Distributing
High-Definition TV
on
Coax

InfoComm
June 9-11, 2010
Las Vegas, NV
Overview

[1] Digital 101
   TV Standards
   Transmission Standards
   Interfaces & Measurements

[2] Digital Solutions

[3] Troubleshooting QAM
Commercially-made television sets, or TVs, have been available since 1928. And although TVs today use various display technologies such as CRT (Cathode Ray Tube), LCD (Liquid Crystal Display), or PDP (Plasma Display Panel, or Plasma), they all can be classified into two basic types, namely Analog TV and Digital TV.

**Analog TV**

An analog TV is **equipped with an analog tuner** and is capable of displaying video and sound information received in an analog format only. In North America, that analog format must adhere to the NTSC standard. Analog TVs typically utilize a CRT display with a screen width-to-height ratio of 4:3. Per FCC mandate, televisions sold in the US after May 25, 2007 should contain a digital tuner (also known as ATSC tuner) compatible with the 8VSB standard (Digital Off-Air), or should be identified at the point-of-sale as not having one.

**Digital-Ready TV**

Not exactly a Digital TV, nor exactly an Analog TV, Digital-Ready TVs are typically an **Analog TV equipped with an internal digital tuner (ATSC tuner)**. A digital-ready TV can receive and display analog and digital off-air programs without the need for an external 8VSB-to-analog converter box. To ensure that a TV set is equipped with digital/ATSC tuner you should consult its user manual or manufacturer’s documentation. However, most digital-ready TVs are marketed with labels such as “Integrated Digital Tuner” or “Digital Tuner Built-In.” In some cases, the word “Receiver” may be substituted for “Tuner”. In other cases, the words “DTV”, ATSC”, or “HDTV” may be substituted for “Digital.” Most digital-ready TVs have a display aspect ratio of 4:3. Per FCC mandate, all TVs sold in the US after July 1, 2007 were equipped with ATSC tuner.
Digital TV

A digital TV is equipped with an analog tuner, a digital/ATSC tuner, and a QAM (Quadrature Amplitude Modulation) tuner. Digital TV sets typically utilize an LCD or Plasma display and are classified, based on their display resolution, as an SDTV (Standard-Definition Television) or HDTV (High-Definition Television).

**SDTV:** A digital TV capable of displaying 480 actively-interlaced vertical lines of resolution is usually considered an SDTV. As such, an SDTV is also known as a “480i” set. A typical SDTV has a display aspect ratio of 4:3, and a resolution of 720x480 (345,600 pixels).

**HDTV:** A digital TV set capable of displaying at least 720 vertical lines of resolution is usually considered a HDTV. A typical HDTV has a display aspect ratio of 16:9 and is available in the following video formats and display resolutions:

<table>
<thead>
<tr>
<th>Video</th>
<th>Display Resolution</th>
<th>Displayed Pixels</th>
</tr>
</thead>
<tbody>
<tr>
<td>720p</td>
<td>1280 x 720</td>
<td>921,600</td>
</tr>
<tr>
<td>1080i</td>
<td>1280 x 1080</td>
<td>1,382,400</td>
</tr>
<tr>
<td>1080p</td>
<td>1920 x 1080</td>
<td>2,073,600</td>
</tr>
</tbody>
</table>
Interlace
First, all odd lines are scanned (1/60 sec), then all even lines (1/60 sec), presenting a full picture (1/30 sec)

Progressive
All lines are scanned in a single pass, presenting a full picture (1/60 sec)
Analog NTSC: Off-Air & Modulated RF

Standard: Vestigial Sideband (VSB)

Low Edge of Channel: 1.25 MHz

6 MHz Channel Width

High Edge of Channel: 4.5 MHz

3.58 MHz

Video Carrier

Video Info

Audio Info

Color Carrier

Sound Carrier

0.25 MHz
One 8VSB channel may contain 1 High-Definition (HD) program identified as 2.1 and several Standard-Definition (SD) programs identified as 2.2, 2.3, 2.4, etc.

Each 8VSB channel occupies almost the entire 6 MHz (5.6 MHz) bandwidth.
Each QAM channel occupies almost the entire 6 MHz channel allocation.

Available QAM modes are 16, 32, 64, 128, 256, 512 & 1024.

In the US, QAM 64 and 256 are the most common.
**SDI** (Serial Digital Interface) refers to a family of video interfaces standardized by SMPTE (Society of Motion Picture and Television Engineers).

One of the standards, known as **HD-SDI** (High-Definition Serial Digital Interface) or SMPTE 292M, provides a nominal data rate of 1.485 Gbit/s.

A second standard, known as **SD-SDI** (Standard-Definition Serial Digital Interface) or SMPTE 259M, provides a nominal data rate of 270 Mbit/s.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Name</th>
<th>Common Bitrate</th>
<th>Typical Video Formats</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMPTE-259M</td>
<td>SD-SDI</td>
<td>270 Mbit/s</td>
<td>480i</td>
</tr>
<tr>
<td>SMPTE-292M</td>
<td>HD-SDI</td>
<td>1.485 Gbit/s</td>
<td>720p, 1080i</td>
</tr>
</tbody>
</table>
Quadrature Amplitude Modulation (QAM)

Uses two carrier waves of identical frequency, shifted 90 degrees apart, each modulated to one of two or more possible discrete amplitude levels. Each combination of amplitude levels on the two carriers translates to a binary bit pattern.

I and Q components

Are two halves of a digital data bit pattern transmitted simultaneously, as voltage levels of two identical frequency carriers, but phase shifted 90 degrees apart. The I (Incidence or in-phase) component modulates the carrier in-phase with the clock (unshifted). The Q (Quadrature) component modulates the carrier phase-shifted 90 degrees from the clock.
QAM 256

256-Point Signal Constellation
38.8 Mbps bitrate
Can accommodate:
- 1xHD (1080i) channel at 36.5 Mbps,
- or 2xHD (720p) channels each at 17.6 Mbps,
- or 4xSD channels (480i) each at 8.8 Mbps,
- or 1xHD (720p) channel at 17.6 Mbps + 2xSD (480i) channels at 8.8 Mbps,
- Etc.

QAM 64

64-Point Signal Constellation
26.9 Mbps bitrate
Can accommodate:
- 1xHD (1080i) channel at 17.9 Mbps,
- or 4xSD channels (480i) each at 4.2 Mbps,
- or 1xHD (720p) channel at 8.8 Mbps + 2xSD (480i) channels at 4.2 Mbps,
- Etc.
QPSK/ 8PSK Transmission

In North America, the satellite programs are transmitted primarily in digital format using the following two standards:

- **QPSK** (Quadrature Phase Shift Keying)
- **8PSK** (8th-order Phase Shift Keying)

The QPSK programs are typically transmitted in the C-band (3.7 to 4.2 GHz) and the Ku-band (11.7 to 12.2 GHz).

The 8PSK programs are typically transmitted in DBS (12.2 to 12.7 GHz). DBS (Direct Broadcast Satellite), also known more broadly as direct-to-home, is a term used to refer to satellite television broadcasts intended for home reception.

QPSK/8PSK transcoders are typically designed to receive and then transcode to QAM all programs transmitted from each satellite transponder while maintaining all Digital features.

If, however, the programs are encrypted, appropriate de-encrypting set-top boxes are required (for example for DishNetwork & Hits programs).
## Analog & Digital Interfaces

<table>
<thead>
<tr>
<th>Name</th>
<th>Video</th>
<th>Audio</th>
<th>Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite/RCA</td>
<td>Analog</td>
<td>Analog</td>
<td><img src="image" alt="Composite/RCA" /></td>
</tr>
<tr>
<td>S-Video</td>
<td>Analog</td>
<td>Analog</td>
<td><img src="image" alt="S-Video" /></td>
</tr>
<tr>
<td>Component</td>
<td>HD Analog</td>
<td>Analog</td>
<td><img src="image" alt="Component" /></td>
</tr>
<tr>
<td>RGB</td>
<td>HD Analog</td>
<td>Analog</td>
<td><img src="image" alt="RGB" /></td>
</tr>
<tr>
<td>DVI</td>
<td>Digital</td>
<td>Analog</td>
<td><img src="image" alt="DVI" /></td>
</tr>
<tr>
<td>ASI / SDI</td>
<td>Digital</td>
<td>Digital</td>
<td><img src="image" alt="ASI / SDI" /></td>
</tr>
<tr>
<td>HDMI</td>
<td>Digital</td>
<td>Digital</td>
<td><img src="image" alt="HDMI" /></td>
</tr>
</tbody>
</table>

*Other ports or connectors you may see on CATV equipment:*

- **Toslink**: a fiber connector used for Digital Audio
- **Coaxial**: an RCA type connector used for Digital Audio
**S-Video (Super-video):** sends video signals over a multi-wire cable, dividing the video information into two separate signals (75 ohm coax or twisted pair cables) - one for luminance (Light) 'Y' and one for chrominance (Color) 'C'. Each signal is sent shielded, enclosed in a 4-pin Mini-DIN. S-Video is synonymous with Y/C "Component" video. S-Video cables are available from 1.5 to 150 feet in length.

**Composite Video:** is a composite of the black-and-white information (Y) and the color information (C). The video signal is sent over a single "Yellow" shielded RCA jack (75 ohm coax cable), and the audio signal is sent the “Red & White” RCA jacks. Composite Video may also be called VBS (Video, Blanking and Syncs), or CVBS (Color, Video, Blanking, and Sync). Composite Video cables are available from 1.5 to 150 feet in length.

**Component Video:** is also called YPbPr, or YCbCr and transmits the picture information in a luminance and phase-opposite chrominance pair over three coax cables (Red, Green, and Blue). Component Video cables are available from 1.5 to 150 feet in length.

**HDMI:** The High Definition Multimedia Interface cable supplies both high-definition video and multi-channel, digital audio for consumer Audio Visual (AV) entertainment equipment. The HDMI interface is all digital, with no analog signals. HDMI cables are available from 1.5 to 60 feet in length.

**ASI & SDI:** Asynchronous Serial Interface and Serial Digital Interface are digital signals transmitted at 270 Mbps over a single 75 ohm coaxial cable (BNC connector) for up to 600 feet. These signals are typically QAM-modulated for distribution over a CATV network. BNC cables are available from 1.5 to 150 feet in length.
# Units of Measurement (dBmV vs Microvolt)

**Reference Voltage Level:**

0 dBmV = 1000 microvolts across 75 Ω

<table>
<thead>
<tr>
<th>dBmV</th>
<th>uV</th>
</tr>
</thead>
<tbody>
<tr>
<td>-10</td>
<td>300</td>
</tr>
<tr>
<td>-6</td>
<td>500</td>
</tr>
<tr>
<td>0</td>
<td>1000</td>
</tr>
<tr>
<td>+5</td>
<td></td>
</tr>
<tr>
<td>+6</td>
<td>2000</td>
</tr>
<tr>
<td>+12</td>
<td>4000</td>
</tr>
<tr>
<td>+15</td>
<td></td>
</tr>
<tr>
<td>+18</td>
<td>8000</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>+60</td>
<td>1V</td>
</tr>
</tbody>
</table>

**Typical Digital Input Range to a Tuner**

**Typical Analog Input Range to a Tuner**
BER (Bit Error Rate) is the ratio of errored bits to the total number of bits transmitted, received, or processed over a defined length of time.

Example: 3 errored bits in a total of 1,000,000 transmitted bits will result in a BER of: $\frac{3}{1,000,000} = 0.000003 = 3 \times 10^{-6}$.

MER (Modulation Error Ratio) is the ratio, in decibels, of average symbol power to average error power: \[ \text{MER(dB)} = 10 \times \log \left( \frac{\text{average symbol power}}{\text{average error power}} \right) \]

MER is influenced by everything present in the signal’s transmission path such as: Phase Noise; CNR (Carrier-to-Noise Ratio); CTB distortion (Composite Triple Beat); CSO distortion (Composite Second Order); Cross Modulation (X-mod); Micro-reflections (Ghosting); Amplitude tilt/ripple; Group Delay; Ingress.

<table>
<thead>
<tr>
<th>Picture Quality</th>
<th>MER (8VSB)</th>
<th>MER (QAM 64)</th>
<th>MER (QAM 256)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>Greater than 30 dB</td>
<td>Greater than 38 dB</td>
<td>Greater than 38 dB</td>
</tr>
<tr>
<td>Good</td>
<td>25 to 30 dB</td>
<td>30 to 38 dB</td>
<td>35 to 38 dB</td>
</tr>
<tr>
<td>Marginal</td>
<td>18 to 25 dB</td>
<td>23 to 30 dB</td>
<td>30 to 35 dB</td>
</tr>
<tr>
<td>Non-Functional</td>
<td>Less than 18 dB</td>
<td>Less than 23</td>
<td>Less than 30 dB</td>
</tr>
</tbody>
</table>
CNR vs BER

CNR (dB)

BER

QPSK

16-QAM

64-QAM

256-QAM

10^{-2} 10^{-3} 10^{-4} 10^{-5} 10^{-6} 10^{-7} 10^{-8} 10^{-9} 10^{-10} 10^{-11} 10^{-12}
Mixing Analog & Digital Channels

To help maintain the relative signal level difference between Analog and Digital after adjusting for a sloped output from the amplifier, do the following:

When using QAM 64, set signal level of digital channels **8 to 10 dB below** the equivalent Analog channels.

When using QAM 256, set signal level of digital channels **6 to 8 dB below** the equivalent Analog channels.

**Note:** Last channel shown in diagram above is an analog pilot channel.
Overview

[1] Digital 101
  TV Standards
  Transmission Standards
  Interfaces & Measurements

[2] Digital Solutions

[3] Troubleshooting QAM
Off-Air Solution #1 (18VSB In > 18VSB Out)

1. Program broadcast in Digital (8VSB Standard)
2. Roof-top Antenna (Blonder Tongue BTY series)
3. Digital Processor (Blonder Tongue DHDP series)
4. Combiner (Blonder Tongue OC series)
5. 8VSB-to-Analog Converter is required to view the program on an Analog TV

NOTE: Not all ATSC capable TV’s can receive 8VSB broadcasts on a CATV channel assignment. In this scenario a conversion to another broadcast channel assignment would be necessary.
Off-Air Solution #2 (1 8VSB In > 1 QAM Out)

1. An existing Analog HeadEnd & Distribution Network
2. Program broadcast in Digital (8VSB Standard)
3. Roof-top Antenna (Blonder Tongue BTY series)
4. 8VSB-to-QAM Transcoder (Blonder Tongue AQT series)
5. QAM-to-Analog Converter

---

1. TV: Analog (Analog Tuner Only)  
   Display: ONLY the Analog CATV programs
2. TV: Analog (Analog Tuner Only)  
   Display: BOTH the Analog CATV & the Digital off-air programs,  
   but not in Hi Def quality
3. TV: Digital-Ready (Analog + ATSC Tuners)  
   Display: ONLY the Analog CATV programs
4. TV: Digital-Ready (Analog + ATSC + QAM Tuners)  
   Display: BOTH the Analog CATV & the Digital off-air programs,  
   but not in Hi Def quality
5. TV: Digital (Analog + ATSC + QAM Tuners)  
   Display: BOTH the Analog CATV & the Digital off-air program,  
   in Hi Def quality
Satellite Solution #1  (1 QPSK/8PSK In > 1 QAM Out)

1. An existing Analog HeadEnd & Distribution Network
2. CLEAR[1] feed from satellite provider in QPSk or 8PSK formats
3. QPSK/8PSK-to-QAM Transcoder (Blonder Tongue QTM series)
4. QAM-to-Analog Converter

[1] CLEAR means that the program is NOT encrypted by the satellite provider. If the program is encrypted, then additional de-coding settop boxes must be installed at the TV set.
Satellite Solution #2 (1 QPSK/8PSK In > 1 QAM Out)

1. An existing Analog HeadEnd & Distribution Network
2. Encrypted[1] feed from satellite provider in QPSk or 8PSk formats
3. Integrated Receiver Decoder (IRD) with ASI output
4. ASI-to-QAM Modulator (Blonder Tongue AQM series)
5. QAM-to-Analog Converter

[1] ENCRYPTED means that the program is encrypted by the satellite provider. The IRD performs the decoding, therefore, no additional settop boxes are necessary at the TV set.
Application: Free-to-Guest Premium HD Services

1. Premium HD programs (HBO, ESPN, …) are acquired by the satellite receivers whose output is in encrypted IP format (DTCP-1P) – not suitable for distribution over coaxial cable.

2. DTCP-1P streams are aggregated on a typical Gigabit Ethernet (GbE) switch.

3. The GbE output of the switch is then fed into **Blonder Tongue EdgeQAM-400** series which converts the DTCP-1P streams into Pro:Idiom™-encrypted QAM that can be distributed over hotel’s existing coaxial network.

4. Each EdgeQAM-400 can deliver up to 24 Pro:Idiom™-encrypted programs which ensures content protection during transmission.

5. HD programs are delivered to every room as part of the Free-to-Guest TV service.

6. Using a remote control, hotel guests can watch the HD programs for free and on a Pro:Idiom™ Digital TV – No convertor box is required.
Cable Solution (1 QAM In > 1 QAM Out)

1. An existing Analog HeadEnd & Distribution Network
2. CATV feed from cable company containing CLEAR[1] Digital CATV (QAM) programs
3. QAM-to-QAM Transcoder (Blonder Tongue AQT series)
4. QAM-to-Analog Converter

NOTE: Most QAM-to-QAM transcoders maintain all digital information including Aspect Ratio, Program Info, and SD Multicasts. They also provide a complete regeneration of the digital input which results in an optimal MER performance.

[1] CLEAR means that the program is NOT encrypted by the cable company. If the program is encrypted, then additional decoding settop boxes must be installed at the TV set.
Adding HD/SD (to an existing Analog Headend)

Input modes supported:
1: (1)xHD 1080i only
2: (1)xHD 720p+ (2)xSD (Shown here)
3: (0)xHD + (4)xSD

Satellite Receiver
- SDI (480i) (Digital Video/Audio)

Video Server
- SDI (480i) (Digital Video/Audio)

Studio Camera & Microphone
- HD (720p) (Digital Video/Audio)

Blonder Tongue HDE-ASI
Coaxial Distribution Network

Blonder Tongue AQM
QAM
Multiplexing 12 SDs onto 1 QAM channel

Blonder Tongue
SD4E-ASI

ASI #1
(270 Mbps)

ASI #2
(270 Mbps)

ASI #3
(270 Mbps)

SD Programs
#1 to #4

SD Programs
#5 to #8

SD Programs
#9 to #12

QAM

Coaxial Distribution Network

Blonder Tongue
DQMx
Multiplexing 10 SDs or AVs onto 1 QAM channel

- Video Server
- Studio Camera
- Model: AQD Stock No. 6245
  - 2x SD-SDI (480i)
- Digital Broadcast (8VSB)
- Model: MDDM Stock No. 6273
- Satellite Receiver
- 3x AV or 5x AV
- Output set to RF Channel 55
- 1x QAM
- 10 programs on 10 virtual channels 14.3, 49.8, ...

User can configure PSI P table to allow the 10 programs to be displayed on any major/minor channel combination.

Blonder Tongue SD10E-QAM
Multiplexing 2 YPbPr & HDMI onto 1 QAM channel

1x QAM
Output set to RF Channel 55

2 programs on Virtual channels 40.3 & 70.12

Blonder Tongue Laboratories 2010 InfoComm
Multiplexing 2 HDs onto 1 QAM channel

Blonder Tongue HDE-ASI

HD Program#1 (1080i)

ASI #1 (270 Mbps)

HD Program#2 (1080i)

ASI #2 (270 Mbps)

Blonder Tongue DQMx

QAM

Coaxial Distribution Network
1. Content in AV/SD/HD/HDMI/YP_{b}P_{r} formats is encoded and modulated into sub-band QAM (Blonder Tongue Encoders such as SD10E, HDE-ASI, ...)

2. Content is sent to the head end over the coax via return path

3. 8VSB/QAM-to-QAM Processor re-inserts the content into the standard channel lineup (Channels 2-135) (Blonder Tongue AQP)
Blonder Tongue Laboratories 2010 InfoComm

**Blonder Tongue MDDA**
Availability: 3Q2010

8VSB OR QAM → ASI

**Blonder Tongue EQAM-420**
Availability: 4Q2010

Clear IP (GbE) → 8x QAM
(24 HD Programs)

**Blonder Tongue IPAT**
Availability: 3Q2010

IP (GbE) → ASI → IP (GbE)
Overview

[1] Digital 101
  TV Standards
  Transmission Standards
  Interfaces & Measurements

[2] Digital Solutions

[3] Troubleshooting QAM
Modulation Error Rate (MER), and (estimated) Bit Error Rates (BER) are two important measurements used to determine system impairments.

Both require test gear designed specifically for the QAM or 8VSB digital signals.

Minimum recommended MER to subscriber = 32 dB
Measuring QAM Signals
QAM 64 Constellation Analysis

[1] Good Constellation
Pattern of dots in this constellation diagram are very close to the center (crosshairs), indicating a normal constellation with no noise or distortion issues.

[2] Phase Shift Constellation
Circular effect where points in each cell are stretched out perpendicular to a radius line, in proportion to the distance from the center of the diagram, giving an overall appearance of circles around the center of the diagram. Usually caused by residual FM - typically a headend problem.

[3] CTB/CSO Constellation
Caused by coherent noise, poor CTB and CSO will cause circular patterns in each cell.

[4] Poor CNR Constellation
Fuzzy circular pattern in each cell, occupying most of the cells. Picture quality may remain good, but slight further degradation of the signal may cause loss of picture all together.
Thank You.