Broadband Instruments and Systems

Practical Field Testing
DOCSIS 3.0

August, 2009

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think ahead.

Overview

- Quick discussion of DOCSIS 3.0 importance
- Impact of D3 on testing
- Pertinent D3 signal characteristics
- Preparation for D3 deployment and preventive maintenance
- Practical methods for testing D3 signal transmission quality
- Tests for troubleshooting
- Test equipment D3 evolution

DOCSIS 3.0

- **Higher Data Rates**
  - Channel Bonding
- **More Subscribers per Channel**
  - Statistical Multiplexing from Channel Bonding
- **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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How is D3 Important?

- D3 is a tool that enables the cable company to provide services that help company grow revenue

D3 Market Drivers

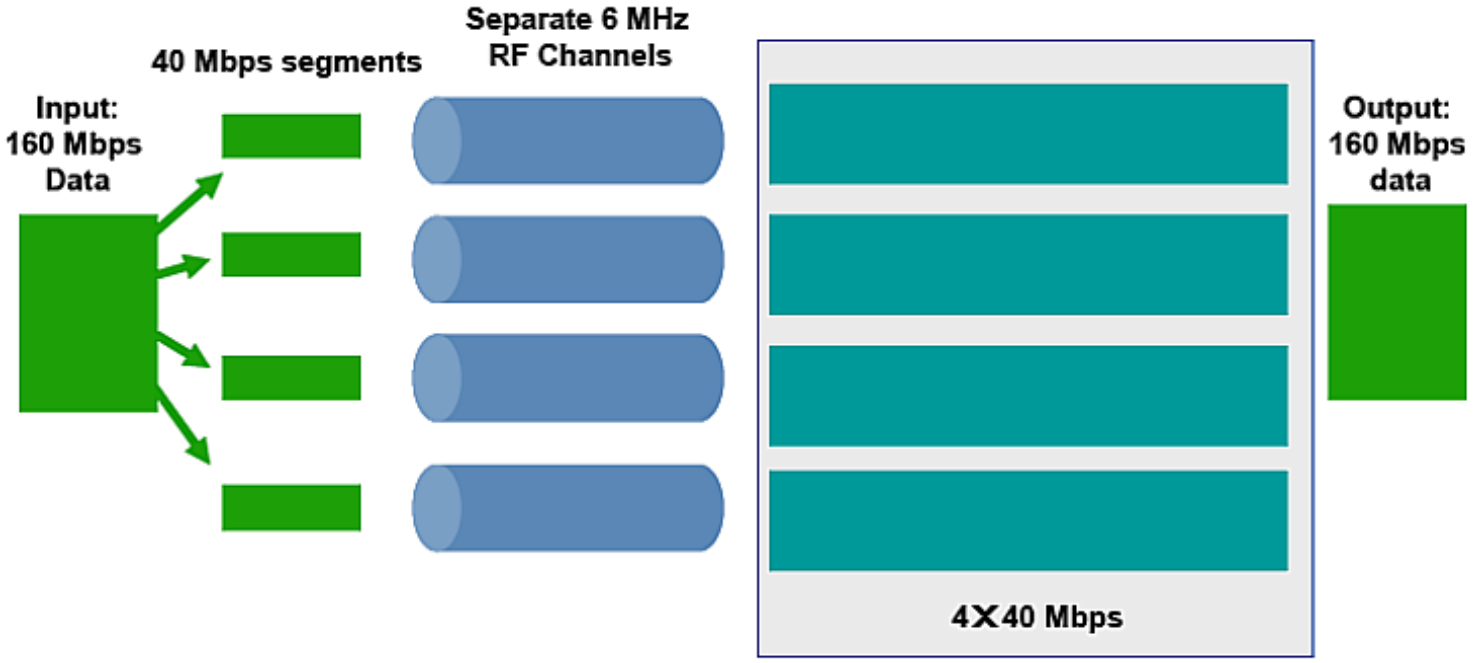
- To beat back the competition - by having the FAST (fastest) data service offering
- To meet the needs of business customers – reliability is key – symmetrical bandwidth and AES encryption
- To meet increasing bandwidth requirements of residential customers
  - Gaming, movie downloads, HDTV streaming, multicasts, video telephony, video conferencing, and network backups of home content.
- To provide T-1 cellular backhaul service to wireless providers
- High price for D3 means high expectations for quality and reliability

D3 Impact on Testing

- Group of signals (bonded) with interrelated relevance
- Physical transmission is same as DOCSIS 2.0
- Provisioning becomes a sticking point

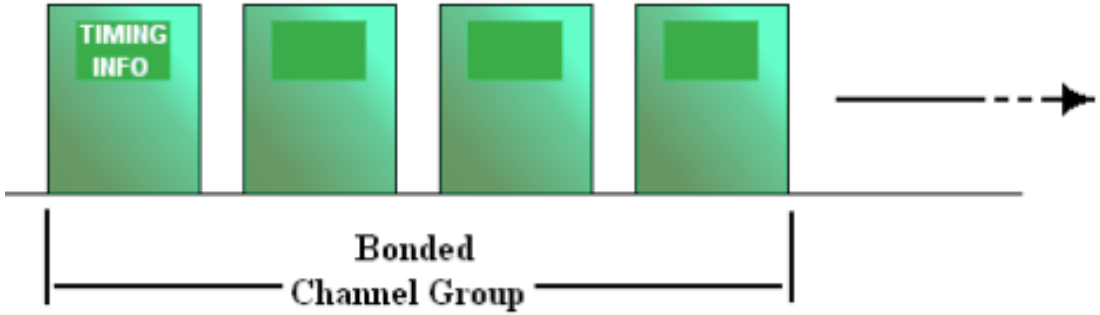
Channel Bonding

- Example:

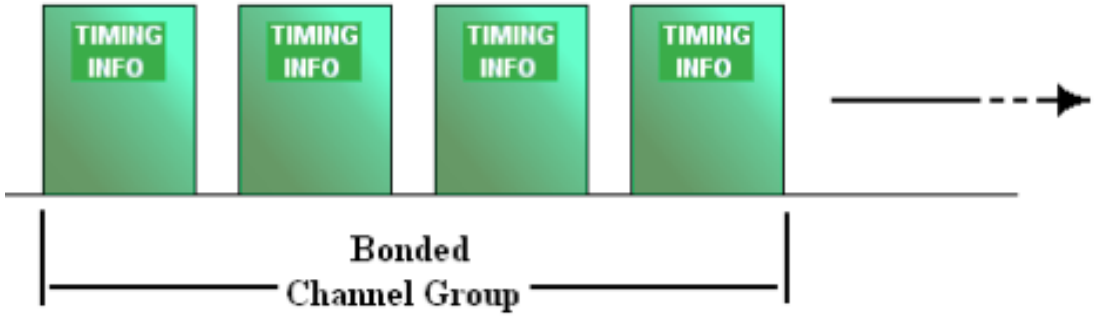


"Primary" Channels

- One Channel in Group carries timing info for whole group



- Each Channel in Group carries its own timing information



DOCSIS 3.0 Checklist

- **Plant qualification**
  - 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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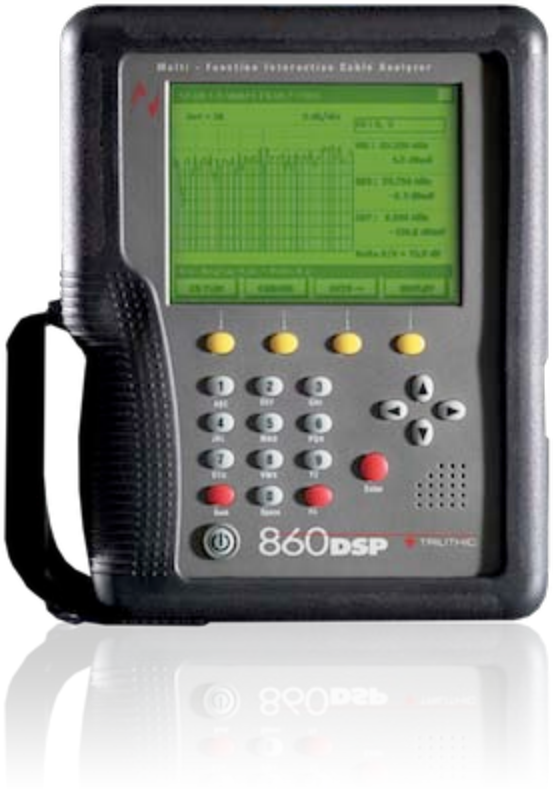
64QAM Impact

- Increased average power, if power/Hz is maintained
  - Increased bandwidth, increased average power
  - Threat of laser clipping – check design parameters
- MER is likely to decrease by at least 3dB

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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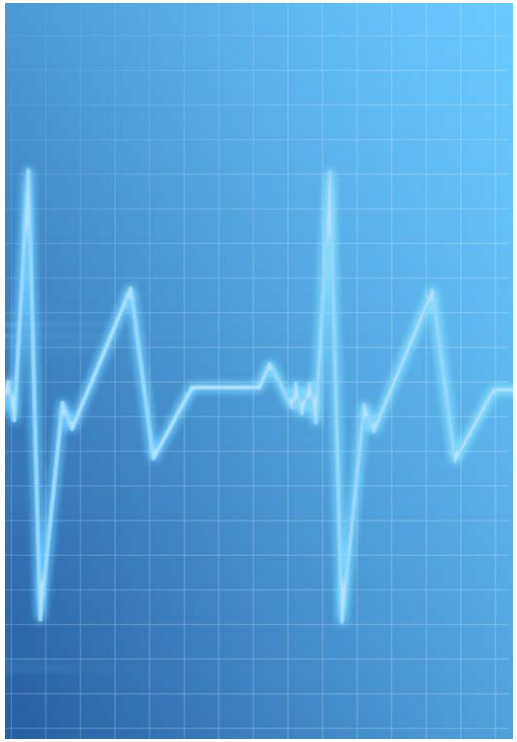
DOCSIS 3.0 Checklist

- Preventive Maintenance
  - 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)

Field Analyzer Test Capability

- Full Physical Tests, Analog, Digital
- VoIP, HSD Test Suites
- Automatic Data Analysis: “Health Check”
- Data Up/Download to Data Management Server



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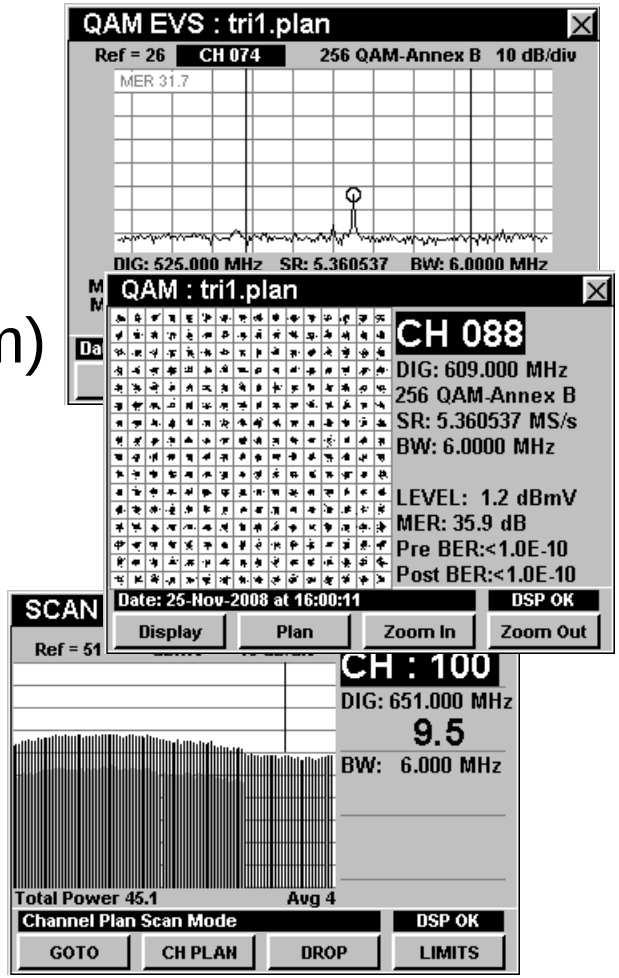
Physical Tests

- Signal Level Scan
- QAM Level
- Spectrum Analysis
- QAM EVS (Error Vector Spectrum) and TraffiControl™
- Constellation
- MER
- BER
- iBER – Long-term BER
- Upstream QAM Source



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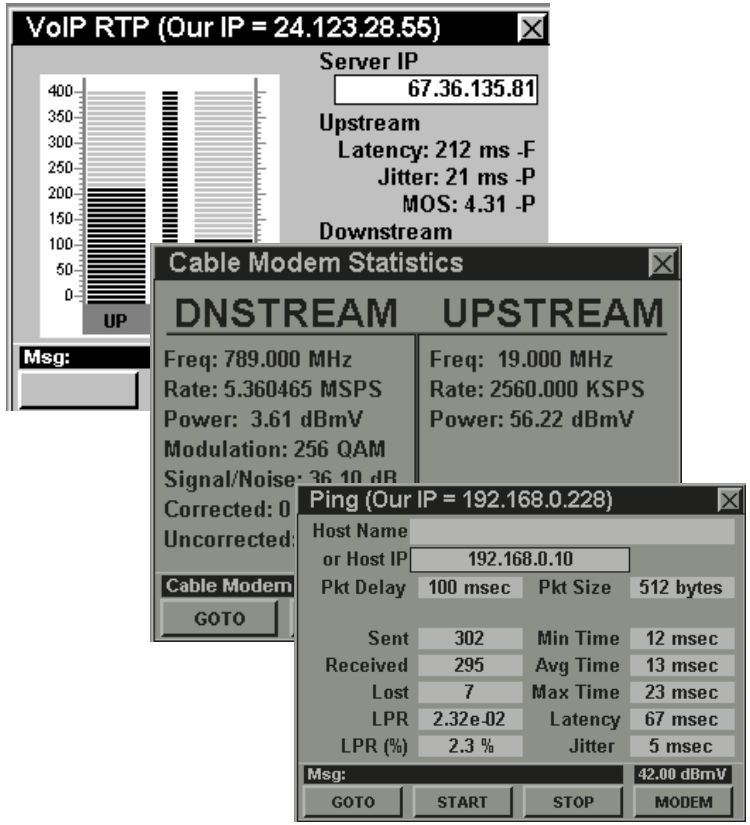
IP Tests

- VoIP
- Cable Modem Statistics
- Ping
- Trace Route
- Web Browser
- High-Speed Throughput

(approximately 40 Mbps per bonded signal)



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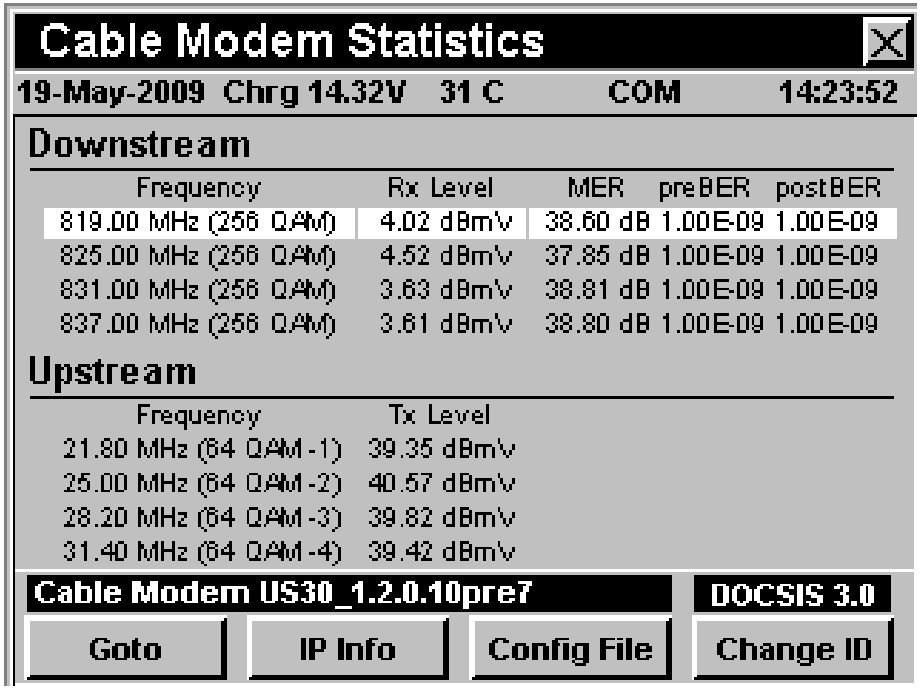
D3 Cable Modem Stats Test

- Comprehensive measurement data
- Gives results quickly with only one range and register process for the bonded set



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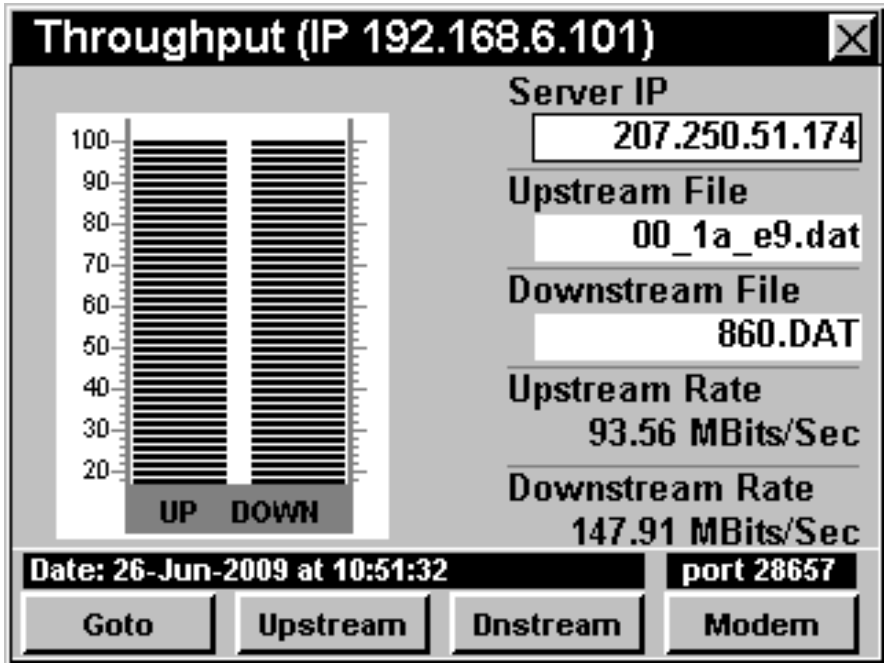
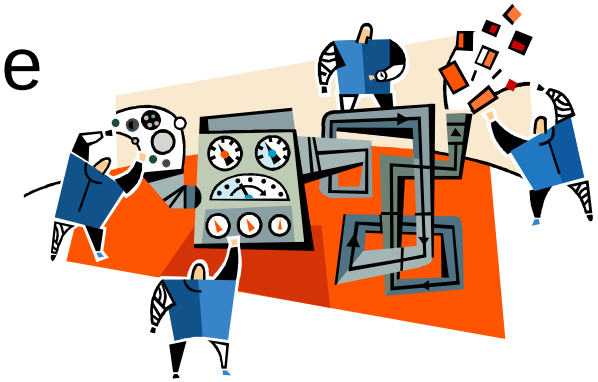
D3 Throughput Test

- Measures to limit of bonded channel range
- Works with ACTS application software



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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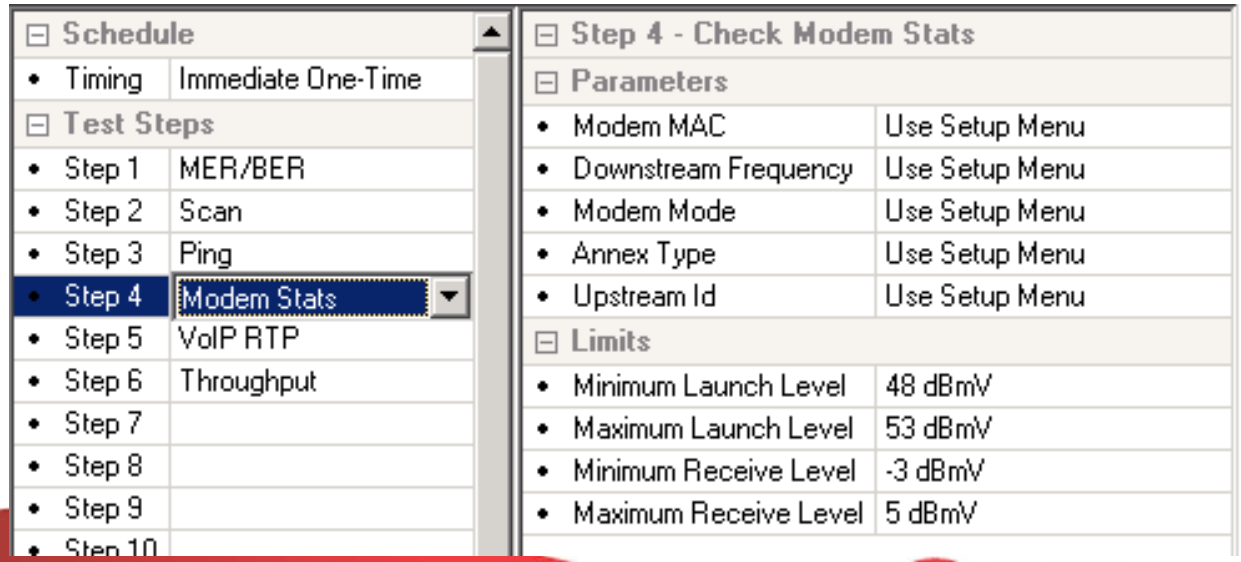
Typical D3 Autotest

- Only one test step to collect all modem info
- Test all relevant parameters (steps 1 through 6 shown here)



Schedule	
Timing	Immediate One-Time
Test Steps	
Step 1	MER/BER
Step 2	Scan
Step 3	Ping
Step 4	Modem Stats
Step 5	VoIP RTP
Step 6	Throughput
Step 7	
Step 8	
Step 9	
Step 10	

Step 4 - Check Modem Stats	
Parameters	
Modem MAC	Use Setup Menu
Downstream Frequency	Use Setup Menu
Modem Mode	Use Setup Menu
Annex Type	Use Setup Menu
Upstream Id	Use Setup Menu
Limits	
Minimum Launch Level	48 dBmV
Maximum Launch Level	53 dBmV
Minimum Receive Level	-3 dBmV
Maximum Receive Level	5 dBmV

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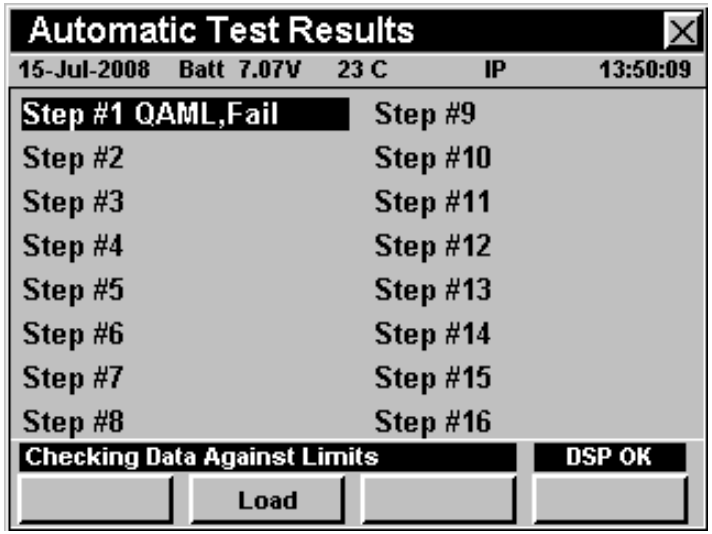
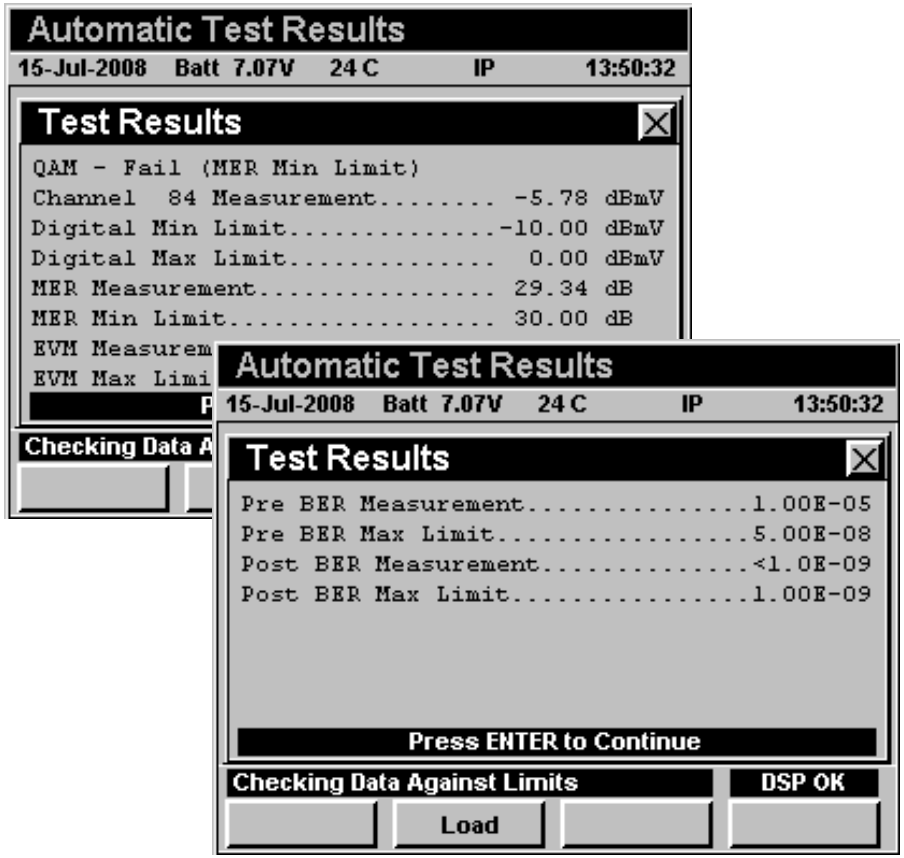
Typical Autotest for D3 Tests

- 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 Tests

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



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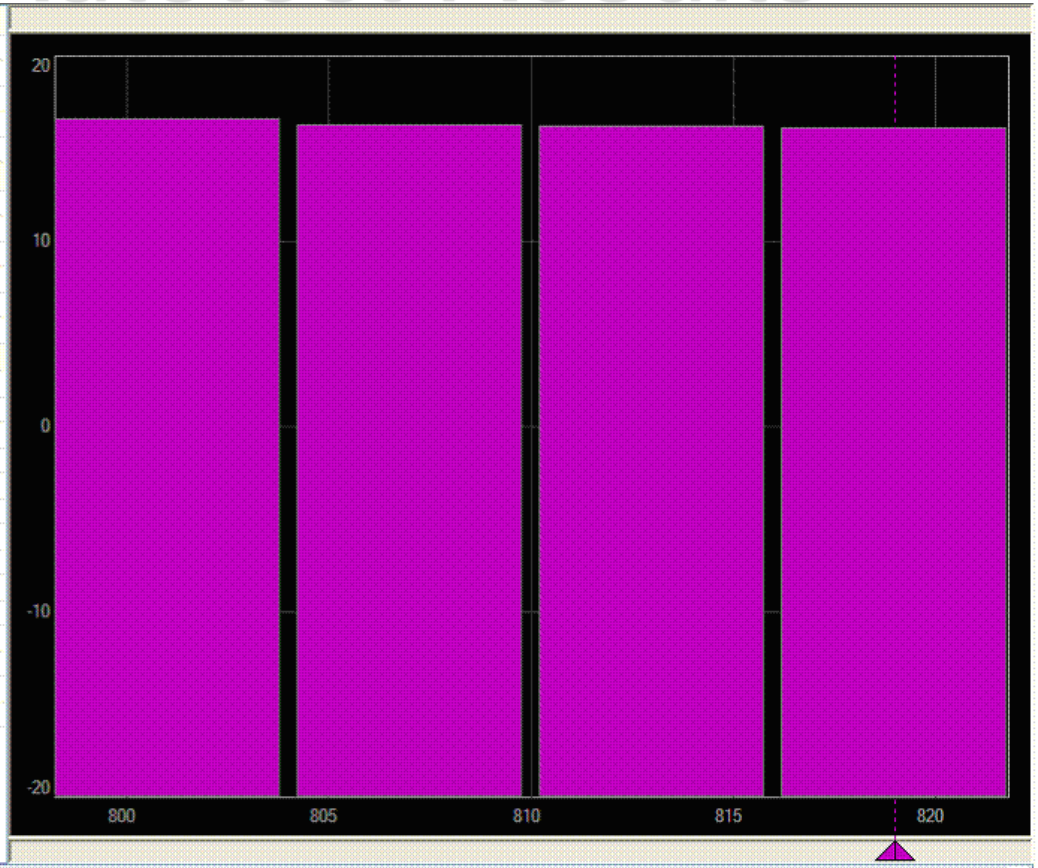
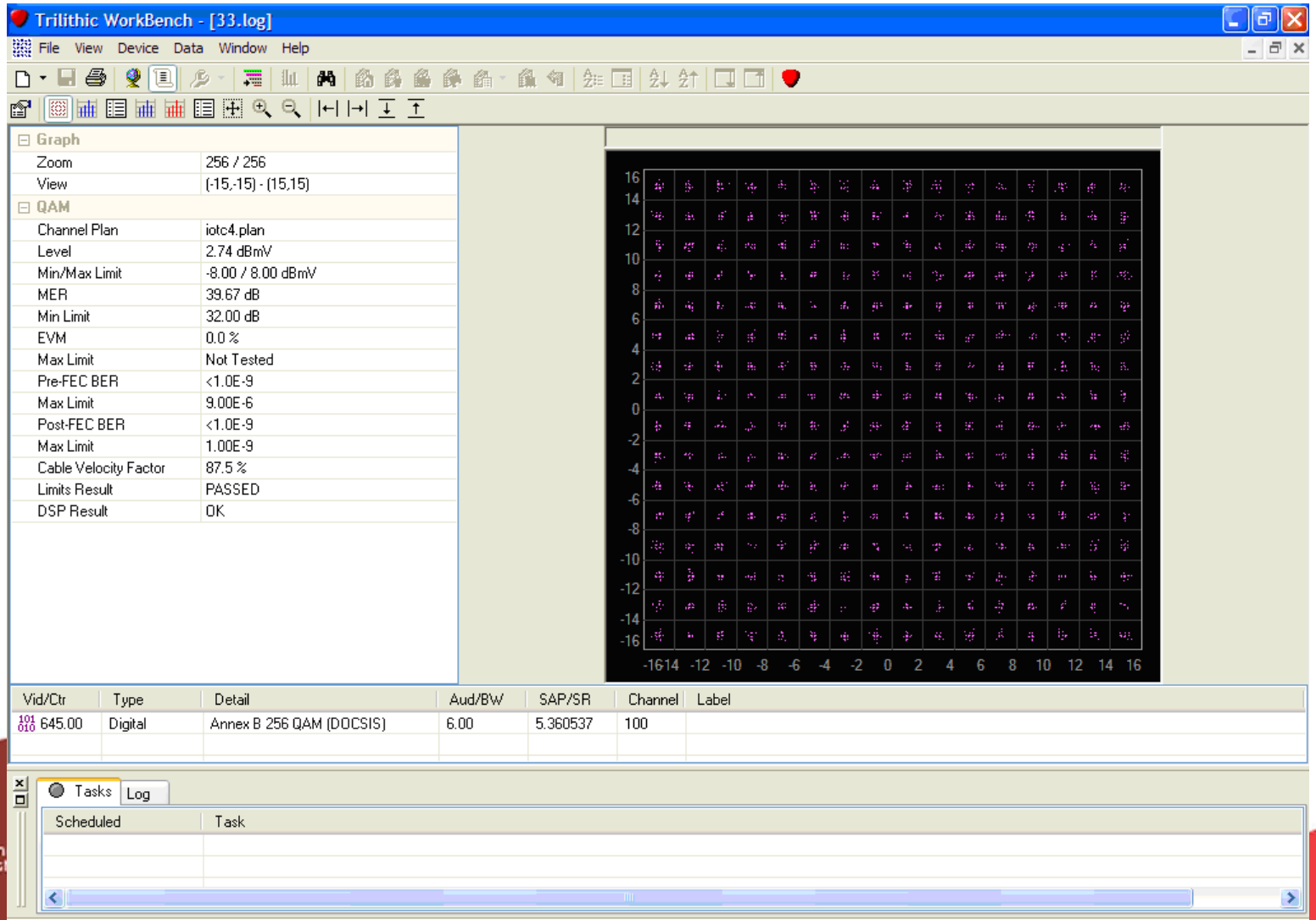
D3 Autotest Results

Graph	
Display	Bar
Ref Level	20 dBmV
Scale	10 dB/Div
Start Freq	801.00 MHz
End Freq	819.00 MHz
Markers	
Mode	Channel
Marker 1	819.00 MHz Ch. 128 Digita
Level 1	16.16 dBmV
Marker 2	
Level 2	
Delta	
Scan	
Channel Plan	tri2.plan
Total Power	42.84 dBmV
Min/Max Video	6.75 / 12.43 dBmV
Min/Max Limit	0.00 / 15.00 dBmV
Min/Max VA Delta	12.61 / 17.28 dB
Min/Max Limit	10.00 / 18.00 dB
Min/Max Digital	3.25 / 16.64 dBmV
Min/Max Limit	-10.00 / 17.00 dBmV
Max Video Delta	5.68 dB
Max Limit	17.00 dB
Max Adj Video Delta	2.23 dB
Max Limit	3.00 dB
Limits Result	PASSED
DSP Result	OK

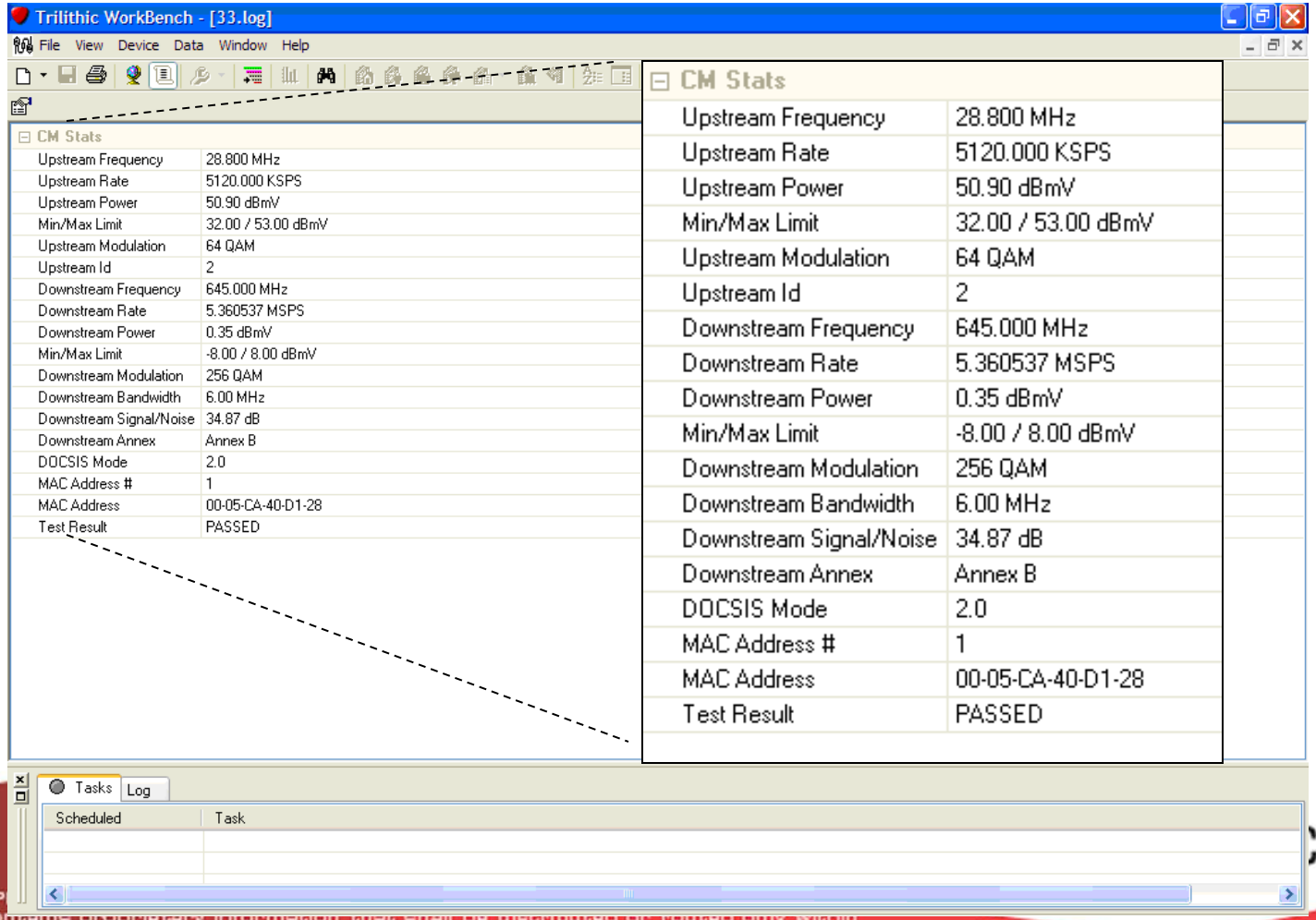


Center	Type	Detail	Bandwidth	Smbl Rate	Channel	Label
801.00	Digital	Annex B 256 QAM (DOCSIS)	6.00	5.360537	125	
807.00	Digital	Annex B 256 QAM (DOCSIS)	6.00	5.360537	126	
813.00	Digital	Annex B 256 QAM (DOCSIS)	6.00	5.360537	127	
819.00	Digital	Annex B 256 QAM (DOCSIS)	6.00	5.360537	128	

D3 Autotest Results

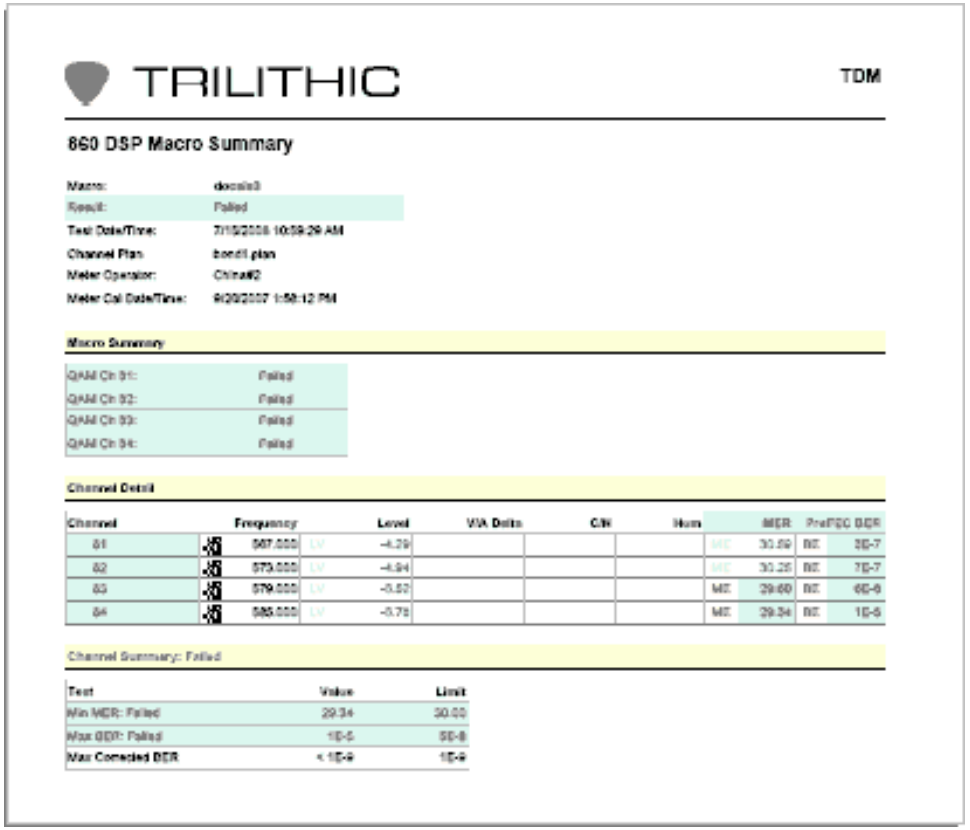


D3 Autotest Results



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:	7/19/2008 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 91:	Failed
QAM Ch 92:	Failed
QAM Ch 93:	Failed
QAM Ch 94:	Failed

Channel Detail

Channel		Frequency		Level	V/A Delta	C/N	Hum	MER	PreFEC BER
91		567.000	LV	-4.29				MI: 30.59	BI: 3E-7
92		573.000	LV	-4.94				MI: 30.28	BI: 7E-7
93		579.000	LV	-5.53				MI: 29.60	BI: 6E-6
94		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

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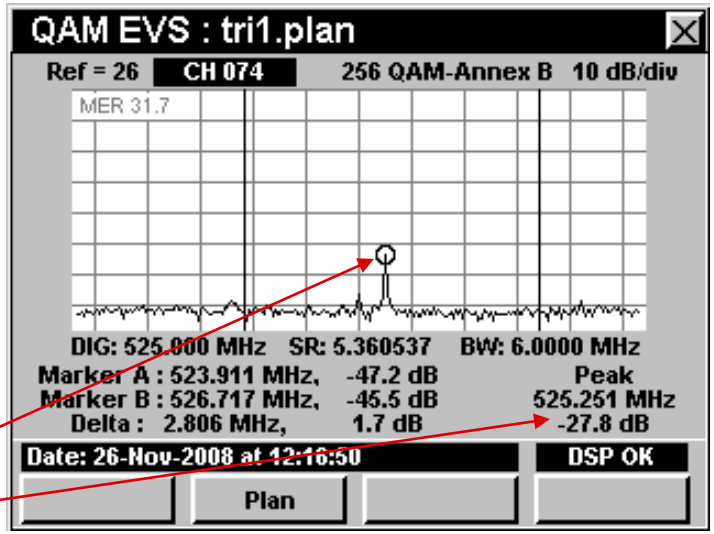
Troubleshooting Low MER

- 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.)

Troubleshooting Low MER

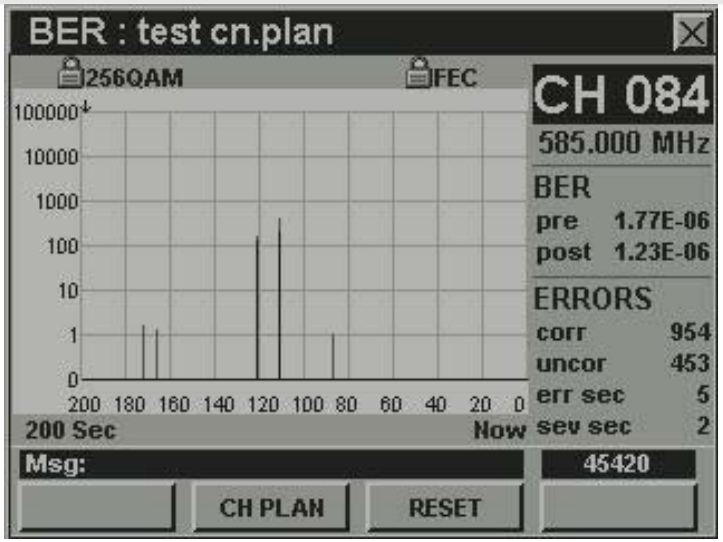
- Spectrum analysis helps
  - Use error vector spectrum to see within the channel range (under the haystack)
    - Ingress at 525.25 MHz
    - 28 dBc



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

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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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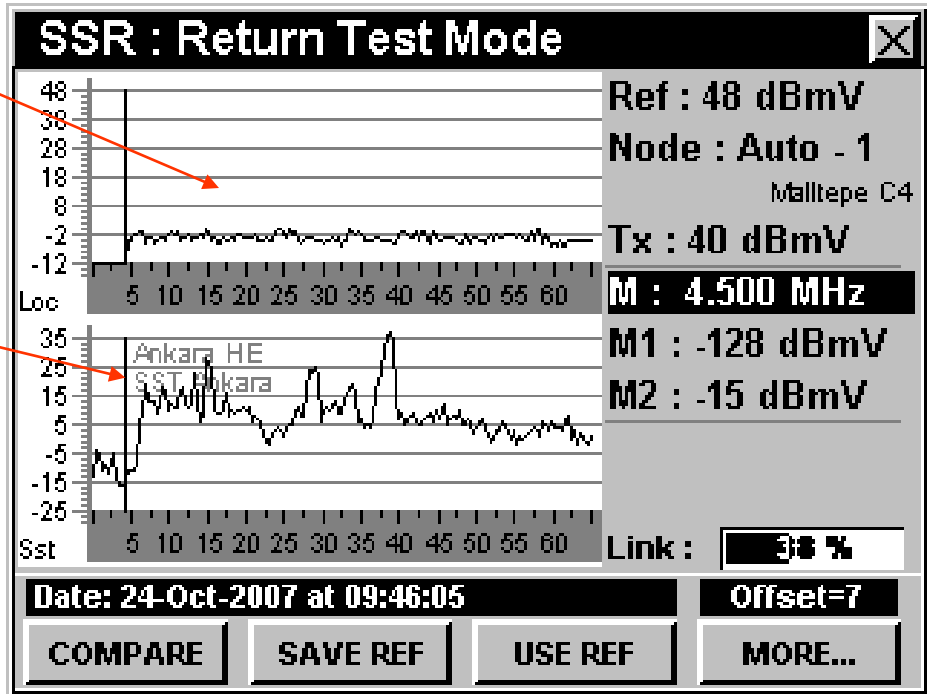
Reverse Ingress

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

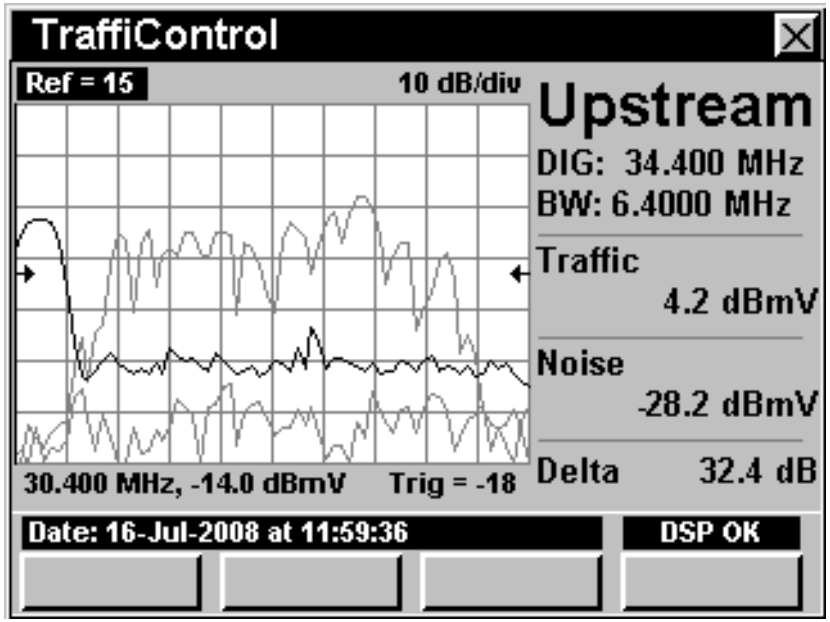


Troubleshooting transients in upstream signal bands

- 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

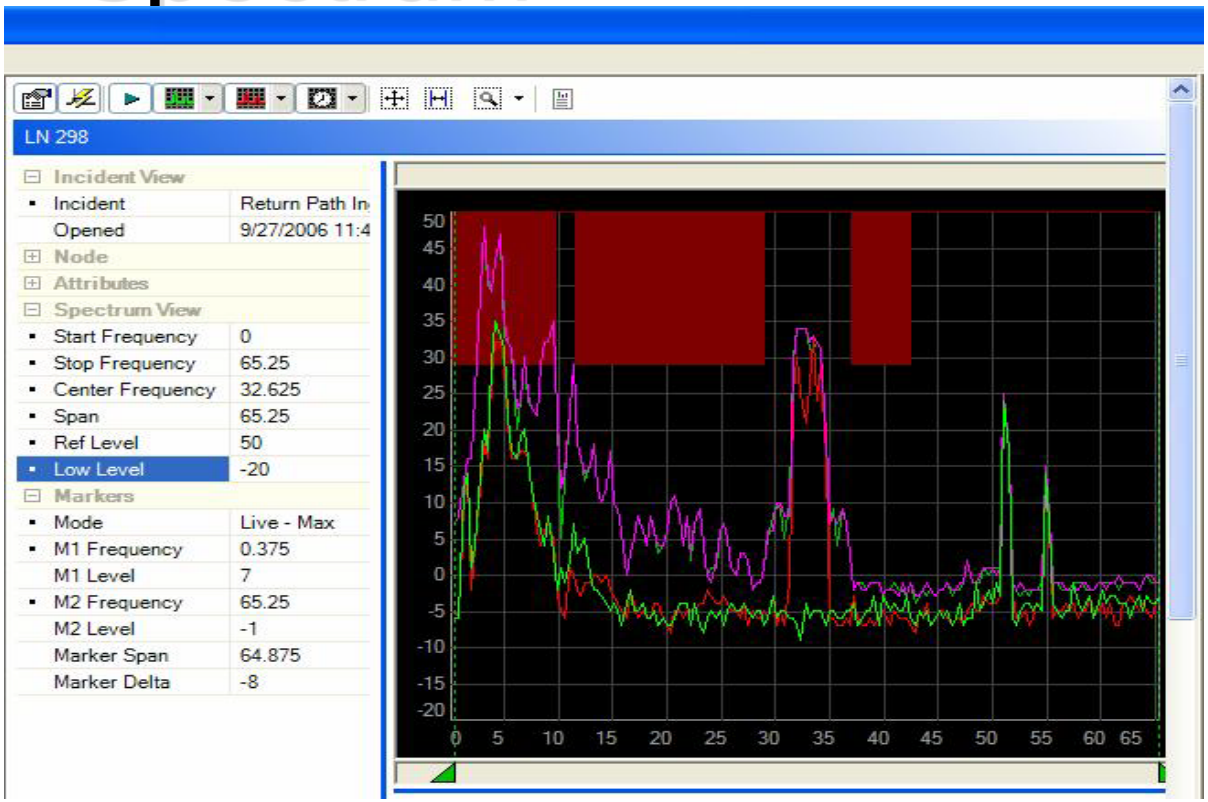


Laser Clipping

- 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

Laser Clipping Return Path Spectrum

- Note the products above 42 MHz



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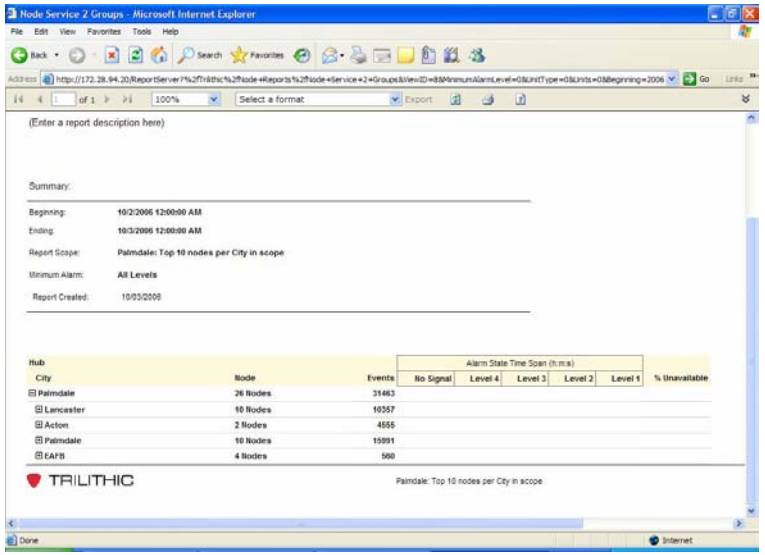
Return Path Reports

- 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



Return Path Monitoring and D3

- Return path maintenance system serves multiple functions
  - Must have high transient capture speed for detecting and troubleshooting impulse noise and some forms of ingress
    - DOCSIS 3.0 spec assumes RF upstream characteristics to include no noise bursts ≥10µS
  - May combine monitoring with field test/alignment features
    - Reverse sweep tests
    - Ingress analysis with simultaneous hub/headend and local test point spectrum view
    - Installation tests, reverse transmit level and C/I

Test equipment evolution

- Many tests can be performed with D2 modem equipped analyzers
- D3 option offers improvements
  - Tests that require modem provisioning not limited to “primary” signals
  - Shortened test time
  - Consolidated test results for simpler, quicker analysis
- Need to purchase new, or retrofit existing meters to D3?
  - Flexible platform enables retrofit at reasonable cost
  - D3 modem increases capability and speed

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Review

- DOCSIS 3.0 improves competitive position, and revenue
- Reliability is crucial, testing helps
- D3 signals are similar to D2
- Practical preparation for D3 deployment and preventive maintenance check lists
- Performing practical tests of D3 signal transmission quality now
- Tests for troubleshooting
- Test equipment D3 evolution

Thanks. Questions?