Forward and Return Sweep

03.28.2016

Agenda

Setting up Transmitters

Forward and Return Sweep

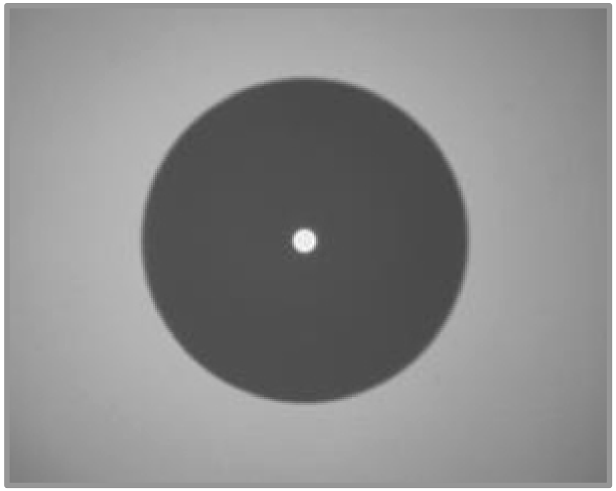
Supporting Docsis 3.1

Fiber Testing

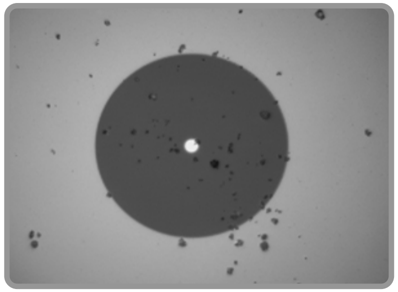
Types of Contamination

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

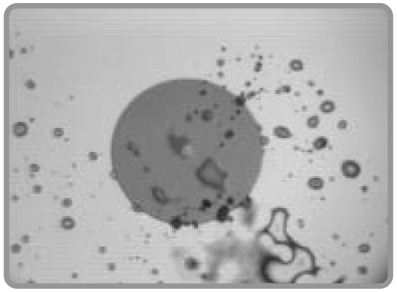
SINGLEMODE FIBER



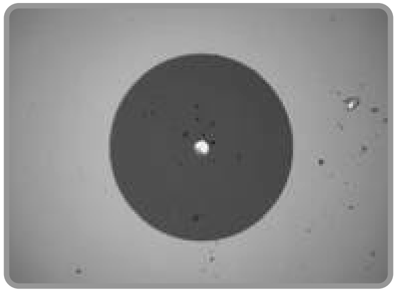
Common types of contamination and defects include the following:



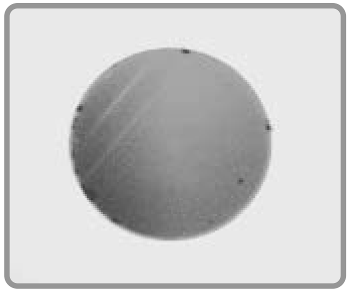
Dirt



Oil

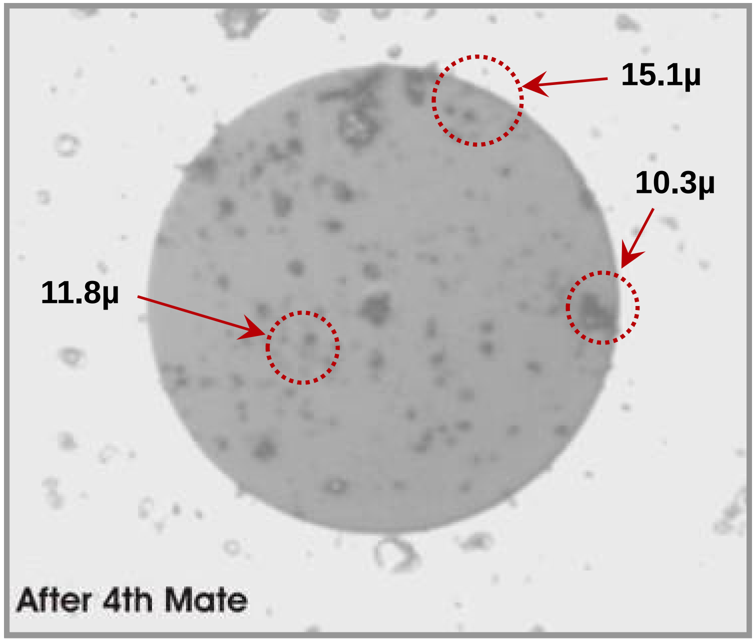


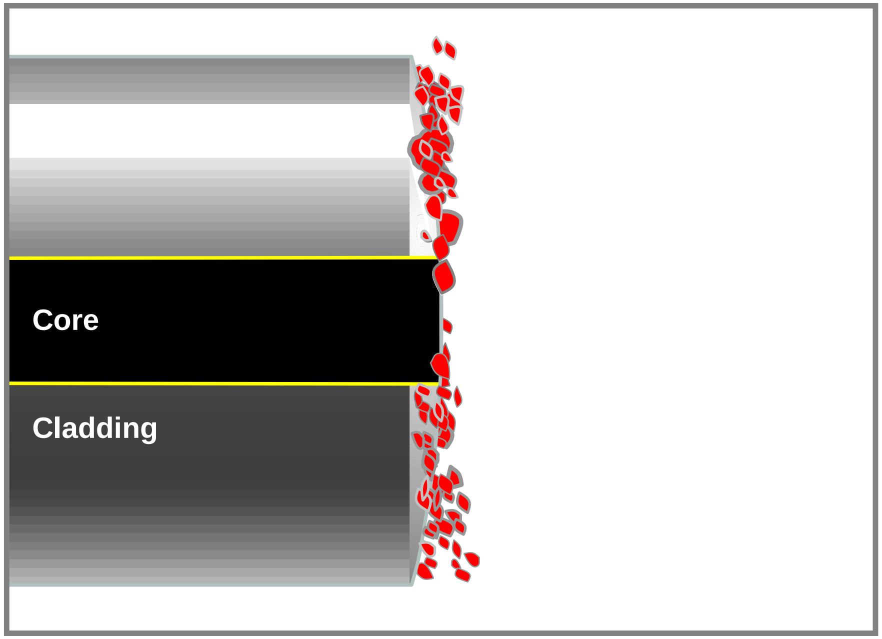
Pits & Chips



Scratches

Illustration of Particle Migration

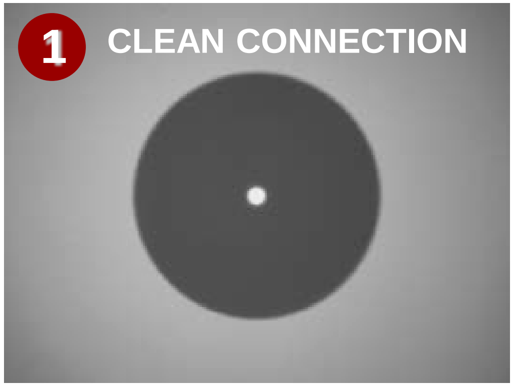




Actual fiber end face images of particle migration

- Each time the connectors are mated, particles around the core are displaced, causing them to migrate and spread across the fiber surface.
- Particles larger than 5µ usually explode and multiply upon mating.
- Large particles can create barriers ("air gaps") that prevent physical contact.
- Particles less than 5µ tend to embed into the fiber surface, creating pits and chips.

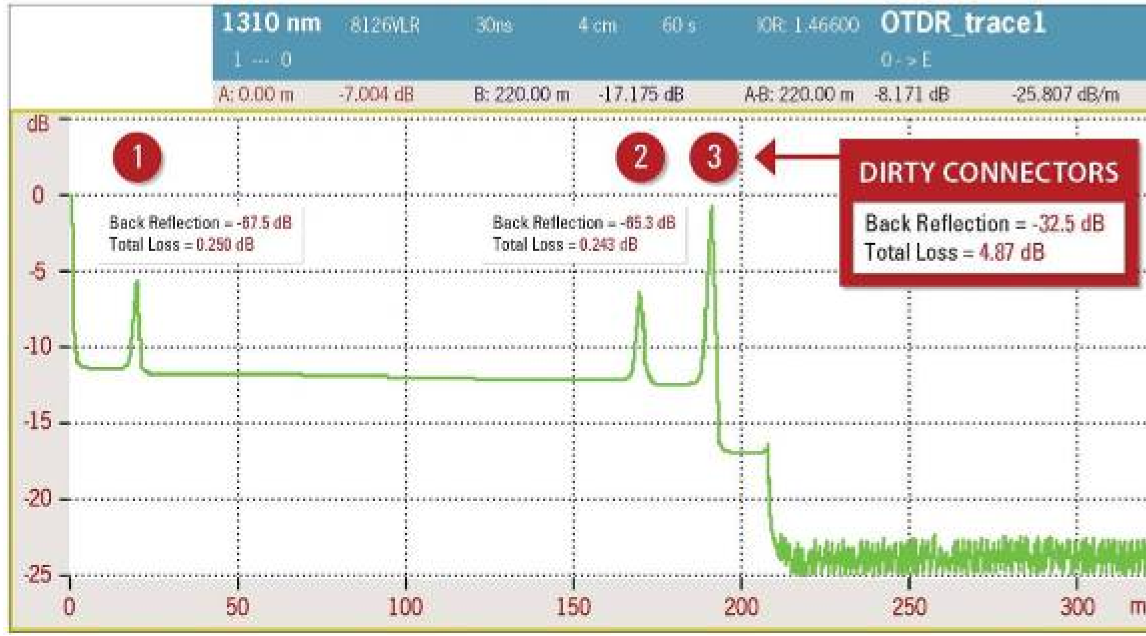
Contamination & Signal Performance



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

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

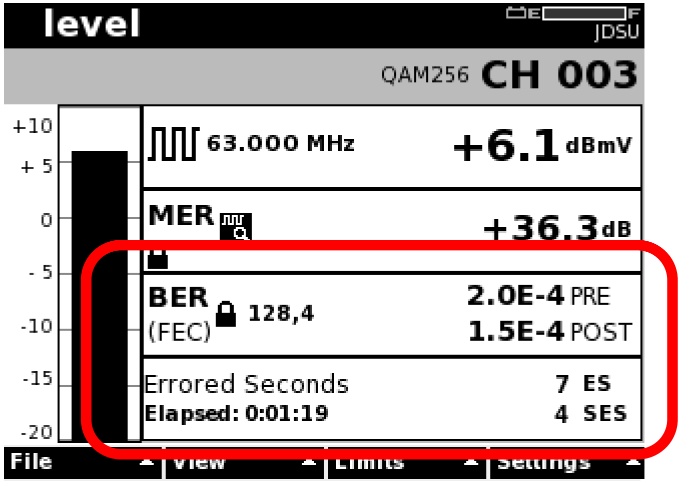
Fiber Contamination and Its Effect on Signal Performance



Clean Connection vs. Dirty Connection

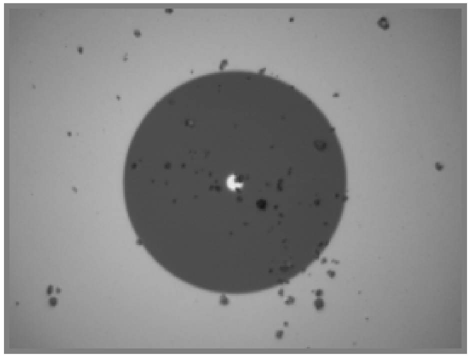
This OTDR trace illustrates a significant decrease in signal performance when dirty connectors are mated.

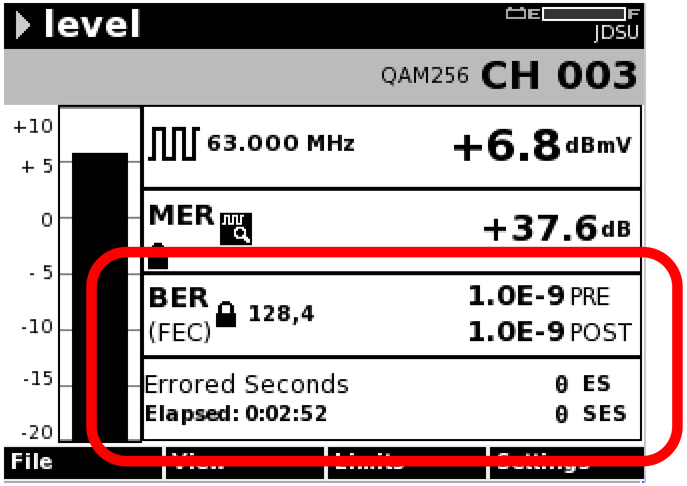
Fiber Connector Cleaning Improves Plant Health Metrics



Before Cleaning

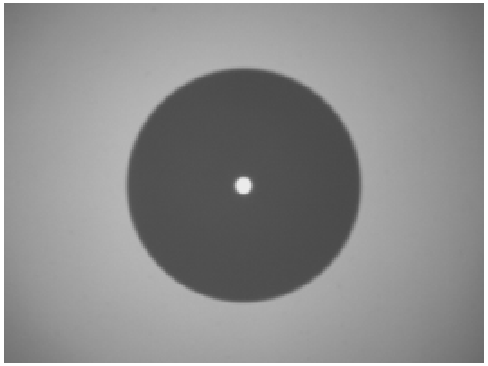
- Level and MER okay
- Notice Bit Errors both pre and post
- Also shows errored seconds
- Definitely customer affecting





After Cleaning

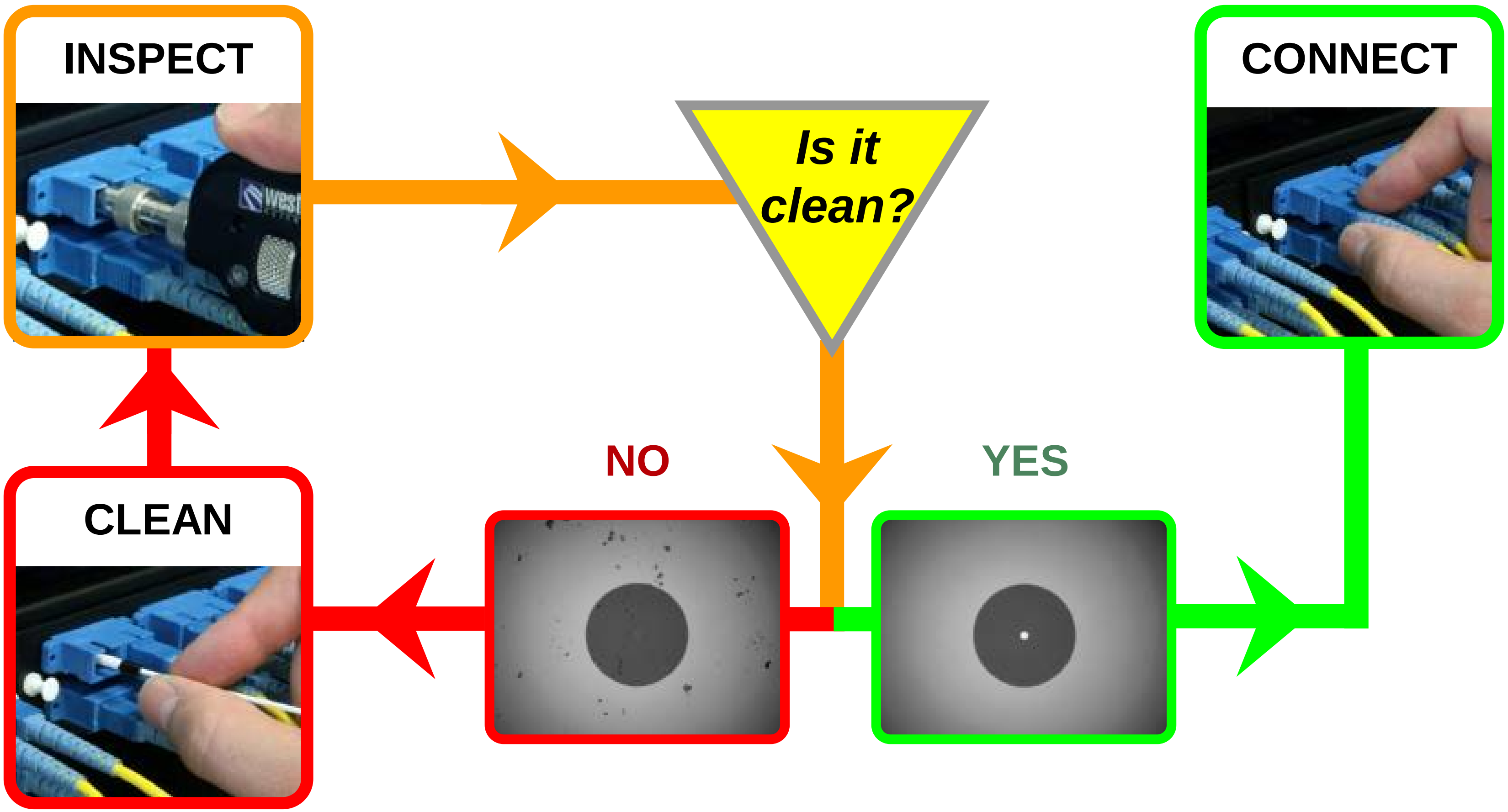
- MER and Level improvement
- Pre and Post Bit Error issue is corrected
- Errored Seconds corrected



VIAVI

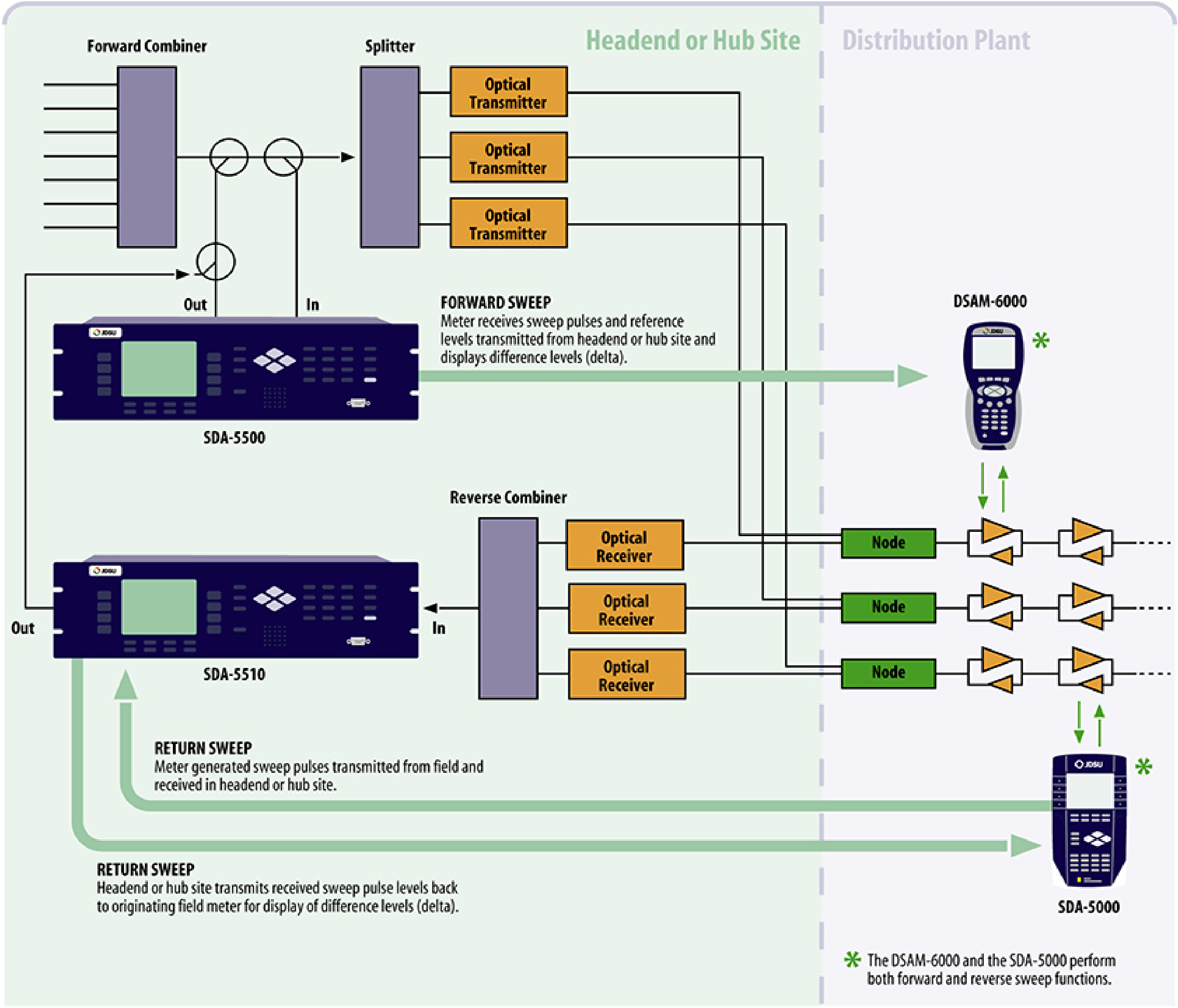
Inspect Before You Connect

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



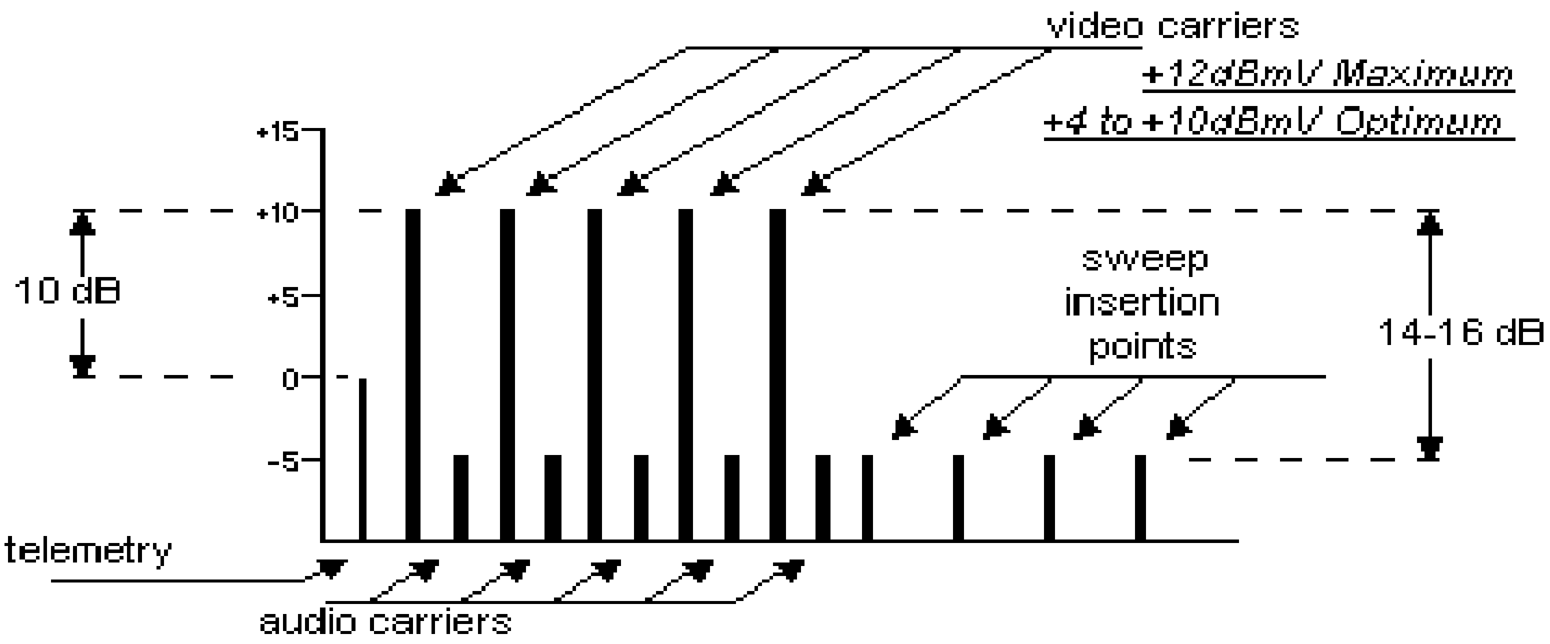
Sweep Tx and Meter Setup

DSAM-6000: Forward & Reverse Sweep within One Instrument



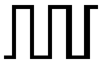
- Provides non-interfering forward and reverse sweep operation
- Continuously provides updating between the headend and field units
- Only system that sweeps analog, digital and DOCSIS® carriers
- Uniquely covers entire frequency band (4 – 1000MHz)
- References active carriers with out degrading service quality
- Sweep the return path with up to 10 meters simultaneously

Recommended Levels for Forward Sweep Transmitter

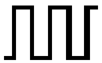


- **Forward Telemetry Level (Transmit and SDA Compatible Transmit (OPT2) modes only):** This setting determines the level of the telemetry signal (FSK). This should be set 10 dB below the video reference level. The telemetry level is adjustable from 20-50 dBmV in 2 dB increments. The max is 50 dBmV, however some older units may have a max of 40 dBmV.

Icon information for Forward Channel Plan

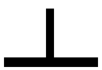


- **Digital Carrier (DIGITAL):** Digital Carrier can be used for continuous digital carriers. DIGI is supported only in the Level, Sweep, Spectrum, and Scan measurement modes. An RMS detection mode measures the level of a digital channel.

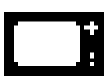


- **QAM Digital Stream (QAM):** Use QAM for QAM 64 or 256 digital carriers.

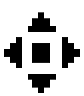
- **Video + Dual Audio Channels (DUAL):** DUAL is a European system, incorporating video plus two independent audio carriers.



- **Single Carrier (SINGLE):** SNGL can be used as a carrier for FM or data.

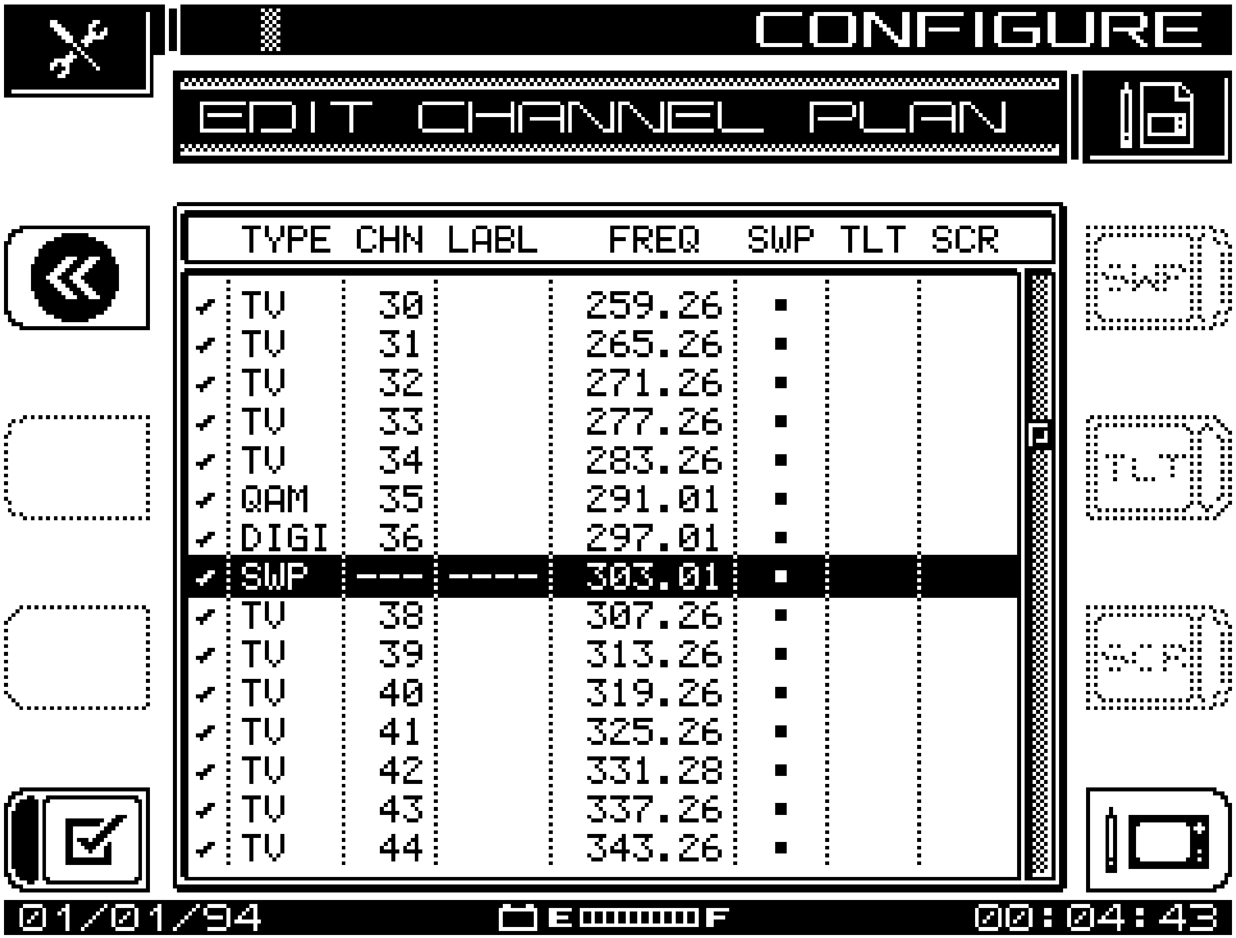


- **Video Channel (TV):** Video Channel includes the standard video carrier with audio carrier offset.



- **Sweep Insertion Point (SWEEP):** This type enables the channel for use as a sweep insertion point.

Sweep TX Forward Channel Plan Set up



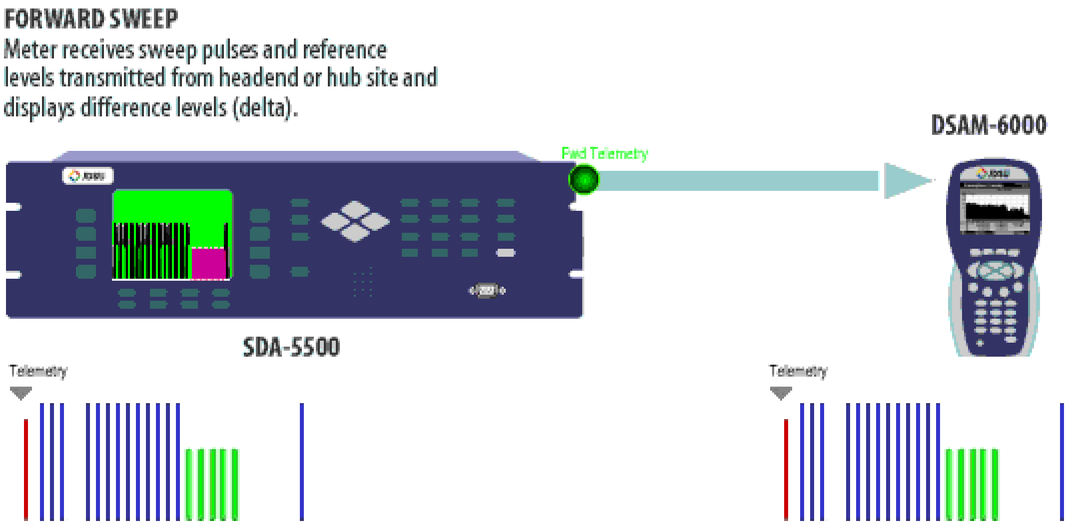
Qam Type for Digital and Docsis Active Channels.
Digi Type for OFDM and Data Channels.
Swp Type to add sweep points for Blank Channels.

Transmitter Set up Parameters

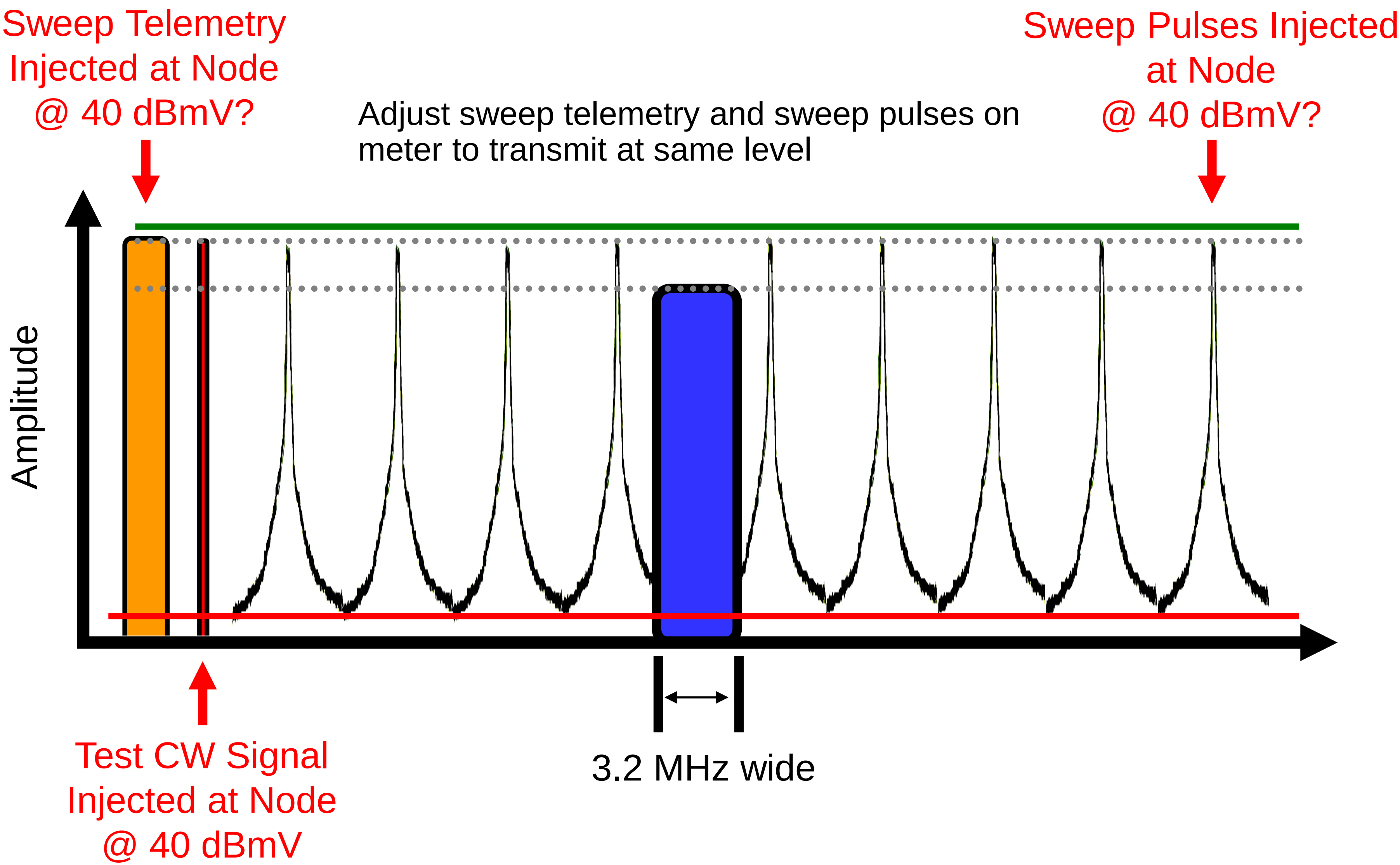
Transmit SDA Compatible Required for Dsam Platform

SDA and DSAM Sweep

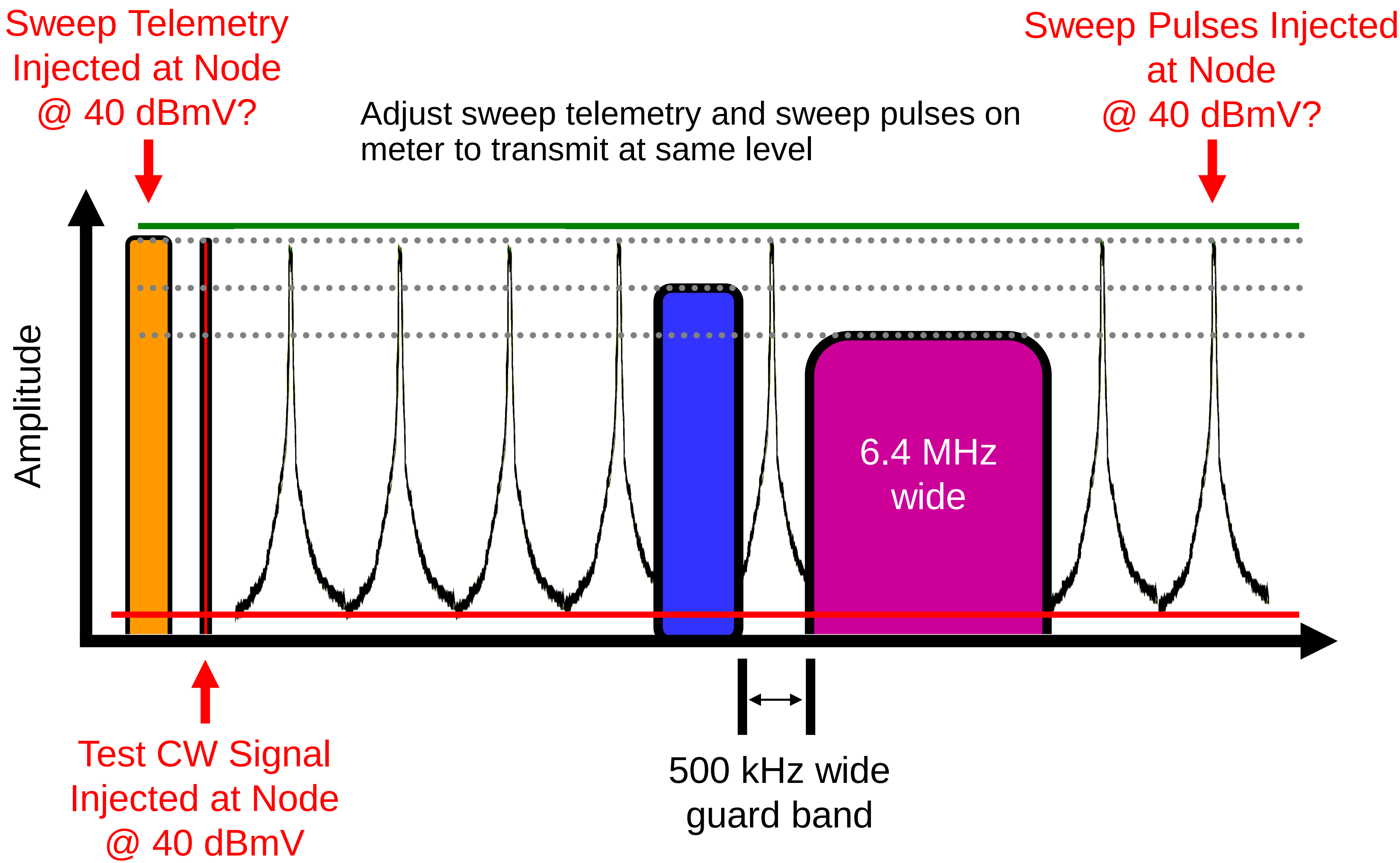
- Sweep transmitter and headend monitor
- Constantly monitors video, audio, and digital carriers plus sweep insertion points
- Transmits any level variations to the SDA-5500 or DSAM 6000 on a telemetry carrier to update the reference
  - Keeps receiver up to date on headend levels



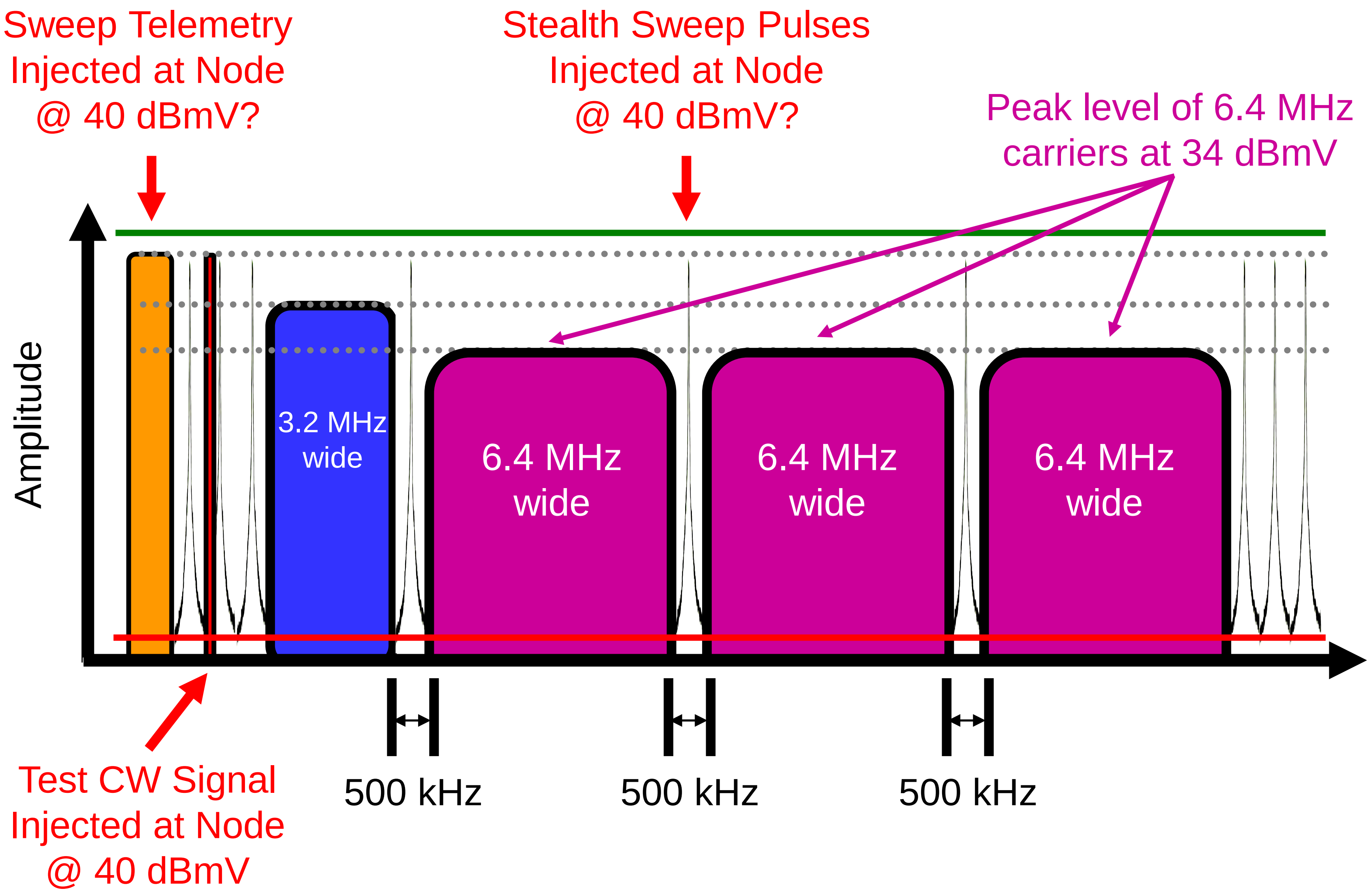
Sweep Pulses Compared to Carrier



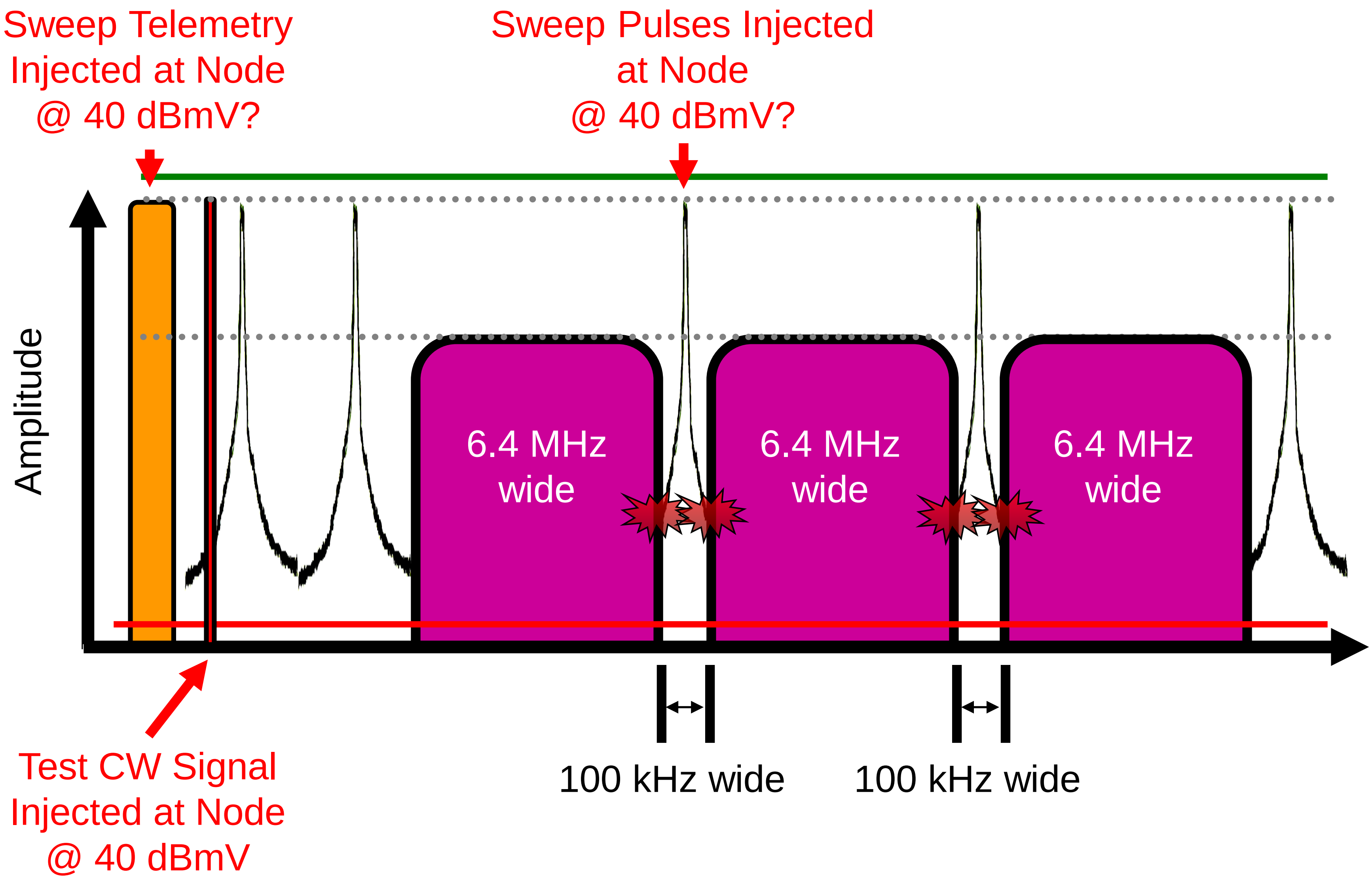
Sweep Pulses Compared to Carriers



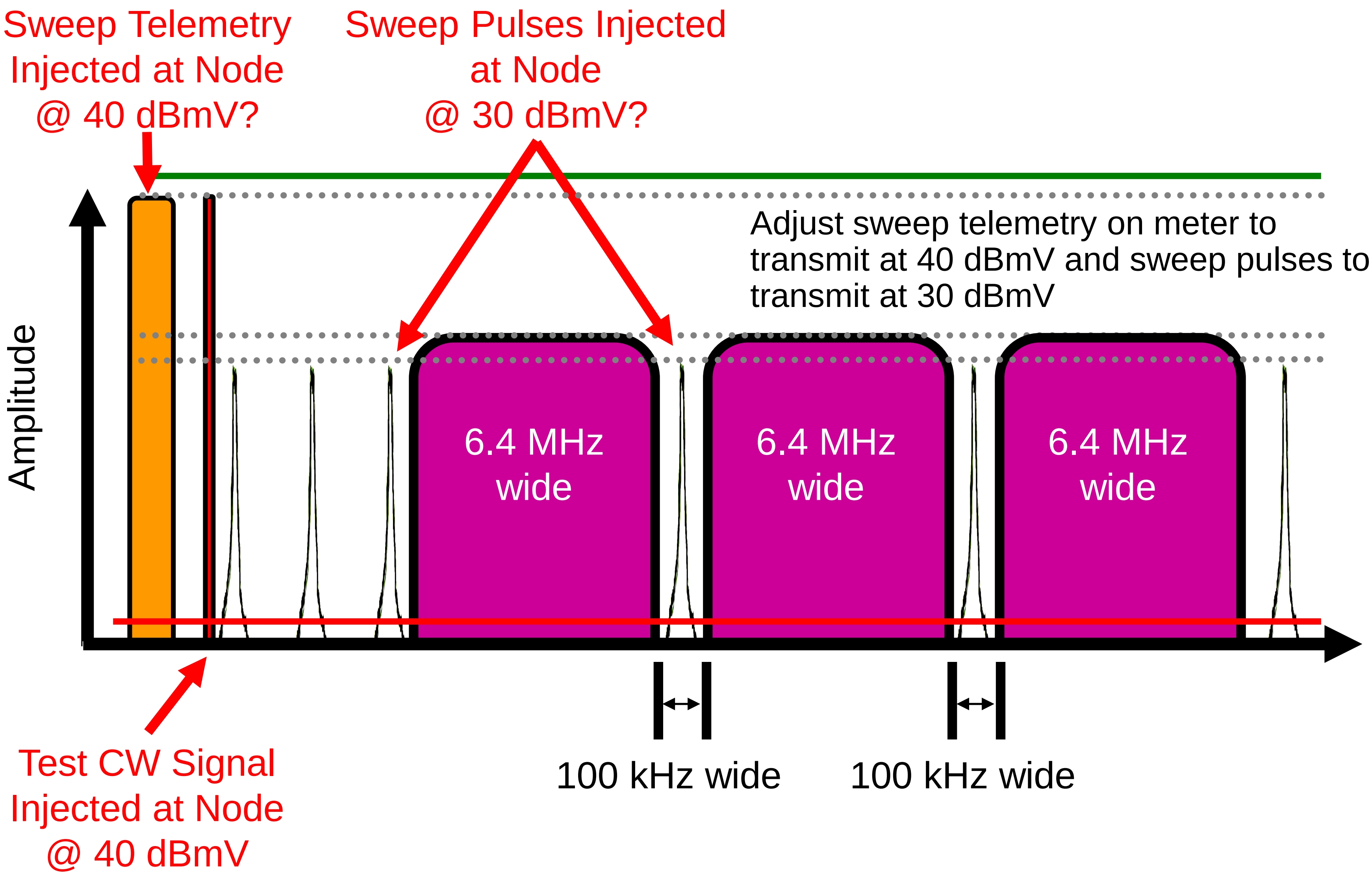
Sweep Pulses Compared to Carriers



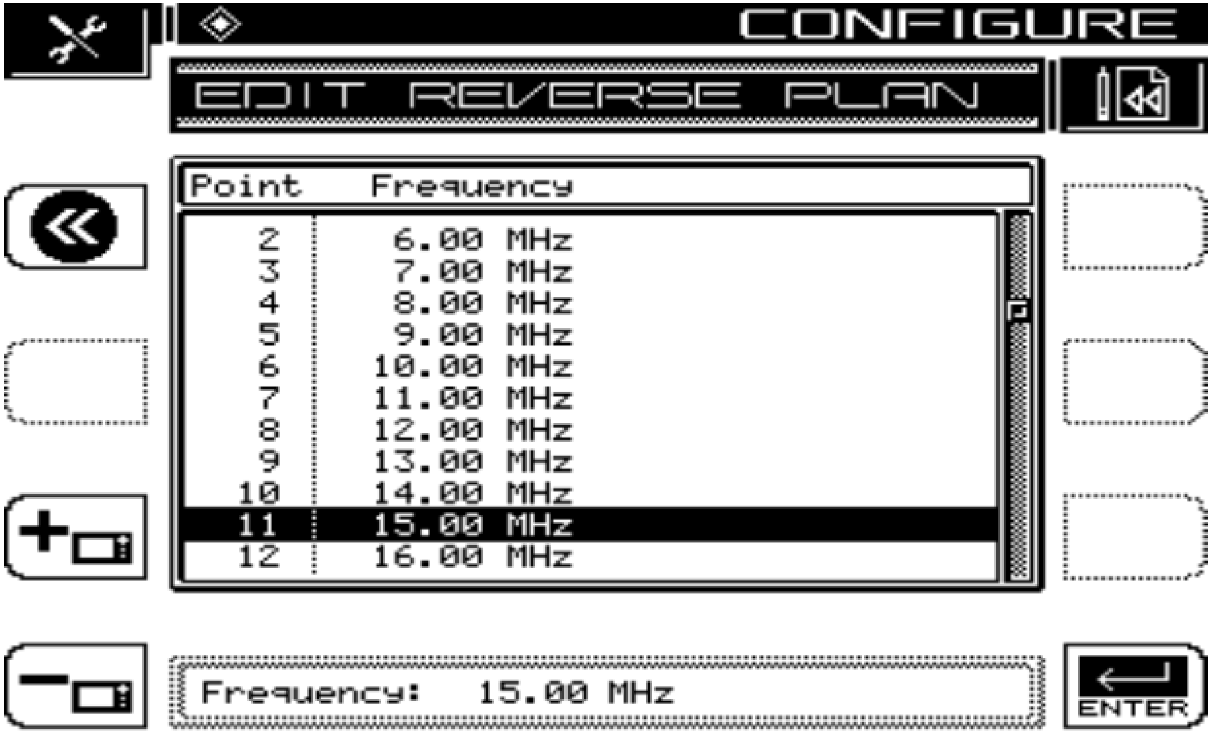
Sweep Pulses Compared to Carriers



Sweep Pulses Compared to Carrier



Reverse Channel Plan Set Up



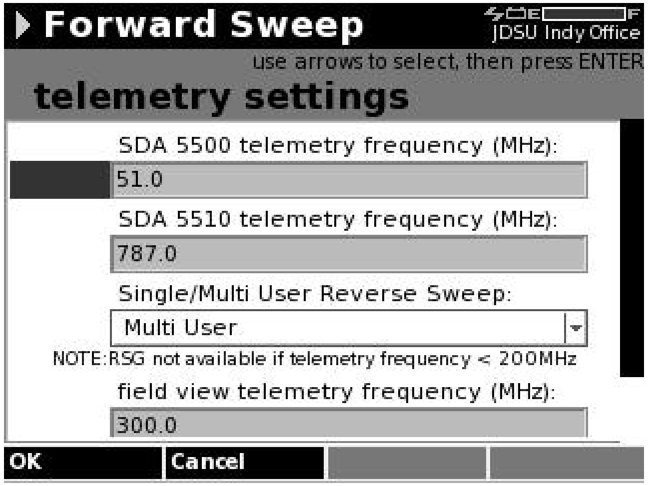
- The best way to set up the reverse sweep channel plan is to build a plan with 250 kHz sweep insertion points from 5 to 45 MHz and then delete points that fall within the service frequencies. A close look at the peak held scan, using a marker, may indicate frequencies within the bands specified above for insertion points (34.5 MHz, for example).

More Sweep Points = More Resolution to find Plant Faults

Meter Set up for Telemetry Carriers

- ❑ Set up under Channel Plans

  Configure key > Channel Plan Soft Key > Down Stream Plans > Soft Key under Plan > Select Telemtry



- ❑ Set up under Sweep

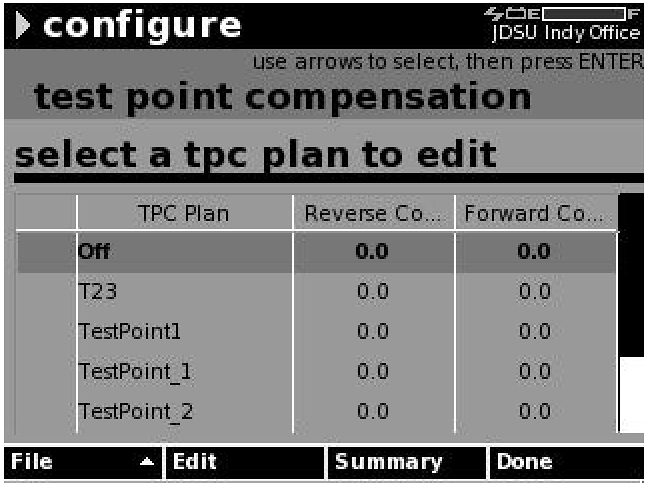
  Round Measure Key > Forward Sweep > Soft Key Under Settings > Telemetry

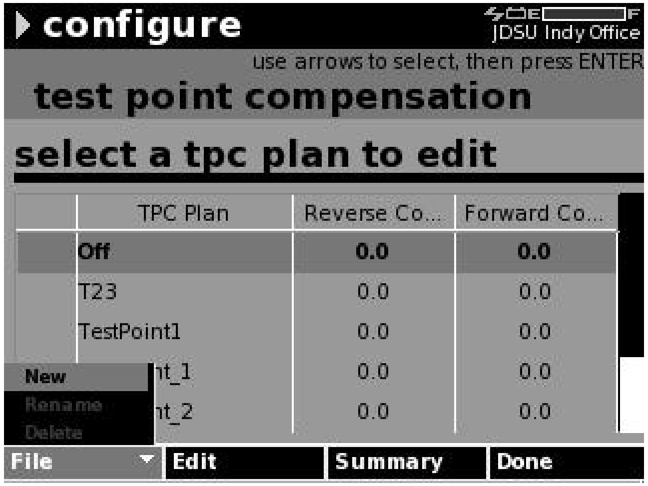
Note: Telemetry Frequencies Need to match Transmitter setup.

Muti user when sweeping to 5500 And 5510 Transmitters.

Single User when sweeping to 5500 Transmitter only..

Test Point Compensation (TPC) for Sweep

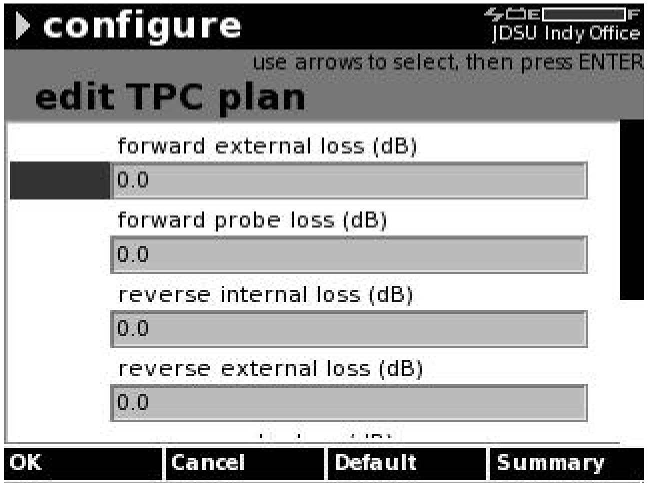


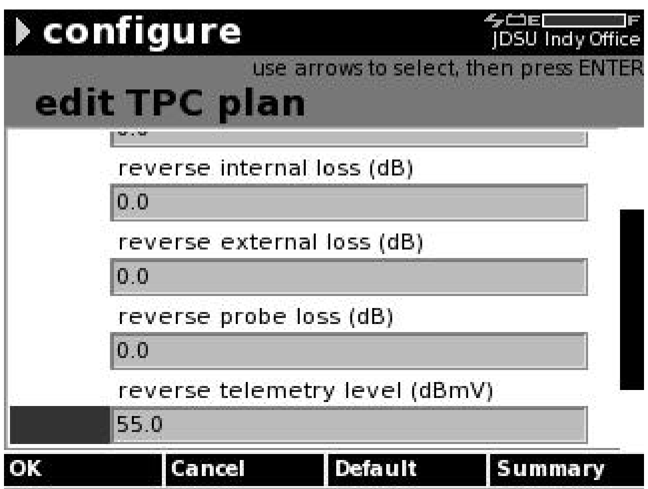


- ➢ Default plan is off which sets TPC to Zero
- ➢ Additional plans need to be added for Test Equipment that have different TP Values or Different Injection levels
- ➢ TPC plans are critical for Setting up the Reverse Network

Short cut Key: Blue Shift Key > 4 key

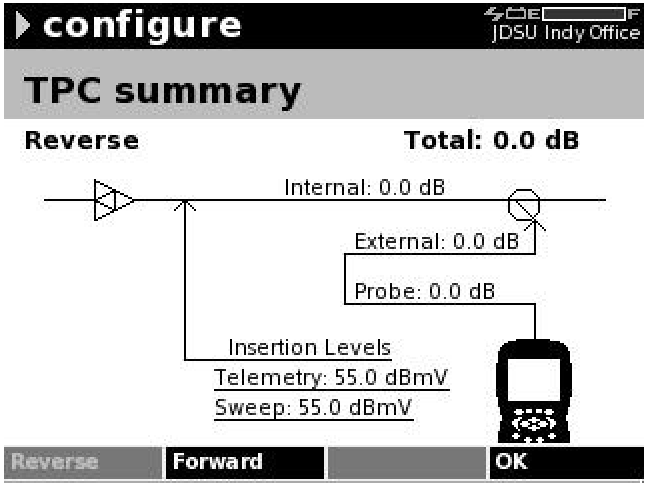
Test Point Compensation Set Up

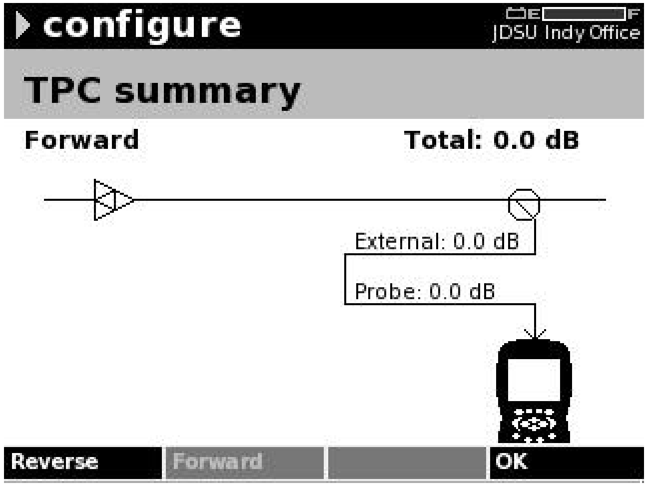




- Reverse Injections can be with Total Level for Reverse Telmetry Level and Reverse Sweep Insertion Level with Loss Boxes set to Zero.
- Reverse Injection levels can be set to Track Input Levels with Loss added to Reverse Loss boxes.

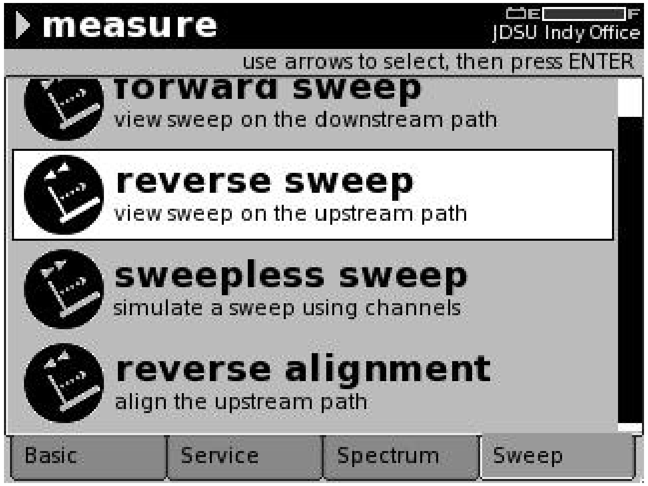
Test Point Compensation Set Up

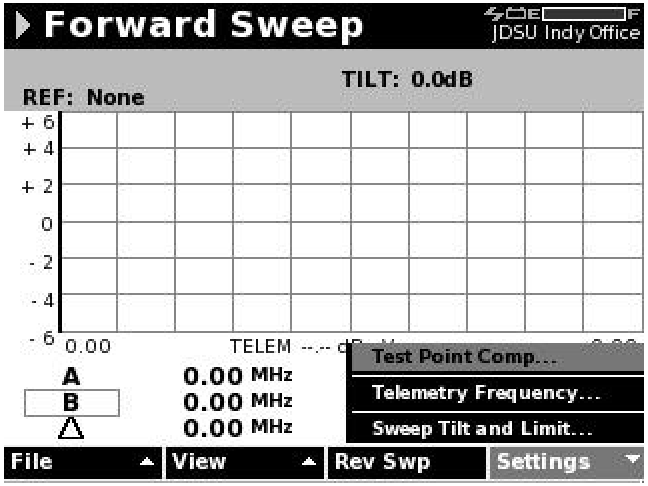


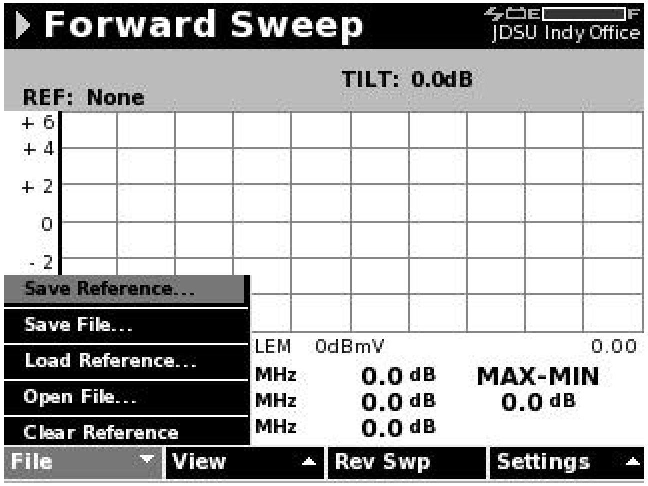


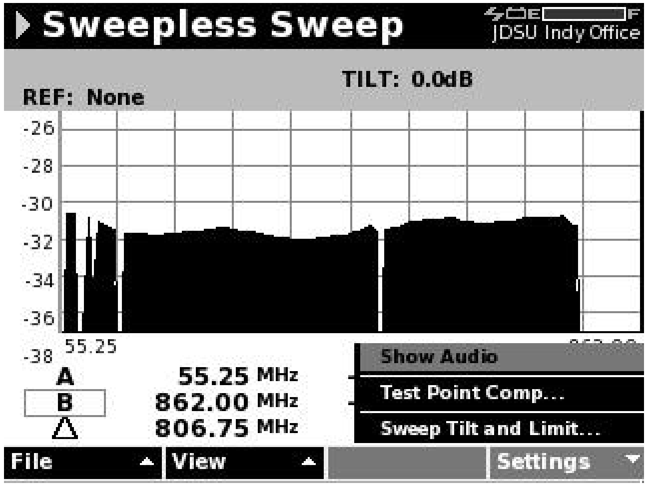
Summary View to verify levels are set Up correctly for Forward and Return Test Points.

Meter Sweep Functions







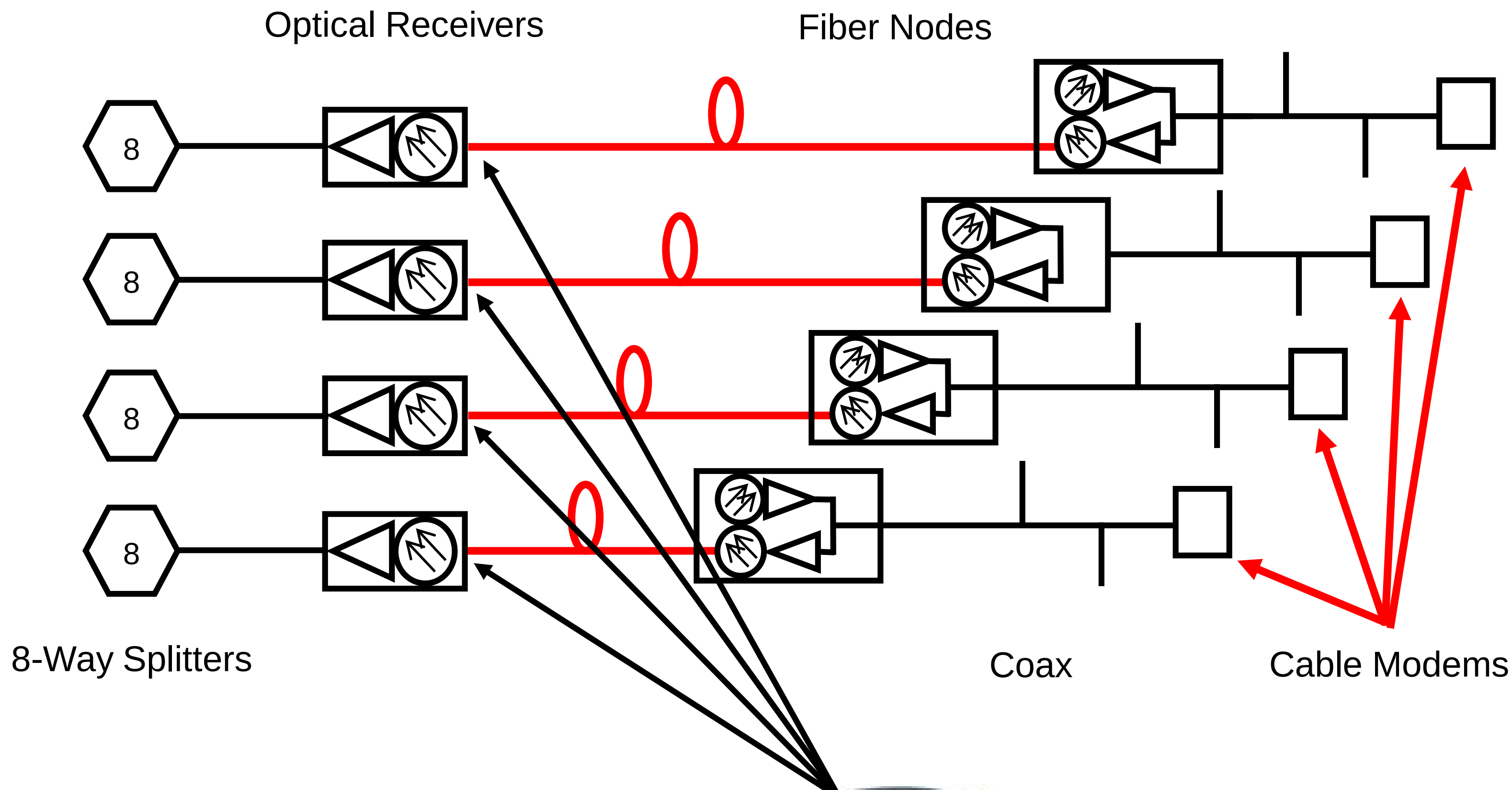


Setting the Transmitter "Window"

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

*Source - Cisco Systems, Inc.

Optimize the Optical Links in Your HFC Networks!

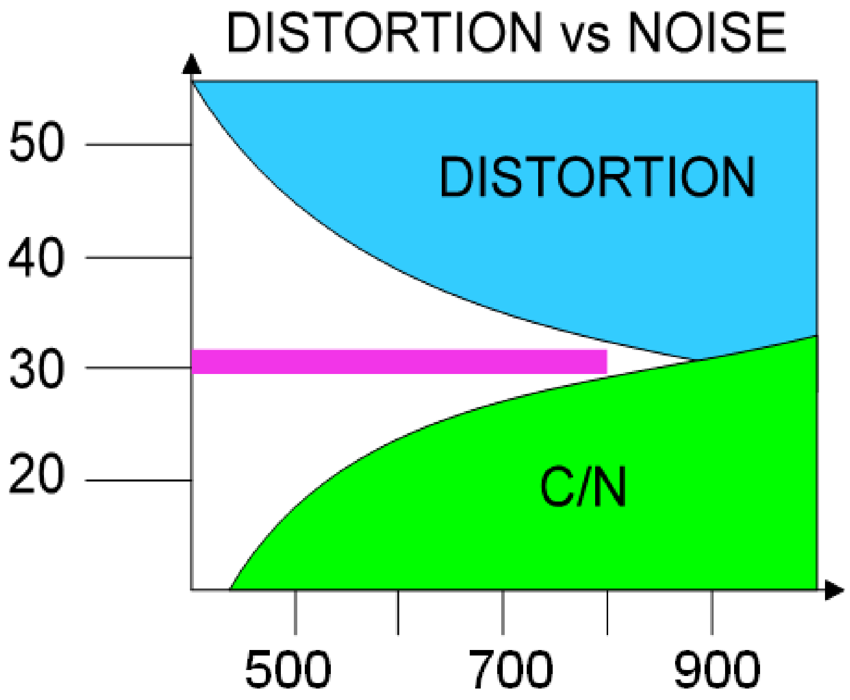


Verify that all optical links have the correct light level at the input of each optical receiver!

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

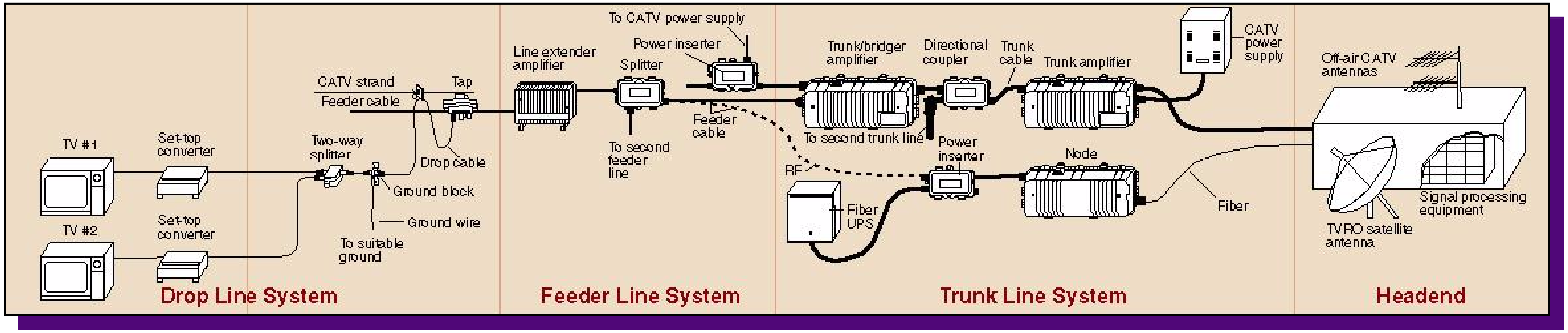
Forward and Return Sweep

WHY SWEEP?



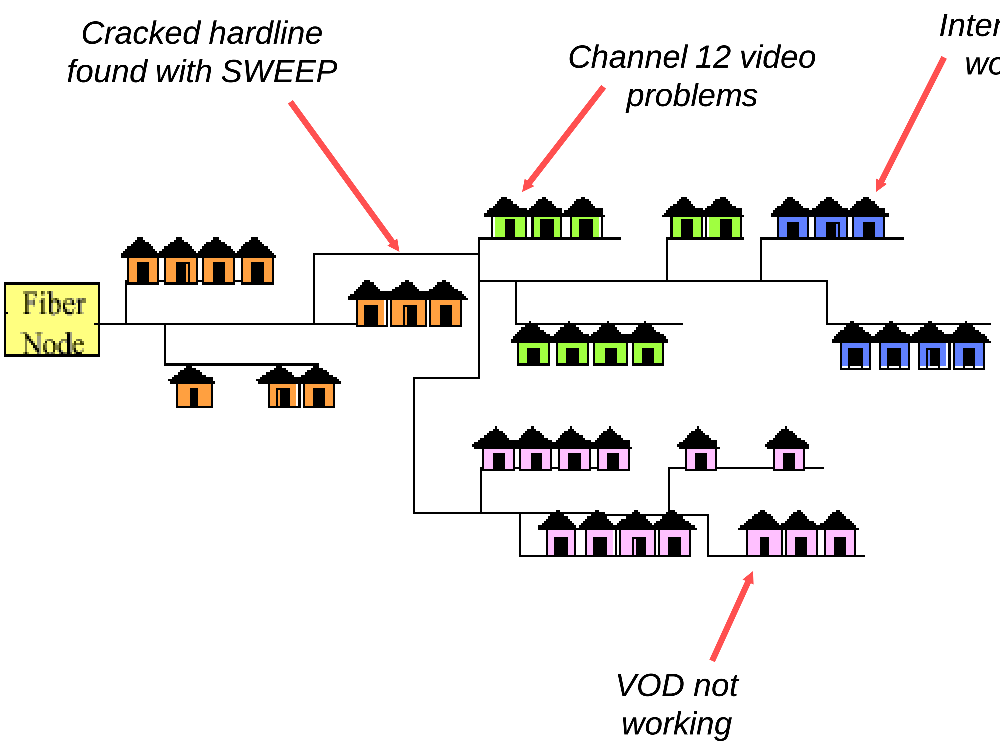
- CATV amplifiers have a trade-off between noise and distortion performance
- Tightly controlling frequency response provides the best compromise between noise and distortion.

Sweep vs. Signal Level Meter Measurements



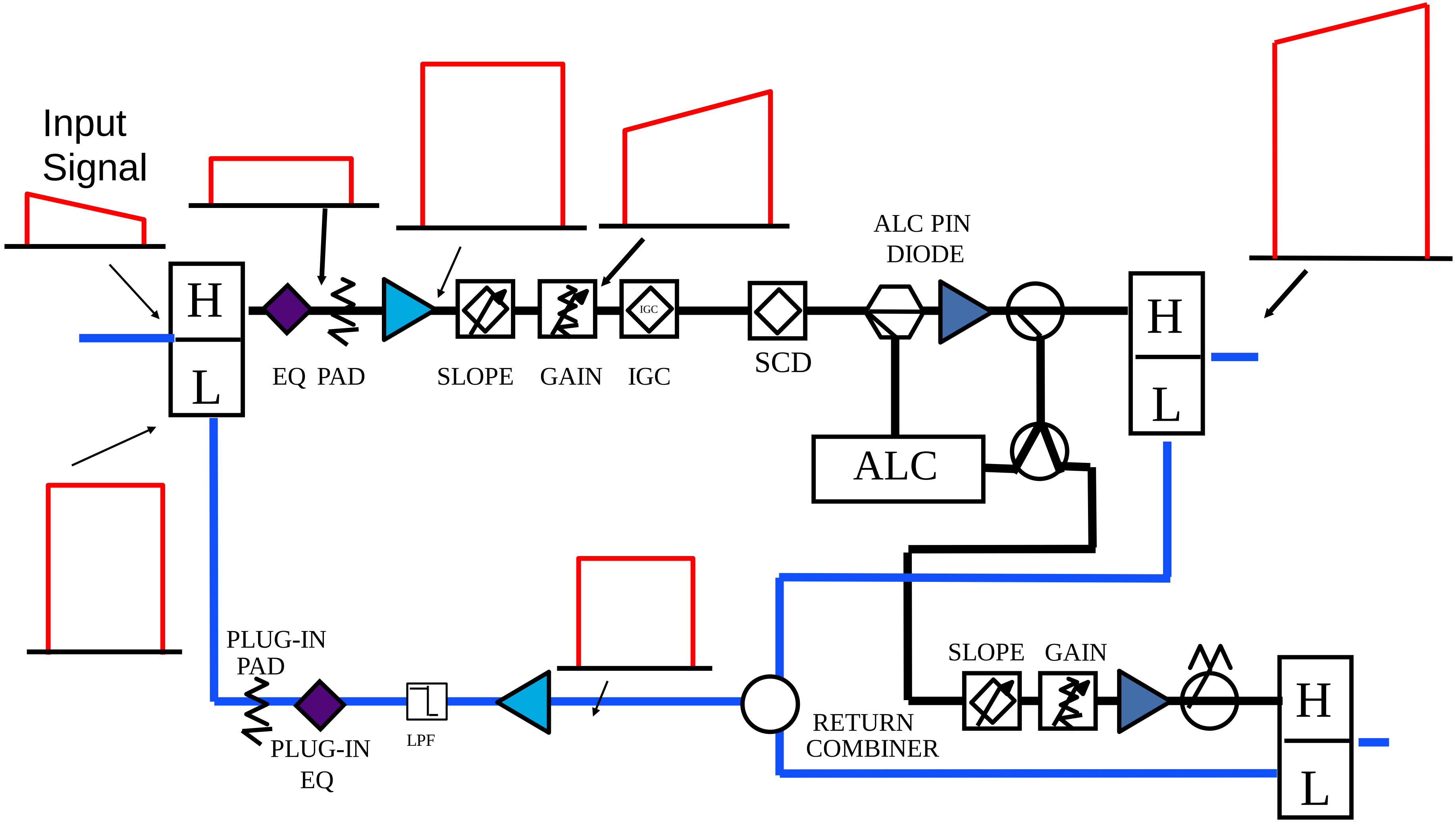
- References: Sweep systems allow a reference to be stored eliminating the effect of headend level error or headend level drift.
- Sweep Segments: Stealth makes it possible to divide the HFC plant into network sections and test its performance against individual specifications.
- Non-Invasive: Sweep 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.

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

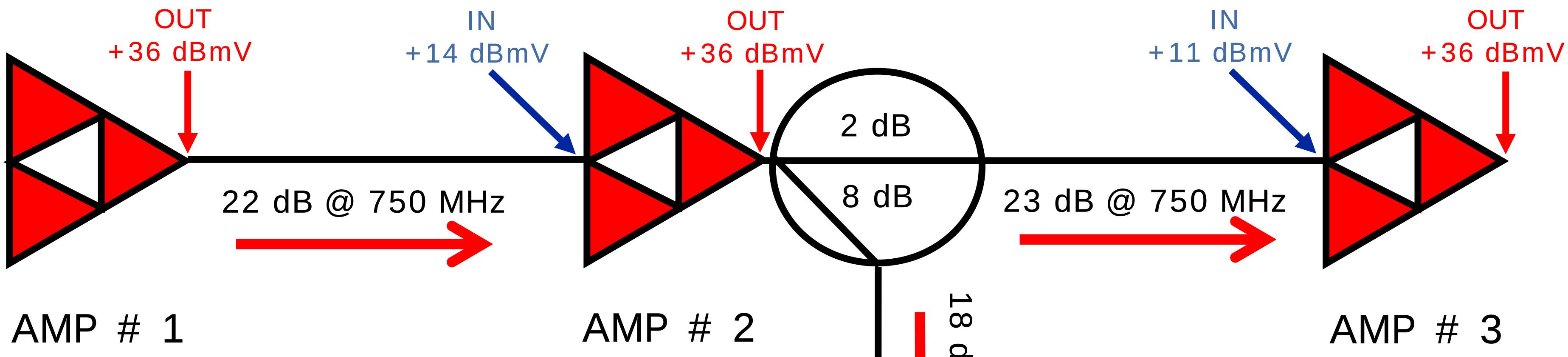
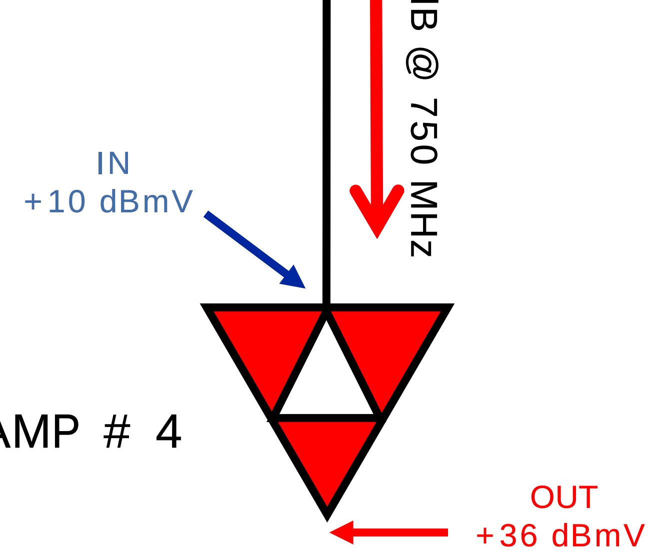


VIAVI

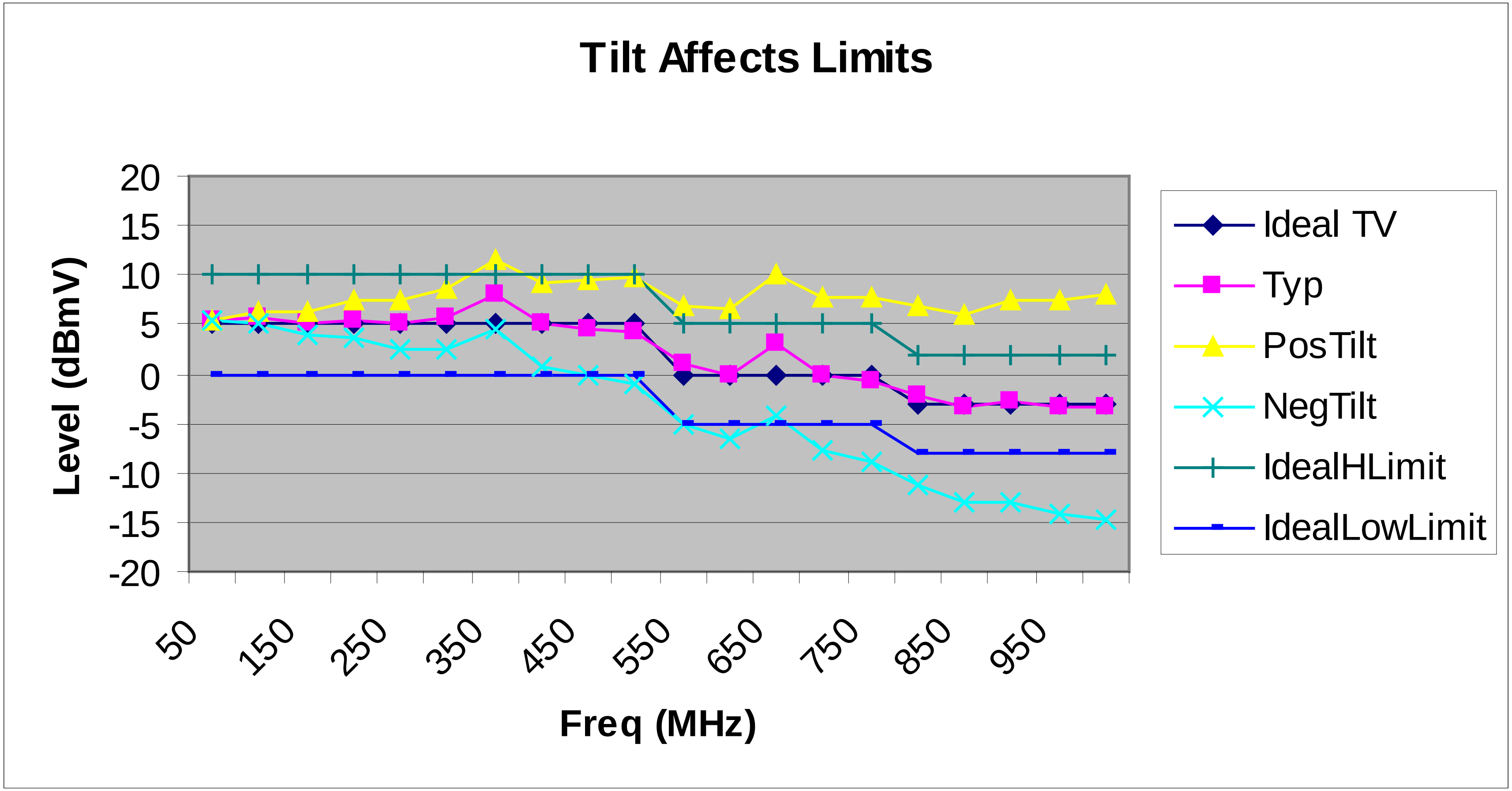
Functional Block Diagram



Forward Path Unity Gain

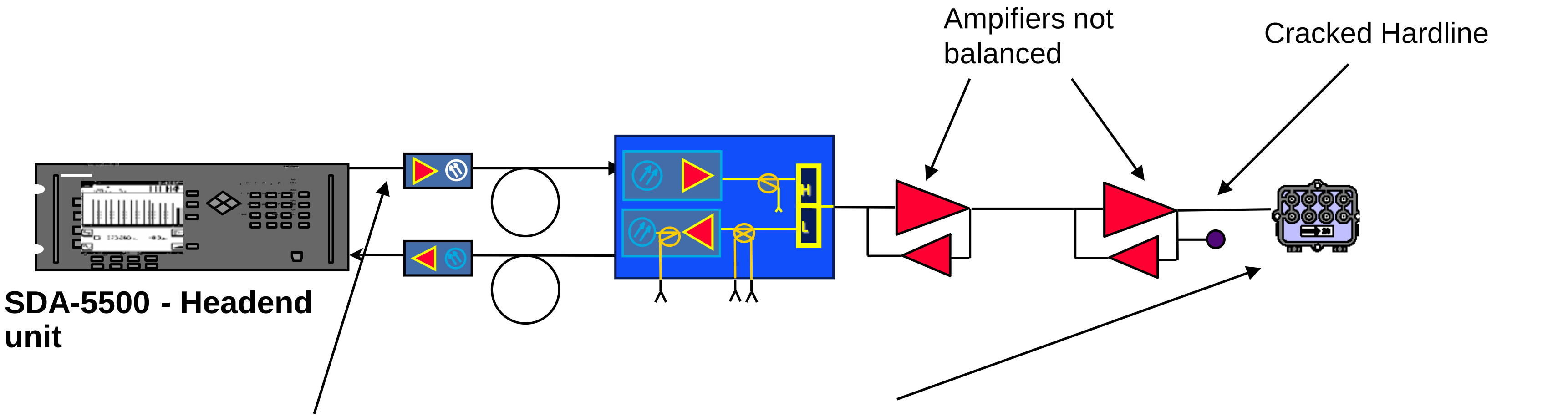



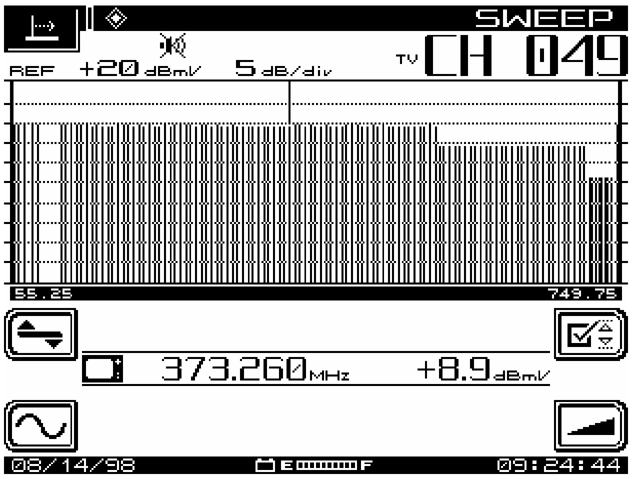
In real systems – tilt happens!

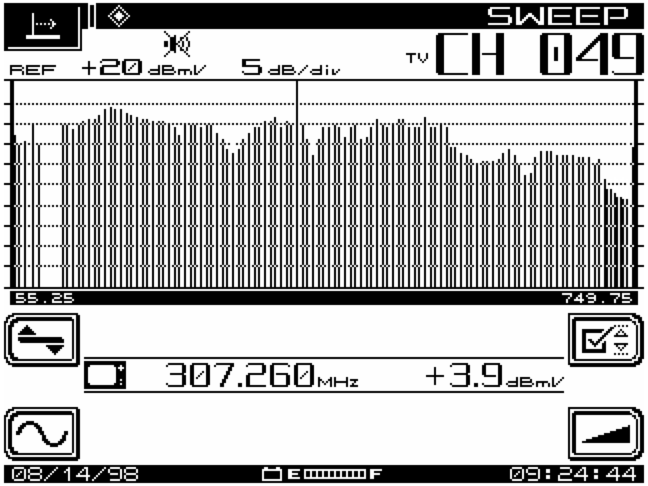


Headend to Tap

Typical system not swept or balanced for 6 months







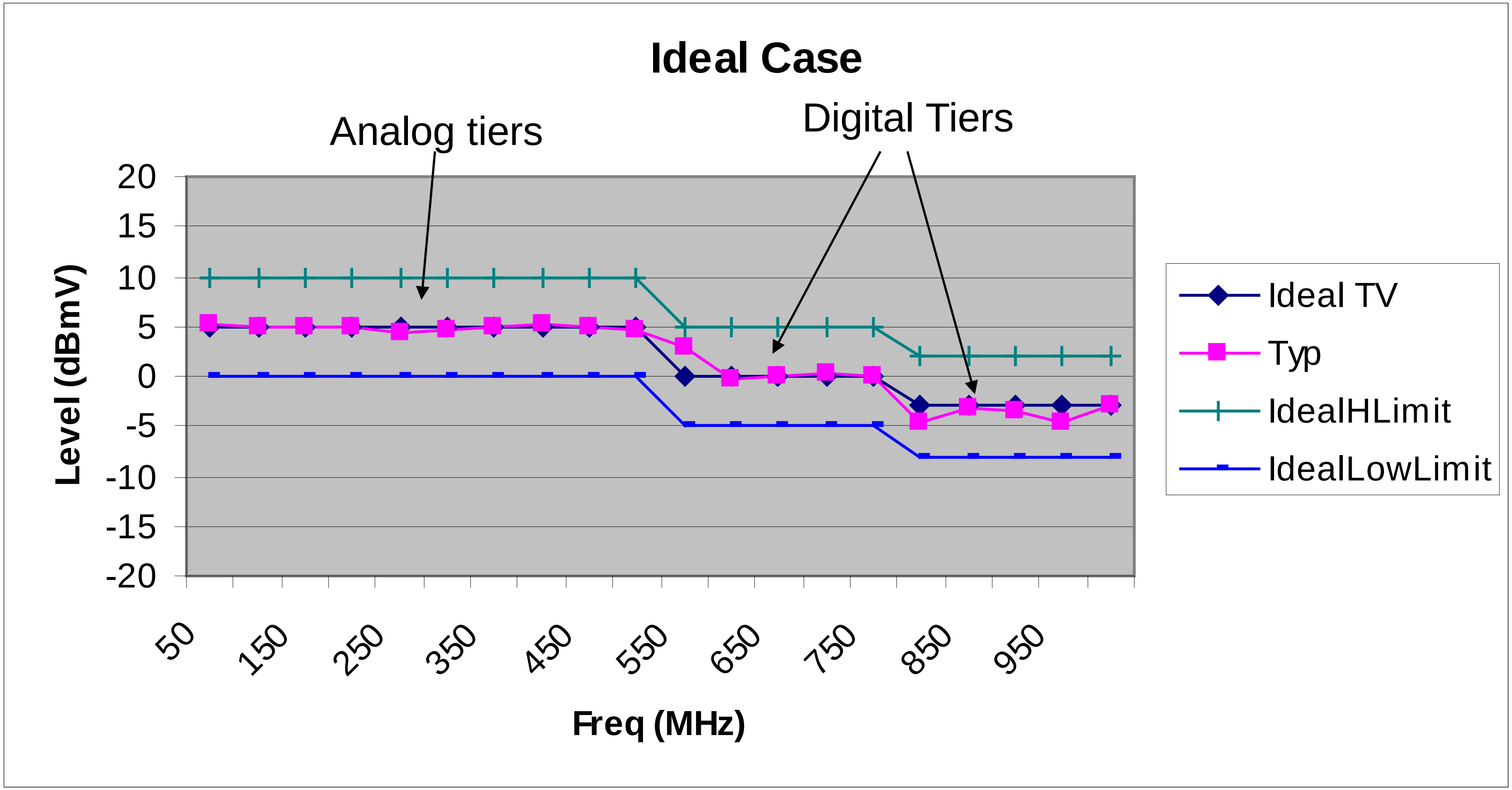
FCC Proof Failure

Customer Complaints

Noisy pictures!

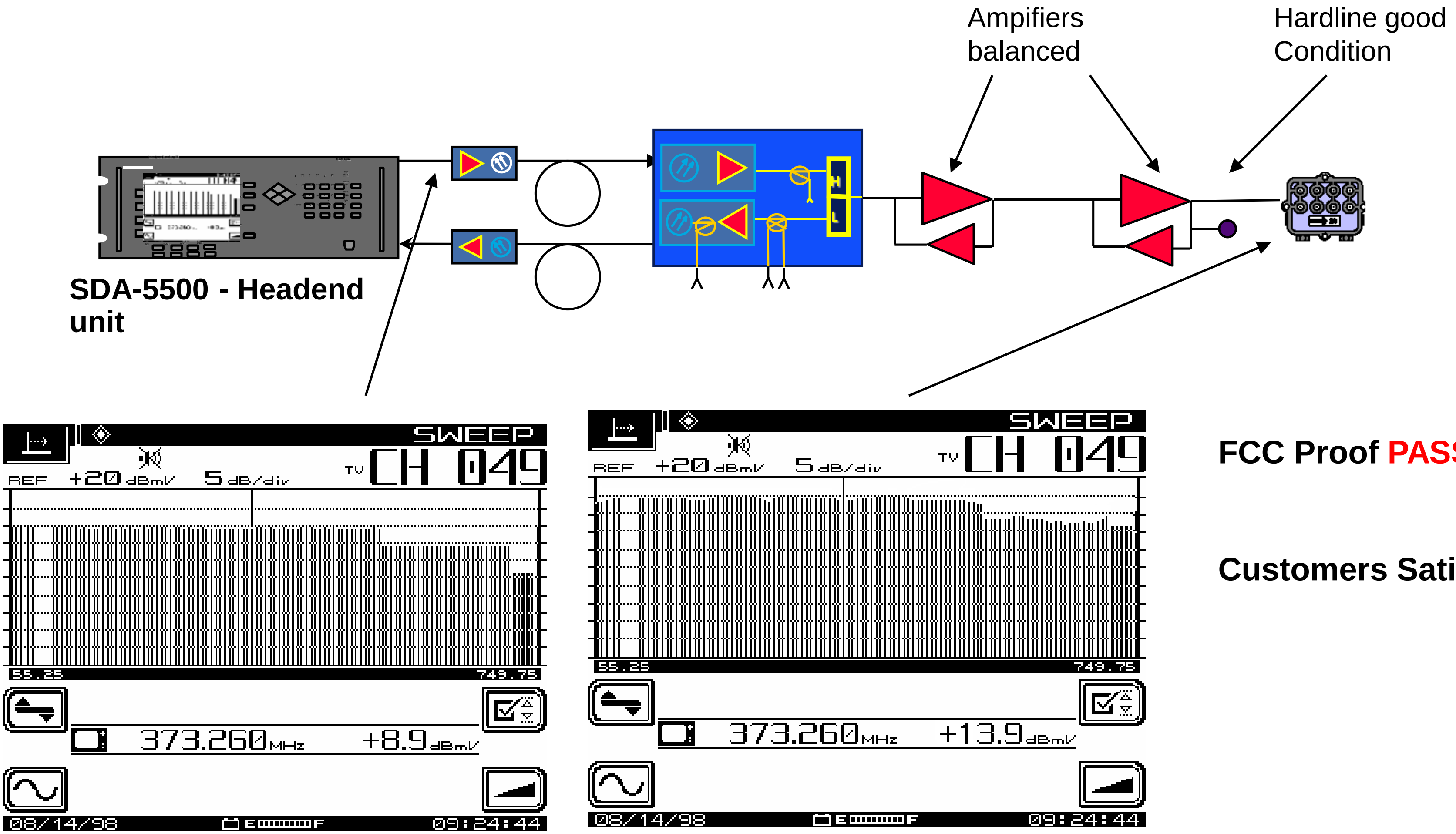
HD Tiling

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



Headend to Tap

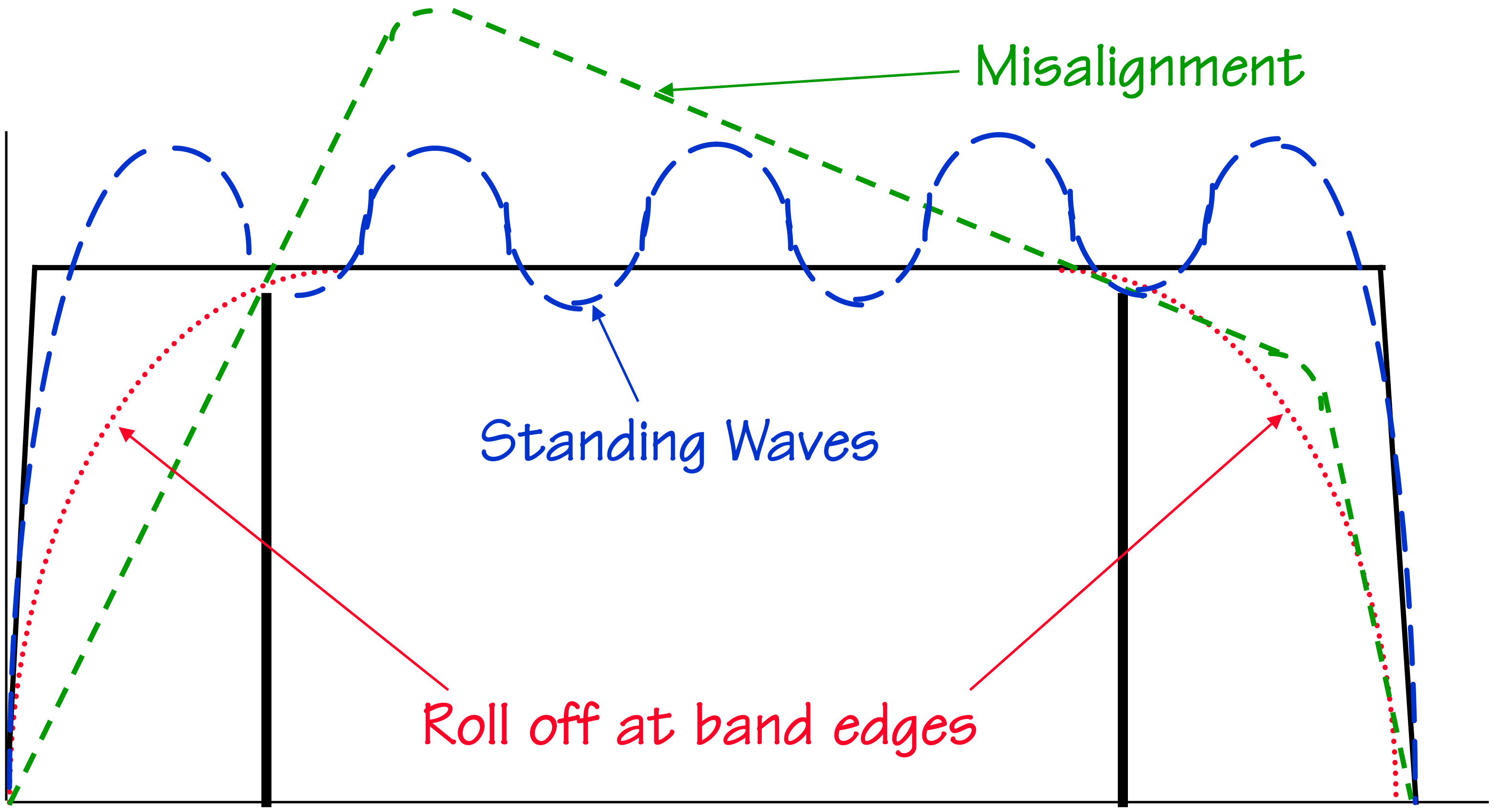
Typical system after Sweep and Balance



FCC Proof PASS!

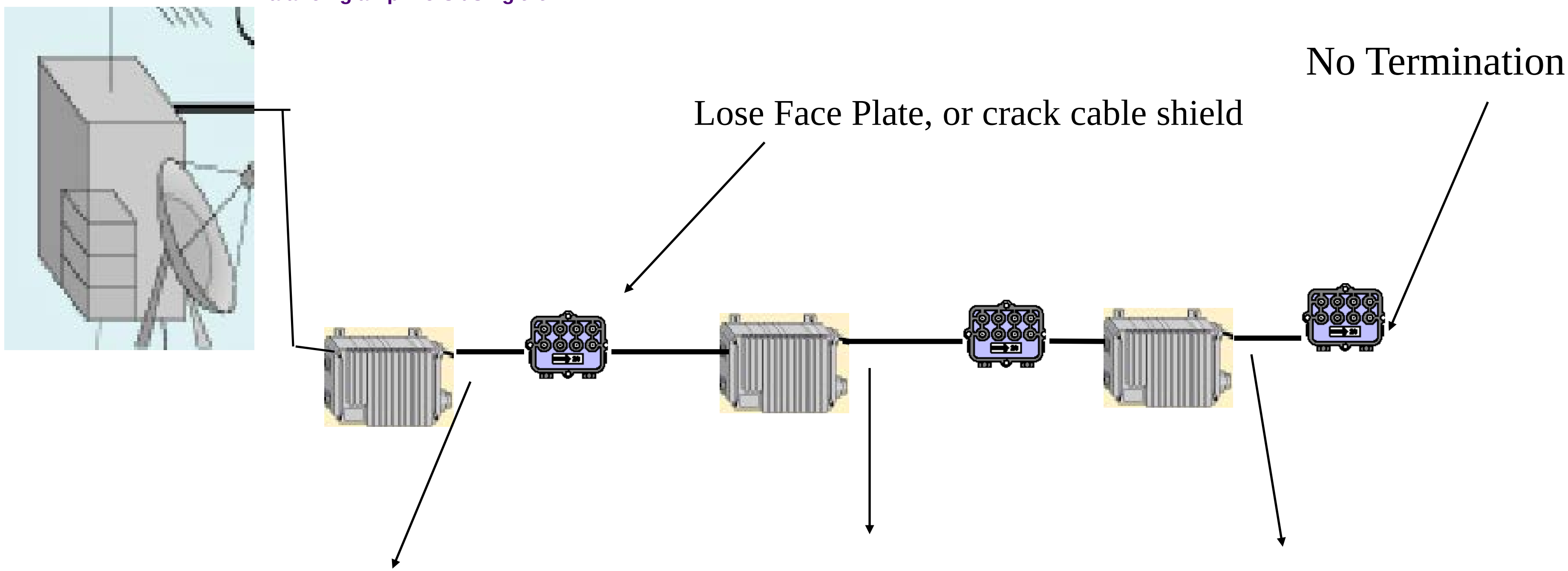
Customers Satisfied!

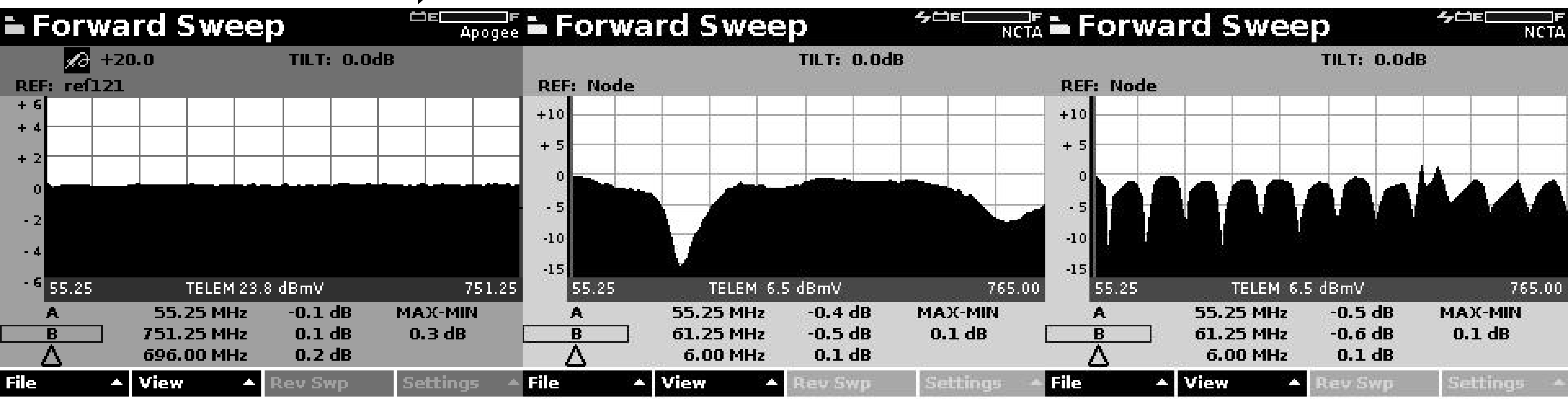
A Sweep Finds Problems That Signal Level Measurements Miss



Balancing Amplifiers

Balancing amplifiers using tilt





Node Reference Signal

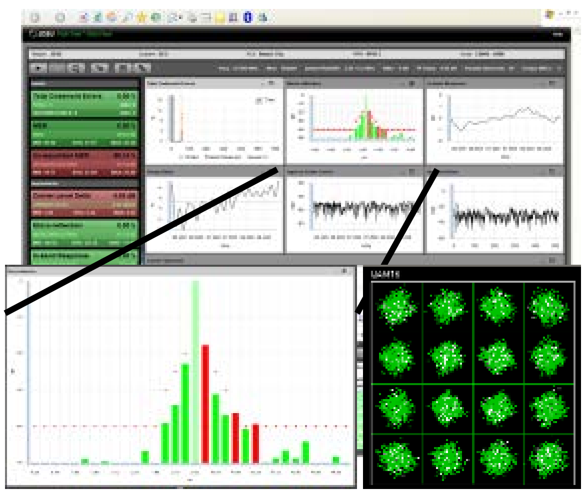
Sweep response with a Resonant Frequency Absorption

Sweep response with standing waves

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

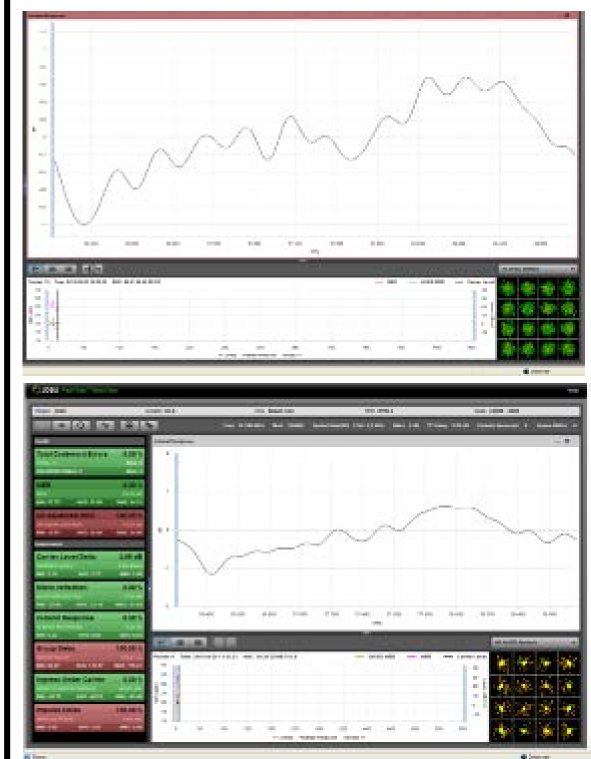


Group Delay

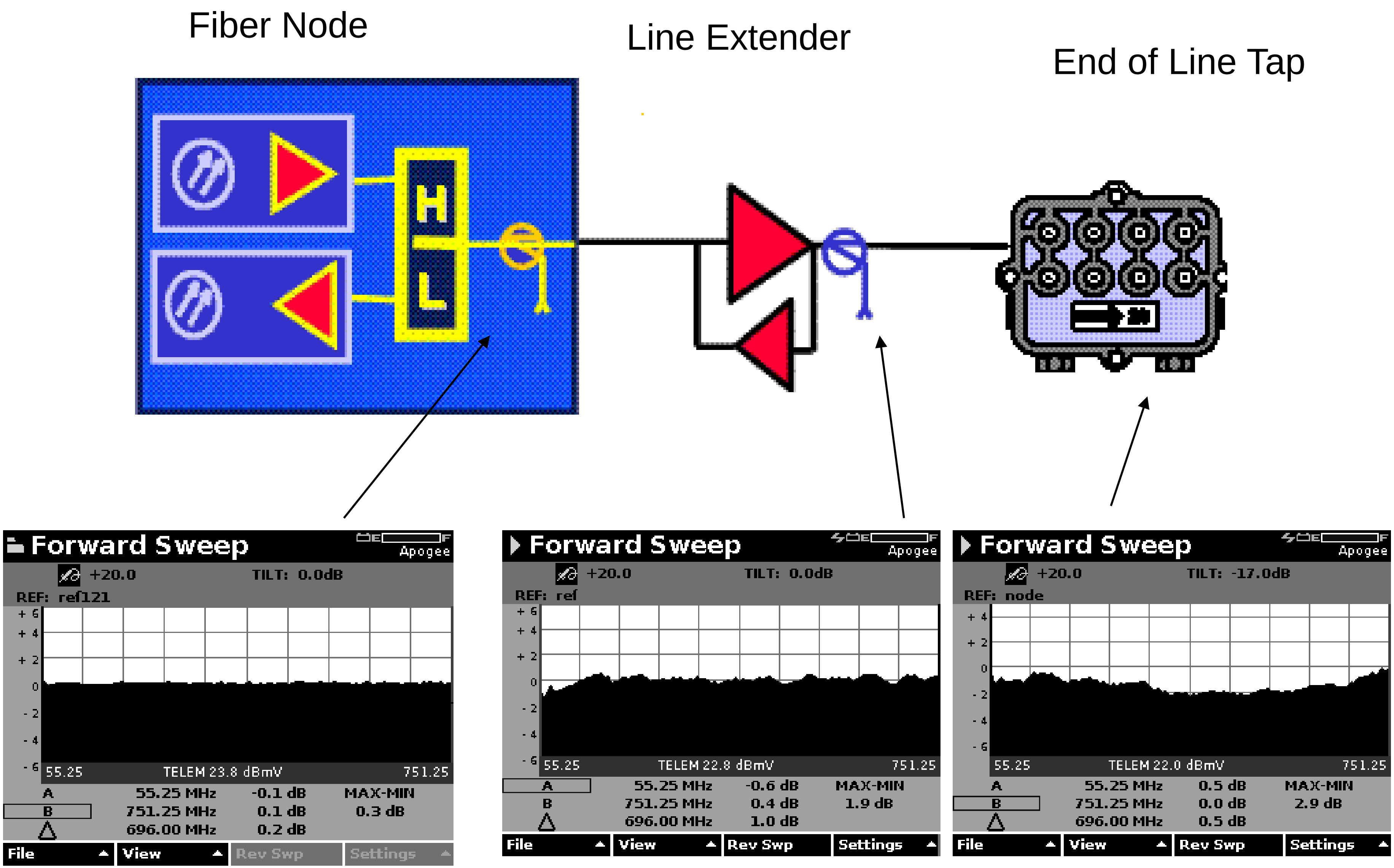
- Common Causes
  - Operation too close to diplex roll-off
  - Defective diplex filters
  - AC power coils/chokes
  - Notch Filters (high-pass, HSD-only, etc)
  - Micro-reflections

In-channel Freq. Response

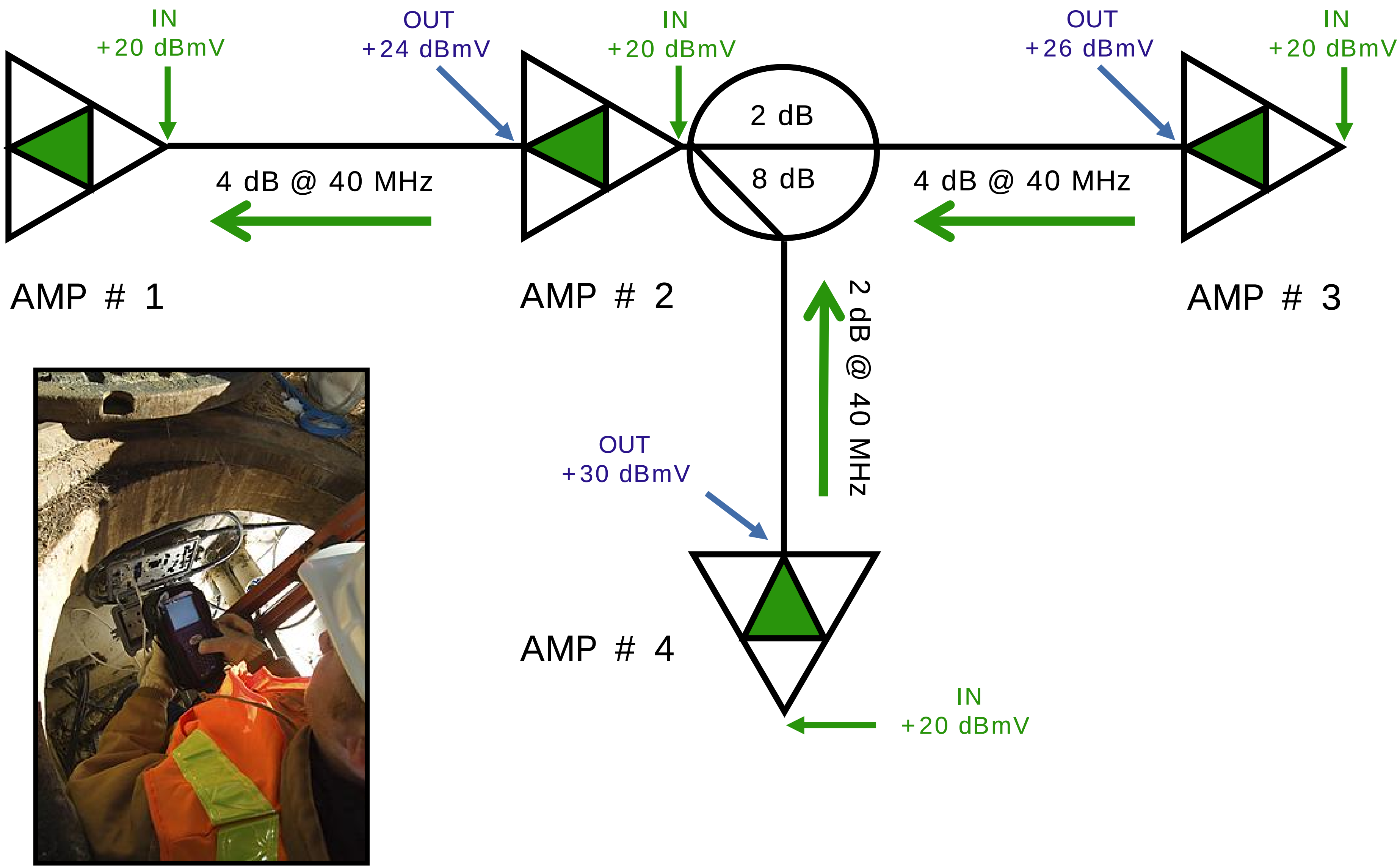
- Common Causes
  - Misalignment
  - Impedance mismatches



Typical Forward Sweep Response



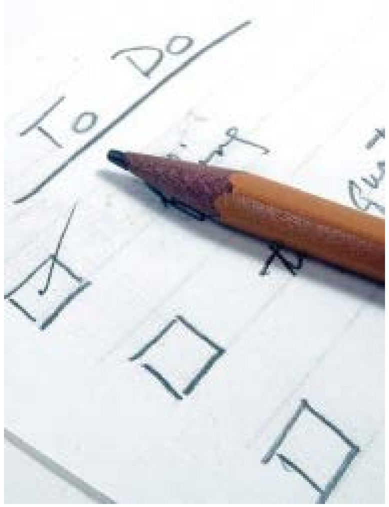
Return Path Unity Gain



- Choose operating levels that maximize the distortion performance (dynamic range) of your return path

- Get all of the information that you can on your nodes and amps from your manufacturer

- Create a sweep procedure for your system
    - make up a chart showing injection levels at each test point

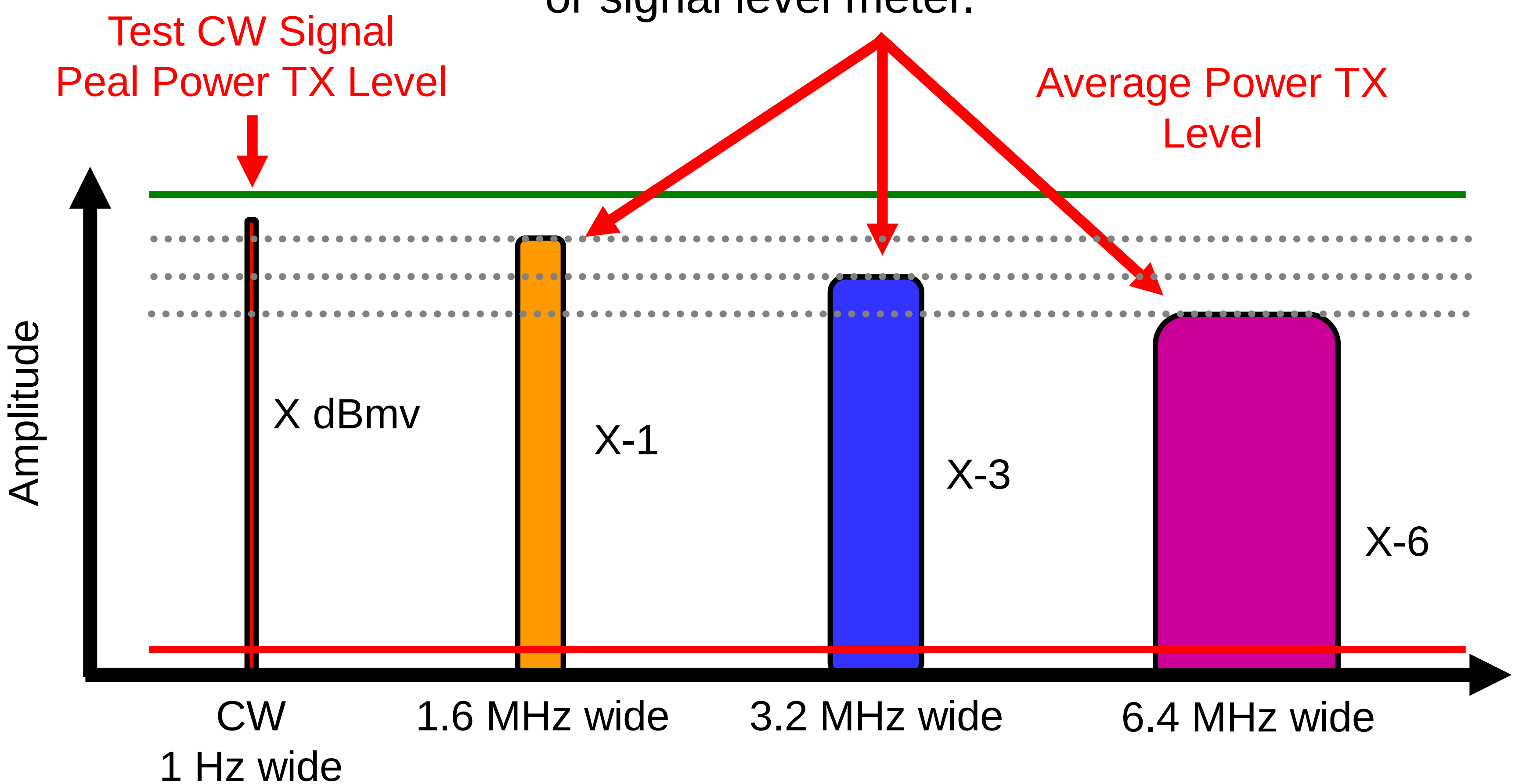


Example chart showing injection levels at each test point

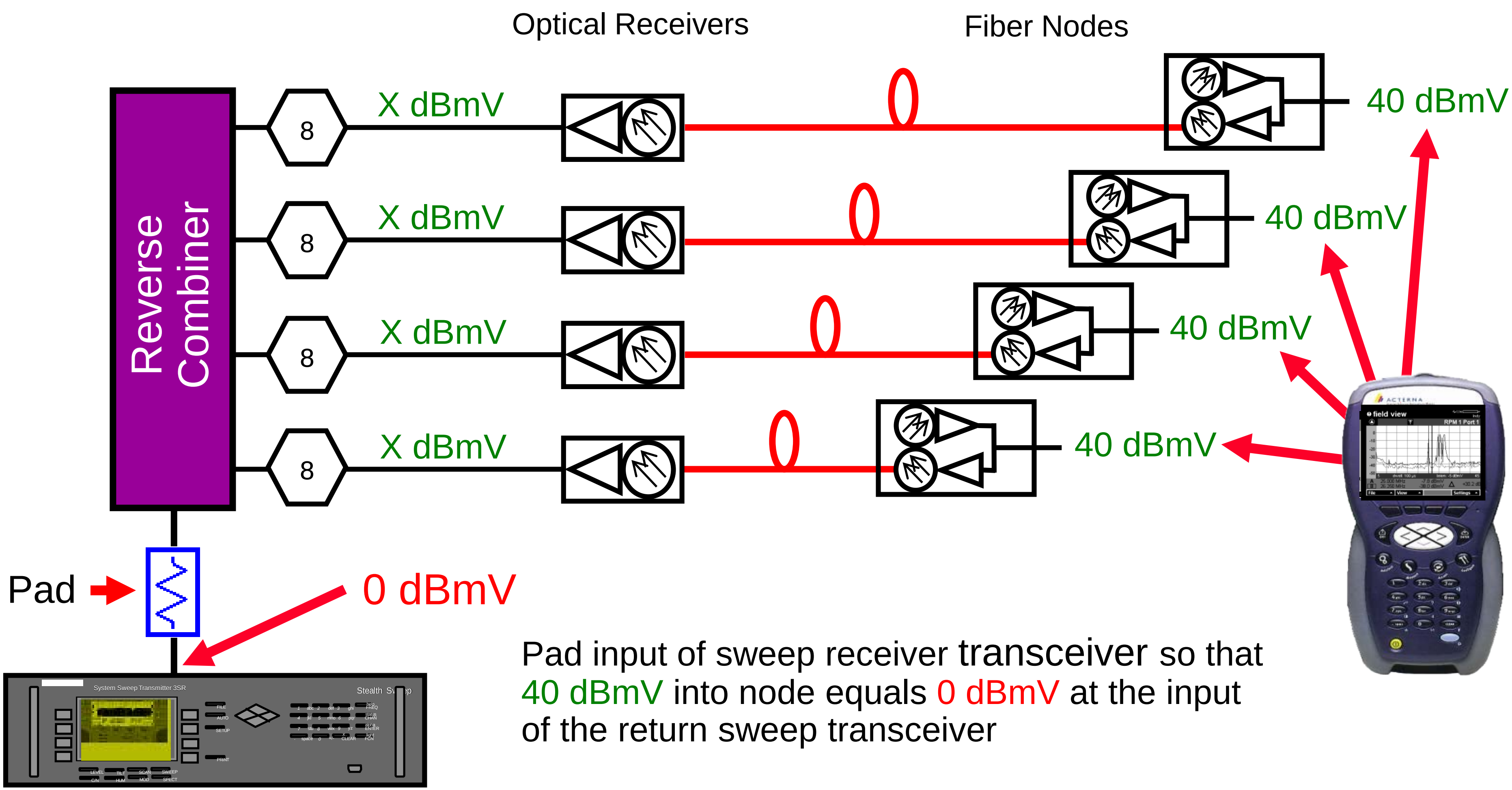
Return Sweep Cheat Sheet - Sweeping to the Input of a Return Amp				
	Various Types of Test Points			
	Node Return Test Point Compensation (TPC)	Trunk Amp Test Point Compensation (TPC)	Bridger Amp Test Point Compensation (TPC)	Line Extender Amp Test Point Compensation (TPC)
Desired Input Level into Return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

Measuring Upstream Carrier Amplitudes

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



Optimize the RF Input to Return Sweep Transceiver

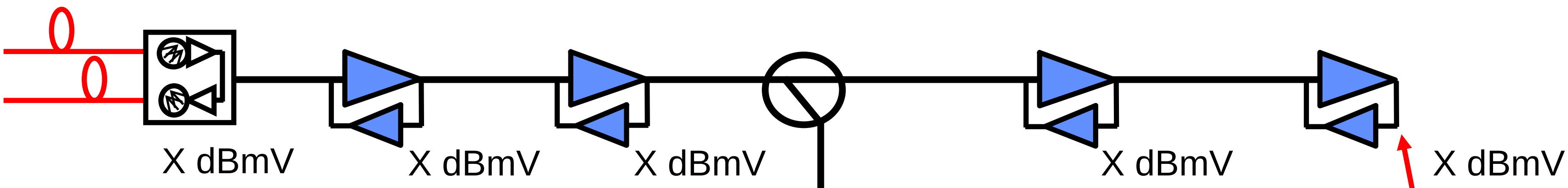


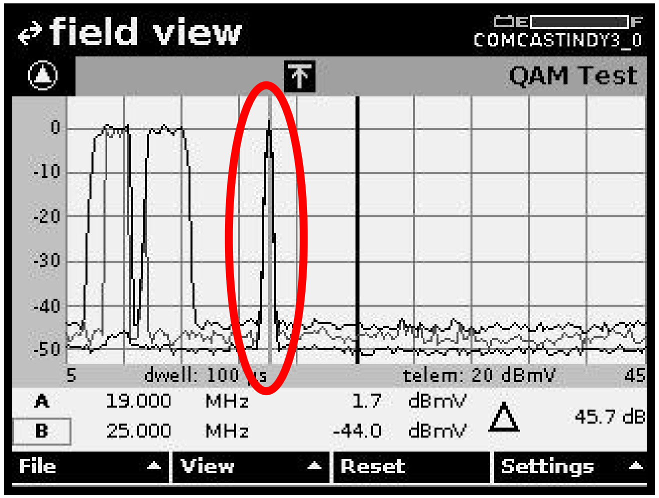
Pad input of sweep receiver transceiver so that 40 dBmV into node equals 0 dBmV at the input of the return sweep transceiver

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

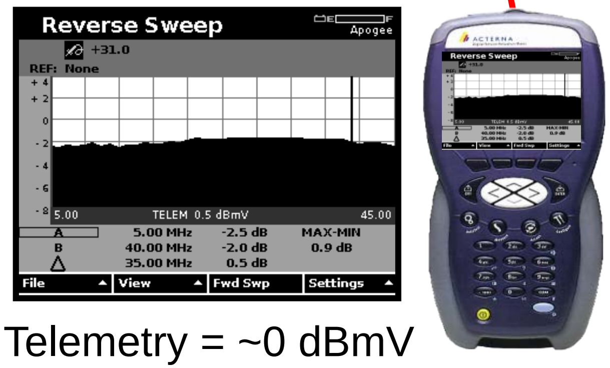
Optimize the HFC Pipe for Unity Gain

Maintain unity gain with constant inputs





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

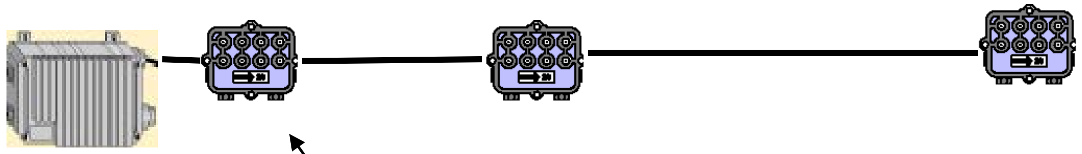


Telemetry = ~0 dBmV

Set TP Loss as required

Sweep and Balancing Amplifiers

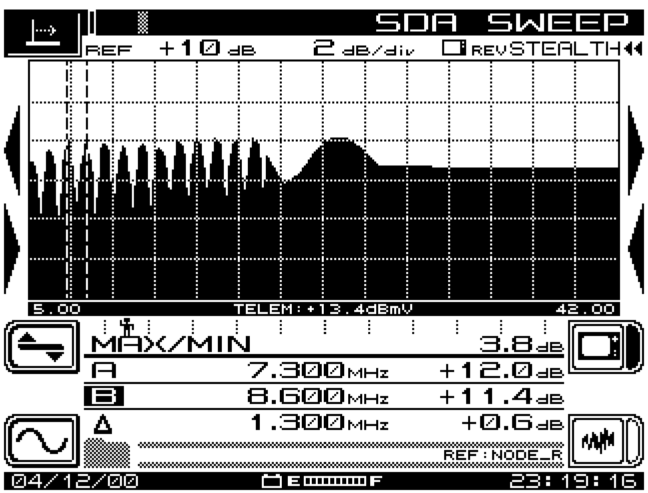
1 ft 160 ft 310 ft



Sweeping the
Seizer screw
with a 6dB pad

Where is the problem?

$$\frac{492 \times VOP}{FRE} = \text{Distance}$$

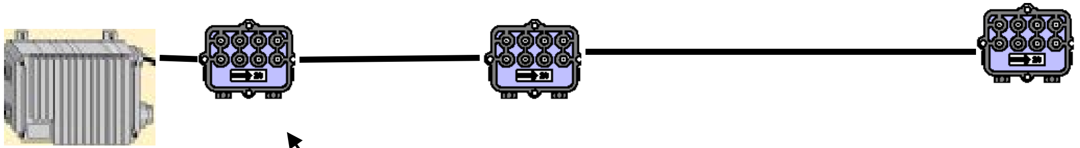


Result

$$\frac{492 \times 0.82}{1.3} = \frac{403}{1.3} = 310 \text{ feet}$$

Sweep and Balancing Amplifiers

1 ft 160 ft 310 ft

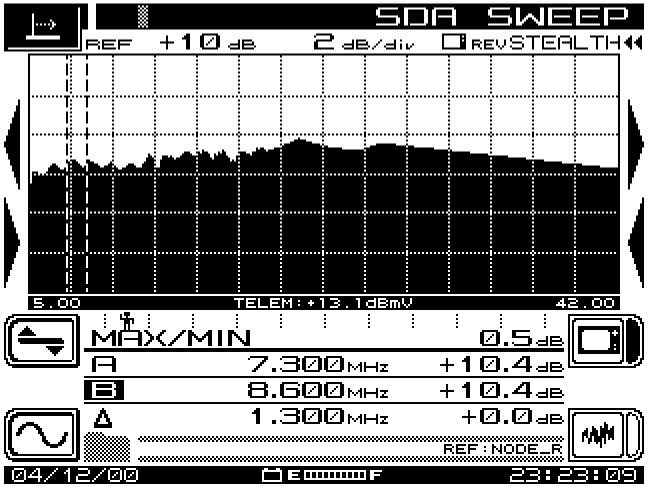


Terminate Tap

Sweeping the Seizer screw with a 6dB pad

Where is the problem?

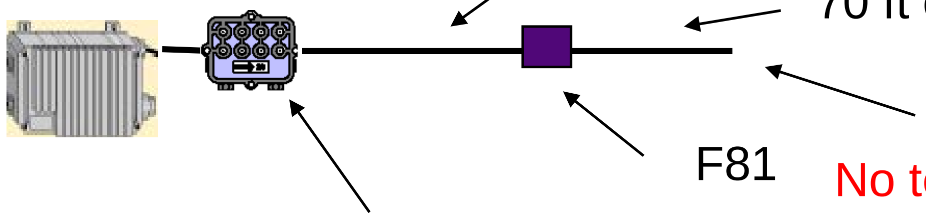
$$\frac{492 \times VOP}{FRE} = \text{Distance}$$



Result

$$\frac{492 \times 0.82}{1.3} = \frac{403}{1.3} = 310 \text{ feet}$$

Sweepless Sweep for Distance



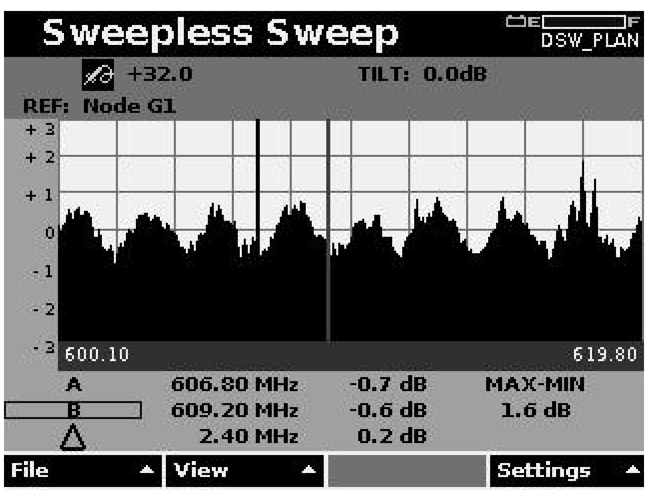
Sweeping the Seizer screw

600 MHz to 620 MHZ

100 KHz Resolution

Where is the problem?

$$\frac{492 \times VOP}{FRE} = Distance$$

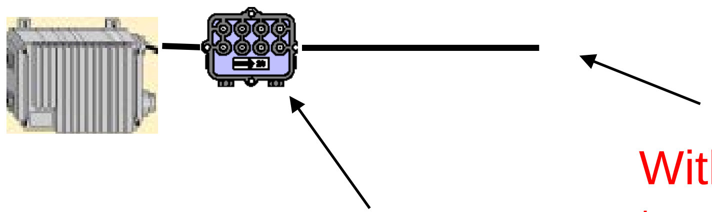


Result

$$\frac{492 \times 0.82}{2.4} = \frac{403}{2.4} = 168 \text{ feet}$$

Sweepless Sweep for distance

1 ft   100 ft



With termination

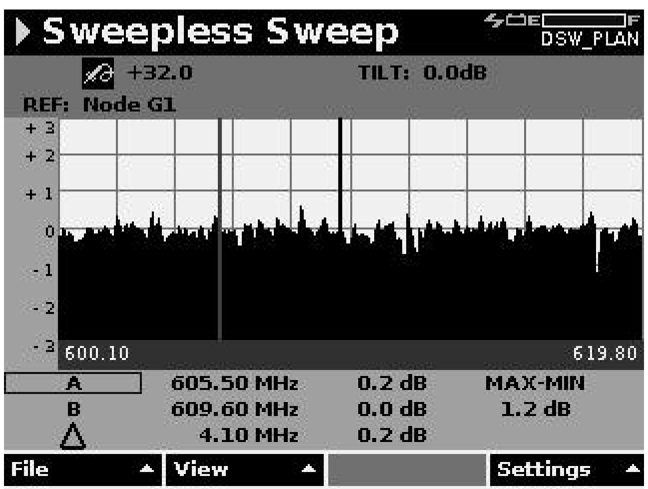
Sweeping the Seizer screw

600 MHz to 620 MHZ

100 KHz Resolution

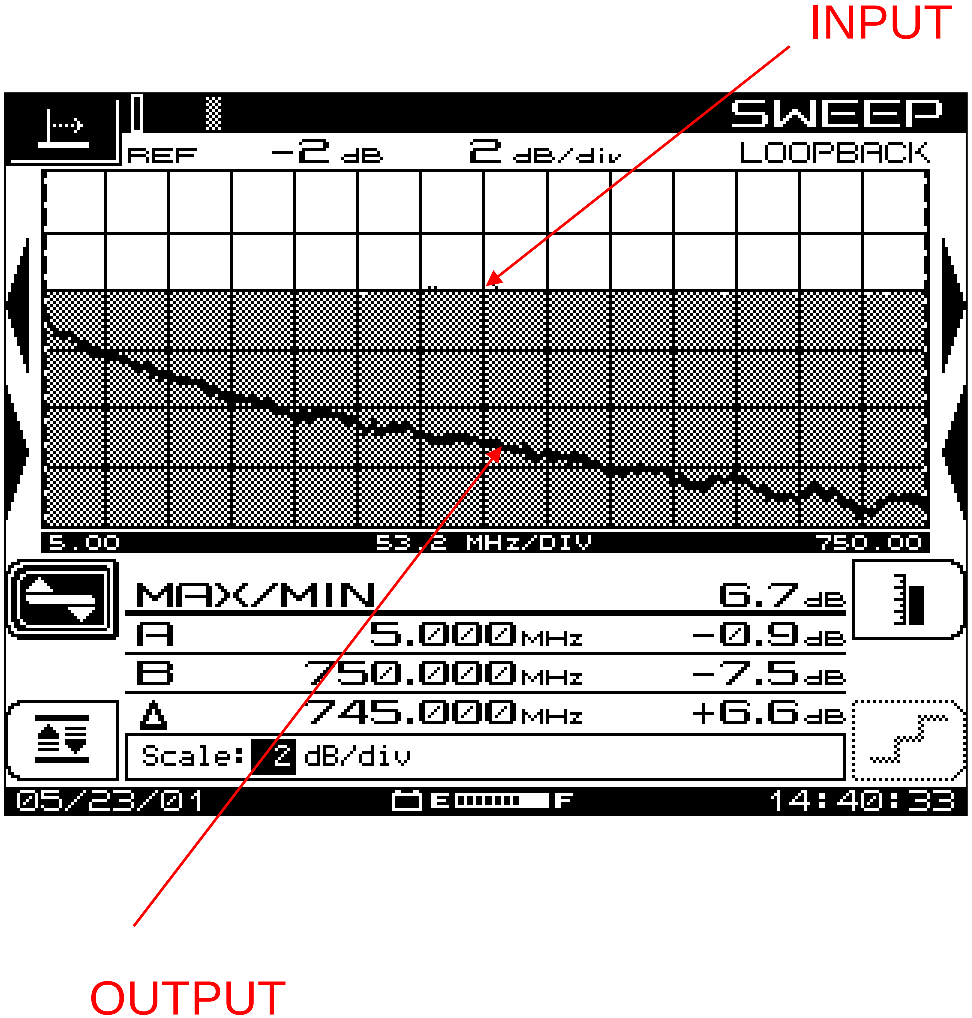
Where is the problem?

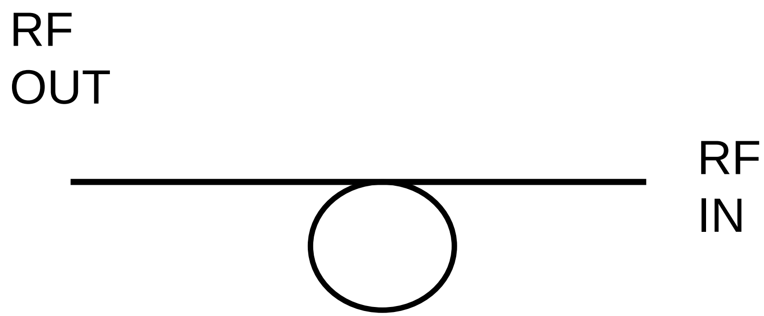
No Problem



Result

100 ft of RG-59 cable

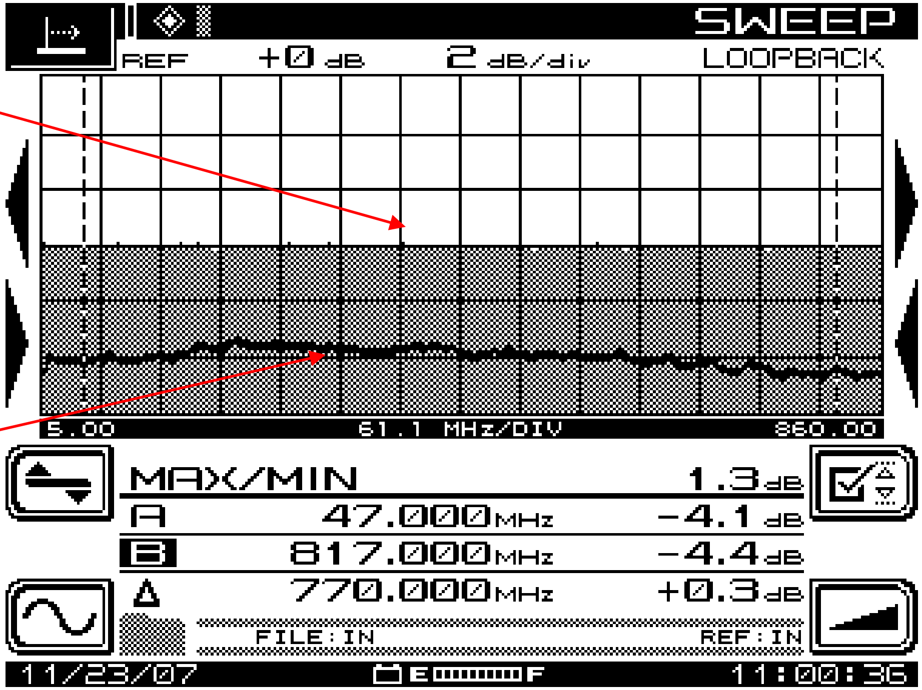




Sweep Reponse of a Splitter

INPUT

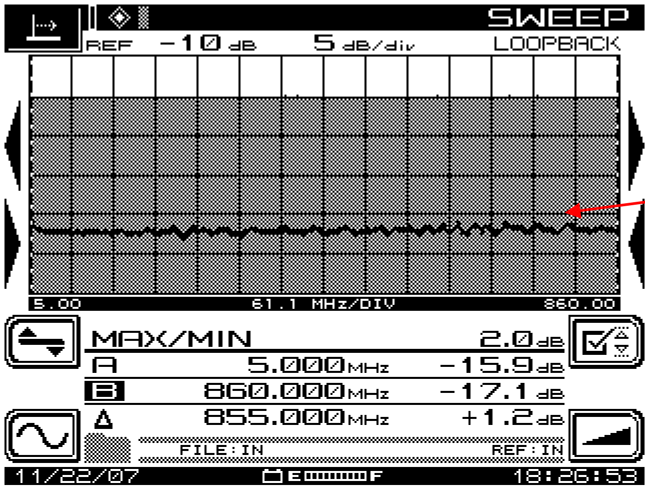
OUTPUT



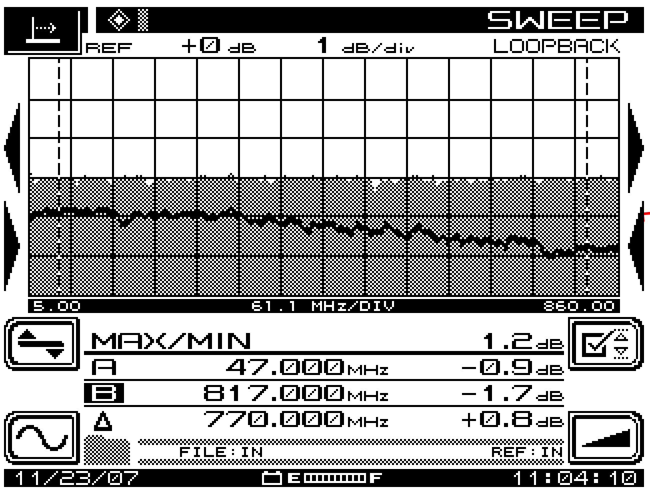
RF OUT

RF IN

Sweep response of 17dB Tap



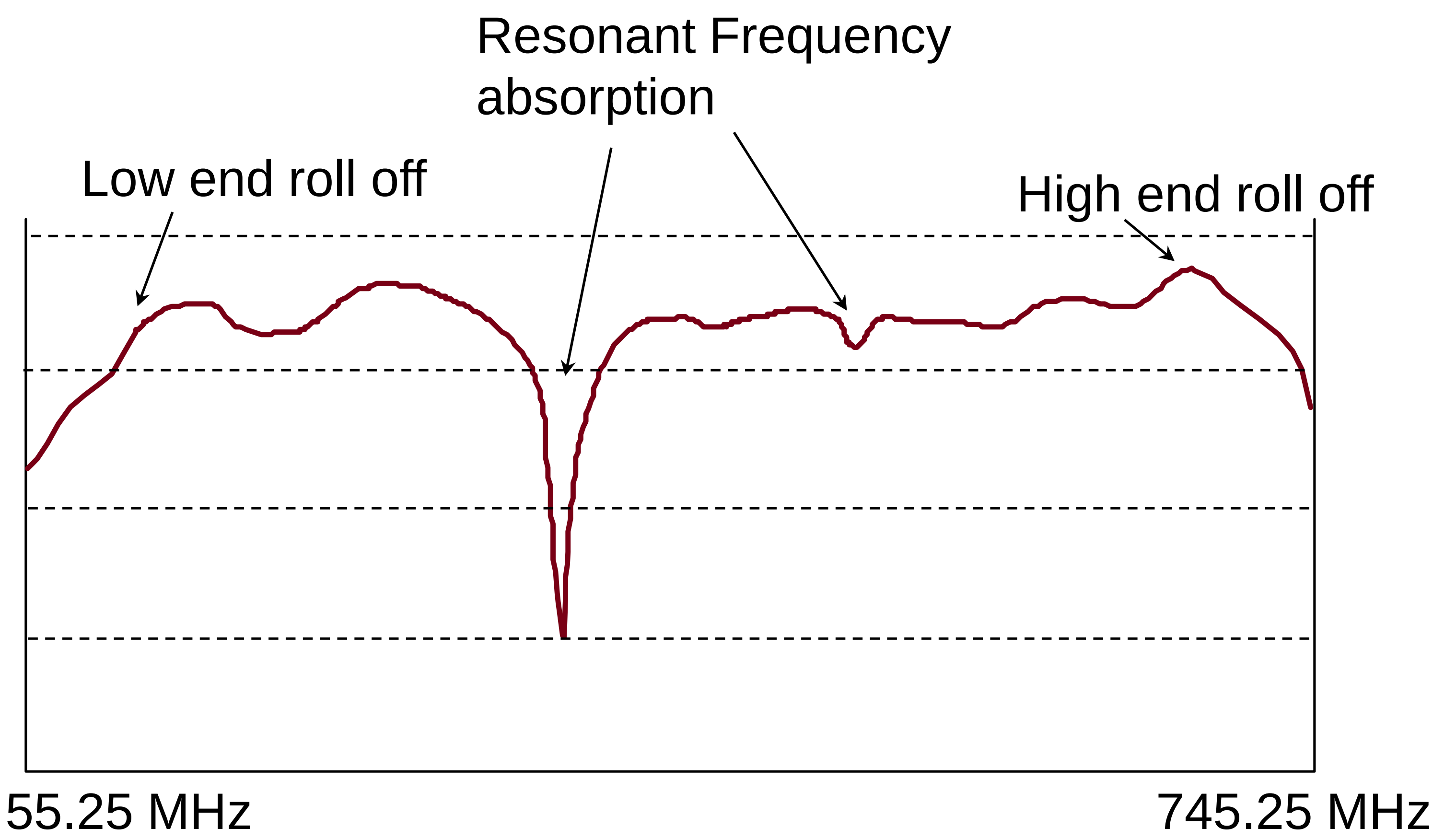
Tap
Port



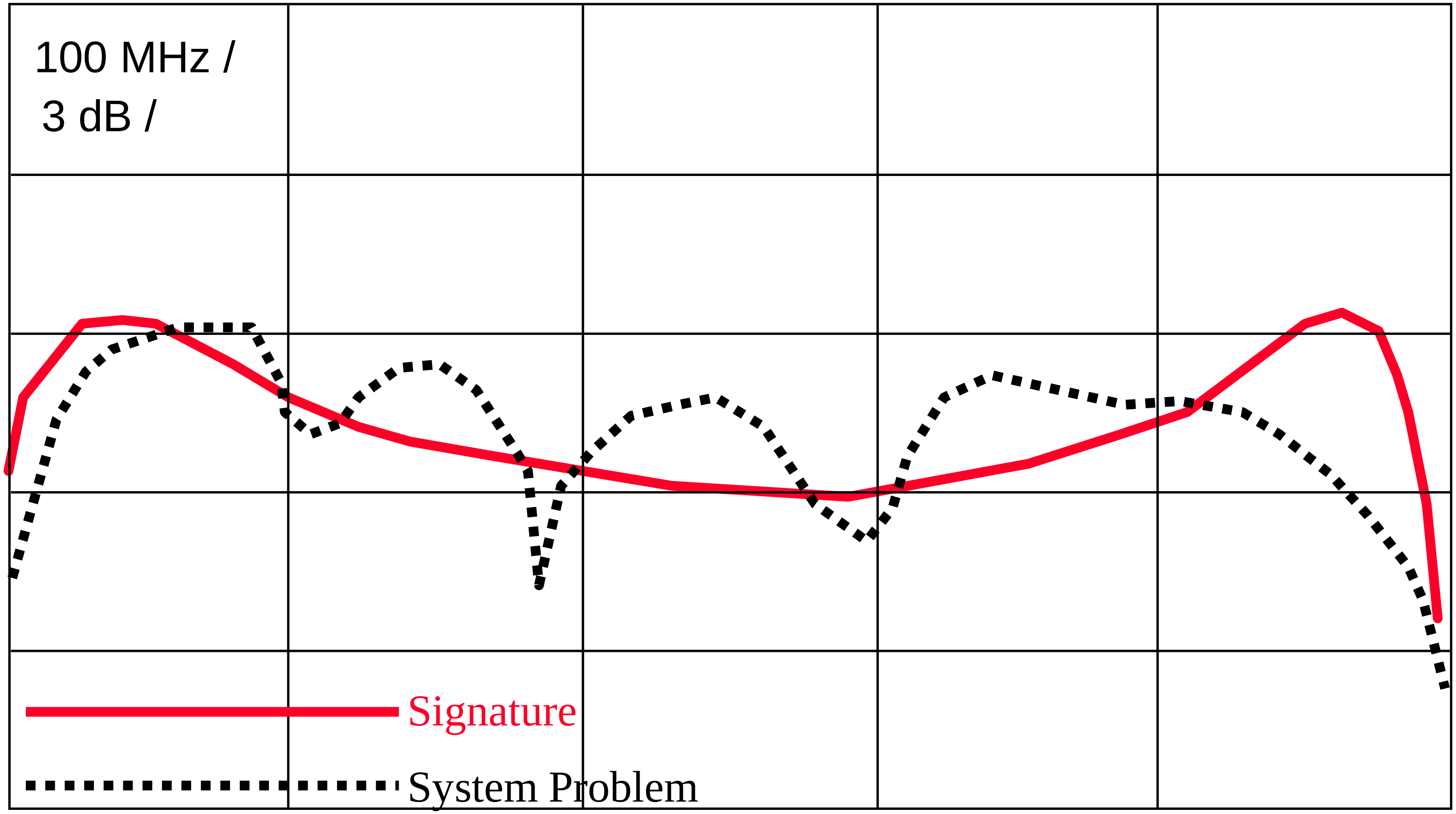
Tap RF

Out

System Problems



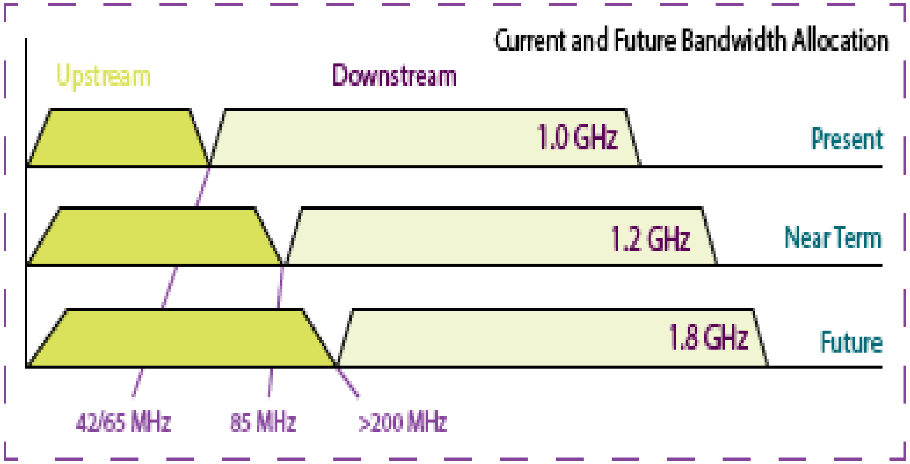
System Problem Vs. Signature



Docsis 3.1

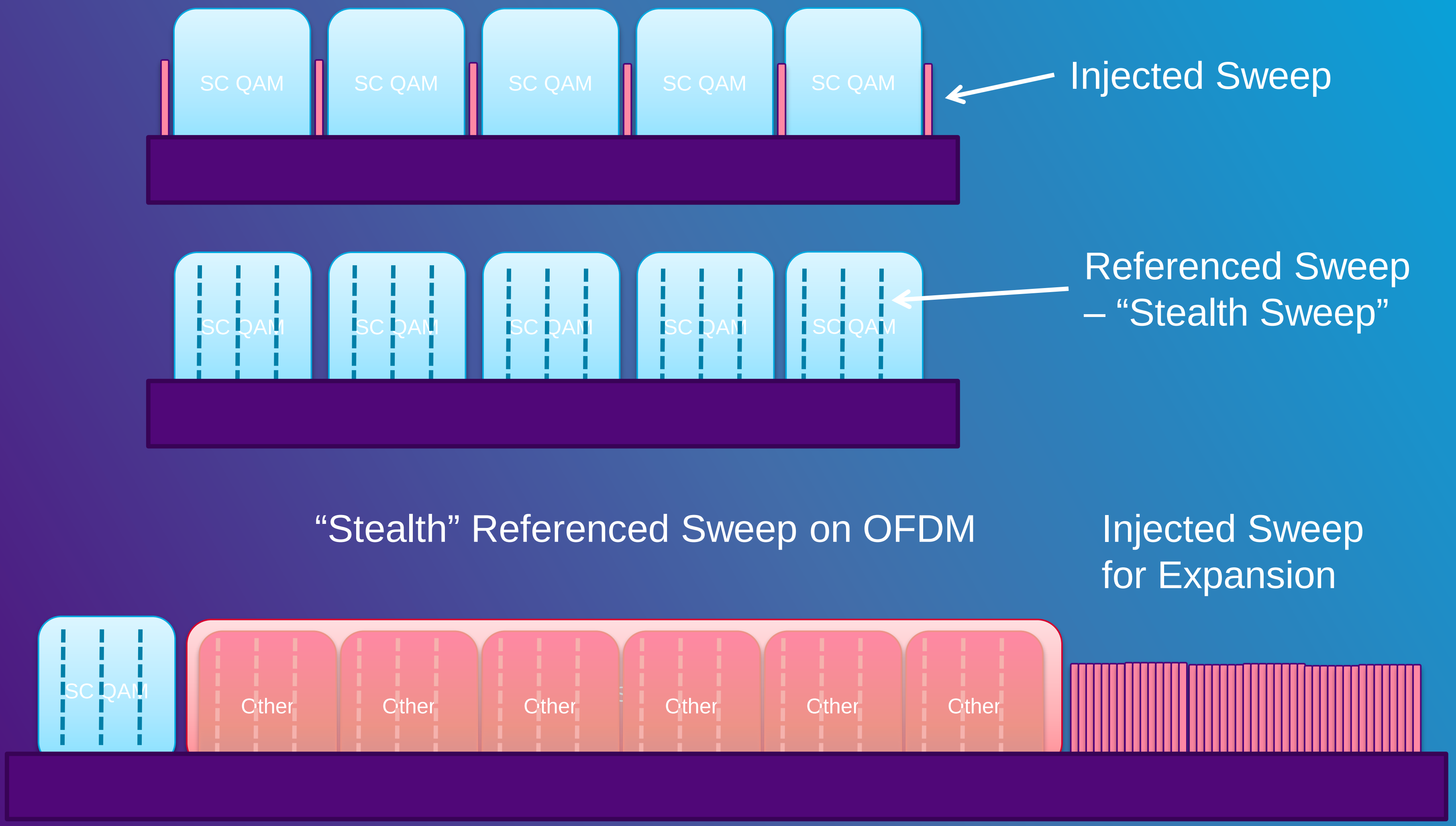
RF Network Changes

- Docsis 3.0
  - 32 Downstream 8 Upstream
- Docsis 3.1
  - 192 Mhz Channel Downsteam
  - 24Mhz channel upstream.
  - OFDM Modulation – More Robust
- Plant Design Changes
  - Node plus 1 Active or Node plus 0 (passive)
  - Return path spectrum to 85 Mhz or 200 Mhz
  - Downstream Path Spectrum to 1.2 Ghz or 1.8 Ghz
  - RFog



Source: SCTE

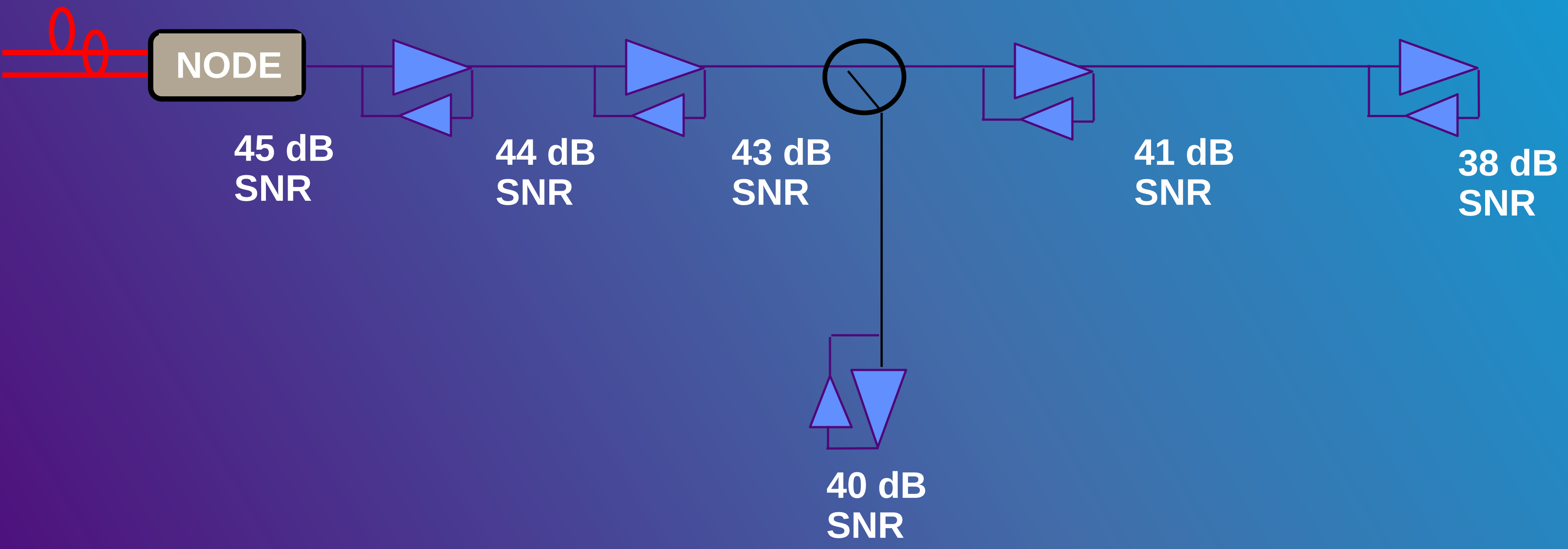
So how does OFDM affect sweep?



What do I need to do in order to get maximum efficiency?

Profiles for Higher Modulation

Need to have clean plant



VIAVI

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

Node plus Zero Design considerations

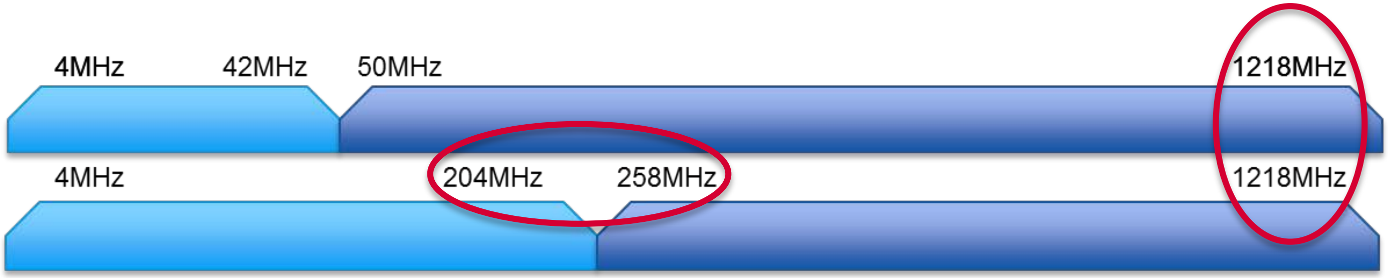
- Return Path setup
- Forward Path Setup
- Tilt
- Forward and Return levels at the Tap

DOCSIS 3.1 – Sweeping for maximum benefit

- Test DOCSIS 3.1 signal physical performance and service (IP) quality
  - Measure OFDM signal level, MER, check ingress under carrier
  - Check for codeword errors, verify profiles lock and no uncorrectable codeword errors
- Verify network RF transmission performance by sweeping
  - Adding OFDM signals, typically at higher frequencies
  - Some extending frequency range of upstream and downstrea
  - Need to optimize performance to obtain optimum efficiency
- RF Amplifiers still must operate within linear transfer range
  - Levels too low result in low MER, CN – unable to achieve higher order QAM
  - Levels too high result in intermodulation noise and distortion – again, unable to achieve higher order QAM

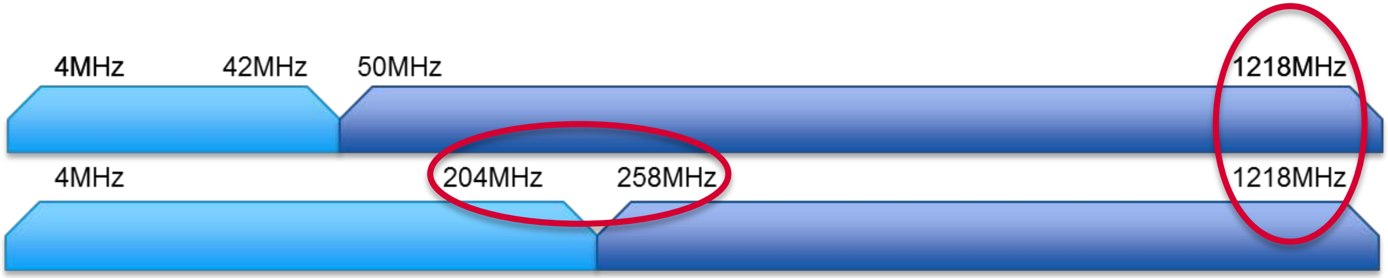
What's Driving Frequency Extensions?

- DOCSIS 3.1 offers >1Gbps speeds, enables spectrum usage to 200 MHz in return, and 1,200 MHz (1,800) in forward
- OFDM signal can be 192 MHz wide, and multiple signals
- Expanding return band to improve speeds can squeeze forward band if not expanded at the same time



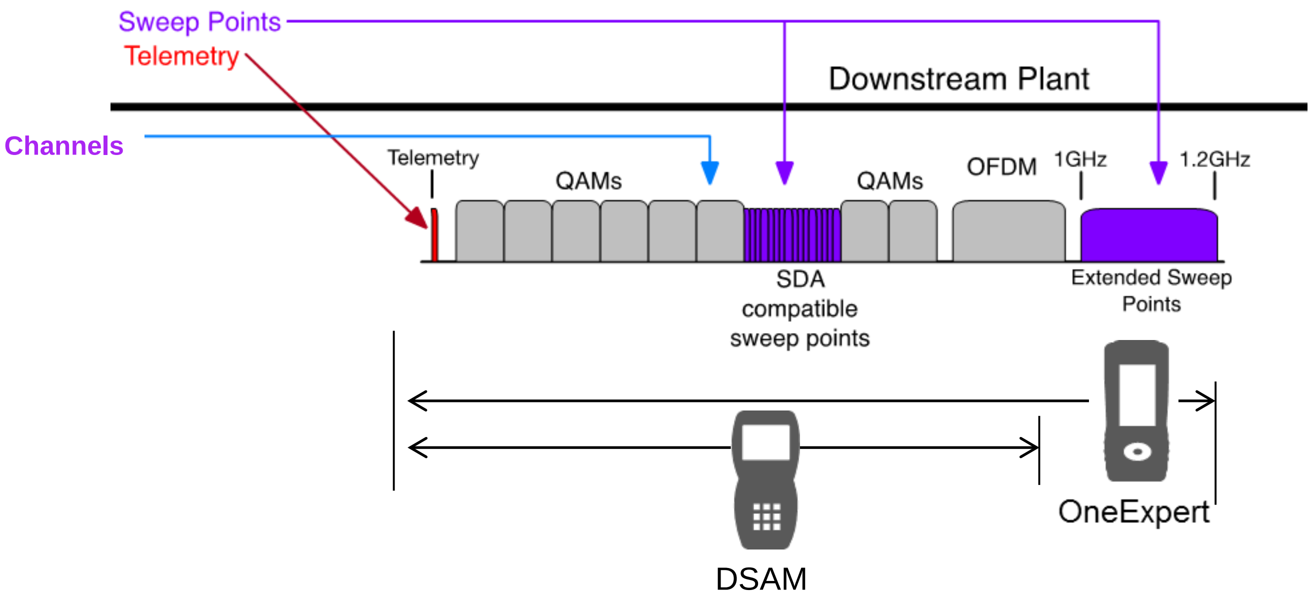
Testing Plant frequency Extensions

- Need to verify amplitude vs frequency response of extended frequency range
- Inserting test signal is inadequate, as it only tests one frequency
  - Can't assume other frequencies have same performance
  - Must have meter or analyzer that reads test frequency
- Contractor constructing the extension must certify performance
- Maintenance techs need up-to-date tools to maintain and troubleshoot upgraded plant issues
- Built-in switchable diplexers are very important



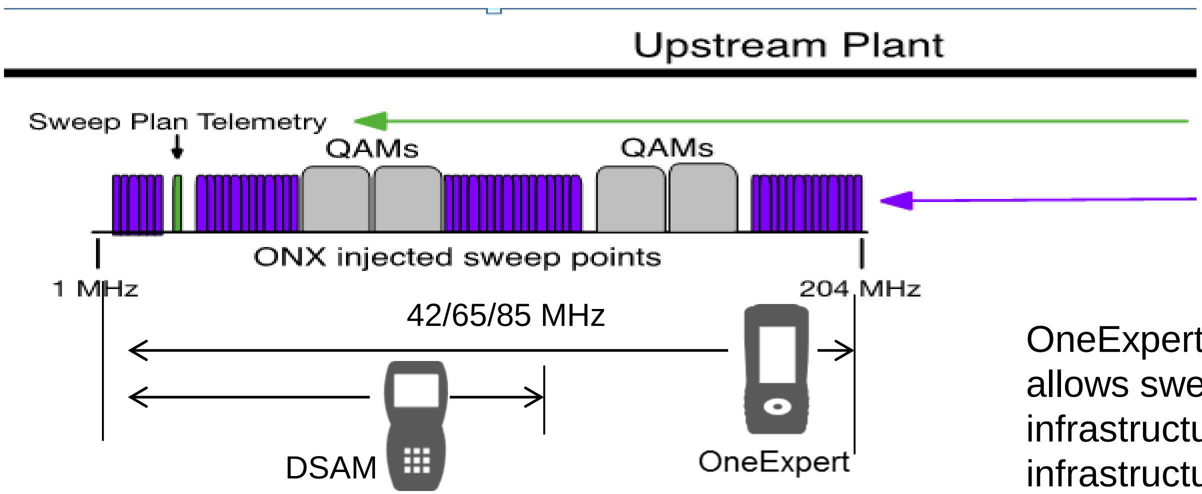
Sweep beyond 1GHz

SCU-1800



- ONX coupled with new Sweep Control unit can provide sweep to 1.2GHz and beyond
- DSAM units on same system are still compatible up to 1GHz.

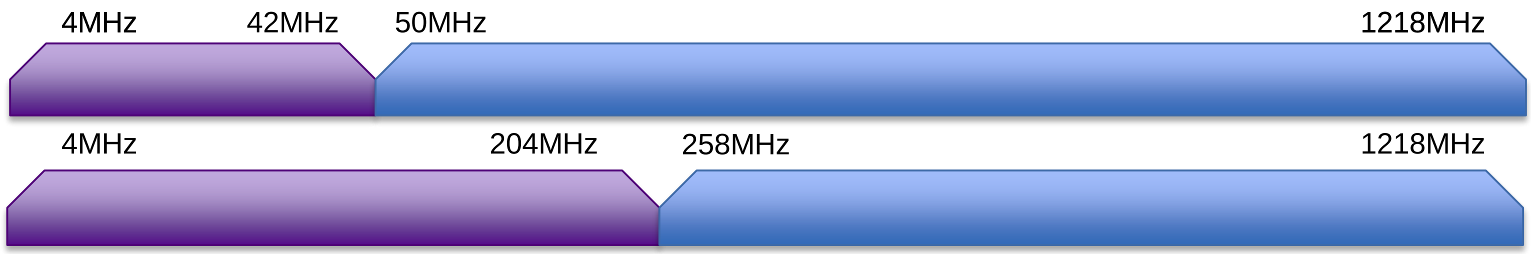
Reverse Sweep to 204 MHz



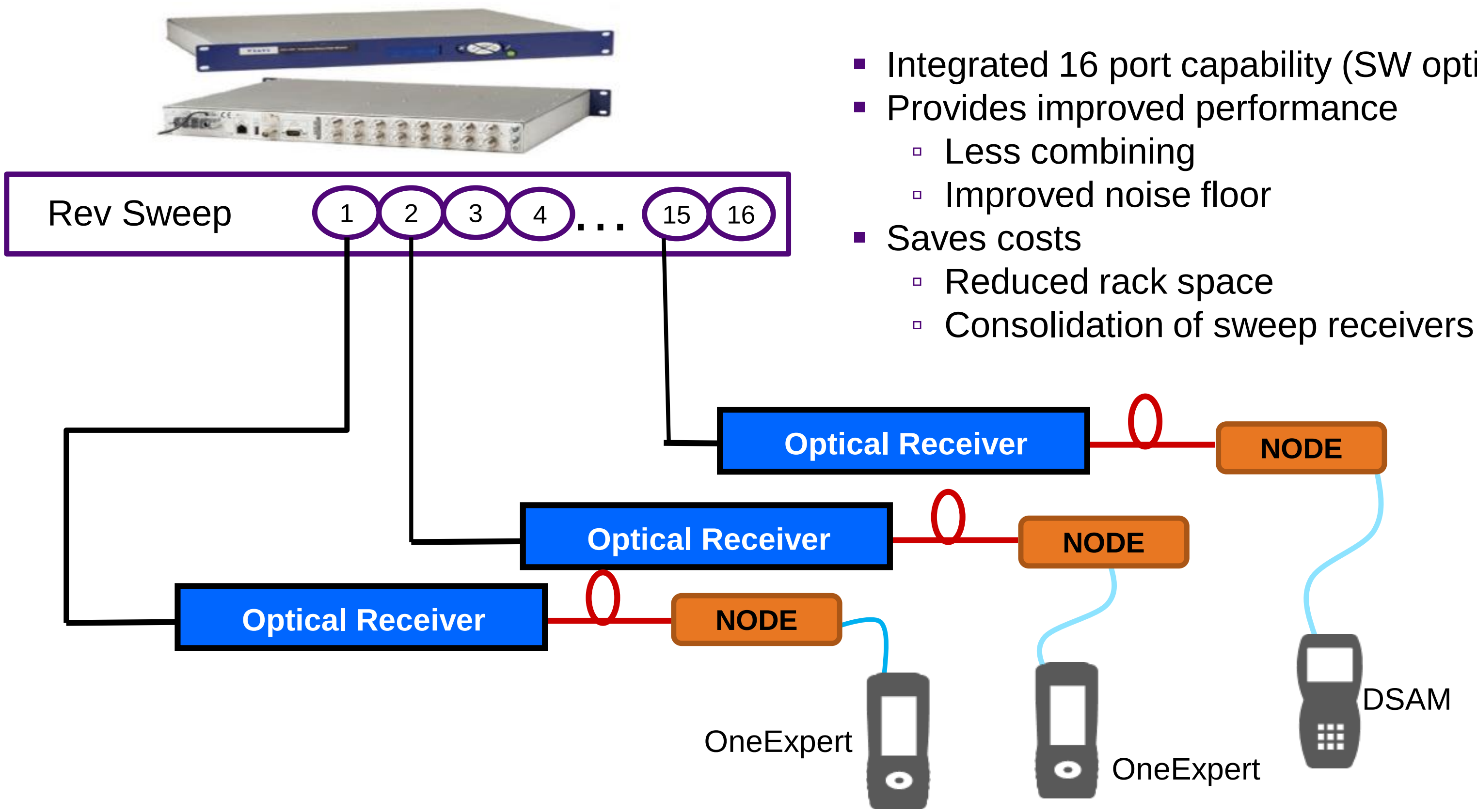
Upstream Sweep Telemetry

Upstream Sweep Points

OneExpert's flexible architecture allows sweeping on existing infrastructure or expanded infrastructure up to 204MHz (or anywhere in between)



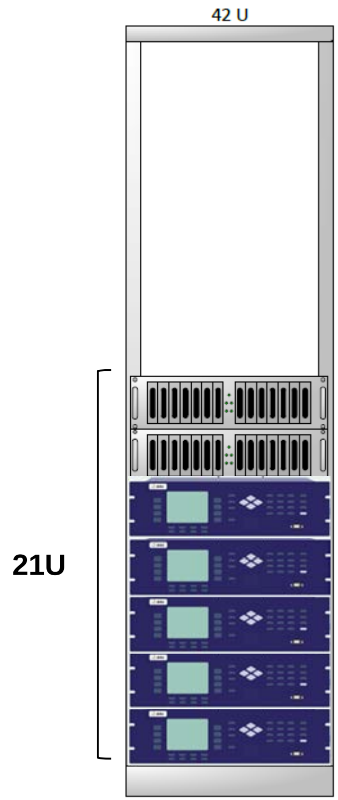
Multiple reverse sweep input ports
Reduces costs and improves performance



- Integrated 16 port capability (SW optional)
- Provides improved performance
  - Less combining
  - Improved noise floor
- Saves costs
  - Reduced rack space
  - Consolidation of sweep receivers

VIAVI

Conserving rack space, power consumption, and spectrum



Before

Telemetry
Spectrum:
2.5 MHz

Combiners

SDA 5500

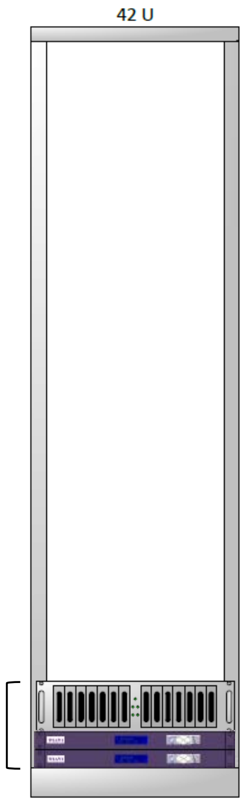
SDA 5510

SDA 5510

SDA 5510

SDA 5510

5U



After

Telemetry
Spectrum:
1 MHz

Improved Noise performance on telemetry and sweep pulses

Combiners

SCU-1800-FWD-REV-16P
SCU-1800-REV-MU-16P

Example:

- Typical hub with 256 nodes

Assumptions:

- Using 16 return sweep ports on FWD sweep transmitter
- Using 16 ports on MU REV sweep receiver
- Combining 8 nodes per SCU return input

Improved sweep flow

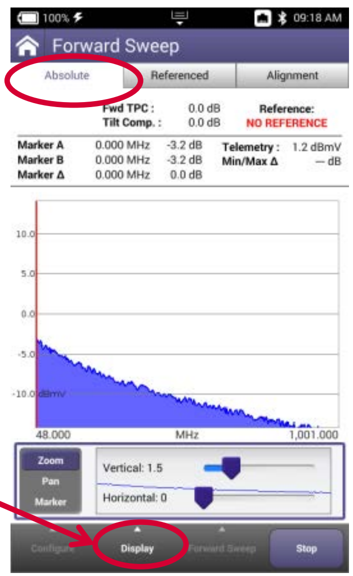
Consolidated sweep screens expedite the test process

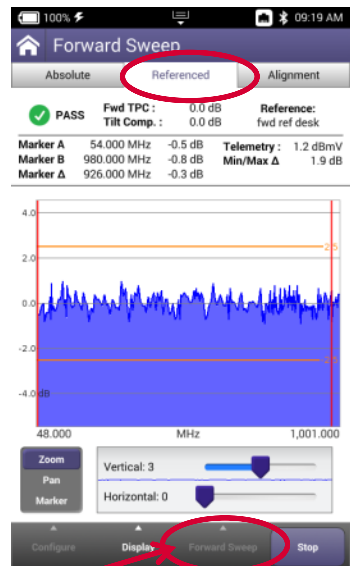
View the raw/absolute unreferenced sweep to save as a reference

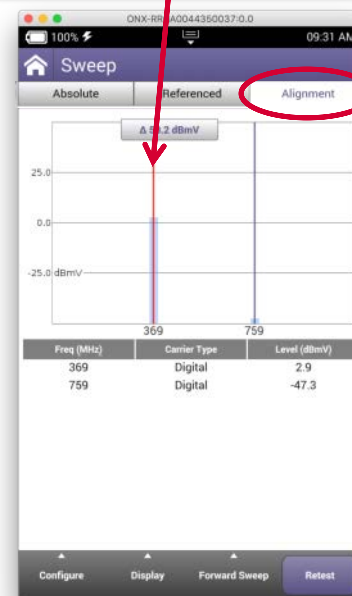
View the normalized referenced sweep to identify issues

Pick tilt carriers for fast gain and alignment check. Sweep points or live carriers

Toggle between Portrait and Landscape mode



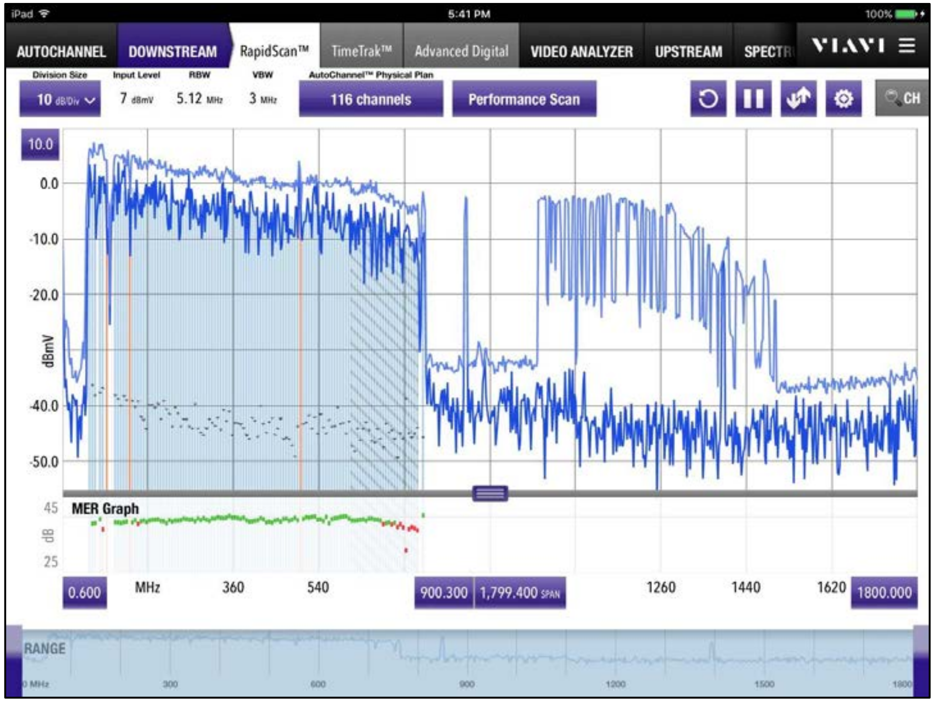


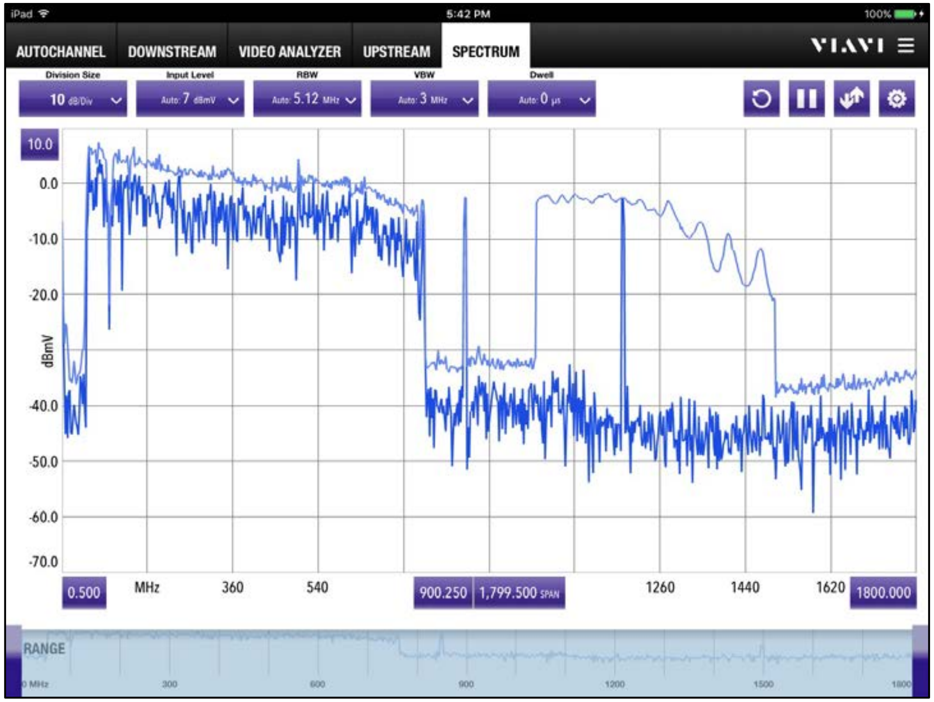


Easily change sweep modes Forward/Reverse

Spectral Frequency Expansion up to 1800MHz (1.8GHz)

- Have visibility up to 1.8GHz in RapidScan and Spectrum Modes
- See how the network effects higher frequency signals to ensure future operation of higher frequency OFDM carriers >1GHz
  - Identify frequency roll off, standing waves, excess attenuation, etc…

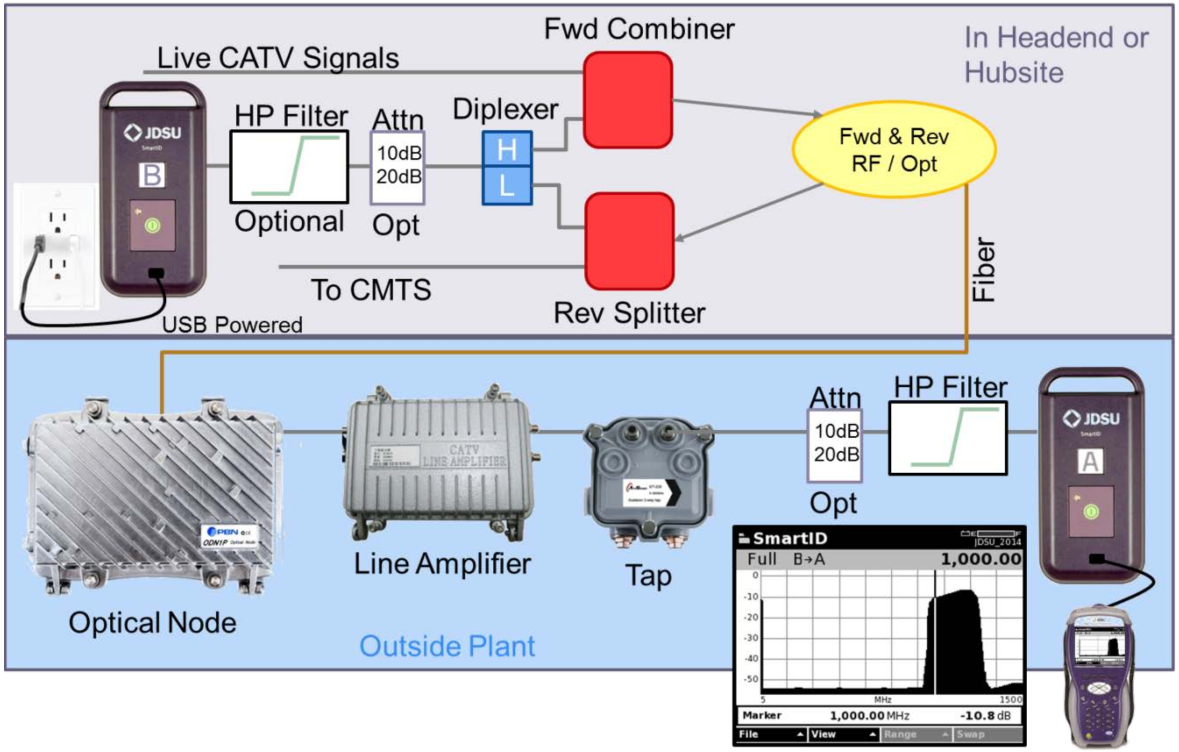




SmartID Sweep Mode

Use Case #1 – Test frequencies above active carriers on live network

- One SmartID will Transmit Sweep above active channels
  - One way signal transmission – Broadcast in downstream at specified frequencies
- Another SmartID in the field will detect and display sweep carriers
  - Connected to plant through a high pass filter – To remove active plant from SmartID's Broadband power detector

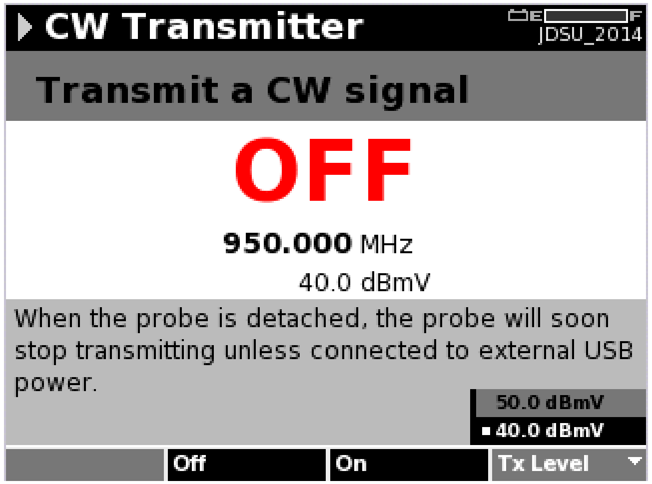


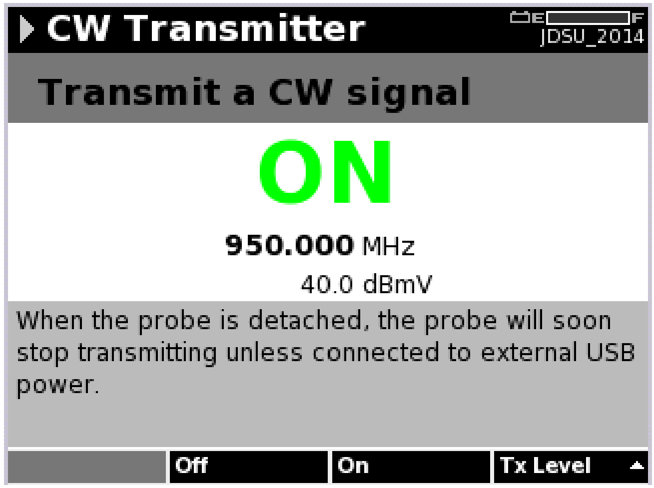
- No Hardware modifications
- Requires Firmware updates to both the SmartID and the DSAM
- Can be applied to extended Upstream testing with use of diplex and high-pass filters
- Minimal configuration of each SmartID would be required to perform this test
  - Tx or Rx
  - Freq range
  - Telemetry Freq

SmartID CW Transmitter – Power Level and Activation

- The CW mode has two power levels
  - 50 dBmV (110dBµV) OR
  - 40 dBmV (100dBµV)
- Use the "Tx Level" button to select which power level is desired
  - A white dot indicates which power level is currently selected
- Adding external attenuators in-line is recommended if a lower power level is desired

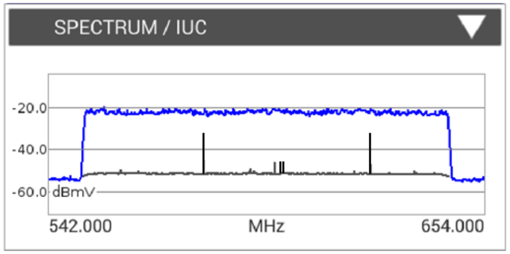
- To activate the CW mode press the "On" softkey
  - The green ON indicator will be evident when the CW is active on the SmartID connected
- Press the "Off" softkey when to turn off the CW
  - OR press the power button on the SmartID to power the SmartID off



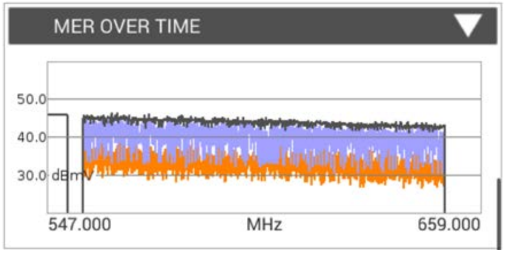


VIAVI

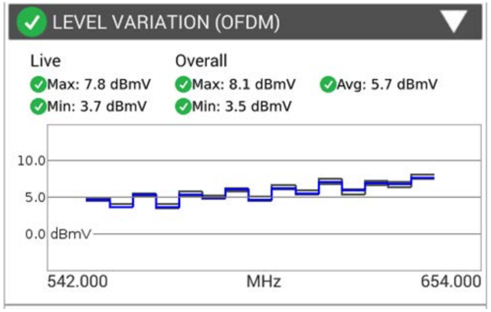
DOCSIS 3.1 Signal Testing and Troubleshooting



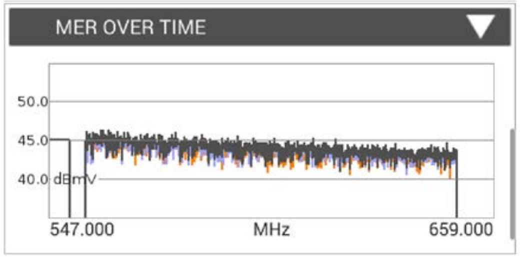
Spectrum and noise identify portions of a carrier where degradation may occur and require possible profile adjustment.



Unstable MER with drops below 30 means only lower profiles running 256 QAM or lower will work.

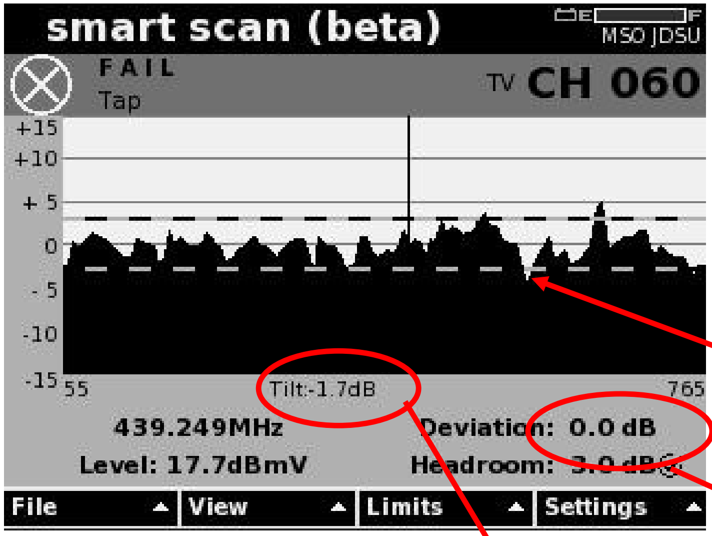


Level variation within the OFDM channel band provides insight into frequency-response related issues.



Stable MER better than 40 dB means QAM 2048 and 4096 will work.

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

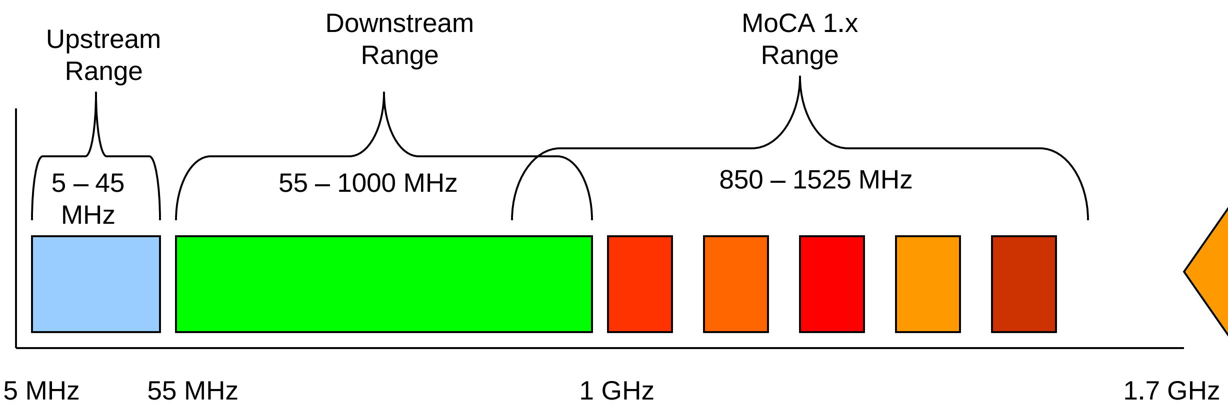
Identifies tilt level at tap

SmartScan will be optional upon final release

SmartScan Technology is Patent Pending

MoCA Just Evolved to V2.0

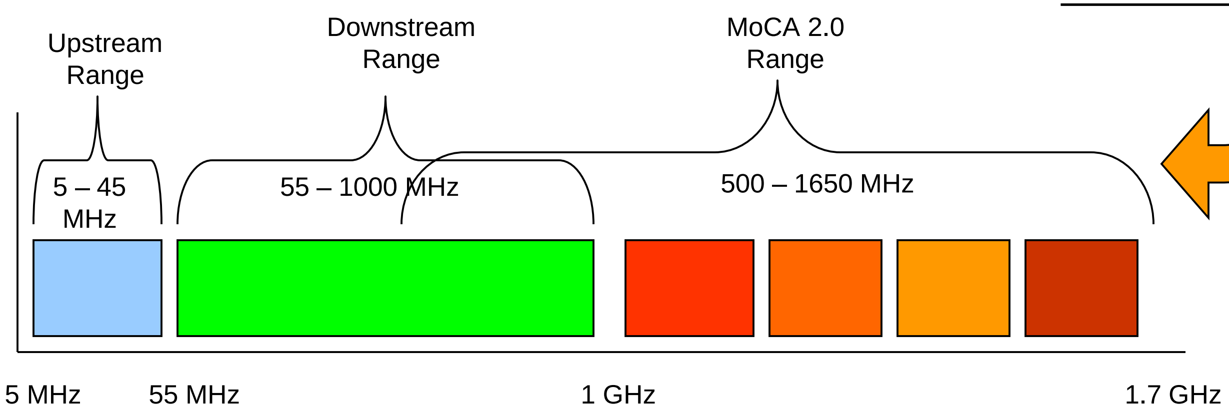
MoCA 1.x Frequency View



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

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

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

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

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Questions?

Mark Ortel

Sales Consultant Engineer

VIAVI

CVIT Division

www.viaviasolutions.com

National SCTE Member

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Mark.Ortel@viavisolutions.com