



# Broadband Instruments and Systems



## Practical Field Testing DOCSIS 3.0

August, 2009



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



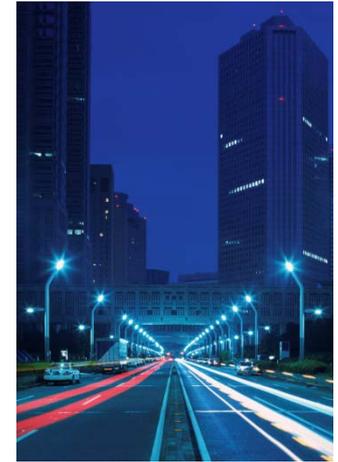


# DOCSIS 3.0

- **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



# 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



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# 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





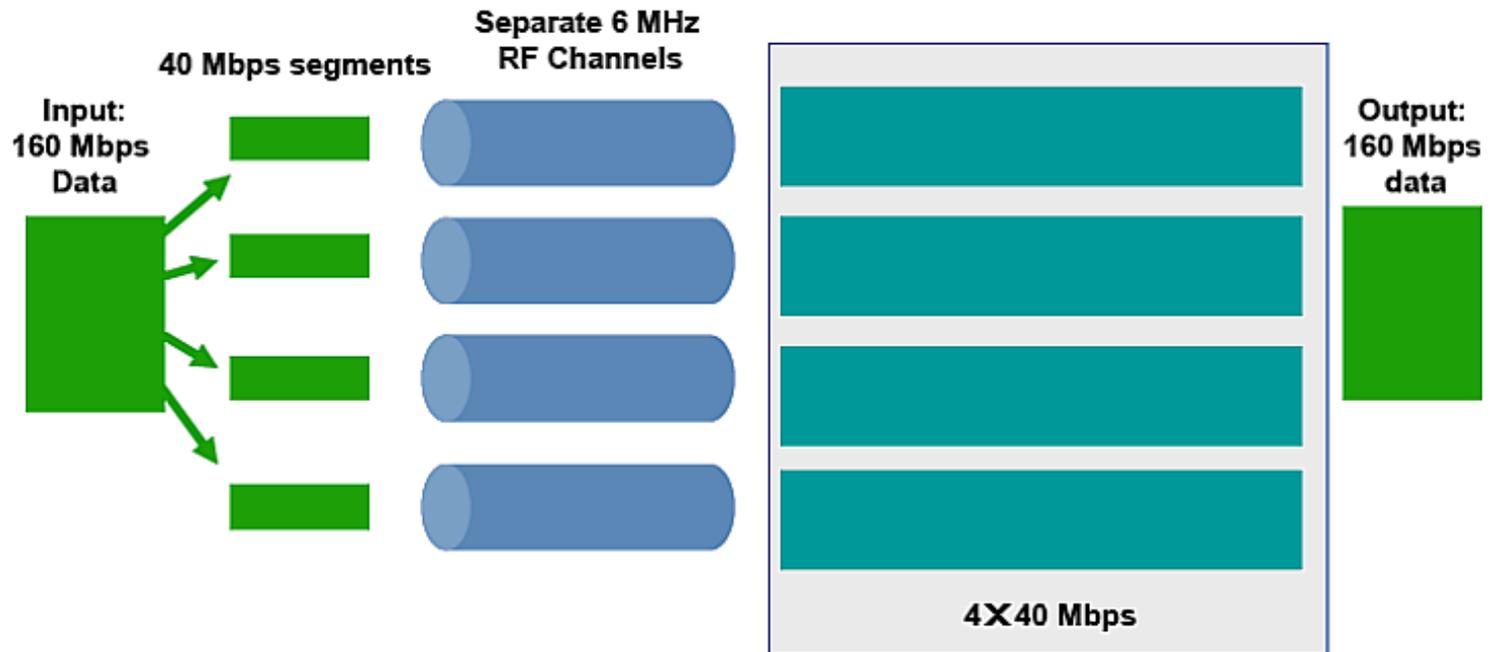
# D3 Impact on Testing

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



# Channel Bonding

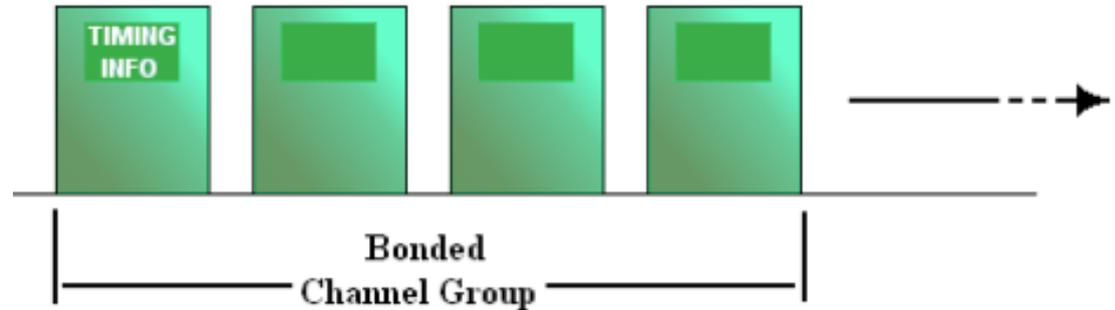
- Example:



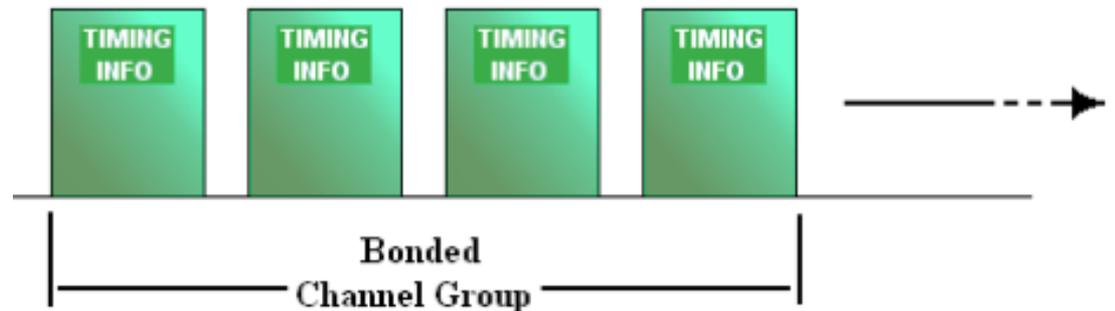


# “Primary” Channels

- 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





# Practical Field Testing – DOCSIS 3.0



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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





# 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)





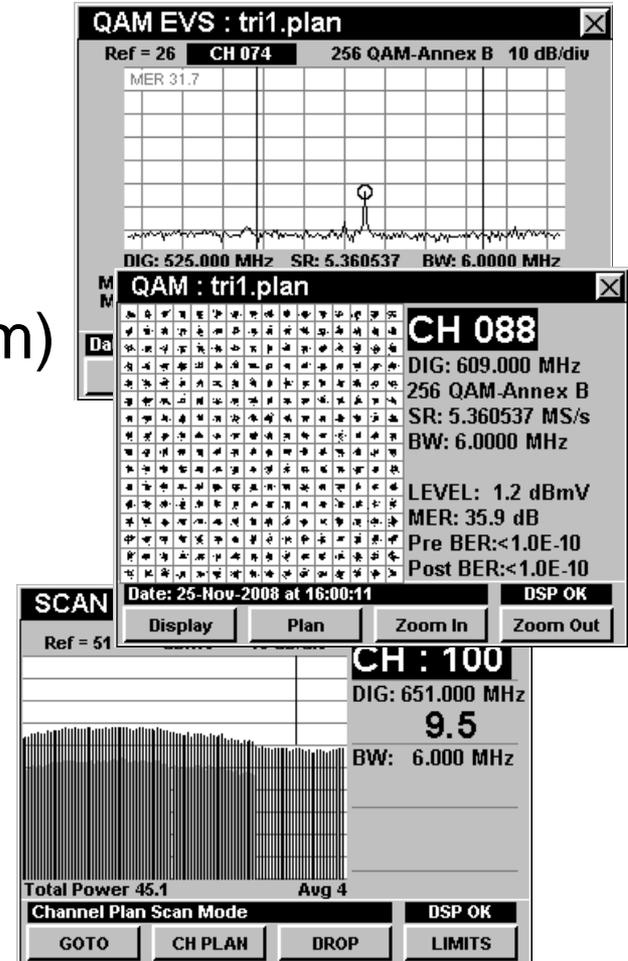
# Field Analyzer Test Capability

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



# Physical Tests

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



# IP Tests

- VoIP
  - Cable Modem Statistics
  - Ping
  - Trace Route
  - Web Browser
  - High-Speed Throughput
- (approximately 40 Mbps per bonded signal)

The image displays three overlapping screenshots from a network testing application:

- VoIP RTP (Our IP = 24.123.28.55)**: Shows a server IP of 67.36.135.81. Upstream statistics include Latency: 212 ms .F, Jitter: 21 ms .P, and MOS: 4.31 .P. Downstream statistics are also present.
- Cable Modem Statistics**: A table comparing DNSTREAM and UPSTREAM metrics.
 

DNSTREAM		UPSTREAM	
Freq:	789.000 MHz	Freq:	19.000 MHz
Rate:	5.360465 MSPS	Rate:	2560.000 KSPS
Power:	3.61 dBmV	Power:	56.22 dBmV
Modulation:	256 QAM		
Signal/Noise:	36.10 dB		
Corrected:	0		
Uncorrected:			
- Ping (Our IP = 192.168.0.228)**: Shows a host IP of 192.168.0.10. Packet delay is 100 msec and packet size is 512 bytes. Summary statistics: Sent 302, Received 295, Lost 7, LPR 2.32e-02, LPR (%) 2.3%. Min Time 12 msec, Avg Time 13 msec, Max Time 23 msec, Latency 67 msec, Jitter 5 msec. Signal strength is 42.00 dBmV.





# D3 Cable Modem Stats Test

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

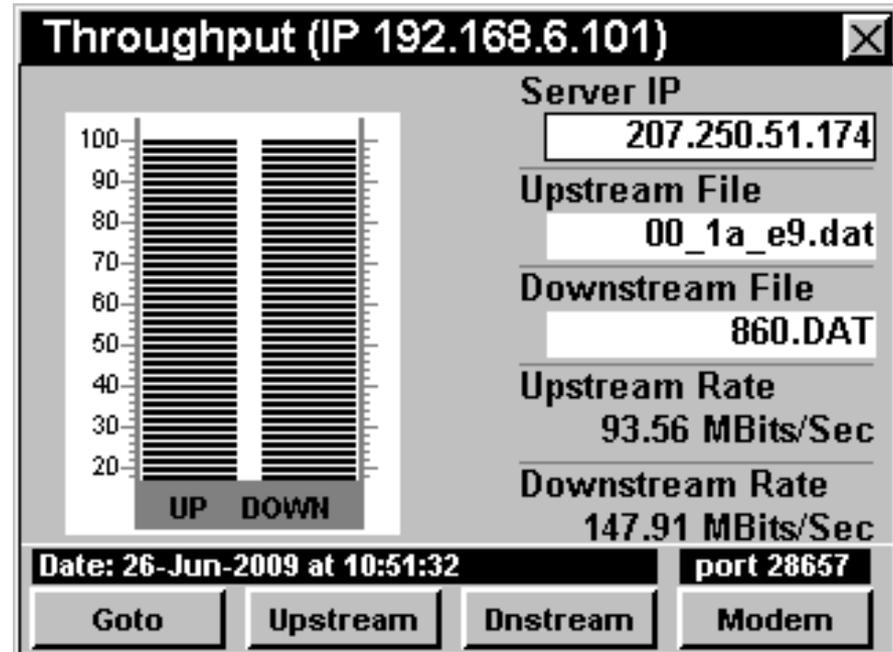
Cable Modem Statistics					
19-May-2009		Chrg 14.32V	31 C	COM	14:23:52
<b>Downstream</b>					
Frequency	Rx Level	MER	preBER	postBER	
819.00 MHz (256 QAM)	4.02 dBm/v	38.60 dB	1.00E-09	1.00E-09	
825.00 MHz (256 QAM)	4.52 dBm/v	37.85 dB	1.00E-09	1.00E-09	
831.00 MHz (256 QAM)	3.63 dBm/v	38.81 dB	1.00E-09	1.00E-09	
837.00 MHz (256 QAM)	3.61 dBm/v	38.80 dB	1.00E-09	1.00E-09	
<b>Upstream</b>					
Frequency	Tx Level				
21.80 MHz (64 QAM -1)	39.35 dBm/v				
25.00 MHz (64 QAM -2)	40.57 dBm/v				
28.20 MHz (64 QAM -3)	39.82 dBm/v				
31.40 MHz (64 QAM -4)	39.42 dBm/v				
<b>Cable Modem US30_1.2.0.10pre7</b>				<b>DOCSIS 3.0</b>	
Goto		IP Info		Config File	
				Change ID	





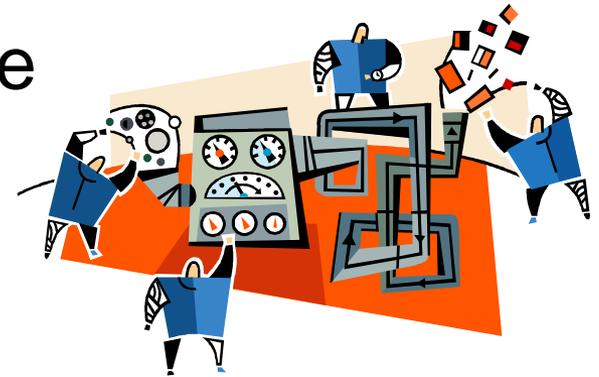
# D3 Throughput Test

- 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



# Typical D3 Autotest

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

<input type="checkbox"/> <b>Schedule</b>		<input type="checkbox"/> <b>Step 4 - Check Modem Stats</b>	
• Timing	Immediate One-Time		
<input type="checkbox"/> <b>Test Steps</b>		<input type="checkbox"/> <b>Parameters</b>	
• Step 1	MER/BER	• Modem MAC	Use Setup Menu
• Step 2	Scan	• Downstream Frequency	Use Setup Menu
• Step 3	Ping	• Modem Mode	Use Setup Menu
• Step 4	Modem Stats	• Annex Type	Use Setup Menu
• Step 5	VoIP RTP	• Upstream Id	Use Setup Menu
• Step 6	Throughput	<input type="checkbox"/> <b>Limits</b>	
• Step 7		• Minimum Launch Level	48 dBmV
• Step 8		• Maximum Launch Level	53 dBmV
• Step 9		• Minimum Receive Level	-3 dBmV
• Step 10		• Maximum Receive Level	5 dBmV



# 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

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
<b>Checking Data Against Limits</b>	
	DSP OK
	Load



# Typical Autotest for D3 Tests

- 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

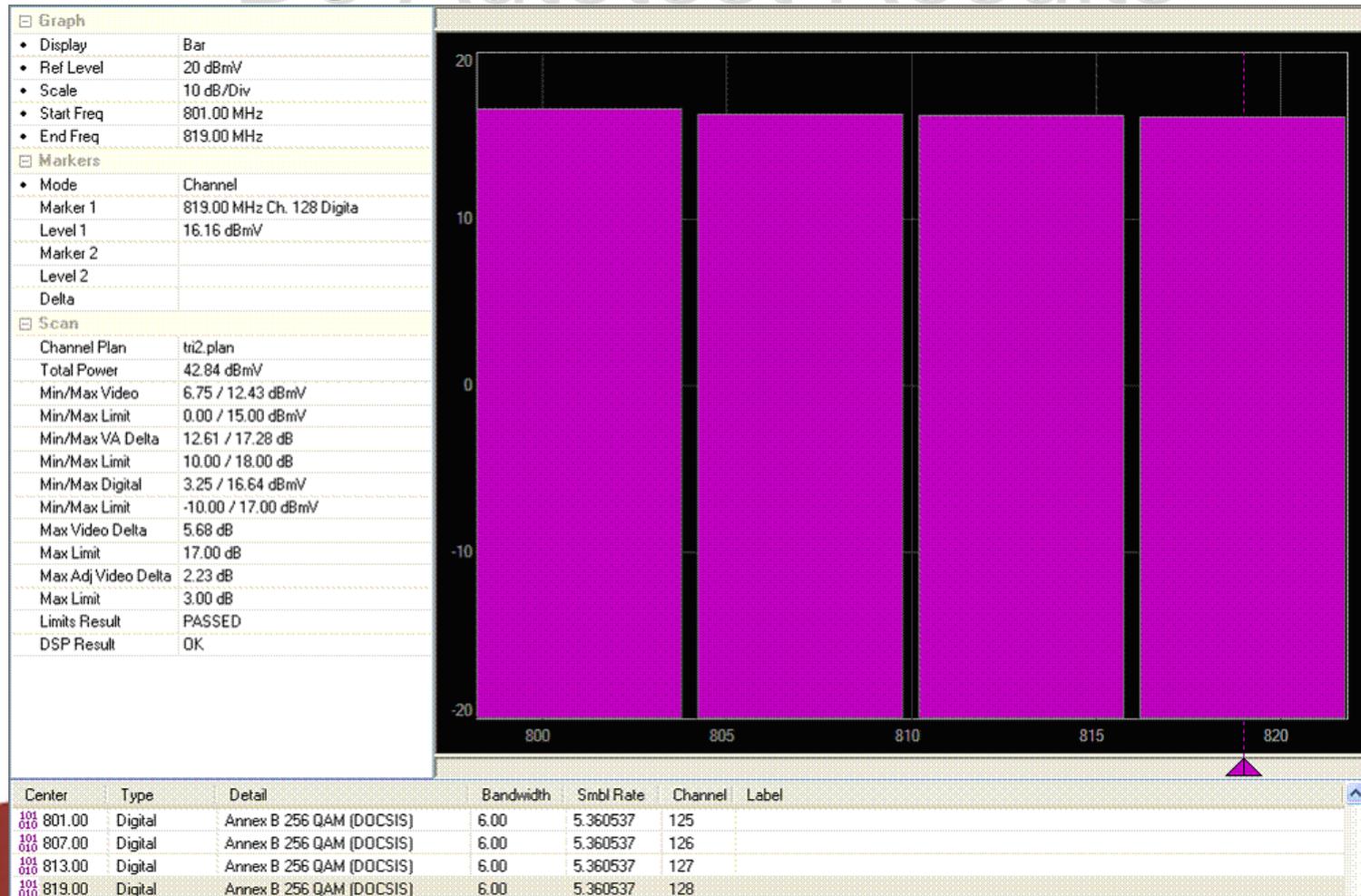
Press ENTER to Continue

Checking Data Against Limits DSP OK

Load



# D3 Autotest Results



# 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

**Table:**

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

The constellation diagram shows a grid of points from -16 to 16 on both axes, with a dense cluster of points in the center, indicating a successful QAM test.

# D3 Autotest Results

The screenshot shows the Trilithic WorkBench application window with the following details:

- Title Bar:** Trilithic WorkBench - [33.log]
- Menu Bar:** File, View, Device, Data, Window, Help
- Toolbar:** Contains various icons for file operations and device management.
- Left Panel (CM Stats):**

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
- Right Panel (CM Stats):**

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
- Bottom Panel (Tasks):**

Scheduled	Task



# D3 Test Macro Summary Report

- Results may be retained, displayed in supporting software


TRILITHIC
TDM

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**860 DSP Macro Summary**

Macro: docsis3  
 Result: Failed  
 Test Date/Time: 7/10/2018 10:59:29 AM  
 Channel Plan: bond1 plan  
 Meter Operator: ChinaID  
 Meter Cal Date/Time: 8/20/2017 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	BER	PreEQ BER
01	507.000	LV -4.29				ME 30.59	BE 35-7
02	575.000	LV -4.94				ME 30.26	BE 35-7
03	579.000	LV -5.52				ME 29.60	BE 65-8
04	585.000	LV -5.78				ME 29.34	BE 15-5

---

**Channel Summary: Failed**

Test	Value	Limit
Min BER: Failed	29.34	30.00
Max BER: Failed	15-5	35-8
Max Corrupted BER	< 1E-4	1E-4



# 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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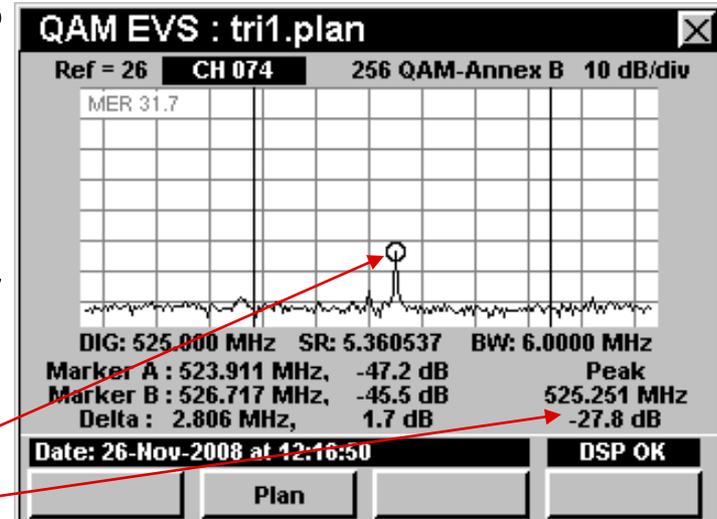
# Troubleshooting Low MER

- 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





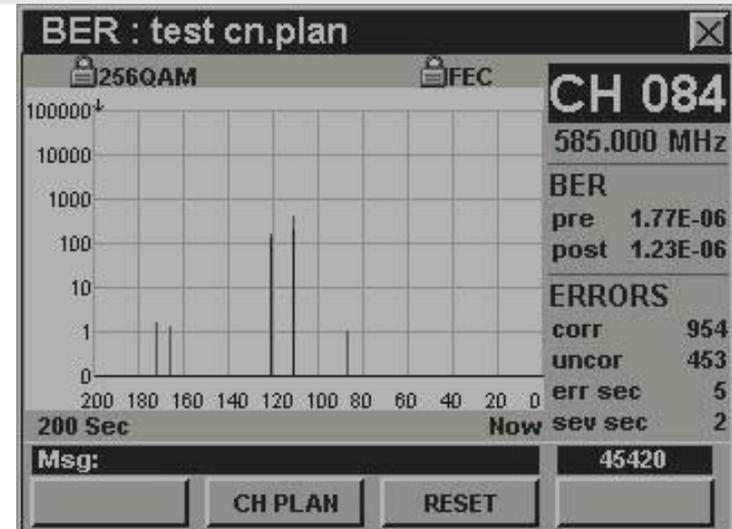
# Troubleshooting High BER

- 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





# 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

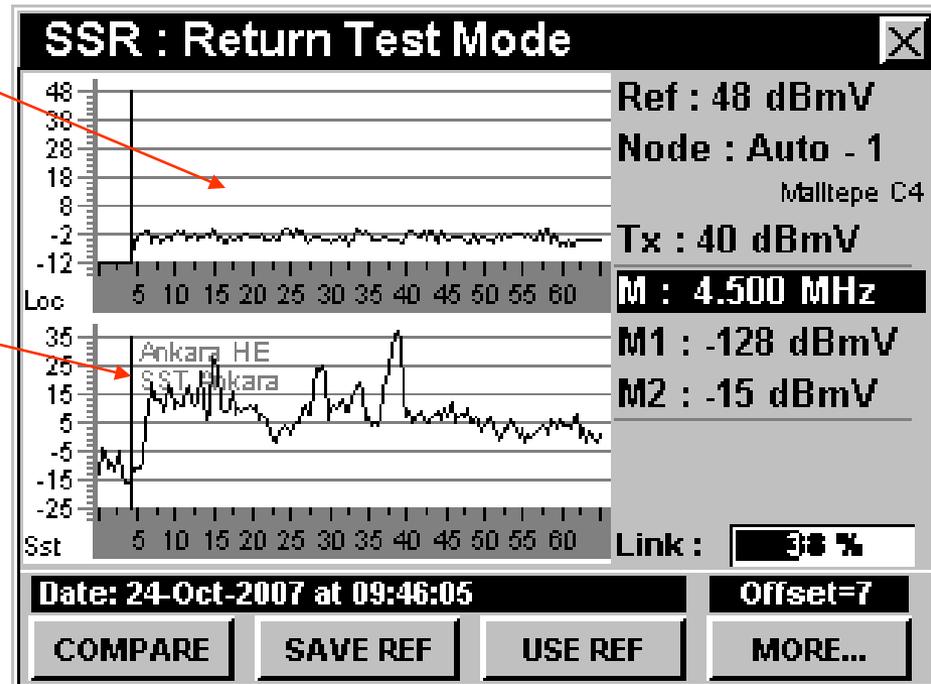


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# Reverse Ingress

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





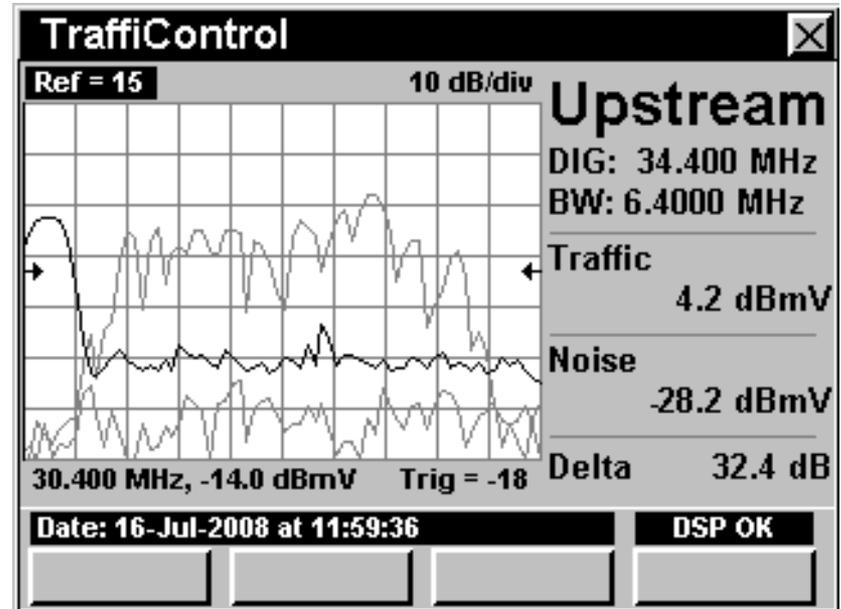
# Troubleshooting transients in upstream signal bands

- 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





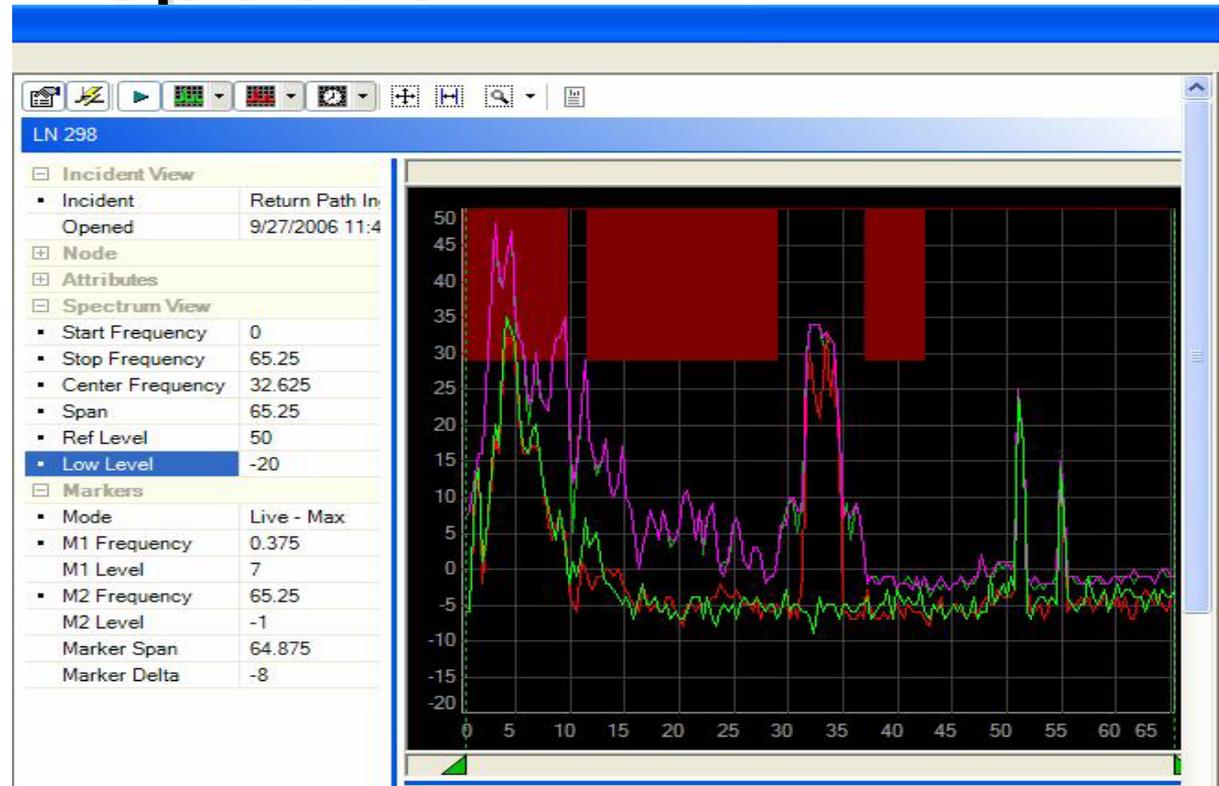
# Laser Clipping

- 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



# 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

Summary:

Beginning: 10/2/2006 12:00:00 AM  
 Ending: 10/3/2006 12:00:00 AM  
 Report Scope: Palmdale: Top 10 nodes per City in scope  
 Minimum Alarm: All Levels  
 Report Created: 10/03/2006

Hub	City	Node	Events	Alarm State Time Span (h:m:s)					% Unavailable
				No Signal	Level 4	Level 3	Level 2	Level 1	
	Palmdale	26 Nodes	2463						
	Lancaster	10 Nodes	1057						
	Acton	2 Nodes	455						
	Palmdale	10 Nodes	1591						
	EAFB	4 Nodes	560						

TRILITHIC Palmdale: Top 10 nodes per City in scope





# 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  $\geq 10\mu\text{S}$
  - 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





# 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?



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