Broadband Instruments and Systems

"Maintenance Activities on the Digital HFC Network"

for
CCTA Member Companies
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Technical Session Overview

- Challenges faced by the technician
- The importance of the parameters which affects QoS
- Implementing a well planned maintenance program
- Understanding the Triple Play
- What tools are available to increase technician efficiency

Session One

- Downstream/Upstream Testing
- Return Path Monitoring
- Certifying the Return Path
- Work Management Logging
- Generating Reports

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Downstream/Upstream Testing

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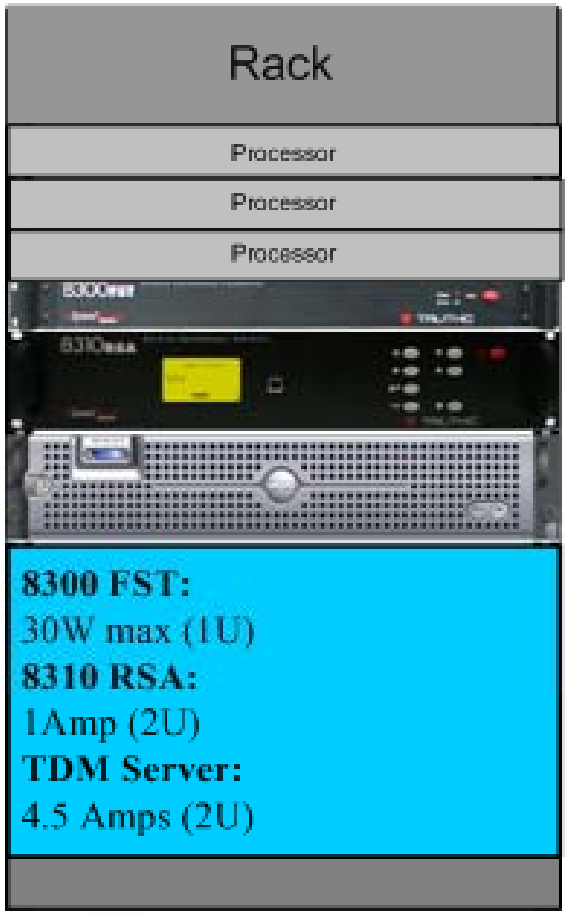
Aligning the Forward Path



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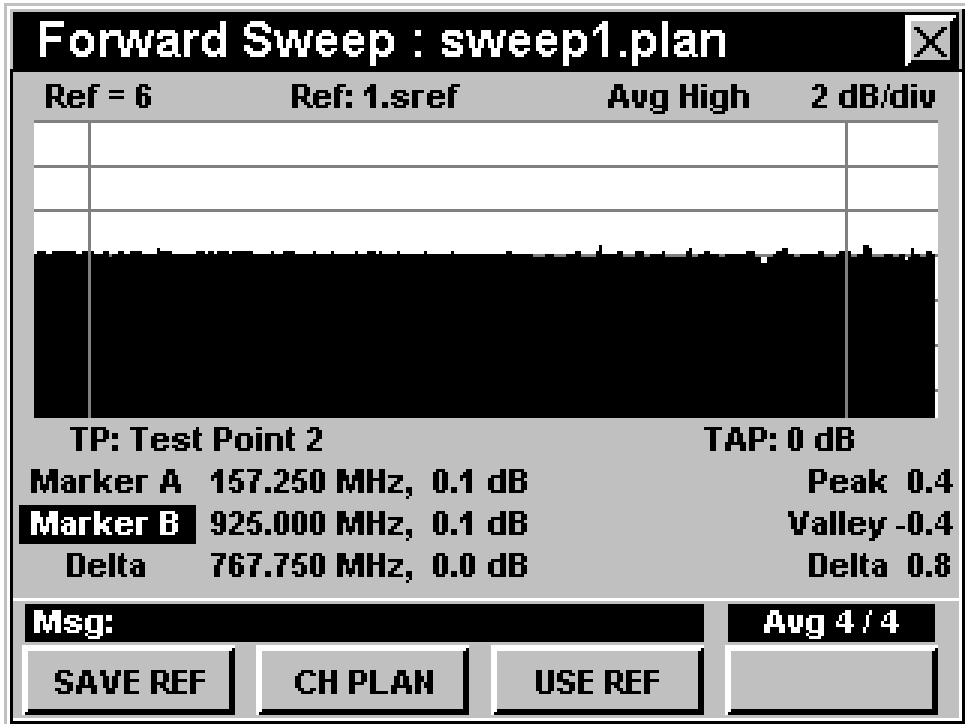
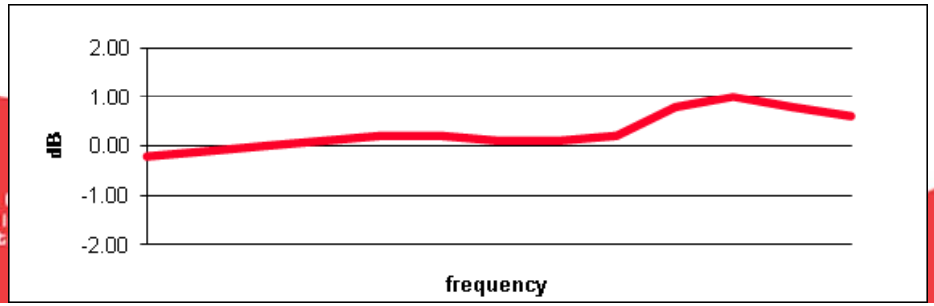
Forward Sweep



Frequency Response Definition

- System's ability to properly transmit signals from head-end to subscriber throughout the designed frequency range
- "Sweep" tests verify performance to design specifications
- Expected results: *n*/10 + x = max flatness variation
  - Where n = number of amplifiers in cascade
  - Where x = best case flatness figure (supplied by manufacturer)



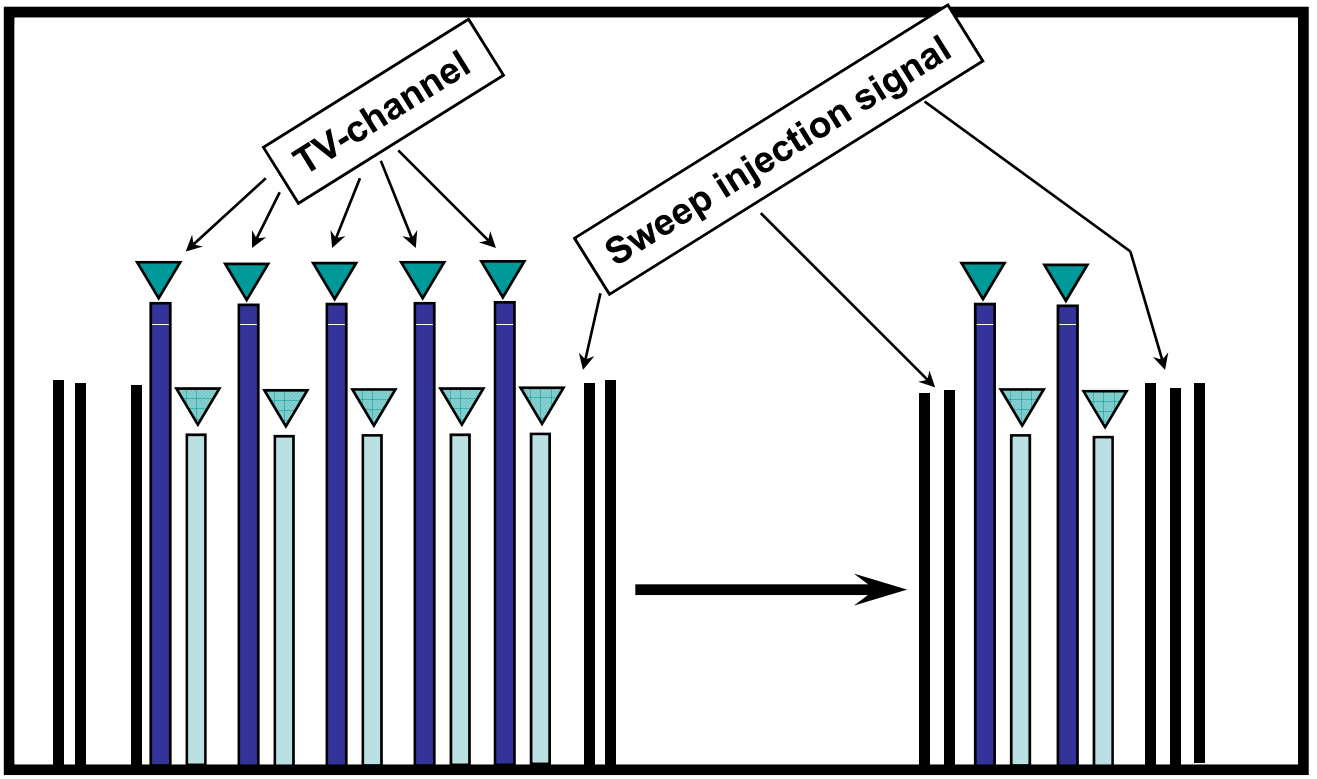
Why Sweep?

- SpeedSweep makes it easier for technicians to find:
  - Reflections
  - Water Migration
  - Damaged cable
  - Suck-Outs
  - Cable Roll-Off
  - Loose or cracked connectors
  - Craftsmanship errors

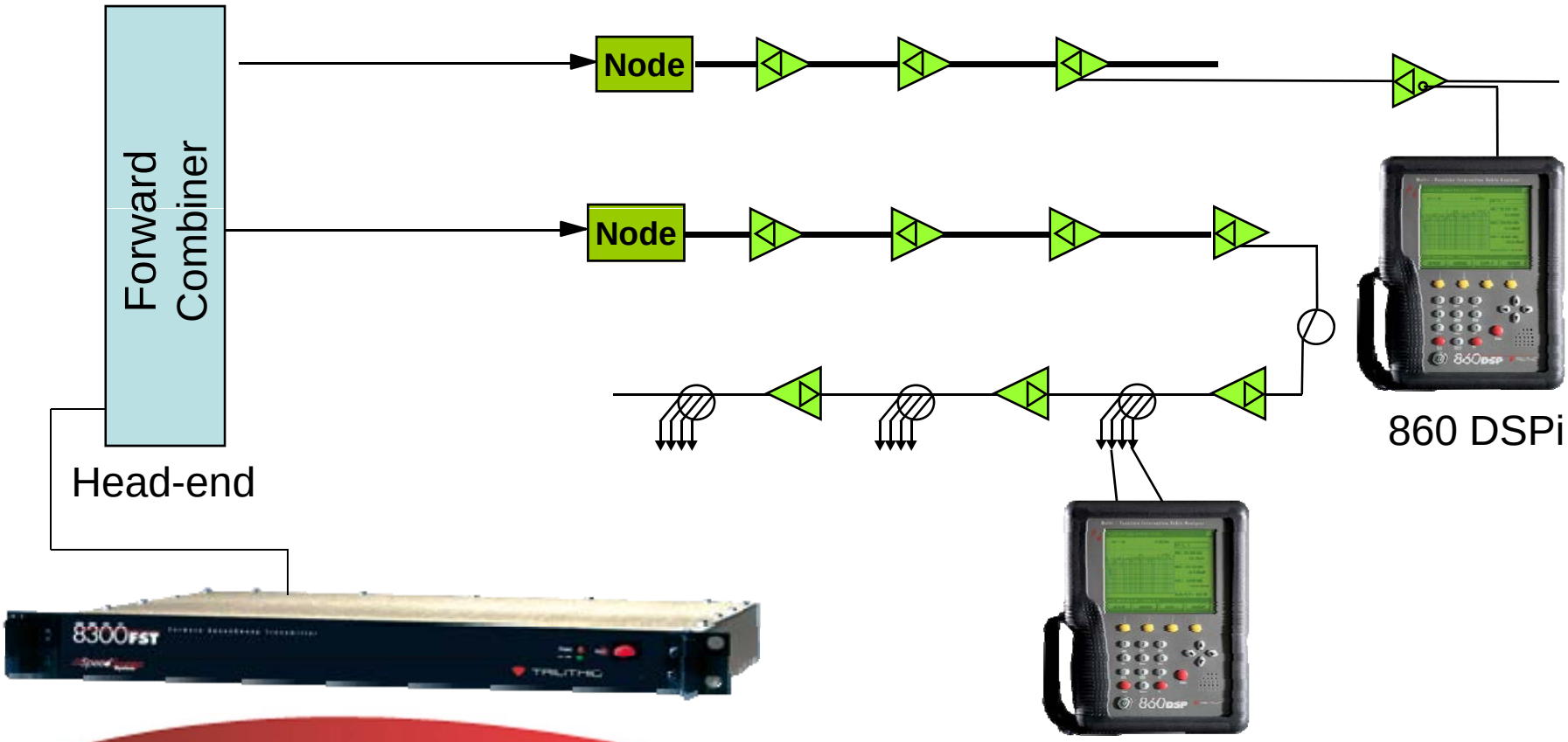
Why Sweep?

- Allows a reference to be stored
  - Sweep makes it possible to divide the HFC plant into network sections and test its performance against individual specifications
- Can measure in unused frequencies
  - This is most important during construction and system overbuilding

Maintenance Activities on the Digital HFC Network



Insertion Diagram



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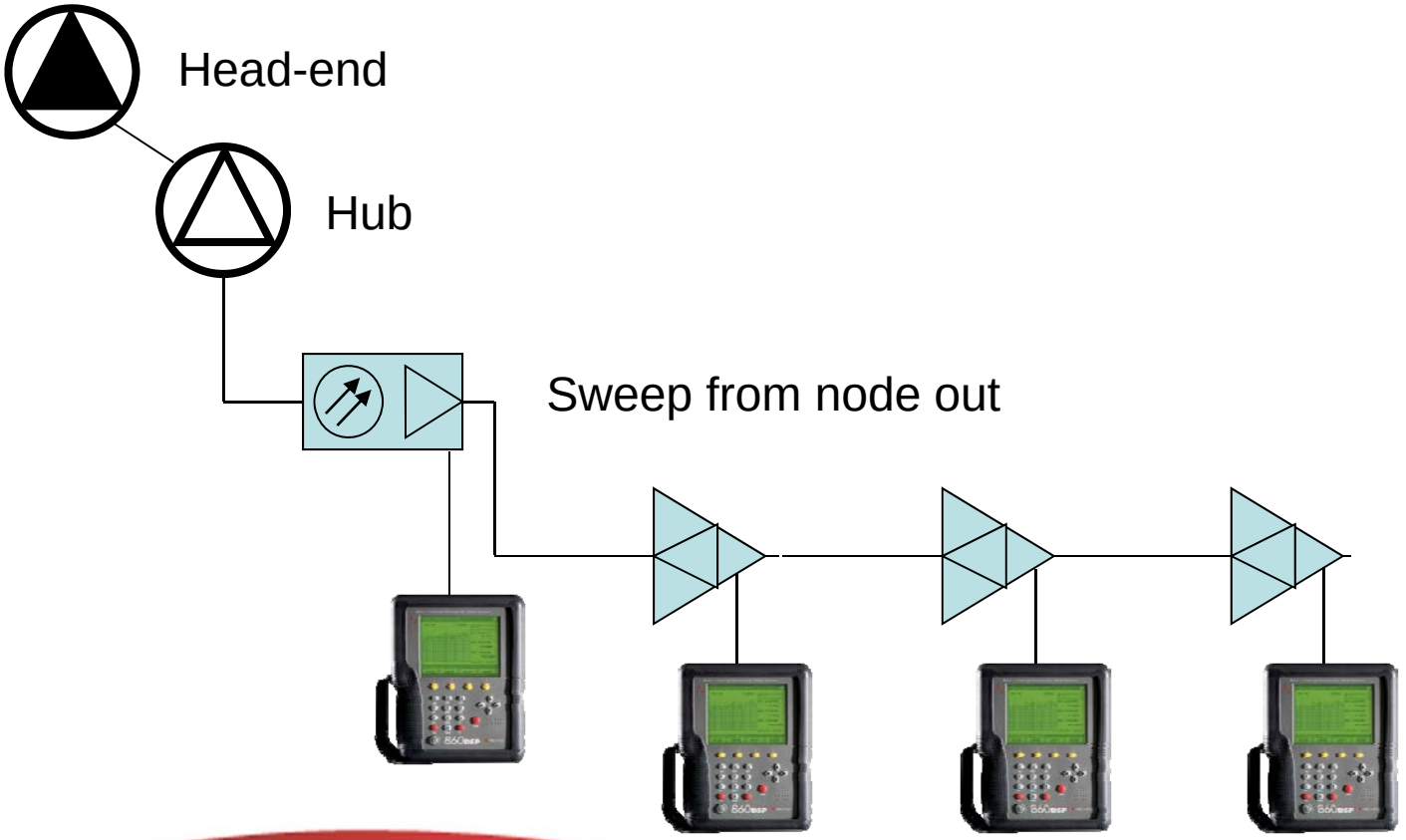
Sweep Forward Path



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Sweep Forward Path

- Start at node
  - Verify unity gain
  - Align RF portion of node at test point
- Store a reference at the node
  - Balance trunk first
  - Then work out into the feeder

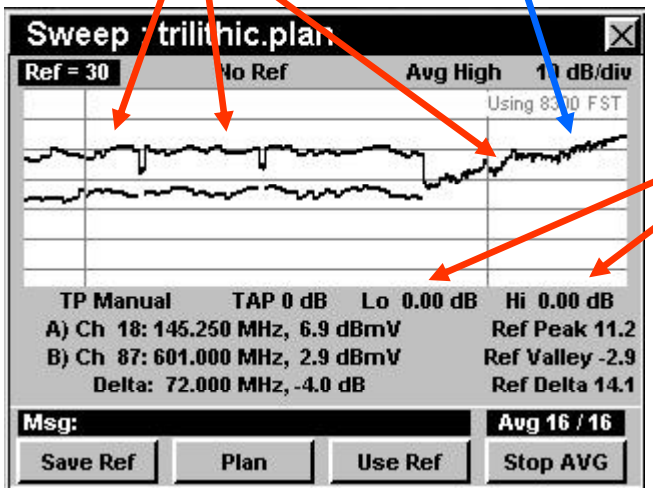
Sweep on 860 DSPi

Reference name can have up to 8 alphanumeric characters

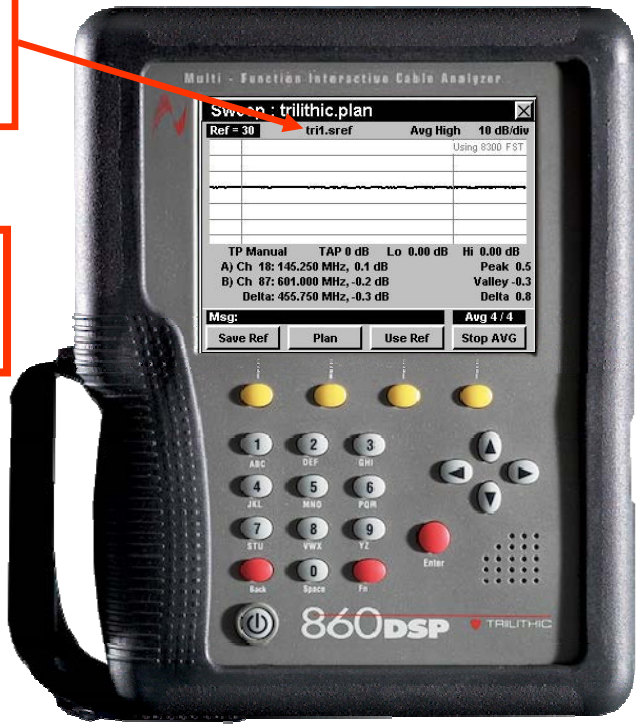
channels

sweep points

Tilt Compensation

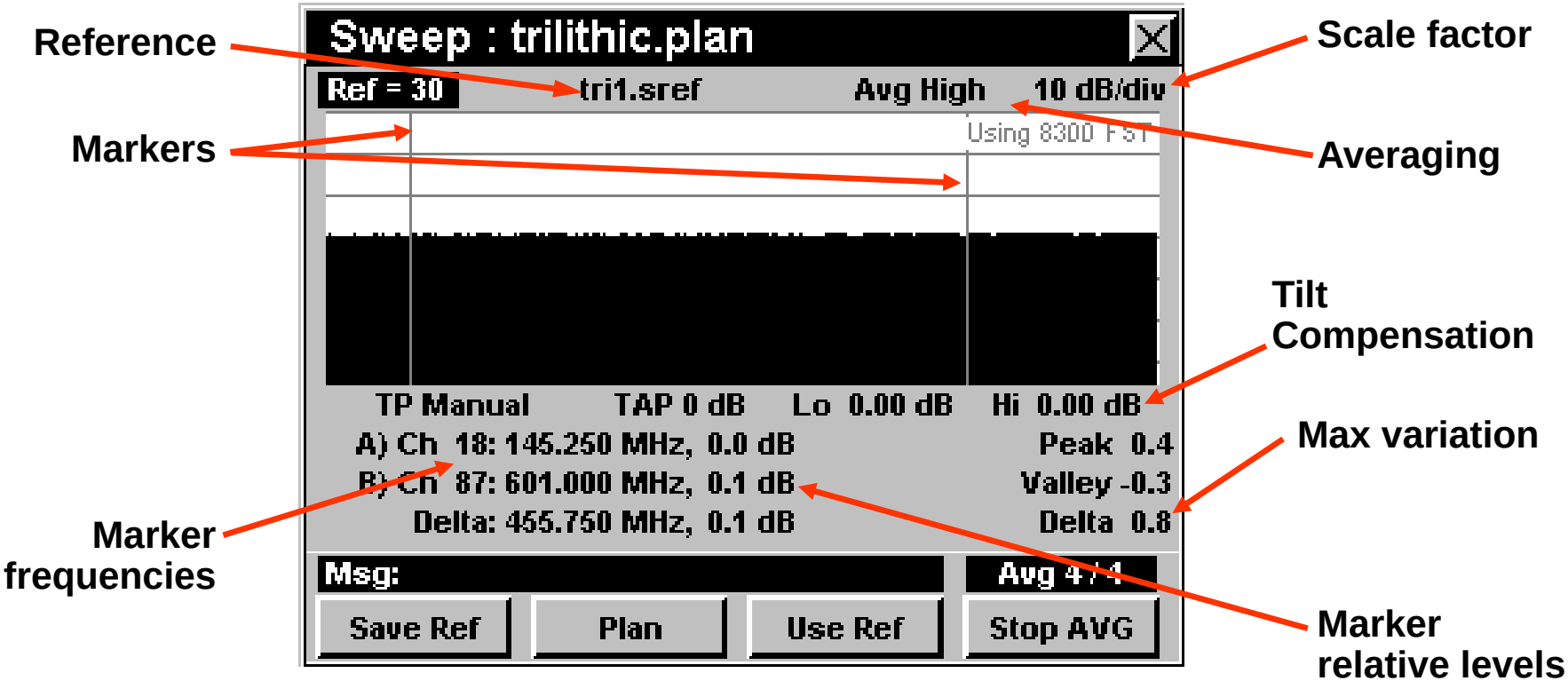


860 DSPi with no reference



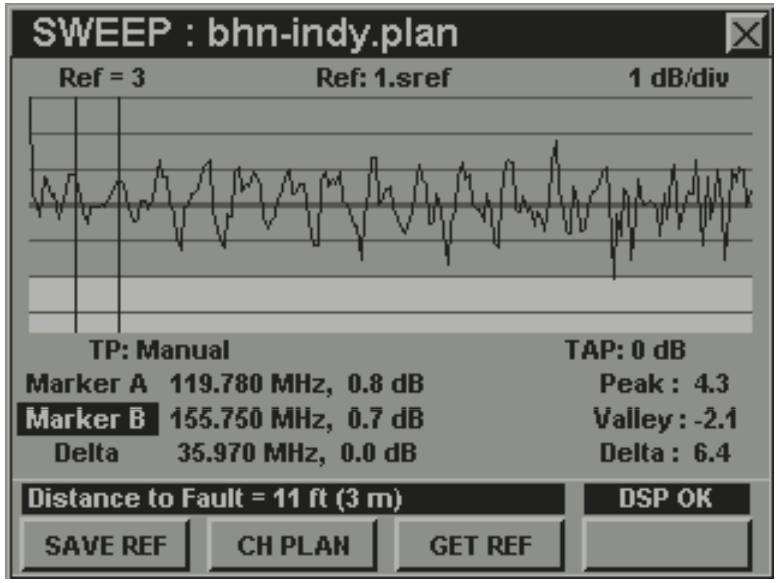
860 DSPi with reference

860 DSPi Sweep Display

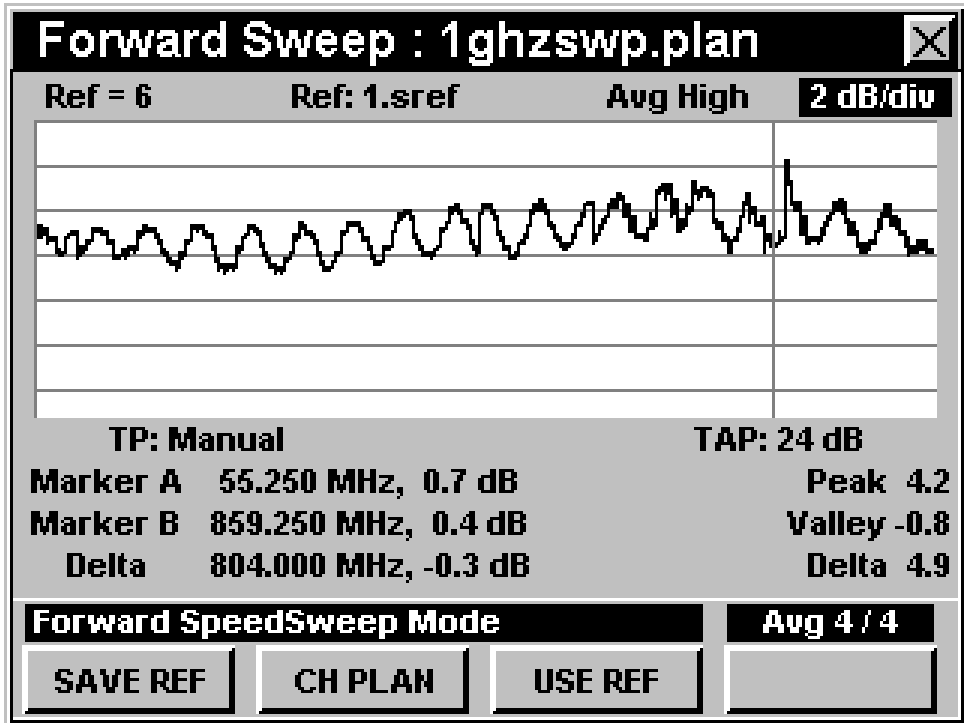


Standing Waves

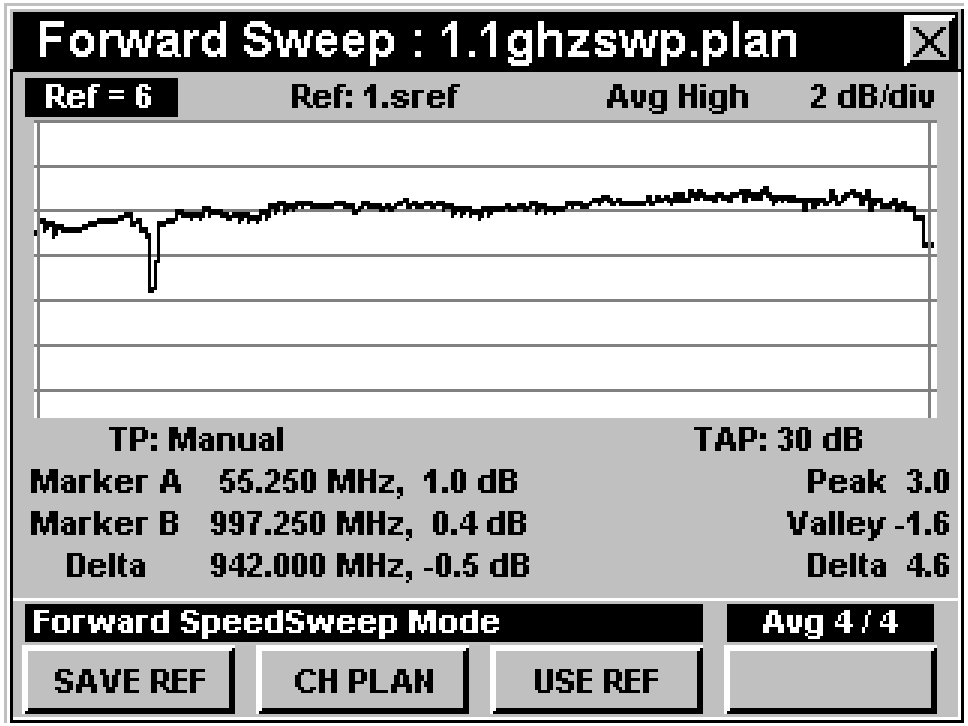
- Automatic distance to fault



Standing Waves



Suck-Out



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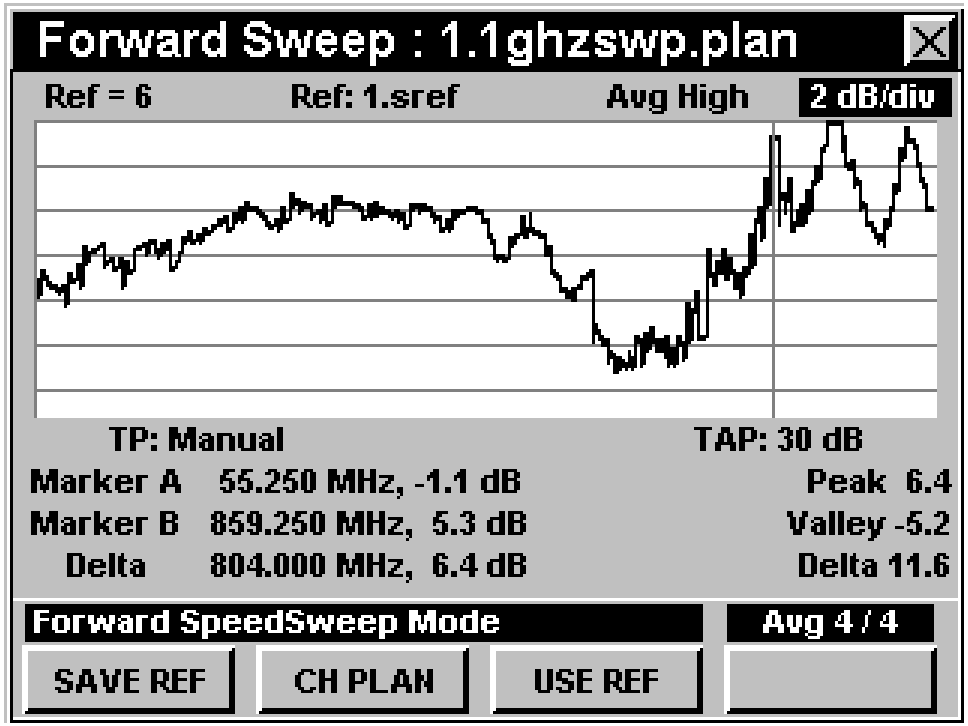
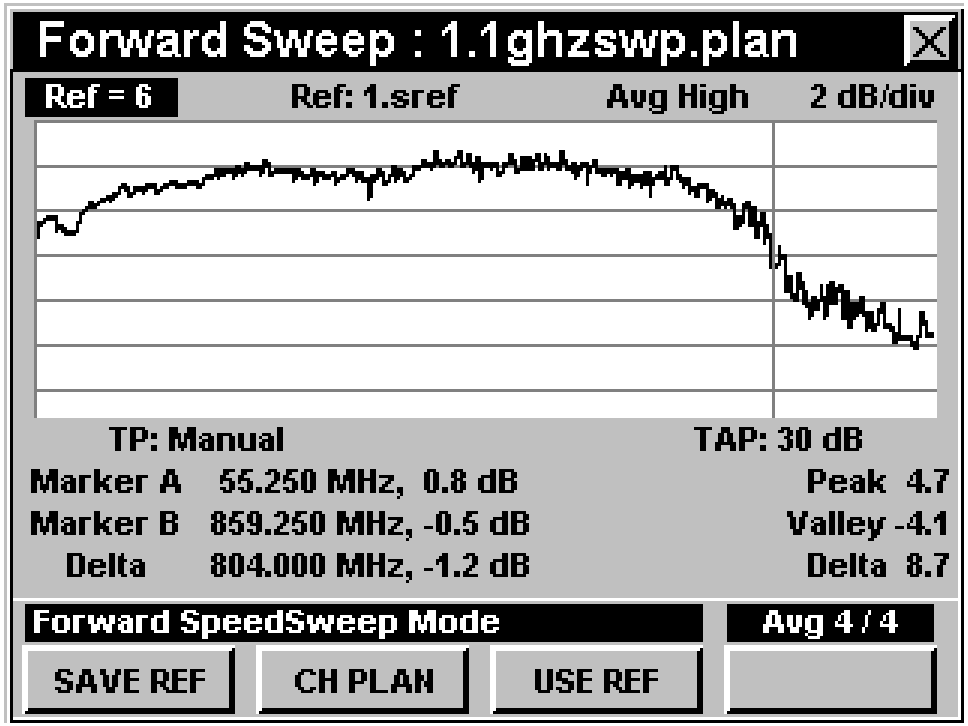


Roll-Off



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Return Path Testing

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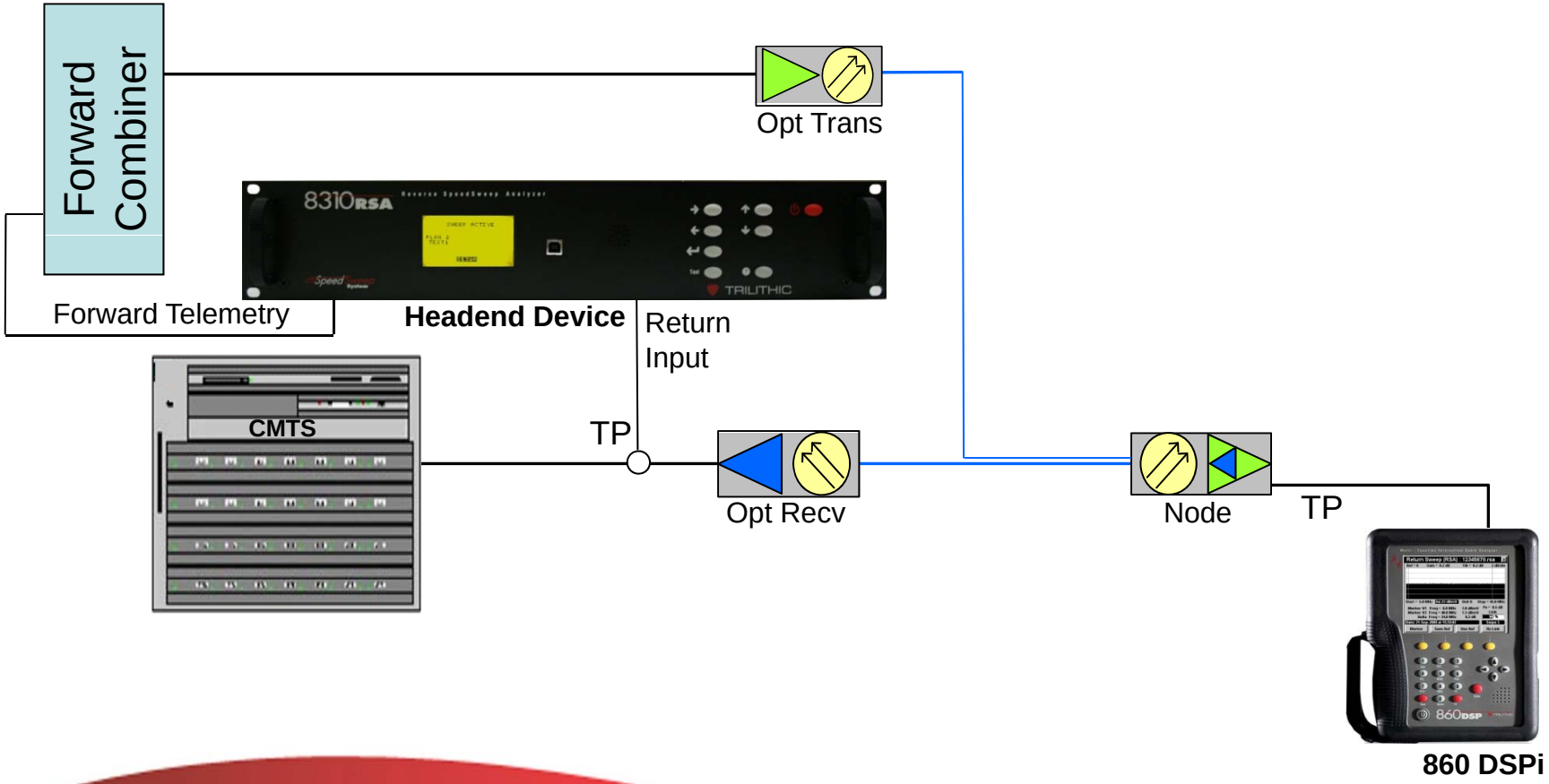
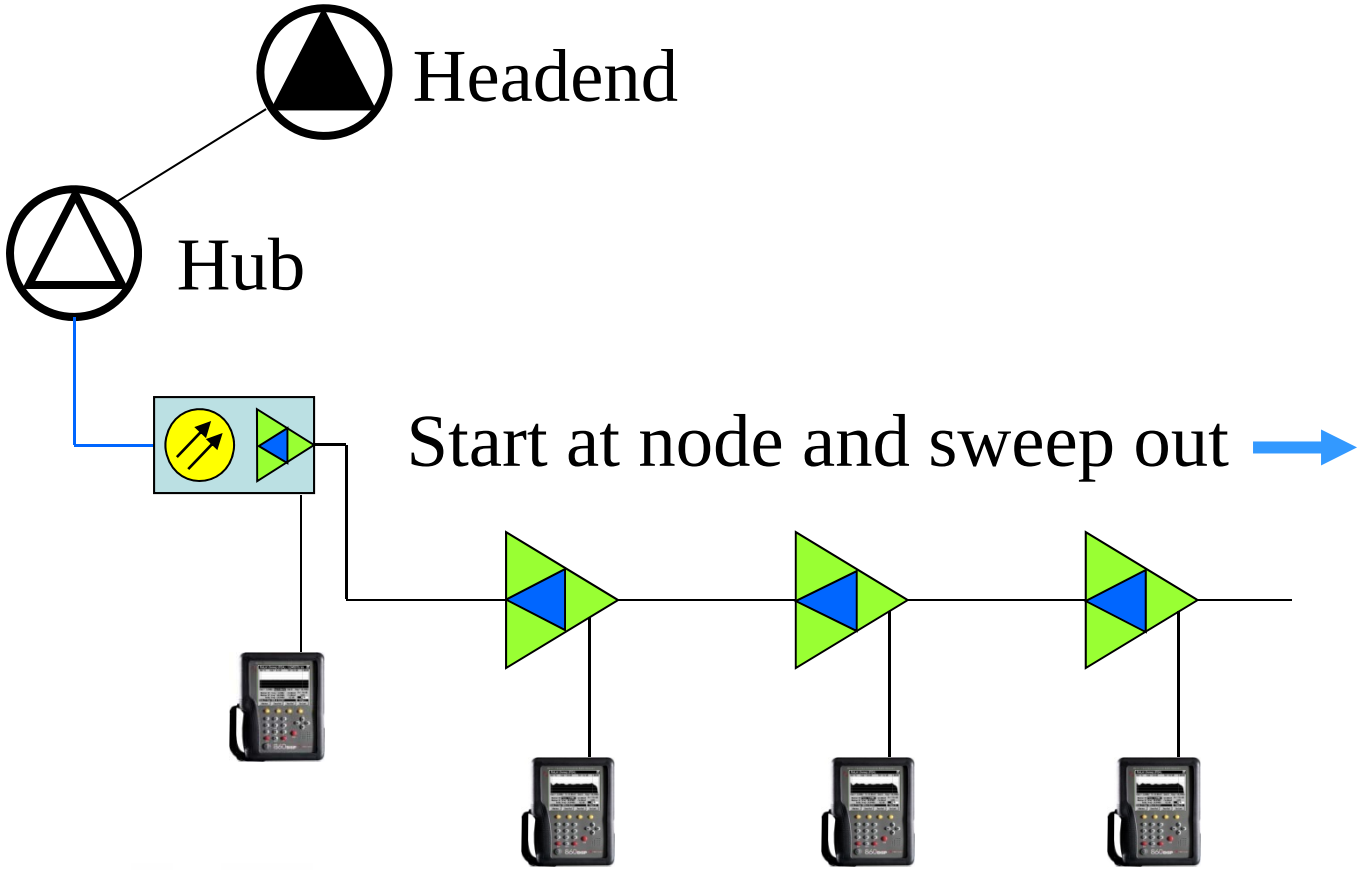
Headend Diagram



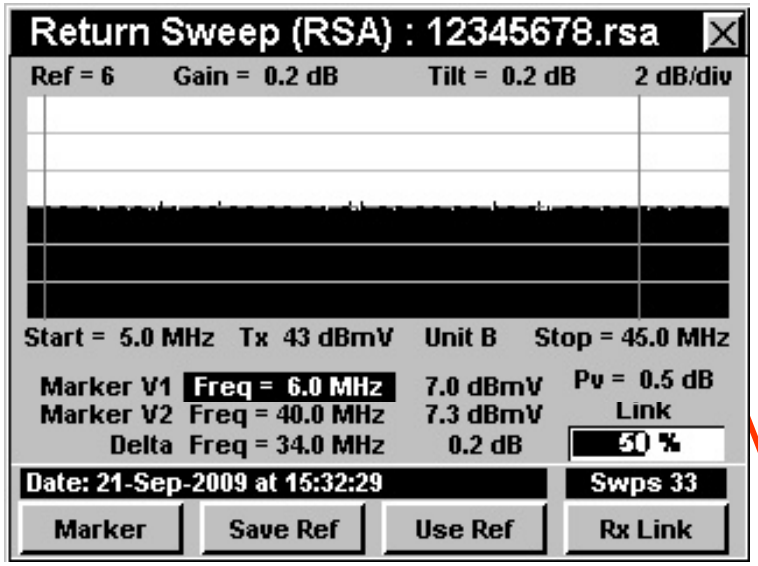
Return Sweep

- Balancing of the System
  - Sweep Signals transmitted by field unit are recovered and analyzed at headend
    - Gain, Tilt and Frequency Response of sweep carriers are returned to the field unit via a downstream telemetry carrier (50 MHz to 1 GHz)
  - Start at node
    - Store Reference trace
    - Proceed to amplifier

Sweep Return Path

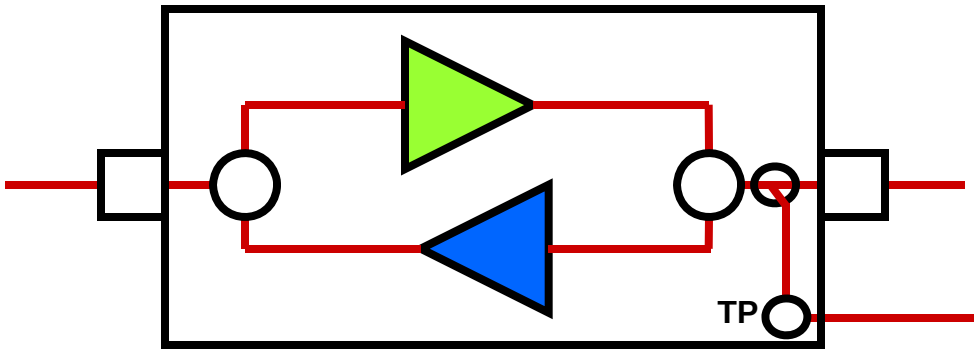


Return Sweep



- Sweep Screen
  - Plots received level in the Headend for each sweep carrier
  - Scale 1, 2, 5, & 10 dB per Division
    - Ideal Trace is a flat line
  - Gain Information
    - Difference between Headend nominal and sweep carrier level
  - Tilt Information
    - Difference between low and high pilot carrier levels
- Displays impairments to frequency response
  - Damaged cable, actives, or passives
  - Low or High end roll off

Return Sweep



- The return sweep displays the Gain &Tilt at the top of the screen

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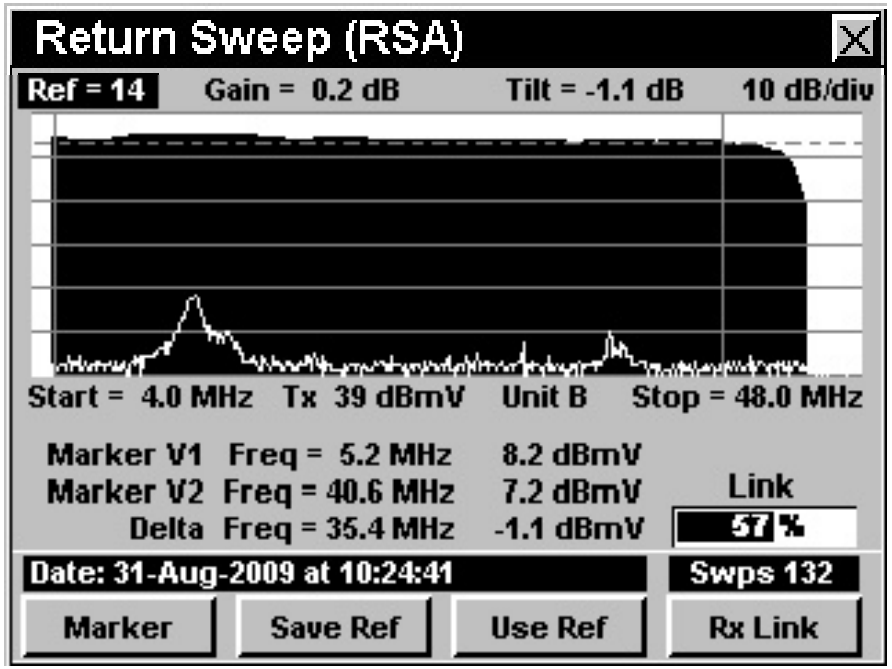
Return Sweep

- Displays both sweep & ingress screen while sweeping
  - The Ingress can be turned
    - ON/OFF
    - Via the FN Key



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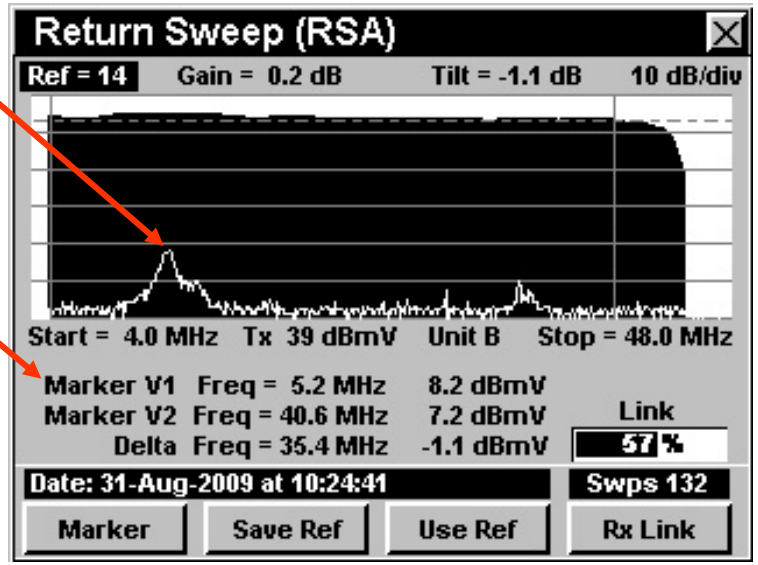
Return Sweep

- Sweep & Ingress
- Move marker location until locate the frequency of the ingress



Return Sweep

- Possible causes of High Noise Levels
  - Excessive gain
  - System integrity

- Remedies:
  - Balance trunk first then work out into the feeder to adjust Pads & EQ's
  - Keep all fittings tight, fix all rodent chews & tree rubs, plus watch out for backhoes

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Return Path Certification and Monitoring

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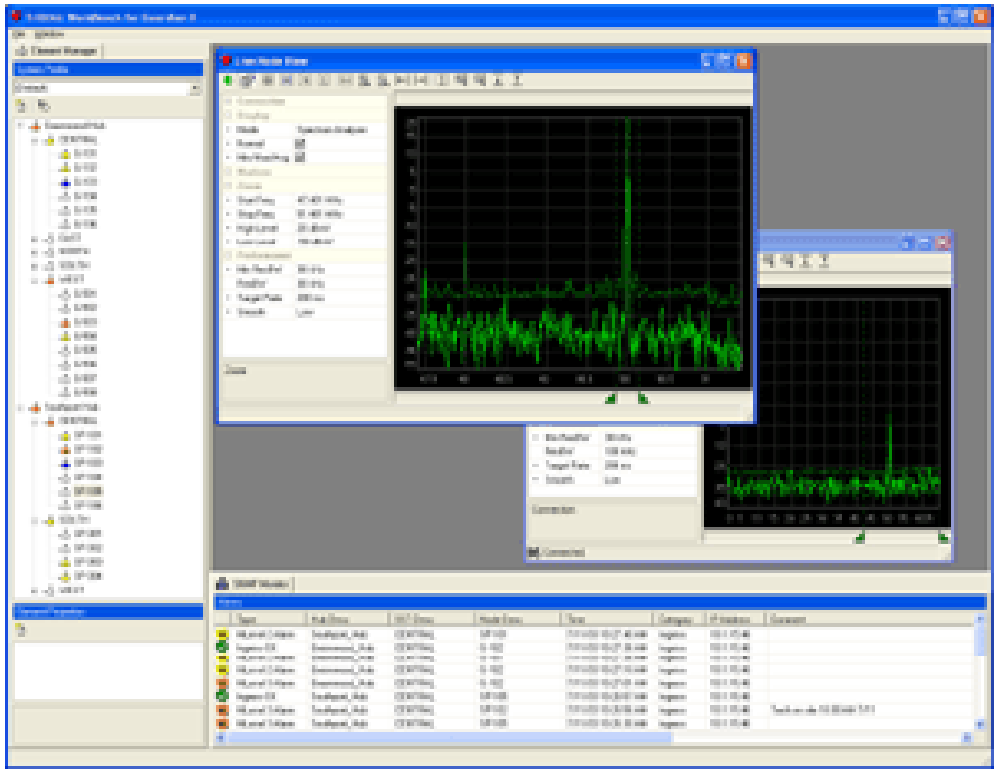
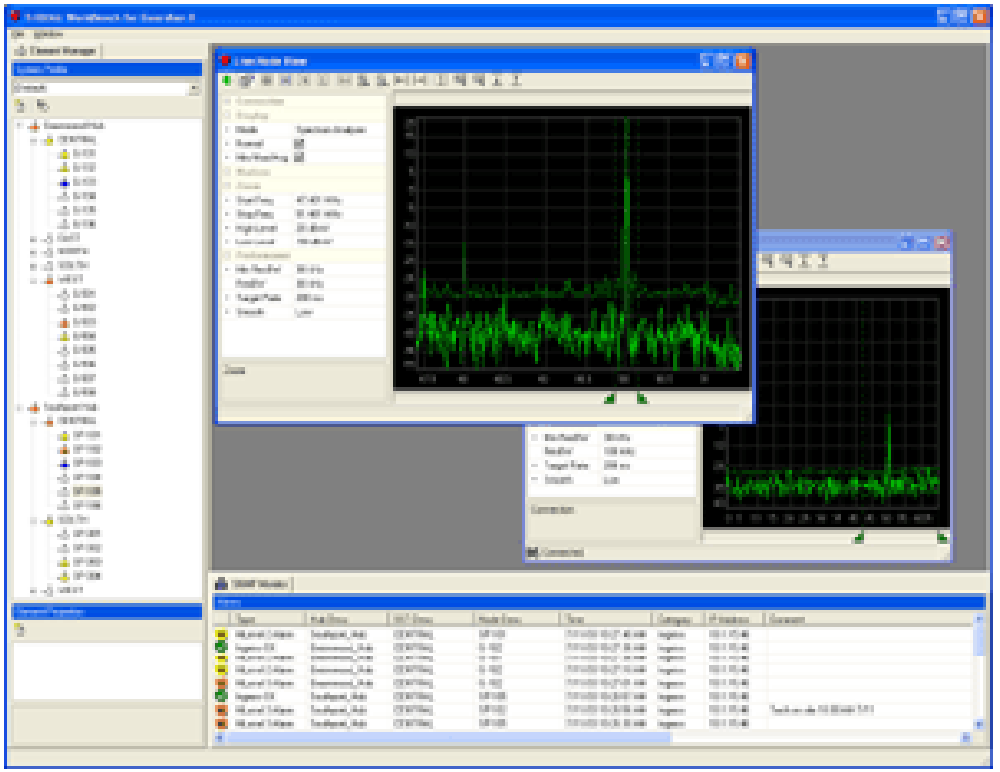
Certifying Return Path

- There have been as many methods and specifications
- Examples include
  - a one-hour max hold
  - ten minutes max hold
- The results are considered to demonstrate that over this period the network would either pass or fail based on the amount of junk viewed



Certifying Return Path (cont.)

- Voip is not a 1 hour service
  - 24 hour
  - 7 days a week
- This maximum measurement is also not indicative of the true performance of the network
- The certification process should be at least a twenty-four hour certification
- Should be an on-going figure of merit.



Troubleshooting Summary

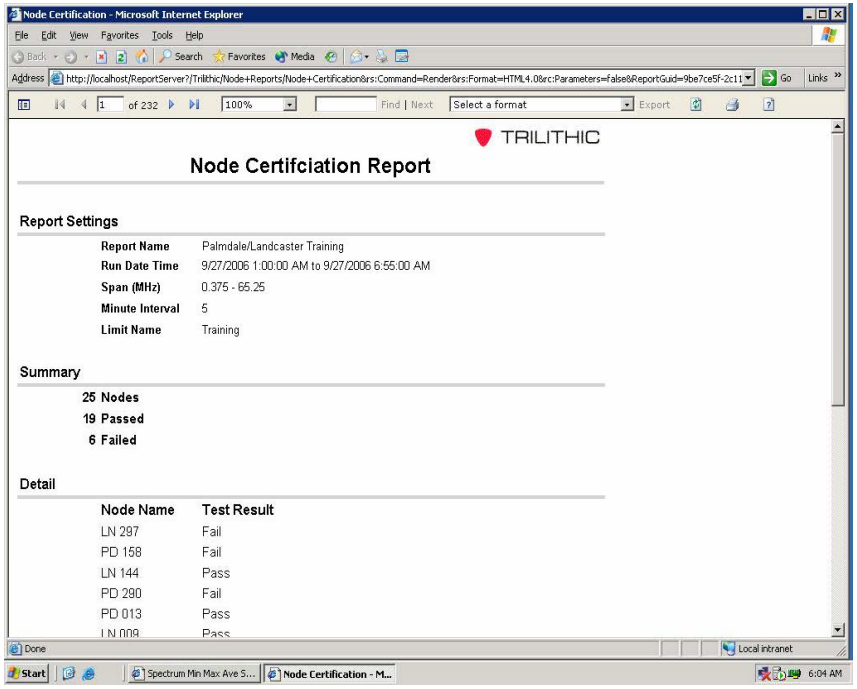
- Verify at the node
  - Determine which leg(s) are contributing to the problem
- Identify the span
  - Using amplifier test points “Get ahead” of the problem
- Isolate to the tap
  - Using a return path test probe isolate the problem
- Pinpoint the origin
  - To a tap (subscriber premise)
  - Damaged Cable

Node Certification Report

- Automates node certification testing
- Specify Locations and time span
- Returns Pass/Fail results based on ingress levels vs. user specified limits

Node Certification Report

- Summary Report
  - Includes Header information
  - Summary of test results
  - Pass/Fail results by node



Historical Analysis

- Specifically designed for convenient and efficient historical analysis
  - Archives up to a year of data
- Displays both historical and live spectral views
- Calculates the average probability that a node will exceed its thresholds over time

Historical Analysis Tools

- Recall spectral information over selected time periods
- View frequency availability of the return path for new service launches
- Evaluate the impact of changes in modulation schemes on system services
- Verify existing services are meeting performance standards
- Generate figure of merit calculations for return performance

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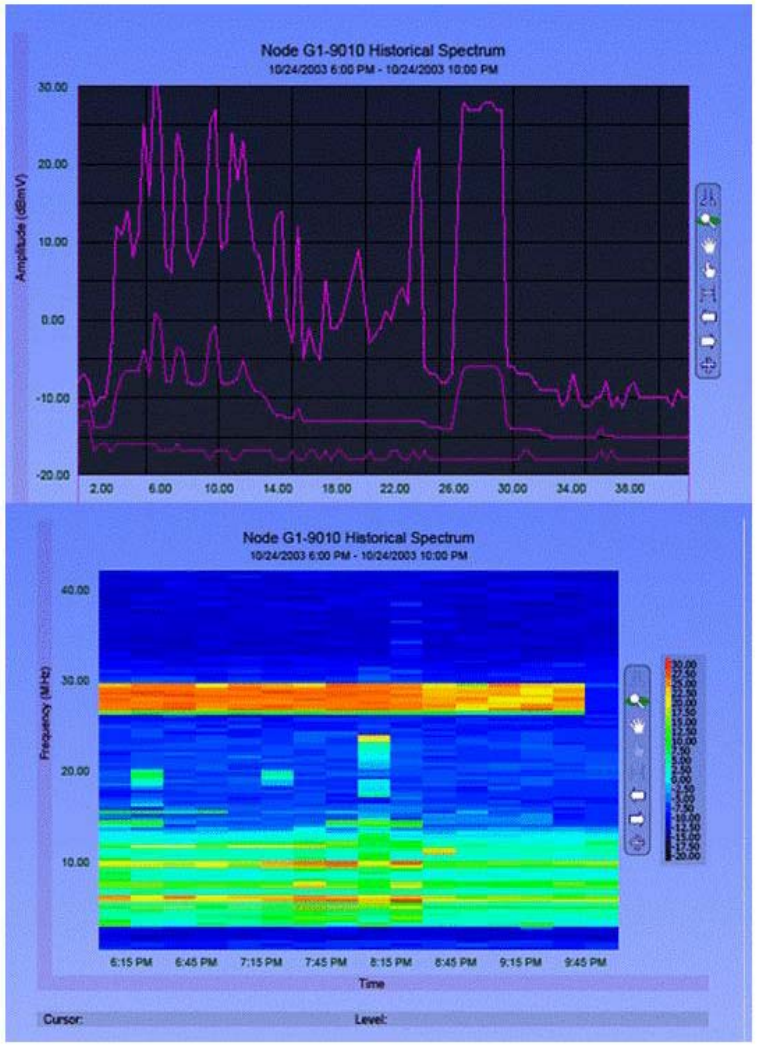
Spectral History

- Retrieve Spectral History
  - Both spectral and time based views
  - Evaluate the severity and duration of ingress related events
  - View the waterfall graph



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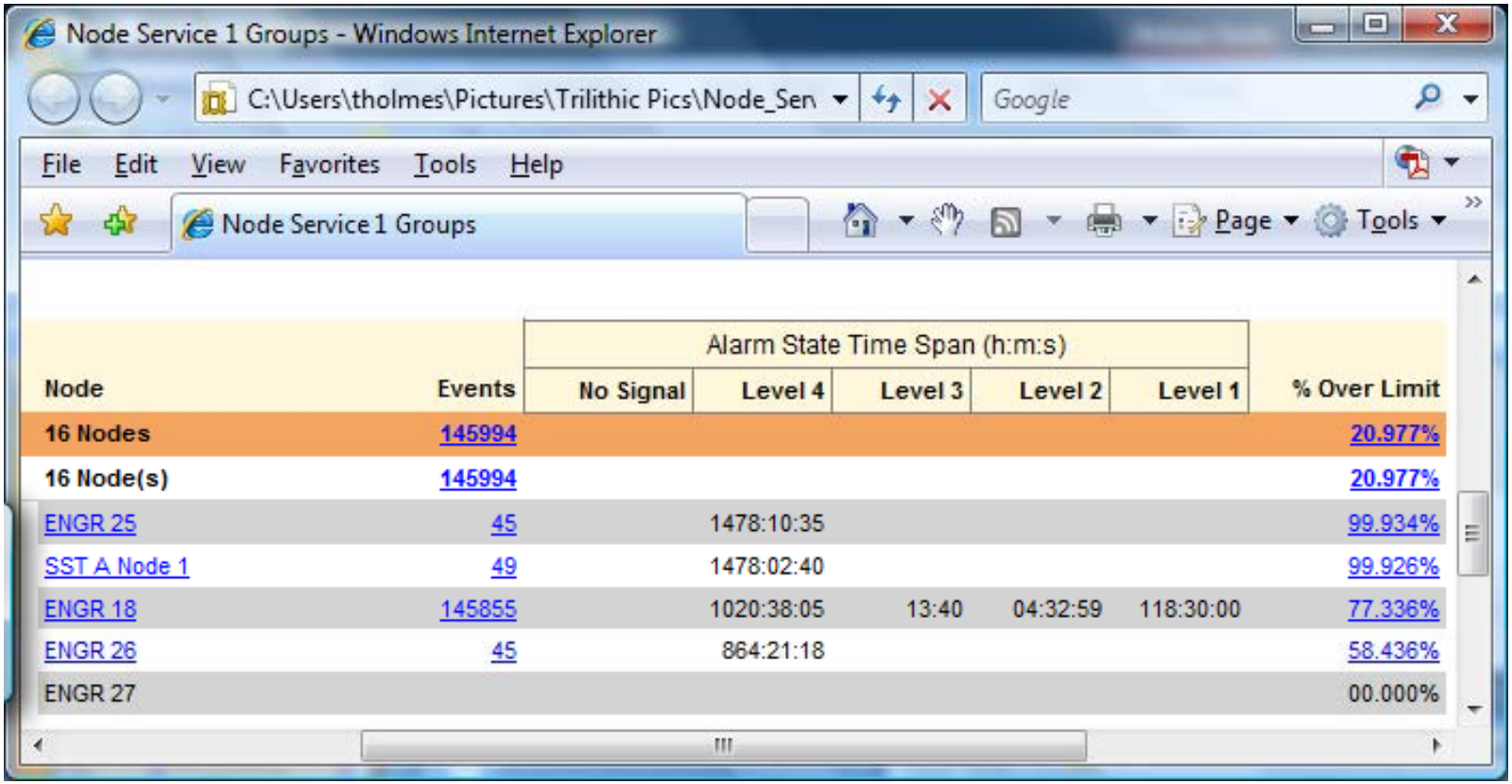
ADIA Node Service Report



Node	Events	Alarm State Time Span (h:m:s)					% Over Limit
		No Signal	Level 4	Level 3	Level 2	Level 1	
16 Nodes	145994						20.977%
16 Node(s)	145994						20.977%
ENGR 25	45		1478:10:35				99.934%
SST A Node 1	49		1478:02:40				99.926%
ENGR 18	145855		1020:38:05	13:40	04:32:59	118:30:00	77.336%
ENGR 26	45		864:21:18				58.436%
ENGR 27							00.000%

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Work Management Logging

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Field Measurement Data Mgmt.

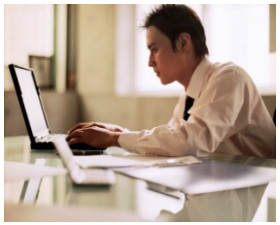
- Helps ensure that proper testing is done
- Leads to higher service quality
- Cuts down the number of truck rolls
- Provides data for effective management
  - Reports
  - Queries
- Saves $$$

System Diagram

860 DSPi
- Work order retrieval
- Test macros/temp storage
- File transmission

Billing/WFM System
- Data file generation

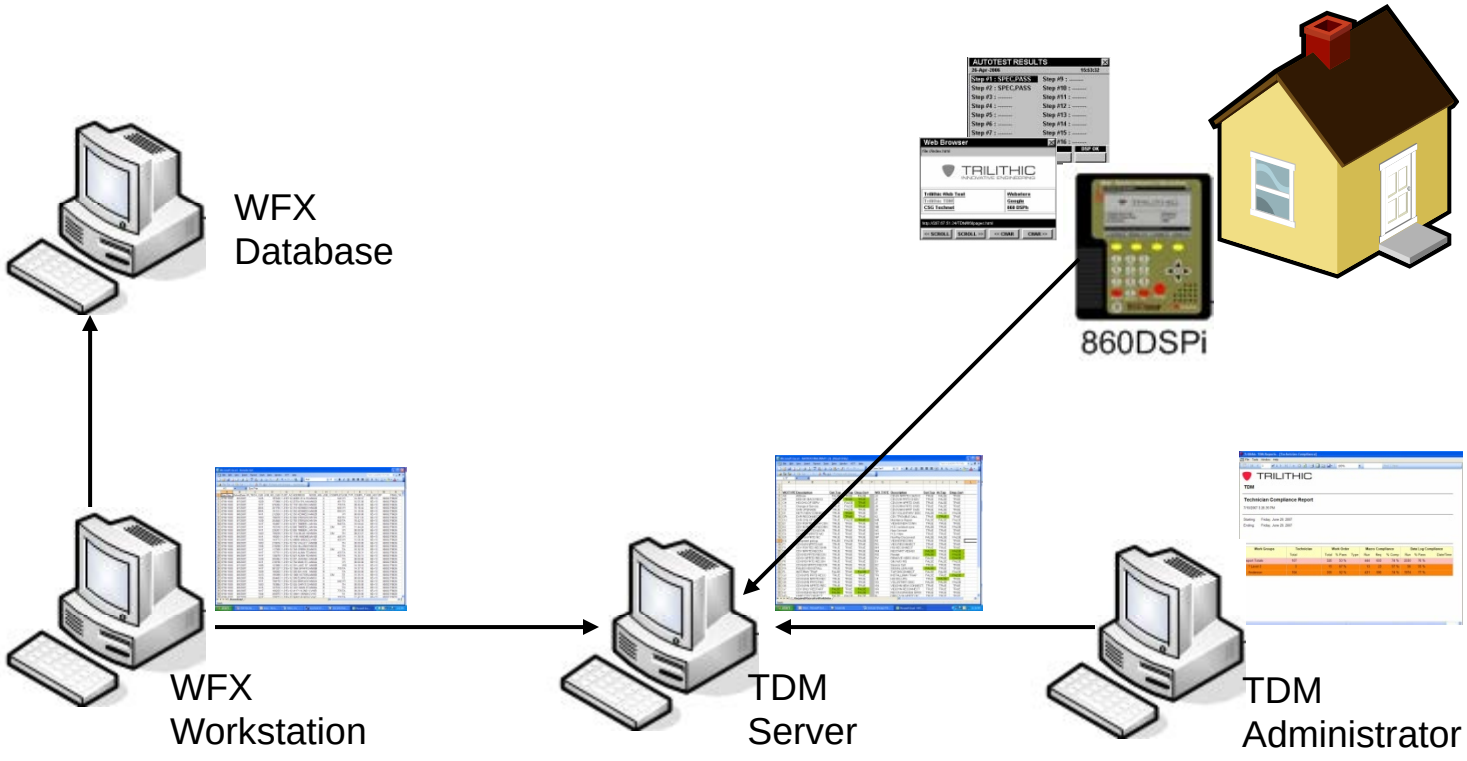
WorkBench/TDM Component
- TDM user interface
- Data display and analysis
- Queries, Reports



TDM Server
- Data communication
- Measurement database

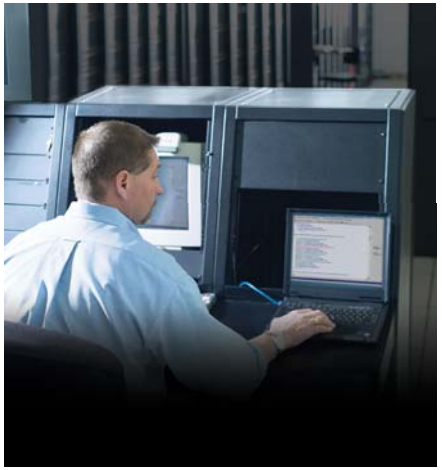
Microsoft IE Browser
- Manager/Supervisor access to reports

System Integration



Administrator Interaction

- Administrator (manager/supervisor)
  - Queues-up 860 DSPi configuration changes
    - Channel plans
    - Test macros
    - Firmware
    - Packages
  - Runs reports and queries data as desired



Technician Interaction

- Morning
  - Work order data is replenished daily with data through the use of an automated script – may be replenished at any time or frequency.
  - Technician connects to TDM with 860
    - Gets configuration updates from queue
    - Downloads work orders for the day, or
    - Creates work orders directly on the meter

Technician Interaction

- Daily routine
  - At job site, technician performs tests with macros
    - Saves results to work order task ID (provided by TDM)
  - Technician accesses next job, which was downloaded from TDM this morning
    - Addresses for all queued jobs are viewable in 860 DSPi task folder
- Evening
  - Technician uploads all completed data logs to TDM

Reports

- Macro summary
- At-tap node history
- Calibration check
- House history
- Meter inventory
- Set-top compliance
- Technician compliance

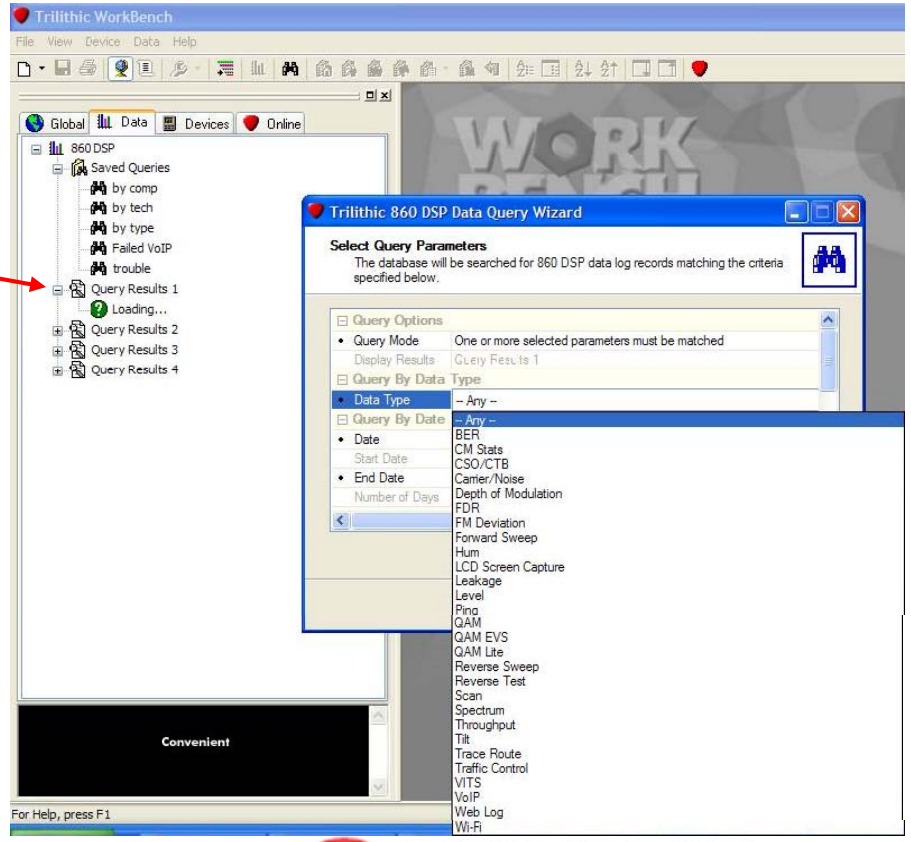
- All reports are storable, and can be emailed with expansion/contraction features intact

WorkBench Queries

- Queries enable a user to search for specific data
- They can be customized to find particular information
- They can be saved and repeated on demand
- This is a very flexible, powerful tool

WorkBench Queries

- Select a saved query or run custom query



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End of Session One
Questions?

Session Two

- Troubleshooting the QAM Carrier
- Ingress Troubleshooting Using Leakage Detection
- HSD Troubleshooting
- VoIP Services
- The Challenges and Diagnostic Tips
- Using the Tools and Test Equipment Properly

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QAM Measurements

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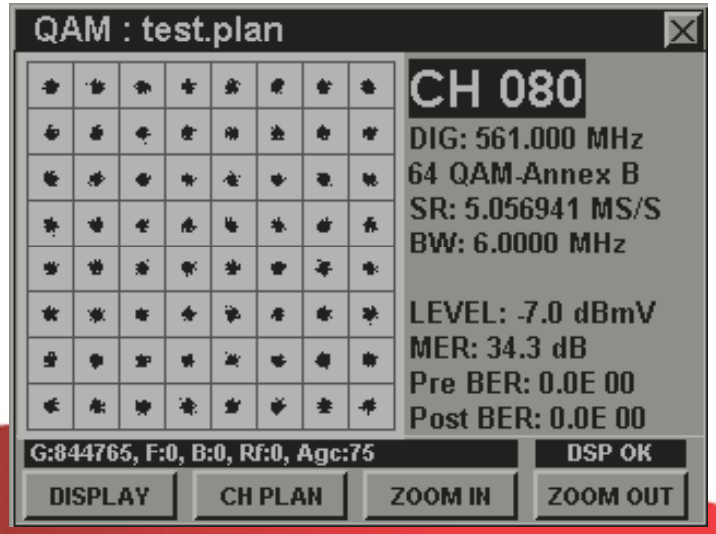
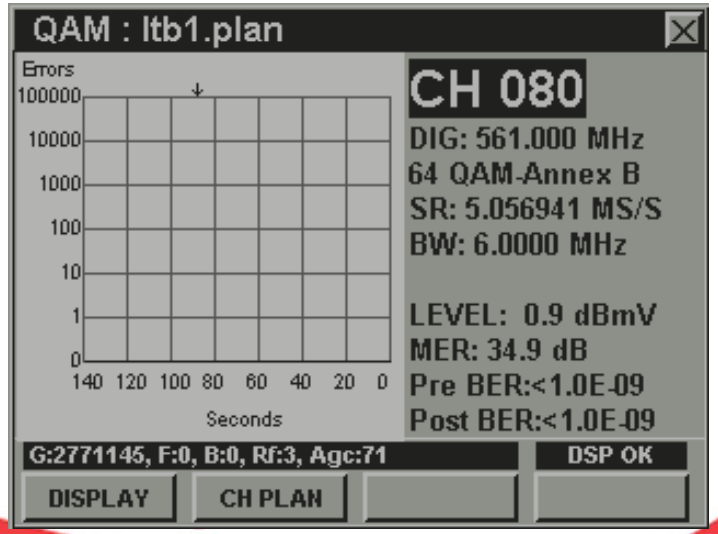
QAM Measurements

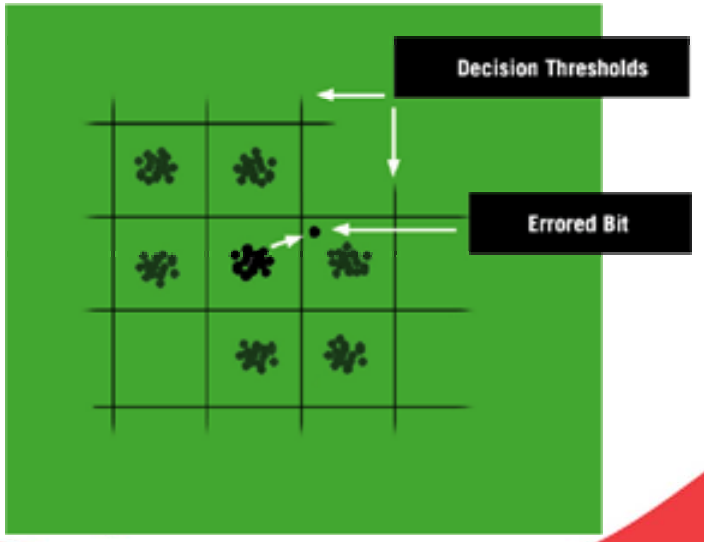
- Constellation Display
- MER
- BER
  - True BER or Estimated





Reading Constellation Diagrams

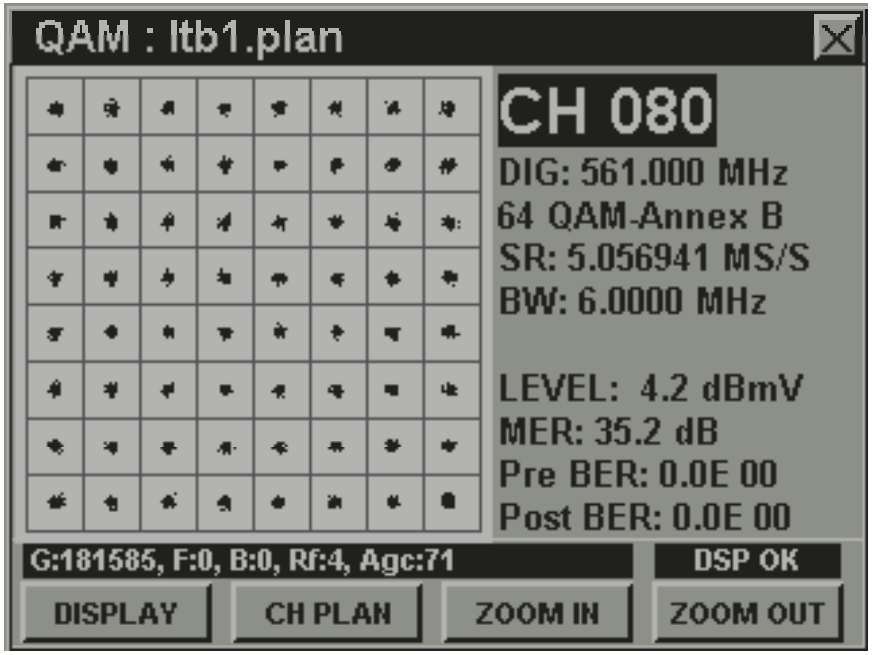
- The boundary is called the "Decision Threshold“
- If a signal disturbance pushes a symbol across the Threshold it is incorrectly interpreted as belonging in the neighboring box, and becomes a "bit error“
- Symbols that are not disturbed enough to be pushed across Thresholds are always interpreted correctly
- A constellation diagram is a good troubleshooting aid and can give clues concerning the source and nature of a disturbance



Constellation

- The constellation display shows both I and Q

- Helps determine modulation problems:
  - Amplitude Imbalance
  - Quadrature Error
  - Phase Error
  - MER



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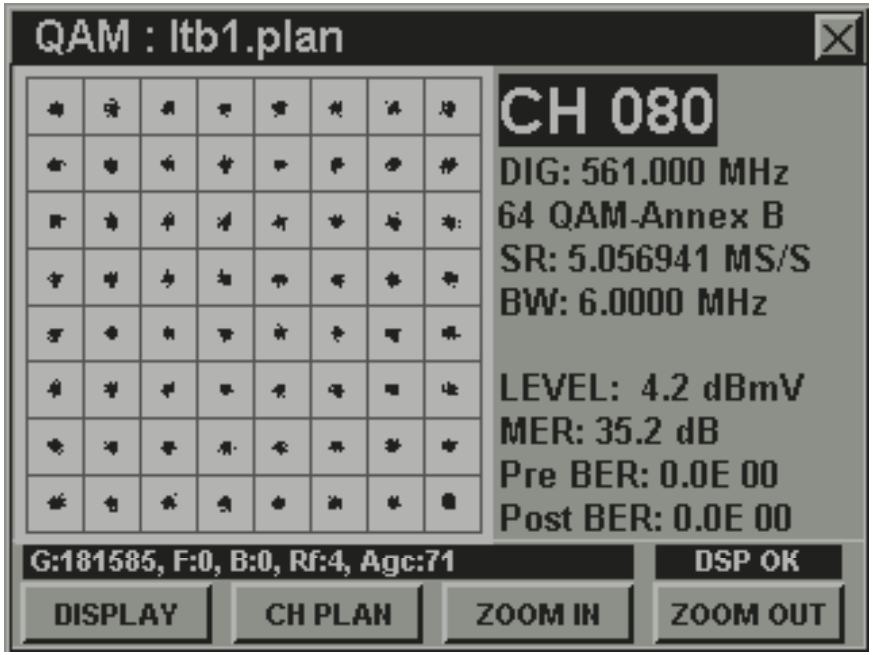
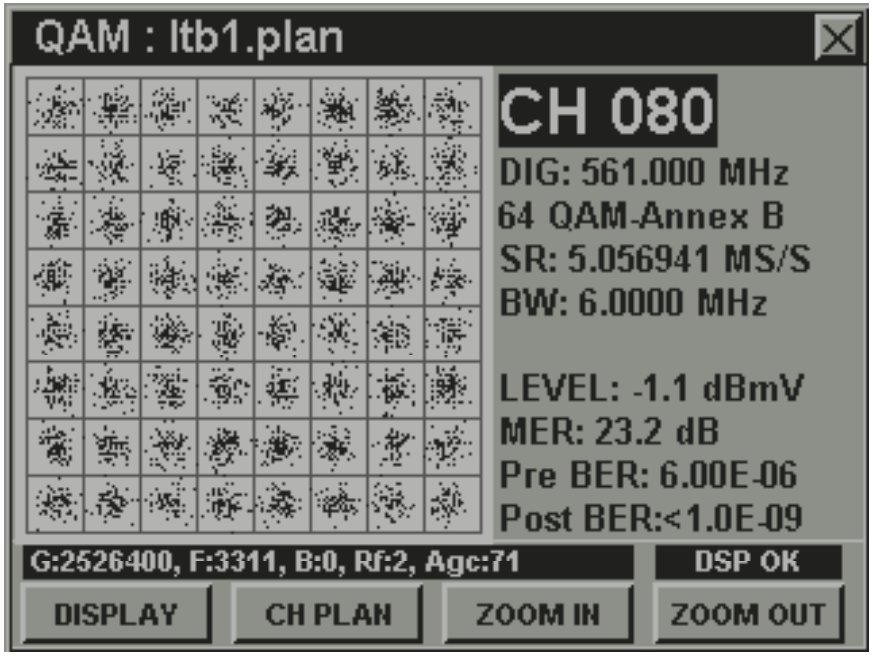
Constellation

Deviation from the ideal location



Good MER



Poor MER

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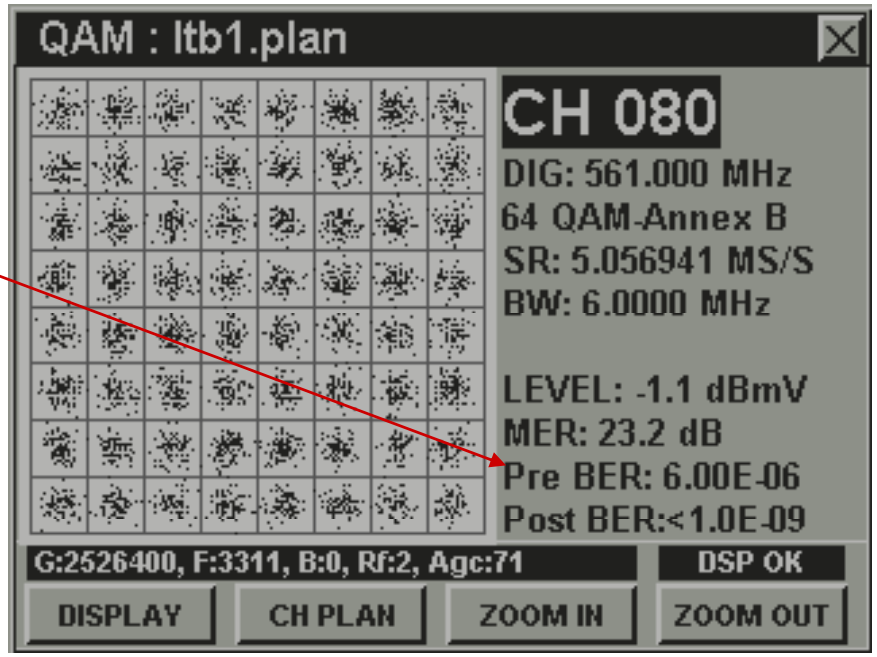
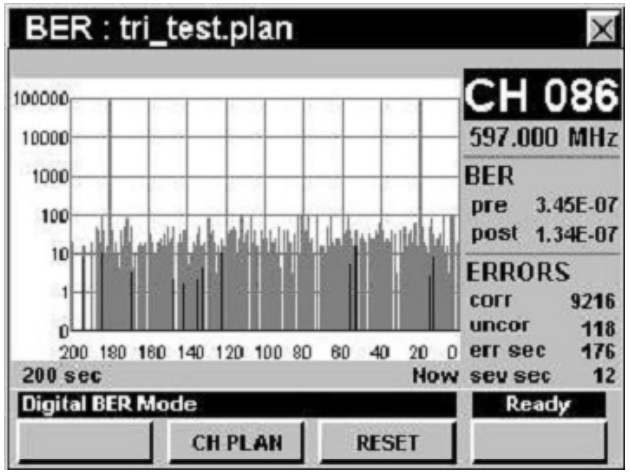
BER

- Bit Error Rate is the number of bits in error divided by the total number of bits in the data transmission
- Pre BER
  - System Margin



BER

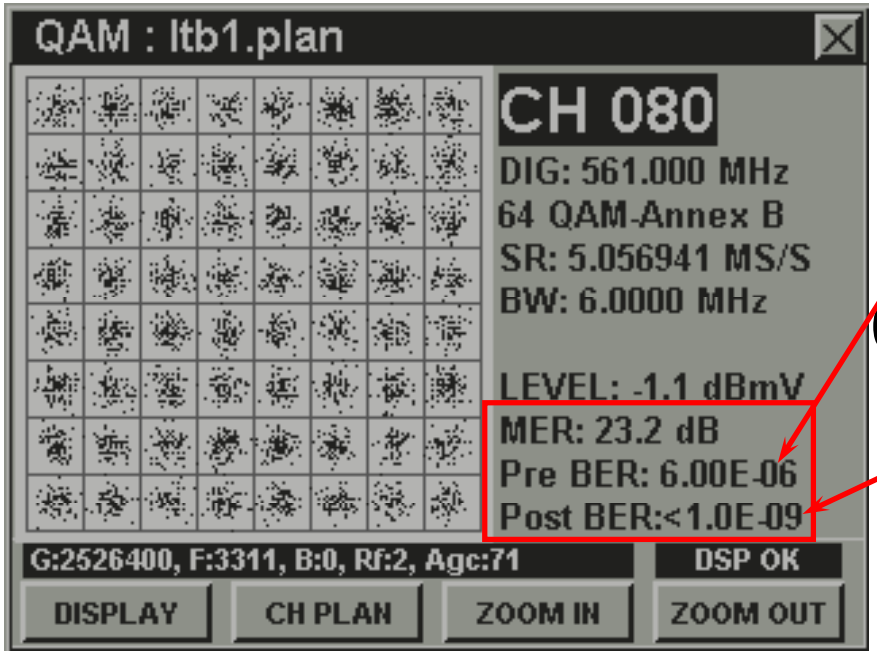
- Digital signals work well until very close to the point of failure
- Measurement of digital carriers critical to determine the system margin
  - Signal level
  - MER
  - BER



- The BER Mode helps to find problems

Forward Error Correction

- FEC
  - Corrects errors to a point



Pre FEC BER
(Before Correction)

Post FEC BER
(After Correction)

Digital Troubleshooting Tips

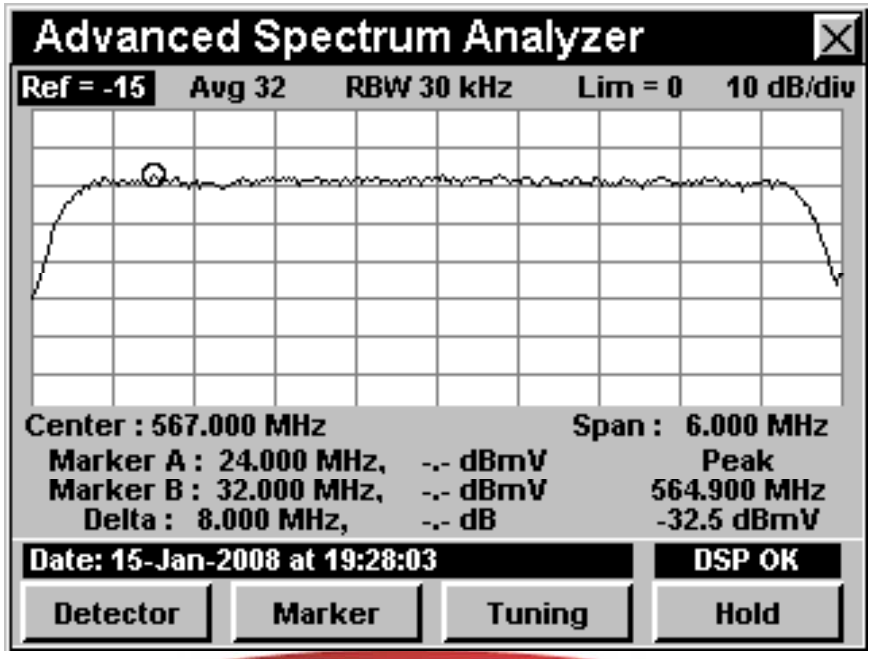
- Verify that the problem is happening before you troubleshoot
- Check
  - RF levels
  - MER
  - BER
  - Constellation
  - Signal Leakage

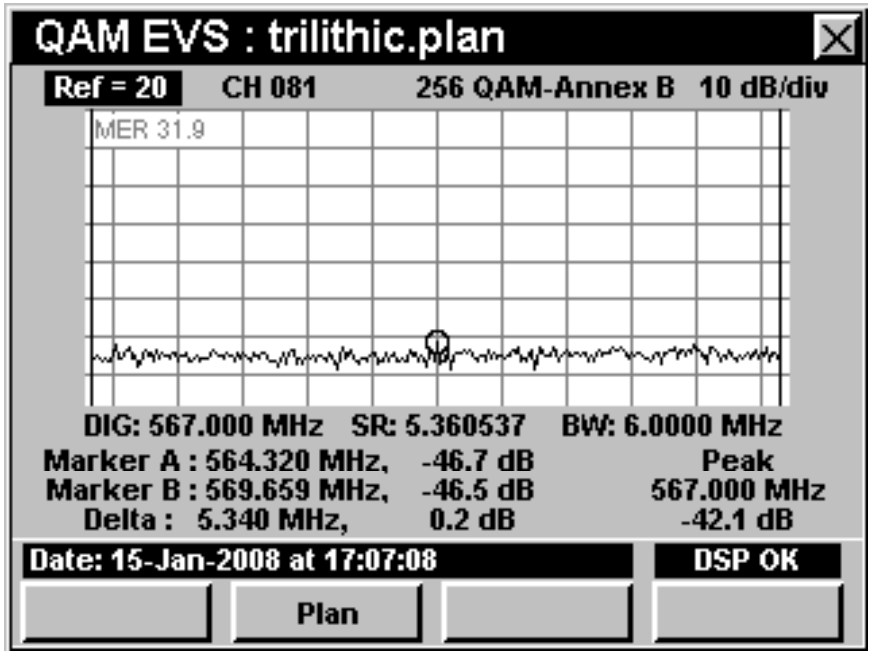
Digital Troubleshooting Tips cont.

- The return spectrum for excessive noise
- What channels are being effective
- Adaptive Equalizer for reflections
- Connectors
- Wiring
- What time the problem occurs
- Diagnostic screens on the set top
- The noise floor under QAM

Error Vector Spectrum

- To view the noise floor under QAM the carrier needs to be removed





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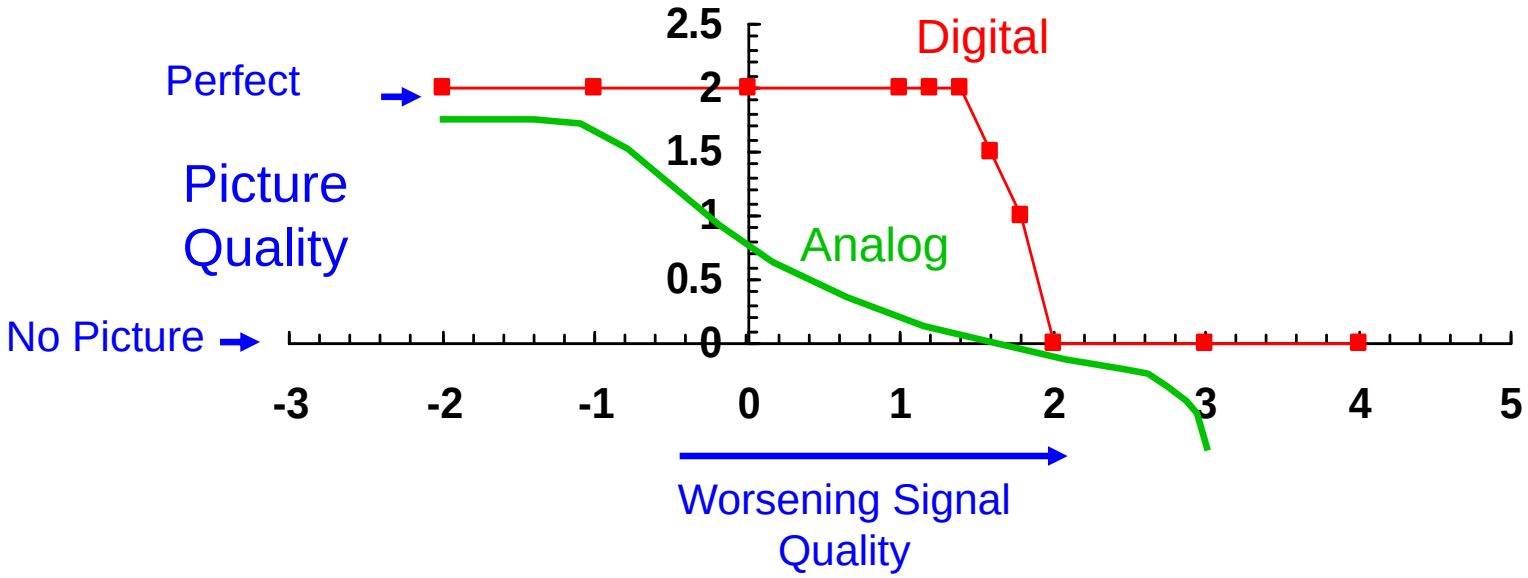
Threshold and Margin

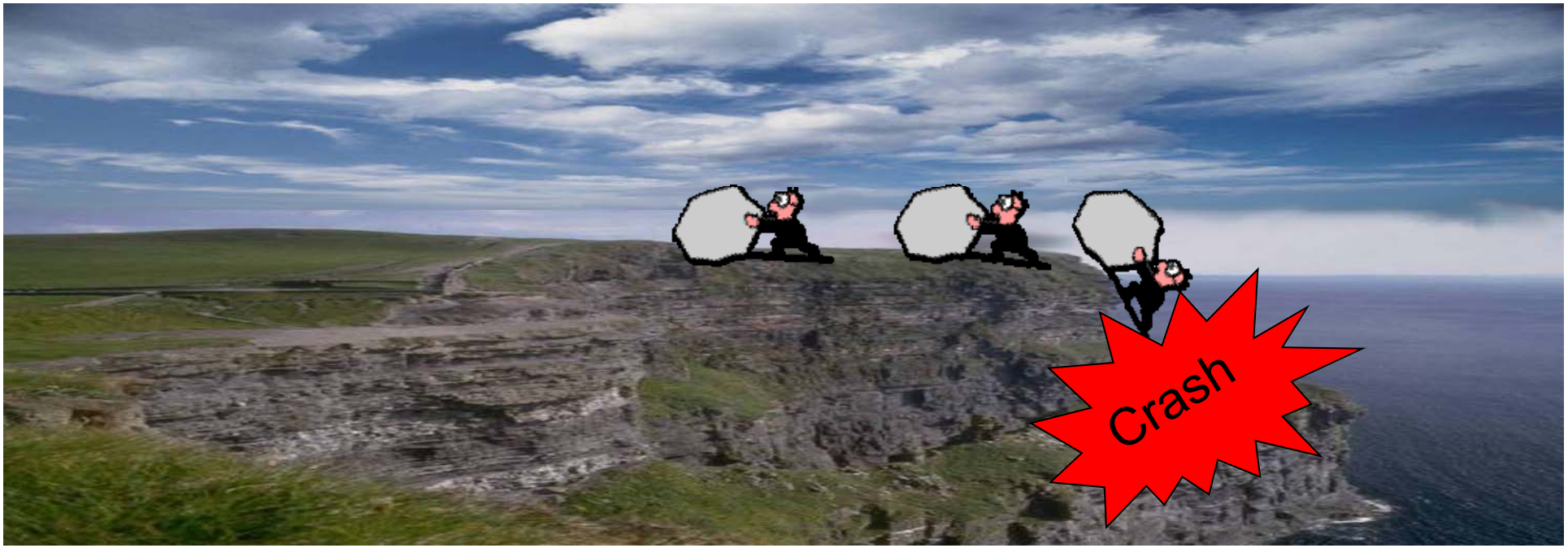
Signal Quality versus Picture Quality



MER TARGET - *THE "CLIFF" EFFECT*

- What is The "Cliff Effect"?

Maintenance Activities on the Digital HFC Network

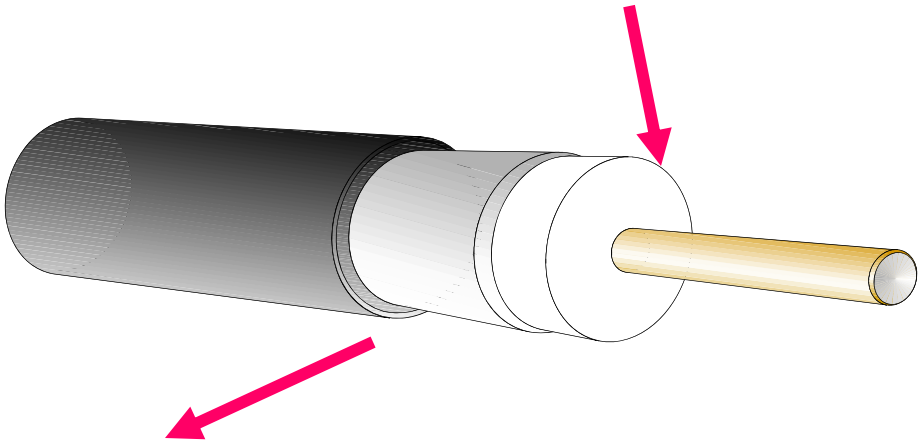


Operating margin Zone

Risk Zone

Crash Zone

Ingress & Egress



- Ingress
  - RF or electrical energy that enters the coaxial environment
- Egress
  - RF signal leaking out of the coaxial environment

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Leakage Detection Benefits

- Eliminates Ingress
- Improves System Performance
- Reduces Repeat Service Calls
- Locate Physical Problems within the network

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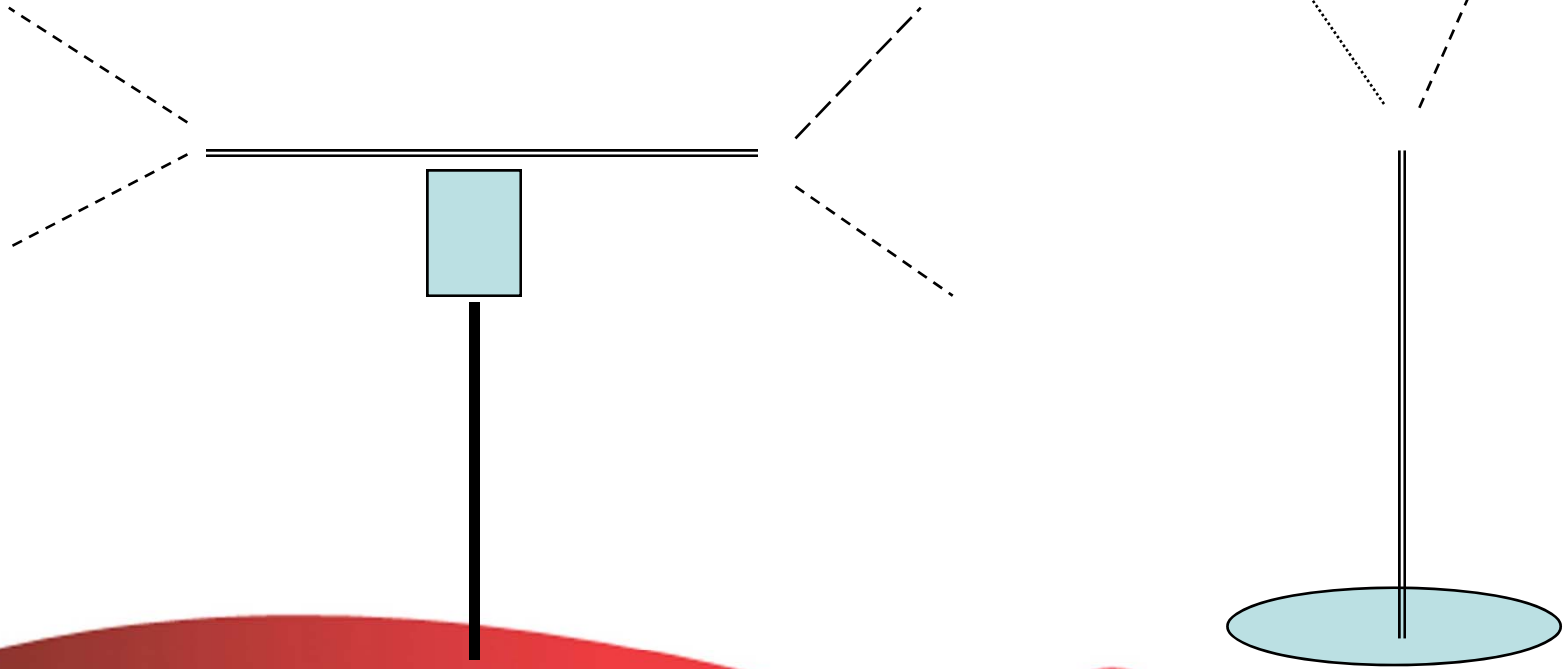
Polarization Angle

Dipole

Monopole



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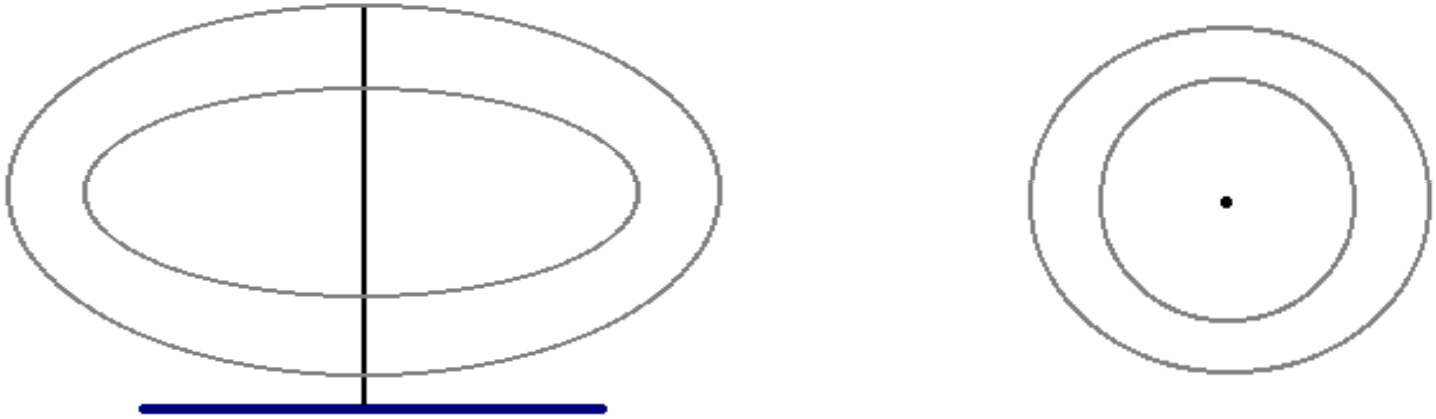
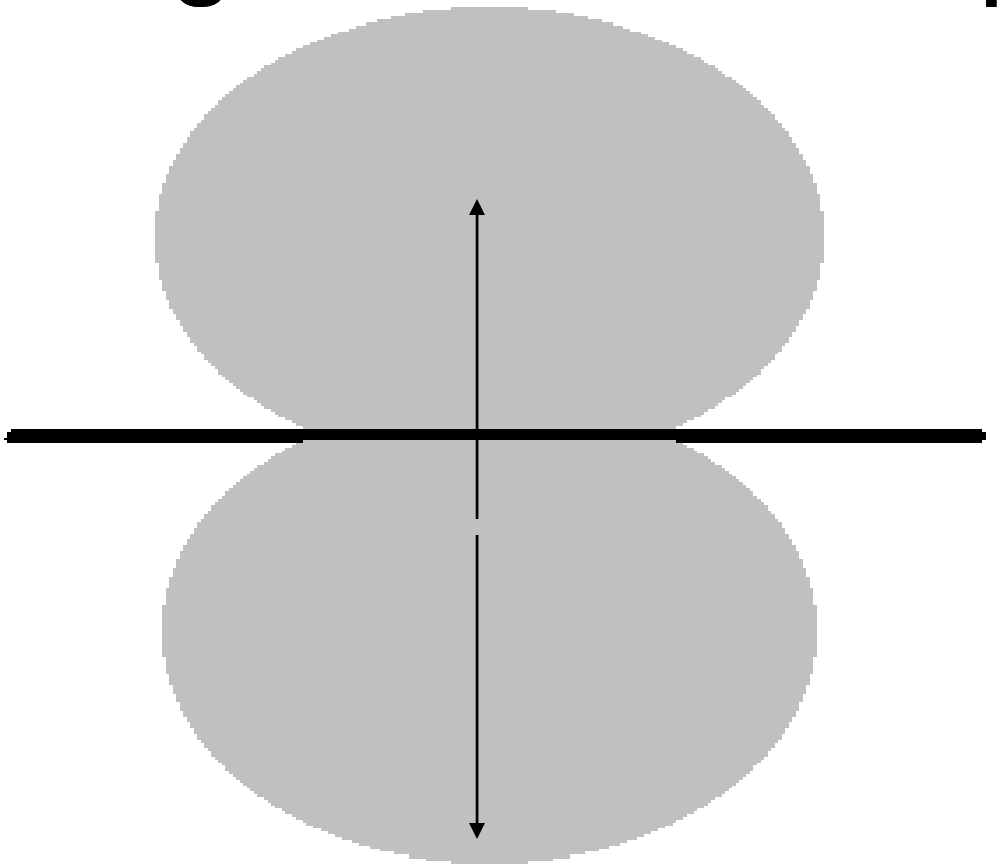
Leakage Antennas-Whip



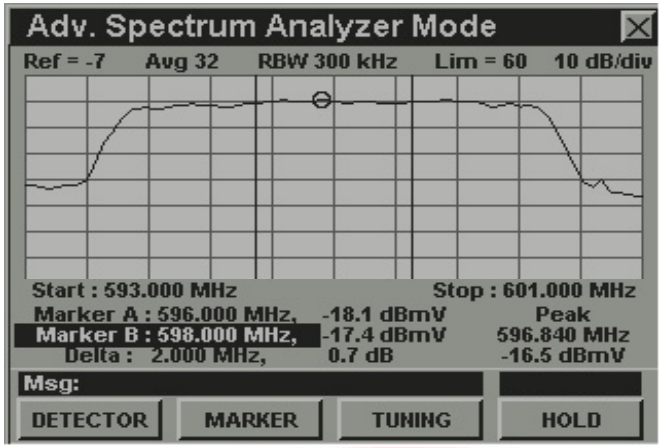
Leakage Antennas-Dipole

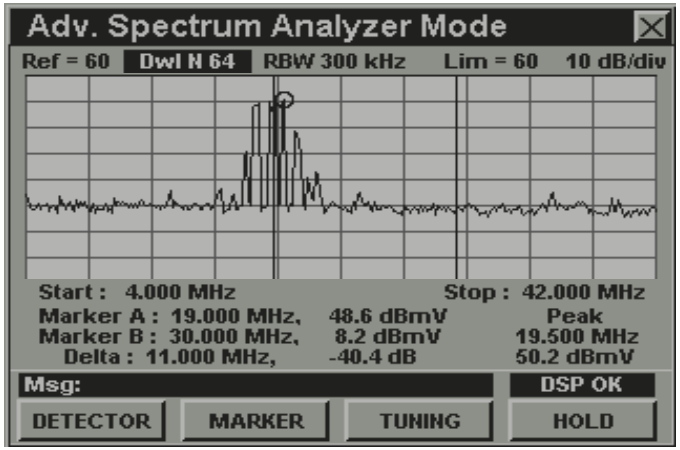


HSD Troubleshooting Tips

High Speed Data

- Downstream is streaming data
  - Constant signal
- Upstream data signals are bursty





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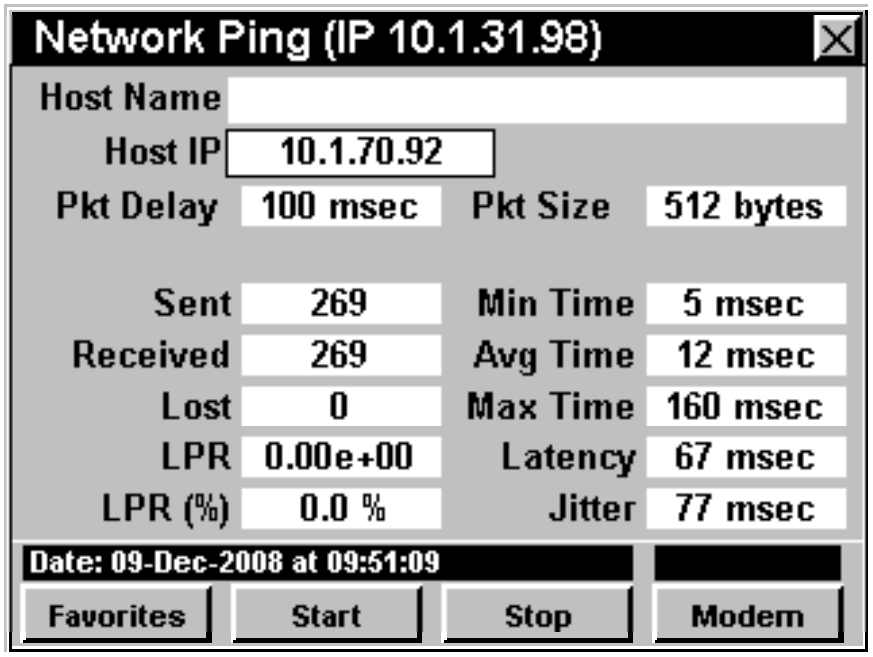
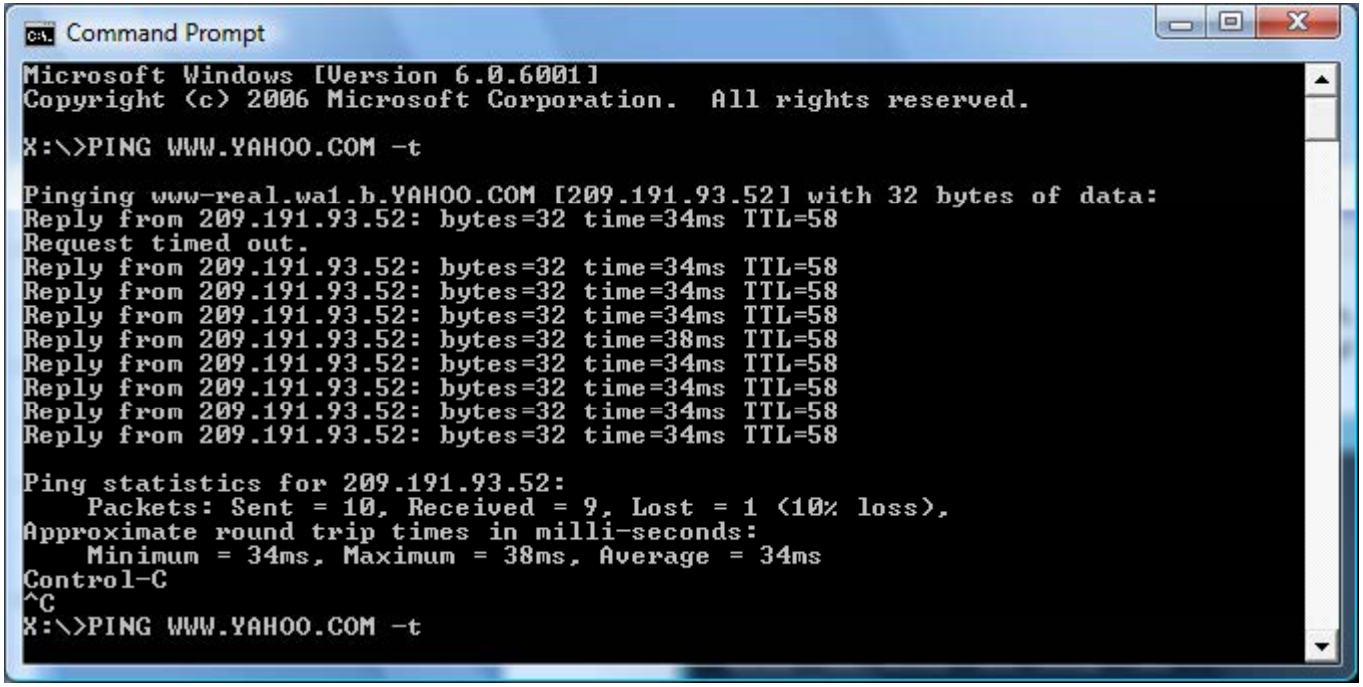
Network Ping

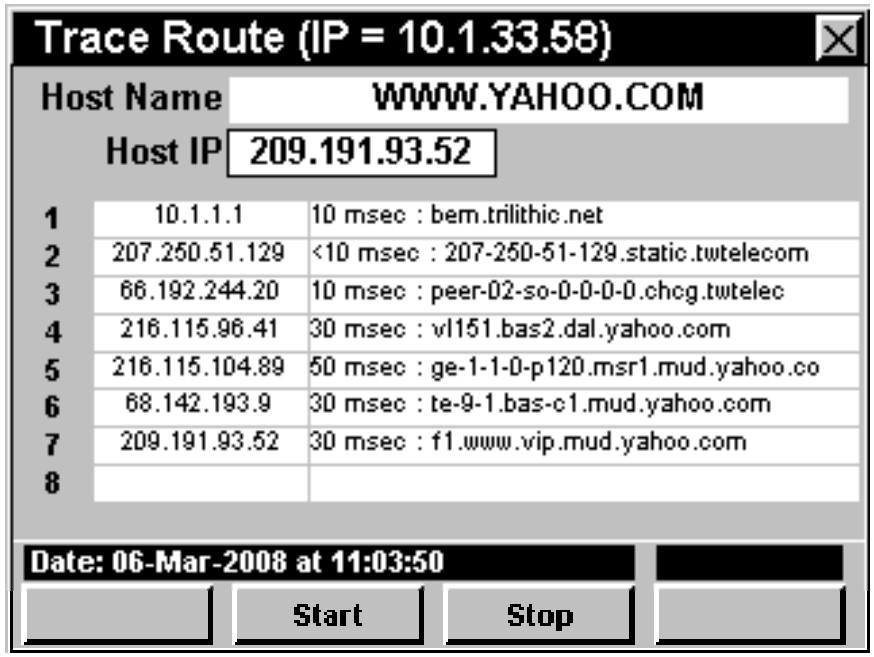
- Enter Host Name or Host IP
- Packet Delay (how often packets are transmitted
- Packet Size (size of packets transmitted
- Sent and Received Packets
- Lost Packets
- LPR (Loss Packet Rate)
- LPR(%) (Percentage of Loss Packets)



Ping from the PC

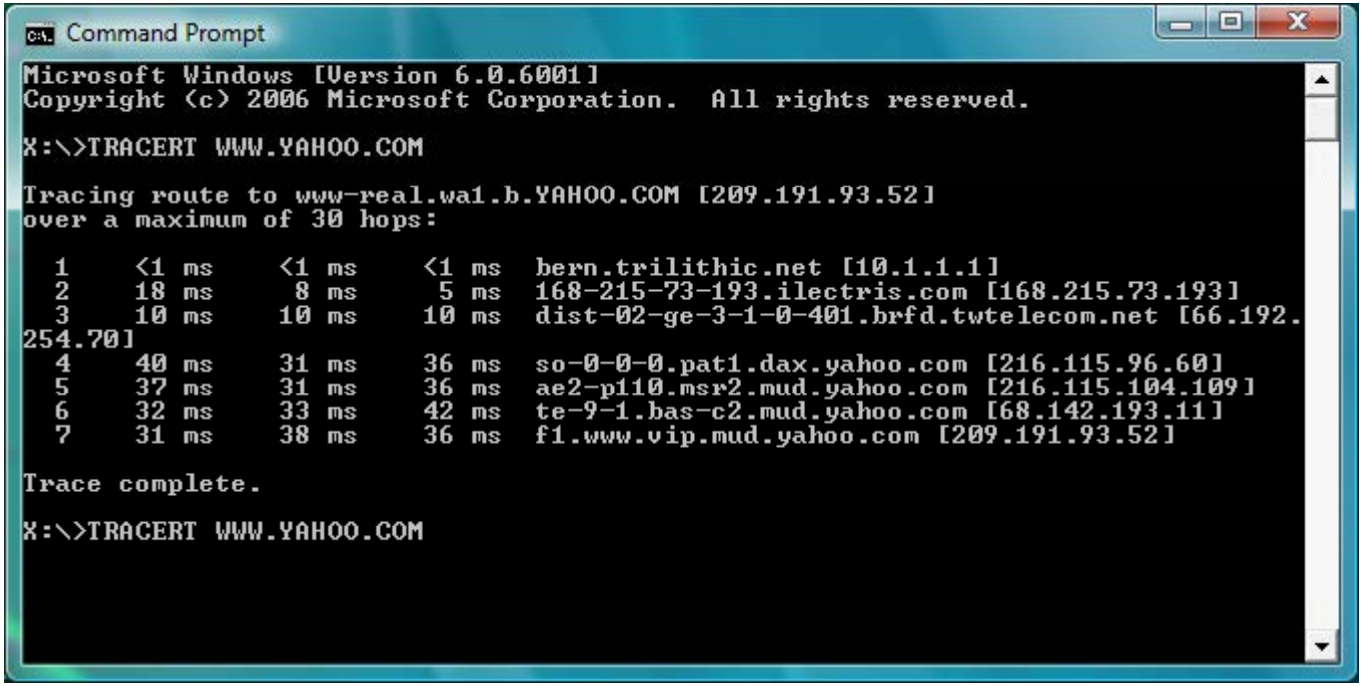


Trace Route



- Sometimes it's helpful to run a trace Route from the subscriber's PC
- This will show the routing point where the transmission stops
- Some devices can be configured not to respond to ping, as a security measure
  - firewalls for instance

Trace Route from the PC



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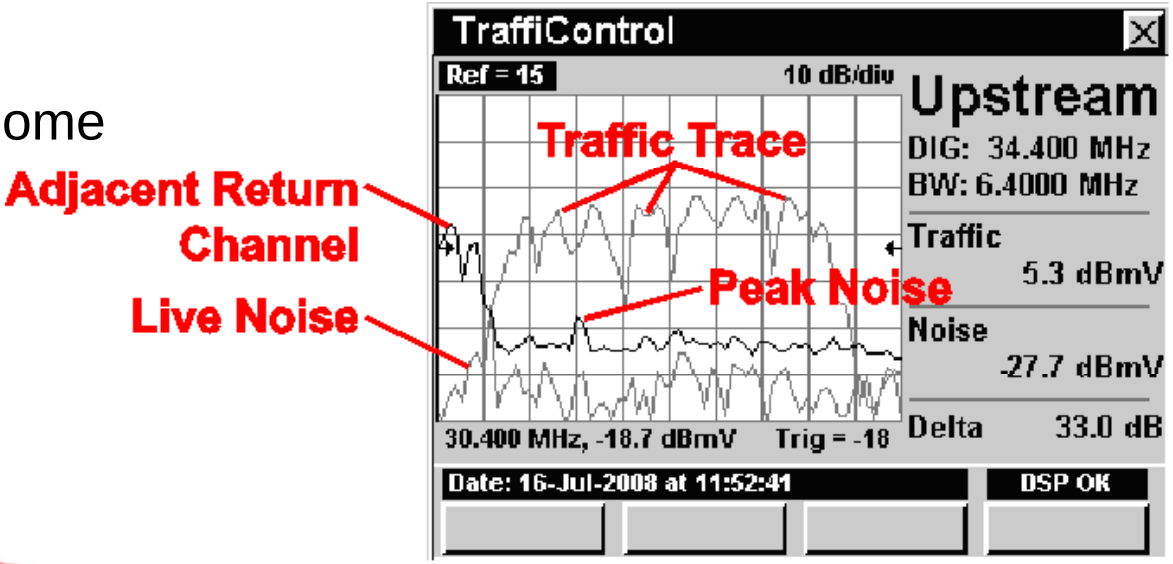
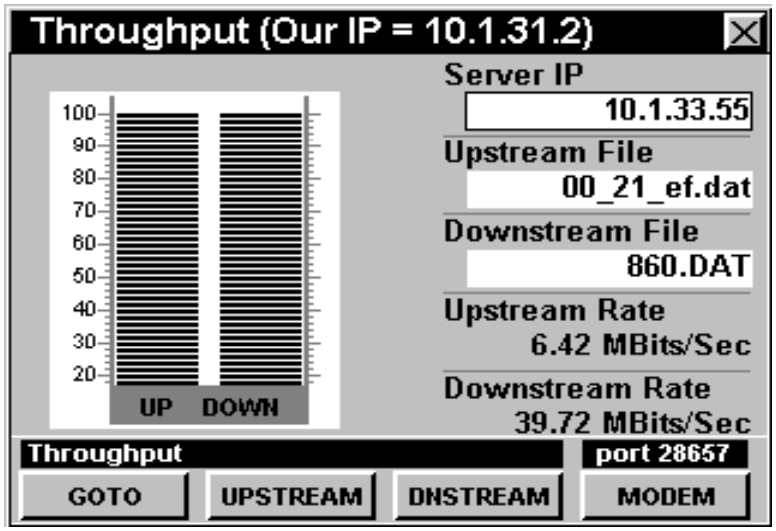
Traffic Mode

- Traffic mode can be used to see the ingress that is present “underneath” an upstream cable modem carrier, VoIP carrier, or any bursty signal
- Troubleshooting made easy
  - Divide & Conquer
  - Source typically a home



TRILITHIC

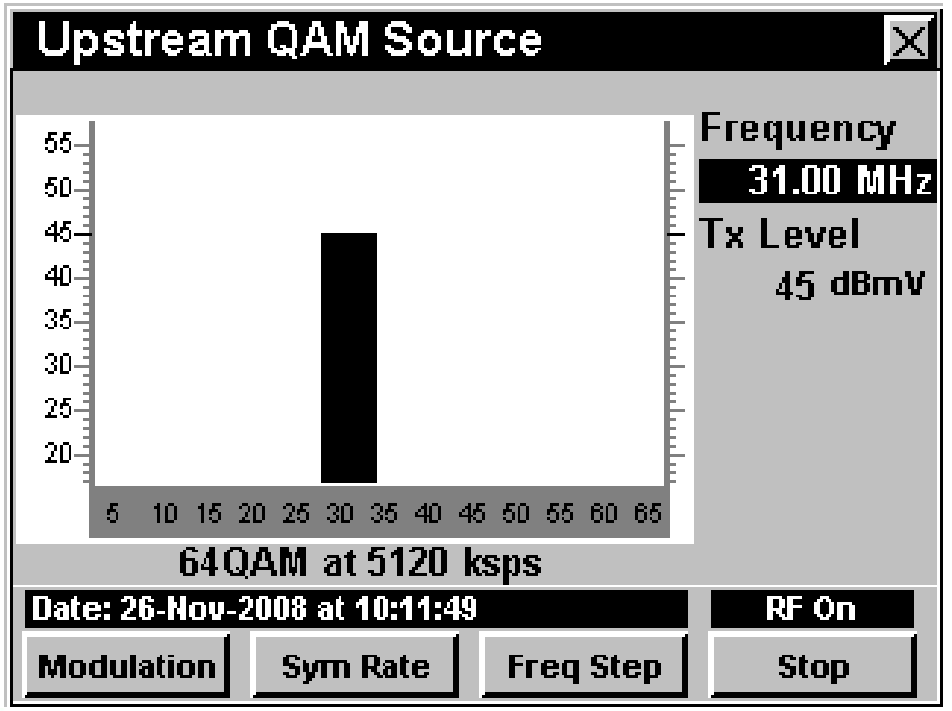
Throughput Test



- Throughput rates up to 40Mbps
- Select test at fixed throughput rates, such as 5 Mbps, 10 Mbps, 15 Mbps, 30 Mbps, and 40 Mbps to test various tiered services
- Test at both the desired speed and one speed higher to prove that the cable modem is provisioned correctly

QAM Source

- Upstream QAM source verifies the transmission capability of the network for higher order QAM signals
  - QPSK
  - 16 QAM
  - 64 QAM
- Adjustable
  - Symbol Rate
  - Level
  - Frequency



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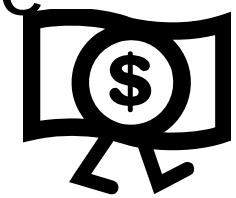
VoIP Troubleshooting

How Testing Helps

- Must be quick to identify, isolate, and solve problems – know system health
- Recruiting customers is expensive, and long-term retention is critical to ROI
- Loss of voice customer may also mean loss of the rest of the triple-play revenue



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Broadband Instruments and Systems

VoIP Tests, Pre-Activation

think ahead.

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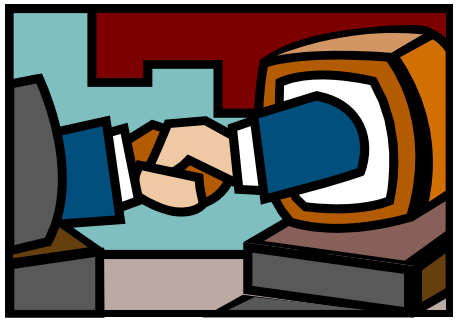
Pre-Infrastructure VoIP Testing

- Prepares system for VoIP service offering by pre-testing
- RTP (Real-time Transport Protocol) tests for packet loss, jitter, and delay, with MOS
- Inexpensive solution, with low-cost headend based server

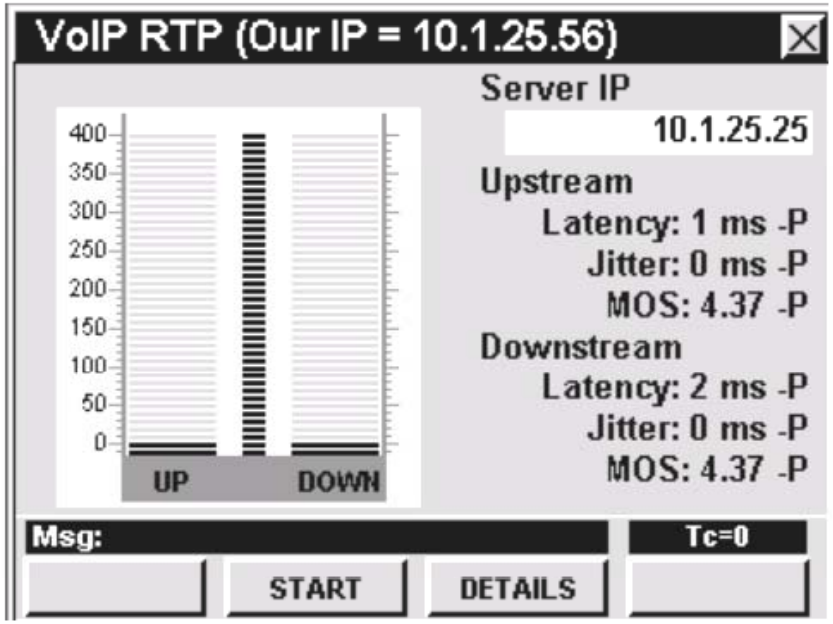
RTP Test

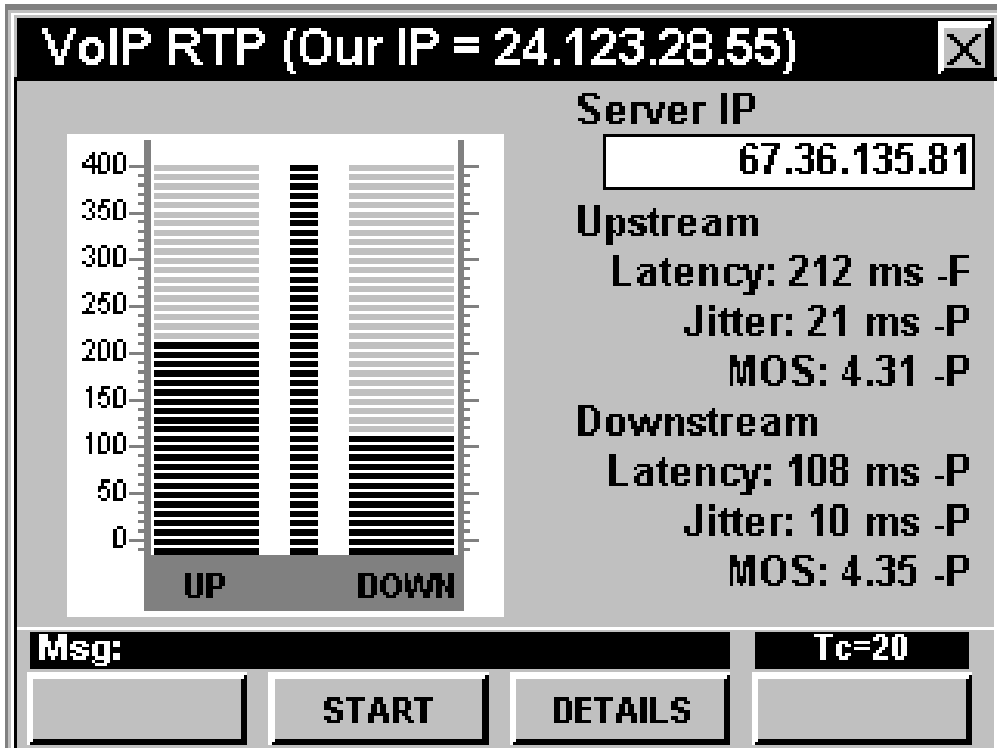
- Communication established
- Server and analyzer synchronize test parameters and clocks



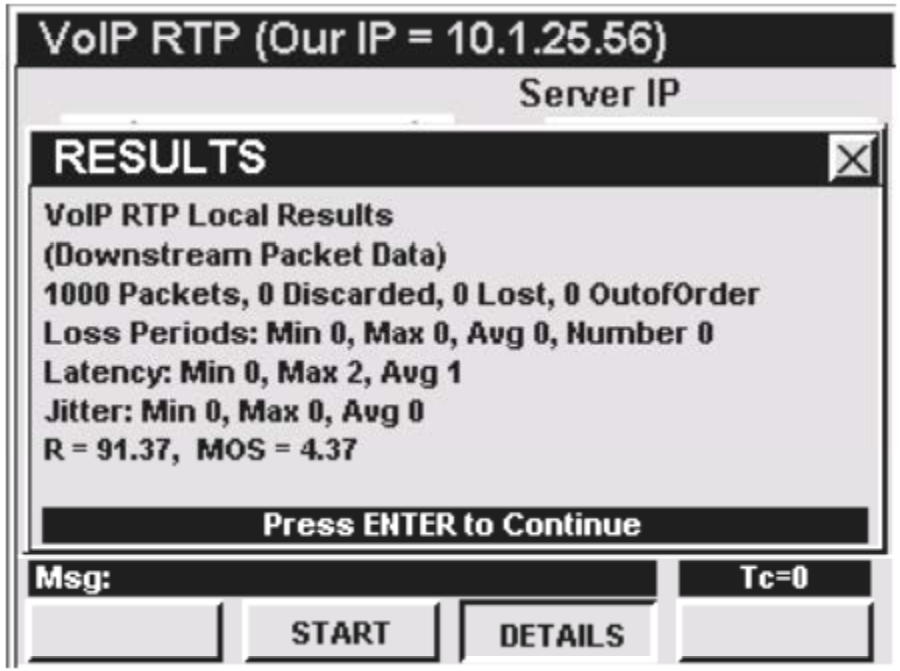
- Communication occurs using RTP over UDP (User Datagram Protocol) at pre-negotiated port
- Results are calculated and compared to limits – Pass/Fail results

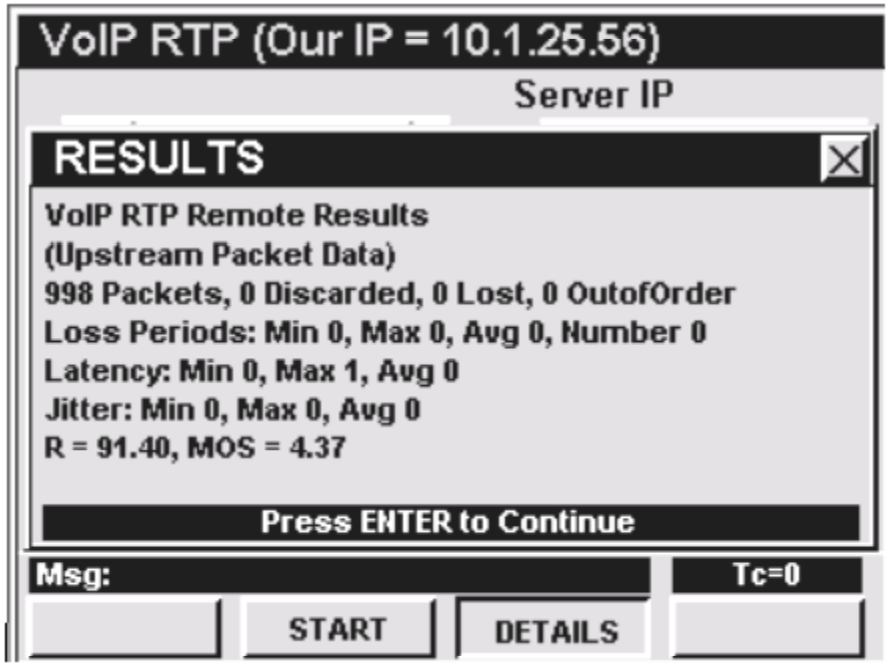
Sample Results





Sample Results – Drill Down





Downstream **Upstream**

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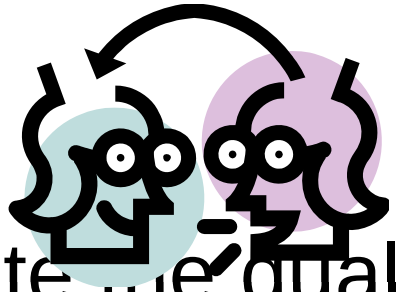
Mean Opinion Score (MOS)

- Subjective voice quality score based on the perception of a random group of people listening to speech over a communication system.



- Group of males and females rate the quality of test sentences read
- Each person rates from 1 to 5
- MOS is average: 1 (worst), 5 (best)

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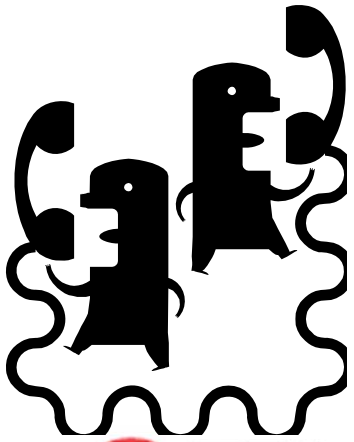
Mean Opinion Score (MOS)

Rating	Definition	Description
5	Excellent	A perfect speech signal recorded in a quiet booth
4	Good	Intelligent and natural like long distance telephone quality
3	Fair	Communication quality, but requires some hearing effort
2	Poor	Low quality and hard to understand the speech
1	Bad	Unclear speech, breakdown

Latency (Delay)

- Causes Echo and Talker Overlap
- When delay is > 50 msec, echo becomes a problem; echo cancellation is required
- Talker overlap is significant when one-way delay is > 250 msec



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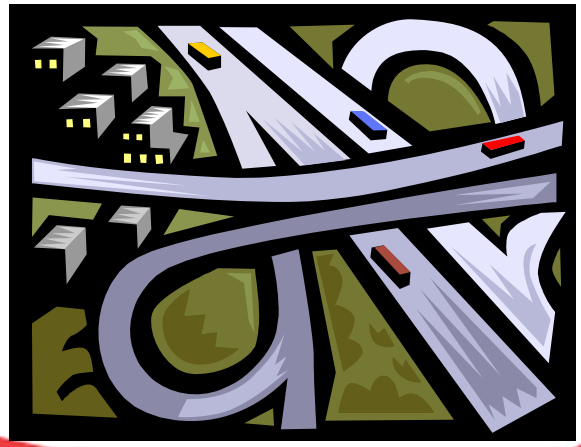
Latency (Delay)

- Can seriously impair communication
- Usually a by-product of switching and routing
- Must be less than 300 msec. round trip

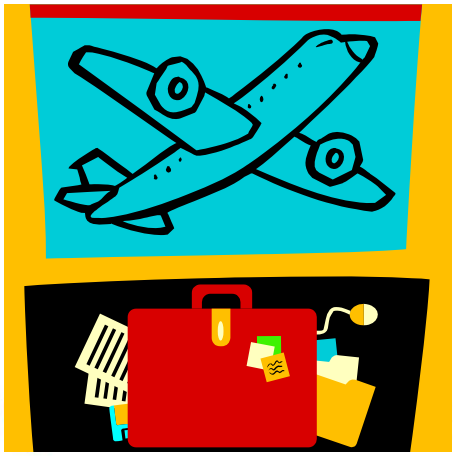


Jitter

- Packets arrive at destination out of timing or sequence
- Jitter buffer is used to enable re-ordering of packets
- Increasing size of jitter buffer threatens delay
- Should be less than twice packetization rate
- Jitter buffer overflow causes packet loss

Packet Loss

- Can be caused by network congestion, jitter buffer overflow, or ingress
- Random packet loss is less noticeable than “bursty” packet loss
- Target <1%, which is less noticeable when loss is random; >4% renders service unusable



Task for Headend, Maintenance and Service techs

- Verifies that the home network will support extended service (HSD, VoIP, VOD, Digital, etc)
- To detect faults at the premise
- Why clean it up?
  - The Issues
    - Home wiring architectures
    - Component Requirements
- Testing & Troubleshooting
  - Recommendations
  - Suggestions for a more available service

Broadband Instruments and Systems

What checks should we make to ensure a good install

think ahead.

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Broadband Instruments and Systems

Ingress Concerns

think ahead.

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Ingress on Analog and Digital Channels

- Lines in picture
- High speed data problems
- Interference with two-way radio services using the same frequencies
- Macro Blocking
- Freeze Frame
- Loss of Picture and Sound

Alternative Maintenance Techniques

- High Pass Filters
  - Attenuate Return Path Noise and Ingress coming from the subscriber premise
  - Isolate entertain services from data services
- Return Path Attenuators
  - Increase the tap loss in the return path only
  - Equalize the loss for subscriber devices and increase isolation between subscriber premise and cable system
- Drop Testing
  - Testing the integrity of the subscriber wiring

Broadband Instruments and Systems

Autotest Macros

think ahead.

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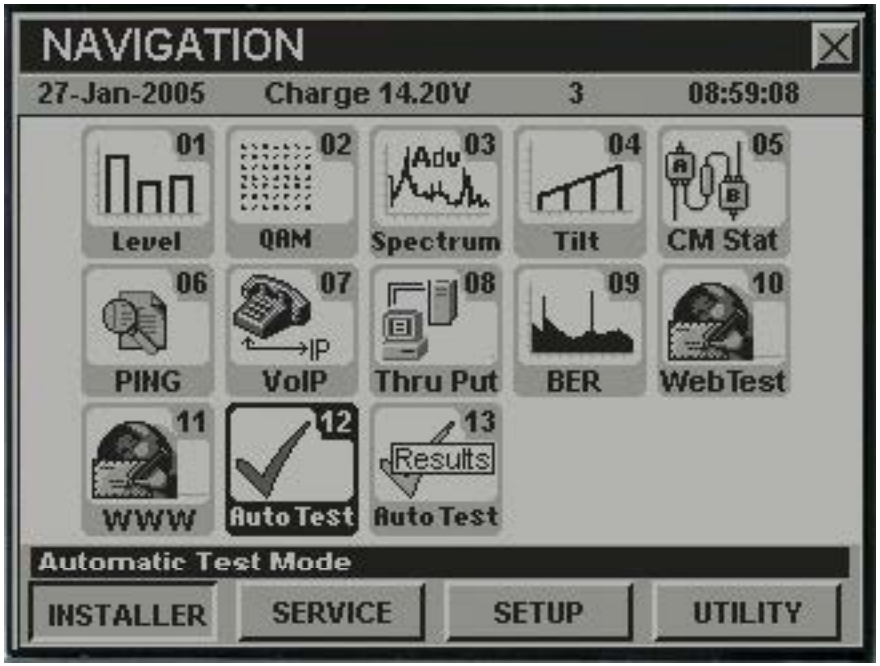
Auto Test Functions



- Automated Testing of…
  - Level (Single or Scan)
  - Hum
  - VoIP
  - Ping
  - QAM
  - Reverse Levels, Ingress
- Selectable Timing, Channel Plan, Label
- Test to Limits
- Results Labeled, Displayed and Stored

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Broadband Instruments and Systems

Remote Signal Monitoring & Analysis

think ahead.

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Scheduled Reporting Challenge

- Common task – report test signal analysis results
  - all signals
  - on regular schedule
- Techs required to visit remote locations
  - to verify and report signal quality
- Time consuming and expensive process, begging for automation

Eliminate Unnecessary Travel

- Trips to remote sites no longer required to perform a wide variety of signal quality tests
- Automate measurements
- Access for “live” measurements using browser

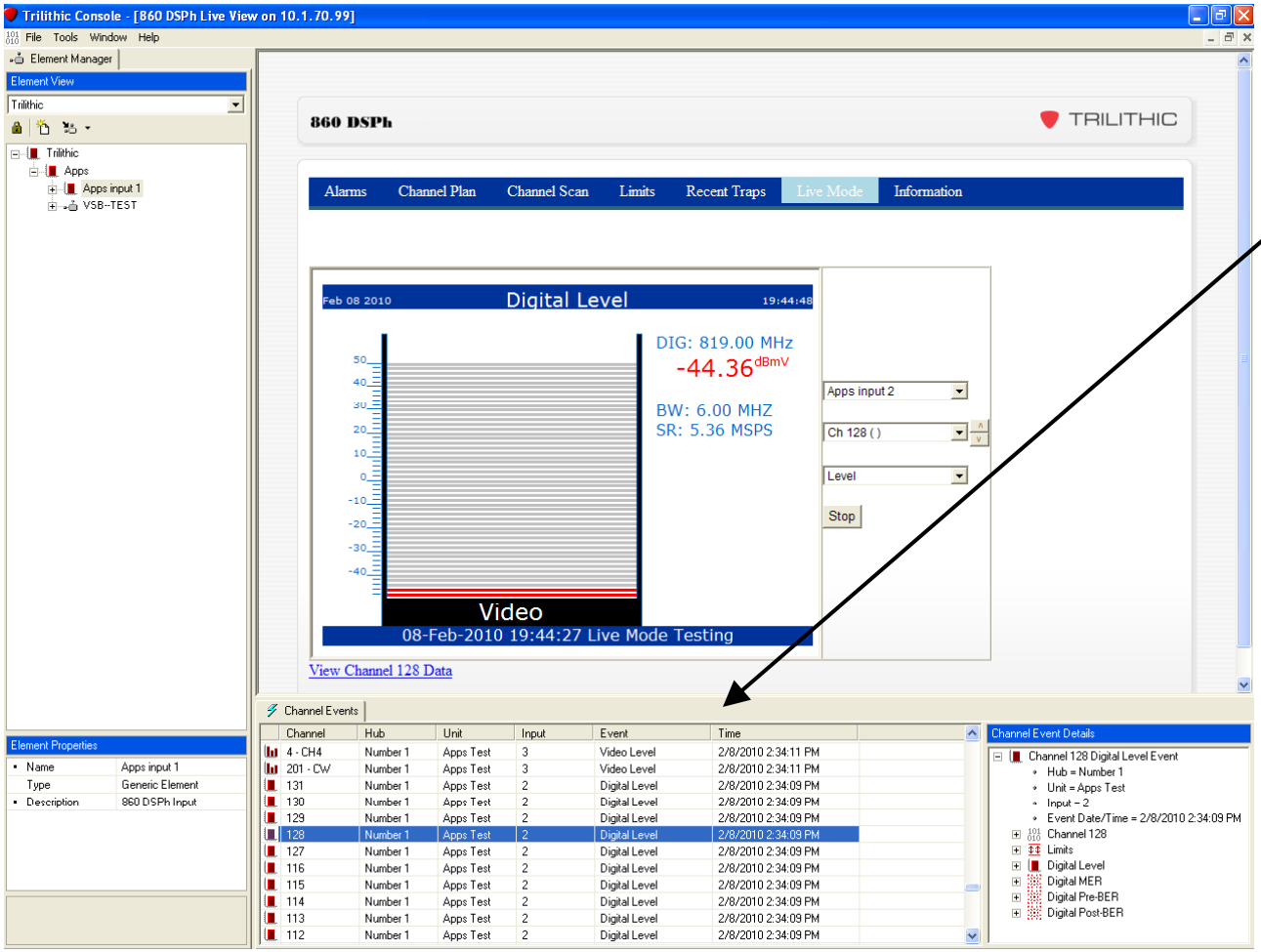
Applications

- Monitor forward signal quality
  - User definable limits
  - Management application software
    - Manages traps from
    - E-mail alarm notification
      - Designated technician/engineer/manager
- Check current status
  - Similar to 860 DSPi browser access/control

Alarm Analysis

- Display current alarm status
  - Based on traps received
- Provide easy access to remote devices
- Activate email notification of specified user

Maintenance Activities on the Digital HFC Network

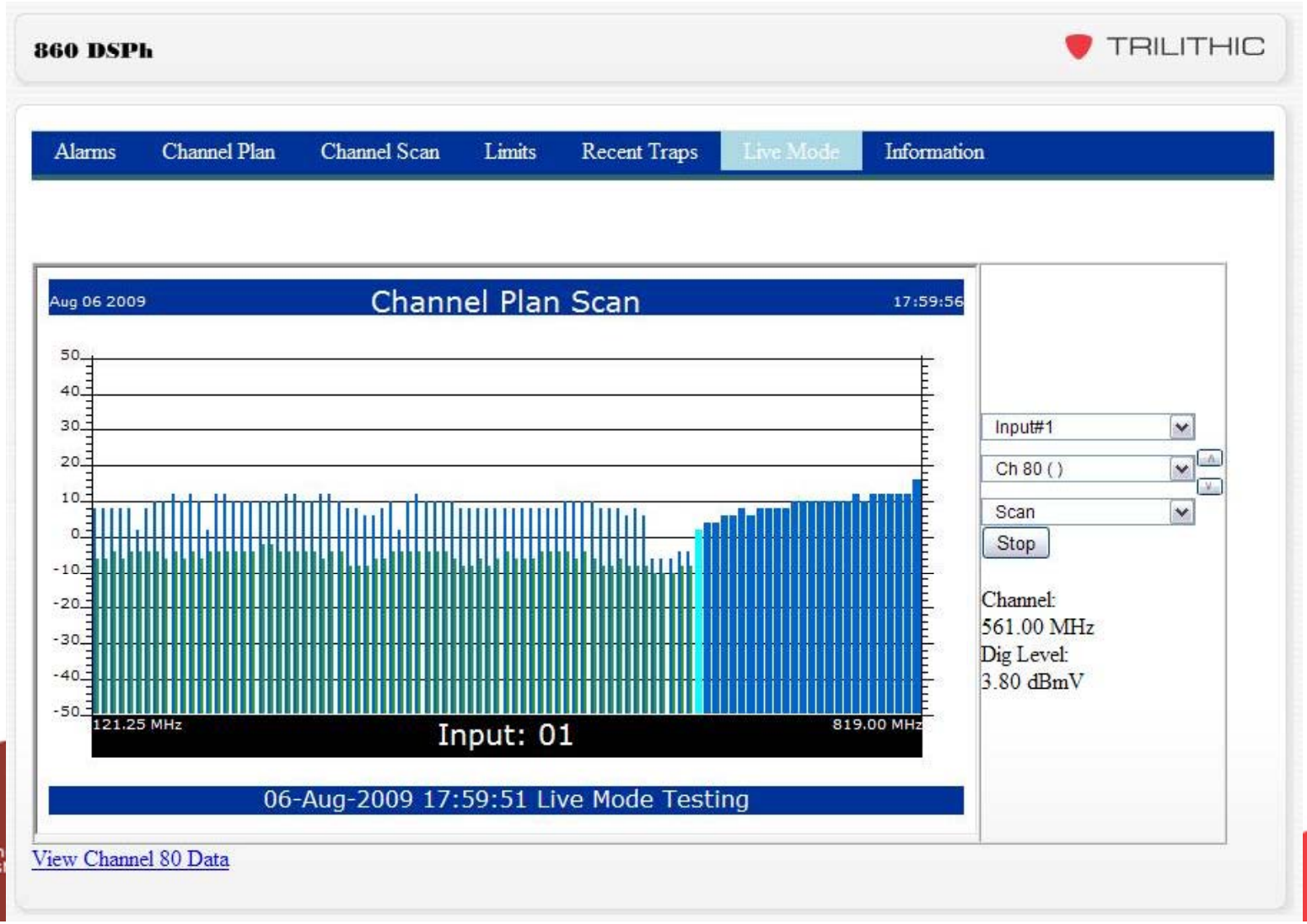


Channel Events
Displays channel alarms received from devices.

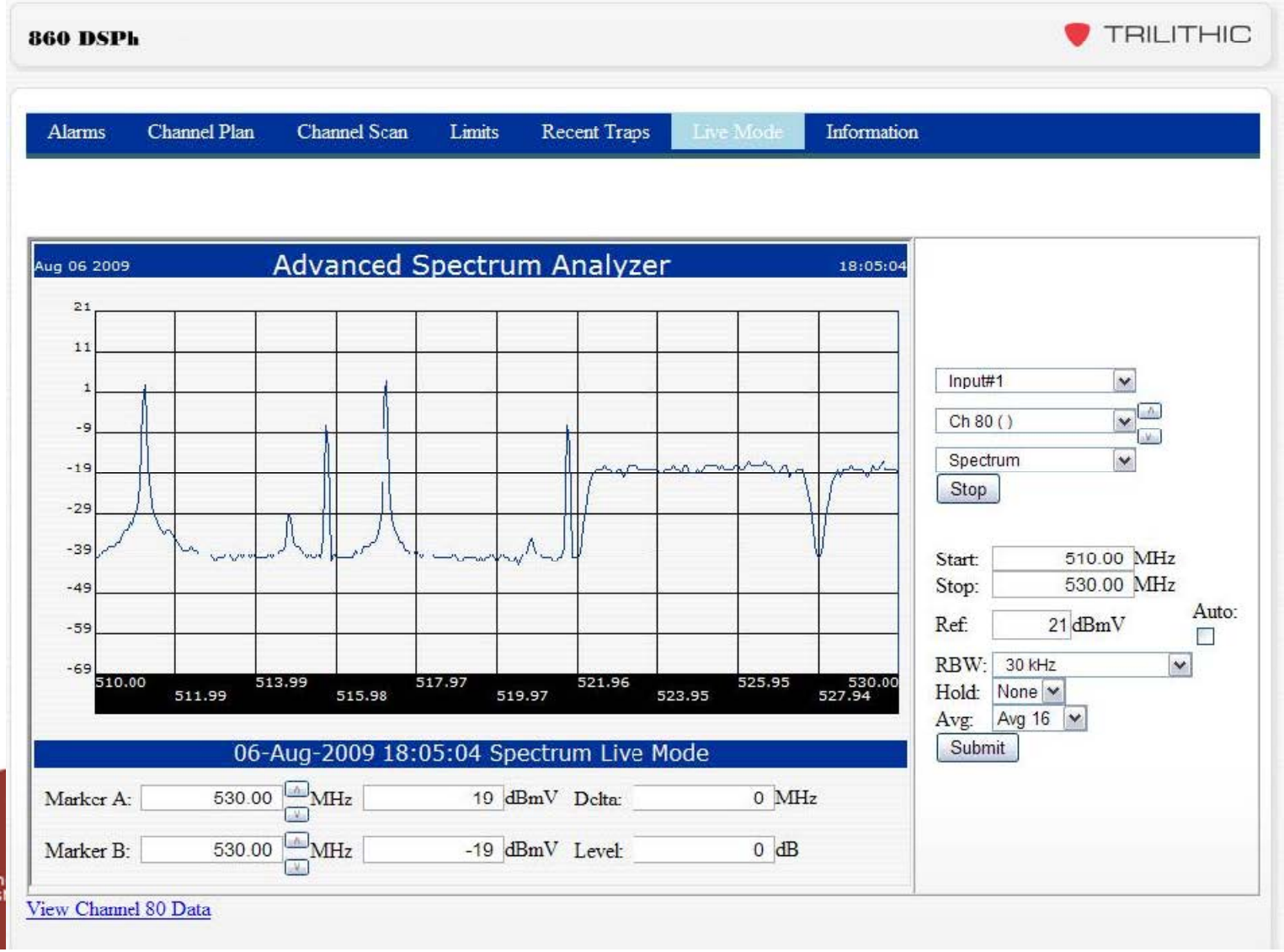
Click once on a channel event to see the Channel Event details.

Double-click on a channel event to bring up a live view mode to monitor current channel measurements.

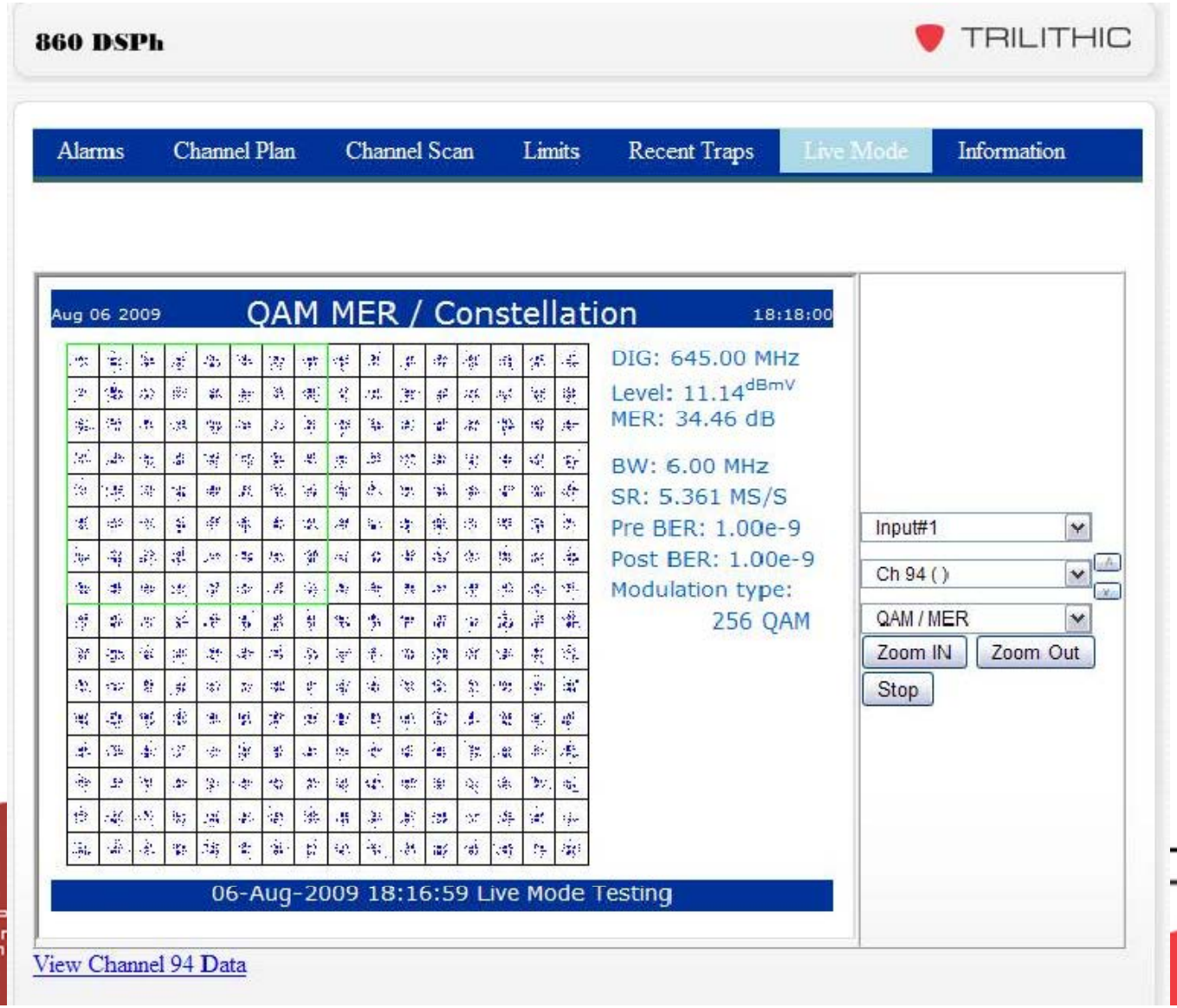
Channel Scan (Live Mode)



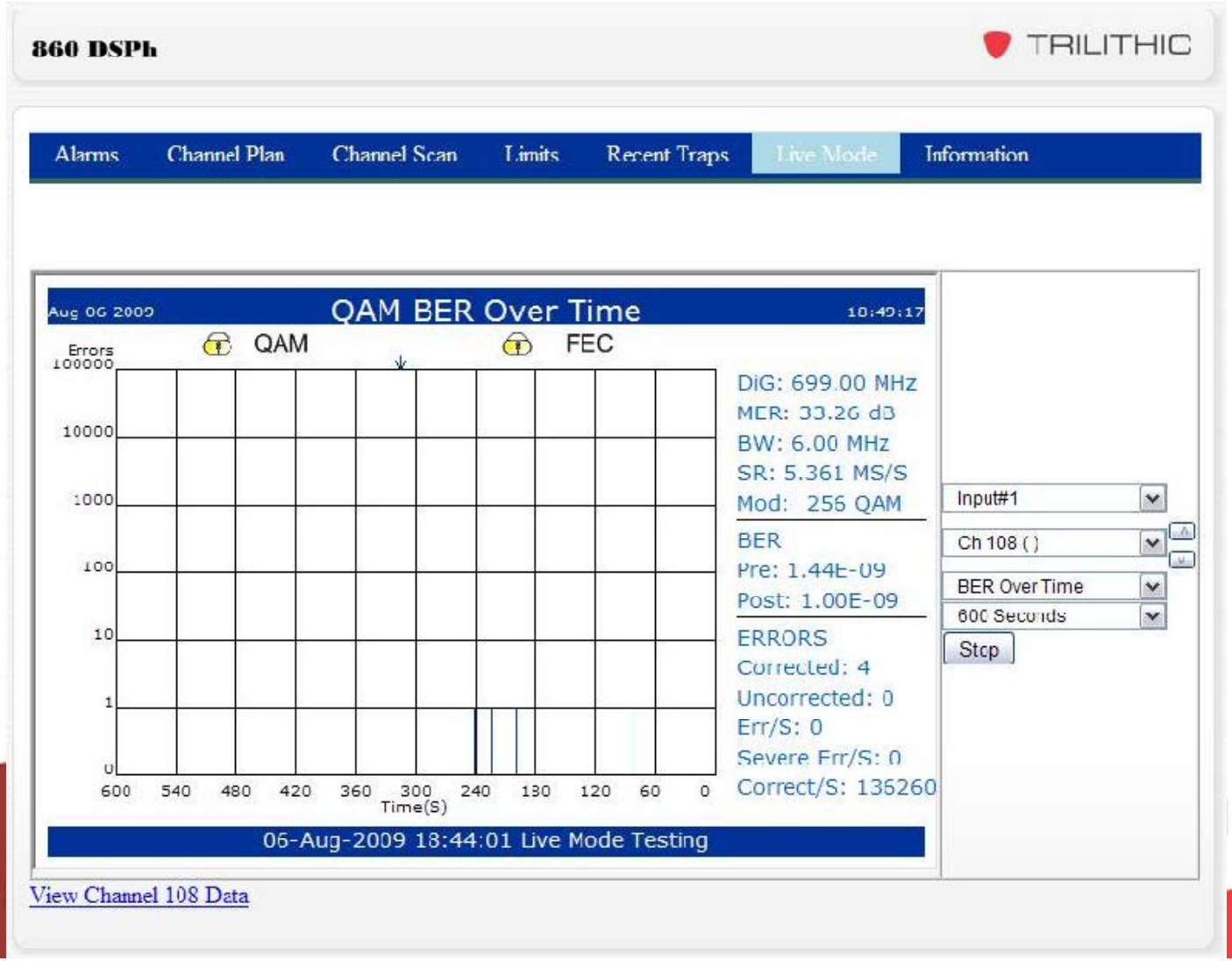
Spectrum Analyzer (Live Mode)



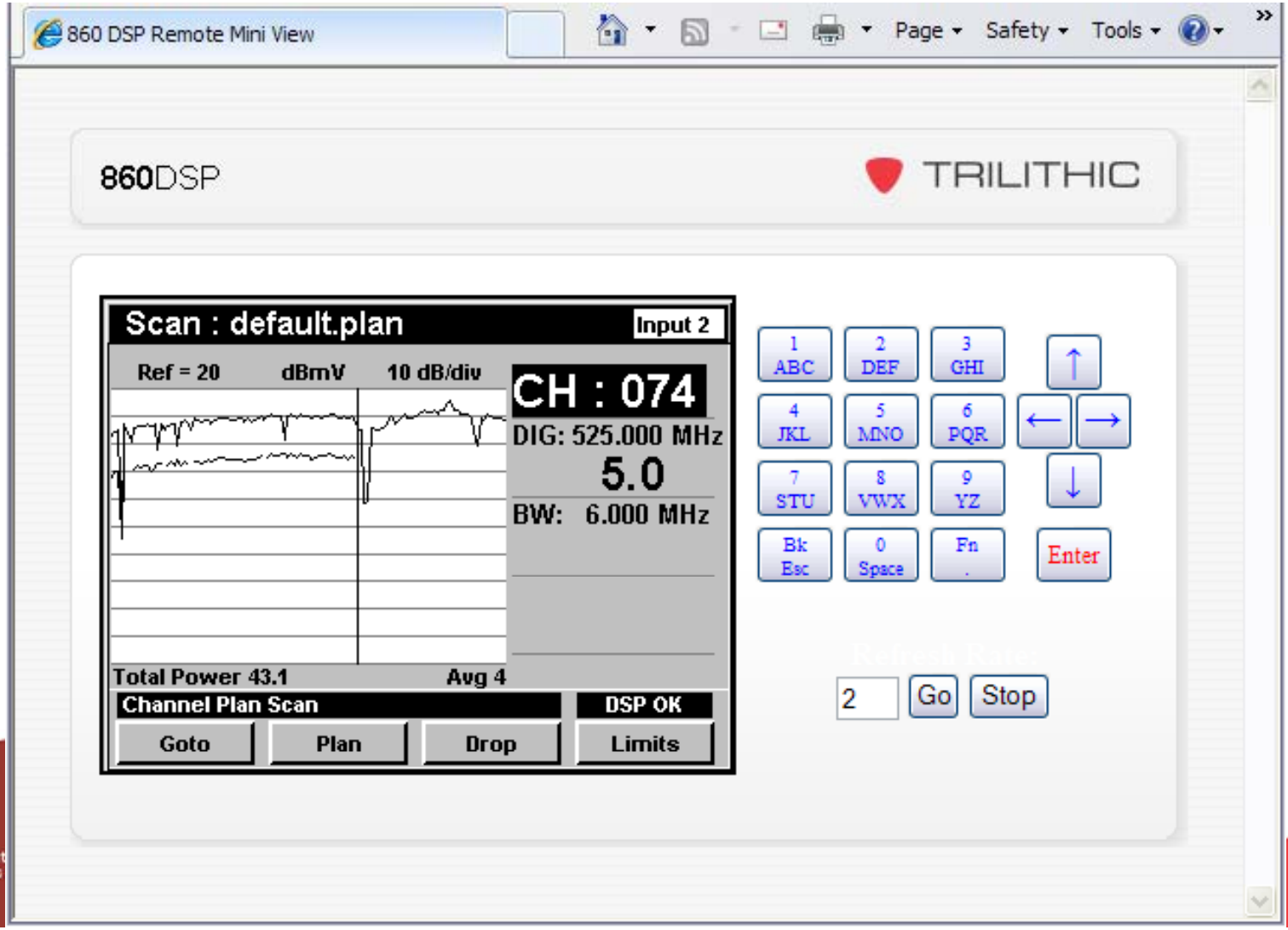
Constellation Diagram (Live Mode)



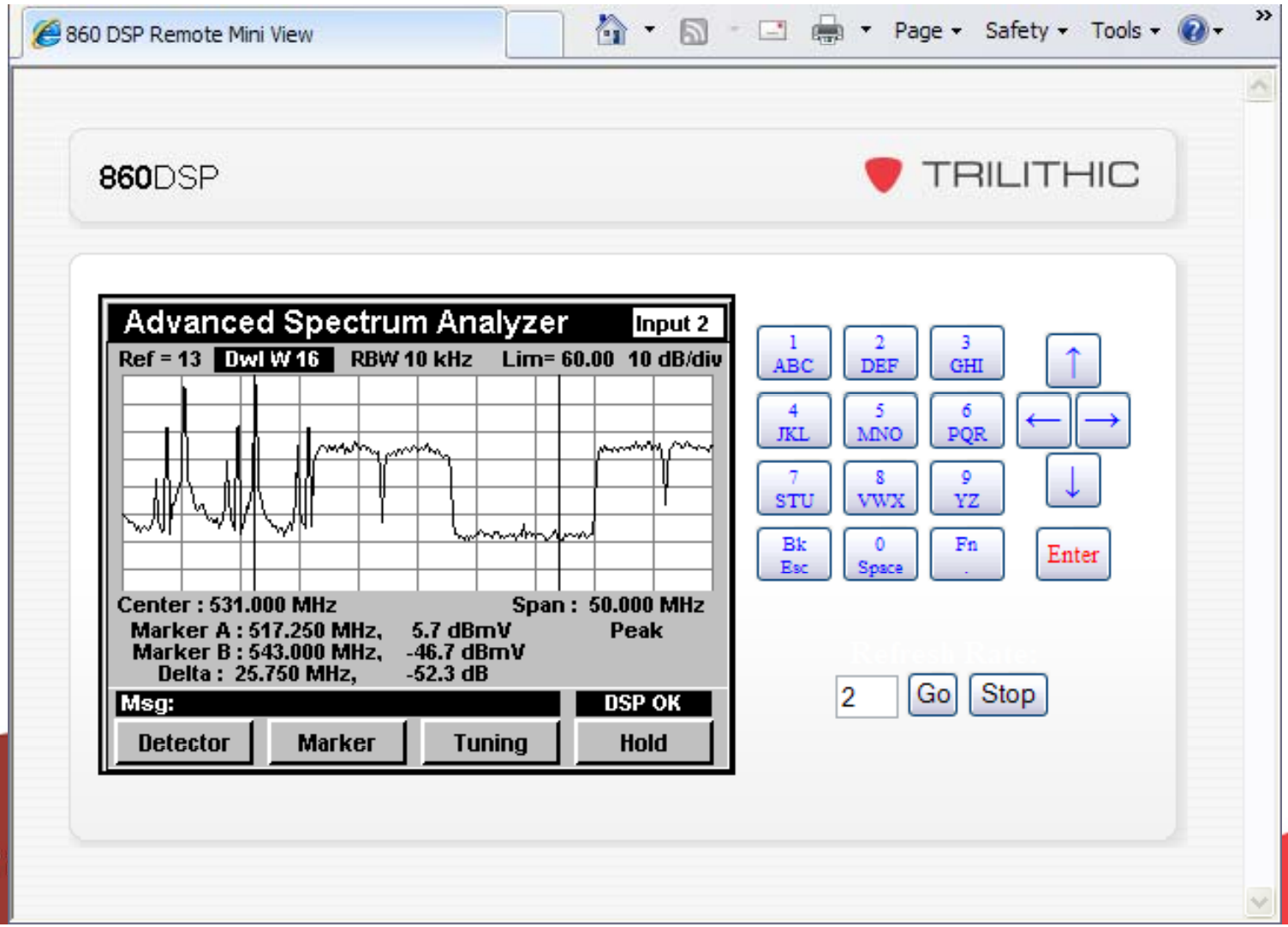
BER Over Time (Live Mode)



Channel Scan



Spectrum Analyzer



Tools of the Trade

- Return Sweep and Balance
- Forward Sweep and Balance
- Ingress Monitoring
- Work Management
- Leakage

Tools of the Trade

- Digital Measurement
- HSD
- VoIP
- Remote Monitoring

End of Session Two
Questions?

Thank you-Gracias-Merci-Masha Danki…

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