

Precision Validation, Maintenance and Repair of Satellite Earth Stations

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Co-sponsored by



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Component Test Division
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



Telemetry, Tracking and Command (TT&C)



Gateways and Hubs



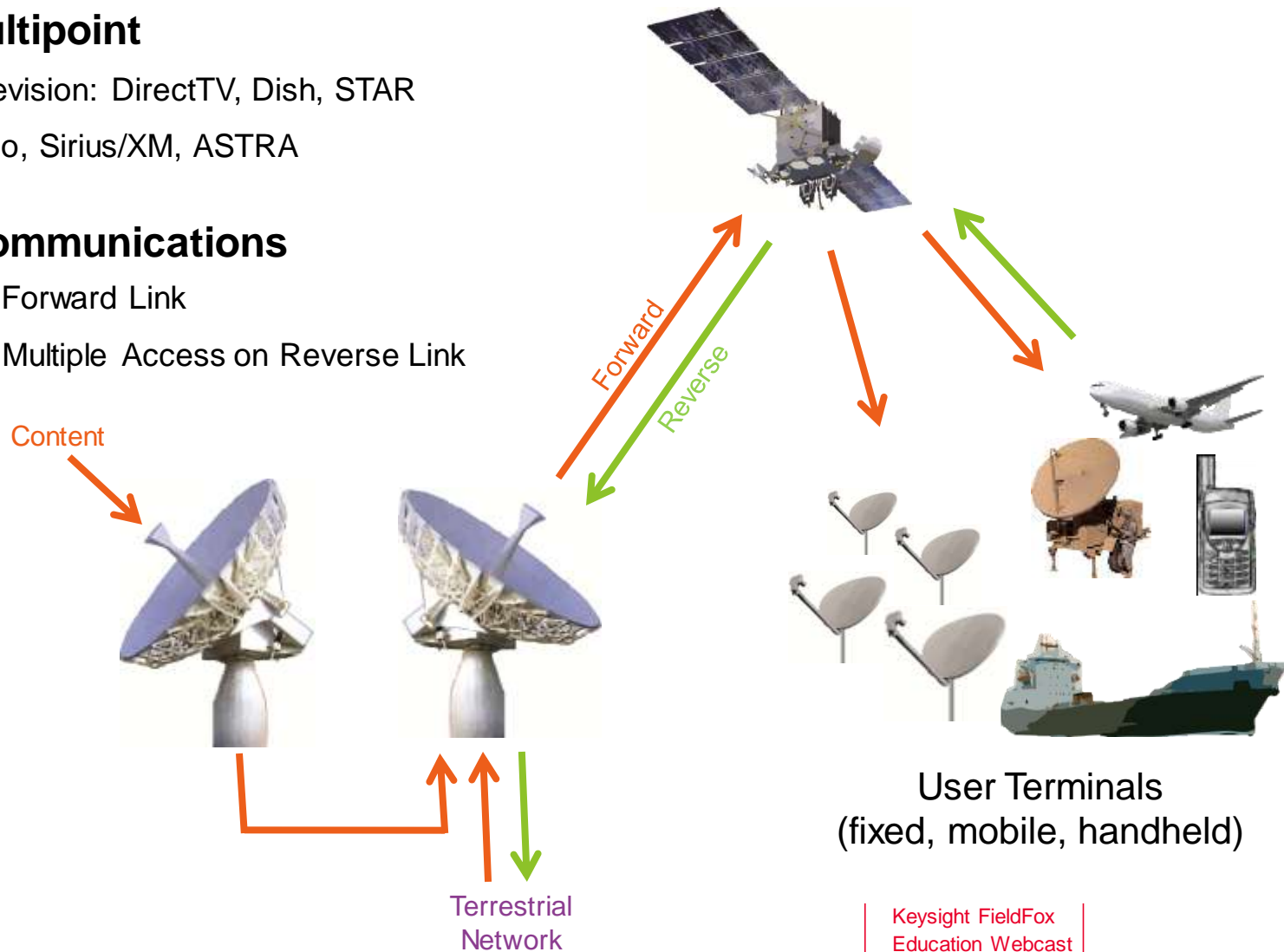
Broadcasting and Duplexing

Point-to-Multipoint

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

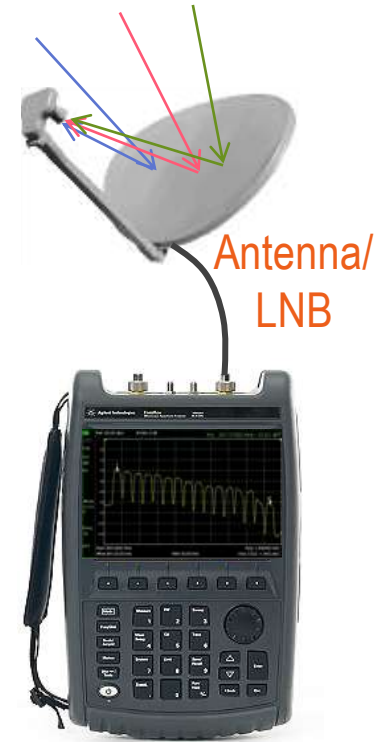
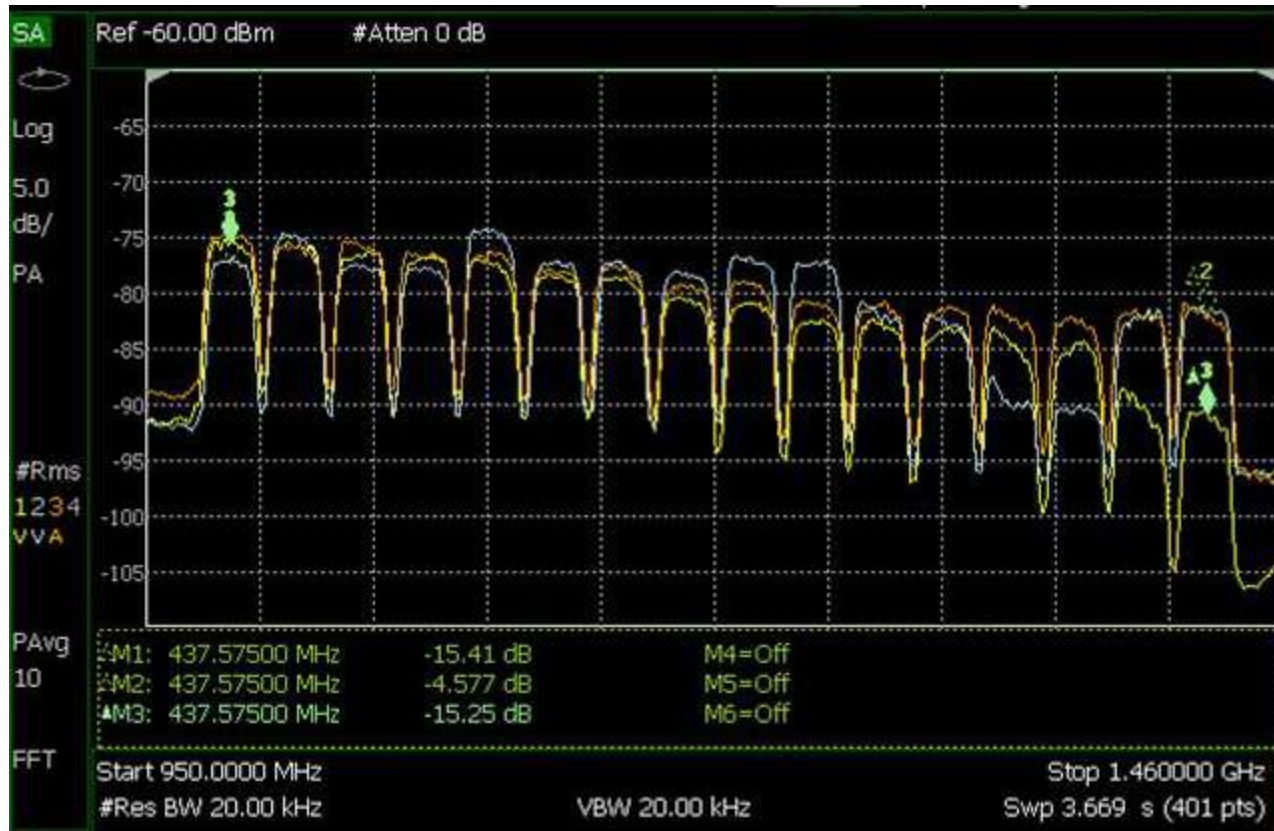
Two-Way Communications

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



Spectrum Measurement of Received Signal

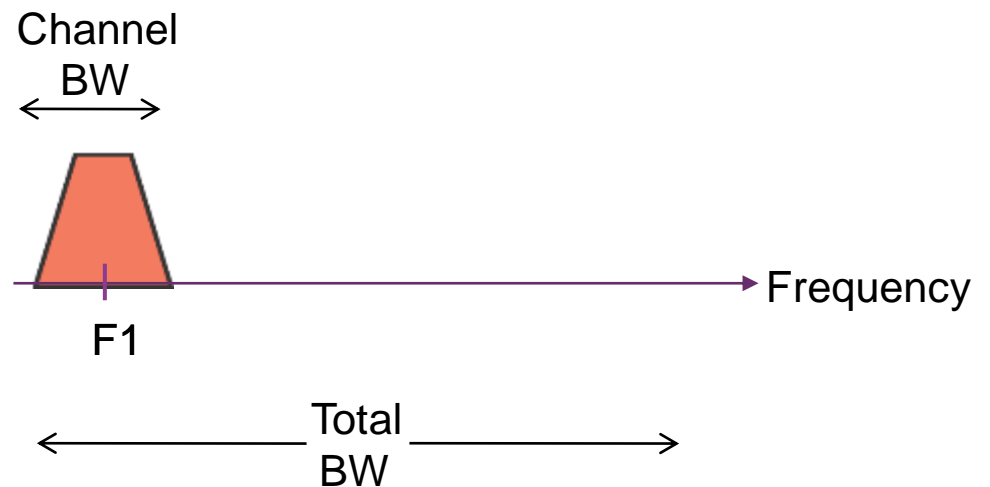
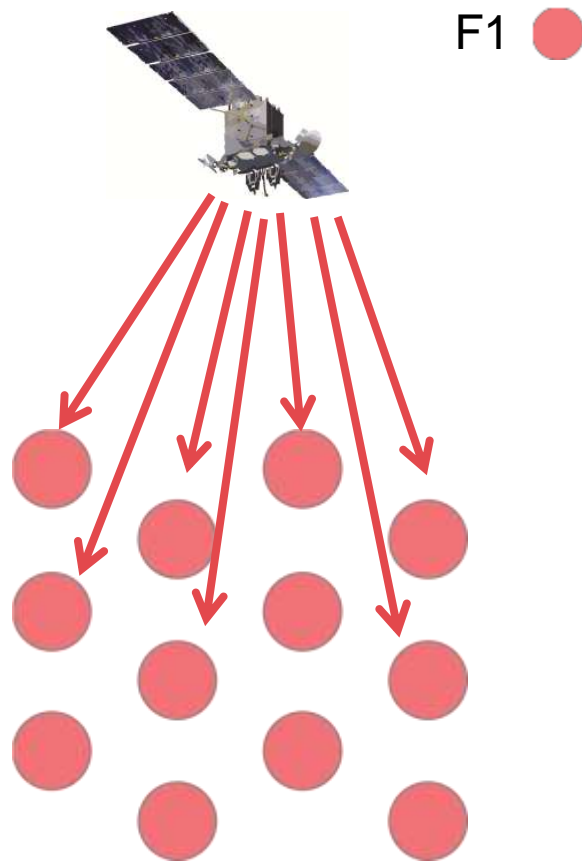
Television Broadcast Signal at Ku-Band



Keysight
FieldFox
(SA Mode)

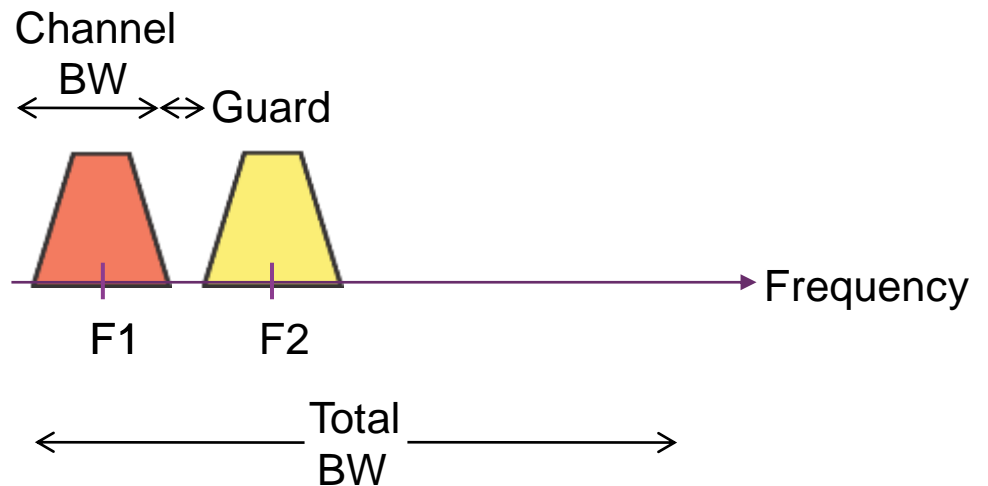
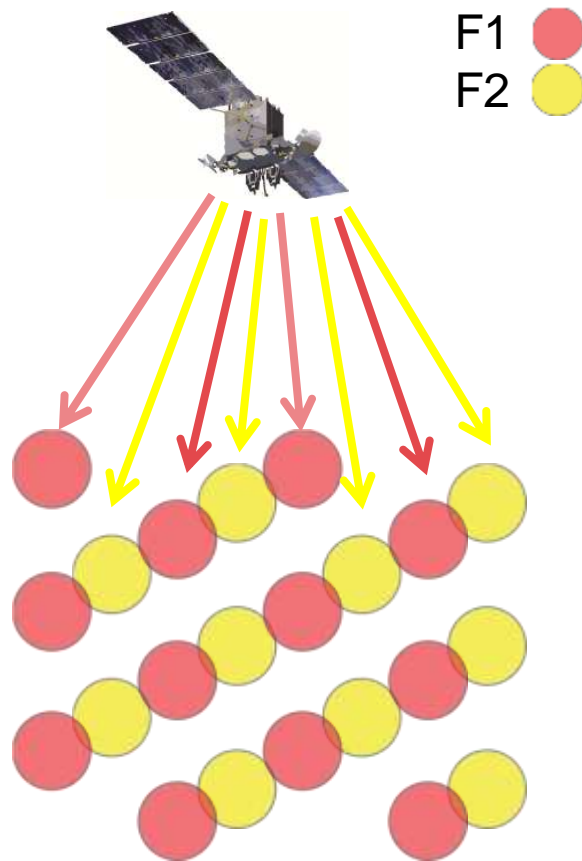
High Throughput Satellites (HTS)

Frequency Re-Use and Spot Beams



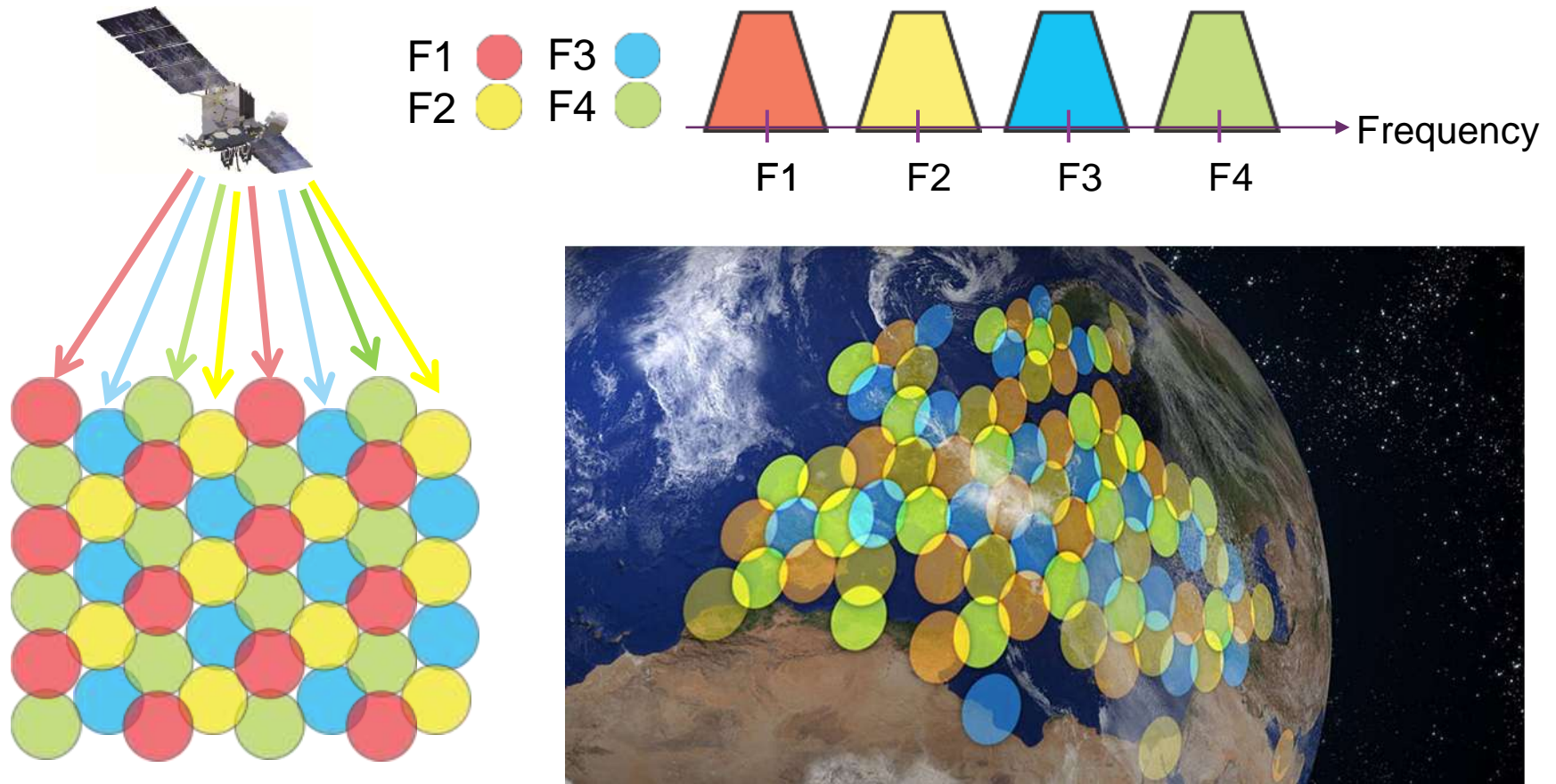
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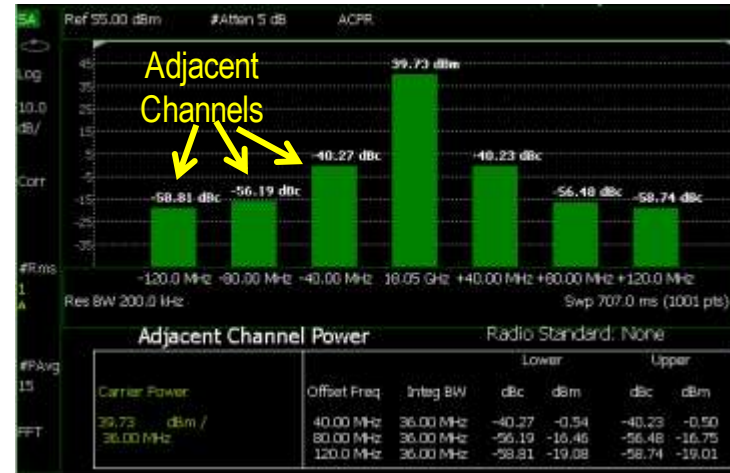
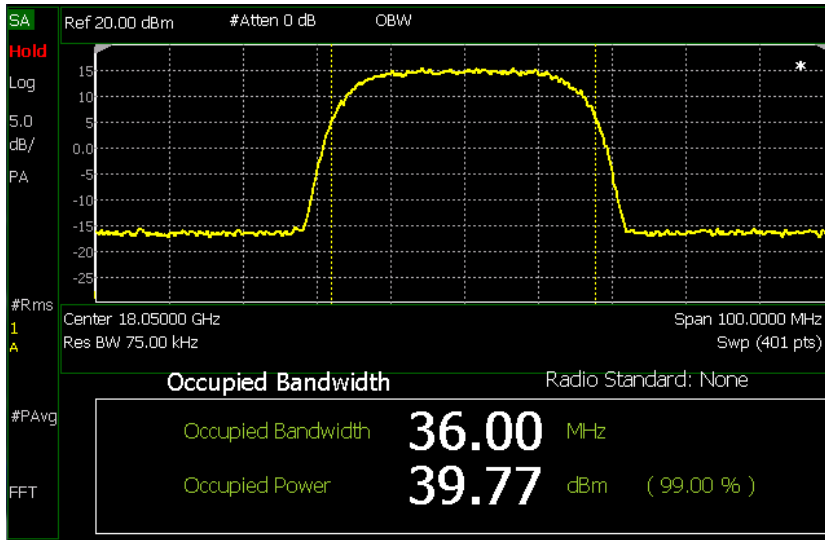
High Throughput Satellites (HTS)

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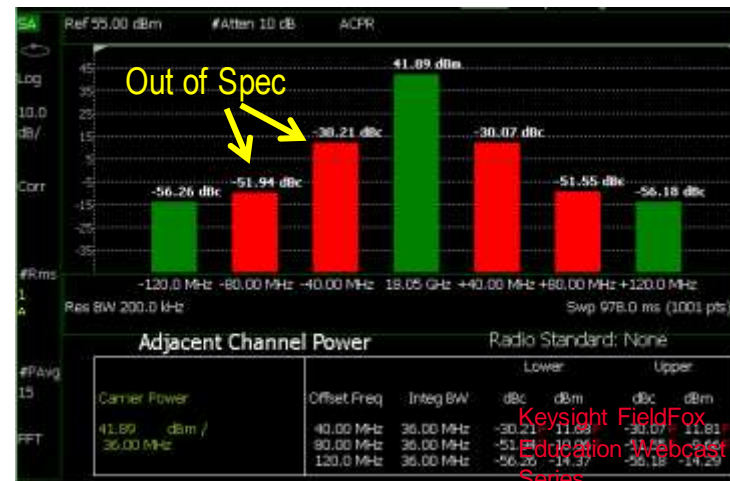
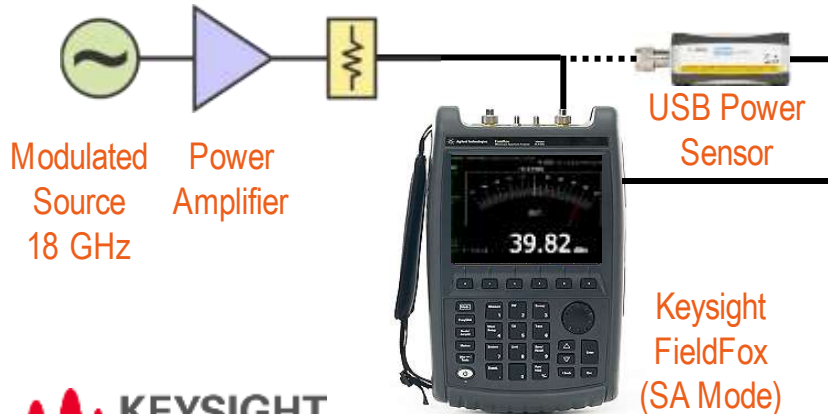


Nonlinearities Increase Channel Interference

Measured spectrum of a communications signal

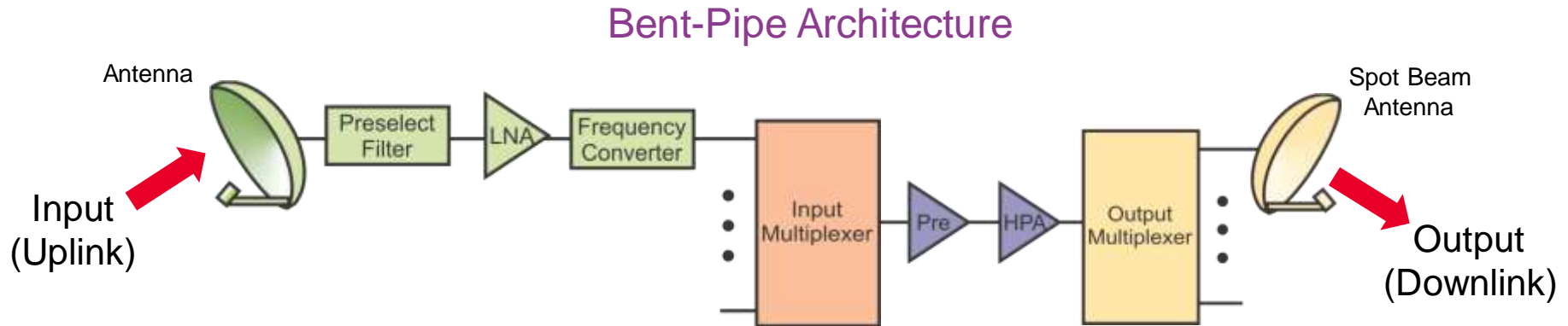


Non-Saturated Amplifier



Saturated Amplifier

Satellite Payload Design



Bent-Pipe

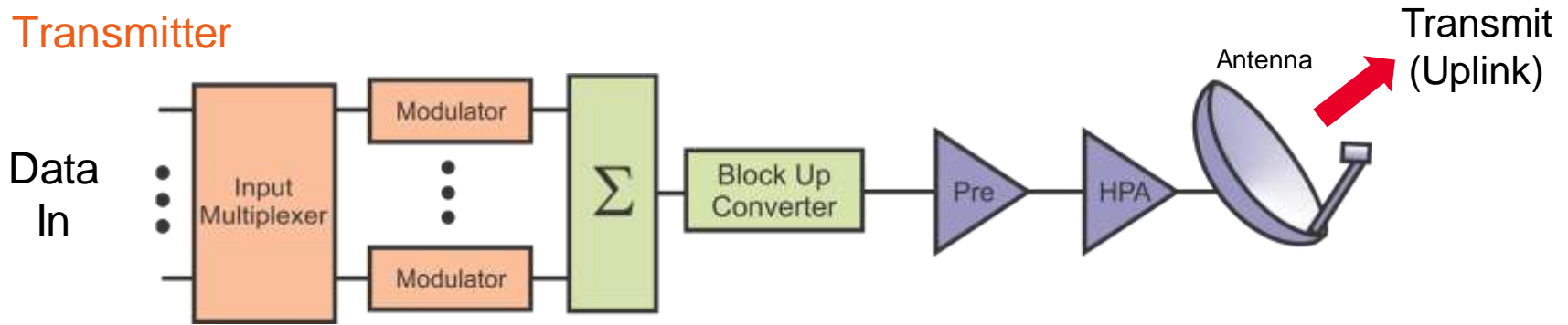
- All analog processing
- Frequency conversion

Processing

- Non-regenerative
 - Input digitized
 - Filtered and processed
 - No demodulation
- Regenerative
 - Input digitized
 - Demodulation / modulation

Earth Station Design

Transmitter



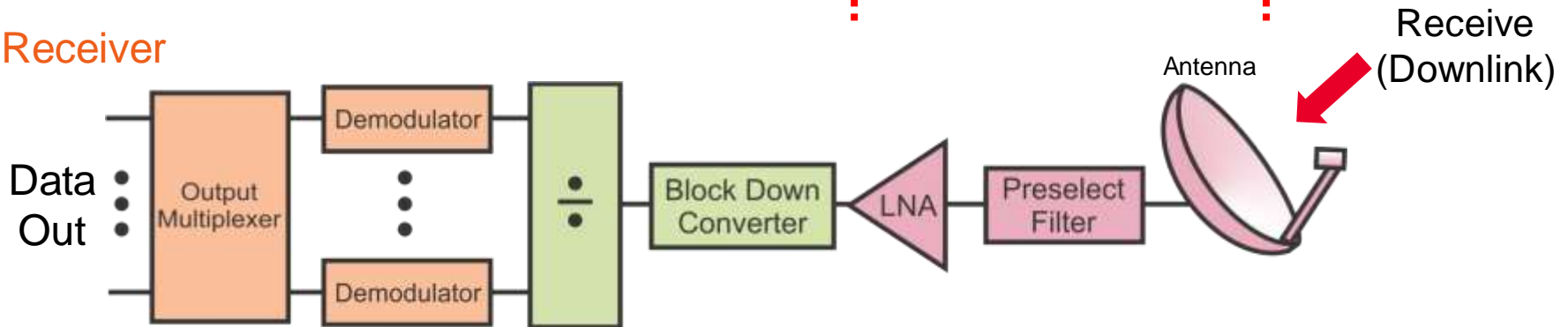
Channel IF
• 70 MHz +/- 20 MHz
• 140MHz +/- 40 MHz

IF

RF

L, C, X, Ku, Ka-bands

Receiver



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

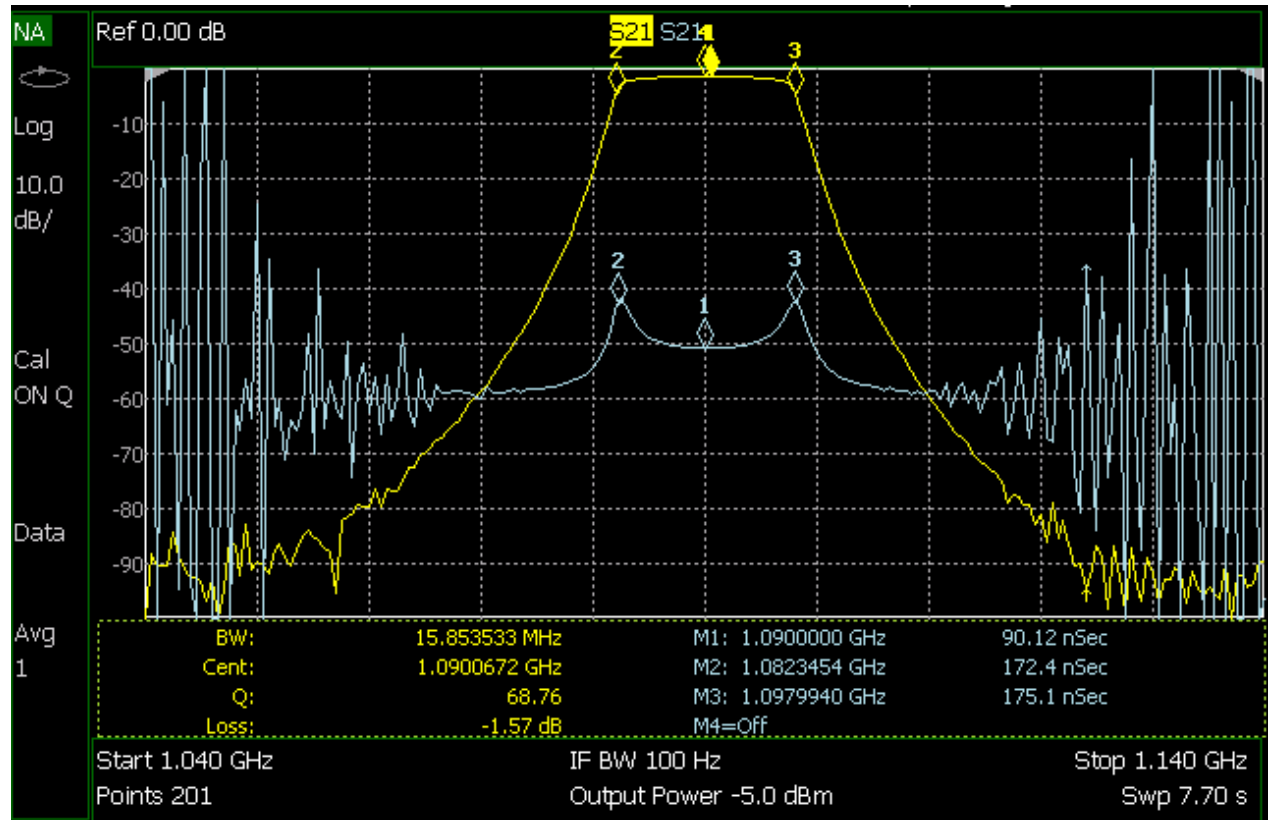
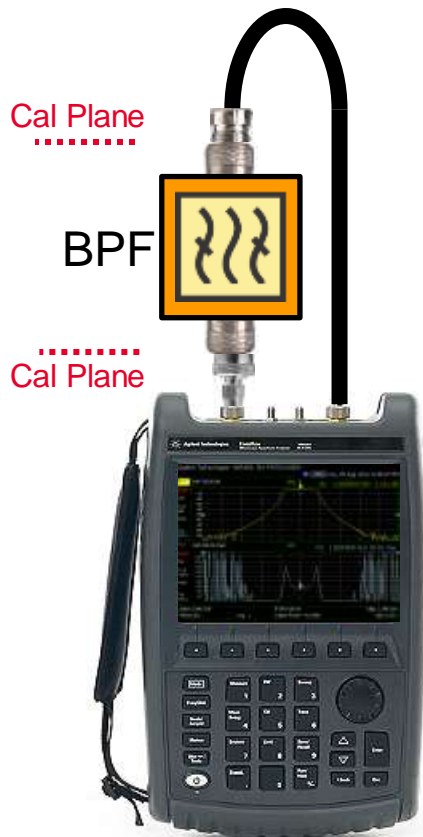


Keysight
USB Power
Sensor



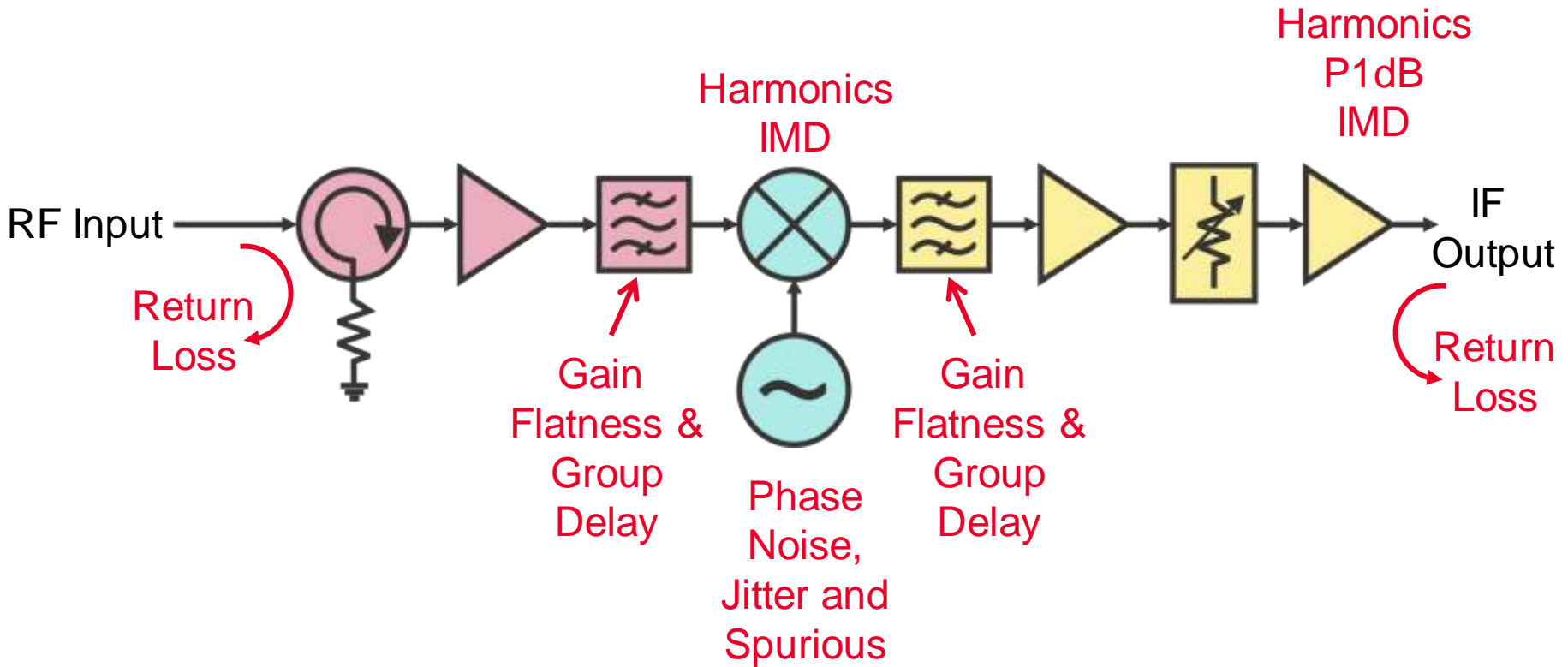
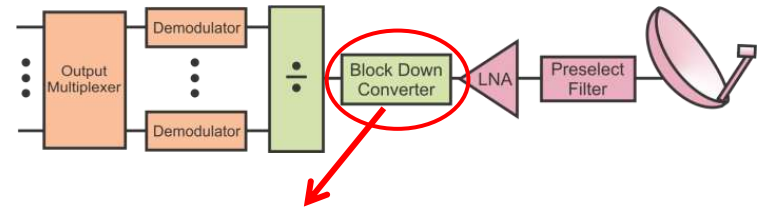
Filter Measurement

VNA (S21) Loss and Group Delay



Converter Block Diagram

Signal Impairments

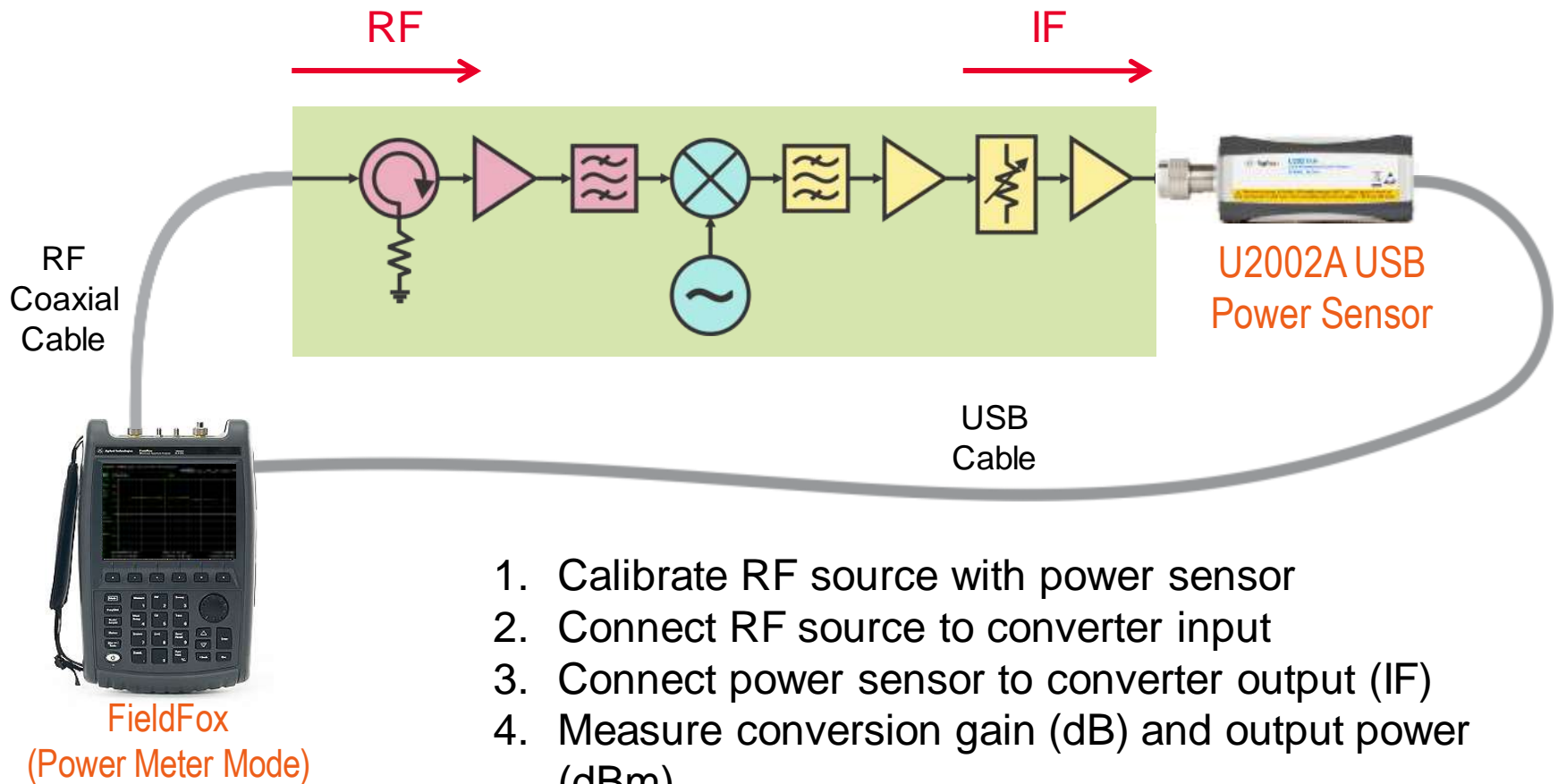


Testing Requires

- Spectrum analyzer
- VNA
- Conversion measurement capability

Converter Measurement Configuration

Swept measurement of gain through frequency conversion



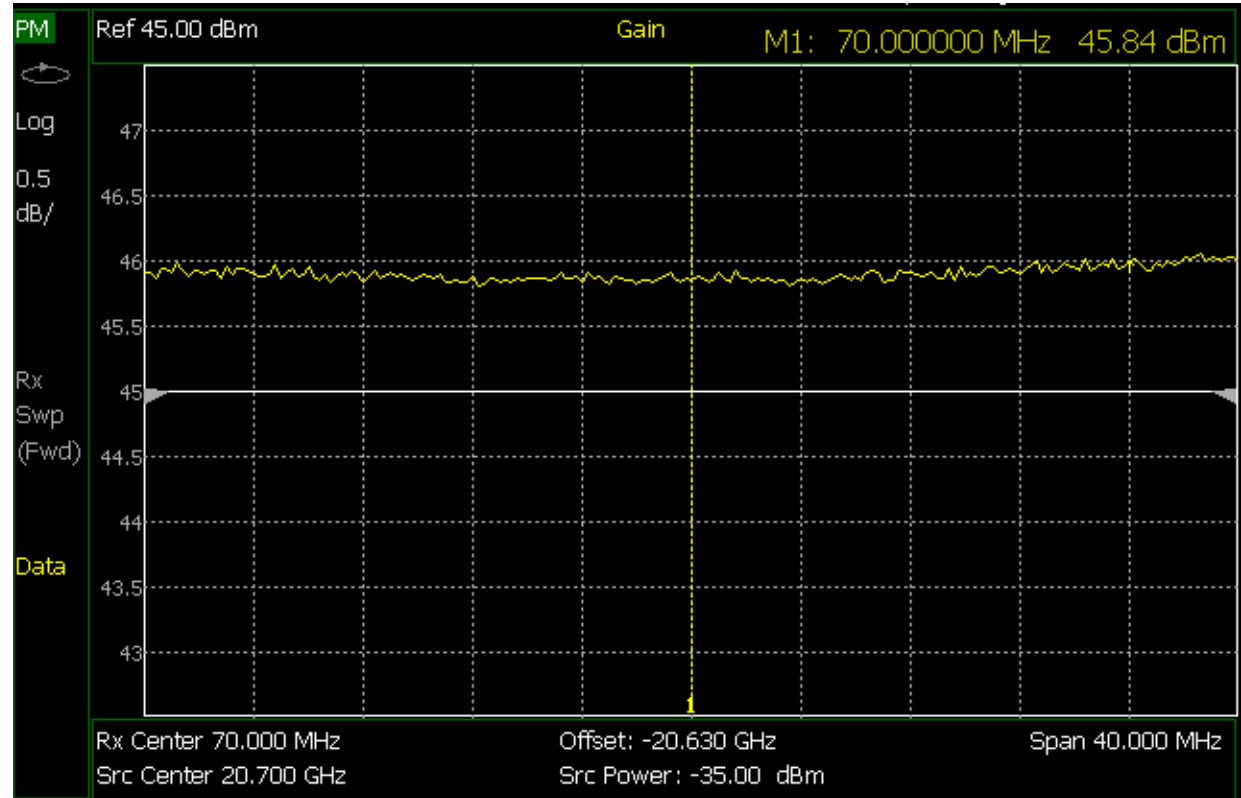
Conversion Gain Measurement

Ka-band to 70 MHz down converter

FieldFox Frequency Offset Cal Wizard



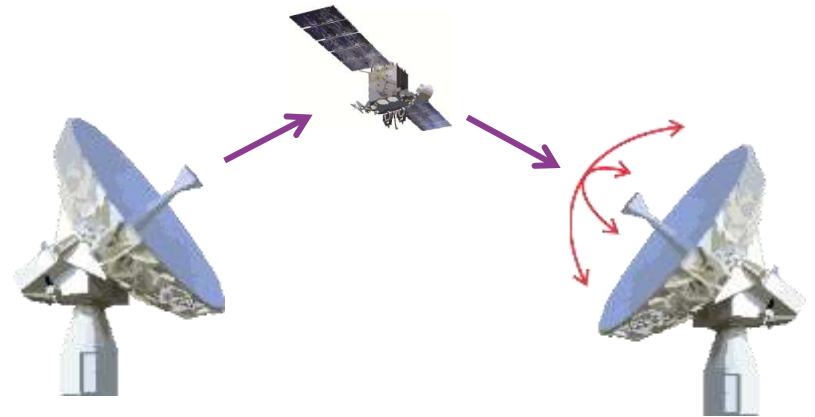
Converter Testing



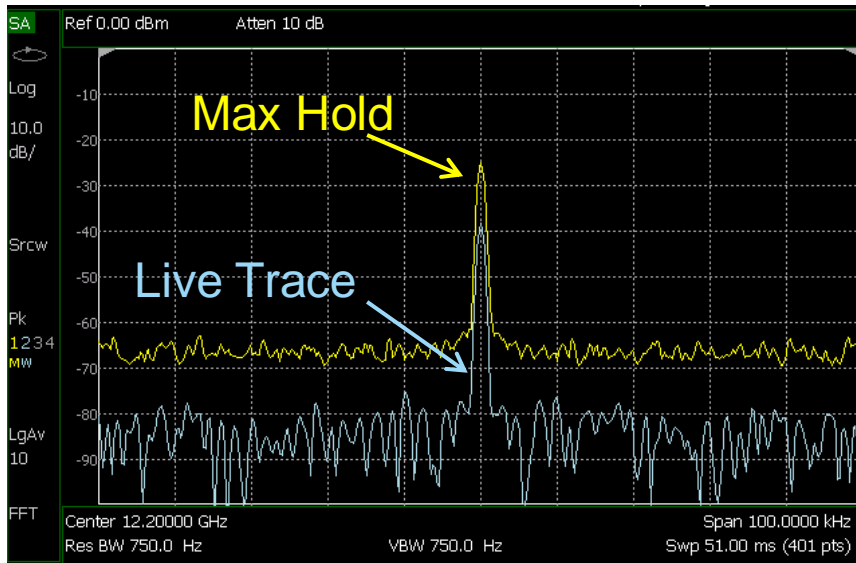
Measurements and image courtesy of MITEQ

Antenna Peaking

Measure beacon signal



Narrow Frequency Span



Ch1: Max Hold, Ch 2: Clr/Wr

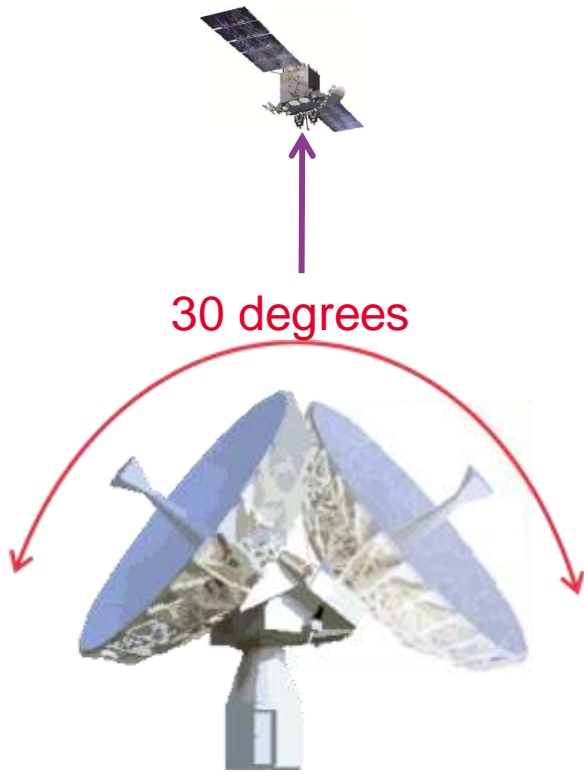
Zero Span Mode



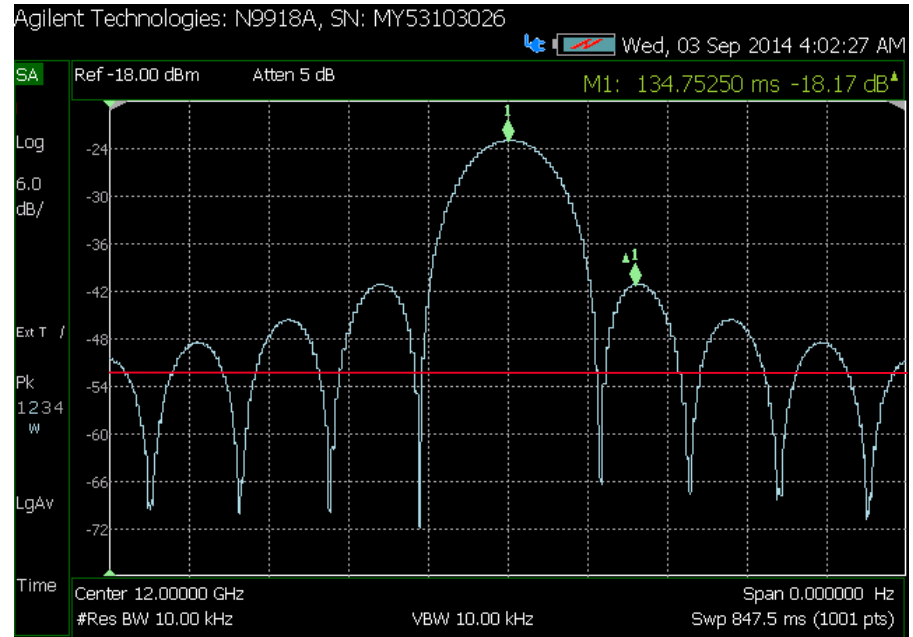
Ch1: Max Hold, Ch 2: Clr/Wr

Useful for pointing and polarization adjustments

Antenna Sidelobes

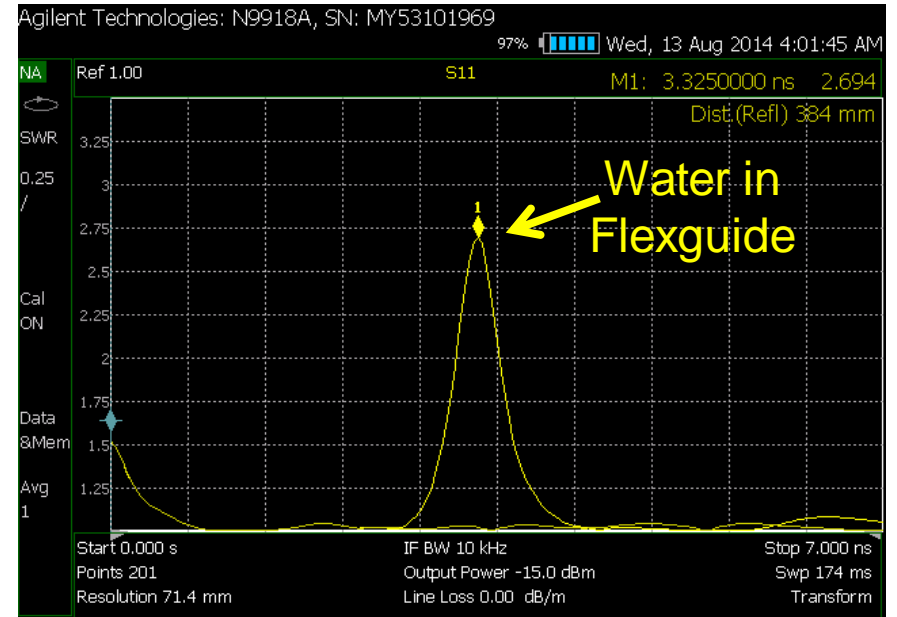
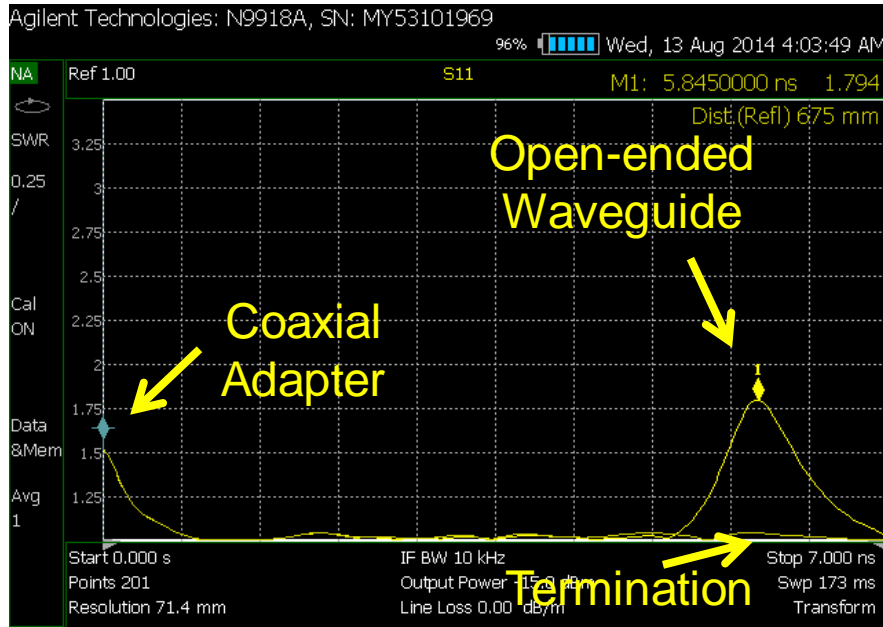
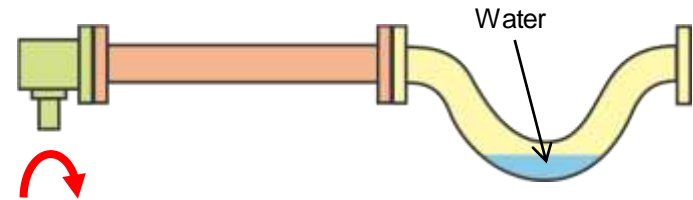
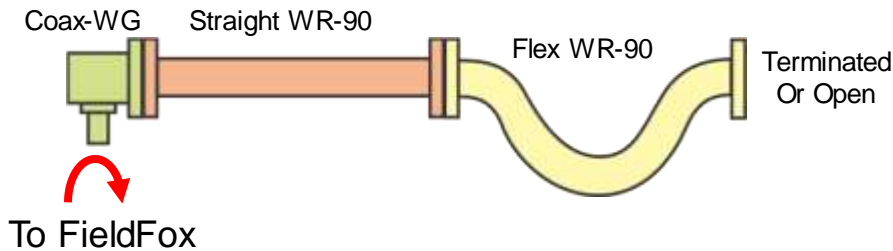


Max hold, sweep time ~ antenna slew rate



Distance to Fault (DTF / Time Domain)

X-Band Flexible Waveguide and Termination



Remote Monitoring and Control

FieldFox mounted on antenna flange

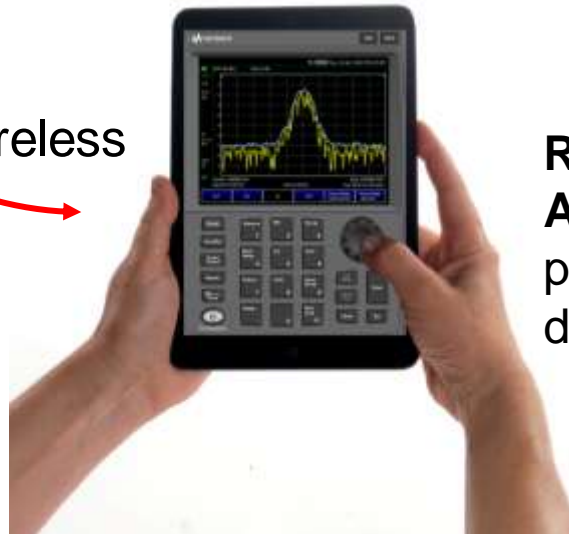


FieldFox Remote Display software provides remote display and control from a PC



Wired or Wireless

Wireless



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

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)



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 **26.5 GHz**

- 6.6 pounds (3 kg)
- Built-in GPS
- 3.5 hour battery life

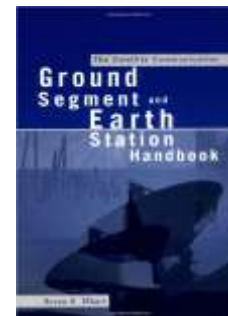


Carry precision with you - Keysight-quality measurements

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

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



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?

Keysight FieldFox
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References

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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. ; Soumholphakdy, 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

Agilent Application Note, Techniques for Precise Calibrations in the Field Using FieldFox handheld analyzers, Literature Number 5991-0421EN, February 2013.

Agilent Application Note, Techniques for Precise Interference Measurements in the Field, Literature Number 5991-0418, February 2013