



Broadband Instruments and Systems



Technical Training Seminar on
“Practical Field Testing DOCSIS 3.0”
for
CCTA Member Companies
August 24, 25 and 26, 2010 San Juan, Puerto Rico

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COMMUNICATIONS INC.

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Solutions efficaces aux télécommunications à large bande

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 TRILITHIC

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





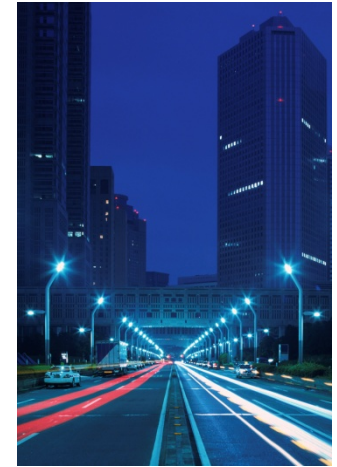
DOCSIS 3.0

- **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





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





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

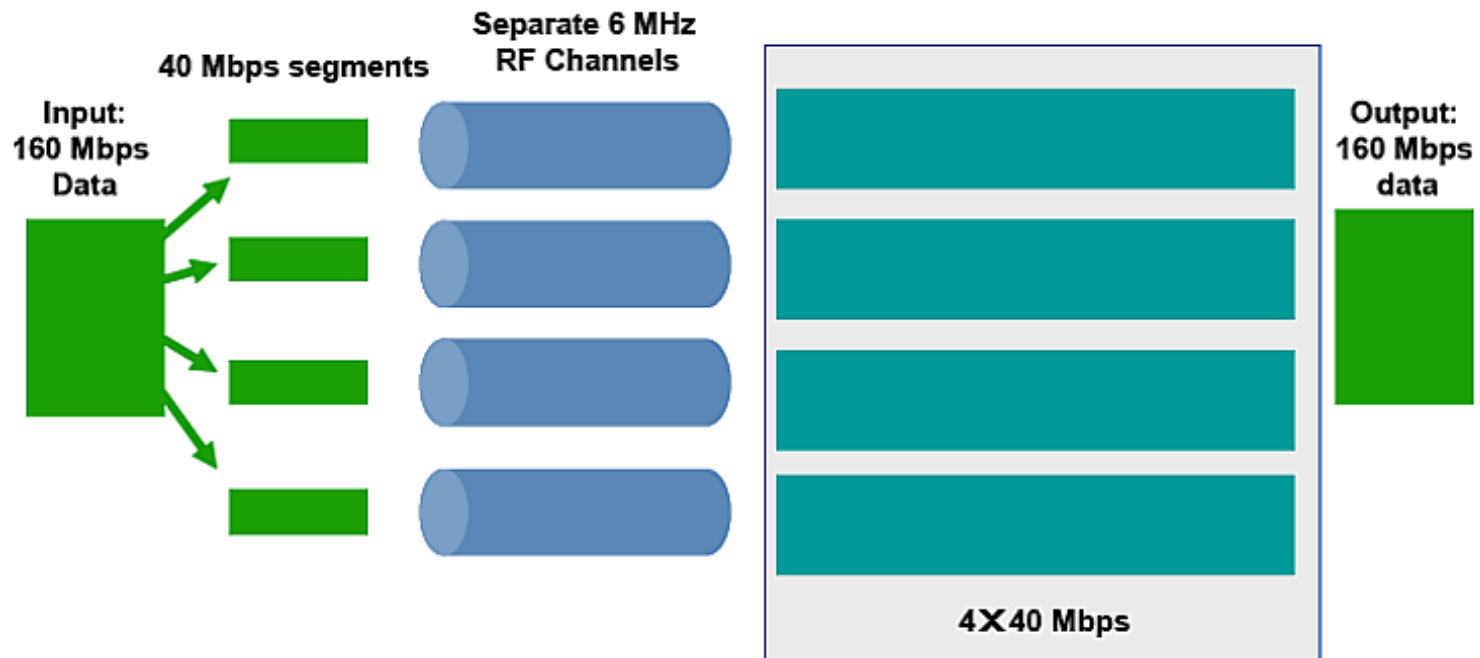
- **Upstream Capacity with 6.4MHz & 64QAM**
 - Two channels, 60 Mbps
 - Three channels, 90 Mbps
 - Four channels, 120 Mbps
- **Downstream Capacity with 6MHz & 256QAM**
 - Two channels, 80 Mbps
 - Three channels, 120 Mbps
 - Four channels, 160 Mbps
 - **Eight channels, 320 Mbps**





Channel Bonding

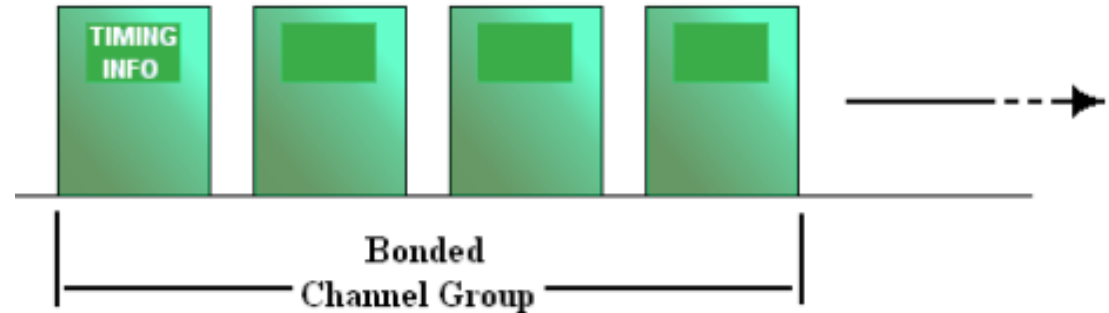
- Example:



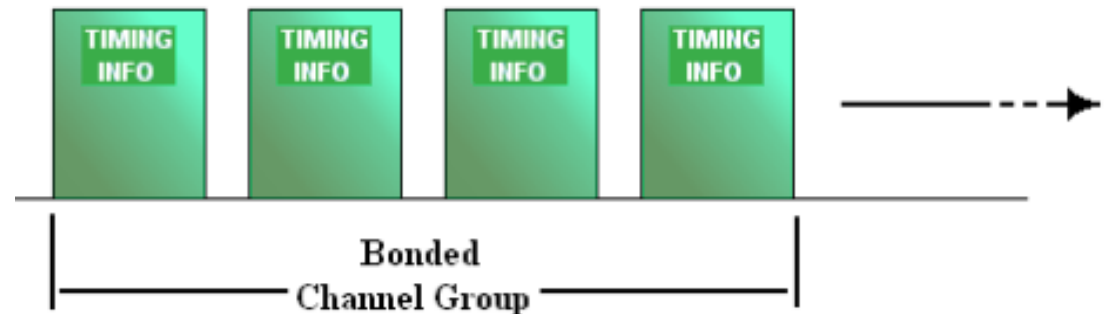


“Primary” Channels

- One Channel in Group carries timing info for whole group



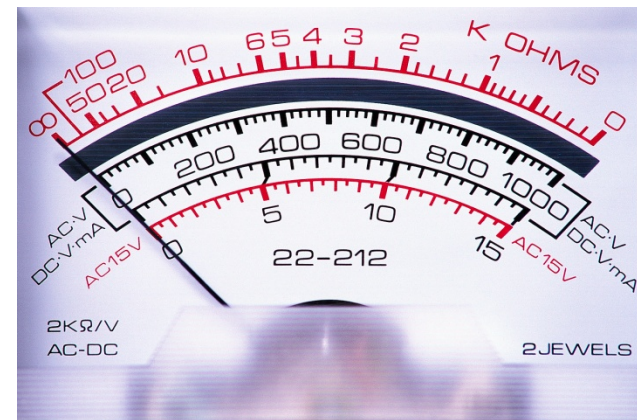
- Each Channel in Group carries its own timing information





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





DOCSIS 3.0 Checklist

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





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)





Installation Testing Pays Off

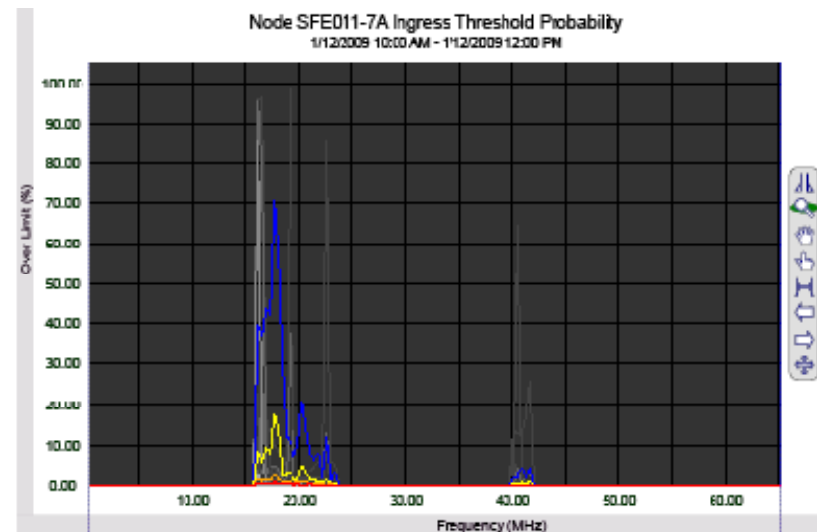
- Comprehensive with minimal impact on Tech time
 - Establishes baseline
 - “Certification” leads to higher quality and reliability
- Level scan, MER, BER, cable modem statistics, ingress, leakage





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





Post-Deployment Testing

- Installation
 - Cable modem statistics
 - Throughput

Cable Modem Statistics

19-May-2009 Chrg 14.32V 31 C COM 14:23:52

Downstream					
Frequency	Rx Level	MER	preBER	postBER	
819.00 MHz (256 QAM)	4.02 dBmV	38.60 dB	1.00 E-09	1.00E-09	
825.00 MHz (256 QAM)	4.52 dBmV	37.85 dB	1.00 E-09	1.00E-09	
831.00 MHz (256 QAM)	3.63 dBmV	38.81 dB	1.00 E-09	1.00E-09	
837.00 MHz (256 QAM)	3.61 dBmV	38.80 dB	1.00 E-09	1.00E-09	

Upstream	
Frequency	Tx Level
21.80 MHz (64 QAM-1)	39.35 dBmV
25.00 MHz (64 QAM-1)	40.57 dBmV
28.20 MHz (64 QAM-1)	39.82 dBmV
31.40 MHz (64 QAM-1)	39.42 dBmV

Cable Modem US30_1.2.0.10pre7 DOCSIS 3.0

Goto IP Info Config File Change ID

Throughput (IP 192.168.6.101)

Server IP: 207.250.51.174

Upstream File: 00_1a_e9.dat

Downstream File: 860.DAT

Upstream Rate: 93.56 MBits/Sec

Downstream Rate: 147.91 MBits/Sec

Date: 26-Jun-2009 at 10:51:32 port 28657

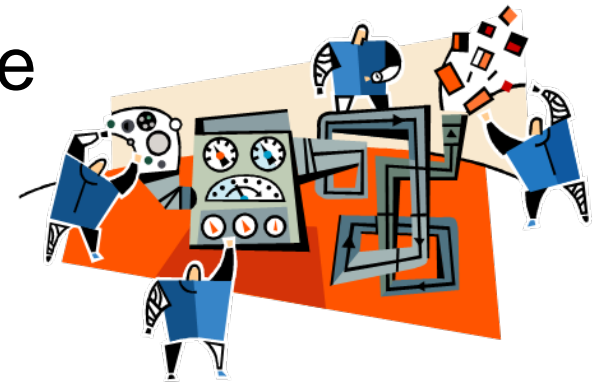
Goto Upstream Dnstream Modem





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





Typical D3 Autotest

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

☐ Schedule		☐ Step 7 - Check Modem Stats	
• Timing	Immediate One-Time	☐ Parameters	
☐ Test Steps		• Modem MAC	MAC #1
• Step 1	MER/BER	• Downstream Frequency	821.000 MHz
• Step 2	Modem Stats	• Modem Mode	DOCSIS 2.0
• Step 3	VoIP RTP	• Annex Type	Annex B
• Step 4	Throughput	• Upstream Id	Use Setup Menu
• Step 5	Modem Stats	☐ Limits	
• Step 6	Modem Stats	• Minimum Launch Level	30 dBmV
• Step 7	Modem Stats	• Maximum Launch Level	50 dBmV
• Step 8		• Minimum Receive Level	-10 dBmV
• Step 9		• Maximum Receive Level	40 dBmV
• Step 10			
• Step 11			
• Step 12			
• Step 13			
• Step 14			
• Step 15			
• Step 16			





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

Automatic Test Results	
15-Jul-2008	Batt 7.07V 23 C IP 13:50:09
Step #1 QAML,Fail	Step #9
Step #2	Step #10
Step #3	Step #11
Step #4	Step #12
Step #5	Step #13
Step #6	Step #14
Step #7	Step #15
Step #8	Step #16
Checking Data Against Limits	
	DSP OK
	Load





Typical Autotest for D3

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

Automatic Test Results
15-Jul-2008 Batt 7.07V 24 C IP 13:50:32

Test Results

QAM - Fail (MER Min Limit)	
Channel 84 Measurement.....	-5.78 dBmV
Digital Min Limit.....	-10.00 dBmV
Digital Max Limit.....	0.00 dBmV
MER Measurement.....	29.34 dB
MER Min Limit.....	30.00 dB
EVM Measurement.....	
EVM Max Limit.....	

Automatic Test Results
15-Jul-2008 Batt 7.07V 24 C IP 13:50:32

Test Results

Pre BER Measurement.....	1.00E-05
Pre BER Max Limit.....	5.00E-08
Post BER Measurement.....	<1.0E-09
Post BER Max Limit.....	1.00E-09

Press ENTER to Continue

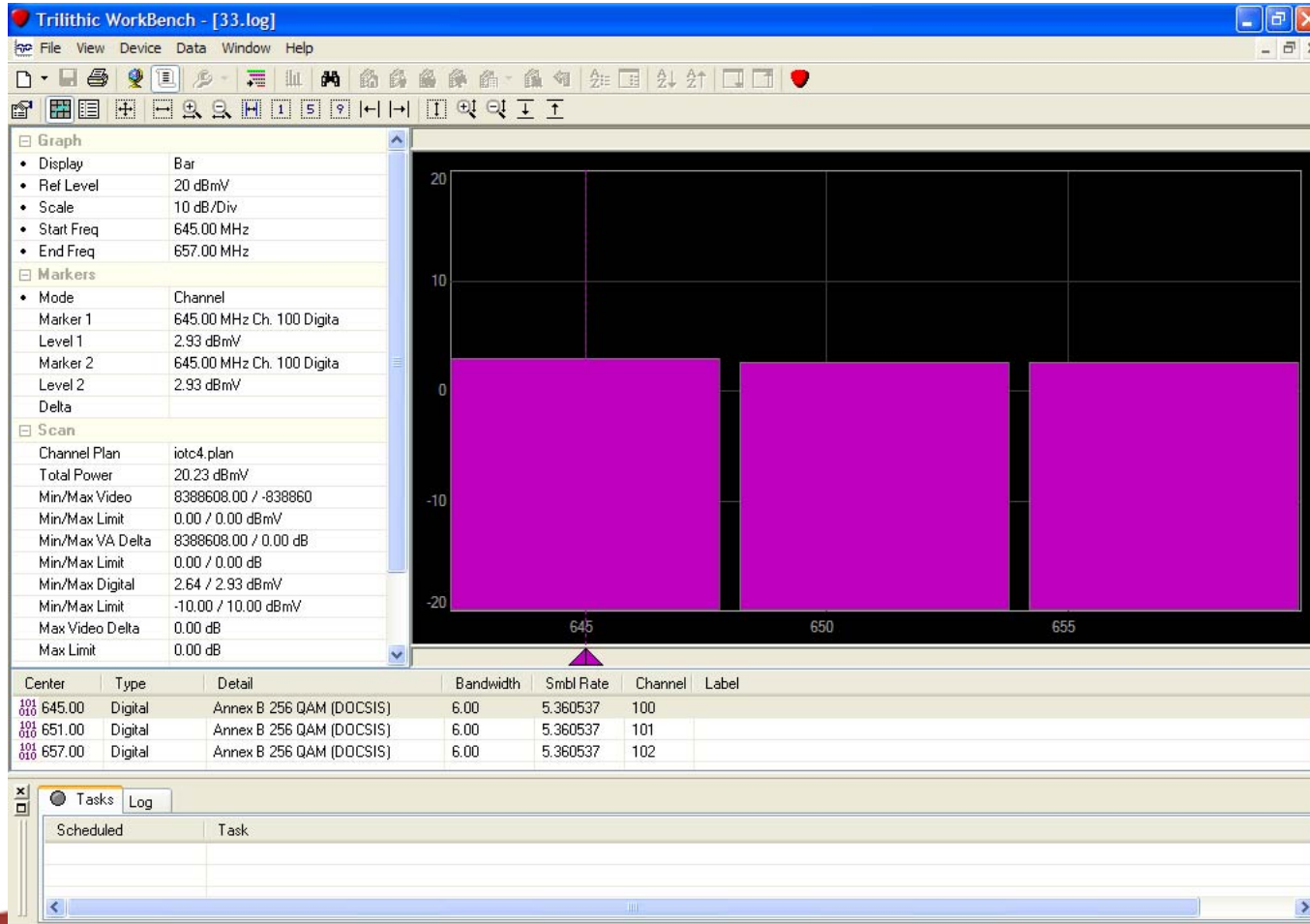
Checking Data Against Limits DSP OK

Load





D3 Autotest Results



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D3 Autotest Results

Trilithic WorkBench - [33.log]

File View Device Data Window Help

Graph

Zoom	256 / 256
View	(-15,-15) - (15,15)

QAM

Channel Plan	iotc4.plan
Level	2.74 dBmV
Min/Max Limit	-8.00 / 8.00 dBmV
MER	39.67 dB
Min Limit	32.00 dB
EVM	0.0 %
Max Limit	Not Tested
Pre-FEC BER	<1.0E-9
Max Limit	9.00E-6
Post-FEC BER	<1.0E-9
Max Limit	1.00E-9
Cable Velocity Factor	87.5 %
Limits Result	PASSED
DSP Result	OK

Vid/Ctr	Type	Detail	Aud/BW	SAP/SR	Channel	Label
645.00	Digital	Annex B 256 QAM (DOCSIS)	6.00	5.360537	100	

Tasks Log

Scheduled	Task
-----------	------



D3 Autotest Results

Trilithic WorkBench - [33.log]

File View Device Data Window Help

CM Stats

Parameter	Value
Upstream Frequency	28.800 MHz
Upstream Rate	5120.000 KSPS
Upstream Power	50.90 dBmV
Min/Max Limit	32.00 / 53.00 dBmV
Upstream Modulation	64 QAM
Upstream Id	2
Downstream Frequency	645.000 MHz
Downstream Rate	5.360537 MSPS
Downstream Power	0.35 dBmV
Min/Max Limit	-8.00 / 8.00 dBmV
Downstream Modulation	256 QAM
Downstream Bandwidth	6.00 MHz
Downstream Signal/Noise	34.87 dB
Downstream Annex	Annex B
DOCSIS Mode	2.0
MAC Address #	1
MAC Address	00-05-CA-40-D1-28
Test Result	PASSED

CM Stats

Parameter	Value
Upstream Frequency	28.800 MHz
Upstream Rate	5120.000 KSPS
Upstream Power	50.90 dBmV
Min/Max Limit	32.00 / 53.00 dBmV
Upstream Modulation	64 QAM
Upstream Id	2
Downstream Frequency	645.000 MHz
Downstream Rate	5.360537 MSPS
Downstream Power	0.35 dBmV
Min/Max Limit	-8.00 / 8.00 dBmV
Downstream Modulation	256 QAM
Downstream Bandwidth	6.00 MHz
Downstream Signal/Noise	34.87 dB
Downstream Annex	Annex B
DOCSIS Mode	2.0
MAC Address #	1
MAC Address	00-05-CA-40-D1-28
Test Result	PASSED

Tasks Log


Scheduled	Task

This document is a screenshot of the Trilithic WorkBench software interface. The main window displays two side-by-side tables of 'CM Stats' for a DOCSIS 3.0 device. Both tables show identical data, including upstream and downstream parameters like frequency, rate, power, modulation, and bandwidth. The 'Test Result' for both is 'PASSED'. At the bottom, there is a 'Tasks Log' window with a table for tracking scheduled tasks. The interface includes a menu bar (File, View, Device, Data, Window, Help) and a toolbar with various icons for file operations and device management.



D3 Test Macro Summary Report

- Results may be retained, displayed in supporting software

TDM

860 DSP Macro Summary

Macro: docsis3
Result: Failed
Test Date/Time: 7/15/2016 10:39:29 AM
Channel Plan: bond1 plan
Meter Operator: China#2
Meter Cal Date/Time: #2002007 1:58:12 PM

Macro Summary

QAM Ch 01:	Failed
QAM Ch 02:	Failed
QAM Ch 03:	Failed
QAM Ch 04:	Failed

Channel Detail

Channel	Frequency	Level	VIA Delta	C/N	Hum	MER	PreFEC BER
01	507.000	LV	-4.29			MC 30.59	BE 30-7
02	573.000	LV	-4.34			MC 30.25	BE 75-7
03	579.000	LV	-0.52			MC 29.60	BE 66-6
04	585.000	LV	-0.78			MC 29.34	BE 10-5

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





Transmission System Troubleshooting Tools



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



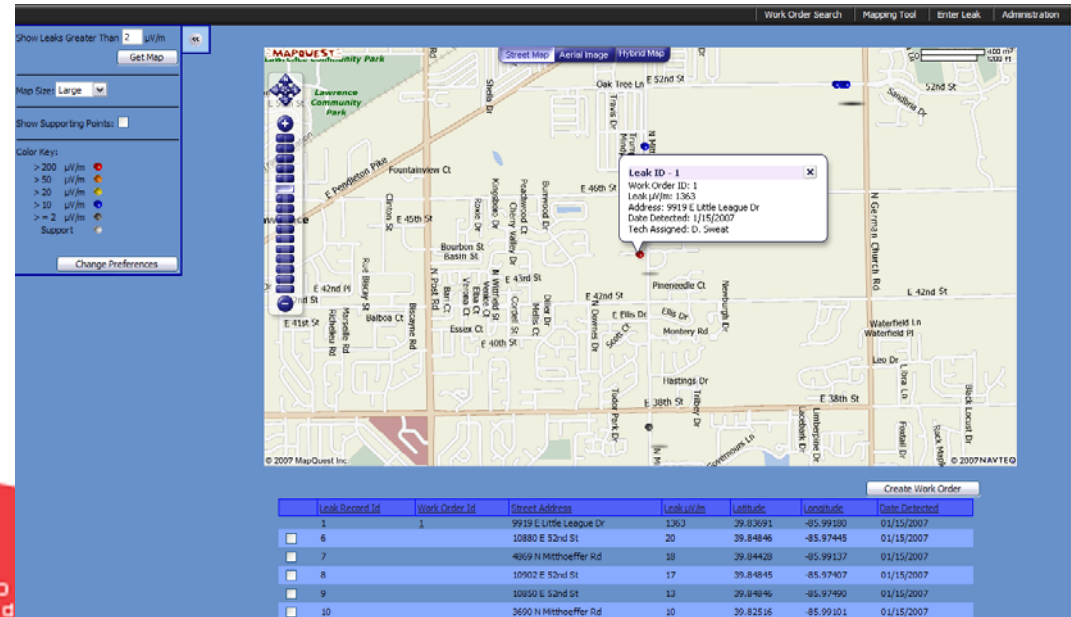
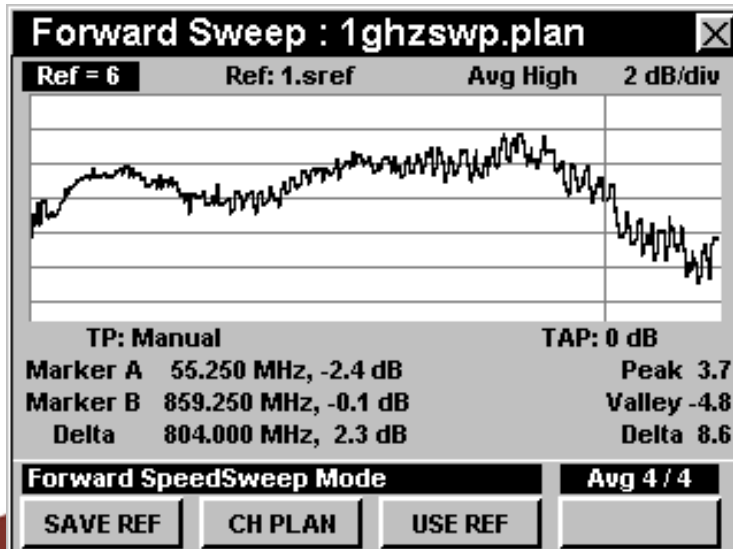
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Plant Performance Testing

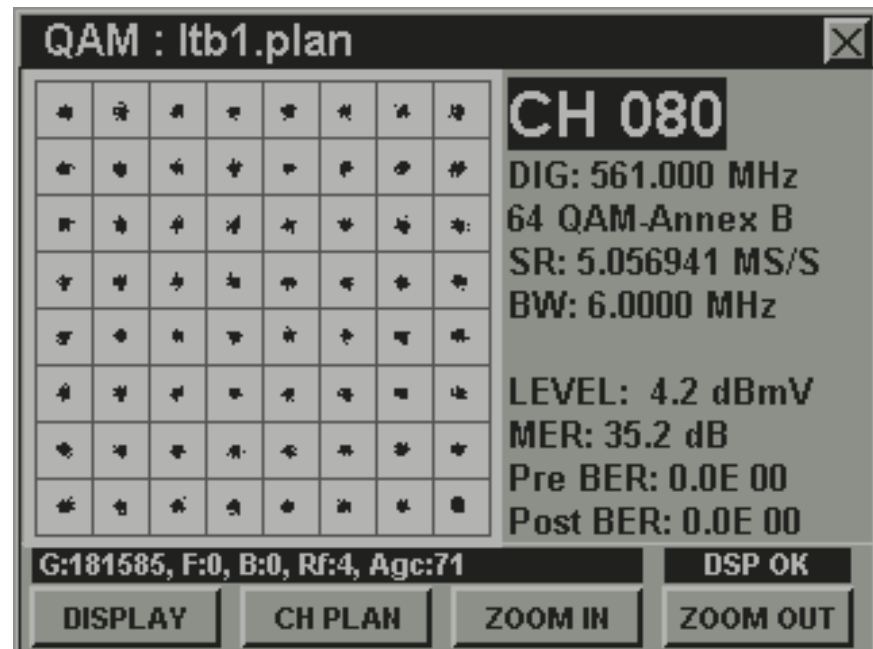
- Forward and reverse sweep
- Upstream QAM analysis from EOL
- Leakage (tightened threshold?)





MER

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





Troubleshooting Low MER

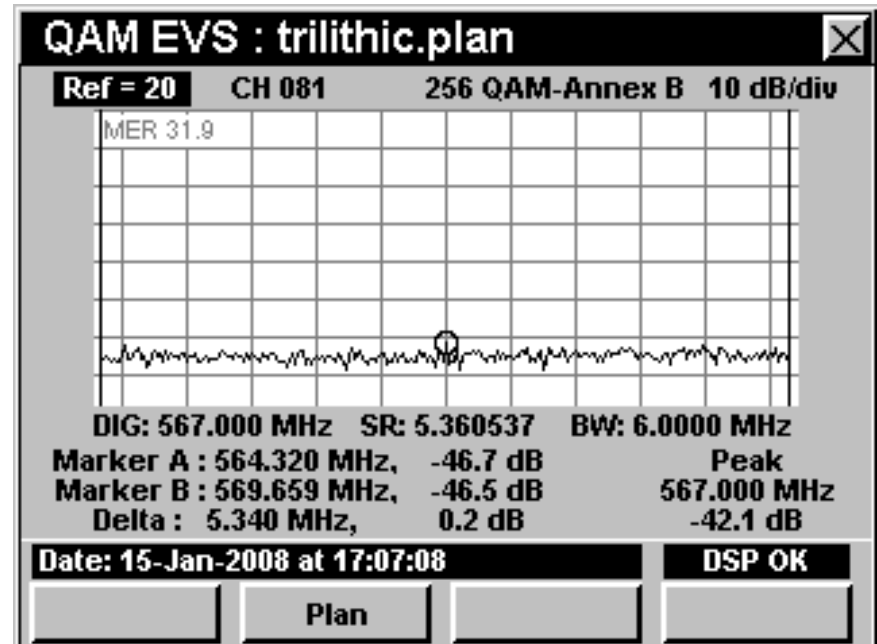
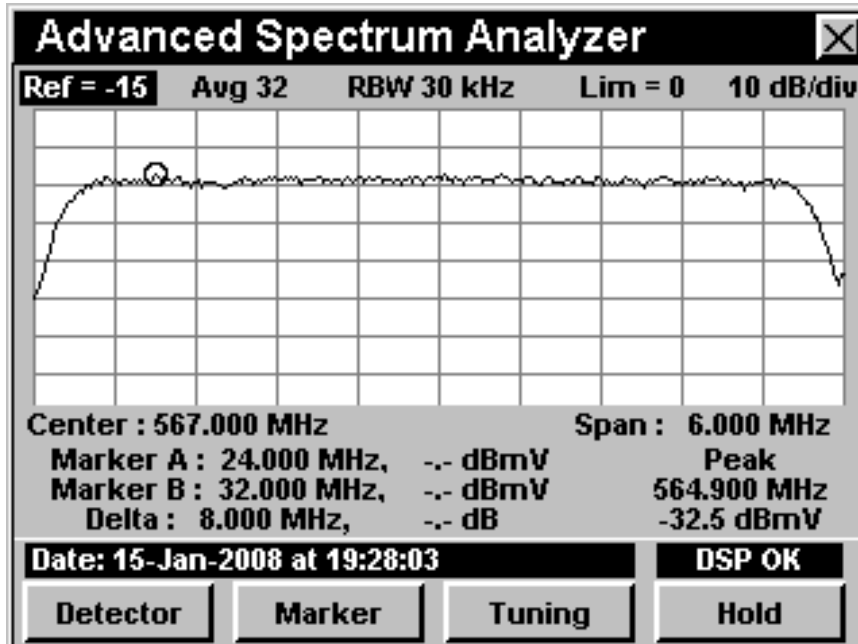
- Is it noise or interference?
 - Noise may indicate an amplifier or other active component failure
 - Interference may indicate:
 - Distortion – active component
 - Ingress – leakage (stray RF in means RF straying out)
- Spectrum analysis helps
 - Use error vector spectrum to see within the channel 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





Troubleshooting High BER

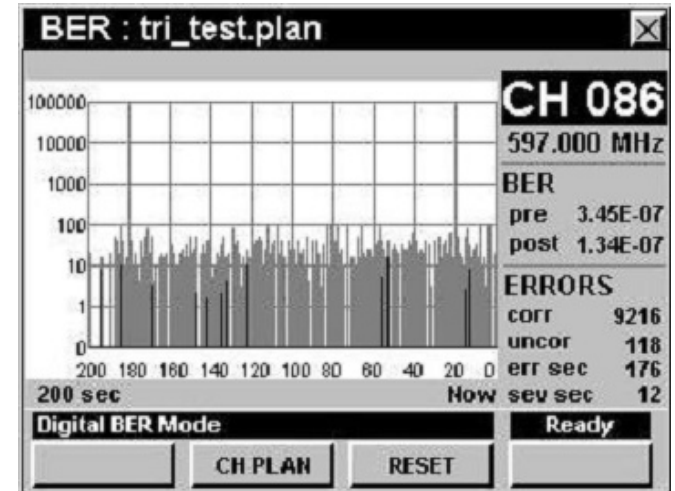
- Is MER low? (see last advice)
- Pre-FEC or Post-FEC, measure of severity
- Are bit errors continuous or sporadic?
 - Look at graph of errors over time
 - Can time signature be determined? (may give clue to cause)
- Is BER failure frequency (channel) specific and sporadic?
 - Look at error vector spectrum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





Impulse BER

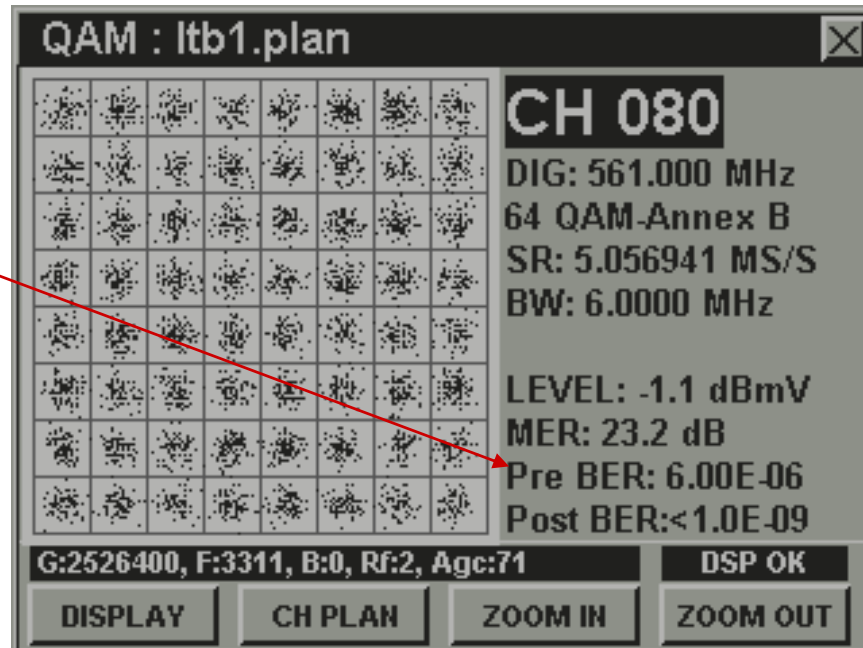
- BER
 - Corrupted bits/total bits received
- Shows BER before and after FEC
- Errored Seconds
 - The number of seconds with at least one corrected codeword
- Severely Errored Seconds
 - The number of seconds with at least one uncorrectable codeword
- Valuable troubleshooting tool
 - Whenever there are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





BER

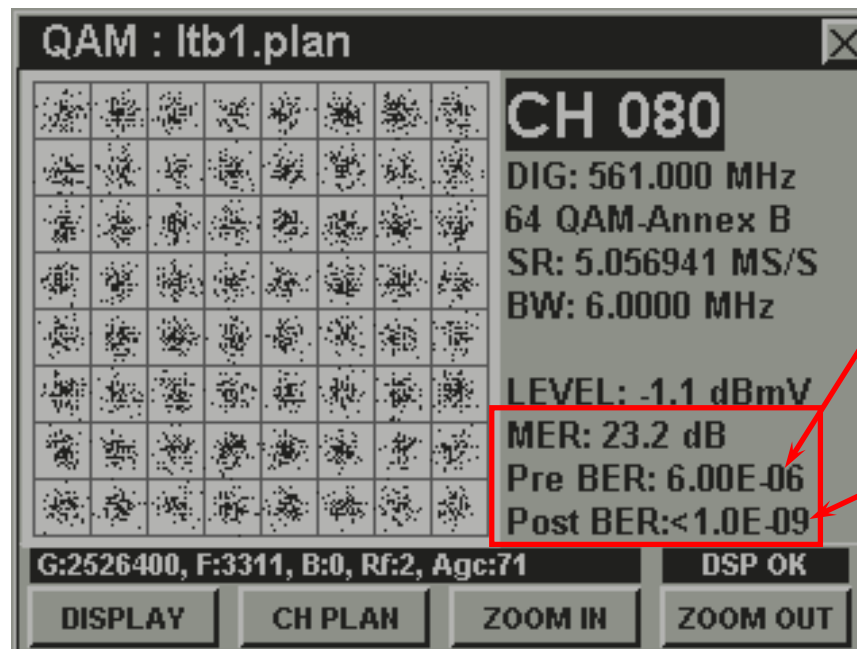
- Bit Error Rate is the number of bits in error divided by the total number of bits in the data transmission
- Pre BER
 - System Margin





Forward Error Correction

- FEC
 - Corrects errors to a point



Pre FEC BER
(Before Correction)

Post FEC BER
(After Correction)





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



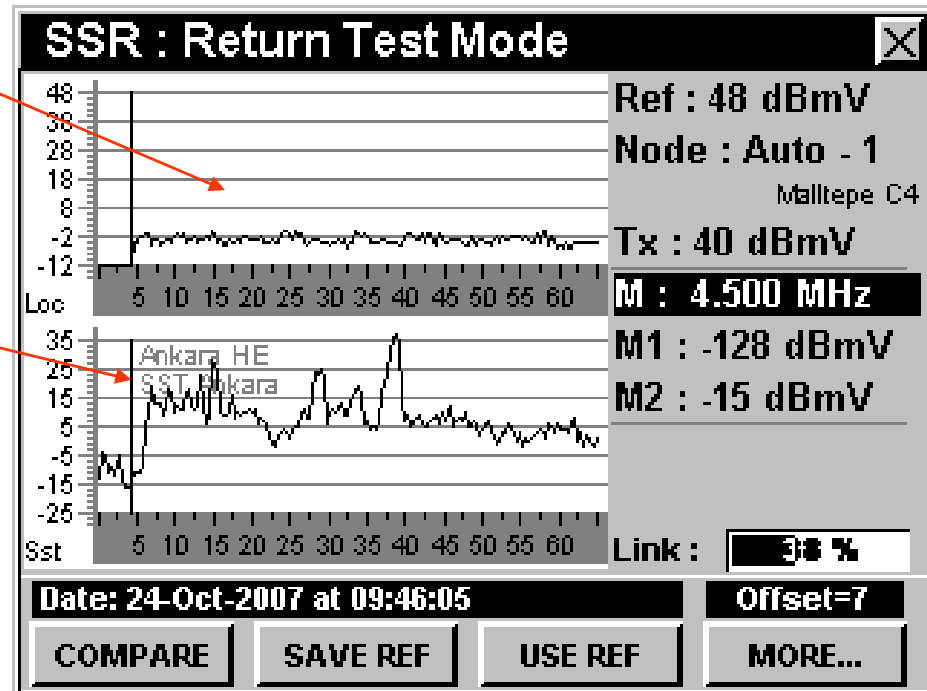
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Reverse Ingress

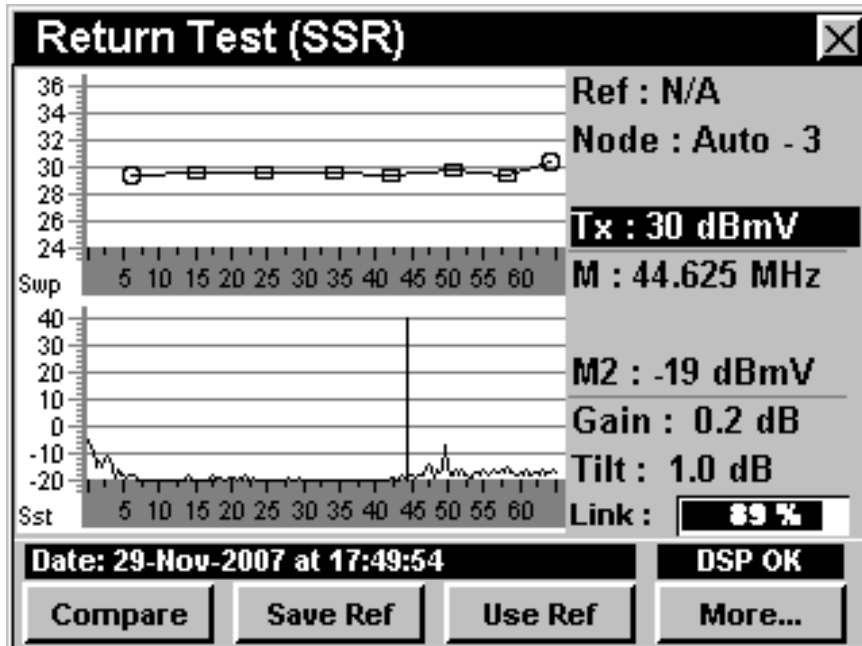
- Top displays Local
- Bottom displays headend
- Move your location until you find the source of the ingress





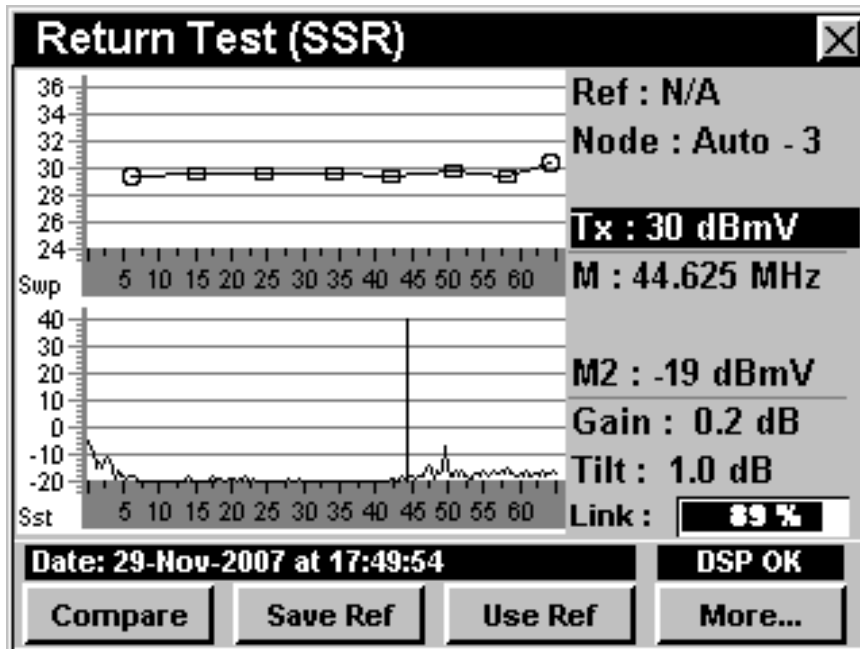
Return Sweep Mode

- 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





Return Sweep Mode

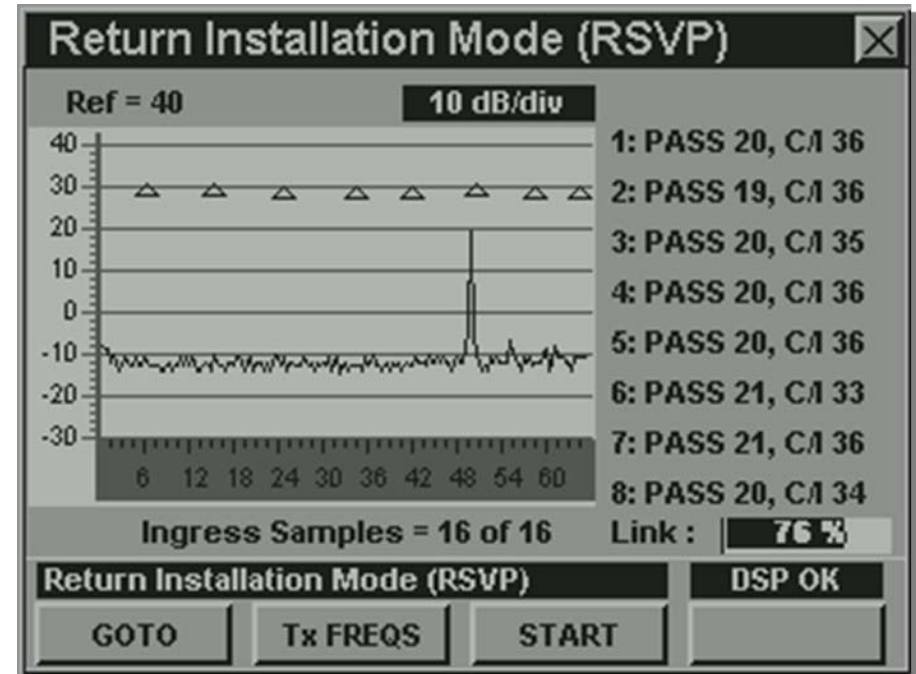


- Frequency Response Trace
 - Plots received (Headend) level for each sweep carrier
 - Scale per Division 2 dB
 - Ideal Trace is a flat line
- Impairments to frequency response
 - Damaged Cable
 - Damaged actives or passives
 - High Ingress Levels



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





Troubleshooting transients in upstream signal bands

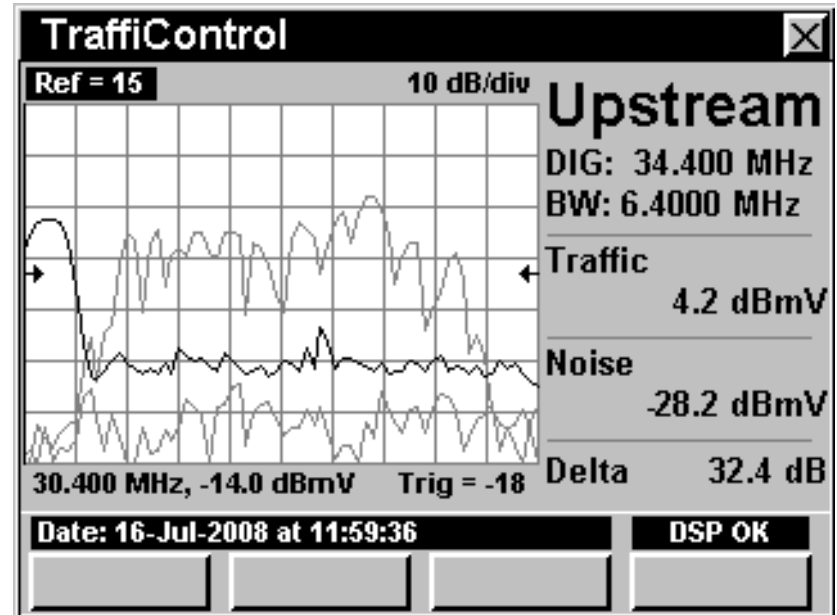
- Test feature uses limits to remove legitimate traffic from the spectrum view
- Removes the haystack and reveals the needle
- Provides insight in monitoring as well as troubleshooting
- Spectrum acquisition speed reveals fast transients





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





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



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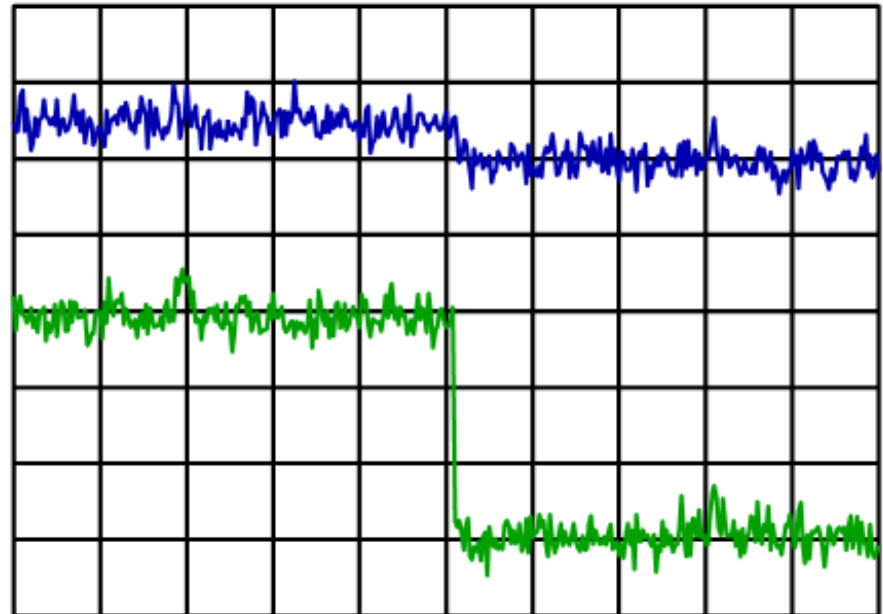
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Is It System Noise?

Internal spectrum analyzer noise may be too high to allow system noise measurement

* use the disconnect test

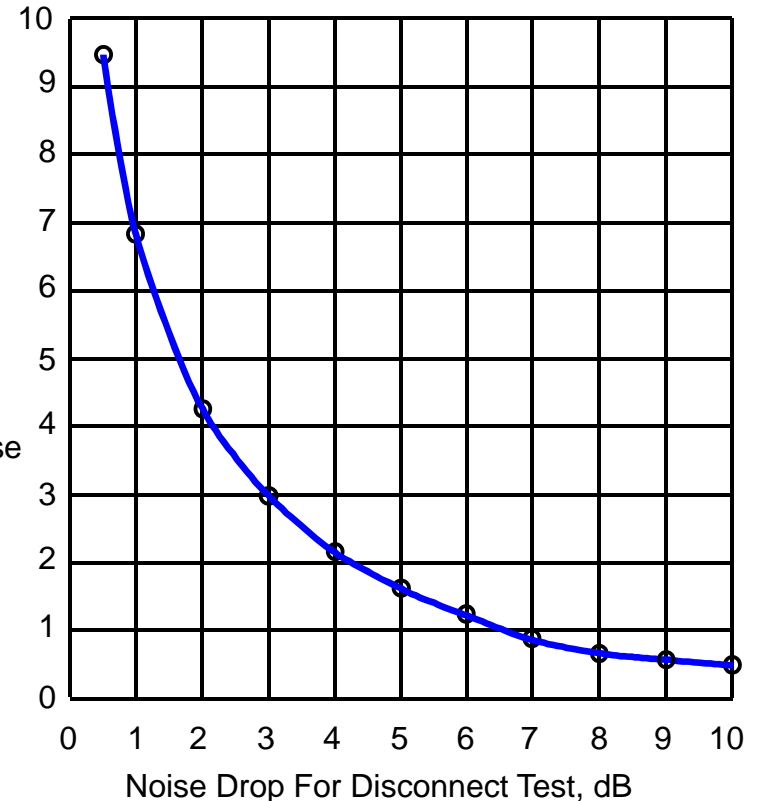




The Disconnect Test

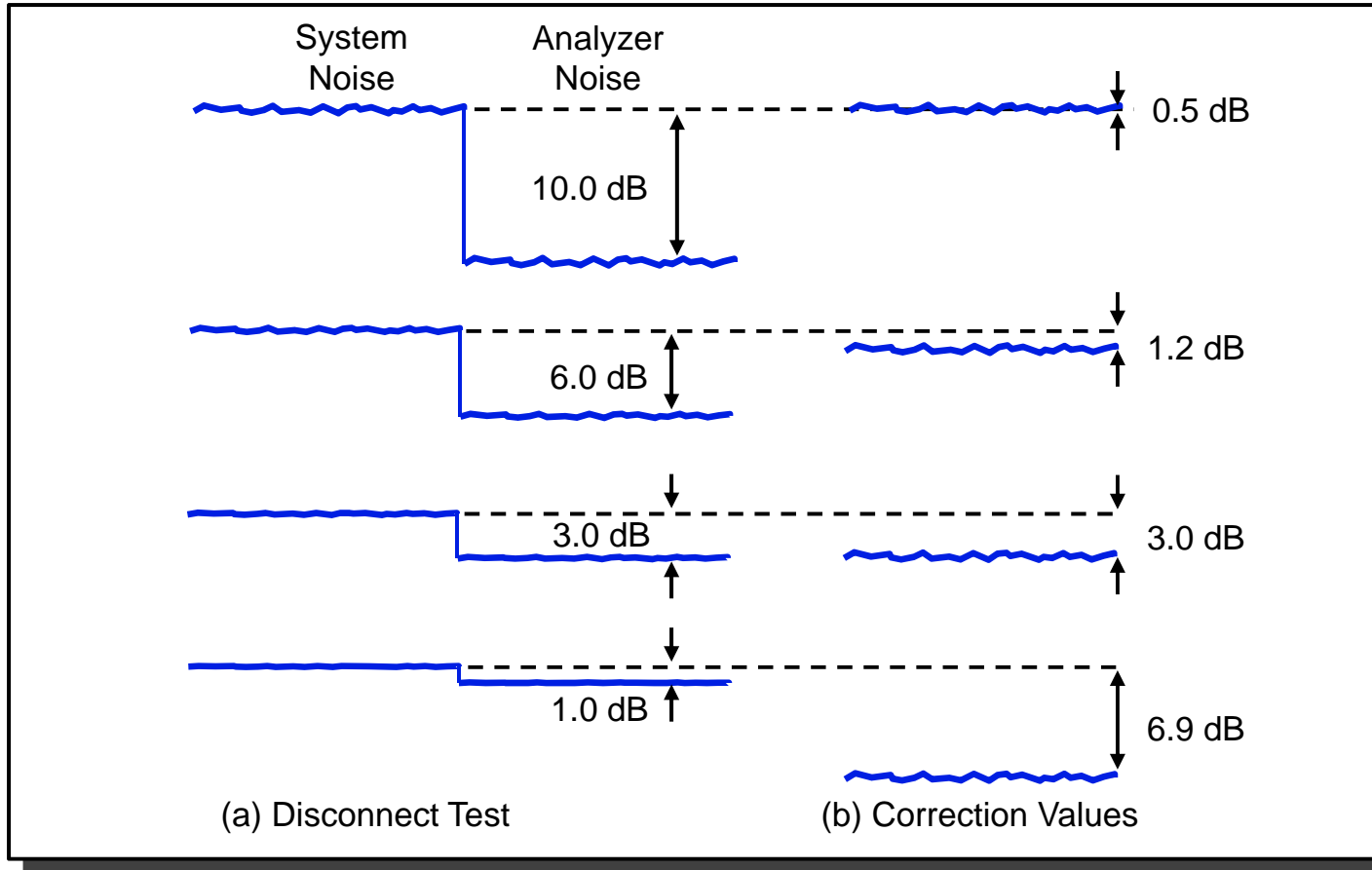
- If > 10 dB drop, no corrections needed
- If > 3 dB drop, correct by using the graph below
- If < 3 dB drop, use a 20-30 dB gain, < 10 dB noise figure preamplifier

Noise-Near-Noise
Correction (dB)





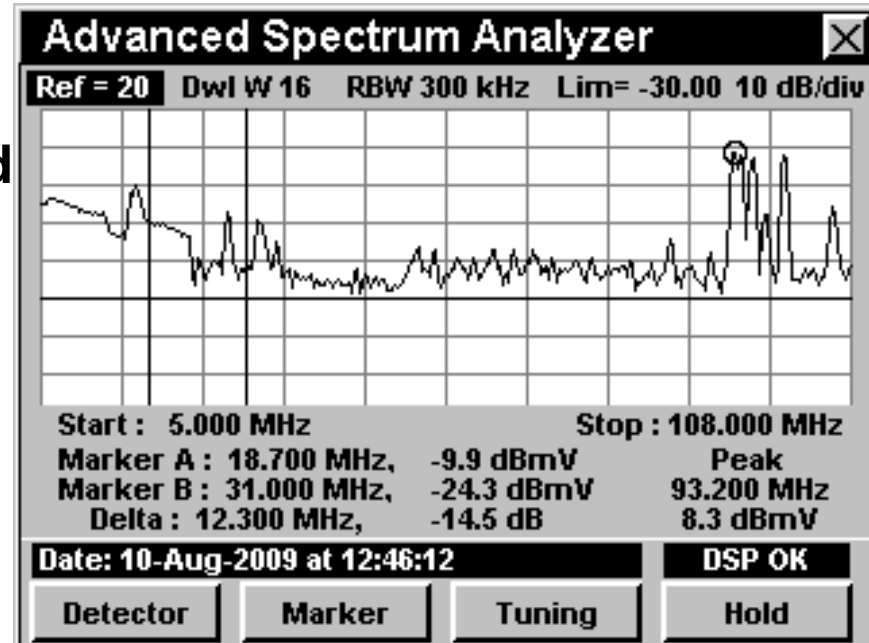
Correcting Analyzer for Noise-Near-Noise





Ingress Mitigation Test

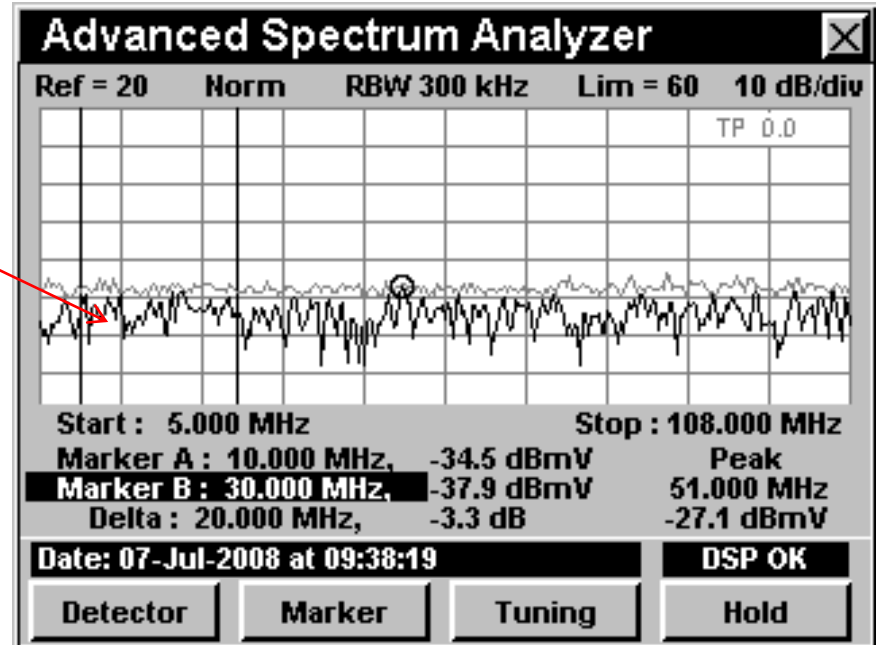
- This is a test where you can quickly check the drop and home wiring for ingress
- Set Ref level so as to not over-load the meter
- Detector set for averaging
- RBW at 300 KHz
- 10 db/div
- Spectrum 5-108 MHz
- Use peak hold





Ingress Mitigation Test

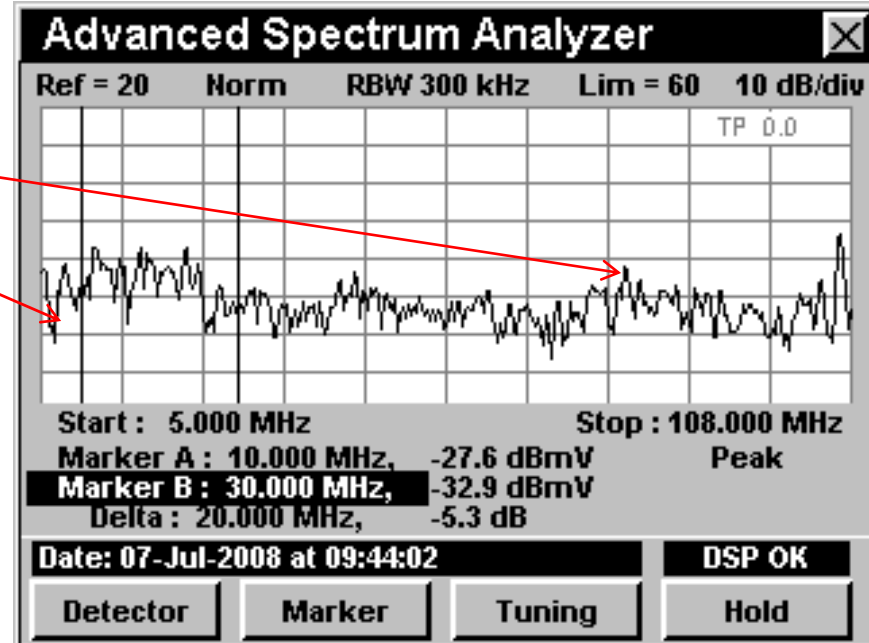
- What you should see is NOTHING!
- Just the noise floor





Ingress Mitigation Test

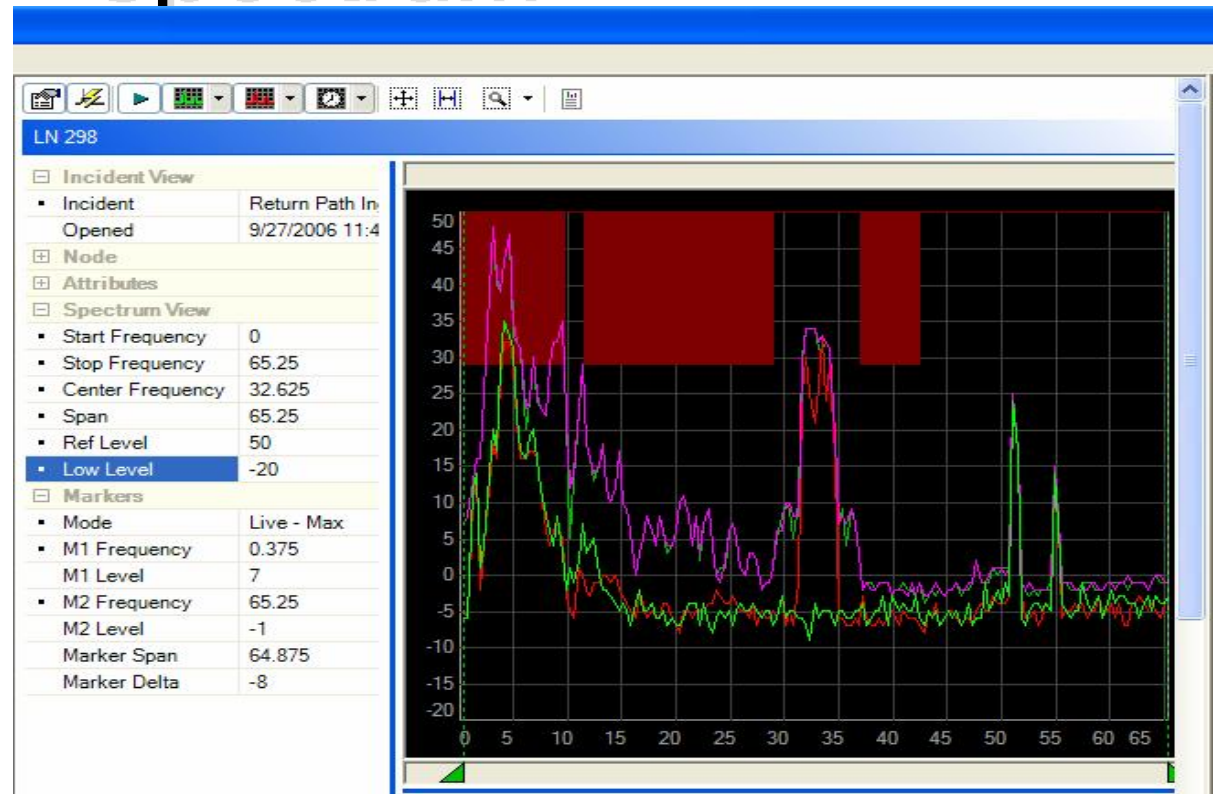
- Look for ingress by using the “Peak Hold” function
- Identify the problem by working back towards the house





Laser Clipping Return Path Spectrum

- Note the products above 42 MHz





Monitoring the Return



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Viewer II User Interface

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

The screenshot displays the Trilithic Viewer II software interface for element AC059. The interface is divided into several panes:

- Element Manager:** A tree view showing a hierarchy of elements under 'Metro'. The selected element is 'Return Path Ingress - Level 4'.
- Spectrum Display:** A graph showing signal levels over time (0 to 65 seconds). The y-axis ranges from -60 to 40. A red shaded area indicates a signal level above 20.
- Return Path Ingress Events:** A list of events with timestamps and levels. The events are:
 - 9/21/2006 10:22:16 AM Level 4
 - 9/21/2006 10:22:13 AM Level 3
 - 9/21/2006 10:22:10 AM Level 4
 - 9/21/2006 10:22:07 AM Level 3
 - 9/21/2006 10:22:04 AM Level 4
 - 9/21/2006 10:21:46 AM Level 3
- Open Incidents:** A table listing incidents with columns for Incident, Element, Status, Status Duration, Incident Duration, City, and Hub. The incidents are:

Incident	Element	Status	Status Duration	Incident Duration	City	Hub
Return Path Ingress	AC059	Level 4	-5 min	5 days 13 hr 58 min	Van Nuys	Van Nu...
Return Path Ingress	AC120	Level 4	5 hr 13 min	7 hr 48 min	Van Nuys	Van Nu...
Return Path Ingress	AC139	Level 4	-6 min	5 days 13 hr 37 min	Van Nuys	Van Nu...
Return Path Ingress	AC189	Level 4	1 hr 29 min	5 days 12 hr 50 min	Van Nuys	Van Nu...
Return Path Ingress	AC192	Level 4	1 hr 29 min	5 days 13 hr 2 min	Van Nuys	Van Nu...
- Return Path Ingress on AC059:** A detailed view of the selected incident, showing it was opened on 9/15/2006 at 8:21:23 PM. The element name is AC059.



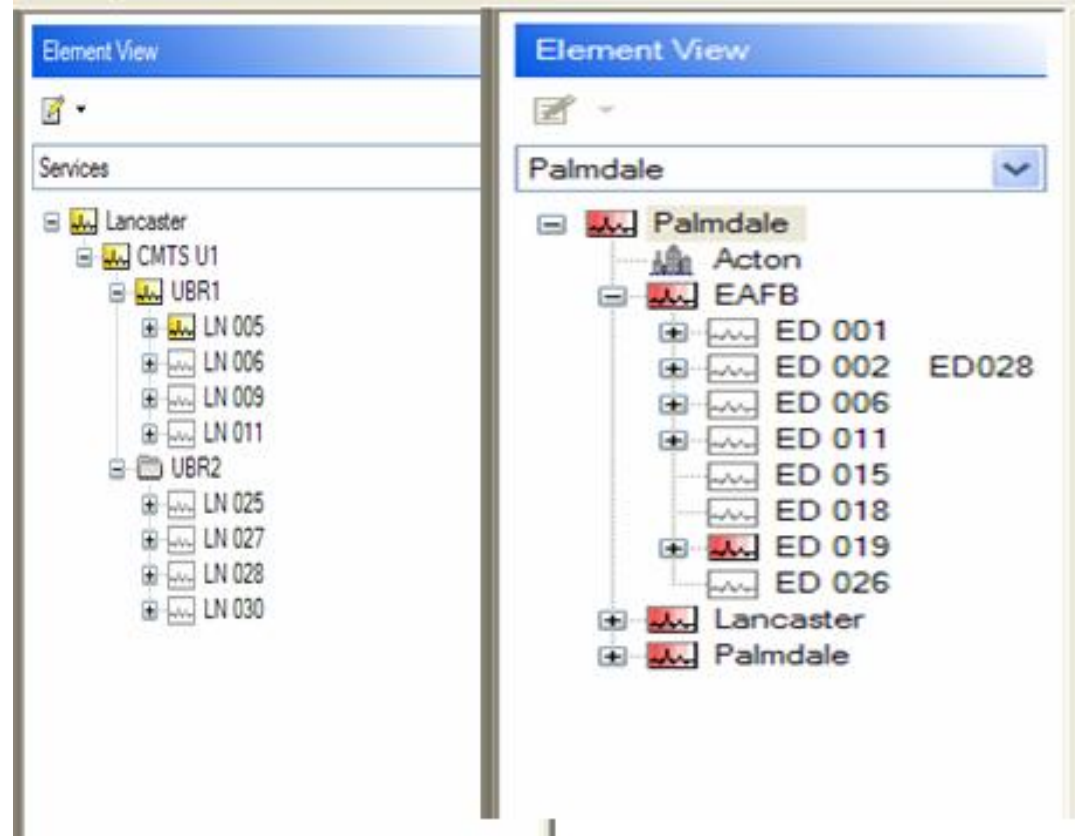
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Node Status Tree

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





ADIA Historical Analysis Server

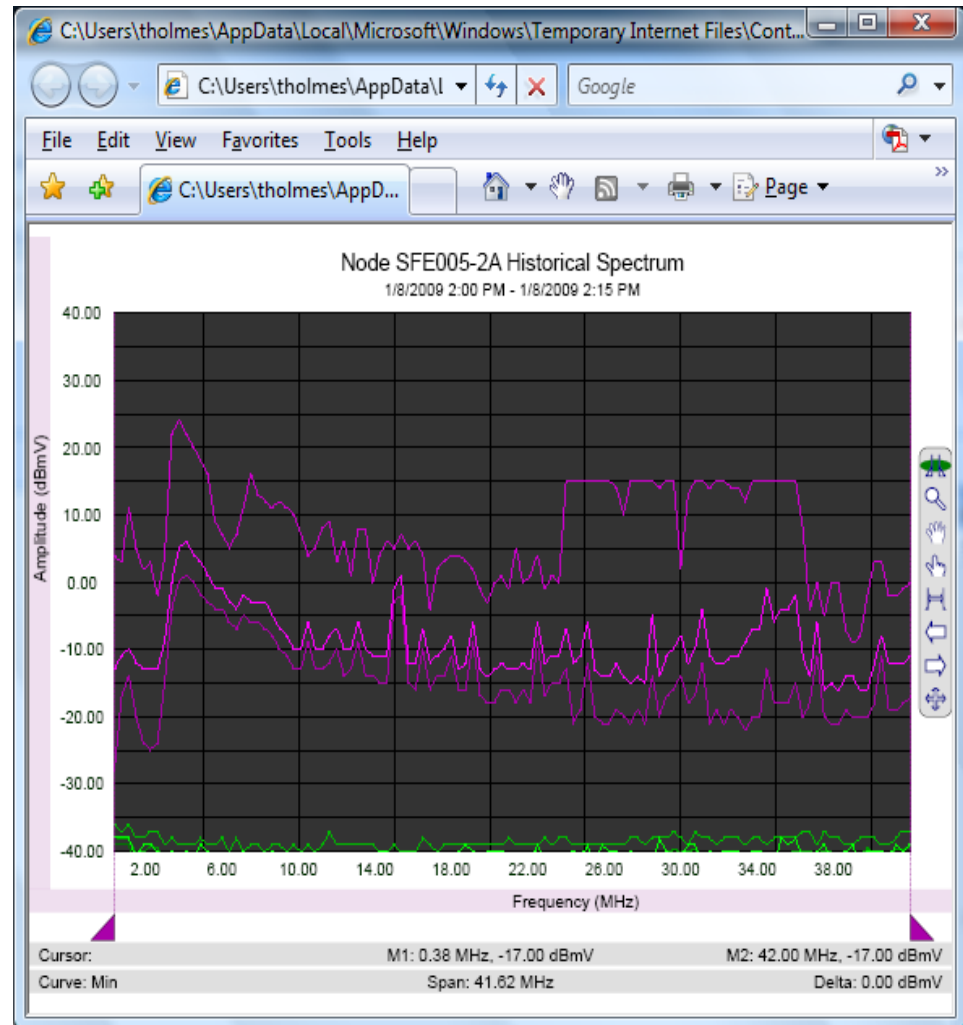
- Collects spectral information from the 9581 SST headend units
 - Spectral information contains Max/Min/Avg ingress information collected in 9581 SST and compressed into 15 minute summaries
 - Return Path performance information against user specified limits
- Provides database storage for 3000 nodes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





Spectral History

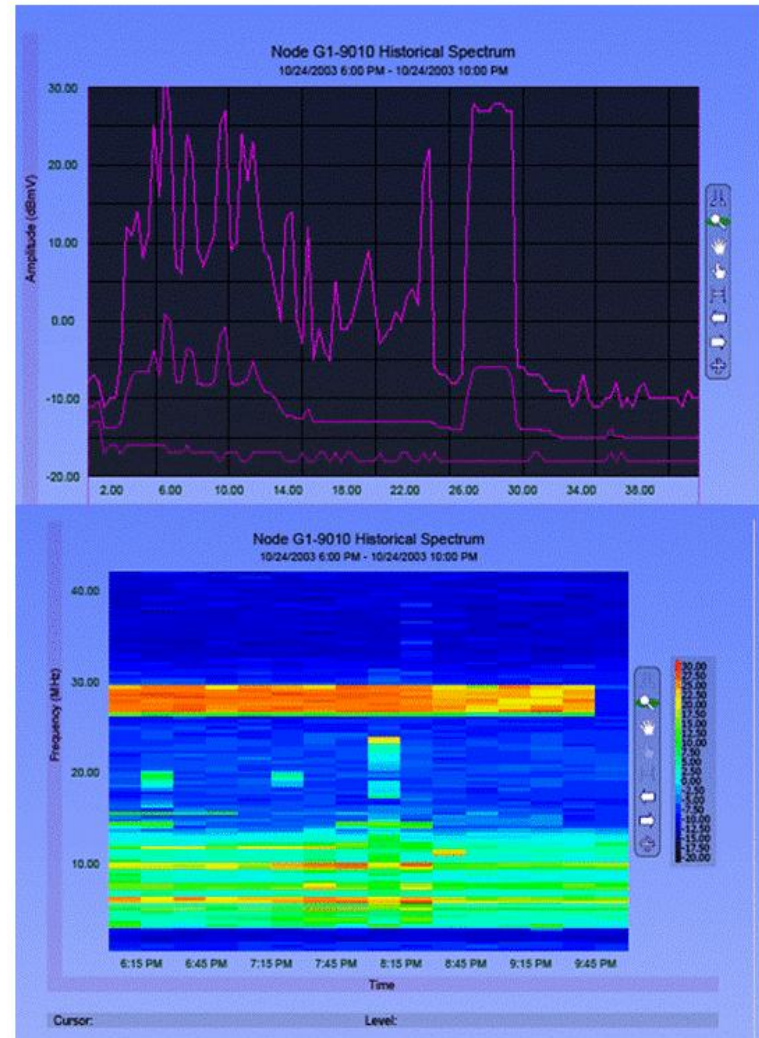
- Review ingress signature of selected node
 - Over user specified time period
 - Max/Min/Avg traces
 - With live spectral overlay





Spectral History

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





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%





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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