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מצגות לימודיות להוראת מיקרו-מעבדים, אסמבלר, תקשורת, מערכות הפעלה.



**שאל קובל**




**חיות - סוגי חוטים**




**Wiring Cabling**

יום חמישי 25 מאי 2006

1  
saul@covul.net



## על פי תוכנית לימודים של משרד החינוך:



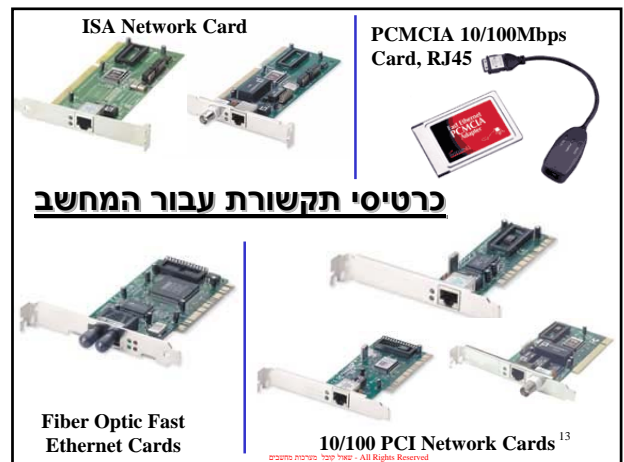
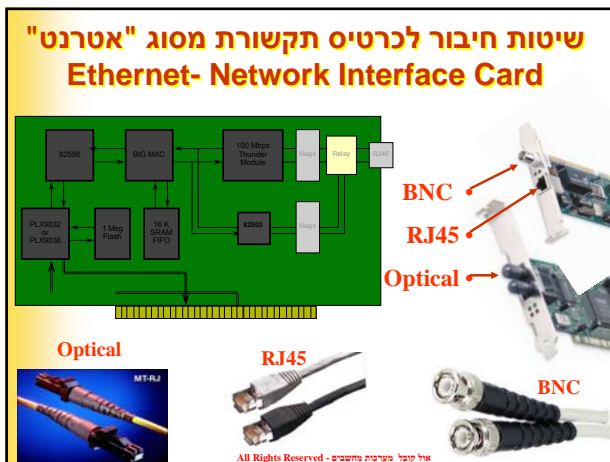
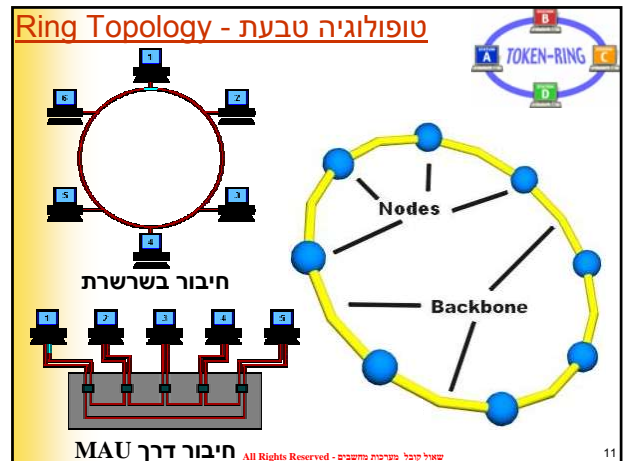
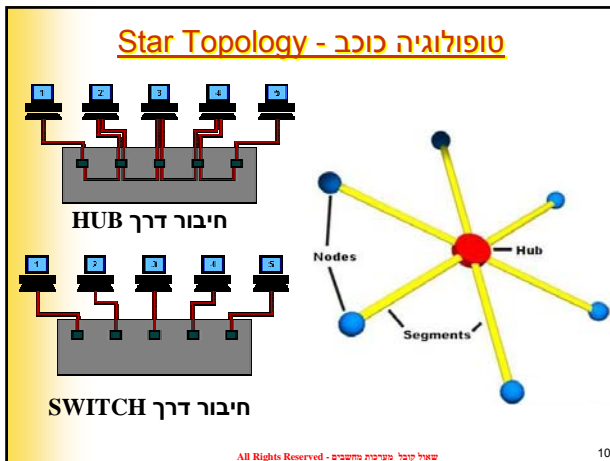
### סוגי תווכים פסיים נפוצים

- אופו חיבור מחשבים לרשת, מרחק קצב שידור, איתור תקלות
- כבל קוואקסיאלי דק / עבה
- מחברי BNC כבל דק
- TRANSIVER , TRANSIVER CABEL כבל עבה
- איתור תקלות
- זוג שזור, מסוכך – תיאור, מפרט טכני
- זוג שזור לא מסוכך
- כבל סיב אופטי
- הכנת כבלים
- הכרת כלים – לוחץ מחברים (RJ4), סכין חיתוך, מברג פיליפס
- מגלה חוטים, לוחץ קרנוה
- הכנת כבלי גישור עם מחברי RJ45
- חיבור כבלים בין נקודה בקרי ל-PATCH PANEL
- צידוד בדיקה – בודק כבלים

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[naali@conal.net](mailto:naali@conal.net)  
<http://www.conal.net>

# תזכורת בנושאי טופולוגיות חיבורי מחשבים



## כלי עבודה בחיווט - Cable Tools



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### Modular Crimp Tool

- For RJ11, RJ12 and RJ45
- Made of hardened carbon steel
- Cuts, strips and crimps



### Modular RJ45 Crimp toll

Modular Crimping tool for cutting, stripping and crimping



### Terminal Block Impact Tool

Metal Impact tool for 110/88 and 66 Terminal Blocks and Keystone Jacks with adjustable impact pressure control.



### Crimp Tool for Shielded RJ45 Plugs

This tool was designed for professional crimping of screened plugs RJ45 (8P8C) Hirose type of Cat. 5 and for crimping the strain relief



### Disposable Impact Tools

Disposable Impact Tool for 110 Terminal Blocks incl. cable stripper (UTP) יום חמישי 25 מאי 2006



Disposable Impact Tool for 110 Terminal Blocks and Keystone Jacks (UTP)



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## סוגי חיווט לתקשורת - Types of Media

Coaxial



Fiber-optic



Twisted Pair has 4 or 8 wires arranged in a spiral pattern

Unshielded Twisted Pair



Fiber optic cable is not susceptible to electromagnetic interference.

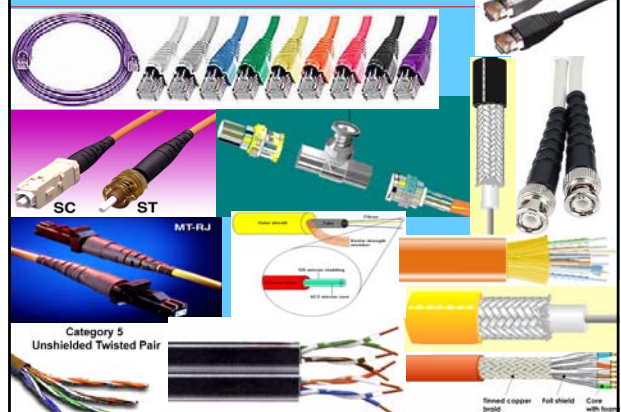
Various types of network media.

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## סוגי חוטים ומחברים



## כלי בדיקה של החיווט



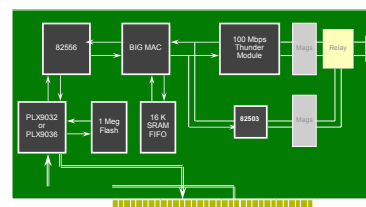
בודק תקינות החוטים  
Cable Tester



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## שיטות חיבור לכרטיס תקשורת מסוג "אתרנט" Ethernet- Network Interface Card



BNC

RJ45

Optical

Optical



RJ45



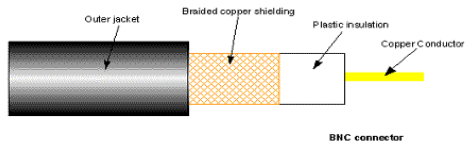
BNC



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## חוט קואקסיאלי

### Coaxial Cable



Speed and throughput: 10 - 100Mbps  
 Average \$ per node: Inexpensive  
 Media and connector size: Medium  
 Maximum cable length: 500 m (medium)



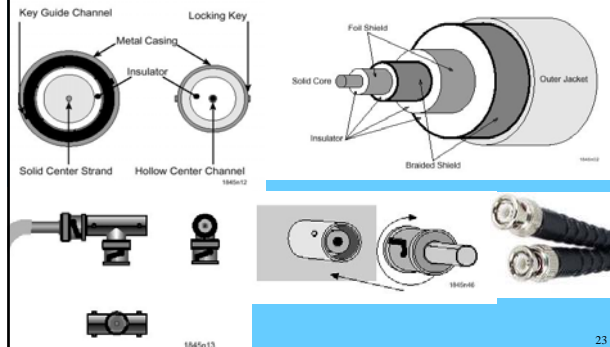
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## חיבור BNC

### חוט קואקסיאלי - Coaxial Cable



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## חוט קואקסיאלי - Coaxial Cable

### יתרונות - Advantages

- קל להתקנה - Simple to install
- תחום תדרים גבוה - Higher bandwidths
- מעט הפרעות כולל סיכור - Resists interference better than UTP
- זול מסיבים אופטיים - Cheaper than fibre optic

### חסרונות - Disadvantages

- הנחתה גבוהה (נמוכה מסוג TP) - Moderately high attenuation (lower than TP)
- יקר יחסית - More expensive than TP
- דורש יותר מקום בתעלות חיווט.
- אימפדנס ב-LAN: 50 Ω (ב-CATV: 75 Ω)
- מהירות שידור: 10-100 Mbps

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## חוט קואקסיאלי - Coaxial Cable

### Thinnert (RG-58U)

- 10Base2
- חיבורים וקצבות - BNC Connector & terminators
- מקסימום צמתים: 30
- אורך מקסימאלי: 550m
- Thicknet (RG-8)
- 10Base5
- Vampire Tap
- מקסימום צמתים: 100
- אורך מקסימאלי: 1500m

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## חוט קואקסיאלי - Coaxial Cable

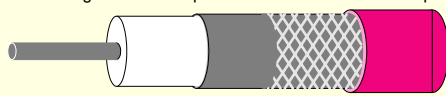
- מורכב מצינור מוביל חיצוני וחלול שמקיף מוביל פנימי ויחיד מנחושת וסביבו בידוד ורשת סיכור. הבידוד יכול להיות אוויר, פלסטי או קרמיקה.

### תכונות חשמליות - Characteristics

- Bandwidth of about 400 MHz
- less susceptible to interference
- lower attenuation than twisted pair

### שימושים - Applications

- CATV
- Long-distance telephone and Short distance computer links
- LANS



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## סוגי חוט קואקסיאלי

### Coaxial Cable Types

- Rigid or air coaxial line
- Flexible or solid coaxial line
- Electrical configuration of both is the same

### Rigid Coaxial Cable

- Consists of a wire mounted inside of and coaxially with a rigid tubular outer conductor. (wire within a tube)
- The inner conductor is insulated from the outer conductor by insulating spacers or beads, at regular intervals.
- The spacers are made of Pyrex or polystyrene, located at regular intervals

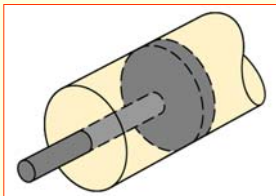
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## יתרונות - Advantages

- Chief advantage of this line is its ability to minimize the radiation losses
- The electric and magnetic fields do not extend outward from the outer conductor
- The fields are confined to the space between the two conductors
- Noise pick up is also prevented



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## חסרונות - Disadvantages

- Expensive to construct
- Must be kept dry to prevent excessive leakage between the two conductors, although leakage can be reduced by backfilling the cable with inert gas
- Excessive high frequency losses limit the length of line used

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## Flexible Coaxial Cable

- The inner conductor consists of flexible wire insulated from the outer conductor by a solid continuous insulating material
- Flexibility may be gained if the outer conductor is made of braided wire
- Polyethylene plastic as well as Teflon, is used to separate the two conductors.
- The use of the plastic for insulation results in greater losses than for the air dielectric but cuts down on losses due to moisture
- These losses are much less than for other dielectrics.

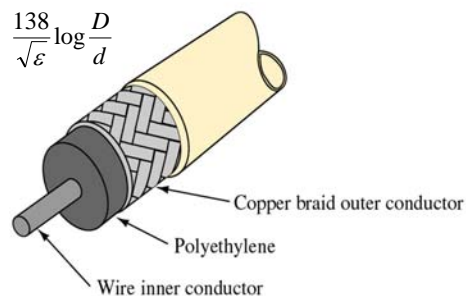
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## Characteristic Impedance of Coax

$$Z_0 = \frac{138}{\sqrt{\epsilon}} \log \frac{D}{d}$$

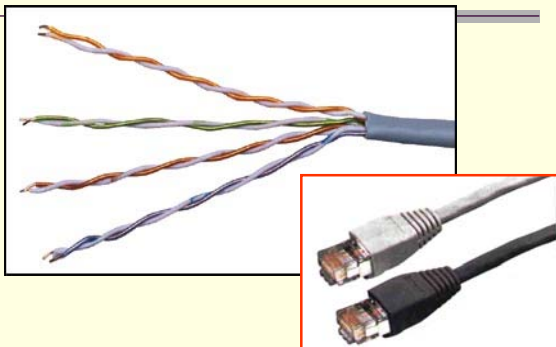


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## דוג חוטים - Twisted Cable



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## Unbalanced Line—Coaxial

- The electrical signal is carried by the center conductor with respect to the shield or grounded outer conductor

### Balanced Line—two wire

- The same current flows in each wire but 180° out of phase with that flowing in the center conductor
- Another way to look at it: the currents in the two wires of a balanced line are equal, but flowing in opposite directions.

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## Common Mode Rejection (CMR)

- Measures the ability of a balanced line to reject signals flowing in the same direction in both conductors.
- Any noise or unwanted signal picked up by the balanced line is picked up by both conductors, thus the noise is effectively canceled out
- Practical CMMRs are from 40 to 70dB

## Baluns

- Circuits that convert unbalanced to balanced lines
- Typically center tapped transformers
- Sections of transmission line may also be used

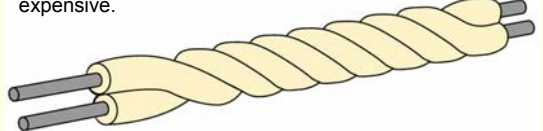
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## What is Twisted Pair?

- Two insulated wires twisted to form a flexible line without the use of spacers.
- It is not used for high frequencies because of the high losses that occur in the insulation
- Wet lines increase losses dramatically
- It has 6 to 12 twists per inch.
- Tighter twisting provides better performance but is more expensive.



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## Categories

- |         |         |                   |
|---------|---------|-------------------|
| ■ CAT 3 | Class C | Telephone lines   |
| ■ CAT5  | Class D | Computer networks |
| ■ CAT5e |         | Computer networks |
| ■ CAT6  | Class E | up to 250MHz      |
| ■ CAT7  | Class F | up to 600MHz      |

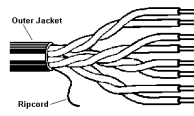
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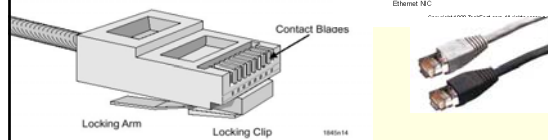
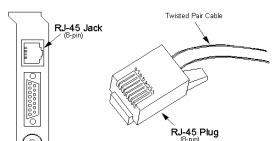
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## חיבור RJ45 Twisted Cable - זוג חוטים

### UTP Cable (4-pair)



### RJ-45 Connectors



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## זוג חוטים שזורים - Twisted pair cable



- חוטי נחושת, מוליך ברמה גבוהה  
Copper wires good conductors
- זוג חוטים שזורים ללא סיכוך

### UTP – Unshielded Twisted Pair

- סטים של זוגות חוטים עם בידוד פשוט מפלסטי
- Sets of twisted pairs with simple plastic encasement as insulation
- מחבר מסוג RJ45 - RJ45 Connector

### זוג חוטים שזורים עם סיכוך - STP – Shielded Twisted Pair

- חוט מבודד - Insulated cable
- לזוגות חוטים עם סיכוך
- Bundled pairs wrapped in foil shielding -

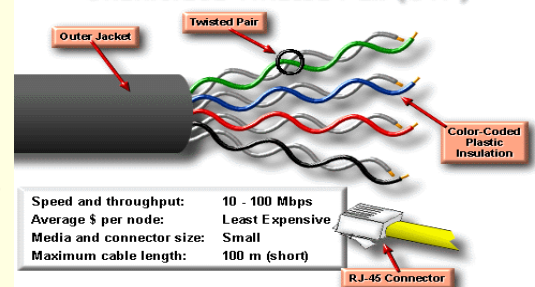
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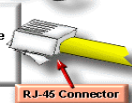
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## זוג חוטים שזורים ללא סיכוך Unshielded Twister Pair

### Unshielded Twisted Pair (UTP)



Speed and throughput: 10 - 100 Mbps  
Average \$ per node: Least Expensive  
Media and connector size: Small  
Maximum cable length: 100 m (short)



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## UTP

### IEEE Standards:

- 10BaseT
- 100BaseT
- 1000BaseT

### Advantages:

- Thin, flexible, easy to install
- Doesn't crowd wiring ducts as much as coax
- cheap

### Disadvantages:

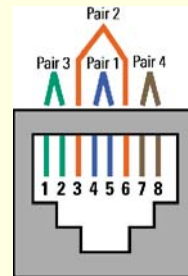
- More susceptible to interference than most other types of cabling
- Limited to segments of 100 meters.

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## UTP (Unshielded Twisted Pair)



- 4 זוגות חוטים (full-duplex).
- זוגות שזורות מורידות ה- crosstalk.
- יותר סיבובים – יותר התנגדות לרעש.
- יותר סיבובים – יותר הנחתה.
- 10BaseT or 100BaseT.
- Max nodes: 1024
- Length: 100m
- אורך מקסימלי של סגמנטים:
- 5 for 10BaseT
- 3 for 100BaseT
- RJ45 Connector

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## UTP (Unshielded Twisted Pair)

הפרוטוקול TIA/EIA 568 מגדיר קטגוריות ה-UTP.

- קטגוריה 5 (Cat 5) ממשיך להיות הנפוץ ביותר.
- קטגוריה 6 היא כוללת יותר סיכון ומוגנת נגד אש.
- מגדילה המוליכות \* 6.
- לקטגוריה 7 - מחבר שונה ומאפשר 1Gbps.

חוטנים פלסטיות צבעוניים לצורך זיהוי

זוג שזור

ציפוי חיצוני

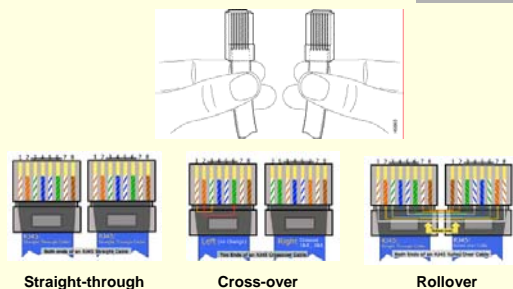
חיבור RJ45

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## Unshielded Twisted Pair (UTP)



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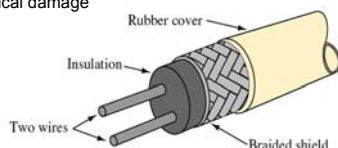
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## Shielded Pair

### What is Shielded Pair?

- Consists of parallel conductors separated from each other and surrounded by a solid dielectric.
- Conductors are contained within a copper braid tubing that acts like a shield
- Assembly is covered by a rubber coating for protection from elements and mechanical damage



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## Shielded Pair

- Principal advantage is the the conductors are balanced to ground
  - The capacitance between the cables is uniform through out the line
  - Copper braid shield isolates the conductors from external noise and prevents the signal on the shielded pair cable from radiating to and interfering with other systems
- Twisted pairs of copper wire are sorrounded with metallic braid or sheathing.
- Characteristic impedance is 150 Ohms.

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## Shielded Twisted-Pair

Similar to UTP, but has shielding

Speed and throughput:	10 - 100 Mbps
Average \$ per node:	Moderately Expensive
Media and connector size:	Medium to Large
Maximum cable length:	100 m (short)

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## Shielded Twisted-Pair STP

### Advantages:

- Greater protection than UTP from interference. due to sheathing
- At lower data rates STP provides better performance than UTP.
- It creates less electrical noise.

### Disadvantages:

- More expensive than UTP
- Heavier and less flexible than UTP
- May not fit down narrow cabling ducts

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## (Shielded Twisted Pair) STP

זוג שזור עם סיכוך.

תוספת הסיכוך מאפשרת:

- פחות רעש.
- יותר מוליכות.
- אורך הסגמנטים יותר גדול.
- תוספת במחיר.

חוטאים פלסטיים צבעוניים לציור זיהוי

STP חיבור

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## FTP o ScTP (Foil Twisted Pair o Screened Twisted Pair)

זוג שזור

סיכוך כולל

ציפוי חיצוני

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ScTP חיבור

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## חוט מומלץ עבור קטגוריה 7 (STP: Shielded Twisted Pair)

STP, 4 pair, 100 Ohm Impedance, typically 23 AWG (0.57 mmØ) bare copper

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## התחברות לשקע - 10BaseT Pinout

הערה: היציאות TX ו-RX חייבים להיות הפוכים בצד מכשיר התקשורת (Hub-Router).

מחבר מסוג RJ45 Connector

Note that TX and RX are going to be reversed on the hub side, Thus when connecting hub to hub, the need for MDI/MDIX. MDIX looks for a NIC, MDI looks for a repeater port

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## Basic Cable Construction Steps

- Acquire 3 pcs. Cat 3 or 5 cable approx. 6 ft. long.
- Acquire 6 RJ45 connectors.
- Follow the diagrams provided for each cable type.
- Strip off approx. 3/4" of the outside insulation. (Be careful not to cut too deep)
- Arrange the wires in their proper order.
- Trim the ends of the wires to insure that they are even.
- Insert the ordered wires into the connector making sure there is one wire per slot and that they are as deep into the connector as possible.
- Place the connector with the wire in it into the crimping tool and crimp firmly.
- Repeat the process for the other end according to each wire's diagram.
- Test the wire with the Fluke Cable Tester.
- If it passes, move on to the next cable.
- When finished clean up your mess and put away the tools.
- Label each cable with its type and your name.
- Turn in for grading.



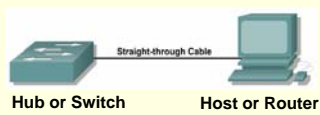
RJ-45

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## לאורך כל הכבל UTP Straight-through Cable



Hub or Switch

Host or Router

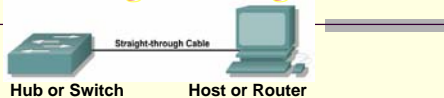


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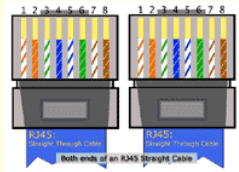
## לאורך כל הכבל UTP Straight-through Cable



Hub or Switch

Host or Router

Pin 1	-----	Pin 1
Pin 2	-----	Pin 2
Pin 3	-----	Pin 3
Pin 4	-----	Pin 4
Pin 5	-----	Pin 5
Pin 6	-----	Pin 6
Pin 7	-----	Pin 7
Pin 8	-----	Pin 8



Both ends of an RJ45 Straight Cable.

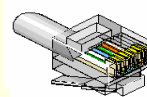
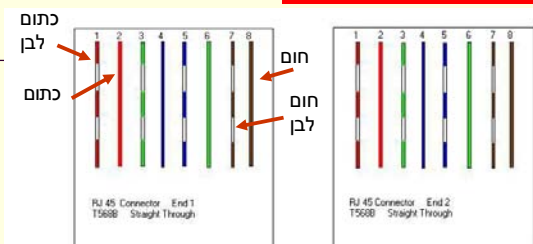
- The cable that connects from the switch port to the computer NIC port is called a straight-through cable.
- Connects unlike devices.

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## חיבור מחבר RJ45



RJ-45

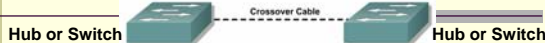
Straight Through Cable  
לאורך כל הכבל

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## UTP Cross-over Cable חוט מוצלב

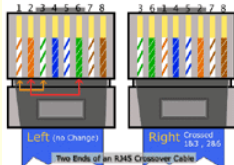


Hub or Switch

Hub or Switch

An Ethernet (10BASE-T and 100BASE-TX) cross-connect cable has only four active wires 1, 2, 3, and 6

Pin 1	-----	Pin 3
Pin 2	-----	Pin 6
Pin 3	-----	Pin 1
Pin 4	-----	Pin 4
Pin 5	-----	Pin 5
Pin 6	-----	Pin 2
Pin 7	-----	Pin 7
Pin 8	-----	Pin 8



Two Ends of an RJ45 Crossover Cable

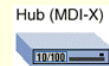
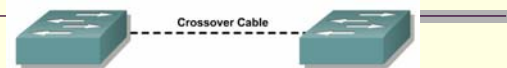
- The cable that connects from one switch port to another switch port is called a crossover cable.
- Connects like devices.

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## חוט מוצלב UTP Cross-over Cable



Hub (MDI-X)



Switch (MDI-X)

1 (RX+)	-----	1 (RX+)
2 (RX-)	-----	2 (RX-)
3 (TX+)	-----	3 (TX+)
6 (TX-)	-----	6 (TX-)
4 Not used	-----	4 Not used
5 Not used	-----	5 Not used
7 Not used	-----	7 Not used
8 Not used	-----	8 Not used

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## חיבור מחבר RJ45

RJ45 Connector End 1  
T568B Cross Connect

RJ45 Connector End 2  
T568B Cross Connect

**חוט מוצלב**

**Cross Connect Cable**

**CROSS OVER**

For DCE connection to DCE

RJ-45  
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**דבר נוספת:**

1-3

2-6

3-1

6-2

## חיבור מחבר RJ45 חוט מעריך

RJ45 Connector End 1  
T568B Rollover Cable

RJ45 Connector End 2  
T568B Rollover Cable

**חוט מעריך**

**Rollover Cable**

For CONSOLE connection to PC

RJ-45  
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## קטגוריות של חוטים

### UTP - Category 1

- Voice-grade, UTP telephone cable. This describes the cable that has been used for years in telephone communications. Officially, such cable is not considered suitable for data-grade transmissions (in which every bit must get across correctly)

### UTP - Category 2

- Data-grade UTP, capable of supporting transmission rates of up to 4 Mbps
- 22 or 24 AWG Solid Wire

### UTP - Category 3

- Data-grade UTP, capable of supporting transmission rates of up to 10 Mbps
- 24 AWG Solid Wire
- Most Common UTP Wire
- A 10BaseT network requires such cable
- impedance is 100 Ohms.

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### UTP - Category 4

- Data-grade UTP, capable of supporting transmission rates of up to 16 Mbps.
- Same Design as Cat 3
- A 16 Mbps IBM Token Ring network requires such cable

### UTP - Category 5

- Data-grade UTP, capable of supporting transmission rates of up to 155 Mbps (but officially only up to 100 Mbps at 90 meters).
- The CDDI (Copper Distributed Data Interface) networks and 100Base-X network architecture require such cable.
- 22 or 24 AWG with RJ45 Connector
- Characteristic impedance is 100 Ohms.
- Cat5 is recommended, for data since it can support higher bandwidths.

### UTP - Category 5e

- Newer standard
- Used to support Gigabit Ethernet over UTP wire out to 100 meters, similar to the limits on 100BaseTx

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## קטגוריות של חוטים

### Category 6 and 7

Protocols are in the proposal stage

- Testing to higher levels of performance
  - Must support 100 MHz for Cat5
  - Cat 6 and 7, they are looking at 350 – 1500 MHz

יש הברים נוספים בהמשך ....

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## קטגוריות של החוטים השזורים

קטגוריה	סיבובים/מ"מ	Frec. Máx. (MHz)	מקסימום נתונים (Mb/s)
1	0	לא מוגדר	ללא שימוש
2	0	1	4 (זוגות 2)
3	10-16	16	100 (2 זוגות)
4	16-26	20	100 (2 זוגות)
5	26-33	100	1000 (4 זוגות)
5e		100	1000 (4 זוגות)
6		250	4000
7		600	10000?

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## חטי נחושת קטגוריה 6

### הגדרות חדשות

## Category 6 Copper Cables Last Stand



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### FAQ

Q: What is the difference between Cat3, Cat5, Cat5e, Cat6, etc.?

A: This is actually a somewhat complex question to answer as it involves a number of technical details. The most basic answer is that each Category of cable is supposed to meet (or exceed) a specific set of standards, the most significant of which, is the ability to pass all signals up to a particular carrier frequency (or signaling rate). Additional standards have to be met include values for attenuation, near end cross talk (NEXT), ACR, etc.

Below is a table of the types of Category Cable we install. The table shows the Maximum Carrier Frequencies required by the EIA/TIA 568 Standards for each category of cable and the Maximum Frequencies the manufacturer actually tests the cable to.

Category	Typical Applications	Frequency Required	Tested to	EIA/TIA Ratified Standard?
Cat 3	Voice	16 MHz	16 MHz	Yes
Cat 5	Voice, Data (10/100 Mbps Ethernet)	100 MHz	100 MHz	Yes
Cat 5e	Voice, Data (10/100 Mbps/ Gigabit Ethernet)	100 MHz	200 MHz	Yes
Cat 5 ENH <sup>1</sup>	Voice, Data (10/100 Mbps/ Gigabit Ethernet)	*	350 MHz	See note 1.
Cat 6 <sup>2</sup>	Voice, Data (10/100 Mbps/ Gigabit Ethernet)	200(250?) MHz	500 MHz	Draft

<sup>1</sup> Cat 5 ENH is another version of Cat 5e offered by the manufacturer we use that further exceeds the Cat 5e EIA/TIA Standard.

<sup>2</sup> The Cat 6 Standard has not yet been officially ratified by the EIA/TIA so the specs used by the manufacturer to claim the cable is Cat 6 are based on the current draft of the Standard.

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## WARNING

Cabling installation is not for the untrained

CAT6 cabling systems are CRAFT INTENSIVE

Extreme care must be used when installing or servicing CAT6 cable systems

MARCS = Moves, Adds, Removals, & Changes demand the same level of care

Our surveys indicate this is a universal rule for all (Vendors) CAT6 cabling systems

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## Why do I need all the bandwidth of category 6?

As far as I know, there is no application today that requires 200 MHz of bandwidth.

Bandwidth precedes data rates just as highways come before traffic.

Doubling the bandwidth is like adding twice the number of lanes on a highway.

The trends of the past and the predictions for the future indicate that data rates have been doubling every 18 months.

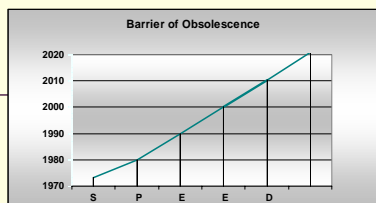
With additional throughput requirements right around the corner, it makes sense to plan ahead.

*Note: Bandwidth is defined as the highest frequency up to which positive power sum ACR (attenuation-to-crosstalk ratio) is greater than zero.*

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The barrier of obsolescence is the point where the functionality of copper based communications cabling can no longer deliver the required speeds of the network.

For many years the communications industry has "guessed" at the maximum effective speed of copper (UTP) cabling. Today many experts are in agreement that the need for speed is approaching copper's max. We must begin to look at hybrid designs that incorporate new technologies mixed with the traditional copper UTP.

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## Network Cable

- Category 5 Cable (UTP)** (Unshielded Twisted Pair) A multipair (usually 4 pair) high performance cable that consists of twisted pair conductors, used mainly for data transmission. Note: The twisting of the pairs gives the cable a certain amount of immunity from the infiltration of unwanted interference. category-5 UTP cabling systems are by far, the most common (compared to SCTP) in the United States. Basic cat 5 cable was designed for characteristics of up to 100 MHz. Category 5 cable is typically used for Ethernet networks running at 10 or 100 Mbps.
- Category 5 E Cable** (enhanced) Same as Category 5, except that it is made to somewhat more stringent standards (see comparison chart below). The Category 5 E standard is now officially part of the 568A standard. Category 5 E is recommended for all new installations, and was designed for transmission speeds of up to 1 gigabit per second (Gigabit Ethernet).
- Category 6 Cable** Same as Category 5 E, except that it is made to a higher standard (see comparison chart on next slide). The Category 6 standard is now officially part of the 568A standard.

**Category 7** Same as Category 6, except that it is made to a higher standard (see comparison chart below). The Category 7 standard is still in the works (as of this writing) and is not yet part of the 568A standard. One major difference with category 7's construction (as compared with category 5, 5 E, and 6) is that all 4 pairs are individually shielded, and an overall shield encraps all four pairs. Category 7 will use an entirely new connector (other than the familiar RJ-45).

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If we use a Cat 5e RJ45 connector and connect it to a Cat 6 UTP cable, will the installation be Cat5e or Cat 6?

By definition (of the standard), it will be a Cat 5e channel. The actual performance will probably be somewhat better, but nowhere near Cat 6 requirements. Of course, you can set up a channel using any components and measure it using a Cat 6 (level III) compliant tester, and if it passes, it is Cat 6 performance compliant. It would not be standards compliant however, because the components have requirements in and of themselves to assure interoperability with other Cat 6 components.

Category 6 cabling recognizes advances in cabling technology and is designed to be backward compatible with Categories 3, 5 and 5e. This ensures that any applications that operate on lower category cabling will be fully supported by Category 6 cabling. When different category components are mixed with Category 6 components, the resultant cabling will satisfy the category transmission requirements of the lower performing component.

<http://pulse.baseline.org/article.cfm?id=849>

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Is there a limitation on the size of bundles one can have with category 6? Can you have 200-300 and still pass category 6?

**MAYBE NOT!**

There is no limit imposed by the standards on the maximum number of Category 6 cables in a bundle. This is a matter for the market and the industry to determine based on practical considerations. It should be pointed out that after six or eight cables, the performance in any cable will not change significantly since the cables will be too far away to add any additional external (or alien) NEXT.

**What is the shortest link that the standard will allow?**

There is no short length limit. The standard is intended to work for all lengths up to 100 meters. There is a guideline in ANSI/TIA/EIA-568-B.1 that says the consolidation point should be located at least 15 meters away from the telecommunications room to reduce the effect of connectors in close proximity. This recommendation is based upon worst-case performance calculations for short links with four mated connections in the channel.

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Are the connectors for category 5e and category 6 different? Why are they more expensive?

Although Category 6 and Category 5e connectors may look alike, Category 6 connectors have much better transmission performance. For example, at 100 MHz, NEXT of a Category 5e connector is 43 decibels (dB), while NEXT of a Category 6 connector is 54 dB. This means that a Category 6 connector couples about 1/12 of the power that a Category 5e connector couples from one pair to another pair. Conversely, one can say that a Category 6 connector is 12 times less "noisy" compared to a Category 5e connector. This vast improvement in performance was achieved with new technology, new processes, better materials and significant R&D resources, leading to higher costs for manufacturers.

**Will contractors be able to make their own patch cords?**

Category 6 patch cords are precision products, just like the cables and the connectors. They are best manufactured and tested in a controlled environment to ensure consistent, reliable performance. This will ensure interoperability and backward compatibility. All this supports patch cords as a factory-assembled product rather than a field-assembled product.

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**Why wouldn't I skip category 6 and go straight to optical fiber?**

You can certainly do that, but you will find that a fiber system is still very expensive.

Ultimately, economics drive customer decisions, and today optical fiber together with optical transceivers is about twice as expensive as an equivalent system built using Category 6 and associated copper electronics.

Installation of copper cabling is more craft-friendly and can be accomplished with simple tools and techniques. Additionally, copper cabling supports the data terminal equipment (DTE) power standard developed by IEEE (802.3af).

PCs ship with copper network interfaces included, in fact, recent announcements indicate that the major PC vendors are shipping 10/100/1000 with all new systems. Moving to fiber would mean buying a fiber-based network card to replace equipment already included in the PC.

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**When should I recommend or install category 6 vs. category 5e?**

From a future proofing perspective, it is always better to install the best cabling available. This is because it is so difficult to replace cabling inside walls, in ducts under floors and other difficult places to access.

The rationale is that cabling will last at least 10 years and will support at least four to five generations of equipment during that time.

If future equipment running at much higher data rates requires better cabling, it will be very expensive to pull out Category 5e cabling at a later time to install Category 6 cabling. So why not do it for a premium of about 20 percent over Category 5e on an installed basis?

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**Which standard addresses the combination of electrical cable and Cat 6 regarding performance or sensitivity?**

I'm an ICT Consultant for a university and in process of designing the infrastructure for them. They are using Cat 6 cable as horizontal cabling and fiber optic as backbone.

We are facing a problem with M & E consultant on the trunking design.

They are proposing the use of a 4-way service box which contains cables for electrical and Cat 6. We cannot find in the standard about the combination of electrical cable and Cat 6 cabling either of performance or sensitivity.

TIA/EIA-569 "Commercial Building Standard for Telecommunications Pathways and Spaces" includes all necessary provisions for service boxes and enclosures.

There are no special considerations associated with Cat 6 cabling.

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## TESTING

### Copper verification: it pays

For datacom installers, copper verification has become part of daily testing for good reason: it pays to verify before you certify. For network owners and installers who are constantly swapping cubes and stations and making other infrastructure changes, Fluke Networks provides the troubleshooting tools to master cabling installation and subsequent adds, moves and changes. Our tools are ideal for verifying Cat 5, 5e, 6, twisted pair, coaxial cabling and security wiring, covering a broad range of physical media that is typically installed in commercial and residential buildings.

Total integration. Total control. Total Network SuperVision™. That's Fluke Networks' promise to you. New! 2003 Network SuperVision Solutions Catalog for the Copper and Fiber Cabling Infrastructure-- take a look at the most comprehensive line of premises network testing solutions (1.6MB)

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## List of cables and street prices as of 3/9/2004

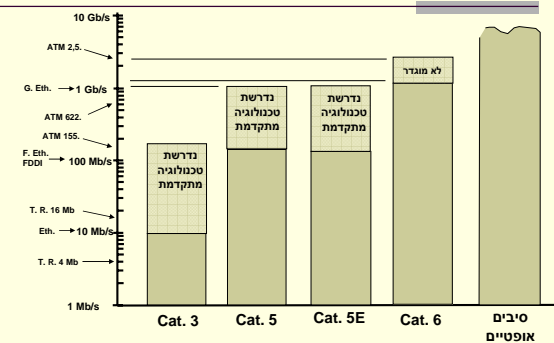
Cat 5e Non Plenum	\$66.00
Cat 6 Non Plenum	\$98.50
6 Strand Multi-Mode Fiber Non Plenum	\$460.00
6 strand Single-Mode Fiber Non Plenum	\$220.00
Cat 5e Plenum	\$194.00
Cat 6 Plenum	\$332.00
6 Strand Multi-Mode Fiber Plenum	\$490.00
6 Strand Single-Mode Fiber Plenum	\$240.00
Cat 5e Limited Combustible-CMP	\$ no price available*
Cat 6 Limited Combustible-CMP	\$445.00*
*Passes UL/NFPA 262 & 255 - all FEP construction	
Limited Combustible Cable - <b>NOT IN STOCK</b>	

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## שימוש של החומים הסטנדרטיים



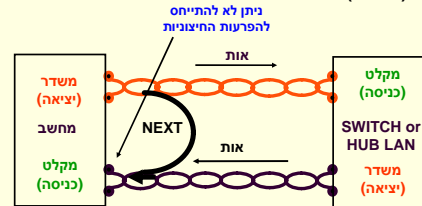
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## היחס בין אות לרעש

אות קבלה = אות המשרדר לאחר הנחתה  
רעש = NEXT (במיוחד)



שידור של אות בחיבור רשת מקומית המבוססת בחומים שזורים

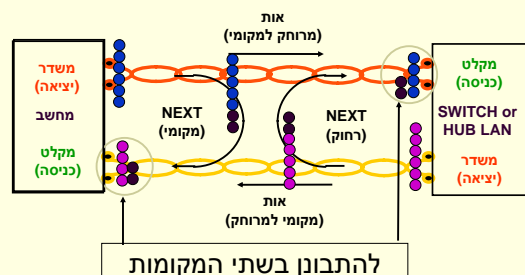
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## תופעת ה-NEXT

יש צורך של אות חזקה יותר (אלקטרונים כחולים וסגולים)  
מאותות ה-NEXT (אלקטרונים אפורים/שחורים)

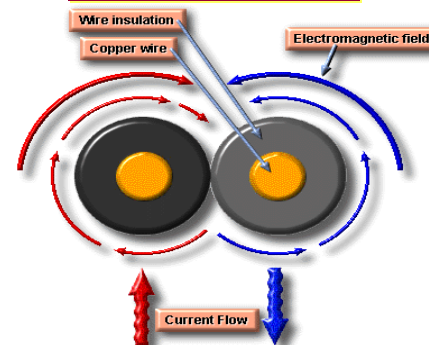


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## Cross - Talk



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## Crosstalk

**האות החשמלית המשודרת על ידי חלק אחד, מעביר בהשראה זרמים בזוגות שכנים**

**האות המושרה (induced) בחושים שכנים מתפזר בכל הכיוונים**

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## Near end Crosstalk (NEXT)

**ה-NEXT מייצר האות עם השראות (induction) שחוזרת וניקלצת בצד המשדר.**

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## Far end crosstalk (FEXT)

**ה-FEXT מייצר האות עם השראות (induction) ונקלצת בצד המקלט. היא יותר חלשה מ-NEXT.**

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## דרך מדידה

### Near end Crosstalk (NEXT) Far end crosstalk (FEXT)

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## UTP Implementation

EIA/TIA specifies an RJ-45 connector for UTP cable.

The letters RJ stand for registered jack and the number 45 refers to a specific wiring sequence.

The RJ-45 transparent end connector shows eight colored wires.

Four of the wires, T1 through T4, carry the voltage and are called tip.

The other four wires, R1 through R4, are grounded and are called ring.

The RJ-45 connector is the male component, which is crimped on the end of the cable.

When a male connector is viewed from the front, the pin locations are numbered from 8 on the left to 1 on the right.

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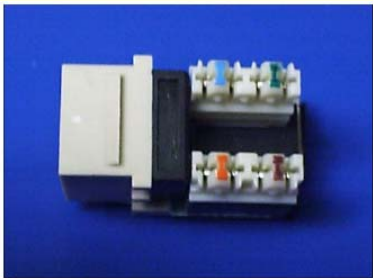
## UTP Implementation

The jack is the female component in a network device, wall outlet, or patch panel.

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## UTP Implementation

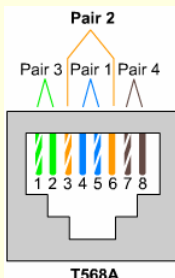
The punch-down connections at the back of the jack are where the Ethernet UTP cable connects.



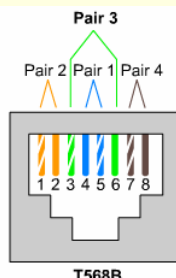
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## UTP Implementation

For electricity to run between the connector and the jack, the order of the wires must follow T568A or T568B color code found in the EIA/TIA-568-B.1 standard



T568A



T568B

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## UTP Implementation

If the two RJ-45 connectors of a cable are held side by side in the same orientation, the colored wires will be seen in each.

If the order of the colored wires is the same at each end, then the cable is a straight-through.

Pin	Label	1	2	3	4	5	6	7	8
1	TD+	Orange							
2	TD-		Orange						
3	RD+			Green					
4	NC				Green				
5	NC					Blue			
6	RD-						Blue		
7	NC							Brown	
8	NC								Brown

Wires on cable ends are in same order.

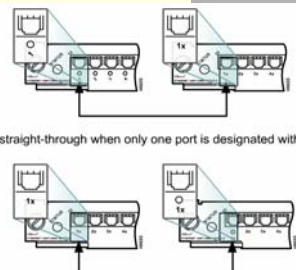
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## UTP Implementation

**Straight-through :**  
Switch to router  
Switch to PC or server  
Hub to PC or server

**Cross-over:**  
Switch to switch  
Switch to hub  
Hub to hub  
Router to router  
PC to PC  
Router to PC

**Roll-over:**  
Terminal to console port



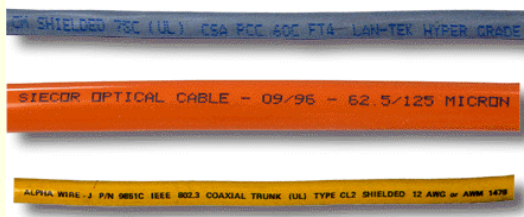
Use straight-through when only one port is designated with an "X".

Use crossover cable when BOTH ports are designated with an "X".

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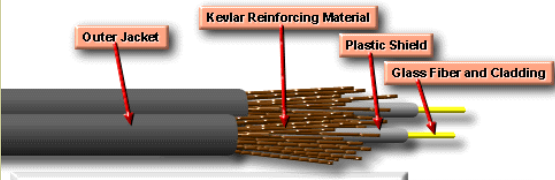
## תקן UL

The UL is primarily concerned with safety standards, however, they also rate twisted pair networking media for performance.



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## סיבים אופטיים - Fiber-Optic Cable



Speed and throughput: 100+ Mbps

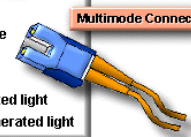
Average \$ per node: Most Expensive

Media and connector size: Small

Maximum cable length: up to 2 Km

Single mode: One stream of laser-generated light

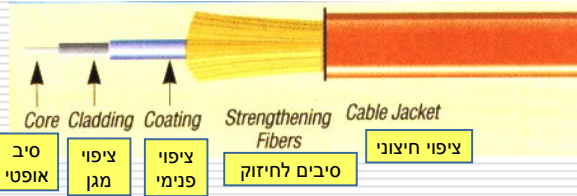
Multimode: Multiple streams of LED-generated light



Multimode Connector

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## סיבים אופטיים - Optic Fiber



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## סיבים אופטיים - Optic Fiber

### נתונים כלליים

- ☐ מעביר אותות של אור.
- ☐ המוליך הוא חוט זכוכית או פלסטי.
- ☐ סביב הסיב יש כיסוי זכוכית בשם cladding.
- ☐ חיצוני יש כיסוי פלסטי מגן.
- ☐ סיבים מיוחדים נותנים ציפוי מגן נוסף נגד שינוי טמפרטורה, כיפופים ושבר.

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## Fiber Optic Cable

Fiber optic technology is a revolutionary departure from the traditional message-carrying systems of copper wires

It utilizes high speed streams of light pulses from lasers or LEDs that carry information through hair-thin strands of glass or plastic cables called **optical fibers or fiber optic cables**

It can carry huge amount of data at extremely fast data rates making it ideal for the simultaneous transmission of voice data, and image signals

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## Fiber Optic Cable

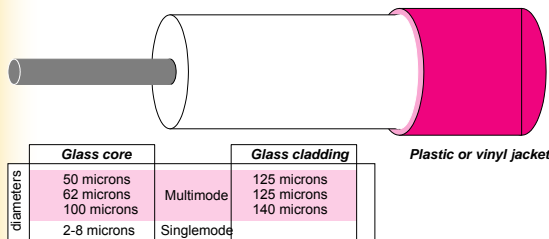
### Characteristics

- data rates of upto 2 Gbps over 10s of miles
  - small size and light weight *over coax or a bundle of twisted pair cables.*
  - lower attenuation
  - no electromagnetic interference
  - greater repeater spacing
- Theoretically 50Gbps are possible over fiber optic.
  - Data rates of 4.8 Gbps over tens of kilometers have been demonstrated.
  - Current data rates are limited by the electronics and the optical transmitter/receivers.

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## Guided Media: Fiber Optic Cable



Note: A micron is a millionth of a meter

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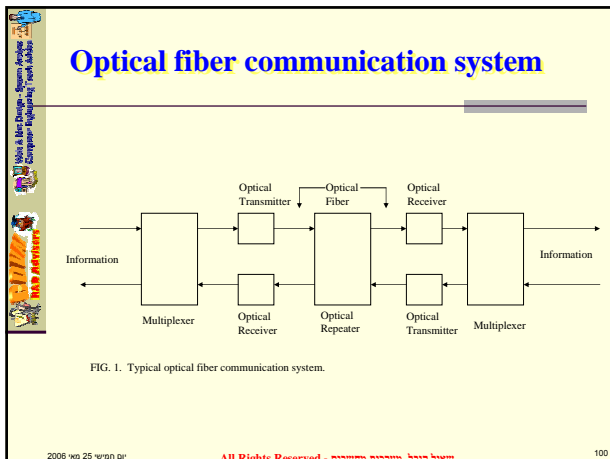
## Fiber-Optic Cable

- Uses light rather than electricity
- No concerns with Electromagnetic Interference (EMI) or Radio Frequency Interference (RFI)
- Supports longer segments than UTP or Coax
- More expensive and harder to work with than UTP or Coax
- Applications
  - long distance communications
  - high bandwidth communications
  - local area networks
  - cable TV

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### סיבים אופטיים - יתרונות וחסרונות

**יתרונות:**

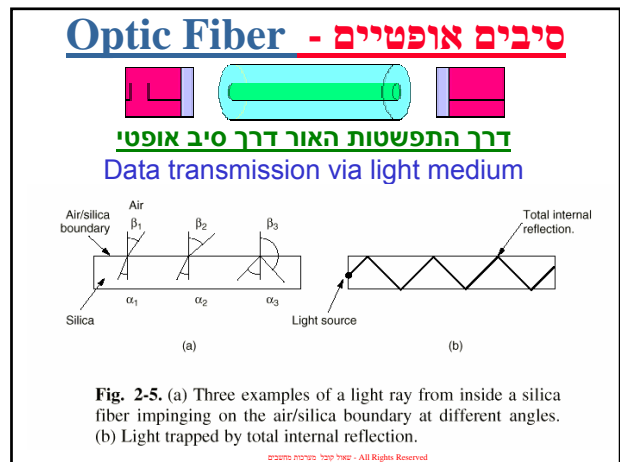
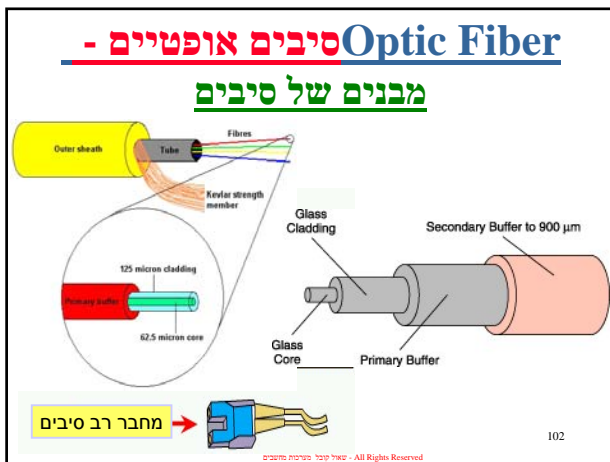
- חסין נגד הפרעות מגנטיות ונפילות.
- הנחתה נמוכה (לא צריך משחזרים).
- מהירות גבוהה.
- בטוח.

**חסרונות:**

- מחיר גבוה.
- קושי בהתקנה.
- החיבורים חייבים להיות מדויקים.

**מחבר של סיב אחד**

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### סיבים אופטיים - Optic Fiber

- השידור הוא Simplex, שידור דו כיווני דורש 2 סיבים.
- שני סוגי דיודות:
  - LED (Light Emitting Diode), של אור רגיל, שידור למרחק קצר ומחיר נמוך.
  - מוליך למחיצה מסוג לייזר, אור מכון מדויק, שידור למרחק גדול ומחיר גבוה.
- שתי סוגים של סיבים:
  - Multimode (אור רגיל) 50/125 μm o 62,5/125 μm
  - Monomode (לייזר) 9/125 μm

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### Fiber Optic Cable

The earliest fiber optic systems were **multimode**, meaning that light could reflect inside the cable at many different angles. Multimode cables are plagued by excessive signal weakening and dispersion, limiting its effective length to 500 meters

**Graded multimode cable**, attempts to increase the effective length to 1000 meters by changing refractive properties of glass fiber such that light signals that travels through edges reaches at the same time as those signals that travels in center

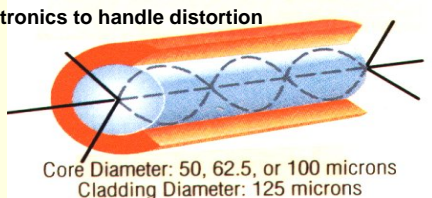
**Single mode** fiber optic cables transmit a single direct beam of light through a cable that ensures the light only reflects in one pattern

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## Multi-mode Fiber

Multi-mode fiber-optic cable has a wider core, so that a beam of light has room to follow multiple paths through the core. Multiple modes (light paths) in a transmission produce signal distortion at the receiving end.

Needs electronics to handle distortion



Core Diameter: 50, 62.5, or 100 microns  
Cladding Diameter: 125 microns

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## Single Mode Fiber

- In single-mode fiber-optic cable, the core is so narrow (generally less than 10 microns) that the light can take only a single path through it.
- Single-mode fiber has the least signal attenuation, usually less than 2 decibels (dB) per kilometer.
- This type of cable is the most difficult to install, because it requires the greatest precision, and it is the most expensive of the major fiber-optic types.
- Transmission speeds of 50 Gbps and higher are possible.
- More Expensive

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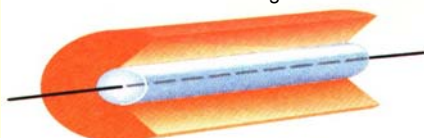
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## Single Mode Fiber

The cladding diameter should be about ten times the core diameter. This ratio makes it possible to make the cladding the same size as for popular multi-mode fiber-optic cable.

This helps create a de facto size standard. Keeping the cladding large also makes the fiber and cable easier to handle and more resistant to damage.



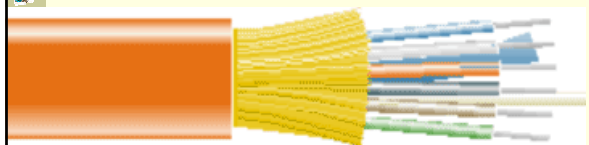
Core Diameter: 7.1 or 8.5 microns  
Cladding Diameter: 125 microns

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## Fiber Example – Multiple Fiber



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## Fiber Advances

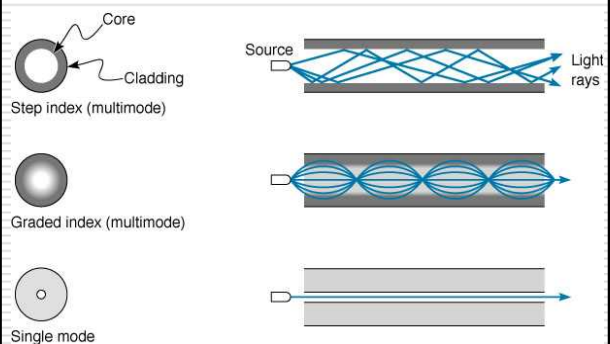
- To get a sense of this magnitude, note that a 10 Gbps line can carry 130,000 voice channels.
- Now seeing Dense Wave Division Multiplexing (DWDM) of different light streams to increase the capacity of fiber
  - Uses many light streams or channels into a single mode fiber

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## סיבים אופטיים - Optic Fiber

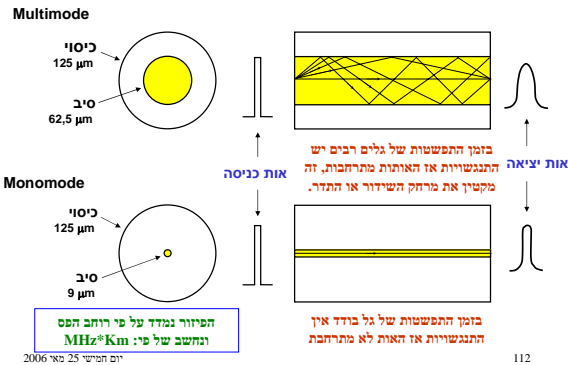


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## סוגי שידור בסיבים אופטיים



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## השוואה בין שידורים דרך סיבים אופטיים דרך:

### LED - לייזר

נתונים	LED	לייזר semiconductor
מהירות מקסימאלית	(622 Mb/s)	(10 Gb/s)
סוג הסיבים Fiber	Multi-mode	Multi-mode & Mono-mode
מרחק - Distance	2 Km	160 Km
אורך חיים	ארוך	קצר
רגישות לשינוי טמפרטורה	קטן	גדול
מחיר	נמוך	גבוה

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## DWDM Fiber

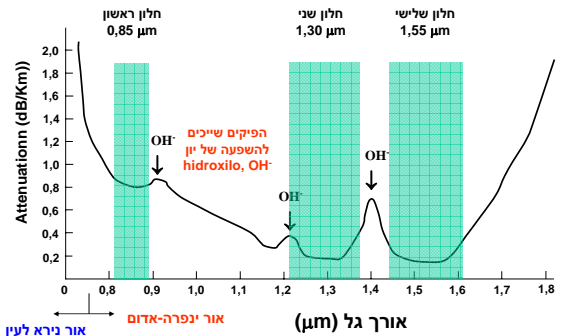
- Normal Fiber Long Haul Lines-TDM
  - OC48-2.5 G/sec and OC192-10 G/sec
- With DWDM
  - OC48 x 16 ch = 40 G/sec up to 80km
  - OC48 x 24 ch = 60 G/sec up to 80km
  - OC48 x 40 ch = 100 G/sec up to 80km
  - OC48 x 96ch = 240 G/sec up to 80km

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## הנחתה בסיב אופטי כפונקציה של אורך גל



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## Optic Fibres Atenuation (dB/Km)

Type - סוג	כוטר הסיב	כוטר ההיקף	1 <sup>st</sup> V. 850 nm	2 <sup>nd</sup> V. 1310 nm	3 <sup>rd</sup> V. 1550 nm
Monomode	5,0	85 6 125	2,3		
	8,1	125		0,5	0,25
Multimode	50	125	2,4	0,6	0,5
	62,5	125	3,0	0,7	0,3
	100	140	3,5	1,5	0,9

- המרכז דק יותר ב-Monomode כי האור לא מתפזר

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## Learn This Table

Media	Cost	Installation	Data Rate	Attenuation	EMI
UTP	Very low	Easy	1 – 100 Mbps	High (100m)	High
STP	Low	Fairly Easy	1 – 100 Mbps	High (100m)	Little less than UTP
Coax	Lowish	Fairly Easy	1 Mbps – 1 Gbps	Moderate (few 100m)	Less than UTP
Fibre Optic	High	Difficult	10Mbps – 2 Gbps	Low (few km)	Immune

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## מהירות הפצה של גלי אלקטרומגנטיות

מהירות (Km/s)	דרך
300.000	אוויר
200.000 (aprox.)	נחושת
180.000 (aprox.)	סיב-אופטי

- מהירות ההפצה גורם להאטה מינימאלית בשידור של תקשורת, בנוסף יש להוסיף זו של הציוד.
- סוג החומרים בחיזוי מגדירים מהירות והמרחק של הרשת.

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## Unbounded or Wireless Media: becoming airbourne

- Three Types
  - ♦ Microwave
  - ♦ Light Transmission
  - ♦ Radio Waves

Each of the three types has it's own sub-categories with different forms of transmission

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## Light Transmission: walk towards the light

- Infrared Transmission System
  - ♦ Infrared light used to transmit signals from node to node
  - ♦ Restricted to line of sight in a single room
  - ♦ Infrared transmitter-receiver installed
  - ♦ Infrared beam similar to remote control
- Laser Transmission System
  - ♦ Narrow infrared beam divided into pulses in order to carry data
  - ♦ Beam received and translated into bits
  - ♦ Can replace microwave over very small distances

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## Light Transmission (cont.): I'll shoot you with my "laser"

Type of System	Advantages	Disadvantages
Infrared Transmission System	<ul style="list-style-type: none"> <li>•Cost effective</li> <li>•Medium speeds</li> <li>•Good where cables aren't</li> <li>•Immune to eaves-dropping</li> </ul>	<ul style="list-style-type: none"> <li>•Short distances only</li> <li>•Reflective sources problematic</li> <li>•Atmospheric conditions and obstacles may cause attenuation</li> </ul>
Laser Transmission System	<ul style="list-style-type: none"> <li>•High speeds of data transmission possible</li> <li>•Immune to EMI and eaves-dropping</li> </ul>	<ul style="list-style-type: none"> <li>•Short distances</li> <li>•Atmospheric conditions and alignment cause attenuation</li> <li>•Radiation</li> <li>•Cannot reflect off surfaces like infrared</li> </ul>

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## Radio Waves

- Radio Wave Transmission System
  - ♦ Frequencies between 10KHz and 1 GHz
  - ♦ Line of sight antennas
- Cellular Radio Transmission System
  - ♦ Users cell phone connected to cellular site
  - ♦ Connected via fibre optic to telephone network
  - ♦ From telephone network data is transmitted via satellite, cable or microwave

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## Radio Waves: radio vs. cell

Type of System	Advantages	Disadvantages
Radio Wave Transmission System	<ul style="list-style-type: none"> <li>•Directional Equipment unnecessary</li> <li>•Globally accessible</li> <li>•Stations can be stationary</li> <li>•Transceivers are cheap</li> </ul>	<ul style="list-style-type: none"> <li>•Only low to moderate speeds possible</li> <li>•Susceptible to eaves-dropping and EMI</li> </ul>
Cellular Radio Transmission System	<ul style="list-style-type: none"> <li>•High speeds of data transmission possible</li> <li>•Can be implemented over long distances</li> </ul>	<ul style="list-style-type: none"> <li>•Susceptible to eaves-dropping and EMI</li> <li>•Atmospheric conditions may cause attenuation</li> </ul>

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## Wireless Transmission Media: comparison

Media	Cost	Installation	Data Rate	Attenuation	EMI
Radio	Medium	Easy	1 – 10 Mbps	High (25m)	High
Micro-wave	Medium	Fairly Complex	1 – 10 Mbps	Depends on conditions	High
Satellite	High	Extremely Difficult	1 – 10 Mbps	Depends on conditions	High
Infrared	Medium	Fairly Simple	100 Kbps – 16 Mbps	Depends on quality of light	Fairly Immune

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## Bluetooth: one bluetooth, many bluteeths?

- Short-range technology
- Connects devices within 10 meters, 100 meters with power boost
- 720 Kbps
- Transmits in unlicensed 2.4 GHz band
- Connects devices in a PAN
- Relatively low cost
- Can transmit through physical barriers
- Line of sight not required
- Printers connecting to cell-phones
- Cell-phones connecting to fridges
- Cat connected to your hamster etc.

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## IEEE Identifiers



- **10BASE5 (Thick Ethernet)**
  - ♦ 10 refers to 10 Mbps
  - ♦ **Baseband:** Dedicated to carrying one type of service
  - ♦ **Broadband:** (Cable television) Designed to deliver multiple channels
  - ♦ 5 refers to 500 meter maximum distance
- **100BASE-TX (Most widely used variety of Fast Ethernet)**
  - ♦ 100 refers to 100 Mbps
  - ♦ TX Two pairs of Category 5 Twisted-pair cable

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## Cable Costs

- Coax - .13/ft + 3.00 per connector
- UTP category 5 -
  - ♦ Plenum - .33/ft + 1.00 per connector
  - ♦ PVC - .13/ft + 1.00 per connector
- Multi-mode Fiber - .35/ft + 15.00 per connector
- Single mode Fiber - .50/ft + 15.00 per connector

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## Infrared

- In this method infrared light is modulated by transmitter.
- Transceivers must be in line of sight either directly or via reflection from a light colored surface such as a ceiling of a room.
- Data rates of upto 20Mbps are possible.
- No security or interference problems, as infrared transmission does not penetrate the walls.
- License is not required.
- Short range, point to point and potential eye damage if exposed to IR rays are the main disadvantages of infrared transmission.

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