Growing Services Consuming HFC Spectrum

- **More HD Video Services**
  - Growth plans to 100+ HD channels

- **More SD Video Content**
  - Expansion to nx100 SD chs to compete w/ satellite

- **Personalized Video Services**
  - Migration from Broadcast to Unicast services
  - VoD, Startover, MyPrimetime, etc

- **Broadband Internet Services Growth**
  - Migration from Web to Web2.0, Video Streaming and P2PTV Applications
  - Increased per home BW consumption
  - Expansion of the peak hour to whole evening

- **Competitive pressure!**
MOBILE POWER USERS CLOG NETWORKS

Average monthly data usage per user (MB)

Source: The Nielsen Company

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

Nearly 60% by 2015

Source: Pipeline Magazine
EXPLOSION IN CONNECTED DEVICES:

50 TO 500 BILLION BY 2020

Source: Ericsson, 2011
Voice Quality Impairments – it’s not always the plant!

Where is the Problem?
What is the Problem?

PSTN

Telco Problem?
Cable Provider Problem?
Customer Problem?

Cable Provider Problem?

CMTS-Blade-Port or Switch-Slot-Port?
What’s the problem?

Core IP NTWK
High utilization lead to congestion causing jitter, dropped packets and increased transit delay, mis-configured routing can cause inappropriate hops leading to increased latency

Cable Provider Problem?

CABLE PLANT
RF downstream and/or upstream errors leading to IP packet loss, bandwidth capacity limitations (esp. upstream) may lead to CMTS congestion (dropped IP packets) and excessive jitter (packet drops by codec)

HOME
Background noise, handset speaker/mic interference, inadequate volume, inside wiring, mis-configured MTA (CoS-Diffserv / firewall settings), wireless phone delay exacerbates echo problems, MTA DSP/echo canceller performance

MEDIA GW POP
DSP codec performance, echo canceller config., jitter buffer config. / packet drops

Where is the Problem?

Router-Slot-Port? LSP/VLAN, Route?
What’s the problem?

MEDIA GW POP

HUB SITE
Excessive NE polling and/or high utilization lead to congestion causing jitter, dropped packets and increased transit delay

MEDIA POP

Cable Provider Problem?

Cable Modem
MTA
POTS Phone
Common Impairments: Laser Clipping

- Caused by Overdriving Laser
  - Low end ingress
  - Improper laser setup
  - Adding carriers without compensating

- Very distinct constellation footprint
  - Also see as junk above diplex in spectrum
  - Optical receiver issues can look similar

Before/After: Faulty Optical Receiver
Similar to Laser Clipping
Optical Link is Critical to Upstream Performance

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

WebView v2.5  FFT View of the Upstream
Amplifier Compression

Amplifier compression often manifests as rounding of the corners of the constellation. Laser clipping often manifests as increased spread in the corners of the constellation. Both are caused by overdriving an amplifier or laser usually due to ingress or misalignment. (unity gain)

May become more prevalent as more DOCSIS® upstream carriers are added.
CATV amplifiers have a trade-off between noise and distortion performance.

Tightly controlling frequency response provides the best compromise between noise and distortion.
Forward Path Unity Gain

AMP # 1

OUT +36 dBmV

IN +14 dBmV

22 dB @ 750 MHz

AMP # 2

OUT +36 dBmV

IN +11 dBmV

23 dB @ 750 MHz

AMP # 3

OUT +36 dBmV

AMP # 4

IN +10 dBmV

18 dB @ 750 MHz

OUT +36 dBmV
Incorrect Levels

- Low Video Levels
  - Produces noise in the picture

- High Video Levels
  - Produces distortion in the picture
Low Digital levels

- Causes Digital signal to Degrade.

- This causes Tiling and Loss of high Speed internet access.
Return Path Unity Gain

AMP # 1
IN +20 dBmV
4 dB @ 40 MHz
OUT +24 dBmV

AMP # 2
IN +20 dBmV
2 dB
OUT +8 dB

AMP # 3
IN +20 dBmV
4 dB @ 40 MHz

AMP # 4
OUT +30 dBmV
2 dB @ 40 MHz
IN +20 dBmV
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.

![Diagram showing amplitude comparison of different carrier widths](image)

- **CW**: 1 Hz wide
- **1.6 MHz wide**
- **3.2 MHz wide**
- **6.4 MHz wide**
Optimize Dynamic Input Range of the CMTS

Example: Some systems will add 26 dB of external padding between the splitter and CMTS to attenuate the injected CW signal down to a peak level of 0 dBmV at the input port of the CMTS. The CMTS is typically configured to instruct the 6.4 MHz modem carriers to hit the input port of the CMTS at 0 dBmV “constant power per carrier”.
Docsis 3
### Maximum and (Maximum Usable) DownStream Speeds

<table>
<thead>
<tr>
<th>Version</th>
<th>DOCSIS</th>
<th>EuroDOCSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.x</td>
<td>42.88 (38) Mbit/s</td>
<td>55.62 (50) Mbit/s</td>
</tr>
<tr>
<td>2.0</td>
<td>42.88 (38) Mbit/s</td>
<td>55.62 (50) Mbit/s</td>
</tr>
<tr>
<td>3.0</td>
<td>171.52 (+152) Mbit/s</td>
<td>+222.48 (+200) Mbit/s</td>
</tr>
<tr>
<td>3.0</td>
<td>+343.04 (+304) Mbit/s</td>
<td>+444.96 (+400) Mbit/s</td>
</tr>
</tbody>
</table>
Channel Requirements

- Combines down and upstream channels for added performance
  - “Technically” could support 10 bonded down streams.
  - Plans are currently for 4 DS and up to 4 u/s channels to be bonded
    - Do not have to be adjacent to each other – but must be within 60 MHz.
      » “Bonded” in data layer – not Physical layer
      » Each DS channel remains a 6 MHz 256QAM
      » A DOCSIS 3.0 QAM can be a Primary or Secondary
      » Primaries carry all info needed for a CM to register
      » Secondary's do not have registration data – only payload
      » ALL down streams can be provisioned as primaries but there MUST be at least 1 primary.
    - Possible combinations of u/s and d/s
      - 2x1, 2x2, 3x1, 3x2, 3x3, 4x1, 4x2, 4x3, 4x4
      - Each provides its own performance capability - and is scalable.
Un-Bonded Upstream Data rates

Data Rates by Modulation and Channel Width

- QPSK 1.6 MHz
- QPSK 3.2 MHz
- 16 QAM 1.6 MHz
- 16 QAM 3.2 MHz
- 32 QAM 3.2 MHz
- 64 QAM 3.2 MHz
- 16 QAM 6.4 MHz
- 32 QAM 6.4 MHz
- 64 QAM 6.4 MHz

Modulation Scheme

- **DOCSIS 1.0**
- **DOCSIS 1.1**
- **DOCSIS 2.0**

*Courtesy Motorola*
# SCTE Docsis 3.0 Downstream RF Spec

## Table 5-1 - Assumed Downstream RF Channel Transmission Characteristics

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum analog video carrier level at the CM input</td>
<td>17 dBmV</td>
</tr>
<tr>
<td>Maximum number of analog carriers</td>
<td>121</td>
</tr>
</tbody>
</table>

\textsuperscript{1}. Measurement methods defined in [NCTA] or [CableLabs1].

\textsuperscript{2}. Measured relative to a QAM signal that is equal to the nominal video level in the plant.

Source: SCTE
### Assumed Upstream RF Channel Transmission Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency range</td>
<td>5 to 42 MHz edge to edge or 5 to 85 MHz edge to edge</td>
</tr>
<tr>
<td>Transit delay from head-end to most distant customer</td>
<td>( \leq 0.800 \text{ ms} ) (typically much less)</td>
</tr>
<tr>
<td>Carrier-to-interference plus ingress (the sum of noise, distortion, common-path distortion and cross modulation and the sum of discrete and broadband ingress signals, impulse noise excluded) ratio</td>
<td>Not less than 25 dB(^1)</td>
</tr>
<tr>
<td>Carrier hum modulation</td>
<td>Not greater than -23 dBC (7.0%)</td>
</tr>
<tr>
<td>Burst noise</td>
<td>Not longer than 10 ( \mu \text{s} ) at a 1 KHz average rate for most cases(^2,3)</td>
</tr>
<tr>
<td>Amplitude ripple across upstream operating frequency range</td>
<td>0.5 dB/MHz</td>
</tr>
<tr>
<td>Group delay ripple across upstream operating frequency range</td>
<td>200 ns/MHz</td>
</tr>
<tr>
<td>Micro-reflections – single echo</td>
<td>-10 dBC @ ( \leq 0.5 \text{ ( \mu \text{s})} )</td>
</tr>
<tr>
<td></td>
<td>-20 dBC @ ( \leq 1.0 \text{ ( \mu \text{s})} )</td>
</tr>
<tr>
<td></td>
<td>-30 dBC @ ( &gt; 1.0 \text{ ( \mu \text{s})} )</td>
</tr>
<tr>
<td>Seasonal and diurnal reverse gain (loss) variation</td>
<td>Not greater than 14 dB min to max</td>
</tr>
</tbody>
</table>

\(^1\) Ingress avoidance or tolerance techniques may be used to ensure operation in the presence of time-varying discrete ingress signals that could be as high as 10 dBC. The ratios are guaranteed only within the digital carrier channels.

\(^2\) Amplitude and frequency characteristics sufficiently strong to partially or wholly mask the data carrier.

\(^3\) Impulse noise levels more prevalent at lower frequencies (<15 MHz).
DOCSIS 3.0 Downstreams

Add to Channel plan as DOCSIS carriers
Add in to autotest/Home Cert to validate DOCSIS performance

Add to Channel Plan as Video Carrier
secondary carriers do not contain channel descriptors or ranging information
Add in to autotest/Home Cert to validate carrier performance
Diamond Steiner Manufacturing

DSAM 3.0 Bonded Carrier testing – coming soon

- Keeping it simple for the technicians
- Validate overall performance
- Identifying individual US/DS channel issues
Customer Networks
What Type of Problem: Common Impairments

- **Ingress**
  - Still the most common
  - Use return path monitoring system to know when to chase

- **Common Path Distortion**
  - Old news in analog DS plant
  - New look in all-digital plant

- **Impulse Noise**
  - Impulse noise troublesome for CMTS
  - RFI detector for power-line noise
Downstream and Upstream Noise Additions

Reverse System “Noise Funneling”

Ingress from seven amplifiers ends up at the headend.

Forward Signals

Noise

Noise
Testing for Ingress on Forward Digital Carriers
What Causes Signal Leakage & Ingress?

- Most common source of leakage is within the home wiring (approximately 75%) and drop cable (approximately 20%). There’s a lot of homes that still have the original wiring from 20-30 years ago!

- Inferior quality coaxial cable, passives, connectors

- Poor installation of splices and connectors - water and weather can result in pulled out, loose or corroded connectors

- Illegal connections to neighbor’s cable

- Some of the older TV sets with poor tuner shielding can produce leakage and ingress problems
What Causes Signal Leakage & Ingress?

- Some less abundant sources, such as trunk or bridger amplifiers output, are likely to radiate much greater RF energy and produce a bigger effect on the system’s total leakage.

- Radial cracks in the expansion loop

- Improperly terminated splitters, jumpers from drops to taps or ground blocks

- Accidents (vehicles crashing into poles)

- The environment, weather, landscape & even animals (squirrel chews) could have an effect
Wide Band Impulse Noise and Laser Clipping

Impulse noise goes past diplex roll-off at 42 MHz
Tracking Down Ingress – Divide and Conquer

View local spectrum on each return path test point of node to determine which leg has the source of ingress

Use divide and conquer technique to identify and repair source of ingress
**Typical Problem Areas**

- **Taps**
  - Most ingress comes from houses off of low value taps of approximately 17 dB or less

- **Home Wiring**
  - Drop Cable, splitters & F Connectors are approximately ~95% of Problem

- **Amplifiers, hard line cable** and the rest of the system are a small percentage of the problem if a proper leakage maintenance program is performed
If the problem is at the FWD Input and not the FWD Output, then the problem is likely from one of the drops.

If the problem is at the FWD Output of tap, continue on towards end of line.
Taps are made up of a Directional Coupler and Splitters

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

Disconnect one drop at a time to determine the point of entry.
Common problems in HFC Networks
Beware of Taps

Port 1 2thru8 not terminated

Port 1 2thru8 terminated
RF ingress — The 5-42 MHz reverse spectrum is shared with numerous over-the-air users.

Signals in the over-the-air environment include high power shortwave broadcasts, amateur radio, citizens band, government, and other two-way radio communications.
There are Many Possible Sources of Interference

Off-Air Broadcast

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

Electrical Devices

• Doorbell transformers
• Toaster Ovens
• Electric Blankets
• Ultrasonic pest controls (bug zappers)
• Fans
• Refrigerators
• Heating pads
• Light dimmers
• Touch controlled lamps
• Fluorescent lights
• Aquarium or waterbed heaters
• Furnace controls
• Computers and video games
• Neon signs
• Power company electrical equipment
• Alarm systems
• Electric fences
• Loose fuses
• Sewing machines
• Hair dryers
• Electric toys
• Calculators
• Cash registers
• Lightning arresters
• Electric drills, saws, grinders, and other power tools
• Air conditioners
• TV/radio booster amplifiers
• TV sets
• Automobile ignition noise
• Sun lamps
• Smoke detectors
### LTE Overview

#### Frequency Bands and Channel Numbers

<table>
<thead>
<tr>
<th>E-UTRA Band</th>
<th>Downlink (DL) band</th>
<th>Uplink (UL) band</th>
<th>Duplex Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$F_{DL_{low}}$</td>
<td>$F_{UL_{low}}$</td>
<td>$N_{Offs-DL}$</td>
</tr>
<tr>
<td>1</td>
<td>2110 MHz</td>
<td>18000</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>1930 MHz</td>
<td>18600</td>
<td>600</td>
</tr>
<tr>
<td>3</td>
<td>1805 MHz</td>
<td>19200</td>
<td>1755 MHz</td>
</tr>
<tr>
<td>4</td>
<td>2110 MHz</td>
<td>26000</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>869 MHz</td>
<td>894 MHz</td>
<td>840 MHz</td>
</tr>
<tr>
<td>6</td>
<td>2620 MHz</td>
<td>20750</td>
<td>2500 MHz</td>
</tr>
<tr>
<td>7</td>
<td>925 MHz</td>
<td>21450</td>
<td>880 MHz</td>
</tr>
<tr>
<td>8</td>
<td>1844.9 MHz</td>
<td>21800</td>
<td>1749.9 MHz</td>
</tr>
<tr>
<td>9</td>
<td>2110 MHz</td>
<td>22150</td>
<td>1710 MHz</td>
</tr>
<tr>
<td>10</td>
<td>1475.9 MHz</td>
<td>22750</td>
<td>1427.9 MHz</td>
</tr>
<tr>
<td>11</td>
<td>728 MHz</td>
<td>23000</td>
<td>698 MHz</td>
</tr>
<tr>
<td>12</td>
<td>746 MHz</td>
<td>23180</td>
<td>777 MHz</td>
</tr>
<tr>
<td>13</td>
<td>758 MHz</td>
<td>23280</td>
<td>788 MHz</td>
</tr>
<tr>
<td>...</td>
<td>734 MHz</td>
<td>23730</td>
<td>704 MHz</td>
</tr>
<tr>
<td>17</td>
<td>1900 MHz</td>
<td>36000</td>
<td>1900 MHz</td>
</tr>
<tr>
<td>33</td>
<td>2010 MHz</td>
<td>36200</td>
<td>2010 MHz</td>
</tr>
<tr>
<td>34</td>
<td>1850 MHz</td>
<td>36350</td>
<td>1850 MHz</td>
</tr>
<tr>
<td>35</td>
<td>1930 MHz</td>
<td>36950</td>
<td>1930 MHz</td>
</tr>
<tr>
<td>36</td>
<td>1910 MHz</td>
<td>37550</td>
<td>1910 MHz</td>
</tr>
<tr>
<td>37</td>
<td>2570 MHz</td>
<td>37750</td>
<td>2570 MHz</td>
</tr>
<tr>
<td>38</td>
<td>2620 MHz</td>
<td>38250</td>
<td>2620 MHz</td>
</tr>
<tr>
<td>39</td>
<td>2300 MHz</td>
<td>38650</td>
<td>2300 MHz</td>
</tr>
<tr>
<td>40</td>
<td>2400 MHz</td>
<td>38650</td>
<td>2400 MHz</td>
</tr>
</tbody>
</table>

**DL Center Frequency** ($F_{DL}$) = $F_{DL_{low}} + 0.1(N_{DL} - N_{Offs-DL})$

**Channel Number** ($N_{DL}$) = ($F_{DL} - F_{DL_{low}}$)/0.1 + $N_{Offs-DL}$
## LTE Downlink Channels

<table>
<thead>
<tr>
<th>DL Channels</th>
<th>Description</th>
<th>Modulation Format</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>PBCH</td>
<td>Physical Broadcast channel</td>
<td>QPSK</td>
<td>Carrier Cell specific information.</td>
</tr>
<tr>
<td>PDCCH</td>
<td>Physical Downlink Control Channel</td>
<td>QPSK</td>
<td>Transports format, resource and hybrid-ARQ information related to DL-SCH, UL-SCH and PCH.</td>
</tr>
<tr>
<td>PDSCH</td>
<td>Physical Downlink Shared Channel</td>
<td>QPSK, 16QAM, 64QAM</td>
<td>User data payload.</td>
</tr>
<tr>
<td>PMCH</td>
<td>Physical Multicast Channel</td>
<td>QPSK, 16QAM, 64QAM</td>
<td>Payload for multiple users, Multimedia Broadcast Multicast service (MBMS)</td>
</tr>
<tr>
<td>PCFICH</td>
<td>Physical Control Format Indicator Channel</td>
<td>QPSK</td>
<td>Carries the number of symbols (1,2 or 3) used for control channels (PDCCH) in a subframe.</td>
</tr>
<tr>
<td>PHICH</td>
<td>Physical Hybrid ARQ Indicator Channel</td>
<td>BPSK</td>
<td>Carries the error detection (hybrid ARQ ACK/NAK) feedback to the UE for the UL blocks received by the eNB.</td>
</tr>
<tr>
<td>P-SCH</td>
<td>Primary Synchronization Channel</td>
<td>Zadoff – Chu</td>
<td>Used for cell search and cell identification. Carries part of the cell ID</td>
</tr>
<tr>
<td>S-SCH</td>
<td>Secondary Synchronization Channel</td>
<td>BPSK</td>
<td>Used for cell search and cell identification. Carries the remainder of the Cell ID</td>
</tr>
<tr>
<td>RS</td>
<td>Reference Signal (Pilot)</td>
<td>Complex I+Q pseudo random sequence</td>
<td>Used for DL channel estimation. Exact sequence derived form Cell ID. Enable UE to calculate transmission corrections.</td>
</tr>
</tbody>
</table>

### MODULATION SCHEMES

- **BPSK**
- **Zadoff-Chu**
- **QPSK**
- **16QAM**
- **64QAM**
In-Home Wiring is a Challenge

- Each home is a “headend” for the reverse path
- Home wiring frequently has inferior components and craftsmanship
- Replacing all home wiring is economically unacceptable,
- Each year the cable industry buys somewhere in the neighborhood of 2 billion feet of drop cable.
The subscriber drop remains the weakest link in the cable network

Seven out of ten service calls are generated by problems at the drop

Ingress caused in the home wreaks havoc on the reverse path
  – Must be found in the home before connecting to network when possible
  – Must be monitored continuously and eliminated quickly

Replacing all home wiring is economically unacceptable, testing is required to find faults and bring the home wiring up to standards necessary for new services.
Common Problems Typically Identified in the Drop

- Kinked or damaged cable (including cracked cable, which causes a reflection and ingress)
- Use of staples that perforate or compress coaxial cable resulting in impedance mismatches
- Cable-ready TVs and VCRs connected directly to the drop (Return loss on most cable-ready devices is poor)
- Older splitters and amplifiers may not be rated for 750MHz, 860MHz or 1GHz
- Some traps and filters have been found to have poor return loss in the upstream, especially those used for data-only service
Electrical Impulse Noise from One House

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

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

*All HW versions
Testing the Home for Ingress Contribution

If ingress is detected, scan spectrum at ground block for ingress

Disconnect drop from tap and check for ingress coming from customer’s home wiring

INGRESS SPECTRUM MEASUREMENTS
Ingress - CB Radio

Marker: Max Hold
Marker: Delta(Absolute)
In-Band Power

29.005 MHz
1.480(30.485) MHz

-2.606 dBmV
-10.269(-12.875) dB
-1.220 dBmV

CB Radio
Wideband Impulse Noise = Code Word Errors!

Diplex roll-off at 42 MHz
Wide Band Impulse Noise and Laser Clipping

Impulse noise goes past diplex roll-off at 42 MHz
A 7/16” wrench is a “hi-tech” tool?!

“Finger tight ain’t good enuff!”
Home Networking Technologies

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

### Technical Specification Overview

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Throughput (MAC/PHY)</td>
<td>128 / 200 Mbps</td>
</tr>
<tr>
<td>Latency</td>
<td>10 ms</td>
</tr>
<tr>
<td>Jitter</td>
<td>&lt; 1 ms</td>
</tr>
<tr>
<td>PER</td>
<td>1e-7 (~1e-10 BER)</td>
</tr>
<tr>
<td>Number of Nodes</td>
<td>8 max</td>
</tr>
<tr>
<td>Max Length</td>
<td>400 ft</td>
</tr>
<tr>
<td>Loss Budget</td>
<td>50 dB</td>
</tr>
<tr>
<td>Modulation</td>
<td>OFDM</td>
</tr>
<tr>
<td>Frequency</td>
<td>4-12 MHz or 12-28 MHz</td>
</tr>
<tr>
<td>RF Power</td>
<td>-7 dBm</td>
</tr>
<tr>
<td>QoS</td>
<td>Yes</td>
</tr>
</tbody>
</table>

### Diagram: True Mesh Network

- Node 1
- Node 2
- Node 3
- Central Coordinator

Each link segment has a separate profile: (Rate, Modulation, Level)
HomePNA™ - Home Networking

Ethernet to Coax
HPNA Adapter

Features
• Uses your existing coaxial wiring
• Perfect for transferring large multimedia files such as movies, music, and photos
• Uses existing coax cabling
• Supports speeds up to 144 Mbps burst, 95 Mbps sustained
• Complies with the HPNA 3.1 over coax specification (ITU G.9954)
• Supports point-to-point and point-to-multipoint network configurations
HPNA Physical Network Topology

Coax Network Configuration

WAN Entry Point

3-Way

Node Device

Node Device

Node Device

Node Device

TV

Twisted Pair Star Configuration

Telco NID

Node Device

Node Device

Node Device

Node Device

Splitter Jumping

< 25 dB loss < 300 ft
Wideband HomePNA™ Ingress in the Return Path

“The HomePNA™ Alliance develops triple-play home networking solutions for distributing entertainment data over both existing coax cable and phone lines.”
“Products based on the HomePlug 1.0 and HomePlug AV specifications can bridge an existing networking technology (such as a wireless or Ethernet network) and your home's power lines.”

Network your TV with HomePlug AV
HomePlug AV Technical Features

- 150 Mbps MAC / 200Mbps Phy
  - Expected performance of 50-80 Mbps in most installs
- Works over existing AC power lines
- Actively adapts to the wiring
- Can support multiple networks on a single media. (with performance degradation)
- True peer-to-peer mesh network
- OFDM Modulation
- 2-28 MHz
- Encrypted data transfer
- QoS
Home Plug Interference

HomePlug uses 917 OFDM sub-carriers. OFDM modulation allows co-existence of several distinct data carriers in the same wire.

“The number of whole-home DVR installations is expected to grow at a CAGR of over 100 percent from 2006 to 2008.”

-- In-Stat
What is MoCA?

- Stands for: Multimedia over Coax Alliance

- Main applications:
  - Whole Home DVR
  - Connect IP enabled devices

- MoCA is very robust
  - 50-60dB of loss

- Excess Attenuation is the biggest killer of MoCA

- Several Operators estimate that MoCA services will first be available end of this year or early next year
A MoCA filter (aka: POE filter) performs two jobs.

- First it removes the MoCA signal from entering a neighbors house
  - Stops MoCA signal from leaving the home
- Second it gives MoCA a point of reflection for the signal
  - MoCA relies on the signals to “bounce” output to output on splitters
MoCA Just Evolved to V2.0

MoCA 1.x Frequency View

MoCA 2.0 Frequency View

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

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

DIFFERENT HARDWARE

5 MHz 55 MHz

1 GHz 1.7 GHz
MoCA 2.0 Detailed

- **MoCA 2.0 (June 15, 2010)** - Similar to MoCA 1.1 but with the following differences:
  - Three new modes of operation:
    - **Baseline Mode:**
      - 400+ Mbps MAC throughput
      - 700 Mbps PHY Rate
      - Single 100 MHz Channel
    - **Enhanced Mode**
      - 800+ Mbps MAC throughput
      - 1.4 Gbps PHY Rate
      - Two bonded 100 MHz Channels ("Channel Bonding")
    - **"Turbo" mode** for a point-to-point configuration that allows:
      - 500+ Mbps MAC throughput between two connected devices when operating in Baseline mode
      - 1+ Gbps MAC throughput when operating in Enhanced mode
  - All three modes now have an extended frequency range
    - 500 MHz through 1650 MHz (center frequencies)
  - Backward compatibility with MoCA 1.0 and 1.1 devices
    - MoCA 2.0 devices can operate at MoCA 2.0 speeds while MoCA 1.x devices are communicated to at their maximum respectable speeds on the same network

NOTE: MoCA 2.0 is different hardware than previous MoCA 1.1 HW versions
Put a RF tester at each location inside the home where a Set-top-box or Cable Modem will be located (or is desired to be tested)

- Connect one RF Tester to the DSAM’ s USB port
- Then Connect that RF Tester to the POE looking into the home toward CPE (ie: drop cable, ground block, or main split)
Certify each Coax Path Independently

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

Shortcut: Press #1
Seeing how everything is connected

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

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

Shortcut: Press #4

Upstream Freq Response

Downstream Freq Response – with MoCA filter in place
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
Group Delay / Microreflections

If the accumulation takes on a diamond shape, the problem is likely a group delay issue

- Constellation may take on a diamond or square shape
- Clarity of diamond shape will vary with percentage of packets affected
  - Microreflections are a common cause of group delay
  - Often caused by unterminated or improperly terminated lines or faulty CPE (cheap TV or VCR)
  - Group delay can also result from a carrier placed too close to the band edge of the diplex filter
Linear Distortions Tests

Return Path

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

<table>
<thead>
<tr>
<th>Service</th>
<th>Typical achievable Data Rate</th>
<th>Distances</th>
</tr>
</thead>
<tbody>
<tr>
<td>MoCA</td>
<td>(&gt;100\text{Mb/s}) typ. 140 \text{MB/s} max</td>
<td>(&gt;300\text{ ft.})</td>
</tr>
<tr>
<td>HPNAv3</td>
<td>86-128\text{ Mb/s} typ</td>
<td>(&gt;400\text{ ft})</td>
</tr>
<tr>
<td>802.11a/g</td>
<td>(~10\text{Mb/s}) Typical</td>
<td>(~90\text{ ft})</td>
</tr>
<tr>
<td>802.11n</td>
<td>(~40\text{Mb/s}) Typical</td>
<td>(~150\text{ ft})</td>
</tr>
<tr>
<td>HomePlug A/V</td>
<td>150\text{ Mb/s} Max published</td>
<td>(&lt;300\text{ estimated})</td>
</tr>
<tr>
<td>Wired Ethernet</td>
<td>100\text{ Mb/s}</td>
<td>300\text{ ft}</td>
</tr>
</tbody>
</table>
Back to the Basics

- Check for leakage sources
- Check for ingress sources
- Do a visual inspection of cable / connectors / passives
- Replace questionable cable / connectors / passives
- Tighten F-connectors per your company’s installation policy
  - Be very careful not to over tighten connectors on CPE (TVs, VCRs, converters etc.) and crack or damage input RFI integrity
Back to the Basics

- Majority of problems are basic physical layer issues
- Most of the tests remain the same
- Check AC power
- Check forward levels, analog and digital
- Sweep forward & reverse
You never have too much training!

- Learn everything you can about Triple Play & HFC networks
  - Company sponsored training
  - SCTE Chapter Meetings & Certification programs
  - SCTE EXPO & Emerging Technologies
  - CED and Communications Technology magazines
  - Vendor “product specific” training

- Learn everything you can about the devices in your network, both the physical layer and data layer
  - **Headend**: Modulators, Multiplexers, CMTS etc.
  - **Outside plant**: Nodes, Amps, Passives etc.
  - **Subscriber’s drop**: Digital Converter, DVRs, Cable Modems, eMTAs, house amps etc.

- Learn how to get the most out of your test equipment & CPE diagnostics
  - most vendors will train you

Be thorough - Take pride in your work!

- Do the installation right the first time
- Take the time to properly certify every drop for Triple Play services
See digital in a whole new light!

Questions?

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Thank You!

Mark Ortel

Sales Support Engineer

Cable Networks Division

www.jdsu.com

National SCTE Member

Supporter of the National

And Local SCTE Chapters