Multi-Signal, Multi-Format Analysis With Agilent 89600 VSA Software

Ken Voelker
Agilent Technologies Inc.
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Agenda

• Introduction: New Measurement Challenges
• Multi-Measurements – an overview
• Practical Use Cases
The basic workflow of signal verification hasn’t changed much in 50+ years…

D.U.T. Configure → Execute → Display

One test at a time…

Test List

1. GSM Power
2. GSM Mod. Error
3. GSM PvT
4. GSM Mask

Reconfigure for next test.
Today’s complex devices make ‘one-at-a-time’ testing much less attractive....

Test List

- GSM Power
- GSM Mod. Error
- GSM PvT
- GSM Mask
- GSM OBW
- GSM Spurious
- WCDMA Power
- WCDMA Mod Error
- WCDMA PvT
- WCDMA Mask
- WCDMA OBW
- WCDMA Spurious
- Bluetooth Power
- **Bluetooth EVM**
- Bluetooth Flatness
- Bluetooth Mask
- Bluetooth OBW
- Bluetooth Spurious
- WLAN Power
- WLAN EVM
- WLAN Flatness
- WLAN Mask
- WLAN OBW
- WLAN Spurious

Configure → Execute → Display

Test #1 ∴ Test #1 ∴ Test #1

Reconfigure for next test.
Today’s complex devices make ‘one-at-a-time’ testing much less attractive….

ISSUES:
- Tends to be slow – even when automated – due to time spent changing modes.
- Measurements are non-simultaneous; unable to show signal interactions.
- Results are not persistent; each new measurement replaces the previous one.
Introducing “Multi-Measurements”

An architectural enhancement for the Agilent 89600 VSA software that enables it to perform multiple measurements in parallel.

List of tasks:
1. GSM Power
2. GSM Mod. Error
3. GSM Mask
4. Bluetooth Power
5. Bluetooth Mod Err.
6. Bluetooth Mask
   ...

Configure ➔ Execute ➔ Display
- all tests
- Test #1
- Test #2
- Test #3
- all results

Done!
What is “Multi-Measurements”? 

It’s a departure from traditional, one-at-a-time measurements:

- **DUT**
- **Acquisition HW**
- **VSA Software on Windows PC**

One signal at a time:
- Acquire
- Process
- Display

Measurement: LTE EVM
What is “Multi-Measurements”? 

It’s a departure from traditional, one-at-a-time measurements:

**Multi-Measurement concepts:**
- Users pre-define a *collection* of VSA measurements (not just one).
- Measurements reside in memory, instantly ready to run.
- Choice of execution styles, from true simultaneous to fast-sequencing.
- Powerful display tools combine and/or correlate multiple results.
What is “Multi-Measurements”? 

Multiple signals are acquired at once by the wide-BW hardware. Measurements are processed simultaneously and results are shown on the combined display.

- **Multi-Standard Device**
  - Multiple signals

- **Acquisition HW**
  - Wide-BW hardware acquires all signals at once

- **VSA Software on Windows PC**
  - Measurement: LTE EVM
  - Measurement: GSM Mod. Quality
  - Measurement: Composite Pk-Avg.

- **Display**
  - Results shown on combined display
What is “Multi-Measurements”? 

**DUT** 
- Multi-Standard Device

**Acquisition HW** 
- wide-BW hardware acquires all signals at once.

**VSA Software on Windows PC** 
- measurements processed simultaneously
- results shown on combined display

- Measurement: LTE EVM
- Measurement: GSM Mod. Quality
- Measurement: Bluetooth EVM

**Display**

*When all signals won’t fit within a single bandwidth, just add another instrument!*
Multiple Simultaneous *Insights*

*Meas. 01*
(Full BW)
Composite Spectrum + Composite CCDF

- 1 acquisition
- 4 simultaneous measurements, each with user-selectable:
  - freq/span settings
  - meas./demod. setups
  - trace type(s)

Meas. 02
GSM Spectrum & Constellation

Meas. 03
WCDMA Spectrum & Constellation

Meas. 04
LTE-DL Spectrum & Constellation
Multi-Measurements: How it works

- hardware choice & config
- input setup: freq, span, range, trigger
- meas. setup: time/freq/demod parameters
- display setup: traces, markers, layouts

User creates measurement configuration. ➞ VSA “builds” the measurement, saves in memory. ➞ Measurement executes at run-time.

Traditional Single Meas.
Multi-Measurements: How it works

- User creates multiple measurement configurations.
- VSA “builds” all measurements, keeps them all in memory.
- Measurements execute simultaneously on separate cores.

- Fully independent configurations for each measurement
  - hardware choice & config
  - input setup: freq, span, range, trigger
  - meas. setup: time/freq/demod parameters
  - display setup: traces, markers, layouts

*GUI runs on separate core, not shown.
Who Needs Multi-Measurements?

Developers who need to:

• Simultaneously verify all carriers in a multi-carrier device (e.g. MCPA).
• Simultaneously verify all signals in a multi-standard device.
• Explore interactions between multiple TX paths in the same device.
• Analyze UL and DL signals within a single frame, for either TDD or FDD.
• Compare same signal at different test points within the same signal path.
• Perform several diverse measurements at once, such as measuring in-channel modulation quality while testing for spurious or harmonic emissions.
Use Case #1: Multi-Standard Device Testing

Shared Acquisition

Benefits:
• faster than one-at-a-time.
• truly simultaneous; able to observe interactions.
• side-by-side results.
Step 1: Create the Measurements

**Measurement 1**
- Center 1.8575 GHz
- Span 15.5 MHz
- Spectrum, CCDF

**Measurement 2**
- Center 1.8508 GHz
- Span 1.0 MHz
- GSM Mod. Quality

**Measurement 3**
- Center 1.855 GHz
- Span 5.0 MHz
- WCDMA Mod. Qual.

**Measurement 4**
- Center 1.8624 GHz
- Span 6.0 MHz
- LTE Mod. Quality
In “Shared Acquisition”, the analyzer acquires all signals at once, with a single, wide-BW acquisition.
Step 2: Define the Acquisition Style

Acquisition span: 15.5 MHz total

Measurement List

“Shared” Acquisition

Overall 1.850 GHz
GSM 1.855 GHz
WCDMA 1.862 GHz
LTE 1.862 GHz
Step 3: Run Measurements, Observe Results

Benefits:
- faster than one-at-a-time
- truly simultaneous; see interactions.
- side-by-side results
Use Case #1: Multi-Format Device Testing
Shared Acquisition
Use Case #2: Simult. Wide/Narrow RBW Analysis

**Challenge:**
Mask test on bursted WLAN signal, 20 MHz Wide.

Simultaneously check level of bursted spur, but signal is below the broadband noise floor.

**Solution:**
- **Meas01** mask test uses 140 MHz span, 1 MHz RBW. Spur at 2.46 GHz is not visible.
- **Meas02** at 48 MHz offset uses 13 MHz span and 3 kHz RBW. Noise floor is 25 dB lower.
Summary – Use “Shared Acquisition” When:

• All signals to be measured are:
  - within the IF bandwidth of your measurement hardware.
  - accessible from the same physical test point / antenna / etc.

• You need truly simultaneous measurements in order to understand interactions between the signals.

• You need to measure:
  - multiple carriers in a single TX path or Power Amp.
  - multiple formats in a single TX path or Power Amp.
  - wide-BW modulation and narrow-band spurious together.
  - UL and DL signals within the same frame (TDD or FDD).
What if my signals are too far apart?

- LTE: 1.8624 GHz
- WLAN: 2.412 GHz

~650 MHz
Use Case #3: Multi-Format Devices – Wide $\Delta F$

Independent Acquisition

- LTE
- WLAN

~650 MHz

Trig.
Scenario: Intermittent Error Spikes on LTE Signal

Meas01: LTE Demod (EVM vs. Time)
LTE + WLAN Demod: Time Relationships Visible

Meas01: LTE Demod (EVM vs. Time)
Meas02: WLAN Demod (Power vs. Time)

LTE Error spikes are aligned with WLAN Bursts
Combined Display Proves Time-Correlated Error
Use Case #3: Multi-Format Devices – Wide $\Delta F$

Independent Acquisition

Benefits:
- not limited by analyzer BW.
- faster than one-at-a-time
- view interactions
- side-by-side results

LTE $\sim$650 MHz WLAN
Summary: Shared vs. Independent Acquisition

- Single instrument + VSA SW.
- Single acquisition.
- Measurements are inherently time-aligned.
- Frequency separation limited to hardware’s IF bandwidth.

- 2 (or more) instruments + VSA SW.
- Multiple coordinated acquisitions.
- Measurements may be time-aligned using external triggering.
- Unlimited frequency separation.
Use Case #4: Check Signal at Multiple Test Points

Independent Acquisition

• Check EVM at each test point -or-
• Use math functions to compute:
  - BB to RF transfer function
  - Digital BB to RF transfer function
  - IF Gain/Flatness/Group Delay
Simultaneous Baseband, RF Measurement Setup

• **Meas01: Baseband**
  Hardware: 2-ch. scope (I + Q)
  Center Freq: 0 Hz
  Span: 2 MHz
  Meas Type: Spectrum, Time

• **Meas02: RF Output**
  Hardware: RF signal analyzer
  Center Freq = 1.001 GHz
  Span = 2 MHz
  Meas Type: Spectrum, Time

• **Freq Resp = Meas02 / Meas01**
Importance of Synchronization

Spectra must be perfectly sync’ed to obtain a smooth result.
Importance of Synchronization

Post-demod spectra are accurately sync’ed.

(j) RF (group delay)

(gain) RF BB

BB RF

DAC X IF RF

Scope Trig. Signal Analyzer
Use Case #4: Compare Signals at Diff. Test Points

Independent Acquisition

Benefits:
- quickly compare signal quality at key points along signal path.
- compute frequency response via user-defined math functions.
One More Acquisition Style...

Independent (Single Instrument)

- Fast-switched, single-instrument measurements.
- Rapidly switch among members of a measurement collection.
- Can be sequenced with a built-in macro (supplied with VSA SW.)

Shared (1 instr.)

• Simultaneous or time-coordinated measurements, using single or multiple instruments.
Use Cases for Fast-Switched Measurements

- Step quickly through a series of diverse tests.
- Step quickly through the same test repeated at several frequencies.
- Any use case for “shared” acquisition where true simultaneity is not required.
Summary: Multi-Measurements with the 89600 VSA Software

**Simultaneous**

- **Shared:** acquire once, then perform multiple, truly simultaneous meas. within the max span width.

**Unlimited BW**

- **Independent, multi-box:** “loosely” synchronized measurements at same/different freqs, spans, formats, etc. using multiple HW front ends.

**Fast switching**

- **Independent, same-box:** non-simultaneous measurements at various freq’s, spans, formats, etc. using a single HW front end.