Precision Validation of Radar System Performance in the Field

August 19, 2015
Precision Validation of Radar System Performance in the Field
Outline

• Radar and Monopulse Systems
• Time and Frequency Domain Measurements
• Field Test Requirements
• Measurement Examples
• Remote Operation
• Cost of Test
• Conclusions
Radio Detection and Ranging (Radar)

System Types

**Civilian**
- Airport Surveillance
- Aircraft Landing
- Marine navigation
- Weather

**Military**
- Detection and Tracking
- Fire Control
- Missile guidance
- Reconnaissance

System Outputs
- Range
- Relative Velocity
- Angular Position
- Target Size
- Shape
- Identification

Field Measurements
- Power
- Frequency
- Timing
- Amplitude
- Phase
Typical system output includes

- Single pulse tracking
- Improved azimuth and/or elevation estimation

*Numerous line replaceable units (LRU) create a radar system*
The SLS adds additional LRUs and complexity to the system.
Example: Air Traffic Control Radar Beacon System (ATCRBS)

Numerous instrument types are required for testing at the LRU level
Time and Frequency Domains

Example: Pulsed Radar

**Time**
- Absolute: dBm, μsec
- Relative: ΔdB, ΔT

**Frequency**
- Absolute: dBm, GHz
- Relative: ΔdB

 KEYSIGHT TECHNOLOGIES
Time and Frequency Domains (Instrumentation)

**Time**
- Peak Power Meter
- Spectrum Analyzer
- Vector Network Analyzer

**Frequency**
- Peak Power Meter
- Vector Network Analyzer
- Vector Voltmeter

Absolute

Relative
Field Testing – Benchtop Instruments

Traditional LRU testing
- multiple specialized instruments
- pack and ship to test site
- additional weather protection
- equipment warm-up
- obsolete equipment

Typical Commercial Aviation Configuration

8990 Peak Power Analyzer + Peak Power Sensor
8753 Vector Network Analyzer
8563EC Spectrum Analyzer
8508 Vector Voltmeter

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FieldFox – Handheld “All-in-one” Analyzer

Modern LRU testing
• one multi-function instrument
• easy transport to test site
• weather resistant, IP53 tested
• wide temperature range
• user definable states on USB or SD

Combination Handheld includes
• Peak Power Meter
• Vector Network Analyzer
• Spectrum Analyzer
• Vector Voltmeter
• DC Source Voltage/Current Meter

FieldFox with Peak Power Sensor
Comparing Benchtop and Handheld Measurements

Time Domain

Example of Mode S transmitter showing P2-to-P6 first sync phase reversal

FieldFox in Pulse Mode
Comparing Benchtop and Handheld Measurements

Frequency Domain

8753D

FieldFox in VNA Mode

Example: RF duplexer based on ferrite circulator
Additional Measurement Comparisons

Keysight Application Note: Correlating Microwave Measurements between Handheld and Benchtop Analyzers

Webcast also available at Keysight.com
Measurement of Radar Pulse in Time

Power and Timing Characteristics

Auto Analysis: Peak, Avg, Rise, Fall, Width, PRF, etc.

Power sensor determines measurement accuracy

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 GHz</td>
<td>+/- 0.18 dB</td>
</tr>
<tr>
<td>40 GHz</td>
<td>+0.25 / -0.27 dB</td>
</tr>
</tbody>
</table>

U2022X, 0dBm, 1.1:1 DUT VSWR, average power, triggered

26.5 GHz FieldFox

40 GHz Peak Power Sensor

Power Meter

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1. Trigger peak power sensor
2. Measure Primary data (memory)
3. Measure Auxiliary data
4. Markers for timing difference
Rotary Joint Measurements

Rotation over 360°

Vector Network Analyzer Mode

FieldFox VNA Log Mag

Rotation=12°
+0.5dB
-0.5dB

Rotation=148°

FieldFox VNA Phase

Rotation=117°
+3.5deg
-3.5deg

Rotation=12°

Normalized S21 at rotation = 0°
Remote Operation

Observe and control live measurements on Apple® iPAD® while manually turning rotary joint.

Photos courtesy of Cobham Antenna Systems

iOS interface
STALO Phase Alignment

1. Configure VVM to A/B
2. Configure VVM to IF freq.
3. Zero through \( \Sigma \) channel
4. Measure on \( \Delta \) channel
5. Adjust system phase as required

FieldFox Vector Voltmeter A/B

Vector Voltmeter Mode

A/B ratio
Phase Matching Cables using Time Domain Mode

Start with FieldFox VNA S11

Transform to Time Domain

Time domain mode with marker at peak determines cable phase length

Typical value for cable match is +/- 0.010 nsec = +/- 2 degrees

Direct phase measurement possible with vector voltmeter
Cost of Test

1 FieldFox combination analyzer can replace all RF instrumentation for civilian radar test in the field

FieldFox data correlates extremely well with Keysights high performance benchtop instruments

Using equipment that is out of support life will dramatically increase cost of test:
- Maintaining spare parts inventory
- Maintaining spare instrument inventory
- Suffering high instrument failure rate cost and downtime

Using a single field-ready unit is much more cost effective than 4 benchtop units
- Capital Expenditure (CapEx) reduction:
  FieldFox is less expensive than comparable benchtop instruments
- Operational Expenditure (OpEx) reduction:
  Single calibration per year vs. 4 calibrations plus calibrations for spares
  FieldFox has the lowest failure rate of any complex benchtop from Keysight (and MUCH lower than any other handheld)
  One 7.2 lb. instrument that replaces 4 bench tops speeds time to radar site and measurement, and makes troubleshooting and repair easier and faster
  3 year standard warranty reduces overall repair cost
Keysight FieldFox Combination Analyzers

Combination Analyzers can be configured with the following capabilities:

- Peak Power Meter (Pulse Mode), up to 40 GHz
- Vector Network Analyzer (VNA)
- Spectrum Analyzer
- Vector Voltmeter (VVM)
- Cable and Antenna Test (CAT)
- Independent Source
- Vector Voltmeter (VVM)

- Models include frequencies up to 50 GHz
- 7.2 pounds (3.2 kg)
- Built-in GPS
- 3.5 hour battery life

Carry precision with you - Keysight-quality measurements
Conclusions

Radar systems are complex, requiring many instruments to test to the LRU level in the field.

Mission critical systems require accurate instrumentation.

FieldFox combination analyzers deliver high accuracy and flexibility.

FieldFox can be remotely controlled for difficult test environments.

Both CapEx and OpEx cost of test are reduced using modern, field ready technology.

FieldFox is the ideal tool for field testing of radar systems.

Photo courtesy of INDRA, SA
For More Information

Contact: Tom Hoppin, tom_hoppin@non.keysight.com
Web: www.keysight.com/find/FieldFox

Literature: FieldFox Handheld Analyzers, brochure, literature number 5990-9779EN

7th in a series of application webcasts

✔ Sept 26, 2012: Interference Testing
✔ Oct 24, 2012: Cable and Antenna Measurements
✔ Nov 28 2012: Calibration and Alignment
✔ Jan 23 2013: Time Domain Measurements
✔ Mar 27 2013: Precise Power Measurements
✔ Jul 24 2013: Precise Data Correlation

Registration: www.keysight.com/find/FieldFoxWebcasts

Thank you for your time
Questions?
References

- Keysight Application Note, *Techniques for Precise Interference Measurements in the Field Using FieldFox handheld analyzers*, Literature Number 5991-0418EN, February 2013
- Keysight Application Note, *Techniques for Precise Cable and Antenna Measurements in the Field Using FieldFox handheld analyzers*, Literature Number 5991-0419EN, June 2013
- Keysight Application Note, *Techniques for Precise Calibrations in the Field Using FieldFox handheld analyzers*, Literature Number 5991-0421EN, February 2013
- Keysight Application Note, *Correlating Microwave Measurements between Handheld and Benchtop Analyzers*, Literature Number 5991-0422EN, November 2013