KEYSIGHT

Signal Analysis and Monitoring update

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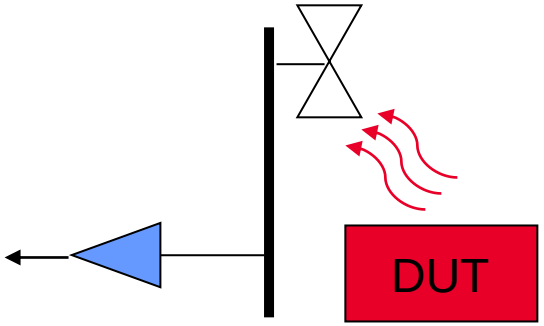
15/06/2023

Agenda

- EMC/EMI Signal Fundamentals
- Signal Management trends
- Keysight Spectrum Management Software (KSMS) overview
- Direction finding
- Configurations
- FieldFox solutions

EMI Emission Measurements

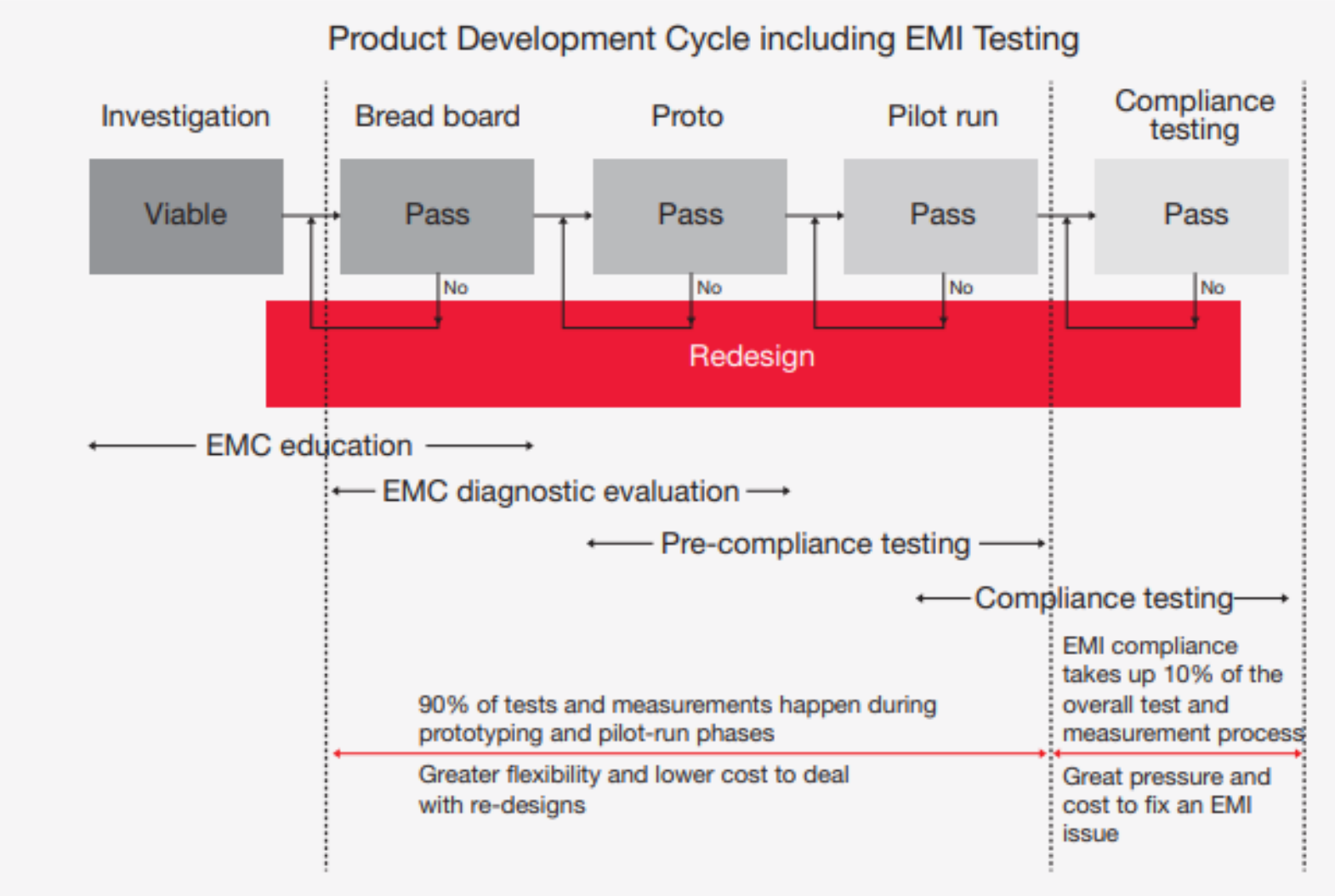
Radiated Emissions



Conducted Emissions

LISN (line impedance stabilization network)

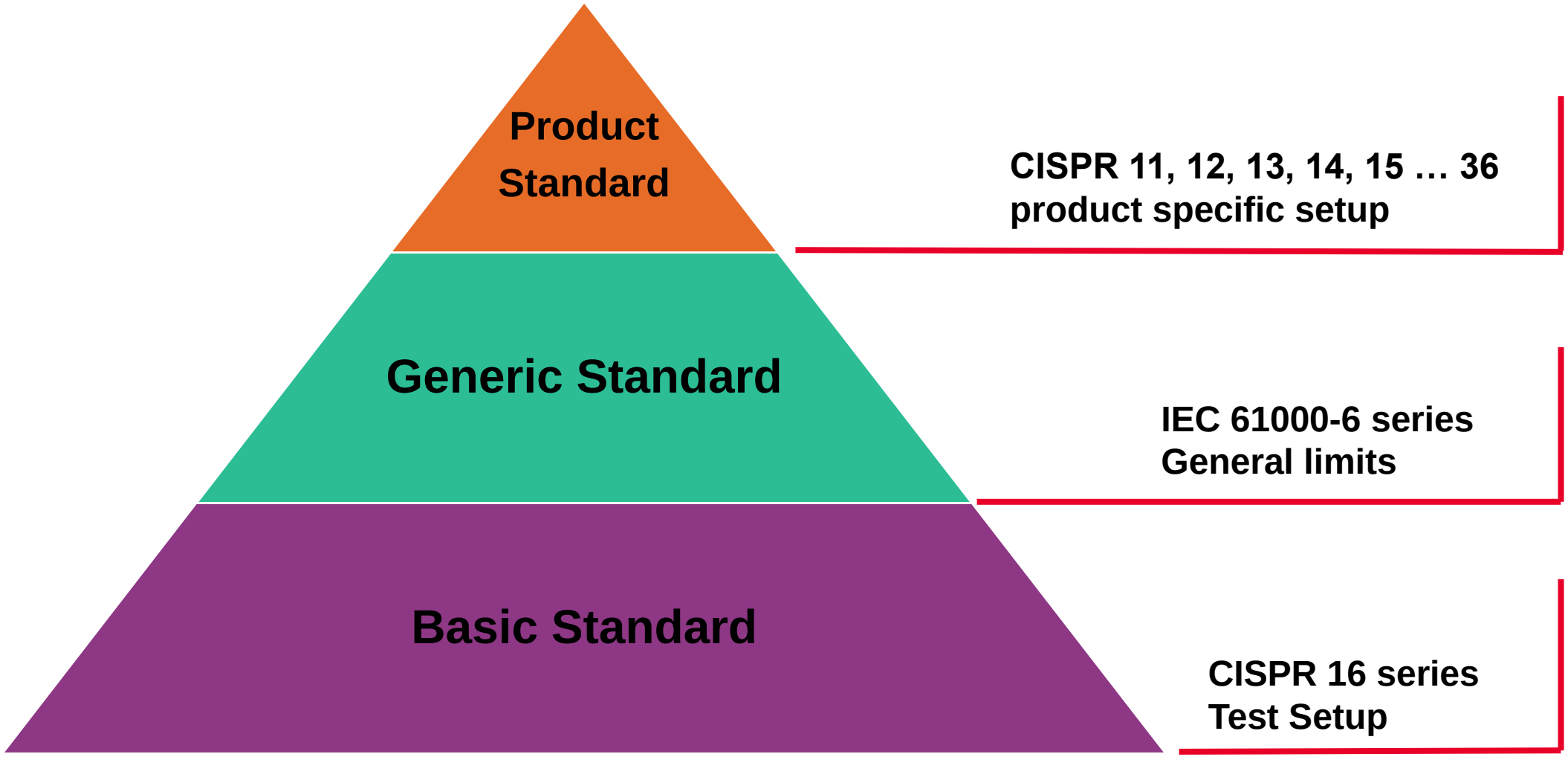
EMI Pre-Compliance Fundamentals



N9038/48B MXE EMI Receiver

FieldFox A or B Model

CISPR Standards



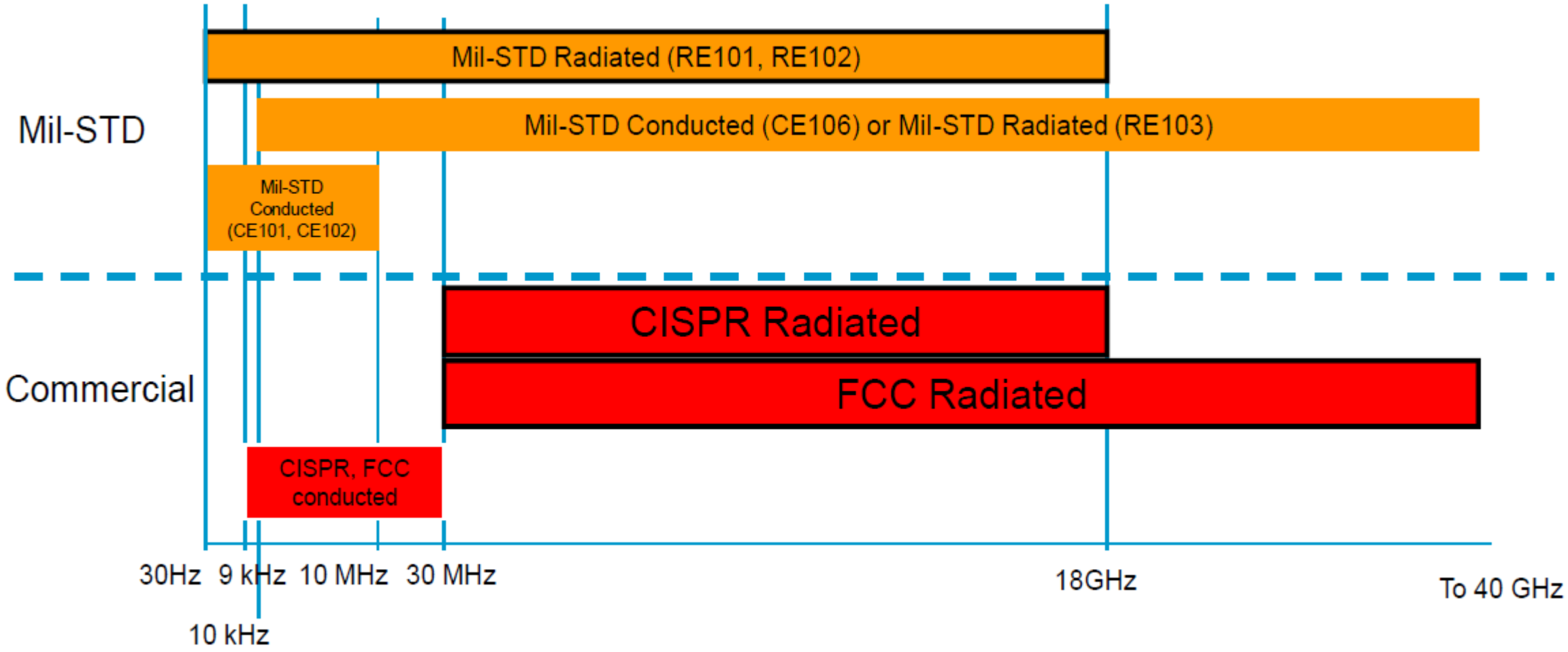
FieldFox EMI Solution

CISPR Product Standard

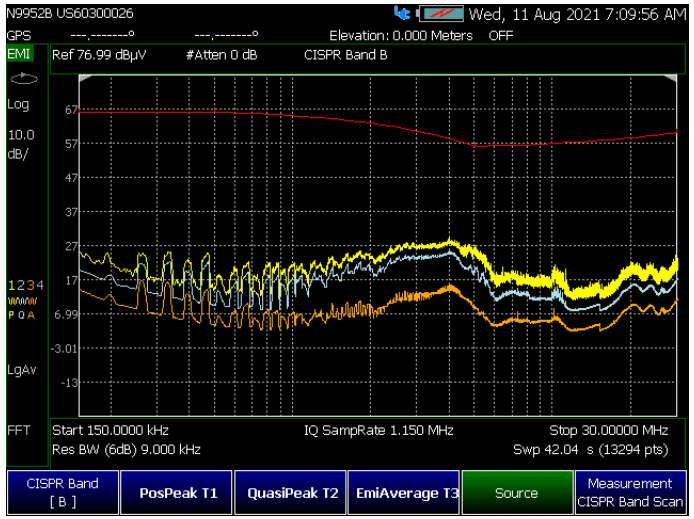
CISPR	Title	Freq Range [Hz]	Detector	RBW(-6dB)
11	Industrial, scientific and medical (ISM) radio-frequency equipment	9k-18G	QP/AVE (9k-30M)	9kHz
			QP/AVE (30M-1G)	120kHz
			PK (1G-18G)	1MHz Impulse
12	Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of off-board receivers (Vehicle)	30M-1G	PK/QP/AVE	120kHz
14-1	Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission	150k-30M	QP/AVE	9kHz
15	Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment	9k-300M	QP/AVE (9k-30M) QP (30M-300M)	120k

Note: AVE is EMI-Avg unless specified otherwise.

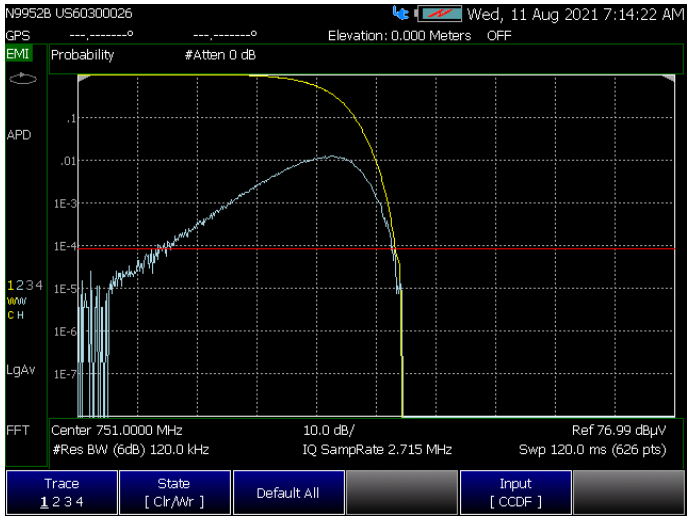
EMC Frequency Bands



All in one pre-compliance EMI handheld analyzer



- CISPR bandwidth: 200Hz, 9kHz, 120kHz and 1MHz
- CISPR detectors (6dB bandwidth): peak, quasi-peak and EMI average
- CISPR bands: A/B/C/D/E

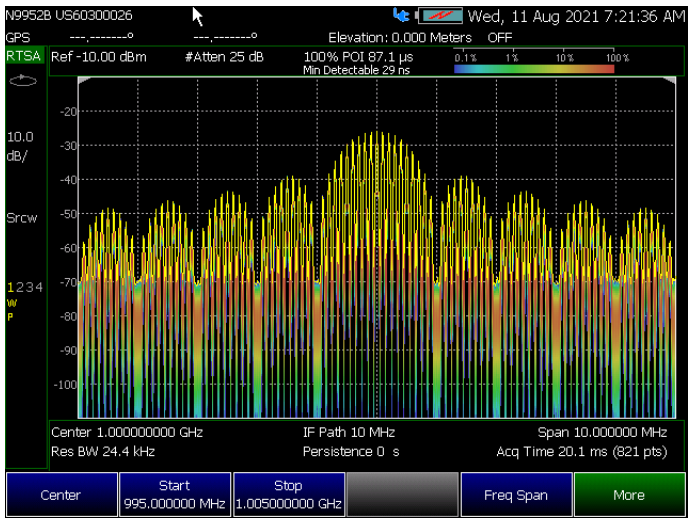


APD (Amplitude Probability Distribution)

- CCDF
- Histrogram
- CISPR and MIL 461 6dB bandwidth

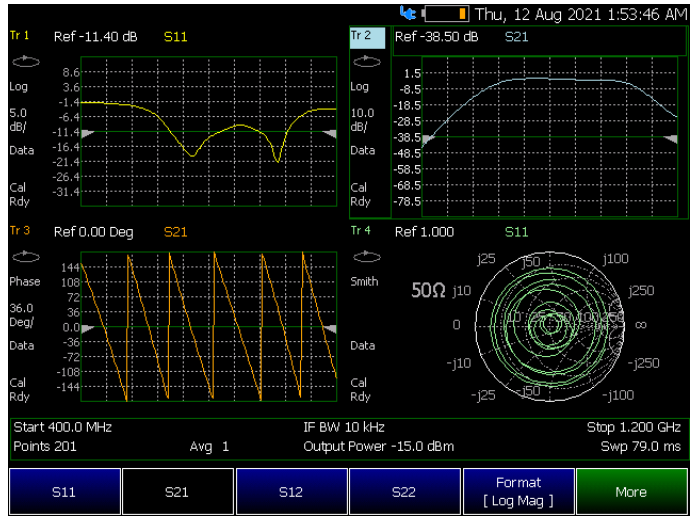
Real Time SA

- 120MHz real time bandwidth
- POI: 5.5us
- Min. Det. Signal: 47ns
- Density, spectrogram and trace modes



Full 2 port VNA

- 4 s parameters
- Magnitude and phase
- Group delay
- Impedance
- Smith Chart
- VSWR



What's happening today…

Increased demand for spectrum to support new commercial wireless services.

Spectrum is changing, frequencies are re-allocated or re-purposed

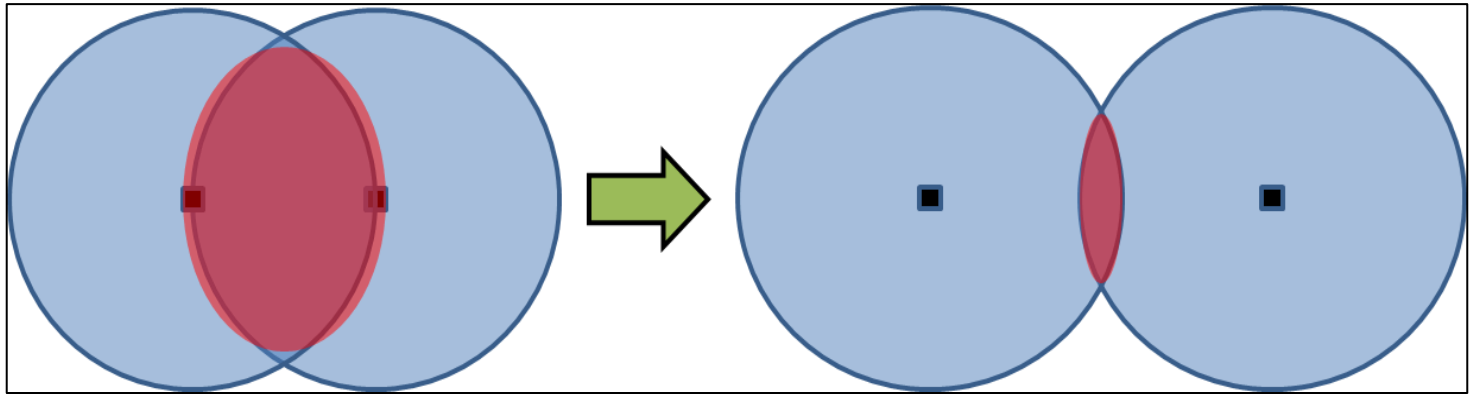
More services packed into less spectrum, tighter guard bands

More RF station equipment co-located

Increase in unlicensed transmitters problematic for legitimate paid services

Monitoring Equipment is Changing

The area where rogue emitters can be located using DF is shown in red – between the locations of the monitoring stations. RF Detection Range is shown in blue.



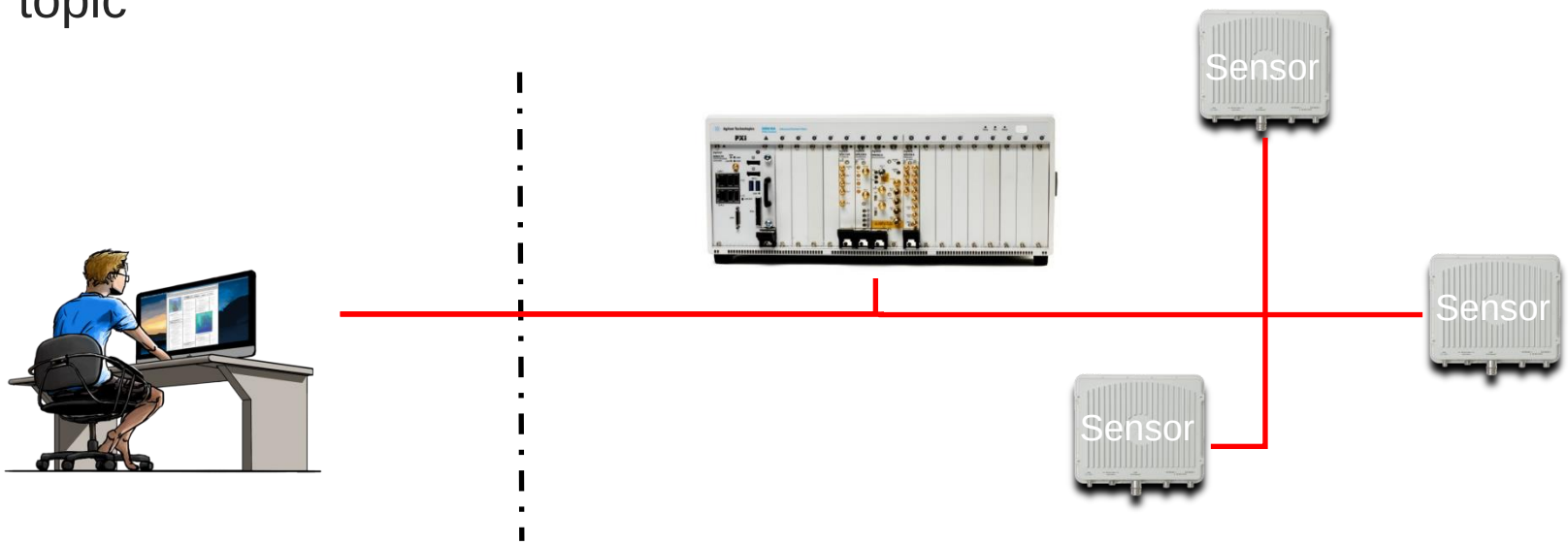
‘Angle of Arrival’ technique for ‘DF’ Direction Finding

Spectrum Monitoring Centralization

Centralized network managed by special teams focused on software, little interest RF theory, limitations, etc... It just needs to work.

Trend towards lower cost, internal development versus large ‘turn-key’ networks.

Software is a key topic



Frequency bands

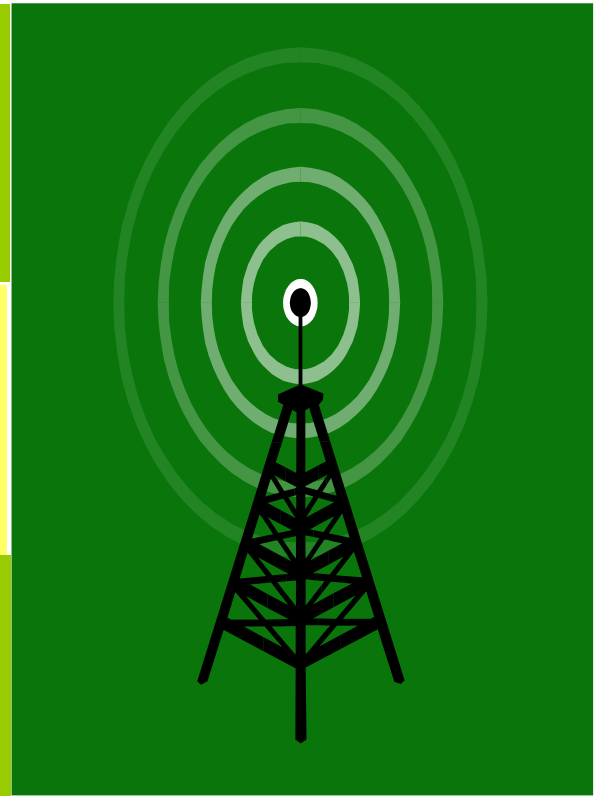
Overview frequency bands

Frequency bands | RTR

ECO Frequency Information System (cept.org)

Spectrum Management Trends

Challenge: Easily **monitor** & **validate** known spectrum occupancy and as needed, detect and locate non-cooperative modern signals which may be intermittent, be of short duration, spread spectrum, have low power and/or low energy.

Spectrum & Bandwidths Increasing	***Signal Complexity Increasing***	
Number of Transmit Devices Increasing	***Lower Transmitter Power***	
Spectrum Management Evolving	***Need for flexibility***	

RF Trends Drove Needs for Distributed Sensor Network

Networked Sensors

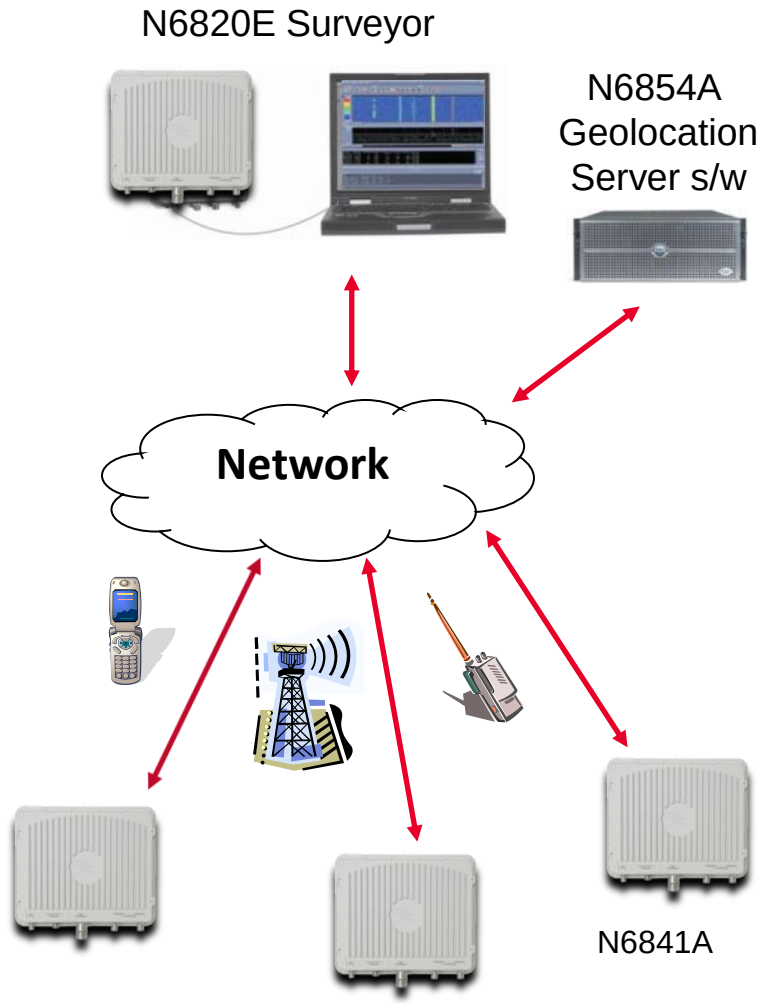
- Transfer data to common processing point for *processing gain*
- Distributed (redundant) measurements

Synchronization

- Required because of dynamic signal environment
- Required for geolocation

Quantity of Sensors

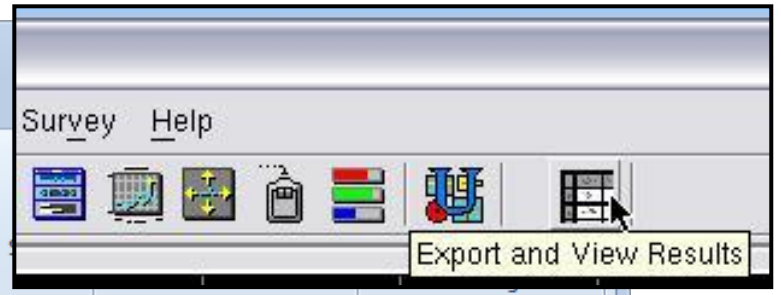
- Trade off density with price/performance of individual receivers
- Proximity to target provides gain



Spectrum Data and Report Generation

Combines signal internal, external parametric data with classification.

Surveyor 4D can create automated Survey reports in Microsoft Excel © with one click…



xml - Microsoft Excel

Paste | Arial | 10 | Wrap Text | General | Conditional Formatting | Format as Table | Merge & Center

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O312

1	A Frequency (MHz)	B Bandwidth (kHz)	C Amp (dBm	D First Intercept	E Last Intercept	H Intercepts	I Duration (s)	J Occupancy (%)	K Alarms	L Symbol Rate	M Freq Spacing	N Summary	O Digital	P iDen FSK
216	854.161287	12.13	-111.5	6/25/15 23:00:03	6/26/15 0:32:54	3404	0.0	0.1	1808	4801	1780	iDen FSK		1
220	854.262500	16.25	-119.2	6/25/15 22:20:54	6/25/15 22:43:56	54748	0.4	1.1	3684	14003		Digital	3	
221	854.337500	15.44	-115.0	6/25/15 22:20:54	6/27/15 0:03:16	4486791	1.8	90.8	64463	13990		Digital	8	
225	854.486545	10.31	-81.2	6/25/15 22:22:52	6/26/15 23:59:35	885	0.0	0.0	853	4801	1704	iDen FSK		2
226	854.511426	10.25	-118.0	6/25/15 22:27:16	6/26/15 22:14:55	106	0.0	0.0	98	4801	1779	iDen FSK		1
233	854.937002	11.13	-110.9	6/25/15 23:34:30	6/26/15 23:52:47	308	0.0	0.0	310	4801	1790	iDen FSK		1
234	854.962113	11.00	-111.3	6/25/15 22:52:03	6/26/15 0:53:22	2607	0.0	0.1	1622	4801	1745	iDen FSK		1
237	855.062353	10.30	-109.6	6/25/15 22:23:30	6/27/15 0:02:28	20152	0.0	0.4	11897	4801	1718	iDen FSK		22
241	855.161299	10.00	-108.3	6/25/15 22:23:14	6/27/15 0:02:42	2536	0.0	0.1	1992	4801	1662	iDen FSK		4
242	855.187500	14.88	-119.5	6/25/15 22:20:54	6/26/15 8:22:08	20272	0.4	0.4	1470	13490		Digital	4	
243	855.211859	11.00	-107.0	6/25/15 22:22:49	6/27/15 0:02:59	2082	0.0	0.0	1690	4801	1757	iDen FSK		1

Survey

Ready 80 of 397 records found 100%

Distributed Sensor Network

TDOA

- Small antennas and size allow for flexibility in siting
- Better suited for high multipath environments (indoors, stadiums, dense urban)
- Faster to deploy, no recalibration after siting
- More efficient spacing of sensors is possible due to TDOA processing gain.

DF (AoA)

- More restrictive requirements: Typically on tall masts or towers
- Avoid local wavefront distortion due to nearby obstacles, ground reflections, and ground conductivity changes (i.e. rural)
- May require recalibration after installation to reduce frequency and direction dependent errors
- Overlap of RF detection range is required for successful geolocation.

KEYSIGHT

FieldFox RF Analyzer
Carry Precision with you

Ruggedized Design

No vents, light, weather resistant. The only full functional handheld instrument can work under any tough environments, rain, dust, hot and cold.

Most Reliable

Projected MTBF of 42k hrs means lower cost of ownership, less down-time for critical test missions.

InstAlign

FieldFox can instantly align SA measurement to reach optimum power measurement accuracy regardless of temperature fluctuations during test. ONLY on FieldFox!
±1.2 dB ≤26.5 GHz

Unmatched ACCURACY

In a ruggedized design

Independent Signal Source

Built-in independent microwave signal source (30 KHz– 54 GHz*) provides both CW and tracking generator signal for field test, 90 dB power range with 1 dB adjustment step.

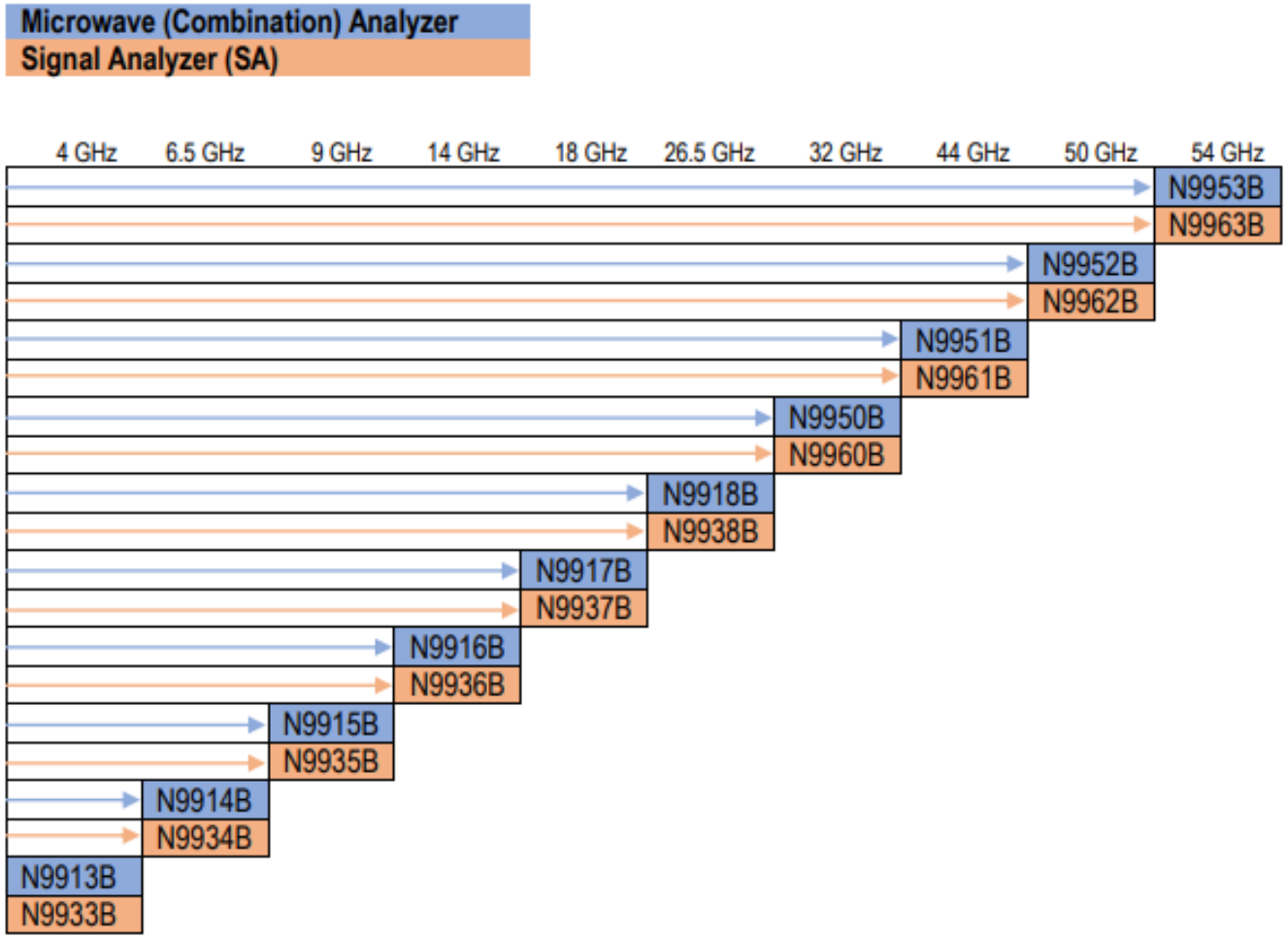
CalReady / Unknown Thru Cal

CalReady allows user to make good measurement at test ports without Cal kit. Keysight proprietary Unknown Thru Cal engine allows user to make very accurate non – insert-able device measurement – ONLY on FieldFox!!

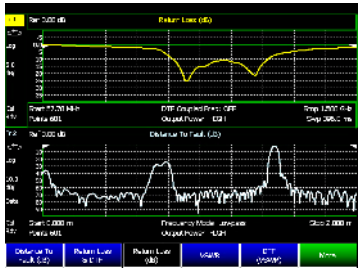
FieldFox B model: from 4 to 54 GHz (max) frequency

- **Microwave (Combination) analyzers**
- Base: Cable antenna analyzer
- 30+ Softkey options

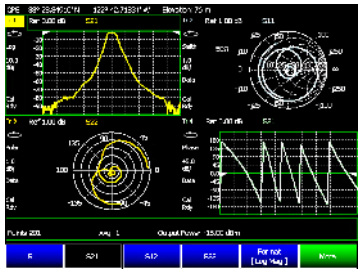
- **Microwave Spectrum analyzers**
- Base: Spectrum analyzer
- Pre-selection built-in
- 25+ Softkey options



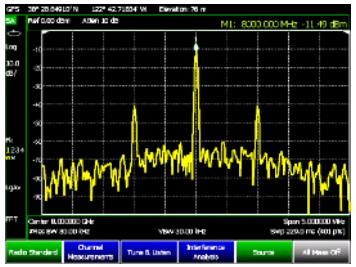
FieldFox B model: 30+ softkey license options available



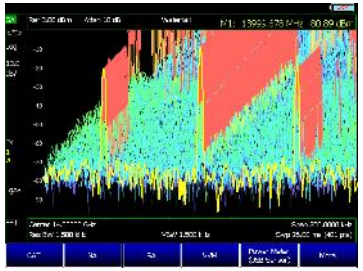
Cable and antenna analysis



Vector network analysis

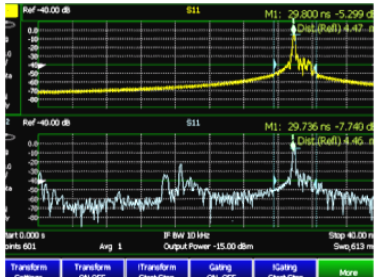


Spectrum analysis

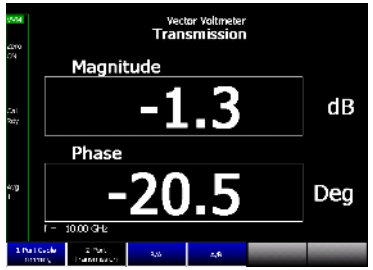


Interference analysis

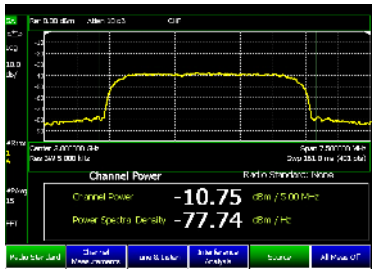
Power meter



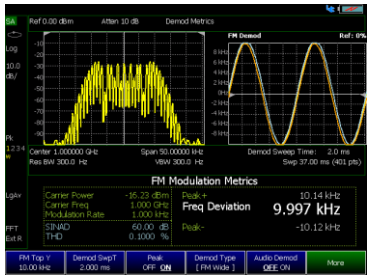
Time domain



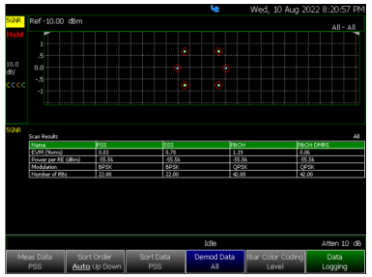
Vector voltmeter



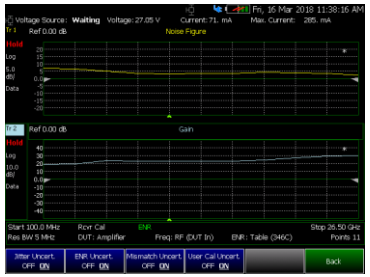
Channel power measurement



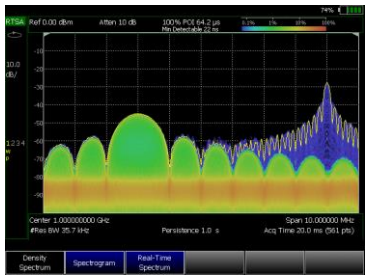
Analog demodulation



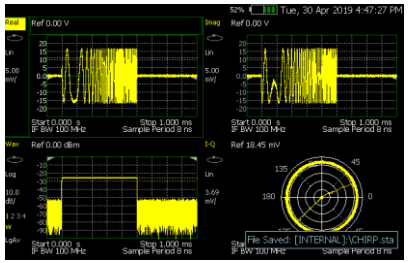
Digital demodulation



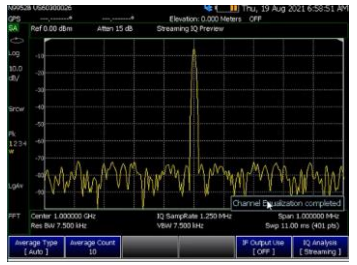
Noise Figure measurement



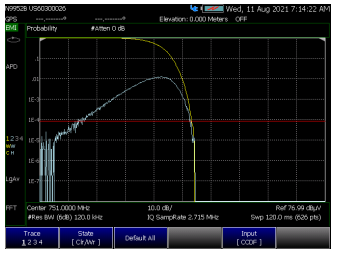
Real-time Spectrum Analysis



IQ Capture ≤120 MHz



IQ Streaming



EMI pre-compliance + APD

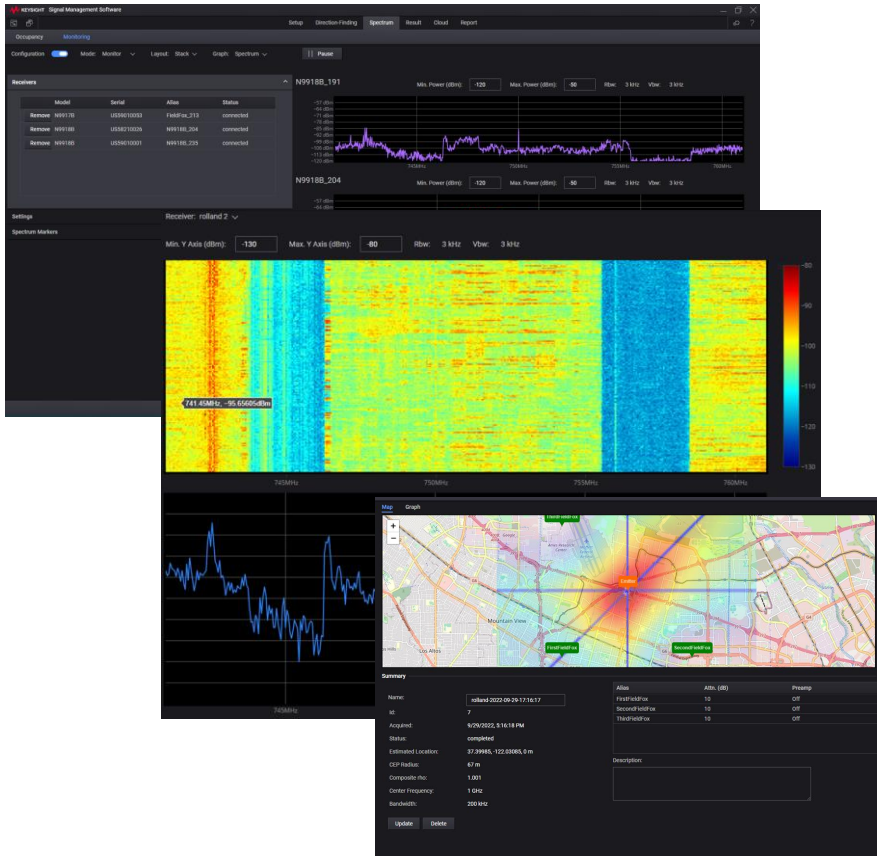
Keysight Spectrum Management Software + FieldFox

KSMS

1. Spectrum Monitoring
2. Spectrum Verification
3. Spectrum Occupancy
4. Spectrum Record & Playback
5. Remote Control
6. Direction Finding

FieldFox Signal Analysis

7. Spectrum Analysis
8. Real-time Spectrum Analysis
9. FFT Time Gating
10. Interference Analysis
11. Channel Scanning
12. Analog demodulation (AM/FM/PM)
13. Digital demodulation (LTE FDD/TDD, 5G NR FR1/FR2)
14. I/Q Capture & Streaming
15. EMF/EMI Pre-compliance
16. GNSS Receiver for Time Sync.

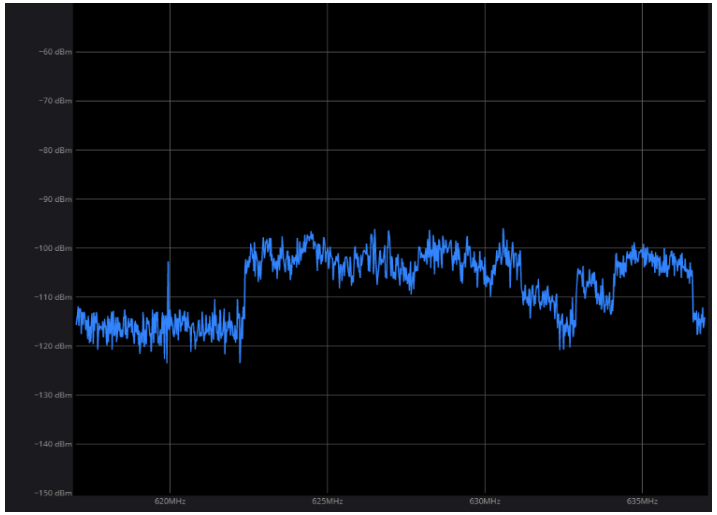


Spectrum Monitoring (Frequency Domain Analysis)

- Monitor multiple receivers at same time
- Spectrum trace from each receiver can be in single window, stack and overlay

Multi- receiver stack mode display

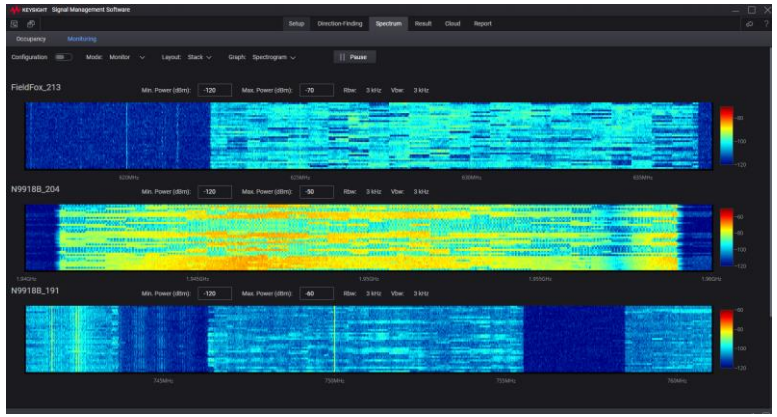
Spectrum overlay



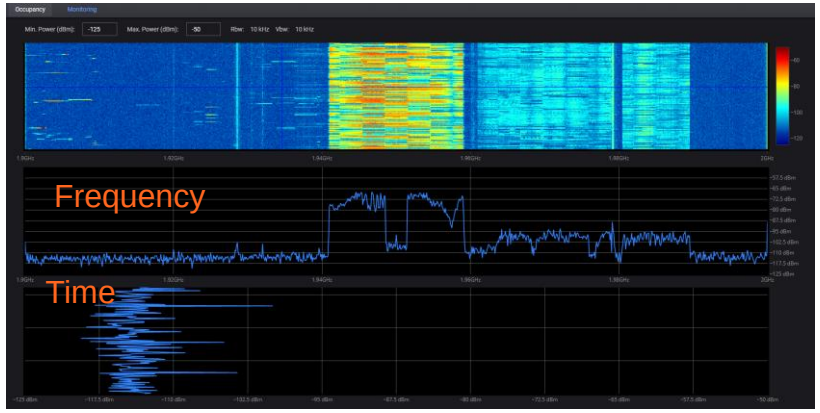
Single receiver spectrum

Spectrograms (Time Domain Analysis)

Single receiver spectrogram



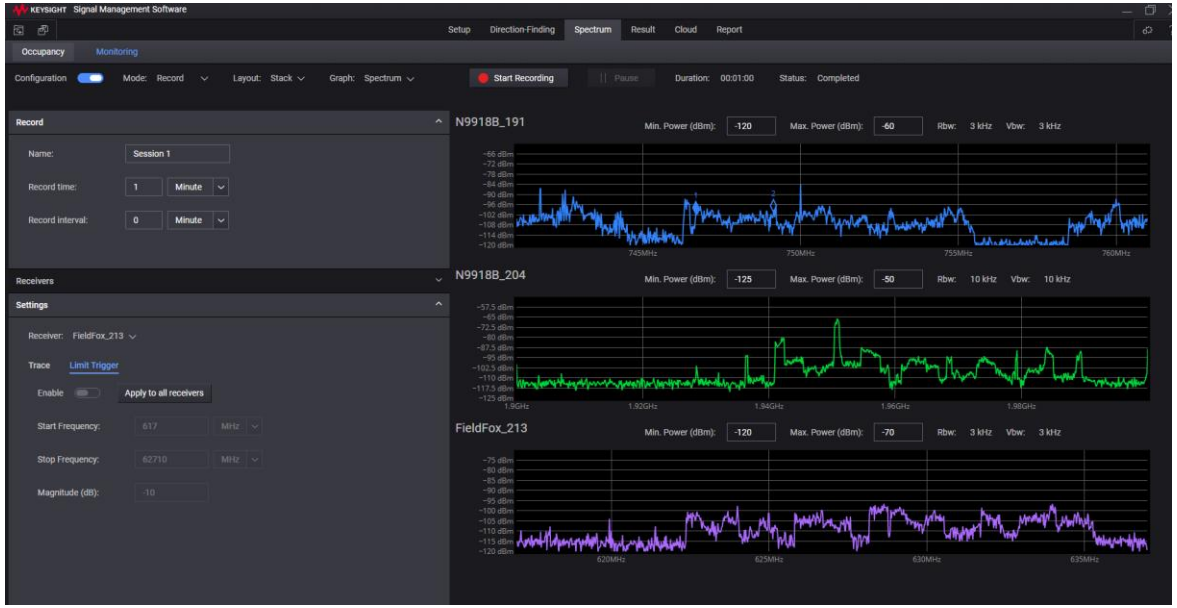
Multi-receiver spectrogram



Cross domain spectrogram

- Top: spectrogram
- Middle: spectrum trace at marker or current record
- Bottom: time domain display at marker frequency

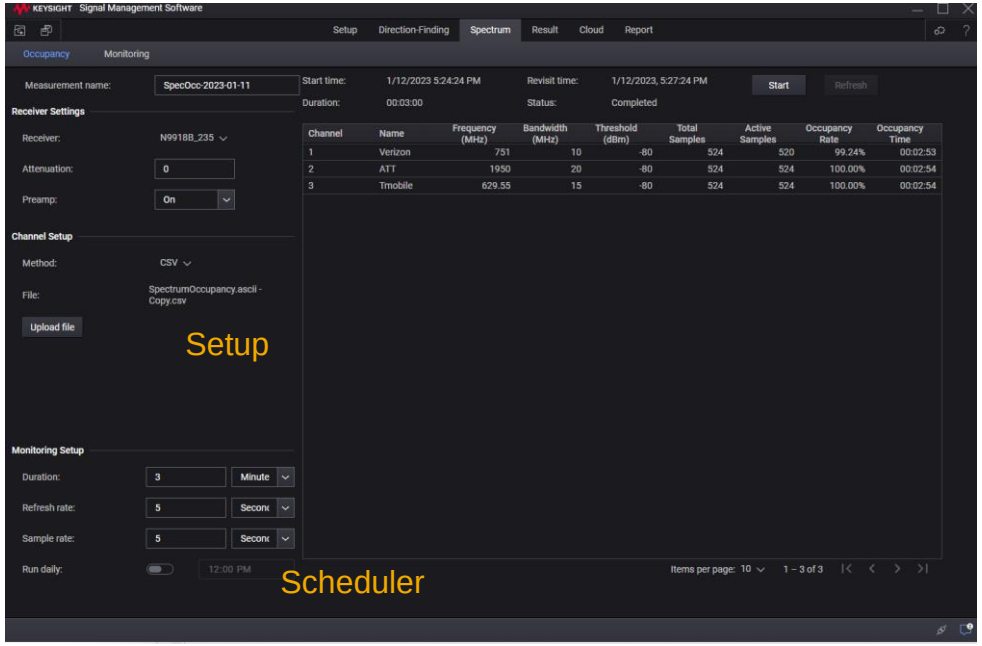
Spectrum Record and Playback

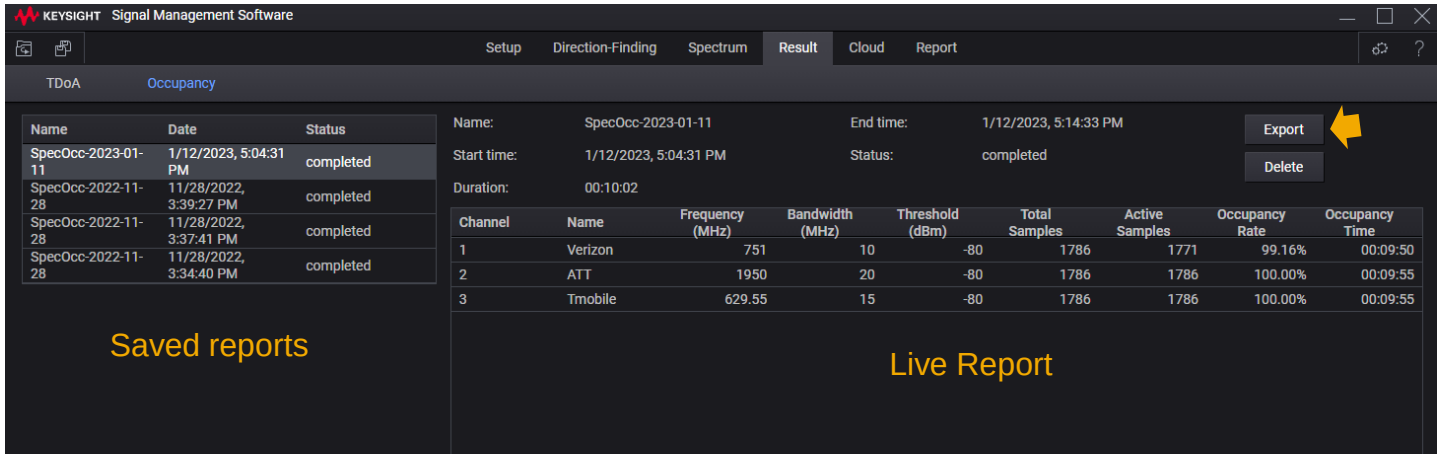


Record spectrum with limit-mask trigger

Play data and tagging during playback

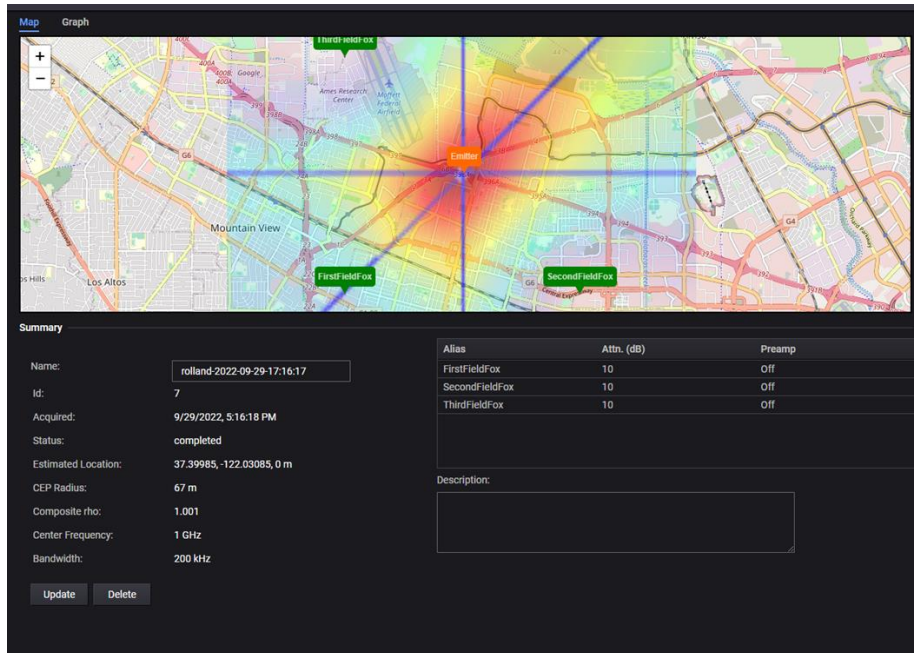
Spectrum Occupancy Reporting



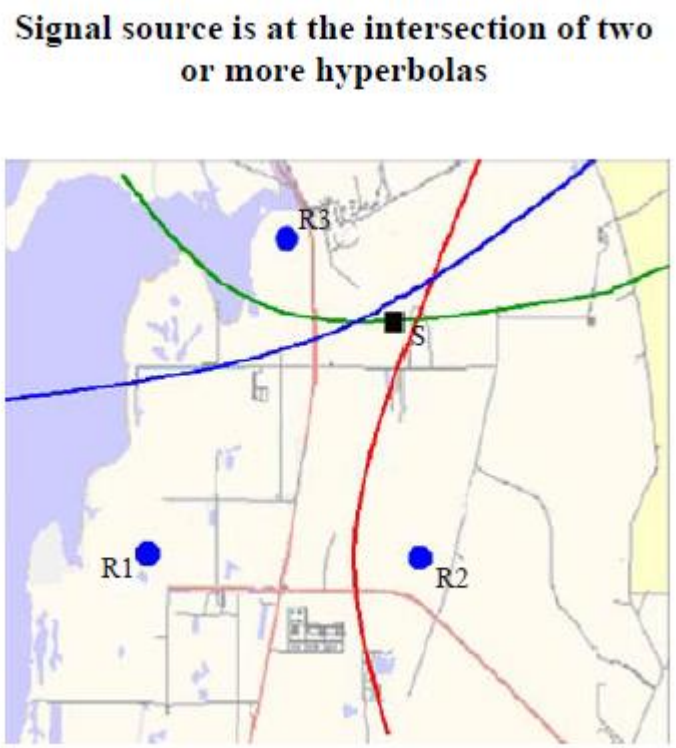


- Monitor spectrum utilization rate
- Ad hoc and long-term spectrum activity monitoring
- Reports active samples, occupancy rate and occupancy time
- Daily collection scheduler
- Results can be exported to .csv file

Direction Finding

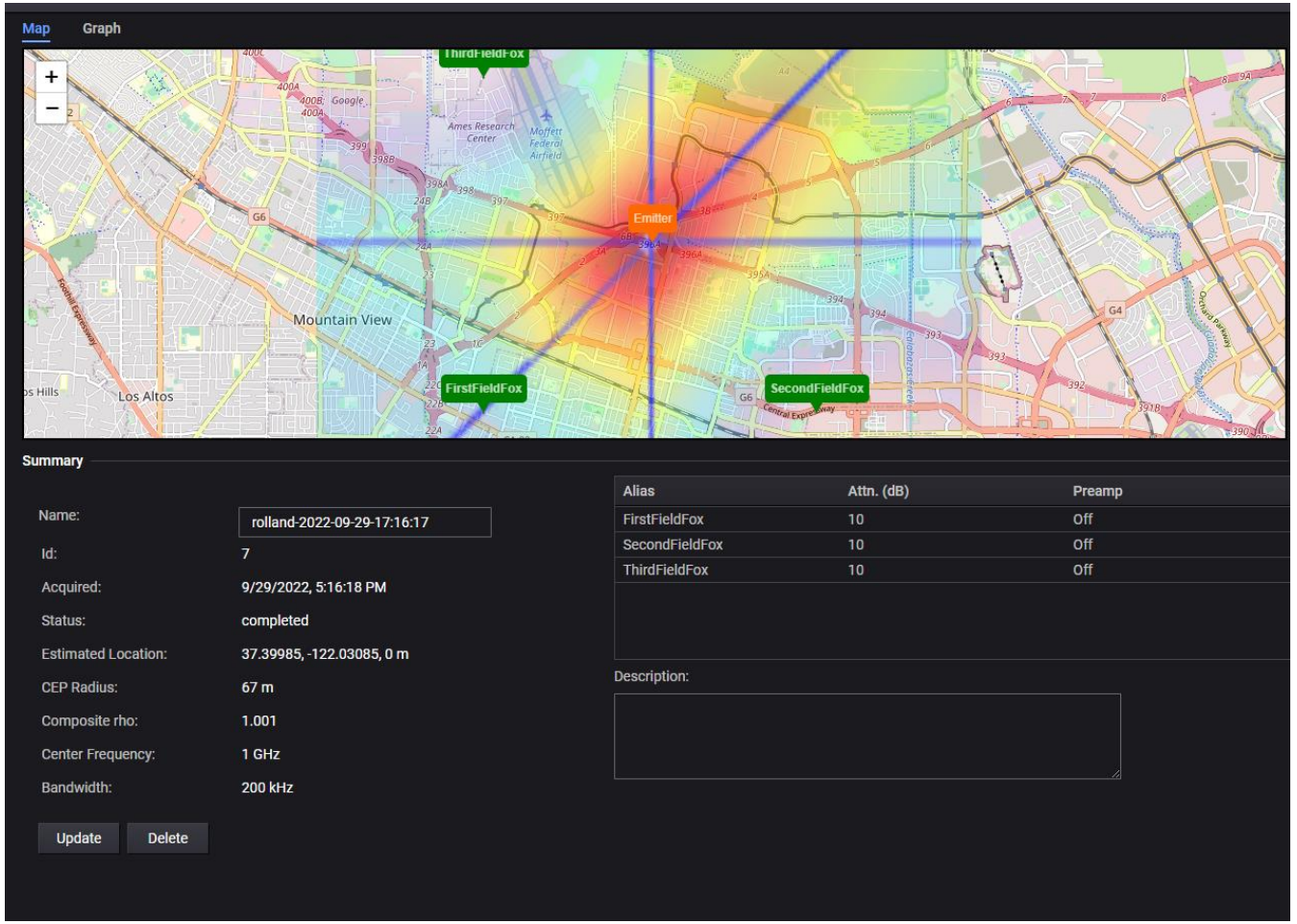


Coherent Signal Detection using TDOA



- Time difference of Arrival (TDOA) is a DF method to determine emitter location using the relative arrival times of a signal at multiple receivers.
- From the observed time-difference, a difference-distance can be easily computed as the product of the time-difference and the signal's velocity.
- Hyperbolic line represent a constant distance difference, intersection of hyperbolas is the potential location of emitter.
- TDOA system requires at least 3 receivers to determine location

KSMS Direction Finding



- FieldFox used as mobile sensors
- Networked 3 or more FieldFox
- Measure estimated transmitter location
- Display hyperbola curves
- OpenStreetMap support

N6841A RF Sensor + N6850A Omni-directional antenna

- 20 MHz to 6 GHz tuning range
- 20 MHz processing bandwidth (completely digital IF)
- 4.8 seconds of IQ capture (LookBack) memory
- Integrated GPS receiver for location and time synchronization
- Compact, low-power design (15-24VDC, 30W max)
- Standard 100 baseT network interface for data output, command and control
- Integrated 2-port RF Input Switch
- 7 pre-selector bands, pre-amplifiers and attenuators (62 dB range)
- Onboard computer (LINUX kernel) and FPGA
- IP 67 rated

Omni-antenna 20 MHz to 6 GHz
16 x 6 in. IP67 1.15 Kg

RF receiver 20 MHz to 6 GHz

KEYSIGHT

Thank you for your time !