“Best Practices for Proactively Maintaining Your Return Paths”

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See digital in a whole new light!
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Advanced Optical Technologies

Communications & Commercial Optical Products

Communications Test & Measurement

Currency, Defense, Authentication, and Instrumentation

Cable, Telecom, Datacom, Submarine, Long Haul, Biotech, and Microelectronics

Service Provider, Government, Business, and Home Networks
Bandwidth Demand is Growing Exponentially!

- Web Browsing
- E-mail
- Digital Music
- VoIP
- Digital Photos
- Video on Demand
- Video Mail
- Online Gaming
- Podcasting
- Video Blogs
- High Definition Video on Demand
- All Video on Demand Unicast per Subscriber
- Megabits per Second
- Time

Bandwidth Demand is Growing Exponentially!
The HFC Pipe to the Home is Huge!

The BAD news is that ingress from one home can potentially kill upstream services for hundreds of your subscribers!!!
New Specifications
- DOCSIS 3.0 Interface Specifications (released December 2006)
- CPE equipment in development stages (Bronze, Silver, Full)

Downstream data rates up to 300 Mbps
- Channel Bonding
  - 1 x 256QAM => “up to” ~40Mbps
  - 8 x 256QAM => “up to” ~320 Mbps

Upstream data rates of 120 Mbps or higher
- Channel Bonding
  - 1 x 64QAM => “up to” ~30Mbps
  - 4 x 64QAM => “up to” ~120 Mbps

Internet Protocol version 6 (IPv6)
- IPv6 greatly expands the number of IP addresses
  - Expands IP address space from 32 bits to 128 bits
  - IPv6 supports $3.4 \times 10^{38}$ addresses
  - Colon-Hexadecimal Format
  
  4923:2A1C:0DB8:04F3:AEB5:96F0:E08C:FFEC

100% backward compatible with DOCSIS 1.0/1.1/2.0
DOCSIS® 3.0 – Channel Bonding

- In a nutshell, channel bonding means data is transmitted to or from CMs using multiple individual RF channels instead of just one channel.

- Channels aren't physically bonded into a gigantic digitally modulated signal; bonding is logical.

4 Bonded 256 QAM DOCSIS channels

DOCSIS v3.0 Spec requires devices to be able to bond a minimum of 4 upstream channels into one and 4 downstream channels into one for 4 times increased throughput in both directions.

The MSO does not have to use all 4 channels, but the devices which are 3.0 compliant must have the ability to bond 4 or more channels in both directions.

4 x 256QAM

4 x ~40Mbps = ~160 Mbps
DOCSIS® 3.0 adds Capability to Bond up to 4 Upstream 64QAM Carriers!

Four times 6.4 MHz = 25.6 MHz! (without guard-bands)

- Increased chances for laser clipping
- Increased probability of problems caused by ingress, impulse noise, group delay, micro-reflections and other linear distortions
- Inability to avoid known problem frequencies such as Citizens’ Band, Ham, Shortwave and CPD distortion beats
- What frequencies are you going to monitor for problems?
Today’s Agenda

- **Getting ready for DOCSIS® 3.0 - Optimize Your HFC network now!**
  - Verify optimal setup and performance (dynamic range) of both Optical & RF portion of the HFC network
  - Forward & Reverse sweep for unity gain throughout coaxial network

- **Troubleshooting Upstream Impairments**
  - Trouble Shooting Tools
  - Ingress
  - Common Path Distortion (CPD)
  - Impulse Noise
  - Linear Distortions
HFC Networks

- Combines fiber optics with coaxial distribution network
- Return path is more sensitive than the forward path
- Most of the ingress comes from home wiring on low value taps
- Wide variety of aging hardware with many connectors

Today’s “HFC” networks must be optimized for both forward and reverse performance
Monitoring and Maintaining the Return Path

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Loose Fiber Connector

- SC connector not pushed in all the way

Before

![Before Image](image1)

After

![After Image](image2)
Types of Fiber Contamination

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

Common types of contamination and defects include the following:

- Dirt
- Oil
- Pits & Chips
- Scratches
Where is it? – Everywhere!

Your biggest problem is right in front of you... you just can’t see it!

DIRT IS EVERYWHERE!

- Airborne, hands, clothing, bulkhead adapter, dust caps, test equipment, etc.
- The **average dust particle is 2–5µ**, which is not visible to the human eye.
- A single spec of dust can be a major problem when embedded on or near the fiber core.
- **Even a brand new connector can be dirty.** Dust caps protect the fiber end face, but can also be a source of contamination.
- Fiber inspection microscopes give you a clear picture of the problems you are facing.
What Controls What?

Contact the manufacturer of your lasers, optical receivers and CMTS and ask them for their recommended RF and Optical input/output levels and setup procedures.
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!
Too Much Optical Power into Optical Receiver

Too much optical power (light level) into the input of a return optical receiver can cause an abnormal rise in the noise floor above the diplex filter roll-off frequencies.
After adding 2 dB of optical attenuation at the input of the optical receiver, the noise floor above diplex filter roll-off frequency now looks normal.

42 MHz diplex filter roll-off frequency

2 dB of additional optical attenuation was added to the return input of the optical receiver and resulted in a “flatter noise floor” above the diplex filter roll-off frequencies.
When sweep pulses were injected into the return path, “impulse distortions” showed up in the noise floor above the diplex filter roll-off frequencies.

After inserting sweep pulses into the return path, the noise floor above diplex roll-off frequency now exhibits impulse noise created by sweep pulses.
6 dB of additional optical attenuation was added to the return input of the optical receiver and resulted in a “flatter noise floor” above the diplex filter roll-off frequencies, even when sweep pulses were injected into the return path.
Dynamic range of the return path in an HFC network is typically set up by injecting one or more CW test signals and then measured with a typical spectrum analyzer or signal level meter.
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 FFT Spectrum View of the Upstream

- 30 MHz
- 36 MHz
- 60 MHz
- 72 MHz
Bad Optical Receiver

- Note the before/after spectrum analyzer shots – no sign of a problem!
- QAM Analyzer needed to detect source of problem and know when it’s fixed in real time

**Before Fix:**
Spectrum Looks Great
QAM Looks Bad

**After Fix:**
Spectrum Looks Good
QAM Looks Great
Optimize the RF Output of the Optical Receiver

All return path RF signal levels must be set to proper “X” (or Y?) output level at the optical receiver in the headend or hubsite with the correct “X” level injected at the node.

Store test results in a “birth certificate” file folder for each node.

All return path RF signal levels must be set to proper “X” (or Y?) output level at the optical receiver in the headend or hubsite with the correct “X” level injected at the node.
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.
Monitoring and Maintaining the Return Path

- **Getting ready for DOCSIS 3.0 - Optimize Your HFC network now!**
  - Verify optimal setup and performance (dynamic range) of both Optical & RF portion of the HFC network
  - **Forward & Reverse sweep for unity gain throughout coaxial network**

- **Troubleshooting Upstream Impairments**
  - Trouble Shooting Tools
  - Ingress
  - Common Path Distortion (CPD)
  - Impulse Noise
  - Linear Distortions
WHY SWEEP?

• Less manpower needed
• Sweeping can reduce the number of service calls
Sweep Verifies Construction Quality

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 leakage, ingress and micro-reflection problems!
Test Probes

- Will always be bi-directional unless they are in series with the circuit
- Higher loss probes provide less of an impedance mismatch, but lower levels
- F-to-Housing adapters cause severe standing waves because of:
  - Bad grounding
  - RF power splitting
  - Impedance mismatch
- Be careful with in-line pads while probing seizure screws
  - Not usually dc blocked
Balancing Amplifiers - Forward Sweep

Balancing amplifiers using tilt only

Headend

Node Reference Signal

Sweep response with a Resonant Frequency Absorption (A.K.A. suckout)

Lose Face Plate, or crack cable shield

No Termination

\[ D = 492 \times \frac{V_p}{F} \]
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
Sweeping the Return Path

Example chart showing injection levels at each test point

### Return Sweep Cheat Sheet - Sweeping to the Input of a Return Amp

<table>
<thead>
<tr>
<th>Desired Input Level into Return Amp or Return Laser</th>
<th>Various Types of Test Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Node Return Test Point Compensation (TPC)</td>
<td>17 dBmV</td>
</tr>
<tr>
<td>Trunk Amp Test Point Compensation (TPC)</td>
<td>17 dBmV</td>
</tr>
<tr>
<td>Bridger Amp Test Point Compensation (TPC)</td>
<td>17 dBmV</td>
</tr>
<tr>
<td>Line Extender Amp Test Point Compensation (TPC)</td>
<td>17 dBmV</td>
</tr>
<tr>
<td>Internal Coupling Loss</td>
<td>5 dB</td>
</tr>
<tr>
<td>Test Point Loss</td>
<td>30 dB</td>
</tr>
<tr>
<td>Total Loss Between Sweep meter and return amp input</td>
<td>35 dB</td>
</tr>
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<td>Sweep Telemetry and Sweep Pulse insertion level</td>
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<td>Line Extender Amp Test Point Compensation (TPC)</td>
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Optimize the RF Input to Return Sweep Transceiver

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

Pad input of sweep receiver transceiver so that 40 dBmV into node equals 0 dBmV at the input of the return sweep transceiver.
Stealth Sweep Pulses Compared to Carrier

Sweep Telemetry Injected at Node @ 40 dBmV?

Adjust sweep telemetry and sweep pulses to same transmit level

Sweep Pulses Injected at Node @ 40 dBmV?

Test CW Signal Injected at Node @ 40 dBmV
Inject correct “X” level into node test point and then take a sweep reference.

At next amp reverse sweep displays the effects of the network segment between the last amp and this one.

Telemetry level shown below return sweep trace should read around 0 dBmV if the SDA-5510 is padded properly.
Optimize the HFC Pipe for Unity Gain

Maintain unity gain with constant inputs

Telemetry = ~0 dBmV

Set TP Loss as required

Use the DSAM Field View Option to inject a CW test signal into various test points and view remote spectrum
Frequency response— Frequency response problems are due to improper network alignment, un-terminated lines, or damaged components. When reverse frequency response and equipment alignment have been done incorrectly or not at all, the result can be excessive thermal noise, distortions, and group delay errors.
Balancing Amplifiers - Reverse Alignment

TILT = 6 MHz at 3.4 dBmV – 42 MHz at 2.3 dBmV
TILT = -1.1 dB because of slope is from left to right

Marker at 6 MHz not active (no Box)

DSAM output is 50 dBmV at 6 MHz

Headend receive level is 3.4 dBmV at 6 MHz

At Headend (SDA-5500 or 5510)

Marker at 42 MHz active (Box)

DSAM output is 50 dBmV at 42 MHz

Headend receive level is 2.3 dBmV at 42 MHz

At Headend (SDA-5500 or 5510)
Sweep Pulses Compared to Carrier

Adjust sweep telemetry and sweep pulses on meter to transmit at same level.

- **Sweep Telemetry Injected at Node @ 40 dBmV**
- **Test CW Signal Injected at Node @ 40 dBmV**
- **Sweep Pulses Injected at Node @ 40 dBmV**

- **3.2 MHz wide**
Sweep Pulses Compared to Carriers

Sweep Telemetry Injected at Node @ 40 dBmV?

Adjust sweep telemetry and sweep pulses on meter to transmit at same level

Sweep Pulses Injected at Node @ 40 dBmV?

Test CW Signal Injected at Node @ 40 dBmV

6.4 MHz wide

500 kHz wide guard band
Sweep Pulses Compared to Carriers

Sweep Telemetry Injected at Node @ 40 dBmV?

Stealth Sweep Pulses Injected at Node @ 40 dBmV?

Peak level of 6.4 MHz carriers at 34 dBmV

Test CW Signal Injected at Node @ 40 dBmV

- 3.2 MHz wide
- 6.4 MHz wide
- 6.4 MHz wide
- 6.4 MHz wide

500 kHz 500 kHz 500 kHz
Sweep Pulses Compared to Carriers

Sweep Telemetry Injected at Node @ 40 dBmV?

Sweep Pulses Injected at Node @ 40 dBmV?

Test CW Signal Injected at Node @ 40 dBmV

100 kHz wide

6.4 MHz wide

6.4 MHz wide

6.4 MHz wide

100 kHz wide
Sweep Pulses Compared to Carrier

- **Sweep Telemetry** injected at Node @ 40 dBmV
- **Sweep Pulses** injected at Node @ 30 dBmV

Adjust sweep telemetry on meter to transmit at 40 dBmV and sweep pulses to transmit at 30 dBmV

- Test CW Signal injected at Node @ 40 dBmV
- 6.4 MHz wide
- 100 kHz wide

@ 30 dBmV
- 6.4 MHz wide
- 100 kHz wide

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Monitoring and Maintaining the Return Path

- **Getting ready for DOCSIS 3.0 - Optimize Your HFC network now!**
  - Verify optimal setup and performance (dynamic range) of both Optical & RF portion of the HFC network
  - Forward & Reverse sweep for unity gain throughout coaxial network

- **Troubleshooting Upstream Impairments**
  - Trouble Shooting Tools
  - Ingress
  - Common Path Distortion (CPD)
  - Impulse Noise
  - Linear Distortions
Typical PathTrak Interface with DOCSIS® Network

PathTrak RPM Card

Upstream Optical Receivers

Fiber Nodes

Coax and splitters

Fiber

Coax

Cable Modems
Typical PathTrak Interface with DOCSIS® Network

It is critical to optimize the dynamic range of each RPM port!

External attenuation may be added to achieve 0 dBmV peak level on widest upstream carrier at RPM input port.
Dynamic Range “Measurement Window”

The “peaks” of the upstream carriers below are outside of the measurement window of this particular RPM port. This is called “measurement over range”.

In order to accurately measure the peaks of these carriers and the system noise floor you must optimize the dynamic range of every RPM port.
New Measurement “Over Range” Indicator

Measurement Over-range warning!
New Measurement “Over Range” Indicator

With 20 dB attenuation NO Measurement Over-range warning!
Optimized Dynamic Range

The “peaks” of the upstream carriers are now within the measurement window of this particular RPM port.
Analyzing and Interpreting Performance History

Use Performance History’s Detailed Maximum Trace to see wide band impulse noise trending over time.

Maximum Trace in spectrum analyzer shows wide band impulse noise.
Analyzing and Interpreting Performance History

Average Trace in spectrum analyzer shows rise in noise floor & CPD

Use Performance History’s Detailed Average Trace to see rise in noise floor & CPD over time
Monitoring and Maintaining the Return Path

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  - Ingress
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The Situation

Can’t justify taking the system down to troubleshoot!

- Unacceptable to the subscribers who will;
  - Lose communication
  - Get a slower throughput
  - Have periodic “clicking” in their telephone calls

- To be non-intrusive we must;
  - Understand test points
  - Apply new procedures and applications
  - Learn new troubleshooting techniques
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
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
Return Path Troubleshooting Can Require Two People or a Lot of Driving Unless You Have the Right Tools

The ingress is still there, keep looking! Unfortunately, I have to go to a meeting and then I have to leave early today so you’ll have to drive back here to make sure that you’ve really fixed the problem.

I’ve found something and I think that I may have fixed the issue. What’s it look like at your end?
Troubleshoot Return Path Impairments in the HFC network – WITHOUT tying up Headend Technicians!

Remotely view live spectrum analyzer from RPM card using the SDA and DSAM Field View Option in the field.

Configure frequency span and dwell time of remote spectrum analyzer in Field View Broadcast Properties via PathTrak client.
“Out of Band” 64QAM Test Signal

“Out of band” 64QAM test signal generated by Field meter.
The new QAMTrak displays and controls are only available in WebView v2.5
Test Unoccupied Spectrum Before Launch

PathTrak RPM Card

Upstream Optical Receivers

Fiber Nodes

Cable Modems

Coax and splitters

Fiber

Coax
Monitoring and Maintaining the Return Path

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  - Trouble Shooting Tools
    - **Ingress**
    - **Common Path Distortion (CPD)**
    - **Impulse Noise**
    - **Laser Clipping**
    - **Linear Distortions**
Common problems in HFC Networks
Common problems in HFC Networks

- Kinked or damaged cable (including cracked cable, which causes a reflection and ingress).

- Defective or damaged actives or passives (water-damaged, water-filled, cold solder joint, corrosion, loose circuit-board screws, etc.).

- Cable-ready TVs and VCRs connected directly to the drop. (Return loss on most cable-ready devices is poor.)

- Some traps and filters have been found to have poor return loss in the upstream, especially those used for data-only service.
Common problems in HFC Networks

- Damaged or missing end-of-line terminators
- Damaged or missing chassis terminators on directional coupler, splitter or multiple-output amplifier unused ports
- Loose tap faceplates and loose center conductor seizure screws
- Unused tap ports not terminated. This is especially critical on lower value taps
- Use of so-called self-terminating taps (4 dB two port; 8 dB four port and 10/11 dB eight port) at feeder ends-of-line. Such taps are splitters, and do not terminate the line unless all F ports are properly 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.
Ingress - Off-air Broadcast Radio Carrier

If the constellation looks like it has “donut shapes” in it, the problem is likely to be some form of coherent interference. Often caused by off-air ingress such as citizens band radio, shortwave radio, or other broadcast radio sources.
The Shortwave Broadcast radio carrier @ 6 MHz was identified in the Node Ranking Report as the "Worst Frequency".

The Shortwave Broadcast radio carrier @ 6 MHz had exceeded Threshold 1 (-25 dBmV) for 100% of the time during the 15 minute spectrum summary timeframe.
Resolution bandwidth (RBW) filters determine the smallest frequency that can be resolved.

The graphs above represent the same 3 narrow band signals with various RBW filters applied.
Ingress - Off-air AM Radio Carriers Below 5 MHz

AM Radio Carriers
Measured with 300 kHz RBW (between 600 to 1,600 kHz)
Ingress - Off-air AM Radio Carriers Below 5 MHz

AM Radio Carriers
Measured with 30 kHz RBW
(between 600 to 1,600 kHz)
Ingress - Off-air AM Radio Carriers Below 5 MHz

AM Radio carriers
Measured with 300 kHz RBW
(between 600 to 1,600 kHz)
Ingress - Off-air AM Radio Carriers Below 5 MHz

AM Radio carriers
Measured with 30 kHz RBW (between 600 to 1,600 kHz)
Typical Problem Areas

- **Taps**
  - Most ingress comes from houses off of with 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
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.
Testing with Seizure Screw Probes

Forward Path

Return Path

4 Port Tap
Testing with Seizure Screw Probes

- Spring loaded seizure screw probes create a good ground and quick connect without causing outages.
- Use a 20 db pad with AC block when using a field meter and a spring loaded seizure screw probe.

Remove protective cap and probe the seizure screws.
Taps - Probe the Seizure Screws for Ingress & CPD

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.

Forward Path

Return Path
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.
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
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
Reverse Path Impairments – Laser Clipping

Harmonic at twice the frequency of the carrier

Dots in the outer squares of constellation are “pulling towards the center of graph
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.
Reverse Path Impairments – Bad Optical Receiver

This constellation pattern is noticeably distorted due to a defective optical receiver.

The constellation pattern “returned to normal” after replacing the defective optical receiver!
Common Path Distortion (CPD) — common path distortion usually occurs at a dissimilar metals interface where a thin oxide layer has formed.
Common Path Distortion (A.K.A. CPD)

- **Non-linear mixing from a diode junction**
  - Corrosion (metal oxide build-up) in the coaxial portion of the HFC network
  - Dissimilar metal contacts
  - 4 main groups of metals
    * Magnesium and its alloys
    * Cadmium, Zinc, Aluminum and its alloys
    * Iron, Lead, Tin, & alloys (except stainless steel)
    * Copper, Chromium, Nickel, Silver, Gold, Platinum, Titanium, Cobalt, Stainless Steel, and Graphite

- **Second and third order distortions**
Common Path Distortion (CPD) beats

- 18 MHz
- 30 MHz
- 12 MHz
- 24 MHz
- 6 MHz
- 36 MHz
- 42 MHz
Common Path Distortion (CPD) beats
Common Path Distortion (CPD) beats 24 MHz +/- 1.25 MHz

- 25.25 MHz
- 23.75 MHz
- 6 MHz
CPD Troubleshooting

- Pull a forward or return pad to see if the return “cleans-up”?
  - This is definitely CPD or ingress
  - Very intrusive though – pulling pads when troubleshooting is not acceptable!

- Try not to disturb anything in this tracking process
  - Vibrations and movement can “break away” the diode/corrosion causing this CPD
  - Voltage surges can also destroy the diode
    - At least long enough to warrant a return visit!

- Visually inspect hardware and replace defective components

- Tighten all seizure screws and connectors to specifications
As operators add more and more QAM carriers to the downstream, Common Path Distortion beats can show up in the return spectrum as distinct “haystacks” in the noise floor which are spaced in 6 MHz intervals!
Impulse noise — Most reverse data transmission errors (i.e. Code Word Errors) have been found to be caused by bursts of impulse noise. Impulse noise is characterized by its fast rise-time and short duration.
- <100 microseconds
- Most impulse noise is less than 10 microseconds in duration

Common sources include cracked ceramic insulators (a.k.a. lightning arresters) on power lines, electric motors, electronic switches, neon signs, static from lightning, and household appliances.
Wideband Impulse Noise = Code Word Errors!

Diplex roll-off at 42 MHz
What is Dwell Time and When do I use it?

Impulse Noise
Measured with 20 µS Dwell Time
What is Dwell Time and When do I use it?

Impulse Noise
Measured with 2,000 µS Dwell Time
# HFC Performance/Health Metrics

<table>
<thead>
<tr>
<th>Spectrum Health</th>
<th>Carrier-to-interference – An RF measurement of the ratio of desired carrier amplitude to undesired interference amplitude. Interference may be noise, ingress, nonlinear distortions.</th>
</tr>
</thead>
</table>
| Signal Health   | MER (“SNR”) – The ratio of average symbol power to average error power. In effect, a measure of the “fuzziness” of a constellation’s symbol landings distortions.  
  - Unequalized MER is the MER before an adaptive equalizer compensates for channel response impairments  
  - Equalized MER is the MER after an adaptive equalizer compensates for channel response impairments |
| Data Health     | CWE (Corr and Uncorr) – Pass/Fail indication of whether each codeword in each packet contains data errors  
  BER (Pre- and Post-FEC) – The ratio of errored bits to the total number of bits transmitted, received, or processed |
What Are CWEs and Why Are They So Important?

• What is a Codeword?
  – A Codeword is a data bucket within a DOCSIS packet
    • Typical 64-QAM data packet has 5-8 codewords
    • Typical 64-QAM CW contains 100-255 bytes

• What Is a Codeword Error?
  – A byte-level data packet corruption resulting from displacement of individual QAM symbols across constellation decision boundaries
  – Correctable vs. Uncorrectable determined by number of corrupted symbols relative to CMTS forward error correction level settings

• Why are they so important?
  – Codeword errors capture the impact of all HFC impairments on customer packets!
    • If you are having CWEs, you may be losing data
    • Uncorrectable CWEs indicate dropped packets (think post-FEC in DS)
      – Retransmit is required for recovery with HDS users
      – There is no recovery from dropped packets for real-time apps like VoIP!
    • Correctable CWEs are an early warning that the uncorrectable threshold may be near! (think pre-FEC BER in DS)
Wide Band Impulse noise starts each day at around 4:00 PM
Spectrum Power Density Chart – 120 Hrs

Wide Band Impulse noise starts each day at around 7:00 PM

Maximum Hold Trace
Electrical Impulse Noise from One House

Reverse Spectrum shot at customer's drop
Packet of data transmitted by a DOCSIS® cable modem

Impulse noise under the DOCSIS® cable modem
Impulse Noise Detectors

RFI locators detect sparks and corona that cause radio and T.V. interference (RFI TVI).

Detects indoor sparking and electronic sources.
Wide Band Impulse Noise and Laser Clipping

Impulse noise goes past diplex roll-off at 42 MHz
“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 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
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 Mpbs 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
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. “

6.4 MHz DOCSIS® Carrier

HPNA signal from a single home!
**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

- **In-channel Freq. Response**
  - Common Causes
    - Misalignment
    - Impedance mismatches

- **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
Linear Distortions – Micro-reflection

Approximation of channel impulse response

Red dots indicate Microreflection Threshold for each bar (DOCSIS Spec – Headroom)

Any bar violating threshold is colored red
- **Note:** Bar that violates threshold may not be the tallest bar (note stepdown of thresholds)

Main Tap (time = zero) will always be the largest, will always be green

Chart is generated from equalized data (vs unequalized data)

- **X-Axis:** Time bin in nS relative to main tap
- **Y-Axis:** Amplitude of signal relative to the carrier (dBc)

**Interpretation:**
- The farther the bar is to the right, the later the reflection arrived at the headend
- The higher the level of a bar, the stronger the microreflection as received at the headend

**Common Causes:**
- Damaged/missing terminators, loose seizure screws, water-filled taps, cheap/damaged splitters or CPE, kinked/damaged cable, install Issues
QAM Analyzer View – Group Delay & Micro-reflections

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.

Micro-reflections are a common cause of group delay.

Often caused by un-terminated 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 – In-Band Frequency Response

- Frequency response chart across a given carrier's frequency
- Think of it like a sweep display for the discrete carrier frequency range
- Chart is generated from equalized data (vs unequalized data)
- Value reported by QAMTrak is the highest amplitude point minus the lowest amplitude point per 1MHz slice of the carrier frequency range

- X-Axis: Frequency (covers frequency range of the carrier)
- Y-Axis: Amplitude of signal at each frequency relative to the average carrier level
- Interpretation:
  - A carrier with an ideal frequency response will have a flat response chart
  - Modems with very similar in-band response footprints may be impacted by a common impairment
    - Same water-filled tap, etc
Upstream Adaptive Equalization Example

Upstream 6.4 MHz bandwidth 64-QAM signal

Before adaptive equalization:
Substantial in-channel tilt caused correctable FEC errors to increment at a rate of about 7000 errored codewords per second (232 bytes per codeword). The CMTS’s reported upstream MER (SNR) was 23 dB.

After adaptive equalization:
DOCSIS 2.0’s 24-tap adaptive equalization —actually pre-equalization in the modem— was able to compensate for nearly all of the in-channel tilt (with no change in digital channel power). The result: No correctable or uncorrectable FEC errors and the CMTS’s reported upstream MER (SNR) increased to ~36 dB.
Upstream Adaptive Equalization Example

- Frequency response of the modem’s carrier can be adversely affected by various impedance mismatches and diplex filters.
- With Adaptive Equalization enabled on the CMTS and modems, the CMTS instructs the modems to pre-distort the carrier based on what they look at the input of the CMTS.
- This makes the carrier’s frequency response “flatter” at the input of the CMTS.
Basic QAM Constellation Analysis

Good 16QAM Constellation

Bad 16QAM Constellation?
PathTrak QAM Analyzer View – Good Node

- MER & Level Avg/Max/Min
- QPSK & 16QAM Constellation
- Live MER, Level & Symbol Count
- MER & Level Graphed over Time
PathTrak QAM Analyzer View – Bad Node?

- Interference easily visible in 16 QAM constellation
- Individual modem with very low MER
Clean Return Spectrum (Below 45 MHz)
Bad In-Band Response from a Single Modem

Move this marker and all of the displays will show the corresponding measurements for each packet.
Good In-Band Response from a Single Modem

Move this marker and all of the displays will show the corresponding measurements for each packet.
Bad In-Band Response from a Single Modem

Move this marker and all of the displays will show the corresponding measurements for each packet.
Good In-Band Response from a Single Modem

Move this marker and all of the displays will show the corresponding measurements for each packet.
Bad In-Band Response from a Single Modem

Move this marker and all of the displays will show the corresponding measurements for each packet.
Good In-Band Response from a Single Modem

Move this marker and all of the displays will show the corresponding measurements for each packet.
These “diamond shapes” in the constellation pattern indicates the presence of linear distortions such as micro-reflections and group delay.

This “2nd harmonic of the Cable Modem carriers also indicates the presence of laser clipping!
Linear Distortions – Group Delay

Chart displays the delay of the signal from the CM to RPM3000 over the frequency of the carrier

Chart is generated from equalized data (vs unequalized data)

Common Causes:
- Operation too close to diplex roll-off
- Defective diplex filters
- Notch Filters
- Microreflections

- X-Axis: Frequency (covers frequency range of the carrier)
- Y-Axis: Delay of the signal in nS at each frequency
- Interpretation:
  - Max peak to peak variation across the entire carrier frequency can exceed Threshold value and still not fail
    - Remember: Pass/Fail is based on peak to peak per 1MHz slice of spectrum
Delay versus frequency

- If delay through a filter is plotted on a graph of frequency (x-axis) versus time delay (y-axis), the plot often has a parabola- or bathtub-like shape.
Imagine a group of runners with identical athletic abilities on a smooth, flat track …

All of the athletes arrive at the finish line at exactly the same time and with equal time delay from one end of the track to the other!

Example courtesy of Holtzman, Inc.
Group Delay: An Analogy

Now let’s substitute a group of RF signals for the athletes. Here, the “track” is the equivalent of a filter’s passband.

All of the frequencies arrive at the destination at exactly the same time and with equal time delay through the filter passband!
Back to athletes, but now there are some that have to run in the ditches next to the track. Some athletes take a little longer than others to arrive at the finish line. Their time delay from one end of the track to the other is unequal.

Example courtesy of Holtzman, Inc.
Substitute RF signals for the athletes again. The “track” is a filter’s passband, the “ditches” are the filter’s band edges.
Group delay exists, because some frequencies—the ones near the band edges—took longer than others to travel through the filter!

Now take the dotted line connecting the frequencies and flip it on its side. The result is the classic bathtub-shaped group delay curve.
Common Sources of Group Delay

- Common sources of group delay in a cable network
  - AC power coils/chokes (affects 5~10 MHz in the upstream)
  - Node and amplifier diplex filters (affect frequencies near the diplex filter cutoff region in the upstream and downstream)
  - Band edges and roll-off areas
  - High-pass filters, data-only filters, step attenuators, taps or inline equalizers with filters
  - Group delay ripple caused by impedance mismatch-related micro-reflections and amplitude ripple (poor frequency response)
The Fix?

- Use adaptive equalization available in DOCSIS 1.1, 2.0 and 3.0 modems (not supported in DOCSIS 1.0 modems)
- Avoid frequencies where diplex filter group delay is common
- Sweep the forward and reverse to ensure frequency response is flat (set equipment to highest resolution available; use resistive test points or probe seizure screws to see amplitude ripple)
- Identify and repair impedance mismatches that cause micro-reflections
- Use specialized test equipment to characterize and troubleshoot group delay (group delay can exist even when frequency response is flat)
Filter on a DSAM MAC using MACTrak

- Choose the **Filter** Tab from the **QAMTrak Analyzer** Settings Screen
- Select which item(s) you wish to filter on
  - Filters can be combined – any combination of the three
- MER filter can use Equalized or Unequalized MER
- Codeword Error filter can filter on packets with Uncorrectable codeword errors or any Codeword errors
  - Filters on number of CWE’s per packet, not CWE rate
- MAC address filter can use “.”, “;”, or no separators between character pairs

**Filter on a DSAM’s MAC Address**
“Ping” To Any IP Device On The Network

Allows up to 10 pre-stored IP addresses

Configure the Ping feature for a Packet Size of 1518 and the Time Between Pings for 0 seconds

- **Packet Size Selection:** 64, 128, 256, 512, 1024 & 1518 (in bytes)
  - Select 1518 for MACTrak Filtering

- **Time Between Pings:** 0, 10 ms, 25 ms, 50 ms, 100 ms, 1 sec, 2 sec & 5 sec
  - Select 0 for MACTrak Filtering
Field View QAM Option on DSAM\textsuperscript{XT} Meters

- Field View QAM is a chargeable option for DSAM\textsuperscript{XT} hardware ONLY!
- Works with RPM3000 cards and HCU200s
- Requires remote access to WebView from outside the firewall

Only measures packets from DSAM based on DSAM MAC address

QAMTrak/MACTrak measurement results displayed on DSAM\textsuperscript{XT}
Field View QAM Option

- Single person troubleshooting with live “in-band” DOCSIS® upstream carriers
- View critical “in-band” QAMTrak measurements right on your DSAM
- More convenient than laptop for out-of-truck usage for:
  - Seeing node health status from the field (CWE’s still occurring?)
  - Localizing “invisible” linear impairments in the field
  - Quantifying DOCSIS channel parameters from any point in the field to the headend/hub
  - Use Field View QAM after identifying and fixing issue to verify that repair was effective
Testing for Linear Distortions in the Home

House

Drop Cable

1. TAP
2. 2-Way Splitter
3. High Pass Filter
4. 4-Way Splitter

Ground Block

OLDER TV SET

DIGITAL SET-TOP

COMPUTER

VoIP

ONLINE GAMING

eMTA-CABLE MODEM

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JDSU CONFIDENTIAL & PROPRIETARY INFORMATION
Testing for Linear Distortions in the Home
Testing for Linear Distortions in the Home

1. TAP
2. Drop Cable
   - Ground Block
   - 2-Way Splitter
   - 4-Way Splitter
   - High Pass Filter
   - House
   - eMTA-CABLE MODEM
   - ONLINE GAMING
   - VoIP
   - COMPUTOR
   - DIGITAL SET-TOP
   - OLDER TV SET

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How To Troubleshoot/Localize Linear Impairments

1. Start at customer's ground block, register meter on suspect carrier
   1a. Check meter packets demod’d at headend on laptop
2. If bad go to tap, check packets
3. If bad at tap, go to input test point at next amp that is feeding tap.
4. If good at amp test point, then either the tap or hardline cable
   between the amp and subscriber’s residence may be bad.
5. Once localized fix the issue (Bad hardline cable in this example)
6. **VERIFY FIX** using customer CM or DSAM meter packets.
DSAM SmartID™

USB to Mini-USB

Tap or Ground Block

CPE Locations
Trouble shooting displays show fault location and cause

20dB loss
Value & Benefits
– Dramatically reduced test and fault find time for in-home wiring
– It’s a coax qualifier and fault locator
– Certify in-home coax wiring for future service turn ups and avoid repeat visits
– Know if a faulty drop cable can be salvaged or not.

Why should you care
– By focusing on fixing the physical issues that impact all services in the home, contractors/installers/operators can be assured that no matter which version of technology is present, the coax will be capable of handling it.
Powerful Digital Testing and Troubleshooting

Find impairments with QAM Ingress!

Track down intermittent performance with DQI!

Find signal issues
Identify amplifier problems

Segment Voice problems

Prepare for VOD & HSD

Reduce service calls
– 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
JDSU – See Digital in a Whole New Light!

See digital in a whole new light!

Questions?

kelly.watts@jdsu.com
Defective modem
Bad Mini-Connector at the Input of CMTS Causing Excessive Loss
3.2 MHz Wide Carriers Spaced at 3.0 MHz

These 3.2 MHz wide carriers should be spaced at a minimum of 3.2 MHz between center frequencies!
Severe Transient Hum Modulation

- The RF choke can saturate with too much current draw and cause the ferrite material to break down.
- Same thing can happen in customer installed passives.
- Notice that this looks a lot like CPD.
DSAM with HomeID: Deliver Whole-Home DVR Service with Lowest Rate of Return Service Calls

- Overcome the new challenges of higher frequency and signal path used by MoCA
- 70~80% of all issues are from Tap down
  - 80% of those are from physical / craftsmanship problems: loose connectors, bad cables etc.

- Now there will be a way to rapidly certify and troubleshoot the most untested part of the plant
  Available Summer of 2011
  - Locate coax issues loose connectors and cables
  - MoCA + Triple-play coverage (4 MHz ~ 1.6 GHz)
  - Home wiring topology
  - Cost effective integration with DSAM\textsuperscript{XT}
  - < 6 months pay back by just reducing 2 repeat truck rolls / month / technician
PathTrak™ Return Path Monitoring Benefits

Troubleshoot nodes faster to reduce MTTR and increase workforce efficiency

• Identify impairments before rolling a truck using both spectrum and LivePacket™ technology
• Use Field View™ with SDA and DSAM field meters to quickly locate ingress, the most common impairment
• View performance history to understand transient problems to roll a truck at the right time to find and fix the issue

Reduce trouble tickets and customer churn by identifying problems before your subscribers

• Rank nodes using convenient web-based reports for proactive maintenance
• Easily and quickly detect impairments such as fast impulse noise, ingress, CPD, and laser clipping on all nodes 24/7
• View live spectrum, QAMTrak™ analyzers and a wide array of reports conveniently via the web
How RPM3000s Help You Solve Your Toughest Problems

With RPM3000 cards and WebView 2.5 you can:

- **Identify which impairments are causing customers service to be impacted**
  - Codeword errors indicate high likelihood of data corruption within packets

- **Troubleshoot an intermittent issue with repeat truck rolls (over a long period) using MACTrak**
  - Filter on customers MAC, capture at *what time they go bad* and the *nature of the impairment*

- **Troubleshoot a customer complaint before rolling a truck using MACTrak**
  - Filter on customers MAC address, see if their packets are bad *right now* and *why?*

- **Segment linear impairments using a DSAM**
  - Filter on DSAM packets and see impairment turn off *in real time* via WebView if problem fixed was “The” problem

- **Identify plant impairments on a node flagged by your corporate node ranking system**
  - Find and fix the impairments to get your nodes off of the regional worst nodes list quickly

- **Check robustness of a 16QAM carrier before converting to 64QAM**
  - Measure group delay, in-band response, microreflections, MER without disrupting customer HSD/VOIP services

- **Identify bad cable modems** (faulty equipment for impairments like noisy transmitters)

- **Test out of band prior to advanced DOCSIS 3.0 carrier turn-up**
  - Know that empty spectrum is ready to support advanced services before live carrier turn-up
Key HFC T&M Solutions that JDSU Provides

JDSU designs award winning solutions that provide greater visibility into your HFC network health and enabling your workforce to proactively monitor and perform preventative maintenance activities

- **PathTrak™ Return Path** Monitoring
  - Real-time RF spectrum and QAM analyzer troubleshooting

- **PathTrak WebView** - Web Based Access to Live Spectrum and QAM analyzers and Historical Measurements plus Node Certification and Ranking Reports

- **PathTrak Video** Monitoring - RF/QAM and MPEG - Real-time RF spectrum and QAM MPEG analyzer troubleshooting

- **SDA** and **DSAM** portable field QAM and RF Spectrum Analyzer and Sweep Platforms
  - PathTrak Field View - remote spectrum analyzer on SDA and DSAM meters

- **Test Productivity Pack** – Web Based Meter Management software and Home Certification Reports

- **DTS** – Portable and Rack Mounted MPEG Analyzers

- **NetComplete** - End-to-end Status Monitoring, and Performance Management
  - QT-600 VoIP/MPEG IP Probe

**Buy one solution at a time or buy them all together…. Either way JDSU has you covered**
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
References

- Hranac, R. “Group delay” *Communications Technology*, January 1999
- Williams, T. “Tackling Upstream Data Impairments, Part 1” *Communications Technology*, November 2003
References

- Williams, T. “Tackling Upstream Data Impairments, Part 2” *Communications Technology*, December 2003

- Hranac, R. “Microreflections and 16-QAM” *Communications Technology*, March 2004

- Hranac, R. “Linear Distortions, Part 1” *Communications Technology*, July 2005

- Hranac, R. “Linear Distortions, Part 2” *Communications Technology*, August 2005
64 QAM and 256 QAM are used for both digital video and DOCSIS® downstream carriers, allowing more digital data transmission using the same 6 MHz bandwidth

- Transmit equivalent of 10 to 12 standard definition or 2 to 3 high definition (HDTV) programs over one 6 MHz bandwidth

QPSK (4 QAM) and 16 QAM are part of the DOCSIS 1.0/1.1 upstream specifications

32 QAM & 64 QAM are also part of the DOCSIS 2.0/3.0 upstream specifications
QAM Data Capacity (Annex B)

<table>
<thead>
<tr>
<th></th>
<th>16 QAM (Upstream)</th>
<th>64 QAM (Downstream)</th>
<th>256 QAM (Downstream)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symbol Rate (Msps)</td>
<td>2.560 (@ 3.20 MHz)</td>
<td>5.0569 (@ 6 MHz)</td>
<td>5.3605 (@ 6 MHz)</td>
</tr>
<tr>
<td>Bits per symbol</td>
<td>4</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Channel Data Rate (Mbps)</td>
<td>10.24</td>
<td>30.3417</td>
<td>42.8843</td>
</tr>
<tr>
<td>Information Bit Rate (Mbps)</td>
<td>9.0</td>
<td>26.9704</td>
<td>38.8107</td>
</tr>
<tr>
<td>Overhead</td>
<td>12.11%</td>
<td>11.11%</td>
<td>9.5%</td>
</tr>
</tbody>
</table>
Upstream Data Rates (Mbps)

Data Rates by Modulation and Channel Width

DOCSIS 2.0 enables the use of 32 QAM and 64 QAM and up to 6.4 MHz wide channels

Source: Motorola
Nielsen’s Law - Per User Bandwidth Consumption

The per-user bandwidth consumption trend shows increased utilization over time.

Source: Motorola
Pre and Post FEC BER

- **Forward Error Correction**
  - when working will output $>10^{-9}$
    - 1 error in 1 billion bits
    - Less than 1 error every 25 seconds
    - MPEG-2 likes good BER
- **FEC will work to about $10^{-6}$**
  - 1 error in million bits
  - 40 errors every second
- **FEC causes Cliff Effect**
DOCSIS® Testing – Levels, MER & BER

Verify proper receive level at cable modem
Should be seeing: 0dBmV

MER shows that downstream is clean and clear with margin

BER shows that downstream is clean and clear of impulse noise

Shows that upstream is properly aligned and CMTS has “ideal” receive level with margin to spare. Recommend: (45dBmV – 50dBmV)

Pass/Fail Indicator:

Downstream Information
Frequency, Modulation type, Channel

Upstream Information
Frequency, Modulation type, Channel BW, DOCSIS version

Downstream Information
Frequency, Modulation type, Channel

Upstream Information
Frequency, Modulation type, Channel BW, DOCSIS version
DOCSIS® – Throughput Testing

Check Throughput for proper speeds

DSAM tests at full DOCSIS 3.0 speeds

Ensure customer can get what they pay for
DOCSIS® 3.0 Bonded Carrier Testing

Verify full DOCSIS 3.0 bonded speeds

Drill down to see performance details of each individual QAM channel

Summary view quickly identifies overall performance

Example of downstream graph view

Example of upstream table view
DOCSIS® – Packet Loss Testing

- Check Packet Loss and determine if upstream is good
- View Downstream performance
- Overall loop information, Upstream & Downstreams
- Upstream Signal to Noise Ratio
DOCSIS® VoIPCheck Testing

Test network performance with RTP packets

- Uses RTP packets instead of Internet Control Message Protocol (ICMP) messages (Ping messages)
- CMTS won’t discard test messages returning incorrect test results
- DOCSIS data testing for:
  - Throughput
  - Packet Loss

**Ping test still uses Ping messages**
VolPCheck™ Diagram – Segmentation Screen

DSAM

HFC

CMTS

Core IP Network

JDSU’s Advanced IP Server

Real VoIP Communications

Media Gateway

Customer Premise

Headend or Hubsite

VoIP Network

JDSU’s Advanced IP Server

Media Gateway
VoIP Testing over DOCSIS®

- Segment HFC and IP impairments
  - Identify if issues are occurring in HFC Plant or in the IP network

- Quick quality (MOS) verification of VoIP over DOCSIS channel

- Good to check VoIP packet statistics
  - Noise and Ingress on plant are major causes of Packet Loss
VoIPCheck™ over DOCSIS®

- **HFC Performance**
  - Packet Statistics
    - Packet loss
    - Delay
    - Jitter
  - VoIP Quality
    - MOS
    - R-Value
  - Test Result Totals
    - Current
    - Min
    - Max
    - Average

VoIP check parameters (jitter buffer, codec, etc.) can be adjusted to match parameters of deployed MTA's