Providing Customer Quality with Testing and Monitoring

1.19.2016

Agenda

New Technology

Fiber

RF Networks

Customer Networks

Growing Services Consuming HFC Spectrum

- **More HD Video Services**
  - Growth plans to 100+ HD channels
- **More SD Video Content**
  - Expansion to nx100 SD chs to compete w/ satellite
- **Personalized Video Services**
  - Migration from Broadcast to Unicast services
  - VoD, Startover, MyPrimetime, etc
- **Broadband Internet Services Growth**
  - Migration from Web to Web2.0, Video Streaming and P2PTV Applications
  - Increased per home BW consumption
  - Expansion of the peak hour to whole evening
- **IoT – Internet of Things**
- **Competitive pressure!**

Seeing the Future

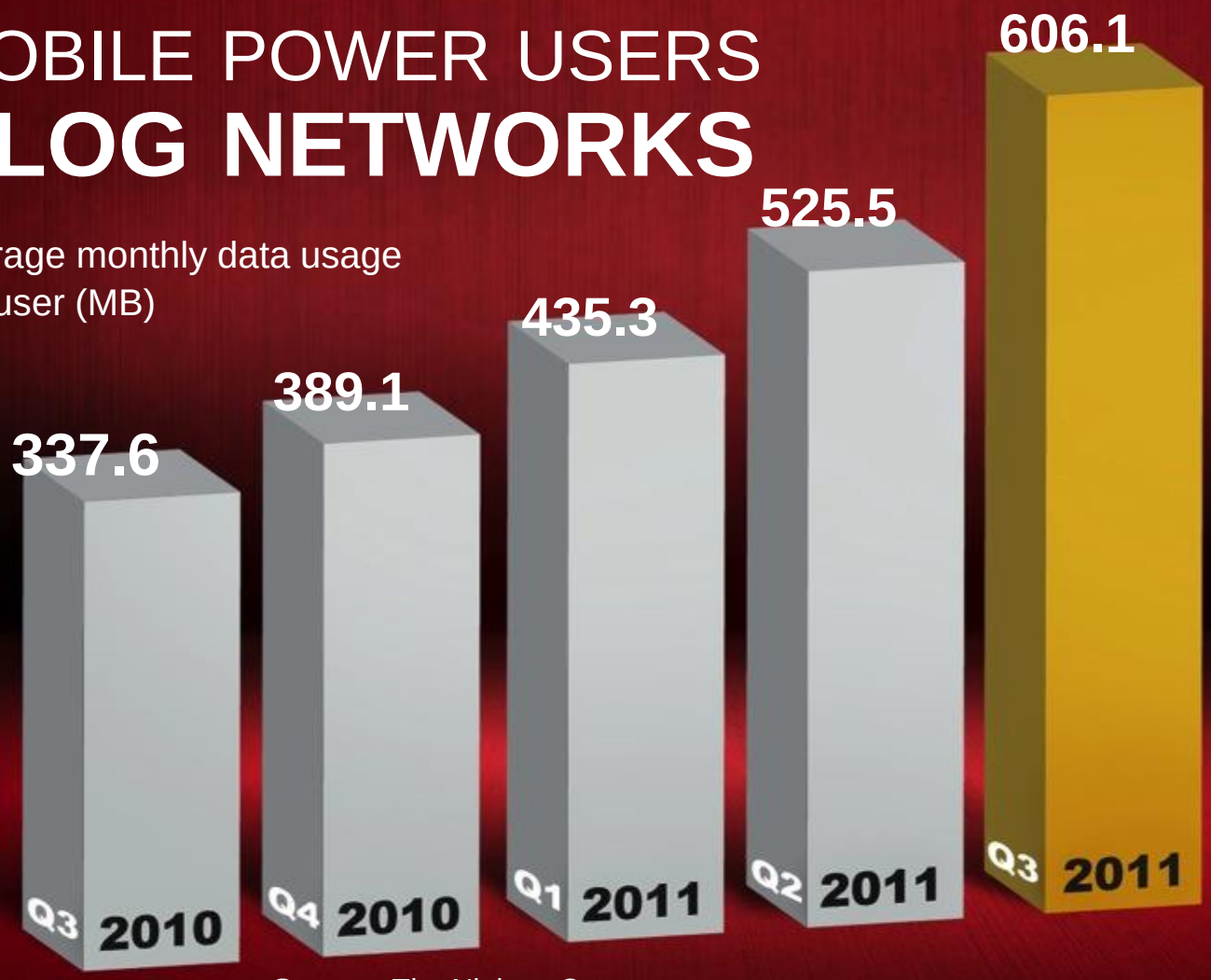
STREAMING VIDEO
DOMINATES WEB TRAFFIC

Nearly 60% by 2015

Source: Pipeline Magazine

MOBILE POWER USERS CLOG NETWORKS

Average monthly data usage per user (MB)



Source: The Nielsen Company

Average monthly per-user data consumption by U.S. smartphone customers jumped 80% from the third quarter of 2010 to the third quarter of 2011.

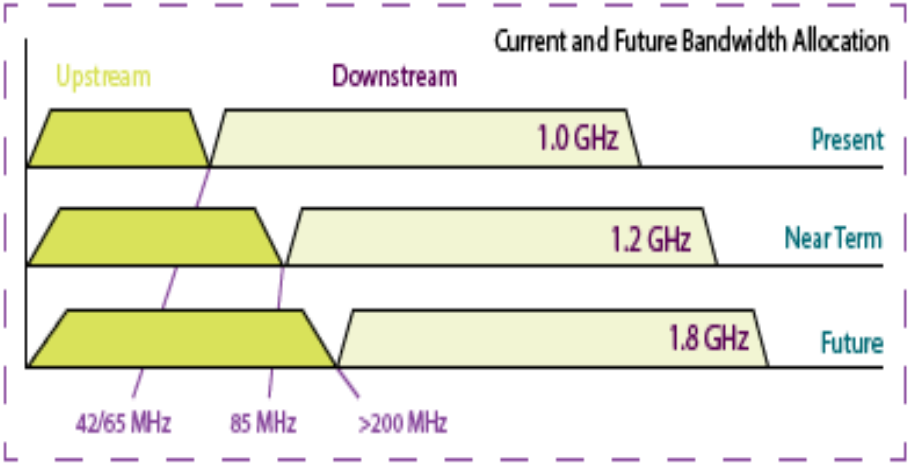
Seeing The Future

EXPLOSION IN CONNECTED DEVICES:

Source: Ericsson, 2011

RF Network Changes

- Docsis 3.0
  - 32 Downstream 8 Upstream
- Docsis 3.1
  - 192 Mhz Channel Downsteam
  - 24Mhz channel upstream.
  - OFDM Modulation – More Robust
- Plant Design Changes
  - RFog
  - Node plus 1 Active or Node passive
  - Return path spectrum to 85 Mhz or 200 Mhz
  - Downstream Path Spectrum to 1.2 Ghz or 1.8 Ghz



Source: SCTE

SCTE Docsis 3.0 Downstream RF Spec – 32 X 8 Bonded

Table 5-1 - Assumed Downstream RF Channel Transmission Characteristics

Parameter	Value
Frequency range	Cable system normal downstream operating range is from 50 MHz to 1002 MHz. However, the values in this table apply only at frequencies ≥ 108 MHz (including Pre-3.0 DOCSIS modes).
RF channel spacing (design bandwidth)	6 MHz
Transit delay from head-end to most distant customer	≤ 0.800 ms (typically much less)
Carrier-to-noise ratio in a 6 MHz band	Not less than 35 dB[1,2]
Carrier-to-Composite triple beat distortion ratio	Not less than 41 dB[1,2]
Carrier-to-Composite second order distortion ratio	Not less than 41 dB[1,2]
Carrier-to-Cross-modulation ratio	Not less than 41 dB[1,2]
Carrier-to-any other discrete interference (ingress)	Not less than 41 dB[1,2]
Amplitude ripple	3 dB within the design bandwidth[1]
Group delay ripple in the spectrum occupied by the CMTS	75 ns within the design bandwidth[1]
Micro-reflections bound for dominant echo	-10 dBc @ ≤ 0.5 µs -15 dBc @ ≤ 1.0 µs -20 dBc @ ≤ 1.5 µs -30 dBc @ > 1.5 µs[1]
Carrier hum modulation	Not greater than -26 dBc (5%)[1]
Burst noise	Not longer than 25 µs at a 10 Hz average rate[1]

Parameter	Value
Maximum analog video carrier level at the CM input	17 dBmV
Maximum number of analog carriers	121

1. Measurement methods defined in [NCTA] or [CableLabs1].
2. Measured relative to a QAM signal that is equal to the nominal video level in the plant.

Source: SCTE

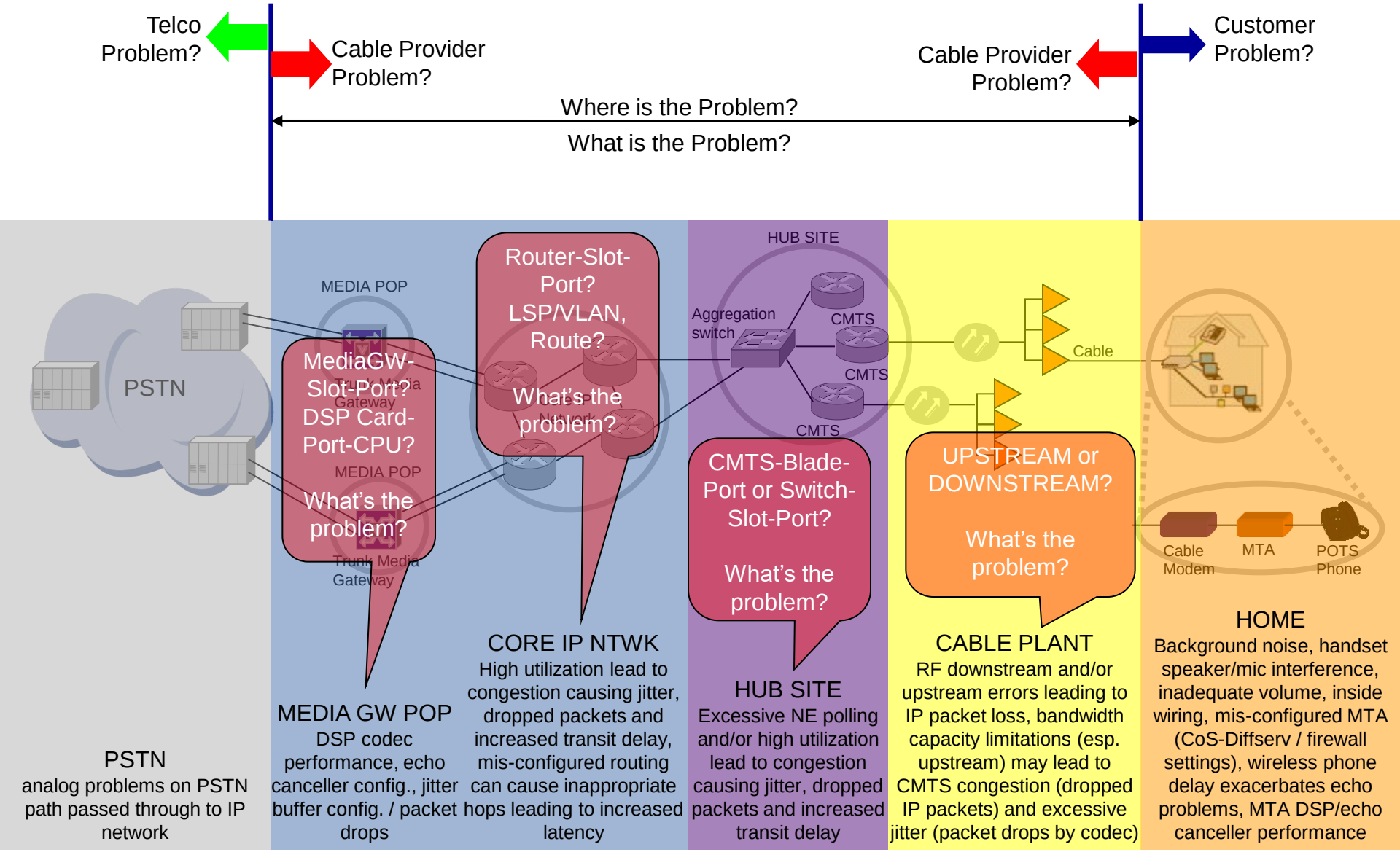
SCTE Docsis 3.1 Downstream RF Spec – 192 Mhz Channel

Parameter	Value
Frequency range	Cable system normal downstream operating range is from 54 MHz to 1002 MHz. Extended operating ranges include lower downstream edges of 108 MHz and 258 MHz and upper downstream edges of 1218 MHz and 1794 MHz.
RF channel spacing (design bandwidth)	24 to 192 MHz
One way transit delay from headend to most distant customer	≤ 0.400 ms (typically much less)
Signal to Composite Noise Ratio	≥ 35 dB
Carrier-to-Composite triple beat distortion ratio	Not less than 41 dB
Carrier-to-Composite second order distortion ratio	Not less than 41 dB
Carrier-to-Cross-modulation ratio	Not less than 41 dB
Carrier-to-any other discrete interference (ingress)	Not less than 41 dB
Maximum amplitude variation across the 6 MHz channel (digital channels)	≤ 1.74 dB pk-pk/6 MHz

Parameter	Value
Group Delay Variation	≤113 ns over 24 MHz
Micro-reflections bound for dominant single echo	-20 dBc for echos ≤ 0.5 µs -25 dBc for echos ≤ 1.0 µs -30 dBc for echos ≤ 1.5 µs -35 dBc for echos > 2.0 µs -40 dBc for echos > 3.0 µs -45 dBc for echos > 4.5 µs -50 dBc for echos > 5.0 µs
Carrier hum modulation	Not greater than -30 dBc (3%)
Maximum analog video carrier level at the CM input	17 dBmV
Maximum number of analog carriers	121
NOTE: Cascaded group delay could possibly exceed the ≤113 ns value within approximately 30 MHz above the downstream spectrum's lower band edge, depending on cascade depth, diplex filter design, and actual band split.	

Source: SCTE

Voice Quality Impairments – it's not always the plant!



Fiber Testing

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.

Where is it? – Proliferation of Dirt

There are a number of different sources where dirt and other particles can contaminate the fiber.

- **Test Equipment**
- **Dust Caps**
- **Bulkheads**
- **People**
- **Environment**

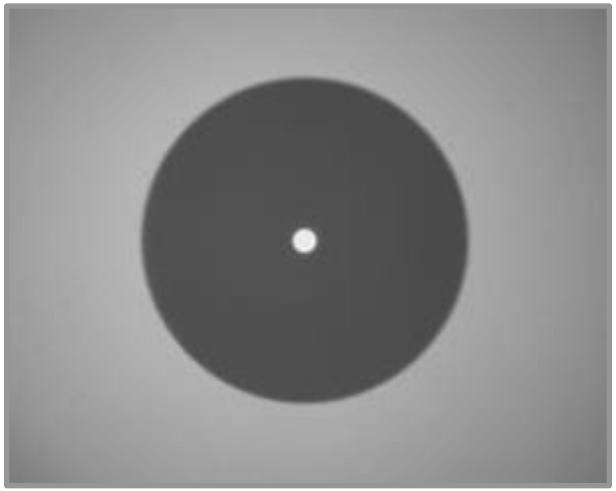
Connectors and ports on test equipment are mated frequently and are highly likely to become contaminated. Once contaminated, this equipment will often cross-contaminate the network connectors and ports being tested.

Inspecting and cleaning test ports and leads before testing network connectors prevents cross-contamination.

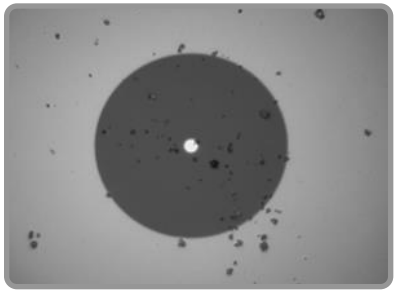
Types of Contamination

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

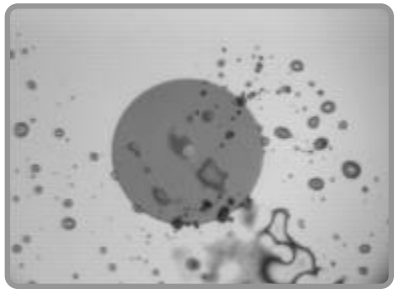
SINGLEMODE FIBER



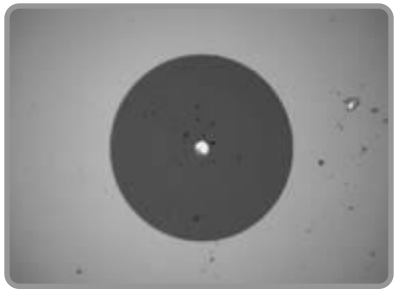
Common types of contamination and defects include the following:



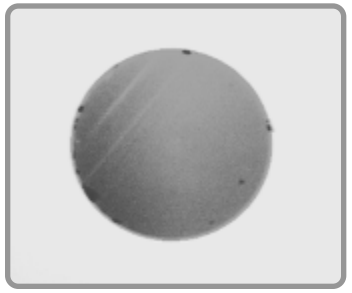
Dirt



Oil



Pits & Chips



Scratches

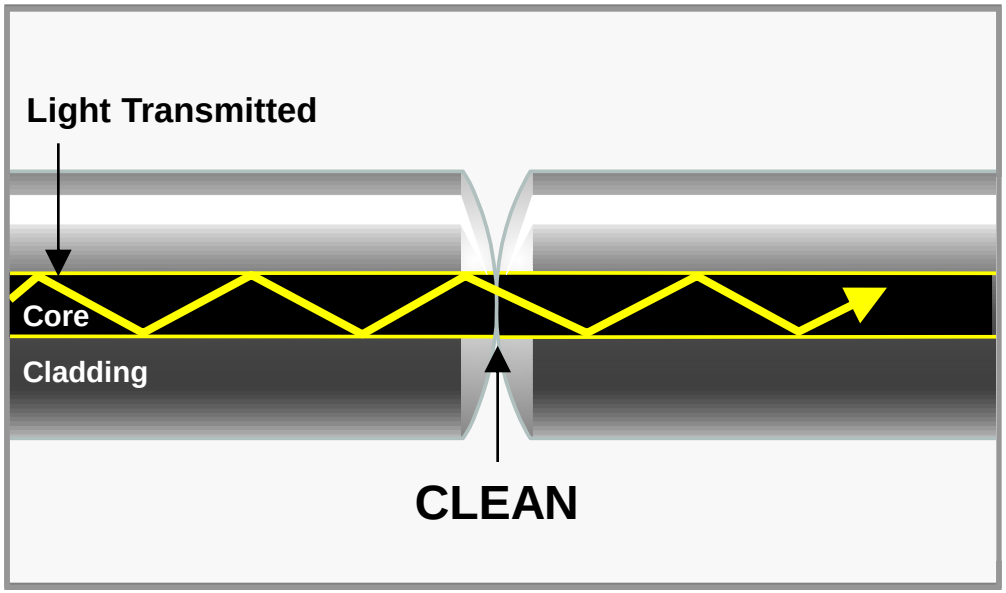
What Makes a GOOD Fiber Connection?

The 3 basic principles that are critical to achieving an efficient fiber optic connection are "The 3 P's":

Perfect Core Alignment

Physical Contact

Pristine Connector Interface



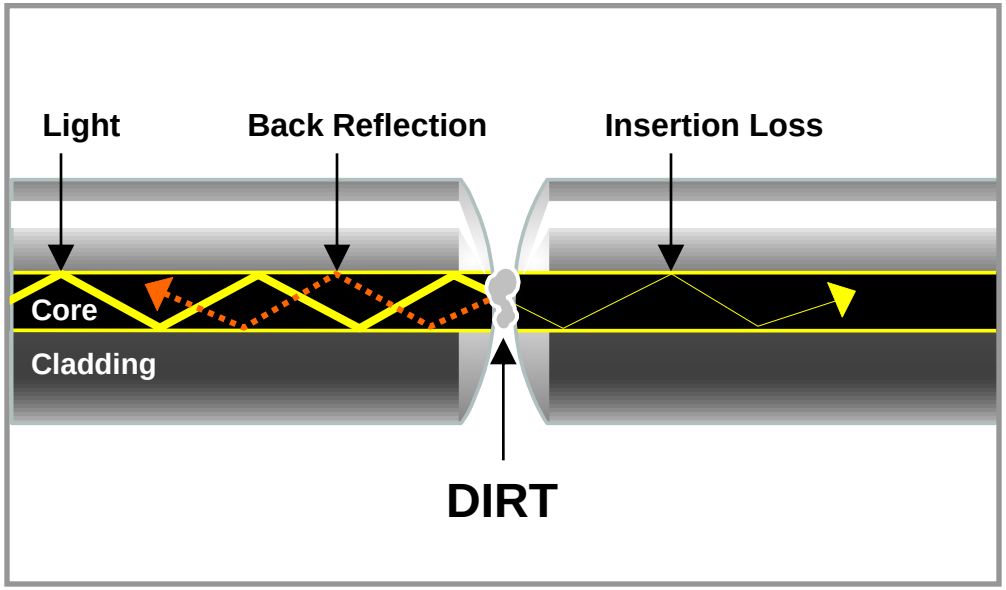
Today's connector design and production techniques have eliminated most of the challenges to achieving core alignment and physical contact, but they are *SENSITIVE TO CONTAMINATION!*

What Makes a BAD Fiber Connection

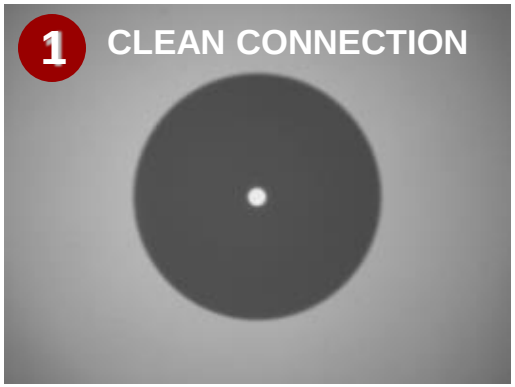
Maintaining a clean connector end face is the real challenge!

As a result, **CONTAMINATION is still the #1 source for troubleshooting** in optical networks.

A single particle mated into the core of a fiber can cause significant **back reflection**, **insertion loss,** and even **equipment damage.**



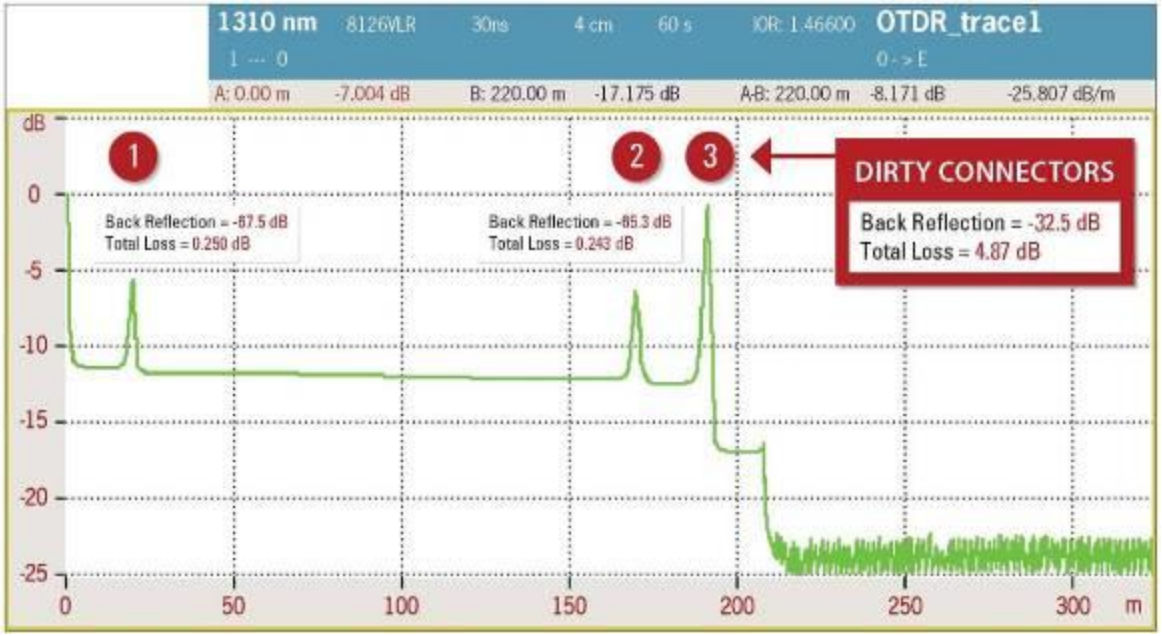
Contamination & Signal Performance



Back Reflection = **-67.5 dB**
Total Loss = **0.250 dB**

Back Reflection = **-32.5 dB**
Total Loss = **4.87 dB**

Fiber Contamination and Its Effect on Signal Performance



Clean Connection vs. Dirty Connection

This OTDR trace illustrates a significant decrease in signal performance when dirty connectors are mated.

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Proactive versus Reactive Inspection

PROACTIVE INSPECTION:

Visually inspecting fiber connectors at every stage of handling ***BEFORE*** mating them.

Connectors are much easier to clean prior to mating, before embedding debris into the fiber.

Fiber ***AFTER*** Cleaning

REACTIVE INSPECTION:

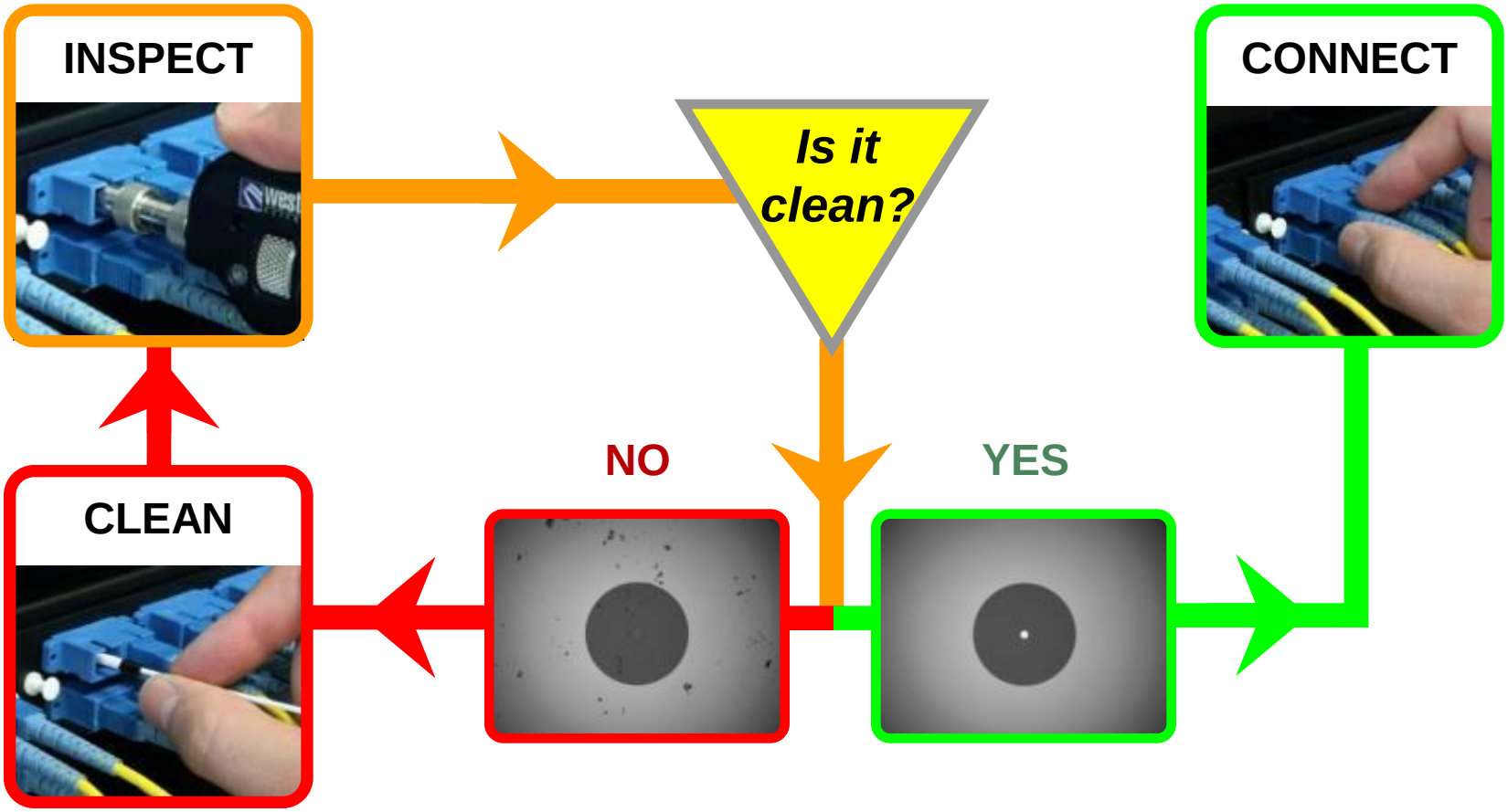
Visually inspecting fiber connectors ***AFTER*** a problem is discovered, typically during troubleshooting.

By this time, connectors and other equipment may have suffered permanent damage.

Fiber ***AFTER*** Mating and Numerous Cleanings

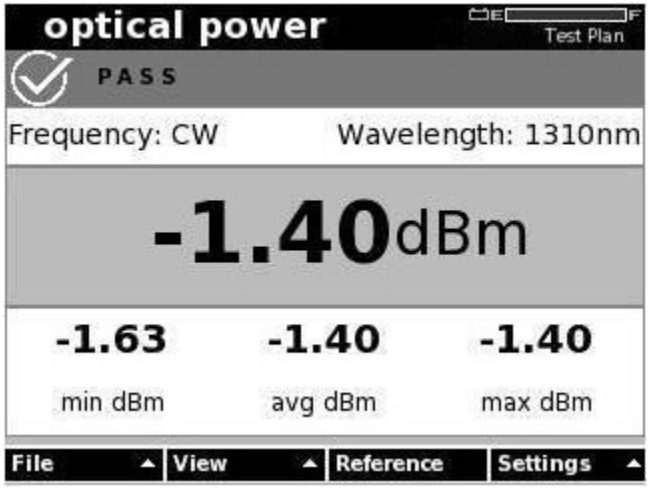
Inspect Before You Connect

Follow this simple **“INSPECT BEFORE YOU CONNECT”** process to ensure fiber end faces are clean prior to mating connectors.



Innovative solutions

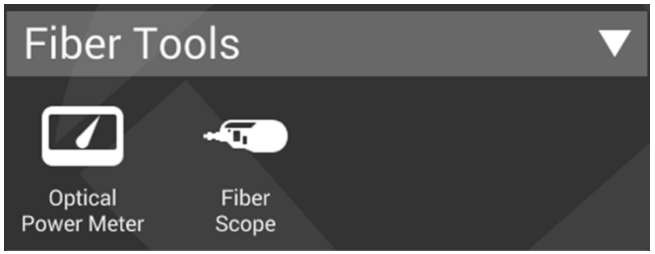
- **Optical Power Meter** – verify optical power at node
  - Enable quick power check without requiring a separate meter

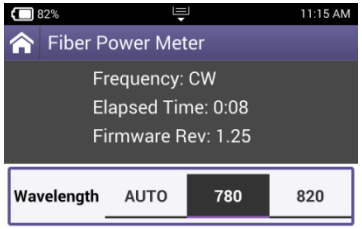


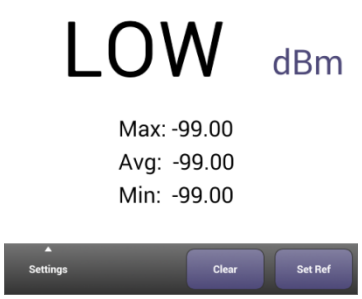
- **Fiber Scope** – ensure clean fiber connection
  - "*Inspect before you connect*" polic
  - Improves reliability
  - No separate meter required

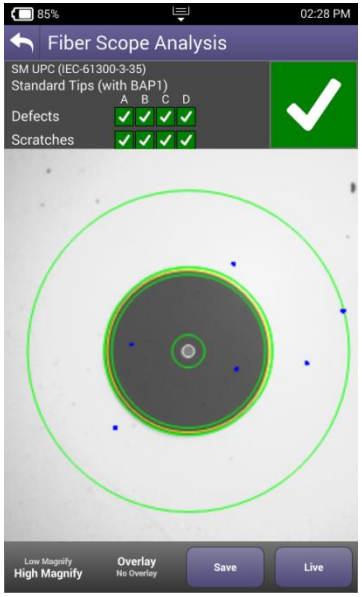
Fiber Optic Testing made easier

- **Fiber testing made easier**
- **Inspect before you connect**
  - Fiber Inspection
    - P5000i Automatic fiber scope support
      - Auto Centering
      - Automated testing
      - Simple pass/fail
  - Power Meter
    - USB power meter support
    - MP-60 & MP-80









RF Testing

Incorrect Levels

- **Low Video Levels**
- **Produces noise in the picture**

- High Video Levels

Produces distortion in the picture

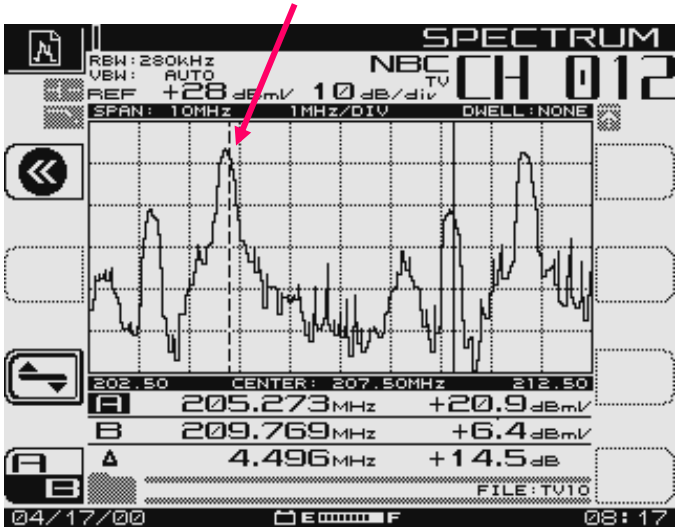
Low Digital levels

- **Causes Digital signal to Degrade.**
- **This causes Tiling and Loss of high Speed internet access.**

Digital vs. Analog

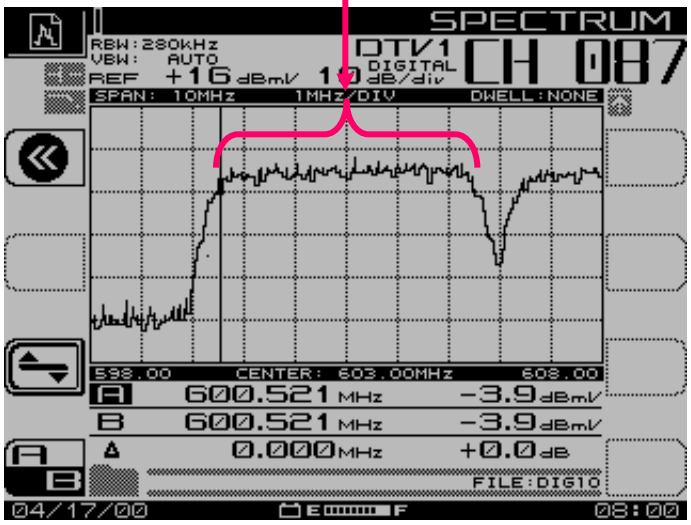
- Power on digital carriers is spread across the channel.
- Almost all power on an analog carrier is concentrated at the video carrier frequency.

Channel Power



Analog Video Spectrum

Channel Power

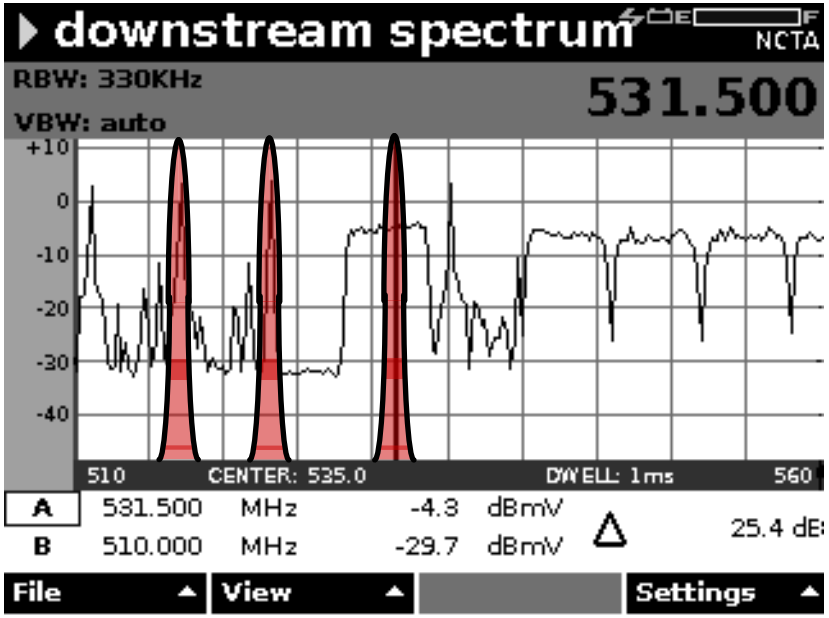


Digital Video/Cable Modem Spectrum

Digital Average Power Level Measurements

Digital Average Power Measurements and Measurement Bandwidth

- The spectrum analyzer view is an excellent tool to see discreet RF-carriers.
  - Caution is needed when viewing digital modulated signals (haystack). The signal's level measurement is derived from the selected measurement bandwidth (resolution bandwidth). At an RBW of 300 kHz, a 64QAM - 6 MHz wide digital signal reads in the spectrum analyzer trace 3 dB too low.
- The Average Power principle takes small slices from the integrated RF-energy, summing them together to one total power reading in the LEVEL-mode.



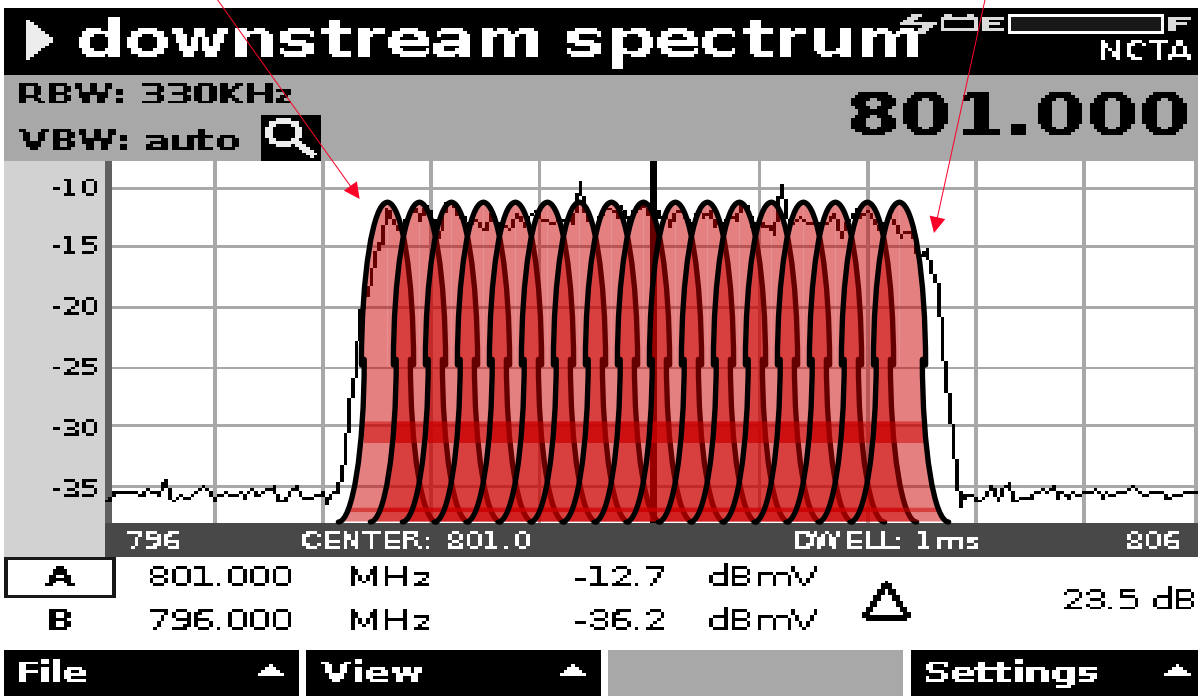
Analog and digital (broadcast) QAM signal. The recommended delta in level should be 6 to 10 dB.

Measuring the Digital “Haystack”

Digital carrier under test
(6 MHz BW)

Non measured area based on 280 kHz step size within 6 MHz total Bandwidth

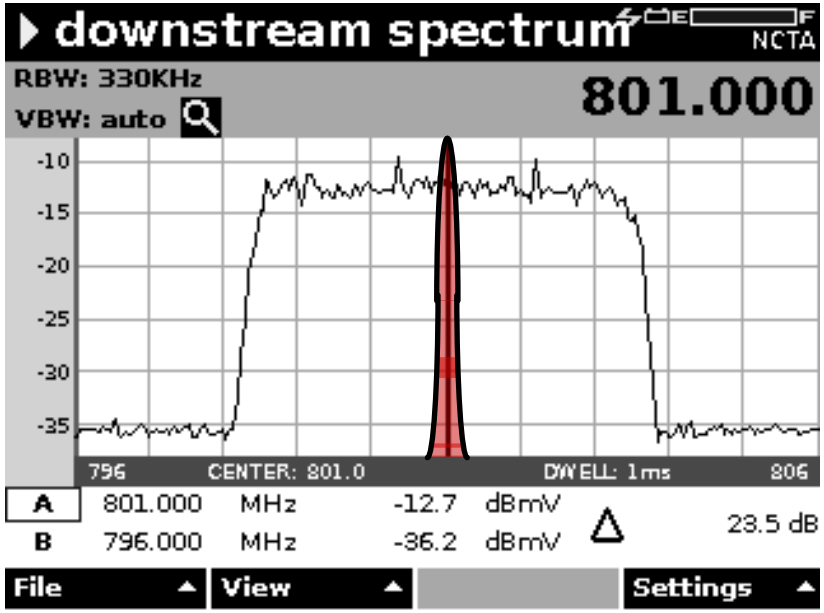
IF Measurement Bandwidth = 280 kHz



Summing slices of the total integrated energy

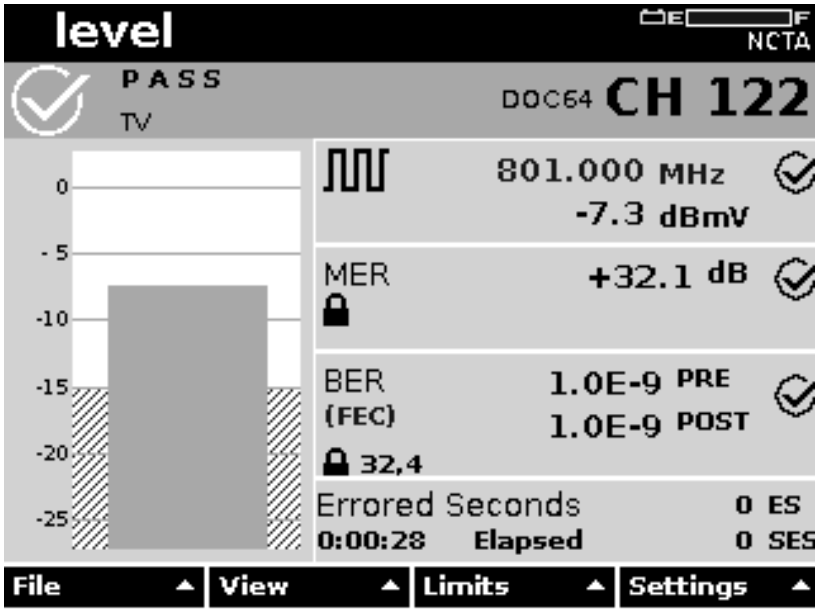
Measuring the Digital “Haystack”

Measuring the Peak Level of the Digital Haystack



280 kHz
Bandwidth power

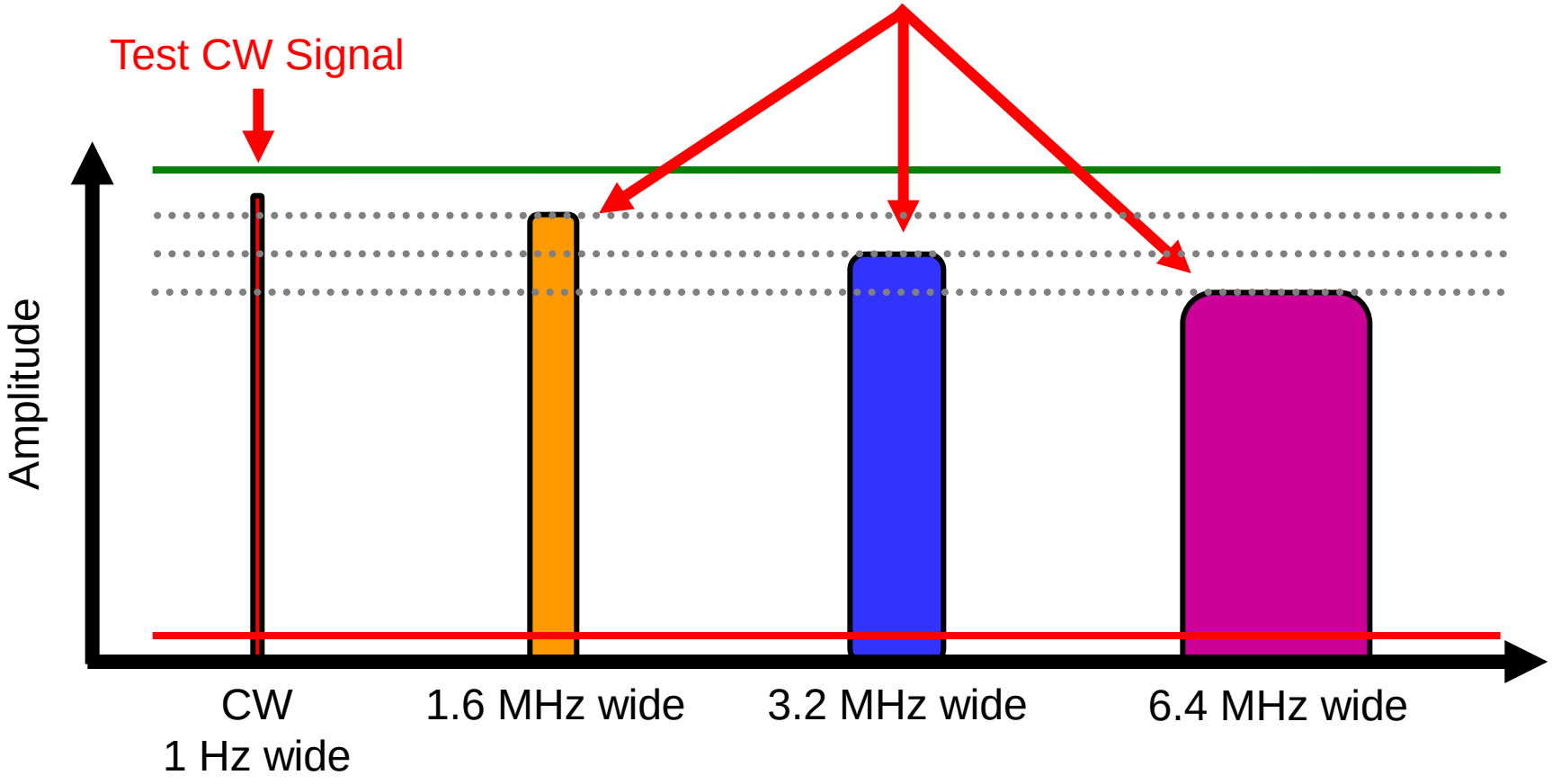
Measuring the Average Level of the Digital Haystack



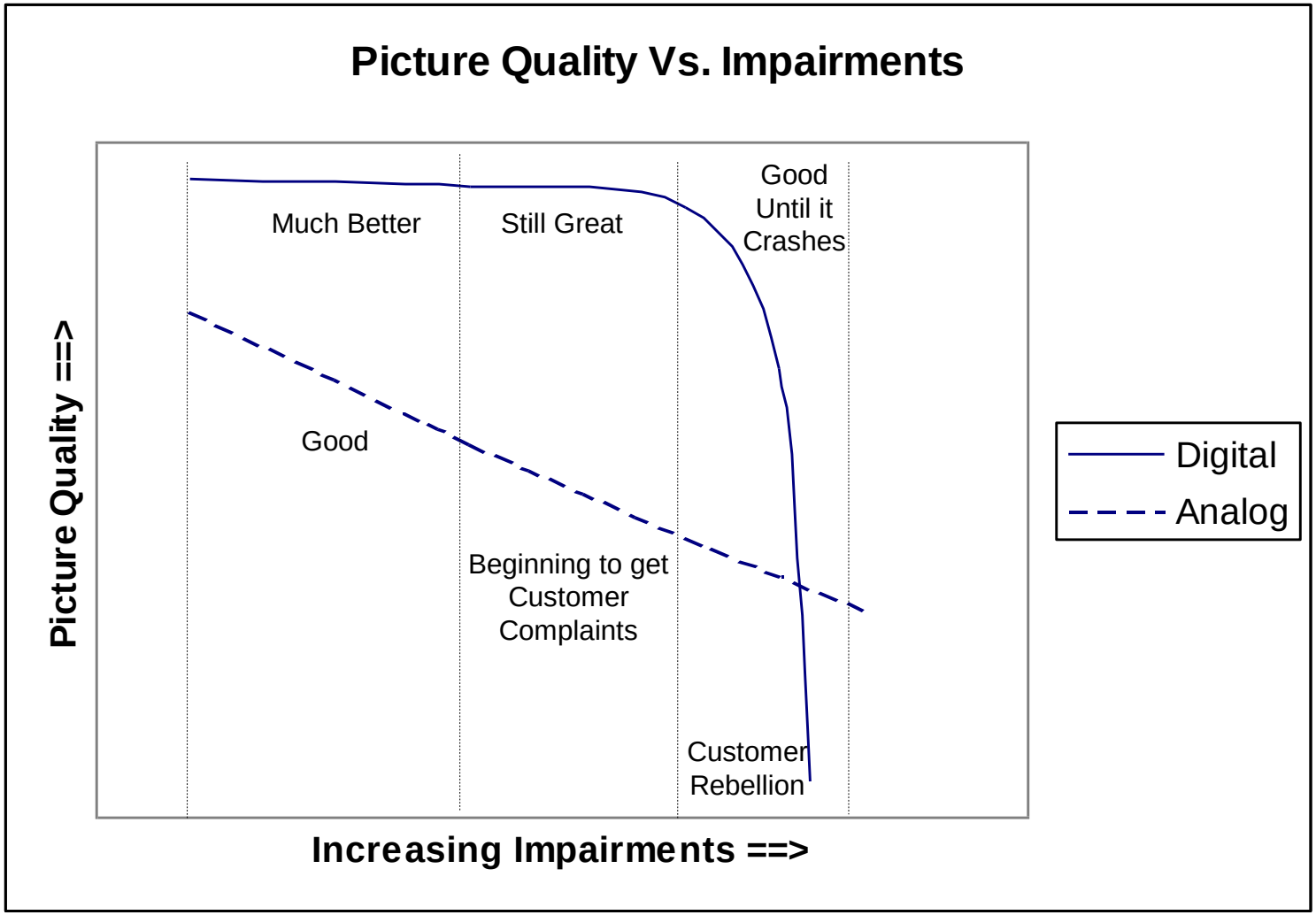
5 MHz
Bandwidth power

Measuring Upstream Carrier Amplitudes

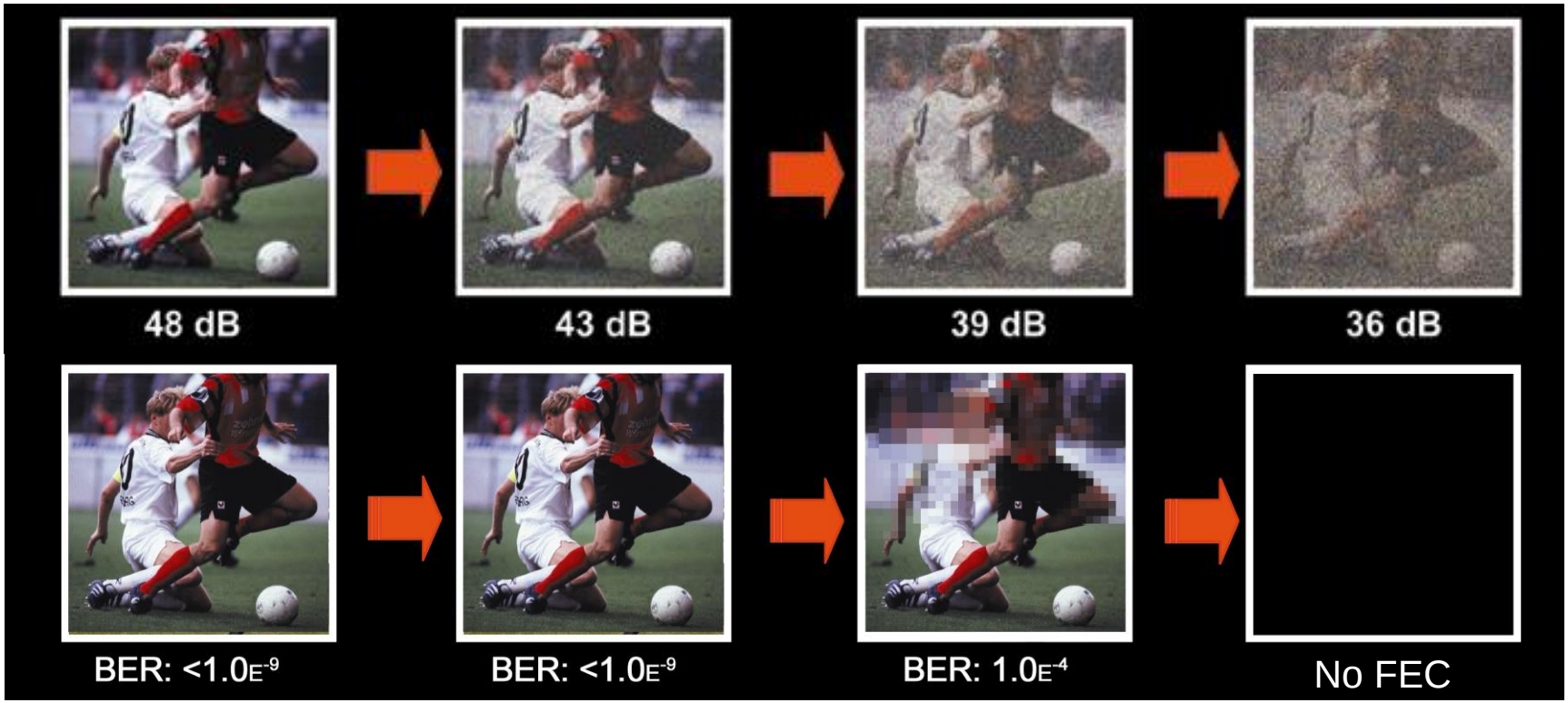
These three DOCSIS® carriers will NOT have the same peak amplitude when hitting the input port of a CMTS at 0 dBmV "constant power per carrier" and then measured with a typical spectrum analyzer or signal level meter.

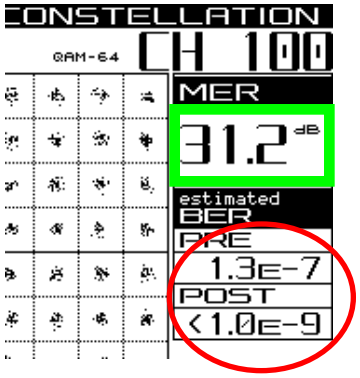


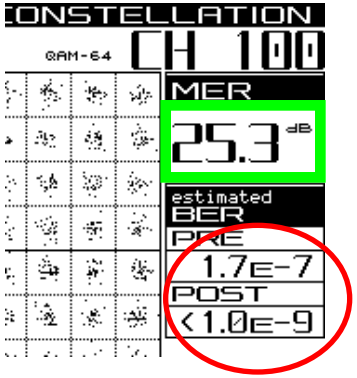
Digital TV Waterfall Graph

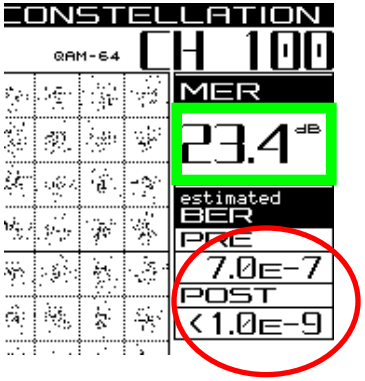


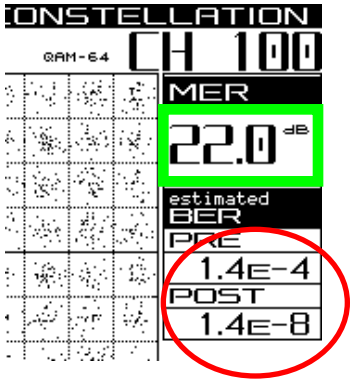
C/N vs. BER vs. MER



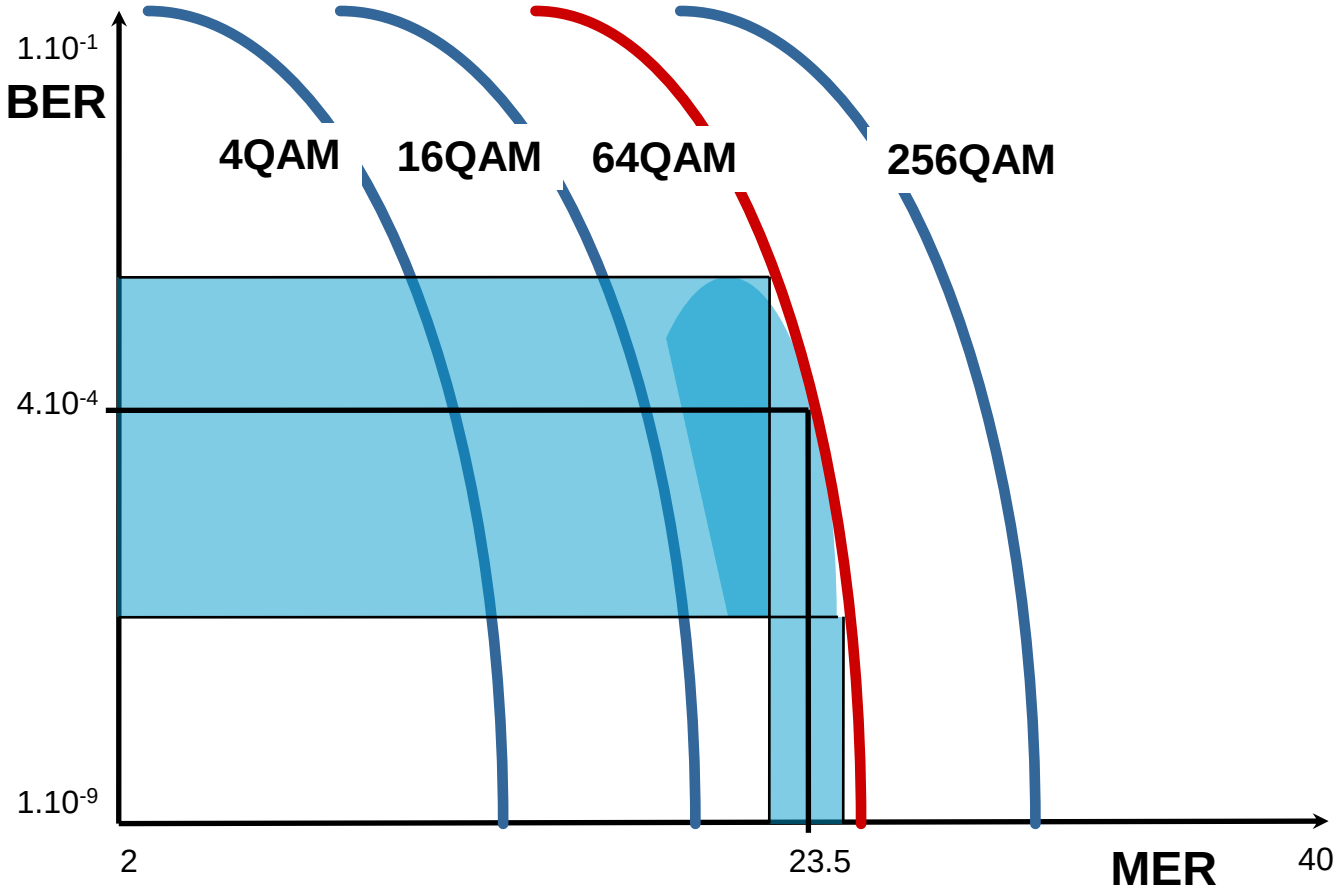








FEC causes Cliff Effect



- A small variation in MER (+/- 1 dB) will cause a large variation in BER measurement.
- Using BER for trouble-shooting and fault location is not repeatable and very inaccurate.

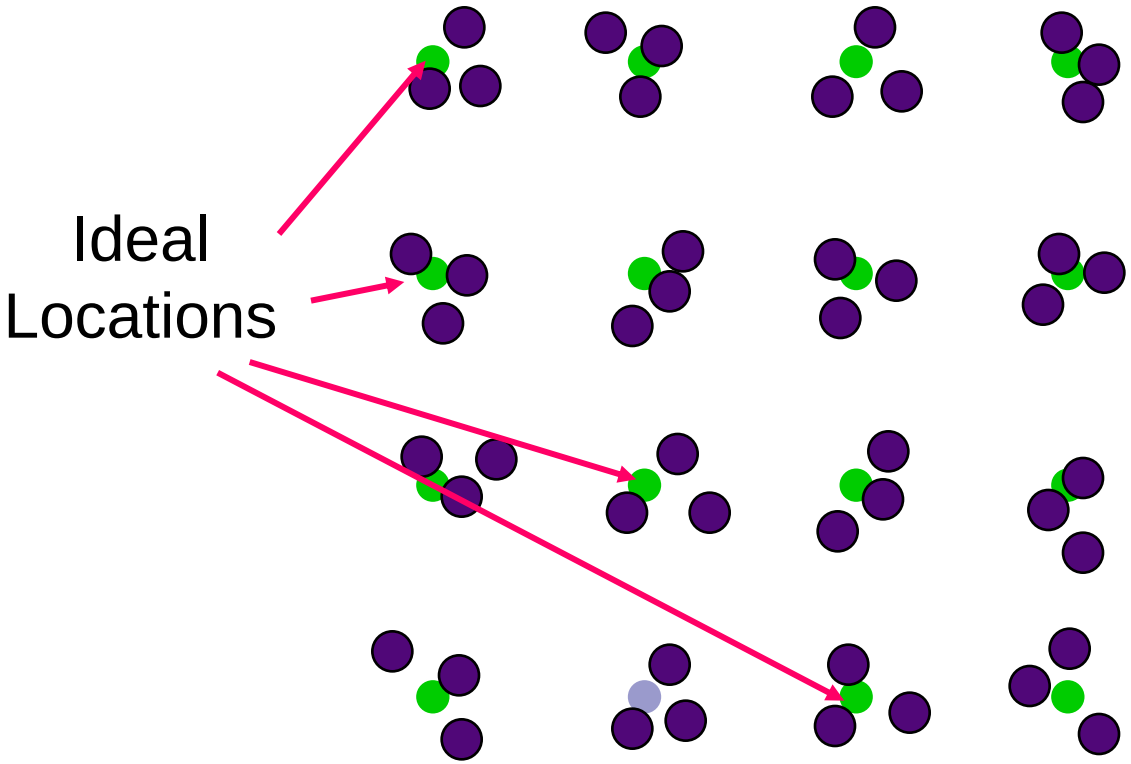
BER Example

- A 256QAM channel transmits at a symbol rate of 5M symbols per second
- Bit rate = 8 bits per symbol X 5M symbol per second =40M bits per second
- Error Incident = Bit rate X BER = Errors Per Second

BER	Error Frequency	Error Incident
10^{-12}	1 in 1 Trillion bits	25000 secs between errs (6.94 hrs)
10^{-11}	1 in 100 Billion bits	2500 secs between errs (41.67 mins)
10^{-10}	1 in 10 Billion bits	250 secs between errs (4.167 mins)
10^{-9}	1 in 1 Billion bits	25 seconds between errors
10^{-8}	1 in 100 Million bits	2.5 seconds between errors
10^{-7}	1 in 10 Million bits	4 errors per second
10^{-6}	1 in 1 Million bits	40 errors per second
10^{-5}	1 in 100 Thousand bits	400 errors per second
10^{-4}	1 in 10 Thousand Bits	4000 errors per second
10^{-3}	1 in 1 Thousand bits	40000 errors per second

Effects of Noise and Interference

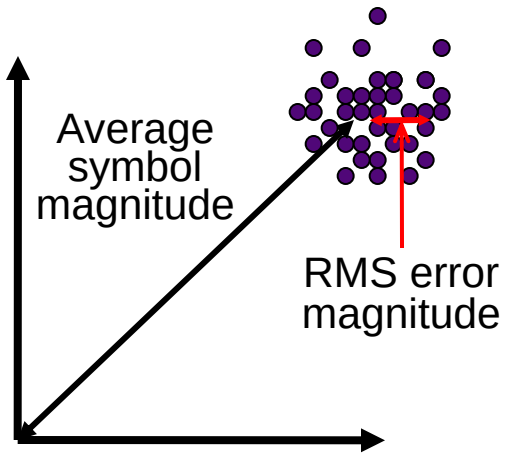
- **Noise and Interference moves the carrier away from its ideal location causing a spreading of the cluster of dots.**



Modulation Error Ratio (MER)

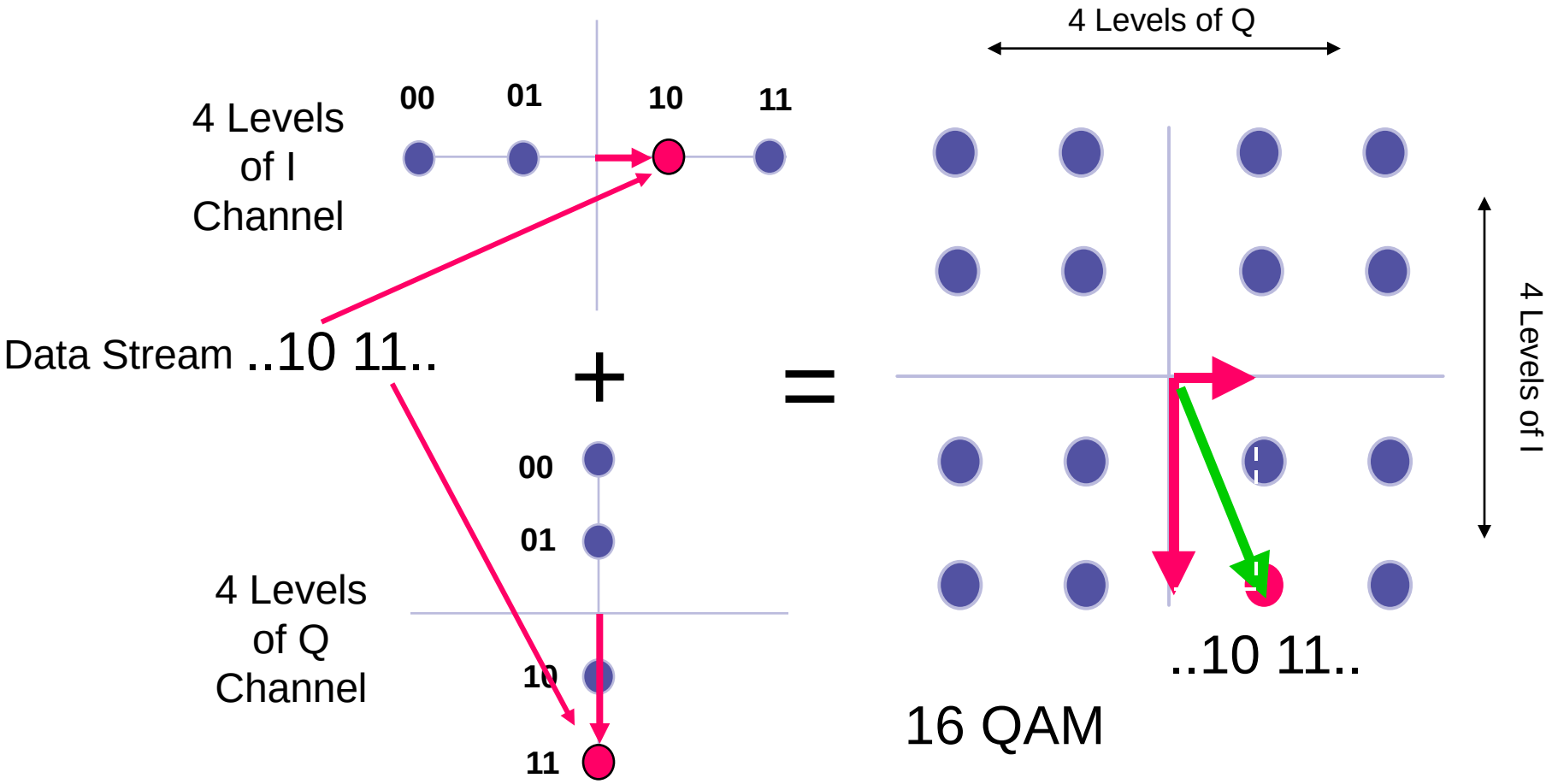
- Analogous to S/N
- A measure of how symbols (I vs. Q) are actually placed, compared to ideal placement

- $\text{MER(dB)} = 20 \times \log \left[\frac{\text{RMS error magnitude}}{\text{average symbol magnitude}} \right]$
- Good MER
  - 64 QAM: 28 dB MER
  - 256 QAM: 32 dB MER



Vector Sum of I and Q Channels

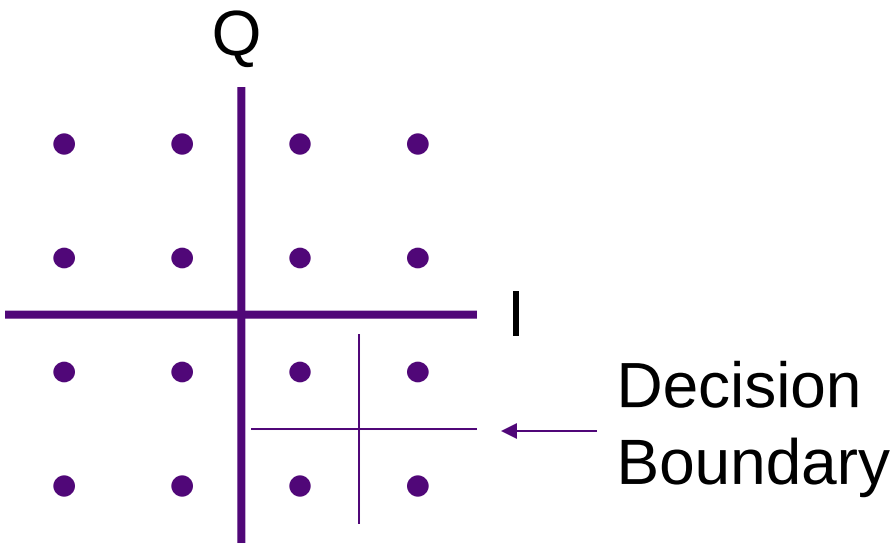
- Combining 2 carriers 90° of out of phase results in a carrier with amplitude and phase modulation



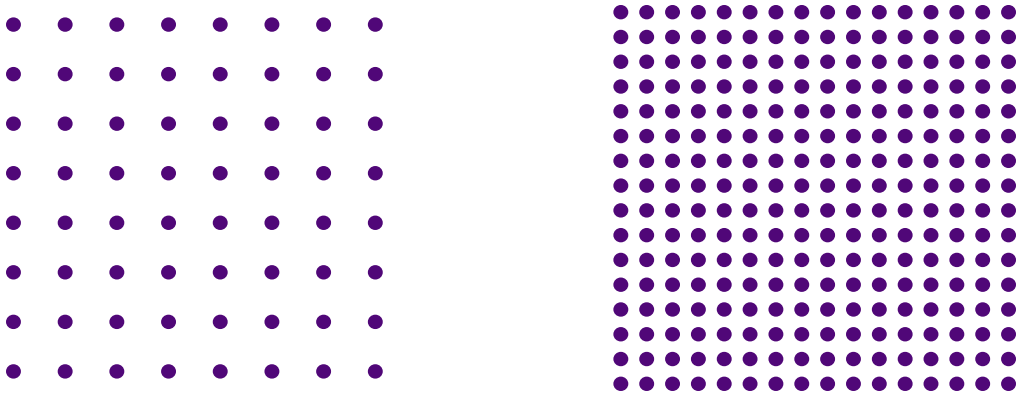
Typical Constellations

16 QAM

- 16 combinations of amplitudes and phases



16 QAM

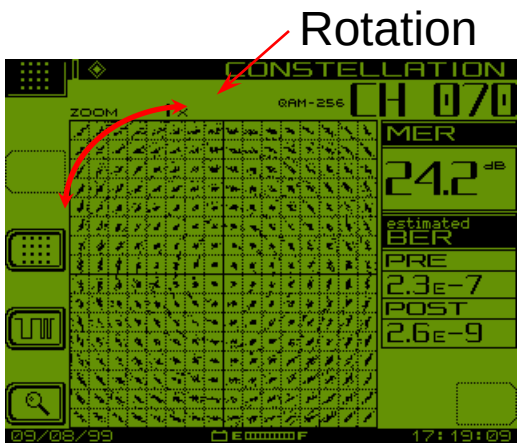


64 QAM

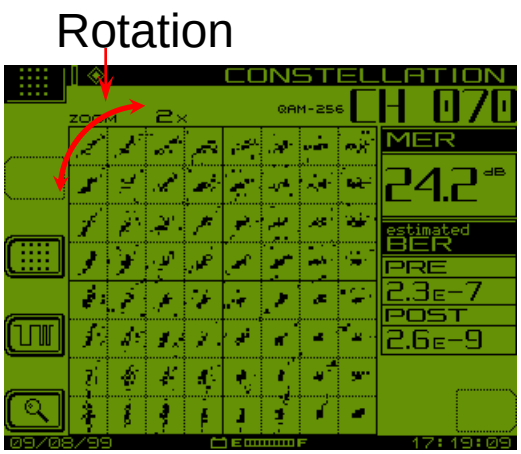
256 QAM

Phase Noise

- Display appears to rotate at the extremes
- HE down/up converters can cause phase noise
- Random phase errors cause decreased transmission margin
- Caused by transmitter symbol clock jitter
- Bad LO in meter can cause phase noise Constellation



Constellation with Phase Noise

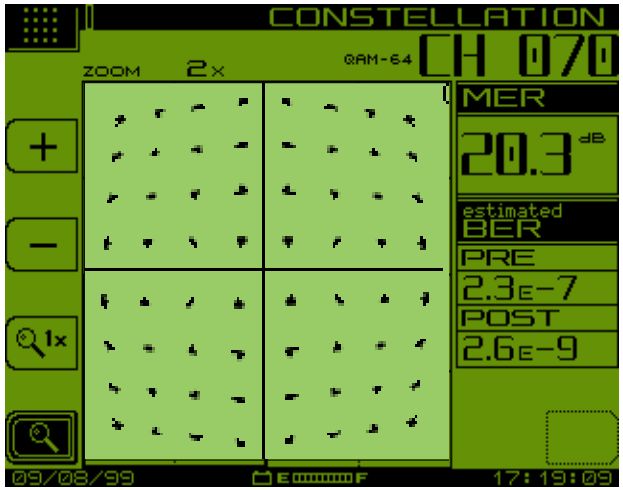


Zoomed Constellation with Phase Noise

Gain Compression

- If the outer dots are pulled into the center while the middle ones are not affected, the signal has gain compression
- Gain compression can be caused by IF and RF amplifiers and filters, up/down converters and IF equalizers

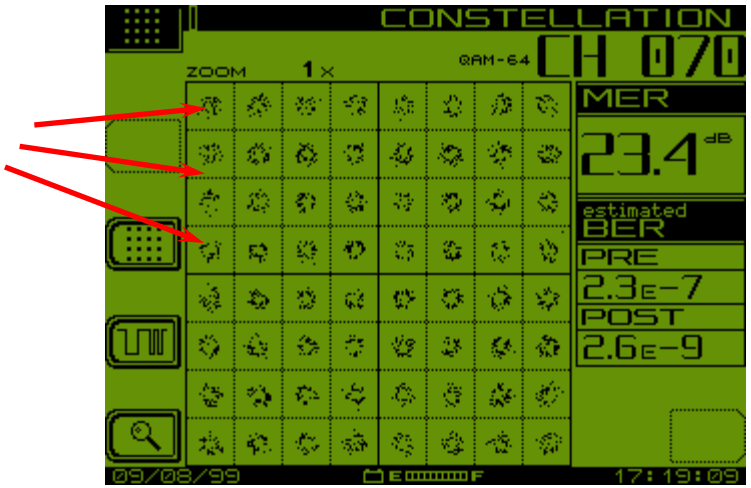
Outer edges pulled in

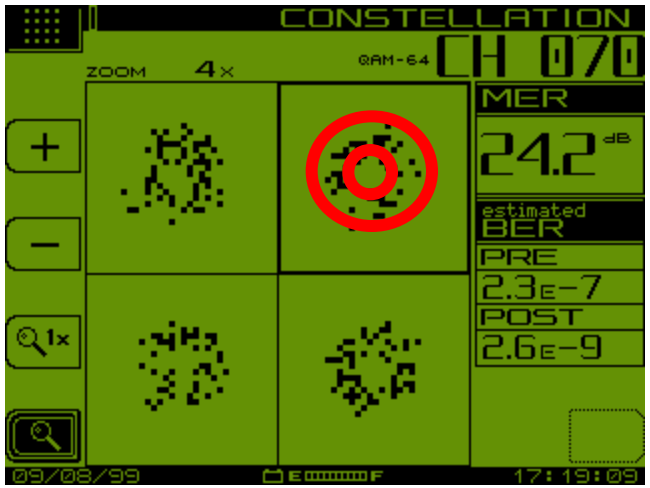


Coherent Interference

- If the accumulation looks like a “donut”, the problem is coherent interference
  - CTB, CSO, Off-Air Carriers (ingress)
- Sometimes only a couple dots will be misplaced
  - This is usually laser clipping or sweep interference

Circular “donuts”

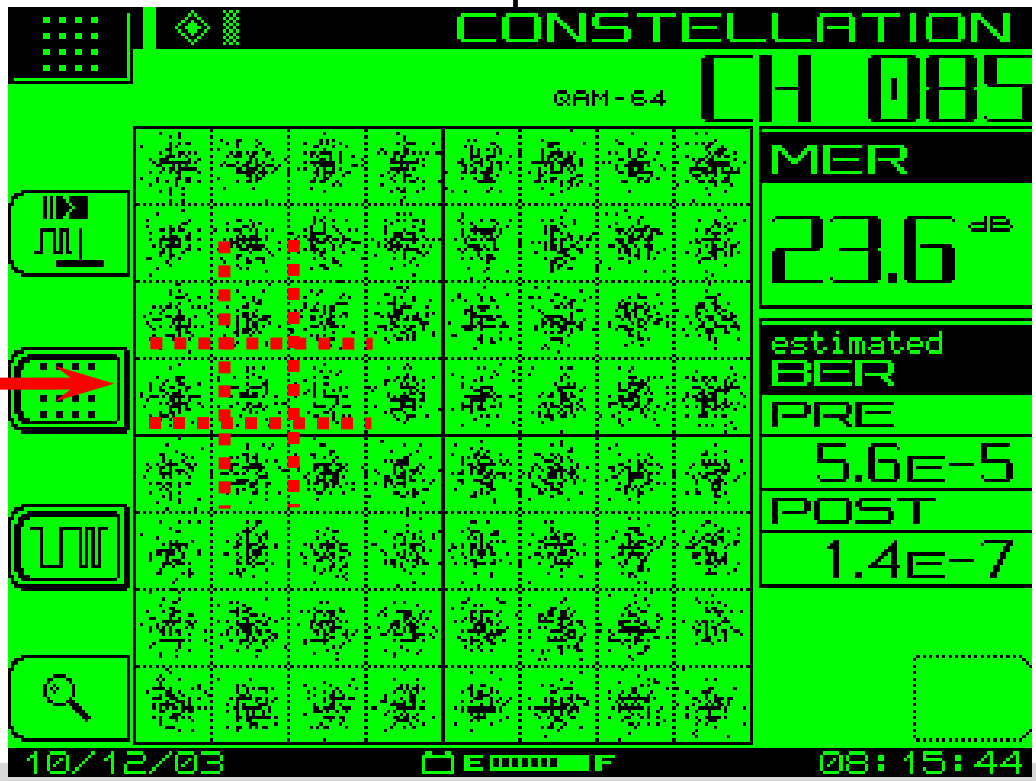




System Noise

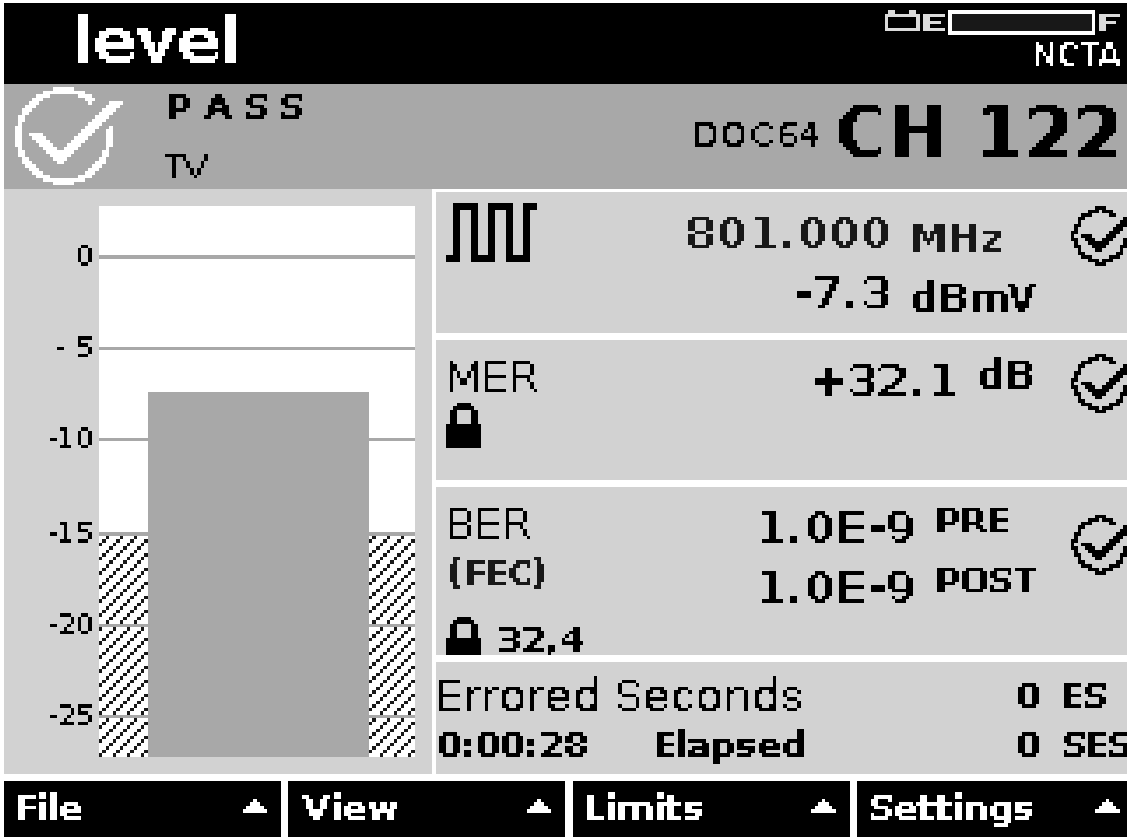
- A constellation displaying significant noise
- Dots are spread out indicating high noise and most likely significant errors
  - An error occurs when a dot is plotted across a boundary and is placed in the wrong location
- Meter will not lock if too much noise present

Dots are spread out showing error

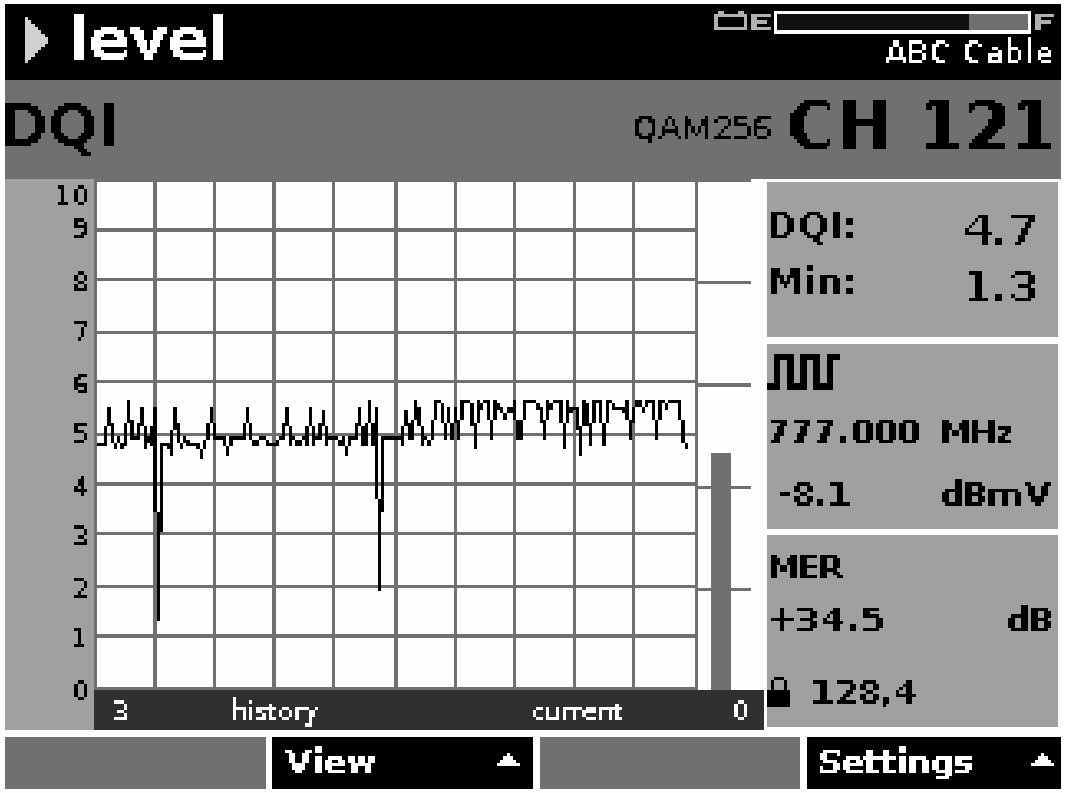


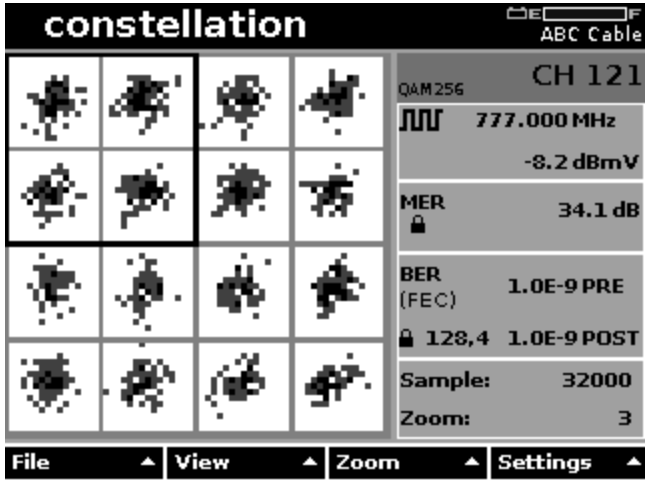
Digital – more than just dB's

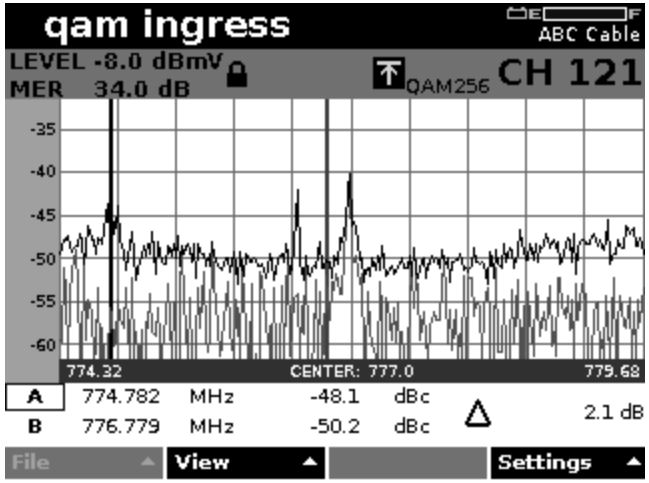
MER and Pre and Post BER measurements are key to insuring Digital Quality



High Frequency QAMs Have Margin Issues





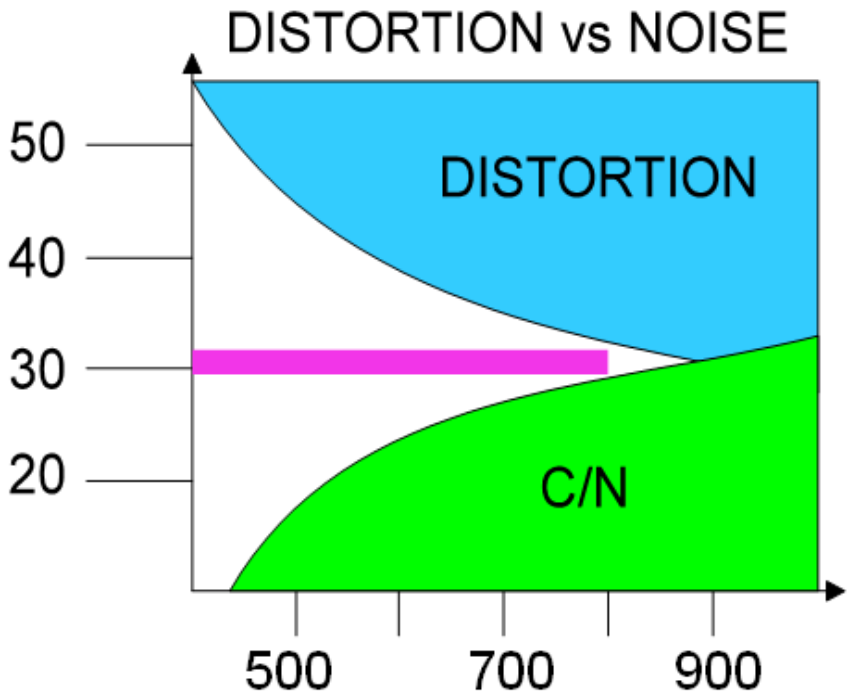


Expected MER & BER Results

Digital video		MER		Pre FEC BER	Post FEC BER
		64 QAM	256 QAM		
Headend	Excellent	35 dB	35 dB	0.0 E-00	0.0 E-00
	Acceptable	33 dB	35 dB	1.0E-08	0.0E+00
	Marginal	30 dB	32 dB	1.0E-07	1.0E-08
Node	Excellent	34 dB	35 dB	0.0 E-00	0.0 E-00
	Acceptable	31 dB	34 dB	1.0E-08	0.0 E-00
	Marginal	28 dB	30 dB	1.0E-07	1.0E-08
Amp	Excellent	33 dB	35 dB	1.0E-09	0.0 E-00
	Acceptable	30 dB	32 dB	1.0E-08	1.0E-09
	Marginal	25 dB	29 dB	1.0E-07	1.0E-08
Tap	Excellent	32 dB	35 dB	1.0E-08	0.0 E-00
	Acceptable	28 dB	31 dB	1.0E-07	1.0E-09
	Marginal	24 dB	28 dB	1.0E-06	1.0E-08
Set-top	Excellent	32 dB	35 dB	1.0E-08	0.0 E-0
	Acceptable	27 dB	31 dB	1.0E-07	1.0E-08
	Marginal	23 dB	27 dB	1.0E-06	1.0E-07

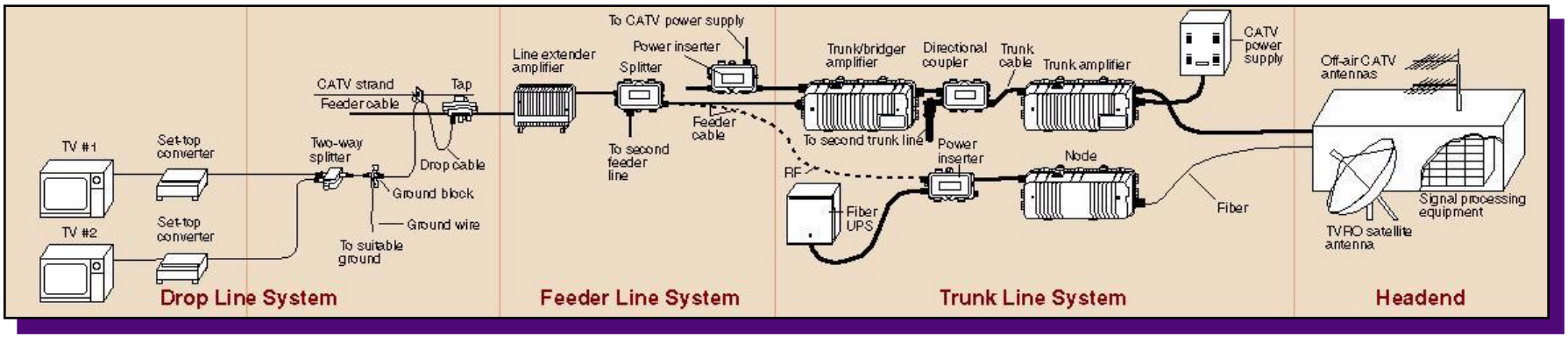
HFC Network

WHY SWEEP?



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

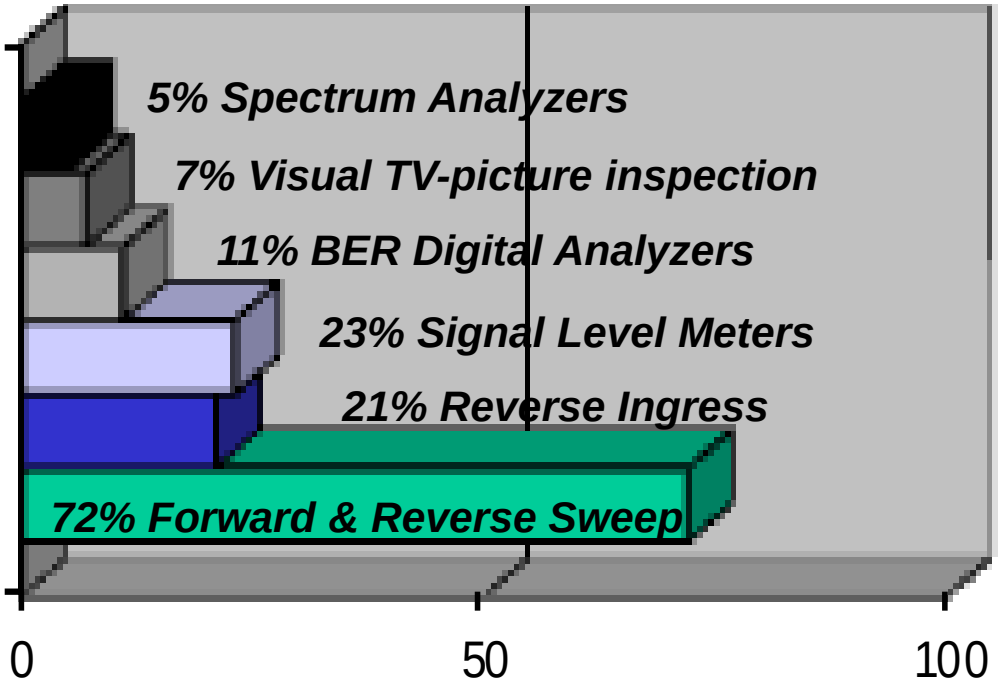
Sweep vs. Signal Level Meter Measurements



- References: Sweep systems allow a reference to be stored eliminating the effect of headend level error or headend level drift.
- Sweep Segments: Stealth makes it possible to divide the HFC plant into network sections and test its performance against individual specifications.
- Non-Invasive: Sweep systems can measure in unused frequencies. This is most important during construction and system overbuilding.
- BEST Solution to align: Sweep systems are more accurate and faster.

What faults cause CATV signals to fail ?
(80-90% of the time, the same faults…)

- Success rate of finding and fixing the following problems using:
  - Signal Levels
  - TILT
  - Gain / Loss
  - Suck-outs (notches)
  - C/N
  - HUM
  - CTB/CSO Intermodulation
  - CPD - Forward and Reverse
  - Reverse Ingress
  - BER / MER
  - Reflections / Standing waves

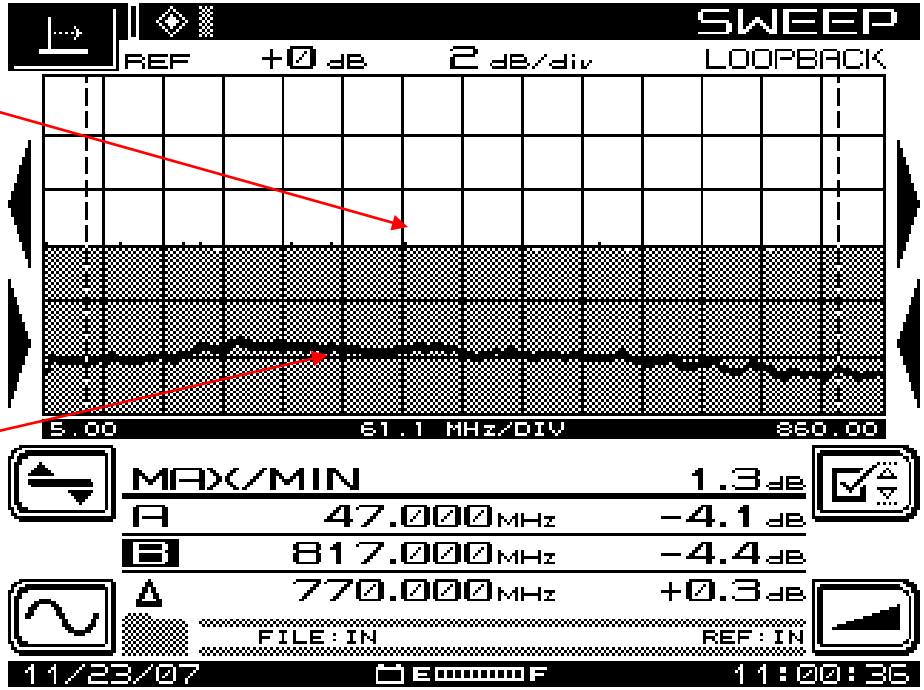


Source: Research 11/97-2/98 Market survey with 200 US and European CATV operators

Sweep Reponse of a Splitter

INPUT

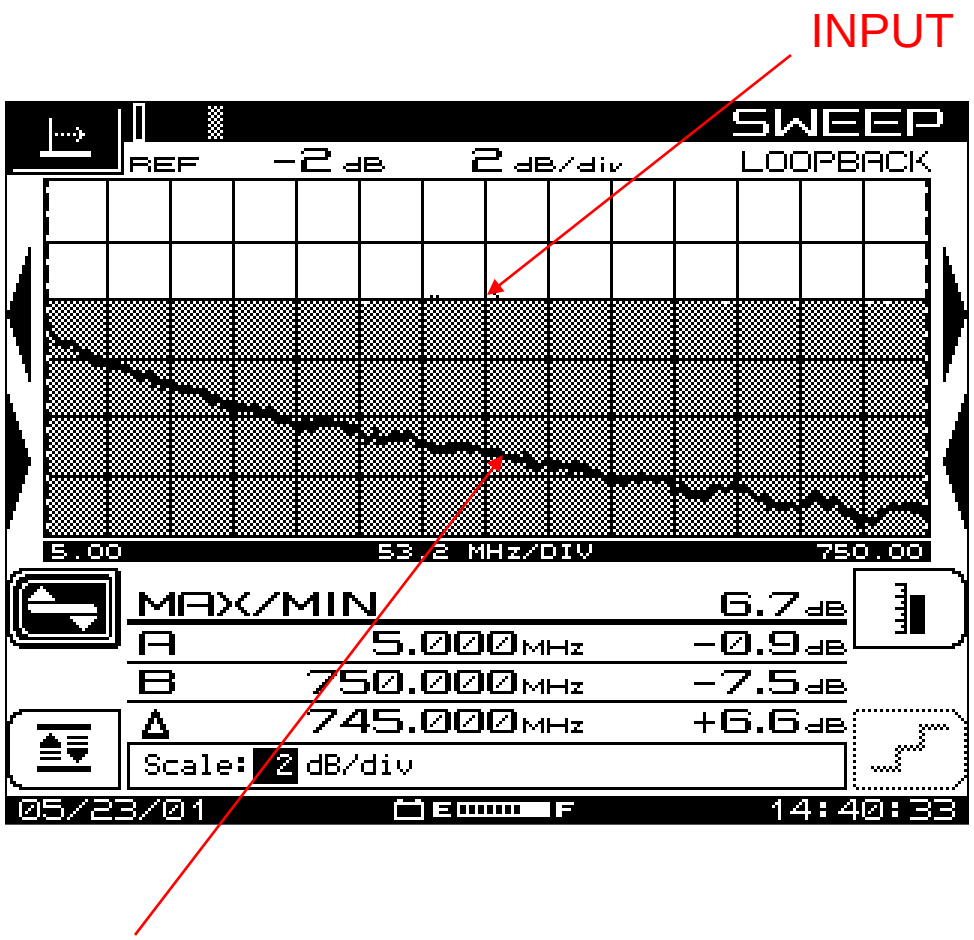
OUTPUT

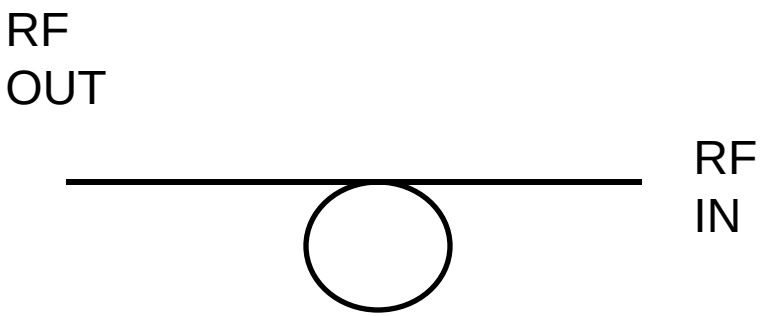


RF OUT

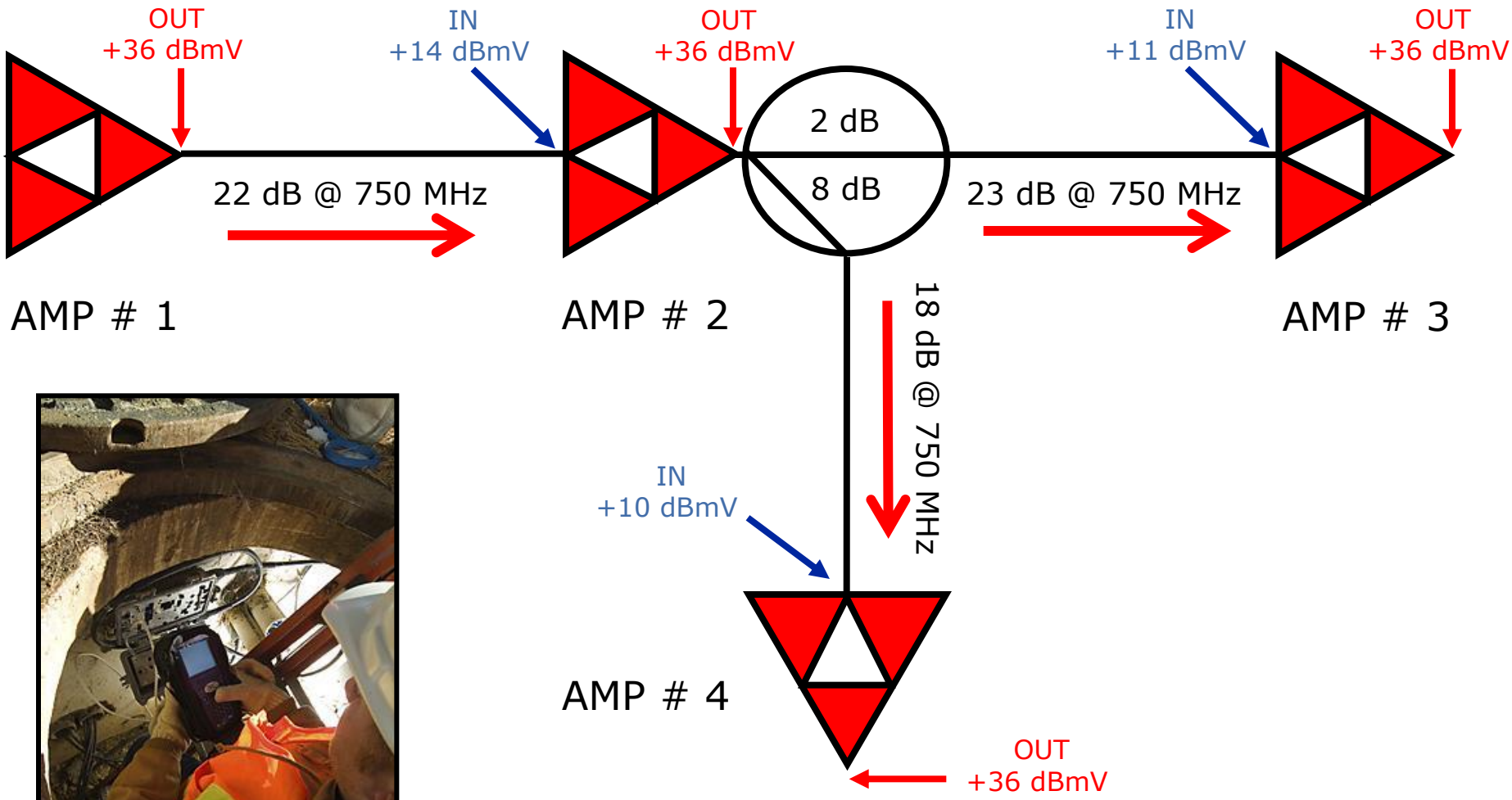
RF IN

100 ft of RG-59 cable

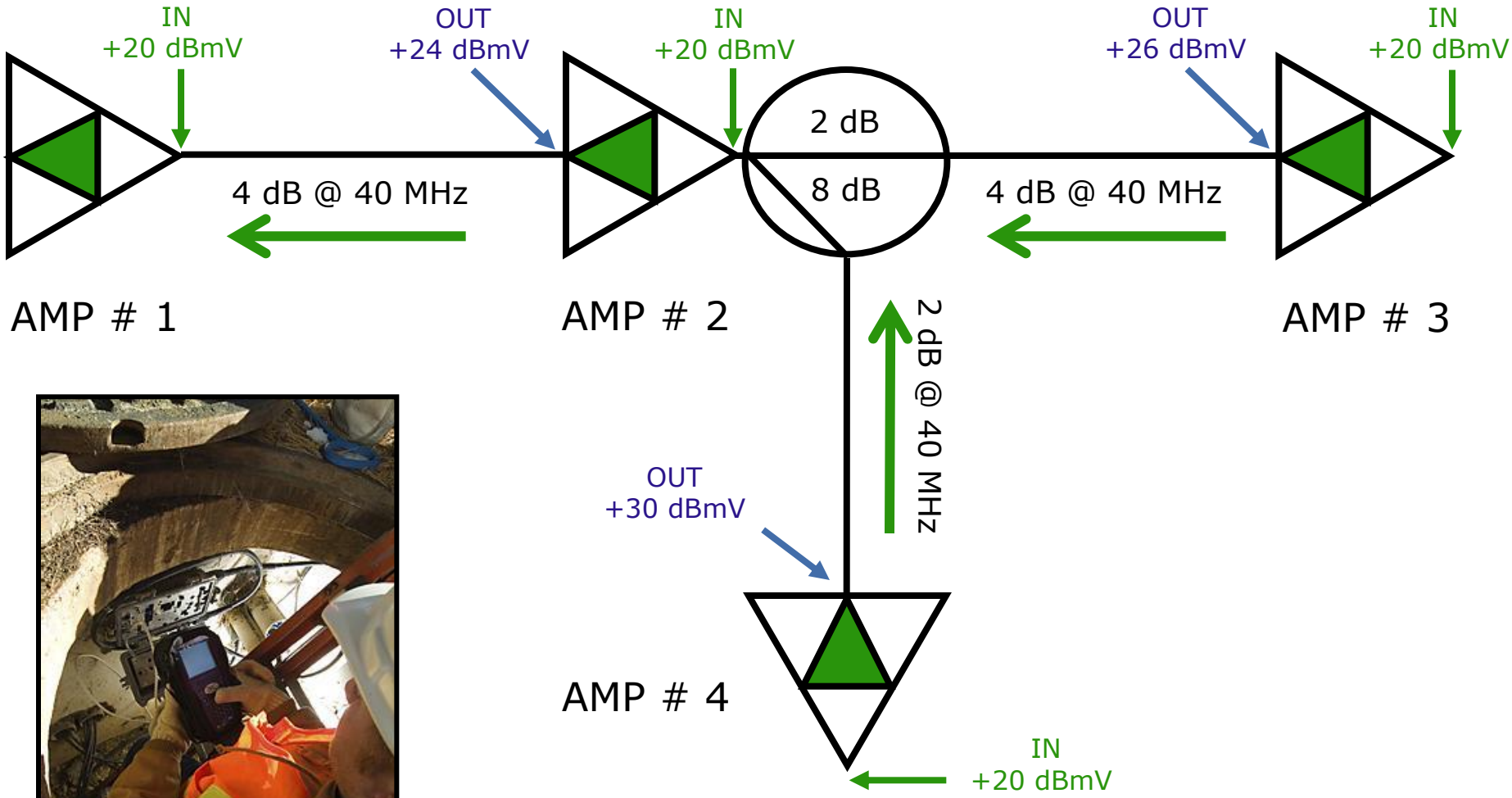




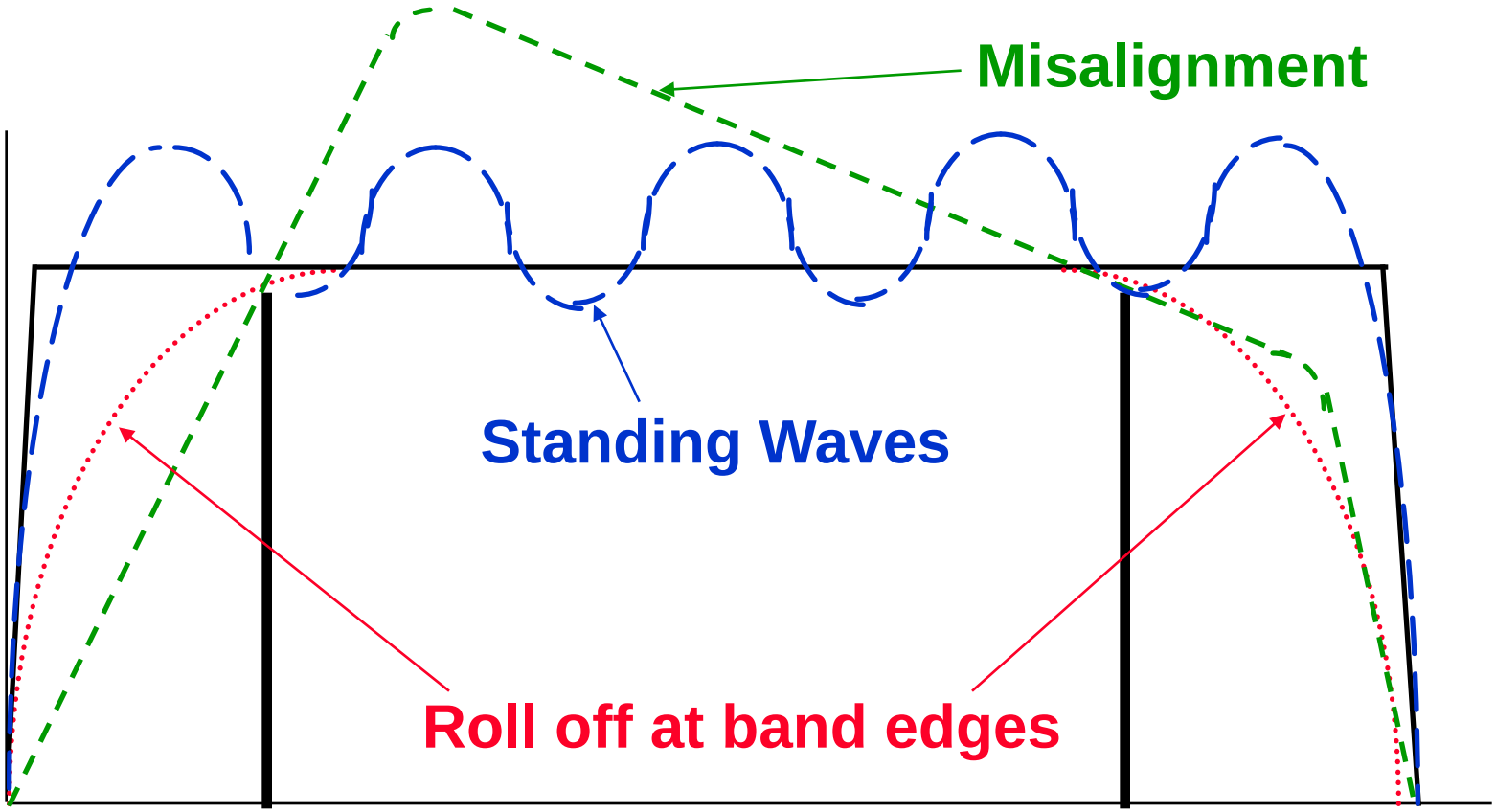
Forward Path Unity Gain



Return Path Unity Gain

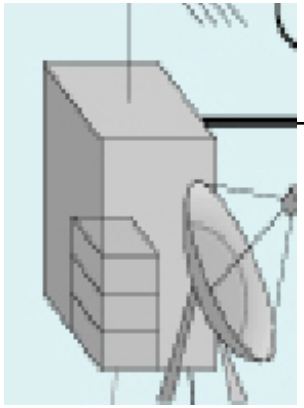


A Sweep Finds Problems That Signal Level Measurements Miss



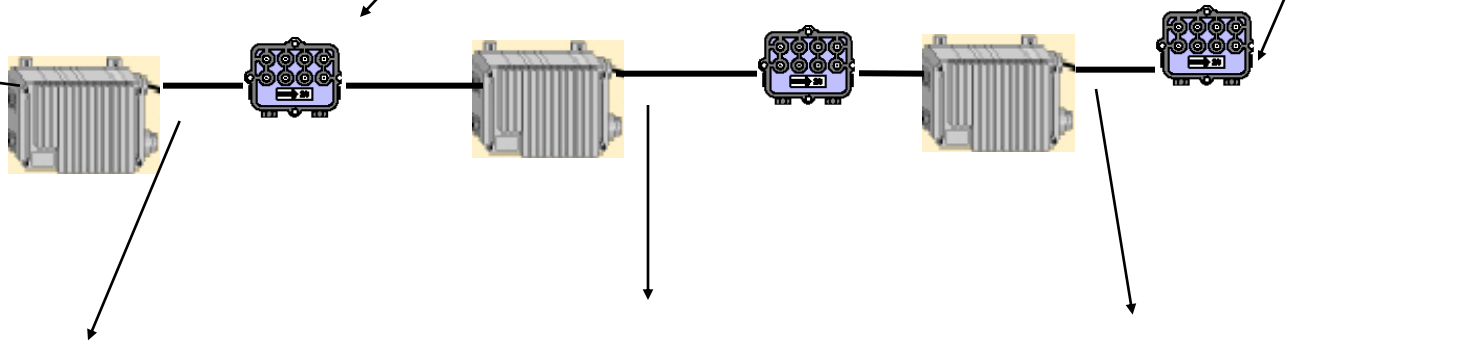
Balancing Amplifiers

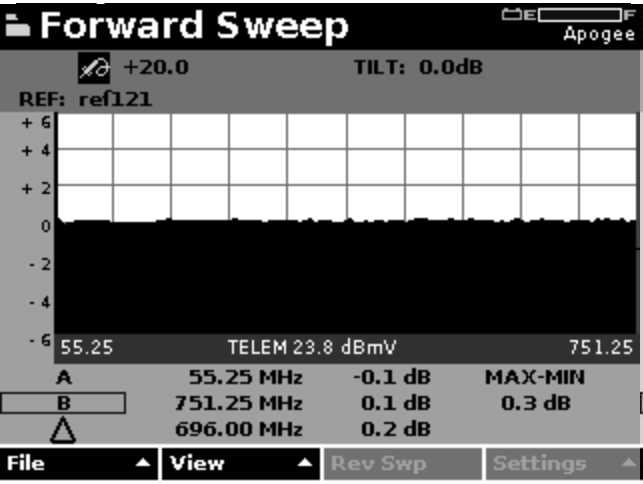
Balancing amplifiers using tilt

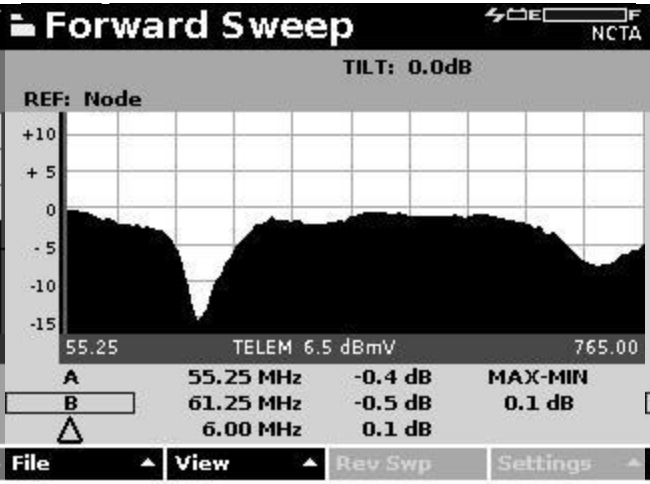


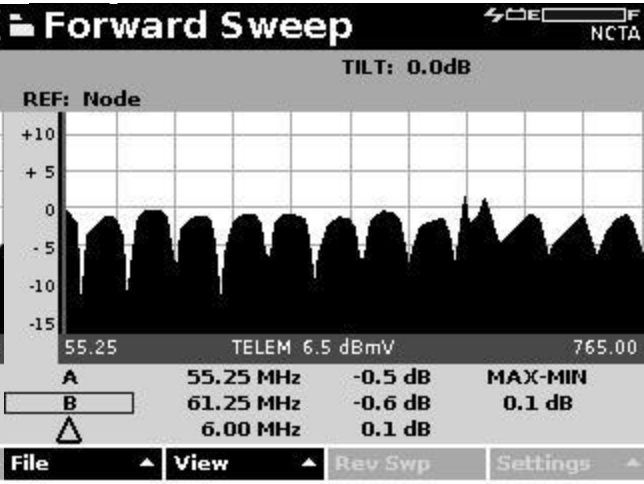
No Termination

Lose Face Plate, or crack cable shield









Node Reference Signal

Sweep response with a Resonant Frequency Absorption

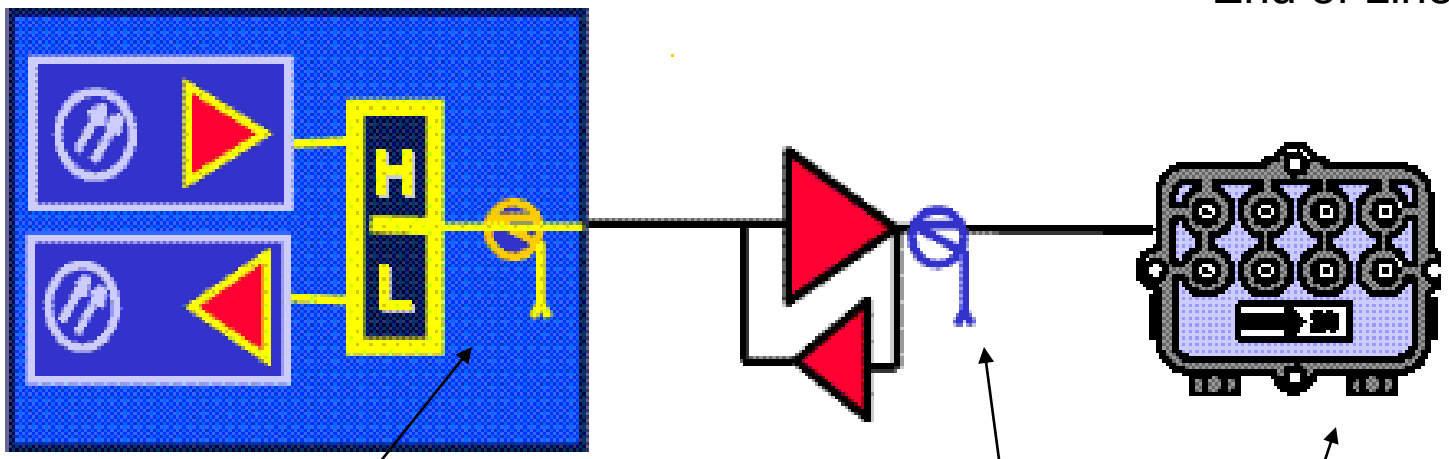
Sweep response with standing waves

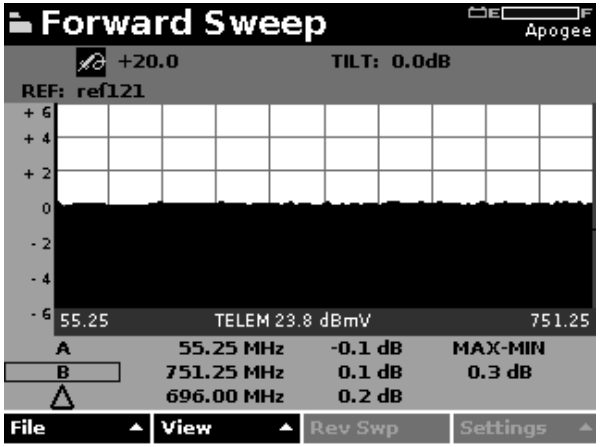
Typical Forward Sweep Response

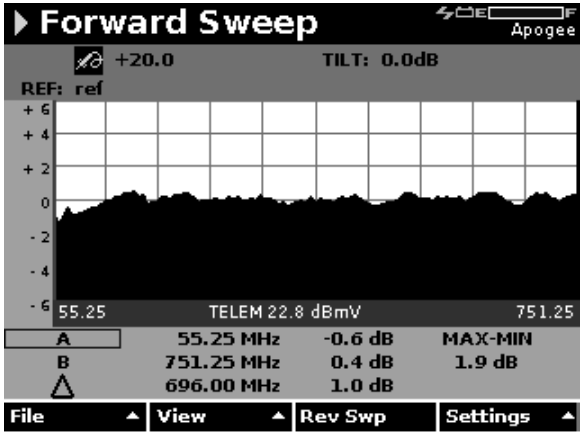
Fiber Node

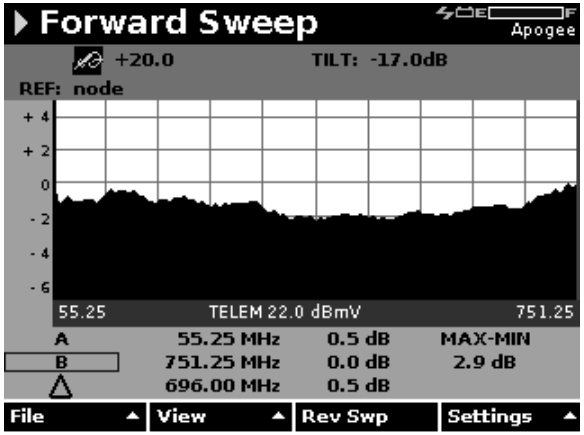
Line Extender

End of Line Tap









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 seizure screws, module hardware, …….

Customer Netoworks

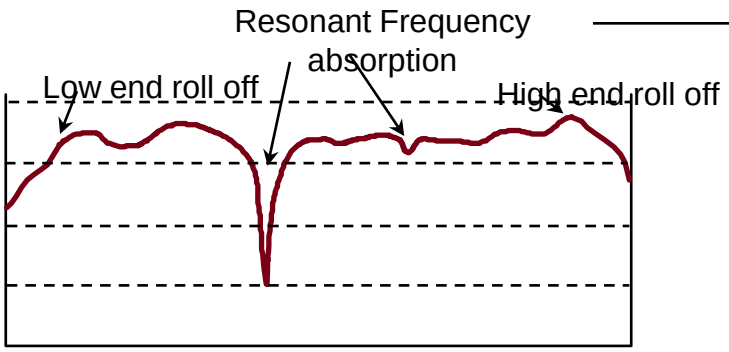
Validate tap performance

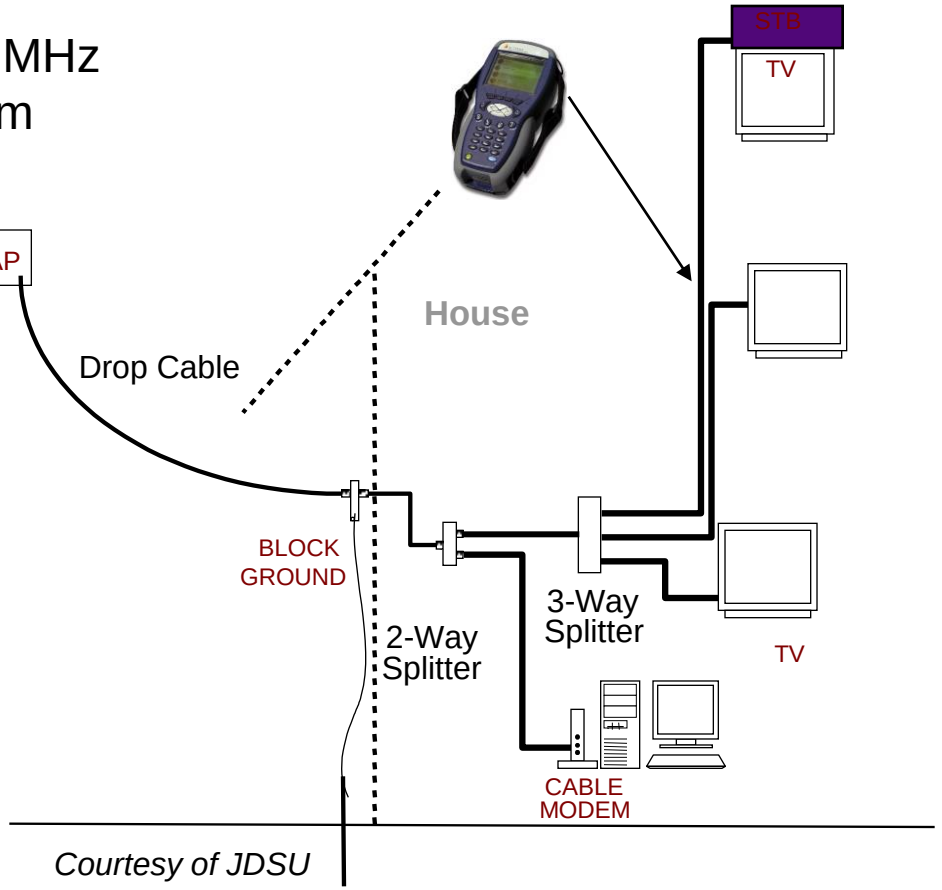
Power Levels must be maintained for high frequency losses

Min analog Video
Ch 2-78 15.6dBmv

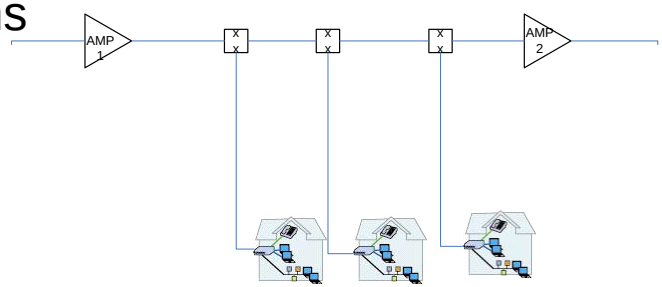
Min QAM
Ch 79-158 8.75 dBmV

1000 MHz system



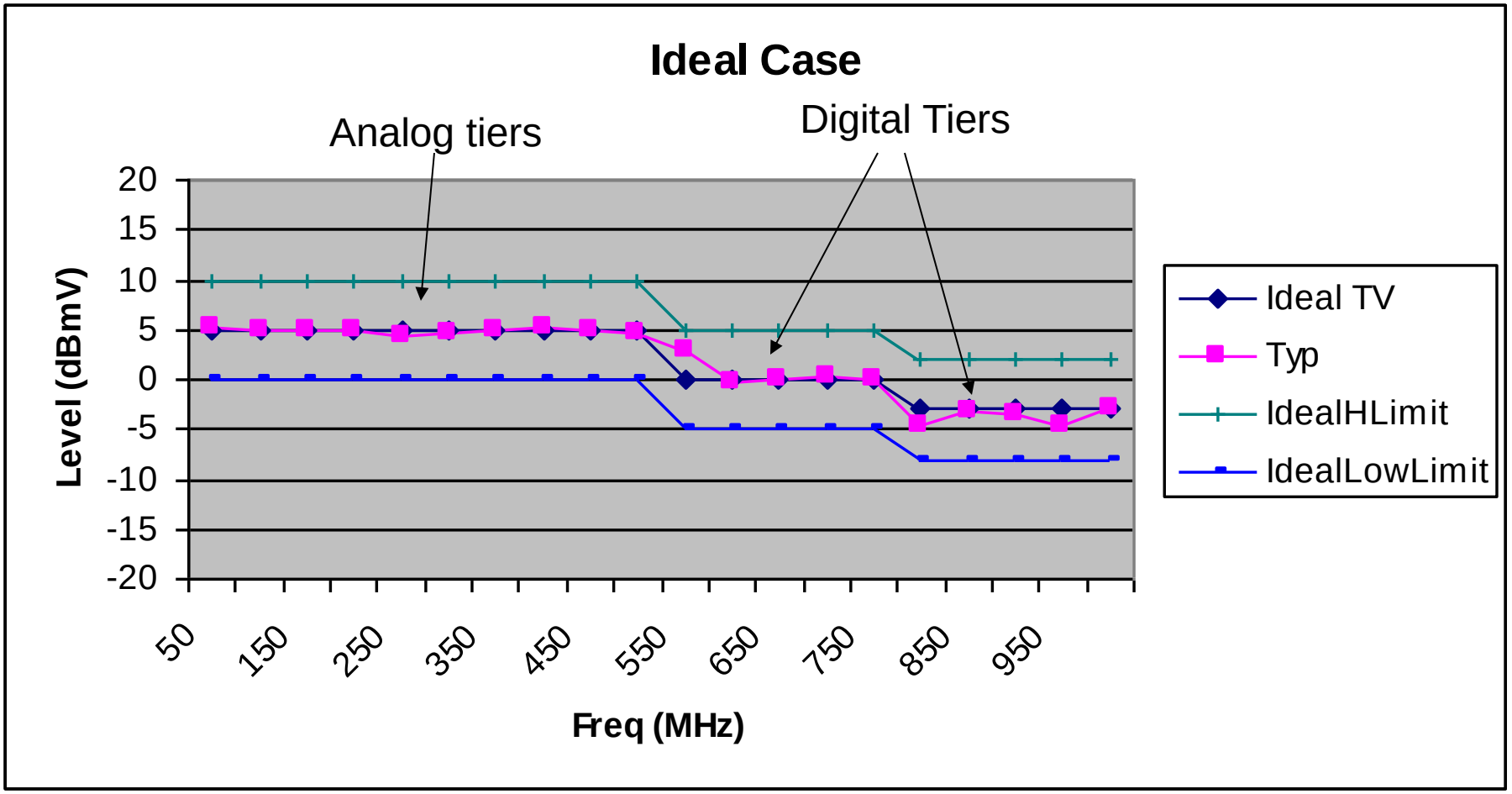


Mechanical issues cause customer problems

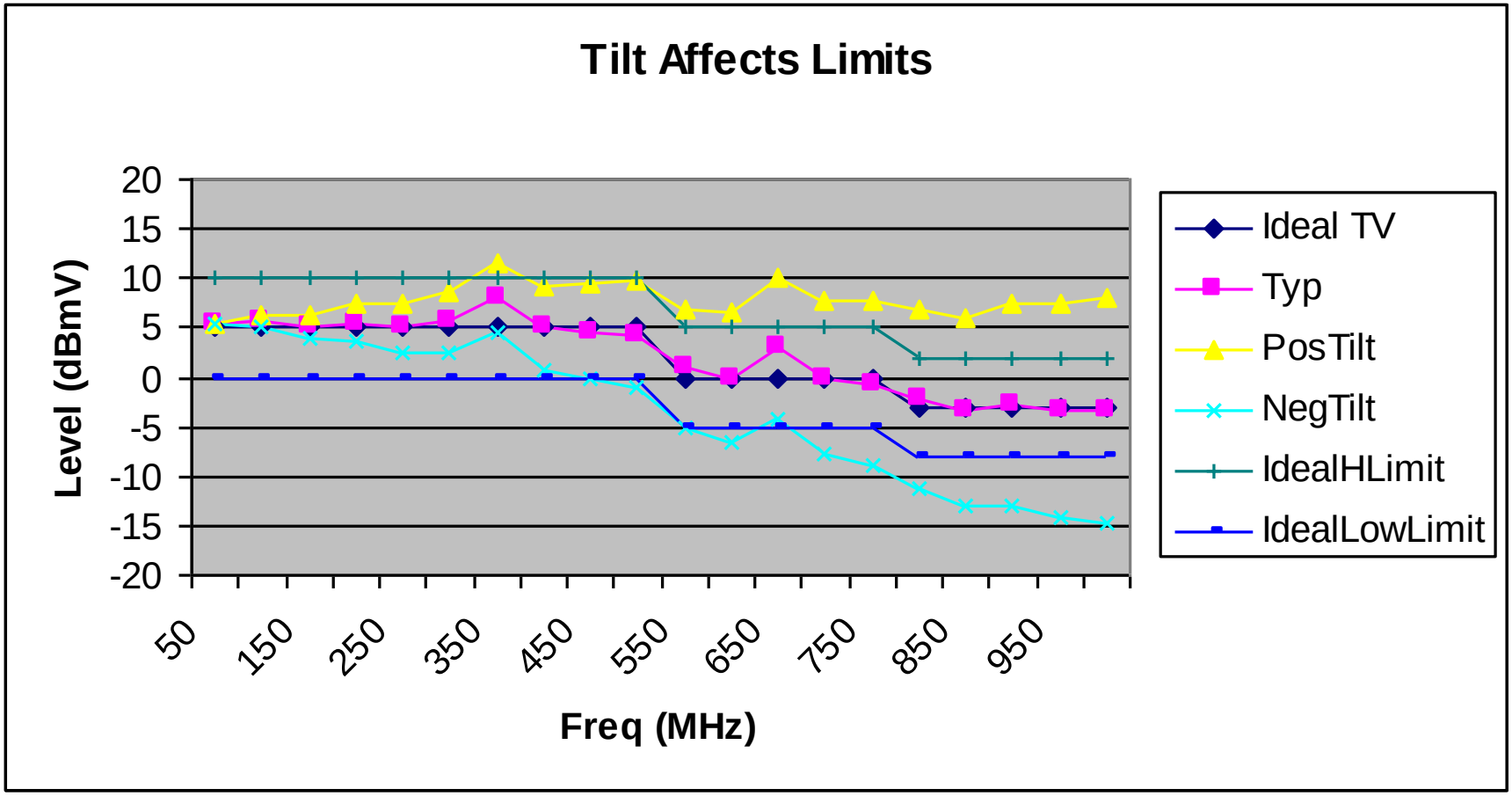


Tilt and power levels change from TAP to TAP

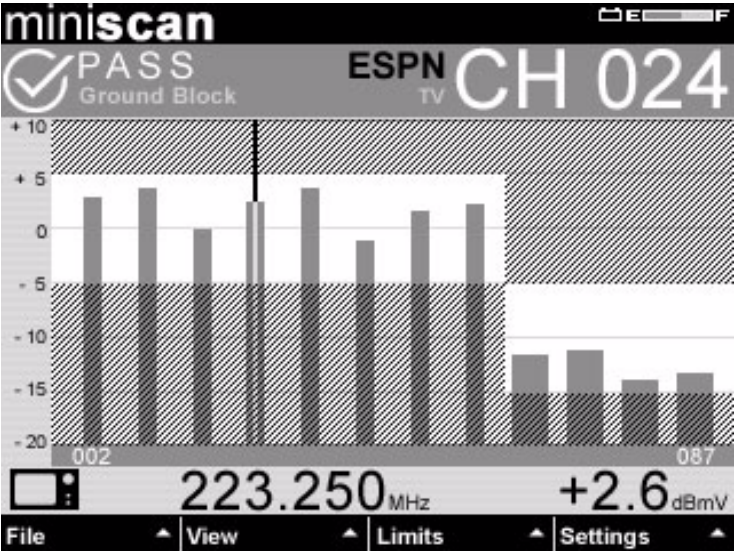
If systems were flat!
Tight limit bands would be a simple solution



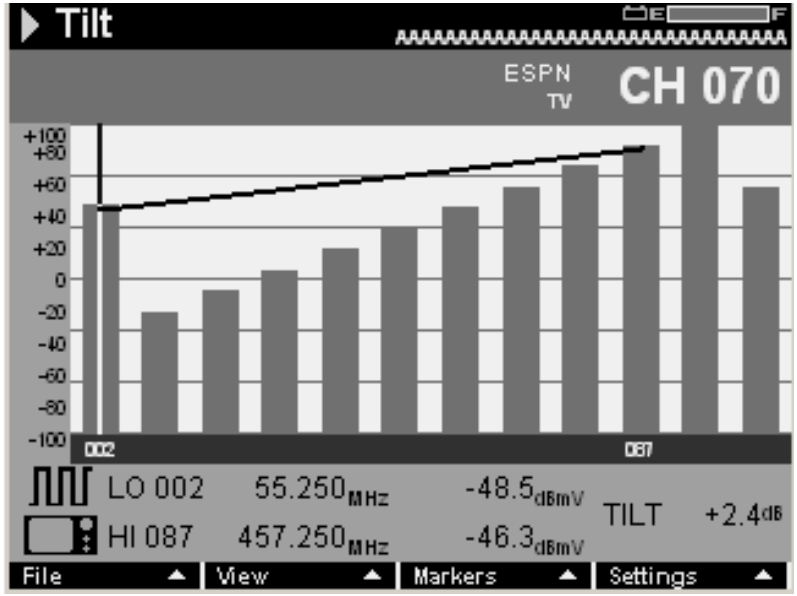
In real systems – tilt happens!

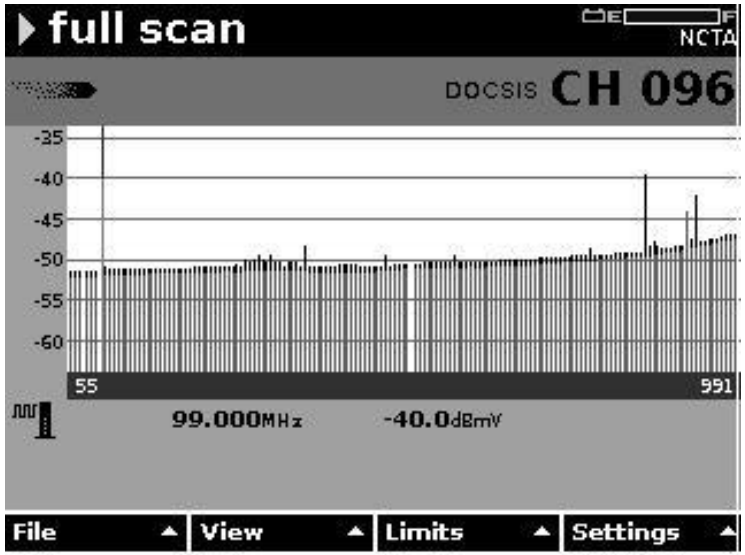


Miniscan and Tilt Views
Quick View of Channels with LIMITS



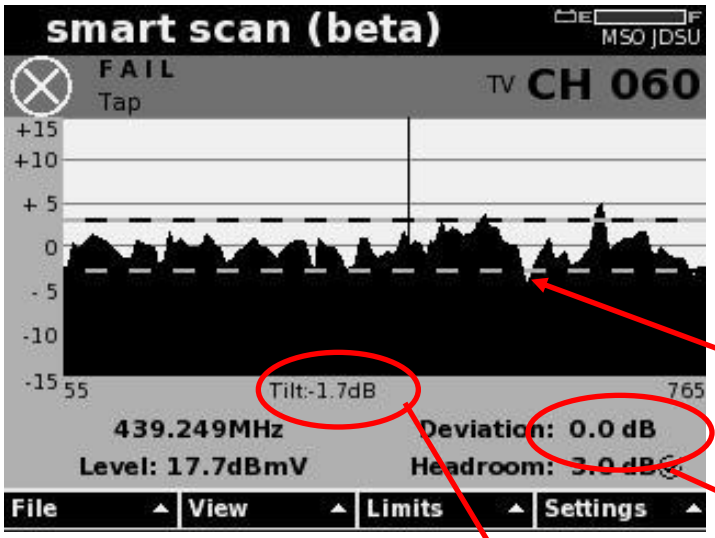
Mix all channels, analog and digital





Tilt enhances view for quick check of alignment

SmartScan™ - Finds RF problems at tap



Finds RF response issues that are out of spec

Compares against existing limit set plus peak to valley and max/min tilt

(the peak to valley limit is labeled drop check in the limit set during this beta version)

Automatically Tilt Compensates and Normalizes analog and digital measurements to identify Peak to Valley issues

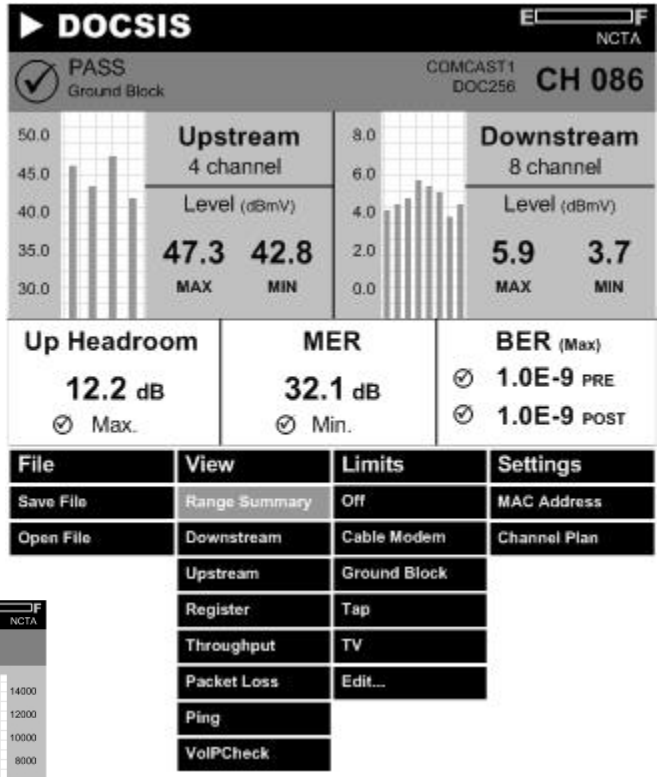
Identifies tilt level at tap

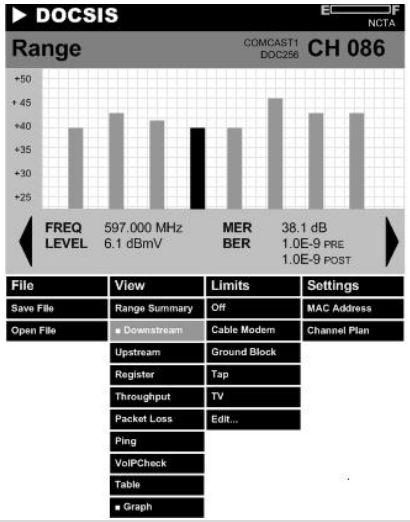
SmartScan will be optional upon final release

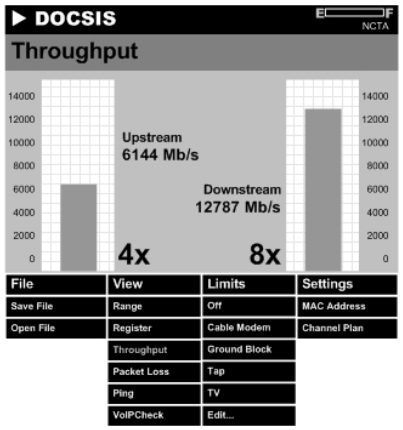
SmartScan Technology is Patent Pending

DSAM 3.0 Bonded Carrier testing – coming soon

- Keeping it simple for the technicians
- Validate overall performance
- Identifying individual US/DS channel issues

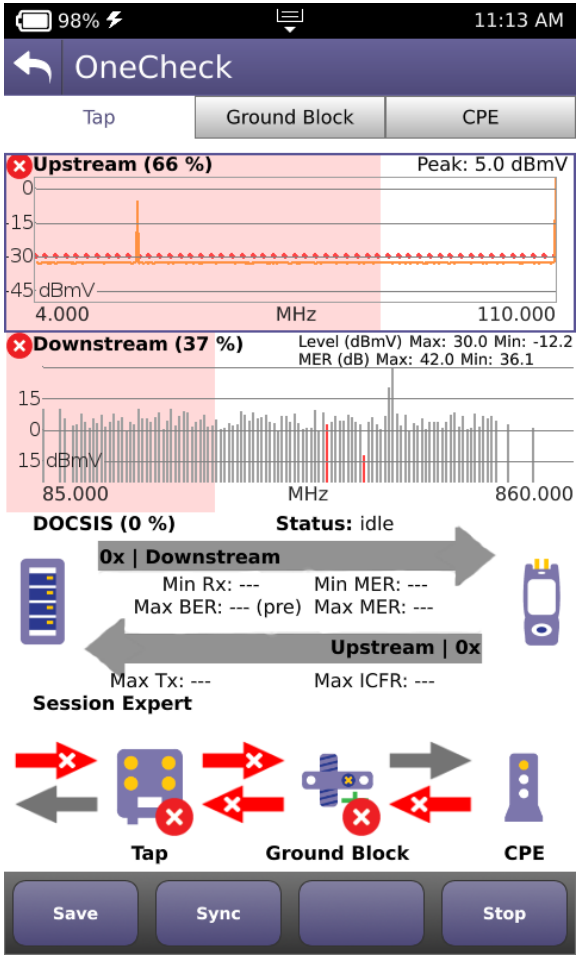






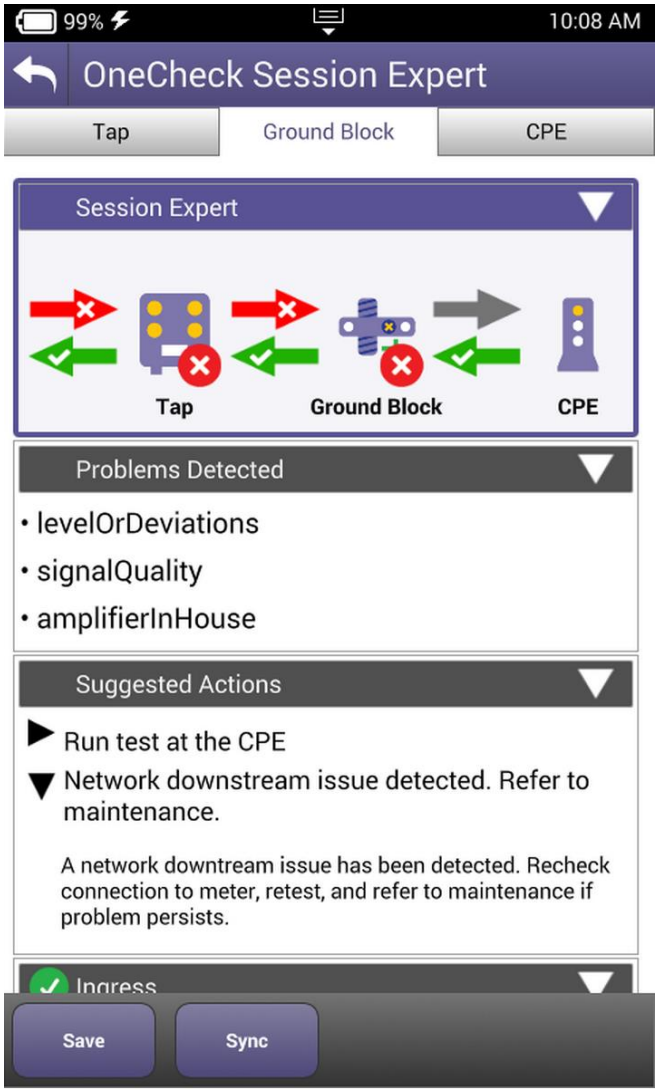
Complete RF and DOCSIS service testing made easier

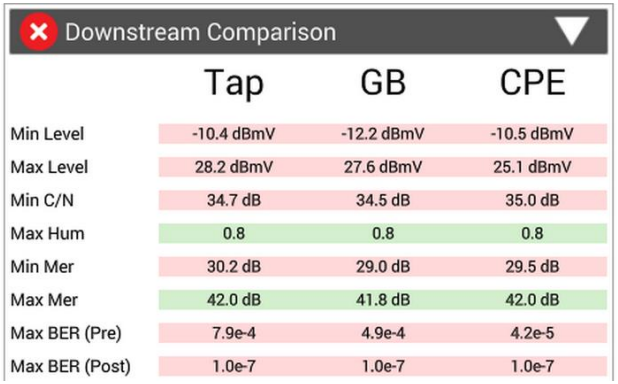
- **DOCSIS, Video and Ingress Scan made easier**
- **Validate faster & more efficiently**
  - Ultra-Fast testing of 136 channels in <30 seconds (including MER, BER, Level)
- **Ingress detection made easier**
  - 2nd port 4-110 MHz simultaneous ingress scan with connection detection™
  - Background scanning for Ingress in LTE bands or other off-air bands
- **Guided problem resolution**
  - Session Expert directs to suggested next actions based on measurements
  - Easily compare between the demarcation points



Complete RF and DOCSIS service testing made easier

- **Troubleshooting between demarcation points made easier**
- **Test Location aware helps guide technicians to problems**
- **Session awareness uses data at the demarcation points to suggest next actions**
- **Side by side comparison helps technicians prove they have fixed the problems**

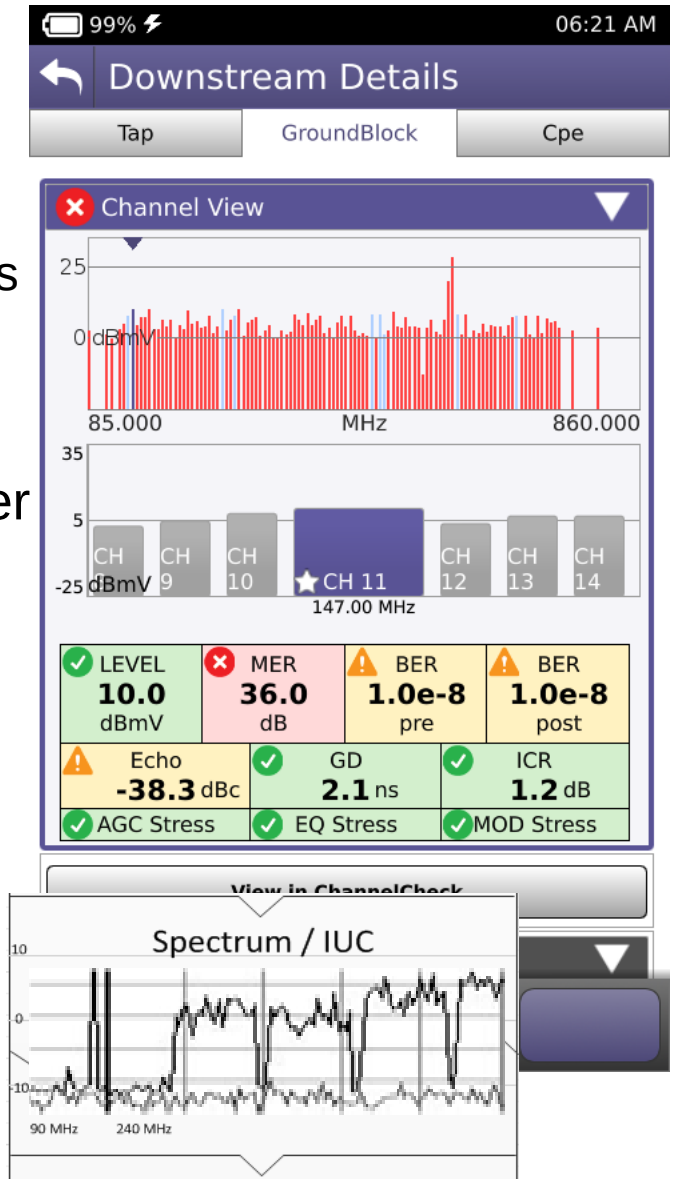




	Tap	GB	CPE
Min Level	-10.4 dBmV	-12.2 dBmV	-10.5 dBmV
Max Level	28.2 dBmV	27.6 dBmV	25.1 dBmV
Min C/N	34.7 dB	34.5 dB	35.0 dB
Max Hum	0.8	0.8	0.8
Min Mer	30.2 dB	29.0 dB	29.5 dB
Max Mer	42.0 dB	41.8 dB	42.0 dB
Max BER (Pre)	7.9e-4	4.9e-4	4.2e-5
Max BER (Post)	1.0e-7	1.0e-7	1.0e-7

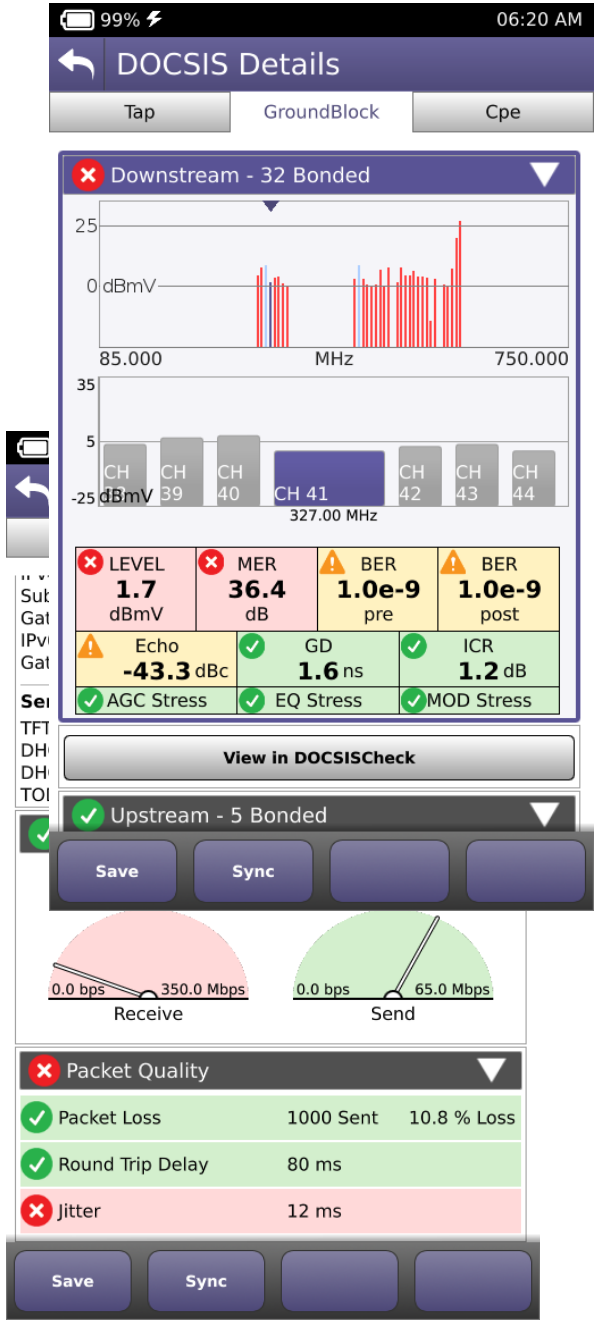
QAM testing made easier

- **QAM – testing made easier & faster**
  - Troubleshoot faster & more efficiently
    - Ultra-Fast testing of 136 channels in <30 seconds (MER, BER, Level)
- **Ingress detection**
  - Integrated in-channel Ingress Under the Carrier detects interferers
- **Easily find intermittent problems**
  - **Concurrent measurements**
  - **No need to guess which tool to use**
  - **ANY technician can identify problems**
  - DQI over
  - MER, BER over time



DOCSIS troubleshooting made easier

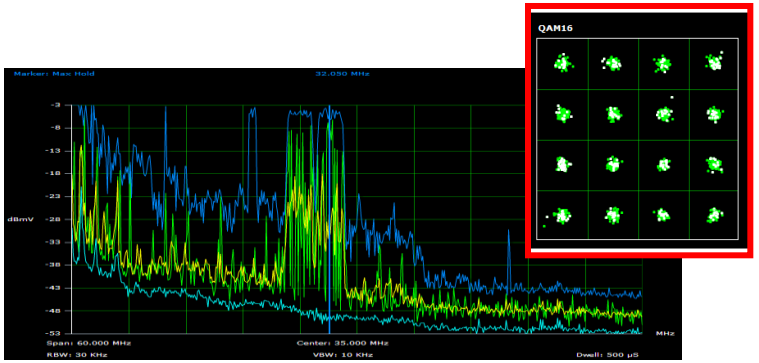
- **DOCSIS – testing made easier & faster**
  - Test and Bond up to 32 carriers simultaneously
  - Upstream testing and bonding of up to 8 carriers
- **Gigabit DOCSIS service testing**
  - Validate your premium service offerings with **32x8** Throughput and Packet Quality
- **Identify and resolve Physical Layer issues**
  - **Simultaneous testing of Phy layer and Service layer identifies carrier and noise problems**
  - DQI over time
  - MER, BER over time
  - LTE & Off Air Ingress

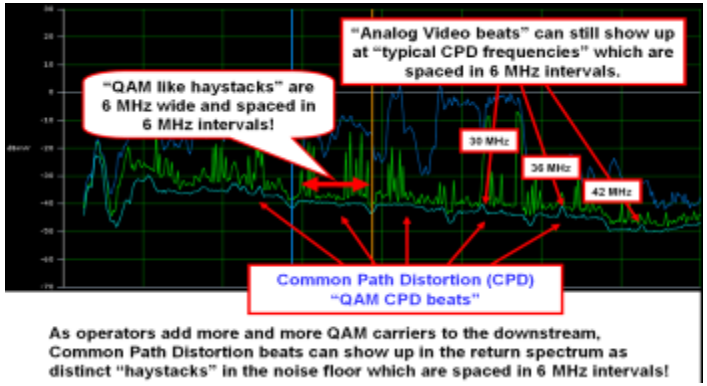


Ingress and Egress

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

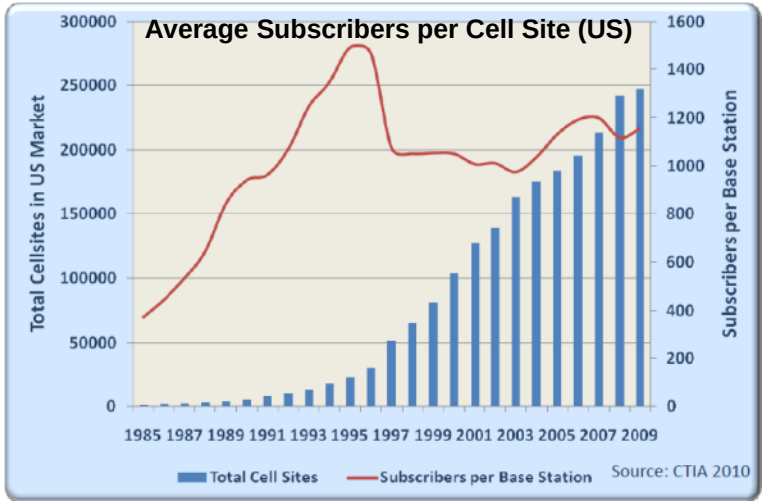




Mobile Networks are Strained

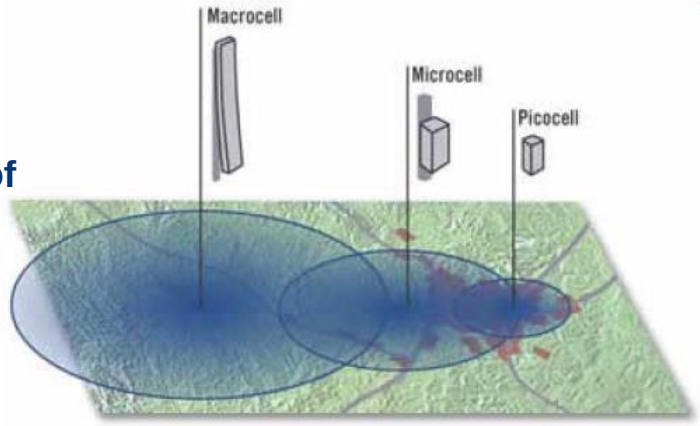
More Cells Required

- For example: a 700 MHz LTE network with 10 MHz, provides 15 Mbps of sector throughput .
- In the US alone there could be on average 1000 subscribers site, or 333 per sector.
- **Each subscriber will be sharing 15 Mbps!**



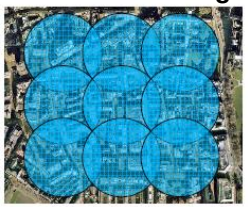
Too many users are simultaneously using the same capacity

- **LTE/4G build out requires an order of magnitude more cell sites.**



Macrocell Coverage

Microcell Coverage



More Cells & Antennas Required to Reduce Subscriber Density

Massive Antenna Expansion Required

- Macrocell expansion alone is not practical
  - An Order of Magnitude Increase Needed
  - Costly
  - Energy hungry
  - Unsightly: Not In My Backyard

- Compact Radio Heads
  - Affordably enable an order of magnitude more antennas
  - Lower power, closer to subscribers
  - Reduce deployment costs, improve user experience

Source: Alcatel-Lucent

New Remote Radio Backhaul Strategies are Required

LTE Uplink and frequency ranges

The frequency ranges used for LTE downlink in various regions around the world are shown in the table below.

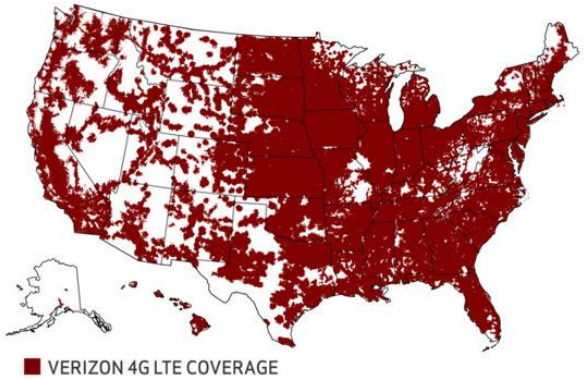
Region	Operator	DL Start, MHz	DL End, MHz	CATV Channels Affected
US	Verizon	746.000	756.000	Ch. 116, 117
US	AT&T	734.000	744.000[1]	Ch. 114, 115
US	Unallocated "D Block"	758.000	768.000	Ch. 118, 119
US	Sprint Nextel	859.000	894.000	Ch. 135-140
Japan	KDDI	860.000	875.000	Ch. 78-80
Japan	NTT DOCOMO	875.000	900.000	Ch. 80-84
EU	Various	791.000	821.000	U61-U64[2]
EU/LA	Various	925.000	960.000	U77-U82
LA, Israel, South Korea	Various	869.000	894.000	Ch. 136-140

Frequency range used for LTE Uplinks

Region	Operator	UL Start, MHz	UL End, MHz	CATV Channels Affected
US	Verizon	777.000	787.000	Ch. 121-123
US	AT&T	704.000	716.000	Ch. 109-111
US	Unallocated "D Block"	788.000	798.000	Ch. 123, 124
US	Sprint Nextel	814.000	849.000	Ch. 127-133
Japan	KDDI	815.000	830.000	Ch. 70-72
Japan	NTT DOCOMO	830.000	845.000	Ch. 73-75
EU	Various	832.000	862.000	U66-U69
EU/LA	Various	880.000	915.000	U72-76
LA, Israel, South Korea	Various	824.000	849.000	Ch. 129-133

QAM Egress Option Market Drivers

- LTE interference to cell service providers and to cable customers
  - Fear of FCC fines/regulation
  - Potential loss of bandwidth
  - Churn from dissatisfied customers (strong competitive environment)



- Competition – optimum reliability/performance
  - Leakage in UHF band tightly linked to plant integrity
  - Signals higher due to system tilt
  - Leak characteristics match test wavelength

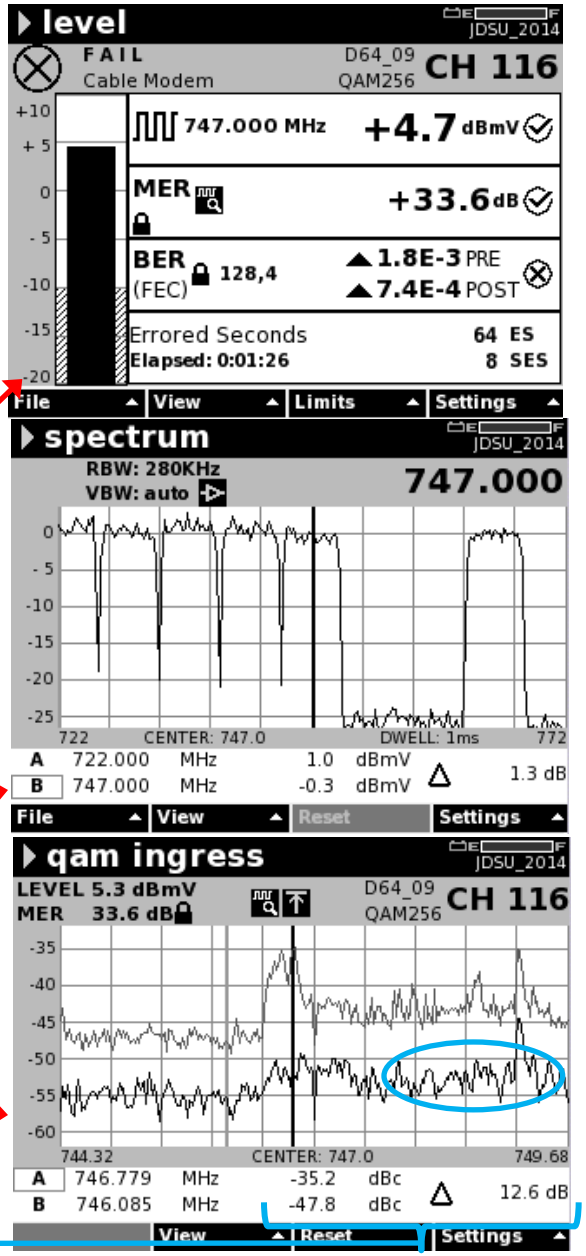
Best Practices (considering LTE presence)

- Optimize signal levels to networked devices
- Use components with good shielding integrity
- Follow proper procedures for good craftsmanship and tightening
- Avoid locating CPE devices close to uplink devices
  - Femtocells, MiFi wireless repeaters
  - Power-down these devices as troubleshooting step
- Tech, put cell phone in “airplane” mode while testing/troubleshooting
  - Transmit power ~2.2V/m at 3 feet (worst case)
    - 3V/m is target RF immunity of CPE
    - (UHF Signal Leakage and Ingress, Hranac, R., Segura, N., 2013)

Finding service-affecting LTE Ingress

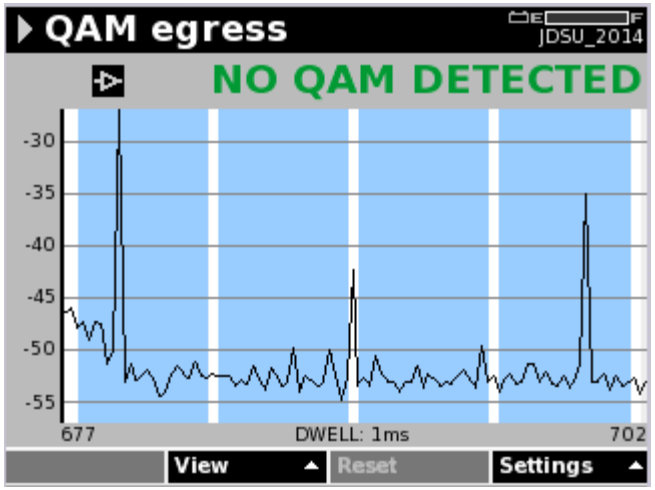
Plant faults allow LTE signals to enter network and impact subscriber services

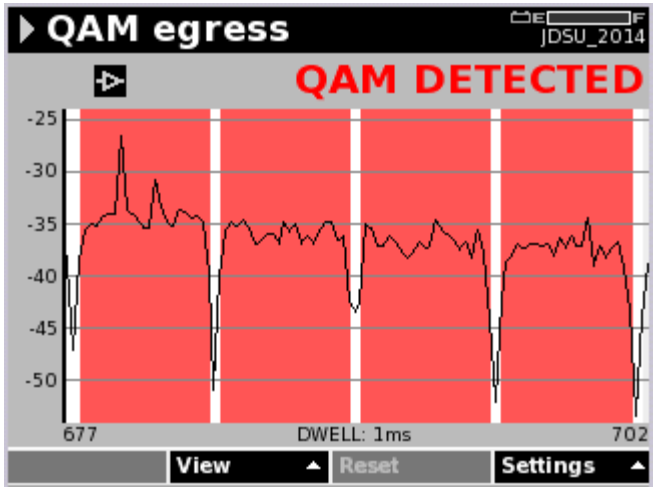
- Strong LTE ingress causes MER and BER degradation
  - Video: freezing, tiling, and pixelating
  - HSD and VoIP: Slow surfing or lost connection
- LTE signals may not be visible using traditional spectrum views
- QAM Ingress can see below active carrier to find LTE interference



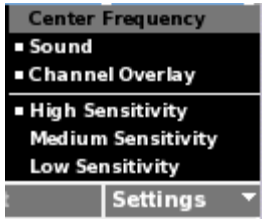
LTE carrier below live QAM carrier

QAM Egress Test Option – Screens





- Uses active channel plan to identify QAM channels in spectrum
- Blue regions mark QAM signal boundaries in active channel plan when QAM signature is not currently detected
- The mode allows users to adjust :



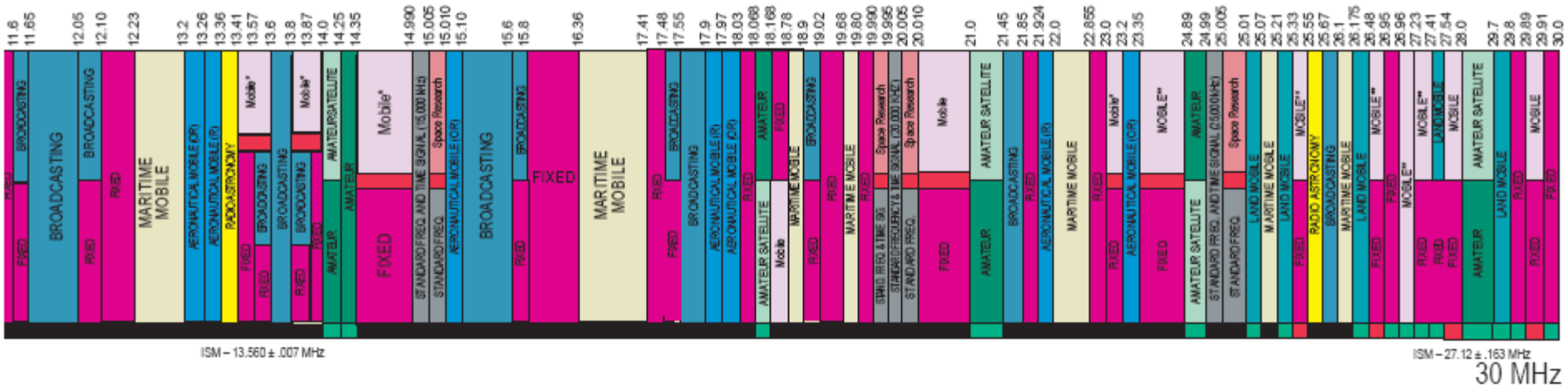
  - Center frequency
  - QAM signature detection beep (on/off)
  - Active channel plan overlay (on/off)
  - Adjustable QAM detection sensitivity (Low, Med, High)

- When blue channel highlights turn RED, QAM signature detected based on selected threshold

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**

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.

There are Many Possible Sources of Interference

Off-Air Broadcast

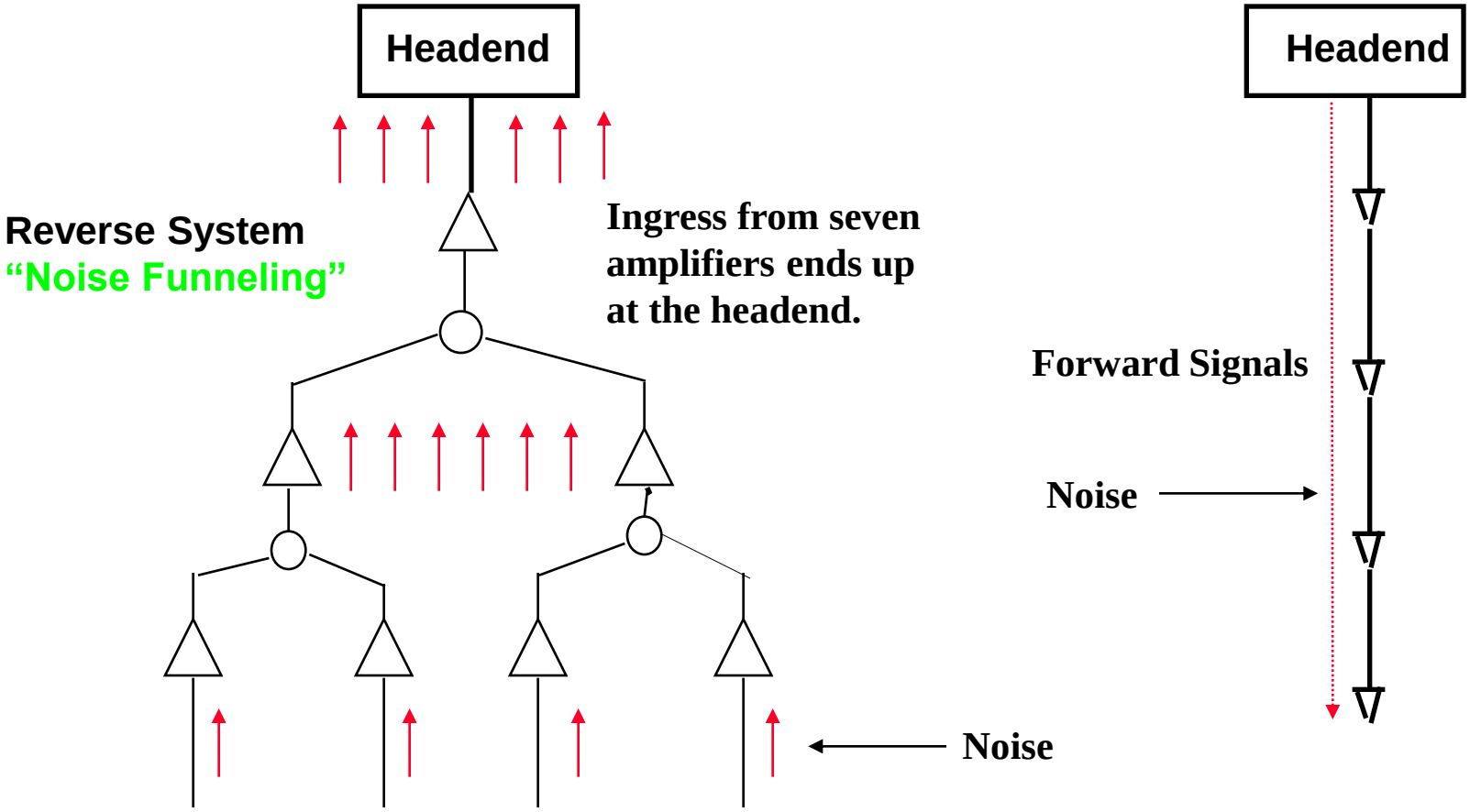
- AM Radio Station
- FM Radio Station
- TV Station
- Two-way Radio Transmitters
- Citizens Band (CB)
- Amateur (Ham)
- Taxi
- Police
- Business
- Airport/Aircraft
- Paging Transmitters

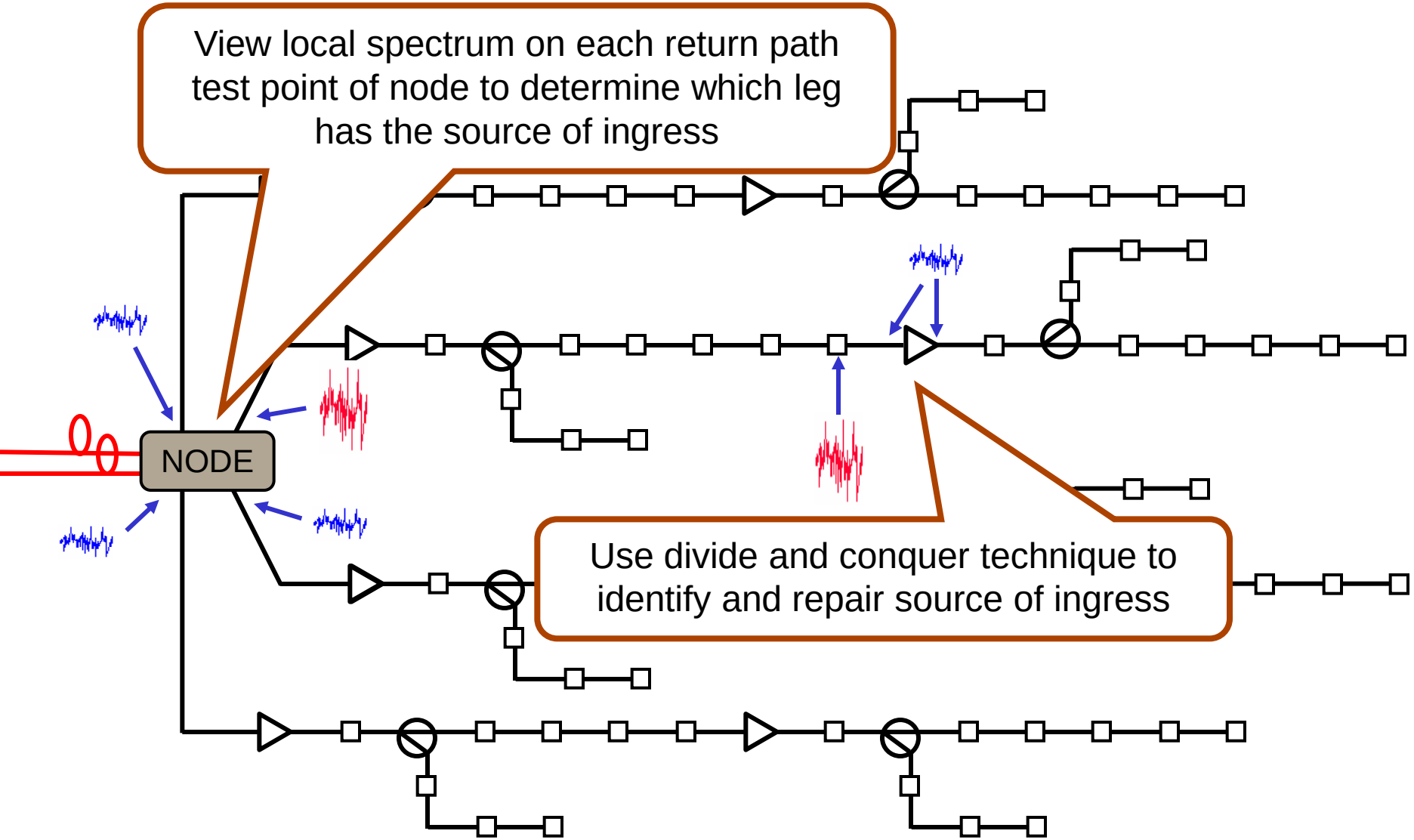
FEDERAL
COMMUNICATIONS
COMMISSION

Electrical Devices

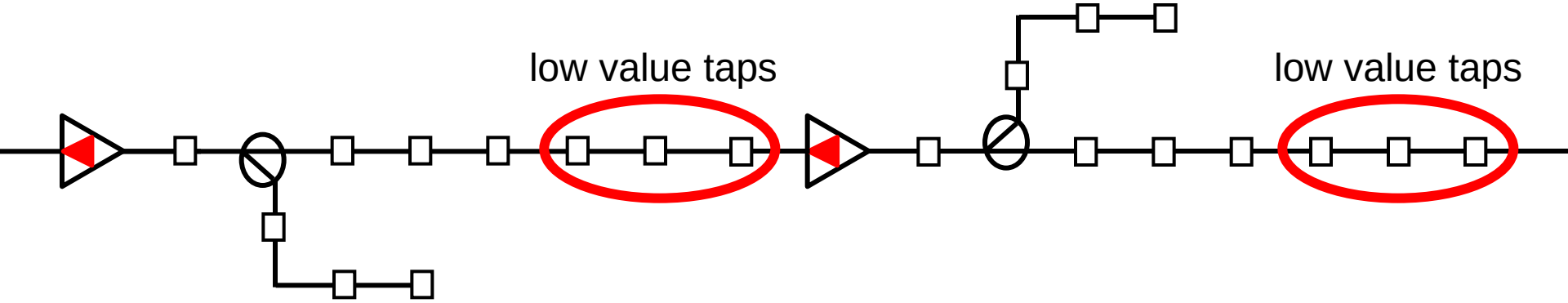
- Doorbell transformers
- Toaster Ovens
- Electric Blankets
- Ultrasonic pest controls (bug zappers)
- Fans
- Refrigerators
- Heating pads
- Light dimmers
- Touch controlled lamps
- Fluorescent lights
- Aquarium or waterbed heaters
- Furnace controls
- Computers and video games
- Neon signs
- Power company 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

Downstream and Upstream Noise Additions





Typical Problem Areas

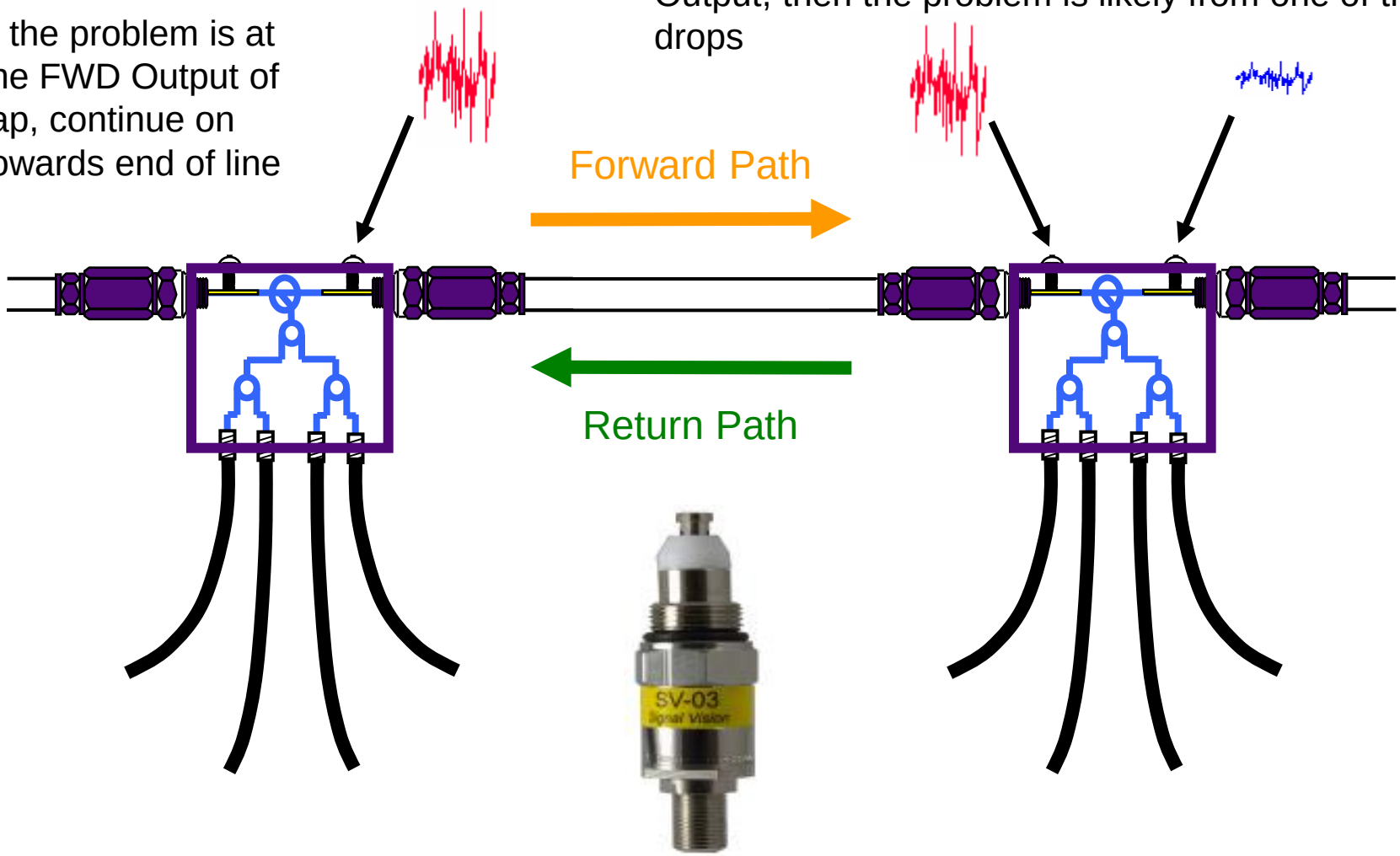


- **Taps**
  - Most ingress comes from houses off of with low value taps of approximately 17 dB or less
- **Home Wiring**
  - Drop Cable, splitters & F Connectors are approximately ~95% of Problem
- **Amplifiers, hard line cable** and the rest of the system are a small percentage of the problem if a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

Taps - Probe the Seizure Screws for Ingress & CPD

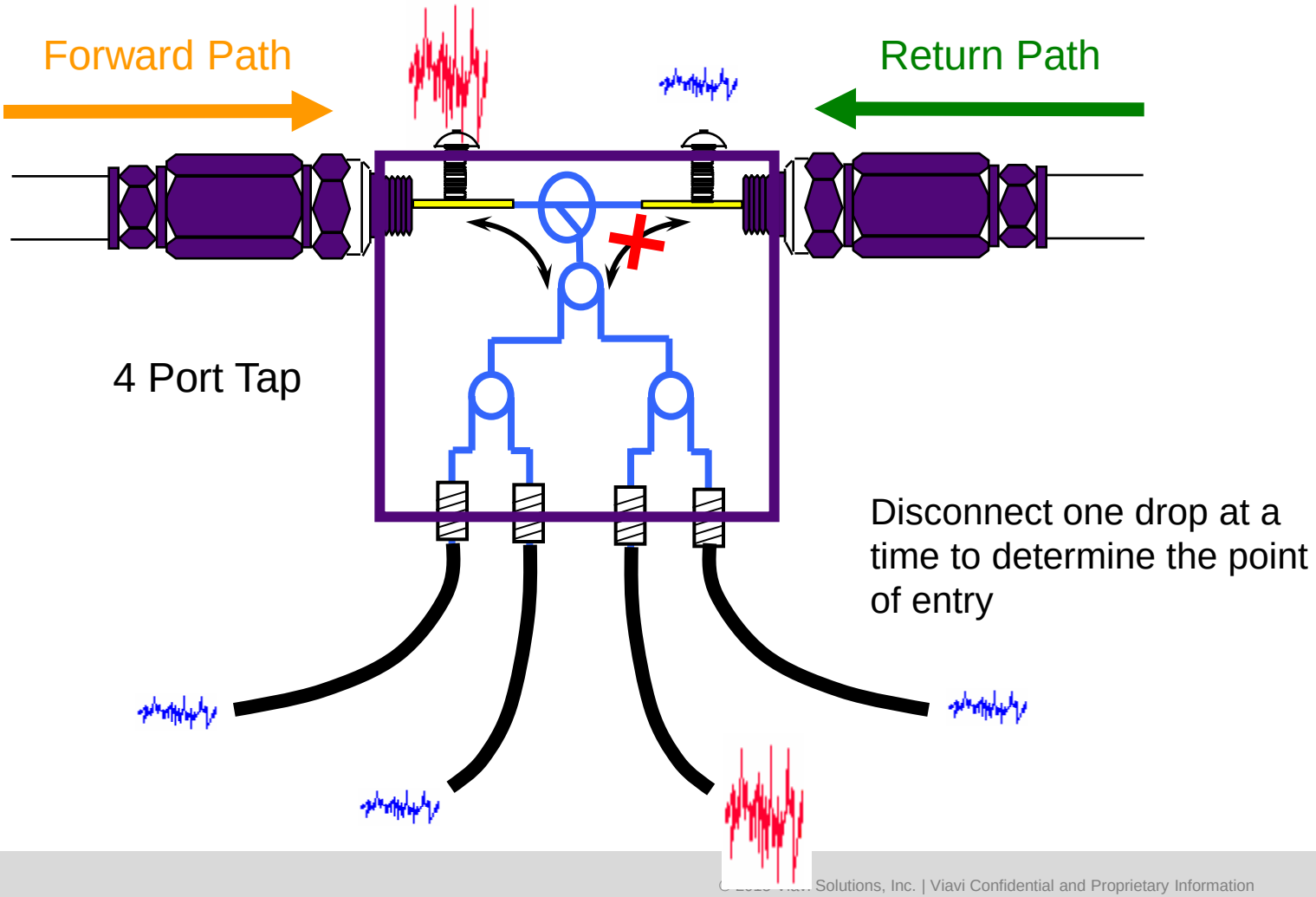
If the problem is at the FWD Output of tap, continue on towards end of line

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

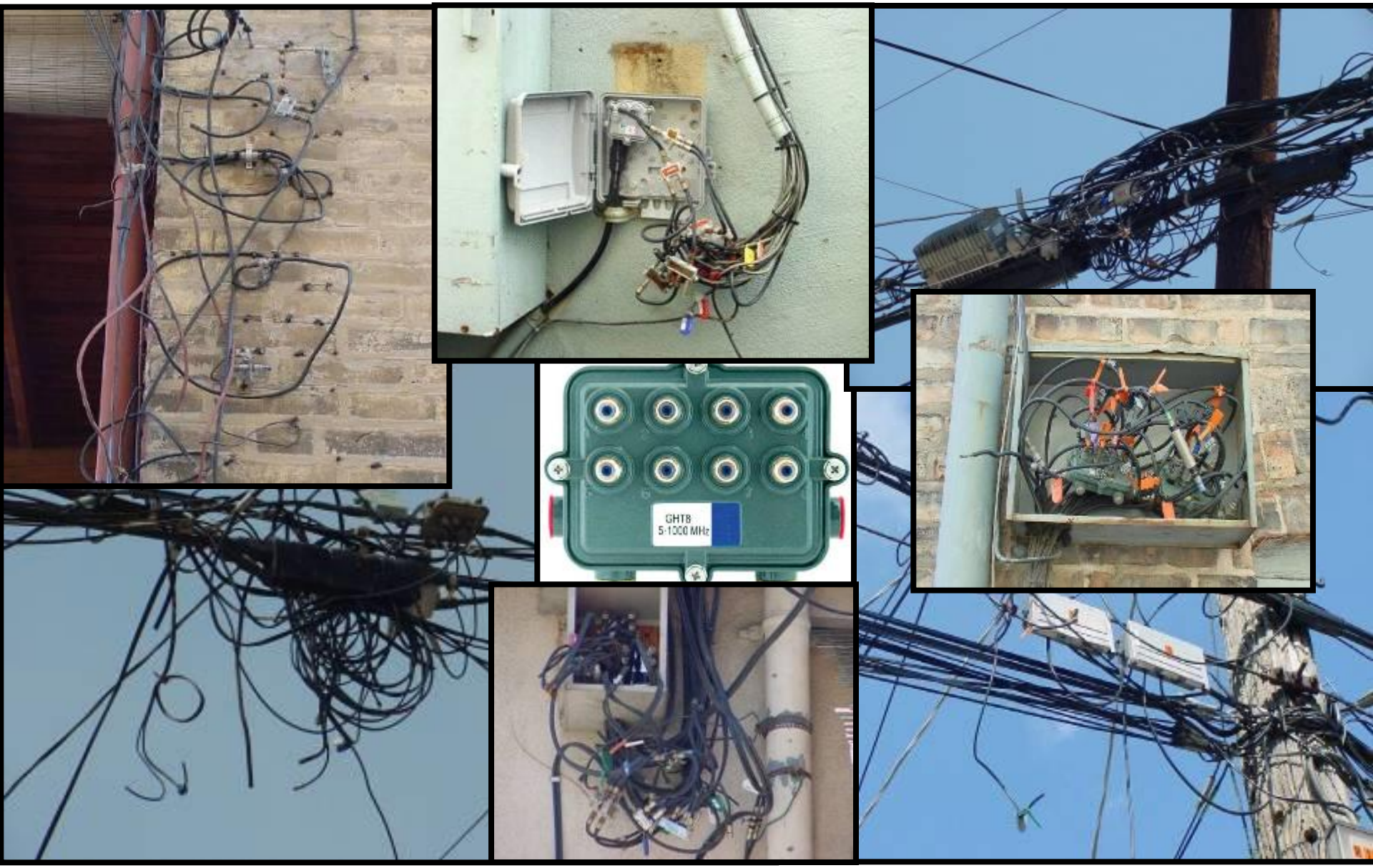


Taps are made up of a Directional Coupler and Splitters

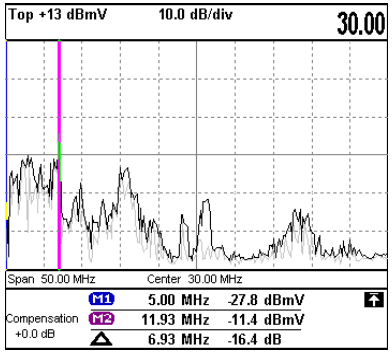
- If the problem is at the Forward Input and not the Forward Output, then the problem is from one of the drops

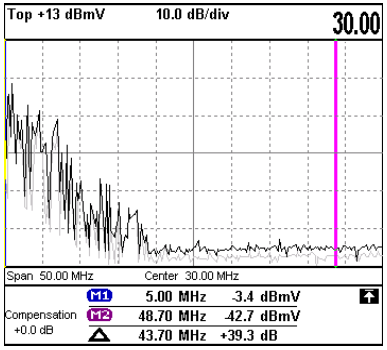


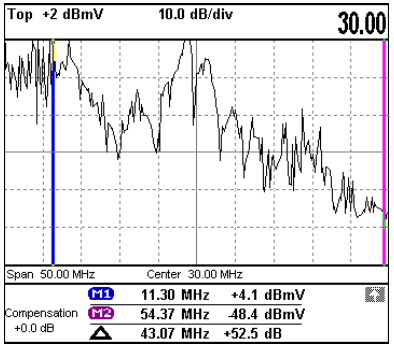
Common problems in HFC Networks

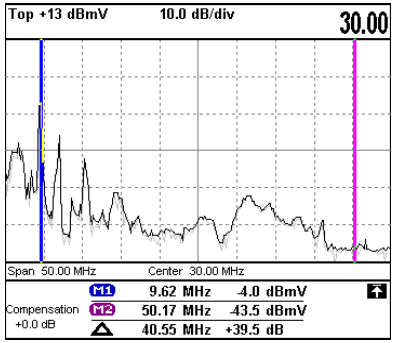


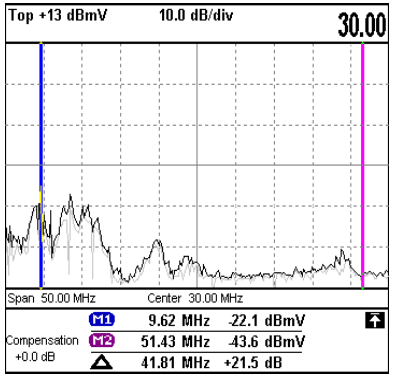
Local Drop Reverse Spectrum Samples

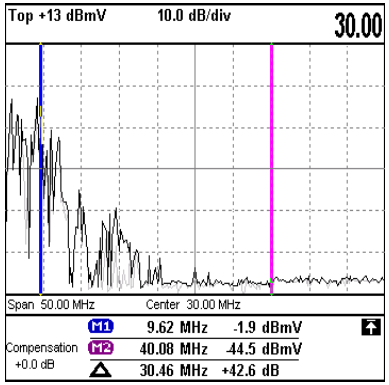


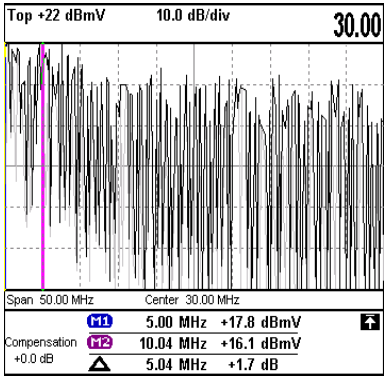


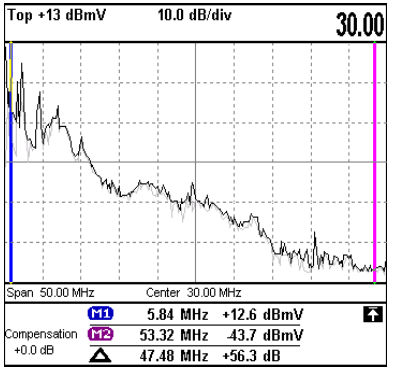


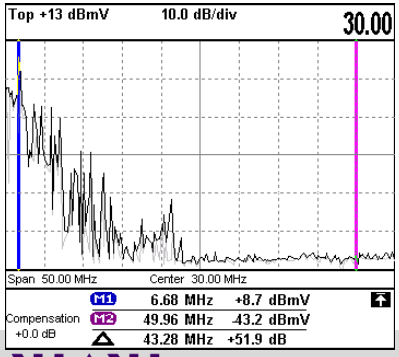


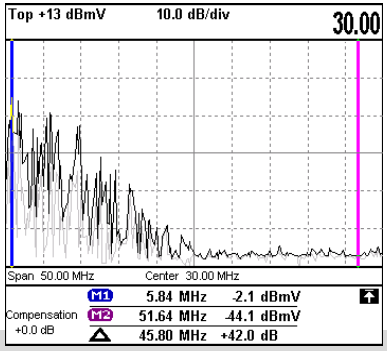


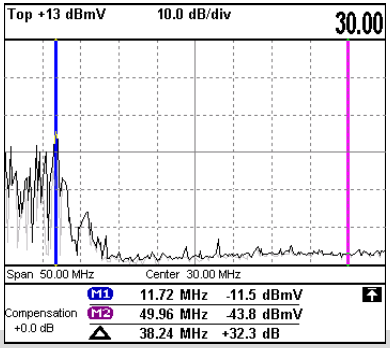


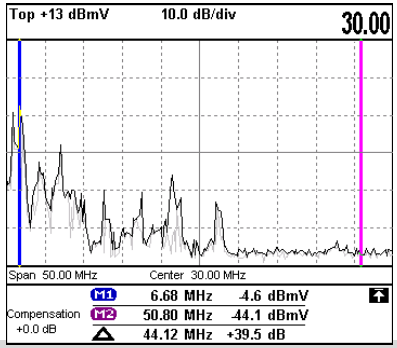






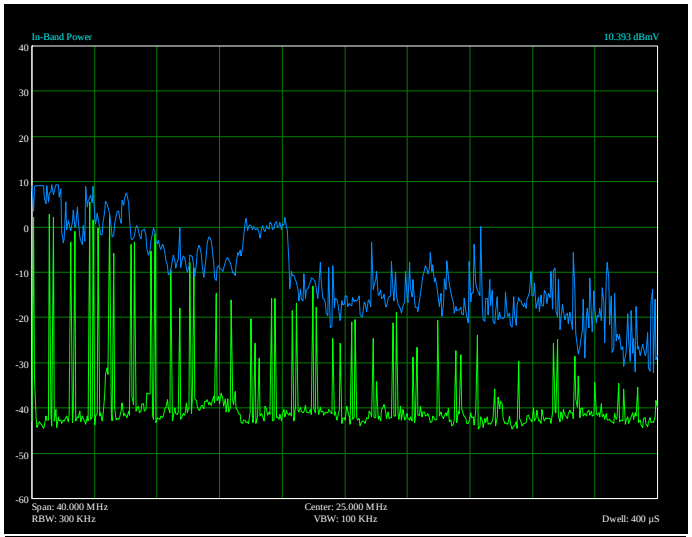


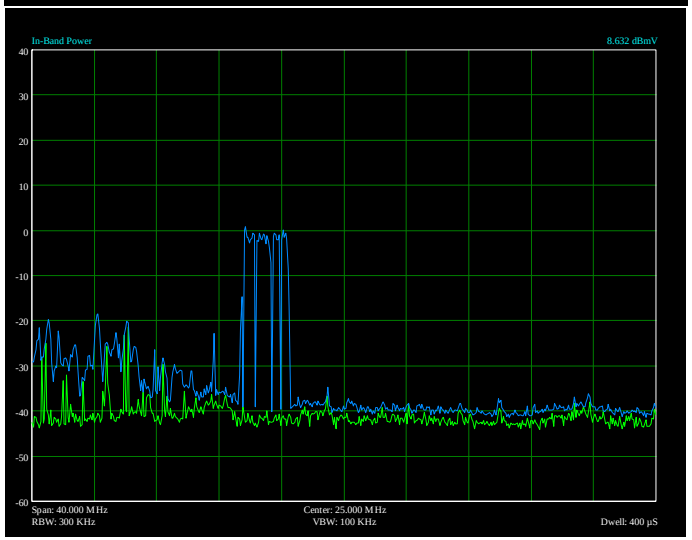


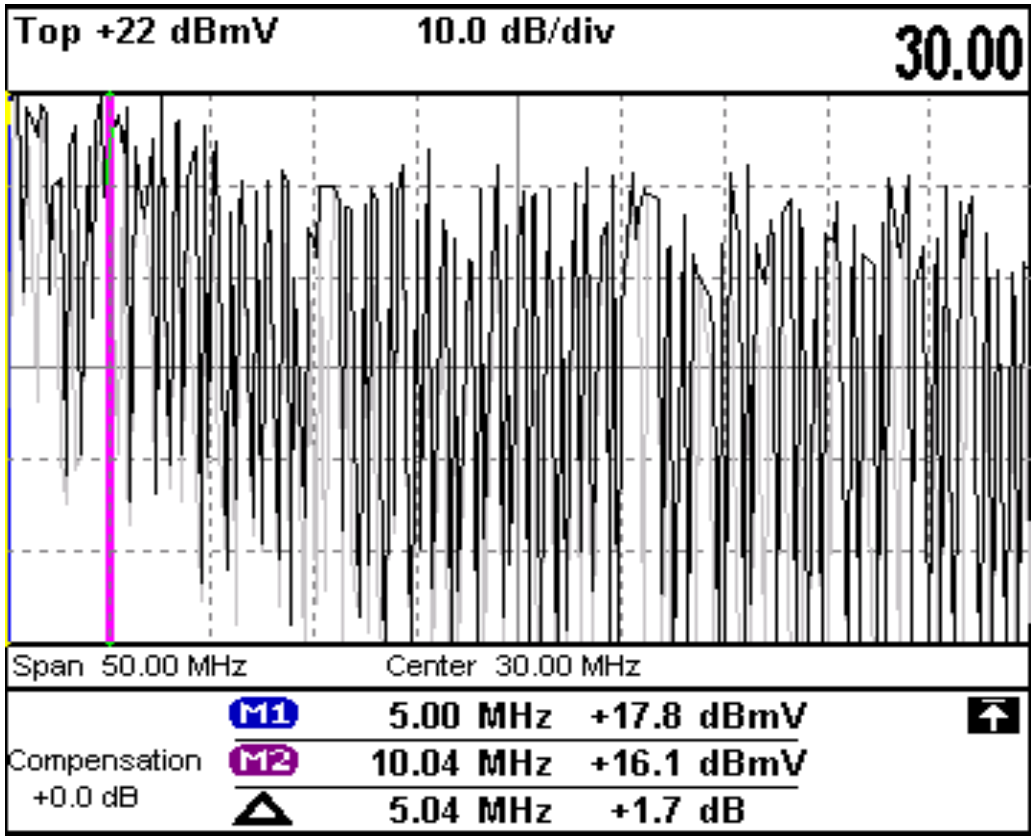


- **The subscriber drop remains the weakest link in the cable network**
- **Seven out of ten service calls are generated by problems at the drop**
- **Ingress caused in the home wreaks havoc on the reverse path**
  - **Must be found in the home before connecting to network when possible**
  - **Must 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.**

Electrical Impulse Noise from One House

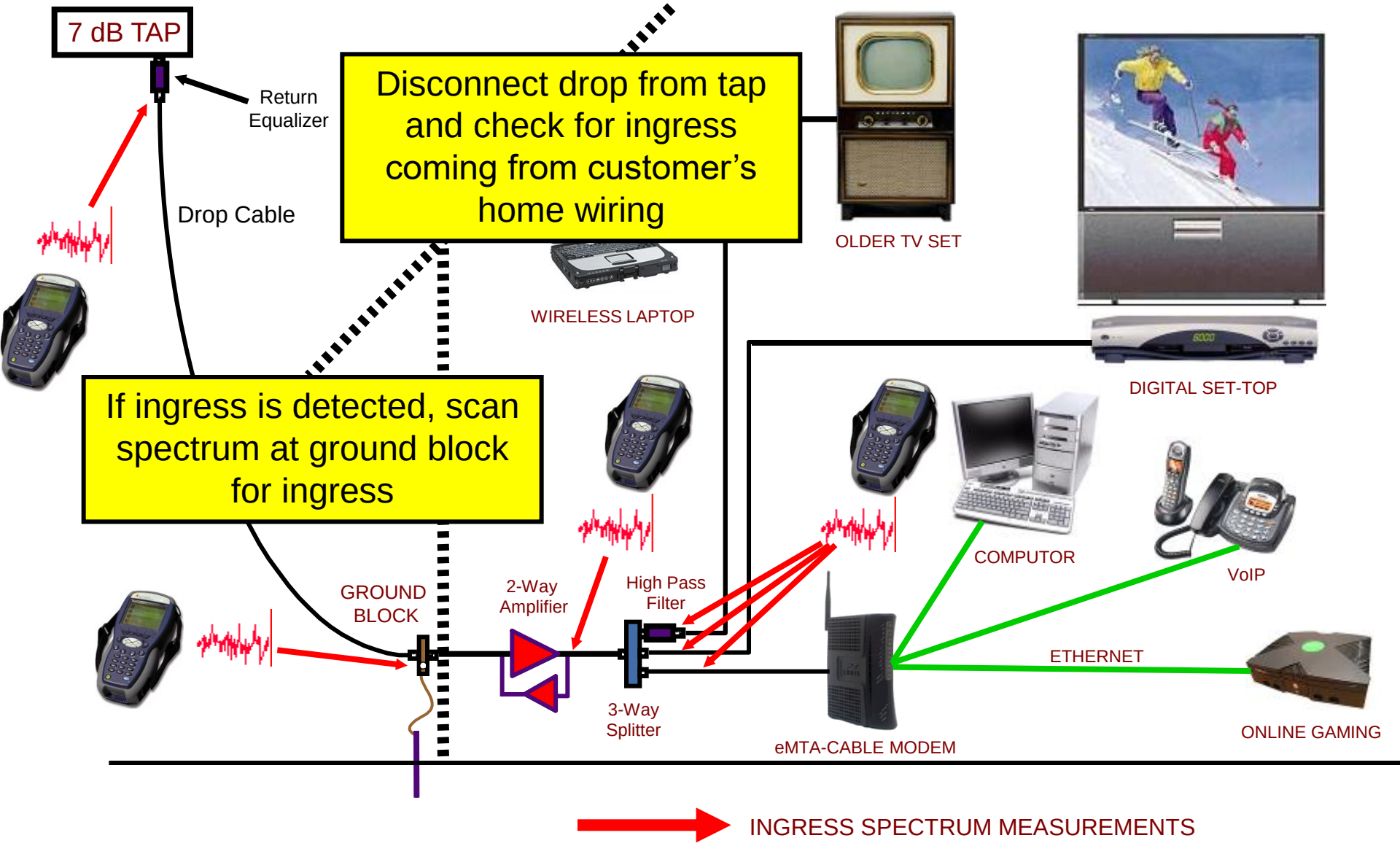






- Reverse Spectrum shot at customer's drop

Testing the Home for Ingress Contribution

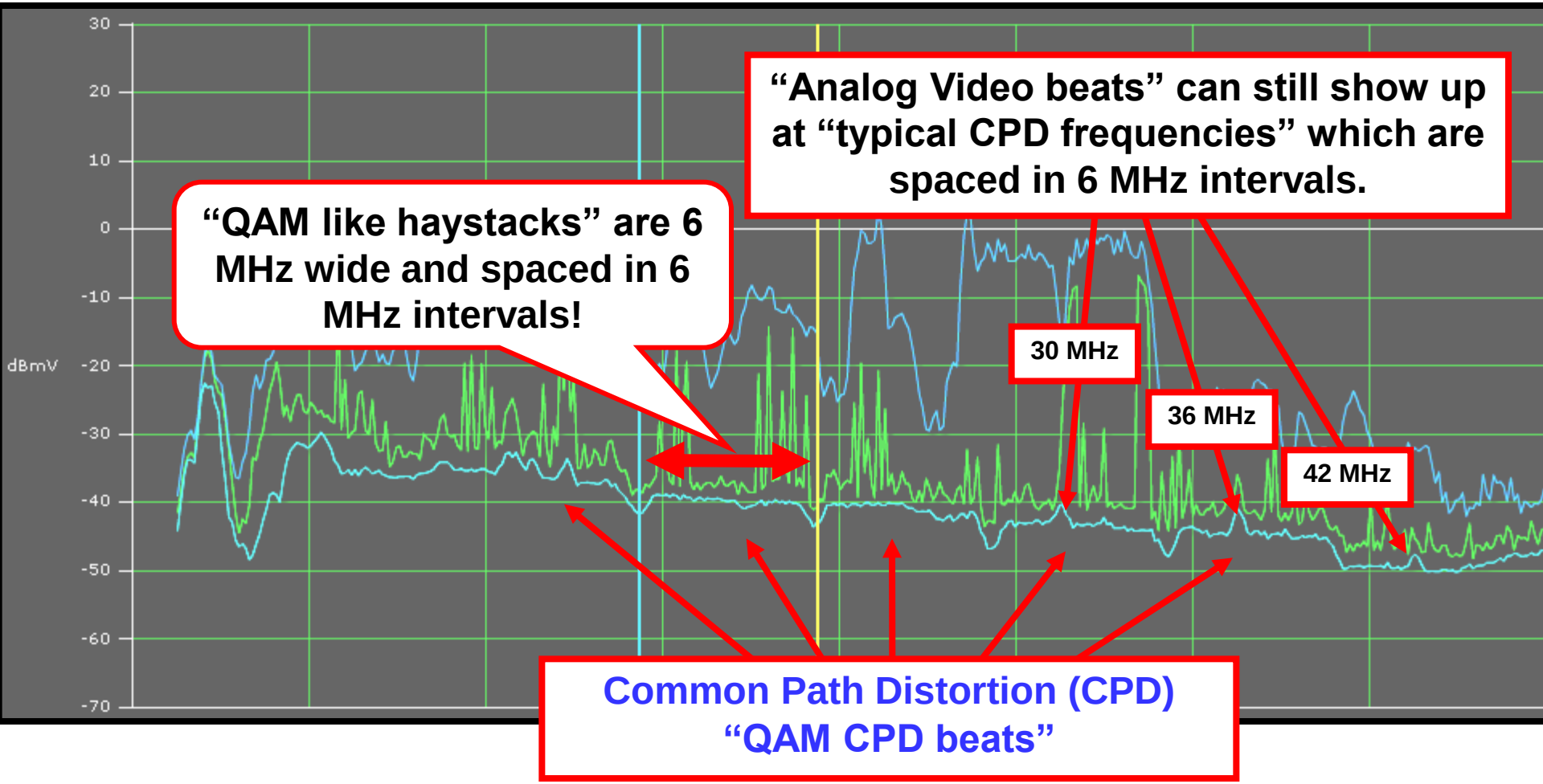


Testing and Troubleshooting House Wiring Homes

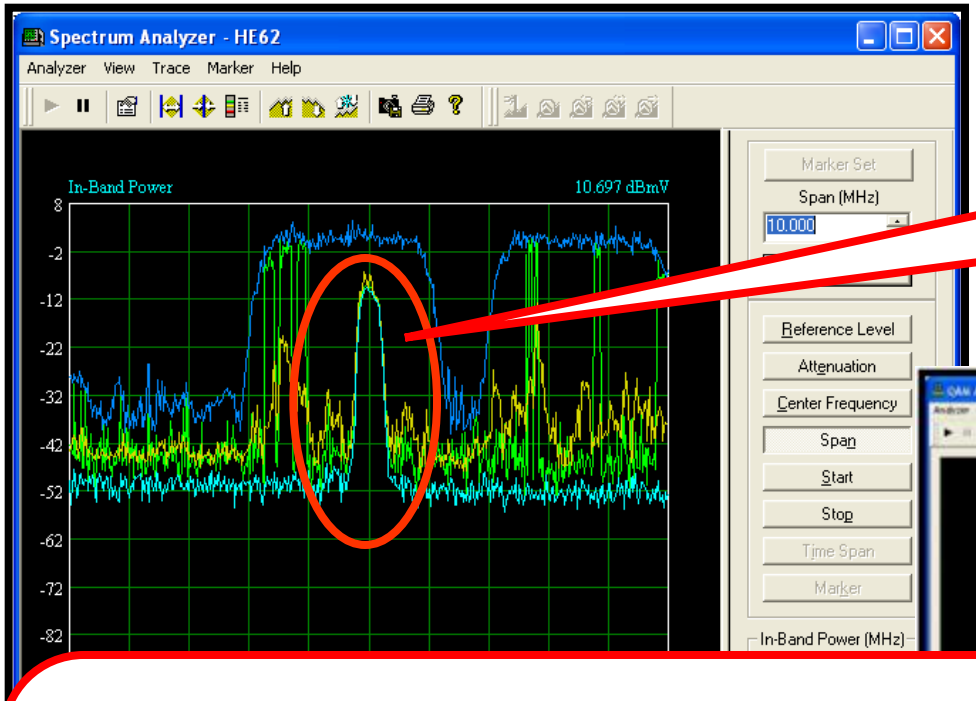
- **Measuring signal levels throughout the spectrum is a standard requirement for analog cable TV services.**
- **Leakage detection finds wiring damage or poor craftsmanship that can result in ingress points, which impacts upstream and downstream signals.**
- **Spectrum analysis of the reverse spectrum can identify ingress.**
- **Frequency response checks ensure that there are no bandwidth problems.**
- **Locating faults for repair can help eliminate reflections which can seriously impact digital signals.**

Common Problems Typically Identified in the Drop

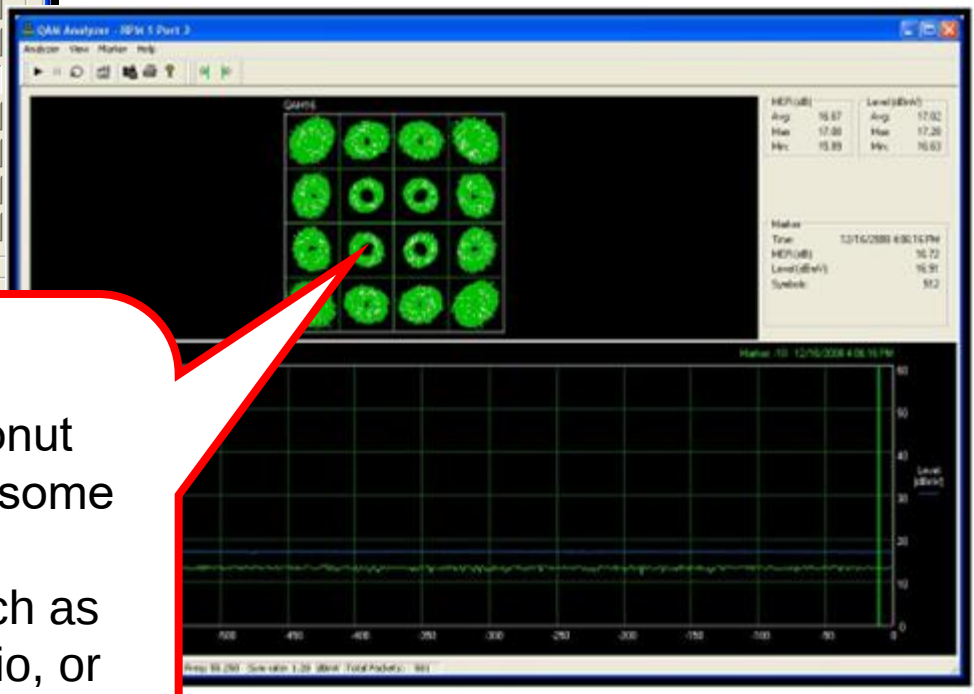
- **Kinked or damaged cable (including cracked cable, which causes a reflection and ingress)**
- **Use of staples that perforate or compress coaxial cable resulting in impedance mismatches**
- **Cable-ready TVs and VCRs connected directly to the drop (Return loss on most cable-ready devices is poor)**
- **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**



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!



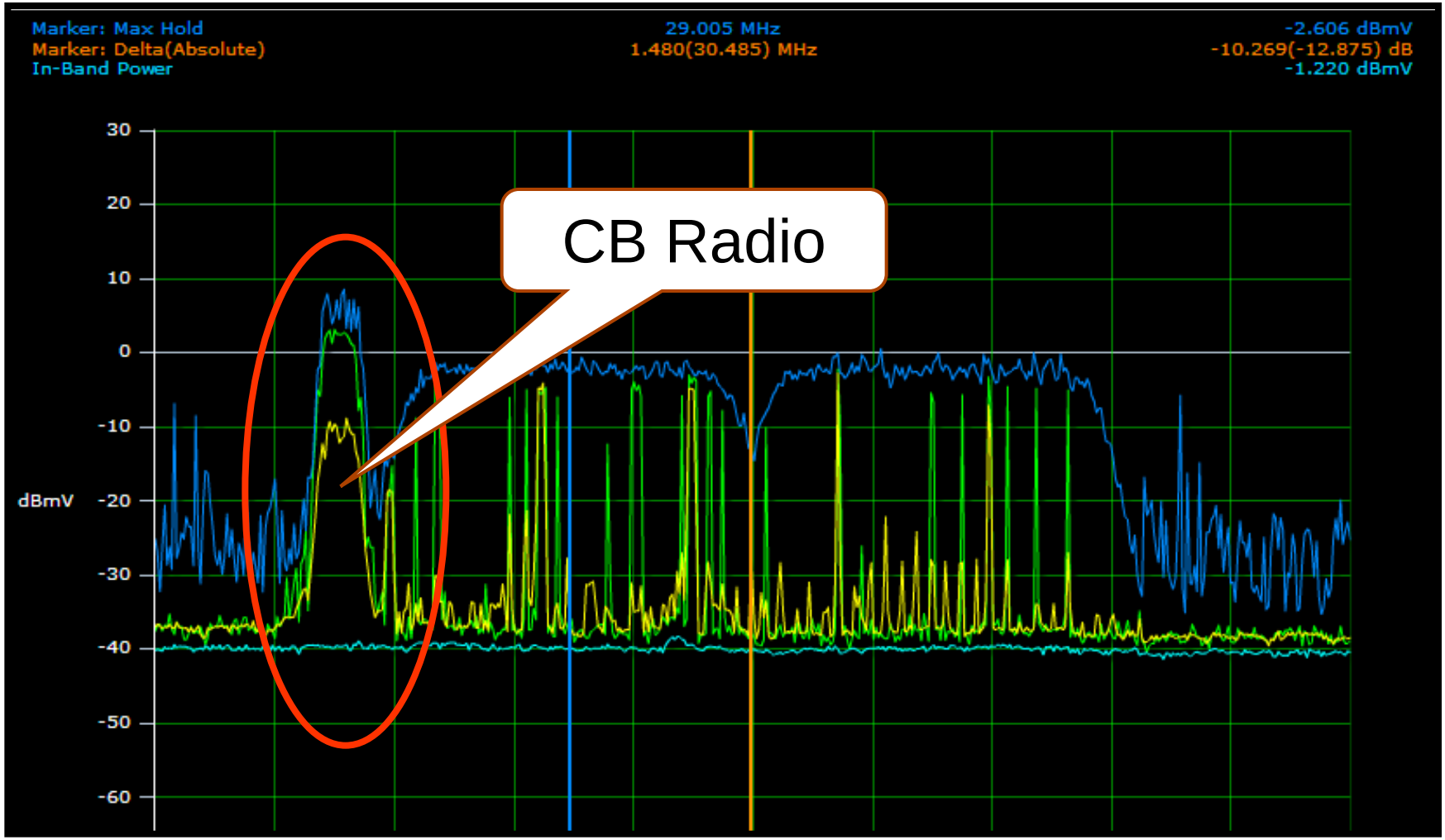
Off-air public broadcast radio carrier under the DOCSIS® 16QAM carrier

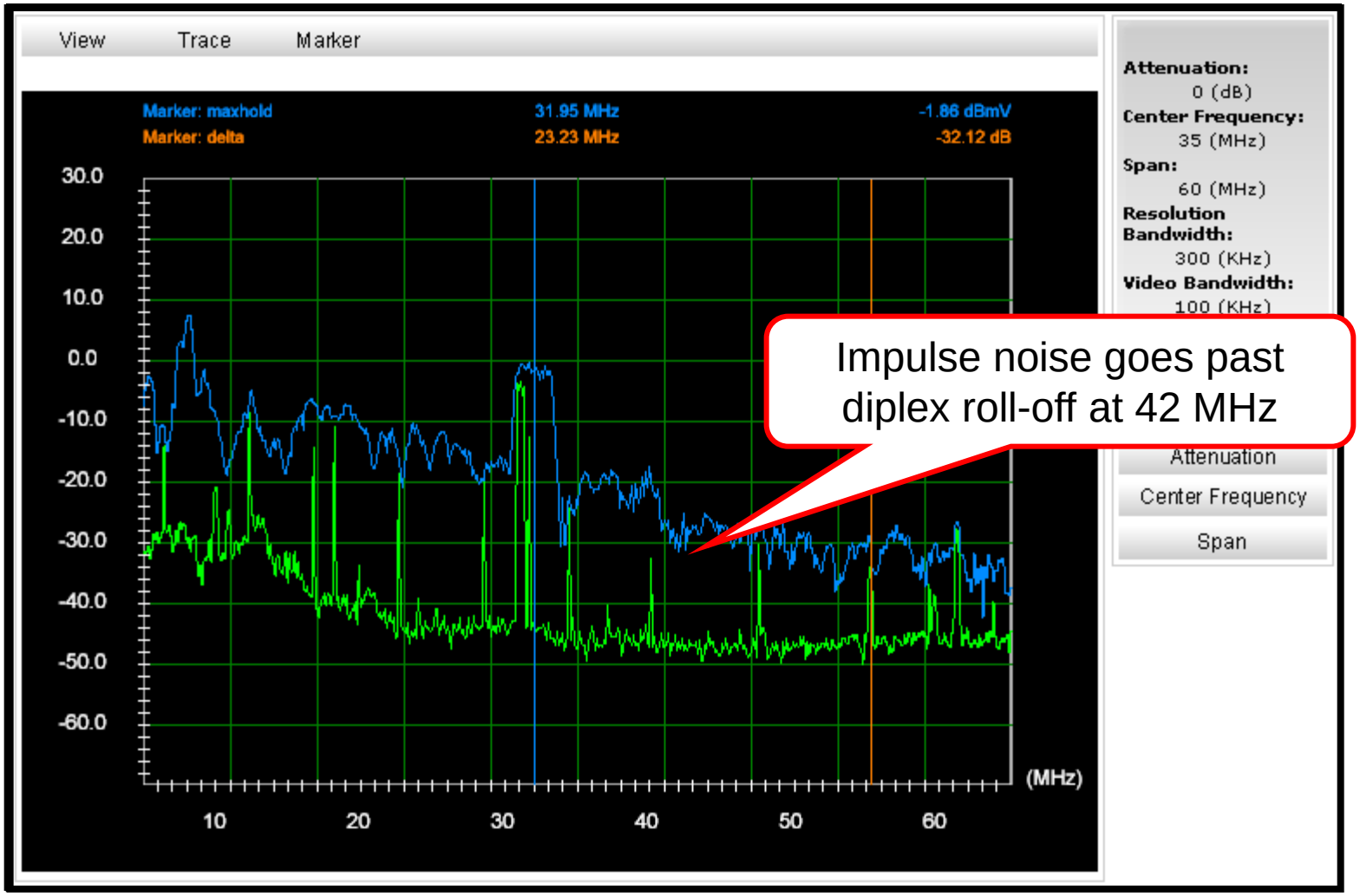


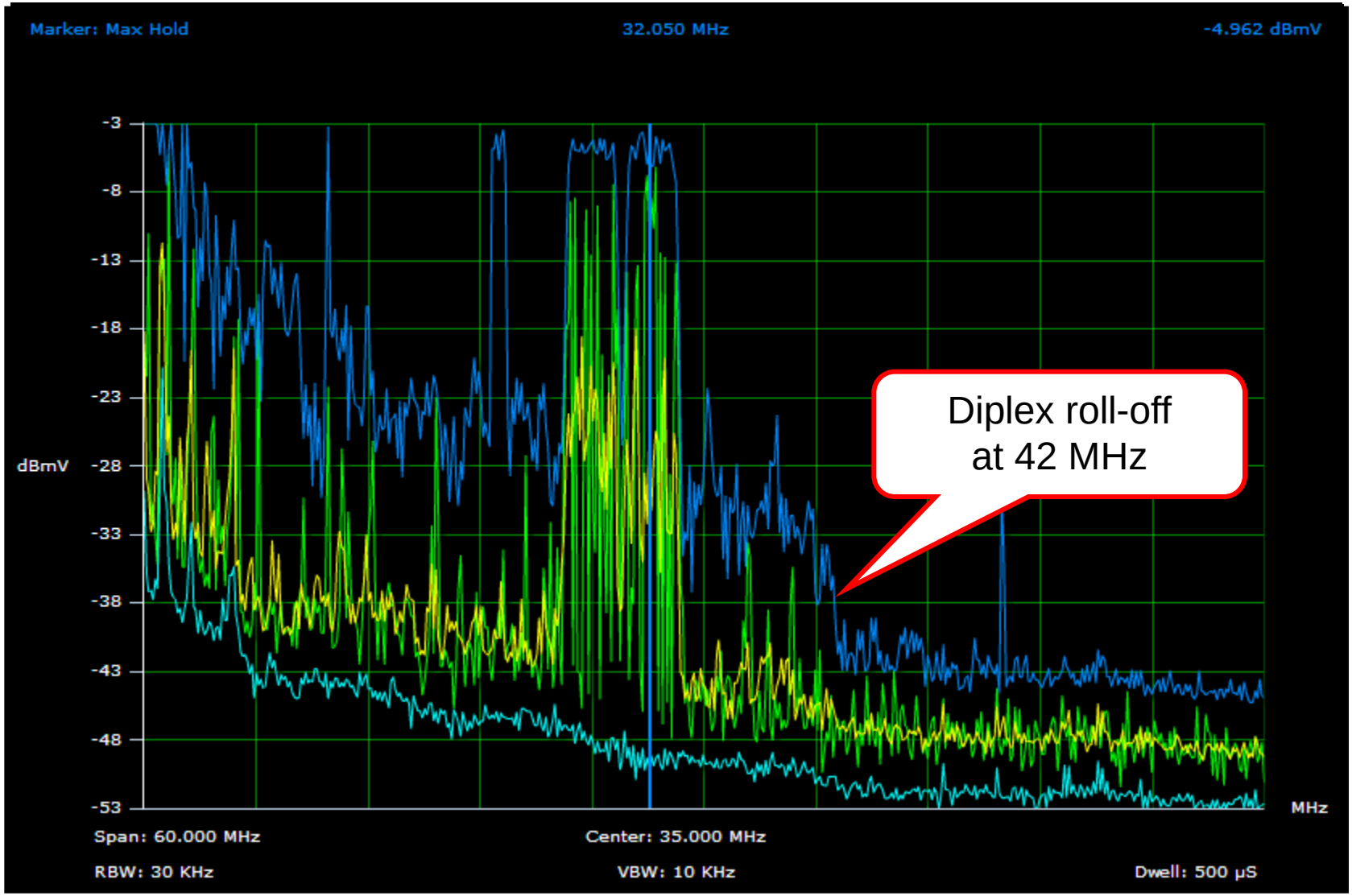
Coherent Interference

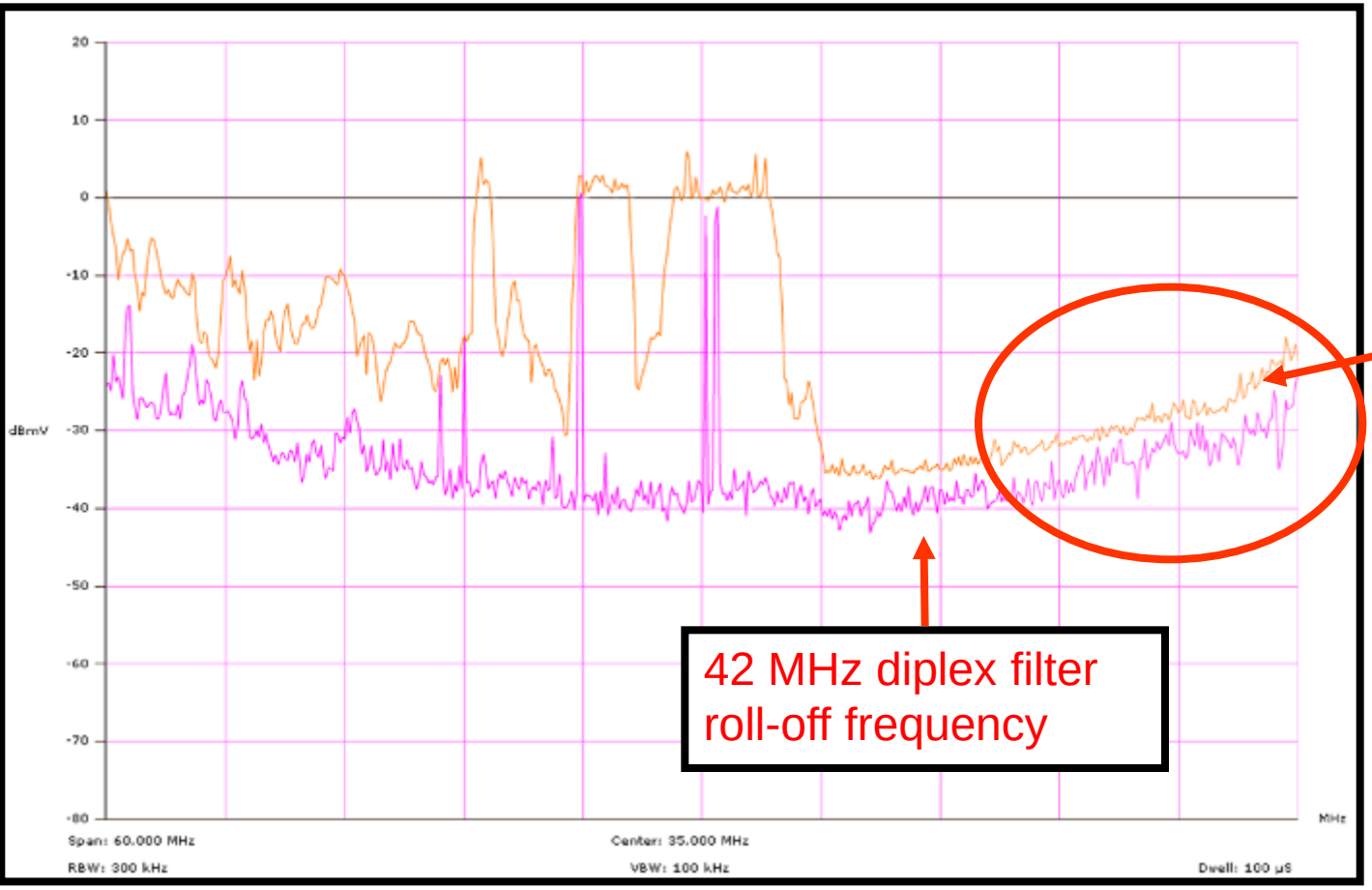
If the constellation looks like it has “donut shapes” in it, the problem is likely to be some form of coherent interference.

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

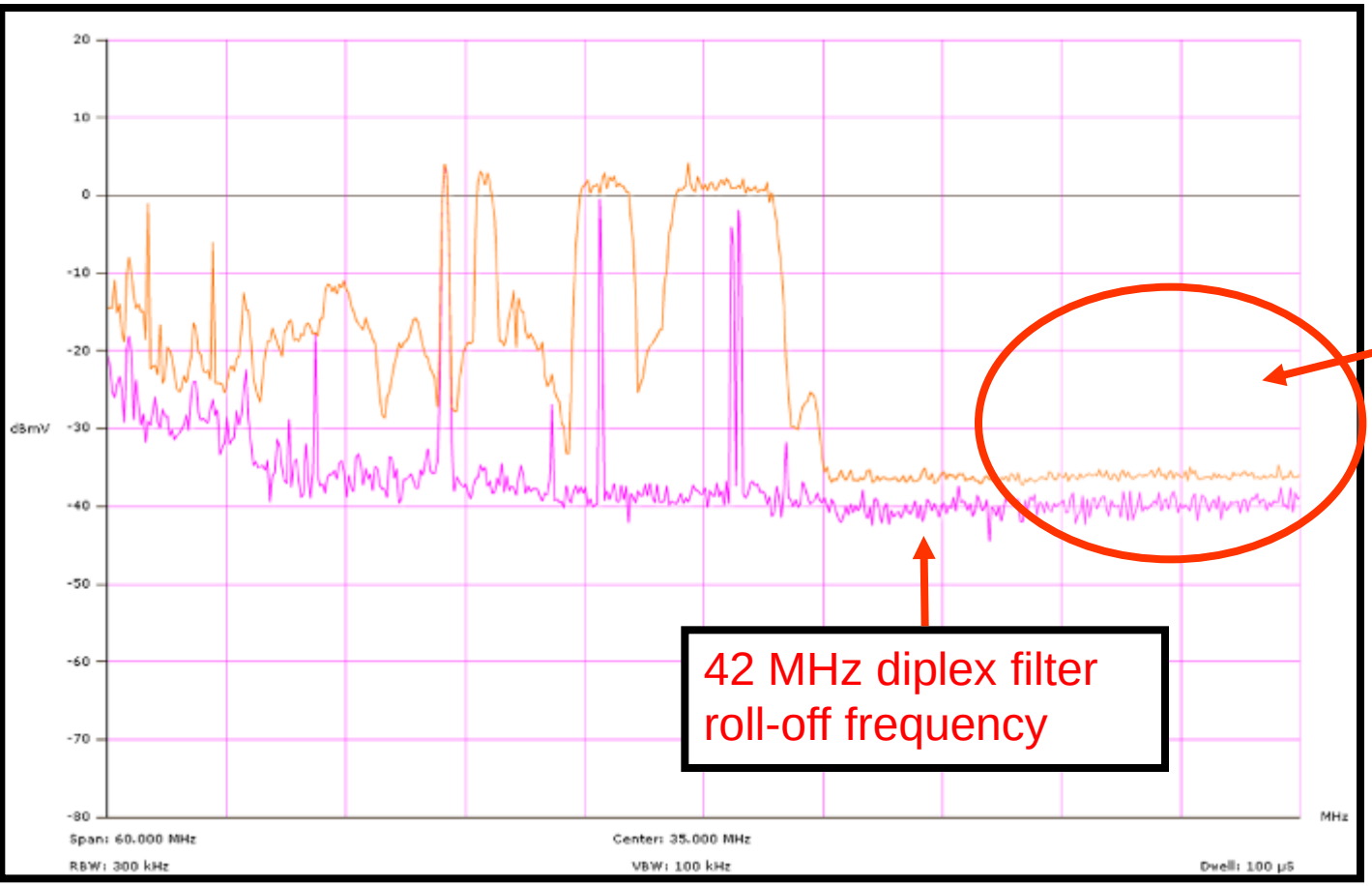








Too much optical power (light level) into the input of a return optical receiver can cause an abnormal rise in the noise floor above the diplex filter roll-off frequencies.



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.

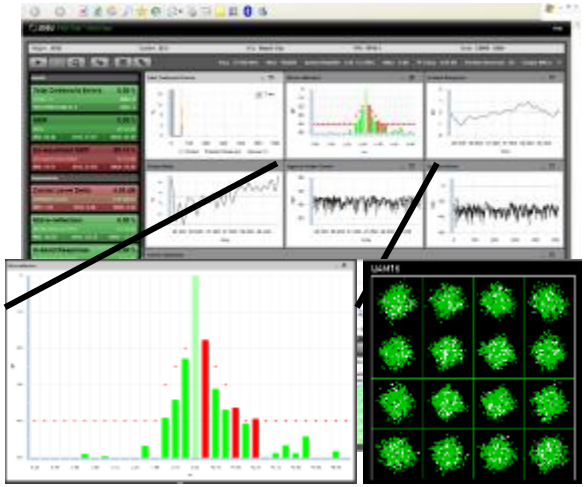
2 dB of additional optical attenuation was added to the return input of the optical receiver and resulted in a “flatter noise floor” above the diplex filter roll-off frequencies.

Linear Distortions

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

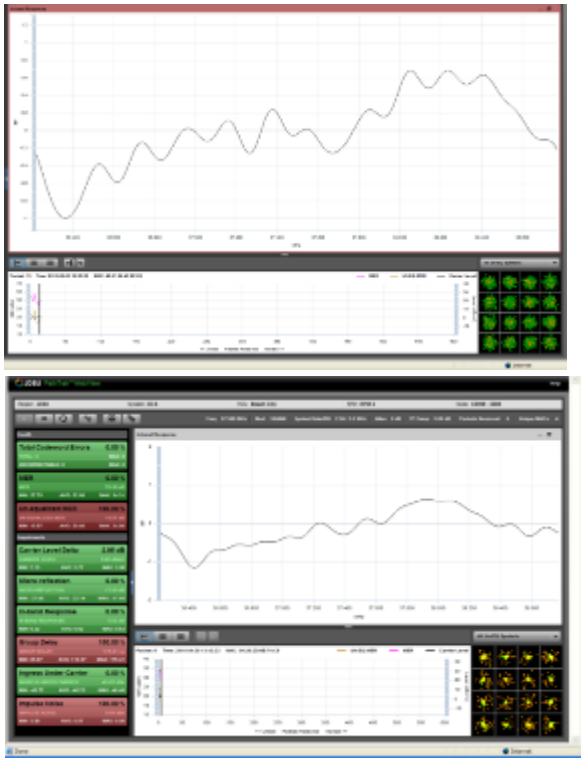


Group Delay

- 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

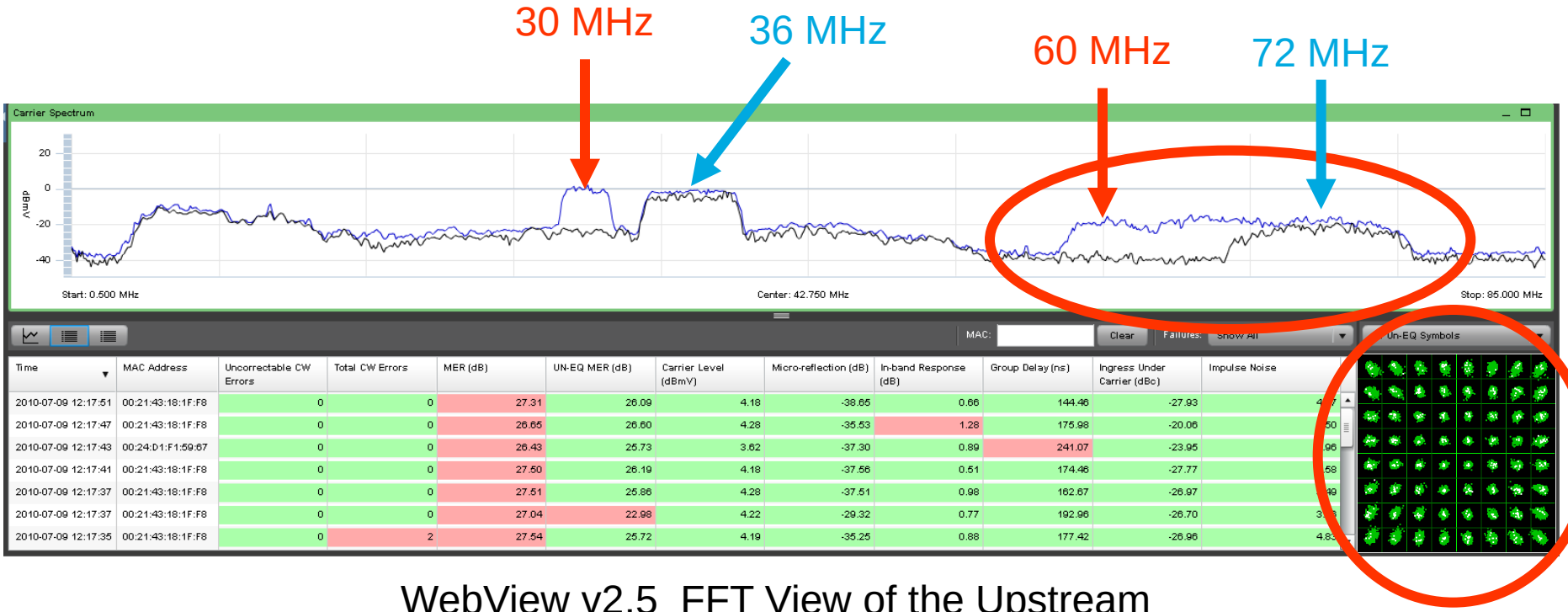
In-channel Freq. Response

- Common Causes
  - Misalignment
  - Impedance mismatches



Optical Link is Critical to Upstream Performance

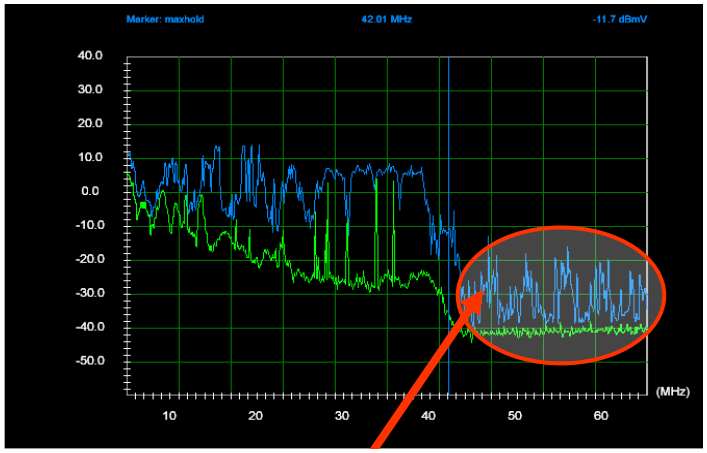
- RF level is too high at input of return laser
  - Verify light level at input of return optical receiver
  - Verify RF level at input of return laser
  - Verify RF spectrum above diplex frequency at input of return laser



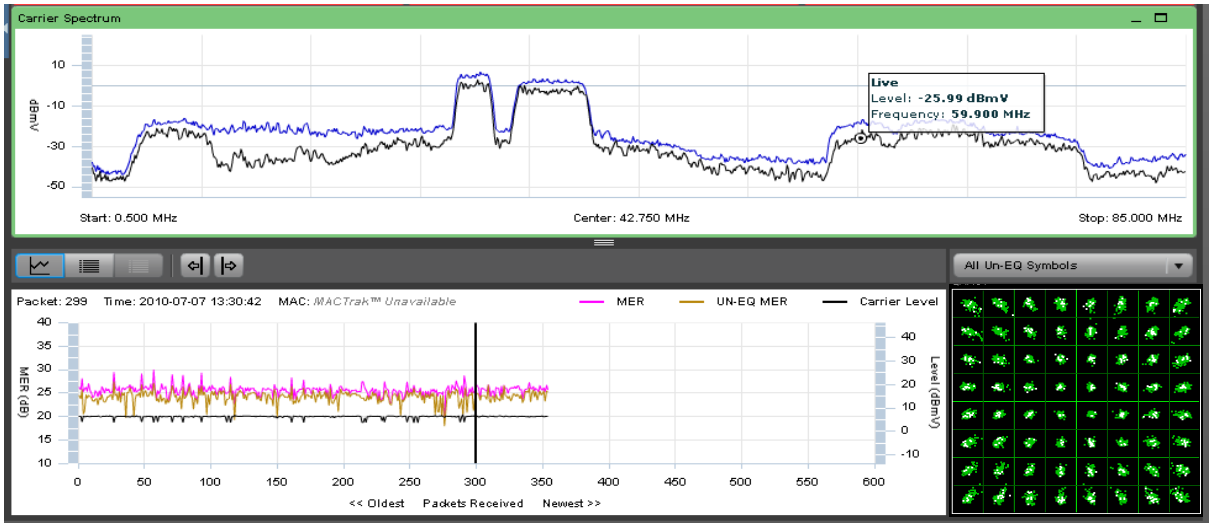
WebView v2.5 FFT View of the Upstream

Common Impairments: Laser Clipping

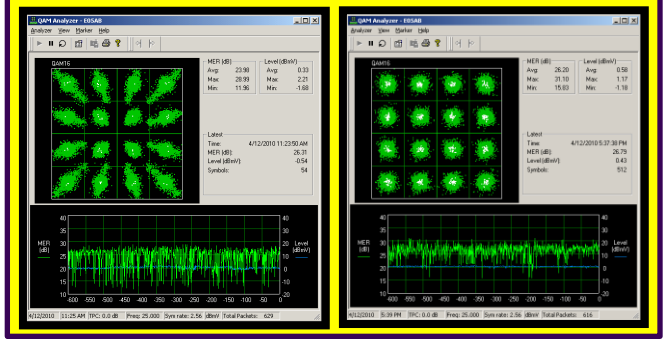
- Caused by Overdriving Laser
  - Low end ingress
  - Improper laser setup
  - Adding carriers without compensating
- Very distinct constellation footprint
  - Also see as junk above diplex in spectrum
  - Optical receiver issues can look similar



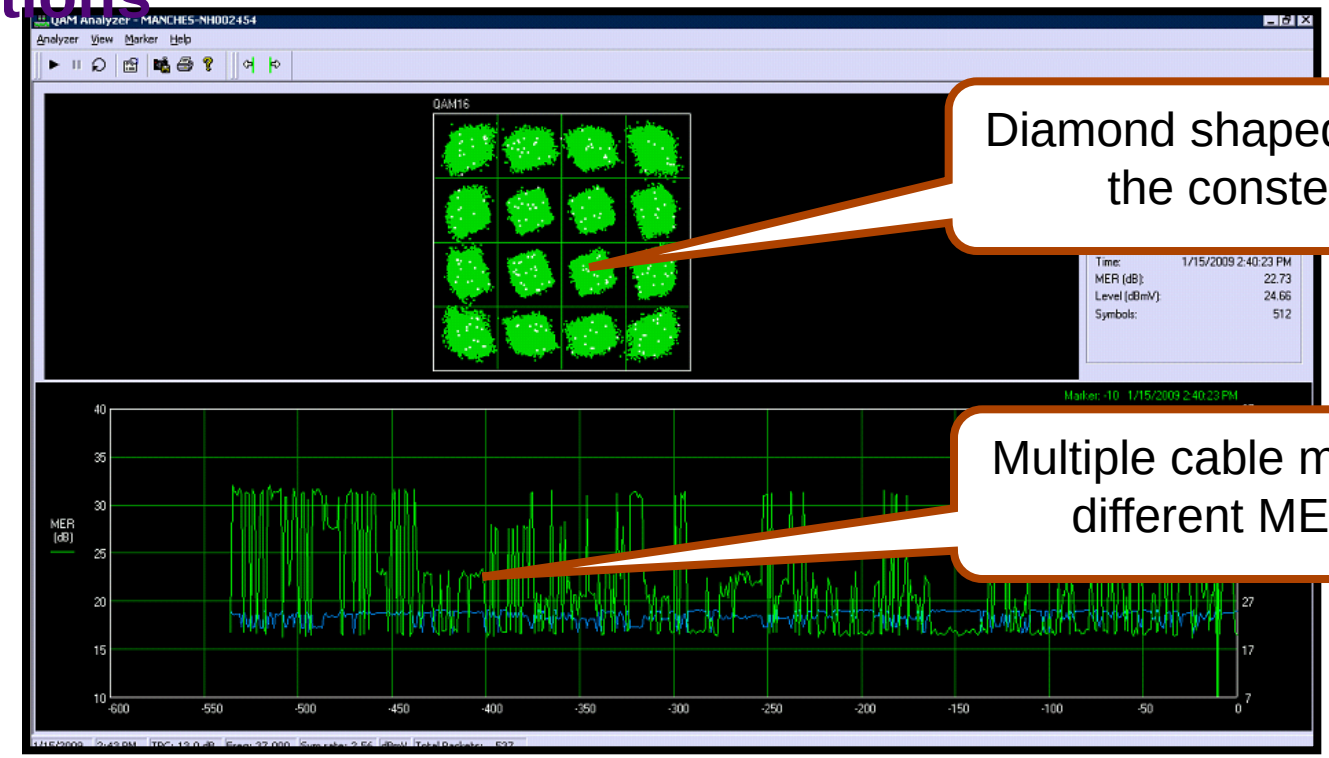
Wide band impulse noise above diplex roll-off frequency



Before/After:
Faulty Optical Receiver
Similar to Laser Clipping



PathTrak QAM Analyzer View – Group Delay & Micro-reflections



Diamond shaped clusters in the constellation

Multiple cable modems with different MER levels

Group Delay / Microreflections

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

Bad In-Band Response from a Single Modem

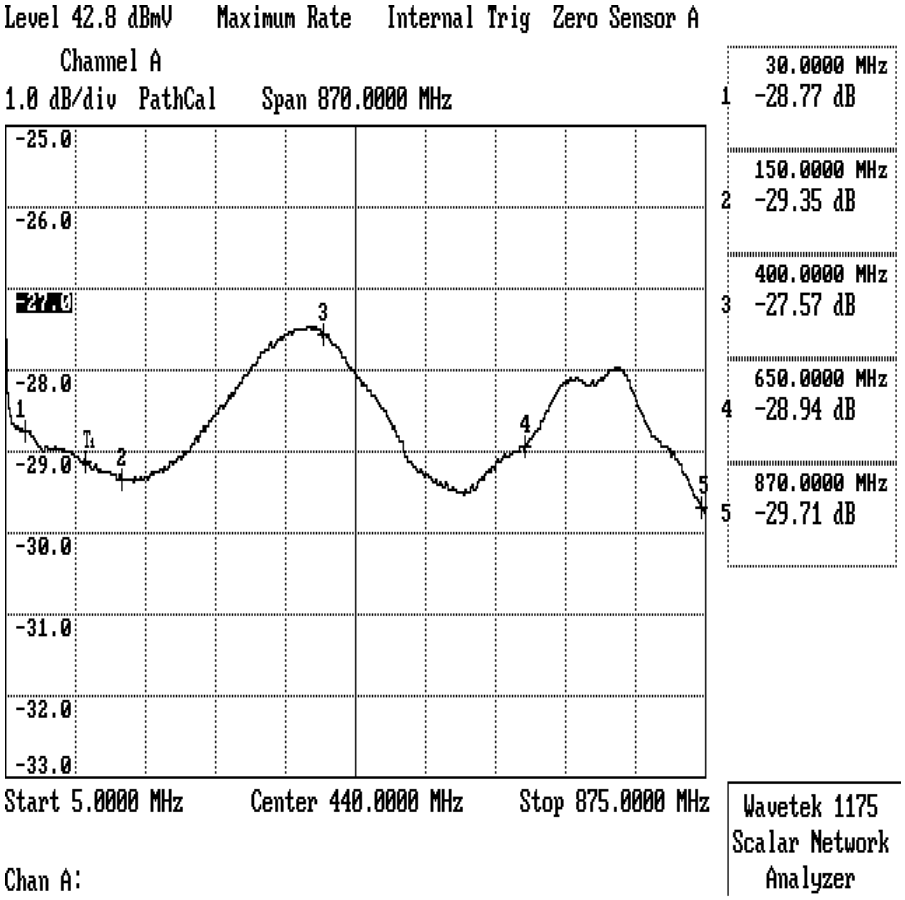
Move this marker and all of the displays will show the corresponding measurements for each packet

Good In-Band Response from a Single Modem

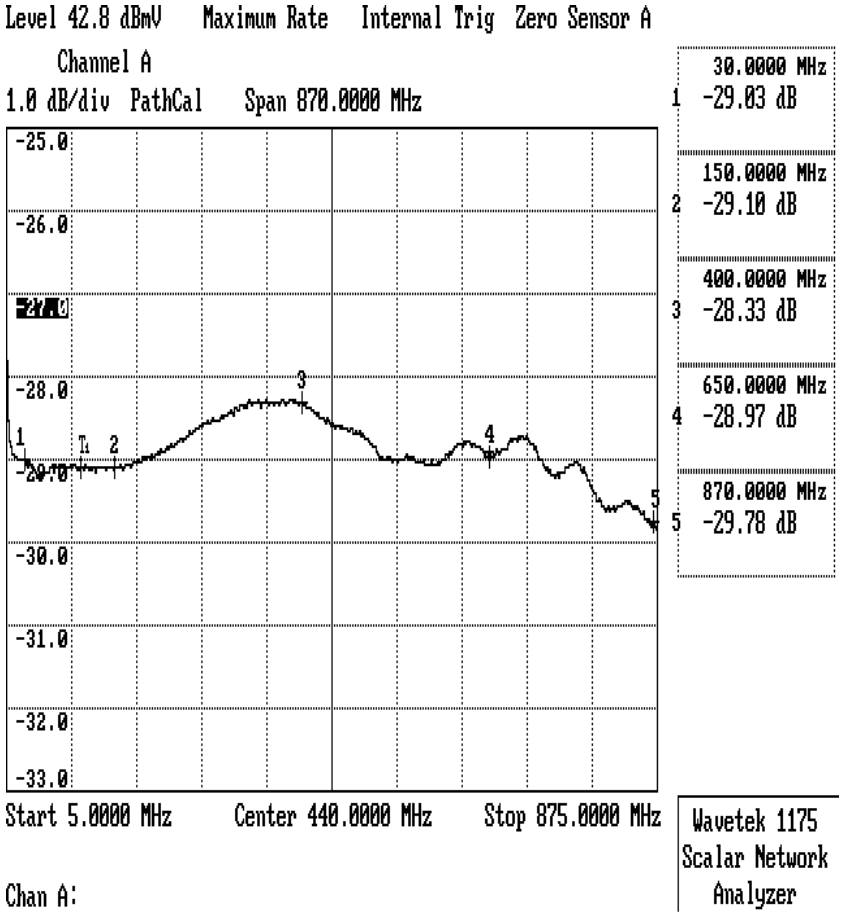
Move this marker and all of the displays will show the corresponding measurements for each packet

Beware of Taps

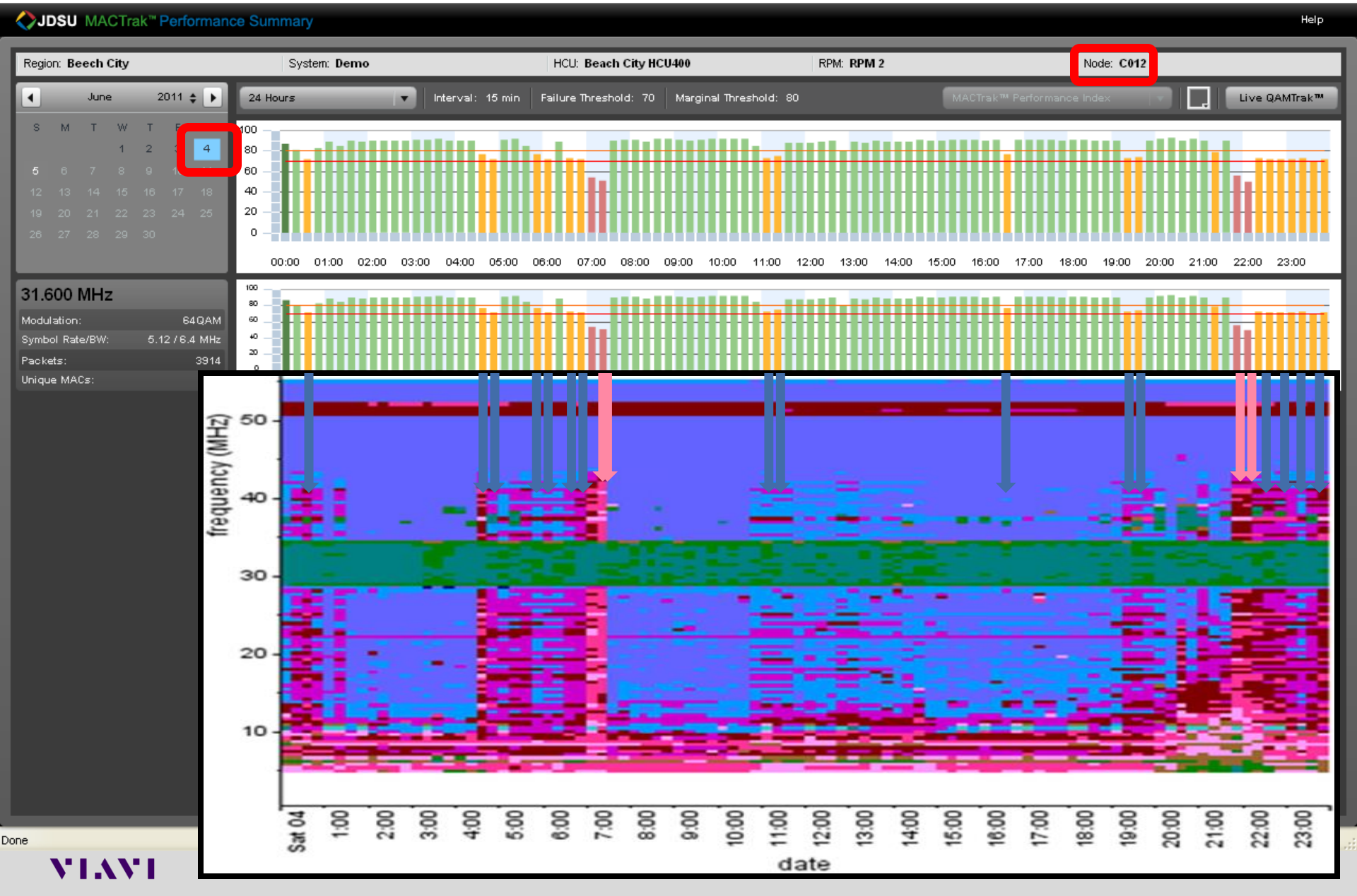
Port 1 2thru8 not terminated



Port 1 2thru8 terminated



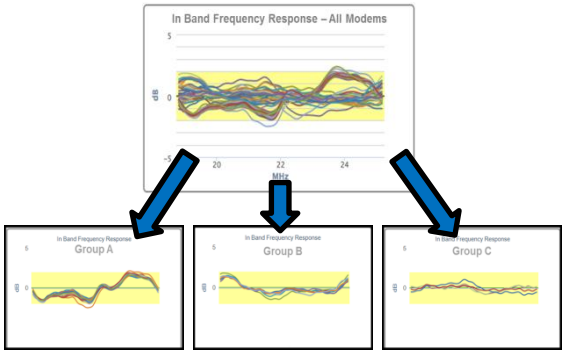
Node Performance Summary - Node C012 on June 4th
Impulse Noise = Codeword Errors



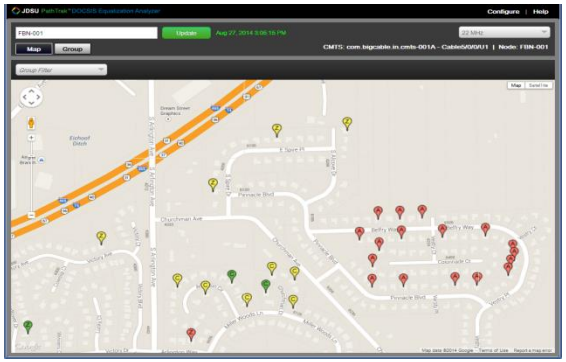
How Pre-Equalization Data Can Help Cable Operators

Correlate, Localize, and Pinpoint Impairments Quickly – Right From Your Desk

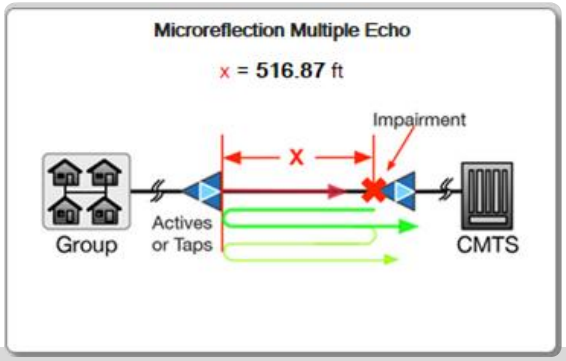
- **Correlate:** Automatically Separate Modems With Statistically Similar Freq Responses Into Groups
  - Their packets are passing through the same impairment(s)



- **Localize:** Plot Modem Groups on Google Map To Allow Identification of Last Common Isolation Point
  - Where to start field find and fix from

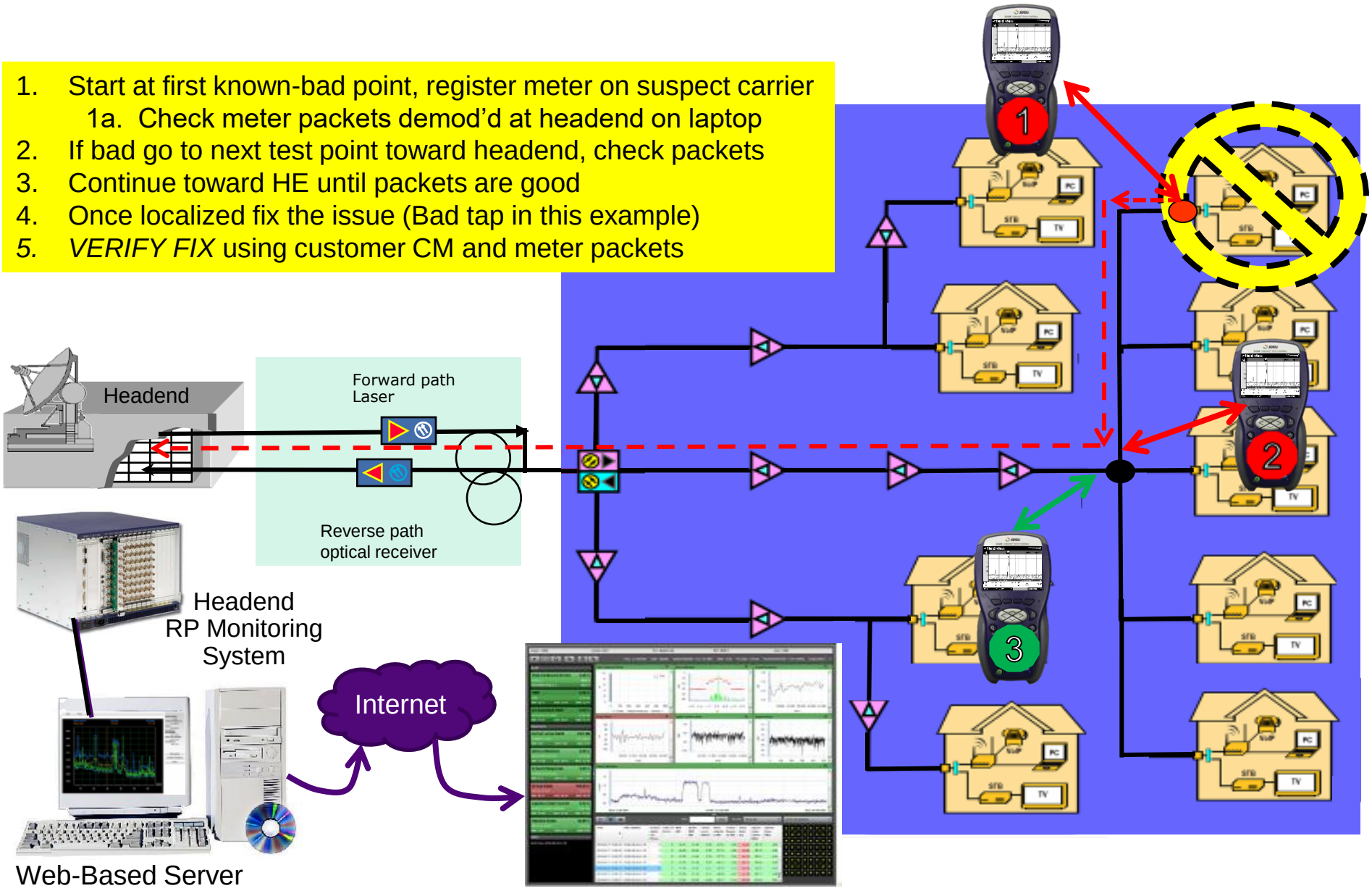


- **Pinpoint:** Use Microreflection Data To Calculate "Echo Cavity" distance
  - Dispatch to fix, not to find

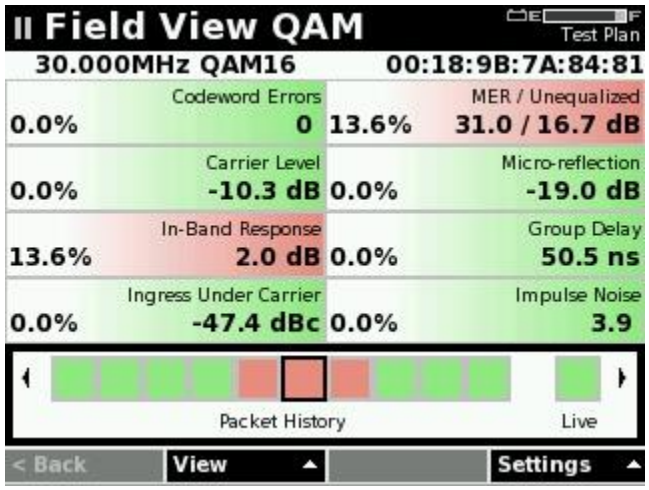


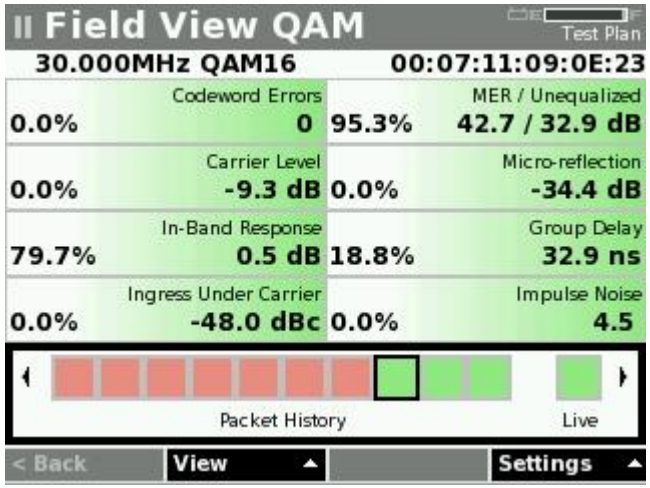
How To Troubleshoot/Localize Linear Impairments

1. Start at first known-bad point, register meter on suspect carrier
   1a. Check meter packets demod'd at headend on laptop
2. If bad go to next test point toward headend, check packets
3. Continue toward HE until packets are good
4. Once localized fix the issue (Bad tap in this example)
5. *VERIFY FIX* using customer CM and meter packets

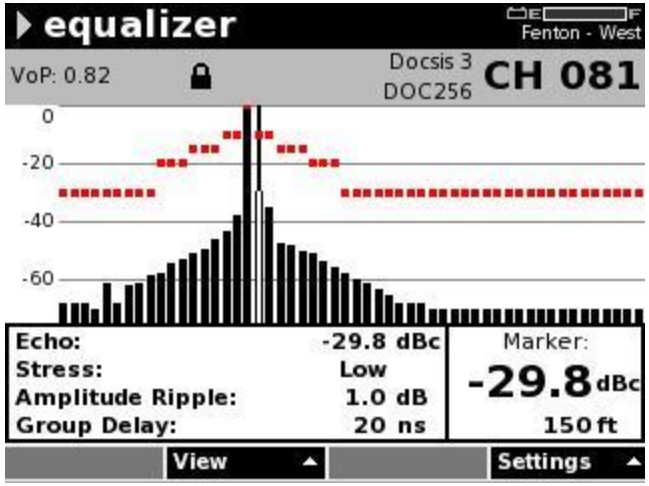


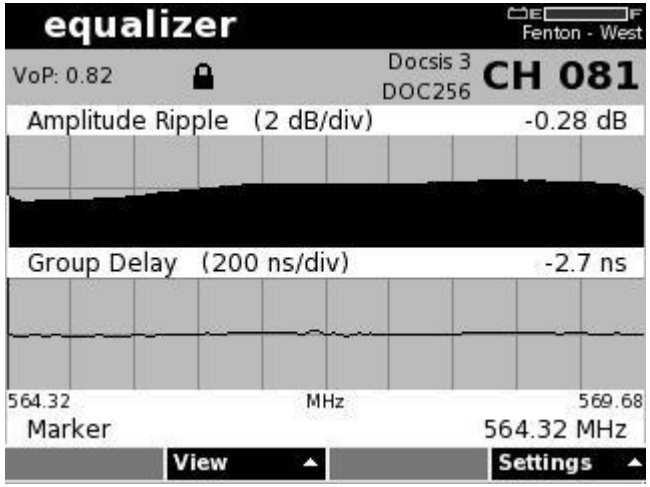
Linear Distortions Tests





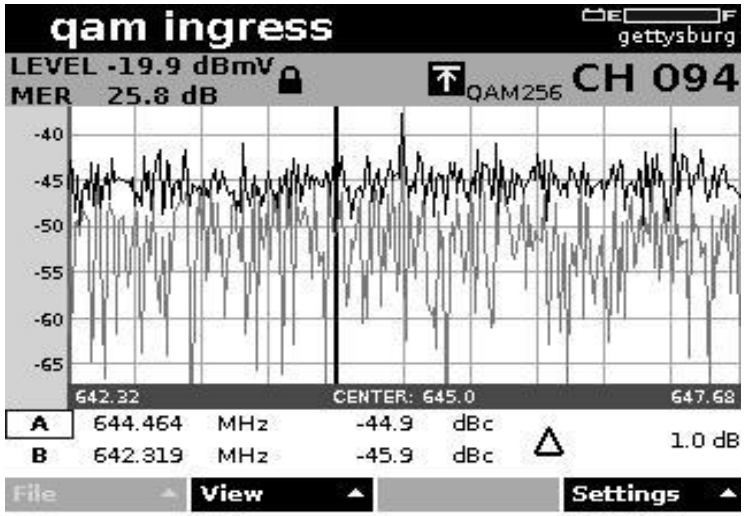
Return Path

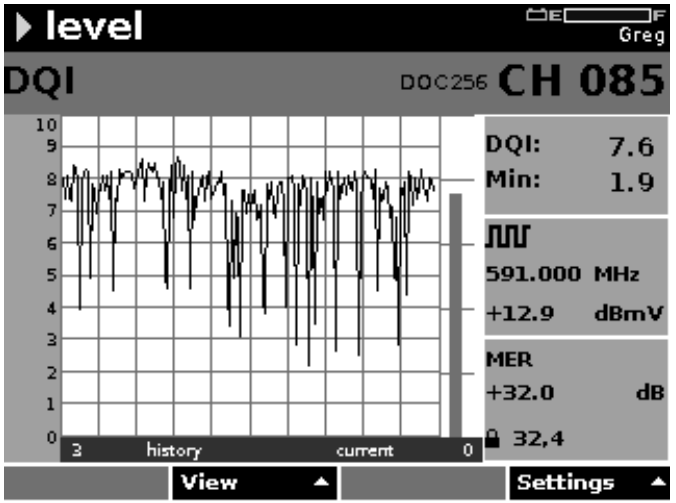




Forward Path

Testing for Ingress on Forward Digital Carriers

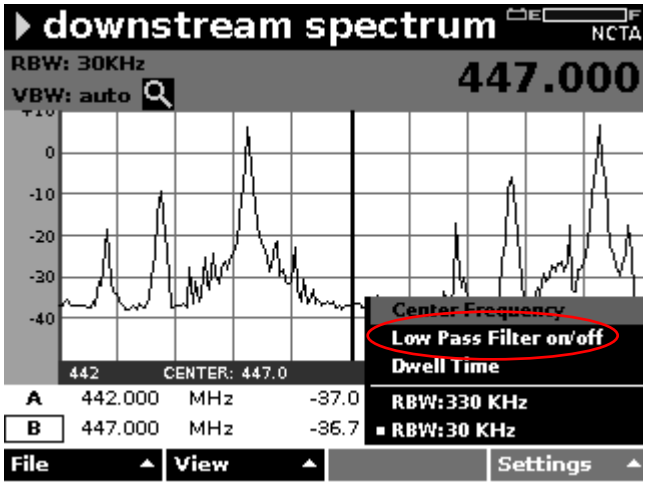


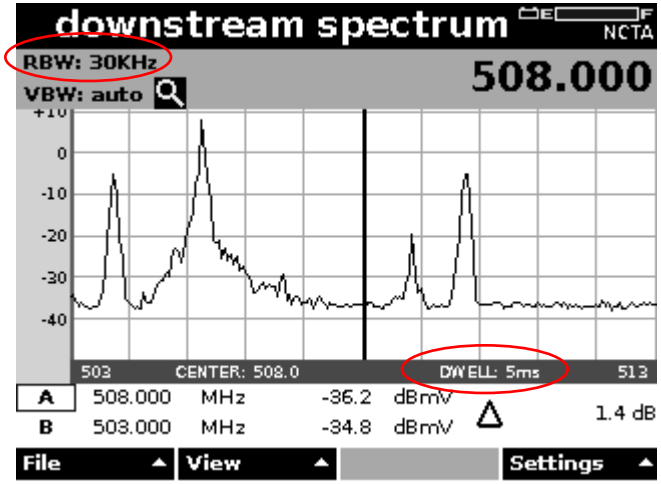


Tools for Troubleshooting

Users can now adjust the spectrum mode to better see intermittent ingress, harmonics, and other channel anomalies. They can also look over both the upstream and downstream spectrums in one mode as well as isolate the return path from the forward path, eliminating noise leaking down into the return path.

- View 4MHz – 1GHz, in either 10 or 50 MHz spans, without changing modes
- While viewing return spectrum; enable a Low Pass Filter
  - Cuts out the higher frequency noise
  - Cleaner return path view; lower noise floor
- Increase Dwell time (1-25ms) per frequency scan
  - Find intermittent impairments better/quicker
- Adjust resolution bandwidth (RBW) from 330KHz to 30KHz
  - Shows more spectrum characteristics with smaller spectral slices adding to the overall resolution

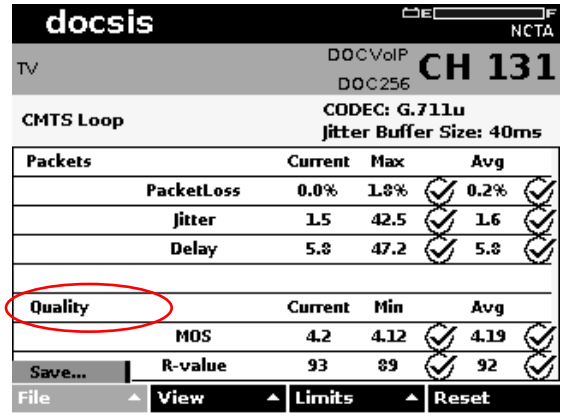


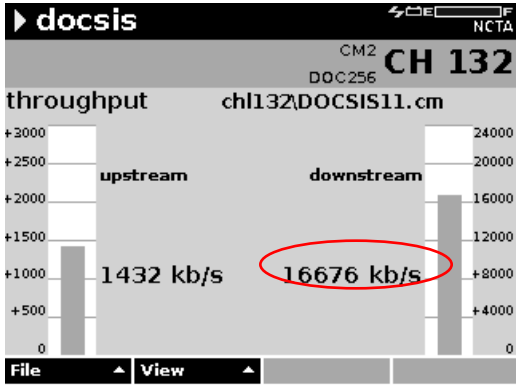


*All HW versions

Qualifying Data over RF

- VoIPCheck Save
  - Save and Archive VoIPCheck results
  - TPP file archiving and result viewing
- Increased DOCSIS Throughput
  - DOCSIS 1.1
    - 1.5 MB/s US; 15 MB/s DS





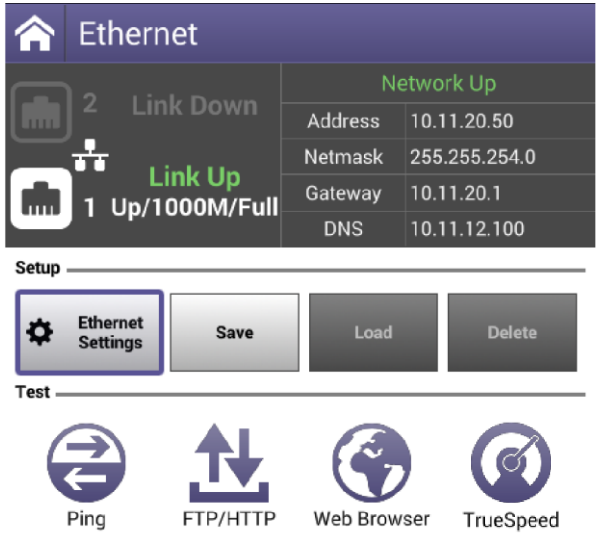
Home Networks

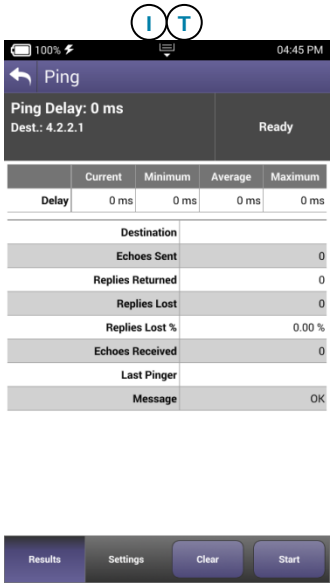
Home Networking Technologies

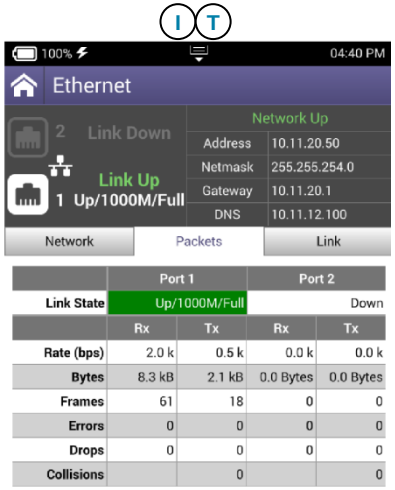
- Ethernet
  - Runs on Cat-5
  - Less than 5% of Homes wired for Ethernet
- MoCA™ Multimedia over Coax Alliance
  - Runs on existing Coax
- HPNAv3 Home Phone Network Alliance
  - Runs on Coax OR over existing phone lines
- HomePlug® A/V
  - Runs over AC wiring
- Proprietary over coax
  - TV Net(Coaxsys)/HomeRan(TMT Networks)
- Wireless 802.11 b/g/a/n/ac
  - Range limited due to propagation through walls

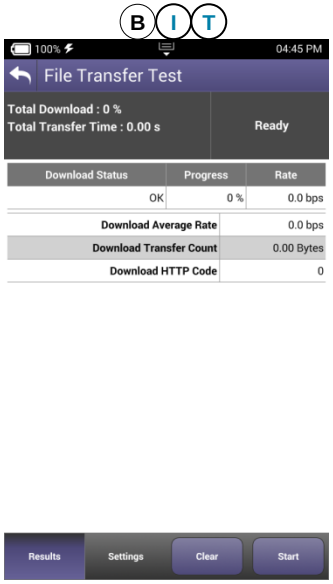
Ethernet testing made easier

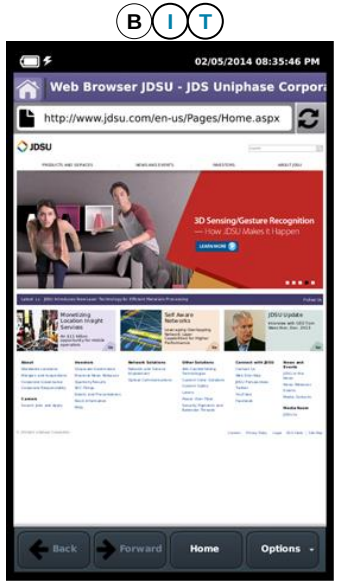
- **Ethernet testing made easier**
  - Dual 1G Ethernet ports
  - Ping
  - HTTP/FTP transfer tests
  - Web Browser test
  - TrueSpeed (stand alone option)



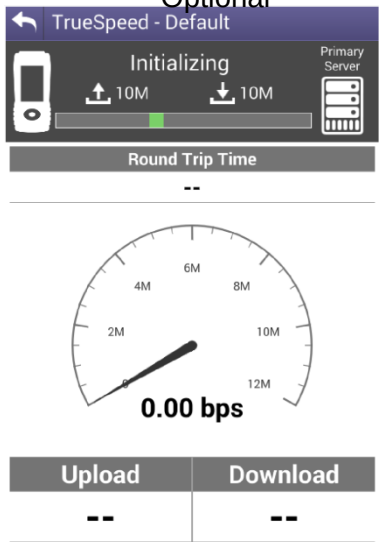


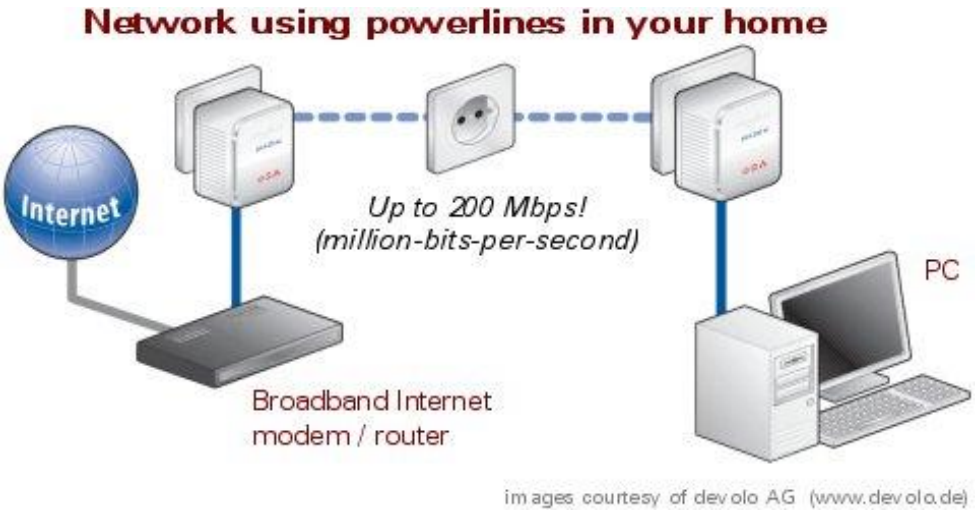






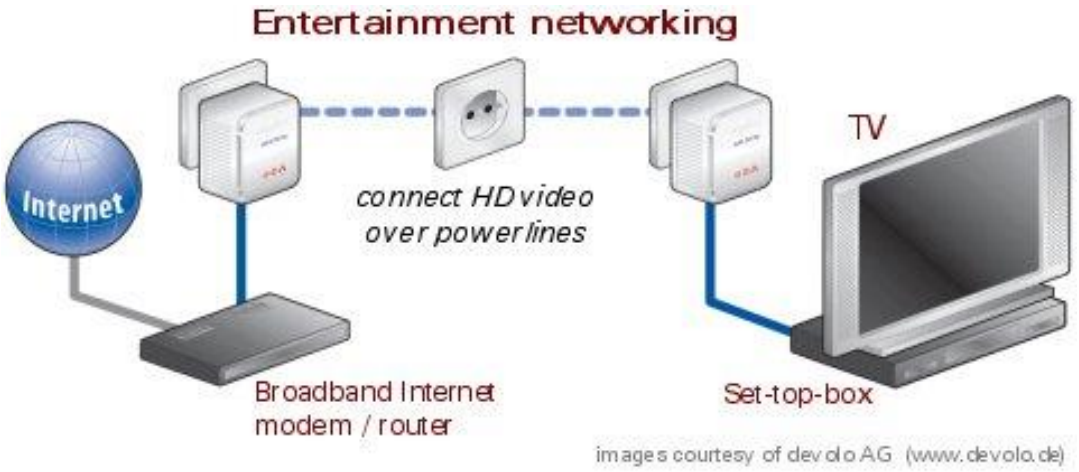
Optional

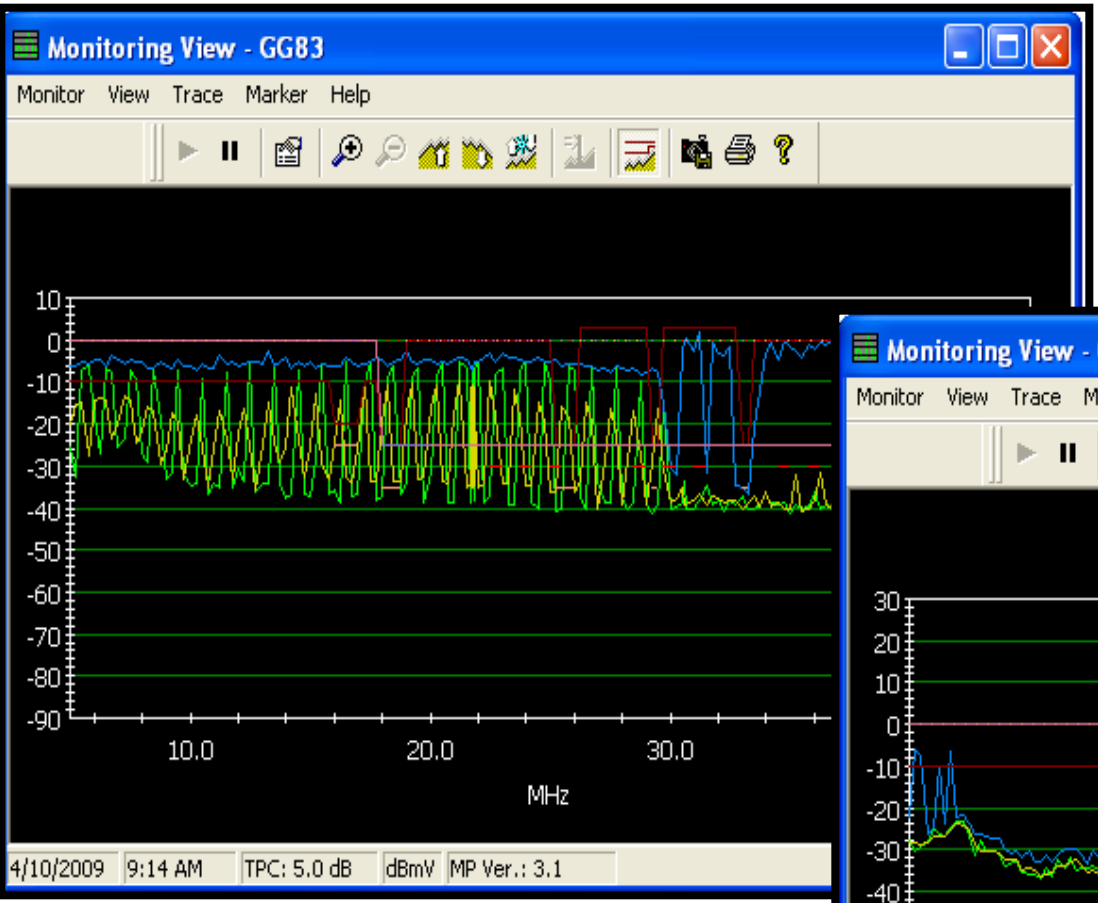




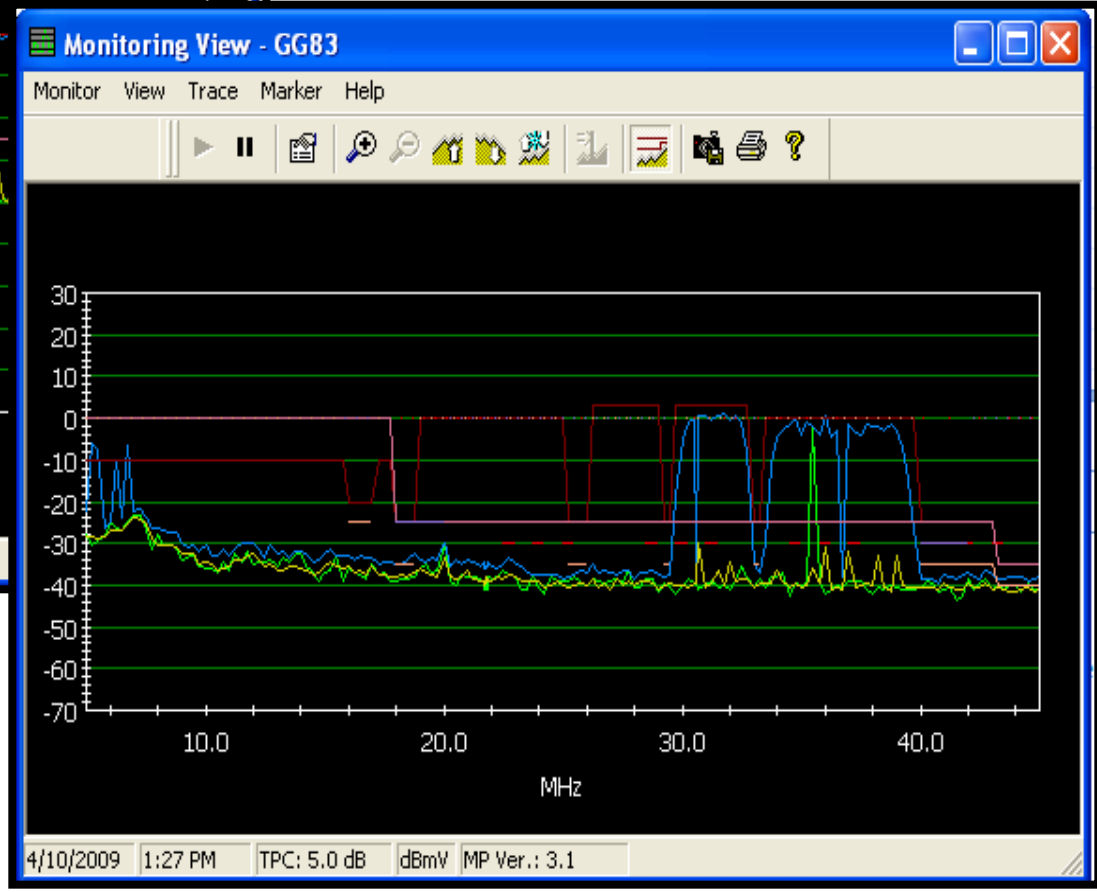
"Products based on the HomePlug 1.0 and HomePlug AV specifications can bridge an existing networking technology (such as a wireless or Ethernet network) and your home's power lines. "

Network your TV with HomePlug AV





HomePlug 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

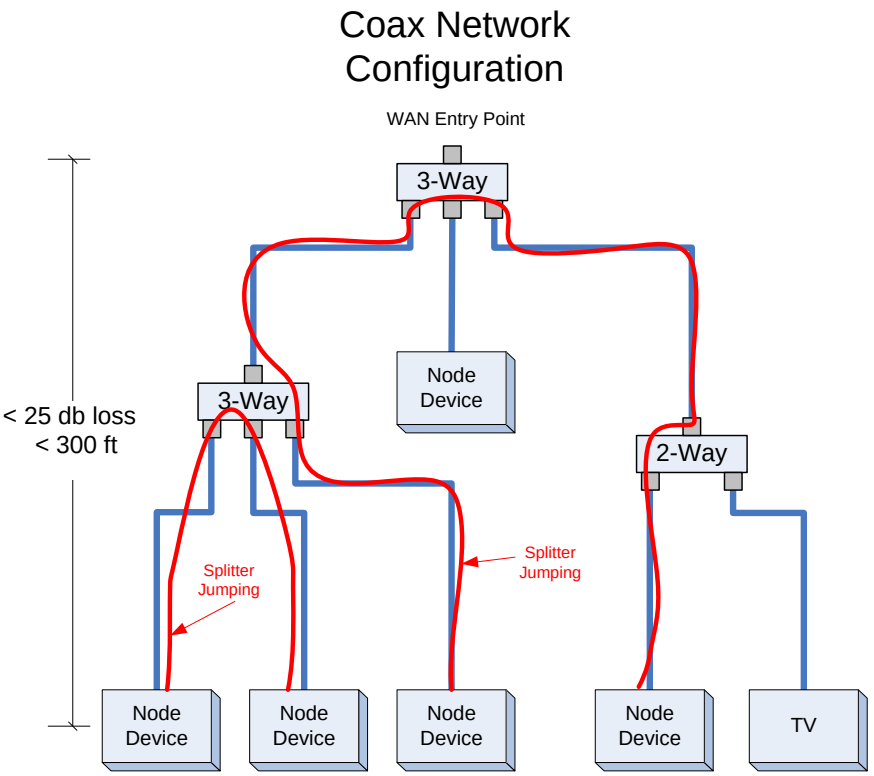
HomePNA™

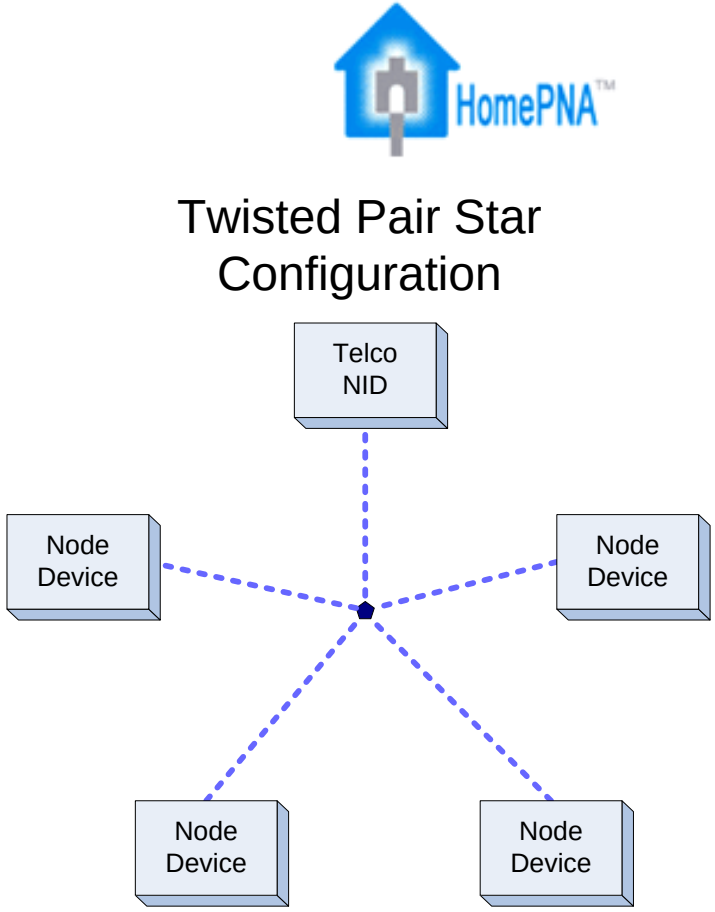
Ethernet to Coax HPNA Adapter

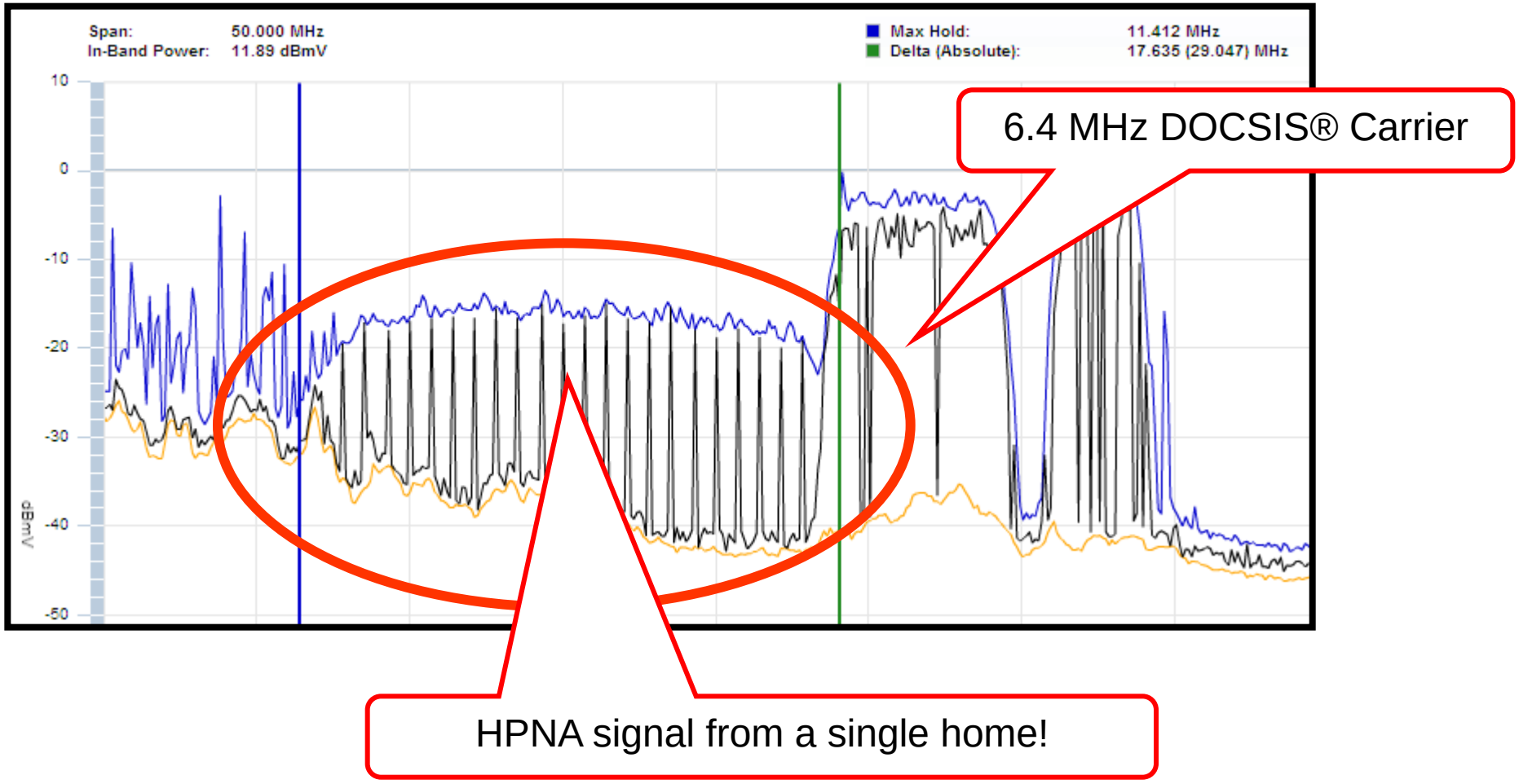
Features

- 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

HPNA Physical Network Topology

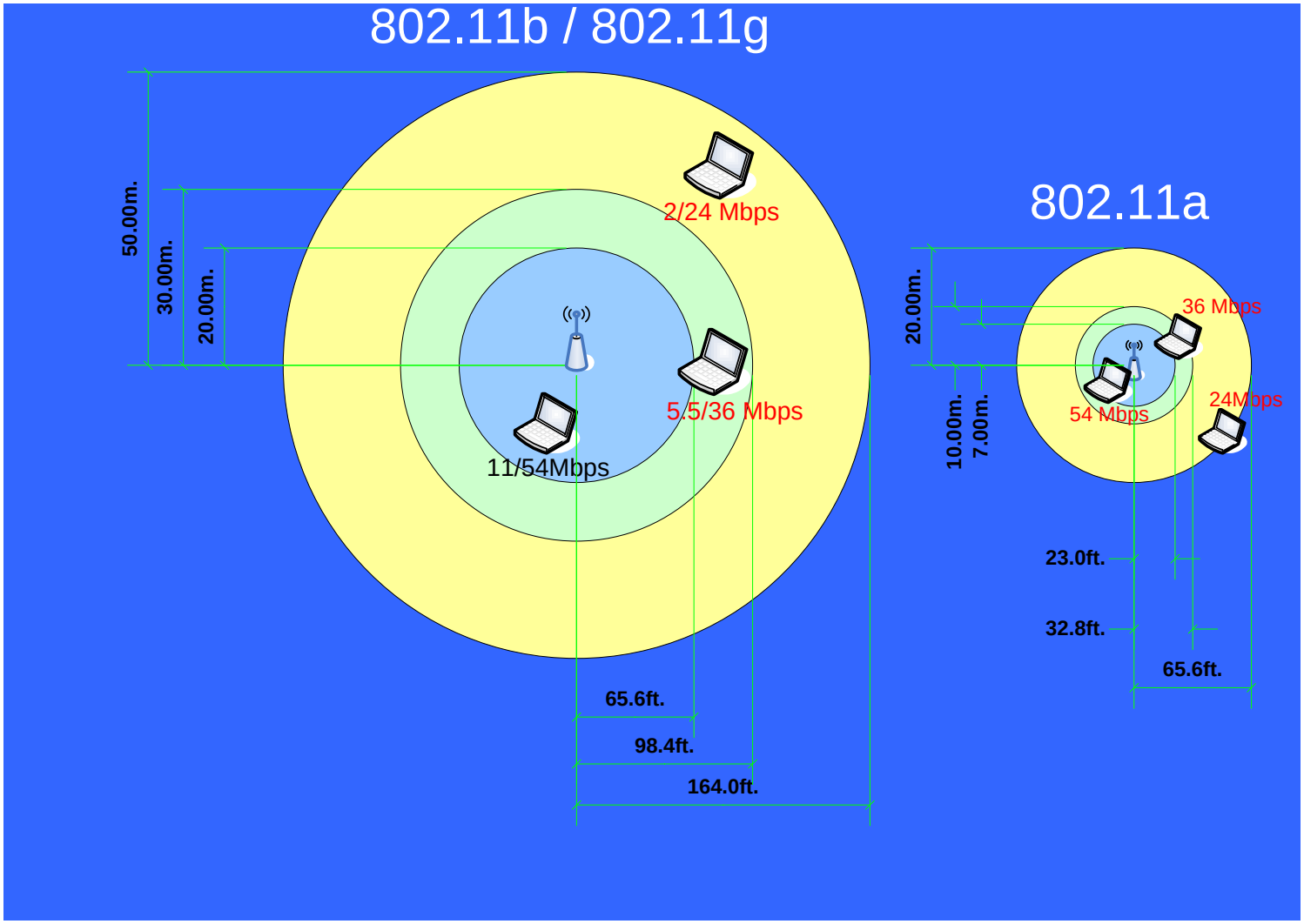






"The HomePNA™ Alliance develops triple-play home networking solutions for distributing entertainment data over both existing coax cable and phone lines. "

Wireless



WiFi Uses - Subscriber Issue:

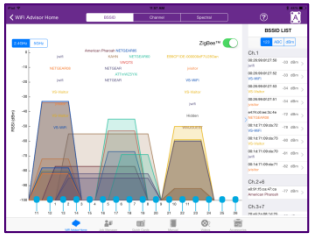
- Can’t maintain good connection to wireless access point (AP) or Slow surfing speed
  - Tech checks the following on the subscribers network
    - If Signal strength at location of interest is low – Move the AP
      - Avoid large distances or obstructions that can weaken the WiFi signal
        - Brick/Concrete/Metal Walls, appliances, or furniture can absorb or deflect WiFi signals
      - WiFi signals typically transmit at the same level in all directions so placing the AP in a more central location allows for the most coverage
    - Identify a less occupied channel and move the AP to that channel
      - If many networks use the same WiFi Channel they will conflict and cause slower surfing speeds on all networks on the same channel
      - Try to use non-overlapping channels to prevent the most conflicts
        - In the 2.4GHz range only channels 1, 6, and 11 do not overlap
    - Secure the WiFi network with Password protection
      - Unsecure, or Open, networks leave the subscriber open for anyone to use the WiFi network which could mean unauthorized users are using too much of the network’s available bandwidth – causing WiFi speed to slow down to the subscriber
      - Open networks are also potential security holes for hackers

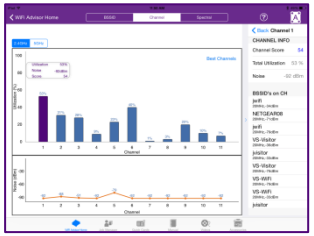
Typical Residential / SOHO WiFi Problems Addressed

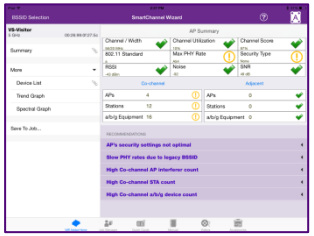
Problem	WiFi Advisor Solutions
▪ Signal Strength and Coverage Problems ▫ Attenuation with distance and materials in the home ▫ 5GHz has shorter reach than 2.4 GHz	RSSI, SNR, noise trending and throughput testing
▪ 802.11 Interference Sources ▫ Co-Channel interference (forces your AP to share the channel) ▫ Adjacent Channel interference (looks like noise to your AP)	Co / adjacent channel occupancy visualization & analysis
▪ Non-802.11 Interference Sources ▫ Microwaves, AV transmitters, cordless phones, baby monitors, etc.	2.4 & 5 GHz Spectrum Analyzer
▪ High Channel Utilization: ▫ The more AP's in a channel the higher the *potential* utilization ▫ High utilization, low noise = high 802.11 traffic on the channel ▫ High utilization, high noise = potential non-802.11 interferer	Channel utilization & noise analysis
▪ 802.11a/b/g devices in your network ▫ Slow a/b/g PHY rates occupy the channel longer than modern PHY rates for the same amount of information transfer ▫ Old security types (WEP) limit connection to lower 802.11 rates	SmartChannel Wizard auto-detection & recommendations
▪ Understanding *real* WiFi Throughput is critical to reliable install ▫ Physical and Link layer results provide *indications* of actual WiFi throughput performance, but… ▫ WiFi is adaptive. *Actual* performance is dependent on many environmental factors and under-the-hood design complexities	Whole-Home Site Assessment and throughput margin testing

Single Ended!

WiFi Advisor Use Models



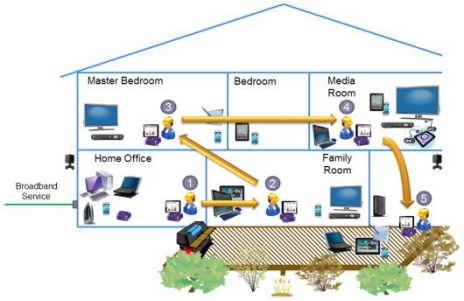


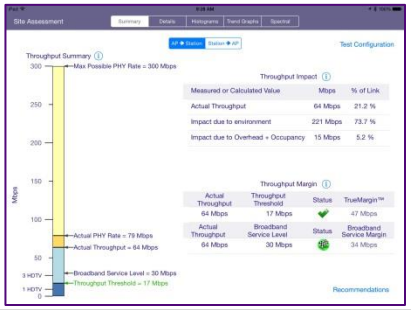


Single Ended Operation

Troubleshoot common WiFi problems quickly with:

- BSSID / Occupancy view
- Channel / Utilization view
- Spectrum Analyzer
- *SmartChannel Wizard* helps novice users optimize WiFi networks



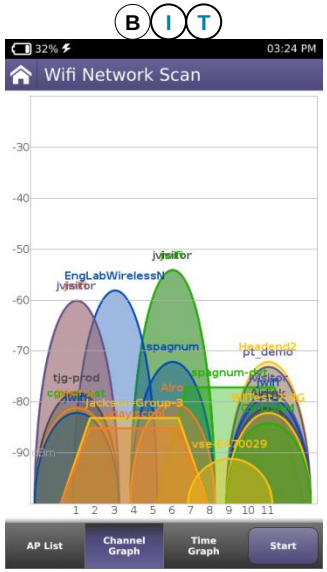


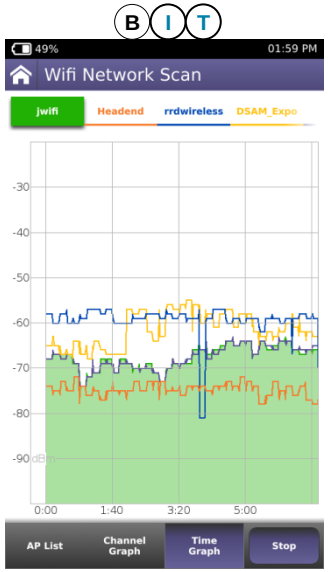
Dual Ended Operation

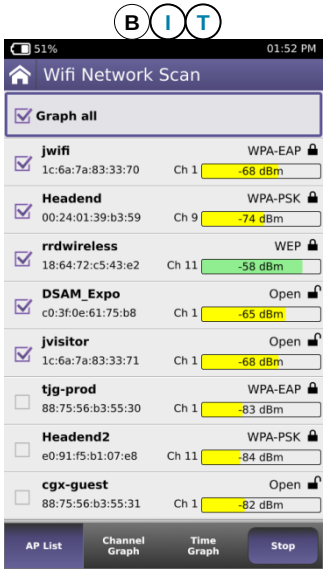
- Whole-Home Performance Testing
- Optimizes AP placement
- Ensures resilient WiFi network installation
- Identifies sources of WiFi degradation
- Educates / sets proper end-user expectations on real WiFi performance

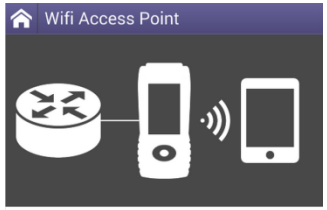
WiFi testing made easier

- **Wi-Fi testing made easier**
  - Integrated 802.11 a/b/g/n for 2.4 and 5GHz testing
    - SSID Scanning
    - Signal Strength over Time
    - Channel clearing
    - (future) External option
      - WiFi Advisor interface for TrueMargin, 802.11ac 3x3 and Site Assessment
  - WiFi Access Point
    - Test customer CPE for connectivity and provisioning









SSID:
JDSU-ONX-ARQA0000550003

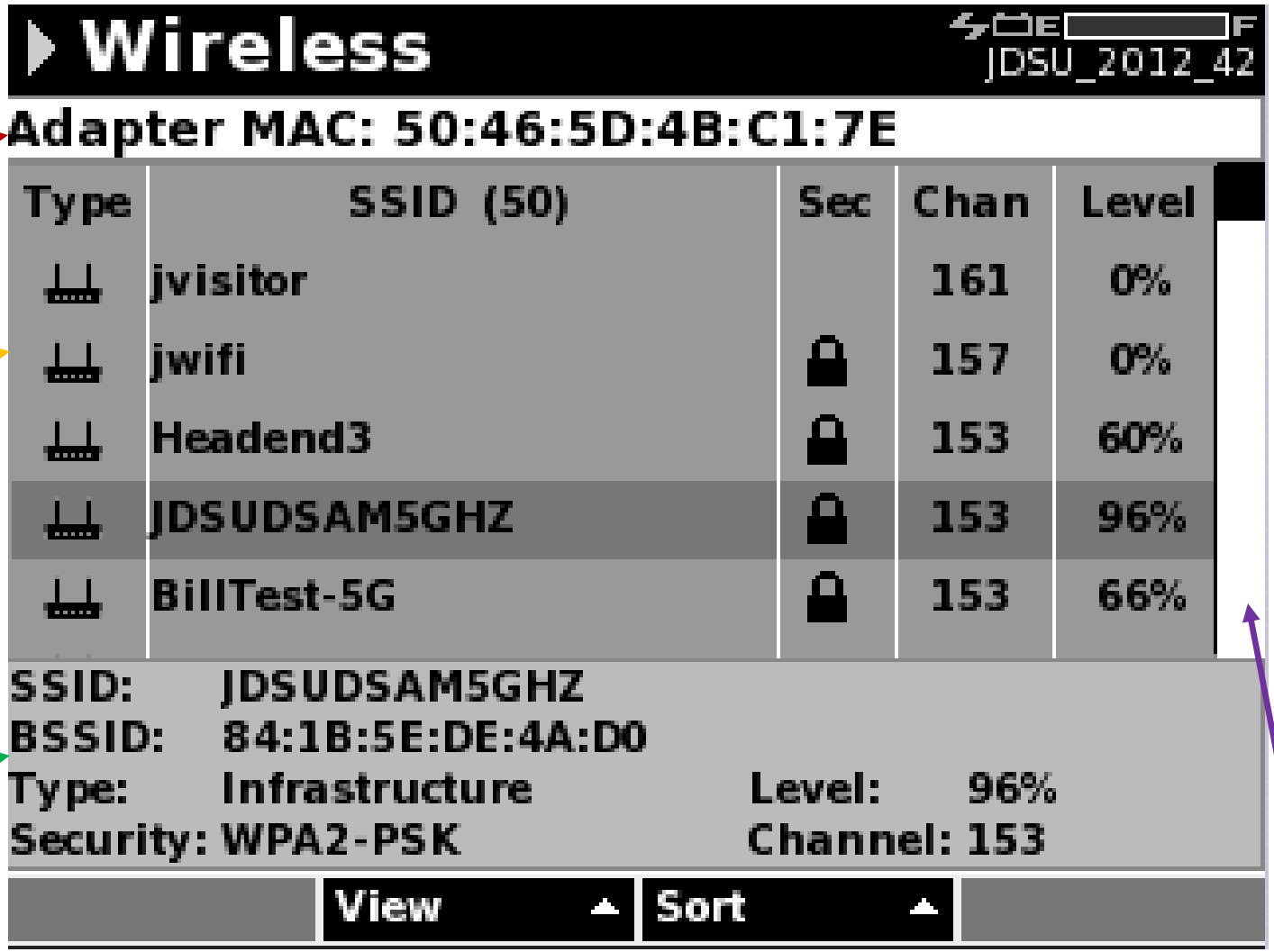
I T

Wireless Site Survey Screen

DSAM's WiFi Adapter MAC

List of WiFi networks detected

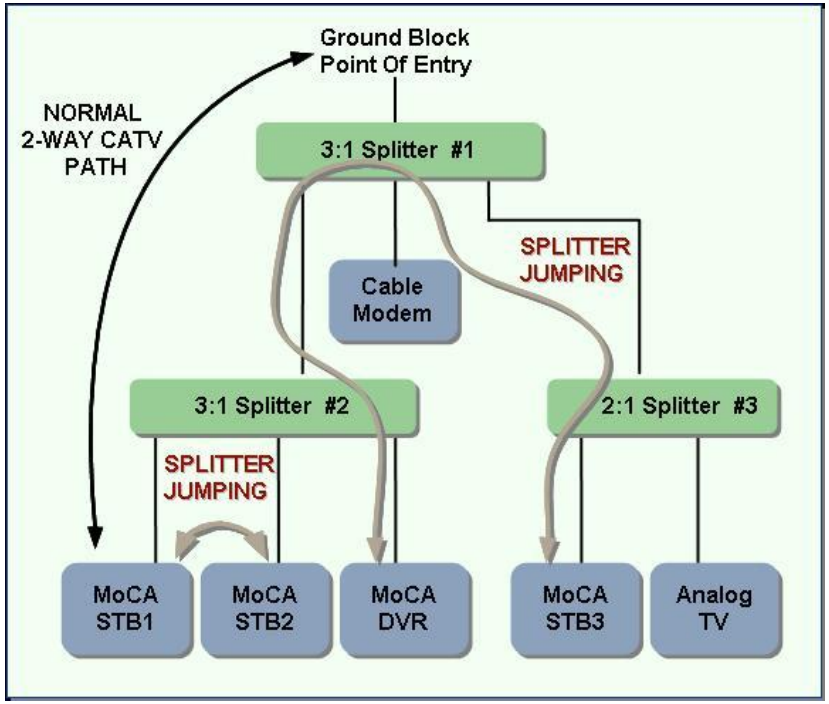
Highlighted Network's Information



Scroll bar indicated that more networks than can be displayed are available for viewing

What is MoCA?

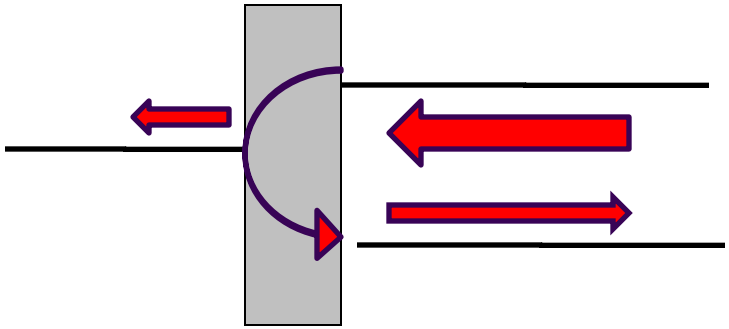
- Stands for: Multimedia over Coax Alliance
- Main applications:
  - **Whole Home DVR**
  - **Connect IP enabled devices**
- MoCA is very robust
  - 50-60dB of loss
- Excess Attenuation is the biggest killer of MoCA

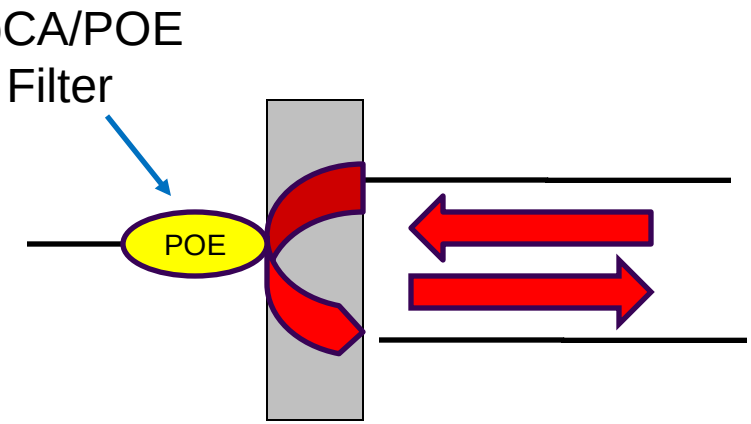


- Several Operators estimate that MoCA services will first be available end of this year or early next year

Point of Entry (POE) Filter

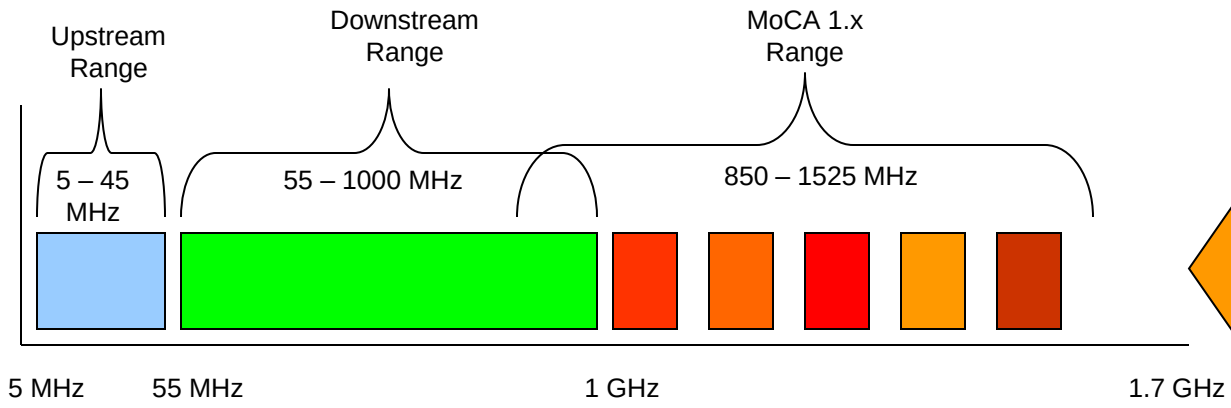
- A MoCA filter (aka: POE filter) performs two jobs.
  - First it removes the MoCA signal from entering a neighbors house
    - Stops MoCA signal from leaving the home
  - Second it gives MoCA a point of reflection for the signal
    - MoCA relies on the signals to “bounce” output to output on splitters





MoCA Just Evolved to V2.0

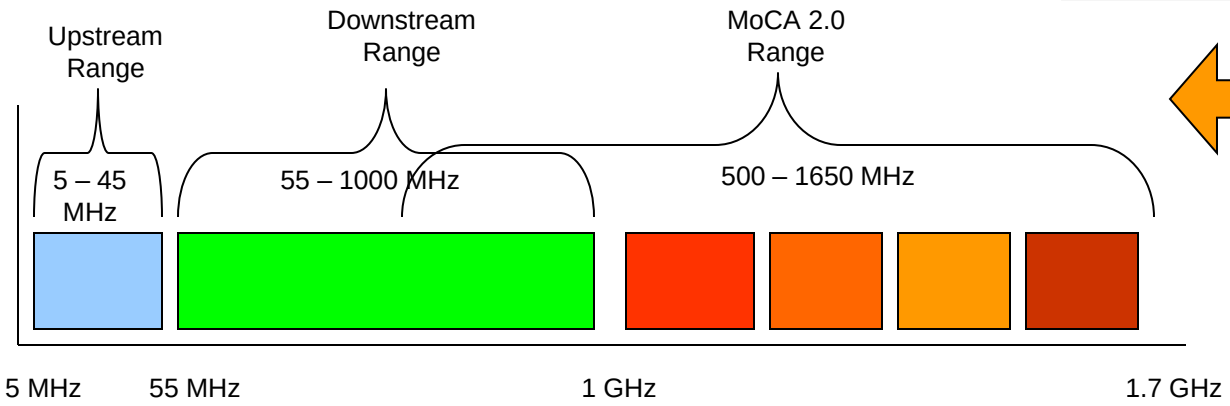
MoCA 1.x Frequency View



850MHz and 1.525GHz
50MHz wide 'channels'
Speeds up to 175Mbps

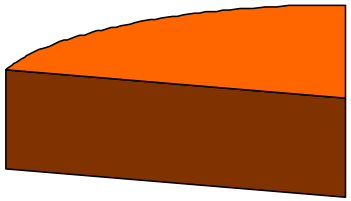
DIFFERENT HARDWARE

MoCA 2.0 Frequency View



500MHz and 1.65GHz
100MHz wide 'channels'
Speeds above 400Mbps

In-Home Wiring / Cabling 17%



	Potential In-Home Coax Network Impairment:
1	Bad Splitters
2	Too Many Splitters
3	Hidden Splitters
4	High Frequency Roll off of Splitter (rated @ or below 900MHz)
5	Poor Connector (Wrong type/Hex Crimp)
6	Impedance Mismatches
7	Loose Connection (Ingress)
8	Loose Connection (Intermittent Signal)
9	Lossy Cable
10	Broken Coax Shield (ingress)
11	Wrong Coax Path
12	Bad Barrel (or wallplate)
13	Corroded Barrel
14	Bad Box (STB, ONT, BHR) MoCA not working
15	Diplex filter or Directional Coupler instead of a splitter (Wrong Coax Element)
16	House Amplifier (1 or 2 way)
17	Provisioning Issues (STB, ONT, BHR)
18	Spliced Coax Cable (Ingress and signal loss)

Typical problems “Shorts, opens, cuts, connectors, corrosion”

RG – 6 Loss at 1.2 GHz = 3.5 + 3.5 + 3.5 + 3.5 + 30? + 4.5 + 4.5 + 7 = 60

50ft Rg-6 cable loss

Isolation of input splitter with reflection

Splitter loss

Dielectric

Worn

50ft F81 barrel STB with MoCA

Tap 100ft Splitter 50ft

STB with MoCA

50ft F81 barrel

Ground Block

STB with MoCA

F81 barrel

50ft

Corrosion

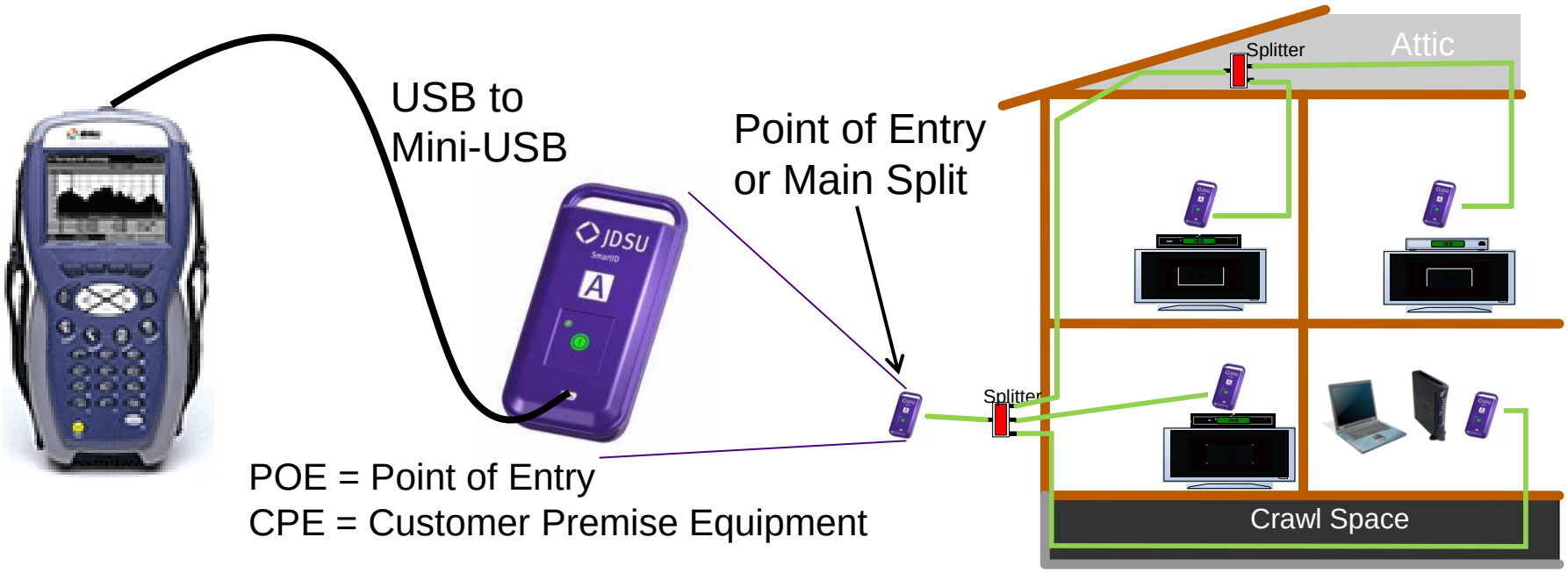
Cable modem

Shorted

Cut on Cable

Note: 28 cable connections

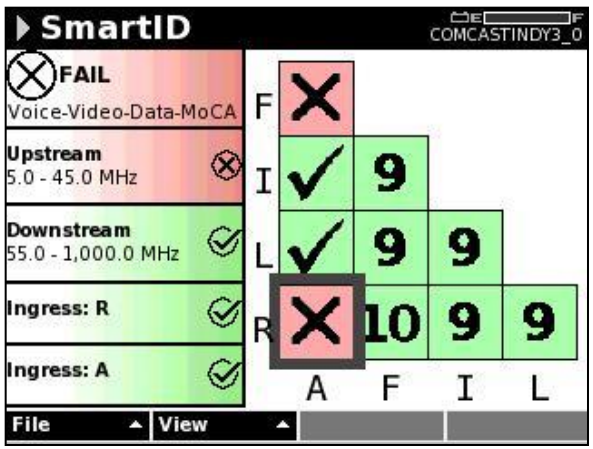
Verifying the Customers RF Network

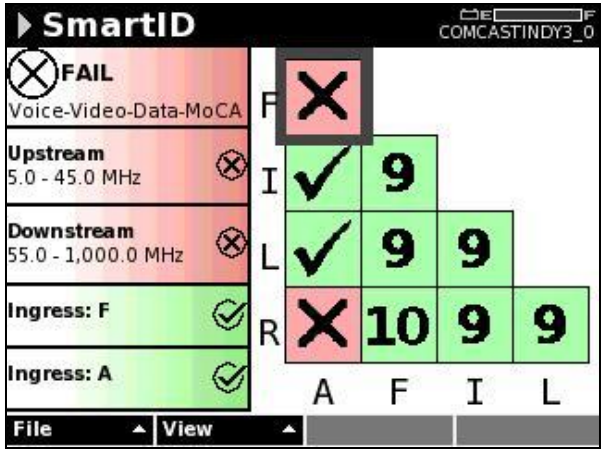


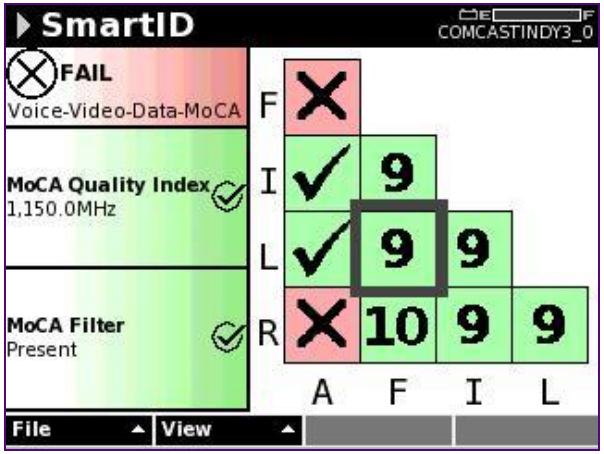
- Put a RF tester at each location inside the home where a Set-top-box or Cable Modem will be located (or is desired to be tested)
- Connect one RF Tester to the DSAM's USB port
- Then Connect that RF Tester to the POE looking into the home toward CPE (ie: drop cable, ground block, or main split)

Certify each Coax Path Independently Shortcut: Press #1

- Qualification Screen shows Pass/Fail
  - If all metrics pass the coax paths are good for the services its was tested against
  - If a failure exists then further action is required
    - The columns on the left indicate which parameters failed for the movable bold box – Different paths may have different results
    - Additional detail about the failure can be collected from the Detail and the Network Overview screens – Accessible by pressing View
    - A frequency response graph can be used to help determine why the result was failing the limits set by the test

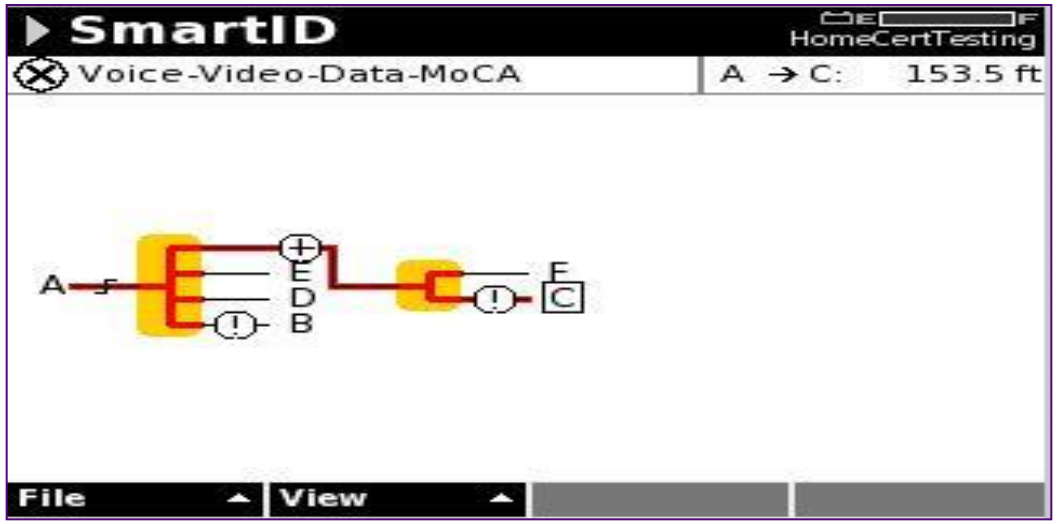






Seeing how everything is connected

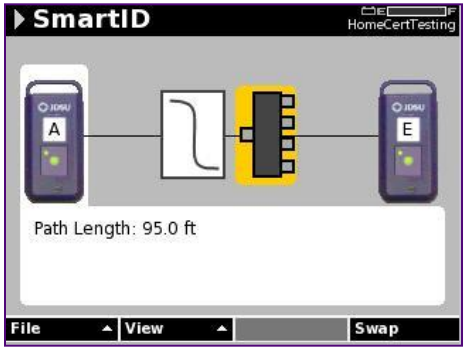
- Network Overview shows what is connected
  - RF Tester can determine what it believes is connected and where those elements have common connections
  - Each element is shown on the topology map including: splitters, filters, amplifiers, and found mismatches
  - Users can easily identify if unexpected elements are discovered and trace where those elements are located before beginning to troubleshoot the coax network

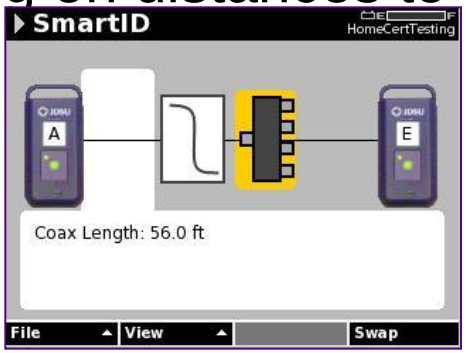


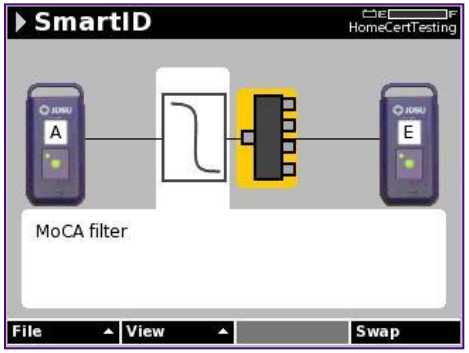
Details View

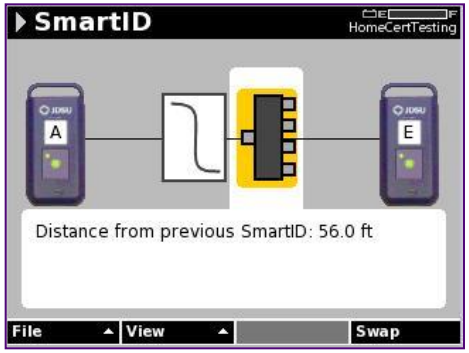
Shortcut: Press #2

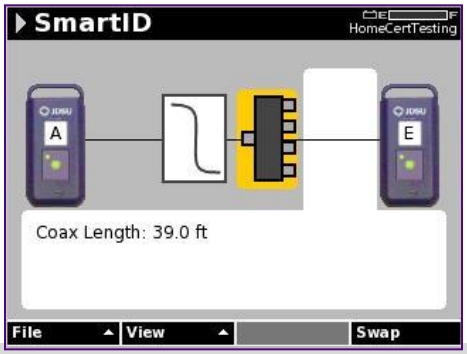
- Shows all items in the path between the two SmartIDs Shown – Arrow Left and Right to highlight different segments
- Each segment and element has additional information available in the text box
- Swap will reverse the orientation from left to right to ease understanding on distances to elements

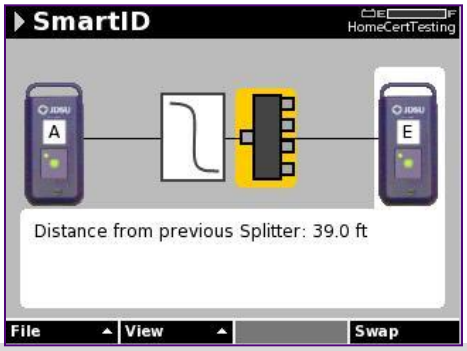


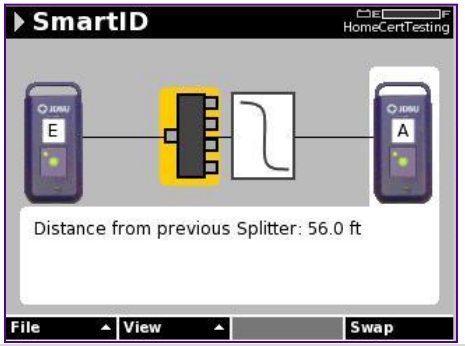










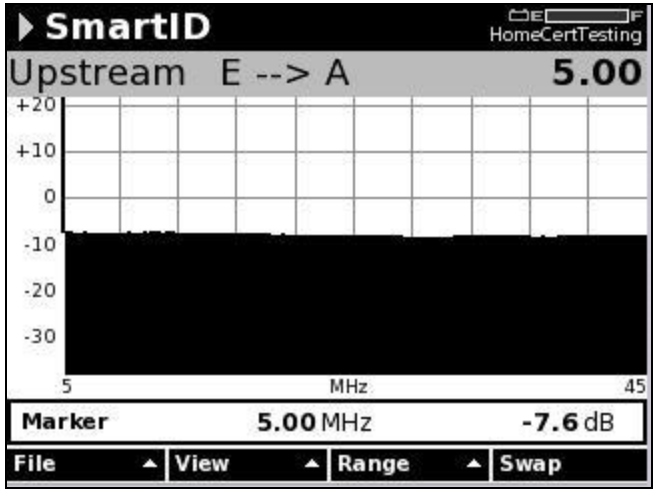


Swapped

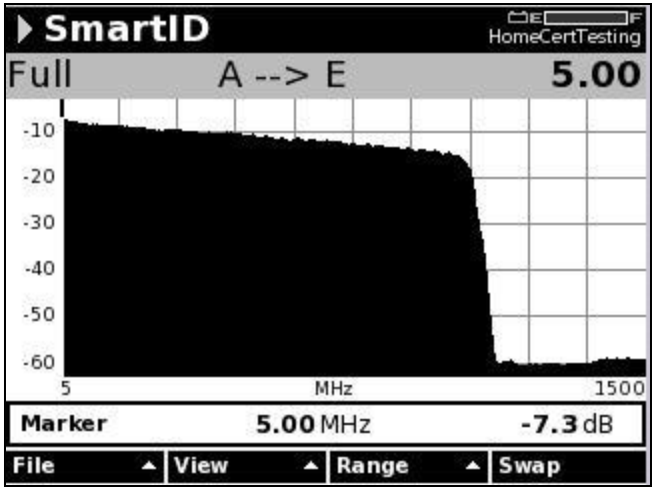
Sweep Trace – Freq Response

Shortcut: Press #4

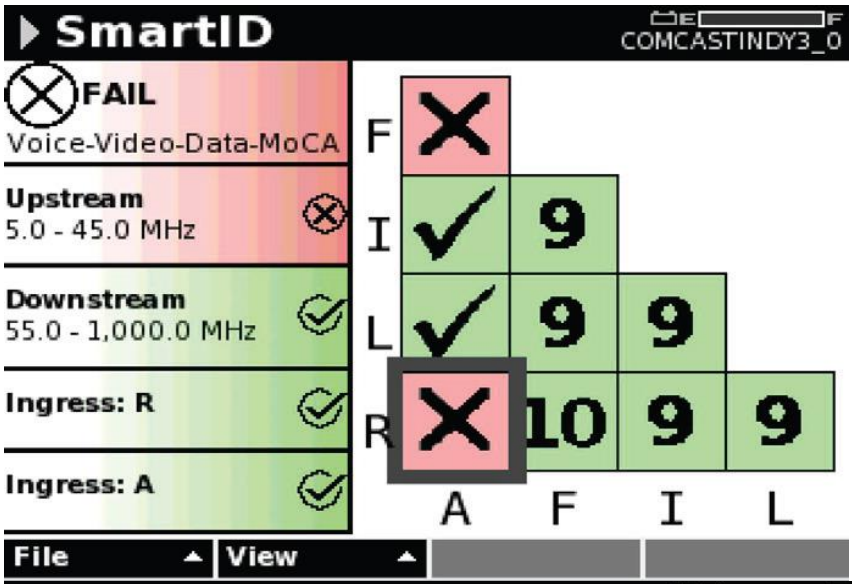
- Shows POE to CPE for Full and Upstream Sweeps
- User Arrow keys to See amplitude at a specific frequency
- Type in the specific freq on the keypad
- Press cancel button to go back

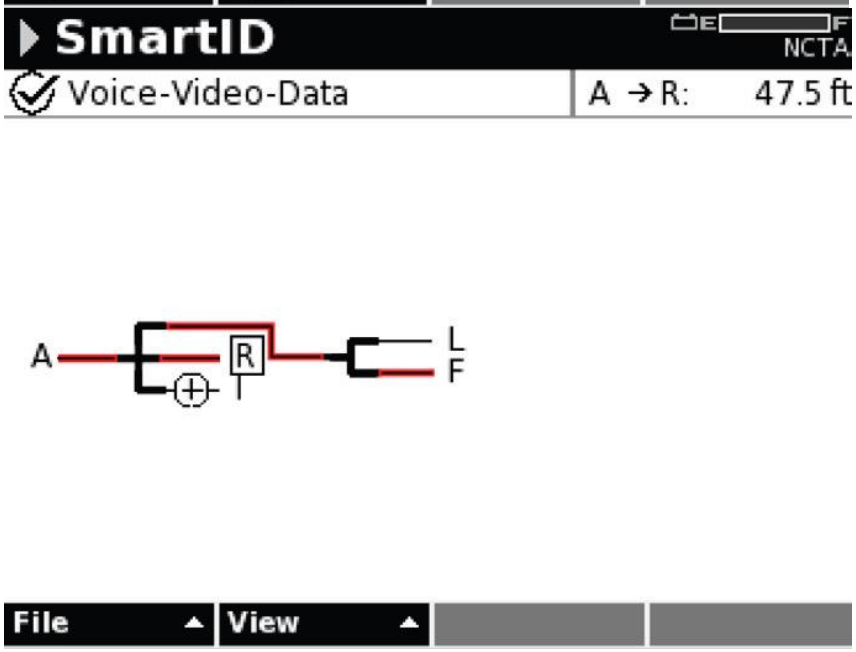


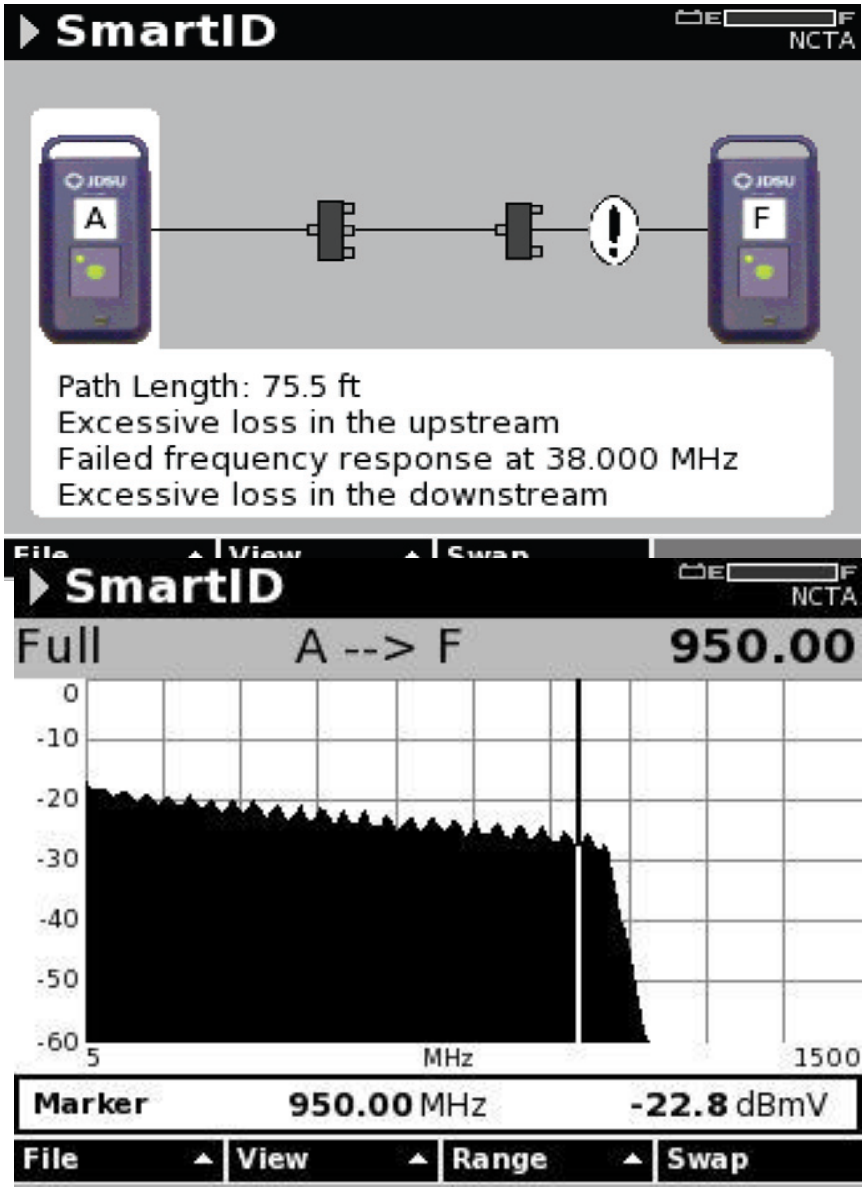
Upstream Freq Response



Downstream Freq Response – with MoCA filter in place







MQI score relate to data rate over copper infrastructure

Single Path Scores

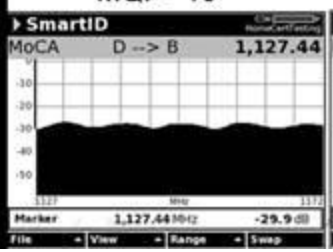
JDSU

Estimated Throughput	MQI Score
≥ 240	10
≥ 228	9
≥ 216	8
≥ 204	7
≥ 192	6
≥ 180	5
≥ 160	4
≥ 140	3
≥ 120	2
≥ 100	1
< 100	0

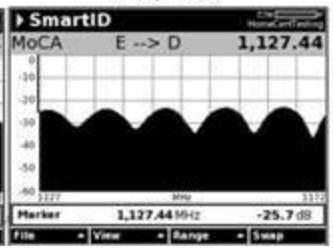
- Highest throughput is about 270
- Hard to get much over 250
- Modems seem to drop out when throughputs drop much below 100
- I wanted 180 to be the lowest acceptable throughput
- We may want to refine these thresholds

Qualifying MoCA
195KHz steps within the MoCA Channel at the subcarrier freqs

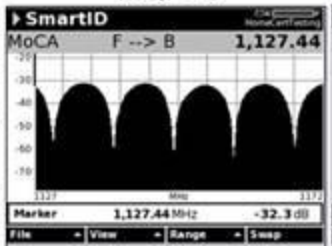
MQI = 10



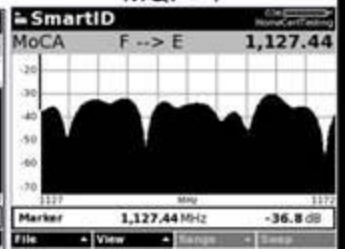
MQI = 9



MQI = 8



MQI = 7



How quickly can I move data from host to client Set top Box

Summary of In-Home Wiring Options

Service	Typical achievable Data Rate	Distances
MoCA	>100Mb/s typ. 140 MB/s max	>300 ft.
HPNAv3	86-128 Mb/s typ	>400 ft
802.11a/g	~10Mb/s Typical	~90 ft
802.11n	~40Mb/s Typical	~150 ft
HomePlug A/V	150 Mb/s Max published	<300 estimated
Wired Ethernet	100 Mb/s	300 ft

Fundamental Rule

- If the customers' cabling system within the residence has physical layer problems, it will not support the service!

- …no matter how good the offering is or how much technology was applied outside the home/apartment.

- Troubleshooting Customer's network is by invitation only.

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

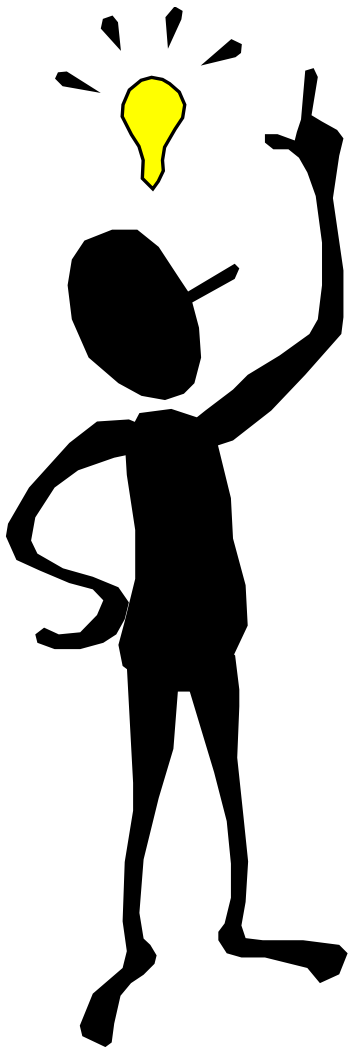
Back to the Basics

- 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 – Critical for Frequency Response.
- Understand which Tests To use Troubleshoot

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

A 7/16” wrench is a “hi-tech” tool?!



“Finger tight ain’t good enuff!”

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Questions?

Mark Ortel

Sales Consultant Engineer

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