NETWORK AND TELECOMMUNICATION

ACADEMIC BACKGROUNDS:

- 1987-1993 Georgia University of Technology (Former USSR) **Specialize: Radio Transmitting Device of Satellite Telecommunication Systems** (Master of Science).
- 1997-1998 Advanced course at the Saint–Petersburg State University of Technology in computer simulation of ground stations Modem for Sputnic communication (Russia).

PREVIOUS EMPLOYMENT:

- 2002-2018 The World Bank Cambodia (IT Analyst, Client Services).
- 1999 -2001 Worked as Systems Engineer at VIRTU International Limited.
- 1995 -1997 Worked as assistant manager in operation and technical department at CAMINTEL.
- 1993 – 1995 Worked as engineer in Operations and Technical Department in HUB-station (ex-UNTAC Networks) at Ministry of Post and Telecommunications of Cambodia.

Teaching Experiences:

- 2000 Royal Academy of Cambodia (MSc.IT).
- 2002 Build Bright University (MSc.IT).
- 2019 National Polytechnic Institute of Cambodia (BSc.Telecom).
- 2020 Norton University (BSc.IT)
- 2023 Cambodia Academy of Digital Technology (BSc.Telecom).

Enterprise Computer Networks:

- Most enterprise computer networks can be separated into two general types of technology:

a) Local-Area Networks (LANs).

b) Wide-Area Networks (WANs).

- **LANs** → Typically used to connect nearby devices: devices in the same room, in the same building, or in a campus of buildings.
- **WANs** → Typically used to connect devices that are relatively far apart.
- Together, LANs and WANs create a complete enterprise computer network, working together to do the job of a computer network: delivering data from one device to another.

Overview of Local Area Networks (LANs):

- Many types of LANs have existed over the years, but today's networks use two general types of LANs:

  a.1) Ethernet LANs IEEE 802.3.

  a.2) Wireless LANs IEEE 802.11.

- Ethernet LANs happen to use cables for the links between nodes, and because many types of cables use copper wires, Ethernet LANs are often called ***wired*** *LANs*.
- Ethernet LANs also make use of fiber-optic cabling, which includes a fiberglass core that devices use to send data using light.
- Wireless LANs do not use wires or cables, instead using radio waves for the links between nodes.

Typical SOHO LANs:

- Although Figure 2-1 shows the switch and router as separate devices, many SOHO Ethernet LANs today combine the router and switch into a single device.
- These devices typically have “router” on the packaging, but many models also have 4-port or 8-port Ethernet LAN switch ports built in to the device.
- Typical SOHO LANs today also support wireless LAN connections.

- You can build a single SOHO LAN that includes both Ethernet LAN technology as well as wireless LAN technology, which is also defined by the IEEE.
- Wireless LANs, defined by the IEEE using standards that begin with 802.11, use radio waves to send the bits from one node to the next.

Typical SOHO LANs:

- Most wireless LANs rely on another networking device: a wireless LAN access point (AP).
- The AP acts somewhat like an Ethernet switch, in that all the wireless LAN nodes communicate with the wireless AP.
- If the network uses an AP that is a separate physical device, the AP then needs a single Ethernet link to connect the AP to the Ethernet LAN, as shown in Figure 2-2.

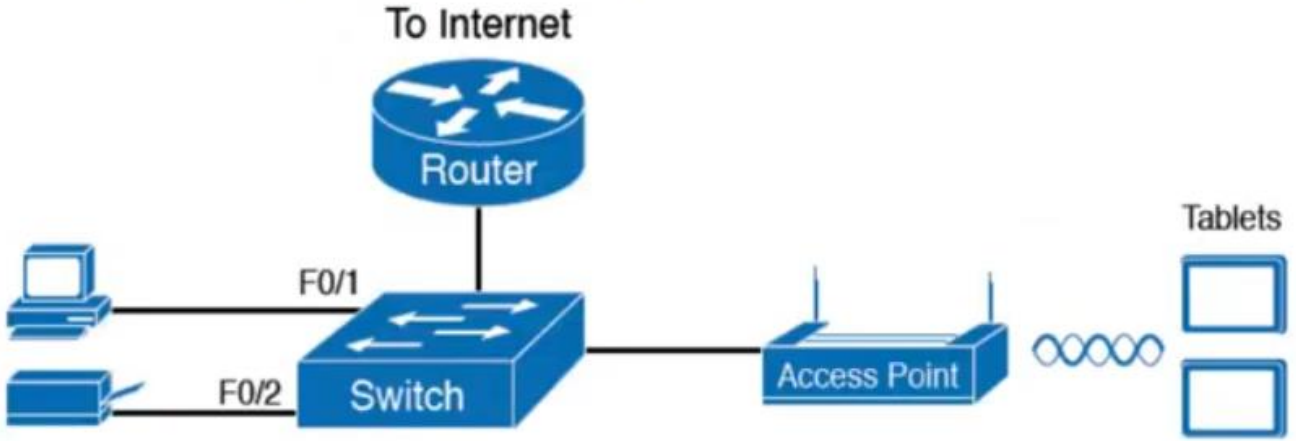


Figure 2-2 *Typical Small Wired and Wireless SOHO LAN*

Typical Enterprise LANs:

- Enterprise networks have similar needs compared to a SOHO network, but on a much larger scale.

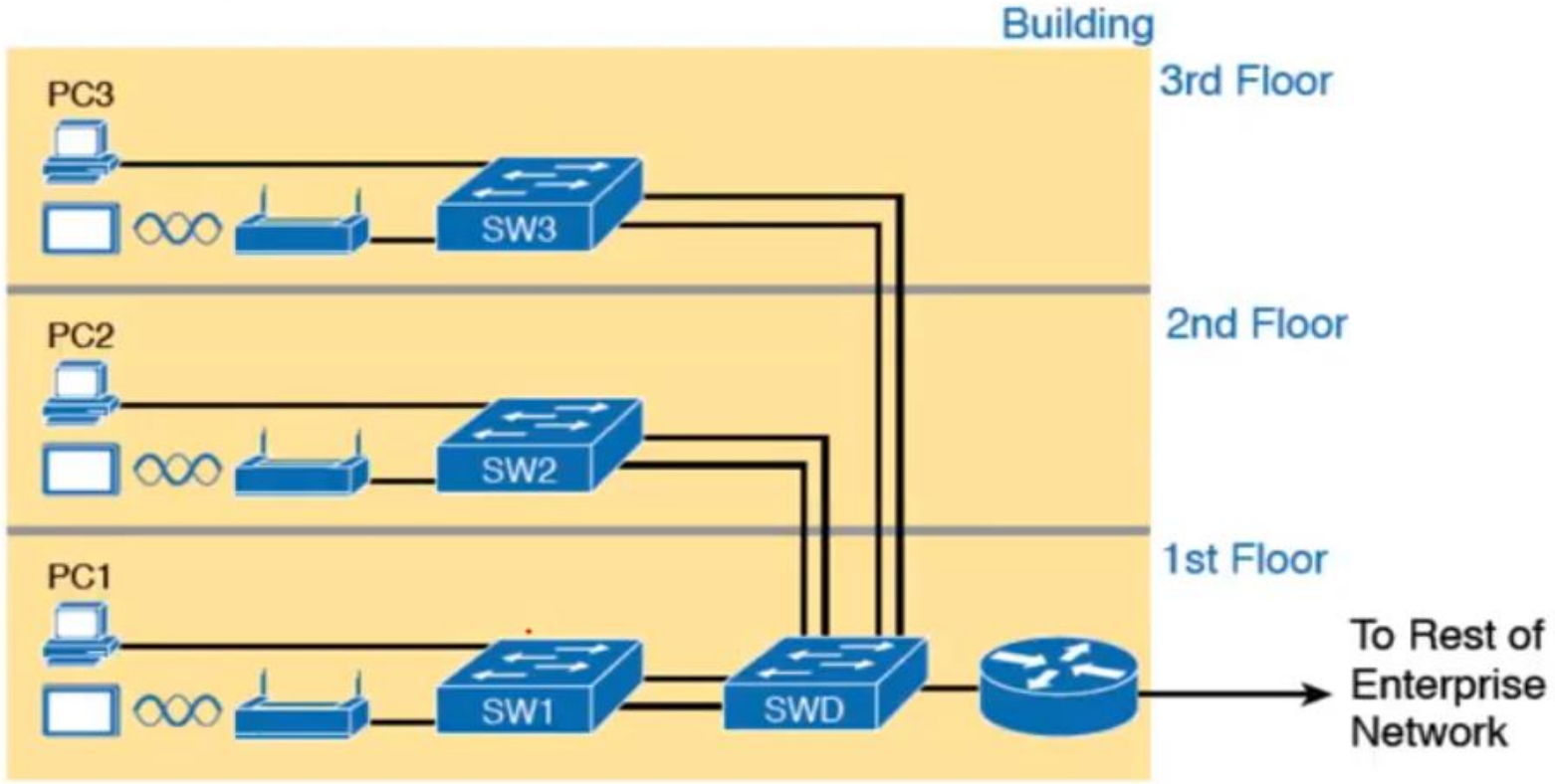


Figure 2-3 *Single-Building Enterprise Wired and Wireless LAN*

Building Physical Ethernet LANs with UTP/STP:

Breaking Down a UTP/STP Ethernet Link:

- **Ethernet link** ➔ Refers to any physical cable between two Ethernet nodes.

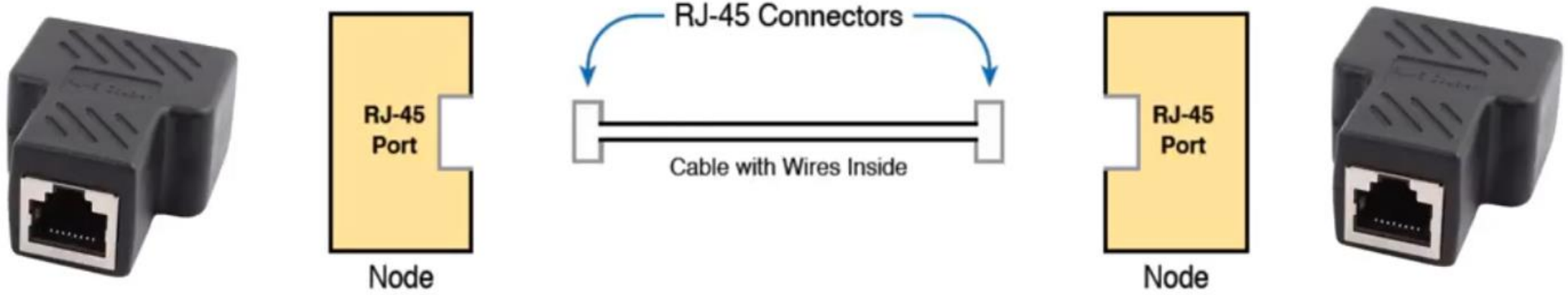
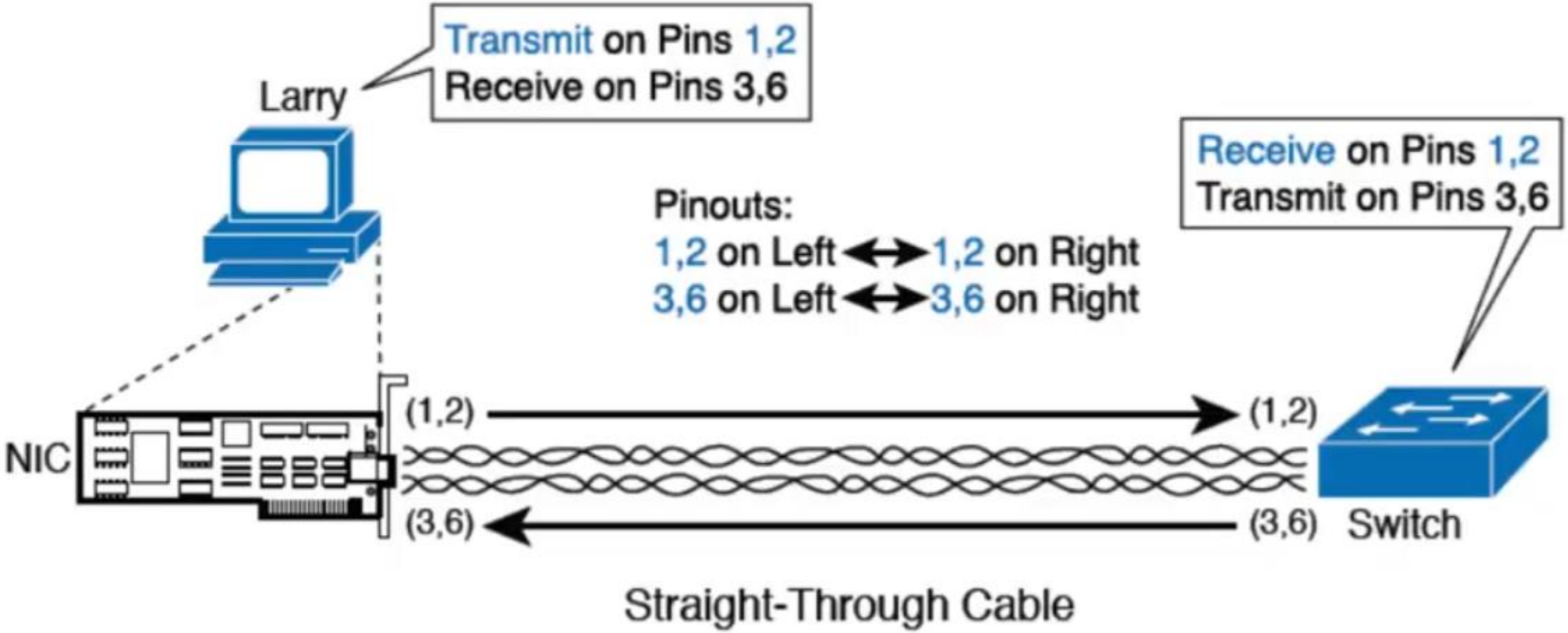


Figure 2-6 *Basic Components of an Ethernet Link*

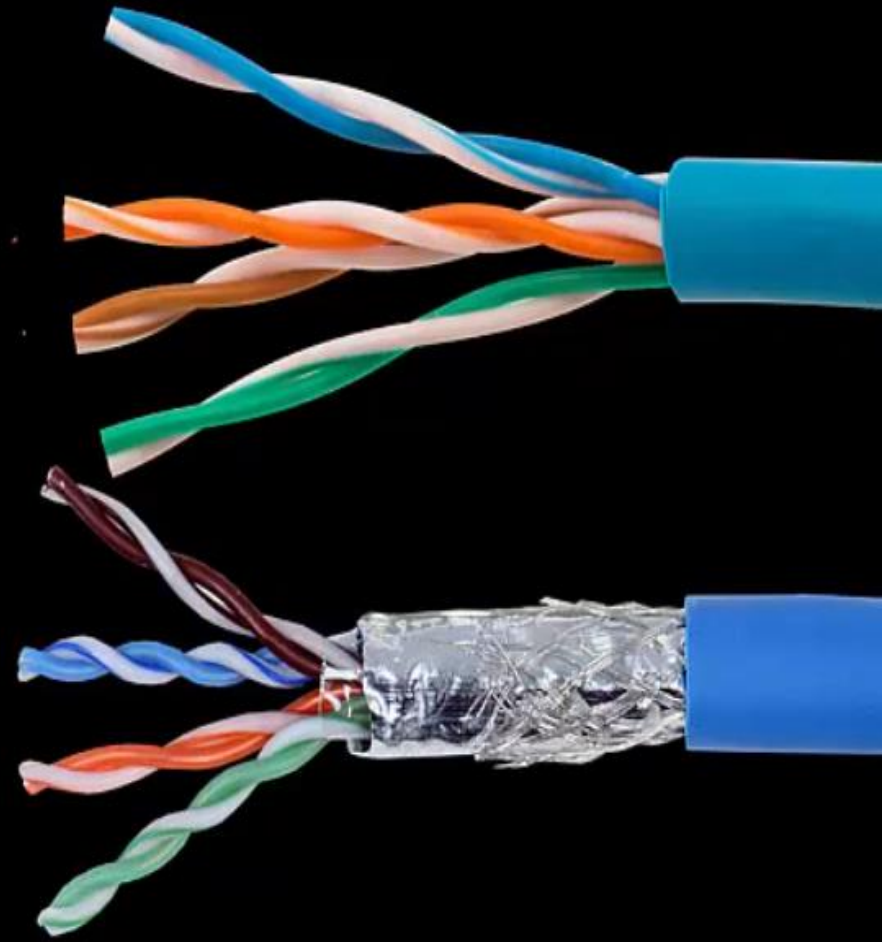

Transmit on Pins 1,2
Receive on Pins 3,6
Larry
Pinouts:
1,2 on Left ↔ 1,2 on Right
3,6 on Left ↔ 3,6 on Right
Receive on Pins 1,2
Transmit on Pins 3,6
NIC
(1,2)
(1,2)
(3,6)
(3,6)
Switch
Straight-Through Cable

Type of Media – Copper Media - UTP

- UTP – Unshielded Twisted Pair
- Very common, cheap, easy to install
- It consists of 4 pairs of color-coded wires that have been twisted together
- The twisting has the effect of canceling unwanted signals.
- This cancellation effect also helps avoid interference from internal sources called crosstalk.
- Crosstalk is the interference caused by the magnetic field around the adjacent pairs of wires in the cable

Ethernet Cables:

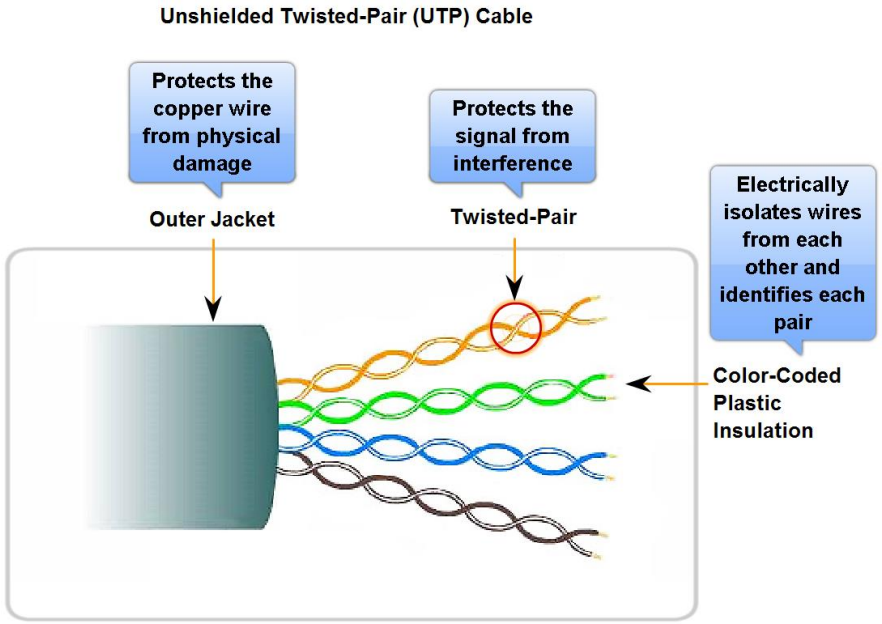
- Unshielded Twisted Pair (UTP) Cable



- Shielded Twisted Pair (STP) Cable

Characteristics & Uses of Network Media

- Identify the basic characteristics of UTP cable

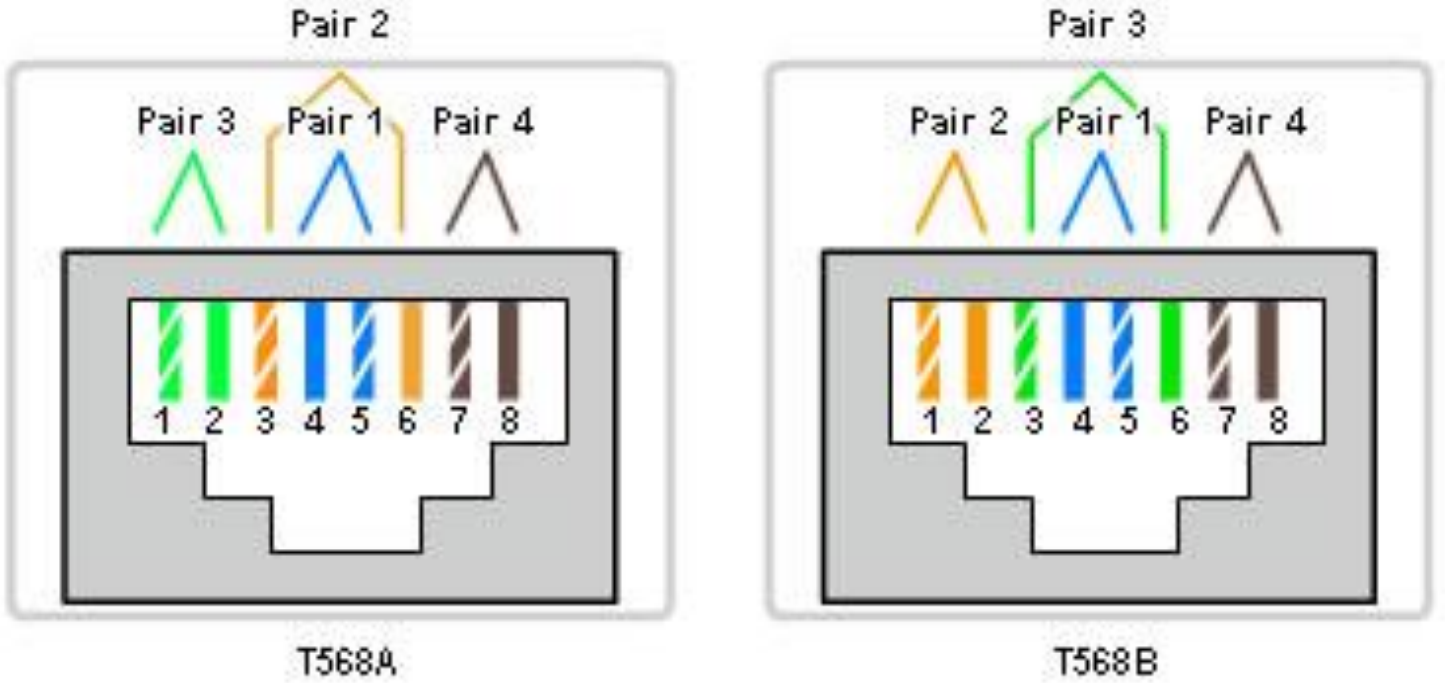


RJ-45 Connector

The following are main cable types that are obtained by using specific wiring conventions:
- Ethernet Straight-through,
- Ethernet Crossover &
-Rollover

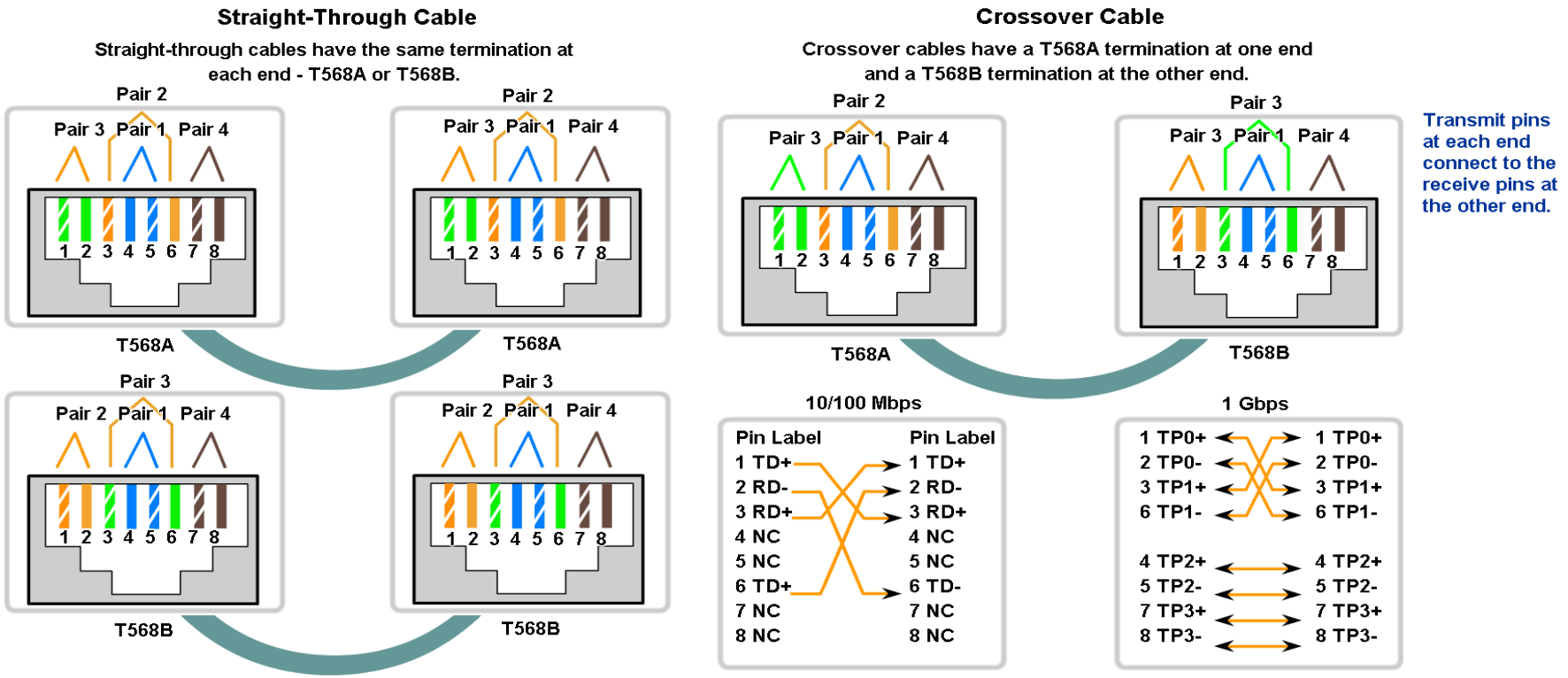
Straight-through, Crossover, and Rollover Cable Types

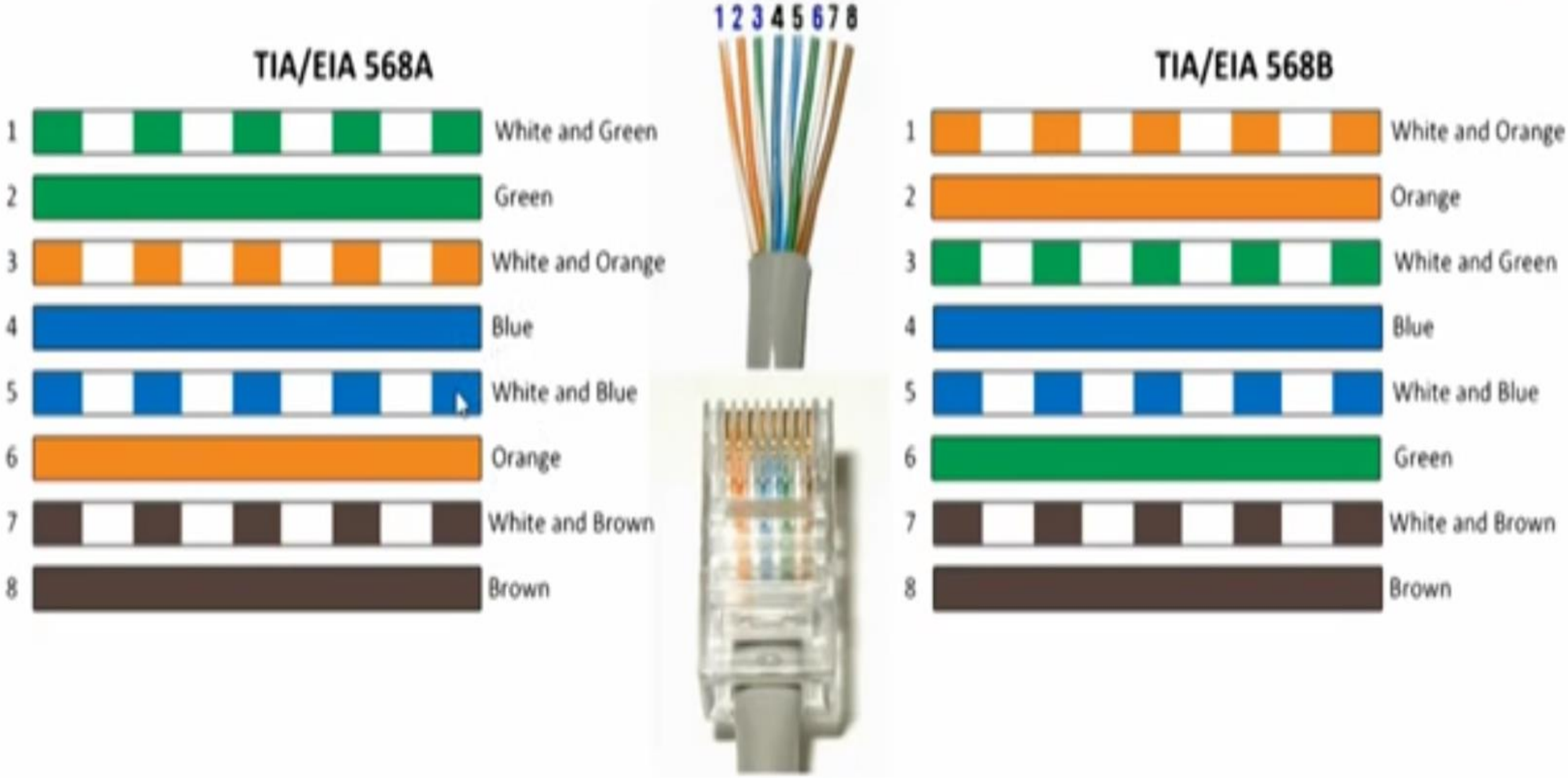
Cable Type	Standard	Application
Ethernet Straight-through	Both end T568A or both end T568B	Connecting a network host to a network device such as a switch or hub.
Ethernet Crossover	One end T568A, other end T568B	Connecting two network hosts. Connecting two network intermediary devices (switch to switch, or router to router).
Rollover	Cisco proprietary	Connect a workstation serial port to a router console port, using an adapter.



Types of Connections in a LAN

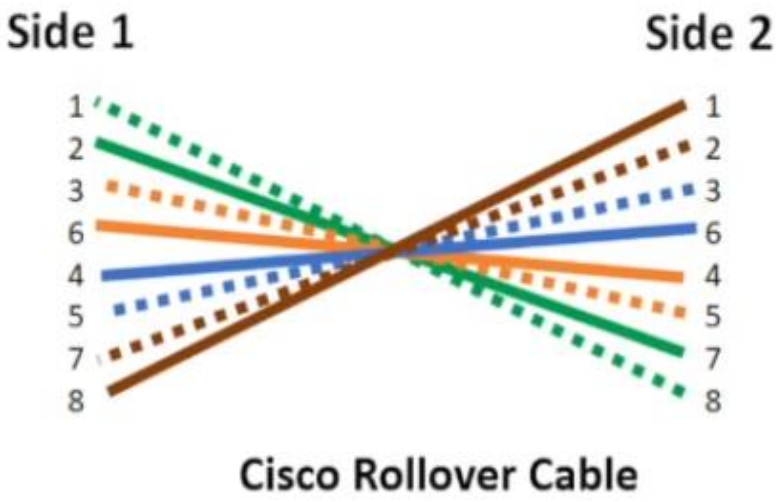
- Identify the pin out of the straight-through and cross-over cables



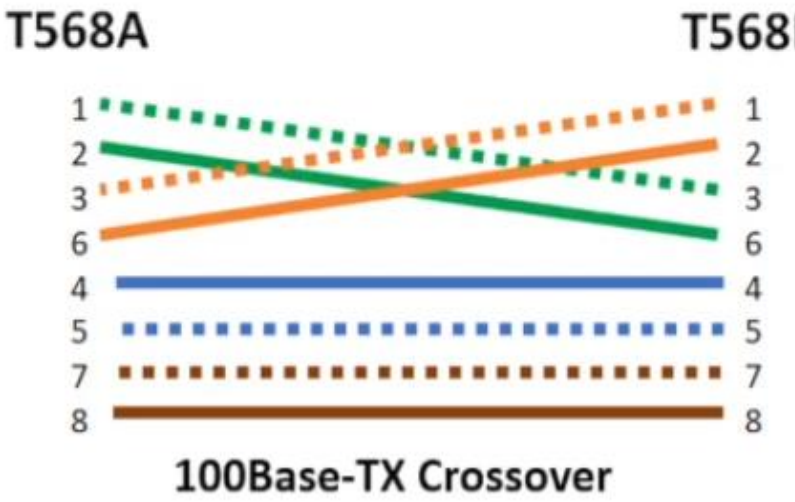

TIA/EIA 568A
1 White and Green
2 Green
3 White and Orange
4 Blue
5 White and Blue
6 Orange
7 White and Brown
8 Brown
1 2 3 4 5 6 7 8
TIA/EIA 568B
1 White and Orange
2 Orange
3 White and Green
4 Blue
5 White and Blue
6 Green
7 White and Brown
8 Brown

Physical Faults – Wire map (Mis-wired) – CAUTION!

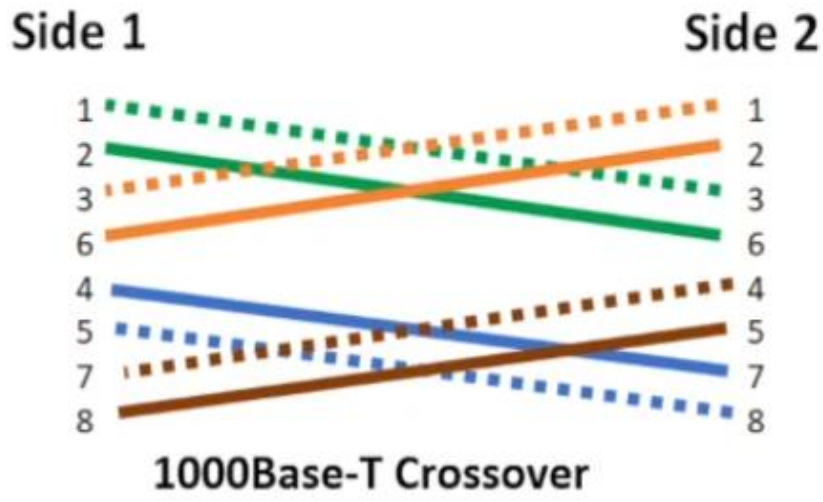
Some wire maps may look like they have been connected improperly but are intended to be this way



Cisco Rollover Cable



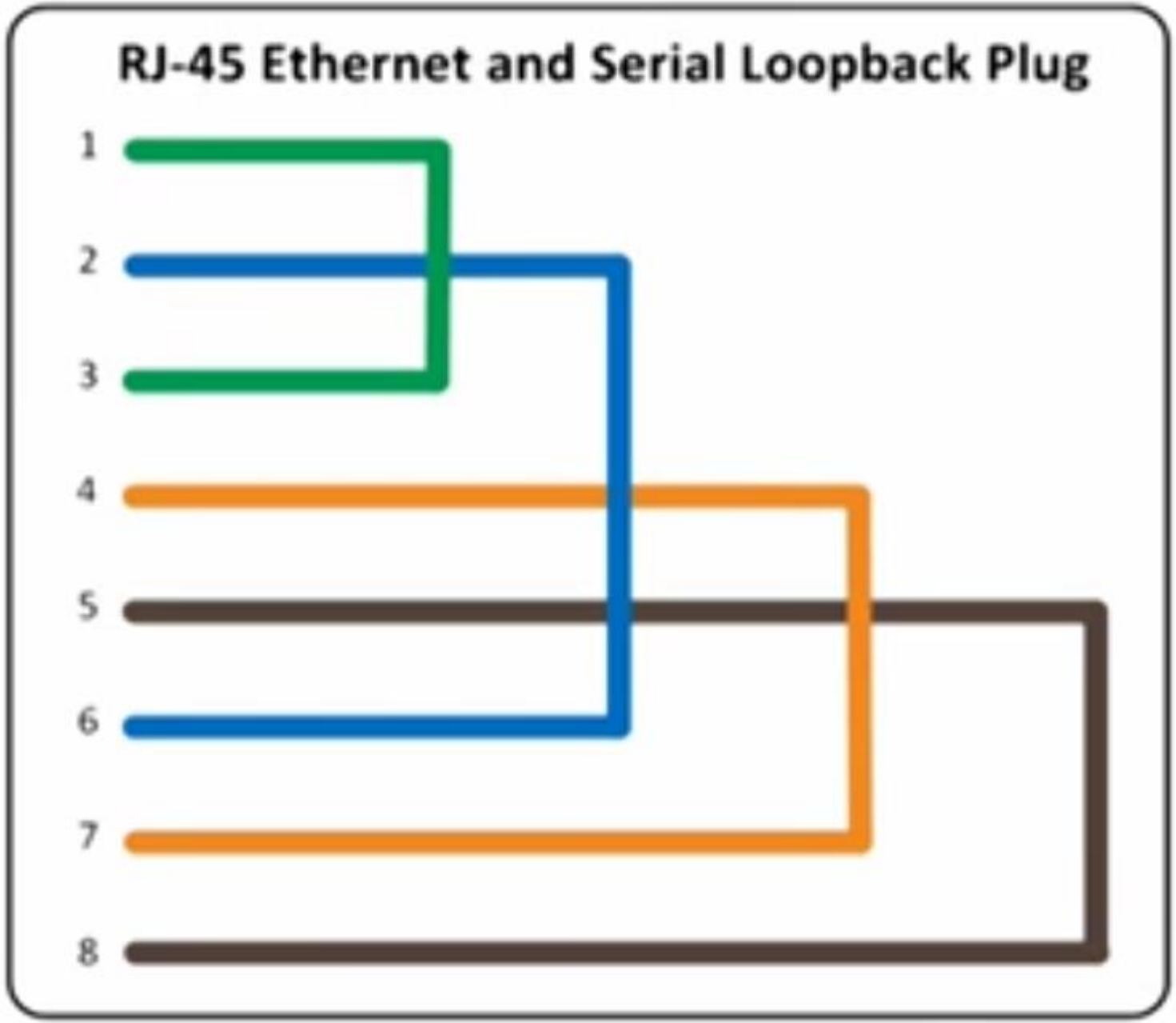
100Base-TX Crossover



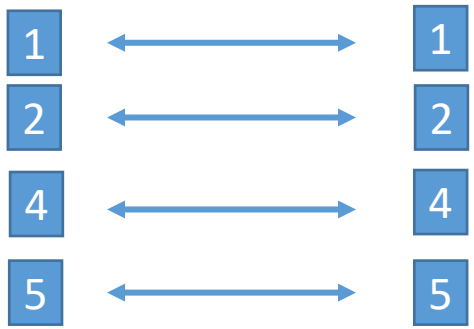
1000Base-T Crossover

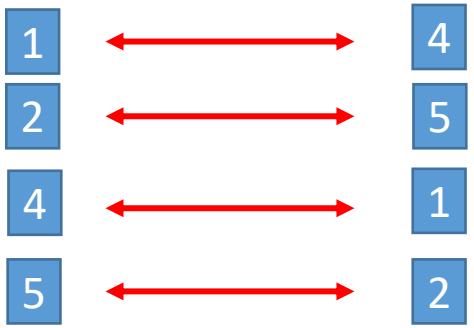
- Serial cable “standard” proposed by Dave Yost

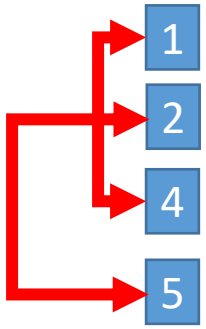
Useful for testing physical ports

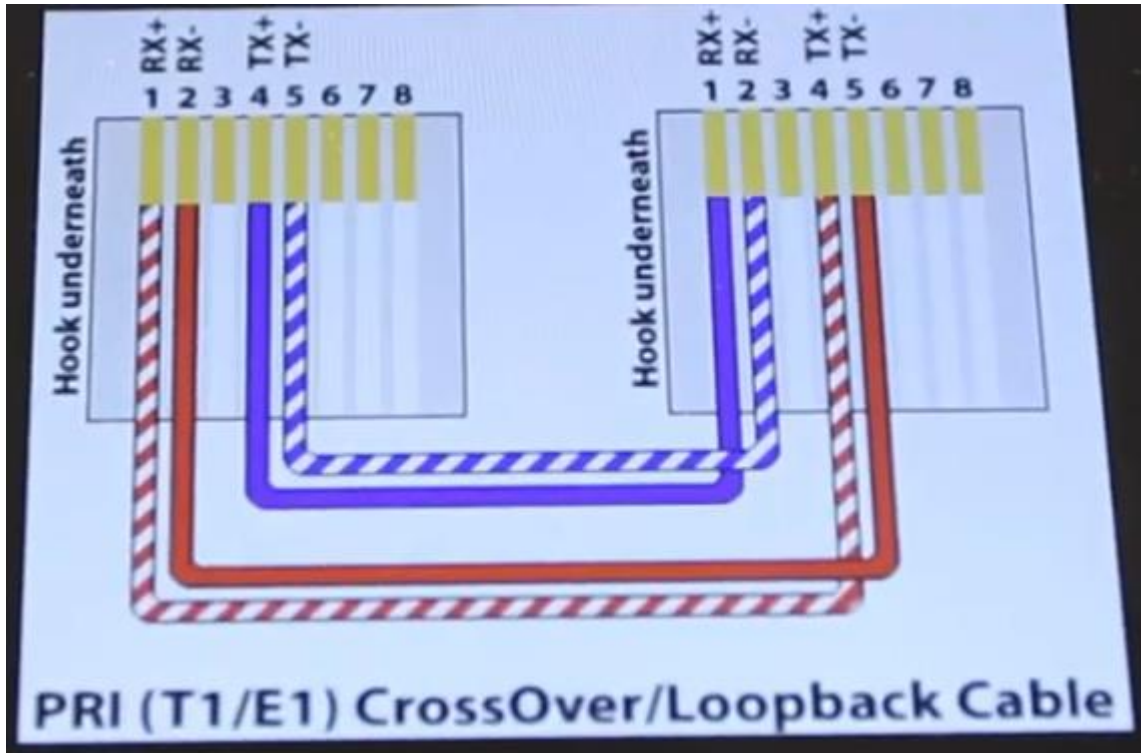


E1 /Cross Over/Loopback Cable





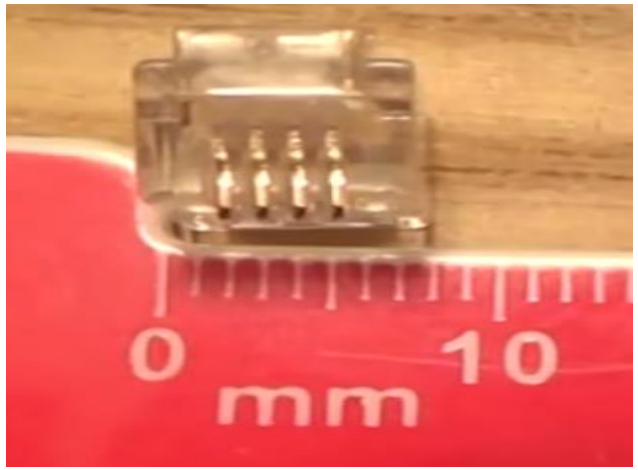




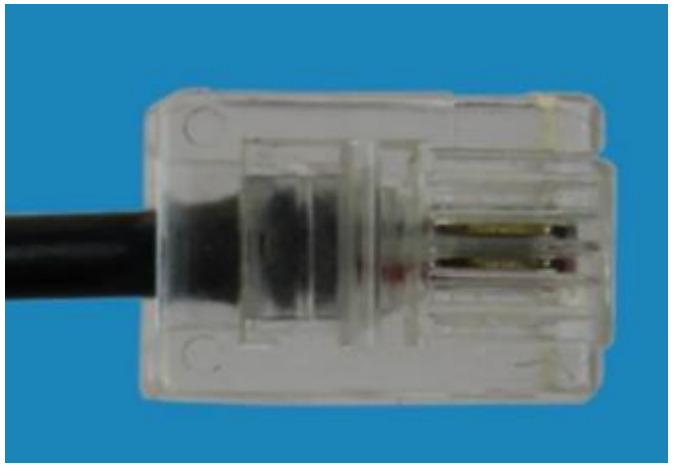
Voice pin in RJ45

RJ10, RJ11, RJ12,RJ45

RJ10-4P-4C use for handset



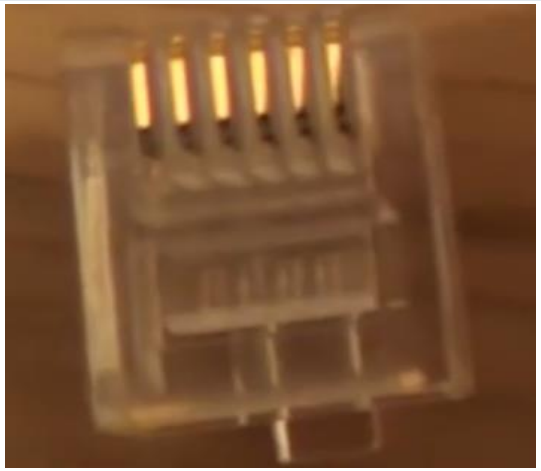
RJ11-4P-2C



RJ45-8P-8C-use for Network

RJ10-6P-4C use for fax

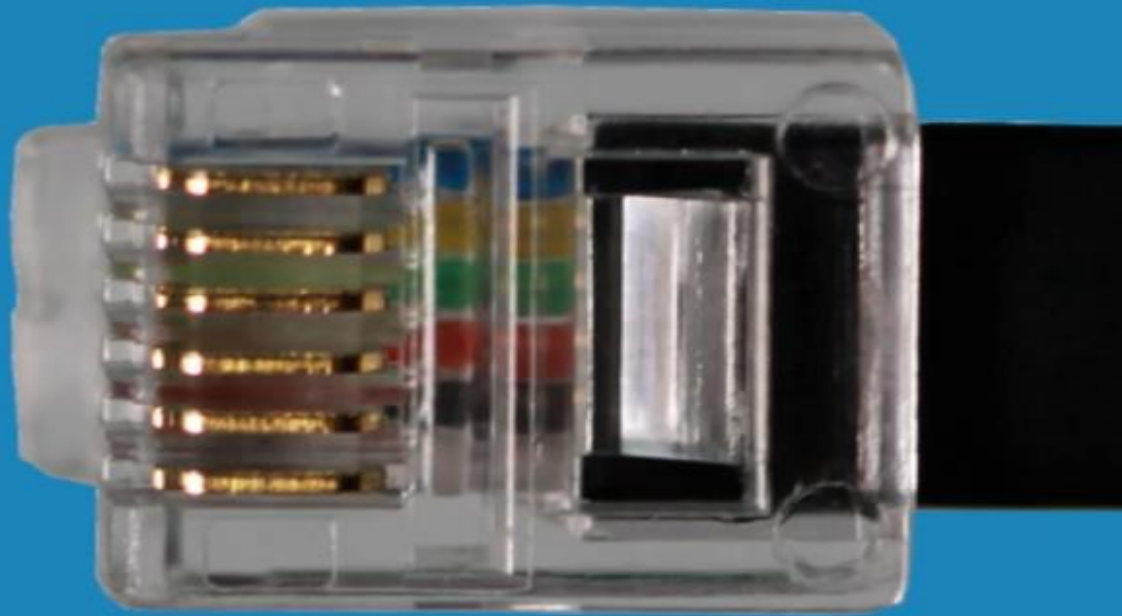
RJ12-6P-6C-use for phone system



RJ11

- Six positions
- Two wires (One pair)

- Six positions
- Six wires (Three pairs)
- We call it RJ11



RJ Summary

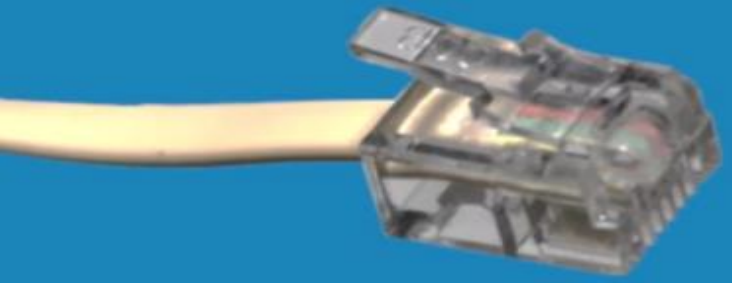
- Eight connectors for wires (Positions)
- In IT
  - Any number of wires it's RJ45

- Six connectors for wires (Positions)
- In IT
  - Any number of wires it's RJ11

Modular Connector

- RJ11 can be plugged into RJ45 and others

Four pairs



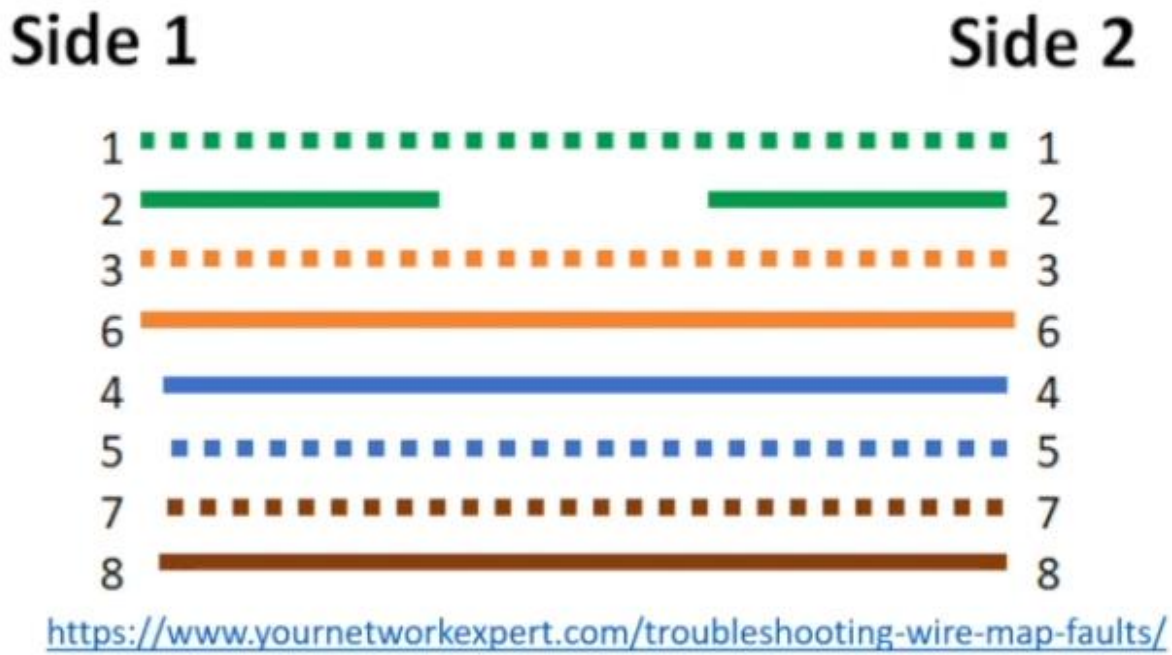
Two pairs

One pair

Wiring

Physical Faults – Wire map (Opens)

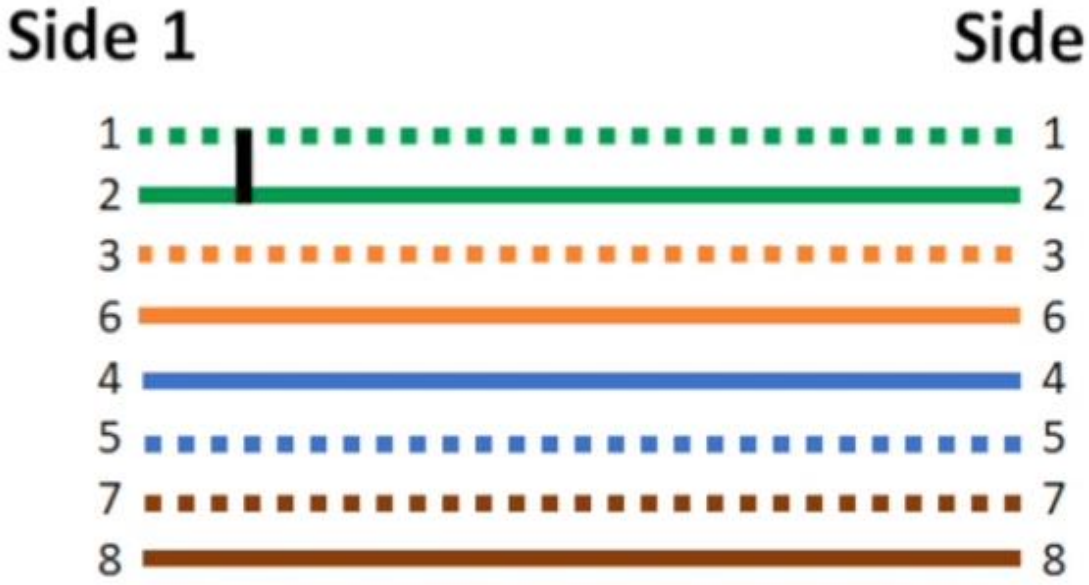
- Opens are when a wire is not providing continuity
- Checks to ensure that all the wires in the cable are connected properly
- Some testers will check for shield continuity
- Opens are caused by:
  - Damage to the cable
  - Improper termination
  - Faulty connector/jacks



https://www.yournetworkexpert.com/troubleshooting-wire-map-faults/

Physical Faults – Wire map (Shorts)

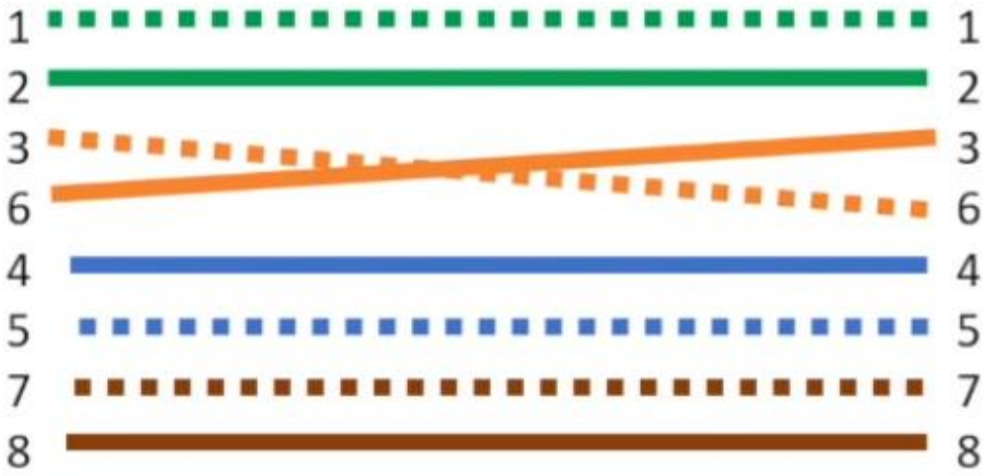
- Shorts happens when two wires are “connected” to each other
- This causes a direct electrical path from one wire to another.
- Shorts are caused by:
  - Damage to the insulation on the wires: causing metal-on-metal connection
  - Improper termination
  - Faulty connector/jacks
  - Damage to the cable by such things as nails or screws

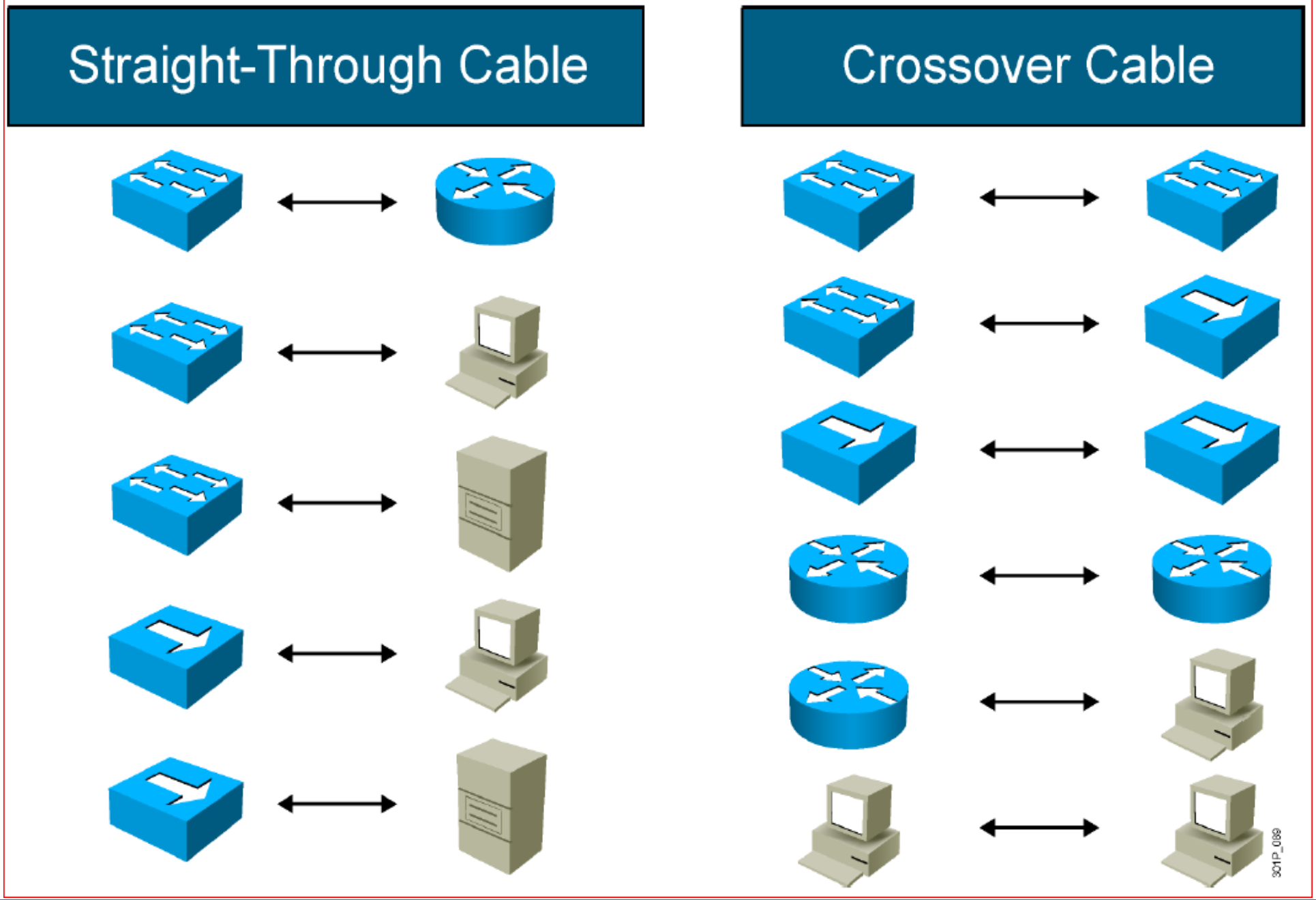


https://www.yournetworkexpert.com/troubleshooting-wire-map-faults/

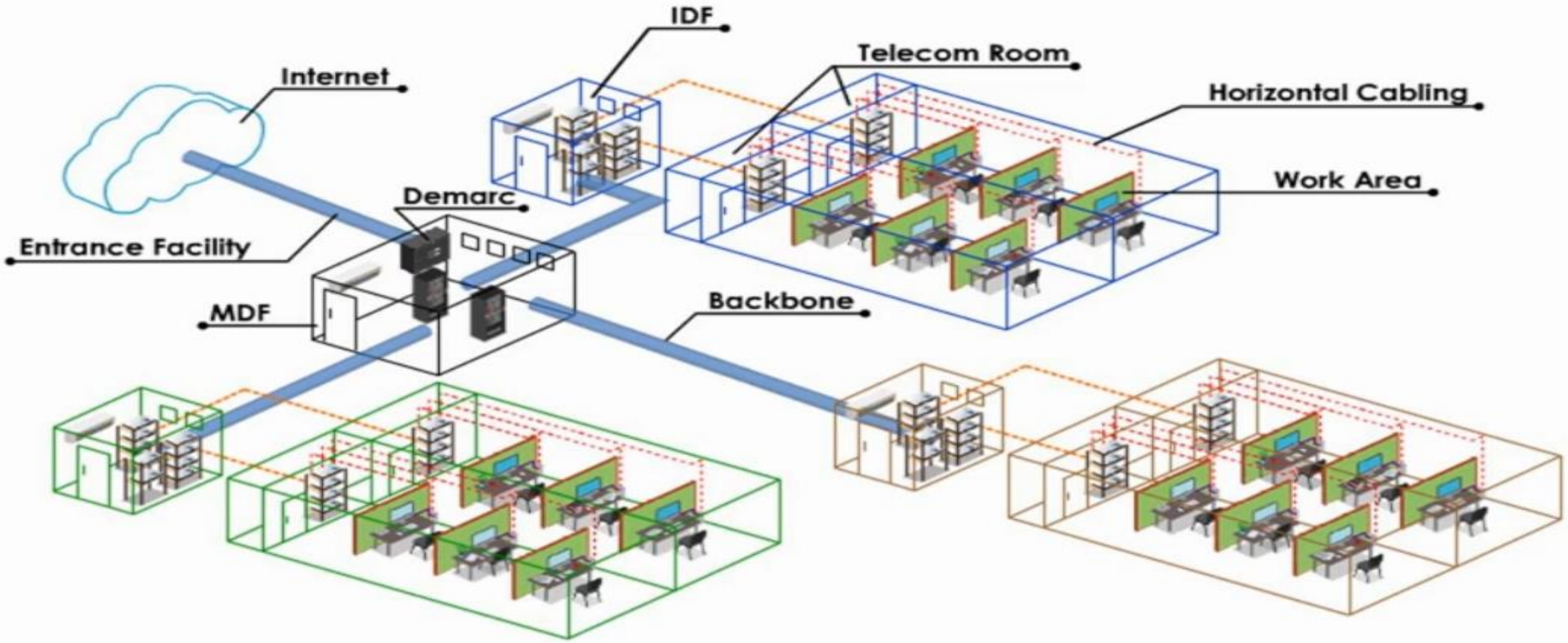
Physical Faults – Wire map (Mis-wired)

- **Mis-wired is when the wires are not connected to the corresponding pin outs**
- **Mis-wired are caused by:**
  - Improper termination
  - Faulty connectors

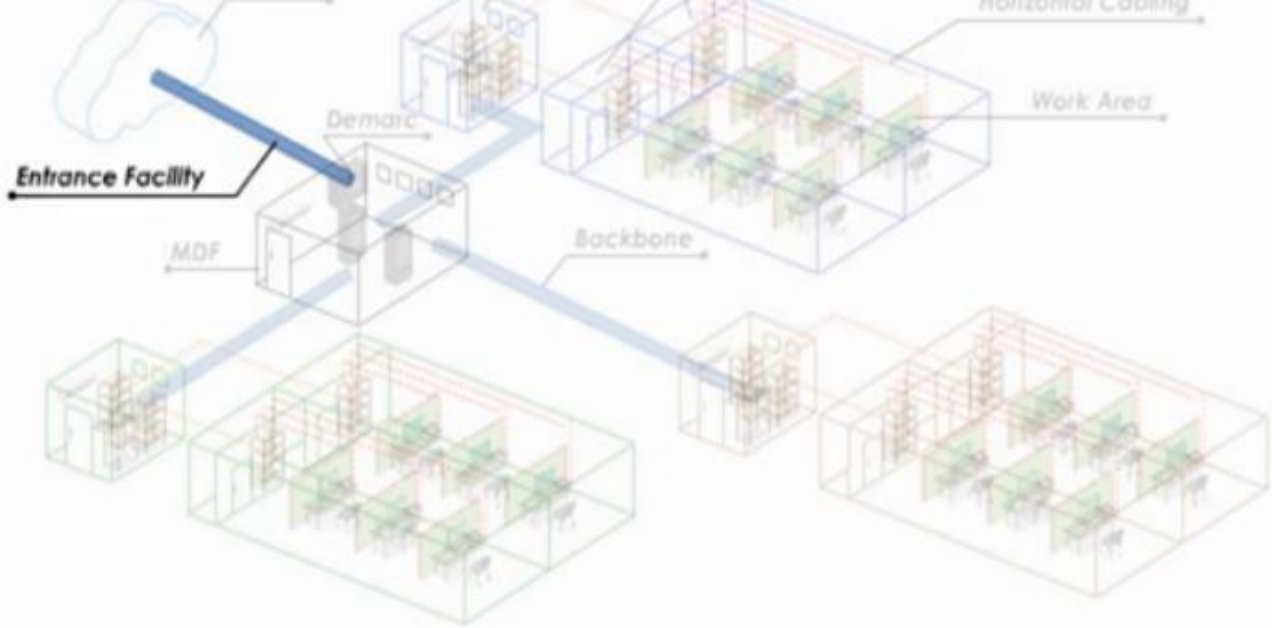



Straight-Through Cable
Crossover Cable
301P_089

A Bird's-Eye View of Structured Cabling

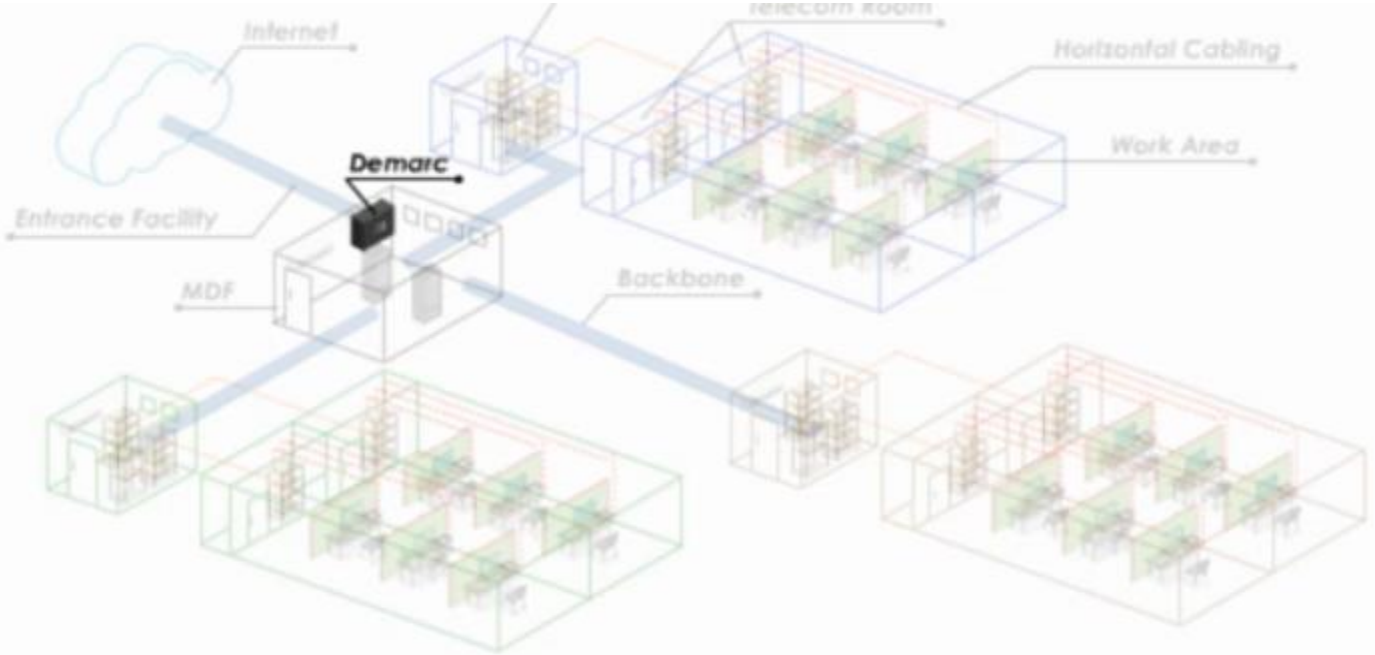


Structured cabling defines how to design,



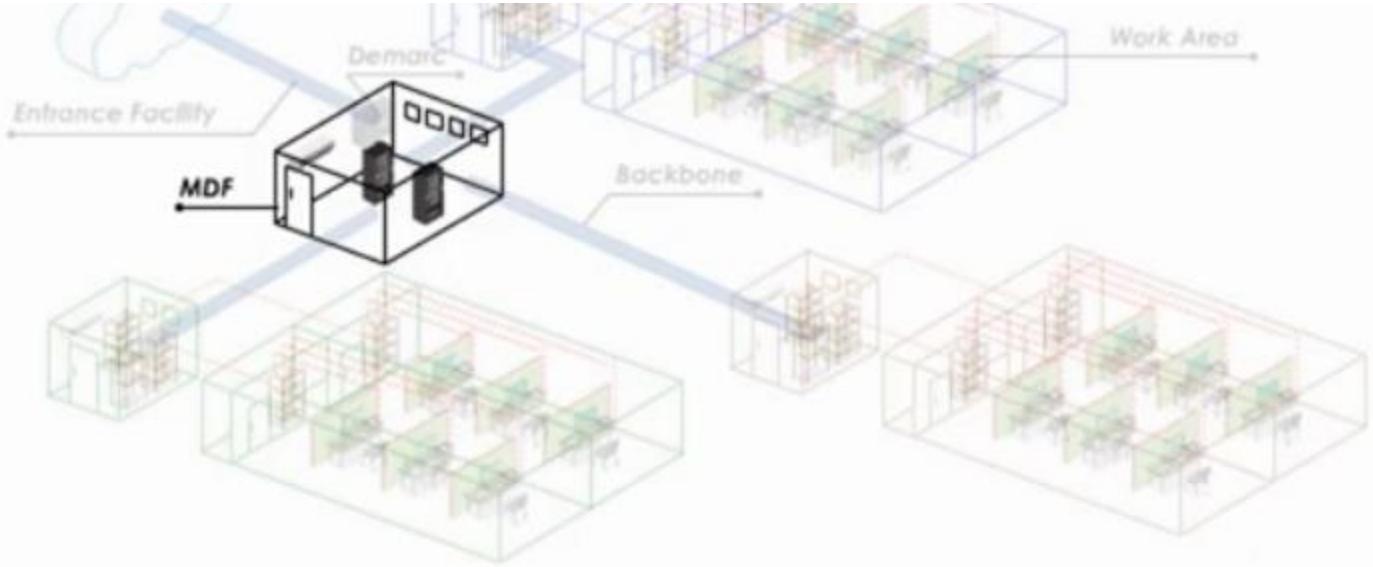
Entrance Facility:

- It includes the cabling component connecting the internal network to the Internet:
  - fiber-optic, UTP, coaxial, satellite, or wireless
- It also contains connecting devices, protection devices, or other necessary equipment:
  - transceivers, multiplexers, and others



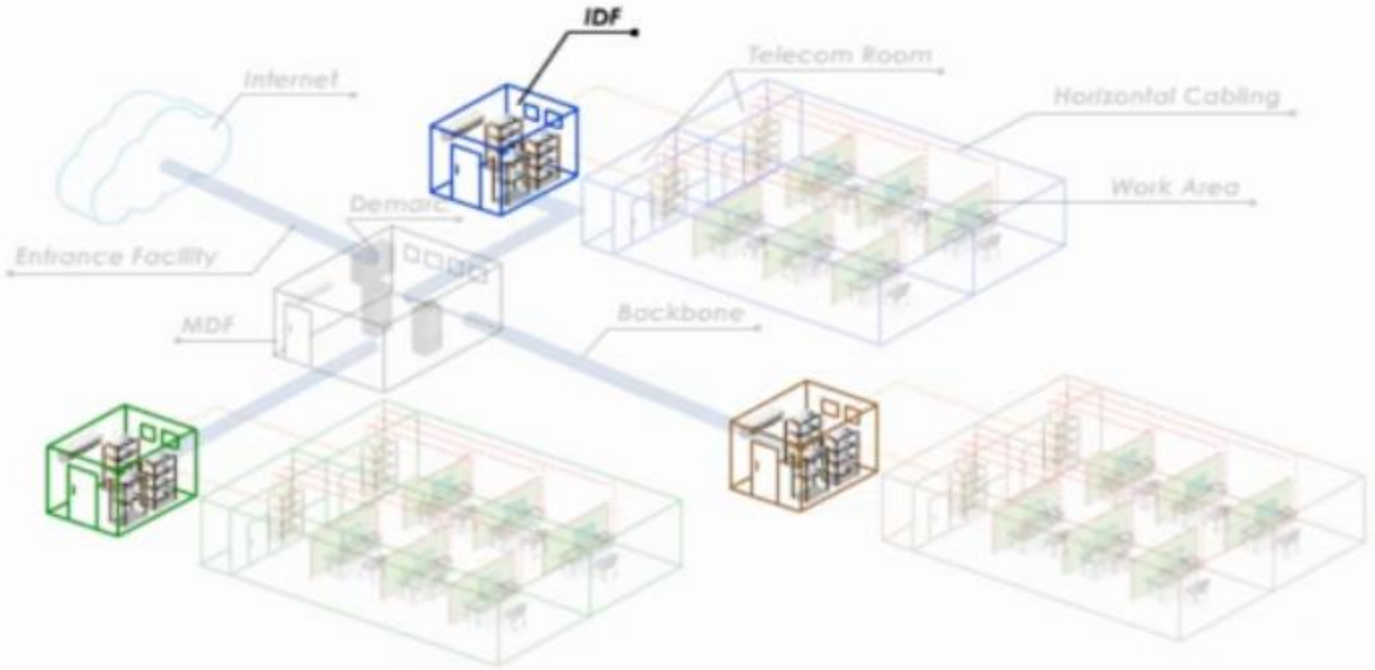
Demarc:

- Demarcation point - the point of division between the service provider' network and the internal network
- The best way to think of demarc is in terms of responsibility:
  - If something breaks on the internal side, it's the customer's problem
  - Beyond the demarc, it's service provider's problem



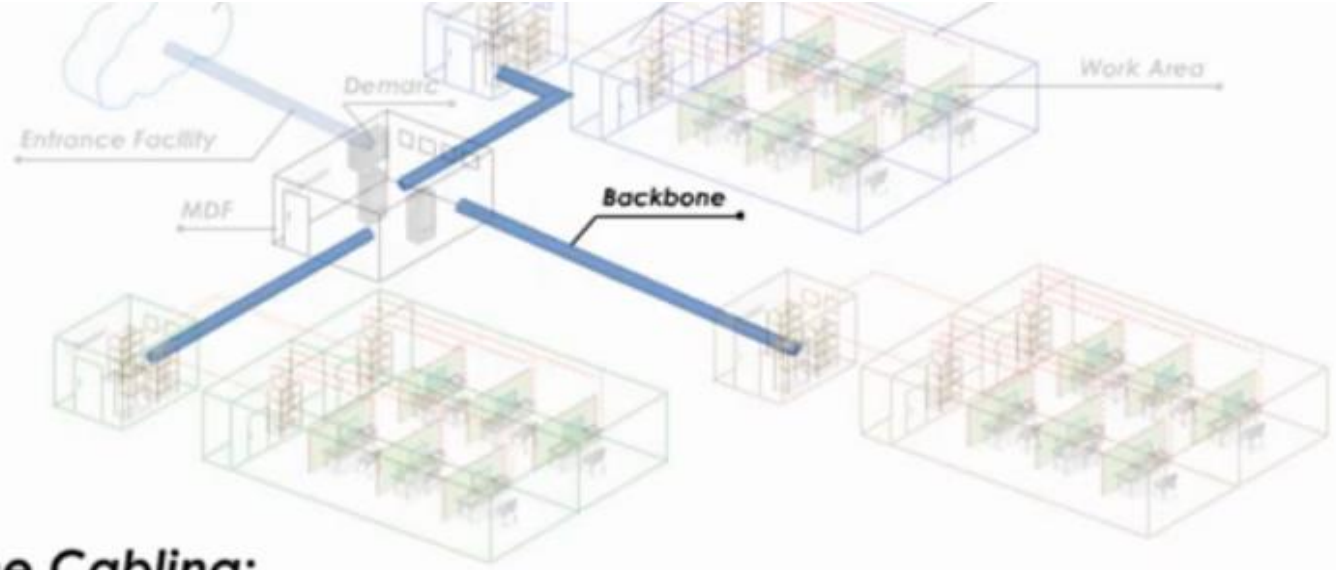
MDF:

- Main Distribution Frame - the central point of the entire network
- Also known as data center/server's room
- It is a central distribution point between IDFs
- It houses routers, firewalls, switches, telephone devices, and others
- It is the gateway between the external network and the internal network
- MDF, demarc, and entrance facility may share one space/room



IDF:

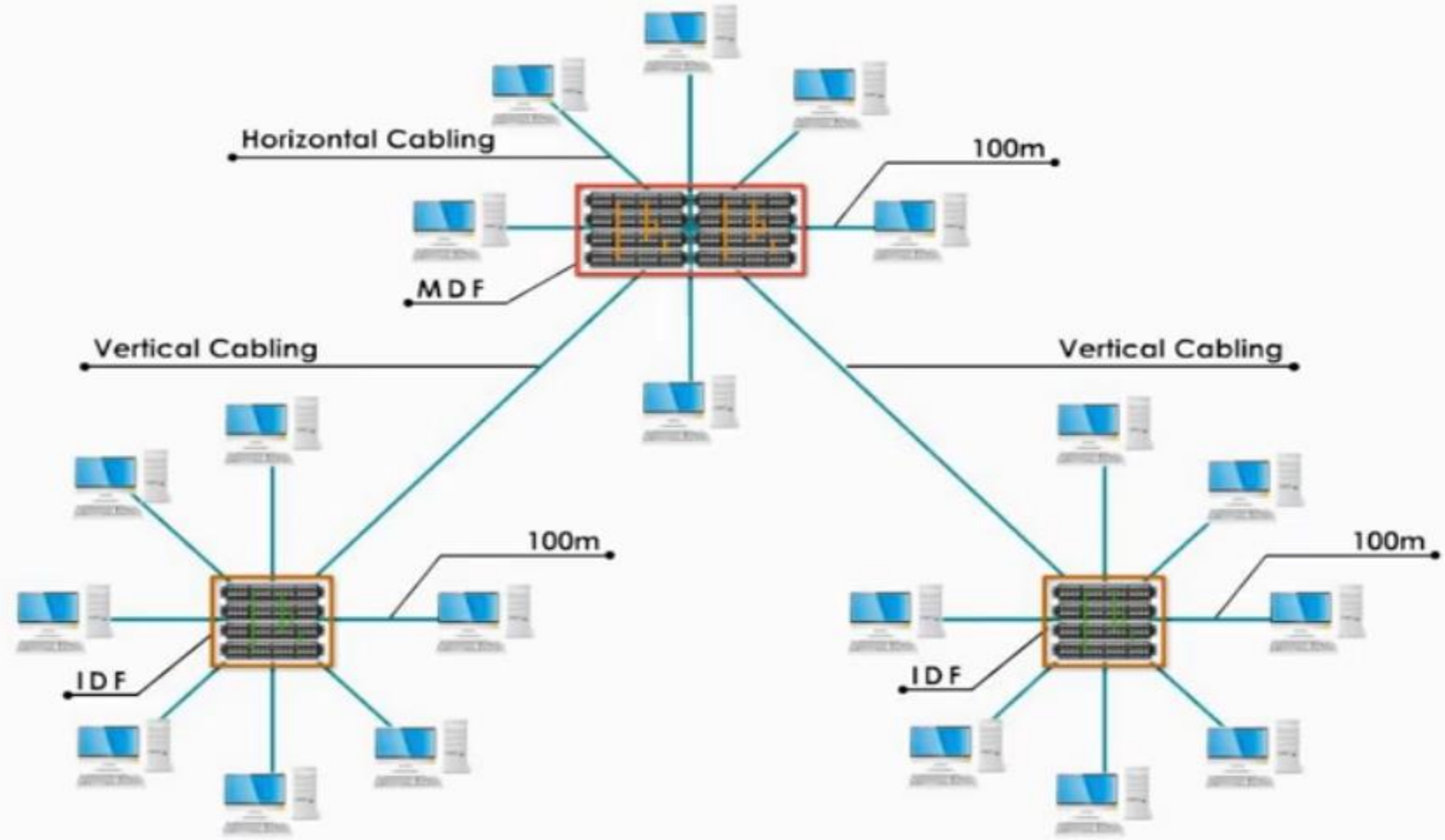
- Intermediate Distribution Frame
- A joint point between the MDF and telecom room
- Can be same/confused as telecom room/closet/enclosure
    - Intermediate-size network
    - A cable rack that interconnects between the MDF and workstations



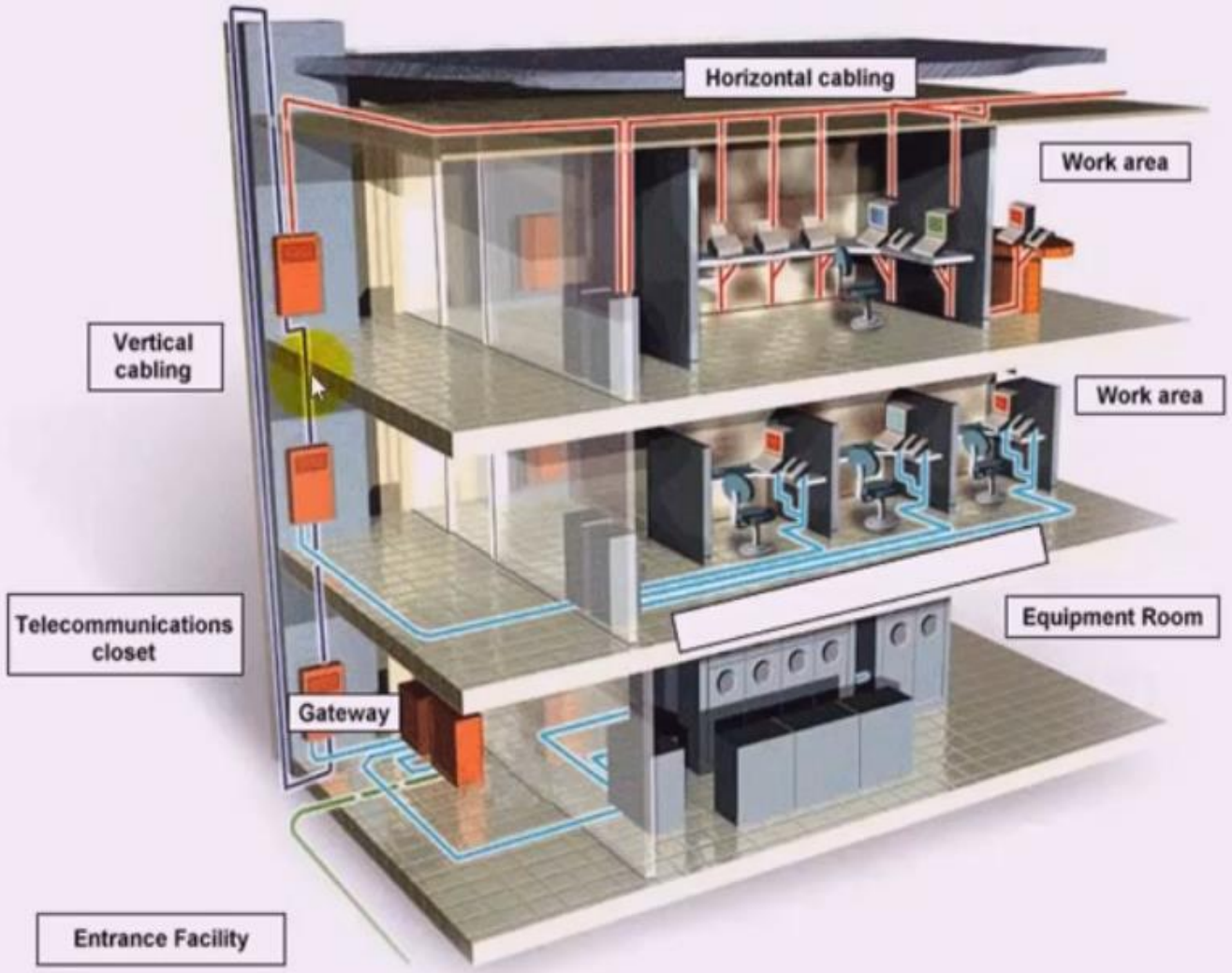
Backbone Cabling:

- Cabling between the telecom room, IDF, MDF, and entrance facility
- Also known as vertical cabling
- Inter-building and intra-building cabling
    - building to building on a typical college campus
    - floor to floor in a multistory building
- UTP/STP should be less than 30 meters
- Fiber cable is recommended

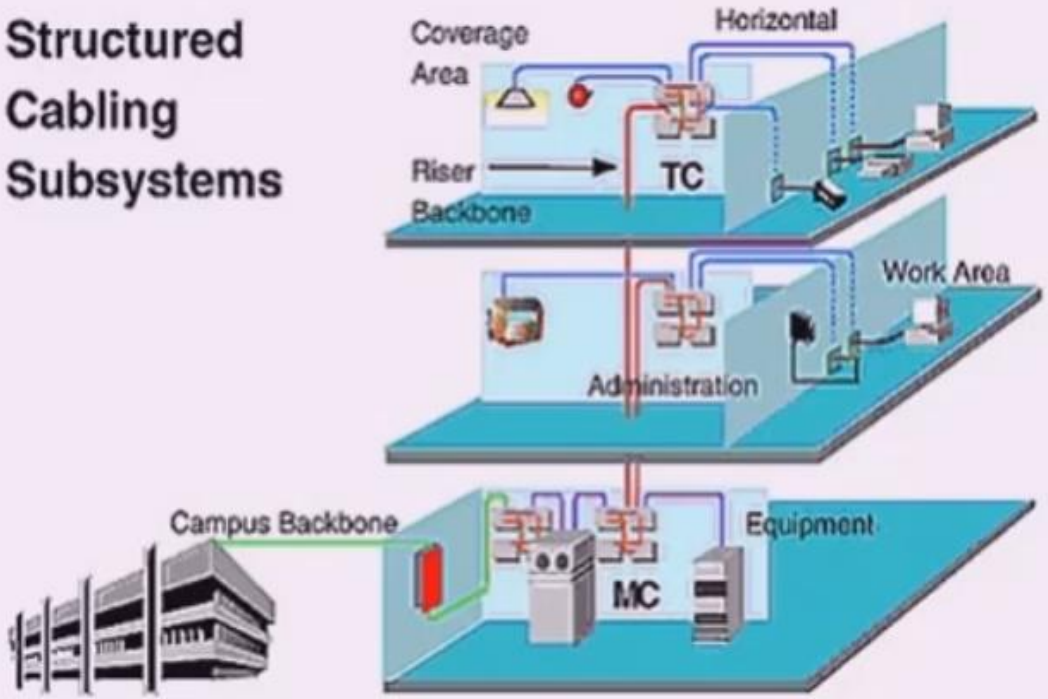
Vertical Cabling vs Horizontal Cabling



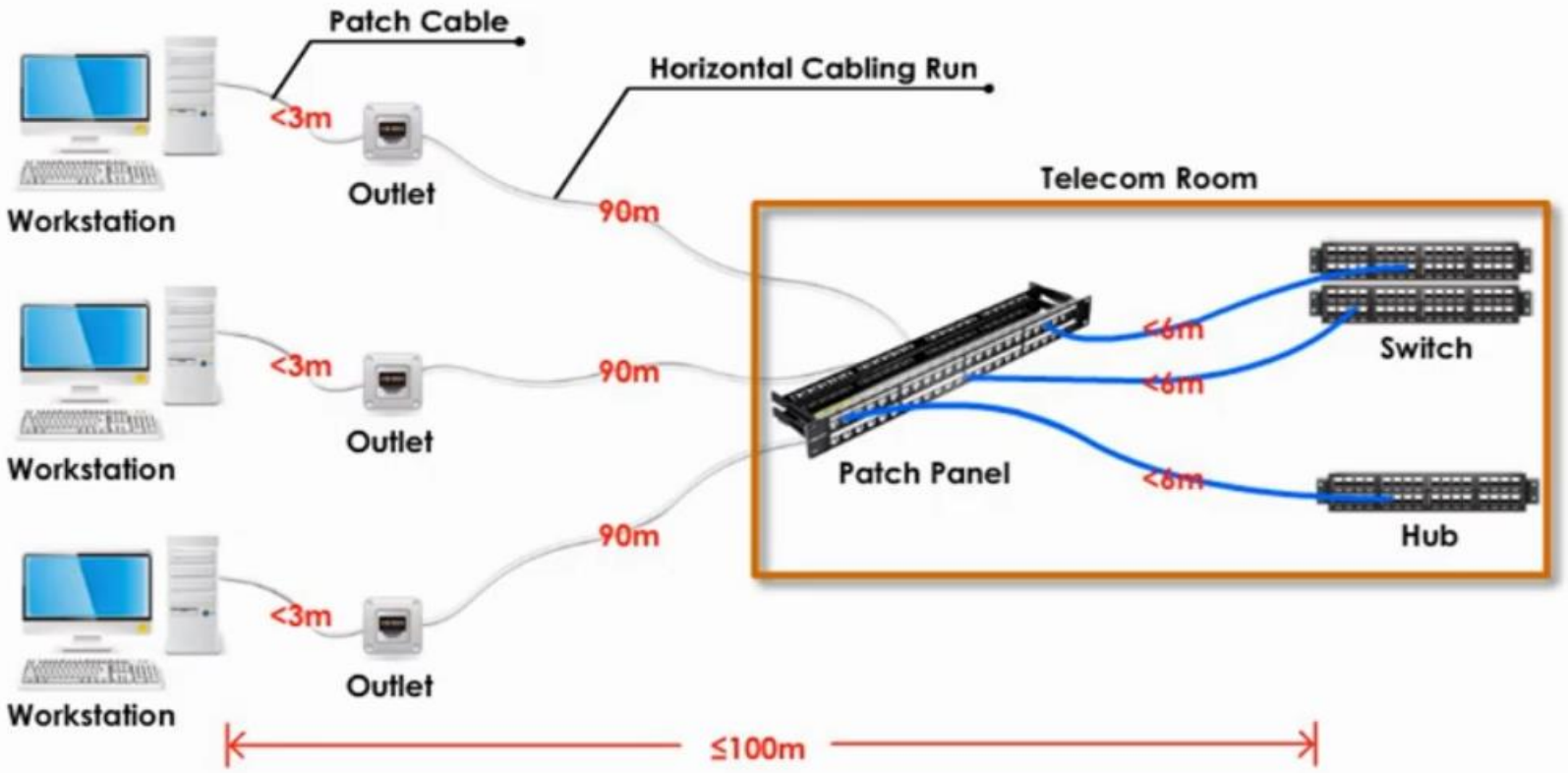
Structured Cabling Components



Structured Cabling Subsystems



3 Basic Components of Structured Cabling



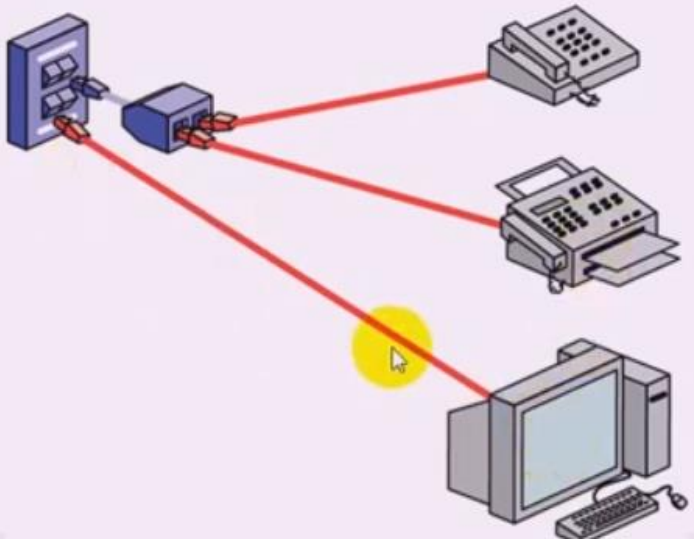
To comply with EIA/TIA-568 wiring standard

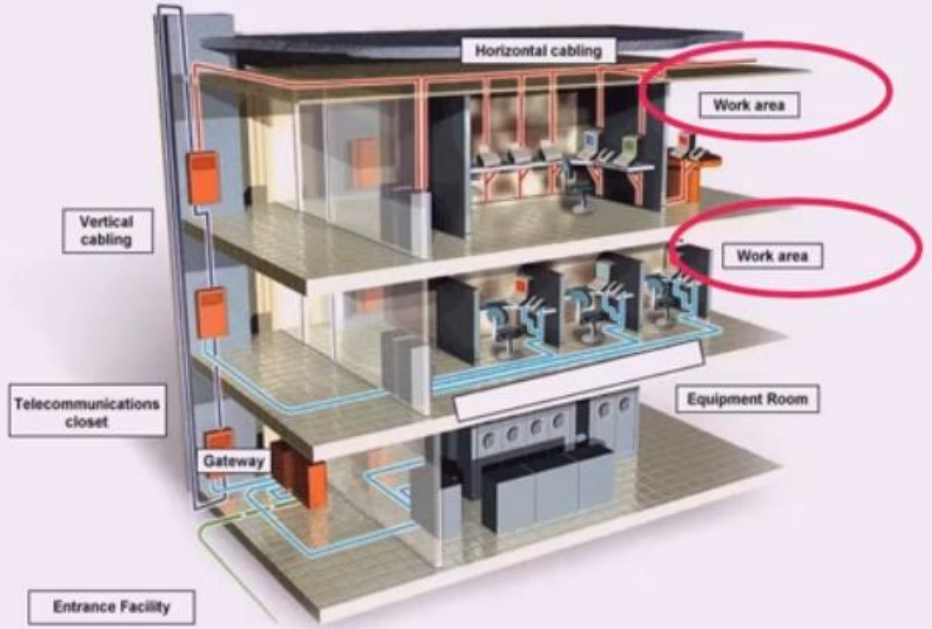
Horizontal Wiring

- The horizontal wiring system runs from each workstation outlet to the telecommunication closet.
- The maximum horizontal distance from the telecommunication closet to the communication outlets is 90 meters (295 feet) independent of media type.
- An additional 6 meters (20 feet) is allowed for patch cables at the telecommunication closet and at the workstation, but the combined length cannot exceed 10 meters (33 feet).

Work Area

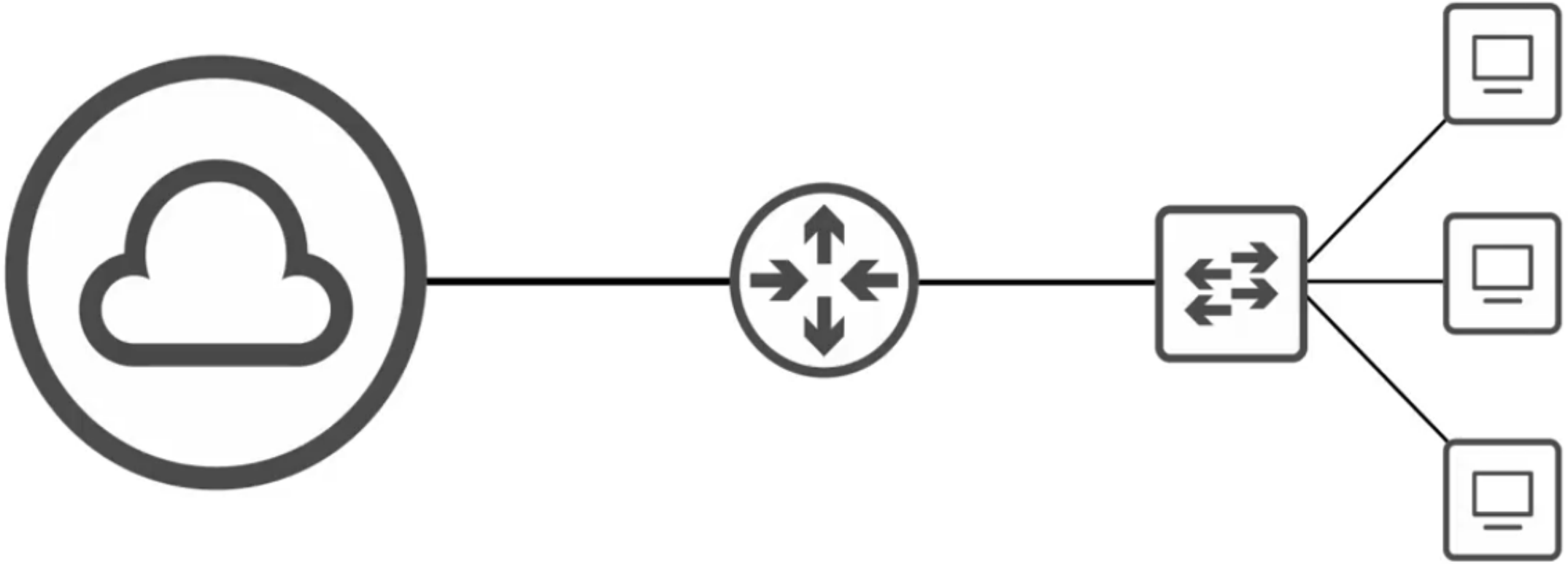
- The work area wiring subsystem consists of the communication outlets (wallboxes and faceplates), wiring, and connectors needed to connect the work area equipment (computers, printers, and so on) via the horizontal wiring subsystem to the telecommunication closet.
- The standard requires that two outlets be provided at each wall plate-one for voice and one for data.

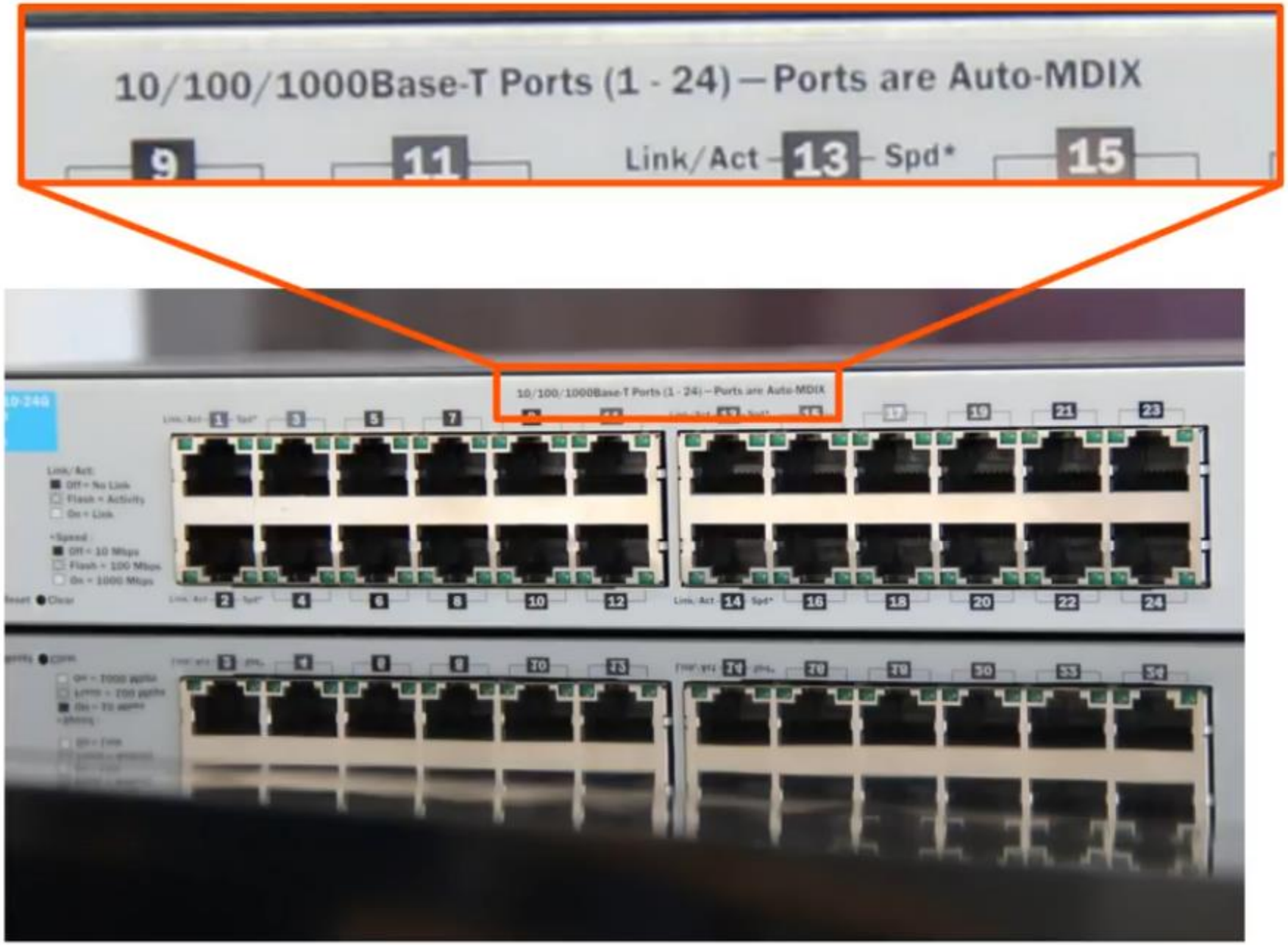




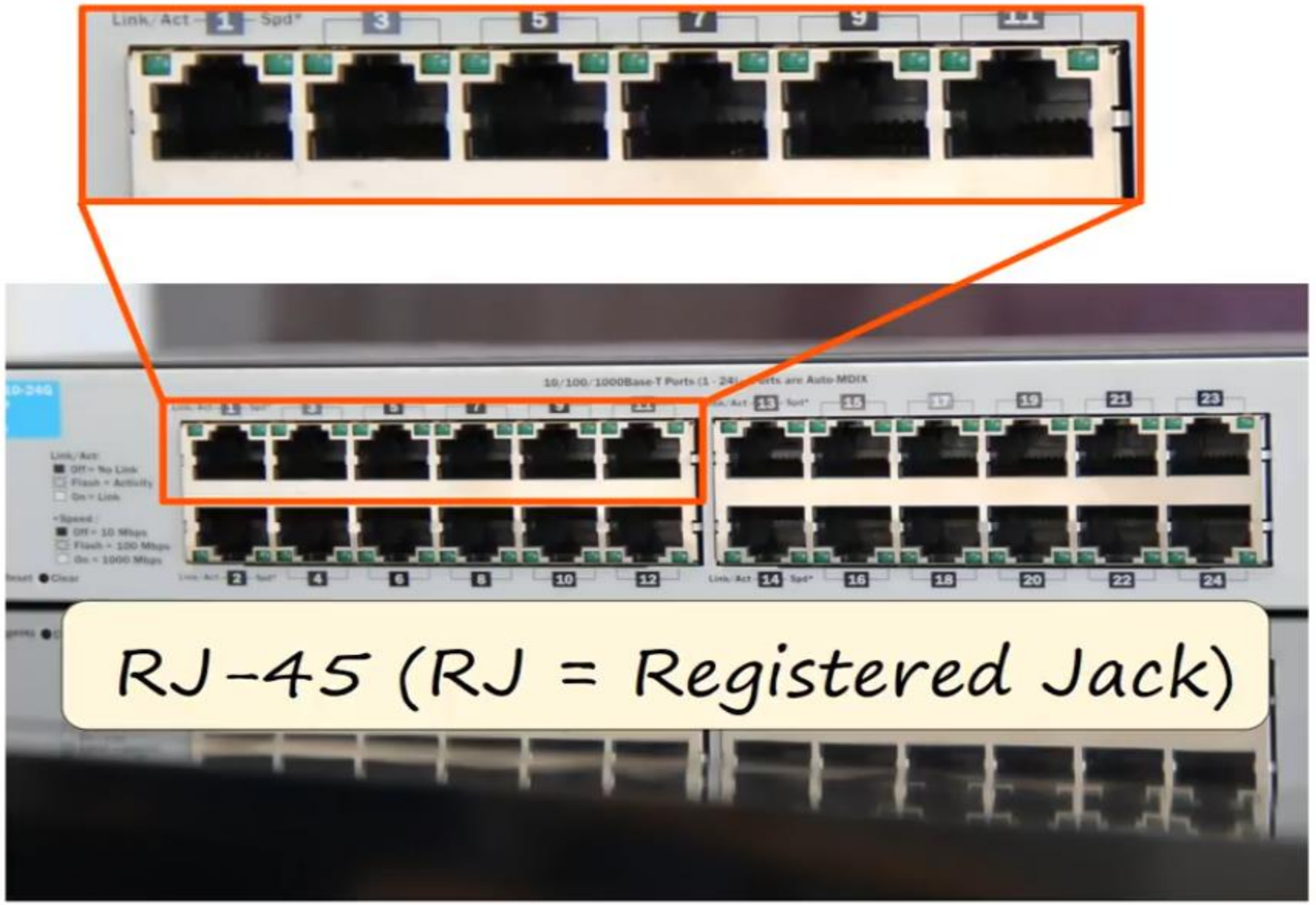
CCNA 200-301 Day 2

Interfaces and Cables

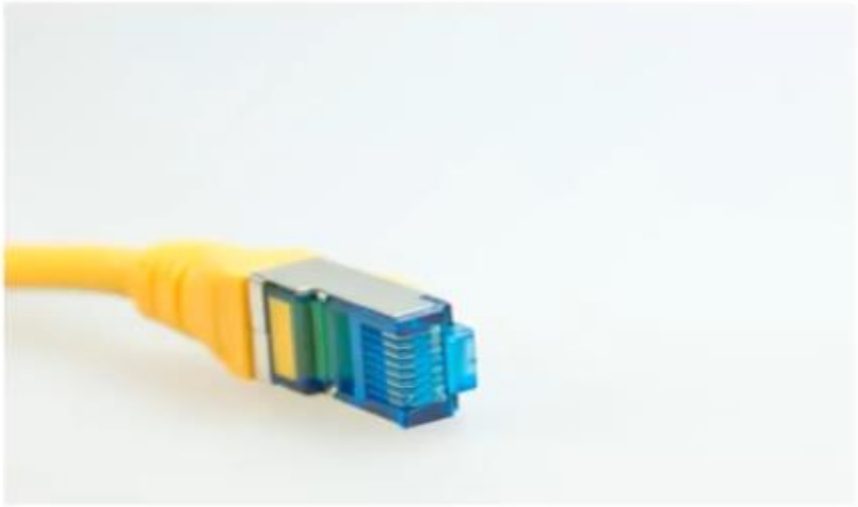



10/100/1000Base-T Ports (1 - 24) — Ports are Auto-MDIX
9
11
Link/Act
13
Spd*
15

RJ-45

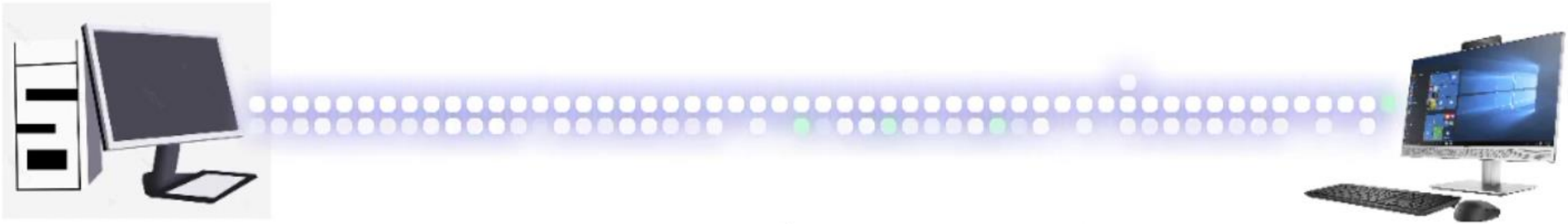


RJ-45



"bits"

bits is measured in bits per second



Kilobits per second (kbps)

Megabits per second (mbps)

Gigabits per second (gbps)

Speed is measured in bits per second

Kilobits per second (kbps)

Megabits per second (mbps)

Gigabits per second (gbps)

Not (Bytes per second)

1 Kilobit = 1000 bits

1 Megabit = 1,000,000,bits

1 Gigabit = 1,000,000,000 bits

1 Terabit = 1,000,000,000,000 bits

Data on Hard drive is measured in Bytes

Kilobyte (KB) is 8 times
larger than kilobit (kb)

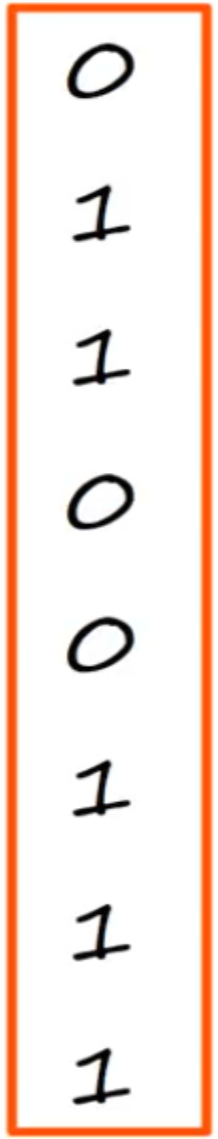
Megabyte (MB) is 8 times
larger than Megabit (Mb)

Gigabyte (GB) is 8 times
larger than Gigabit (Gb)

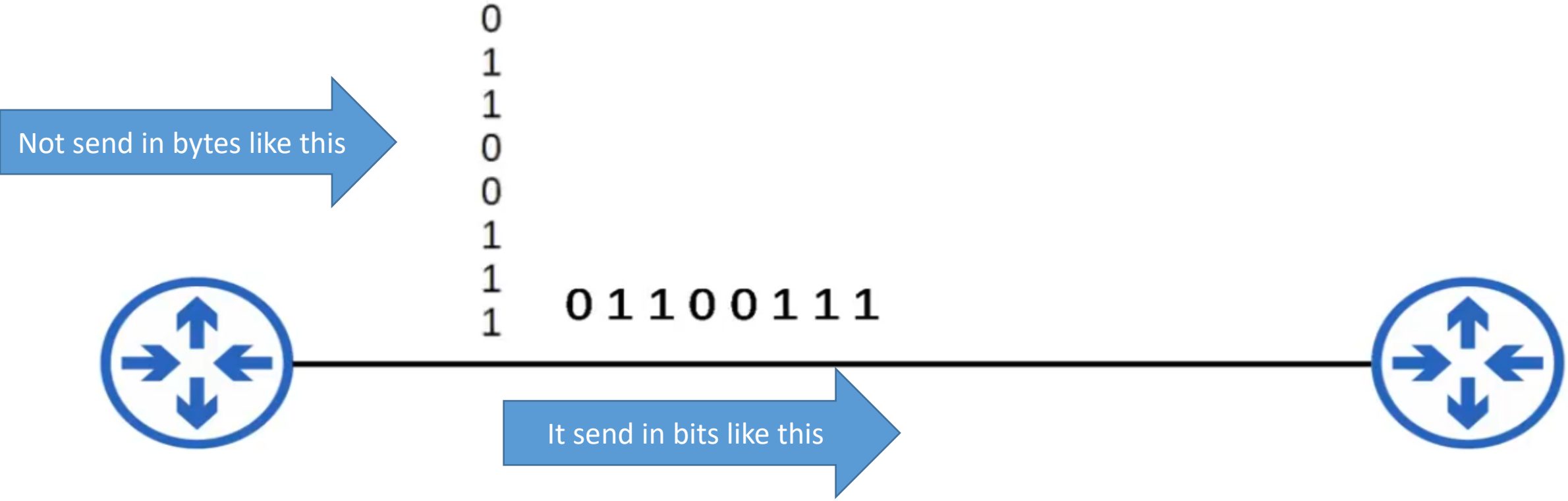
Bits and Bytes

- 0
- 1
- 1
- 0
- 0
- 1
- 1
- 1

8 bits = 1 byte



Bits and Bytes

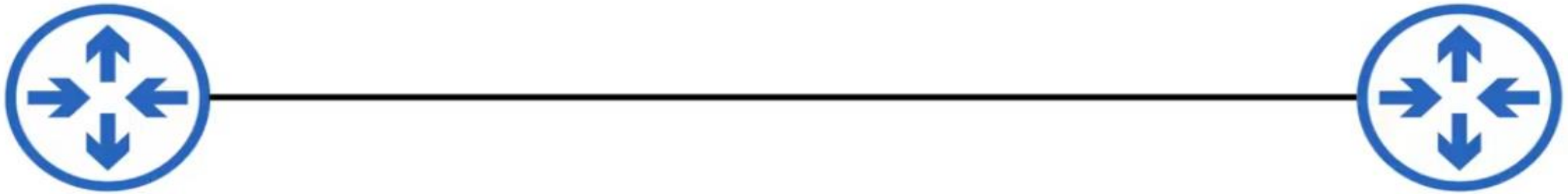


Speed is measured in **bits per second** (Kbps, Mbps, Gbps, etc), not bytes per second.

Bits and Bytes

- 1 kilobit (Kb) = 1,000 bits
- 1 megabit (Mb) = 1,000,000 bits
- 1 gigabit (Gb) = 1,000,000,000 bits
- 1 terabit (Tb) = 1,000,000,000,000 bits

Decimal			
Value		SI	
1000	10^3	kbit	**kilobit**
1000^2	10^6	Mbit	megabit
1000^3	10^9	Gbit	gigabit
1000^4	10^{12}	Tbit	terabit
1000^5	10^{15}	Pbit	petabit
1000^6	10^{18}	Ebit	exabit
1000^7	10^{21}	Zbit	zettabit
1000^8	10^{24}	Ybit	yottabit



Ethernet Standards

- Defined in the IEEE 802.3 standard in 1983
- IEEE = Institute of Electrical and Electronics Engineers

IEEE

Ethernet Standards (copper)

Speed	Common Name	IEEE Standard	Informal Name	Maximum Length
10 Mbps	Ethernet	802.3i	10BASE-T	100 m
100 Mbps	Fast Ethernet	802.3u	100BASE-T	100 m
1 Gbps	Gigabit Ethernet	802.3ab	1000BASE-T	100 m
10 Gbps	10 Gig Ethernet	802.3an	10GBASE-T	100 m

Ethernet Standards (copper)

BASE = refers to baseband signaling
T = **twisted pair** (more on that soon!)

			Informal Name	Maximum Length
10 Mbps	Ethernet	[illegible]i	10BASE-T	100 m
100 Mbps	Fast Ethernet	802.3u	100BASE-T	100 m
1 Gbps	Gigabit Ethernet	802.3ab	1000BASE-T	100 m
10 Gbps	10 Gig Ethernet	802.3an	10GBASE-T	100 m

10BaseT

10

Prefix

Speed in Mb/s
10, 100, 1000
G indicates Gb/s

Base

Middle stuff

Baseband vs. Broadband

Baseband – one data stream
Broadband – more than one stream

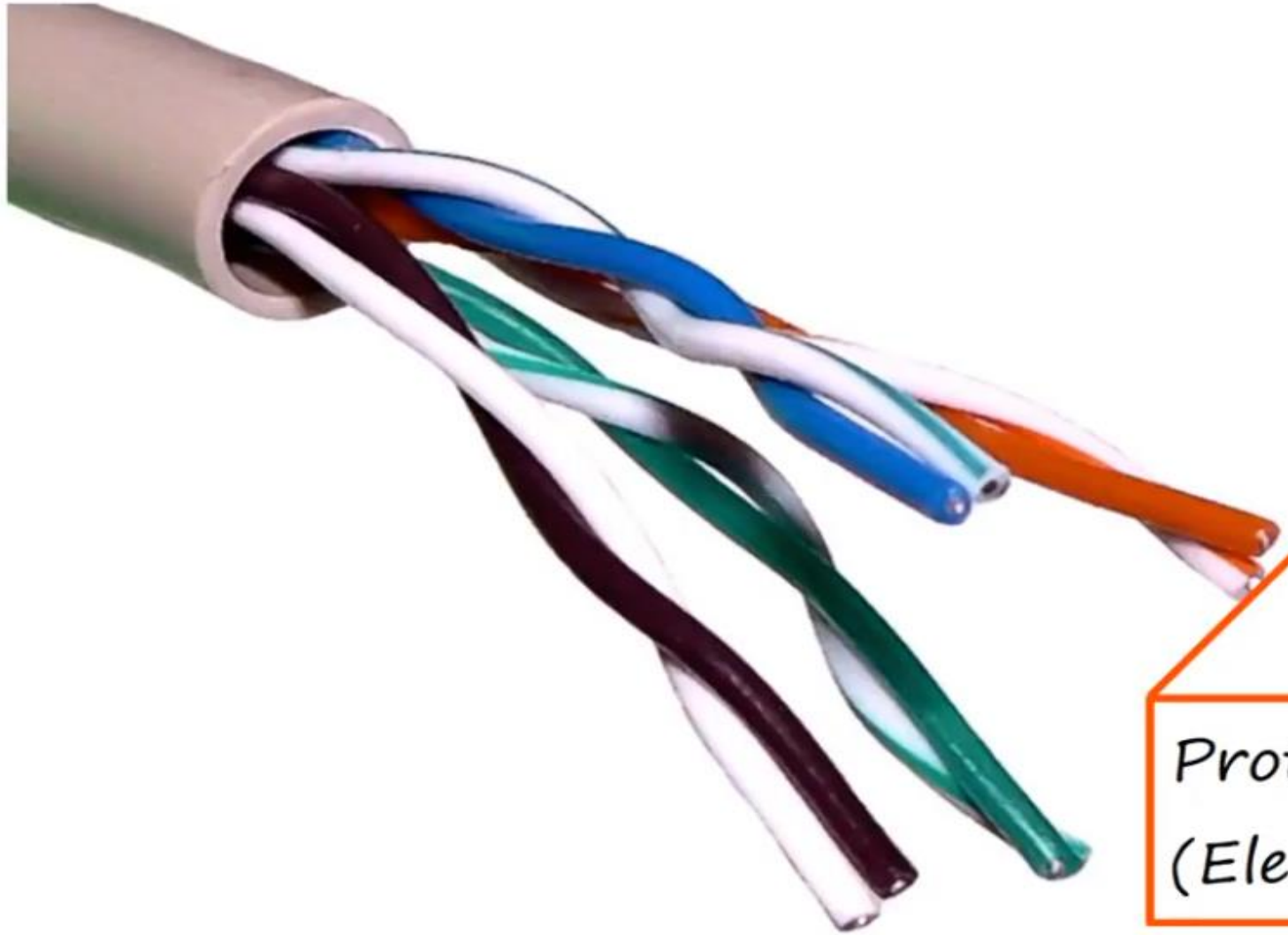
T

Suffix

Cable Type and Maximum Distance

Numbers 2 and 5: Coax at are ~200m and 500m
T-letters: Twisted pair at 100m, always
Other letters: Fiber at various lengths
E – extended 40km (25 miles) SMF
F – 2000m, MMF
S – 300m, MMF

UTP Cables



Unshielded

Twisted

Pair

Protects against EMI

(Electromagnetic Interference)

UTP Cables

10BASE-T
100BASE - T
= 2 pairs (4 wires)

1000BASE-T
10GBASE-t
= 4 pairs (8 wires)

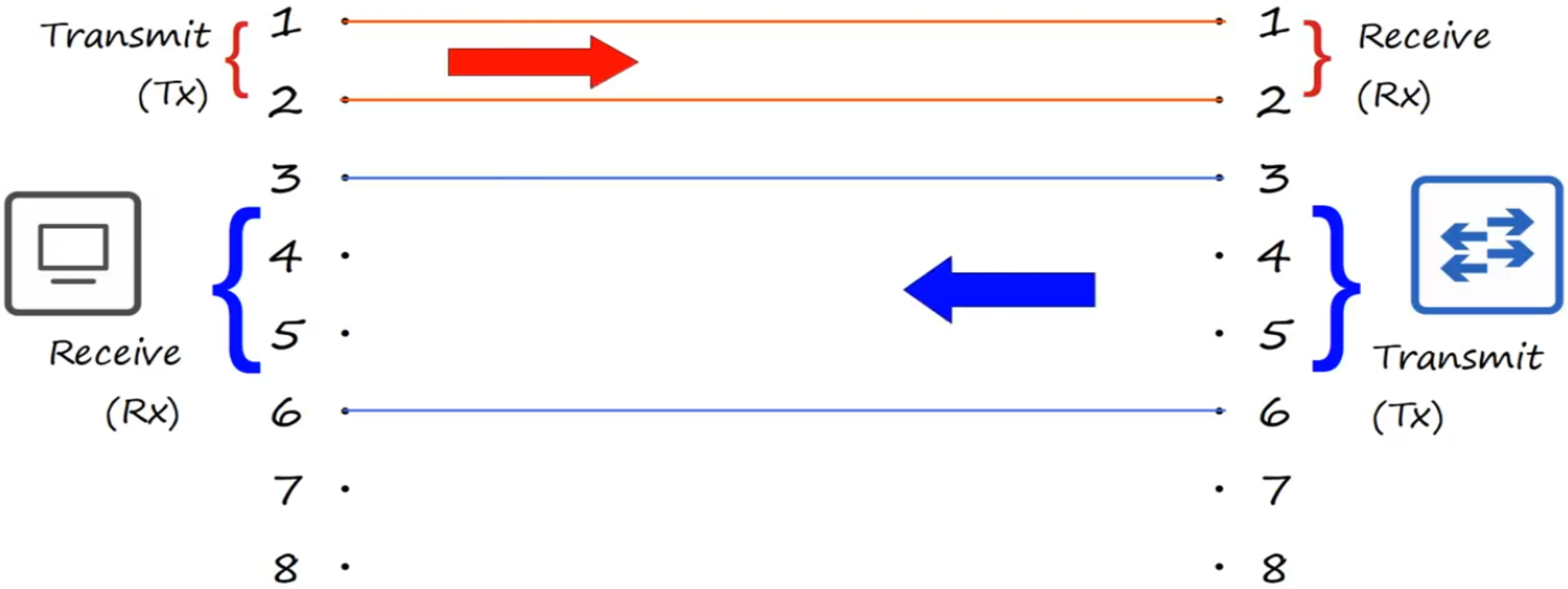
MORE DEFINITIONS – RJ45

There are 8 wires in a network cable

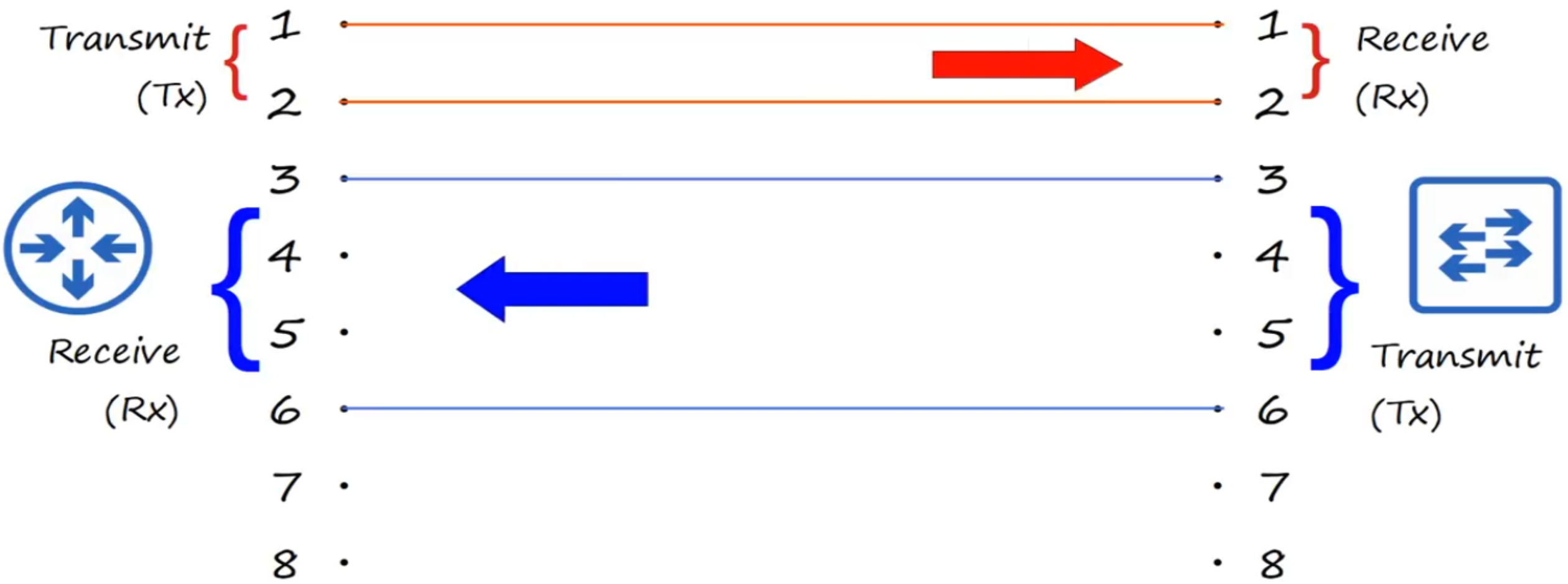
- 10/100BASE-T
  - 4 wires carry data signals (1/2, 3/6)
  - 4 wires are unused (4/5, 7/8)
- 1000BASE-T
  - All 8 wires carry data signals (1/2, 3/6, 4/5, 7/8)

UTP Cables (10BASE-T, 100BASE-T)

Full-Duplex

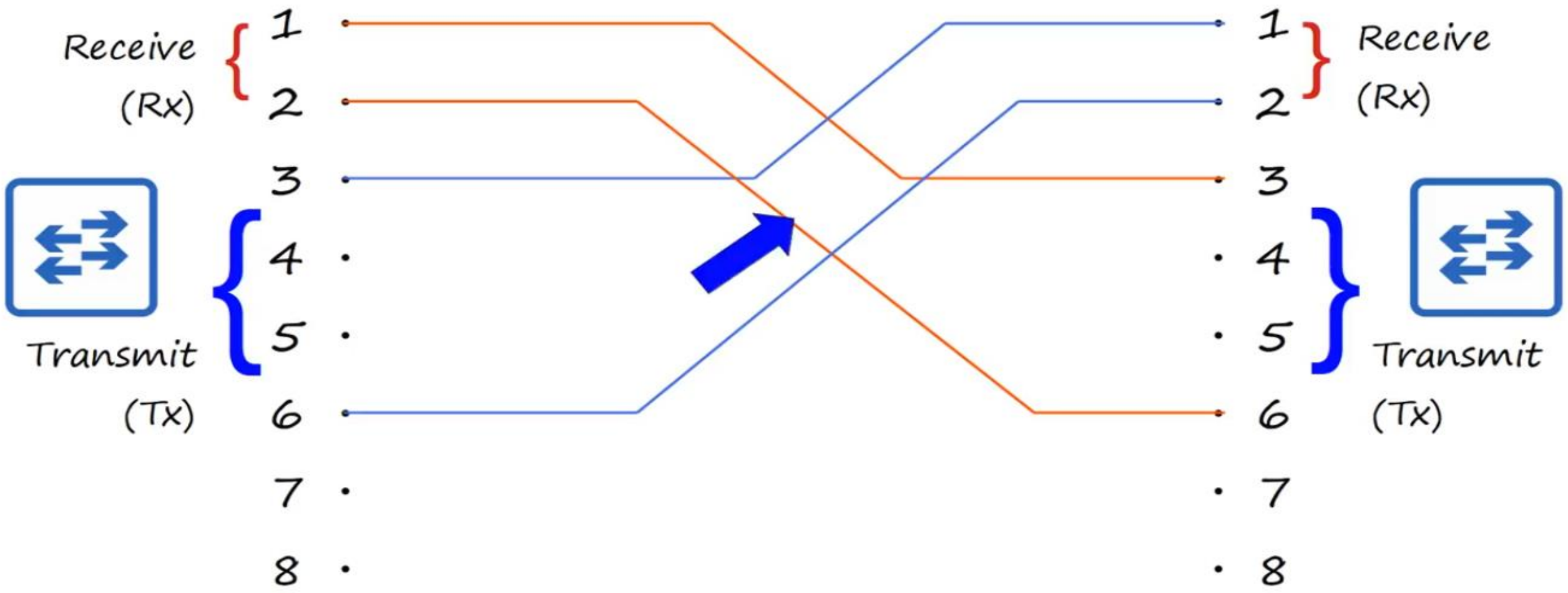


UTP Cables (10BASE-T, 100BASE-T)



UTP Cables (10BASE-T, 100BASE-T)

Crossover cable

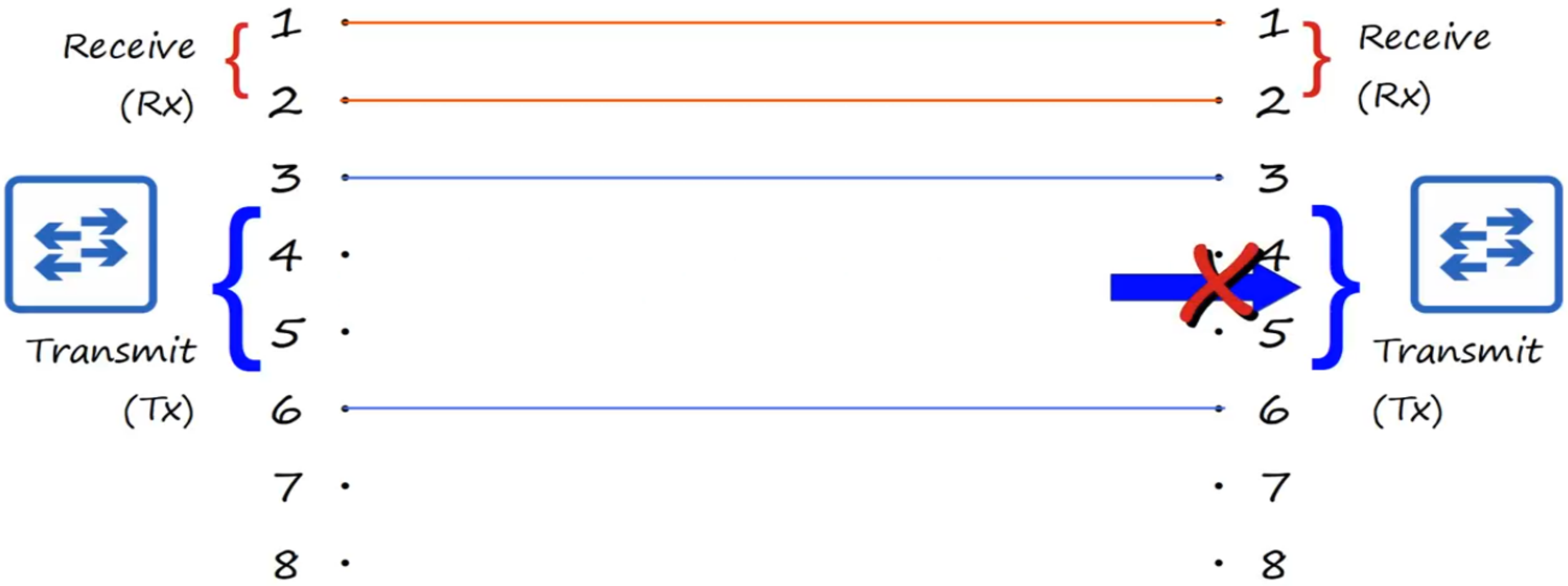


UTP Cables (10BASE-T, 100BASE-T)

Device Type	Transmit (Tx) Pins	Receive (Rx) Pins
Router 	1 and 2	3 and 6
Firewall 	1 and 2	3 and 6
PC 	1 and 2	3 and 6
Switch 	3 and 6	1 and 2

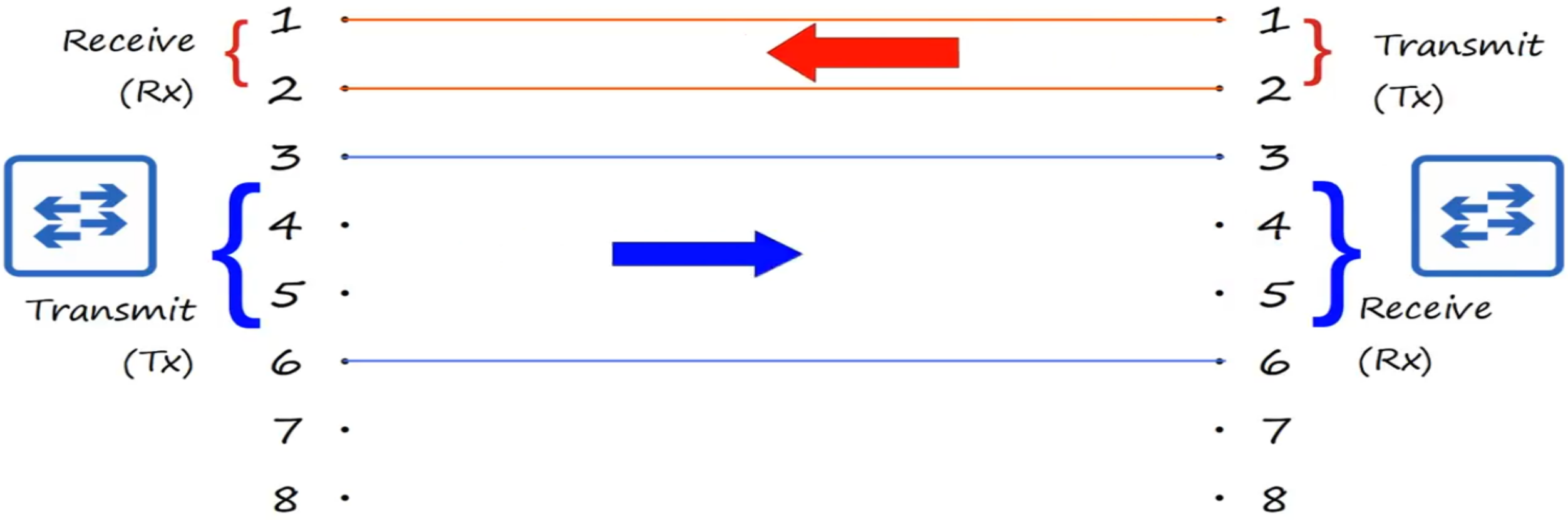
UTP Cables (10BASE-T, 100BASE-T)

Auto MDI-X



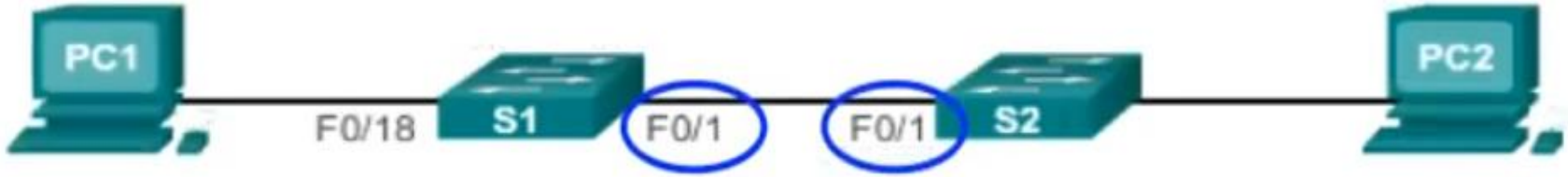
UTP Cables (10BASE-T, 100BASE-T)

Auto MDI-X



Auto MDI-X allows devices to detect which pins and wires their neighbor is using to transmit and receive data, and adjust their own operations to match.

Configuring MDIX Setting



- **`mdix auto`** interface configuration
  - Requires the commands **`speed auto`** and **`duplex auto`**

```
S1(config)# interface fa0/1
S1(config-if)# speed auto
S1(config-if)# duplex auto
S1(config-if)# mdix auto
S1(config-if)#
```

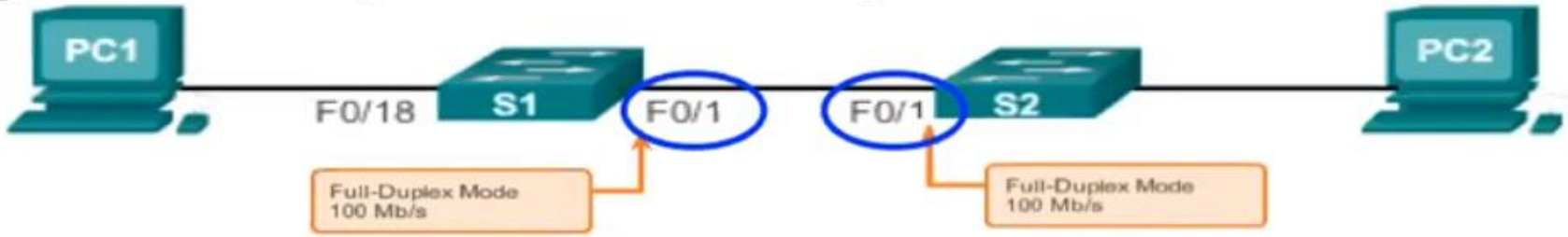
```
S1(config)# interface fa0/1
S1(config-if)# speed auto
S1(config-if)# duplex auto
S1(config-if)# mdix auto
S1(config-if)#
```

- **Note:**
  - The auto-MDIX feature is enabled by default on many new Cisco switches.

Verify MDIX Setting

```
S1# show controllers ethernet-controller fa 0/1 phy | include Auto-MDIX
 Auto-MDIX                       :  On    [AdminState=1    Flags=0x00056248]
S1#
```

Configure Duplex and Speed



- It's best practice is to manually set the speed/duplex settings when connecting to known devices (i.e., servers, dedicated workstations, or network devices).

```
S1(config)# interface fastethernet 0/1
S1(config-if)# speed ?
  10    Force 10 Mbps operation
  100   Force 100 Mbps operation
  auto  Enable AUTO speed configuration
S1(config-if)# speed 100
S1(config-if)# duplex ?
  auto  Enable AUTO duplex configuration
  full  Force full duplex operation
  half  Force half-duplex operation
S1(config-if)# duplex full
S1(config-if)# ^Z
S1#
```

```
S2(config)# interface fastethernet 0/1
S2(config-if)# speed 100
S2(config-if)# duplex full
S2(config-if)# ^Z
S2#
```

UTP Cables (1000BASE-T, 10GBASE-T)

Each pair is bidirectional.

Type	Use
Category 1 (1Mhz)	Voice Only (Telephone Wire)
Category 2 (4Mhz)	Data to 4 Mbps (LocalTalk)
Category 3 (16Mhz)	Data to 10 Mbps (Ethernet)
Category 4 (20Mhz)	Data to 20 Mbps (16 Mbps Token Ring)
Category 5 (100Mhz)	Data to 100 Mbps (Fast Ethernet)
Category 5e (100Mhz)	Data to 1000Mbps (Full Duplex Fast Ethernet and Gigabit Ethernet)
Category 6 (250Mhz)	Data to 1000Mbps (more stringent specifications for crosstalk and system noise)

Category	Maximum data rate	Usual application
CAT 1	Up to 1 Mbps (1 MHz)	analog voice (POTS) Integrated Services Digital Network Basic Rate Interface in ISDN Doorbell wiring
CAT 2	4 Mbps	Mainly used in the IBM Cabling System for Token Ring networks
CAT 3	16 Mbps	Voice and data on 10BASE-T Ethernet
CAT 4	20 Mbps	Used in 16 Mbps Token Ring Otherwise not used much
CAT 5	100 Mbps 1000 Mbps (4 pair)	100 Mbps TPDDI 155 Mbps ATM No longer supported; replaced by 5E
CAT 5E	1000 Mbps (10000 Mbps prototype)	100 Mbps TPDDI 155 Mbps ATM Gigabit Ethernet Offers better near-end crosstalk than CAT 5
CAT 6	Up to 400 MHz	Super-fast broadband applications Most popular cabling for new installs
CAT 6E	Up to 625 MHz (field-tested to 500 MHz)	Support for 10 Gigabit Ethernet (10GBASE-T)
CAT 7 (ISO Class F)	600-700 MHz 1.2 GHz in pairs with Siemon connector	Full-motion video Teleradiology Government and manufacturing environments Shielded system

Common Ethernet Types

Common Name	Formal Standard	Speed	Type	Max Length
Ethernet	10BASE-T / 802.i	10Mb/s	Copper	100M
Ethernet	10BASE-FL / 802.3j	10Mb/s	Fiber	2,000m
Fast Ethernet	100BASE-T / 802.3u	100Mb/s	Copper	100m
Fast Ethernet	100BASE-FX / 802.3u	100Mb/s	Fiber	2,000m
Gigabit Ethernet	1000BASE-T / 802.3ab	1Gb/s	Copper	100m
Gigabit Ethernet	1000BASE-LX / 802.3z	1Gb/s	Fiber	5,000m
10 Gigabit Ethernet	10GBASE-T / 802.3an	10Gb/s	Copper	100m
10 Gigabit Ethernet	10GBASE-LR/W / 802.3ae	10Gb/s	Fiber	10,000m

Twisted Pair CABLE

CATEGORY	SPEED	
CATEGORY 3	10 Mbps	
CATEGORY 5	100 Mbps	
CATEGORY 5e	1 Gbps	Enhanced
CATEGORY 6	1 Gbps	10 Gbps (cable length under 100 meters)
CATEGORY 6a	10 Gbps	Augmented
CATEGORY 7	10 Gbps	Added shielding to the wires.

Data Cabling Comparison Chart

	Cat5	Cat5e	Cat6	Cat6a	Cat7	Cat8
Maximum Bandwidth	100mhz	100mhz	250mhz	500mhz	600mhz	2000mhz
1 GIG Distance	n/a	100m	100m	100m	100m	100m
10 GIG Distance	n/a	n/a	55m	100m	100m	100m
40 GIG Distance	n/a	n/a	n/a	n/a	n/a	30m
Cable Construction	UTP	UTP / STP	UTP / STP	UTP / STP	STP	STP

Differences in Network Cabling

	1 Gigabit	10 Gigabit	40 Gigabit	Freq	Distance	Comments
Cat 5e	Yes	NO	NO	100 MHz	100 Meters	
Cat 6	Yes	35 Meters	NO	250-500 MHz	100 Meters	
Cat 6a	Yes	Yes	NO	250-500 MHz	100 Meters	Thicker Conductors (23 AWG)
Cat 7	Yes	Yes	*10 Meters Max*	600 MHz	100 Meters	Thicker Conductors (23 AWG)
Cat 8	Yes	Yes	30 Meters	2000 MHz	30 Meters	Thicker Conductors (22 AWG)

Ethernet Standards for Copper Cabling

Ethernet Standard	Media Type	Bandwidth Capacity	Distance Limitation
10BASE-T	Cat 3 (or higher) UTP	10 Mbps	100 m
100BASE-TX	Cat 5 (or higher) UTP	100 Mbps	100 m
1000BASE-T	Cat 5 (or higher) UTP	1 Gbps	100 m
10GBASE-T	Cat 6/Cat 6a (or higher)	10 Gbps	55 m/100 m
40GBASE-T	Cat 8	40 Gbps	30 m

VeEX
The Verification Experts

1 Gbps Standards

	1000BASE-T	1000BASE-SX	1000BASE-LX	1000BASE-ZX
Media	Cat 5E UTP 4 pairs	850 nm 62.5 or 50 µm Multimode fiber	1,310 nm 50 µm Multimode Or 9 µm Single-mode fiber	1,550 nm Single-mode fiber
Max. segment length	100 m	500 m (50 µm) 220 m (62.5 µm)	10 km (SM) 550 m (MM)	100 km
Connector	RJ45	SC /LC	SC/LC	SC/LC

VeEX
The Verification Experts

10GE Standards

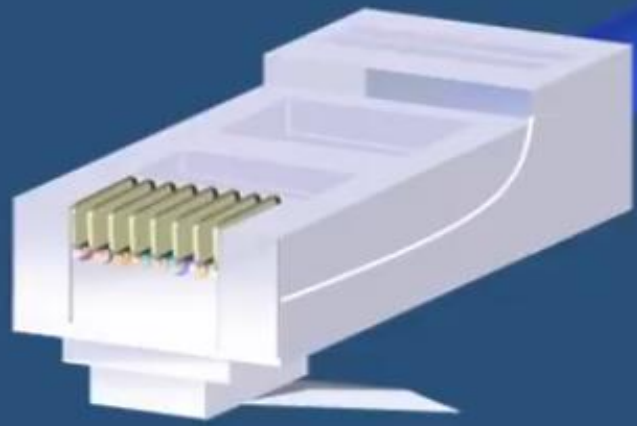
	10GBASE-SR	10GBASE-LR	10GBASE-ER	10GBASE-SW	10GBASE-LW	10GBASE-EW
Media	850 nm 50 µm Multimode fiber	1,310 nm 9 µm Single-mode fiber	1,550 nm Single-mode fiber	850 nm 50 µm Multimode fiber	1,310 nm 9 µm Single-mode fiber	1,550 nm Single-mode fiber
Max. seg. length	300 m	10 km	30 km	300 m	10 km	30 km
Connector	SC	SC	SC	SC	SC	SC
PHY	LAN	LAN	LAN	WAN	WAN	WAN

RJ-45 CONNECTOR

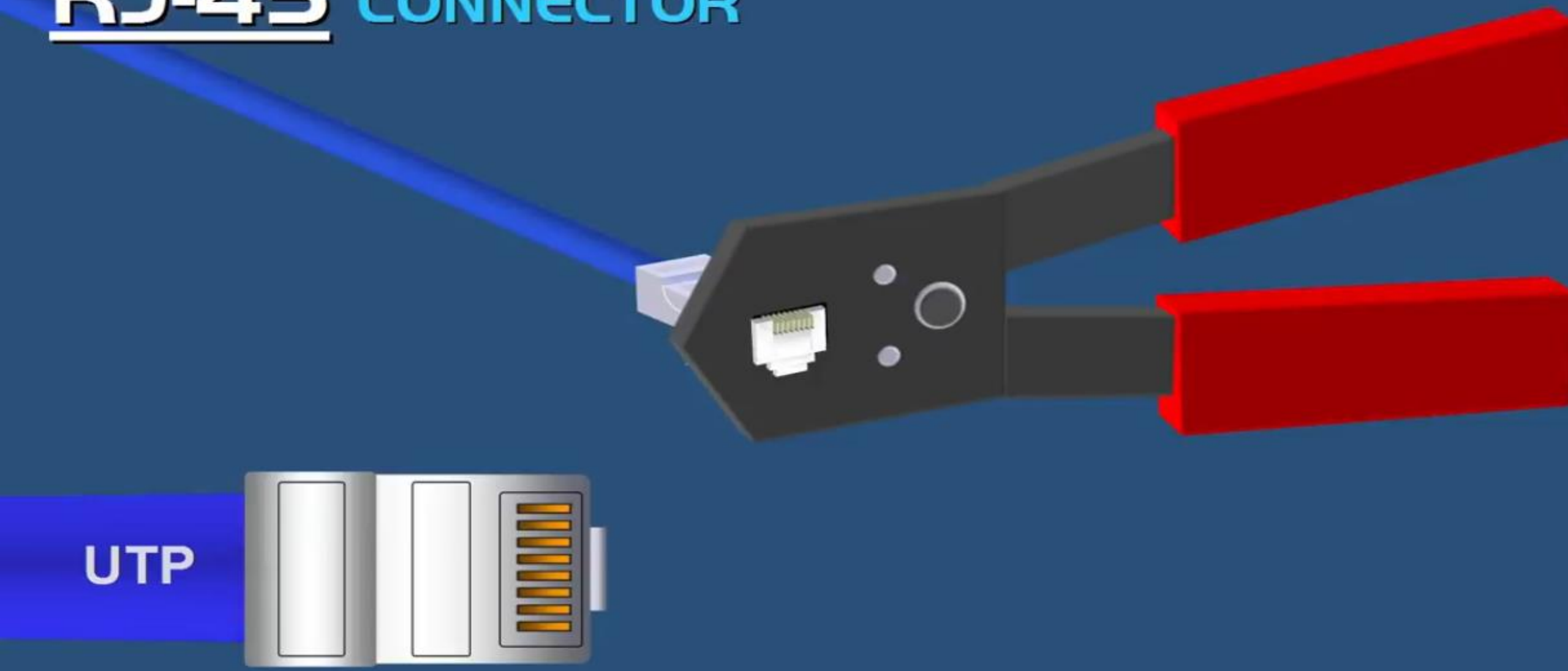
The most common network connector that is used in networking.

8 pin modular connector.

Used to connect computers and network devices in a local area network.



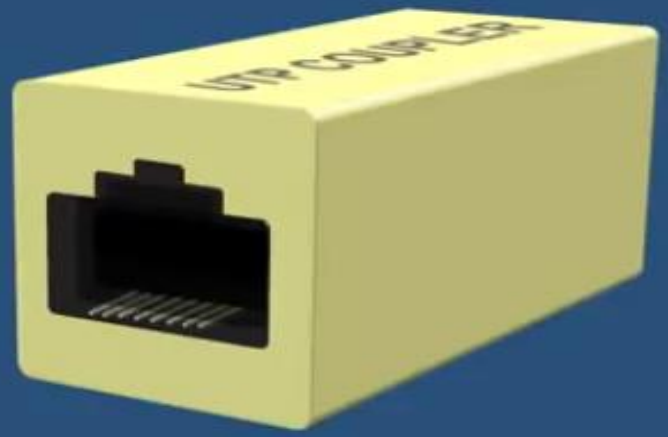
RJ-45 CONNECTOR



UTP COUPLER

Used to connect UTP network cables.

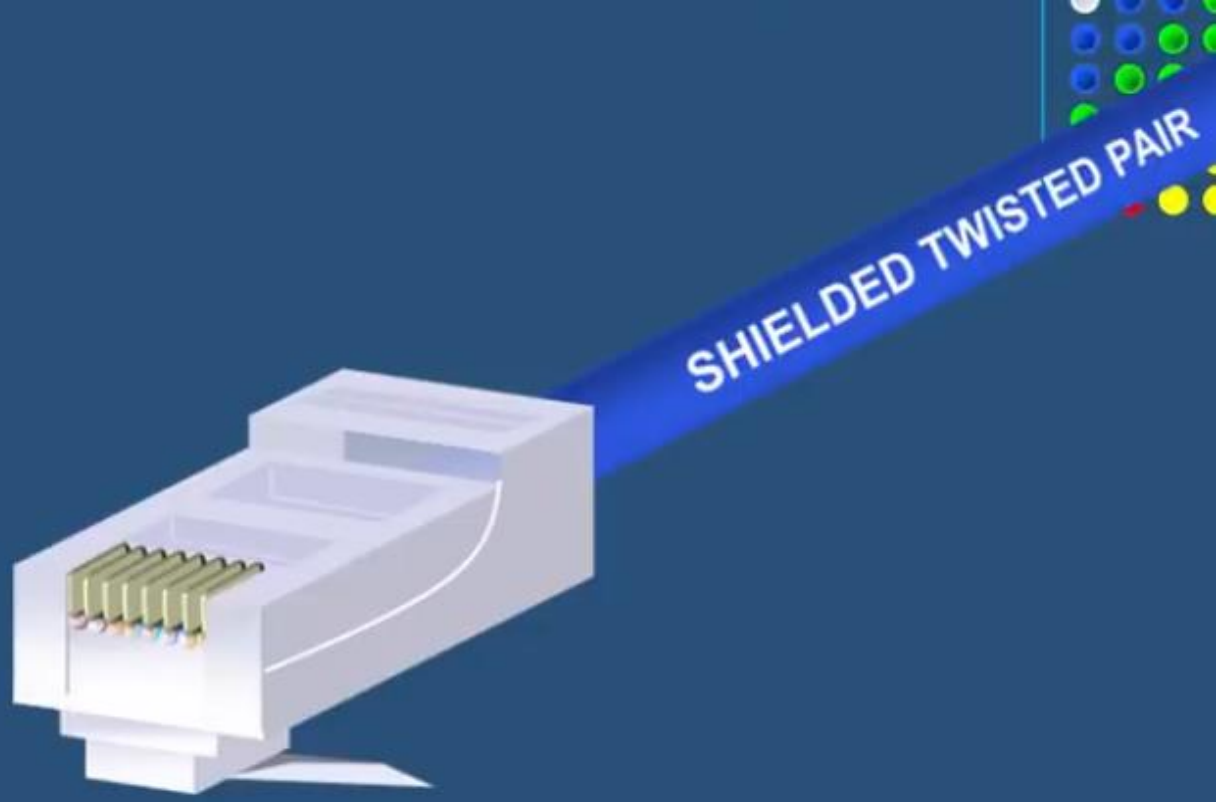
Typically used when running a longer cable is not an option.

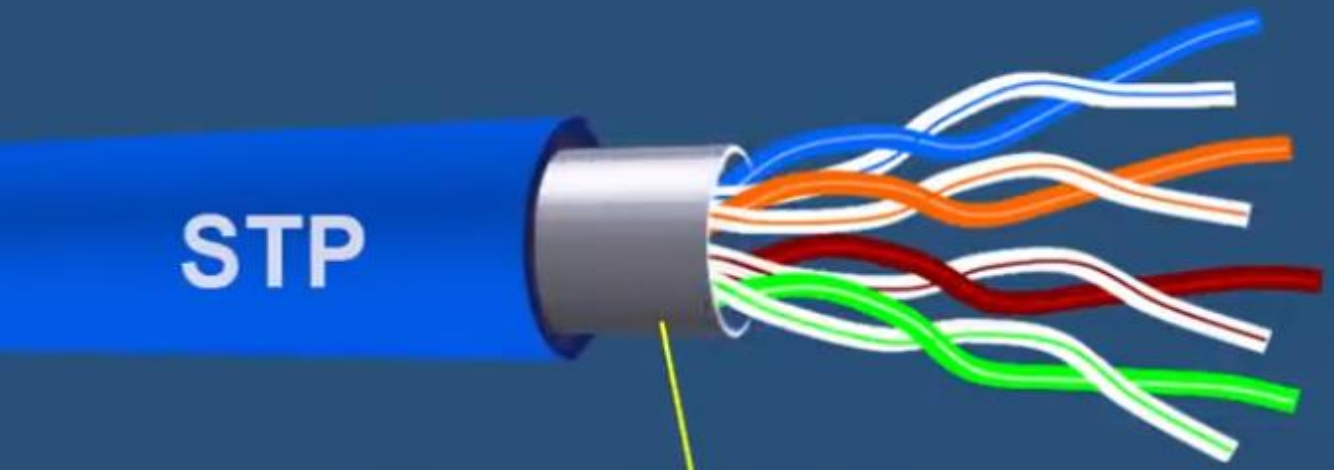


RJ-48 CONNECTOR

Looks similar to the RJ-45.

Used with shielded twisted pair cable.

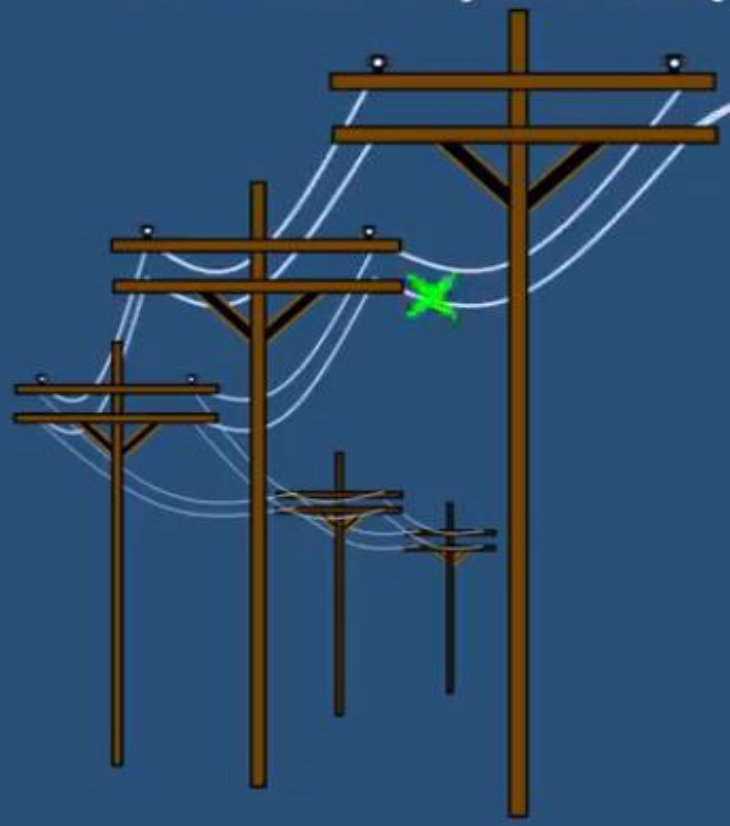


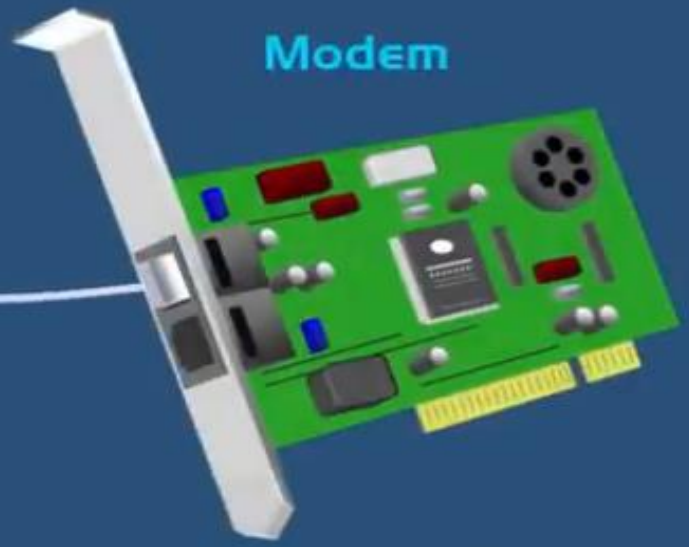


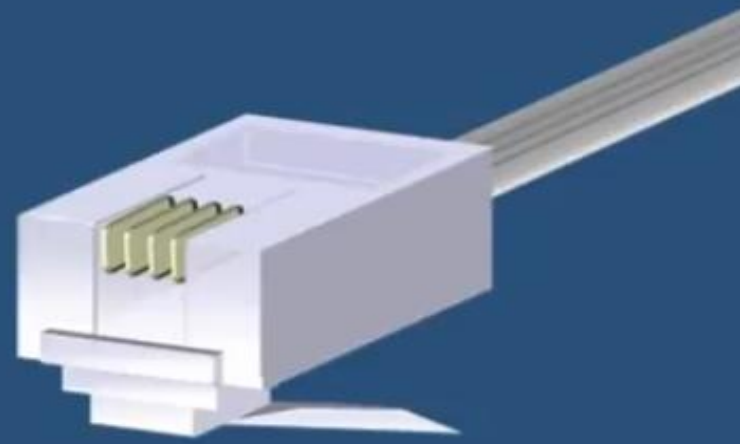
STP has a foil shield that covers the wires.

RJ-II CONNECTOR

4 wire connector mainly used to connect telephone equipment.







Connects computers to a network through the computer's modem.

Introduction to Power over Ethernet (PoE)

- Power over Ethernet or PoE technology describes a system to safely transfer electrical power, along with data, to remote devices over standard data cables in an Ethernet network (Cat3/Cat5/Cat5e/Cat6).
- The original IEEE 802.3af-2003 standard version of PoE supplies up to 15.4 W of DC power (minimum 44 VDC and 350 mA) to each device. Only 12.95 W is assured to be available at the powered device (PD) as some power is dissipated in the cable.
- No affect on network performance of 10/100/1000 Mbps links to the PD.

Introduction to Power over Ethernet (Cont.)

- Power is remotely supplied from a central location (e.g. wiring closet) for distances under 100 meters without the Ethernet devices having to be individually powered by an AC outlet.
- PDs include IP Phones, Wireless LAN Access Points, IP Security Cameras and various other network devices
- IEEE 802.3af-2003 standard specifies Power over Ethernet (PoE) technology in two different methodologies:
  - Power-Supplying Equipment (PSE) may use either End-Span or Mid-Span
  - Powered devices (PD's) accept power from either type of power source
- Over 70 million PoE PSE ports shipped in 2008

http://www.poweroverethernet.com/

IEEE

5

PoE Key Benefits

- Installation Cost Savings
  - Eliminates the need for electrical outlet installation
  - Dramatically reduces cost of deployment – savings up to $1,000 per PD
  - No need for bulky AC power adaptors
- Simplifies Installation
  - Uses a single Cat5/5e/6 cable for both data and power
- Centralized Power Backup
  - Continuous operation during power interruptions
- Centralized Power Management
  - Devices can be remotely powered down during periods of low usage or for security purposes
- SAFE Power
  - Will not damage Non-PoE devices or legacy peripherals

6

DEFINITIONS

Power Sourcing Equipment (PSE)

- Device that provides power in a PoE network
  - Endspan PSE – located at the end of a link segment
  - Midspan PSE – located in the middle of a link segment

Powered Device (PD)

- Device that draws power from a PSE

A valid PD presents a hardware "signature" to the PSE
- Without it, the PSE will NOT send power
- But WILL still link up and pass data traffic

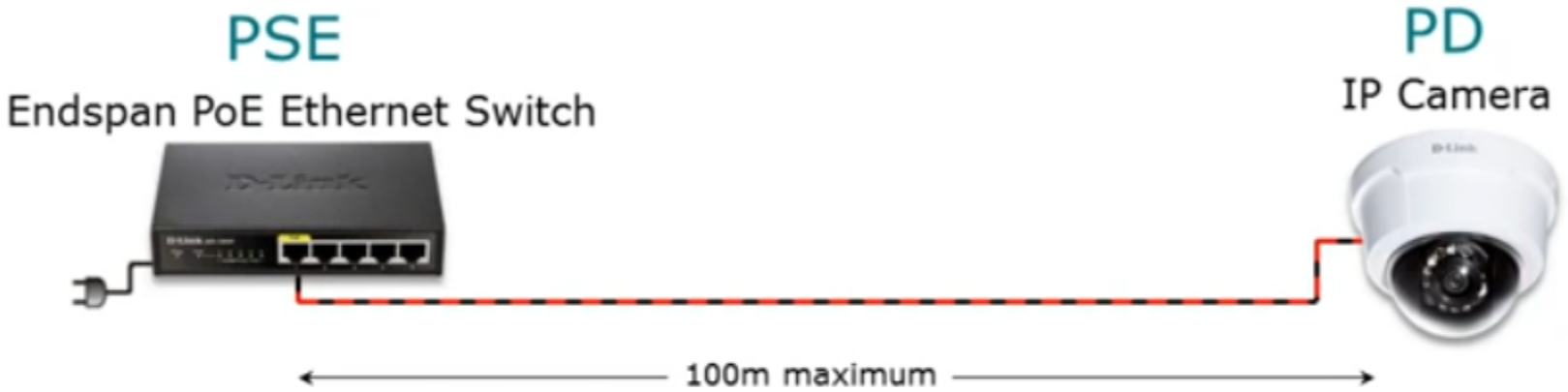
Multimeter

MIDSPAN PSE

Examples:

(yes, this is also a mid-span)

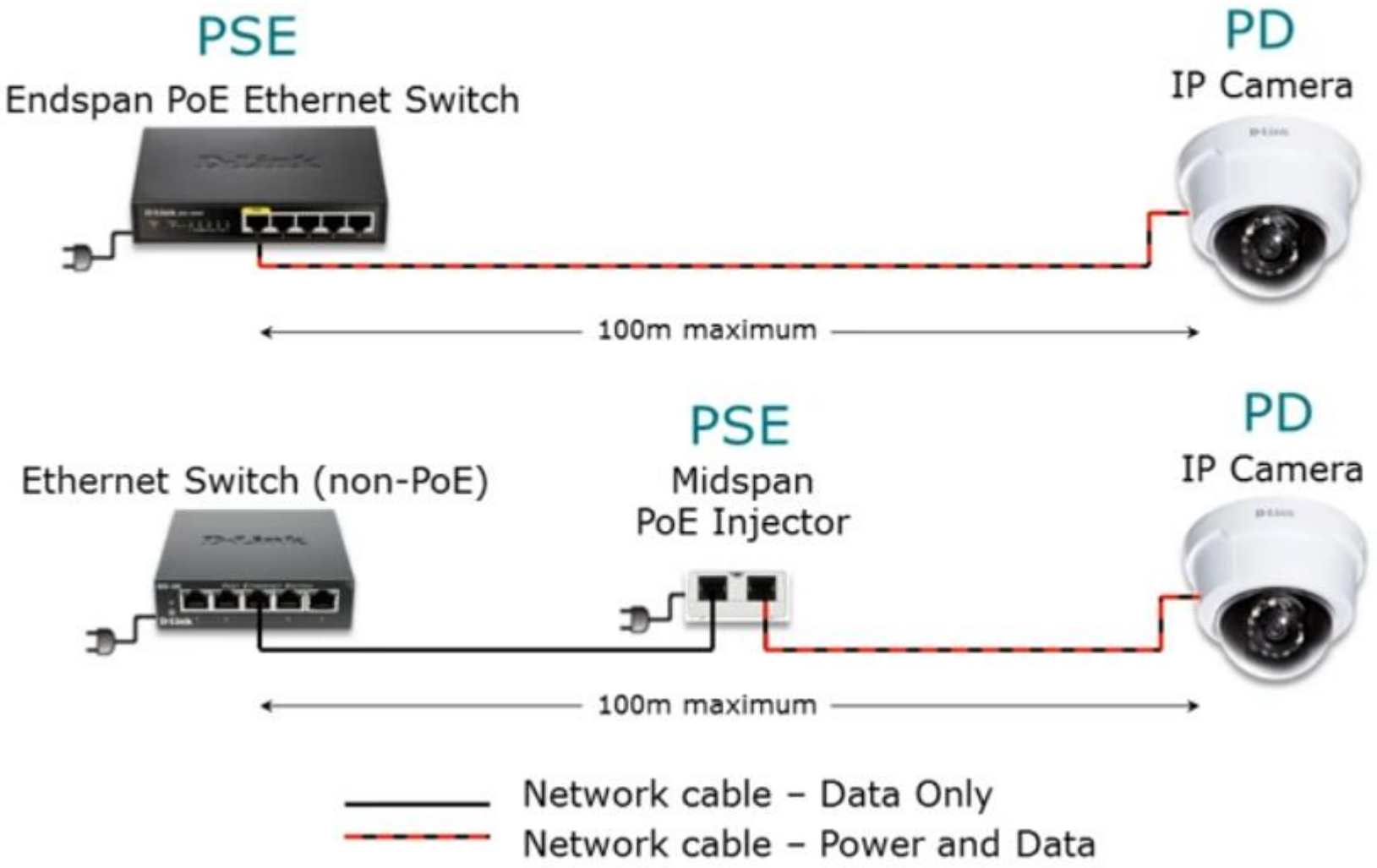
ENDSPAN vs. MIDSPAN



Network cable – Data Only

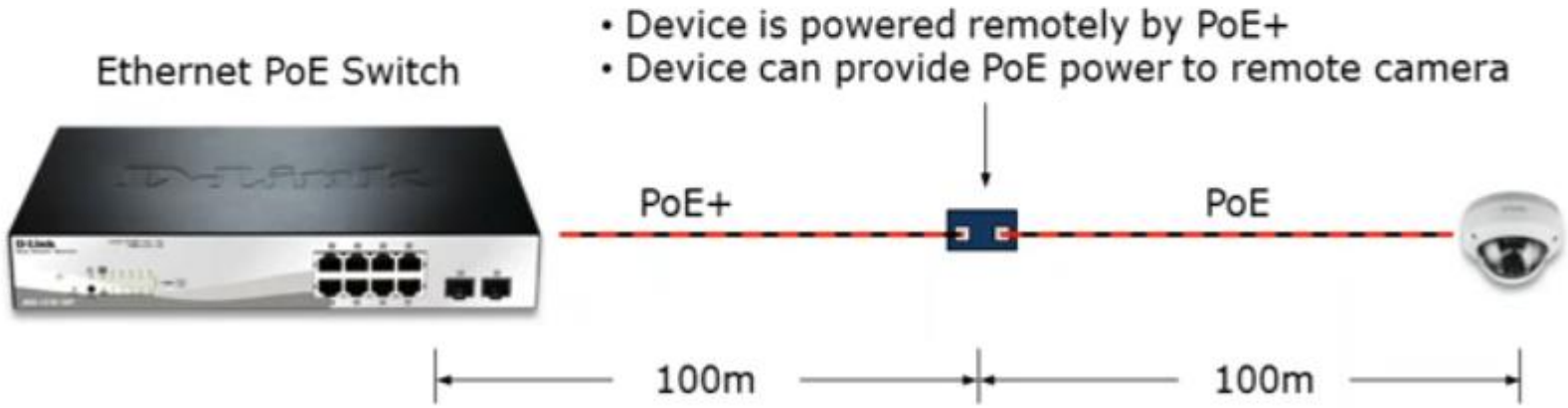
Network cable – Power and Data

ENDSPAN vs. MIDSPAN



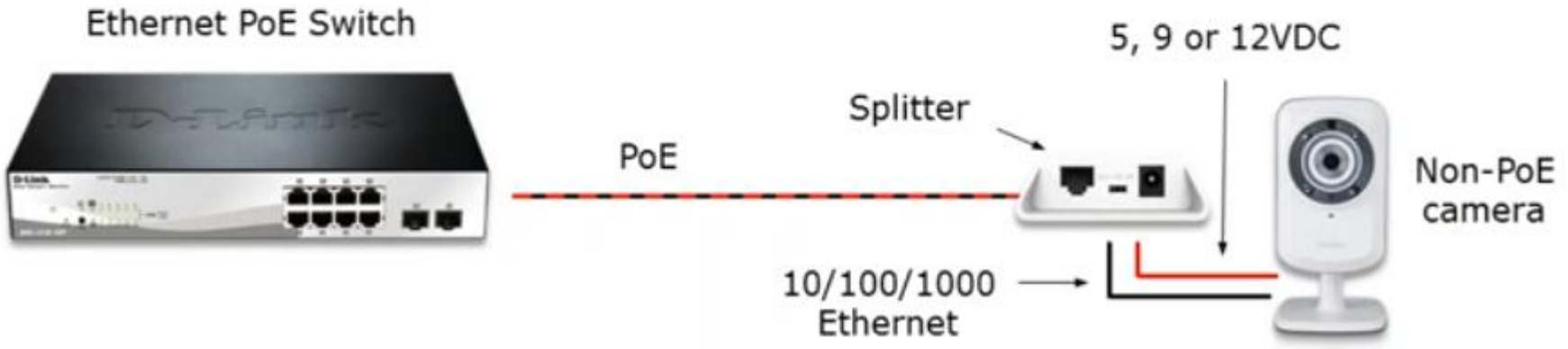
ETHERNET REPEATERS

- Ethernet signal repeater (2-port switch)
  - Extend Max distance from 100m to 200m
  - Can also provide power to end device



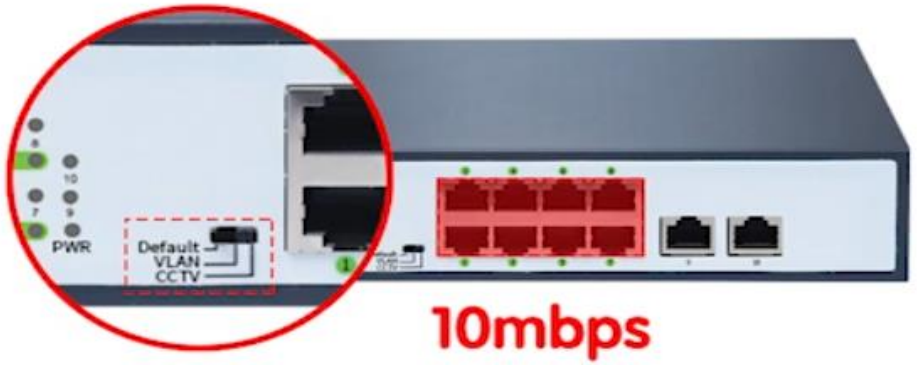
PoE SPLITTERS

- Converts incoming PoE power to 5VDC, 9VDC or 12VDC
- Used for non-PoE IP cameras and other devices



100mbps

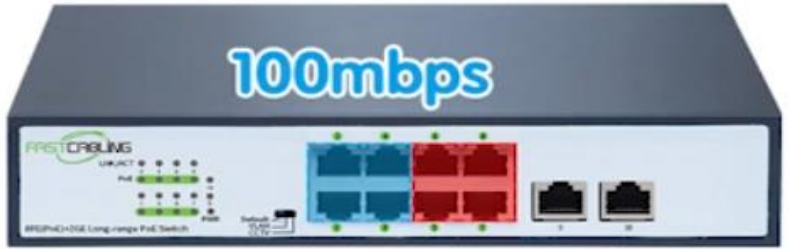
Max Distance 500m



10mbps

Max Distance 250m

100mbps



10mbps

Max Distance 250m

POWER BUDGET

Examples:

	DGS-1210-10P	DES-1018MP	DES-1008P+	DGS-3120-24PC w/DPS-700
IEEE Standard	802.3at (30W)	802.3af (15.4W)	802.3at (30W)	802.3at (30W)
Total PoE Power Budget	78W	246.4W	140W	740W
Number of PoE Ports	8	16	8	24
Avg. Power per Port	9.8W	15.4W	17.5W	30.0W

PDs only draw as much power as they need. Most require far less power than the 12.95W allowed by the 802.3af standard

TYPES OF PoE SWITCHES

Fully Managed

- Managed via CLI through out-of-band Console port, or GUI
- Full suite of L2/L2+/L3 switching functionality

Managed – "Smart"

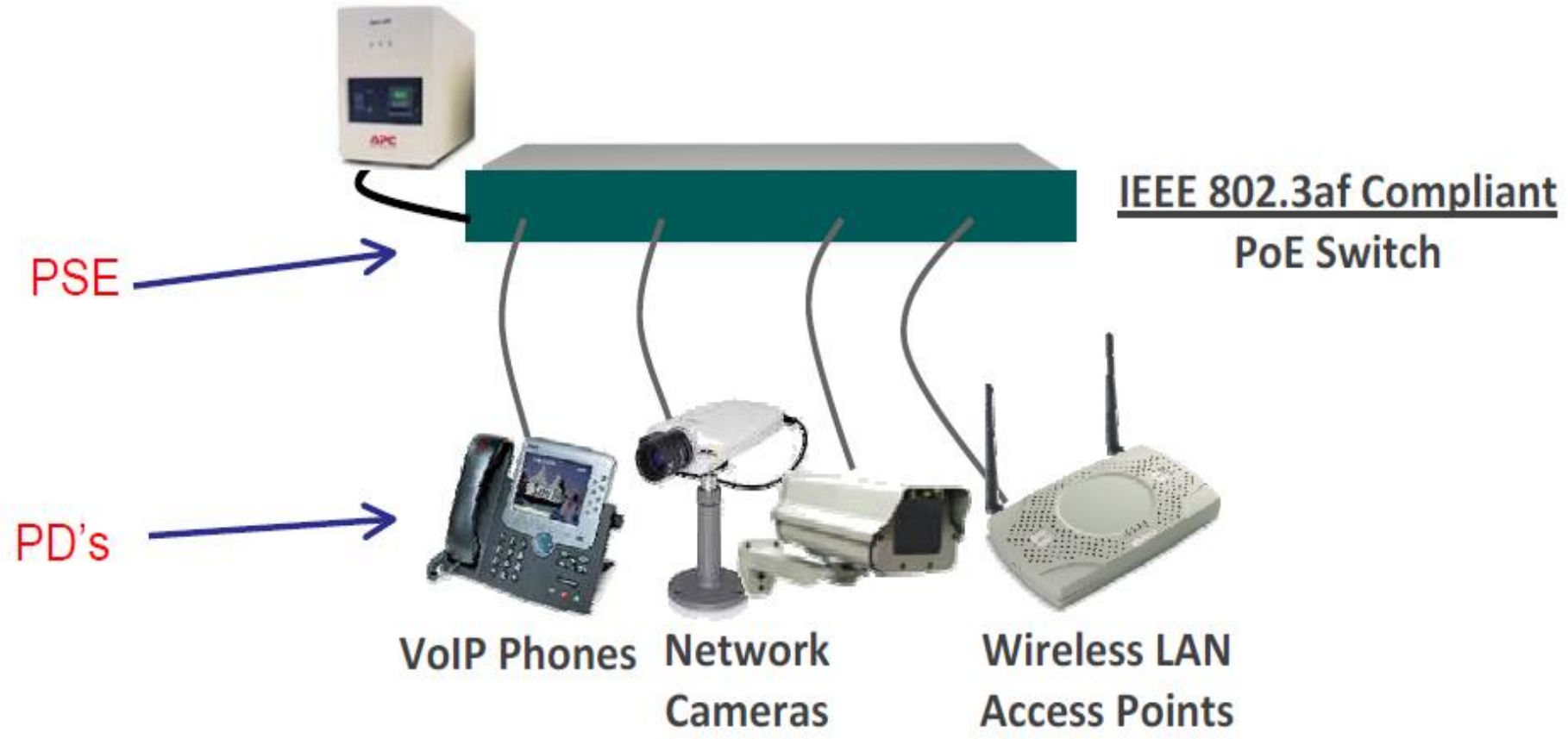
- Managed via browser-based GUI
- Limited suite of L2/L2+ switching functionality

Unmanaged

- Simple – plug it in and turn it on
- Not configurable

PoE Switch = PSE End-Span

UPS – Battery Backup



Power Originating from an End-Span (Ethernet Switch)

End-Span technology -Power originates from a powered port on an Ethernet Switch and is super-imposed on data transmission wire pairs 1,2,3, and 6

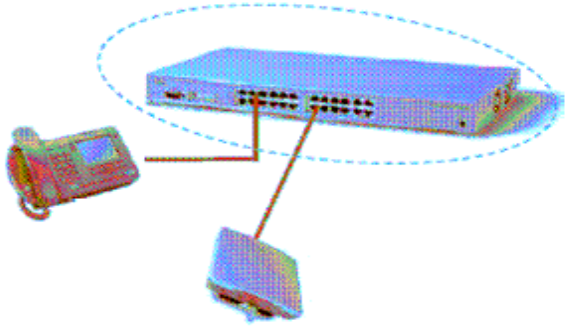
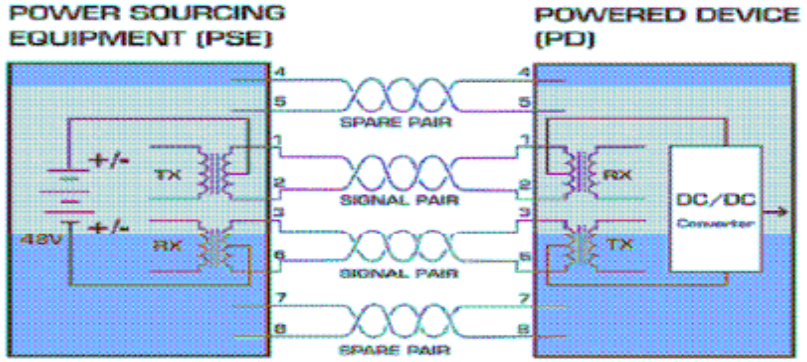


Figure 1: Endspan PoE deployment

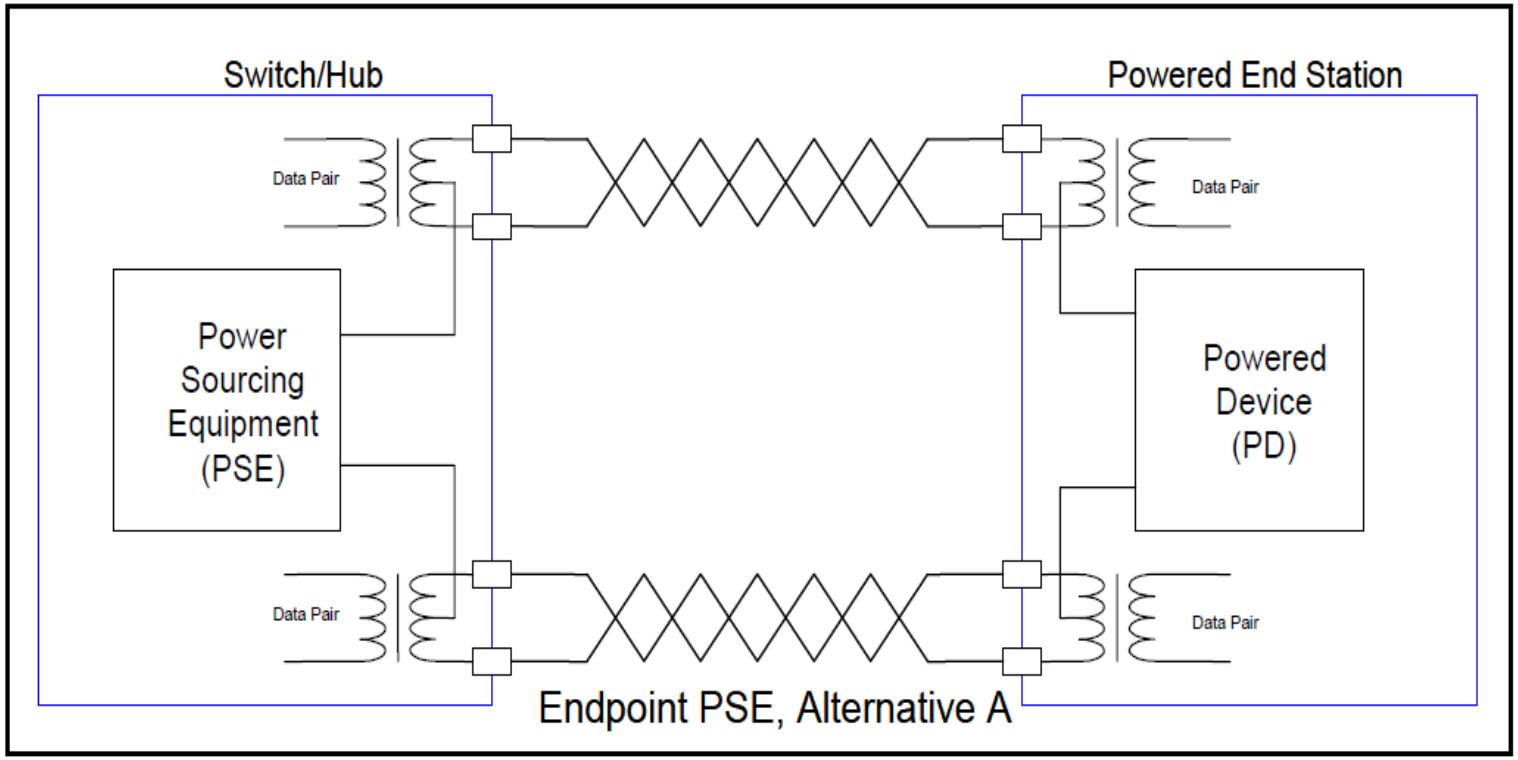


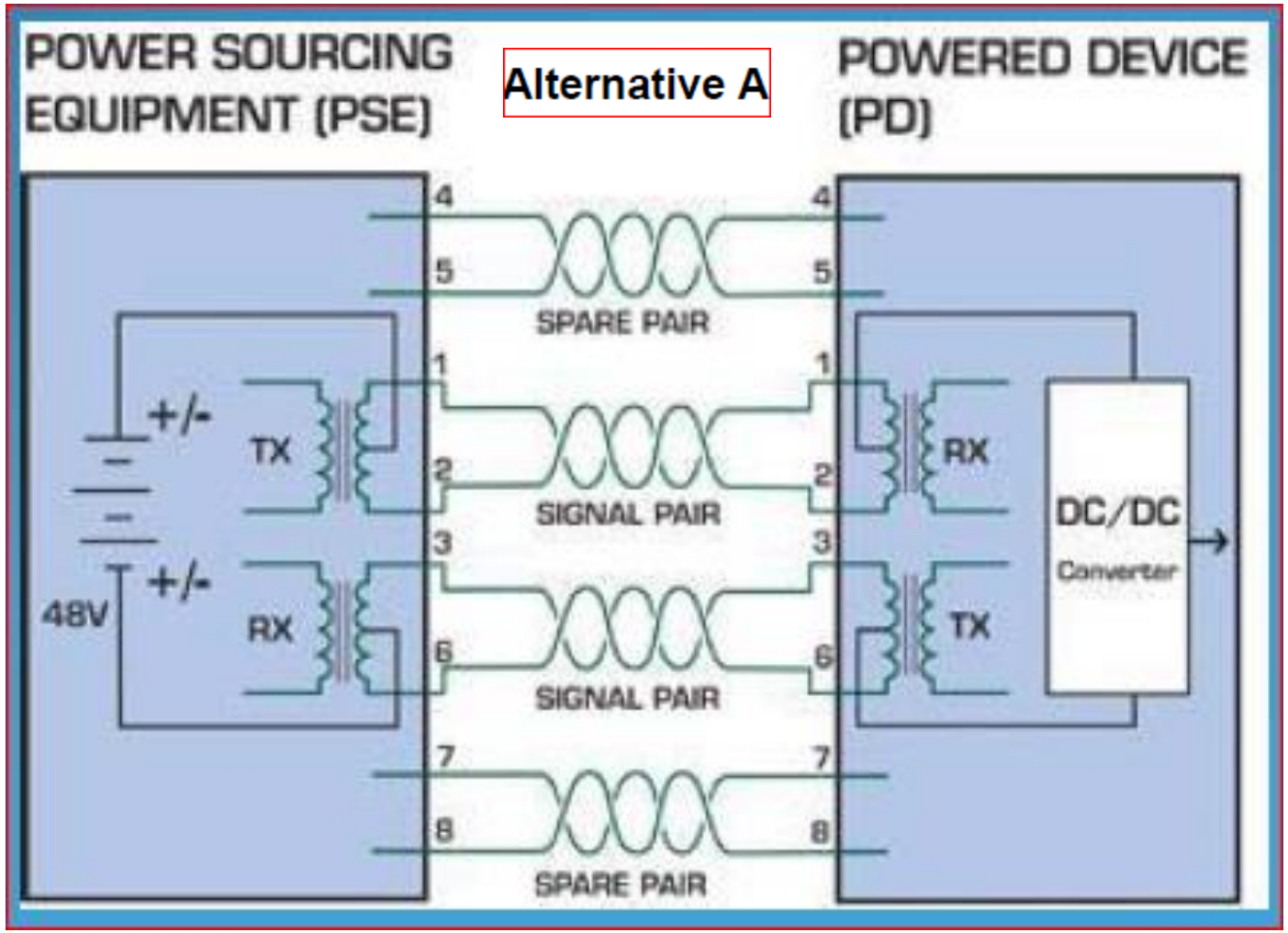
Option A for Midspan: Power can be sourced from the PSE through the data lines via data transformer center taps.

Alternative A

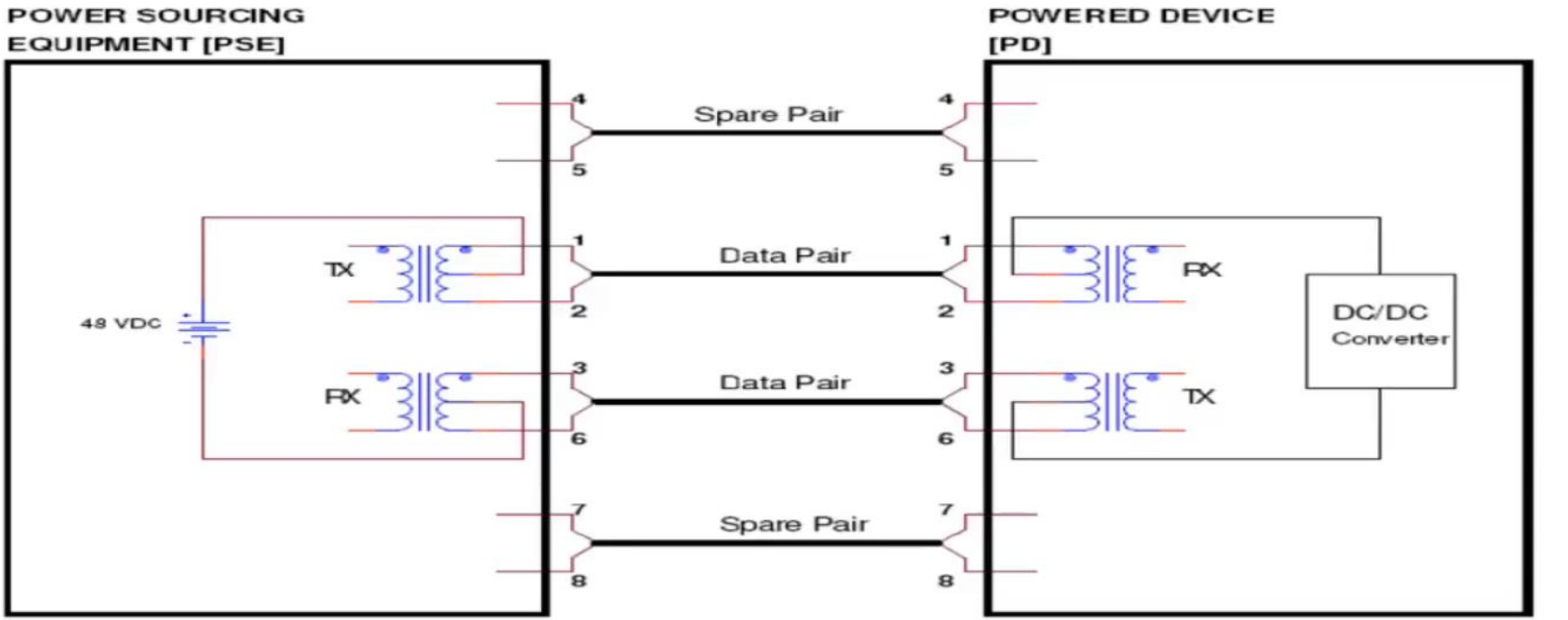
Power is carried over the data pairs (1/2 & 3/6) using the "Phantom Feeding" method, described in Figure 3, which illustrates one pair only.

Delivering power through an RJ-45 connector's center tap ("Phantom Feeding") guarantees that bi-directional data flow is maintained, regardless of a module's power status.



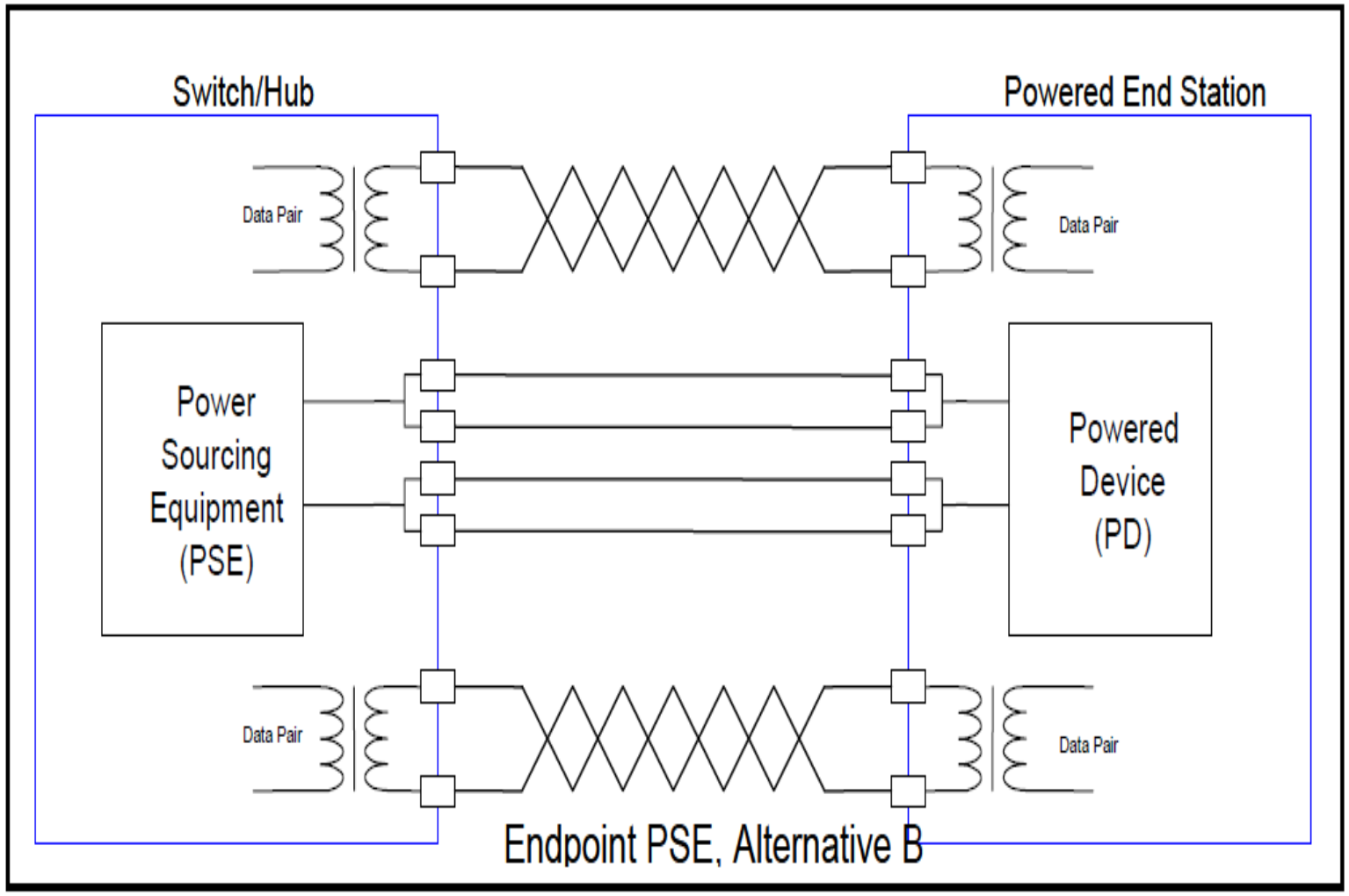

POWER SOURCING EQUIPMENT (PSE)
Alternative A
POWERED DEVICE (PD)
4
5
SPARE PAIR
4
5
1
2
SIGNAL PAIR
1
2
3
6
SIGNAL PAIR
3
6
7
8
SPARE PAIR
7
8
+/-
TX
48V
+/-
RX
RX
TX
DC/DC
Converter

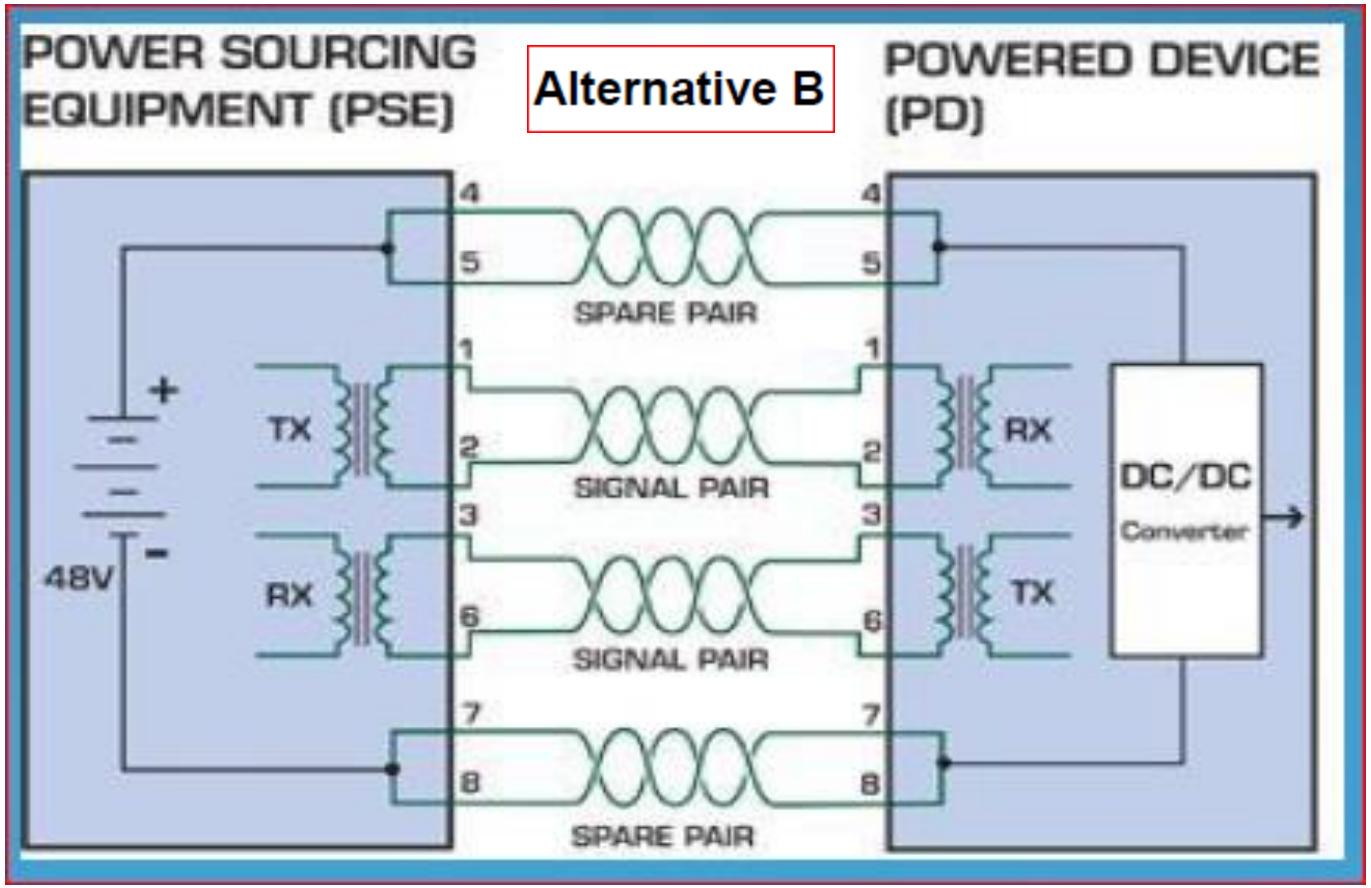
Alternative A Method



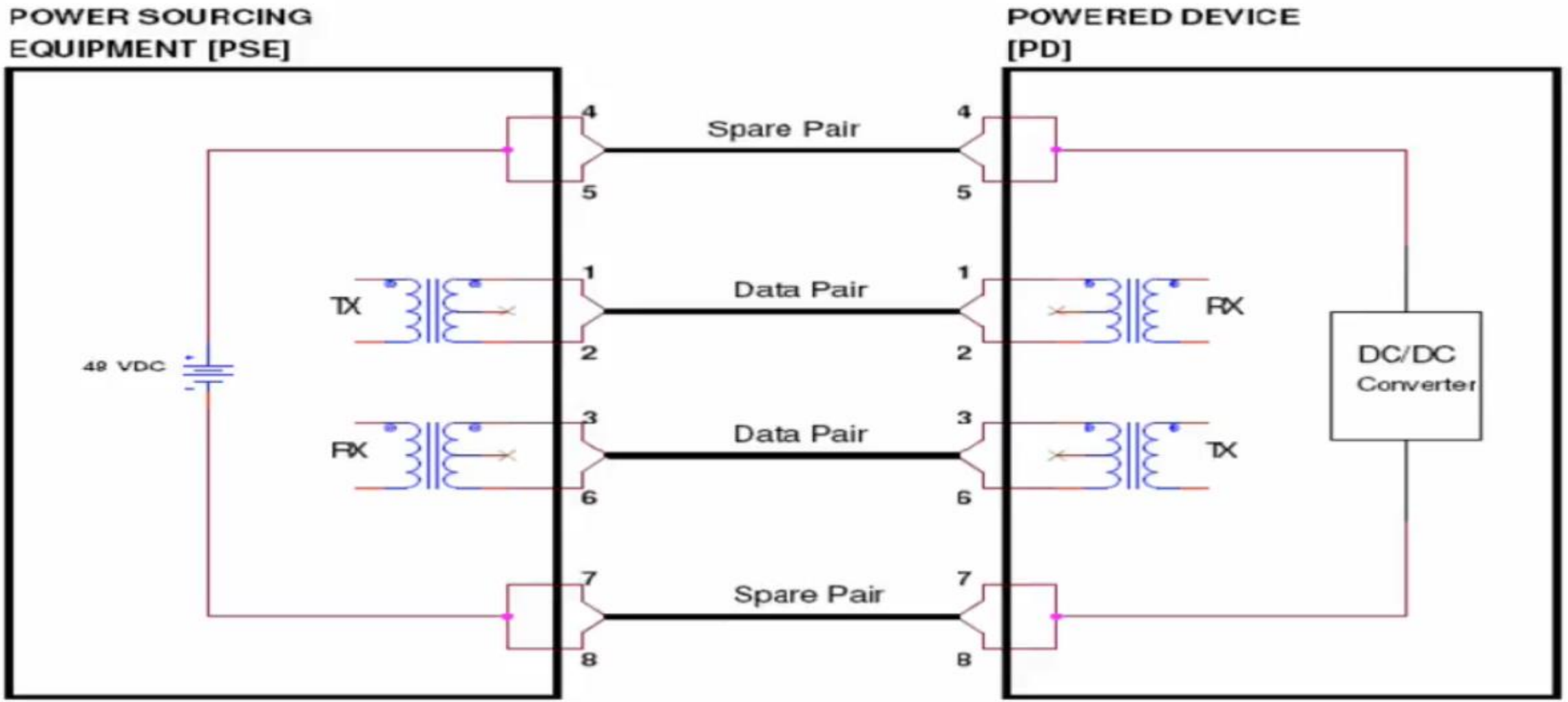
Alternative B

Power is carried over the spare pairs (4/5 & 7/8). Each pair's wires are shorted to one another (Figure 4).




POWER SOURCING EQUIPMENT (PSE)
Alternative B
POWERED DEVICE (PD)
4
5
SPARE PAIR
4
5
1
2
SIGNAL PAIR
1
2
3
6
SIGNAL PAIR
3
6
7
8
SPARE PAIR
7
8
+
48V
-
TX
RX
RX
TX
DC/DC
Converter

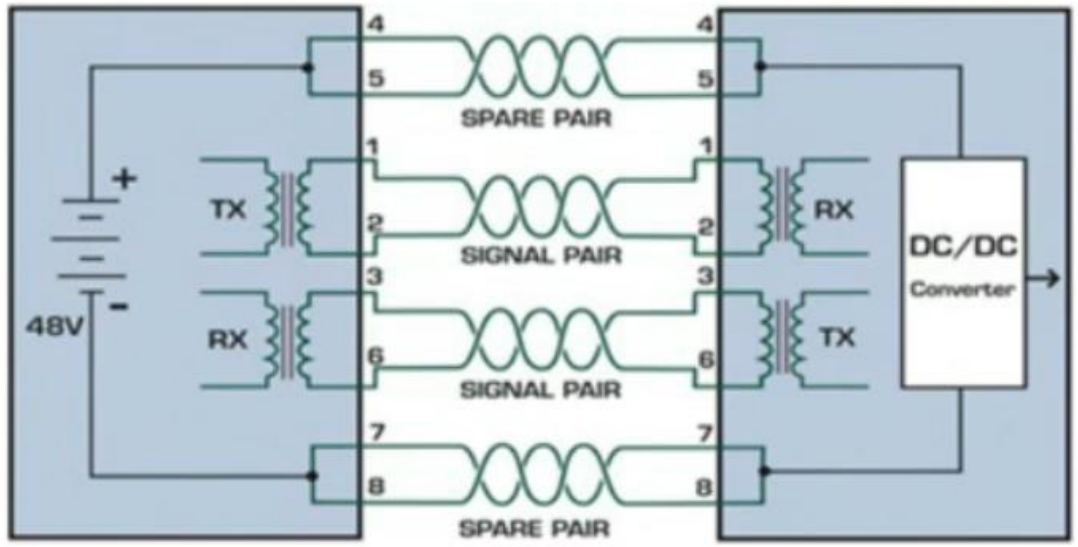
Alternative B Method



Power over Ethernet Classes

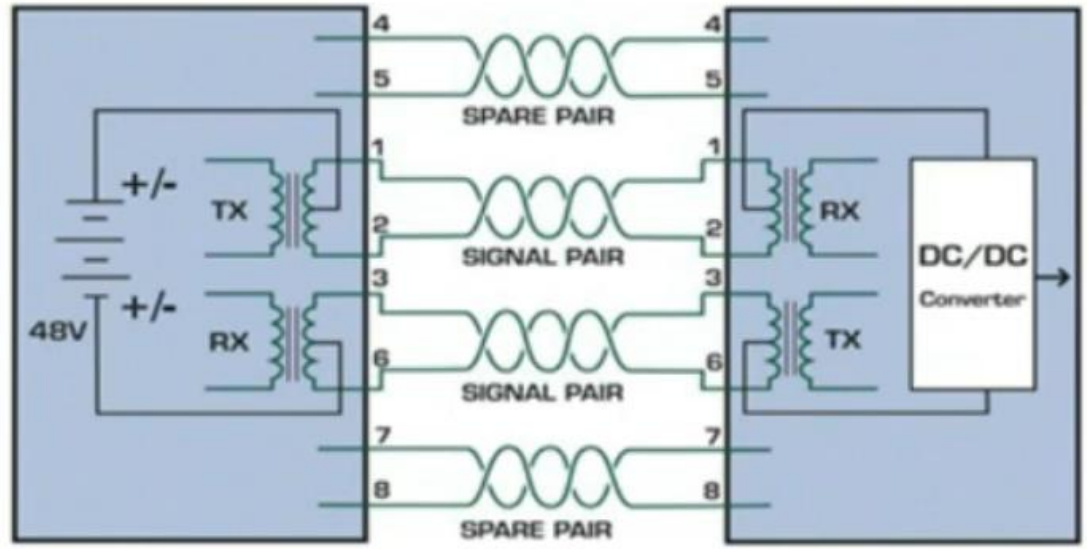
Alternative A vs. Alternative B

Alternative B



Different wire pairs for data and power

Alternative A



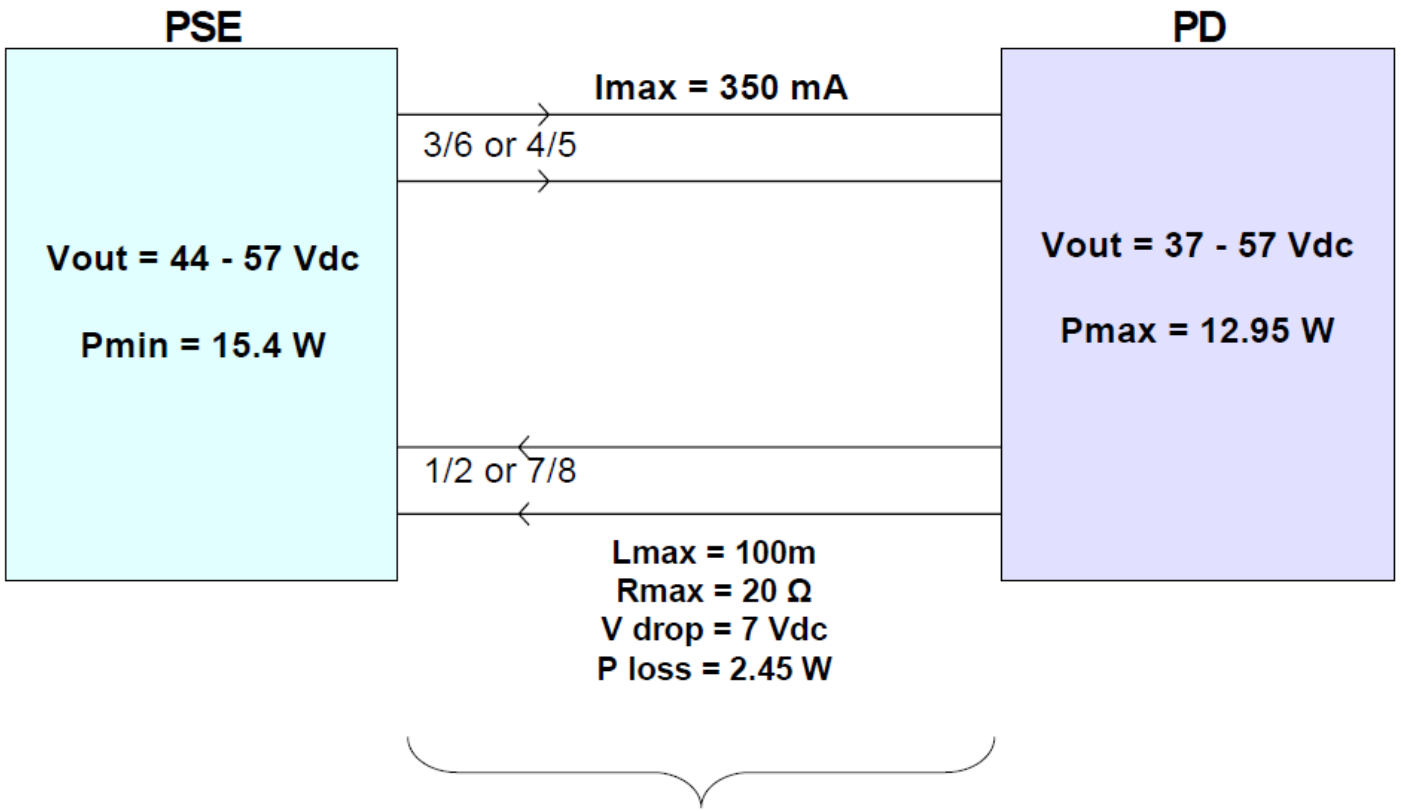
Same wire pairs for data and power

Compliant Powered Devices (PD) must support both “Alternative A” and “Alternative B” models

What are PSE and PD?

The IEEE 802.3af specification defines PSE as the element responsible for inserting power onto a Ethernet cable. The PSE may be located at the switch (Endspan configuration), or it may be a separate device located between the switch and the PD (Midspan configuration).

The PD is the natural termination of this link, receiving the power, and could be an IP phone, a WLAN access point or any other IP device requires power.



class	purpose	minimum act level at the exit of PSE
0	default	15.4 watt
1	optional	4.0 watt
2	optional	7.0 watt
3	optional	15.4 watt
4	reserved for future applications	handle as class 0

Table 2.2: PoE PSE power classes

Class	purpose	minimum act level at the entry of PD´s
0	default	0.44 to 12.95 watt
1	optional	0.44 to 3.84 watt
2	optional	3.84 to 6.49 watt
3	optional	6.49 to 12.95 watt
4	not allowed	reserved for future applications

Table 2.4: PD power classes

Table 3.2 *802.3af Power Classes*

802.3af Power Class	Power Allocated	Actual Power Used
Class 0	15.4W	0.44 to 12.95W
Class 1	4.0W	0.44 to 3.84W
Class 2	7.0W	3.84 to 6.49W
Class 3	15.4W	6.49 to 12.95W

Note Also notice that the maximum power used in the "Actual Power Used" column of Table 3.2 is slightly less than the maximum power allocated for each class. This is due to a power loss received through the cabling and in the device power supplies (device power supplies cause a loss of 10 to 20 percent of power).

Note The IEEE standards body is currently working on an 802.3at PoE standard (also called PoE Plus), the goal of which is to increase the current maximum PoE wattage from 15.4W to 30W or more.

Power losses

The PSE sends a maximum power of 15.4W with 350mA at a minimum voltage of 44V to the PD. A standard Cat5 cable with a length of 100m attains a resistance of approx. 20Ω giving a power loss of approx. 2.45W.

$R_{CABLE} = (20\Omega||20\Omega) + (20\Omega||20\Omega) = 20\Omega$
$P_{CABLE} = (350mA)^2 * 20\Omega = 2.45W$
$P_{PD} = 15.4W - 2.45W = 12.95W$

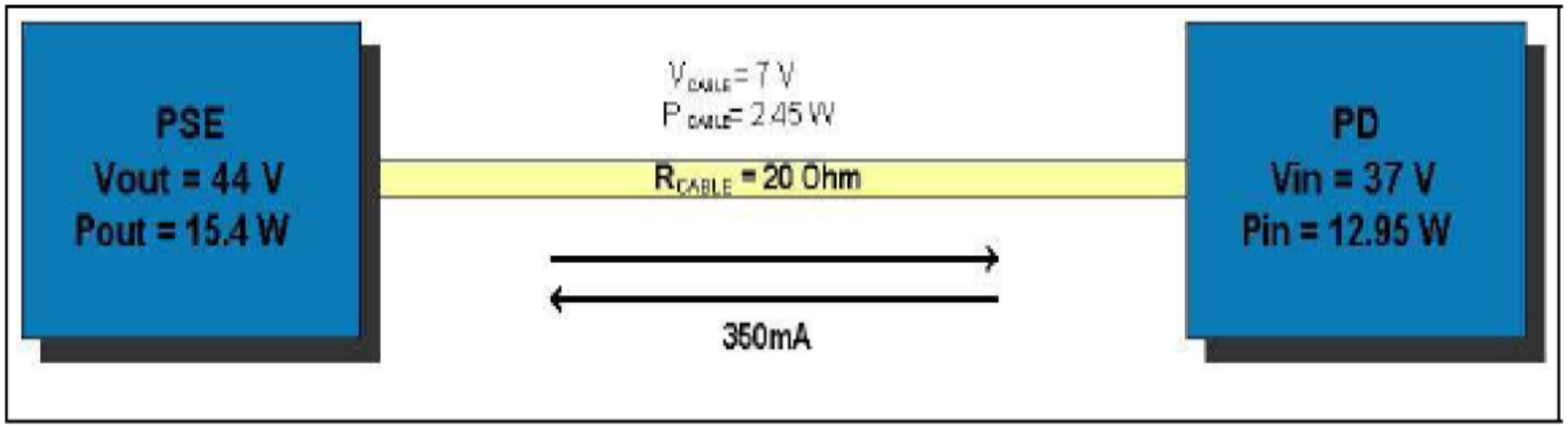


Figure 2.5: Power losses

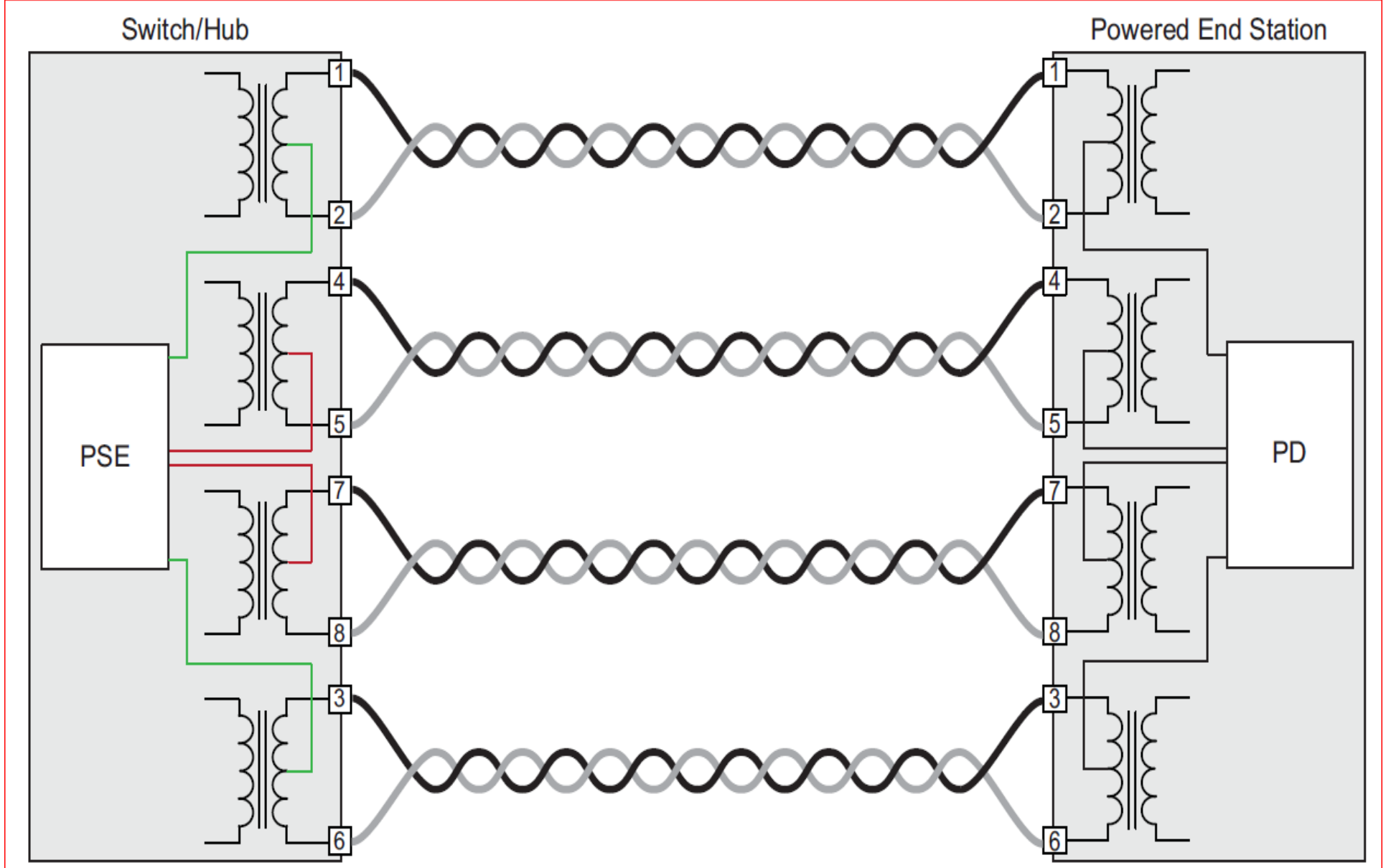


Figure 2: **1000BASE-T Endspan Powered (Alternative A – Green; Alternative B – Red)**

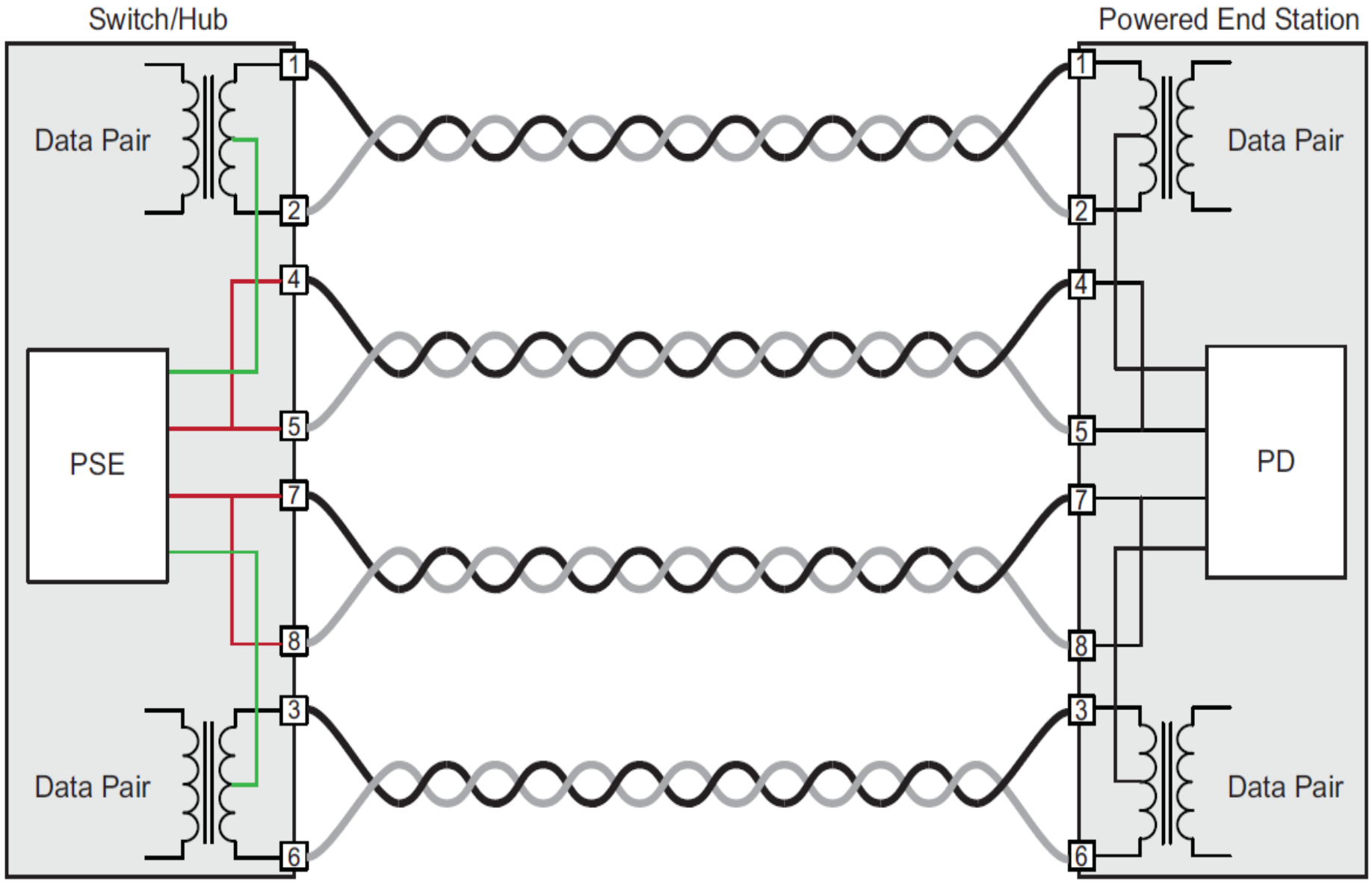


Figure 1: **10BASE-T/100BASE-TX Endspan Powered (Alternative A – Green; Alternative B – Red)**

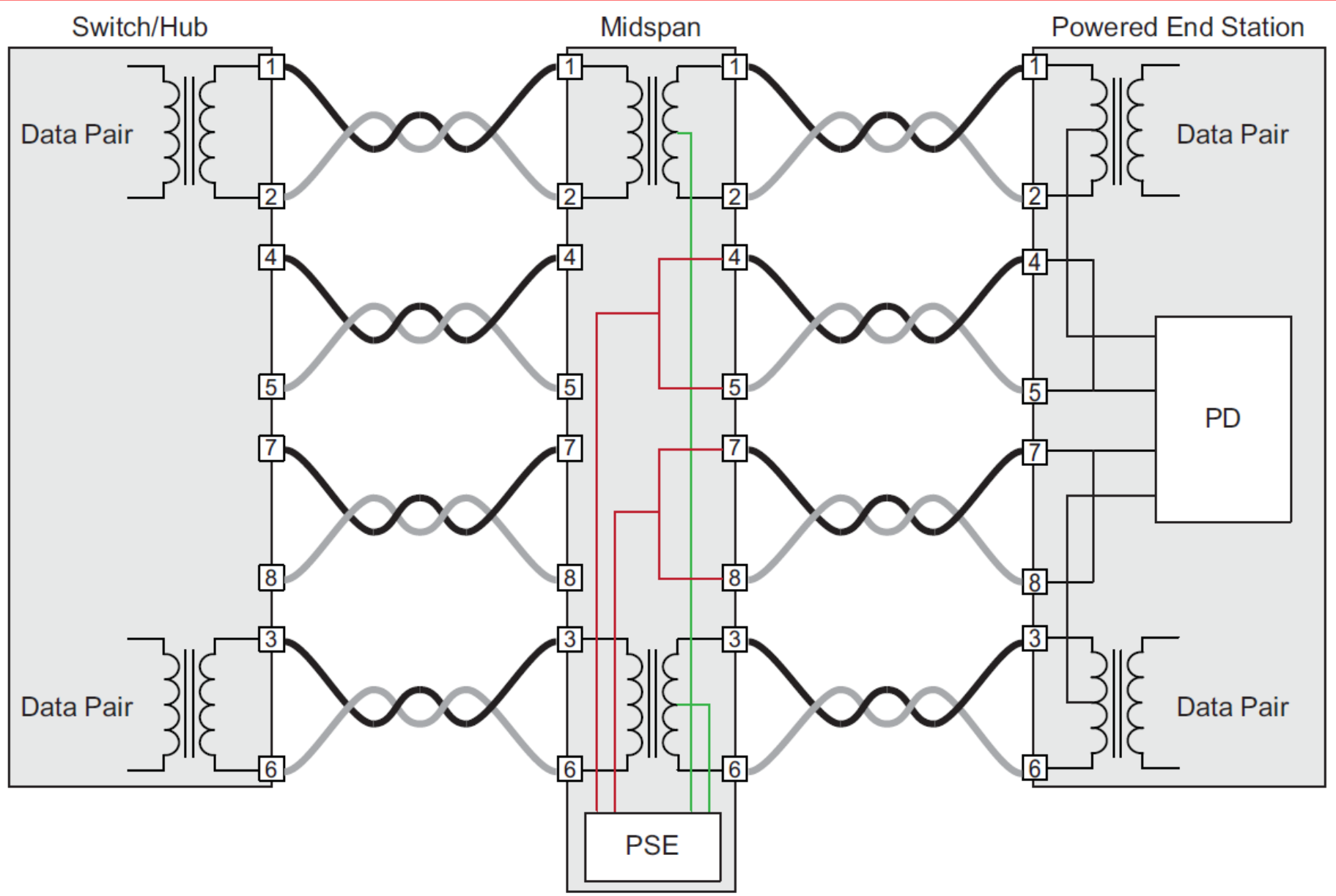


Figure 3: **10BASE-T/100BASE-TX Midspan Powered (Alternative A – Green; Alternative B – Red)**

Power over Ethernet

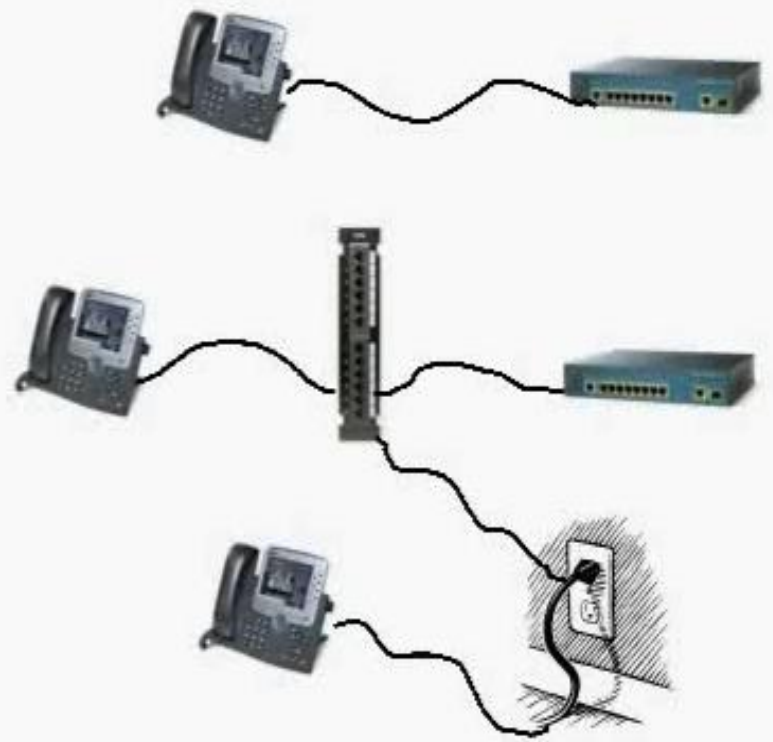
- Three ways you can power a phone:

  -Inline power

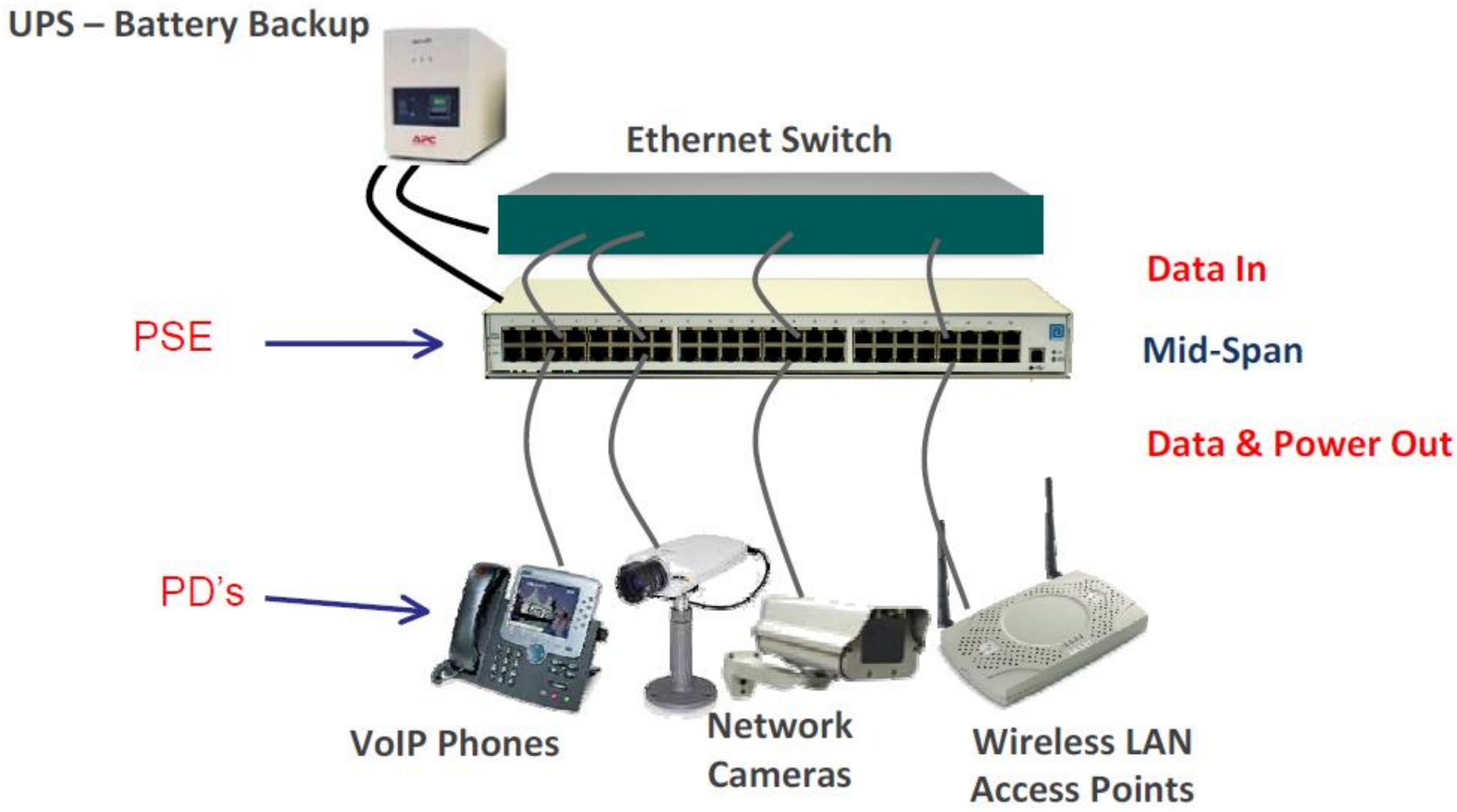
  * Cisco Pre-standard PoE
  * IEEE 802.3af

  -Midspan power

  -Wall power



Switch + PoE Injector = PSE Mid-Span



Power Originating from an External Mid-Span Device

Mid-Span technology-Power is added to the non-data wire pairs 4,5,7, and 8 from a patch-panel style hub

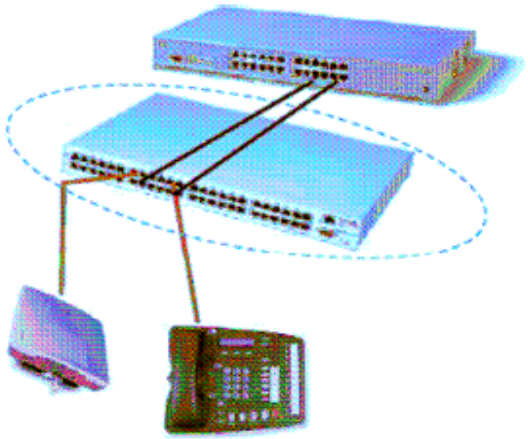
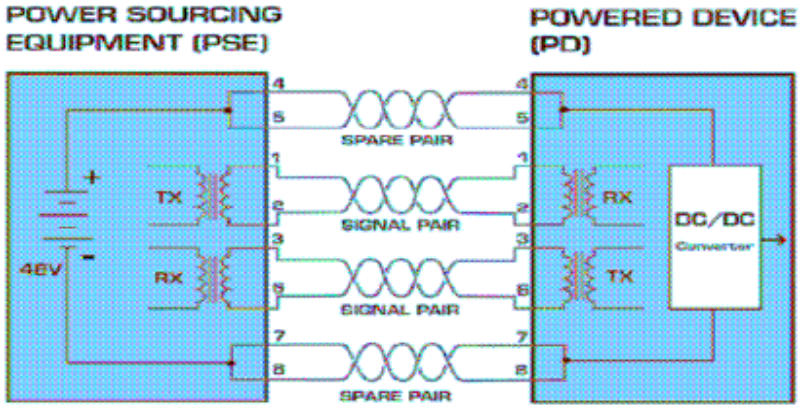


Figure 2: Midspan PoE Deployment



Option B for Endspan: Power can be sourced from the PSE through spare lines in the CAT-5 cable.

Power over Ethernet PDs

Voice and Video IP Phones

WiFi Access Points a/b/g/n

Network Security Cameras – Enclosures – Heaters – Pan and Tilt

Building / Access Control – Gas and Fire Alarms – Digital Signs

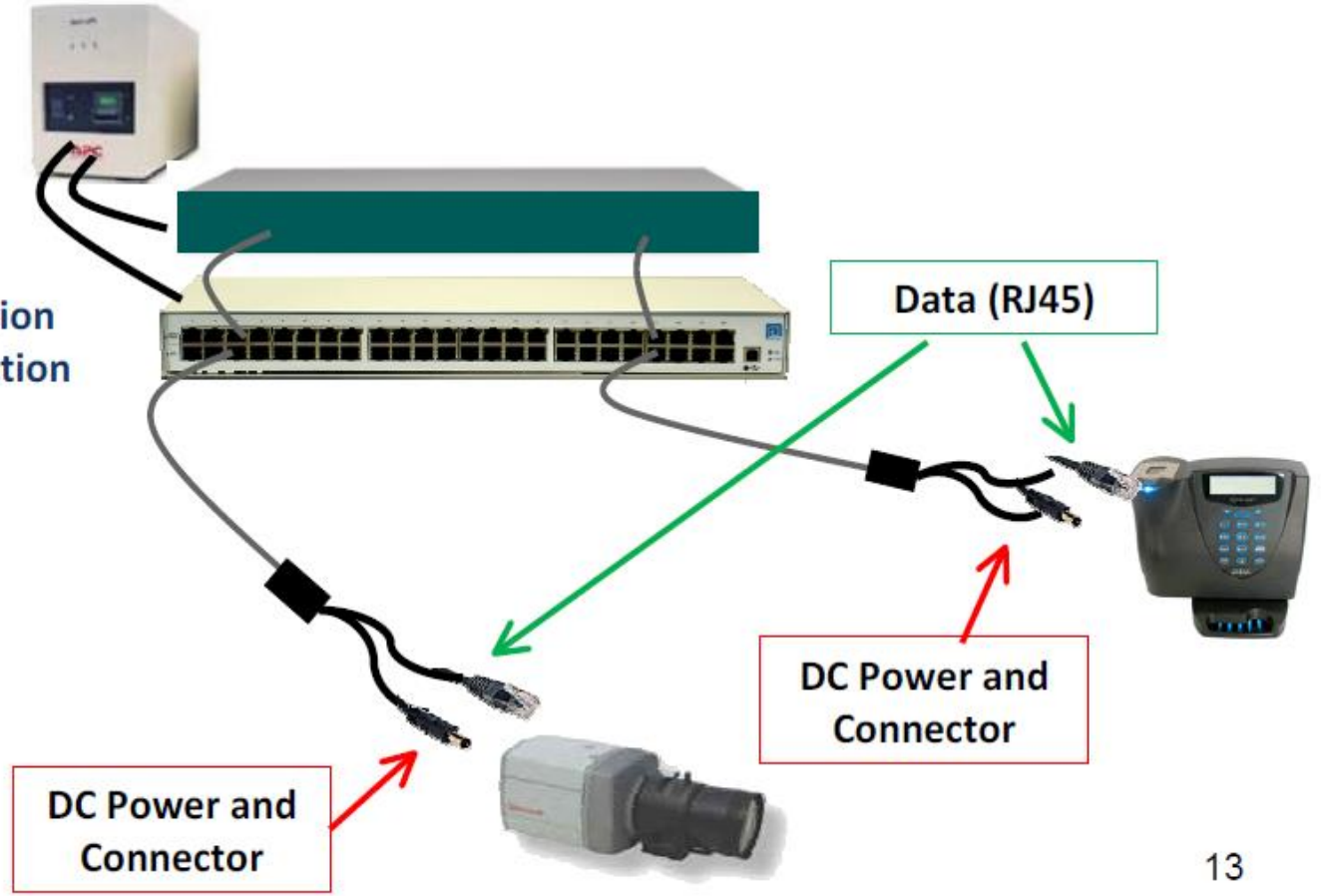
Digital and School Clocks – SIP IP Paging – Door locks - Gateways

Splitters for PoE

Active PoE Splitters allow PoE power on non-PoE devices

Typical Splitters Feature

- Safe Power with IEEE detection
- IEEE connect and disconnection
- 10/100/1000



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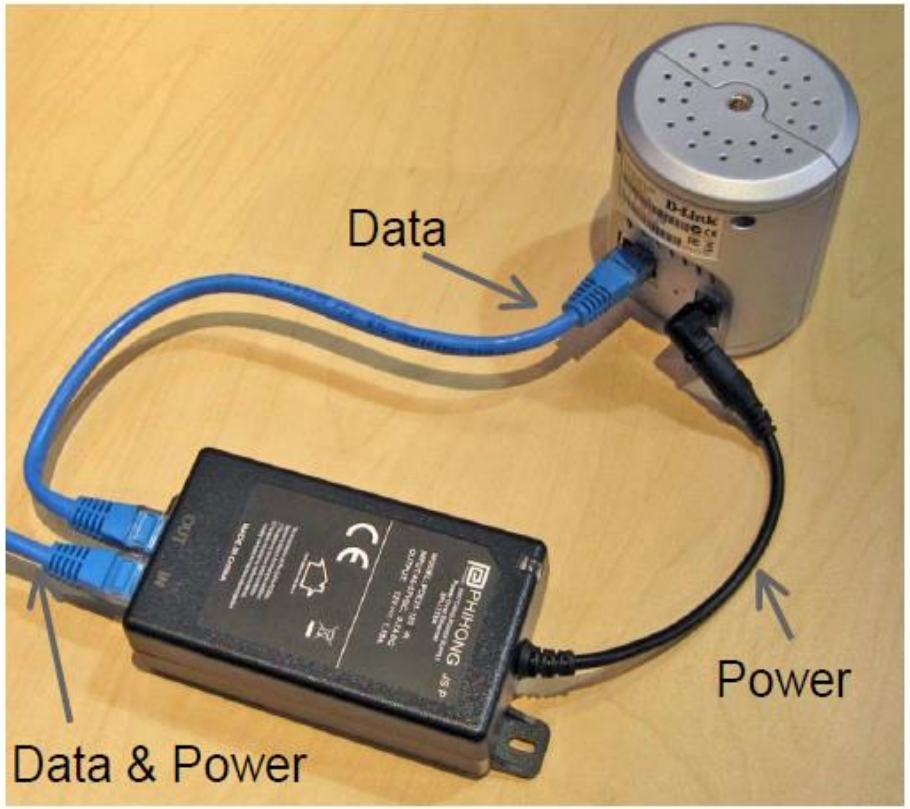
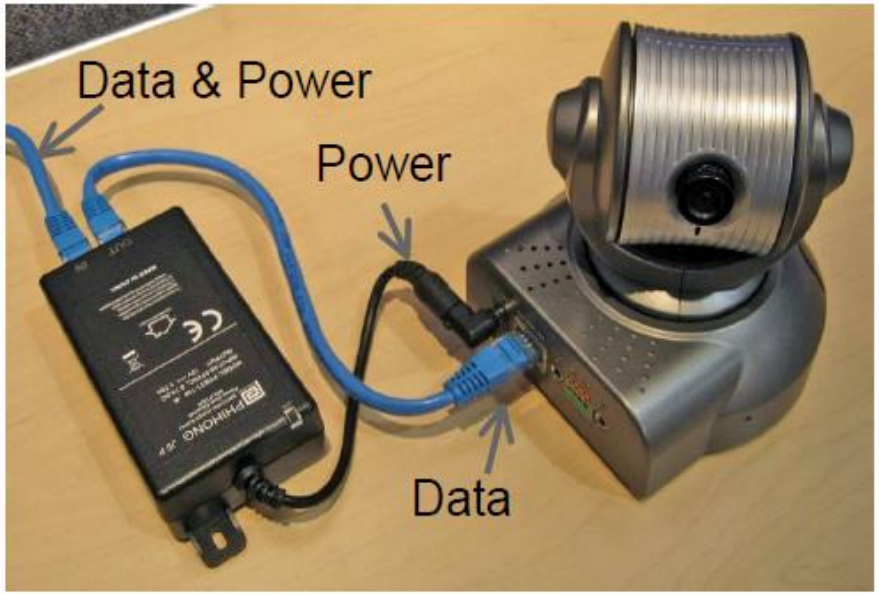
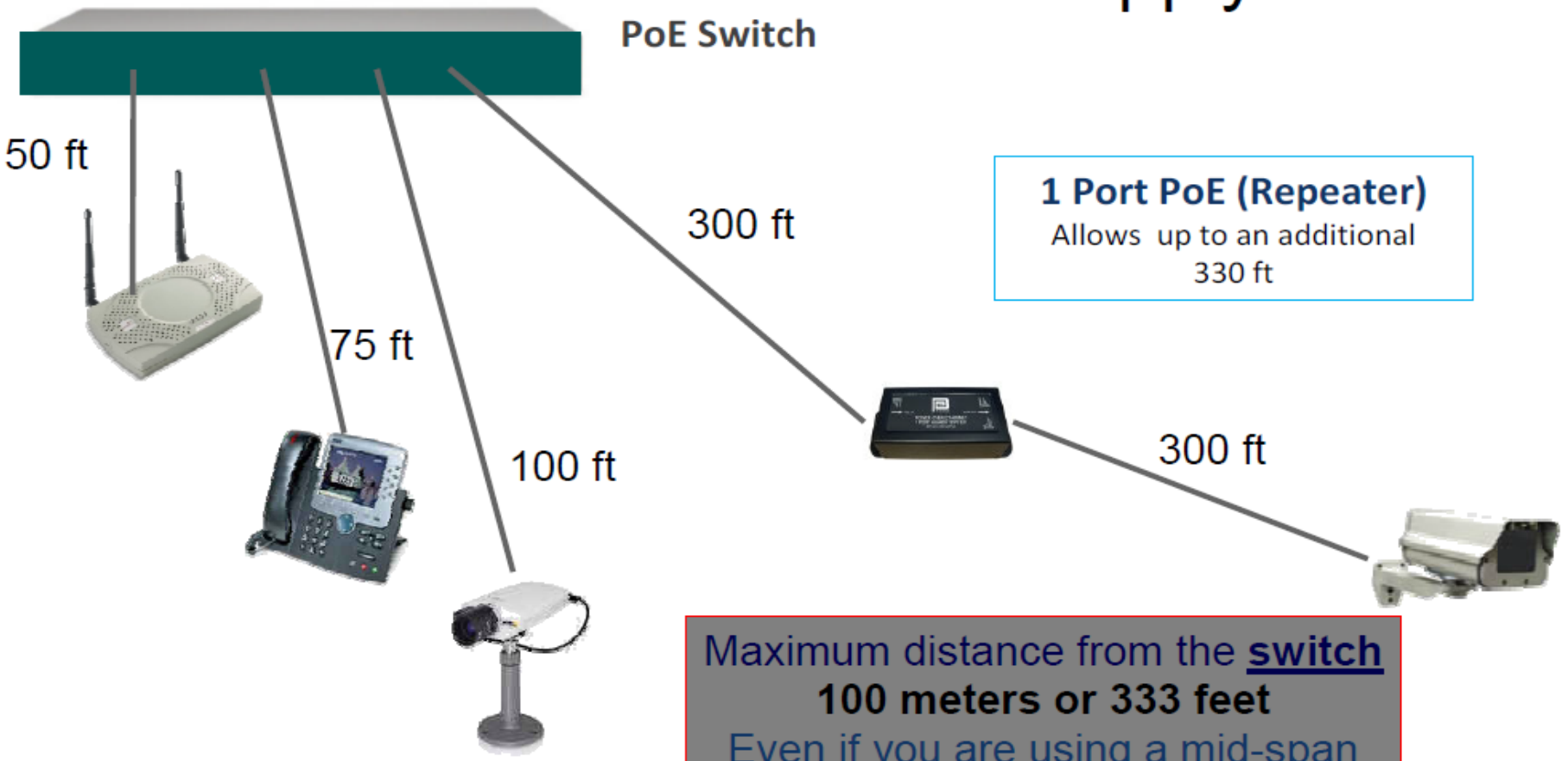
PoE Splitters Application Example





IEEE802.3af Distance Limitations

Standard Ethernet distance rules apply



1 Port PoE (Repeater)
Allows up to an additional 330 ft

Maximum distance from the **switch**
100 meters or 333 feet
Even if you are using a mid-span

15

Market and Competitive Analysis

- **Ethernet Switch Ports:** This report estimates that global shipments of PoE-enabled ports in enterprise switches are expected to reach over 132 million ports in 2012. By 2012, PoE ports will represent one quarter of all enterprise Ethernet ports.
- **Mid-Spans:**. Mid-Span shipments will be healthy over the next several years as people who have not yet deployed PoE or PoE-Plus switches will still want to take advantage of PoE benefits without having to purchase new switch gear.
- **PDs:** In 2007, shipments of PoE-enabled business IP phones exceeded 10 million units. VDC expects shipments of enterprise wireless LAN access points to grow to 11.2 million units in 2012.
- **PoE Controllers:** There are only two vendors who have any significant market share of PSE controllers, Linear Technology and Microsemi. The PD controller market is a bit more fragmented, with several companies having significant market share in 2007.

802.3af Power Classification

In the start-up process when a PoE connection is made, the PD can advertise its power class which is an indication of how much power is required

Class	Min. PSE Power	Max. PD Power	Sample PD's
1	4 Watts	3.84 Watts	IP Phones
2	7 Watts	6.49 Watts	IP Camera
3,4, or 0	15.4 Watts	12.95 Watts	Wireless AP

"Power cannot be forced down the cable" - *a common misconception* -

The PD presents a load to the cable and draws as much as it needs. Most PoE powered devices will draw a fixed level of power.

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IEEE802.3at Objectives

- At least 24W power supplied to the PD
  - As much as economically feasible
- Backwards compatible with IEEE802.3af-2003
  - Type 2 PD's that cannot operate with less than 12.95W must give indication to user when connected to Type 1 PSE
  - Type 2 PD's that can operate with less than 12.95W must be able to be powered by a Type 1 PSE
- PD MIB to be created
- Support for Gigabit Midspan

Type 1: "low power"
Type 2: "high power"

PoE
High Power

Devices Evolve and Require More Power

- Access Points migration to 802.11n
  - Cisco AP-1200 with g radio : 802.3af (6.5W)
  - Cisco AP-1200 with a+g radios : 802.3af (11.6W)
  - Cisco AP 1250 for 802.11n : ~ (20+W)

- Migration to Advanced Network Cameras
  - Sony SNC-Z20N Zoom Camera : 802.3af (<12.95W)
  - Sony SNC-RZ30N Pan/Tilt/Zoom : (21.6W)
  - Sony SNC-RZ30N Pan/Tilt/Zoom/Heated Enclosure : (50W)
- IP Phones evolving into Video Phones
  - Wooksung Video Phone : 18.4W
  - Packet8 Video Phone : 25W
  - Leadtek IP Broadband Video Phone : 25W
  - WorldGare Video Phone : 36W

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IEEE 802.3af Enhancements

The 802.3at specification expands upon 802.3af is several key areas:

http://www.ieee802.org/3/at/

- Enable higher power PD's such as wireless access points, panning security cameras, video phones, and audio appliances requiring continuous power to 25.5 watts up to 100M from the PSE.
- High Power PSE's must furnish at least 30.0 Watts at the PSE port.
- Provide full backward compatibility and interoperability to existing 802.3af compliant PSE's and PD's.
- Enable Mid-Span PSE's to support 1000BaseT connections.
- Restrict cost increases for PSE ports and PD equipment in areas such as PSE controller devices and PoE capable magnetics such that PoE+ (high power) could become ubiquitous.
- Improve potential power management granularity and power budgeting capability over time.
- Resolve well known issues of specification clarity inherent in the 802.3af specification

IEEE802.3at Specifications

- **Cabling**: CAT5E required
- **Voltage**: PSE voltage from 44V to 57V (50V for Type-2 PSEs)
- **Current level**: 600mA assuming cable temperature is 50C or lower
- **Polarity:** End-Spans can use MDI or MDI-X (Positive or Negative Polarity)
- **Pulse transformer inductance:**
  - End-Span PSE (Switch) & PDs: 120µH (allows usage of IEEE802.3af magnetics)
  - Mid-Span: 350µH, Midspan Alternative-A 10/100 installations require regulation
- **Power Feeding**: 2-pairs and 4-pairs possible
  - Focus on 2-pairs Medium Power: PSE 30W output, **PD 25.5W** input
  - 4-pairs High Power should be based on 2x2-pairs: PSE 60W output, **PD 51W** input

IEEE802.3at Specifications (cont.)

- **Power Detection & Removal Essentially Unchanged**
  - 25K signature resistance will not be changed
- **Classification**
  - Classic Method enhancement: 2-Event Classification (two pulse) that is transparent to 802.3af but allows Type-2 PD presents Class 4 to request maximum power.
  - Type-2 PSE may use either single-event or 2-event classification
  - PD must support Layer 1 and Layer 2 classification
  - PSE must support either Layer 1 or Layer 2 classification
  - Layer 2 Classification Method: Using a data link layer protocol such as Link Layer Discovery Protocol (LLDP).
- **1000Base-T Mid-Span in scope of IEEE802.3at**
  - Any Mid-Span power interface can be Type A (4,5,7,8) or Type B (1,2,3,6)

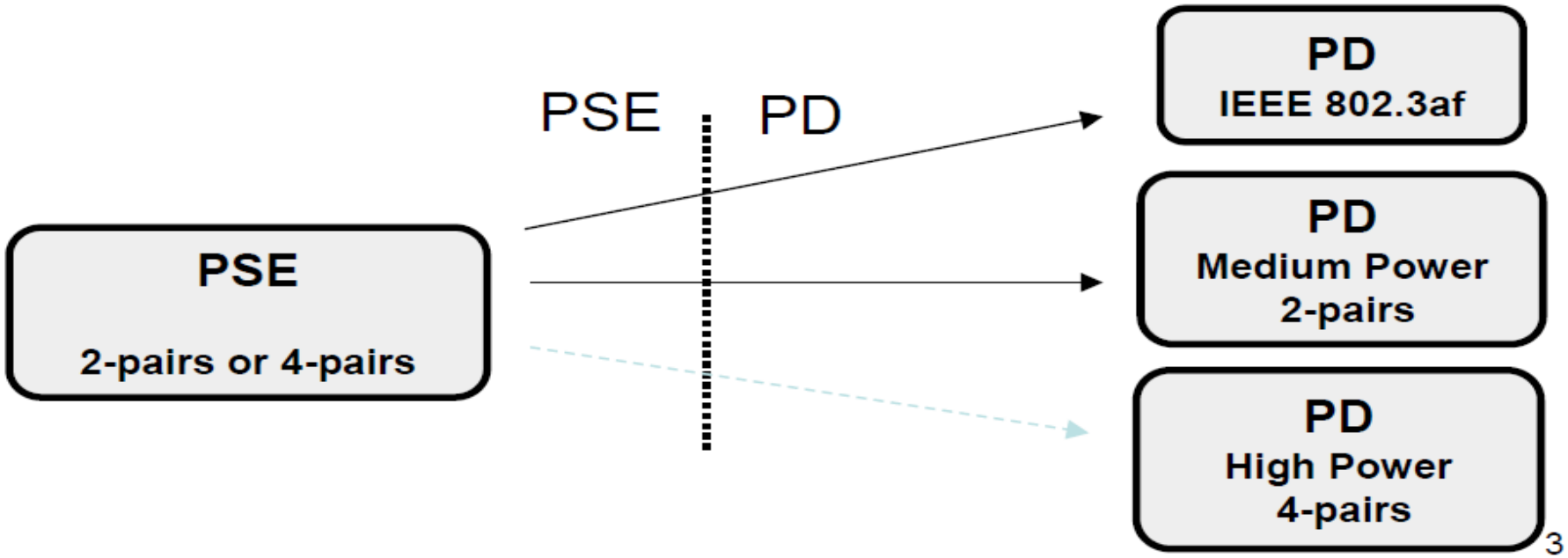
802.3at Power Classification

Category	PSE Power	PD Power	L1 Classification	L2 Classification
Type-1	15.4 Watts	.44 - 13 Watts	PSE: Optional PD: Required	PSE: Optional PD: Optional
Type-2	30.0 Watts	13 - 25.5 Watts	PSE: Required PD: Required	PSE: Optional PD Required

PSE Type	Classification	Guaranteed Power at PSE Output	Minimum Power at PSE Output	Units
Type-1	Class 0	15.4	~ 0.5	Watts
	Class 1	4.0	~ 0.5	
	Class 2	7.0	~ 4.0	
	Class 3	15.4	~ 7.0	
Type-2	Class 4	30.0	~ 15.4	

IEEE 802.3at Specification Latitude

- The 802.3at standard allows for the following PSE/PD Topologies
  - High Power, over 4-pairs (two 802.3at PDs per device)
  - Medium Power 802.3at, over 2-pairs
  - 802.3af complaint, over 2-pairs
- 2-pairs End-Span can support 4-pairs PD with Mid-Span
- Standard and Proprietary Detection Schemes



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Sample 15.4W and 30W Mid-Span Products

- POE125U-8C (15.4W/Port)
  - 8 Port Legacy Power 15.4W
  - 19” Rack Mountable with Optional Brackets
  - All Ports = Full Power
  - Gigabit compliant
  - Native Cisco legacy support
  - SNMP (optional)

- POE125U-4AT (30W/Port)
  - 4 Port 802.3at PoE Plus Power
  - 19” Rack Mountable with Optional Brackets
  - All Ports = Full Power
  - Gigabit compliant

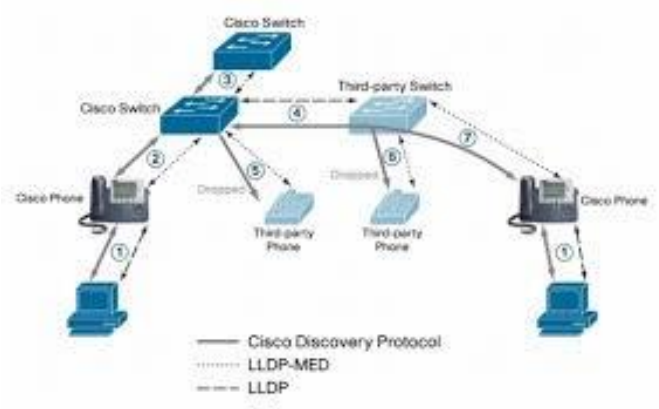
http://www.phihong.com/midspans_website/

Table 1– Powered Device Classification

Class Signature	Powered Device Classification	Power Available for the Powered Device
0	Default, Type 1	0.44W to 12.95W
1	Type 1	0.44W to 3.84W
2	Type 1	3.84W to 6.49W
3	Type 1	6.49W to 12.95W
4	Type 2	12.95W to 25.5W

Cisco IP Phone Power Support

Cisco IP Phone Model	PoE Type
7906G	Cisco Pre-standard or 802.3af
7911G	Cisco Pre-standard or 802.3af
7914/7915/7916 Expansion Modules	Local power only
7931G	802.3af only
7937G Conference Station	802.3af only
7940G	Cisco Pre-standard only
7941G	Cisco Pre-standard or 802.3af
7941G-GE	802.3af only
7942G	Cisco Pre-standard or 802.3af
7945G	802.3af only
7960G	Cisco Pre-standard only
7961G	Cisco Pre-standard or 802.3af
7961G-GE	802.3af only
7962G	Cisco Pre-standard or 802.3af
7965G	802.3af only
7970G	Cisco Pre-standard or 802.3af
7971G-GE	802.3af only
7975G	802.3af only
7985G	802.3af only



Power	IEEE Power over Ethernet 802.3af and 802.3at supported, class 4. The 8961 is compatible with both class 3 and class 4 IEEE PoE switch blades and supports both Cisco Discovery Protocol (CDP) and Link Layer Discovery Protocol - Power over Ethernet (LLDP-PoE)

Table 3. Power Requirements

Power Requirement	Description
IEEE 802.3af PoE	The phones can receive power from IEEE 802.3af-compliant blades. The phone is Power over Ethernet (PoE) Class 2.
Local power	The phones can also be powered locally with a power adapter (CP-PWR-CUBE-3=) along with one of the power cords listed in Table 4.

8945 (User Phone)

Power Requirements

The Cisco Unified IP Conference Station 7937G is interoperable IEEE 802.3af PoE (Class 3 device); 48 VDC is required; it can be supplied locally at the desktop using an optional AC-to-DC power supply (part number CP-PWR-CUBE-3=). Use of the power supply also requires the Cisco Unified IP Conference Station 7937G Power Splitter and one of the corresponding AC country cords

Power over Ethernet (PoE) Technology

PoE was originally released by Cisco using proprietary terminology (Cisco Inline Power) just after the year 2000

In 2003, the first Standard (IEEE 802.3af) was released for PoE having a maximum power capability of 15.4 watts [a.k.a. POE type 1]

In 2009, an updated version was released (IEEE 802.3at) having maximum power of 30 watts [a.k.a. POE+ type 2]

Finally in 2018, the current version (IEEE 802.3bt) was released in two types; type 3 reaching 60 watts and type 4 reaching 100 watts [a.k.a. POE++ types 3 & 4]

Power Over Ethernet Specifications

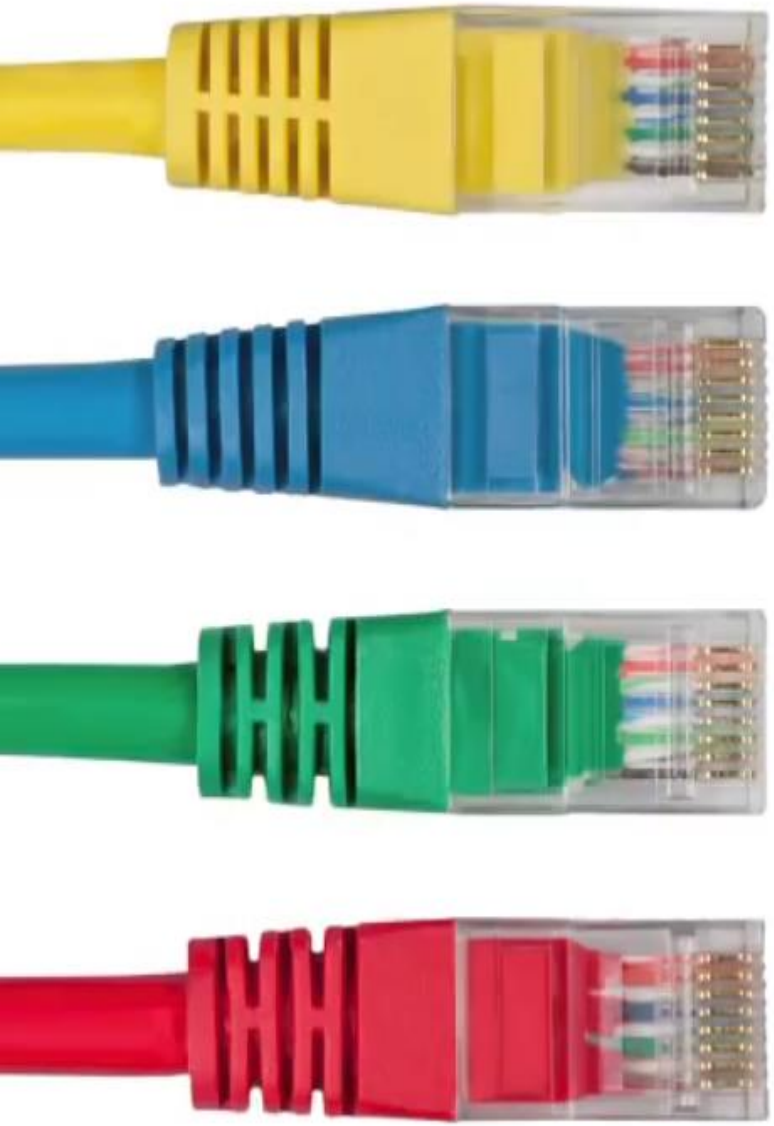
	PoE	PoE+	PoE++	
IEEE Standard	IEEE 802.3af (2003)	IEEE 802.3at (2009)	IEEE 802.3bt (2018)	
PoE Type	Type 1	Type 2	Type 3	Type 4
	Switch Port Power			
Max. Power Per Port	15.4W (12.95W)	30W (25.5W)	60W (51W)	100W (71W)
Port Voltage Range	44–57V	50-57V	50-57V	52-57V
	Powered Device Power			
Max. Power to Device	12.95W	25.5W	51W	71W
Voltage Range to Device	37-57V	42.5-57V	42.5-57V	41.1-57V
	Cables			
Twisted Pairs Used	2-pair	2-pair	4-pair	4-pair
Recommended Cables	Cat5 or better		Cat6 or Better 'Preferred'	

Power Over Ethernet (POE) Advantages

- A single low-voltage cable is used to install a device
- Power bricks and/or electricians are NOT needed to complete an installation
- Reduced electrical shock hazards
- With a managed PoE switch, device power can be remotely controlled
- Also with a managed PoE switch, Backup power is only needed for the switch
- Additional PoE devices can be quickly deployed to existing Ethernet wiring

Power Over Ethernet (POE) Technology

PoE	PoE+	PoE++
802.3af	802.3at	802.3bt
12.95 Watts	25.5 Watts	51/71 Watts
Types of Devices Supported	Types of Devices Supported	Types of Devices Supported
 VoIPs	 Pan/Tilt/Zoom Cameras	 Laptops
 APs	 Video IP Phones	 TVs
	 Alarm Systems	



802.3af PoE = PoE

Delivers up to 15.4W per port

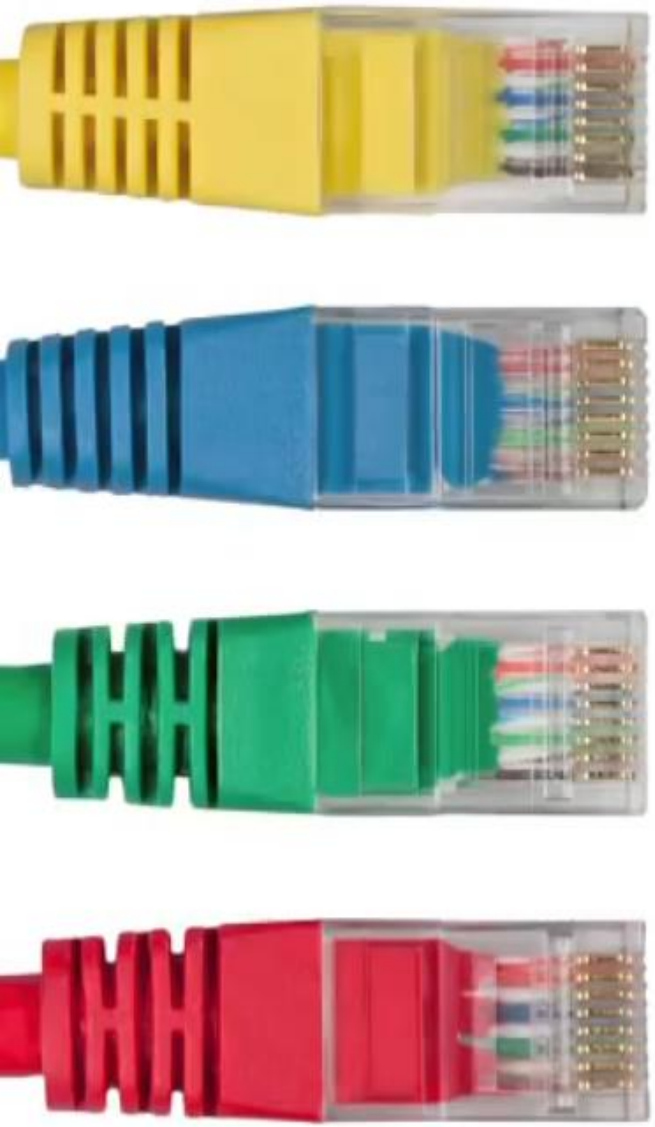
IEEE 802.3af

802.3af "PoE" (2003)

- Available power at the PD: 12.95W
- Available power at the PSE port: 15.4W
  - PSE Output voltage range: 44 to 57 VDC
  - Maximum current: 350 mA
- CAT3 cable okay, but CAT5, CAT5e and CAT6 are recommended
- Sends power over 4 (of 8) wires in the cable

Type 1

Power	• 15.40 W at PSE to deliver 12.95 W at PD
Voltage	• 44.0–57.0 V at PSE
Cabling	• Category 3 and Category 5
Standard	• IEEE 802.3af-2003 (802.3at Type 1)



802.3at PoE = PoE+

Delivers 30W or more per port

Backwards compatible with 802.3af

IEEE 802.3at

802.3at "PoE+" (2009)

- Available power at the PD: 25.5W
- Available power at the PSE port: 30.0W
  - PSE Output voltage range: 50 to 57 VDC
  - Maximum current: 600 mA
- CAT5 cable okay, but CAT5e or better recommended
- Sends power over 4 (of 8) wires in the cable
- Interoperable with 802.3af
  - An 802.3at PSE can power an 802.3af PD using CAT3/CAT5 cabling.

Type 2

Power	• 30 W at PSE to deliver 25.50 W at PD
Voltage	• 50.0–57.0 V at PSE
Cabling	• Category 5
Standard	• IEEE 802.3at-2009

	Type 3	Type 4
Power	• 60 W at PSE to deliver 51 W at PD	• 100 W at to deliver 71 W at PD
Voltage	• 50.0–57.0 V at PSE	• 52.0–57.0 V at PSE
Cabling	• Category 5	• Category 5
Standard	• IEEE 802.3bt-2018 "4PPoE"	• IEEE 802.3bt-2018 Type 4

PoE, PoE+, and PoE++

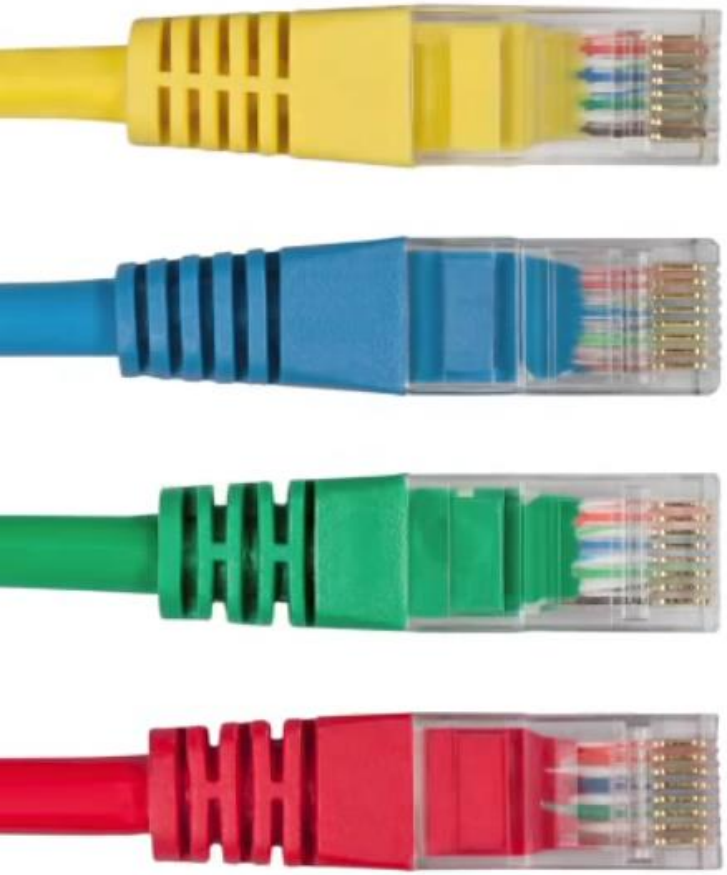
Comparison

Type	IEEE Standard	Maximum Current (mA)	Powered Pairs	Power @ Device (Watts)	Maximum Data Rate	Standard Ratification Date
PoE	802.3af 802.3at (Type 1)	350mA	2	12.95W	1000BASE-T	2003
PoE+	802.3at (Type 2)	600mA	2	25.5W	1000BASE-T	2009
PoE++ (4PPoE)	802.3bt (Type 3)	600mA	4	~ 50W	10GBASE-T	Expected 2016/2017
	802.3bt (Type 4)	960mA		~ 70W		

IEEE 802.3.bt → 60 W and 100 W @ PSE

Class Number	PSE Output Power [W]	PD Input Power [W]	PD Type	Notes
0	15.4	12.95	1	IEEE802.3af
1	4	3.84	1	
2	7	6.49	1	
3	15.4	12.95	1	
4	30	25.5	2	IEEE802.3at
5	45	40	3	IEEE802.3bt
6	60	51	3	
7	75	62	4	
8	90	73	4	

Property	802.3af (802.3at Type 1) "PoE"	802.3at Type 2 "PoE+"	802.3bt Type 3"4PPoE"	802.3bt Type 4
Power available at PD	12.95 W	25.50 W	51 W	71 W
Maximum power delivered by PSE	15.40 W	30.0 W	60 W	100 W
Voltage range (at PSE)	44.0–57.0 V	50.0–57.0 V	50.0–57.0 V	52.0–57.0 V
Voltage range (at PD)	37.0–57.0 V	42.5–57.0 V	42.5–57.0 V	41.1–57.0 V
Maximum current	350 mA	600 mA per mode	1200 mA	1731 mA
Maximum cable resistance	20 Ω (Category 3)	12.5 Ω (Category 5)	6.25 Ω	6.25 Ω
Supported cabling	Category 3 and Category 5	Category 5	Category 5	
Supported modes	Mode A (endspan), Mode B (midspan)	Mode A, Mode B		



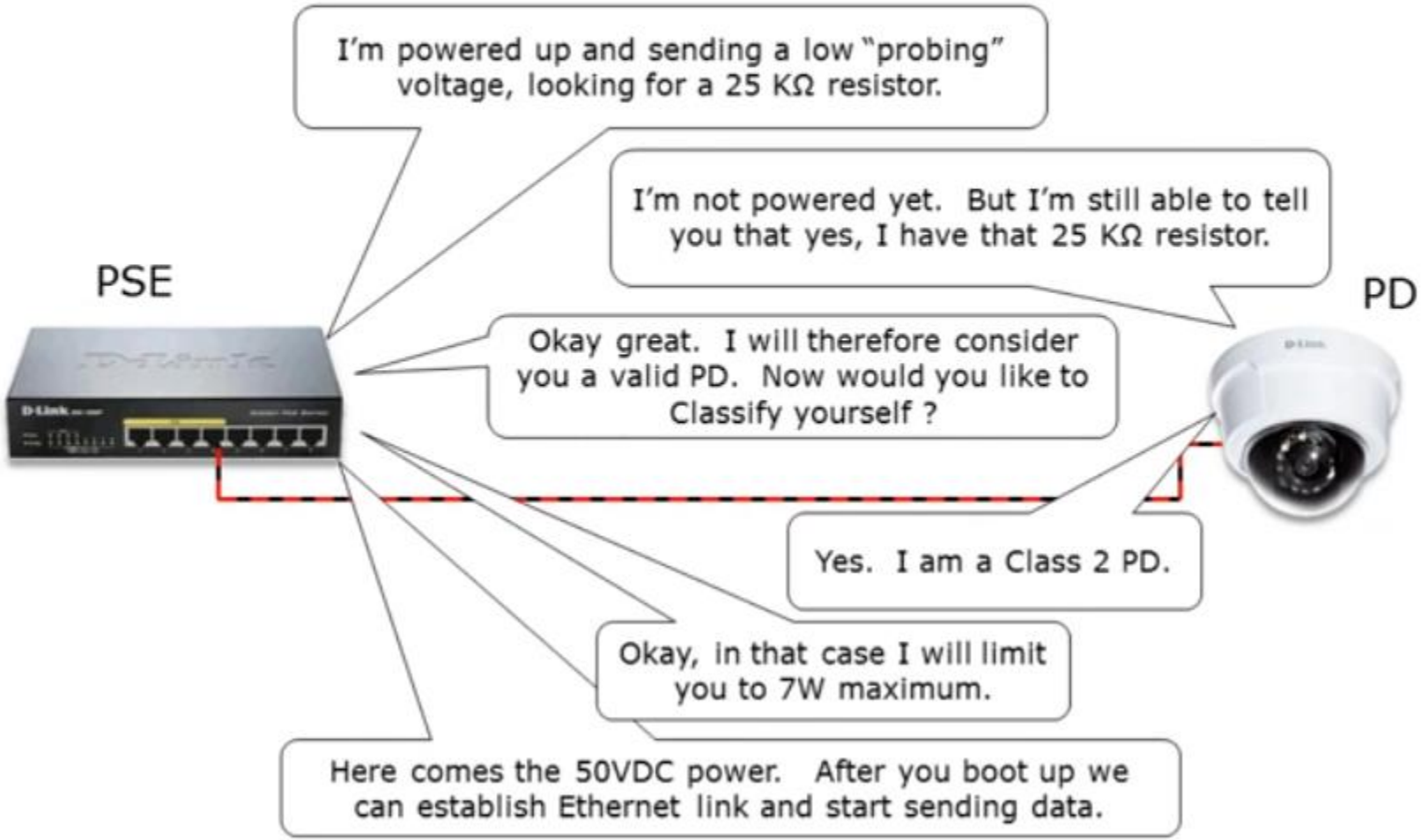
PoE Injectors and Midspans

10/100 Mbps

10/100/1000 Mbps

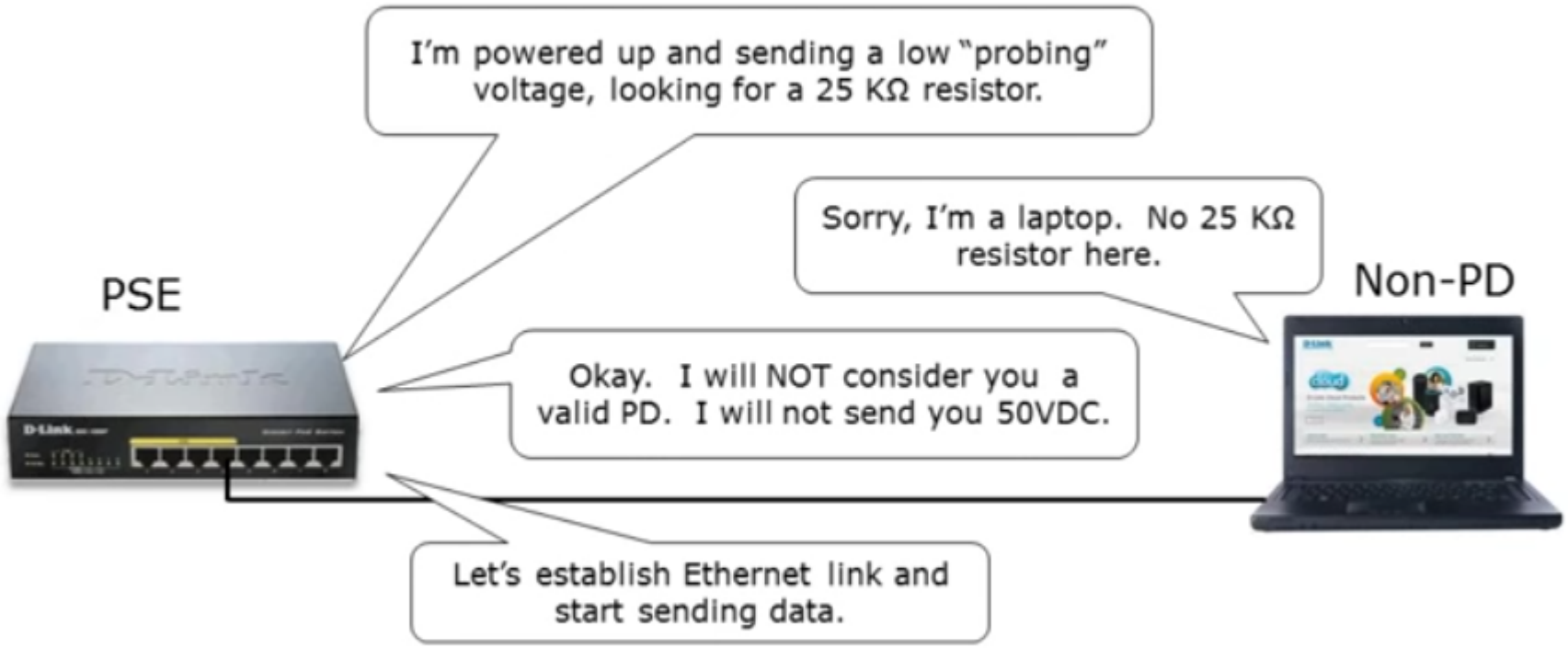
PoE DETECTION PROCESS*

*simplified



PoE DETECTION PROCESS*

*simplified



PSE POWERING MODES

IEEE Alternative A

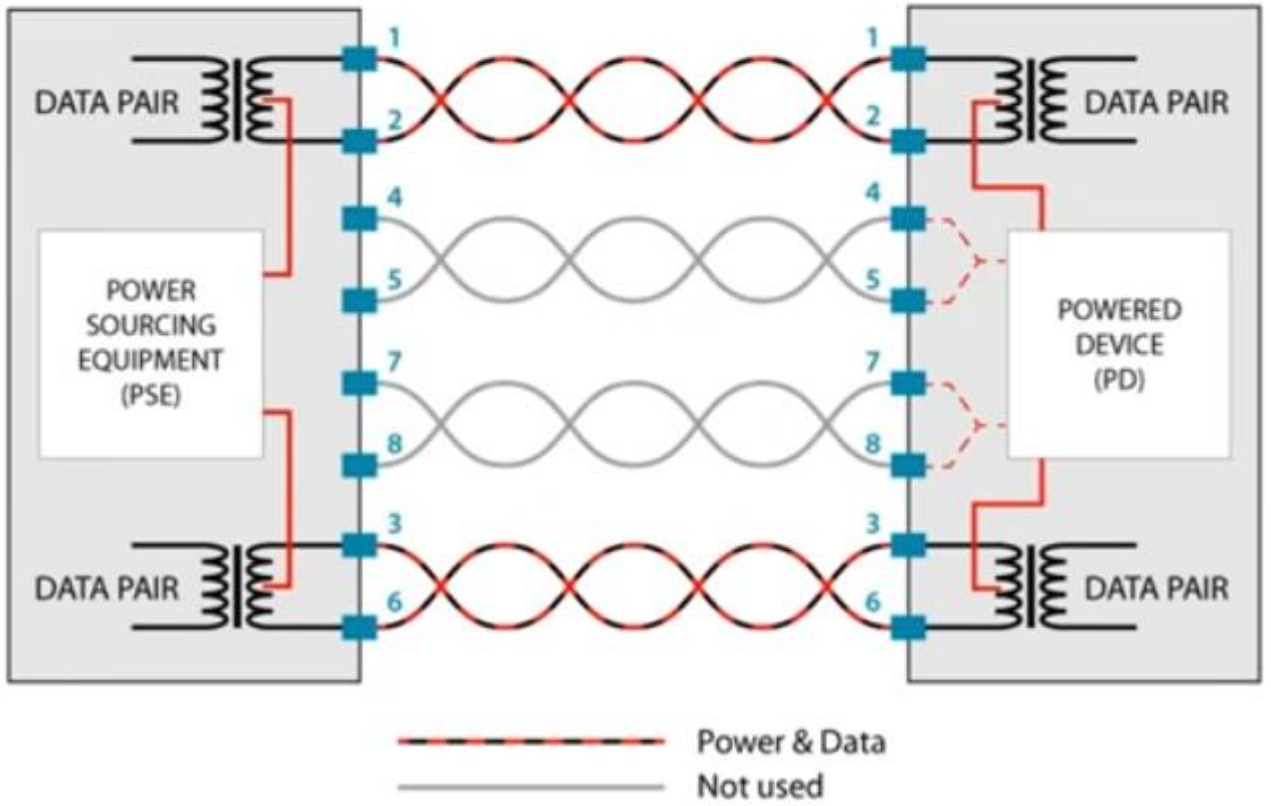
- Applies PoE power to pins 1,2 and 3,6

IEEE Alternative B

- Applies PoE power to pins 4,5 and 7,8

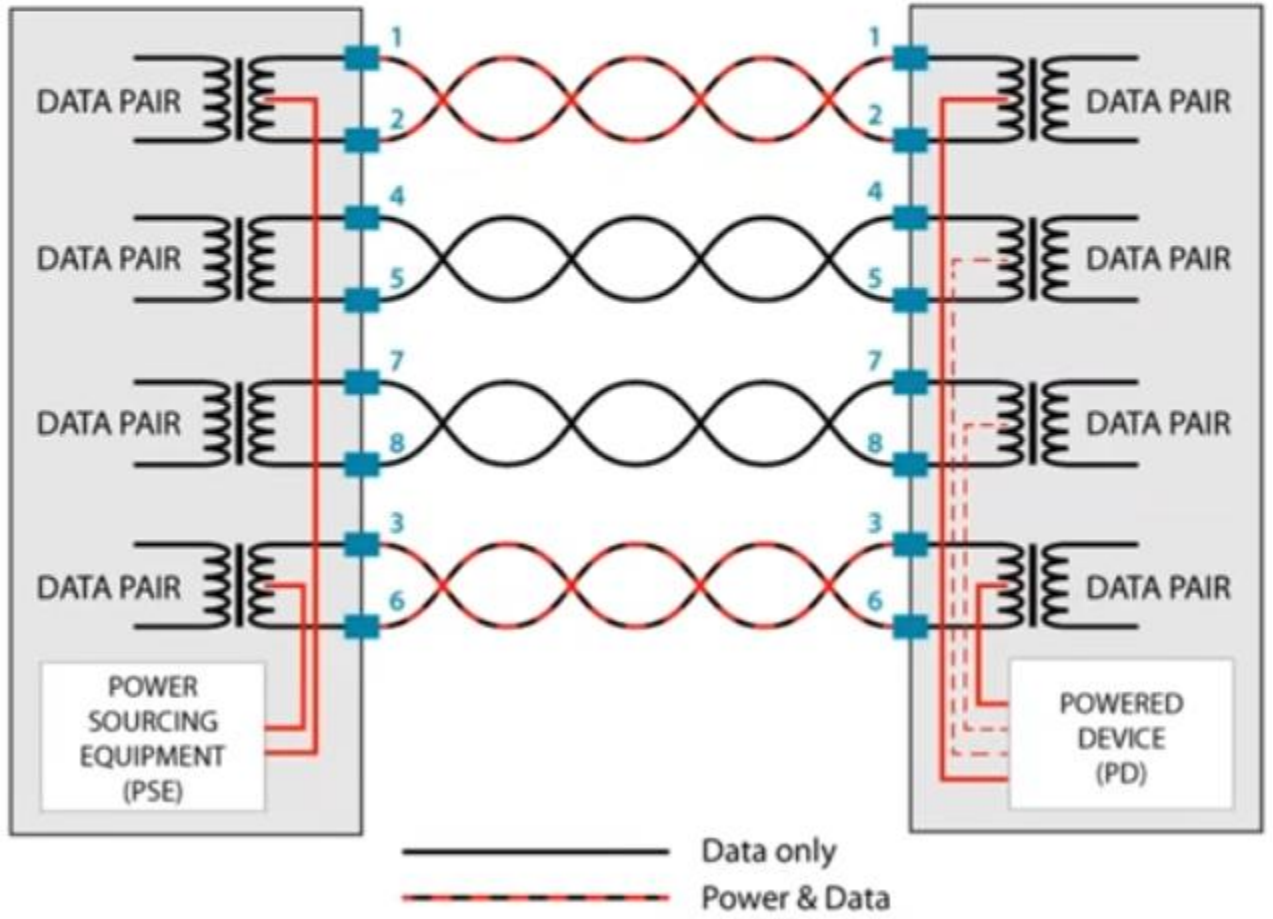
10/100BASE-T (ENDSPAN)

IEEE Alternative A – uses Phantom Power



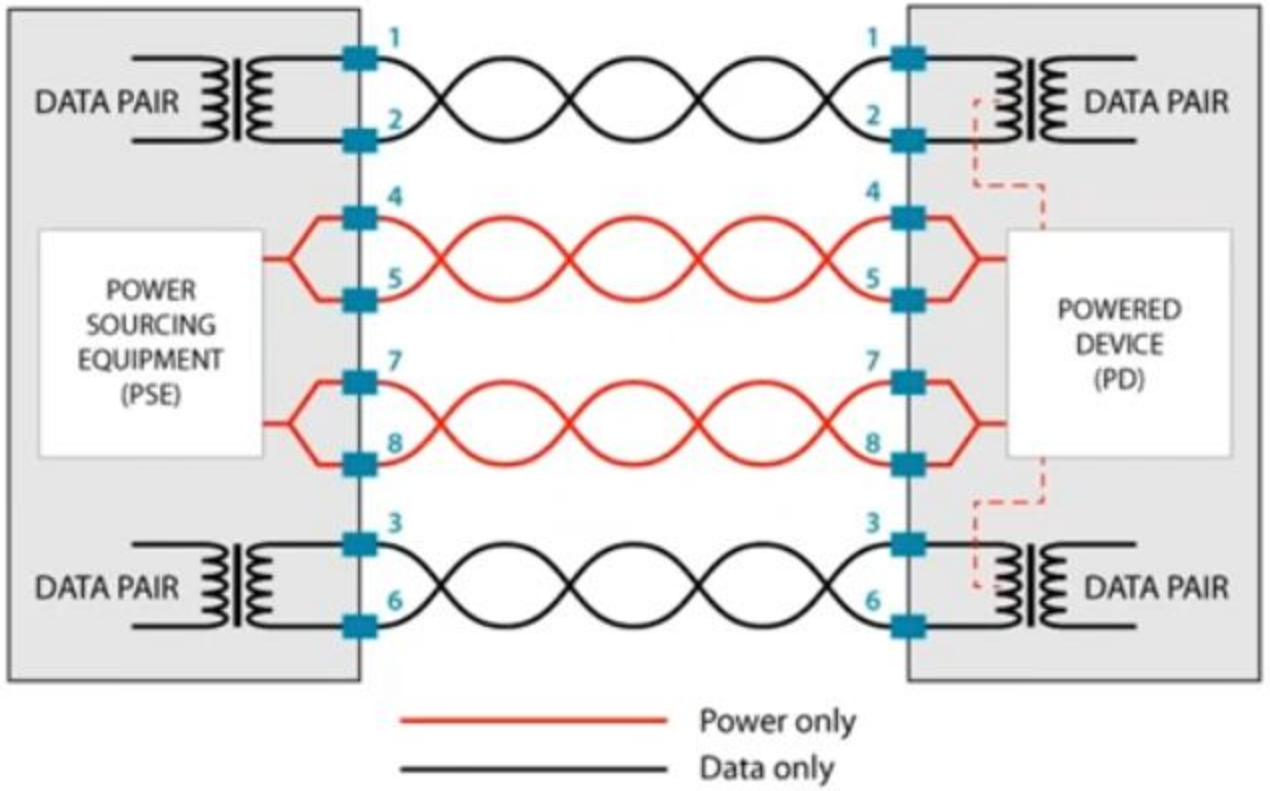
1000BASE-T (ENDSPAN)

IEEE Alternative A – uses Phantom Power



10/100BASE-T (ENDSPAN)

IEEE Alternative B – uses spare pairs



IEEE 802.3bt “PoE++” (2018)

PoE Type 3:

- Available power at the PSE port: 60W
- Available power at the PD: 51W
- CAT5e cable or better
- Sends power over 8 of 8 wires in the cable
- Cable length 100m
- Also compatible with 10GBASE-T
- Backwards compatible with 802.3af and 802.3at

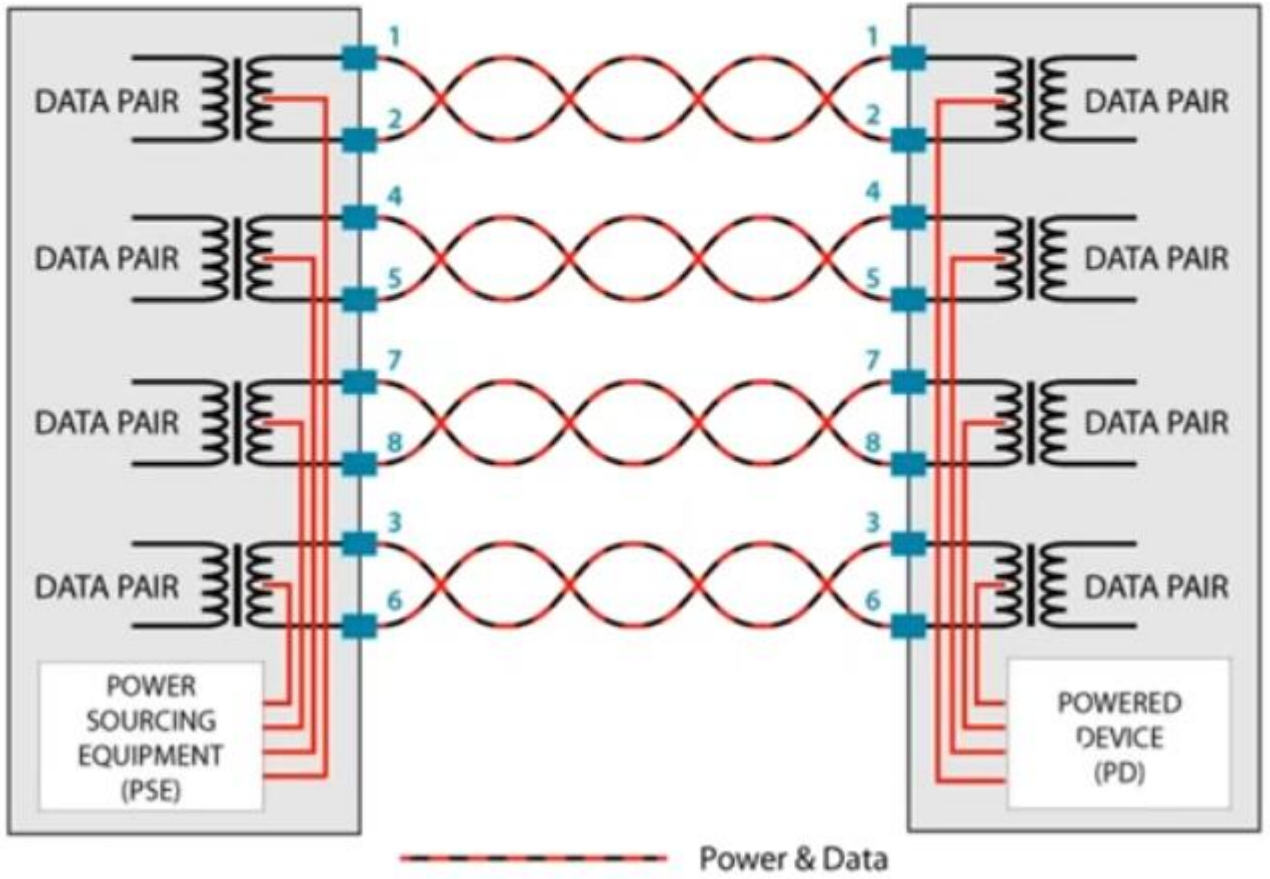
IEEE 802.3bt “PoE++” (2018)

PoE Type 4:

- Available power at the PSE port: 90W
- Available power at the PD: 71.3W
- CAT5e cable okay, but CAT6A or better recommended to minimize loss and heat
- Sends power over 8 of 8 wires in the cable
- Cable length 100m
- Also compatible with 10GBASE-T


802.3bt
60~95W
Thin Client
POS System
Digital Signage
Health Care
Lighting
802.3at
30W
Door Phone
PTZ Camera
11ac Wi-Fi AP
802.3af
15W
IP Phone
IP Camera

4-PAIR PoE


DATA PAIR
DATA PAIR
DATA PAIR
DATA PAIR
1
2
4
5
7
8
3
6
POWER SOURCING EQUIPMENT (PSE)
POWERED DEVICE (PD)
Power & Data

POWERING MODES

Summary

		Wire Pair			
		1,2	4,5	7,8	3,6
10/100BASE-T	Alt. A	Data + Power	(unused)	(unused)	Data + Power
	Alt. B	Data only	Power only	Power only	Data only
1000BASE-T	Alt. A	Data + Power	Data only	Data only	Data + Power
	Alt. B	Data only	Data + Power	Data + Power	Data only

BENEFITS OF PoE

Flexibility:

- Install end-devices where it is hard to get power
- Easily move end-devices to wherever there is a LAN cable

Functionality:

- End devices can be reset remotely

Simplicity:

- Install LAN cable (only) to the end device. Minimizes cable clutter

Cost Savings:

- No need to install power outlets

Safety:

- No AC power is needed for outdoor applications

PoE Overview

PoE (Power over Ethernet) technology allows PSE (Power Sourcing Equipment, such as a PoE switch) to use Ethernet cables to deliver both power and data simultaneously to PD (Powered Device, like IP cameras and VoIP phones).

PSE

PoE standards –

- IEEE 802.3af,
- IEEE 802.3at
- IEEE 802.3bt

PD

PoE Standards

PoE — 802.3af — 15.4 Watts

- VoIP
- WiFi

PoE+ — 802.3at — 30 Watts

- Pan/Tilt/Zoom Cameras
- Video IP Phones
- Alarm Systems

PoE++ — 802.3bt — Type1 60W, Type2 100W

- IP Camera
- Laptops
- Video IP Phones

Power over Ethernet (PoE) Standards

Name	Standards/Type	Maximum power delivered by PSE	Power available at PD	Max Current	Number of Energized Pairs	Standard Ratified Year
PoE	802.3af (802.3at Type 1)	15.40 W	12.95 W	350 mA	2	2003
PoE+	802.3at Type 2	30.0 W	25.50 W	600 mA	2	2009
4PPoE	802.3bt Type 3	60 W	51 W	600 mA per pair	4	2018
	802.3bt Type 4	100 W	71 W	960 mA per pair	4	

Emerging PoE applications

PoE Switch

802.11ac Access Point

802.3at PoE+ (30W)

802.3af PoE (15.4W)

IP Voice/Video Phone

802.3bt PoE (up to 100W)

IP Camera

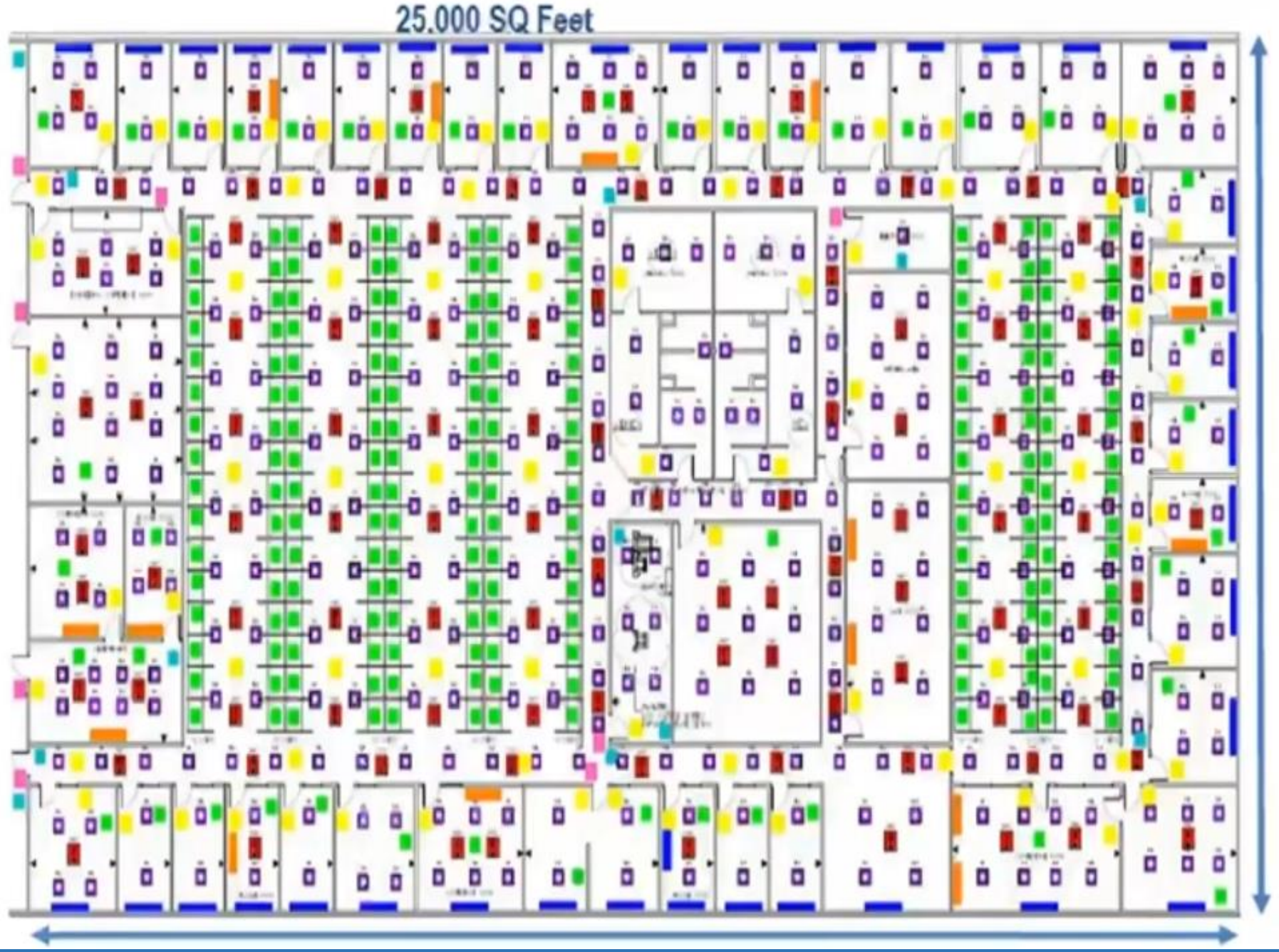
PoE Applications

- ✓ Intelligent LED lighting
- ✓ Occupancy and Climate Sensors
- ✓ Access points
- ✓ PTZ cameras
- ✓ Building Automation Controls
- ✓ Kiosks
- ✓ Point of Sale (POS) terminals
- ✓ Video Conferencing
- ✓ Thin clients
- ✓ Televisions
- ✓ Digital Signage

PoE, PoE+ Switches

PoE Infrastructure

LED Lighting	389
Phone, Client, Monitor	192
Display	16
Occupancy Sensors	89
WAP	107
Shade Control	40
Security Camera	12
Access Controls	8
Total	**853**



LAN Connectivity – PoE

LAN Connectivity - PoE Budget Calculation

PoE Switches Power Budget

- PoE Switches have limitation on the amount of power they can supply to all PoE devices – the **PoE Power Budget**.
- The PoE Power Budget is specified in the switch specifications.
- Best practice when calculating PoE budget requirements – add 15% for power loss over distance.

Example: How many Cameras can be powered by this PoE switch?

PoE	PoE Standard	IEEE 802.3af and IEEE 802.3at
	PoE Power Budget	Max. 185 W

Power Consumption	• 10.5 watts ± 5%

$$\frac{185 \text{ Watts}}{(10.5 \text{ Watts} + 15\%)} = 15 \text{ cameras}$$

Per Camera PoE Required = 10.5W, for 15 Camera = 10.5X15=157.5W.
Considering 15% buffer, we need total 185-Watt PoE switch.

LAN Connectivity - D-Link PoE Series

Examples of PoE switches			PoE ports	PoE power budget
	DGS-1210-10P	Smart Managed 10 port Gigabit switch with 2 Combo SFP ports	8	78 Watts
	DGS-1210-28P	Smart Managed 24 port Gigabit switch with 4 Combo SFP ports	24	193 Watts
	DGS-1210-28MP	Smart Managed 24 port Gigabit switch with 4 Combo SFP ports	24	370 Watts
	DGS-3130-30PS DGS-3130-54PS	Managed 24/48 ports Gigabit switch with 6 10Gbports (RJ45 and SFP+)	24 48	370-740* Watts
	DPE-301GI	PoE+ injector. Suitable for PoE/PoE+ devices.	1	30 Watts

Long Range (250meter) PoE applications

Long Range PoE – 250m

250m Long Reach PoE Solution - Up to 250m

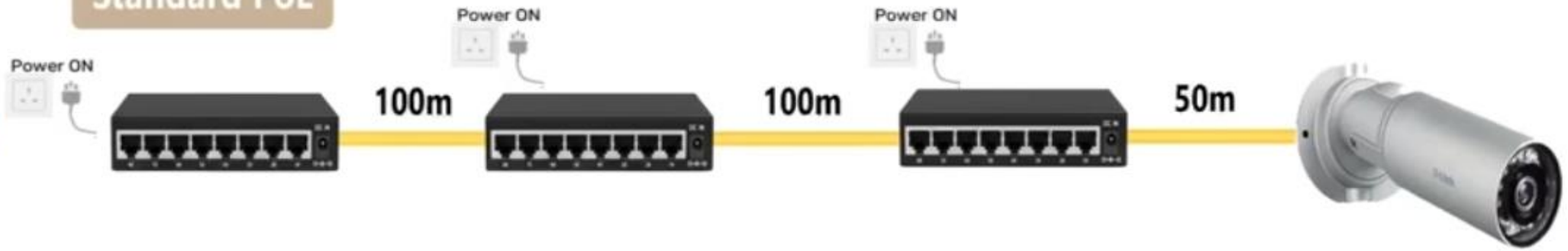
6kV Surge Protection

GIG Gigabit Uplink Ports (On Selected Models)

Built-in Smart Features (VLAN Support, QoS, PoE Device Monitoring)

Standard PoE

3 points of failures



250m PoE

Less Point of failures

Long Range (500meter) PoE applications

Long Range PoE – 500m

250m Long Reach PoE Solution - Up to 250m

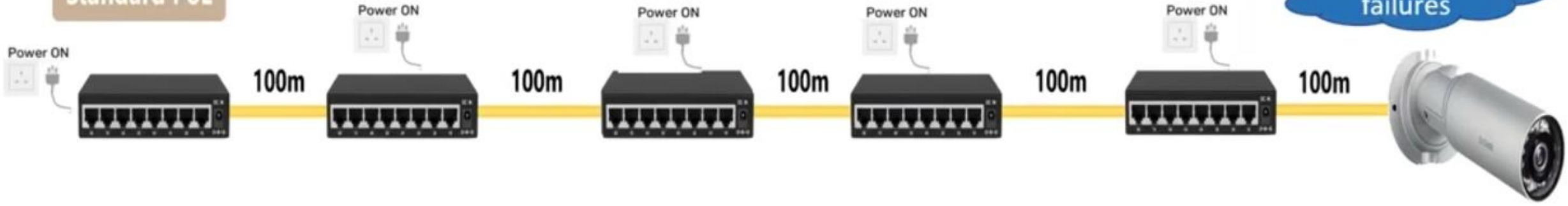
6kV Surge Protection

GIG Gigabit Uplink Ports (On Selected Models)

Built-in Smart Features (VLAN Support, QoS, PoE Device Monitoring)

Standard PoE

5 point of failures



500m PoE

Less Point of failures

500 meter

Product Portfolio – Long Distance PoE F-Series

DES-F1006P-E

PoE Budget 60 Watts

DIP switch settings

1. VLAN
2. Extended (250m)
3. PoE
4. QoS (Priority)

Switch Detect IP Camera "**Unresponsive**"

DES-F1010P-E

PoE Budget 120 Watts

DGS-F1010P-E

PoE Budget 120 Watts

6Kv Surge Protection

DGS-F1018P-E

PoE Budget 150 Watts

Power ON/OFF the PoE
automatically to recover the device

D-Link Smart Series

DGS-1510-28X
DGS-1510-28XMP **(370W)**
DGS-1510-52XMP **(740W)**

D-Link Smart Series

DGS-1210-10
DGS-1210-10P(65W)
DGS-1210-10MP(130W)
DGS-1210-12TS/ME

DGS-1210-28
DGS-1210-28P(193W)
DGS-1210-28MP(370W)

D-Link Smart Series

DGS-1250-28X
DGS-1250-28XMP(**370W**)

D-Link Smart Positioning

DES-F1000 Series

FE Unmanaged Switches

Unmanaged Series

- ✓ PoE Budget - 60,120,150W
- ✓ Support PoE, PoE+
- ✓ Support 250m
- ✓ Support 6Kv Surge
- ✓ Support QoS, Ext. Mode, Traffic Segment using DIP Switches

DGS-1210 Series

Gigabit Smart Managed Switches

Smart Managed

- ✓ PoE Budget - 65,130,193, 370W
- ✓ Easy Mngt- GUI
- ✓ IPv6 Ready
- ✓ Support SNMPv1,v3,v3
- ✓ Support Green Ethernet
- ✓ Auto Voice VLAN
- ✓ Support LACP
- ✓ Support STP, RSTP, MSTP
- ✓ Basic L3 – 4 IP Interface

DGS-1250 Series

10-Gigabit Smart Managed Switches

- New Arrival -

Smart 10G uplink

- ✓ 4X10G SFP+ Uplink ports
- ✓ 6Kv Surge Protection
- ✓ Support Safeguard Engine
- ✓ Easy Mngt – GUI, CLI
- ✓ Support QoS
- ✓ Security - IMPB Support
- ✓ PoE Budget -193, 370W
- ✓ Basic L3 – 4 IP Interface

DGS-1510 Series

Gigabit Stackable Smart Managed Switches with 10G Uplinks

Smart Managed PRO

- ✓ Support Physical Stacking
- ✓ Support sFlow
- ✓ Support ERPS
- ✓ Support GVRP
- ✓ Support DHCP Server
- ✓ Support Advance QoS
- ✓ PoE Budget -193, 370W
- ✓ Basic L3 – 16 IP Interface

How to read D-Link Switch Models

D-Link switch: DGS-1100-16

16-port switch

DGS-1210-28P

28-port switch

PoE ports

DGS-3130-54S

54-port switch

SFP ports

RJ45 ports

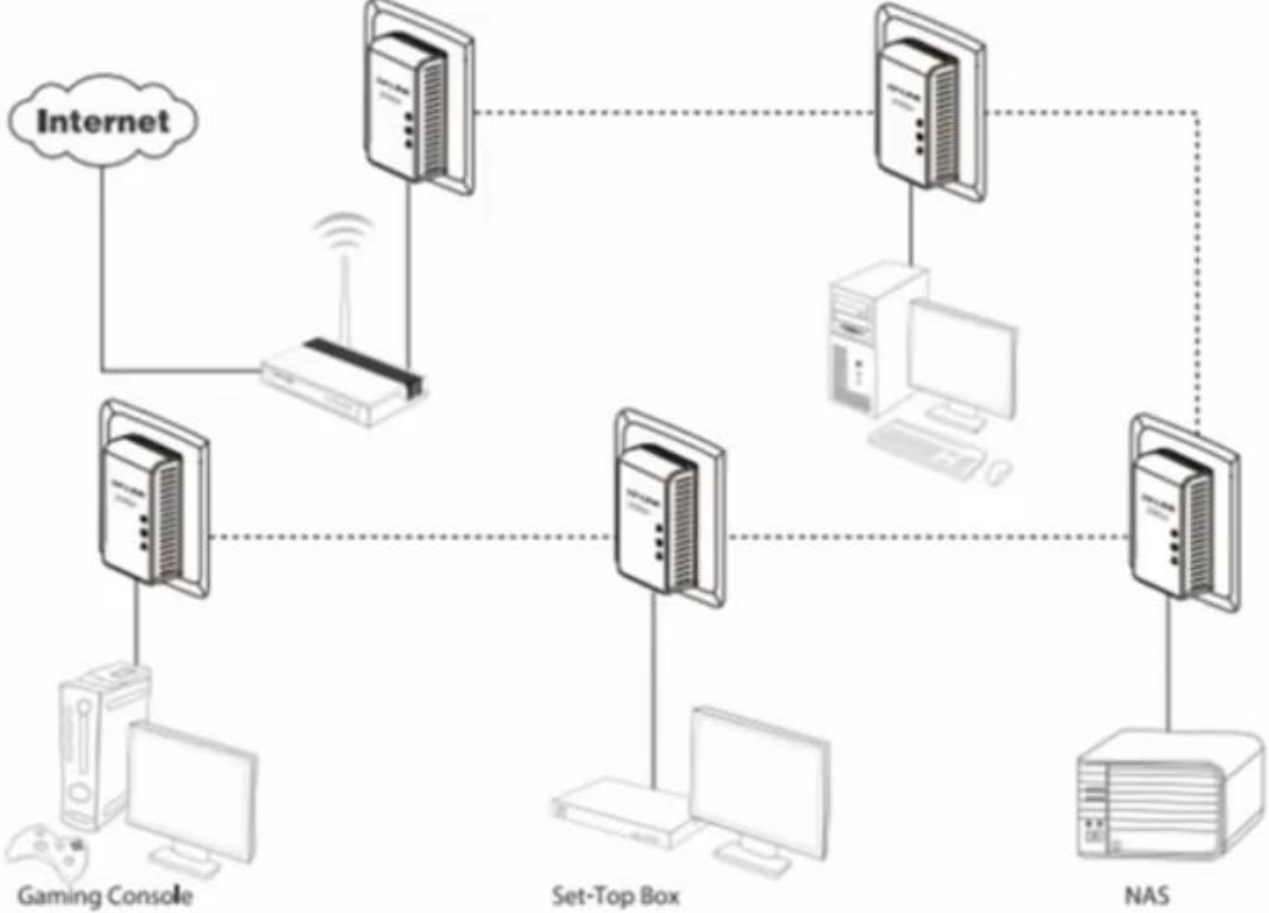
SFP or SFP+ ports for Fibre Optic Transceivers

TP-LINK
The Reliable Choice

TP-LINK All Wired Powerlines

Setup and Installation Guide

TP-LINK
The Reliable Choice

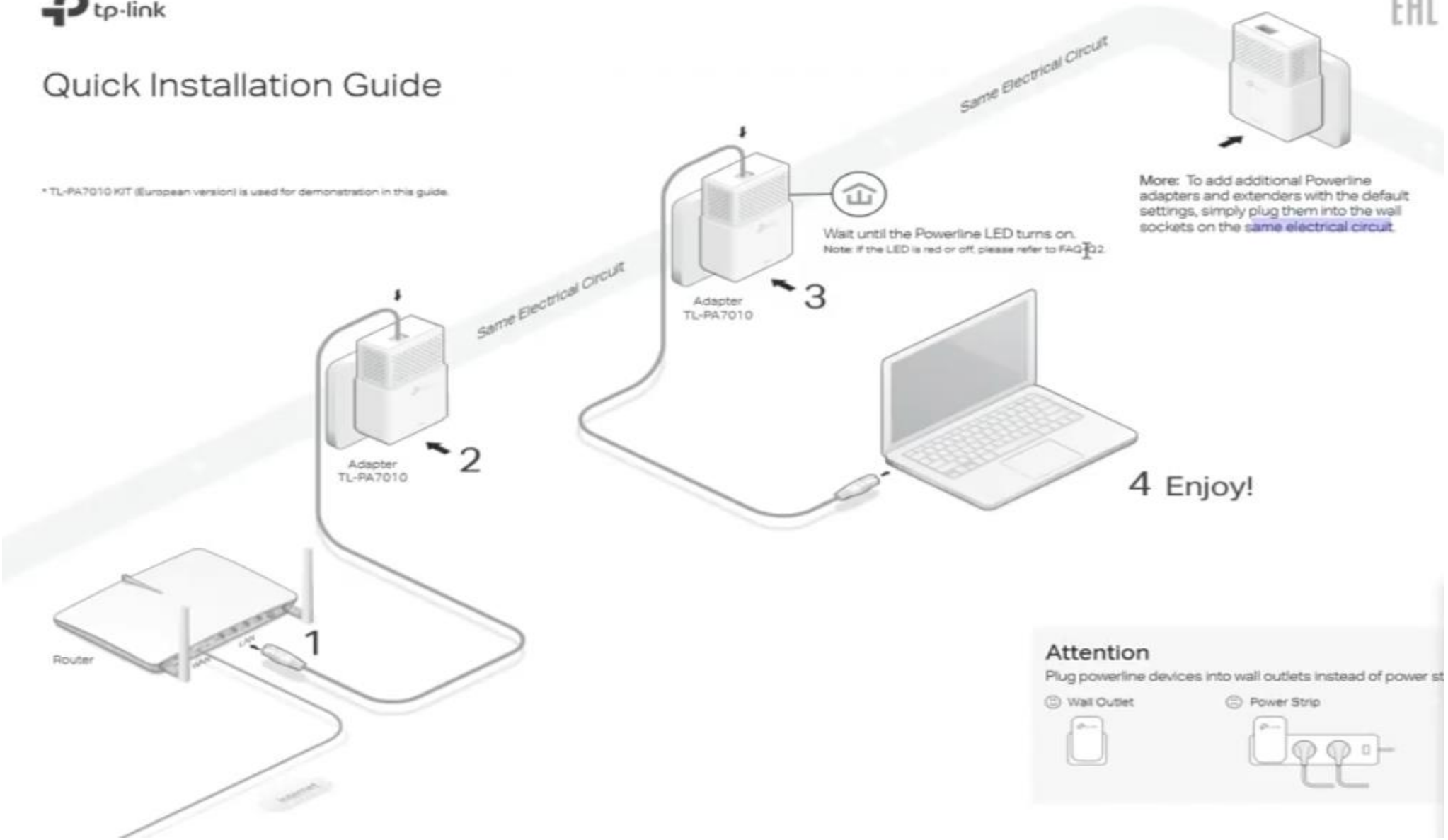


Please make sure all Powerline adapters use the same electrical circuit or electrical meter

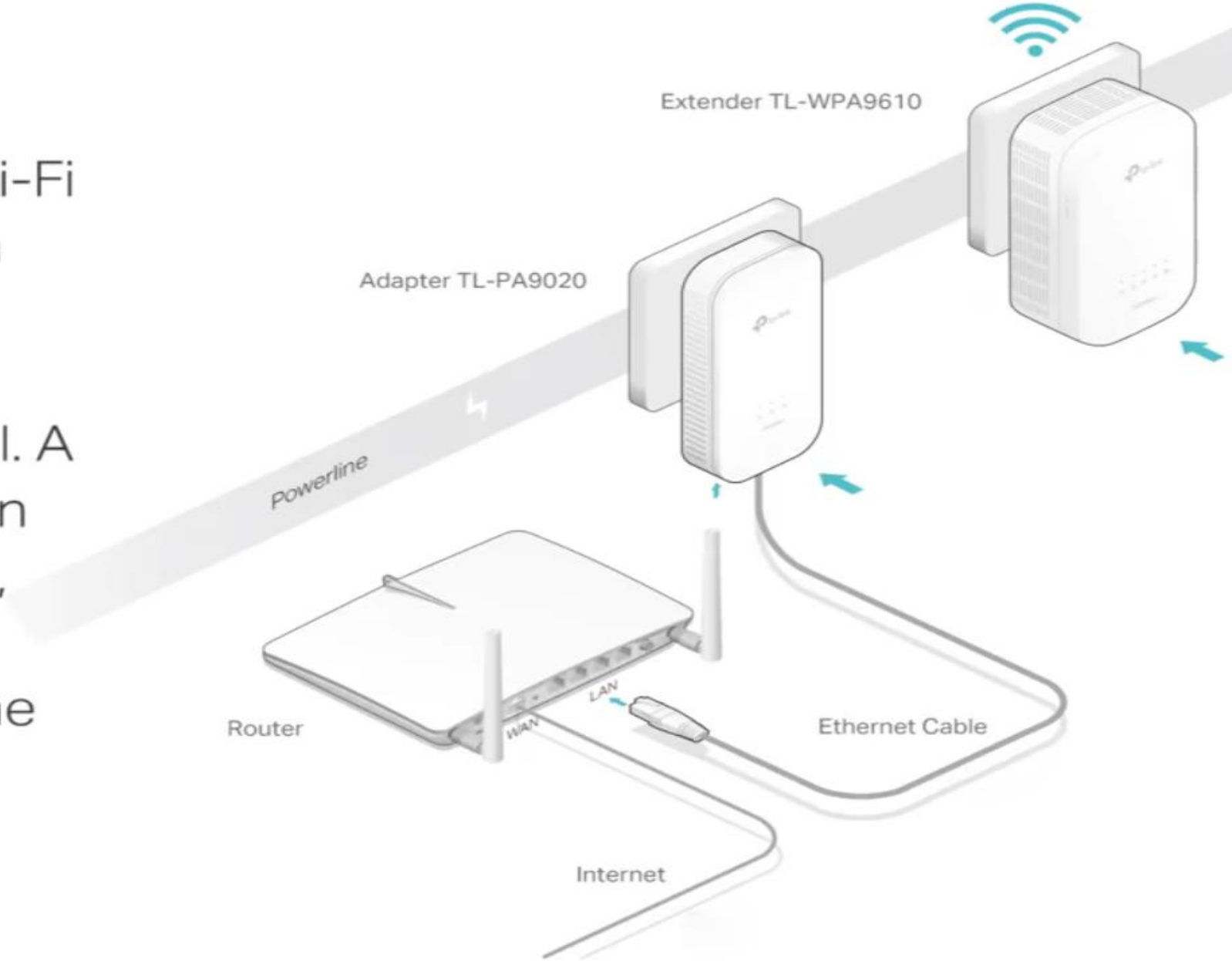
tp-link

Quick Installation Guide

* TL-PA7010 KIT (European version) is used for demonstration in this guide.



Normally,the powerline Wi-Fi kit works by connecting a powerline adapter to the router via Ethernet cable, then plugging it into a wall. A powerline extender is then plugged into another wall, receiving the adapter's network signal through the home's electrical wiring.



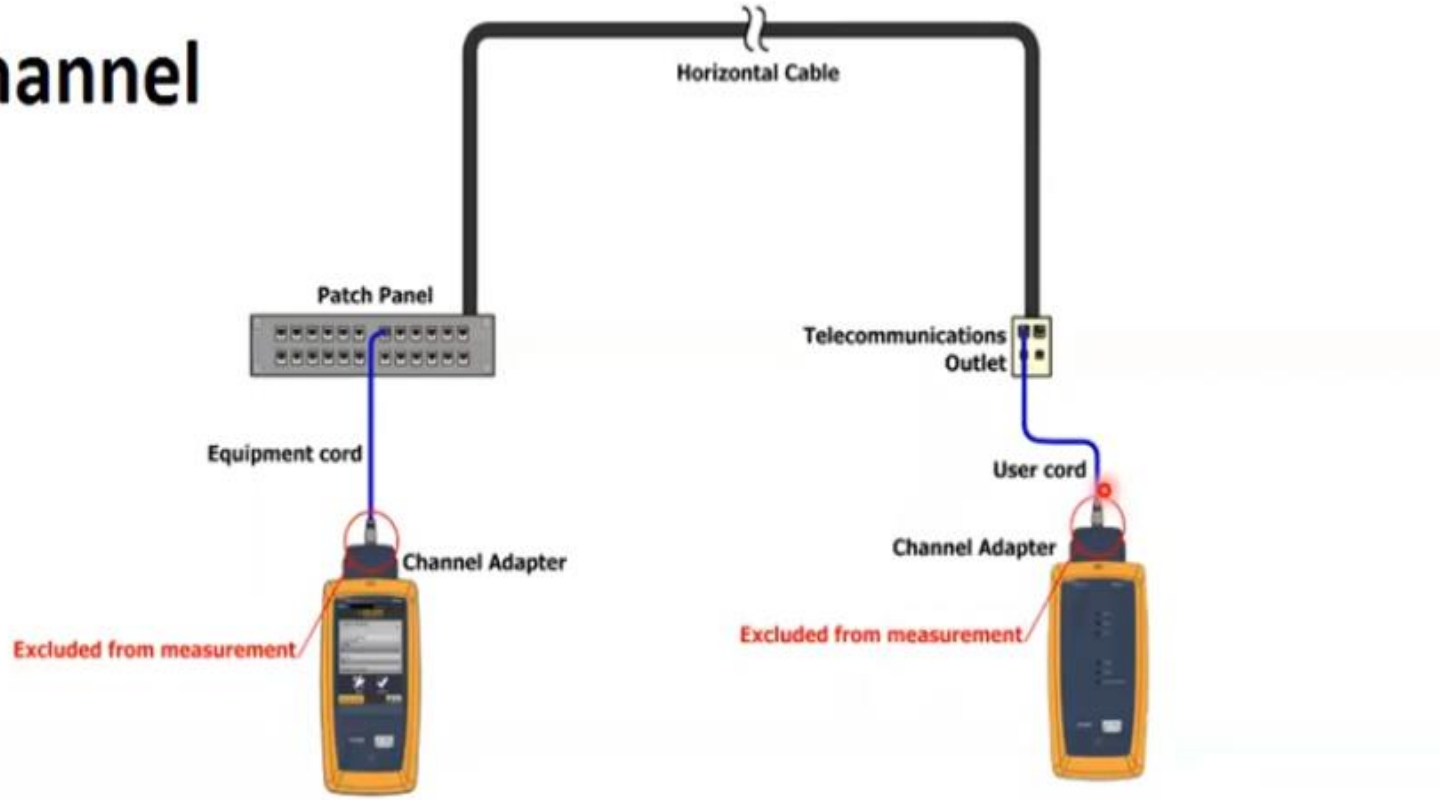
Specifications

Standards	HomePlug AV2, HomePlug AV, IEEE 1901, IEEE 802.3, IEEE 802.3u, IEEE 802.3ab
Powerline Security	128-bit AES Encryption
Range	Up to 300 meters /1000 feet over existing electrical wiring
LEDs	Power, Powerline, Ethernet
Dimensions (W × D × H)	3.8 × 2.4 × 1.4 in (98 × 60 × 36mm)


www.CableSupply.com
NOVA

Cable tester

Channel



Cable Certification Report from LinkWare

LINKWARE™ PC
CABLE TEST MANAGEMENT SOFTWARE

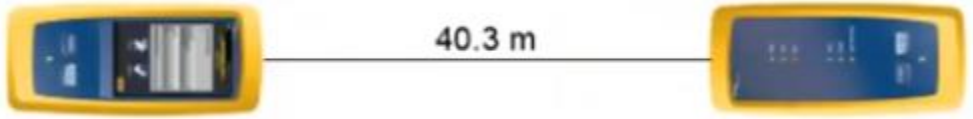
Cable ID: CU-06
Test Limit: TIA Cat 6 Perm. Link
Limits Version: V7.5
Date / Time: 06/08/2020 08:46:41 AM
Operator: Jim
Headroom 7.2 dB (RL 4,5)
Cable Type: Cat 6A U/UTP
NVP: 68.2%

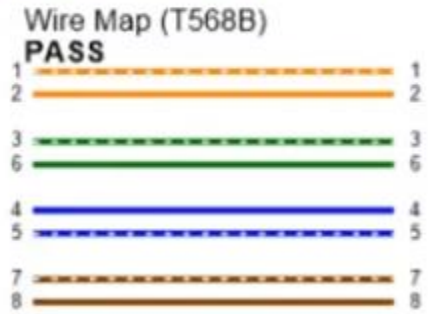
Main: Versiv
S/N: 1623063
software version: v6.5 build 20200428-1823 dev-k...
Calibration Date: 06/06/2019
Adapter: DSX-8000 (DSX-PLA804)
S/N: 3465015

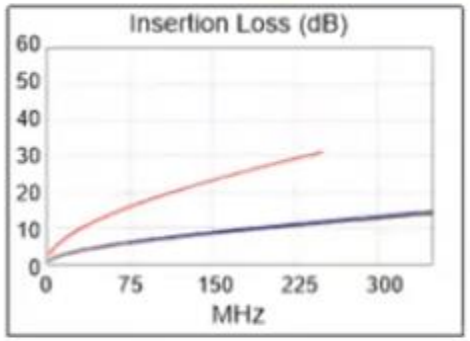
Test Summary: PASS
Remote: Versiv
S/N: 1623097
software version: v6.5 build 20200428-1823 dev-k...
Calibration Date: 12/19/2016
Adapter: DSX-8000R (DSX-PLA804)
S/N: 4064150

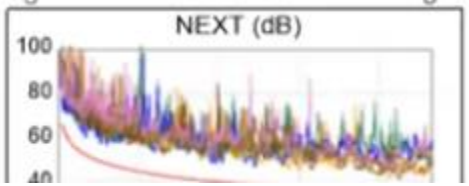
Length (m), Limit 90.0	[Pair 7,8]	40.3
Prop. Delay (ns), Limit 498	[Pair 4,5]	213
Delay Skew (ns), Limit 44	[Pair 4,5]	16
Resistance (ohms)	[Pair 4,5]	4.73
Insertion Loss Margin (dB)	[Pair 4,5]	19.3
Frequency (MHz)	[Pair 4,5]	250.0
Limit (dB)	[Pair 4,5]	31.1

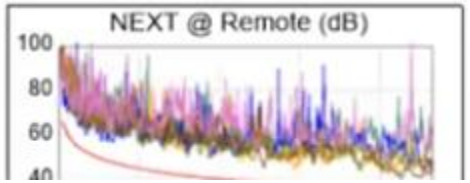
	Worst Case Margin		Worst Case Value	
PASS	MAIN	SR	MAIN	SR
Worst Pair	1,2-7,8	3,6-4,5	1,2-3,6	1,2-3,6
NEXT (dB)	8.1	7.2	8.5	7.7
Freq. (MHz)	24.9	192.0	226.0	220.0
Limit (dB)	51.6	37.2	36.1	36.2
Worst Pair	1,2	7,8	3,6	3,6
PS NEXT (dB)	9.2	8.6	9.7	9.0
Freq. (MHz)	24.9	25.1	238.0	238.5







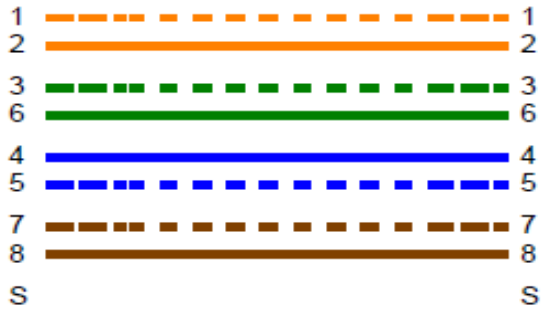


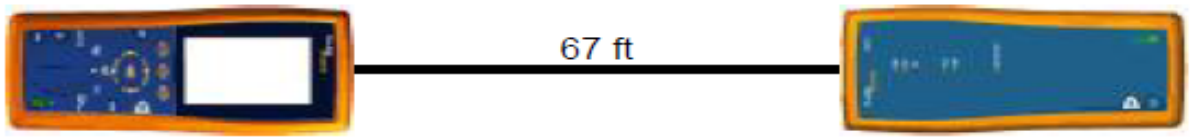


Remote Adapter: DTX-CHA001

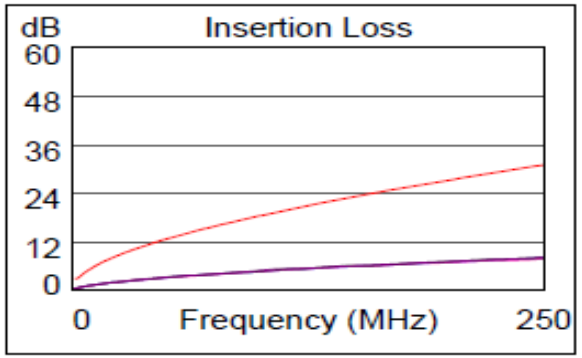
Wire Map (T568B)

PASS

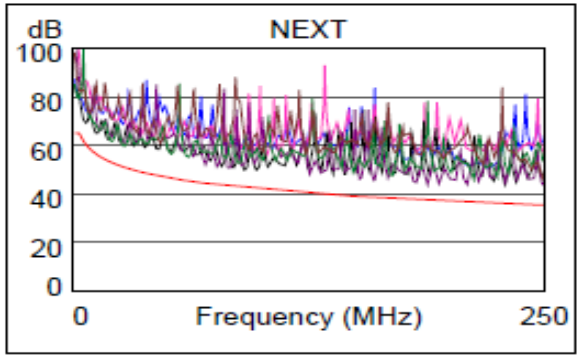


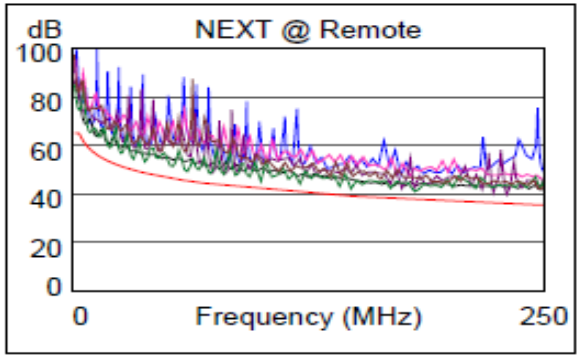


Length (ft), Limit 295	[Pair 45]	67
Prop. Delay (ns), Limit 498		103
Delay Skew (ns), Limit 44		5
Resistance (ohms)	[Pair 12]	3.4
Insertion Loss Margin (dB)	[Pair 12]	22.9
Frequency (MHz)	[Pair 12]	250.0
Limit (dB)	[Pair 12]	31.1

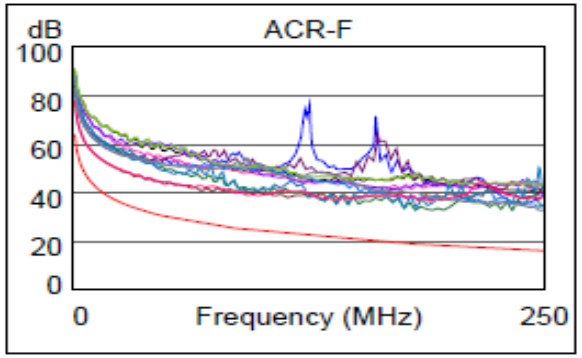


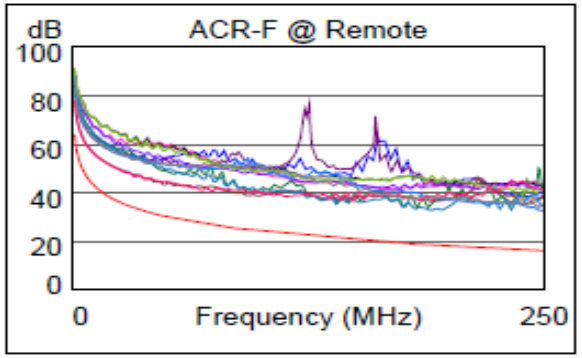
	Worst Case Margin		Worst Case Value	
PASS	MAIN	SR	MAIN	SR
Worst Pair	36-45	36-78	36-45	36-45
NEXT (dB)	6.0	2.6	6.4	3.1
Freq. (MHz)	132.5	148.0	201.5	224.0
Limit (dB)	39.9	39.1	36.9	36.1
Worst Pair	36	36	45	78
PS NEXT (dB)	7.9	2.8	8.5	4.5
Freq. (MHz)	201.5	181.5	250.0	248.0
Limit (dB)	34.3	35.0	32.7	32.8





PASS	MAIN	SR	MAIN	SR
Worst Pair	36-78	78-36	36-45	45-36
ACR-F (dB)	12.8	12.8	13.7	13.8
Freq. (MHz)	32.5	32.5	189.0	189.0
Limit (dB)	34.0	34.0	18.7	18.7
Worst Pair	36	36	45	36
PS ACR-F (dB)	14.5	14.5	17.0	15.2
Freq. (MHz)	6.3	5.9	248.0	189.0
Limit (dB)	45.3	45.8	13.3	15.7






FLUKE networks
FLUKE networks
MS2-POE-KIT

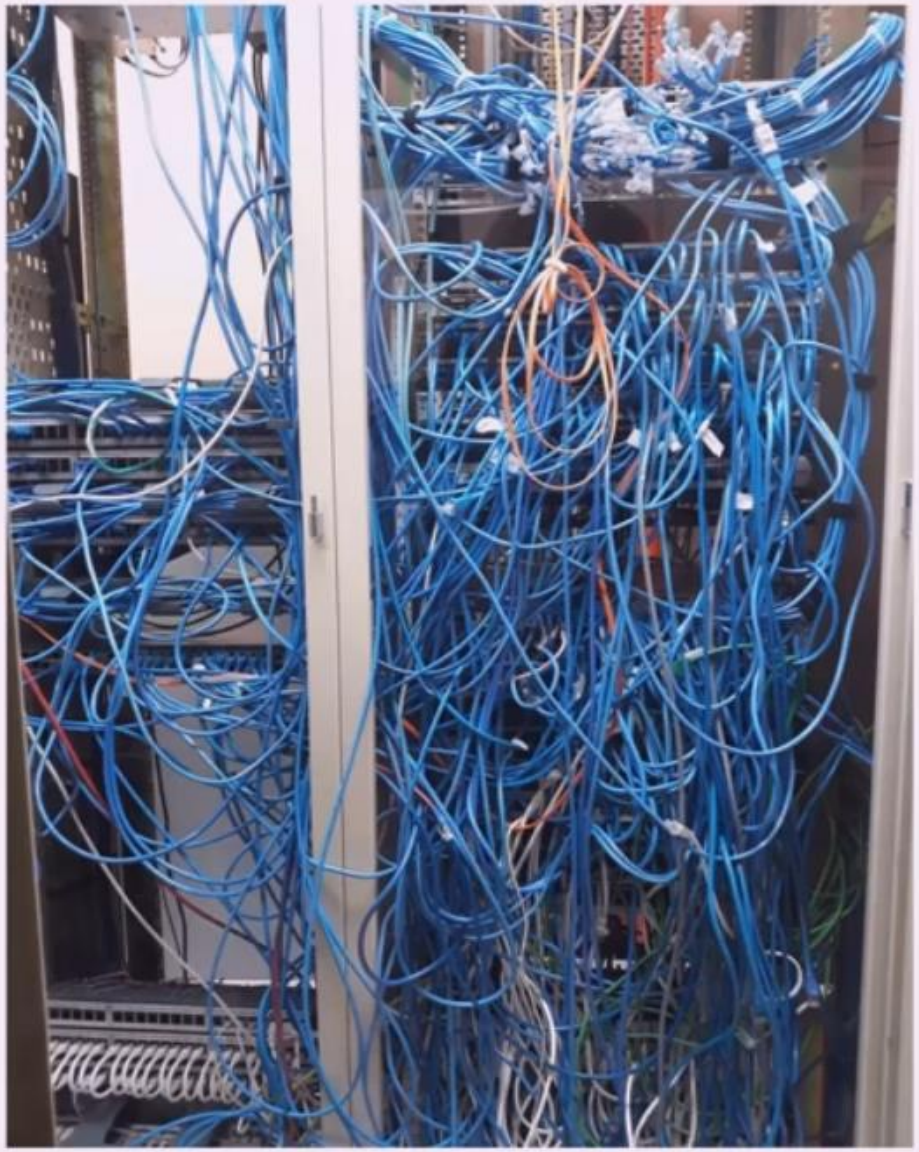
Cable Punch

Crimpers

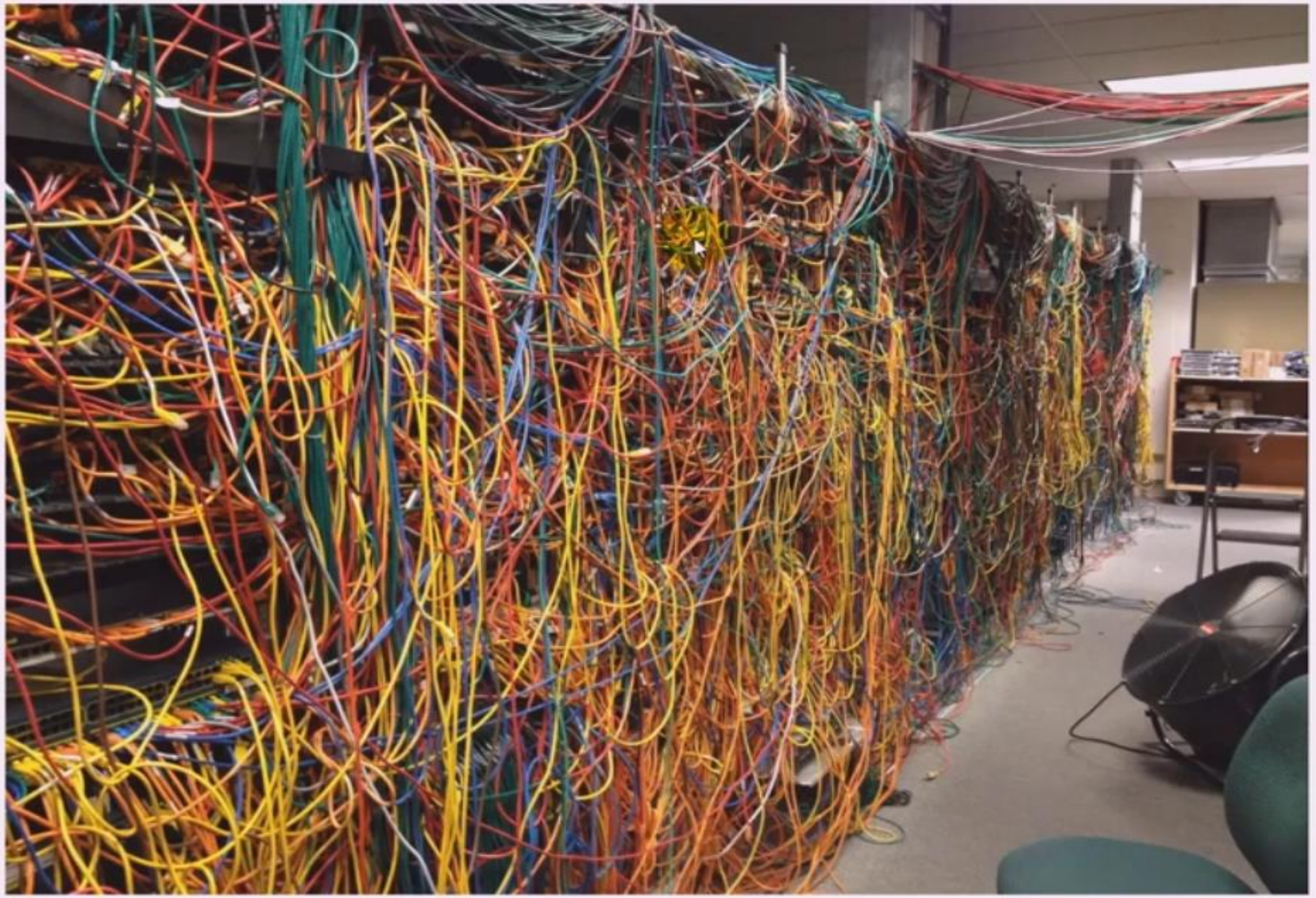
Cable Comb

Label Printer

Telecommunication Closet



Telecommunication Closet



Telecommunication Closet

Horizontal Wiring

Horizontal Wiring