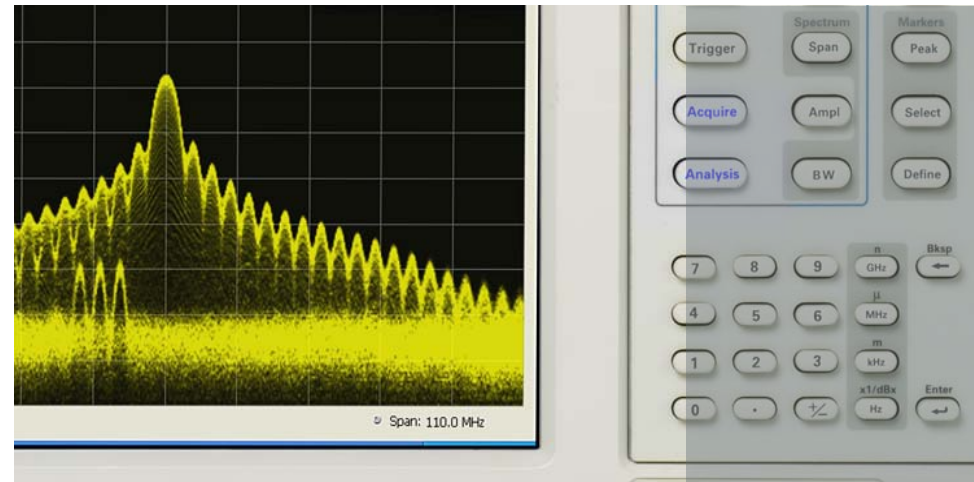


如何**100%**保證發現並捕捉分析暫態訊號 (EMI,干擾,通訊訊號)



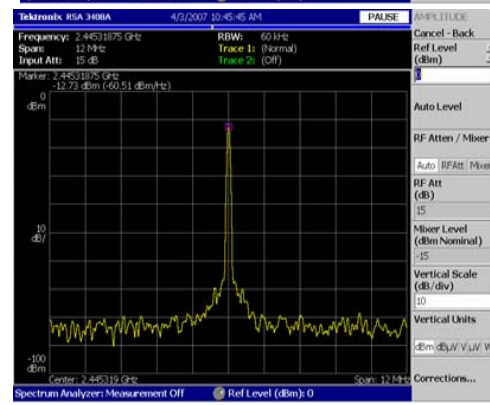
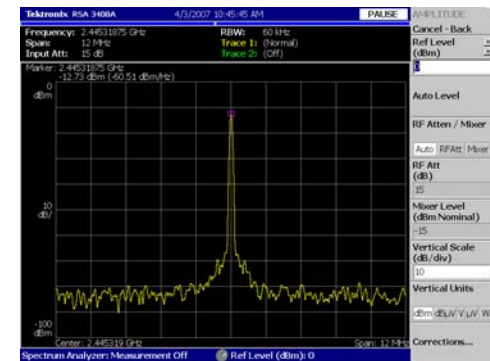
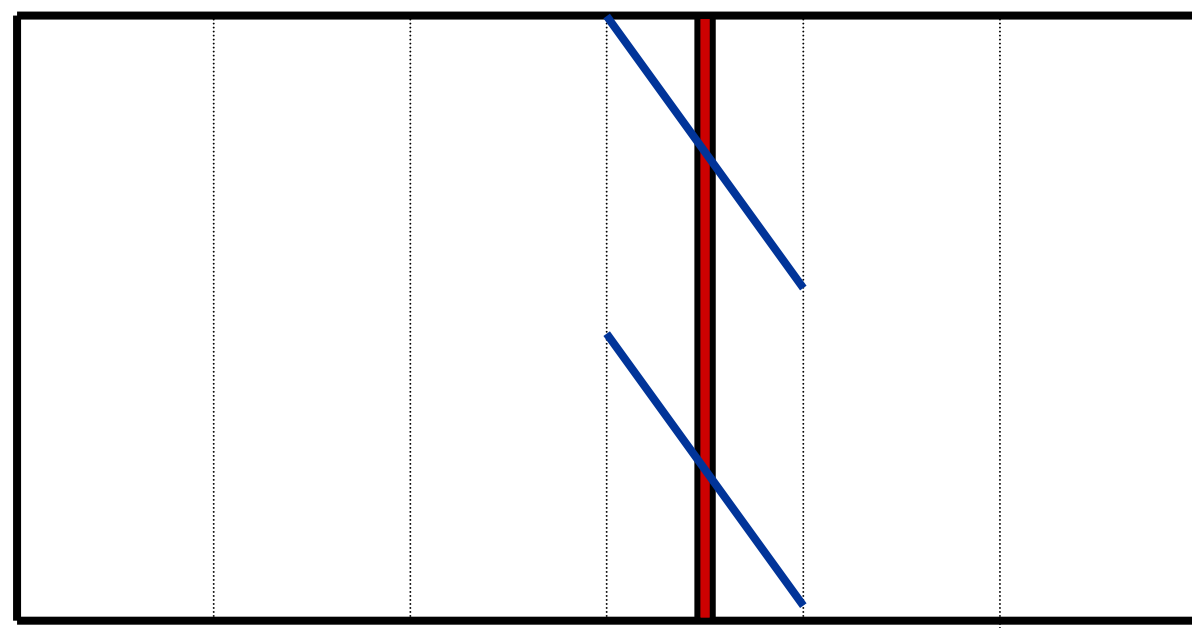
RF Product Manager Dio Yang (楊宗文)

Tektronix[®]

- 如何保證**100%**不間斷頻譜顯示 & Demo
- 如何攔截捕捉特定訊號
- 多域同步分析
- 應用實例(**Case Study**)

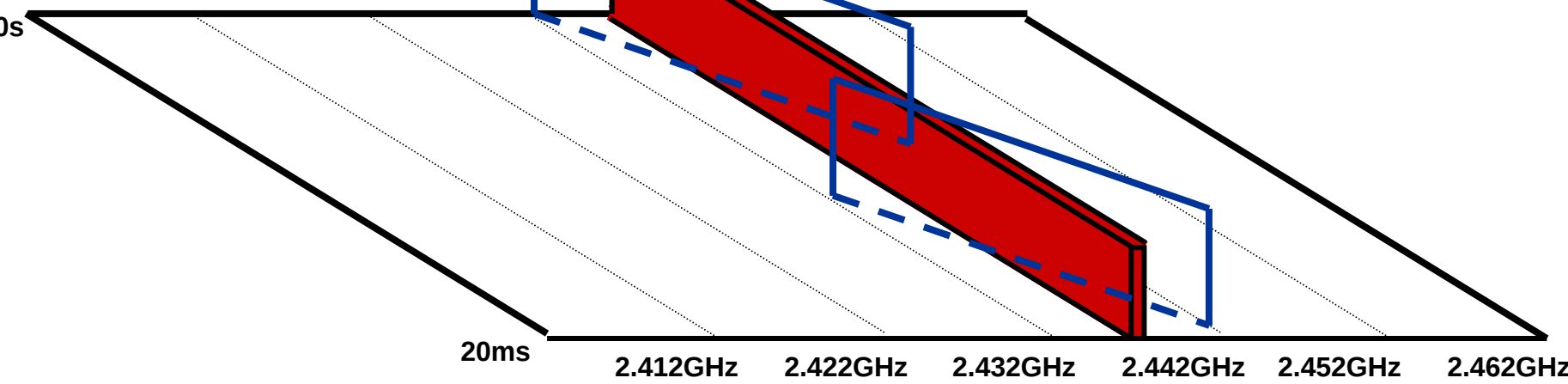
0s

20ms

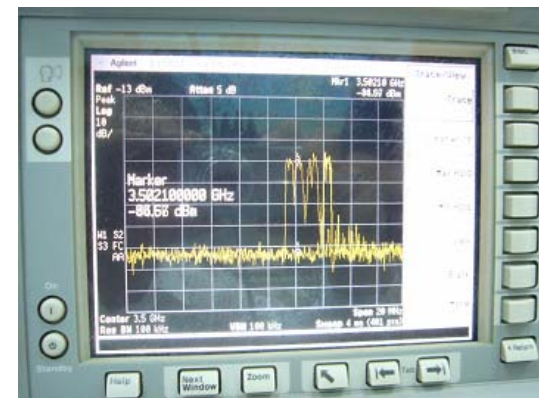
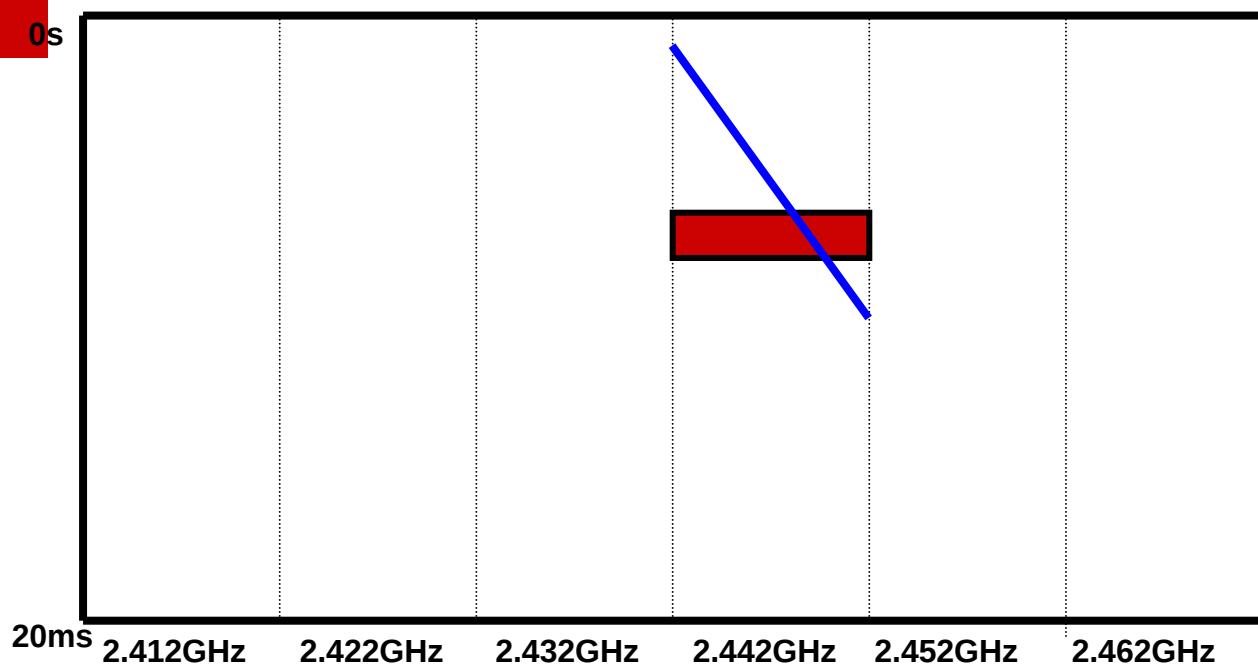


0s

20ms



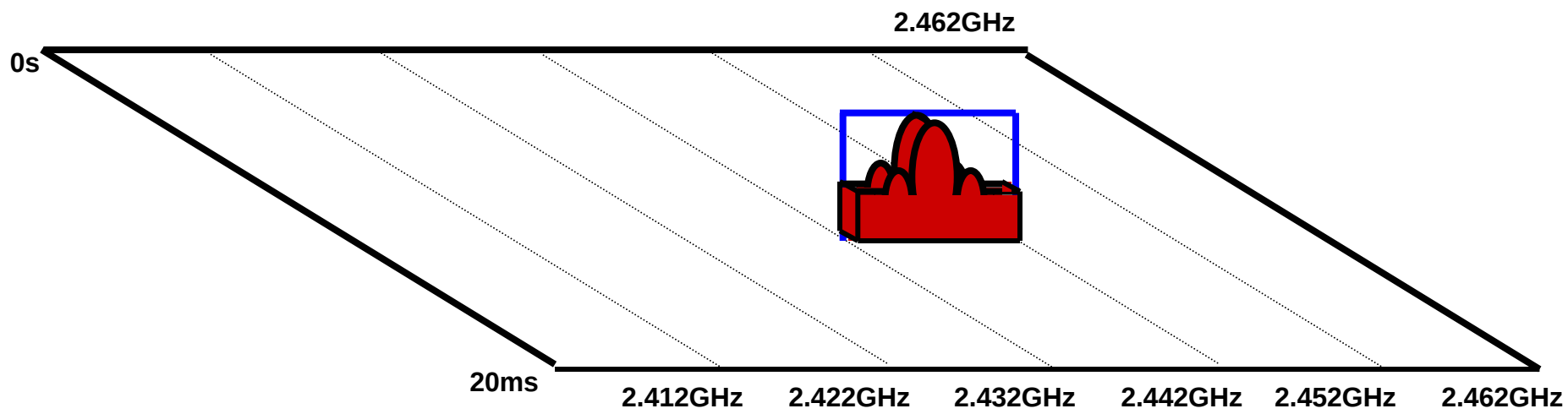
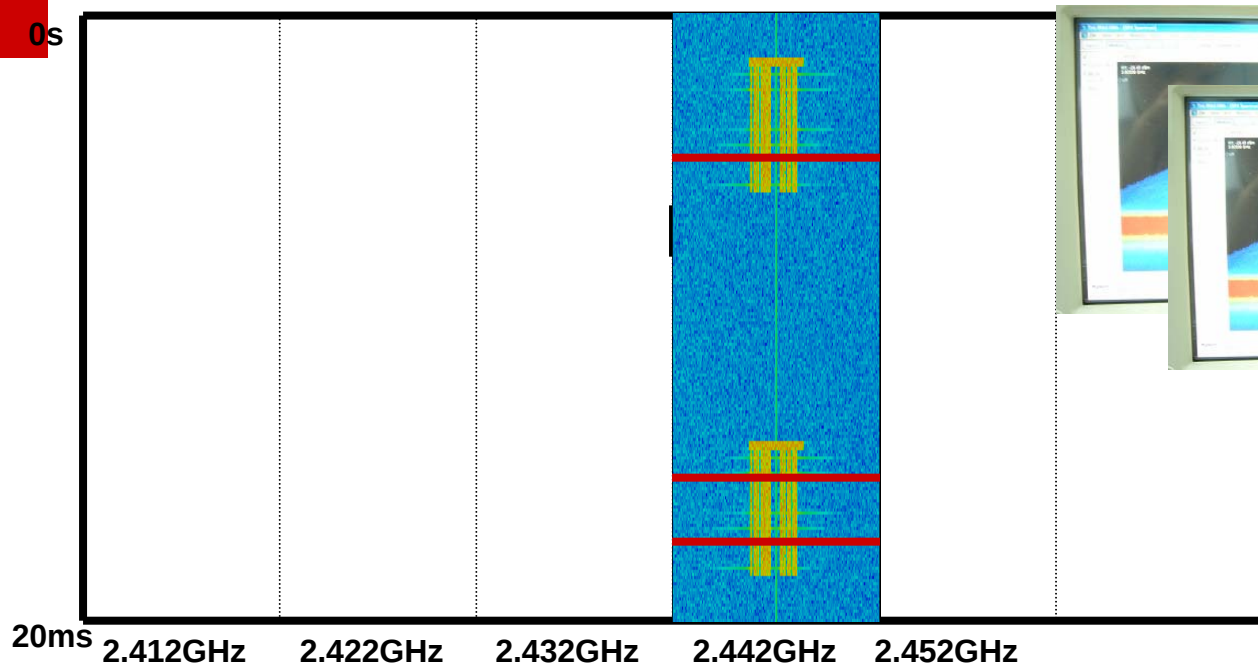
0s



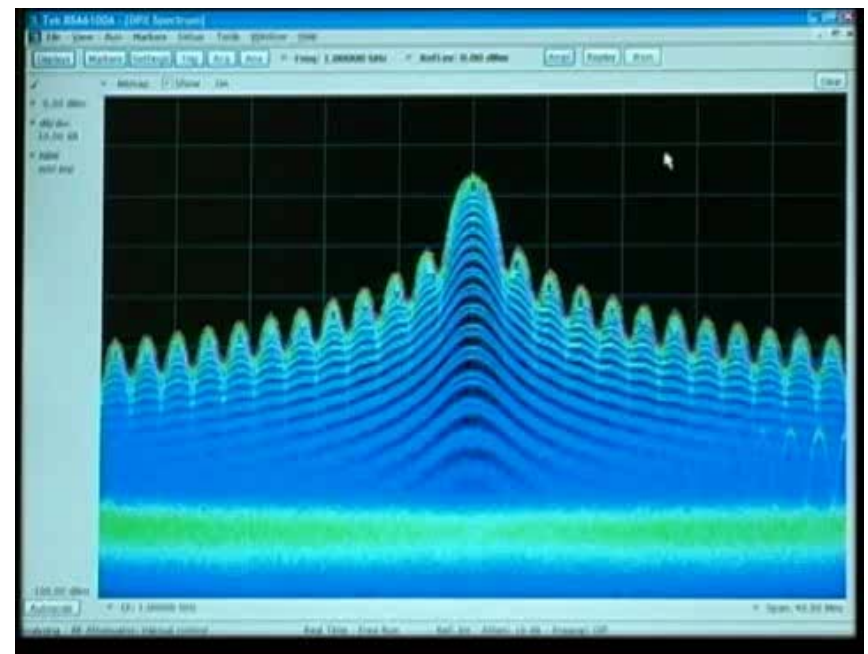
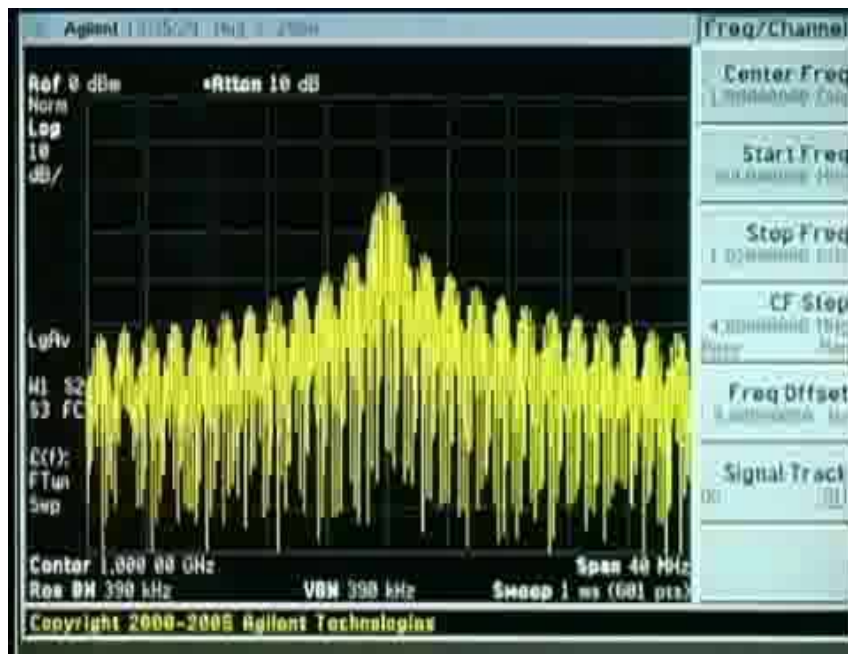
0s

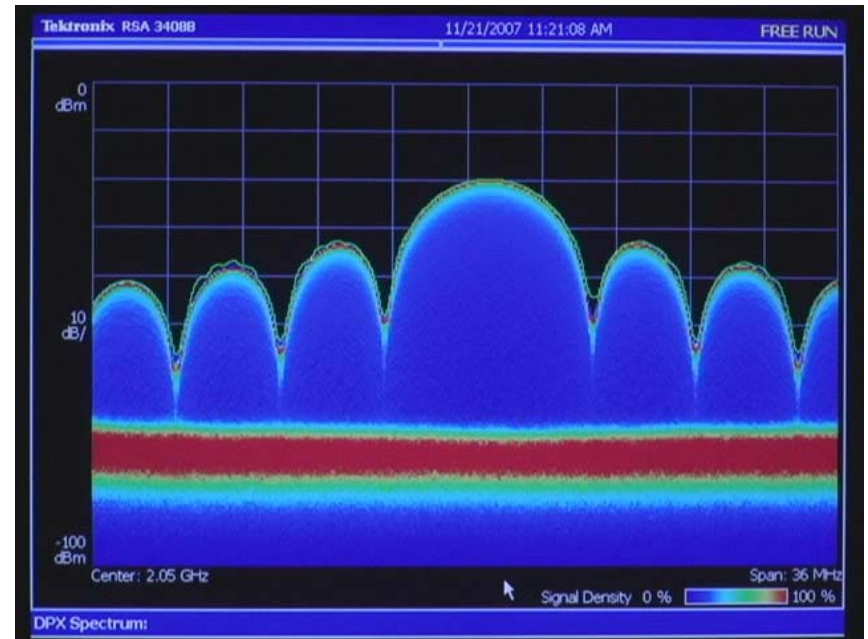
20ms

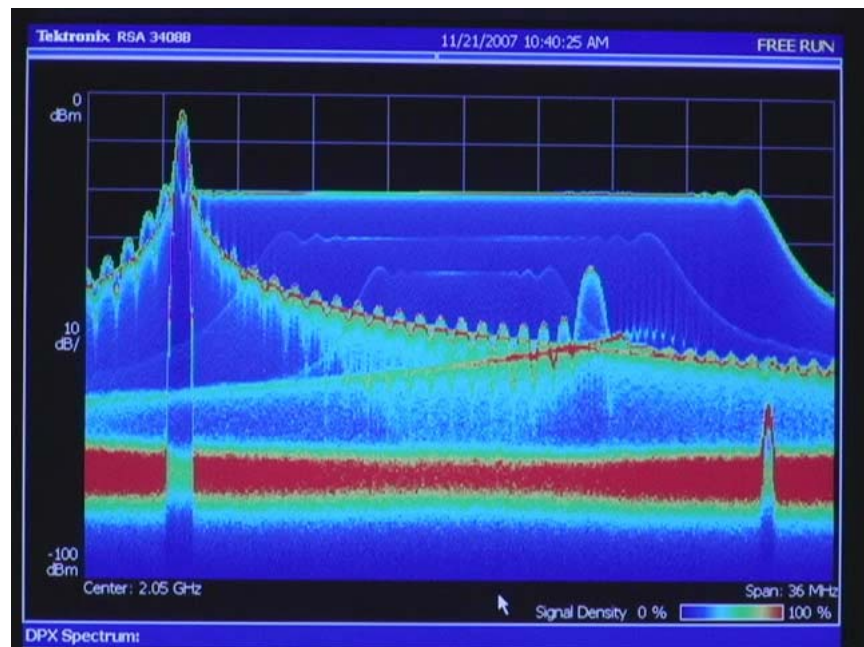
2.412GHz 2.422GHz 2.432GHz 2.442GHz 2.452GHz 2.462GHz

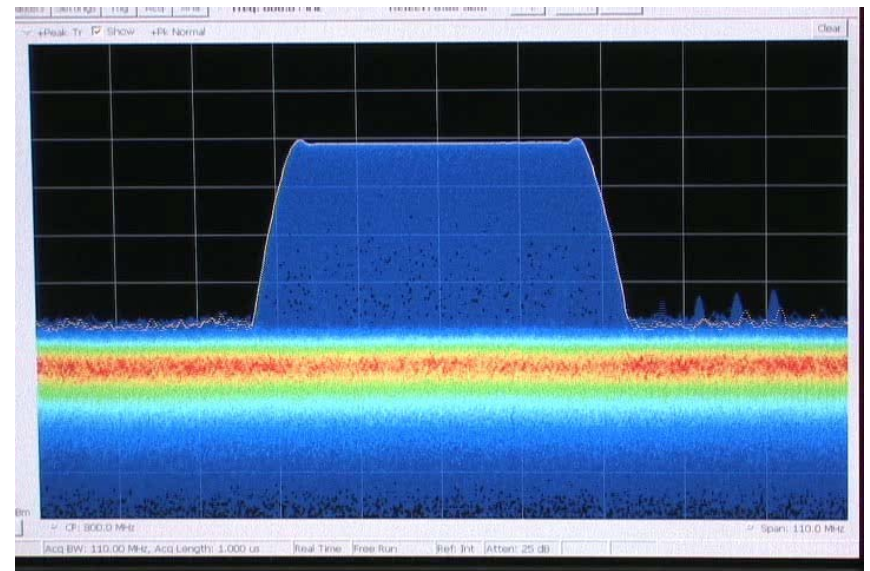
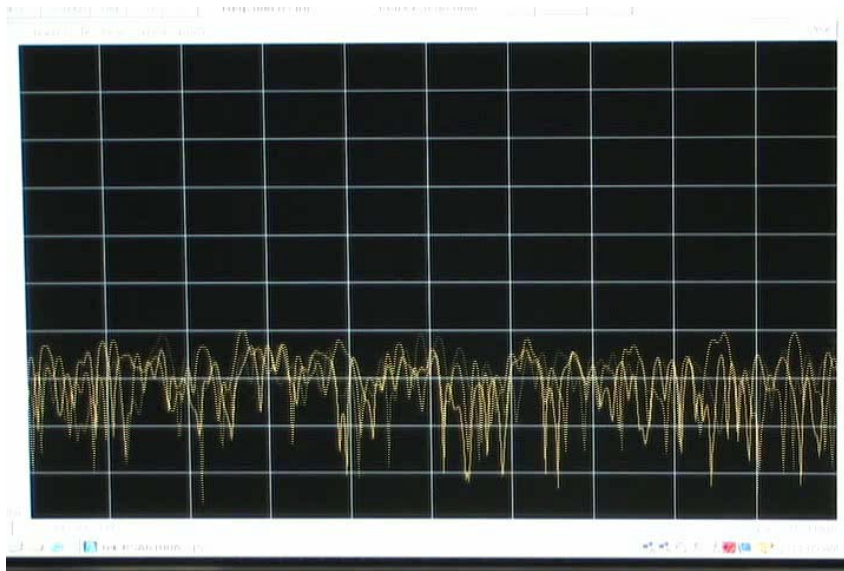




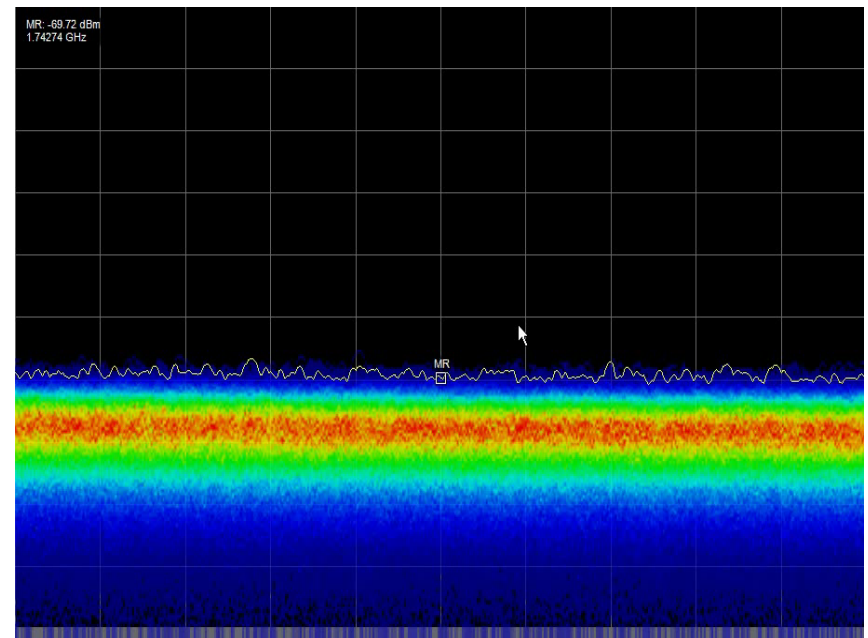
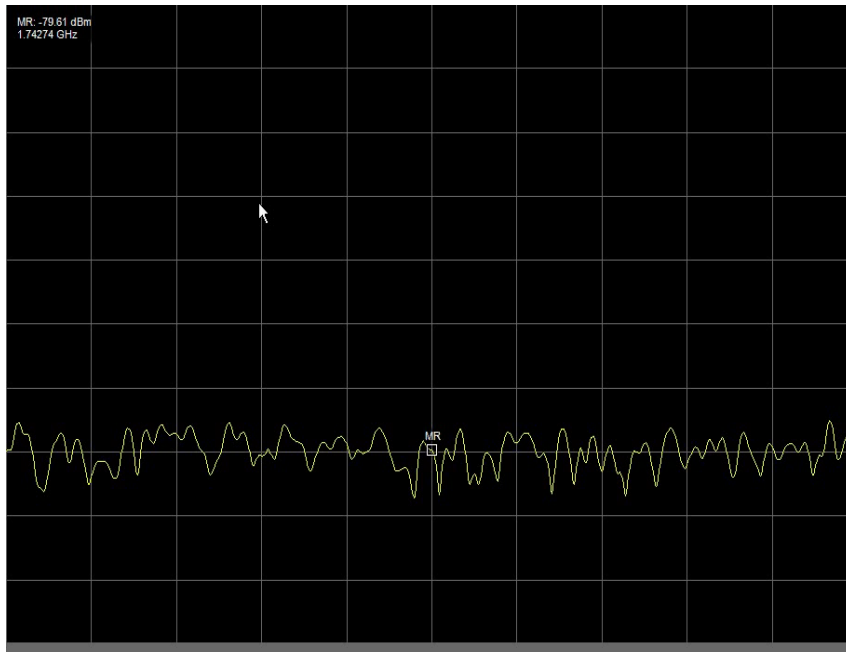




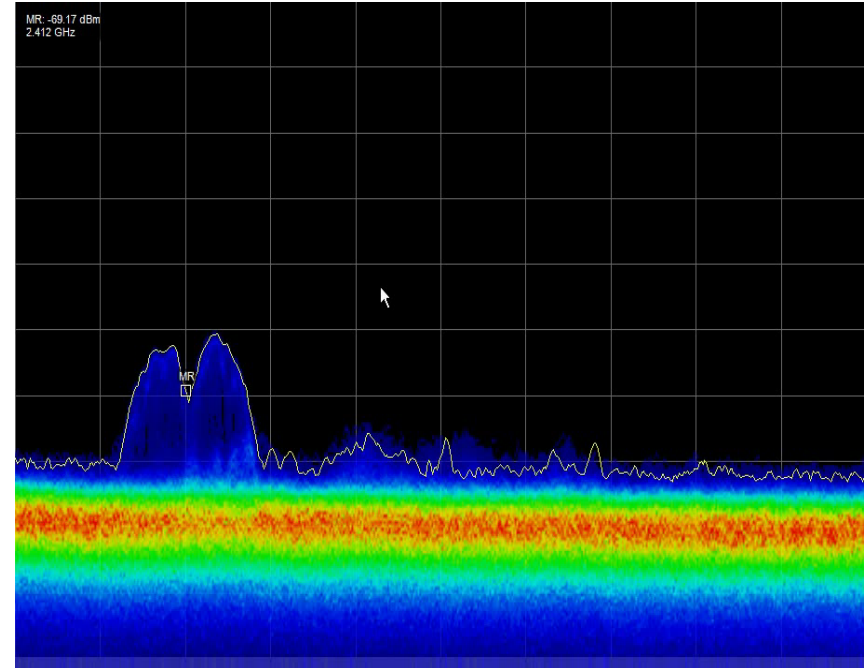
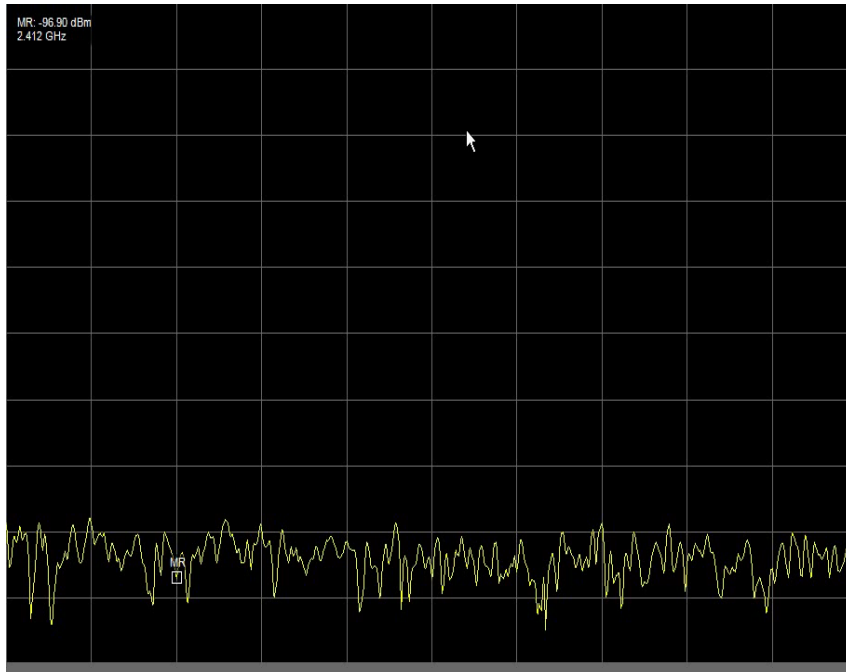




GSM 1800

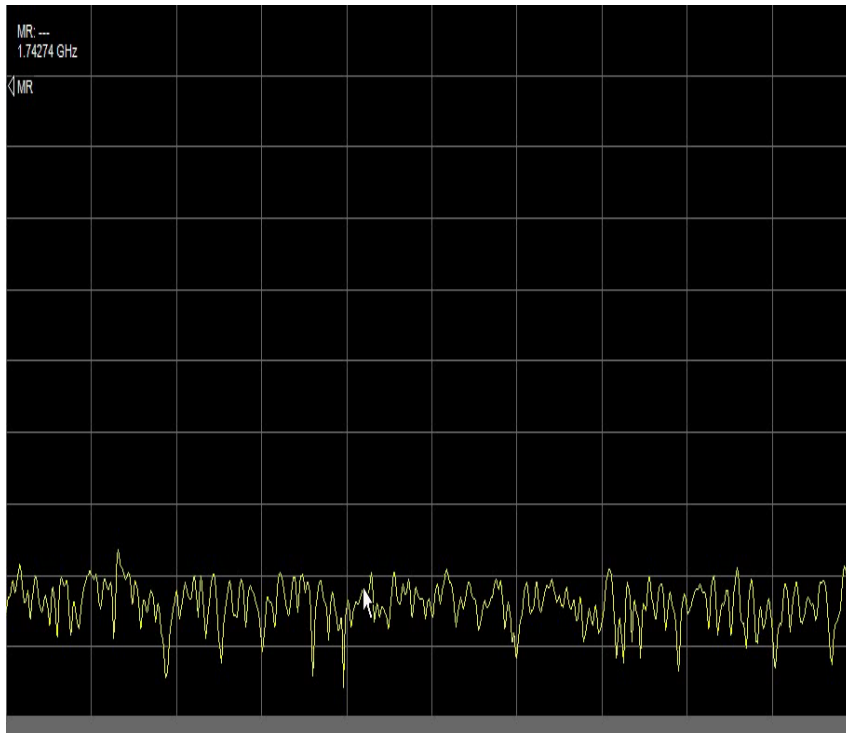


ISM band (WLAN802.11b/g & Bluetooth)

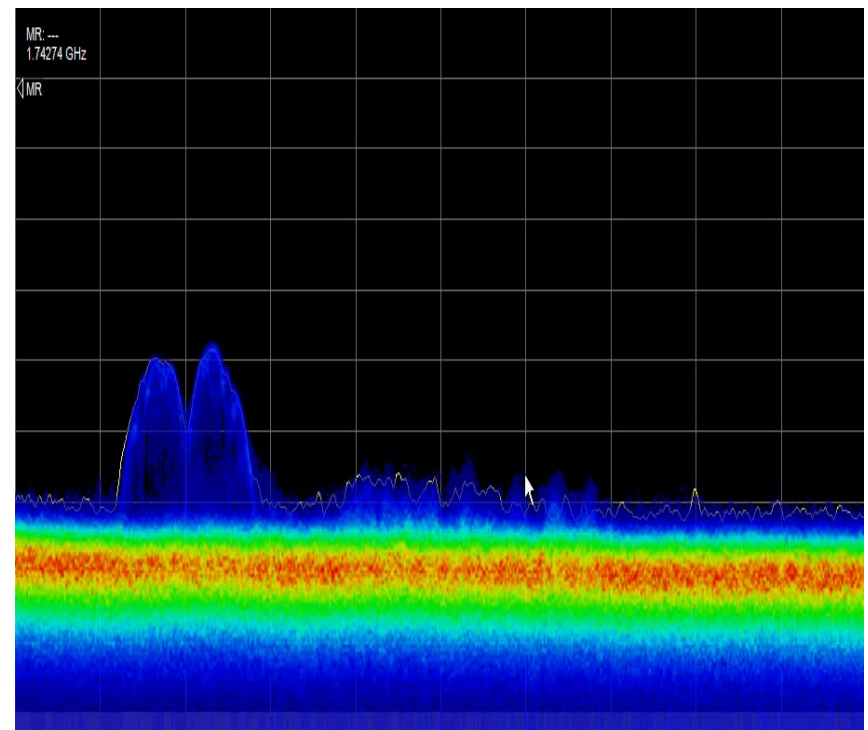


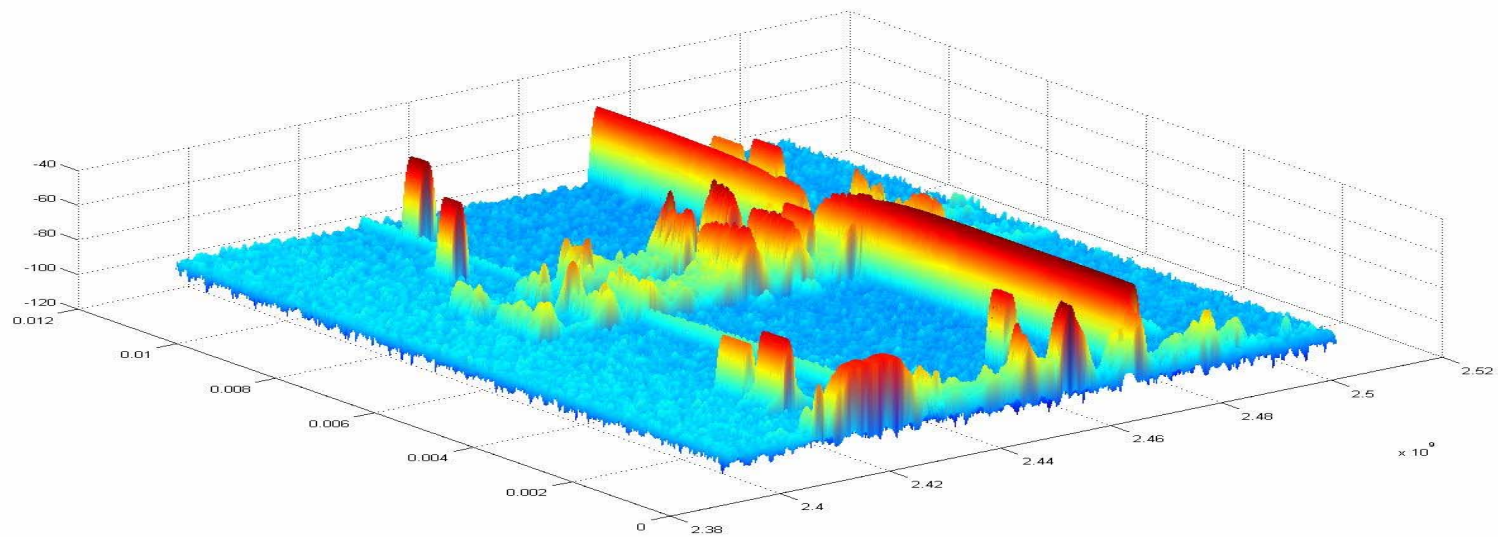
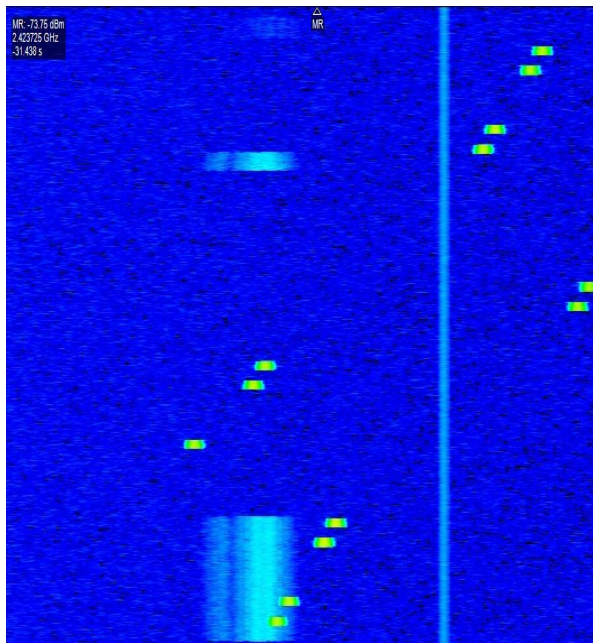
ISM band (WLAN802.11b/g & Bluetooth)

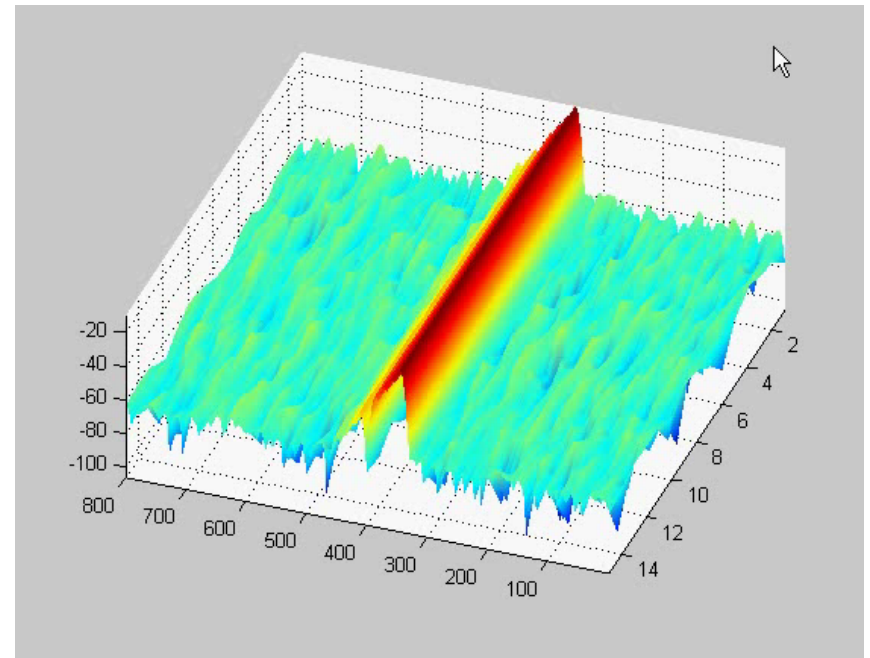
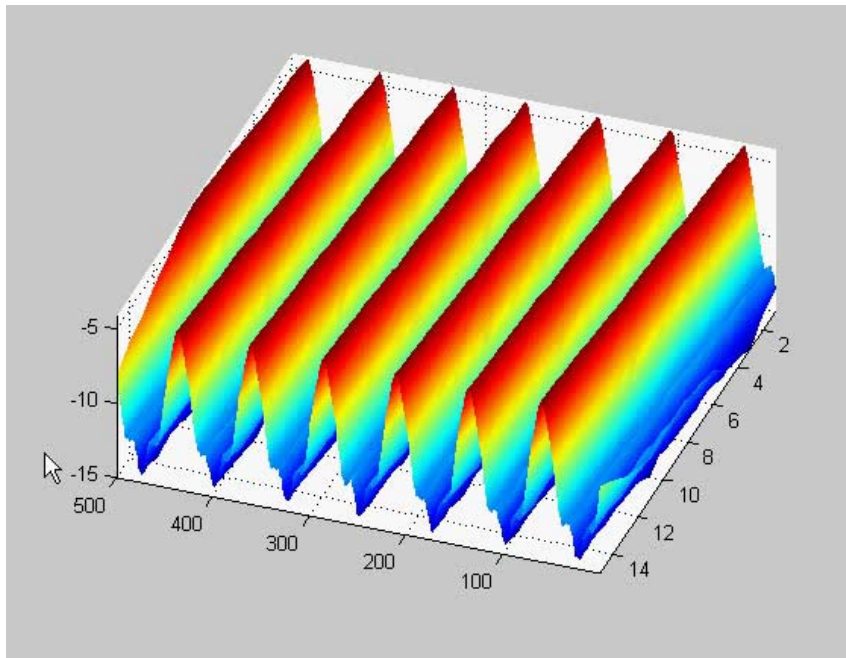
MaxiumHold



Bitmap infinite



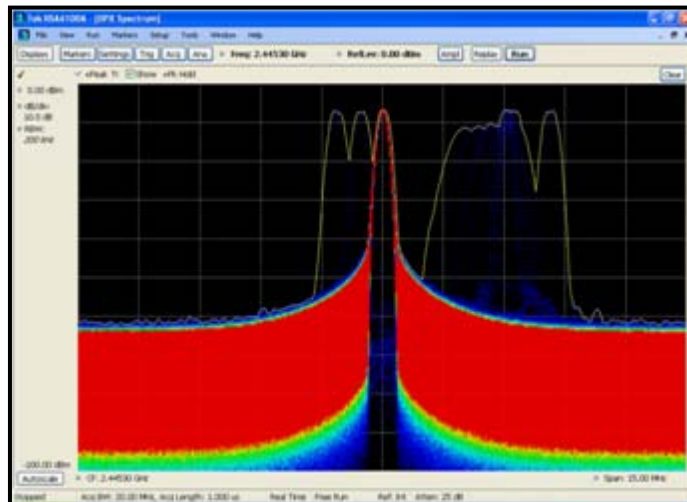




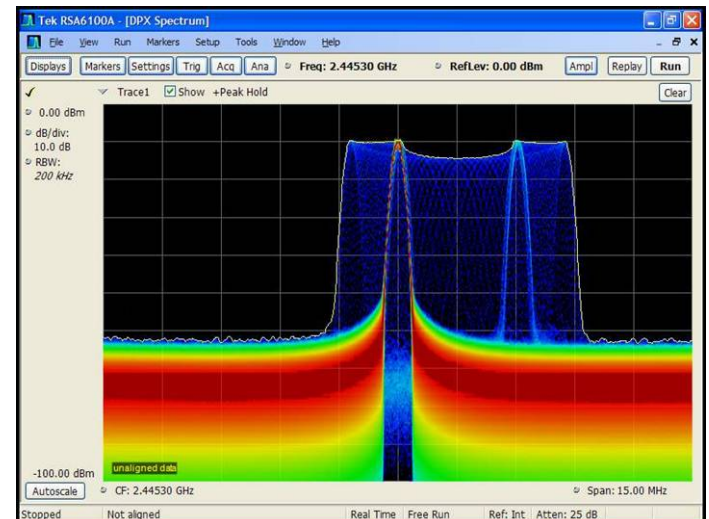
DPX demo

2nd Generation DPX™ Live RF Spectrum Display

■	DPX 第一代	DPX 第二代
■ 每秒頻譜更新率	48,000張/每秒	292,000張/每秒
■ 100%攔截訊號	24us	10.3us
■ 畫面解析度	201 x 501	201 x 801
■ 每畫數點可累積之量測次數	65K	8,000,000K
■ 解析度RBW	不可調	可調
■ 使用DPX觸發擷取異常訊號	不可	可



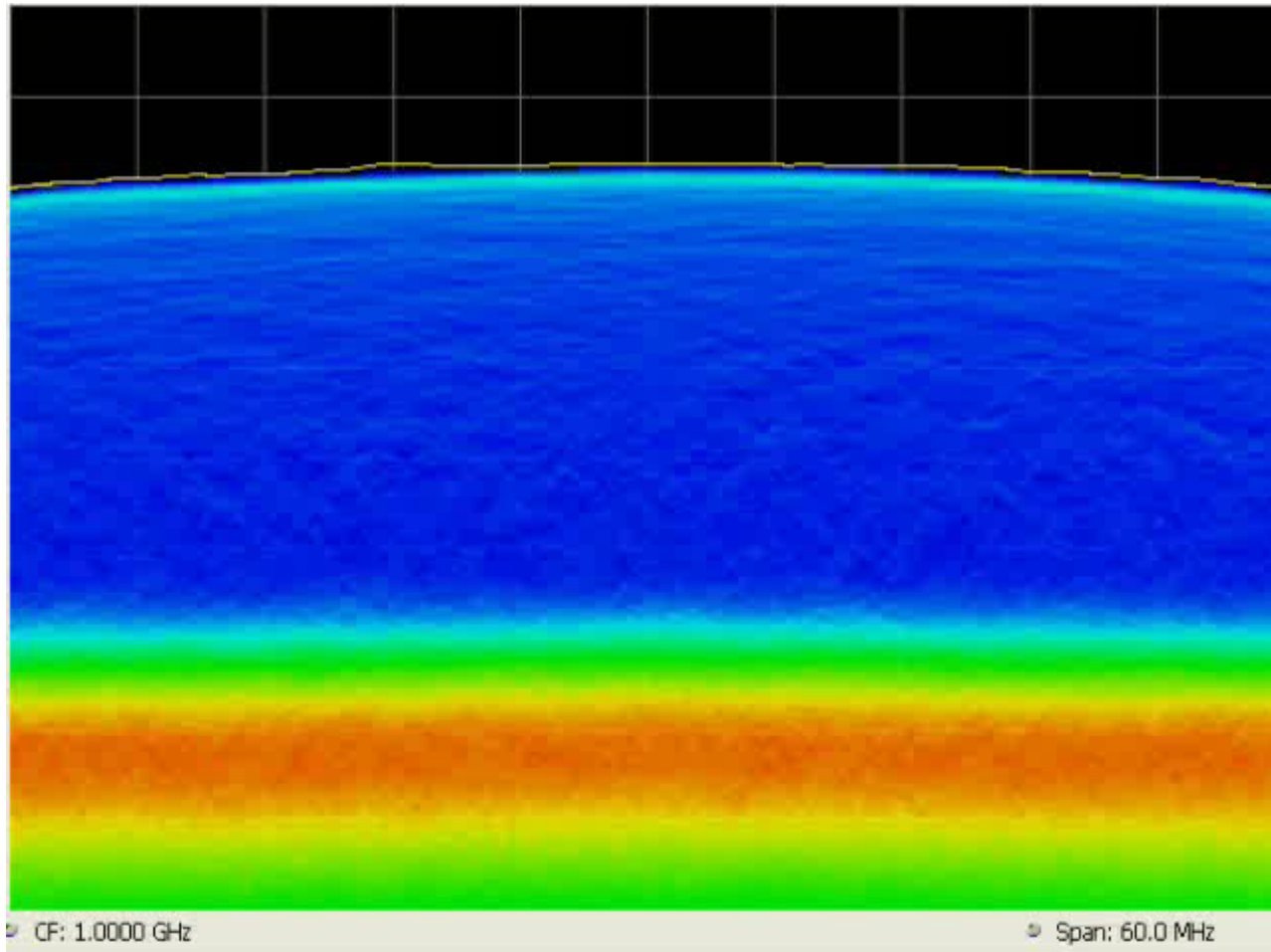
1st Generation DPX (~5s)



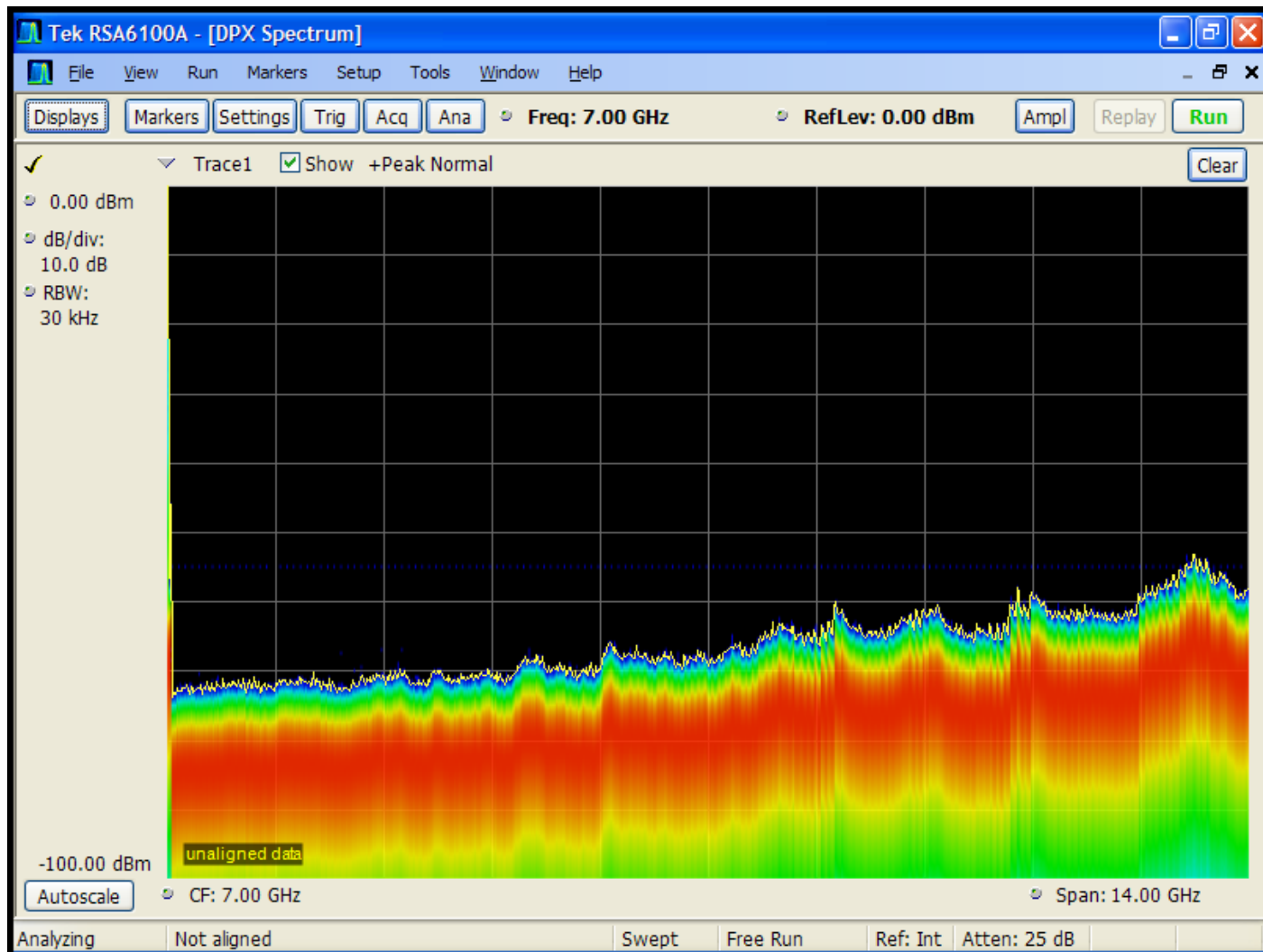
2nd Generation DPX (~5s)

Re-invention of Swept Spectrum Analysis

- Improved wideband signal search with highest probability of detection

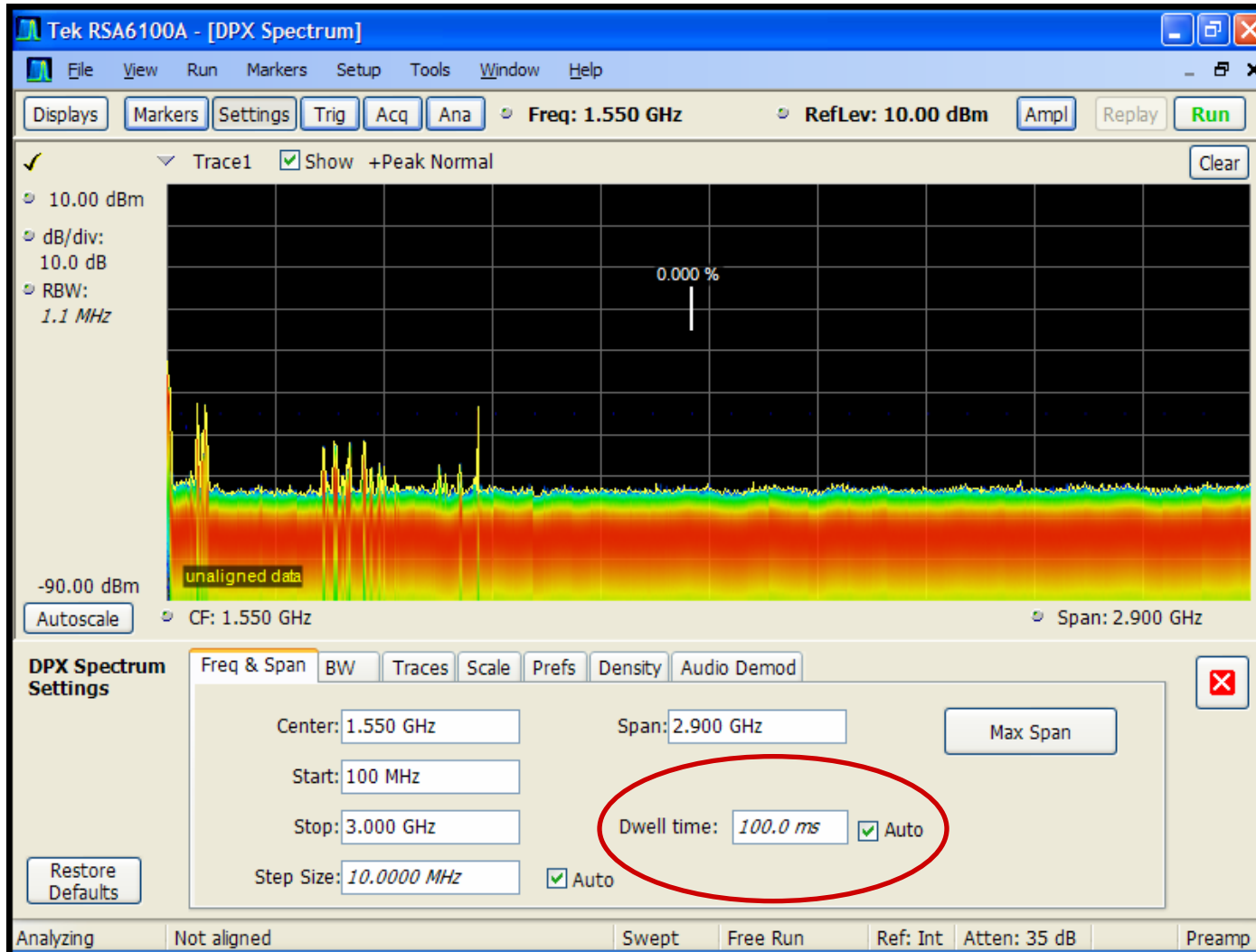


Swept DPX! 9 kHz – 20 GHz DPX



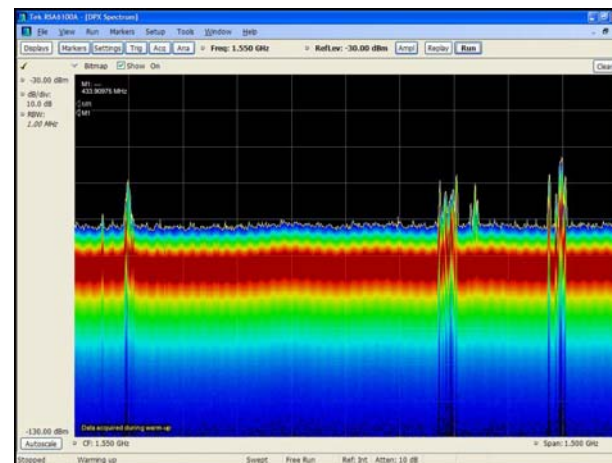
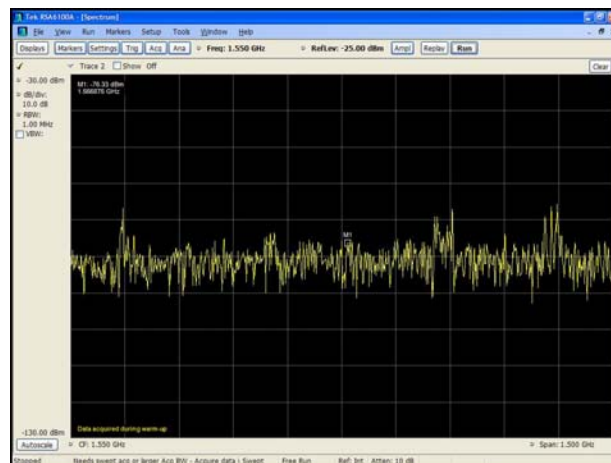
Swept DPX!

set Step Size and Dwell Time in wide band sweep

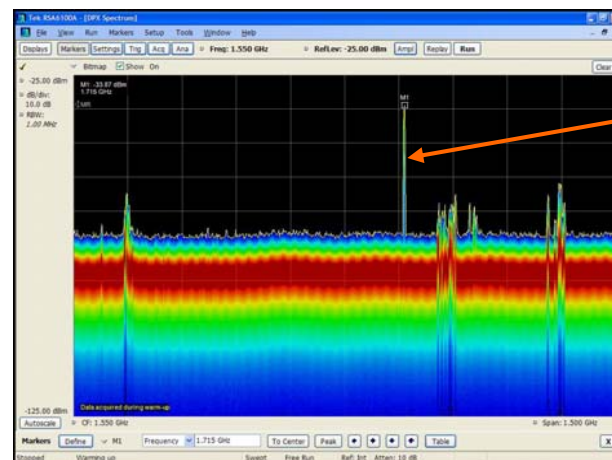
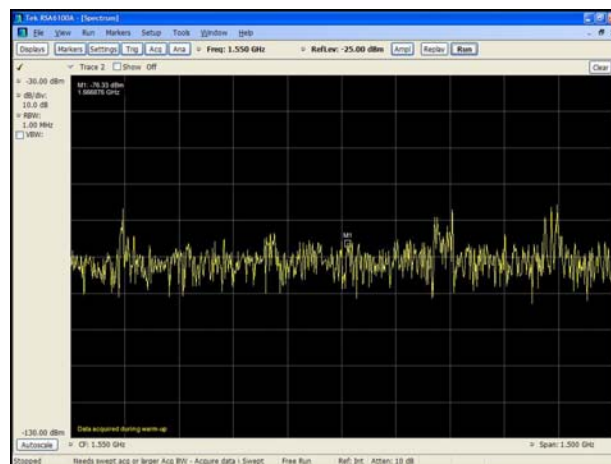


Dwell time:
40 msec to
100 sec

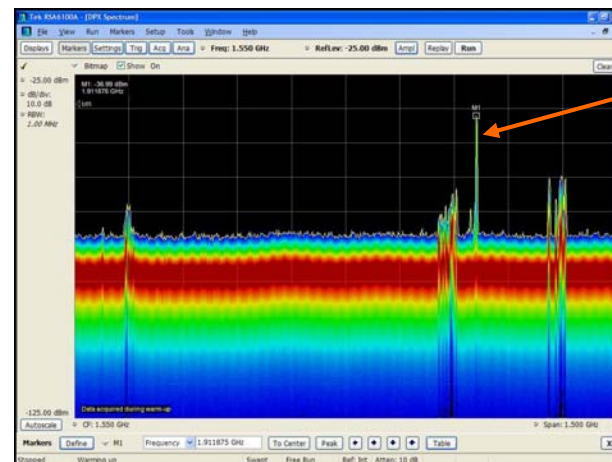
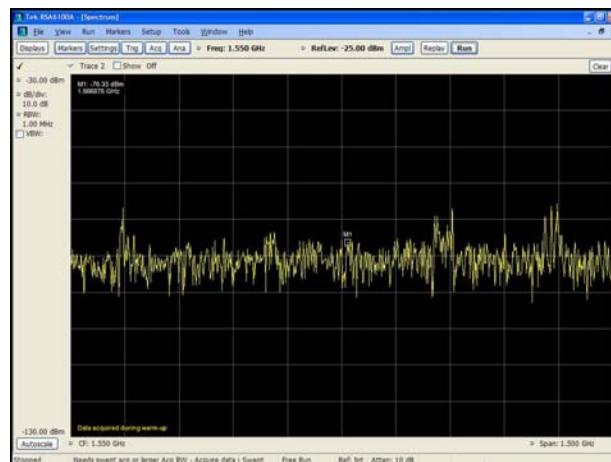
背景訊號頻譜



撥打GSM



撥打PHS



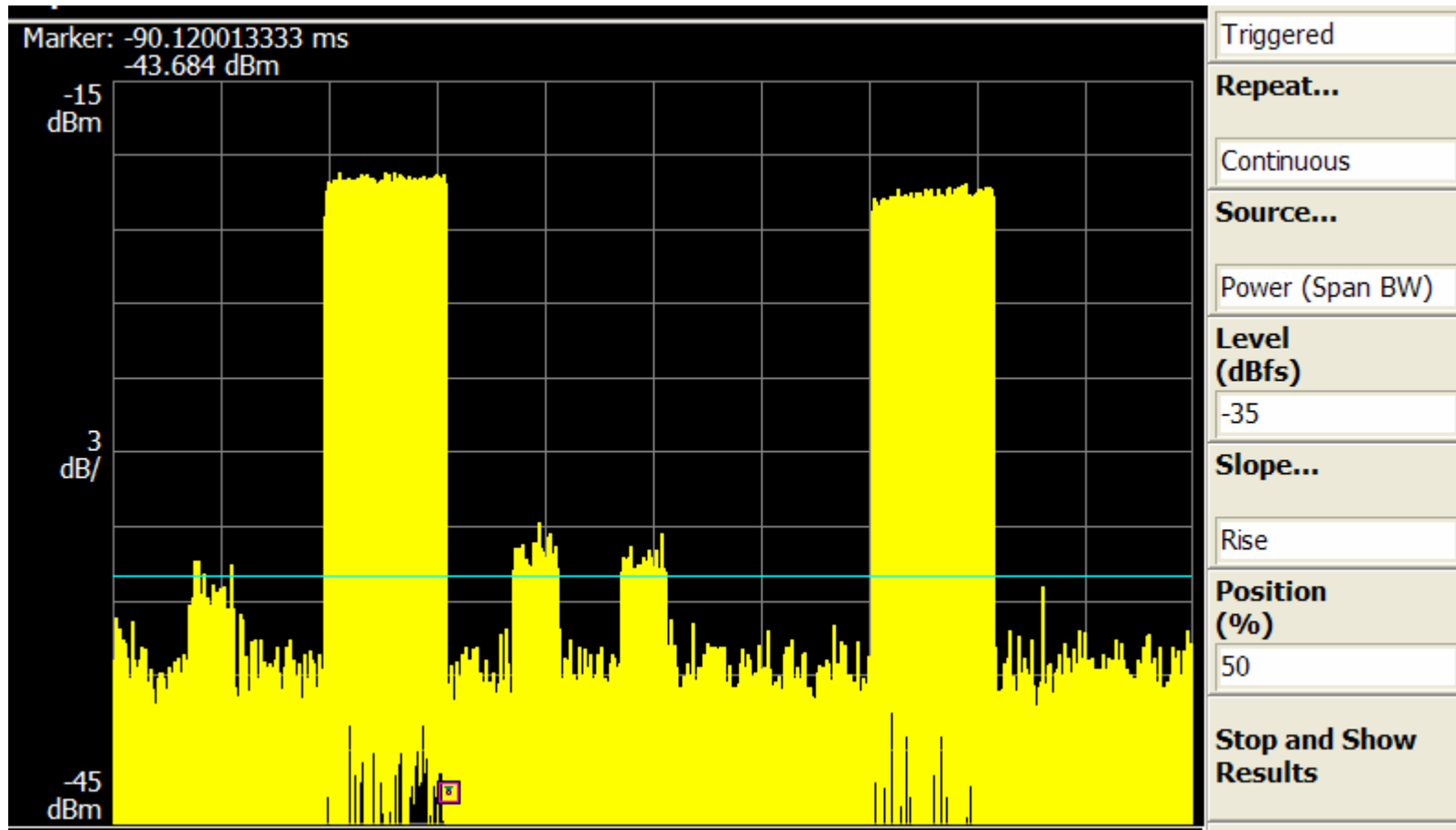
Sweep-DPX Demo

- 如何保證**100%**不間斷頻譜顯示 & Demo
- 如何攔截捕捉特定訊號
- 多域同步分析
- 應用實例(**Case Study**)

如何捕捉攔截特定訊號

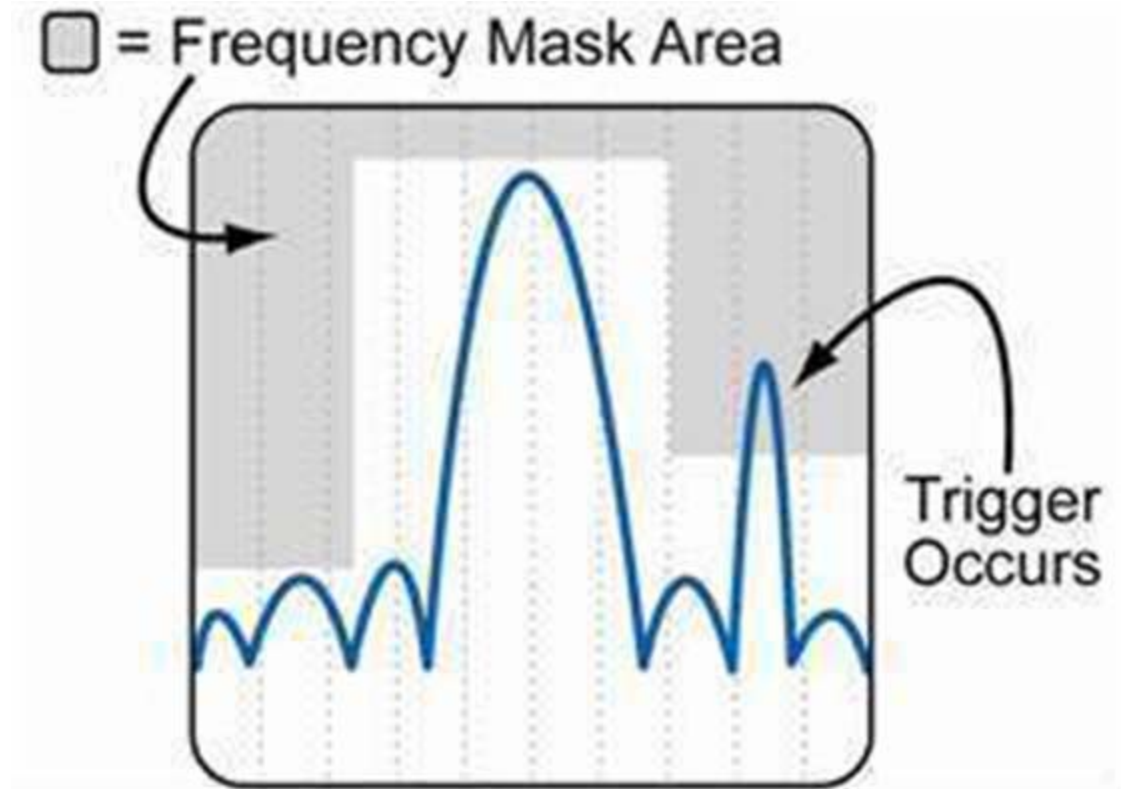
- 觸發功能
 - 能量觸發(Level/Power Trigger)
 - 外部觸發(External Trigger)
 - 數位螢光圖像觸發/頻譜密度觸發(DPX Trigger)
 - 時間軸觸發(Time domain Trigger)

能量觸發 (Level/Power Trigger)



Frequency Mask Trigger. Unique to Tektronix.

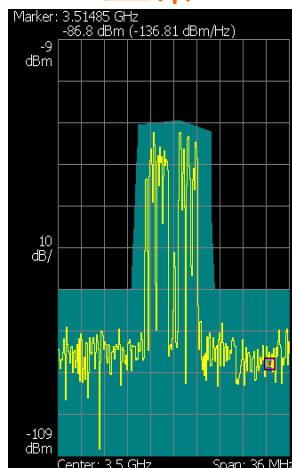
- Define a frequency mask which can be used to trigger on specific events in the frequency domain
- Reliably detect and capture elusive RF signals that a level trigger cannot see in a crowded spectral environment



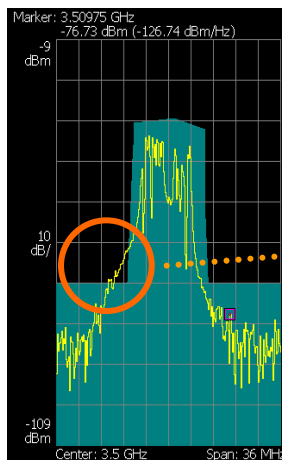
頻罩觸發(Frequency Mask Trigger)

檢查頻譜異常
之WiMAX訊號

正常

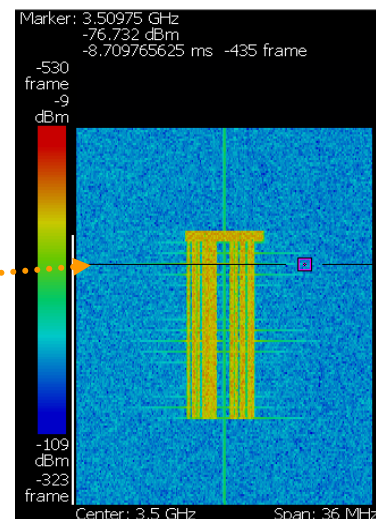


異常



觸發點

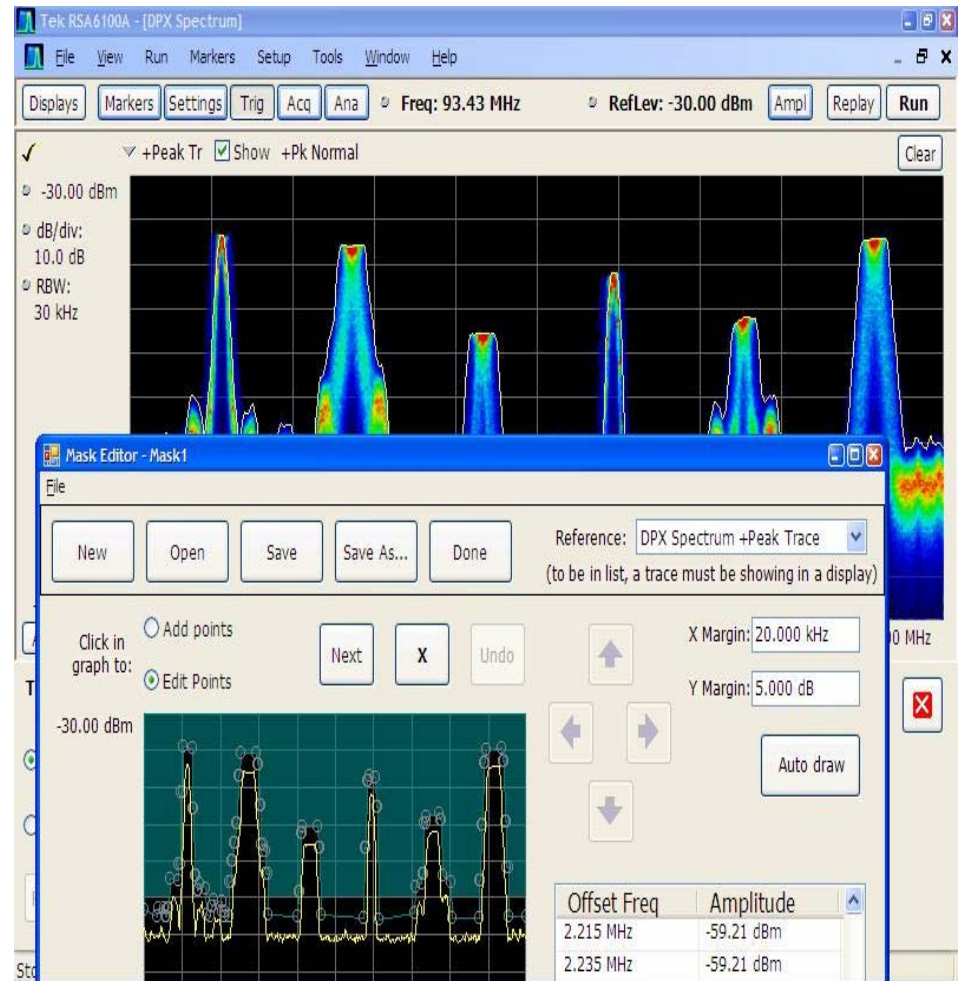
擷取問題訊號



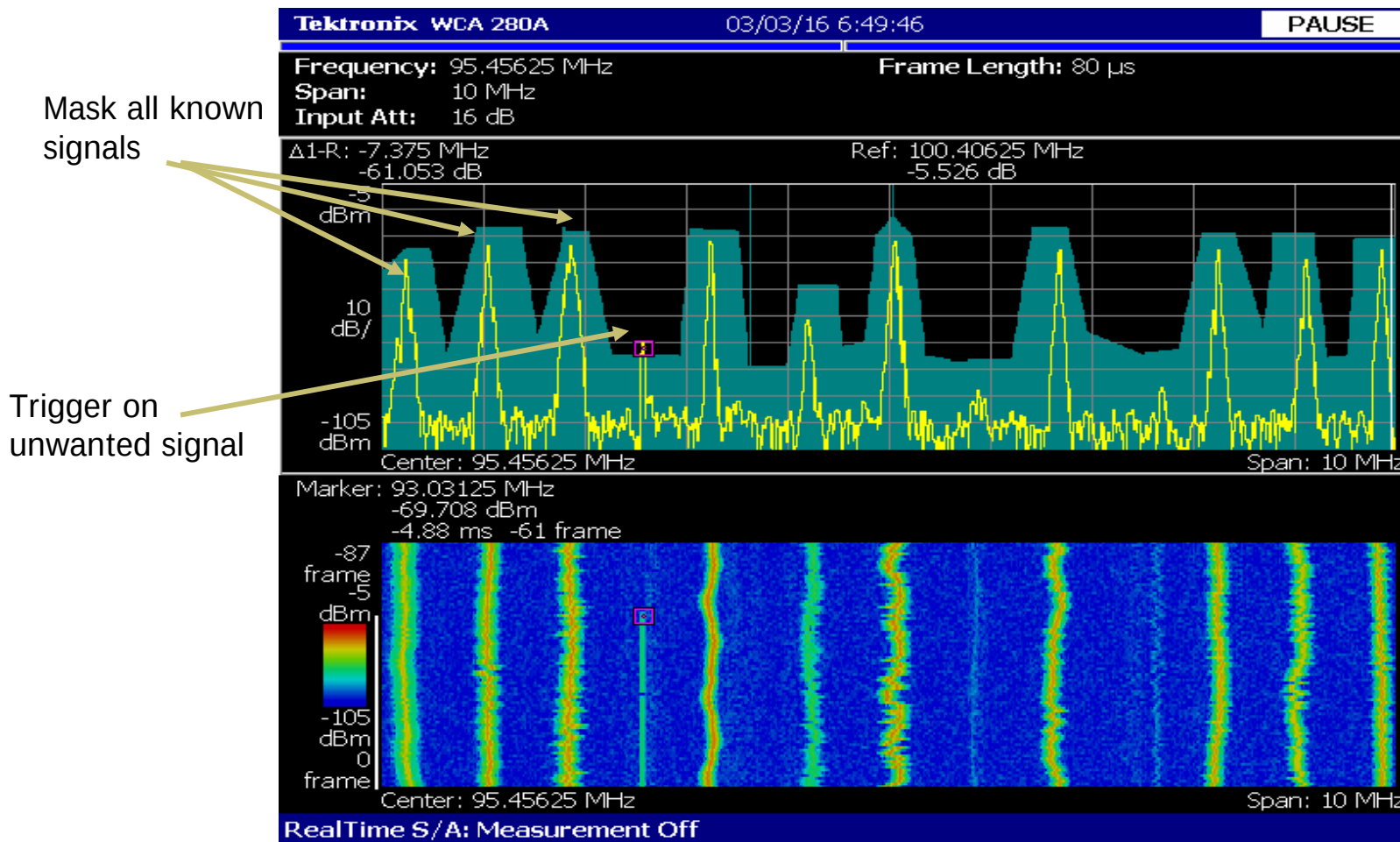
輕易抓出異常的訊號頻譜與干擾訊號!!

Why do you need Trigger

- Why do you trigger?
 - Efficient use of Captured Memory
 - Time correlation of events
- How do you trigger?
 - Power trigger
 - External event trigger
 - Frequency Mask Trigger (FMT)
 - Set a Mask Precisely & Capture

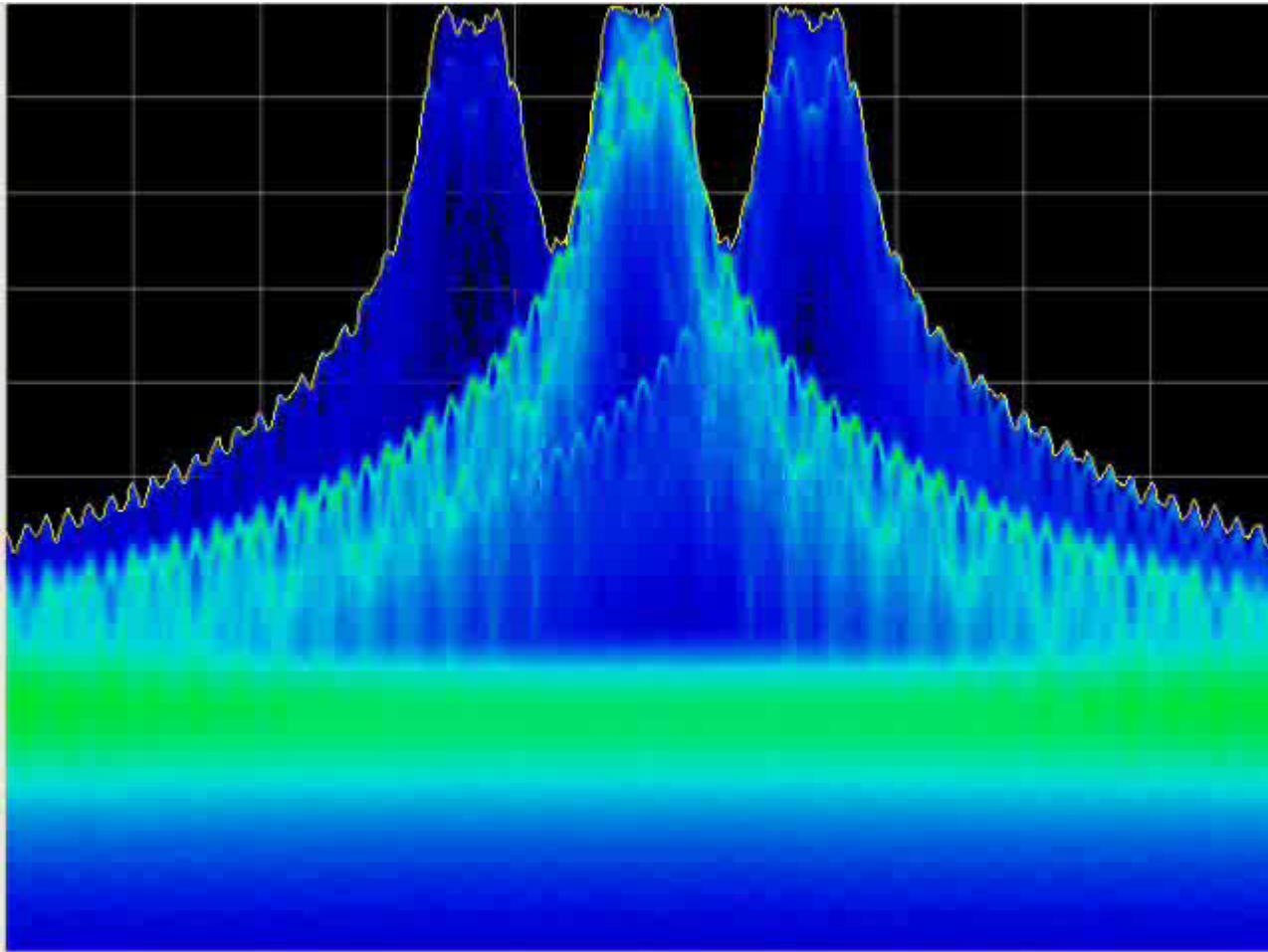


Frequency Mask Trigger and Spectrogram Example



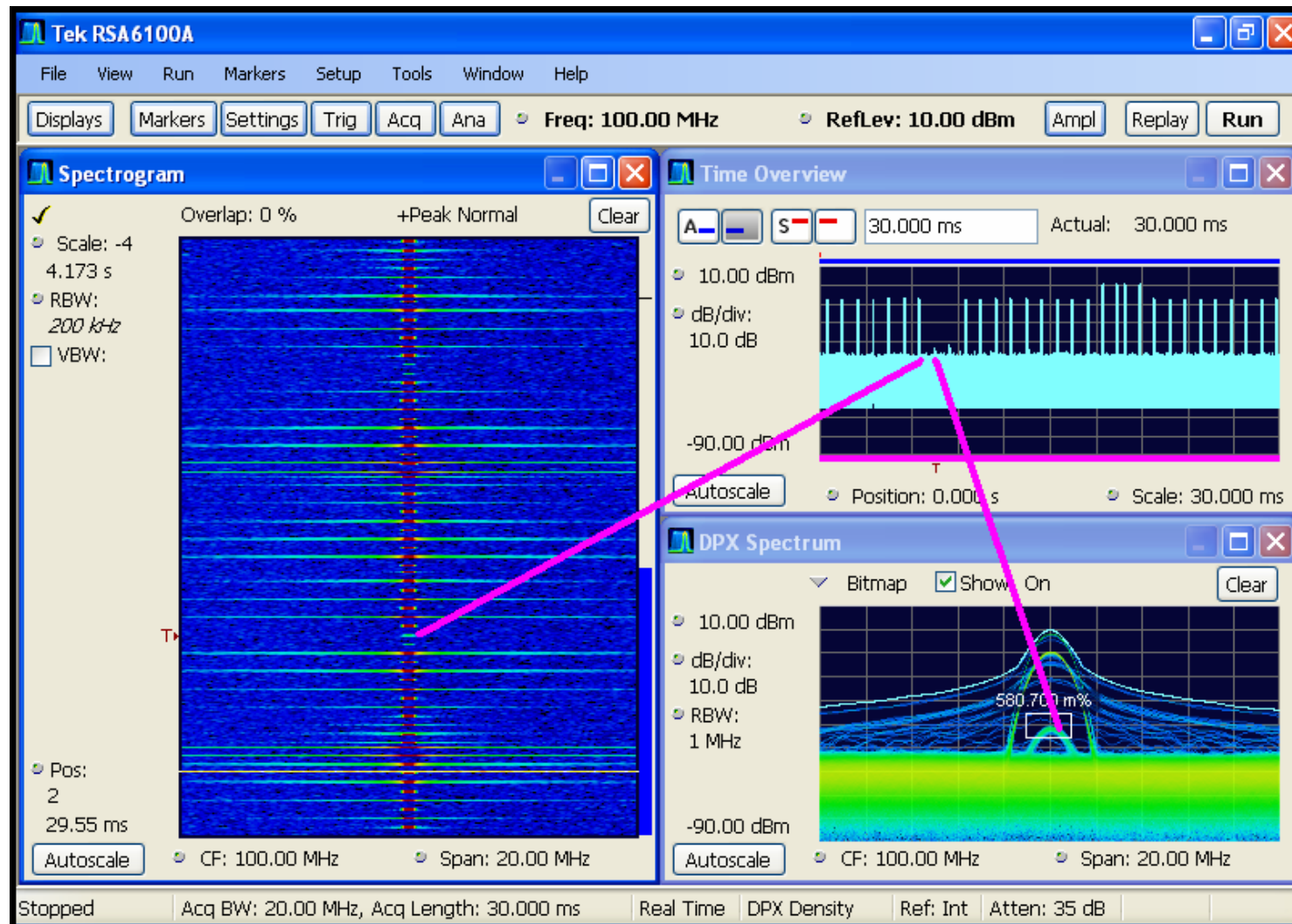
數位螢光圖像觸發/頻譜密度觸發(DPX Density Trigger)

- If you can see it, DPX Density™ trigger will trigger on it



DPX Density ® Trigger

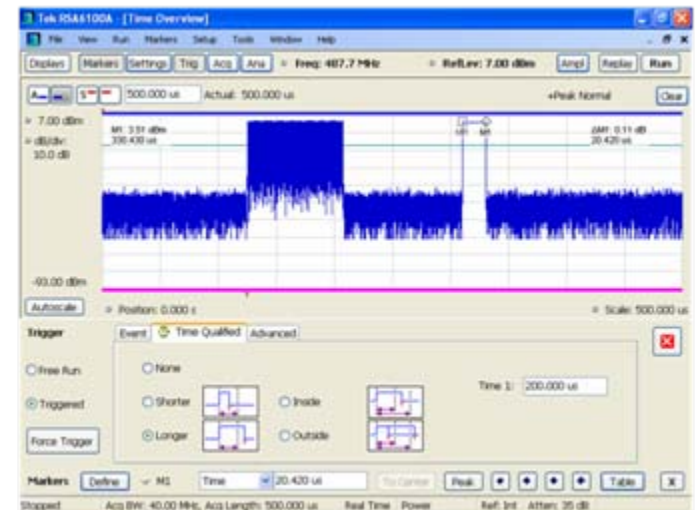
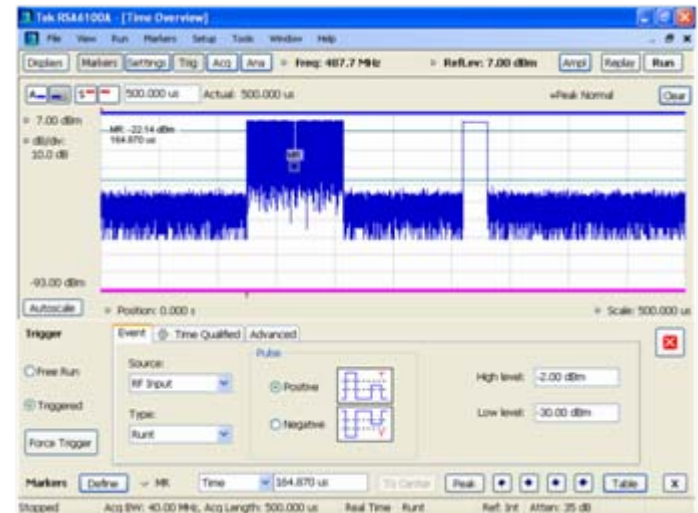
Trigger on signal's actual probability anywhere in display



Note "T" –
Trigger pos
In Time
Overview

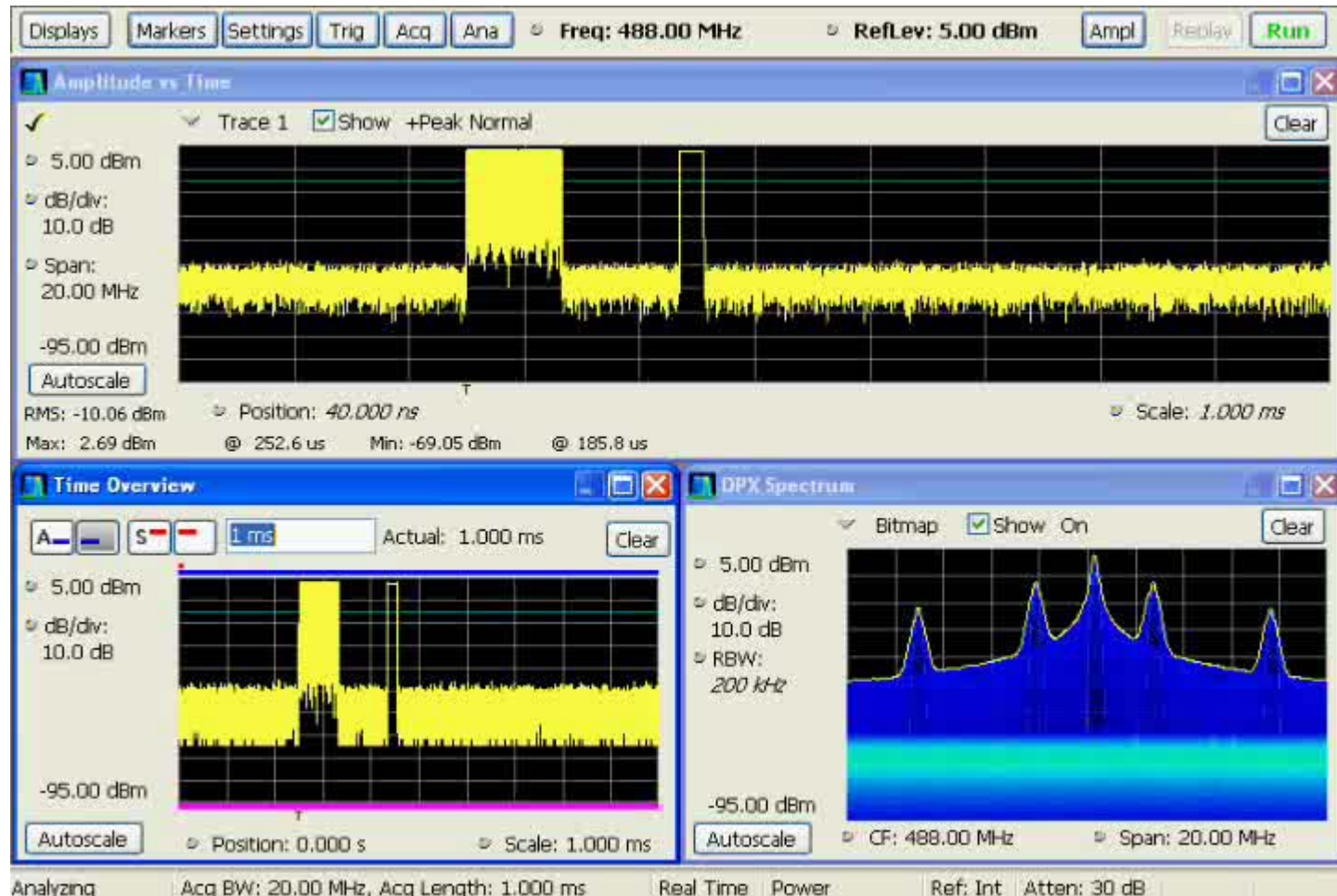
時間軸觸發(Time domain Trigger)

- Leveraging oscilloscope expertise in time-domain triggering
 - Capture only what you care about
- Time qualify and holdoff any triggers
 - Eliminate false triggers
- Runt trigger
 - Amplitude qualified trigger
- For Radar / EW
 - Isolate pulses of specific amplitude and/or width within a pulse train



Time-qualified triggers, runt triggers

- Separate short, high resolution pulses from longer range pulses in a radar
- Find the one pulse in a thousand that doesn't meet specification



- 如何保證**100%**不間斷頻譜顯示 & Demo
- 如何攔截捕捉特定訊號
- 多域同步分析
- 應用實例(**Case Study**)

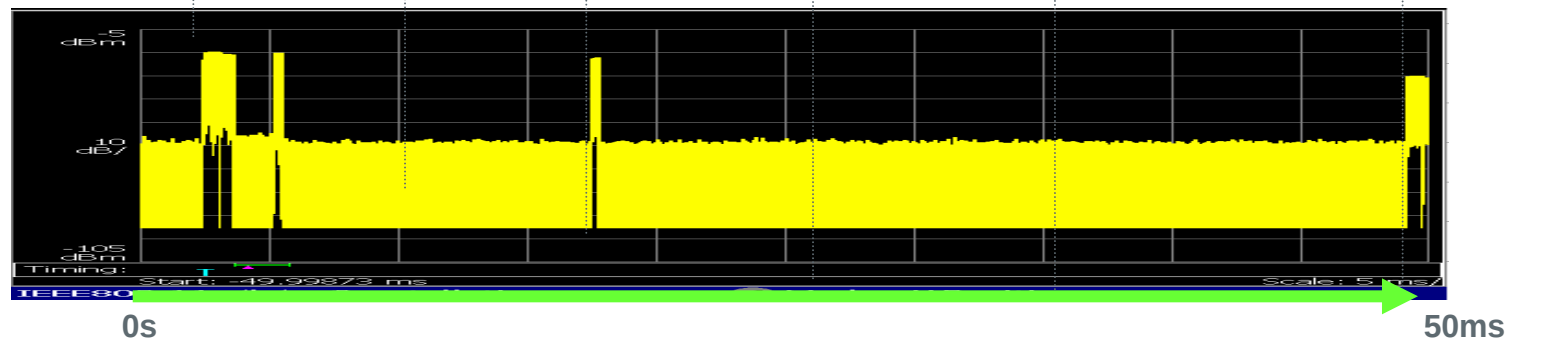
0s

RT Spectrum Analyzer

Continuous
Frequency domain

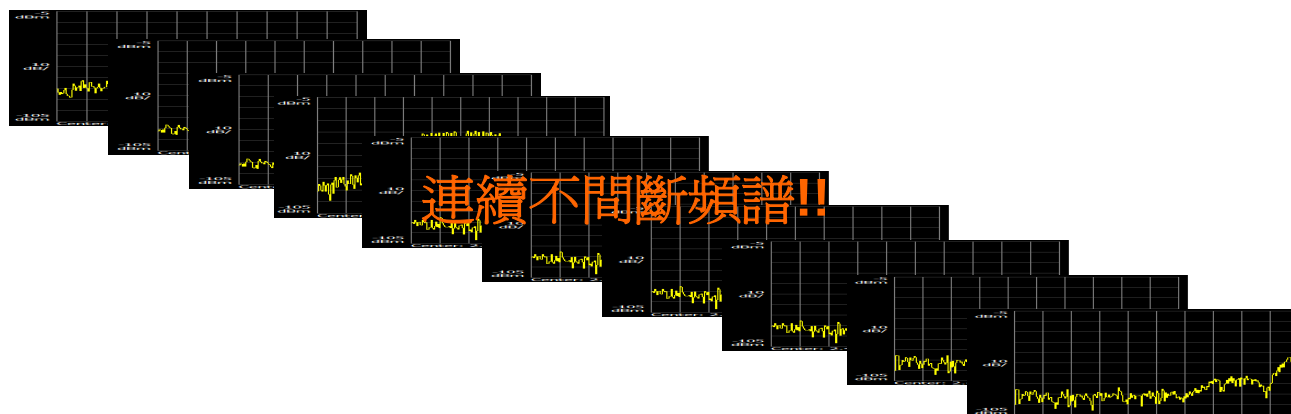
50ms

Time domain

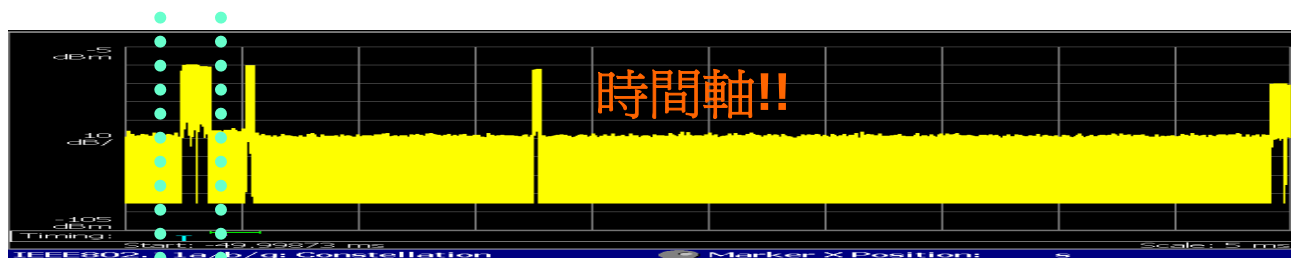


即時頻譜儀(RTSA)功能 三機合一

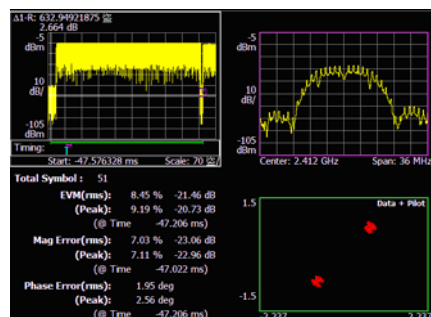
頻譜分析儀(SA)



示波器(Scope)



向量訊號分析儀
(VSA)



任意時間軸訊號分析解調!!

A spectrogram of a speech signal. The x-axis represents time, and the y-axis represents frequency in kHz. The plot shows several distinct formants (vertical bands of energy) corresponding to the vowels in the utterance. A blue box labeled "PAUSE" is positioned over a low-frequency region, with a red arrow pointing to it from the left. The bottom of the plot is a solid red bar.

Tektronix RSA 3408A 12/21/2006 11:13:01 AM **PAUSE**

Frequency: 1.5 GHz
Span: 36 MHz
Input Att: 15 dB

Spectrum Length: 25 μ s
Spectrum Interval: 25 μ s
NBW: 80.174 kHz

Marker: 2.44864 GHz
-69.765 dBm
-14.7 ms -587 frame

-20 dBm
10 dB/

Center: 2.445 GHz Span: 30 MHz

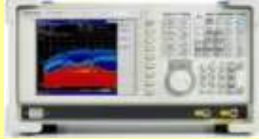
Center: 2.445 GHz Span: 30 MHz

The image shows a Tektronix RSA 3408A spectrum analyzer interface. The top status bar displays the device name, date, time, and a 'PAUSE' button. The left panel shows the main frequency settings: 1.5 GHz, 36 MHz span, and 15 dB input attenuation. The right panel shows the spectrum length (25 μ s), spectrum interval (25 μ s), and noise bandwidth (NBW) of 80.174 kHz. A marker is placed at 2.44864 GHz, indicating a power level of -69.765 dBm and a time of -14.7 ms, corresponding to frame -587. The main display area is split: the left side shows a frequency spectrum with a peak at the marker frequency, and the right side shows a waterfall plot (time-frequency plot) with a color-coded intensity scale from -120 dBm to -20 dBm. The waterfall plot shows a signal that is relatively stable in frequency but has some time-varying characteristics. The bottom of the screen shows the center frequency (2.445 GHz) and span (30 MHz) for both the main spectrum and the waterfall plot. Two orange arrows are overlaid on the image: one points to the 'PAUSE' button, and the other points to the main spectrum plot area.

The screenshot displays a Spectrum Analyzer (SA) interface with the following components:

- Top Bar:** Includes a "PAUSE" button and a "MEASURE" button.
- Frequency Settings:**
 - Frequency: 2.44772 GHz
 - Span: 1 MHz
 - Input Att: 25 dB
- Acquisition Length:** 2 s
- Left Plot (Spectrum):** A waterfall plot showing frequency over time. The y-axis ranges from -1730 frame to -1208 frame, and the x-axis ranges from -20 dBm to -120 dBm. A color bar on the left indicates power levels from -120 dBm to -1730 dBm.
- Right Plot (SA):** A line graph showing the signal spectrum. The y-axis ranges from -20 dBm to -120 dBm, and the x-axis ranges from -2.237 to 2.237. The plot shows a signal with a peak at approximately -20 dBm.
- Marker:** 2.4476 GHz, -67.664 dBm
- Center:** 2.445 GHz, Span: 30 MHz
- Measurements:**
 - EVM: 22.77 % RMS, 53.95 % Peak @ sym 14
 - Mag Err: 14.93 % RMS, -47.97 % Peak @ sym 264
 - Phase Err: 10.16 deg RMS, -32.67 deg Peak @ sym 14
 - Rho: 0.9507
 - Length: 1098 symbols
 - Freq Err: 2.01 MHz
 - Origin Offset: -34.86 dB
 - Scale: 779.383 μ V/Unit
- Bottom Plot (VSA):** A 2D plot showing the signal constellation. The x and y axes range from -1.5 to 1.5. The plot shows a complex signal with multiple clusters of points.
- Right Panel:** A list of measurement options:
 - Cancel - Back
 - Constellation
 - EVM
 - IQ/Frequency versus time (highlighted with an orange arrow)
 - Power versus time
 - Symbol Table
 - Eye Diagram
 - Measurement Off
 - Go to page 2 (of 2)

RSA and SA2600

					
	SA2600	H600	RSA3300B	RSA3408B	RSA6000A
Frequency Range	10kHz – 6.2GHz	10kHz – 6.2GHz	DC – 3/8GHz	DC - 8GHz	9kHz – 6.2/14/20GHz
Analysis Bandwidth	20 MHz	20 MHz	15 MHz	36 MHz	40/110 MHz
DPX Live RF	10000 frames/sec 2500 frames/sec	10000 frames/sec	48000 frames/sec	48000 frames/sec	48000,290000 frames/sec
DPX 100% POI*	125 usec/ 500 µsec	125 µsec	41 µsec	31 µsec	31/24/10µsec
Frequency Domain Triggering			✓	✓	✓

* POI = Probability of Intercept

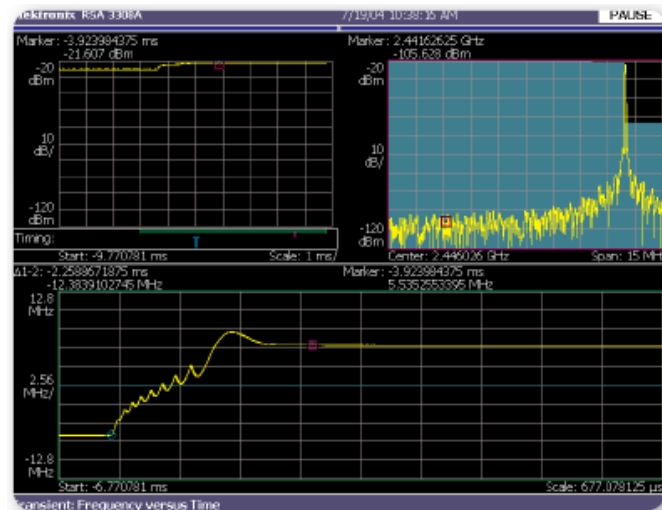
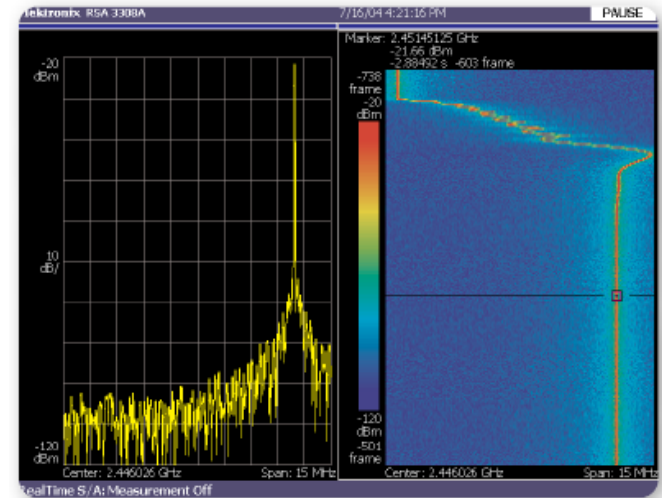
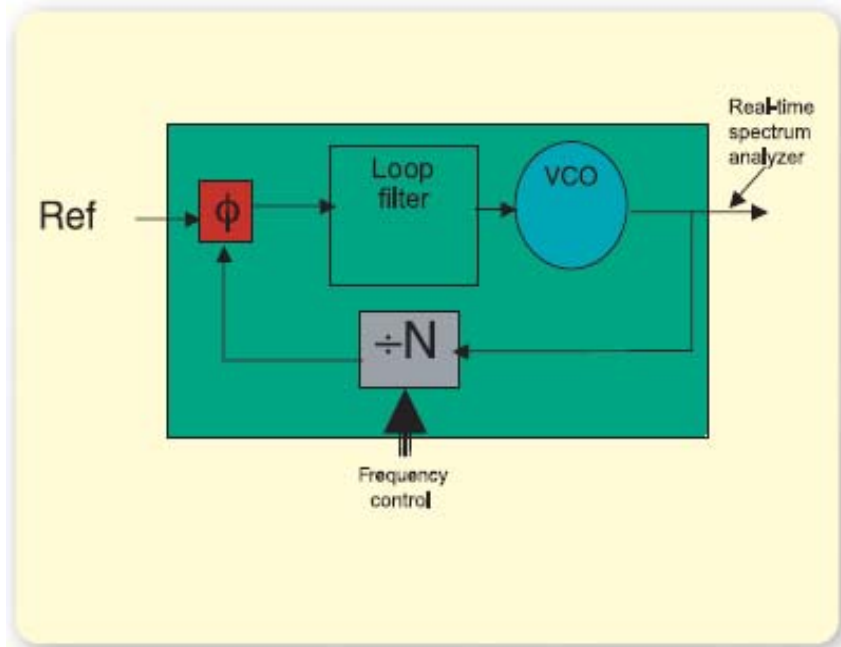
- 如何保證**100%**不間斷頻譜顯示 & Demo
- 如何攔截捕捉特定訊號
- 多域同步分析
- 應用實例(**Case Study**)

Cases Study

- 震盪器
- 放大器
- 即時頻譜監控與紀錄
- 捕捉干擾
- 通訊訊號實測分析
- 通訊系統維運(Base station)
- 暫態電磁干擾(Transient EMI)
- 軍用類比數位跳頻無線電(Military Radio)
- 軟體無線電(Software Define Radio)
- IED (Improvised Explosive Device)
- 分辨解調未知訊號

主動元件效能檢查

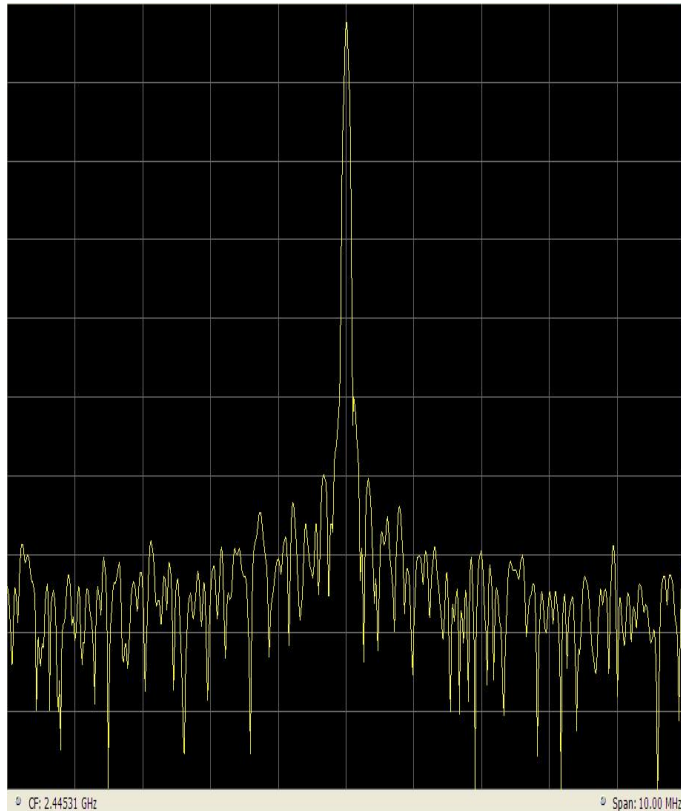
VCO訊號檢視(Real-time & Multi-domains)



主動元件效能檢查

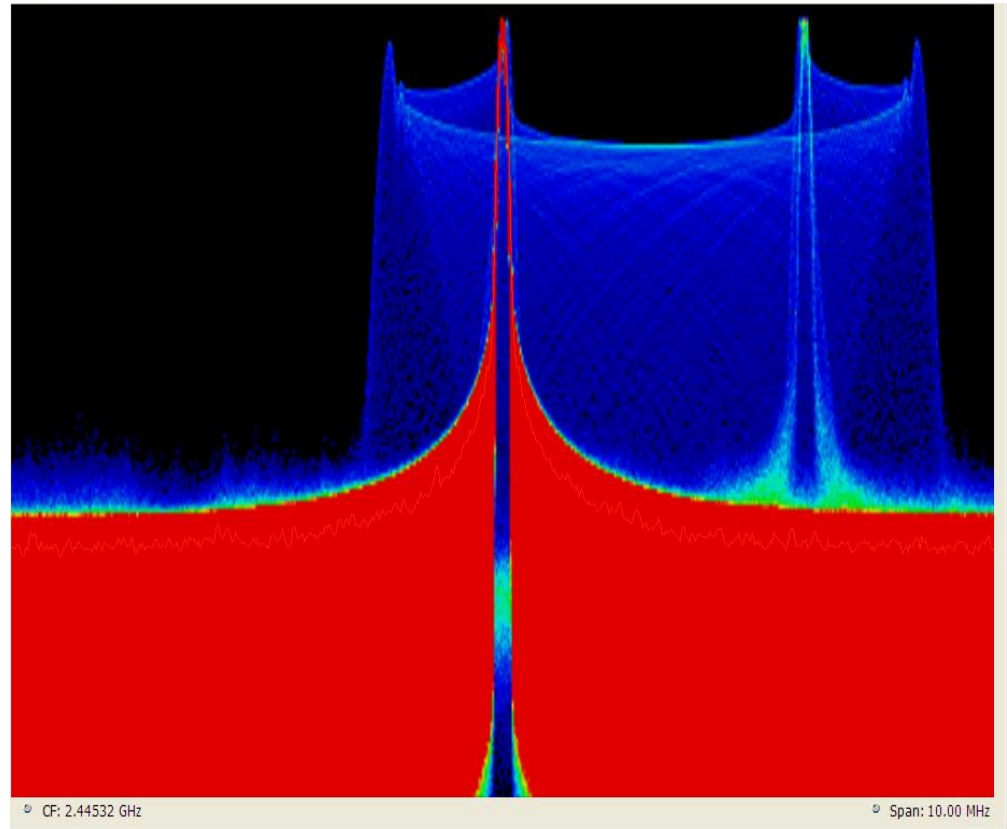
即時頻譜顯示(DPX)

傳統頻譜顯示畫面



掃頻不連續頻譜
每秒**60**張頻譜

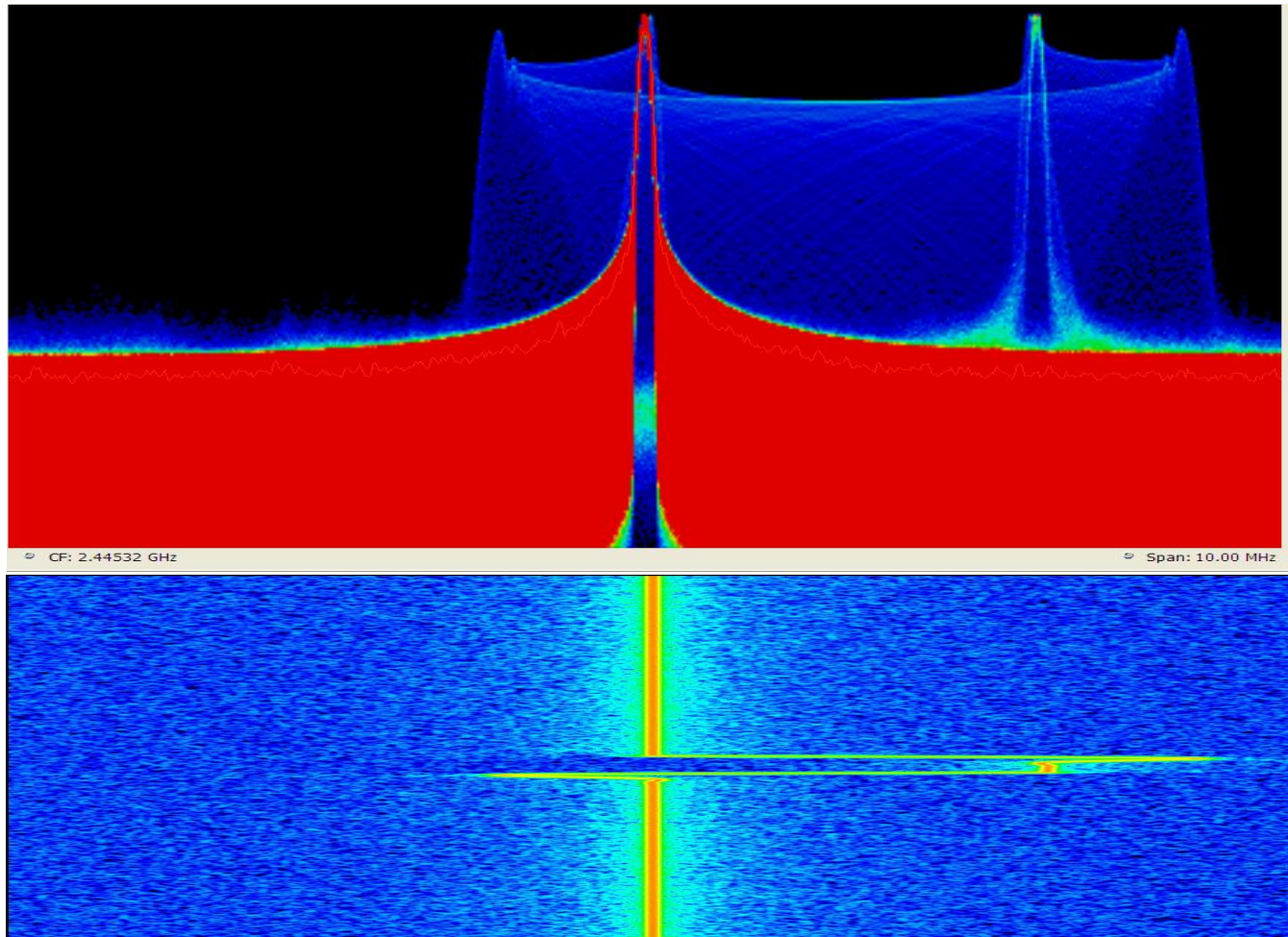
Tektronix RTSA即時頻譜看到的同一訊號異常現象

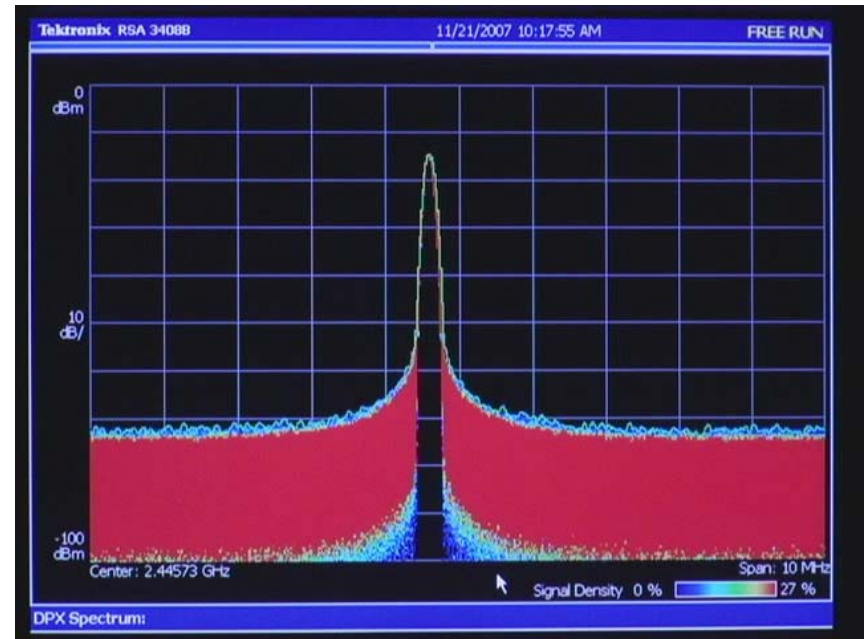
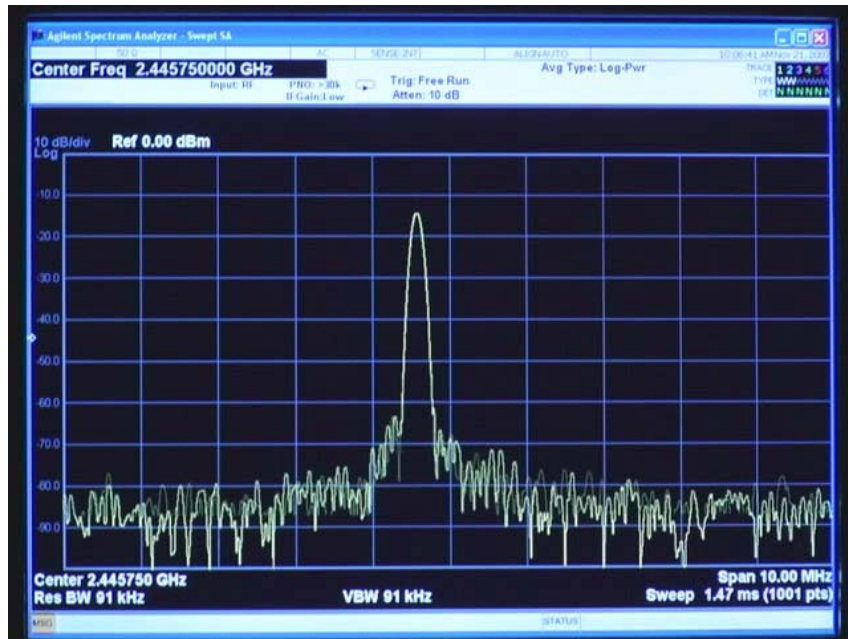


連續不間斷頻譜顯示
每秒**48000**張頻譜

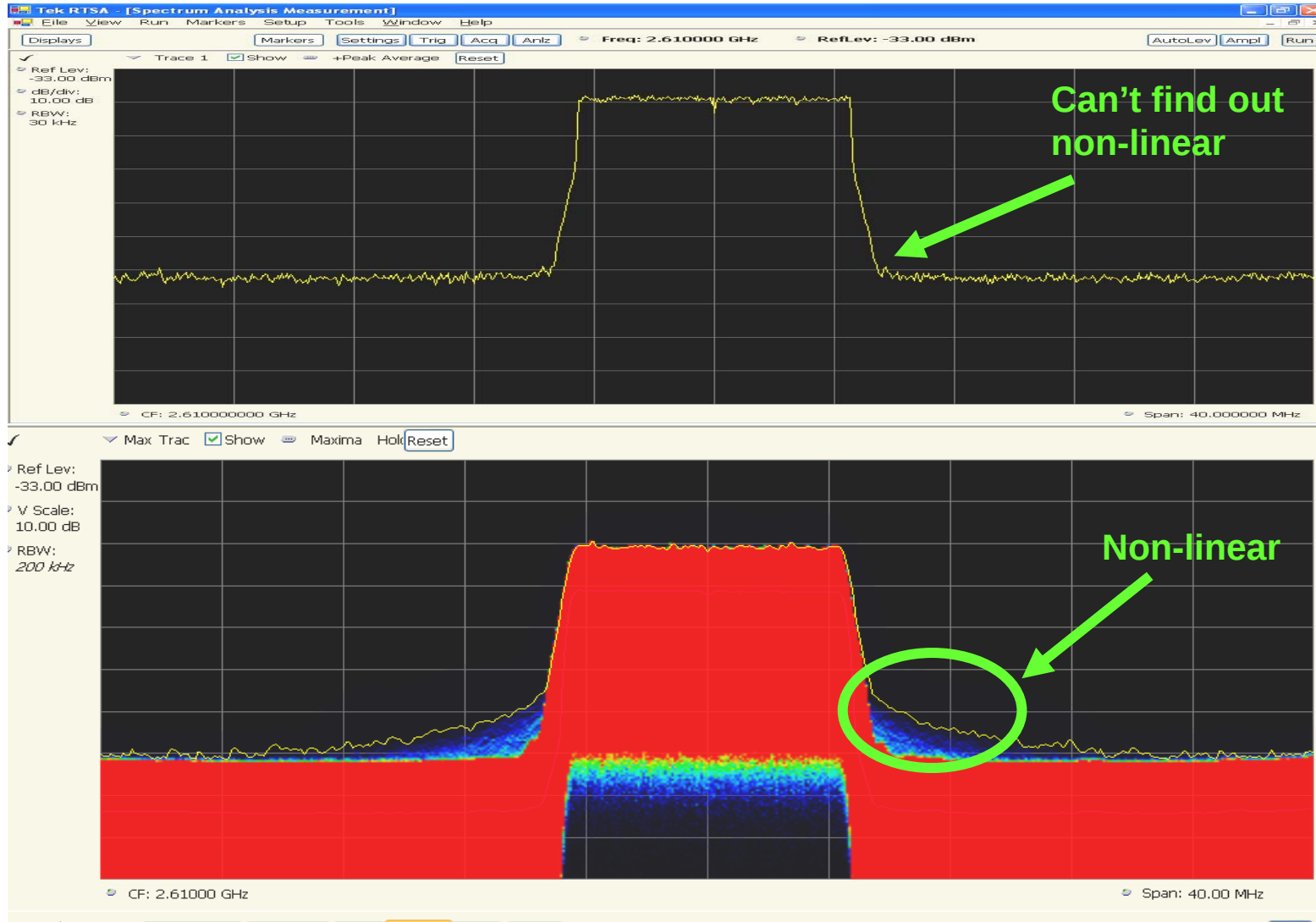
主動元件效能檢查

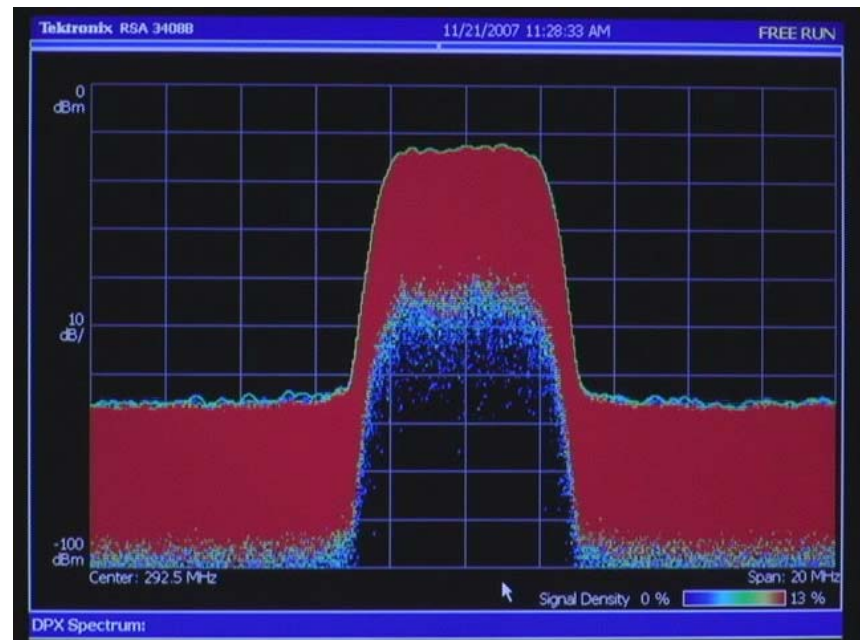
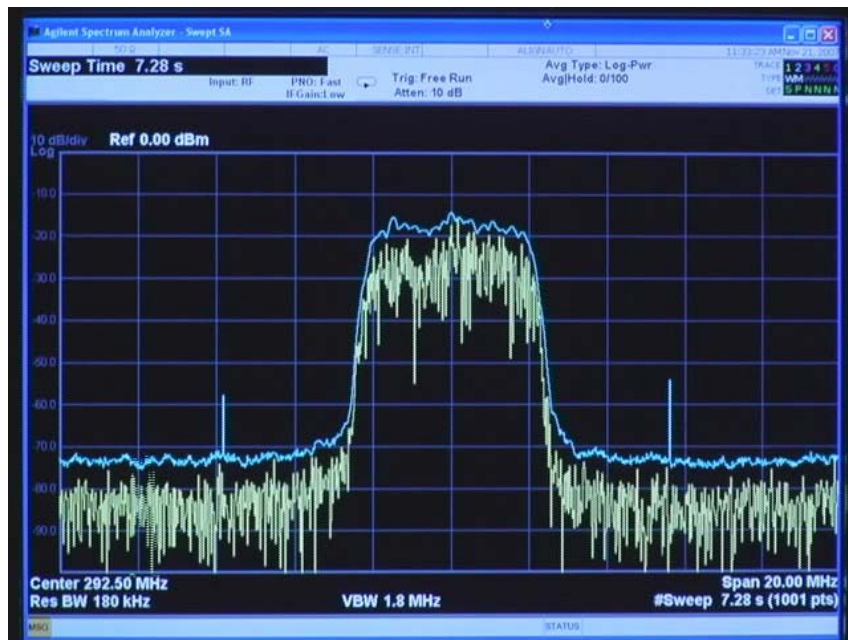
VCO訊號異常檢視(DPX)





放大器設計與線性度效能檢查



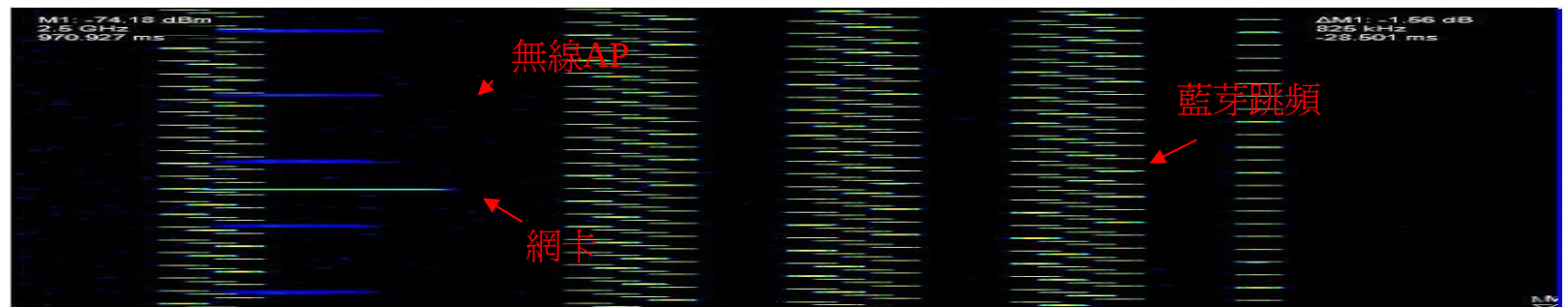
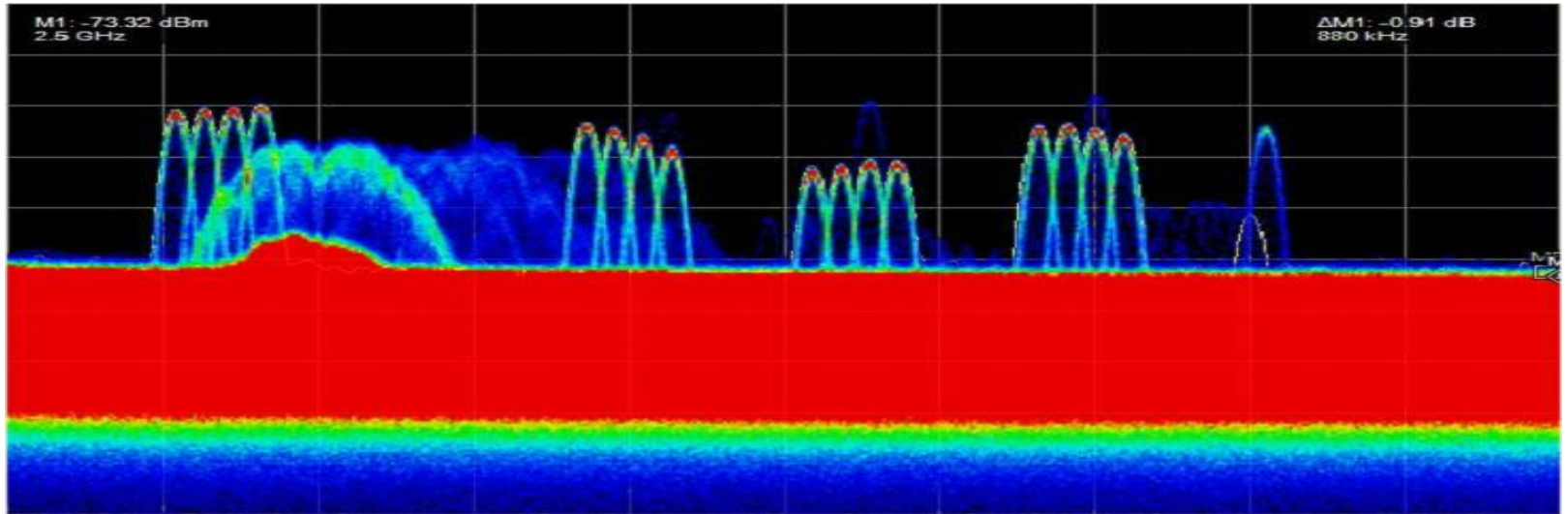


Cases Study

- 震盪器
- 放大器
- 即時頻譜監控與紀錄
- 捕捉干擾
- 通訊訊號實測分析
- 通訊系統維運(Base station)
- 暫態電磁干擾(Transient EMI)
- 軍用類比數位跳頻無線電(Military Radio)
- 軟體無線電(Software Define Radio)
- IED (Improvised Explosive Device)
- 分辨解調未知訊號

即時頻譜顯示(DPX)

Tektronix RTSA即時頻譜顯示的ISM band



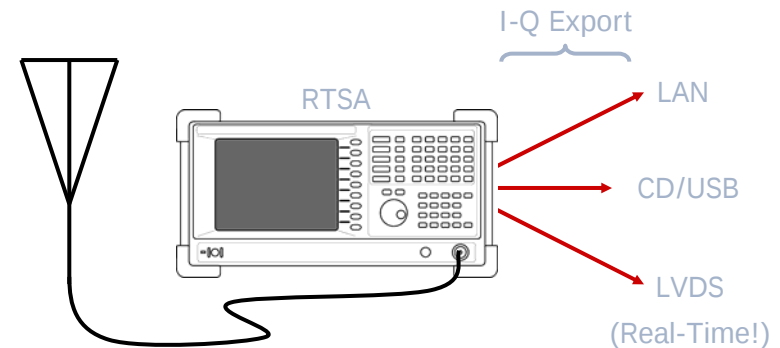
時間軸



Real-Time Digital I-Q Capture

■ RSA 6114A,s I-Q Export Modes

- ASCII or .tiq Files Via CD/DVD, USB or LAN
- Limited to Max. Record Length
- Optional LVDS Real-Time I-Q Output
- Full 110 MHz Bandwidth!
- Store 60-80 minutes of fully corrected I&Q on external data cache for record and playback



<u>Span</u>	<u>Time Resolution</u>	<u>Max. Record Length</u>
110 MHz	6.7 ns	1.7 sec.
40 MHz	20 ns	5.12 sec.
5 MHz	160 ns	41 sec.
1 MHz	640 ns	81.9 sec.
100 kHz	5.12 μ s	10.9 min.
20 kHz	20.48 μ s	43.7 min.

■ RSA 3408B's I-Q Export Modes

- .iqt Files Via Floppy, USB or LAN
- Available .iqt to ASCII Translator
- Limited to Max. Record Length
- Optional LVDS Real-Time I-Q Output
- Full 36 MHz Bandwidth!



Tektronix / X-COM RF Test Suite



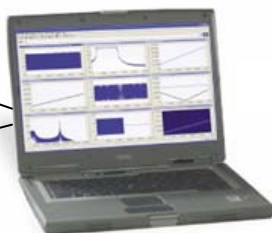
Snapshot Mode Capture and Playback

(typically up to one second cumulative captures)

Tektronix RSA6100A



X-COM WaveCAFE™



Tektronix AWG5000/7000



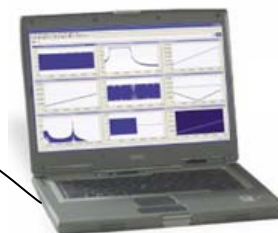
Continuous Mode Capture and Playback

(up to one hour cumulative/continuous captures)

Tektronix RSA6100A



X-COM WaveCAFE™



X-COM IQC2110

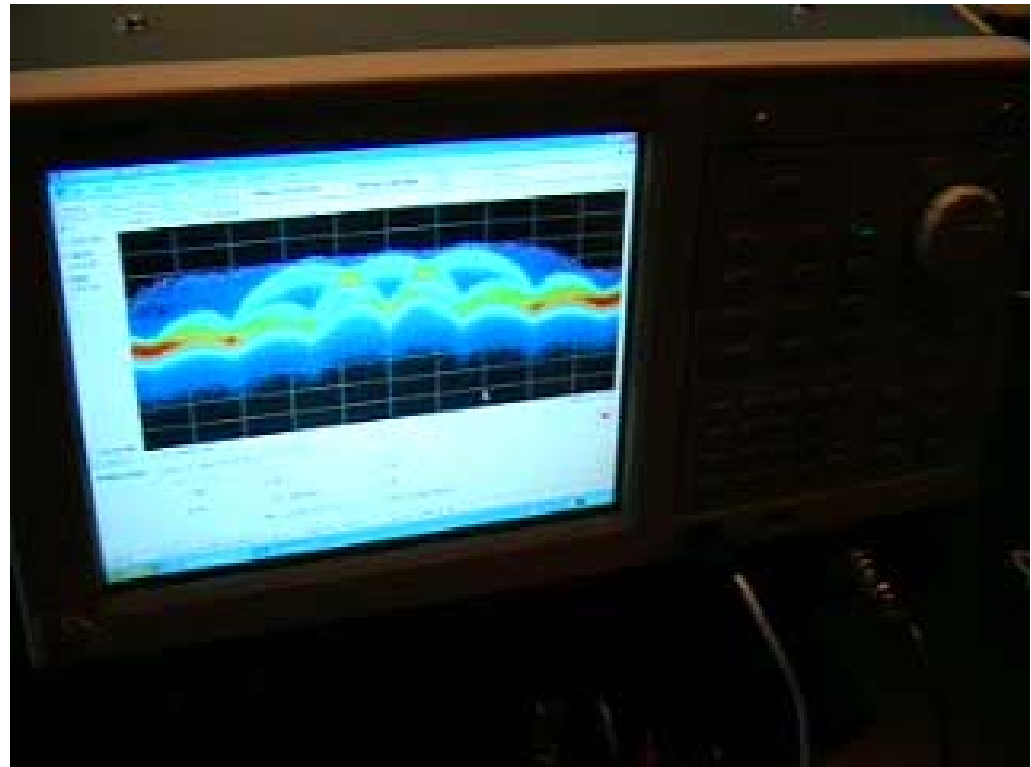
1TB Removable Datapack included



X-COM CPG/VSG Module



Tektronix_recorder
_10nov08

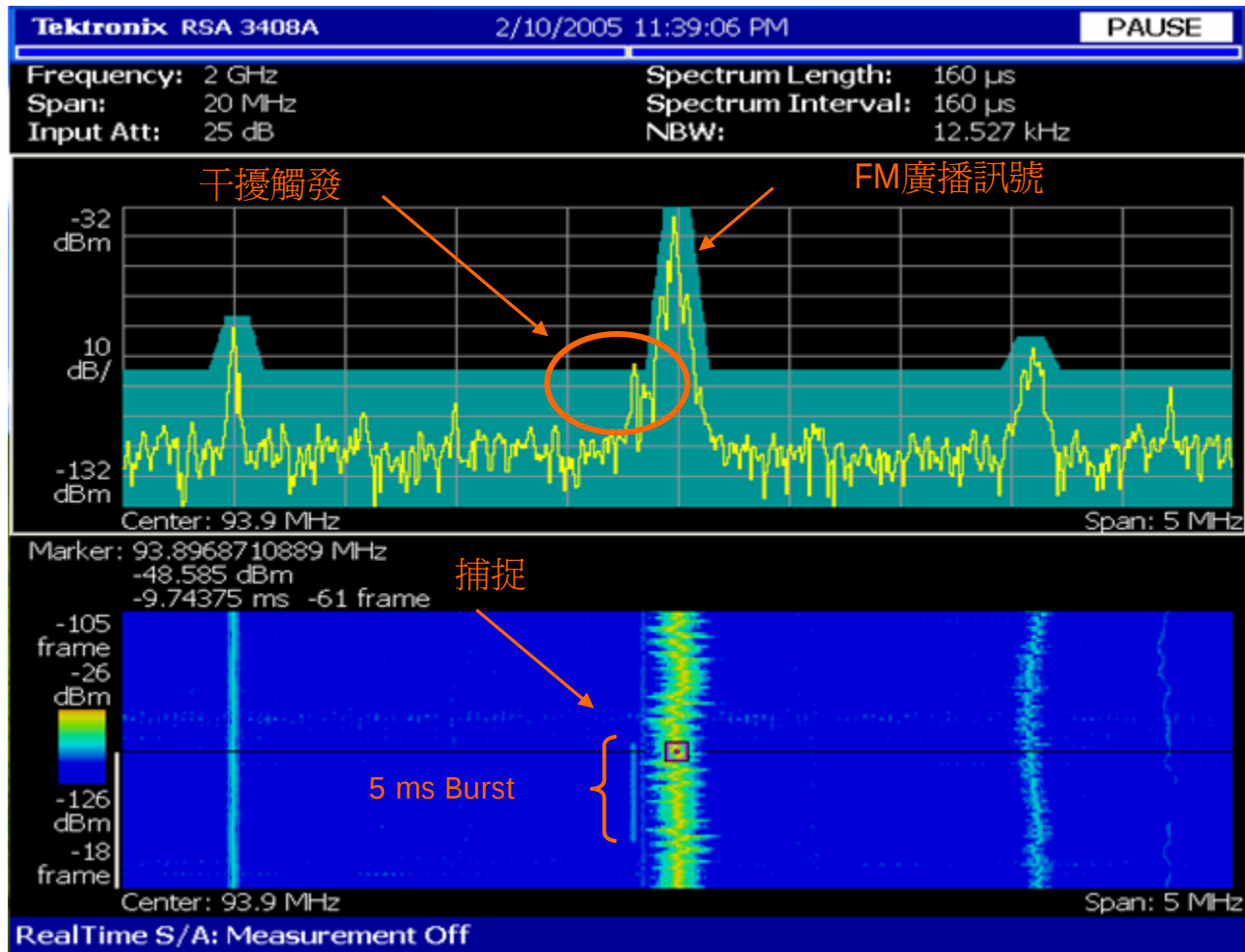


無線通訊系統除錯 (Wireless communication Debug)

- 主動元件效能檢查
- 放大器設計與線性度效能檢查
- 即時頻譜監控
- 即時捕捉干擾,EMI訊號
- Normal mode數位通訊訊號實測分析
 - WiMAX
 - WLAN
 - Zigbee
 - Bluetooth
 - GSM/EDGE
 - Remote controller/TPMS(313/433MHz)
- 通訊系統維運(Base station)
- IED (Improvised Explosive Device)

即時捕捉干擾,EMI訊號

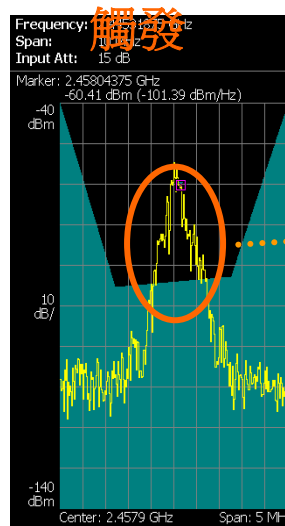
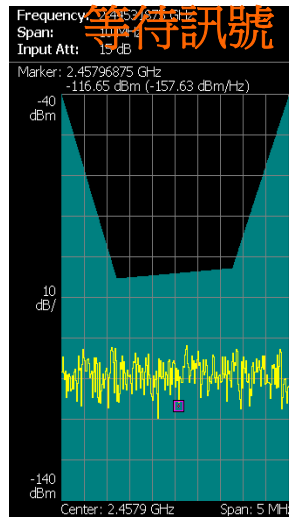
擷取FM頻道干擾訊號



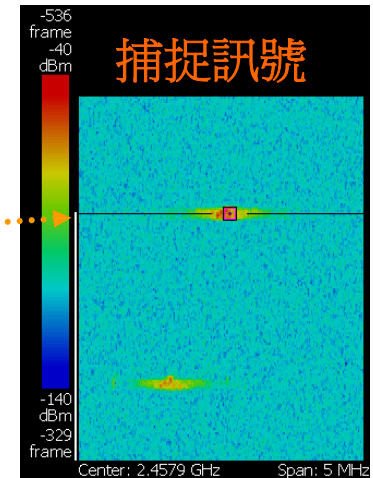
輕易抓出異常的訊號頻譜與干擾訊號!!

擷取通訊中之數位通訊訊號

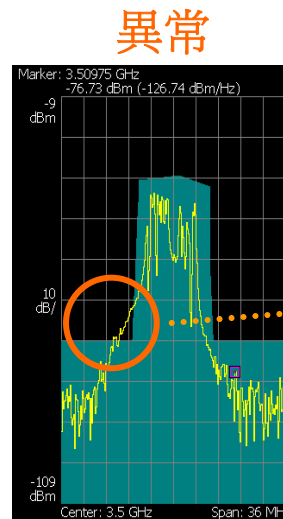
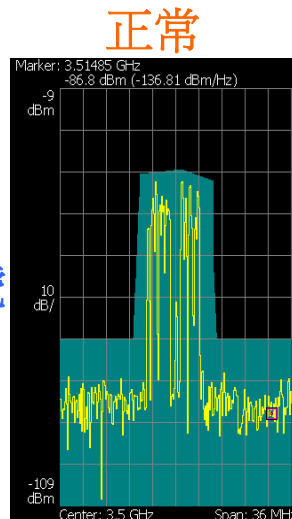
抓取藍芽訊號



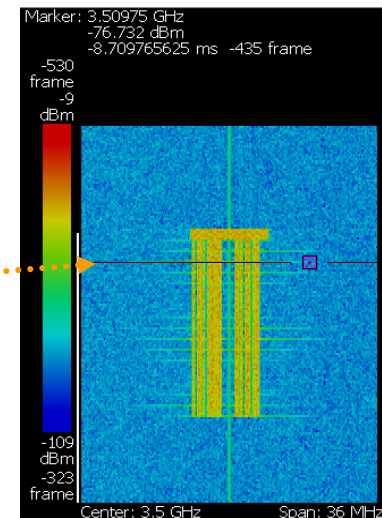
觸發點



檢查頻譜異常之WiMAX訊號

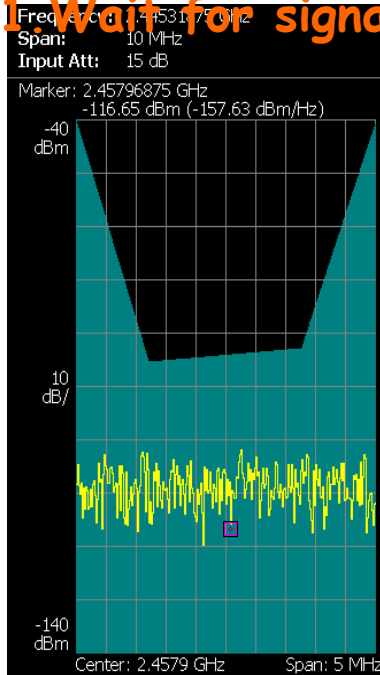


觸發點

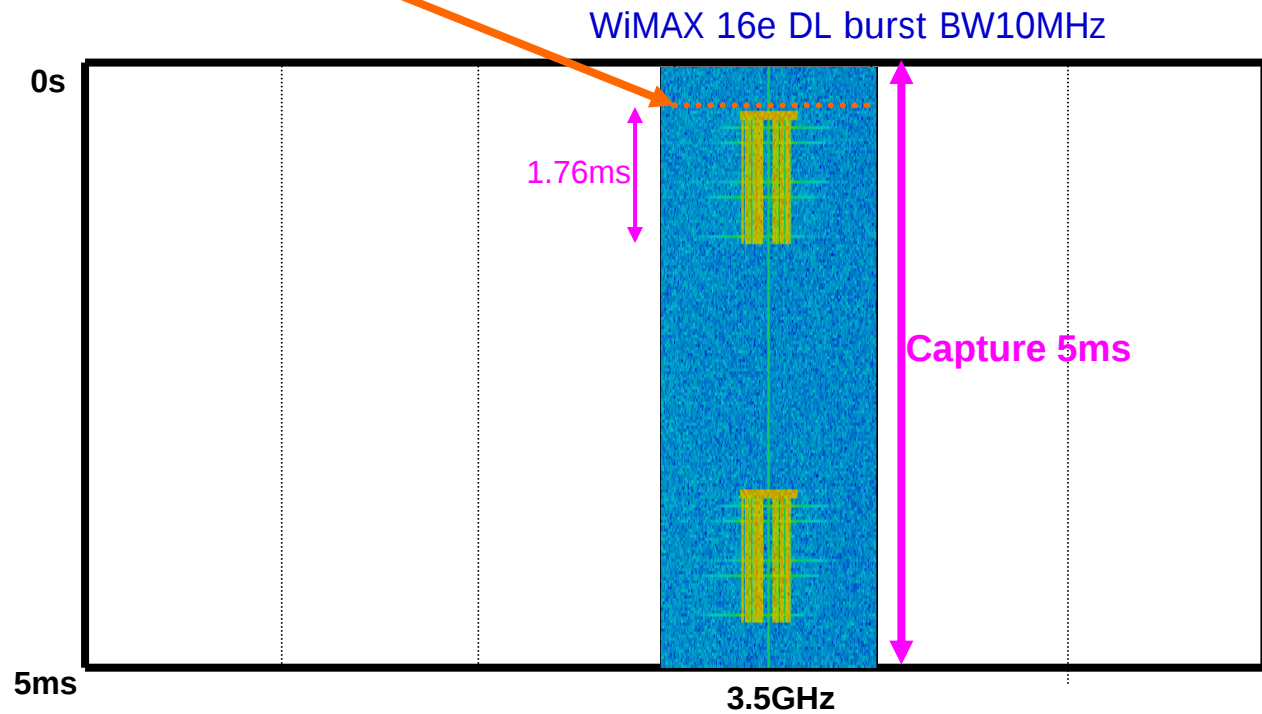


Real time trigger & capture

1. Wait for signal



2. Triggered



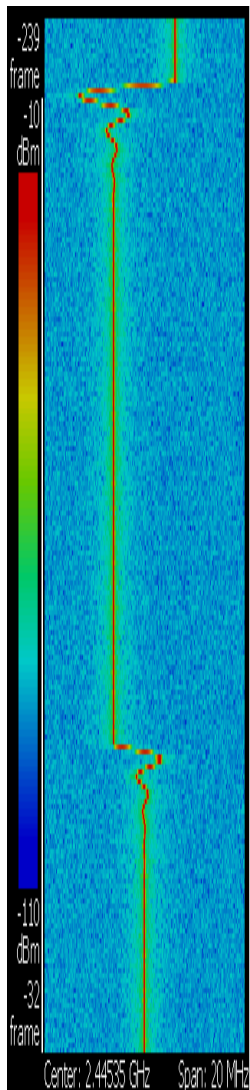
Cases Study

- 震盪器
- 放大器
- 即時頻譜監控與紀錄
- 捕捉干擾
- 通訊訊號實測分析
- 通訊系統維運(Base station)
- 暫態電磁干擾(Transient EMI)
- 軍用類比數位跳頻無線電(Military Radio)
- 軟體無線電(Software Define Radio)
- IED (Improvised Explosive Device)
- 分辨解調未知訊號

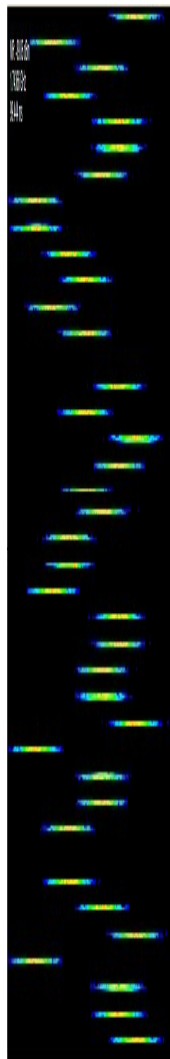
Normal mode數位通訊訊號實測分析

各式數位訊號之頻譜 + 時間軸(2D俯視圖)

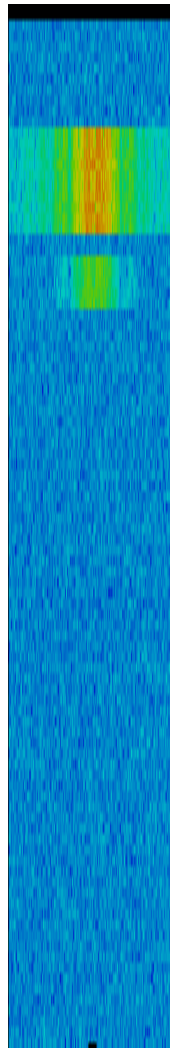
VCO Hopping



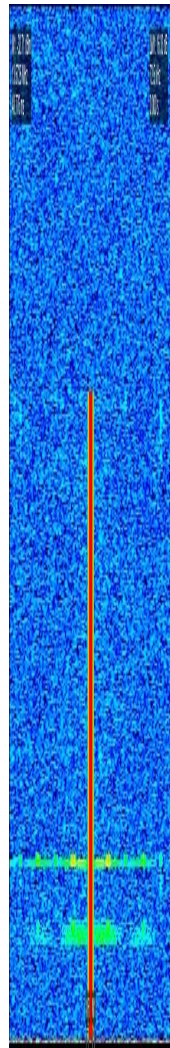
GSM



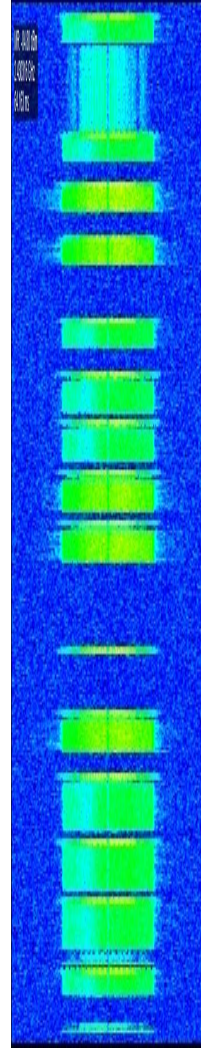
Zigbee



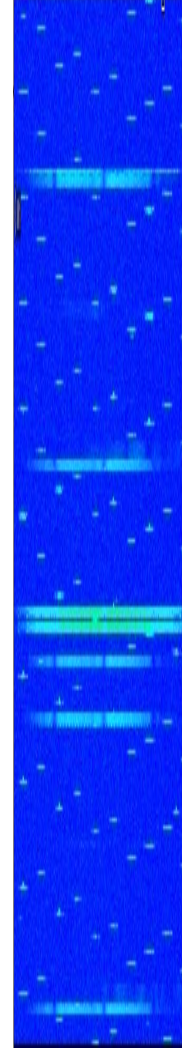
RFID



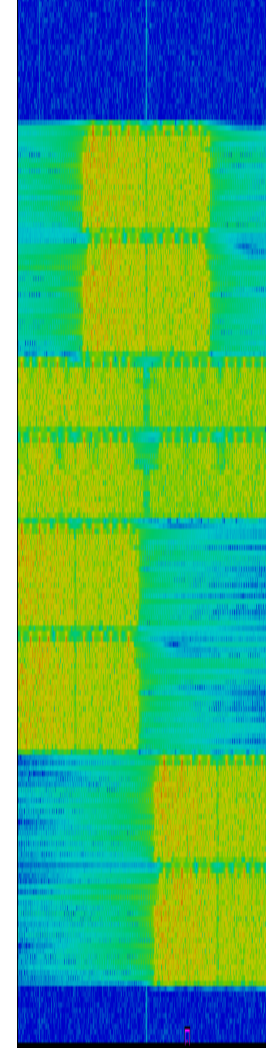
WLAN



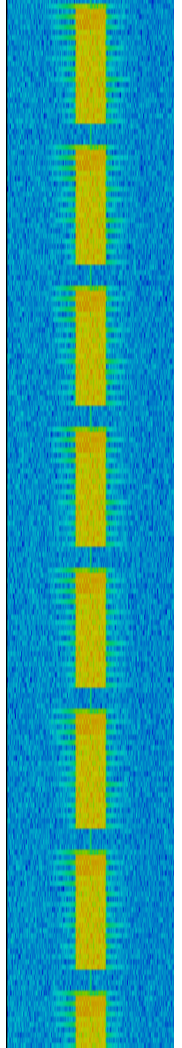
WLAN+BT



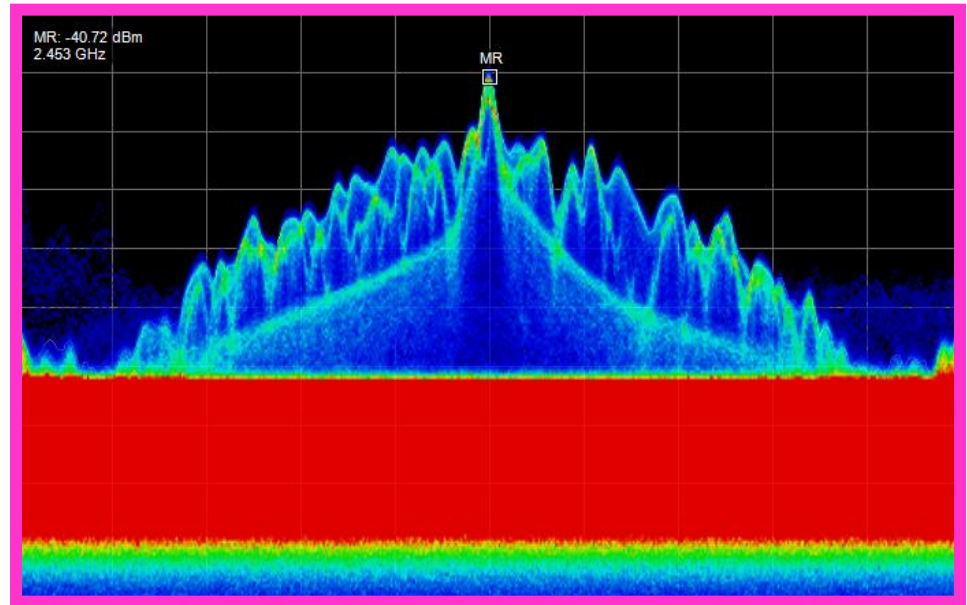
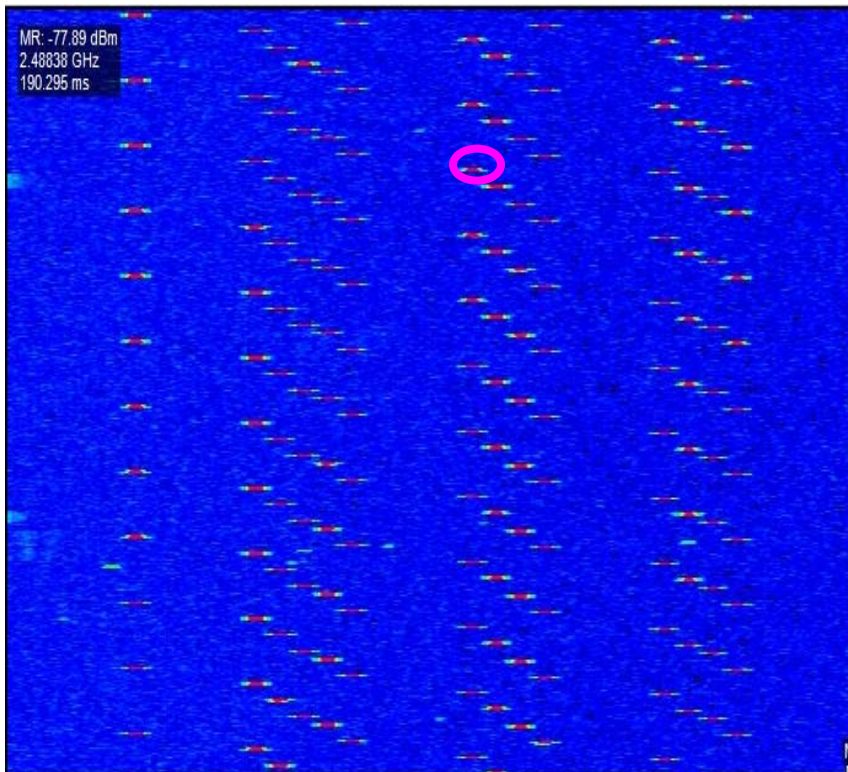
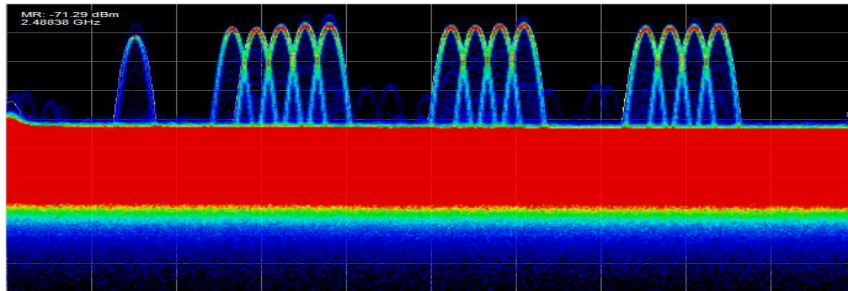
MIMO



WiMAX

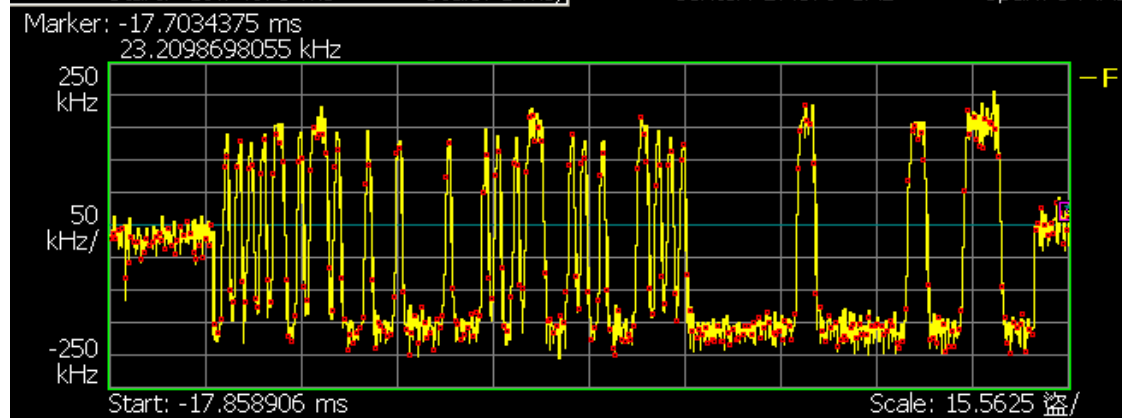
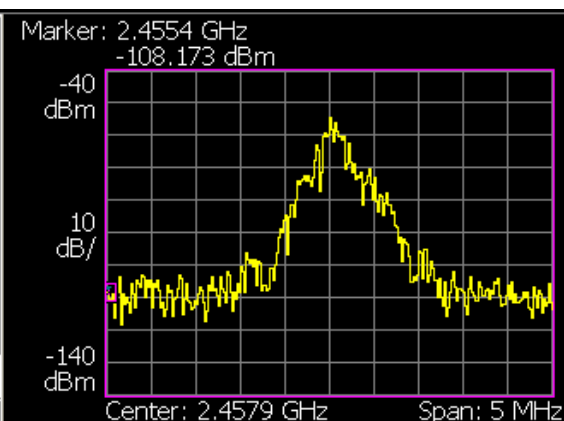
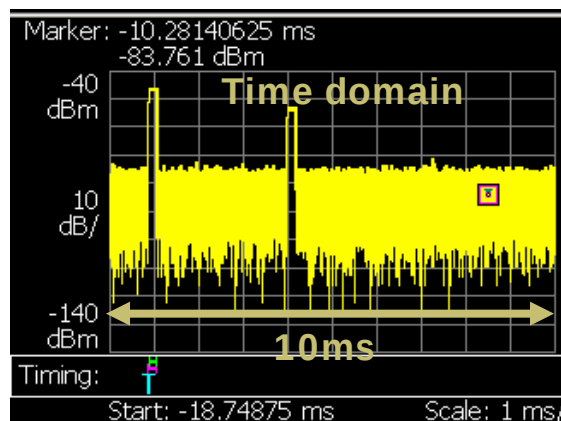
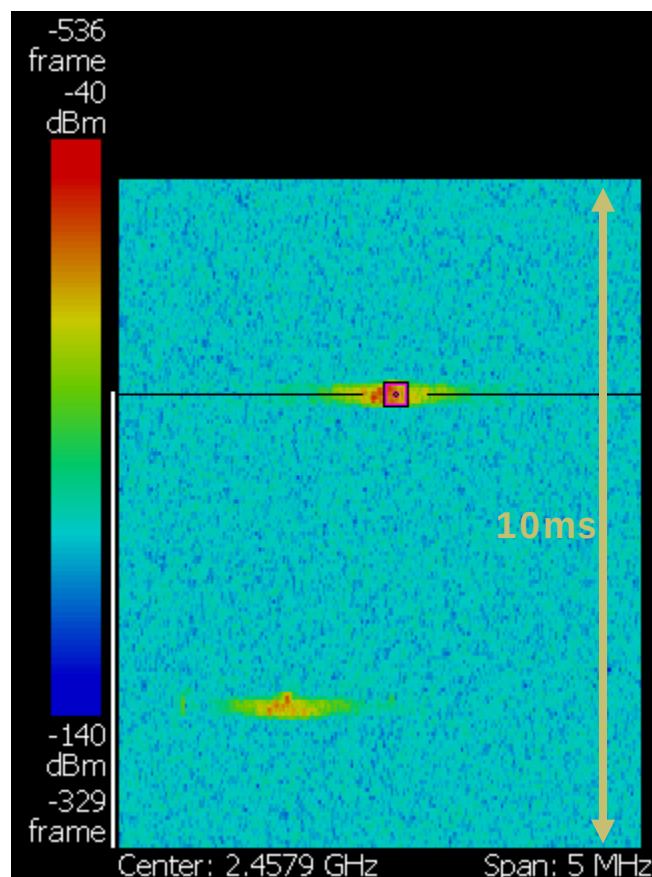


藍芽BT搜尋設備時訊號頻譜

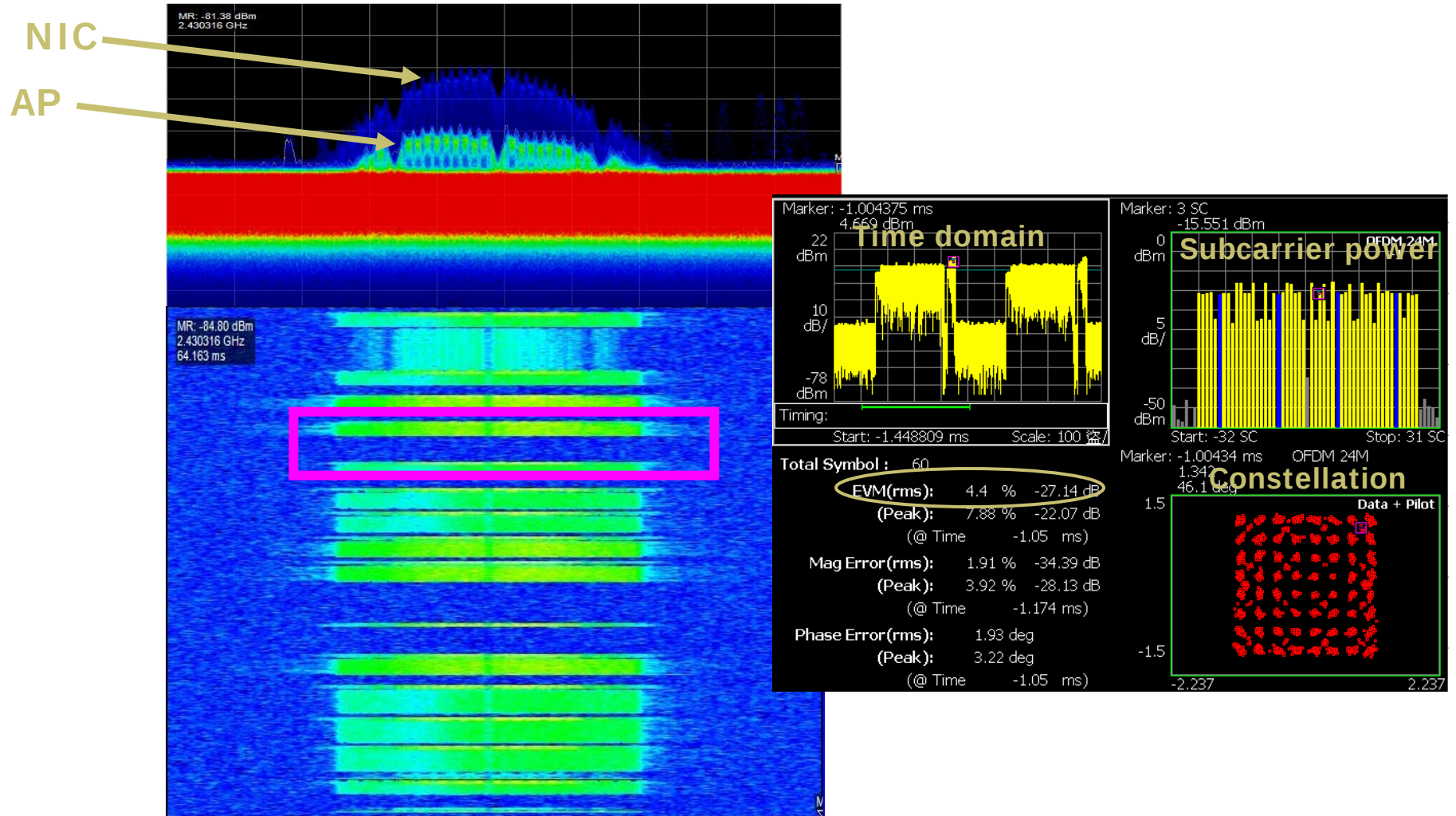


Bluetooth real-time spectrum

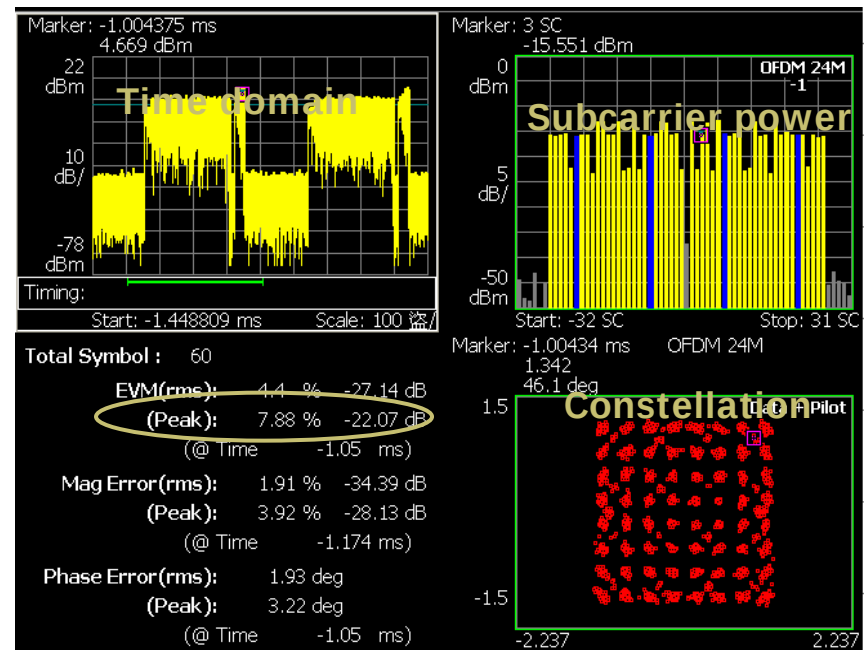
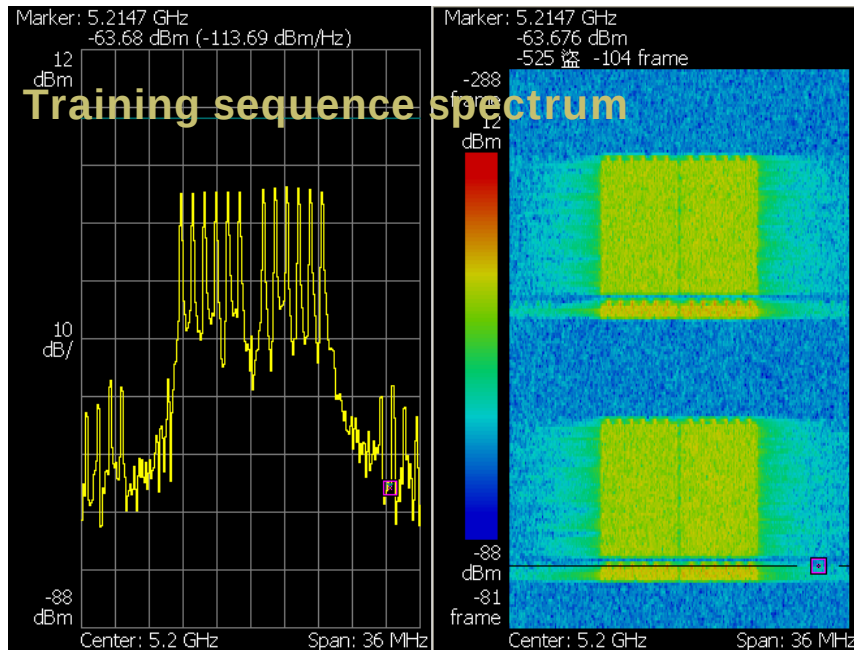
藍芽BT搜尋設備時訊號分析



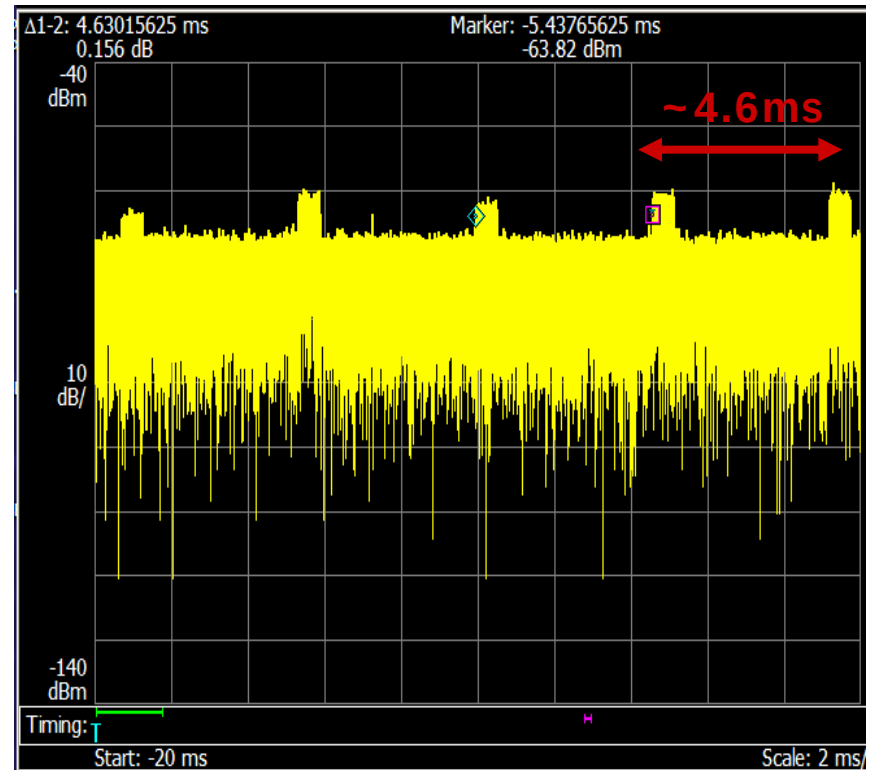
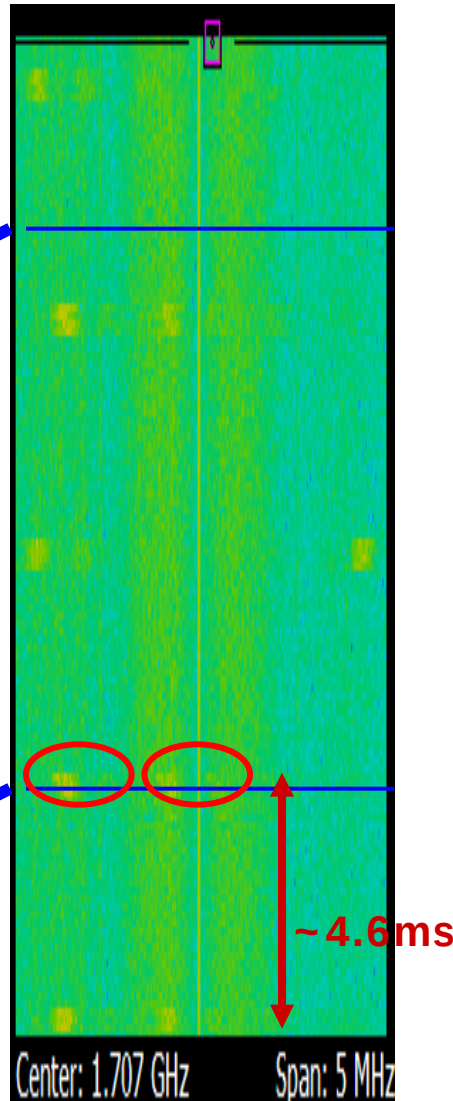
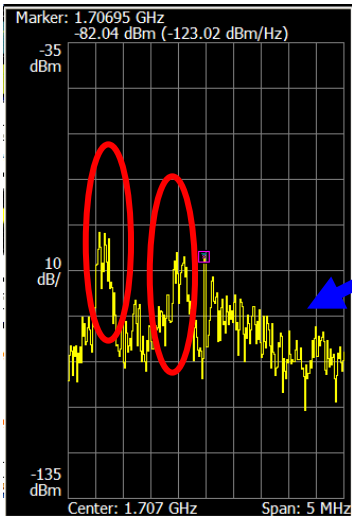
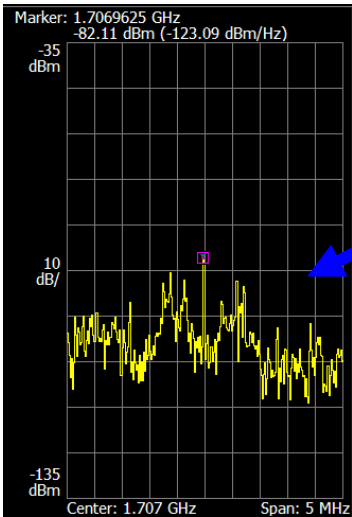
WLAN網卡與AP之間通訊訊號分析



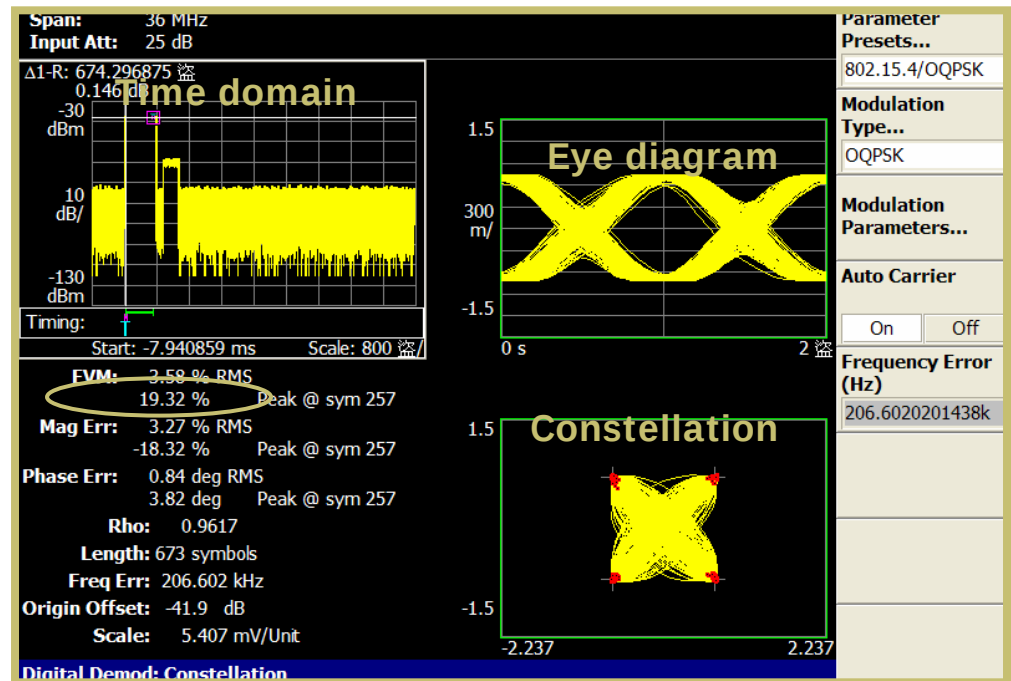
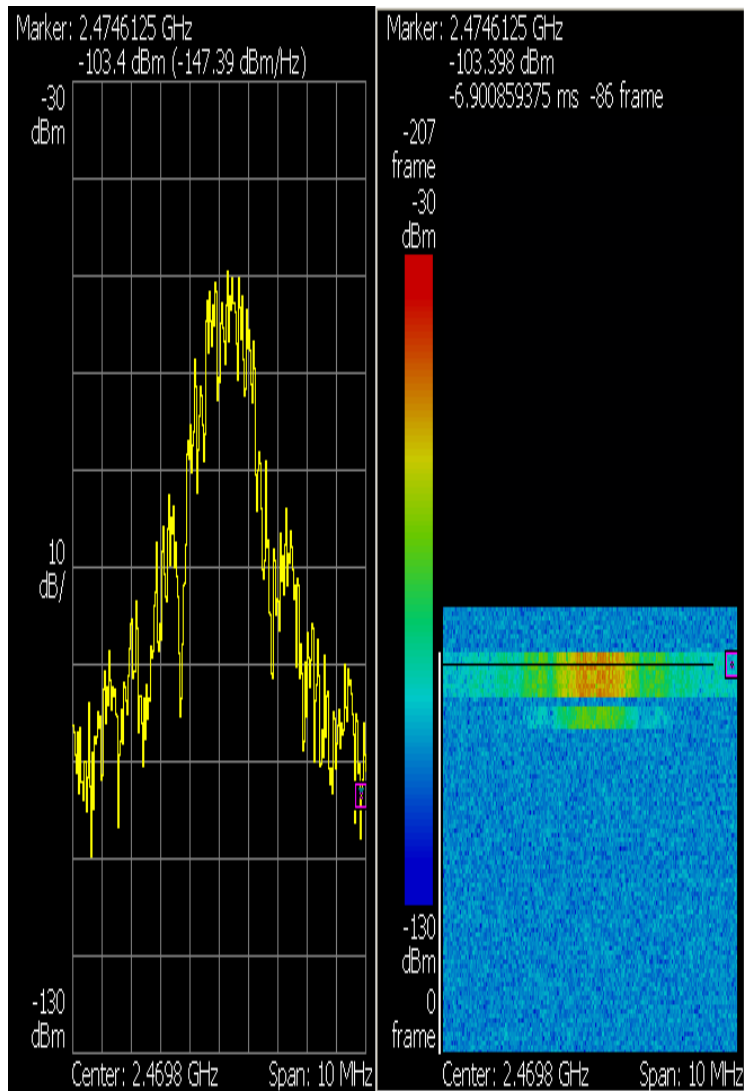
Wi-Fi normal signal Analysis (802.11abg)



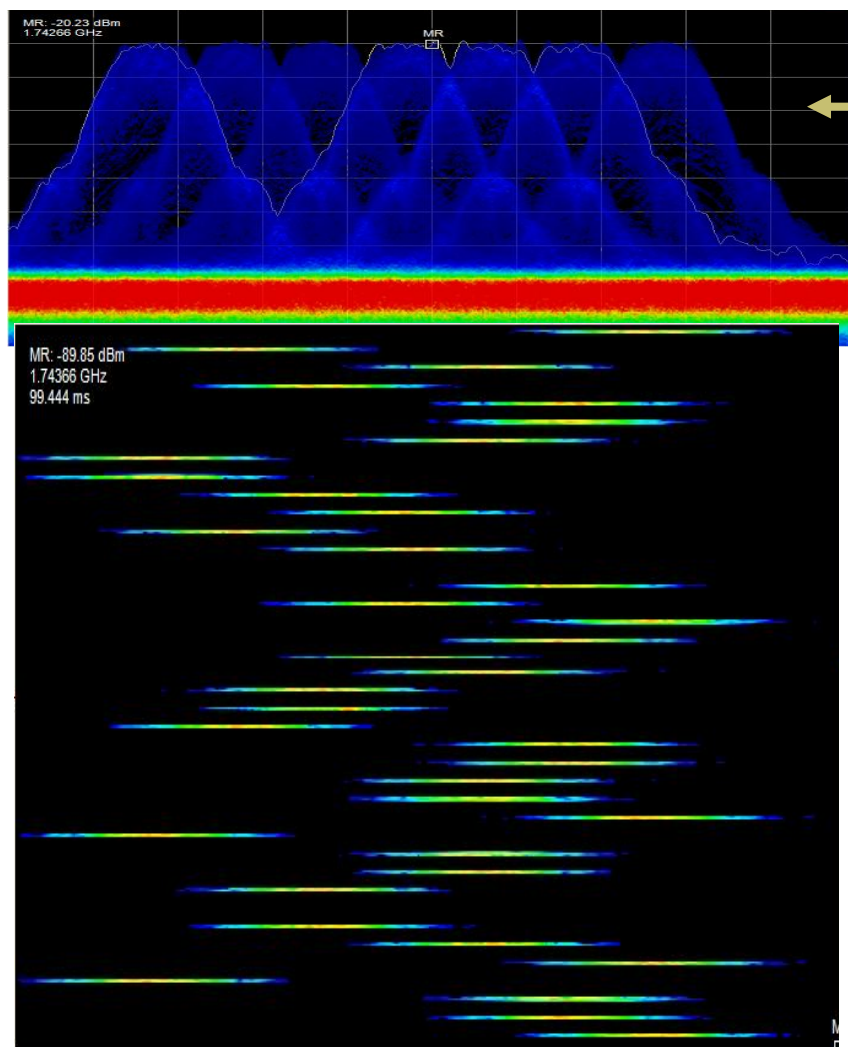
GPS訊號遭到干擾



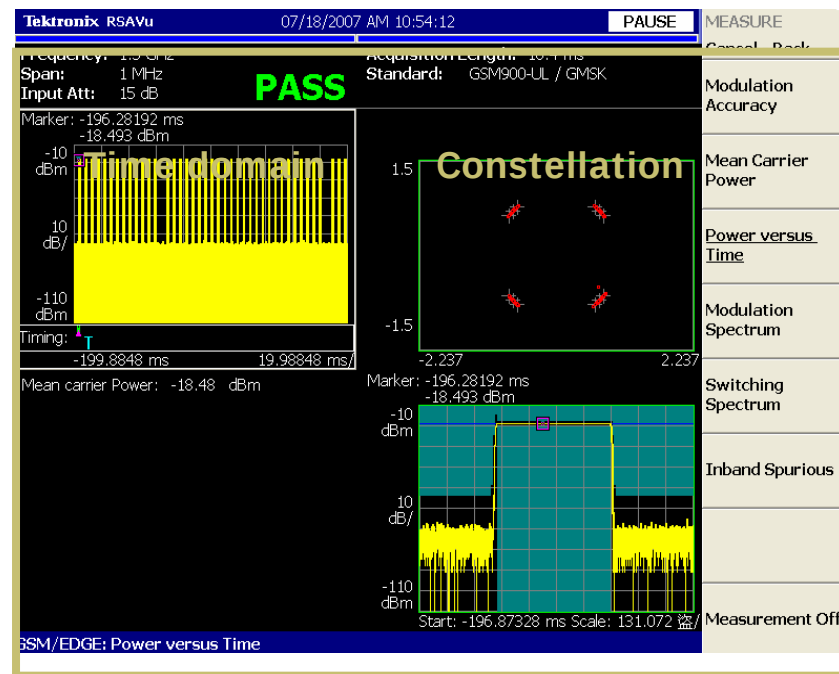
Zigbee控制訊號分析



GSM/EDGE 手機通話時訊號分析



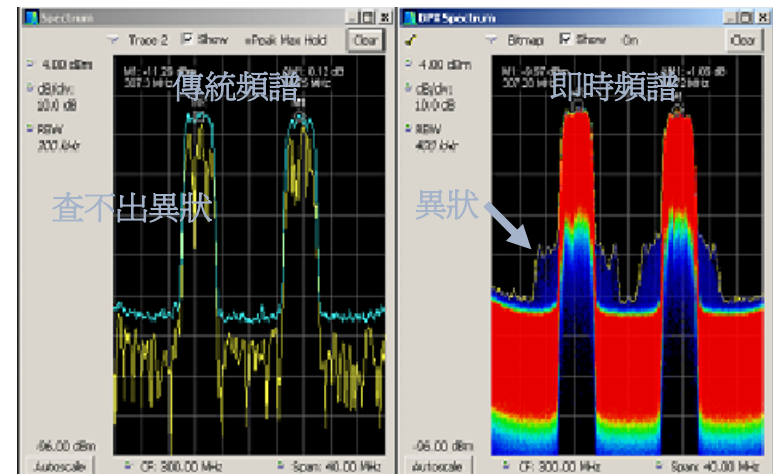
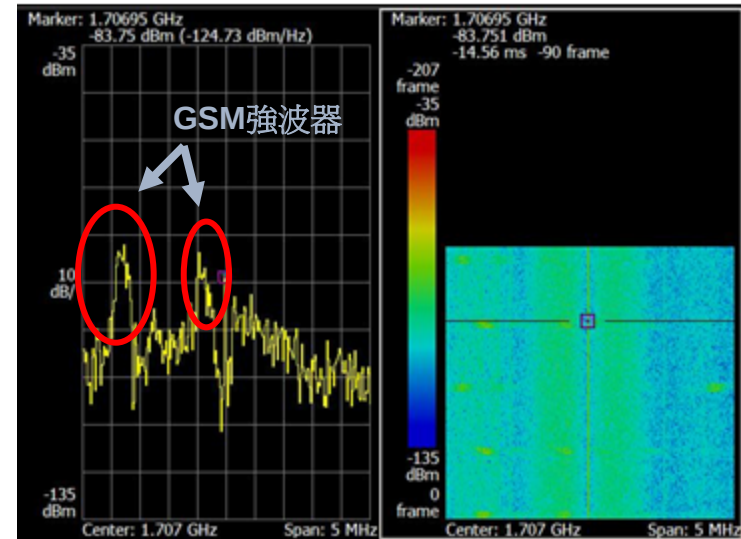
7 channels hopping



通訊系統維運(Base station)

WiMAX基地台場測與維運

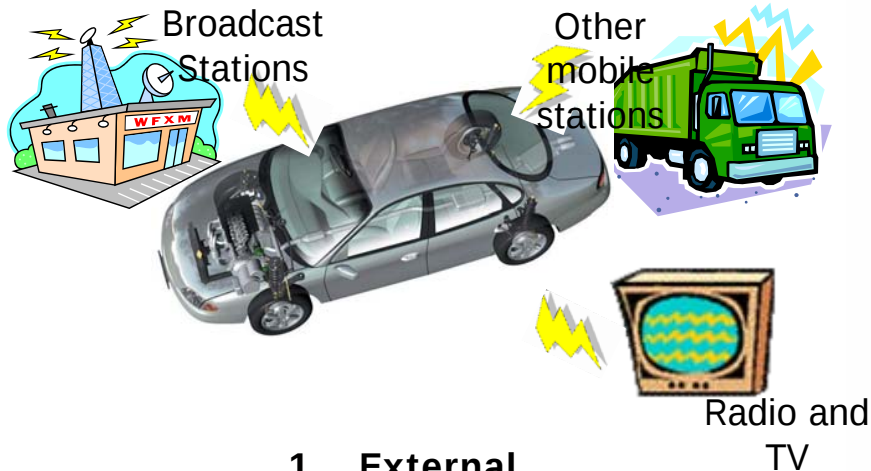
- 環境干擾
 - 影響來源:現場附近強波器、雷達訊號、非法佔用訊號...etc
- 頻譜使用效率
 - 影響來源:基地台發射訊號所佔頻譜寬度



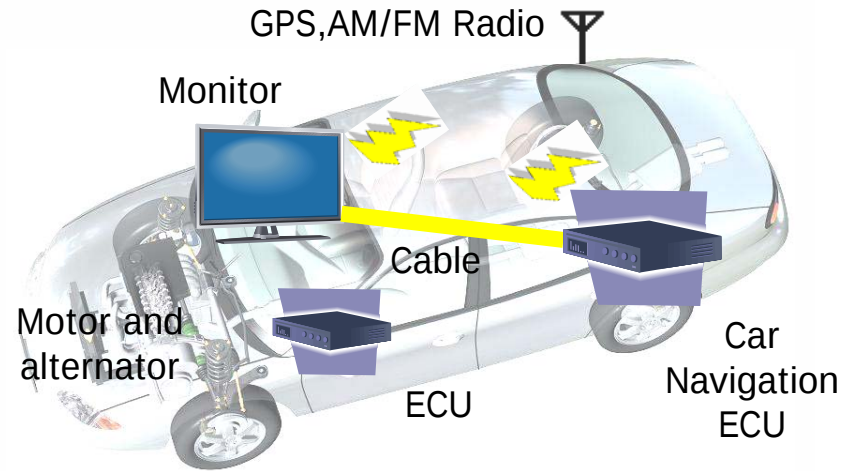
Cases Study

- 震盪器
- 放大器
- 即時頻譜監控與紀錄
- 捕捉干擾
- 通訊訊號實測分析
- 通訊系統維運(Base station)
- 暫態電磁干擾(Transient EMI)
- 軍用類比數位跳頻無線電(Military Radio)
- 軟體無線電(Software Define Radio)
- IED (Improvised Explosive Device)
- 分辨解調未知訊號

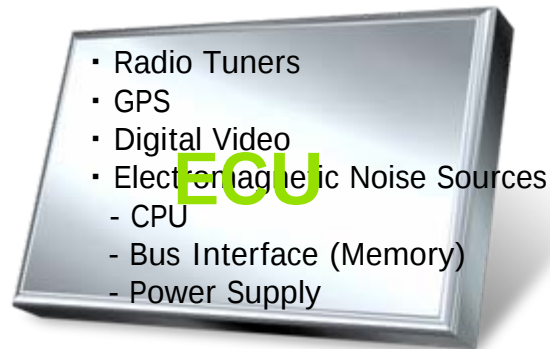
Application Example#1: *Automotive Interference/Noise*



1. External Interferences



2. Interferences Among In-Vehicle Equipments



3. Interferences from Modules on ECU

Reference: Nikkei Electronics

Success Stories#1:

Automotive – Hybrid/Electric Vehicle

Customer: A Company

Application: EMI Diagnostics – Automotive

Customer unmet need or pain point:

- Needs a SA that can discover all the emissions for inverter motor in Hybrid/Electric vehicles, esp. **the transient emissions, that cause interference to equipments, like Digital TV/radios, ECUs, Car Navigation/GPS system**
- Conventional SA and VSA can not show all the transients

Why RTSA was chosen:

- DPX helped customer discover all the **transient emissions** in real time
- FMT and Real Time spectrogram greatly improved customer's **troubleshooting** productivity by reducing the test time from days to hours
- DC to 20MHz Base Band with DANL at less than -100dBm at 100kHz RBW captures low frequency **inverter noise**

Product /Value: RSA3308B and RSA3408B, followed by RSA orders from OEM part vendors

Voice of Customer: "I have said we didn't need more demonstration of the RSA just after seeing the DPX Live Spectrum display and compared to three units of other SA vendors which show only noise floors. I will recommend my OEM vendors use your tester"



Success Stories#2:

Medical – Blood Sugar Monitor

Customer: C Company

Application: EMI Diagnostics – Medical Equipment

Customer unmet need or pain point:

- Needs a multiple-in-one box that demodulates Bluetooth/WLAN as well provides ISM interference analysis
- Lack of confidence for the design evaluation and troubleshooting of the built-in wireless modules that work in ISM band (Bluetooth and WLAN) in blood sugar monitor

Why RTSA was chosen:

- “DPX is the only tool on the market that gives you the closest view to what your receiver is seeing, and how your transmitter is interacting with other emitters in the ISM band”
- Bluetooth/WLAN signals could not be discovered with full insights by Conventional SAs
- FMT opened customer’s eyes by providing unprecedented fast debug capability, which shortened customer’s develop cycle
- All-in-one design with WLAN and Bluetooth demod options

Product /Value: 1 x RSA6114A



Success Stories#3:

Medical – 802.11n Wireless Video Camera

Customer: D Compnay

Application: EMI Diagnostics – Medical Equipment

Customer unmet need or pain point:

- Need to **survey operating rooms to ensure that no interfering signals were present.**
- Need to ensure compliance with IEEE 802.11n standard
- Need to **ensure** that their products **did not produce spurious emissions**

Why RTSA was chosen:

- DPX – Shows WLAN signals that other spectrum analyzers could not display the live signal.
- Supports 802.11n. Testing to the standard and documenting Pass/Fail performance.

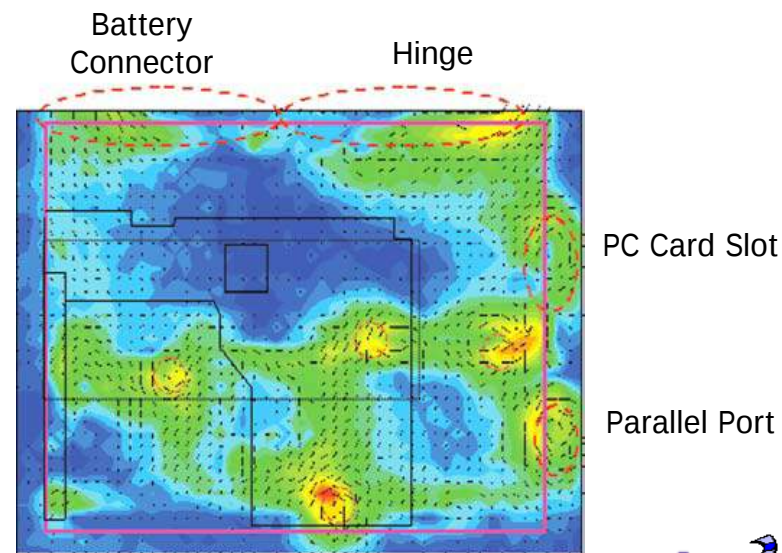
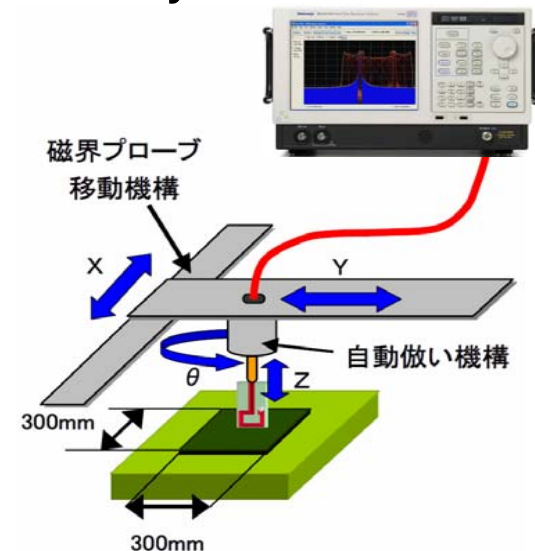
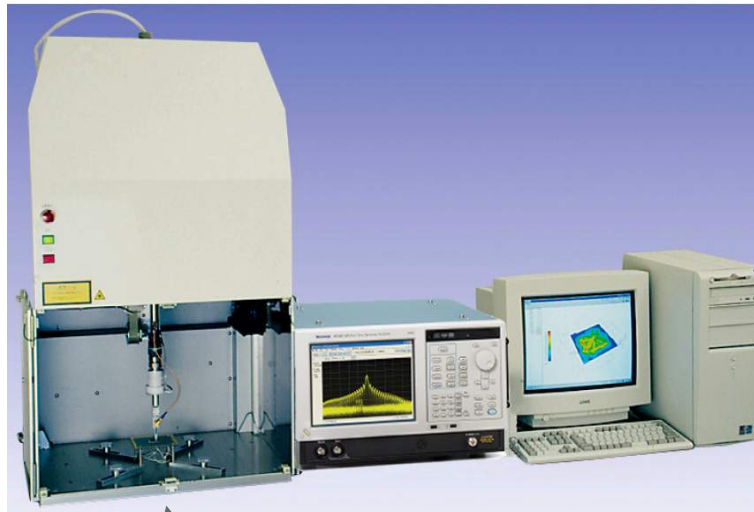
Product /Value: 1x RSA6114A +RSAVu

Voice of Customer: We may also have a need for surveying potential installation sites using the H600. We'll get you in touch with our installation/customer service department.



Application Example : *Consumer Electronics Interference/Noise (Cont'd)*

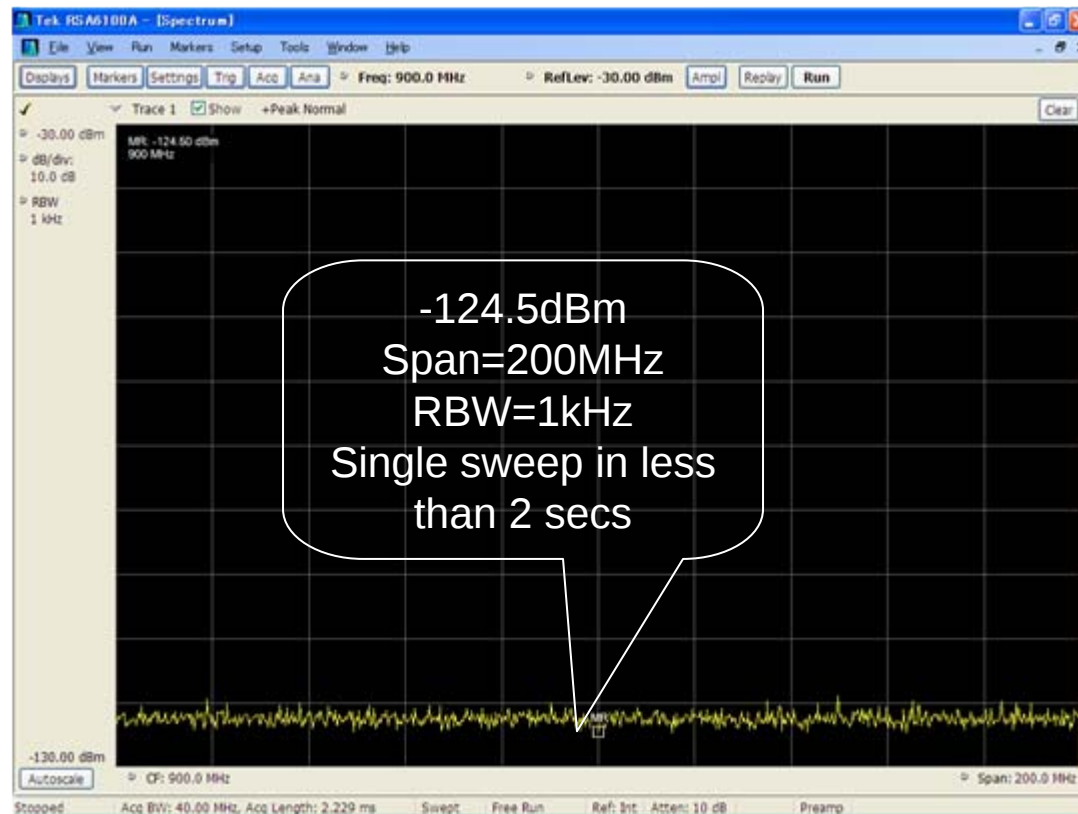
- Hitachi EMV-200 Transient EMI Measurement System



EMI Measurements Approach :

Real Time Spectrum Analyzer: Measurement Speed

- **RTSA helps to shorten the system's EMI evaluation cycle**
 - Comparing with conventional spectrum analyzer that takes at least 4 minutes for a 200MHz 1kHz RBW sweep, RSA6100A Series makes the same measurements in less than 2 seconds!
 - By having 10 or several hundreds of measurements, the overall test time saved is enormous



Cases Study

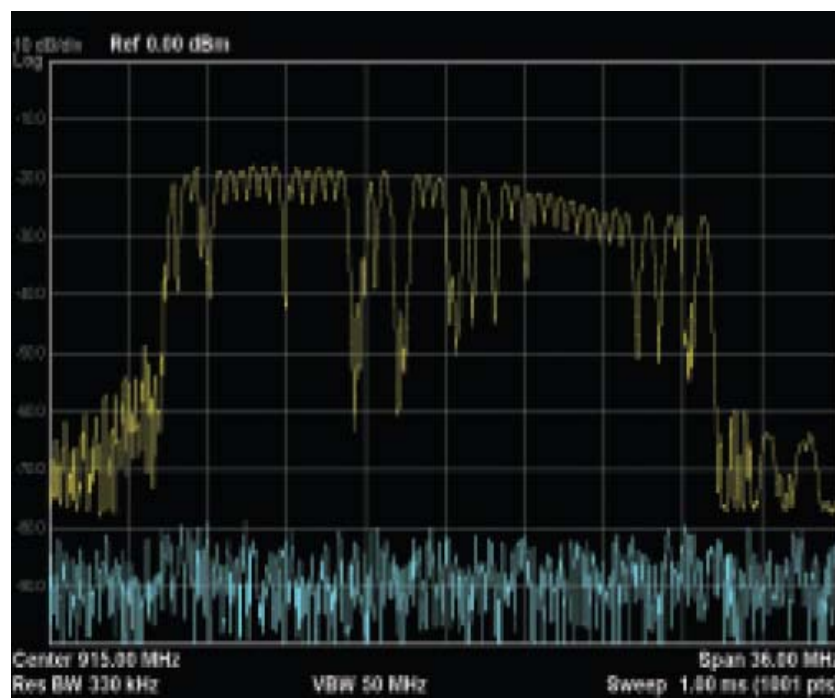
- 震盪器
- 放大器
- 即時頻譜監控與紀錄
- 捕捉干擾
- 通訊訊號實測分析
- 通訊系統維運(Base station)
- 暫態電磁干擾(Transient EMI)
- 軍用類比數位跳頻無線電(Military Radio)
- 軟體無線電(Software Define Radio)
- IED (Improvised Explosive Device)
- 分辨解調未知訊號

跳頻訊號監控量測(RSA3303B,RSA3408B,RSA6106A)

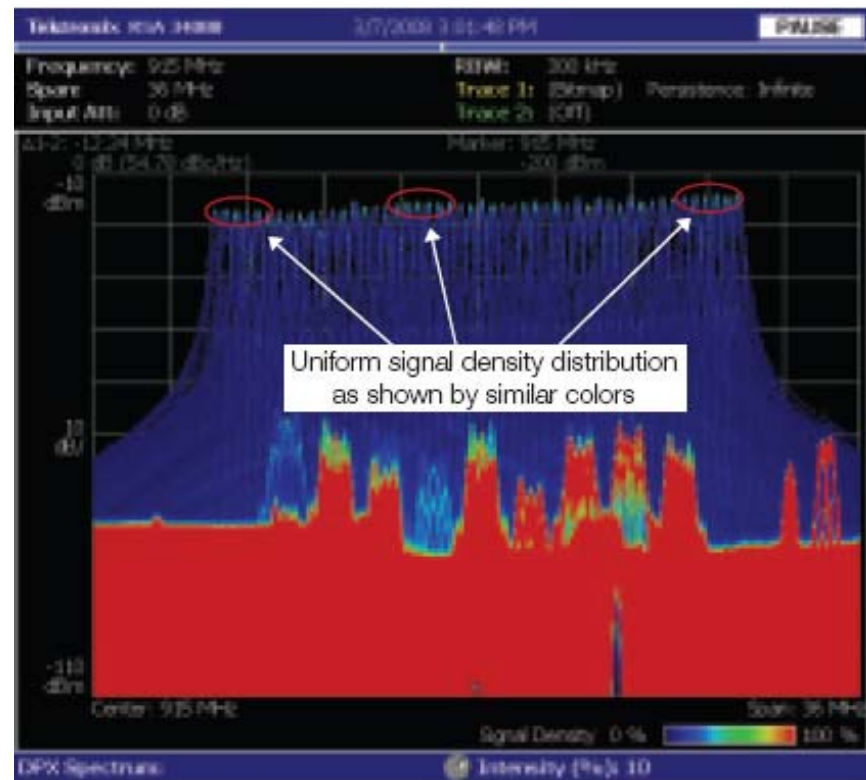
DPX光學顯示頻譜



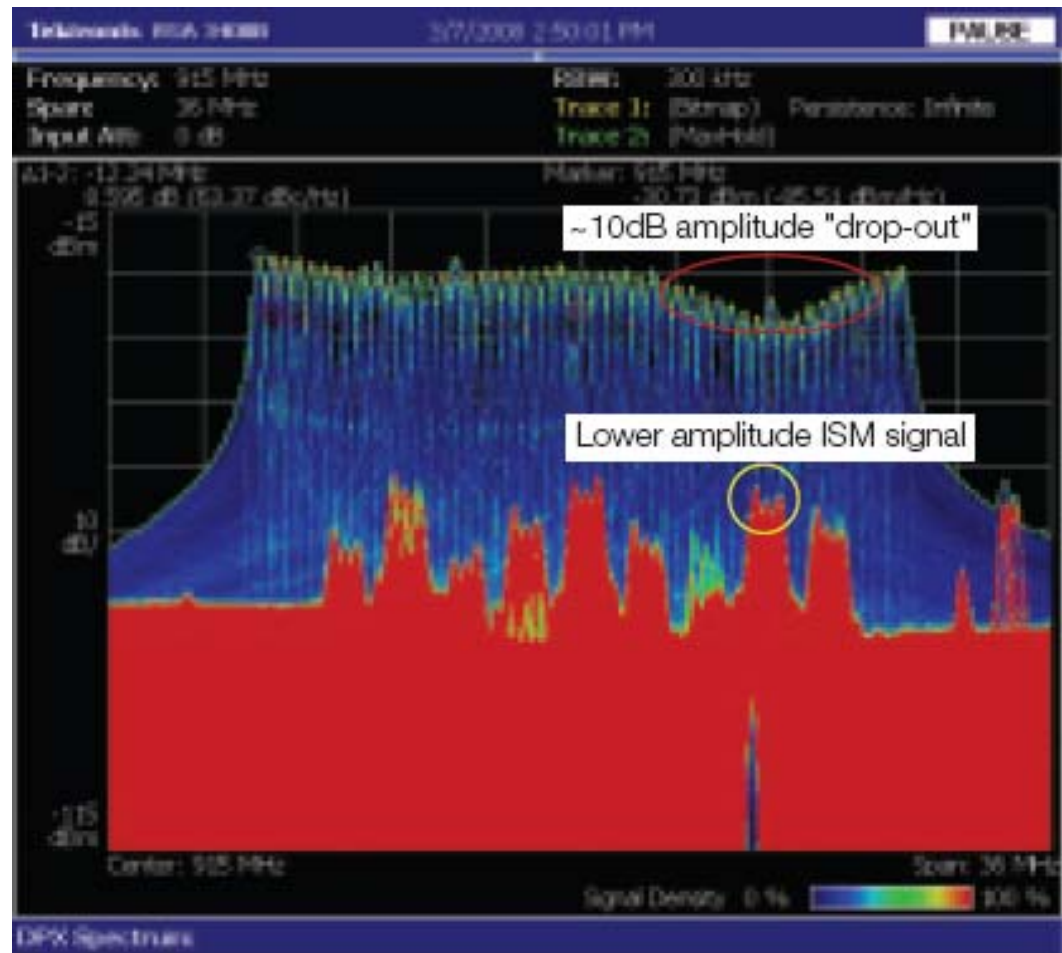
掃頻頻譜分析儀無法捕捉



跳頻訊號跳頻密度與異常量測 (RSA3303B, RSA3408B, RSA6106A)

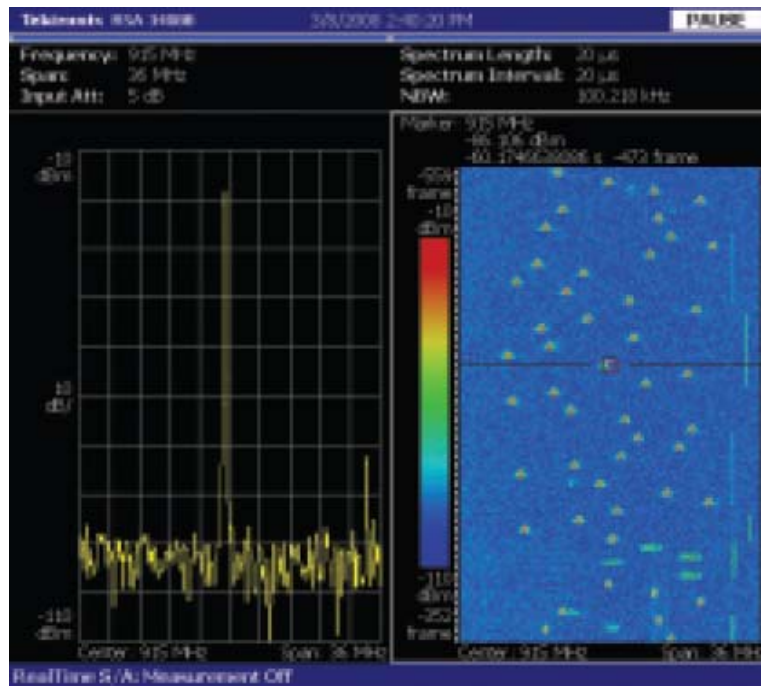


跳頻訊號能量平坦度量測 (RSA3303B, RSA3408B, RSA6106A)

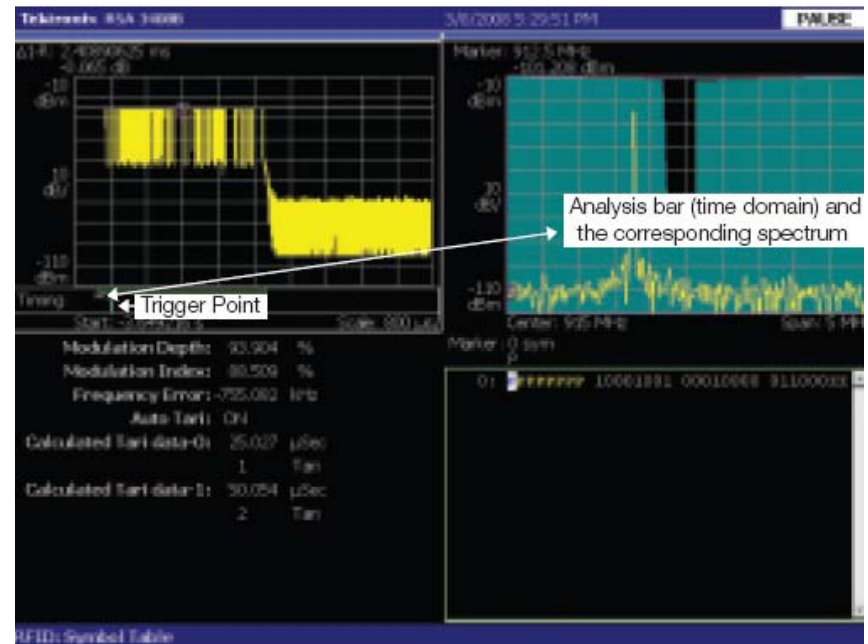


Need **Opt 02** Frequency Mask Trigger & 65.5 MSAMPLE DEEP MEMORY

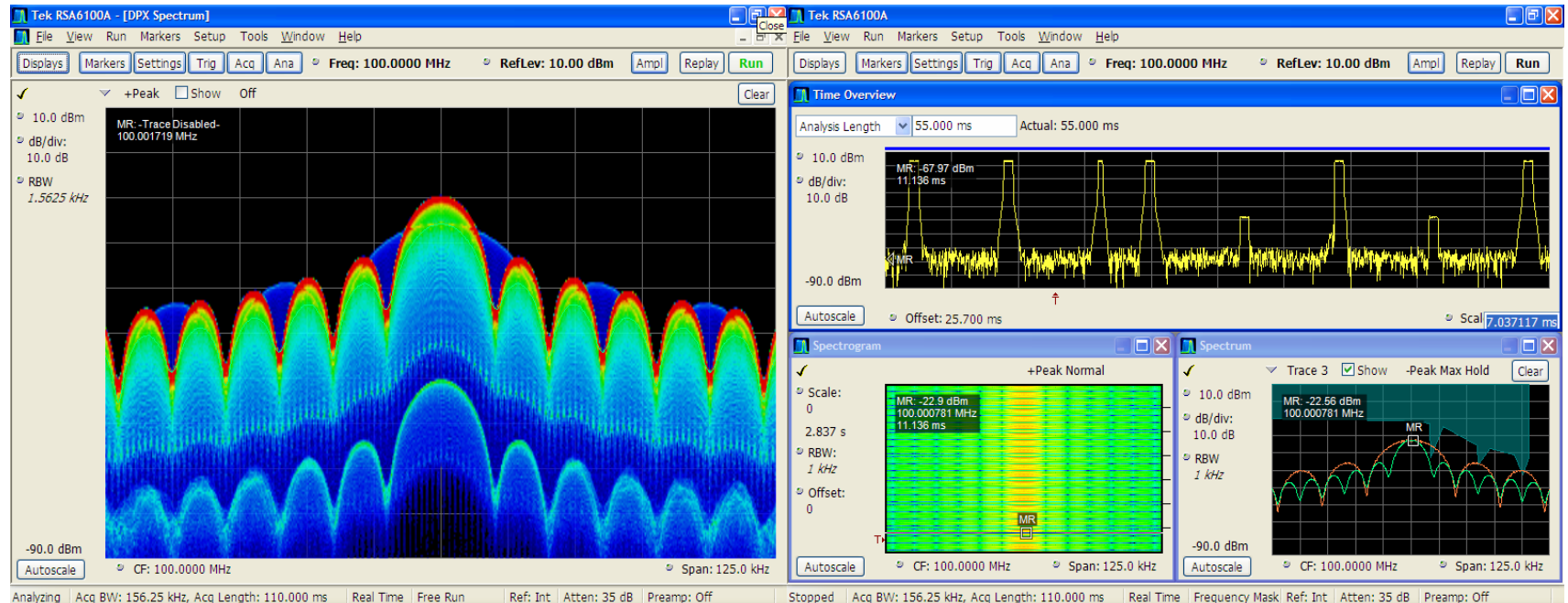
跳頻訊號時序量測



特定頻率跳頻訊號觸發擷取

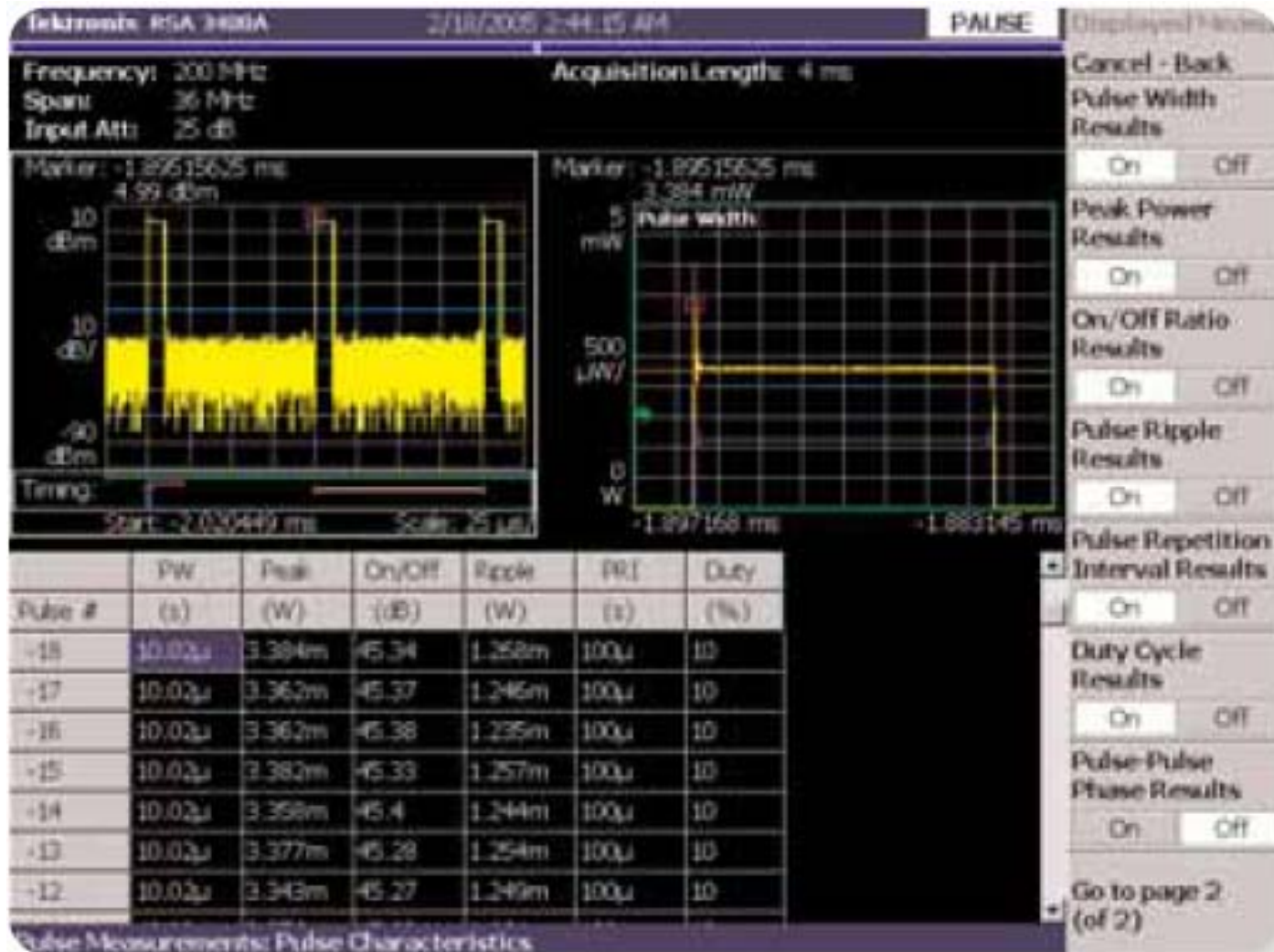


Frequency Mask, DPX, Time domain Triggers



- Use DPX™ to **Discover** the anomaly – infrequent narrow pulse
- 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

跳頻訊號pulse特性量測分析 (Need Opt21 ADVANCED MEASUREMENTS SUITE)



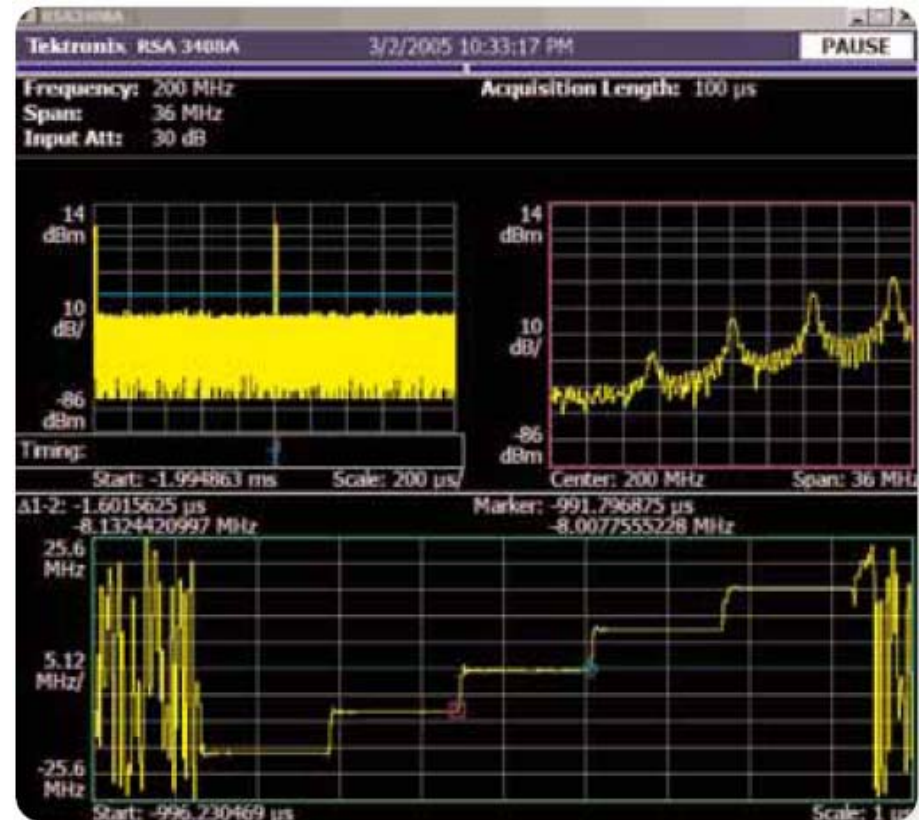
跳頻訊號pulse特性量測分析 (RSA3303B,RSA3408B,RSA6106A)

Phase vs time



► Figure 27. 180° phase transitions are examined on a bi-phase modulated compressed pulse.

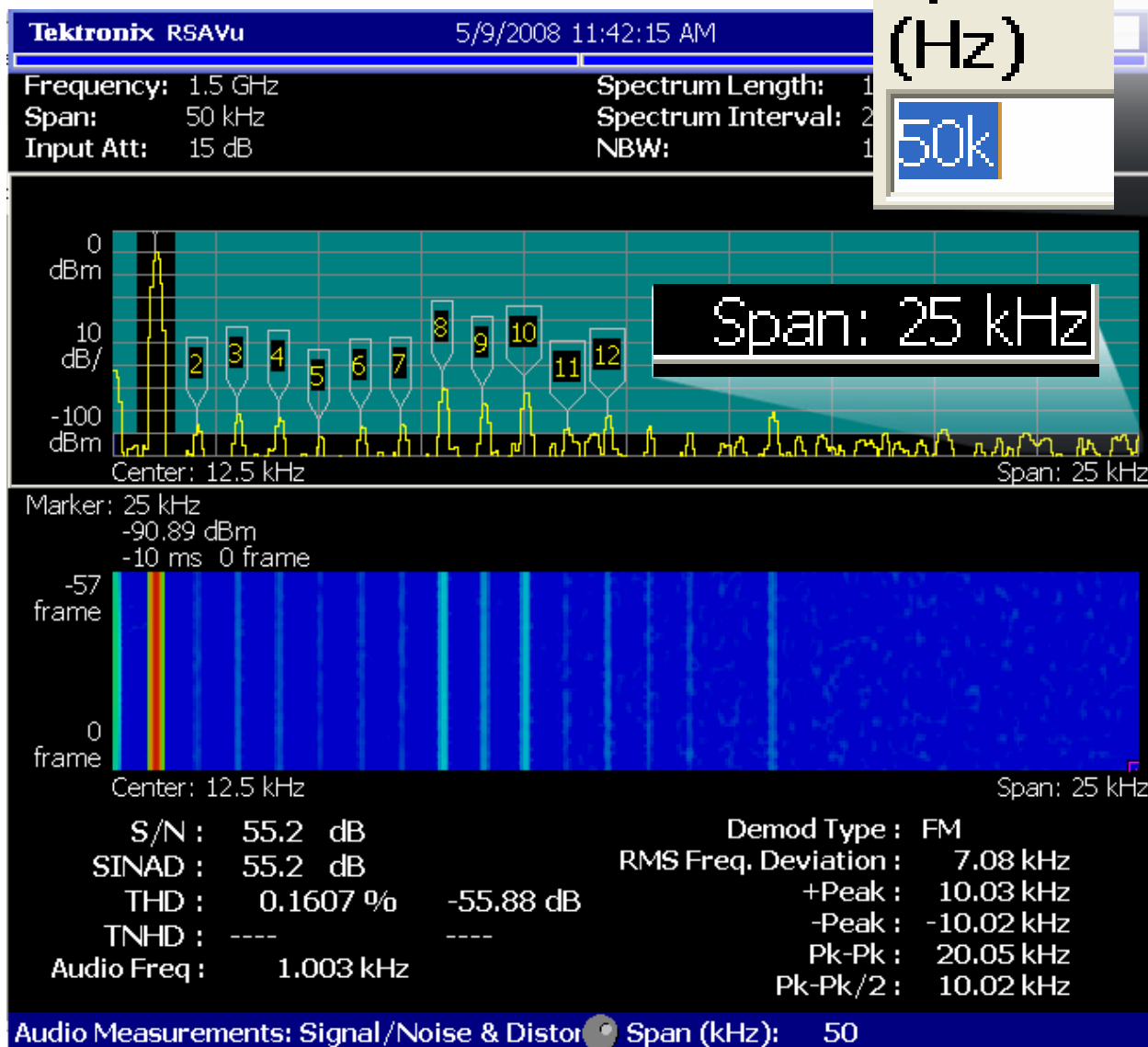
Frequency vs time



► Figure 26. The RTSA measures a five-frequency hop radar pulse. The markers show hop duration is 1.6 μ s.

(Need Opt10 Audio Distortion Analysis)

Audio Span = 1/2 RF Span



Span
(Hz)

50k

SPAN

Cancel - Back

Span
(Hz)

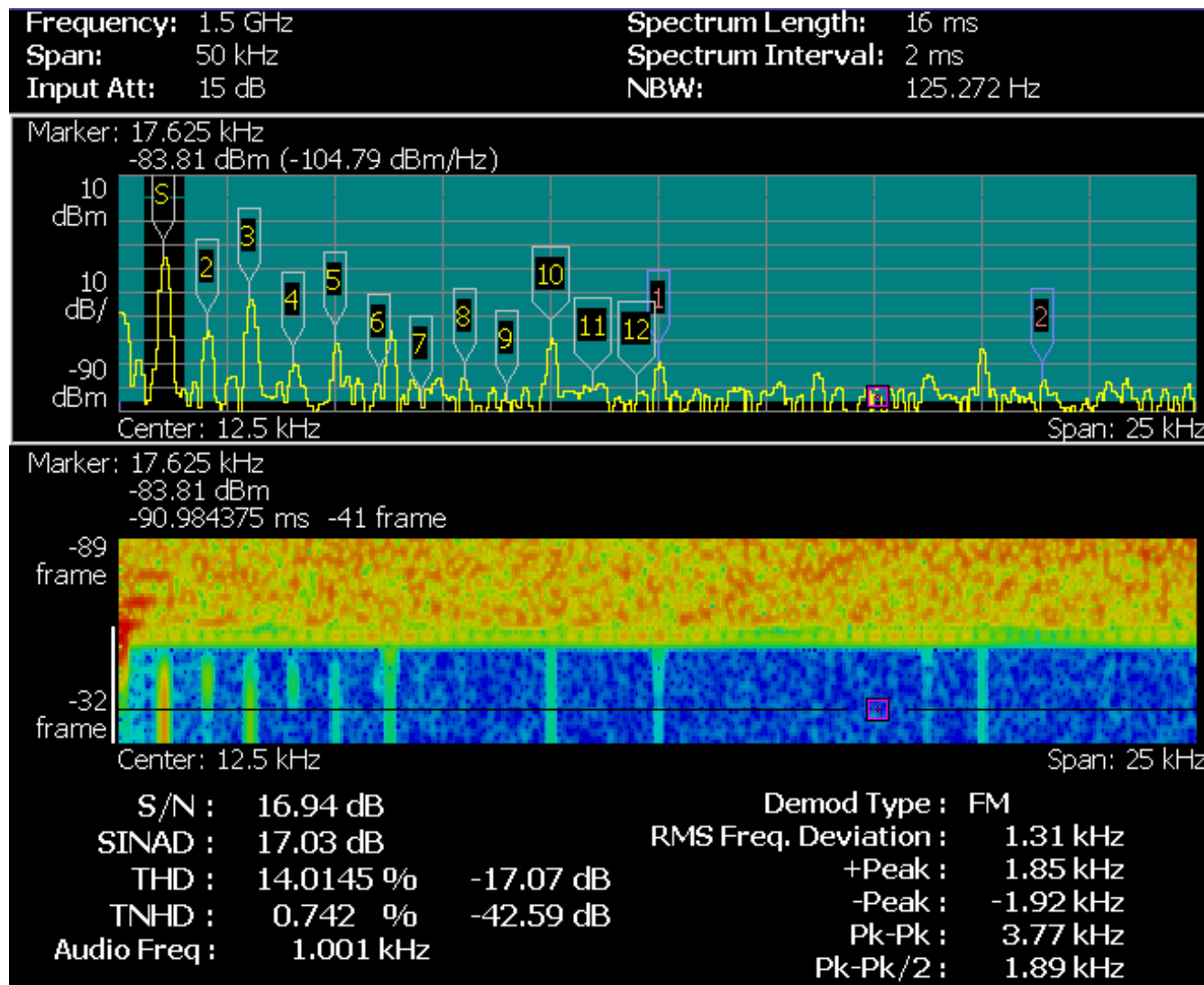
50k

“Span” in Audio Measurements directly relates to the RF Span

“Span” in Audio Spectrum and Spectrogram is 50% of the RF Span

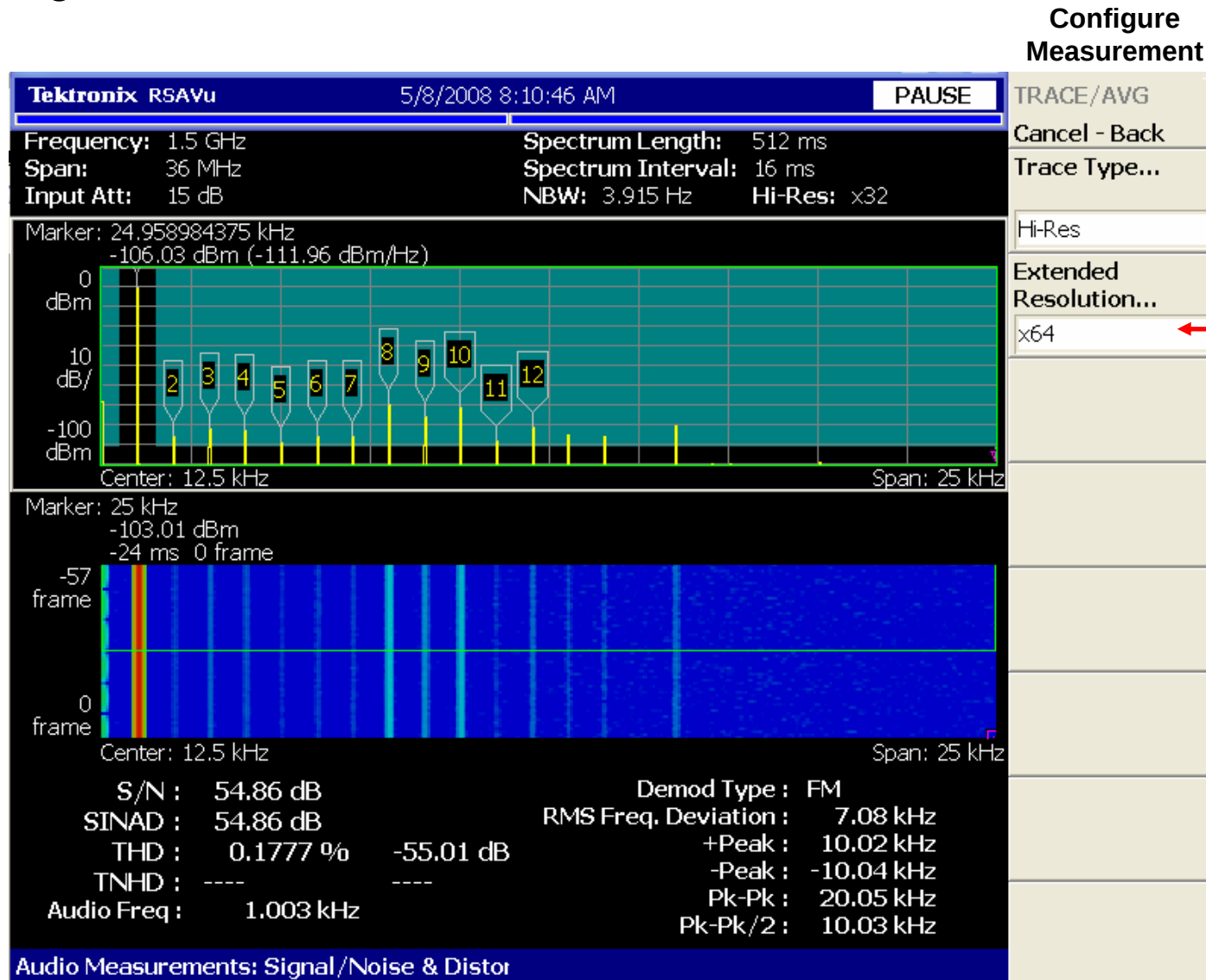
(Need Opt10 Audio Distortion Analysis)

Audio Distortion Measurements – Let's Do a Demo!



Audio Distortion Measurements, cont.

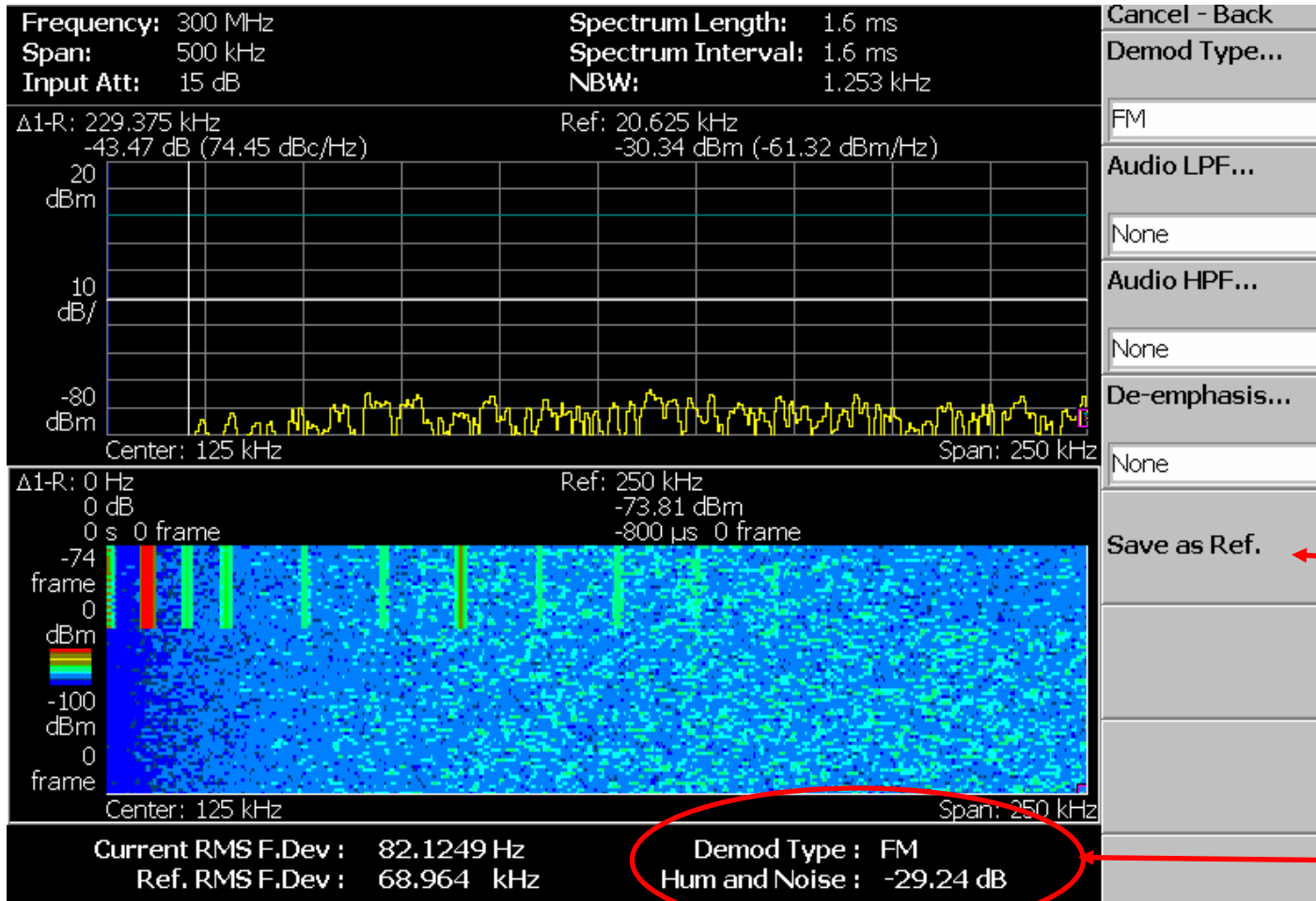
Signal/Noise and Distortion



New Hi-Res Mode
allows variable FFT
length from 1k to 64k

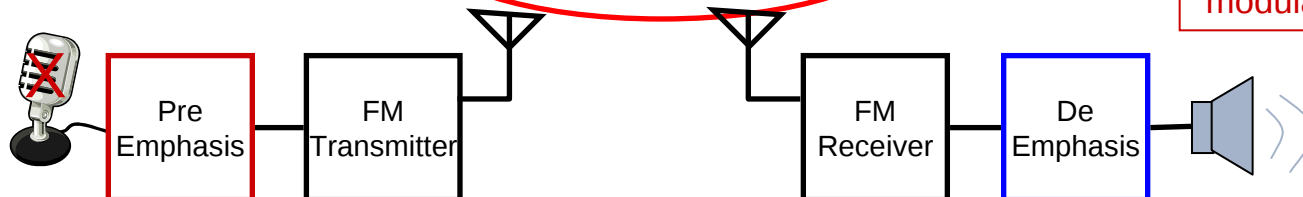
Audio Distortion Measurements

Hum and Noise



Set reference level
with the intended
modulation turned
On

Remove the
intended
modulation and
measure the total
un-intended
modulation + noise



Multi-Level FSK

Customer Challenges

- Measure overall FSK signal quality
- Understand frequency deviation at each symbol point
- Understand symbol timing error

RSA3000 Benefits

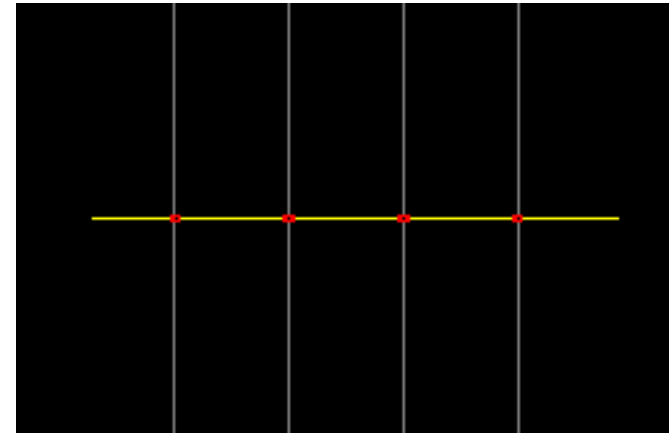


- Supports popular FSK types: 2 -16
- Easy view of frequency deviation at each symbol point



- Automatic calculation of Timing Error and Symbol Rate

4FSK Constellation



FSK Deviations

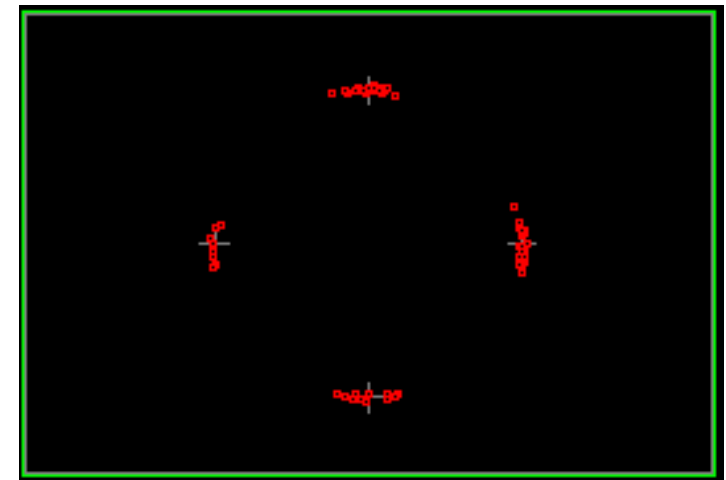
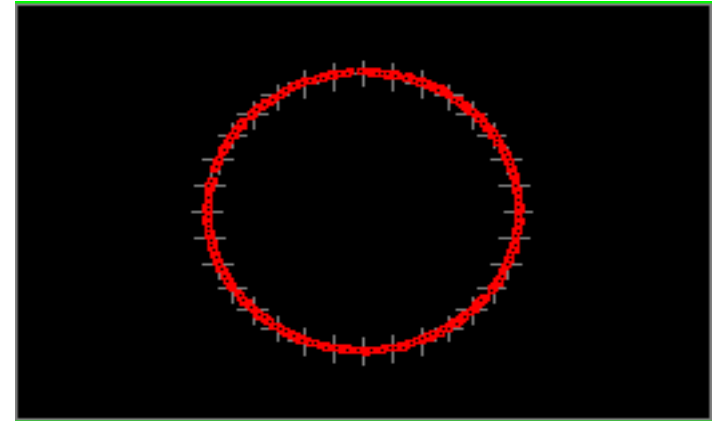
	Max	Avg		
RMS FSK Err:	3.685 %	3.685 %	Symbol Timing Err: 0.036 %	
Peak FSK Err:	13.432 %	13.432 %	Calculated Symbol Rate: 999.6355 kSym/sec	
	-3	-1	+1	+3
Max(Hz)	1.089M	431.857k	424.319k	1.091M
Min(Hz)	897.227k	200.913k	223.877k	893.293k
Avg(Hz)	999.589k	335.621k	327.195k	995.41k

New Modulation Format: CPM

(Continuous Phase Modulation)

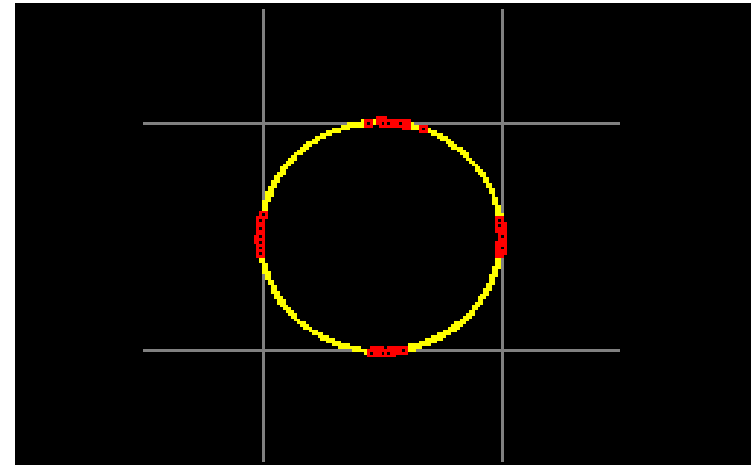
- What is it?
 - Modulation format for multi-mode radios (UHF SatCom)
 - 2 bits per symbol
 - Multi-modulation Indices (multi-*h*)
 - Compliant w/ MIL-STD-188-181B/C
 - Important for US and NATO countries
- Customer Challenges
 - Evaluate CPM preamble and payload bursts
 - Evaluate interoperability with other manufacturers of CPM radios
- RSA3000 Benefits
 -  — Mil-Std supported mandatory multi-*h* pairs (pre-amble & payload)
 -  — Easily evaluate modulation quality with new constellation display (patent pending)

Typical CPM Constellation



New Modulation Format: Shaped-OQPSK

- What is it?
 - Modulation format for multi-mode radios (UHF SatCom)
 - Constant envelop modulation
 - Half-Sine modulation filter
- Challenges
 - Validate UHF SatCom radio designs (EVM)
 - Evaluate interoperability with other manufacturers of SOQPSK radios
- RSA3000 Benefits
 - Demodulate radios using an “alpha” shaping factor of zero
 - Direct readout of signal quality parameters



```
EVM: 1.67 % RMS
      4.55 %      Peak @ sym 13
Mag Err: ----
           ----      Peak @ sym ----
Phase Err: ----
           ----      Peak @ sym ----
      Rho: 0.9911
      Length: 43 symbols
      Freq Err: -1.269 kHz
      Origin Offset: -37.46 dB
      Scale: 7.105 mV/Unit
```

Spectrum Emission Mask Testing

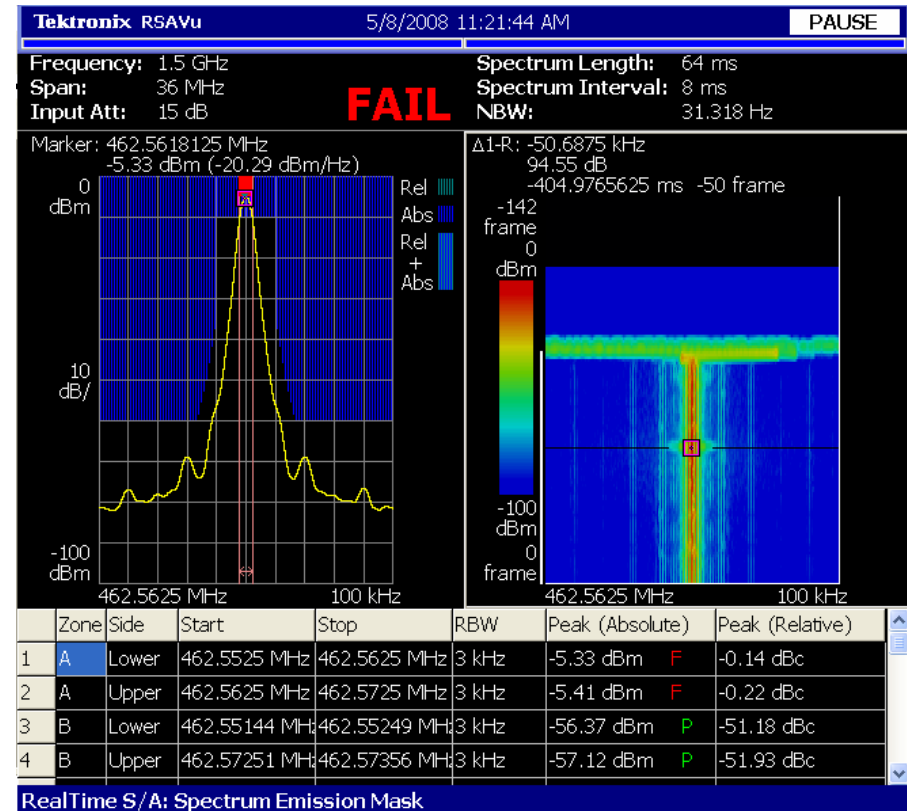
Customer Challenges

- Check emission compliance to regulatory standard
 - Evaluate radio during power-on, power-off and mode changes
 - Evaluate steady-state emissions
- Compliance documentation

RSA3000 Benefits

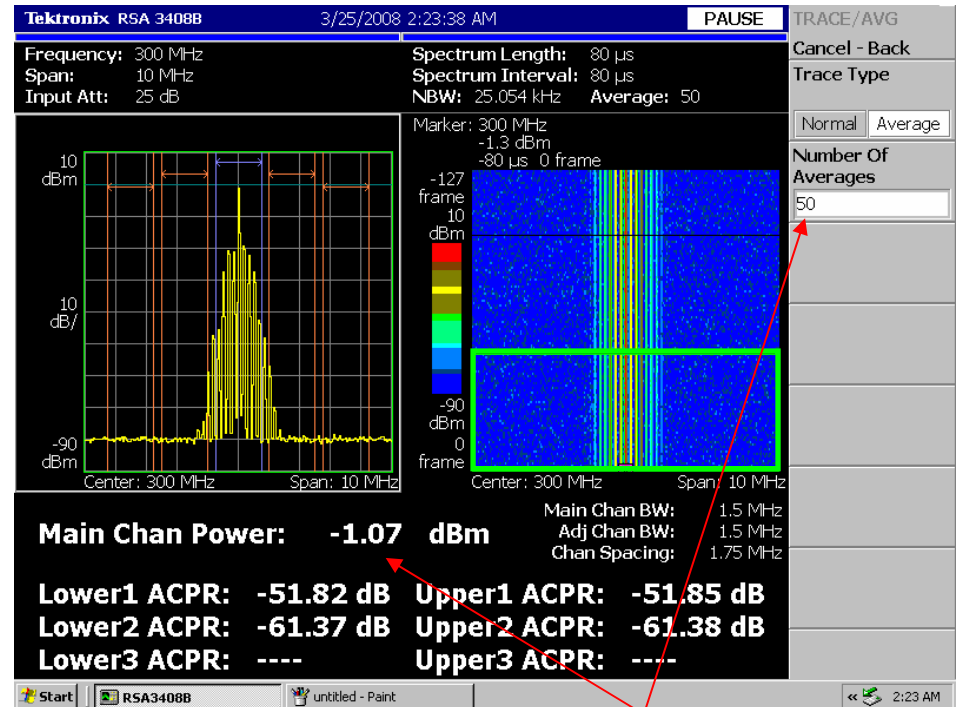


- Easy evaluation of transmitter turn-on emissions with Real-Time SEM
- Easy evaluation of steady-state emissions using Real-Time or SA Mode SEM
- Define and upload SEM masks simple CSV files
- Export results table via GPIB/LAN



Real-Time Averaged ACPR

- Challenge
 - Check adjacent power performance over specified number of averages
- RSA3000 Benefits
 - One-button setup
 - Combinable with instrument triggers
 - Easy-to-see “green” area of measurement averages

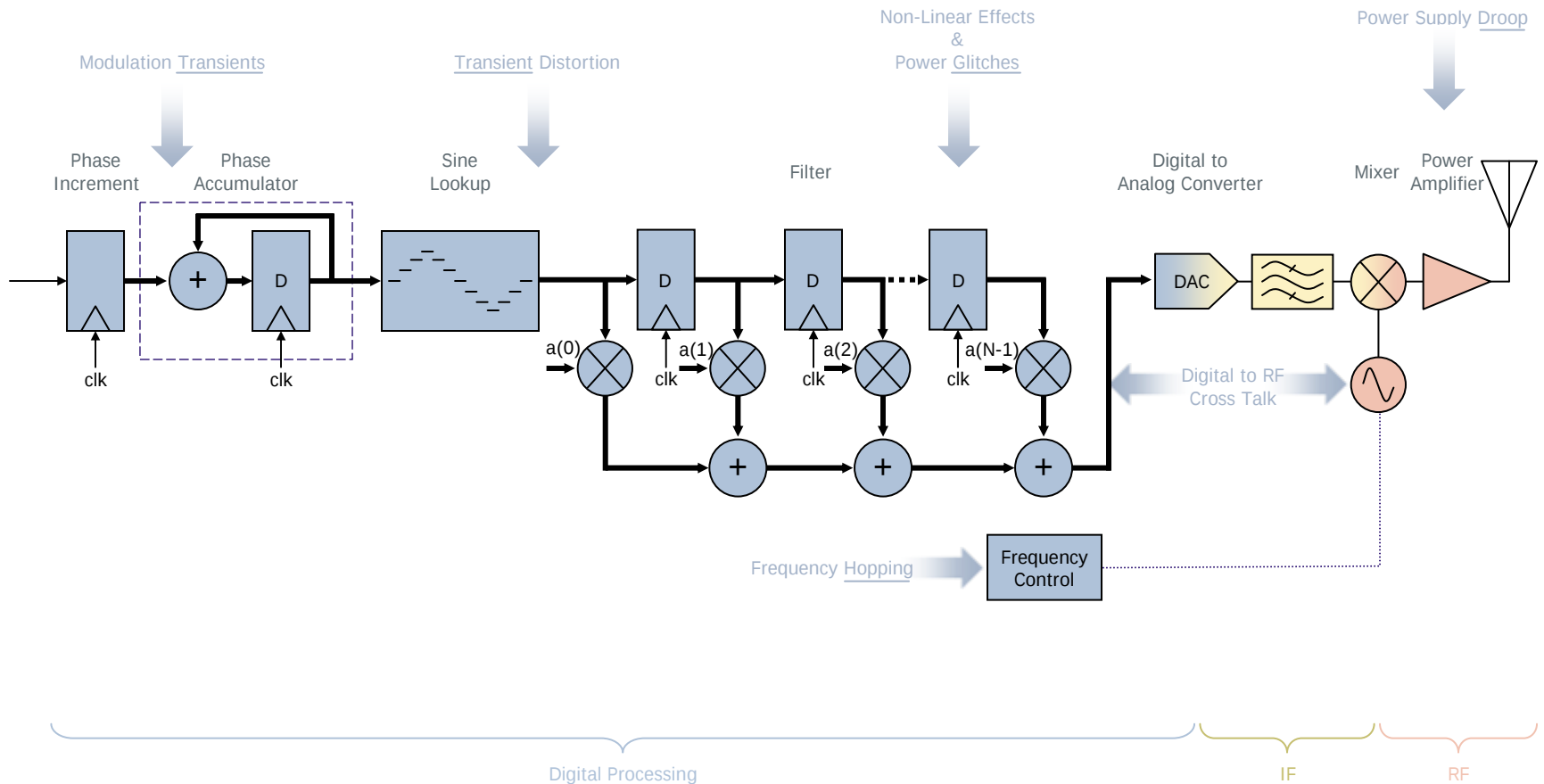


Automatic readout of ACPR
after specified # of averages

Cases Study

- 震盪器
- 放大器
- 即時頻譜監控與紀錄
- 捕捉干擾
- 通訊訊號實測分析
- 通訊系統維運(Base station)
- 暫態電磁干擾(Transient EMI)
- 軍用類比數位跳頻無線電(Military Radio)
- 軟體無線電(Software Define Radio)
- IED (Improvised Explosive Device)
- 分辨解調未知訊號

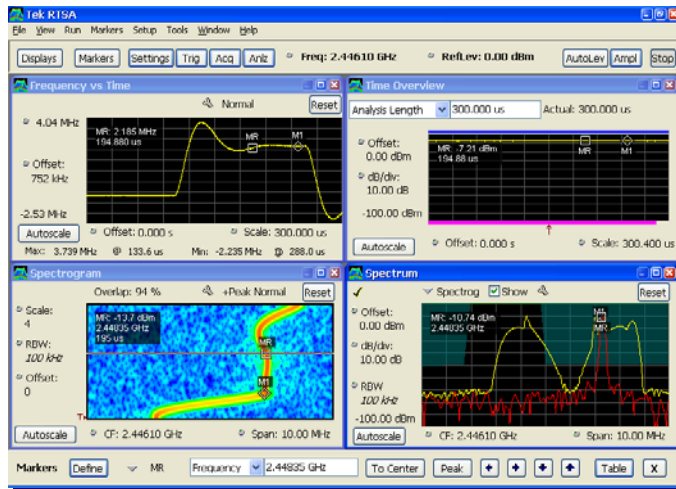
Some SDR Diagnostic Challenges



Beyond Traditional Conformance Testing

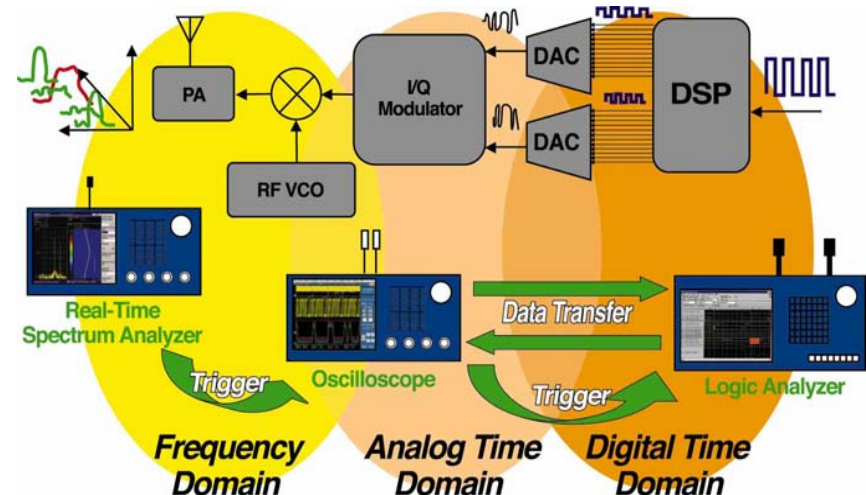
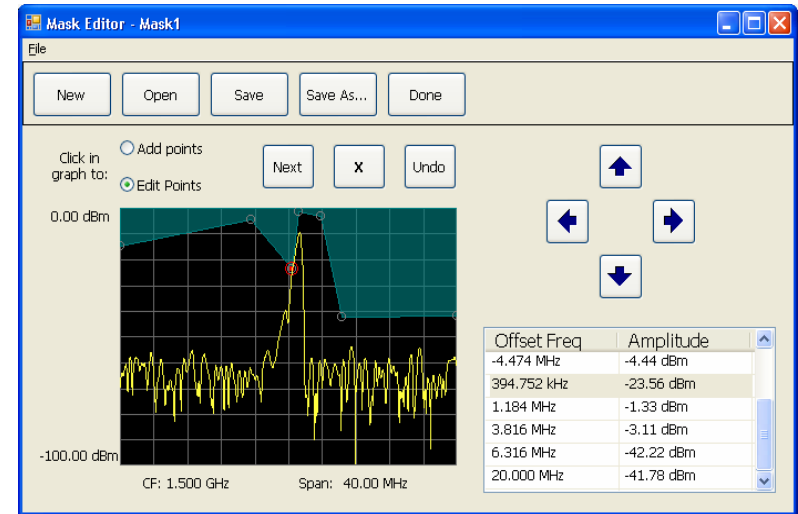


- Typical Radio Tests
 - Regulatory: Freq., OBW, Power
 - Compliance: ACLR, EVM, Rho
- Unique SDR Challenges
 - Overflows, Initializations, Glitches
 - Mode Switching & Variable Rate
- Difficult Test Problem
 - Traditional SA's Limited Capability
 - Little Transient Signal Capability
- RTSA Offers Powerful Capability
 - Ideal for Transient RF Signals
 - Multi-Domain Analysis on a single capture – saves TIME
 - *Unique Triggering Capability*
- RF, Analog & Digital Correlation requires:
 - *Cross-triggering between instruments*
 - Powerful and flexible signal generation



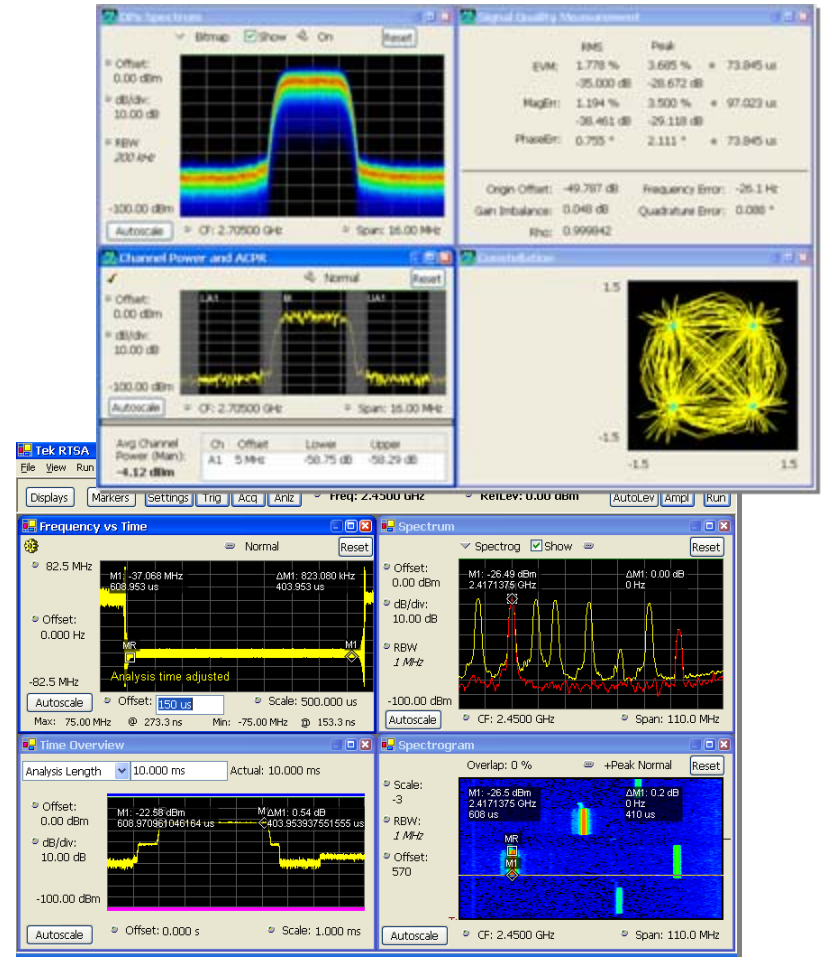
Powerful *Triggering* Features

- **Frequency Mask Trigger (FMT)**
 - Flexible Amplitude/Frequency discriminating trigger
 - Simple mask creation on Spectrum, up to 500 points
- **Power/Amplitude Trigger**
 - Full SPAN or band-pass filtered
 - Adjustable threshold/polarity
- **External Electrical Trigger**
 - Two electrical trigger inputs
 - Independent or Gated
- **Cross-Trigger Capabilities**
 - Trigger RSA from Scope or LA
 - Scope or LA triggered from RSA
 - RSA Triggers Arbitrary Waveform Generator
- **Time-Domain Trigger**



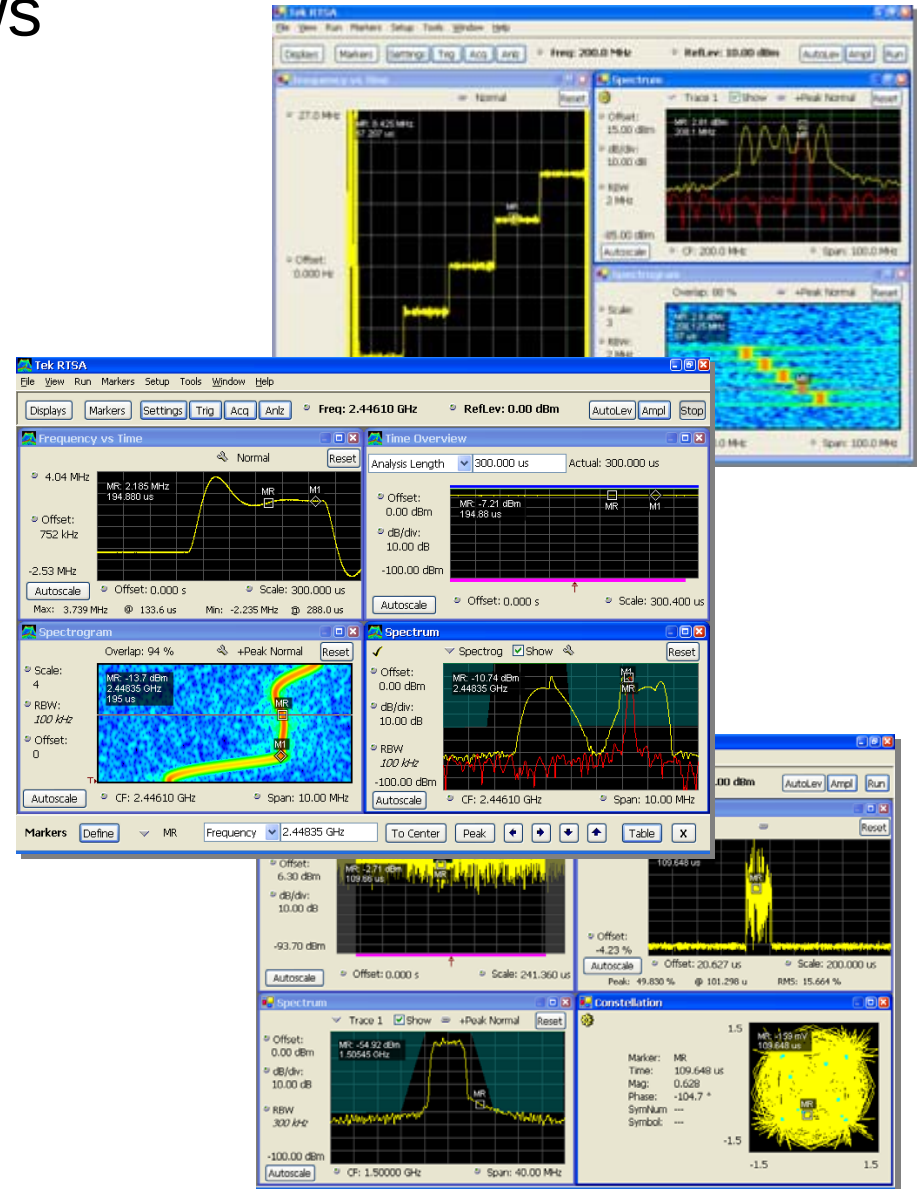
Seamless Capture & Multi-Domain Analysis Benefits

- Seamless capture of RF waveforms
- Captured data is measured simultaneously in frequency, time and modulation domains
- DPX™ can run alongside the post-acquisition measurements
- Markers in all graphs show correlation between data points in the various domains



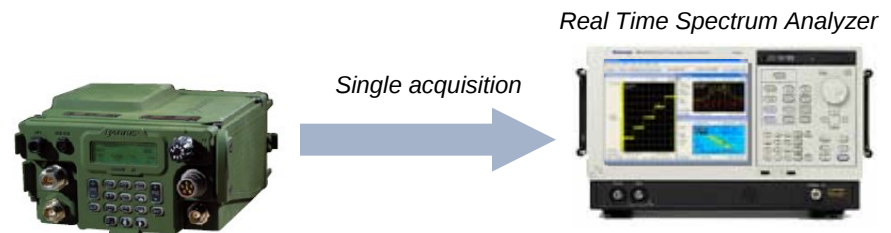
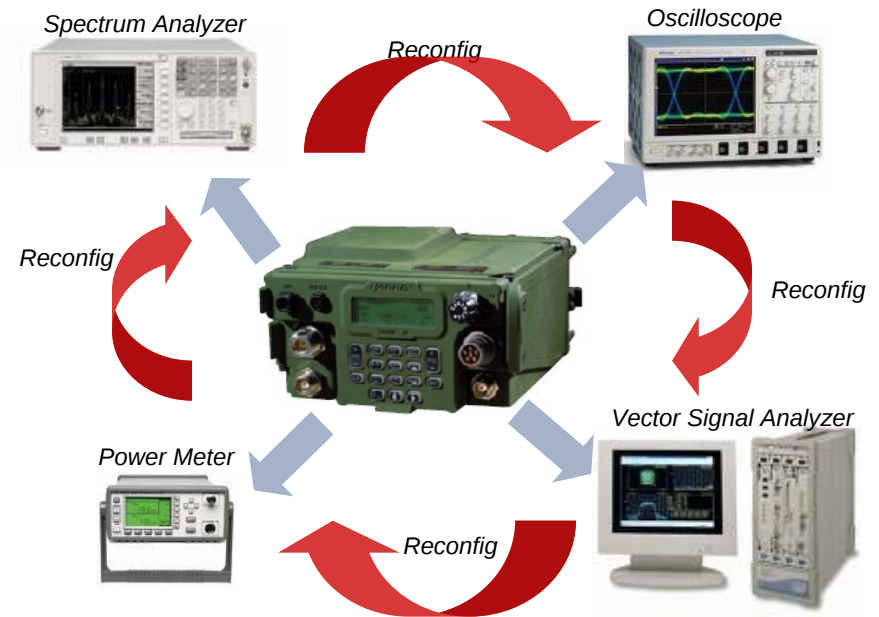
Multi-Domain Analysis Views

- General Analysis
 - DPX™ Spectrums
 - 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
- Pulsed RF Measurements
 - Power, Rise/Fall, PW, PRI, Freq & Phase, Deviation, etc.
- All available at any time...
...on the same acquisition



Multi-Domain Analysis Reduces Test Times

- Traditional Radio Test
 - ACP, Power Ramping, EVM, etc.
 - Multiple test configurations
 - Configuration changes take TIME!
- Multi-Domain Analysis Benefits
 - Many test types on ONE acquisition
 - No re-configuration of equipment
 - Streamlined radio configuration
 - Test multiple parameters on one waveform
- Other Time Saving Features
 - Unique “Replay” analysis options
 - Fast narrow-RBW searches
- *TIME is MONEY*
 - Reduced test time
 - **Reduced equipment needs**

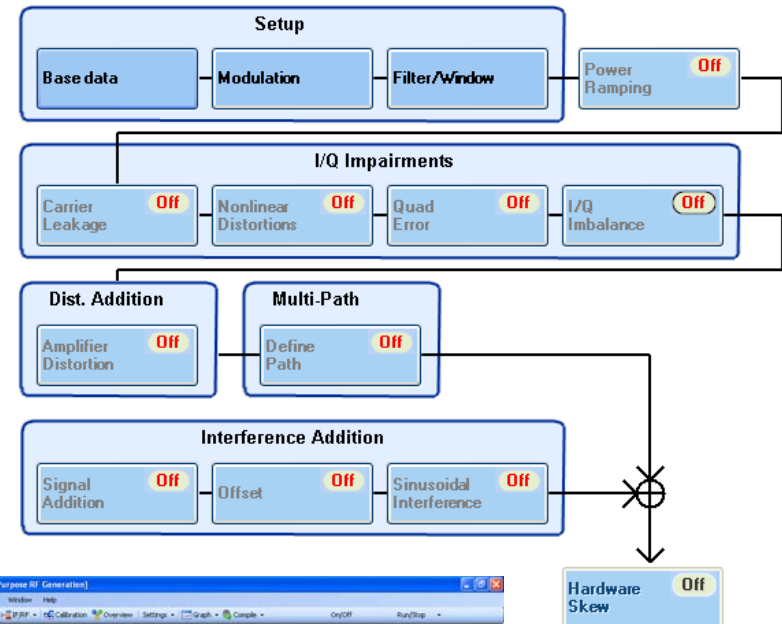


RFXpress™ RF Signal Synthesis (RF / IF / IQ)

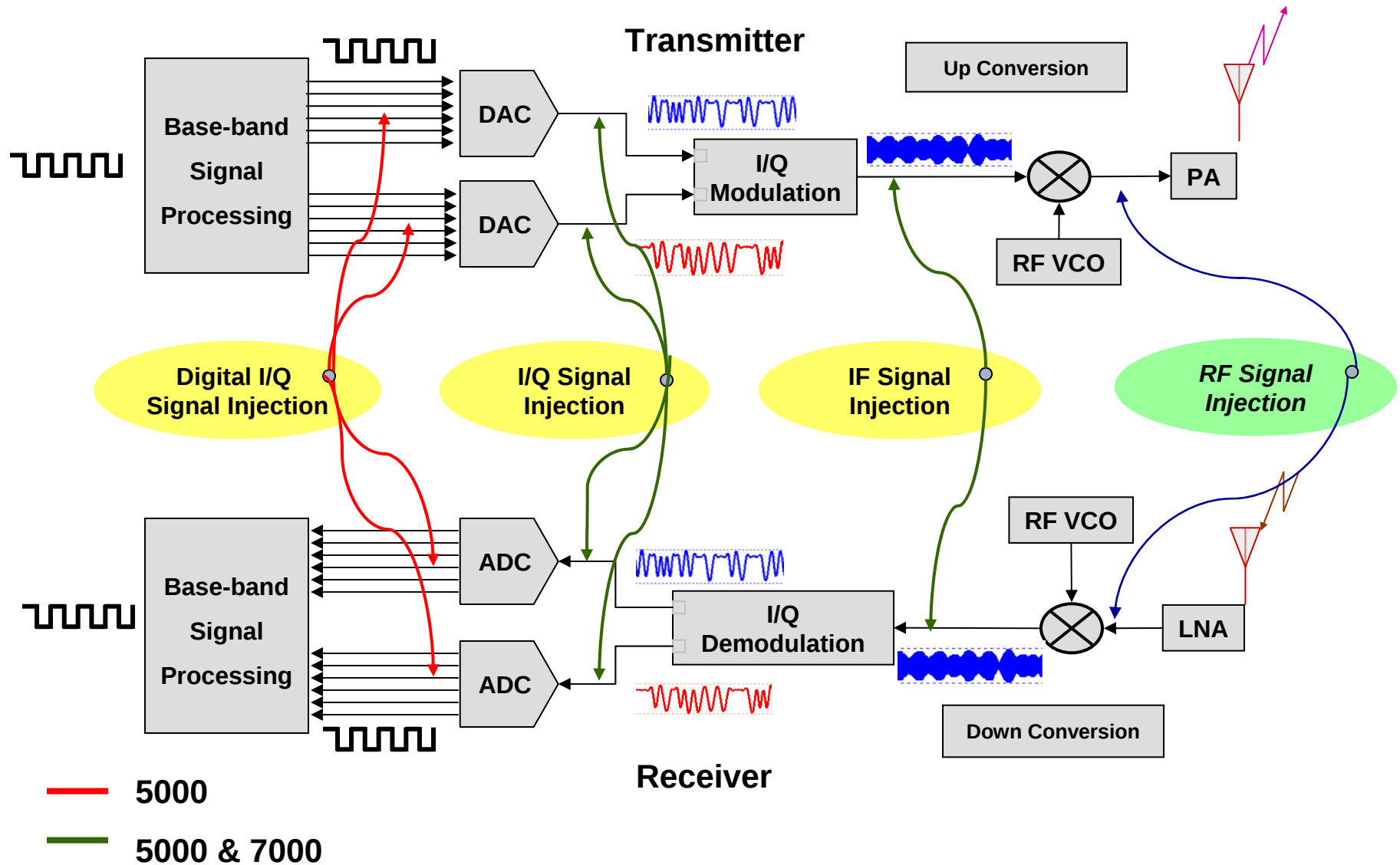
Create RF signals with user defined:

- Number of Carriers (1-512)
- Data to be modulated
- Modulation type
- Carrier Frequency
- Power Ramping
- IQ Impairments
- RF Distortion
- Multipath effects
- Interference

...All on a carrier by carrier basis!



AWGs for Signal Generation and Injection



- RFXpress -> ideal digital IQ
- AWG -> IQ
- AWG -> RF

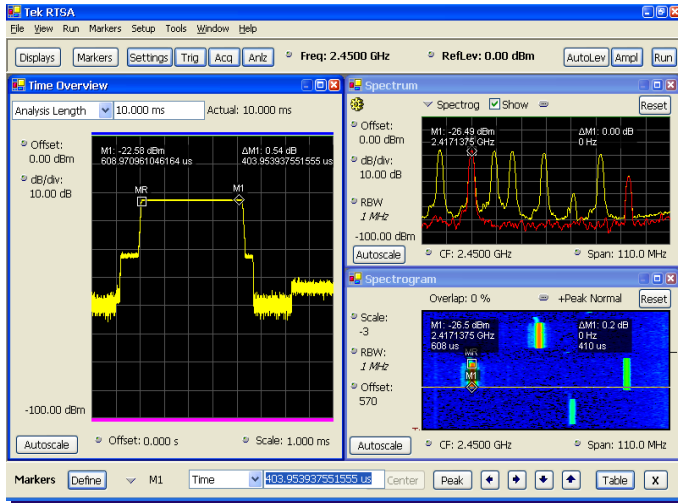
RSA decode

RSA decode

RSA decode

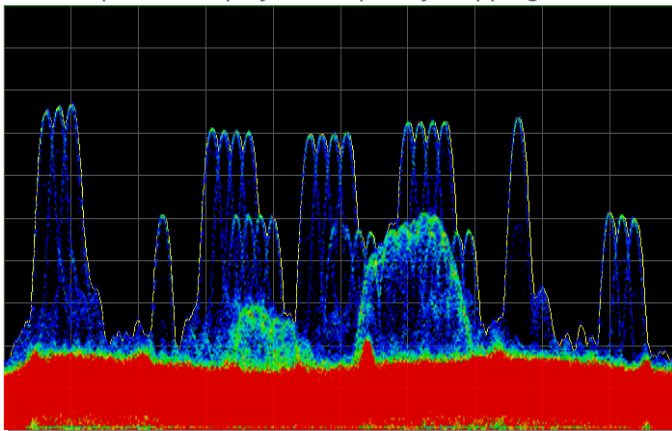
Application: Frequency Hopping & Transmitter Testing

Bluetooth® Frequency Hopping Spread Spectrum



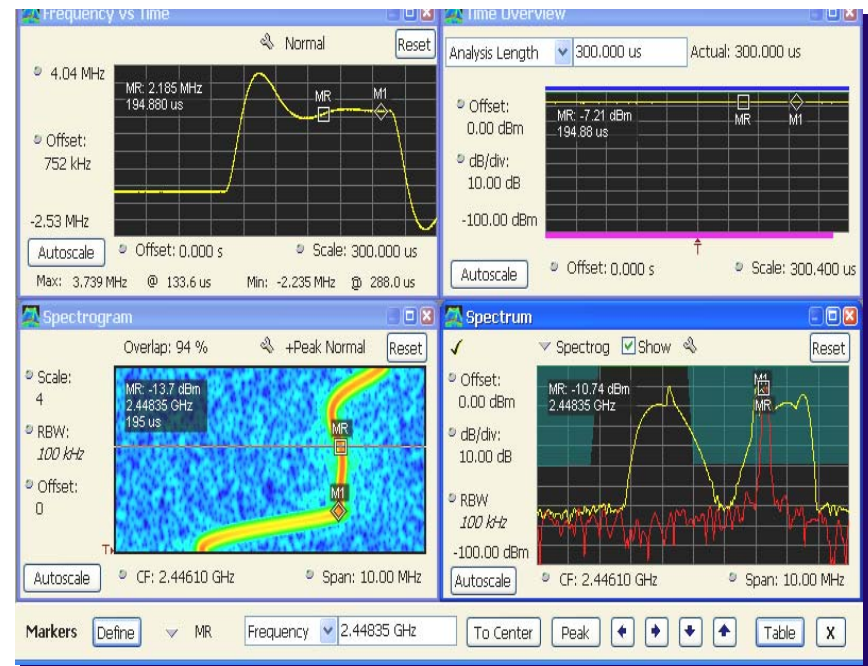
- Hopping Improves Performance...
 - Avoid Affects of Jamming & Interference
 - More Multi-path Robust Data Links
- Need to Test Hopping Performance
 - Hop Timing, Frequency & Amplitude
- Need Wide Analysis Bandwidth
 - To Cover Full Hopping Frequency Range

DPX™ Spectral Display of Frequency Hopping



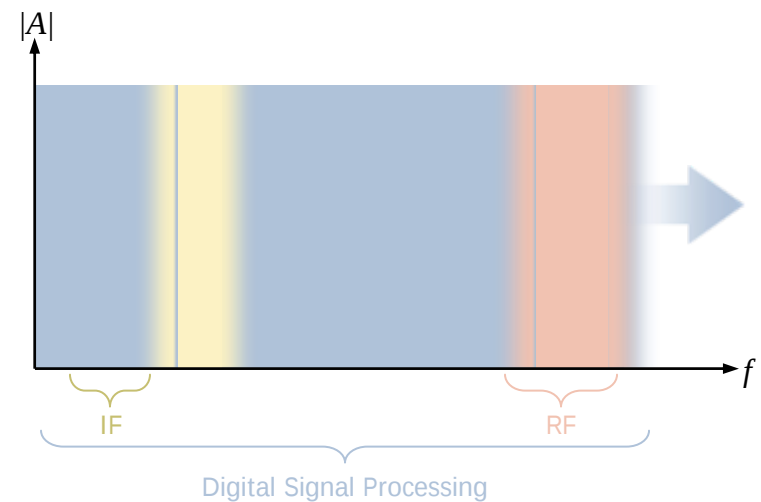
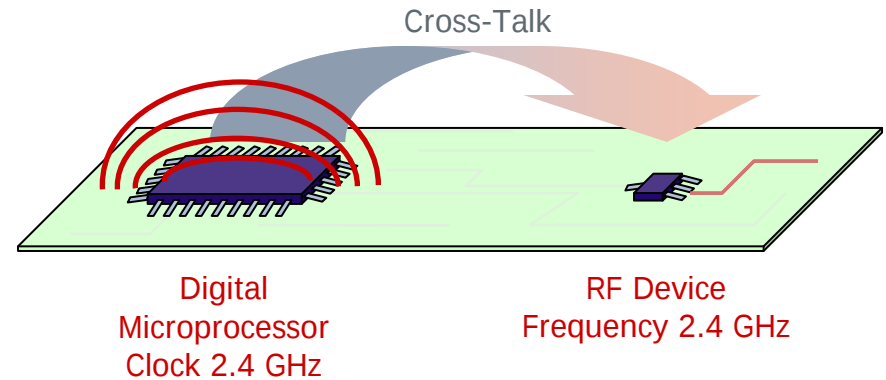
Application: Phase Lock Loop Settling Time

- 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

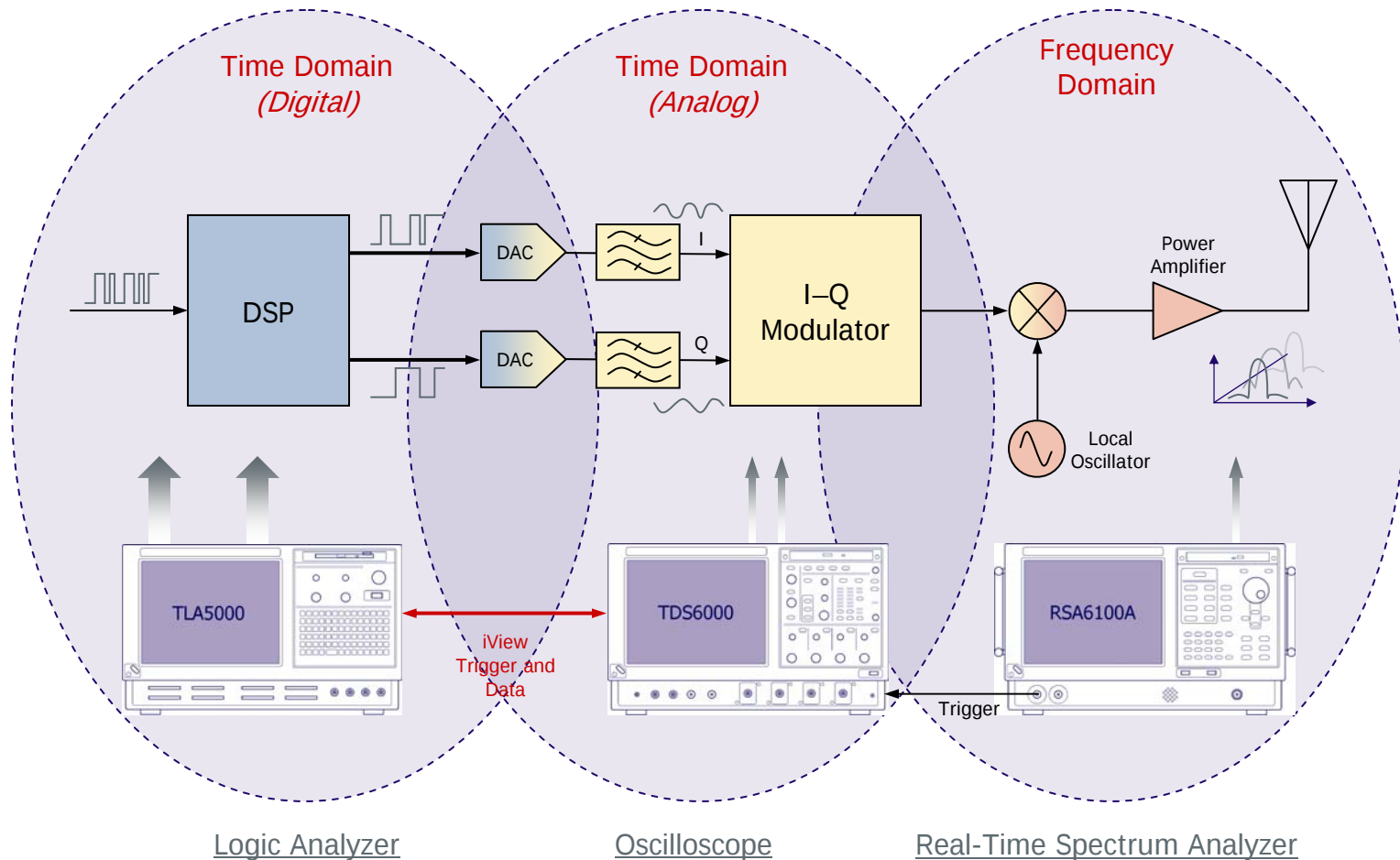


Application: Cross-Talk from Other Devices

- Integration $\Rightarrow$ Shrinking Designs
- Digital and RF Closer Together
- CPU Operating Frequencies Rising
- Digital Parts Now at RF Frequencies
- **Challenge:** Finding Transient Cross-Talk
- **Benefit:** DPX™ Discovers, FMT Captures,
Cross-triggering across platforms debugs



Application: Cross Platform Triggering on Spectral Events

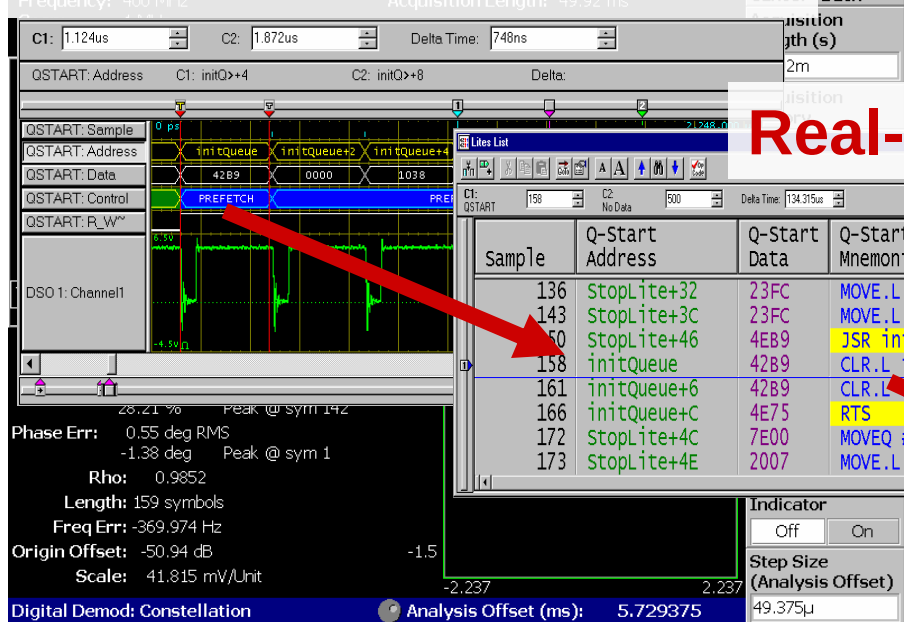


Correlated Multi-Instrument Analysis:

SDR

Across Multiple Platforms

Real-time Hardware Trace



Real-time Instruction Trace

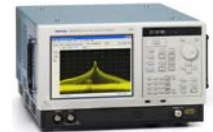
Sample	Q-Start Address	Q-Start Data	Q-Start Mnemonic
136	StopLite+32	23FC	MOVE.L #00001001,stopLights+10
143	StopLite+3C	23FC	MOVE.L #00000401,stopLights+14
150	StopLite+46	4EB9	JSR initQueue
158	initQueue	42B9	CLR.L front
161	initQueue+6	42B9	CLR.L rear
166	initQueue+C	4E75	RTS
172	StopLite+4C	7E00	MOVEQ #000000
173	StopLite+4E	2007	MOVE.L D7,D0

Source Code Debug

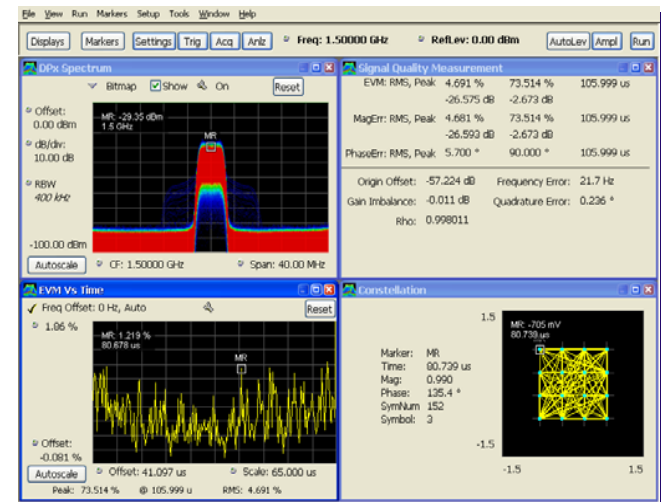
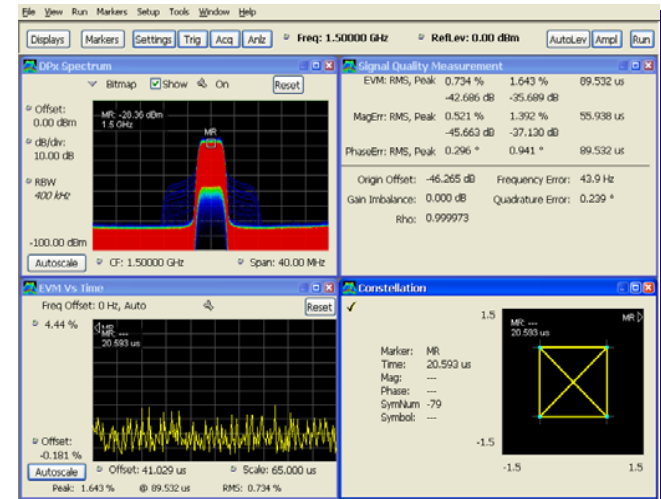
```
Line 31: \queue.c
24
25 /*****
26  * Routine to initialize queue
27  *****/
28 void
29 initQueue()
30 {
31     front = 0;
32     rear = 0;
33 }
34
```

- Trigger, capture, and analyze the RF signal
- View correlated baseband analog and digital data to identify the frequency domain anomaly
- Trace back to line of Code

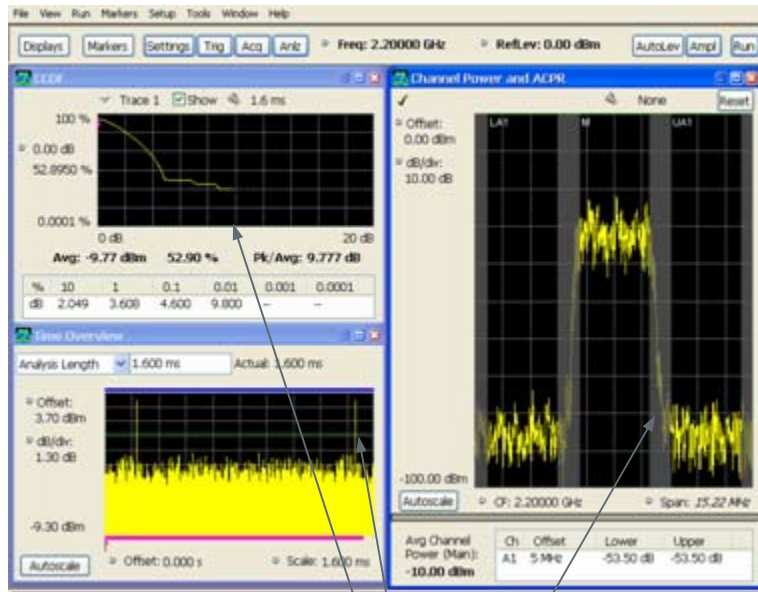
Application: Modulation Transients



- SDRs Often Change Modulations
- Dynamically Switch Format & Coding
- Best Use of Channel Conditions
- Example: 3G HSDPA, QPSK & 16-QAM
- **Challenge:** Finding Brief Transients
- **RTSA Benefit:** DPX™ Easily Discovers



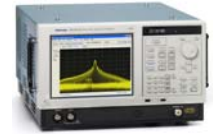
Application: Non-Linear Effects & Digital Glitches



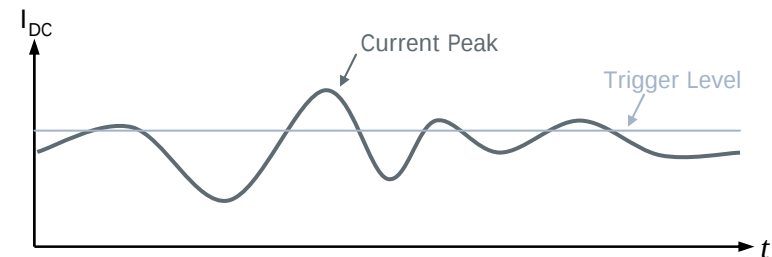
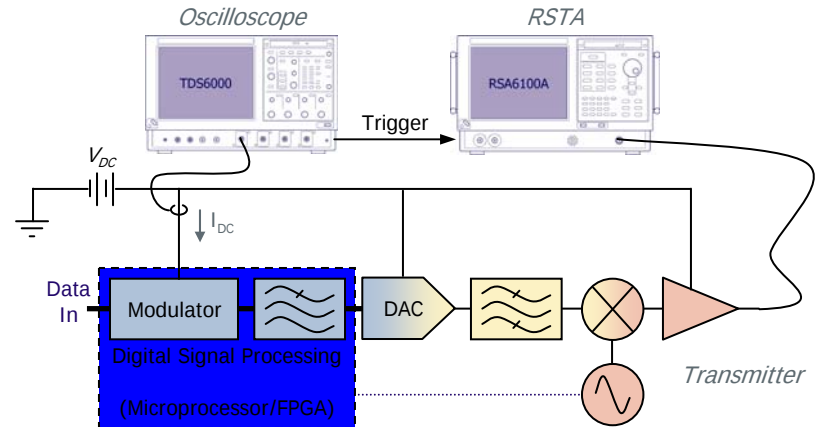
Time Correlated Multi-Domain Analysis

- 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

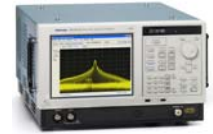
Application: Power Supply Droop & RF Output



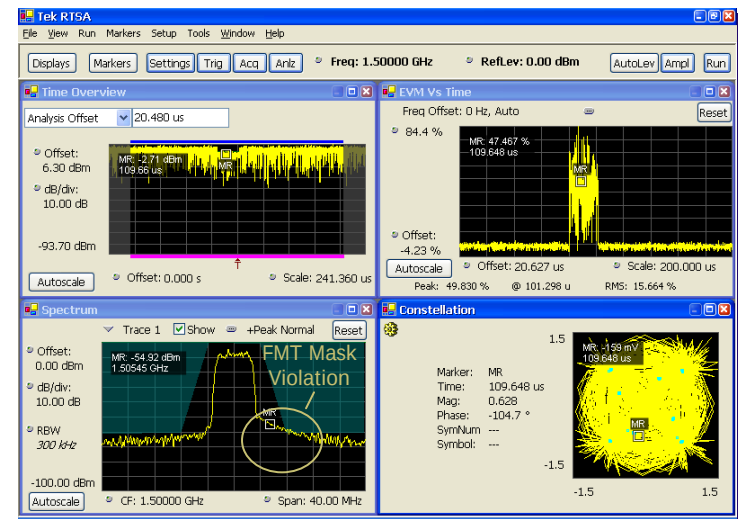
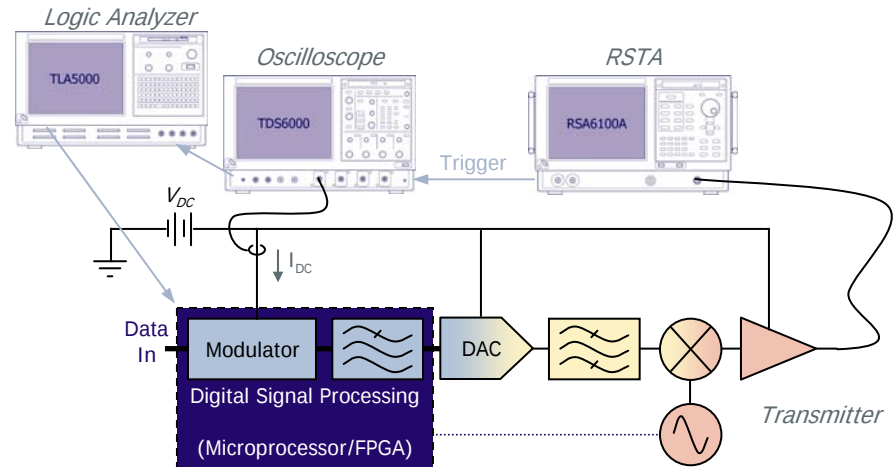
- DSP Power Requirements Vary
 - DSP Processor Executes Complex Routines
 - Result can Vary Bias Voltage on PA
- Code Dependent Analog RF
 - Large Data Changes can Lead to Varying CCDFs & Frequency Domain Fluctuations
- Oscilloscope Current Triggering Approach
 - Trigger on Current Fluctuations & View Spectral Effects
- **Challenge:** Avoid False Triggering
 - Current Peak $\neq$ To Spectral Event?



Application: Power Supply Droop & RF Output



- 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

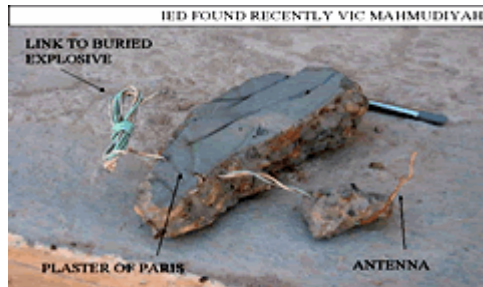


Cases Study

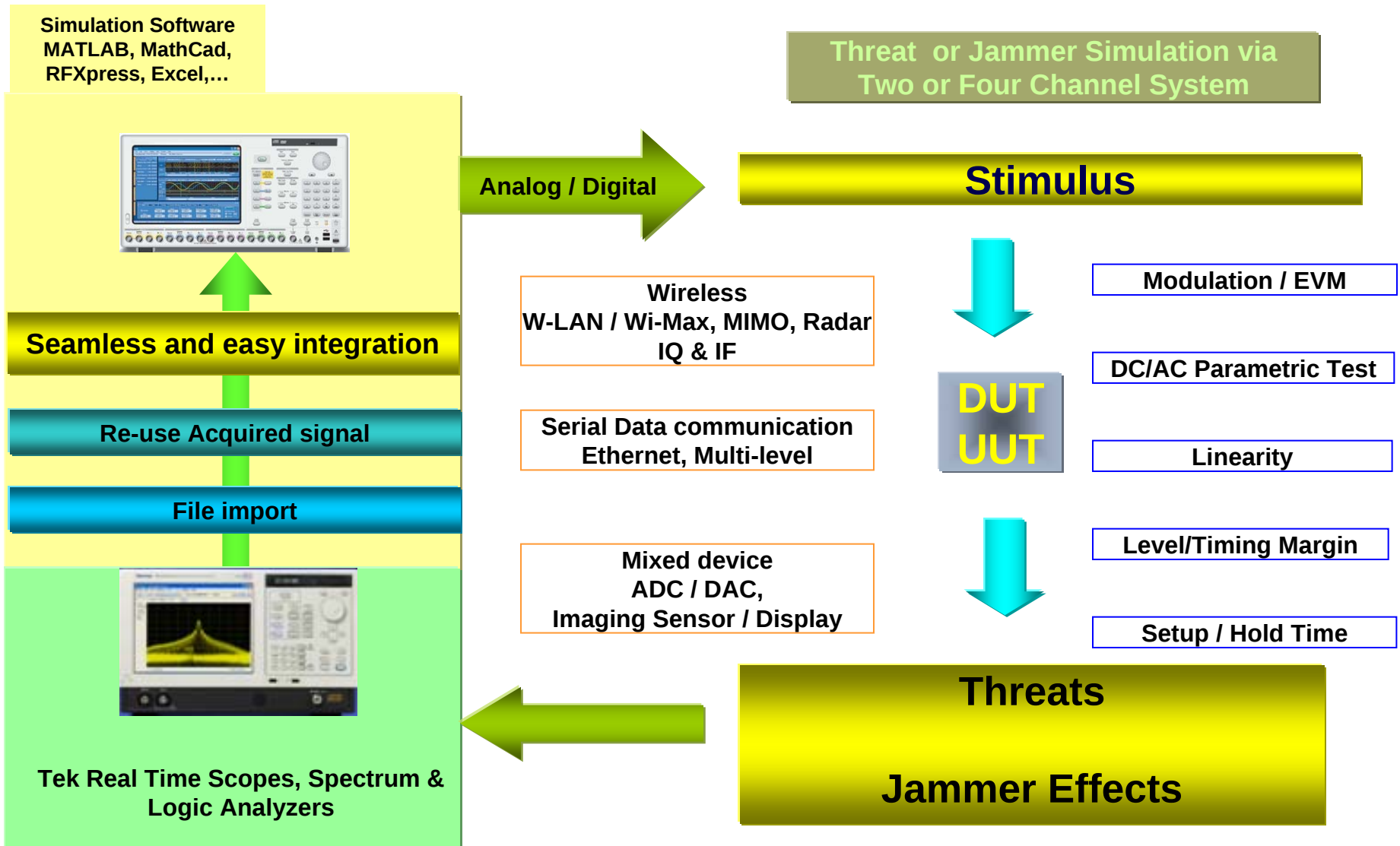
- 震盪器
- 放大器
- 即時頻譜監控與紀錄
- 捕捉干擾
- 通訊訊號實測分析
- 通訊系統維運(Base station)
- 暫態電磁干擾(Transient EMI)
- 軍用類比數位跳頻無線電(Military Radio)
- 軟體無線電(Software Define Radio)
- IED (Improvised Explosive Device)
- 分辨解調未知訊號

Why Do We Need RF Capture & Playback?

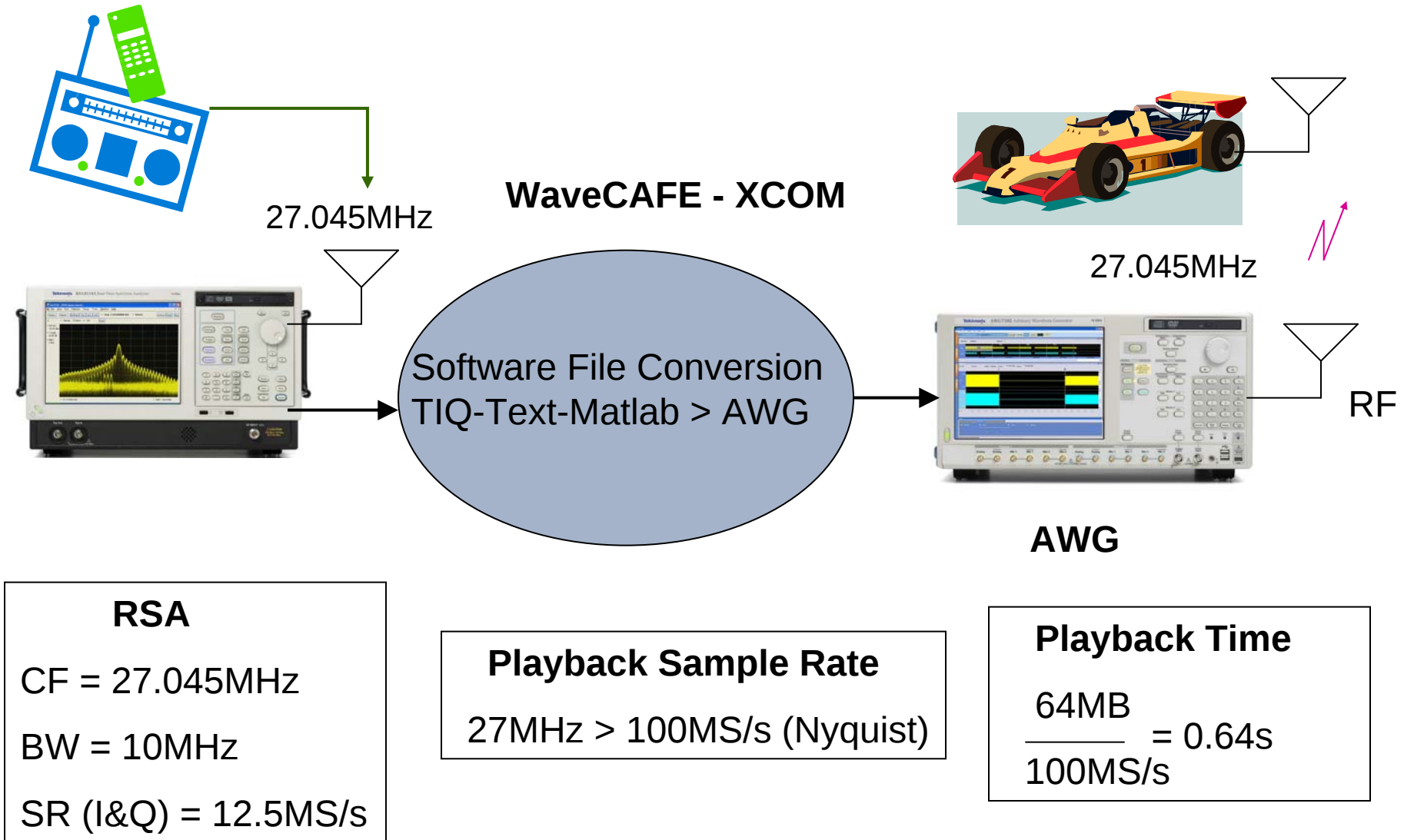
- Why do we need this capability?
 - RF System Development & Test
 - Electronic Warfare, Counter-measures
 - Detecting and Defeating RF Threats, i.e. IED's, etc.
- Focus on RF Threats...
 - Discover the existence and nature of the threat
 - Capture & Analyze the characteristics of the threat
 - Synthesize a signal that will jam the receiver
 - Characterize the timing and effectiveness of the jamming signal



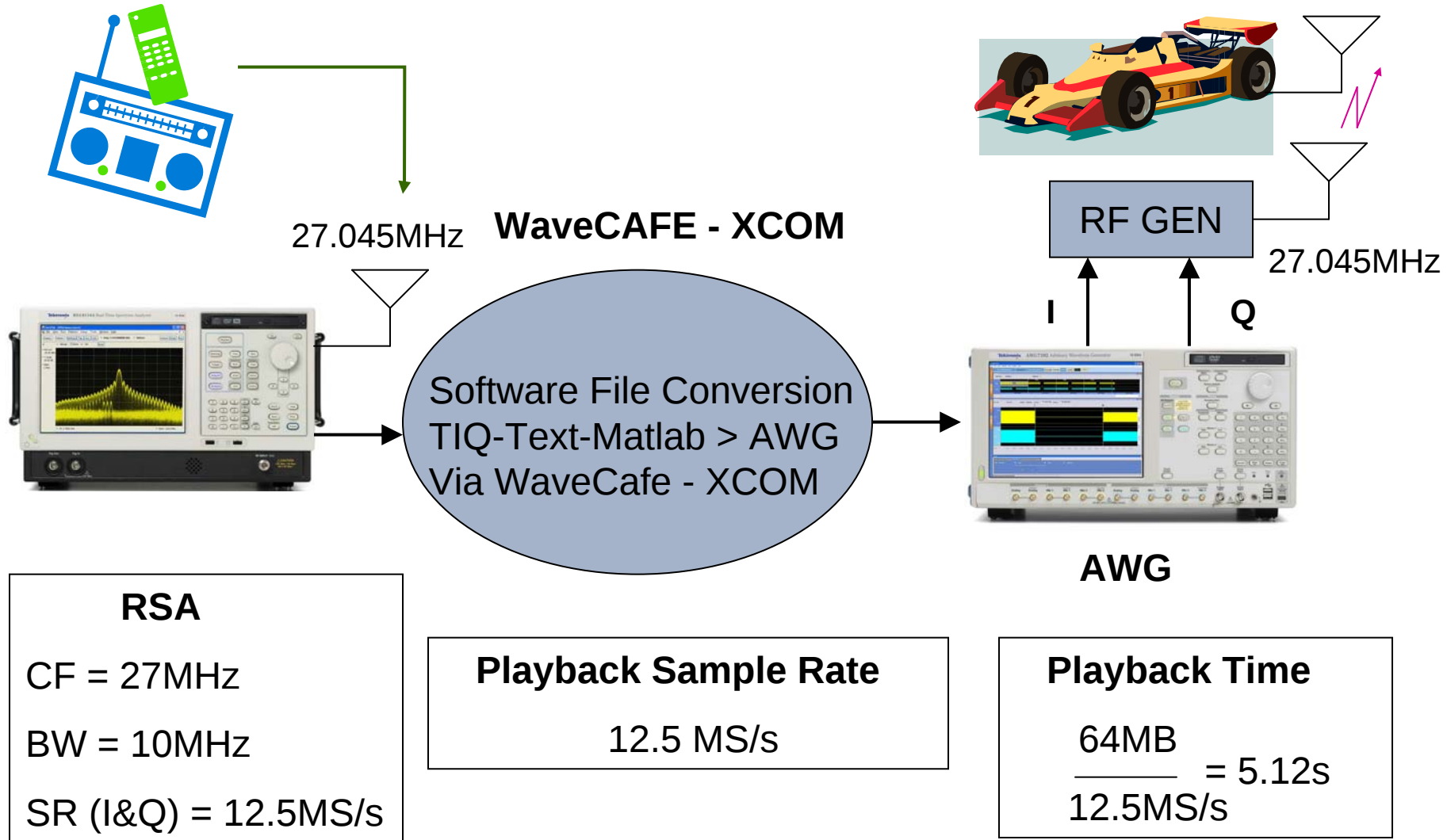
RF Playback & Analysis



RF Playback: Direct RF Generation



RF Playback: I/Q Generation & Modulation



100

characterized

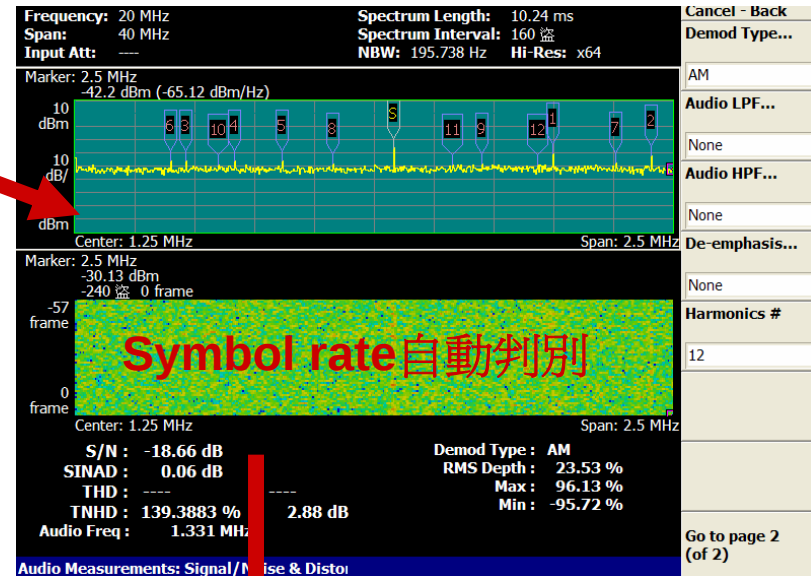
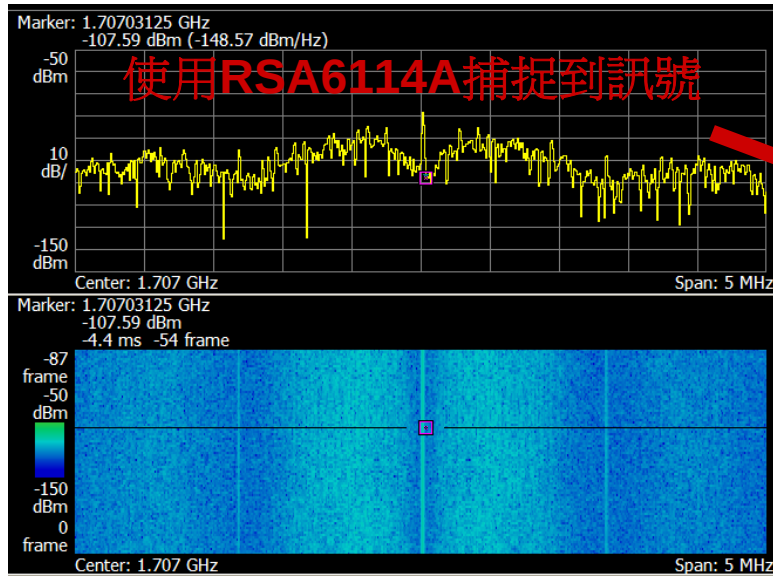
/



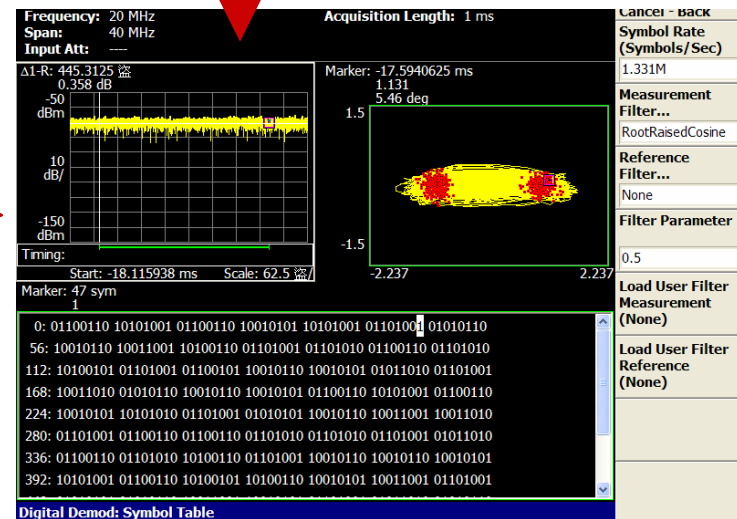
Cases Study

- 震盪器
- 放大器
- 即時頻譜監控與紀錄
- 捕捉干擾
- 通訊訊號實測分析
- 通訊系統維運(Base station)
- 暫態電磁干擾(Transient EMI)
- 軍用類比數位跳頻無線電(Military Radio)
- 軟體無線電(Software Define Radio)
- IED (Improvised Explosive Device)
- 分辨解調未知訊號

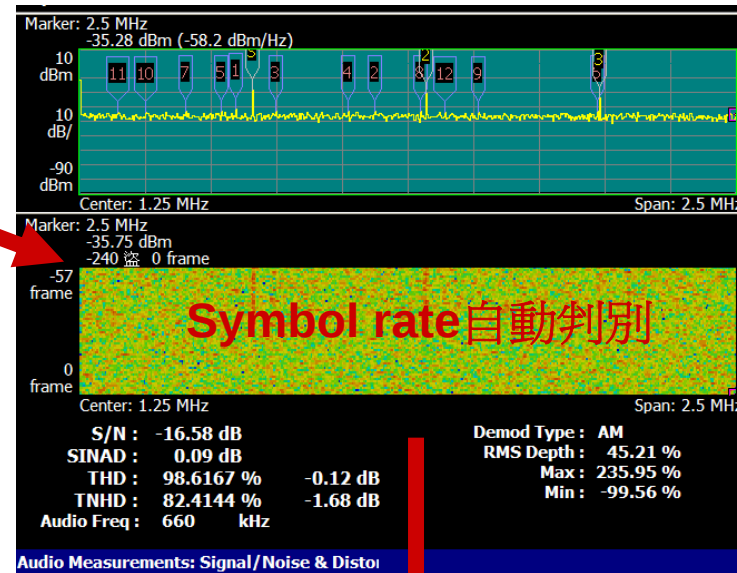
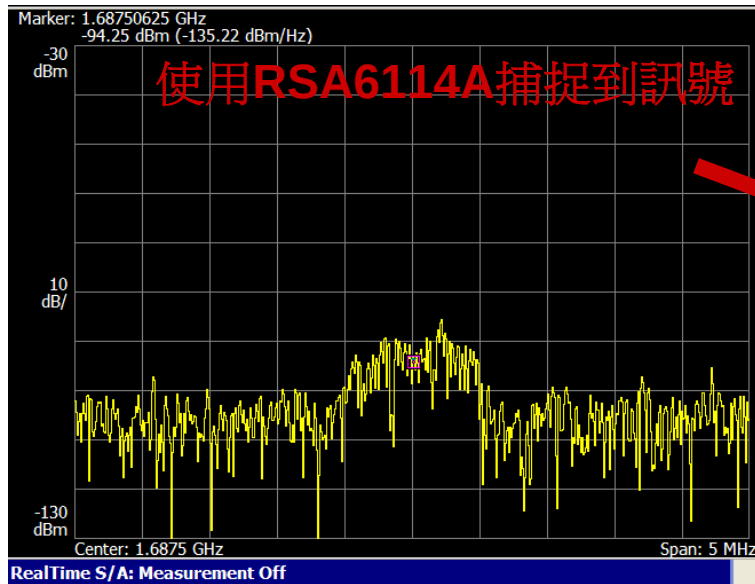
分辨未知氣象衛星1.707GHz GPS訊號



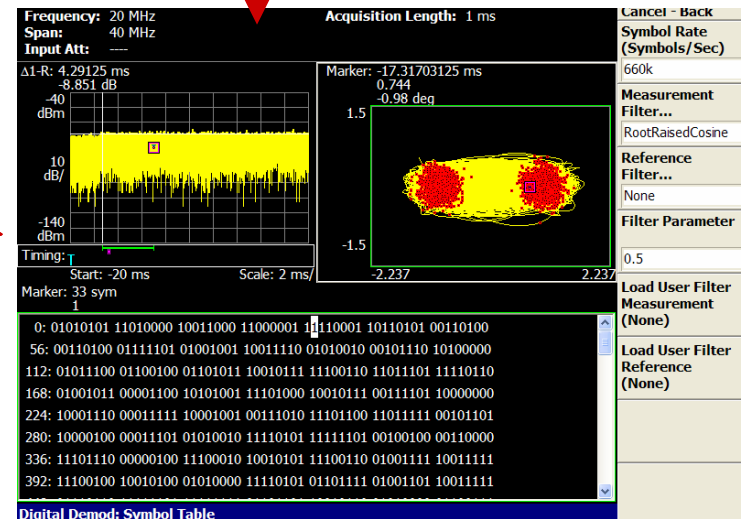
**使用RSAVu 手調數位解調能力解出資料
(GPS: 1.707GHz, BPSK, 1.331Mbps)**



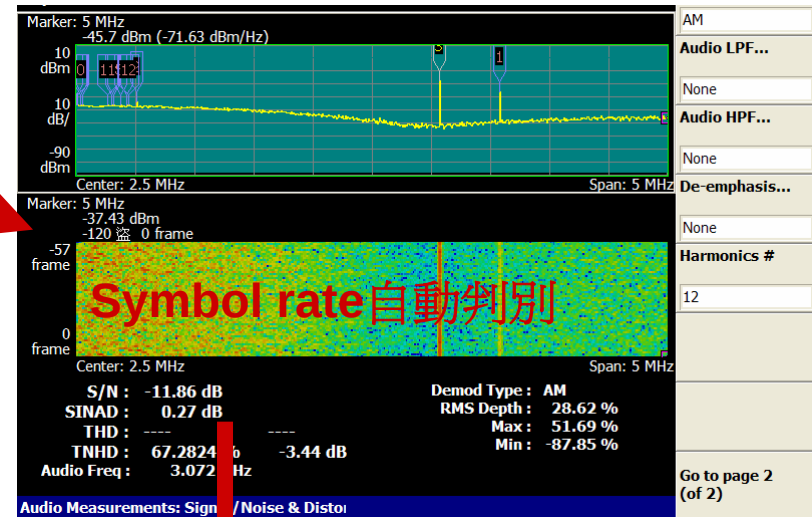
分辨未知中共衛星1.687GHz GPS訊號



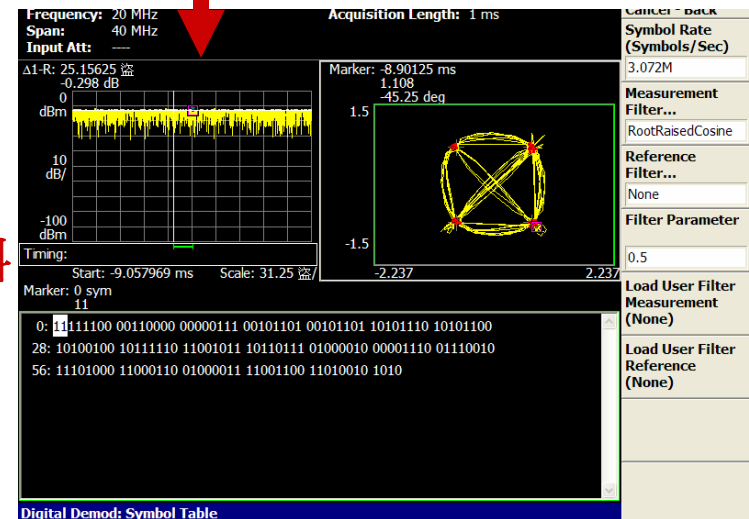
使用RSAVu 手調數位解調能力解出資料
(GPS: 1.687GHz, BPSK, 660Kbps)



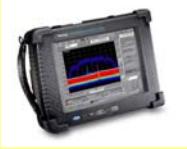
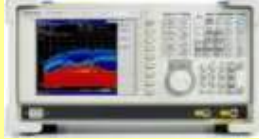
分辨未知訊號



使用RSAVu 手調數位解調能力解出資料
(2.445GHz, QPSK, 3.075Mbps)



RSA and SA2600

					
	SA2600	H600	RSA3300B	RSA3408B	RSA6000A
Frequency Range	10kHz – 6.2GHz	10kHz – 6.2GHz	DC – 3/8GHz	DC - 8GHz	9kHz – 6.2/14/20GHz
Analysis Bandwidth	20 MHz	20 MHz	15 MHz	36 MHz	40/110 MHz
DPX Live RF	10000 frames/sec 2500 frames/sec	10000 frames/sec	48000 frames/sec	48000 frames/sec	48000,290000 frames/sec
DPX 100% POI*	125 usec/ 500 µsec	125 µsec	41 µsec	31 µsec	31/24/10µsec
Frequency Domain Triggering			✓	✓	✓

* POI = Probability of Intercept