10G or Bust: HFC & the Future Access Network

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Thursday, July 15, 2021

11:00 am – 12:00 pm ET

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Today’s Speakers

Alan Breznick
Cable/Video Practice Leader
Light Reading

Dean Stoneback
Senior Director of Engineering & Standards
SCTE

Steve Condra
R&D and Product Management
Teleste Intercept

John J. Downey
Senior CMTS Technical Leader
Cisco Systems

Asaf Matatyau
VP. Solutions & Product Management
Harmonic
Agenda

• **Light Reading** - 10G overview
• **Teleste Intercept** - Possibilities & limitations of ESD return path
• **Cisco** - Path to higher US throughput
• **Harmonic** - Cable broadband investment strategy
• **SCTE** - Training, standards & certifications
• **Audience Q&A**
Cable’s Great 10G Quest

- Branded at CES in 2019 with 5G wireless in mind
- Access network agnostic: HFC, FTTP, wireless, etc.
- Targeting symmetrical speeds of at least 10 Gbit/s
- Enhanced security
- Lower latency
- Greater reliability
Cable’s Early 10G Efforts

- Mediacom conducts 10G Smart Home demo in Ames, Iowa
- Comcast tests symmetrical 1.25 Gbit/s on HFC in Jacksonville, Fla.
- Virgin Media trials symmetrical 2.2 Gbit/s on HFC in Southampton & Manchester
- Comcast tests symmetrical 4+ Gbit/s over HFC (FDX) in Denver lab trial
Scaling HFC Networks in 2020

1) Expand the Pipe
   - Plant Upgrade (1.2 GHz)
     - Mid-Split or High-Split
   - DOCSIS 3.1: OFDM & OFDM-A
     - (Profile Management, PNM)

2) Reduce # of homes sharing the Pipe
   - Fiber Deep
   - Distributed CCAP Architecture
   - Node Splits

3) Deliver data & content more efficiently
   - MPEG-4 Digital Video
   - Managed IPTV
   - Adaptive Bit Rate Encoding
Steve Condra
R&D and Product Management
Teleste Intercept
Possibilities and limitations of the Extended Spectrum DOCSIS return path

Steve Condra
Senior Director, Engineering and Product Management
Teleste Intercept
“DOCSIS 4.0 technology supports up to 10 Gbps speeds downstream capacity and up to 6 Gbps upstream capacity, easily allowing for multi-gigabit symmetric services over HFC networks.”

https://www.cablelabs.com/technologies/docsis-4-0-technology

From HFC standpoint the higher upstream capacity requires:

- Higher frequencies, higher gain, higher RF power
- Advanced constellations (1K, 2K OFDM) requiring better RF performance
- More advanced amplifiers (when N≠0)

- What “more advanced amplifiers” means, besides better RF performance ...
- Why does the changing outdoor temperature become an additional challenge?

Improved RF stability = Higher MER;  Higher MER = Higher Modulation;  Higher Modulation = More Bits

More Bits = More $$
1K OFDMA upstream, amplifier clusters

- Noise cumulation (funneling), assumption: around 20 (4x5) amps below an RPD

\[
MER_{RPD-US} = -10 \log_{10} \left( 10^{\frac{MER_{CM-US}}{-10}} + 4 \times 5 \times 10^{\frac{CNR_{amp}}{-10}} \right) \rightarrow MER_{RPD-US} \approx 40 \text{ dB}
\]

- However, due to the changing outdoor temperature.....
Test (from -4°F to 140°F )

Network Analyzer

Heating Chamber

17 dB@ 1.2 GHz
20 dB@ 1.2 GHz
26 dB@ 1.2 GHz
23 dB@ 1.2 GHz

Note: Internal (but not external) temperature compensation always on

Coax: 100 ft = 2.83 dB @ 1.2 GHz, 100 ft = 1.07 dB @ 204 MHz
Upstream frequency responses

![Graph showing upstream frequency responses with different temperature references. The graph includes lines representing temperatures of -4°F, +77°F, and +140°F. Key points include a 1.5 dB increase at 10 MHz and a 4 dB increase at 204 MHz.](image)

- **Frequency [MHz]**: 10, 30, 50, 70, 150, 170, 190, 204, 220
- **Temperature References**:
  - -4°F
  - +77°F reference
  - +140°F
Consequences

Attenuation decreases, modems have lower output level, at some point input levels of amplifiers are too low.

→ Noise rises → Lower MER

Attenuation increases, modems have higher (if possible) output level, at some point amplifiers are overloaded.

→ Distortion → Lower MER
Note: Internal and external temperature compensation on

By following downstream changes, we can make real-time upstream adjustments

- Return Follows Forward (RFF) = Return path ALSC
- Return path ALSC has been used successfully in Europe together with 204 MHz upstream
Upstream frequency responses (RFF ON)

-4°F RFF ON
+77°F reference
+140°F RFF ON
Summary

1. As upstream frequencies rise, outdoor temperature changes cause return path issues
2. Issues become visible above 100 MHz and problematic above 204 MHz
3. By following forward path changes (RFF), all seasonal maintenance visits can be avoided
4. More information / results above 204 MHz will be published at fall technical forum
For more information, please contact: steve.condra@telesteintercept.com
Audience Poll I

When will the cable industry need to go beyond 1 Gig broadband speeds?

• Cable already needs to go beyond 1 Gig
• By the end of this year
• By the end of 2022
• By the end of 2023
• By the end of 2024
• No need
Path to Higher US Throughput

John J. Downey
Sr. CMTS Technical Leader
Cisco Systems
Prerequisites and Potential Issues

• DAA inevitable
  ➢ High US spectrum on analog link = greater potential laser clipping

• Need to replace line equalizers, subscriber drop pads/EQs (whether standalone or in tap), and house amps

• Adjacent device interference (ADI) affects STB AGC & analog TV IF
  ➢ Filters in house where needed just like MoCA
  ➢ Gateway architecture

• Home passives can generate passive device intermodulation (PDI) distortion when hit with high US Tx

• FM-band & Off-Air Broadcast potential interference

• Leakage testing?
D3.1 - 204 MHz US Pros and Cons

• Pros
  ➢ No special CMs, available to buy with programmable diplex
  ➢ No special nodes with echo cancellation
  ➢ No need for N+0
  ➢ Can still achieve potentially 1.5 Gbps aggregate speed
  ➢ DAA advantages along with no US laser clipping

• Cons
  ➢ 204 MHz could be troublesome for N+3 or higher
  ➢ Coax loss and temperature effects and no US AGC
  ➢ Legacy STB OOB at 104 MHz, DACs at 75 MHz
  ➢ Leakage testing at 138 MHz
  ➢ FM carriage in European markets
D3.1 US Spectrum Thoughts

• Increasing US spectrum = more coax loss & tilt from CM to CMTS
  ➢ US max Tx level issues
  ➢ DRW violations (12 dB)

• More USs may lead to laser clipping
  ➢ OFDMA even in 42 MHz may cause issues with AM link
  ➢ 85 or 117 MHz may necessitate EDR (digital return) (A/D clipping?)
  ➢ 204 MHz may necessitate DAA (Remote-PHY, FMA, …)

• No US ALC/AGC
  ➢ Relying on CM/CMTS long-loop-level control and CM 12 dB DRW
  ➢ Typical +/-2 dB swing @ 42 MHz (annual thermal fluctuations) w/ 4000’ coax
  ➢ CMTS US level settings and adjustable range
Potential Fixes for Higher US Freqs

- **No Coax**

- **Conditioned taps - EQs & InvEQs for levels & DRW issues**
  - Field Equalizers (FEQs) at least
  - EQ 5 MHz - 1.2 GHz, no cutoff & grp delay or concern for diplex changes later

- **Thermal issues**
  - Underground cable
    - Passives still above ground
  - US thermal EQs to help stabilize negative fluctuations on cold days
    - Higher noise floor assuming aerial plant
  - Idea of US AGC driven by DS AGC circuitry or I-AMP

- **D3.0 CM with Extended Pwr ECN = 54 dBmV max for 4-ch bonding**

- **D3.1 CM has ~ 5 dB more power per equivalent 8-ch D3.0 CM**
  - D3.1 = 65 dBmV total avg power
D3.1 CMTS US Rx Example for 85 MHz

Note: OFDMA level displayed on analyzer affected by amount of traffic; have seen where level does not match expected unless peak hold & send enough traffic to reach 70-90%

4 SC-QAM & 43 MHz ODMA
108+352 = 460 Mbps

*Could also drop some ATDMA
Example 1: 23 MHz & 96 MHz OFDMA
54+108+187+807 = 1156 Mbps

Example 2: 66 MHz & 96 MHz OFDMA
108+555+807 = 1470 Mbps

- Need to address CMs that support 42, 85 and 204 MHz in same plant
- Issues locking on correct US BG
  - Have smaller OFDMA from 42 to 85 & another above 85 to avoid concerns
  - Avoid FM band & just do 108-204
    - Then we lose 85-108 spectrum
- Working group looking at this and how to create partial mode scenario properly
D3.1 - 204 MHz Implementation Today

• Surgically place at MDUs

• Compact shelf with modularity provides
  - Multiple RF outputs (SGs) for risers in bldgs
  - Easy powering
  - Rack and stack

• CMs placed where needed

• Older CMs still work fine
Closing Points

• US AGC based on DS ALC possible - if necessary
  ➢ I-node and i-amp could utilize auto-leveling

• Be aware of US temperature affects @ 204 MHz
  ➢ Design 48 dBmV +/-3 dB for taps with < 25 dB of coax between RPD & tap, 46 +/-2 dB otherwise

• Fiber deep architectures with DAA will allow better performance and higher D3.1 modulation along with higher speeds

• Conditioned taps alleviate US power & tilt issues
  ➢ Disparate SC-QAM US ch widths exacerbate D3.1 CM DRW issues
    ✓ Get rid of narrow SC-QAMs in TCS

• Need to research ADI & PDI concerns

• Legacy devices will go through attrition leading to more efficiency
  ➢ Drop SC-QAMs, add more OFDM on DS, & allocate more OFDMA on US
Asaf Matatyau
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July 15, 2021
KEY TRENDS IMPACTING BROADBAND MARKET

CONSUMPTION SURGING
Capacity and peak speed

SERVICE PROVIDER COMPETITION
5G and fiber

GOVERNMENT ENGAGEMENT
Regulatory intervention resulting in investment cycle (e.g., RDOF, municipal fiber, city carriers, European Green Deal)

LightReading
US cable to face stiffer fiber competition as telcos get more aggressive ➔

Fierce Telecom
AT&T eyes multi-gig move as part of fiber plan ➔

Broadband World News
US cable operators face rising fiber threat ➔
CABLE’S NEXT-GEN SOLUTION

DENSIFICATION: FIBER DEEPER
- Multi-Gigabit DOCSIS
- Fiber to the Home (PON)
- Ethernet and Mobile Backhaul

DISAGGREGATION: DAA, VIRTUALIZATION
Scalability & Performance:
- Open, Best-of-Breed Choices
- Lower Cost, Space & Power

VALUE ADD SERVICES
- Higher QoE (Low Latency)
- Network & Service Analytics
- Edge Compute

A CONVERGED BROADBAND PLATFORM
CABLE BROADBAND INVESTMENT STRATEGY
A PORTFOLIO OF OPTIONS

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<th>Datacenter</th>
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<td>CCAP</td>
<td>RF</td>
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**CONVERGED BROADBAND PLATFORM**

**vOLT/vBNG**
**Video core**
**Edge router**
**vCMTS**
**vCMTS**

**Ethernet Switch (DAAS)**

**R-OLT**
**DAA3.1**
**DAA FD**
**R-DAAS**
**DAA4.0**

**SPECTRUM / UPSTREAM BANDWIDTH**

- 100Mbps
- 2Gbps

**DIGITAL NODE = EXPANDED UPSTREAM**

1. **1.7Gbps**
2. **7Gbps**

**SIMILAR TO (1) + FTTH/PON ON R-OLT**
For heavy users and MDUs

3. **1.7Gbps**
4. **7Gbps**
5. **10G Symmetric**

**FIBER DEEP | STEP TO FTTH**
Reuse of DOCSIS for last mile

**NEW DOCSIS 4.0**
For expanded bandwidth. 2024-2025 target

4. **3.5Gbps**
5. **7Gbps**

**FTTH/PON**
Network construction and new CPEs

5. **10G Symmetric**
CABLE / DOCSIS & FIBER / PON CONVERGENCE

MULTI-ACCESS EDGE
A single platform for simpler DOCSIS and PON operation

PON READY
Ethernet-based connectivity to remote devices

CLOUD-NATIVE BENEFITS
Scalability and performance

FEATURE VELOCITY
Leveraging common subscriber and traffic management capabilities
10G
The Next Great Leap for Broadband

SPEED
- DAA
- D3.1 DS, US (1+ Gbps)
- PON (10 Gbps)
- D4.0 Full Duplex (FDX)
- D4.0 Extended Spectrum (ESD)

RELIABILITY
- Proactive Network Maintenance
- Fiber Deep Disaggregation
- Cloud-Native Virtualization
- Connected Operation (AI/ML)

LATENCY
- Low Latency DOCSIS
- Low Latency Xhaul
- Improved Gaming
- VR QoE
- Edge Compute

SECURITY
- AI/ML/Anomaly Detection
- Isolate/Prevent Threats
- Cable and Home Networks
- IoT Services

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• Information Classification: General
CLOUD-NATIVE VIRTUALIZATION
10G NETWORK TRANSFORMATION

Speed
• Runs on COTS servers with 100Gbps NICs
• 1 Gbps+ symmetric services with vCMTS
• 10 Gbps symmetric services with vPON

Reliability
• Improve service uptime for mission critical services
• Smaller operating domains with reduced failover times
• Predict/react to network issues faster

Security
• Software is the defense to quickly adapt and deflect new security threats

Latency
• Deliver best qualify of experience for “real-time” experiences, such as gaming and AR/VR

Future Proof
• Adapt to future requirements with software upgrades
THANK YOU.
When do you plan to deploy PON with DOCSIS in your HFC network?

• In the next year
• In the next 1 to 3 years
• In the next 3 to 5 years
• More than 5 years from now
• No plans to deploy PON
Dean Stoneback
Senior Director
Engineering & Standards
SCTE
SCTE’s Award Winning Standards Are Leading the Cable Telecommunications Industry

Data Communications
Network Operations
Interface Practices
Digital Video
Energy Management

THE ONLY ANSI-ACCREDITED program in the cable industry

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Top service providers and OVER 1,100 subject matter experts.

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10G Initiatives in the SCTE Standards Program

- Reliable network powering (EMS)
- Proactive network maintenance (NOS)
- Measurement practices (NOS)
- Business continuity / disaster recovery (NOS)
- Human impact on network operations (NOS)
- Artificial intelligence / machine learning (DSS)
- 3 GHz actives and passives (IPS)
- Generic Access Platform (IPS)
- Edge computing inside the Generic Access Platform (IPS)

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Standards Supporting Extended Spectrum

3 GHz Task Force

- Evaluate all IPS Standards to determine how to best update them to match the DOCSIS 4.0 specifications.
- Standardized text to be used in IPS standards
- Standardized approaches such as specification tiering or the creation of equipment “classes” so that both legacy and future equipment can be accommodated

1.8 / 3.0 GHz Hardline Taps and Passives

- Created standards for 1.8 / 3.0 GHz taps and passives including:
  - Mechanical specifications and requirements for electrical performance
  - 1.8 GHz faceplate and 3 GHz housing
  - For taps: RF bypass mode that maintains AC and RF through housing when faceplate is removed
- SCTE 264 2020: Broadband Radio Frequency Hardline Taps for Cable Systems
- Coming soon: SCTE 265 Broadband Radio Frequency Hardline Passives for Cable Systems
Standards Supporting Extended Spectrum

1.8 GHz Amplifiers – Being Developed Now – Get Involved

• Traditional bandwidth expansion approach
  • Adds additional 600 MHz of spectrum beyond today’s state-of-the-art amplifiers

• Supports higher upstream speed by standardizing higher frequency upstream/downstream splits (204, 300, 396, 492 MHz, etc.)

• Provides prospective equipment vendors with guidance that will help them to design and manufacture standardized products to support full utilization of DOCSIS 4.0 in the network

• Standards-based product development helps ensure that products meet the needs of operators and enables multi-vendor equipment interoperability

Chairs & Vice Chairs:
David Job, Cox
Greg Kueneman, Shaw
Nick Segura, Charter

Dedicated Authors:
Mike Whitley, ATX
Steve Condra, Teleste

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Wendell Weeks
Chairman & CEO,
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Next Months Webinar

Tapping Into the Cloud

8/19/2021 11:00 am New York / 8:00 am Los Angeles

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