FIBER OPTICS FOR HD-BROADCAST
Introduction - Topics of Discussion

1. System Concept Approach in Fiber Design and Installation
2. From Analog to 24Gb/s - A Brief History of Broadcast Cable Development
3. Why and Where Do We Use Fiber Optics in AV/Broadcast?
4. Types of Fiber Optic Cable and Connectors
5. 4K-8K - Future Standards
6. Demo - Termination and Troubleshooting
7. Q&A
System Approach-Distance + Connection Points
A BRIEF HISTORY
Transition-Analog-Digital-3D-3G-4K-8K
HD/3D Mobile Unit at Kennedy Space Center

Shuttle launch filmed in 3-D by AMV Epic
May 16, 2011
6.75Gb/s Data Rate
<table>
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<tr>
<th>Data Rate</th>
<th>Cable Family</th>
<th>143 Mb/s</th>
<th>270 Mbs/s</th>
<th>1.5Gb/s</th>
<th>3Gb/s</th>
<th>12Gb/s</th>
<th>1080p</th>
<th>UHD-TV</th>
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<td></td>
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<td>NTSC Composite</td>
<td>Component SD-SDI</td>
<td>HD-SDI</td>
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<td>SMPTE 424M (Meters)</td>
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<td>Cable Type</td>
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<td>SMPTE 259M</td>
<td>SMPTE 259M</td>
<td>SMPTE 292M</td>
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<td>407</td>
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</table>

ALL DISTANCES ARE RECOMMENDED VALUES AND CAN VARY BASED ON PARTICULAR INSTALLATION
Standards: loss @ ½ clock frequency: SMPTE 259=30db SMPTE 292 and 424=20db ST2081=40db. NOTE: BER can vary dramatically as calculated limits are approached
TRIA X v. FIBER
PAL TO NTSC ADAPTERS-WORLD CUP 2015

*Dimensional Tolerances
*Materials-Insulation and Separator
*High Frequency Performance
HD VIDEO CONNECTORS

MINI DIN

BNC/ 12G BNC/HD-BNC
WHERE DO WE USE FIBER OPTICS?

Audio and Video Systems
- Camera Boom
- Instrumentation
- Control
- Mixers & Synthesizers
- TV Studios
- Recording Studios
- Sound Systems
- Microphones
- Lighting Controls

Video Walls

Data

HDMI Extenders
HD Cameras (SMPTE)
- Mobile Units
- Remote Camera
WHAT ARE THE ADVANTAGES OF OPTICAL FIBERS?

- Increased bandwidth - more information
- Lower losses - longer distances
- Smaller size & lighter weight - easier to handle
- Interference immunity - no EMI
- Transmission security - very difficult to tap
- Open circuit failure mode-no short circuits
- Inexpensive abundant raw materials
**Relative Max Distance - Copper v. Fiber**

**SINGLE MODE**

- **RG11**

- **RG6**

- **RG59**

**Legend:**
- SMPTE 311 HD
- SMPTE 259M Component
- SMPTE 259M Composite
SIZE COMPARISON: FIBER VS COPPER

To transmit the same information

Digital audio cable
Diameter: 29mm
Weight: 89kg/km

Singlemode (1 fiber)
Diameter: 2.6mm
Weight: 4kg/km
Fibers consist of centric elements of either plastic or glass. Light is guided through the fiber by Total Internal Reflection at the interface between the core and the cladding, where the core has a slightly higher index of refraction.
SINGLE MODE vs MULTIMODE

Multimode-Multiple signal paths

Singlemode-1 path-no reflections
## Optical Characteristics

<table>
<thead>
<tr>
<th>Fiber Type</th>
<th>OS2 Singlemode</th>
<th>OM1</th>
<th>OM3</th>
<th>OM4</th>
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<tbody>
<tr>
<td>Diameter core/cladding (buffer)</td>
<td>9/125µm (900µm)</td>
<td>62.5/125µm (900µm)</td>
<td>50/125µm (900µm)</td>
<td>50/125µm (900µm)</td>
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<tr>
<td>Wavelength (typical)</td>
<td>1310/1550nm</td>
<td>850/1300nm</td>
<td>850/1300nm</td>
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<tr>
<td>Max Attenuation</td>
<td>0.5db/km</td>
<td>3.5db/km</td>
<td>3.5db/km</td>
<td>2.3db/km</td>
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<td>Bandwidth</td>
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<td>200MHZ@850</td>
<td>1500MHZ@850</td>
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<td>Distance Limit (10Gb/s)</td>
<td>80km</td>
<td>30meters</td>
<td>300meters</td>
<td>550meters</td>
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<td>FREQUENCY</td>
<td>WAVELENGTH</td>
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<tr>
<td>1 MHZ</td>
<td>300 Meters</td>
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<tr>
<td>100 MHZ</td>
<td>3 Meters</td>
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<tr>
<td>1 GHZ</td>
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<tr>
<td>100 GHZ</td>
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<tr>
<td>$3 \times 10^{14}$ Hz</td>
<td>1 µ (10⁻⁴ Meter)</td>
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</table>
No individual jacket
Requires breakout kit or direct connection to a panel
Lightweight-Reduced Diameter
BREAKOUT KIT v. BREAKOUT FIBER CABLE
FIBER PATCH CORDS – 1.6mm, 2mm, 3mm
Which is best for YOUR needs?
Characteristics:

Distribution 900u
- Single-mode
- Multimode
- 2-12 Fibers
- Lightweight

Temperature Range:
- -50 a +105C
- Excellent Environmental Resistance
- For use in Harsh Environments
- Use expanded beam, TFOCA, opticalICON, other multi-contact connectors
HYBRID CABLE

- ST (Fiber)
- XLR (Audio)
- Power RJ45
- CAT 5/6
For use in Stadiums and other fixed installations to connect Multiple SMPTE cameras with a single cable

*Groups of 2 fiber (SM)
*Individually shielded groups of copper (4 conductor shielded)
TYPICAL DISCRETE CONNECTORS-1.25mm and 2.5mm
Small Form Factor 2-Fibers (A and B) Common in IT environment Can separate into 2 individual connectors*
MTP CONNECTOR – 12 OR 24 FIBER SM or MM, Standard “D” Size Receptacle
CONNECTOR TERMINATION TYPES

1. Polish-Hand or Machine
   *Many options

2. Mechanical Crimp
   *Fast and Easy
   *Simple Tooling
   *Low Cost

3. Splice On (Fusion)
   High Performance
   Fast

4. Crimp On
   (Matching Gel)
   Fast
   Good performance
   Higher cost
SMPTE CONNECTOR FOR HD CAMERAS
SMPTE STANDARD CONNECTOR
(internal view)

- 2-Fiber (Yellow and Blue)
- 2 pair copper 20awg (use as 2 conductors-black-white)
- 2 cond copper 24awg (signal-red-grey)
- 1-Steel (strength member)
SMPTE 311 CHASSIS CONNECTORS

Male – Type FMW

Female – Type PBW
SMPTE FIBER ADAPTERS AND PANELS

FOA-1FA

Either active or passive
Male or female SMPTE connector
PANELS including multiple fiber types
LEMO SMPTE, opticalCON, MTP, ST
MODULAR PANELS  opticalCON-SMPTE
Wide Range of Options
FIXED PANELS (pigtail construction)
Easy to replace or add channels
opticalCON TO LEMO ADAPTER CABLE
SMPTE FEMALE PIGTAILS TO ST
MULTI-CONTACT CONNECTORS FOR TACTICAL FIBER CABLES

Hermaphroditic up to 36 contact

Mixed contact fiber-copper

TFOCA (common-military)
EXPANDED BEAM

Direct Physical Contact

Expanded Beam (mirror)

Typical Connector - MX
Neutrik opticalCON Family

- Durable – suitable for use in mobile broadcast, sports, field
- Low maintenance
- Interface with low cost standard LC connector
- Versatile – 2-4 fiber, either SM or MM
- MTP Versions 12 or 24 fiber
- DUO-LV 2 fiber+ 4-copper
opticalCON DUO
2 Fiber with or without power - SMPTE

- Robust Construction-Easy maintenance, Common in Mobile Broadcast
- Easy Integration– LC Interface-Economical
- Compatible with LC (front)
- Suitable for use with Tactical or Hybrid Cables
opticalCON QUAD (4 Fiber)

- Robust IP Construction, Auto Shutter
- Low maintenance cost
- Easy Integration—LC Interface—Economical
- Compatible with LC (front)
- Versatile – multi-channel 4 fiber
ADAPTER opticalCON DUO to ST

Other Constructions include Box to Pigtail, Connector to Pigtail, Connector to Box. Fiber Connectors may be ST, LC, or SC.
MATERIALS USED IN FIBER CABLES

**Insulation/Buffer**
PVC

**Jacketing**
PVC-Most Common, general purpose
PE-Polyethylene, rugged, less flexible
PUR-Polyurethane, very durable, flexible
TPE-Flexible, good for outdoor use
FEP-High Temperature, stiff, expensive

**Fillers**
Kevlar (Aramid)-
Polyester

**Central Strength Member**-Stainless Steel
UL CONSIDERATIONS

NEC-National Electric Code

Classifications-CL2, CL3, CM, OF

Riser CMR

Plenum CMP

Sunlight Resistance-SR

Resistance to Oil and Gasoline

Temperature
PRODUCTION OF FOCC24 SMPTE CABLE

Even small changes in braid angle impact cable DCR, Weight, OD, and flexibility.
FIBER TERMINATION TOOLING

Polishing Machine
Consider your specific needs

Cleaver
Critical to achieve high performance fusion splices
TYPES OF POLISHING

UPC (most common)
“Ultra PC” ultra polish
> -50 to -55 dB reflection

APC- Highest performance
Angle Polish (8 deg)
> -60 to -70 dB reflection

PC Common Polish
(but not so much anymore)
> -30 dB de reflexion

APC
“Angled PC” 8 degree angled PC Ceramic ferrule
> -60 to -70 dB back reflection
STANDARD UPC POLISH

Up to 4% of the light can be reflected back towards the source.

APC POLISH

With “Angled Physical Contact” or “APC” finishes the connector tip is cut to 8, which directs the light away from the source.
FUSION SPLICER
Many options available
INSTALLATION OF F2/FS (2.0mm) SMPTE CONTACTS
Diagram 2: Critical symmetry parameters of an optical connector end face

Note in graph 1 that the maximum allowed undercut is a function of the radius of polishing of the end face. Future standards will, logically enough, also include the apex-offset in addition to the radius as a parameter for the allowance of the maximum undercut.
COMMON FIBER TERMINATION FAULTS

Diagram 3: Typical symmetry defects of polished ferrule end faces
TYPICAL POLISHING DEFECTS AND OTHER FIBER DAMAGE

- Over Polished
- Dirty
- Scratched
- Chipped
- Cracked
- Shattered
- Remaining Epoxy
- Broken Fiber

Ideal Endface
KEEPING YOUR CONNECTORS CLEAN IS CRITICAL
BOOTS AND CAPS
KEEP ALL FIBER CONNECTORS CAPPED WHEN NOT IN USE
CLEANING PEN
Dependent on ferrule size
SMPTE TEST SETS (insertion loss-electricals)
With each increase in data rate, copper usable distance shrinks

4K - SMPTE Standard 2081-1 UHDTV1 6Gb/s
8K – SMPTE Standard 2082-1 UHDTV2 12Gb/s
8K - 4320 Line – SMPTE Standard 2082-11 Data Rate of 24Gb/s