“Best Practices for Proactively Monitoring and Maintaining Your Return Paths”

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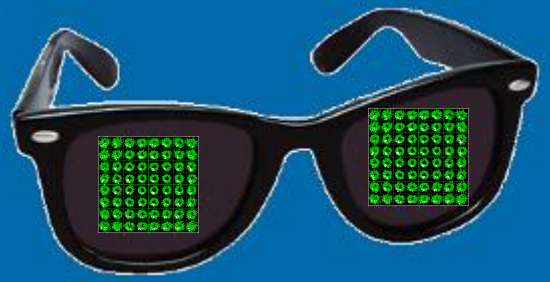


See digital in a whole new light!

Global Leaders in the Markets We Serve

Advanced Optical Technologies

Currency, Defense, Authentication, and Instrumentation

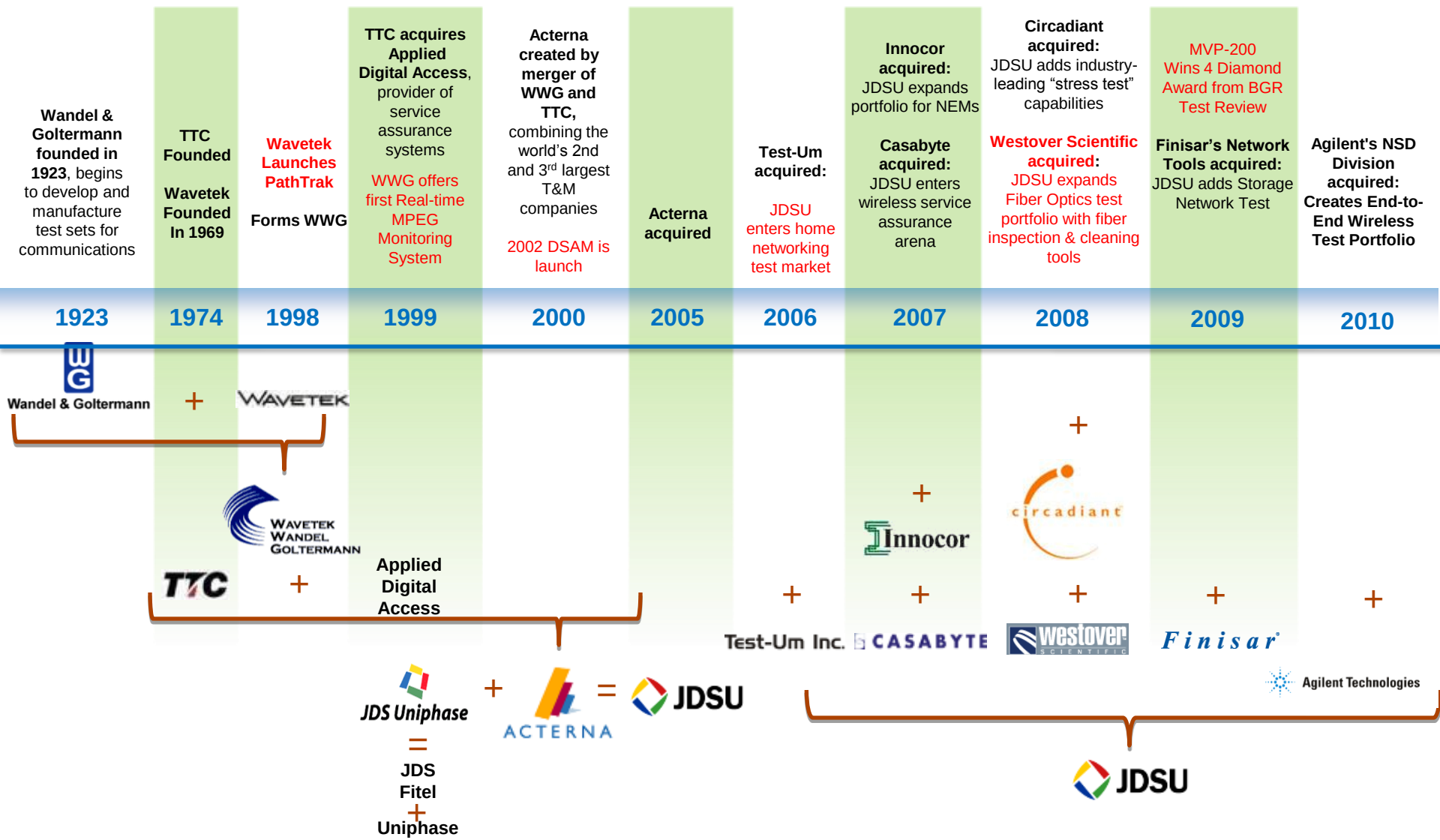
Communications & Commercial Optical Products

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

Communications Test & Measurement

Service Provider, Government, Business, and Home Networks

87 Years of Experience in Test & Measurement



Bandwidth Demand is Growing Exponentially!

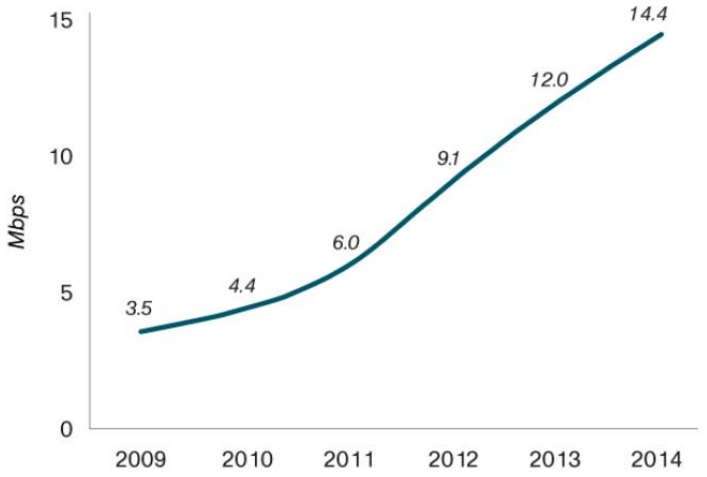
Market Trends => More content to More devices

	Country/ Region	Q4 09 Unique IPs	QoQ Change	YoY Change
-	Global	465,019,509	4.7%	16%
1	United States	124,953,865	4.5%	11%
2	China	52,113,869	6.2%	27%
3	Japan	32,259,547	1.9%	12%
4	Germany	30,912,466	3.9%	10%
5	France	21,477,486	2.8%	16%
6	United Kingdom	20,008,664	3.2%	11%
7	South Korea	16,108,106	5.3%	7.7%
8	Canada	11,402,213	1.6%	4.8%
9	Spain	10,822,929	3.9%	12%
10	Brazil	10,779,132	-0.3%	18%

Figure 4: Unique IP Addresses Seen By Akamai

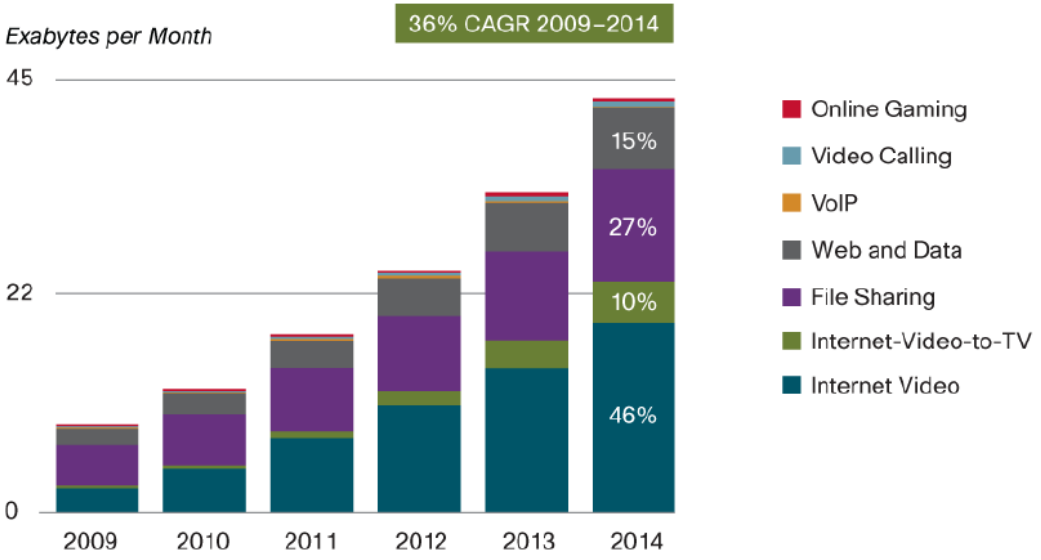
- **IP devices growing**
- **Average broadband speed will quadruple by 2014**
- **IP Traffic consumption will quadruple by 2014 (60% will be video traffic)**

Figure 5. Average Global Broadband Speed Will Quadruple to Reach 14.4 Mbps in 2014



Source: Cisco VNI, 2010

Figure 2. Cisco VNI Global Consumer Internet Traffic Forecast

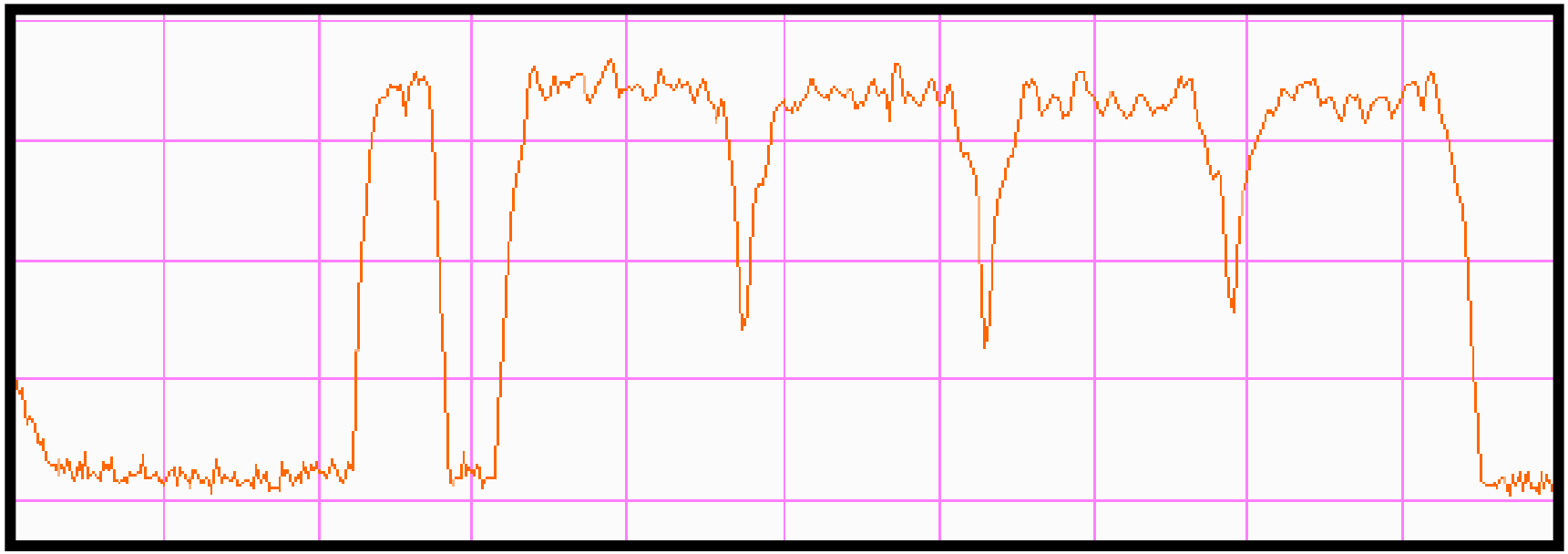


Source: Cisco VNI, 2010

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 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, group delay, micro-reflections and other linear distortions
- Inability to avoid problem frequencies such as Citizens' Band, Ham, Shortwave and CPD distortion beats
- Where are you going to place your sweep points?

Today's Agenda

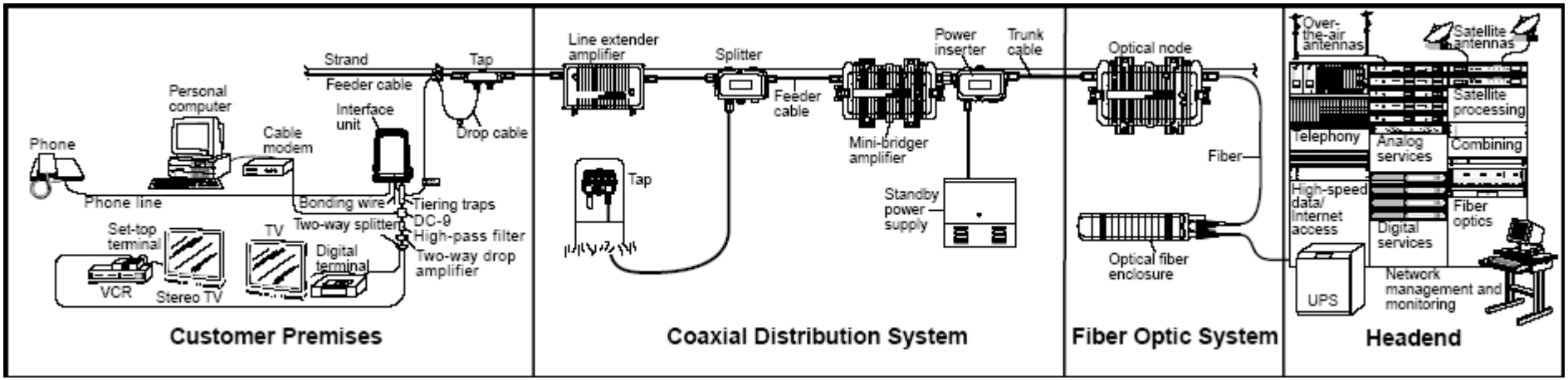
- **Getting ready for DOCSIS 3.0 - Optimize Your HFC network now!**
  - **Verify optimal setup and performance (dynamic range) of both Optical & RF portion of the HFC network**
  - Forward & Reverse sweep for unity gain throughout coaxial network
  - Monitoring the Return Path
- **Troubleshooting Upstream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

Major Operational Challenges

- **Plant Certification and Maintenance:**
  - Elevate plant performance to ensure reliable service
  - HFC: Sweep & advanced return path certification
  - Metro Optical: Fiber and transport analysis
- **Monitor Performance:**
  - Continuously monitor the health of your upstream and downstream carriers
  - Proactively identify developing problems before customers do
  - Monitor both physical HFC & VoIP service call quality
  - Utilize advanced performance trending and analysis to prioritize
- **Get Installations Right the First Time**
  - Improve installation practices to prevent service callbacks & churn
  - Verify physical, DOCSIS® and PacketCable™ performance
  - Drive consistency across all technicians
- **Troubleshoot Fast:**
  - When issues occur, find and fix fast
  - Isolate and segment from NOC, dispatch right tech at right time
  - Field test tools that can find problems and verify fix

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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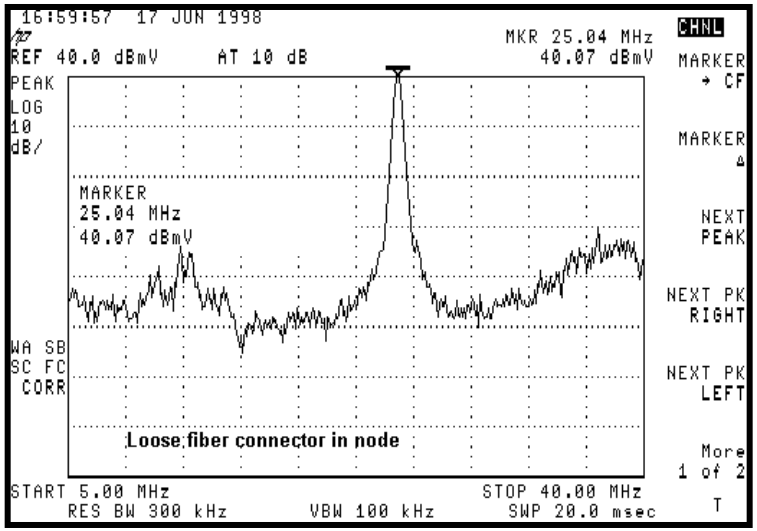
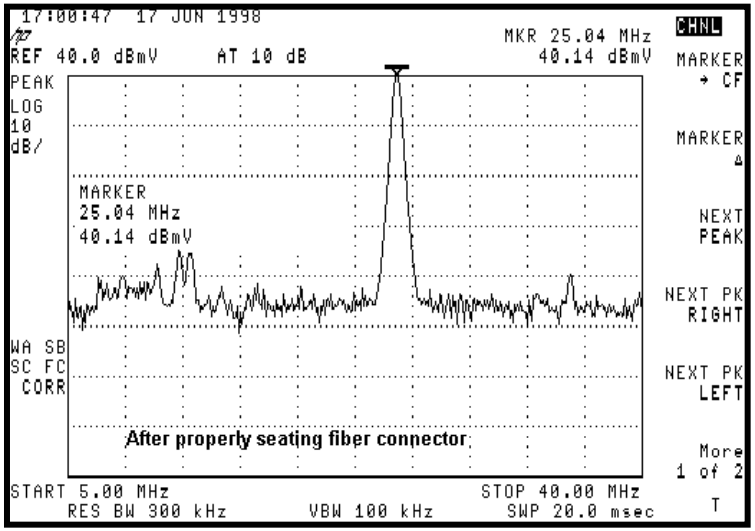
Loose Fiber Connector

- SC connector not pushed in all the way



Before

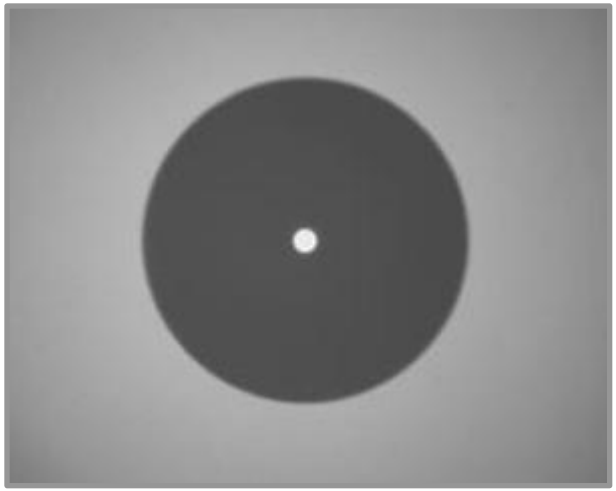


After

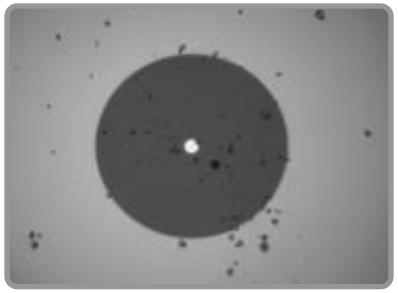
Types of Fiber Contamination

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

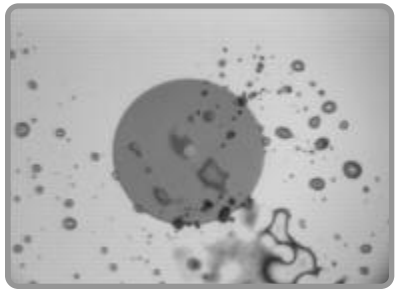
SINGLEMODE FIBER



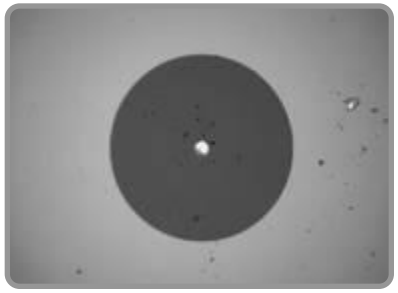
Common types of contamination and defects include the following:



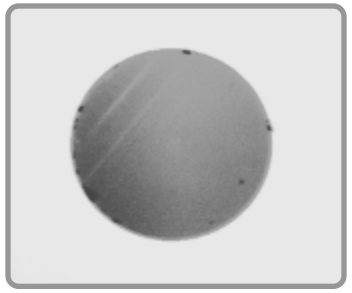
Dirt



Oil



Pits & Chips



Scratches

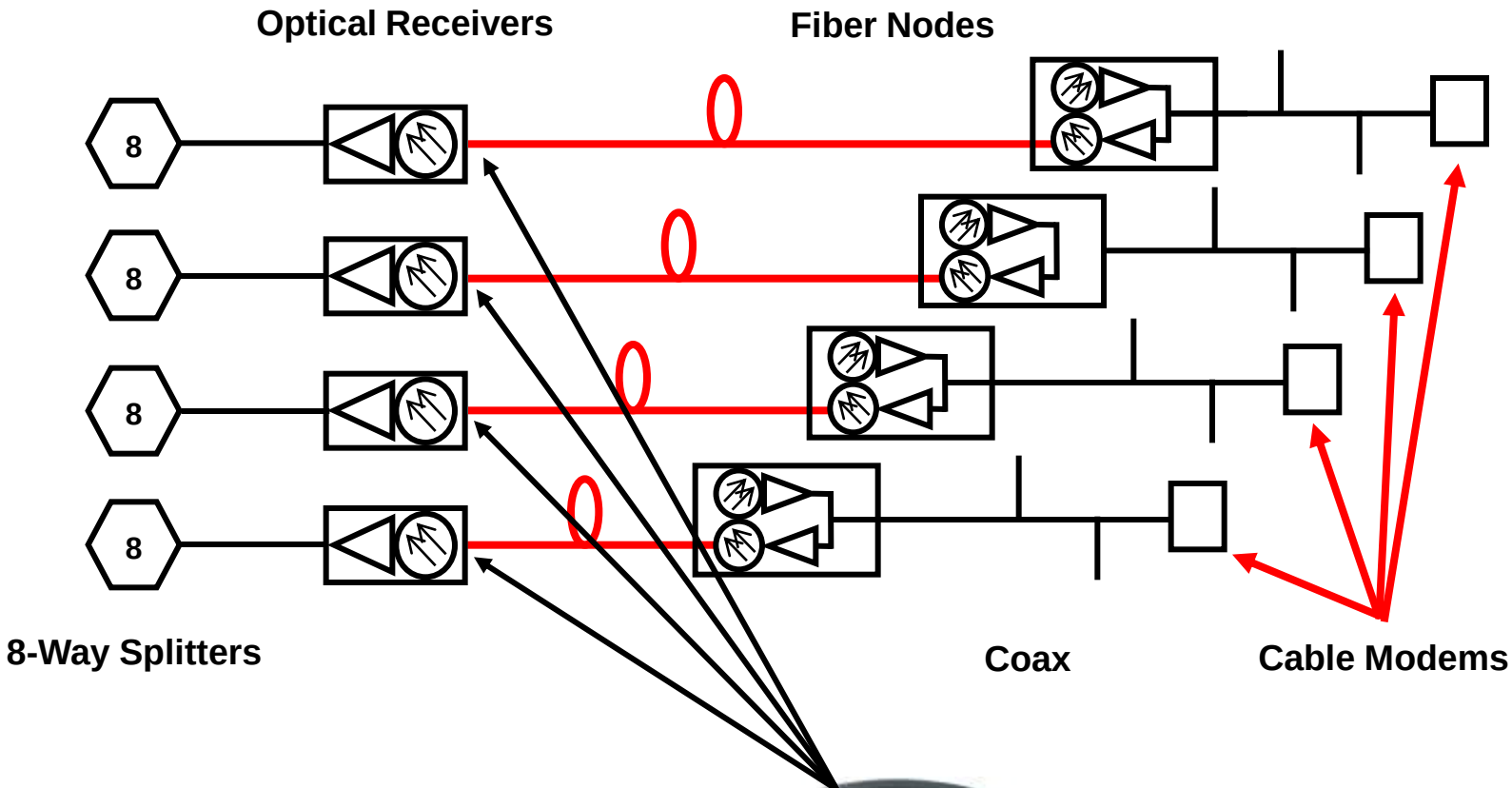
Where is it? – Everywhere

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.

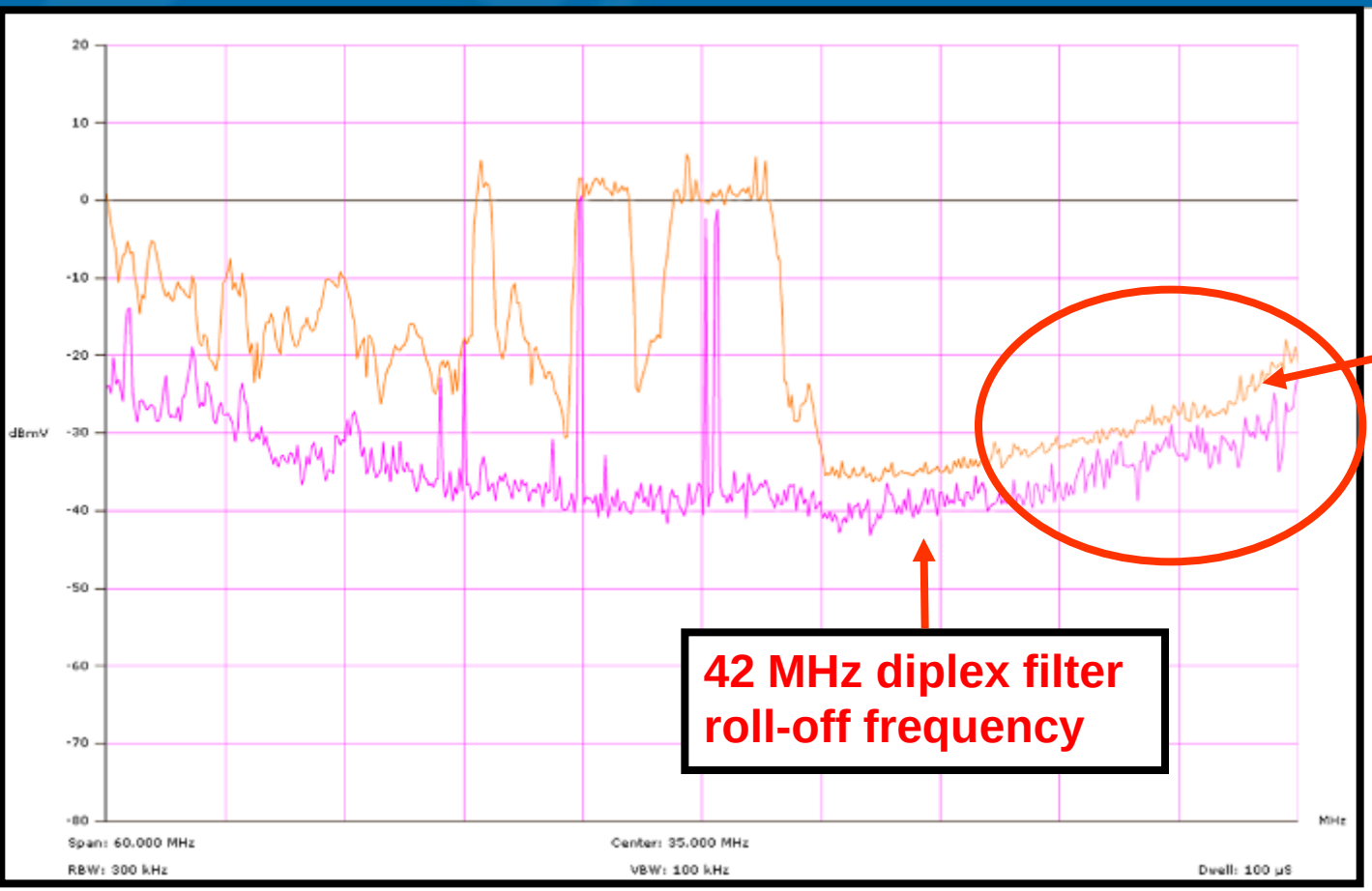
Optimize the Optical Links in Your HFC Networks!



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

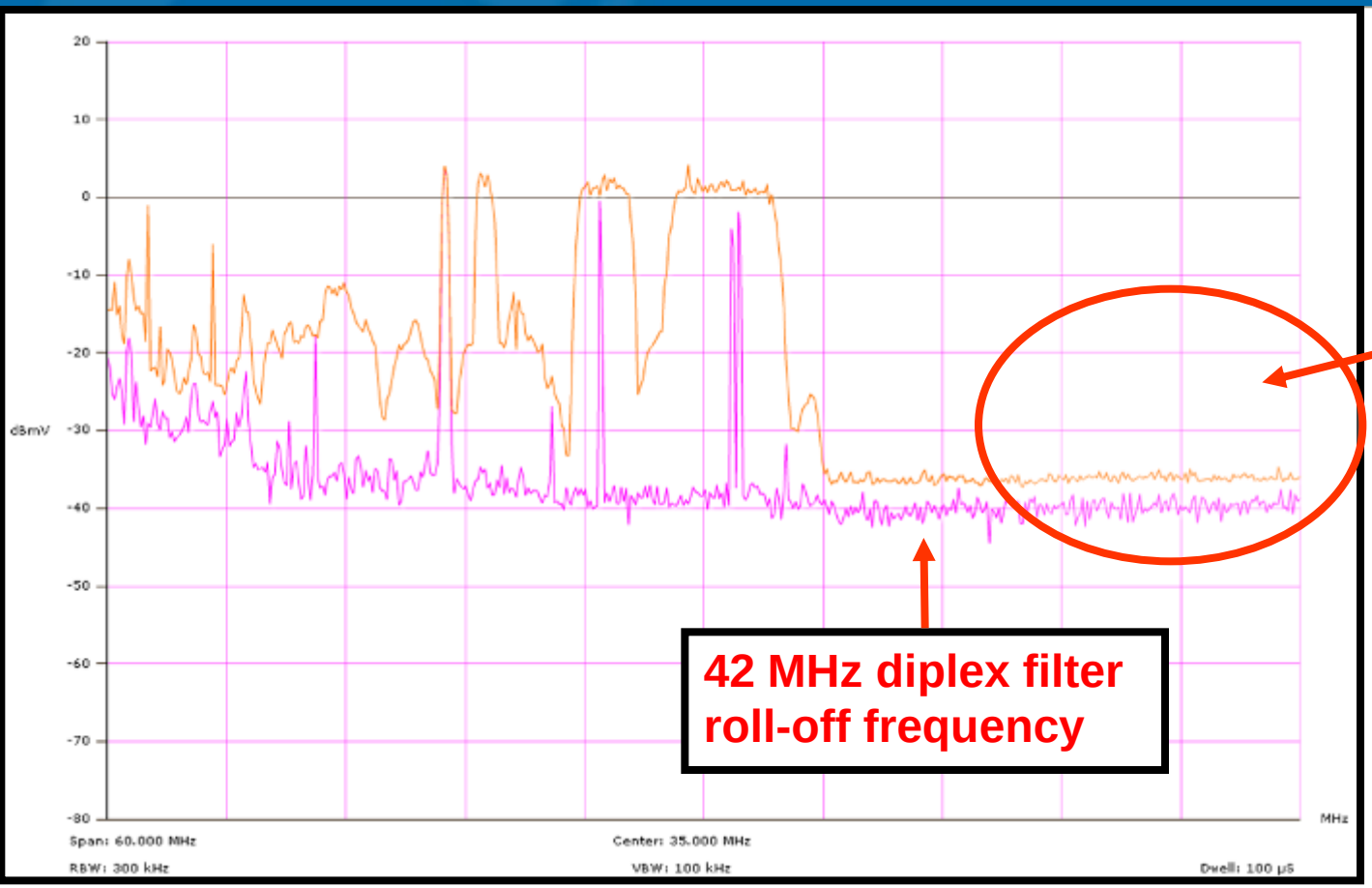
Verify that all fiber and RF connections are secure and properly seated!

Too Much Optical Power into Optical Receiver



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.

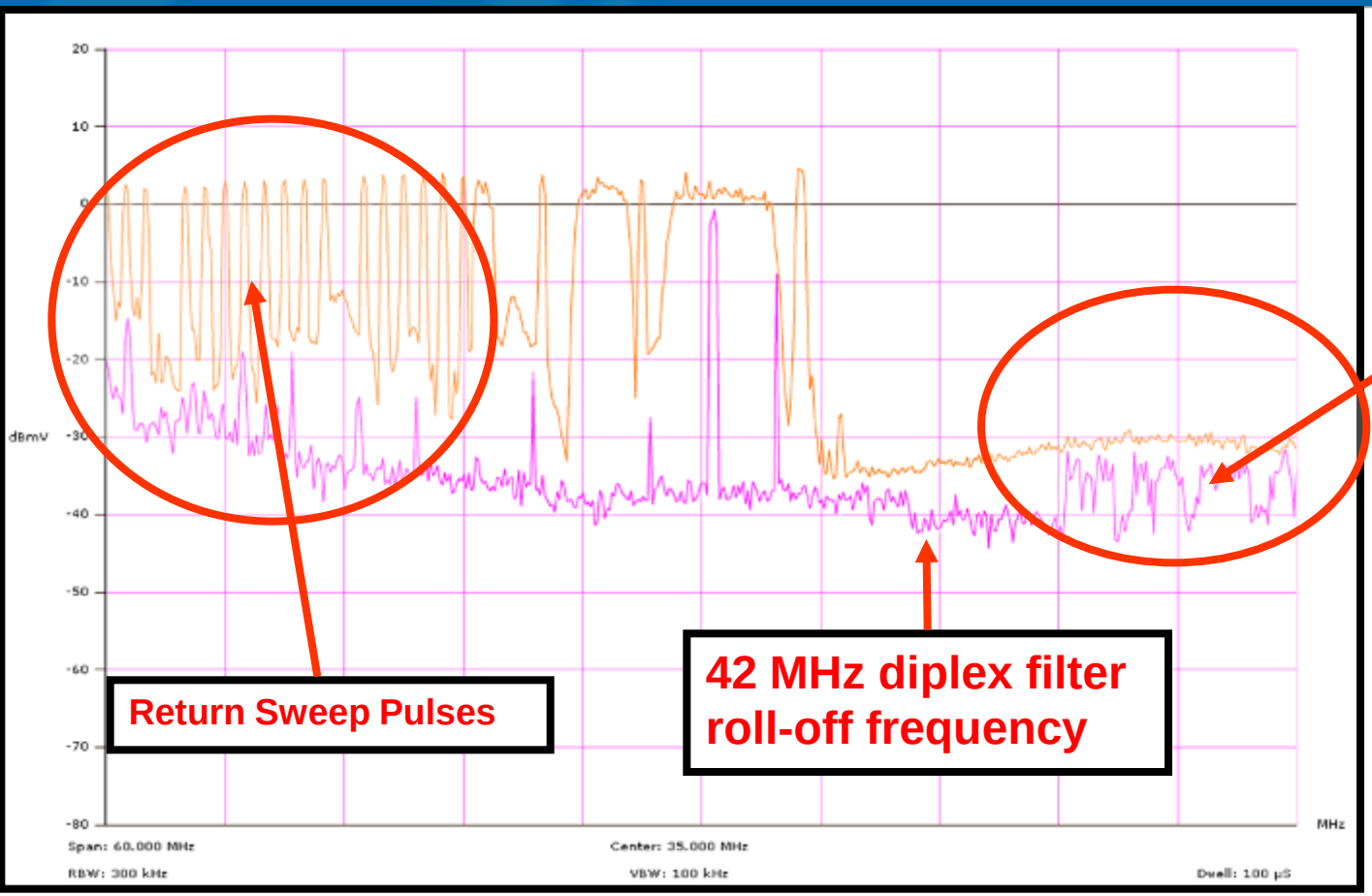
Too Much Optical Power into Optical Receiver



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.

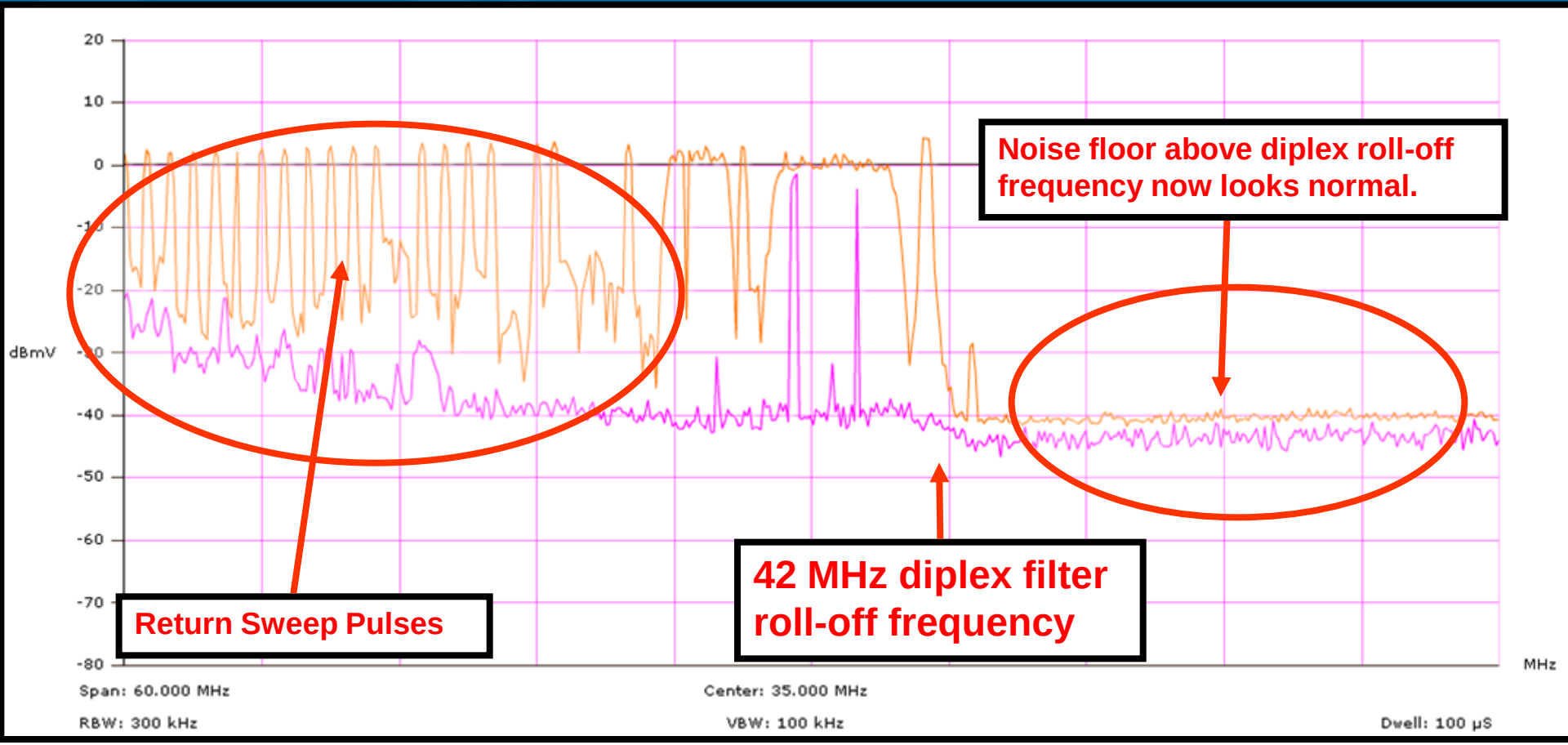
Too Much Optical Power into Optical Receiver



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.

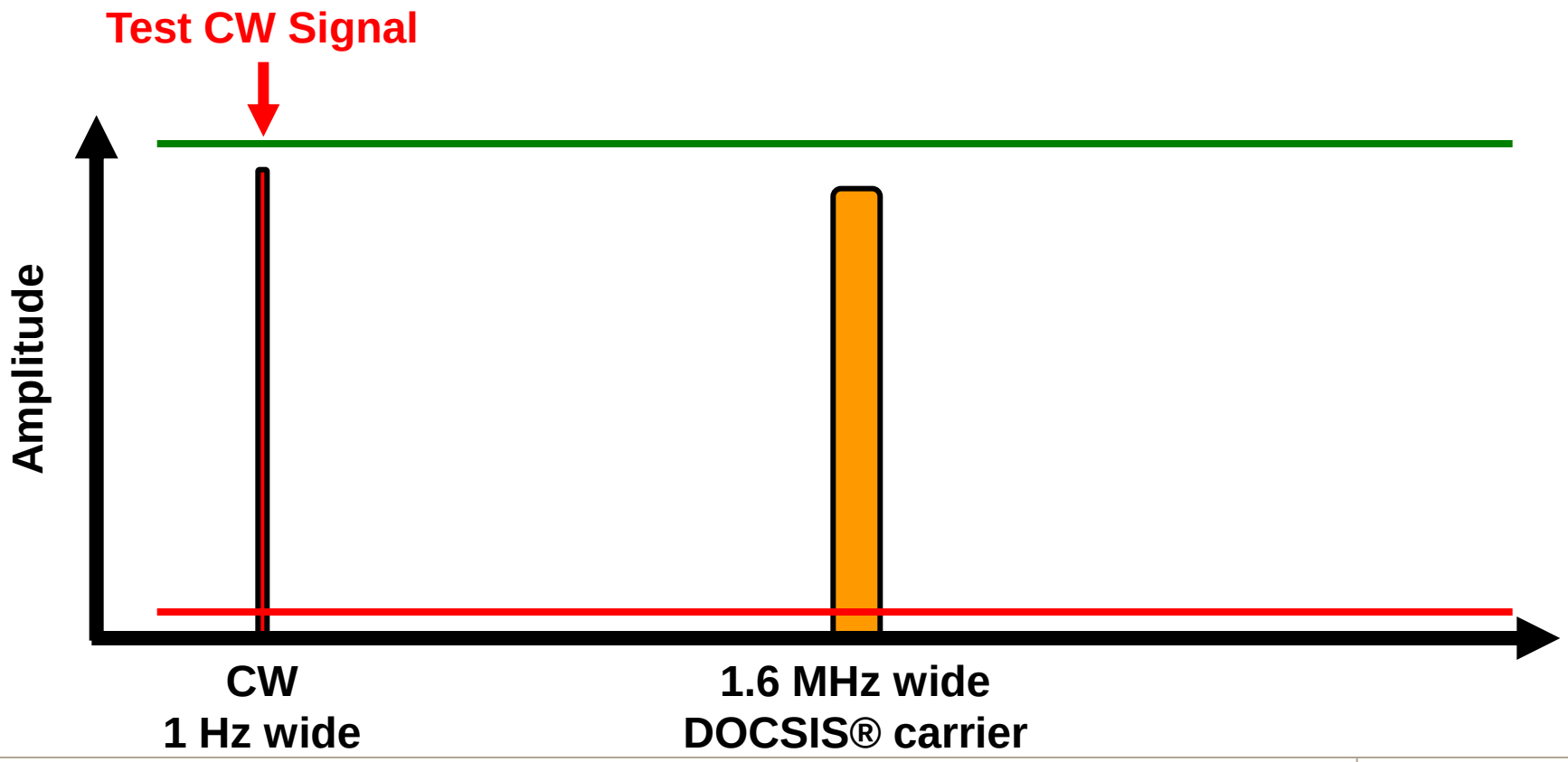
Setting the Transmitter “Window”

- RF input levels into a return laser determine the CNR of the return path.
  - Higher input – better CNR
  - Lower input – worse CNR
- Too much level and the laser ‘clips’.
- Too little level and the noise performance is inadequate
- Must find a balance, or, “set the window” the return laser must operate in
  - Not only with one carrier but all the energy that in in the return path.
  - The return laser does not see only one or two carriers it ‘sees’ the all of the energy (carriers) that in on the return path that is sent to it.

***Source - Cisco Systems, Inc.**

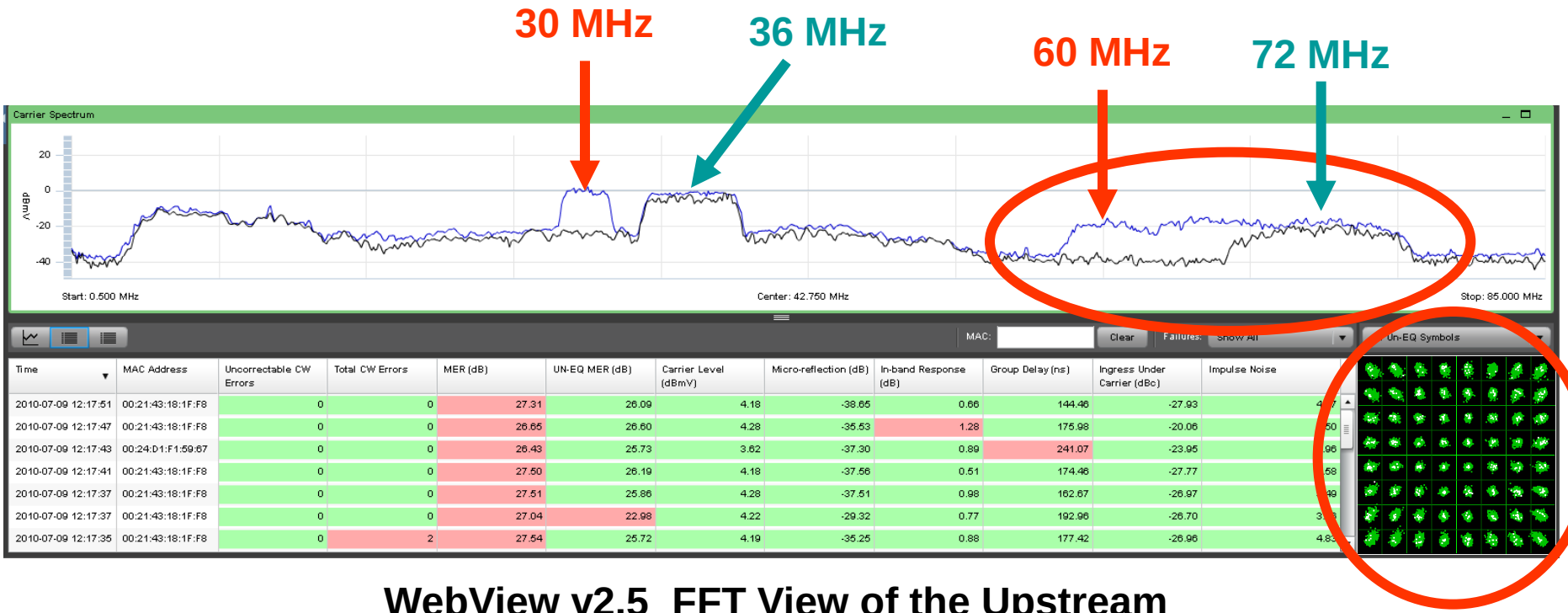
Measuring Upstream Carrier Amplitudes

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.



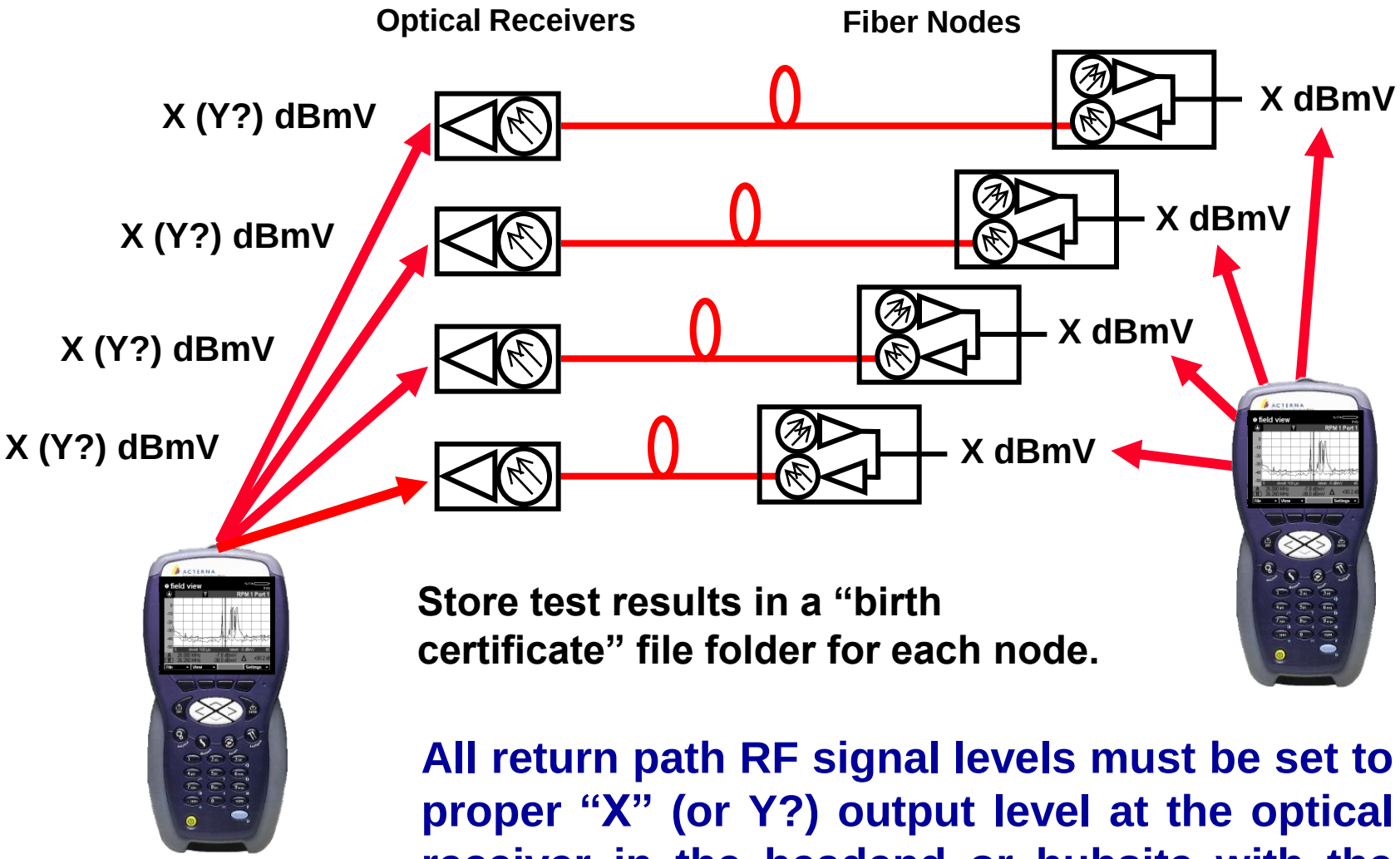
Optical Link is Critical to Upstream Performance

- 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



WebView v2.5 FFT View of the Upstream

Optimize the RF Output of the Optical Receiver

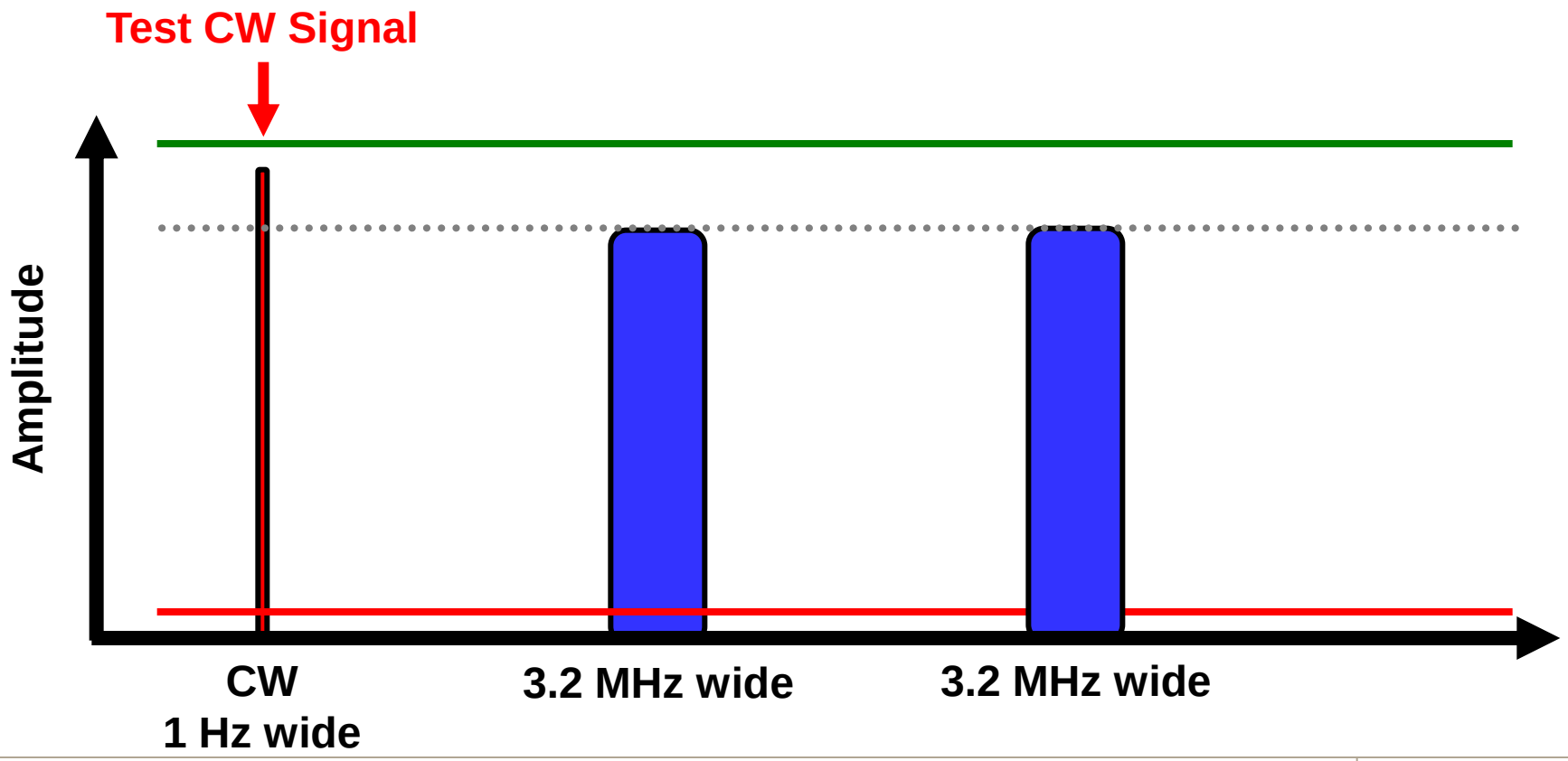


Store test results in a "birth certificate" file folder for each node.

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.

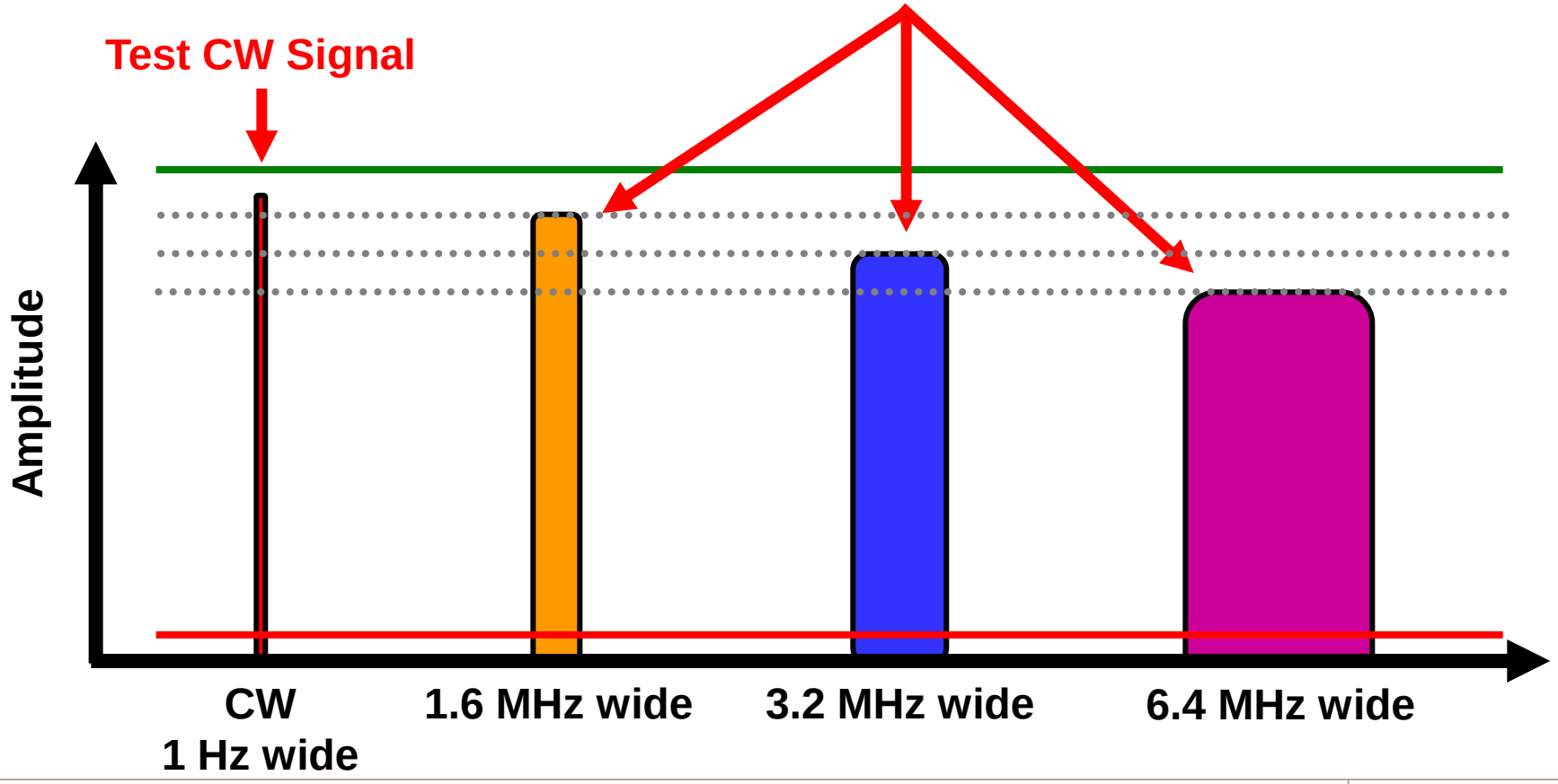
Measuring Upstream Carrier Amplitudes

These two DOCSIS® carriers will 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.

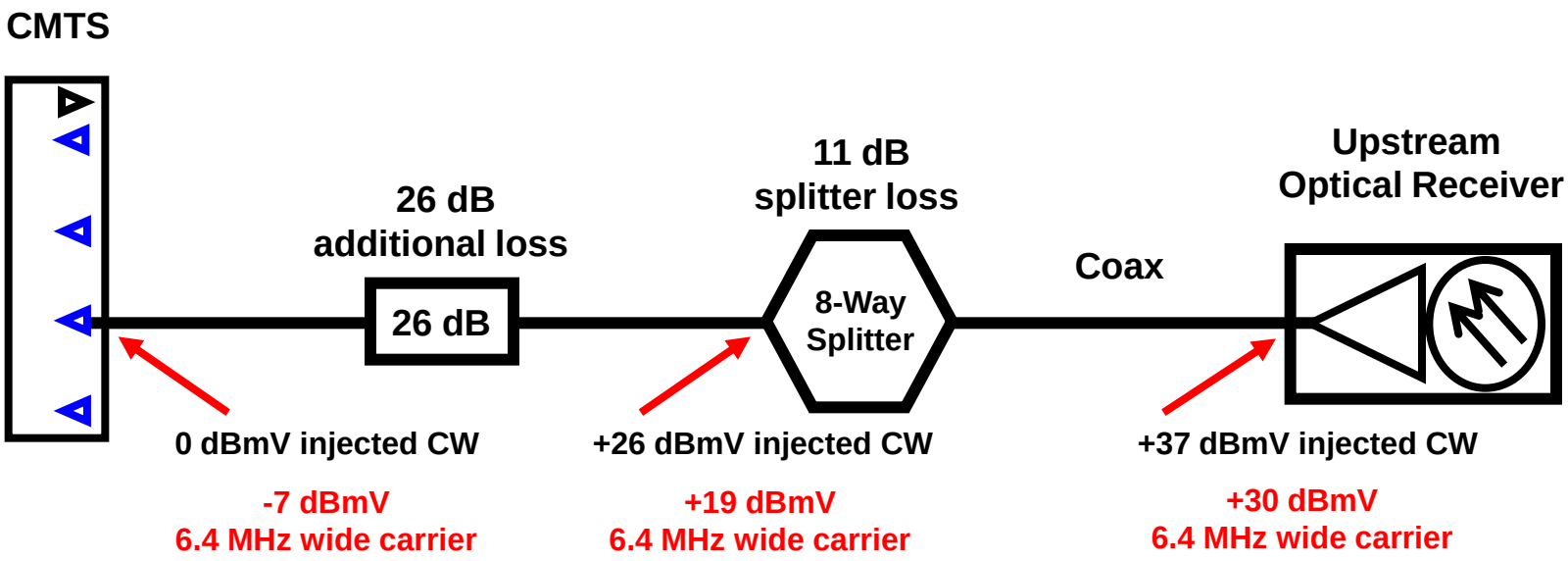


Measuring Upstream Carrier Amplitudes

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.



Optimize Dynamic Input Range of the CMTS



Example: Some systems will add 26 dB of external padding between the splitter and CMTS to attenuate the injected CW signal down to a **peak level** of 0 dBmV at the input port of the CMTS. The CMTS is typically configured to instruct the 6.4 MHz modem carriers to hit the input port of the CMTS at 0 dBmV "**constant power per carrier**".

Monitoring and Maintaining the Return Path

- **Getting ready for DOCSIS 3.0 - Optimize Your HFC network now!**
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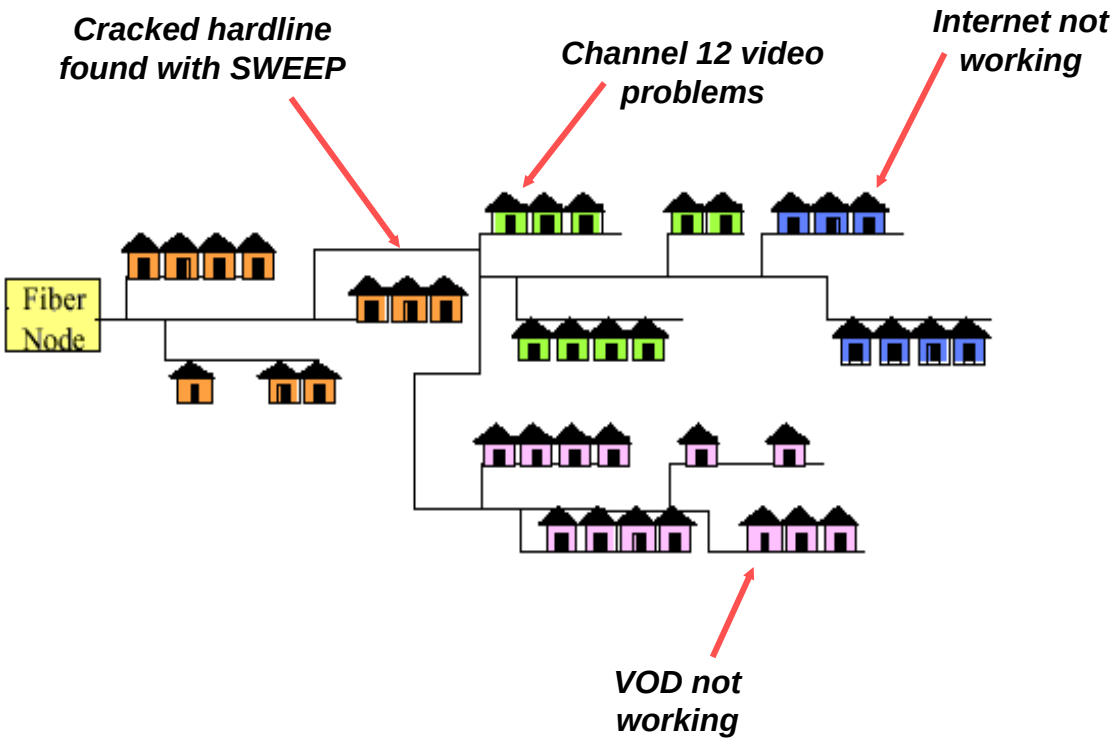
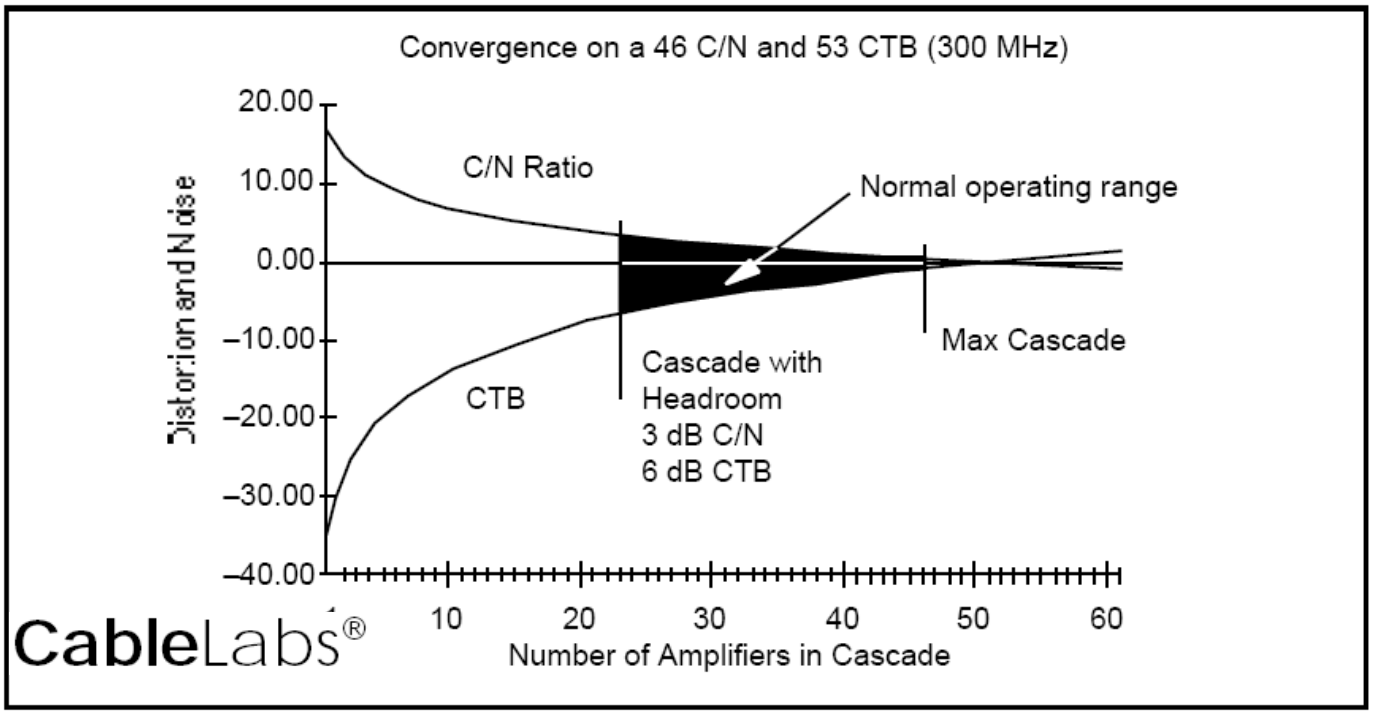
WHY SWEEP?

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



WHY SWEEP?



DISTORTIONS IN A CASCADE

- CATV amplifiers have a trade-off between noise and distortion performance
- Tightly controlling frequency response provides the best compromise between noise and distortion.

Sweep Verifies Construction Quality

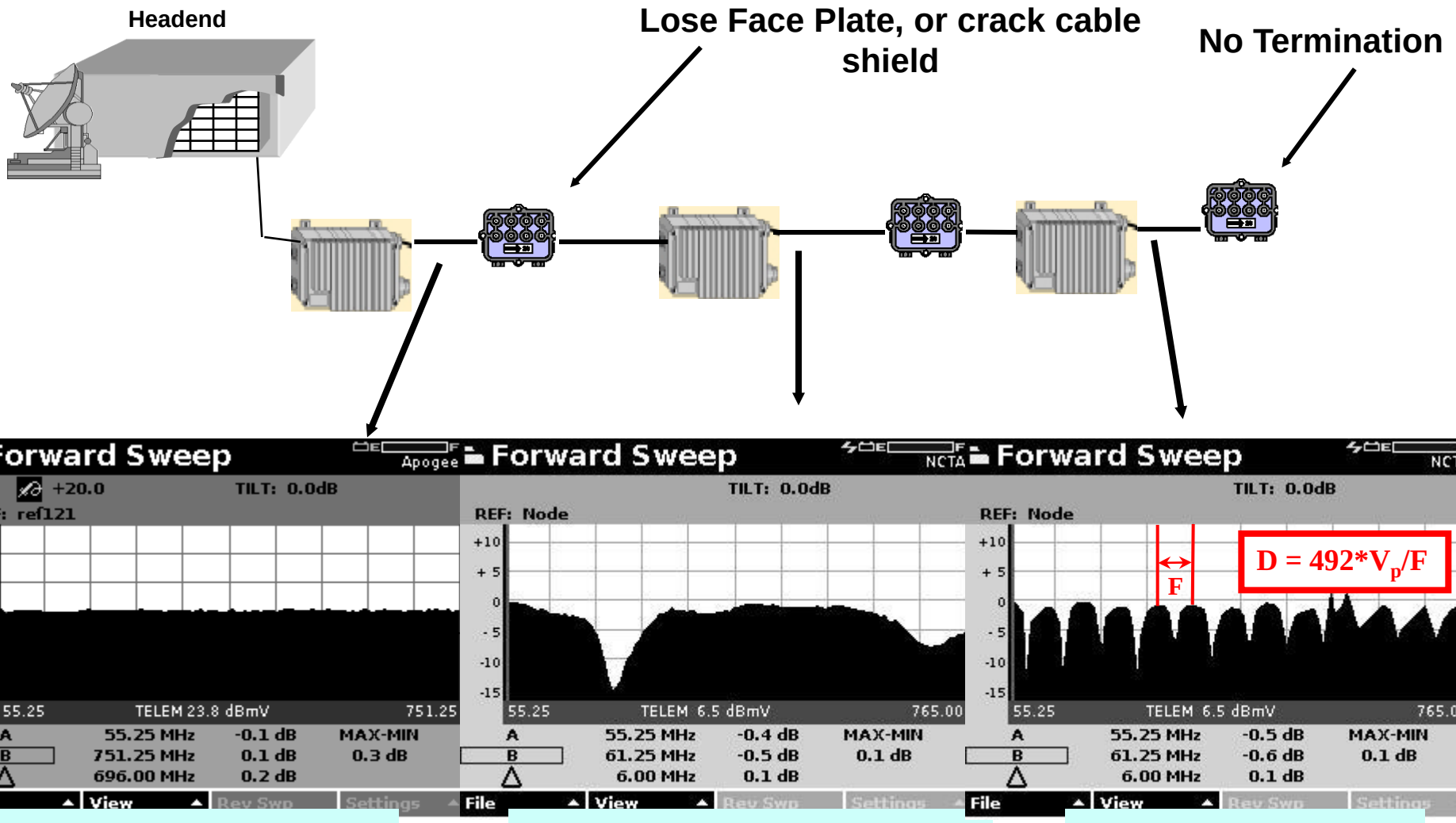
Sweep can find craftsmanship or component problems that aren't revealed with other tests

- 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 ingress and micro-reflection problems!

Balancing Amplifiers - Forward Sweep

Balancing amplifiers using tilt only



Node Reference Signal

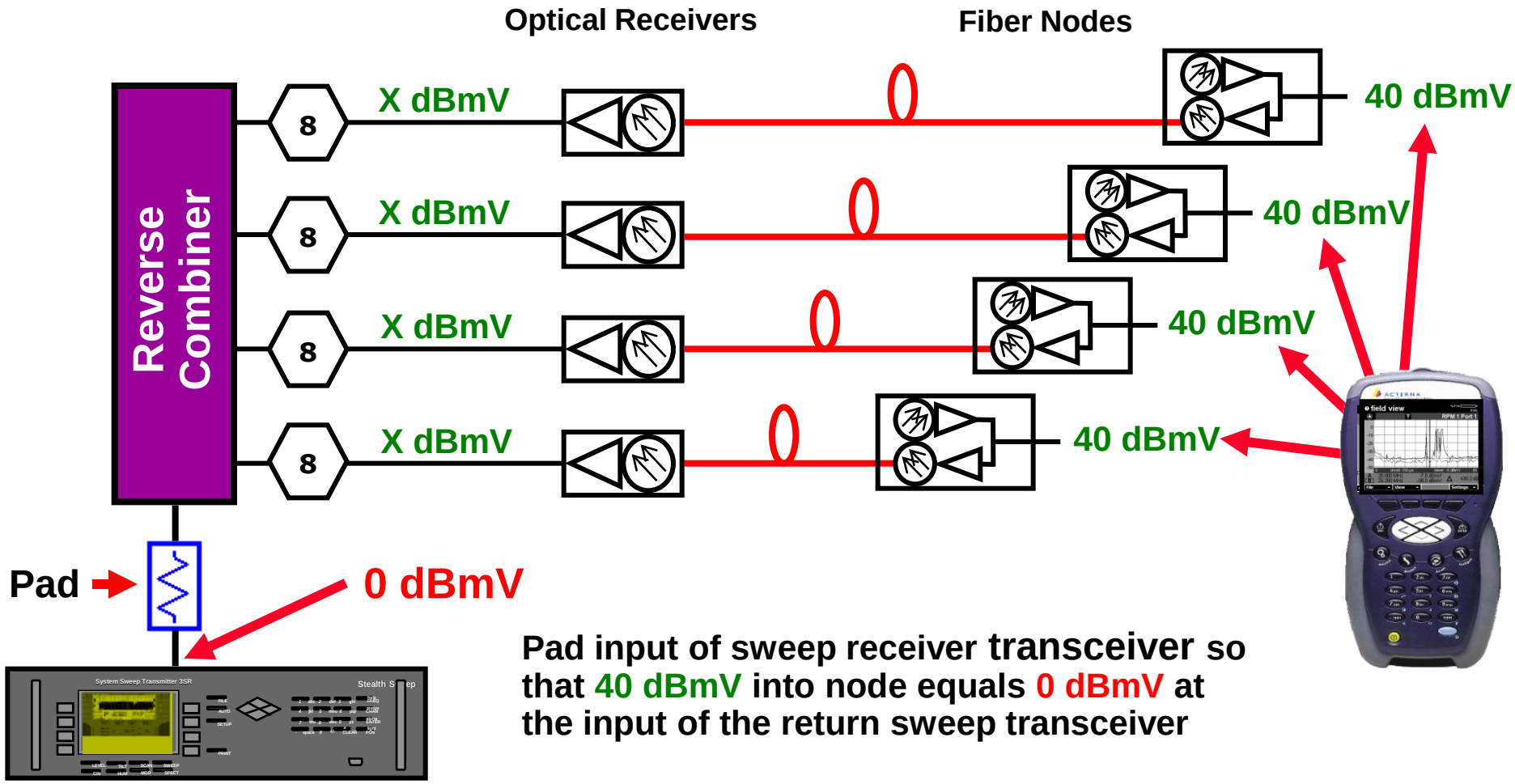
Sweep response with a Resonant Frequency Absorption (A.K.A. suckout)

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

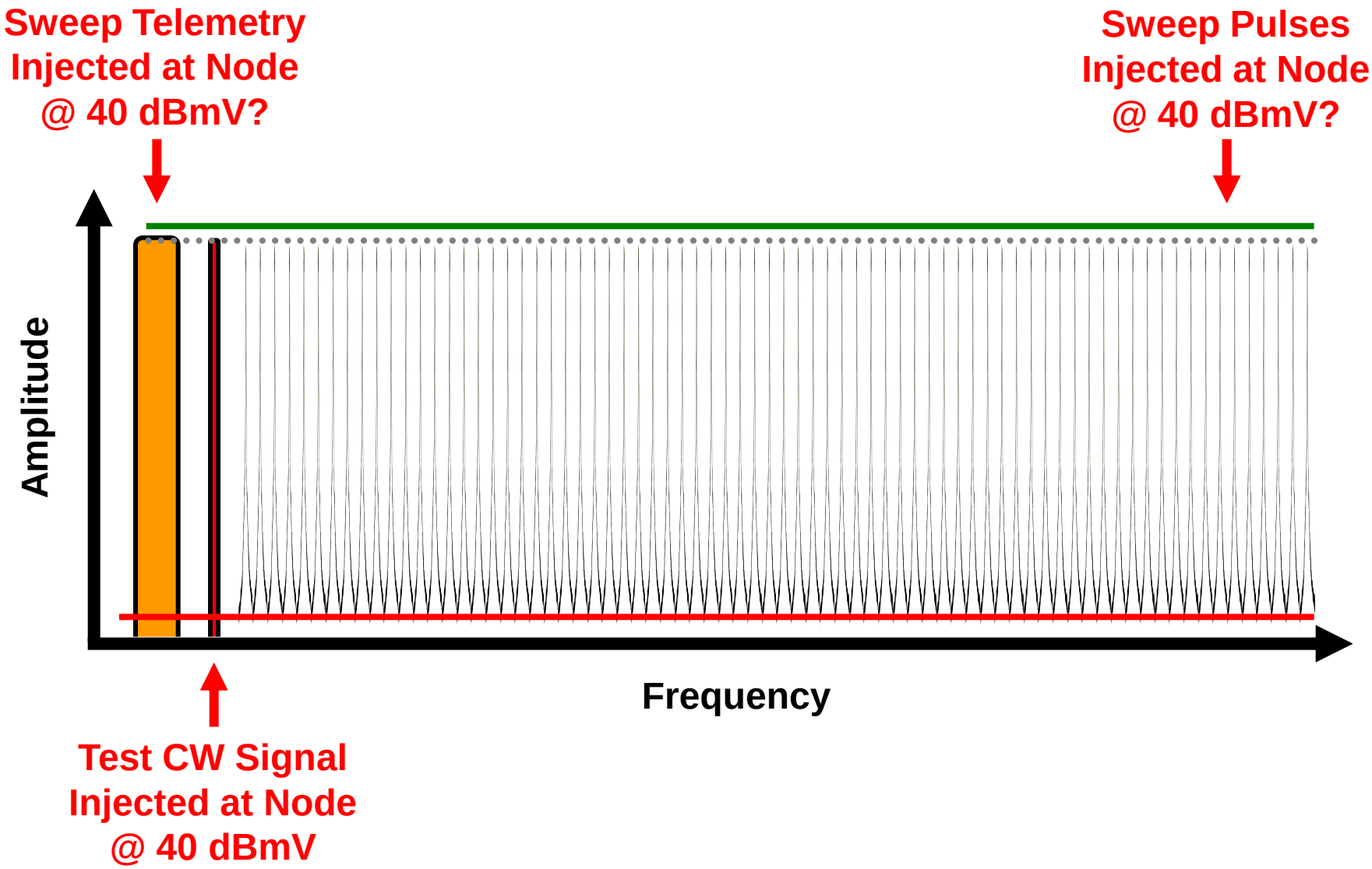
Optimize the RF Input to Return Sweep Transceiver



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

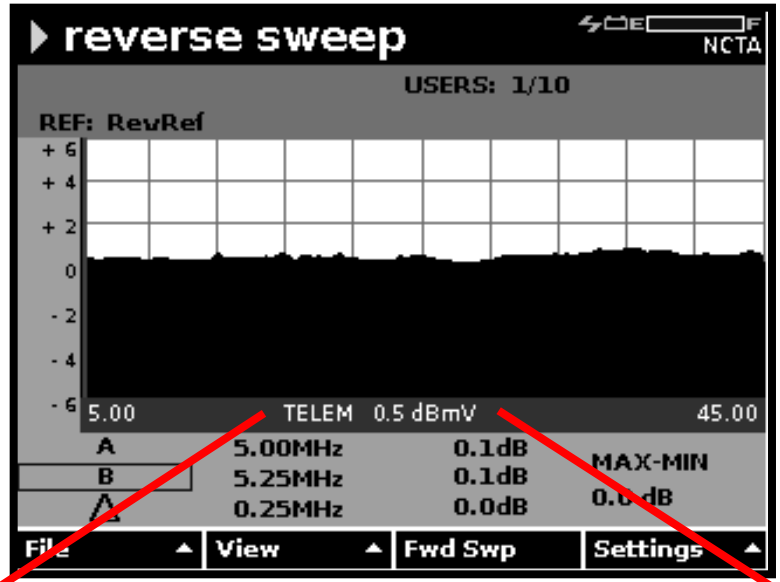
There are typically between 16 and 32 nodes combined together for return path sweeping

Stealth Sweep Pulses Compared to Carrier

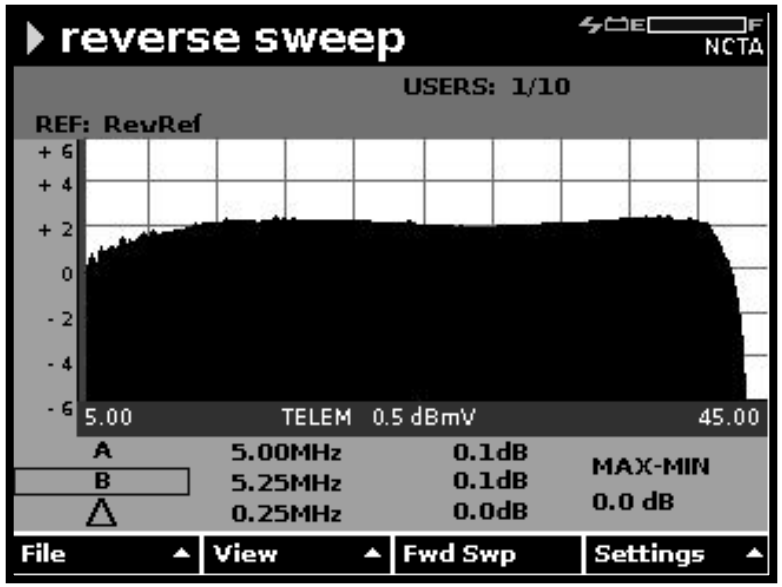


Balancing Amplifiers - Reverse Sweep

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



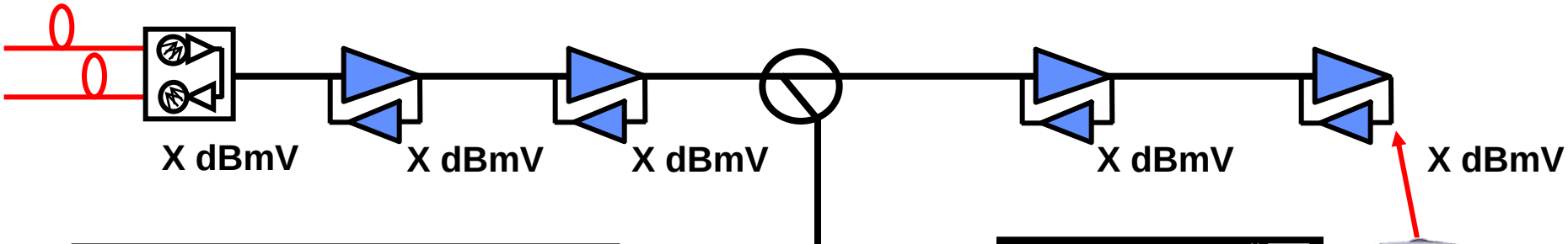
Telemetry level shown below return sweep trace should read around 0 dBmV if the SDA-5510 is padded properly

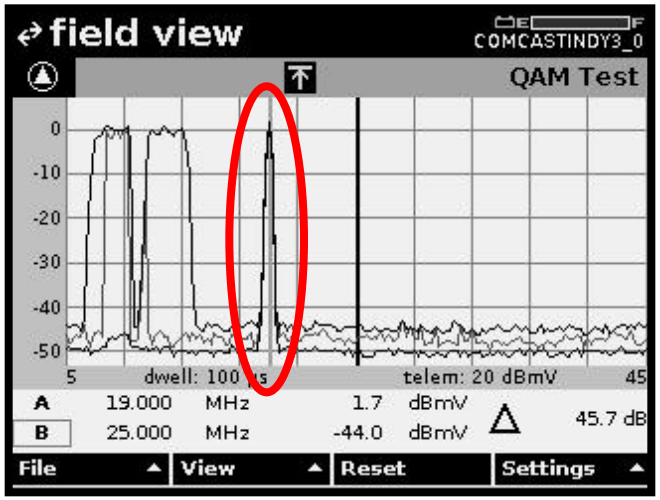


At next amp reverse sweep displays the effects of the network segment between the last amp and this one

Optimize the HFC Pipe for Unity Gain

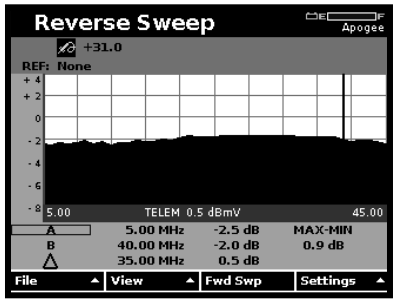
Maintain unity gain with constant inputs





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

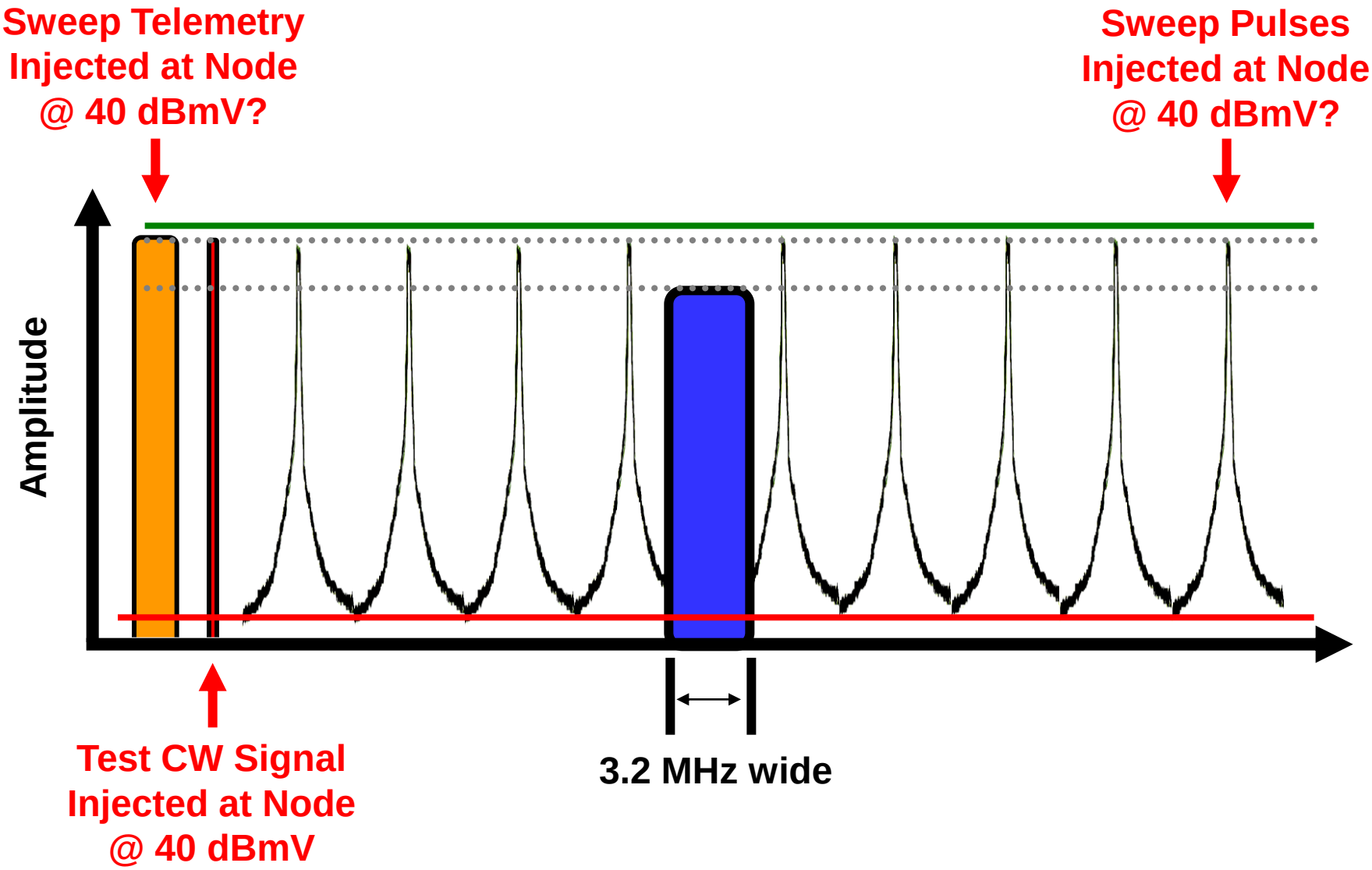
X dBmV



Telemetry = ~0 dBmV

Set TP Loss as required

Sweep Pulses Compared to Carrier



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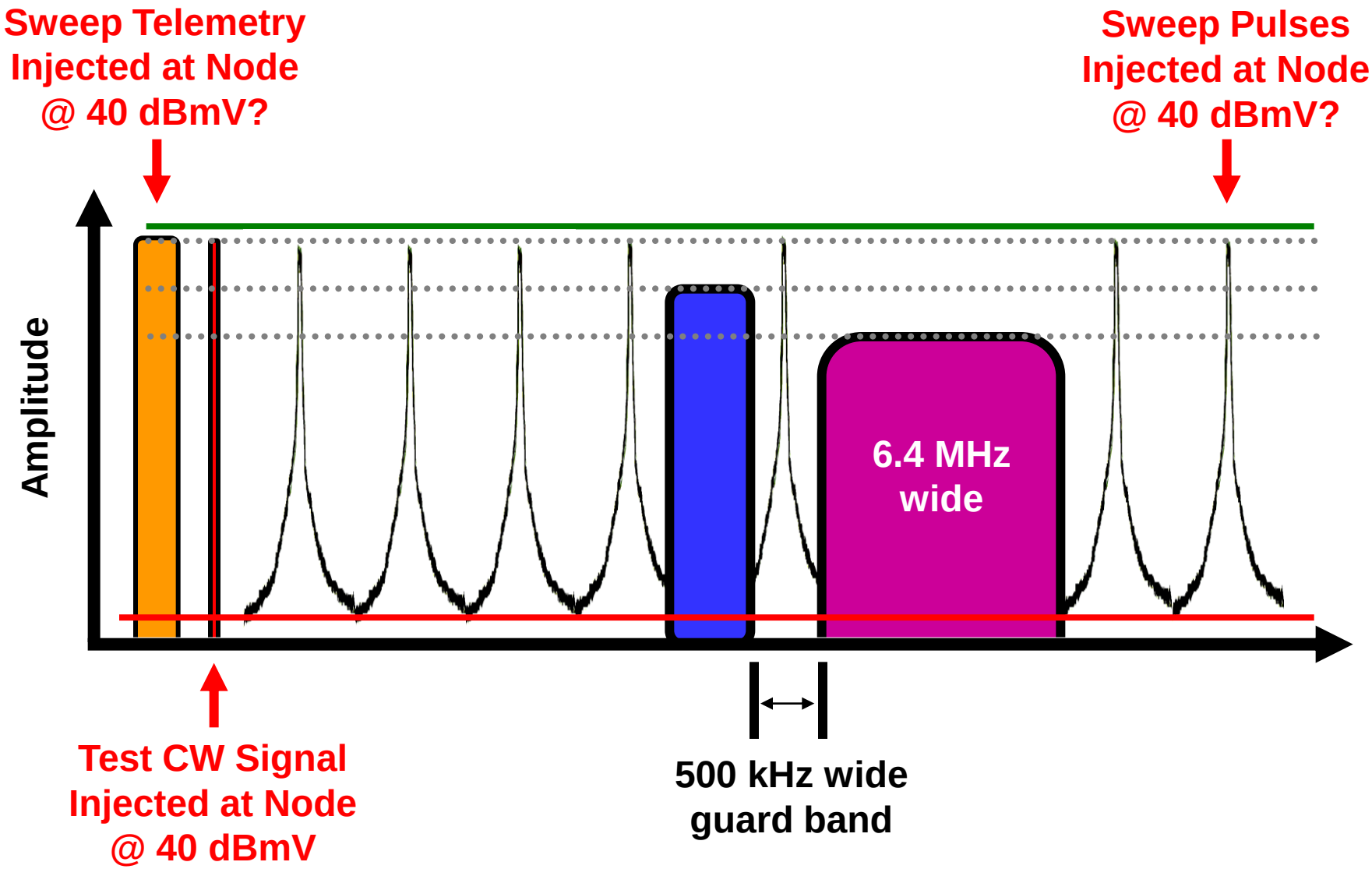

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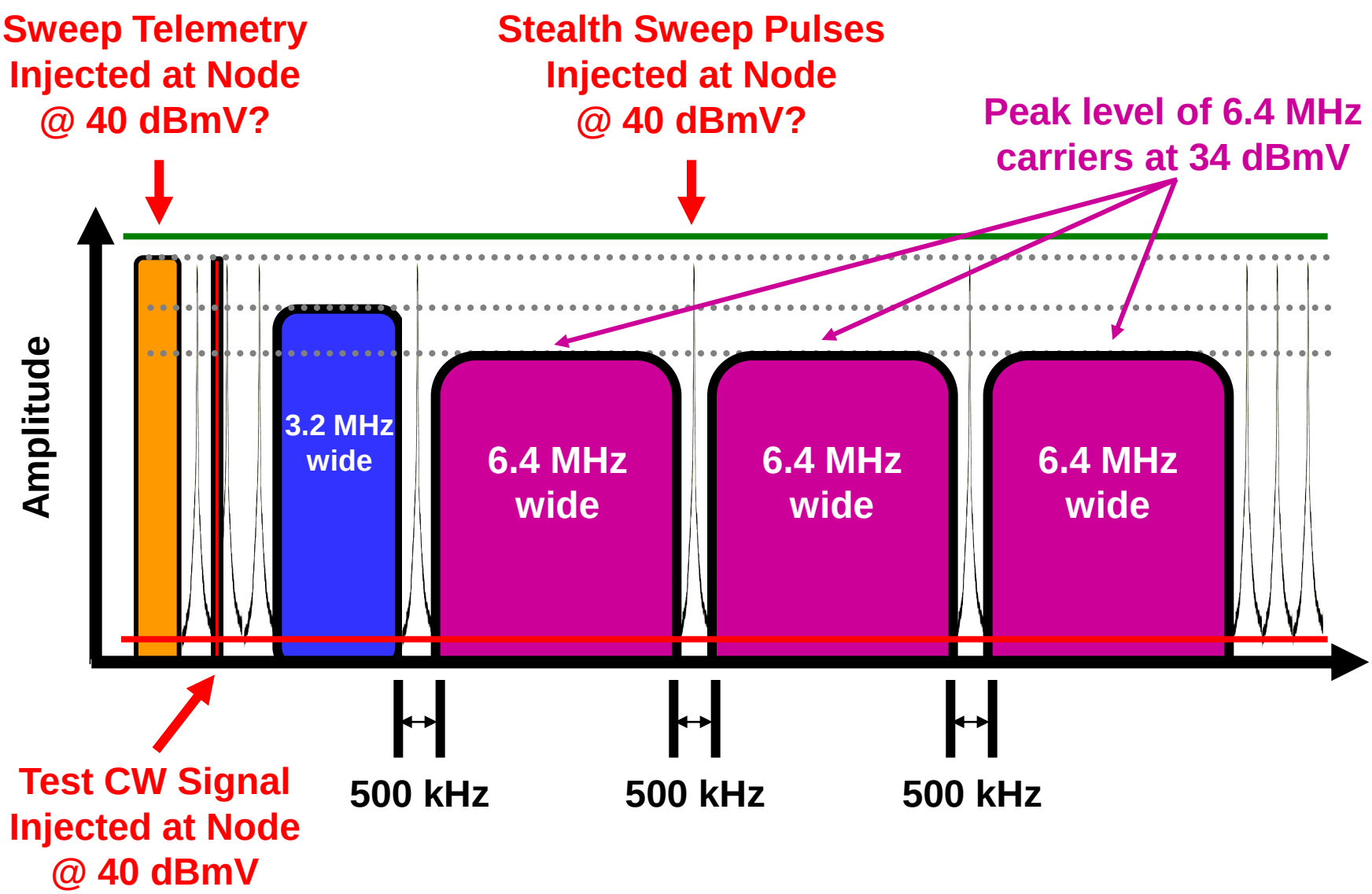
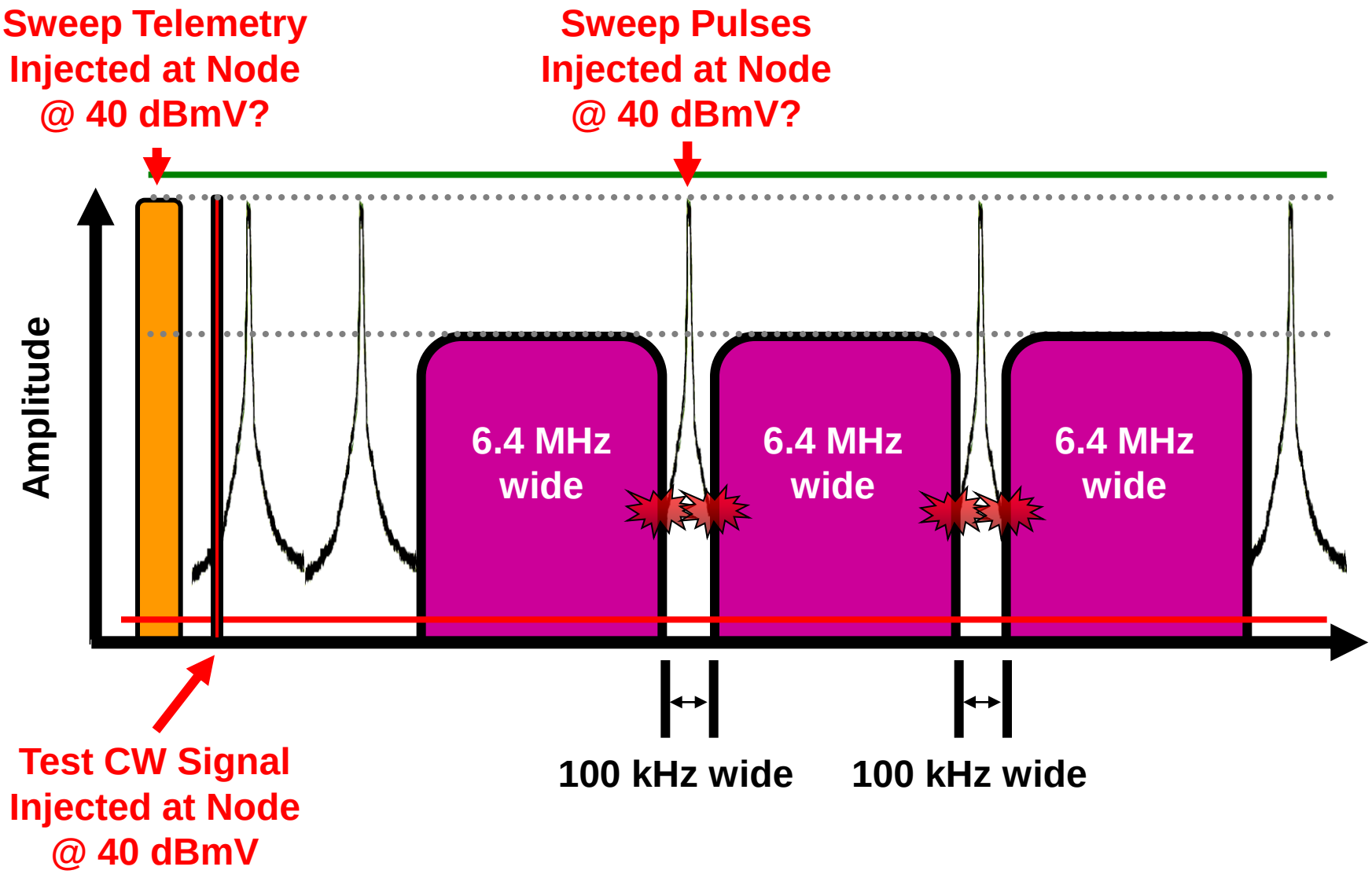
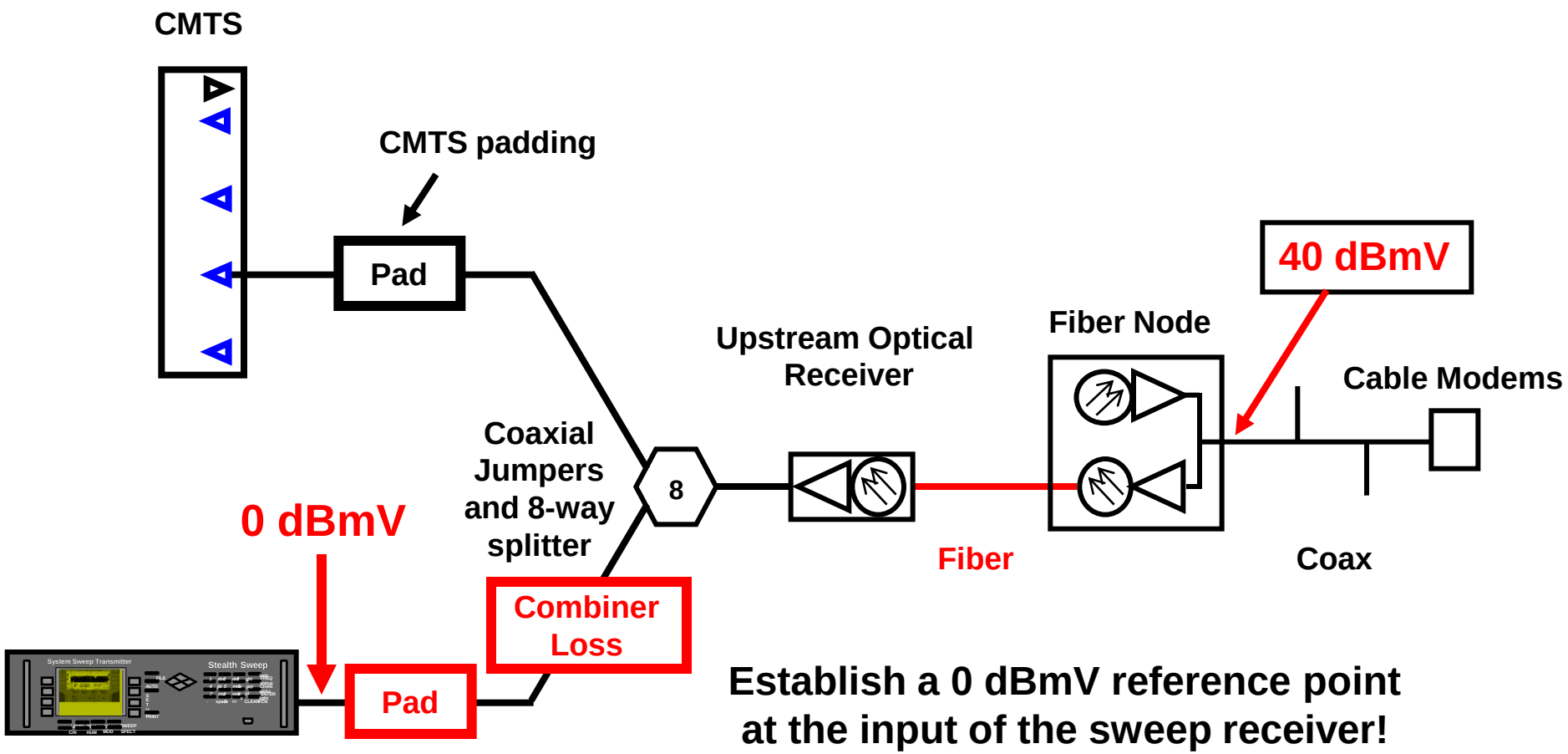


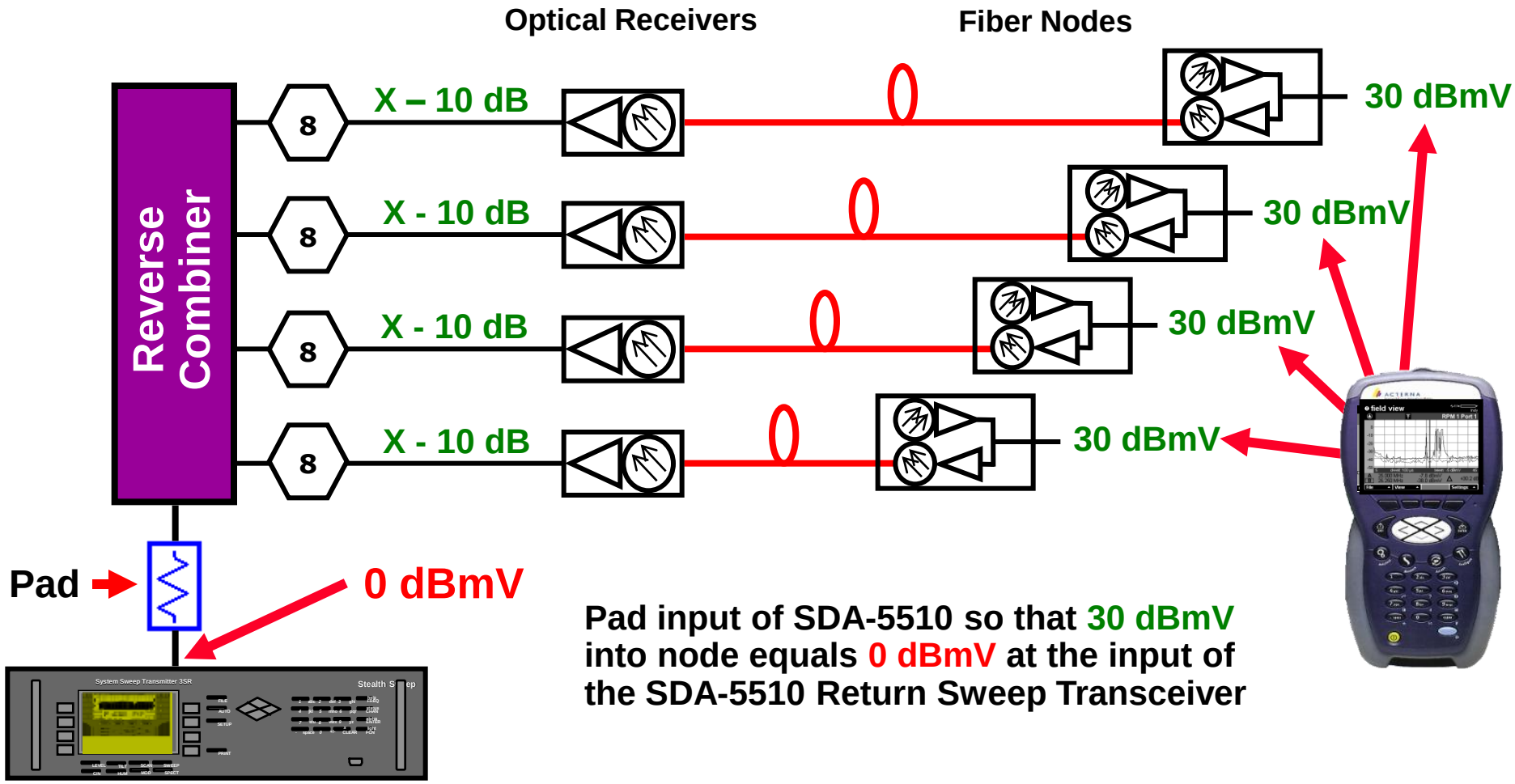
Sweep Pulses Compared to Carriers



Typical Sweep Interface with DOCSIS® Network

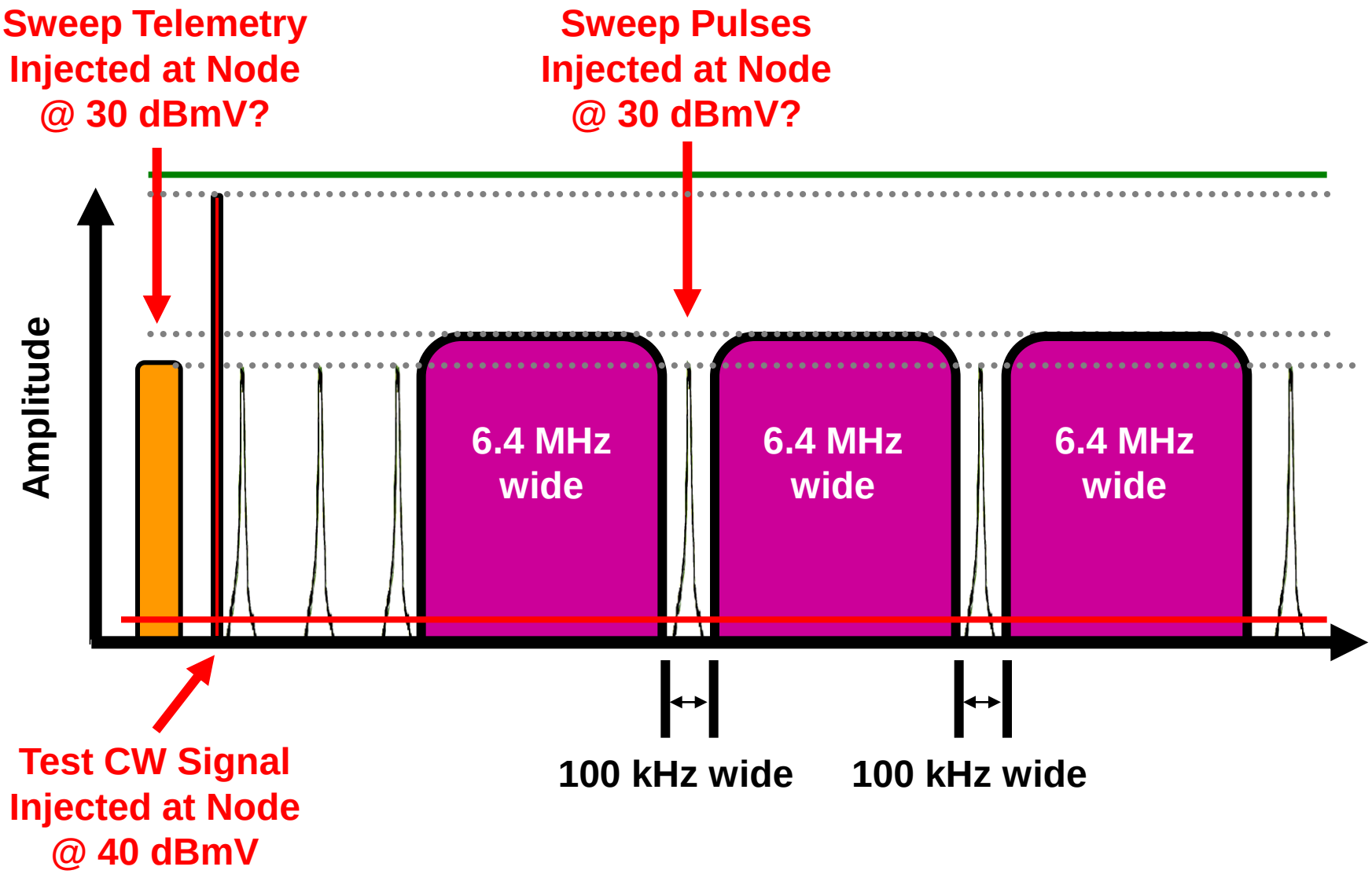


Optimize the RF Input to SDA-5510 Sweep Transceiver



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

Sweep Pulses Compared to Carrier

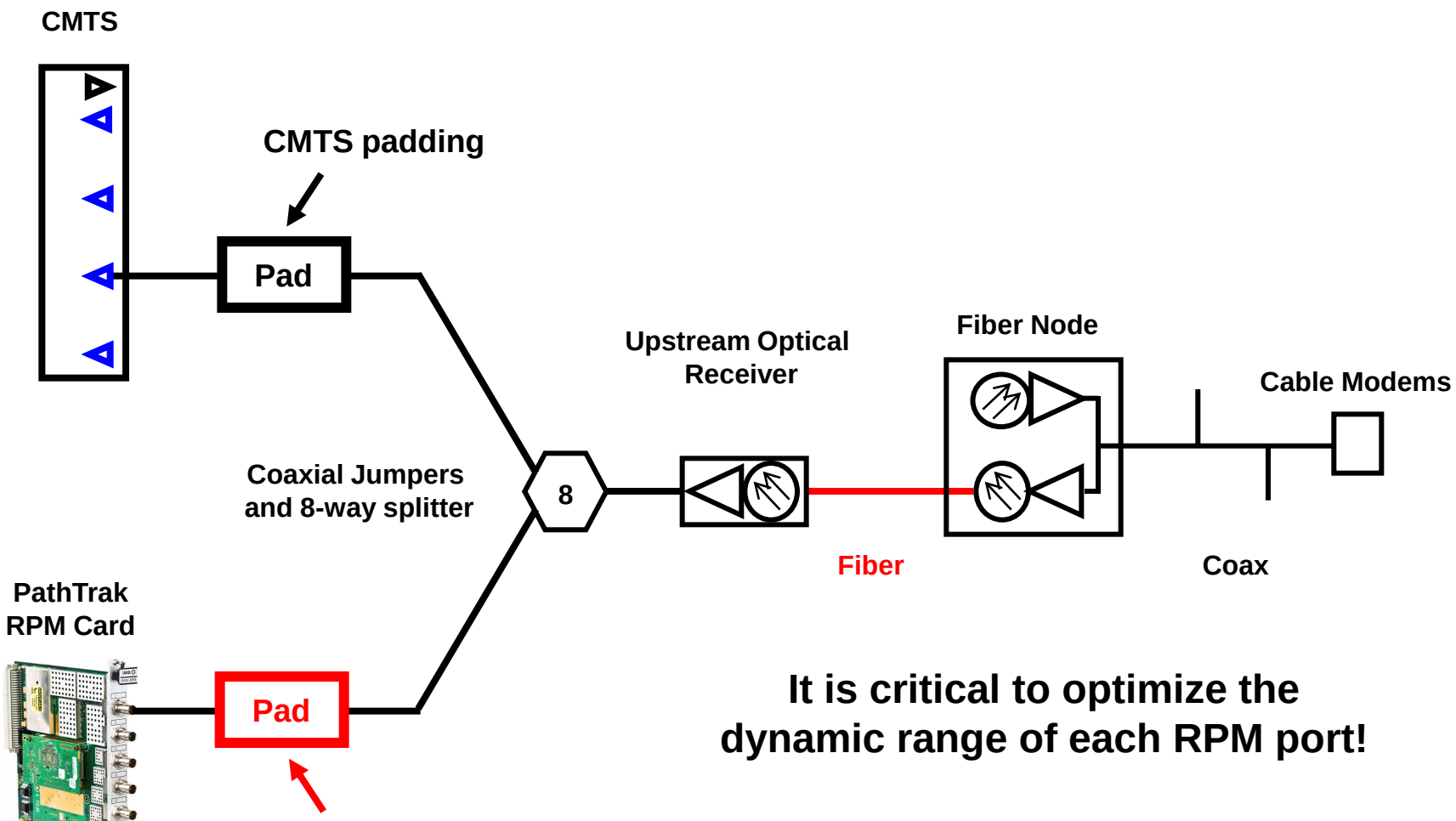


Monitoring and Maintaining the Return Path

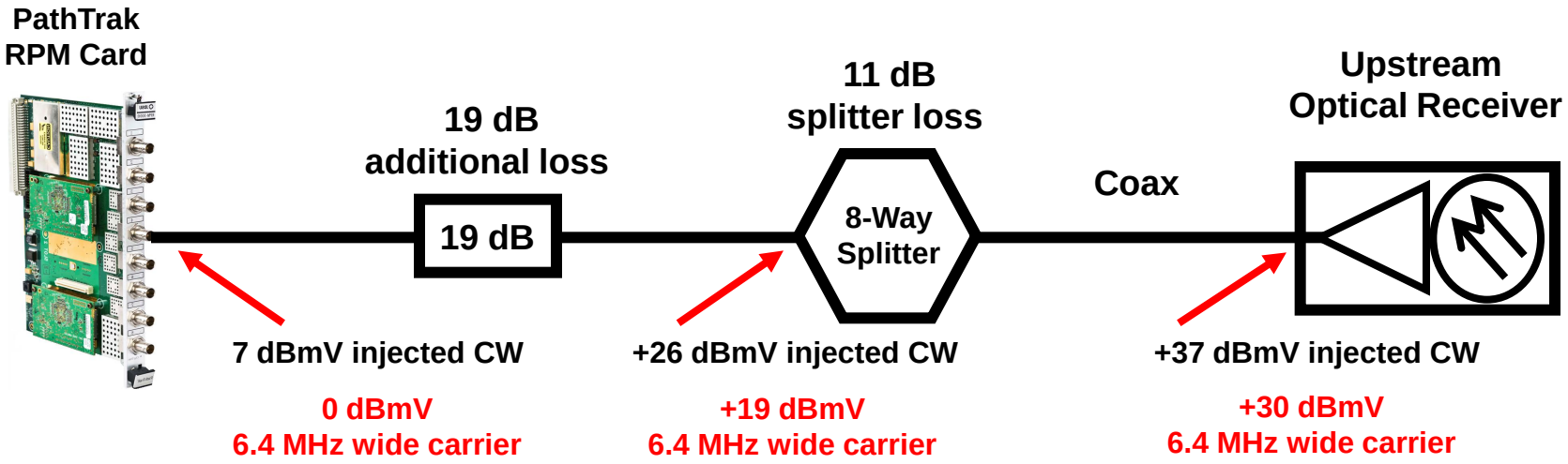
- **Getting ready for DOCSIS 3.0 - Optimize Your HFC network now!**
  - Verify optimal setup and performance (dynamic range) of both Optical & RF portion of the HFC network
  - Forward & Reverse sweep for unity gain throughout coaxial network
  - **Monitoring the Return Path**

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

Typical PathTrak Interface with DOCSIS® Network



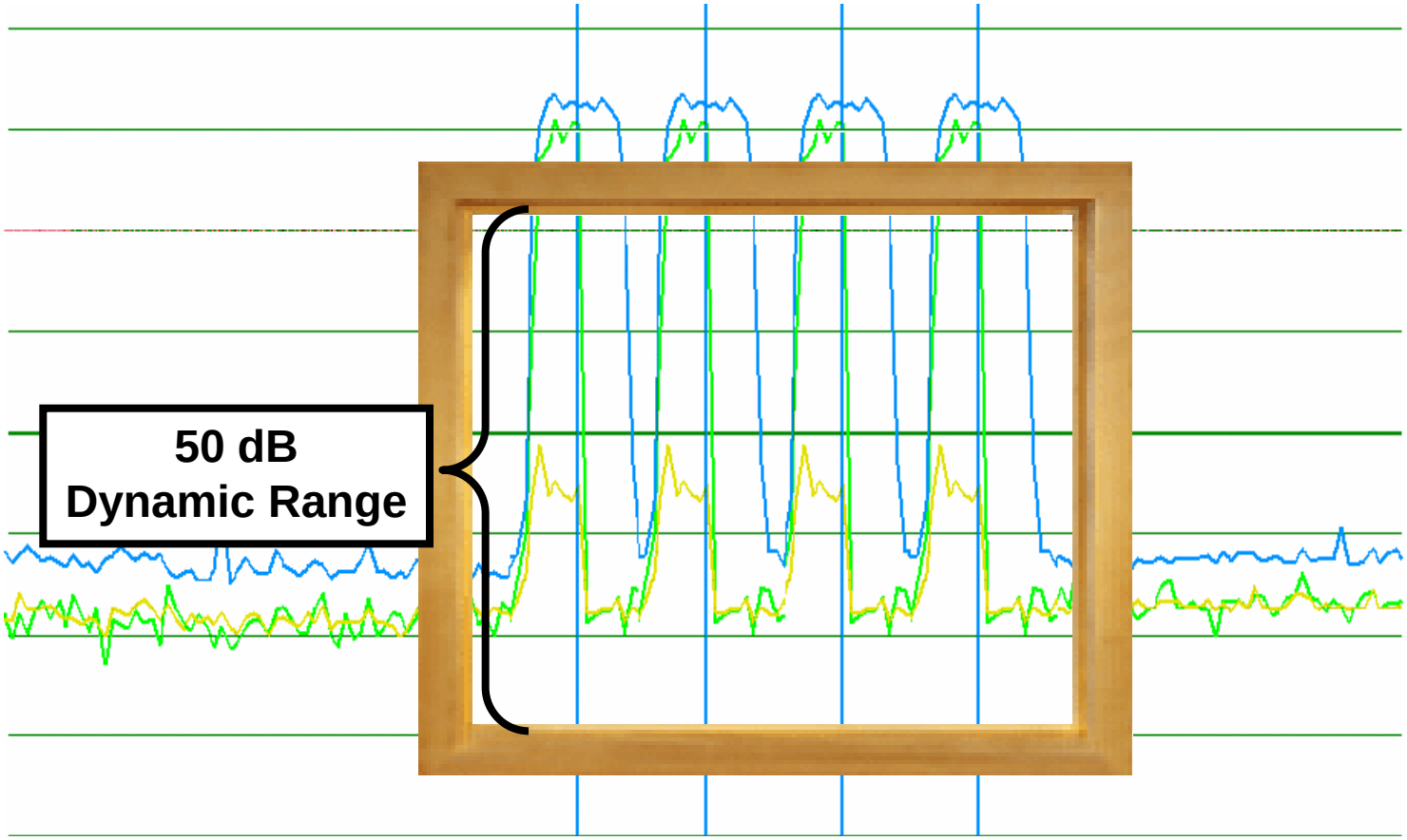
Optimize Dynamic Input Range of the RPM Cards



Example: Some systems will add 19 dB of external padding between the splitter and RPM cards to attenuate the injected CW signal down to a **peak level** of +7 dBmV at the input port of the RPM port. In this example, the **peak level** of the 6.4 MHz carrier is attenuated to 0 dBmV at the input port of the RPM port.

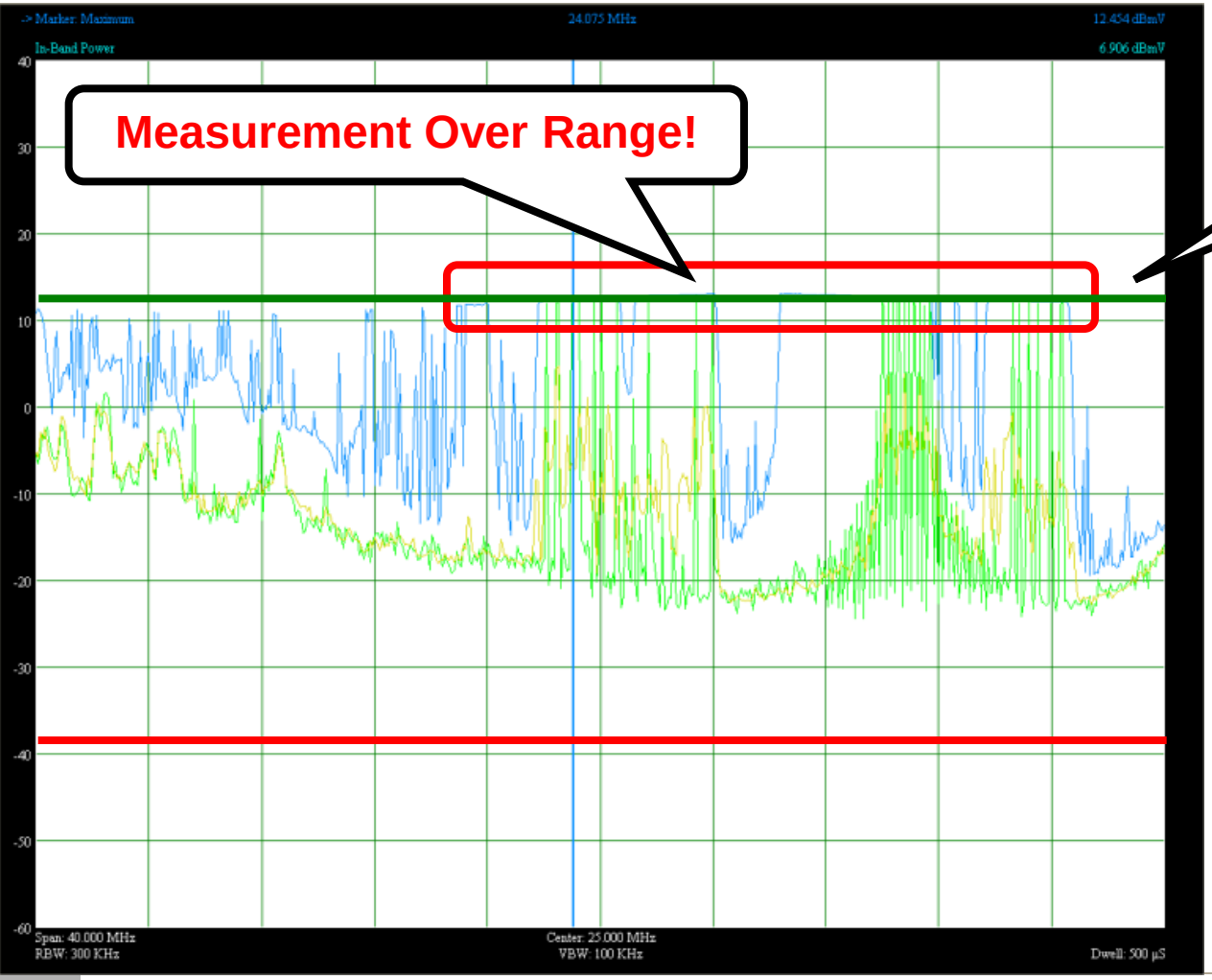
Dynamic Range “Measurement Window”

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.

Measurement Over Range



Measurement Over Range!

0 dB of port attenuation equals +12 dBmV max level

+12 dBmV

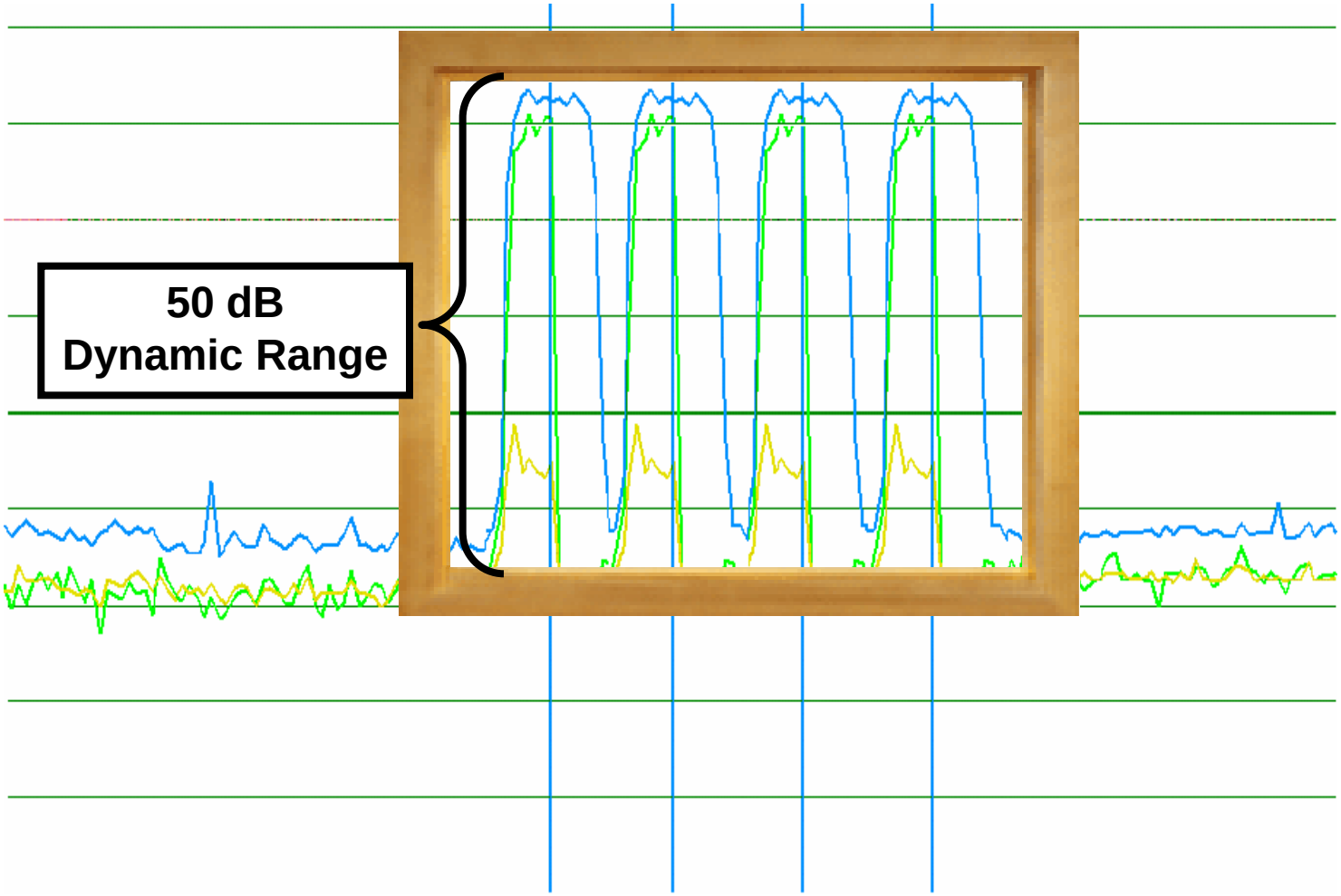
50 dB Dynamic Range

-38 dBmV

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.



Spectrum Analysis – RBW Filters

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

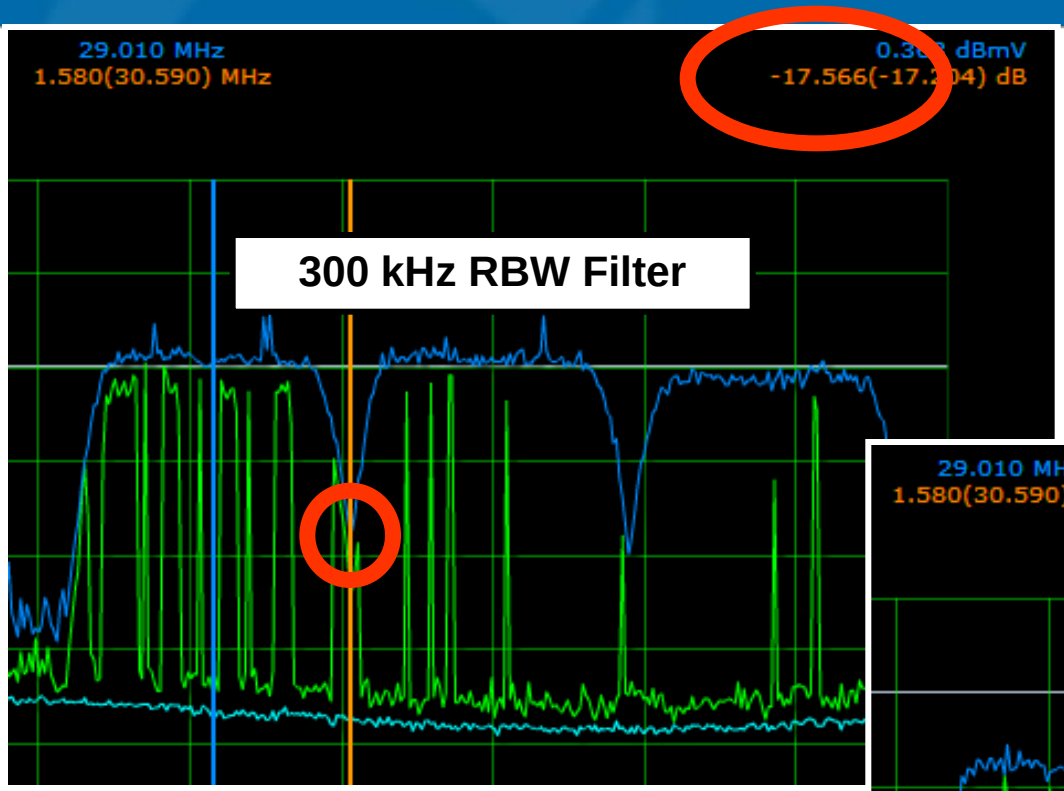
30 kHz RBW

300 kHz RBW

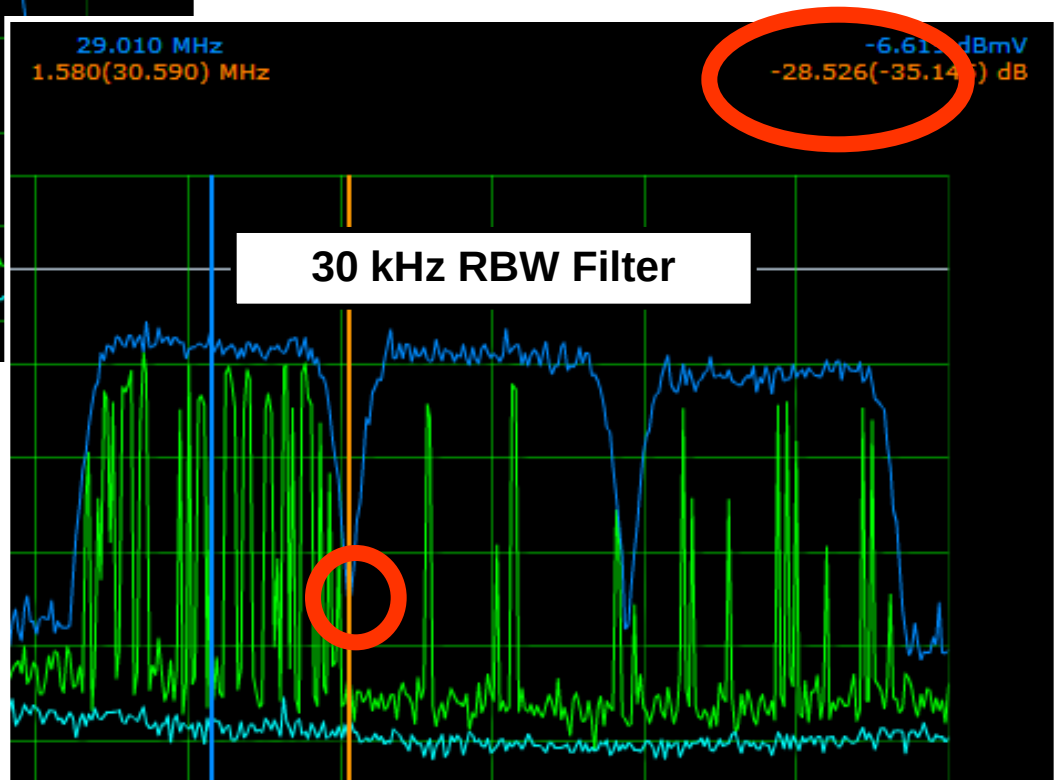
1,000 kHz RBW

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

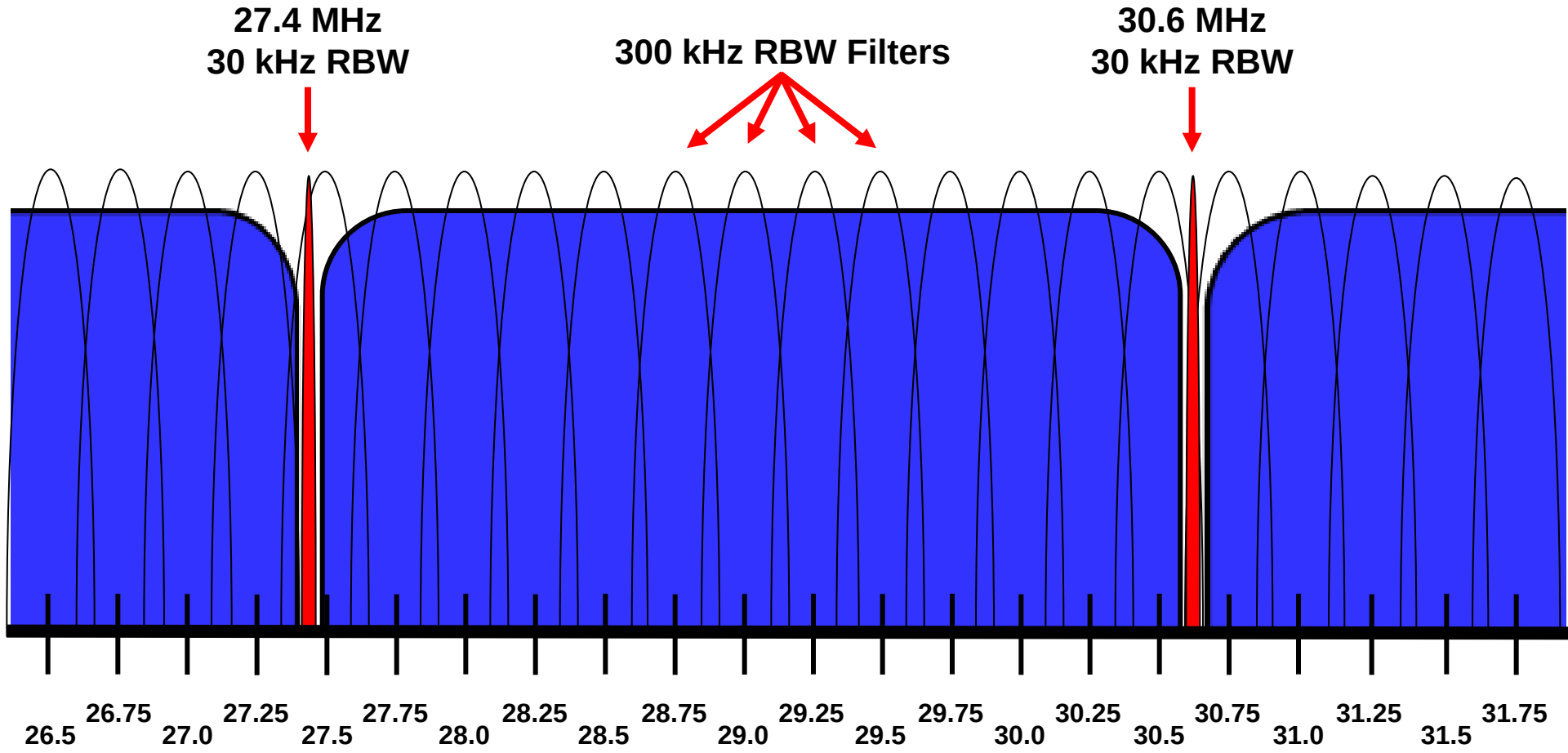
Spectrum Analysis with 300 kHz and 30 kHz RBW Filters



The 30 kHz RBW filter measures the levels in the guard band between adjacent carriers over 10dB lower than the 300 kHz RBW filter

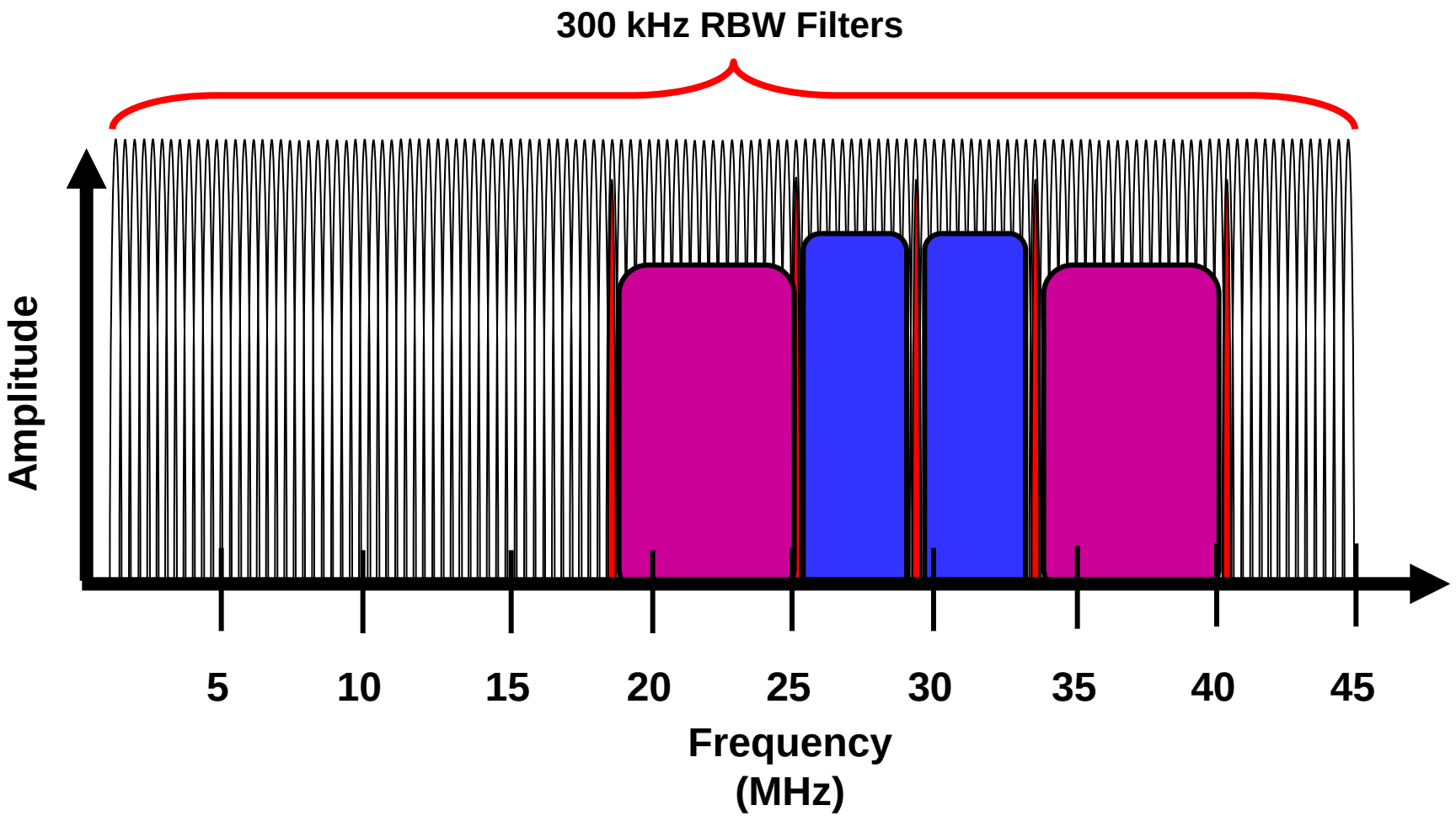


Monitoring between carriers with 30 kHz RBW



Three 16 QAM Carriers
3.2 MHz Wide
centered @ 26.8, 29 and 32.2 MHz

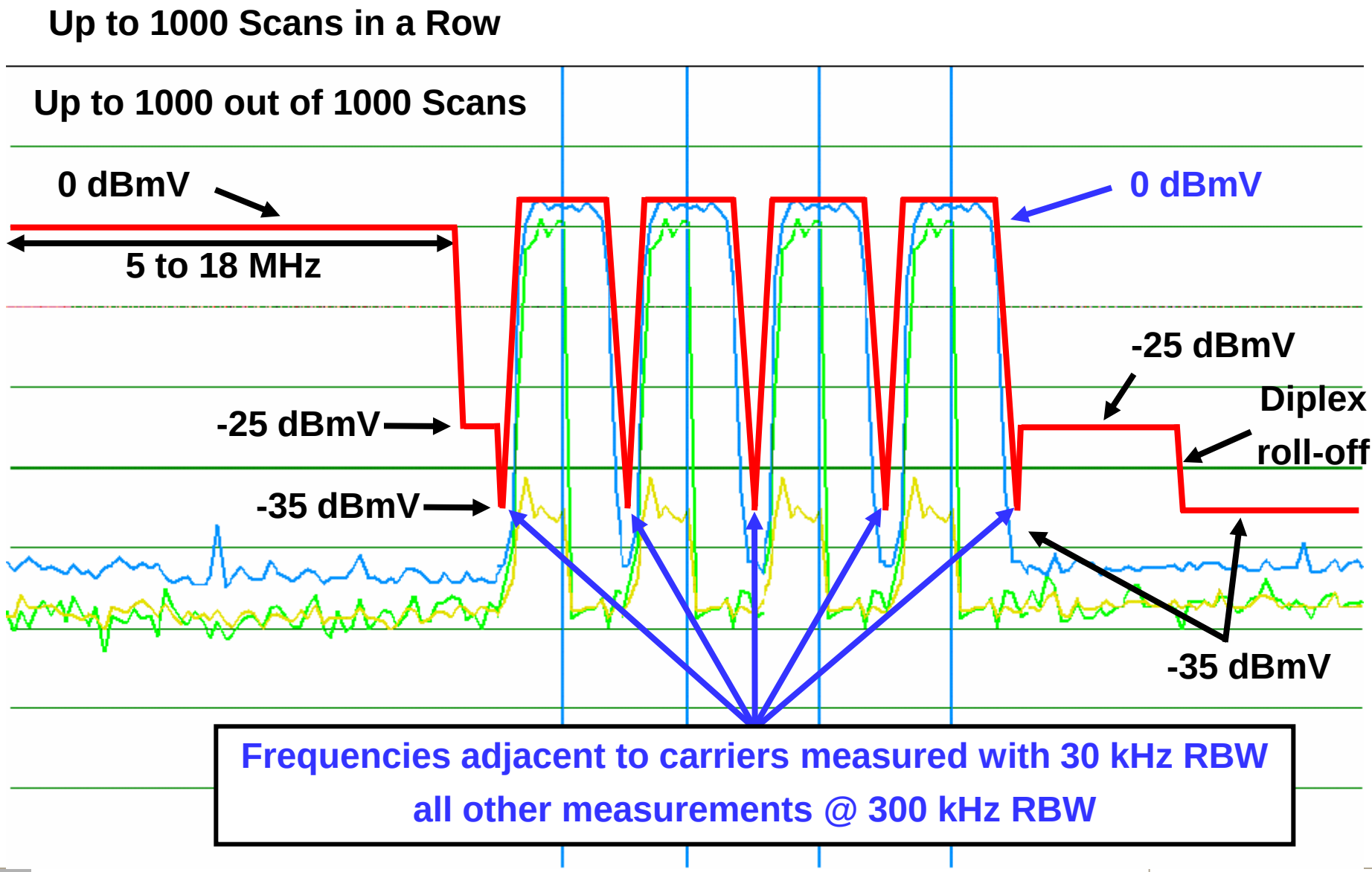
RBW Filters can be different at every Frequency measured in Monitoring View



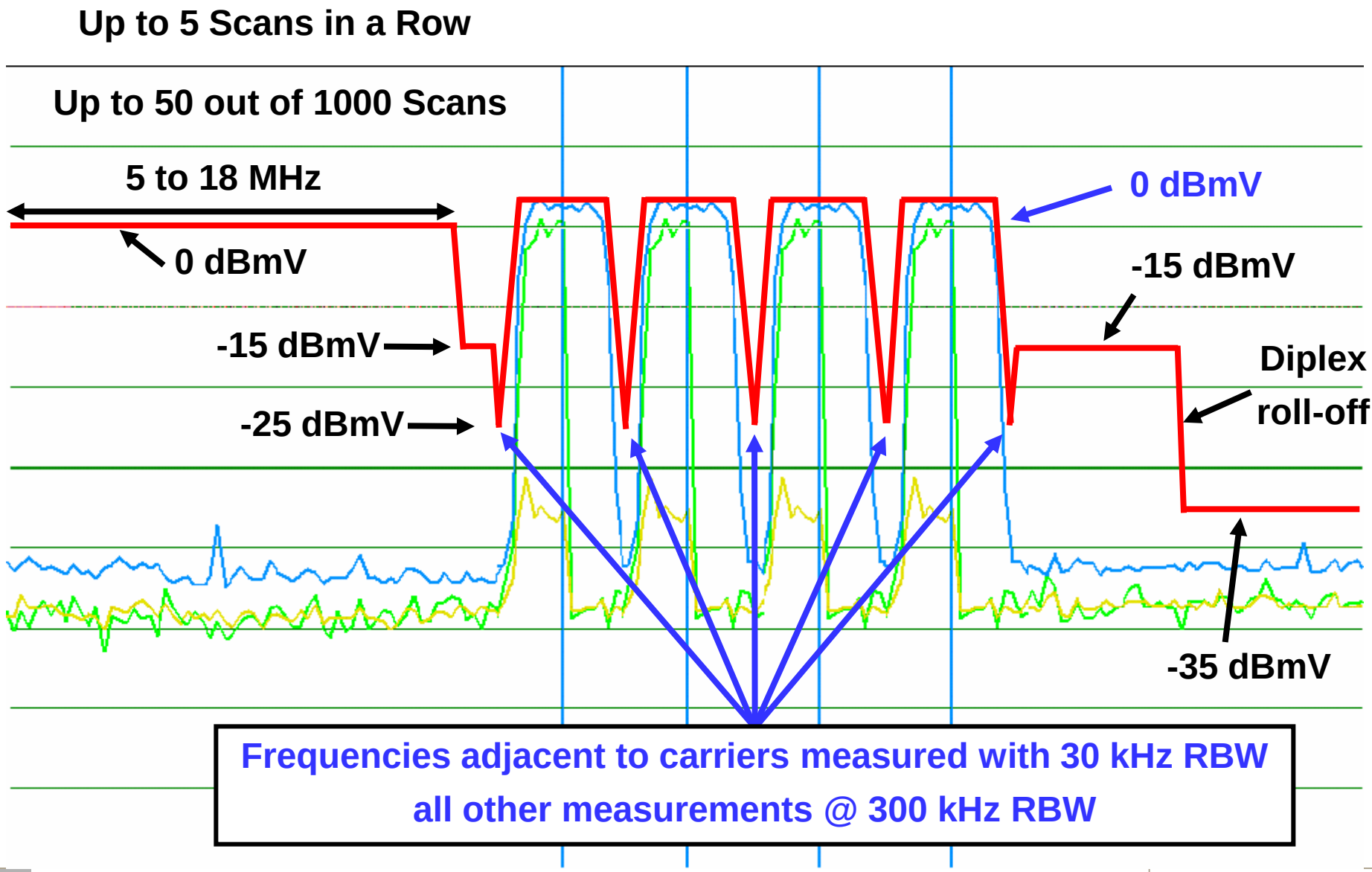
Monitoring Plan with 250 kHz Frequency Spacing

(Monitoring View measures up to 250 Frequencies)

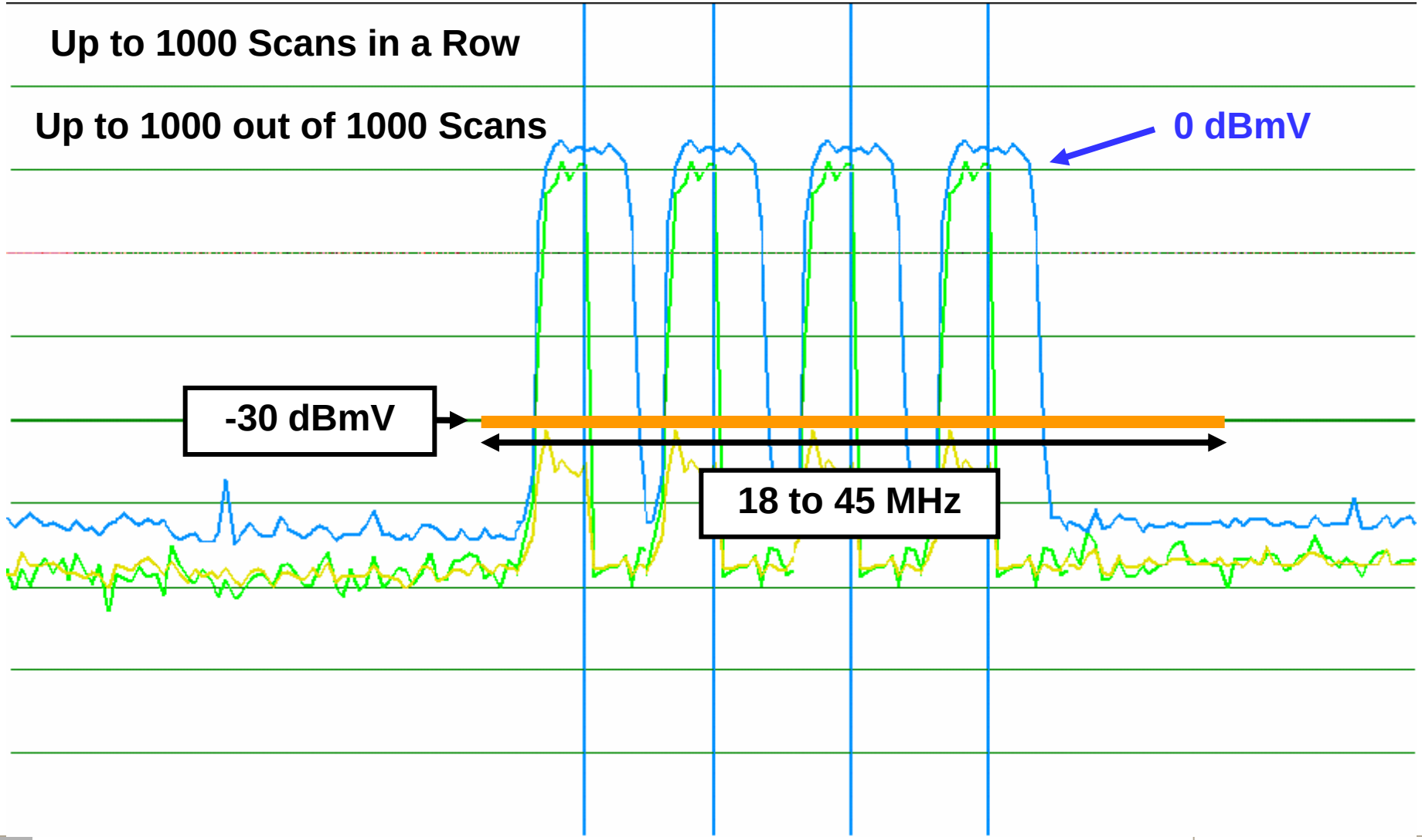
Recommended Node Ranking Threshold



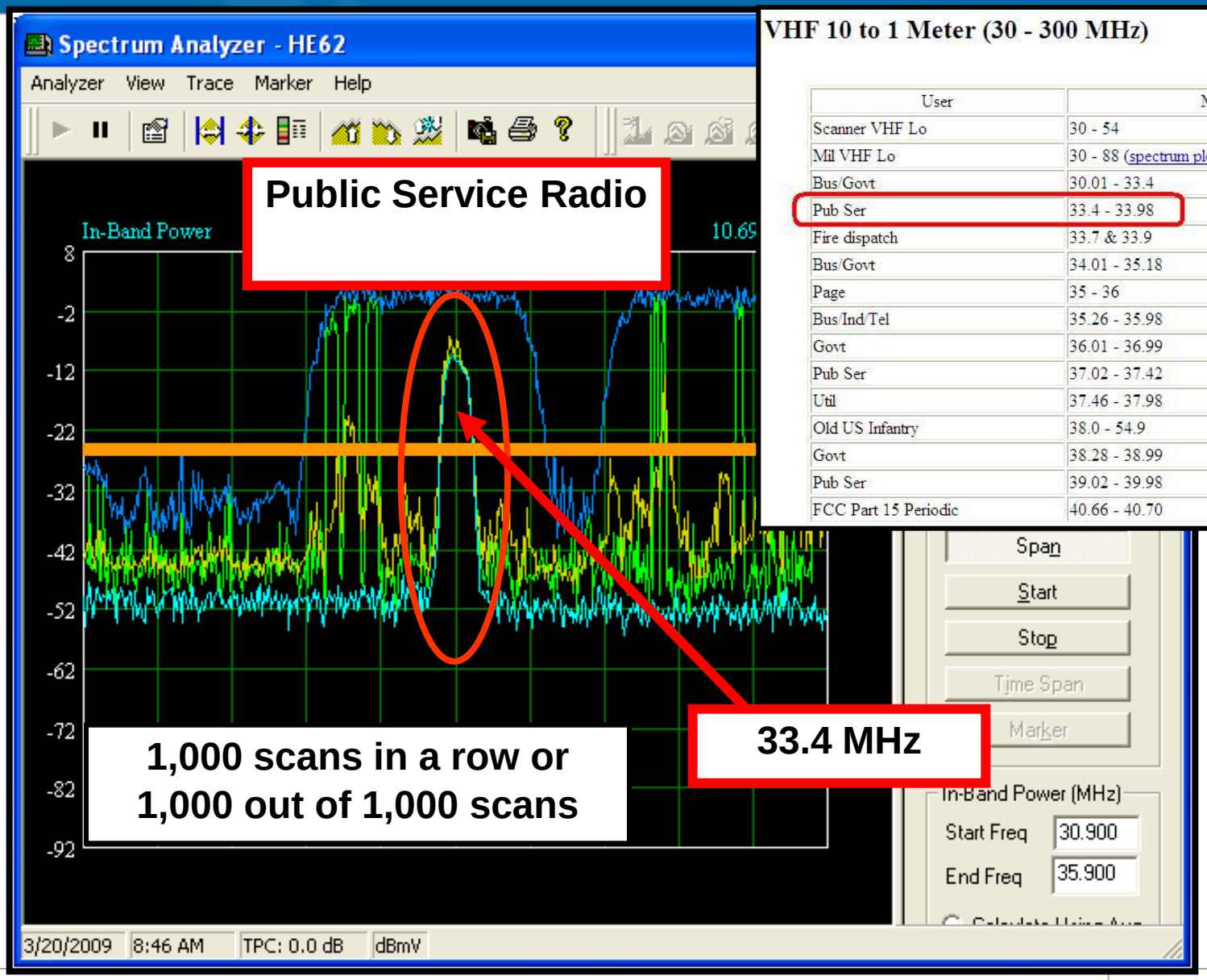
Recommended Impulse Noise Threshold



Recommended Ingress & CPD Threshold



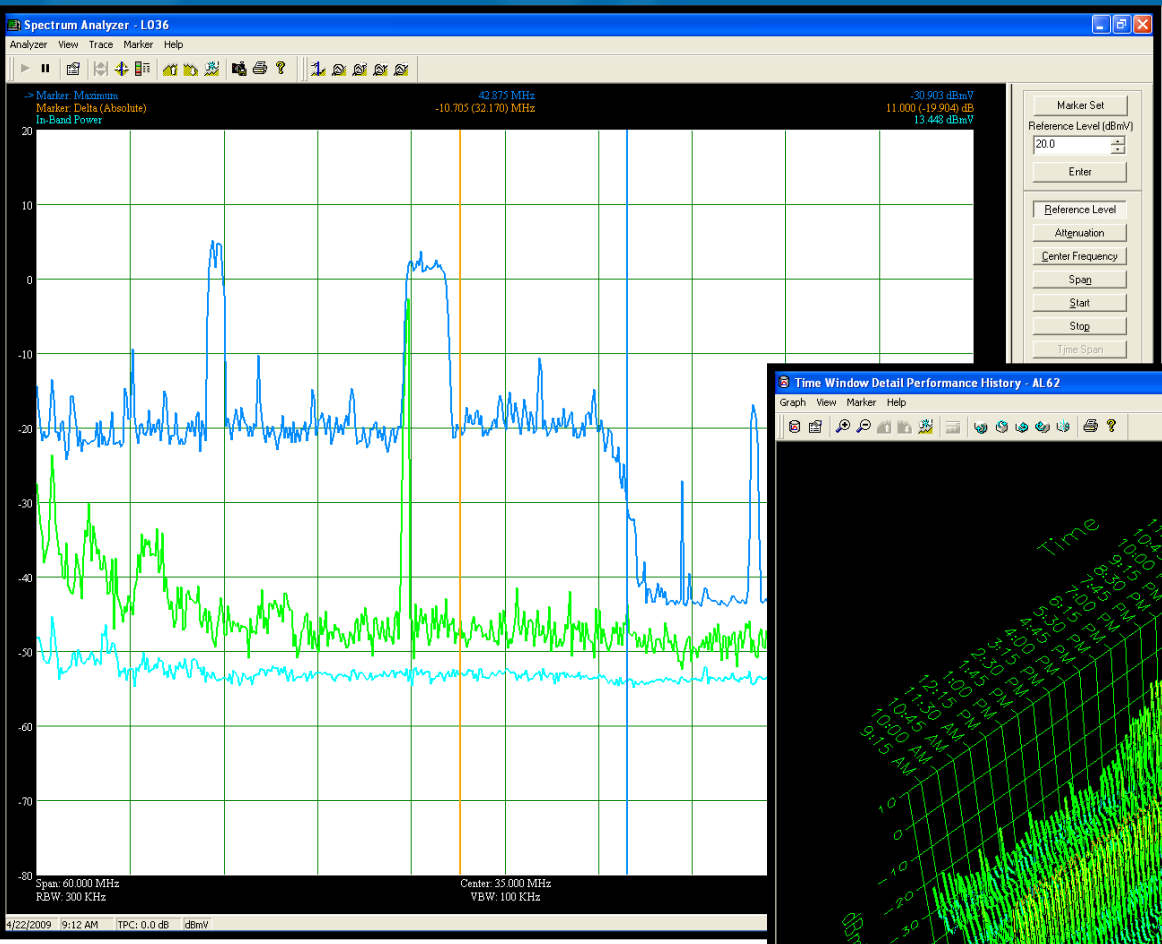
Spectral Monitoring in a Crowded Upstream



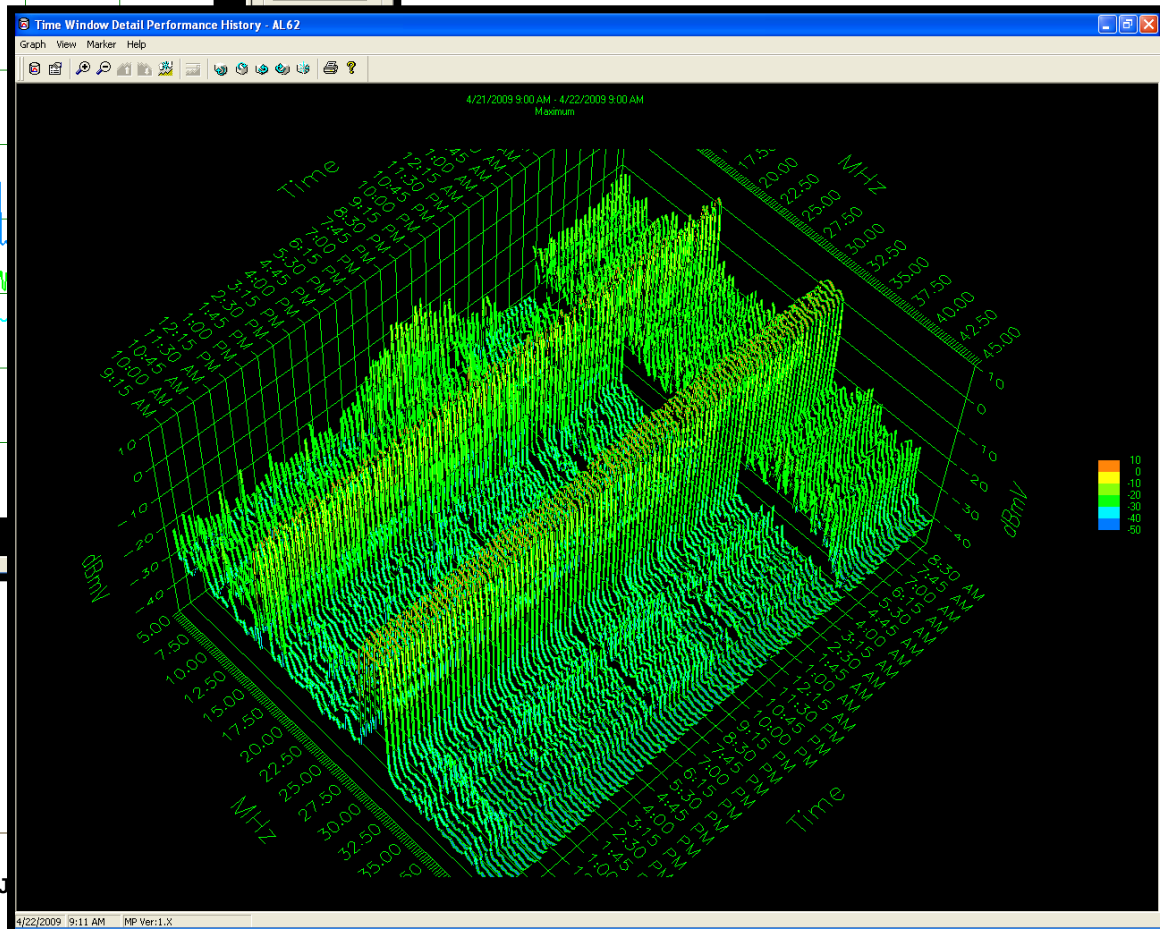
VHF 10 to 1 Meter (30 - 300 MHz)

User	MHz
Scanner VHF Lo	30 - 54
Mil VHF Lo	30 - 88 (spectrum plot)
Bus/Govt	30.01 - 33.4
Pub Ser	33.4 - 33.98
Fire dispatch	33.7 & 33.9
Bus/Govt	34.01 - 35.18
Page	35 - 36
Bus/Ind/Tel	35.26 - 35.98
Govt	36.01 - 36.99
Pub Ser	37.02 - 37.42
Util	37.46 - 37.98
Old US Infantry	38.0 - 54.9
Govt	38.28 - 38.99
Pub Ser	39.02 - 39.98
FCC Part 15 Periodic	40.66 - 40.70

Analyzing and Interpreting Performance History

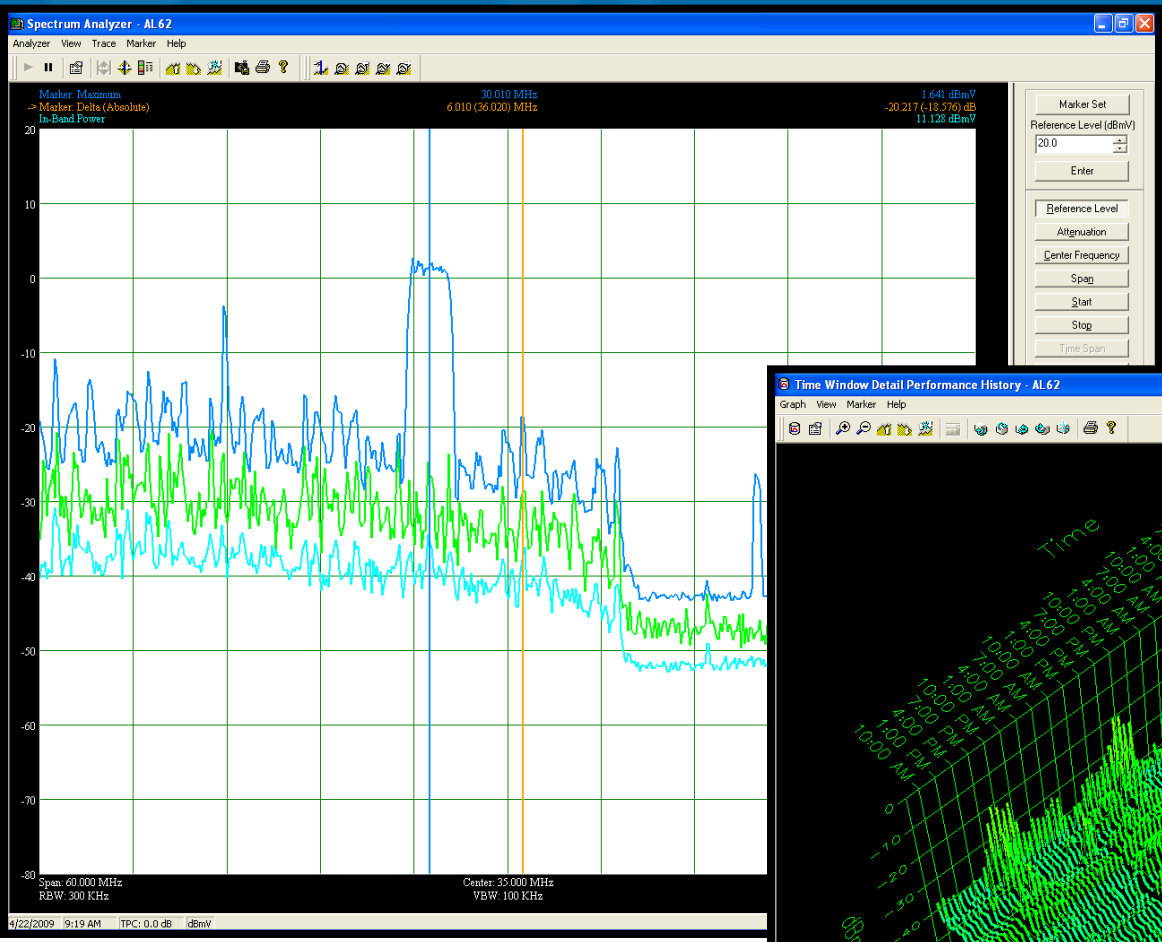


Use Performance History's Detailed Maximum Trace to see wide band impulse noise trending over time

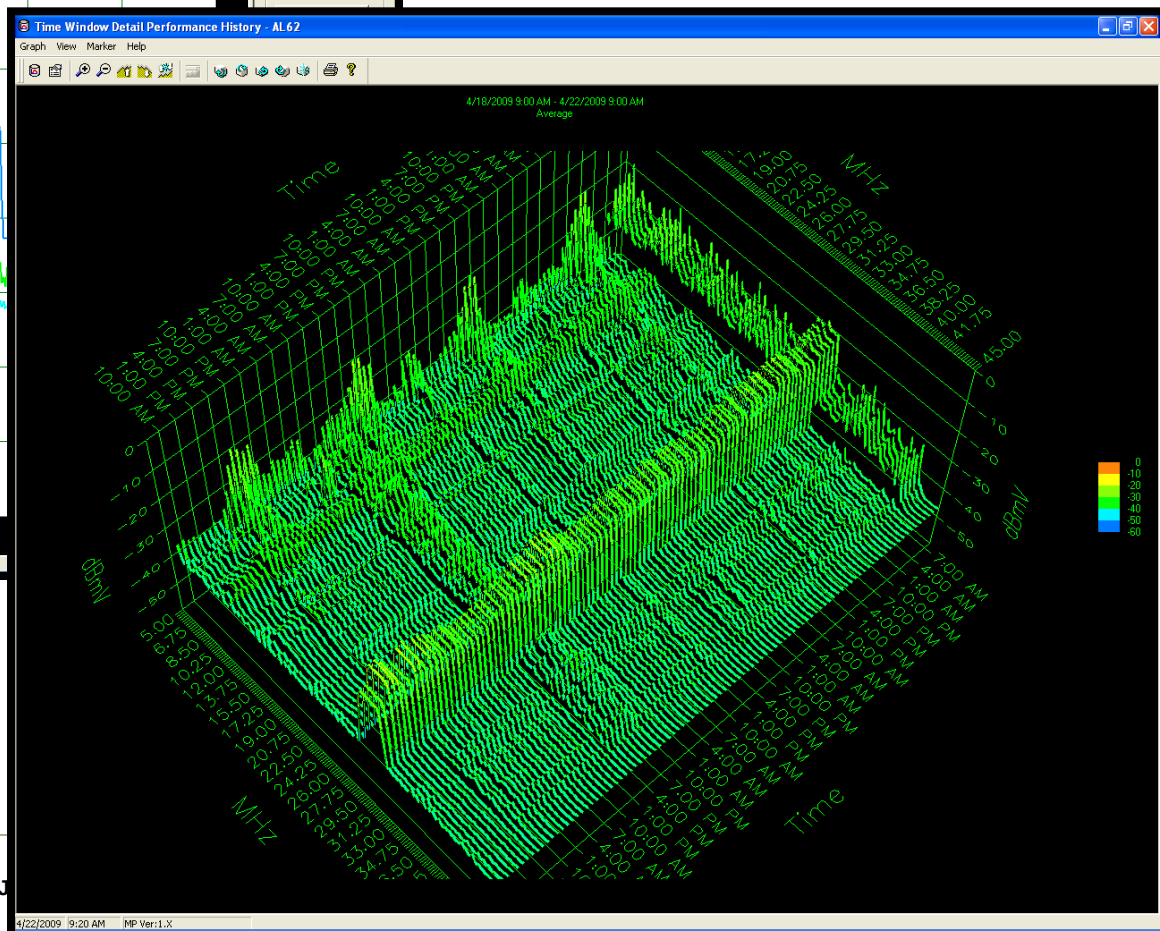


Maximum Trace in spectrum analyzer shows wide band impulse noise

Analyzing and Interpreting Performance History



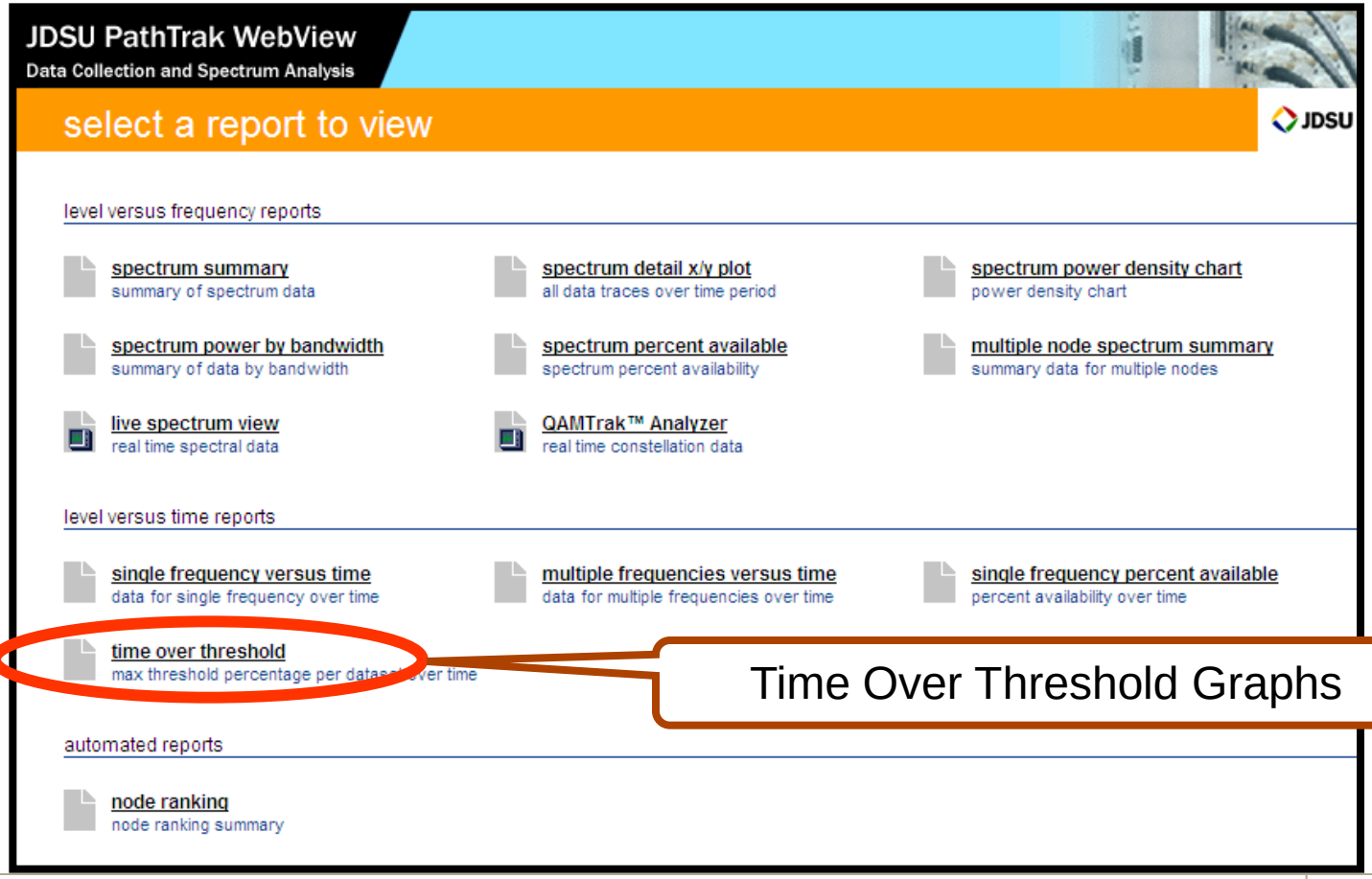
Use Performance History's Detailed Average Trace to see rise in noise floor & CPD over time



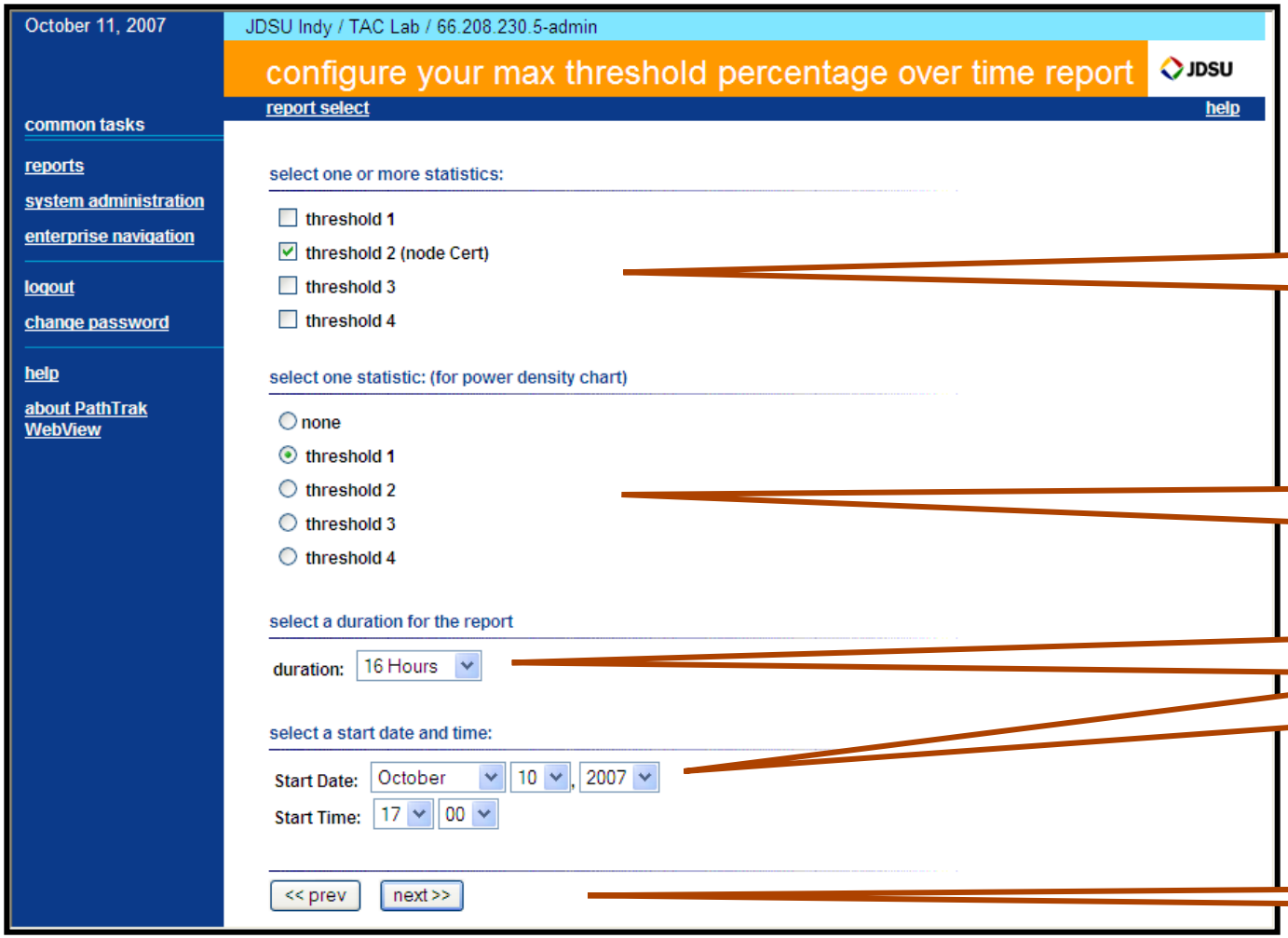
Average Trace in spectrum analyzer shows rise in noise floor & CPD

WebView – Time Over Threshold Graphs

- WebView server enables remote users to access Performance History measurements including “percent of time over threshold” for each on the four PathTrak alarm thresholds. spectrum views from RPM cards via Internet Explorer browser
- Each individual remote user has full control of Performance History graph settings

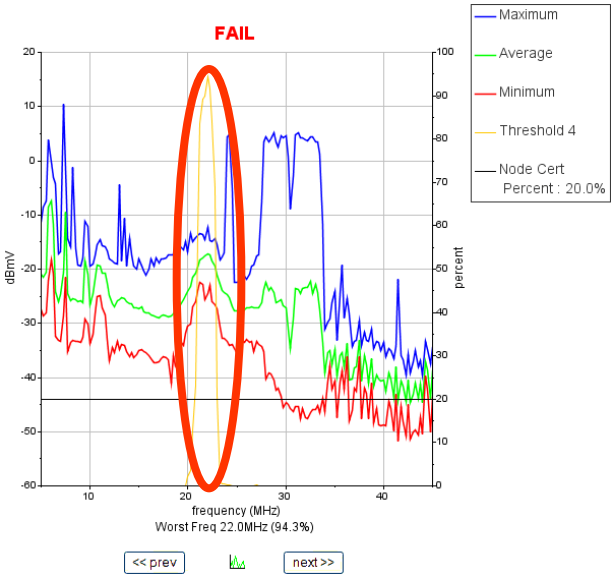


“Percent of Time Over Threshold” Report Setup

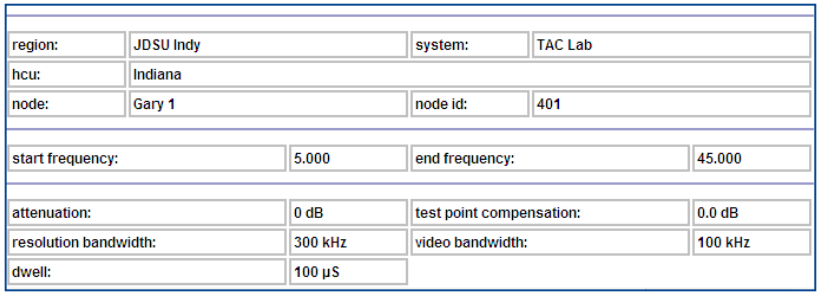


Time Over Threshold Reports

Node Certification Reports



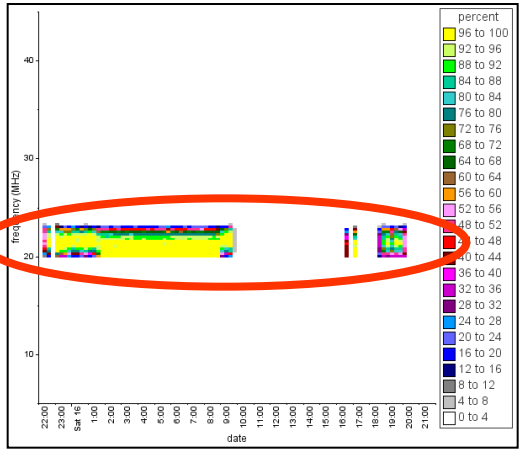
15 Minute Summary of RF Performance



region:	JDSU Indy	system:	TAC Lab
hcu:	Indiana		
node:	Gary 1	node id:	401
start frequency:	5.000	end frequency:	45.000
attenuation:	0 dB	test point compensation:	0.0 dB
resolution bandwidth:	300 kHz	video bandwidth:	100 kHz
dwell:	100 µS		

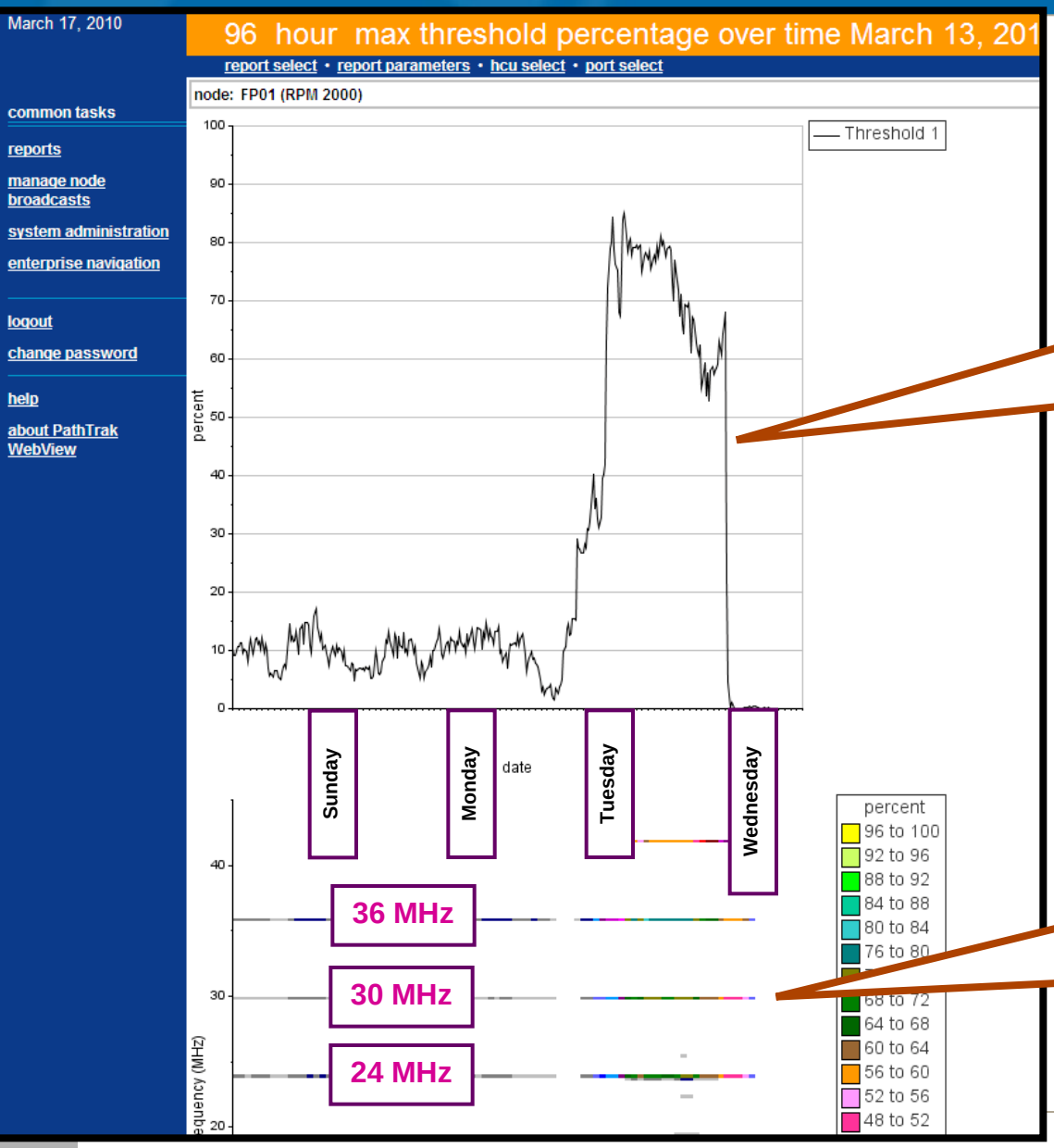
Measurement Details Included with Reports

Threshold Violations Plotted on Graph



…and Percent over Threshold Density View

Percent of Time Over Threshold report for 4 Days

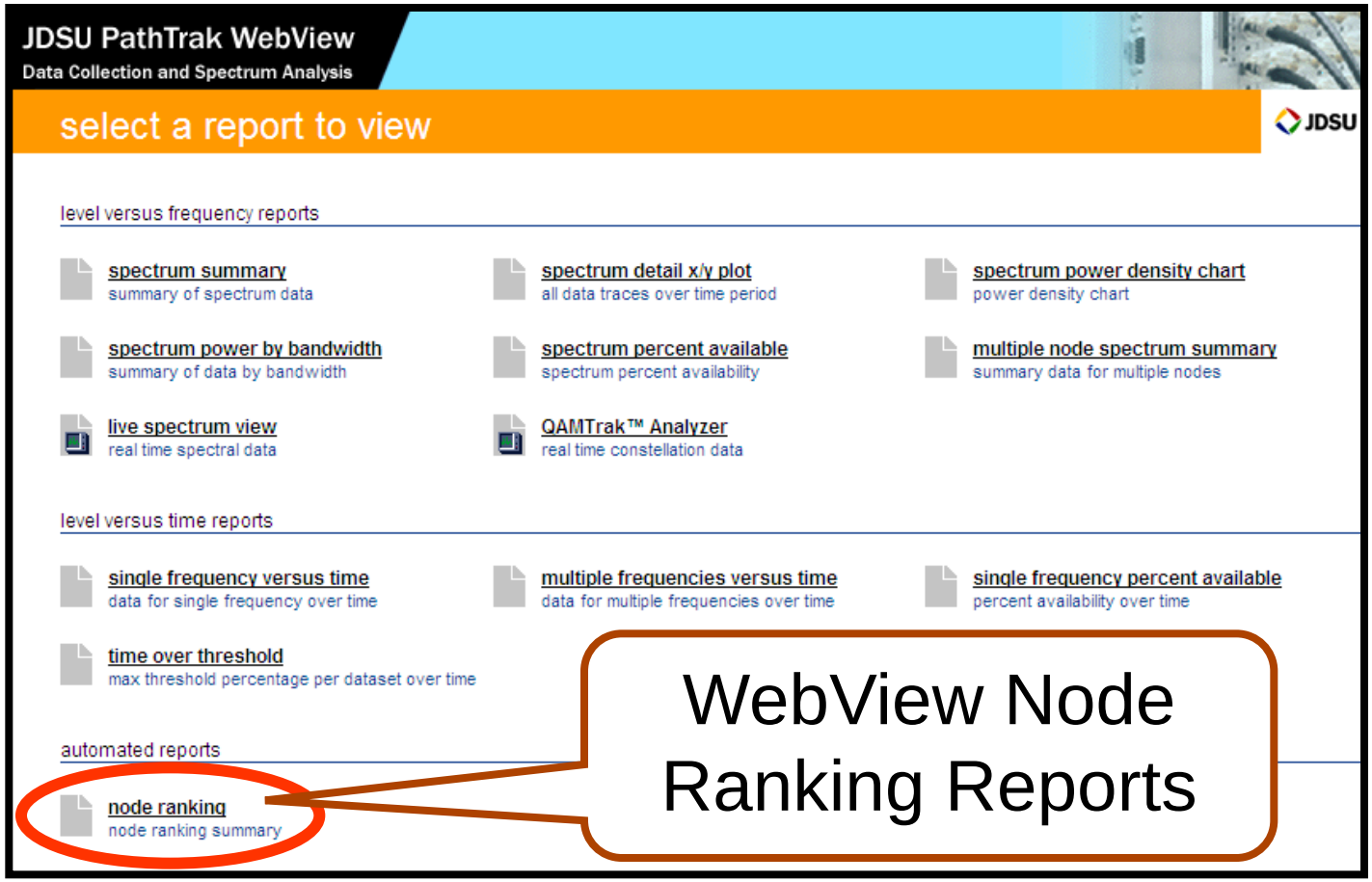


Total percent of time exceeding Threshold 1 over 4 days (96 hours) in 15 minute increments!

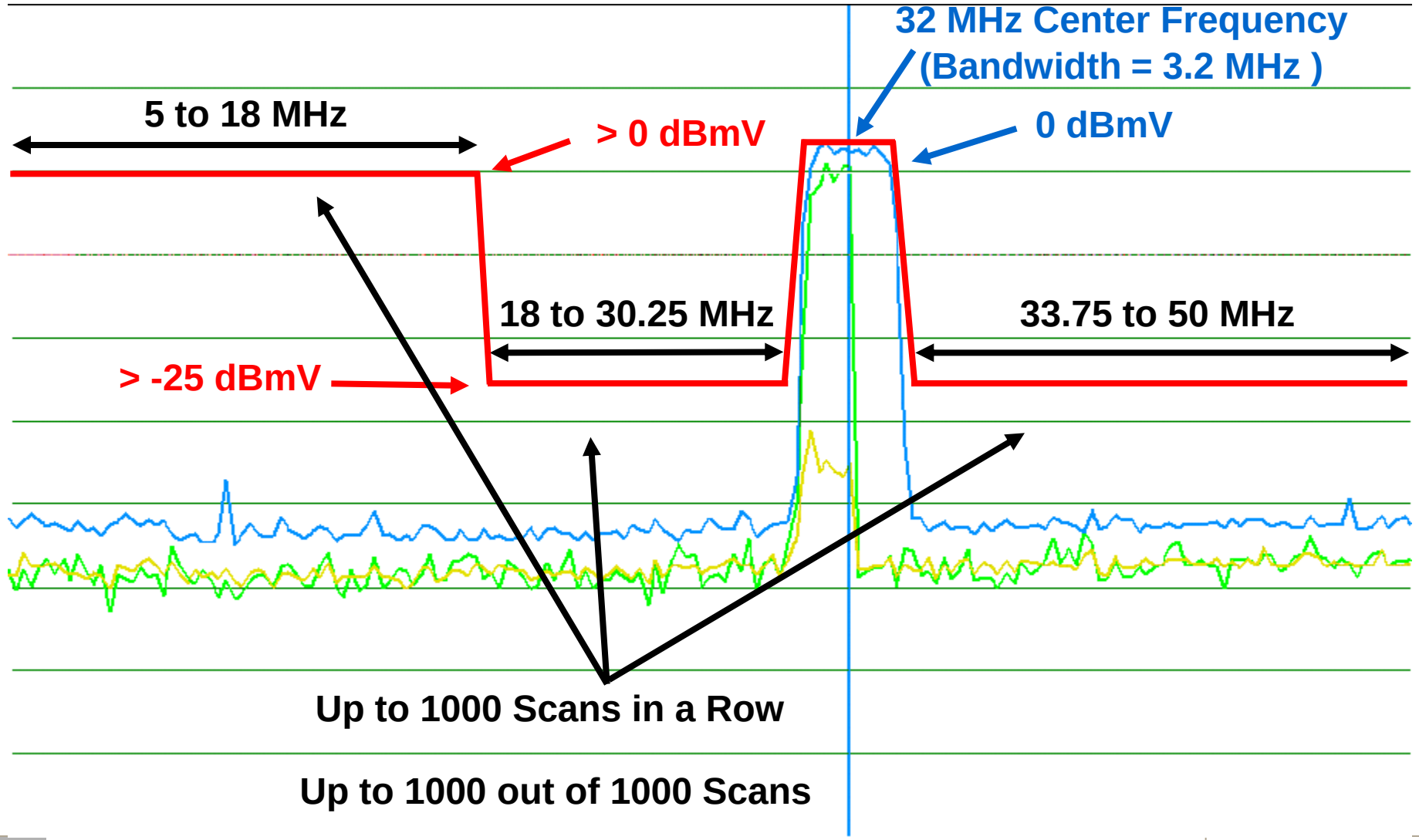
Percent of time by frequency exceeding Threshold 1 over 4 days (96 hours) in 15 minute increments!

WebView v2.5 Node Ranking Reports

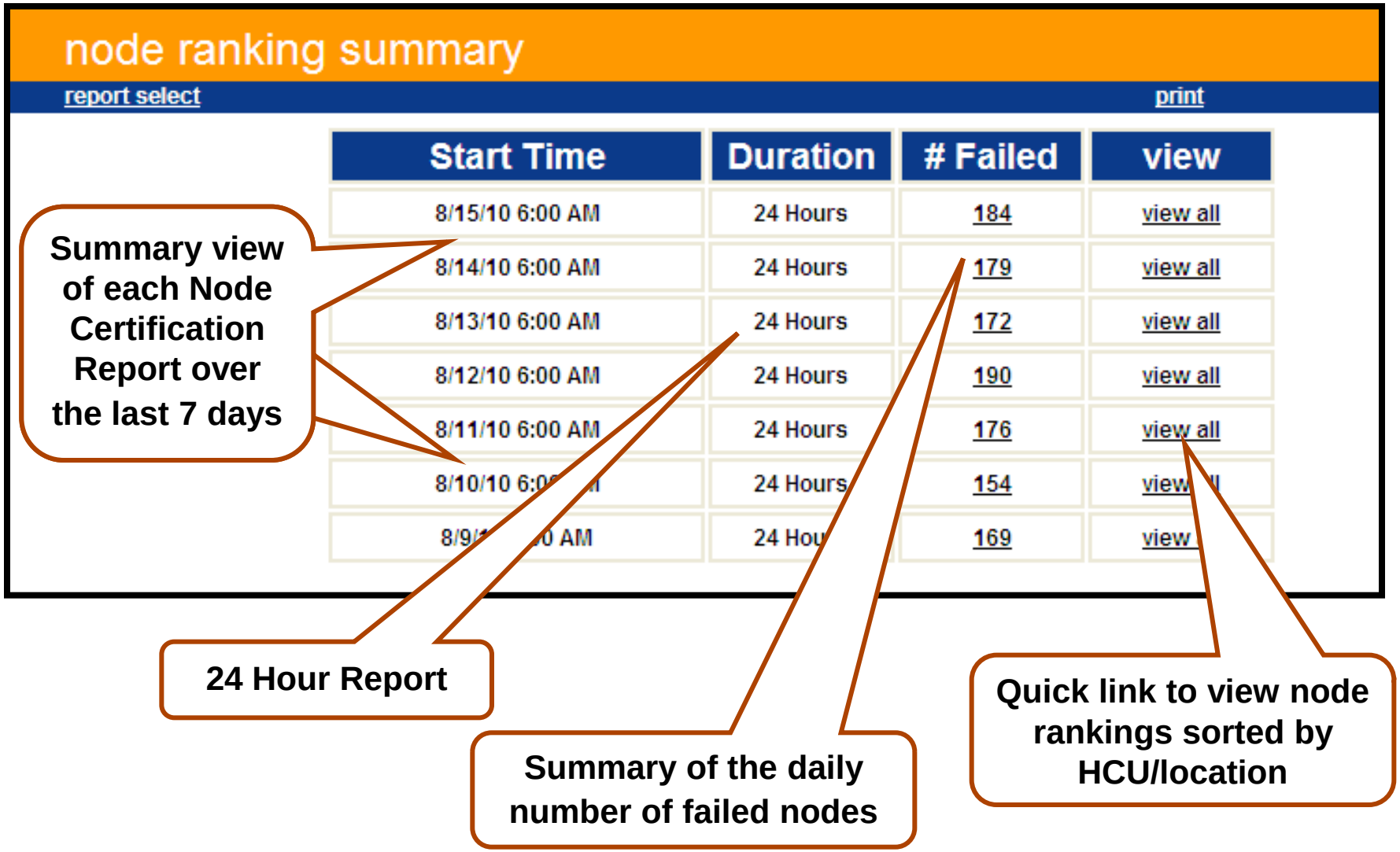
- Automates node certification and node ranking to prioritize field maintenance of “top offenders”
  - Intelligently plan maintenance rather than manually sorting alarms



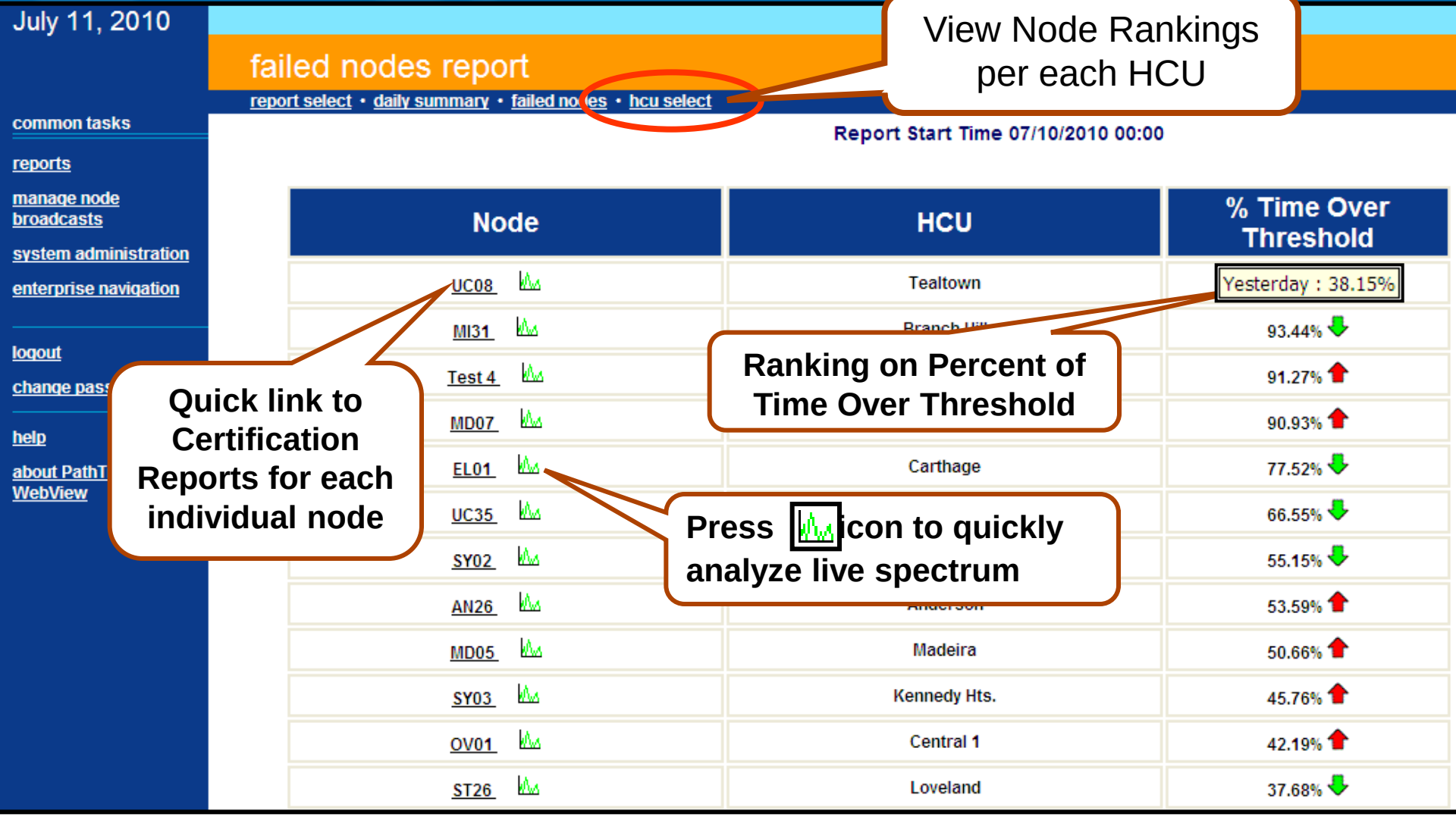
Example Node Ranking Threshold



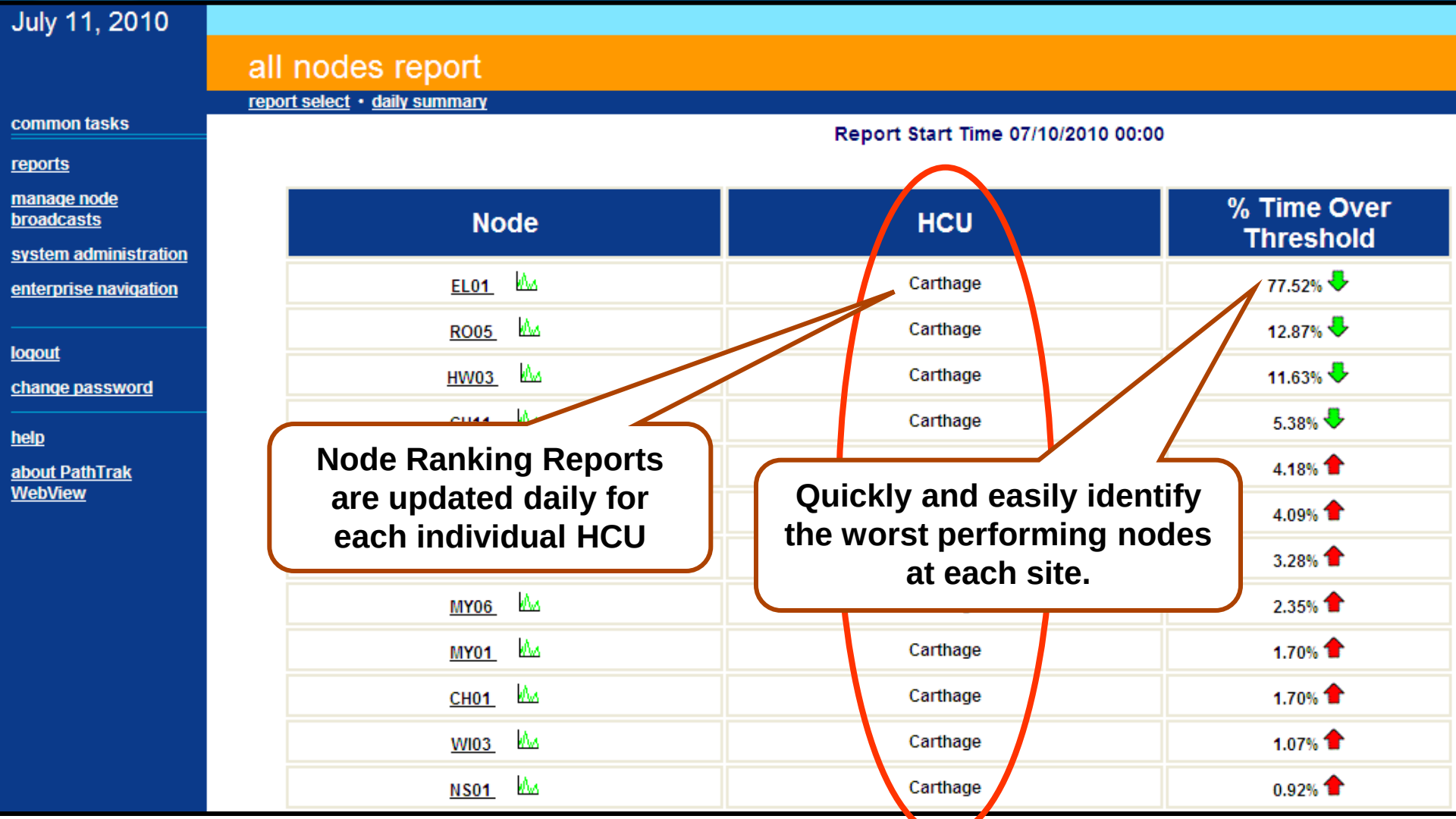
Node Ranking Summary Updated Every Day



Daily Failed Nodes Report

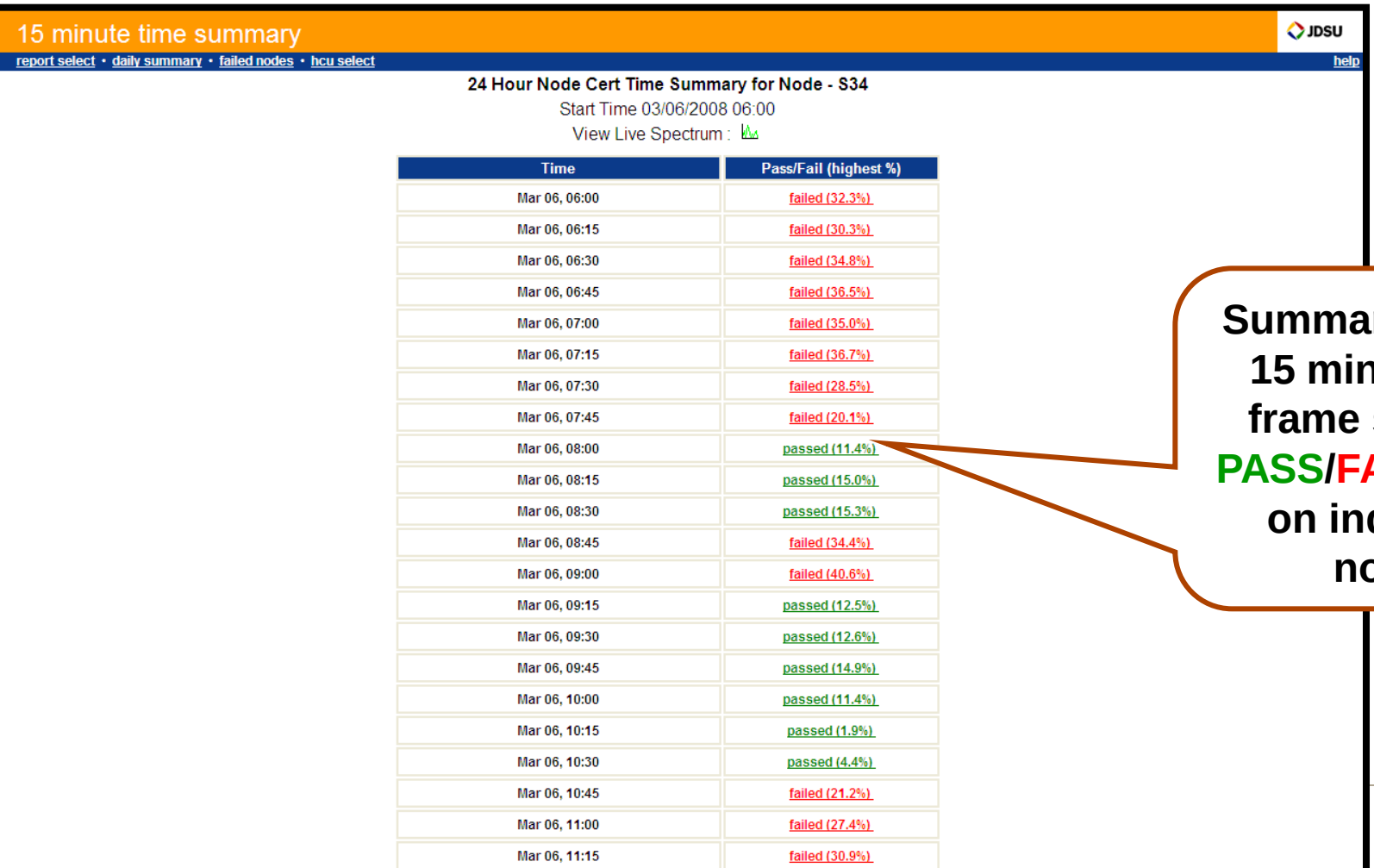


View Node Rankings per HCU Location



Node Certification 15 Minute Pass/Fail Summary

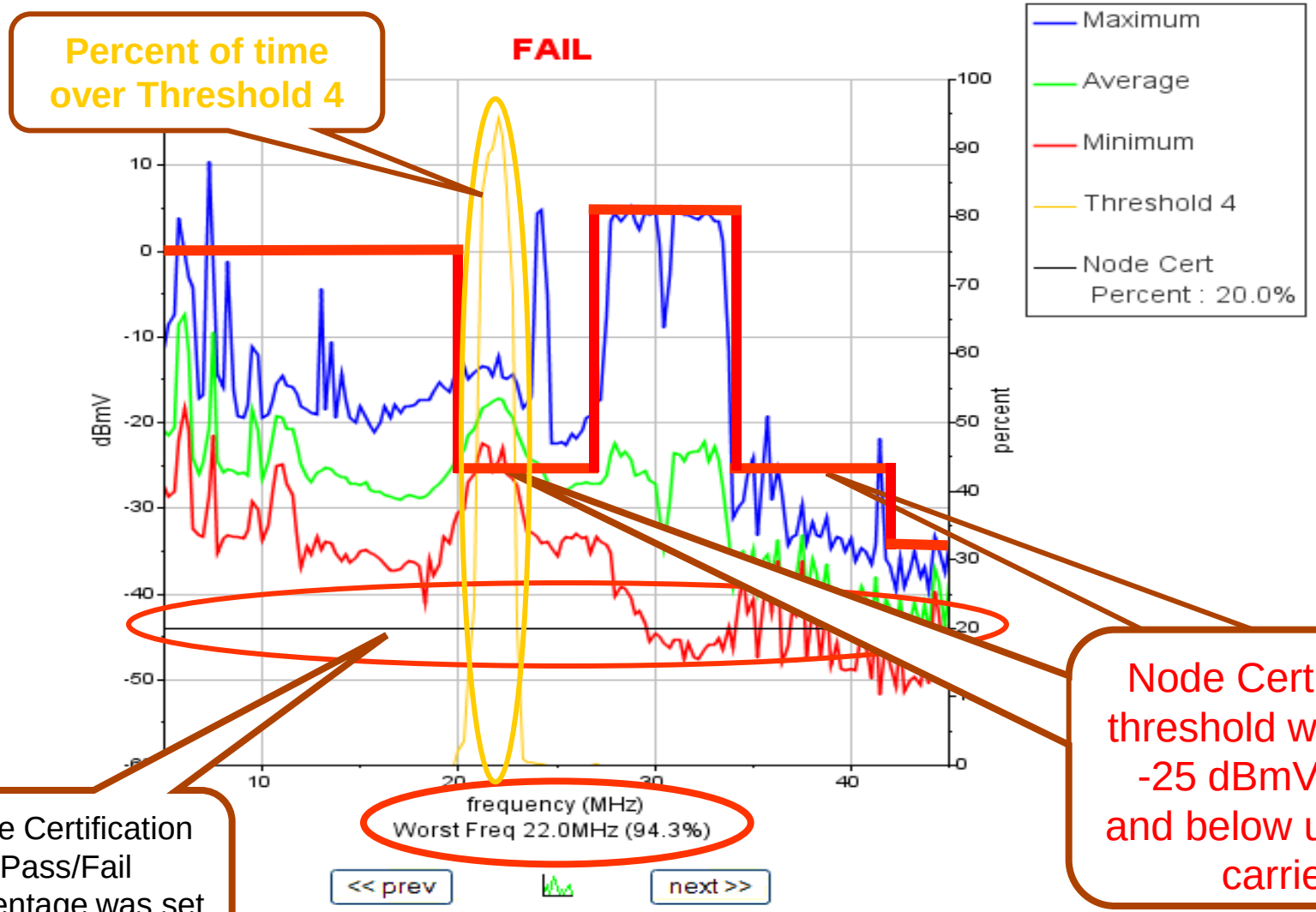
- Increase network availability for lucrative Triple Play services and retain most profitable customers by:
  - Qualifying RF return path performance in the HFC infrastructure as required to deliver triple-play services



Summary of each 15 minute time frame showing PASS/FAIL results on individual nodes

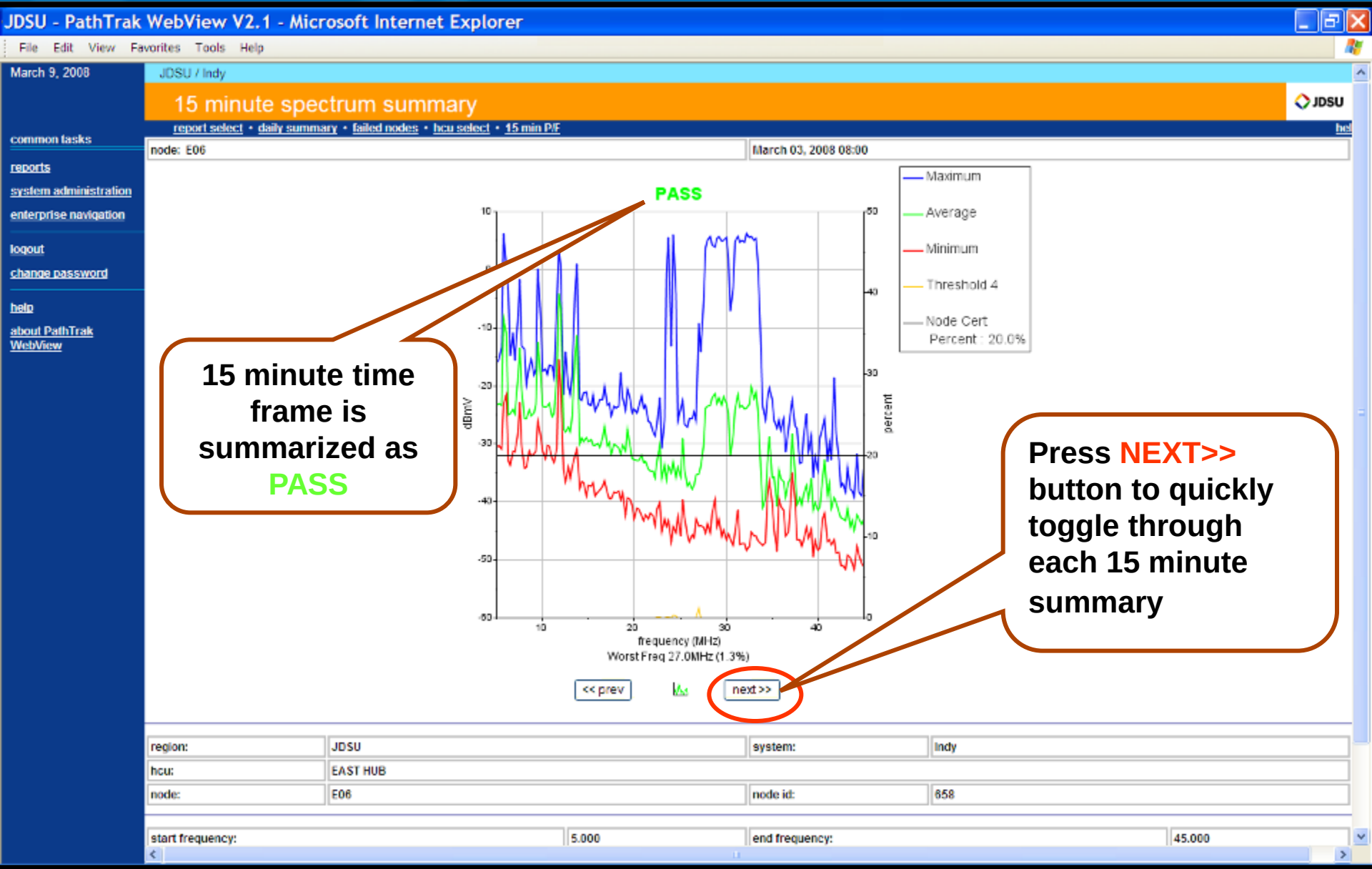
JDSU

Node Certification - 15 Minute Pass/Fail Detail

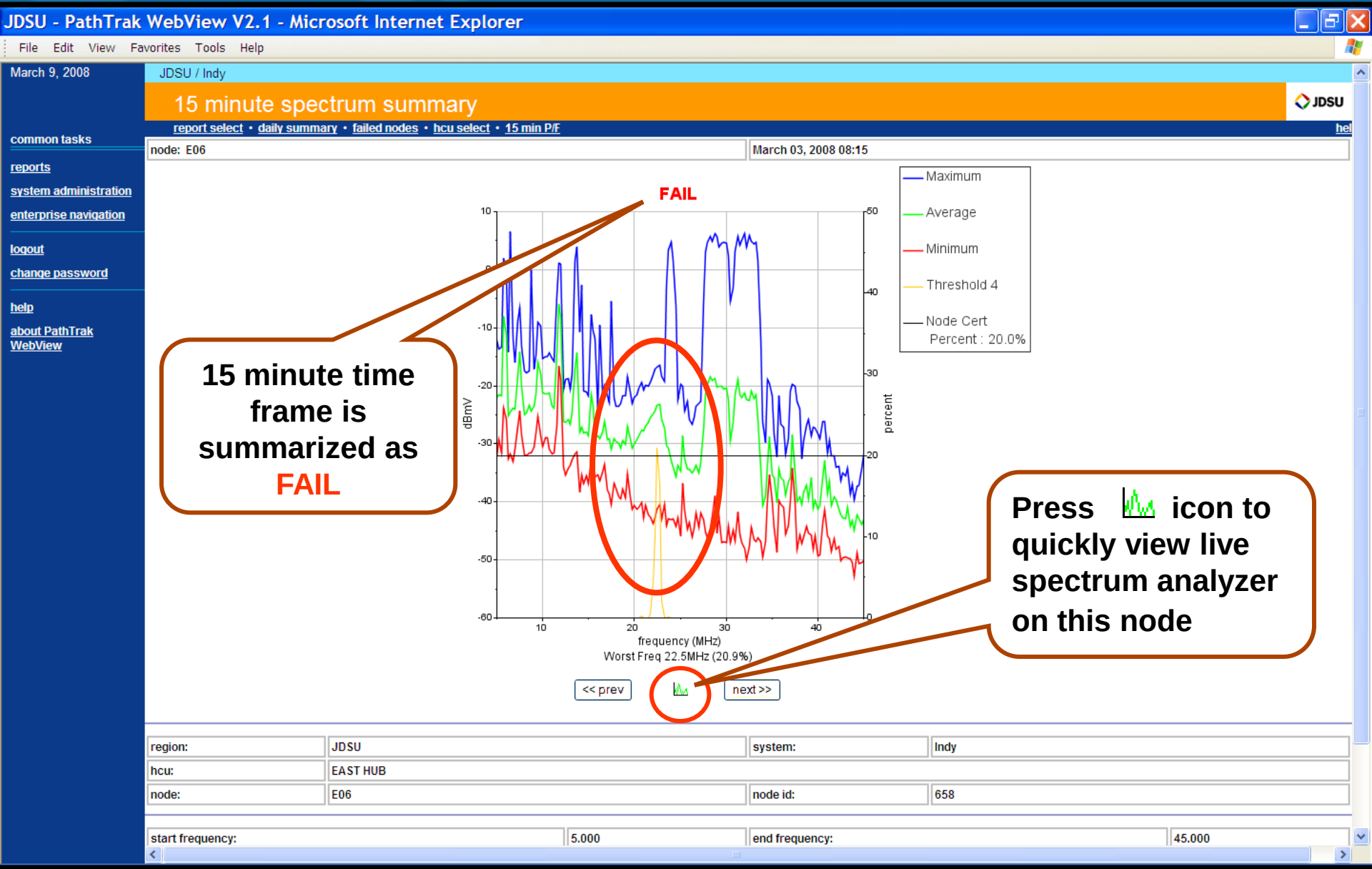


15 Minute Summary of RF Performance

WebView Node Certification - PASS



WebView Node Certification - FAIL



Monitoring and Maintaining the Return Path

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  - Forward & Reverse sweep for unity gain throughout coaxial network
  - Monitoring the Return Path

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

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

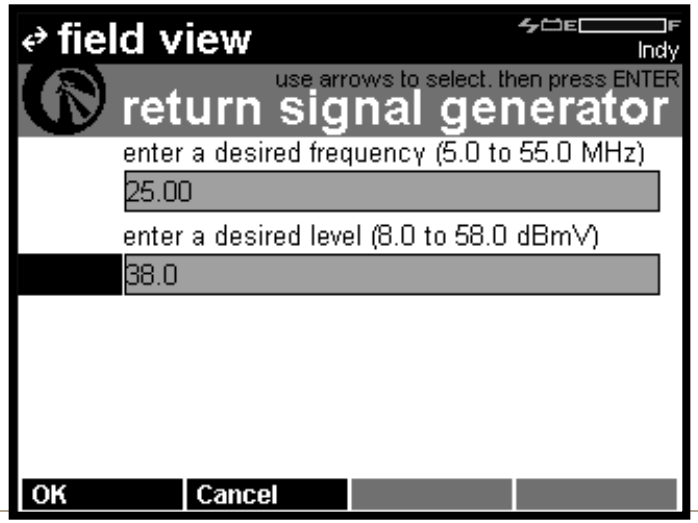
- Majority of problems are basic physical layer issues
- Most of the tests remain the same
- Check AC power
- Check forward levels, analog and digital
- Sweep forward & reverse

Back to the Basics

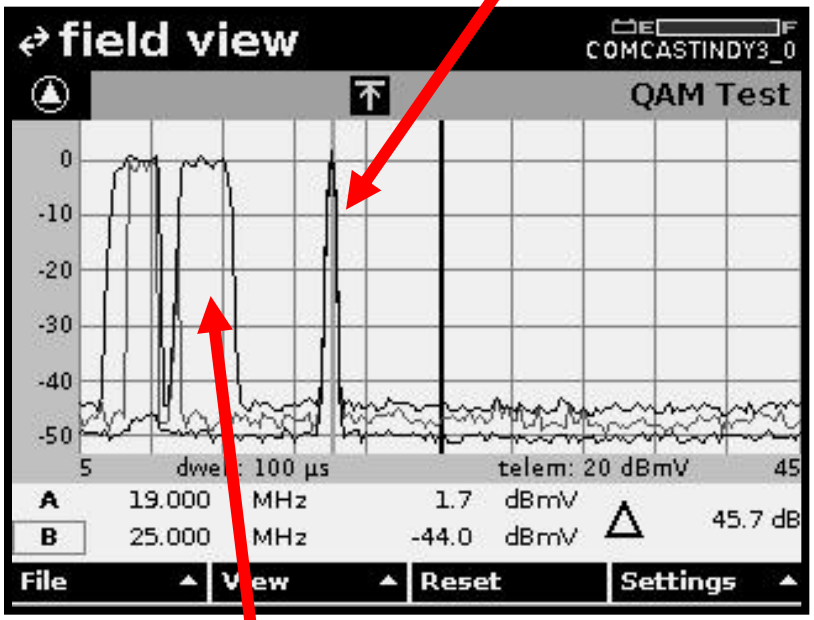
- Check for leakage sources
- Check for ingress sources
- Do a visual inspection of cable / connectors / passives
- Replace questionable cable / connectors / passives
- Tighten F-connectors per your company's installation policy
  - Be very careful not to over tighten connectors on CPE (TVs, VCRs, converters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

DSAM PathTrak Field View Option

- Works with existing PathTrak Return Monitoring systems
- Allows user to see both desired and undesired return signals from the field
- Order with or without user programmable RSG (return signal generator)
- Optional for all DSAM Models

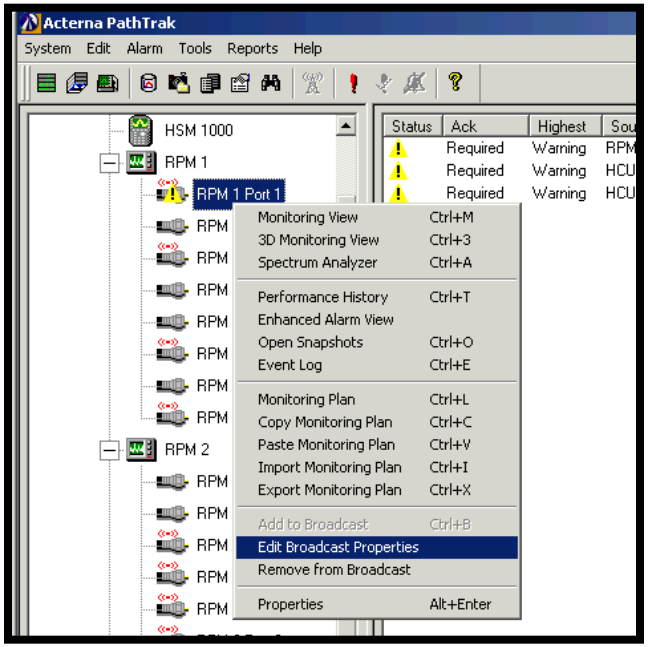


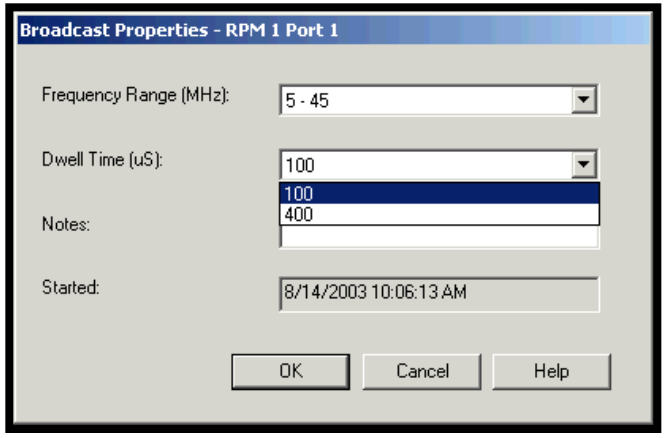
Field Programmable CW Carrier



Live Upstream Modem Carriers

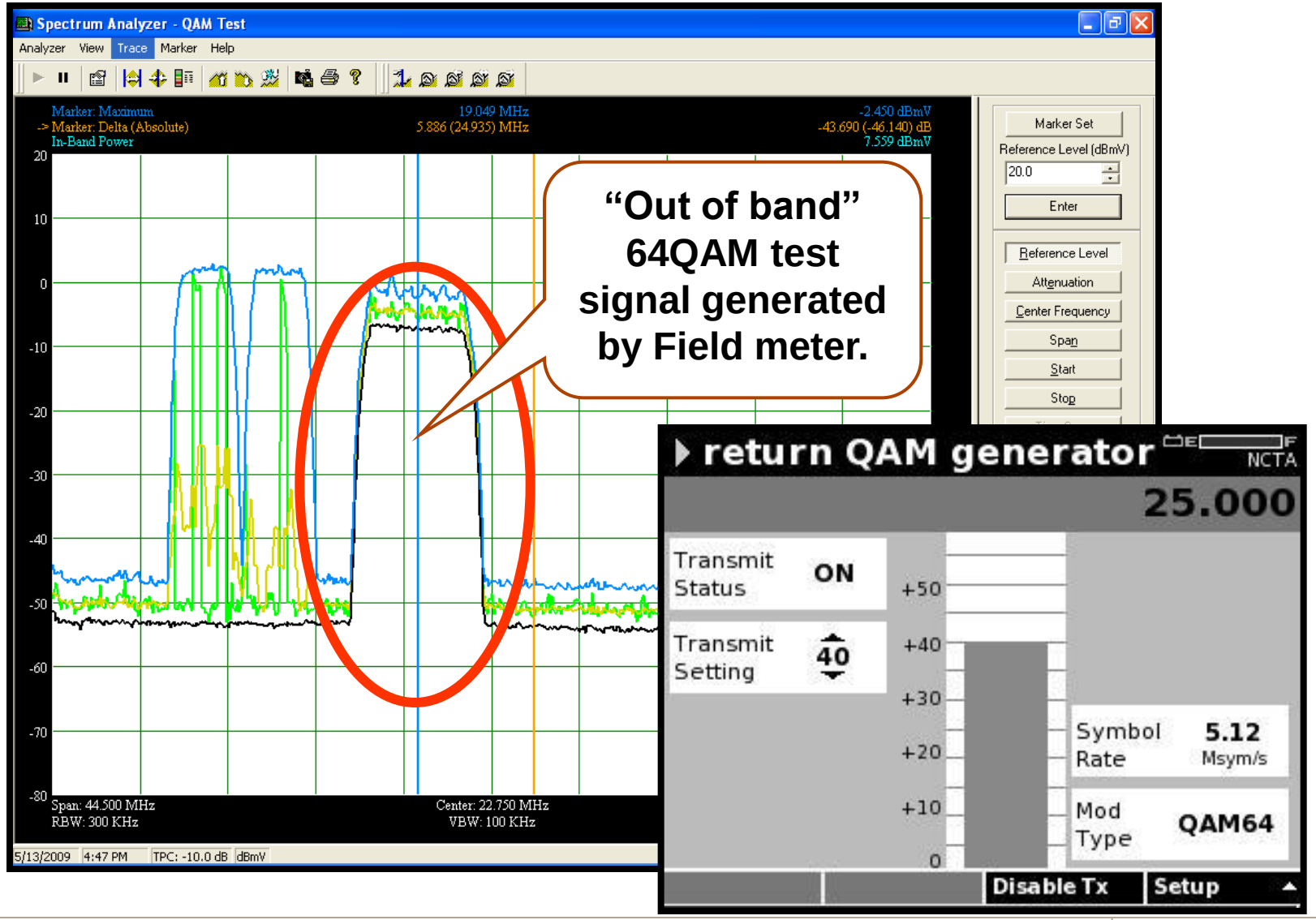
Field View Broadcast Properties of the Port



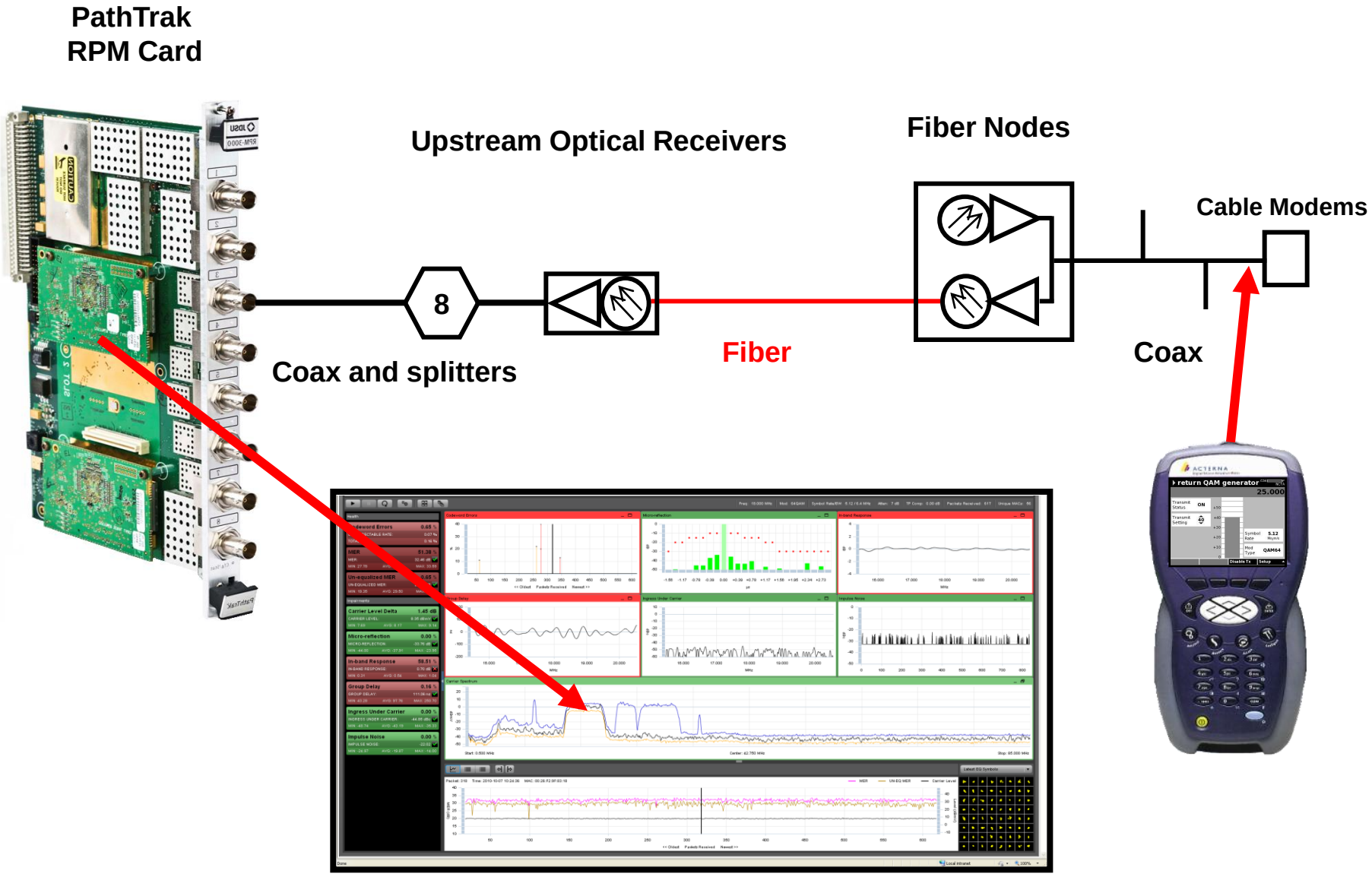


- **Frequency Ranges**
  - 5 to 45 MHz
  - **5 to 55 MHz**
  - 5 to 65 MHz
- **Dwell Times**
  - 100 µS
  - **400 µS**

“Out of Band” 64QAM Test Signal

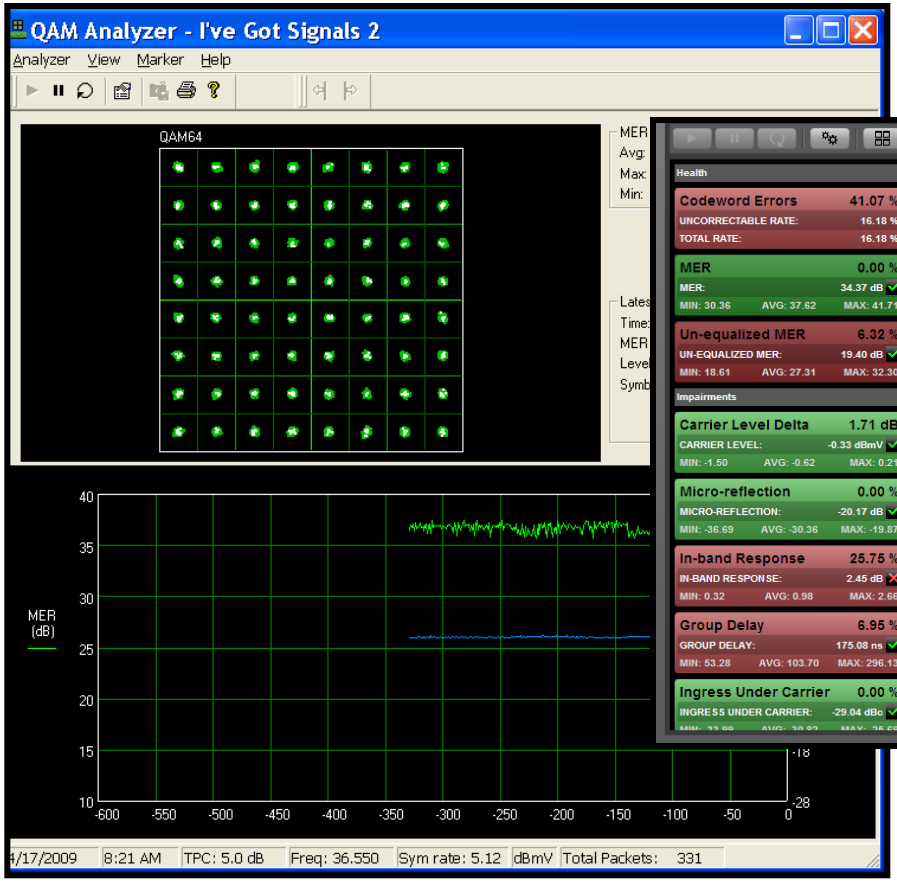


Test Unoccupied Spectrum Before Launch



QAM Analyzer - PathTrak Client vs. WebView v2.5

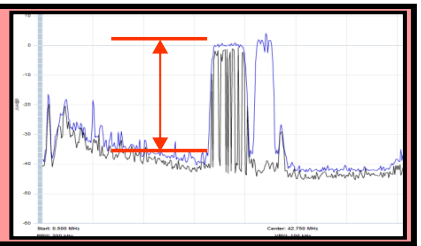
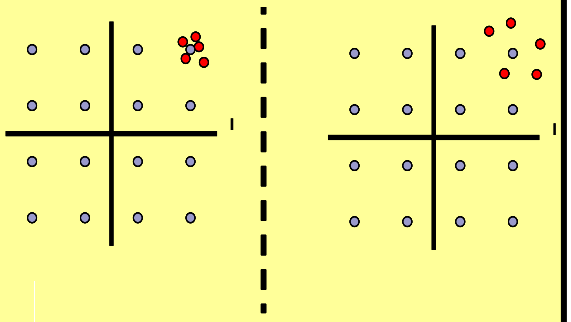
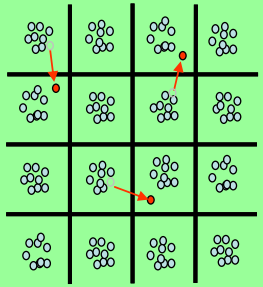
PathTrak Client QAMTrak Analyzer



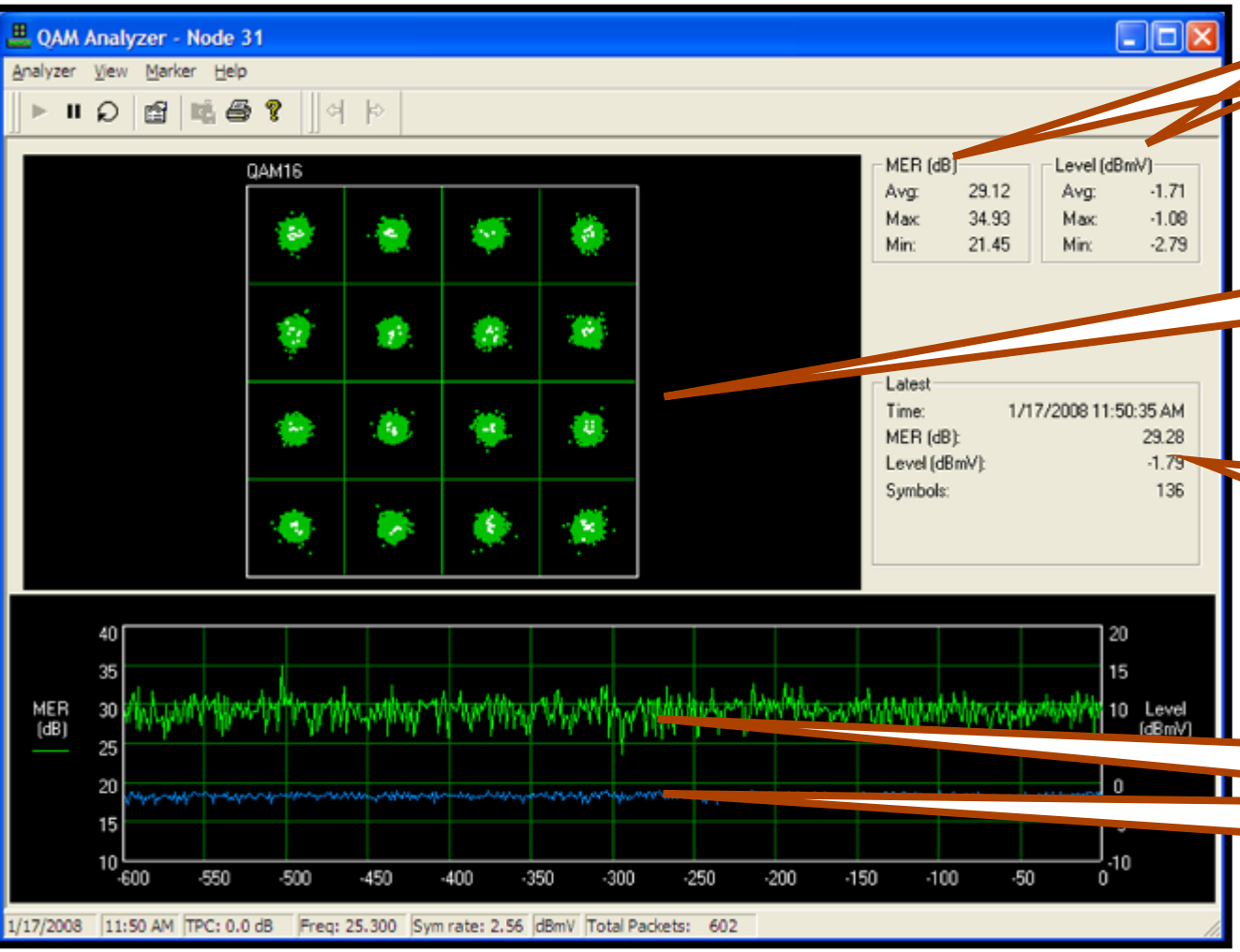
PathTrak WebView v2.5 QAMTrak

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

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 

PathTrak QAM Analyzer View – Good Node



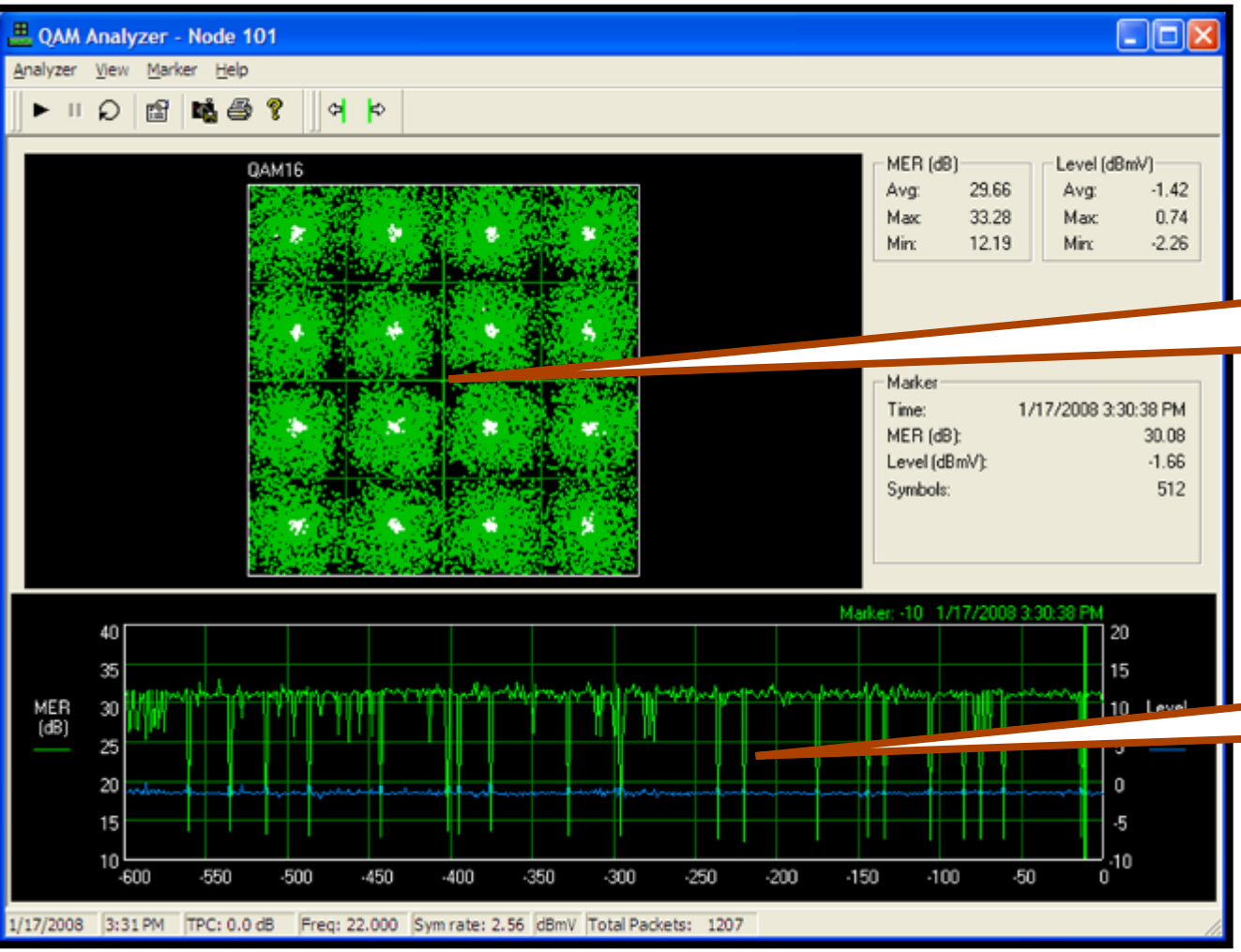
MER & Level Avg/Max/Min

QPSK & 16QAM Constellation

Live MER, Level & Symbol Count

MER & Level Graphed over Time

PathTrak QAM Analyzer View – Bad Node?



Interference easily visible in 16 QAM constellation

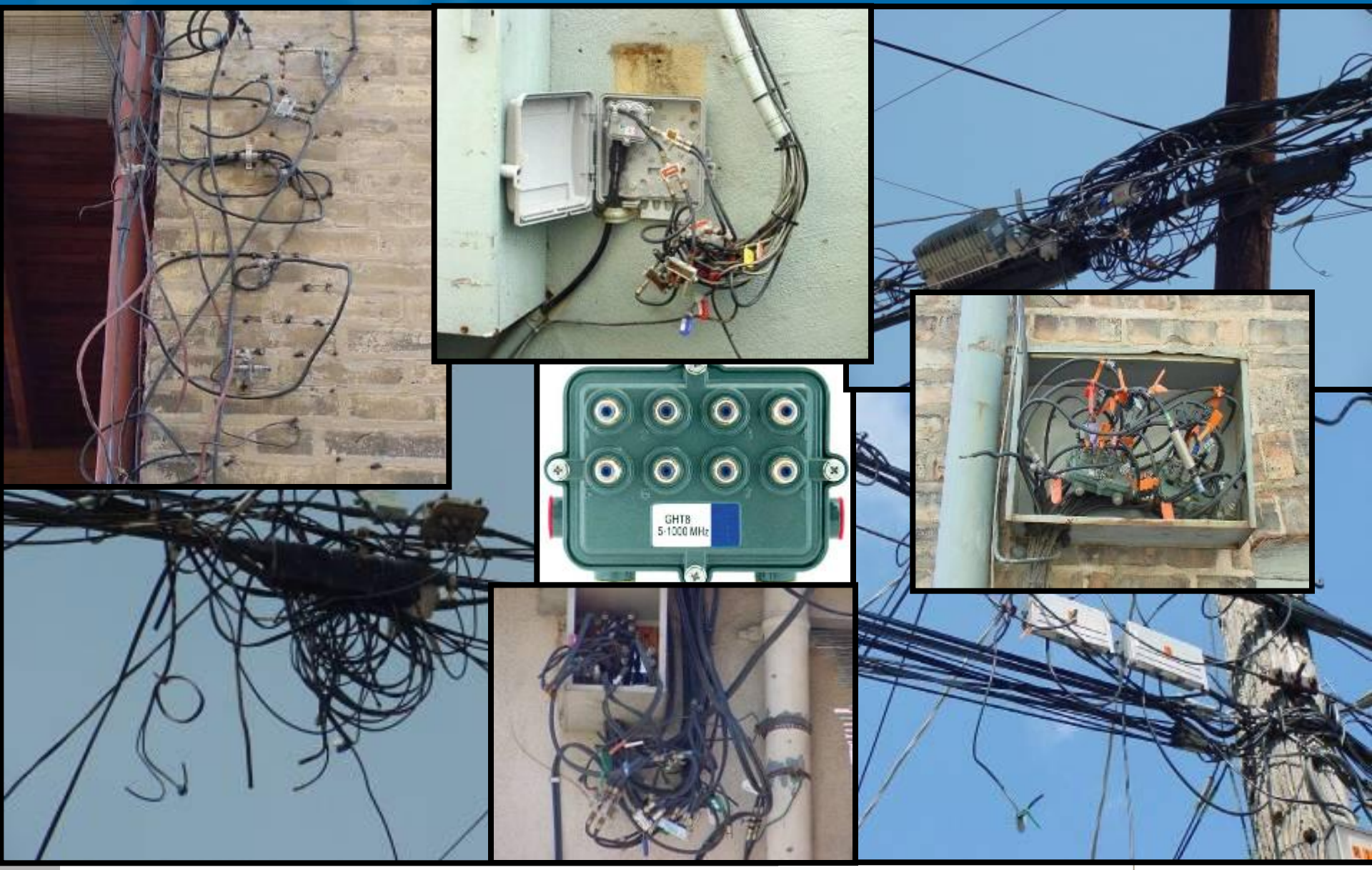
Interference causing intermittent low MER

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
  - Monitoring the Return Path

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

Common problems in HFC Networks



Common problems in HFC Networks

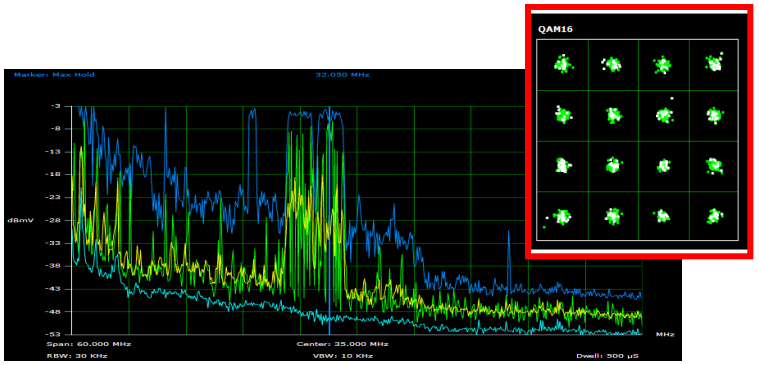
- **Kinked or damaged cable (including cracked cable, which causes a reflection and ingress).**
- **Defective or damaged actives or passives (water-damaged, water-filled, cold solder joint, corrosion, loose circuit-board screws, etc.).**
- **Cable-ready TVs and VCRs connected directly to the drop. (Return 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

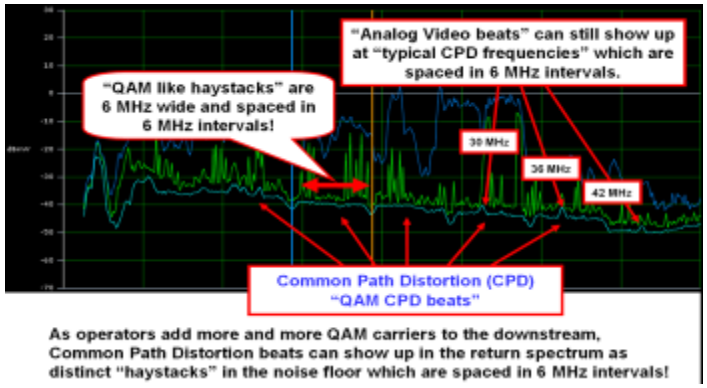
- **Damaged or missing end-of-line terminators**
- **Damaged or missing chassis terminators on directional coupler, splitter or multiple-output amplifier unused ports**
- **Loose tap faceplates and loose center conductor seizure screws**
- **Unused tap ports not terminated. This is especially critical 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**

What Type of Problem: Common Impairments

- **Ingress**
  - Still the most common
  - Use return path monitoring system to know when to chase



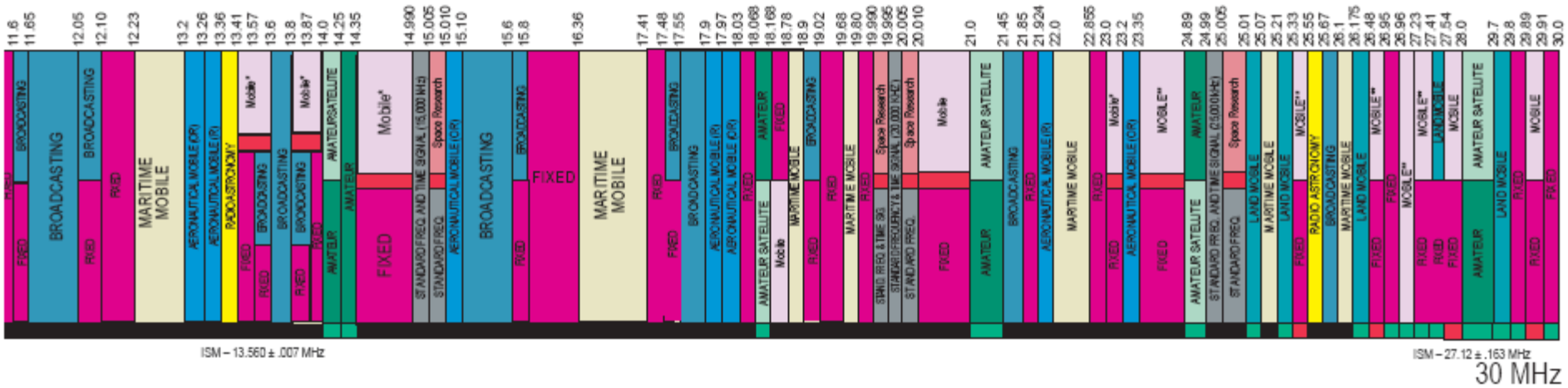
- **Common Path Distortion**
  - Old news in analog DS plant
  - New look in all-digital plant



- **Impulse Noise**
  - Impulse noise troublesome for CMTS
  - RFI detector for power-line noise

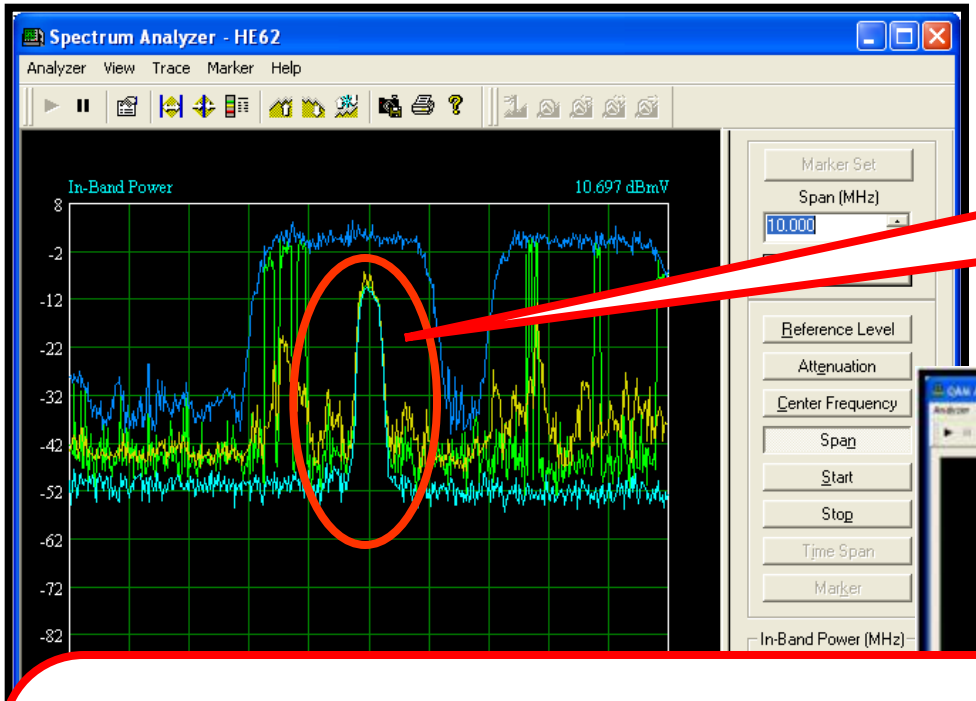
Reverse Path Impairments - Ingress

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

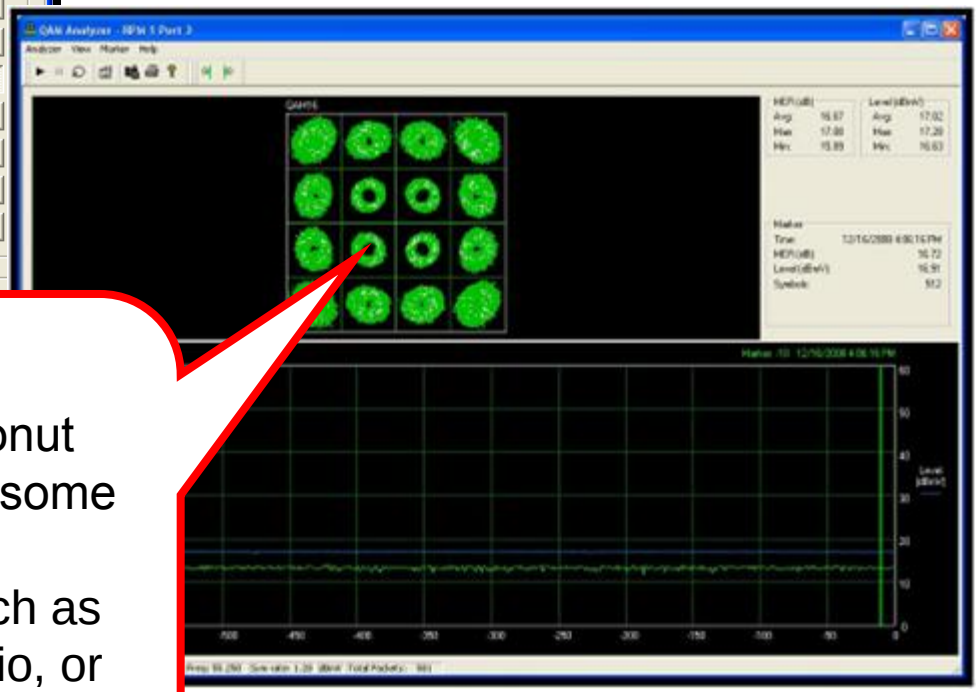


Signals in the over-the-air environment include high power shortwave broadcasts, amateur radio, citizens band, government, and other two-way radio communications.

Ingress - Off-air Broadcast Radio Carrier



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

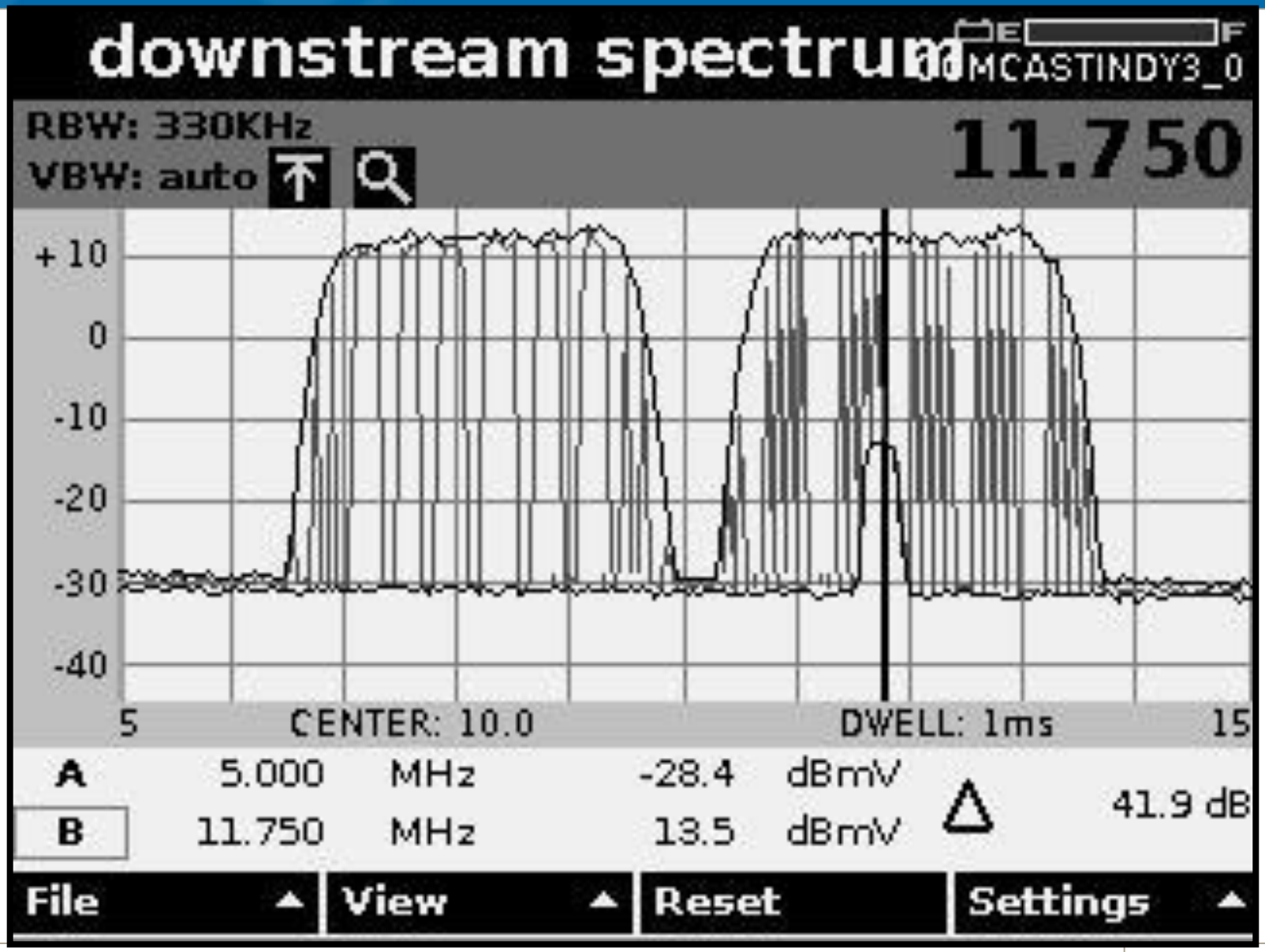


Coherent Interference

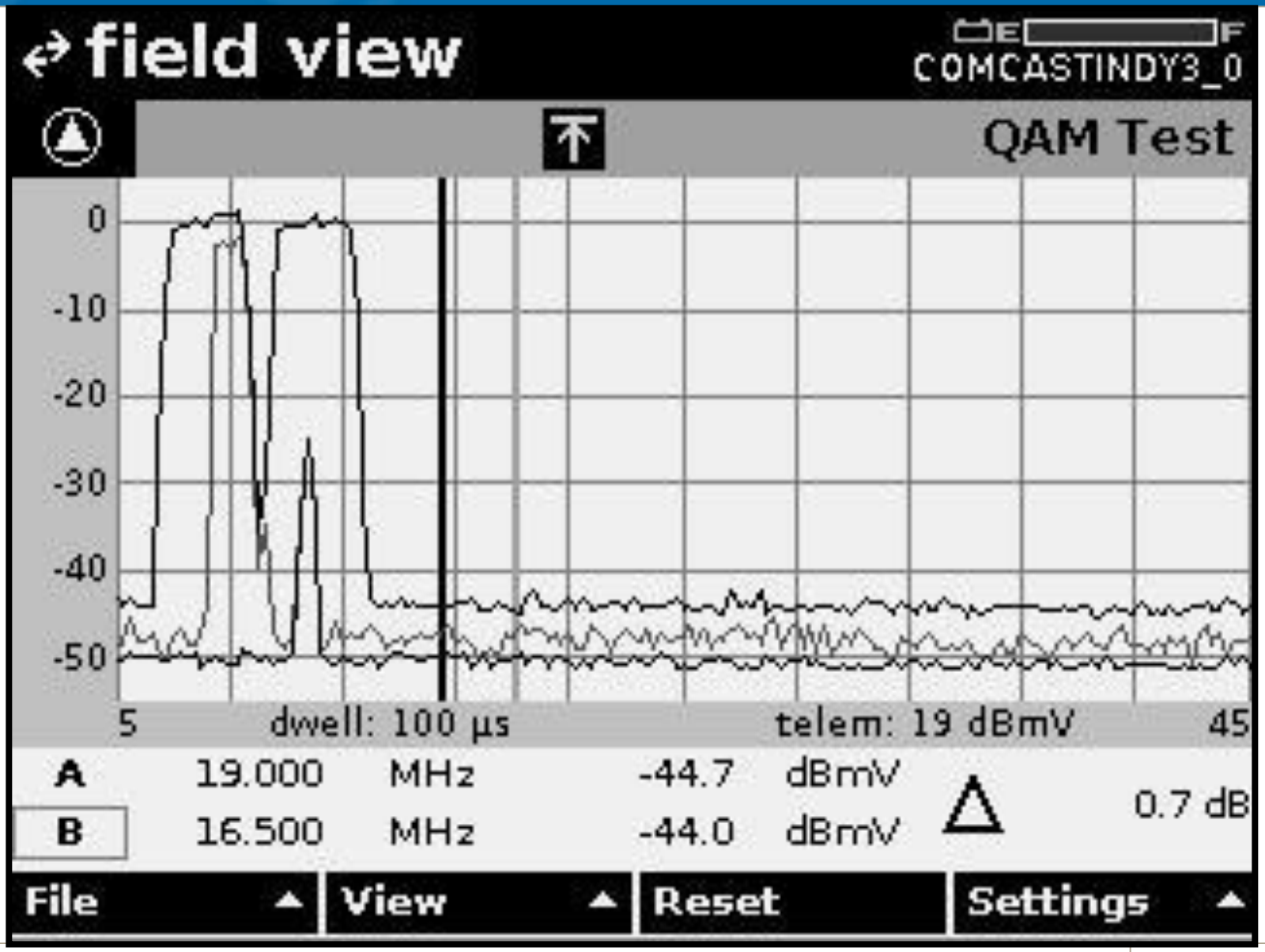
If the constellation looks like it has “donut shapes” in it, the problem is likely to be some form of coherent interference.

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

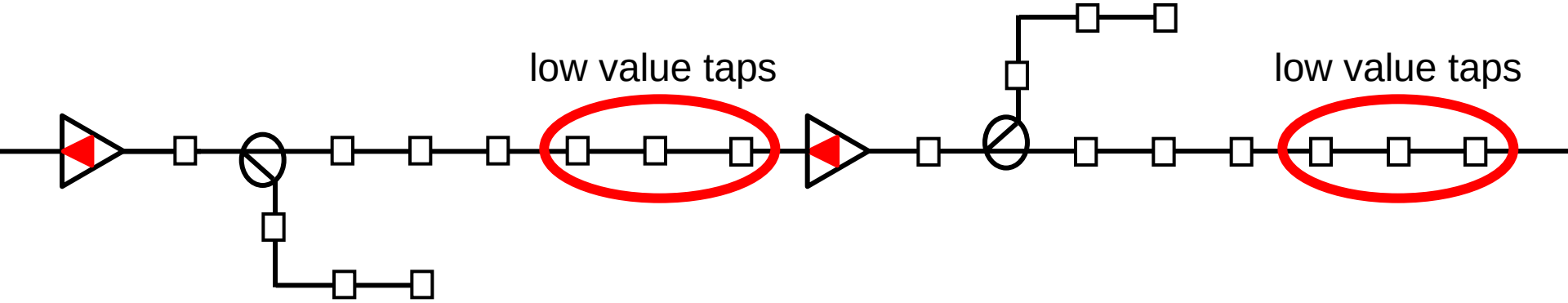
Downstream Spectrum Mode – CW @ 11.75 MHz



Field View – CW @ 11.75 MHz



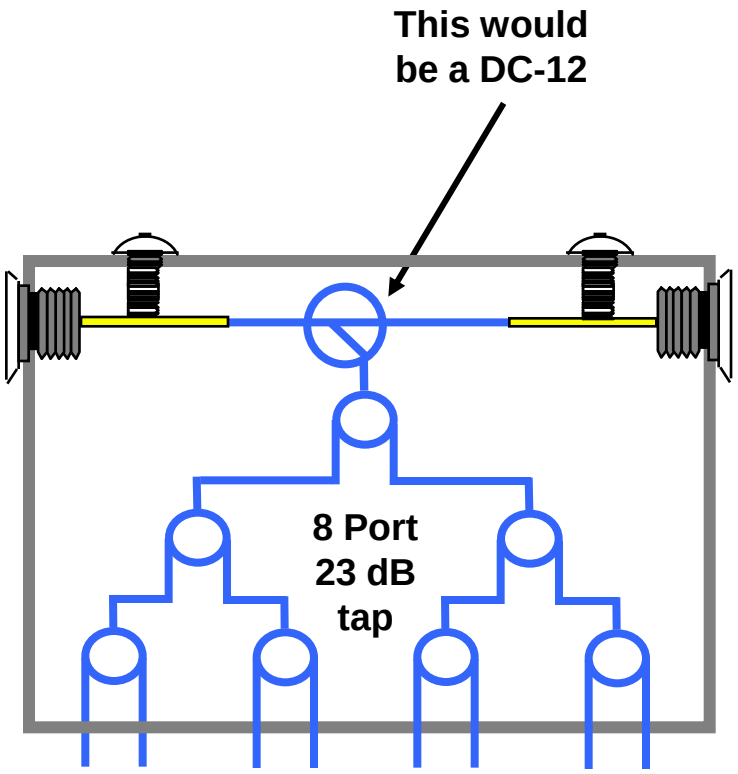
Typical Problem Areas



- **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

Taps

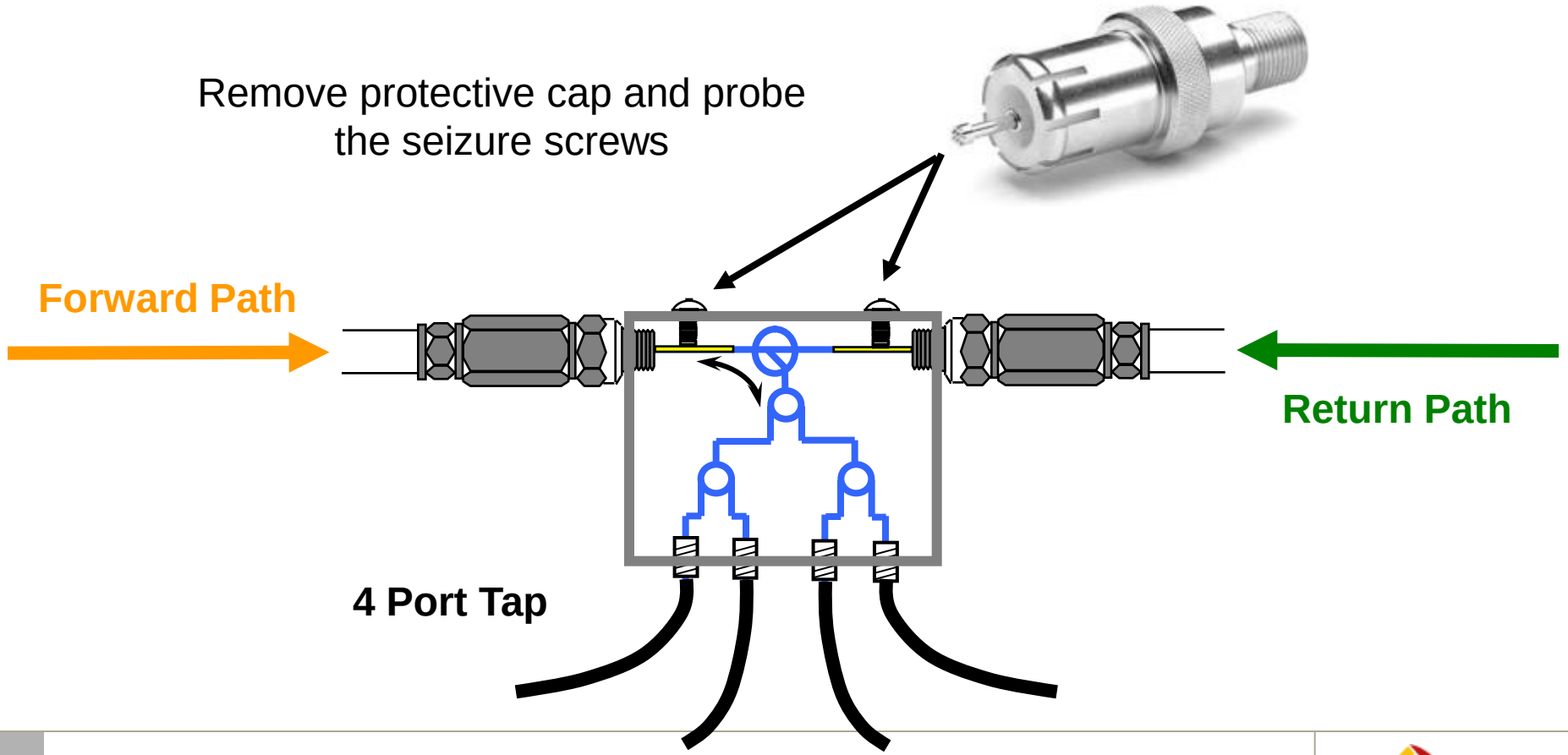
- Taps are a combination of a DC and a splitter network
- Taps give an actual representation of what the subscriber is seeing and transmitting in to
- Points to remember;
  - Lower valued taps equal more through loss



The splitter network = ~11 dB of loss

Testing with Seizure Screw Probes

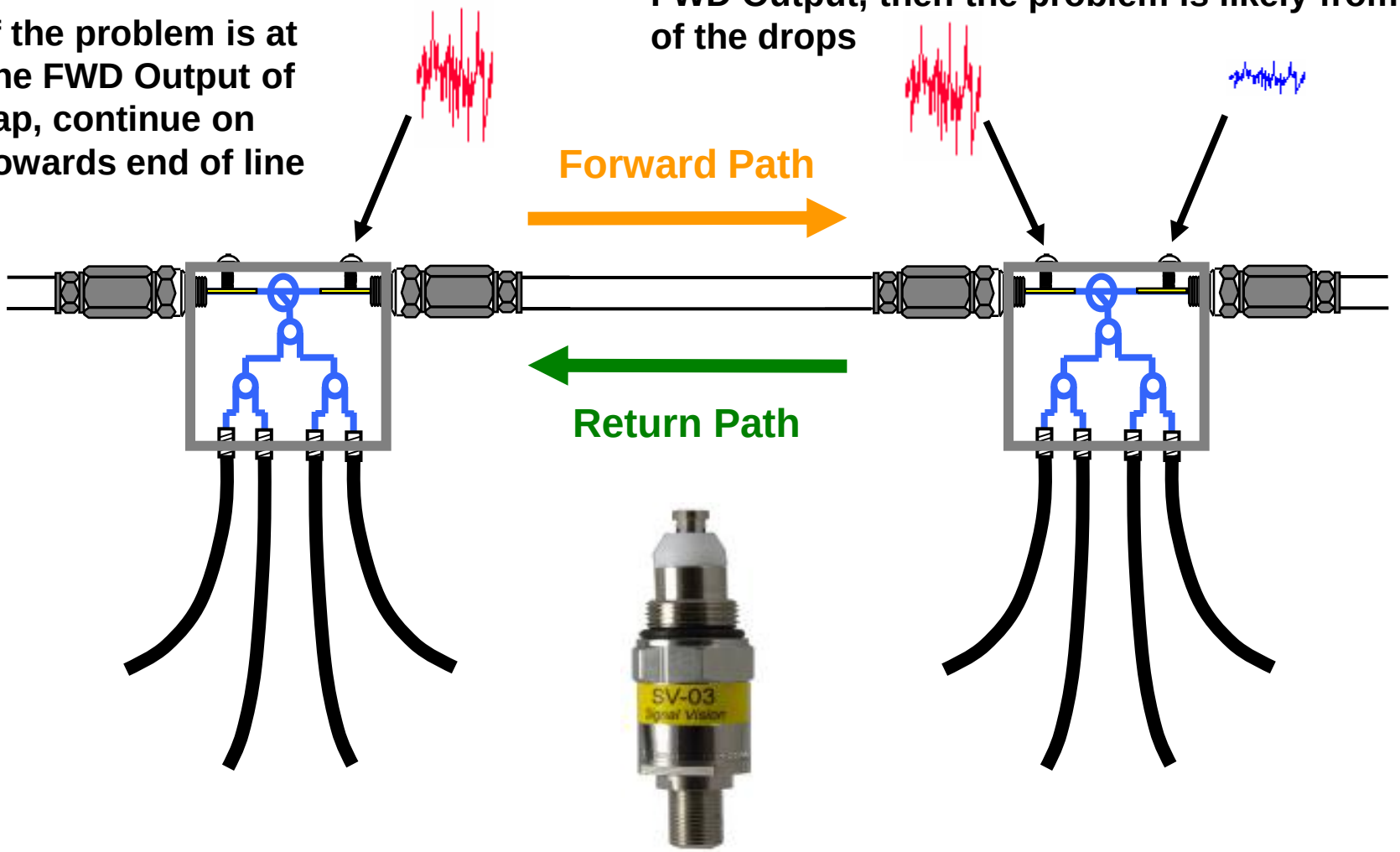
- Spring loaded seizure screw probes create a good ground and quick connect without causing outages
- Use a 20 db pad with AC block when using a field meter and a spring loaded seizure screw probe



Taps - Probe the Seizure Screws for Ingress & CPD

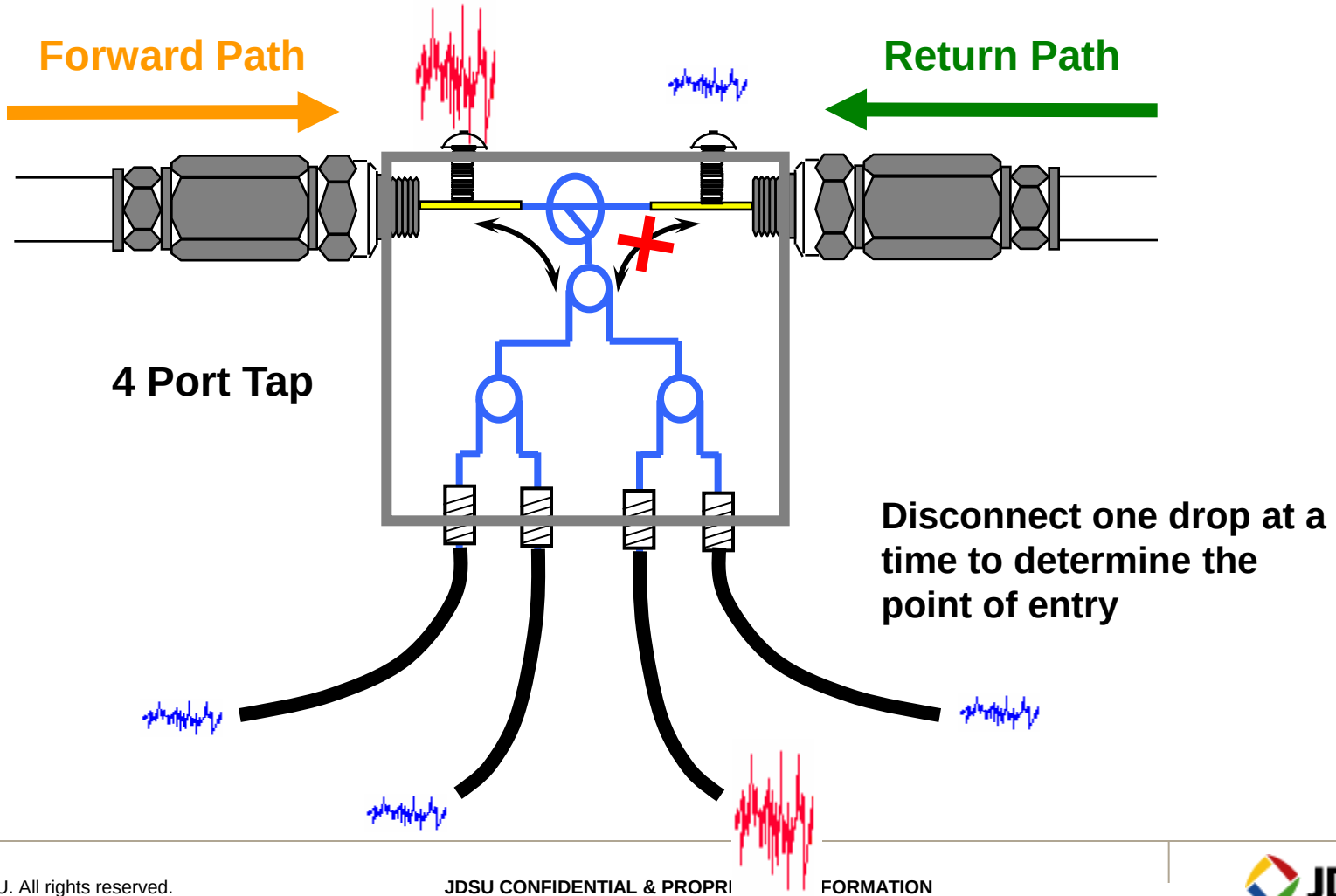
If the problem is at the FWD Output of tap, continue on towards end of line

If the problem is at the FWD Input and not the FWD Output, then the problem is likely from one of the drops

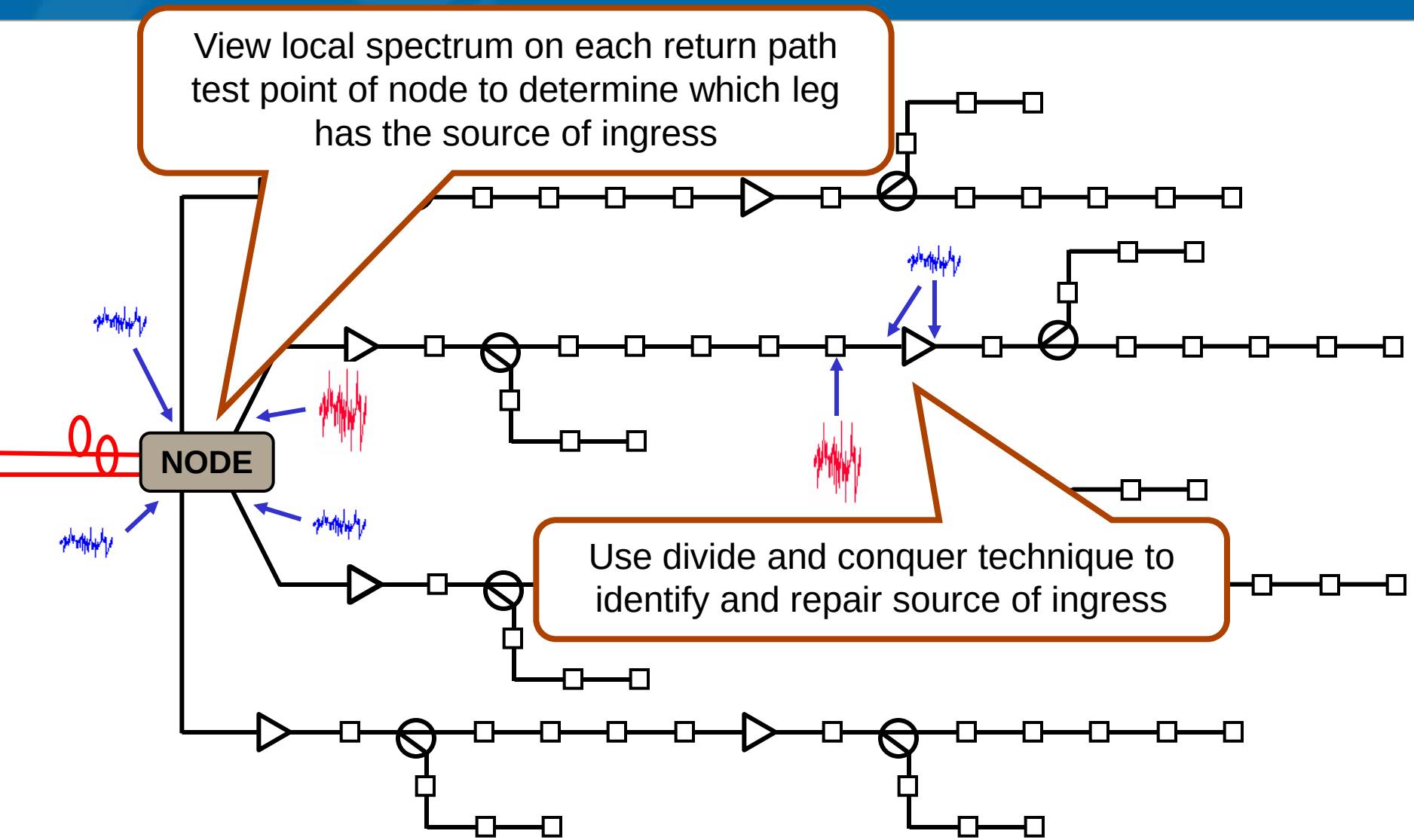


Taps are made up of a Directional Coupler and Splitters

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



Tracking Down Ingress – Divide and Conquer



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

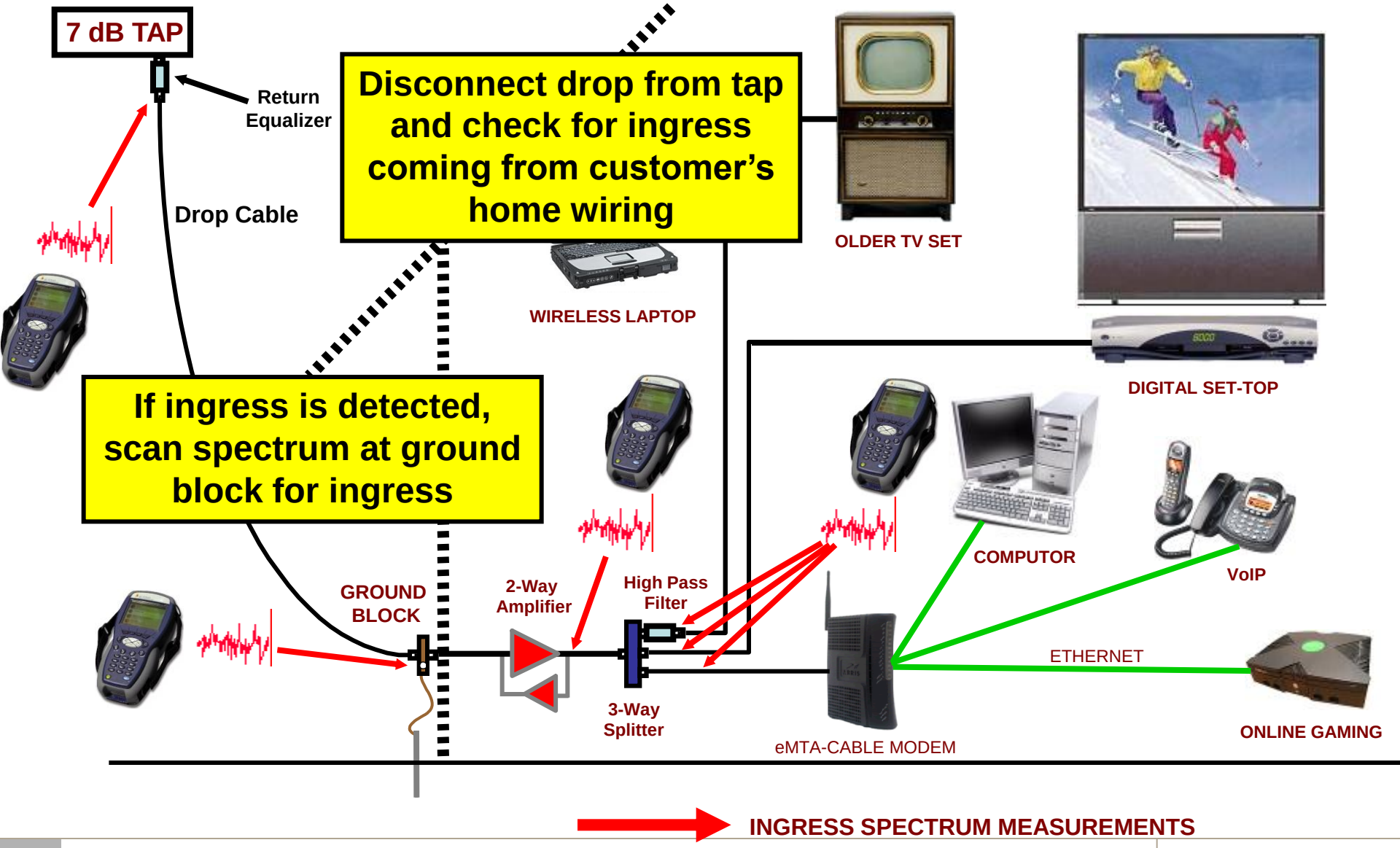
- AM Radio Station
- FM Radio Station
- TV Station
- Two-way Radio Transmitters
- Citizens Band (CB)
- Amateur (Ham)
- Taxi
- Police
- Business
- Airport/Aircraft
- Paging Transmitters

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

Testing the Home for Ingress Contribution



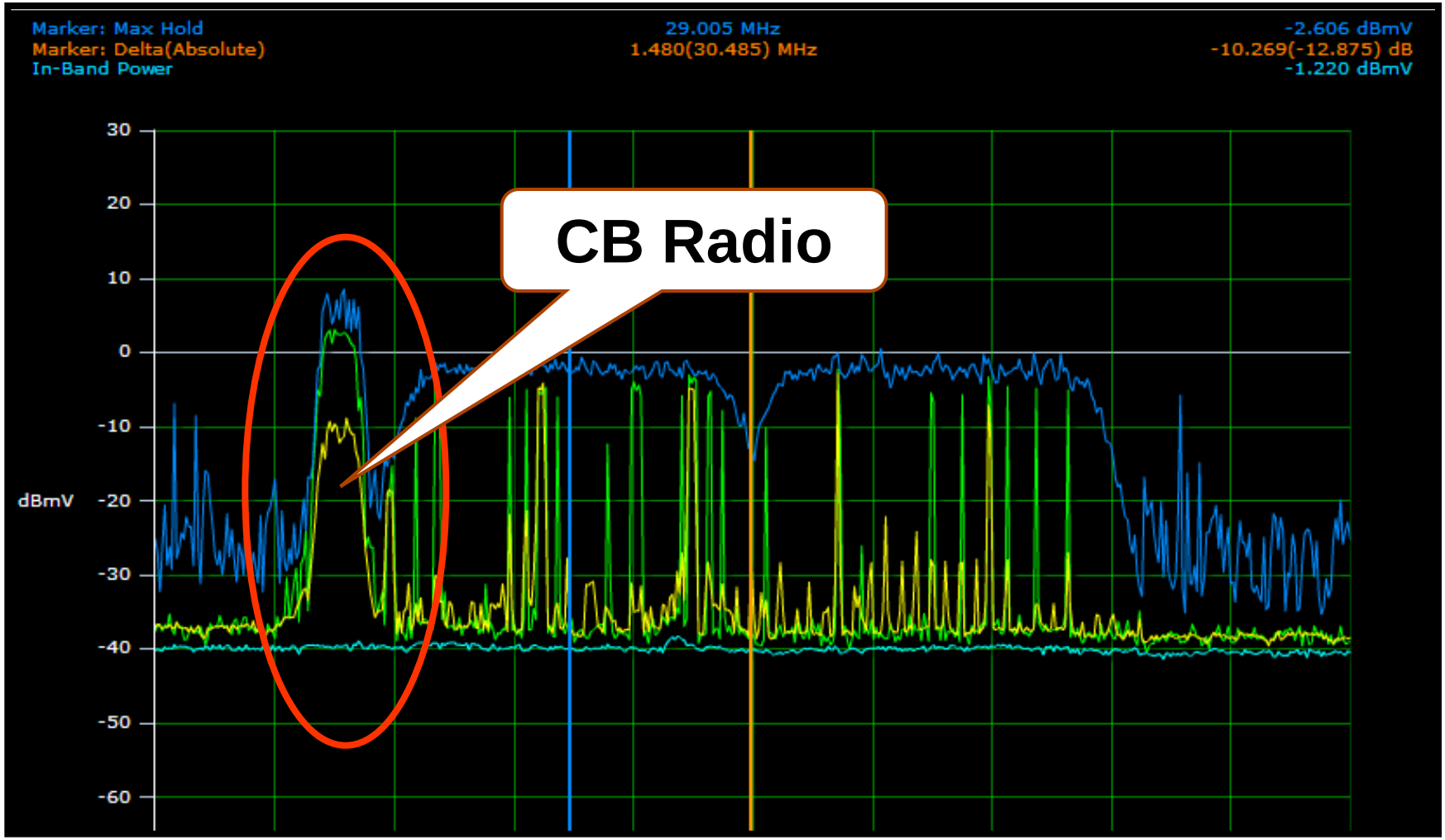
What Causes Signal Leakage & Ingress?

- **Most common source of leakage is within the home wiring (approximately 75%) and drop cable (approximately 20%). There's a lot of homes that still have the original wiring from 20-30 years ago!**
- **Inferior quality coaxial cable, passives, connectors**
- **Poor installation of splices and connectors - water and weather can result in pulled out, loose or corroded connectors**
- **Illegal connections to neighbor's cable**
- **Some of the older TV sets with poor tuner shielding can produce leakage and ingress problems**

What Causes Signal Leakage & Ingress?

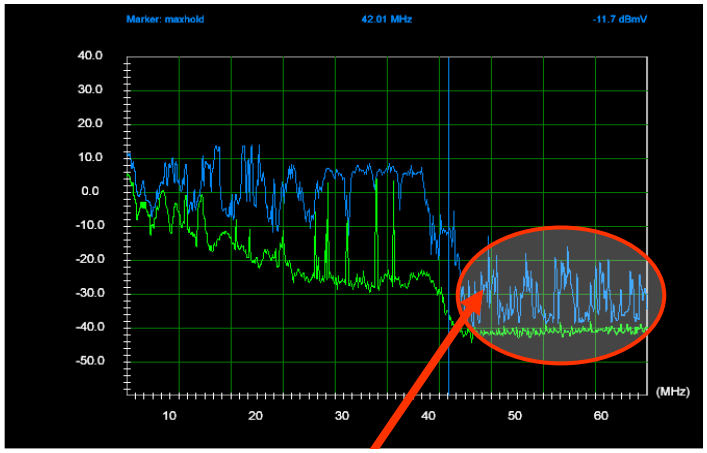
- **Some less abundant sources, such as trunk or bridger amplifiers output, are likely to radiate much greater RF energy and produce a bigger effect on the system's total leakage.**
- **Radial cracks in the expansion loop**
- **Improperly terminated splitters, jumpers from drops to taps or ground blocks**
- **Accidents (vehicles crashing into poles)**
- **The environment, weather, landscape & even animals (squirrel chews) could have an effect**

Ingress - CB Radio

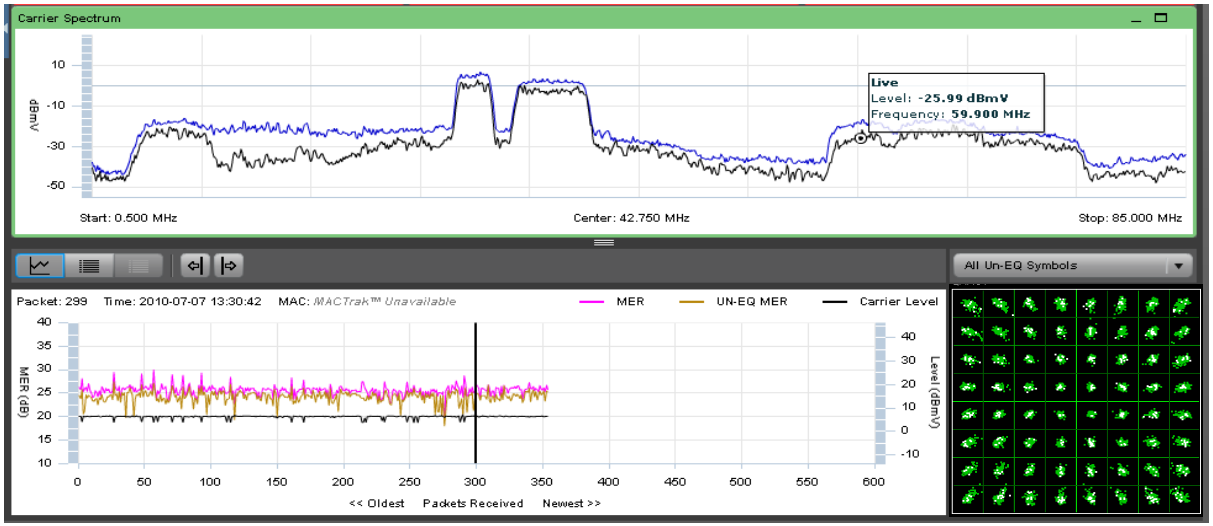


Common Impairments: Laser Clipping

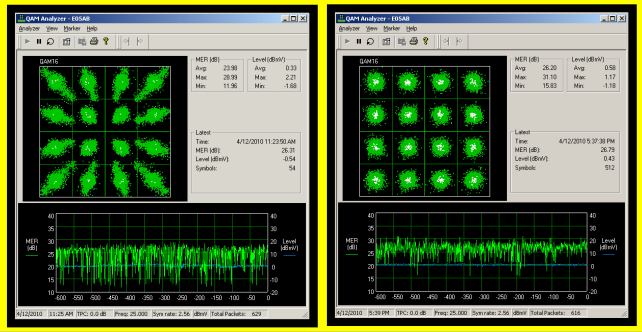
- Caused by Overdriving Laser
  - Low end ingress
  - Improper laser setup
  - Adding carriers without compensating
- Very distinct constellation footprint
  - Also see as junk above diplex in spectrum
  - Optical receiver issues can look similar



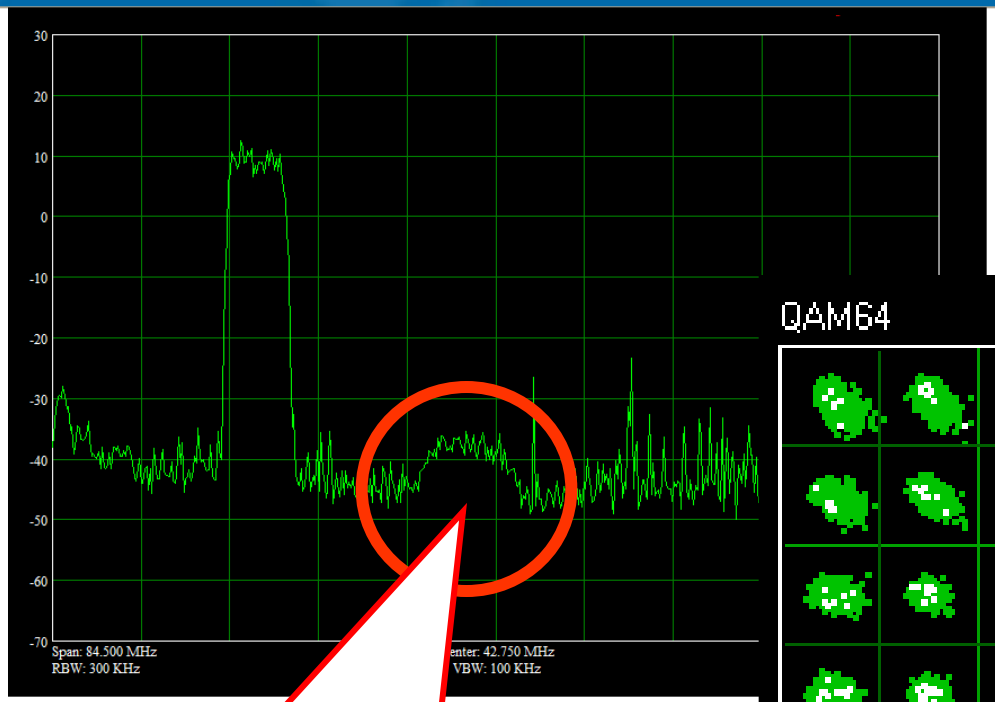
Wide band impulse noise above diplex roll-off frequency

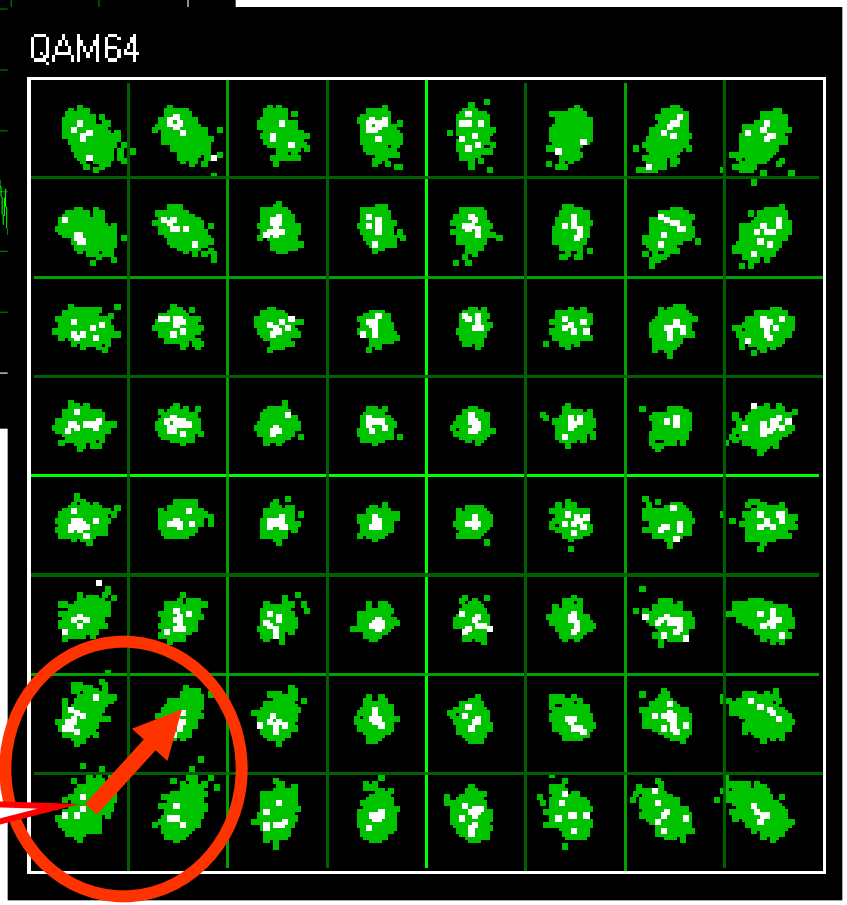


Before/After:
Faulty Optical Receiver
Similar to Laser Clipping



Reverse Path Impairments – Laser Clipping

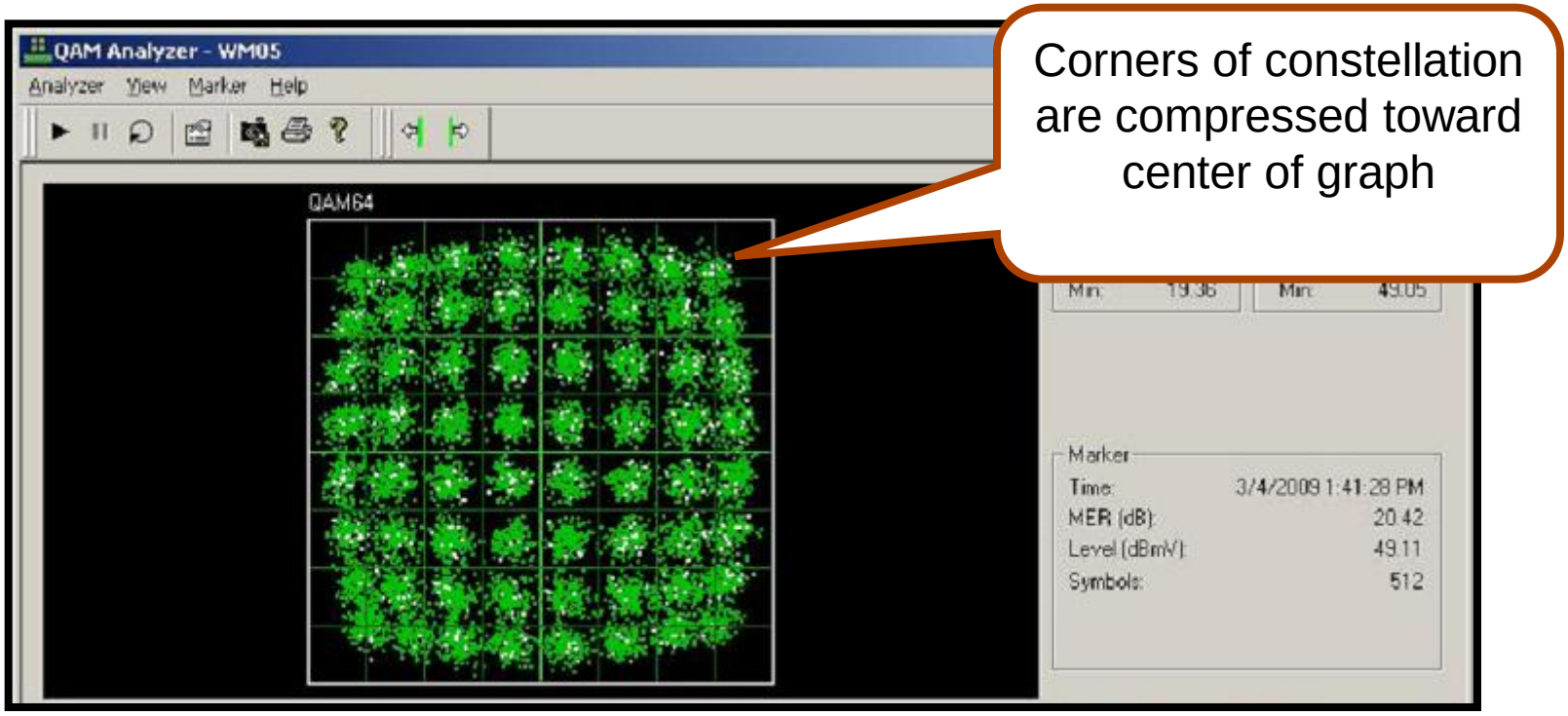




Harmonic at twice the frequency of the carrier

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

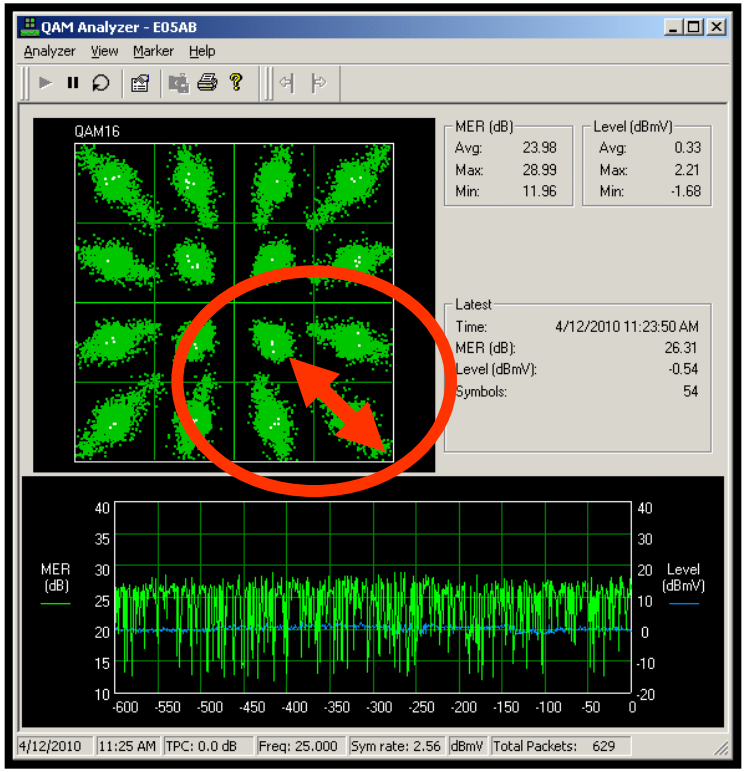
Reverse Path Impairments – Compression

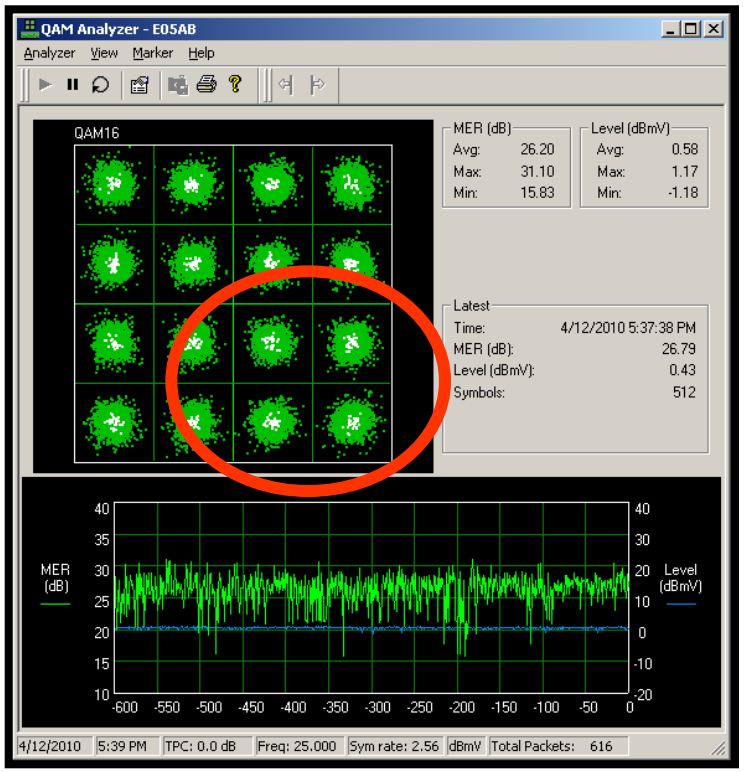


Amplifier Compression

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



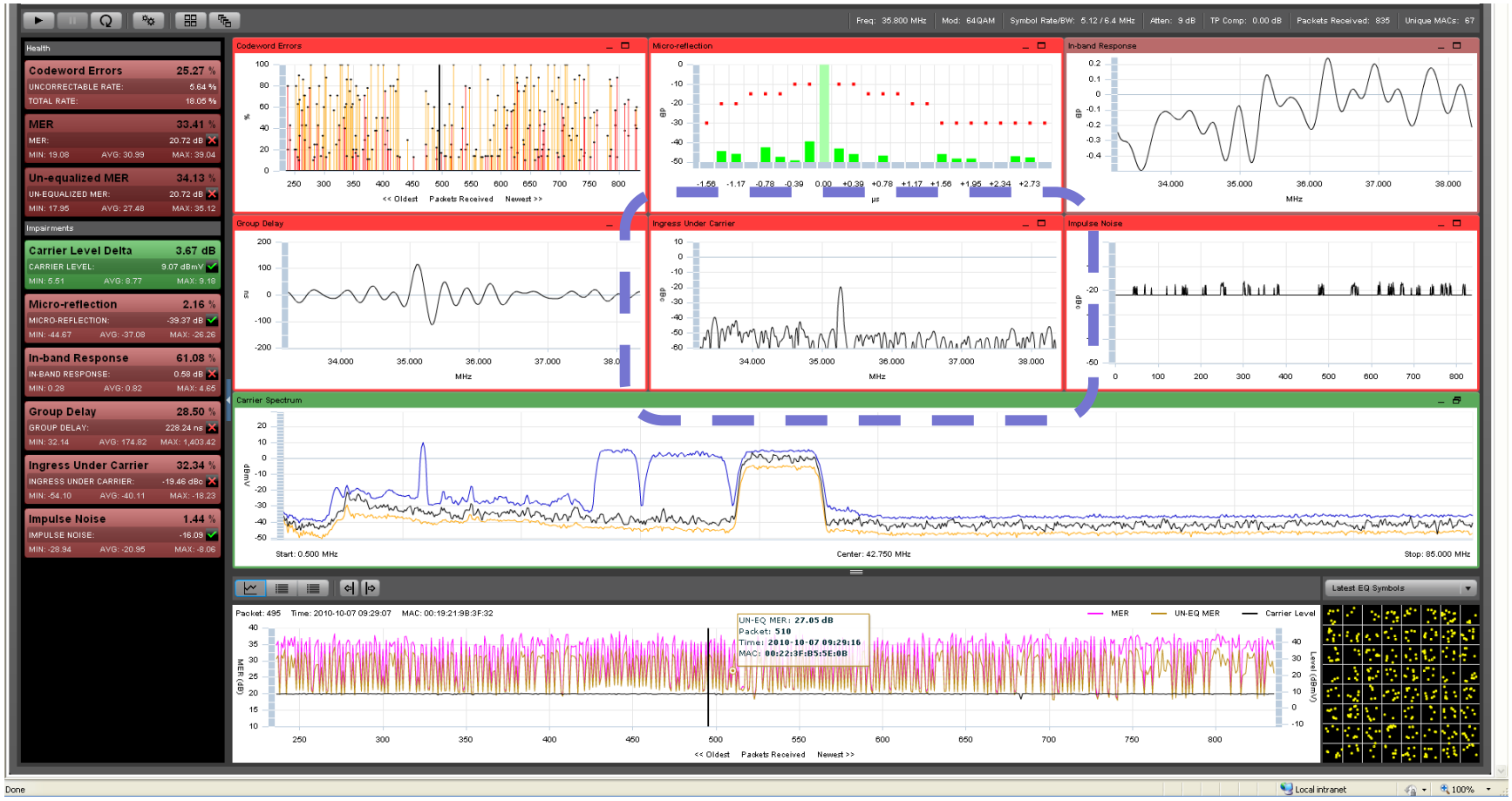


This constellation pattern is noticeably distorted due to a defective optical receiver.

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

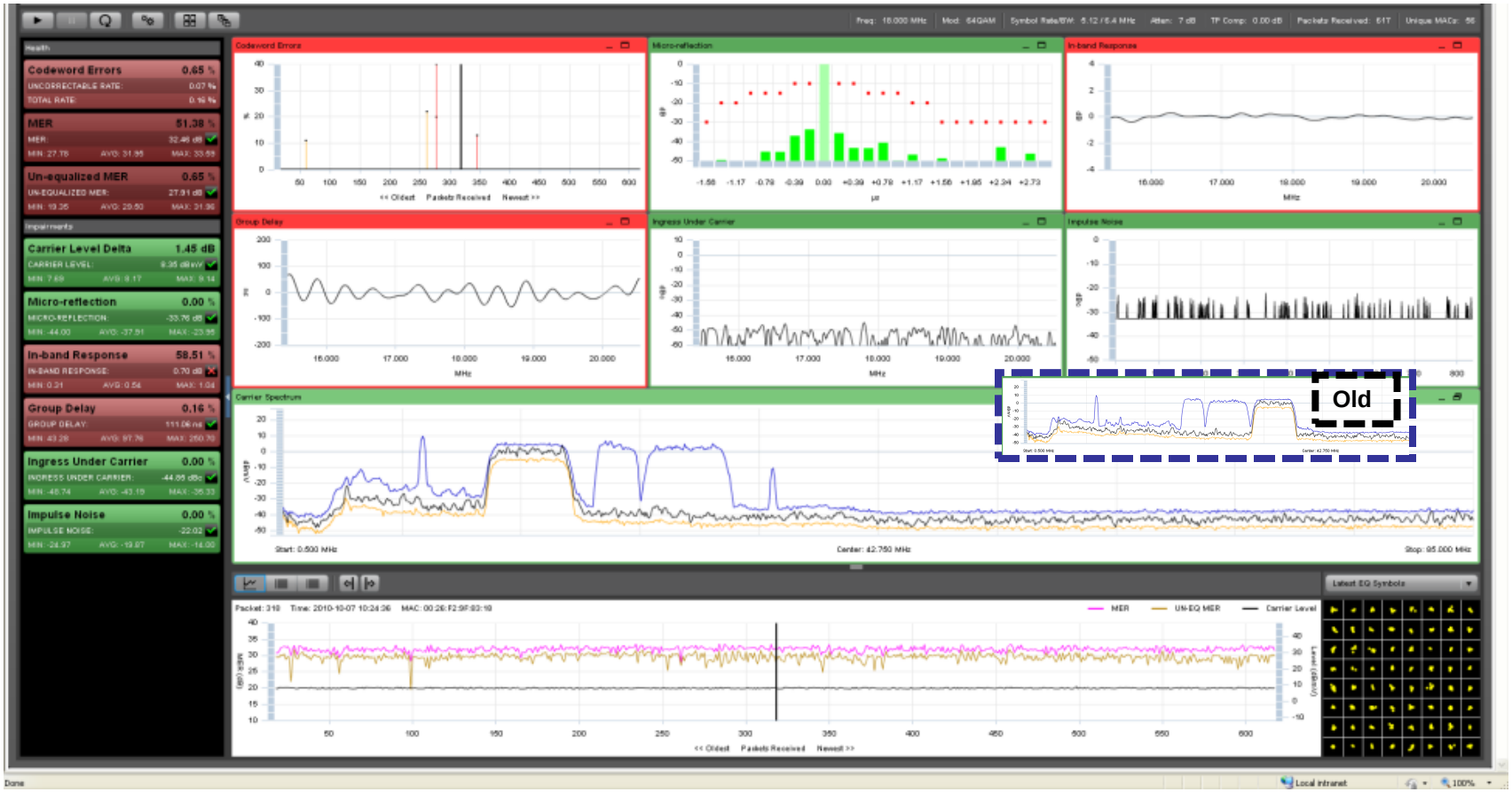
Examples of Problems Solved by MACTrak

- Observation: In-Band Response Looks Bad Largely due to Chart Scaling
  - IBR often more of an effect than a cause – be careful
  - Note Ingress Under The Carrier Display



Examples of Problems Solved by MACTrak

- Temporary Fix: Move The Carrier Away From Interferer
  - Codeword Errors drastically reduced
  - Note Ingressor still there where carrier used to be
    - Doesn't show in min hold (yellow) trace – ingressor is bursty (explains good vs bad packets in previous slide)

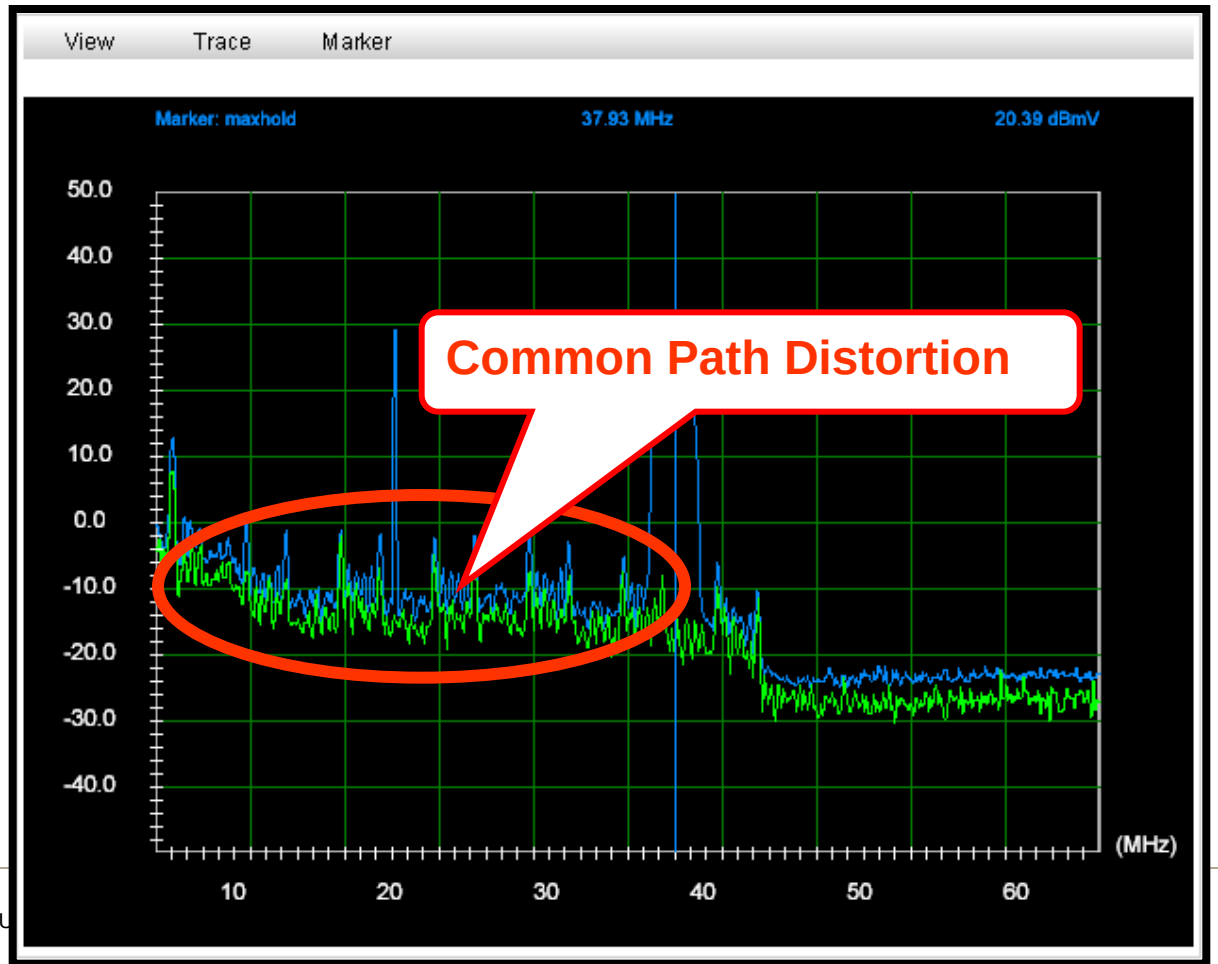


Examples of Problems Solved by MACTrak

- Permanent Fix – Get Rid of Ingressor and Return Carrier to Original Frequency
  - Ingressor caused by illegal hookup tapping into 3-way splitter
  - CWE's nearly completely wiped out, IBR good, MER much better
    - Low end ingress still there – is a problem but was not THE problem

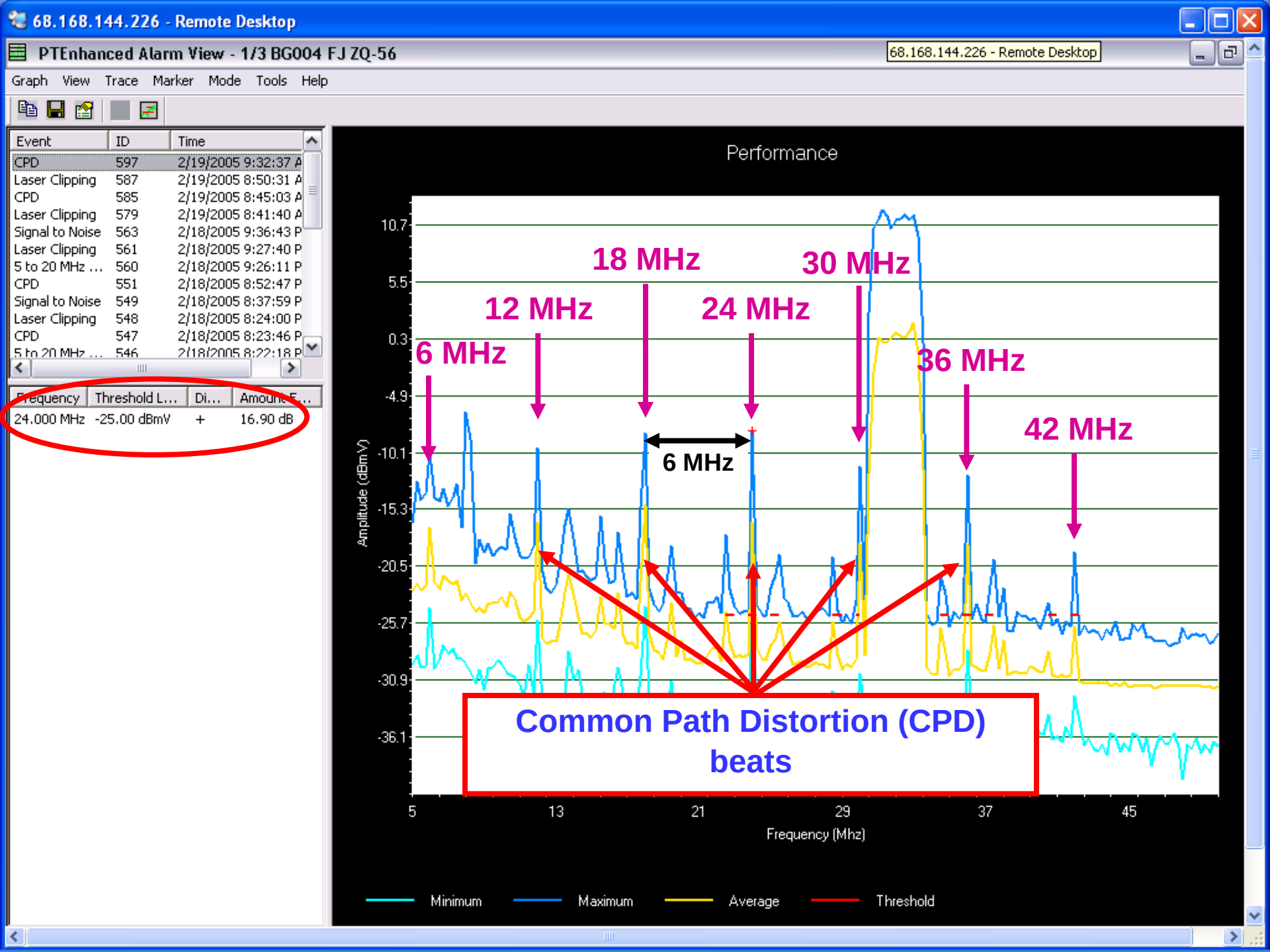
Reverse Path Impairments – CPD

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
6 MHz
12 MHz
18 MHz
24 MHz
30 MHz
36 MHz
42 MHz
6 MHz
Amplitude (dBmV)
10.7
5.5
0.3
-4.9
-10.1
-15.3
-20.5
-25.7
-30.9
-36.1
5
13
21
29
37
45
Frequency (Mhz)
Common Path Distortion (CPD) beats
Minimum
Maximum
Average
Threshold

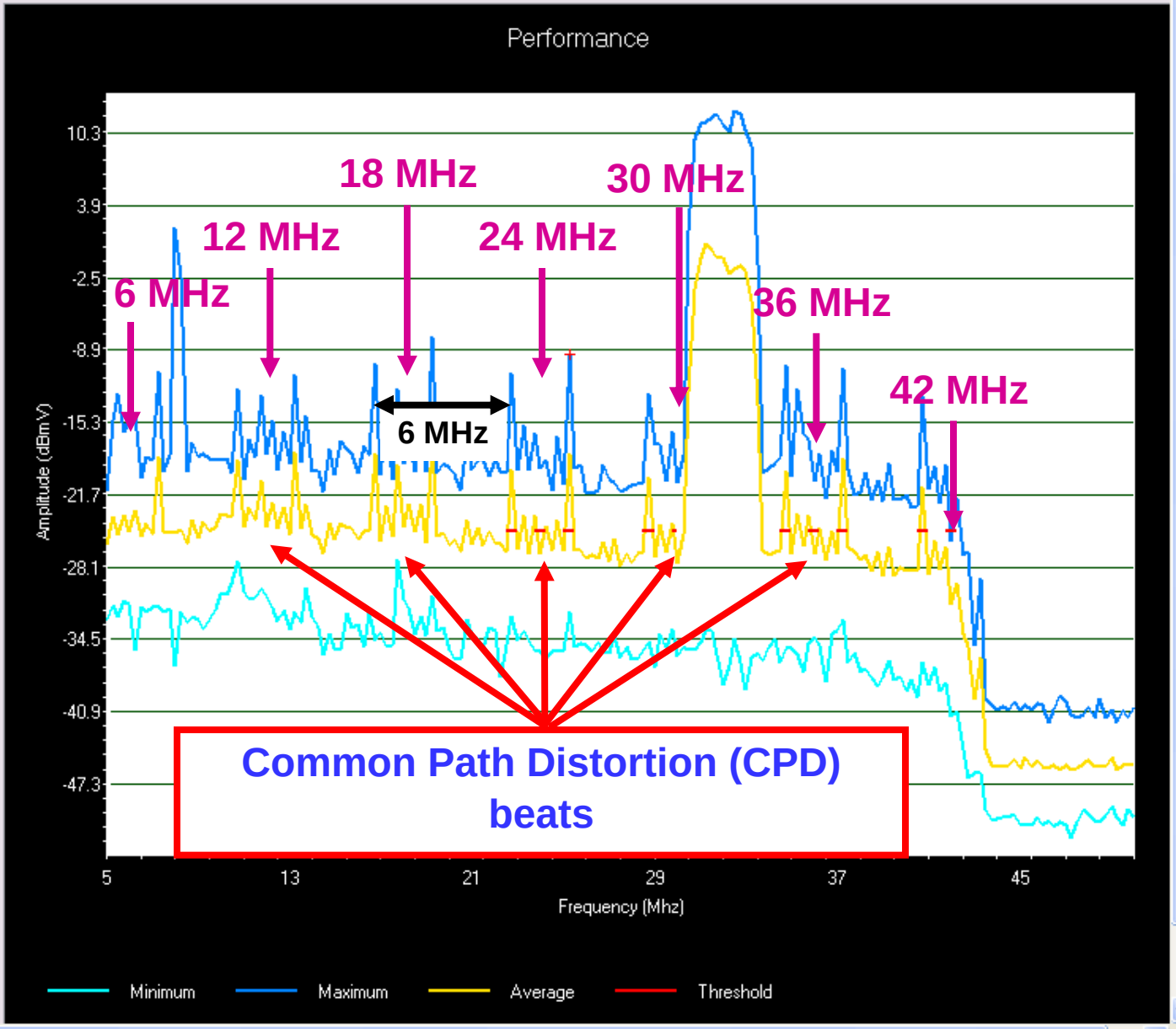
68.168.144.226 - Remote Desktop

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
CPD	458	2/17/2005 8:00:58 P

Frequency	Threshold L...	Di...	Amount E...
25.250 MHz	-25.00 dBmV	+	15.70 dB



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
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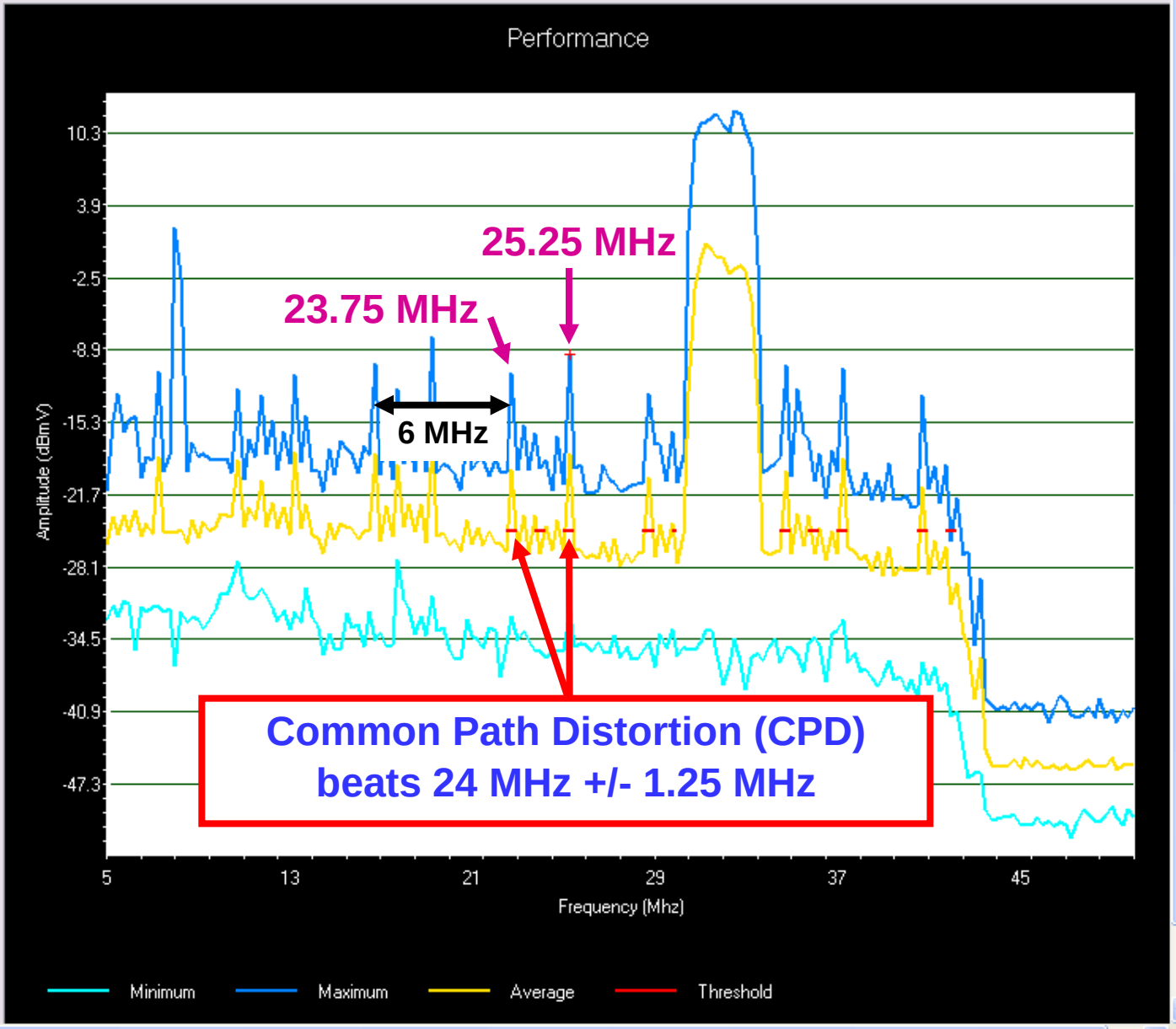
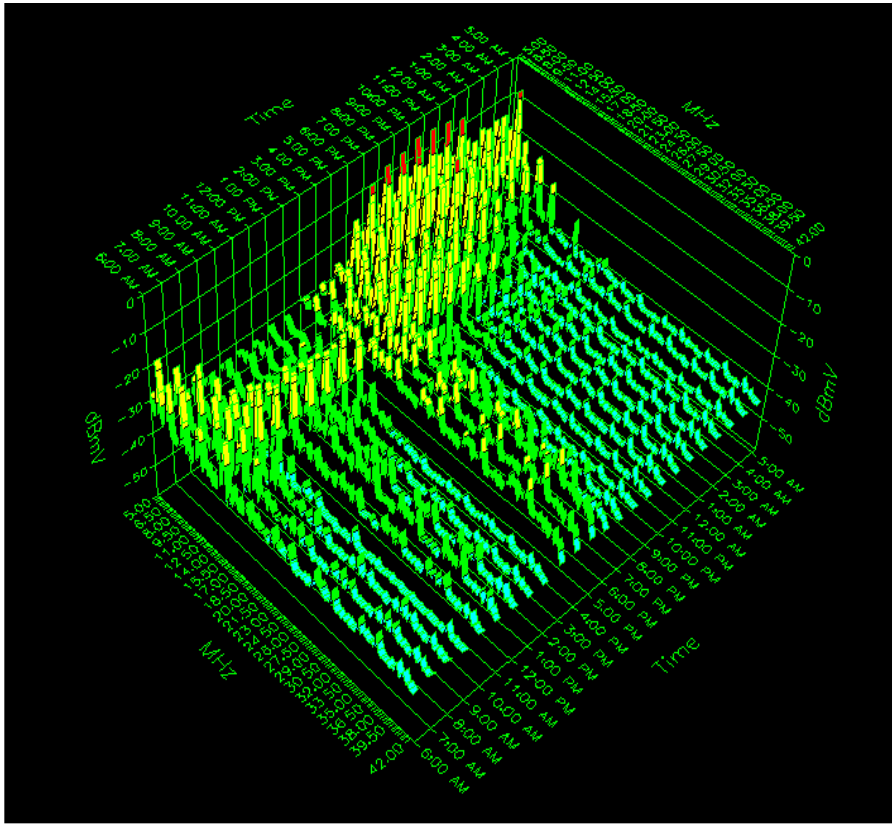


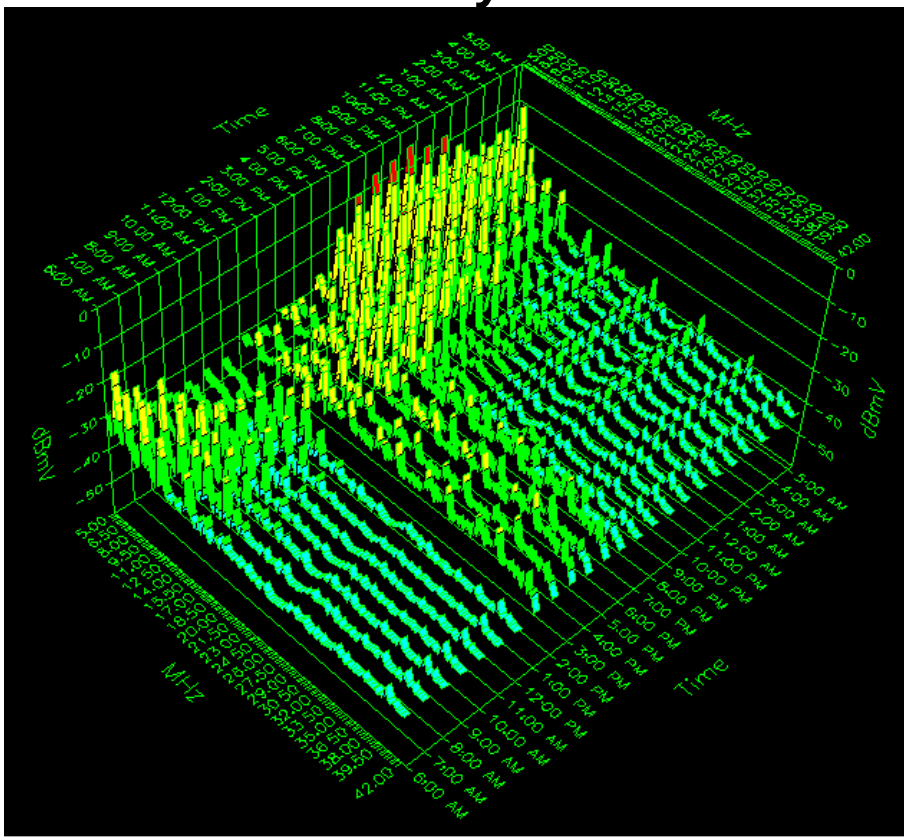
CPD Changes Over Time and Temperature

Average Noise by Hour

Day 1



Day 2

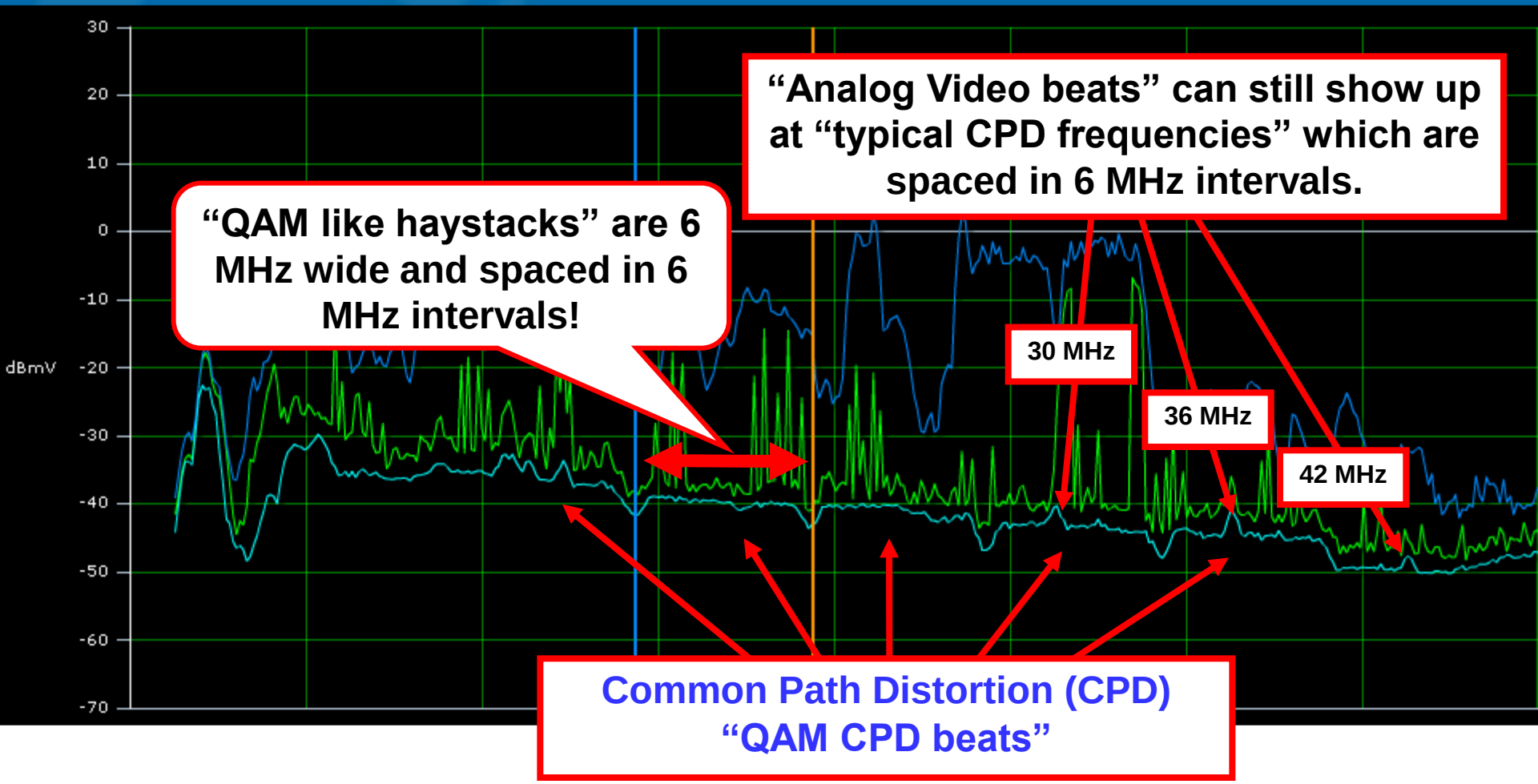


Reverse Path Performance History shows intermittent CPD that varies by time of day. If you only look at snapshot of performance during day you would miss what would affect customer service at night.

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



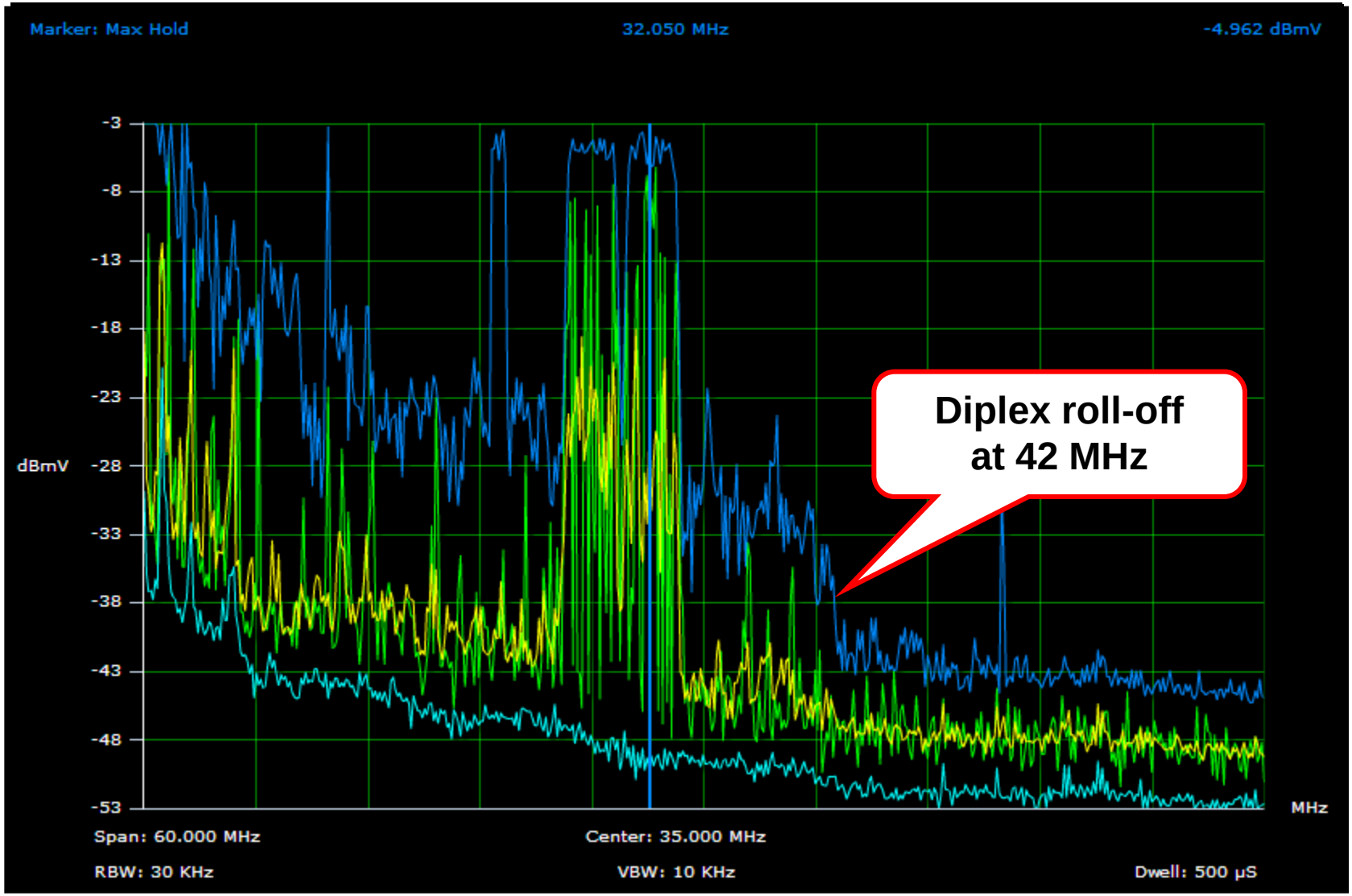
As operators add more and more QAM carriers to the downstream, Common Path Distortion beats can show up in the return spectrum as distinct “haystacks” in the noise floor which are spaced in 6 MHz intervals!

Reverse Path Impairments Electrical Impulse Noise

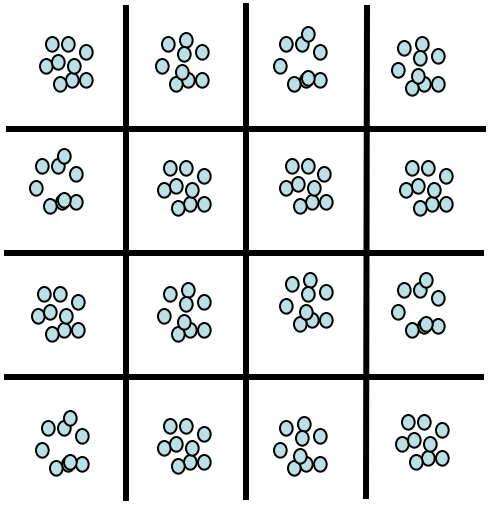
Impulse noise — Most reverse data transmission errors (i.e. Code Word Errors) have been found to be caused by bursts of impulse noise. Impulse noise is characterized by its fast rise-time and short duration.

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

Wideband Impulse Noise = Code Word Errors!

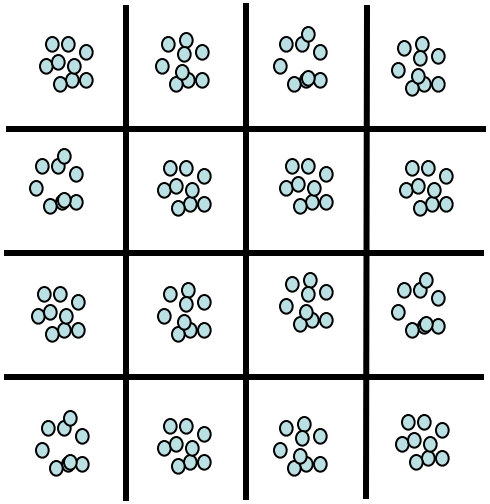


What is An Errored Symbol?



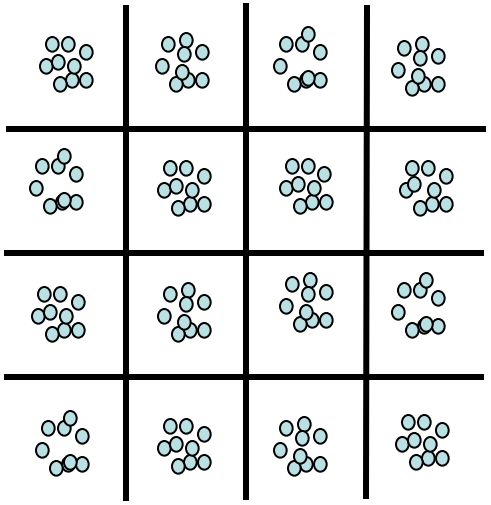
All symbols contained within their correct decision boundaries

Likely Result: No CWEs



One symbol crosses decision boundary into neighboring cell

Likely Result: Correctable CWE



Many symbols cross decision boundaries into neighboring cells

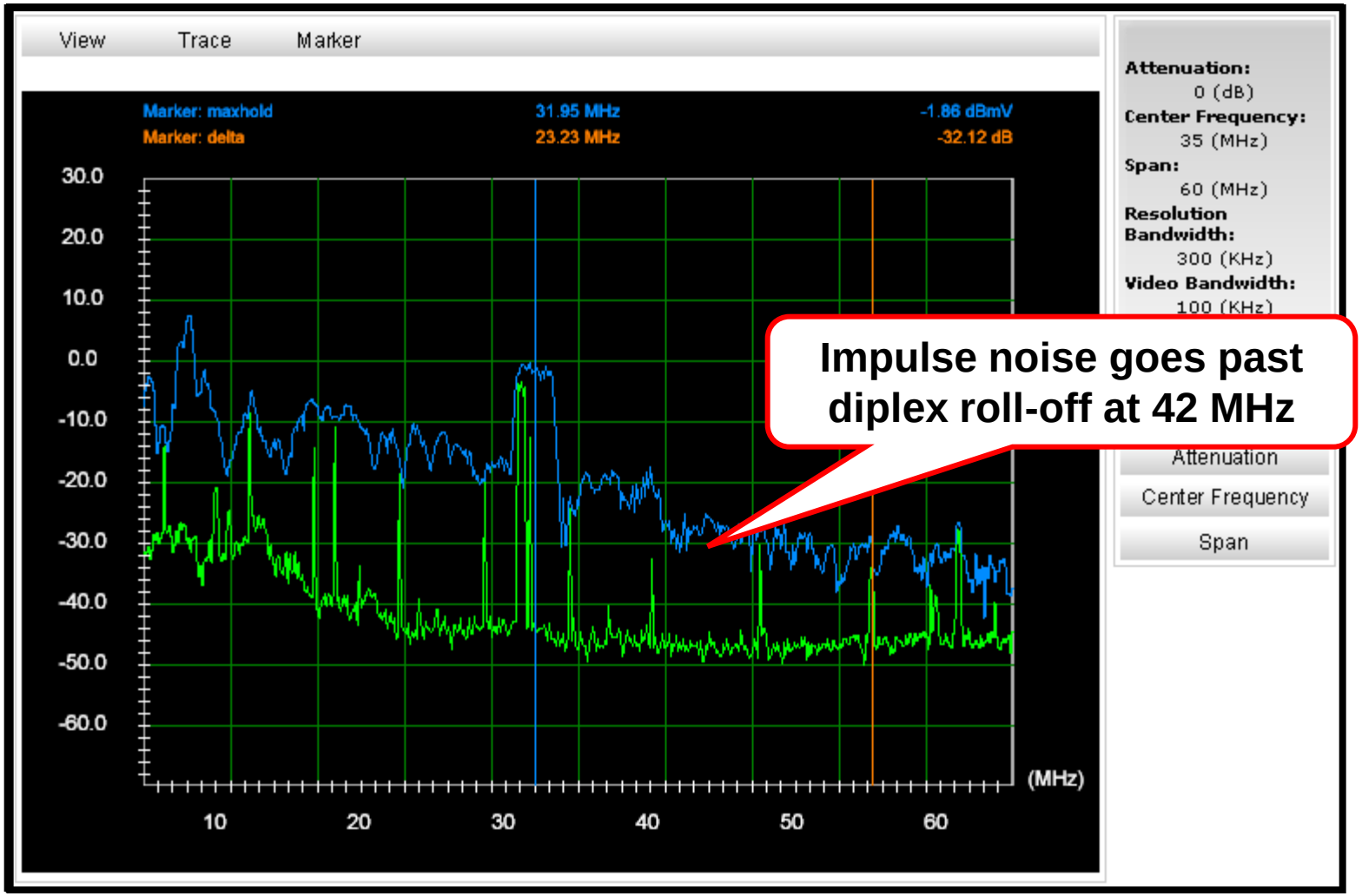
Likely Result: Uncorrectable CWE

Impulse Noise Detectors

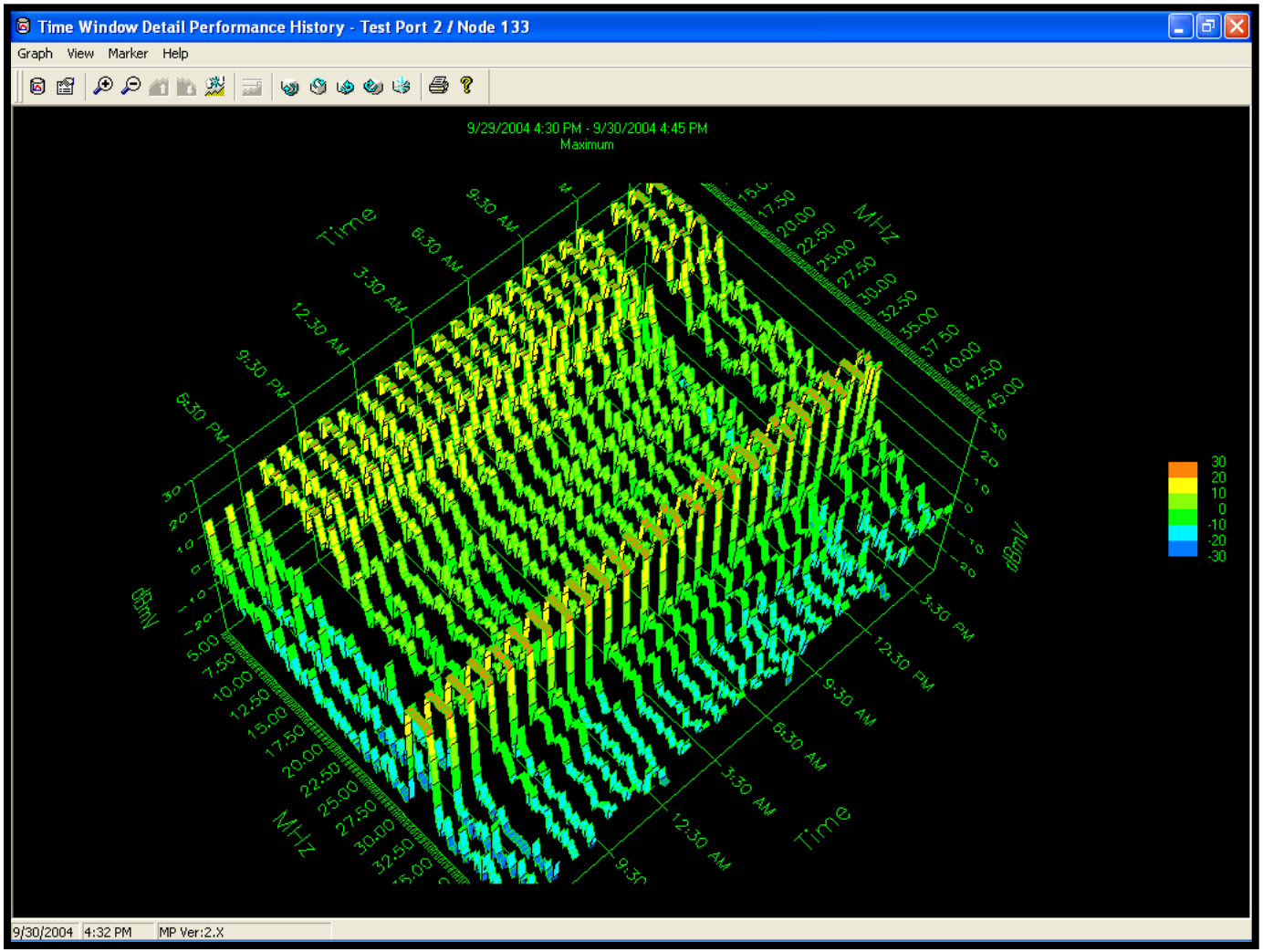
RFI locators detect sparks and corona that cause radio and T.V. interference (RFI TVI).

Detects indoor sparking and electronic sources

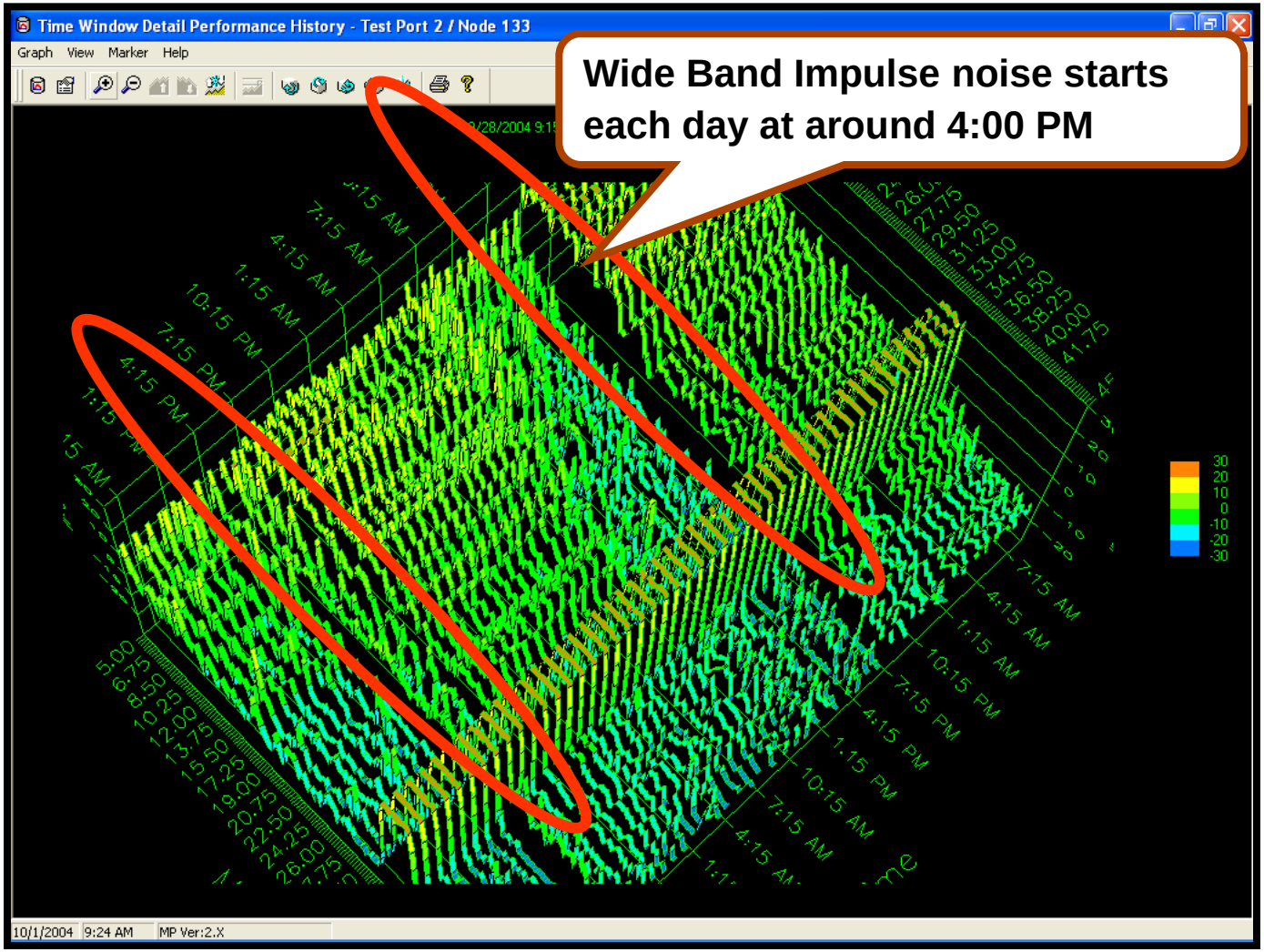
Wide Band Impulse Noise and Laser Clipping



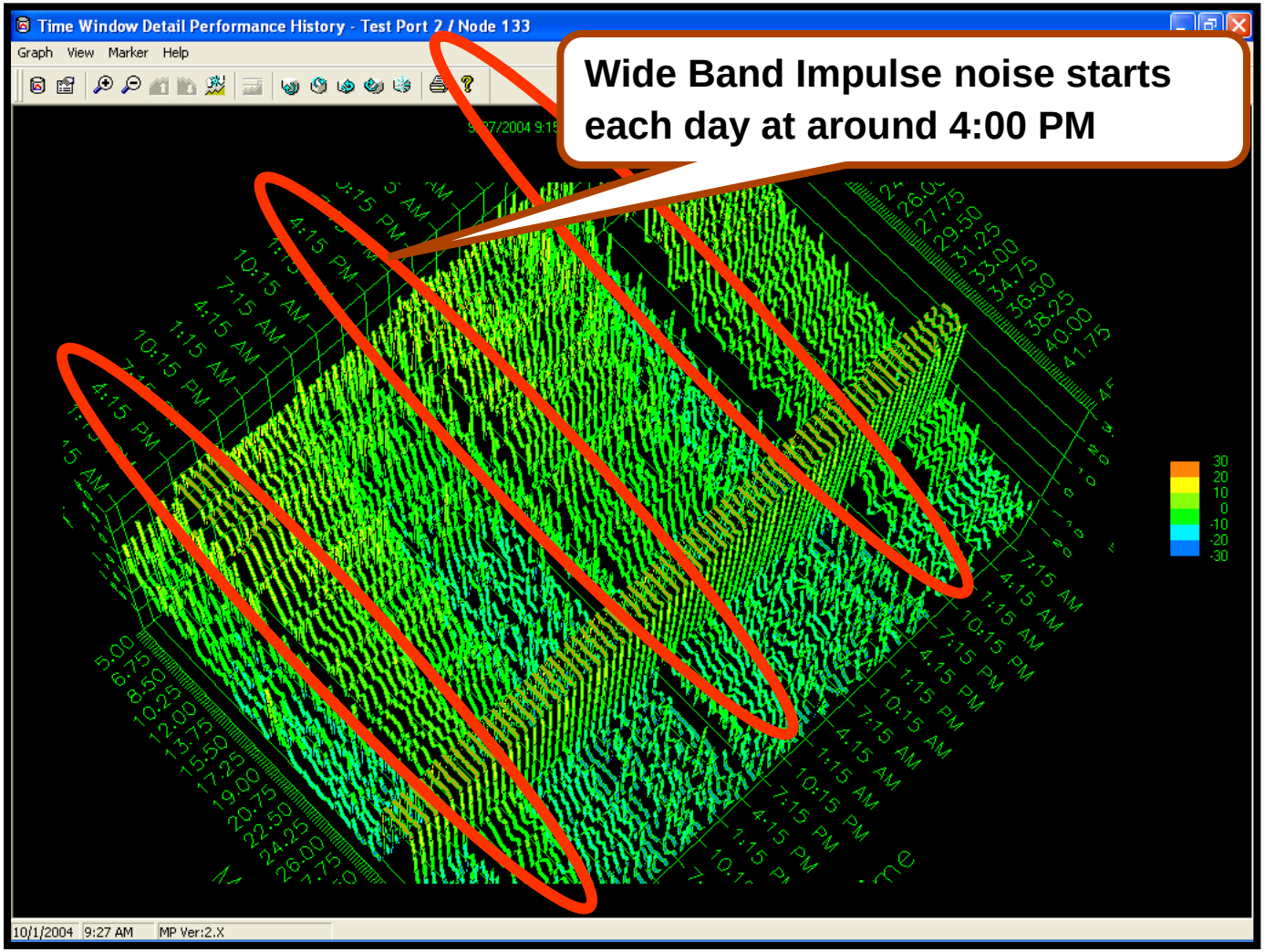
Performance History Maximum Graph – 24 Hrs



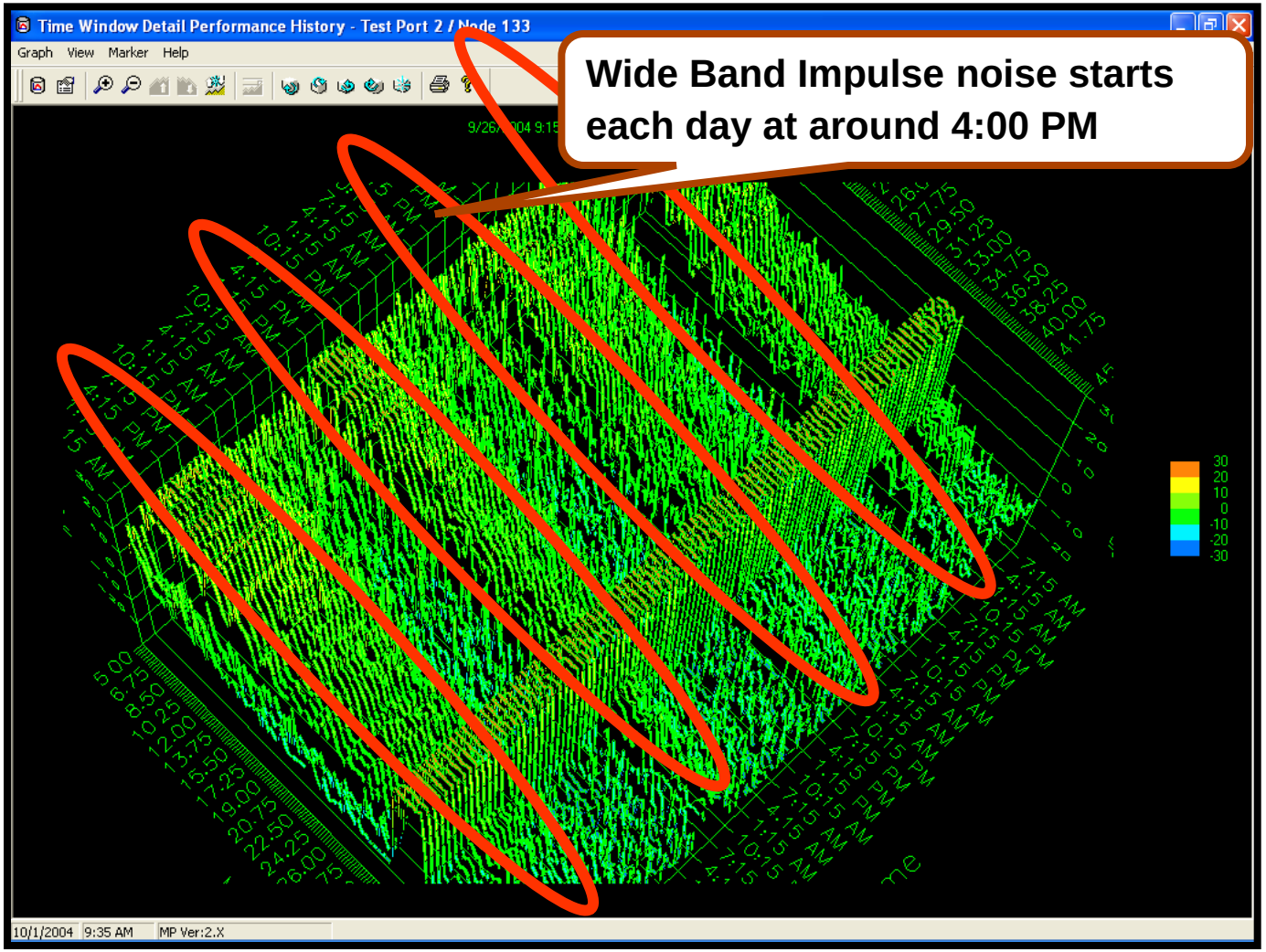
Performance History Maximum Graph – 48 Hrs



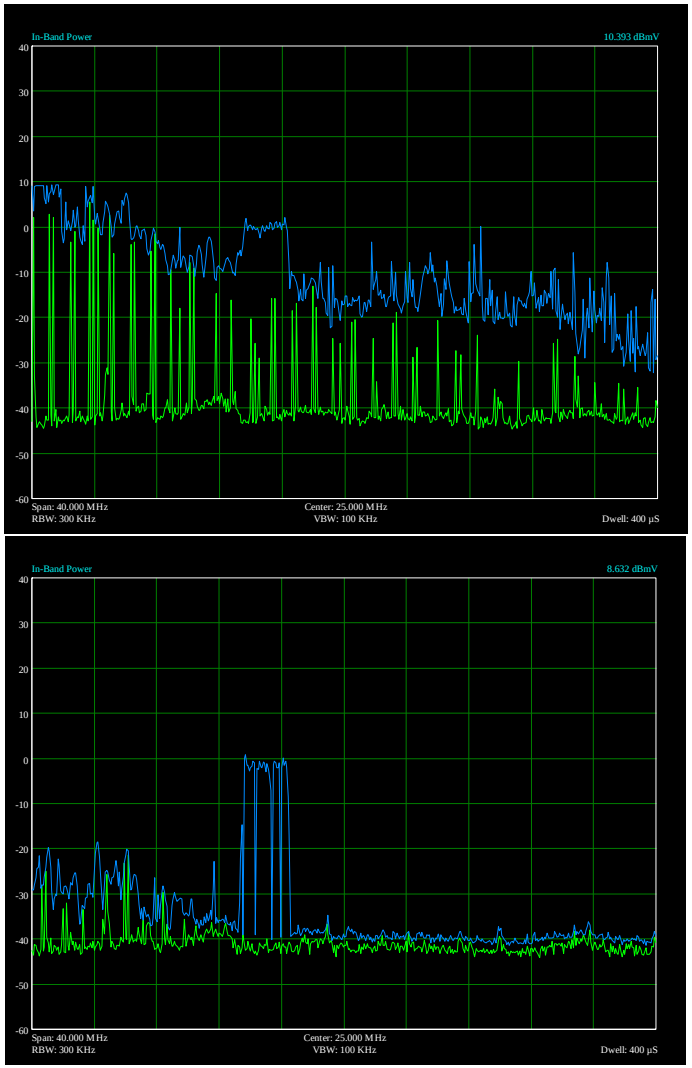
Performance History Maximum Graph – 72 Hrs

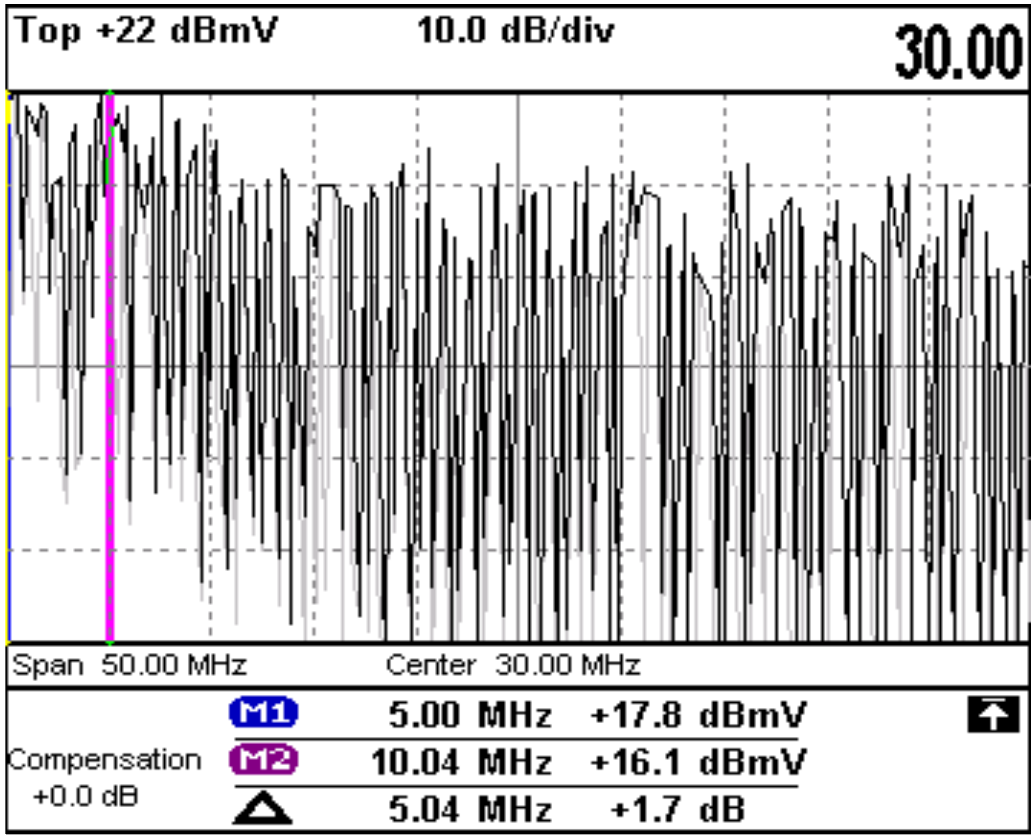


Performance History Maximum Graph – 96 Hrs



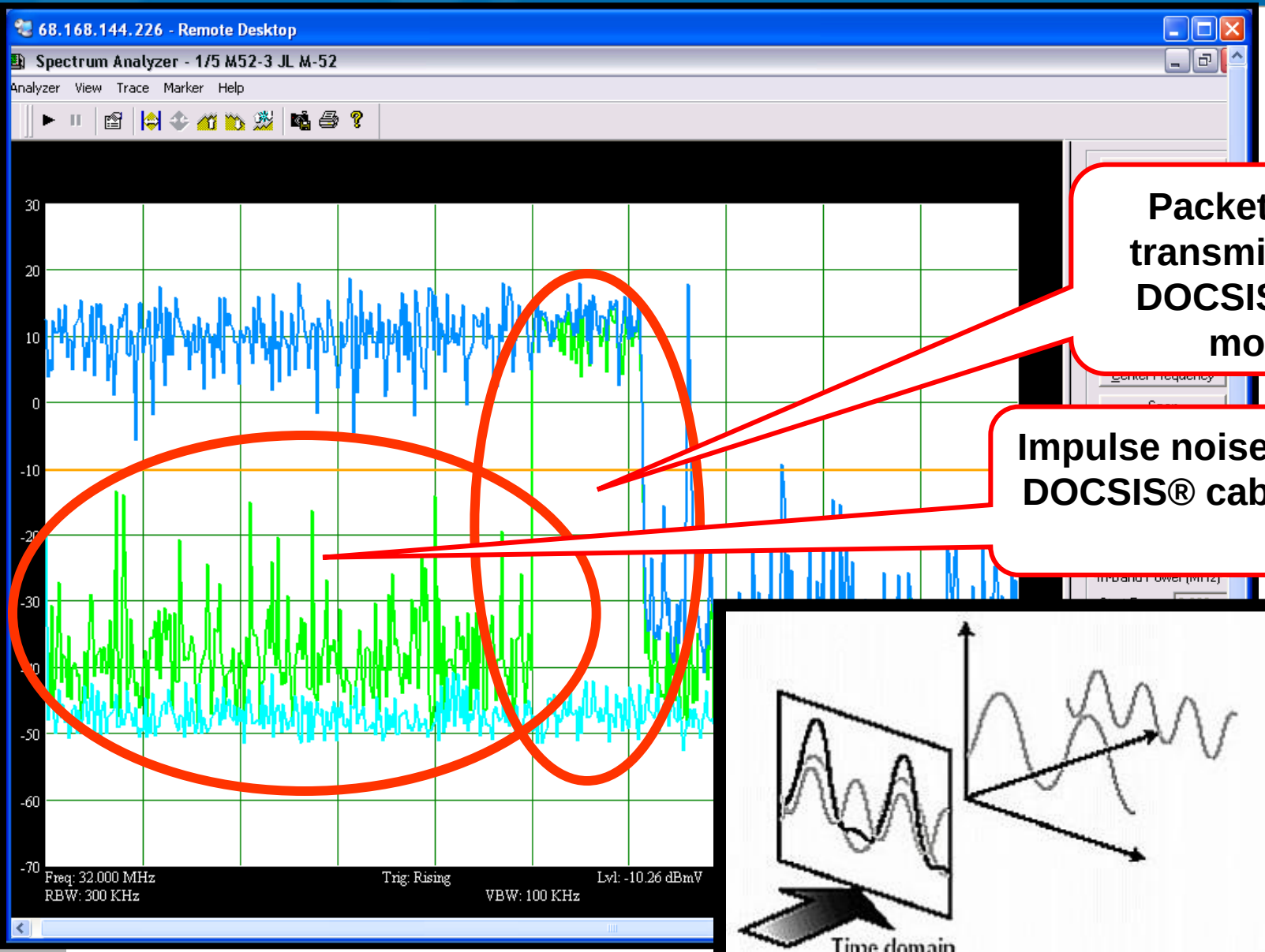
Electrical Impulse Noise from One House





- **Reverse Spectrum shot at customer's drop**

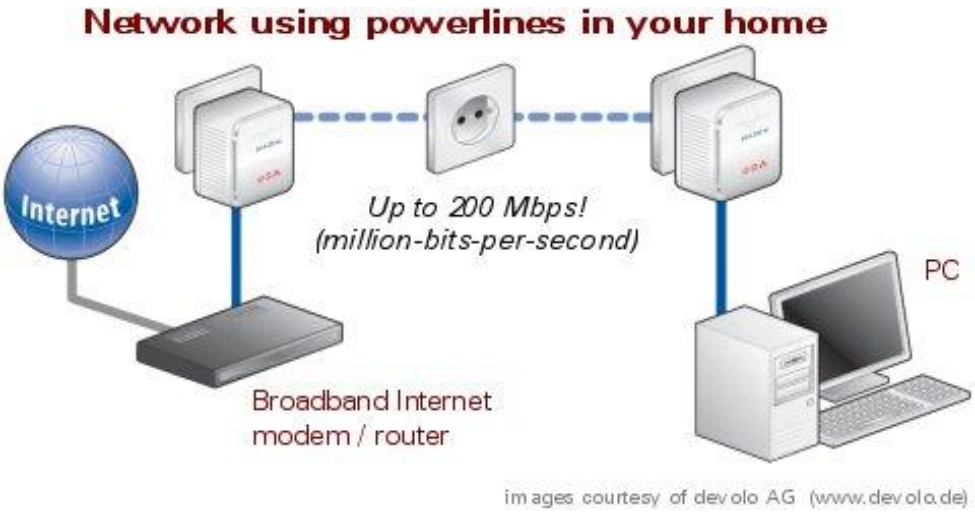
View Impulse Noise in Zero Span (Time Domain)



Packet of data transmitted by a DOCSIS® cable modem

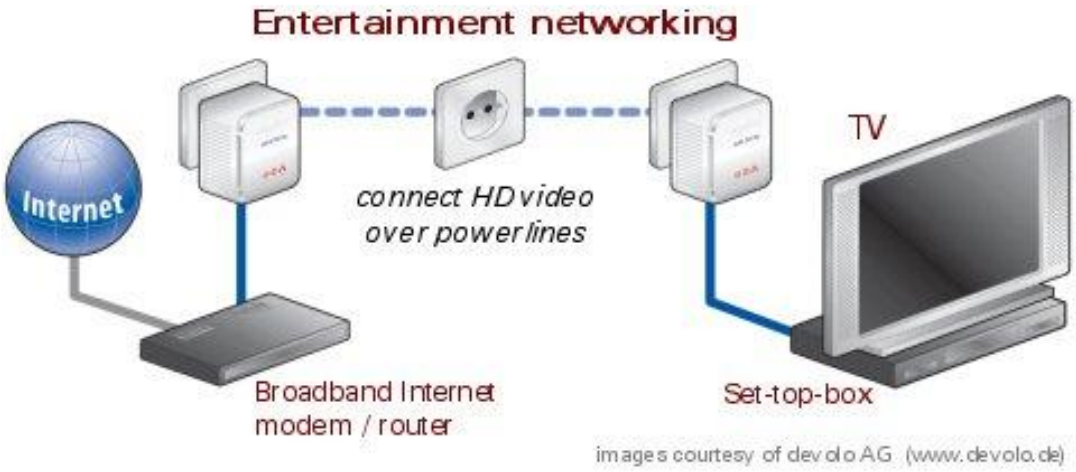
Impulse noise under the DOCSIS® cable modem

HomePlug 1.0 and HomePlug AV

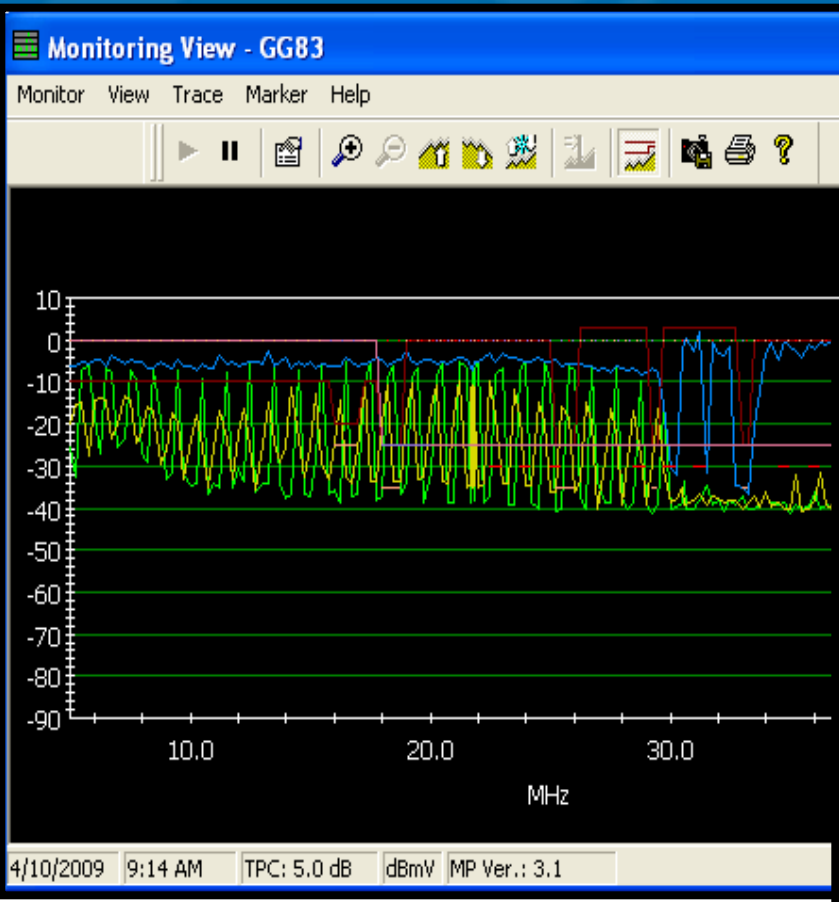


"Products based on the HomePlug 1.0 and HomePlug AV specifications can bridge an existing networking technology (such as a wireless or Ethernet network) and your home's power lines. "

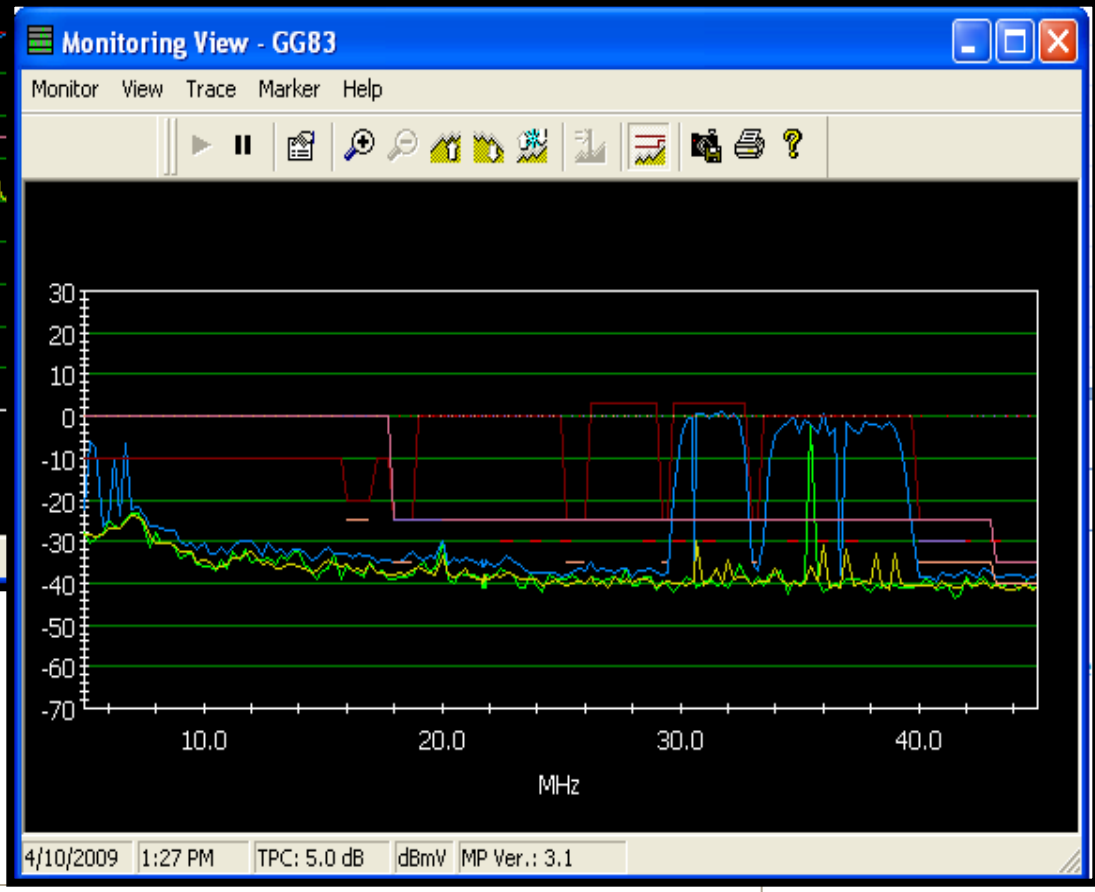
Network your TV with HomePlug AV



Home Plug 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

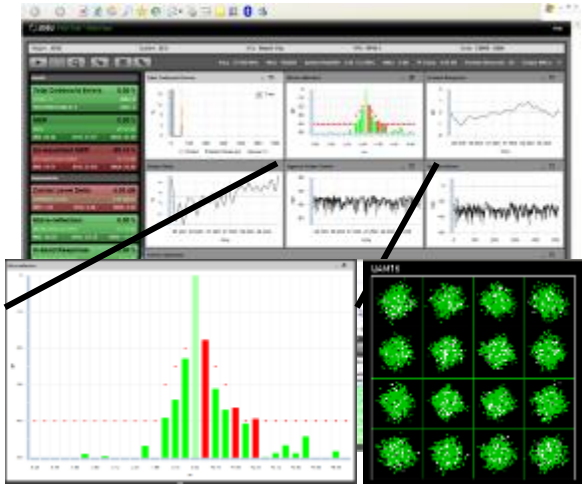
Wideband HomePNA™ Ingress in the Return Path

"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



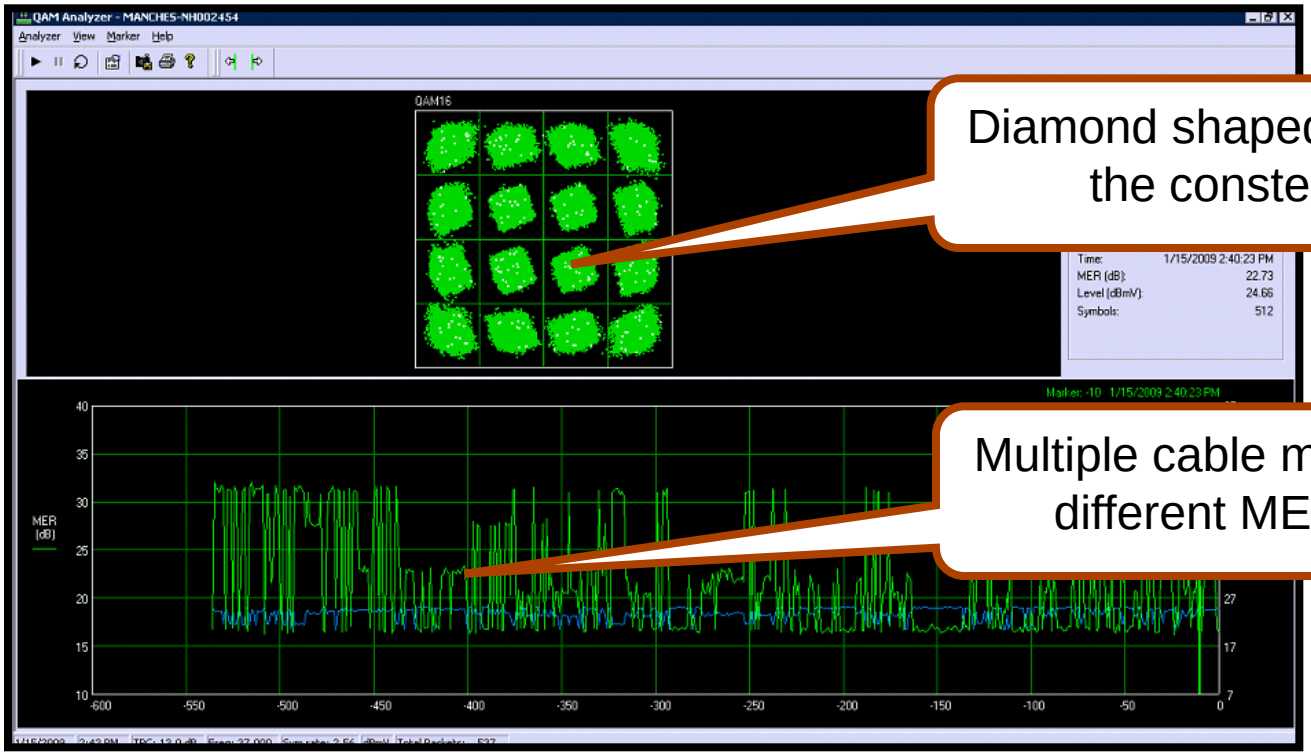
Group Delay

- 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

In-channel Freq. Response

- Common Causes
  - Misalignment
  - Impedance mismatches

QAM Analyzer View – Group Delay & Micro-reflections



Diamond shaped clusters in the constellation

Multiple cable modems with different MER levels

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

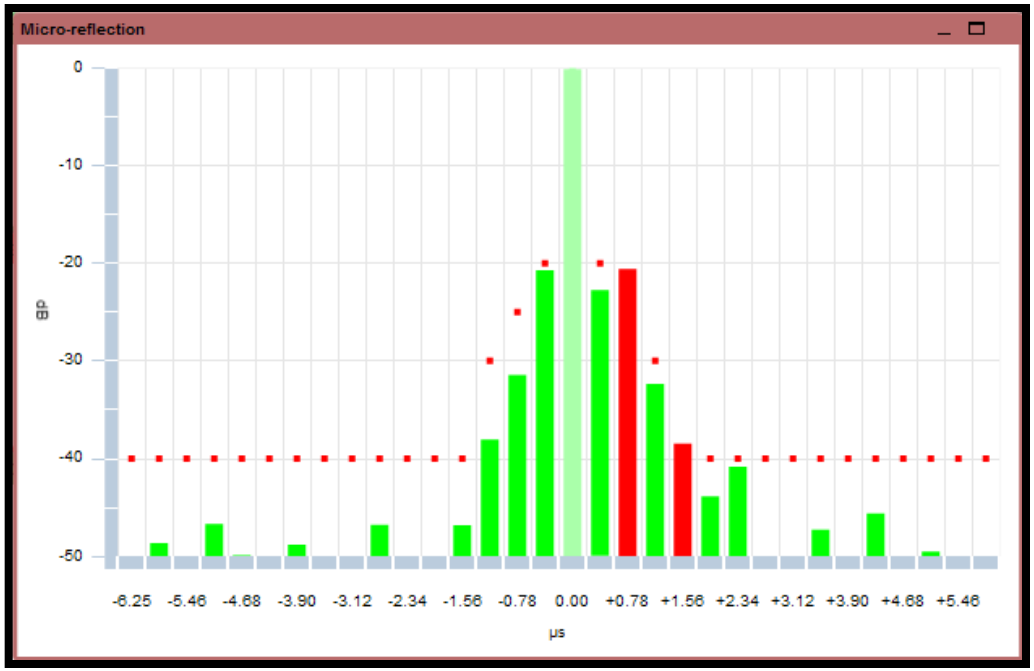
Clarity of diamond shape will vary with percentage of packets affected

Microreflections are a common cause of group delay

Often caused by unterminated 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 – 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

Linear Distortions – Group Delay

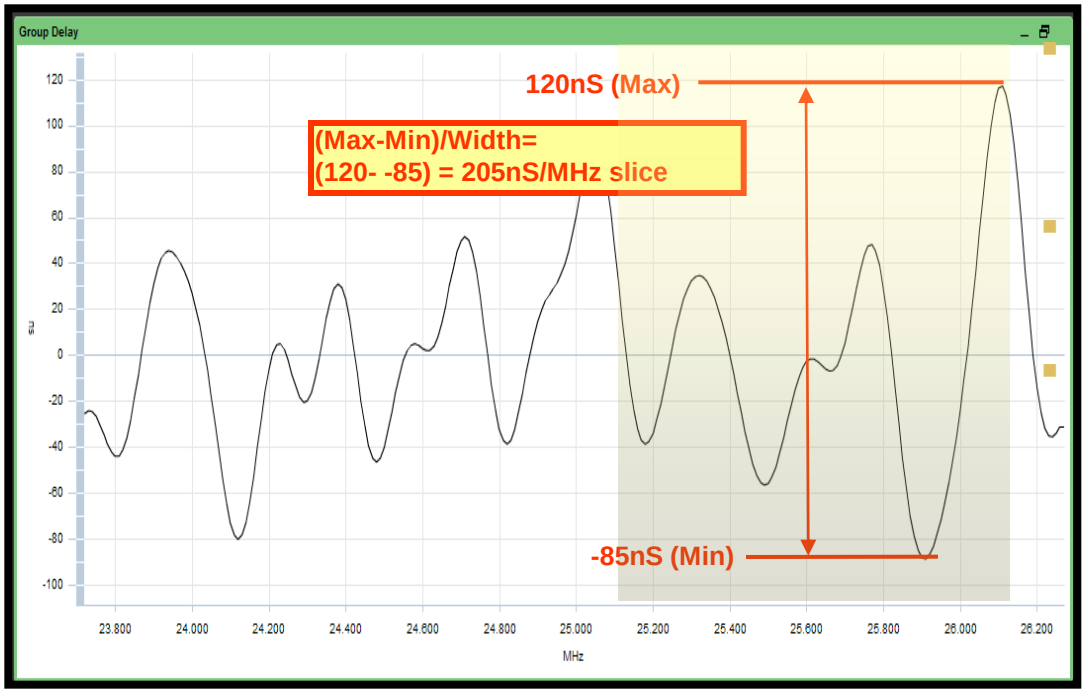


Chart displays the delay of the signal from the CM to RPM3000 over the frequency of the carrier

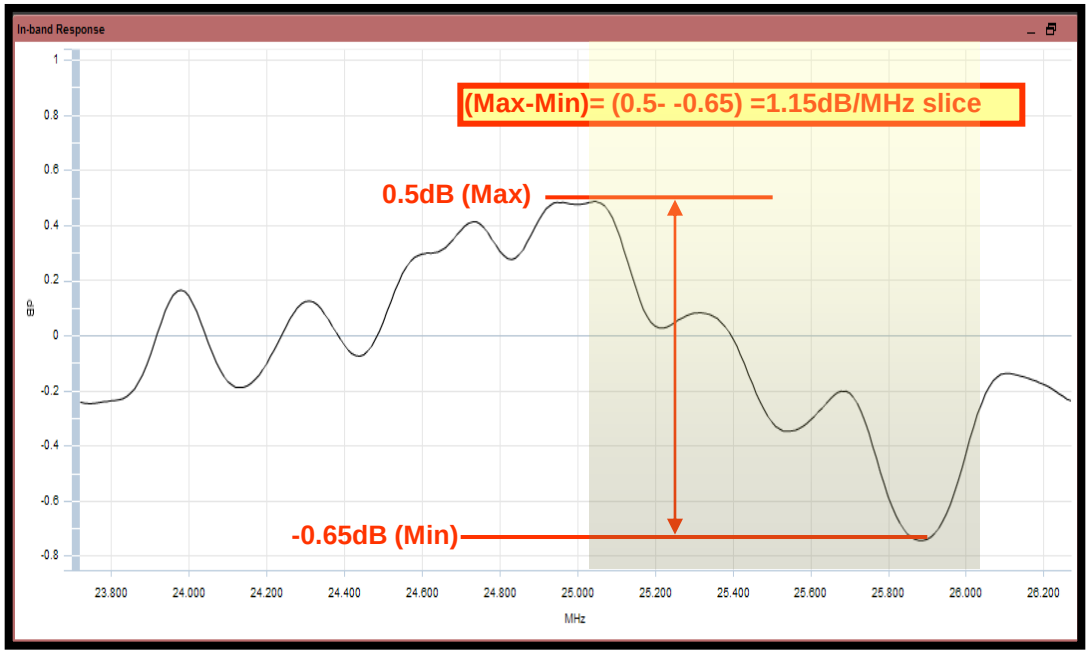
Chart is generated from equalized data (vs unequalized data)

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

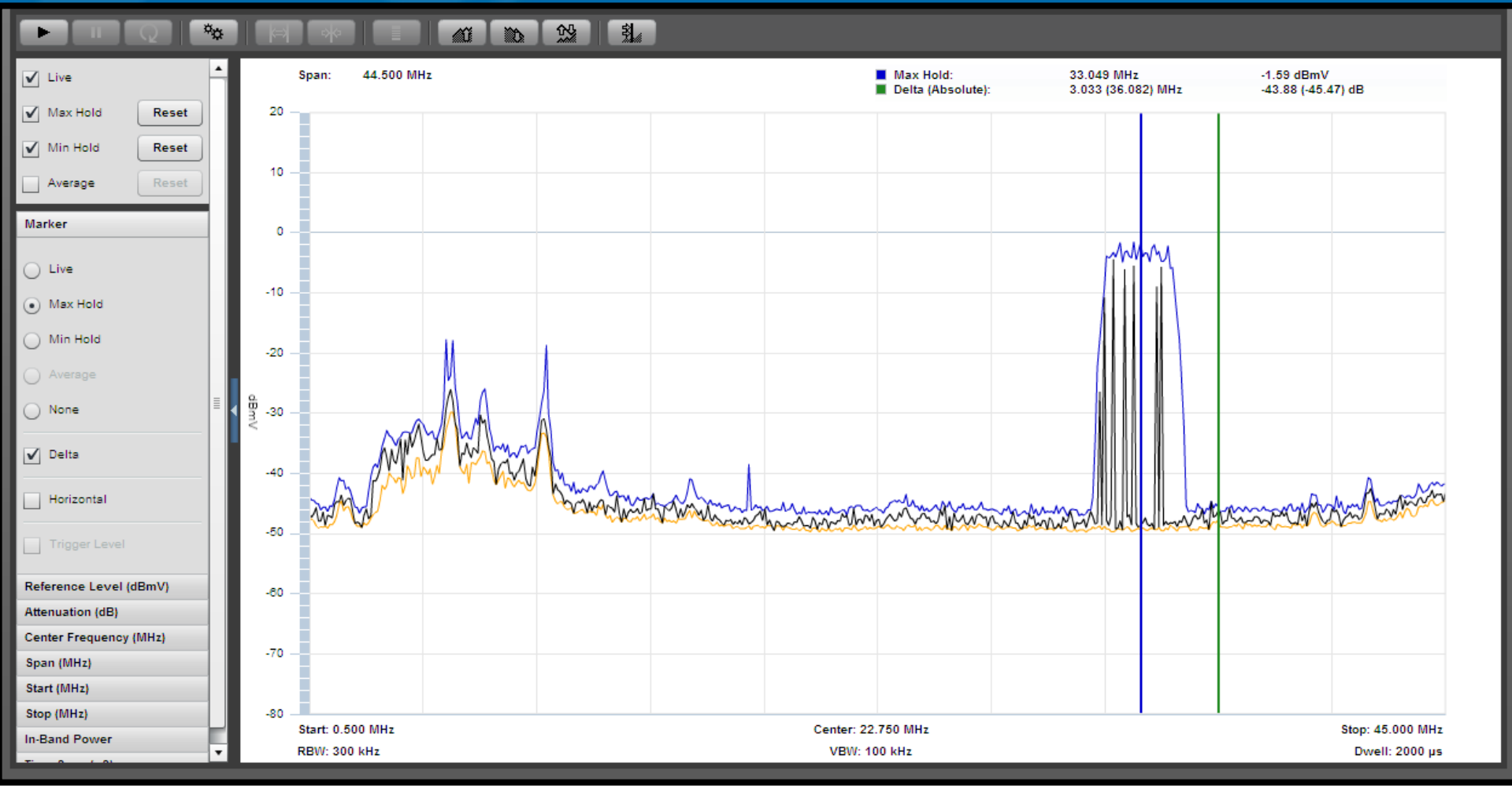
In-Band Frequency Response



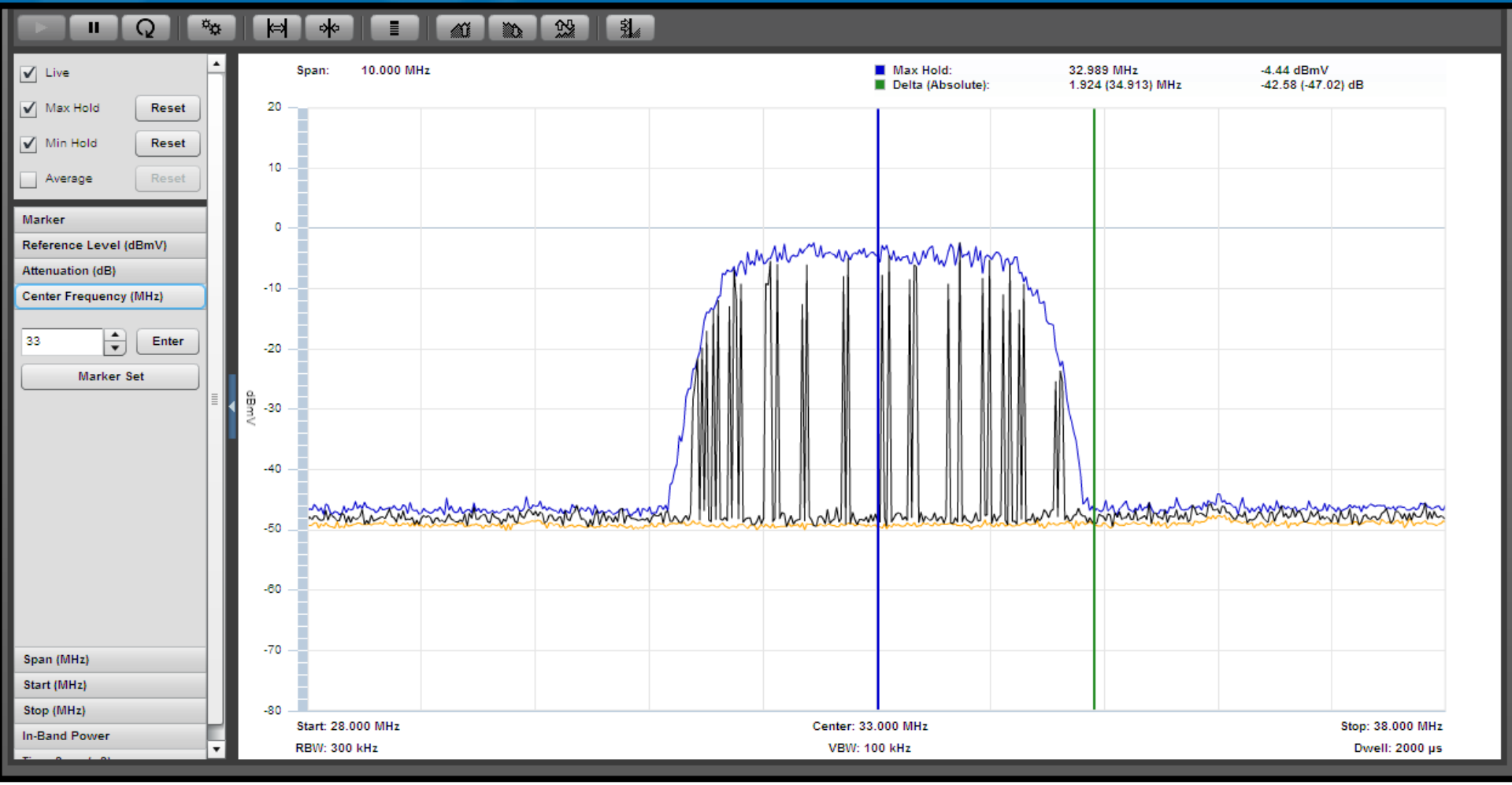
- Frequency response chart across a given carriers frequency
- Think of it like a sweep display for the discrete carrier frequency range
- Chart is generated from equalized data (vs unequalized data)
- Value reported by QAMTrak is the highest amplitude point minus the lowest amplitude point per 1MHz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

Clean Return Spectrum (Below 45 MHz)



Clean Return Spectrum Adjacent to Return Carriers



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

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Bad In-Band Response from a Single Modem

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

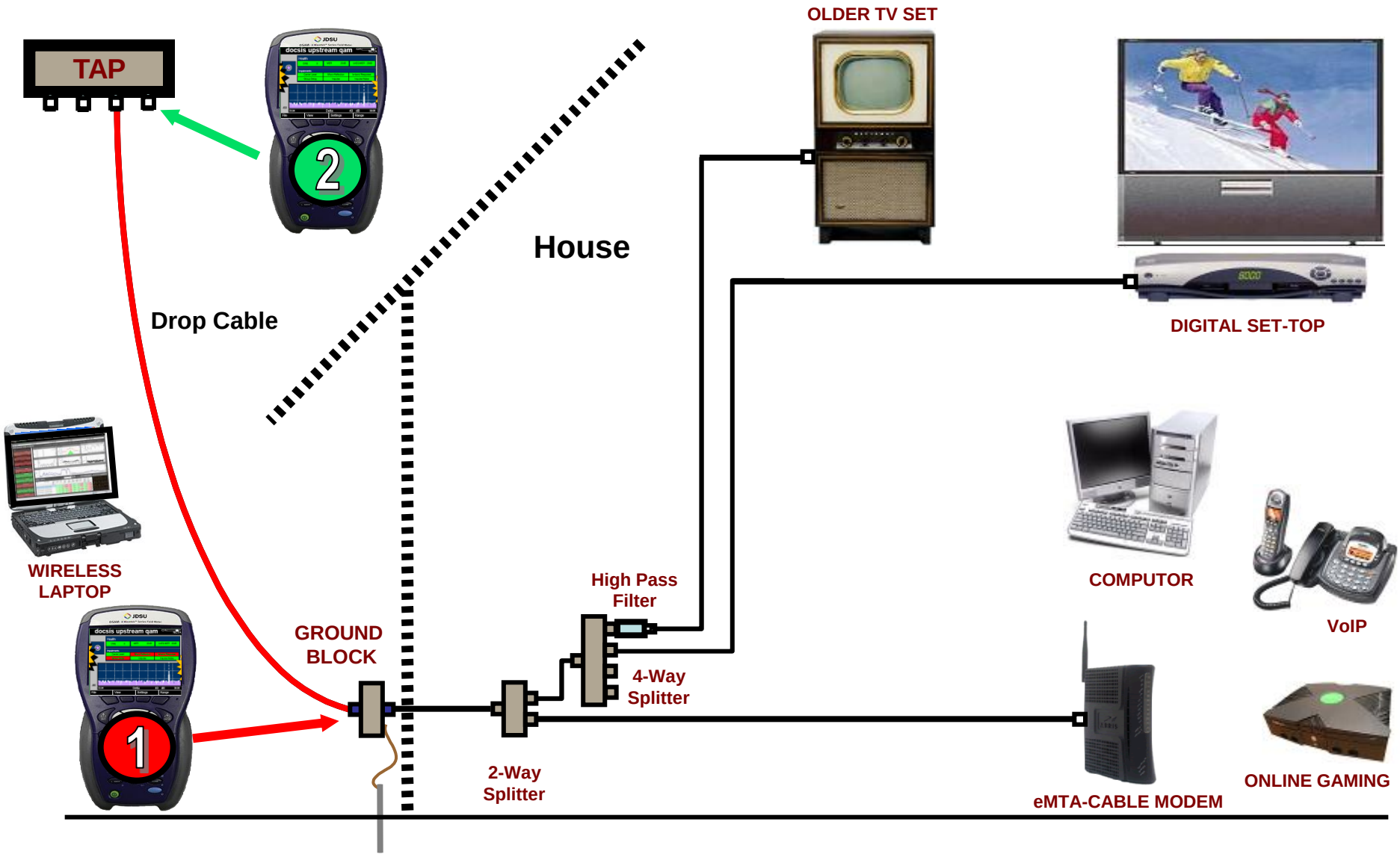
Good In-Band Response from a Single Modem

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

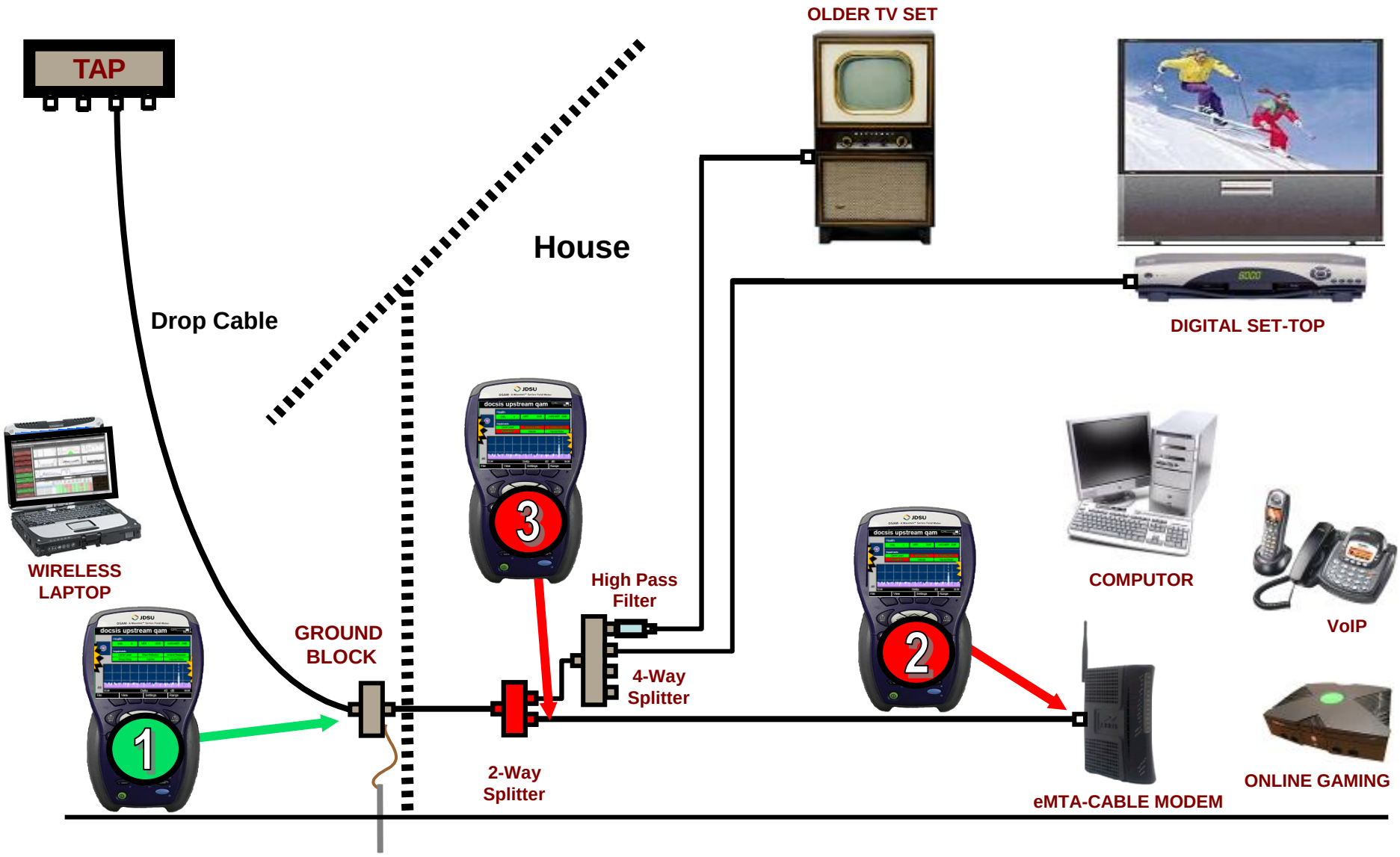
Bad In-Band Response from a Single Modem

This constellation display indicates the presence of linear distortions such as micro-reflections and group delay.

Testing for Linear Distortions in the Home

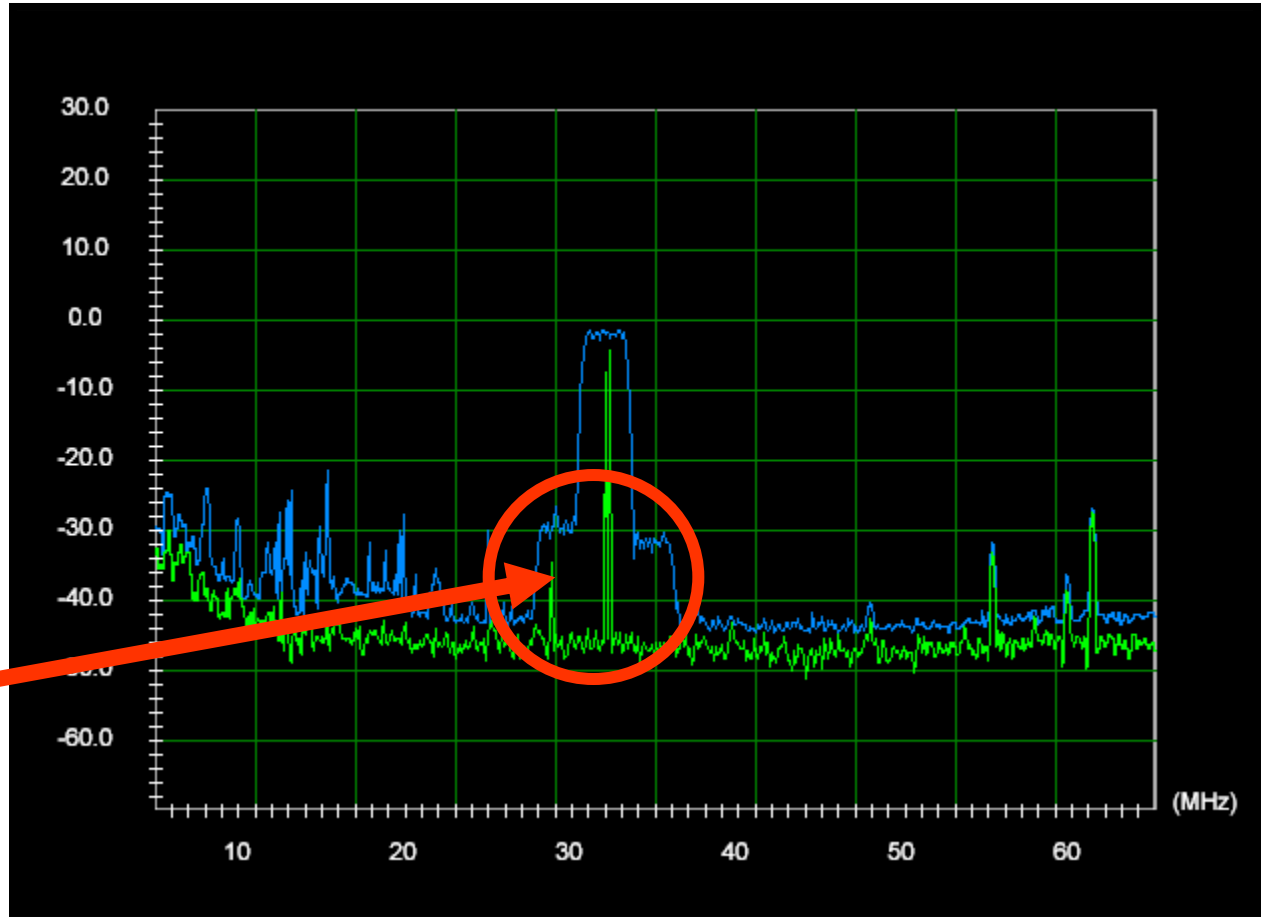


Testing for Linear Distortions in the Home

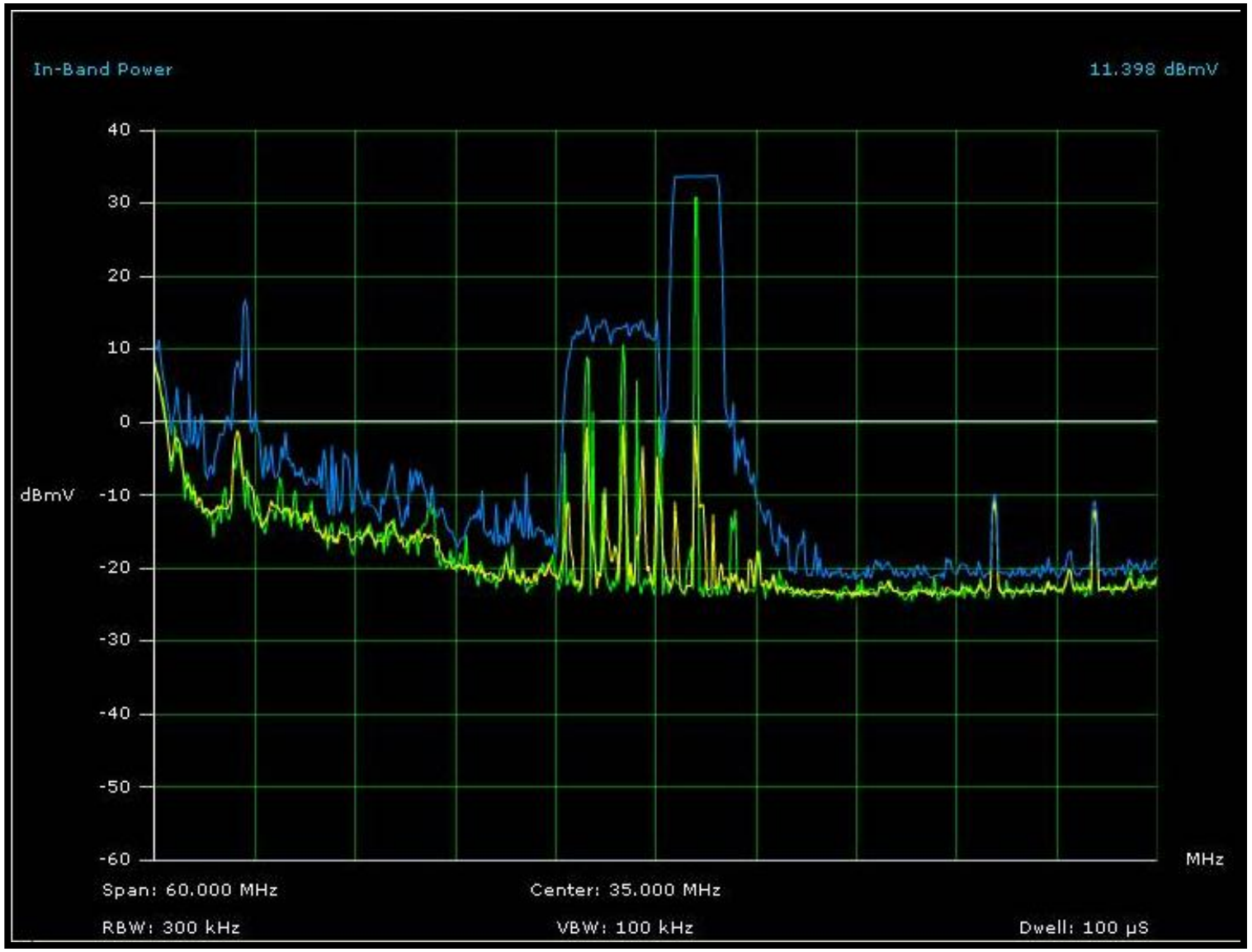


Analyzing and Interpreting live Spectrum Traces

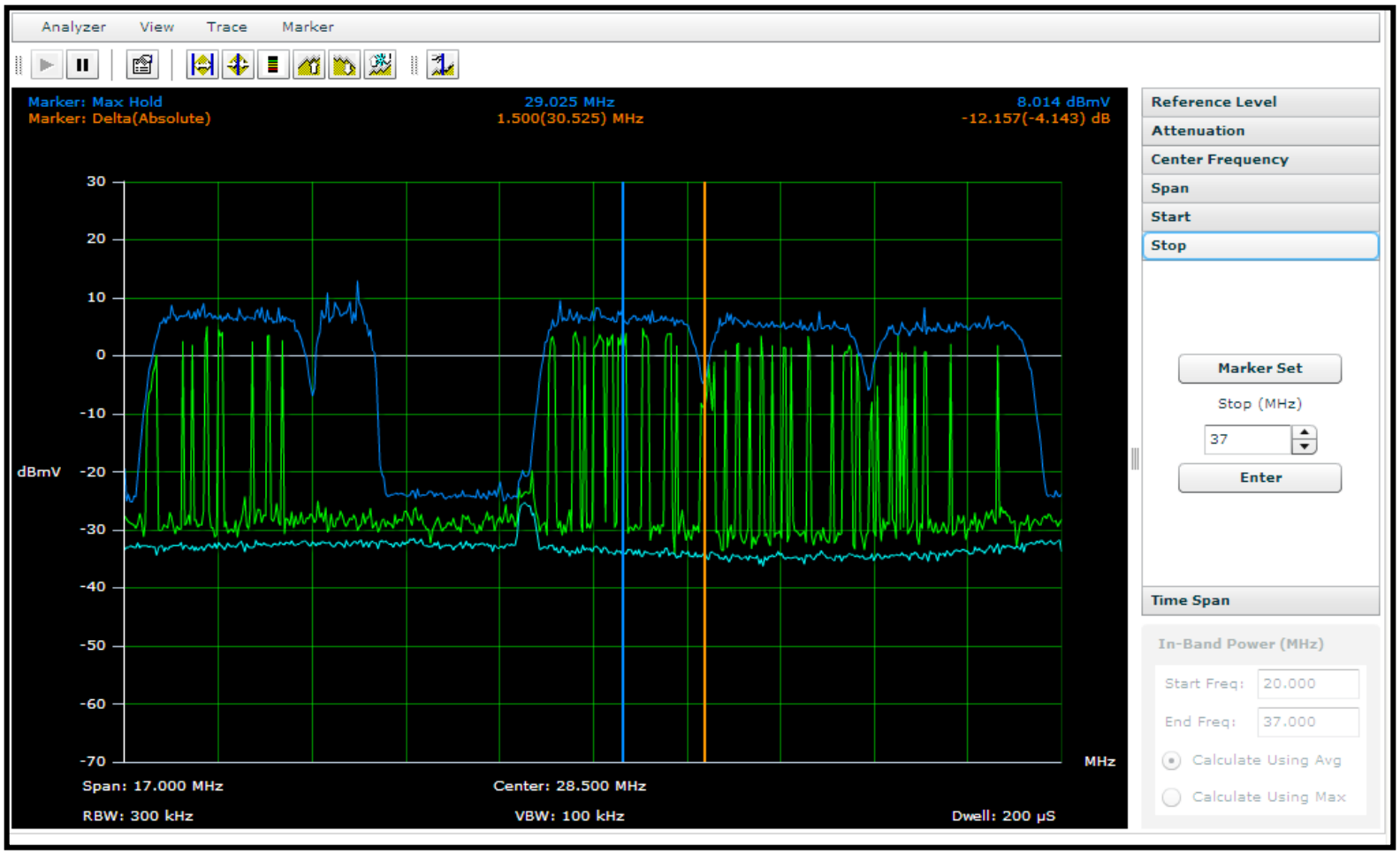
Defective modem



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



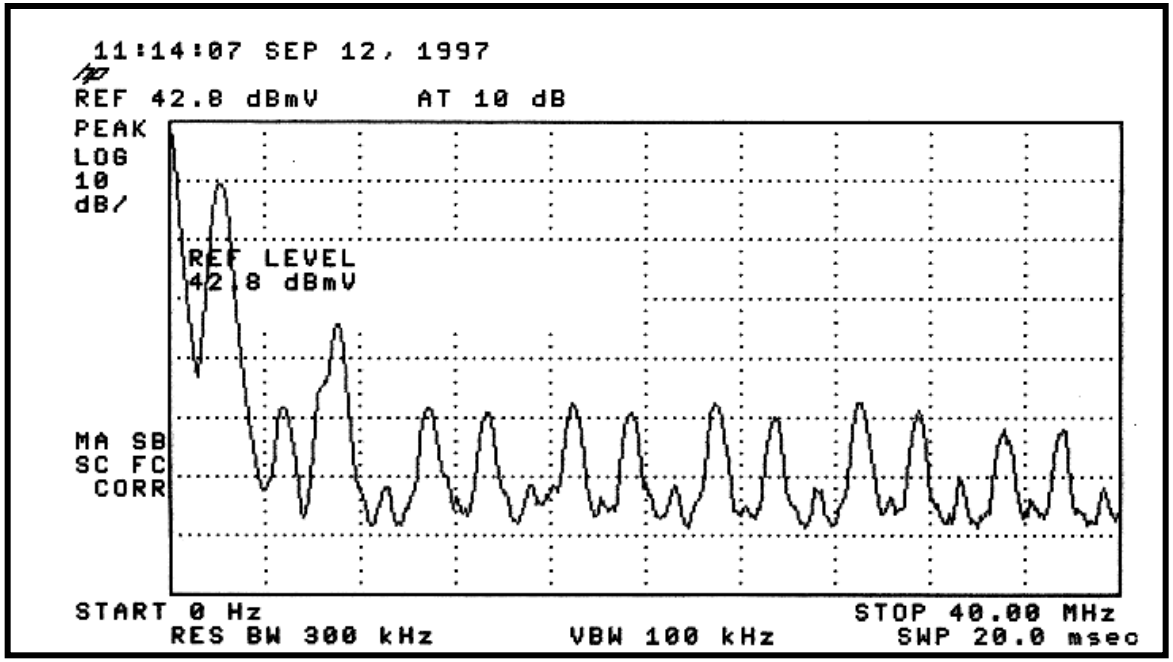
3.2 MHz Wide Carriers Spaced at 3.0 MHz



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

Severe Transient Hum Modulation

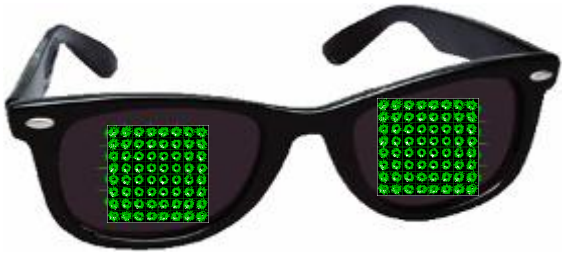
- The RF choke can saturate with too much current draw and cause the ferrite material to break down
- Same thing can happen in customer installed passives
- Notice that this looks a lot like CPD



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

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

With RPM3000 cards and WebView 2.5 you can:

- **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

WebView v2.5 Good Node (at least for a little while)

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