Precision Validation of Radar System Performance in the Field

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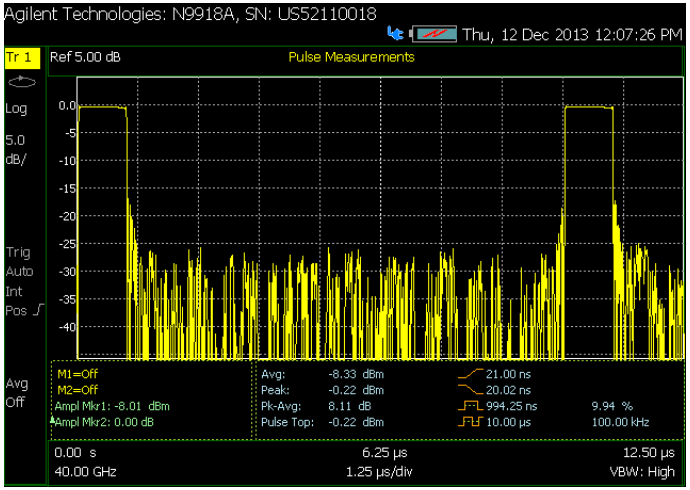
KEYSIGHT TECHNOLOGIES

Precision Validation of Radar System Performance in the Field



KEYSIGHT TECHNOLOGIES

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

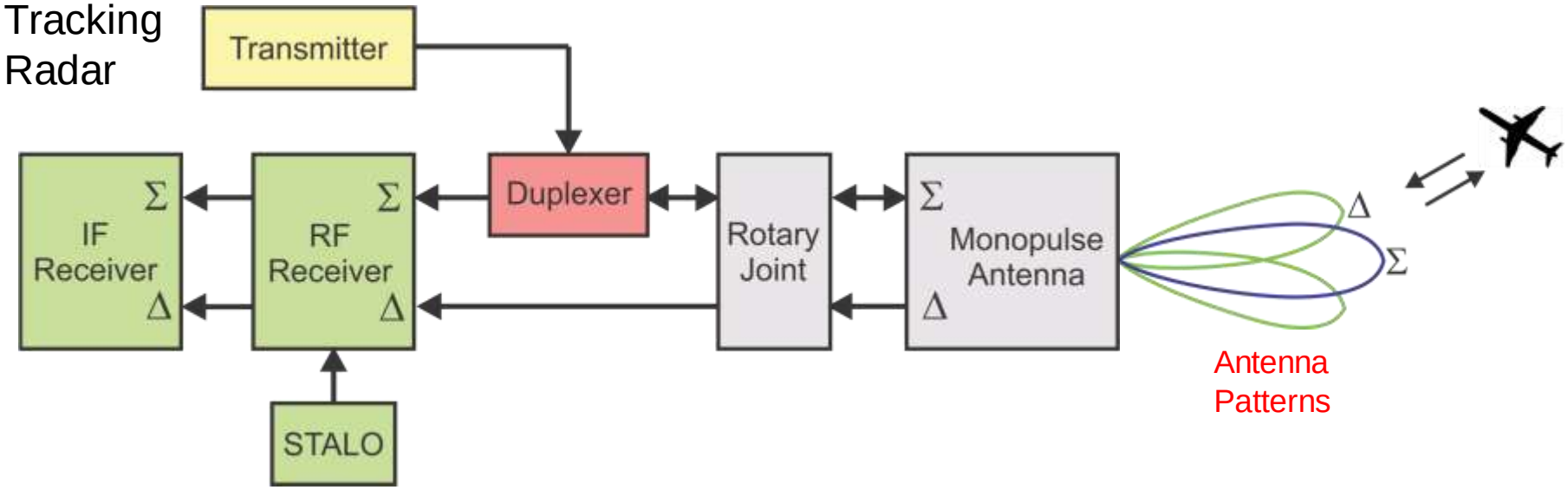
System Outputs

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

Field Measurements

- Power
- Frequency
- Timing
- Amplitude
- Phase

Monopulse Radar System Block Diagram

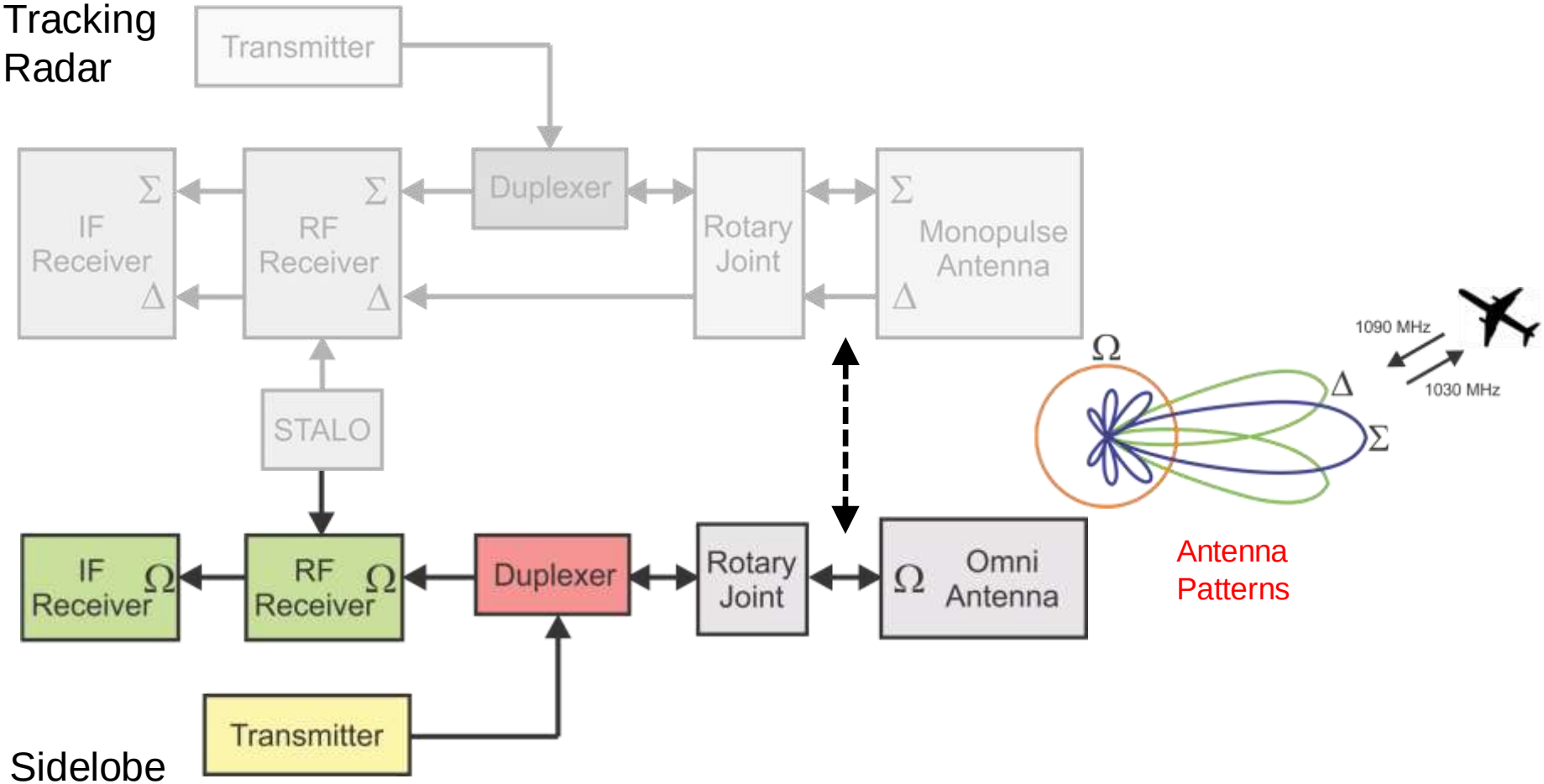


Typical system output includes
- Single pulse tracking
- Improved azimuth and/or elevation estimation

Numerous line replaceable units (LRU) create a radar system

Monopulse Radar System Block Diagram with SLS

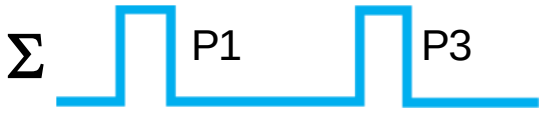
Tracking Radar

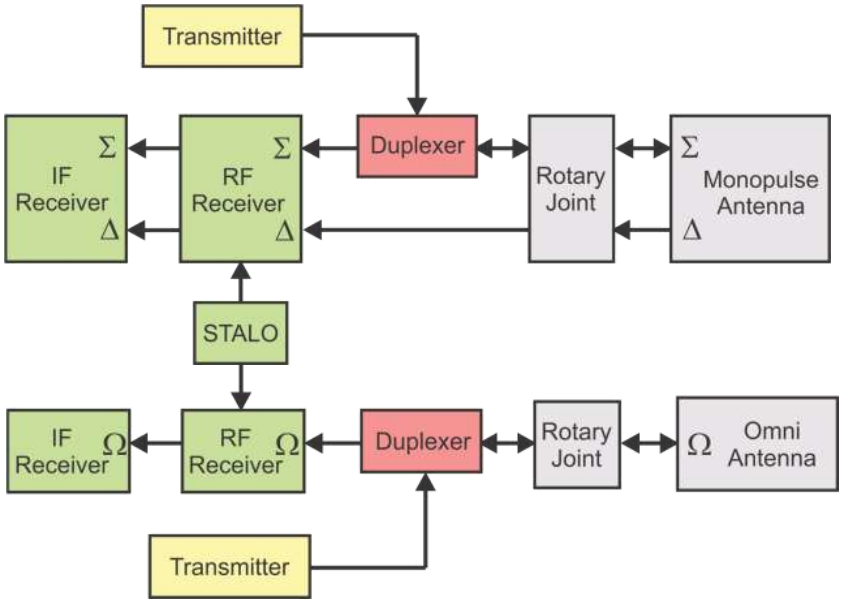


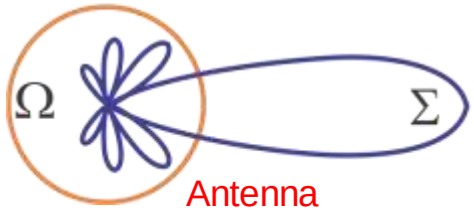
Sidelobe Suppression (SLS)

The SLS adds additional LRUs and complexity to the system

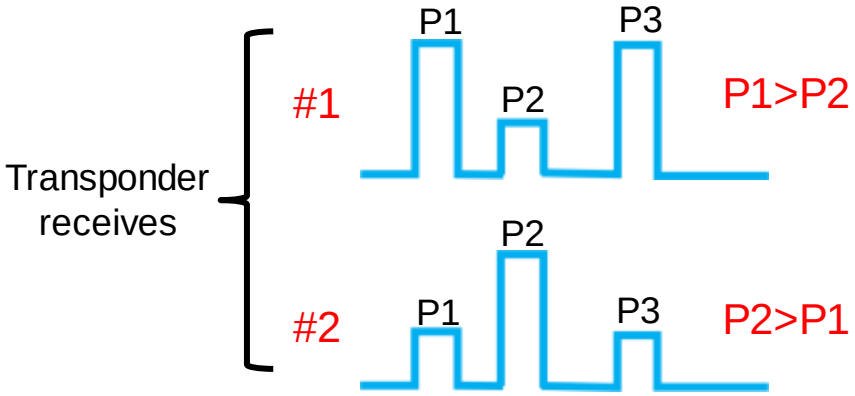
Example: Air Traffic Control Radar Beacon System (ATCRBS)







Antenna Patterns



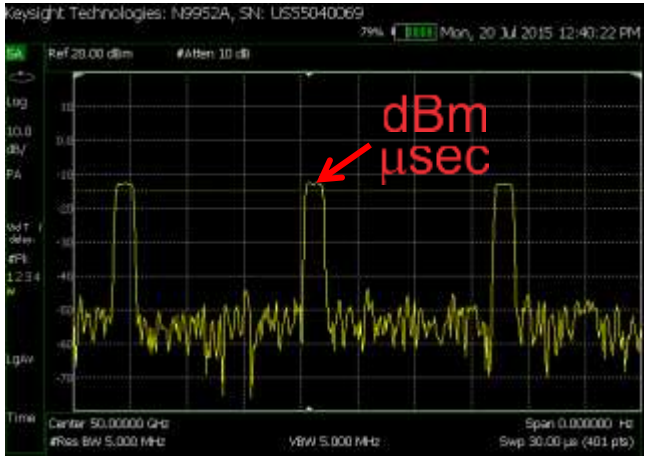
Numerous instrument types are required for testing at the LRU level

Time and Frequency Domains

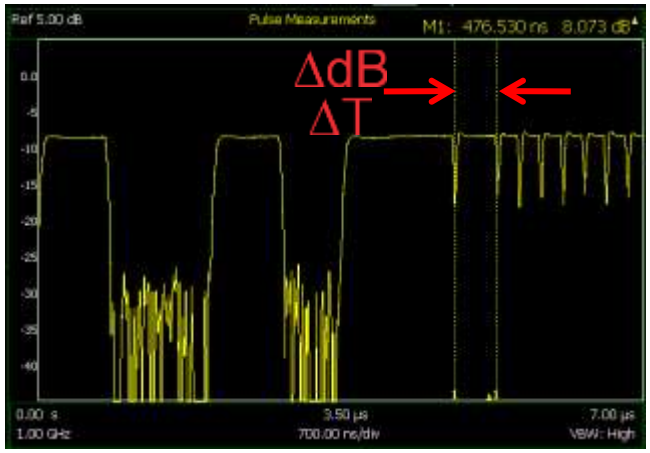
Example: Pulsed Radar

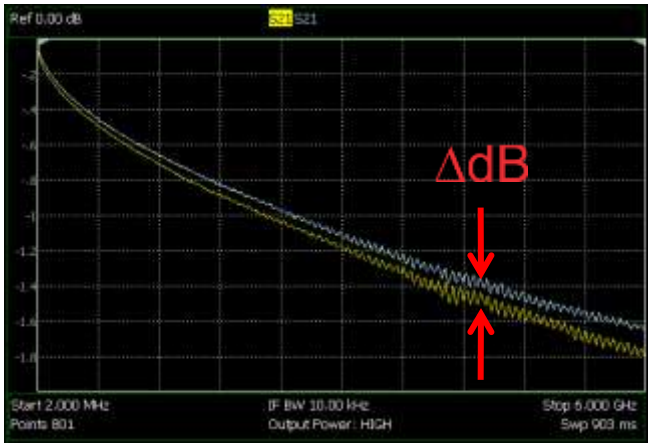
Time | **Frequency**

Absolute



Relative





Time

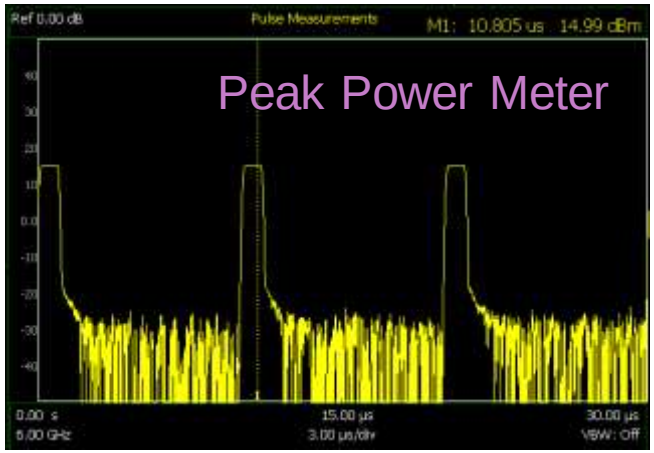
Frequency

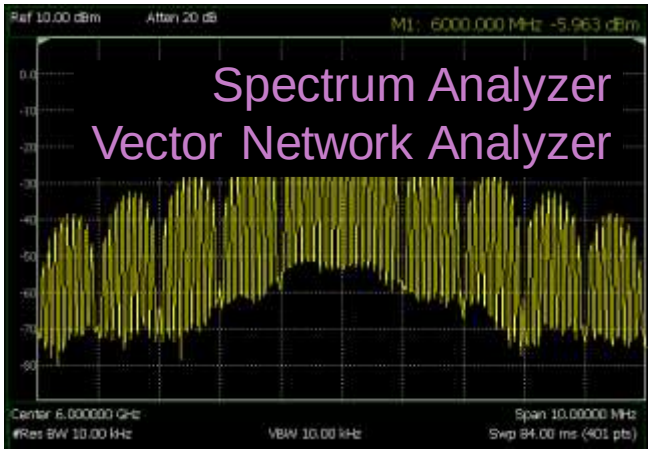
KEYSIGHT TECHNOLOGIES

Time and Frequency Domains (Instrumentation)

Time | **Frequency**

Absolute





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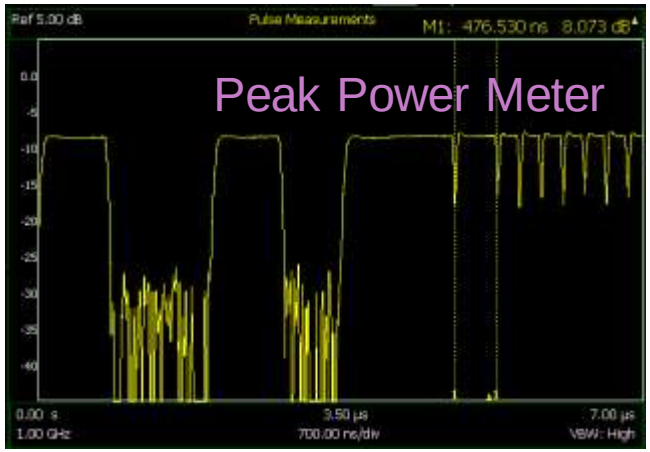
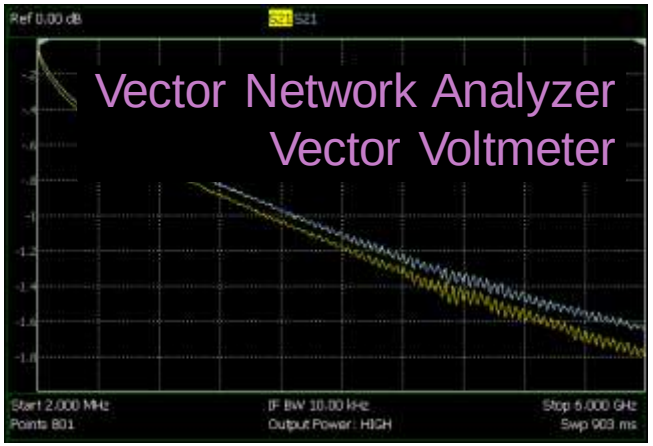




Time

Frequency

KEYSIGHT TECHNOLOGIES

Field Testing – Benchtop Instruments

8990 Peak Power Analyzer +

Peak Power Sensor

8753 Vector Network Analyzer

8563EC Spectrum Analyzer

8508 Vector Voltmeter

Traditional LRU testing

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

Typical Commercial Aviation Configuration

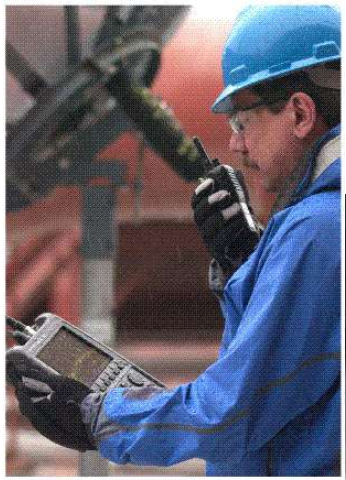
KEYSIGHT TECHNOLOGIES

FieldFox – Handheld “All-in-one” Analyzer

FieldFox with Peak Power Sensor

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

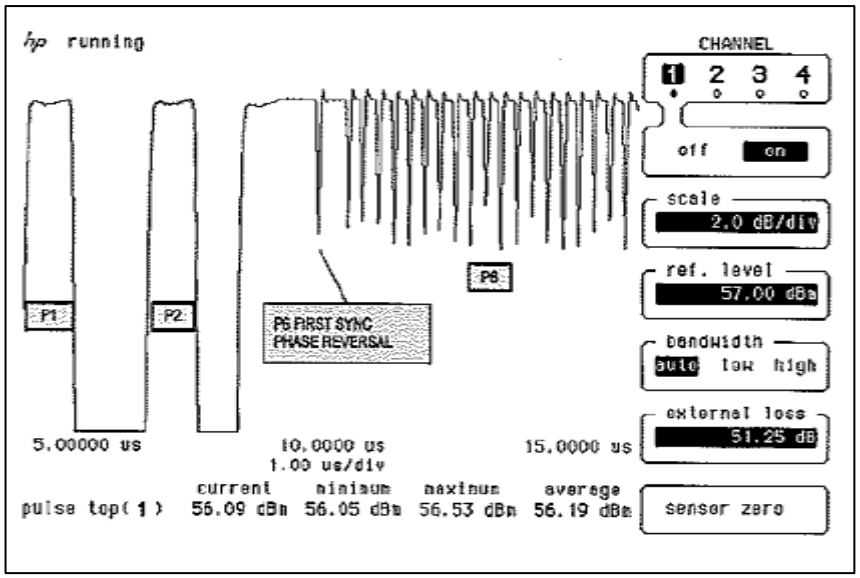
- Peak Power Meter
- Vector Network Analyzer
- Spectrum Analyzer
- Vector Voltmeter
- DC Source Voltage/Current Meter

KEYSIGHT TECHNOLOGIES

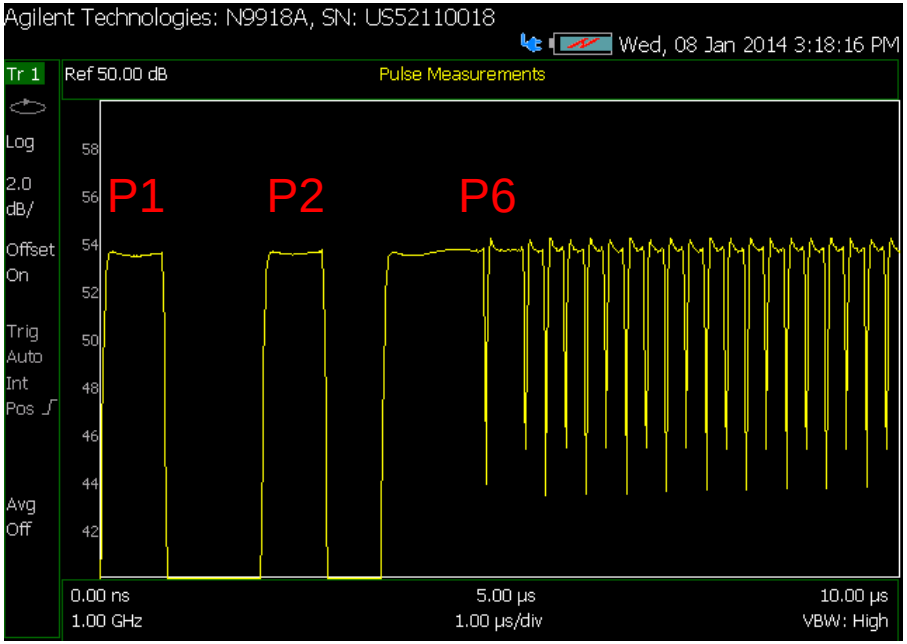
Comparing Benchtop and Handheld Measurements

Time Domain

8990A



FieldFox in Pulse Mode

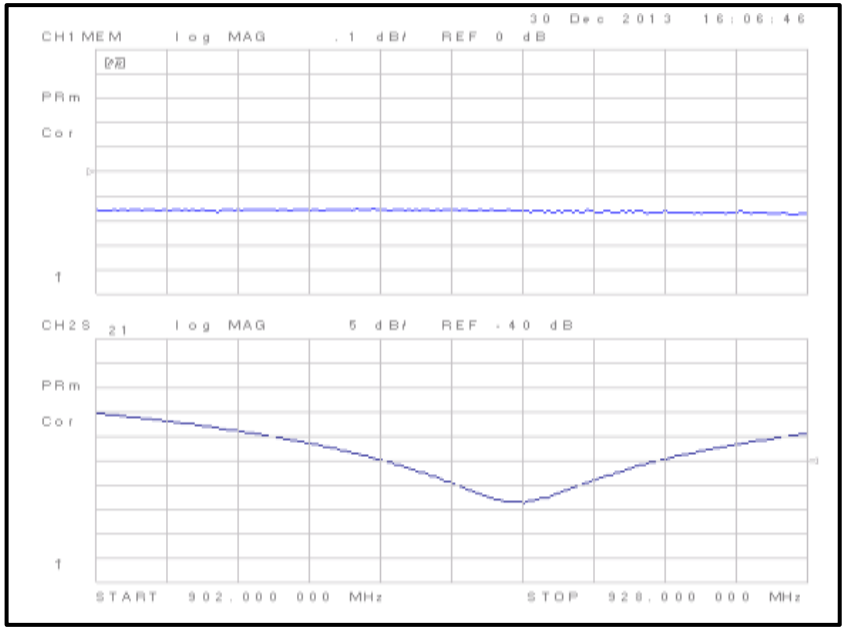


Example of Mode S transmitter showing P2-to-P6 first sync phase reversal

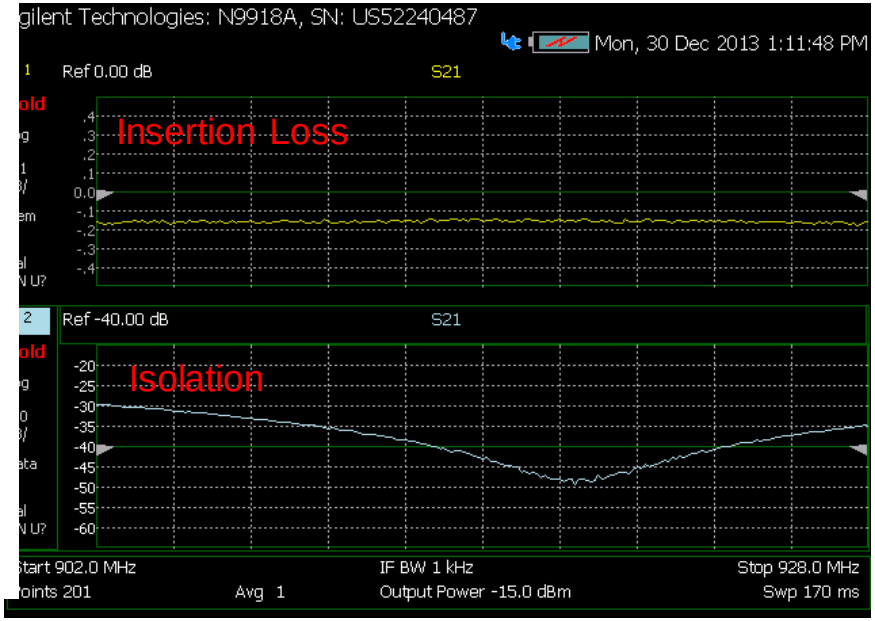
Comparing Benchtop and Handheld Measurements

Frequency Domain

8753D



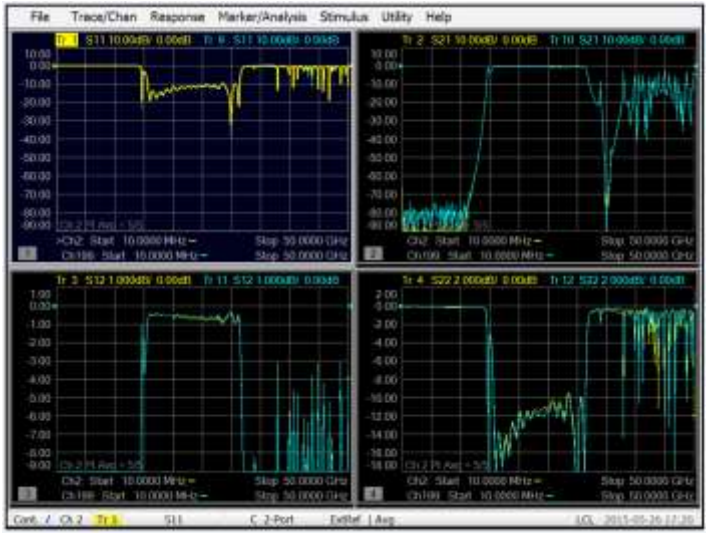
FieldFox in VNA Mode

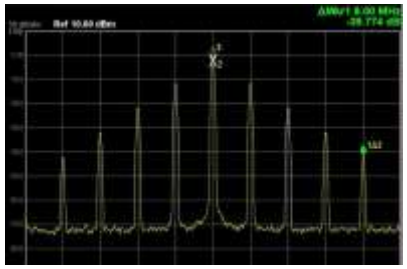


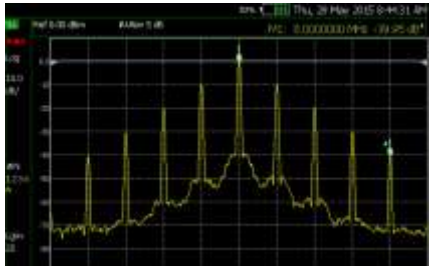
Example: RF duplexer based on ferrite circulator

Additional Measurement Comparisons

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







Webcast also available at Keysight.com

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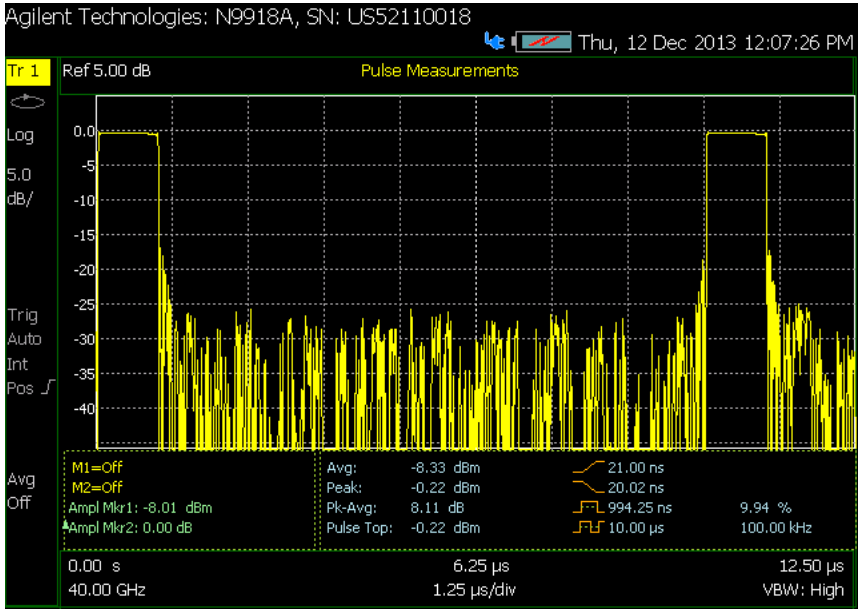
Measurement of Radar Pulse in Time

Power and Timing Characteristics



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

26.5 GHz FieldFox

40 GHz Peak Power Sensor

Power Meter

Peak and Average

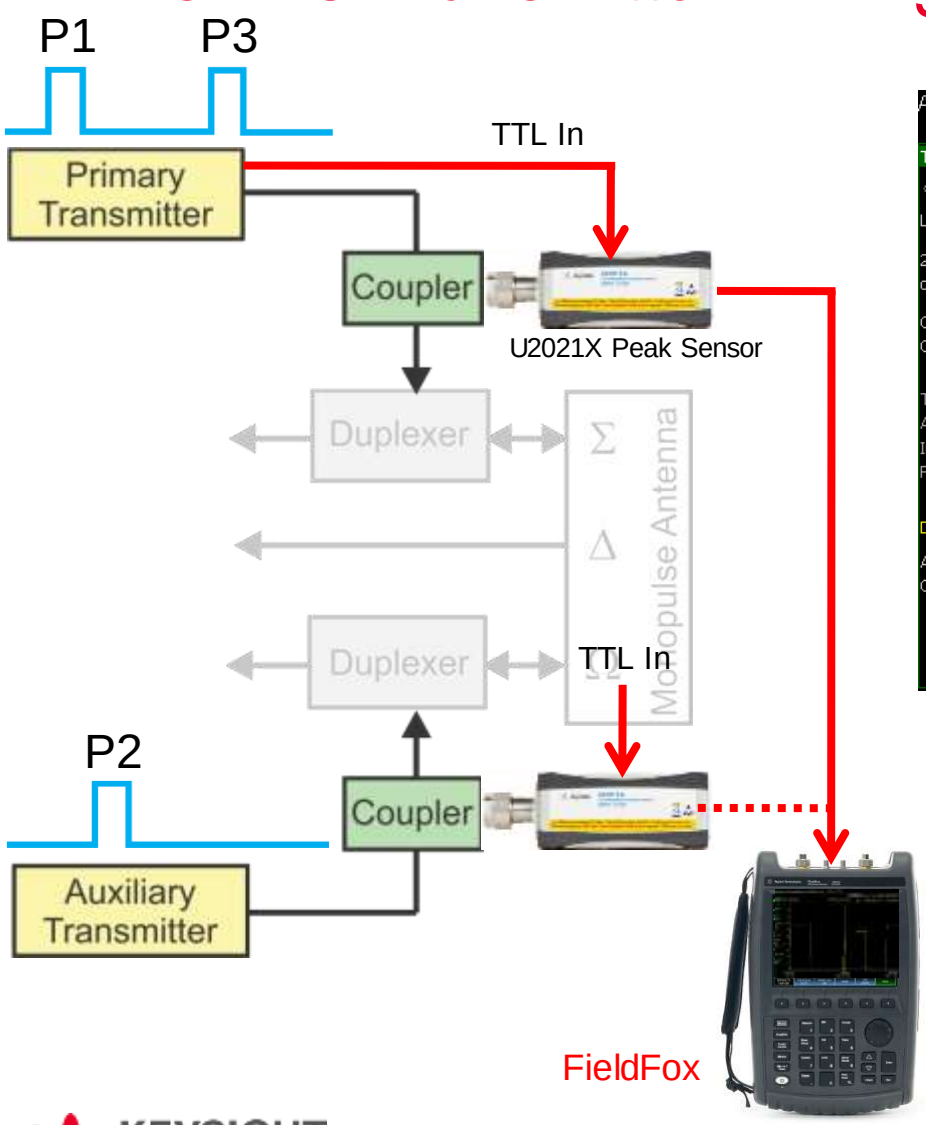
Power sensor determines measurement accuracy

Frequency	Accuracy
1 GHz	+/- 0.18 dB
40 GHz	+0.25 / -0.27 dB

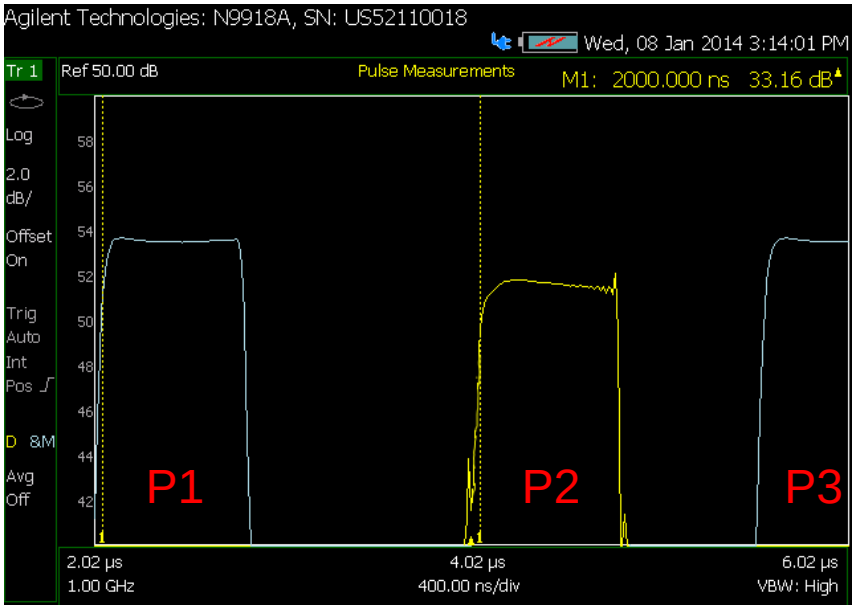
U2022X, 0dBm, 1.1:1 DUT VSWR, average power, triggered

KEYSIGHT TECHNOLOGIES

ATCRBS Transmitter Timing Offset



FieldFox in Pulse Mode

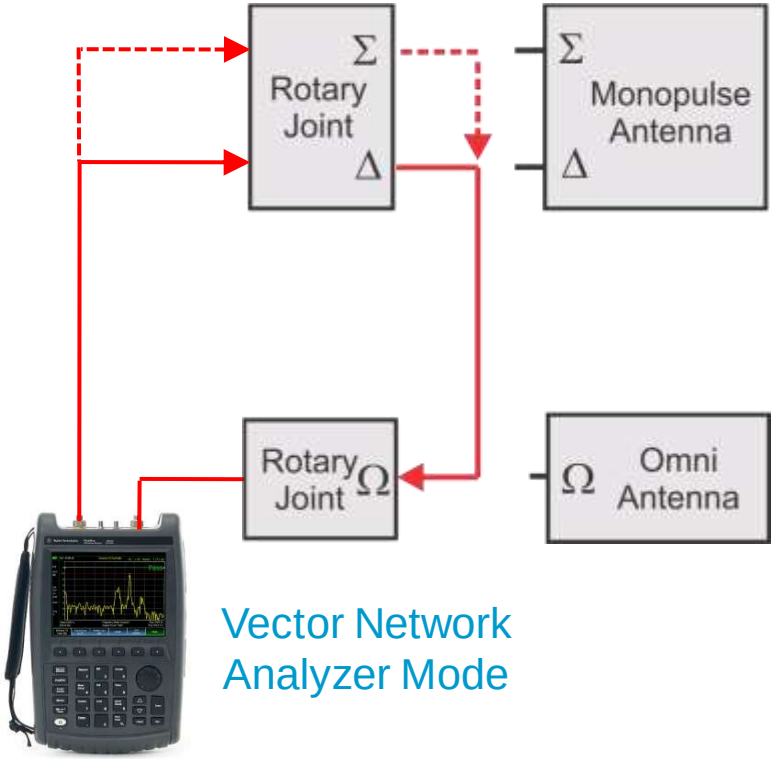


1. Trigger peak power sensor
2. Measure Primary data (memory)
3. Measure Auxiliary data
4. Markers for timing difference

KEYSIGHT TECHNOLOGIES

Rotary Joint Measurements

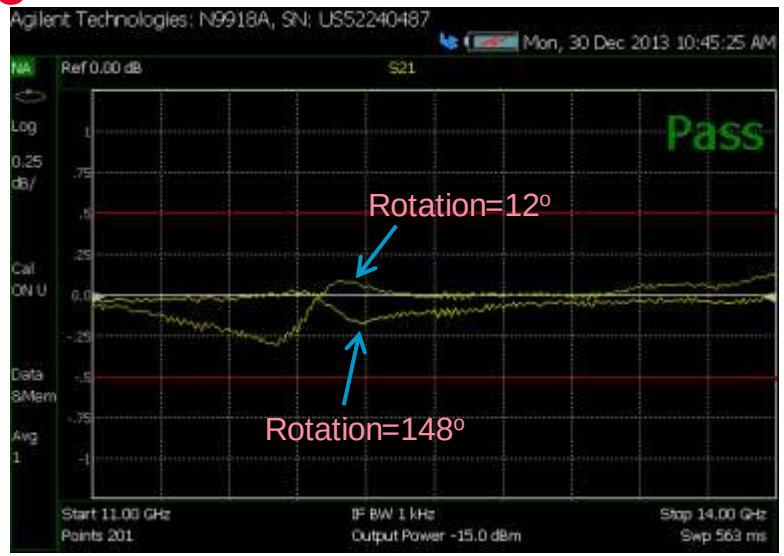
Rotation over 360º



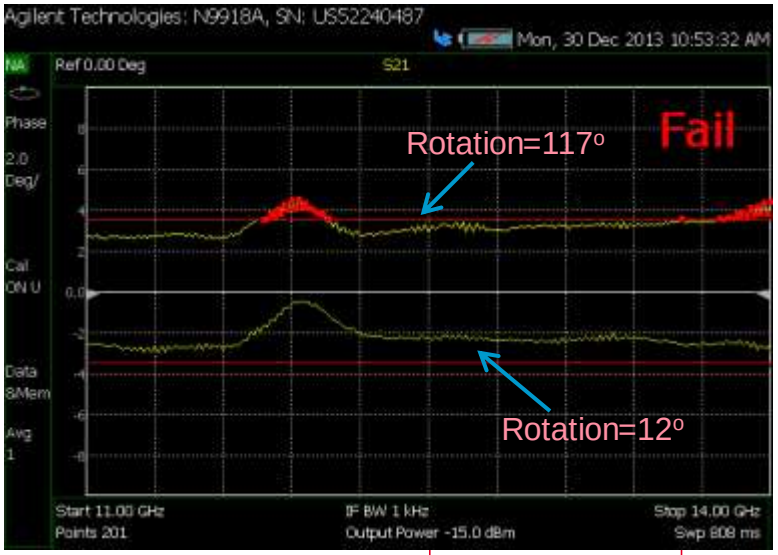
Vector Network Analyzer Mode

Normalized S21 at rotation = 0º

FieldFox VNA Log Mag

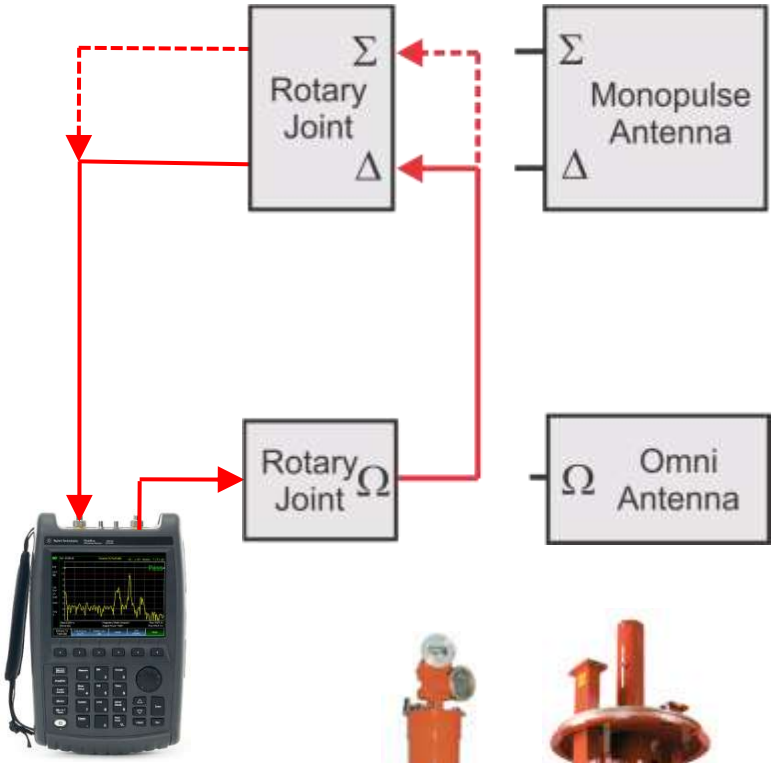


FieldFox VNA Phase



KEYSIGHT TECHNOLOGIES

Remote Operation



Vector Network Analyzer Mode

Photos courtesy of Cobham Antenna Systems

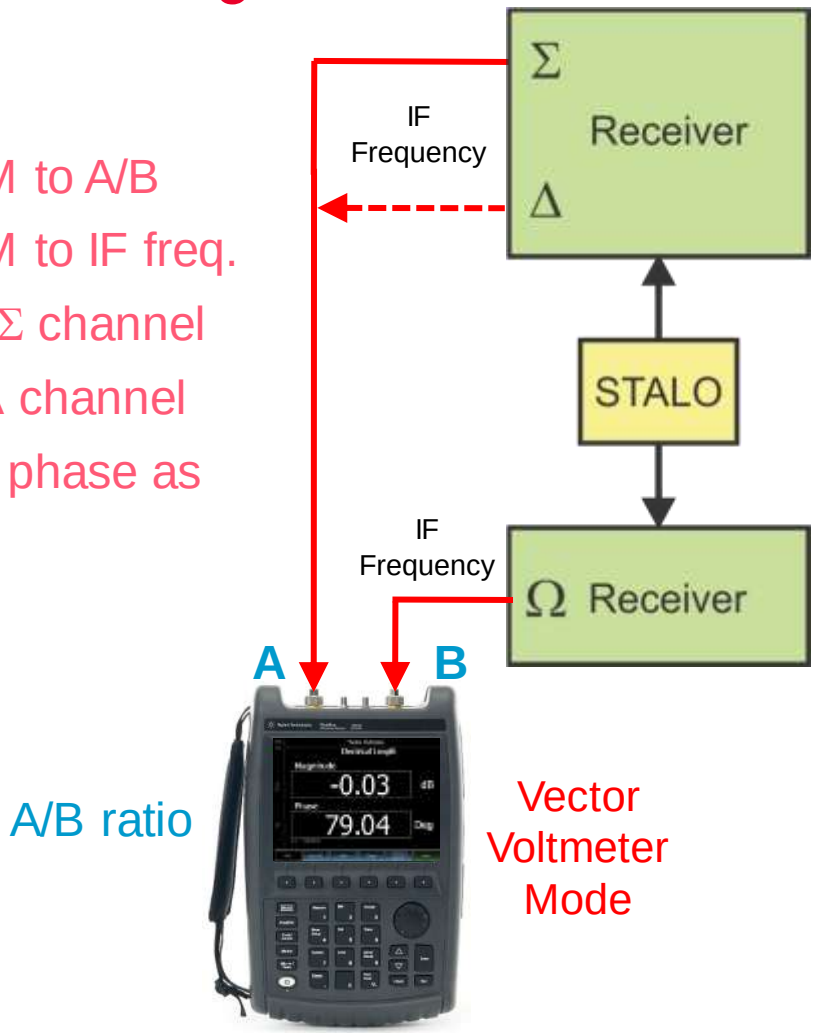
iOS interface

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

KEYSIGHT TECHNOLOGIES

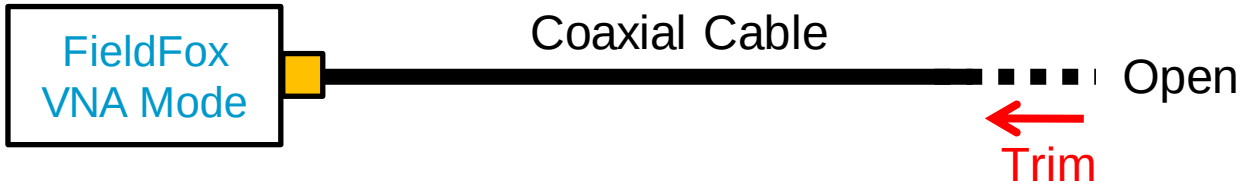
STALO Phase Alignment

1. Configure VVM to A/B
2. Configure VVM to IF freq.
3. Zero through Σ channel
4. Measure on Δ channel
5. Adjust system phase as required

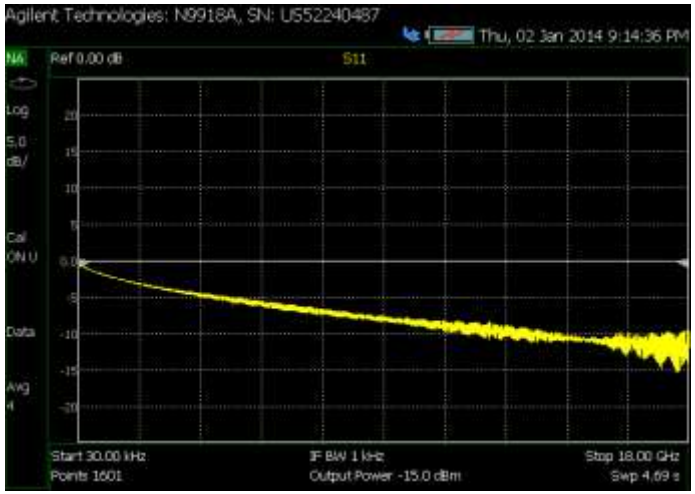


FieldFox Vector Voltmeter A/B

Phase Matching Cables using Time Domain Mode



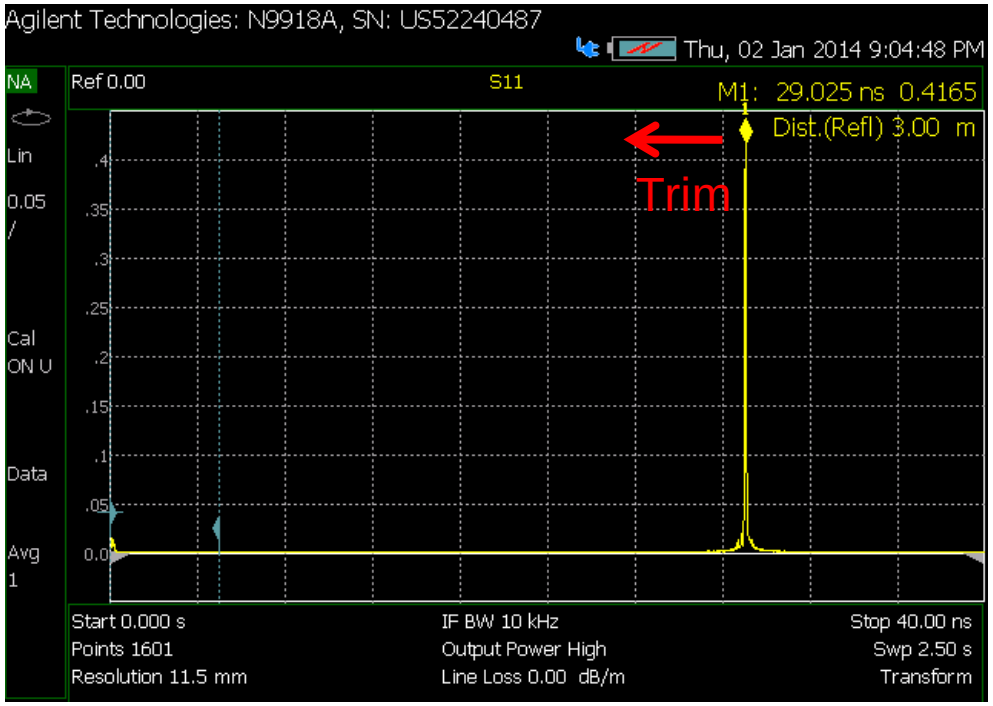
Start with FieldFox VNA S11



Time domain mode with marker at peak determines cable phase length

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

Transform to Time Domain



Direct phase measurement possible with vector voltmeter

KEYSIGHT TECHNOLOGIES

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

Photo courtesy of INDRA, SA

FieldFox is the ideal tool for field testing of radar systems

KEYSIGHT TECHNOLOGIES

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

Check Back

Registration: www.keysight.com/find/FieldFoxWebcasts

Thank you for your time
Questions?

References

- Gertz, J. L., “Project Report ATC-65, The ATCRBS Mode of DABS,” FAA-RD-76-39, Lincoln Laboratory, January 31, 1977
- Orlando, V.A., “The Mode S Radar Beacon System,” The Lincoln Laboratory Journal, Volume 2, Number 3 , 1989
- Karp, D., Wood, M. L., “Project Report ATC-72, DABS Monopulse Summary,” FAA-RD-76-219, Lincol Laboratory, February 4, 1977
- 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 Time Domain Measurements Using FieldFox handheld analyzers,* Literature Number 5991-0420EN, March 2013
- Keysight Application Note, *Techniques for Precise Calibrations in the Field Using FieldFox handheld analyzers,* Literature Number 5991-0421EN, February 2013
- Keysight Application Note, *Techniques for Precise Power Measurements in the Field Using FieldFox handheld analyzers,* Literature Number 5991-0423EN, July 2013
- Keysight Application Note, *Correlating Microwave Measurements between Handheld and Benchtop Analyzers*, Literature Number 5991-0422EN, November 2013
- Keysight U2020 X-Series USB Sensor Uncertainty Calculator - Application Note : Measurement Uncertainty Calculator for U2020 X-Series found at http://www.home.keysight.com. Search for “uncertainty calculator”