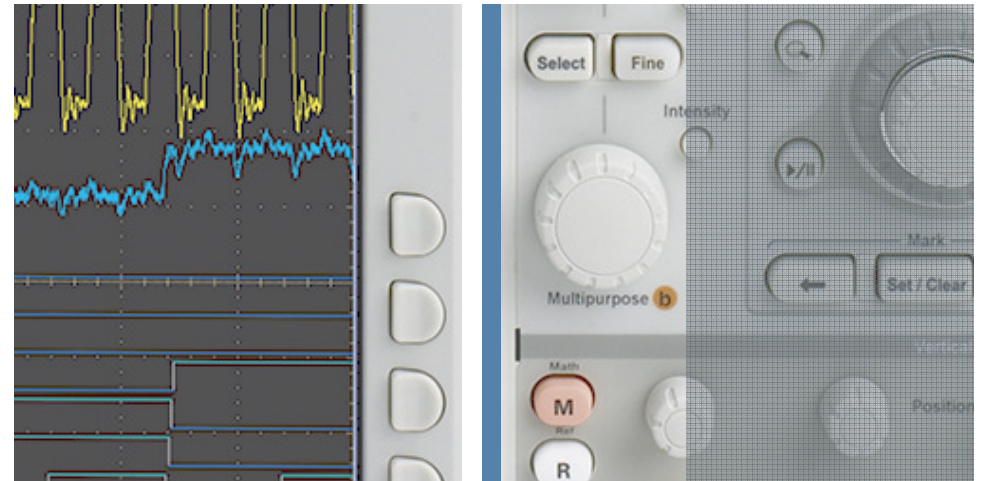
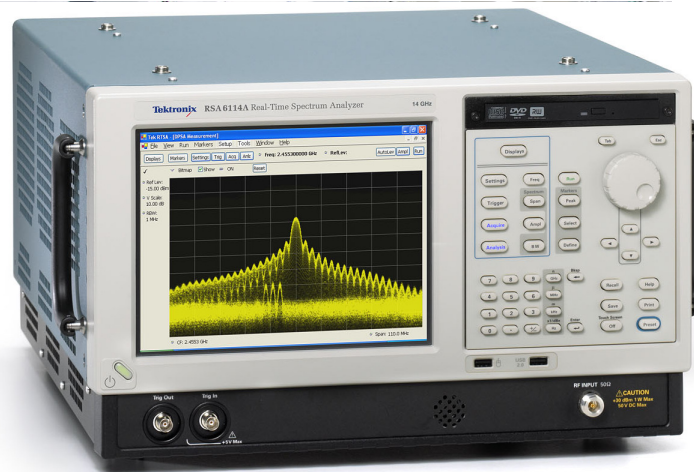


Real-Time Spectrum Analysis

Applied to Complex RF Modulation Analysis – from Software Defined Radio to RFID...

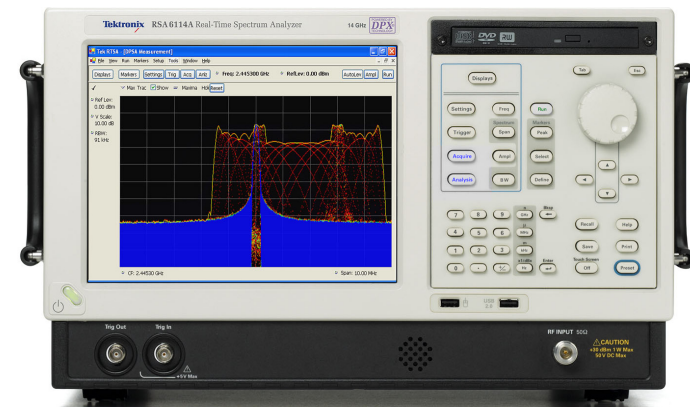


Presented by:
Alan Wolke, W2AEW
RF Application Engineer

Tektronix[®]

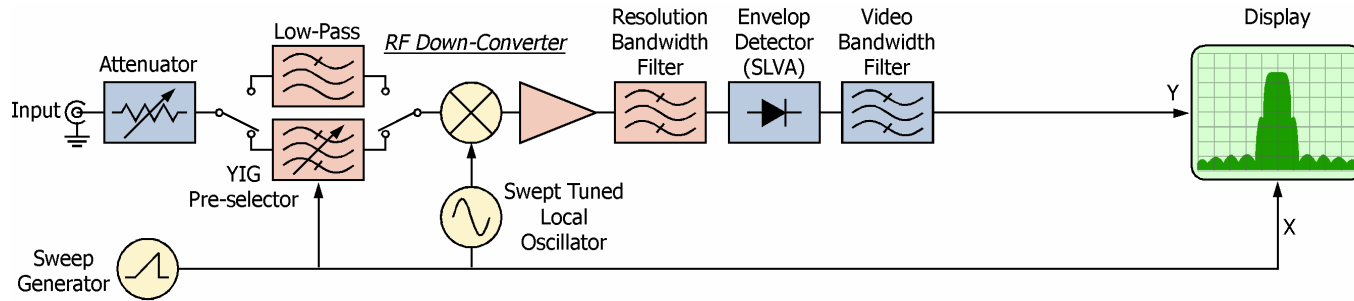
Agenda

- **Introduction to Real-Time Spectrum Analysis**
 - Understand Spectrum Analyzer architectures
 - **Discover**
 - Learn how to see what you've been missing!
 - **Trigger**
 - Multiple Trigger modes to capture the most elusive events!
 - **Capture**
 - Seamless signal capture into deep memory – nothing is missed!
 - **Analyze**
 - Time Correlated, Multidomain displays:
 - Spectral Measurements
 - Analog and Digital Demodulation
 - RF Measurements
 - Pulsed Measurements
- ...***all time correlated!***

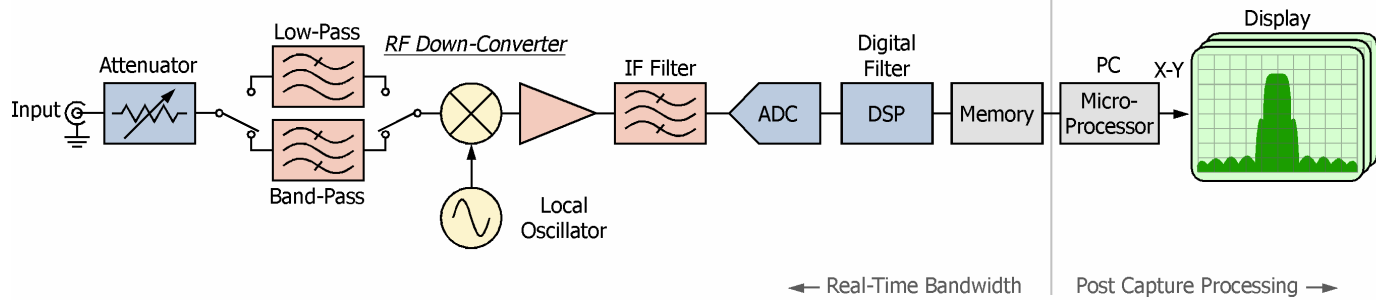


Simplified Analyzer Block Diagrams

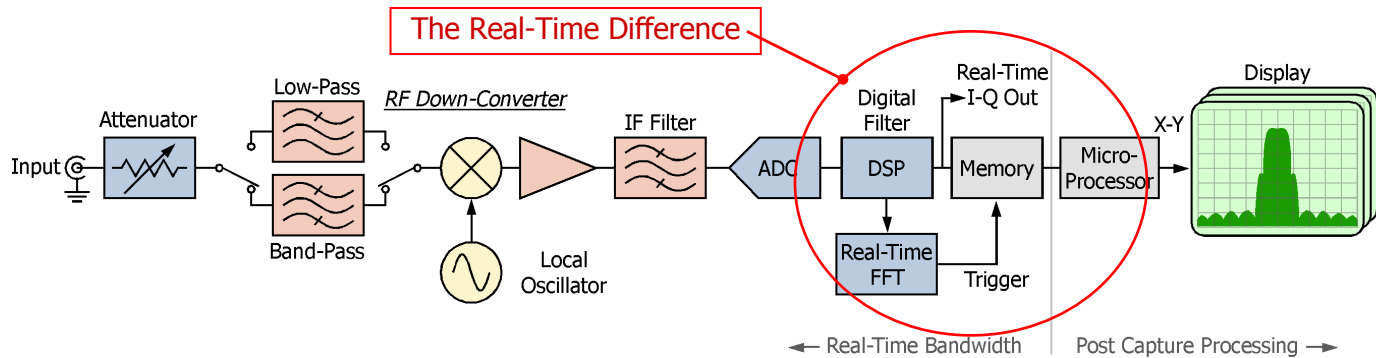
Swept Tuned Spectrum Analyzer (SA)



Vector Signal Analyzer (VSA)

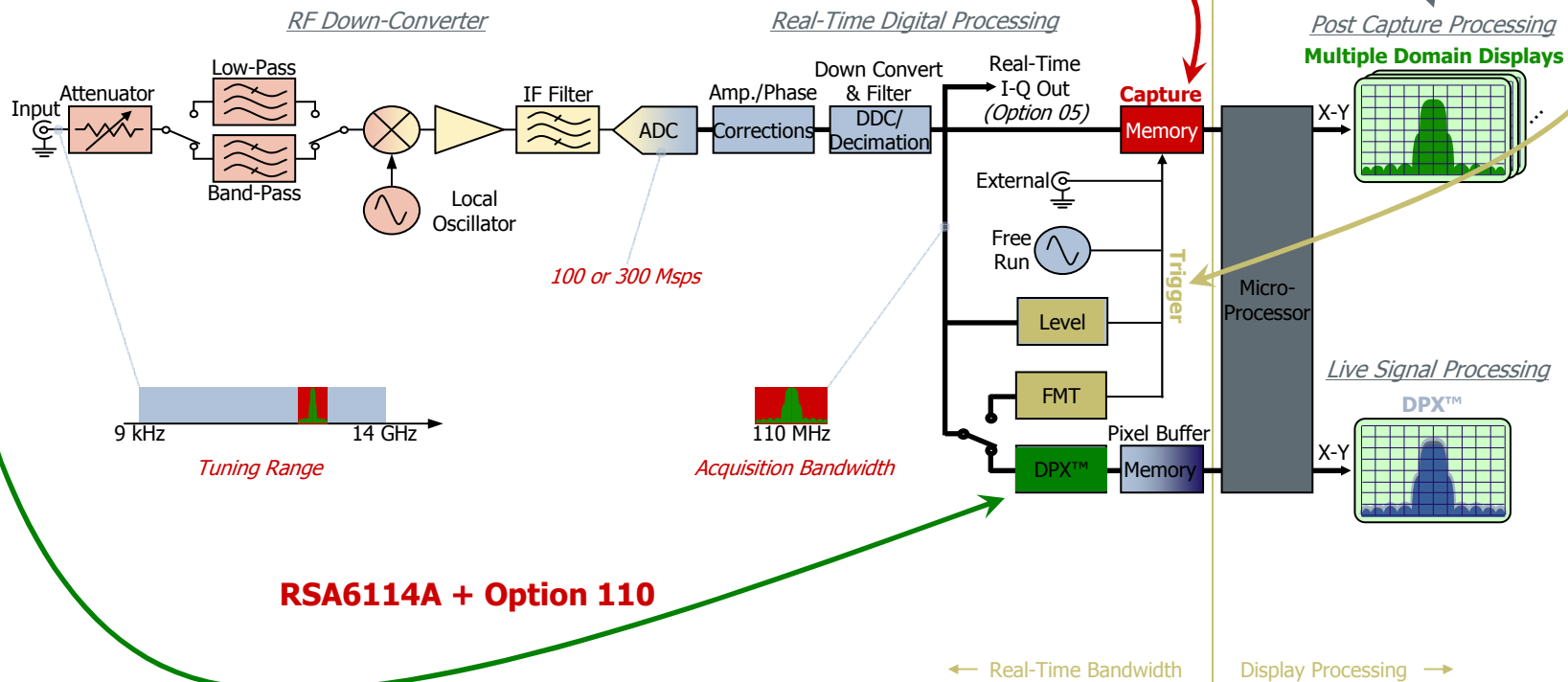


Real-Time Spectrum Analyzer (RTSA)



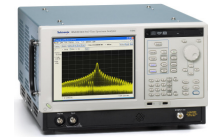
RSA6100A Simplified Block Diagram

- **Discover** with DPX™, **Trigger** in powerful ways
- **Capture** signals into memory, **Analyze** in Multiple Domains



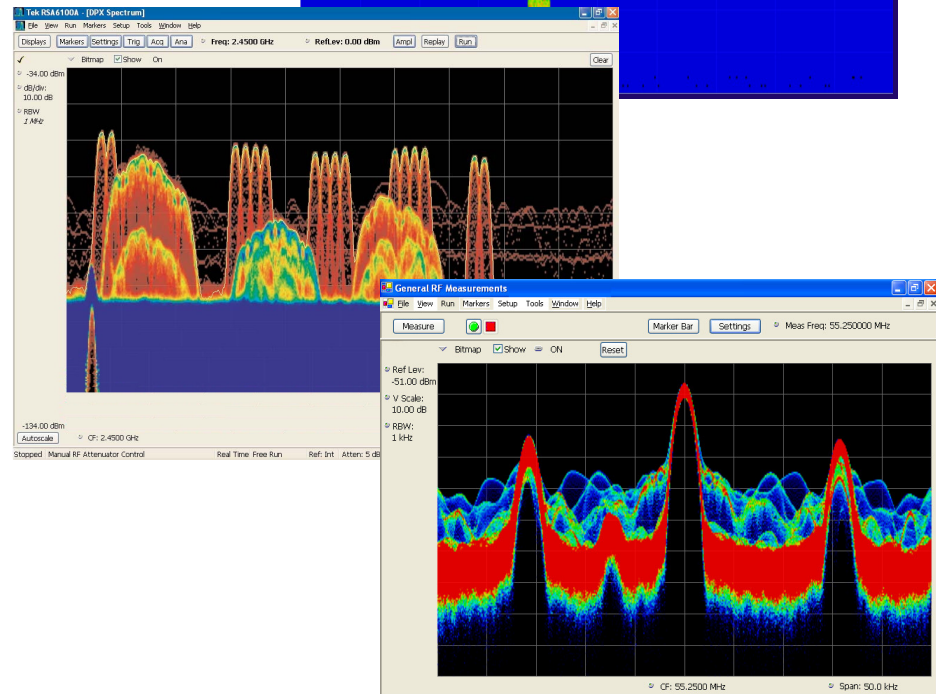
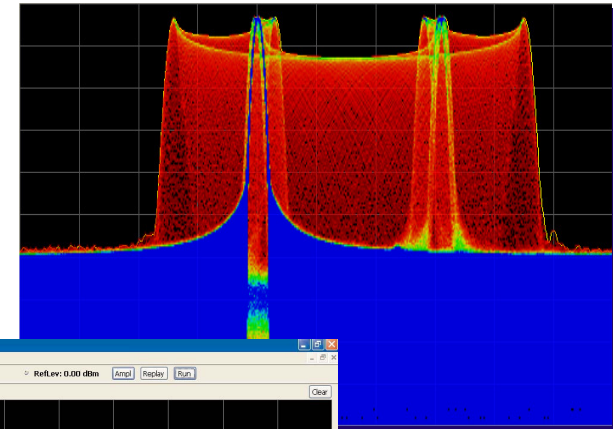
RSA6114A + Option 110

Discovering with DPX™ Spectrum

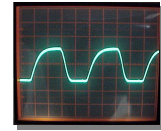


- Oscilloscope DPX™ Now on RTSA
- 48,828 vs. 40 Spectrums/Second
- 100% POI for Transients $\geq 24 \mu\text{s}$
- See signals under signals...
- 'Live' Signal Viewing...
- No Trigger or Capture Issues

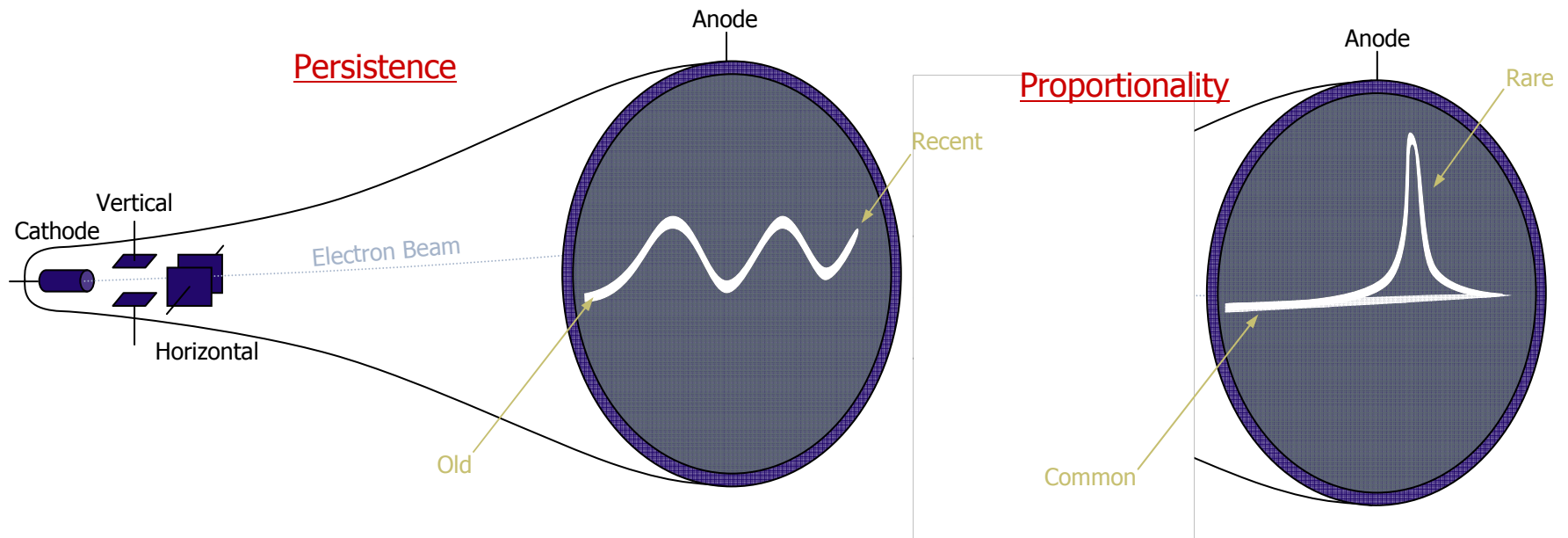
EXCLUSIVE



Digital Phosphor & Cathode Ray Tubes

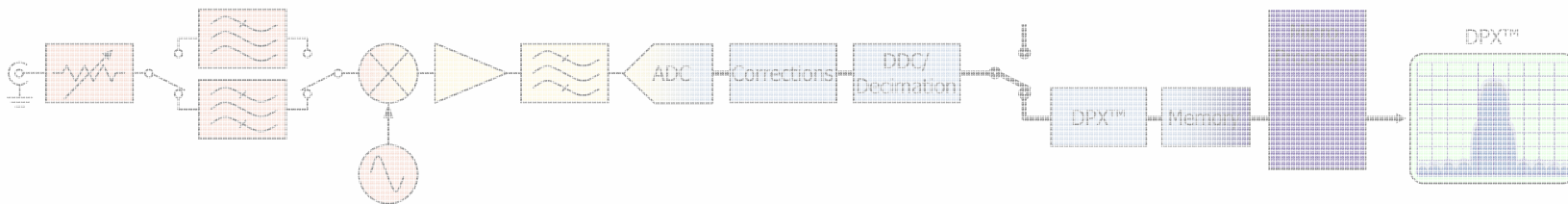
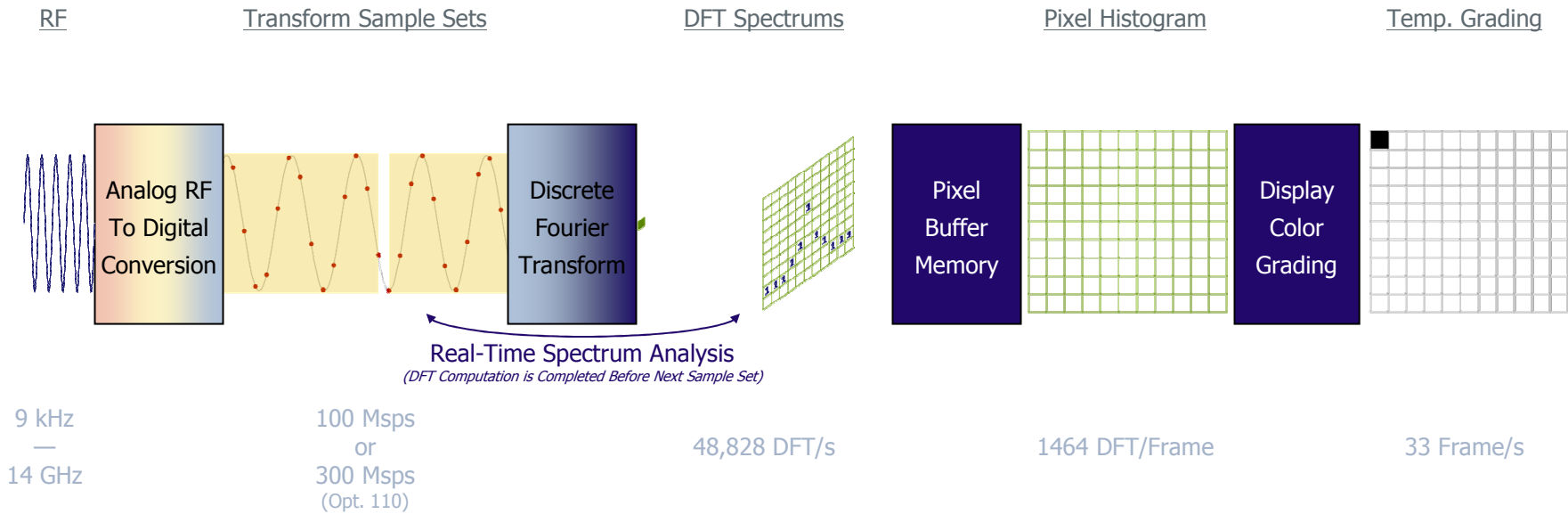
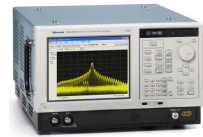


- 'Digital Phosphor' gets its name from the phosphor coating in CRTs.
- The phosphor coating in CRTs has desirable qualities:



- Liquid Crystal Displays (LCDs) do not have these properties.

The DPX™ Transform Engine





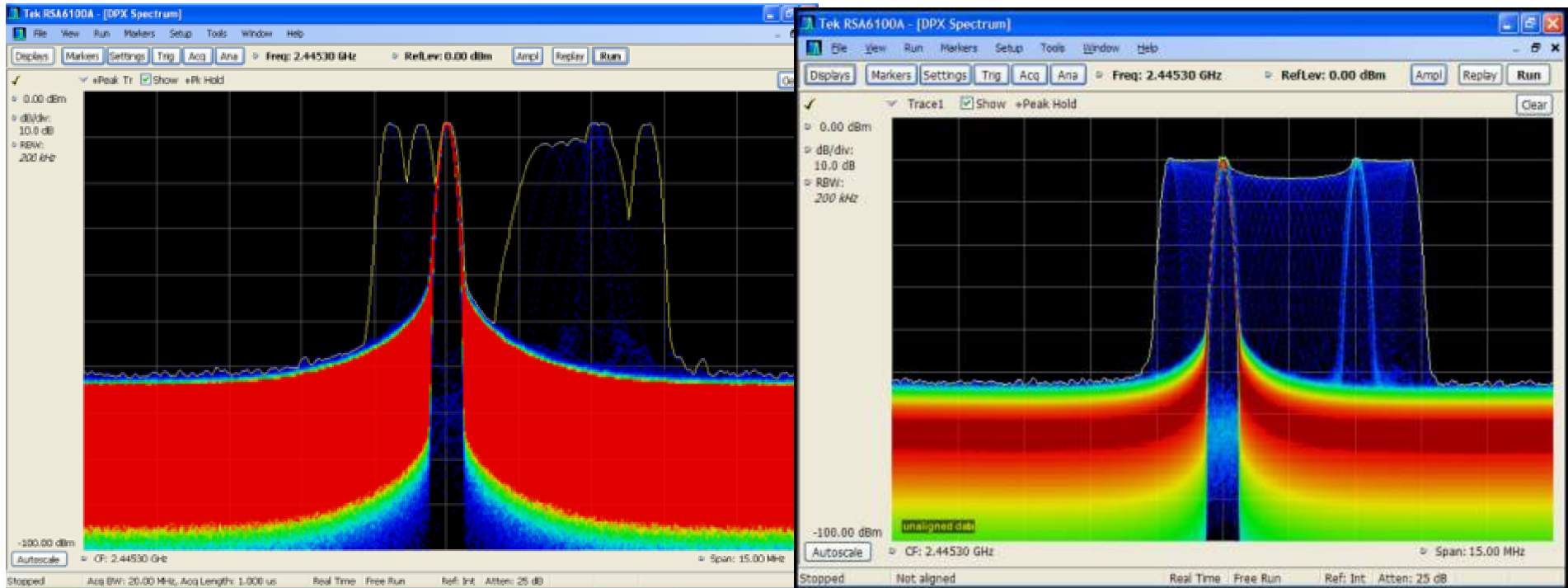
Demonstration of DPX™ on the RSA6114A

- Live RF signal observation
 - See RF signals in a way that you've never seen before
 - See signals “under” other signals, signals in the noise floor
 - Observe interaction of multiple RF sources
- Unmatched infrequent event POI
 - DPX™ shows you the infrequent glitches that drive you crazy
 - Arms you with the knowledge to debug...

Option 200 – Advanced DPX 292,000 Spectrums/Sec! Old DPX – approx 5 seconds



New DPX – approx 5 seconds



- Faster update rate = better POI for shorter signal
- More time-domain dynamic range
 - longer to 'saturate' reds
- 2000X Span/RWB improvement
- DPX Density ® Markers and Triggers....

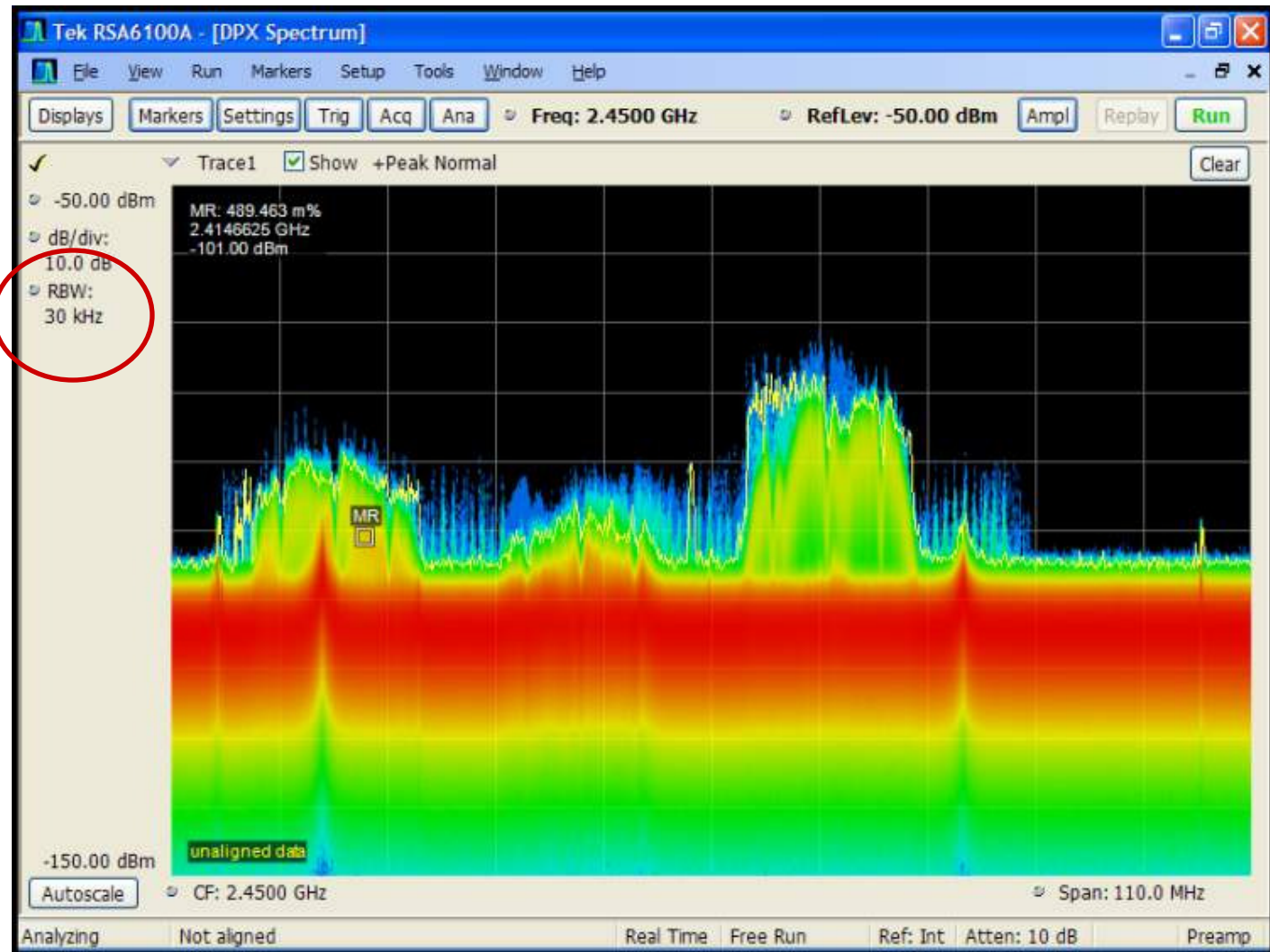
Option 200 – Advanced DPX 292,000 Spectrums/Sec!



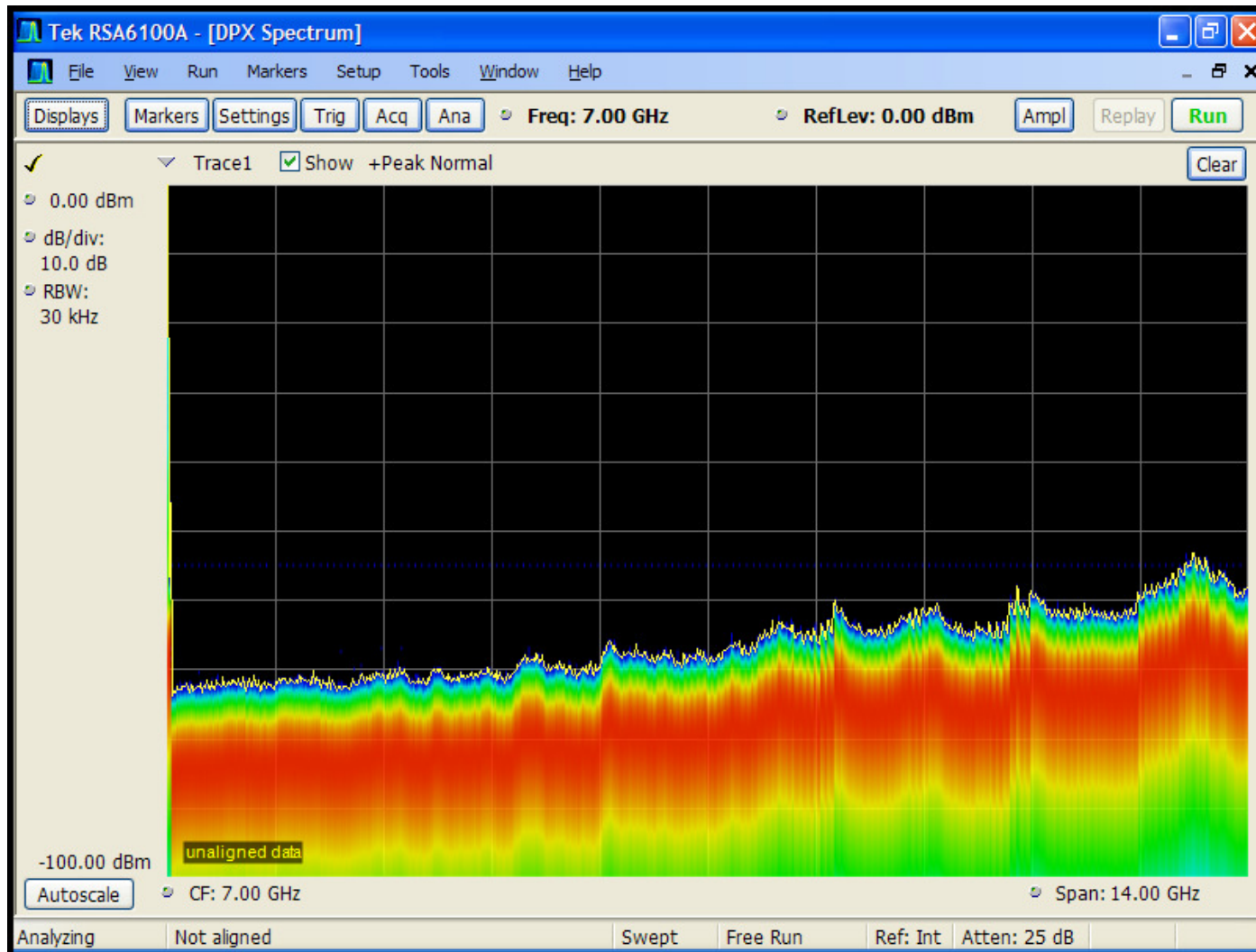
Improved
Span/RBW
ratio

(was 1 MHz
RBW in 110
MHz Span)

*See further
into noise
floor and
resolve more
NB signals



Option 200 - Swept DPX! 9 kHz – 14 GHz DPX



Demonstration of Advanced DPX™ on the RSA6114A

- Signal Density Representation
 - Scale and Colors...
 - Density Measurement
- Narrow Resolution BW
 - See much “deeper” into the noise
- Swept DPX™
 - *Redefining swept spectrum analysis!*



Powerful *Triggering* Features

- **Frequency Mask Trigger (FMT)**

- Flexible Amplitude/Frequency discriminating trigger
- Simple mask creation on Spectrum, up to 500 points across SPAN

EXCLUSIVE

- **Power/Amplitude Trigger**

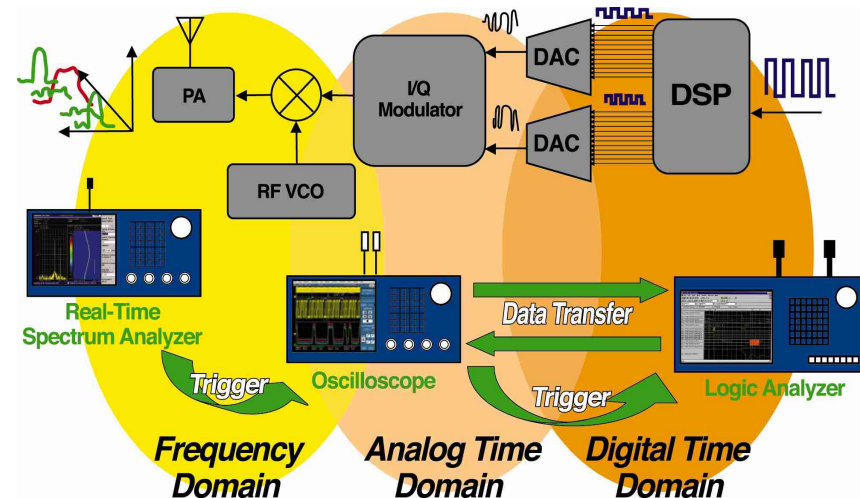
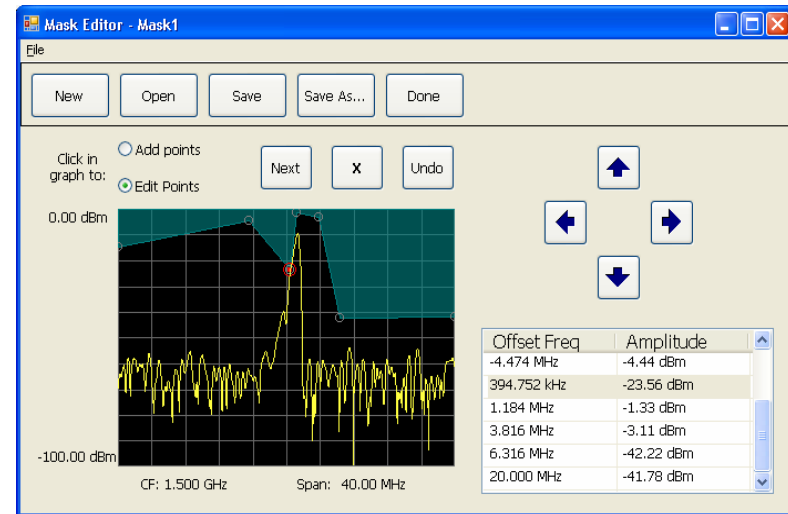
- Full SPAN or band-pass filtered
- Adjustable threshold/polarity

- **External Electrical Trigger**

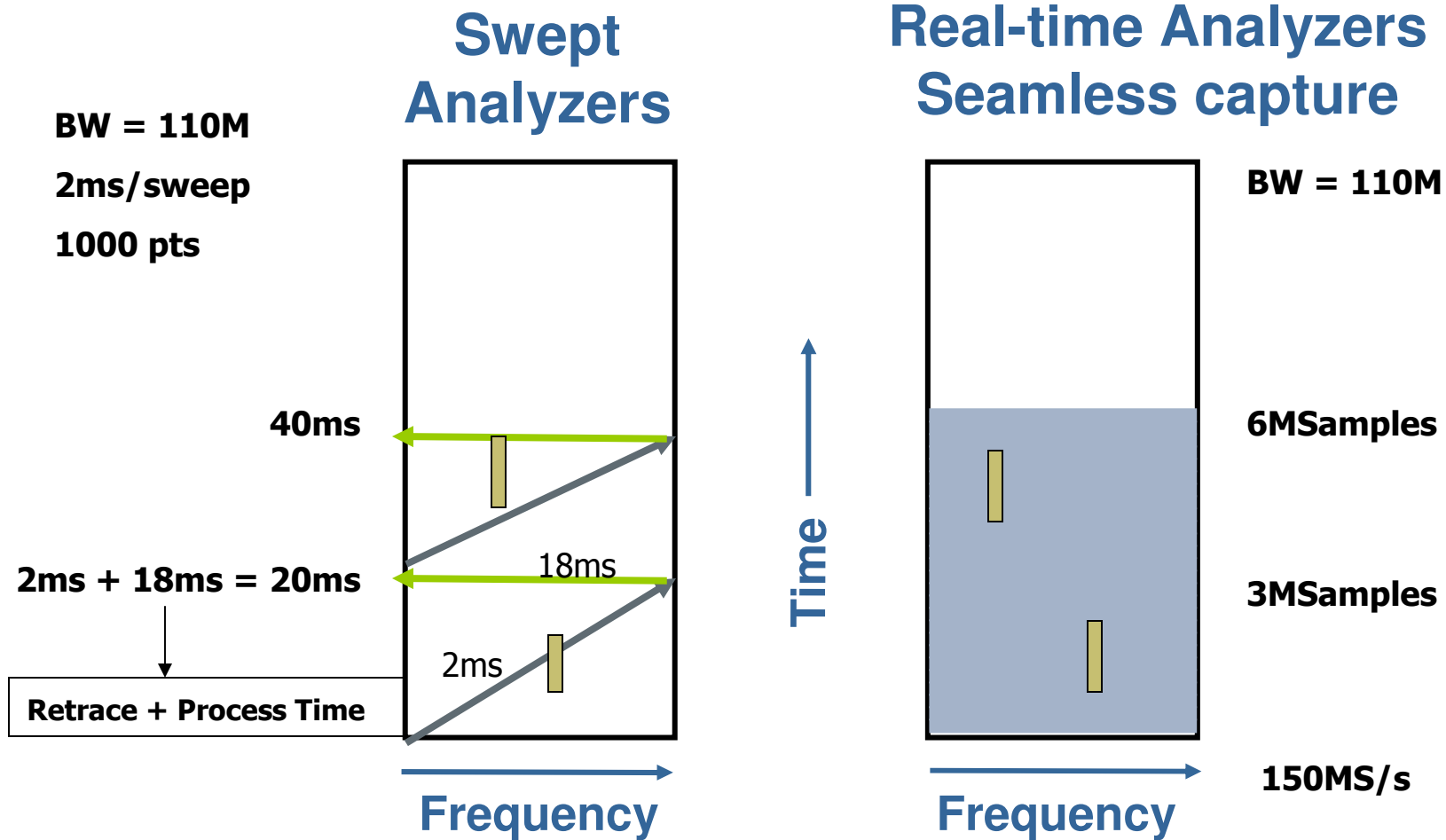
- Two electrical trigger inputs

- **Cross-Trigger Capabilities**

- Trigger RSA from Scope or LA
- Scope or LA triggered from RSA
- RSA Triggers Arbitrary Waveform Generator

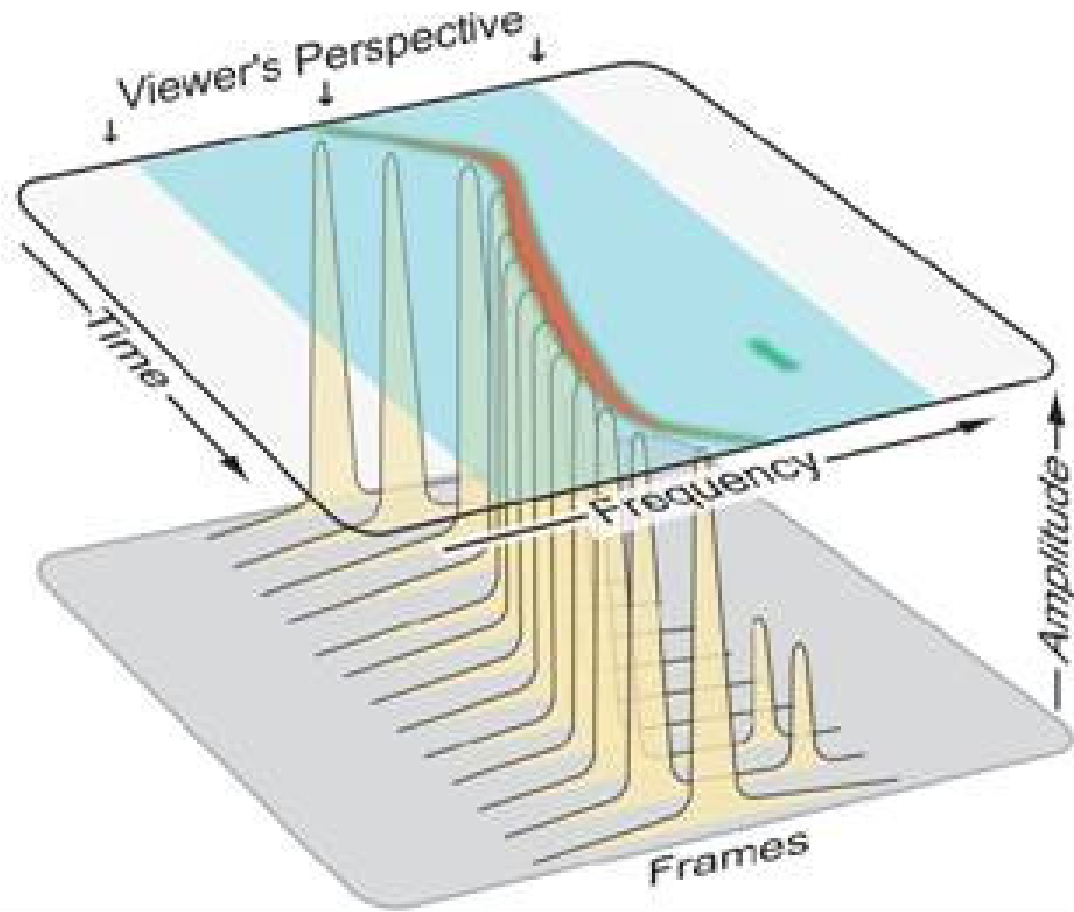


Swept vs. Real-time Seamless *Capture*



Seamless Capture and Spectrogram

- The spectrogram shows how an RF signal changes over time in the frequency domain
- Frequency is the horizontal axis, time is the vertical axis, and power is represented by the color of the trace





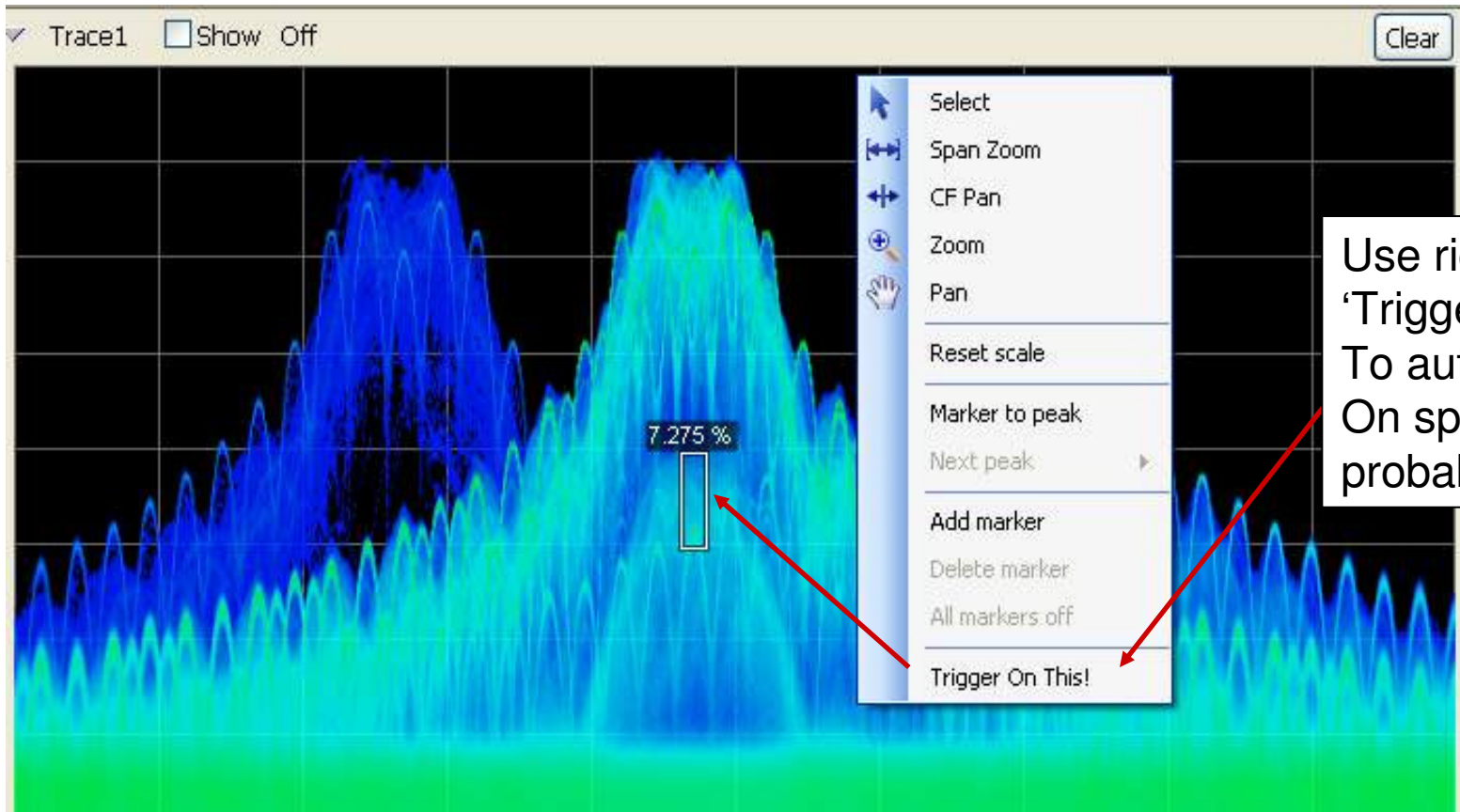
Demonstration: Trigger & Capture Transient Events

- See how FMT triggers on spectral events
- Seamless capture of the RF event into memory
- Analyze the captured signal in multiple domains

- Trigger, Capture and Analyze Key-Fob transmitters

Option 200 - DPX Density ® Trigger!!!!

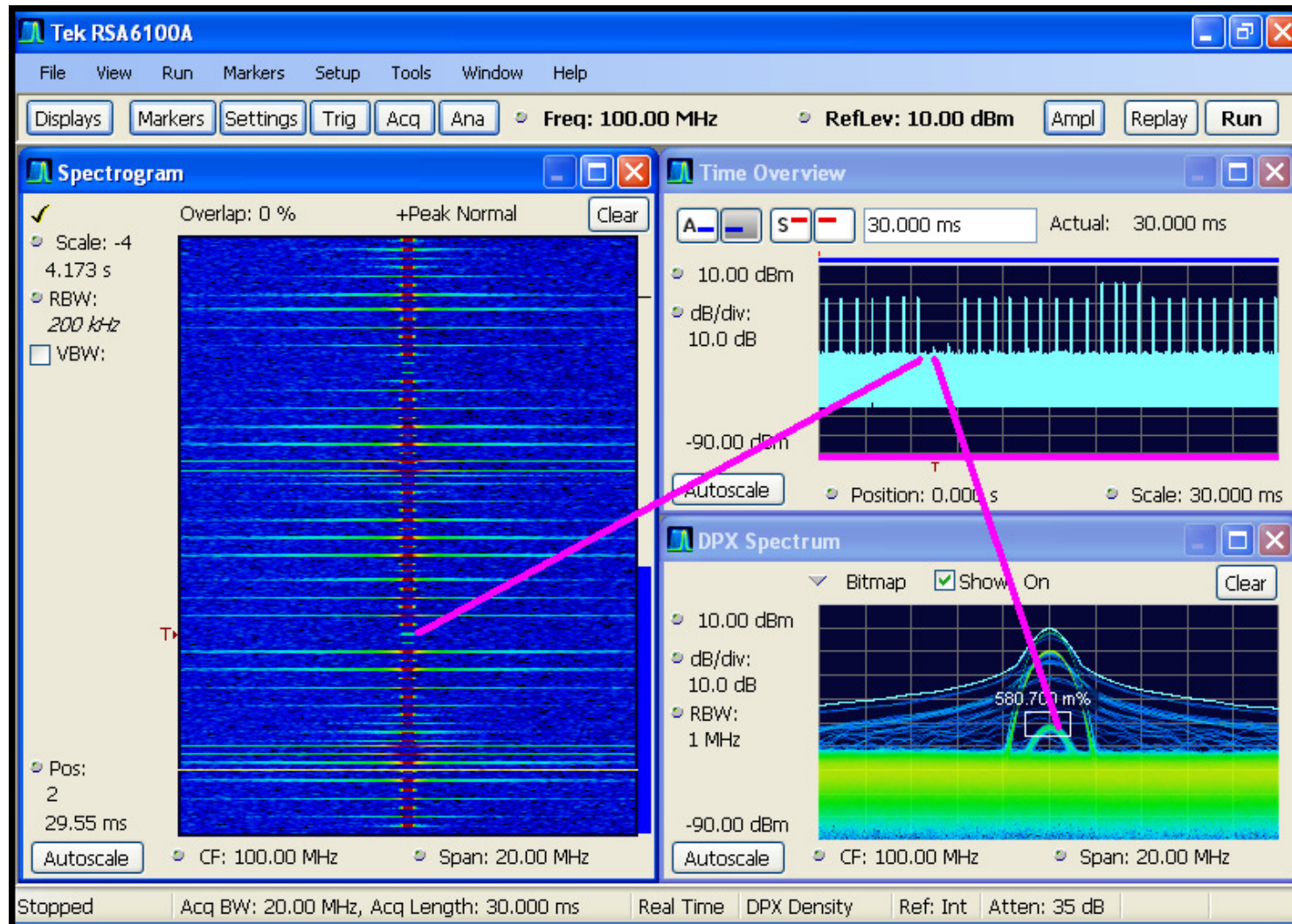
Trigger on signal's actual probability anywhere in display



Use right-click
'Trigger on This!'
To auto-trigger
On specific signal
probabilities

Option 200 - DPX Density ® Trigger

Trigger on signal's actual probability anywhere in display



Note "T" –
Trigger pos
In Time
Overview

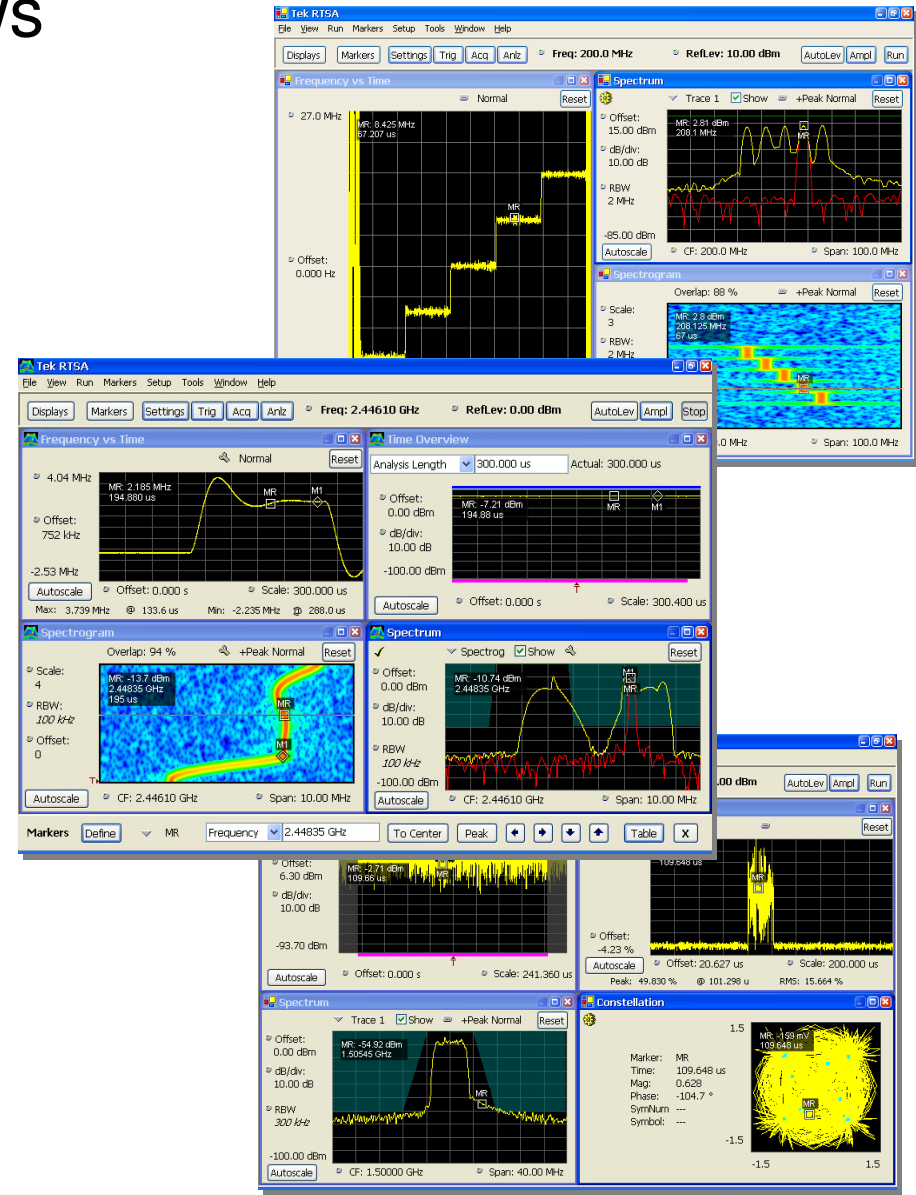


NEW DPX™ Density Trigger Demonstration

- Trigger on Specific DPX Signal Features
 - Pick a feature – Trigger on This!
- Trigger on Specific DPX Density Changes
 - Trigger on signals under signals!

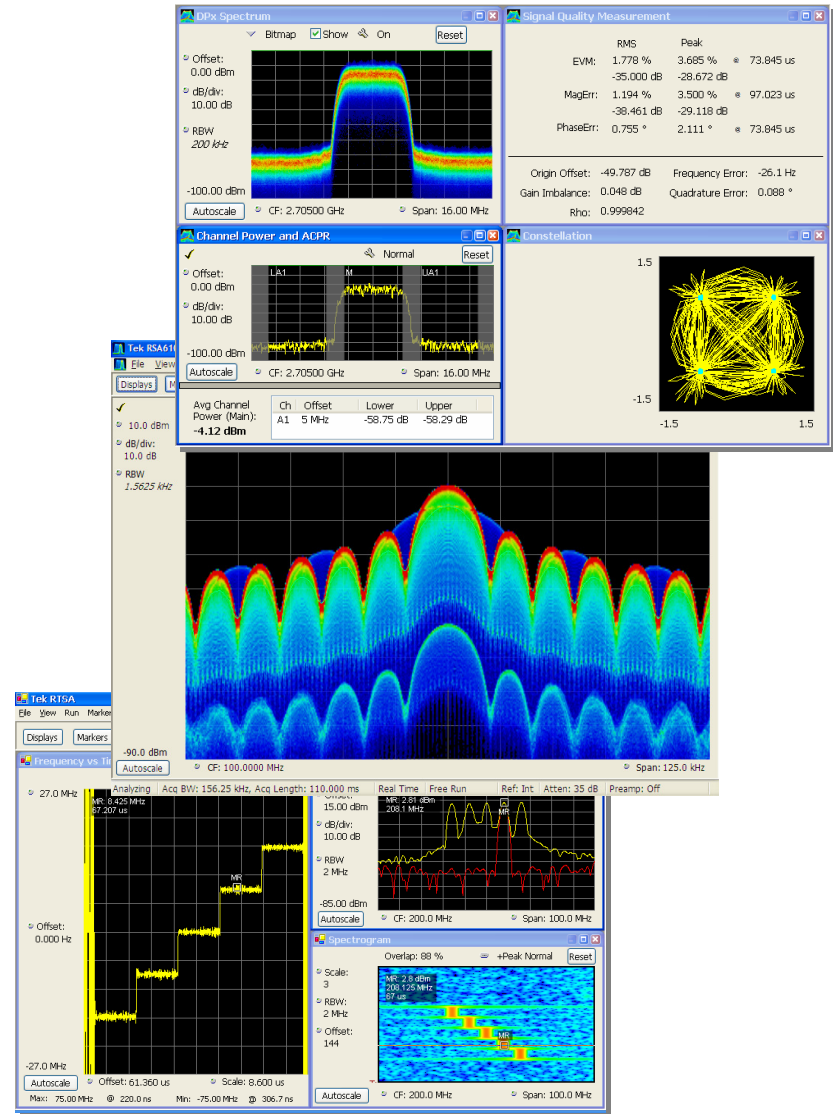
Multi-Domain Analysis Views

- General Analysis
 - DPX™ Spectrum
 - Spectrum, Spectrogram
 - Amplitude, Frequency, Phase, IQ vs. Time
- Digital Demodulation
 - Constellation
 - EVM, Mag/Phase Error vs. Time
 - Symbol Table
- RF Measurements
 - ACLR, MCPR, CCDF, OBW, xdB
 - Multi-Range Spurious, Phase Noise
- Pulsed RF Measurements
 - Power, Rise/Fall, PW, PRI, Freq & Phase, Deviation, Accuracy, etc.
- All available at any time...



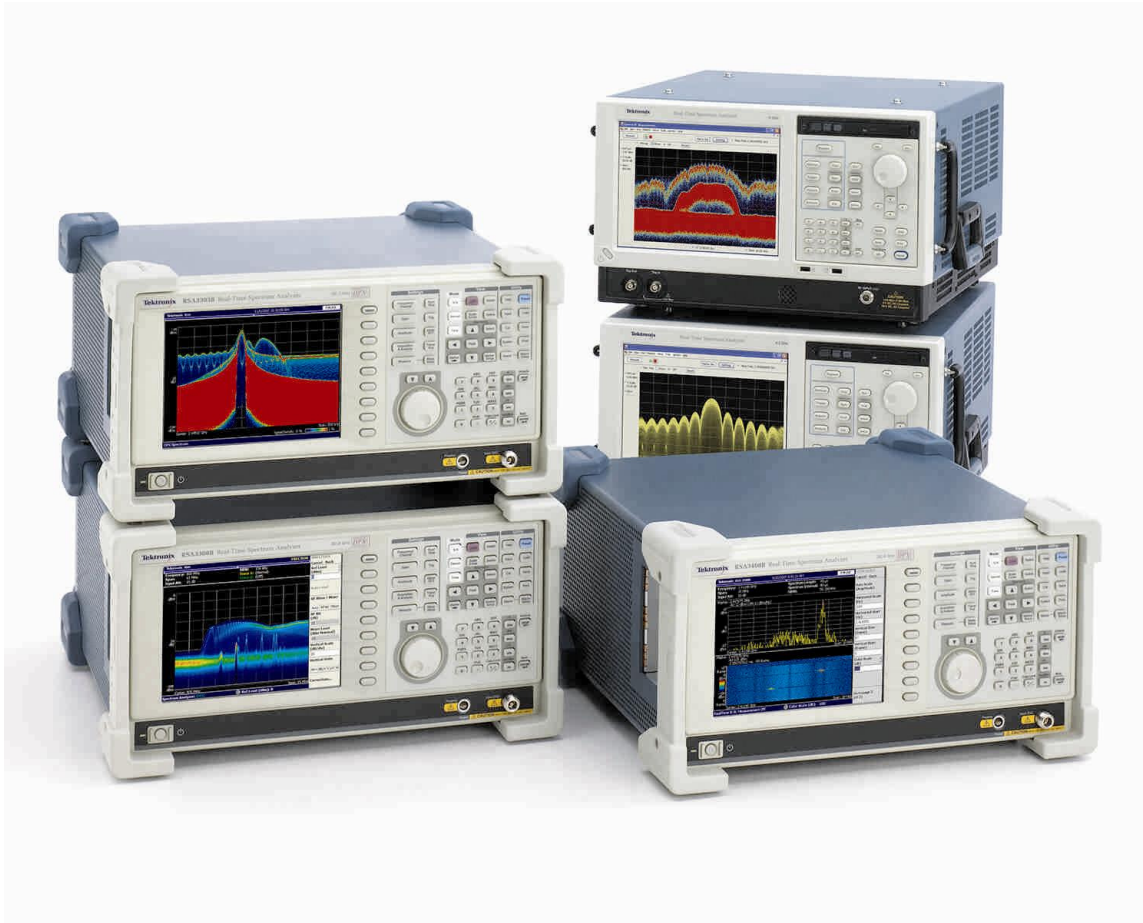
Flexible Display and Analysis Configuration

- Full flexibility in choosing displays
 - Displays from any domain can be open simultaneously
 - All real-time displays are fully time-correlated
- Captured data can be analyzed many ways
 - Add a new display and “replay”
 - Adjust analysis window and “replay”
 - Even adjust Center Frequency, SPAN and RBW and “replay”
- Many Data Export options
 - Save IQ in Internal, CSV and MATLAB formats
 - Save results to CSV or trace files
 - Save images to PNG, JPG, BMP



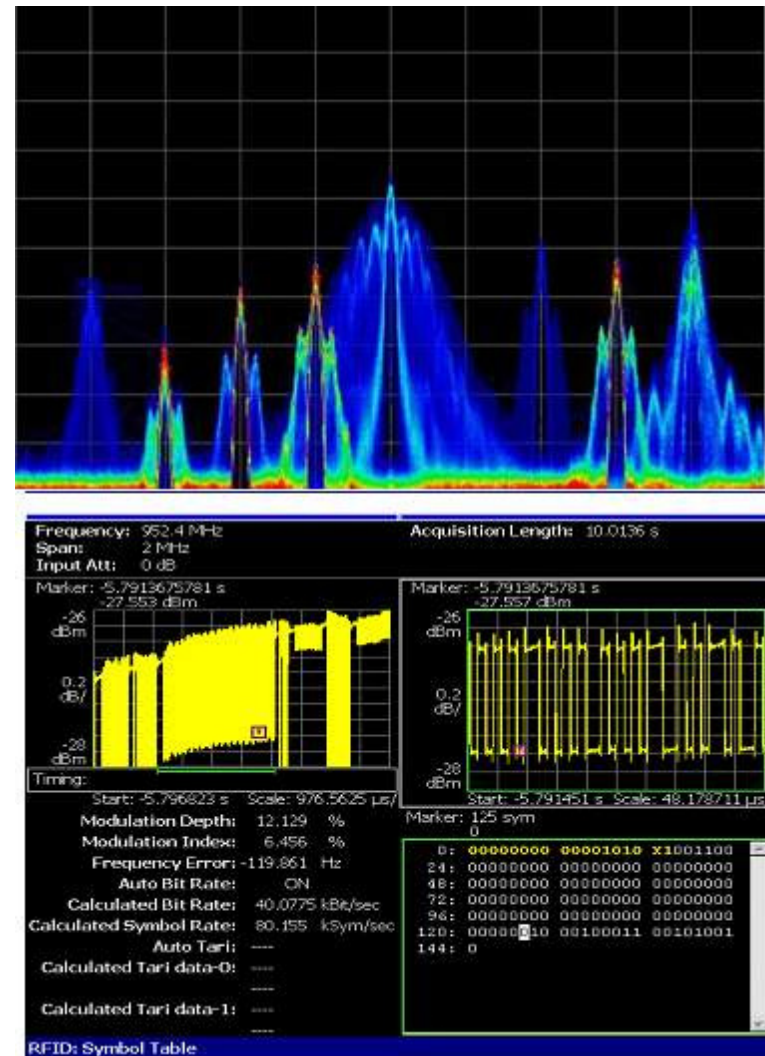
Application Examples

- Applications of both the RSA6100A and RSA3000B Series Analyzers



Application: RFID – Beyond The Conventional Compliance Tester

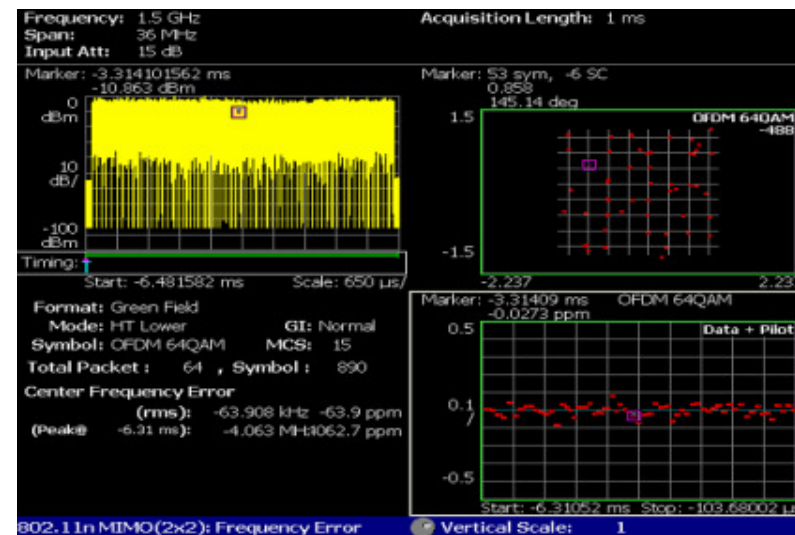
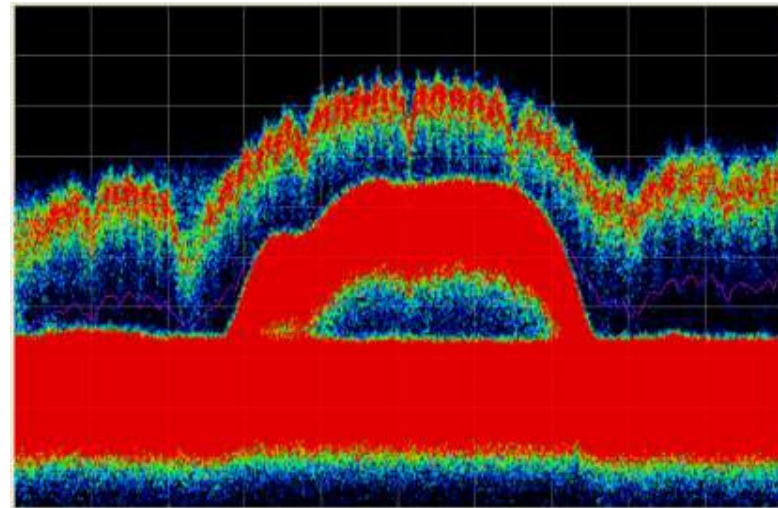
- **Industry's only field interoperability tester and real time interference troubleshooting tool**
 - Unique DPX Sees and measures Interrogator-Tag transactions LIVE to debug problems such as:
 - Tag confusion under adjacent interrogators set up
 - High power tags interference with low power tags
 - Listen-before-talk bugs
- **Most comprehensive set of standards-based analysis for compliance test**
 - First with ISO18000-7 and ISO 15693
 - ISO 18000-4, 18000-6 Type A/B/C, 18092, 14443-2 Type A/B, EPC Global Generation 1 Class 0, Class 1
- **Complete transaction capture with exclusive frequency mask trigger, wide bandwidth, and deep memory**
 - Real time analysis on ISO 18000-6C US 26 MHz hopping operation BW
 - Leading 1.28 seconds capture @ 36 MHz RTBW
 - Industry-leading 73dB dynamic range @ 36MHz capture BW



Application: WLAN

Cost Effective Solution for Your 802.11a/b/g/n inc. MIMO Tests

- ▶ DPX provides Live RF
 - Discover turn-on transients, frequency hopping faults and interference
- ▶ The only mid-range spectrum analyzer capable of 802.11n measurements
 - Full suite of 802.11a/b/g/n with MIMO measurements
- ▶ Tektronix Exclusive Tools for 802.11n Designers – Transfer Efficiency and Transfogram
 - Characterize MIMO EVM
 - Characterize transmission environment
- ▶ Root cause analysis simplified by unique frequency mask trigger
 - Cross triggering to other debug tools available

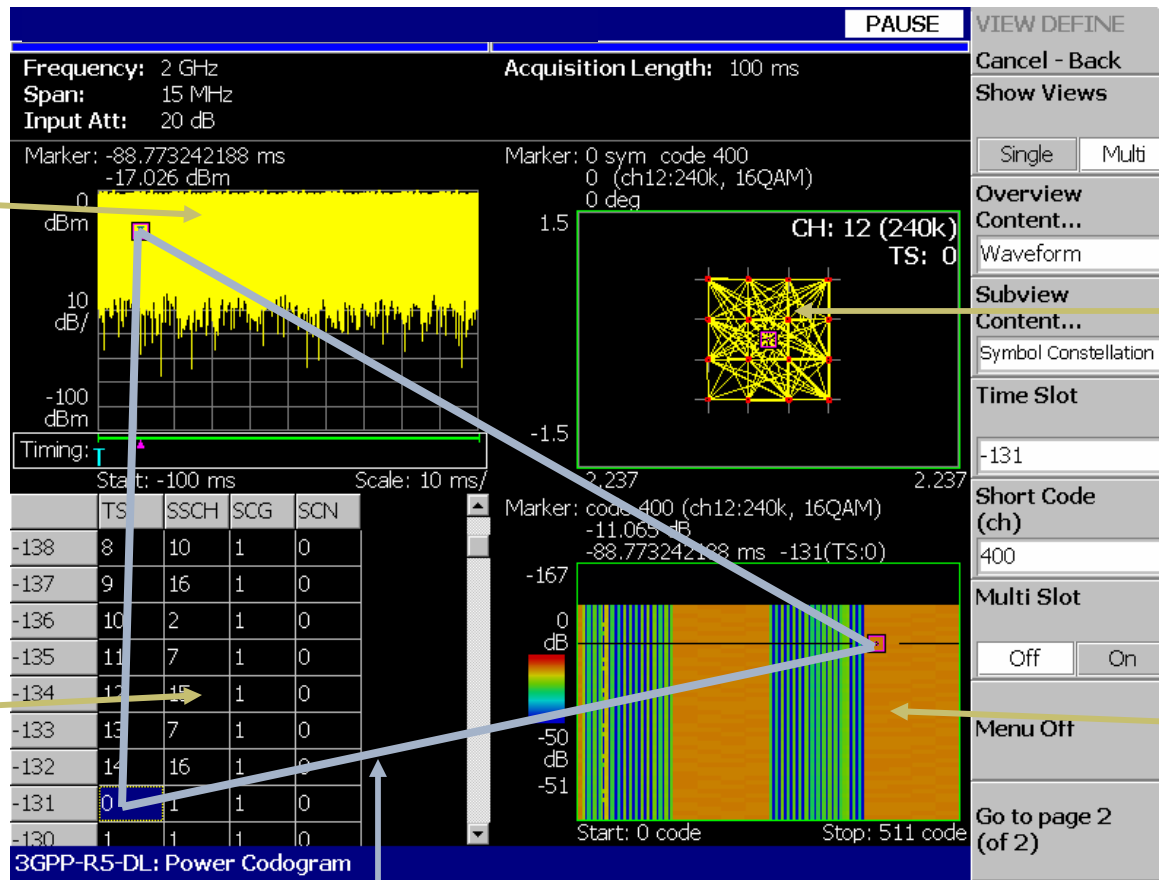


Application: Cellular

Standards based analysis (3GPP shown)

Power vs. Time

Displays the entire capture history



Time Slot Summary

Displays the time slot and other channel data

Time-correlated views

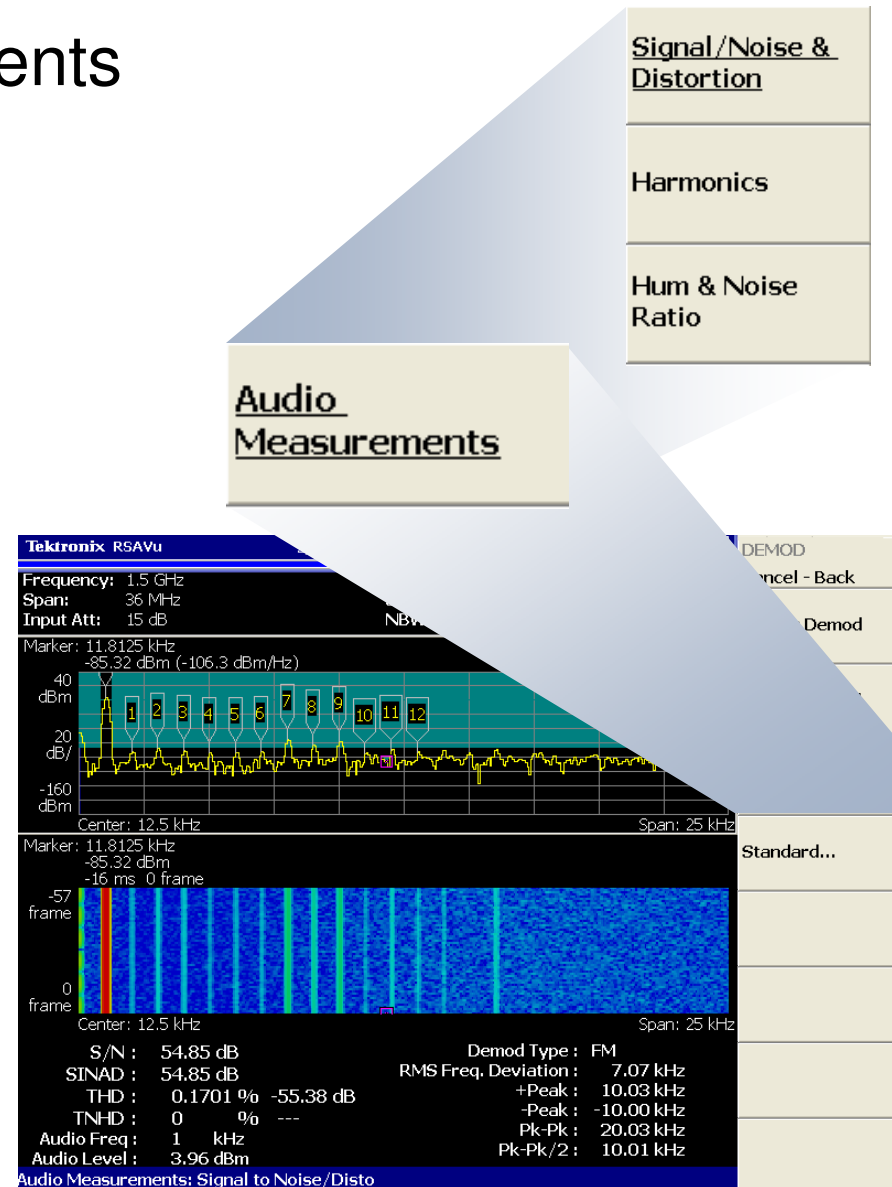
All of the markers are time-synchronized

Constellation

Codogram
Displays changes in the code domain over time

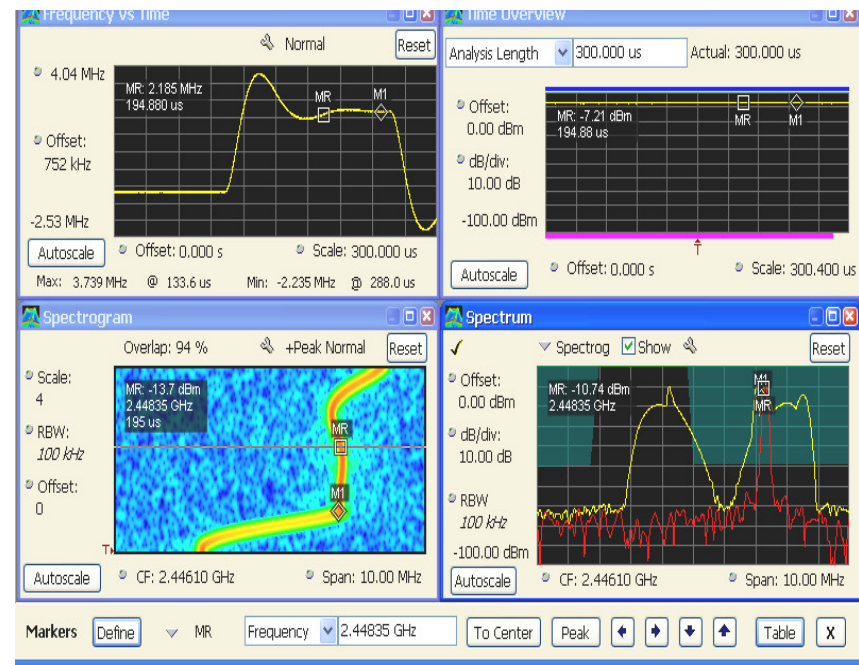
Application: Radio/Audio Audio Distortion Measurements

- Distortion analysis for AM, FM and Baseband signals
- Automatic calculation of key distortion parameters
- Tabulated results of harmonic and non-harmonic components
- Automatic calculation of Hum and Noise
- Display of Audio Spectrum
- Display of Audio Spectrogram



Application: Phase Lock Loop Settling Time

- Step Change in Frequency
 - How long does the change take
 - How much does it overshoot
- Spectrogram display
 - Shows entire SPAN range of frequencies over time
- Frequency vs Time display
 - Allows easy measurement of overshoot/undershoot
- Phase vs. Time Display
 - How long to reach final phase
 - Evaluation performance of DPLL
- Time Overview display
 - Shows signal power during transition
- Frequency Mask Trigger
 - Allows triggering on only the frequency transition of interest

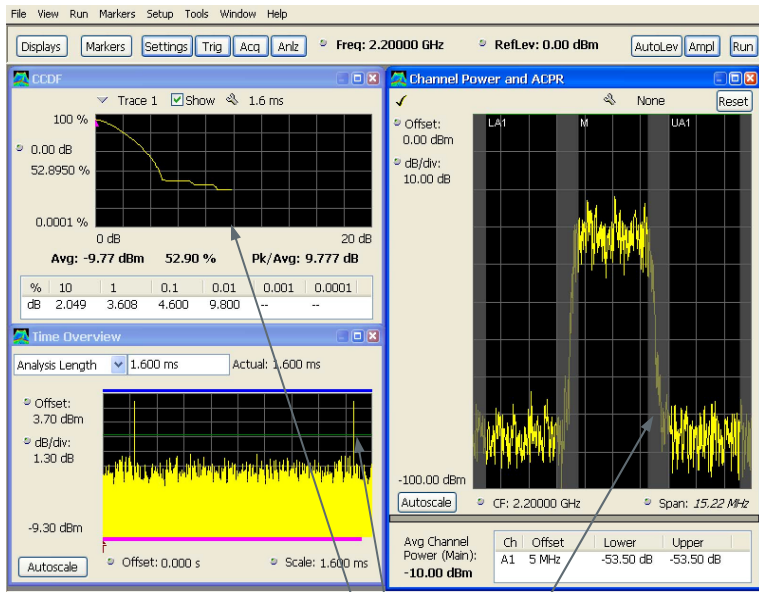




Demonstration of PLL/Synthesizer Tuning & Settling

- Observe, Trigger and Capture PLL Setting behavior
- Analyze Settling time, Stability, etc.
- Show how “Replay” of acquisition data can give new results
 - PLL tuning example
 - Change analysis position and parameters and calculate new results
 - Change/Add/Remove different analysis on same acquisition
 - Examine signal in new ways

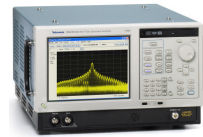
Application: SDR and Amplifiers Non-Linear Effects & Digital Glitches



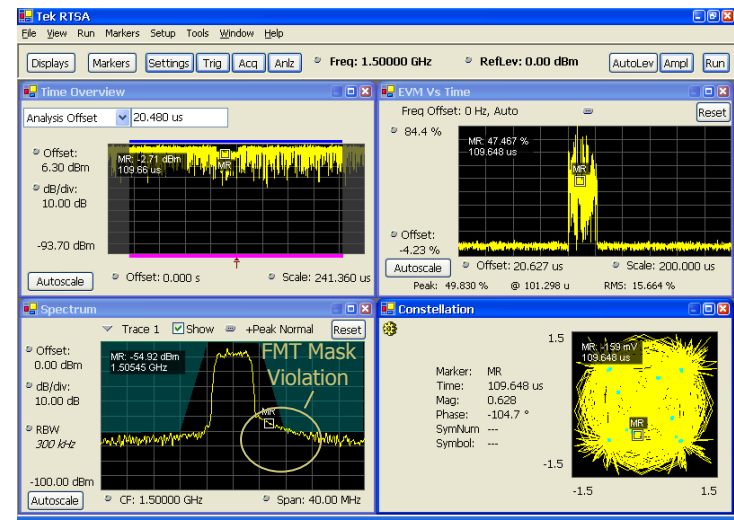
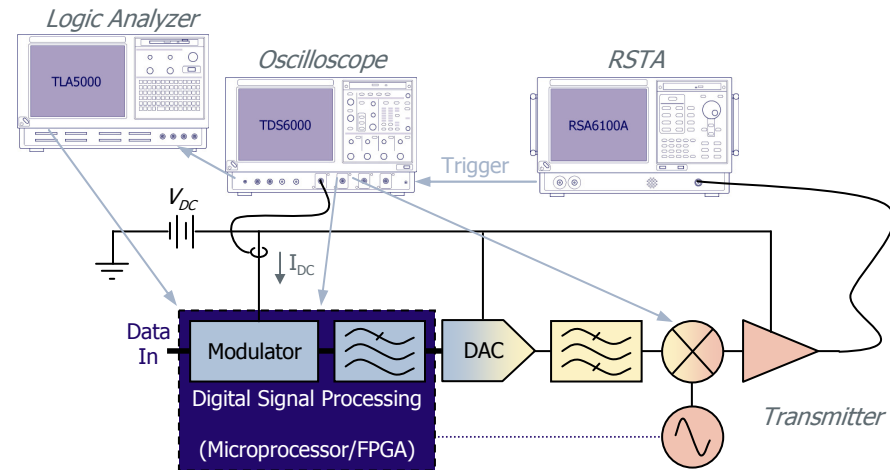
Time Correlated Multi-Domain Analysis

- Complex Digital Pre-Distortion
- Glitches Maybe Data Dependent
- **Challenge:** Trace Source of Glitches
 - Misaligned Modulated Bias Techniques
- **Challenge:** Finding Algorithm Problems
 - i.e. Sources of “Memory,” Overflow, etc..
- **Benefit:** Correlated CCDF, ACPR, etc...
- **Benefit:** RTSA Finds the Problems Fast

Application: SDR and Amplifiers Transient RF Distortion



- RTSA Supplies Trigger to Oscilloscope & TLA
 - Trigger Source Based on Frequency Domain Change, Initiates Data Capture
- Efficient RTSA FMT Triggering
 - Mask Set to Detect Only RF Problems
- Time Correlated Multiple Domains
 - Droop, Re-Growth & EVM Jump can be Correlated to Frequency Domain Event
- **RTSA Benefits:** Avoid False Triggers
 - Correlate Spectrum, EVM & Constellation as well as Current on External Oscilloscope and code on TLA



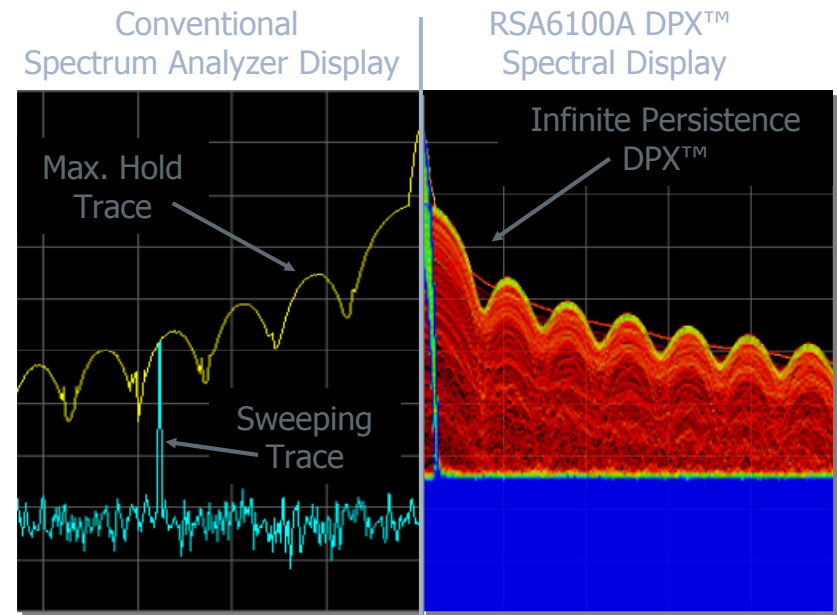


Demonstration of Transient RF Distortion: *Discover, Trigger, Capture and Analyze...*

- Use of DPX™ to *Discover* the problem
- Use of FMT to trigger on the problem
- Seamlessly capture the event into the RSA
- Analyze the signal in multiple-domains
 - VSA-type and SA-type measurements
 - Time correlated, multiple domain analysis

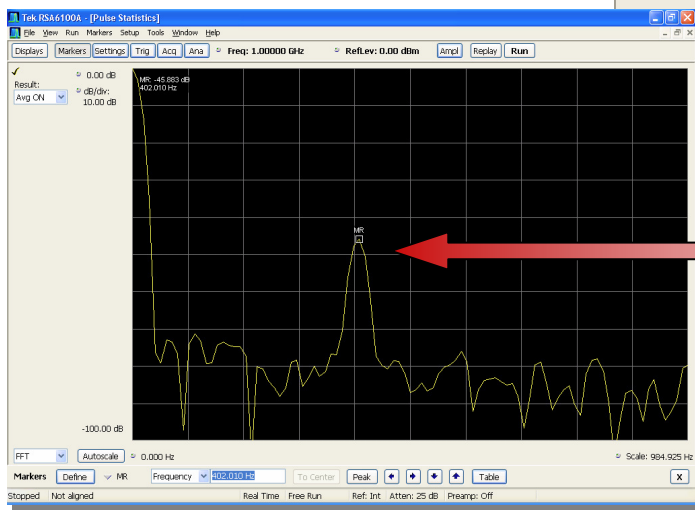
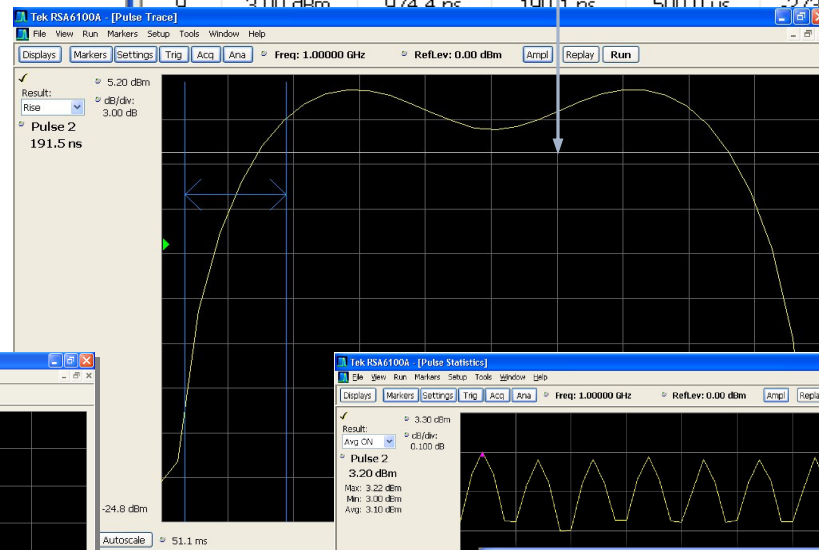
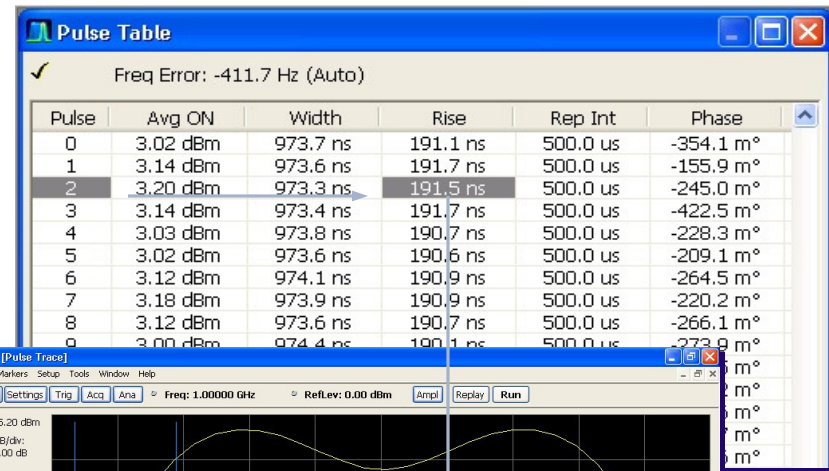
Application: RADAR and Pulsed RF Signals

- Use DPX™ to examine pulsed signals
 - ...and between the pulses!
- Trigger in various ways
- Seamlessly capture pulses into memory
 - ...or even into segmented memory
- Pulse Measurement Suite gives you
 - Automatic detection of pulses
 - 21 pulse parameter measurements
 - Tabular and Graphical Results
 - Analyze up to 10,000 pulses

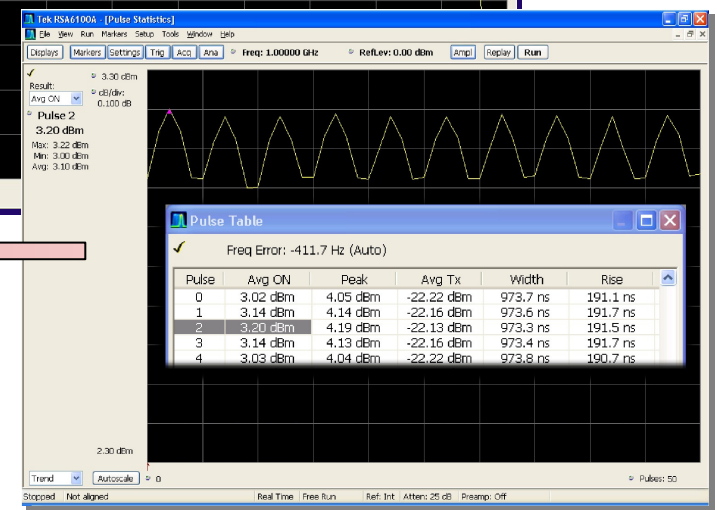


Pulse Parameter Analysis

- ▶ Pulse Table Measurements
- ▶ View Graphical the Pulse Trace
- ▶ View Trend for Parameters
- ▶ Analyze Parameter Trends



FFT



Pulse	Avg ON	Peak	Avg Tx	Width	Rise
0	3.02 dBm	4.05 dBm	-22.22 dBm	973.7 ns	191.1 ns
1	3.14 dBm	4.14 dBm	-22.16 dBm	973.6 ns	191.7 ns
2	3.20 dBm	4.19 dBm	-22.13 dBm	973.3 ns	191.5 ns
3	3.14 dBm	4.13 dBm	-22.16 dBm	973.4 ns	191.7 ns
4	3.03 dBm	4.04 dBm	-22.22 dBm	973.8 ns	190.7 ns



Other Enhanced Trigger Features

- Runt Trigger
 - Trigger on pulses that don't reach full amplitude, or don't fully extinguish
- Time Qualification of Triggering
 - Trigger on Events that
 - Are shorter than defined interval
 - Are longer than defined interval
 - Are outside of a defined time window
 - Are inside of a defined time window
 - Trigger Holdoff Control
 - Applies to ALL trigger modes

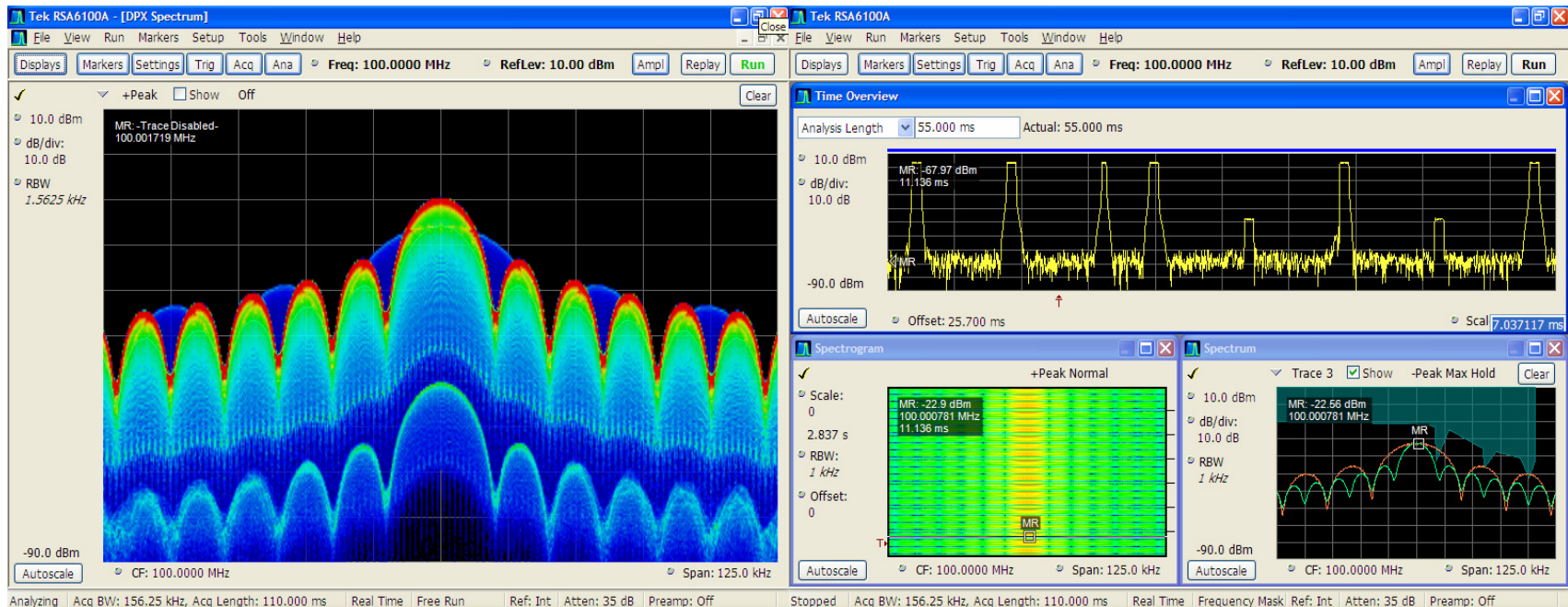


Demonstration: Pulsed RF Signal Characterization

- Use DPX™ to examine Pulsed RF signals
 - See characteristics invisible to conventional analyzers
- Trigger on Pulsed Signals
- Capture into memory
- Analyze with the Pulse Measurement Suite

- Examine:
 - Simple pulsed RF signals
 - Pulsed RF signals with parameter variations
 - Pulsed RF signals with modulation

Summary



- Use DPX™ to **Discover** the anomalies
- Use Frequency Mask Trigger to **Trigger** on the anomaly
- Seamlessly **Capture** the event into memory
- **Analyze** before, during and after the anomaly in multiple domains

Thank You!

Your Tektronix Sales Engineer:

Scott Zederbaum

Cell: 732-616-0080

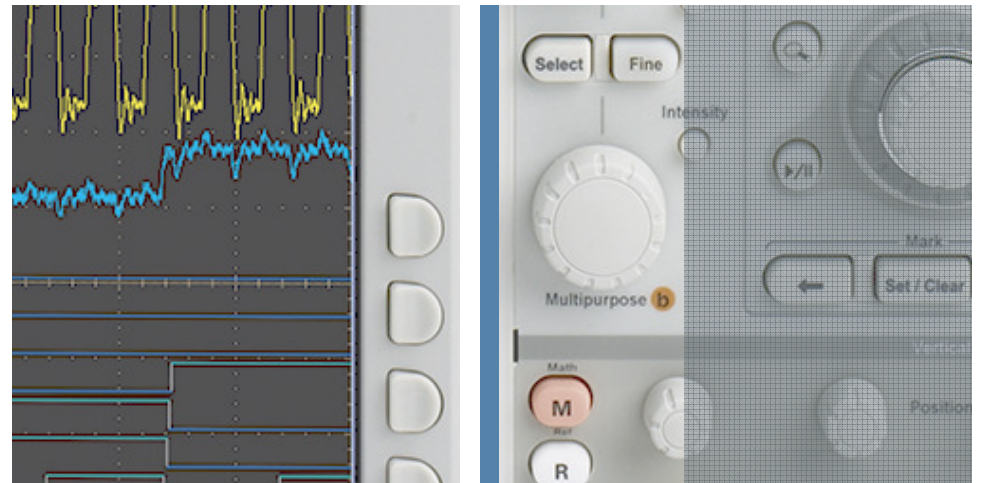
scott.b.zederbaum@tek.com

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Cell: 908-938-9195

alan.wolke@tek.com



RTSA – Discover... Trigger... Capture... Analyze

Tektronix[®]