“Best Practices for Proactively Maintaining Your Return Paths”

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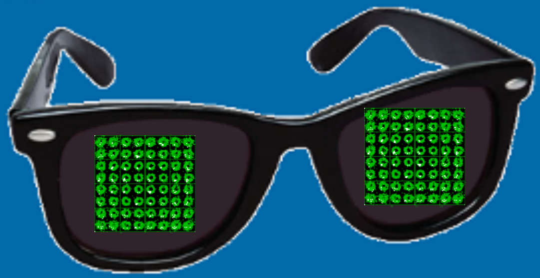
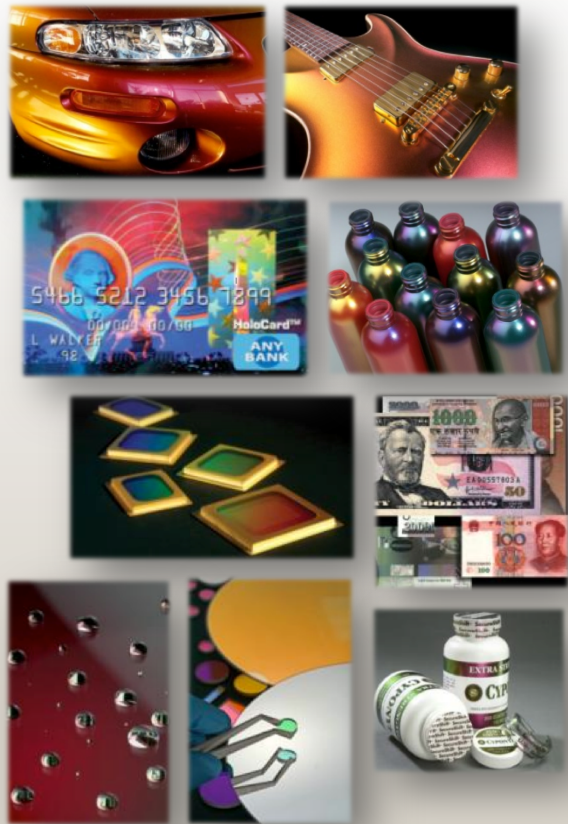


See digital in a whole new light!

Global Leaders in the Markets We Serve

Advanced Optical Technologies



Currency, Defense, Authentication, and Instrumentation

Communications & Commercial Optical Products

Cable, Telecom, Datacom, Submarine, Long Haul, Biotech, and Microelectronics

Communications Test & Measurement

Service Provider, Government, Business, and Home Networks

Bandwidth Demand is Growing Exponentially!

JDSU

The HFC Pipe to the Home is Huge!

The BAD news is that ingress from one home can potentially kill upstream services for hundreds of your subscribers!!!

DOCSIS® 3.0 Overview

- **New Specifications**
  - DOCSIS 3.0 Interface Specifications (released December 2006)
  - CPE equipment in development stages (Bronze, Silver, Full)
- **Downstream data rates up to 300 Mbps**
  - Channel Bonding — 1 x 256QAM => “up to” ~40Mbps
  - Bond up to 8 channels — 8 x 256QAM => “up to” ~320 Mbps
- **Upstream data rates of 120 Mbps or higher**
  - Channel Bonding — 1 x 64QAM => “up to” ~30Mbps
  - Bond up to 4 channels — 4 x 64QAM => “up to” ~120 Mbps
- **Internet Protocol version 6 (IPv6)**
  - IPv6 greatly expands the number of IP addresses
    - Expands IP address space from 32 bits to 128 bits
    - IPv6 supports **3.4×10^{38}** addresses
    - Colon-Hexadecimal Format

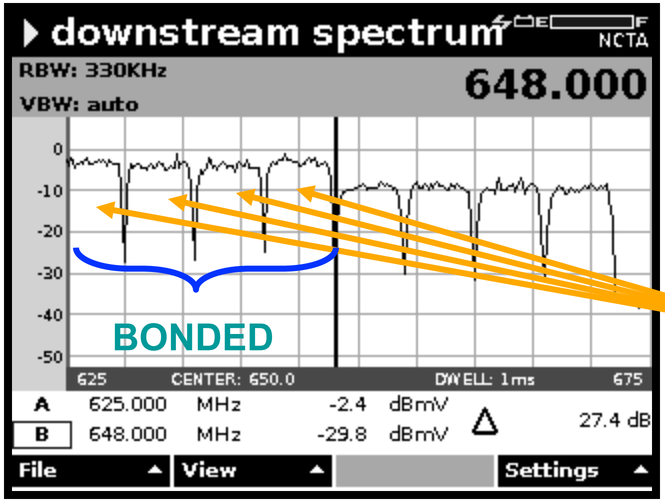
4923:2A1C:0DB8:04F3:AEB5:96F0:E08C:FFEC

- **100% backward compatible with DOCSIS 1.0/1.1/2.0**

DOCSIS® 3.0 – Channel Bonding

- In a nutshell, channel bonding means data is transmitted to or from CMs using multiple individual RF channels instead of just one channel

- Channels aren't physically bonded into a gigantic digitally modulated signal; bonding is logical



4 Bonded 256 QAM DOCSIS channels

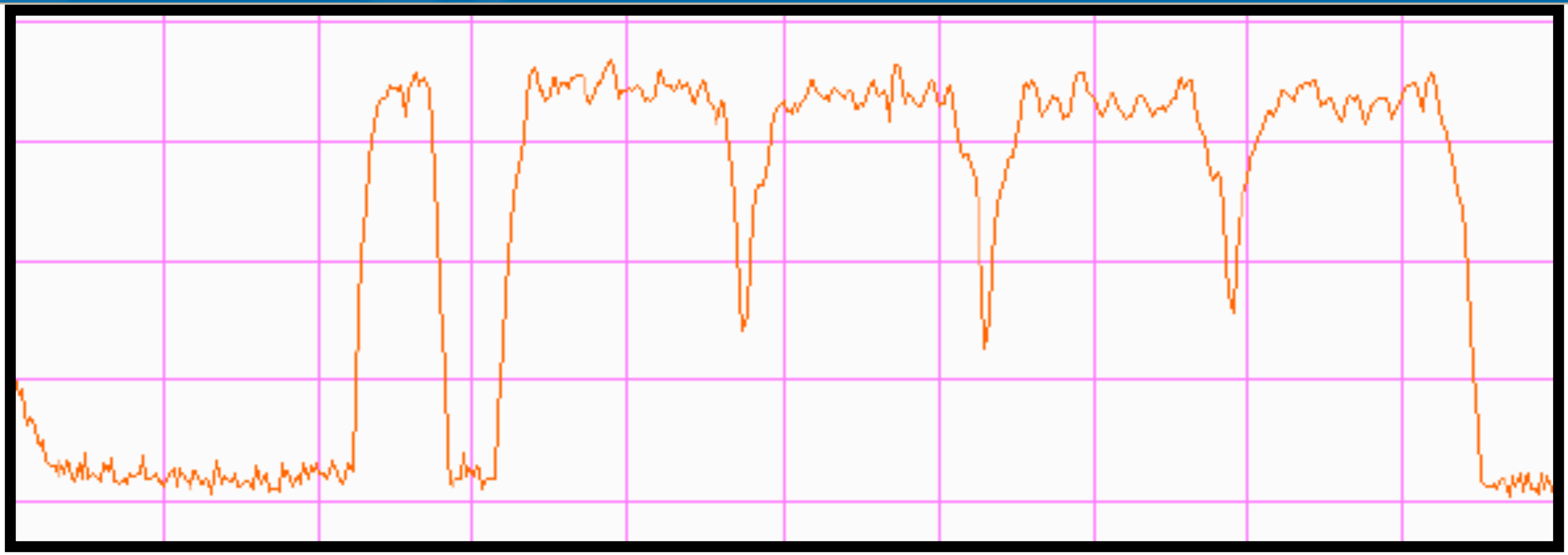
DOCSIS v3.0 Spec requires devices to be able to bond a minimum of 4 upstream channels into one and 4 downstream channels into one for 4 times increased throughput in both directions

The MSO does not have to use all 4 channels, but the devices which are 3.0 compliant must have the ability to bond 4 or more channels in both directions

4 x 256QAM

4 x ~40Mbps = ~160 Mbps

DOCSIS® 3.0 adds Capability to Bond up to 4 Upstream 64QAM Carriers!



Four times 6.4 MHz = 25.6 MHz! (without guard-bands)

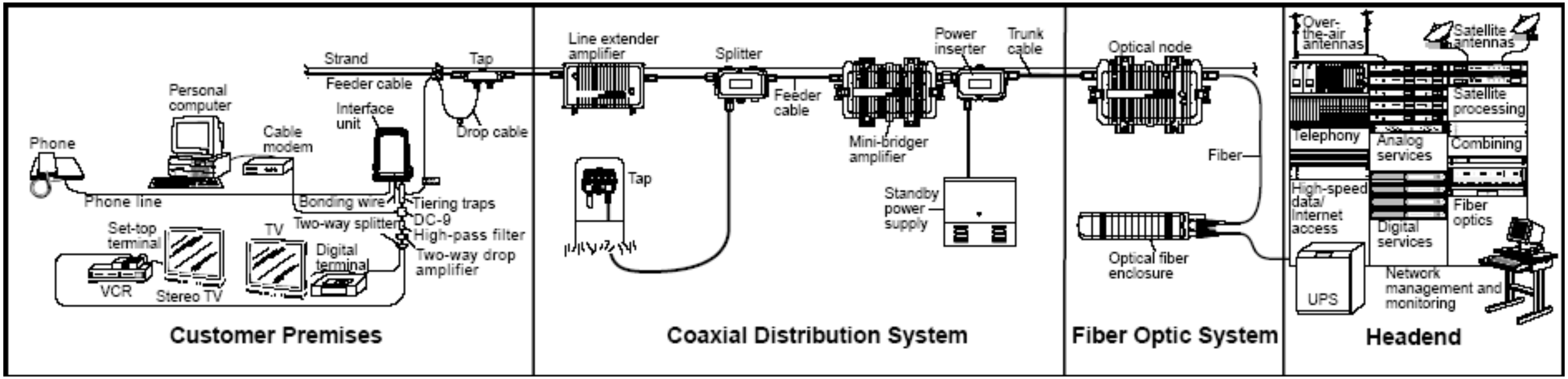
- Increased chances for laser clipping
- Increased probability of problems caused by ingress, impulse noise, group delay, micro-reflections and other linear distortions
- Inability to avoid known problem frequencies such as Citizens' Band, Ham, Shortwave and CPD distortion beats
- What frequencies are you going to monitor for problems?

Today's Agenda

- **Getting ready for DOCSIS® 3.0 - Optimize Your HFC network now!**
  - Verify optimal setup and performance (dynamic range) of both Optical & RF portion of the HFC network
  - Forward & Reverse sweep for unity gain throughout coaxial network
- **Troubleshooting Upstream Impairments**
  - Trouble Shooting Tools
  - Ingress
  - Common Path Distortion (CPD)
  - Impulse Noise
  - Linear Distortions

HFC Networks

- Combines fiber optics with coaxial distribution network
- Return path is more sensitive than the forward path
- Most of the ingress comes from home wiring on low value taps
- Wide variety of aging hardware with many connectors



Today's "HFC" networks must be optimized for both forward and reverse performance

Monitoring and Maintaining the Return Path

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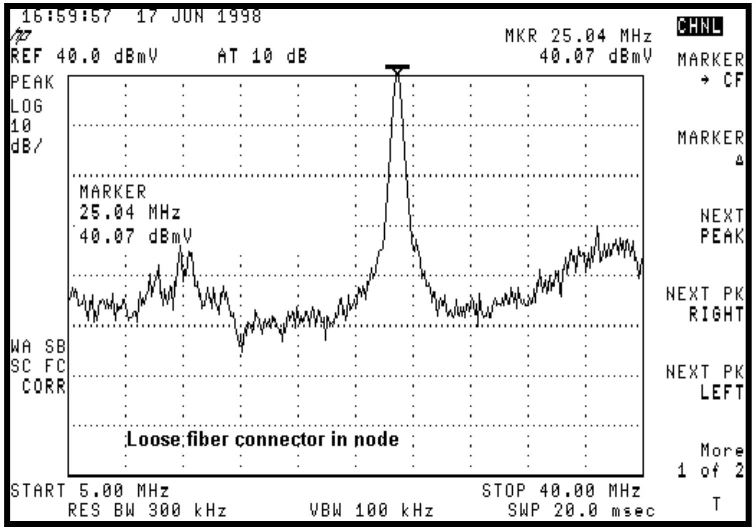
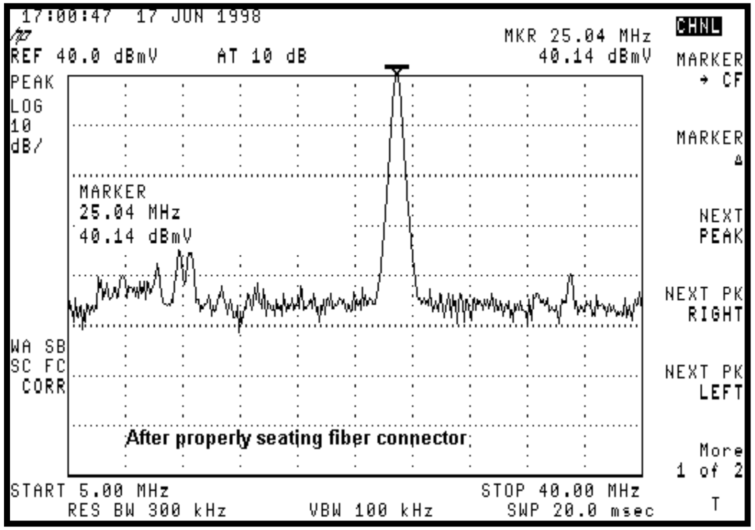
Loose Fiber Connector

- SC connector not pushed in all the way



Before



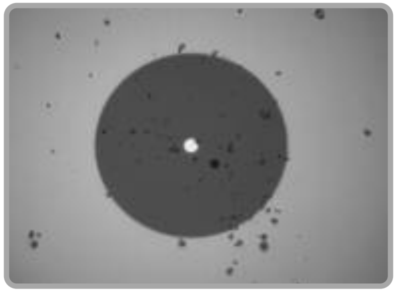
After

Types of Fiber Contamination

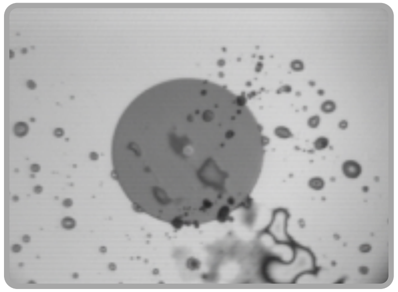
A fiber end face **should be free of any contamination or defects,** as shown below:

SINGLEMODE FIBER

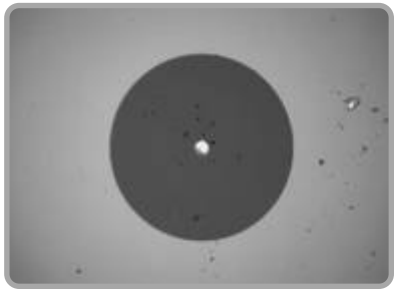
Common types of contamination and defects include the following:



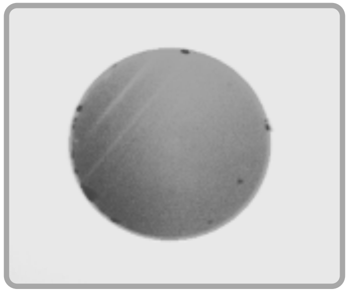
Dirt



Oil



Pits & Chips



Scratches

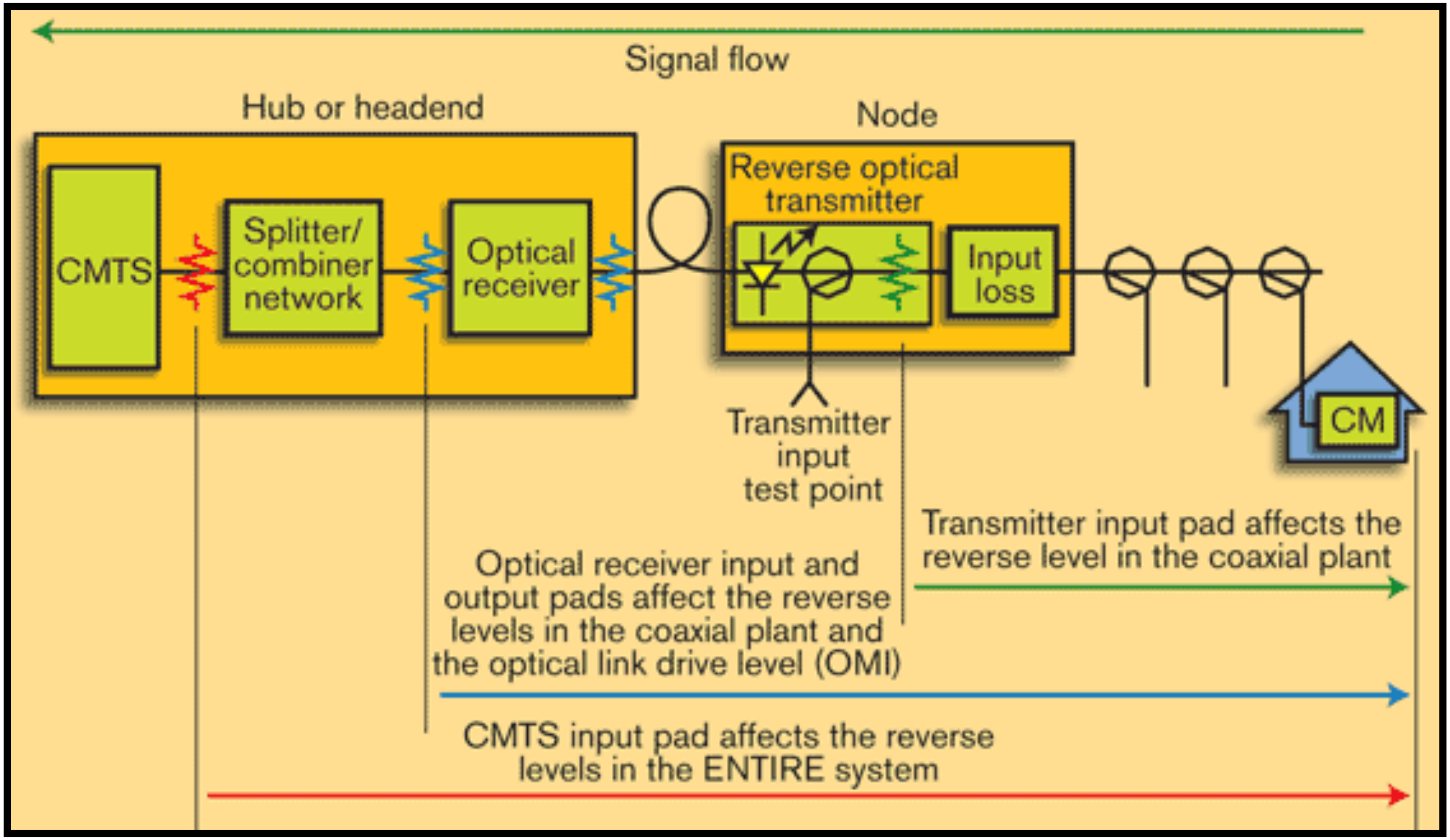
Where is it? – Everywhere!

Your biggest problem is right in front of you… you just can't see it!

DIRT IS EVERYWHERE!

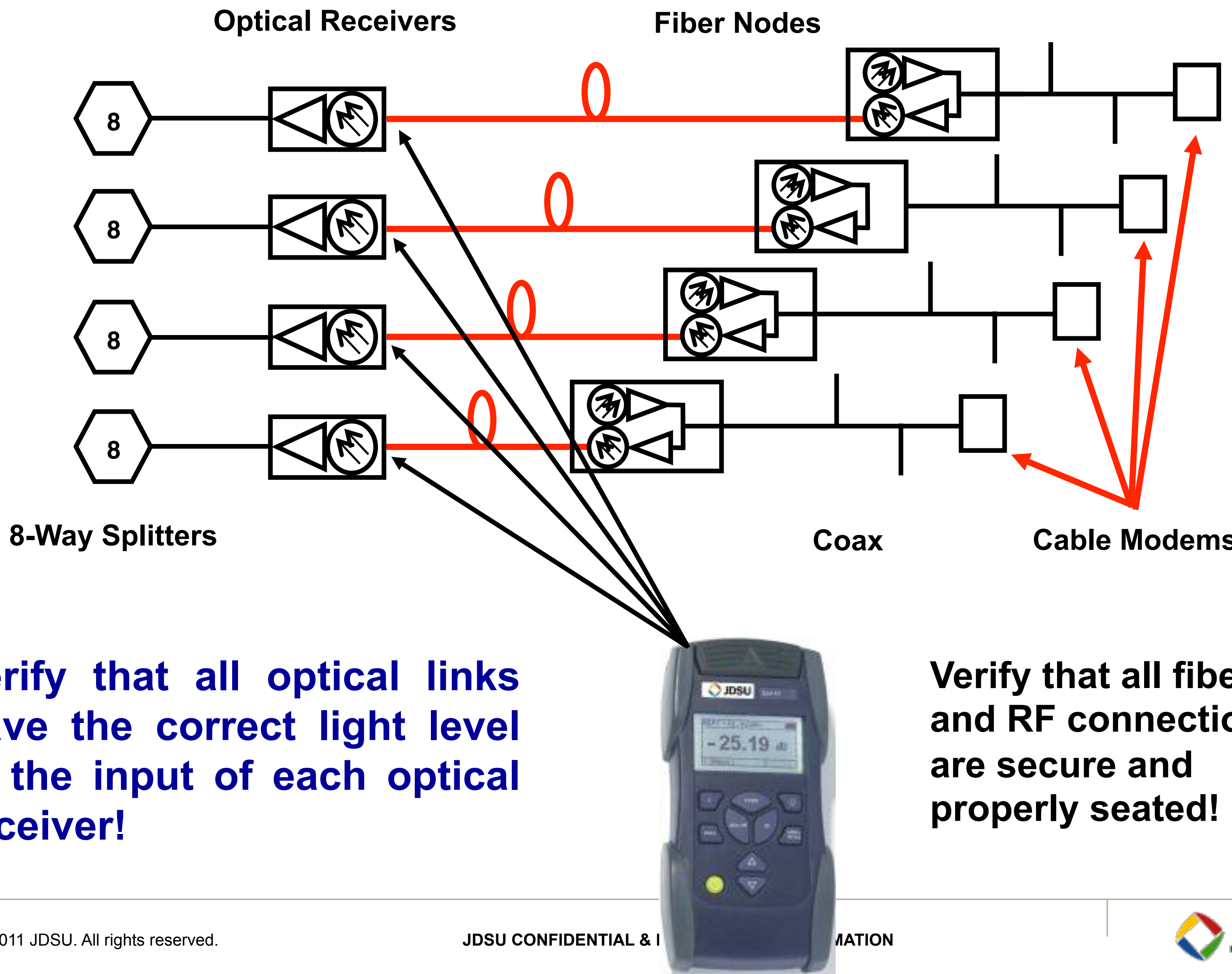
- Airborne, hands, clothing, bulkhead adapter, dust caps, test equipment, etc.
- **The average dust particle is 2–5μ, which is not visible to the human eye.**
- A single spec of dust can be a major problem when embedded on or near the fiber core.
- **Even a brand new connector can be dirty.** Dust caps protect the fiber end face, but can also be a source of contamination.
- Fiber inspection microscopes give you a clear picture of the problems you are facing.

What Controls What?



Contact the manufacturer of your lasers, optical receivers and CMTS and ask them for their recommended RF and Optical input/output levels and setup procedures.

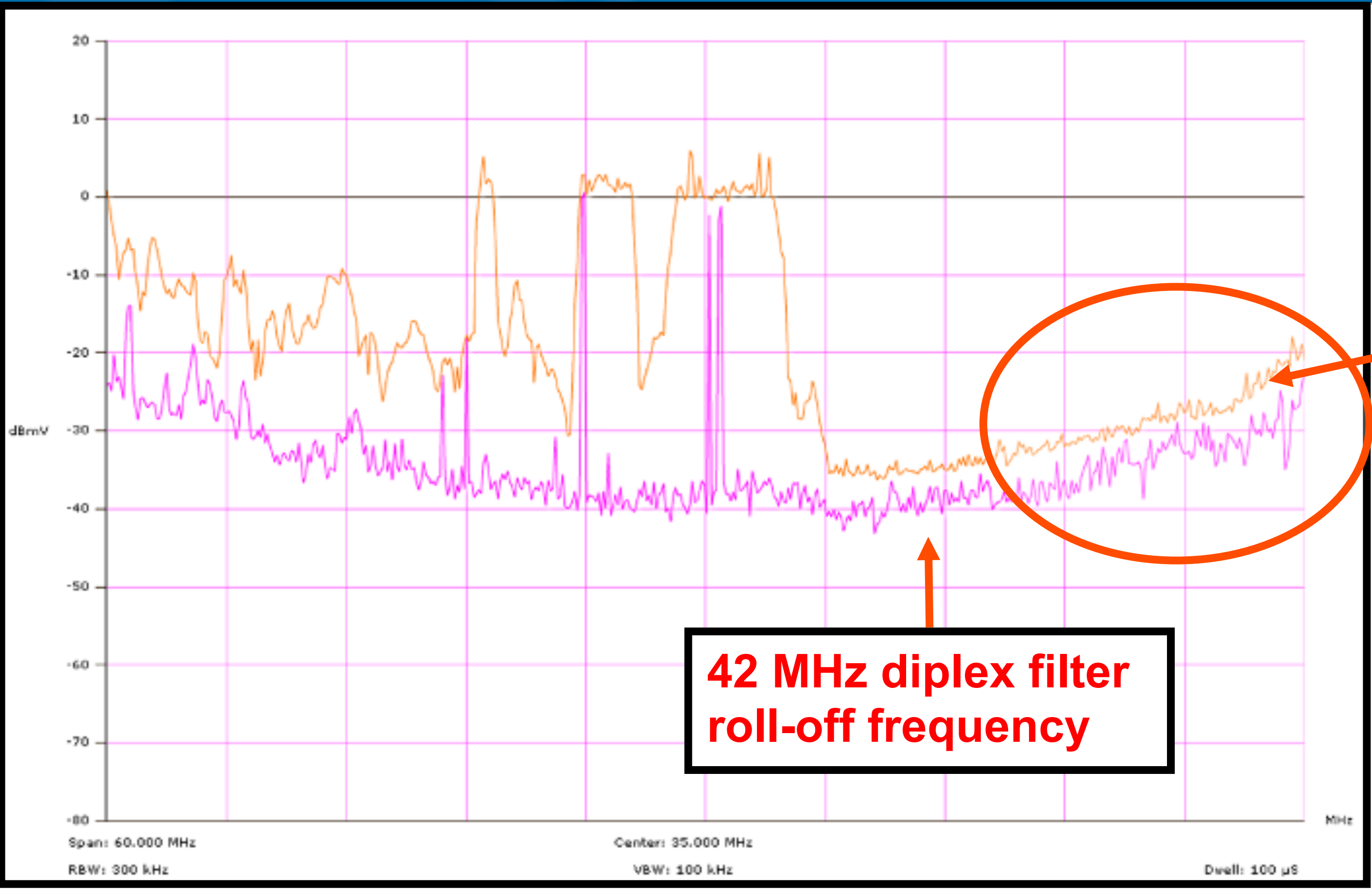
Optimize the Optical Links in Your HFC Networks!



Verify that all optical links have the correct light level at the input of each optical receiver!

Verify that all fiber and RF connections are secure and properly seated!

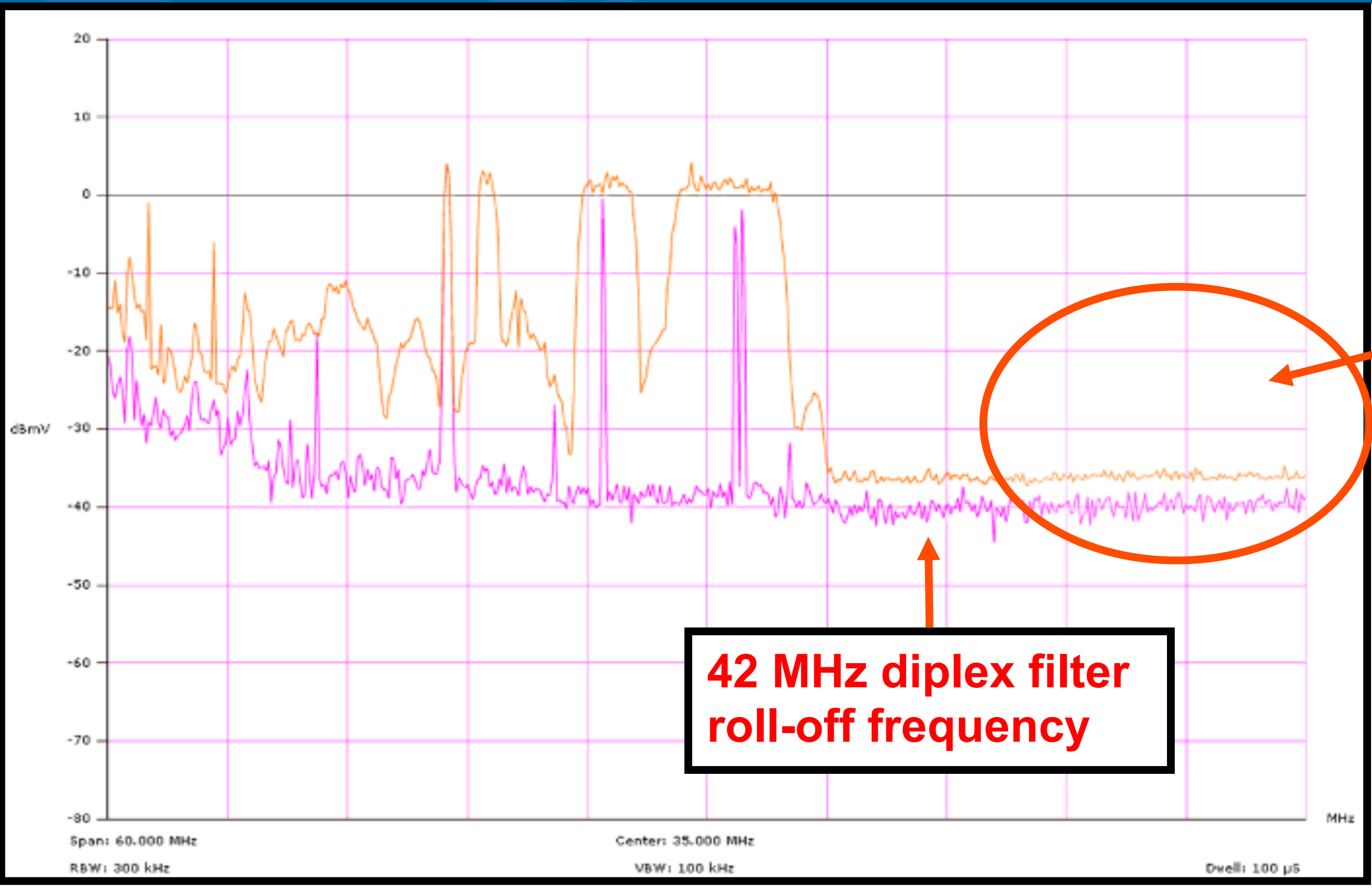
Too Much Optical Power into Optical Receiver



Abnormal rise in the noise floor above diplex roll-off frequency

Too much optical power (light level) into the input of a return optical receiver can cause an abnormal rise in the noise floor above the diplex filter roll-off frequencies.

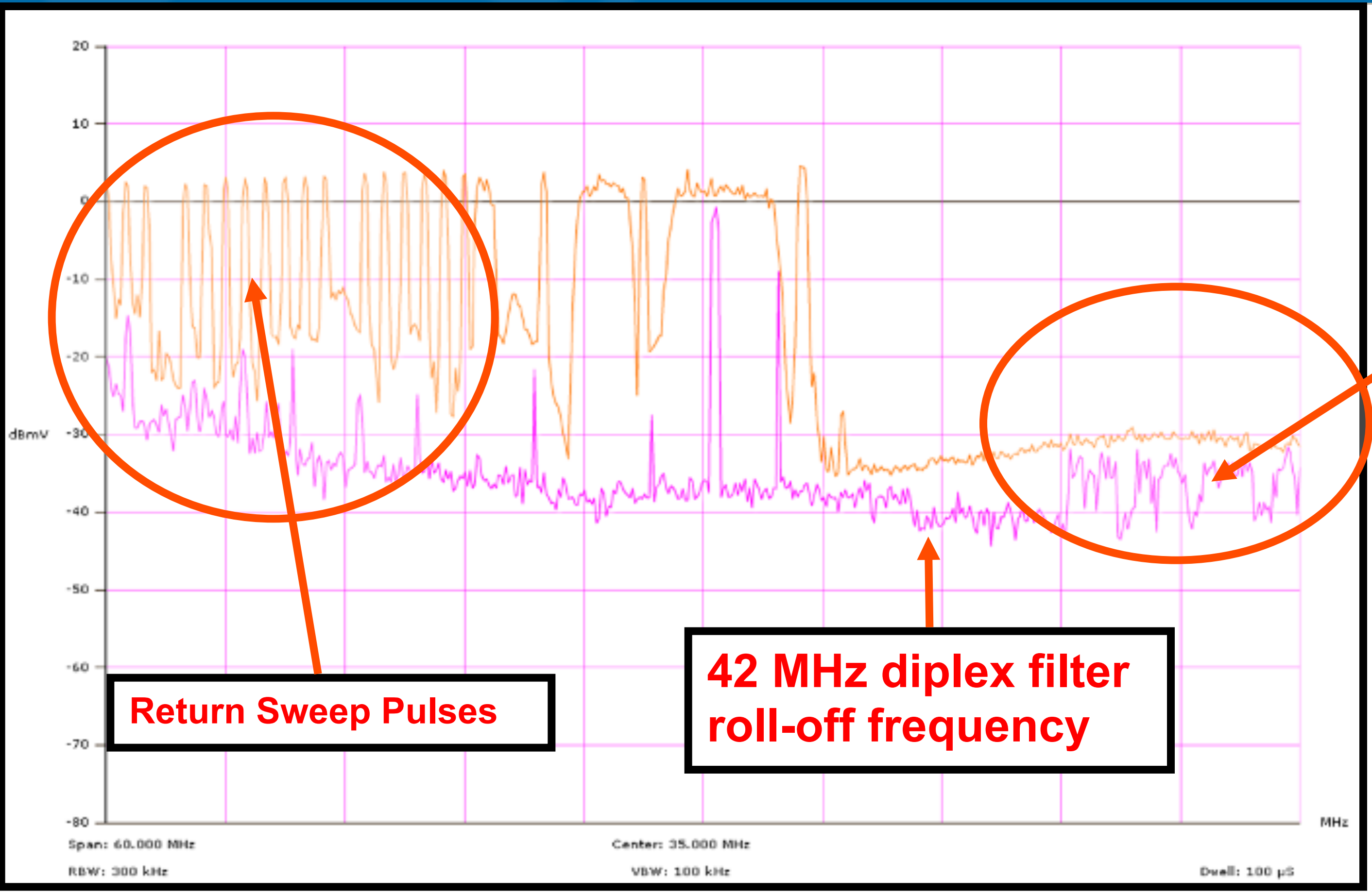
Too Much Optical Power into Optical Receiver



After adding 2 dB of optical attenuation at the input of the optical receiver, the noise floor above diplex roll-off frequency now looks normal.

2 dB of additional optical attenuation was added to the return input of the optical receiver and resulted in a "flatter noise floor" above the diplex filter roll-off frequencies.

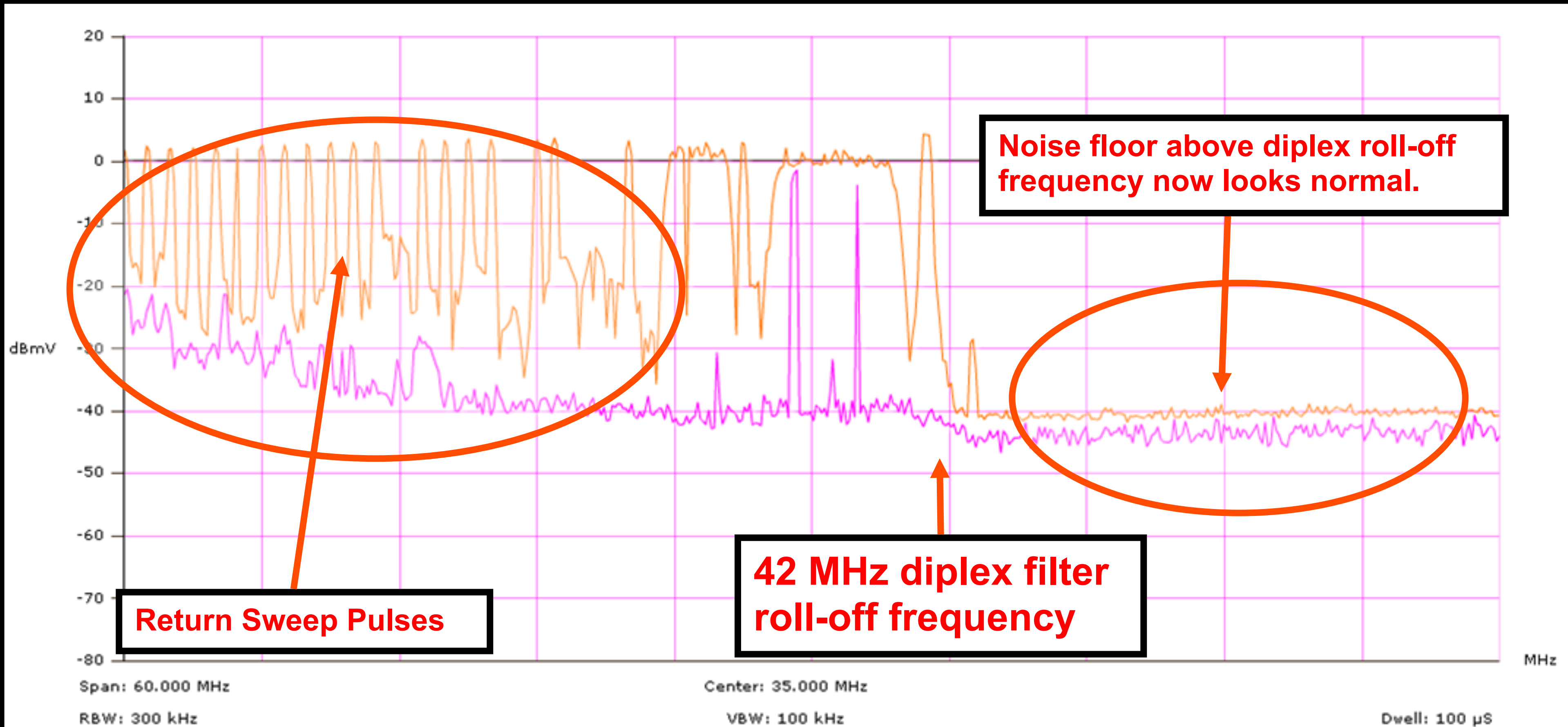
Too Much Optical Power into Optical Receiver



After inserting sweep pulses into the return path, the noise floor above diplex roll-off frequency now exhibits impulse noise created by sweep pulses.

When sweep pulses were injected into the return path, "impulse distortions" showed up in the noise floor above the diplex filter roll-off frequencies.

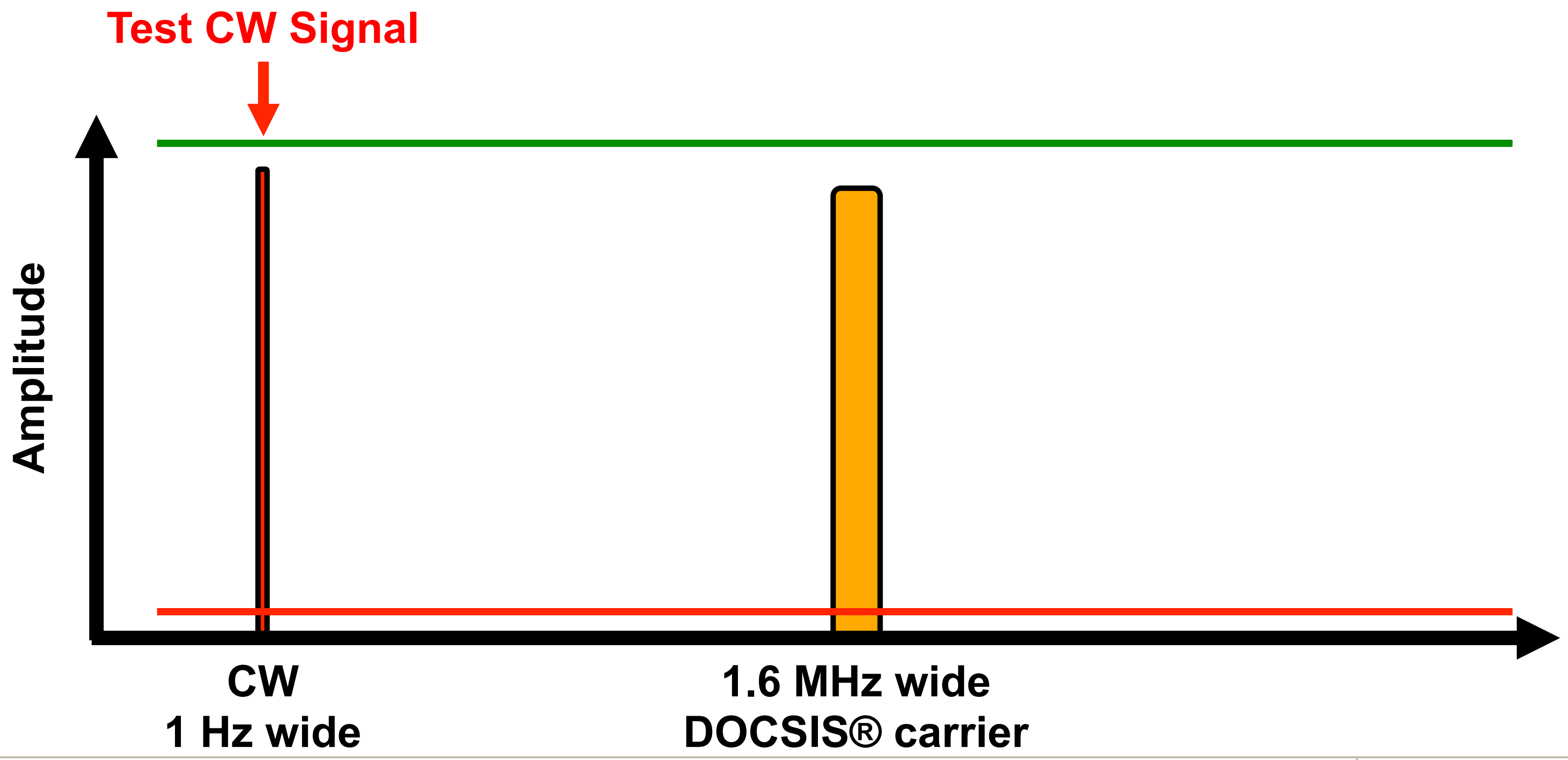
Too Much Optical Power into Optical Receiver



6 dB of additional optical attenuation was added to the return input of the optical receiver and resulted in a "flatter noise floor" above the diplex filter roll-off frequencies, even when sweep pulses were injected into the retun path.

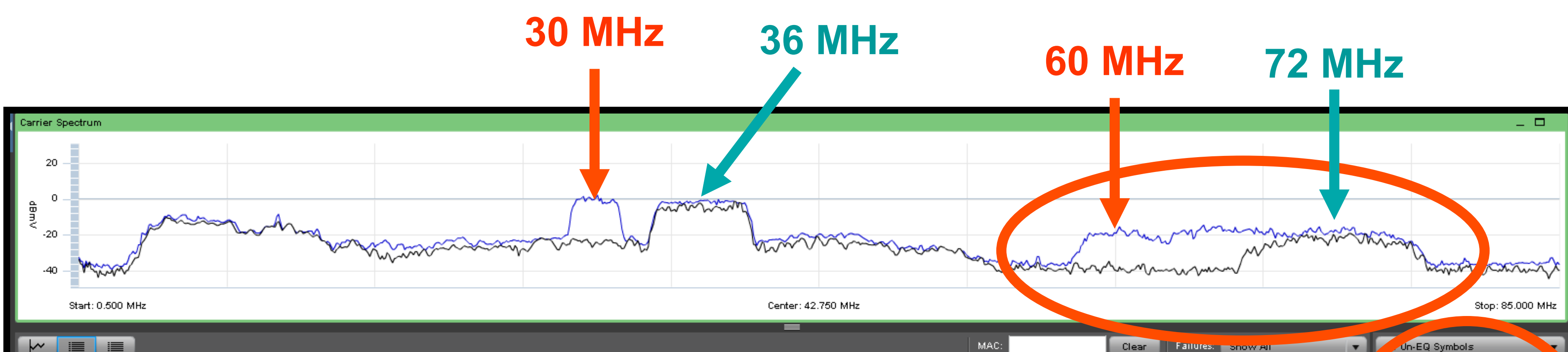
Measuring Upstream Carrier Amplitudes

Dynamic range of the return path in an HFC network is typically setup by injecting one or more CW test signals and then measured with a typical spectrum analyzer or signal level meter.

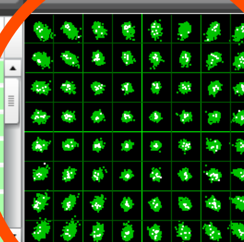


Optical Link is Critical to Upstream Performance

- RF level is too high at input of return laser
  - Verify light level at input of return optical receiver
  - Verify RF level at input of return laser
  - Verify RF spectrum above diplex frequency at input of return laser



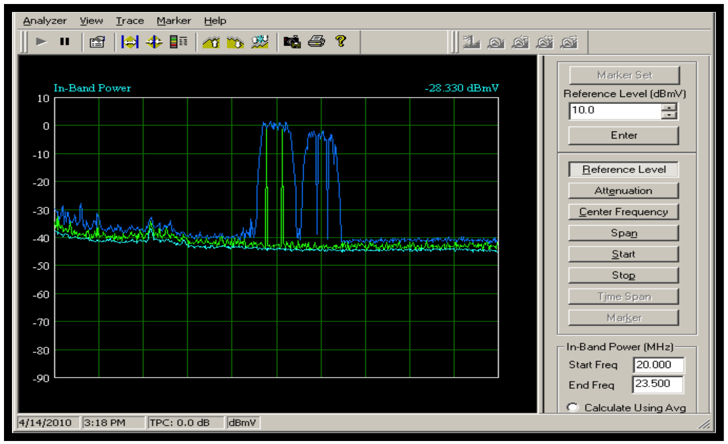
Time	MAC Address	Uncorrectable CW Errors	Total CW Errors	MER (dB)	UN-EQ MER (dB)	Carrier Level (dBmV)	Micro-reflection (dB)	In-band Response (dB)	Group Delay (ns)	Ingress Under Carrier (dBc)	Impulse Noise
2010-07-09 12:17:51	00:21:43:18:1F:F8	0	0	27.31	26.09	4.18	-38.65	0.66	144.46	-27.93	[illegible]
2010-07-09 12:17:47	00:21:43:18:1F:F8	0	0	26.65	26.60	4.28	-35.53	1.28	175.98	-20.06	[illegible]
2010-07-09 12:17:43	00:24:D1:F1:59:67	0	0	26.43	25.73	3.62	-37.30	0.89	241.07	-23.95	[illegible]
2010-07-09 12:17:41	00:21:43:18:1F:F8	0	0	27.50	26.19	4.18	-37.56	0.51	174.46	-27.77	[illegible]
2010-07-09 12:17:37	00:21:43:18:1F:F8	0	0	27.51	25.86	4.28	-37.51	0.98	162.67	-26.97	[illegible]
2010-07-09 12:17:37	00:21:43:18:1F:F8	0	0	27.04	22.98	4.22	-29.32	0.77	192.96	-26.70	[illegible]
2010-07-09 12:17:35	00:21:43:18:1F:F8	0	2	27.54	25.72	4.19	-35.25	0.88	177.42	-26.96	[illegible]

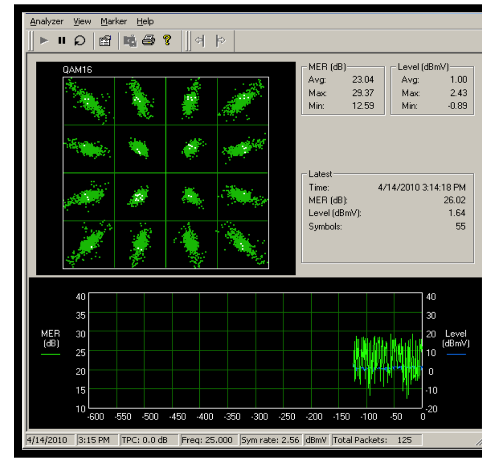


WebView FFT Spectrum View of the Upstream

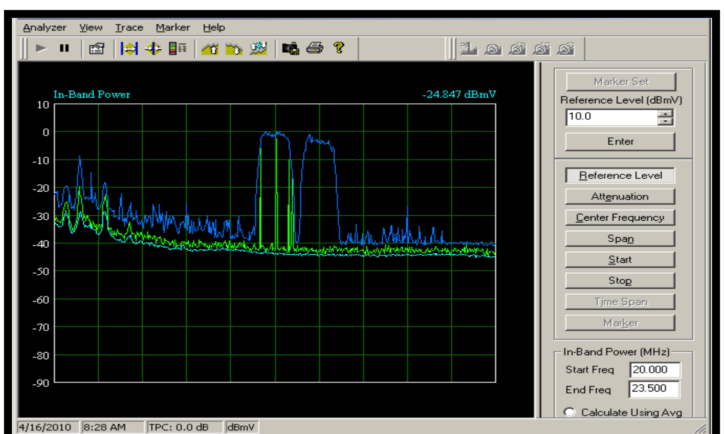
Bad Optical Receiver

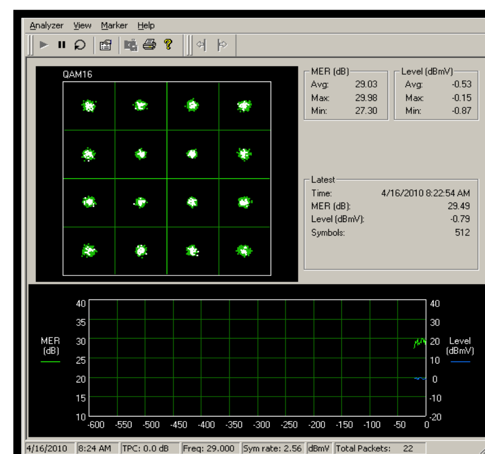
- Note the before/after spectrum analyzer shots – no sign of a problem!
- QAM Analyzer needed to detect source of problem and know when it's fixed in real time





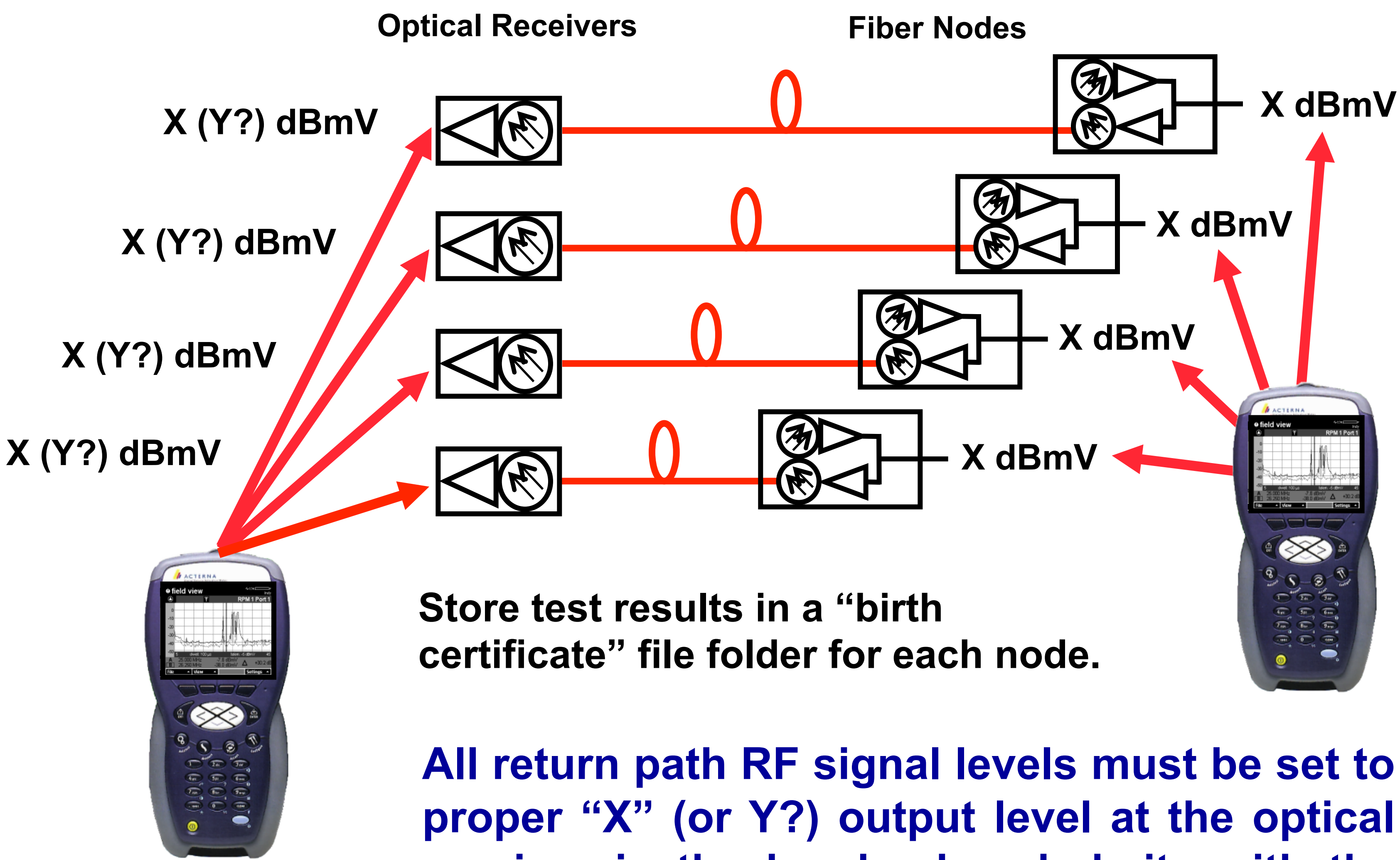
Before Fix:
Spectrum Looks Great
QAM Looks Bad





After Fix:
Spectrum Looks Good
QAM Looks Great

Optimize the RF Output of the Optical Receiver

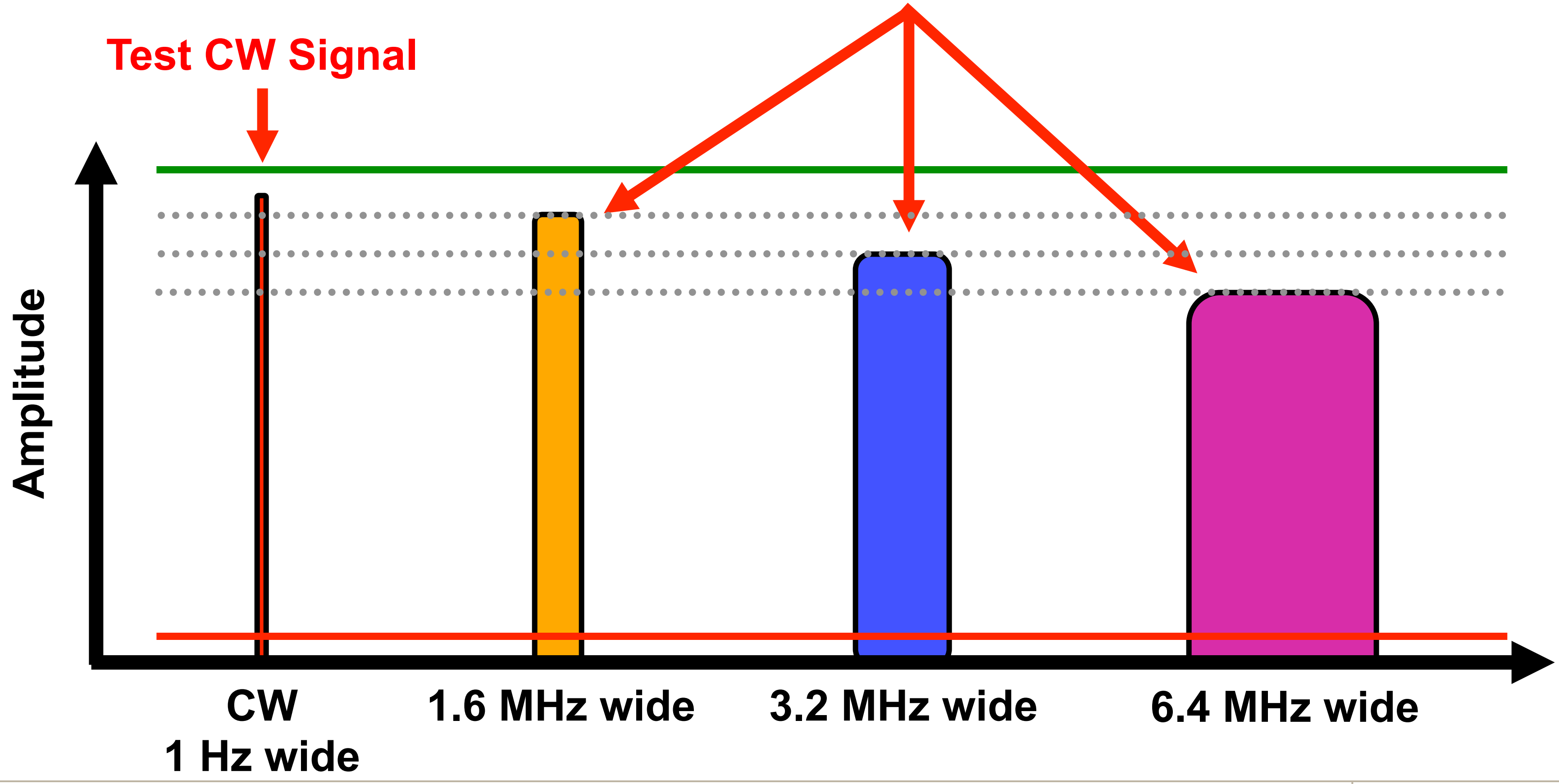


Store test results in a "birth certificate" file folder for each node.

All return path RF signal levels must be set to proper "X" (or Y?) output level at the optical receiver in the headend or hubsite with the correct "X" level injected at the node.

Measuring Upstream Carrier Amplitudes

These three DOCSIS® carriers will NOT have the same peak amplitude when hitting the input port of a CMTS at 0 dBmV "constant power per carrier" and then measured with a typical spectrum analyzer or signal level meter.



Monitoring and Maintaining the Return Path

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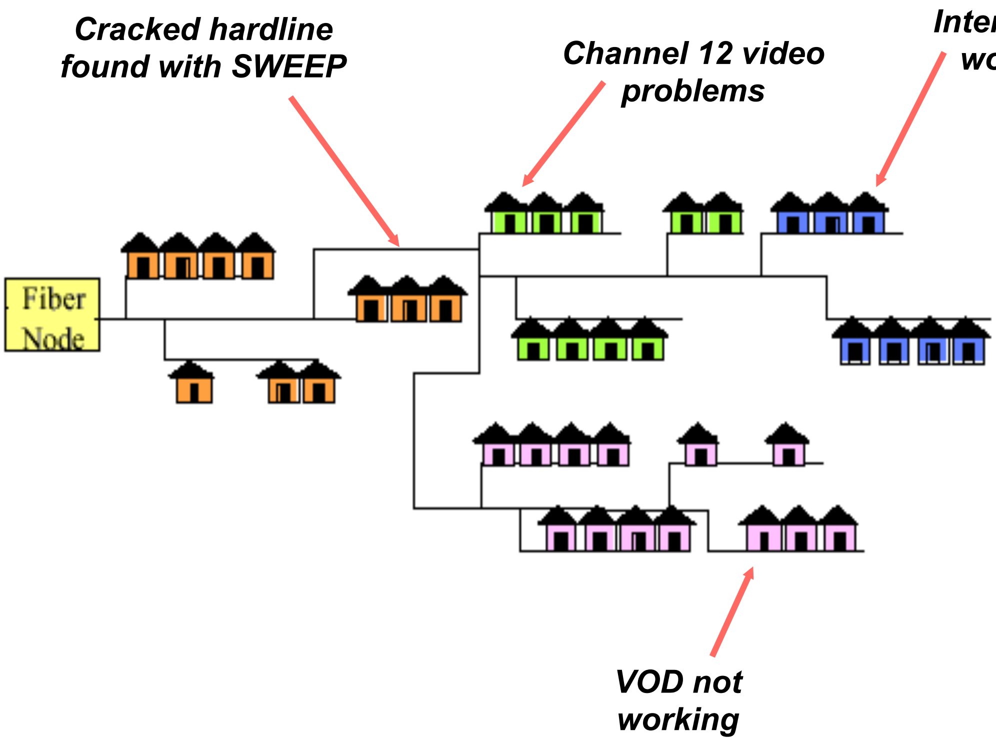
  - Trouble Shooting Tools
  - Ingress
  - Common Path Distortion (CPD)
  - Impulse Noise
  - Linear Distortions

WHY SWEEP?

- Less manpower needed
- Sweeping can reduce the number of service calls



Sweep Verifies Construction Quality

Sweep can find craftsmanship or component problems that aren't revealed with other tests

- Damaged cable
- Poor connectorization
- Amplifier RF response throughout its frequency range
  - Gain
  - Slope
- Loose face plates, seizure screws, module hardware…….

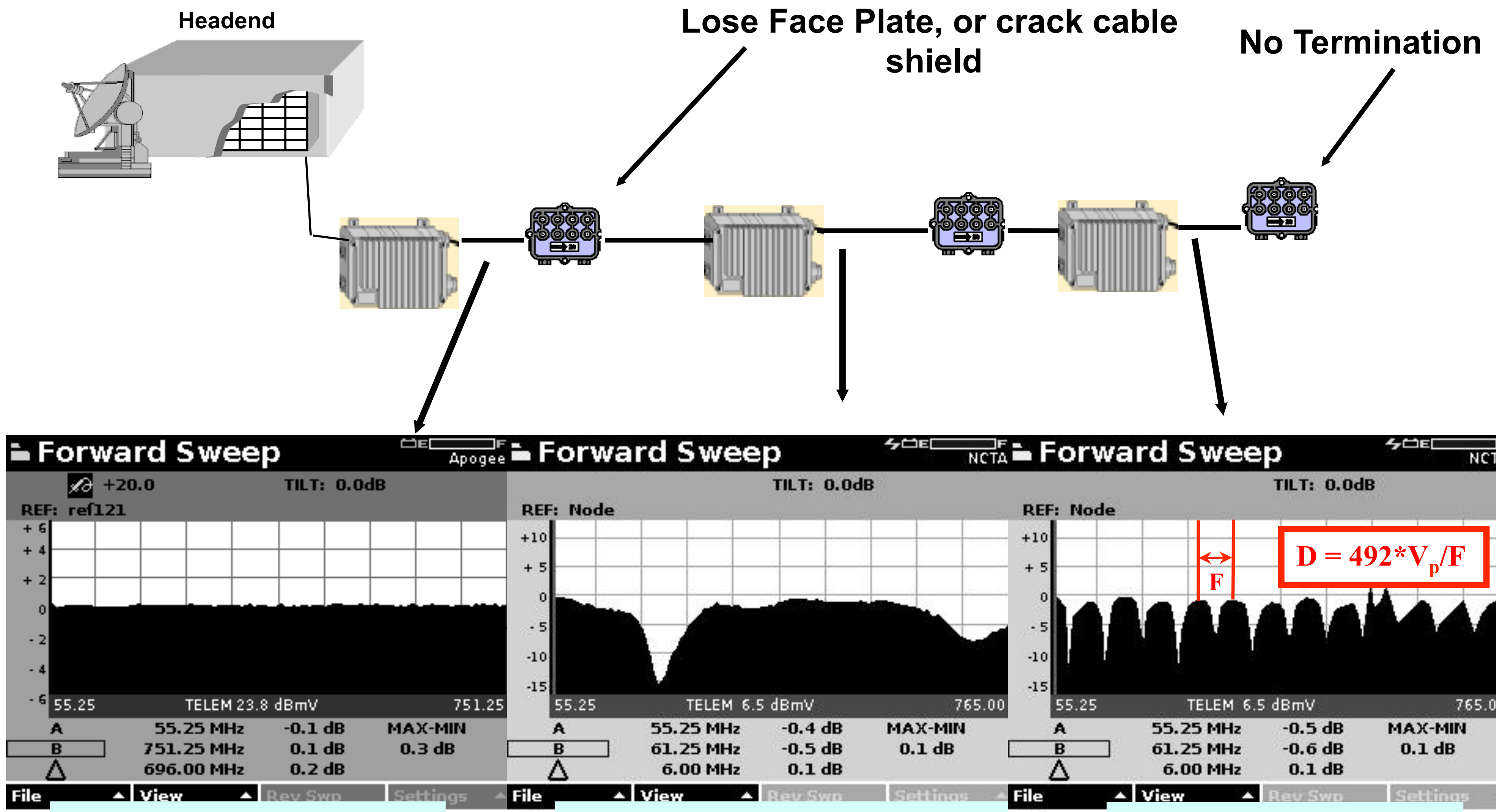
All of these issues could lead to major leakage, ingress and micro-reflection problems!

Test Probes

- Will always be bi-directional unless they are in series with the circuit
- Higher loss probes provide less of an impedance mismatch, but lower levels
- F-to-Housing adapters cause severe standing waves because of;
  - Bad grounding
  - RF power splitting
  - Impedance mismatch
- Be careful with in-line pads while probing seizure screws
  - Not usually dc blocked

Balancing Amplifiers - Forward Sweep

Balancing amplifiers using tilt only



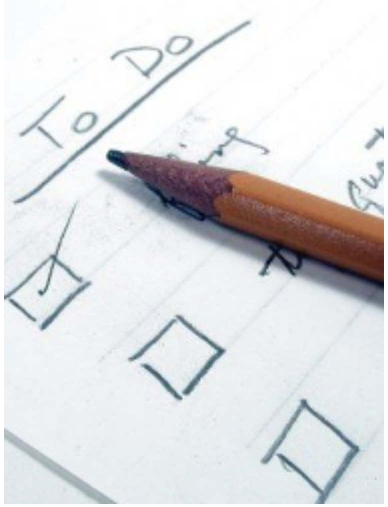
Node Reference Signal

Sweep response with a Resonant Frequency Absorption (A.K.A. suckout)

Sweep response with standing waves

Sweeping the Return Path

- Choose operating levels that maximize the distortion performance (dynamic range) of your return path
- Get all of the information that you can on your nodes and amps from your manufacturer
- Create a sweep procedure for your system
  - make up a chart showing injection levels at each test point

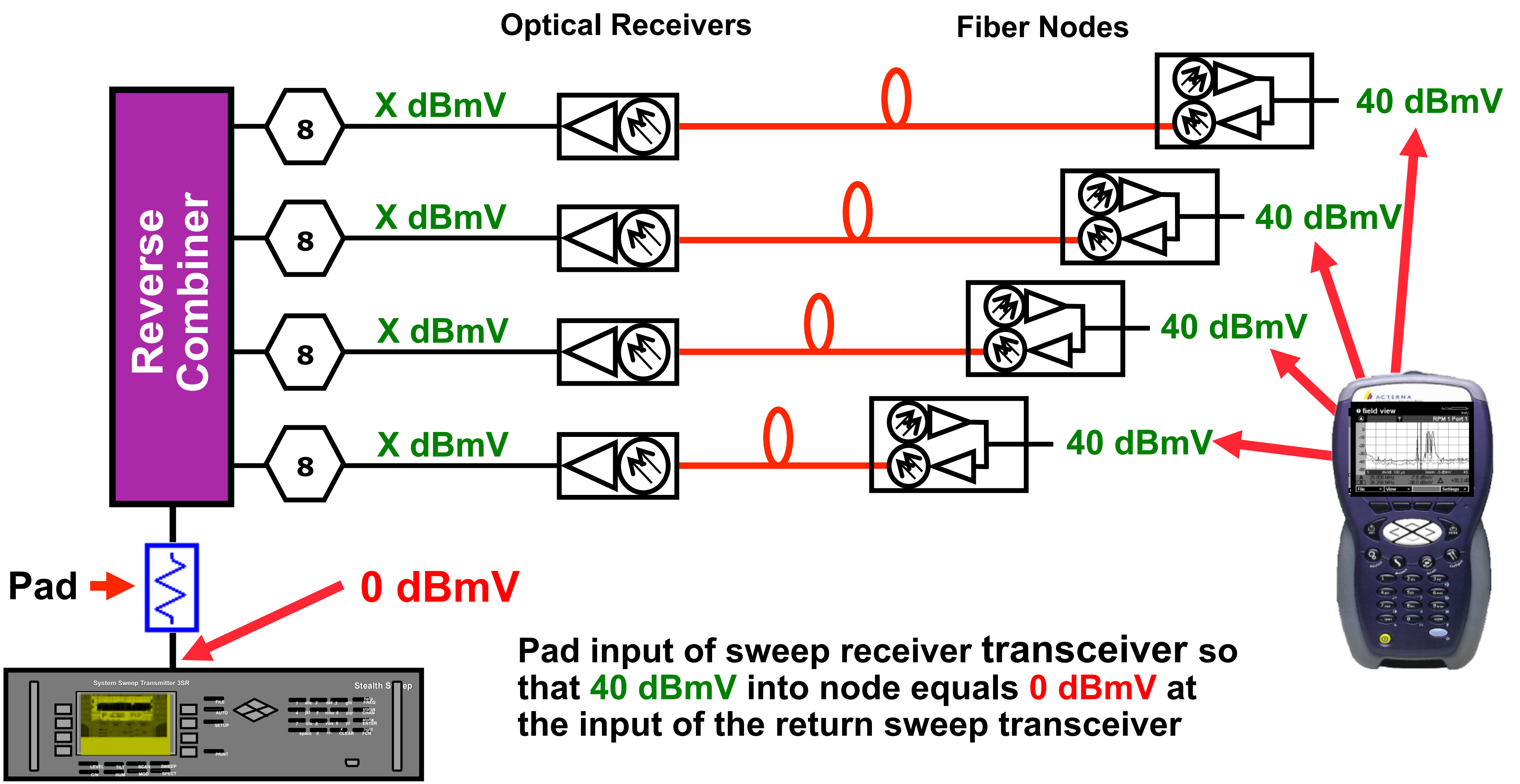


Sweeping the Return Path

Example chart showing injection levels at each test point

Return Sweep Cheat Sheet - Sweeping to the Input of a Return Amp				
	Various Types of Test Points			
	Node Return Test Point Compensation (TPC)	Trunk Amp Test Point Compensation (TPC)	Bridger Amp Test Point Compensation (TPC)	Line Extender Amp Test Point Compensation (TPC)
Desired Input Level into Return Amp or Return Laser	17 dBmV	17 dBmV	17 dBmV	17 dBmV
Internal Coupling Loss	5 dB	1 dB	14 dB	5 dB
Test Point Loss	30 dB	20 dB	20 dB	20 dB
Total Loss Between Sweep meter and return amp input	35 dB	21 dB	34 dB	25 dB
Sweep Telemetry and Sweep Pulse insertion level	52 dBmV	38 dBmV	51 dBmV	42 dBmV

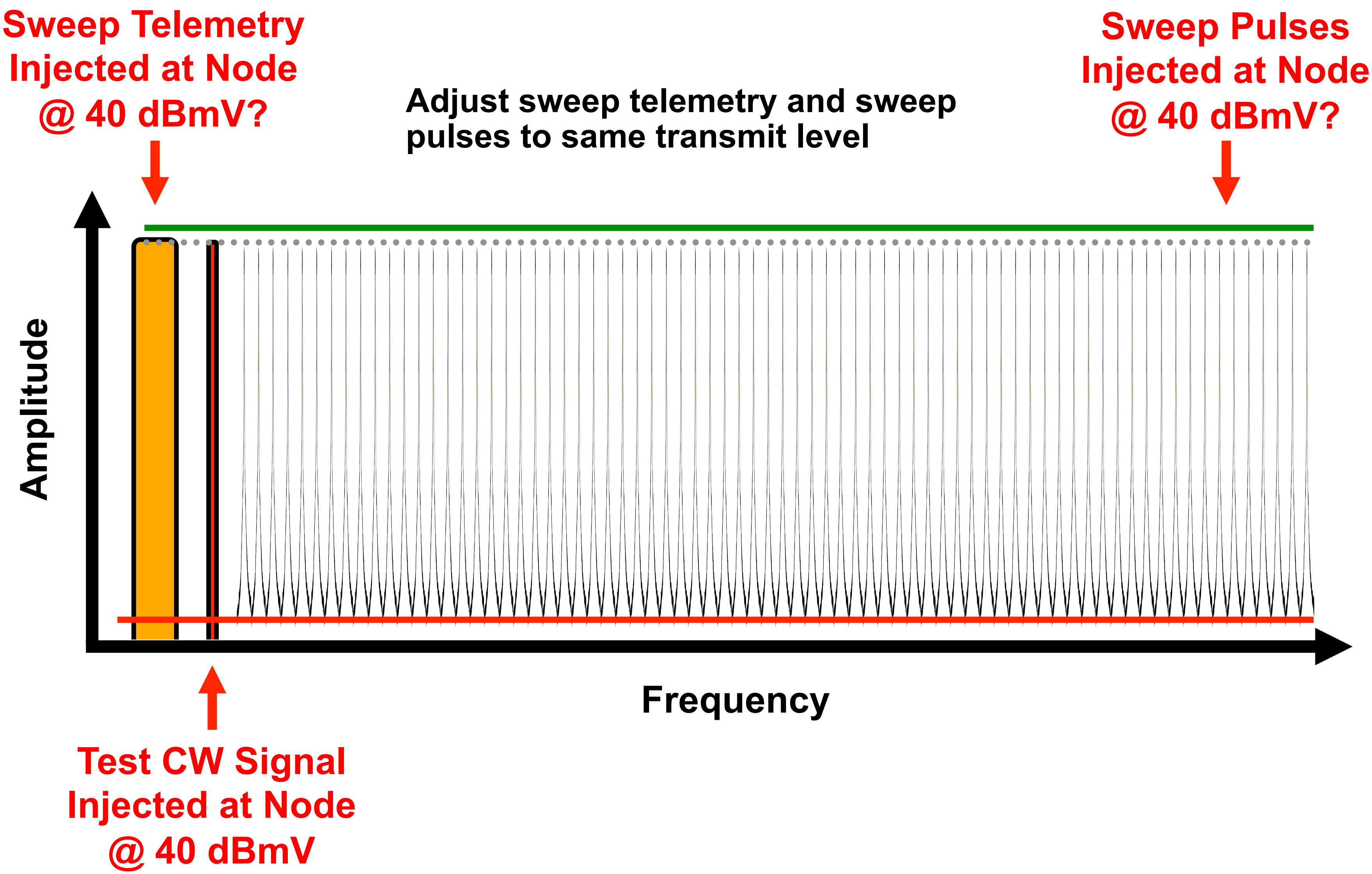
Optimize the RF Input to Return Sweep Transceiver



Pad input of sweep receiver transceiver so that 40 dBmV into node equals 0 dBmV at the input of the return sweep transceiver

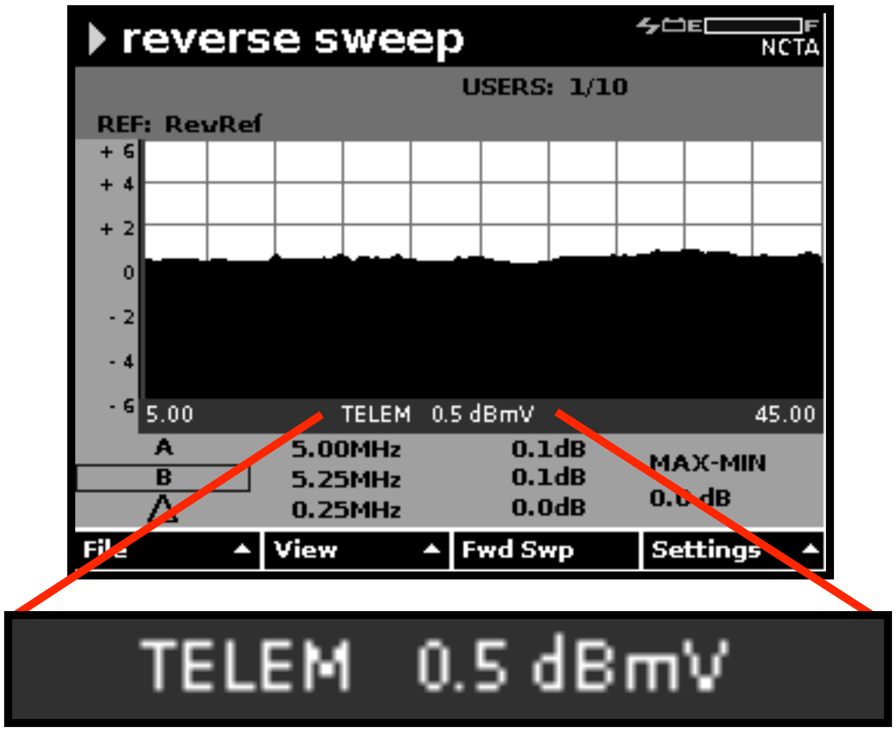
There are typically between 16 and 32 nodes combined together for return path sweeping

Stealth Sweep Pulses Compared to Carrier

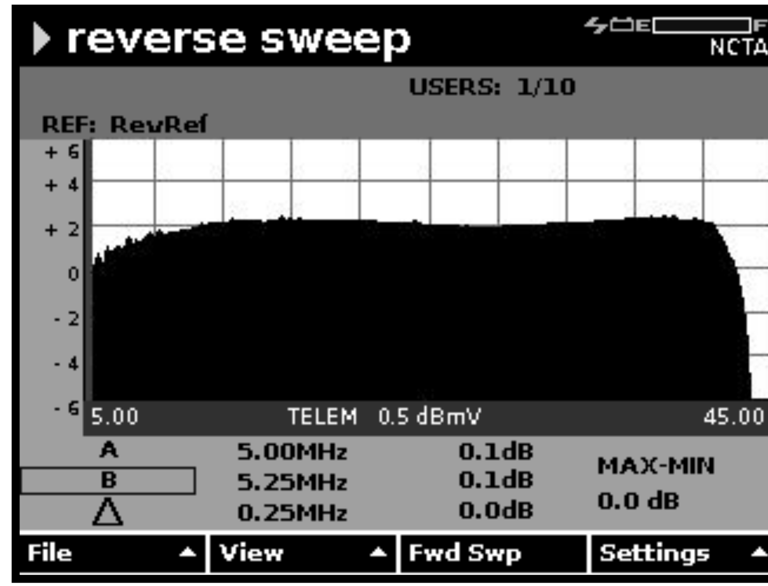


Balancing Amplifiers - Reverse Sweep

Inject correct "X" level into node test point and then take a sweep reference



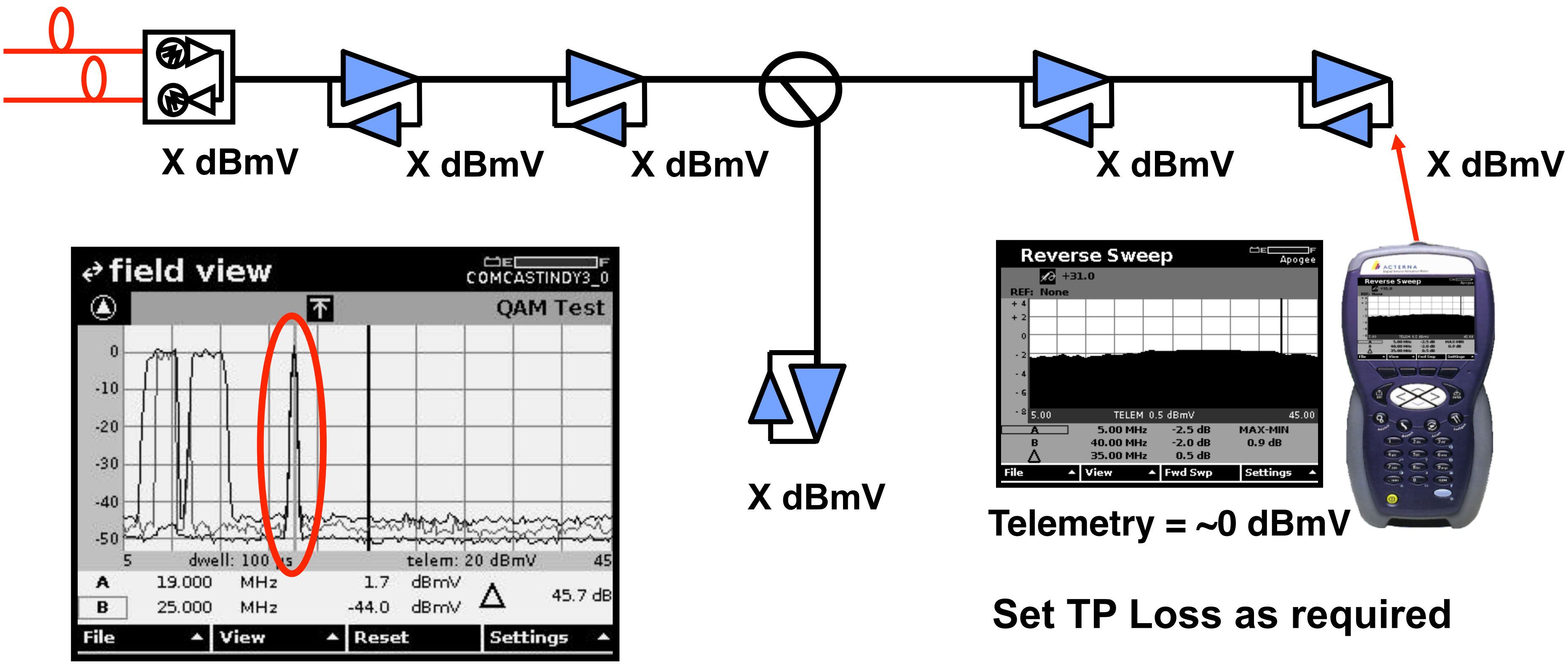
Telemetry level shown below return sweep trace should read around 0 dBmV if the SDA-5510 is padded properly



At next amp reverse sweep displays the effects of the network segment between the last amp and this one

Optimize the HFC Pipe for Unity Gain

Maintain unity gain with constant inputs



Use the DSAM Field View Option to inject a CW test signal into various test points and view remote spectrum

Reverse Path Impairments

Frequency response— Frequency response problems are due to improper network alignment, un-terminated lines, or damaged components. When reverse frequency response and equipment alignment have been done incorrectly or not at all, the result can be excessive thermal noise, distortions, and group delay errors.

Balancing Amplifiers - Reverse Alignment

TILT = 6 MHz at 3.4 dBmV – 42 MHz at 2.3 dBmV

TILT = - 1.1 dB because of slope is from left to right

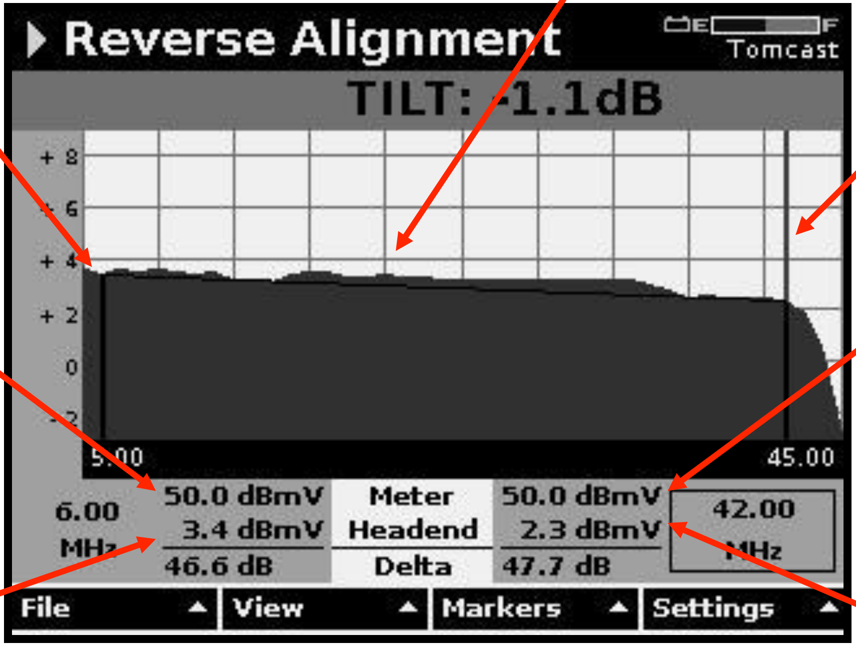
Sweep Carriers

Marker at 6 MHz not active (no Box)

Marker at 42 MHz active (Box)

DSAM output is 50dBmV at 42 MHz

DSAM output is 50 dBmV at 6 MHz



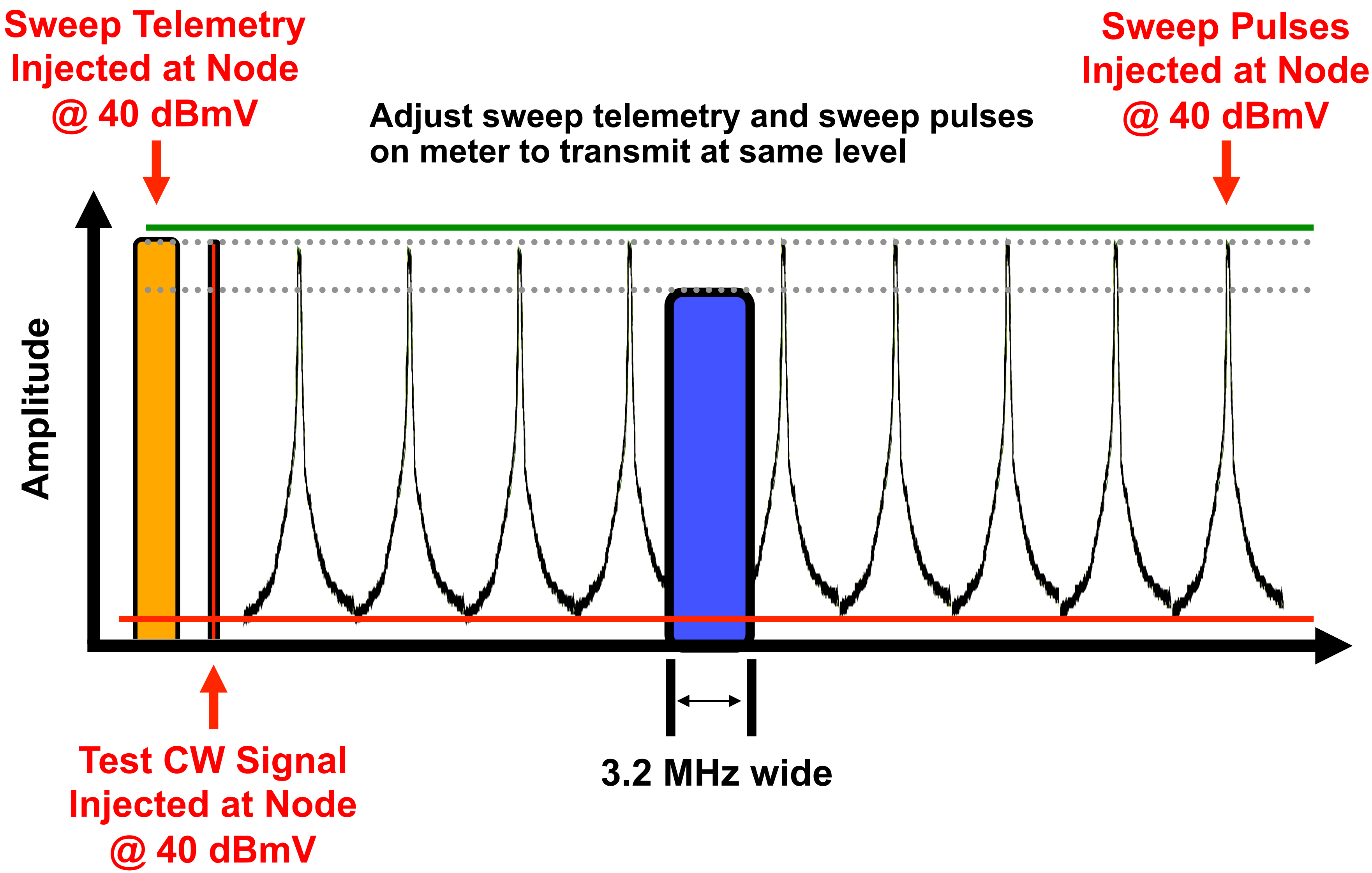
Headend receive level is 3.4 dBmV at 6 MHz

At Headend (SDA-5500 or 5510)

Headend receive level is 2.3 dBmV is at 42 MHz

At Headend (SDA-5500 or 5510)

Sweep Pulses Compared to Carrier



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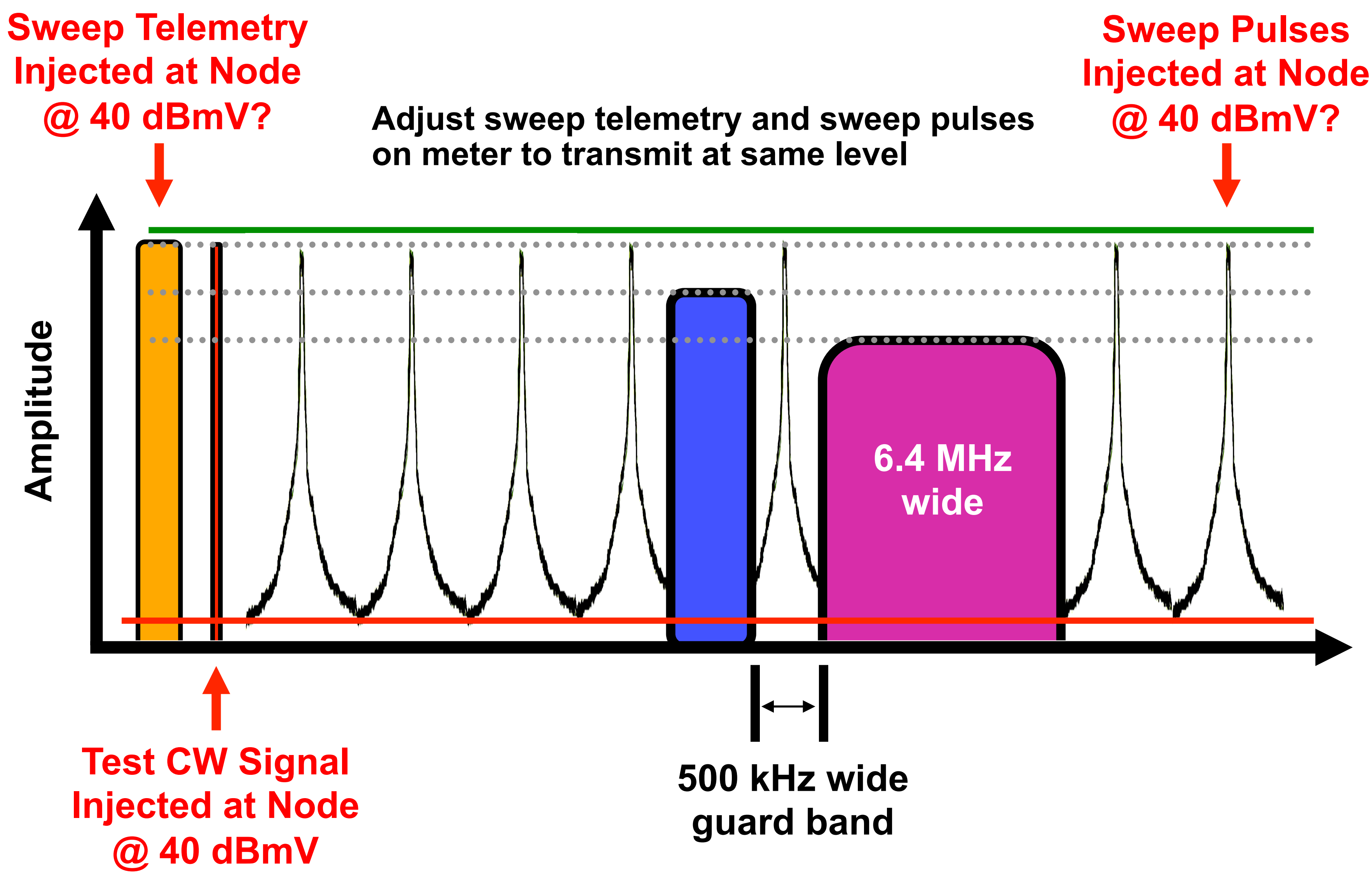

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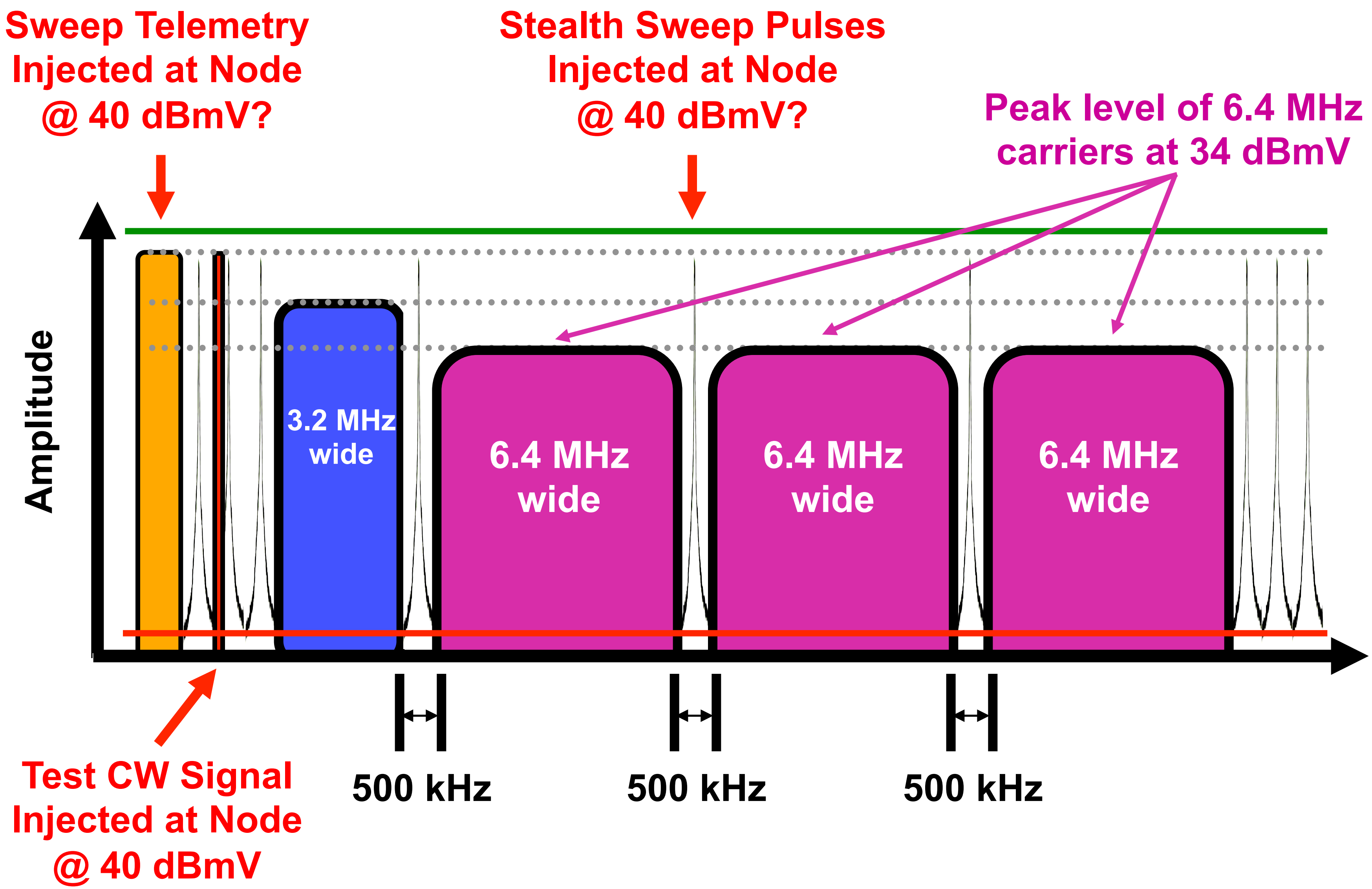

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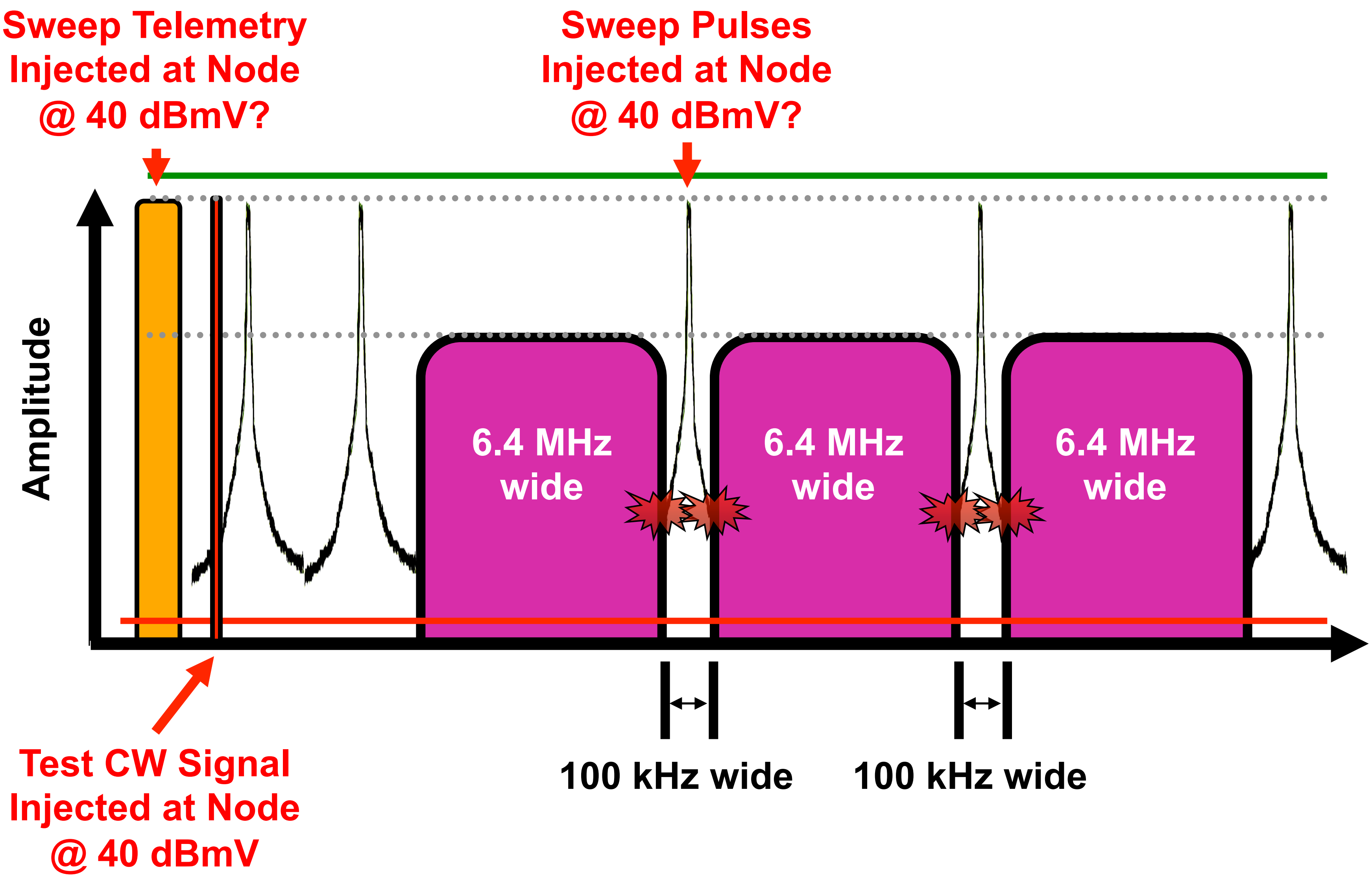

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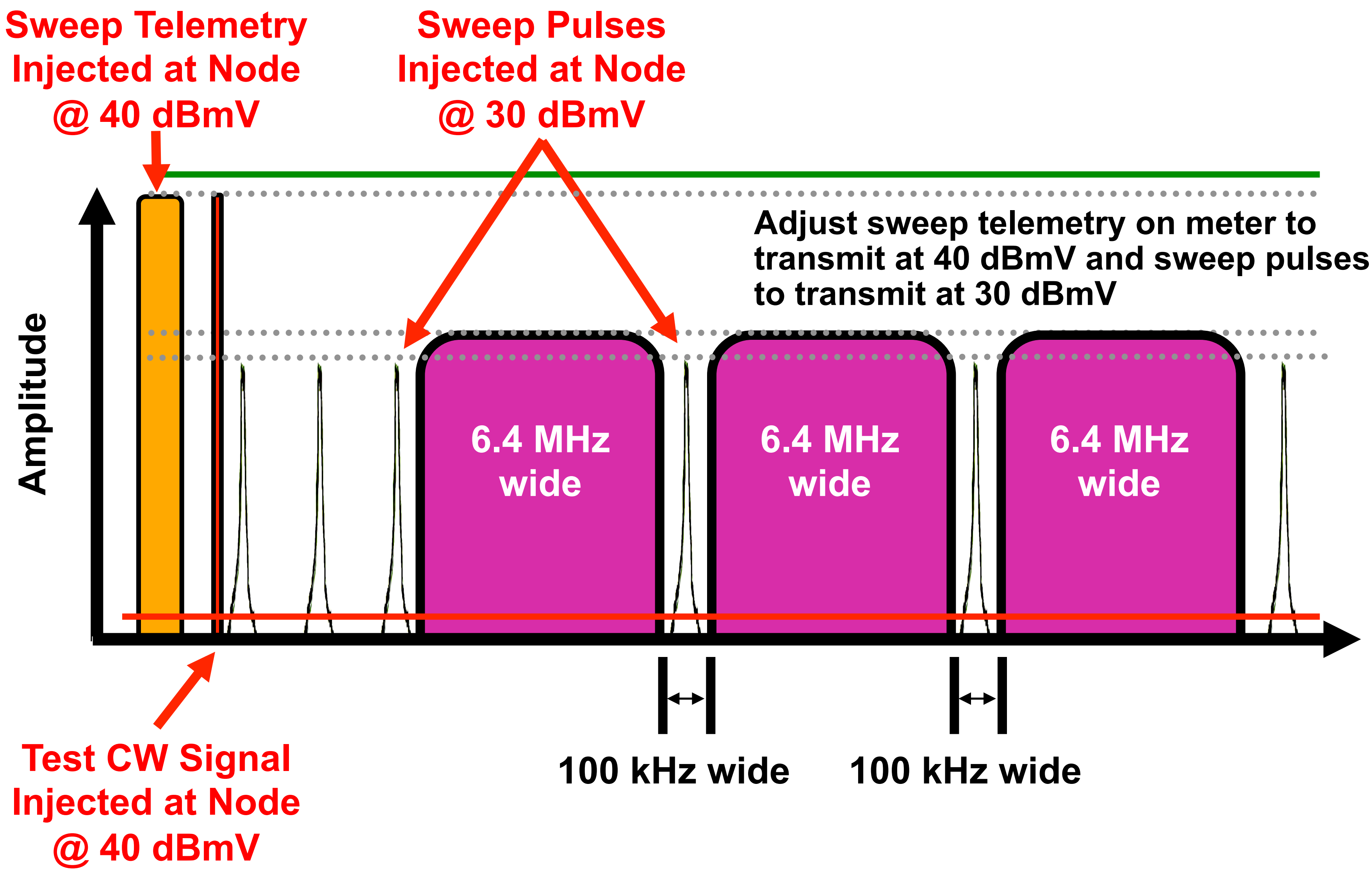

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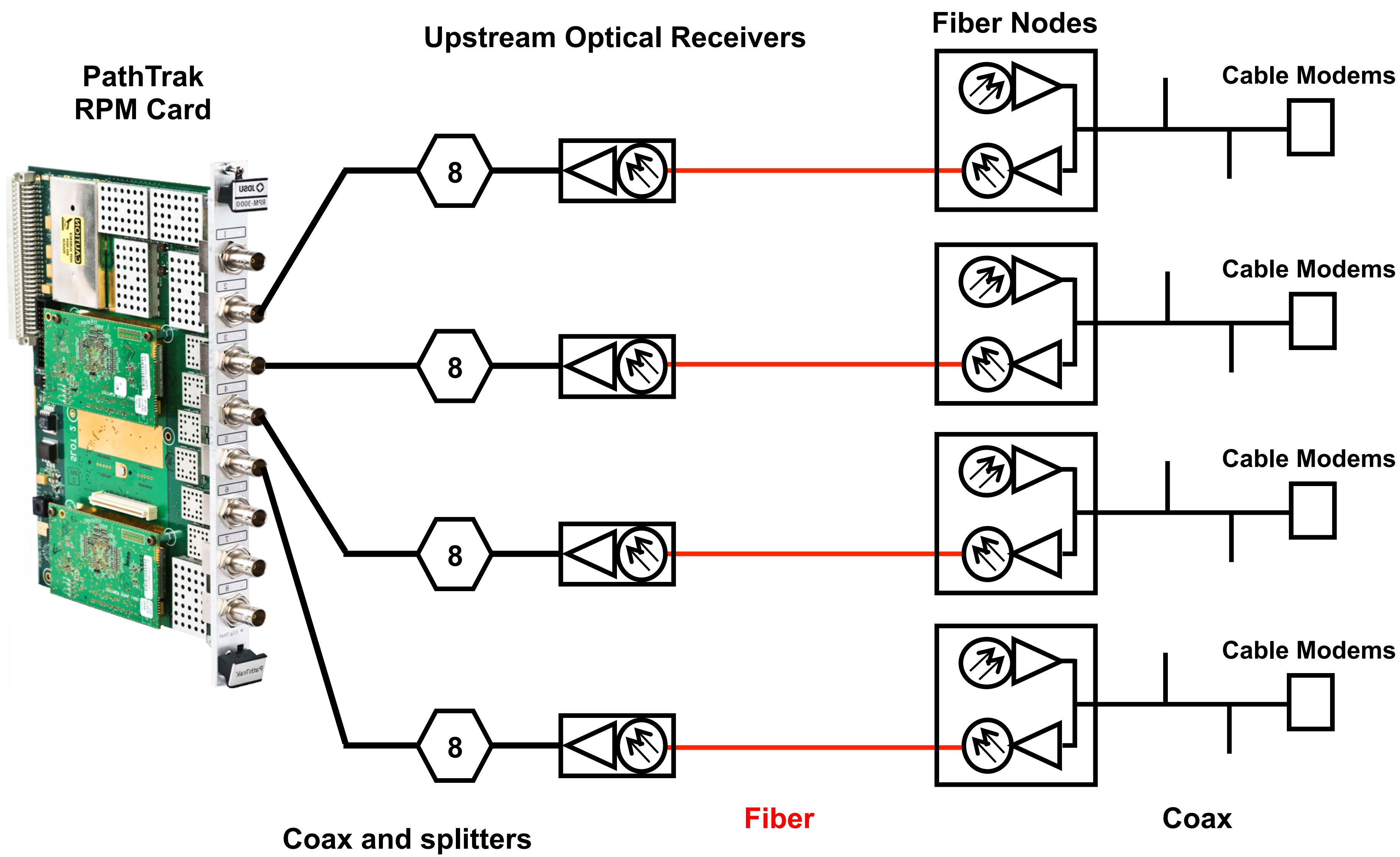
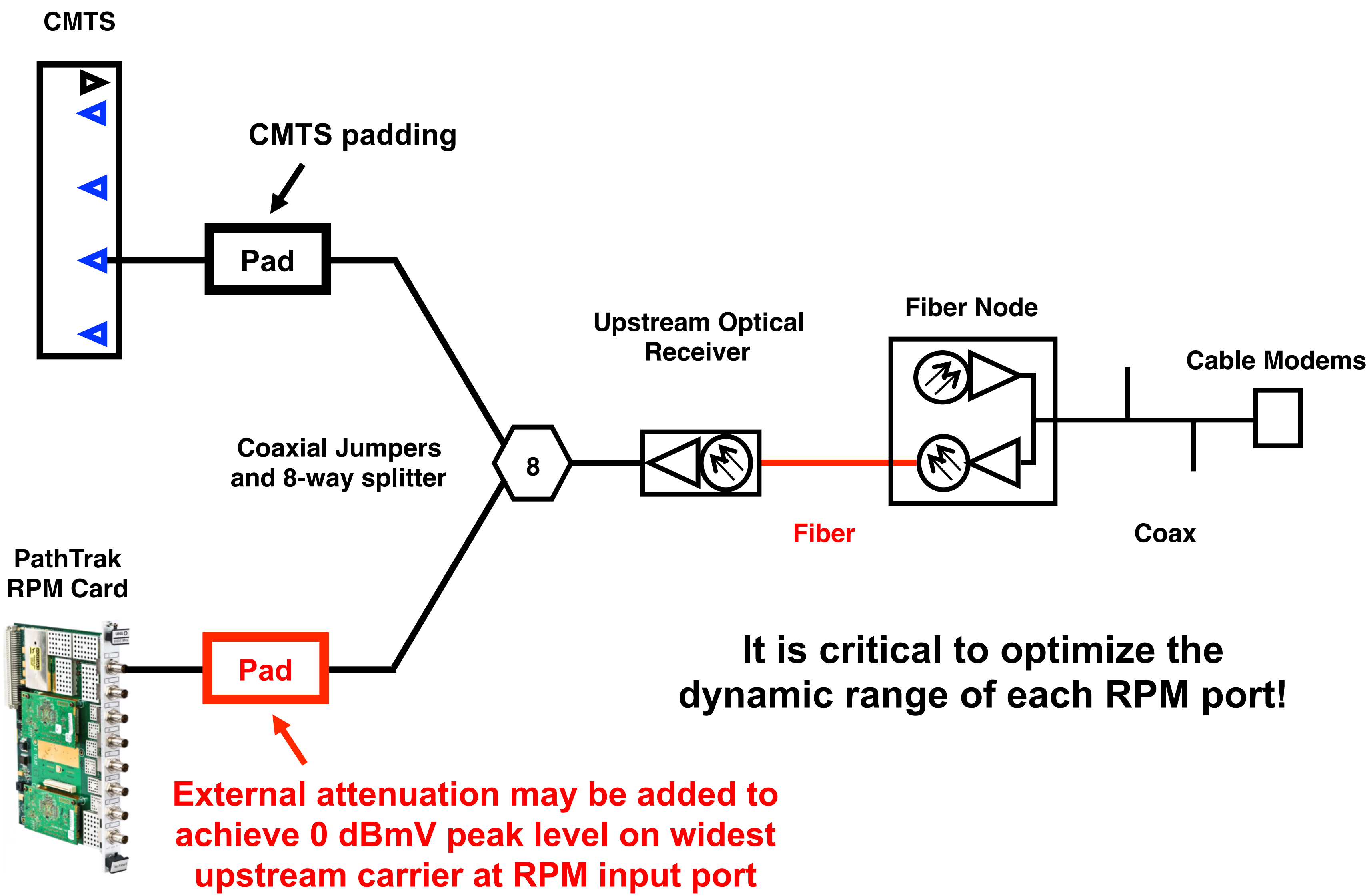
  - Linear Distortions

Typical PathTrak Interface with DOCSIS® Network

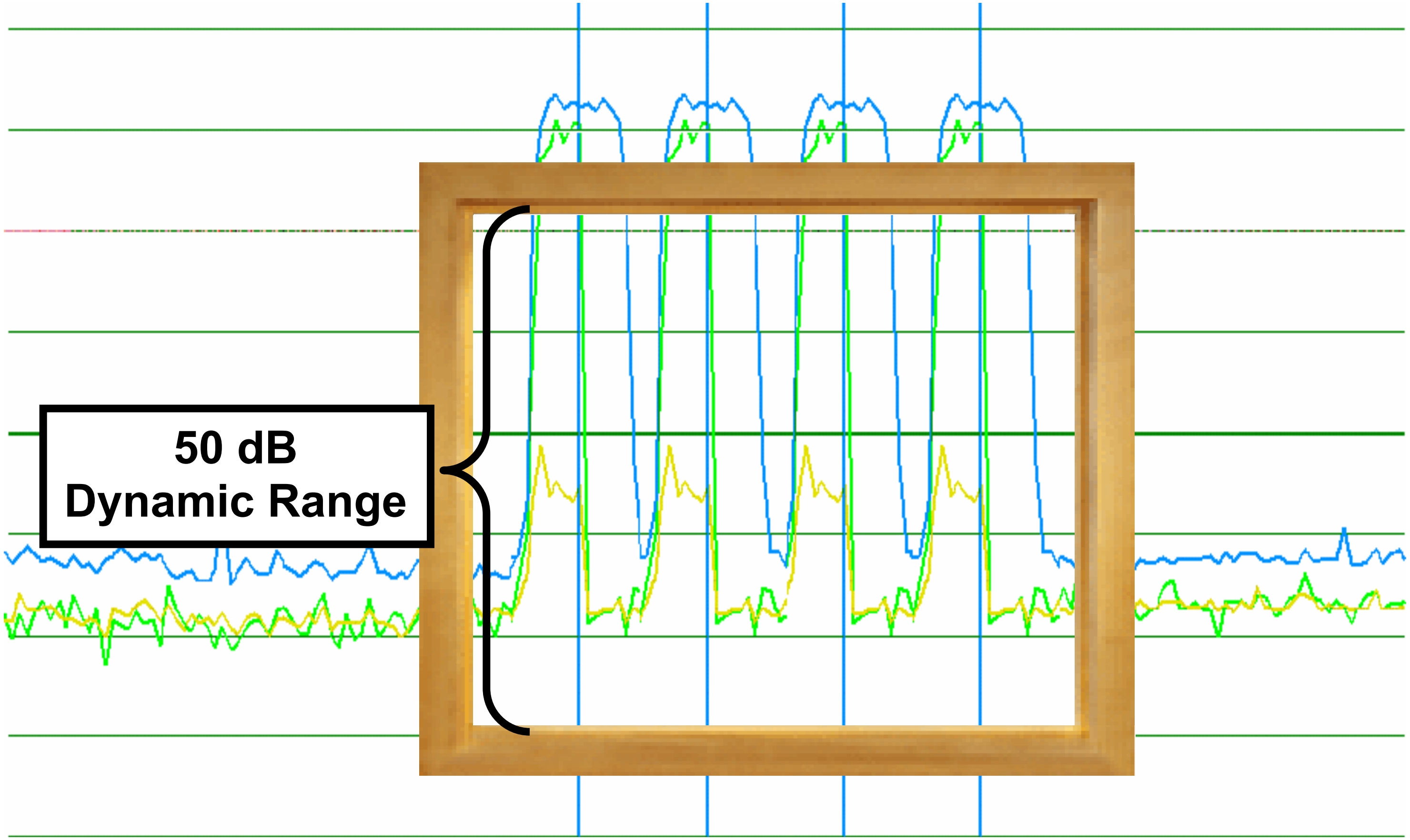


Typical PathTrak Interface with DOCSIS® Network



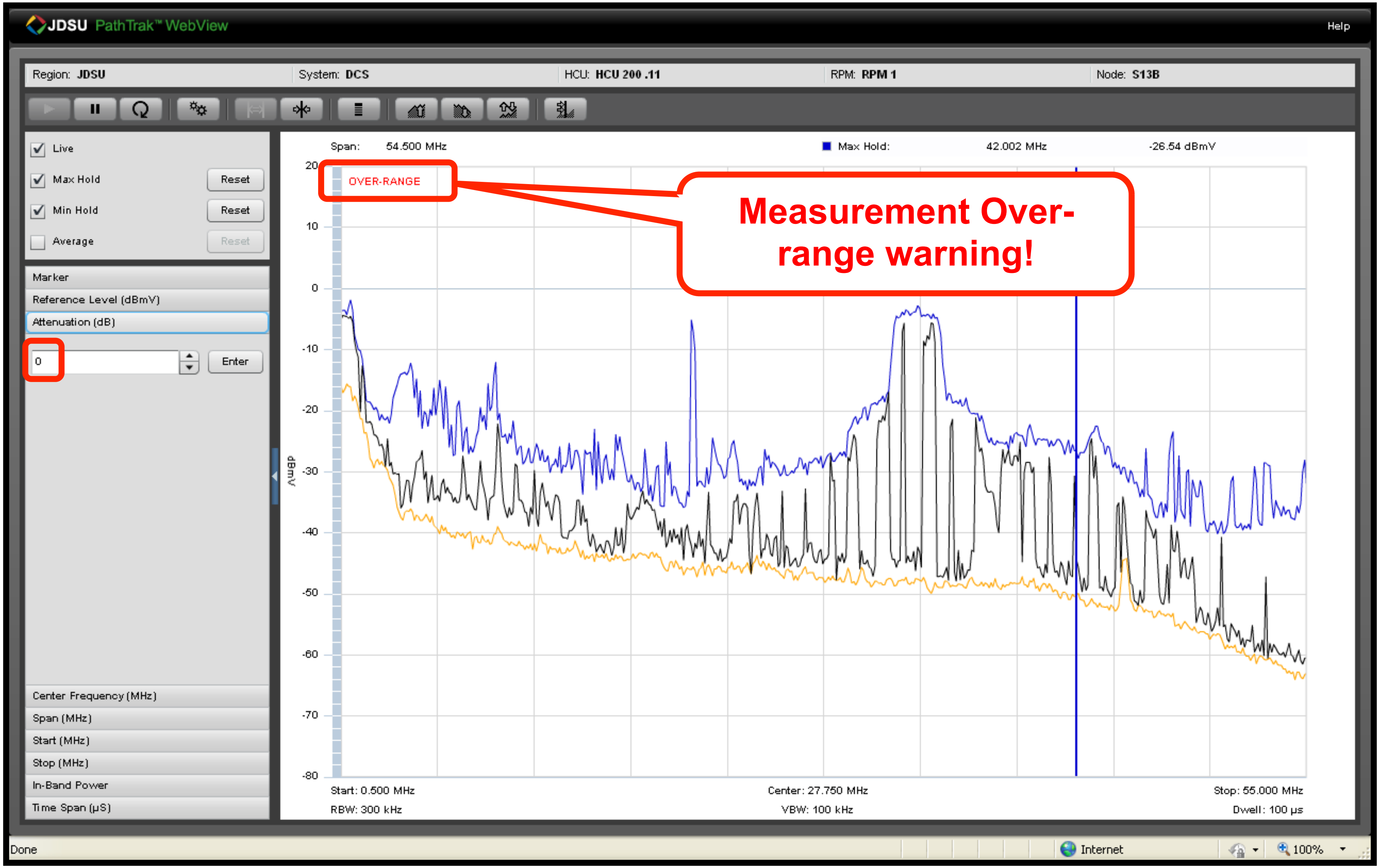
Dynamic Range "Measurement Window"

The "peaks" of the upstream carriers below are outside of the measurement window of this particular RPM port. This is called "measurement over range".

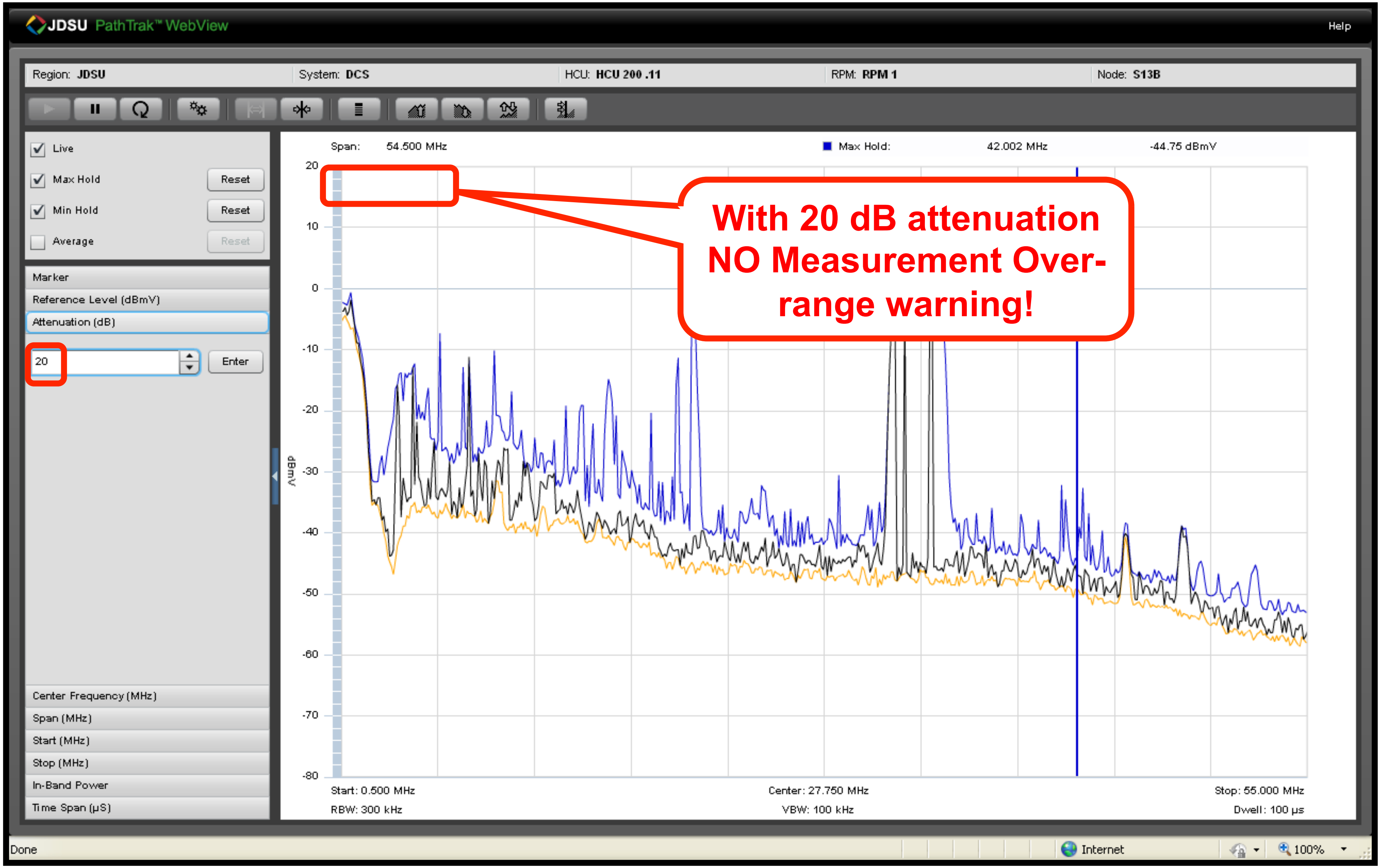


In order to accurately measure the peaks of these carriers and the system noise floor you must optimize the dynamic range of every RPM port.

New Measurement "Over Range" Indicator

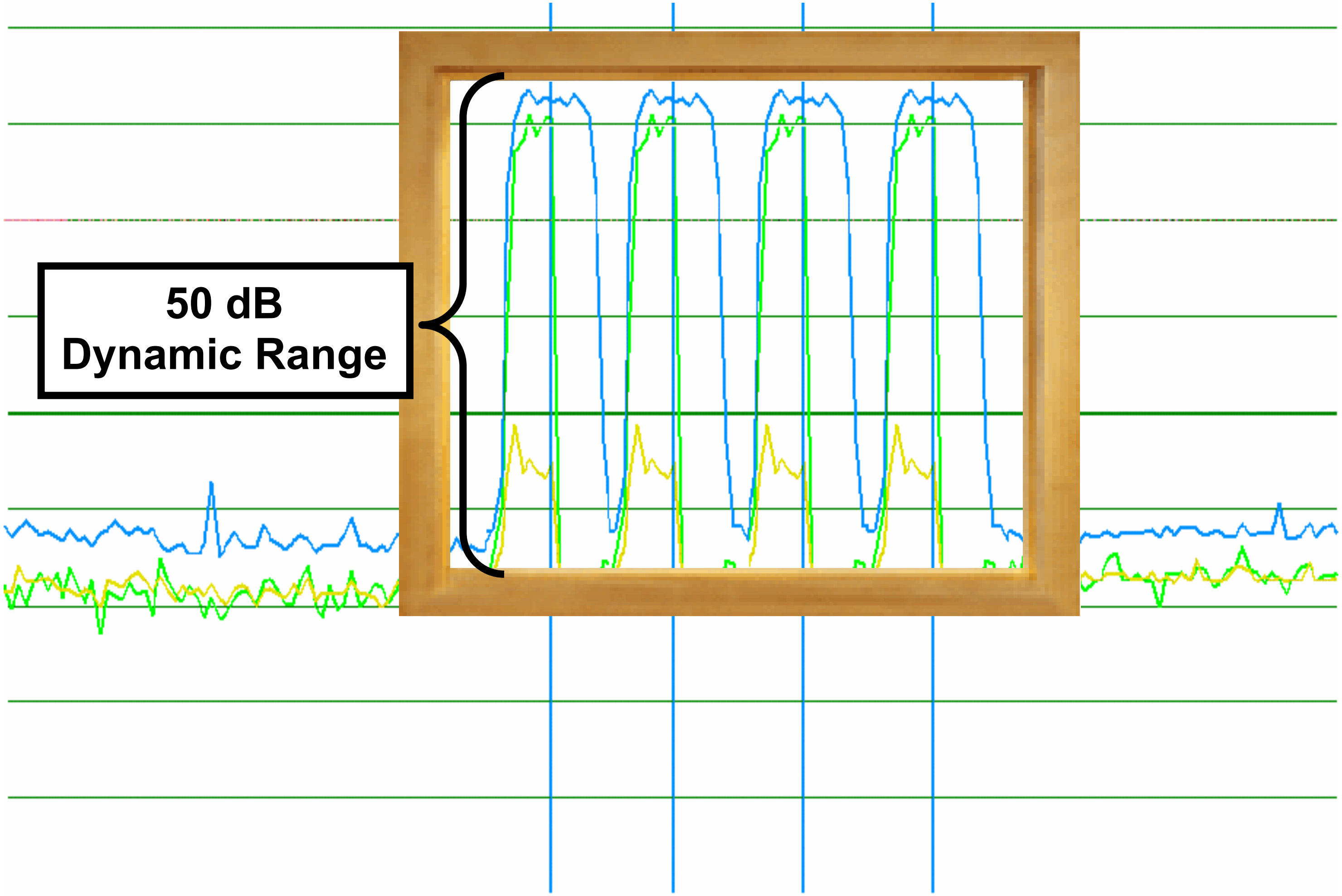


New Measurement "Over Range" Indicator

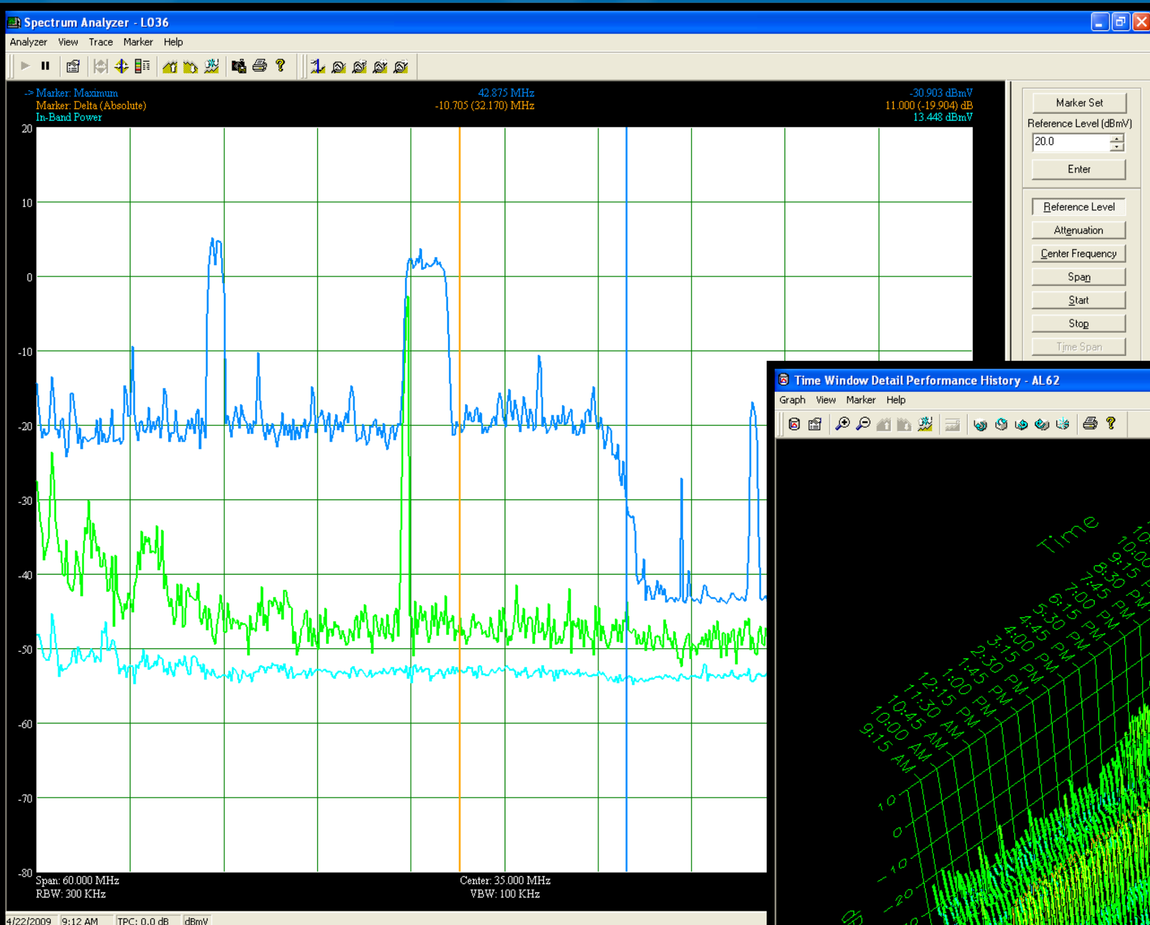


Optimized Dynamic Range

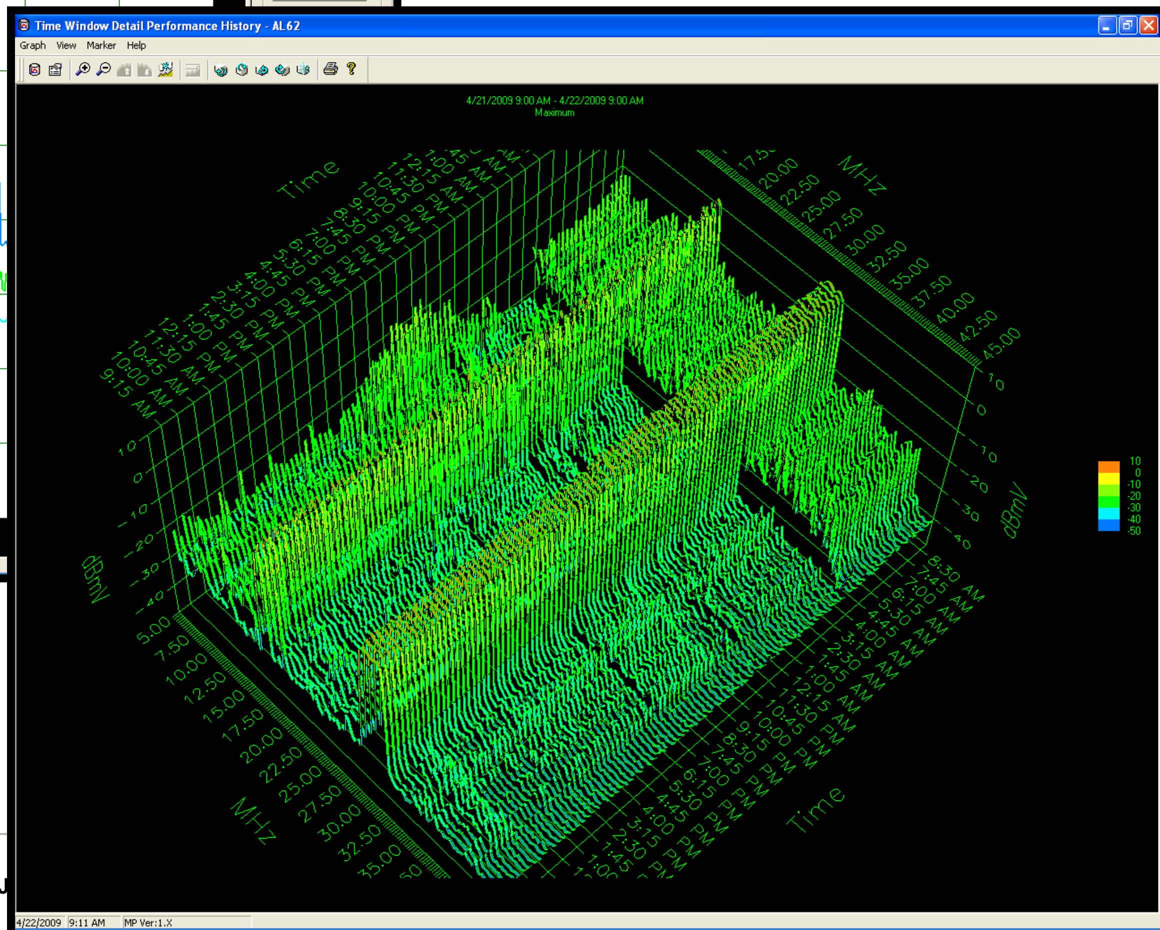
The "peaks" of the upstream carriers are now within the measurement window of this particular RPM port.



Analyzing and Interpreting Performance History

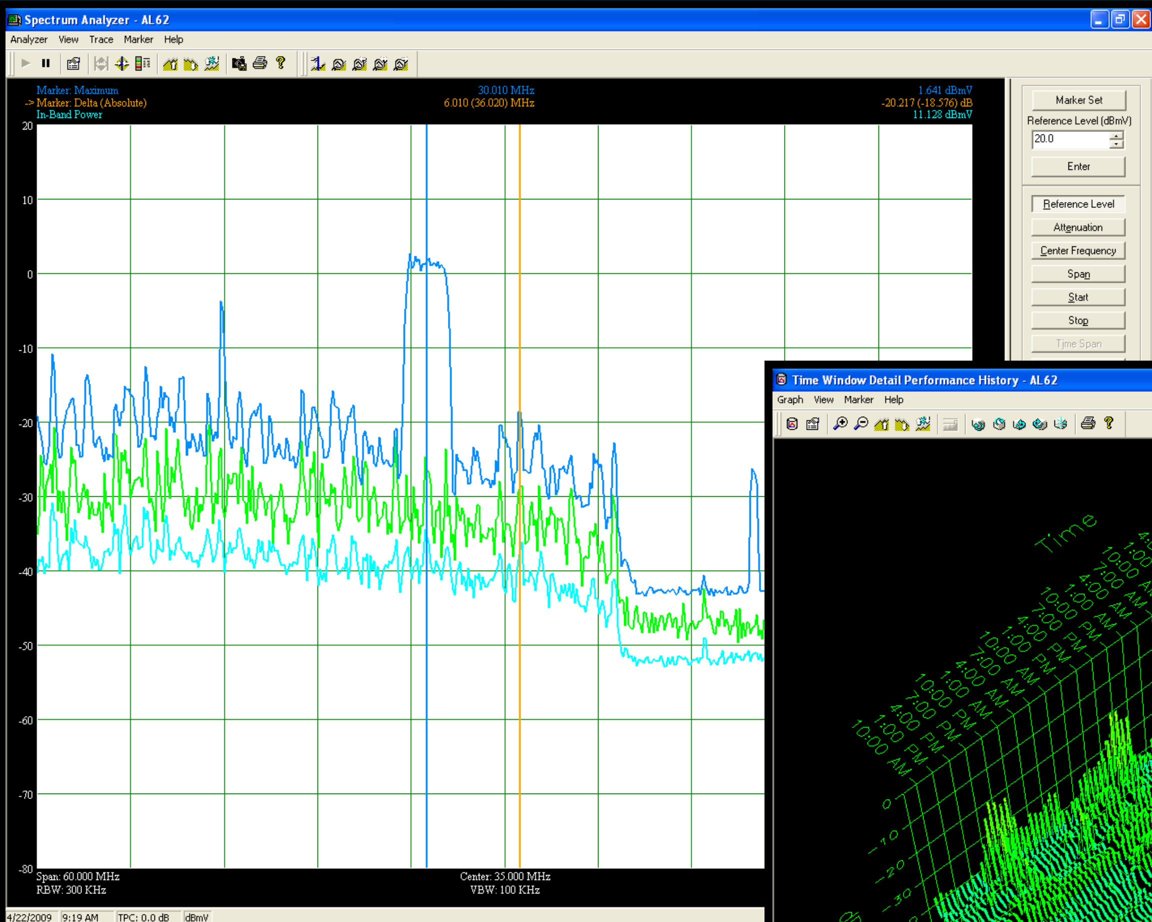


Use Performance History's Detailed Maximum Trace to see wide band impulse noise trending over time

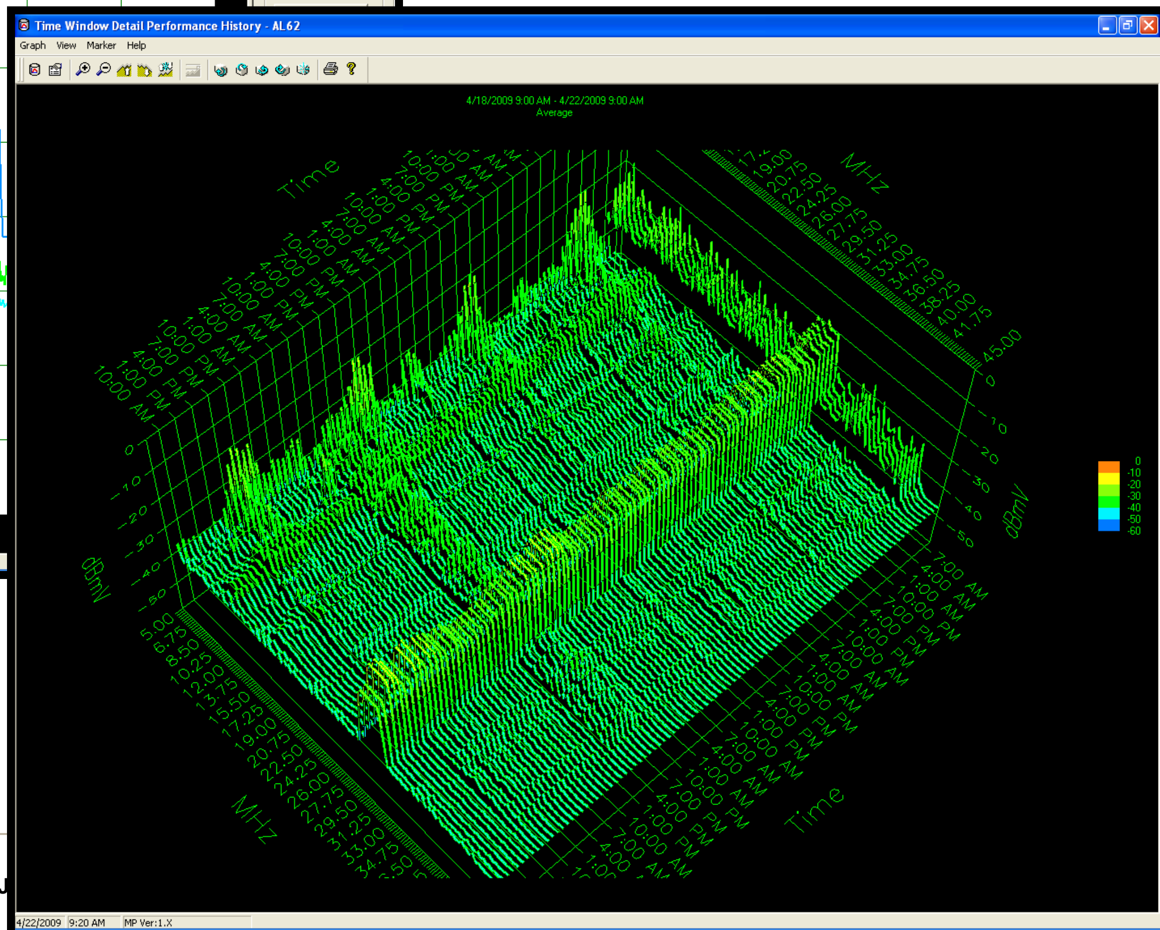


Maximum Trace in spectrum analyzer shows wide band impulse noise

Analyzing and Interpreting Performance History



Use Performance History's Detailed Average Trace to see rise in noise floor & CPD over time



Average Trace in spectrum analyzer shows rise in noise floor & CPD

Monitoring and Maintaining the Return Path

- **Getting ready for DOCSIS 3.0 - Optimize Your HFC network now!**
  - Verify optimal setup and performance (dynamic range) of both Optical & RF portion of the HFC network
  - Forward & Reverse sweep for unity gain throughout coaxial network

- **Troubleshooting Upstream Impairments**
  - **Trouble Shooting Tools**
  - Ingress
  - Common Path Distortion (CPD)
  - Impulse Noise
  - Linear Distortions

JDSU

The Situation

Can't justify taking the system down to troubleshoot!

- **Unacceptable to the subscribers who will;**
  - Lose communication
  - Get a slower throughput
  - Have periodic "clicking" in their telephone calls

- **To be non-intrusive we must;**
  - Understand test points
  - Apply new procedures and applications
  - Learn new troubleshooting techniques

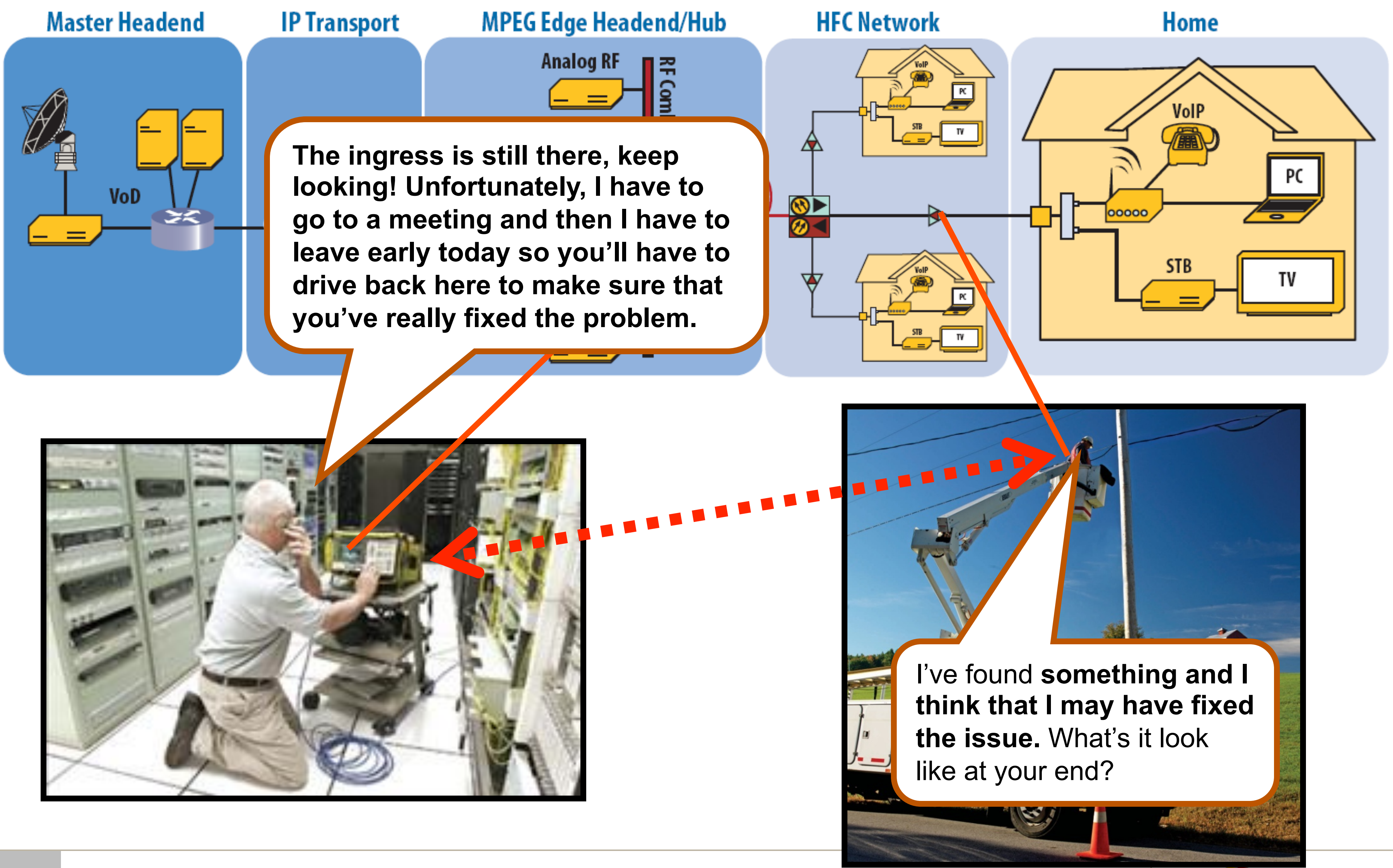
Back to the Basics

- Majority of problems are basic physical layer issues
- Most of the tests remain the same
- Check AC power
- Check forward levels, analog and digital
- Sweep forward & reverse

Back to the Basics

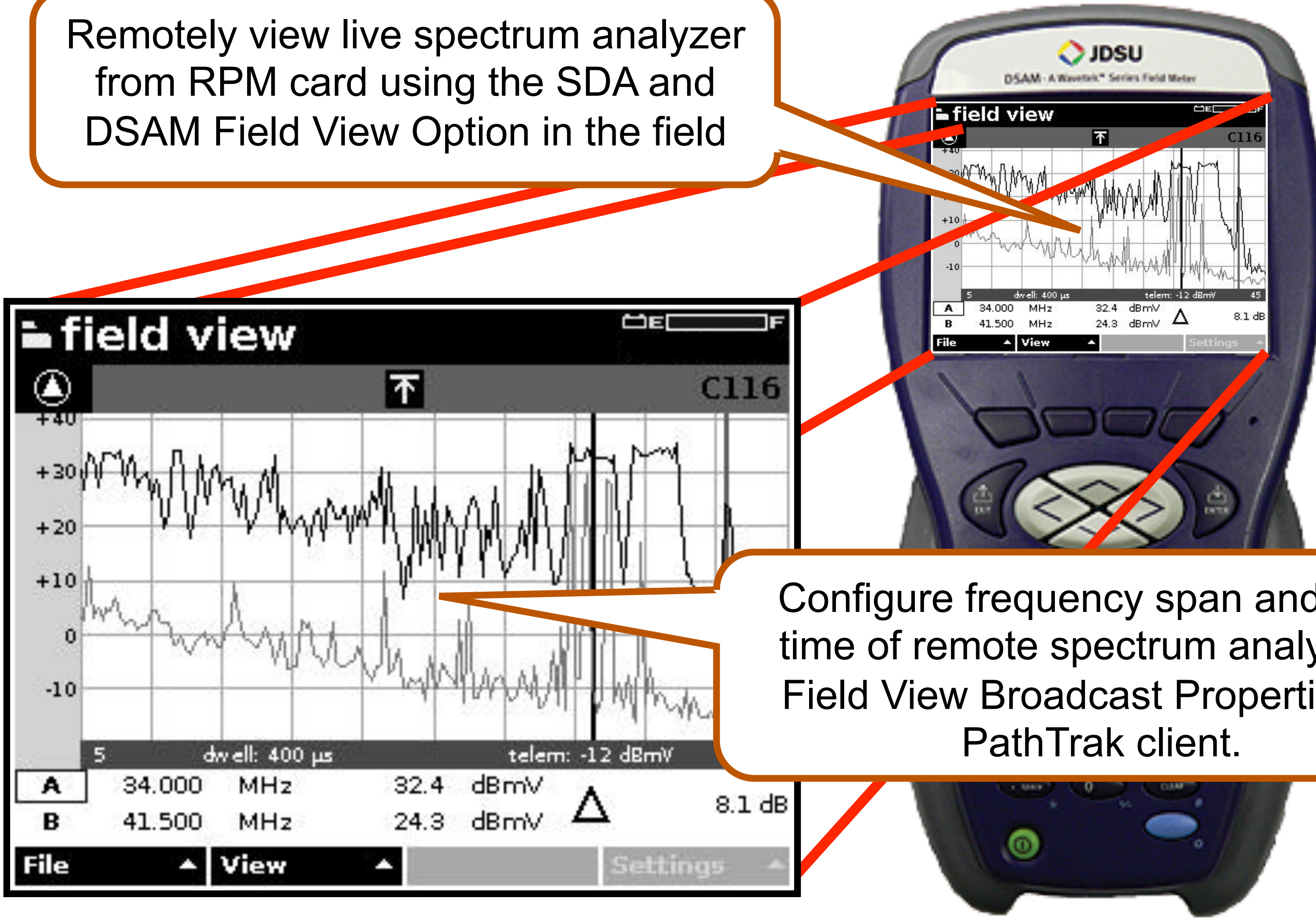
- Check for leakage sources
- Check for ingress sources
- Do a visual inspection of cable / connectors / passives
- Replace questionable cable / connectors / passives
- Tighten F-connectors per your company's installation policy
  - Be very careful not to over tighten connectors on CPE (TVs, VCRs, converters etc.) and crack or damage input RFI integrity

Return Path Troubleshooting Can Require Two People or a Lot of Driving Unless You Have the Right Tools



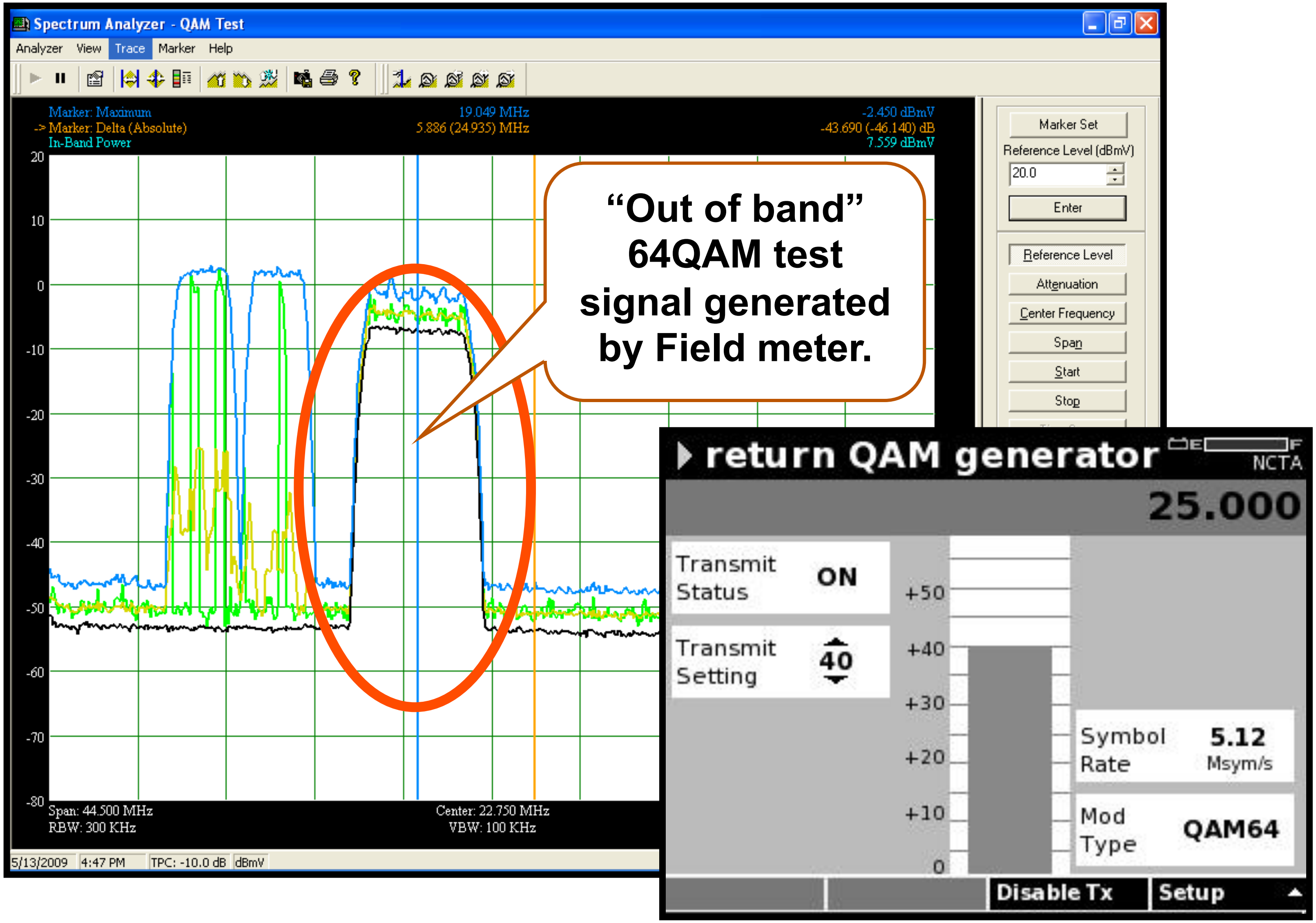
Troubleshoot Return Path Impairments in the HFC network
– **WITHOUT** tying up Headend Technicians!

Remotely view live spectrum analyzer from RPM card using the SDA and DSAM Field View Option in the field



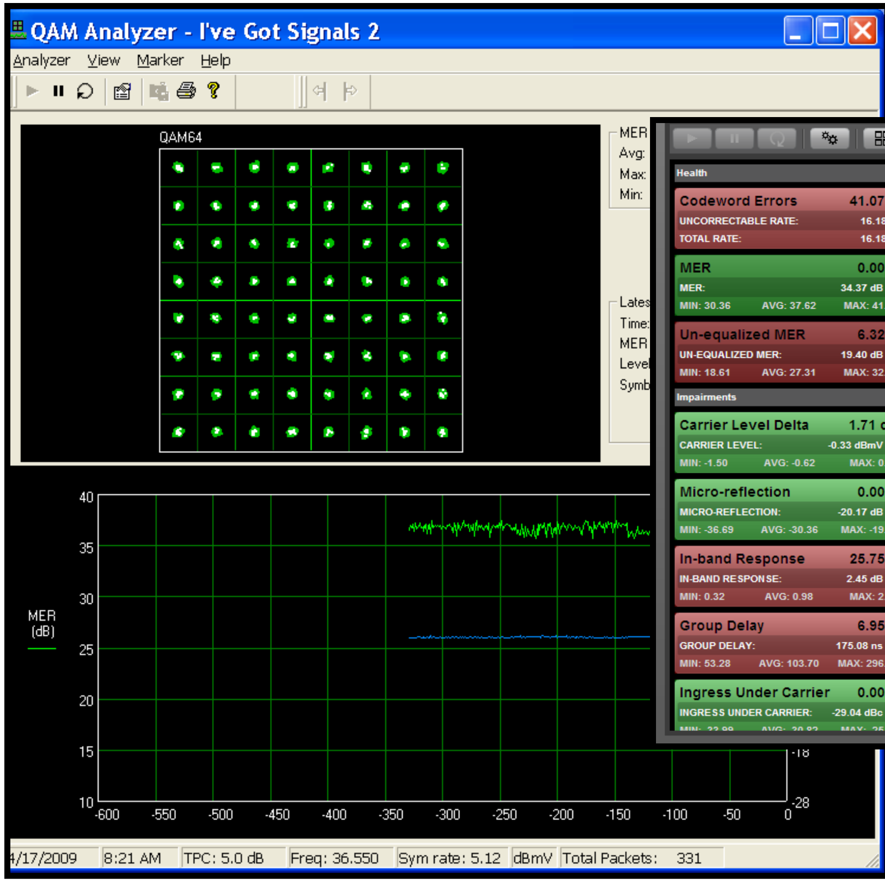
Configure frequency span and dwell time of remote spectrum analyzer in Field View Broadcast Properties via PathTrak client.

"Out of Band" 64QAM Test Signal



QAM Analyzer - PathTrak Client vs. WebView v2.5

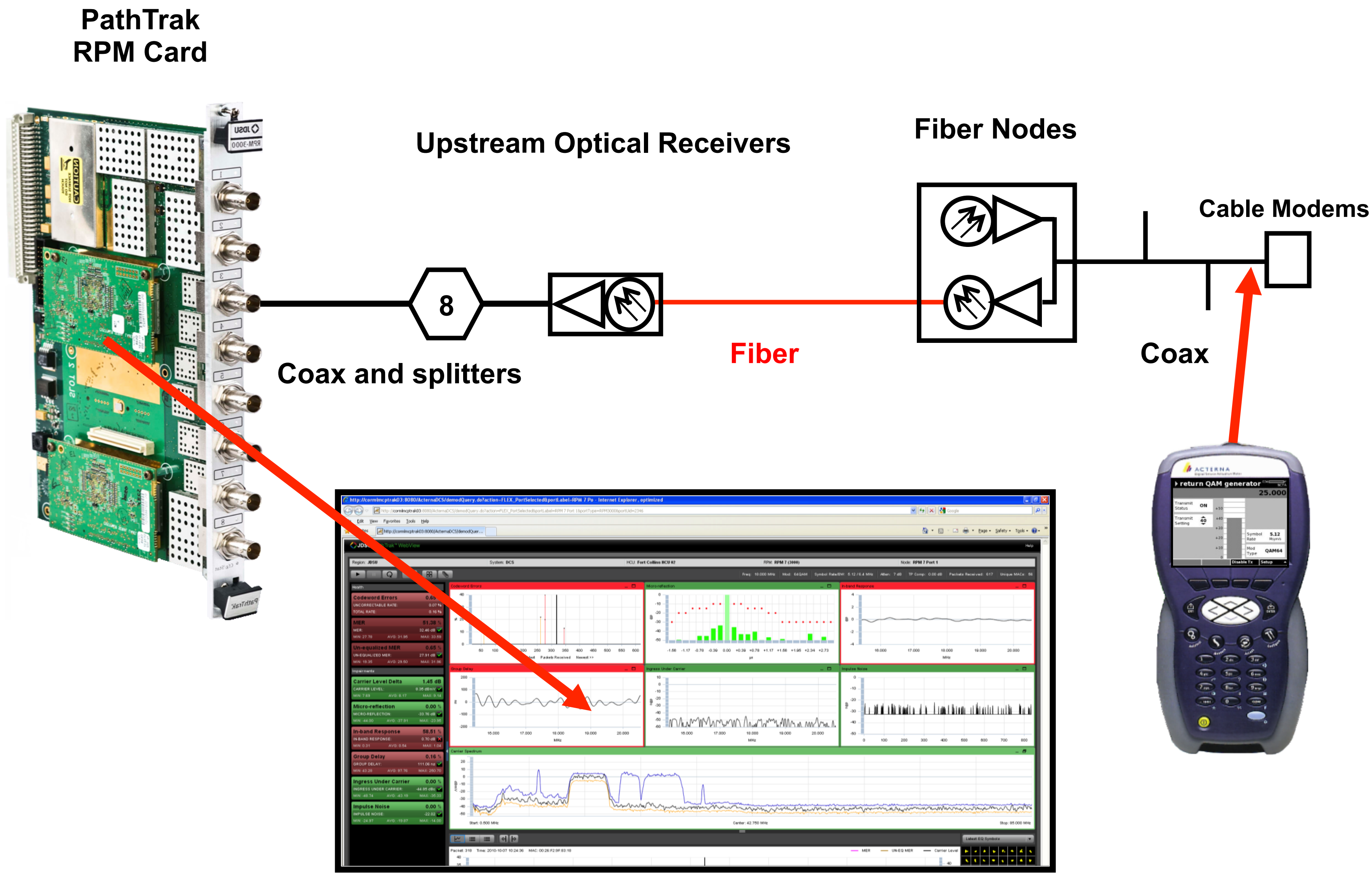
PathTrak Client QAMTrak Analyzer



PathTrak WebView v2.5 QAMTrak

The new QAMTrak displays and controls are only available in WebView v2.5

Test Unoccupied Spectrum Before Launch



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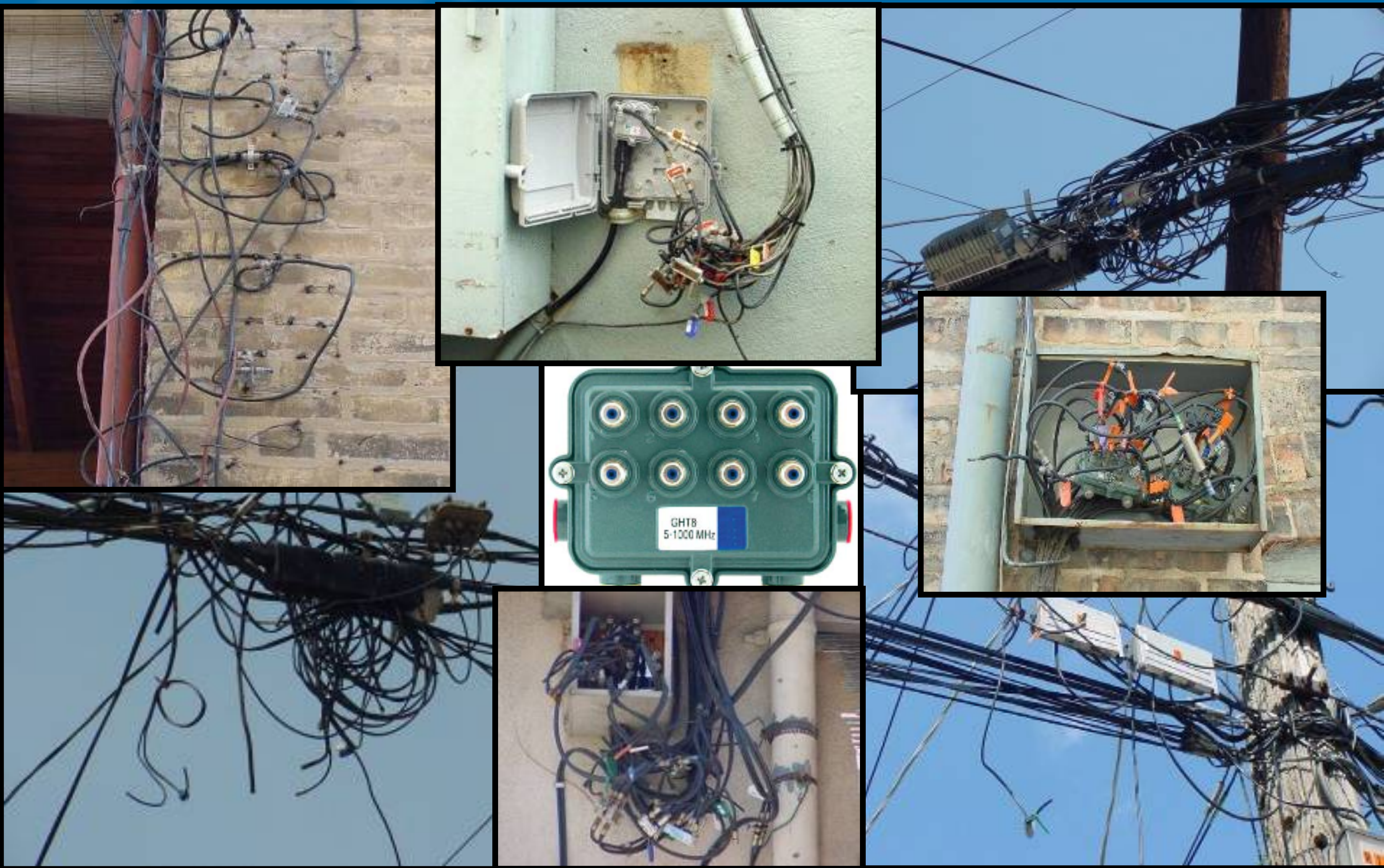
  - **Impulse Noise**
  - **Laser Clipping**
  - **Linear Distortions**

Common problems in HFC Networks



Common problems in HFC Networks

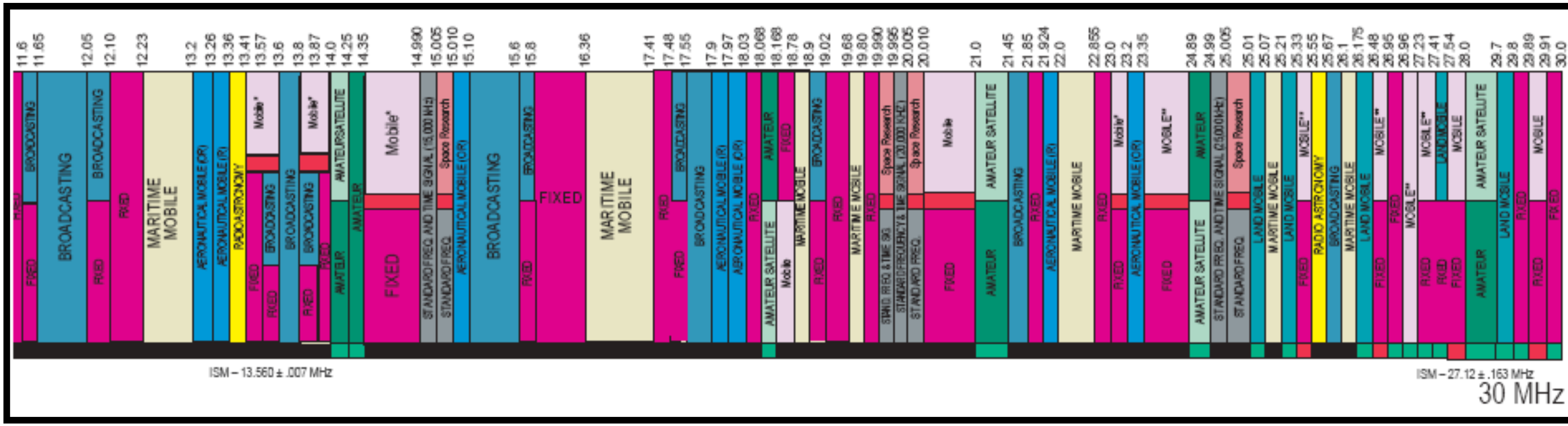
- **Kinked or damaged cable (including cracked cable, which causes a reflection and ingress).**
- **Defective or damaged actives or passives (water-damaged, water-filled, cold solder joint, corrosion, loose circuit-board screws, etc.).**
- **Cable-ready TVs and VCRs connected directly to the drop. (Return loss on most cable-ready devices is poor.)**
- **Some traps and filters have been found to have poor return loss in the upstream, especially those used for data-only service.**

Common problems in HFC Networks

- Damaged or missing end-of-line terminators
- Damaged or missing chassis terminators on directional coupler, splitter or multiple-output amplifier unused ports
- Loose tap faceplates and loose center conductor seizure screws
- Unused tap ports not terminated. This is especially critical on lower value taps
- Use of so-called self-terminating taps (4 dB two port; 8 dB four port and 10/11 dB eight port) at feeder ends-of-line. Such taps are splitters, and do not terminate the line unless all F ports are properly terminated

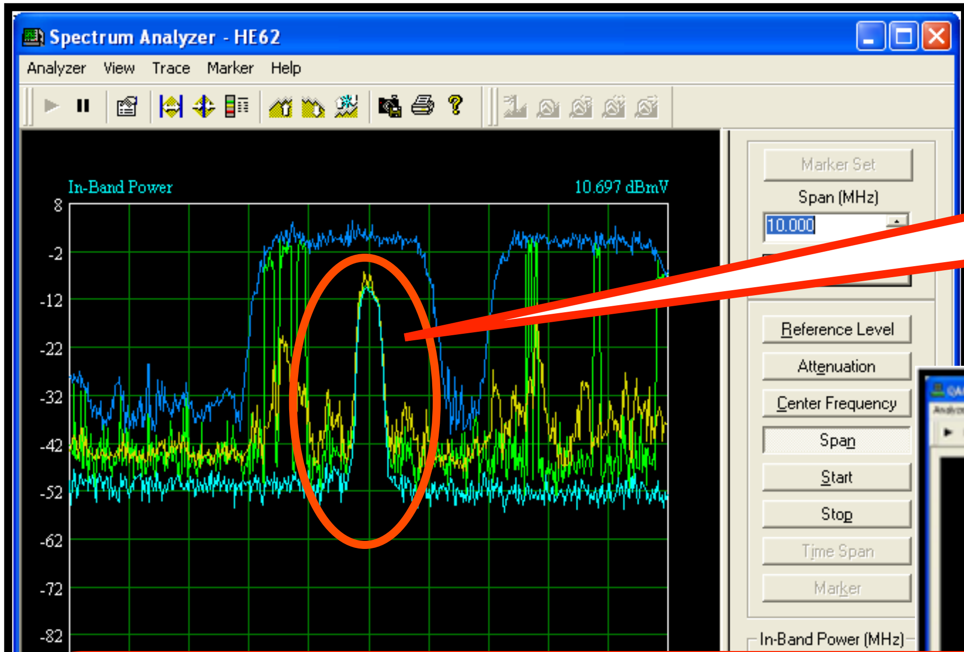
Reverse Path Impairments - Ingress

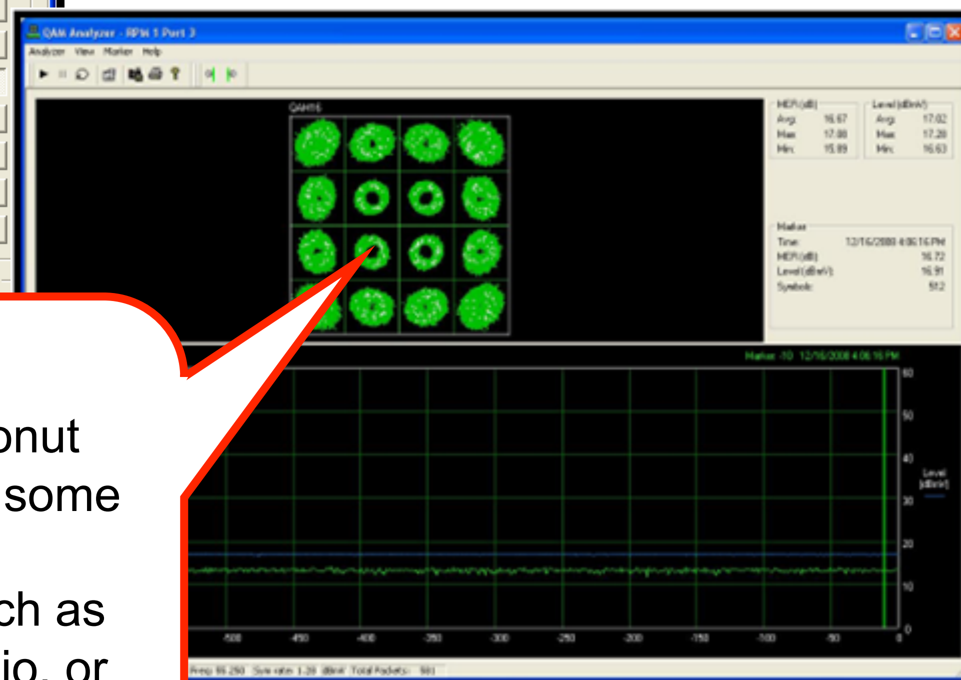
RF ingress — The 5-42 MHz reverse spectrum is shared with numerous over-the-air users.



Signals in the over-the-air environment include high power shortwave broadcasts, amateur radio, citizens band, government, and other two-way radio communications.

Ingress - Off-air Broadcast Radio Carrier





Off-air public broadcast radio carrier under the DOCSIS® 16QAM carrier

Coherent Interference

If the constellation looks like it has "donut shapes" in it, the problem is likely to be some form of coherent interference.

Often caused by off-air ingress such as citizens band radio, shortwave radio, or other broadcast radio sources.

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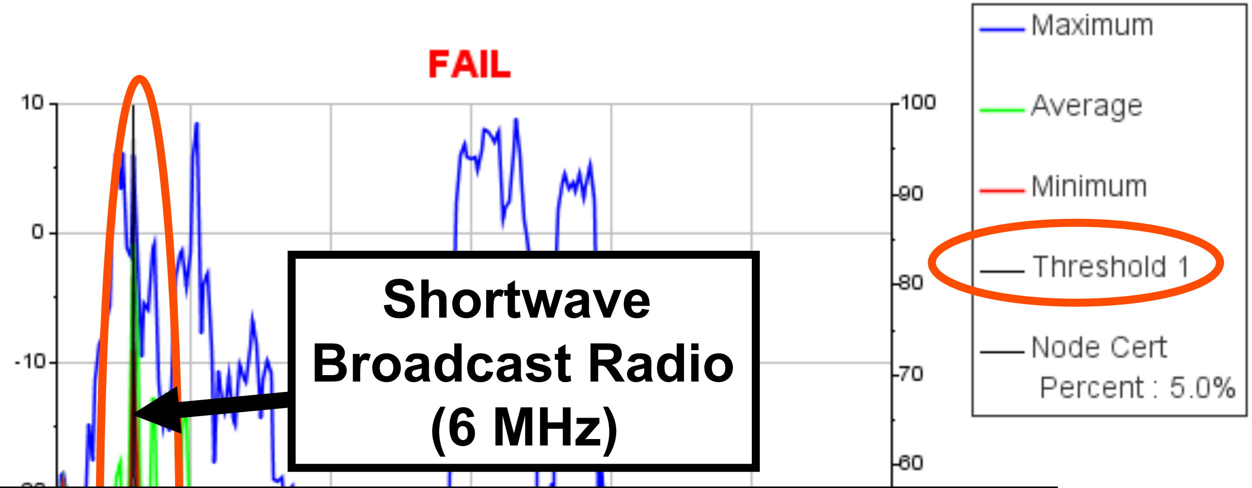
Failed Node Summary – Shortwave Broadcast Radio
15 Minute Interval of Node Ranking Report

The Shortwave Broadcast radio carrier @ 6 MHz was identified in the Node Ranking Report as the "Worst Frequency".

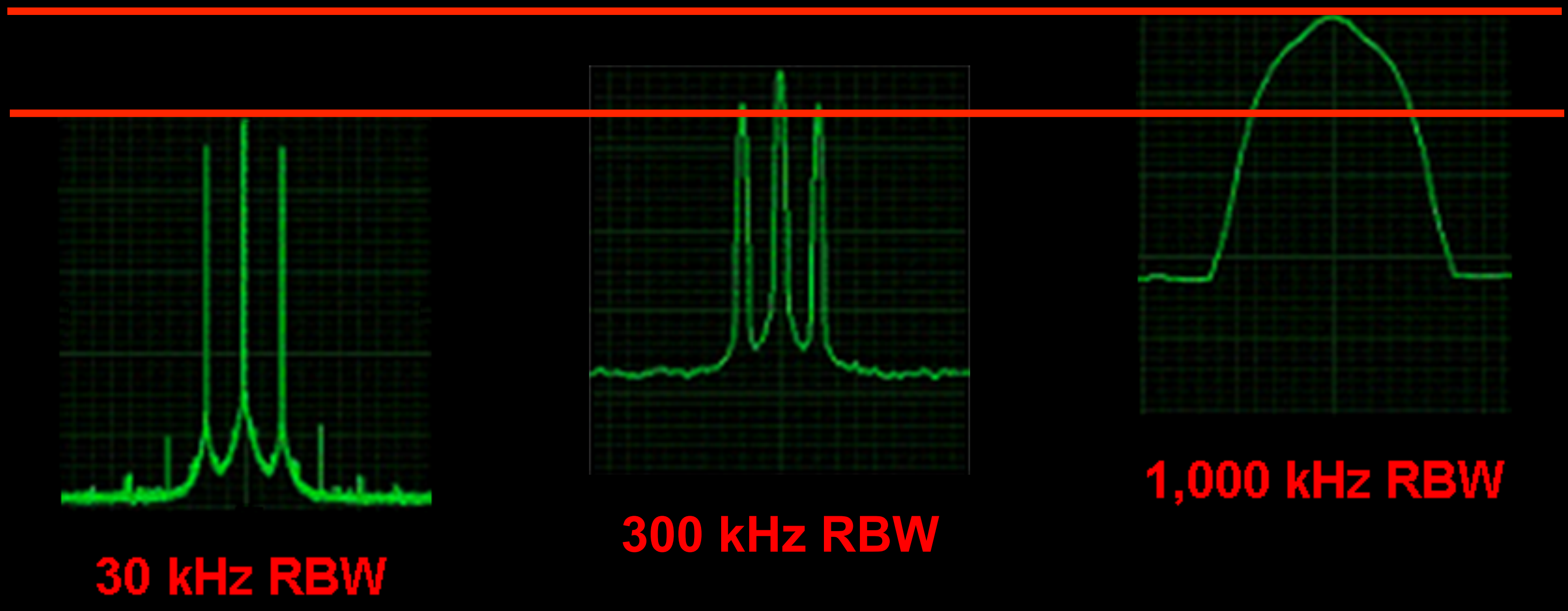


Metre Band	Frequency Range	Remarks
120 m	2300 – 2495 kHz	tropic band
90 m	3200 – 3400 kHz	tropic band
75 m	3900 – 4000 kHz	shared with the North American amateur radio 80m band
60 m	4750 – 5060 kHz	tropic band
49 m	5900 – 6200 kHz	
41 m	7200 – 7450 kHz	shared with the amateur radio 40m band
31 m	9400 – 9900 kHz	Currently most heavily used band
25 m	11,600 - 12,100 kHz	
22 m	13,570 - 13,870 kHz	substantially used only in Eurasia
19 m	15,100 - 15,800 kHz	
16 m	17,480 - 17,900 kHz	
15 m	18,900 - 19,020 kHz	almost unused, could become a DRM band
13 m	21,450 - 21,850 kHz	
11 m	25,600 - 26,100 kHz	may be used for local DRM broadcasting

The Shortwave Broadcast radio carrier @ 6 MHz had exceeded Threshold 1 (-25 dBmV) for 100% of the time during the 15 minute spectrum summary timeframe .

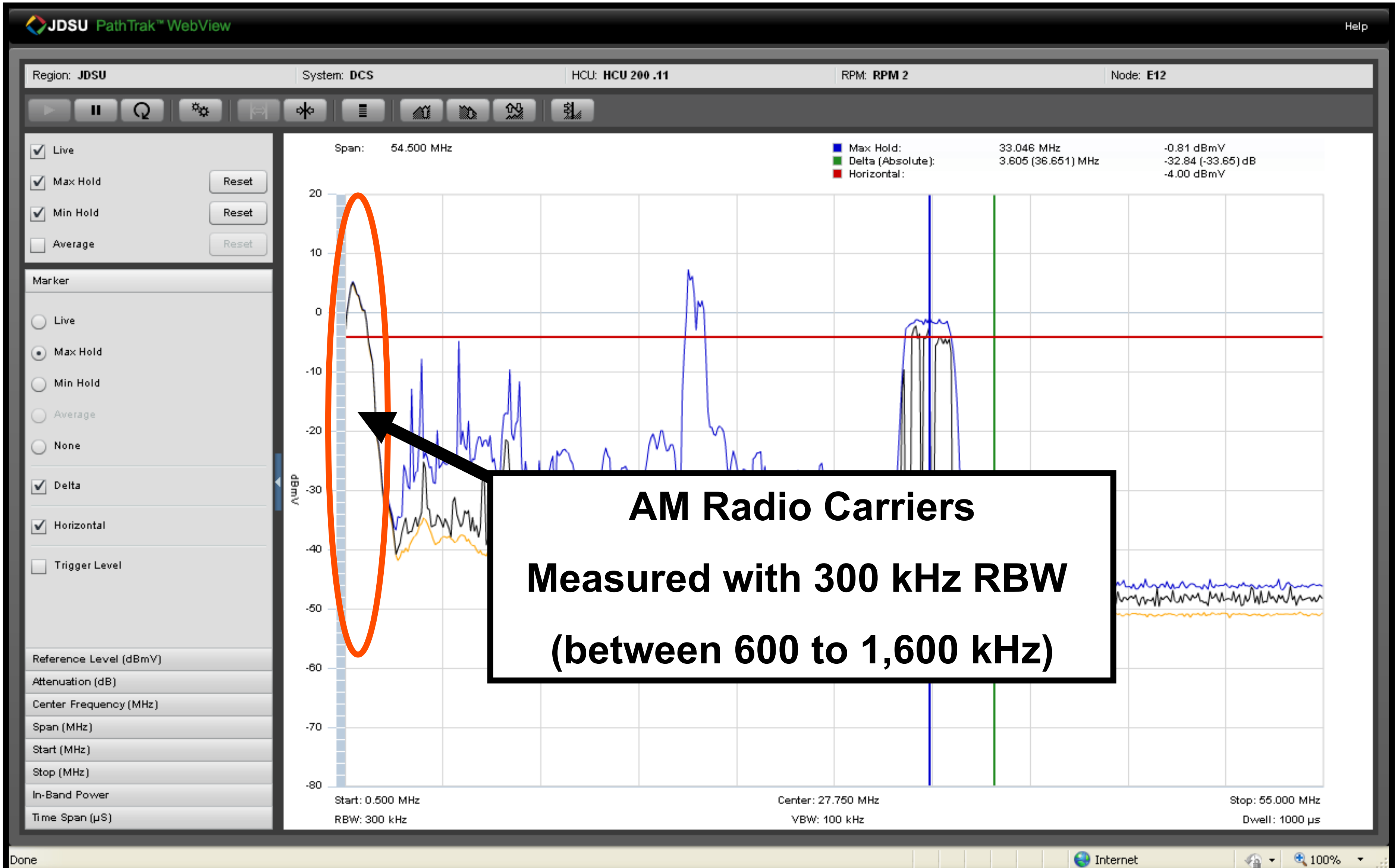
Spectrum Analysis – RBW Filters

Resolution bandwidth (RBW) filters determine the smallest frequency that can be resolved.

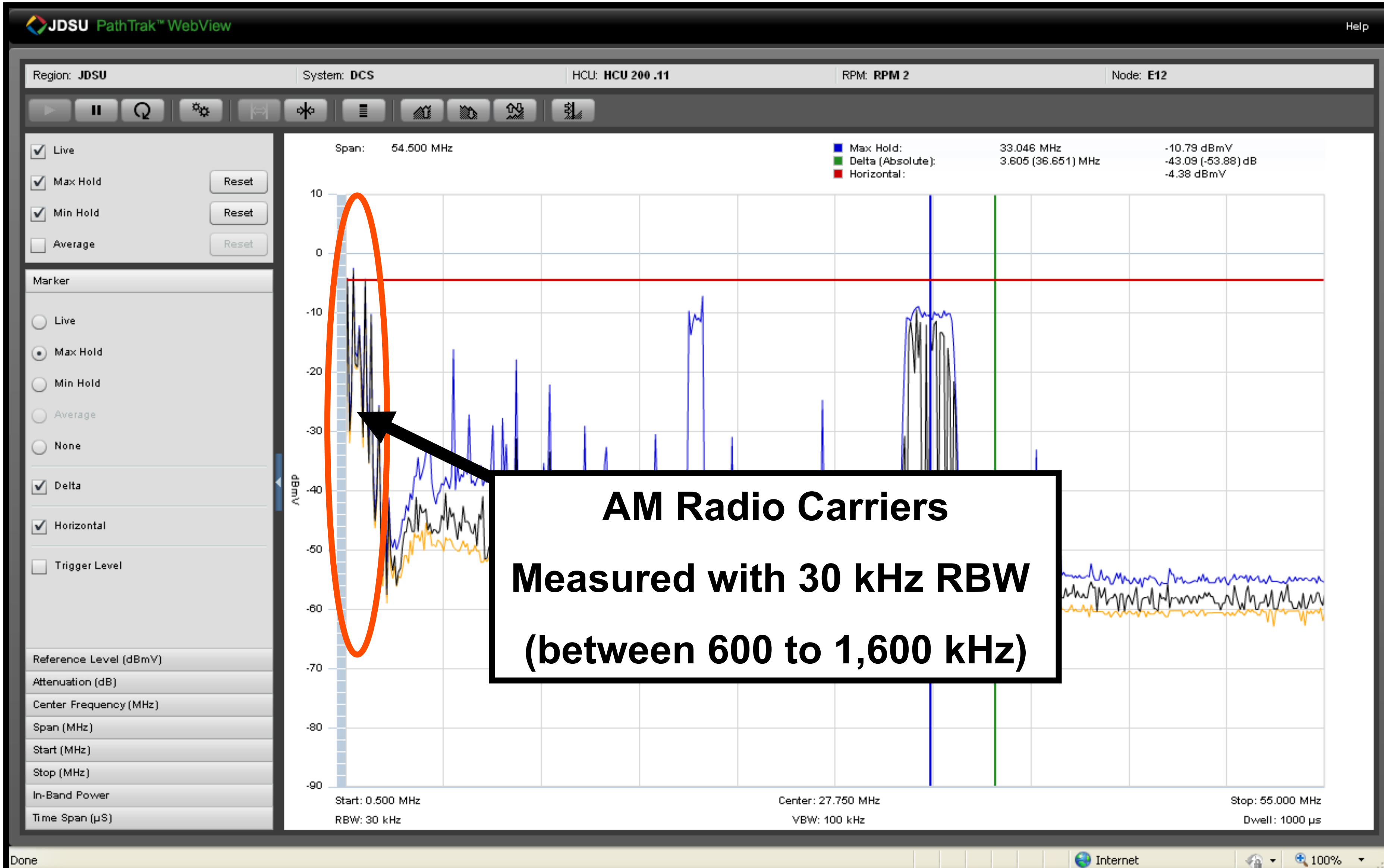


The graphs above represent the same 3 narrow band signals with various RBW filters applied.

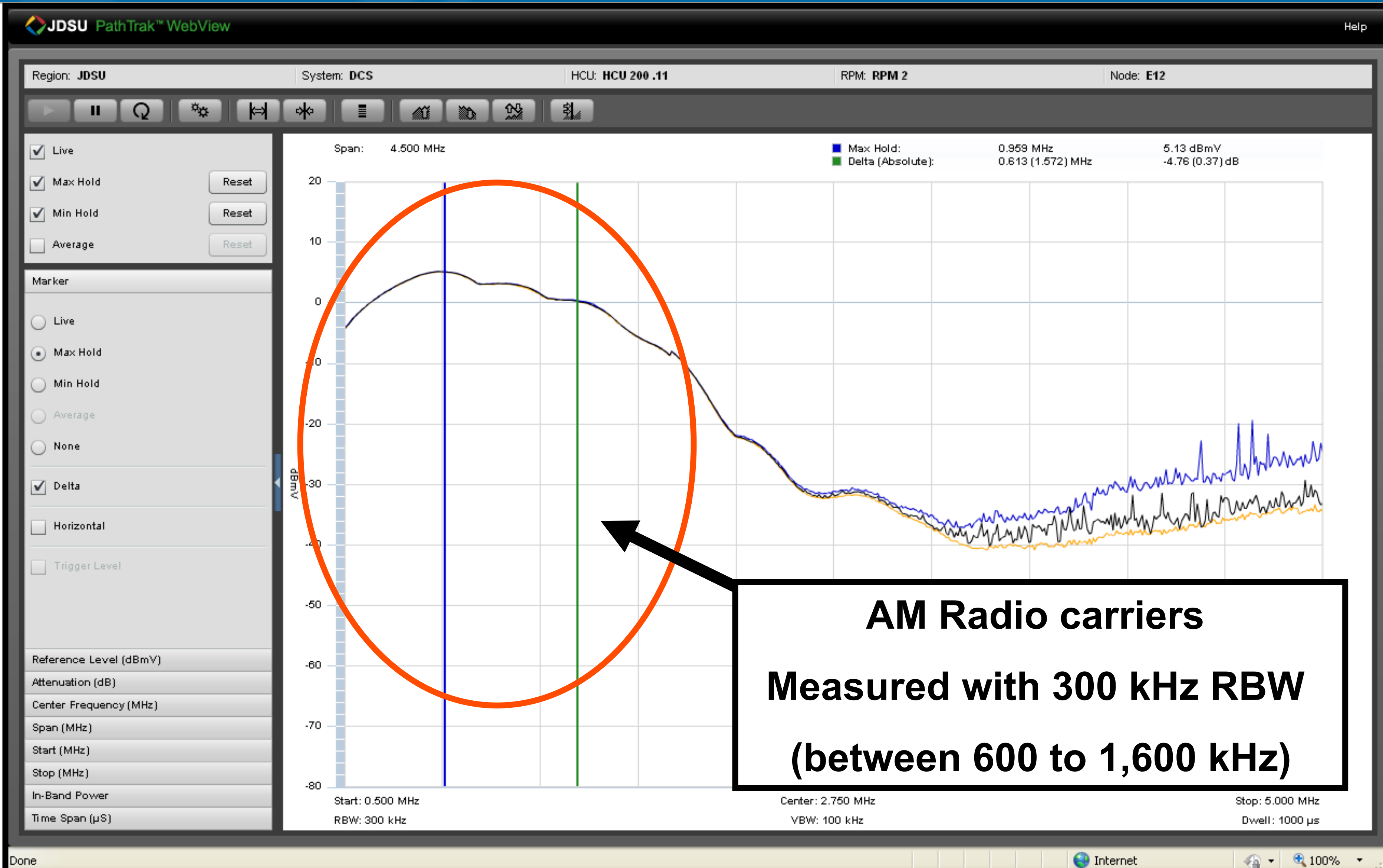
Ingress - Off-air AM Radio Carriers Below 5 MHz



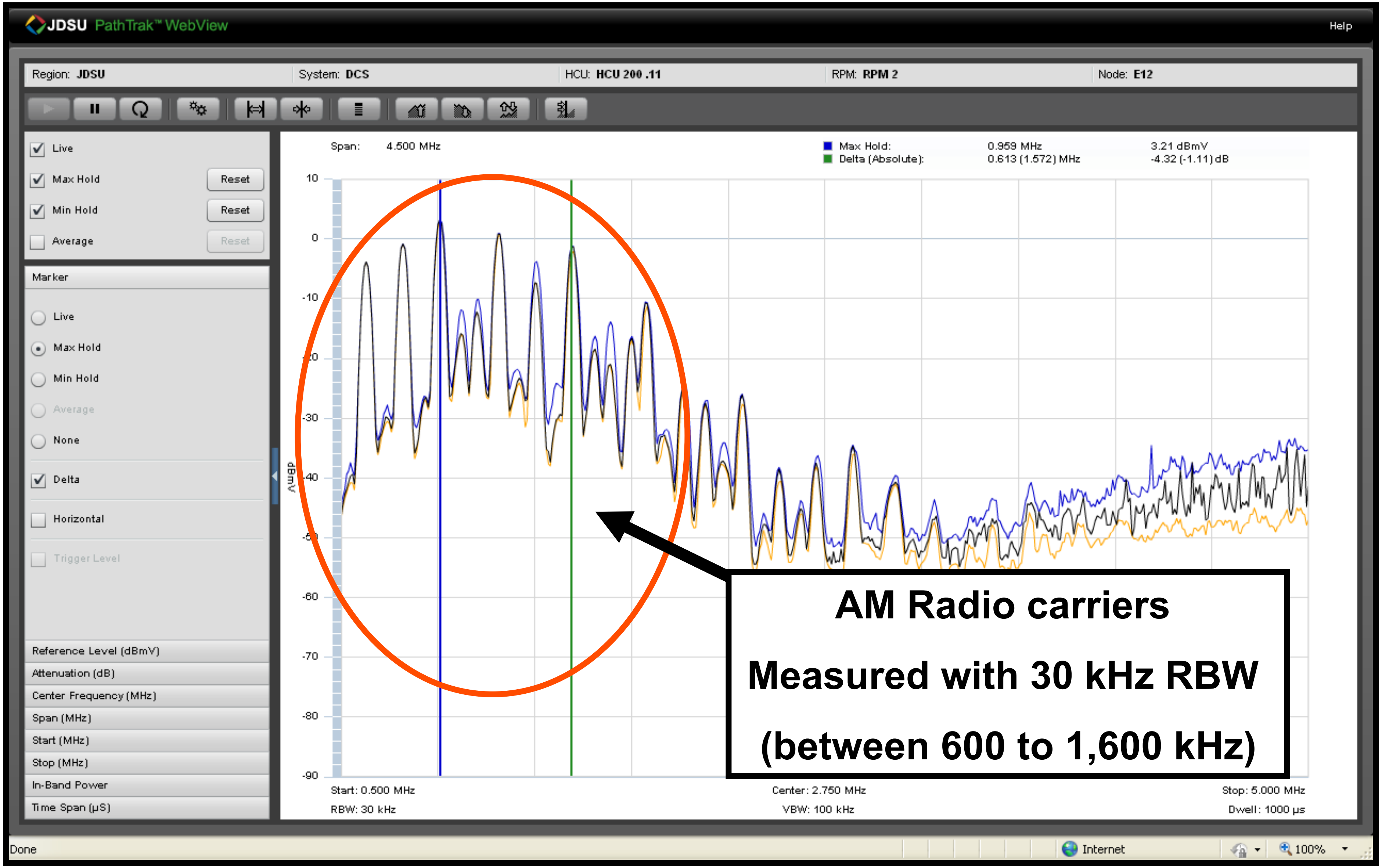
Ingress - Off-air AM Radio Carriers Below 5 MHz



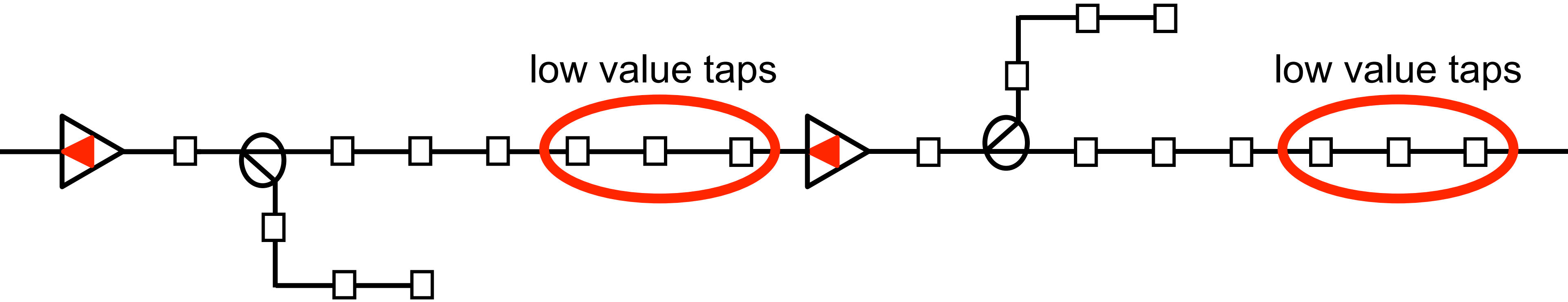
Ingress - Off-air AM Radio Carriers Below 5 MHz



Ingress - Off-air AM Radio Carriers Below 5 MHz

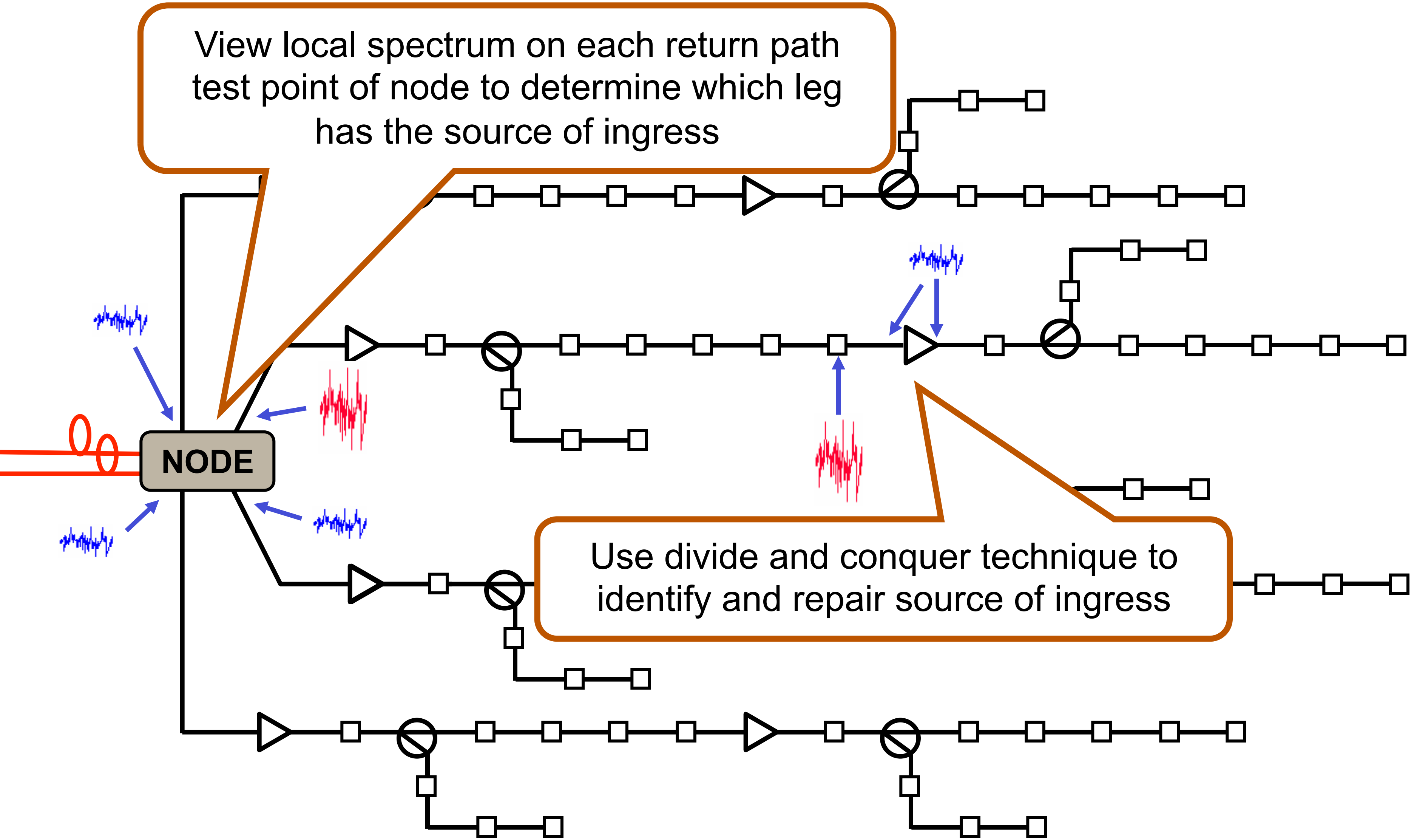


Typical Problem Areas

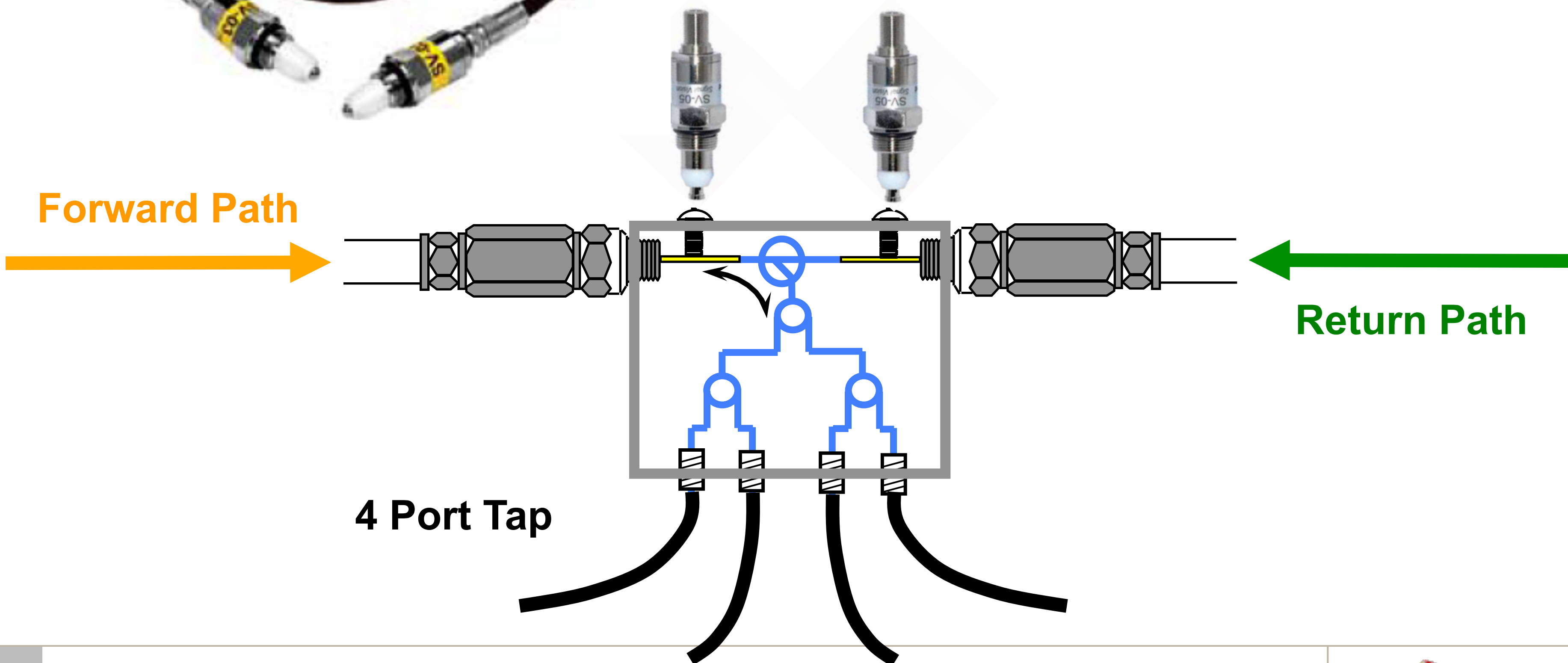


- **Taps**
  - Most ingress comes from houses off of with low value taps of approximately 17 dB or less
- **Home Wiring**
  - Drop Cable, splitters & F Connectors are approximately ~95% of Problem
- **Amplifiers, hard line cable** and the rest of the system are a small percentage of the problem if a proper leakage maintenance program is performed

Tracking Down Ingress – Divide and Conquer

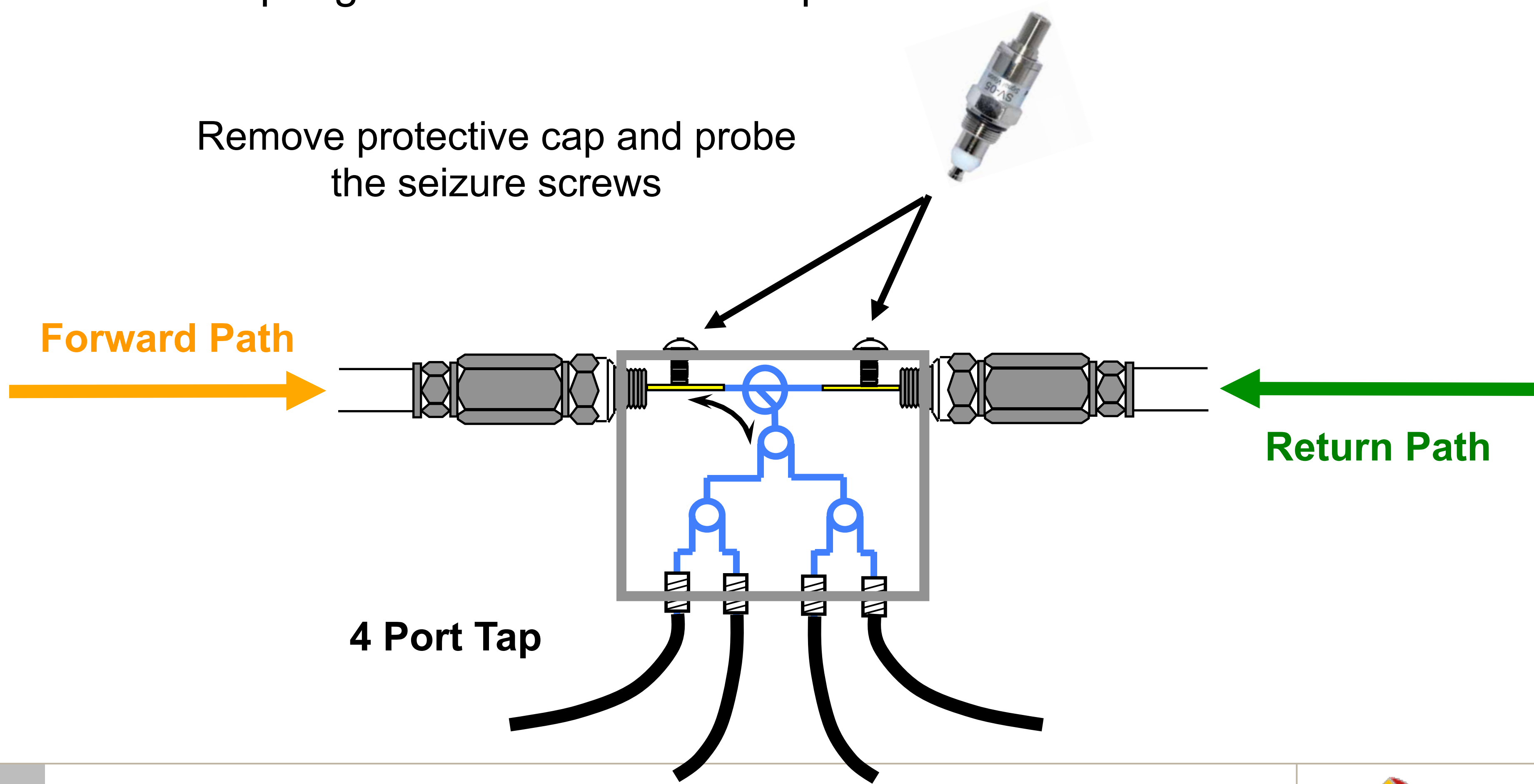


Testing with Seizure Screw Probes

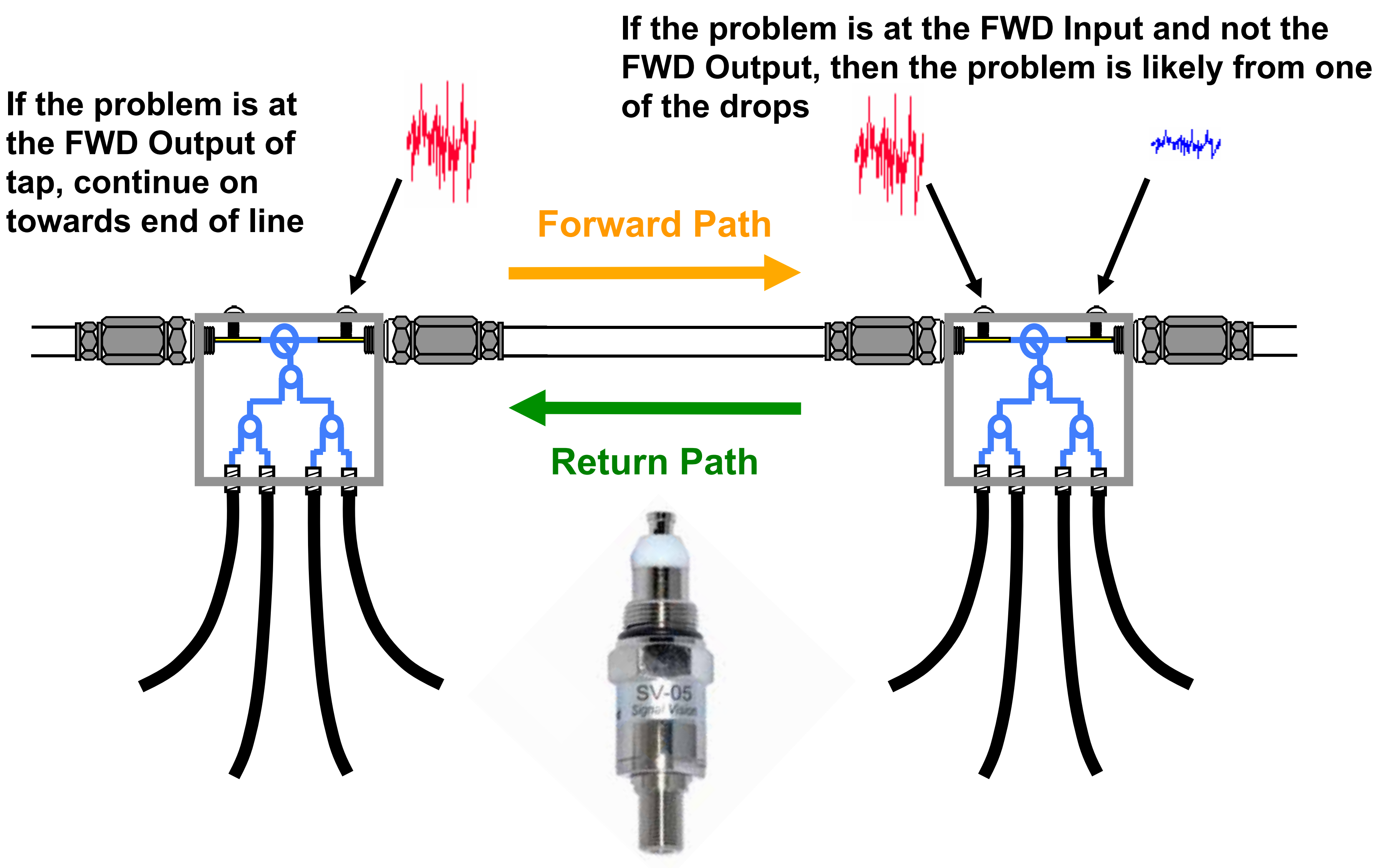


Testing with Seizure Screw Probes

- Spring loaded seizure screw probes create a good ground and quick connect without causing outages
- Use a 20 db pad with AC block when using a field meter and a spring loaded seizure screw probe

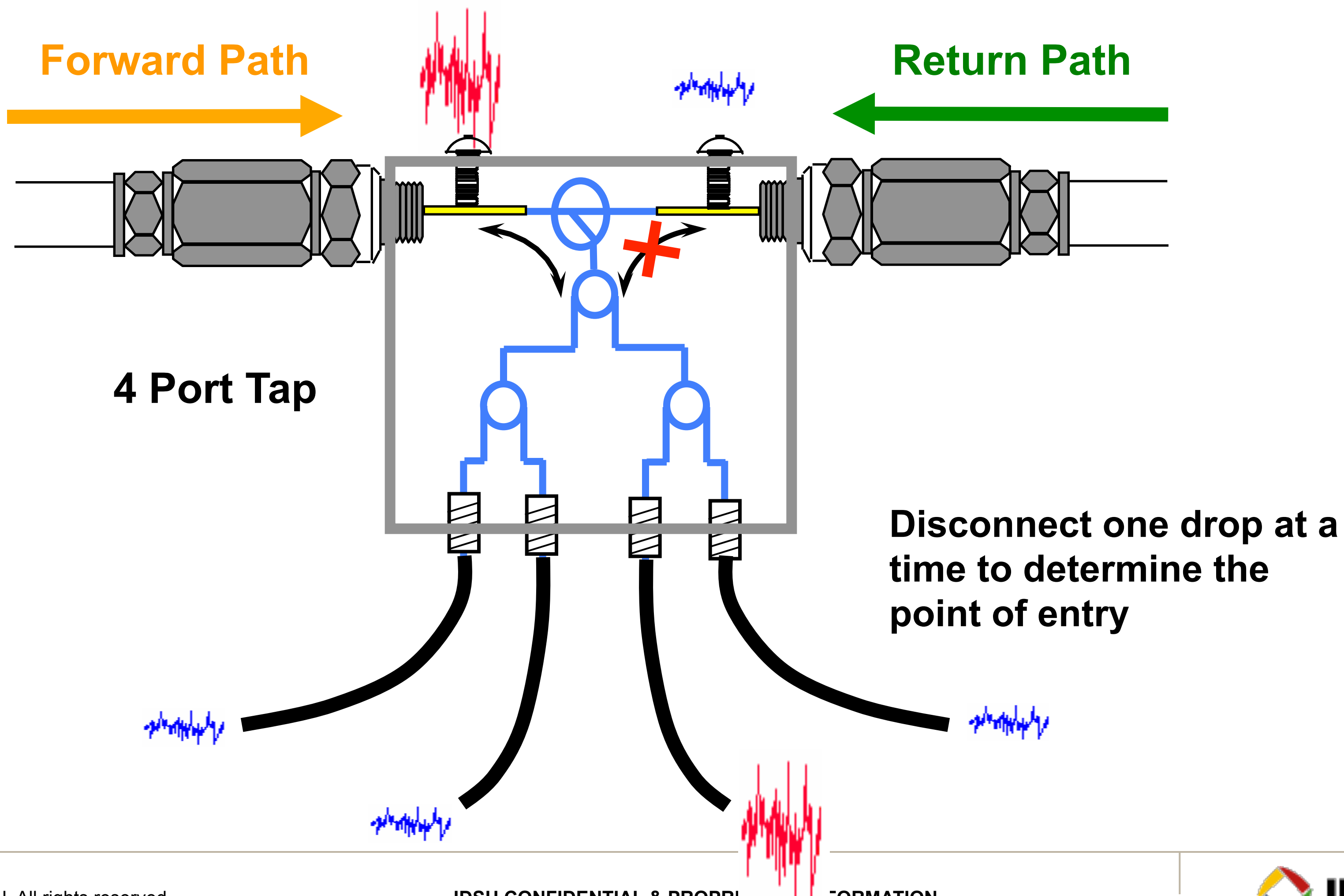


Taps - Probe the Seizure Screws for Ingress & CPD



Taps are made up of a Directional Coupler and Splitters

- If the problem is at the Forward Input and not the Forward Output, then the problem is from one of the drops



In-Home Wiring Is A Potentially Large Stumbling Block

- The subscriber drop remains the weakest link in the cable network
- Seven out of ten service calls are generated by problems at the drop
- Ingress caused in the home wreaks havoc on the reverse path
  - Must be found in the home before connecting to network when possible
  - Must be monitored continuously and eliminated quickly
- Replacing all home wiring is economically unacceptable, testing is required to find faults and bring the home wiring up to standards necessary for new services.

Common Problems Typically Identified in the Drop

- Kinked or damaged cable (including cracked cable, which causes a reflection and ingress)
- Use of staples that perforate or compress coaxial cable resulting in impedance mismatches
- Cable-ready TVs and VCRs connected directly to the drop (Return loss on most cable-ready devices is poor)
- Older splitters and amplifiers may not be rated for 750MHz, 860MHz or 1GHz
- Some traps and filters have been found to have poor return loss in the upstream, especially those used for data-only service

There are Many Possible Sources of Interference

Off-Air Broadcast

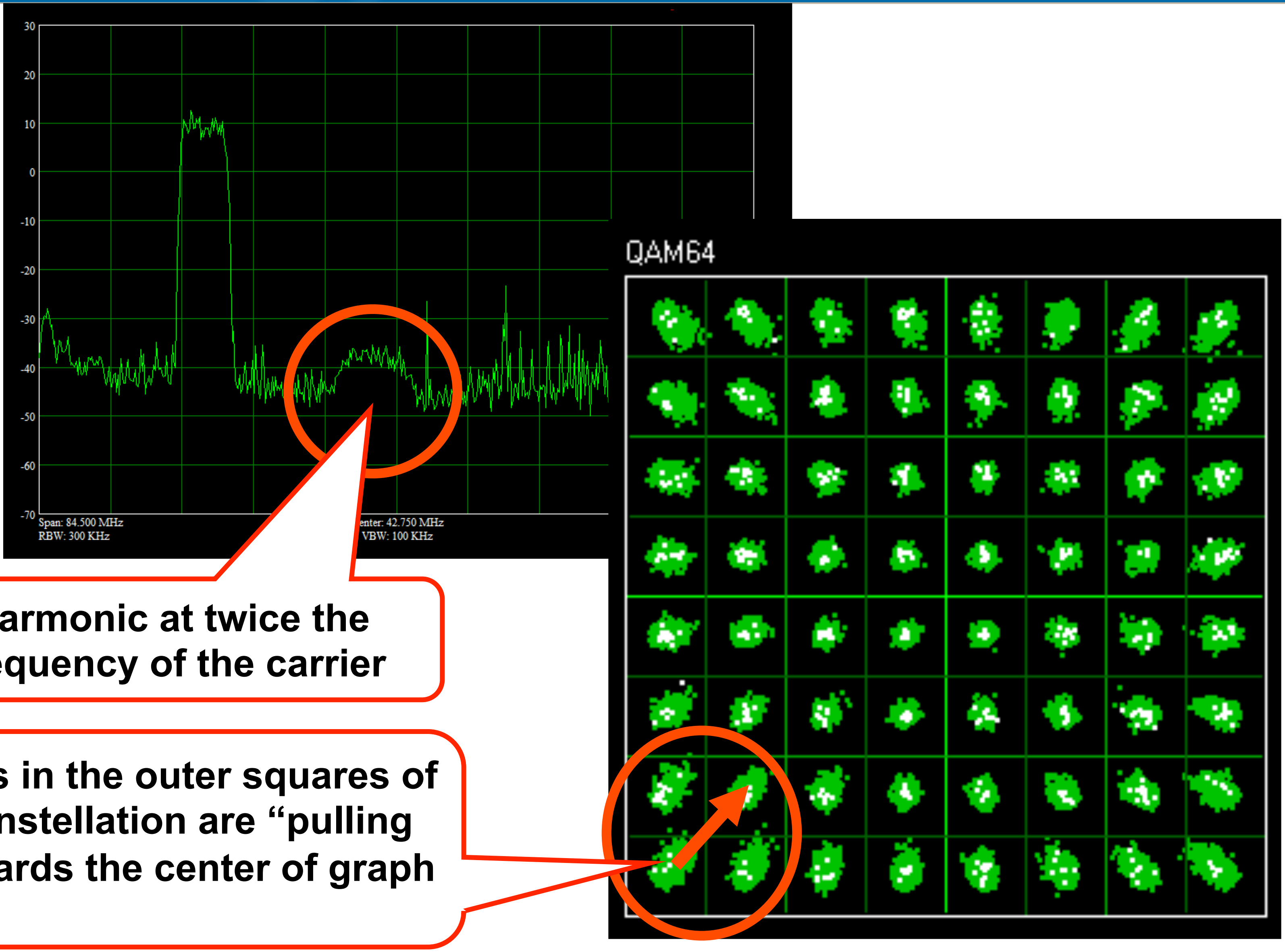
- AM Radio Station
- FM Radio Station
- TV Station
- Two-way Radio Transmitters
- Citizens Band (CB)
- Amateur (Ham)
- Taxi
- Police
- Business
- Airport/Aircraft
- Paging Transmitters

FEDERAL COMMUNICATIONS COMMISSION

Electrical Devices

- Doorbell transformers
- Toaster Ovens
- Electric Blankets
- Ultrasonic pest controls (bug zappers)
- Fans
- Refrigerators
- Heating pads
- Light dimmers
- Touch controlled lamps
- Fluorescent lights
- Aquarium or waterbed heaters
- Furnace controls
- Computers and video games
- Neon signs
- Power company electrical equipment
- Alarm systems
- Electric fences
- Loose fuses
- Sewing machines
- Hair dryers
- Electric toys
- Calculators
- Cash registers
- Lightning arresters
- Electric drills, saws, grinders, and other power tools
- Air conditioners
- TV/radio booster amplifiers
- TV sets
- Automobile ignition noise
- Sun lamps
- Smoke detectors

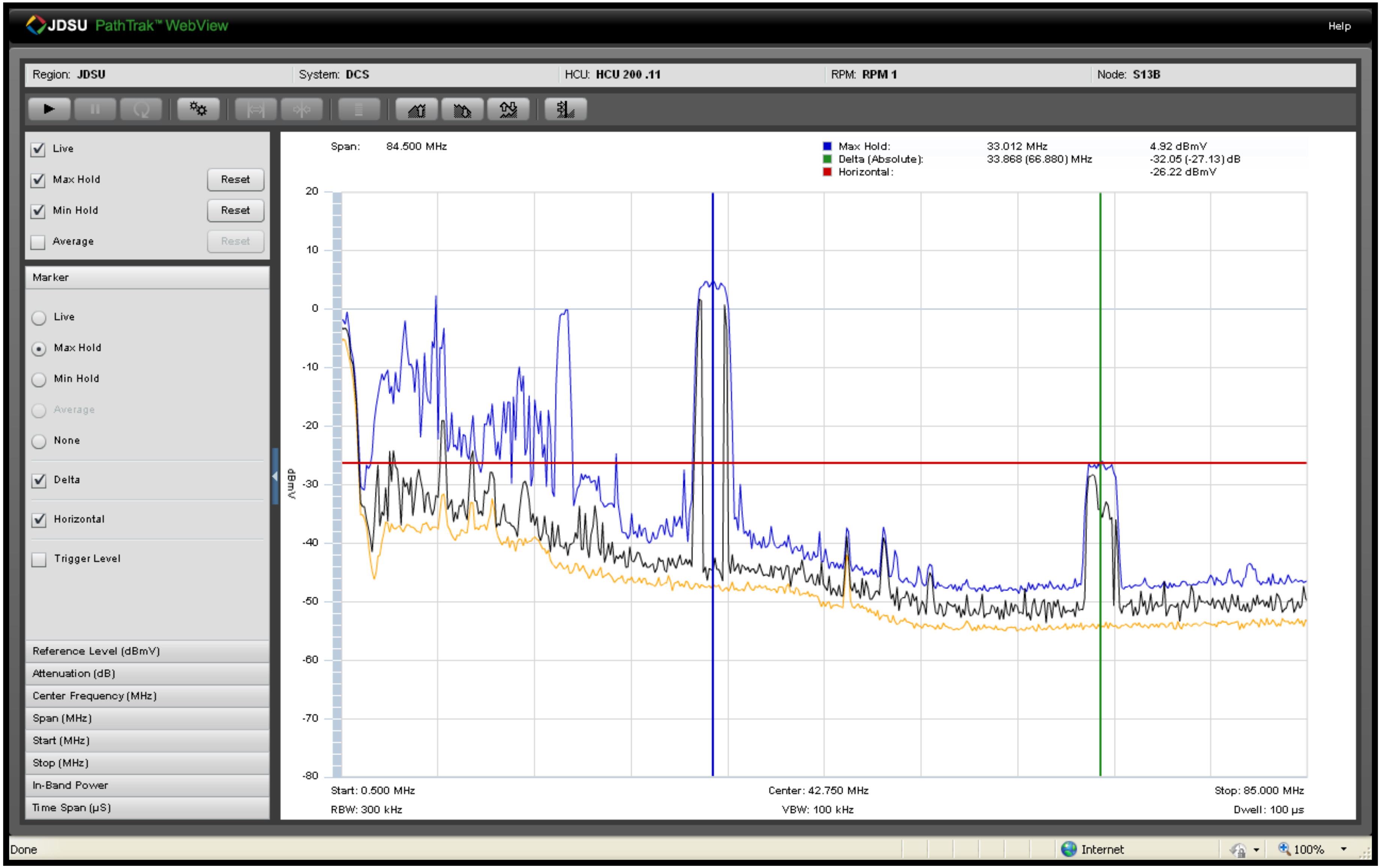
Reverse Path Impairments – Laser Clipping



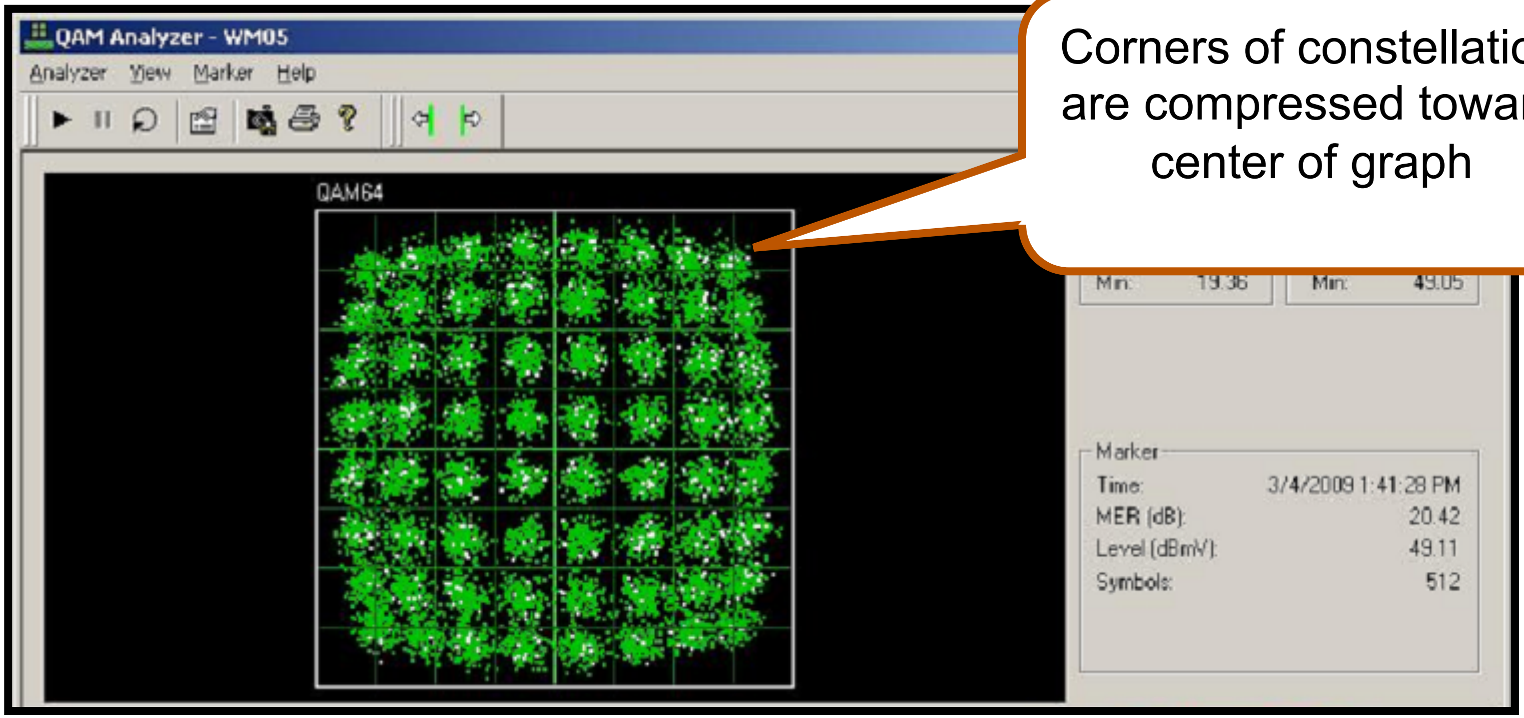
Harmonic at twice the frequency of the carrier

Dots in the outer squares of constellation are "pulling towards the center of graph

Reverse Path Impairments – Laser Clipping



Reverse Path Impairments – Compression

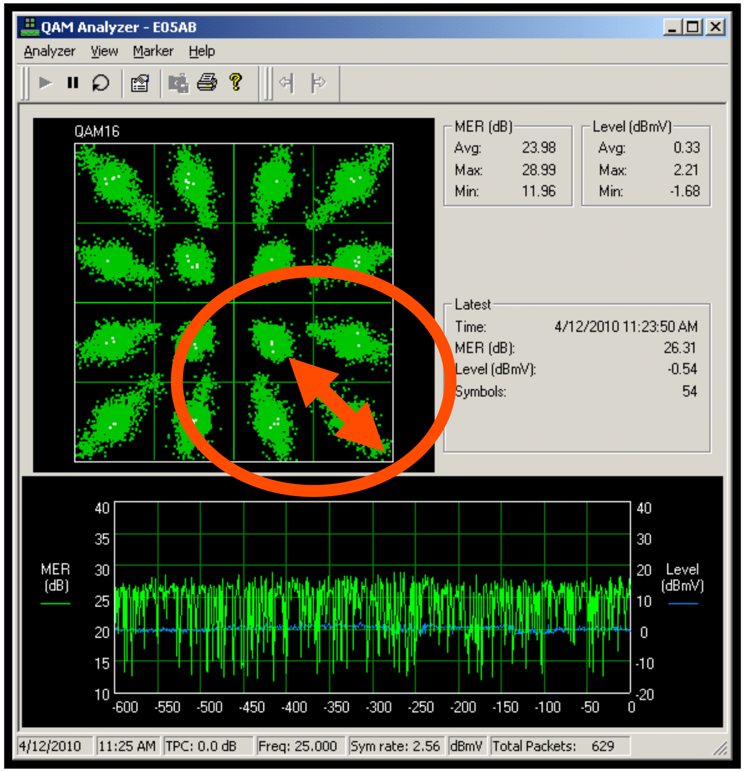


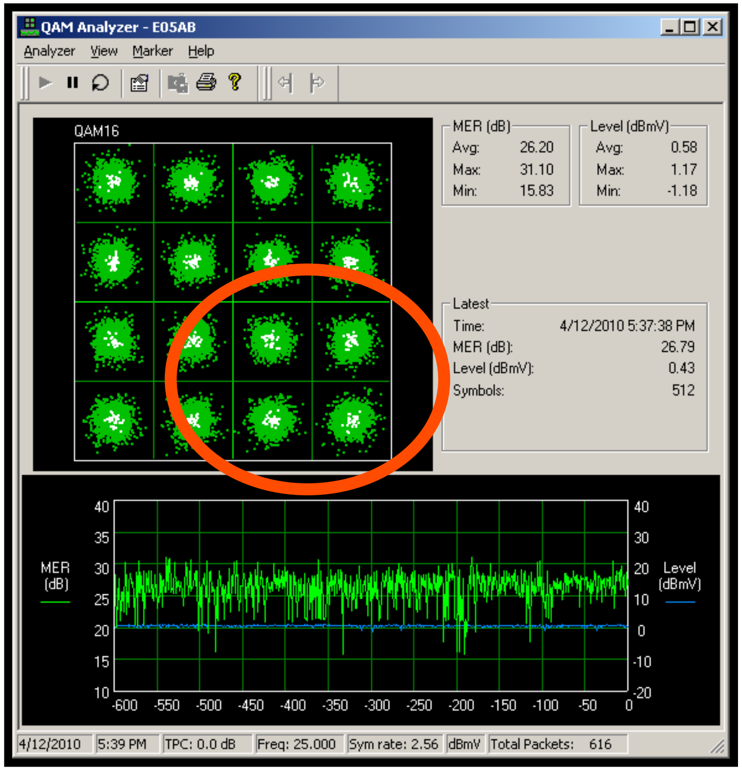
Corners of constellation are compressed toward center of graph

Amplifier Compression

Amplifier compression often manifests as rounding of the corners of the constellation.
Laser clipping often manifests as increased spread in the corners of the constellation.
Both are caused by overdriving an amplifier or laser usually due to ingress or misalignment.
(unity gain)
May become more prevalent as more DOCSIS® upstream carriers are added.

Reverse Path Impairments – Bad Optical Receiver



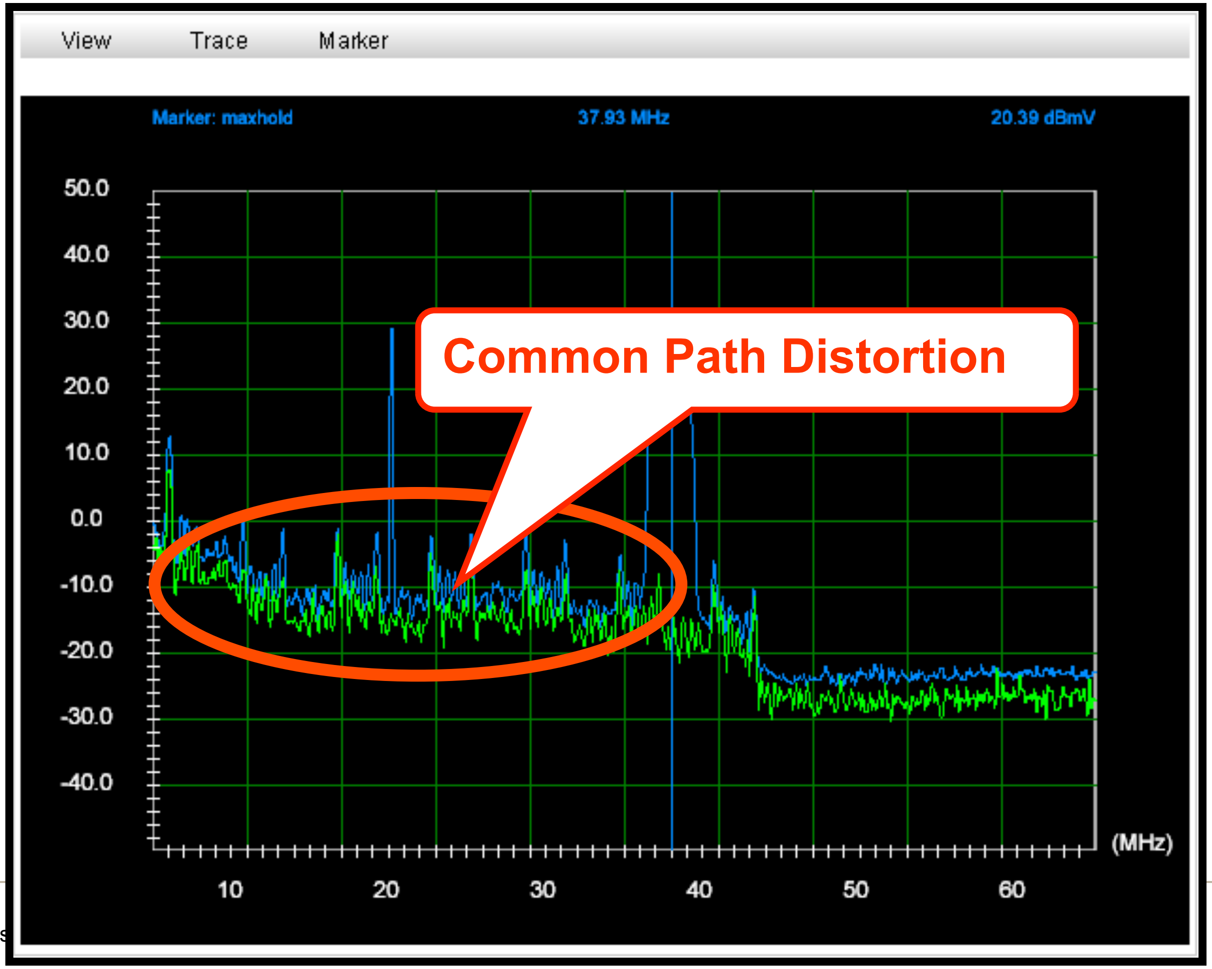


This constellation pattern is noticeably distorted due to a defective optical receiver.

The constellation pattern “returned to normal” after replacing the defective optical receiver!

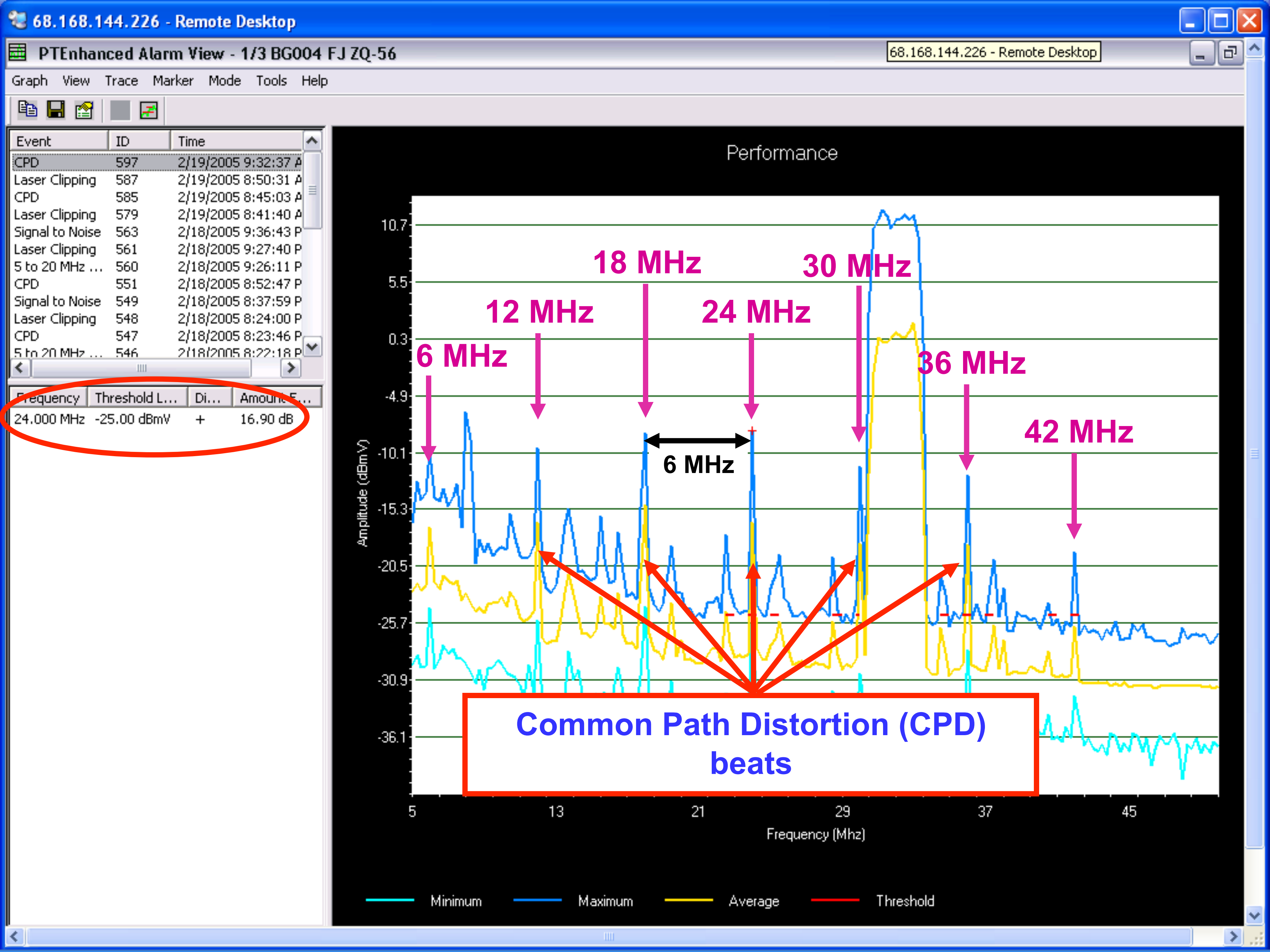
Reverse Path Impairments – CPD

Common Path Distortion (CPD) — common path distortion usually occurs at a dissimilar metals interface where a thin oxide layer has formed.

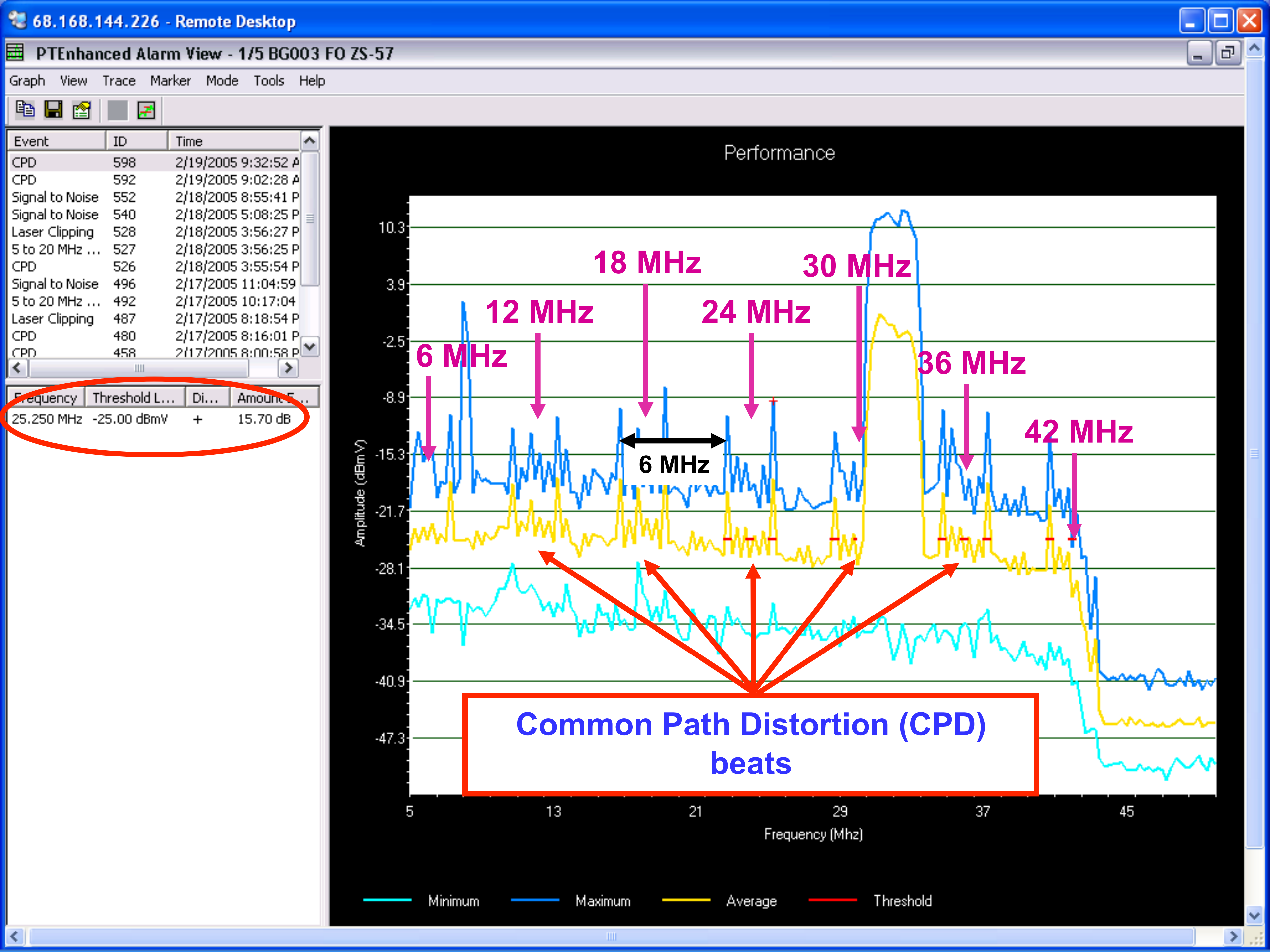


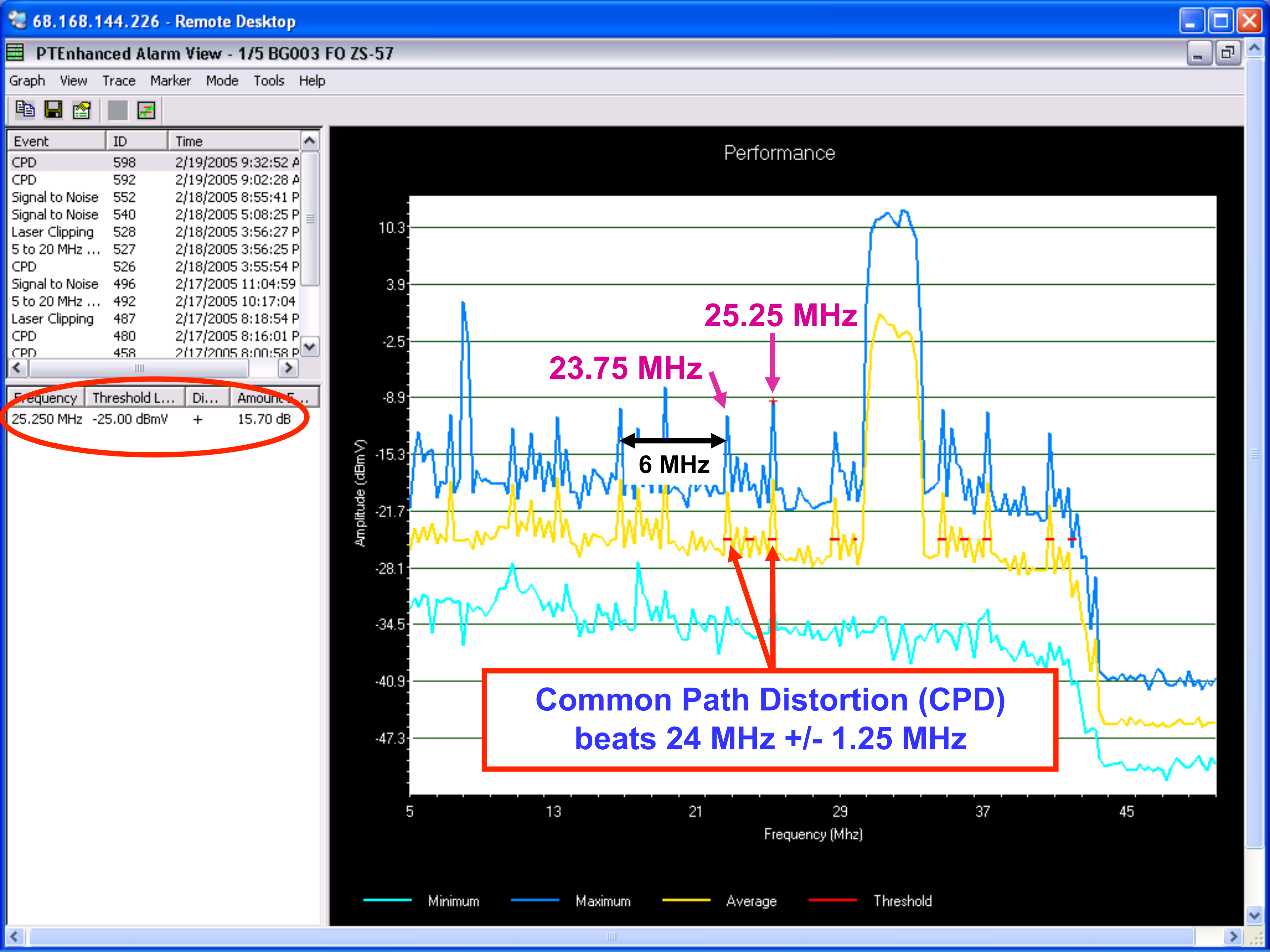
Common Path Distortion (A.K.A. CPD)

- **Non-linear mixing from a diode junction**
  - Corrosion (metal oxide build-up) in the coaxial portion of the HFC network
  - Dissimilar metal contacts
  - 4 main groups of metals
    - Magnesium and its alloys
    - Cadmium, Zinc, Aluminum and its alloys
    - Iron, Lead, Tin, & alloys (except stainless steel)
    - Copper, Chromium, Nickel, Silver, Gold, Platinum, Titanium, Cobalt, Stainless Steel, and Graphite
- **Second and third order distortions**



68.168.144.226 - Remote Desktop
PTEnhanced Alarm View - 1/3 BG004 FJ ZQ-56
68.168.144.226 - Remote Desktop
Graph View Trace Marker Mode Tools Help
Event | ID | Time
CPD 597 2/19/2005 9:32:37 A
Laser Clipping 587 2/19/2005 8:50:31 A
CPD 585 2/19/2005 8:45:03 A
Laser Clipping 579 2/19/2005 8:41:40 A
Signal to Noise 563 2/18/2005 9:36:43 P
Laser Clipping 561 2/18/2005 9:27:40 P
5 to 20 MHz … 560 2/18/2005 9:26:11 P
CPD 551 2/18/2005 8:52:47 P
Signal to Noise 549 2/18/2005 8:37:59 P
Laser Clipping 548 2/18/2005 8:24:00 P
CPD 547 2/18/2005 8:23:46 P
5 to 20 MHz … 546 2/18/2005 8:22:18 P
Frequency | Threshold L… | Di… | Amount E…
24.000 MHz -25.00 dBmV + 16.90 dB
Performance
10.7
5.5
0.3
-4.9
-10.1
-15.3
-20.5
-25.7
-30.9
-36.1
Amplitude (dBm V)
5 13 21 29 37 45
Frequency (Mhz)
6 MHz
12 MHz
18 MHz
24 MHz
30 MHz
36 MHz
42 MHz
6 MHz
Common Path Distortion (CPD) beats
Minimum
Maximum
Average
Threshold

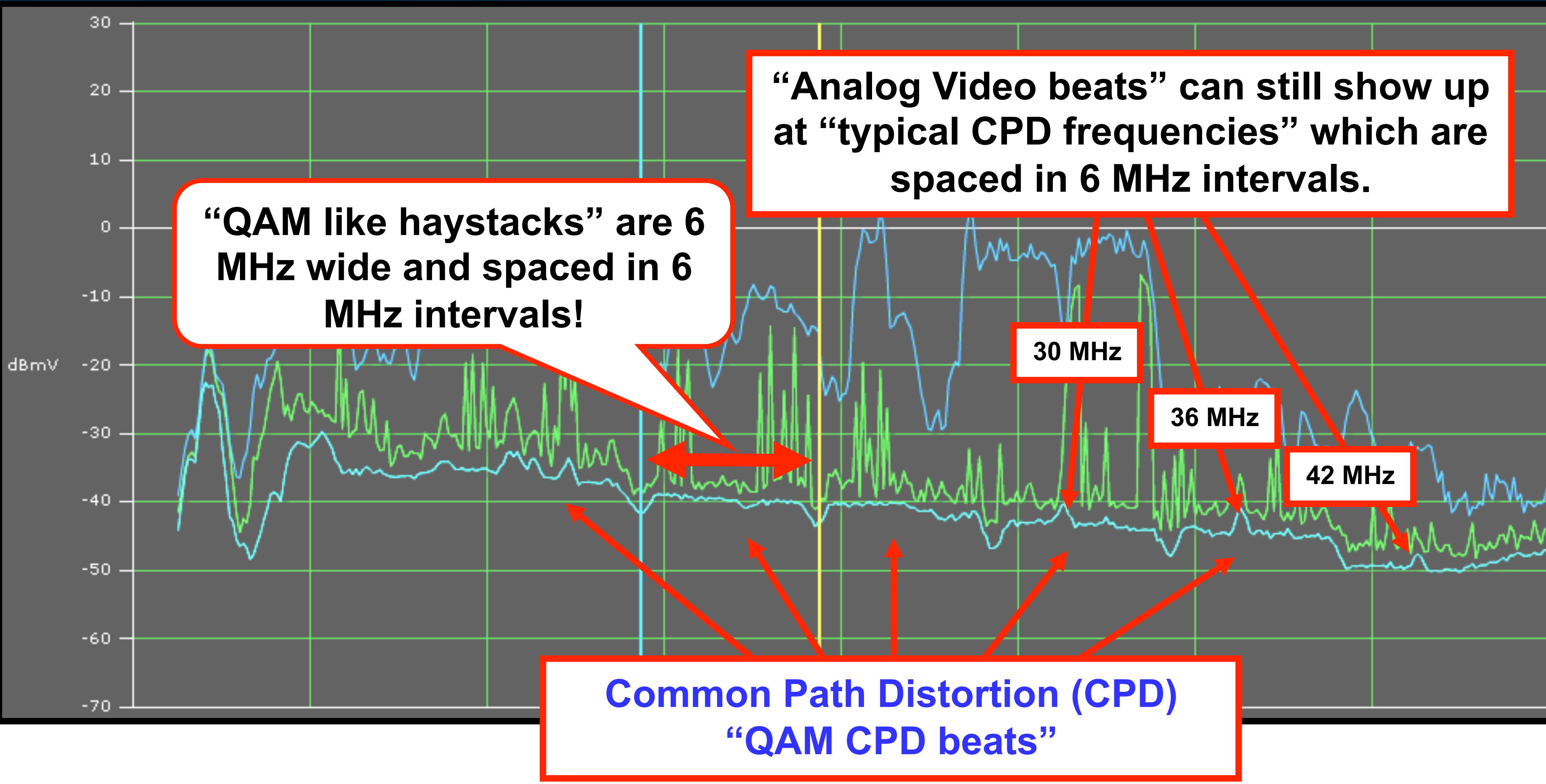

68.168.144.226 - Remote Desktop
PTEnhanced Alarm View - 1/5 BG003 FO ZS-57
Graph View Trace Marker Mode Tools Help
Event | ID | Time
CPD 598 2/19/2005 9:32:52 A
CPD 592 2/19/2005 9:02:28 A
Signal to Noise 552 2/18/2005 8:55:41 P
Signal to Noise 540 2/18/2005 5:08:25 P
Laser Clipping 528 2/18/2005 3:56:27 P
5 to 20 MHz ... 527 2/18/2005 3:56:25 P
CPD 526 2/18/2005 3:55:54 P
Signal to Noise 496 2/17/2005 11:04:59
5 to 20 MHz ... 492 2/17/2005 10:17:04
Laser Clipping 487 2/17/2005 8:18:54 P
CPD 480 2/17/2005 8:16:01 P
Frequency | Threshold L... | Di... | Amount E...
25.250 MHz -25.00 dBmV + 15.70 dB
Performance
6 MHz
12 MHz
18 MHz
24 MHz
30 MHz
36 MHz
42 MHz
6 MHz
Common Path Distortion (CPD) beats
Amplitude (dBmV)
10.3
3.9
-2.5
-8.9
-15.3
-21.7
-28.1
-34.5
-40.9
-47.3
5
13
21
29
37
45
Frequency (Mhz)
Minimum
Maximum
Average
Threshold


68.168.144.226 - Remote Desktop
PTEnhanced Alarm View - 1/5 BG003 FO ZS-57
Graph View Trace Marker Mode Tools Help
Event ID Time
CPD 598 2/19/2005 9:32:52 A
CPD 592 2/19/2005 9:02:28 A
Signal to Noise 552 2/18/2005 8:55:41 P
Signal to Noise 540 2/18/2005 5:08:25 P
Laser Clipping 528 2/18/2005 3:56:27 P
5 to 20 MHz ... 527 2/18/2005 3:56:25 P
CPD 526 2/18/2005 3:55:54 P
Signal to Noise 496 2/17/2005 11:04:59
5 to 20 MHz ... 492 2/17/2005 10:17:04
Laser Clipping 487 2/17/2005 8:18:54 P
CPD 480 2/17/2005 8:16:01 P
Frequency Threshold L... Di... Amount E...
25.250 MHz -25.00 dBmV + 15.70 dB
Performance
25.25 MHz
23.75 MHz
6 MHz
Common Path Distortion (CPD)
beats 24 MHz +/- 1.25 MHz
10.3
3.9
-2.5
-8.9
-15.3
-21.7
-28.1
-34.5
-40.9
-47.3
Amplitude (dBmV)
5
13
21
29
37
45
Frequency (Mhz)
Minimum
Maximum
Average
Threshold

CPD Troubleshooting

- **Pull a forward or return pad to see if the return "cleans-up"?**
  - This is definitely CPD or ingress
  - Very intrusive though – pulling pads when troubleshooting is not acceptable!
- **Try not to disturb anything in this tracking process**
  - Vibrations and movement can "break away" the diode/corrosion causing this CPD
  - Voltage surges can also destroy the diode
    - At least long enough to warrant a return visit!
- **Visually inspect hardware and replace defective components**
- **Tighten all seizure screws and connectors to specifications**

"QAM Generated" Common Path Distortion Beats



As operators add more and more QAM carriers to the downstream, Common Path Distortion beats can show up in the return spectrum as distinct "haystacks" in the noise floor which are spaced in 6 MHz intervals!

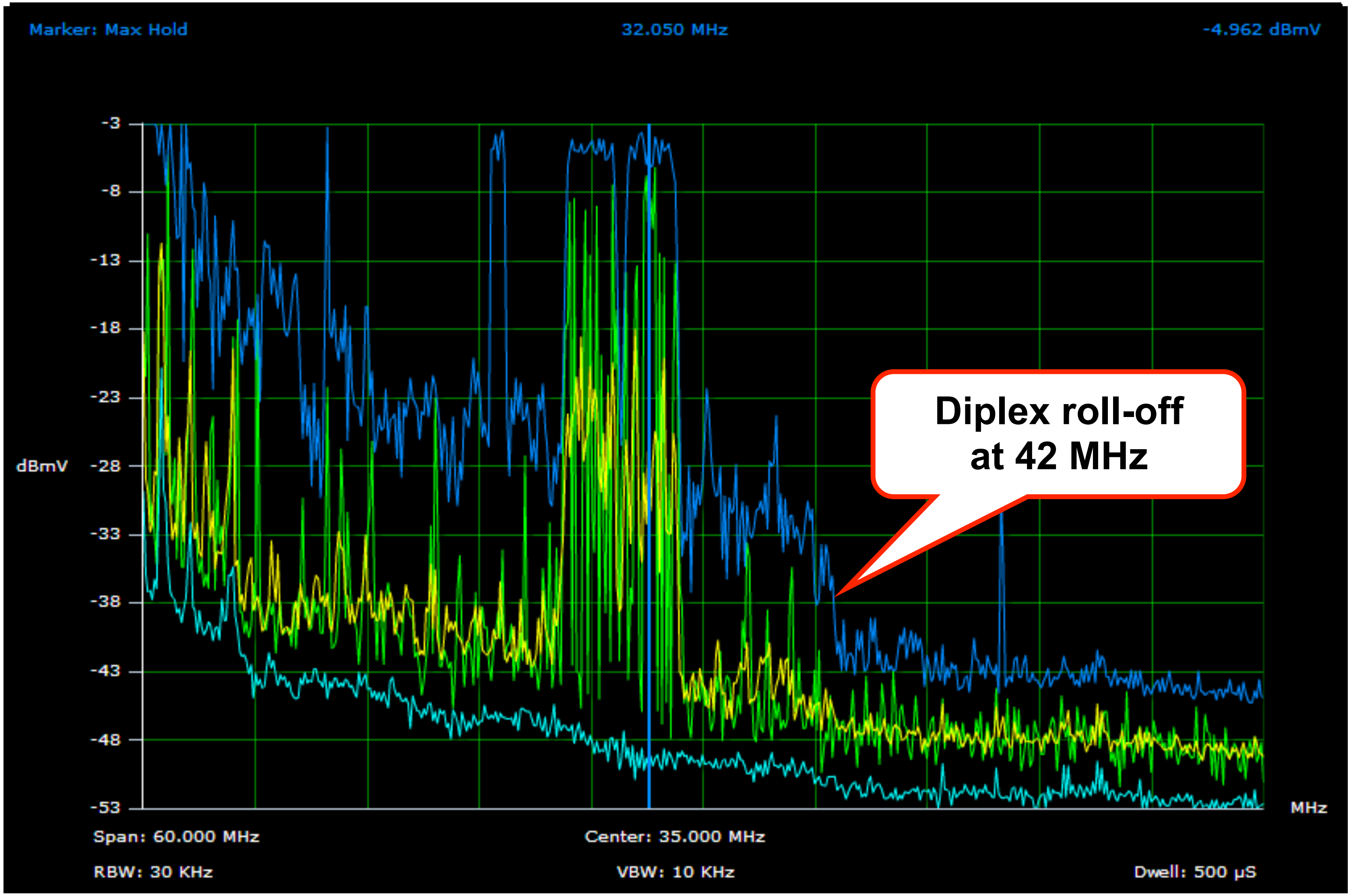
Reverse Path Impairments Electrical Impulse Noise

Impulse noise — Most reverse data transmission errors (i.e. Code Word Errors) have been found to be caused by bursts of impulse noise. Impulse noise is characterized by its fast rise-time and short duration.

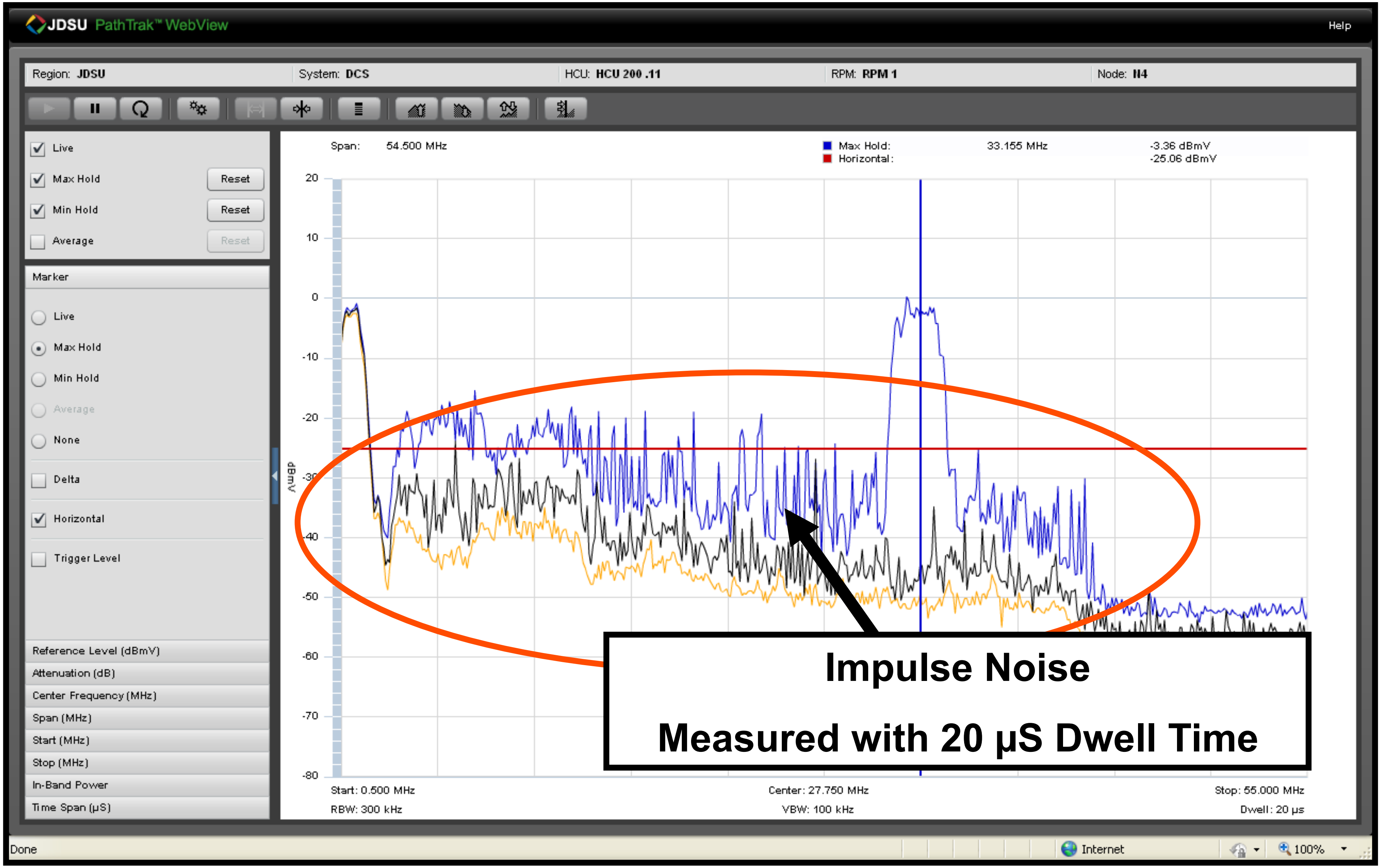
- <100 microseconds
- Most impulse noise is less than 10 microseconds in duration

Common sources include cracked ceramic insulators (a.k.a. lightning arresters) on power lines, electric motors, electronic switches, neon signs, static from lightning, and household appliances.

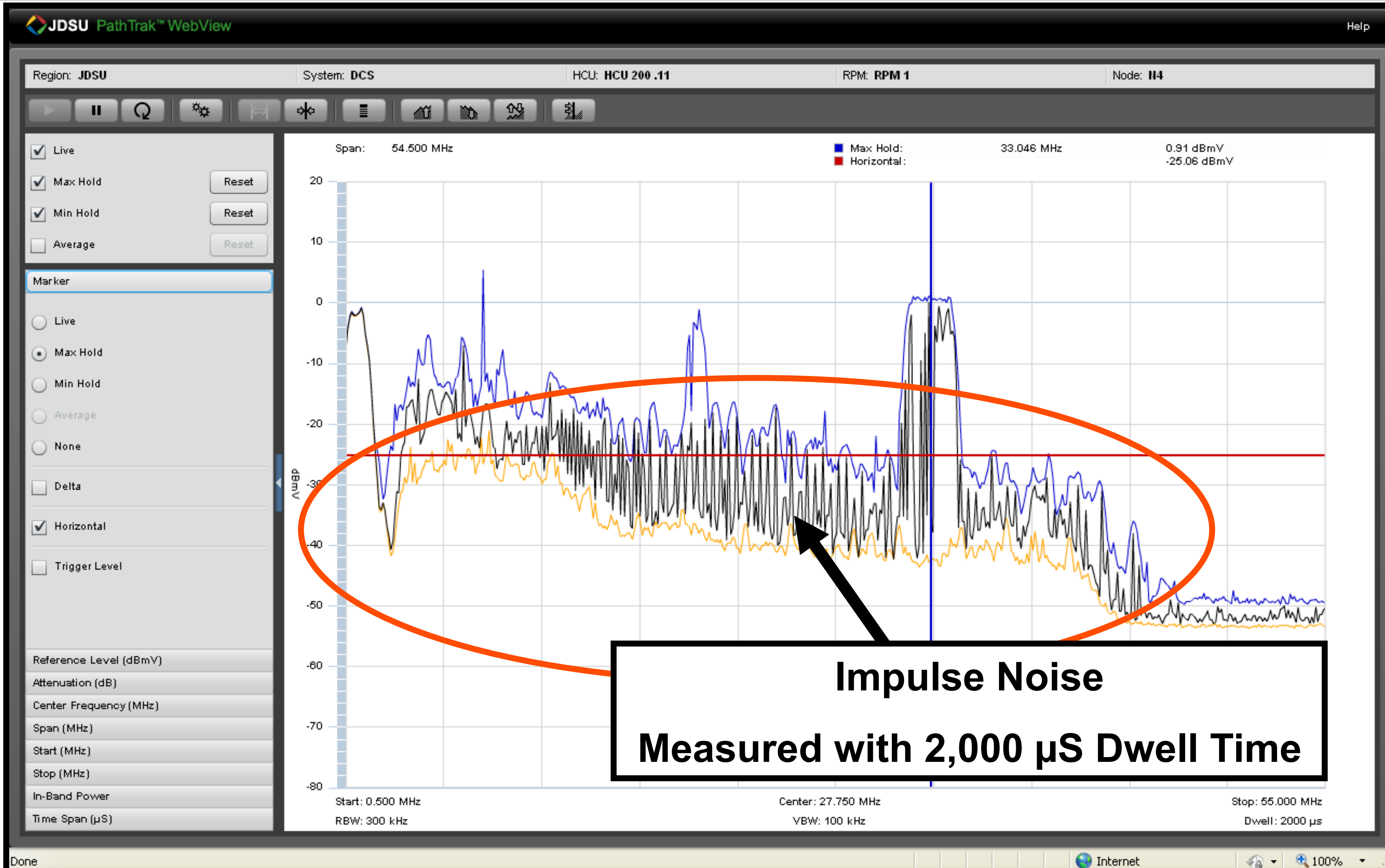
Wideband Impulse Noise = Code Word Errors!



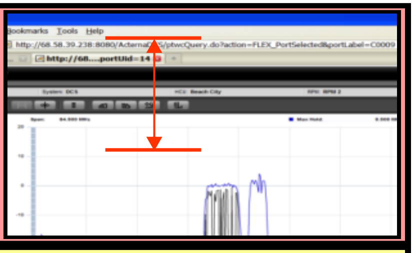
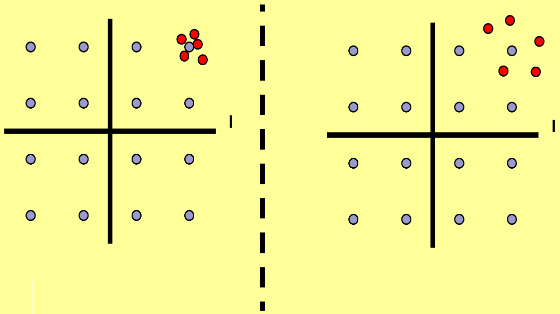
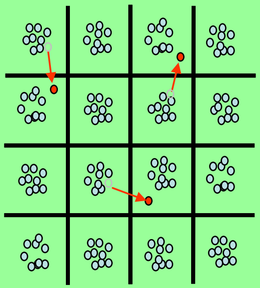
What is Dwell Time and When do I use it?



What is Dwell Time and When do I use it?

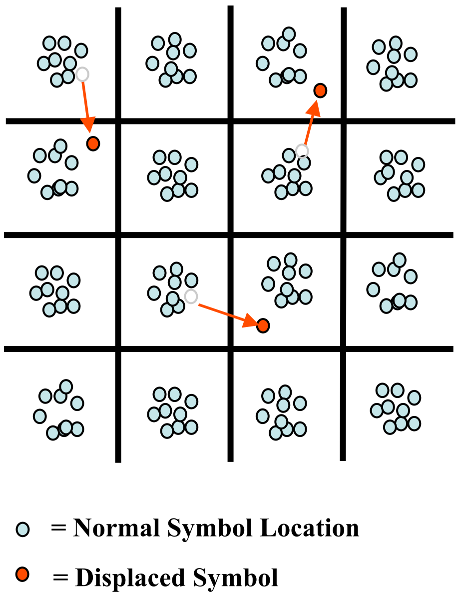


HFC Performance/Health Metrics

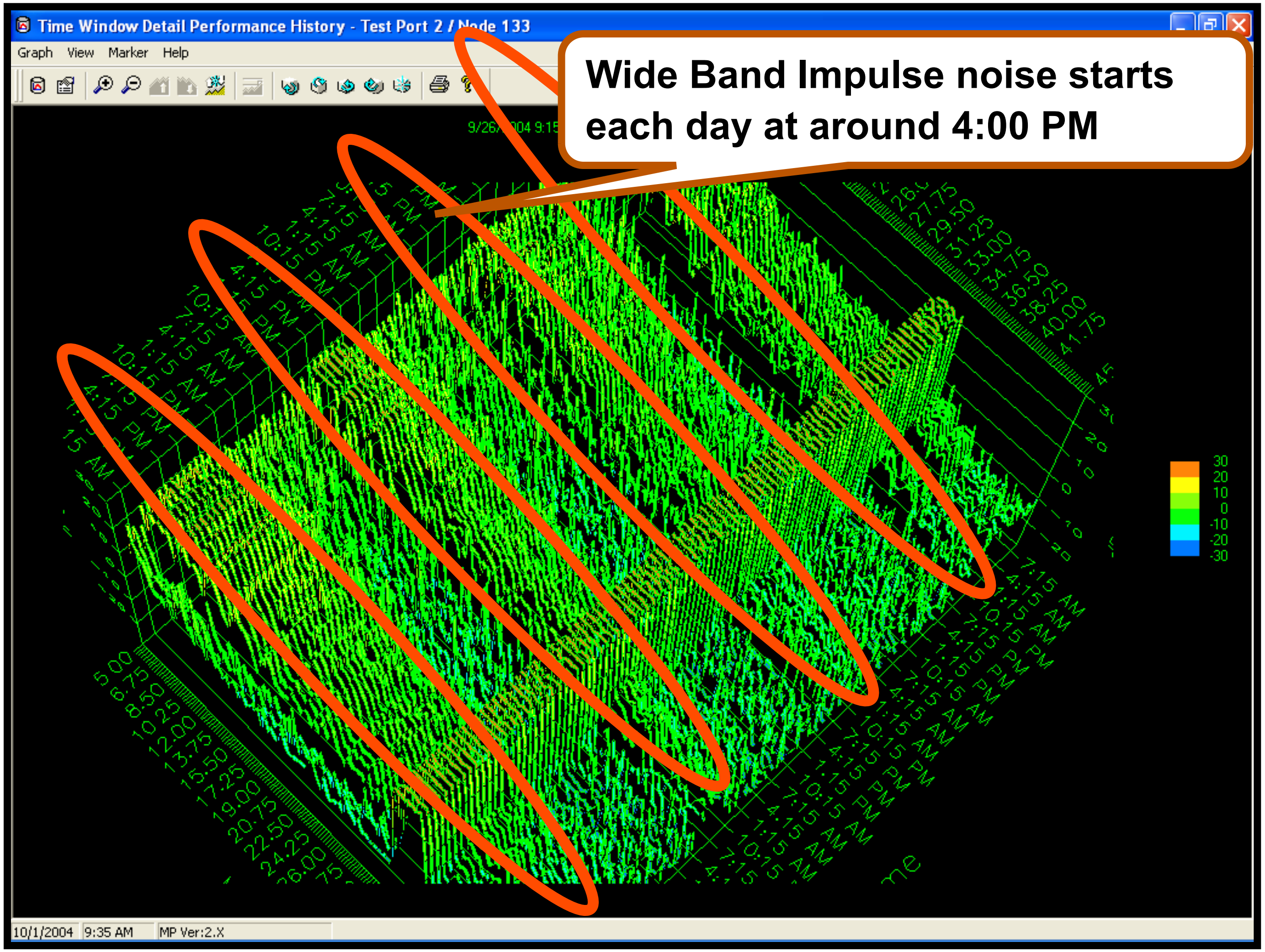
***Spectrum* Health**	**Carrier-to-interference** – An RF measurement of the ratio of desired carrier amplitude to undesired interference amplitude. Interference may be noise, ingress, nonlinear distortions. 
***Signal* Health**	**MER** (“SNR”) – The ratio of average symbol power to average error power. In effect, a measure of the “fuzziness” of a constellation’s symbol landings distortions. – Unequalized MER is the MER *before* an adaptive equalizer compensates for channel response impairments – Equalized MER is the MER *after* an adaptive equalizer compensates for channel response impairments 
***Data* Health**	**CWE** (Corr and Uncorr) – Pass/Fail indication of whether each codeword in each packet contains data errors **BER** (Pre- and Post-FEC) – The ratio of errored bits to the total number of bits transmitted, received, or processed 

What Are CWEs and Why Are They So Important?

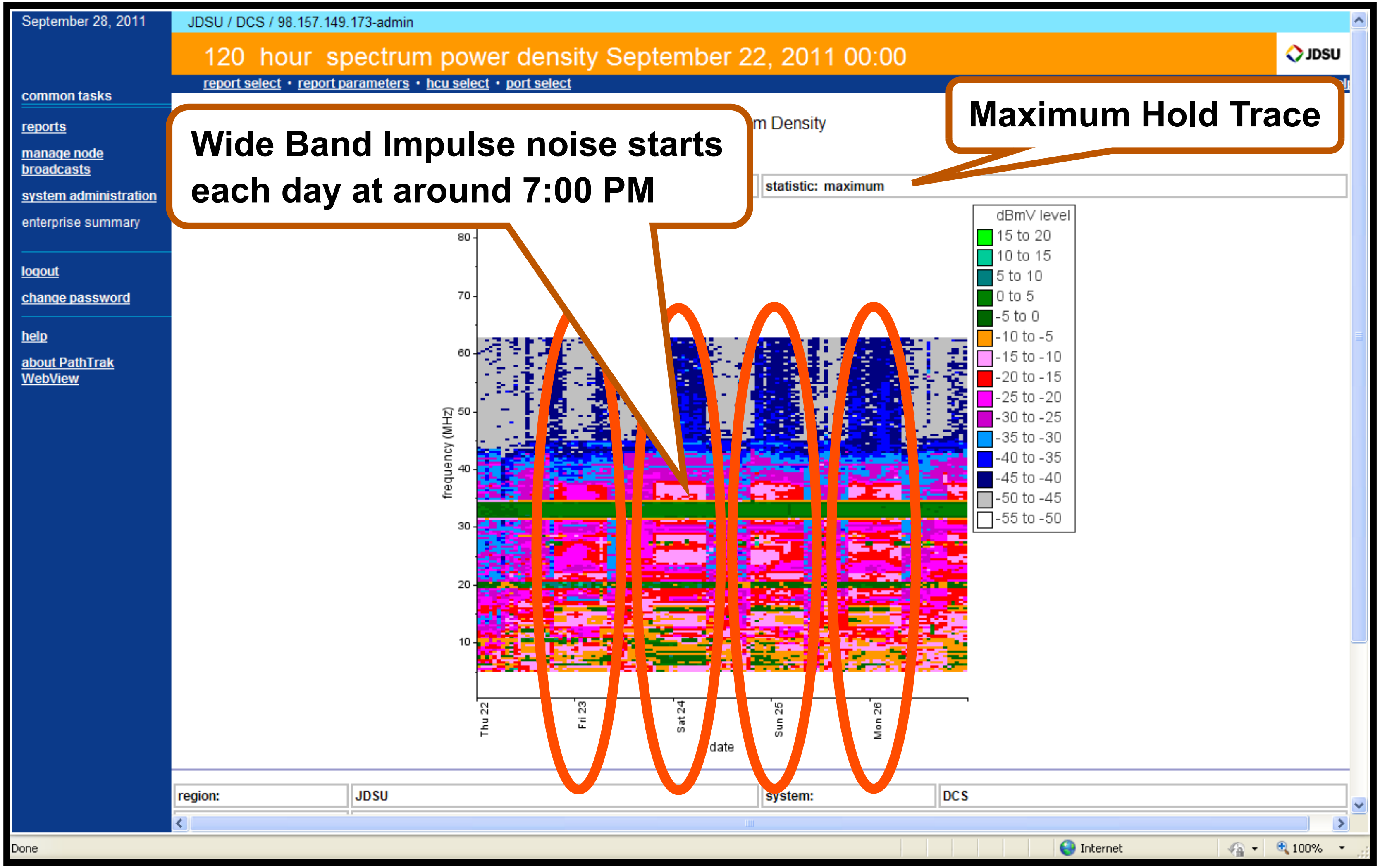
- **What is a Codeword?**
  - A **C**odeword is a data bucket within a DOCSIS packet
    - Typical 64-QAM data packet has 5-8 codewords
    - Typical 64-QAM CW contains 100-255 bytes
- **What Is a Codeword Error?**
  - A byte-level data packet corruption resulting from displacement of individual QAM symbols across constellation decision boundaries
  - Correctable vs. Uncorrectable determined by number of corrupted symbols relative to CMTS forward error correction level settings
- **Why are they so important?**
  - **Codeword errors capture the impact of all HFC impairments on customer packets!**
    - **If you are having CWEs, you may be losing data**
    - **Uncorrectable CWEs indicate dropped packets (think post-FEC in DS)**
      - **Retransmit is required for recovery with HDS users**
      - **There is no recovery from dropped packets for real-time apps like VoIP!**
    - **Correctable CWEs are an early warning that the uncorrectable threshold may be near! (think pre-FEC BER in DS)**



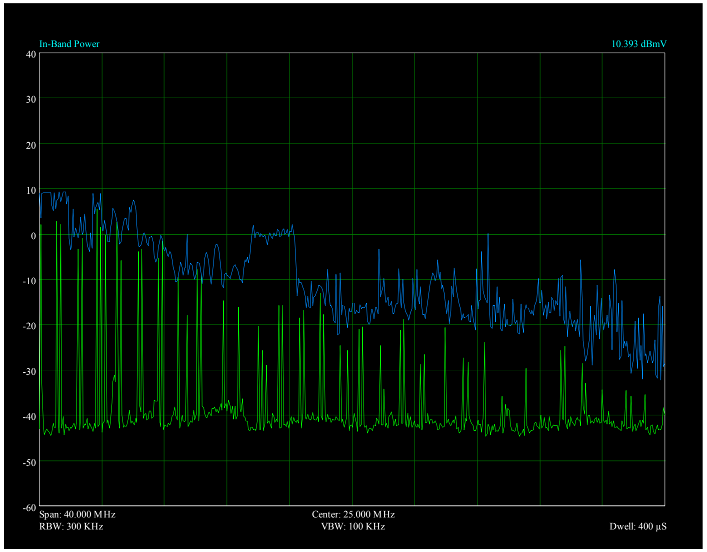
Performance History Maximum Graph – 96 Hrs

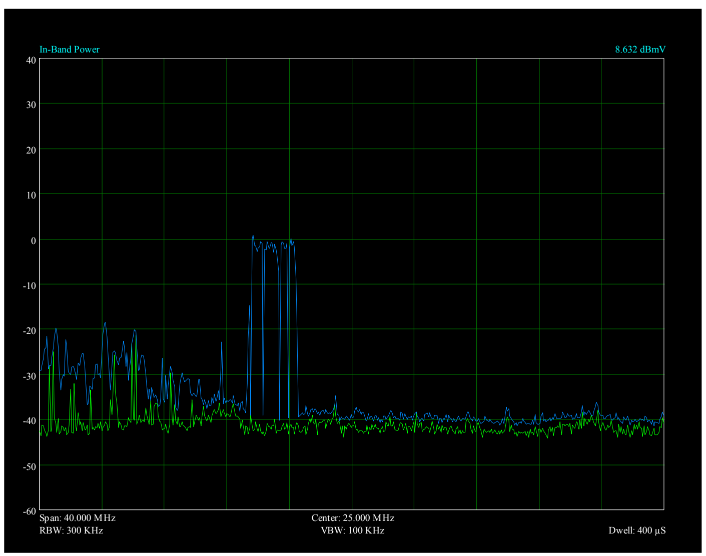


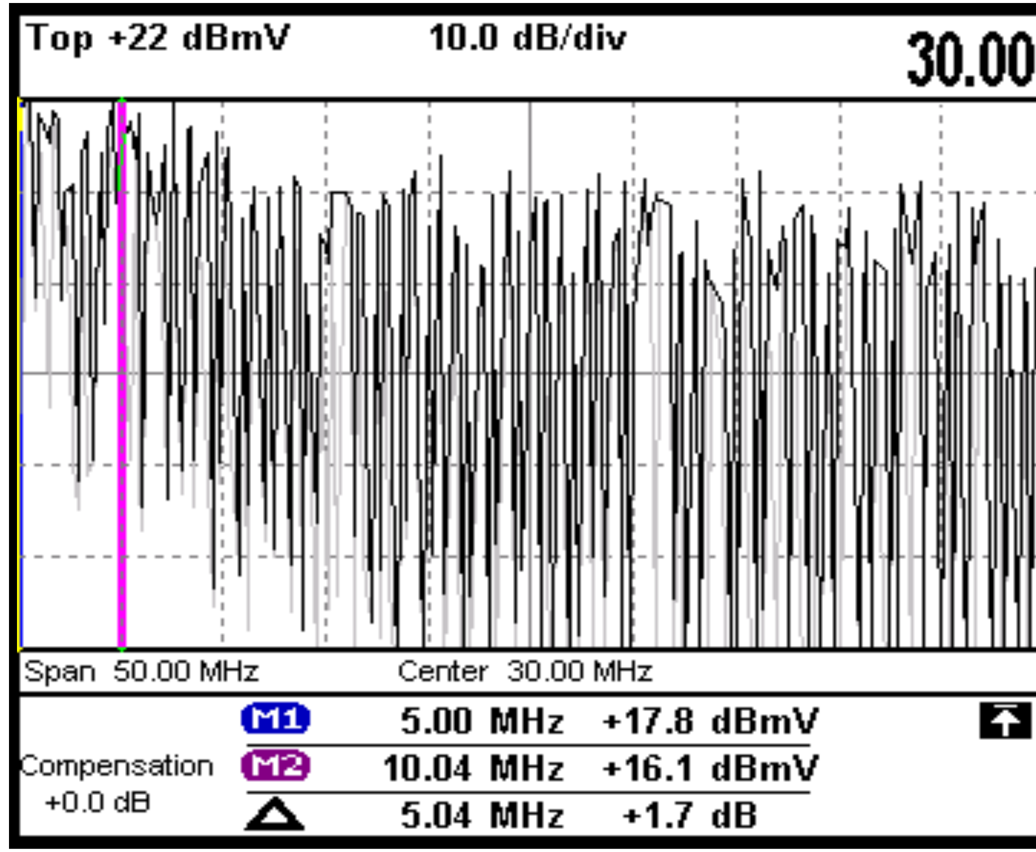
Spectrum Power Density Chart – 120 Hrs



Electrical Impulse Noise from One House

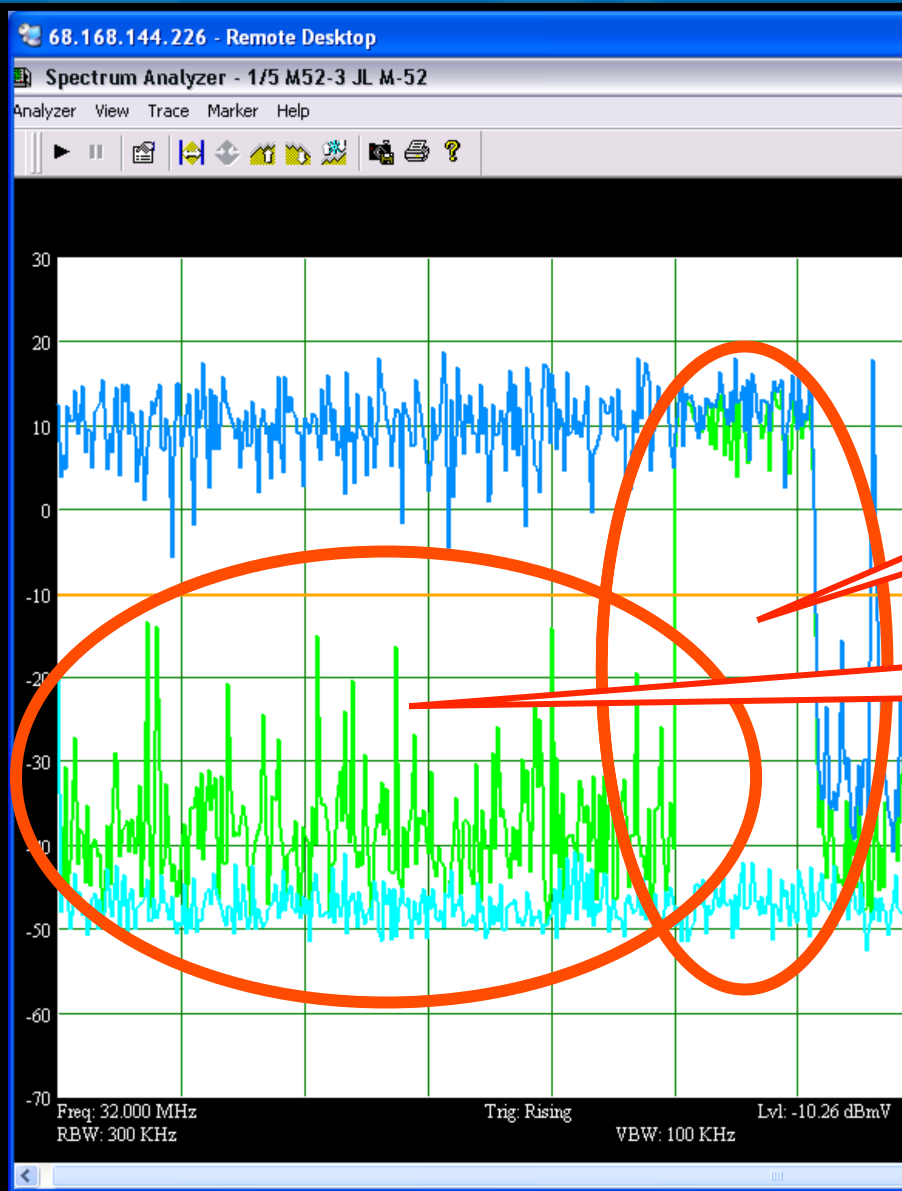






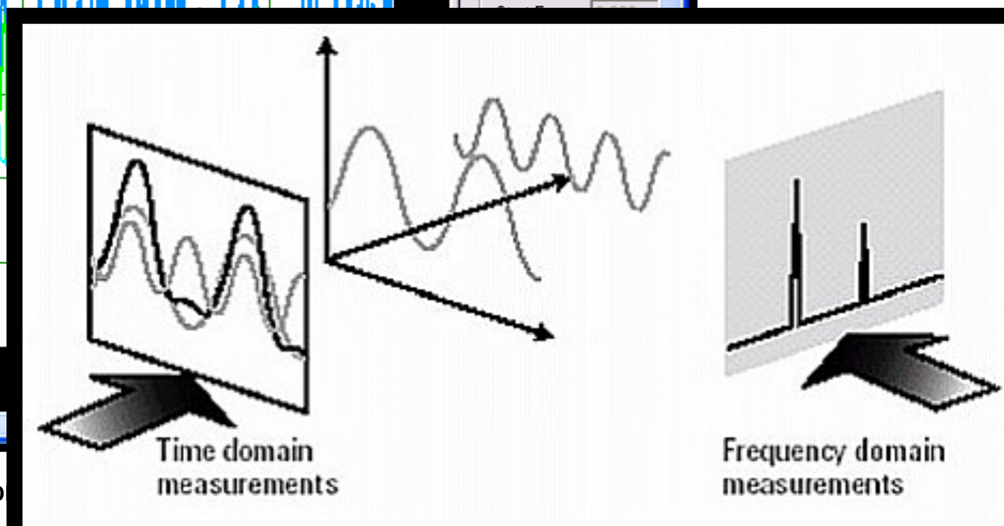
Reverse Spectrum shot at customer's drop

View Impulse Noise in Zero Span (Time Domain)



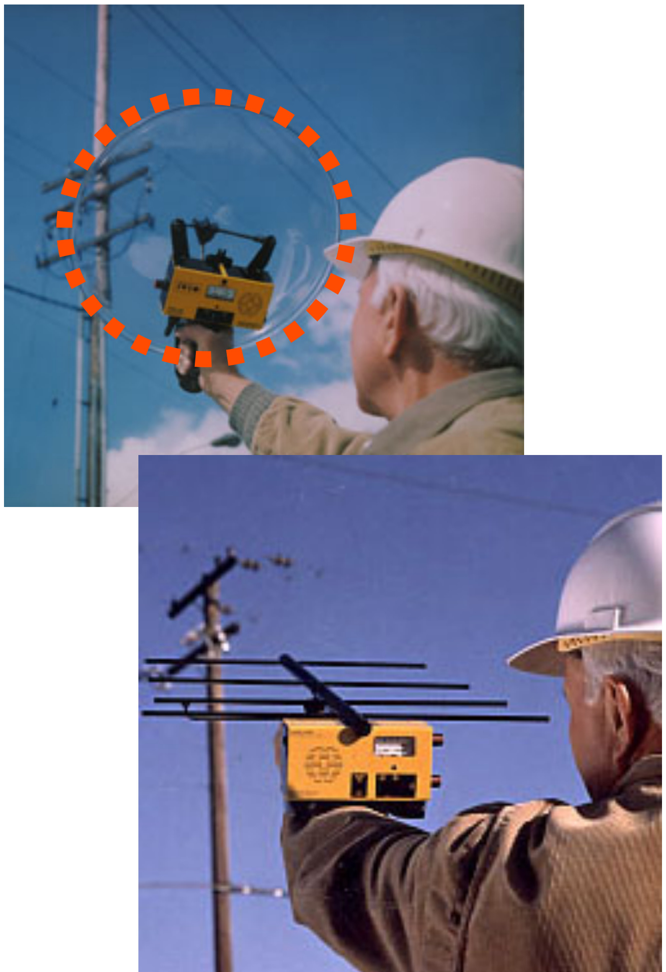
Packet of data transmitted by a DOCSIS® cable modem

Impulse noise under the DOCSIS® cable modem



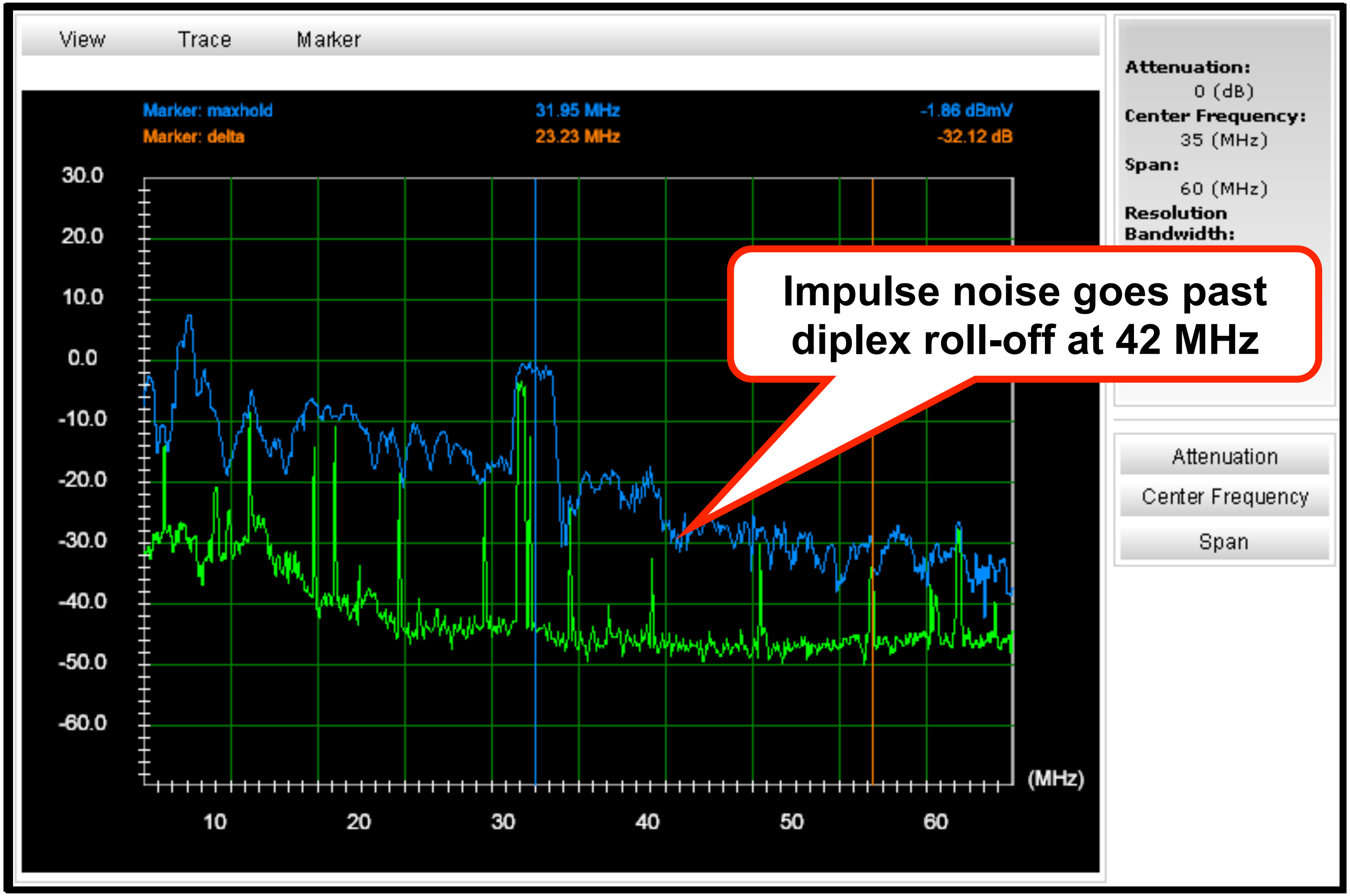
Impulse Noise Detectors

RFI locators detect sparks and corona that cause radio and T.V. interference (RFI TVI).

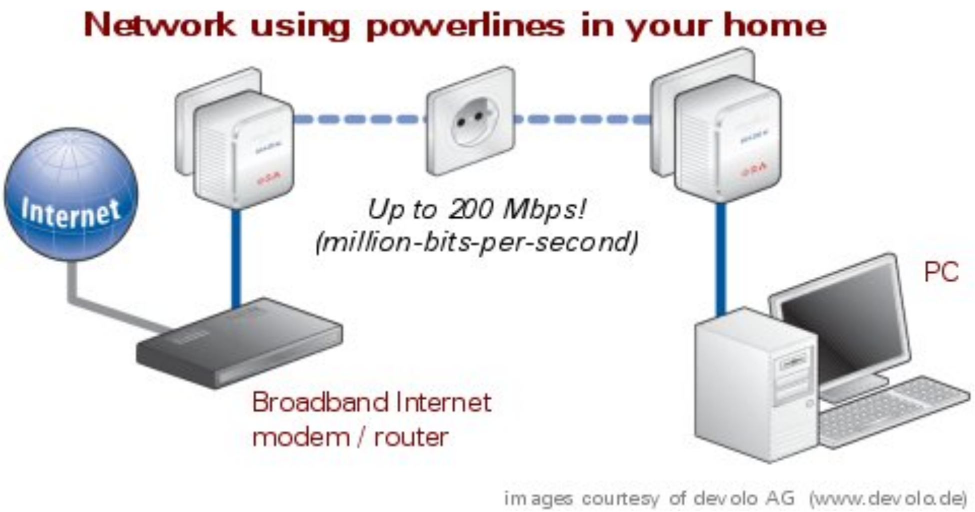


Detects indoor sparking and electronic sources

Wide Band Impulse Noise and Laser Clipping

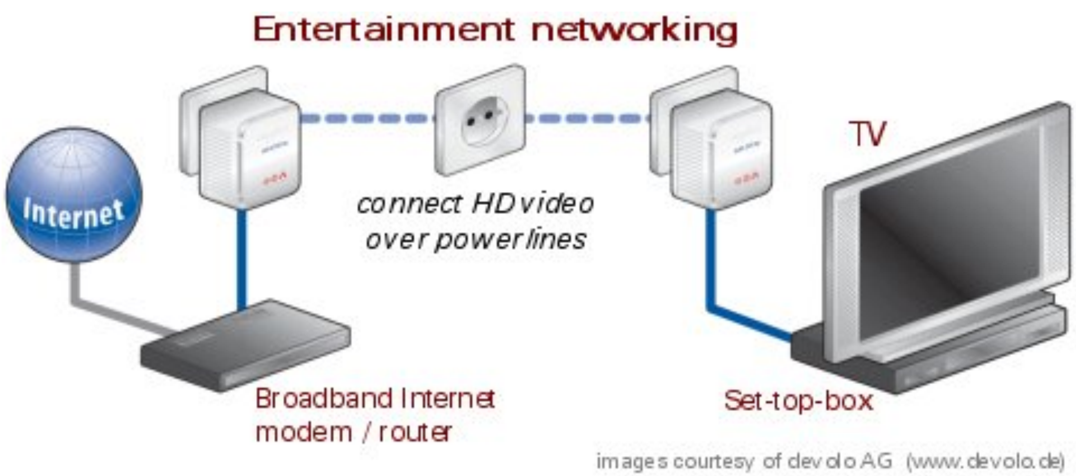


HomePlug 1.0 and HomePlug AV

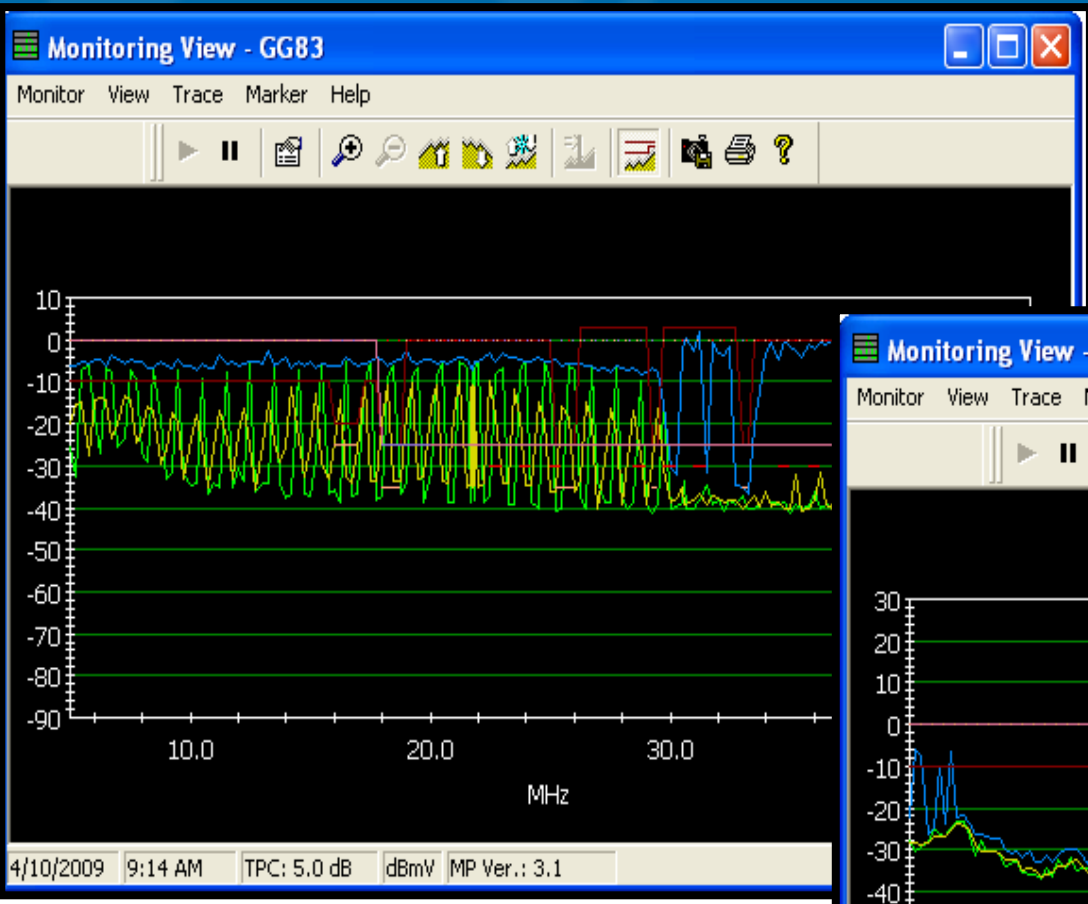


"Products based on the HomePlug 1.0 and HomePlug AV specifications can bridge an existing networking technology (such as a wireless or Ethernet network) and your home's power lines. "

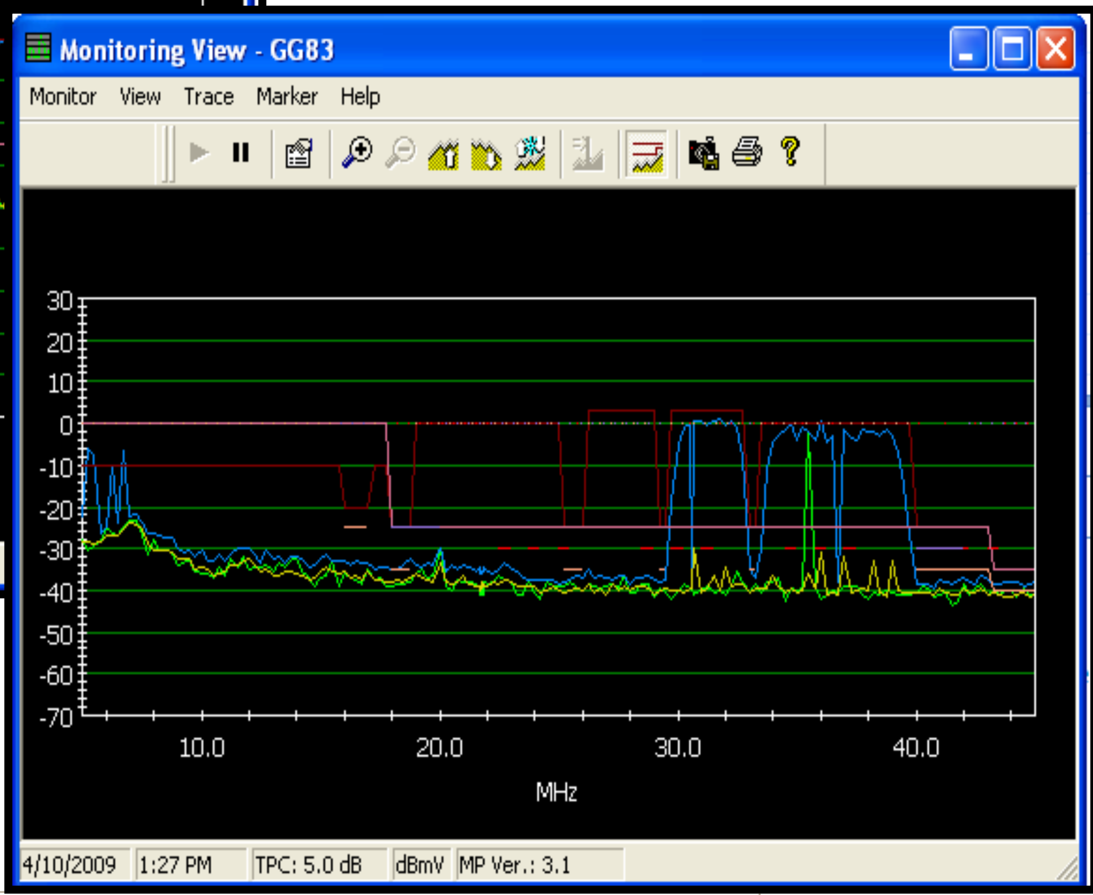
Network your TV with HomePlug AV



HomePlug Interference



HomePlug uses 917 OFDM sub-carriers. OFDM modulation allows co-existence of several distinct data carriers in the same wire.



"The number of whole-home DVR installations is expected to grow at a CAGR of over 100 percent from 2006 to 2008."
-- In-Stat

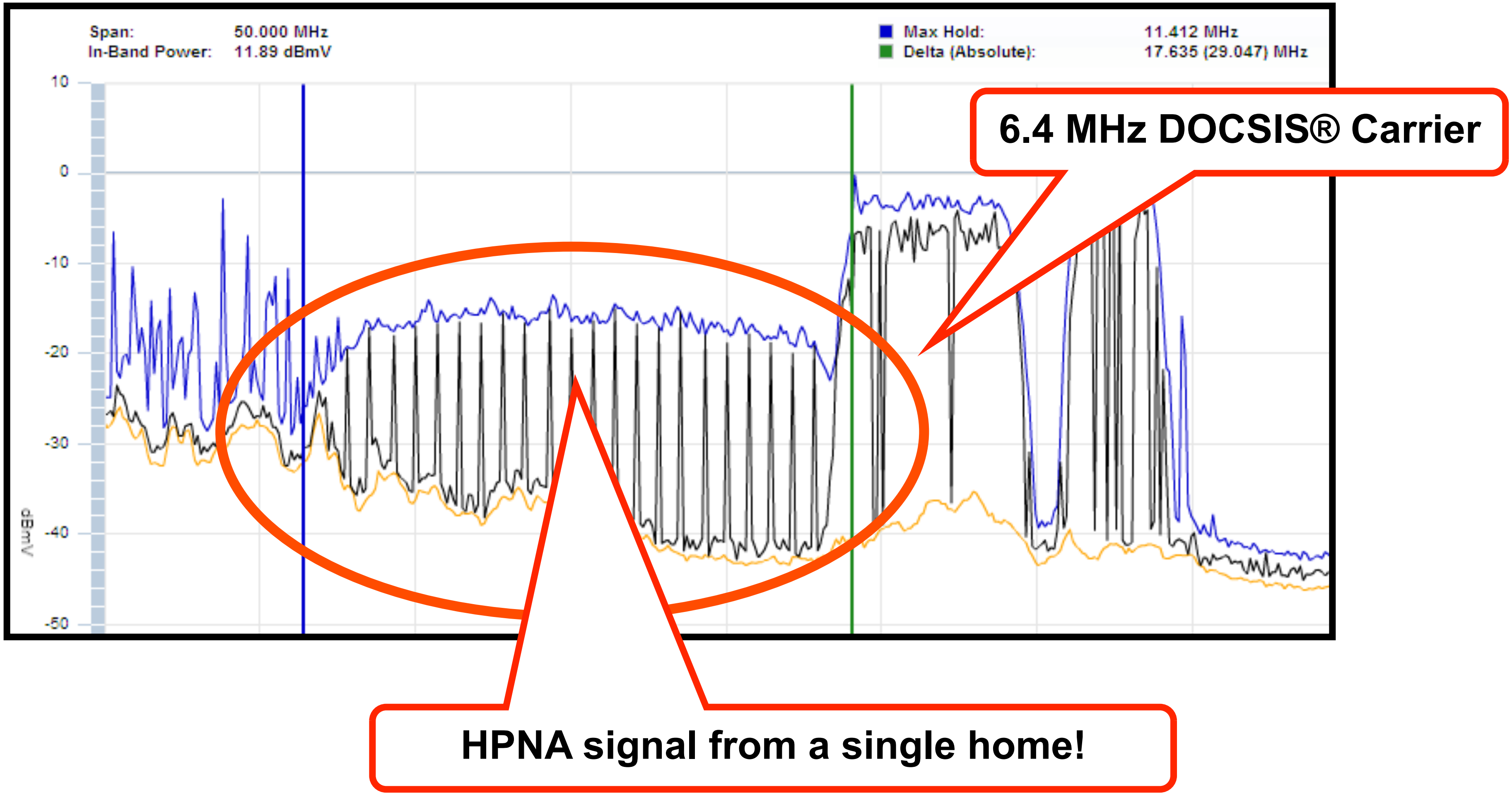
HomePNA™ - Home Networking

Ethernet to Coax
HPNA Adapter

Features

- Uses your existing coaxial wiring
- Perfect for transferring large multimedia files such as movies, music, and photos
- Uses existing coax cabling
- Supports speeds up to 144 Mpbs burst, 95 Mbps sustained
- Complies with the HPNA 3.1 over coax specification (ITU G.9954)
- Supports point-to-point and point-to-multipoint network configurations

Wideband HomePNA™ Ingress in the Return Path

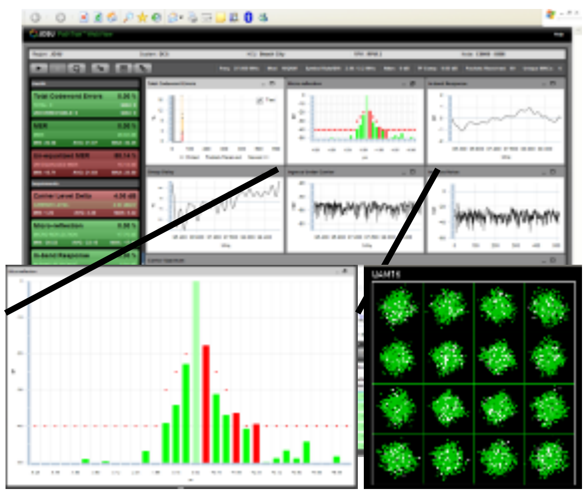


"The HomePNA™ Alliance develops triple-play home networking solutions for distributing entertainment data over both existing coax cable and phone lines. "

Common Linear Distortion Impairment Types

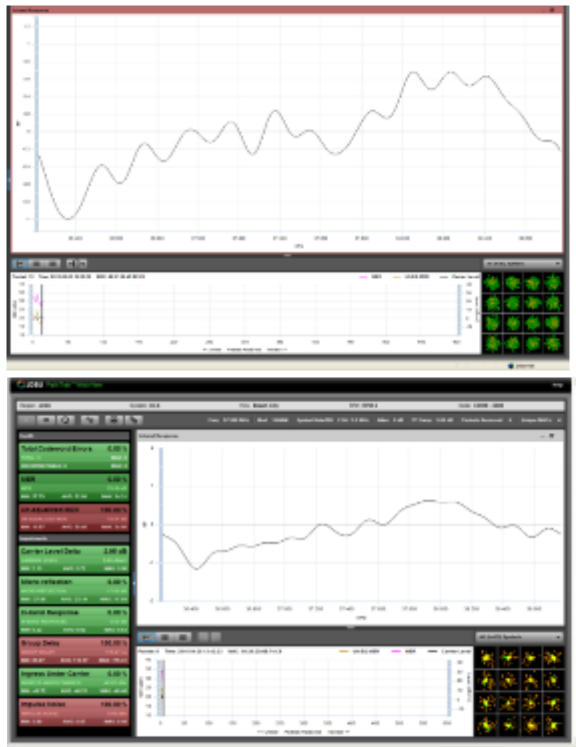
Micro-reflections

- Common Causes
  - Damaged/missing terminators
  - Loose seizure screws
  - Water-filled taps
  - Cheap/damaged splitters or CPE
  - Kinked/damaged cable
  - Install Issues



In-channel Freq. Response

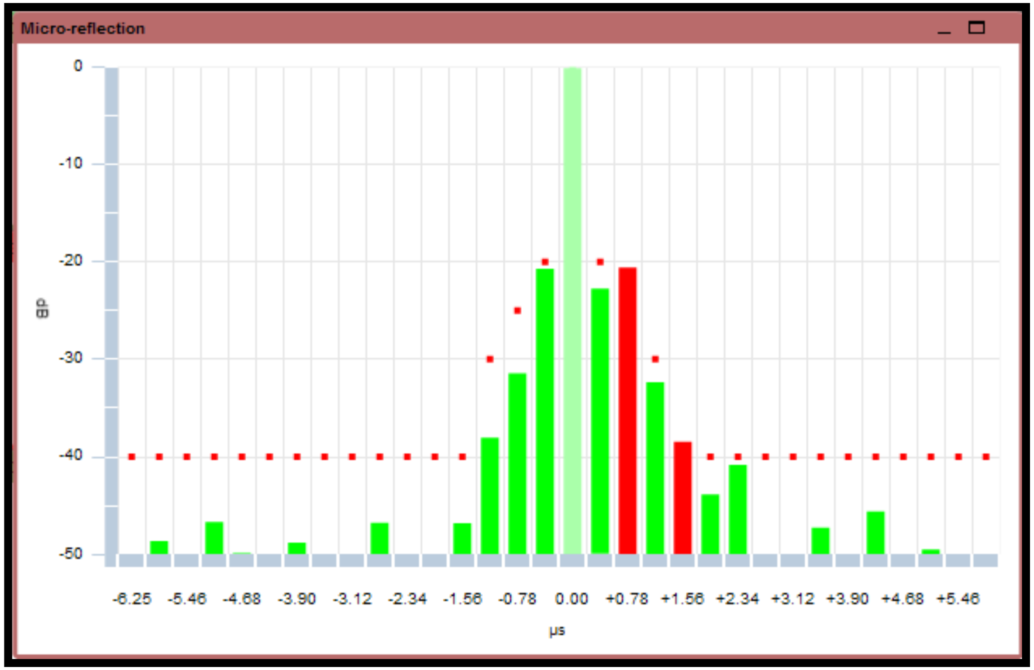
- Common Causes
  - Misalignment
  - Impedance mismatches



Group Delay

- Common Causes
  - Operation too close to diplex roll-off
  - Defective diplex filters
  - AC power coils/chokes
  - Notch Filters (high-pass, HSD-only, etc)
  - Micro-reflections

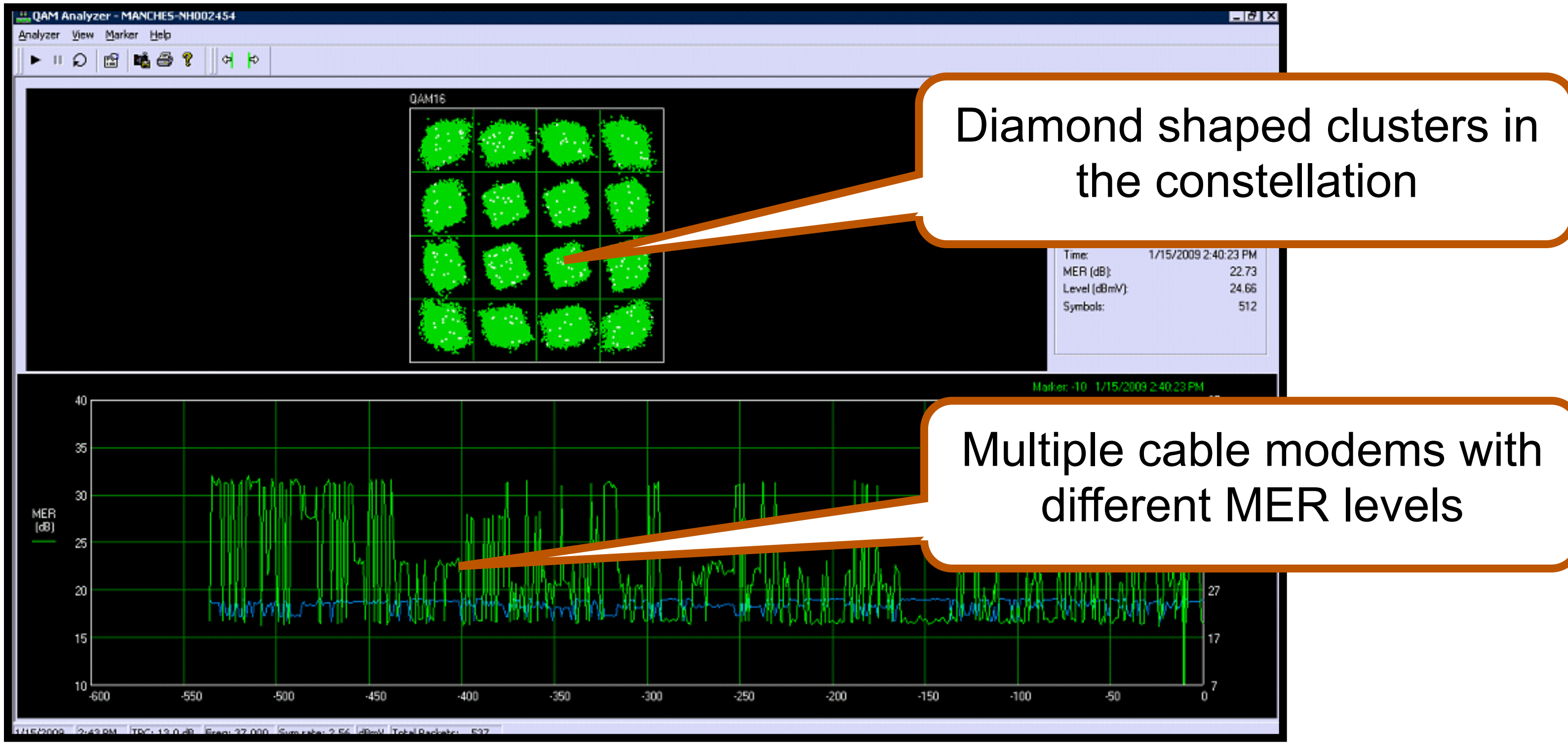
Linear Distortions – Micro-reflection



- Approximation of channel impulse response
- Red dots indicate Microreflection Threshold for each bar (DOCSIS Spec – Headroom)
- Any bar violating threshold is colored red
  - **Note:** Bar that violates threshold may not be the tallest bar (note stepdown of thresholds)
- Main Tap (time = zero) will always be the largest, will always be green
- Chart is generated from equalized data (vs unequalized data)

- X-Axis: Time bin in nS relative to main tap
- Y-Axis: Amplitude of signal relative to the carrier (dBc)
- Interpretation:
  - The farther the bar is to the right, the later the reflection arrived at the headend
  - The higher the level of a bar, the stronger the microreflection as received at the headend
- Common Causes:
  - Damaged/missing terminators, loose seizure screws, water-filled taps, cheap/damaged splitters or CPE, kinked/damaged cable, install Issues

QAM Analyzer View – Group Delay & Micro-reflections



Group Delay / Micro-reflections

If the accumulation takes on a diamond shape, the problem is likely a group delay issue

Constellation may take on a diamond or square shape

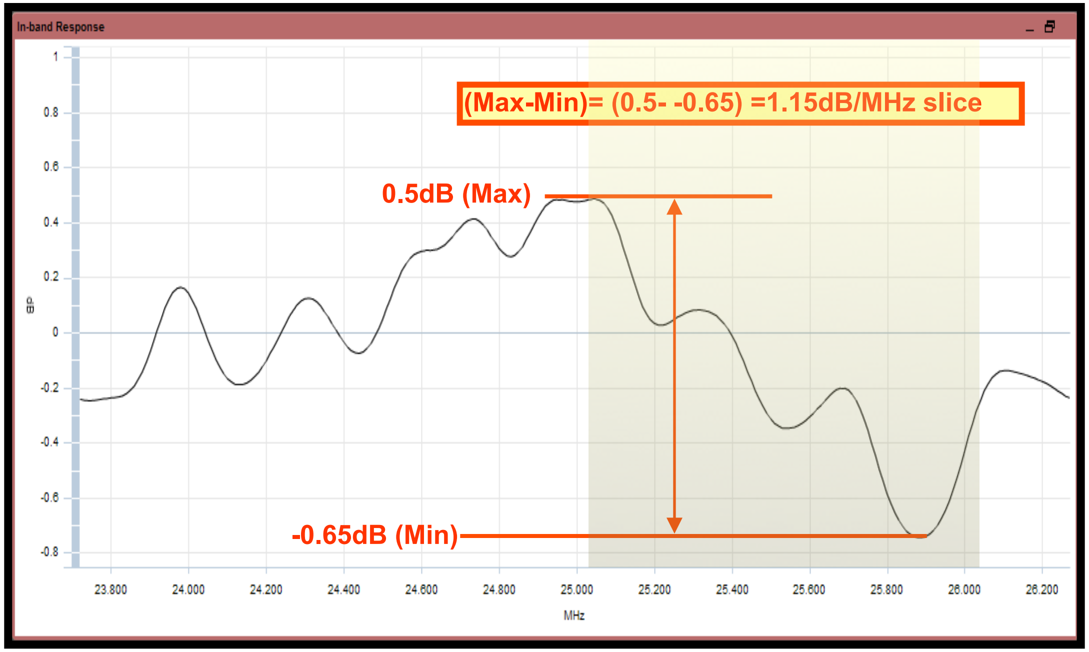
Clarity of diamond shape will vary with percentage of packets affected

Micro-reflections are a common cause of group delay

Often caused by un-terminated or improperly terminated lines or faulty CPE (cheap TV or VCR)

Group delay can also result from a carrier placed too close to the band edge of the diplex filter

Linear Distortions – In-Band Frequency Response

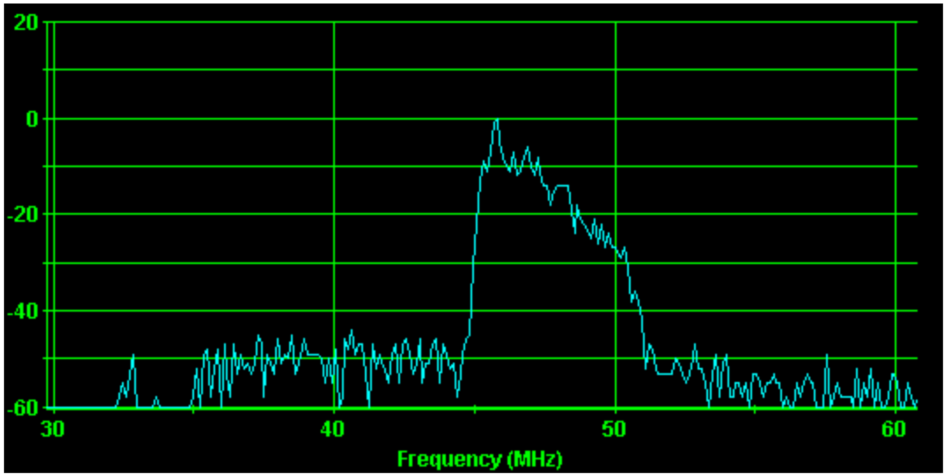


- Frequency response chart across a given carriers frequency
- Think of it like a sweep display for the discrete carrier frequency range
- Chart is generated from equalized data (vs unequalized data)
- Value reported by QAMTrak is the highest amplitude point minus the lowest amplitude point per 1MHz slice of the carrier frequency range

- X-Axis: Frequency (covers frequency range of the carrier)
- Y-Axis: Amplitude of signal at each frequency relative to the average carrier level
- Interpretation:
  - A carrier with an ideal frequency response will have a flat response chart
  - Modems with very similar in-band response footprints may be impacted by a common impairment
    - Same water-filled tap, etc

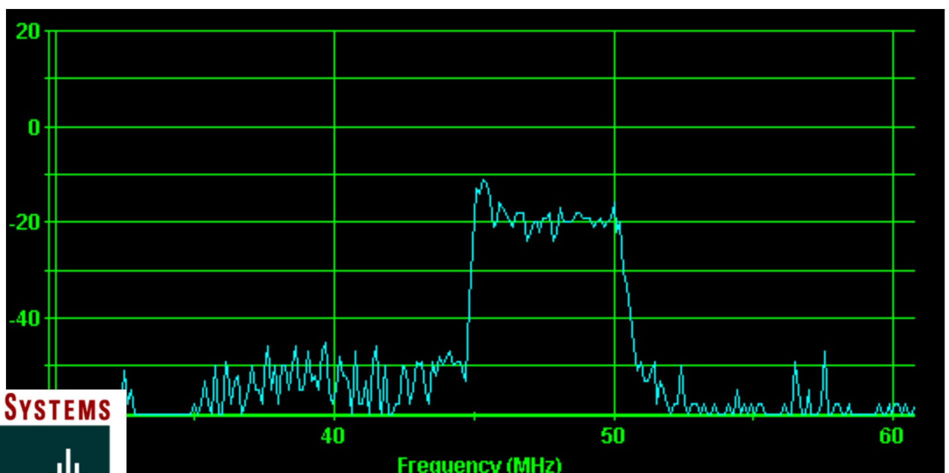
Upstream Adaptive Equalization Example

Upstream 6.4 MHz bandwidth 64-QAM signal



Before adaptive equalization:

Substantial in-channel tilt caused correctable FEC errors to increment at a rate of about 7000 errored codewords per second (232 bytes per codeword). The CMTS's reported upstream MER (SNR) was 23 dB.



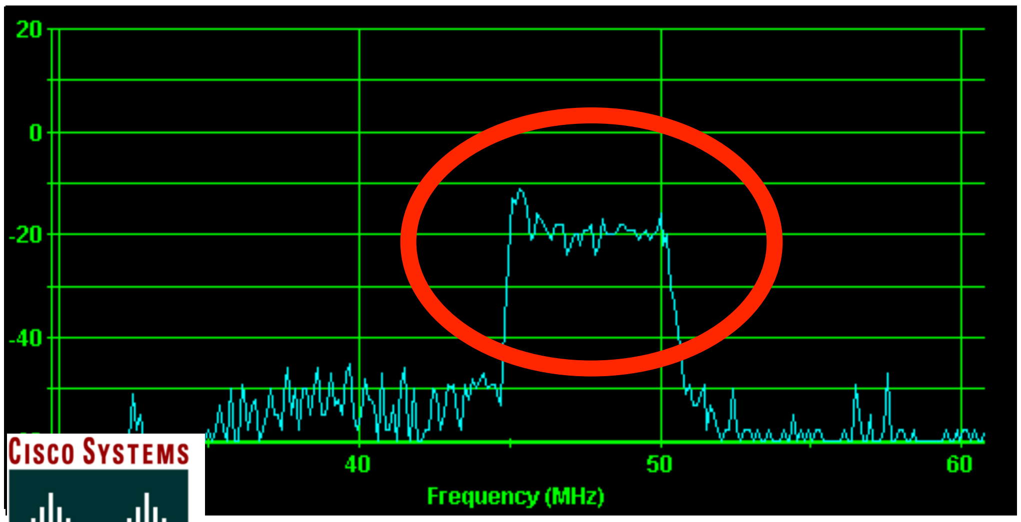
After adaptive equalization:

DOCSIS 2.0's 24-tap adaptive equalization—actually pre-equalization in the modem—was able to compensate for nearly all of the in-channel tilt (with no change in digital channel power). The result: No correctable or uncorrectable FEC errors and the CMTS's reported upstream MER (SNR) increased to ~36 dB.

CISCO SYSTEMS

John Downey

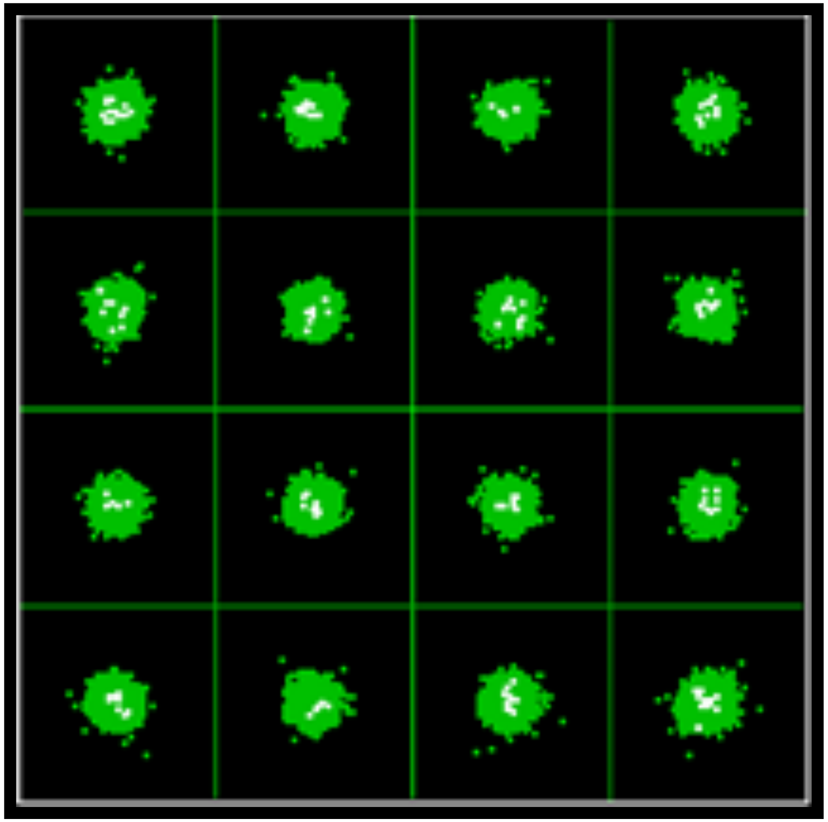
Upstream Adaptive Equalization Example

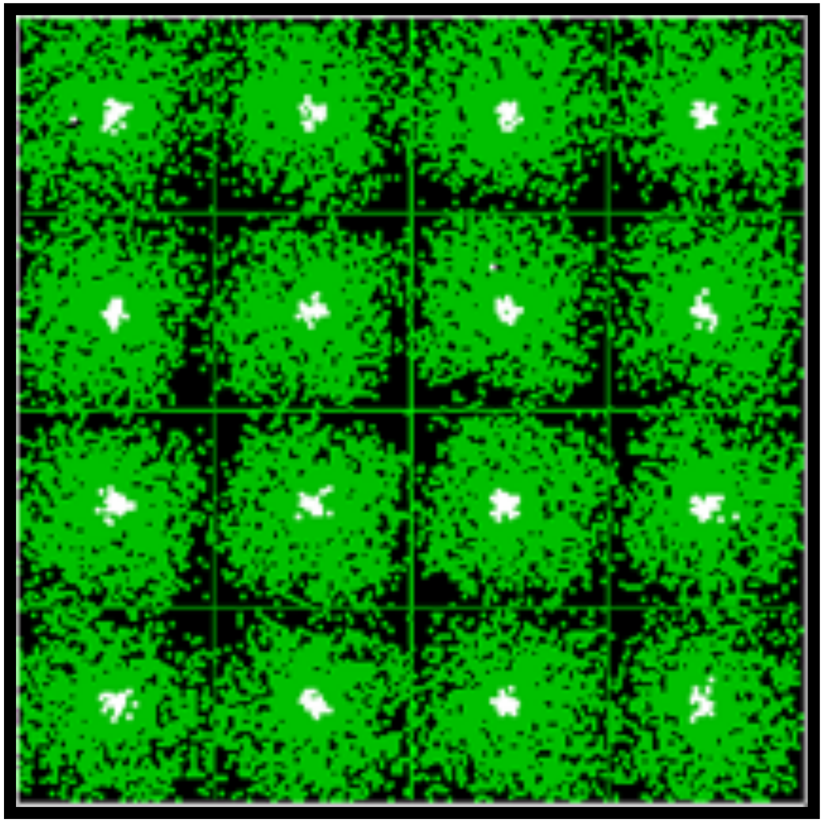


John Downey

- Frequency response of the modem's carrier can be adversely affected by various impedance mismatches and diplex filters.
- With Adaptive Equalization enabled on the CMTS and modems, the CMTS instructs the modems to pre-distort the carrier based on what they look at the input of the CMTS
- This makes the carrier's frequency response "flatter" at the input of the CMTS.

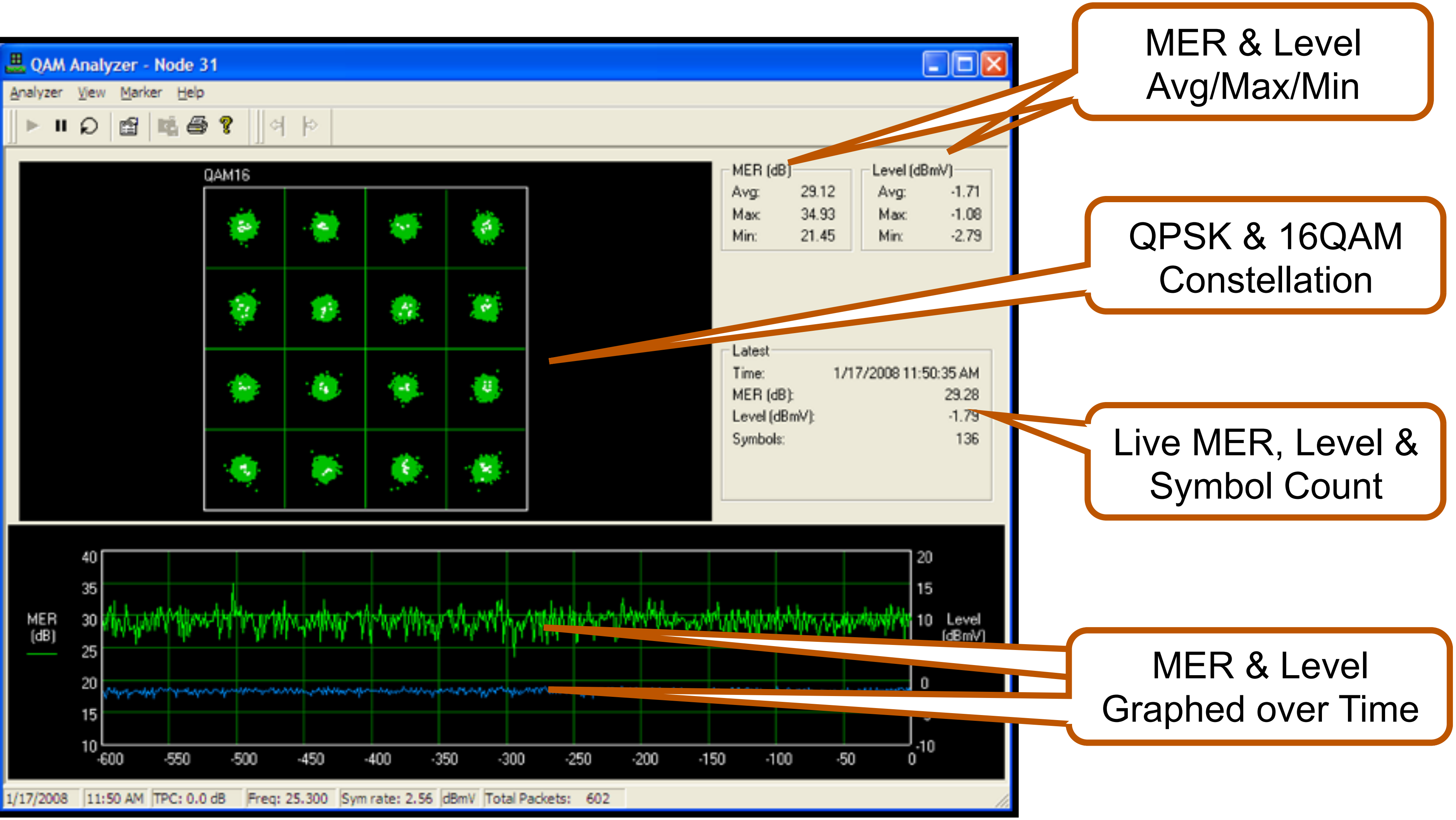
Basic QAM Constellation Analysis



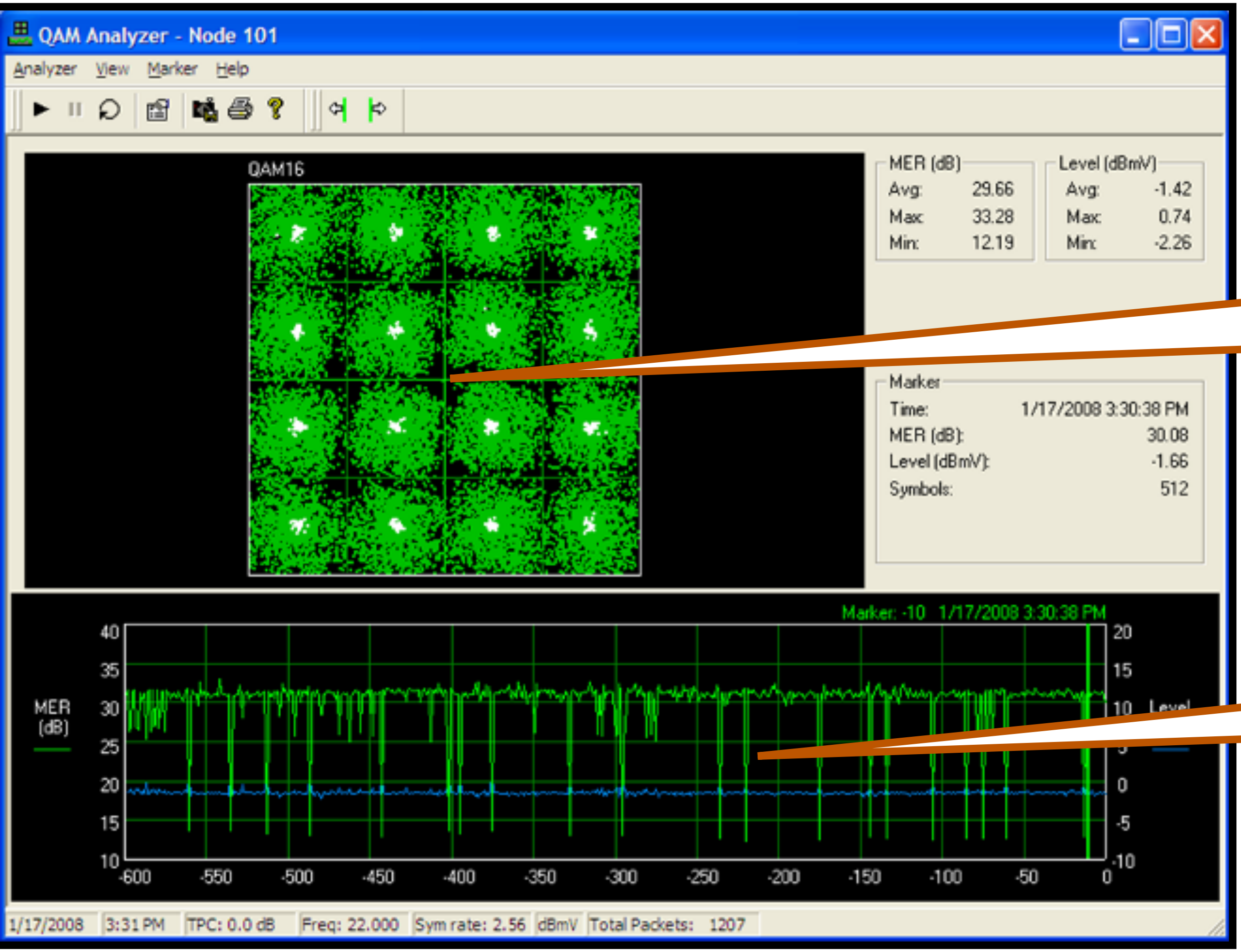


Good 16QAM Constellation **Bad 16QAM Constellation?**

PathTrak QAM Analyzer View – Good Node



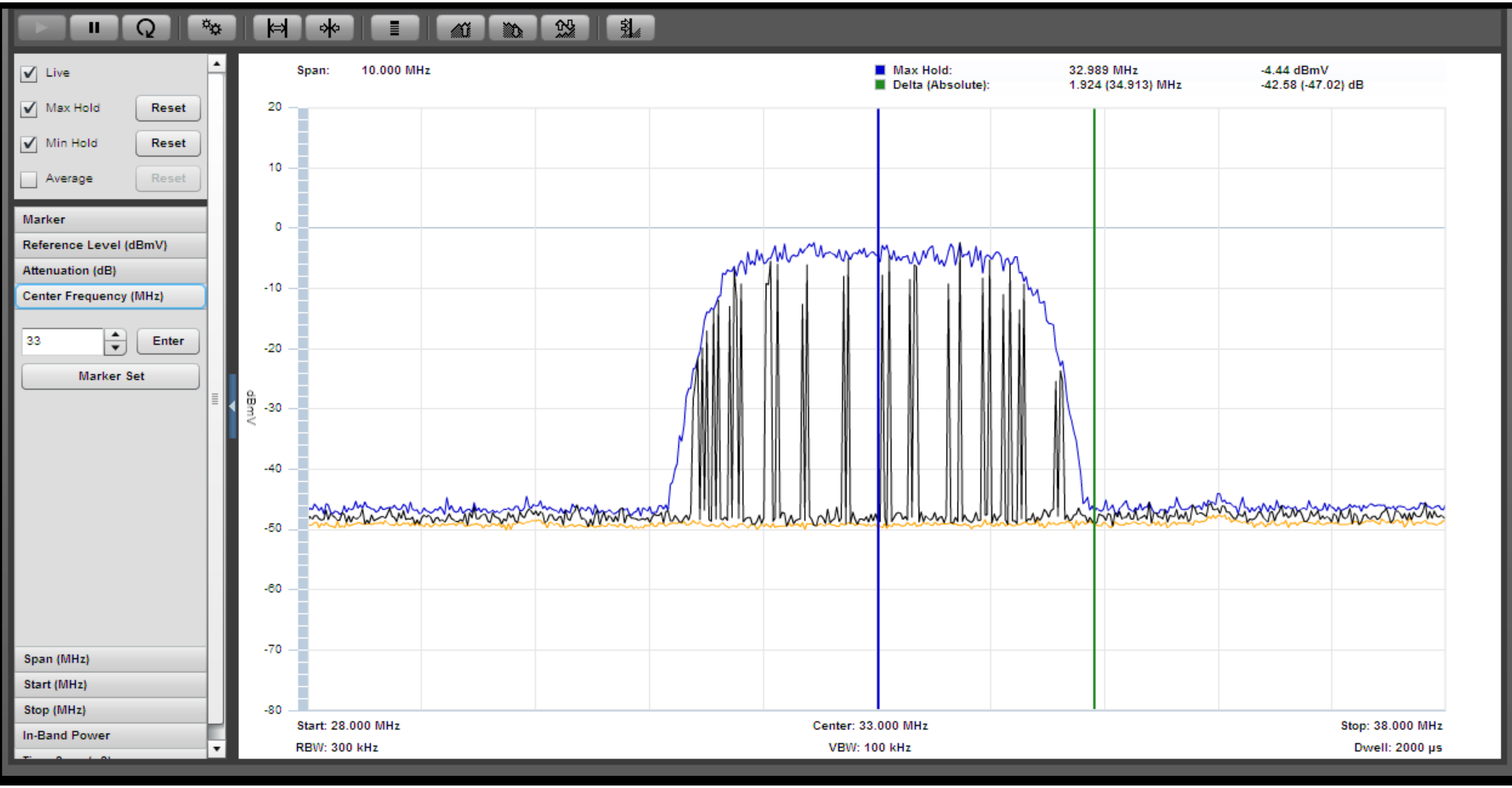
PathTrak QAM Analyzer View – Bad Node?



Interference easily visible in 16 QAM constellation

Individual modem with very low MER

Clean Return Spectrum (Below 45 MHz)



Bad In-Band Response from a Single Modem

Move this marker and all of the displays will show the corresponding measurements for each packet

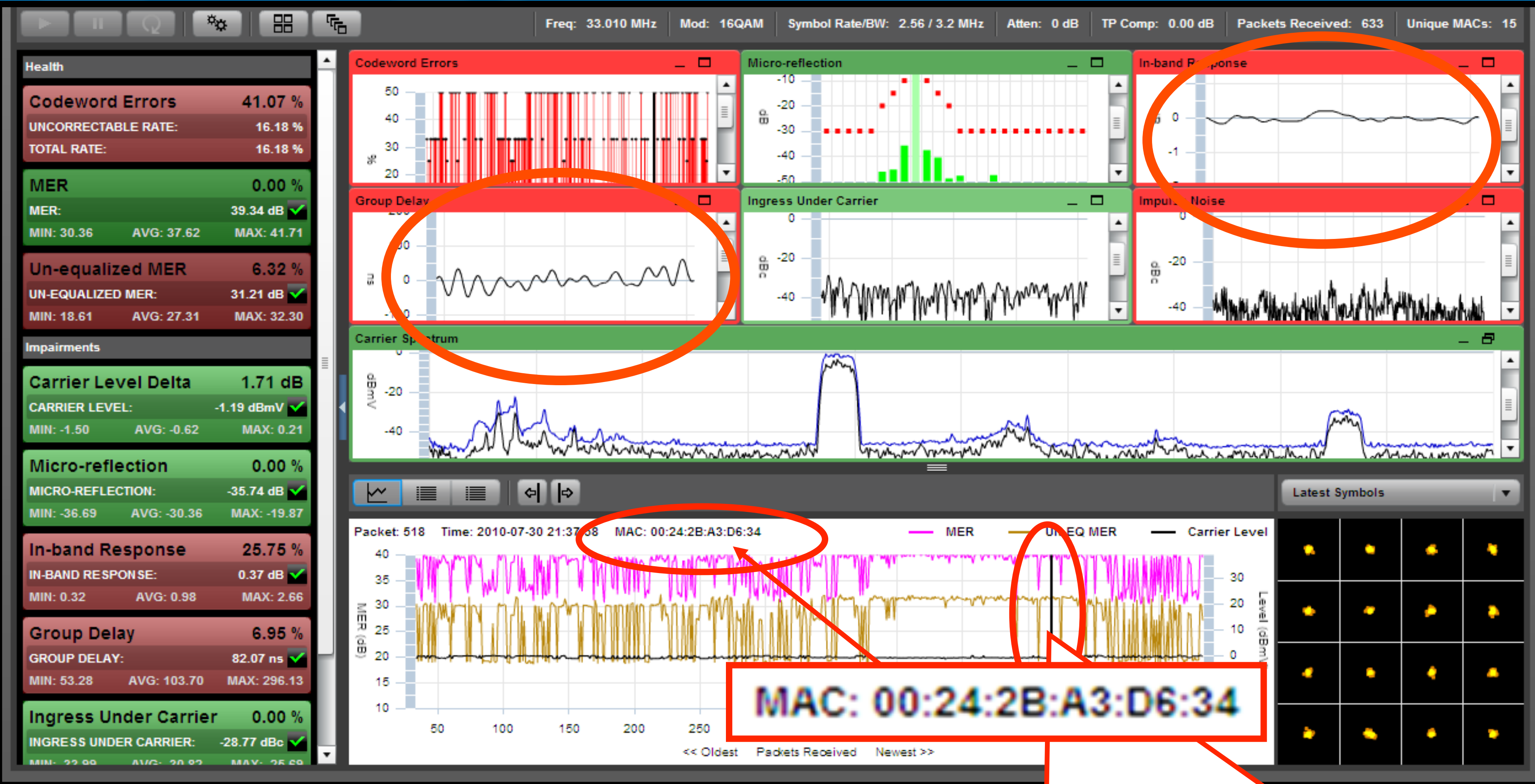
Good In-Band Response from a Single Modem

Move this marker and all of the displays will show the corresponding measurements for each packet

Bad In-Band Response from a Single Modem

Move this marker and all of the displays will show the corresponding measurements for each packet

Good In-Band Response from a Single Modem



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Bad In-Band Response from a Single Modem

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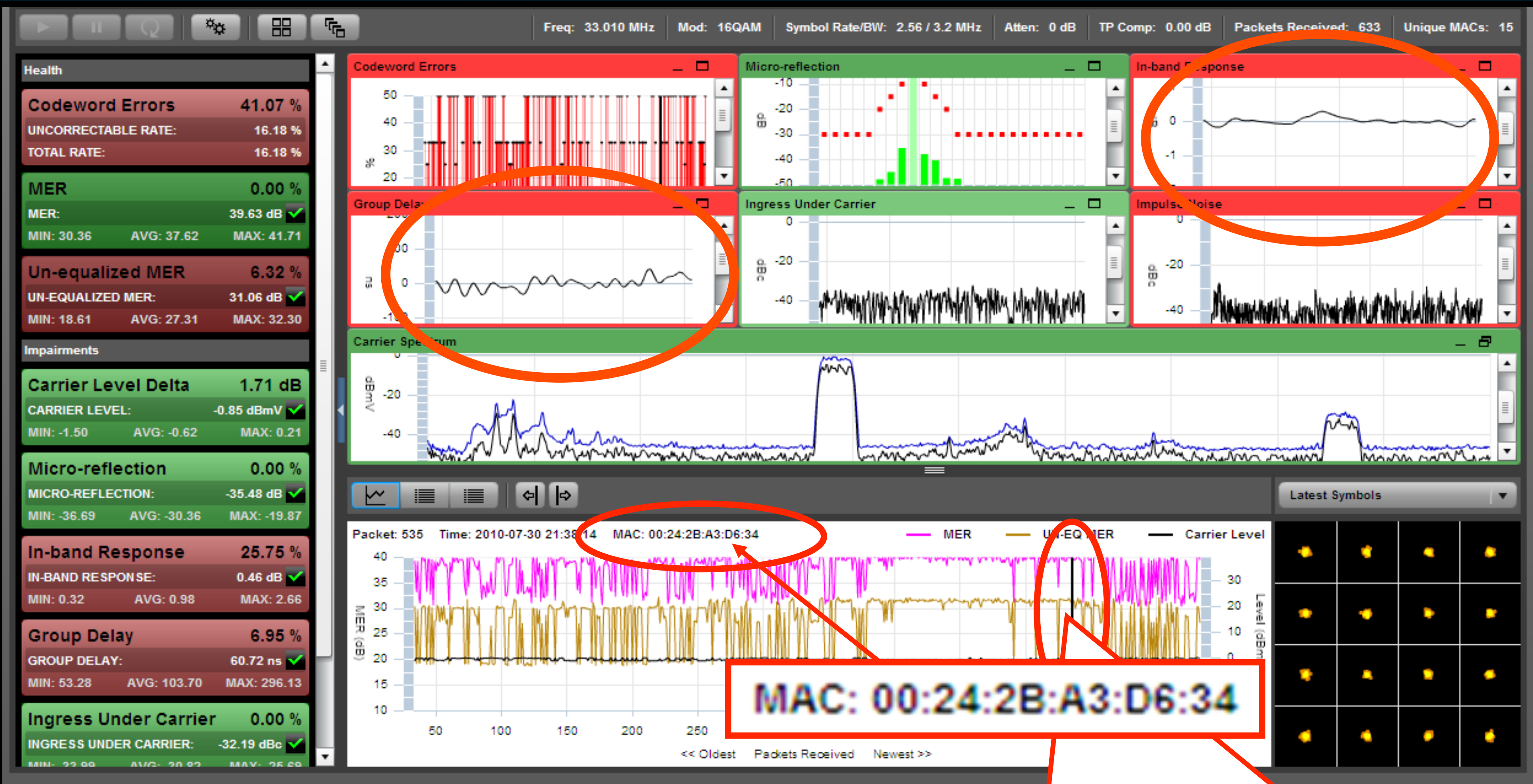
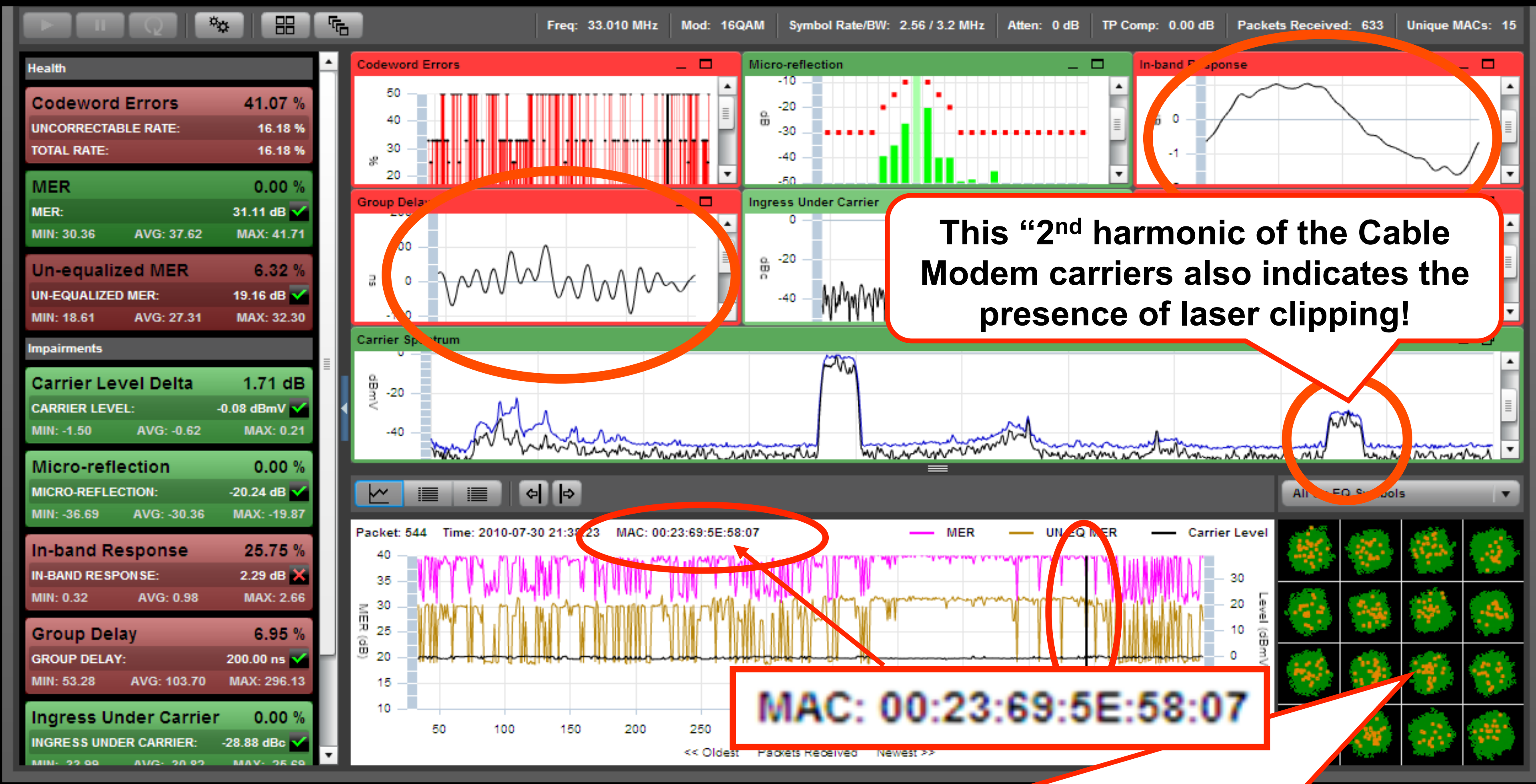
Good In-Band Response from a Single Modem



Move this marker and all of the displays will show the corresponding measurements for each packet

Bad In-Band Response from a Single Modem



This "2[nd] harmonic of the Cable Modem carriers also indicates the presence of laser clipping!

These "diamond shapes" in the constellation pattern indicates the presence of linear distortions such as micro-reflections and group delay.

Linear Distortions – Group Delay

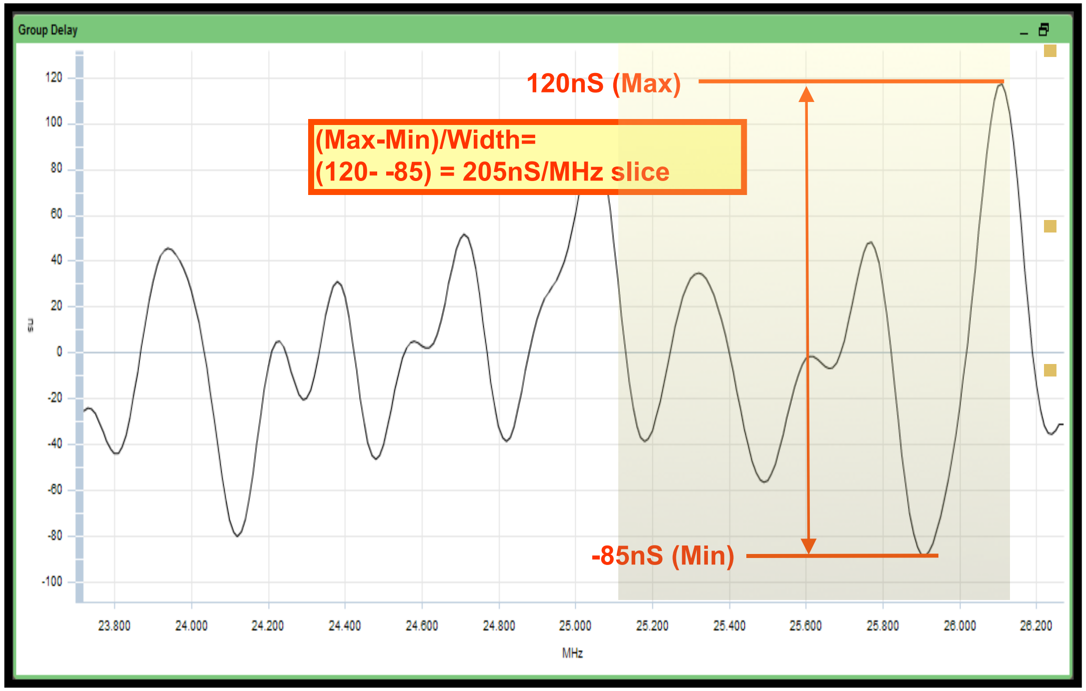


Chart displays the delay of the signal from the CM to RPM3000 over the frequency of the carrier

Chart is generated from equalized data (vs unequalized data)

Common Causes:

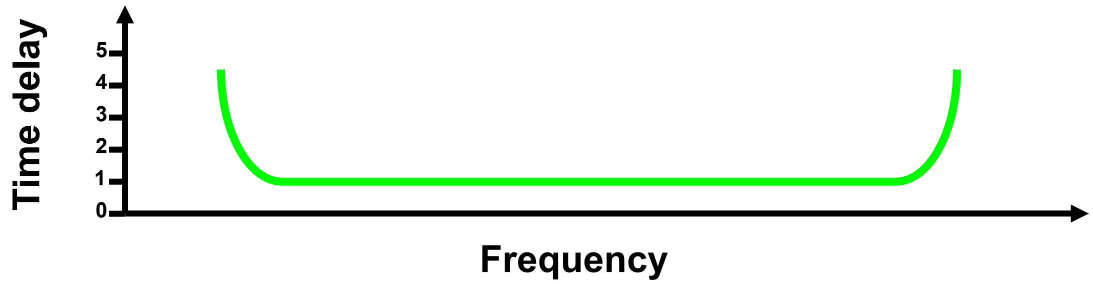
- Operation too close to diplex roll-off
- Defective diplex filters
- Notch Filters
- Microreflections

- X-Axis: Frequency (covers frequency range of the carrier)
- Y-Axis: Delay of the signal in nS at each frequency
- Interpretation:
  - Max peak to peak variation across the entire carrier frequency can exceed Threshold value and still not fail
    - Remember: Pass/Fail is based on peak to peak per 1MHz slice of spectrum

The Basics

Delay versus frequency

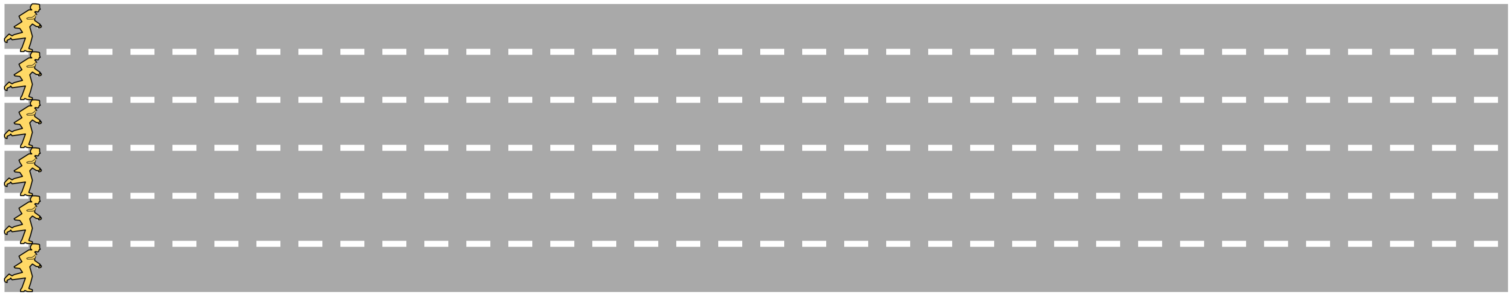
- If delay through a filter is plotted on a graph of frequency (x-axis) versus time delay (y-axis), the plot often has a parabola- or bathtub-like shape



Ron Hranac

Group Delay: An Analogy

Imagine a group of runners with identical athletic abilities on a smooth, flat track …

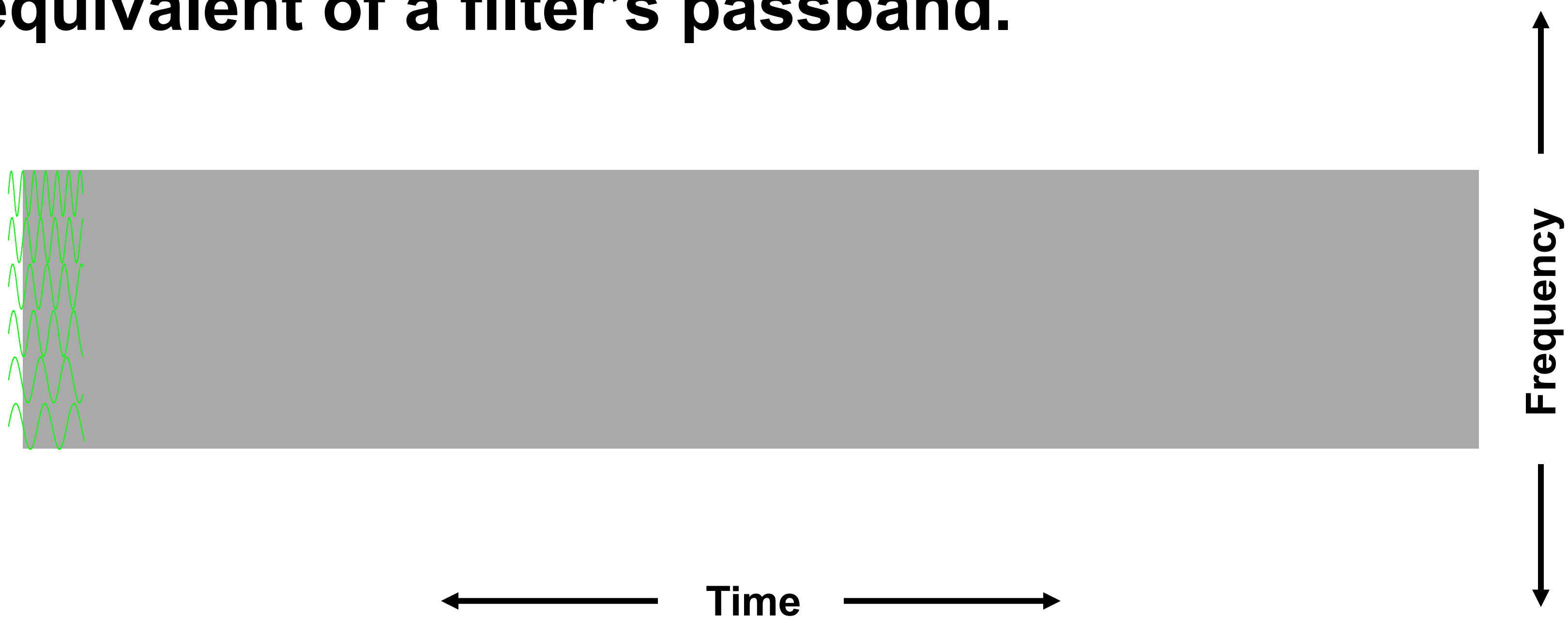


All of the athletes arrive at the finish line at exactly the same time and with equal time delay from one end of the track to the other!

Example courtesy of Holtzman, Inc.

Group Delay: An Analogy

Now let's substitute a group of RF signals for the athletes. Here, the "track" is the equivalent of a filter's passband.



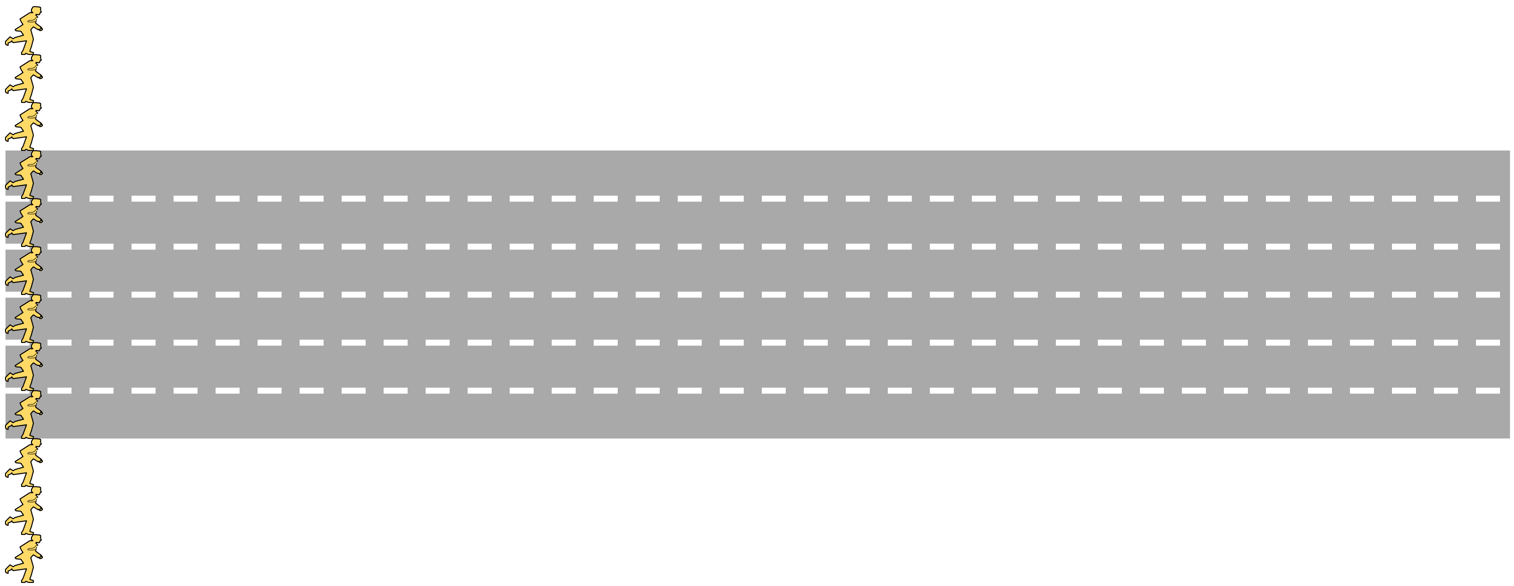
All of the frequencies arrive at the destination at exactly the same time and with equal time delay through the filter passband!

Cisco Systems
Ron Hranac

JDSU

Group Delay: An Analogy

Back to athletes, but now there are some that have to run in the ditches next to the track.

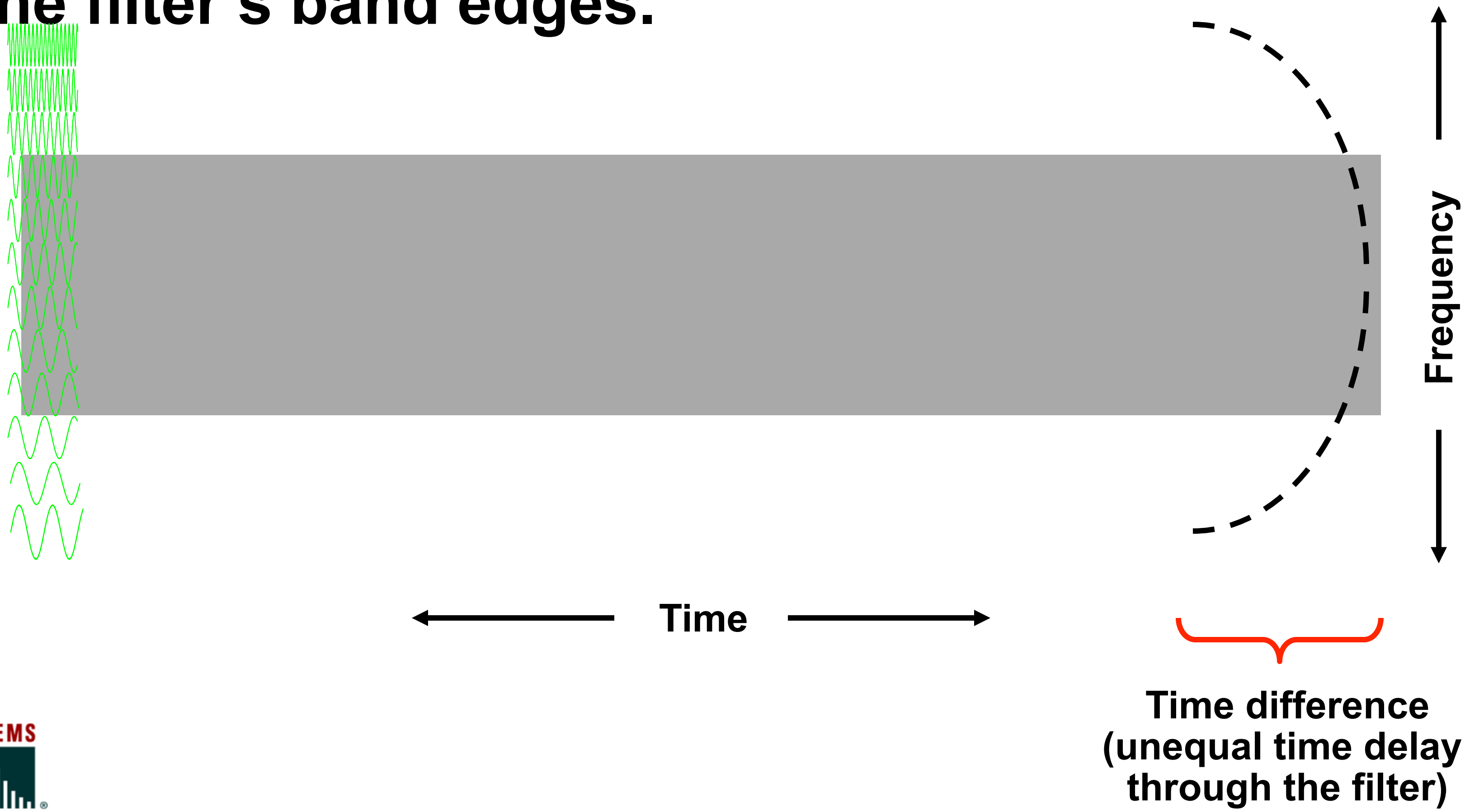


Some athletes take a little longer than others to arrive at the finish line. Their time delay from one end of the track to the other is unequal.

Example courtesy of Holtzman, Inc.

Group Delay: An Analogy

Substitute RF signals for the athletes again. The "track" is a filter's passband, the "ditches" are the filter's band edges.

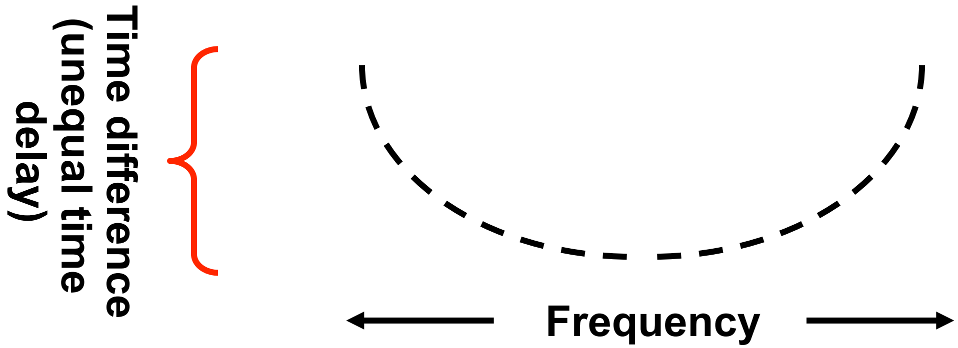


Cisco Systems
Ron Hranac

JDSU

Group Delay: An Analogy

- Group delay exists, because some frequencies—the ones near the band edges—took longer than others to travel through the filter!
- Now take the dotted line connecting the frequencies and flip it on its side. The result is the classic bathtub-shaped group delay curve.



Ron Hranac

Common Sources of Group Delay

- **Common sources of group delay in a cable network**
  - AC power coils/chokes (affects 5~10 MHz in the upstream)
  - Node and amplifier diplex filters (affect frequencies near the diplex filter cutoff region in the upstream and downstream)
  - Band edges and roll-off areas
  - High-pass filters, data-only filters, step attenuators, taps or in-line equalizers with filters
  - Group delay ripple caused by impedance mismatch-related micro-reflections and amplitude ripple (poor frequency response)

Cisco Systems
Ron Hranac

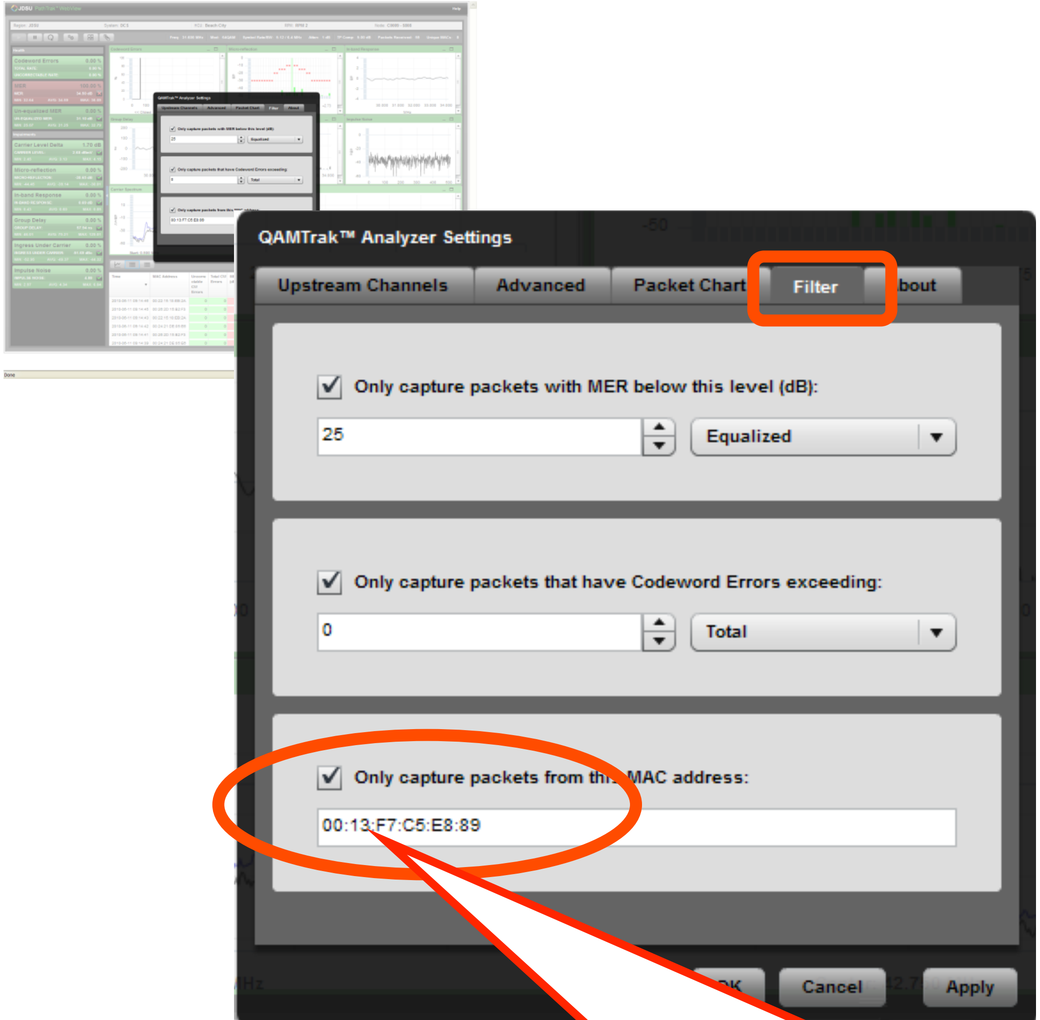
JDSU

How Can You Fix Group Delay

- **The Fix?**
  - Use adaptive equalization available in DOCSIS 1.1, 2.0 and 3.0 modems (not supported in DOCSIS 1.0 modems)
  - Avoid frequencies where diplex filter group delay is common
  - Sweep the forward and reverse to ensure frequency response is flat (set equipment to highest resolution available; use resistive test points or probe seizure screws to see amplitude ripple)
  - Identify and repair impedance mismatches that cause micro-reflections
  - Use specialized test equipment to characterize and troubleshoot group delay (group delay can exist even when frequency response is flat)

Ron Hranac

Filter on a DSAM MAC using MACTrak



Filter on a DSAM's MAC Address

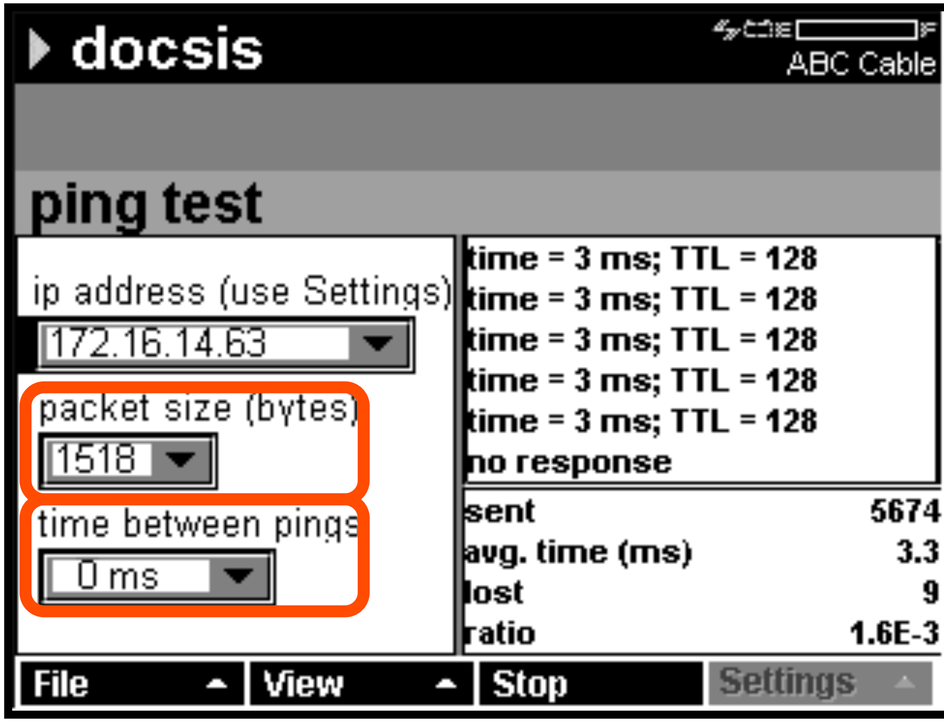
- Choose the **Filter** Tab from the **QAMTrak Analyzer** Settings Screen
- Select which item(s) you wish to filter on
  - Filters can be combined – any combination of the three
- MER filter can use Equalized or Unequalized MER
- Codeword Error filter can filter on packets with Uncorrectable codeword errors or any Codeword errors
  - Filters on number of CWE's per packet, not CWE rate
- MAC address filter can use ".", ";", or no separators between character pairs

"Ping" To Any IP Device On The Network

Allows up to 10 pre-stored IP addresses

Configure the Ping feature for a Packet Size of 1518 and the Time Between Pings for 0 seconds

- **Packet Size Selection:** 64, 128, 256, 512, 1024 & 1518 (in bytes)
  - **Select 1518 for MACTrak Filtering**
- **Time Between Pings**: 0, 10 ms, 25 ms, 50 ms, 100 ms, 1 sec, 2 sec & 5 sec
  - **Select 0 for MACTrak Filtering**



Field View QAM Option on DSAM^{XT} Meters

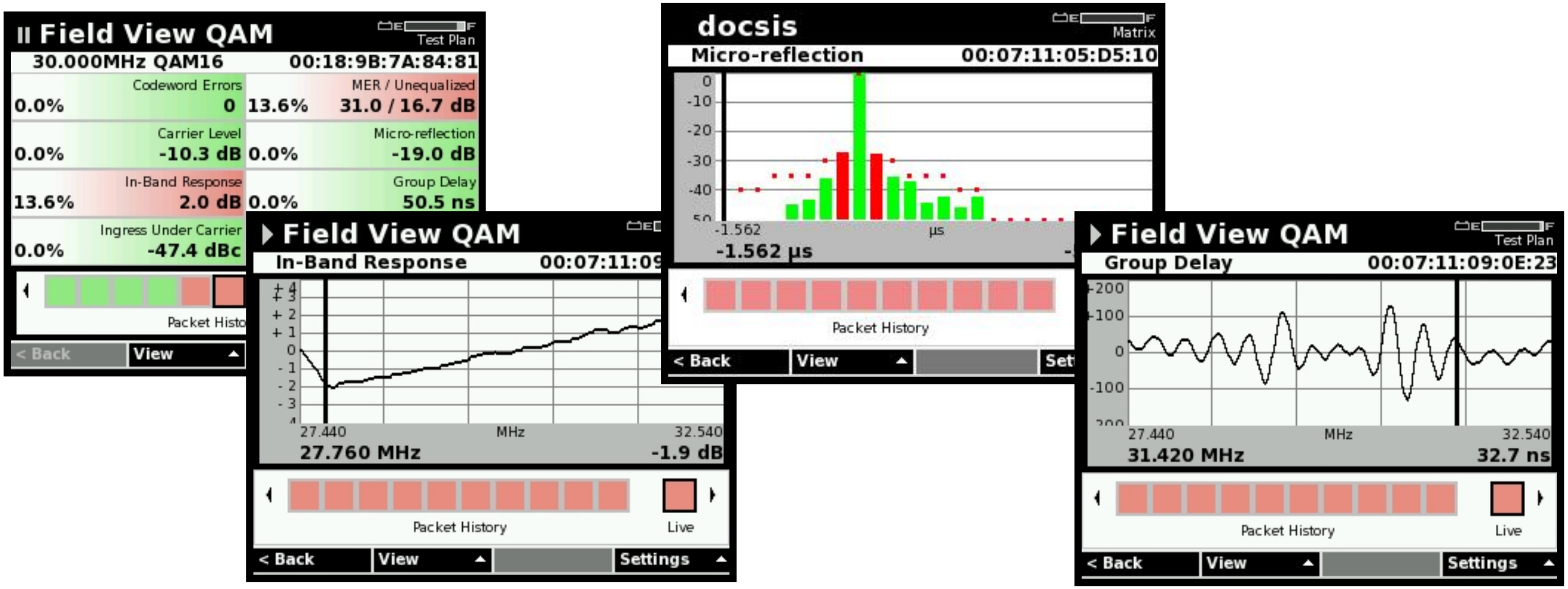
- Field View QAM is a chargeable option **for DSAM^{XT} hardware ONLY!**
- Works with RPM3000 cards and HCU200s
- **Requires remote access to WebView from outside the firewall**

Only measures packets from DSAM based on DSAM MAC address

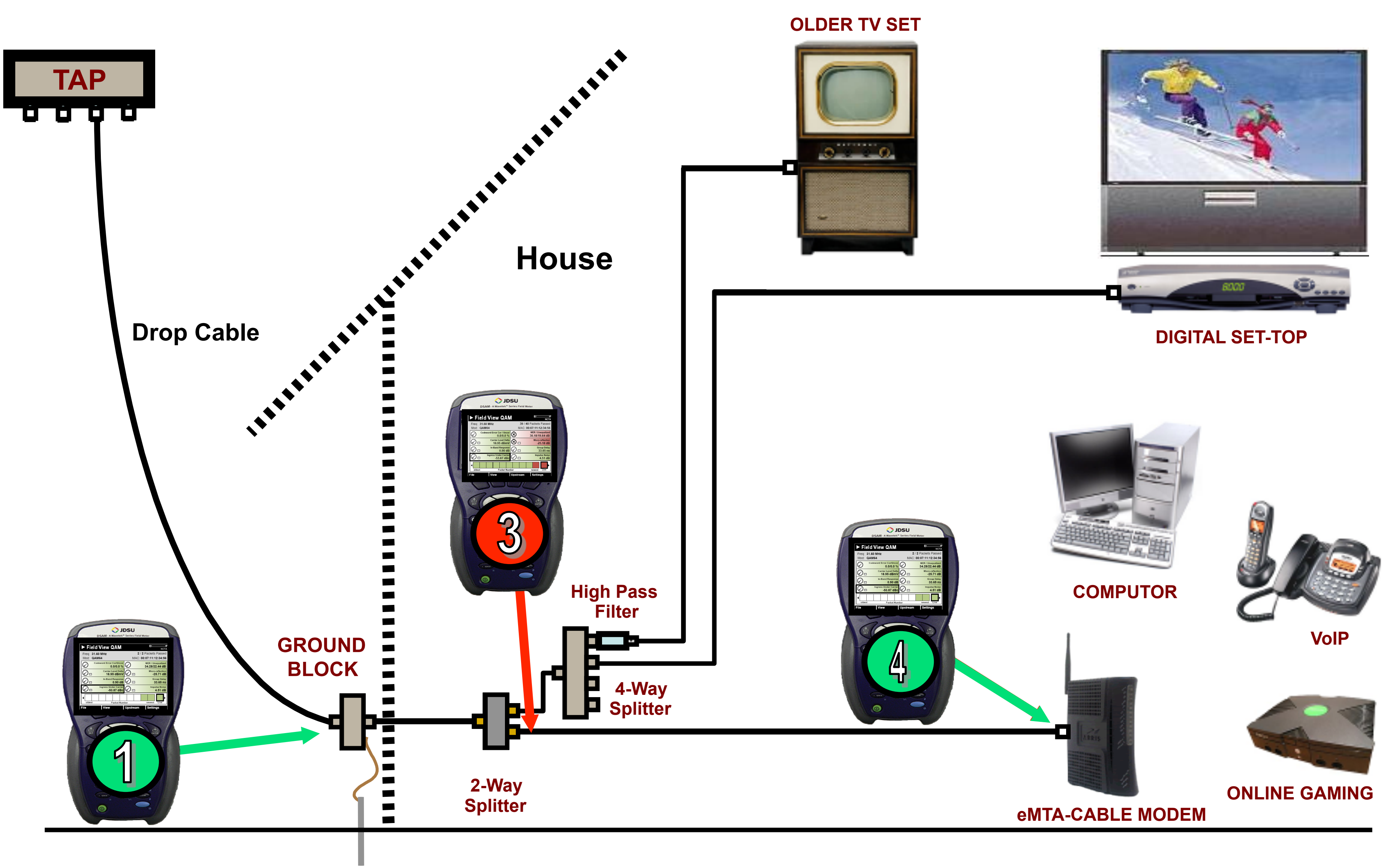
QAMTrak/MACTrak measurement results displayed on DSAM^{XT}

JDSU

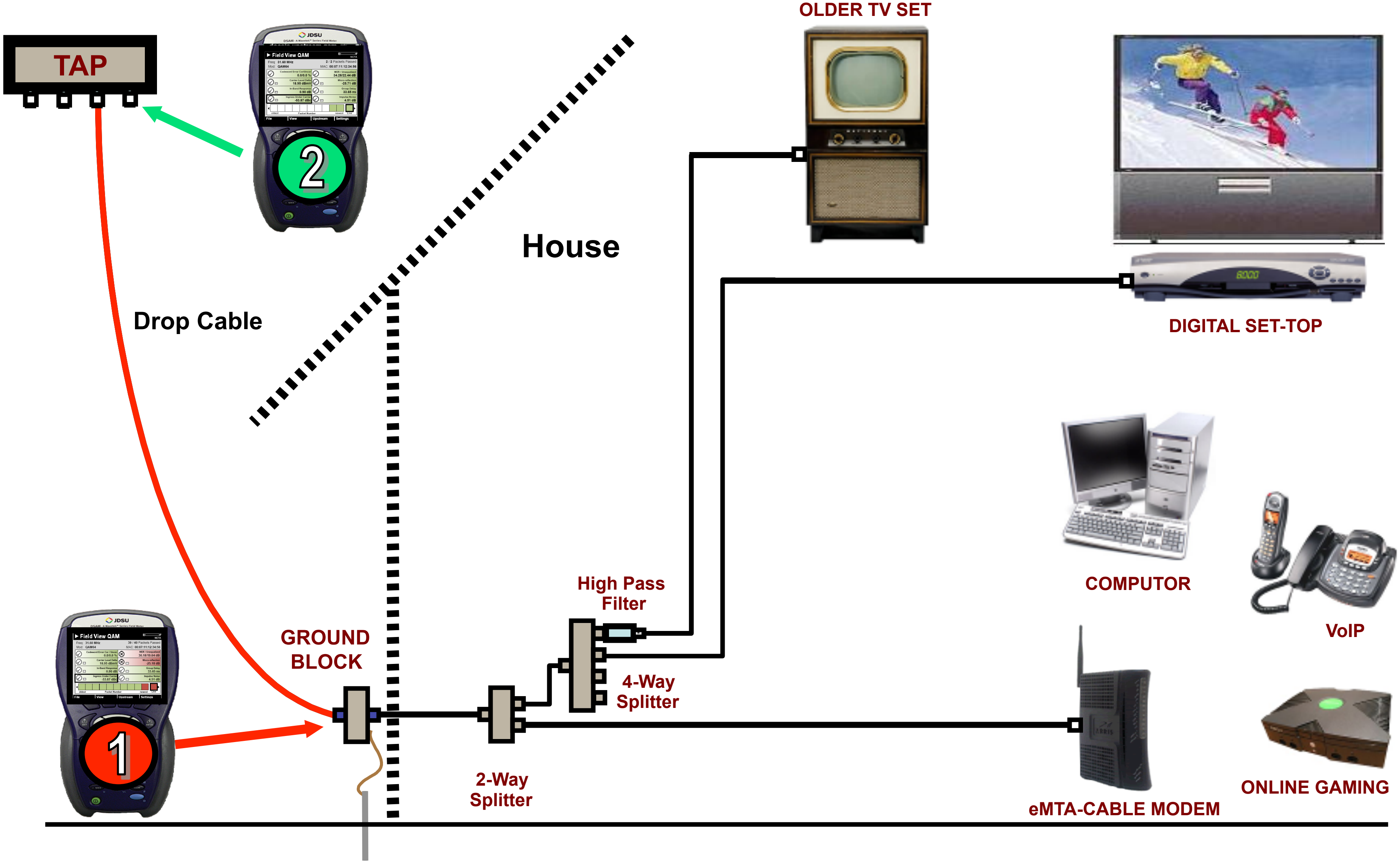
- **Field View QAM Option**
  - Single person troubleshooting with live “in-band” DOCSIS® upstream carriers
  - View critical “in-band” QAMTrak measurements right on your DSAM
  - More convenient than laptop for out-of-truck usage for:
    - Seeing node health status from the field (CWE’s still occurring?)
    - Localizing “invisible” linear impairments in the field
    - Quantifying DOCSIS channel parameters from any point in the field to the headend/hub
    - Use Field View QAM after identifying and fixing issue to verify that repair was effective



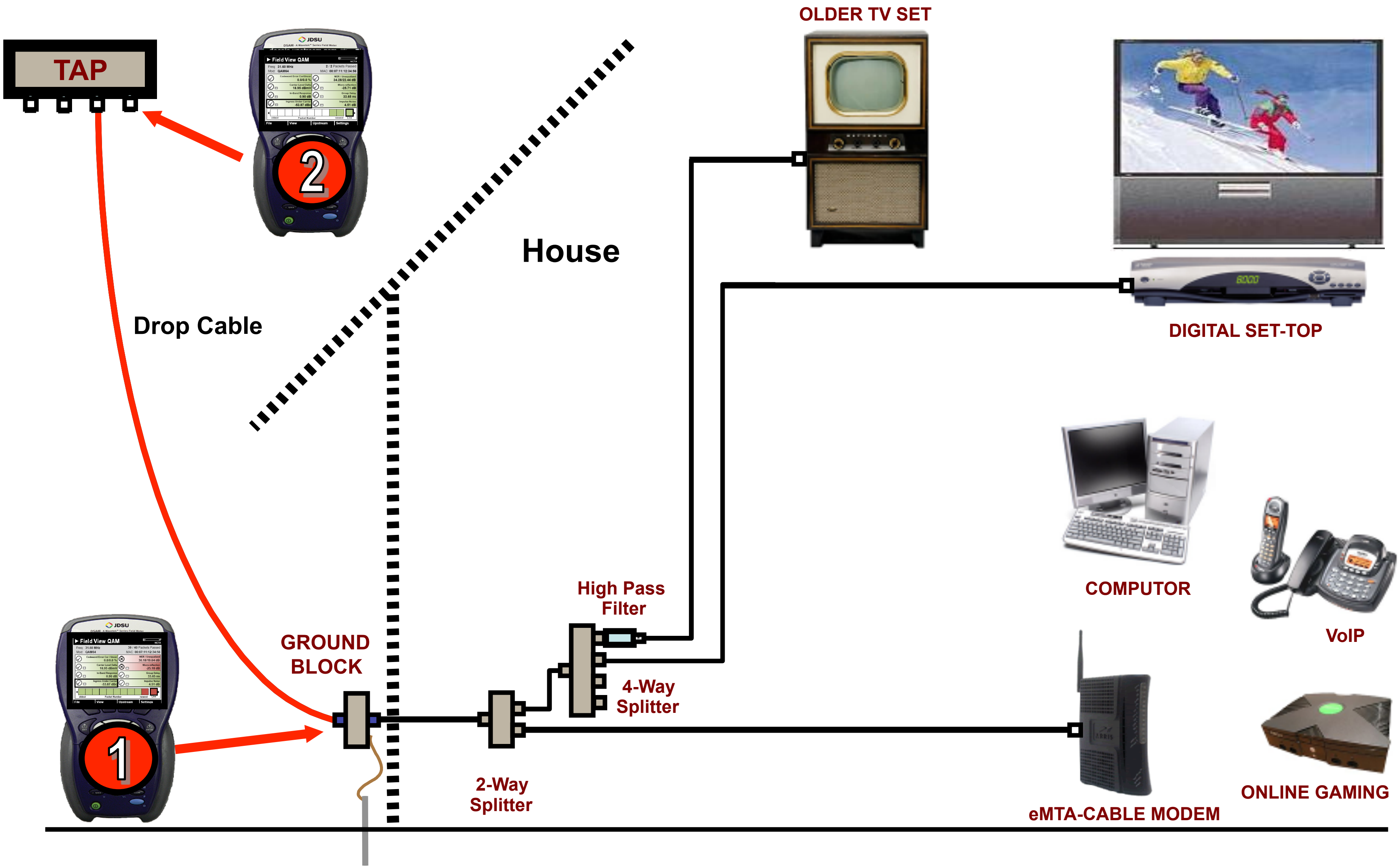
Testing for Linear Distortions in the Home



Testing for Linear Distortions in the Home

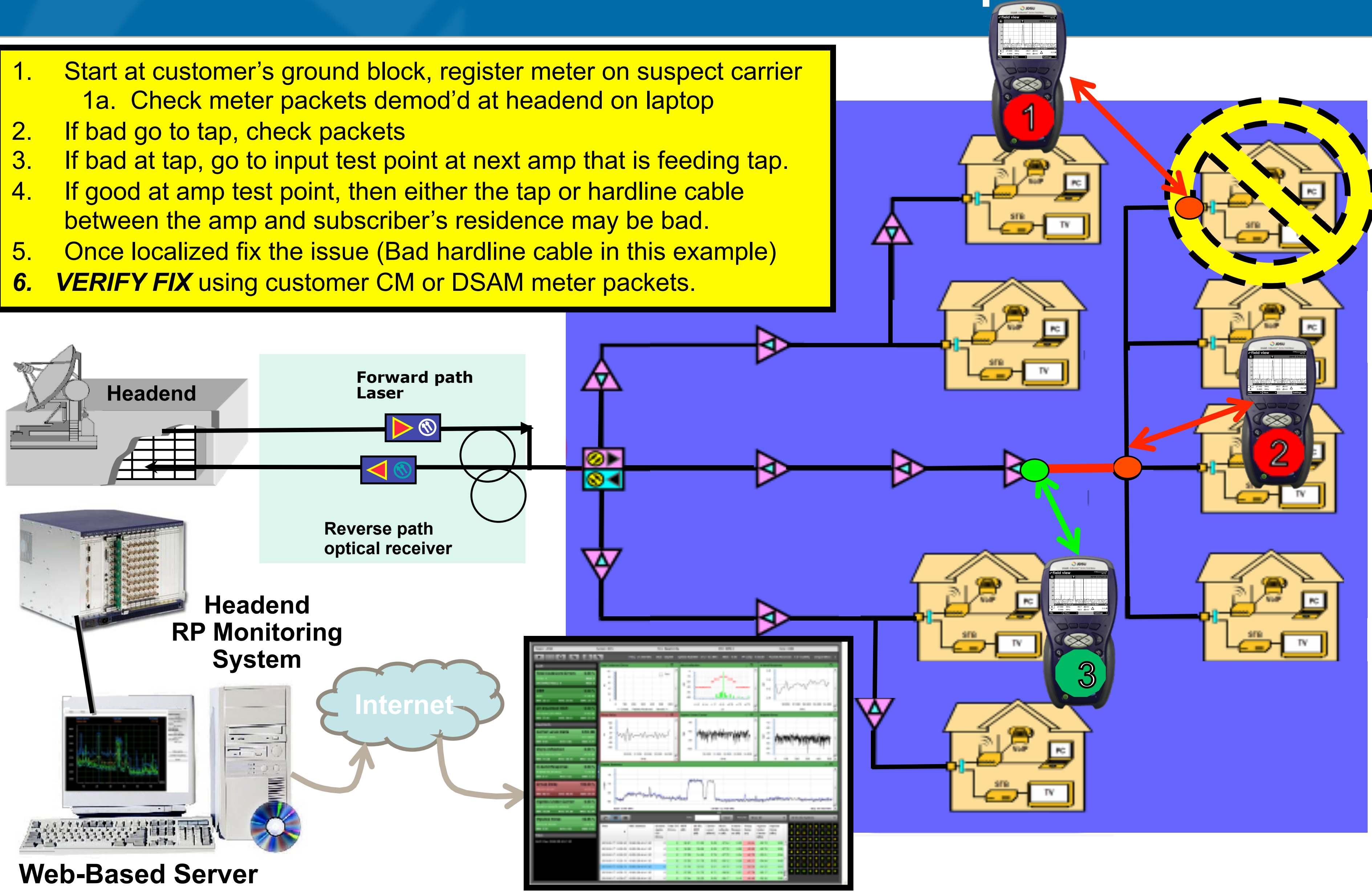


Testing for Linear Distortions in the Home

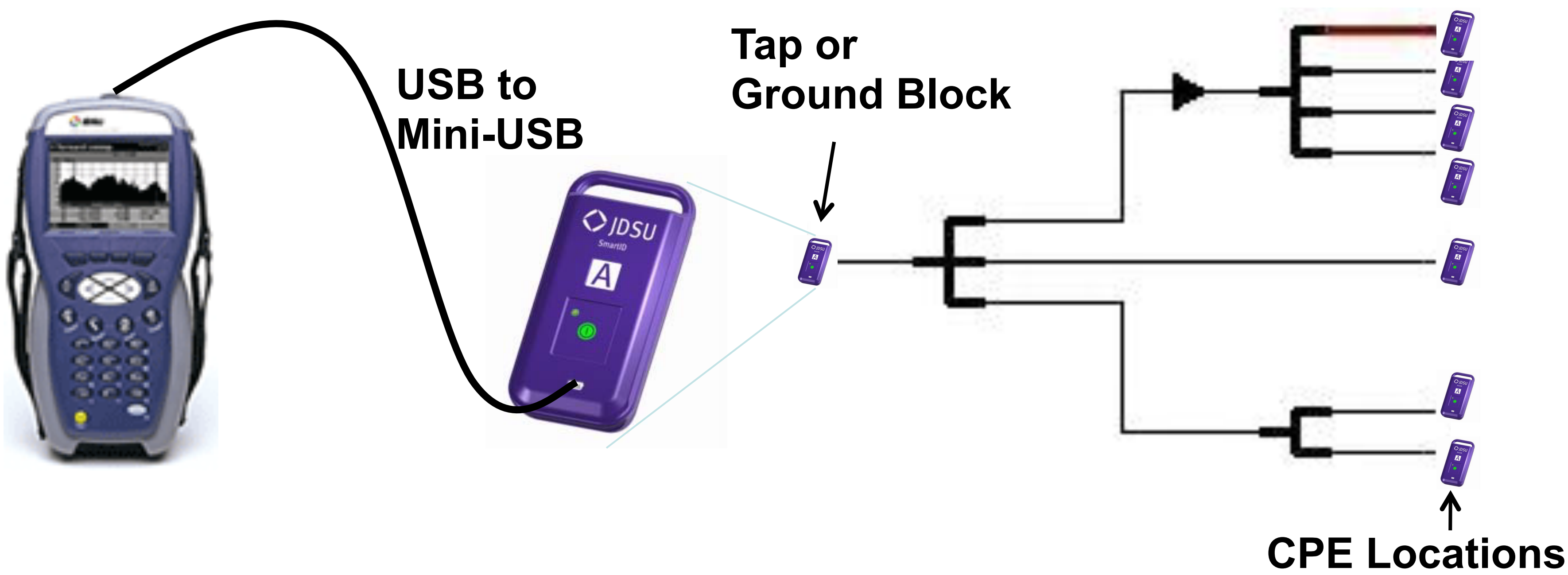


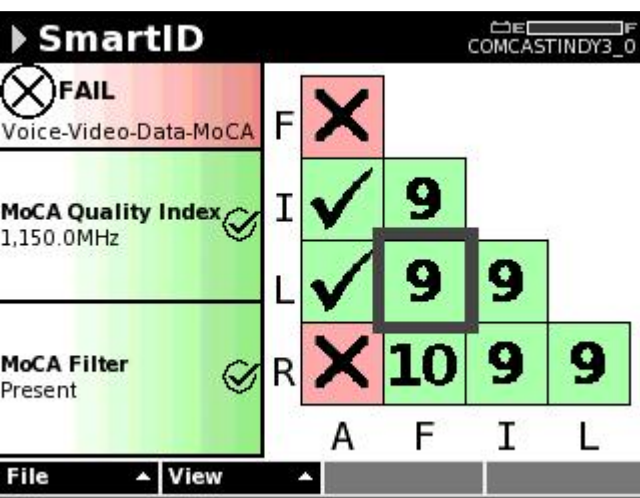
How To Troubleshoot/Localize Linear Impairments

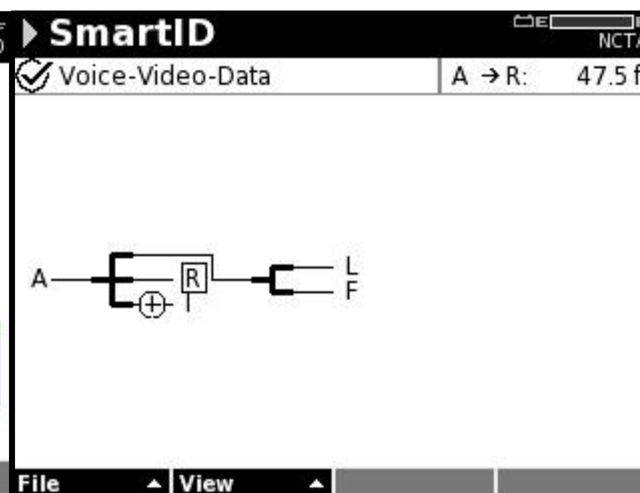
1. Start at customer's ground block, register meter on suspect carrier
   1a. Check meter packets demod'd at headend on laptop
2. If bad go to tap, check packets
3. If bad at tap, go to input test point at next amp that is feeding tap.
4. If good at amp test point, then either the tap or hardline cable between the amp and subscriber's residence may be bad.
5. Once localized fix the issue (Bad hardline cable in this example)
6. ***VERIFY FIX*** using customer CM or DSAM meter packets.

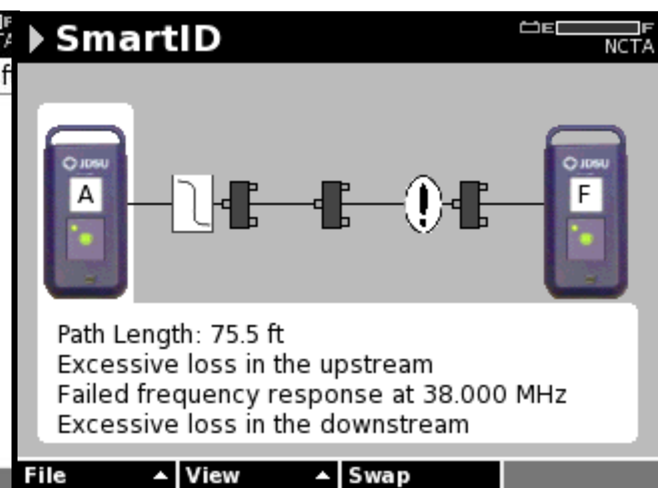


DSAM SmartID™



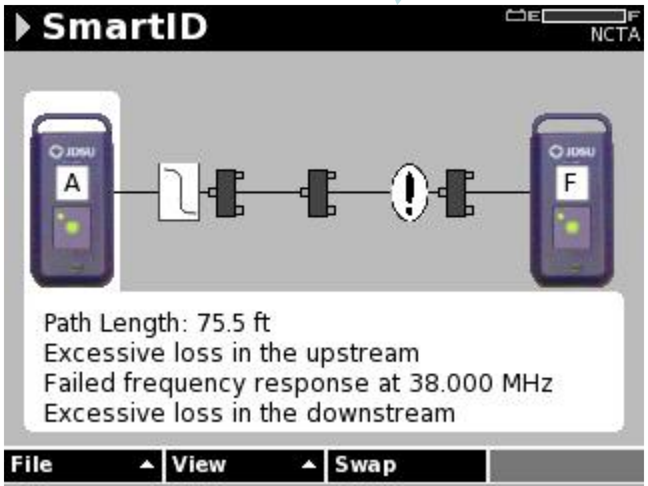


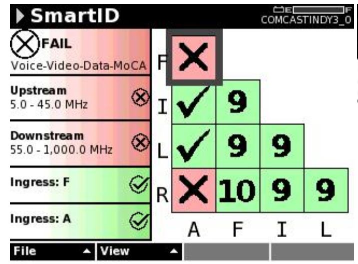


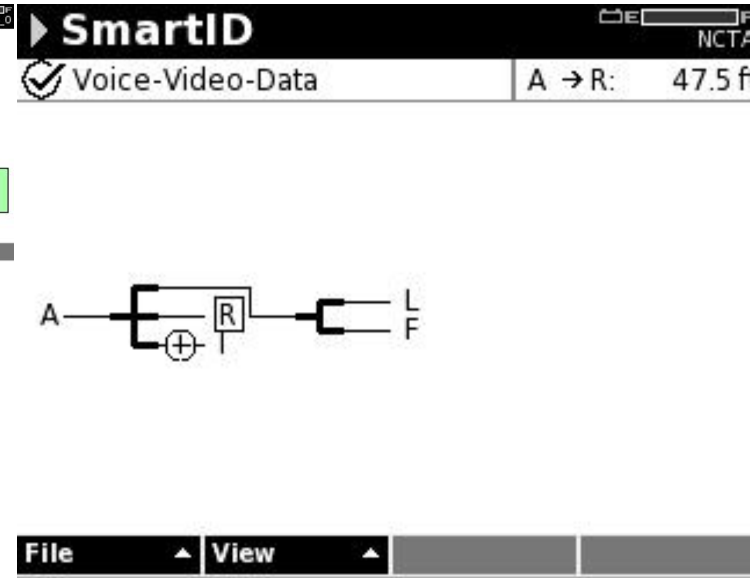


DSAM SmartID™

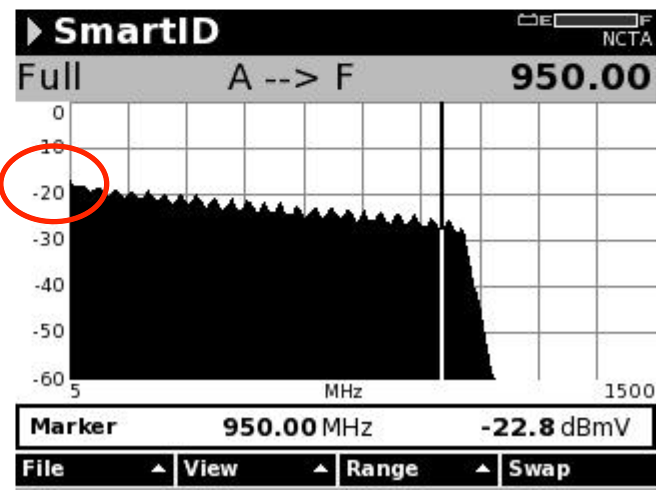
Trouble shooting displays show fault location and cause







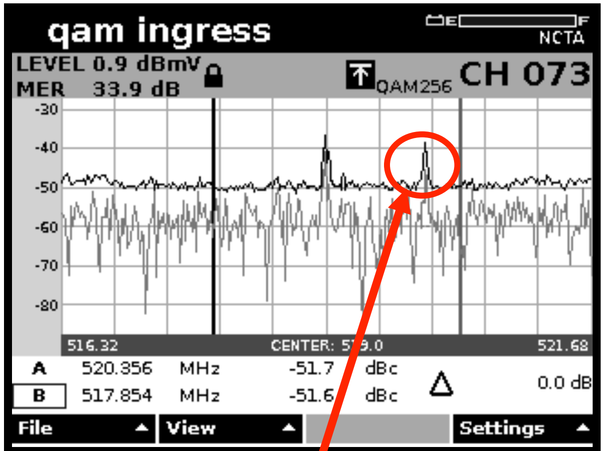
20dB loss



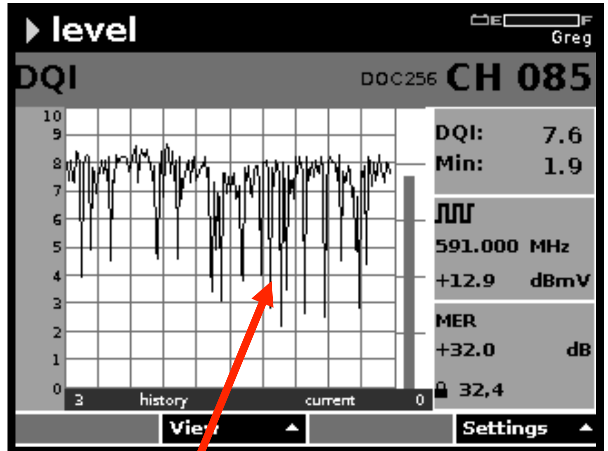
DSAM SmartID™

- **Value & Benefits**
  - Dramatically reduced test and fault find time for in-home wiring
  - It's a coax qualifier and fault locator
  - Certify in-home coax wiring for future service turn ups and avoid repeat visits
  - Know if a faulty drop cable can be salvaged or not.
- **Why should you care**
  - By focusing on fixing the physical issues that impact all services in the home, contractors/installers/operators can be assured that no matter which version of technology is present, the coax will be capable of handling it.

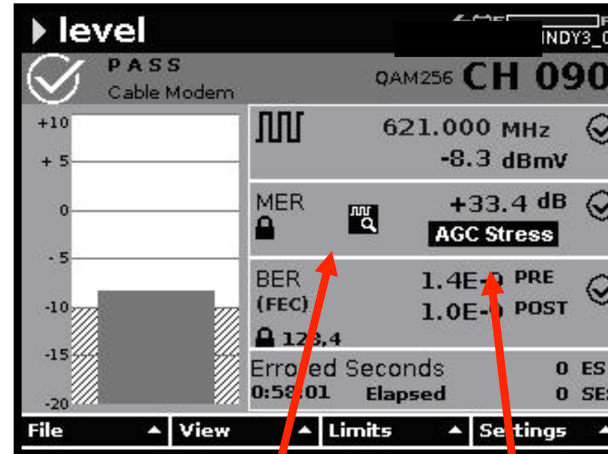
Powerful Digital Testing and Troubleshooting



Find impairments with QAM Ingress!



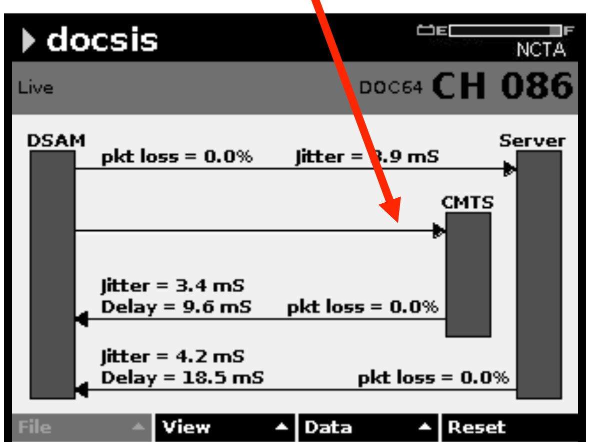
Track down intermittent performance with DQI!



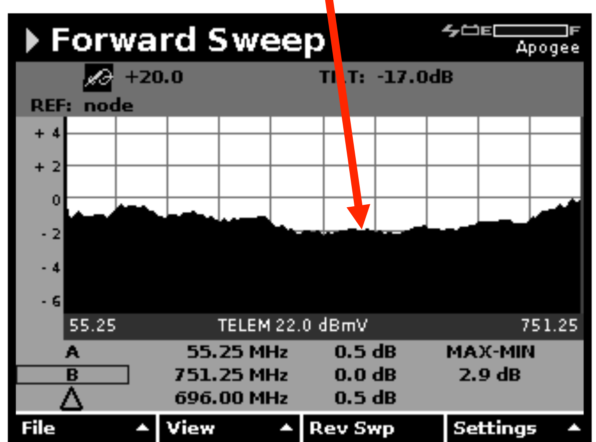
Find signal issues

Identify amplifier problems

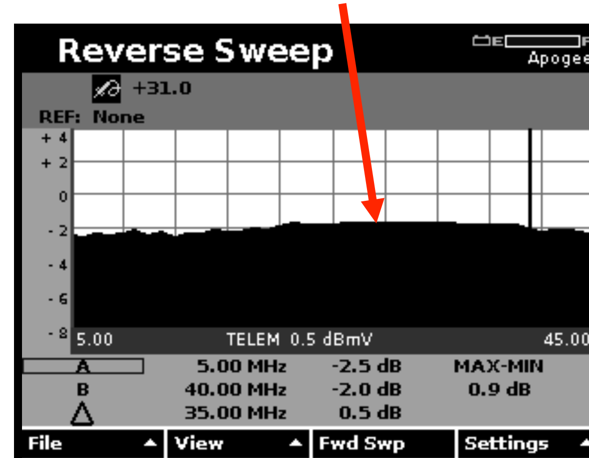
Segment Voice problems



Prepare for VOD & HSD



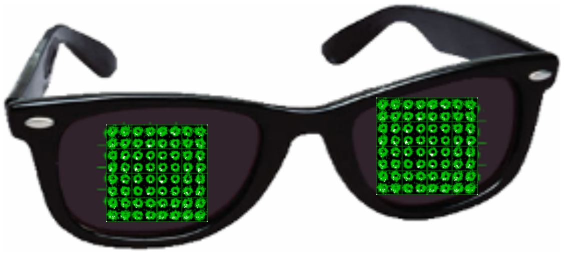
Reduce service calls



Training… Training… Training…

- **You never have too much training!**
  - **Learn everything you can about Triple Play & HFC networks**
    - Company sponsored training
    - SCTE Chapter Meetings & Certification programs
    - SCTE EXPO & Emerging Technologies
    - CED and Communications Technology magazines
    - Vendor “product specific” training
  - **Learn everything you can about the devices in your network, both the physical layer and data layer**
    - **Headend:** Modulators, Multiplexers, CMTS etc.
    - **Outside plant:** Nodes, Amps, Passives etc.
    - **Subscriber’s drop:** Digital Converter, DVRs, Cable Modems, eMTAs, house amps etc.
  - **Learn how to get the most out of your test equipment & CPE diagnostics**
    - most vendors will train you
- **Be thorough - Take pride in your work!**
  - Do the installation right the first time
  - Take the time to properly certify every drop for Triple Play services

JDSU – See Digital in a Whole New Light!

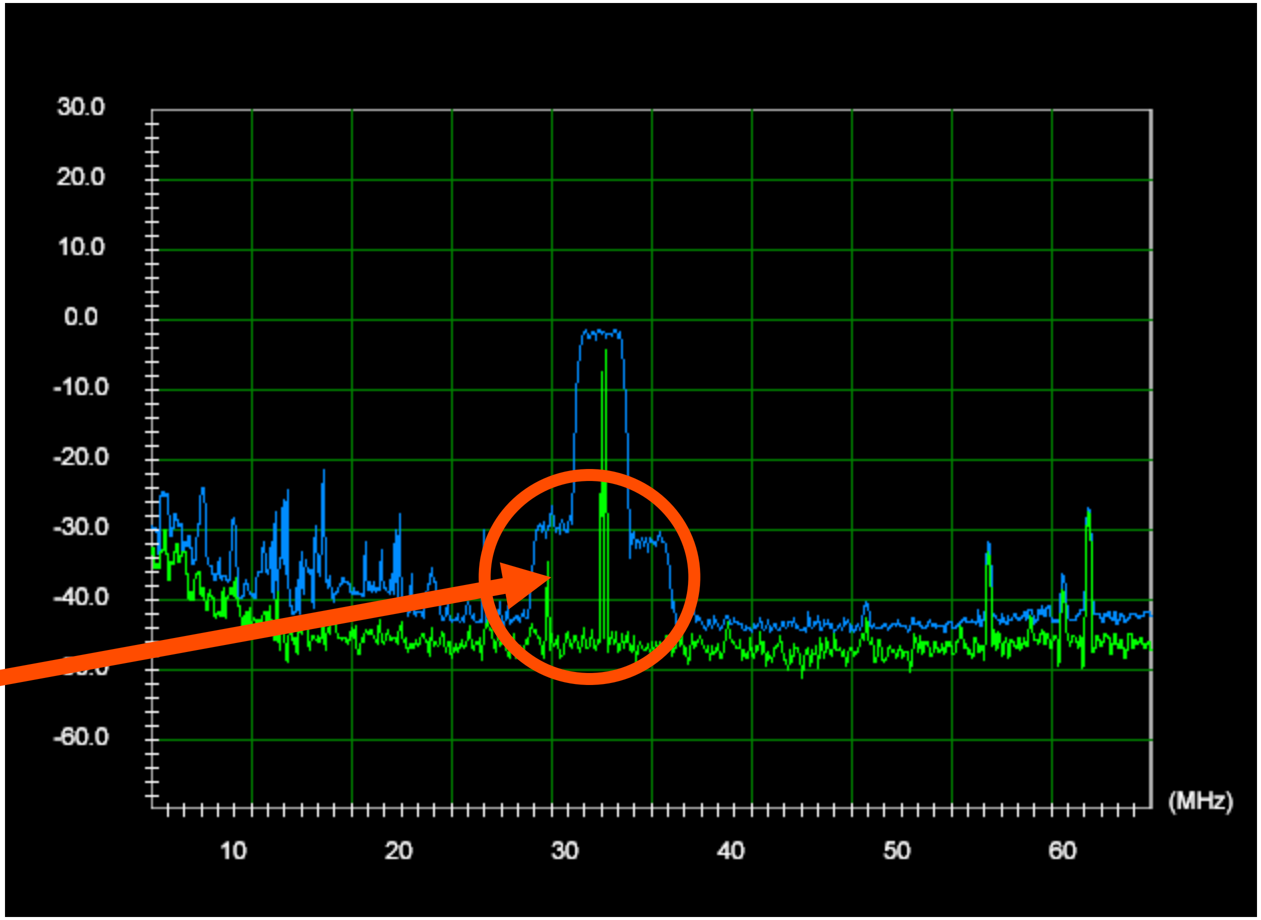


See digital in a whole new light!

Questions?

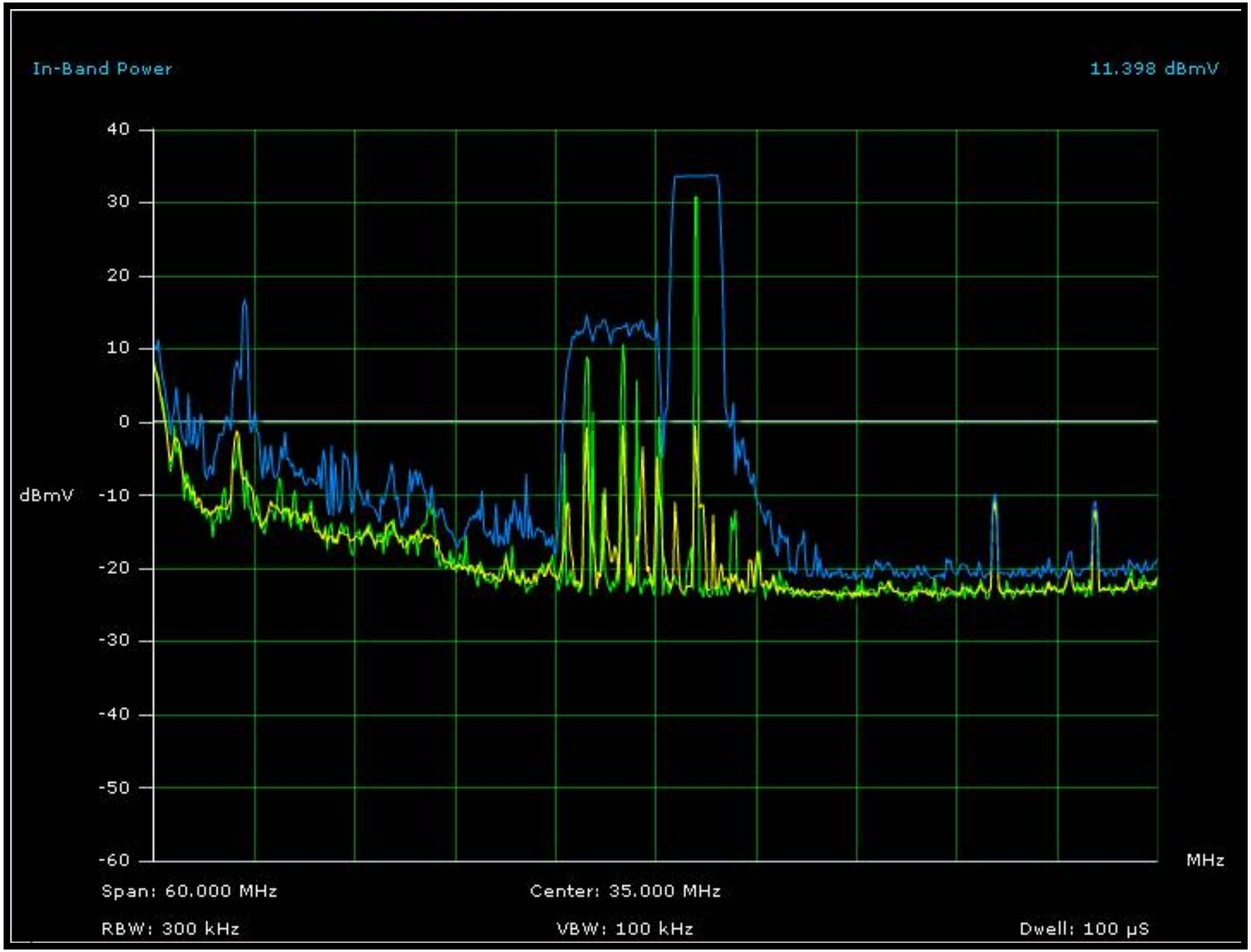
kelly.watts@jdsu.com

Analyzing and Interpreting live Spectrum Traces

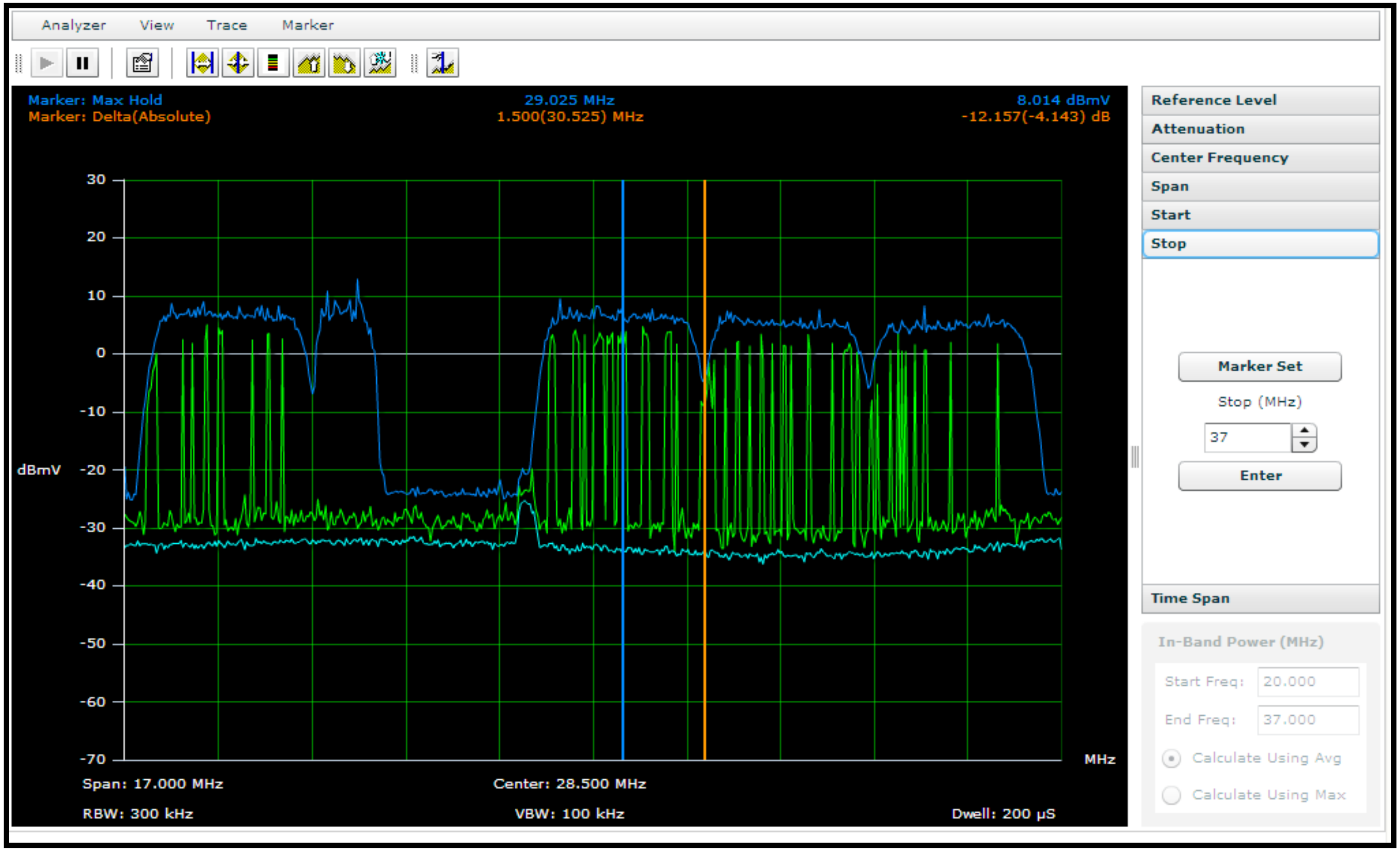


Defective modem

Bad Mini-Connector at the Input of CMTS Causing Excessive Loss



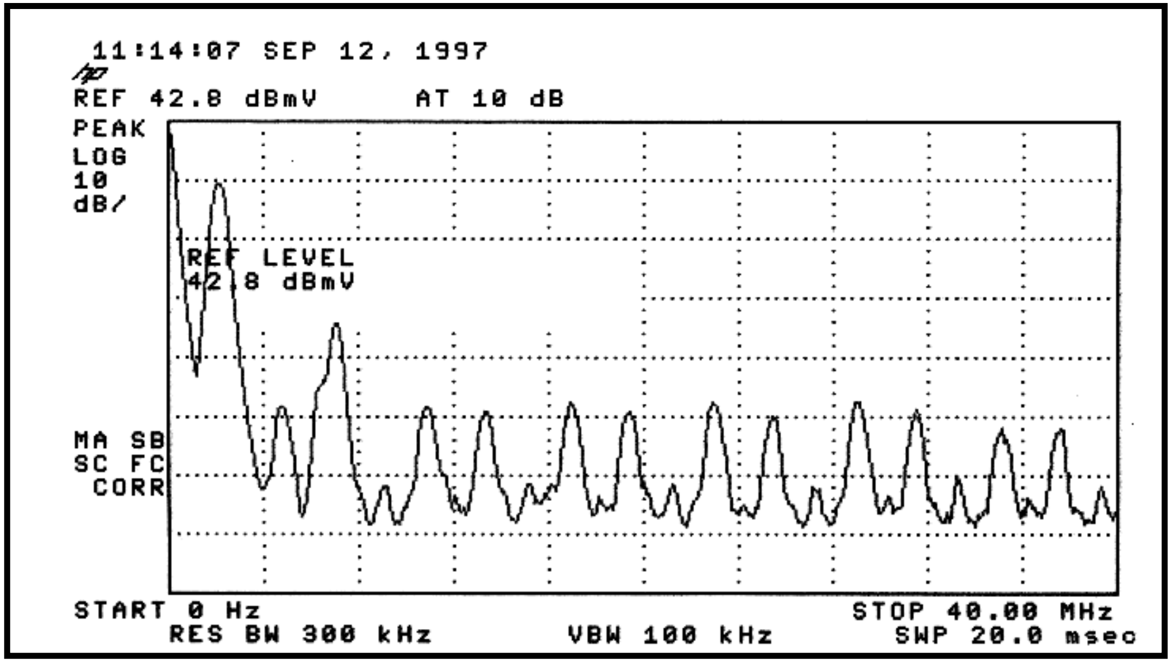
3.2 MHz Wide Carriers Spaced at 3.0 MHz



These 3.2 MHz wide carriers should be spaced at a minimum of 3.2 MHz between center frequencies!

Severe Transient Hum Modulation

- The RF choke can saturate with too much current draw and cause the ferrite material to break down
- Same thing can happen in customer installed passives
- Notice that this looks a lot like CPD



DSAM with HomeID: Deliver Whole-Home DVR Service with Lowest Rate of Return Service Calls

- **Overcome the new challenges of higher frequency and signal path used by MoCA**
- **70~80% of all issues are from Tap down**
  - 80% of those are from physical / craftsmanship problems: loose connectors, bad cables etc.

- **Now there will be a way to rapidly certify and troubleshoot the most untested part of the plant**

Available Summer of 2011
  - Locate coax issues loose connectors and cables
  - MoCA + Triple-play coverage (4 MHz ~ 1.6 GHz)
  - Home wiring topology
  - Cost effective integration with DSAM^{XT}
  - < 6 months pay back by just reducing 2 repeat truck rolls / month / technician

PathTrak™ Return Path Monitoring Benefits

Troubleshoot nodes faster to reduce MTTR and increase workforce efficiency

- Identify impairments before rolling a truck using both spectrum and LivePacket™ technology
- Use Field View™ with SDA and DSAM field meters to quickly locate ingress, the most common impairment
- View performance history to understand transient problems to roll a truck at the right time to find and fix the issue

Reduce trouble tickets and customer churn by identifying problems before your subscribers

- Rank nodes using convenient web-based reports for proactive maintenance
- Easily and quickly detect impairments such as fast impulse noise, ingress, CPD, and laser clipping on all nodes 24/7
- View live spectrum, QAMTrak™ analyzers and a wide array of reports conveniently via the web

How RPM3000s Help You Solve Your Toughest Problems

<u>With RPM3000 cards and WebView 2.5 you can:</u>

- **Identify which impairments are causing customers service to be impacted**
  - Codeword errors indicate high likelihood of data corruption within packets
- **Troubleshoot an intermittent issue with repeat truck rolls (over a long period) using MACTrak**
  - Filter on customers MAC, capture at **what time they go bad** and the **nature of the impairment**
- **Troubleshoot a customer complaint before rolling a truck using MACTrak**
  - Filter on customers MAC address, see if their packets are bad **right now** and **why?**
- **Segment linear impairments using a DSAM**
  - Filter on DSAM packets and see impairment turn off **in real time** via WebView if problem fixed was “**The**” problem
- **Identify plant impairments on a node flagged by your corporate node ranking system**
  - Find and fix the impairments to get your nodes off of the regional worst nodes list quickly
- **Check robustness of a 16QAM carrier before converting to 64QAM**
  - Measure group delay, in-band response, microreflections, MER without disrupting customer HSD/VOIP services
- **Identify bad cable modems** (faulty equipment for impairments like noisy transmitters)
- **Test out of band prior to advanced DOCSIS 3.0 carrier turn-up**
  - Know that empty spectrum is ready to support advanced services before live carrier turn-up

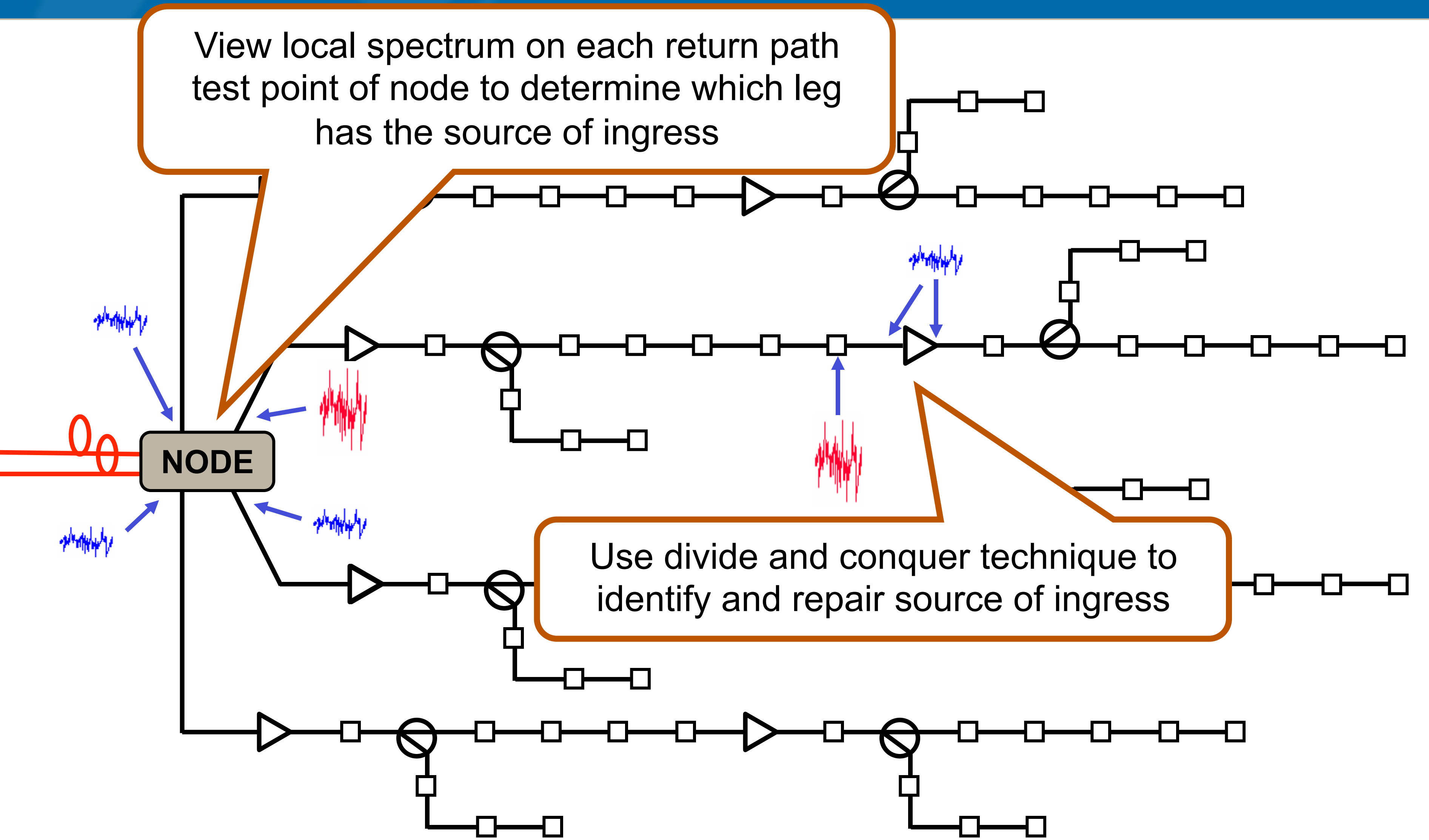
Key HFC T&M Solutions that JDSU Provides

JDSU designs award winning solutions that provide greater visibility into your HFC network health and enabling your workforce to proactively monitor and perform preventative maintenance activities

- **PathTrak™ Return Path** Monitoring
  - Real-time RF spectrum and QAM analyzer troubleshooting
- **PathTrak WebView** - Web Based Access to Live Spectrum and QAM analyzers and Historical Measurements plus Node Certification and Ranking Reports
- **PathTrak Video** Monitoring - RF/QAM and MPEG - Real-time RF spectrum and QAM MPEG analyzer troubleshooting
- **SDA** and **DSAM** portable field QAM and RF Spectrum Analyzer and Sweep Platforms
  - PathTrak Field View - remote spectrum analyzer on SDA and DSAM meters
- **Test Productivity Pack** – Web Based Meter Management software and Home Certification Reports
- **DTS** – Portable and Rack Mounted MPEG Analyzers
- **NetComplete** - End-to-end Status Monitoring, and Performance Management
  - QT-600 VoIP/MPEG IP Probe

Buy one solution at a time or buy them all together….
Either way JDSU has you covered

Tracking Down Ingress – Divide and Conquer



References

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- Hranac, R. "Group delay" *Communications Technology*, January 1999

  www.ct-magazine.com/archives/ct/0199/ct0199e.htm
- Williams, T. "Tackling Upstream Data Impairments, Part 1" *Communications Technology*, November 2003

  www.ct-magazine.com/archives/ct/1103/1103_upstreamdata.html

References

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  www.ct-magazine.com/archives/ct/1203/1203_upstreamdata2.html
- Hranac, R. “Microreflections and 16-QAM” *Communications Technology*, March 2004

  www.ct-magazine.com/archives/ct/0304/0304_broadband.html
- Hranac, R. “Linear Distortions, Part 1” *Communications Technology*, July 2005

  www.ct-magazine.com/archives/ct/0705/0705_lineardistortions.htm
- Hranac, R. “Linear Distortions, Part 2” *Communications Technology*, August 2005

  www.ct-magazine.com/archives/ct/0805/0805_lineardistortions.htm

QAM and CATV

- **64 QAM** and **256 QAM** are used for both digital video and DOCSIS® downstream carriers, allowing more digital data transmission using the same 6 MHz bandwidth
  - Transmit equivalent of 10 to 12 standard definition or 2 to 3 high definition (HDTV) programs over one 6 MHz bandwidth

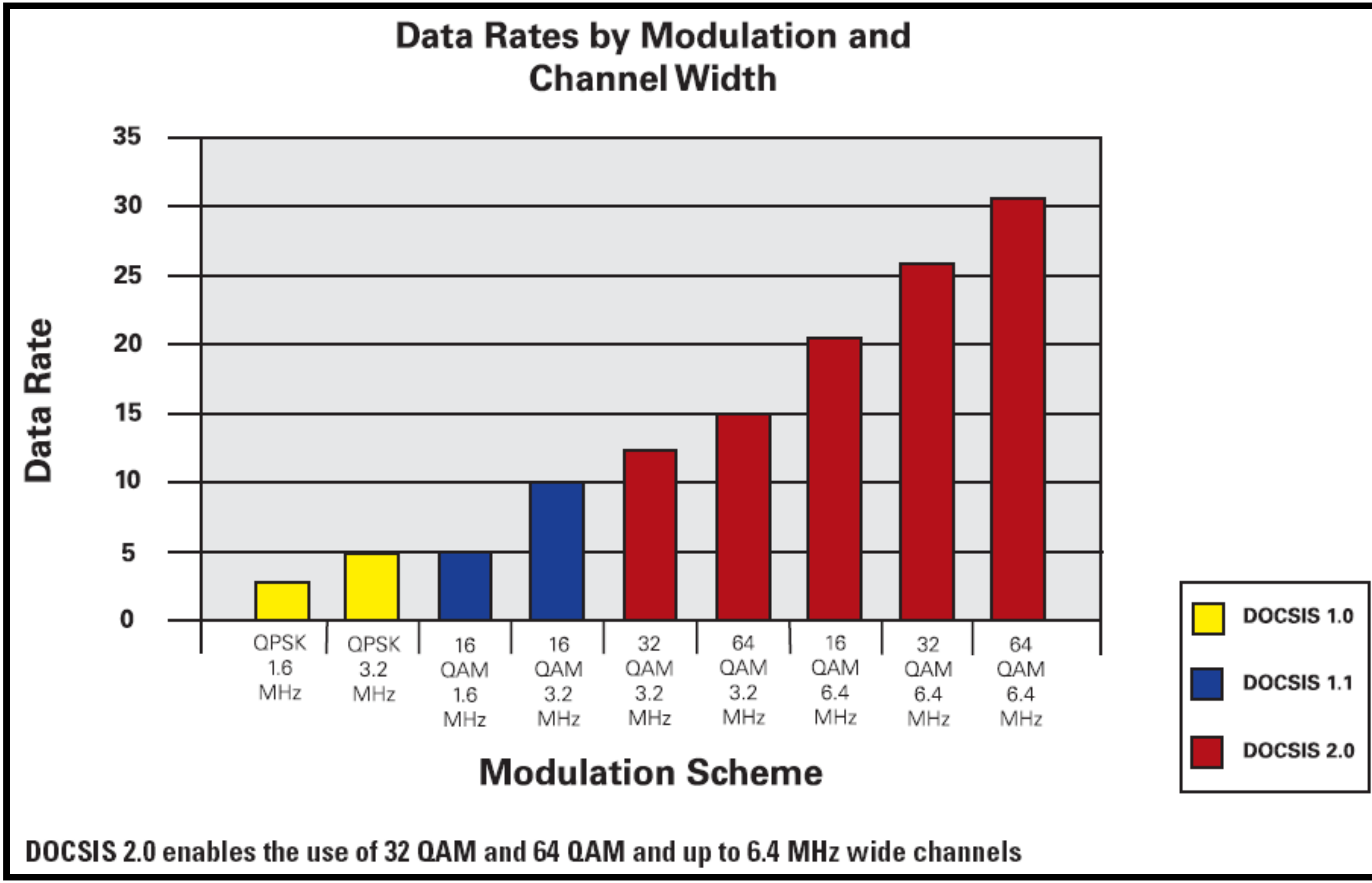
- **QPSK (4 QAM)** and **16 QAM** are part of the DOCSIS 1.0/1.1 upstream specifications

- **32 QAM & 64 QAM** are also part of the DOCSIS 2.0/3.0 upstream specifications

QAM Data Capacity (Annex B)

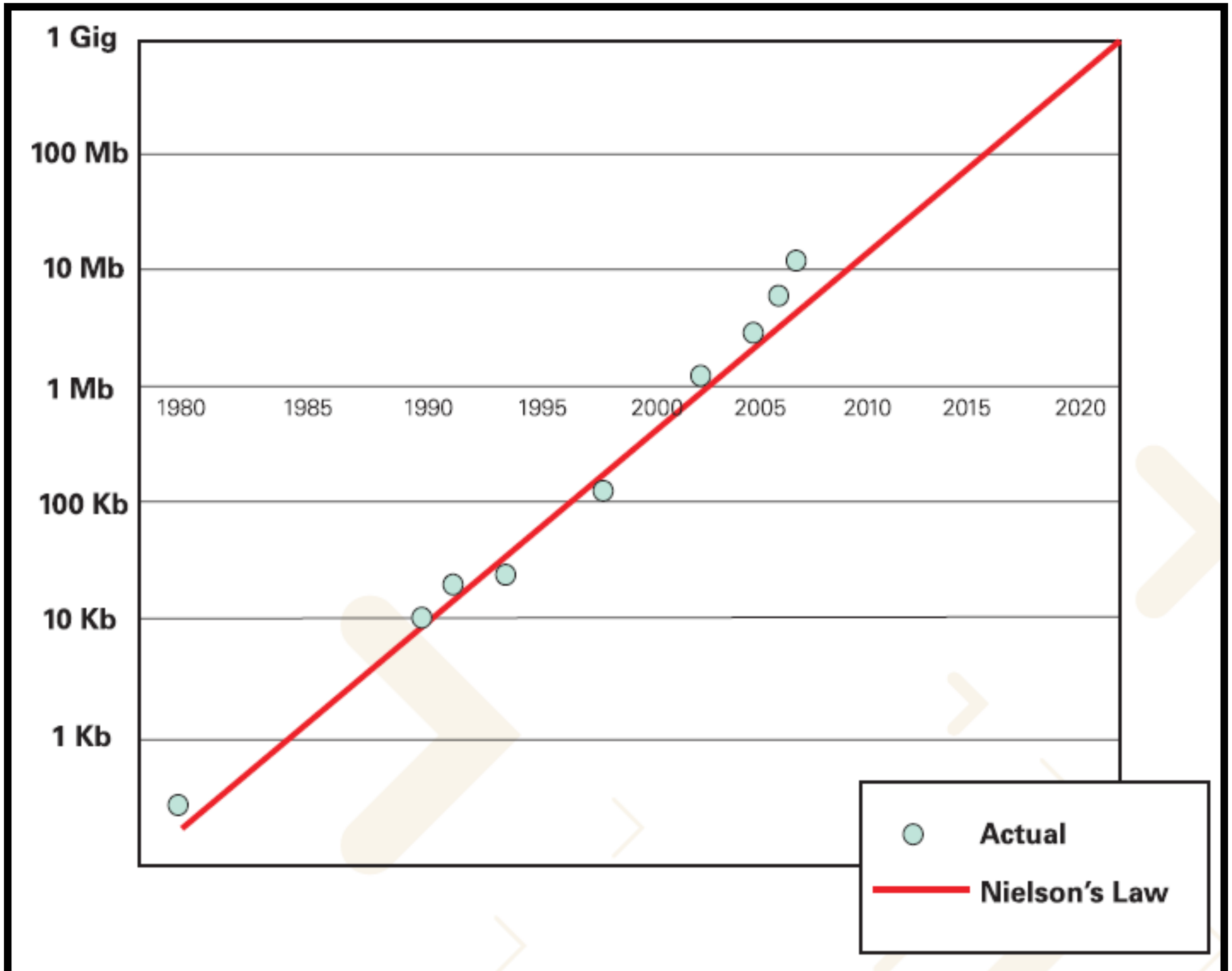
	16 QAM (Upstream)	64 QAM (Downstream)	256 QAM (Downstream)
Symbol Rate (Msps)	2.560 (@ 3.20 MHz)	5.0569 (@ 6 MHz)	5.3605 (@ 6 MHz)
Bits per symbol	4	6	8
Channel Data Rate (Mbps)	10.24	30.3417	42.8843
Information Bit Rate (Mbps)	9.0	26.9704	38.8107
Overhead	12.11%	11.11%	9.5%

Upstream Data Rates (Mbps)



Source: Motorola

Nielson's Law - Per User Bandwidth Consumption

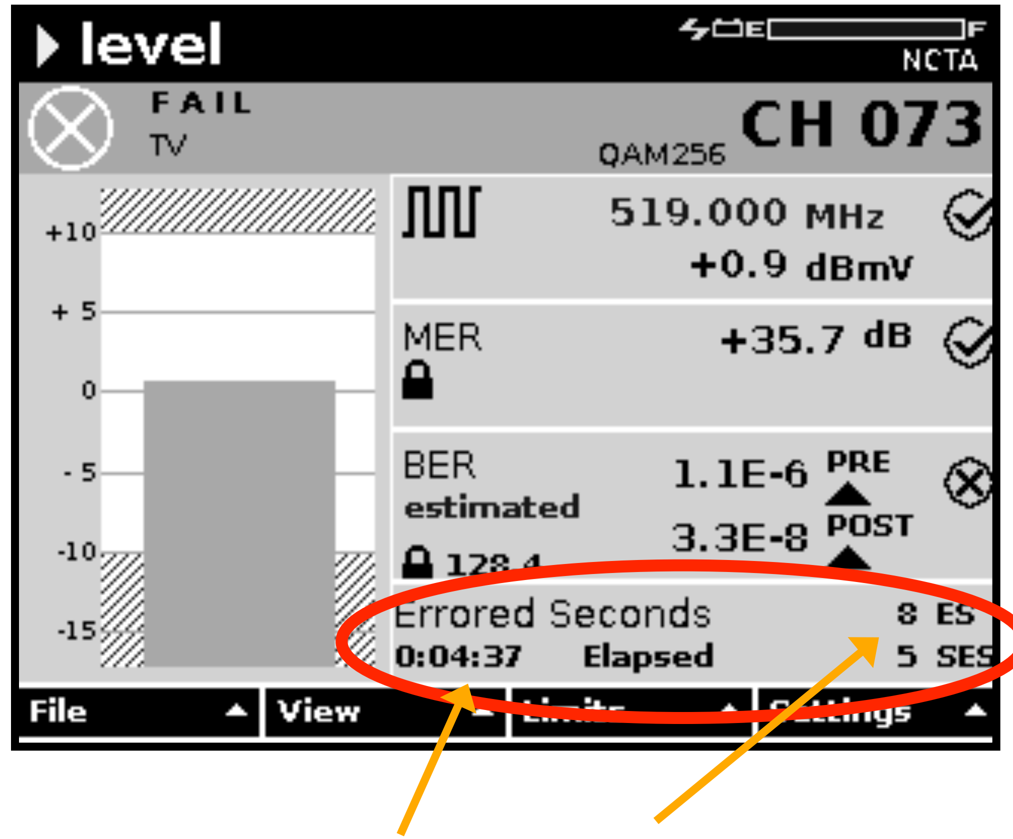


The per-user bandwidth consumption trend shows increased utilization over time

Source: Motorola

Pre and Post FEC BER

- **Forward Error Correction when working will output >10^{-9}**
  - 1 error in 1 billion bits
  - Less than 1 error every 25 seconds
  - MPEG-2 likes good BER
- **FEC will work to about 10^{-6}**
  - 1 error in million bits
  - 40 errors every second
- **FEC causes Cliff Effect**



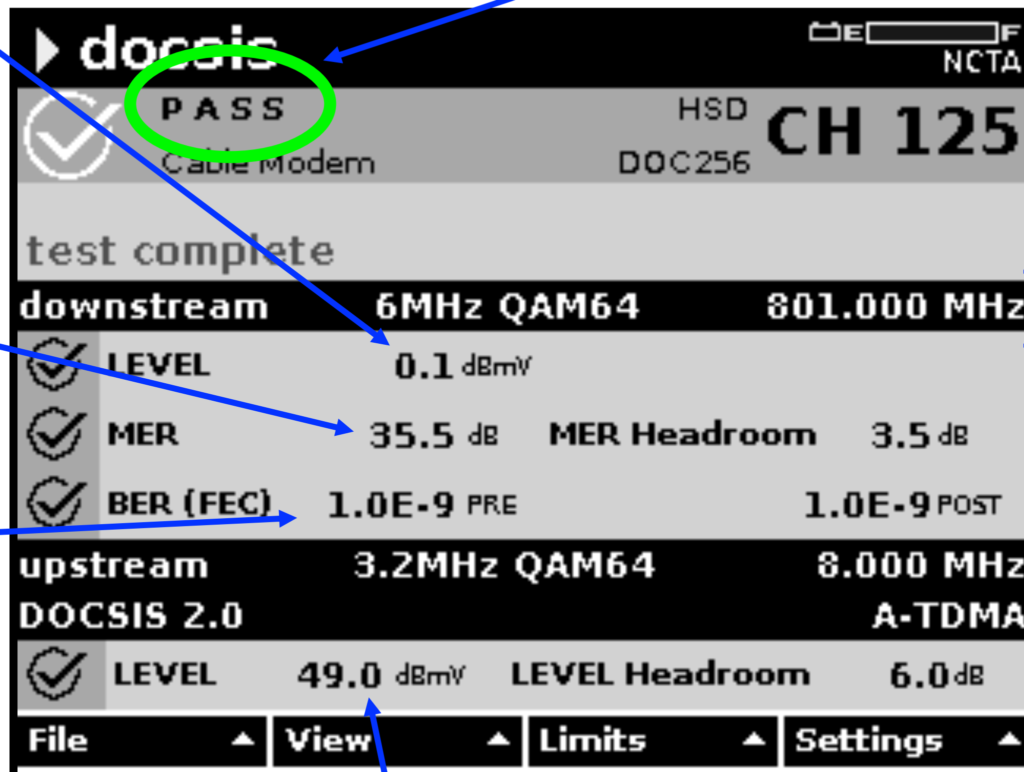
Time since test began

Count of ES and SES since test began

DOCSIS® Testing – Levels, MER & BER

Verify proper receive level at cable modem
Should be seeing: 0dBmV

Pass/Fail Indicator:



MER shows that downstream is clean and clear with margin

BER shows that downstream is clean and clear of impulse noise

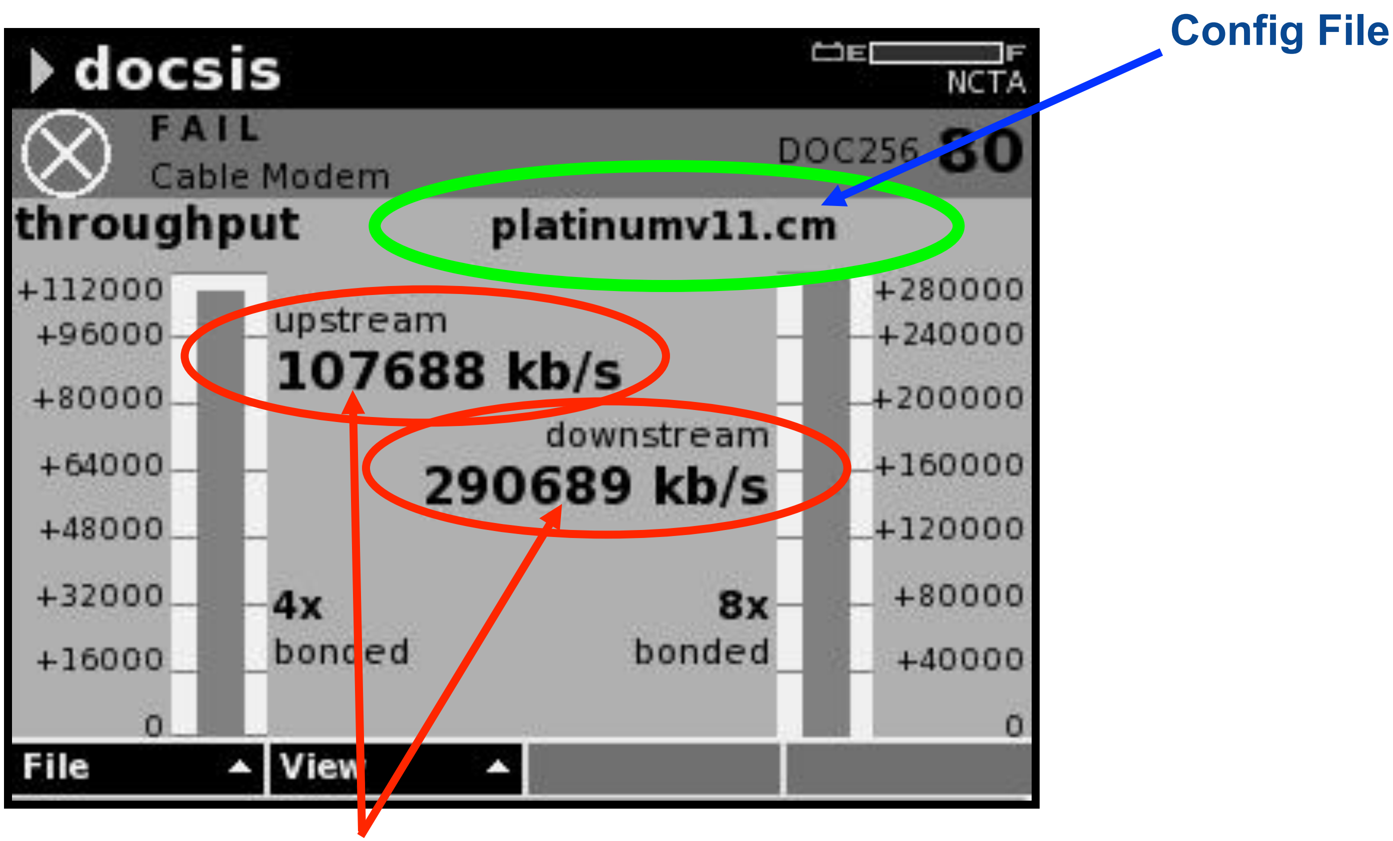
Downstream Information Frequency, Modulation type, Channel

Upstream Frequency, Modulation type, Channel BW, DOCSIS version

Shows that upstream is properly aligned and CMTS has "ideal" receive level with margin to spare. Recommend: (45dBmV – 50dBmV)

DOCSIS® – Throughput Testing

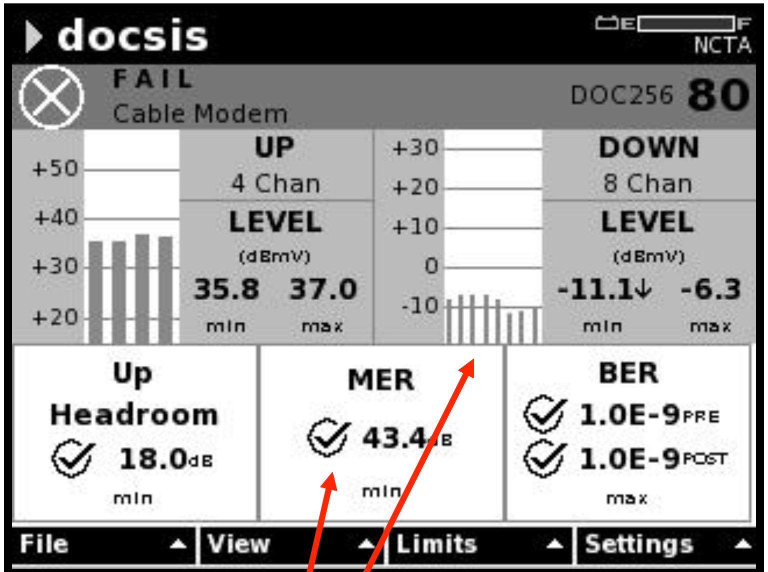
Check Throughput for proper speeds



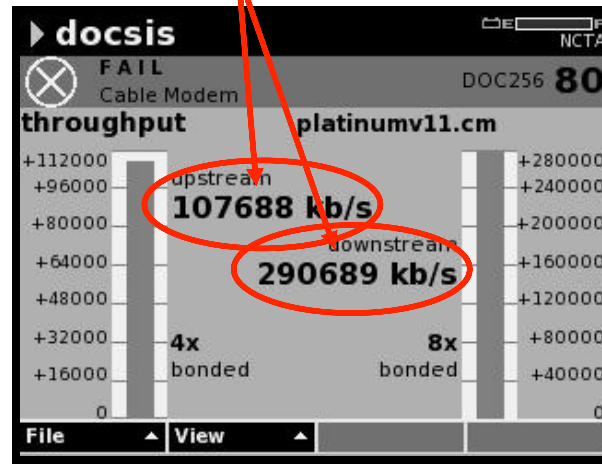
DSAM tests at full DOCSIS 3.0 speeds

Ensure customer can get what they pay for

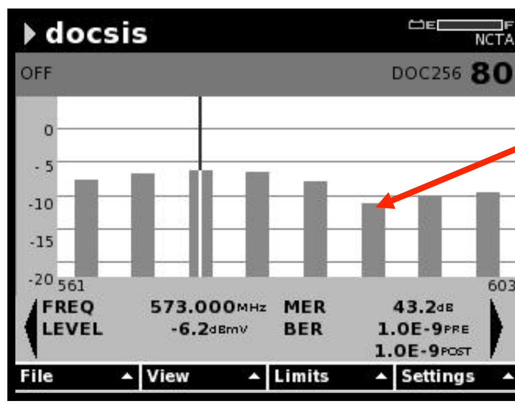
DOCSIS® 3.0 Bonded Carrier Testing



Verify full DOCSIS 3.0 bonded speeds

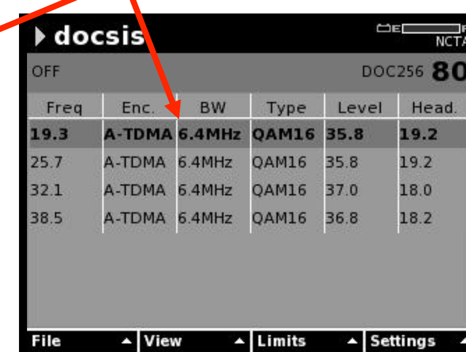


Summary view quickly identifies overall performance



Example of downstream graph view

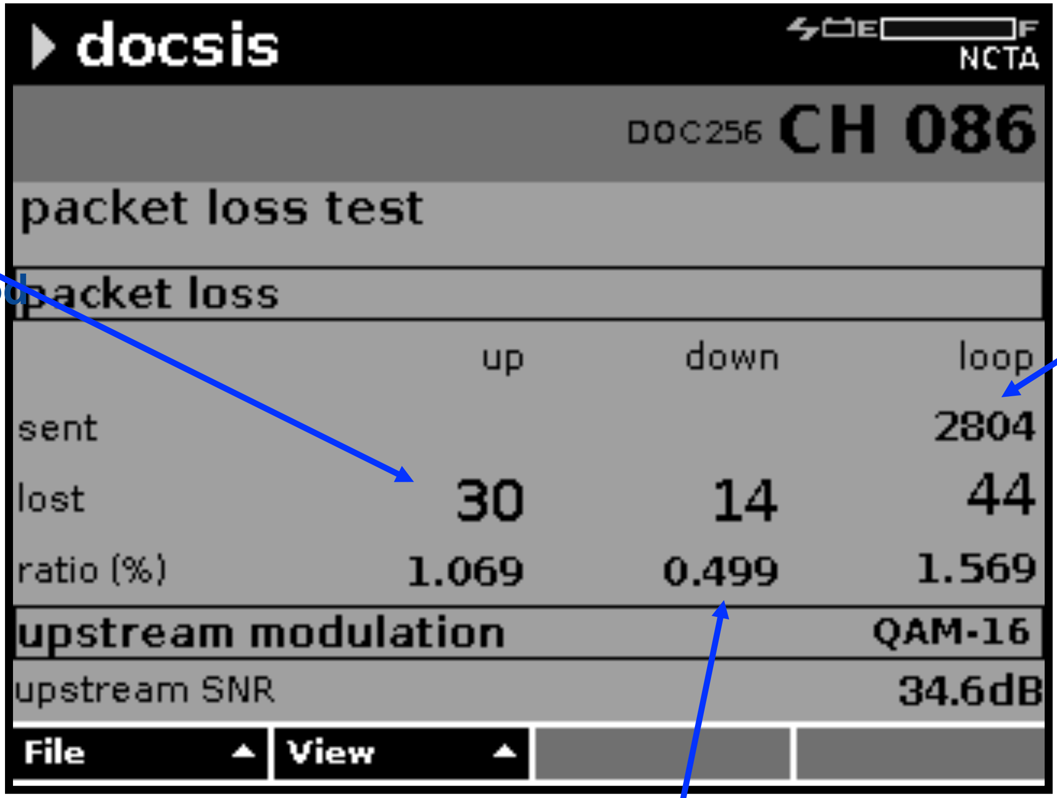
Drill down to see performance details of each individual QAM channel



Example of upstream table view

DOCSIS® – Packet Loss Testing

Check Packet Loss and determine if upstream is good



Overall loop information, Upstream & Downstreams

View Downstream performance

Upstream Signal to Noise Ratio

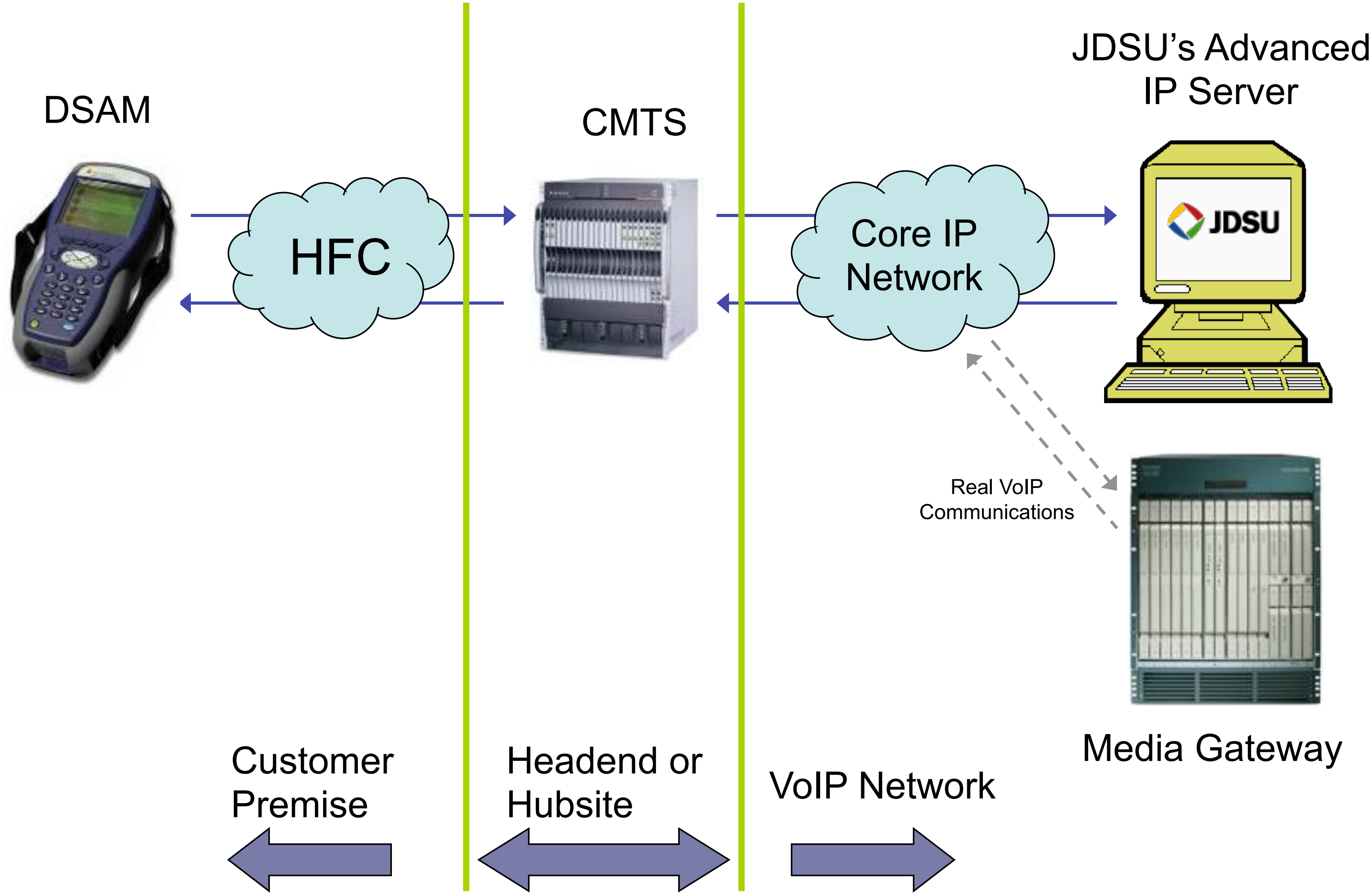
DOCSIS® VoIPCheck Testing

Test network performance with RTP packets

- Uses RTP packets instead of Internet Control Message Protocol (ICMP) messages (Ping messages)
- CMTS won't discard test messages returning incorrect test results
- DOCSIS data testing for:
  - Throughput
  - Packet Loss

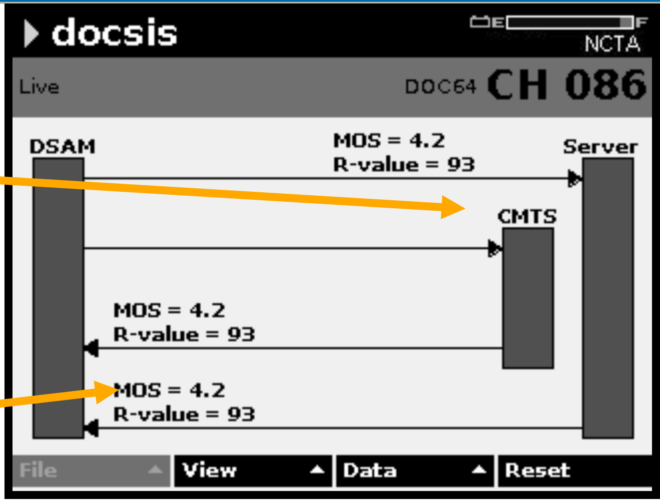
  Ping test still uses Ping messages

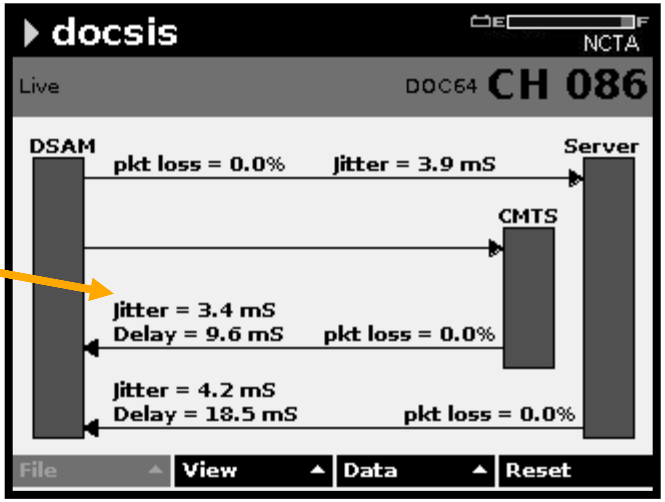
VoIPCheck™ Diagram – Segmentation Screen



VoIP Testing over DOCSIS®

- Segment HFC and IP impairments
  - Identify if issues are occurring in HFC Plant or in the IP network
- Quick quality (MOS) verification of VoIP over DOCSIS channel
- Good to check VoIP packet statistics
  - Noise and Ingress on plant are major causes of Packet Loss





VoIPCheck™ over DOCSIS®

- HFC Performance
  - Packet Statistics
    - Packet loss
    - Delay
    - Jitter
  - VoIP Quality
    - MOS
    - R-Value
  - Test Result Totals
    - Current
    - Min
    - Max
    - Average

VoIP check parameters (jitter buffer, codec, etc.) can be adjusted to match parameters of deployed MTA's