TEL3214
Computer
Communication Networks

Lecture 3

Transmission Media

Jacket – 400 µM Buffer – 250 µM
Cladding – 125 µM
Core – 50/62.5 µM
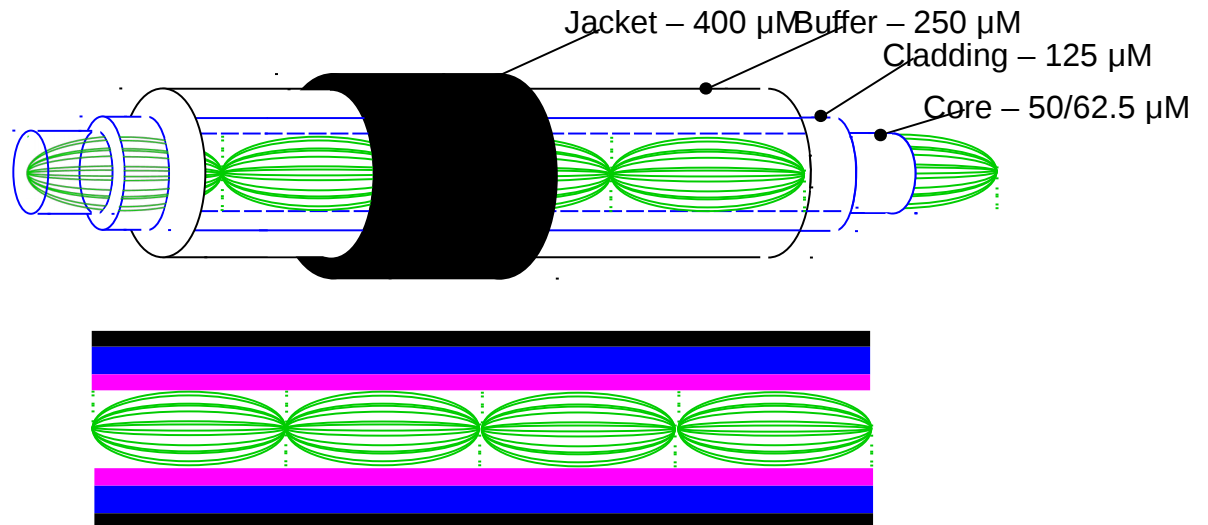
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# Basic transmission medium concepts

- Medium is the physical path between transmitter and receiver in a data transmission system

- Guided Medium
  - Waves are guided along a solid medium path (twisted pair, coaxial cable, and optical fibre).

- Unguided medium
  - Waves are propagated through the atmosphere and inner/outerspace (satellite, laser, and wireless transmissions).

- Conductive
  - Twisted pairs.
  - Coaxial cables.
- Electromagnetic
  - Microwave.
- Light
  - Lasers and optical fibres (need clear line of sight).
- Wireless
  - Inner/outerspace.
 - Satellite.
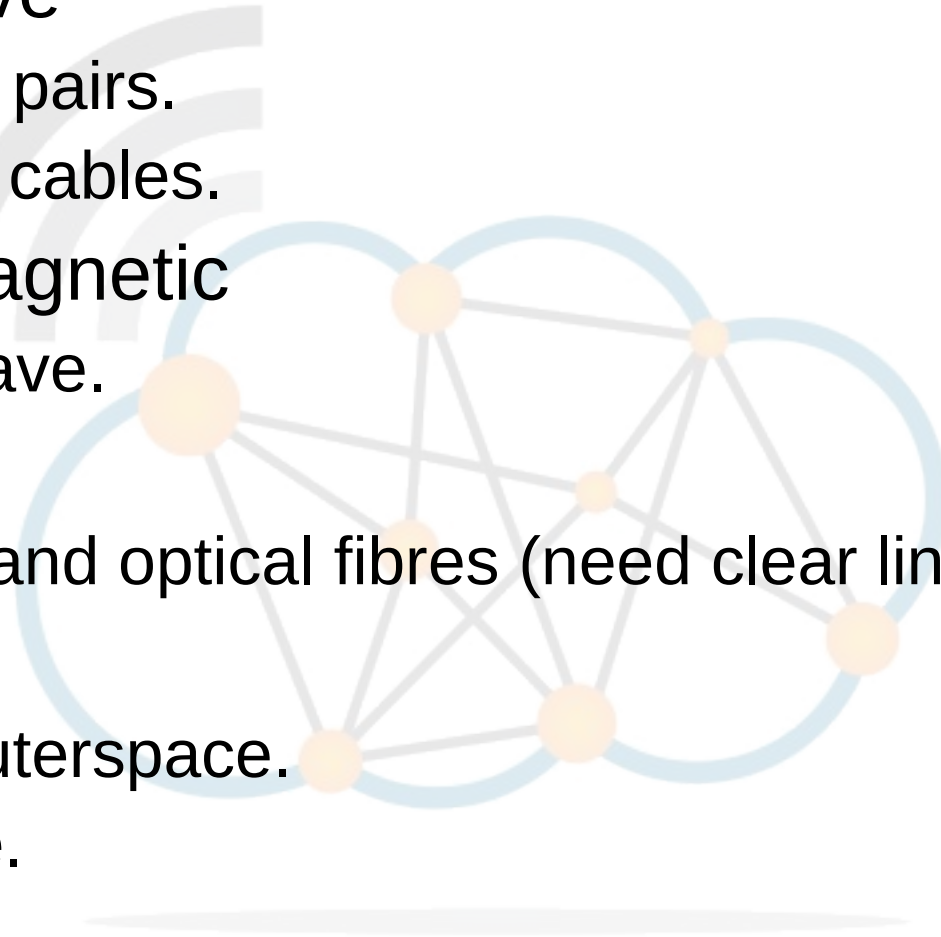
Copper Transmission

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- Widely installed for use in business and corporation Ethernet and other types of LANs in the past.

- Consists of inter copper insulator covered by cladding material, and then covered by an outer jacket.

- Physical Descriptions:

Insulator

Inner conductor

Plastic cover

Outer conductor (Shield)
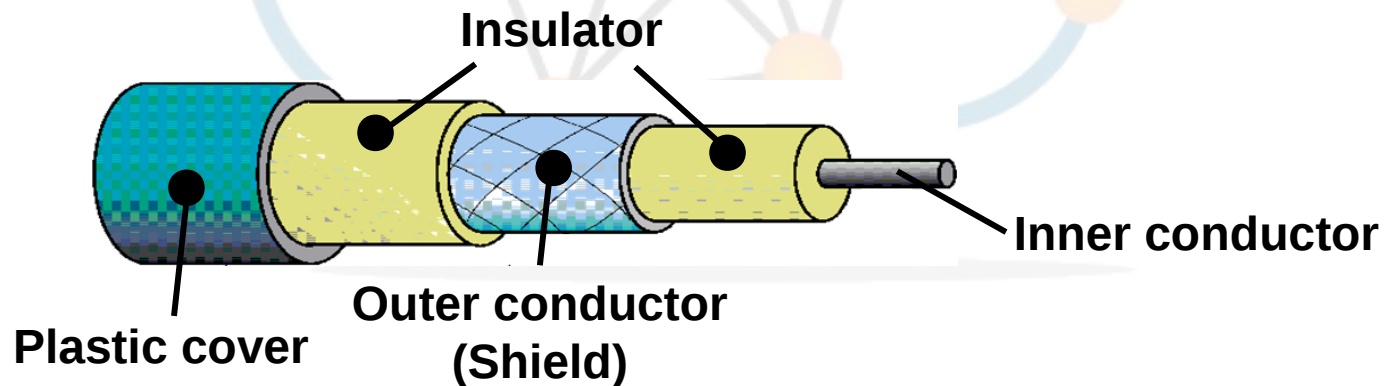
Coaxial cable

- Applications
  - TV distribution (cable tv); long distance telephone transmission; short run computer system links.
  - Local area networks.
- Transmission characteristics
  - Can transmit analogue and digital signals.
  - Usable spectrum for analogue signalling is about 400 MHz.
  - Amplifier needed for analogue signals greater than 1 Km and less distance achievable for higher frequency.
  - Repeater needed for digital signals every Km or less distance achievable for higher data r
  - Operation of 100's Mb/s over 1 Km.
  - ThickNet – 10Base5 – 500M.
  - ThinNet – 10Base2 – 185M (200M).

- RJ11 is a physical interface often used for terminating telephone wires. It is probably the most familiar of the registered jacks, being used for single line POTS telephone jacks in most homes and offices.

- RJ14 is similar, but for a two line telephone jack, and RJ25 is for a three line jack.

Pin	RJ25	RJ14	RJ11	Pair	T/R	±	Colour
1	X			3	T	+	White Green
2	X	X		2	T	+	White Orange
3	X	X	X	1	R	-	Blue White
4	X	X	X	1	T	+	White Blue
5	X	X		2	R	-	Orange White
6	X			3	R	-	Green White

BS6312

- BS6312 is the British Standard governing telephone plugs and sockets.
- There are two types of modern BT plugs — 431A and 631A. 431A is 4-way and 631A 6-way.

BT Socket Wiring		
Pin		**Colour**
1	Leased Line	Green White
2	A wire	Blue White
3	Bell (to 5)	Orange White
4	Earth	White Orange
5	B wire	White Blue
6	Leased Line	White Green
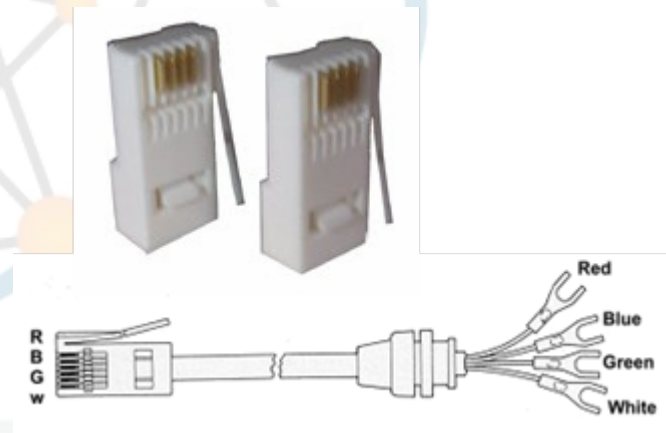
- An 8P8C modular connector has two forms: the male plug and the female jack or socket. Each has eight conductors.

- The 8P8C modular connector is probably most famous for its use in Ethernet as it is nearly universal connector used on Ethernet networks.

Pin	Function		Colour
1	Rx Data+		White Orange
2	Rx Data-		Orange
3	Tx Data+		White Green
4	NC (normally used for telephone		Blue
5	NC (normally used for telephone		White Blue
6	Tx Data-		Green
7	Not Used		White Brown
8	Not Used		Brown

- Physical description
  - Each wire with copper conductor.
  - Separately insulated wires.
  - Twisted together to reduce cross talk.
  - Often bundled into cables of two or four twisted pairs.
  - If enclosed in a sheath then is shielded twisted pair (STP) otherwise often for home usage unshielded twisted pair (UTP) Must be shield from voltage lines.
- Application
  - Common in building for digital signalling used at speed of 10's Mb/s (CAT3) and 100Mb/s (CAT5) over 100s meters.
  - Common for telephone interconnection at home and office buildings.
  - Less expensive medium; limited in distance, bandwidth, and data rate.
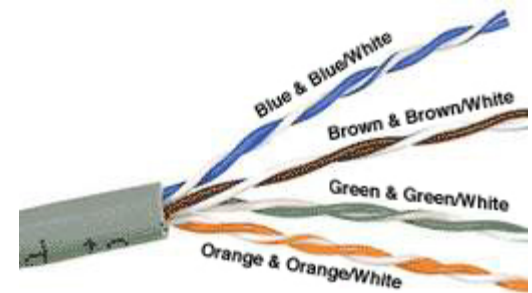
- Cat 5e cable is an enhanced version of Cat 5 that adds specifications for far end crosstalk.

- It was formally defined in 1973 in the TIA/EIA-568-B standard, which no longer recognises the original Cat 5 specification.

- Although 1000BASE-T was designed for use with Cat 5 cable, the tighter specifications associated with Cat 5e cable and connectors make it an excellent choice for use with 1000BASE-T.

- Category 6(CAT6), (ANSI/TIA/EIA-568-B.2-1) is a cable standard for Gigabit Ethernet and other network. protocols that is backward compatible with the Category 5/5e and Category 3 cable standards.

- CAT6 features more stringent specifications for crosstalk and system noise.

- The cable standard is suitable for 10BASE-T / 100BASE-TX and 1000BASE-T (Gigabit Ethernet) and is expected to suit the 10000BASE-T (10Gigabit Ethernet) standards.

- It provides performance of up to 250 MHz.

CAT5e/CAT6 rules

- Maximum segment length is 100 meters.
- One device per segment.
- Segments connect devices to 10BaseT hubs.
- Cable is normally 4 pair, AWG 22, 24, or 26 unshielded twisted pair.
- Connectors are RJ-45 connectors.
- Category 4 or 5 unshielded twisted pair wire can be substituted for best results.
- Wire is normally 4 pair (8 wire) although only 2 pair are used in transmissions.

Categories of Twisted Pairs Cabling System

Category	Maximum data rate	Usual application
CAT 1	Less than 1 Mbps	analog voice (plain old telephone service) 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 (certify 16Mhz signal)**
CAT 4	20 Mbps	Used in 16Mbps Token Ring Otherwise not used much
CAT 5e	**100 Mbps**	**1000BASE-T Gigabit Ethernet** **155 Mbps ATM (100 MHz signal)**
CAT 6	**10 Gbps**	**1000BASE-T Gigabit Ethernet** **10000BASE-T 10 Gigabit Ethernet** **250 MHz**

UTP Pinout
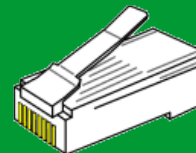
1	White Orange	Rx Data+
2	Orange	Rx Data -
3	White Green	Tx Data +
4	Blue	NC (normally used for Telephone)
5	White Blue	NC (normally used for Telephone)
6	Green	Tx Data –
7	White Brown	Not used
8	Brown	Not Used
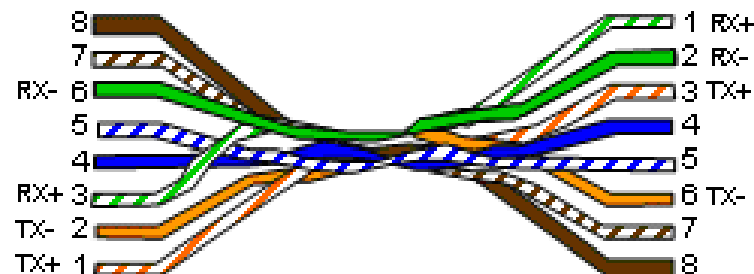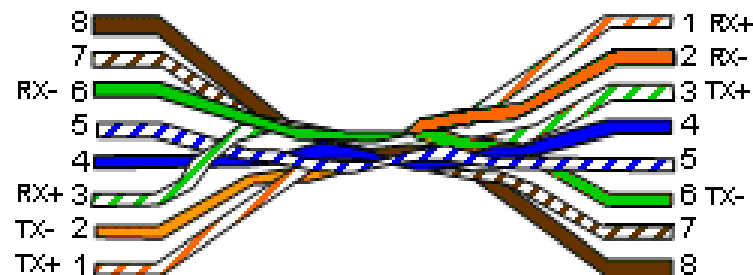
- Straight Through
  - A Straight Through cable is used to connect
    - Connecting hosts to hubs or switches.
    - Connecting routers to hubs or switches.

- Crossover
  - A Crossover cable is used to connect
    - Uplinks between switches.
    - Connecting hubs to switches.
    - Connecting hubs to hubs.
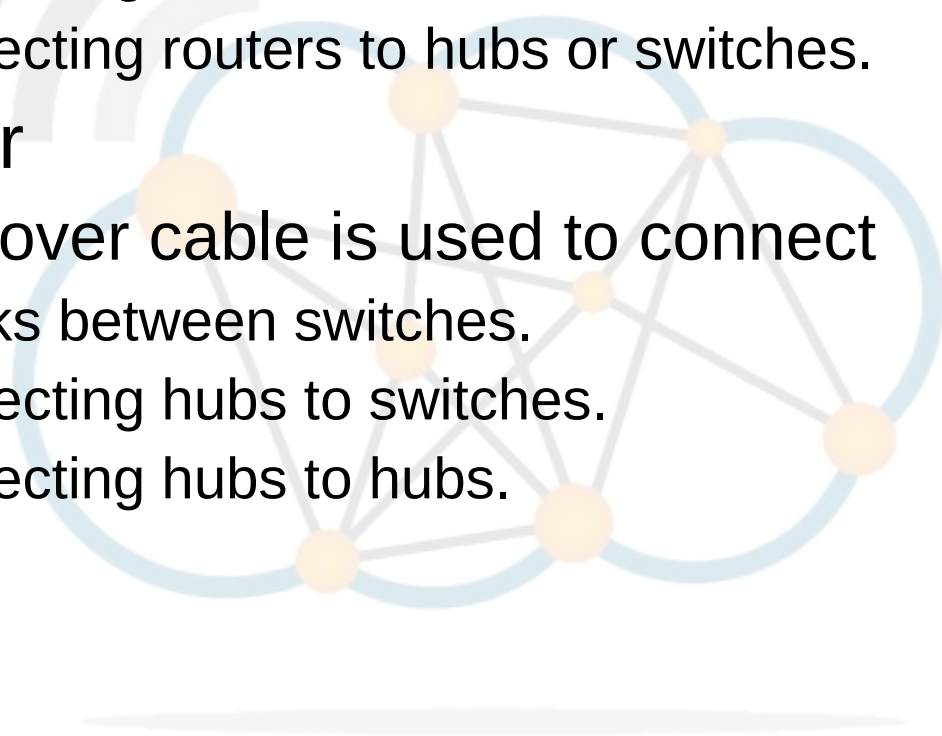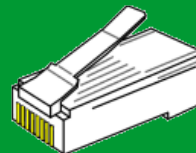
- UTP Patch Leads tested using a MOD-TAP type tester .
- 3-in-1 tester to check USOC, 568A and 568B cables although for most tests the 568B is used.
- Continuously-sequencing LED display provides instant identification of most wiring problems including shorts, opens, reversals and miswires.
- Operates on included 9V battery and features an auto-off to extend battery life.
- The two units conveniently snap together protecting the jacks.

Labwork

UTP Patch Lead Building and Testing

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- RJ48 is used for E1/T1 and ISDN termination and local area data channels/subrate digital services.
- RJ48C is commonly used for E1/T1 lines and uses pins 1, 2, 4 and 5.
- RJ48X is a variation of RJ48C.
- RJ48S is typically used for local area data channels/subrate digital services.
- RJ48 connectors are fastened to STP.

Pin	RJ48C and RJ48X Wiring		RJ48S Wiring	
	Pair	Signal	Pair	Signal
1	R	receive ring from network	R1	transmit ring to network
2	T	receive tip from network	T1	transmit tip to network
3		reserved		(not used)
4	R1	transmit ring to network		(not used)
5	T1	transmit tip to network		(not used)
6		reserved		(not used)
7		shield	T	receive tip from network
8		shield	R	receive ring from network

- The principle of this method of wire termination is that the wire to be terminated is placed in the slot of a forked tag, pressure is applied by a spring-loaded impact tool to force the wire into the tag slot.

- At the end of the insertion stroke the surplus wire is cut off close to the tag.

- The insulation is displaced where the wire passes through the tag and the resultant contact between wire and tag makes a sound electrical and mechanical joint.

- Modern multicore cables usually consist of bare copper conductor, solid 0.5, 0.6 and 0.8 mm.
- They consist of a Polyvinyl chloride (PVC) core insulation with an insulation wall-thickness of 0.2 mm and 0.4 mm.
- The cores are twisted to pairs and pairs stranded in layers with optimal lay-length and then the Core is wrapped with plastic tape.
- This is surrounded with electrostatic screen (St) of plastic coated aluminium foil with drain wire and all is covered with a PVC outer sheath.
- The PVC self-extinguishing and flame resistant.

Multicore Cable

Outdoor

0.5mm tinned annealed copper conductors, PVC insulation, aluminium-polyethylene moisture barrier taped, LSZH sheathed.

Indoor

Internal Unscreened PVC 1/0.5mm tinned annealed copper conductors, PVC insulation/polyester taped/PVC sheathed.

- ***W**hy **R**un **B**ackwards, **Y**ou'll **V**omit*
- ***BOGBR**u**S**h*
- ***B**ell **O**perators **G**ive **B**etter **S**ervice*

	Primary	Secondary
1	White (WH)	Blue (BL)
2	Red (RD)	Orange (OR)
3	Black (BK)	Green (GN)
4	Yellow (YW)	Brown (BN)
5	Violet (VT)	Slate (Grey) (SL)

Labwork

UTP Patch Lead Building and Testing

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Lab

- Build the following network using TIA/EIA 568-B standards and test all connections.

LAN Sockets

Fibre Transmission

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- An optical fibre a small narrow tube plastic or glass which guides light along its length by total internal reflection.
- Optical fibres are widely used in communication particularly in high speed trunks, though nowadays they have found their way down to user PC levels as the bandwidth demands of the modern network user increases.
- They permit digital data transmission over longer distances and at higher data rates than other forms of electronic communication.

- Fibre optic systems transmit using infrared light, invisible to the human eye, because it goes further in the optical fibre at those wavelengths.

Wavelength (nanometers)

850   1300   1550

UV   Visible   Infrared
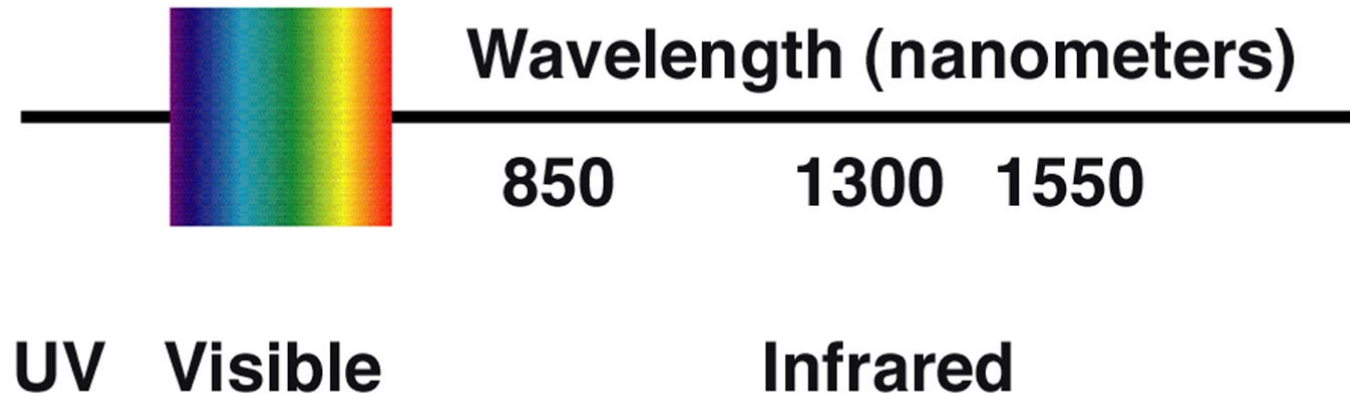
fibre Optic Data Links

- **Transmitter**
  - Takes electrical input and converts it into and optical output
    - Laser diode or LED.
- **Receiver**
  - Detector converts light back into an electrical signal and conditioned for receiving equipment.

Transmitter

Signal Conditioning

LED or laser

Receiver

Signal Conditioning

Photo-diode

FO Cable Plant

Jacket – 400 µM   Buffer – 250 µM

Cladding – 125 µM

Core – 50/62.5 µM
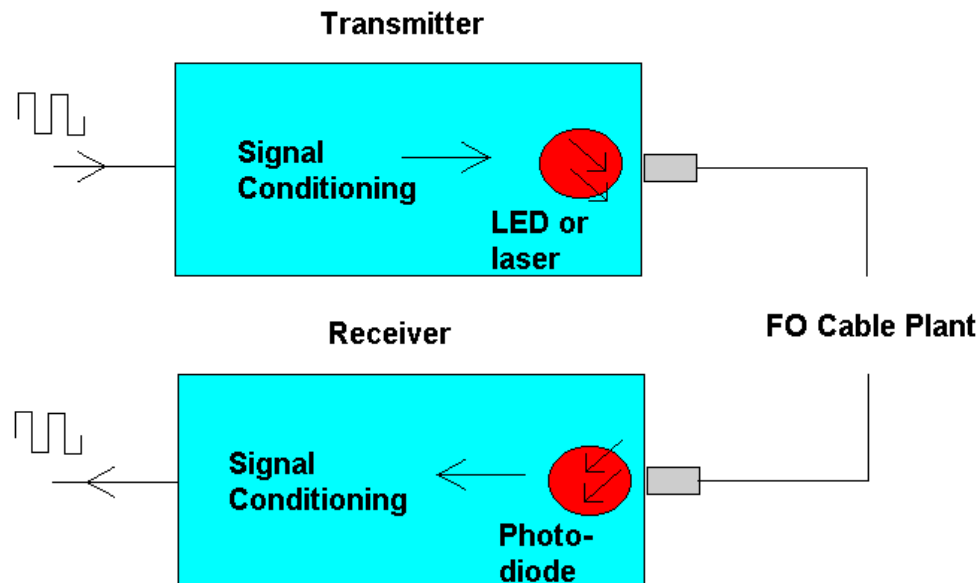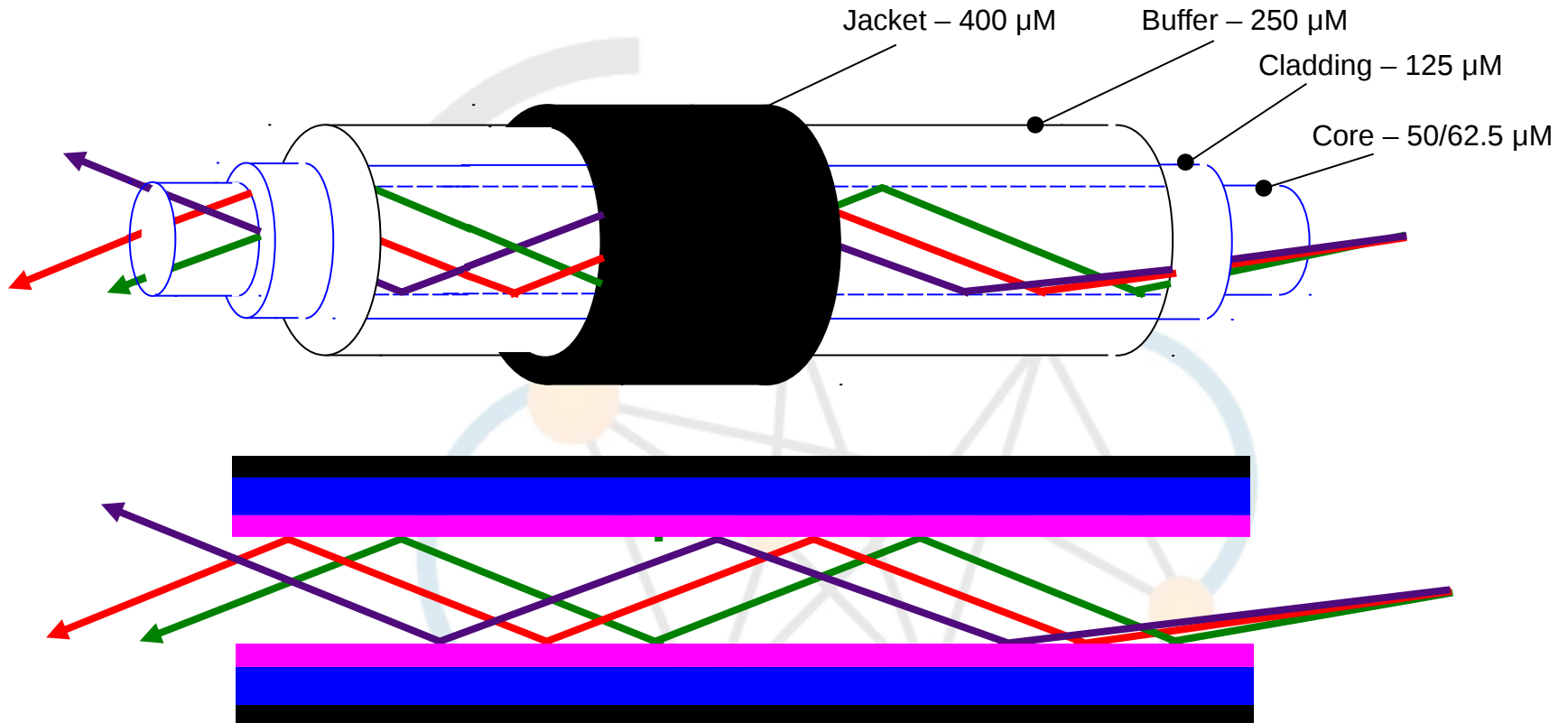
- First fibre design but is too slow for most uses, due to the dispersion caused by the different path lengths of the various modes.
- Step index fibre is rare today except in Plastic Optical Fibre (POF).

Graded Index multimode Fibre

Jacket – 400 μM

Buffer – 250 μM

Cladding – 125 μM

Core – 50/62.5 μM
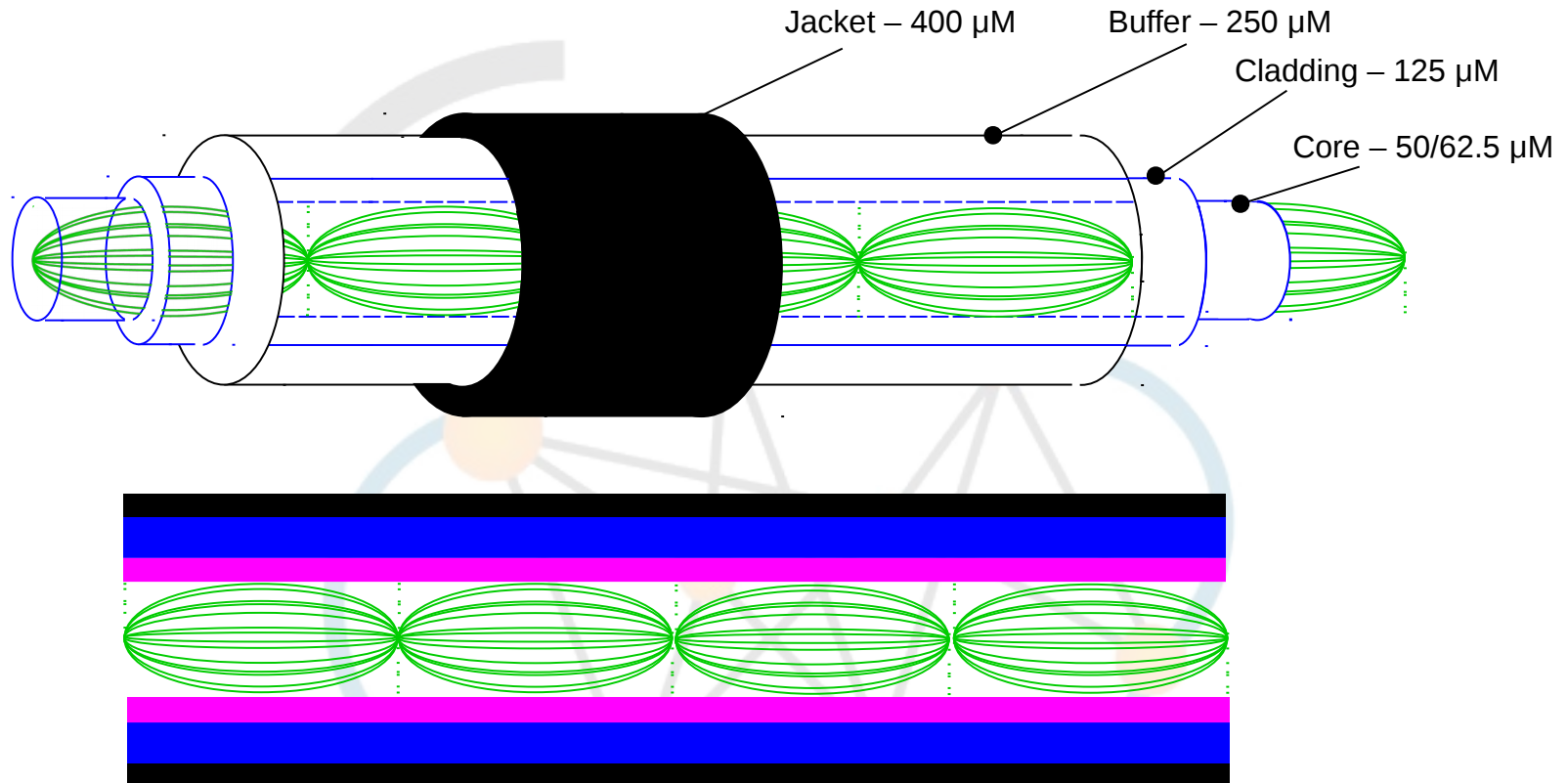
- Uses variations in the composition of the glass in the core to compensate for the different path lengths of the modes.
- It offers hundreds of times more bandwidth than step index fibre - up to about 2 GHz .

Jacket – 400 µM   Buffer – 250 µM

Cladding – 125 µM

Core – 8 µM
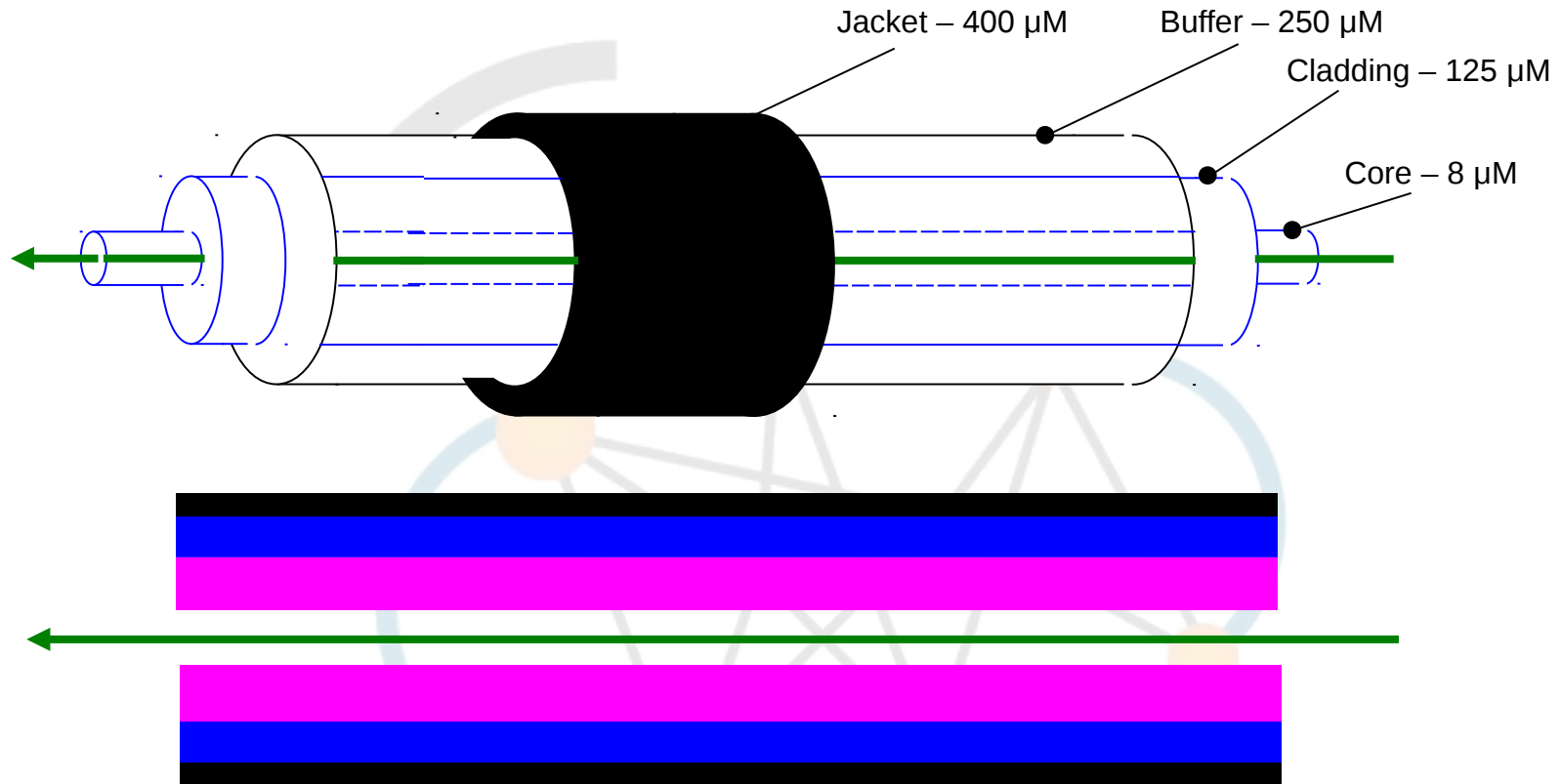
- Very narrow core so light can only travel in a single ray.
- This increases the bandwidth to almost infinity - but it's practically limited to about 100,000 THz (terahertz) 10^{14}.

Fibre Types and Specifications

Core/Cladding	Attenuation	Bandwidth	Wavelength	Applications/Notes
Multimode Graded-Index				
	850/1300 nm	850/1300 nm	850/1300 nm	
50/125 µM	3/1 dB/km	500/500 MHz-km	850/1300 nm	Laser-rated for GbE LANs
50/125 µM	3/1 dB/km	2000/500 MHz-km	850/1300 nm	Optimized for 850 nm - VCSELs
62.5/125 µM	3/1 dB/km	160/500 MHz-km	850/1300 nm	Most common LAN fibre - LEDs
Multimode Step-Index				
200/240 µM	4-6 dB/km	50 MHz-km	850 nm	Slow LANs & links
Singlemode				
8-9/125 µM	0.4/0.25 dB/km	~100 Terahertz	1310/1550 nm	Carrier /CATV/Core LANs
Plastic Optical Fibre (POF)				
1mm	~ 1 dB/m	~5MHz-km	650 nm	Very short links

Fibre Types and Specifications

Core/Cladding	Attenuation	Bandwidth	Wavelength	Applications/Notes
Multimode Graded-Index				
	850/1300 nm	850/1300 nm	850/1300 nm	
50/125 μM	3/1 dB/km	500/500 MHz-km	850/1300 nm	Laser-rated for GbE LANs
50/125 μM	3/1 dB/km	2000/500 MHz-km	850/1300 nm	Optimized for 850 nm - VCSELs
62.5/125 μM	3/1 dB/km	160/500 MHz-km	850/1300 nm	Most common LAN fibre - LEDs
Multimode Step-Index				
200/240 μM	4-6 dB/km	50 MHz-km	850 nm	Slow LANs & links
Singlemode				
8-9/125 μM	0.4/0.25 dB/km	~100 Terahertz	1310/1550 nm	Carrier /CATV/Core LANs
Plastic Optical Fibre (POF)				
1mm	~ 1 dB/m	~5MHz-km	650 nm	Very short links

- Optical fibre connector constitutes a fibre-to-fibre interconnection and aligns the fibre core of two optical fibres.
- Standard connectors are:
  - Lucent Connector/ Local Connector (LC).
  - Ferrule Connector (FC).
  - Subscriber Connector (SC).
  - Straight Tip (ST).
- In general the insertion loss should not exceed 0.75 dB and the return should not be higher than -20 dB.
- Typical insertion repeatability, the difference in insertion loss between one plugging and another, is 0.2 dB.

LC   SC   ST

Fibre Colour Coding

Color coding of Premise Fibre Cable		
Fibre Type / Class	Diameter (µm)	Jacket Colour
Multimode 1a	50/125	Orange
Multimode 1a	62.5/125	Slate
Multimode 1a	85/125	Blue
Multimode 1a	100/140	Green
Singlemode IVa	All	Yellow
Singlemode IVb	All	Red

Fibre bundle Colour Coding

| EIA598 Fibre Colour Chart				
1	Blue	13	Blue	Black Tracer
2	Orange	14	Orange	Black Tracer
3	Green	15	Green	Black Tracer
4	Brown	16	Brown	Black Tracer
5	Slate	17	Slate	Black Tracer
6	White	18	White	Black Tracer
7	Red	19	Red	Black Tracer
8	Black	20	Black	Black Tracer
9	Yellow	21	Yellow	Black Tracer
10	Violet	22	Violet	Black Tracer
11	Rose	23	Rose	Black Tracer
12	Aqua	24	Aqua	Black Tracer

- Alignment devices.
- Hold the two fibre ends in a precisely aligned position thus enabling light to pass from one fibre into the other.
- Typical loss: 0.3 dB.
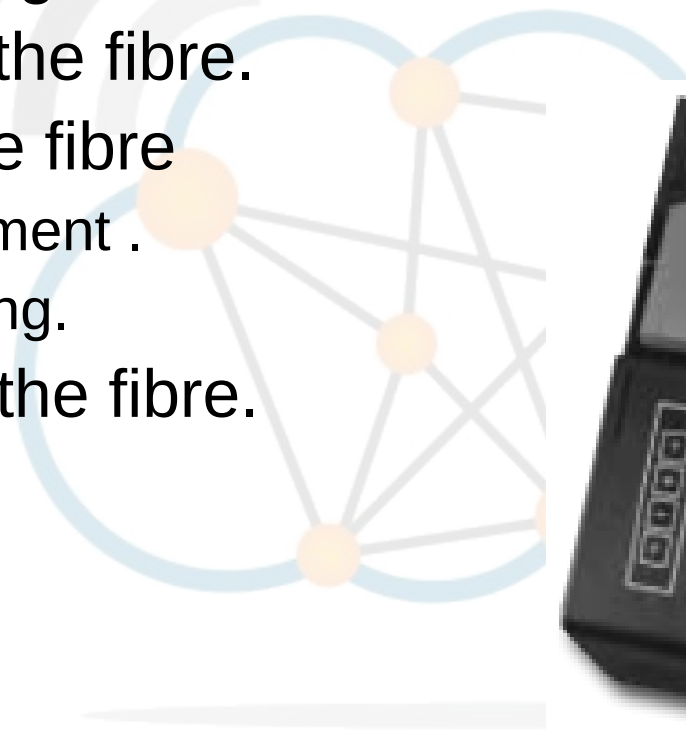
Fibre ——————————————— Fibre

Alignment Sleeve

- Machine precisely aligns the two fibre ends then the glass ends are "fused" or "welded" by an electric arc Continuous connection between the fibres enabling very low loss light transmission.

- Typical loss: 0.1 dB.

Fibre ———————————— Fibre

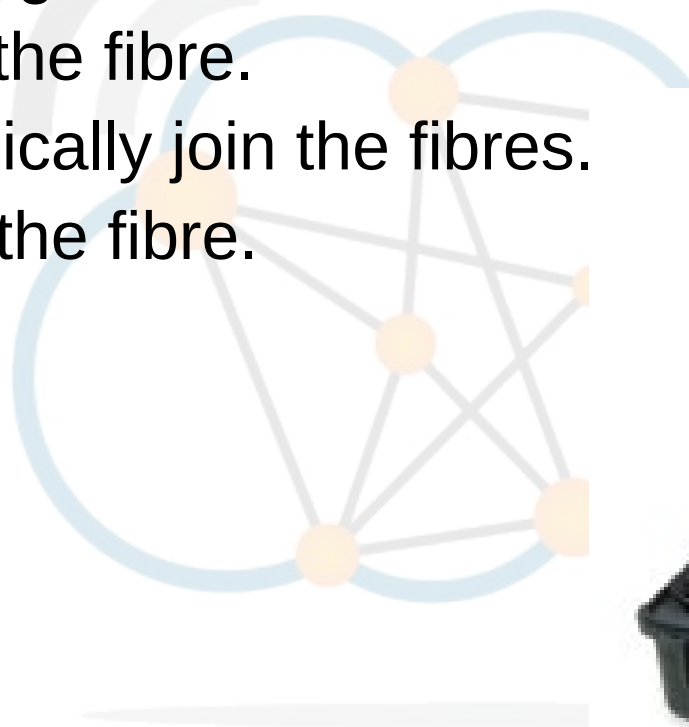Fusion Splice from electrical arc
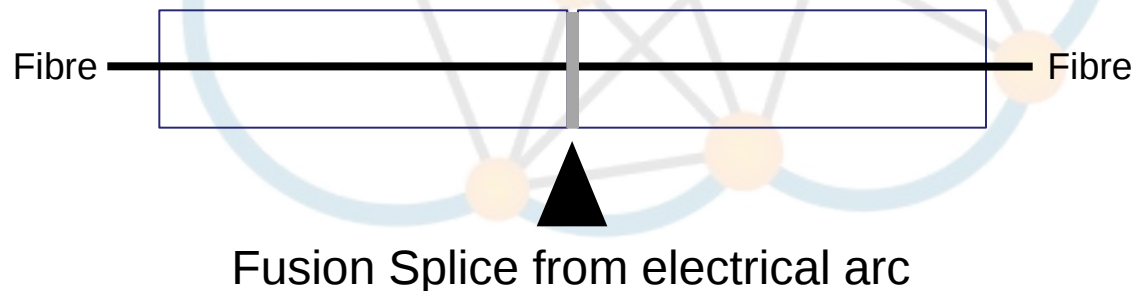
- Four basic steps to completing a proper fusion splice:
  - Preparing the fibre.
  - Cleave the fibre.
  - Fuse the fibre
    - Alignment .
    - Heating.
  - Protect the fibre.

- Four basic steps to completing a proper mechanical splice:
  - Preparing the fibre.
  - Cleave the fibre.
  - Mechanically join the fibres.
  - Protect the fibre.

- Visual Fault Locator (VFL)
  - Universal optical connector style with a 2.5mm ferrule.
  - 650nm laser providing visibility to 5 Km.

- X.21 is a digital signaling interface recommended by ITU-T that includes specifications for DTE/DCE.
  - Physical interface elements.
  - Alignment of call control characters.
  - Error checking.
  - elements of the call control phase for circuit switching services.
- Data trar

- V.35 is an ITU-T physical layer standard.
- Max speed is 2 Mbit/s.
- V.11 specifies the physical and electrical characteristics.
  - standard for balanced electrical circuits for data communication at up to 10 Mbit/s.
  - Used with the 37-pin ISO 4902 connector, it is compatible with EIA RS-422.

- RJ-21 a modular connector using 50 conductors, usually used to implement a 25-line (or less) telephone connection.

- Also known as a 50-pin telco connector, Champ or Amphenol connector.

- Dual RJ-21 connectors are often used on punch blocks to make a breakout box for PBX and other key telephone systems.

- The same connector is used for SCSI-1 connections.

- E.164 is an ITU-T recommendation which defines the international public telecommunication numbering plan used in the PSTN and some other data networks.
- It also defines the format of telephone numbers:
  - E.164 numbers can have a maximum of 15 digits and are usually written with a + prefix.
  - To actually dial such numbers from a normal fixed line phone the appropriate international call prefix must be used.
- The title of the original and revision 1 was "Numbering Plan for the ISDN era".

Labwork

Demonstration of Fibre splicing and termination

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Thank you

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