means there is no confidence that the bits were received correctly, while a ten indicates that the probability of bit errors is less than one in ten billion.

In Quasonix RDMS, DQM is calibrated to BER and has been validated by measuring its correlation with BER. This simplified flowchart summarizes the process:



To ensure DQM faithfully reflects BER in real-world conditions, it has been verified to be accurate under a wide variety channel impairments:

- AWGN - static level
- AWGN - dynamic level (step response)
- Dropouts
- In-band and adjacent channel interference
- Phase noise
- Timing jitter
- Static multipath
- Dynamic multipath (similar to break frequency test)



Data Quality Encapsulation (DQE)

DQM is embedded in the PCM stream and based on statistics developed deep inside the demodulator. Data Quality Encapsulation (DQE) bundles payload data with its DQM to give the Best Source Selectors a valid basis for "Best!"

IRIG DQE Format

Header

- 16-bit sync pattern (0xFAC4)
    - MSB first: 1111101011000100
- 16-bit ID word (format TBD)
- 16-bit DQM = min(round(-log10(LR) / 12 * (2^16)), 2^16 -1)
    - 16-bit unsigned integer, ranges from 0 to 65,535
    - Likelihood Ratio (LR) = BEP / (1-BEP)
    - Easily reversed:

      LR = 10^(-12 * DQM / 2^16)

      BEP = LR / (1 + LR)
    - Q is defined as the "User's DQM":

      Q = 12 * DQM / 65536

      Represents the exponent of 10 in the LR, which approximates the BEP

BEP	LR	DQM	Q
0.5	1.00	0	0.00
1E-01	1.11111E-01	5211	0.95
1E-02	1.01010E-02	10899	2.00
1E-03	1.00100E-03	16382	3.00
1E-04	1.00010E-04	21845	4.00
1E-05	1.00001E-05	27307	5.00
1E-06	1.00000E-06	32768	6.00
1E-07	1.00000E-07	38229	7.00
1E-08	1.00000E-08	43691	8.00
1E-09	1.00000E-09	49152	9.00
1E-10	1.00000E-10	54613	10.00
1E-11	1.00000E-11	60075	11.00
1E-12	1.00000E-12	65535	12.00

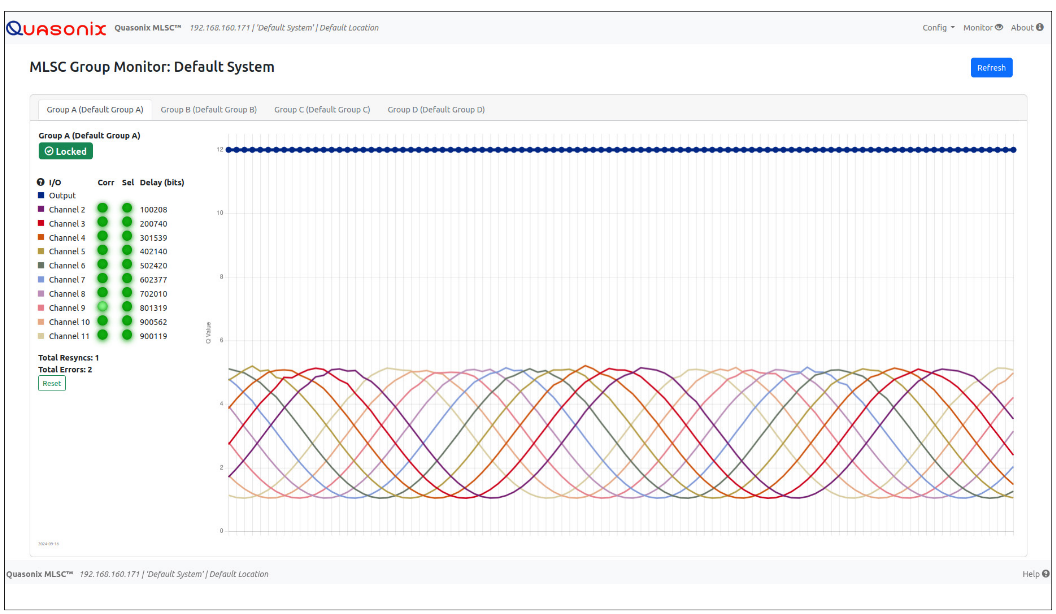
Payload Data

User selectable length, defaults to 4096, except for STC mode, where the default is 3200 bits, and SOQPSK/LDPC or STC/LDPC mode, where the default is the selected LDPC block size.

Network BW Expansion of ~1%

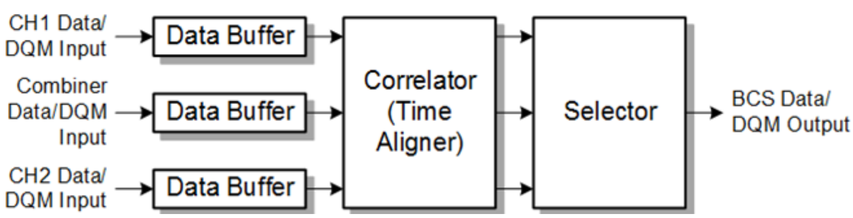
Better BSS

The Quasonix MLSC uses DQE to provide up to six orders of magnitude improvement over the **best** input stream.



The Power of Diversity

Quasonix makes great receivers, but even the best receiver may be limited by range, obstacles/shading, multipath, interference, etc. That's where diversity comes in. Using multiple copies of the transmitted signal—arriving via separate pathways—can dramatically reduce the likelihood of "data dropouts." The RDMS supports diversity at two levels: within each rackmount receiver through our innovative Best Channel Selector (BCS), and between multiple rackmount receivers connected to a Best Source Selector (BSS), through Data Quality Encapsulation (DQE).



Quasonix Best Channel Selector (BCS)

The BCS selects the best data from Channel 1, Channel 2, and the Combiner on a bit-by-bit basis, based on data quality.

Preserves Combiner gain when possible, remedies Combiner issues if they occur — Diversity combining in the RDMS provides polarization, frequency, or small-scale spatial diversity, depending on the system/antenna configuration. The Combiner uses pre-detection maximal ratio combining to synthesize a composite signal from the Channel 1 and Channel 2 input signals.

This approach provides up to 3 dB performance gain when the only channel impairment is noise. But the Combiner may struggle in the face of other common channel impairments like multipath and interference. Since the BCS selects the channel with the highest data quality, it provides a receiver output that is the best possible data the RDMS can provide, regardless of channel conditions.

Time correlation allows "hit-less" source channel switching — No dropped or duplicated data. Correlation is exceptionally fast and robust, due to small and predictable delays between internal receiver channels. The result is superior dynamic performance, handling dropouts and fast fading with ease.

Optimized selection accounts for statistically dependent errors — The optimal selection strategy for statistically independent sources may backfire if sources have correlated errors, which is inevitable with the Combiner and its source channels (Channel 1 and Channel 2). The BCS—unlike an external BSS—"knows" this and simply selects the best channel. This strategy guarantees the RDMS output will always be the best data available.

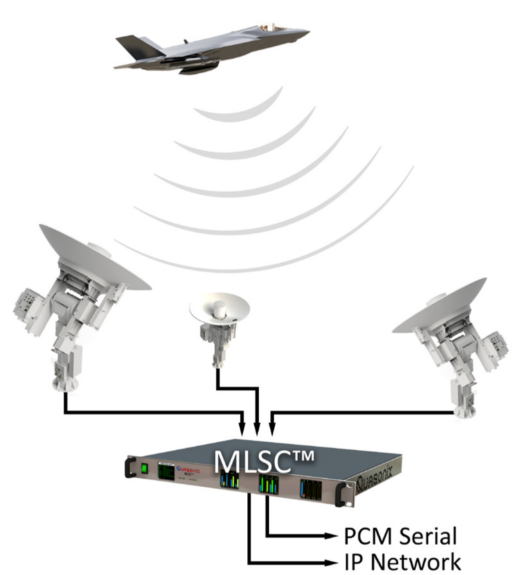
Outputs composite RDMS DQM and data, via DQE — Facilitates range-wide spatial diversity, using a single data stream per receiver (on the Combiner clock and data signals).

Quasonix Maximum Likelihood Stream Combiner (MLSC)

The MLSC (sold separately) creates the best signal source from multiple receivers—outputting data that is better than any individual input source, automatically and transparently.

Correlates sources across almost unlimited range — A wide range of source arrival delays are handled, potentially up to multiple seconds.

Optimal selection using DQM removes bit errors anywhere in the data stream — All correlated input sources contribute information to the output data. This results in a large improvement in data quality because most bit errors are uncorrelated across diverse sources. Typical improvement is a factor of 1000x in bit error rate with three sources. Best of all, it does not require any input source to be error free!



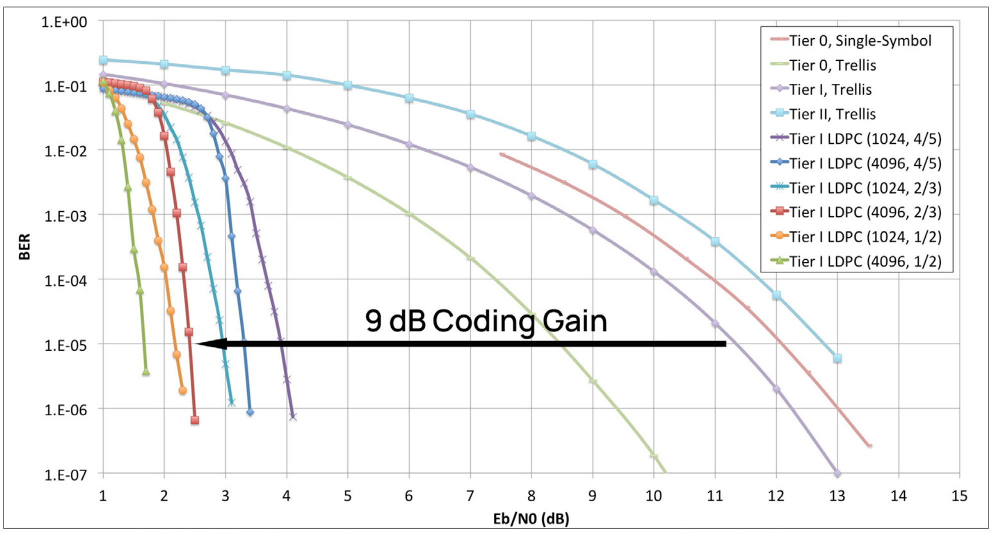
Compact RDMS Receiver-Combiner Features

Low-Density Parity Check (LDPC) Error Correction

When data dropouts occur on a telemetry link between a test article and the ground station, the telemetry data is simply lost, with no opportunity of recovery. The best strategy available is to make the link more reliable – that is, to reduce the number of errors. This is exactly what forward error correcting codes do. By introducing carefully constructed “redundant” bits into the transmitted data stream, it is possible to detect and correct received errors using a suitably equipped receiver.

There are many different coding schemes employed in communications systems. In the aeronautical mobile telemetry market, LDPC codes have emerged as a clearly superior choice. As a result, LDPC codes were adopted as the IRIG standard for the AMT community in 2015.

Quasonix is the only vendor in the market offering LDPC encoding and decoding for serial streaming telemetry. This approach yields nearly triple the communications range, yet it can do so with 22%, or even 34%, less bandwidth than conventional PCM/FM. Payload bit rates up to 35 Mbps are supported.



Improves Link Margin by 8.8 to 9.4 dB at BER = 1e-5 — Link margin improvement is equivalent to nearly tripling the operating distance on your telemetry link.

Fully Integrated Forward Error Correction System — The transmitter automatically synthesizes expanded over-the-air bit rate for encoded blocks and the receiver seamlessly converts back to continuous output at the user bit rate. This operation is completely transparent to data devices.

The IRIG standard calls out six variants of LDPC codes—all combinations of two different information block sizes (k=4096 bits and k=1024 bits) and three different code rates (r=1/2, r=2/3, and r=4/5). The larger block size offers better decoding performance in a static channel, but may work less well in a dynamic channel with fast fading or other impairments. Lower code rates also provide better decoding performance at the cost of increased occupied bandwidth.

Errors in a telemetry link can be costly, requiring more test time to reproduce the lost data, if replicating the test is even possible. LDPC coding reduces the number of errors in a telemetry link, and it does so more cost effectively than any other approach.

Already own Quasonix equipment? The LDPC feature can be retrofitted to most Quasonix transmitters and receivers.

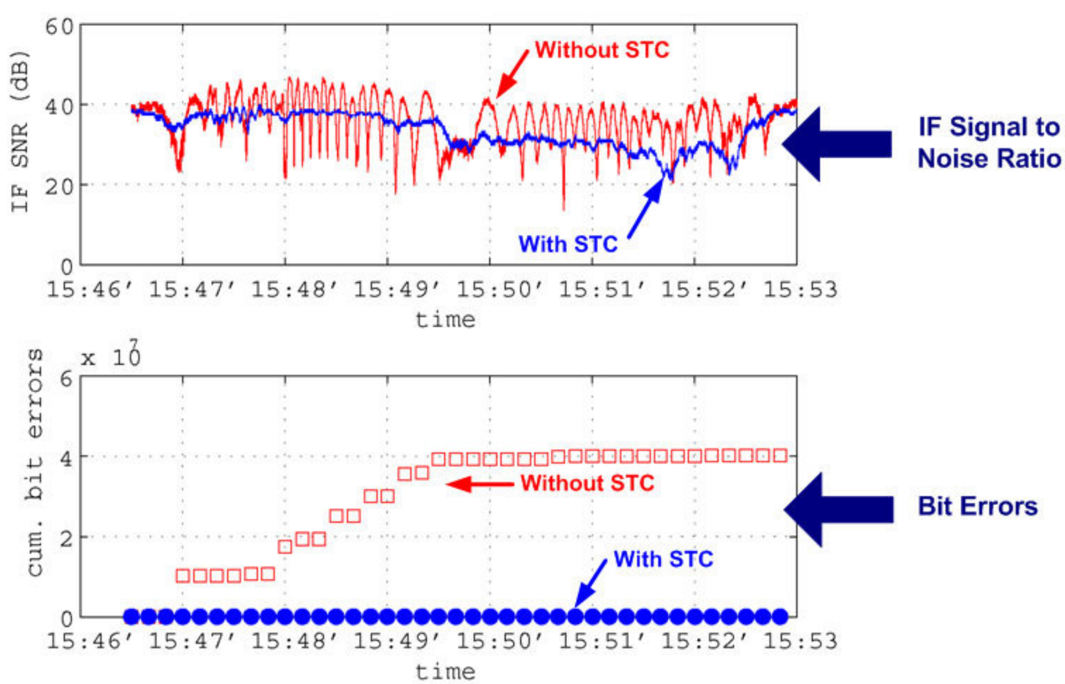
LDPC Error Correction has been adopted by the Range Commander’s Council, IRIG 106-17, Appendix 2-D

Compact RDMS Receiver-Combiner Features (Continued)

Space Time Coding Solution

Problem: "Two-antenna interference"	Solution: Space Time Coding (STC)
• Upper and lower antennas are required to provide LOS path during aircraft maneuvers. • Signals can cancel each other, creating antenna pattern nulls.	Advantages of the Quasonix Space Time Coding Solution: **Eliminates link outages caused by the "two-antenna problem"** • Improves behavior of received signal power • Improves overall link availability **Two transmit/One receive configuration** • Compatible with standard telemetry applications and installations **STC signal spectrum is the same as SOQPSK, with minimal bandwidth expansion (4%)** **Available as a software upgrade to Quasonix RDMS Telemetry Receivers.** Note: Quasonix dual transmitter required.

Illustrations and flight test data used with permission of the authors—originally published in "Space-Time Coding for Aeronautical Telemetry: Part II" - Experimental Results by Michael Rice, Brigham Young University, and Kip Temple, Air Force Flight Test Center, Edwards AFB, California, USA, in Proceedings of the International Telemetering Conference, Las Vegas, NV, October, 2011.



Space Time Coding has been adopted by the Range Commander's Council, IRIG 106-17, Appendix 2-E

Rear Panel Connectors

	Compact Receiver/Combiner		
	Channel 1	Channel 2	Channel 3
Receiver Nomenclature	Connector Number/pin		
IF IN	J1	J4	-
RF IN	J2	J5	-
IF Out	J3	J6	J7
28V DC Power	J8-4		
28V DC Power	J8-5		
28V DC Power	J8-8		
28V DC Power	J8-9		
28VDC Return (GND)	J8-1		
28VDC Return (GND)	J8-2		
28VDC Return (GND)	J8-6		
28VDC Return (GND)	J8-7		
Ethernet RX_p	J9-1		
Ethernet RX_n	J9-6		
Ethernet TX_p	J9-5		
Ethernet TX_n	J9-9		
RS422/Clock A_n	J10-1	J10-5	J10-9
RS422/Clock A_p	J10-14	J10-18	J10-22
RS422/Data A_n	J10-2	J10-6	J10-10
RS422/Data A_p	J10-15	J10-19	J10-23
RS422/Clock B_n	J10-3	J10-7	J10-11
RS422/Clock B_p	J10-16	J10-20	J10-24
RS422/Data B_n	J10-4	J10-8	J10-12
RS422/Data B_p	J10-17	J10-21	J10-25
Ground	J10-13		

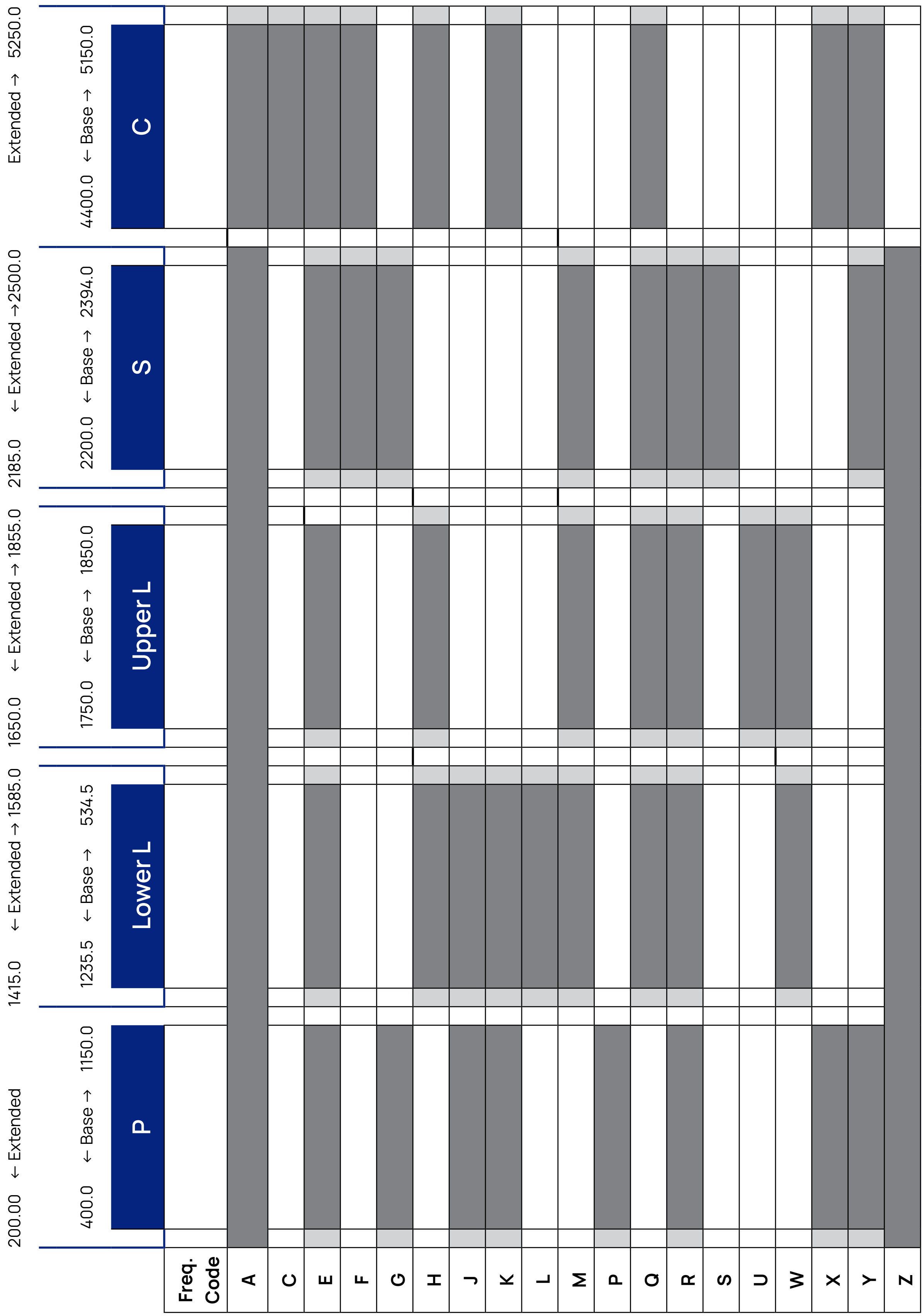
Color Legend	MDM-25	50 Ω SMA	MDM-9

Rear Panel Connectors

	Compact Receiver/Combiner		
	Channel 1	Channel 2	Channel 3
Receiver Nomenclature	Connector Number/pin		
I/VIDEO A	J11-9	J11-5	J11-1
I/VIDEO A GND	J11-22	J11-18	J11-14
Q/VIDEO B	J11-10	J11-6	J11-2
Q/VIDEO B GND	J11-23	J11-19	J11-15
VIDEO C	J11-11	J11-7	J11-3
VIDEO C GND	J11-24	J11-20	J11-16
VIDEO D	J11-12	J11-8	J11-4
VIDEO D GND	J11-25	J11-21	J11-17
Ground	J11-13		
TTL Clock A	J12-1	J12-5	J12-9
TTL Clock A GND	J12-14	J12-18	J12-22
TTL Data A	J12-2	J12-6	J12-10
TTL Data A GND	J12-15	J12-19	J12-23
TTL Clock B	J12-3	J12-7	J12-11
TTL Clock B GND	J12-16	J12-20	J12-24
TT L Data B	J12-4	J12-8	J12-12
TTL Data B GND	J12-17	J12-21	J12-25
Ground	J12-13		
TTL/HT_OUT/AM	J13-1	J13-3	J13-5
HT_OUT GND	J13-14	J13-16	J13-1
AGC	J13-2	J13-4	J13-6
AGC GND	J13-15	J13-17	J13-19
Lock Detect	J13-7	J13-9	J13-11
Sync Detect	J13-8	J13-1	J13-12
Aux Analog A	J13-20	J13-22	J13-24
Aux Analog B	J13-21	J13-23	J13-25
Ground	J13-13		
Power On	J14-20	J14-19	J14-18
TXD	J14-15	J14-17	J14-16
RXD	J14-24	J14-22	J14-23
TDI	J14-12	J14-6	J14-21
TCK	J14-8	J14-2	J14-5
TDO	J14-9	J14-3	J14-11
TMS	J14-10	J14-4	J14-14
3.3 V	J14-13	J14-7	J14-25
Ground	J13-1		

Color Legend	MDM-25

Compact RDMS Receiver-Combiner Band Configurations



Frequency Gap

Standard (Base) Frequency Range

Extended Frequency Range
(available by selecting Extended Tuning = 1 in part number)

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

Compact RDMS Receiver-Combiner Specifications

Receiver	
Type	Dual-conversion superheterodyne
Input RF Frequency	Refer to page 12
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 load impedance	1 KOhm
AGC time constant	Adjustable to any value from 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
VSWR	3:1 Max; 2:1 Typical

Second IF			
IF frequency	70 MHz		
IF output level, nominal (AGC mode)	Channel 1 and 2:	70 and 250 kHz bandwidths: 0.5 – 4.5 MHz bandwidths: 6 and 10 MHz bandwidths: 14 - 40 MHz bandwidths:	-15 dBm -10 dBm -5 dBm -15 dBm
	Combiner:		-5 to -10 dBm
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 modulation type and data rate, with manual override. Optional: 70 kHz, 1.4 MHz, 3 MHz, 6 MHz, 14 MHz, 28 MHz		

Playback Demodulator IF In, Channel 1 and 2

Input Center Frequency	75 kHz - 20 MHz, 70 MHz through any SAW filter
Input Level	-30 dBm ± 10 dB
Input Impedance	50 ohms, nominal

Demodulator

Demodulator type	ARTM Tier 0 (PCM/FM), ARTM Tier I (SOQPSK-TG), ARTM Tier II (Multi-h CPM), Space Time Coding (STC); Legacy suite: Analog FM, BPSK, QPSK, Offset QPSK (OQPSK), Asym- metric QPSK (AQPSK), Unbalanced QPSK (UQPSK), Asymmetric Unbalanced QPSK (AUQPSK), Digital PM
Bit Rates After LDPC encoding, if applicable	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)
Synchronization time Average, at BER = 1e-5	Tier 0: 250 bits, Tier I: 385 bits, Tier II: 2,800 bits
Synchronization acquisition threshold	Tier 0: -5.0 dB Eb/N0; RF Input (dBm): -115.0 (1 Mbps), -105.0 (10 Mbps) Tier I: -4.0 dB Eb/N0; RF Input (dBm): -114.0 (1 Mbps), -104.0 (10 Mbps) Tier II: -8.0 dB Eb/N0; RF Input (dBm): -118.0 (1 Mbps), -108.0 (10 Mbps)
Synchronization dropout threshold	Tier 0: -10.0 dB Eb/N0; RF Input (dBm): -120.0 (1 Mbps), -110.0 (10 Mbps) Tier I: -6.0 dB Eb/N0; RF Input (dBm): -116.0 (1 Mbps), -106.0 (10 Mbps) Tier II: -15.0 dB Eb/N0; RF Input (dBm): -125.0 (1 Mbps), -115.0 (10 Mbps)
Bit Rates After LDPC, Viterbi, Reed-Solomon, and/or PCM encoding, if applicable	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 STC: 5 Mbps to 22 Mbps in 1 bps steps Legacy: 25 kbps to 23 Mbps in Analog FM, 25 kbps to 23 Mbps in BPSK, 50 kbps to 46 Mbps in QPSK in 1 bps steps

Bit Synchronizer

Input codes	NRZ-L/M/S, BIΦ-L/M/S, RZ, DM-M/S, M2-M/S
Output codes	NRZ-L; or input code unaltered
Data and clock out	TTL (BNC) or RS-422
Lock detector out	TTL
Derandomizer	Standard IRIG 15-stage polynomial, selectable On/Off

Video	
Video out DC to 35 MHz	Quad wideband outputs: Ch1 and Ch2; Dual wideband outputs, Combiner
Video filter bandwidth	User programmable
Output level	1 Vp-p nominal, 4 Vp-p maximum
NTSC de-emphasis	Selectable Off/NTSC/PAL

Environmental	
Operating Temperature	-20°C to +70°C
Storage 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	
Size	10.31" x 4.00" x 1.92"
Connectors	RF input: SMA female; IF output: SMA female Power and Ethernet: MDM-9; Analog and Data: MDM-25
Power	28 VDC ± 4 VDC Current: 2.4 A typical, 3.5 A max at 25°C baseplate and 28 VDC
Inrush Current	28 VDC, 5.8 A typical (as measured with a Fluke i30s AC/DC current clamp)

Available Options

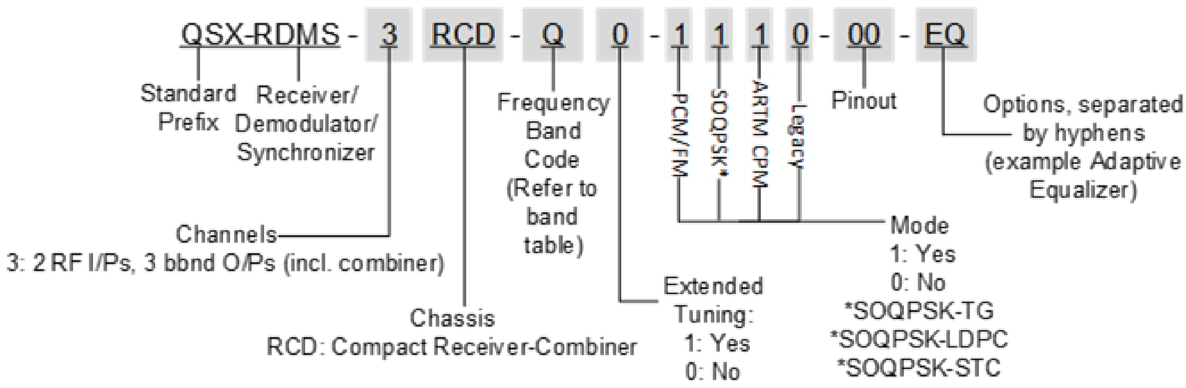
14 — 14 SAW filters (adds 70 kHz, 1.4, 3, 6, 14, and 28 MHz filters)

EQ — Adaptive Equalizer

K7 — K7 Viterbi Decoder (k=7, rate 1/2)

VO — Analog Video Output (hardware option)

Compact RDMS Receiver-Combiner Part Numbering Example



Reinventing Telemetry™

With a razor-sharp focus on the aeronautical telemetry market and a team rich in talent, experience, and sheer determination, Quasonix is able to consistently design, develop, and manufacture what our customers regard as market-leading telemetry products.

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