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Proactive Network Maintenance (PNM) Paves the Way for More Upstream Bandwidth

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Evolution of Pre-Equalization Analysis and PNM

Various Data Sets for Identifying RF Plant Impairments

- Channel ranging status
- Speed test
- Spectrum analysis at CMTS
- Rx power, MER, FEC at CMTS
- Spectrum analysis at CM
- Tx power at CM
- Upstream pre-equalization coefficients at CM

- Pre-equalization coefficients proven most powerful

Evolution of Pre-Equalization Analysis and PNM

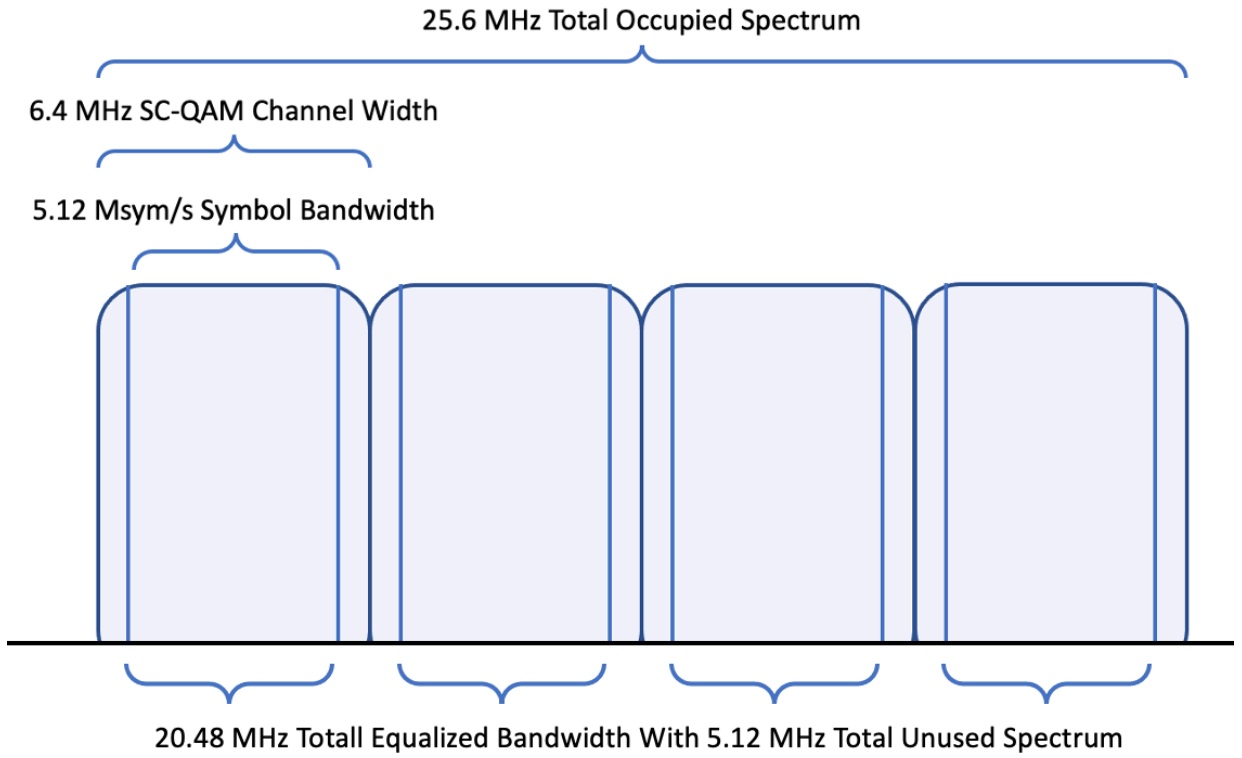
Generations of DOCSIS Spec and PNM

- DOCSIS 1.1 (1999)
  - A single Carrier QAM ~3.2 MHz with 8 coefficients
- DOCSIS 2.0
  - A SC-QAM ~6.4 MHz with 24 coefficients
- DOCSIS 3.0
  - 4 SC-QAMs ~25.6 MHz by channel bonding
  - Wide deployment with CableLabs' formal support of PNM
- DOCSIS 3.1
  - OFDMA channels up to 96 MHz wide each
  - Thousands of subcarriers and their pre-equalization coefficients

Pre-Equalizer: SC-QAM vs OFDMA

SC-QAM – Coarse and Narrow with Gaps

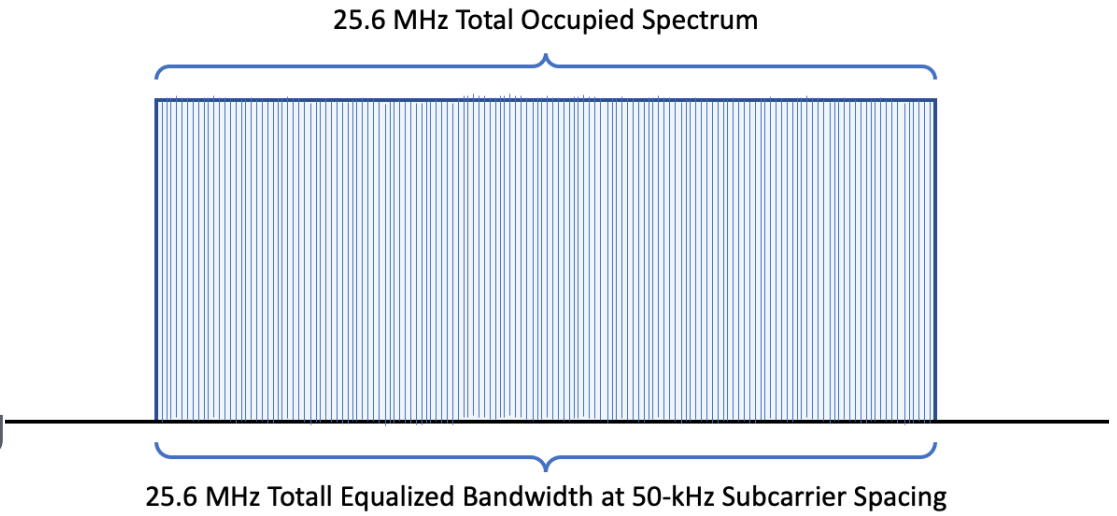
- Time resolution at symbol rate
  - 5.12 MHz for 6.4 MHz channel
  - 2.56 MHz for 3.2 MHz channel
  - Covers 80% of channel width
  - Gaps between channels
- Frequency resolution
  - ~233 kHz for 6.4 MHz channel
  - ~117 kHz for 3.2 MHz channel



Pre-Equalizer: SC-QAM vs OFDMA

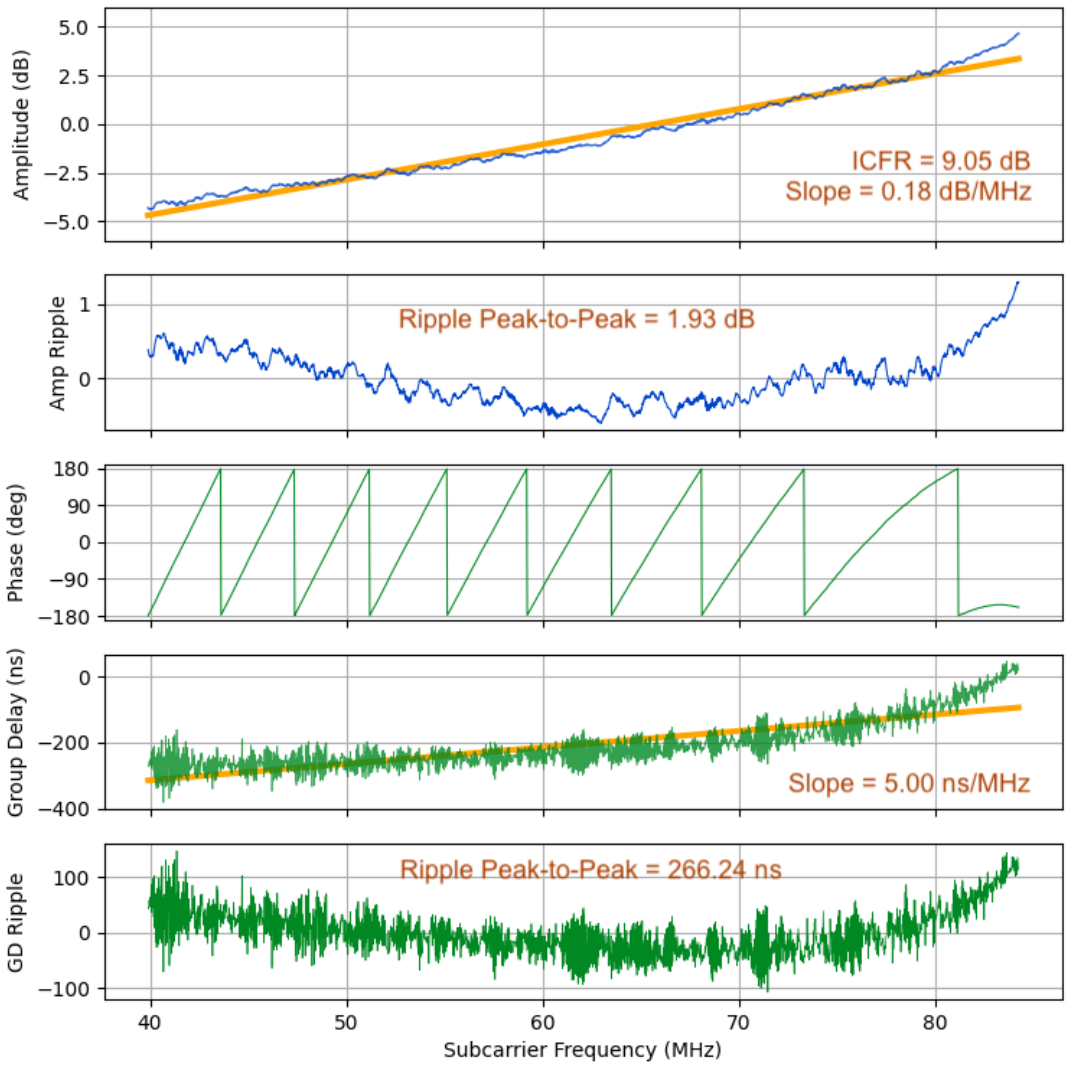
OFDMA – Fine and Wide and Contiguous

- Up to 96 MHz-wide
- Frequency resolution at subcarrier width
  - 25 kHz or 50 kHz
- No gaps across the entire channel
- Many more sample points
  - **88** on 4 SC-QAMs occupying 25.6 MHz
  - **512** on OFDMA with 50 kHz SC spacing
  - **1024** on OFDMA with 25 kHz SC spacing



OFDMA Pre-Eq Coefficients

- Raw coefficients
  - Complex number for each subcarrier
  - Amplitude and phase adjustment
  - Thousands of them
- Group delay
  - Differentials of phase
  - Transit time for each subcarrier
- Metrics
  - ICFR (in-channel frequency response)
  - Amplitude linear fit
  - Group delay linear fit
  - Coefficient overflow and underflow



OFDMA Pre-Eq Coefficients

- D3.1 CMs report the raw coefficients and linear fit parameters for OFDMA channels
- Raw coefficients
  - Take several seconds to retrieve, sometimes fails
  - Involve SNMP polling and TFTP transfer
  - Provide full spectrum view
- Linear fit parameters
  - For amplitude and group delay curves
  - Mean, slope, ripple peak-to-peak & RMS
  - Quicker to retrieve, available directly on SNMP table
  - Useful in finding anomaly
  - Amplitude parameters to estimate ICFR

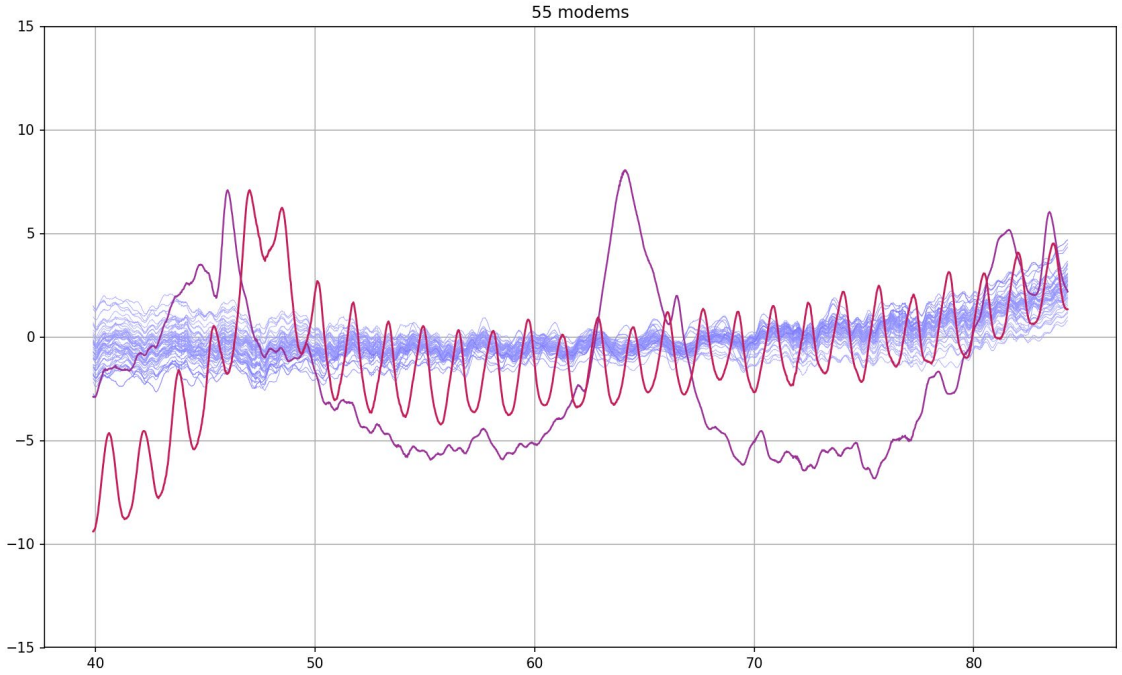
Monitoring Many Modems and Nodes

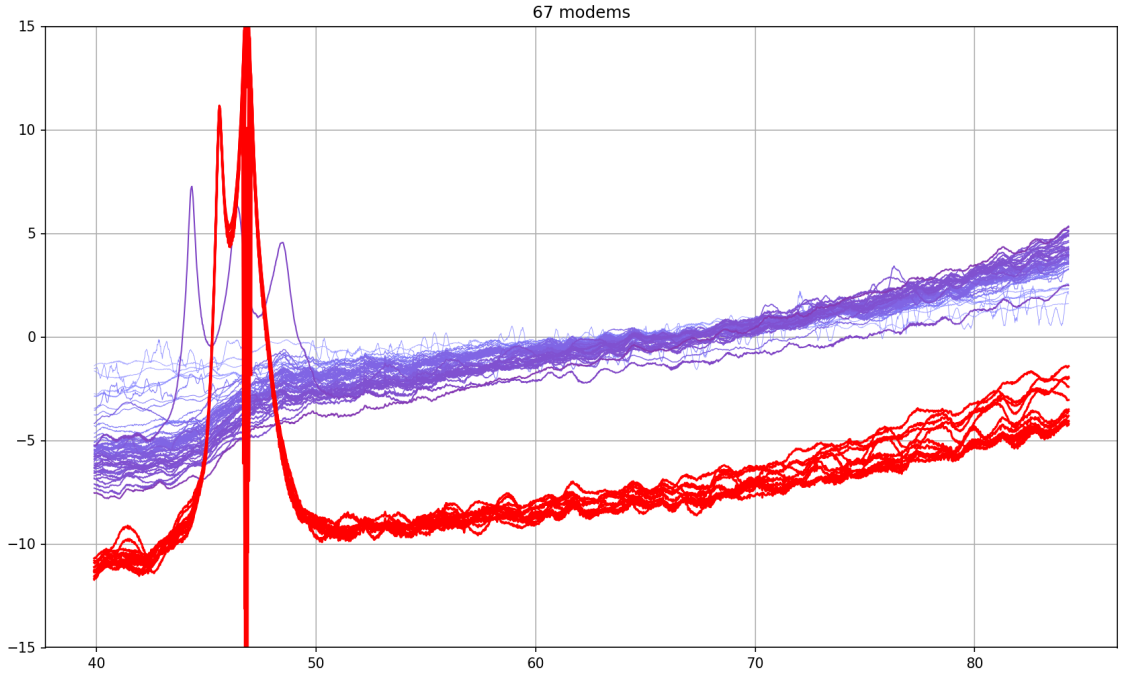
Fast and Economically

- Find CMs of interest
  - Check CMTS OFDMA channels enabled
  - Check CM OFDMA channels enabled and online
  - Check the pre-eq linear fit parameters
    - Available?
    - Bad or interesting enough?
- Get the raw coefficients…
  - From the CMs of interest
  - From the neighbors or the entire node
  - Are the impairments isolated or prevalent?

Overlaying Amplitude Plots

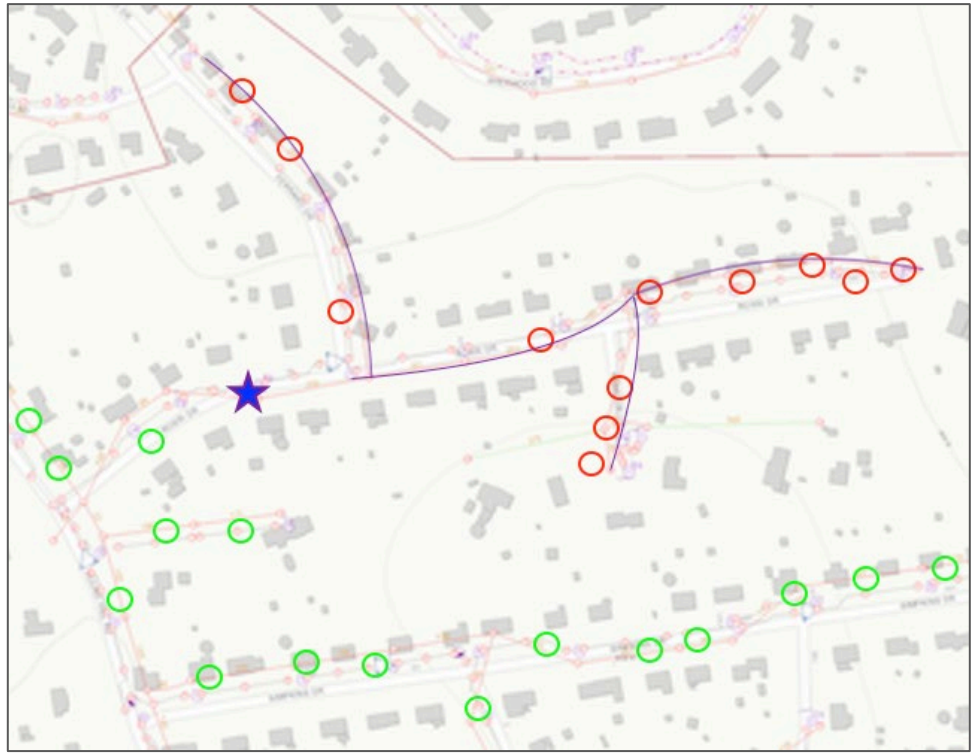
See if the impairments are isolated or prevalent

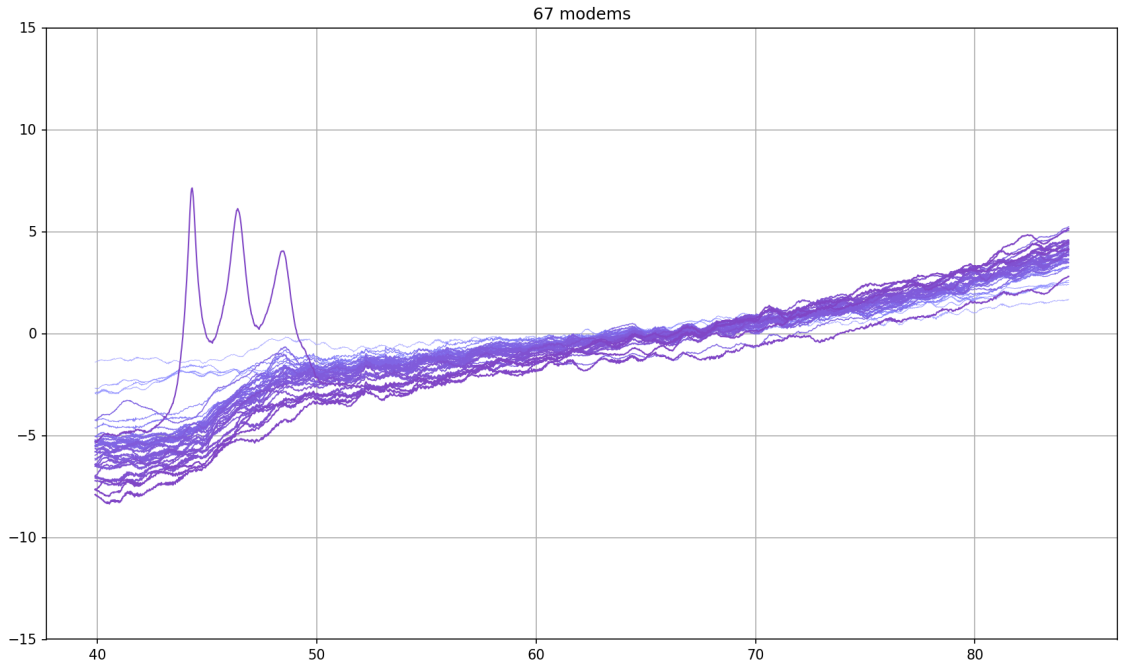




Impairment and Plant Topology

Where are the impaired vs unimpaired CMs?



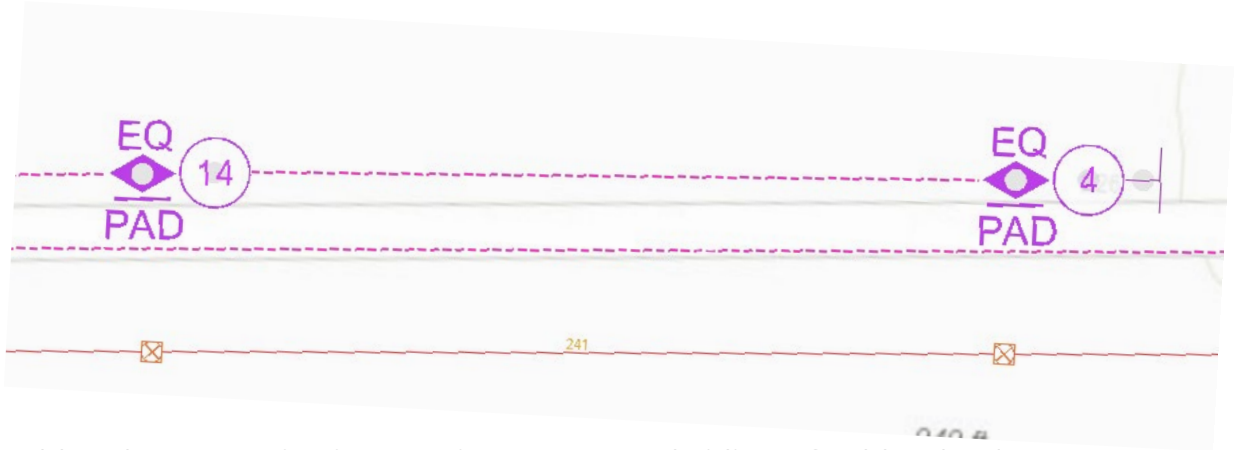


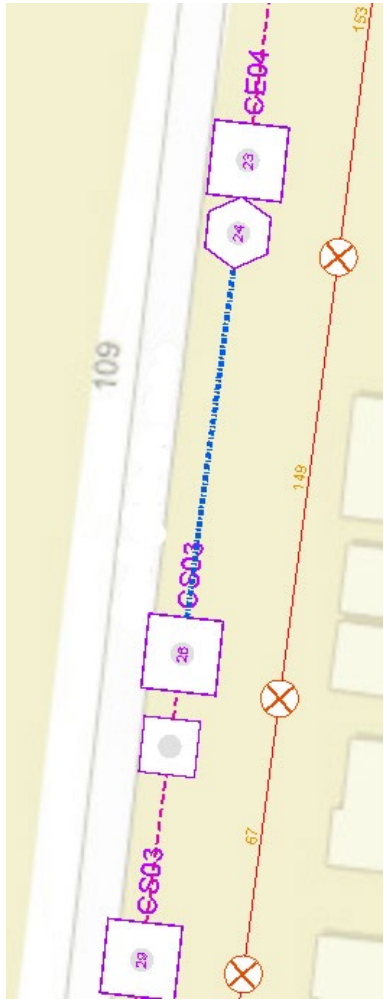
Helps the field tech to find and fix the cause of impairment easily

Learnings from the Field

Legacy Plant

- Legacy system deployments have a wide variety of active and passive components
- Some of them may not be identified in designs or maps
- Undiscovered sub-split diplex filters are not uncommon





Learnings from the Field

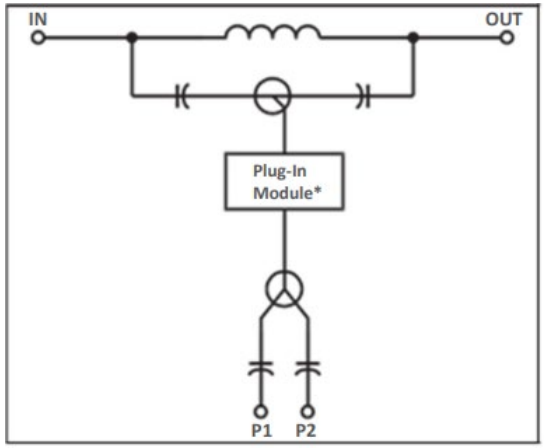
Active Devices

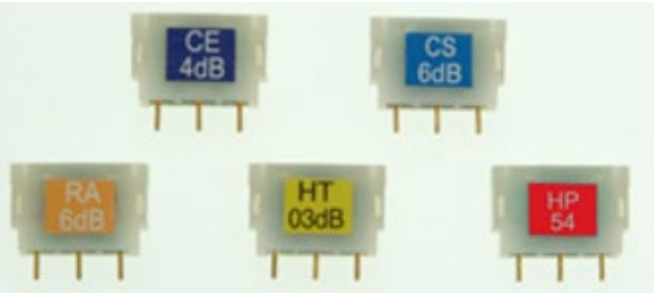
- Sub-Split Amplifiers
  - Temporary placements may be overlooked in walk-out and construction phases
- Sub-Split Amplifier Plug-ins
  - Some sub-split components will fit in expanded bandwidth amplifiers
  - Can be difficult to differentiate

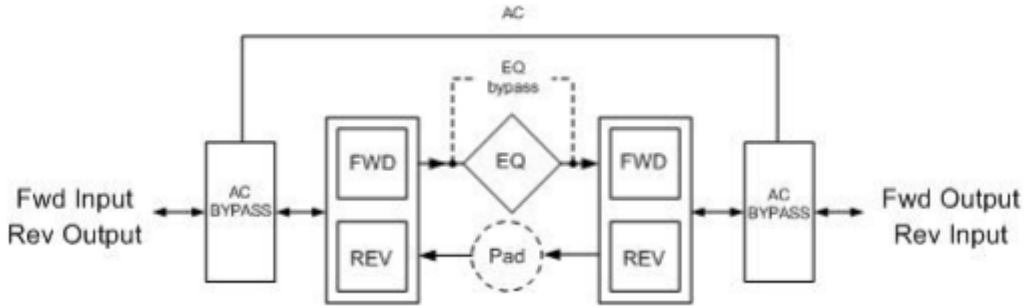
Learnings from the Field

Passive Devices

- Conditioned Taps
  - May contain sub-split Plug-In Modules
- Line Equalizers
  - Can contain sub-split upstream conditioning







Further Work

As we deploy OFDMA to more nodes and customers…

- OFDMA channel configurations
  - High-split ~ wider channels
  - Excluded subcarriers
- Cataloging amplitude curve signatures
  - Spikes/dips vs legacy devices
  - Microreflections vs impairment causes and locations
- Analysis along other measurements (Tx power, Rx MER, etc)
- Automated correlation to plant map and topology

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Thank You!

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