Broadband Instruments and Systems

Technical Training Seminar on
"Practical Field Testing DOCSIS 3.0"
for
CCTA Member Companies
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Broadband Telecommunications Solutions
Solutions efficaces aux télécommunications à large bande

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think ahead.

Overview

- Quick discussion of DOCSIS 3.0 importance
- Impact of D3 on testing
- D3 deployment and preventive maintenance
- Practical methods for testing D3 signal transmission quality
- Troubleshooting the Return Path
- Monitoring the Return Path

DOCSIS 3.0

- **Higher Data Rates**
  - Channel Bonding
- **Dynamic Load Balancing**
  - Dynamic Channel Change & Per Packet Load Balancing
- **Better Bandwidth Utilization**
  - Source Specific Multicast
  - Multicast Header Suppression
- **High Quality IP Video**
  - Multicast Quality of Service
- **More IP Addresses When You Need Them**
  - IPv4 and IPv6 Support

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DOCSIS 3.0

- **Enhanced Security**
  - 128 bit AES encryption (Advanced Encryption Standard)
  - Increased Cable Modem provisioning process security
- **Option to Increase Upstream Bandwidth**
  - Option for 5-85 MHz upstream support
- **Powerful Reporting to Manage Traffic**
  - Cable modem diagnostic log
  - Enhanced signal quality monitoring
  - Service statistics reporting - IPDR

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Impact on Testing

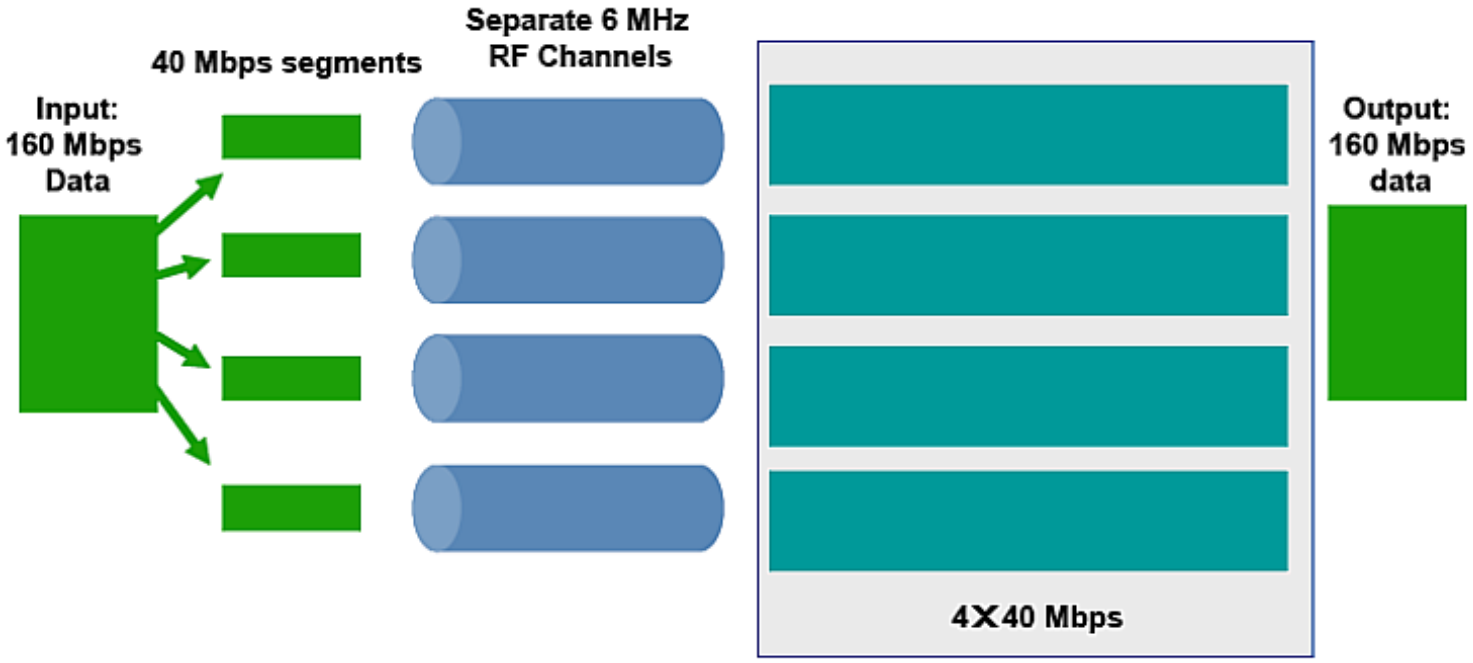
- Need higher reliability and performance, while minimizing operating expense
  - Increase efficiency and productivity
- DOCSIS 3.0 – Group of signals (bonded) with interrelated relevance
- Physical transmission is same as DOCSIS 2.0
- IP related measurements require embedded DOCSIS 3.0 modem

Higher Data Rates

- **Upstream** Capacity with 6.4MHz & 64QAM
  - Two channels, 60 Mbps
  - Three channels, 90 Mbps
  - Four channels, 120 Mbps
- **Downstream** Capacity with 6MHz & 256QAM
  - Two channels, 80 Mbps
  - Three channels, 120 Mbps
  - Four channels, 160 Mbps
  - **Eight channels, 320 Mbps**

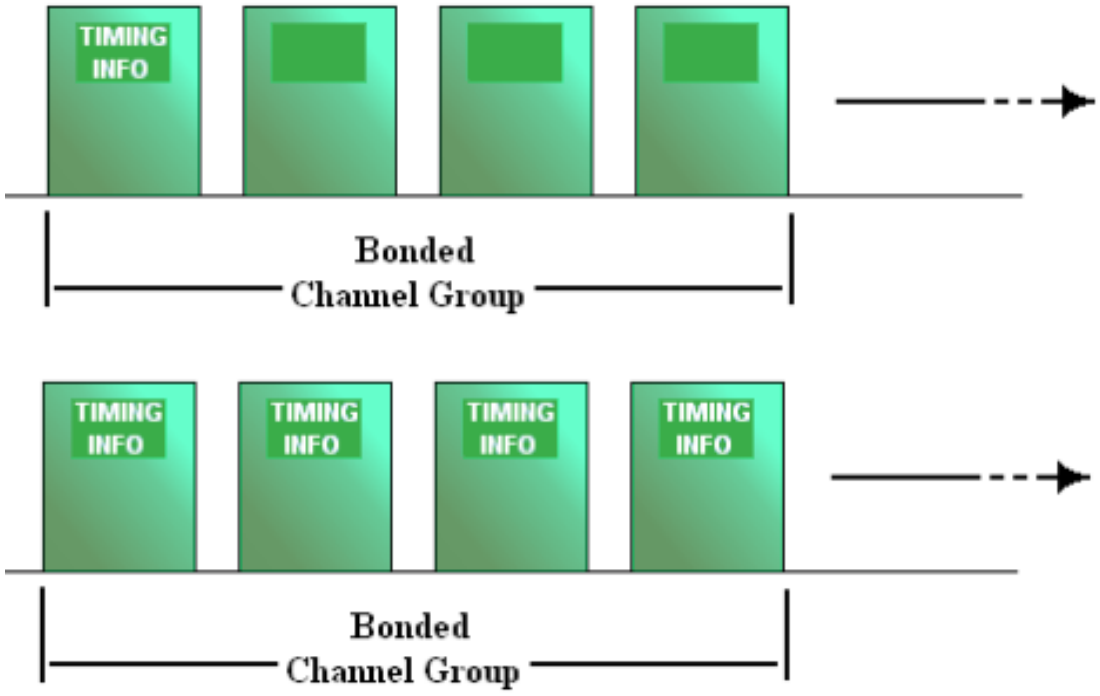
Channel Bonding

- Example:



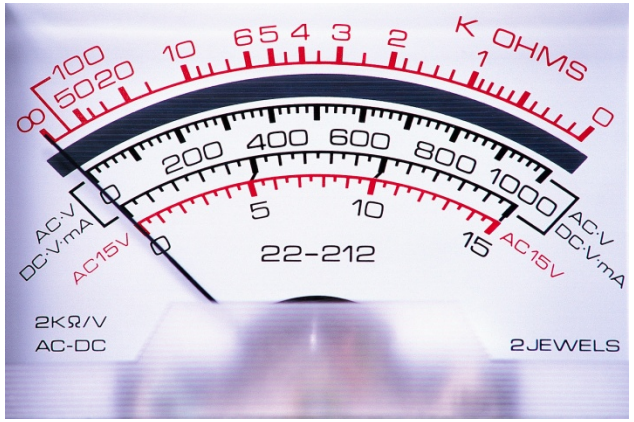
"Primary" Channels

- One Channel in Group carries timing info for whole group
- Each Channel in Group carries its own timing information



Proactive Testing Makes Sense

- Fewer emergencies, lower operating expense, higher customer satisfaction
- "Old school" plant performance testing
  - Sweep
  - Leakage
  - End-of-line testing



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Plant Qualification Checklist

- Headend RF alignment
- Downstream 256-QAM testing and qualification
- Upstream 64-QAM testing and qualification
  - Avoid frequencies near the roll-off or band edges
  - Avoid frequencies susceptible to ingress, if possible
  - Control ingress, noise, CPD and laser clipping
  - Tighten RF leakage thresholds

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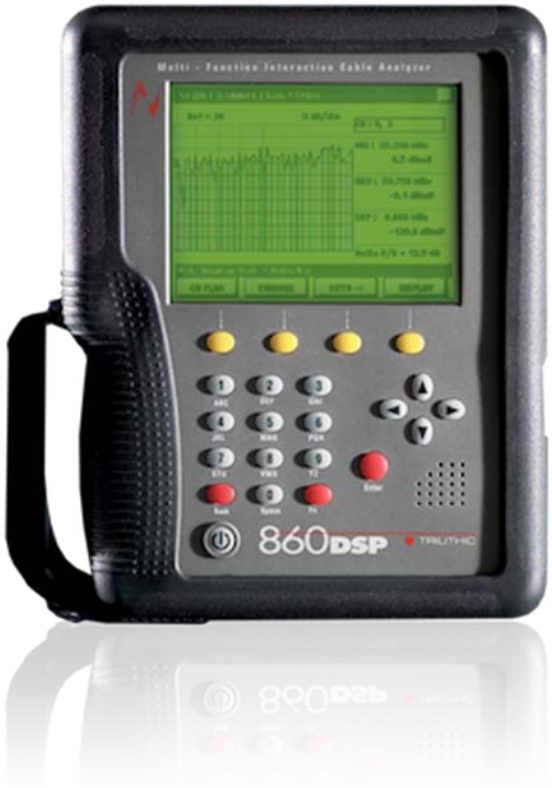
DOCSIS 3.0 Checklist

- **Test equipment**
  - DOCSIS 3.0 field test meter
    - 64-QAM signal source
- Upgrade or purchase new QAM Analyzers



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Preventive Maintenance Checklist

- Do complete system sweep every 12-18 months (all actives)
- End-of-line digital testing (MER & BER)
- Leakage Testing
- Return Path Monitoring
- Daily reports (use as historical references)

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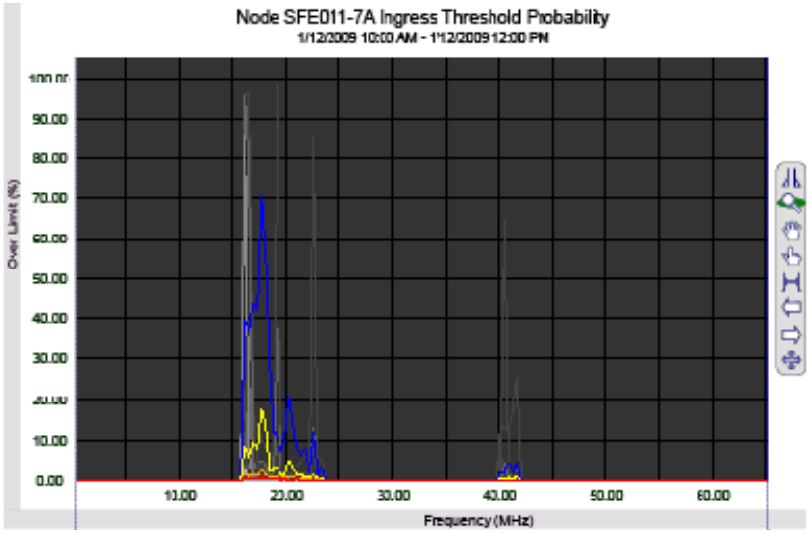
Installation Testing Pays Off

- Comprehensive with minimal impact on Tech time
  - Establishes baseline
  - “Certification” leads to higher quality and reliability
- Level scan, MER, BER, cable modem statistics, ingress, leakage

Preparation Testing

- Upstream needs special attention
- Node certification: return path spectrum
  - Extended period of testing required
- Speed is of the essence
- Spectrum suitability analysis – DISP, ADISP



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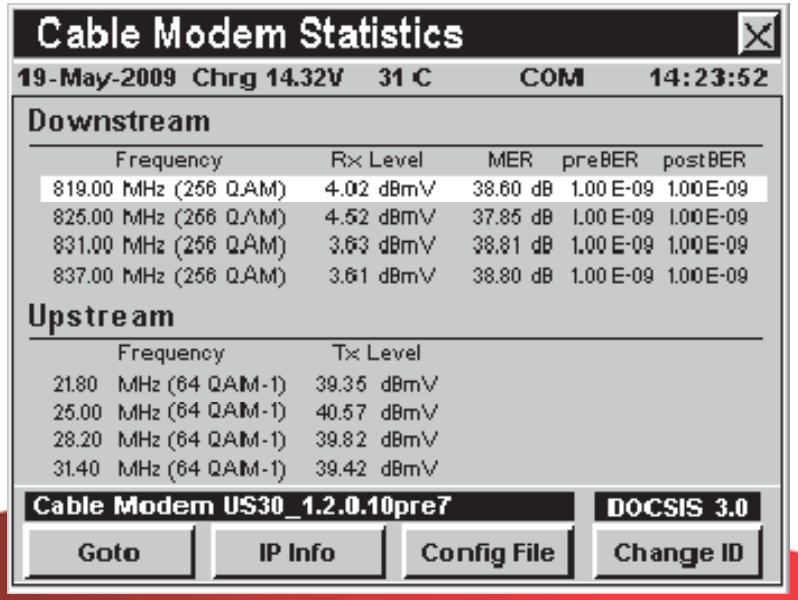
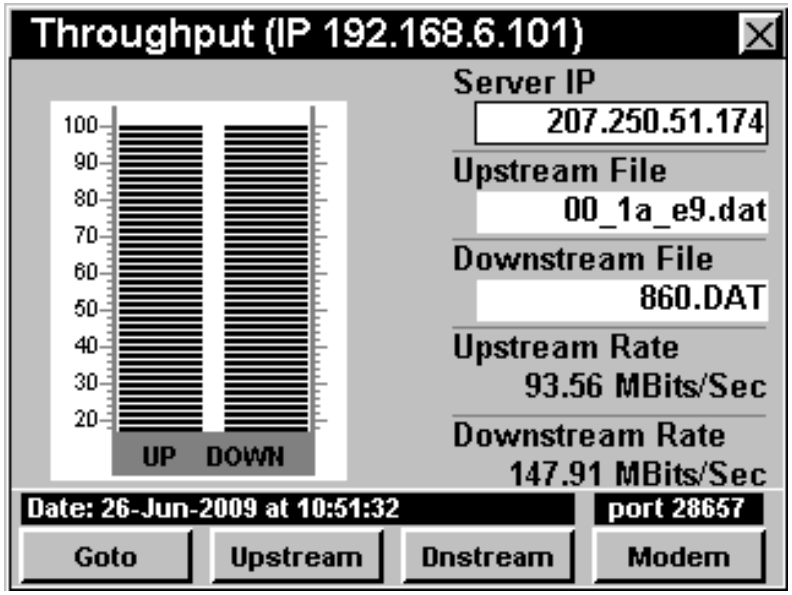
Post-Deployment Testing

- Installation
  - Cable modem statistics
  - Throughput





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Test Automation

- Efficient, error-free testing
- DOCSIS 3.0 environment autotest includes:
  - Channels in a group
  - Set of tests to be performed on each channel
  - Performance limits to analyze test result

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Typical D3 Autotest

- Consider sequence to minimize ranging and registering
- Test relevant parameters

Schedule	
Timing	Immediate One-Time
Test Steps	
Step 1	MER/BER
Step 2	Modem Stats
Step 3	VoIP RTP
Step 4	Throughput
Step 5	Modem Stats
Step 6	Modem Stats
Step 7	Modem Stats
Step 8	
Step 9	
Step 10	
Step 11	
Step 12	
Step 13	
Step 14	
Step 15	
Step 16	

Step 7 - Check Modem Stats	
Parameters	
Modem MAC	MAC #1
Downstream Frequency	821.000 MHz
Modem Mode	DOCSIS 2.0
Annex Type	Annex B
Upstream Id	Use Setup Menu
Limits	
Minimum Launch Level	30 dBmV
Maximum Launch Level	50 dBmV
Minimum Receive Level	-10 dBmV
Maximum Receive Level	40 dBmV

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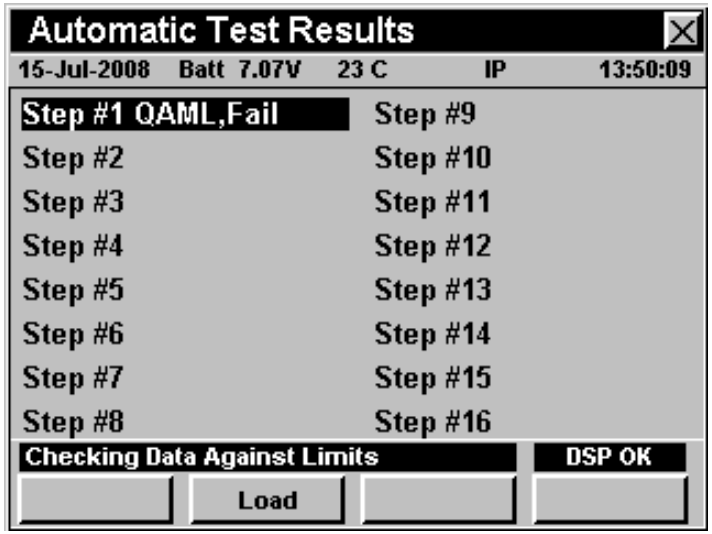
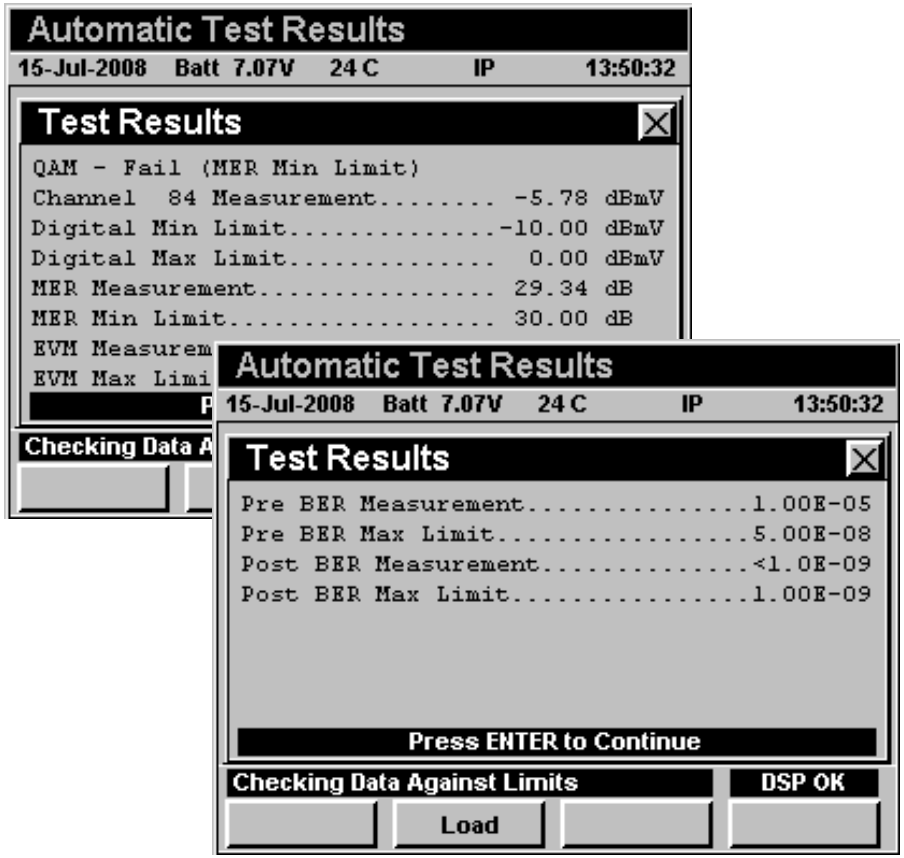
Typical Autotest for D3

- Once the autotest is built and loaded into the meter:
- Tech pushes one button and runs specific tests on specified channels
- Alerts tech to failures right away



Typical Autotest for D3

- Tech can then retrieve and view supporting test details, or save files for uploading to server.



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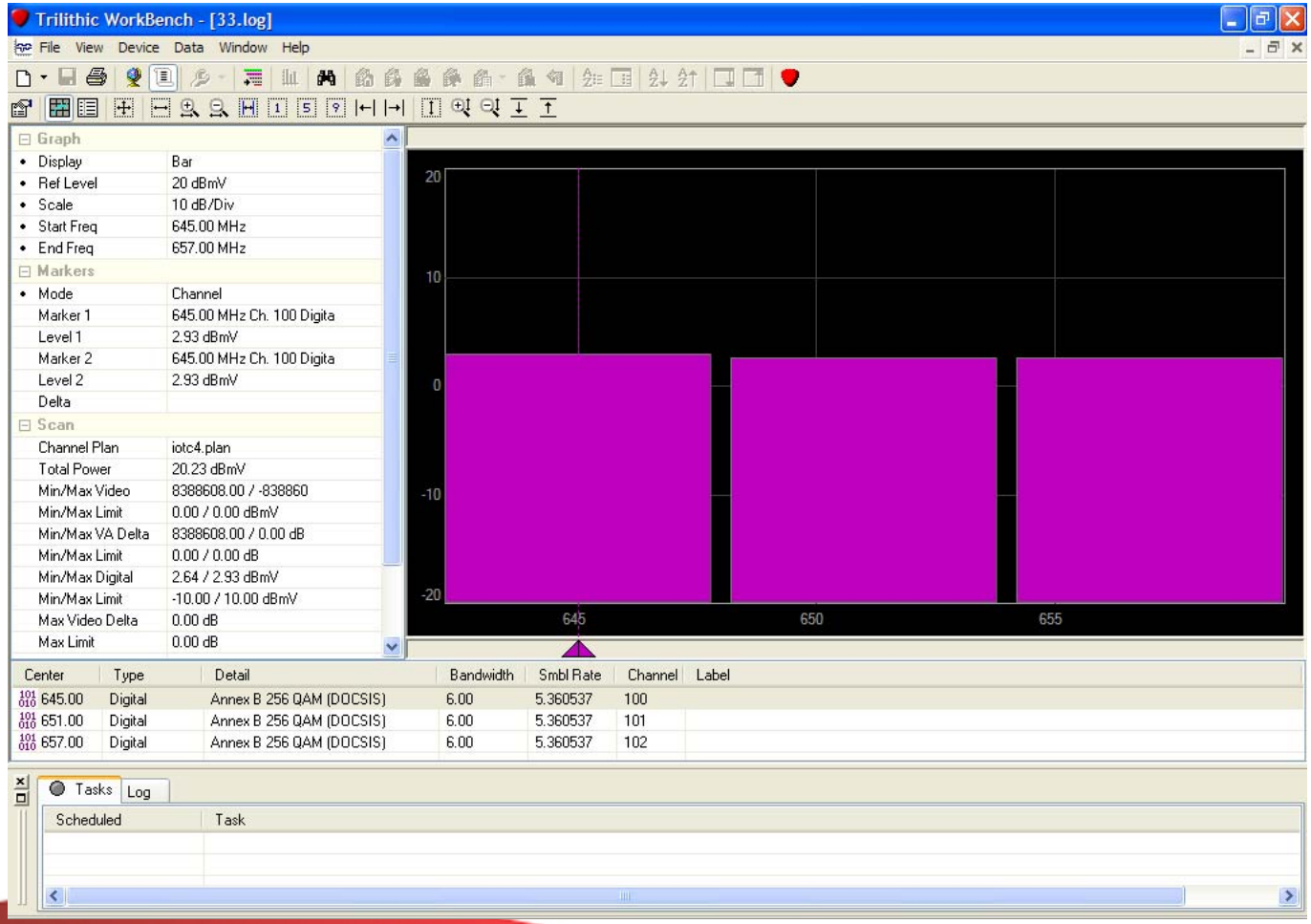
D3 Autotest Results



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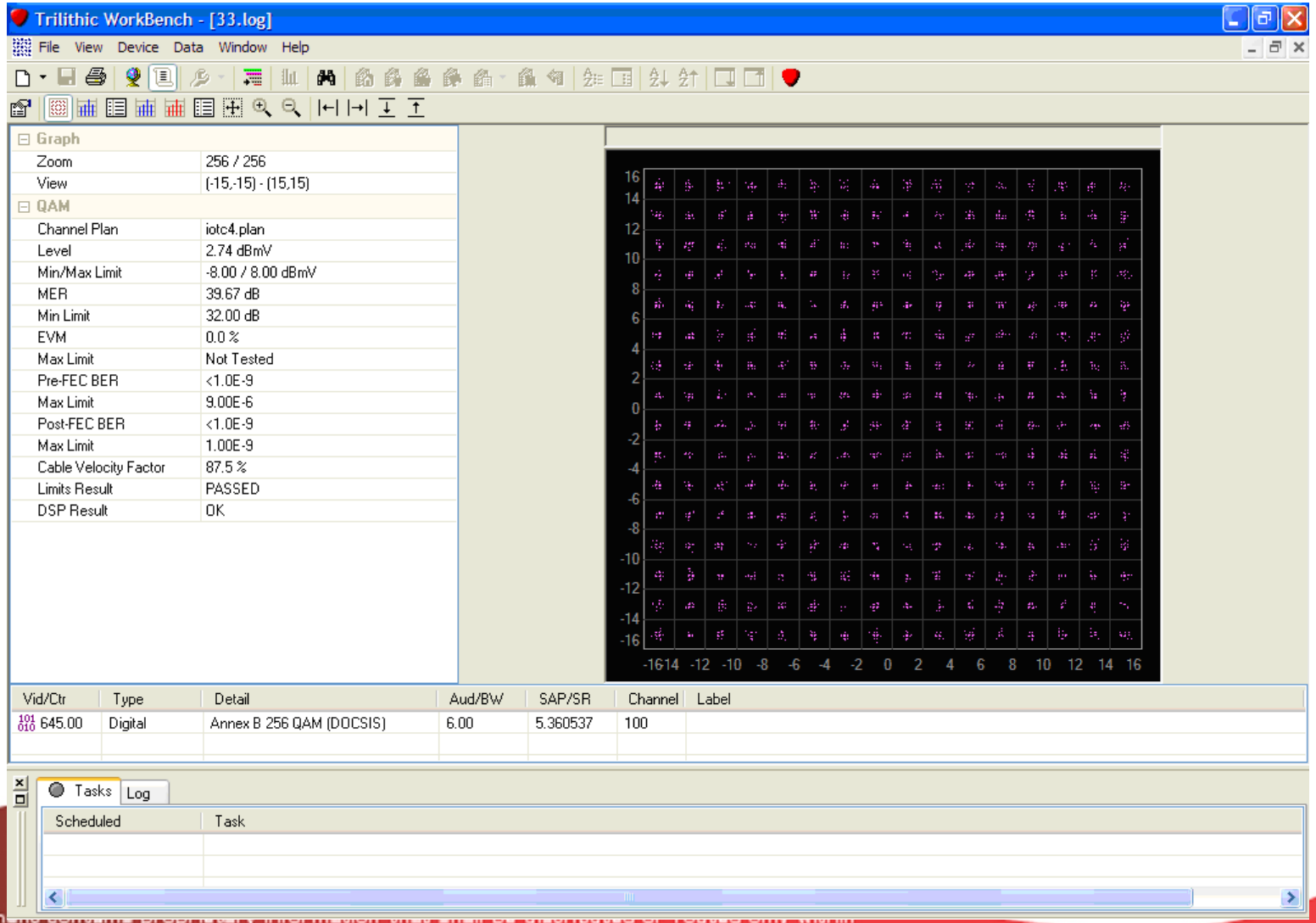
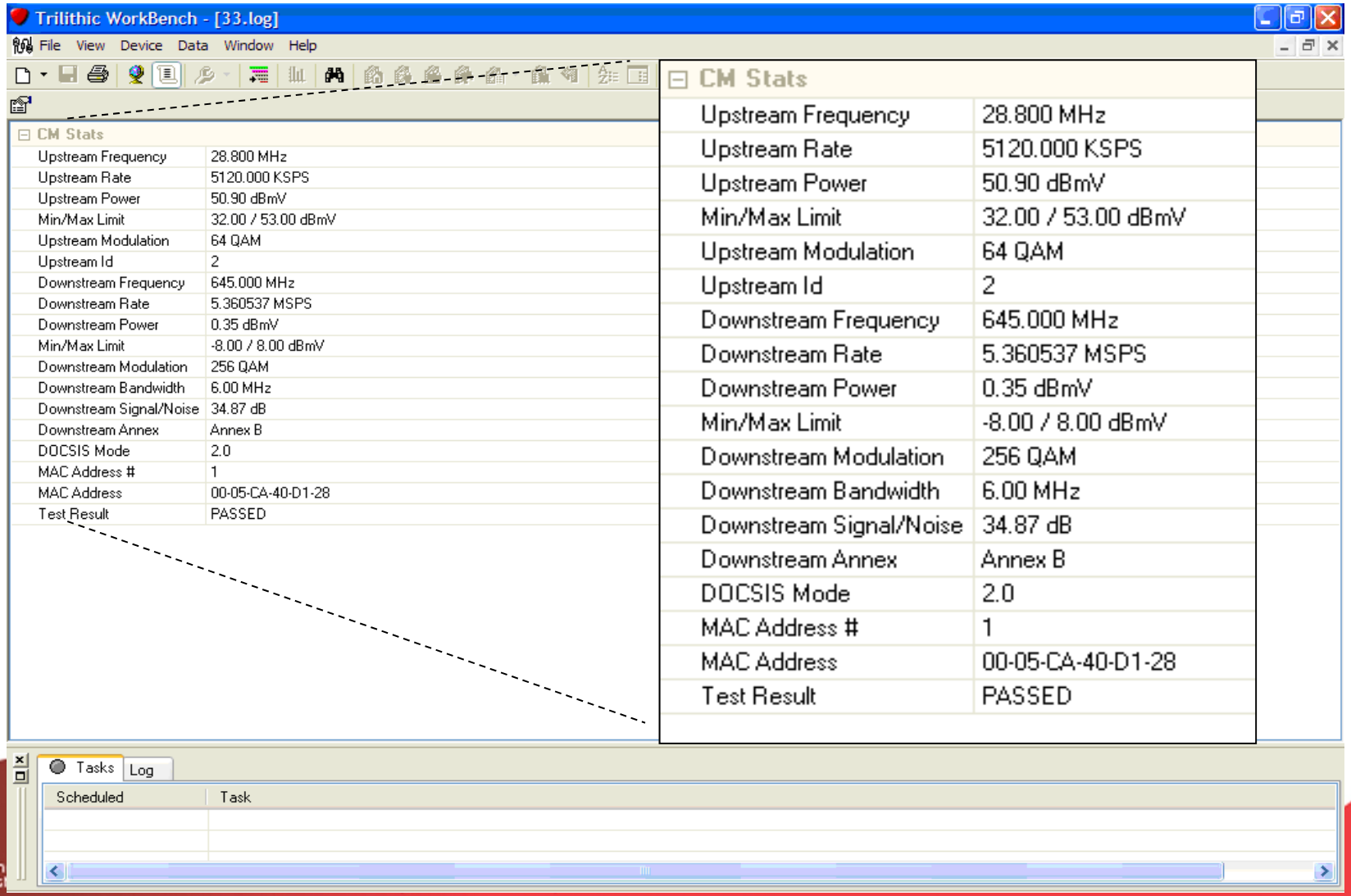
D3 Autotest Results

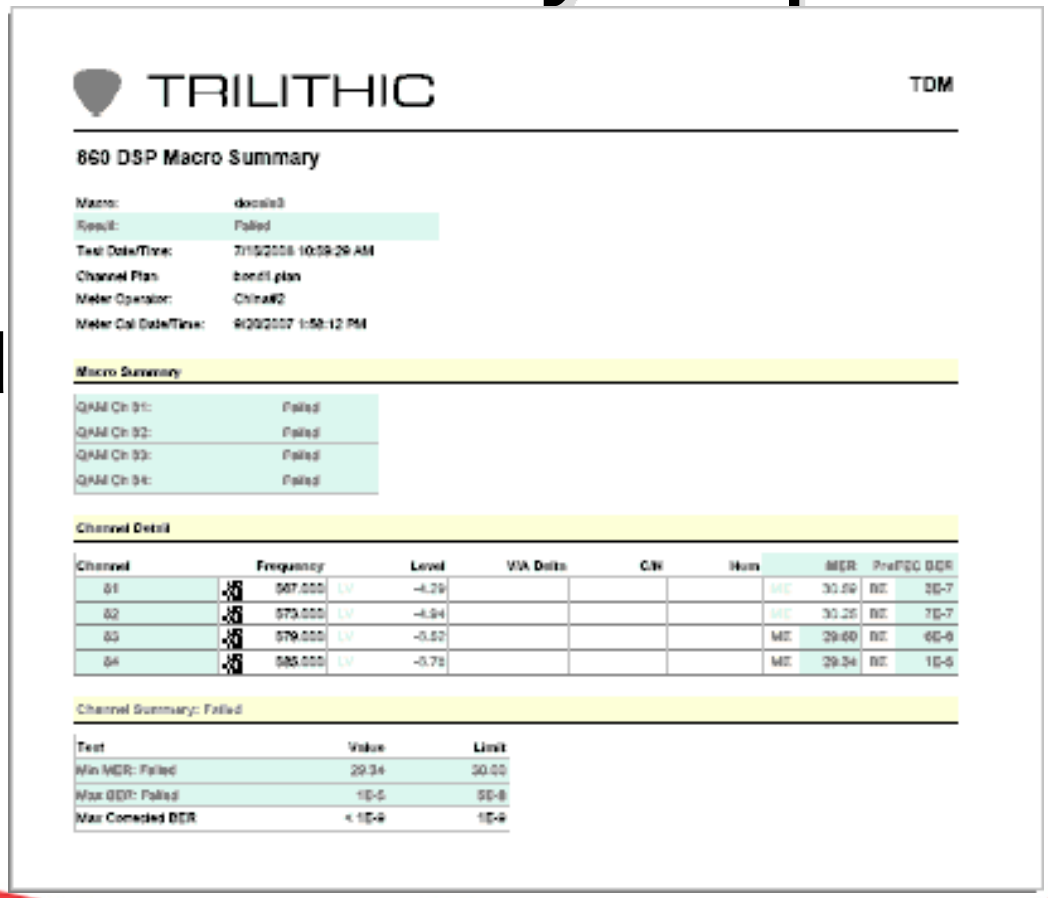


D3 Autotest Results



D3 Test Macro Summary Report

- Results may be retained, displayed in supporting software



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TDM

860 DSP Macro Summary

Macro:	docsis3
Result:	Failed
Test Date/Time:	7/10/2008 10:59:29 AM
Channel Plan:	bondi plan
Meter Operator:	China#2
Meter Cal Date/Time:	6/20/2007 1:58:12 PM

Macro Summary

QAM Ch 81:	Failed
QAM Ch 82:	Failed
QAM Ch 83:	Failed
QAM Ch 84:	Failed

Channel Detail

Channel		Frequency		Level	VIA Delta	C/N	Hum		MER		PreFEC BER
81		567.000	LV	-4.29				MI	30.59	BI	3E-7
82		573.000	LV	-4.94				MI	30.26	BI	7E-7
83		579.000	LV	-5.57				MI	29.60	BI	6E-6
84		585.000	LV	-5.78				MI	29.34	BI	1E-5

Channel Summary: Failed

Test	Value	Limit
Min MER: Failed	29.34	30.00
Max BER: Failed	1E-5	5E-8
Max Corrected BER	< 1E-9	1E-9

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Transmission System Troubleshooting Tools

- QAM Analyzer – in the field and in the headend/hub site
- Return Path Monitoring Equipment
- Probe – bi-directional
- Leakage System

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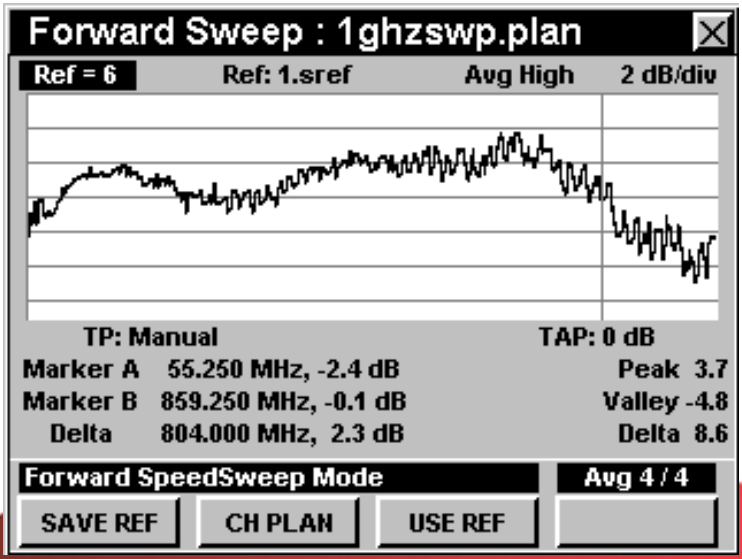
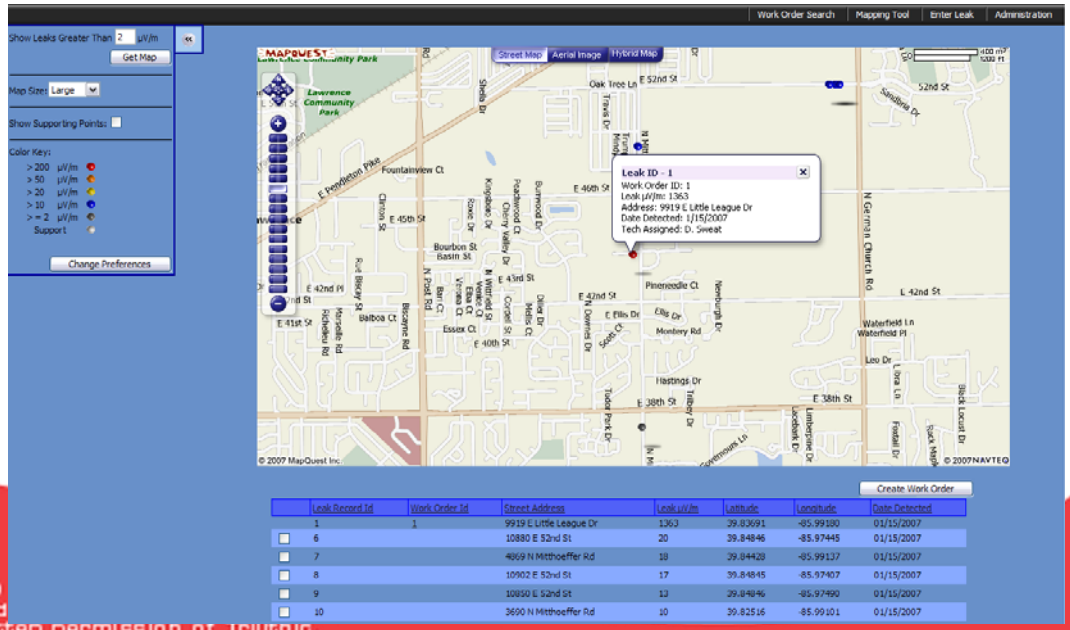
Plant Performance Testing

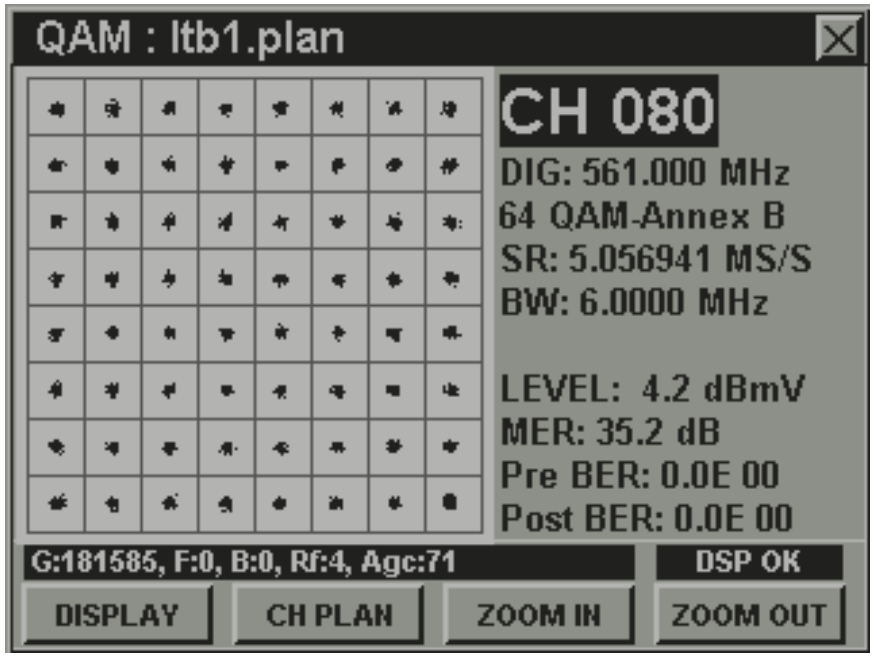
- Forward and reverse sweep
- Upstream QAM analysis from EOL
- Leakage (tightened threshold?)





MER

- MER degradation
  - does not effect picture quality until failure
- MER accounts for
  - amplitude noise
  - phase noise

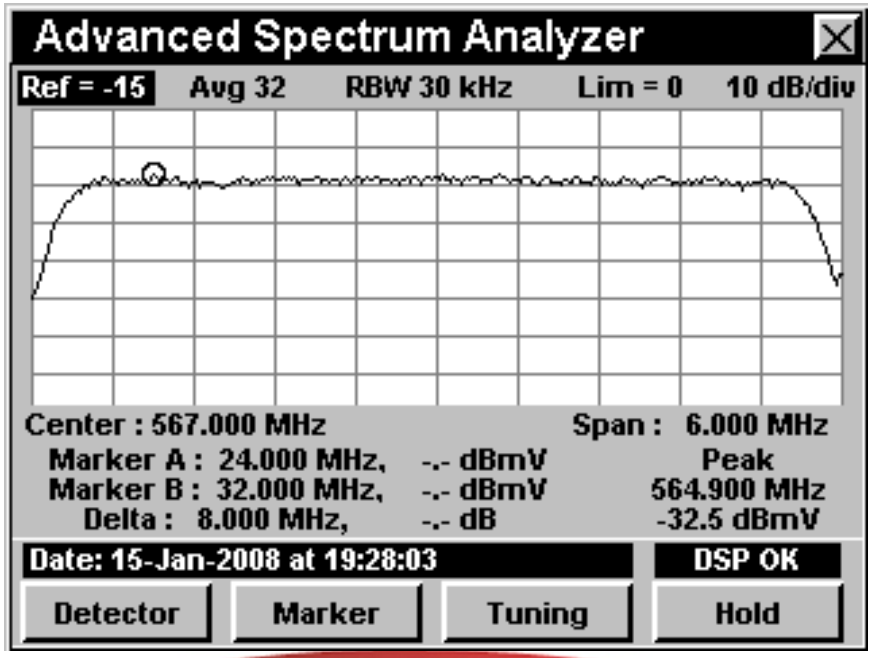


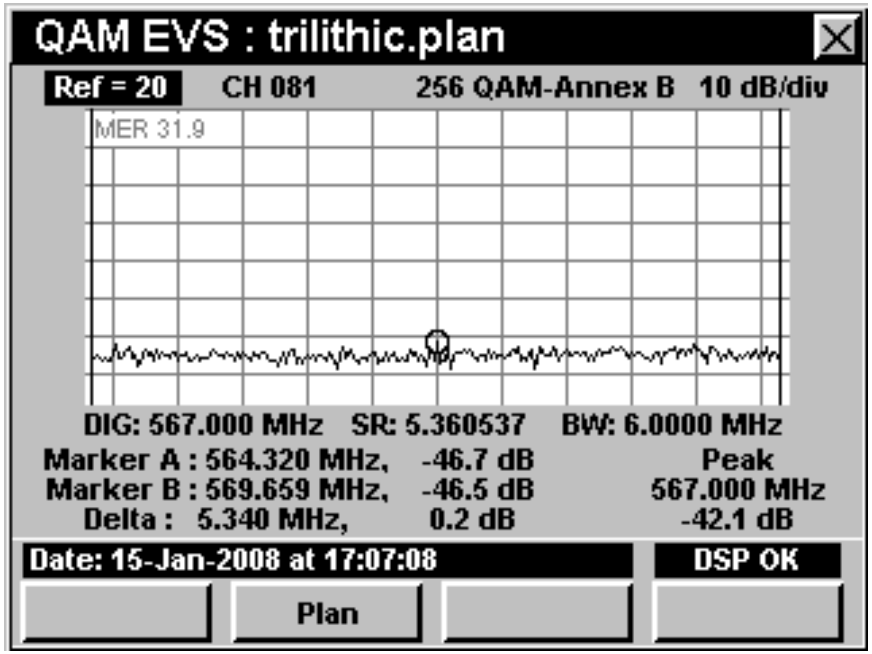
Troubleshooting Low MER

- Is it noise or interference?
  - Noise may indicate an amplifier or other active component failure
  - Interference may indicate:
    - Distortion – active component
    - Ingress – leakage (stray RF in means RF straying out)
- Spectrum analysis helps
  - Use error vector spectrum to see within the channel range (under the haystack)
- Constellation analysis (tell-tale shapes – donuts, clouds, etc.)

Error Vector Spectrum

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





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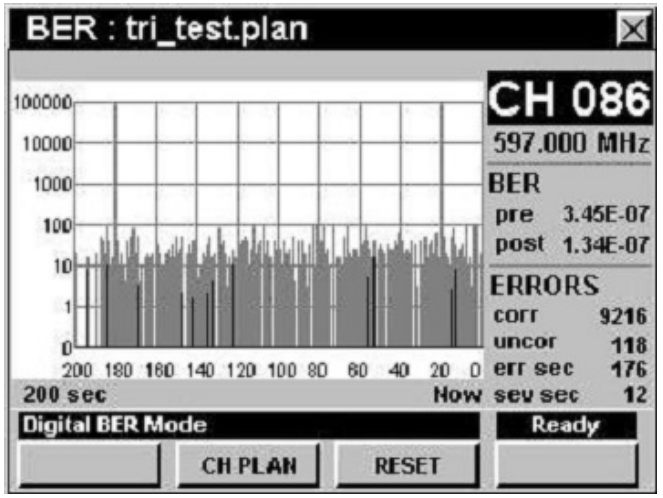
Troubleshooting High BER

- Is MER low? (see last advice)
- Pre-FEC or Post-FEC, measure of severity
- Are bit errors continuous or sporadic?
  - Look at graph of errors over time
  - Can time signature be determined? (may give clue to cause)
- Is BER failure frequency (channel) specific and sporadic?
  - Look at error vector spectrum over time

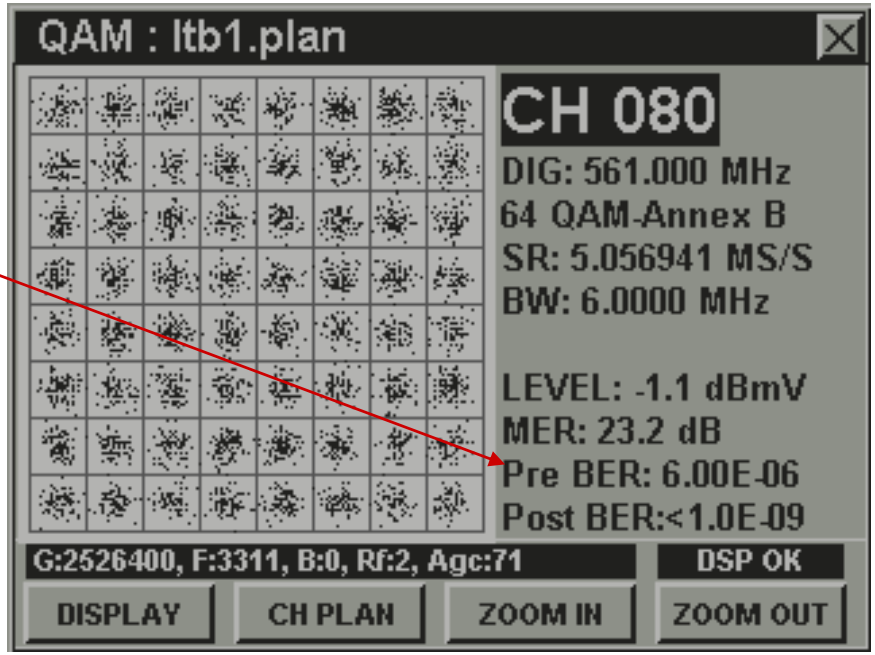
Impulse BER



- BER
  - Corrupted bits/total bits received
- Shows BER before and after FEC
- Errored Seconds
  - The number of seconds with at least one corrected codeword
- Severely Errored Seconds
  - The number of seconds with at least one uncorrectable codeword
- Valuable troubleshooting tool
  - Whenever there are errors use this screen to divide and conquer

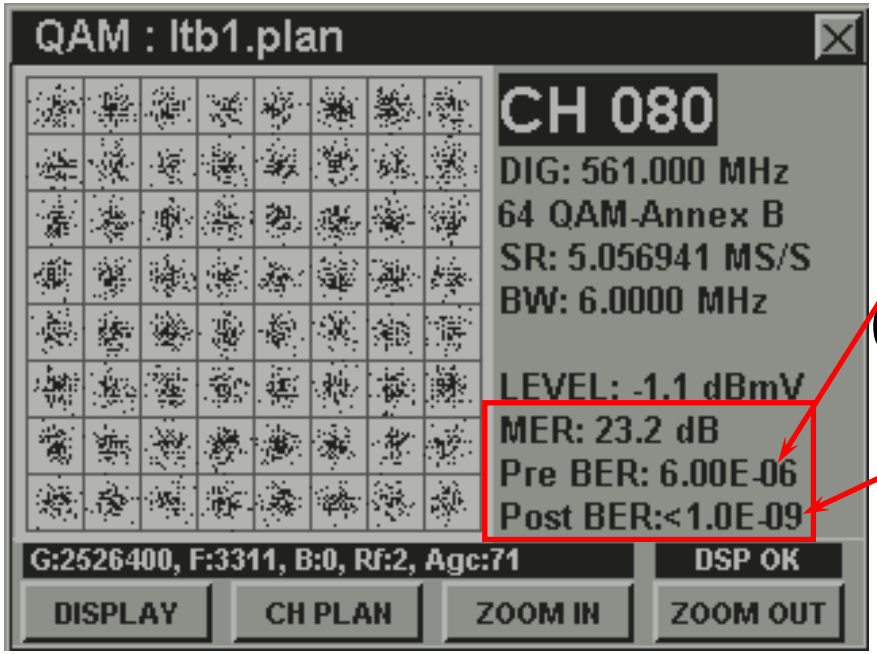
BER

- 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



Forward Error Correction

- FEC
  - Corrects errors to a point



Pre FEC BER
(Before Correction)

Post FEC BER
(After Correction)

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Troubleshooting the Return Path

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Components of The Guardian II System

- Guardian II integrated server package
- 9581 SST R4 Headend unit
- 8310 RSA
- Viewer II client software for NOC operations
- ADIA historical analysis suite
- SST Configure software
- Field units:
  - 860 DSPi
  - RSVP²

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Troubleshooting Ingress

- Compare local test point spectrum to headend/hub spectrum
- Use I-stop probe to load local test point and see if headend spectrum drops
  - If it drops the problem is farther down the line
  - If it doesn't the problem is closer to the headend/hub
  - Low-pass filter is also recommended

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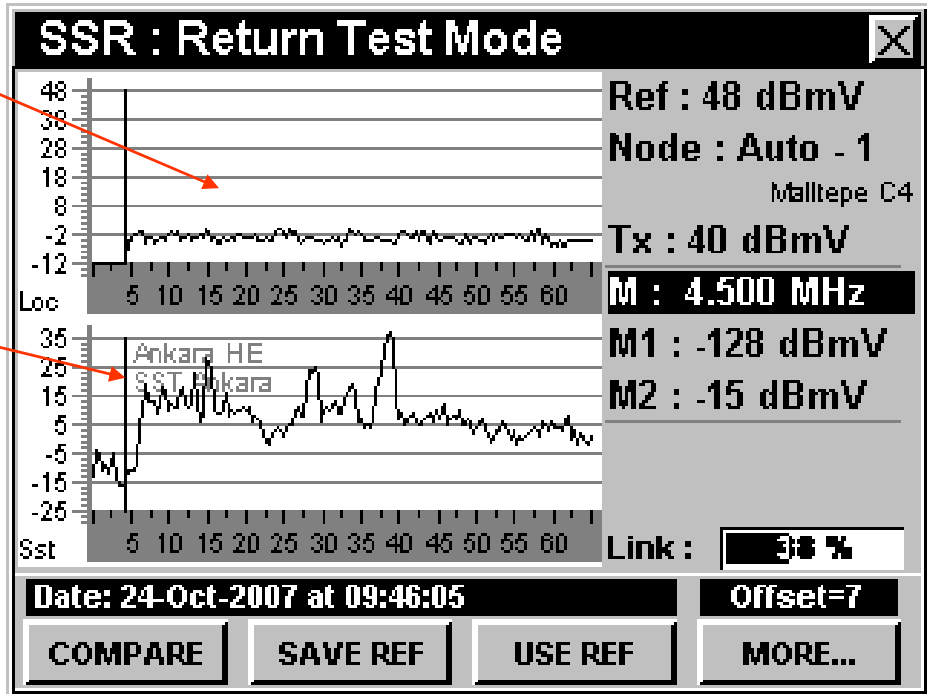
Reverse Ingress

- Top displays Local
- Bottom displays headend
- Move your location until you find the source of the ingress



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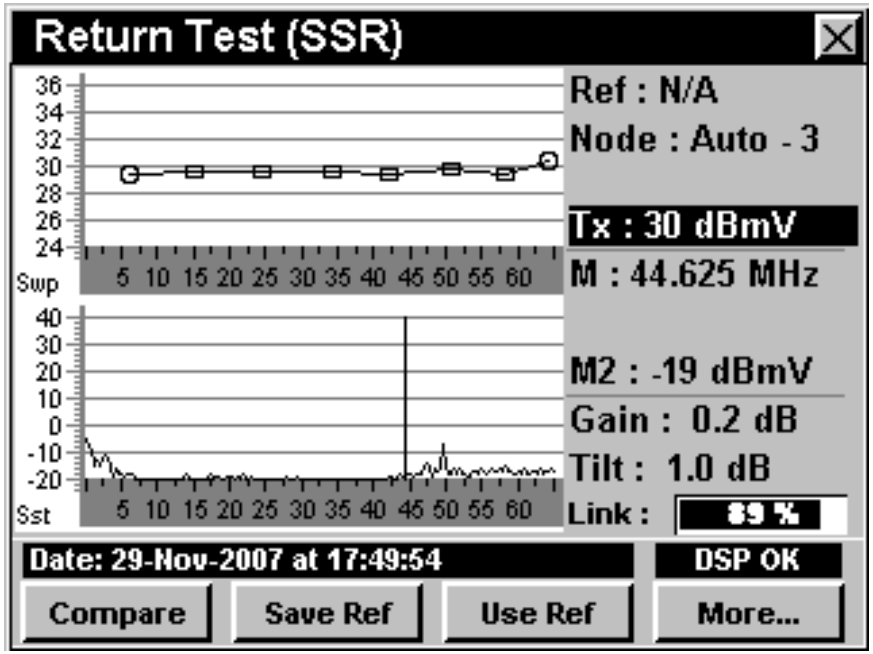
Return Sweep Mode



- Displays
  - Gain/Tilt
  - Frequency Response
  - Headend Ingress levels
- Gain Information
  - Difference between Headend nominal and sweep carrier level
- Tilt Information
  - Difference between low and high pilots carrier levels
- Pads and Equalizers
  - Gain/Tilt values of 0 are perfect
  - Values other than 0 indicate the change in Pad/EQ necessary to bring the system into alignment

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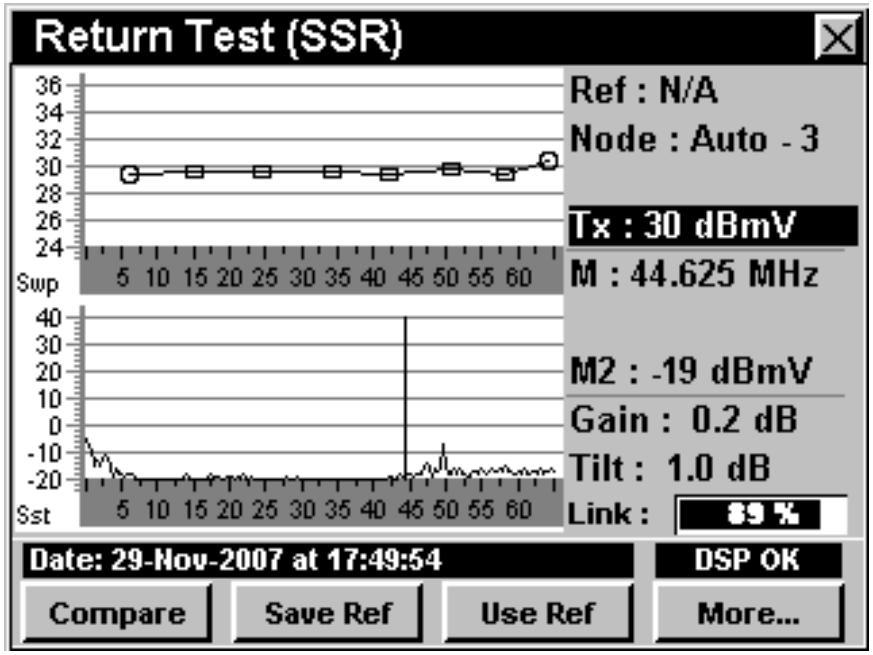
Return Sweep Mode



- Frequency Response Trace
  - Plots received (Headend) level for each sweep carrier
  - Scale per Division 2 dB
  - Ideal Trace is a flat line
- Impairments to frequency response
  - Damaged Cable
  - Damaged actives or passives
  - High Ingress Levels

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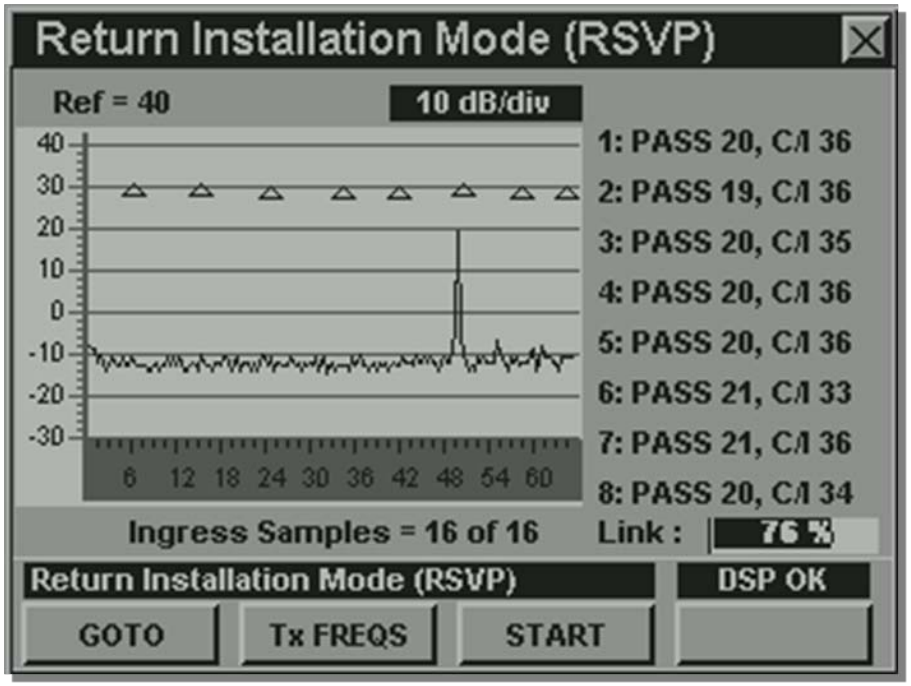
RSVP Installation Verification

- Continuity Test
  - Talks directly to the 9581 SST headend unit
- Measures the C/N
- Displays the test Results
- Shows a Pass or Fail



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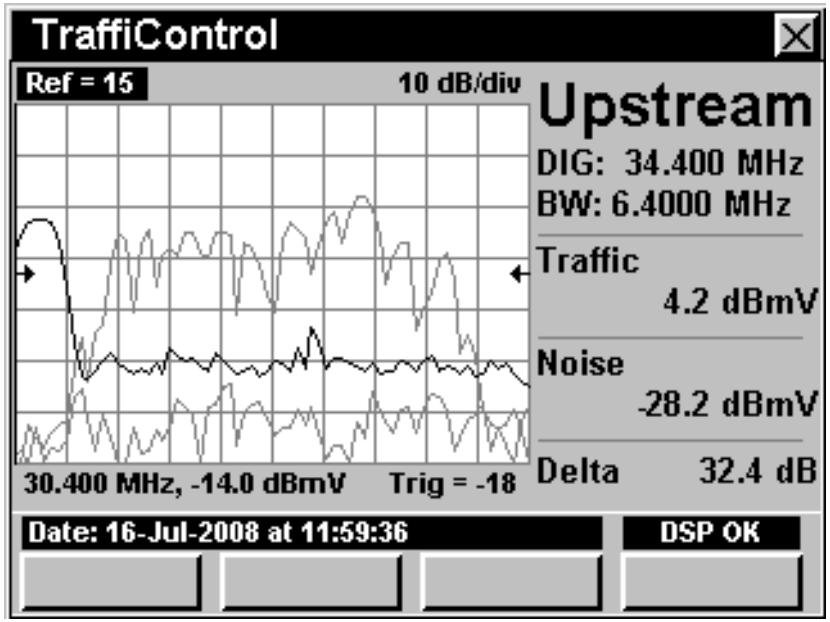
Troubleshooting transients in upstream signal bands

- Test feature uses limits to remove legitimate traffic from the spectrum view
- Removes the haystack and reveals the needle
- Provides insight in monitoring as well as troubleshooting
- Spectrum acquisition speed reveals fast transients

In-channel Upstream Spectrum Analysis

- Return spectrum is getting crowded, making inspection of spectrum problems difficult
- Test mode can be used to see the ingress or distortion “underneath” an upstream cable modem carrier, VoIP carrier, or any bursty signal
- Troubleshooting made easy
  - Divide & Conquer
  - Source typically a home



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Laser Clipping

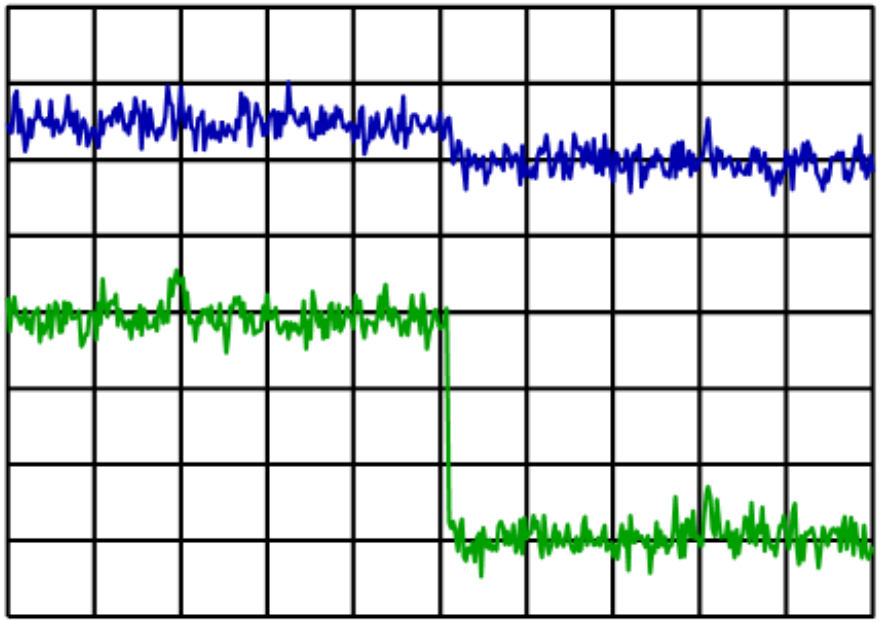
- Typically caused by input overload, operating in non-linear transfer range
- Where it shows up:
  - Return path spectrum, distortion products above max frequency range
  - Constellation – intermittent compression
  - Impulse BER – bit errors due to clipping

Understanding the Spectrum Analyzer

- Reference / Input
- Detector
- Sweep Time
- RBW
- dB/Div
- Frequency Tuning
- Max/Min Hold

Is It System Noise?

- Internal spectrum analyzer noise may be too high to allow system noise measurement
  - **use the disconnect test**



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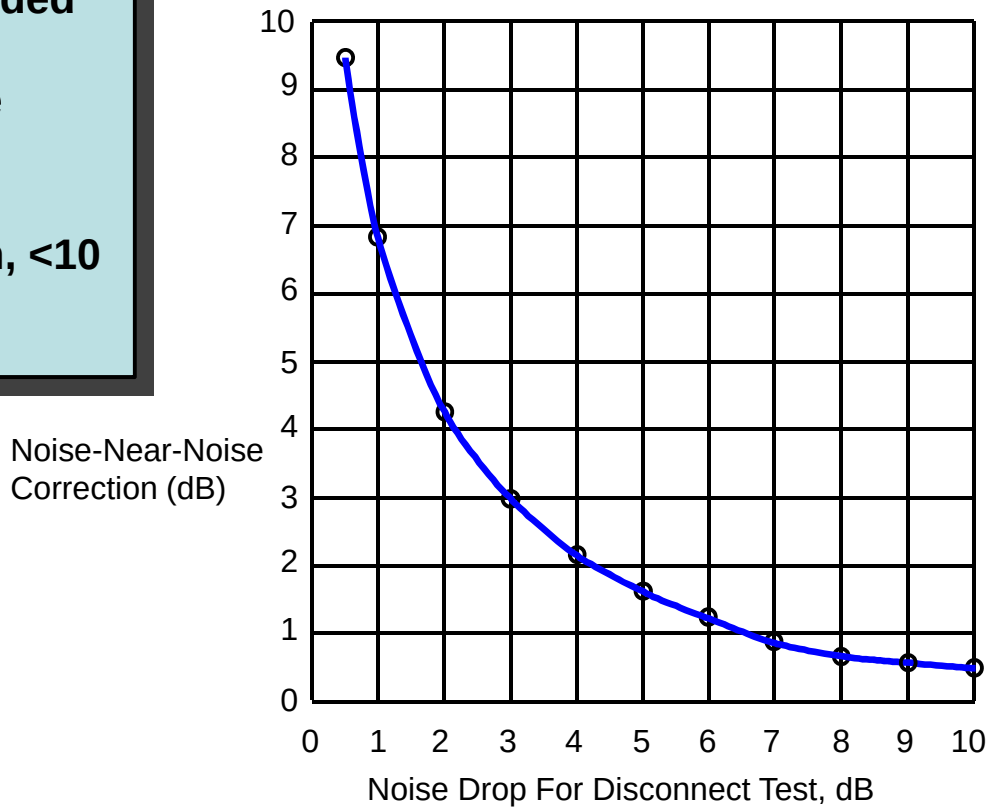
The Disconnect Test

- If > 10 dB drop, no corrections needed
- If > 3 dB drop, correct by using the graph below
- If < 3 dB drop, use a 20-30 dB gain, <10 dB noise figure preamplifier



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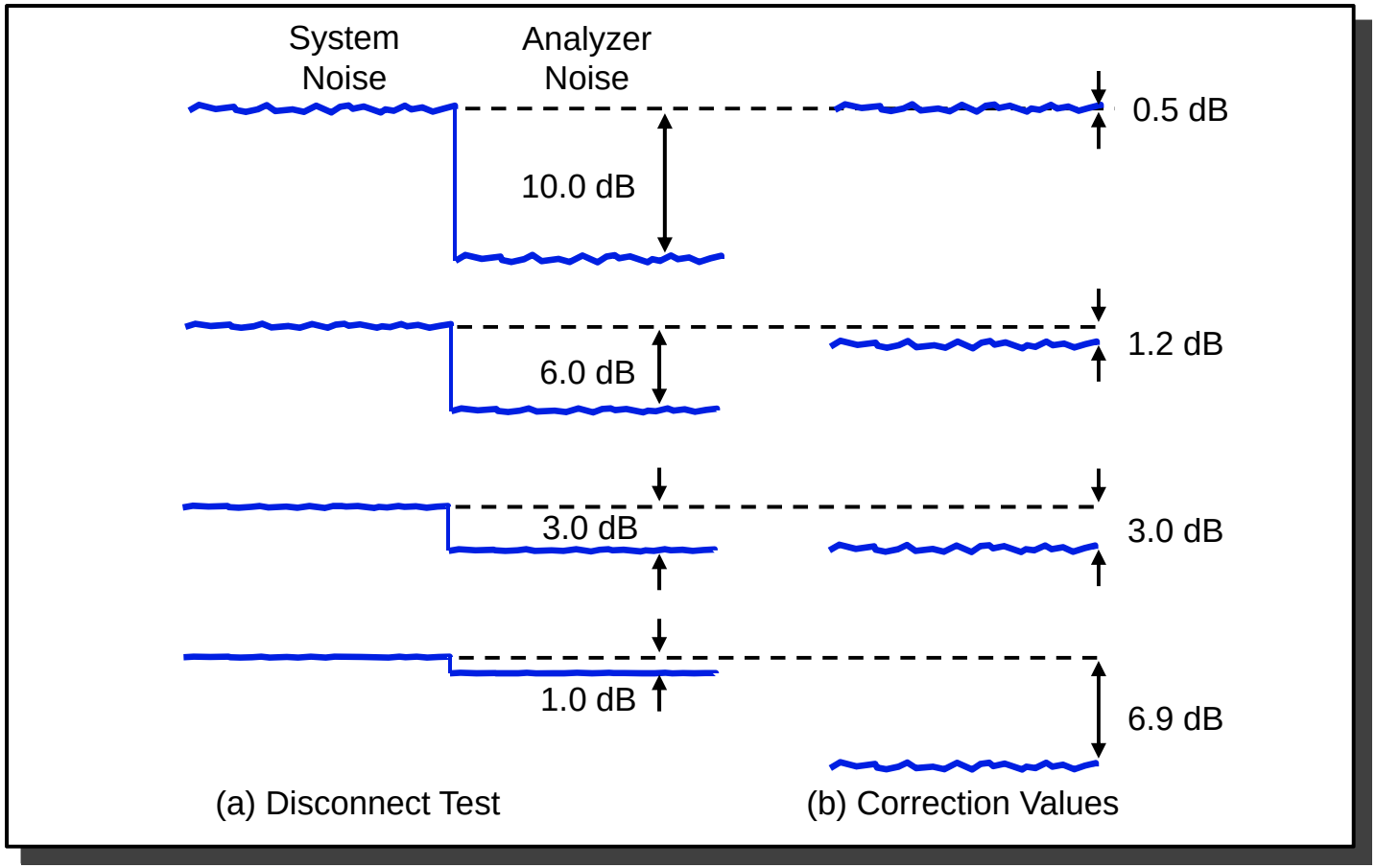
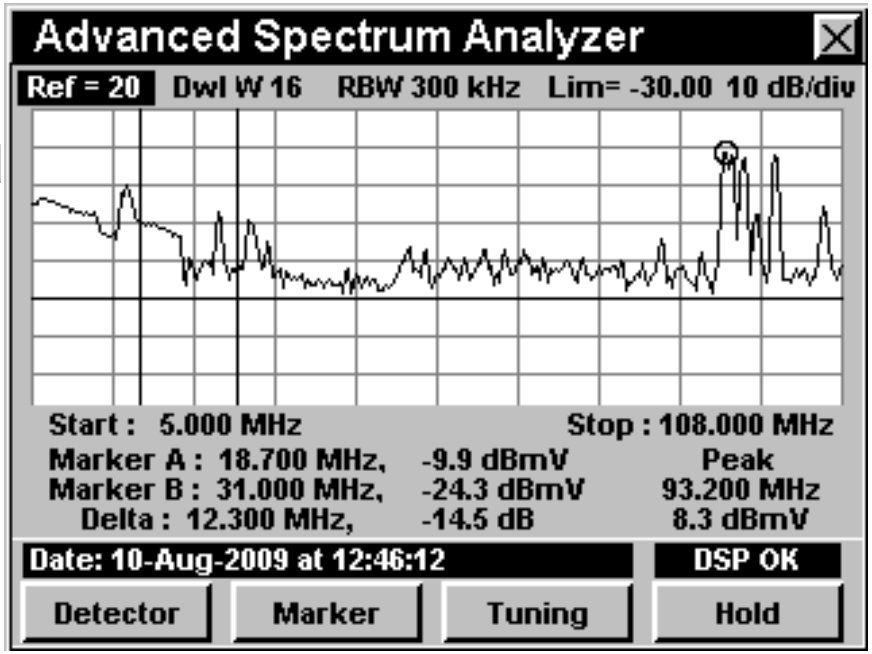
Correcting Analyzer for Noise-Near-Noise



Ingress Mitigation Test

- This is a test where you can quickly check the drop and home wiring for ingress



- Set Ref level so as to not over-load the meter
- Detector set for averaging
- RBW at 300 KHz
- 10 db/div
- Spectrum 5-108 MHz
- Use peak hold

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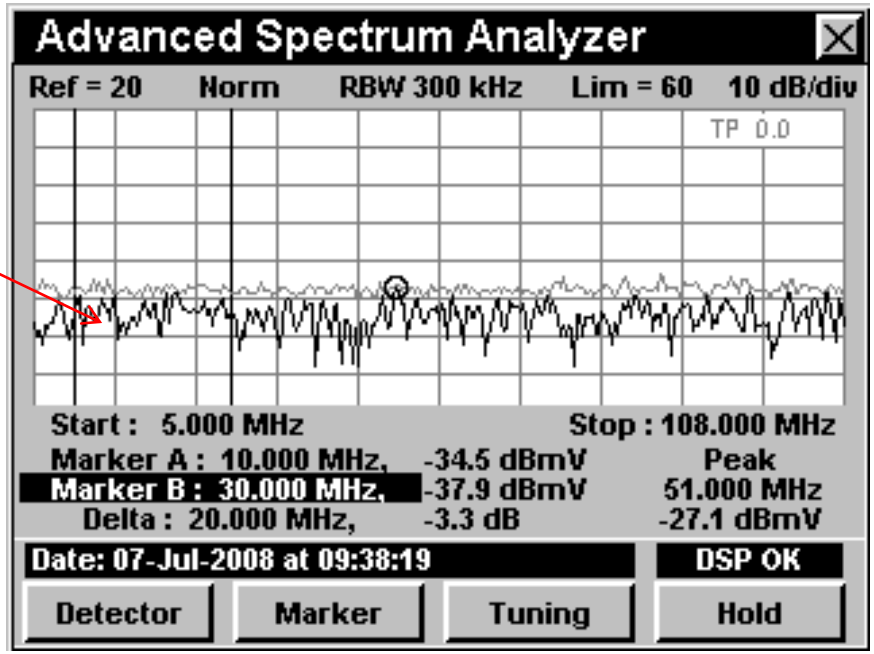
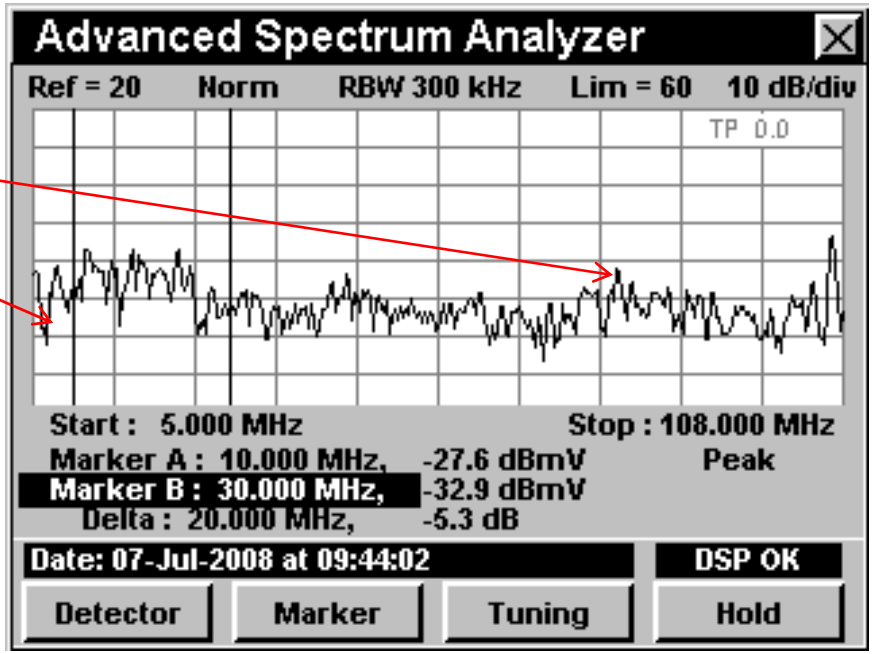
Ingress Mitigation Test

- What you should see is NOTHING!
- Just the noise floor



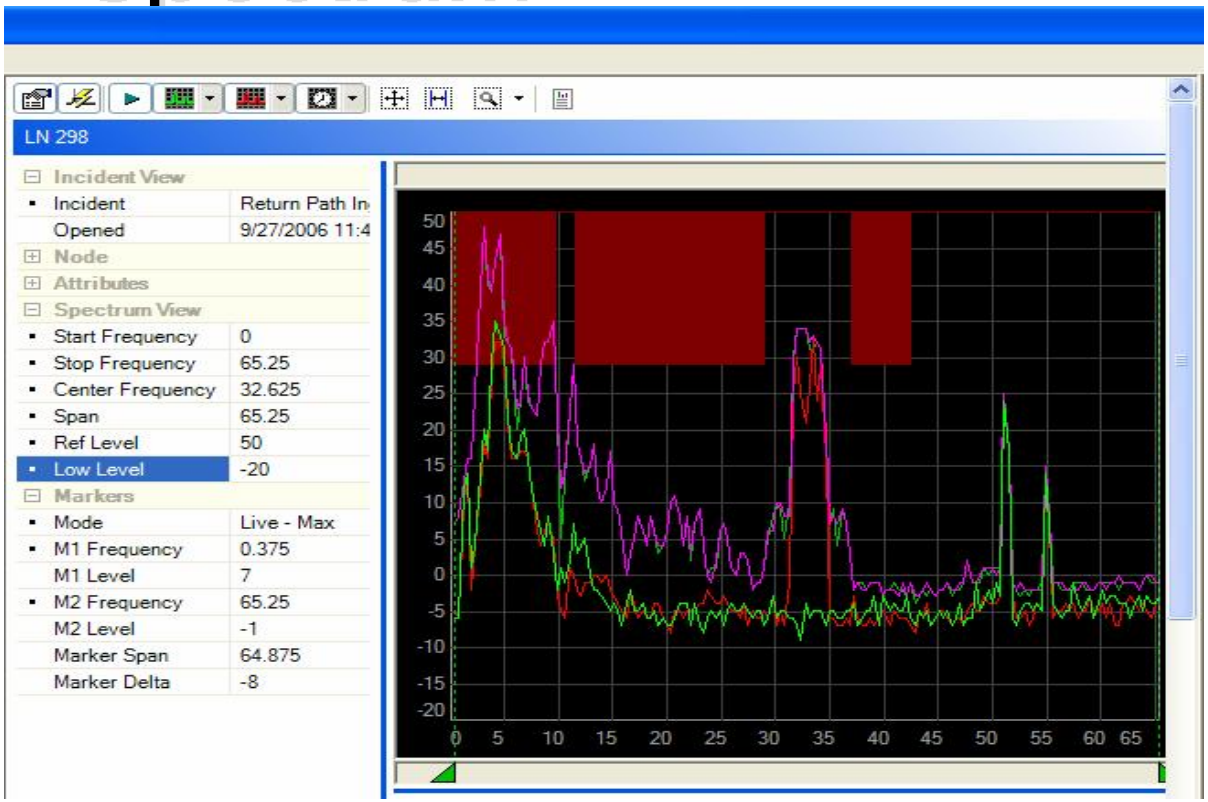
Ingress Mitigation Test

- Look for ingress by using the "Peak Hold" function
- Identify the problem by working back towards the house



Laser Clipping Return Path Spectrum

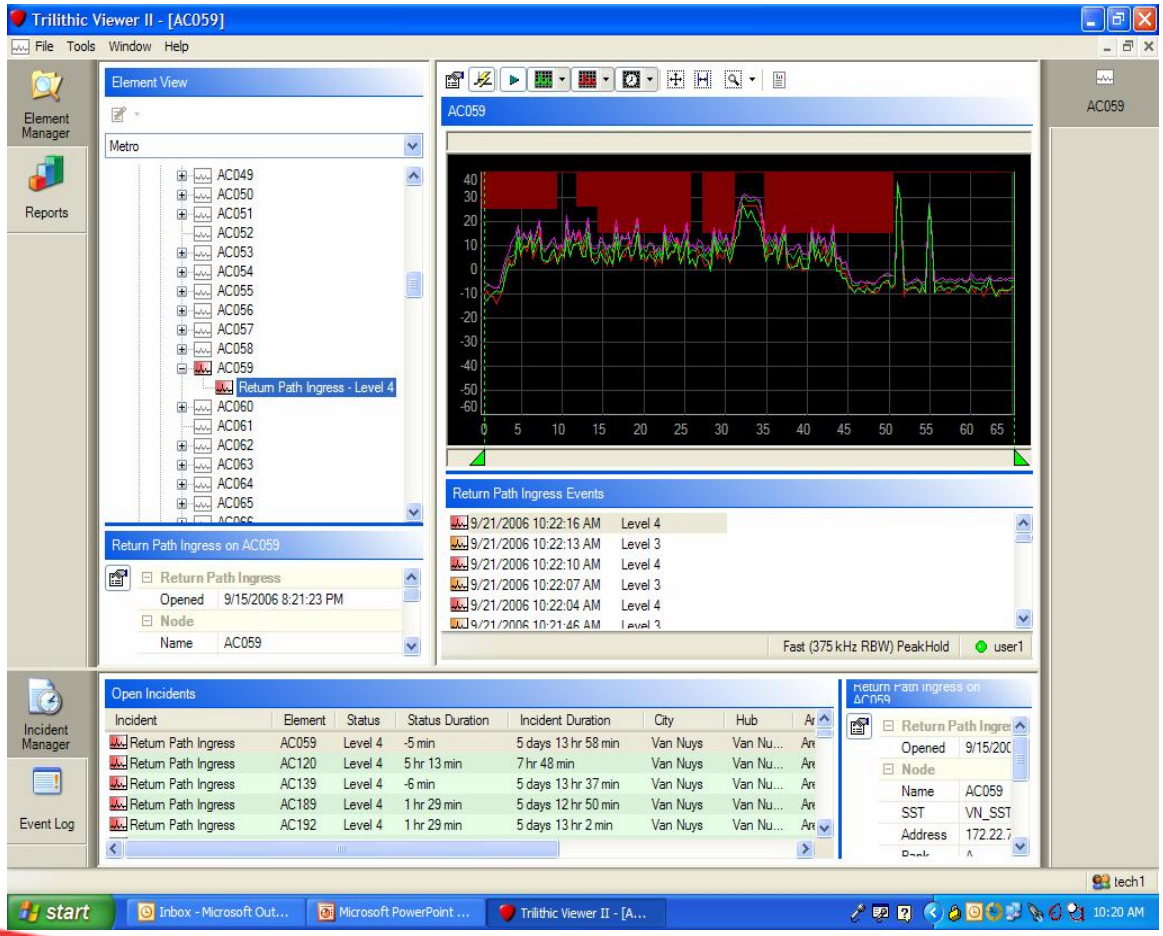
- Note the products above 42 MHz



Monitoring the Return

Viewer II User Interface

- Components
  - Status Tree
  - Incident Log
  - Alarm History
  - Spectrum Display



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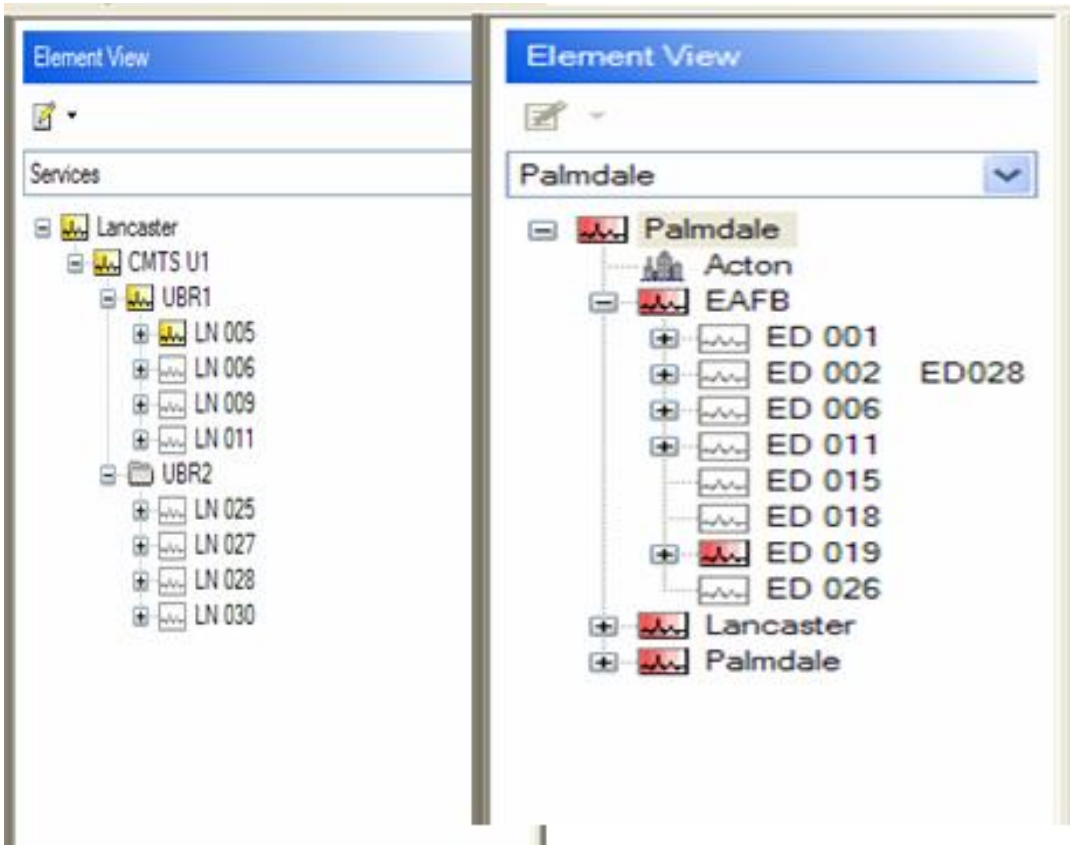
Node Status Tree

- Geography
  - Groups nodes by
    - City
    - Headend
    - Hubsite
- Services
  - Groups nodes by
    - CMTS
    - Blade



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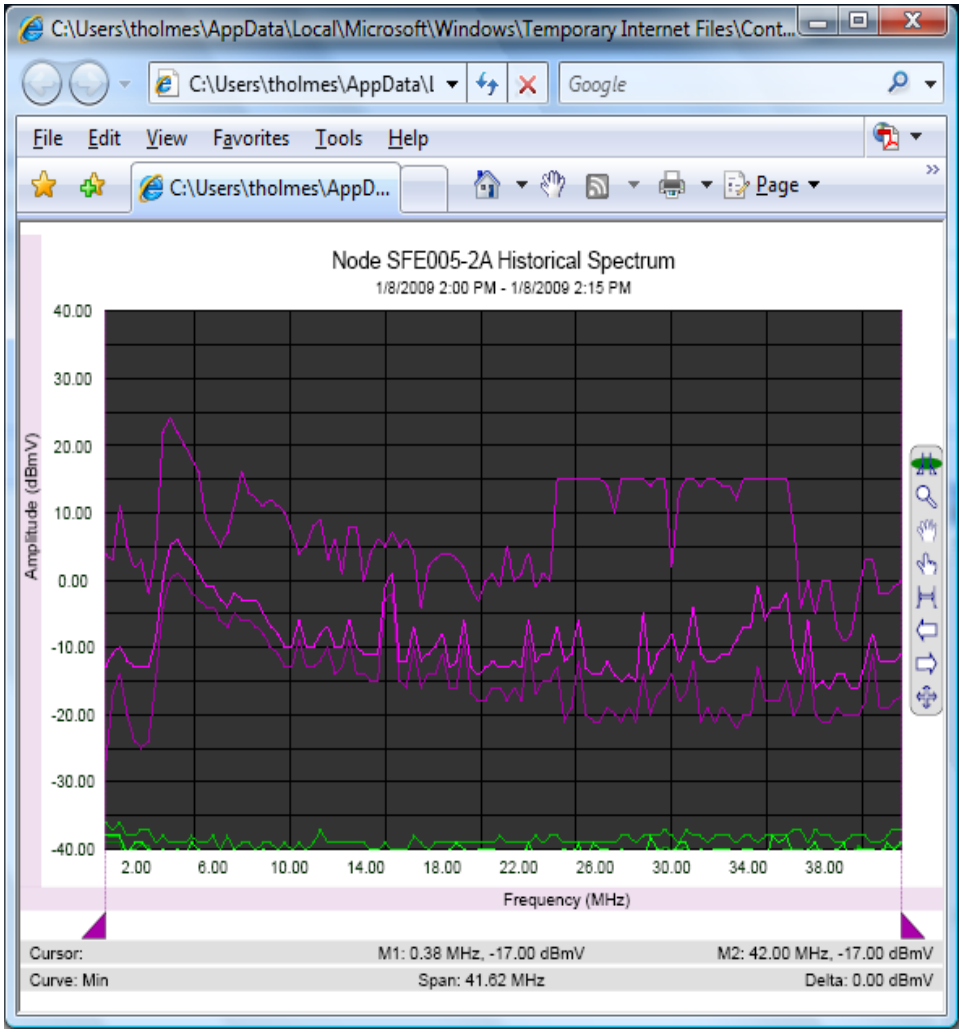
ADIA Historical Analysis Server

- Collects spectral information from the 9581 SST headend units
  - Spectral information contains Max/Min/Avg ingress information collected in 9581 SST and compressed into 15 minute summaries
  - Return Path performance information against user specified limits
- Provides database storage for 3000 nodes over a one year time period

TRILITHIC

Spectral History

- Review ingress signature of selected node
  - Over user specified time period
  - Max/Min/Avg traces
  - With live spectral overlay



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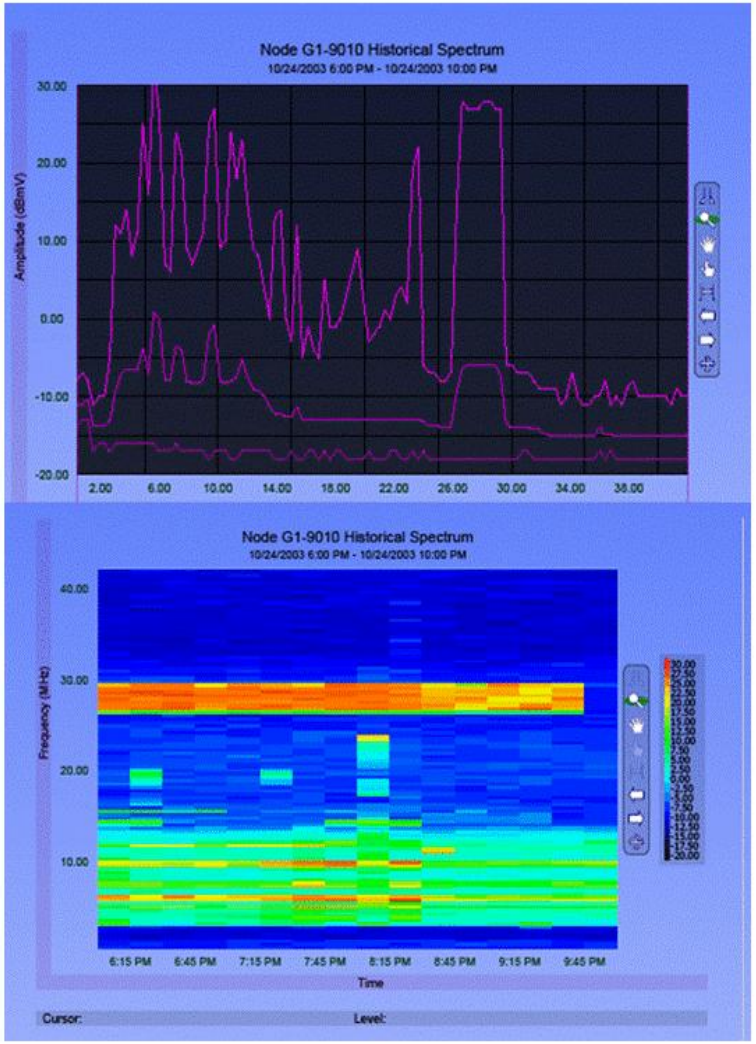
Spectral History

- 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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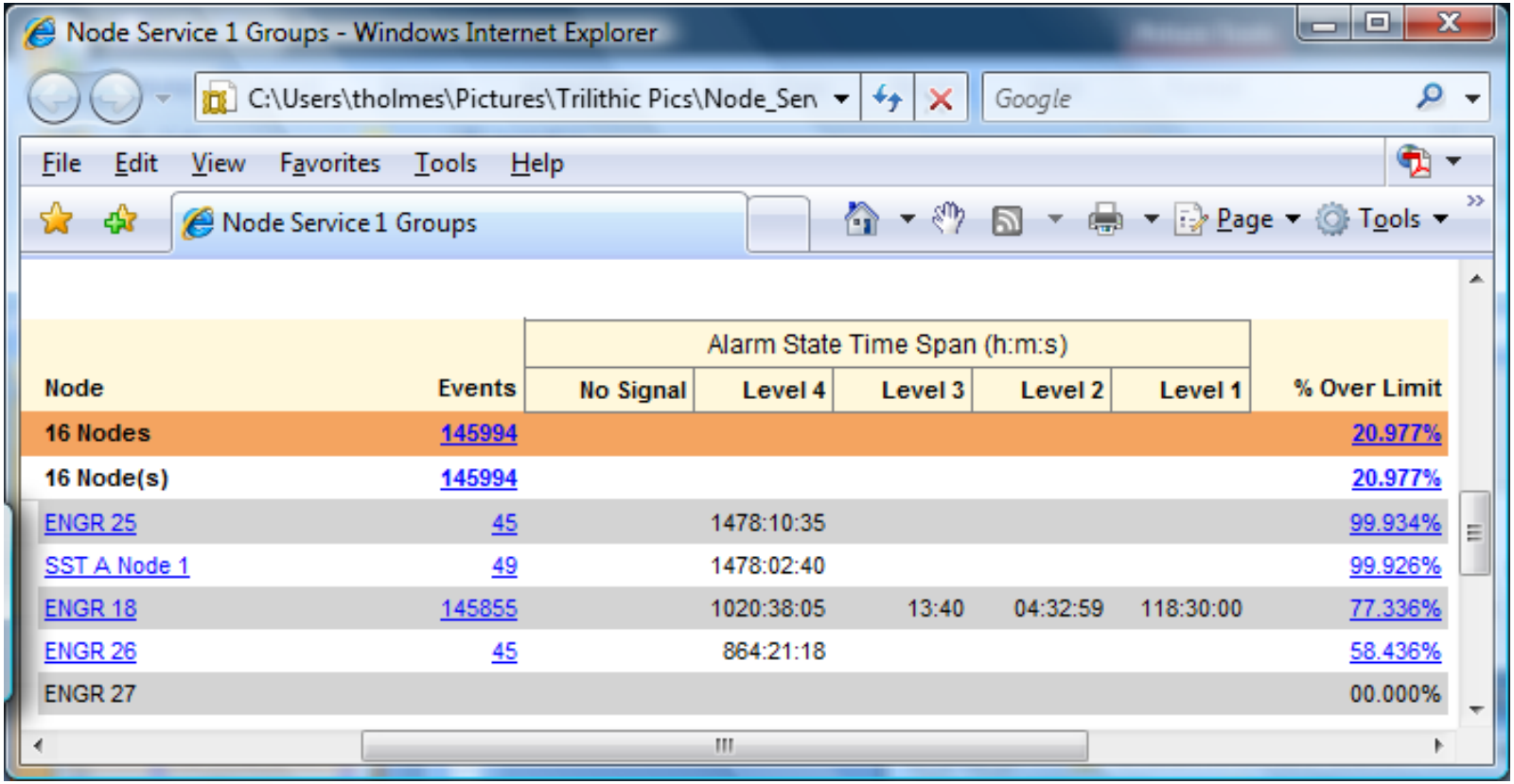
ADIA Node Service Report



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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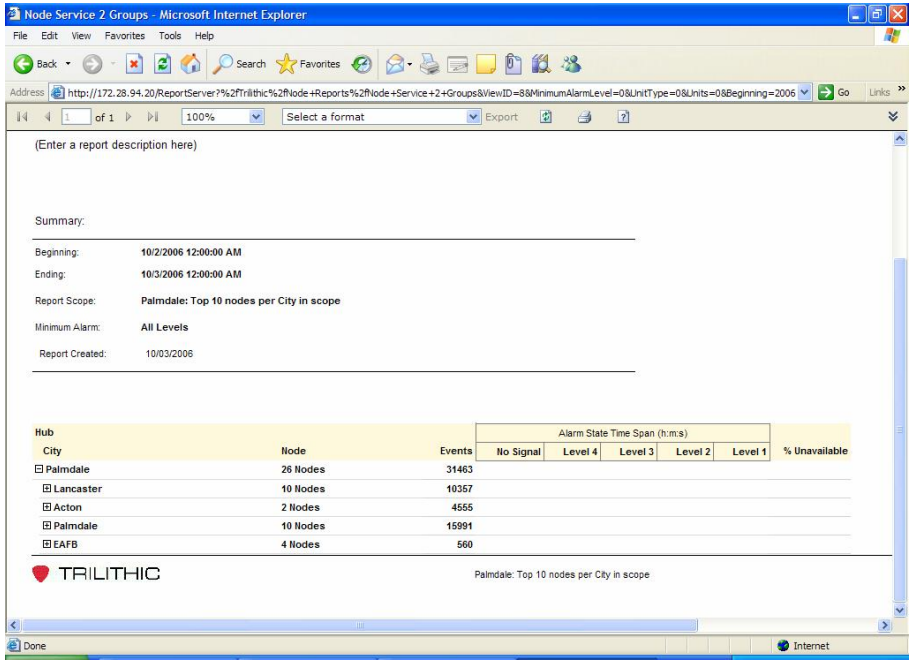
Return Path Reports

- Worst Offenders List
  - Provides summary of worst offending nodes by alarm level over specified time period
- Node Alarm Summary
  - Allows user to view alarms over specified time frame
- Alarm History Over Time
  - Allows user to view alarm history over a time period summarized by hour, day, or month



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Demonstration

Impairments from :

- **Forward Path Ingress**
- **Return Path Ingress**

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Review

- DOCSIS 3.0 improves competitive position, and revenue
- Reliability is crucial, testing helps
- Practical preparation for D3 deployment and preventive maintenance check lists
- Practical D3 signal transmission quality tests
- Tests for troubleshooting
- Test equipment D3 evolution

Response to Your Questions!!!!

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Thank you-Gracias-Merci-Masha Danki…

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