Precision Validation, Maintenance and Repair of Satellite Earth Stations

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Tom Hoppin
Application Specialist
Component Test Division
Keysight Technologies

KEYSIGHT TECHNOLOGIES

Outline

- Satellite Communications
  - Space and Ground Segments
  - Broadcasting, Duplexing and HTS
  - System Design
- Maintenance and Troubleshooting
  - Transmitter Spectrum Testing
  - Filter Group Delay Testing
  - Converter Conversion Loss Testing
  - Antenna Peaking and Pattern Testing
  - Line Sweeping
  - Remote Monitoring

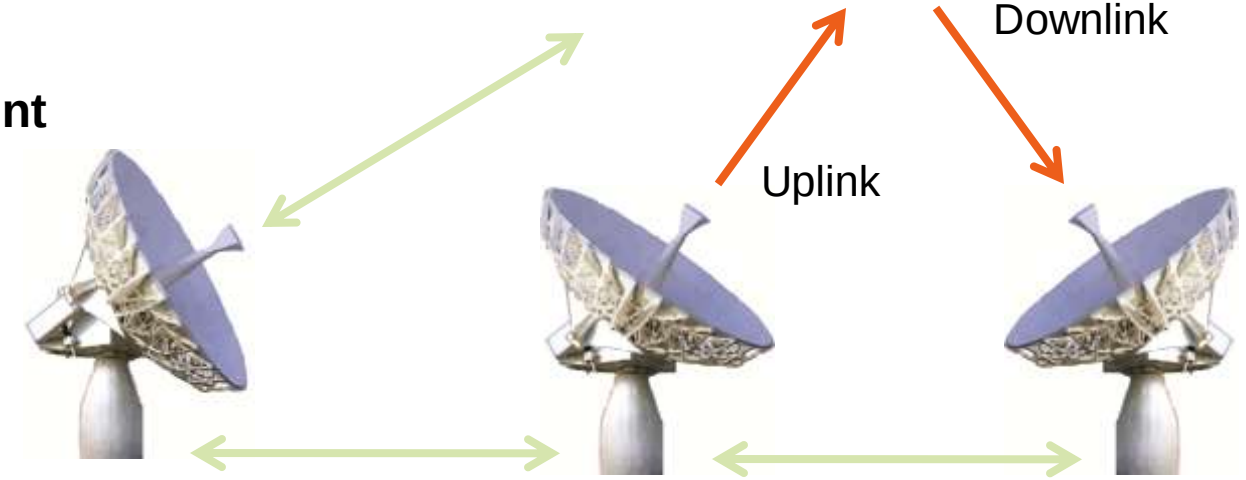
Satellite Communications

Space Segment

- Geostationary Earth Orbit (GEO)
- Medium Earth Orbit (MEO)
- Low Earth Orbit (LEO)

Ground Segment

- TT&C
- Gateway Stations
- Hub Stations
- User Terminals



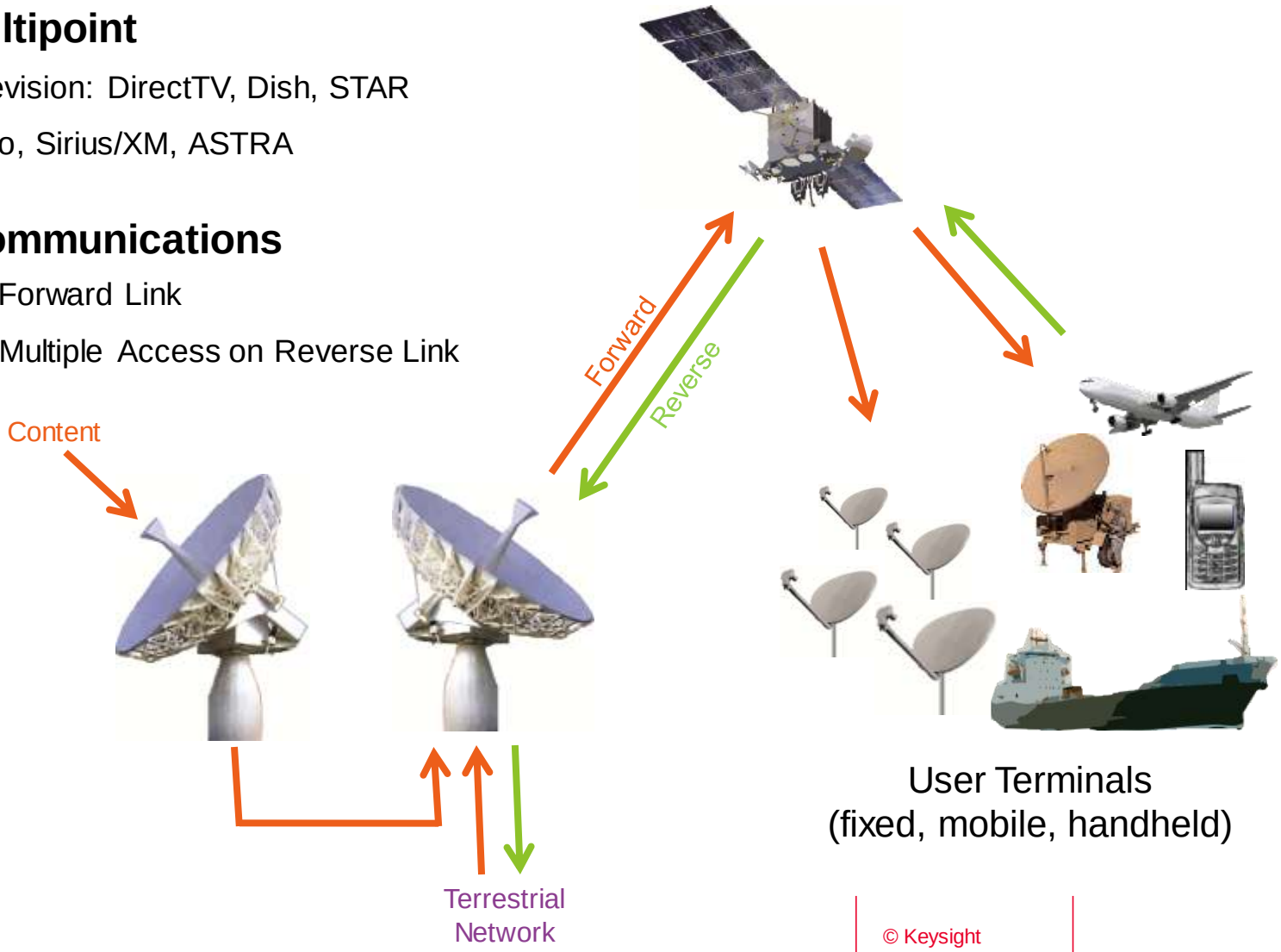
Broadcasting and Duplexing

Point-to-Multipoint

- Broadcast television: DirectTV, Dish, STAR
- Broadcast radio, Sirius/XM, ASTRA

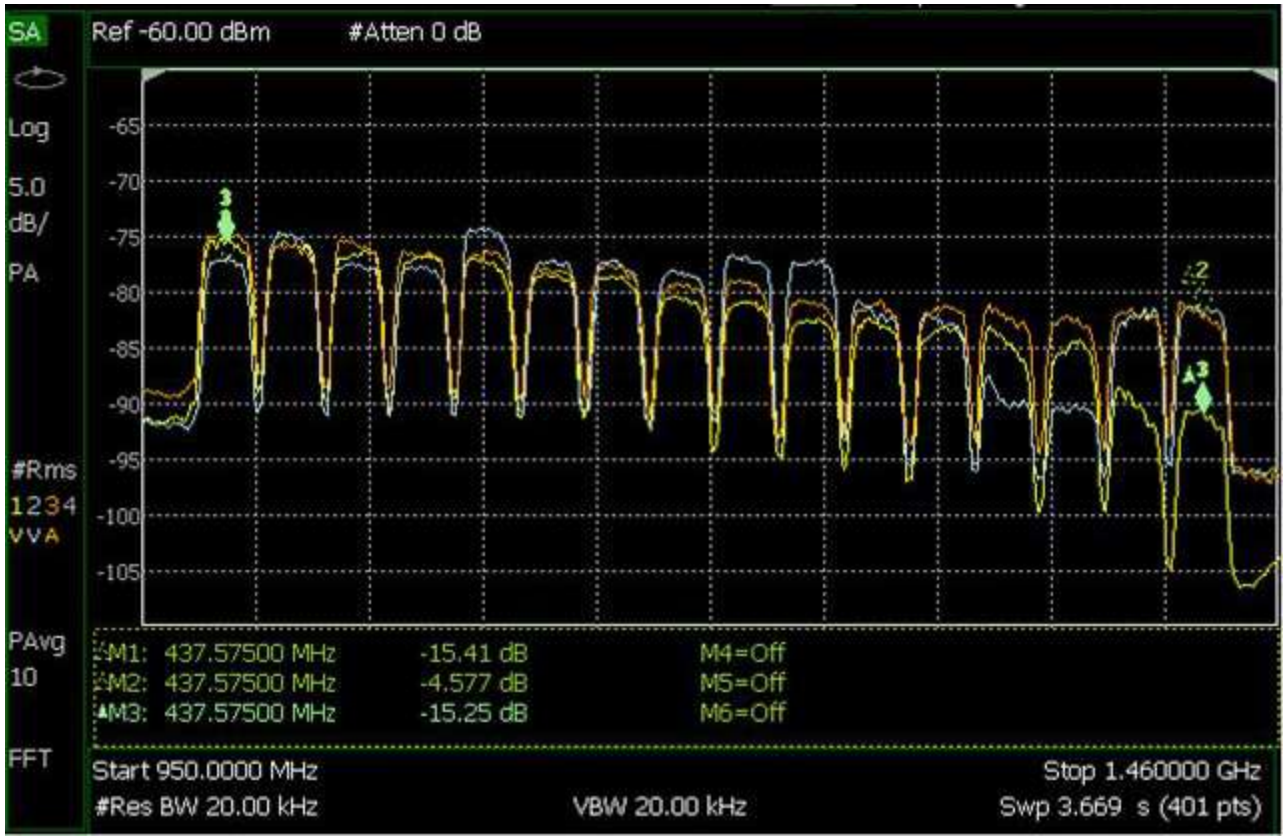
Two-Way Communications

- Broadcast on Forward Link
- Time Division Multiple Access on Reverse Link



Spectrum Measurement of Received Signal

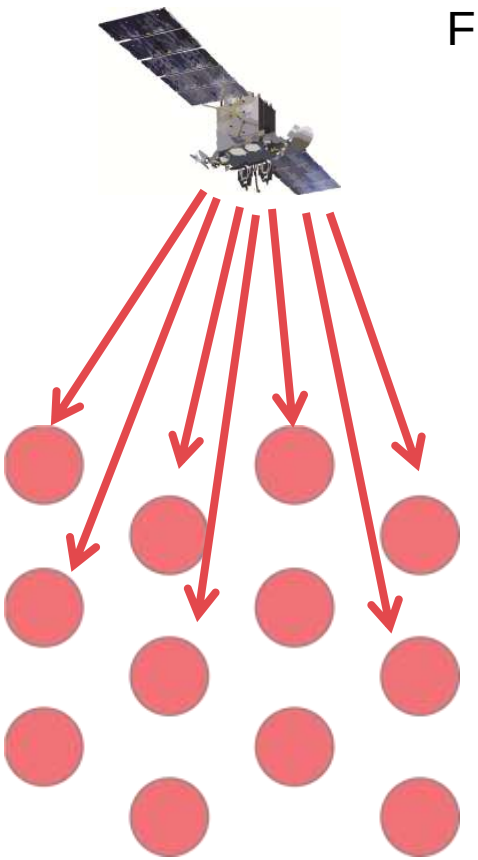
Television Broadcast Signal at Ku-Band

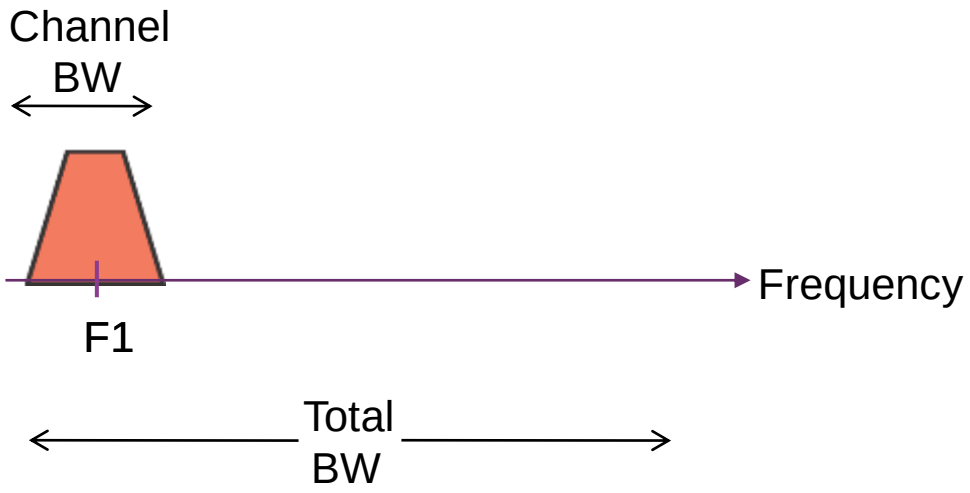


Keysight
FieldFox
(SA Mode)

High Throughput Satellites (HTS)

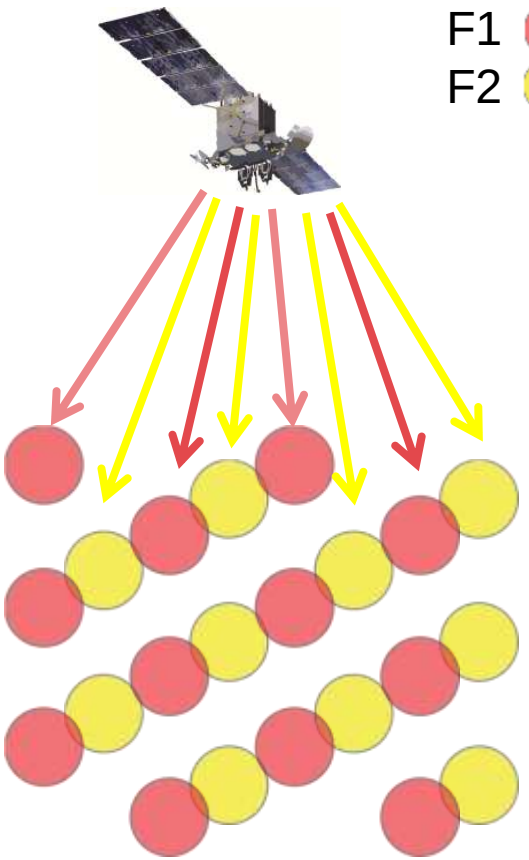
Frequency Re-Use and Spot Beams

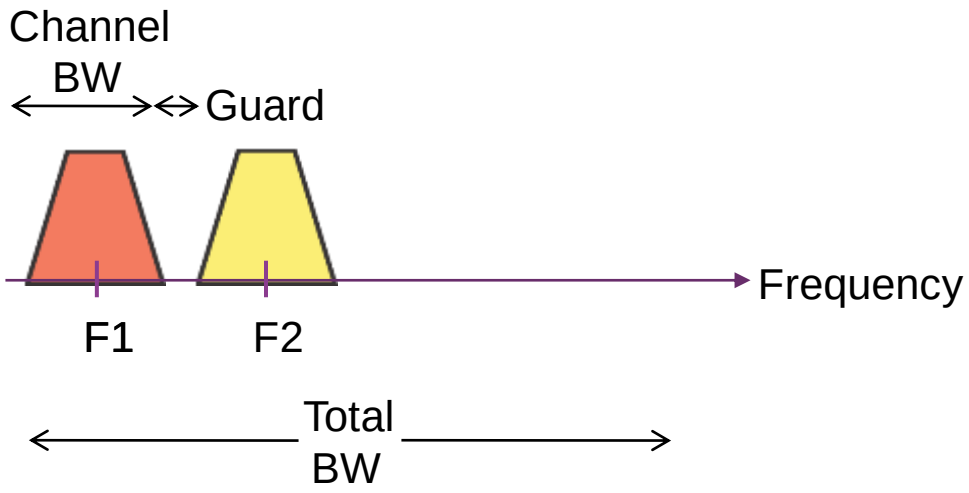




High Throughput Satellites (HTS)

Frequency Re-Use and Spot Beams





High Throughput Satellites (HTS)

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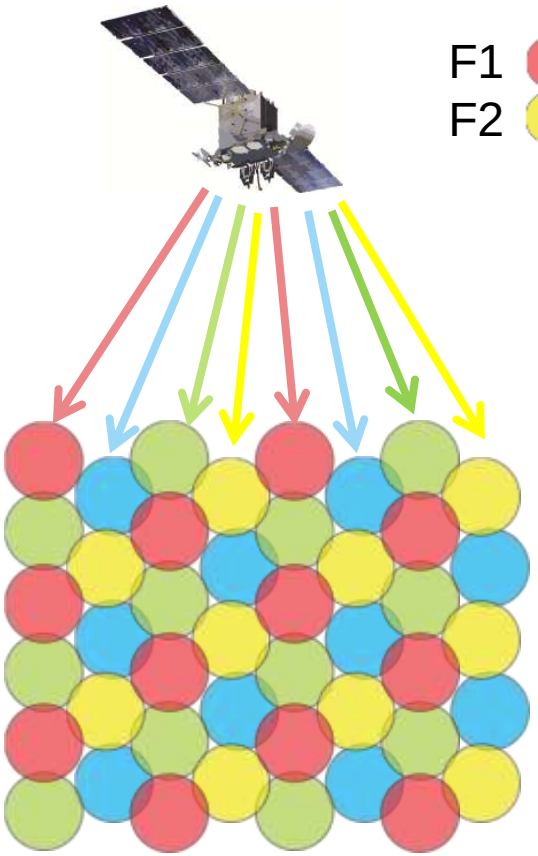
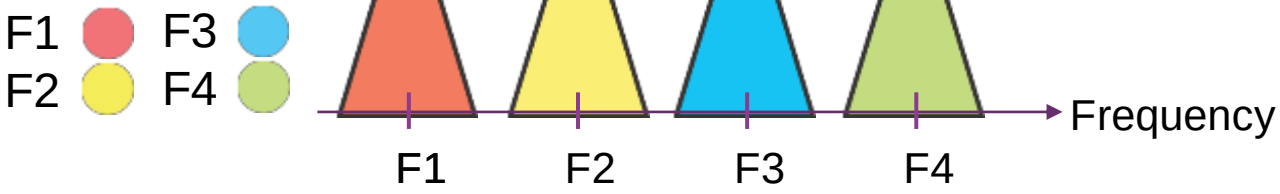
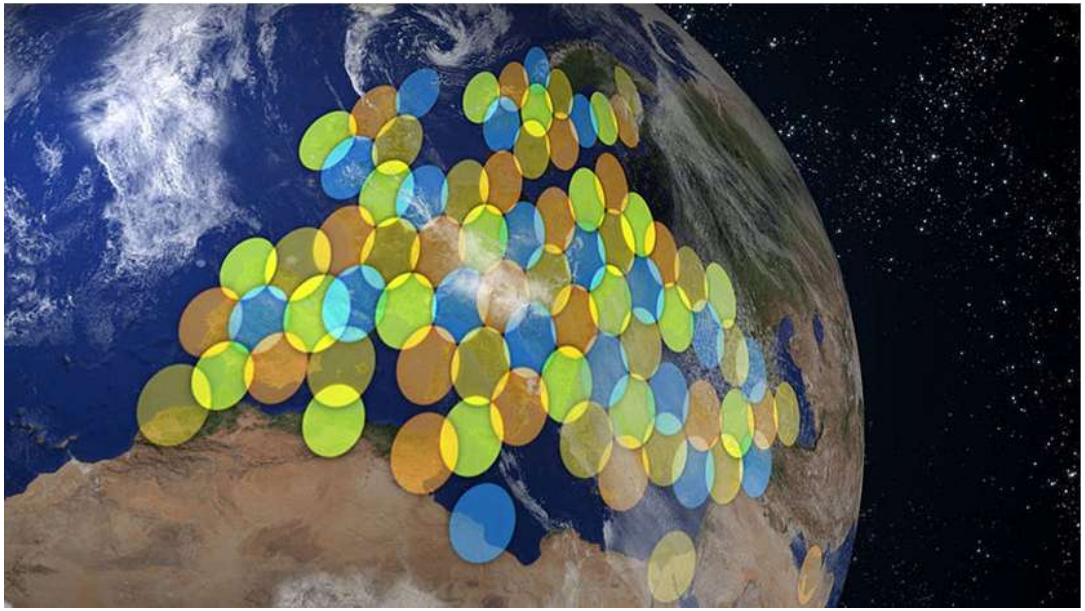
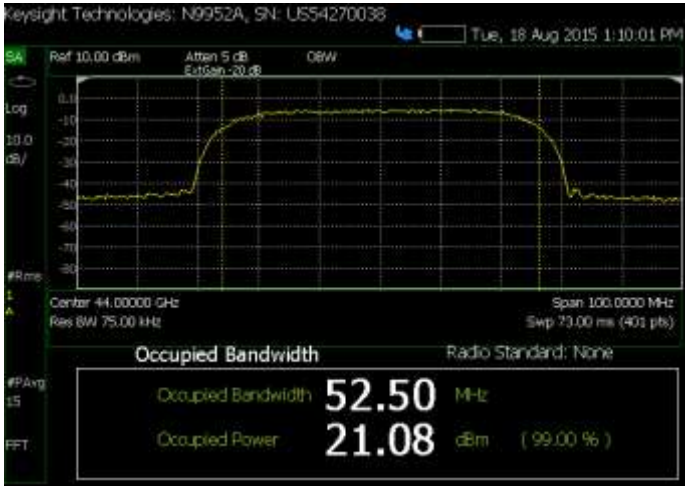


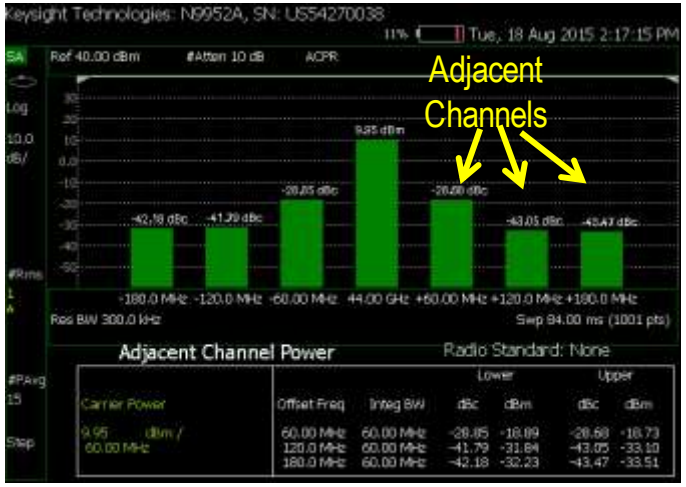




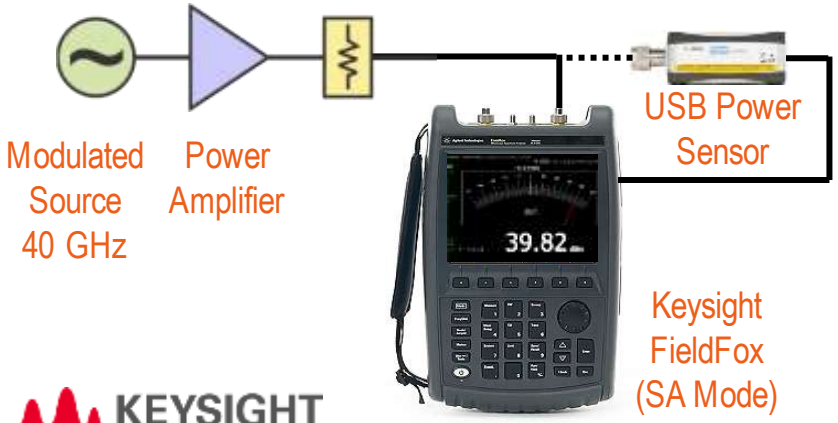
Nonlinearities Increase Channel Interference

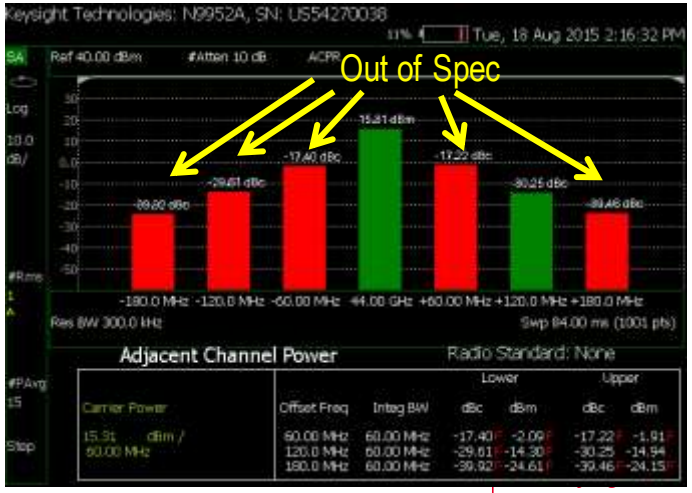
Measured spectrum of a communications signal





Non-Saturated Amplifier





Saturated Amplifier

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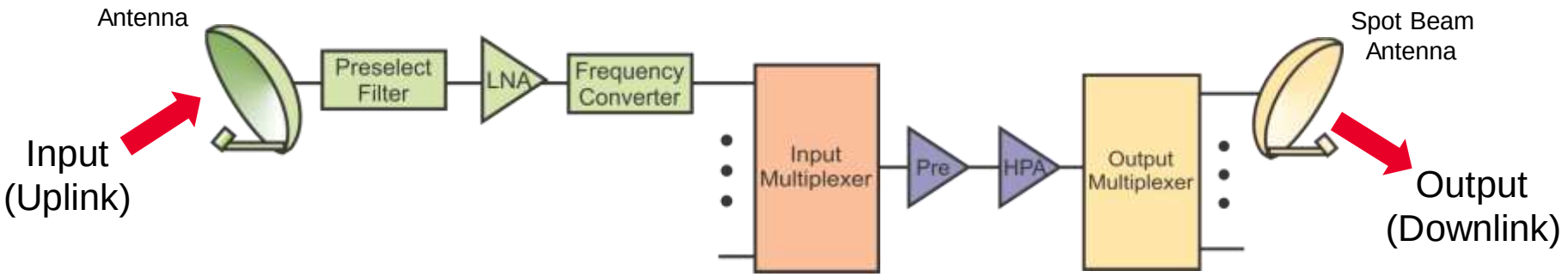
Satellite Payload Design

Bent-Pipe Architecture



Bent-Pipe

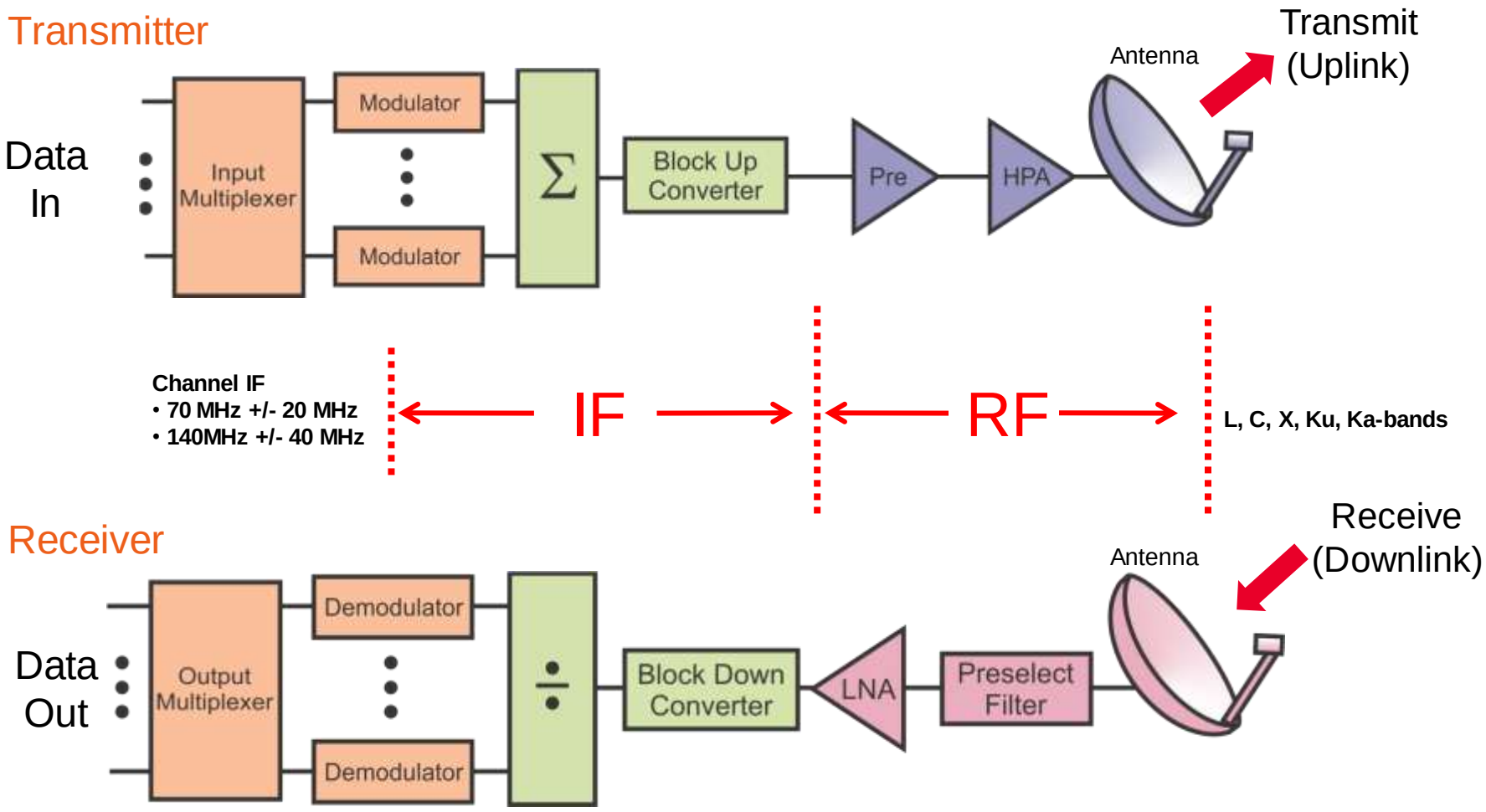
- All analog processing
- Frequency conversion

Processing

– Non-regenerative
  - Input digitized
  - Filtered and processed
  - No demodulation

– Regenerative
  - Input digitized
  - Demodulation / modulation

Earth Station Design



Earth Station Maintenance and Troubleshooting

Focus on IF and RF Subsystems

Testing Requirements

- Antenna
  - Return Loss
  - Alignment
  - Polarization
  - Sidelobe levels
- Transmission lines
  - Cable and waveguide loss
  - Rotary joint VSWR
  - Fault location
- Transmitter
  - HPA performance
  - Converter performance
  - Frequency stability
- Receiver
  - LNA performance
  - Converter performance
  - Interference
  - GPS (mobile applications.)
- System
  - EIRP
  - G/T, C/N
  - BER
  - RFI

Equipment Requirements

- Power Meter
- Spectrum Analyzer
- Vector Network Analyzer
- Line Sweeping (DTF/Time Domain)
- RF Source (CW and Swept)
- DC Source Voltage/Current Meter

Keysight FieldFox

Keysight USB Power Sensor

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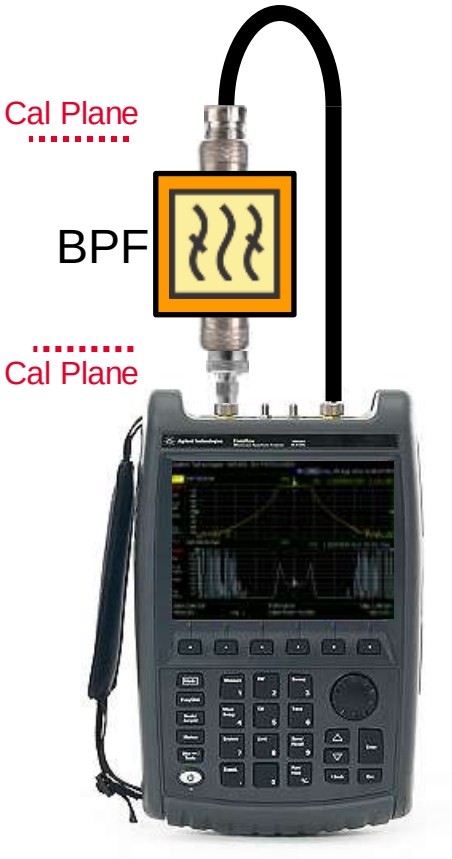
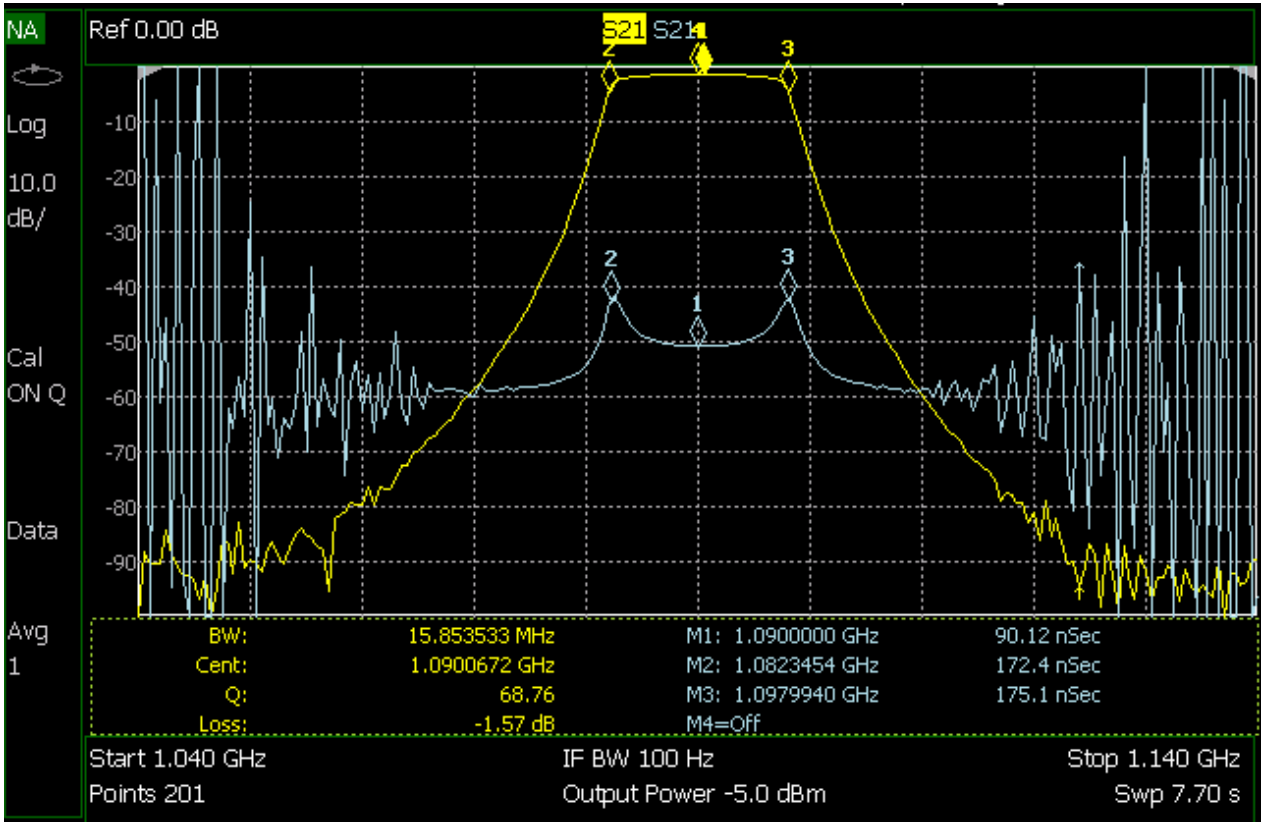
Filter Measurement

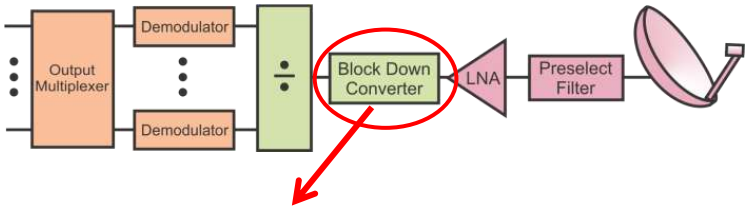
VNA (S21) Loss and Group Delay

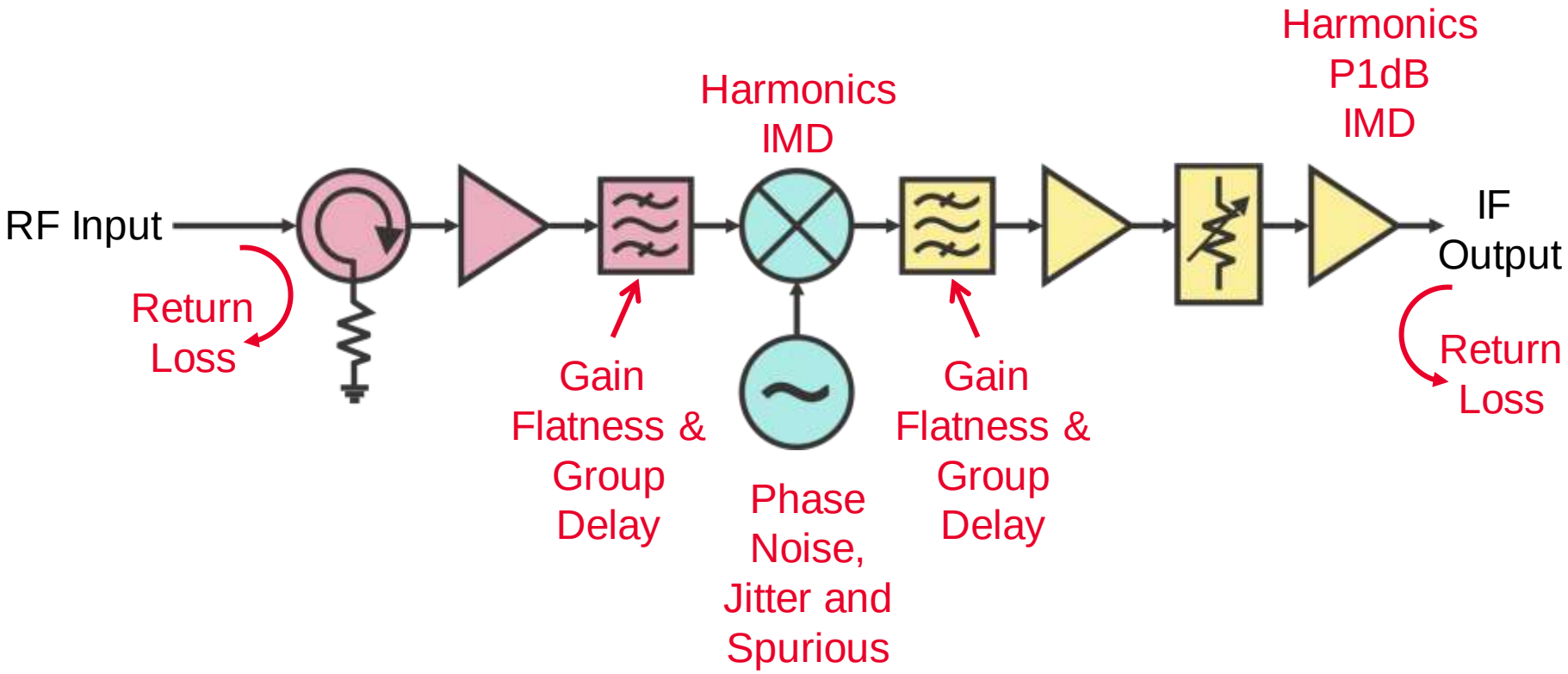




Converter Block Diagram

Signal Impairments





Testing Requires

- Spectrum analyzer
- VNA
- Conversion measurement capability

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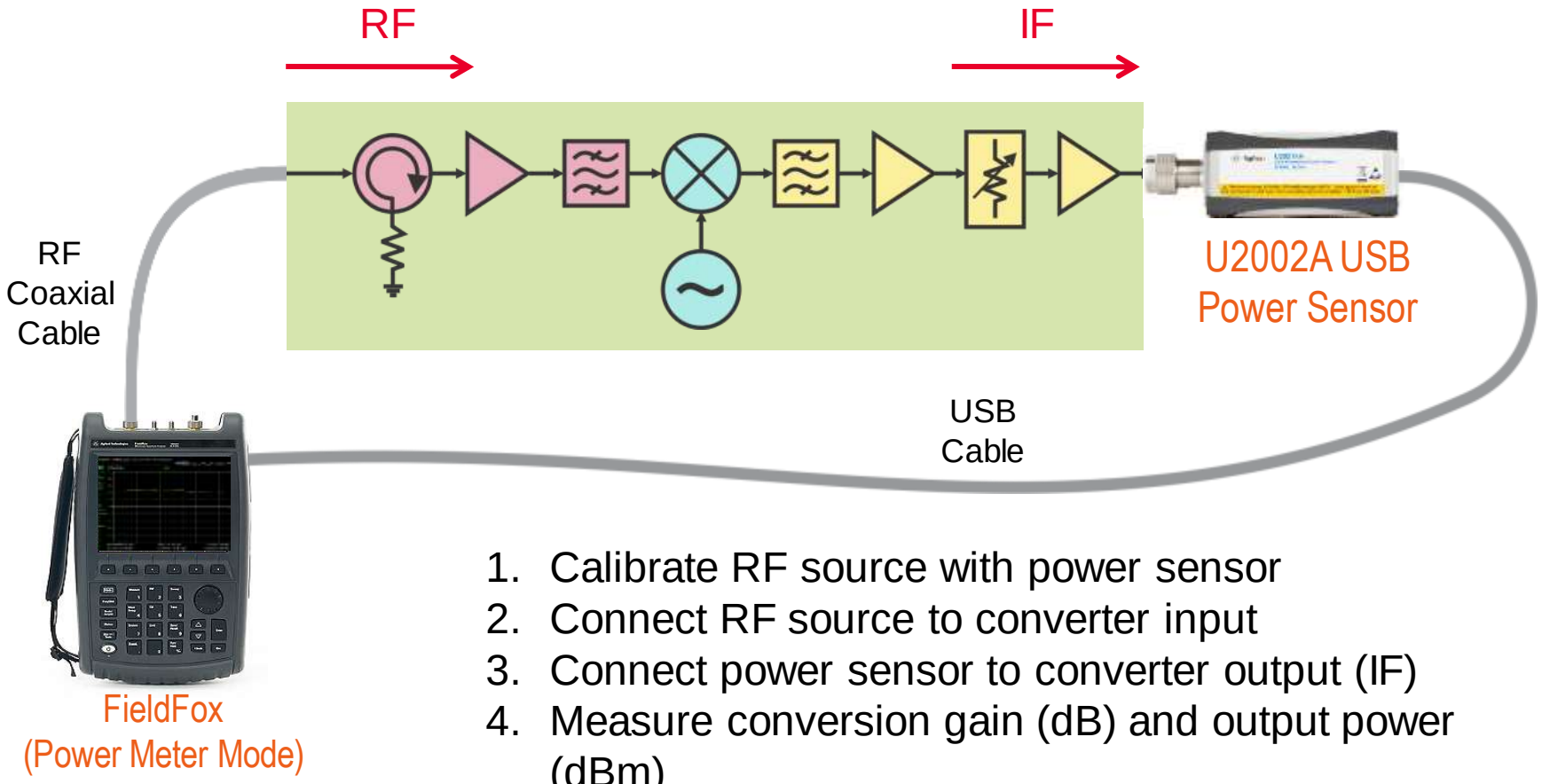
Converter Measurement Configuration

Swept measurement of gain through frequency conversion



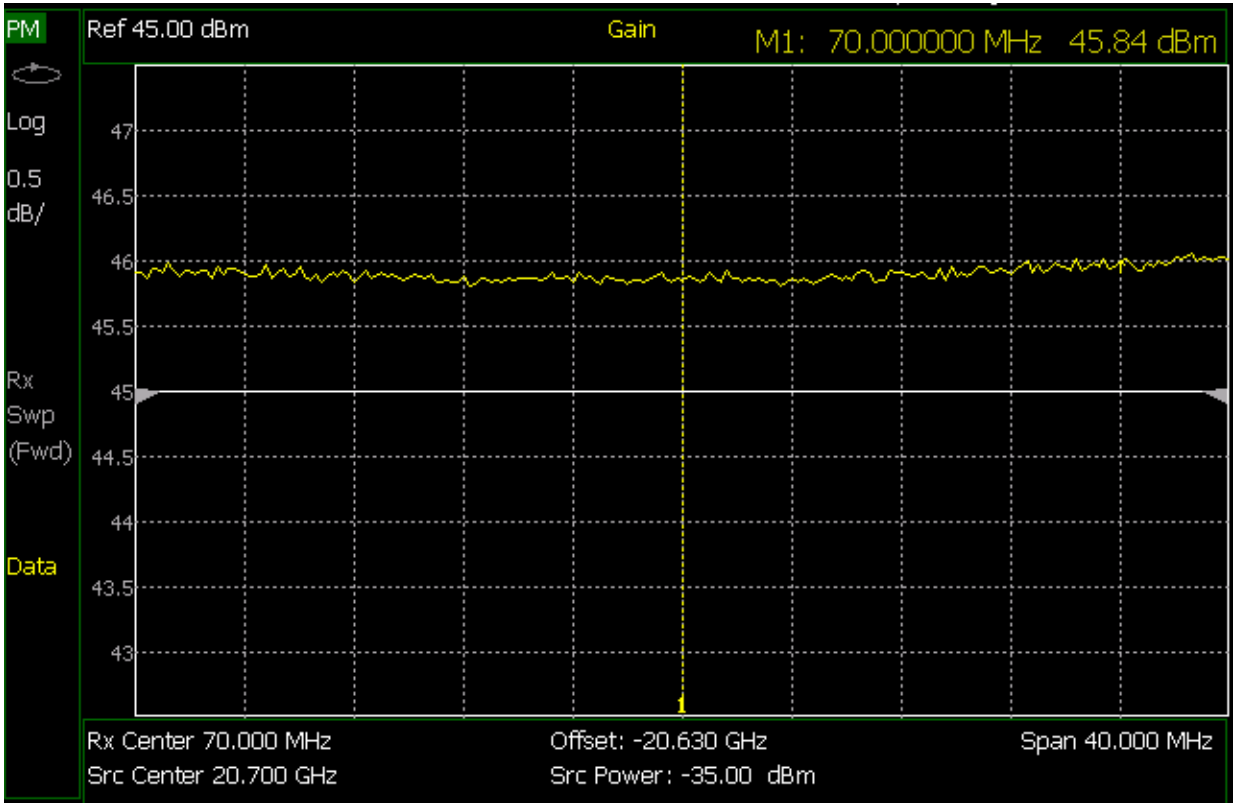
1. Calibrate RF source with power sensor
2. Connect RF source to converter input
3. Connect power sensor to converter output (IF)
4. Measure conversion gain (dB) and output power (dBm)

Conversion Gain Measurement

Ka-band to 70 MHz down converter

FieldFox Frequency Offset Cal Wizard

Converter Testing



*Measurements and image courtesy of **MITEQ***

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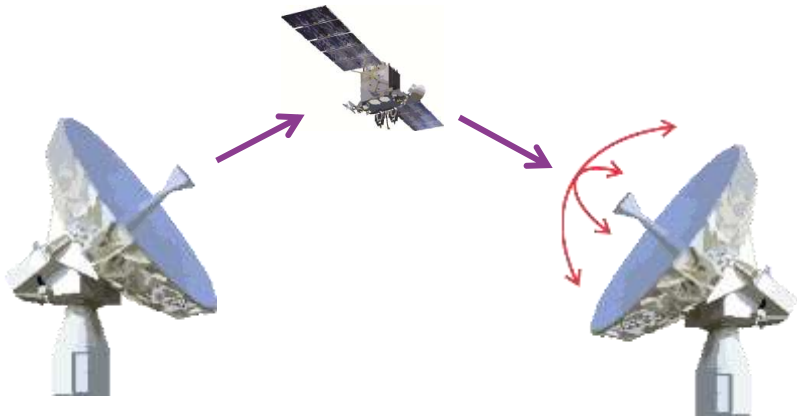
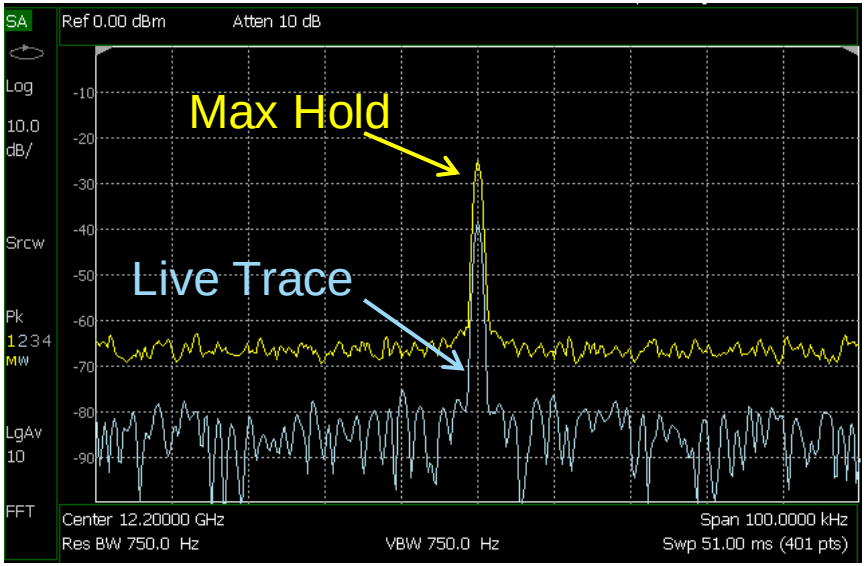
Antenna Peaking

Measure beacon signal

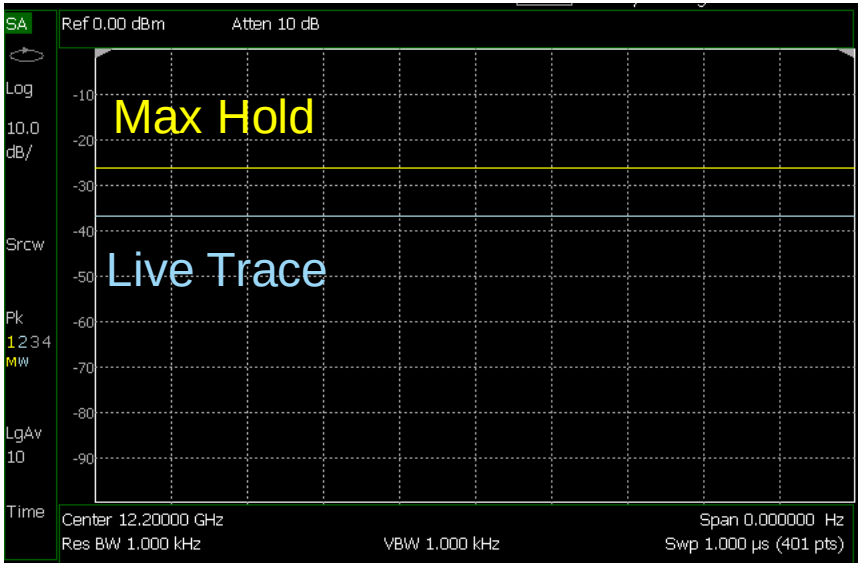


Narrow Frequency Span



Ch1: Max Hold, Ch 2: Clr/Wr

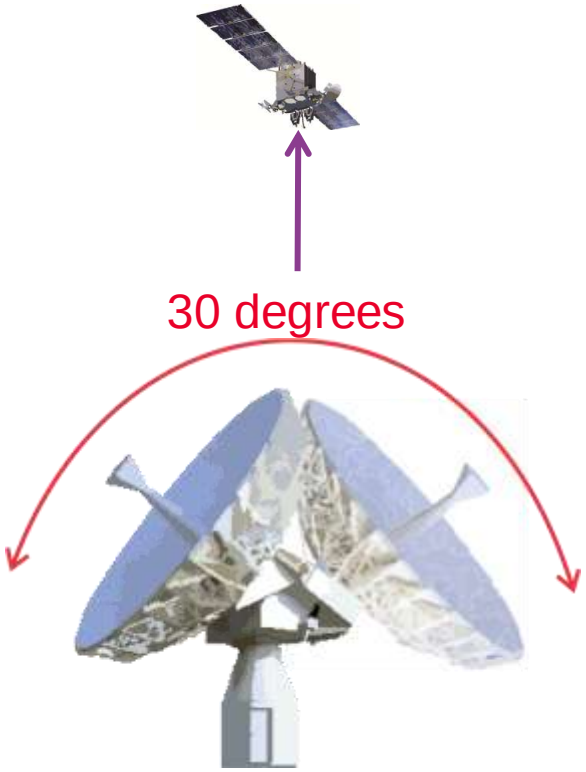
Zero Span Mode



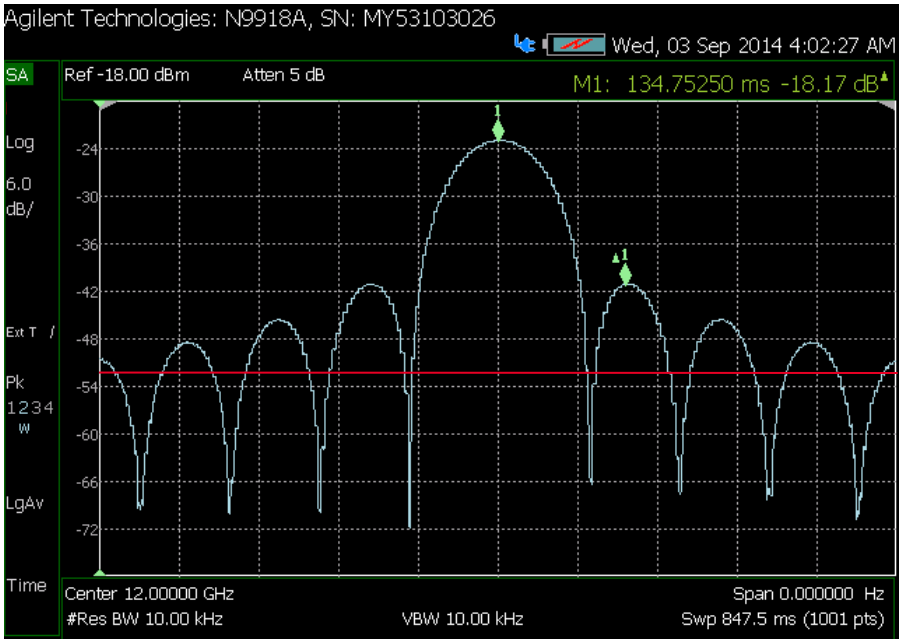
Ch1: Max Hold, Ch 2: Clr/Wr

Useful for pointing and polarization adjustments

Antenna Sidelobes

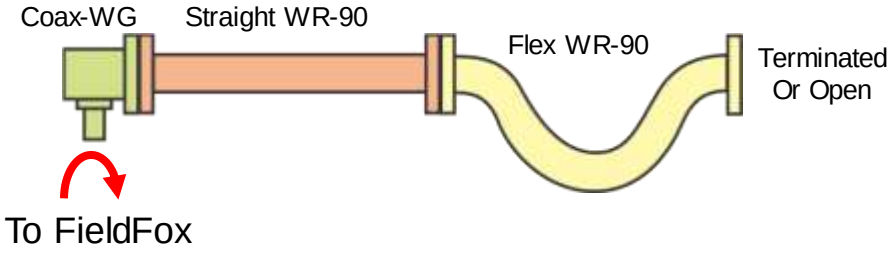


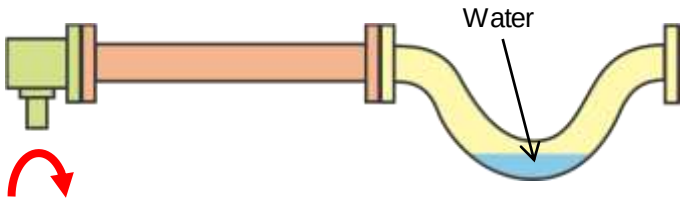
Max hold, sweep time ~ antenna slew rate

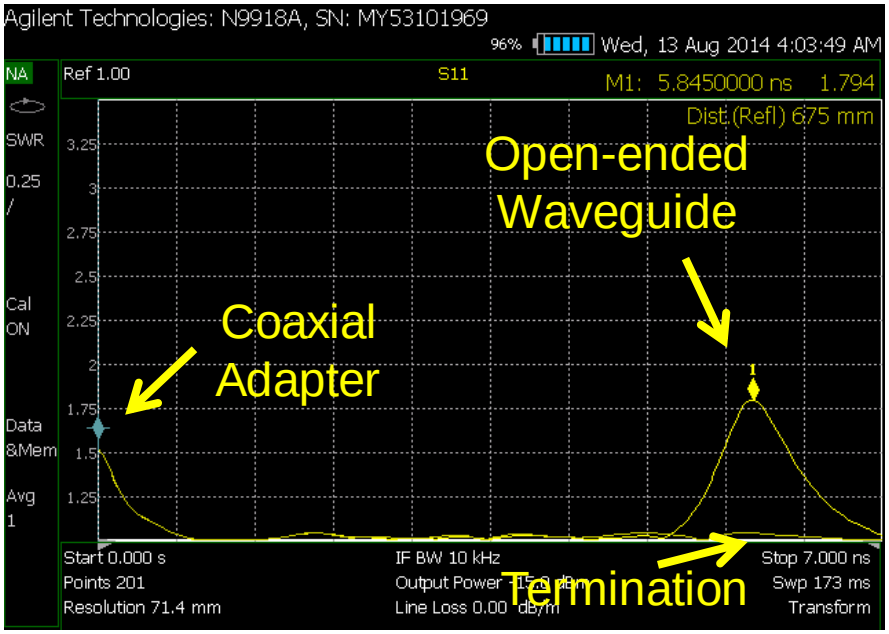


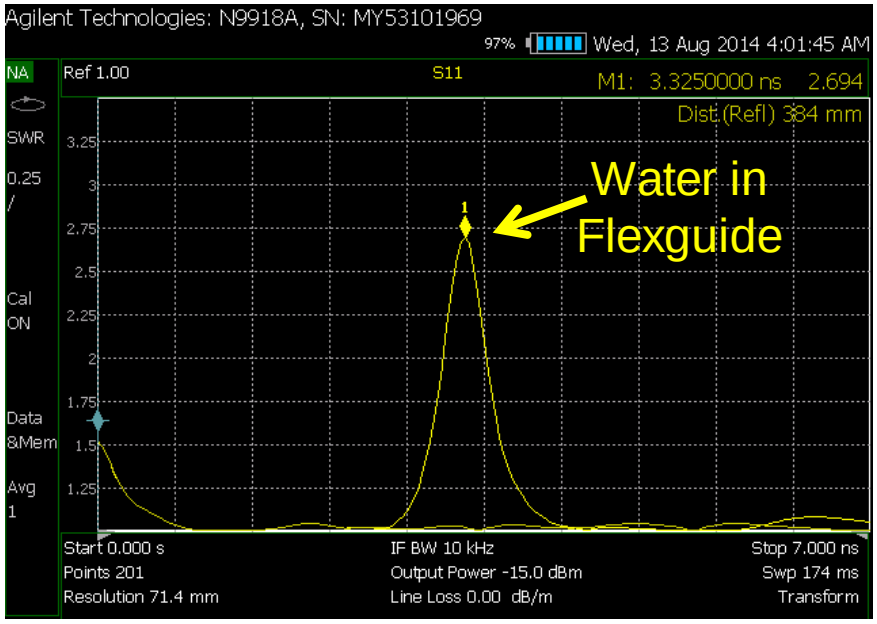
Distance to Fault (DTF / Time Domain)

X-Band Flexible Waveguide and Termination









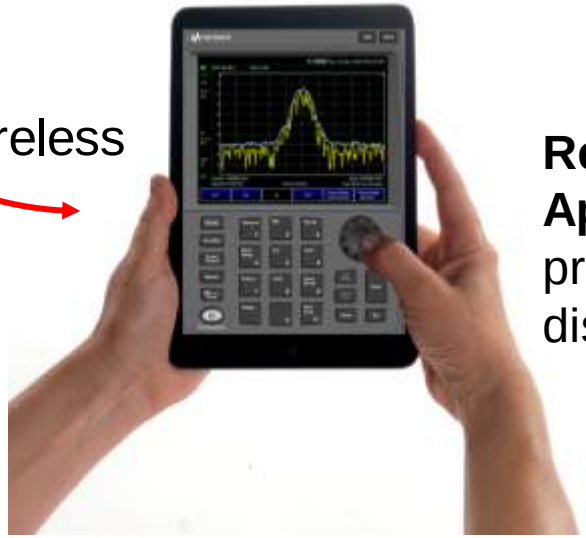
Remote Monitoring and Control

FieldFox mounted on antenna flange

Wired or Wireless

FieldFox Remote Display software provides remote display and control from a PC

Wireless



Remote Viewer iOS App (Apple® Store) provides remote display and control

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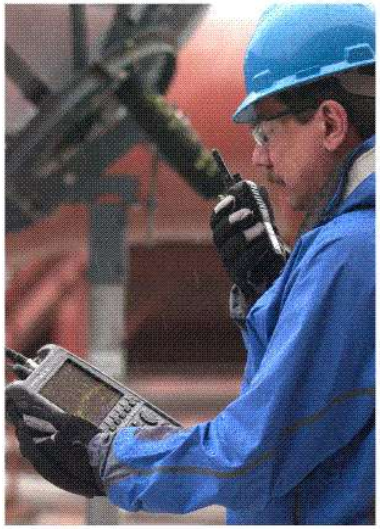
FieldFox Rugged to MIL-PRF-2880F Class 2



MIL-Spec durability

Meets MIL-PRF-28800F Class 2 requirements

Type tested and meets MIL-STD-810G, Method 511.5 Procedure 1 requirements for operation in explosive environments

Field-proof

Type tested to IP53: completely sealed instrument enclosure provides measurement stability in dusty and wet environments

3-year warranty ensures field confidence (standard on all FieldFox analyzers)

Low emissions, meets CISPR Pub 11, class B

Water-resistant chassis, keypad, and case withstand wide temperature ranges, and salty, humid environments

- Case withstands shock and vibrations
- Wide operating temperature -10 to +55 °C (+14 to +131 °F)
- Wide storage temperature -51 to +71 °C (-60 to +160 °F)

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Keysight FieldFox Combination Analyzers

Combination Analyzers can be configured with the following capabilities

- Spectrum Analyzer
- Vector Network Analyzer (VNA)
- Cable and Antenna Test (CAT)
- Vector Voltmeter (VVM)
- Power Meter
- Independent Source

Models include frequencies up to **50 GHz**

- 7.1 pounds (3.2 kg)
- Built-in GPS
- 3.5 hour battery life

Carry precision with you - Keysight-quality measurements

KEYSIGHT TECHNOLOGIES

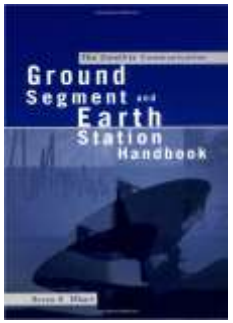
Conclusions

- Satellites and earth stations are complex systems requiring high performance and reliability
- Frequency re-use and spot beams achieve high system throughput
- Earth station maintenance and troubleshooting requires numerous types of high performance test equipment
- FieldFox can be remotely controlled for difficult test environments
- FieldFox combination analyzers are ideal solutions for field testing
- Frequency coverage to 50 GHz enables complete Ka-band analysis

Special thanks to Bruce Elbert for his technical assistance with this webcast

KEYSIGHT TECHNOLOGIES

Ground Segment and Earth Station Handbook



For More Information

Web: www.keysight.com/find/FieldFox

Literature:

- *Techniques for Precise Interference Measurements in the Field,* application note, literature number 5991-0418EN
- *Techniques for Precise Cable and Antenna Measurements in the Field,* application note, literature number 5991-0419EN
- *Correlating Microwave Measurements between Handheld and Benchtop Analyzers,* application note, literature number 5991-0422EN
- Techniques for Precise Measurement Calibrations in the Field, application note, literature number 5991-0421EN

FieldFox handheld education application webcast series
Registration: www.keysight.com/find/FieldFoxWebcasts

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Thank you for your time
Questions?

References

Elbert, B., The Satellite Communication Ground Segment and Earth Station Handbook, 3nd Edition, Artech House, 2014

Volakis, J. L., "Satellite Antennas," in *Antenna Engineering Handbook*, 4th Edition, McGraw-Hill, 2007, pp. 44-2 to 44-4.

Fenech, H. ; Tomatis, A. ; Amos, S. ; Soumpholphakdy, V. ; Serrano-Velarde, D., "Future High Throughput Satellite systems", *IEEE First AESS European Conference on Satellite Telecommunications (ESTEL)*, 2012

Braun, T., Satellite Communications Payload and System, Wiley-IEEE Press, 2012

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 Interference Measurements in the Field, Literature Number 5991-0418, February 2013