Basic MoCA

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Technology Planners,LLC
ENGINEERING FOR TELECOMMUNICATIONS

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Square Pegs in Round Holes

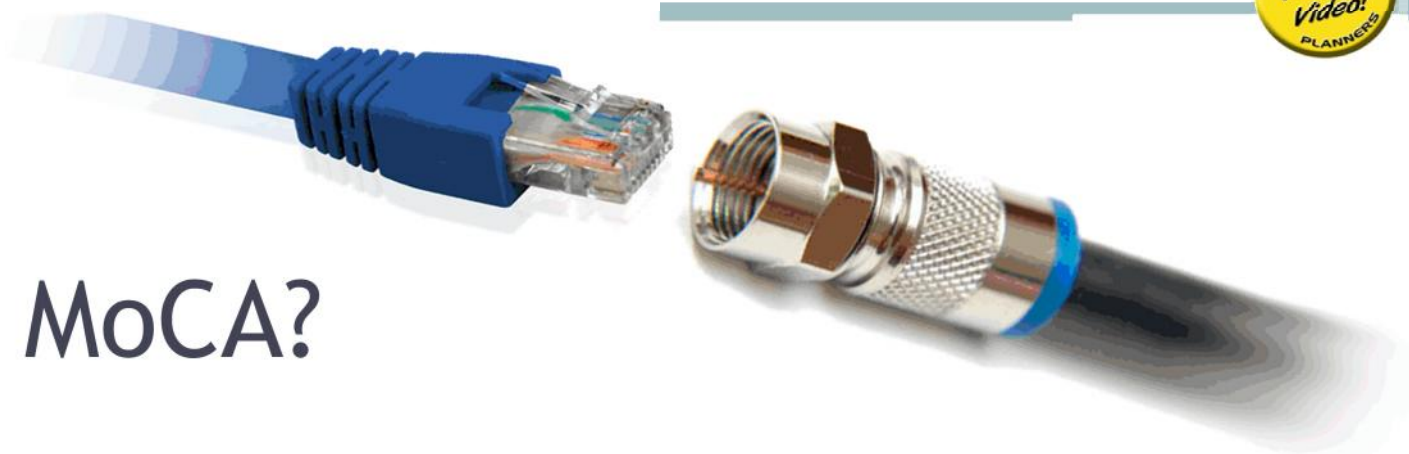When you need to make a data connection…

…but you are only wired for coax.

Using Mocha in the home

MoCA, not Mocha!

What is MoCA?

MoCA (Multimedia over Coax Alliance) is a collection of hardware and content providers, working in conjunction to promote and specify the delivery of video and information over in-home coaxial cable.

Specifically, the MoCA protocol is an Ethernet over coaxial cable technology that is used to "network" audio/video devices in the home, using primarily _existing_ in-home coaxial TV cabling.
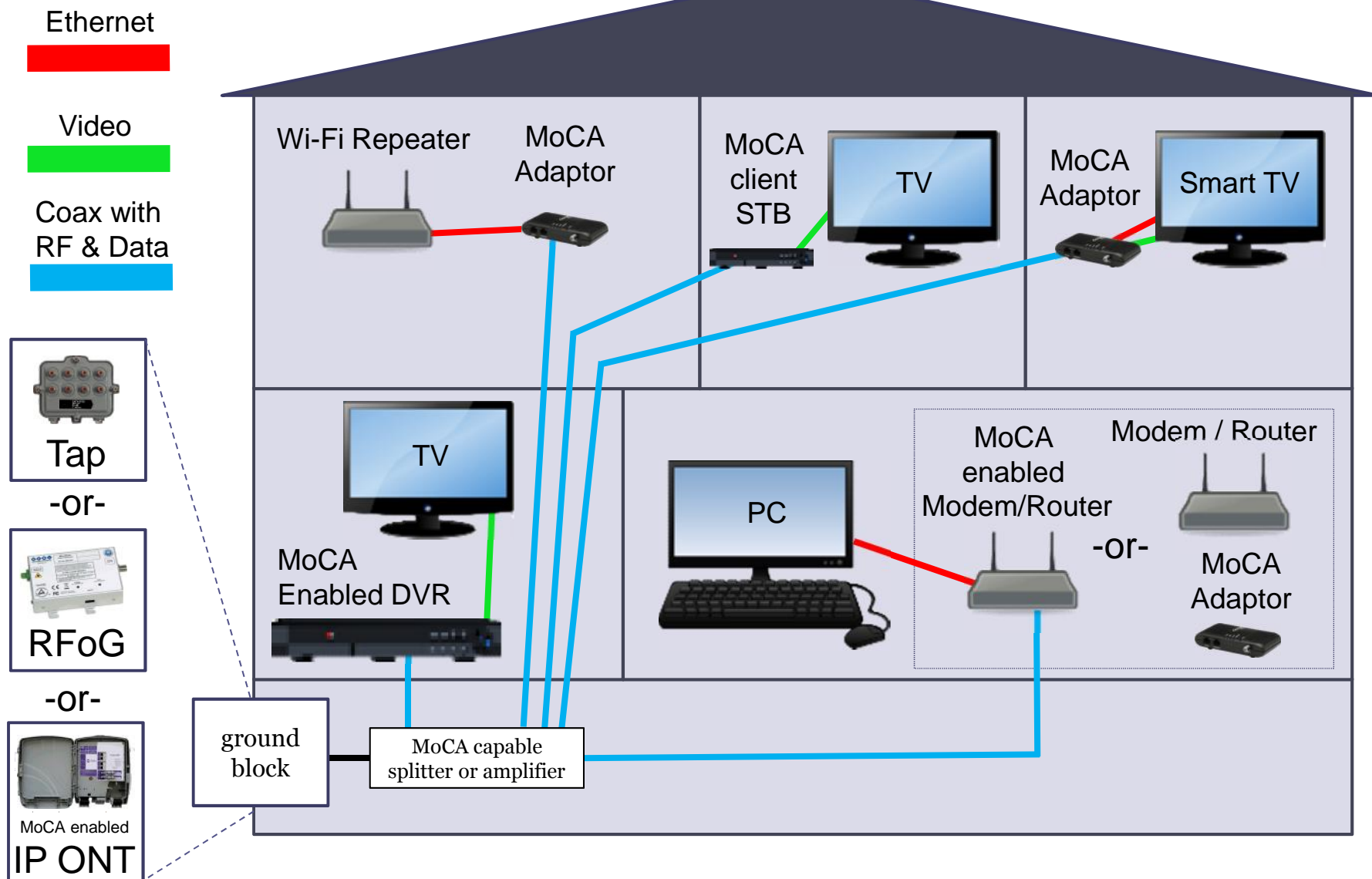
Why use MoCA?

90% of homes in North America already have coax installed to at least some of the TV sets in the home

The use of coaxial cable ensures a high level of shielding, providing immunity to interference and noise (especially when compared to Wi-Fi)

MoCA is compatible with cable modem networks as it occupies bandwidth above the standard HFC frequency range
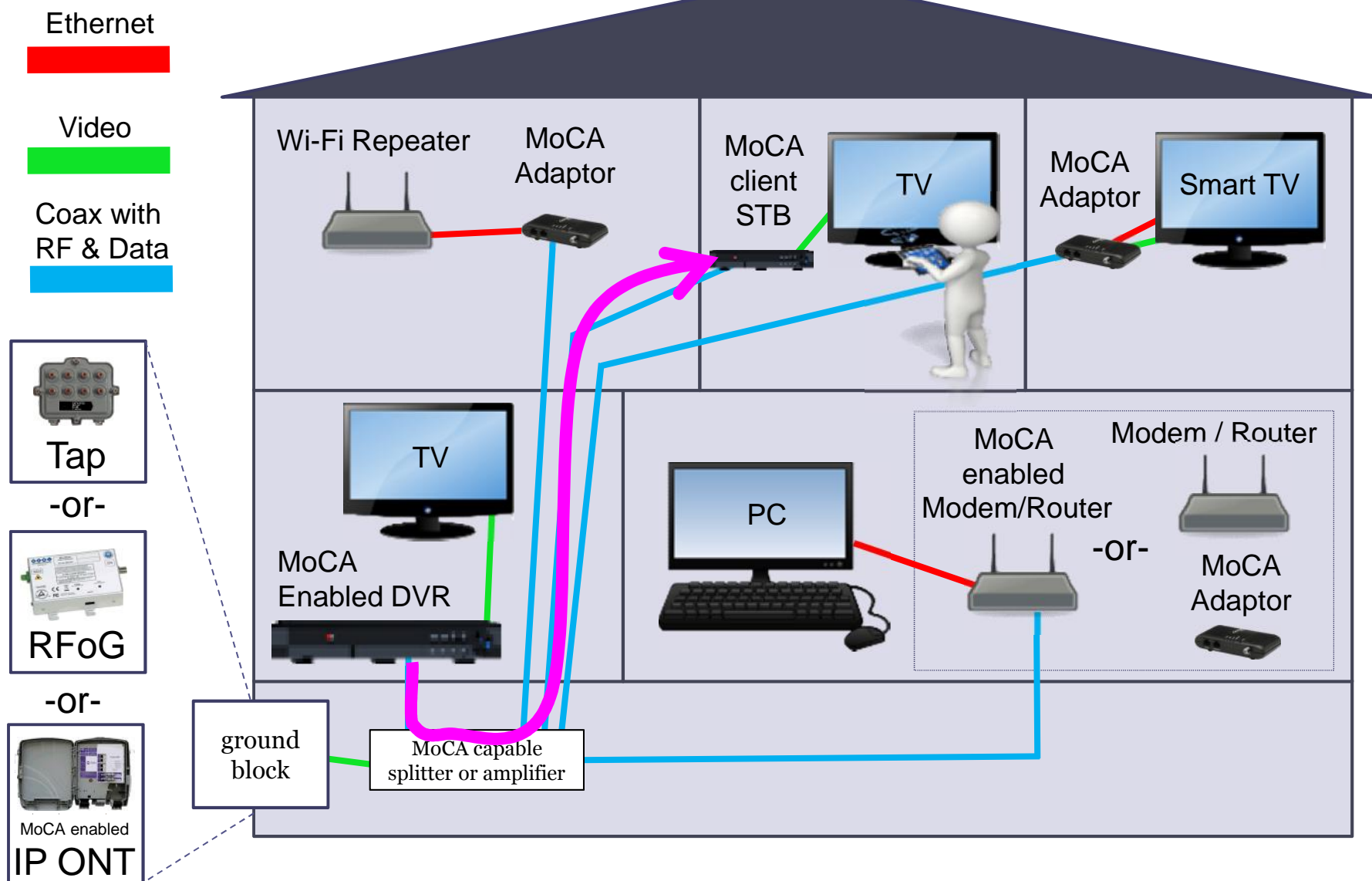
MoCA provides the necessary throughput for transporting multiple data streams carrying multimedia content

MoCA in the home

Ethernet

Video

Coax with RF & Data

Tap
-or-
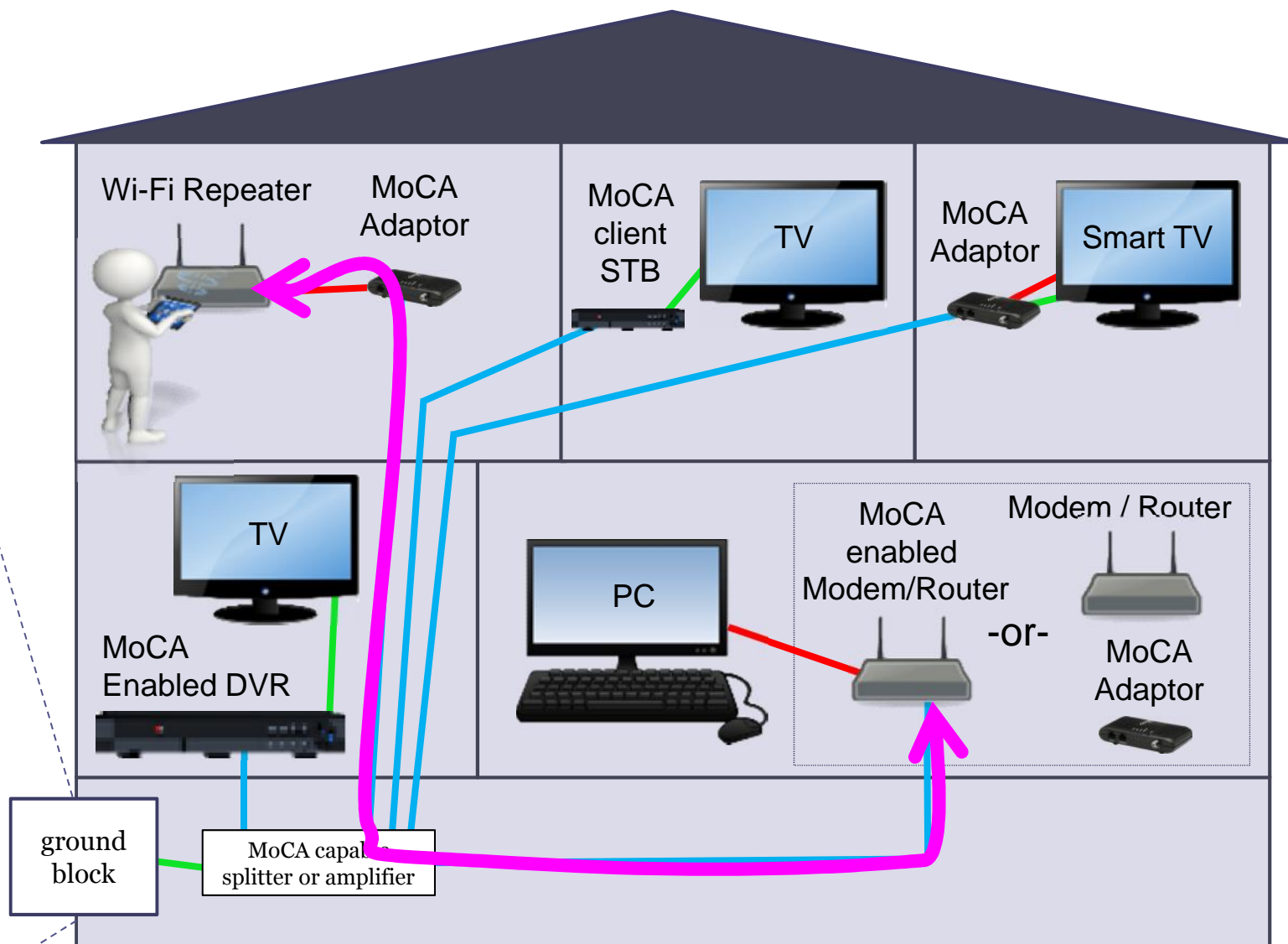RFoG
-or-
MoCA enabled
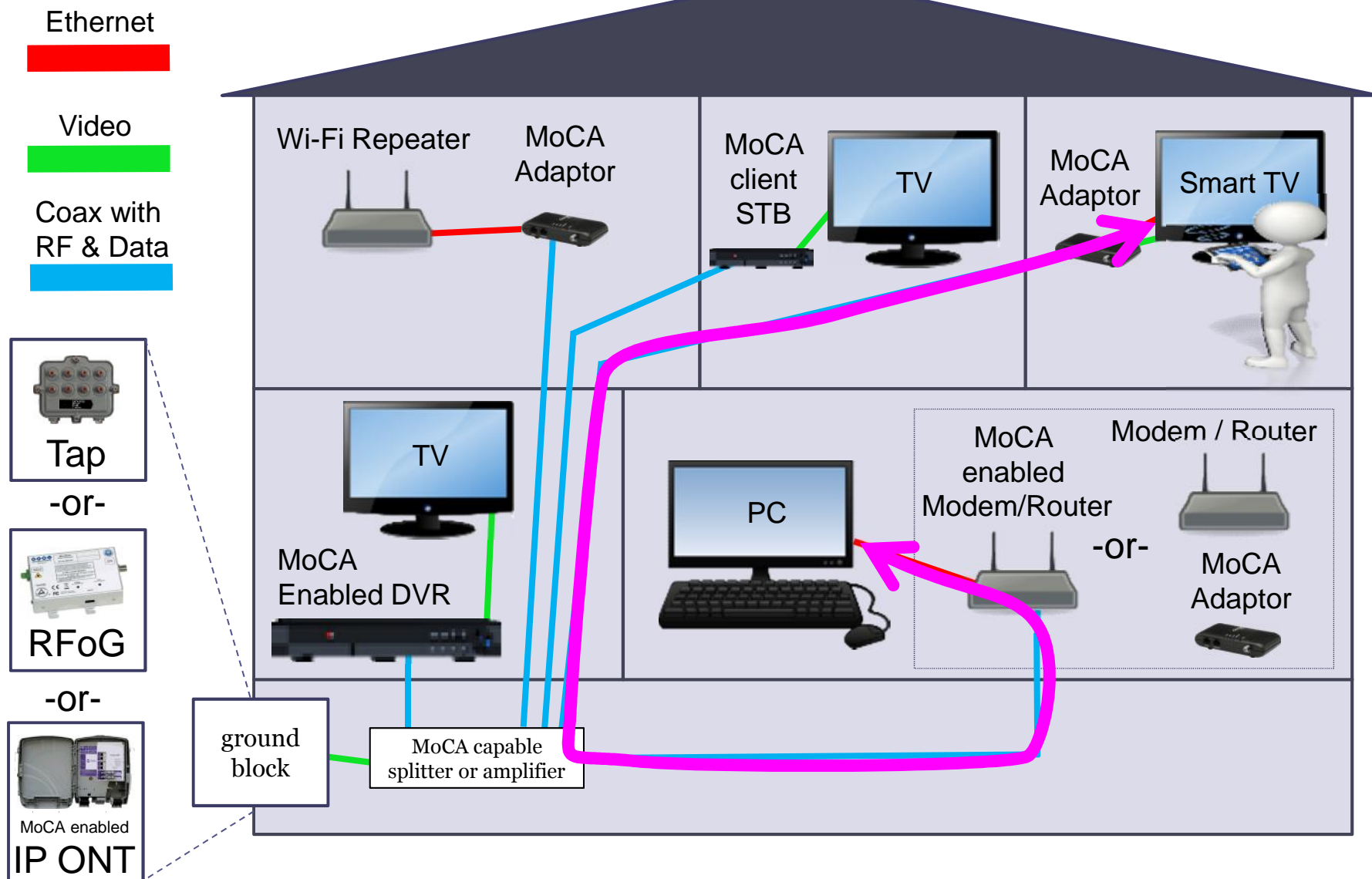IP ONT

Wi-Fi Repeater

MoCA Adaptor

MoCA client STB

TV

MoCA Adaptor

Smart TV

TV

MoCA Enabled DVR

PC

MoCA enabled Modem/Router

Modem / Router

-or-

MoCA Adaptor

ground block

MoCA capable splitter or amplifier

Whole Home DVR

Ethernet

Video

Coax with RF & Data

Tap

-or-

RFoG

-or-

MoCA enabled
IP ONT

Wi-Fi Repeater

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We Are Video!
TECHNOLOGY PLANNERS

Wi-Fi Extension

Ethernet

Video

Coax with RF & Data

Tap

-or-

RFoG

-or-

MoCA enabled
IP ONT

Wi-Fi Repeater

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DLNA Media Player

Ethernet

Video

Coax with RF & Data

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-or-

MoCA enabled
IP ONT

Wi-Fi Repeater

MoCA Adaptor

MoCA client STB

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ground block

MoCA capable splitter or amplifier

MoCA Basics

Home Network

Cat5

Cable TV

Coax

MoCA Adapter

Home Network + Cable TV

Coax

MoCA 1.1

- MoCA 1.1 provides 175 Mbit/s net throughputs (275 Mbit/s PHY rate) and operates in the 500 to 1500 MHz frequency range.
- The Alliance publishes a list of certified products on their home page.

MoCA 2.0

- MoCA 2.0 supports two performance modes, Basic and Enhanced, with 400 Mbit/s and 800 Mbit/s net throughputs (MAC), using 700 Mbit/s and 1.4 Gbit/s PHY rates, respectively.
- Turbo Mode yields 1Gbit/s net throughput.
- Operating frequency range is 500 to 1675 MHz.
- Packet error rate is 1 packet error in 100 million.
- MoCA 2.0 also offers lower power modes of sleep and standby and is backward interoperable with MoCA 1.1

MoCA 1.1 Attributes

Eight 50 MHz RF channels, 1125 to 1525 MHz

Each channel has;

- 256 sub-bands, 224 occupied OFDM (orthogonal frequency-division multiplexing) plus guard bands
- Each sub-band goes from BPSK (binary phase-shift keying) to 256 QAM in near real time
- Channel 1 (1125-1175) is most likely choice, can be made a requirement via addressable set top controls

MoCA 1.1 Attributes

System operation

- 175 Mbps throughput (target PHY rate of 270 Mbps)
- Demonstrated operation to 57 dB dynamic range
- Transmitter lowers power when link exceeds target rate
- Beacon always at maximum output power (56 dBmV)
  (The beacon contains basic information that is necessary for new devices to join the network.)
  - Some MSOs are considering lowering the beacon to 40 dBmV, which also reduces the link budget to 41 dB, due to concerns with overdriving the input to non-MoCA enabled devices with the high beacon carrier level
- Up to 16 devices on the in-home network

MoCA 2.0 Changes

Baseline Mode	400+ Mbps MAC throughput (500+ Mbps in turbo mode)
	700 Mbps PHY rate
	Single 100 MHz channel
Enhanced Mode	800+ Mbps MAC throughput (1+ Gbps in turbo mode)
	1.4 Gbps PHY rate
	Dual bonded 100 MHz channels (channel bonding)
Expanded Operating Frequency Range	500 through 1675 MHz
Additional Changes	Energy saving modes
	Reliability improvements (latency, improved Packet Error Rate, re-transmission)
	Backward Interoperability with MoCA 1.1

MoCA Operating Characteristics

- MoCA Co-exists with CATV and DOCSIS

- Coexistence with other services is required

  - Typical cable modem upstream 5-42 MHz

  - Typical cable operator downstream 55-850 MHz with expansion up to 1 GHz

- OFDM with Reed Solomon Forward Error Correction

- CATV Frequency Plans

  E-band for DirecTV use 400 MHz – 700 MHz
  DECA (DirecTV Ethernet-to-Coaxial Adapter)
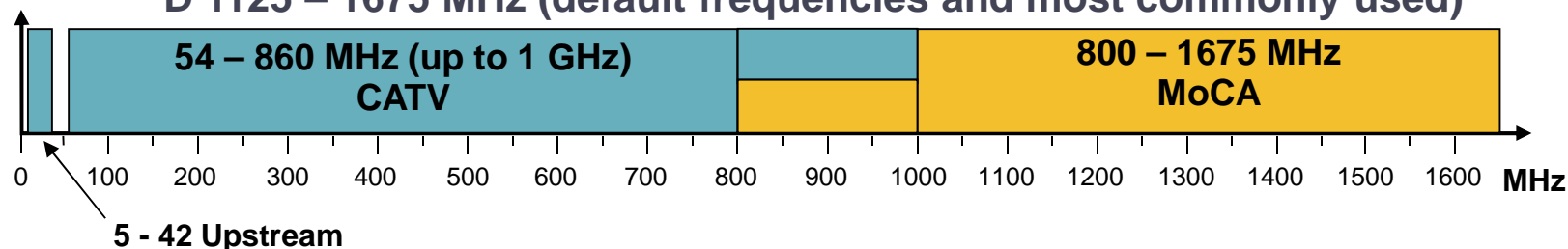
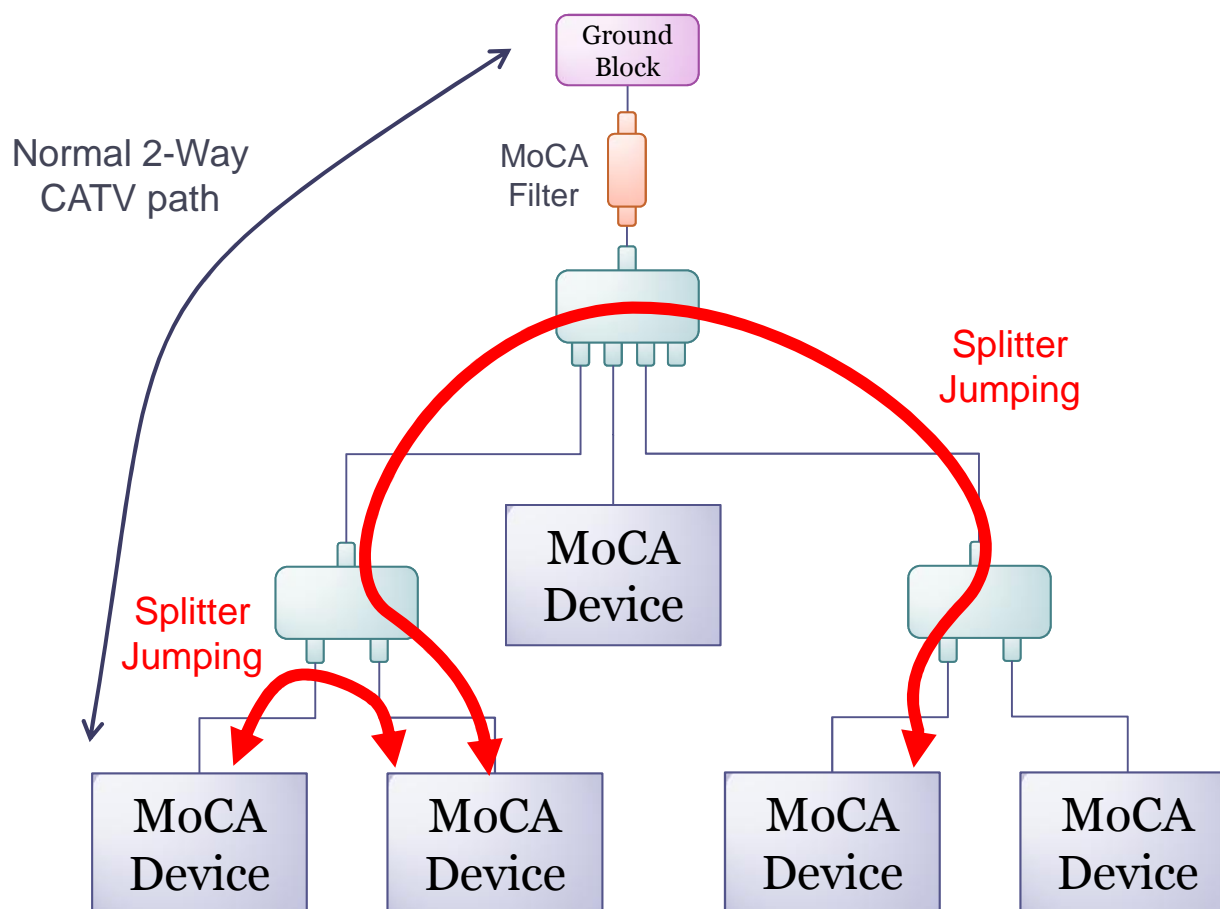 A1 800 – 950 Mhz   B1 850 – 950 MHz

  C1 800 – 1050 MHz   C2 850 – 1075 MHz

  C3 850 – 1100 MHz   C4 875 – 1125 MHz

  D 1125 – 1675 MHz (default frequencies and most commonly used)

MoCA Physical Topology

MoCA Logical Topology

MoCA operates as a fully meshed point-to-point network, where each node is interconnected bi-directionally to every other node in the MoCA network

The speed of each link is determined by the quality of the communications path between those two nodes

The data rates for each link are scalable, up to the aggregate network throughput (400 Mbps for 2.0)
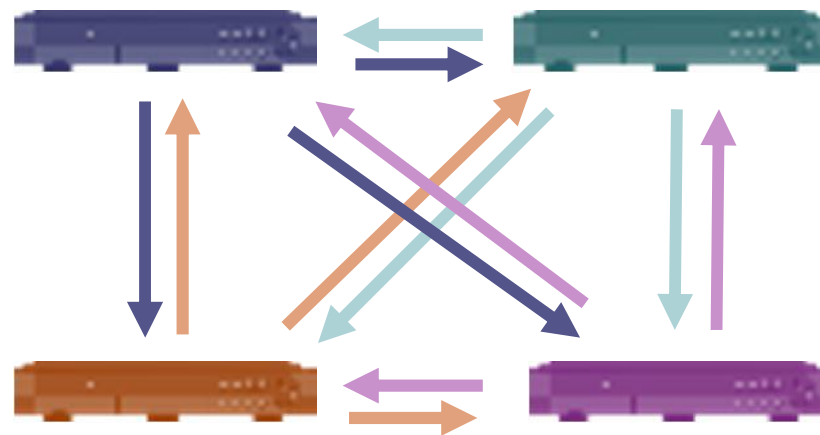
Multi-Room DVR Data Rate Usage Example

- Assuming 1 DVR connected to 3 MoCA enabled STBs
- Each link is bi-directional and contains both control information and the video information
  - Example video is MPEG2 HD @ 20 Mbps per stream
  - Control is < 1 Mbps
  - Each link is 21 Mbps
- Total bandwidth consumed is 3 x 21, or 63 Mbps
- Data rate remaining for other MoCA services is 400 Mbps minus 63 Mbps, or 337 Mbps

Installation Considerations

Standard CATV Install and Service Practices remain in place when MoCA enabled Whole Home DVRs are deployed

- Tap to TV
- Loss Calculations
- Connectors
- Signal Level Requirements
- Cabling
- Splitters

Installation Considerations

Low-pass filter (5 to 1002 MHz) must be installed at each residence to protect against adjacent home interference

- Ideal location is at the first splitter or in the drop amp to maximize benefit

57 dB maximum loss between MoCA nodes

Low splitter insertion loss at MoCA frequencies

- Too high splitter insertion loss may limit the number of MoCA devices that can be on the same network

Low port to port isolation at MoCA frequencies

- Port to port isolation is the loss between output ports on a splitter
- For operation in the return path (5 to 42 MHz), this needs to be $\geq$ 35 dB
- For MoCA frequencies, it should be lower ($\leq$ 20 dB is targeted, but will work with current products with higher port to port isolation)
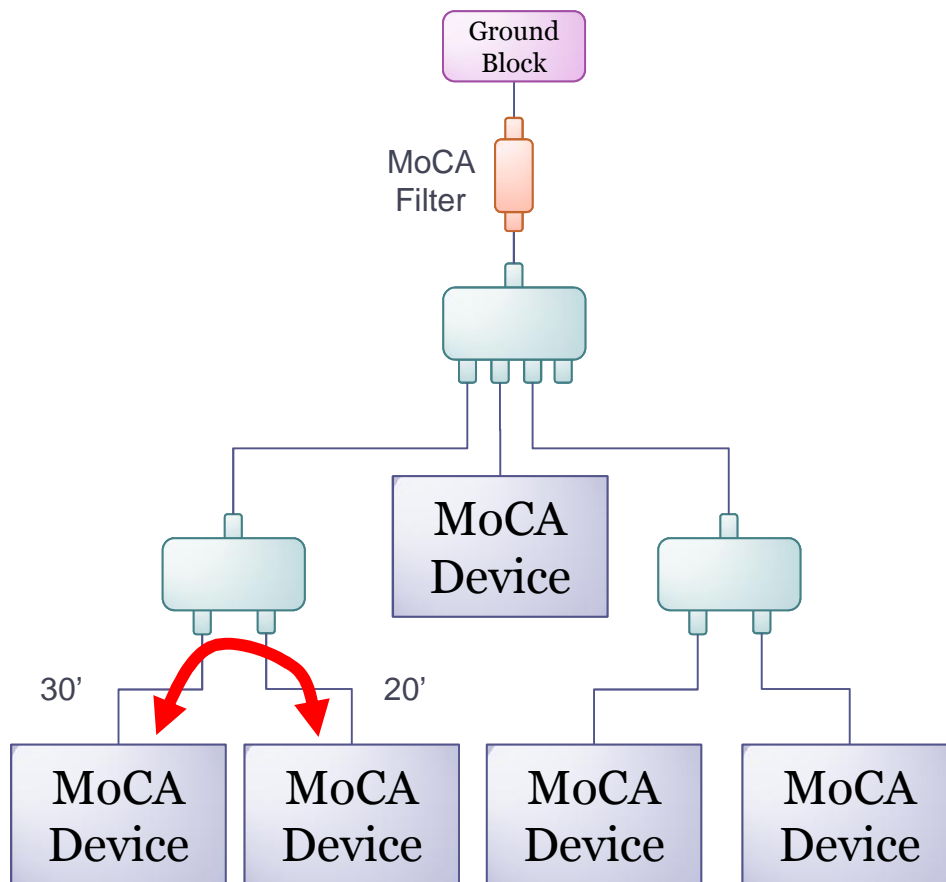
Installation Considerations

The MoCA transmitter adjusts its bit rate automatically, depending on channel quality, to maintain a low bit error rate (BER) at the MoCA receiver

As a result, the PHY rate is a measure of link quality
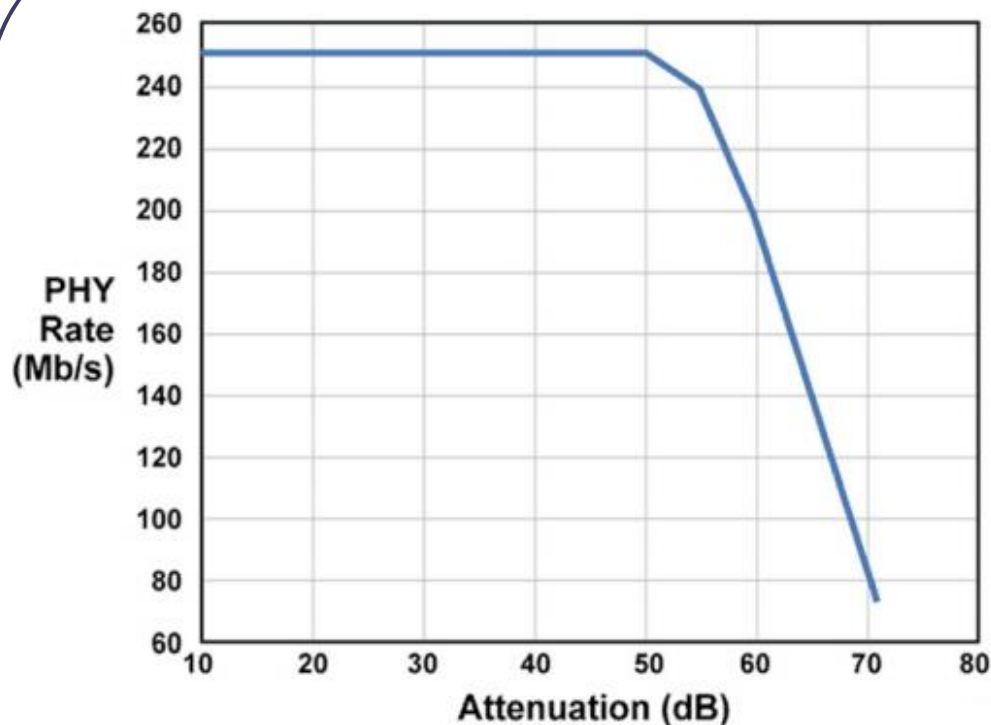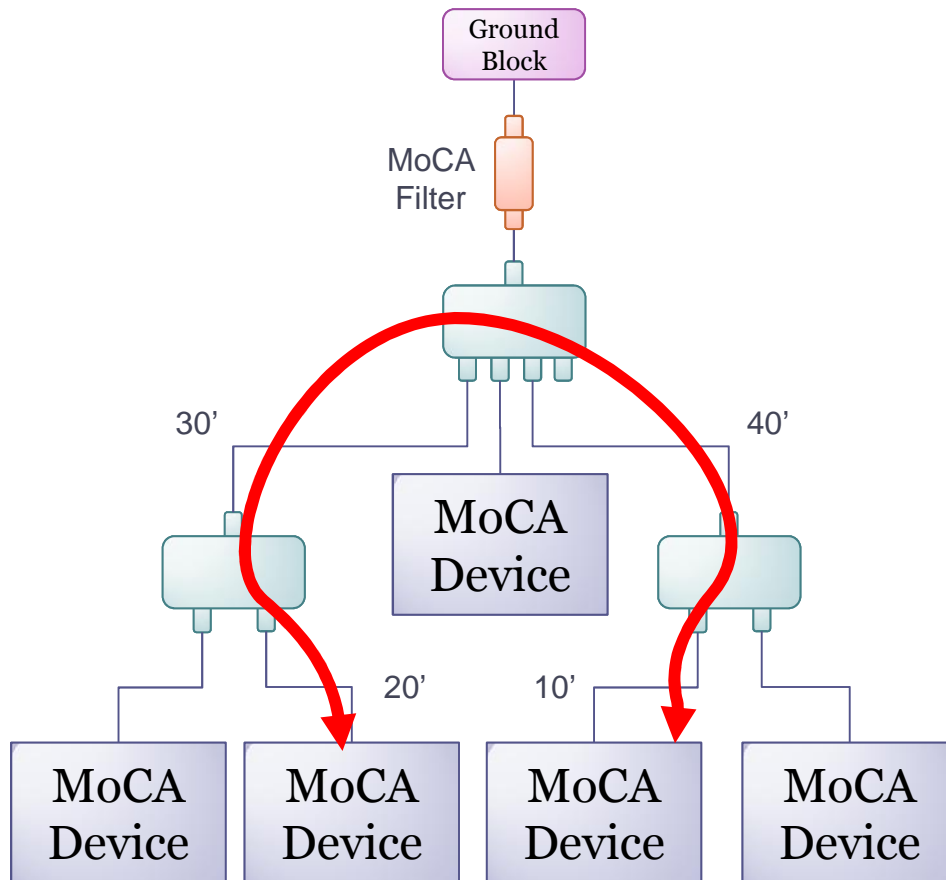

PHY Rate vs. Path Loss

Example Loss Budgets

- Loss Calculations @ 1125 MHz
  - Total cable length 50 ft
  - Cable loss (RG-6) 3.48 dB
  - Port-to-Port isolation 25 dB for a typical 2-way splitter
  - Total loss @ 1125 MHz 28.48 dB
- Loss Calculations @ 1525 MHz
  - Total cable length 50 ft
  - Cable loss (RG-6) 4.05 dB
  - Port-to-Port isolation 21 dB for a typical 2-way splitter
 - Total loss @ 1525 MHz 25.05 dB

Example Loss Budgets

- Loss Calculations @ 1125 MHz
  - Total cable length 100 ft
  - Cable loss (RG-6) 6.95 dB
  - Port-to-Port isolation 25 dB for a typical 4-way splitter
  - Insertion loss 4.1 dB for a typical 2-way
  - Total loss @ 1125 MHz 44.05 dB
- Loss Calculations @ 1525 MHz
  - Total cable length 100 ft
  - Cable loss (RG-6) 8.09 dB
  - Port-to-Port isolation 21 dB for a typical 4-way splitter
  - Insertion loss 4.1 dB for a typical 2-way
  - Total loss @ 1525 MHz 48.19 dB

Point of Entry (POE) Filtering

MoCA Point of Entry (POE) Filter should be placed as close as possible to premise entrance location to avoid potential for Home to Home interference and to improve in-home receive levels

Ground Block

MoCA Filter

MoCA Device

MoCA Device

MoCA Device

MoCA Device

MoCA Device
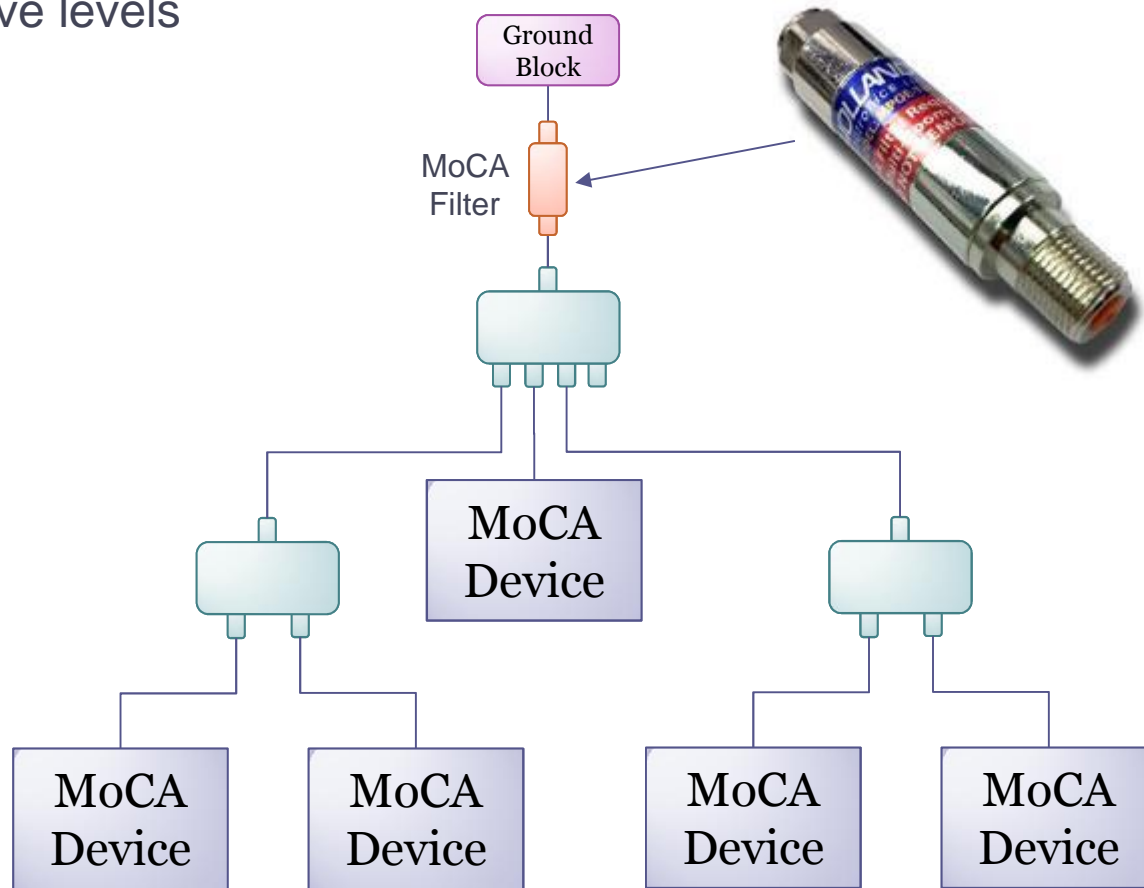
Eagle
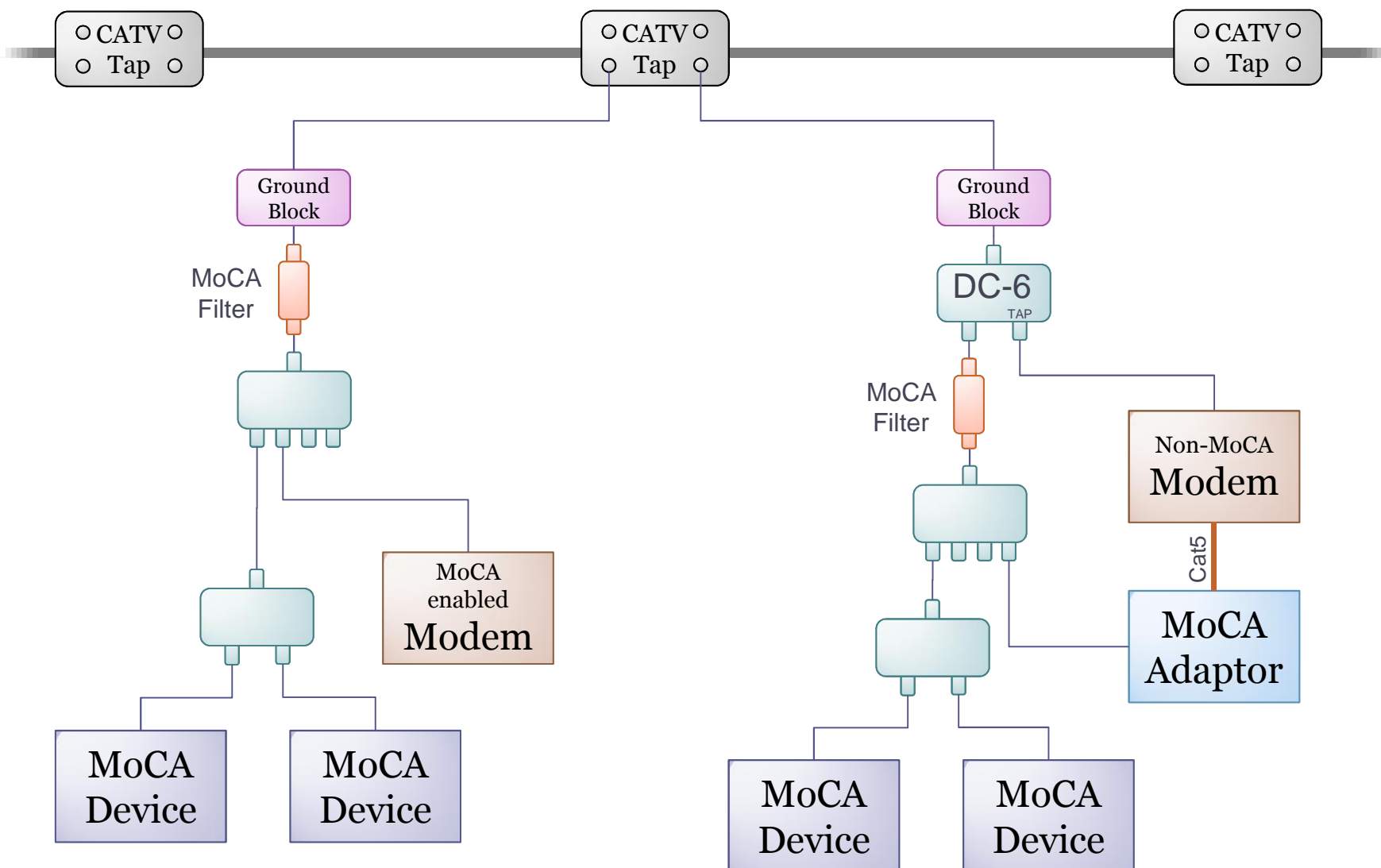Arcom
Holland
Antronics
PCT

Point of Entry (POE) Filtering

MoCA Point of Entry (POE) Filter recommended as close as possible to premise entrance location to avoid potential for Home to Home interference and to improve in-home receive levels

- Prevents interference between MoCA homes on the same tap or Point of Entry
- Minimizes MoCA energy on CATV feeder
- Generally located at Residence Point of Entry (gnd. block) or at the TAP
- Not recommended for self-install – installed by cable tech
- Key Operating Characteristics
  - Passband 5 – 1002 MHz,
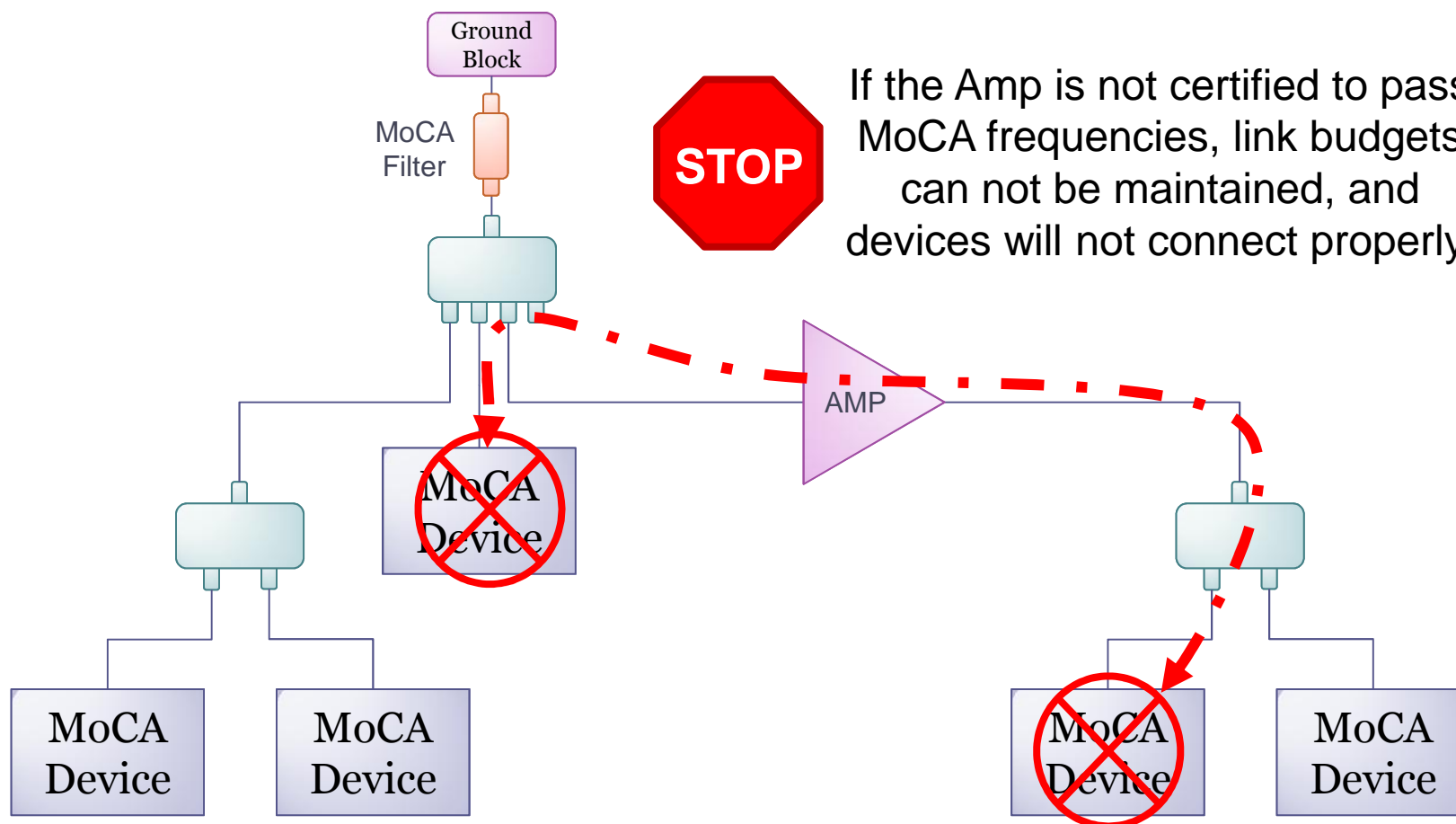 - Stopband -35 dB at 1125 – 1525 MHz

Point of Entry (POE) Filtering

MoCA Ready

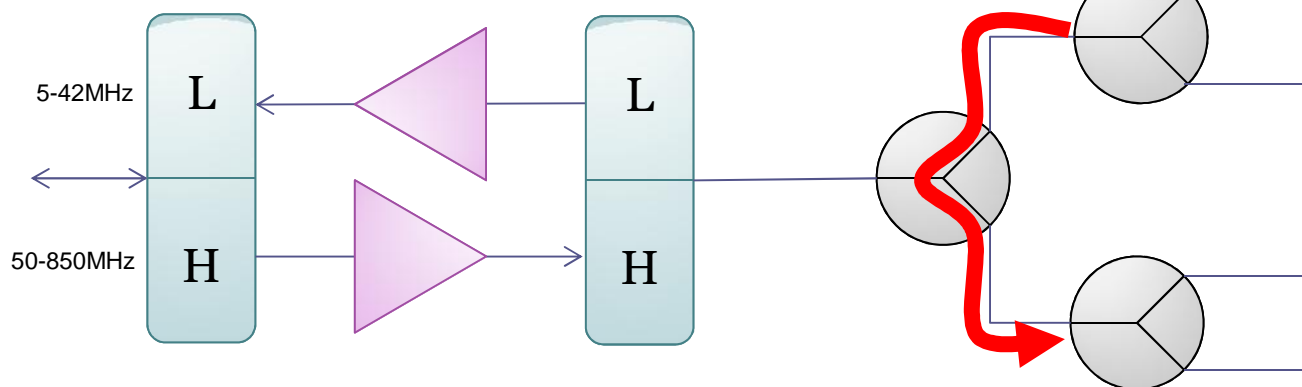Home Amps must be capable of passing MoCA to keep MoCA functioning properly

STOP — If the Amp is not certified to pass MoCA frequencies, link budgets can not be maintained, and devices will not connect properly.

Ground Block

MoCA Filter

AMP

MoCA Device

MoCA Device

MoCA Device

MoCA Device

MoCA Device

MoCA Ready

Benefits of Reflective MoCA Filters

Port-to-Port Isolation =
25 dB Loss @ 1125 MHz

5-42MHz — L

50-850MHz — H

MoCA works in this example, but does not benefit from the reflective energy of a filter, and has a higher loss calculation

5-42MHz — L

MoCA Filter

50-850MHz — H
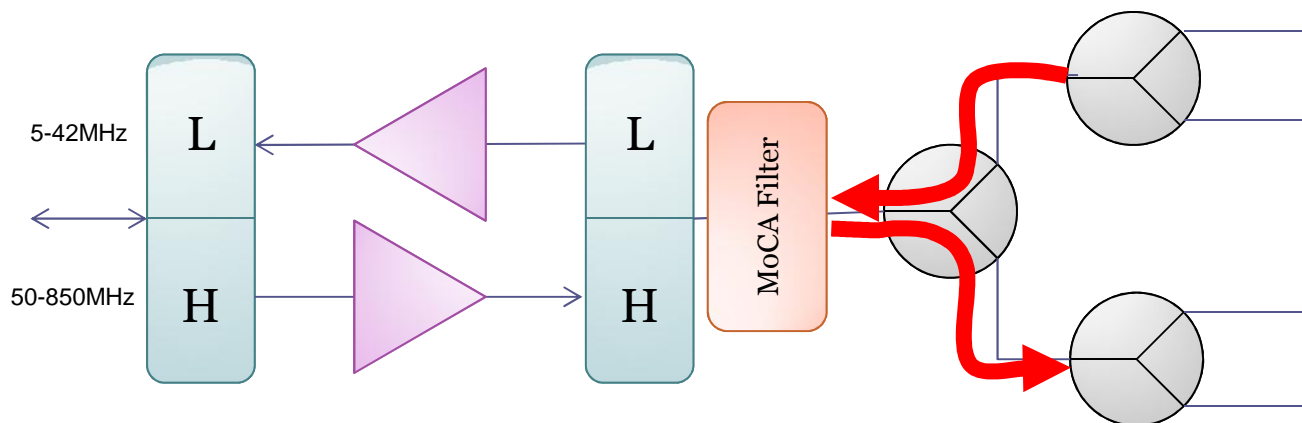
MoCA filters have high reflectivity in the MoCA frequencies and improve loss budgets of the MoCA network, along with preventing upstream migration

Insertion Loss x 2 + Reflective Return Loss =
4.1 dB + 4.1 dB + 1.5 dB =
9.7 dB total Loss @ 1125 MHz

Troubleshooting MoCA

Standard signal level meters don't cover MoCA frequencies above 1 GHz

Drop qualification for MoCA requires a different process than qualification for other services

Node to Node testing for link budget and throughput are both required

Based on cable age, loss at MoCA frequencies may be a concern

Drop passives will vary in performance at MoCA frequencies

Signal leakage and signal ingress are both concerns in MoCA

Drop passive placement in the design is critical to maintaining the 57 dB MoCA Link Budget

Troubleshooting MoCA

|	
Coaxial Cable Plant Quality	Connectors, splitters, filters and amplifiers affecting MoCA carriers?
Spectrum	Noise and interference impacting MoCA carriers?
Network Capacity	Sufficient capacity to support customer's applications?
Customer Equipment Diagnostics	Customer equipment or coaxial cable plant?
Quality of Experience	Verify the customer's quality of experience?

Troubleshooting MoCA

Viavi (formerly JDSU) offers testing equipment specific to testing of MoCA networks in the home.

Using multiple probes, one placed at each location in the home, the meter can make accurate maps of the entire network at once and determine loss calculations to find potential issues.
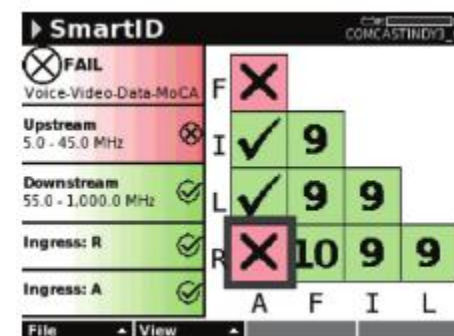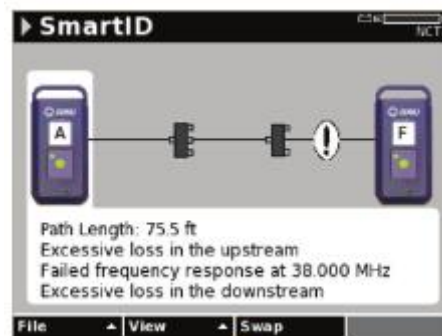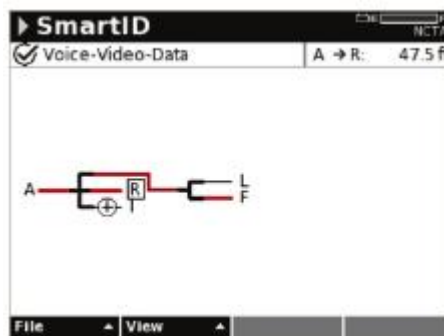
Troubleshooting MoCA

Does the equipment's MoCA interface function properly?

Does a bi-directional data rate issue exist between nodes?

Does the coaxial plant between nodes have a problem?

Does noise or interference affect the MoCA carriers?

Validate the equipment's MoCA interfaces

Connect directly to the equipment and determine data rates

Measure the data rates between MoCA nodes

Use test set to measure the data rates between MoCA nodes

Confirm the integrity of the coaxial cable plant

Assess the coax segment-by-segment

Identify noise/interference using bit loading analysis

Examine the bit loading analysis

Examples of MoCA Enabled Ethernet Bridges & Gateways

NetGear MCAB1001
Ethernet to Coax Bridge

D-Link DXN-221
Coax Ethernet Adapter Kit

Actiontec ECB2200
MoCA Network Adapter

Westell UltraLine Series3
MoCA Gateway

Actiontec MI424WR
Broadband Home Router

Examples of MoCA Enabled Set Top Boxes

ADB ADB-6880CX

Motorola DCX-3400M

Motorola QIP6416

Motorola DCX-3200M

Pace DC900X
HD DVR Network Attached Storage Device

Cisco Explorer 8652HDC
DVR with M-Card Interface

We Are Video!

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