PIEDMONT CHAPTER
SCTE
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Proudly Presents March 16, 2022
Inside Plant Technical Training

The Connected Home - Ingress Test Equipment Training

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Viavi Solutions, Inc., Solutions Engineer

ENVISIONING THE FUTURE OF CONNECTIVITY, TODAY.

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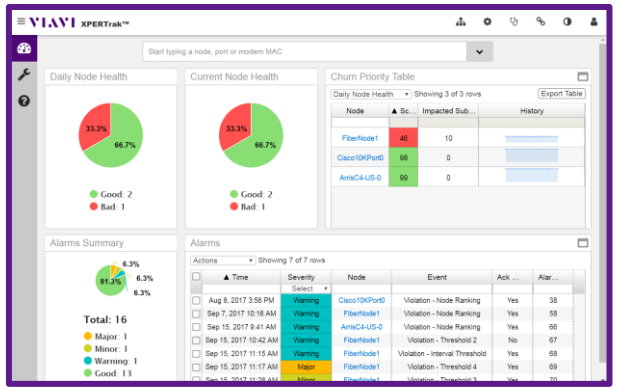
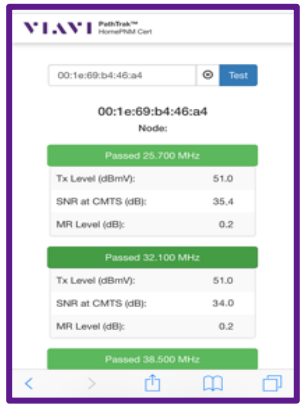
Tools for Resolving Issues

QoE Dashboards



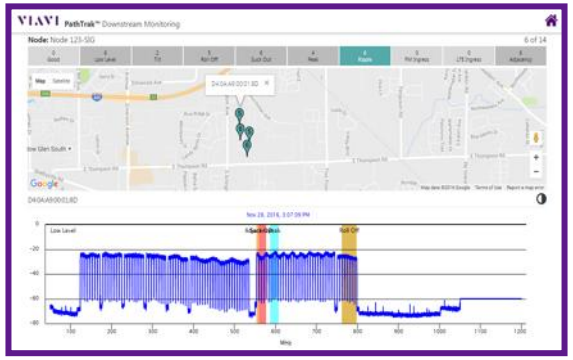
Spectrum

Home Check

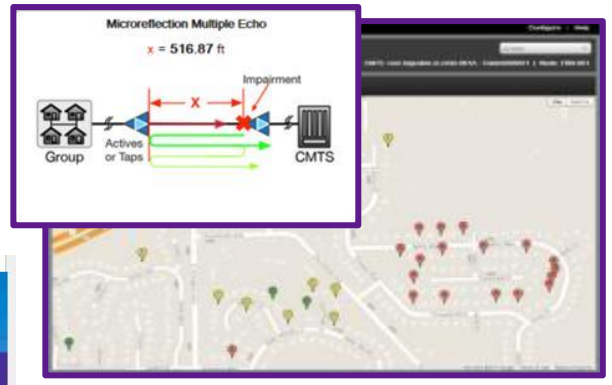


Signal Level Meter

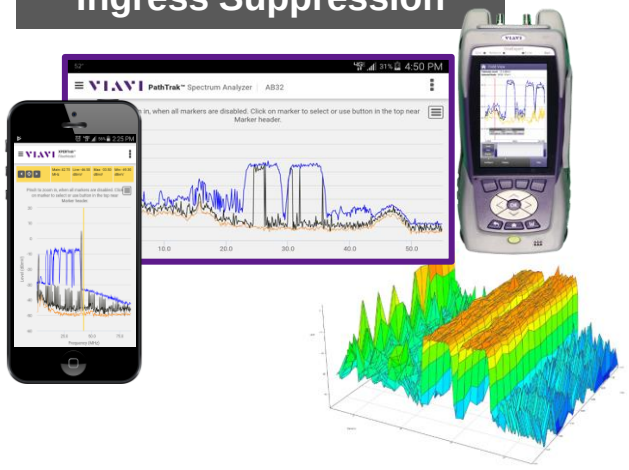
Downstream Localization



Upstream Localization

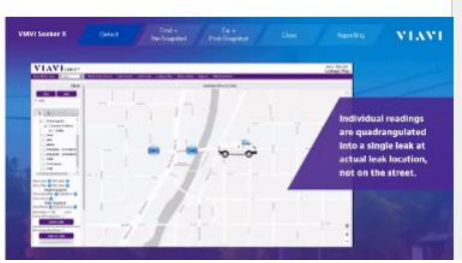


Ingress Suppression



DOCSIS

Leakage



What Noise Does to Our Work

- **Objectives:**
  - What is Noise?
  - What kind of noise is a in CATV Network?
  - What's in those QAM, OFDM, and OFDMA Signals
  - Why Noise Matters is a CATV network
  - Forward Path Noise
  - Return Path Noise
  - How to minimize the noise? Tools for the Job.
  - Live Cable Pressure Test

What is Noise? And why it matters?

Irregular fluctuations that accompany a transmitted electrical signal but are not part of it and tend to obscure it.

- Analogy
- I am talking across the room to another person, and he hears me just find until firetruck passes by the window. He says, “I did not hear everything you said when the truck went by”.
- Loss Of Information

Loudness Graph

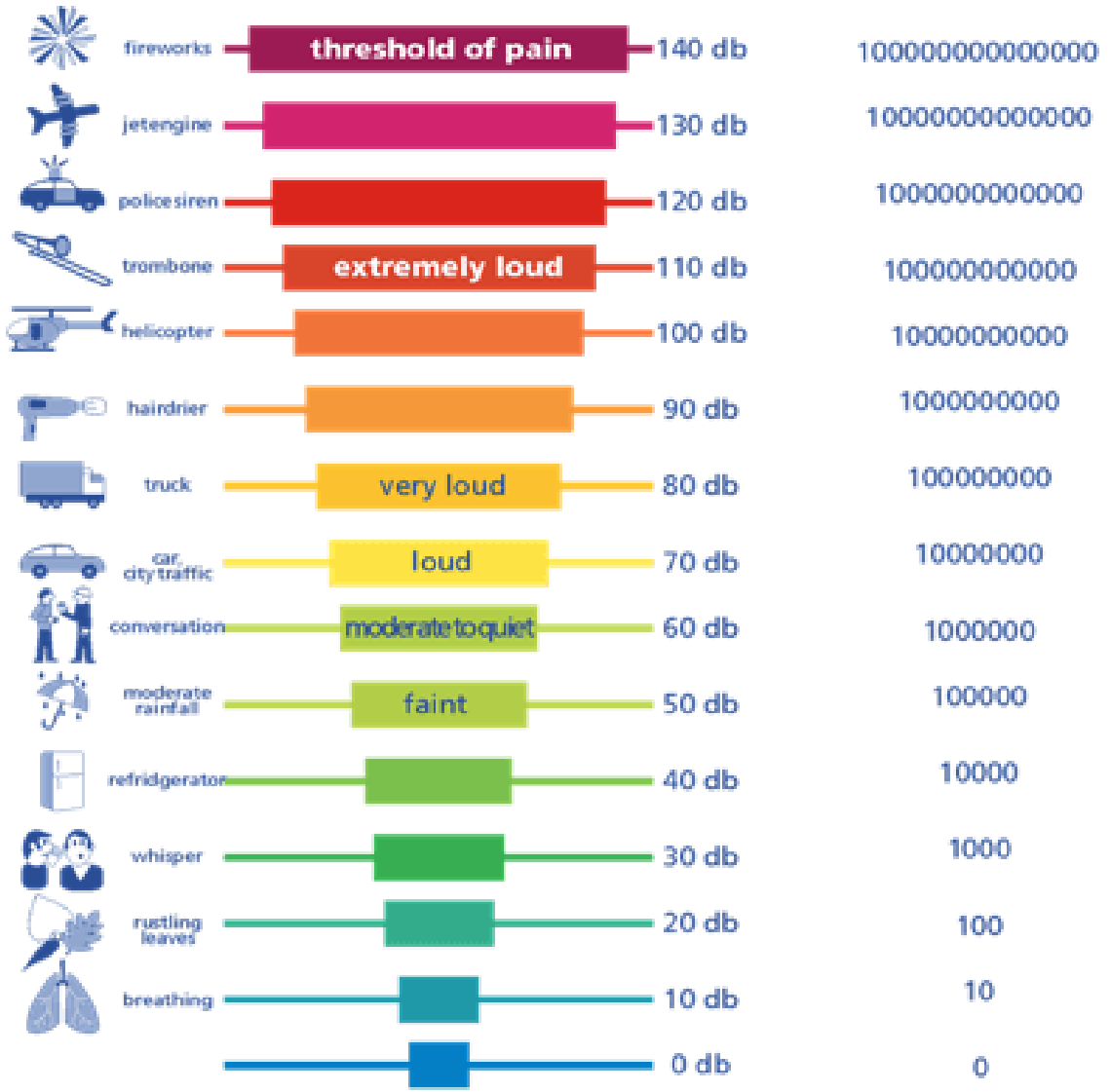
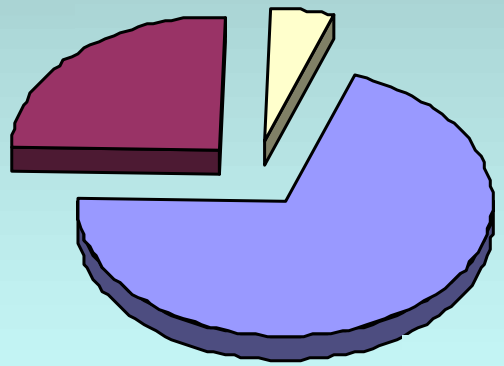


Image https://www.commodious.co.uk/knowledge-bank/noise/measuring-levels

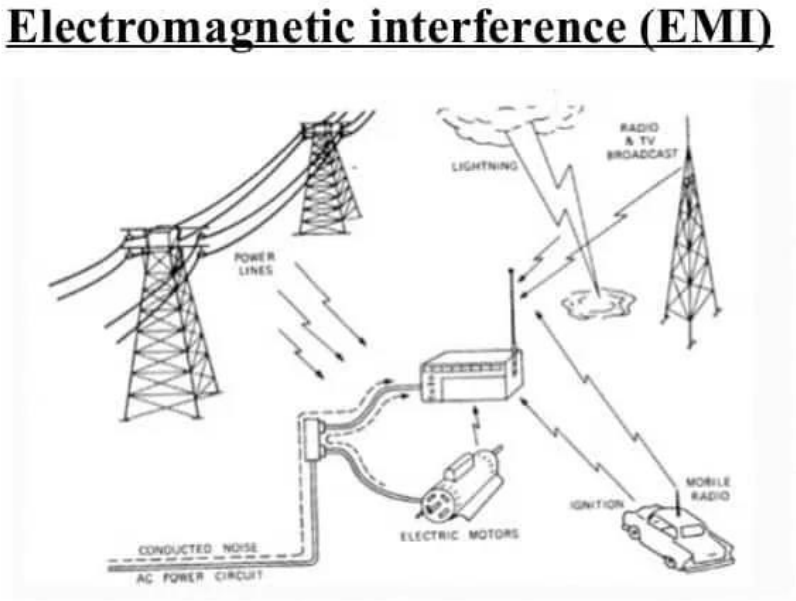
Where is the noise in CATV Network?

Where does ingress come from?



What is noise in a CATV System

- **Electromagnetic interference** (**EMI**), also called **radio-frequency interference** (**RFI**) *"the effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radiocommunication system, manifested by any performance degradation, misinterpretation or loss of information which could be extracted in the absence of such unwanted energy".*
  No. **1.166** of the ITU Radio Regulation



- The interference is created by some electrical source and is detects by radio receiver

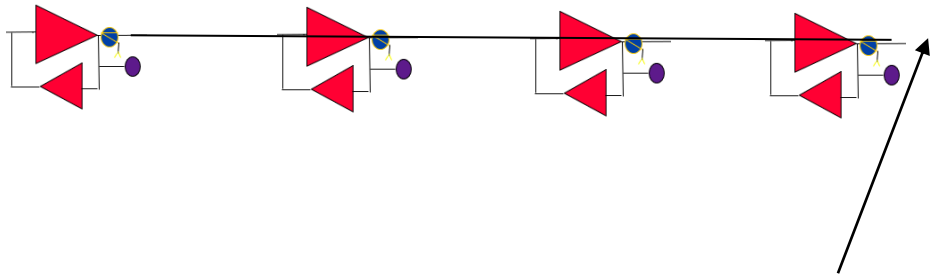
✓ Radiation – electromatic field
✓ Inductive – magnectic field
✓ Capacitance – electric field
✓ Conductance – conductive

Types of Noise

- Additive
  - Intrinsic/Stationery
    - Thermal noise
    - Composite Intermodulation noise (CIN)
    - Common path distortions (CPD)
    - Arcing impulse noise from connectors
  - Extrinsic
- Multiplicative

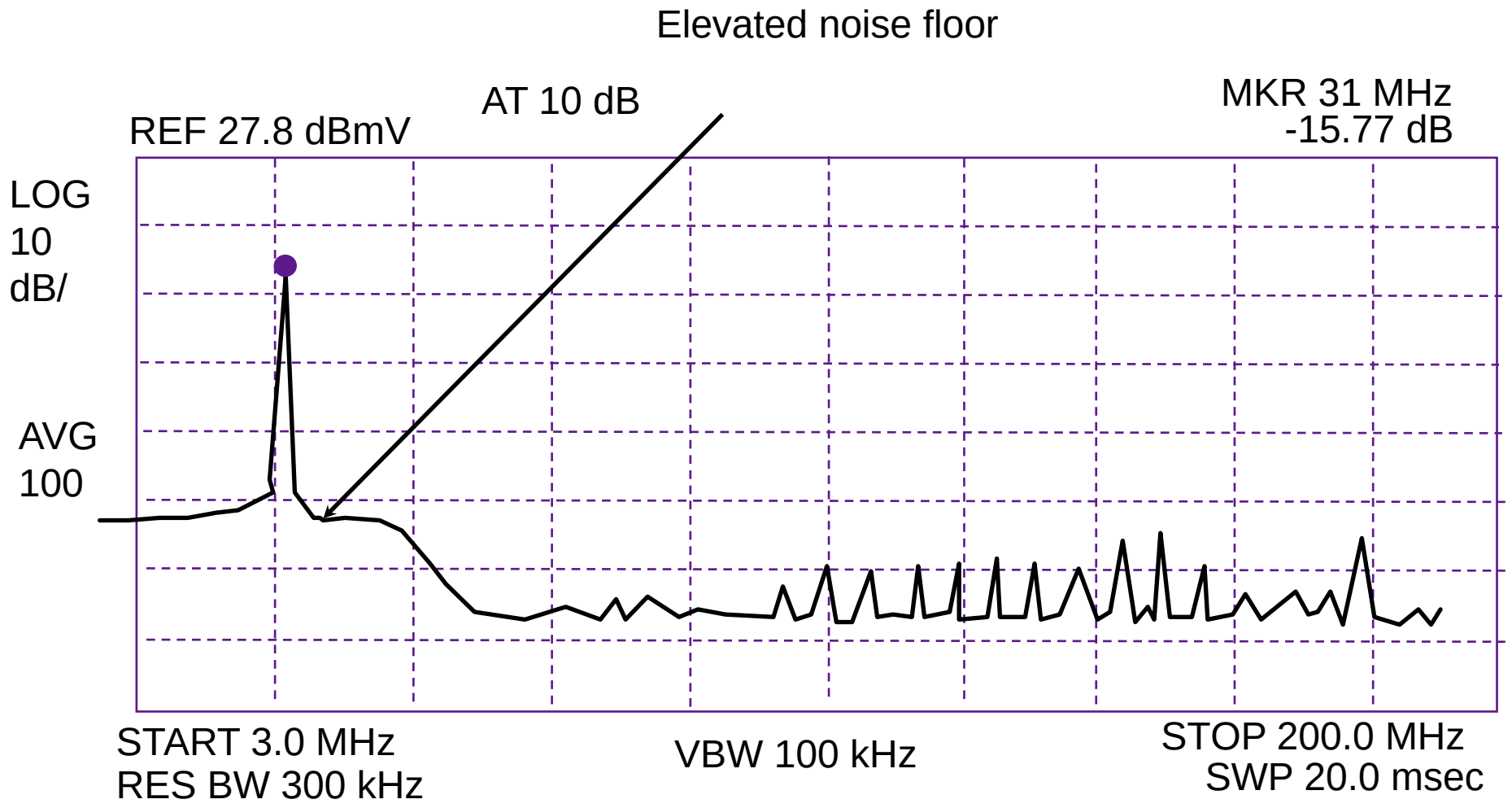
Thermal Noise Floor

- The noise floor in a 4 MHz BW =
  - -59.4 dBmV
- Noise floor in a different BW =
  - $10*\log(Data_{BW}/4) - 59$
- The noise contribution (NC) from the actives =
  - 10*log(# of amps w/similar (NFs)) + NF
- Factor in dissimilar NFs to get the overall noise floor
  - $10*\log(10^{NC1/10} + 10^{NC2/10} + \ldots)$
- Or use; $10*\log(A_1*10^{NF1/10} + A_2*10^{NF2/10} + \ldots)$
  - A_x = the number of actives with a certain NF
- Add the noise floor to the noise contribution



Noise Floor increases

Thermal Noise

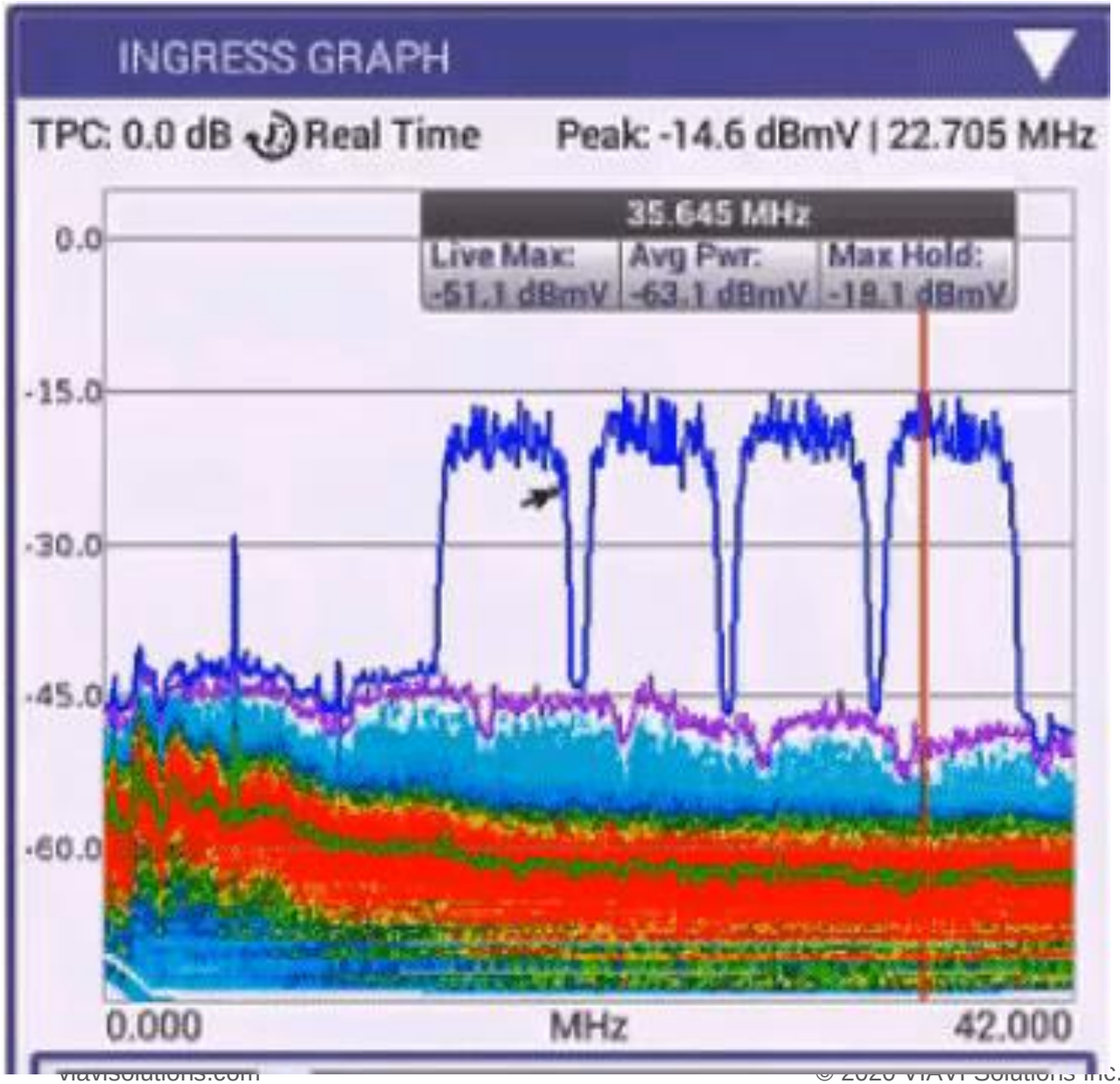


Common Path Distortions (CPD)

- Non-linear mixing from a diode junction
  - Corrosion
  - Dissimilar metal contacts
  - 4 main groups of metals
    - Magnesium and its alloys
    - Cadmium, Zinc, Aluminum and its alloys
    - Iron, Lead, Tin, & alloys (except stainless steel)
    - Copper, Chromium, Nickel, Silver, Gold, Platinum, Titanium, Cobalt, Stainless Steel, and Graphite
- Second and third order distortions
- CPD will make MER worse for forward performance

Common Path Distortions

Over driving an amp can have a similar effect



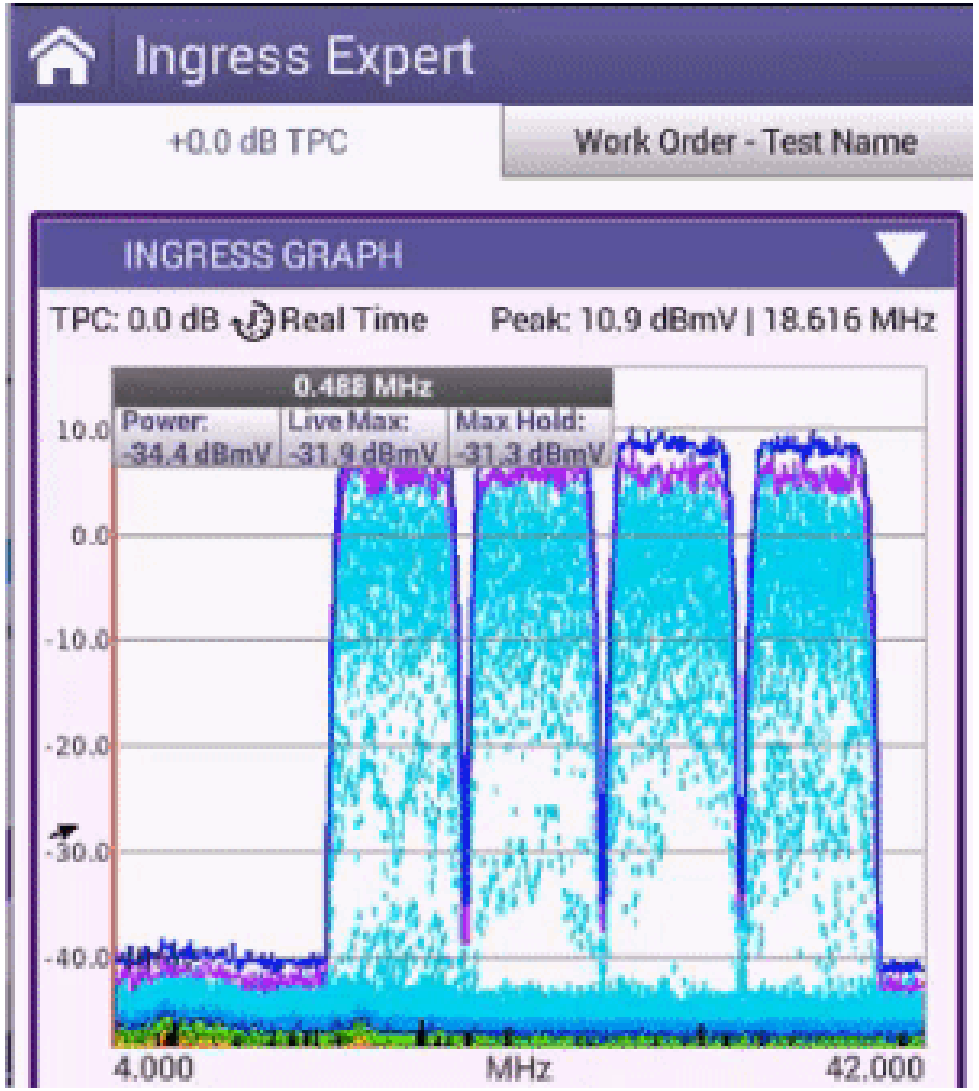
Additive Impairments

- Intrinsic

- Extrinsic
  - Impulse/burst noise
  - Ingress
  - Compression and laser clipping

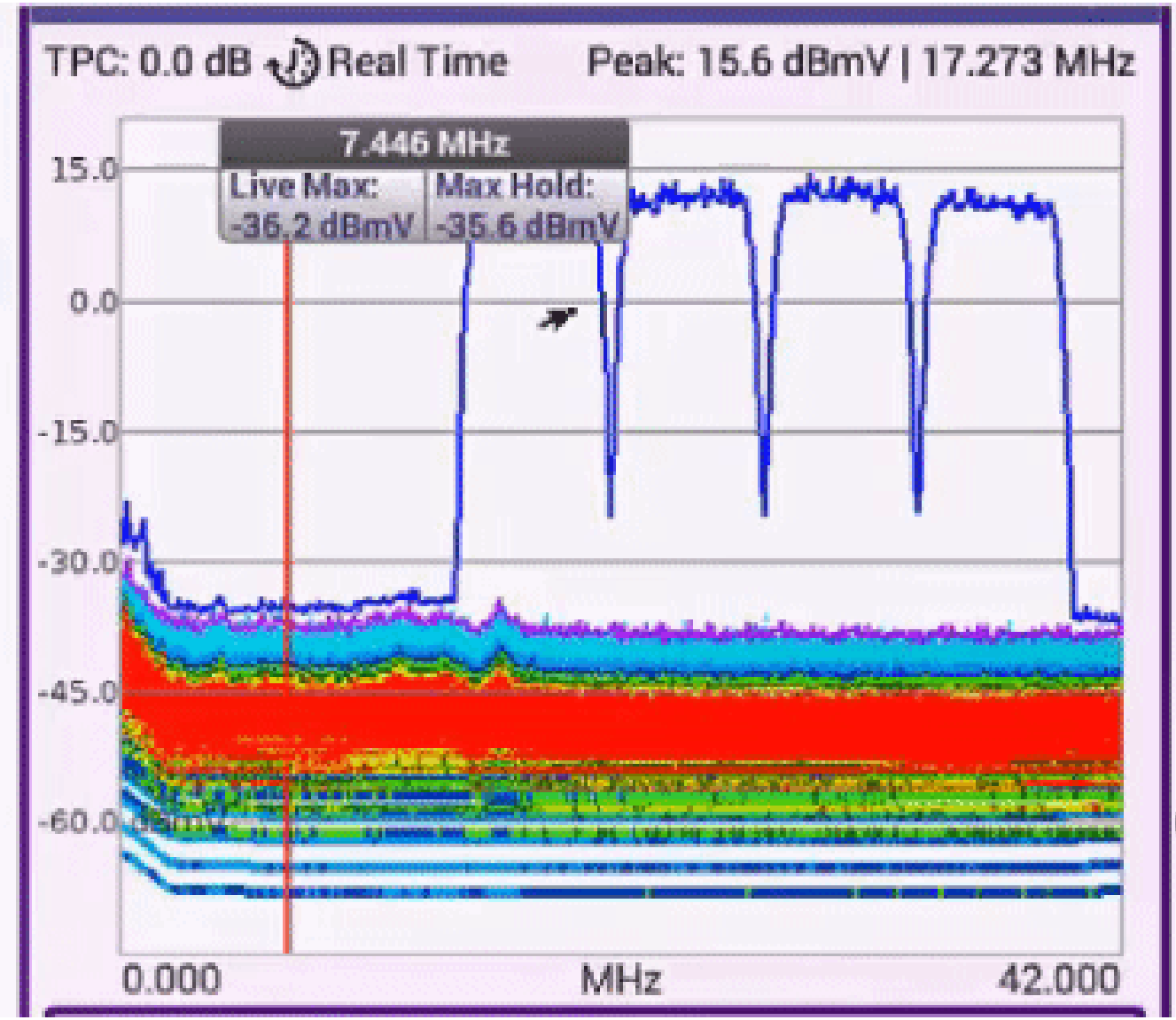
Impulse Noise

- Fast rise time, short duration
  - < 10 microseconds
- Significant energy contribution
- Sources include most household appliances



Impulse Noise Sources

- Electronic motors and switches
- Electric blankets
- Power lines and static from lightning
- Bug zappers
- Neon lights
- Vehicle ignitions
- Arc welders and industrial machinery
- Computers and games



Ingress Sources

- Common IF of most FM Rxs @ 10.7 MHz
- Poorly shielded TVs
- Computer CPUs with video cards installed
  - 25 or 33 MHz
- Short-wave radio / Voice-of-America
- Ham radio operators @ 7 - 30 MHz
  - 7-7.3 MHz, 10.1-10.15, 14-14.35, ~18, 21-21.45
  - 24.89-24.99, and 28-29.7 MHz

Wireless Ingress

- CB @ 27 MHz
- Garage door openers ~300 MHz
- Electronic car door locks? ~ 300 - 315 MHz
- Radio controlled cars 27 & 49.86 MHz
- Land mobile “Walkie Talkies”
- Meter reading equipment? ~ 900 MHz
- Pagers / Intercoms / Cordless phones

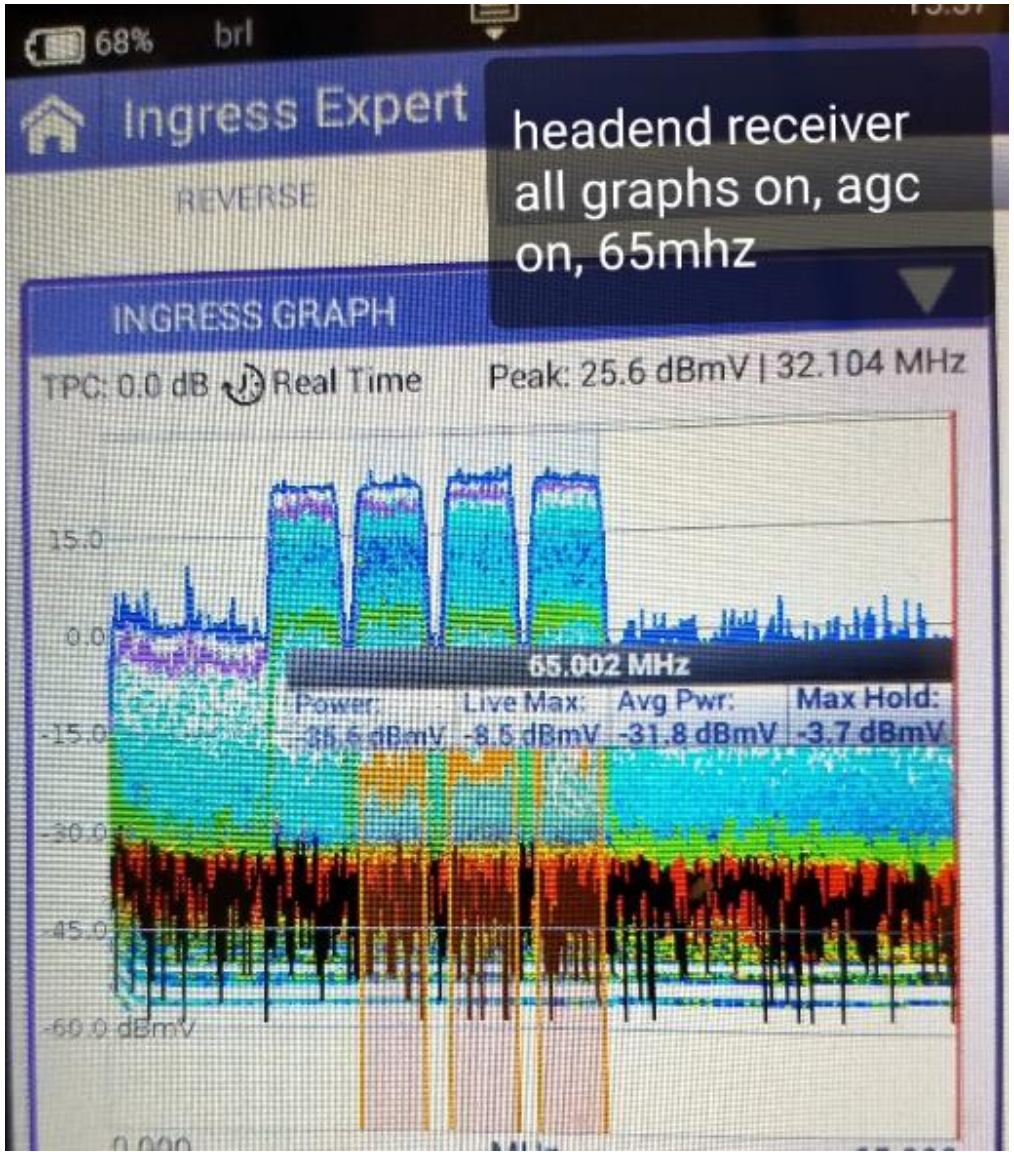
More Ingress Contributors

- Passives with poor isolation (FM radio)
- Do-it-yourselfers
- “Finger tight, ain’t good enough”
- “Good buddy, CB’er with a linear amp”
- Faulty grounds & grounding systems

Laser Performance - Distortion and Clipping

- Overdriving a laser with excessive signal causes clipping in the laser
  - This produces Intermodulation distortions that appear as noise called **Composite Intermodulation Noise** (CIN)
  - CIN adds on a 20log basis when levels are changed
  - CIN cascades on a 20log basis
- Thermal noise and CIN add on a 10Log basis
  - **Carrier-to-Composite Noise Ratio** (CCNR)
- At lower levels, CNR is dominant
- At higher levels, CCNR is dominant

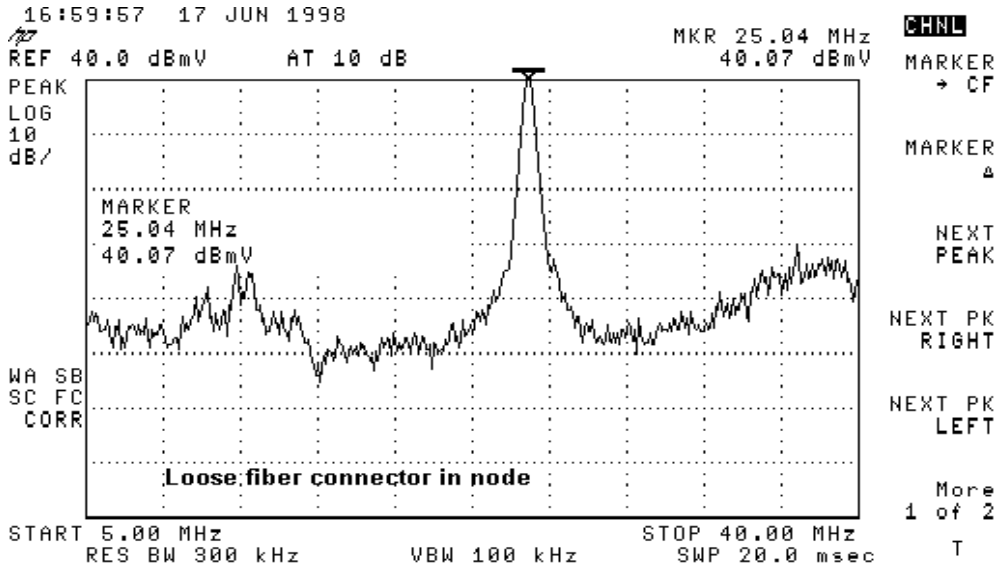
Laser Clipping



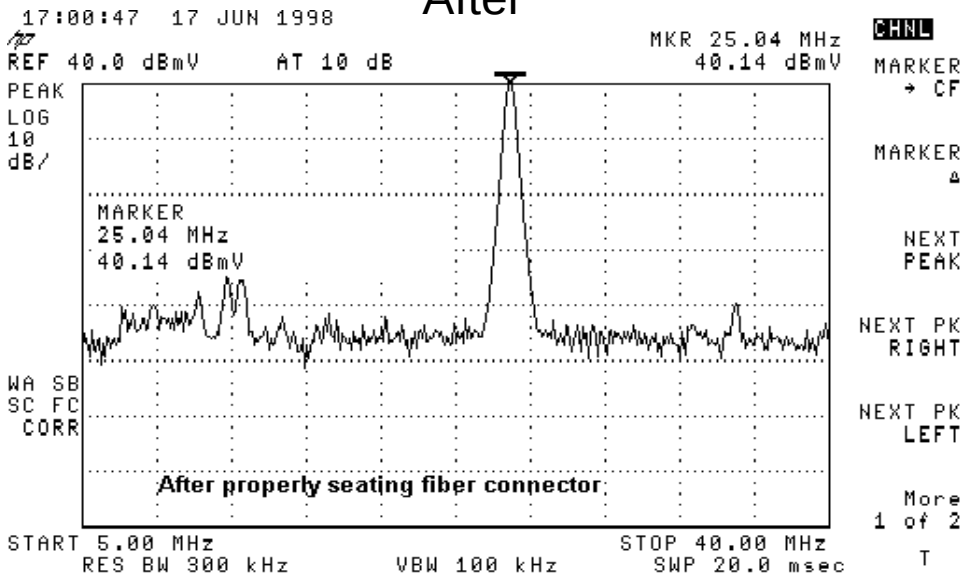
Loose Fiber Connector

- SC connector not pushed in all the way

Before

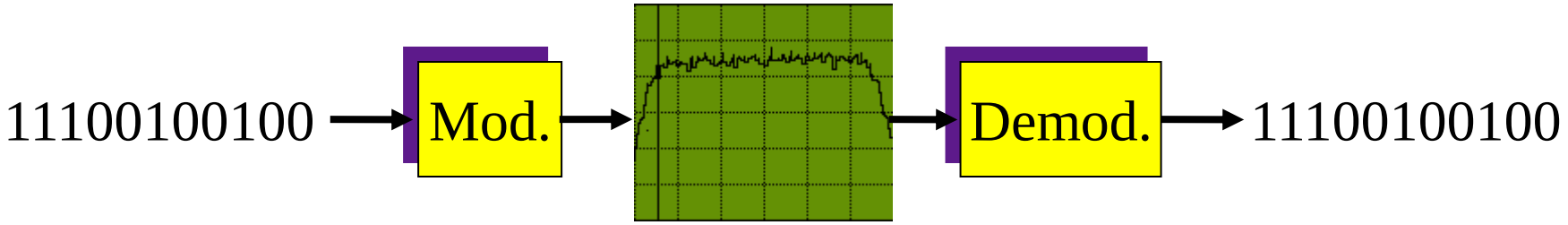


After



Analog to Digital and Forward Path Noise

Digital Signals



→Amplitude Shift Keying “ASK”

→Frequency Shift Keying “ FSK”

→Phase Shift Keying “PSK”

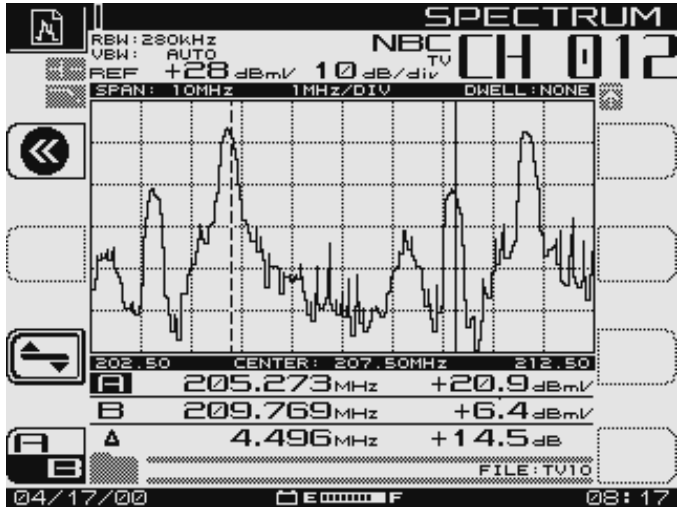
→Bi-Phase Shift Keying “BPSK”

→Quadrature Phase Shift Keying “QPSK”

→Quadrature Amplitude Modulation “QAM”

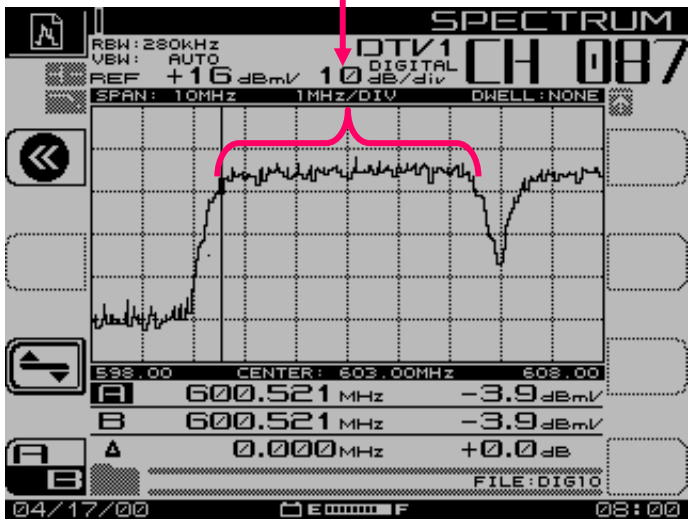
Why go Digital?

Analog Video Spectrum



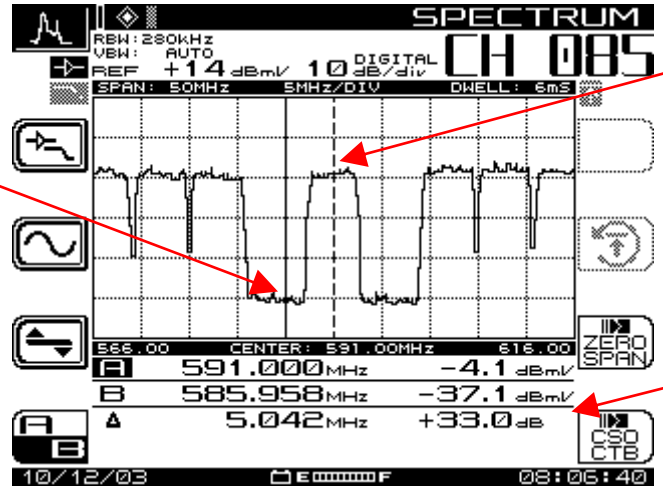
- 6 MHz Analog = 2 programs
- 1 video and audio

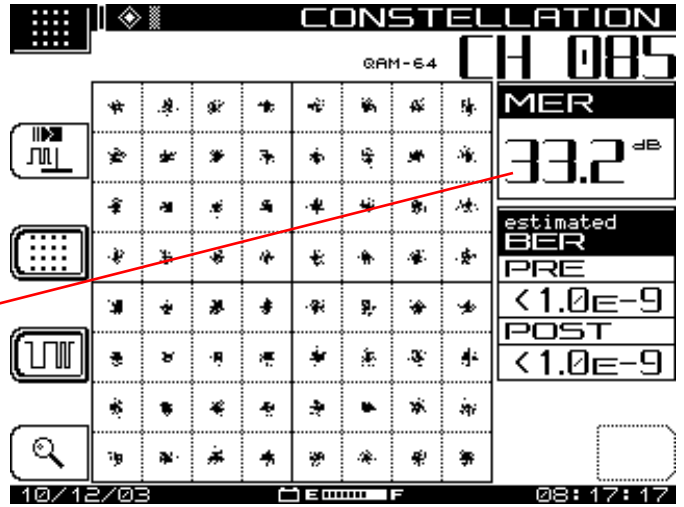
Digital QAM Spectrum

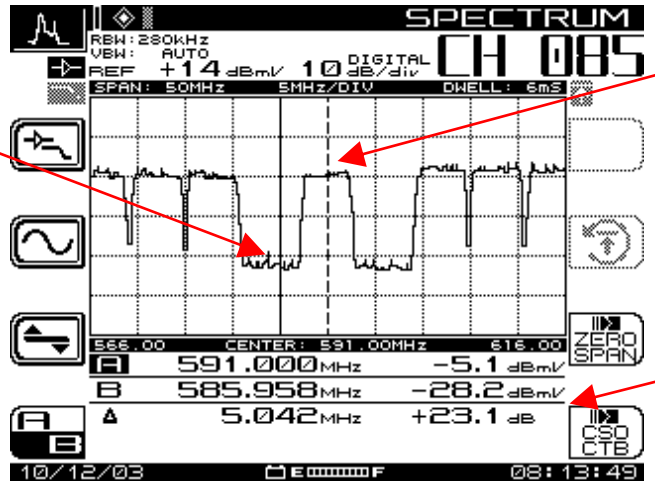


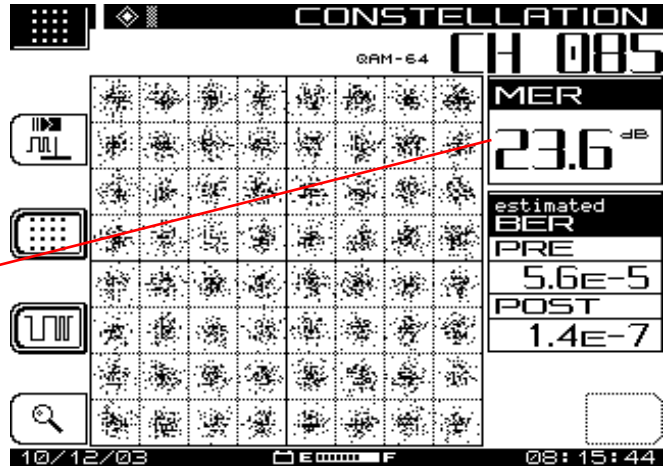
- 6 MHz Digital = 6 - 12 programs depending on compression factors
- Looks like a haystack

What Causes MER and BER to degrade?





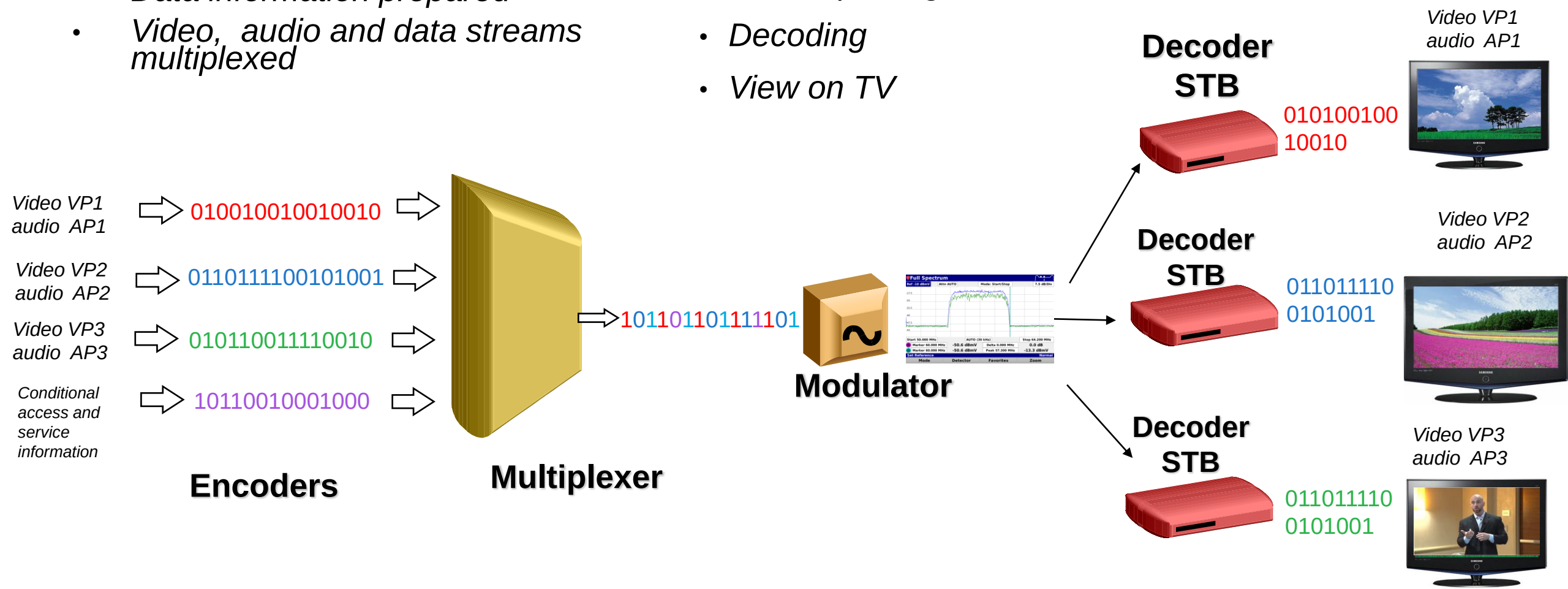




The Digital TV System

- *Video and audio source compressed*
- *Conditional access and service information added*
- *Data information prepared*
- *Video, audio and data streams multiplexed*

- *Transmission by cable/satellite/MMDS/terrestrial*
- *Demultiplexing*
- *Decoding*
- *View on TV*



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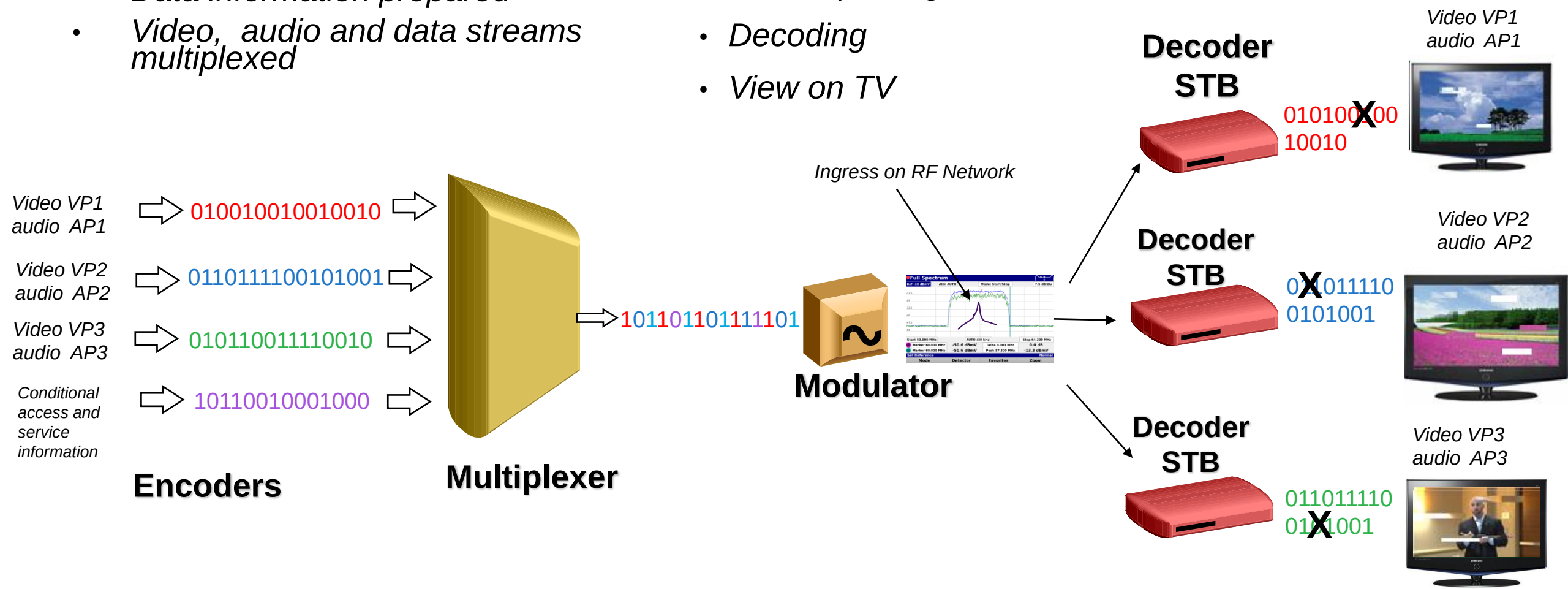
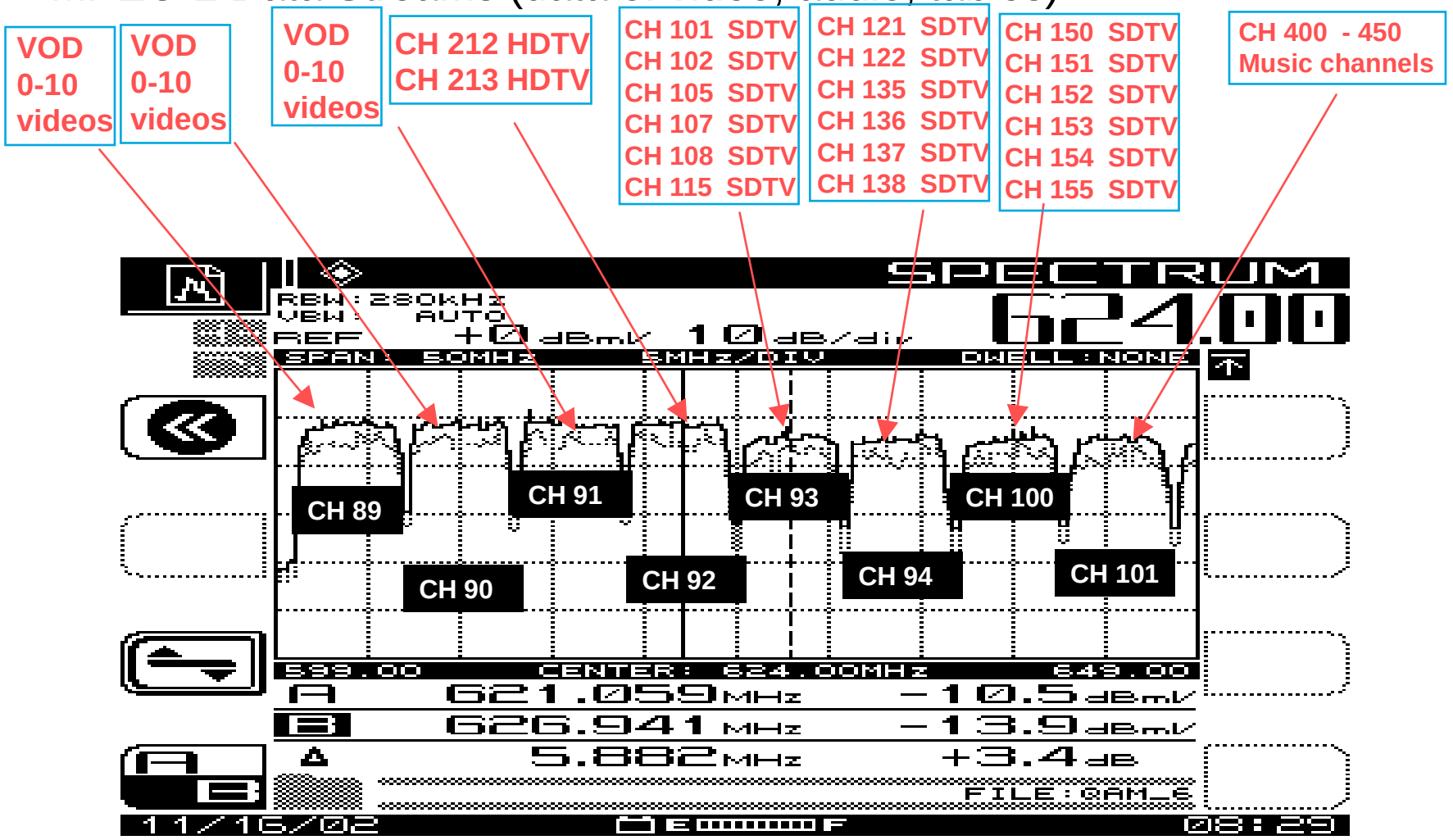
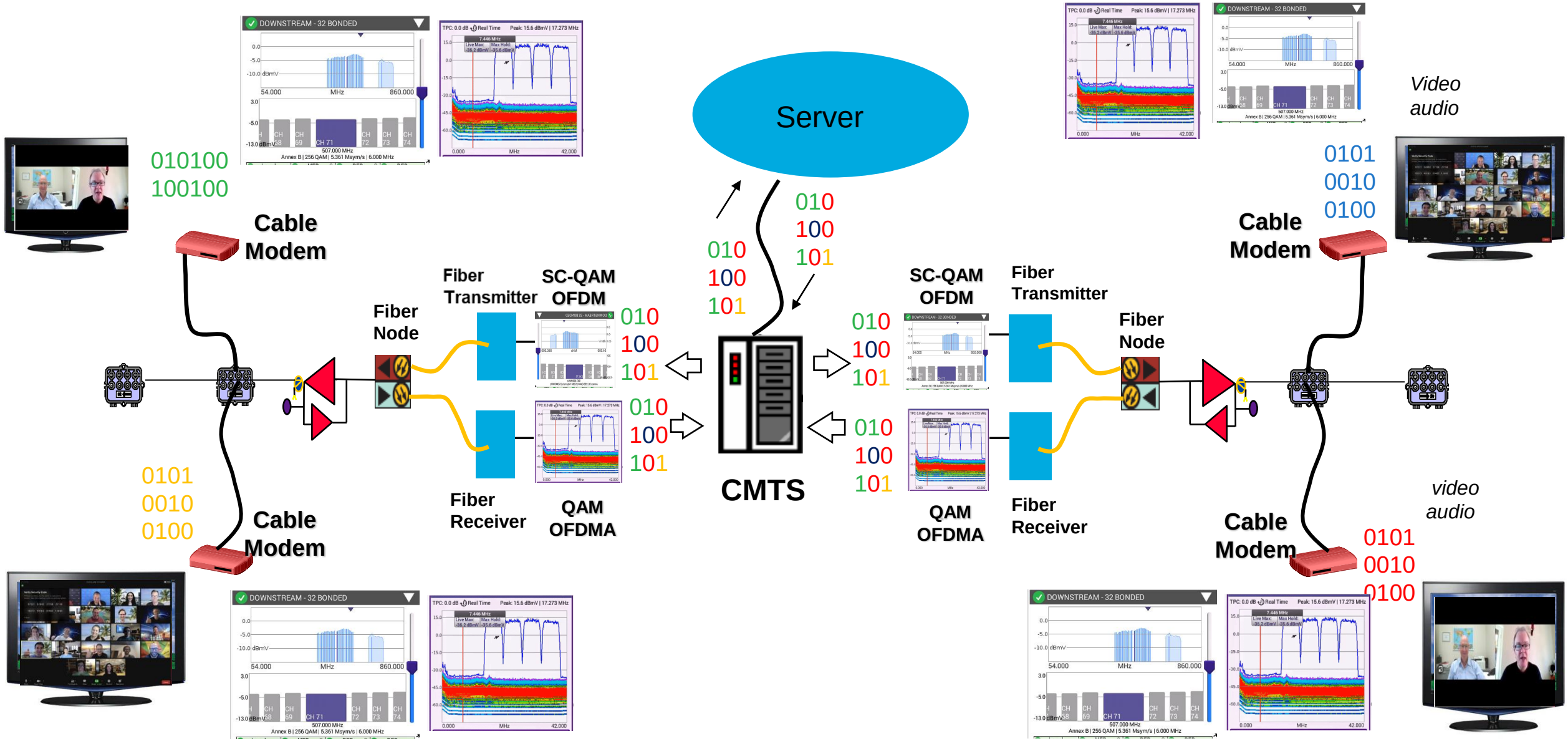


What's in those QAM signals?

- MPEG-2 Data Streams (data of video, audio, tables)



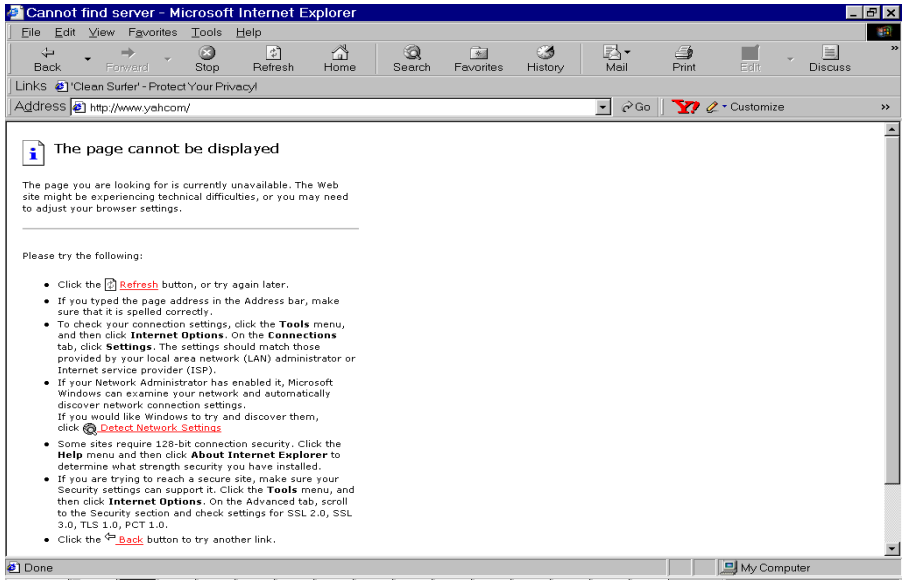
MPEG on the DOCSIS RF Network example



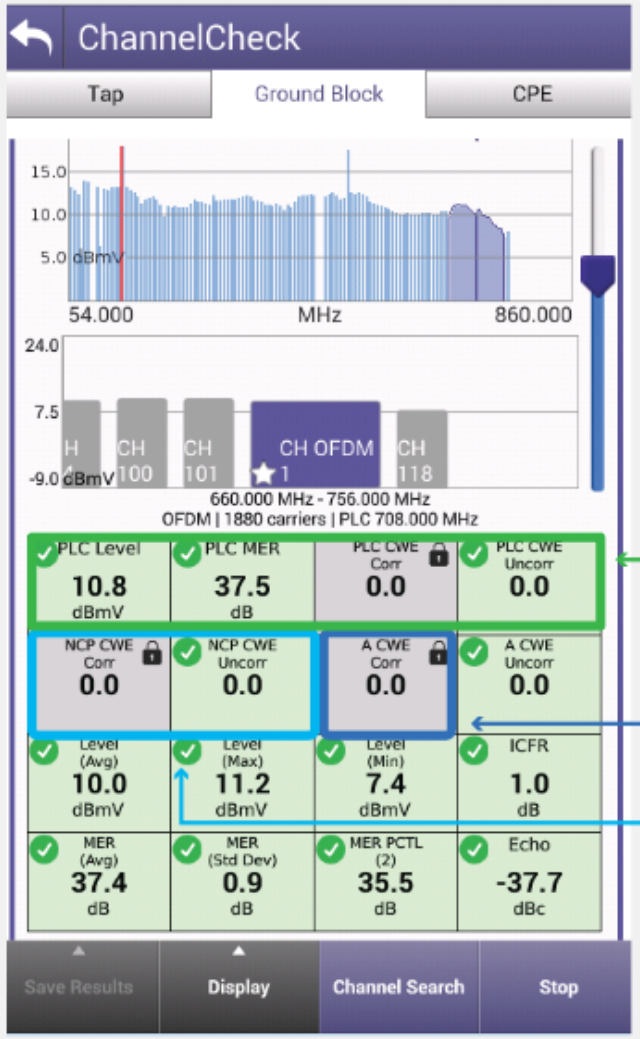
Ingress in QAMs

→ **Ingress causes Digital signals to Degrade.**

→ **This causes Tiling and Loss of high Speed internet access.**



What to Look for on OFDM Carrier



Testing PLC —PHY Link Channel

PLC

PLC contains critical OFDM PLC signal decoding information.

THINGS TO CHECK

Level: >–15 dBmV (6 MHz) ***MER:*** >15 dB (min) ***Lock status:*** locked ***Uncorrectable CWE:*** none ***Other info:*** PLC center frequency

Testing Next Codeword Pointer (NCP)

NCP

The NCP tells the modem which codewords are present and in which profile to find each codeword (codeword error analysis); it is critical for proper data communication.

THINGS TO CHECK

Lock status: locked ***Uncorrectable CWE:*** none

Testing Profile A

Profile A

Profile A is the boot profile; all 3.1 modems must be able to use profile A.

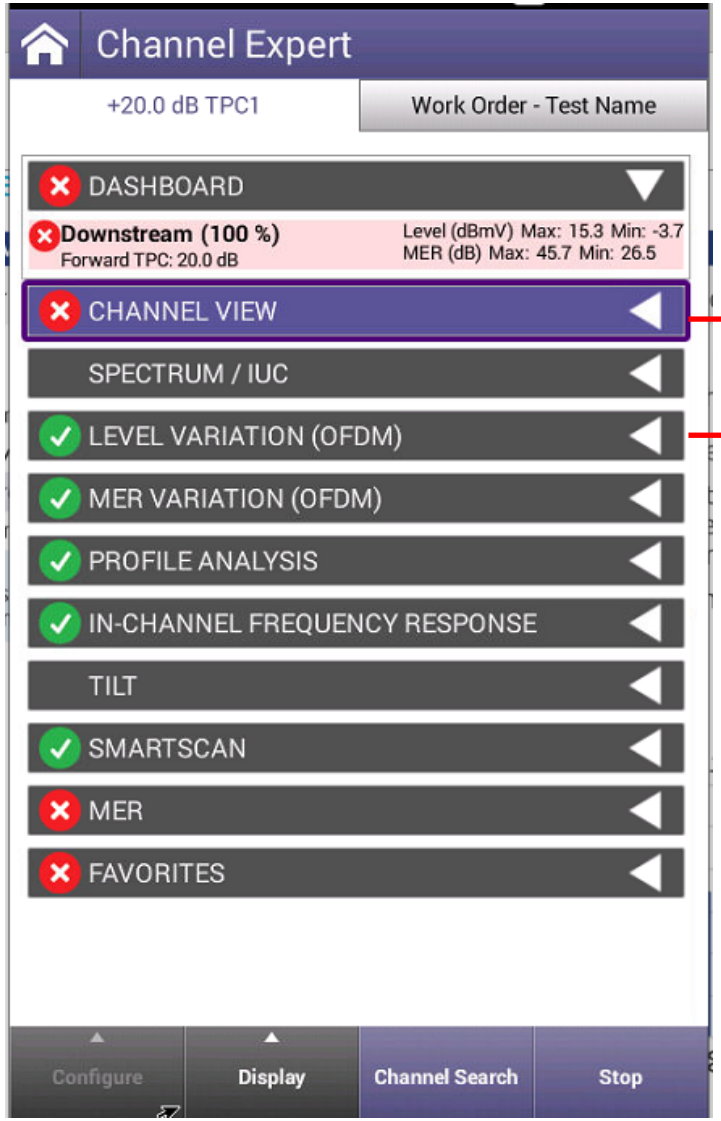
- Profile A is key to D3.1 modem communication via an OFDM carrier. This is where command and control, range, and registration occurs.
- In practice, many operators are migrating to running 256 QAM or 1024 QAM on profile A. It is expected and common that there will be Correctable Codeword Errors. This is OKAY since LDPC is so effective.

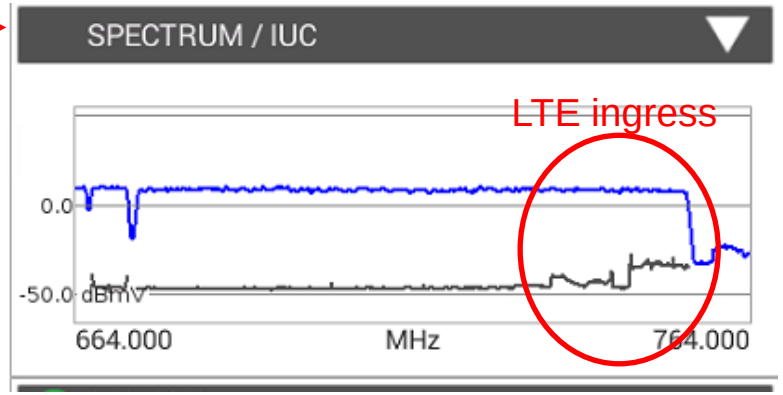
THINGS TO CHECK

Lock status: locked
Uncorrectable CWE: none

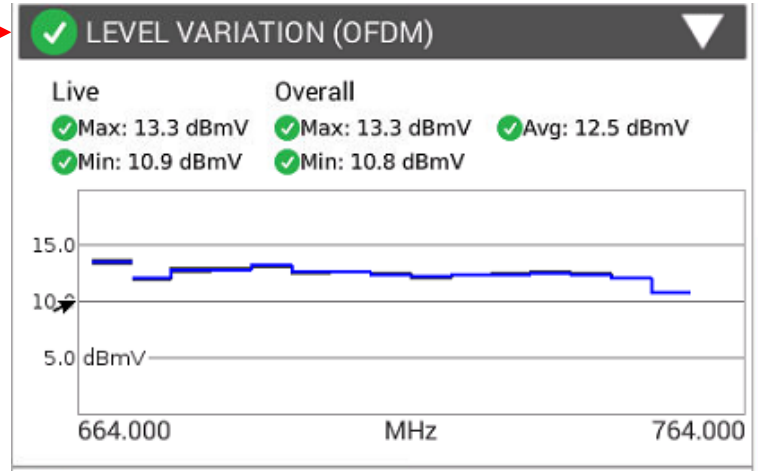
- If profile A isn't locked or has uncorrectable CWE, a modem may roll back and use only SC QAMs in 3.0 mode.

OFDM Ingress Under the Carrier (LTE Band Ingress)





IUC Ingress under carrier



Level of OFDM carries measures at 6 MHz spacing

Where are the problems?

Node Health Parameters

→CM with High Uncorrectable CER”

→CM with High Correctable CER

→CM with Low SNR

→CM with Low Transmit Levels

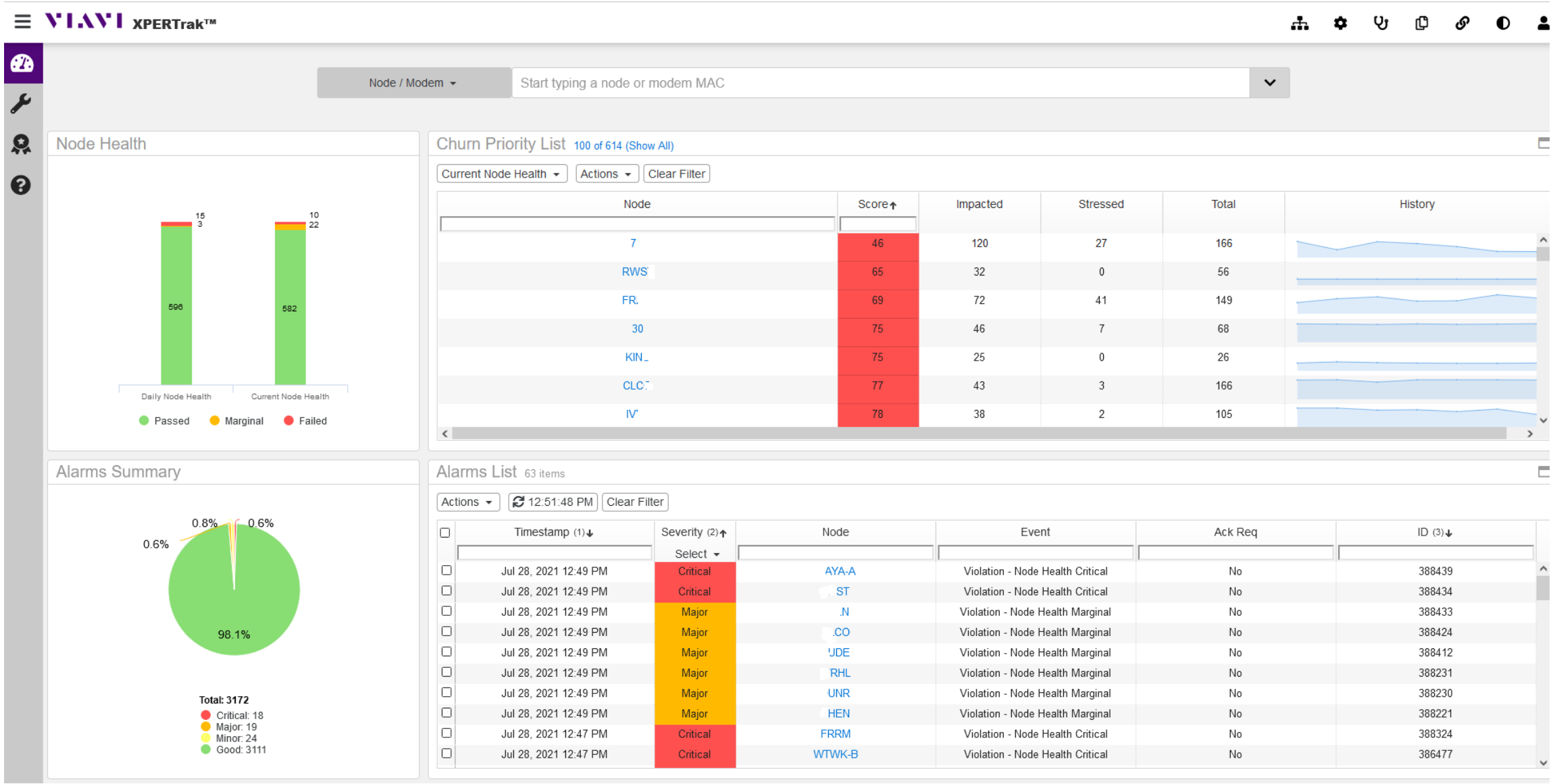
→CM with High Transmit Levels

→CM with High T3 Time outs

→CM with High T4 Time outs

→CM with High Range Aborts

Node Health



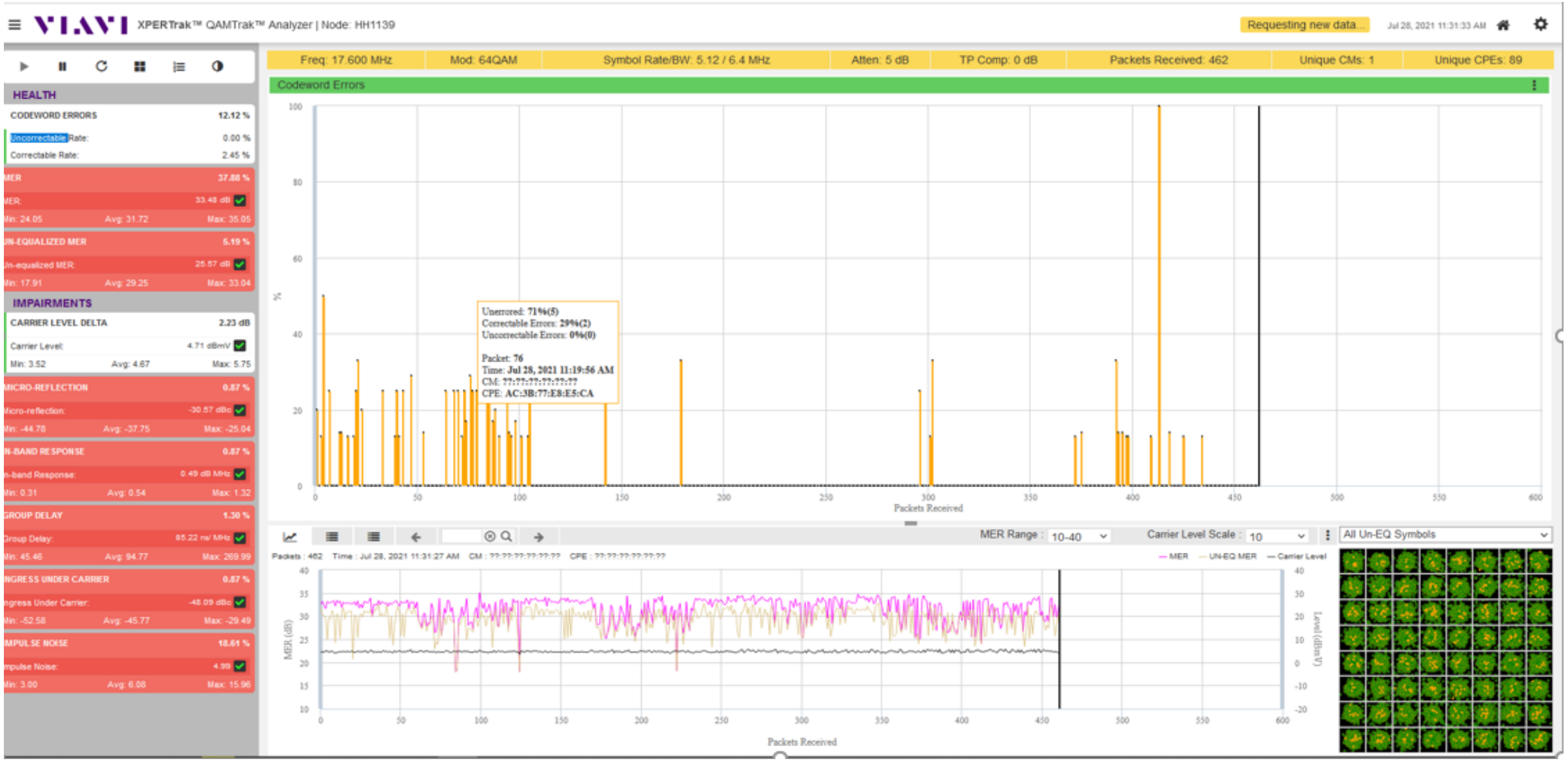
DOCSIS Codeword Errors

- Encoder and the decoder “Cable Modem” “CMTS”
- Take a Large sections of Data from Encoder called Codeword
- Add two bytes of data for correction
- IF codeword were corrupted due to RF impairments it will use the two bytes of correction data to attempt to fix the corrupted bits.
- If the bits can be repaired, then the decoder reports back with a correctable codeword.
- If not repaired the it is an uncorrectable code word.

Return Path Noise and Spectrum Analyzer Tests

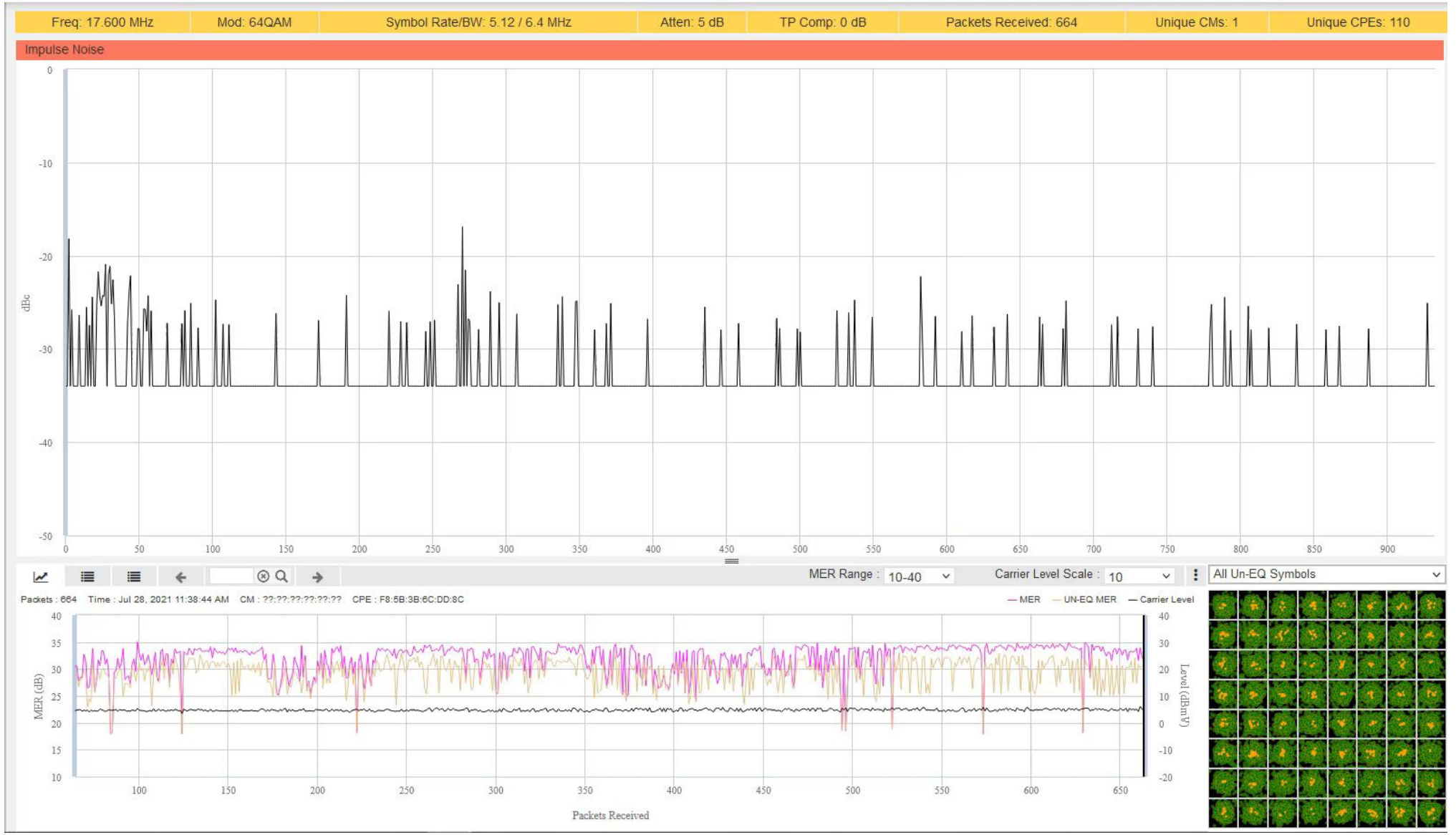
Advance Spectrum Analyzer Tests

Codeword Errors

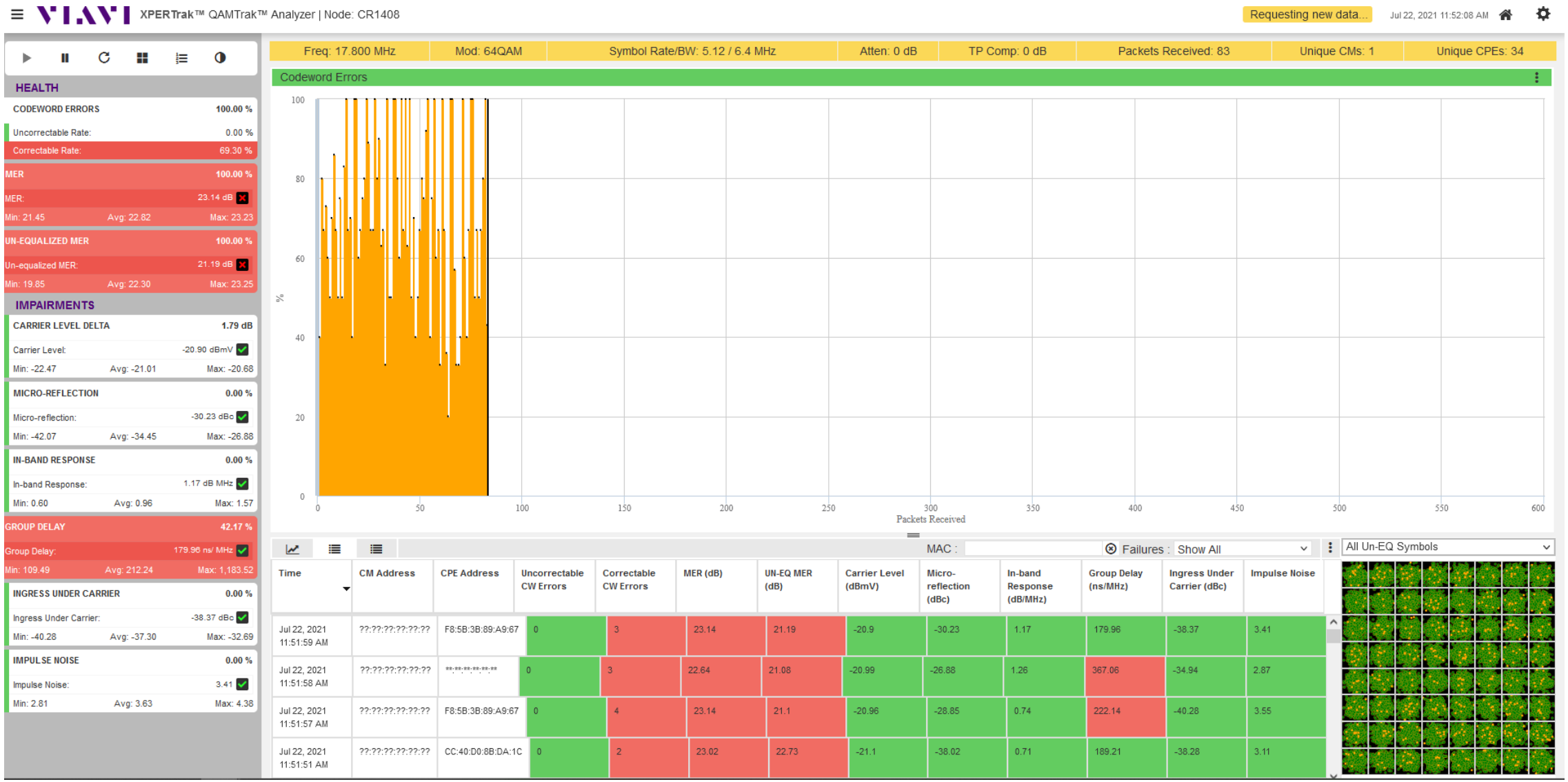


Advance Spectrum Analyzer Tests

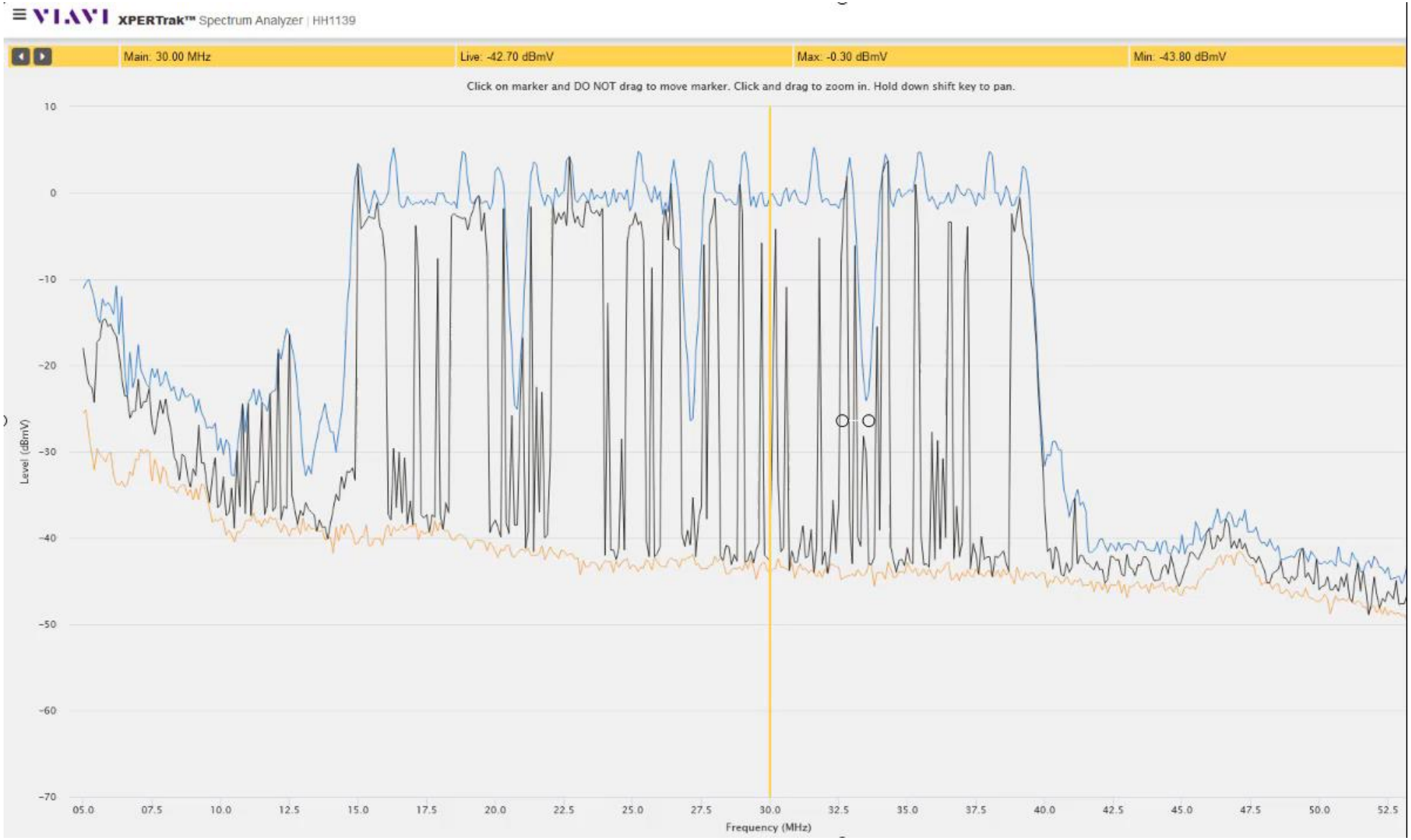
Advance Spectrum Analyzer Tests “Impulse Noise”



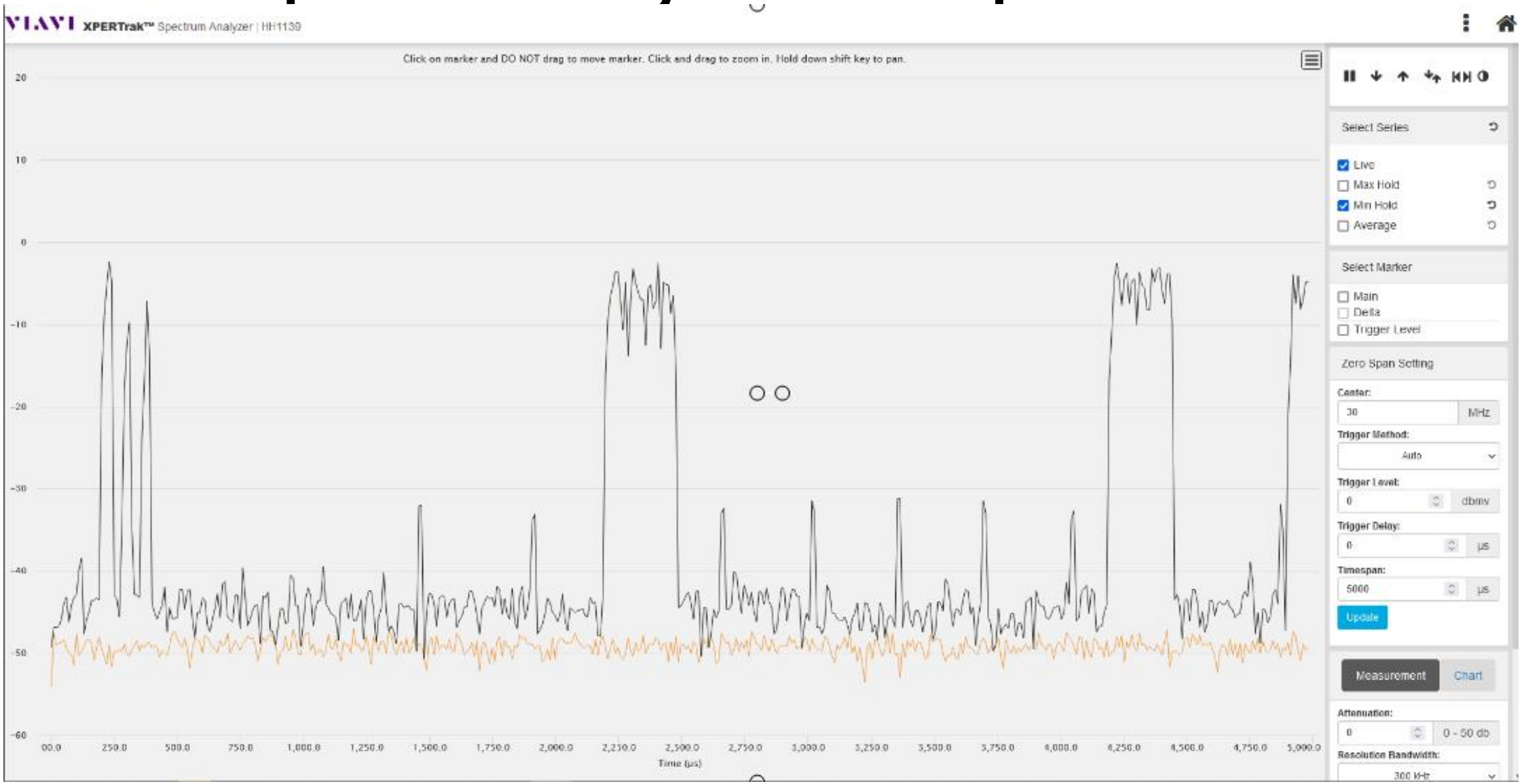
Advance Spectrum Analyzer Tests



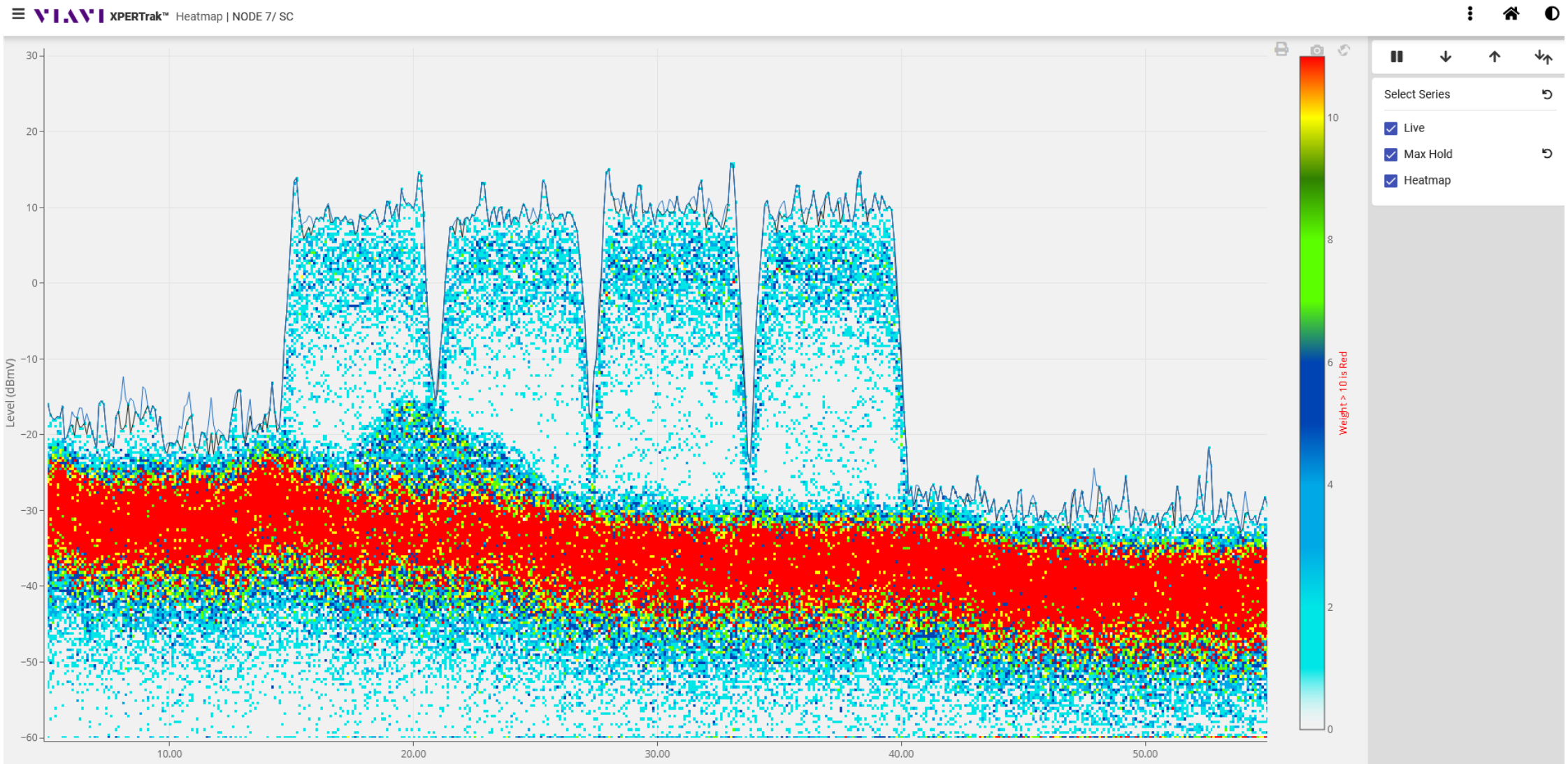
Advance Spectrum Analyzer “Traditional”



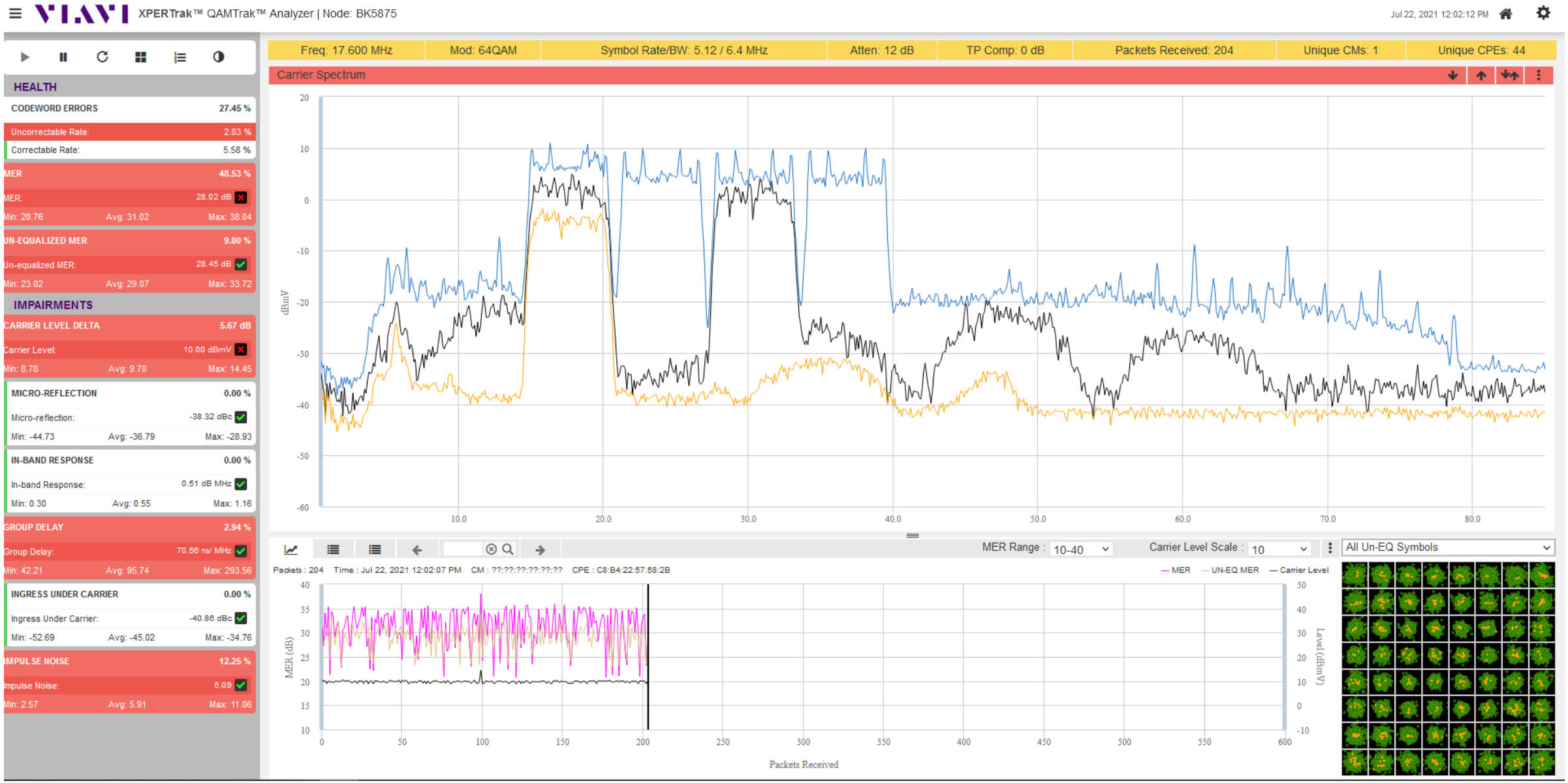
Advance Spectrum Analyzer “Zero Span”



Advance Spectrum Analyzer “Heat Map”



Advance Spectrum Analyzer Tests



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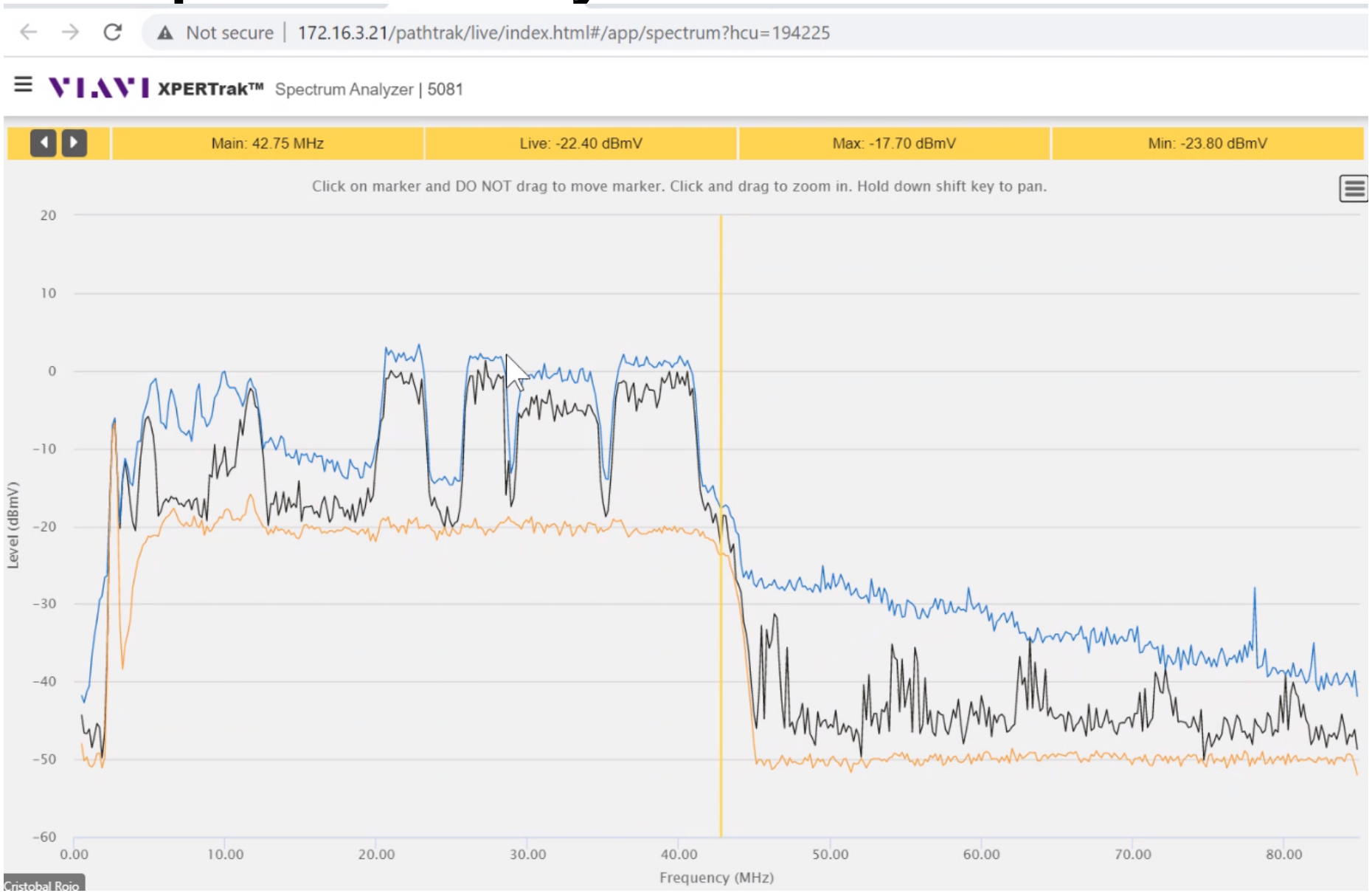
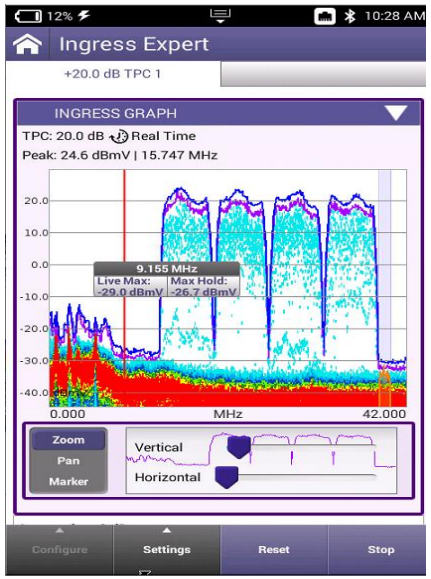
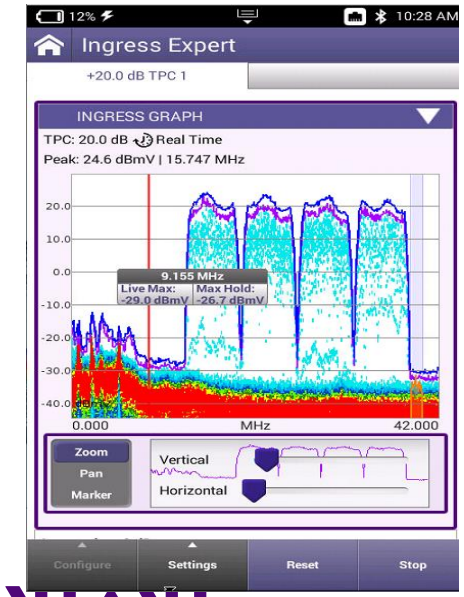
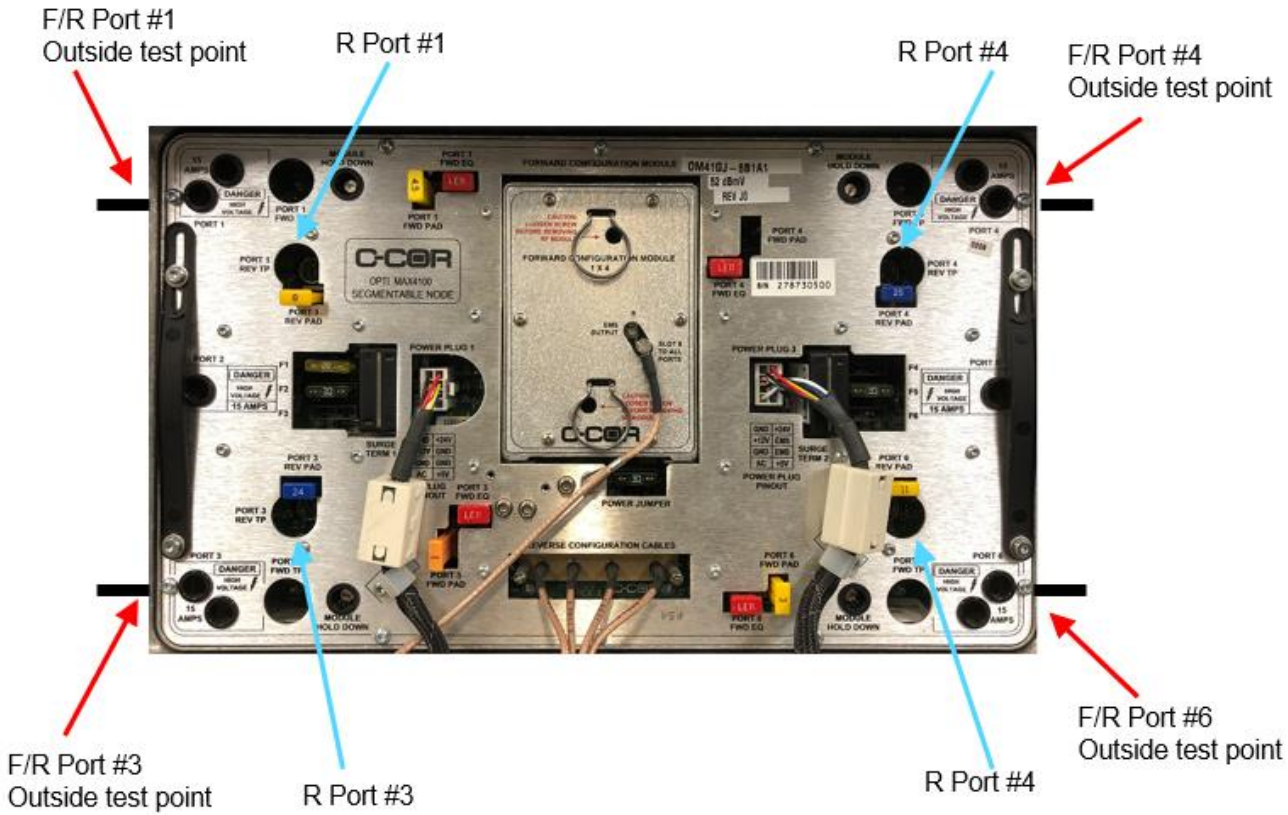


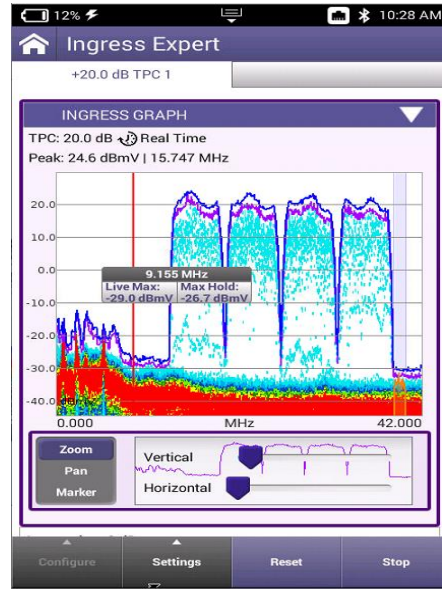
Using Meter to see the Ingress Fiber node

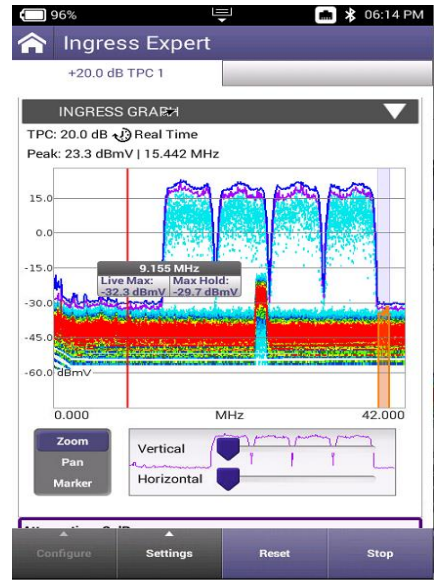
This is a better way
not as intrusive !



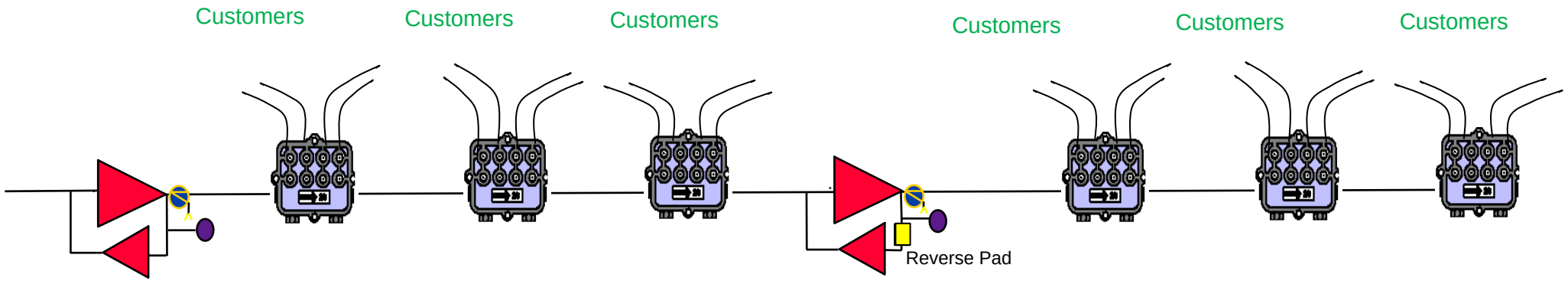


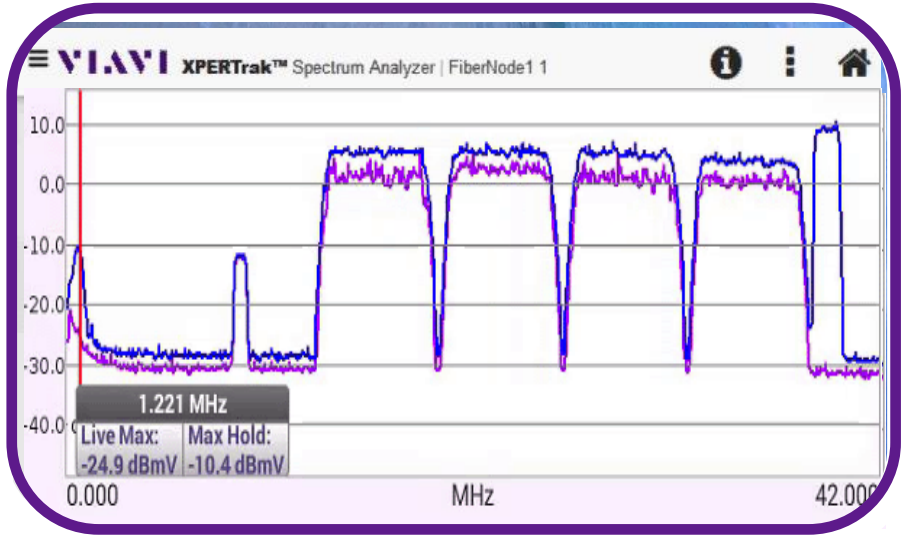




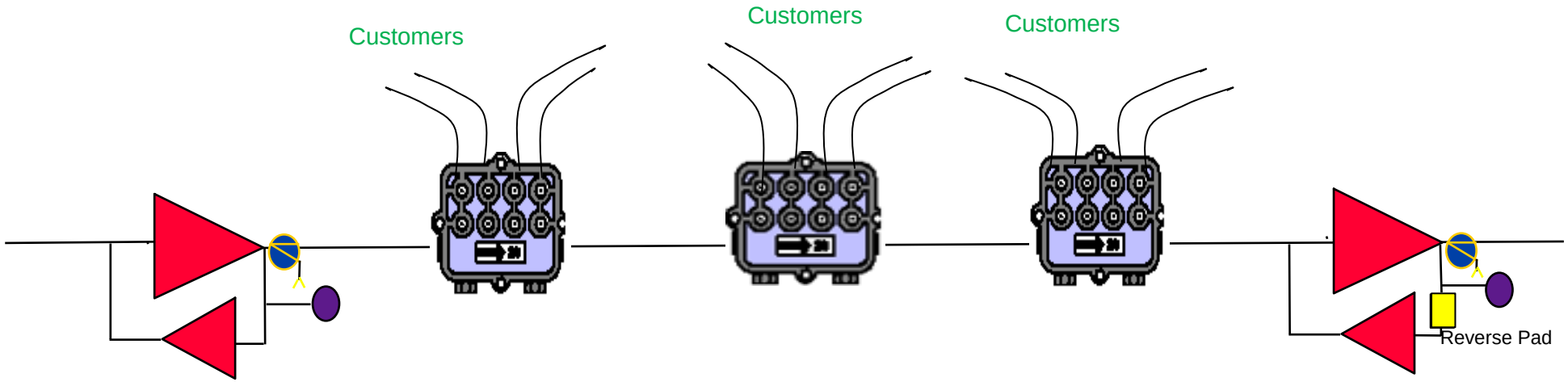


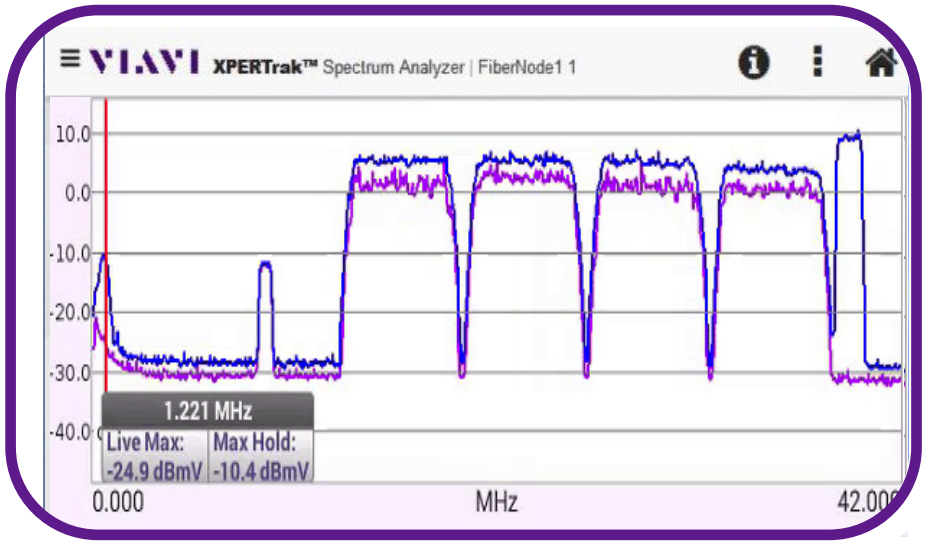
Check the Upper half of Node



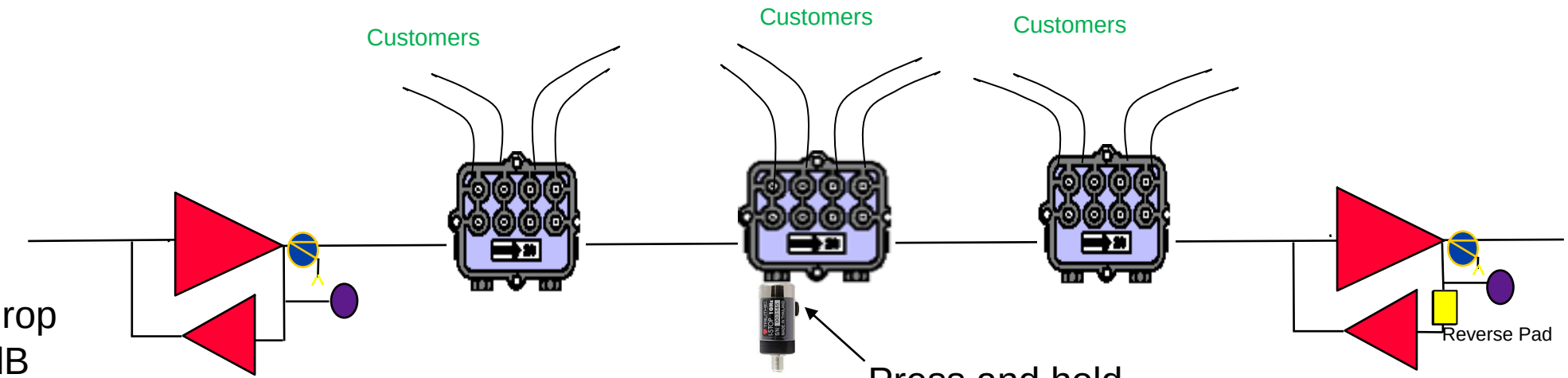


Insert I-Stop probe into the left side of Tap

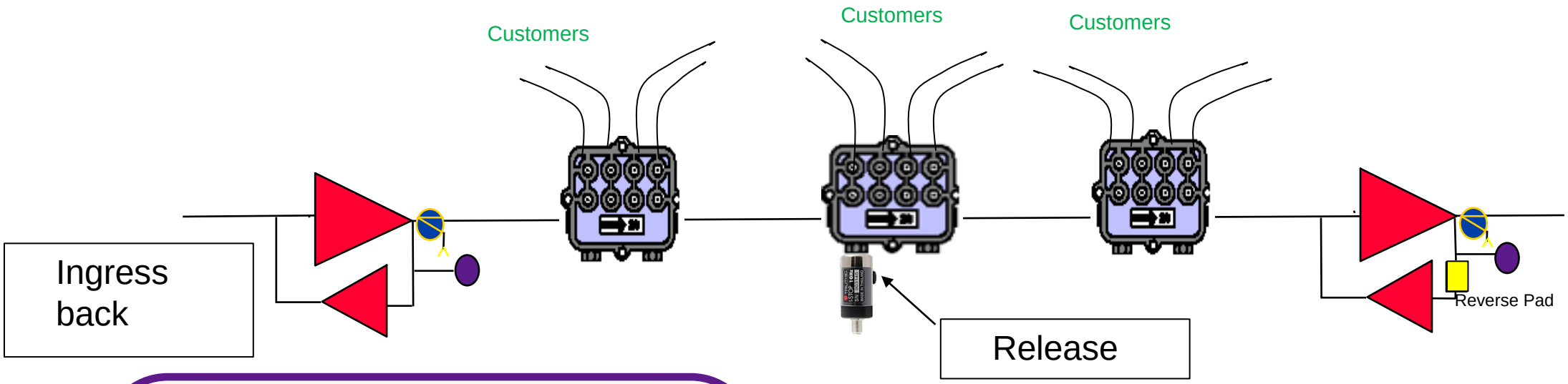




Press and Hold to see if Ingress is Reduced

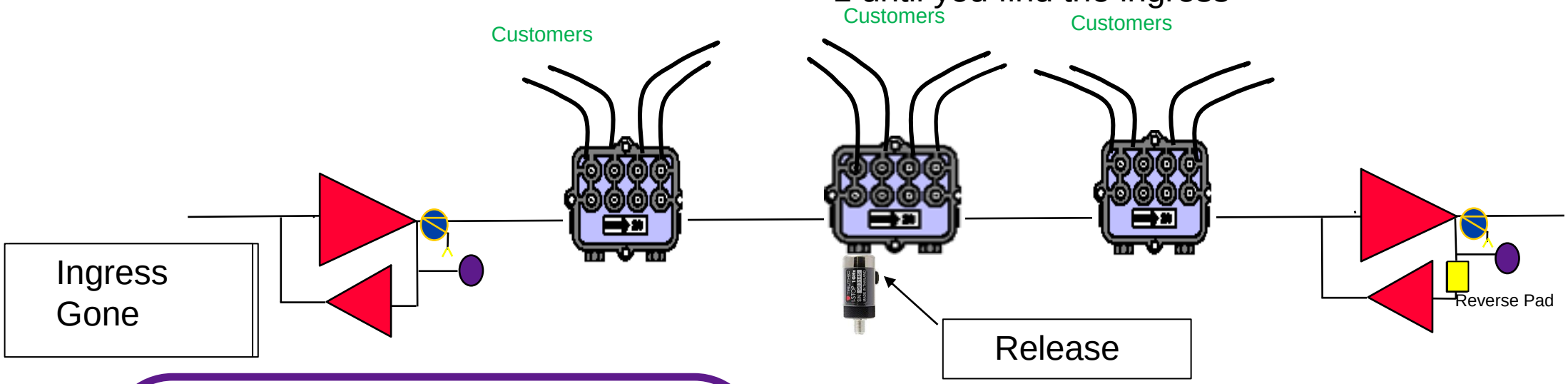


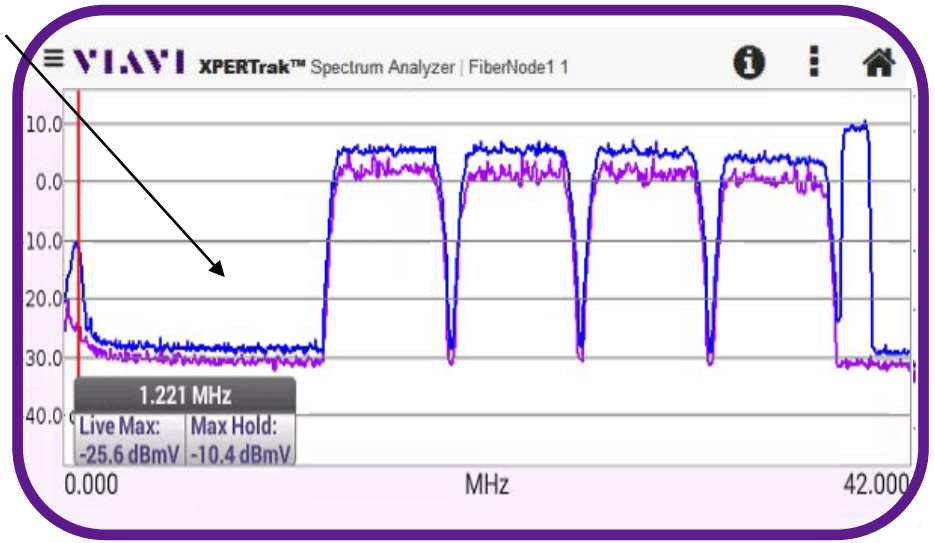
Release to see if Ingress comes back.



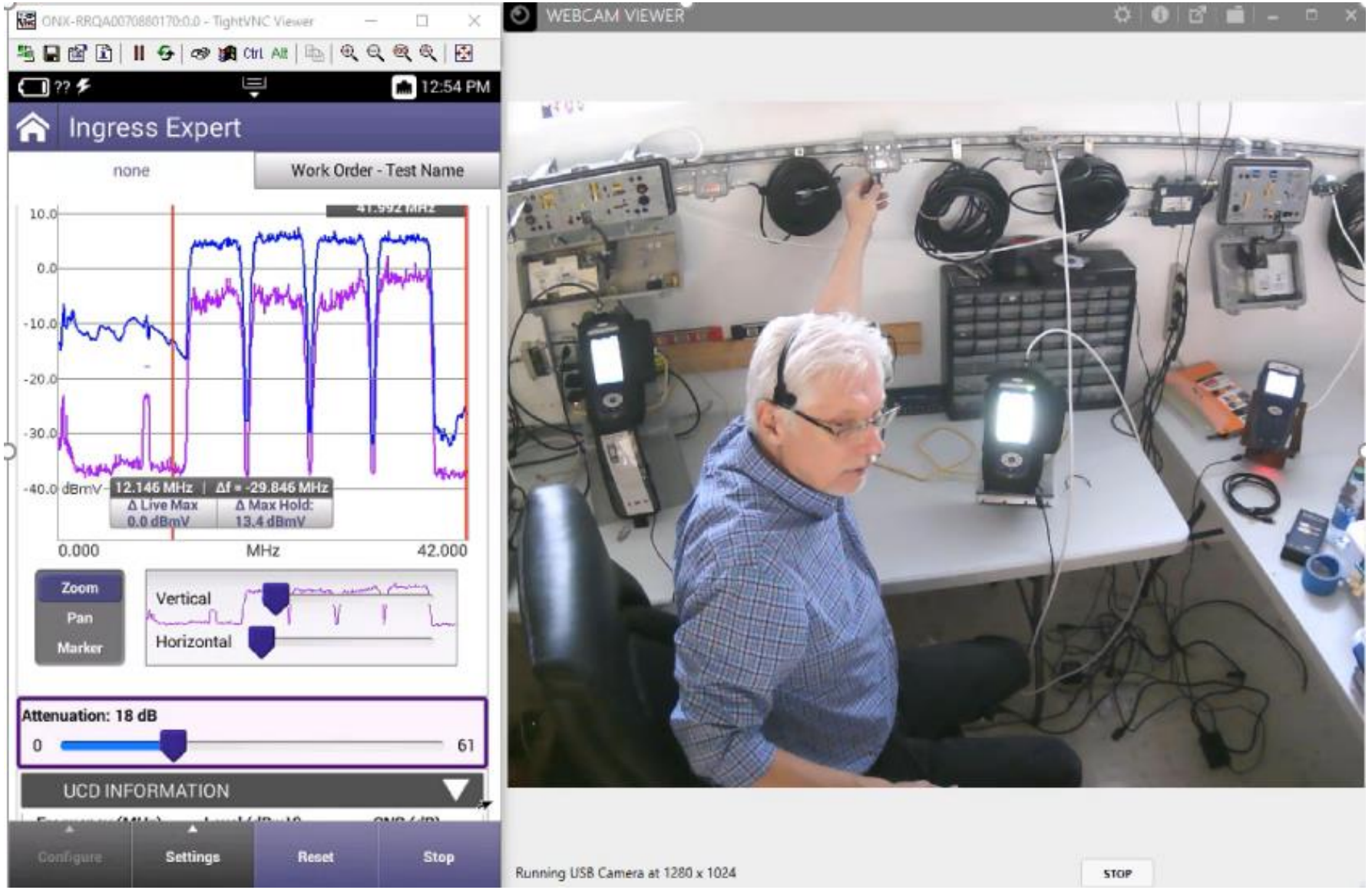
Find the ingress

Disconnect and reconnect customer 1 by 1 until you find the ingress

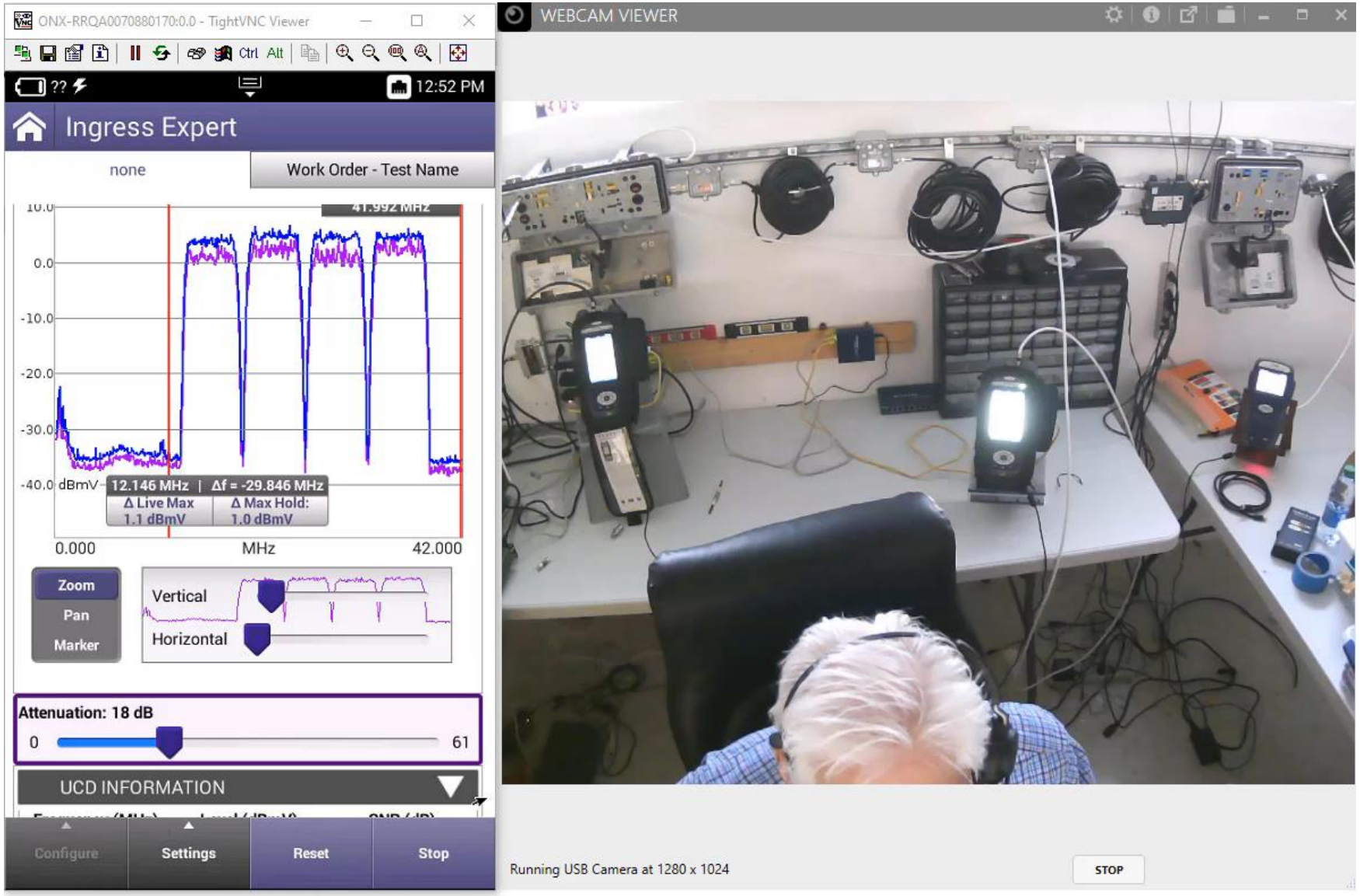




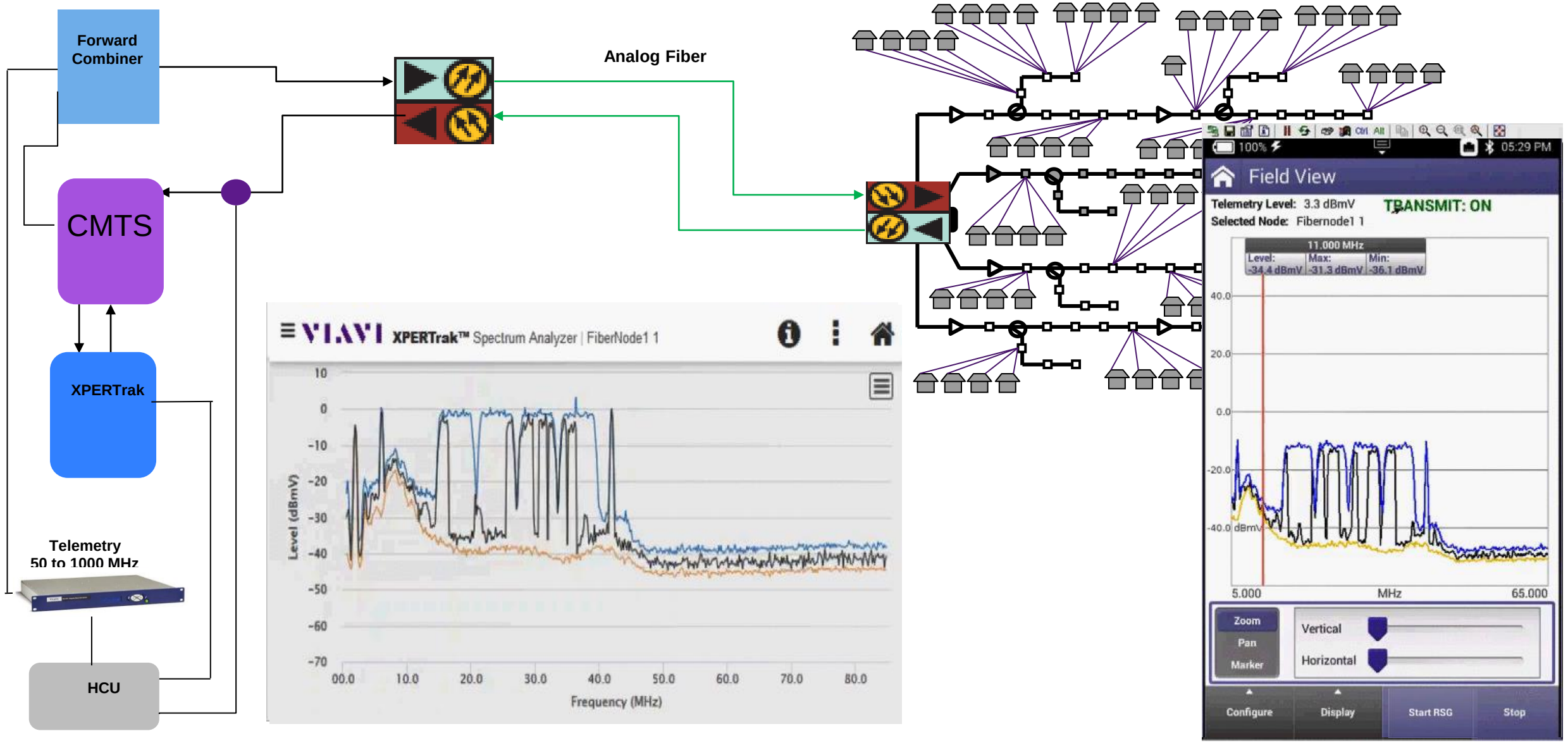
Live View



Live View

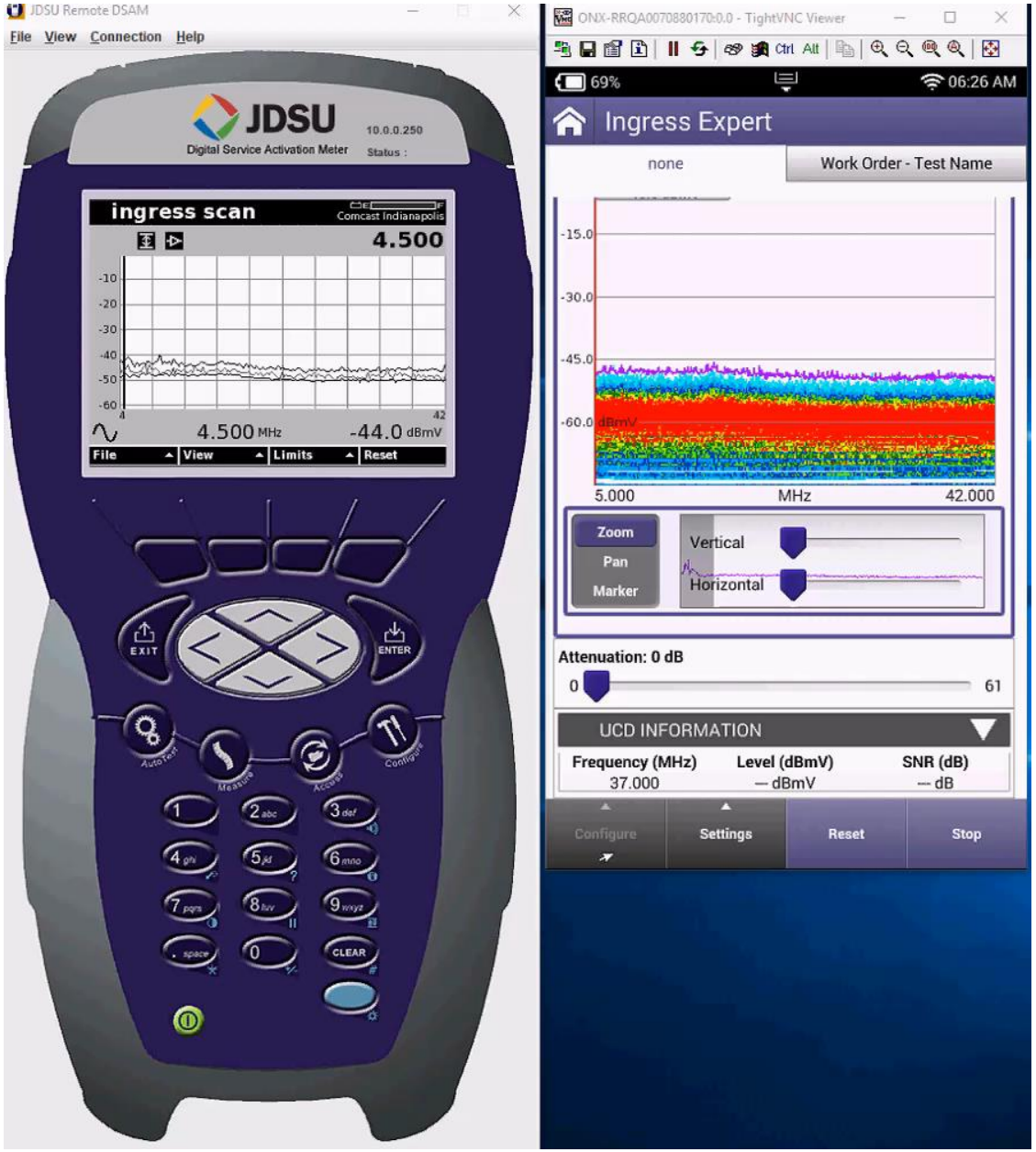


FieldView RSG



Ingress Expert VS DSAM Impulse Noise No QAMS

Swept
Tune



FFT

fast Fourier transform

Paradigm Shift:

Look for RF e**ntering and exiting** your network

Divide and Conquer

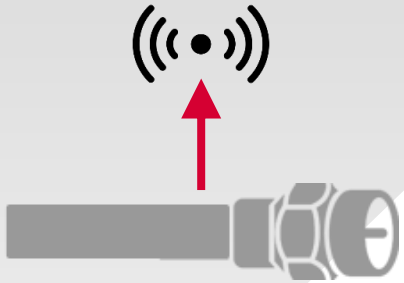
Chasing **INGRESS** is typically looking for RF getting **INTO the Network**

Goal: Find and fix shielding weaknesses

Challenges

- ✓ Funnel effect
- ✓ Intermittent noise
- ✓ Disrupts services

Leakage Detection



Focus on **EGRESS** RF leaking **OUT OF the Network**

Goal: Find and fix shielding weaknesses

Benefits

- ✓ Precise localization
- ✓ Tag always present
- ✓ Not service impacting

PNM Tools

PNM Tools

What Tools can I use for PNM?

- CMTS
- Spectrum Analyzers
- DOCSIS Meters
- Hum
- Sweep

What can PNM do for networks?

Proactively Detect and Address Plant Weaknesses Before Customers Impacted

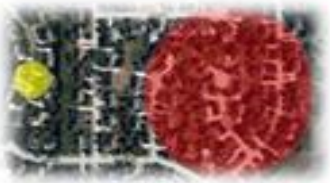
Detect physical plant impairments on DOCSIS performance and reliability

Remotely Localise Location of Plant Weaknesses

- Dispatch to fix, not to find

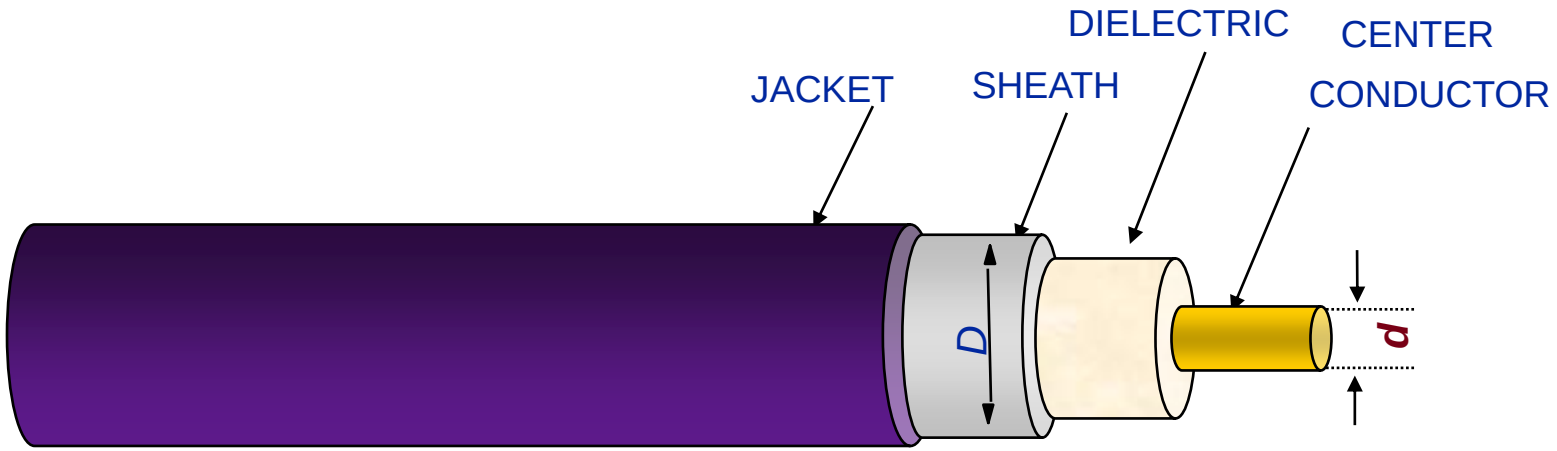
Determine ***Scope*** and ***Severity*** of Plant Weaknesses

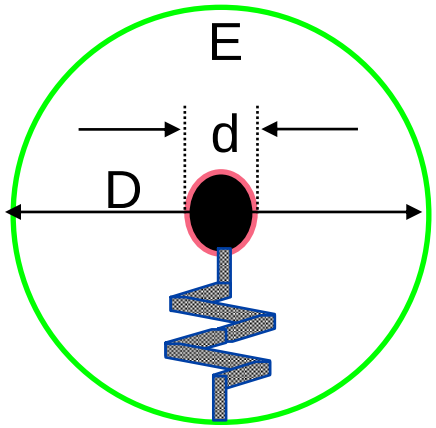
- Which to fix immediately, which to keep an eye on



Identify common causes of faults – *Use this information to augment technician efficiency or target network elements for proactive remediation.*

Cable Properties

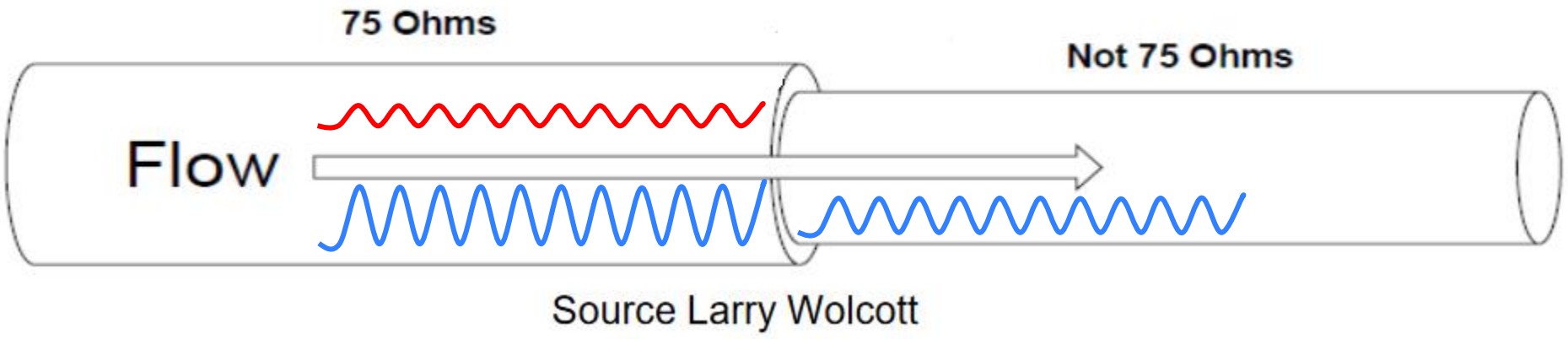




$Z_0 =$ 75 ohm

$$Z_0 = \frac{138}{E^{.5}} * \log\left(\frac{D}{d}\right)$$

Impedence and Reflections



- Transmitted signal arrives at the impedance mismatch and some of the energy is reflected toward the source.
- We can measure the amplitude of the reflected energy.
- We can measure the amount of time it takes for the reflected energy to arrive back at the source.
- Since we know how fast signals travel through the cable, we can calculate the approximate distance to the fault.

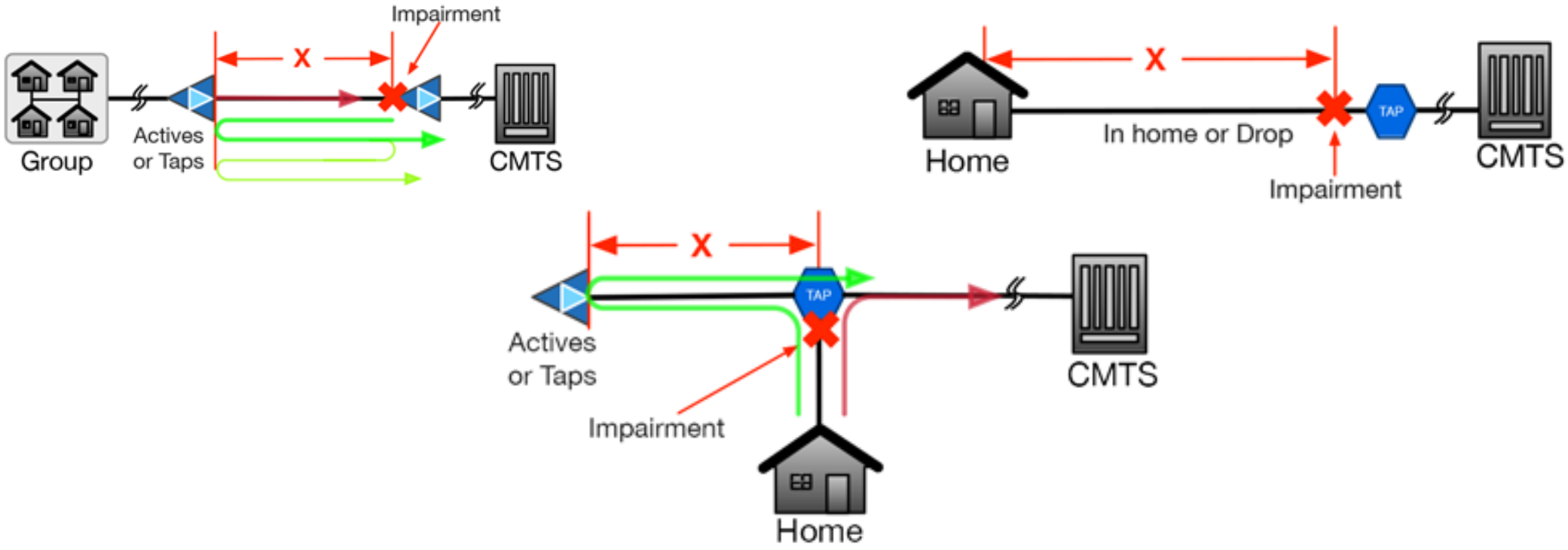
Impedance Mismatch

- Mismatches occur for many reasons
  - Damaged cable
  - Equipment problems
  - Poor connectorization
  - Lack of proper termination
- Kinking of coax changes the inner diameter of the shield
- The use of staple guns for cable attachment can cause standing waves, because they “flatten the cable
- Terminators can be harmed by an AC surge if not protected
- Every connection is an impedance mismatch

Micro-Reflections

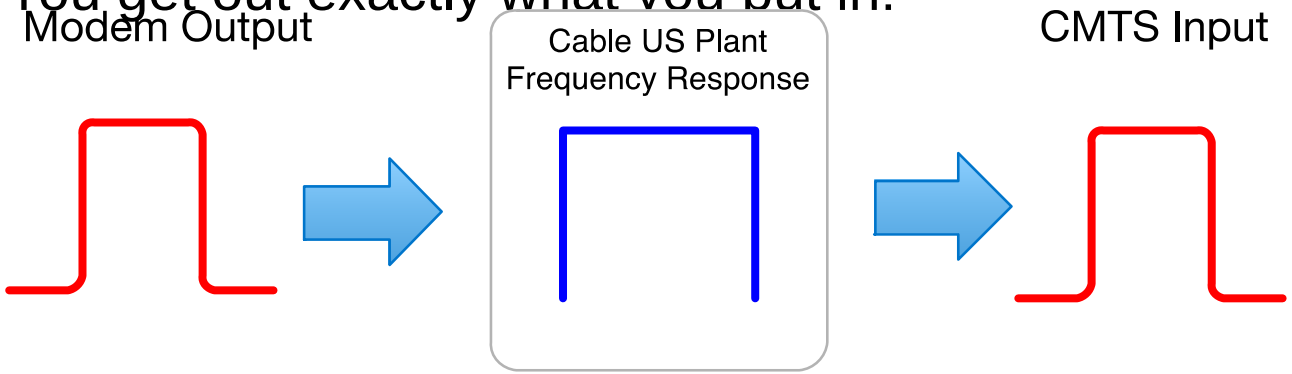
- Micro reflections are caused by impedance mismatches in the transmission line.

- Due to an impedance mismatch a small portion of the signal is reflected and arrives at the CMTS delayed. The delayed signals sum with the main signals and cause standing waves (Ripples in the response).

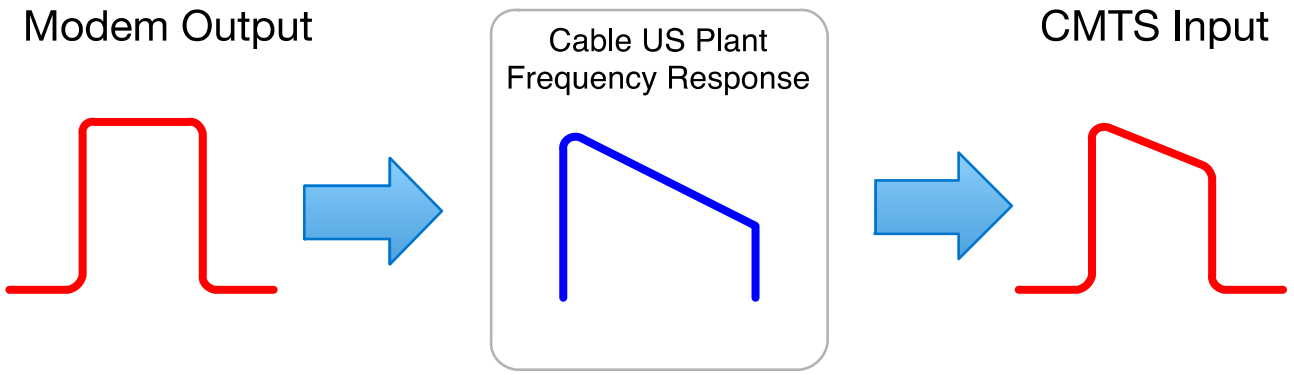


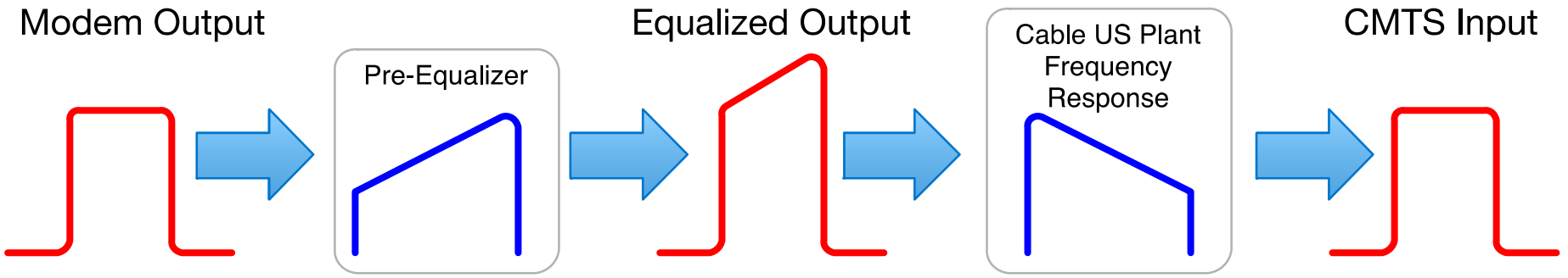
How Does Pre-Equalization Work

- CMTS looks at the RNG-REQ messages and determines the corrections required to improve the response and sends them to the modem
- Then Modem pre-distorts its transmission to counteract network issues, resulting in the CMTS receiving a flat signal.
- In an ideal world cable plants have perfect frequency response
  - You get out exactly what you put in!



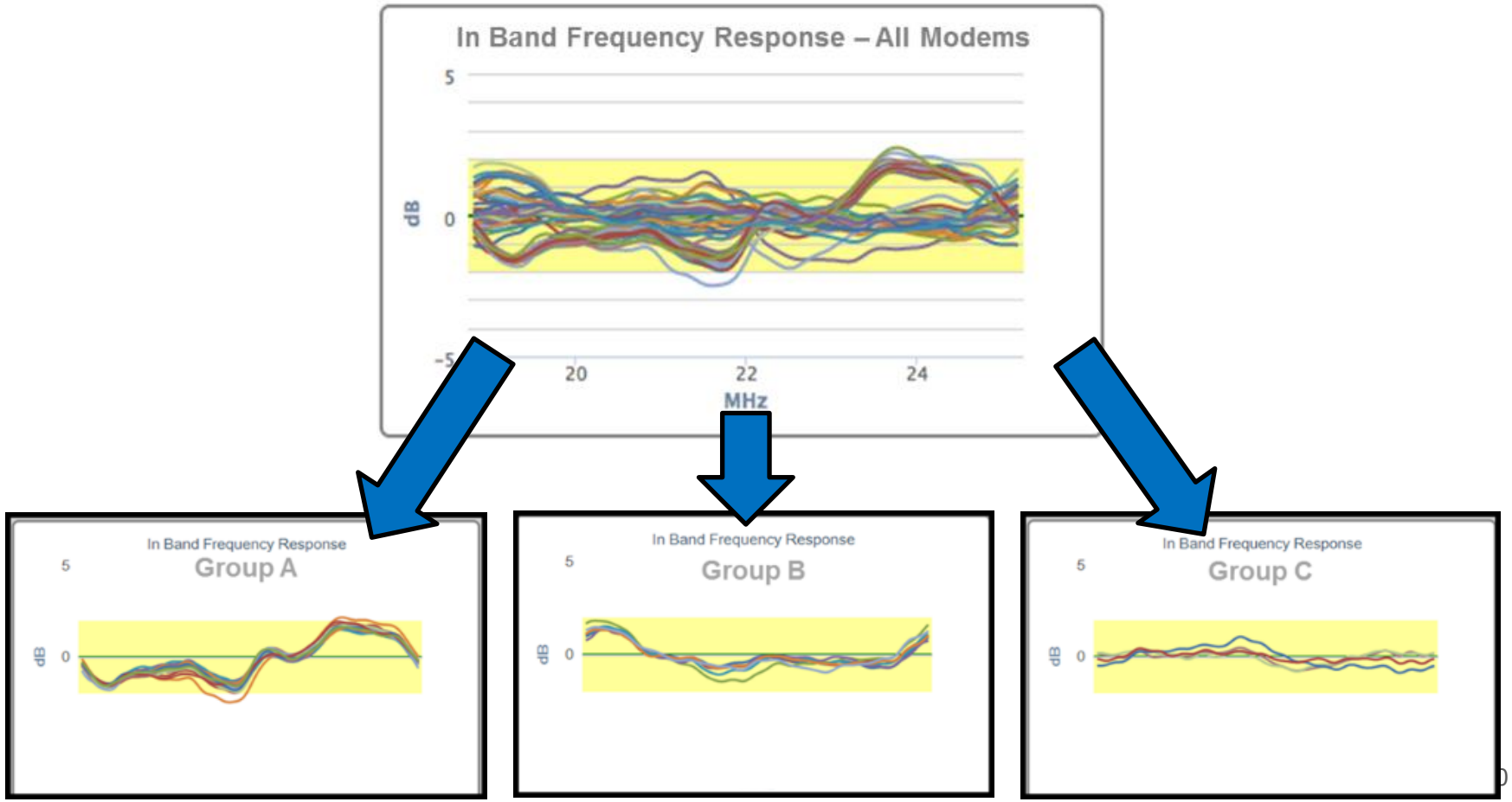
The Real World





How Pre-Equalization Data Can Help Cable Operators

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



How PNM Can Help Cable Operators

- **Correlate:** Automatically Separate Modems With Statistically Similar Freq Responses Into Groups
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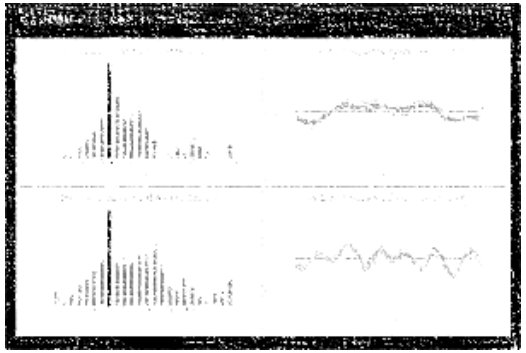
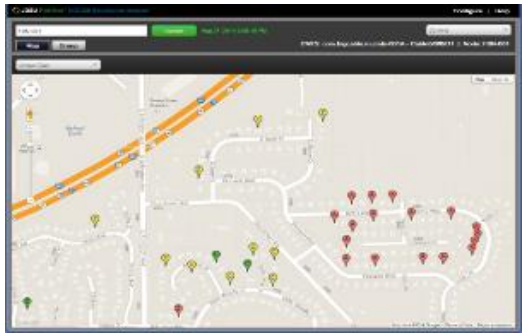
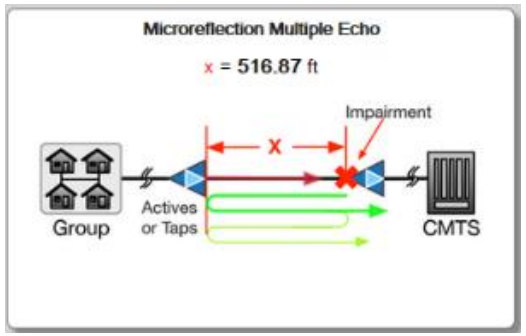


- **Localize:** Plot Modem Groups on Google Map To Allow Identification of Last Common Isolation Point
  - Where to start field find and fix from



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



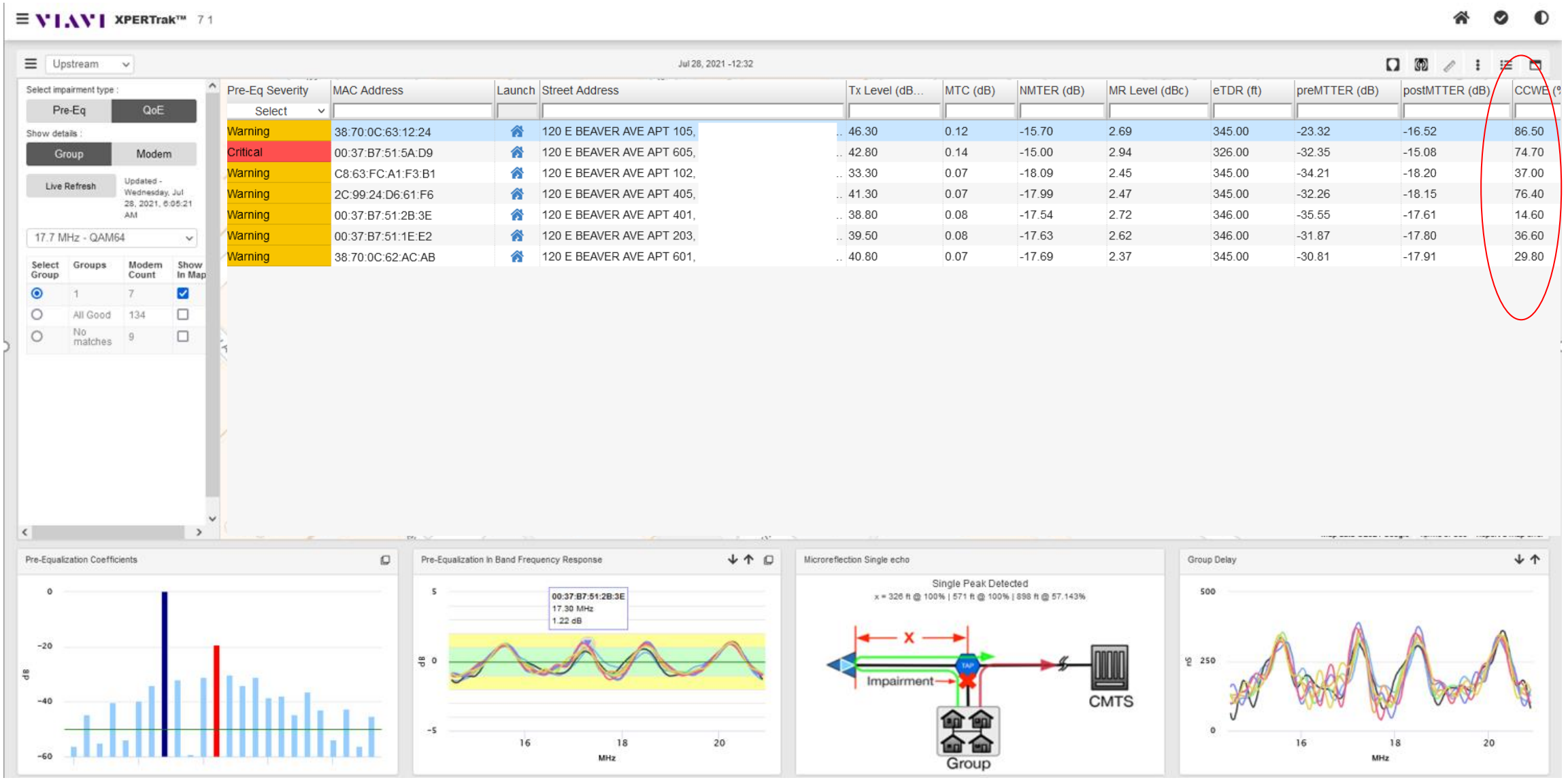
Common Pre-Equalization Use Cases

- **Proactive Plant Hardening**
  - Find nodes with worst impedance mismatches and proactively fix
    - High # of CPE affected by moderate microreflection
    - Moderate # of CPE affected by large microreflection
  - Address problems often responsible for “intermittent” issues

- **Part of Customer Trouble Ticket Triage Process**
  - Does customer modem show significant microreflection?
    - Is microreflection relevant to customer complaint?
    - Is it part of a larger group (plant problem vs home)?

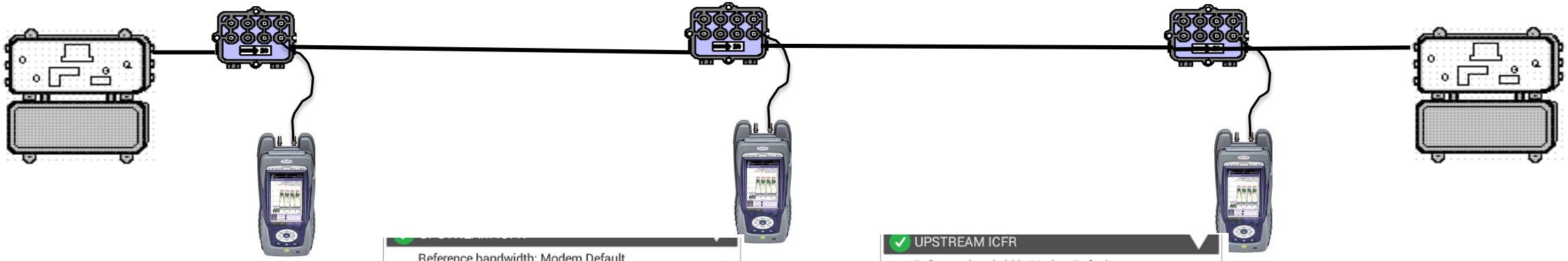
- **New Service Install Verification**
  - Install process not closed if tap-down microreflection remains

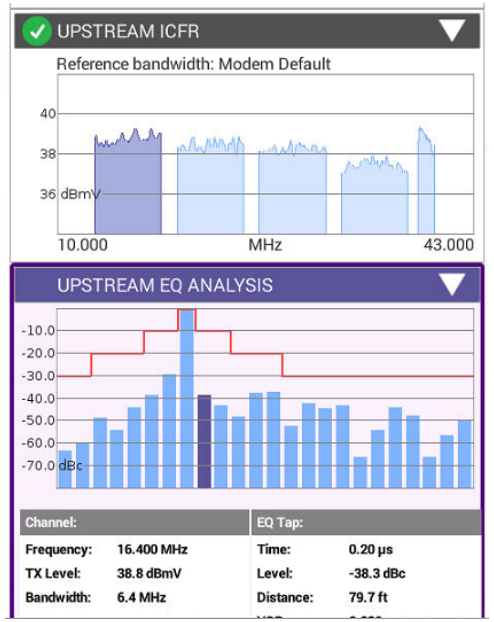
PNM in Action

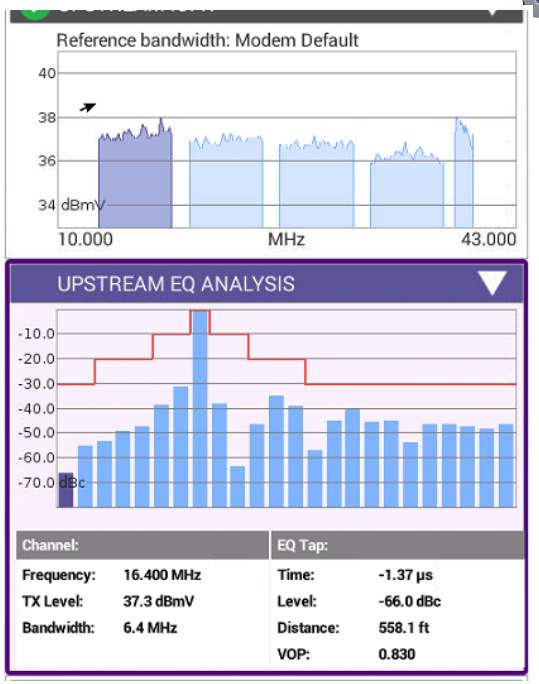


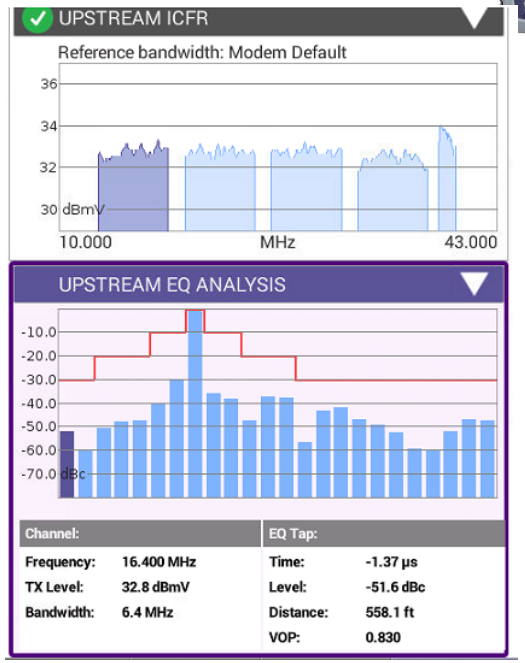
How Pre-Equalization Data Can Help Cable Operators

- **No impairments**



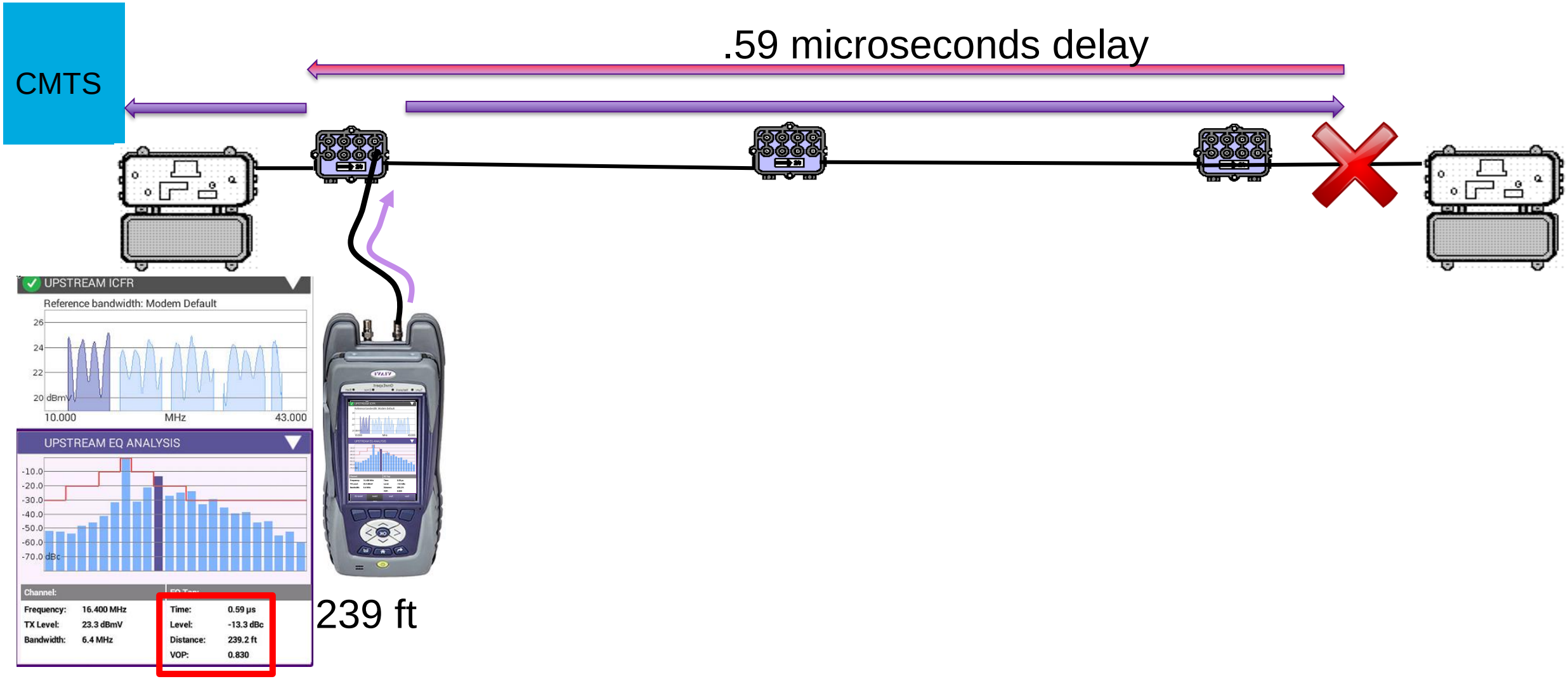






How Pre-Equalization Data Can Help Cable Operators

- **DOCSIS Pre-Equalization in Action**



How Pre-Equalization Data Can Help Cable Operators

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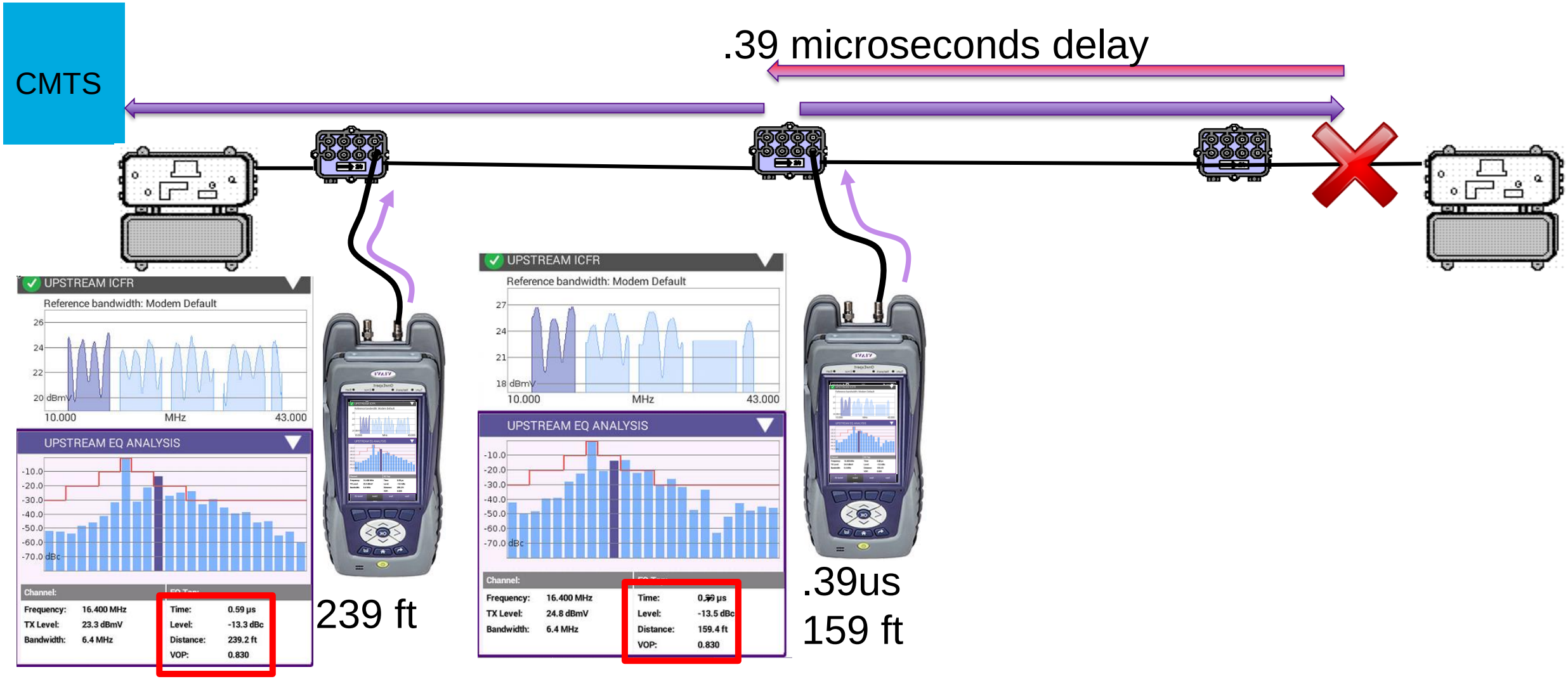
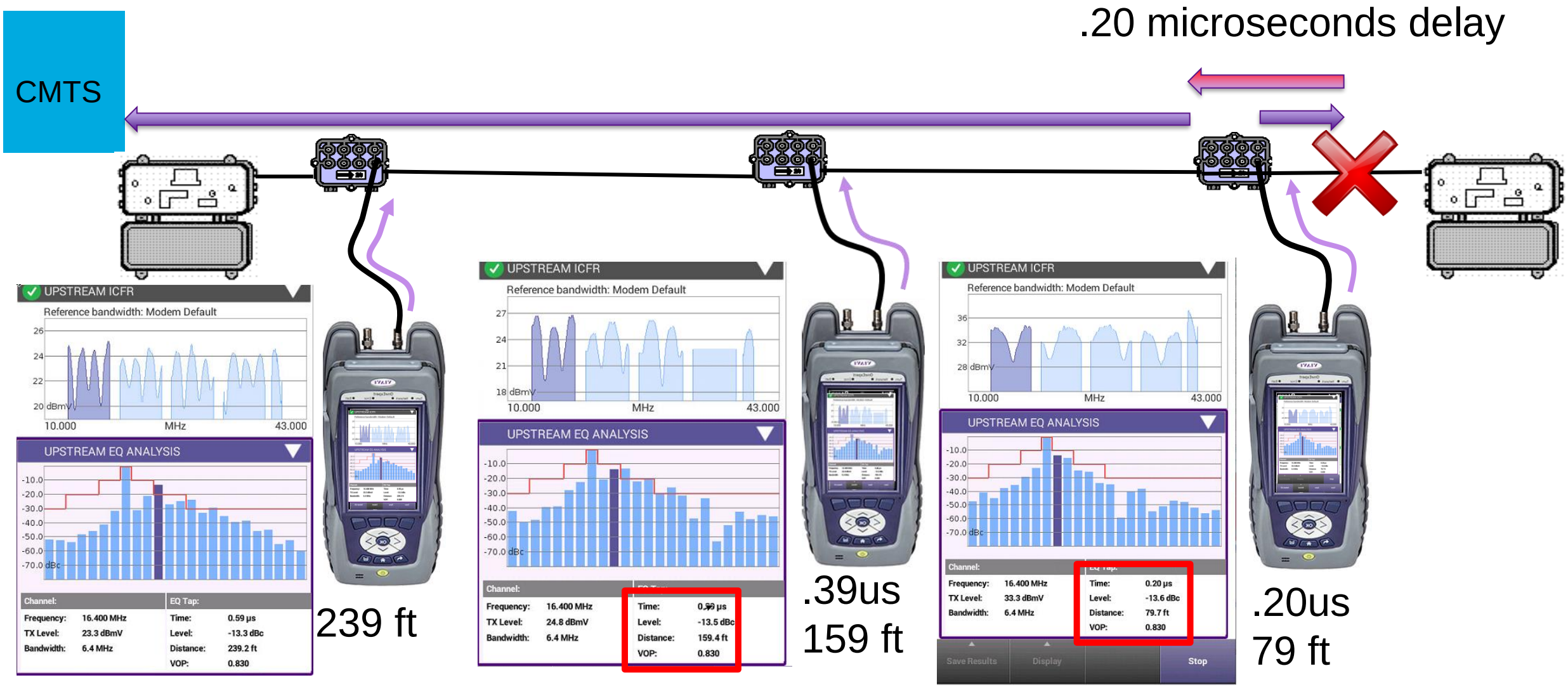
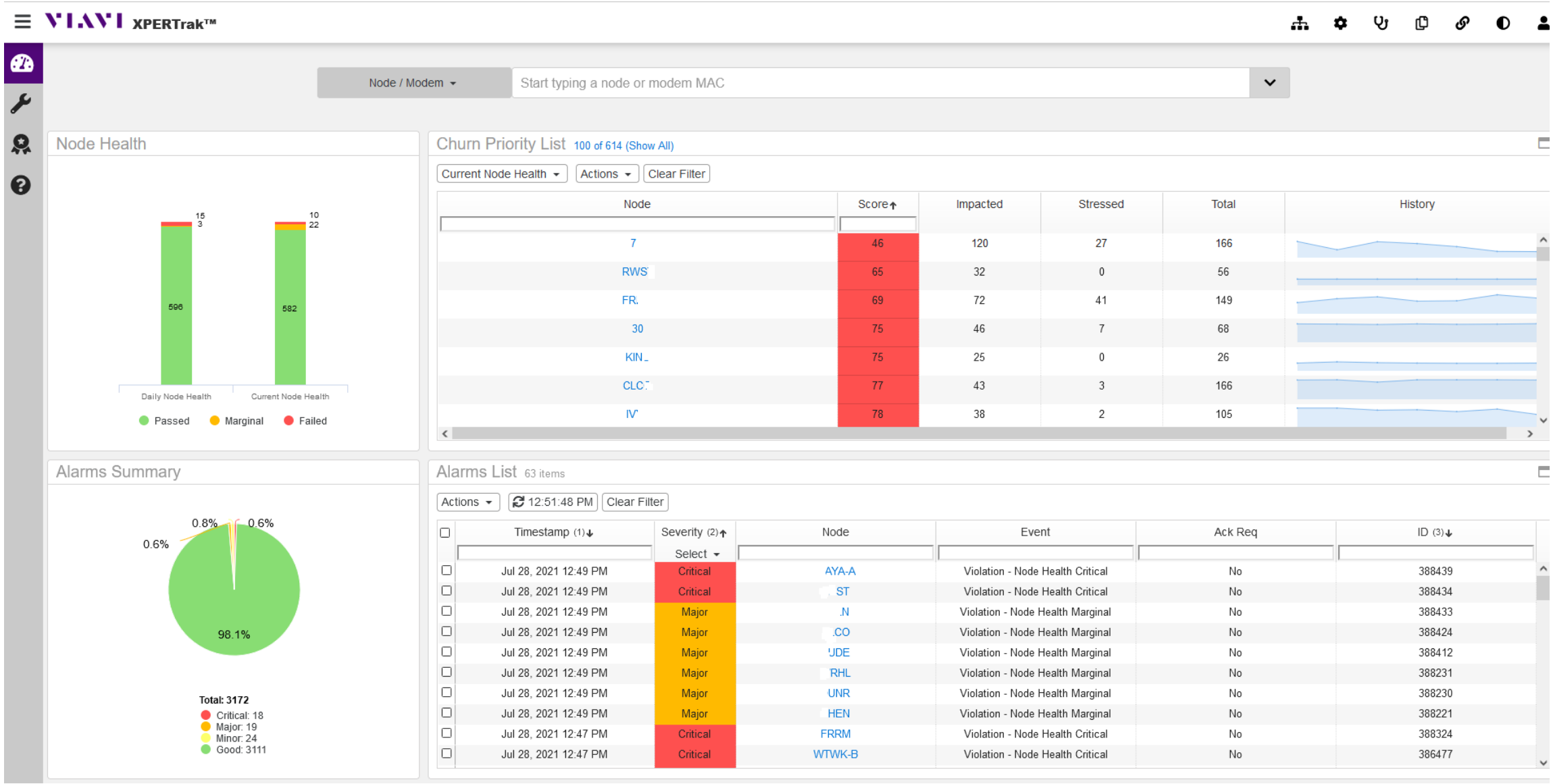


How Pre-Equalization Data Can Help Cable Operators

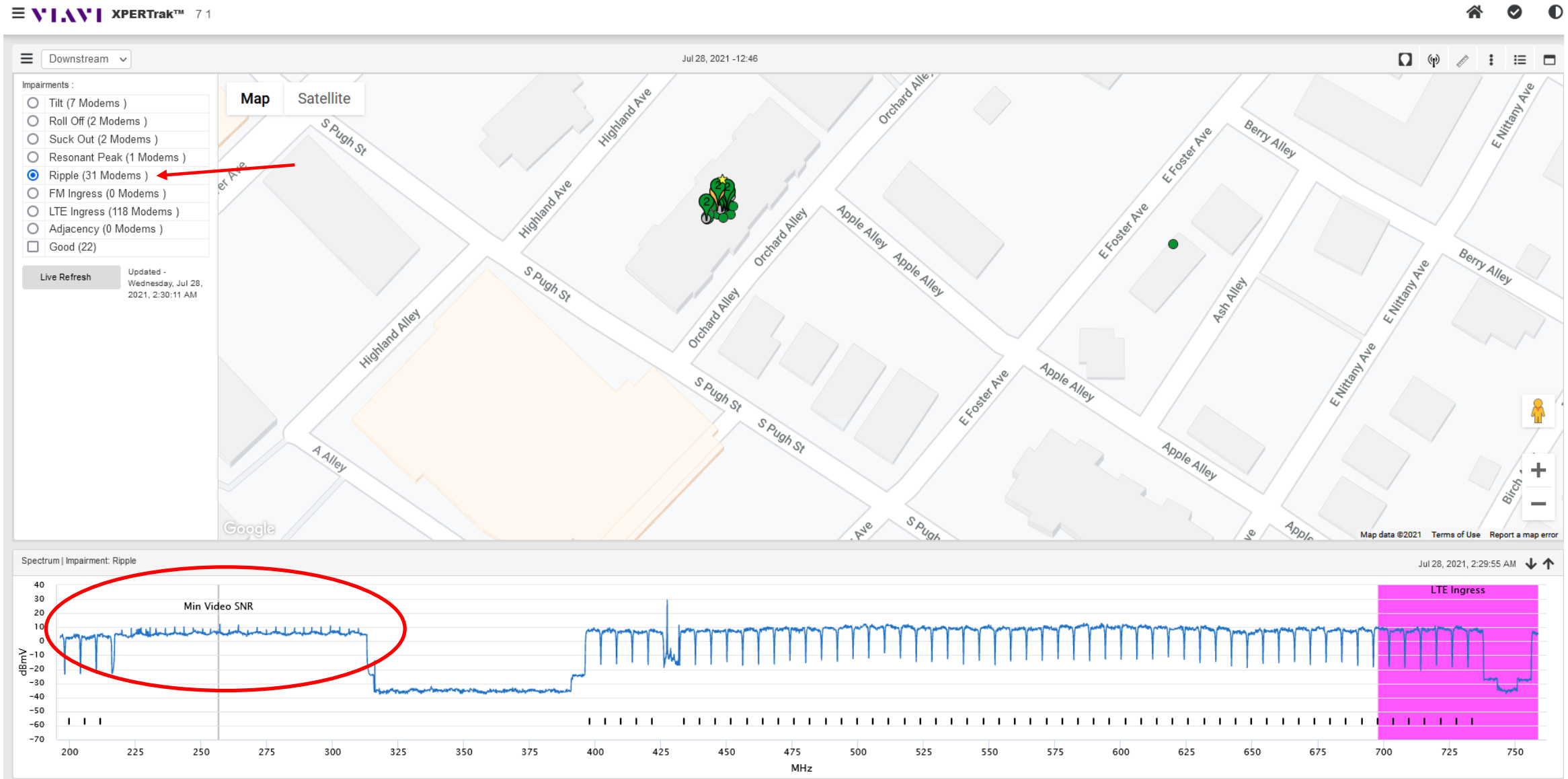
- **DOCSIS Pre-Equalization in Action**



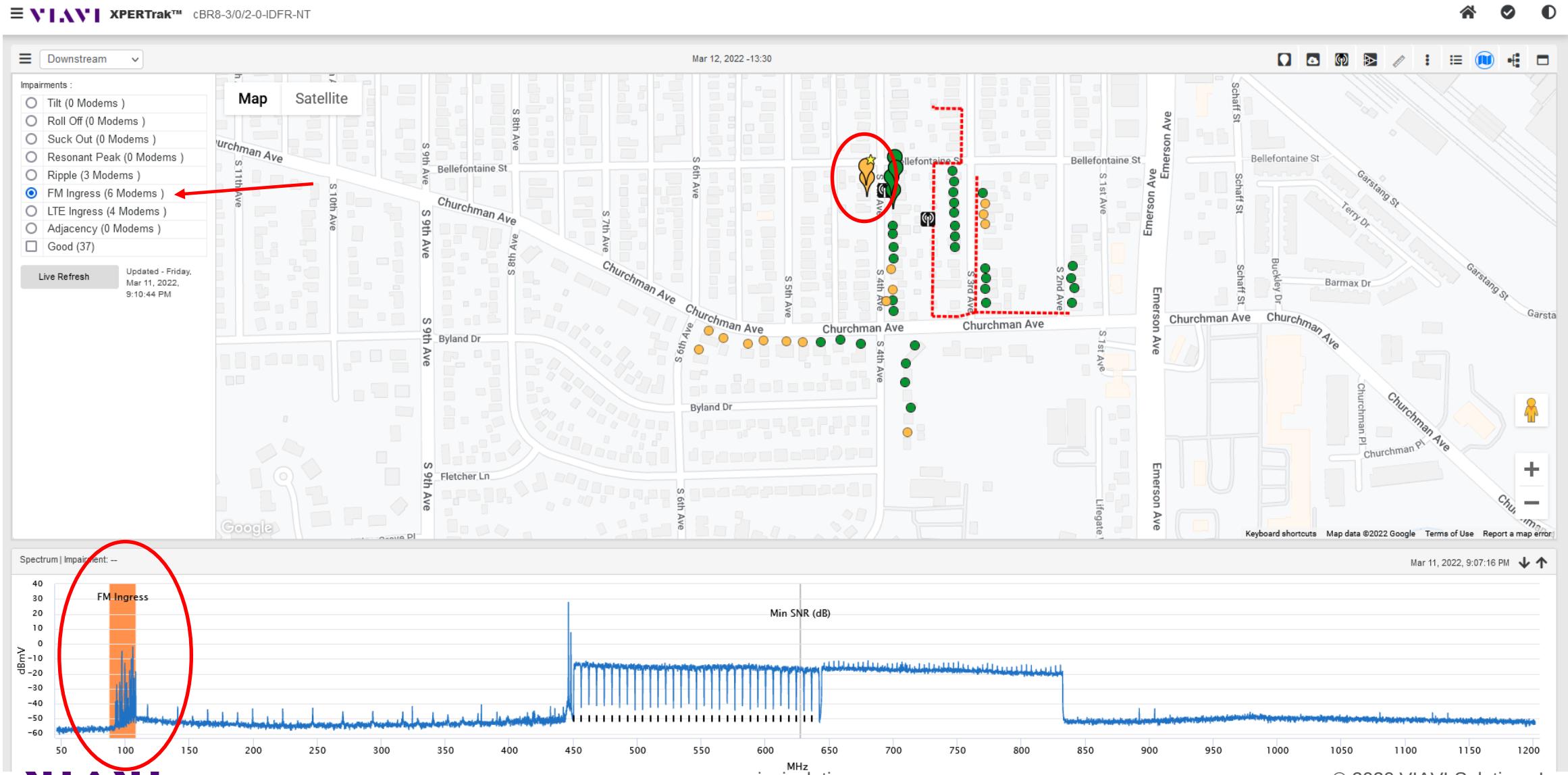
Node Health



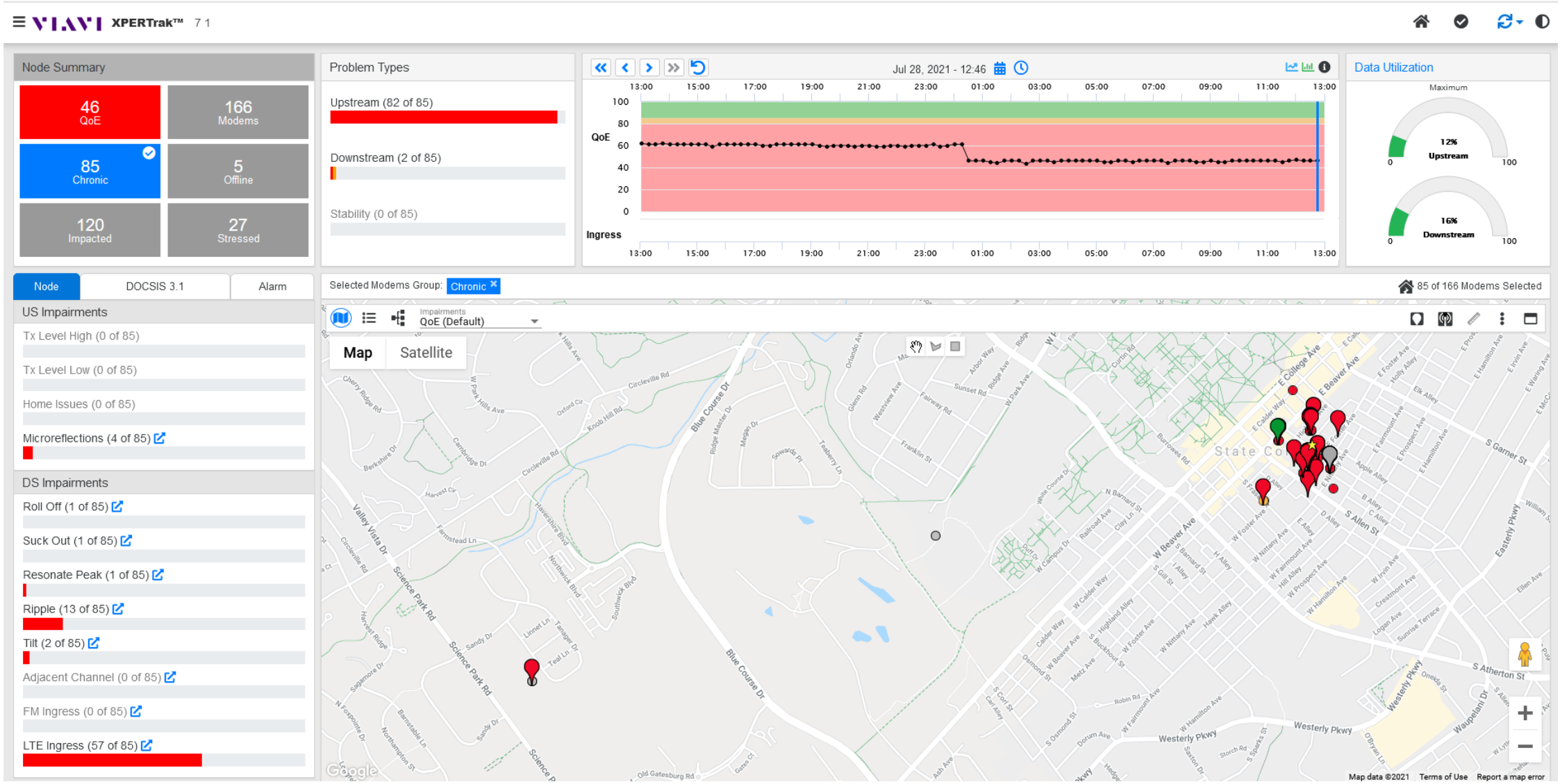
Modem Forward Path Measurements



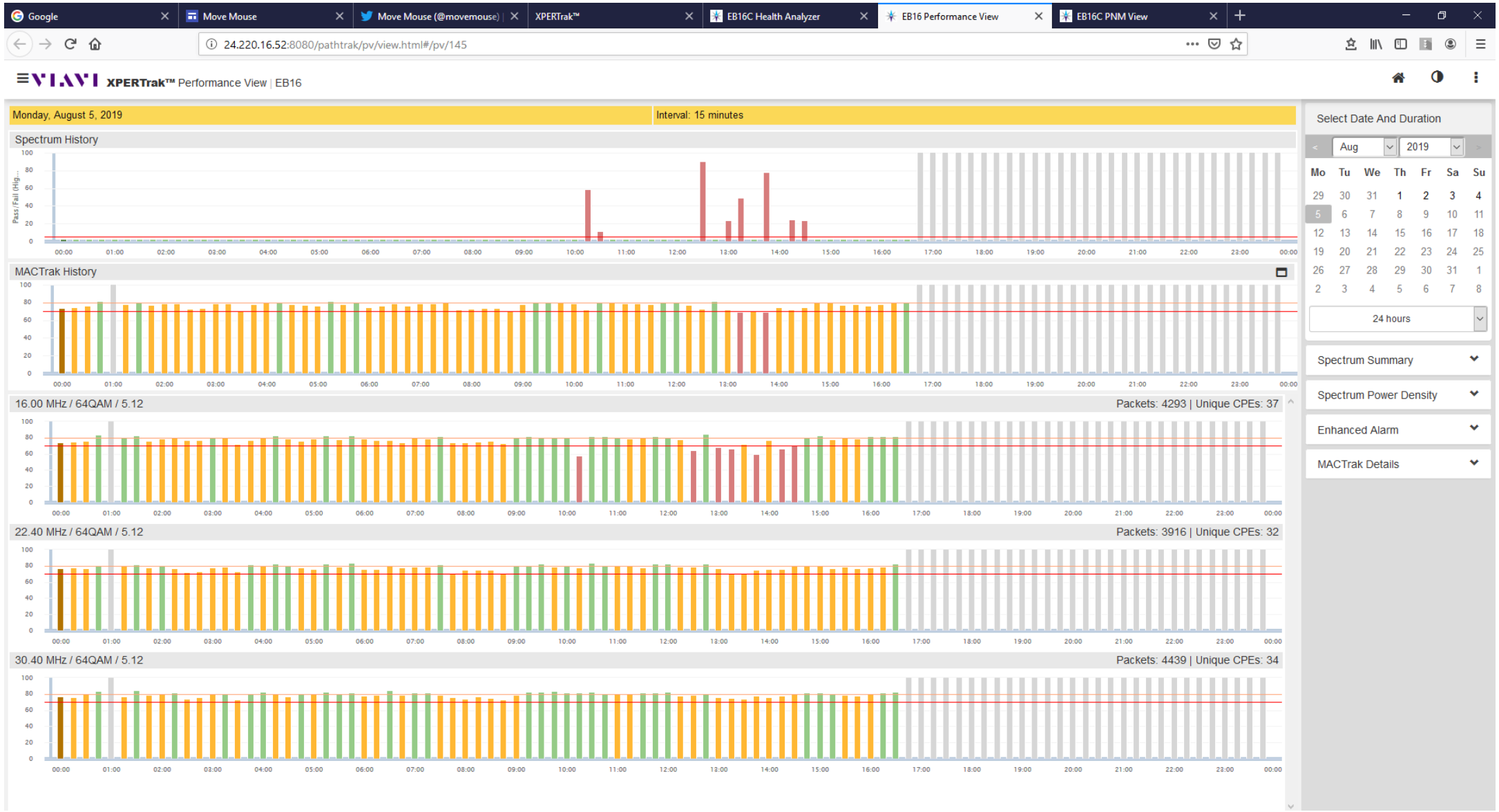
Modem Forward Path Measurements



Specific Node Issues

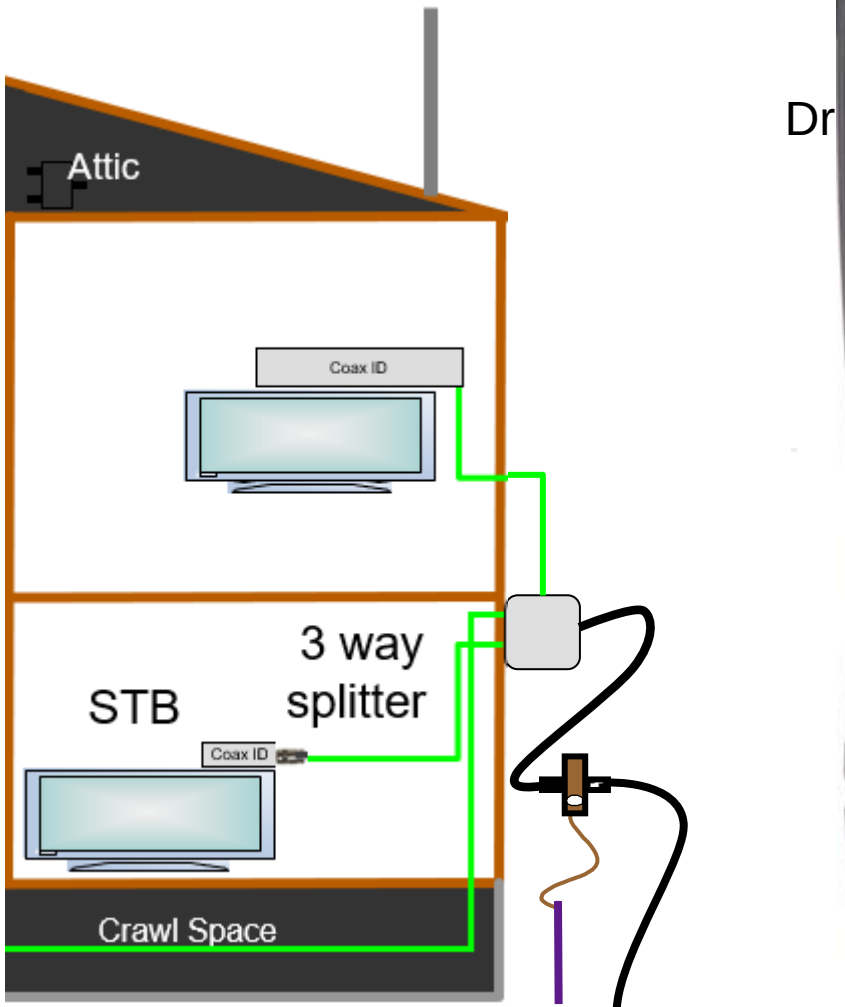


Performance View Over Time

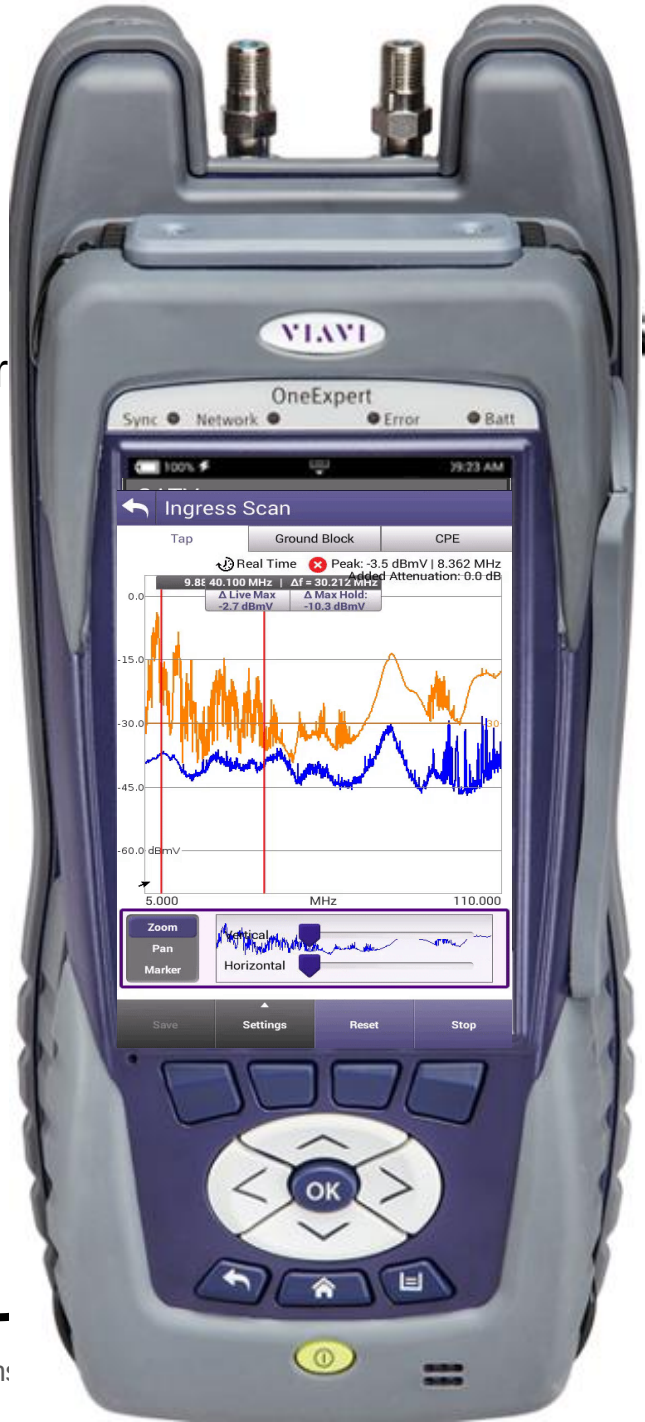


Certify the Drop Ingress at the

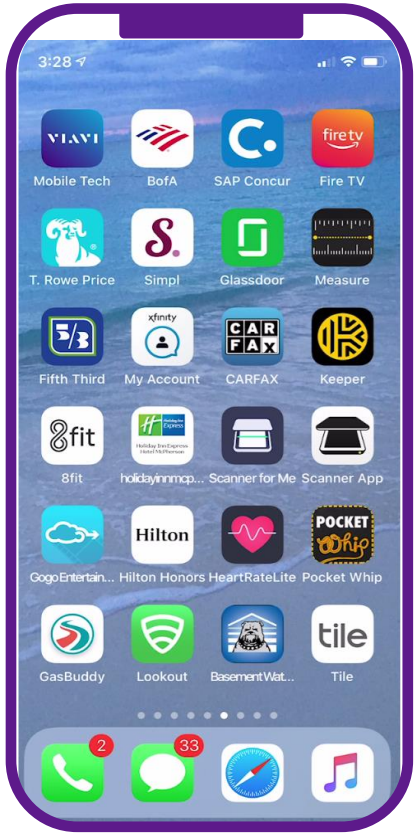
Certify the Drop
Connect port 2 to the drop and verify the ingress using the ingress test

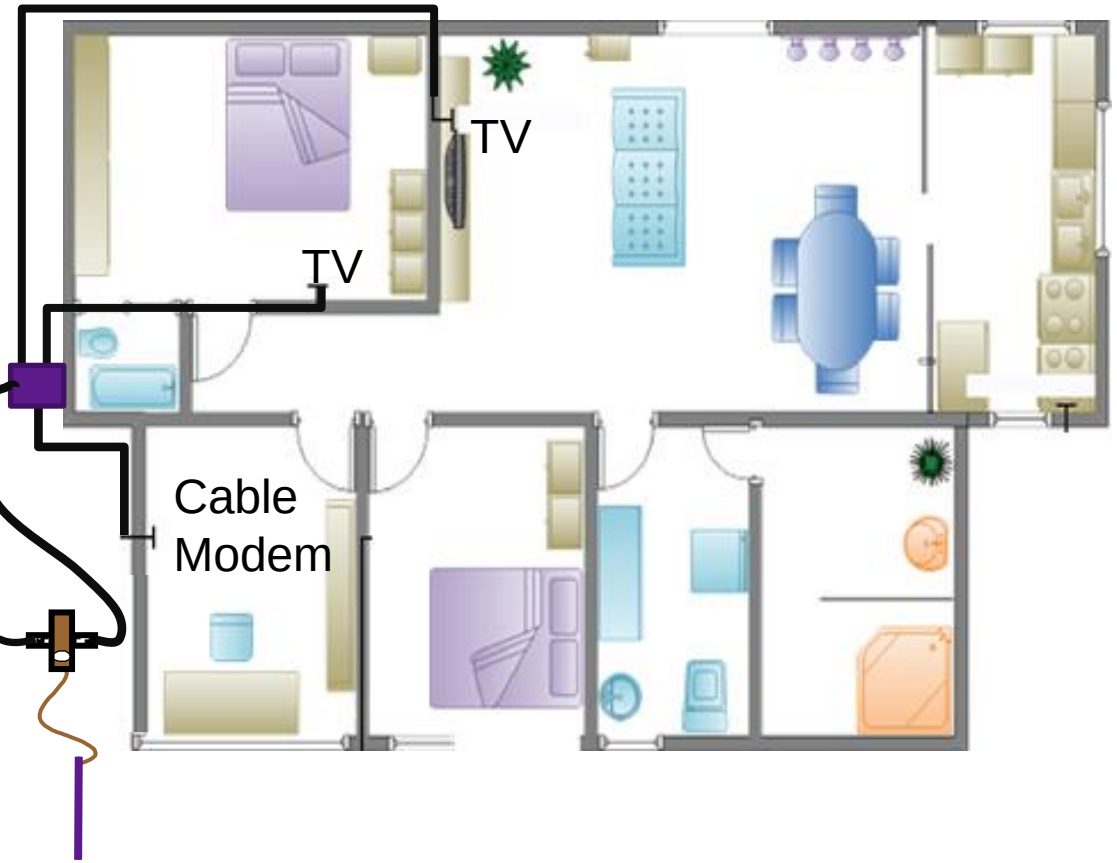


Dr



Remote Display





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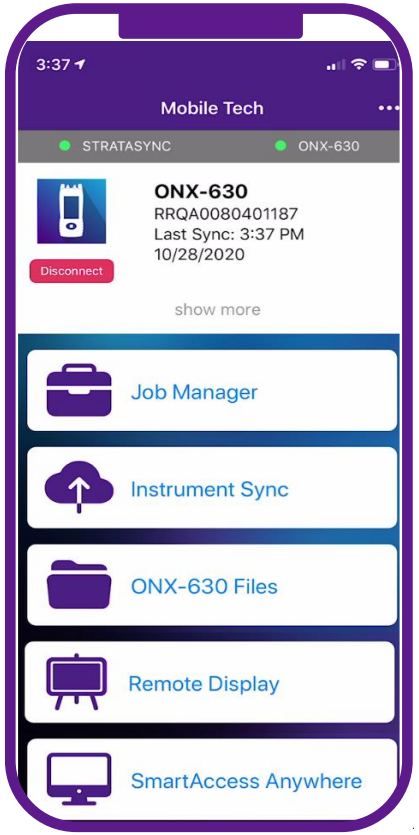

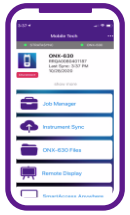

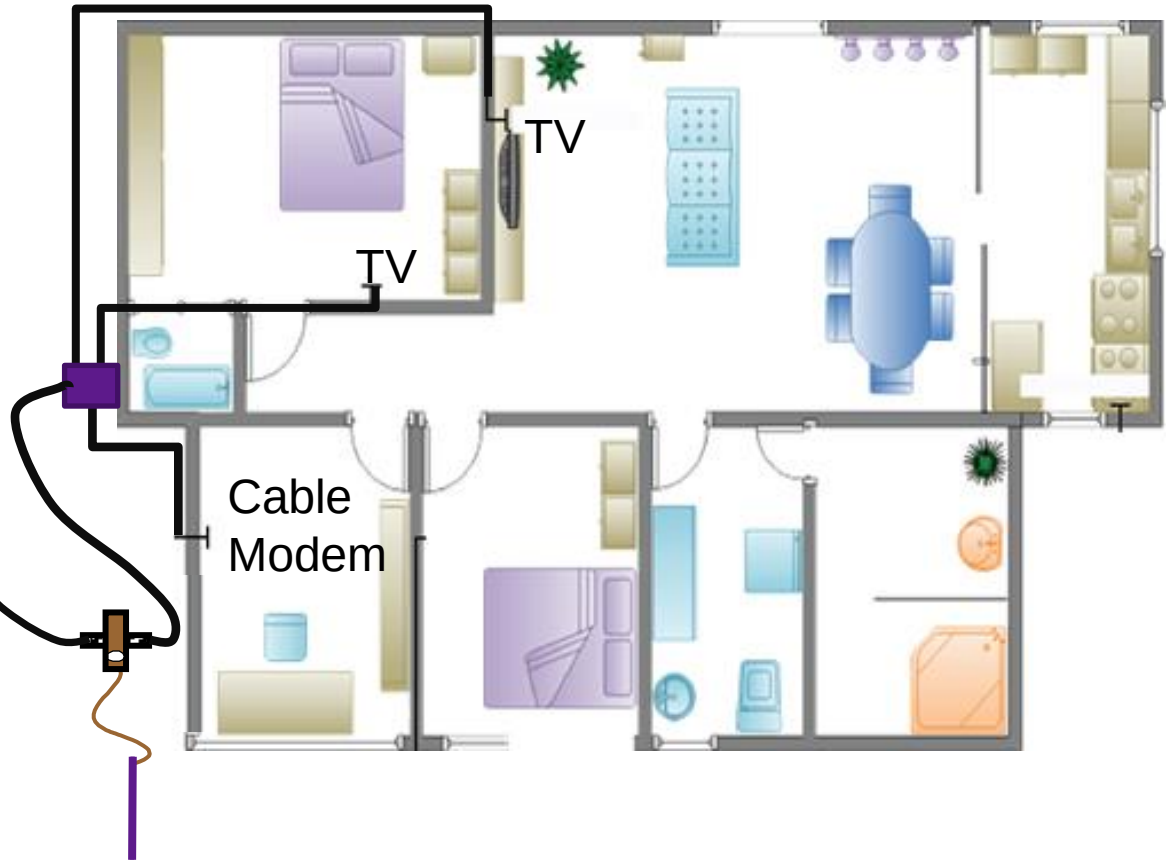

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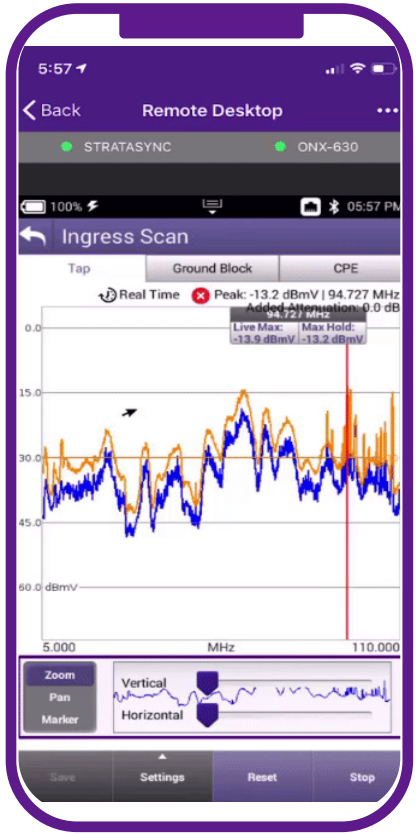
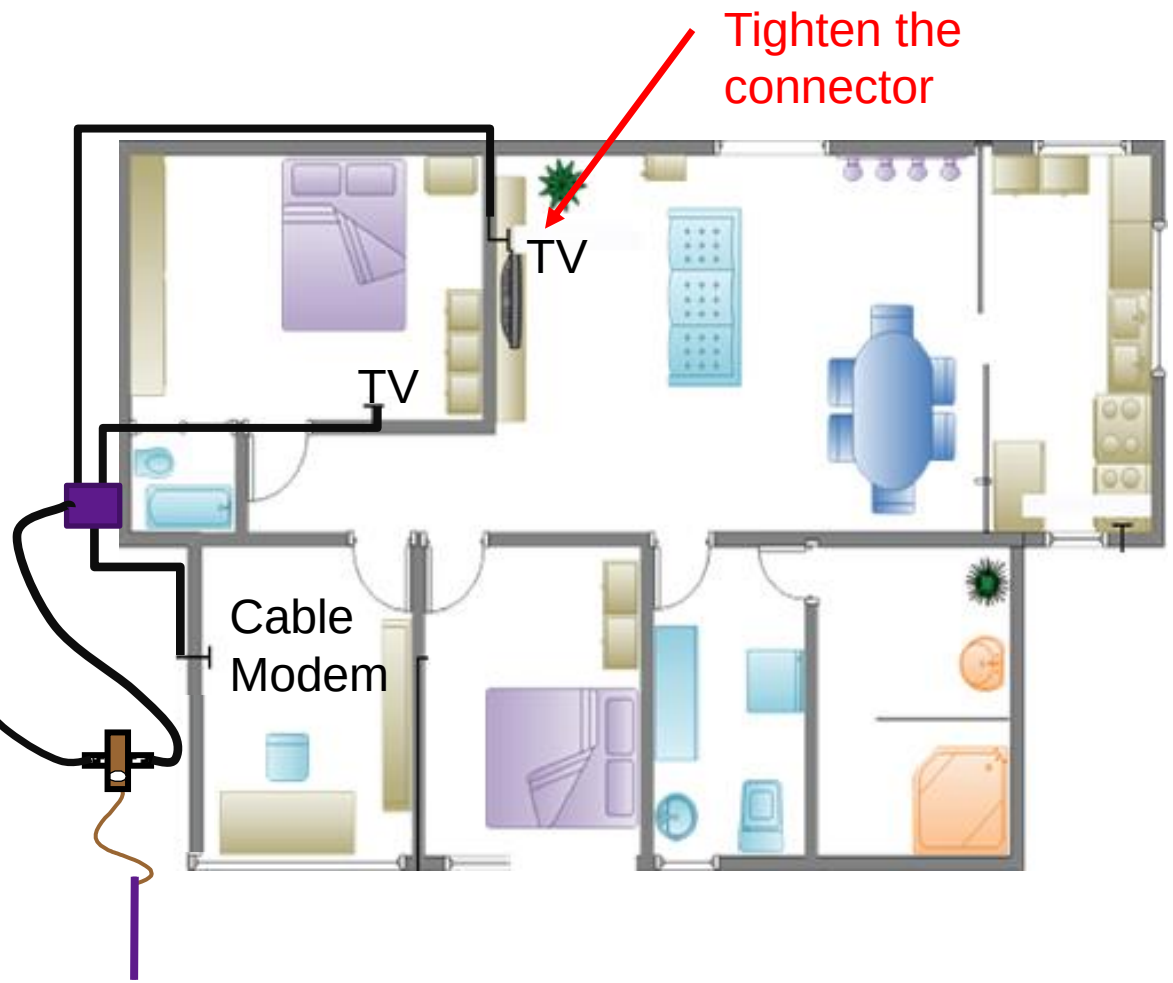
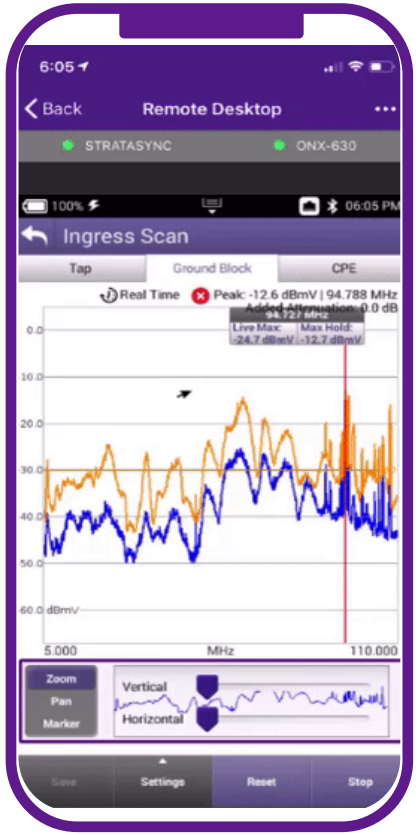
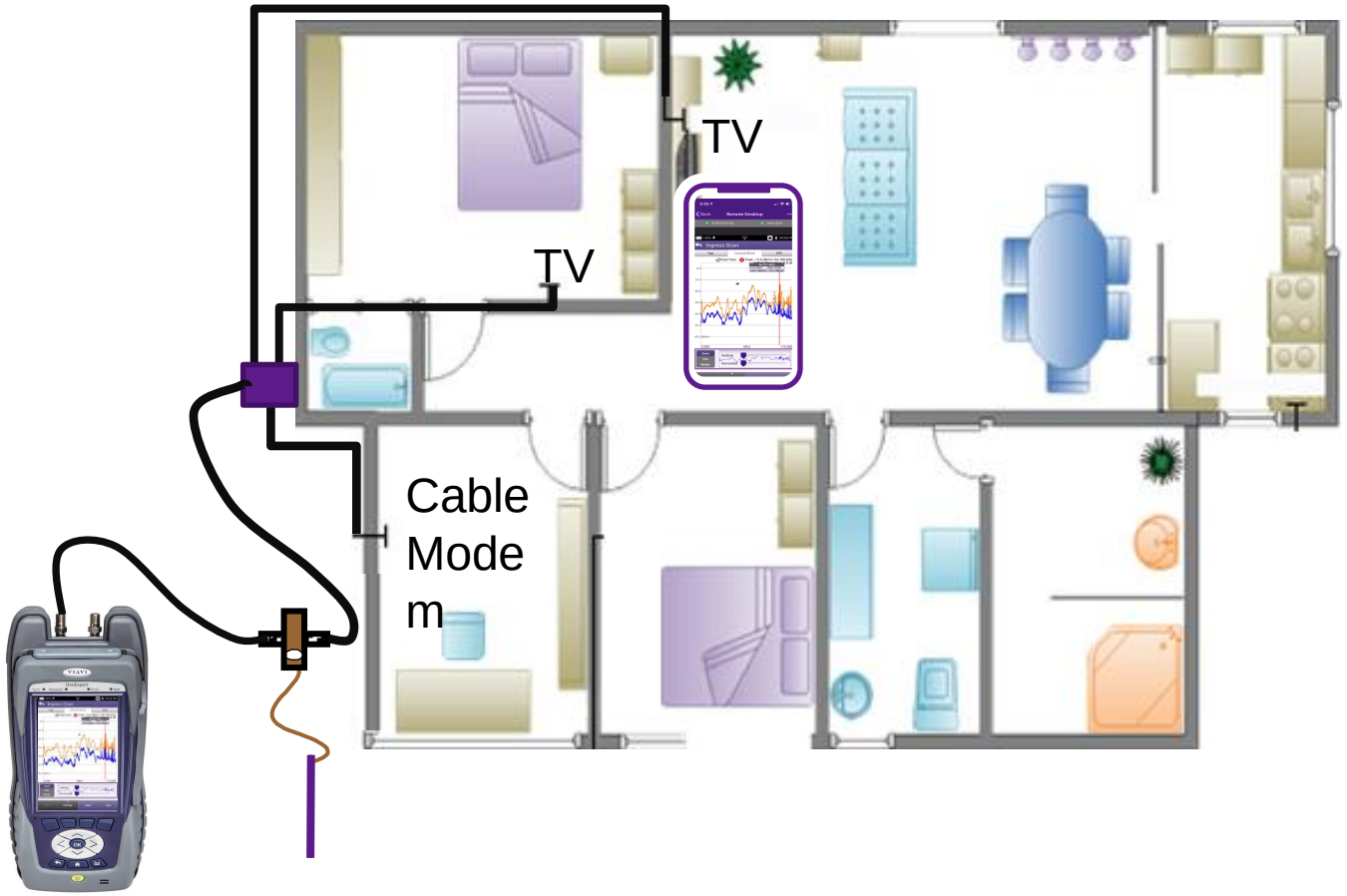


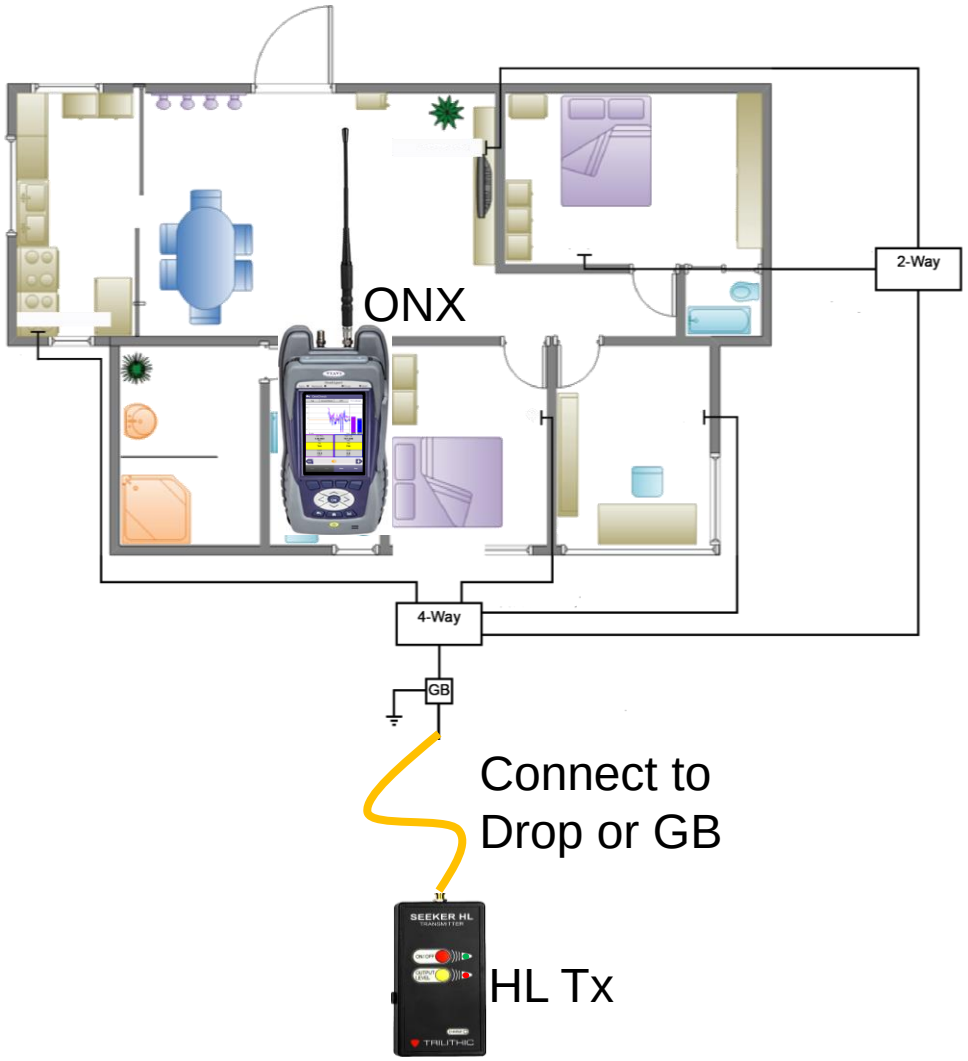


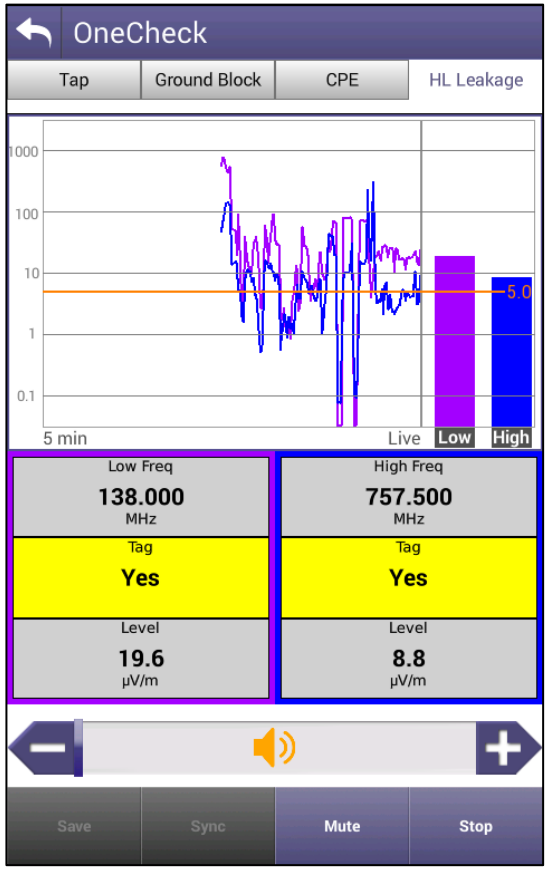
Remote Display





HL Leakage – Advanced Coax Shielding Integrity Testing





- Connect the HL Transmitter to the subscriber's premises coax and turn on the transmitter
- Now walk the subscriber's premises looking and listening for leaks coming out of the coax
- As the measures leakage levels those values will be updated live
- Also a historical graph will be shown representing both Low and High measured frequencies over time
- When complete press the "Stop" button
- Press the back button to return to the OneCheck Selection screen

VIAVI Solutions

ONX-220
HL Leakage

Tim Miller

January 2022

ONX HL Leakage mode overview

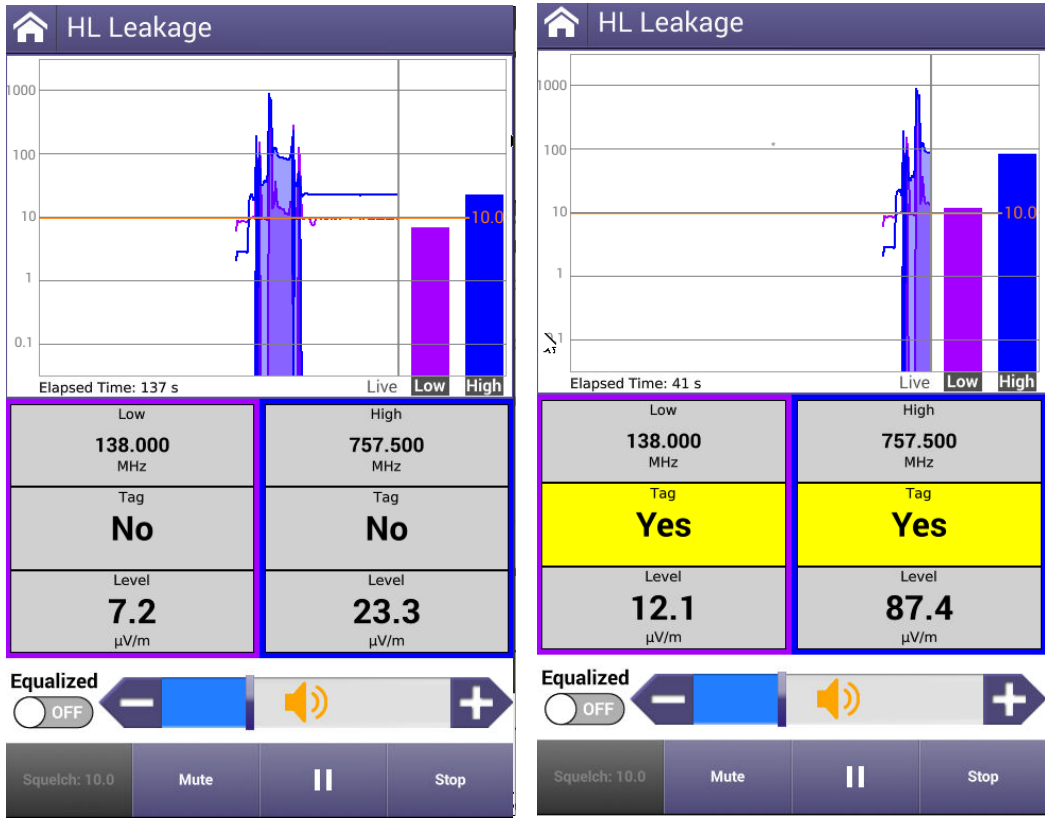
As you walk the subscribers drop with the ONX in HL mode, it is measuring signals off the air looking specifically for the HL Transmitter's two leakage signals. Each signal has a special identification modulation called a "Tag". When either of these two signals are detected, the signal level and Tag are displayed. If the signal's Tag is detected and its measured level exceeds the configured squelch level, then the ONX emits an audible tone and the "Tag" box changes to yellow.

When the Tag box turns Yellow, this is the indication that a leak has been detected above the minimally acceptable level.

In this example the squelch was set to 10µV/m, so the level of the signal must exceed 10µV/m and the Tag must be detected (Yes) to turn the box yellow.

As you get closer to the leak, the measured signal level will rise. The bar graph and history chart are continuously updated to reflect these level variations.

Adjust the audio sound volume using the volume bar at the bottom of the screen, or fully mute the audible tone when desired with the Mute button.



Seeker HL Source Transmitter

→Power On / Off:

- Green – normal operation
- Red – Low Battery
- Blinking Red – Very Low Battery

→Output Level:

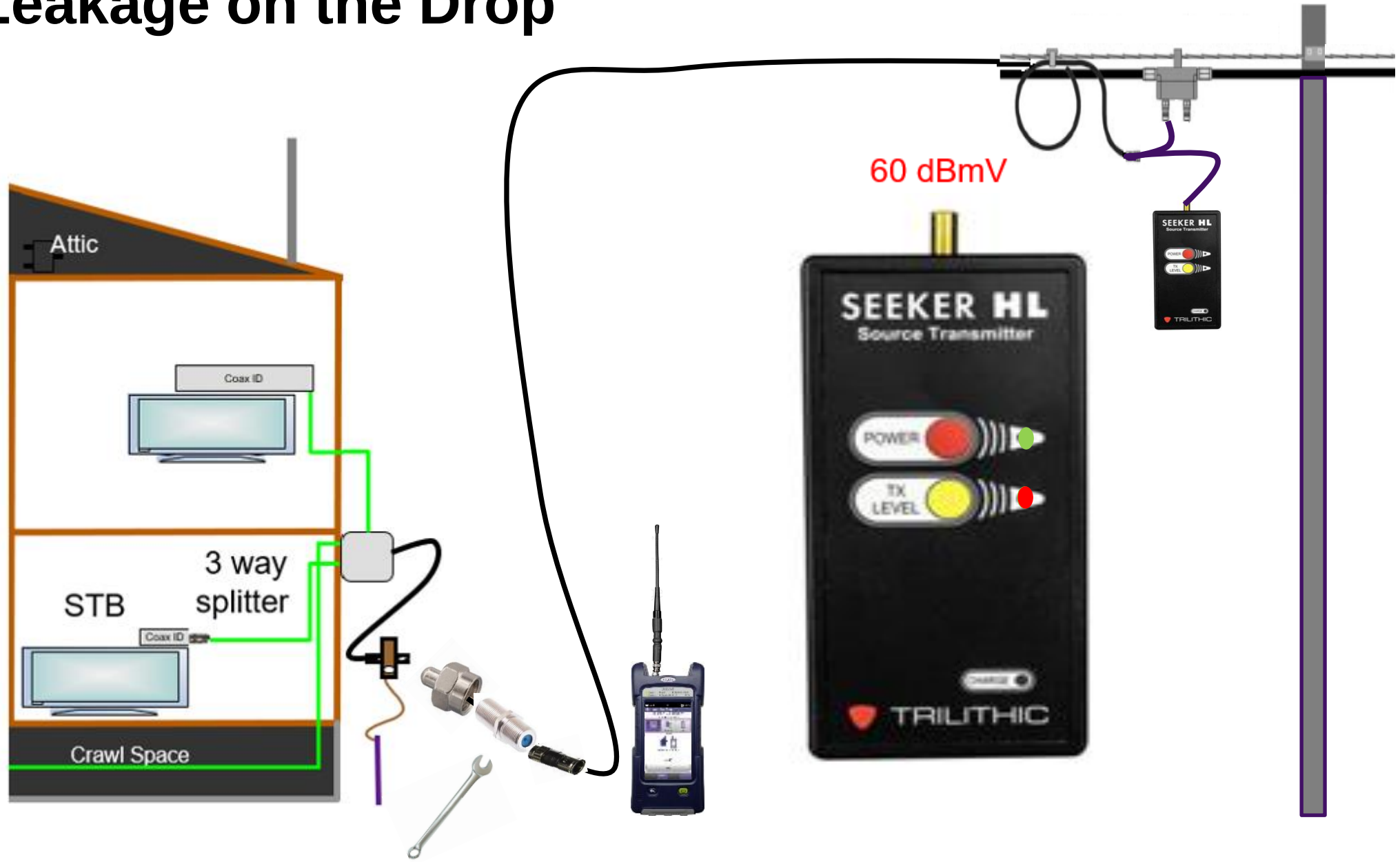
- Green – Low Output (40 dBmV)
- Red – High output (60 dBmV)
- Blinking Red/Green – Device Error

→Charge:

- Green – Done
- Red - Charging

ONX HL Leakage on the Drop

- **Install HL pressure test transmitter to the drop**
- **Wrench tighten terminator at the Ground block**
- **Walk the Drop with then HL leakage application.**



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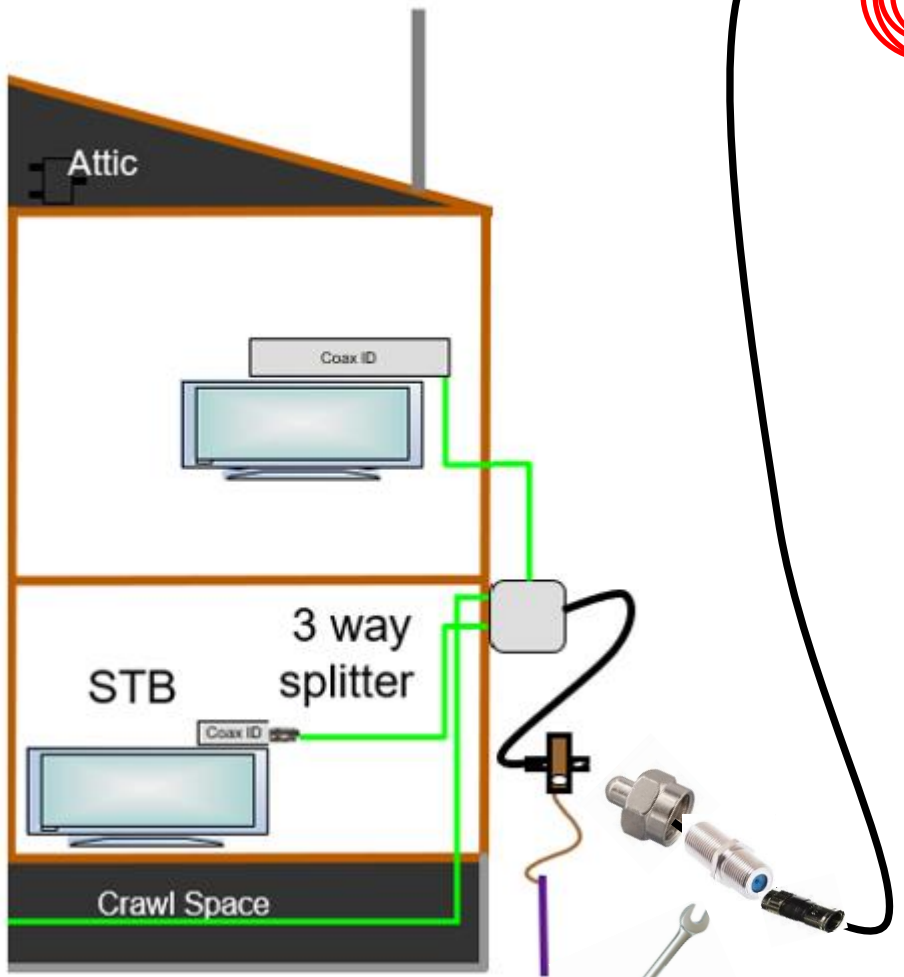
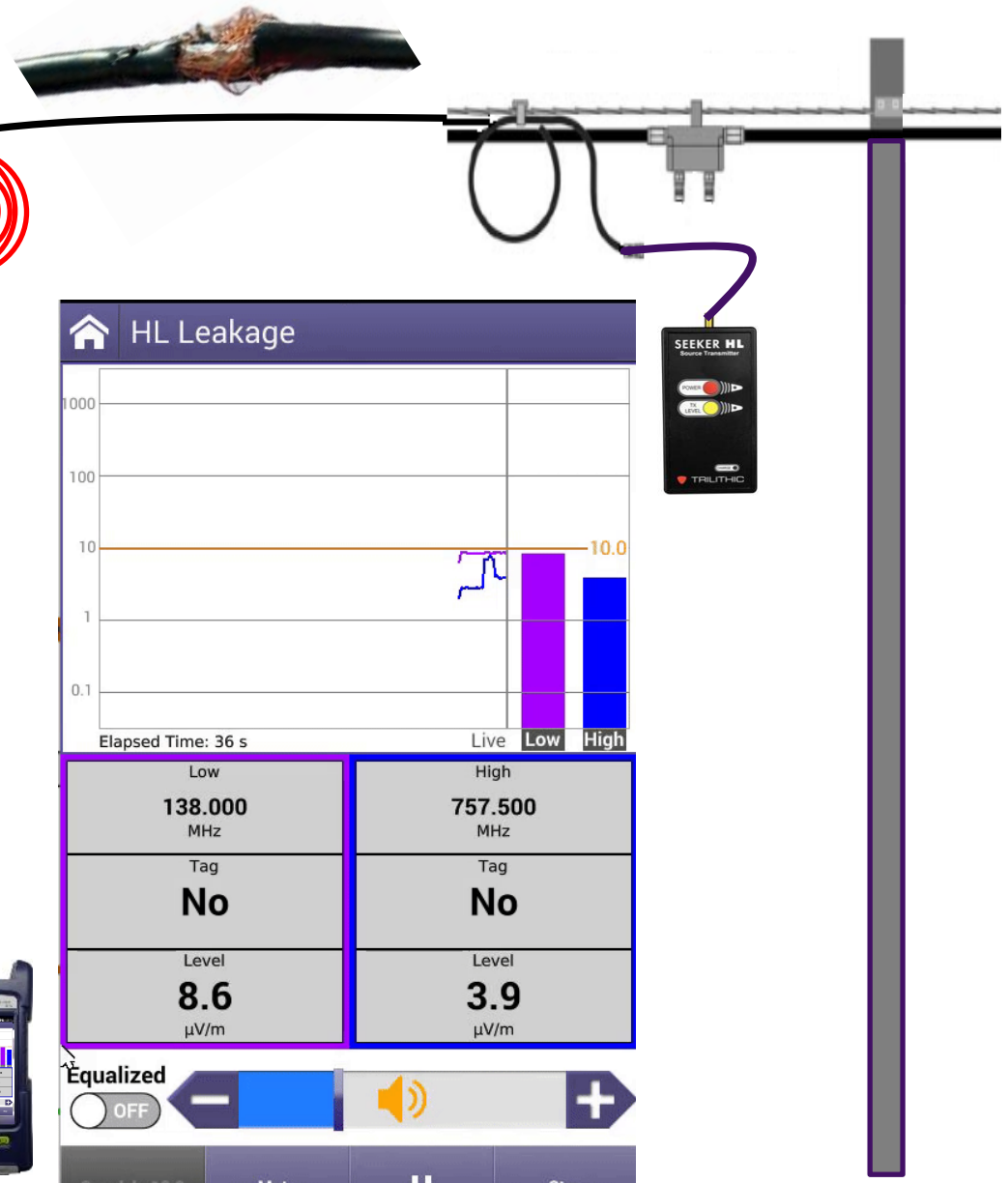
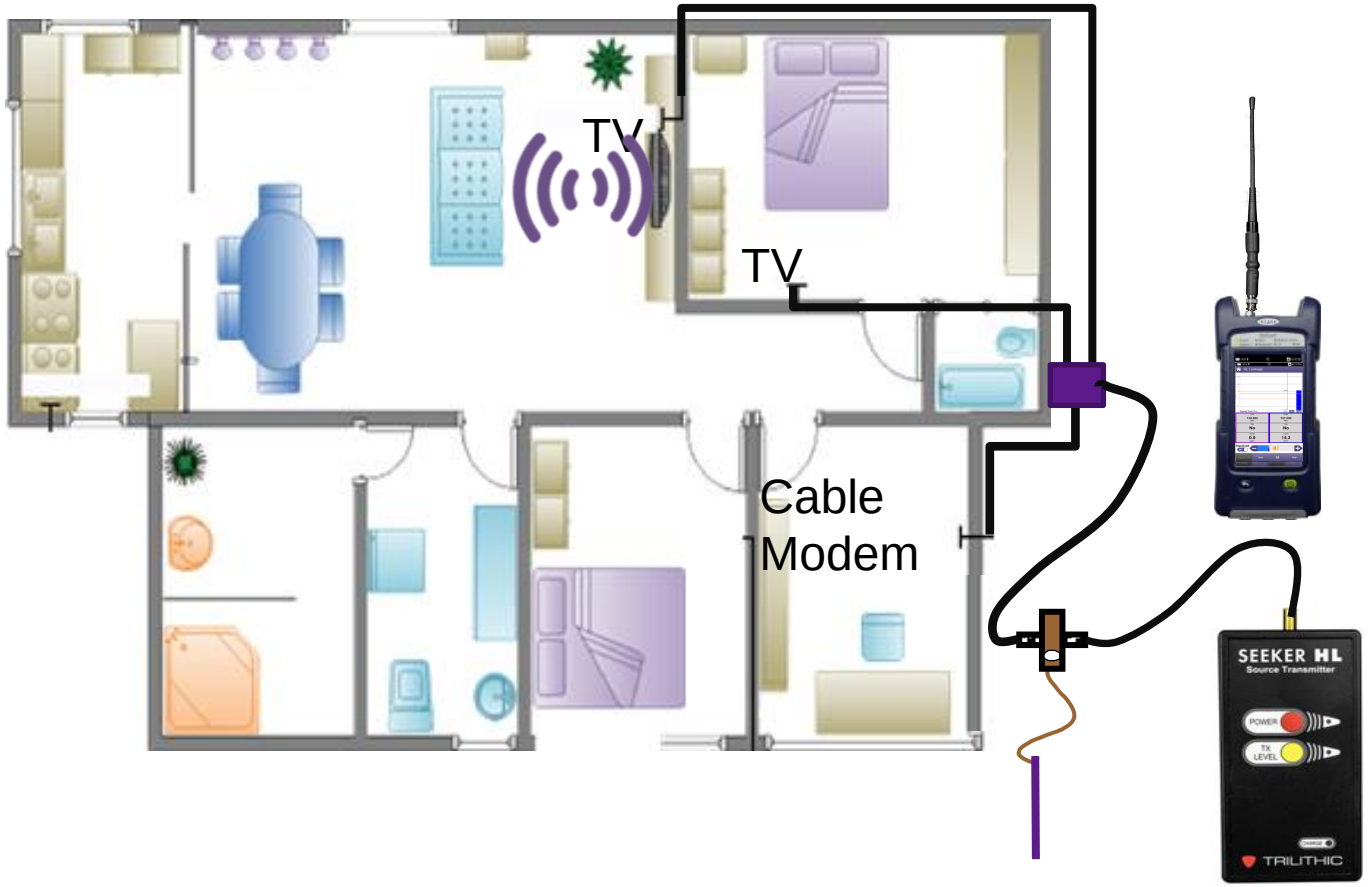
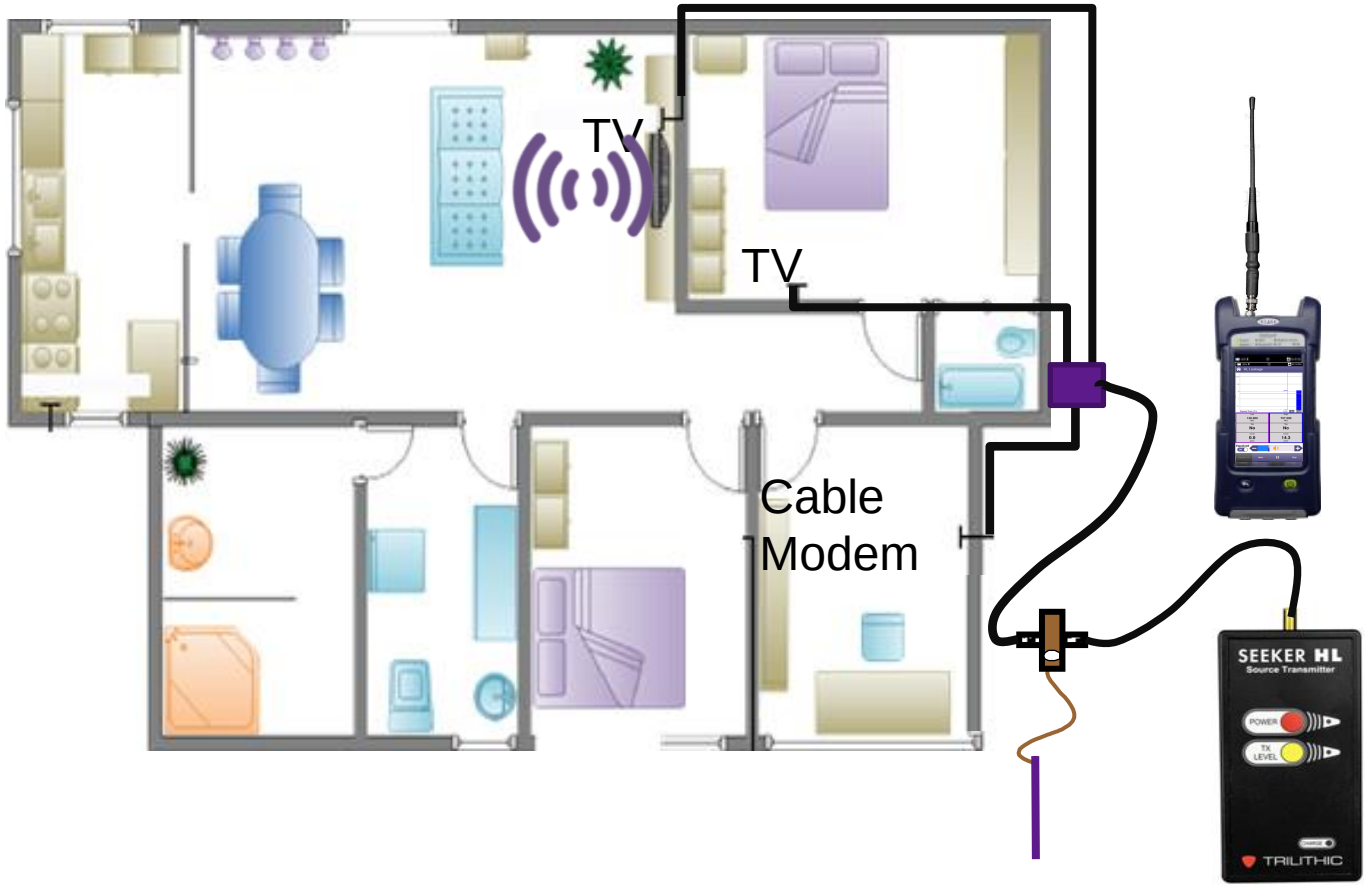




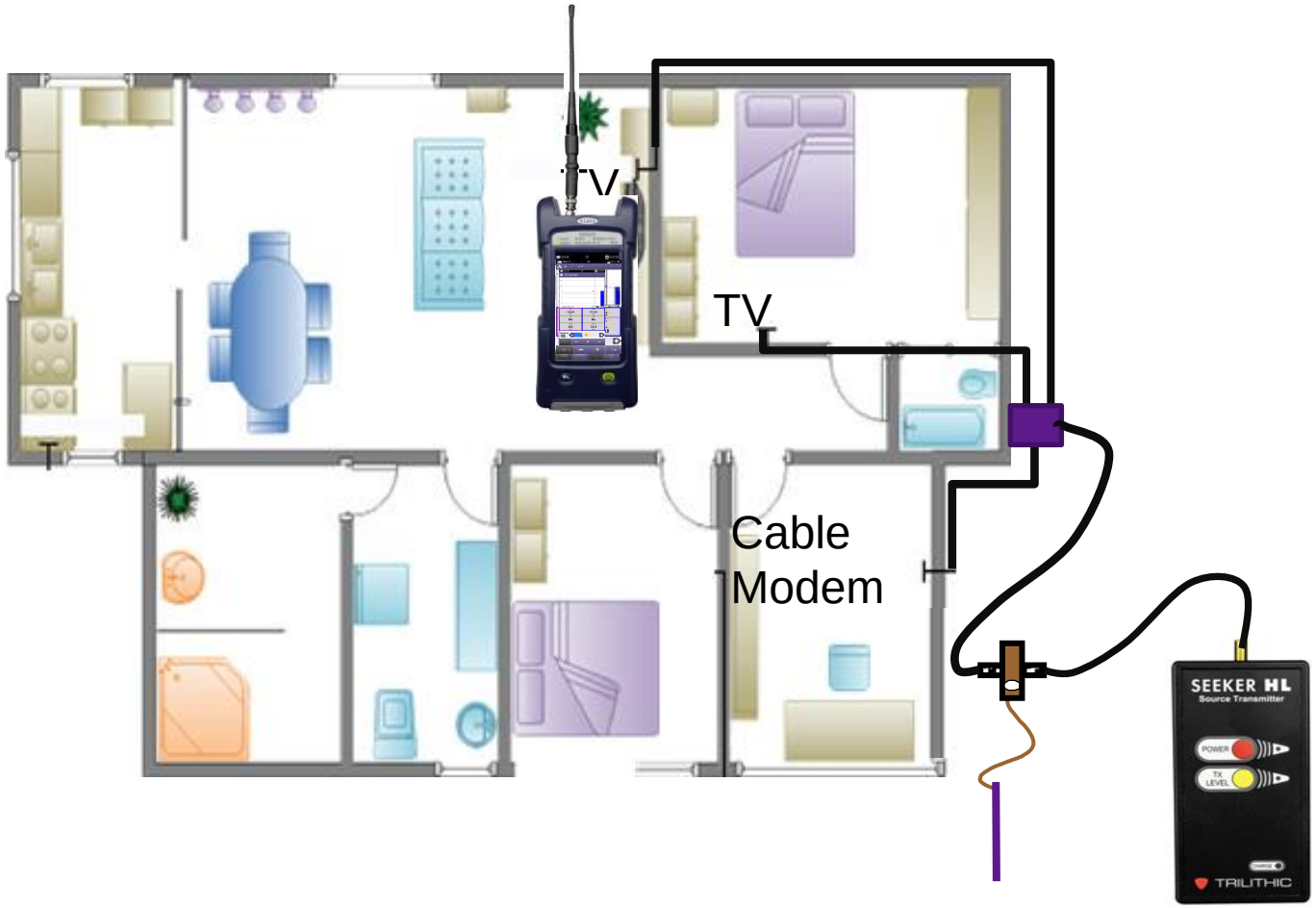
Finding Leaks



Finding Leaks



Finding Leaks



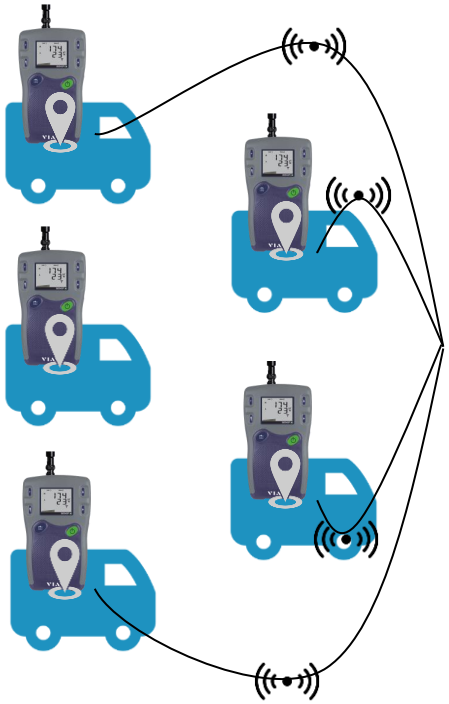
Cable Pressure Test

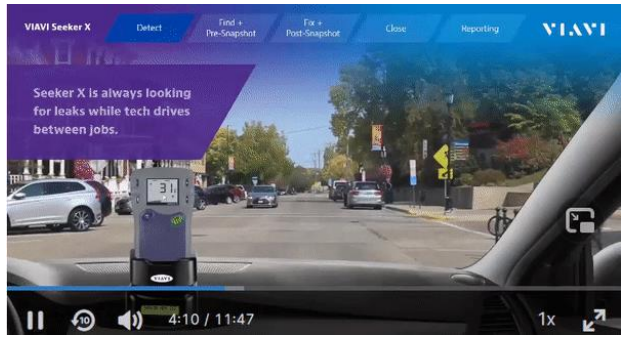
Cable Pressure Test Live

Checking FM Ingress and LTE Live

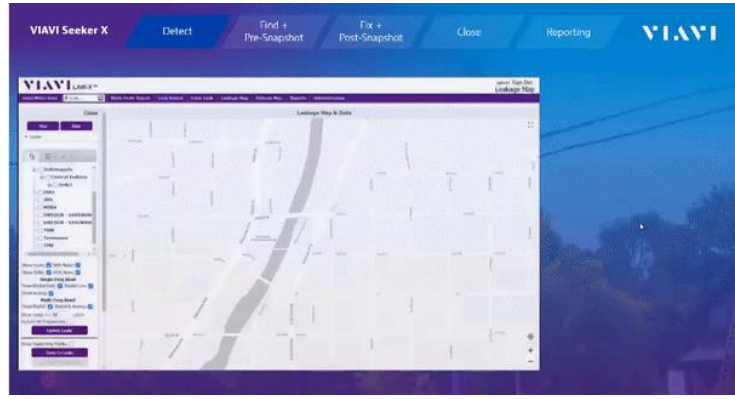
Finding Leaks

1. MCAIII's sync Seeker X leak data to LAW Server via Wifi

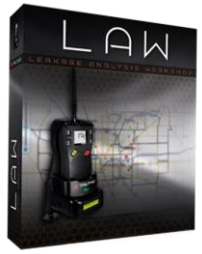




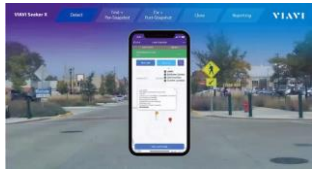
5. Leaks sent via API to XPERTrak for overlay with PNM, QoE data



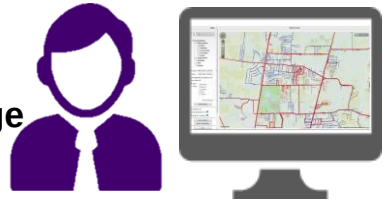
2. LAW Quadrangulates data, localizes & prioritizes leaks



4. Tech fixes leak, closes out work order via Mobile Tech (GPS)



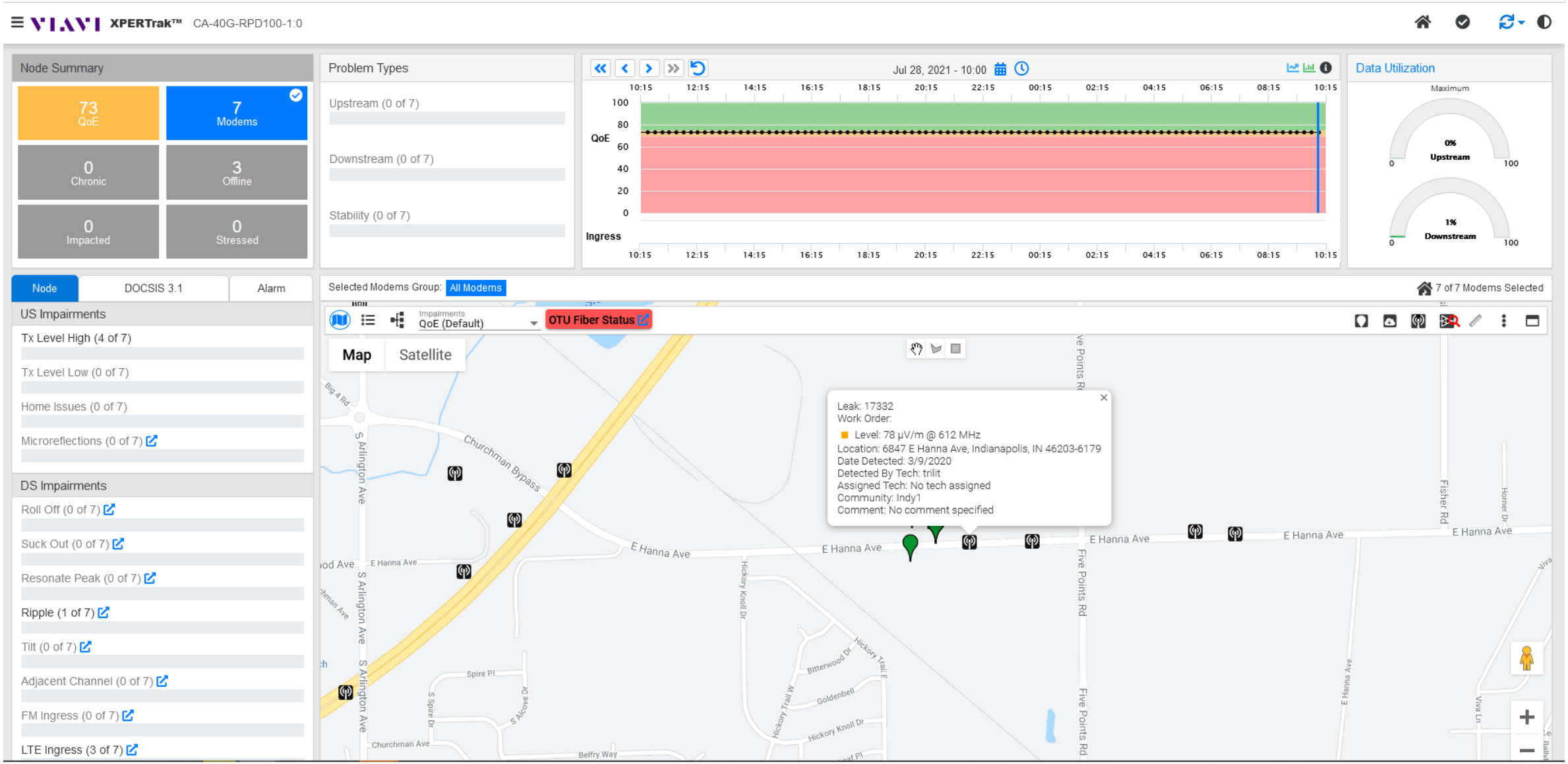
3. Work order created, assigned to Tech



6. NOC uses with XPERTrak to triage issues

7. Director trends overall performance

Leakage Maps in PNM



Hum Test Results

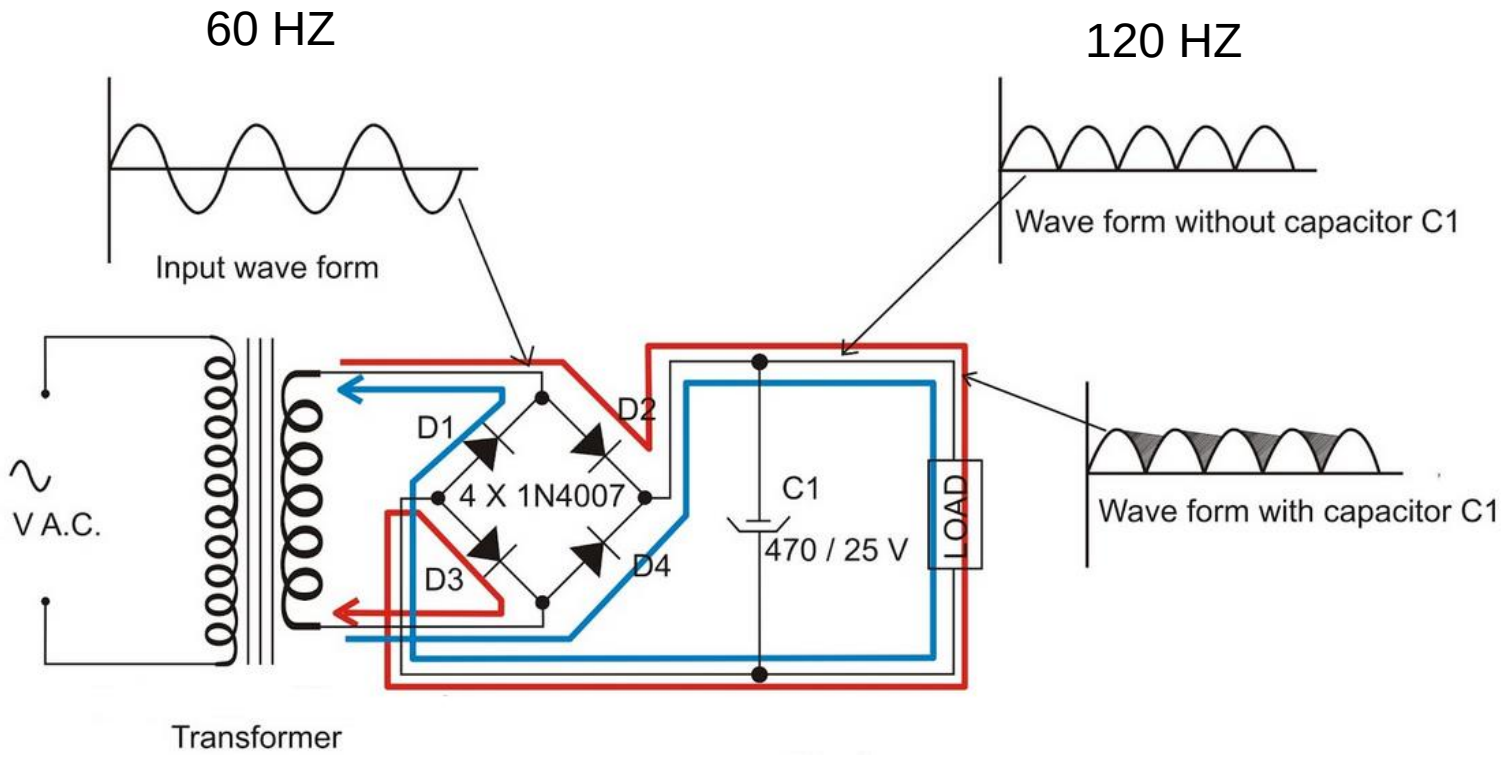
What is Hum?

Hum is a signal impairment which causes the amplitude of a modulated carrier to vary.

Hum is often caused by poor filtering in an amplifier's power supply.

In an analog TV signal, hum causes horizontal lighter/darker bands in the picture

In a digital QAM signal, it can cause a low modulation error ratio (MER), and can raise the bit error ratio (BER) when the hum is severe



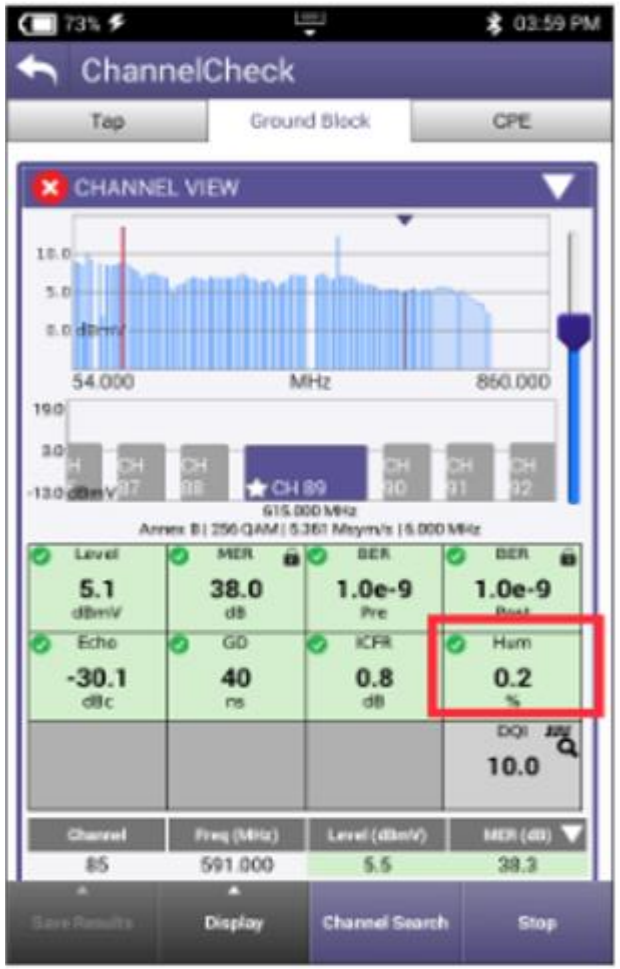
How Much Hum Is Too Much?

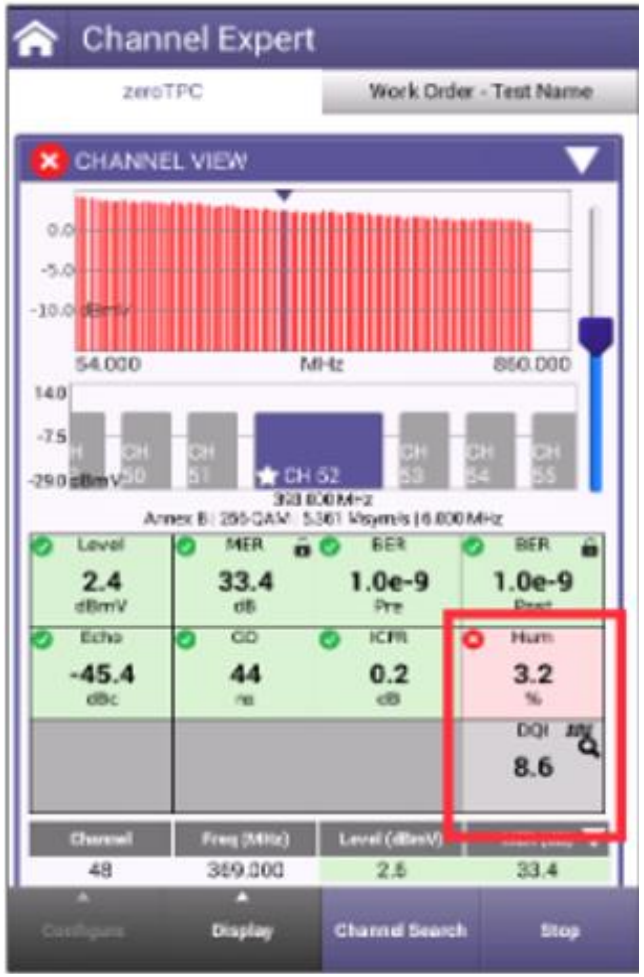
The FCC mandates that TV signals have no more than 3% total hum.

QAM demodulators used in cable modems and set-top boxes vary widely in their ability to cancel hum. They are designed to cancel at least 3% hum, the amount allowed by the FCC

They will typically operate to 5% hum without problems. If the hum reaches 7%, some demodulators will report a MER below 32 dB and will exhibit uncorrected bit errors.

Hum could appear on 1 QAM carrier due to a faulty modulator.





Note: Modern Broadcom demodulators are really good at cancelling out hum and other amplitude problems. We even turn it up to make it better than stock Broadcom cable modems. Customer equipment can't cancel out what our CM can so the ONX may not see Pre or Post BER but will see it in DQI.

What's one of the best tools for fixing ingress?

https://eguides.viavisolutions.com/

What to look for ?

Cut on Cable

Worn

Corrosion

Shorted

Not crimped properly

Note: 28 Connections

Conclusion

- Understand the RF Noise

- Spectrum analyzers are still great tools to see the noise in the network.
  - Zero span
  - Heat Map
- Node Health
- PNM
  - Locate the problem faster

Pressure test the tap to the house for egress

- find points of ingress

VIAVI Solutions

https://eguides.viavisolutions.com/

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