



LIBERTY PLATFORM SOLUTIONS

Multi-Channel Real-Time Spectrum Analyzer (RTSA)

MULTI-CHANNEL REAL-TIME SPECTRUM ANALYZER (RTSA)

Wideband, Phase-Coherent, Gapless Real-Time Spectrum Search, Detection, Recording & Analysis

Overview

Modern wireless, SATCOM, 5G/6G, radar, and configurable EW systems require continuous visibility across wide, dynamic spectrum environments. Traditional swept analyzers and software-based RTSAs often miss short-duration, agile, or multichannel events due to processing gaps and nondeterministic behavior.

The LIBERTY Multi-Channel Real-Time Spectrum Analyzer (MC-RTSA) delivers deterministic, gapless, phase-coherent real-time spectral analysis from 10 kHz to 40 GHz using COTS Keysight PXIe/AXIe platforms paired with Quonset Microwave QM-Series RF converters.

Every digitizer sample is processed in real time with deterministic throughput and no data loss under rated operating conditions, providing 100% Probability of Intercept (POI) for signals longer than 128 ns. Multichannel phase coherence enables beam analysis, correlation, interference detection, coexistence testing, and wideband signal intelligence.

Applications

Commercial Wireless

5G/6G FR1 & FR2, coexistence and interference analysis, MIMO and beamforming, RF environment reconstruction.

SATCOM

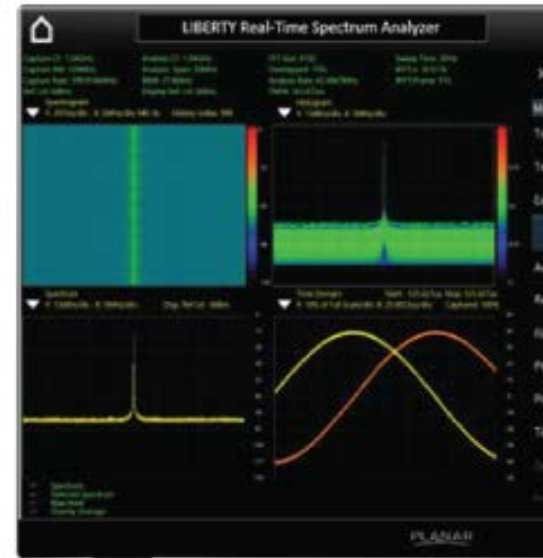
L/S/C/X/Ku/Ka bands, uplink/downlink visibility, Adaptive waveform testing, Wideband interference detection.

Antenna Test & Phased Arrays

Multi-channel coherent RTSA, Real-time beam and element characterization, RTVNA integration

Configurable EW / EMSO

Real-time detection, Correlation of LPI/LPE signals, Wideband capture & replay, Cognitive/AI-enabled systems.





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Multi-Channel Real-Time Spectrum Analyzer (RTSA)

KEY FEATURES

Continuous Frequency Coverage: 10 kHz – 40 GHz
Via LIBERTY digitizers + QM1003, QM1004, and QM1040 RF converters.

Instantaneous Capture Bandwidth (Per Channel)

- 1 GHz today (AXIe)
- 250–500 MHz (PXIe variant)

Ultra-Low Minimum Integration Time

- ~128 ns (T_{min}) real-time FFT update interval
- Enables detection of transient and LPI signals

Gapless, Zero-Loss Recording

All channelization, filtering, and FFT operations occur in FPGA hardware with zero operating system (OS) jitter.

Multi-Channel Phase Coherence

- Amplitude match: $< \pm 0.5$ dB
- Phase match: $< \pm 0.5^\circ$
- Time skew: $< \pm 0.5$ ps

Measured Performance⁽¹⁾

- Maximum Differential Amplitude = 0.0057 dB
- Maximum Differential Phase = 0.124°
- Maximum Differential Skew = 1.6×10^{-13} s

⁽¹⁾ At User-defined center frequency, input reference level, and across capture bandwidth

Decoupled Capture & Analysis Bandwidth⁽²⁾

- Capture at 1 GHz while analyzing at kHz-level bandwidths.
- Up to 30 dB SNR improvement in zoom mode

⁽²⁾ Analysis Bandwidth must be within capture band

Low Noise Floor⁽³⁾

- ~ -82 dBm (1 GHz analysis BW)
- ~ -112 dBm (100 kHz analysis BW)

⁽³⁾ Assumes minimum RF Input reference level

Advanced Real-Time Detection Engines

- Frequency Mask Trigger (FMT)
- Frequency-Density Trigger
- Time-domain & Amplitude triggers
- Software and external triggers

Scalable Multi-Channel Architecture⁽⁴⁾

- Record-only: 4, 8, 16, 20 channels
- Playback: 4x4 and 8x8 MIMO
- RTSA: 4–16 concurrent channels

⁽⁴⁾ Typical number of channels.

Commercial, COTS, Non-ITAR / EAR99

Software-defined, modular test instrument.

LIBERTY SYSTEM COMPONENTS

LIBERTY Real-Time Processing Engine

- Keysight digitizers: M5200A (PXIe), M8131A (AXIe)
- FPGA-based DDC, resampling, filtering, & FFT pipeline
- Center-frequency retuning $< 10 \mu$ s
- Deterministic timing & trigger logic
- PCIe / ODI streaming up to 8–20+ GB/s

LIBERTY Spectral & Metadata Store

- Continuous, gapless spectral recording (minutes → days)
- Time-scroll analysis without interrupting acquisition
- Multi-zoom decimated data levels for fast navigation

High-Speed Recording Subsystem

- NVMe RAID arrays (4–128 TB)
- Configurable for snapshot, continuous, or triggered modes



LIBERTY PLATFORM SOLUTIONS

Multi-Channel Real-Time Spectrum Analyzer (RTSA)

Quonset Microwave RF Front-Ends

Provides full-band coverage and IF translation:

QM1003-0.5-18 Downconverter

- 0.5–18 GHz RF → 50–1500 MHz IF
- Up to 1 GHz IBW
- Low-spur, low-phase-noise conversion

QM1004-26-40 mmWave Converter

- 26–40 GHz RF
- IF options from 50 MHz to 3 GHz
- Supports 1 GHz IBW for 5G FR2 / SATCOM mmWave

QM1040 Expansion Module

- Extends system to 10 kHz – 40 GHz continuous
- Adds HF/VHF down to 10 kHz baseband
- Maintains 1 GHz IBW across the entire span

REAL-TIME RECORDING PIPELINE

High-Resolution, High-Rate FFT Engine

- Deterministic, gapless FFT sequencing
- Configurable FFT rate, overlap, window type
- Peak, average, and density detectors

Zoom & Multi-Zoom Modes

- Capture BW = 1 GHz
- Analysis BW: from full span down to kHz
- SNR boost up to 30 dB

Probability of Intercept (POI)

- 100% for signals $\geq T_{\min}$
- No frame skips or re-arming delays

REAL-TIME DETECTION AND TRIGGERING

Adaptive Real-Time Triggers

- Frequency Mask Trigger (FMT)
- Frequency-Density Trigger
- Amplitude / Power threshold
- Time-domain
- External RF/digital
- Software-controlled

Event Metadata Extraction

- Frequency, bandwidth, duration
- Power, SNR, density
- Multi-channel correlation timing
- Instantaneous channel state

MC-RTSA USER INTERFACE

- Multi-channel waterfall and spectral views
- Full / Partial / Locked channel control modes
- Real-time trigger visualization
- User control of:
 - Center frequency
 - Capture BW
 - Analysis BW
 - Reference level
- Adjustable FFT rate, overlap, detector settings
- Density histograms & spectrogram navigation tools



LIBERTY PLATFORM SOLUTIONS

Multi-Channel Real-Time Spectrum Analyzer (RTSA)

WIDEBAND RECORD & PLAYBACK

Record-Only

- 4, 8, 16, 20 channels

Record + Playback⁽⁵⁾

- 4x4, 8x8 phase-aligned configurations
- Real-time spectral analysis on capture & playback

Playback⁽⁵⁾

- Deterministic waveform synthesis
- Delay-matched reproduction
- Up to 1 GHz per channel playback BW

⁽⁵⁾ Requires RF Playback option.

MULTI-CHANNEL SYNCHRONIZATION & ALIGNMENT ^(6,7)

RF Alignment Specs

- Amplitude: < ±0.5 dB
- Phase: < ±0.5°
- Skew: < ±0.5 ps

Measured Performance

- 0.0057 dB amplitude
- 0.124° phase
- 1.6×10^{-13} s skew

Supported Modes

- Input, output, and mixed-path alignment
- Multi-point frequency operating range alignment
- Single- or multi-channel alignment
- Auto-validation of alignment files

⁽⁶⁾ Requires RF System Setup option.

⁽⁷⁾ Maximum differential channel-to-channel performance across capture bandwidth.

FREQUENCY RANGE & RF OPTIONS

Frequency Range	RF Module	Notes
10 kHz – 40 GHz	QM1040 + QM1004-0.5-18	Full-band continuous coverage
26–40 GHz mmWave	QM1004-26-40	mmWave conversion
0.5–18 GHz	QM1003 / QM1004	Microwave down and up conversion
IF Ranges	50–90 MHz, 50–550 MHz, 100–1100 MHz, 500–1500 MHz, 2–3 GHz	Selectable per module

SPECIFICATIONS

Multi-Channel Real-Time Spectrum Analyzer

- Frequency Range: 10 kHz – 40 GHz
- Instantaneous BW (IBW): 1 GHz/ch (AXIe); 250–500 MHz/ch (PXIe)
- Minimum Integration Time: ~128 ns
- Center-Frequency Retune: <10 μs
- Noise Floor: –82 dBm (1 GHz); –112 dBm (100 kHz)
- Analysis BW: sub-Hz to full capture
- Dynamic Range: >70–80 dB

Digitizers

- Sample Rates: 4.8 GS/s (PXIe), 16 GS/s (AXIe)
- Resolution: 10–12 bits
- Clock Jitter: <100 fs
- SFDR: 70–80 dB typical

Recording

- Throughput: 8 GB/s
- Storage: 4–128 TB NVMe
- Record Duration: 10 ms → hours (IBW-dependent)



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SYSTEM CONFIGURATIONS

LIBERTY PXIe (Narrowband)

- 250–500 MHz IBW (channel dependent)
- 1×1, 2×2, 4×4 options (per module)
- Expandable number of channels
- Ideal for mobility and production test

LIBERTY AXIe (Wideband)

- Full 1 GHz/channel IBW
- Ideal for 4×4 and 8×8 MIMO
- Expandable number of channels
- Ideal for SATCOM, 5G/6G, EW, spectrum monitoring

CUSTOM INTEGRATED SOLUTIONS

LIBERTY can be delivered as:

- Stand-alone multi-channel recorder
- Chamber/OTA ingest subsystem
- Full 10 kHz–40 GHz ingest system
- Multi-rack ingest platforms for programs of record

TEVET provides full-stack integration, rack builds, ATE support, and deployment engineering.