Fiber Optic Workshop:
Understanding the High Bandwidth Infrastructure

2020

CEDIA™

LEARNING ACADEMY
BICSI CONNECT

Before we begin….

- ***Everyone is muted*** – please use the webinar software to type in questions. We will get to these during breaks or at the end of the webinar.
- ***This webinar is being recorded*** – you will receive a link to the recording after the webinar concludes.
- ***This webinar counts toward industry certification and renewal credits*** – please email info@tlnetworx.com for a certificate of completion. We need your name, company, contact information and the date of the seminar.

CEDIA CEU Course Code: CEU868 | 1 CEU
BICSI CEC Course Code: OV-TECHL-WI-0320-1 | 2 CECs

The Fiber Infrastructure

Media **o**ver **F**iber **O**ptics™

Fiber is the future of AV. Signals will continue to grow in bandwidth and fiber will prove the standard in every installation.

Fiber sends signals further, more reliably and with far greater bandwidth than traditional copper. Plus, it's actually easier to work with and comparably priced.

The Fiber Infrastructure

Media **o**ver **F**iber **O**ptics™

And the fiber ecosystem isn't that much different than the copper ecosystem.

The Fiber Infrastructure

Bulk Cable
Corning ClearCurve®
Corning SMF-28 Ultra

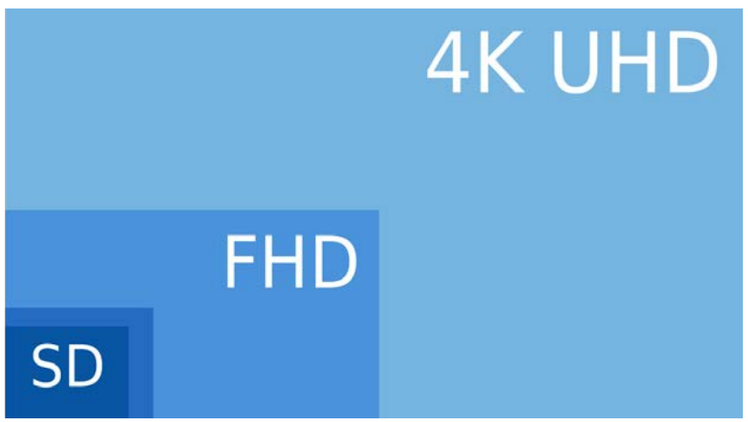
Specialty Cable
Direct burial, armored & tactical, bundled cables

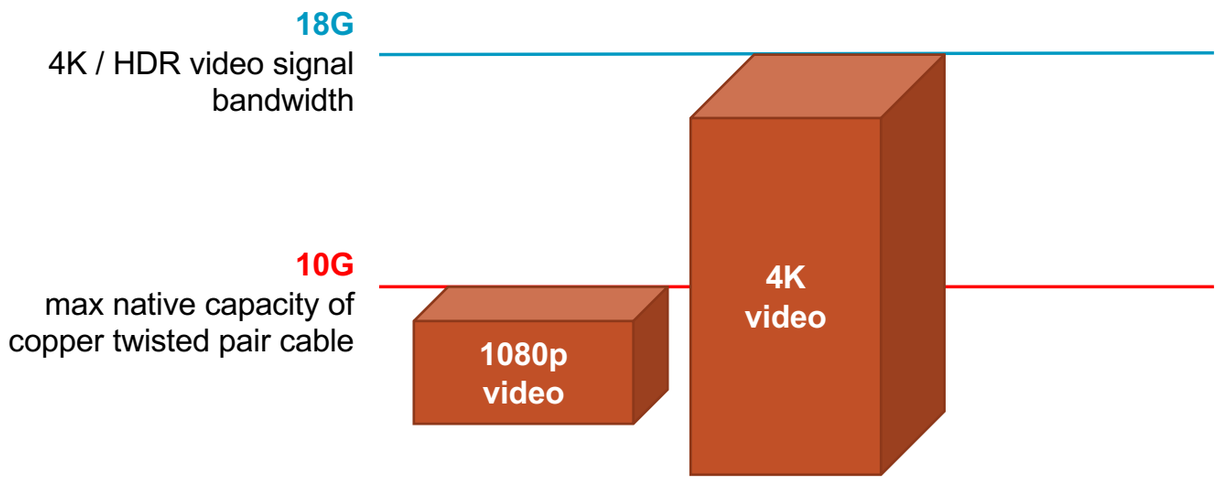
Patch Cords & Premade Cables
Pre-terminated cables built to any length & construction

Accessories
Connectors & installation accessories
Termination & test tools
Rack trays, wall-boxes & wallplates

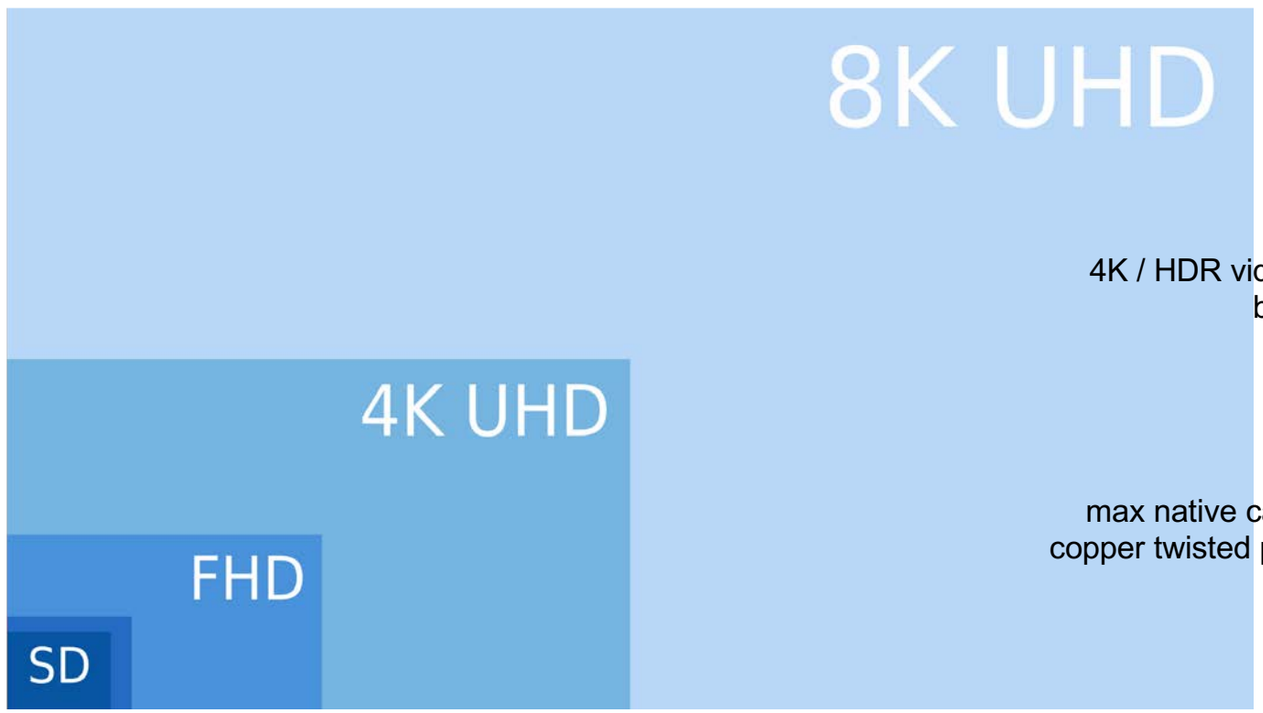
Signal Distribution Electronics
AV over fiber extenders
Network equipment
Media converters

Point-to-Point Video Bandwidth





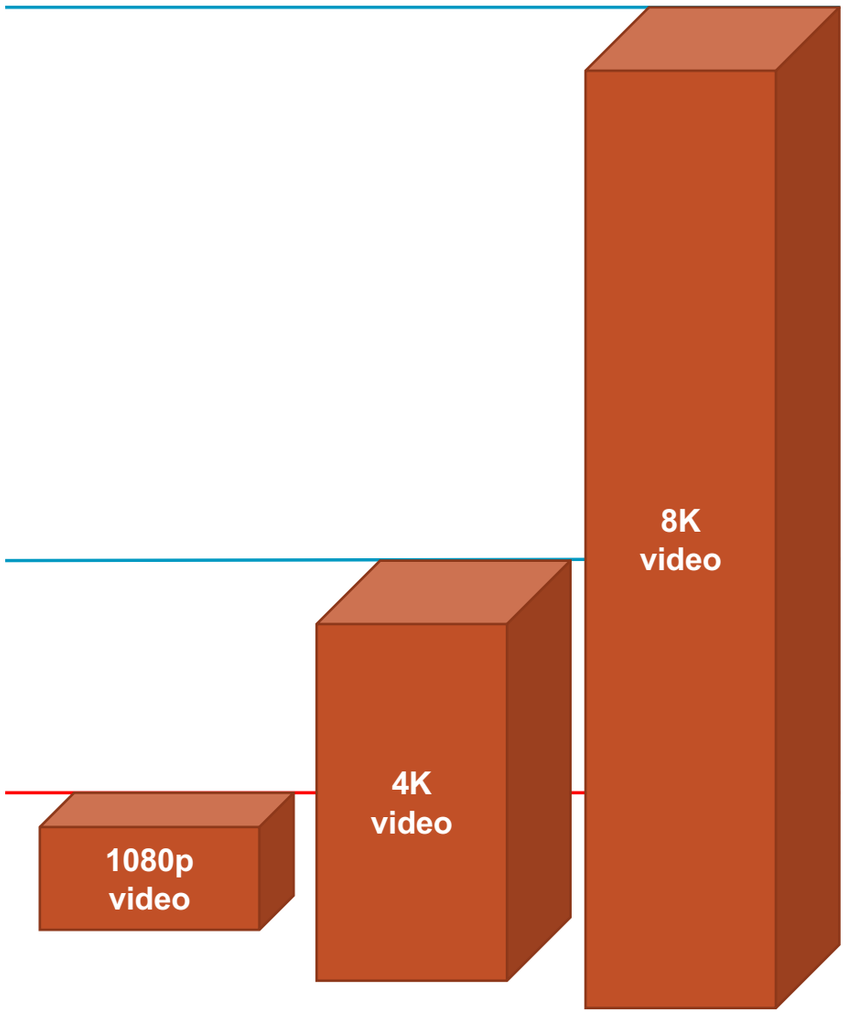
8K Bandwidth



48G
8K video signal bandwidth

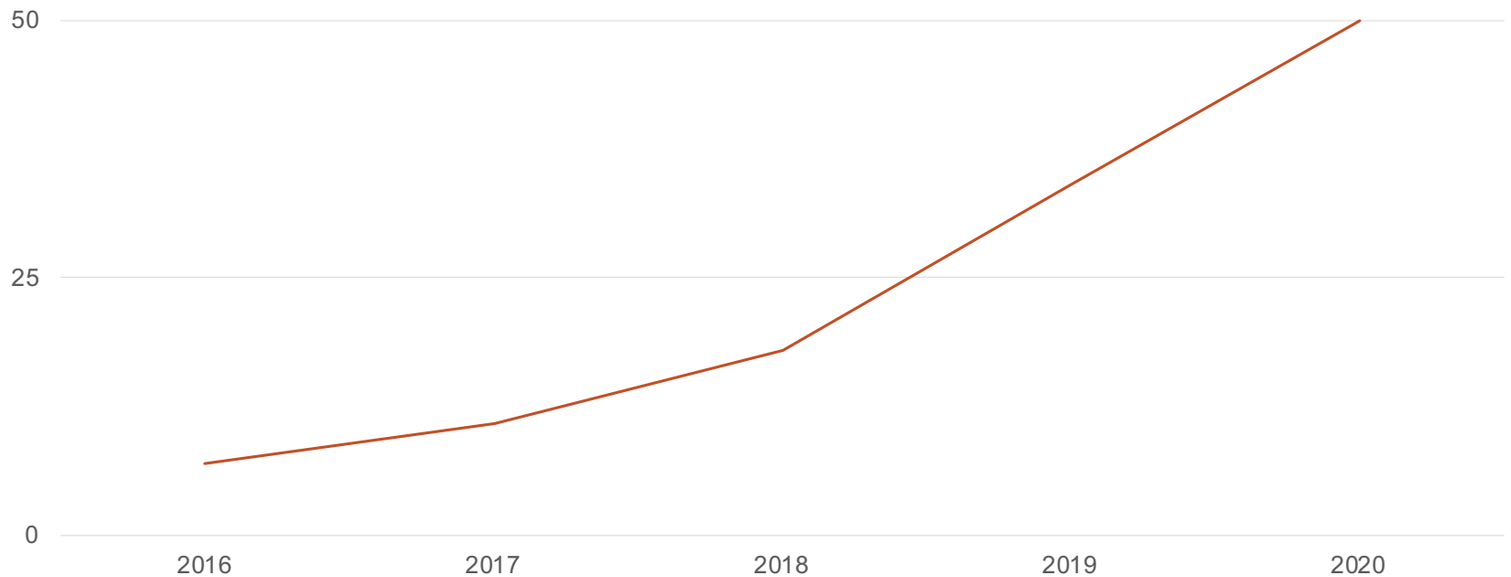
18G
4K / HDR video signal bandwidth

10G
max native capacity of copper twisted pair cable



Network Device Expansion

The growing number of connected devices per household demands a faster cable infrastructure.



Streaming Bandwidth by Device

Low Bandwidth Devices

(per concurrent connection)

- General Web-enabled Devices: 0.2Mbps
- IP Phone: 1Mbps
- Streaming Music: 1Mbps

Streaming Bandwidth by Device

Low Bandwidth Devices

(per concurrent connection)

- General Web-enabled Devices: 0.2Mbps
- IP Phone: 1Mbps
- Streaming Music: 1Mbps

Moderate Bandwidth Devices

(per concurrent connection)

- Video Doorbell: 2Mbps
- IP Security Camera: 2Mbps

Streaming Bandwidth by Device

Low Bandwidth Devices

(per concurrent connection)

- General Web-enabled Devices: 0.2Mbps
- IP Phone: 1Mbps
- Streaming Music: 1Mbps

Moderate Bandwidth Devices

(per concurrent connection)

- Video Doorbell: 2Mbps
- IP Security Camera: 2Mbps

High Bandwidth Devices

(per concurrent connection)

- Online Video Gaming: 6Mbps
- Streaming 1080p Video: 5Mbps
- Streaming 4K Video: 25Mbps
- Streaming 8K Video: 60Mbps

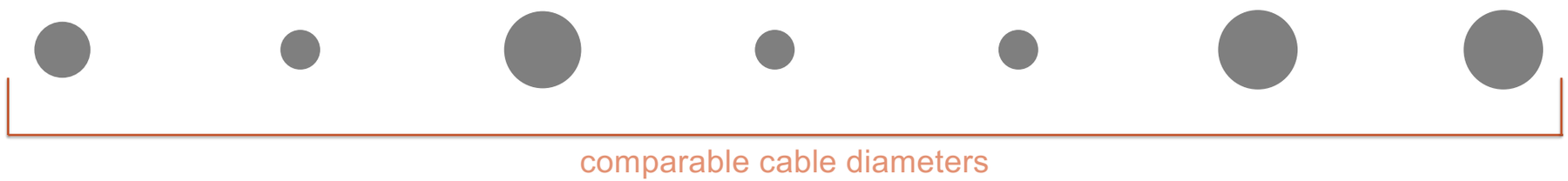
Other Benefits of Fiber

- Immunity to power surges, lightning and static electricity
- Immunity to electromagnetic interference and RF interference
- Immunity to ground loops and signal “hums”
- Zero-latency long distance signal transmission
- Immunity to corrosion

- *Fiber is easier to handle during installation*
- *Fiber is affordable*

Fiber vs. Twisted Pair

	Cat 6	SMF-28 Ultra® Duplex Single Mode	Cat 6A	ClearCurve® Duplex Multimode	Duplex with Cleerline SSF™	Cat 7 (Class F)	Cat 8
Construction	Riser	Plenum	Riser	Plenum	Plenum	Riser	Riser
Environment	Indoor	Indoor / Outdoor	Indoor	Indoor / Outdoor	Indoor / Outdoor	Indoor	Indoor
Max Bandwidth	10G	100G+	10G	100G+	100G+	10G	40G
Bend Radius	122mm	7.5mm	166mm	7.5mm	3mm	160mm	172mm
Pull Tension	25lbs.	100lbs.	25lbs.	100lbs.	220lbs.	25lbs.	25lbs.
Termination Time	<1 min	~2 min	~2 min	~2 min	~1 min	~2 min	~2 min
Cable Diameter	6.1mm	4.4mm	8.38mm	3mm	3mm	8.51mm	8.6mm



comparable cable diameters

Fiber vs. Twisted Pair

	Cat 6	SMF-28 Ultra® Duplex Single Mode	Cat 6A	ClearCurve® Duplex Multimode	Duplex with Cleerline SSF™	Cat 7 (Class F)	Cat 8
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Termination Time	<1 min	~2 min	~2 min	~2 min	~1 min	~2 min	~2 min
Cable Diameter	6.1mm	4.4mm	8.38mm	3mm	3mm	8.51mm	8.6mm
							
	comparable cable diameters						
Price per Foot	**$0.14**	**$0.20**	**$0.29**	**$0.35**	**$0.47**	**$0.48**	**$0.67**

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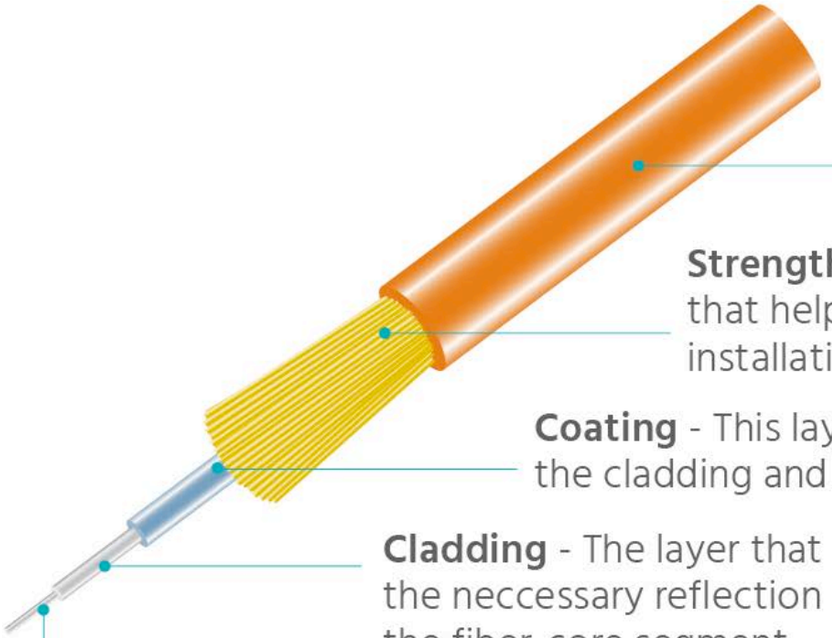
Fiber Optic Cable Construction



Cable Jacket - The outermost layer of the fiber cable.

Strengthening Fibers - The strengthening fibers that help protect the core against damage during installation or from being crushed.

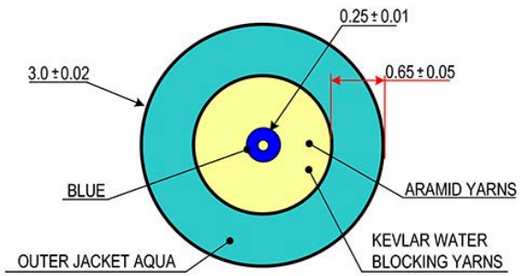
Coating - This layer of thicker plastic surrounds the cladding and helps protect the fiber core.

Cladding - The layer that protects the core and causes the neccessary reflection to allow light to travel through the fiber-core segment.

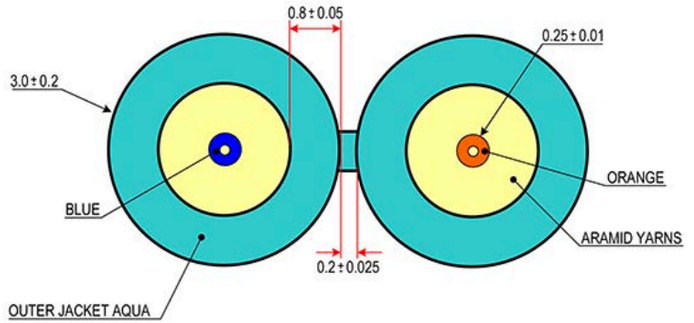
Core - The physical component that transports the optical data signal, made up of a continuous strand of glass. The core's diameter is measured in microns.

Image source: Monoprice

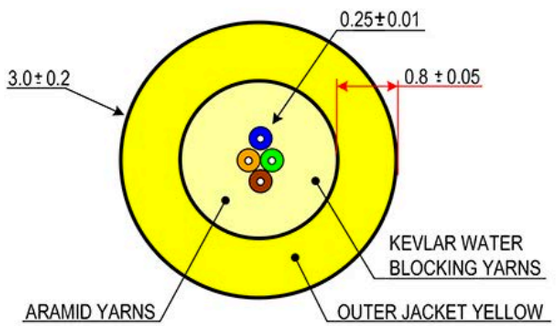
Fiber Optic Cabling: Physical Construction



Simplex Fiber



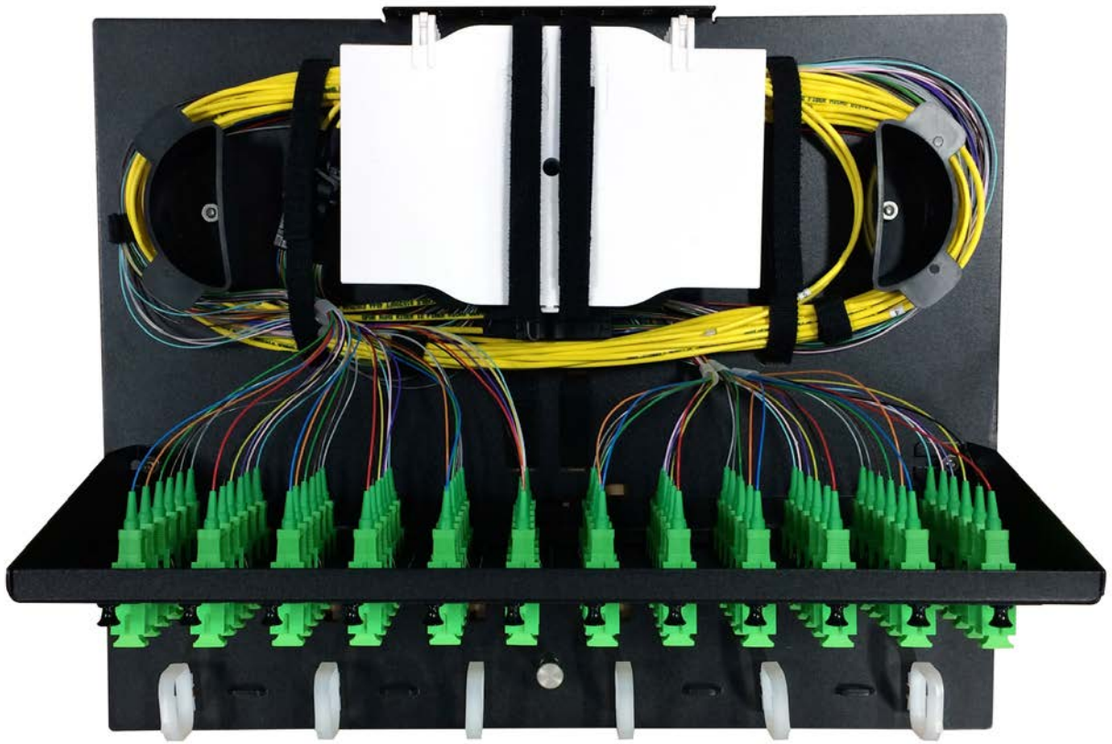
Duplex Fiber



Distribution Fiber

Image source: Cleerline

Rack-mount Enclosures



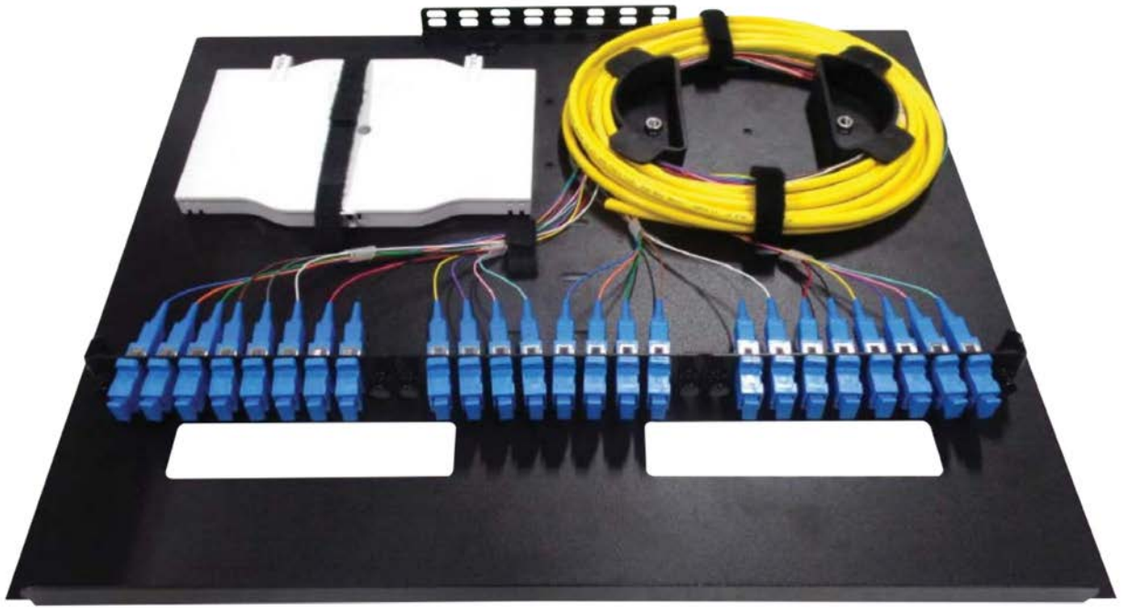
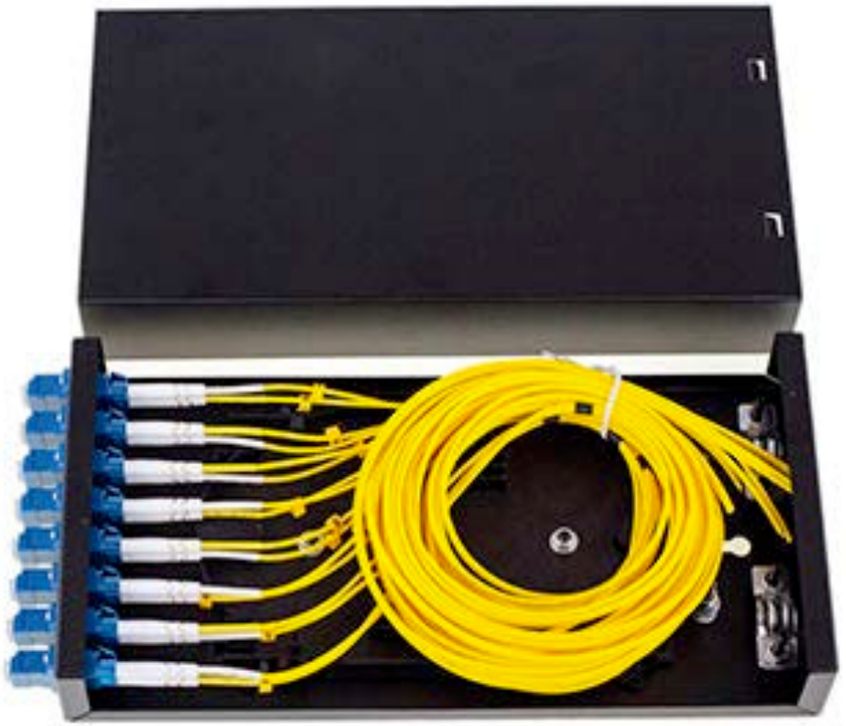


Image source: Cleerline

Wall-box Enclosures



Fiber Optic Cabling: Construction Types

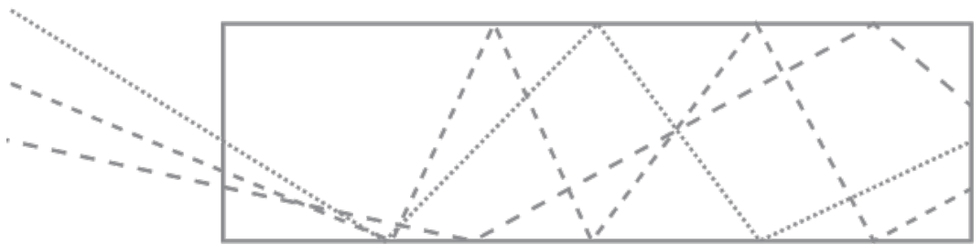
Single Mode (OS2)

- Short distance cable runs (less than 1000ft.)
- Long distance cable runs (greater than 1000ft.)
- Highest bandwidth support
- Lower cable cost
- Higher electronics cost
- Harder to terminate due to smaller core size

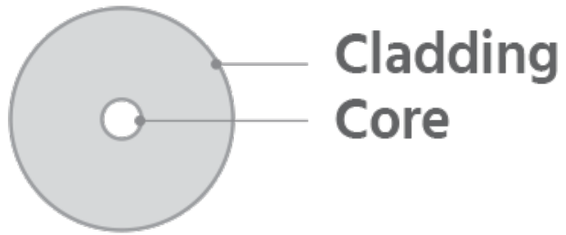
Multimode (OM3, OM4)

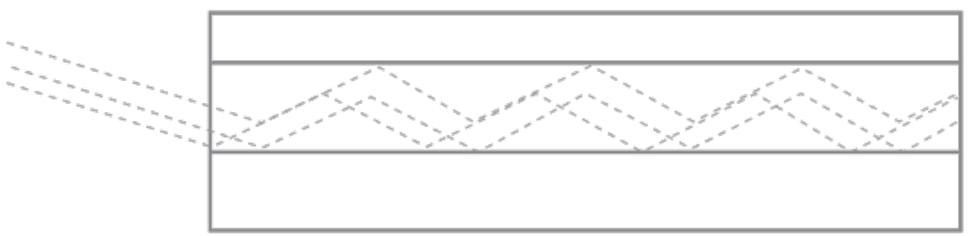
- Short distance cable runs (less than 1000ft.)
- High bandwidth support
- Higher cable cost
- Lower electronics cost
- Easier to terminate due to larger core size

Single Mode vs. Multimode Performance



Multimode





Single Mode

Image source: Monoprice

Single Mode vs. Multimode Performance

Single Mode

- OS1
- OS2

Construction

Multimode

- OM1
- OM2

LED Optimized

- OM3
- OM4
- OM5

Laser Optimized

Fiber Type	Single Mode	Single Mode	Multimode	Multimode	Multimode	Multimode	Multimode
Fiber Grade	OS1	OS2	OM1	OM2	OM3	OM4	OM5
Fiber Core Size	8 – 10.5µm (9µm common)	8 – 10.5µm (9µm common)	62.5µm	50µm	50µm	50µm	50µm
Standard Jacket Color	Yellow	Yellow	Orange	Orange	Aqua	Aqua	Lime Green

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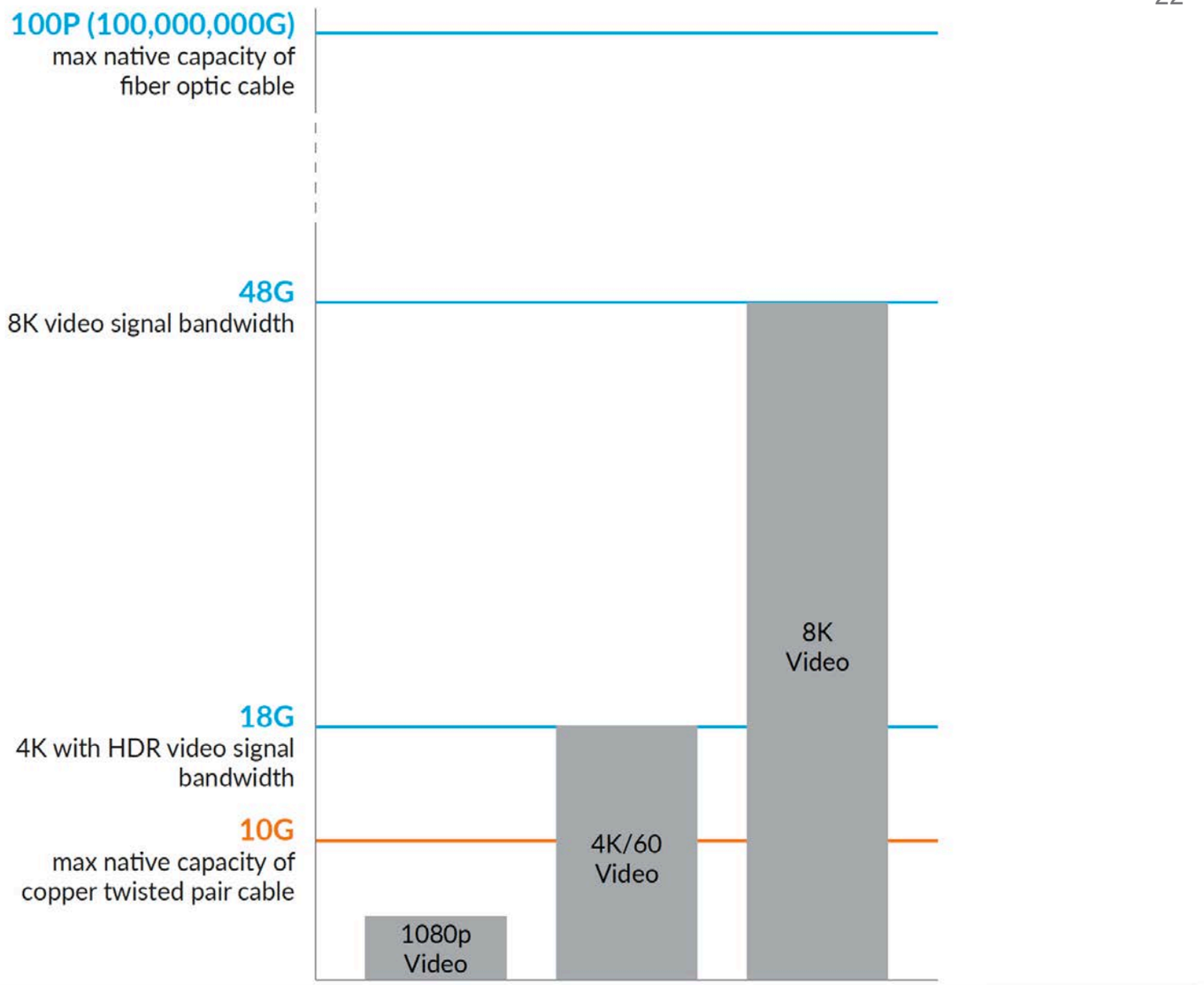
Fiber Cable Capacity



10G **Cat 6**
10G **Cat 7**
40G **Cat 8**
100,000,000G **Multimode OM3**
100,000,000G **Single Mode OS2**

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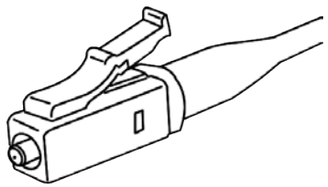
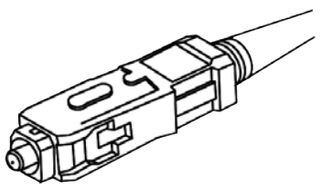
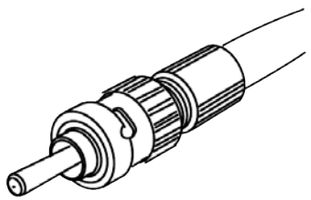
Common Connector Formats



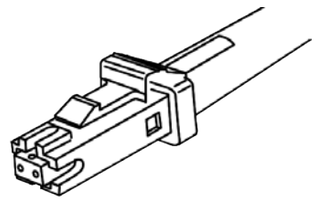
LC Connector



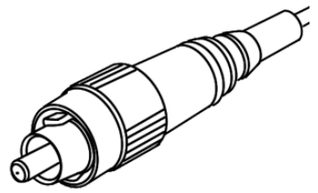
SC Connector



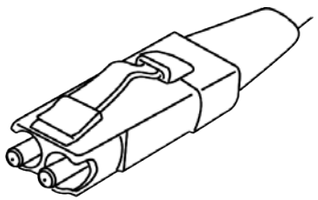
ST Connector



MTRJ Connector



FC Connector



FJ Connector

Common in Residential & Commercial AV

Fiber Type	Fiber Grade	Standard Connector Color	Connector Style	Fiber Core Size
Single Mode	OS1, OS2	Blue	flat (standard)	8 – 10.5µm (9µm common)
Single Mode	OS1, OS2	Green	angled (APC)	8 – 10.5µm (9µm common)
Multimode	OM1	Beige	flat	62.5µm
Multimode	OM2	Black	flat	50µm
Multimode	OM3, OM4	Aqua	flat	50µm
Multimode	OM5	Lime Green	flat	50µm

LC Connectors

LC Connector

- *Lucent Connector*
- Very compact size
- Used for networking, SFP modules, AV over fiber extenders, high-density connection applications

SC Connectors

SC Connector

- *Subscriber or Standard Connector*
- Larger
- Used for networking, multiplexors, media converters, demarc wiring, telecom applications

Termination Process

Step 1: slide the connector boot onto the fiber

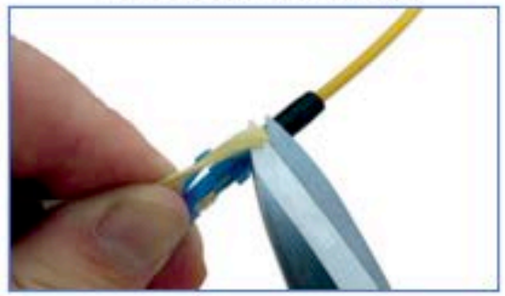
Step 2: strip back 50mm (2 inches) of the outer jacket

Step 3: separate the yarn from the fiber and use your three-hole stripper to remove the inner coating

Step 4: cleave the fiber to length (28mm for SC connectors / 24mm for LC connectors)

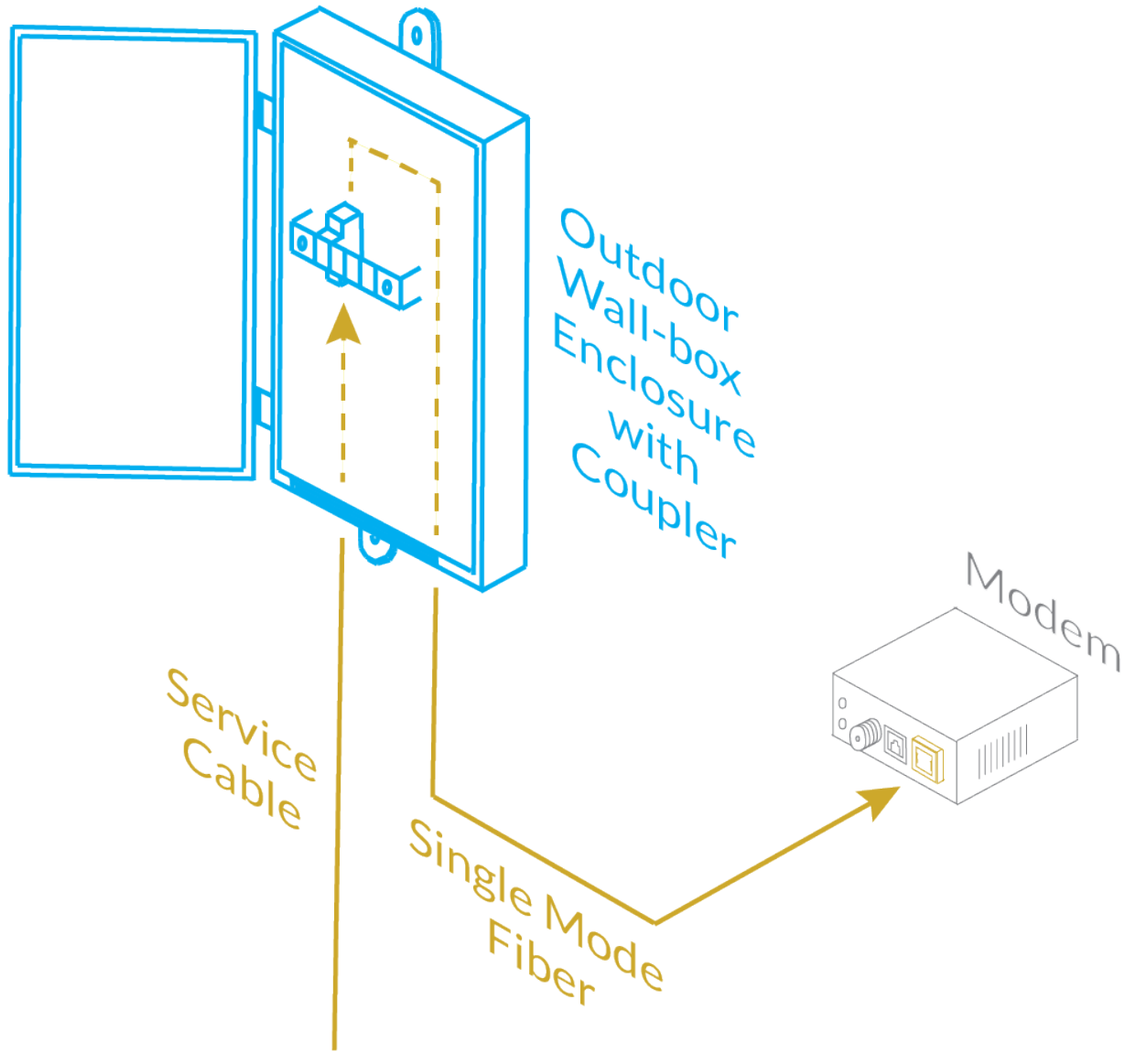
Step 5: clean any impurities from the fiber strand using an alcohol wipe

Step 6: insert the fiber into the connector and slide the locking tab closed

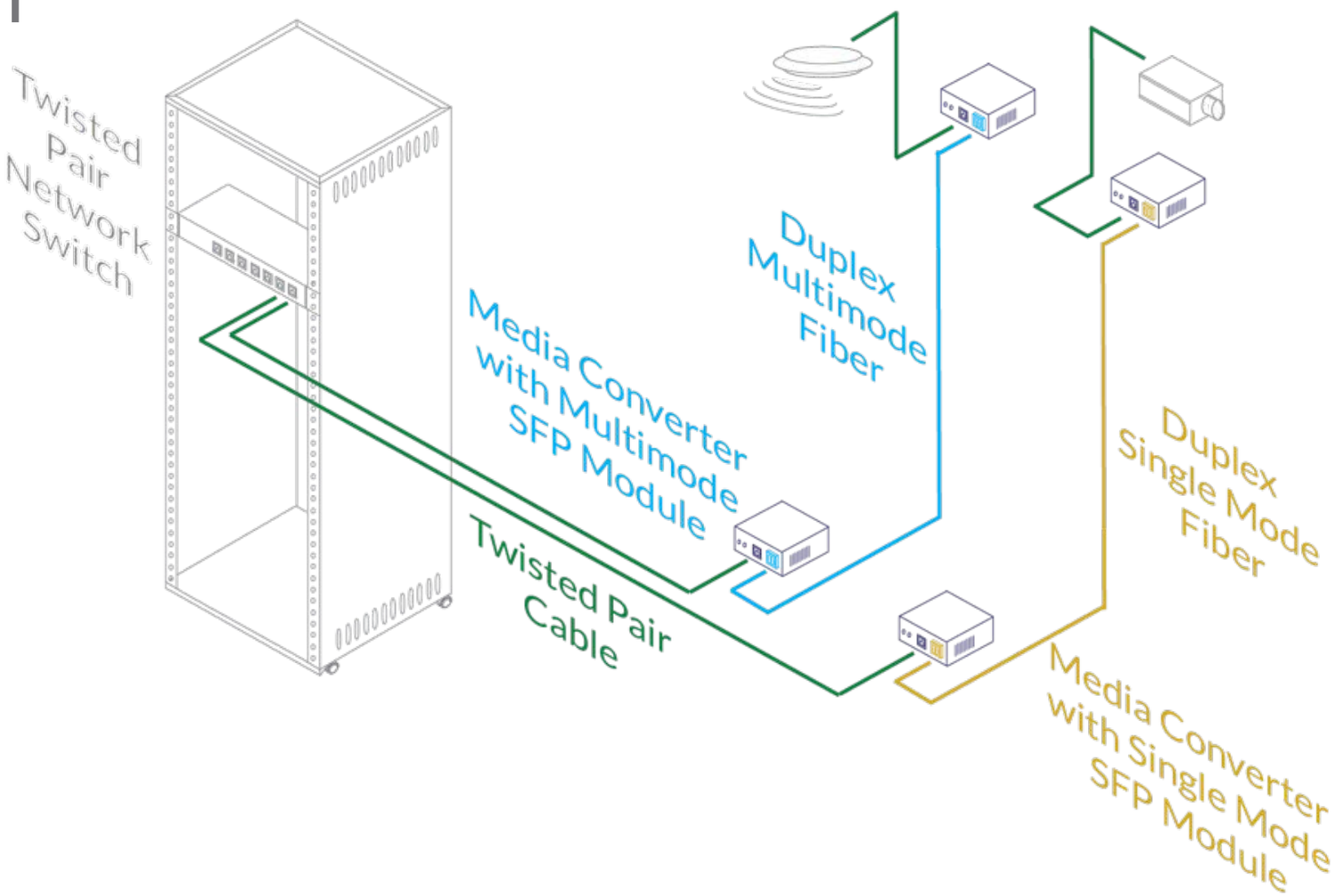


Step 7: screw the connector boot onto the connector, slide on the dust cap, and trim the exposed yarn

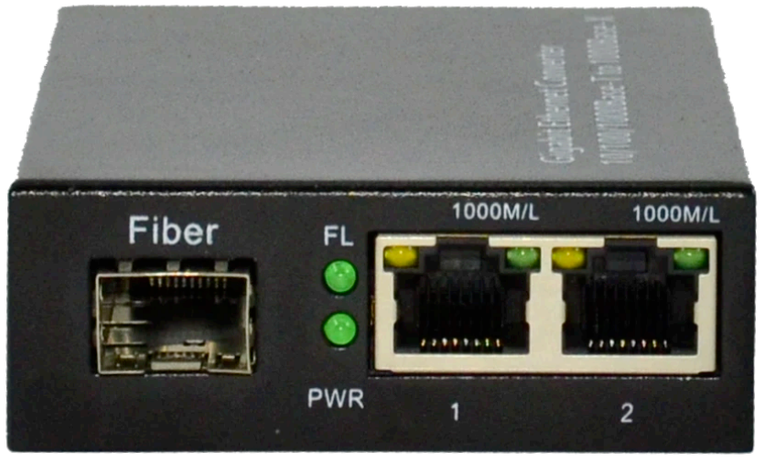
Demarc Wiring



Media Conversion



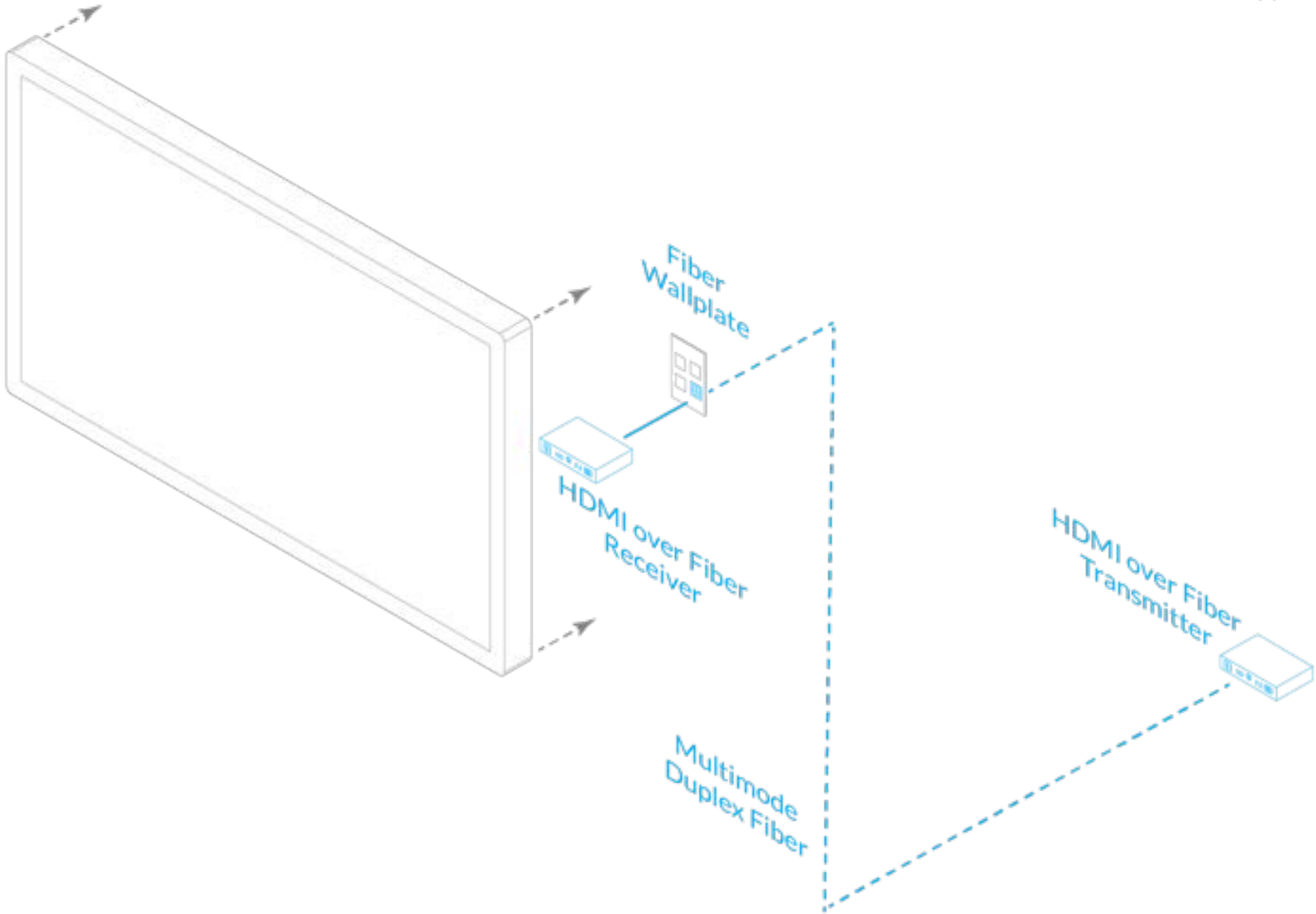
Media Conversion



Fiber optic cable
(feed to network equipment or other media converters)

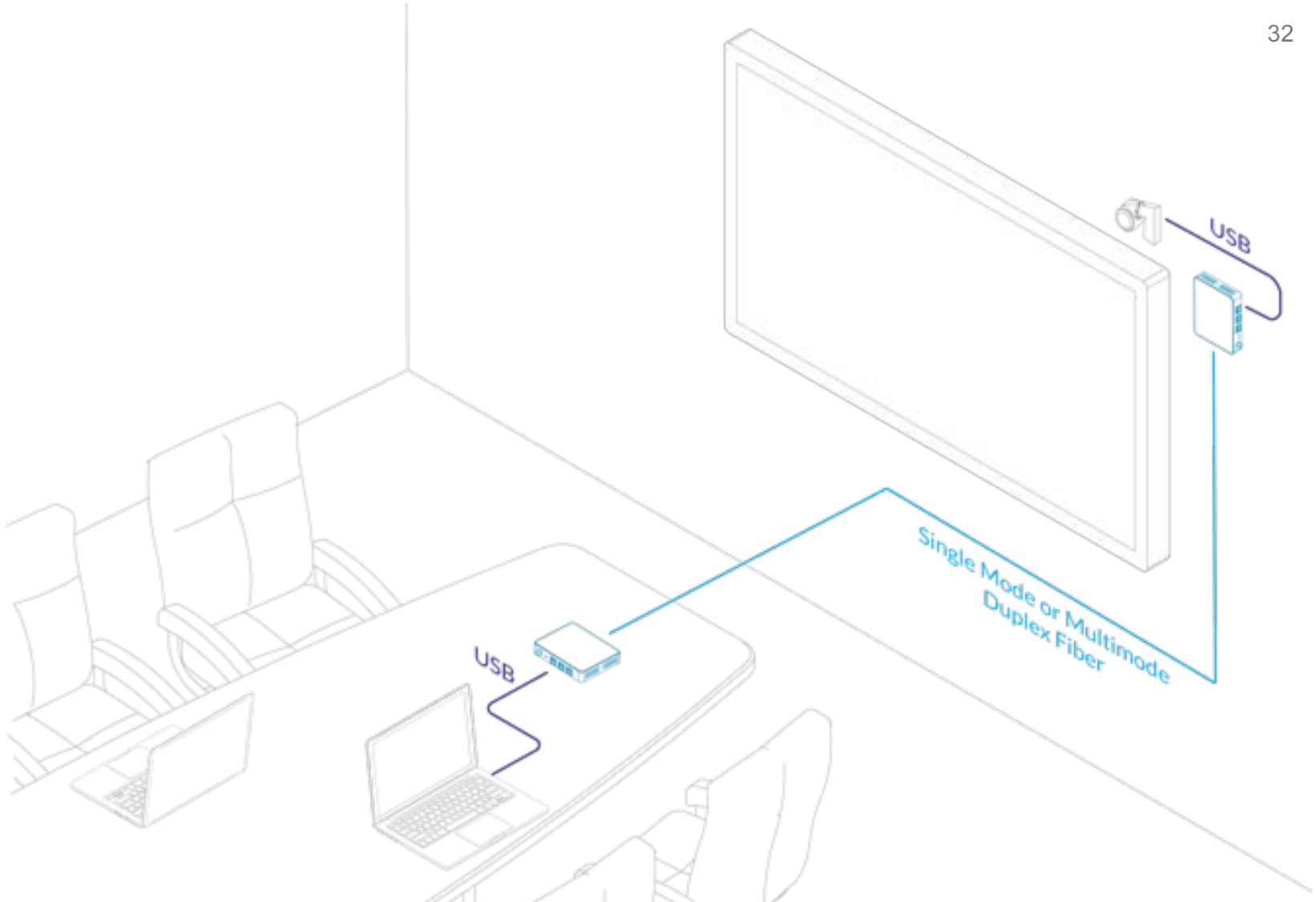
Twisted pair cables
(feed to network equipment or devices with RJ45 connections)

AV over Fiber



AV over Fiber

USB over Fiber



Common Troubleshooting Areas

- Verify “link budgets” and areas of loss
- Verify proper connector termination
- Clean optical connectors & equipment
- Verify proper bend radius’

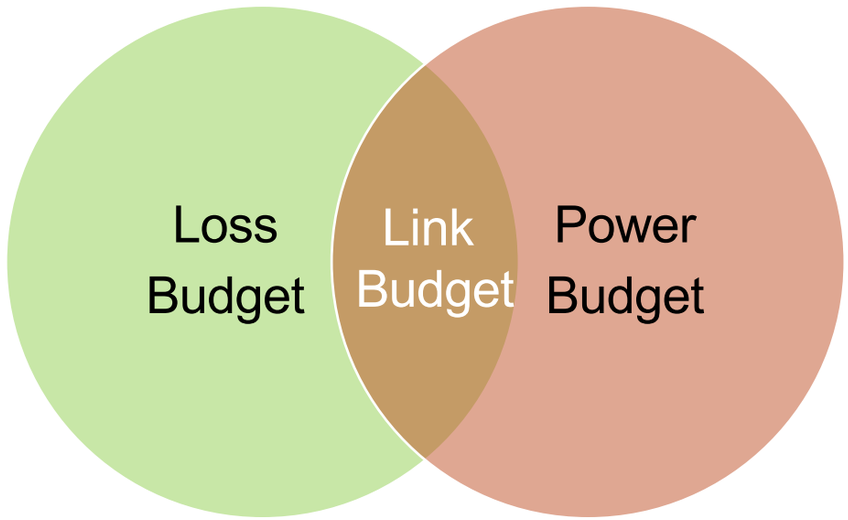
Loss & Power Budgets

Loss Budget

- The amount of anticipated signal loss on a cable run
- Loss is inevitable due to a number of factors – cable distance, connectors, couplers, etc.

Power Budget

- The amount of acceptable signal loss based on the tolerances of your connected devices
- Power budgets can have a min and max rating



Common Areas of Loss

Typical Power Budgets

- Fiber-based HDMI extenders: 3 dB
- Fiber-based AV over IP: 3 dB
- Network equipment: 11 dB

Common Areas of Loss

- Mechanical connectors 0.2 – 0.5 dB
- Factory made connectors 0.1 – 0.2 dB

- Mechanical splice 0.1 – 0.5 dB

- Wallplate keystone 0.2 dB
- Coupler 0.2 dB

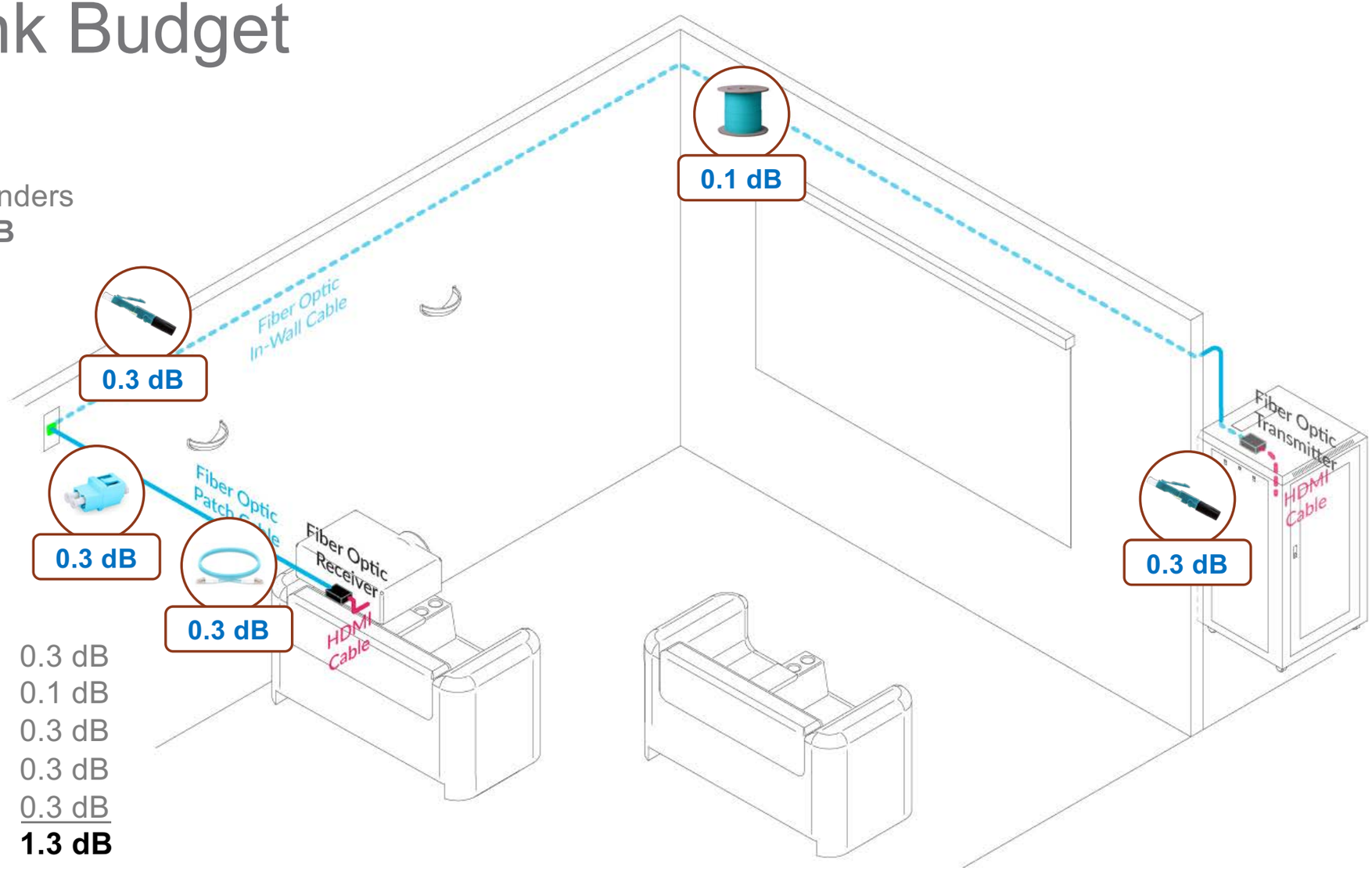
- Factory premade cable 0.3 – 0.5 dB

- 1,000 ft. bulk multimode 0.2 dB
- 1,000 ft. bulk single mode 0.1 dB

Calculating Link Budget

Application

- Fiber-based HDMI extenders
- Power loss budget: **3 dB**



Calculation

• Rack connector:	0.3 dB
• Bulk wire:	0.1 dB
• Wallplate connector:	0.3 dB
• Wallplate keystone:	0.3 dB
• Premade patch cable:	0.3 dB
	1.3 dB

Troubleshooting Tools

Visual Fault Locator (VFL)

- Transmits a visual laser signal through the fiber
- Traces cables
- Shows breaks & poor terminations

Optical Link Test Kit

- Transmits & receives laser wavelengths
- Meters total cable run loss
- Reports on & “certifies” cable runs

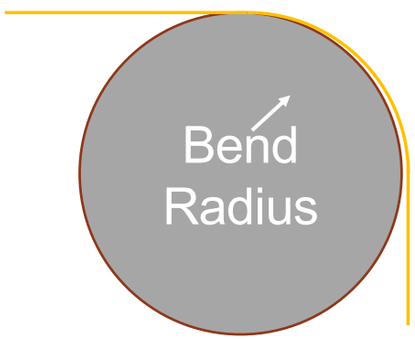
Termination Cleaning

- Fiber connectors & installation hardware ships with dust caps to ensure optical lenses remain clean
- It’s best practice to keep the dust caps in place as long as possible to avoid dust, oils & other contaminants from obstructing the optical lenses
- Contaminants will cause loss, creating signal drops and/or loss of signal altogether

- Clean contaminated lenses with fiber optic “pen-style” or “click” cleaners

Fiber Bend Radius

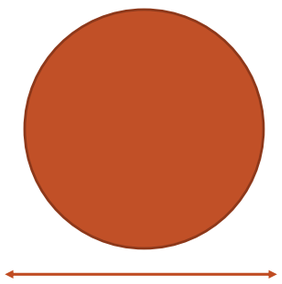
- Do not exceed the rated bend radius of the fiber cabling
- Bending fiber too tightly will cause microfractures, leading to partial signal loss, complete signal loss, and/or failure over time



ClearCurve® & SMF-28 Ultra (bend-insensitive glass) fiber core

7.5mm
(0.29 inches)
Minimum
Bend Radius

Older Bulk Fiber & Premades



30mm
(1.1 inches)
Minimum
Bend Radius

Additional Resources:

- www.tlnetworx.com | white papers, termination videos, design guides
- www.tlnetworx.com/pages/training | additional training sessions
- info@tlnetworx.com | +1-608-960-7242

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