Laboratory Manual
For Copper Cabling

Hands-on Lab Manual
For FOA Certification Classes

Lab Manual For Premises Cabling

Preface

This is a laboratory manual for a wiring premises cabling course for students interested in installing and maintaining structured cabling networks in a career-oriented course for FOA CPCT certification. The material is appropriate for incorporation in courses in a number of other disciplines, including electrical contracting, security and IT or computer networking. For a FOA CPCT Premises Cabling certification course, this manual would be used with the fiber optic lab manual to complete the requirements of the course.

Textbook and References

The FOA Reference Guide to Premises Cabling, the Premises Cabling Section of the FOA Reference Guide Website (www.foaguide.org) and the FOA Premises Cabling Curriculum PowerPoints are the basis of the FOA Premises Cabling Curriculum.

The new textbook *The FOA Reference Guide to Premises Cabling* is the primary reference for this course and has been designed to be an easy book to teach from and use as a reference. The FOA Online Reference Guide (www.foaguide.org), Premises Cabling Section, can be used if the instructor prefers an online textbook. Both will be referenced for each session. *Data, Voice and Video Cabling*, the previous textbook, is still permissible but being phased out.

Certification

The FOA offers CPCT (Certified Premises Cabling Technician) Certification for those working in the field. The reference for the FOA CPCT certification is this curriculum and *The FOA Reference Guide to Premises Cabling or the Premises Cabling Section of the FOA Reference Guide Website (www.foaguide.org*. See the FOA website (www.foa.org) or contact the FOA for information on offering FOA certifications.

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Laboratory Manual For Premises Cabling

Introduction

This FOA manual for hands-on premises cabling labs will help students develop skills in cable preparation, handling, termination and testing. Because these are "hands-on" exercises, we provide recommendations on a toolbox and the components to work use in the labs. You will learn to "install" Cat 3, 5, 5e 6 & 6A UTP (unshielded twisted pair) and coax cables and test them. For FOA CPCT certification courses, there is also a lab manual for fiber optics. To get the most out of these exercises, you should already be familiar with premises cabling by having completed the classroom part of this course.

There are two sections to this hands-on course: coaxial cable for CATV or CCTV, and category 3, 5, 5e 6 and 6A UTP cabling for structured cabling as used in local area networks (LANs), CCTV systems with IP cameras and many building automation systems. For each section, be sure to use the lists provided to insure you have the proper tools and materials for each.

Requirements For Hands-On Labs

FOA expects every student to have what we call KSAs – knowledge, skills and abilities to achieve FOA certification. In order to judge the student's abilities and teach skills, the course will typically have ½ of the class time spent in hands-on lab activities. The actual activities are different for each certification. The requirements for labs are also specific to the way the course is taught, including the length of the course and whether the lab is fixed at a location or moved to onsite courses. Here are some basic guidelines:

Teaching In Fixed Locations

Courses taught in a fixed location have the advantage that they can "build" a network easier than mobile courses. Classrooms can be used to install racks, cable trays (overhead and even under floor, even if simulated on top of the regular floor) and other fixed hardware for premises installation. Some large campuses even install conduit, poles, pedestals and other OSP hardware outdoors. The hardware can be permanent or removable, so each new class has to install it for their work, which is highly recommended. Students can then install cables in a manner similar to actual conditions they will encounter in the field. Classrooms can even be equipped with the same type of equipment (style and manufacturer) as the students will encounter in their work. Providing adequate quantities of components, especially cable, will allow students to see how the installation is done in the real world.

Teaching Mobile/Onsite Classes

Many classes are taught onsite or in local meeting rooms by schools that bring the course to the students. Obviously, it is harder to recreate an authentic teaching environment, so use of some of the hardware is not feasible. However, mobile schools often bring along racks of patch panels and even communications equipment to allow students to see the hardware and work with it in the classroom. Some hardware, like

splice closures, are easily transported for use in hands-on training and are important parts of the learning experience. The FOA has developed a UTP training board that can be easily dismantled and transported to onsite classes.

Equipment for Labs

Every course needs equipment and components for the hands-on labs. The FOA encourages instructors and schools to use the equipment and hardware they are familiar with and/or is being used by their students in the field. In addition, the FOA has a list of vendors that offer special deals to schools.

We encourage instructors to use as many products in their lab as they can so students see what the hardware looks like. It is even appropriate to invite manufacturers to visit the class and demo their products or teach labs, a big advantage for some expensive and unusual equipment but many component manufacturers will even bring components and tools to teach your students installation practices.

Student Pairing For Best Learning

The FOA recommends that each class have students paired off to work in teams. Thus, the amount of equipment needed is half the class size. Thus each pair of students would have a set of cable and termination tools and even. Some equipment, like cable certifiers, are too expensive for most schools to provide for every two students. In that case, if only one or two sets are available, they can be shared in a lab.

Note: Many people in the cabling business for some time refer to UTP cable as "Cat 5." If we do so, remember we mean the whole variety of category-rated UTP cable. Likewise, many people refer to the modular 8 pin connector (plug or jack) as a RJ-45, which is not used in structured cabling but is a telco designation for USOC connectors. The structured cabling connector is actually a "modular 8-pin connector.

Hands-on exercises

Coax CCTV and CATV
Identifying coax types
Handling cable
Terminating F connectors on RG-6
Testing

Cat 3 Telephone wire
Identifying
Handling
Stripping
Terminating in RJ-45 Jack
Terminating in 66 Block
Terminating plugs to make patchcord
Testing connections

UTP/Cat 5
Identifying
Handling
Stripping
Identifying wire pairs
Terminating in 110 jacks for outlets and patch panels
Terminating in 110 block
Terminating in RJ-45 plug to make patchcord
Testing connections
Testing Cat 5 performance (with availability of a Cat 5 tester)
Troubleshooting cable problems

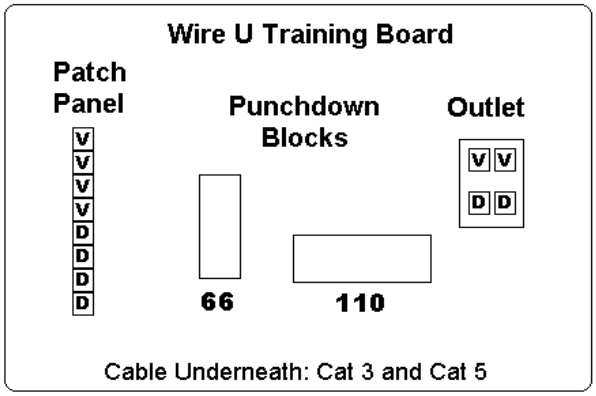
For fiber optic exercises, refer to the appropriate FOA lab manual.

Student Directions

- Follow the instructor's directions exactly. Do not get ahead of the instructor.
- Make certain before you begin that you have everything you need. Refer to the check list on the following page.
- Read the instruction manual from cover to cover to familiarize yourself with the contents of the manual, the steps in the training process and the materials required.
- Allow plenty of time to complete the exercises, especially termination.
- Work in a space where you will not be disturbed. It is important you concentrate on the exercises and follow each step carefully.
- Clean up after your exercises carefully. Some of the scrap you generate can be harmful, such as wires, so we recommend you not work anywhere near food preparation or children's play areas! Place clean paper over your work area to keep from harming the worktable surface.
- Read the "Safety Issues" page **FIRST** carefully and follow it !

Training Board

Here is a way to make a lab work board for UTP cabling with 66 and 110 blocks, 4 position wall outlet and 8 position mini patch panel designed for use in labs.



Training Board Hardware:

Description	Quantity/Board	Quantity/Consumable
Cat 5 jack		4
Cat 3 jack		4
SS Faceplate, 4 port	1	
Blank Patch Panel 8 Port Vertical	1	
Mounting Box, Single Gang	1	
110 Mounting Block, 50 pr	1	
110 Cable Management	1	
110 Connect. Blocks		2
66 Block	1	
Cat 3 Cable	10 m	
Cat 5e, Cat6 or Cat 6A Cable	100 m	(10 m is OK if a Cable Certifier is not available)

Building the Training Board

Under the working surface, leave about 90 meters of 5, 5e or 6 cable for the LAN cable exercise. You will also need a shorter length of Cat 3 for telephone wiring. The top of the board is to be wired for voice, using the "66" block and the voice jacks, and the bottom of the board is for wiring the LAN cable.

We suggest you "install" the link by doing the punchdown at the cross connect first, then terminating the jacks. This creates what is called a "link" and should be tested first. You should use a tester called a “wiremapper” to check correct connections through the link. If you have access to a Cat 5/ 5e/6 tester, use it to test the link for dynamic performance to 100 MHz also.

After testing the link, you will make two patchcords about 3 meters (10 feet) long. Attaching them to the jacks completes the "channel". Retest for wire map and performance as you tested the link.

List Of Tools/Test Equipment Recommended For Hands-On Exercises:

Checklist	Part	Quan.	Notes
	Tester & Tools		
	Wiremapper	1	
	Cable cutter	1	
	Impact tool	1	
	110 blade	1	
	66 blade	1	
	Crimp tool	1	
	Crimp die - coax	1	
	Crimp die – RJ-45	1	
	UTP stripper	1	
	Spudger	1	
	Tone Generator	1	
	Training Board:		
	Blank patch panel	1	
	66 mounting block	1	
	110 mounting block	1	
	Single gang outlet box	1	
	Faceplate – 4 port	1	
	Mounting board	1	
	UTP Consumables:		
	Cat 5e patchcord	1	
	Cat 3 splice	1	
	F connector	4	
	Cat 5e cable	10 – 100 meters	
	Cat 3 cable	10 meters	
	Cat 5e plugs	4	
	Bridging clips	20	
	Cat 5e jack	4	
	Cat 3 jack	4	
	110 block	2	
	Fishing scale	1	
	Hand holder		
	Coax Consumables:		
	Coax cable	2	
	Crimp connector	2	
	Twist connector	2	

Installation Safety

While data, voice and video cabling is considered “low voltage,” there are still hazards involved in installation. Please read the following carefully and understand the issues of installation safety.

Wear Safety Glasses

Many of the processes of installation will involve cutting wires and many small pieces will be send flying around the work area. Always wear safety glasses to prevent getting these into your eyes. All wire scraps should be disposed of safely. Also, working on walls, ceilings and other areas in buildings means dust and particles are always in the air. Protect your eyes with safety glasses at all times.

Keep Your Distance From Power Cables

While low voltage cables are not carrying dangerous voltages, installation often means working near power cables which are dangerous. If you are not trained in electrical installation, a course in National Electrical Code (NEC) is highly recommended. This will teach you how much separation must be maintained between power and communications cabling and how cables should be routed and mounted. Firestopping, or maintaining the fire resistance of the building is also covered in the NEC. In addition, learning the NEC will give you installation guidelines that when followed will insure that your installations will pass any inspections.

Work Safely!

Also, safety in installations includes taking care when working on ladders, in ceiling spaces, etc. Hardhats and other protective gear should be worn. All the safety issues you face in any other installation are important in low voltage installations.

COAX Wiring

Coax CCTV/CATV Cable

Coax Installation

Installing video cabling is relatively simple. Coax cables must be installed with care; that is, they must not be pulled beyond their tension limits, and must not be sharply bent. In addition, they must remain safe from physical damage and from environmental hazards. Care must also be taken when strapping or (especially) stapling cables to structural surfaces (walls, ceilings, etc.). If the staple or strap is cinched too tightly, it will deform the cable, and alter its transmission characteristics. If the staple or strap is overly tight, the system may not work properly, or even at all.

Perhaps most important with CATV cables is proper cable selection and termination. CATV cables are directly connected to the public CATV network. FCC rules limit signal leakage, so it is important to use good cable with proper shielding and terminate properly to prevent signals interference with other electronic devices. In addition, poor termination can cause reflections in the cable that affects the return path, or connection back to the system. Since more networks now are upgrading to a greater number of channels of programming and use or are planning for cable modems for Internet connections, proper CATV installation becomes more important.

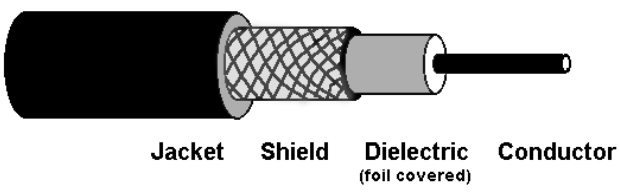
Coax Termination

In the hands-on lab session for coax, we will concentrate on installing connectors, the most critical part of coax cable installation. Most coax connections are made with type F connectors, a screw-on or crimp coax connector that uses the center conductor of the cable as the contact and crimps or screws on the cable jacket and shielding to make contact with the connector body.

Screw-on F connectors are often used to make up cables to go from coax wall outlets to the TV, but the quality of these connectors may allow signal leakage or reflection. They are not recommended for usage in permanent wiring; crimp-on connectors should be used instead.

The most common cable for coax premises wiring is RG-6, which we will use for our exercises. It has a large center conductor, surrounded by a plastic foam dielectric, covered by a metal foil, then woven braid for the shield, and finally a jacket of material appropriate for the locale of the installation. RG-6 can have double or quad shielding, but the construction and termination are similar.

Coaxial Cable Construction



Tools:

For these exercises, we will need a wire cutter, a coax cable stripper and a crimp tool with the coax jaws installed.

Cable Cutter

This special cable cutter with curved cutting jaws is used to allow smooth and neat cutting of coaxial cable and UTP cable without flattening the cable which makes it harder to work with. Use it as you would any other cutter by placing the cable in the jaws and closing the handles.

Coax Stripper

The coax stripper is a adjustable stripper which can make several simultaneous cuts to prepare a coax cable for termination in one step. If the cable is not stripped correctly, refer to the instruction manual for the stripper information and adjust the cutting blades accordingly. (This is one type of coax stripper. Other types may look different, so use the instructions provided with the one you are using.)

Crimper

This is one type of crimper with replaceable jaws for different connectors. One set of jaws is for UTP 8 pin modular connectors and the other is for type F coax connectors. (jaws are sold separately). Make sure the proper jaws are installed before beginning the exercise.

Examining cable construction:

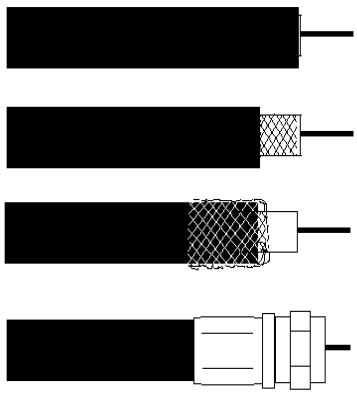
Using the coax cable stripper, insert the coax cable into the stripper and rotate the stripper several turns to make the cuts. Pull the cable from the stripper and it should be ready for termination.

Examine the cable carefully. Note the center conductor that acts as the center pin of the connector also. See how the foam dielectric separates the center conductor from the shield and how it is covered with a foil layer which also assists in shielding the cable. Note the woven shield over the foam. It should be tightly woven to prevent signal leakage.

Terminating Coax with F Connectors

When terminating coax, the braided shield must make solid electrical contact with the connector body to prevent signal leakage and the center conductor must be electrically isolated from the braided and foil shields to prevent shorts.

The process of terminating these cables requires several steps, including two steps to strip the cable properly. The process is as follows:



1. Use the coax stripper to strip the cable jacket for termination.
2. For the first stripping step, cut all the way to the center conductor and remove the jacket, braid and foam insulation to expose the center conductor which will be the center contact of the connector.
3. For the second stripping step, the outer insulating jacket must be stripped away, exposing the braided shield.
4. The braided shield must be pulled back, over the outer jacket, leaving the inner insulation and its foil shield exposed.
5. The exposed center conductor should be checked to make sure it is clean and no wires from the braid are touching it, which can cause shorts.
6. The connector is then placed on the end of the cable and crimped or tightened down.
7. Coax cable can be tested with a coax tester or an ohmmeter can be used to verify continuity to ensure the connector body connects to the braided shield properly.

Hands-On Worksheet
Coax Cable

Complete this worksheet

Name:_____

1. What is the center conductor on the coax cable used for?

2. What type of F connector should be used to minimize signal leakage?

3. True or False: Staples can be used for attaching coax cables to walls or baseboard.

Installation Scorecard Coax Cable Termination

Below is a “scorecard” for UTP installation. Check off “√” when you have correctly completed each step; repeat the step if it is a “X” until it is done correctly. If you have a mentor or instructor, have them provide feedback.

Process Step	Completed		Comments or Mentor/Instructor Feedback
	√	X	
Conducts parts inventory			
Strip cable to center conductor to appropriate length			
Strip cable jacket appropriate length			
Fold shield back exposing foil			
Slide connector on cable			
Crimp connector			
Test with cable tester or ohm meter			

Category 3, 5, 5e, 6 and 6A UTP Wiring

Introduction

Most premises cabling installations use Category 3, 5, 5e, 6 or 6A UTP (unshielded twisted pair) wiring for LANs and most new or rehab construction will install the cabling per EIA/TIA 568 with two UTP cables per work area.

In these exercises, you will "install" a Cat 5, 5e, 6 or 6A cable for LANs and a Cat 3 cable for POTS telephones (POTS = plain old telephone service for analog phones, generally obsolete and replaced by DSL or VoIP phones), using standard hardware, exactly as you would in a real installation. The only difference is you won't be pulling cable.

Warning!

UTP cable and all the hardware associated with it are designed to allow use with LANs operating up to 10 gigabits per second (10 Gigabit Ethernet.) While most of today's LANs are operating at 1 GB/s (Ethernet or Fast Ethernet,) most users assume that at some future date, they will upgrade to the higher bit rates. Therefore, it is necessary to install the network cabling properly and test to the correct specifications. Most users will specify operation to the appropriate specifications and require testing data to verify performance.

In order to ensure optimum performance throughout the network cabling, it is very important to use the correct hardware, including termination blocks, jacks and plugs, and follow installation procedures rigorously – ie: if your network is Cat 5e, all the components have to be 5e also. Sloppy installation practices will degrade your components to lower specifications. (Cat 5e would become Cat 5 or Cat 3 in performance).

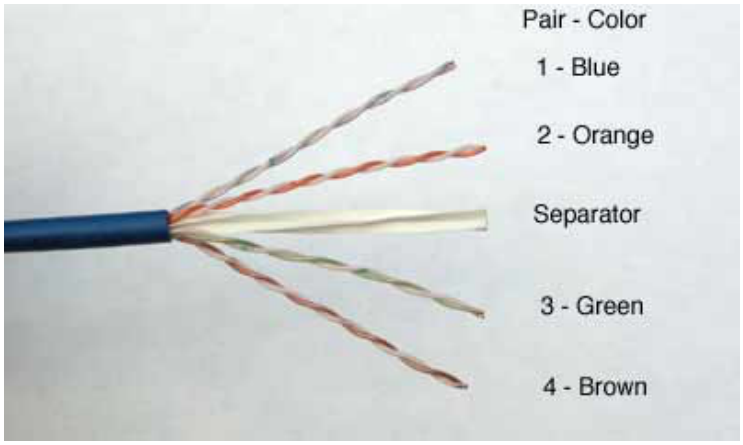
Articles in the trade press have said that as many as 80% of all UTP installations will not meet rated performance specifications due to poor workmanship. Learn how to install UTP cable properly so you do not add to that statistic!

The key to proper performance is maintaining balanced transmission over the controlled twist of the wires. At every connection, it is mandatory to maintain the twist as close to the connections as possible, never allowing the pairs to untwist more than 1/2 inch (13mm). (For Cat 6, allow as little untwisting as possible, as this can cause certification test failures for crosstalk and return loss.)

In addition, the twist can be damaged by pulling the cable too hard. The specification for pulling tension is only 25 pounds. Later on in this exercise, we will show you how to pull cable using a common fishing scale to see how little tension this is! And it is mandatory to never kink the cable when pulling it. Feed it carefully and avoid sharp corners when pulling.

Examining Cable Construction

UTP (unshielded twisted pair) category-rated cable is made from four twisted pairs of 24 to 26 gage copper wire. The cabling permanently installed is solid wire, but patchcords may be made of stranded wire for greater flexibility. Each pair is color coded for identification and twisted at a different rate to reduce crosstalk. Category 6 is the same except it usually has a plastic separator down the center.



Take a sample of your cable provided and strip off about 2 to 4 inches of the outer jacket. Spread out the four pairs and note the color coding and differences in twist rates in each pair. If you look closely at the photo above, you can see the differences in twist rates.

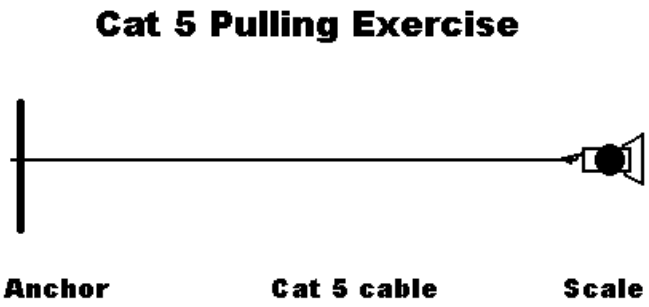
To terminate the cable, you will need to separate the wires and order according to the proper color code for the type of connection being made. In addition, it is imperative to maintain the twist in each pair to within 1/2 inch (13 mm) of the termination point. We'll show you how later in this exercise.

Pulling Cable

It is important to not stress the cable more than necessary when pulling. The maximum pulling tension is only 25 pounds. The performance of the cable is determined by the careful construction of the twists in the pairs. Excess tension on the cable may change the twists in the cables, causing an increase in crosstalk, attenuation or both.

A tension of 25 pounds isn't very much. Some cable in installed in conduit where the pulling tension can get quite high if there are significant bends in the conduit run. Other times, cable is run in open spaces, but has to work its way around obstacles that may create tension or, even worse, try to kink the cable.

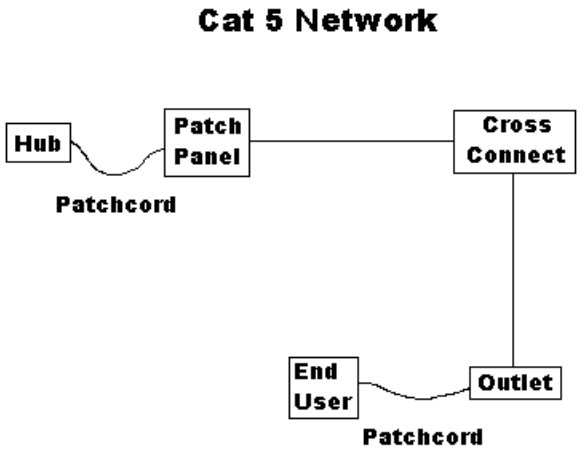
To illustrate how much force it is, you can simulate a cable pull, but with a simple fishing scale attached to measure pulling tension. Find a sturdy place to attach one end of the cable, then set up the exercise below.



Cut a 6 foot (2 meter) section of cable from a roll of UTP cable. Attach one end of it to a sturdy place that will withstand a hefty pull. Attach the other end to the pulling rope that includes the scale. First, pull as hard as you think you should, and while holding the tension, check the scale. Were you over or under 25 pounds? Then pull while watching the scale, to see what effort creates 25 pounds of tension. Try to remember this effort - and don't exceed it!

Build Yourself A Training Board And Install A Simulated Cat 5, 5e 6 Or 6A Network.

The EIA/TIA 568 standard has defined the horizontal connection as up to 90 meters of permanently installed cable and up to ten meters of patchcords. In this exercise, you can use a “Training Board” to simulate the installation of a link. The installation will include wiring two jacks and one 110 punchdown block in the link, with a total length of almost 100 meters. You will also make two patchcords. The link will look like this after you finish:



Hands-On Worksheet

UTP Cable

Complete this worksheet

Name:_____

1. Why do patchcords use stranded, not, solid wire?

2. Each pair is color coded and twisted at a different rate. Why?

3. What is the maximum pulling tension of category-rated UTP cable?

Scorecard UTP Cabling

Below is a "scorecard" for UTP installation. Check off "√" when you have correctly completed each step; repeat the step if it is a "X" until it is done correctly. If you have a mentor or instructor, have them provide feedback.

Process Step	Completed		Comments or Mentor/Instructor Feedback
	√	X	
Conducts parts inventory			Preferably have several grades of cable to compare
Read printing on cable jacket			Note grade of cable _____, UL approval _____ and other information
Strip cable jacket			

Separate pairs and note color codes			Identify the 4 pairs in the cable
Note the rate of twist in the pairs			Why are the twist rates different?
Compare Cat 3 to Cat 5 or any two types of UTP			Why are the twist rates different?
Separate wires			You will do this for termination in next exercises
Attach cable to pull string/tape			
Pull at 25 pounds or 11.3 kg tension			

Terminating UTP Cable – 110 Punchdown Blocks

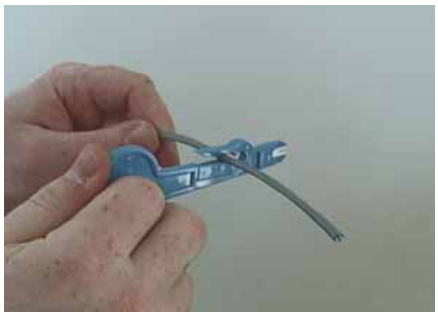
The proper termination of cable is mandatory to maintain the performance specified by EIA/TIA 568 standards and expected by your customers. As we mentioned above, proper cable pulling and handling during installation is important to maintain cable performance. But most problems with cable installations occur at terminations. If you do not maintain the twists right up to the terminations or do not properly terminate the IDC connections, the performance of the cable will be compromised. Remember you must use only properly rated components for every part of the network cabling! (ie: all components must be rated for Cat 5e – one Cat 5 component will degrade the network to Cat 5 or even Cat 3 performance)

The majority of terminations are made with standard IDC connections, using 110 punchdowns or crimped RJ-45 connectors. Almost every manufacturer now has alternative design jacks and patch panels that do not require tools. Each of these have their own termination procedure, which while similar to the normal terminations, requires following their instructions exactly.

For the purposes of this course, we will stick to industry 110 blocks, jacks and crimp connectors. Once you learn these, you can easily learn how to use any other type of termination.

Tools required:

Cable Jacket Stripper



This is one type of cable jacket stripper (there are many) that will make cuts on the outside of UTP cable jackets to allow removal of the required length of jacket quickly and easily. The adjustable blades can be set to the proper depth to assure nick-free strips, very important since nicks can affect the crosstalk of the pair.

Adjusting blade height

This type of jacket stripper can be adjusted so it just cuts the jacket enough to allow easy removal, without nicking the copper wires inside. Try a cut on a sample piece of cable to see if it works properly. If not, follow this procedure below to adjust the blades.

Place the cable in the notch so it is tight against the blade. Twist the screw and adjust the blade to the desired cut depth. Make a test strip to double check the height of the blades. It may be necessary to “fine tune” the blade height several times.

Other Jacket Strippers

Many cabling hardware suppliers offer free cable jacket strippers as promotional items with their logo on them. Some of these work as well as the expensive ones, but it’s best to test them on the cable you are installing to make sure they are compatible with the jacket of that cable.

Punchdown Tool With 110 and 66 Blade

This impact punchdown tool inserts the wire into the 110 block and cuts the ends off. It can be used with solid or stranded 28 - 22 AWG single insulation wire. The blades provide “Punch and Cut”, or just “Punch” by flipping the blade over. In this type of instrument, the extra blade is stored in the bottom of the handle under the cover. Spring compression is adjustable to Hi or Lo with the dial in the handle.

- cut/punch

110 blade

- punch only

- cut/punch

66 blade

- punch only

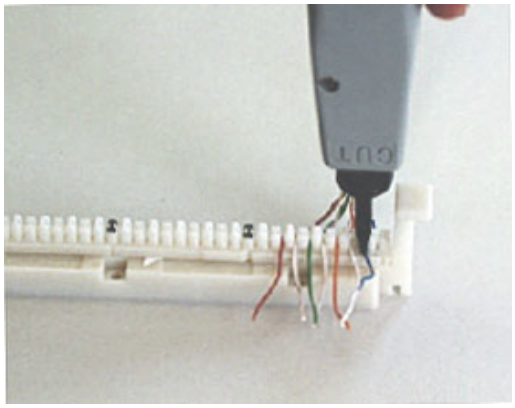
Select the 110 blade and insert in the tool with the "CUT" end out, for performing both punch down and a cut. Install the blade into the top of the tool by pulling down the outside retaining clip and inserting the blade. Line up the key located on the side of the blade with the internal socket. Release the retaining clip to lock the blade into position.

Terminating with 110 Punchdown blocks

Operation of 110 punchdown blocks

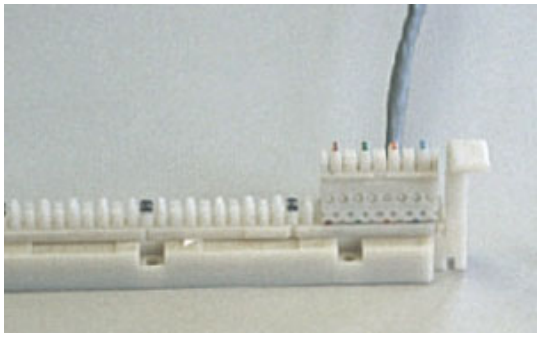
The 110 block is widely used as a interconnect for data wiring. It consists of several parts which are used depending on the interconnection scheme used.

The *wiring block* positions the wires to be terminated by holding them in a plastic base after punchdown. Some types of 110 blocks require an additional mounting piece to mount the wiring block on a panel and may help hold cables neatly in place.



After being punched into the wiring block, a cable can be connected in two ways:

A *connecting block* which has insulation displacement connections on both the top and bottom can be inserted over the punched down wires and other wires punched down into the top of the connecting block to provide interconnection.

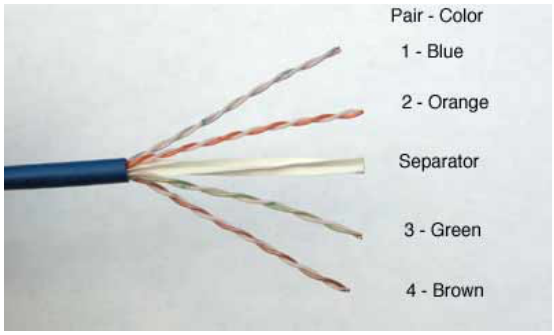


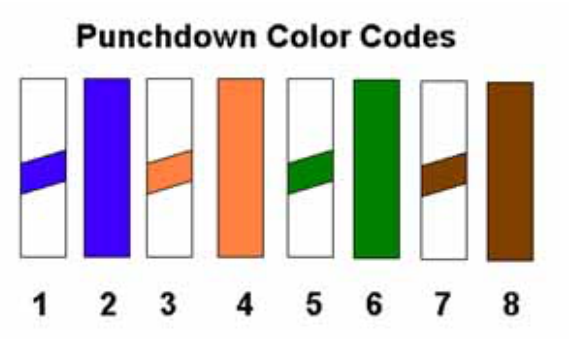
A *patch plug*, which terminates one cable and has insulation displacement connections on the end, can be inserted onto the wiring block to complete the connection

In use, the wires are punched down onto wiring blocks, the connecting block is snapped on, then another cable can be punched down onto the connecting block or cables with patch plugs can be used to interconnect the proper wires.

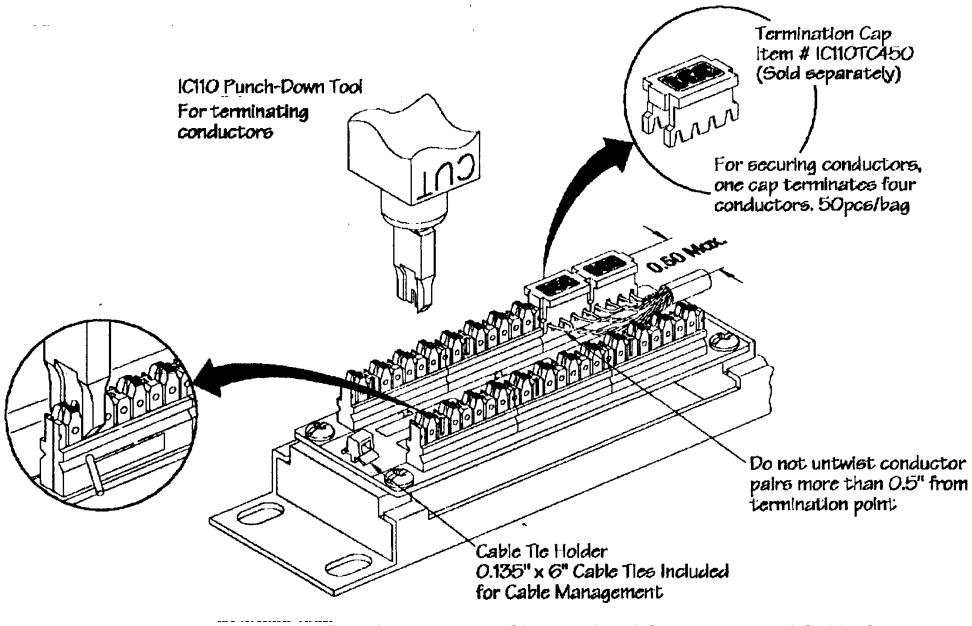
Exercise
To punchdown the wires into a 110 block,
Tools required: Jacket stripper and Punchdown tool with 110 blade (CUT side)

1. Strip about 2 inches of jacket off the cable using the jacket stripper.



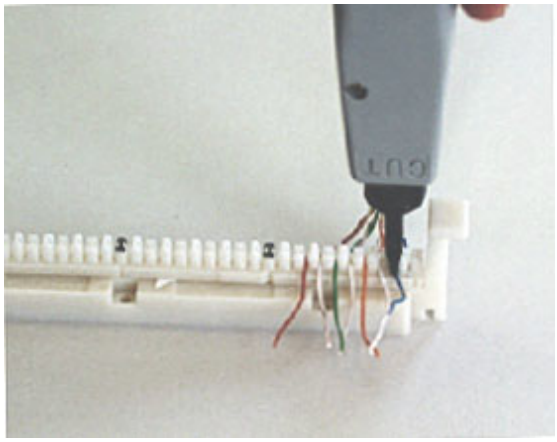


2. Separate the pairs (but DO NOT UNTWIST) in the order shown.



Drawing courtesy of International Connectors and Cable Corp.

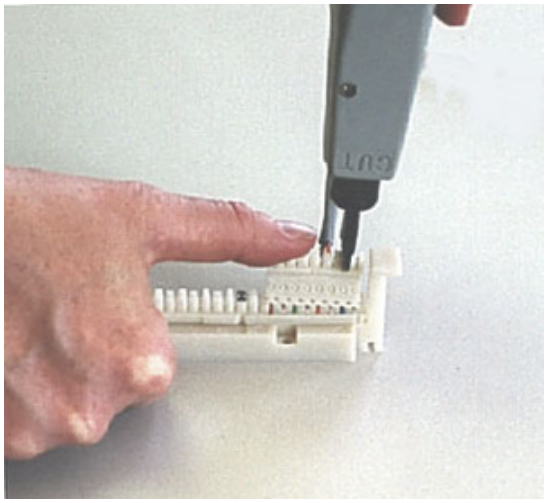
3. For each pair, untwist just enough wire to place each wire in the punchdown slot. Remember it must be untwisted less than 1/2 inch.
4. Place the first wire (W/BL) in the first slot.



5. Punchdown with the tool, with the "CUT" side of the blade on the side where the end of the wire exits the 110 block.
6. Place each wire in order into the slot of the 110 block and punchdown.

Attaching the connecting block

You probably noticed the 110 block has no connector contacts. The contacts are in the connecting block. There is an insulation displacement contact for each wire on one side of the connecting block that inserts into the 110 block after all the wires are punched down. On the other side, the connecting block looks like the 110 block, but this time there are IDC contacts inside the block to connect to the second cable you wish to terminate with the first cable punched down. The block also has color coding to prompt you as to which pair goes where.



Attach the connecting block to the 110 block you just punched wires into by:
Positioning the block with the color coding matching the wire pairs and so the IDC connectors are in the proper location over the wires in the 110 block.
Push the connector firmly down until seated fully and all wires are properly terminated.

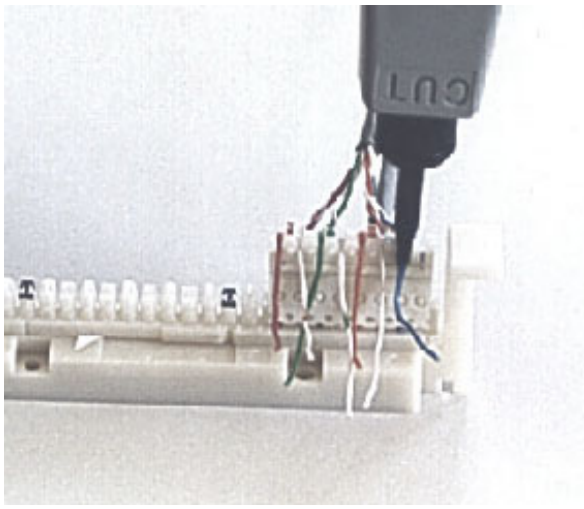
Connecting the mating cable

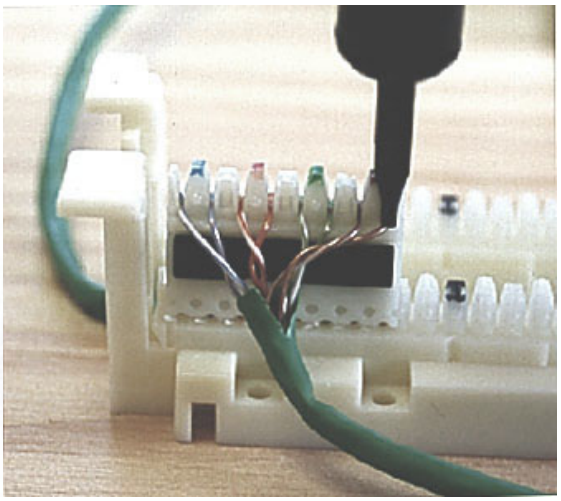
We have two options in connecting another cable to this one. We can punchdown the cable to the top of the connecting block or we can terminate the cable in a patch plug. The punchdown method is simpler, but permanent. If a move is expected, the additional cost of a path plug on the mating cable may be a good investment.

For this exercise, we'll punchdown the mating cable to the top of the connecting block. Start by finding the end of the cable we want to terminate.

Connecting to the connecting block:

1. Strip about 2 inches of jacket off the cable using the jacket stripper.
2. Separate the pairs (but DO NOT UNTWIST) in the same order as before.
3. For each pair, untwist just enough wire to place each wire in the punchdown slot. Remember it must be untwisted less than 1/2 inch**.**
4. Place the first wire (W/BL) in the first slot.





5. Punchdown with the tool, with the "CUT" side of the blade on the side where the end of the wire exits the 110 block.
6. Place each wire in order into the slot of the 110 block and punchdown.

If we've done this properly, we'll have a proper termination, with all wires correctly connected and with less than 1/2 inch untwisted, it should meet performance specifications.

Visually inspect your connections to make sure all wires are terminated to the same color-coded wire in the other cable, and you have finished this exercise.

Hands-On Worksheet

Terminating UTP Cable – 110 Punchdown Blocks

Complete this worksheet

Name:_____

1. Nicking the wire insulation when stripping cable can cause _____.

2. Where are the IDC (insulation displacement contacts) on a 110 punchdown block?

3. What is the order of the wires by color code for punchdown blocks?

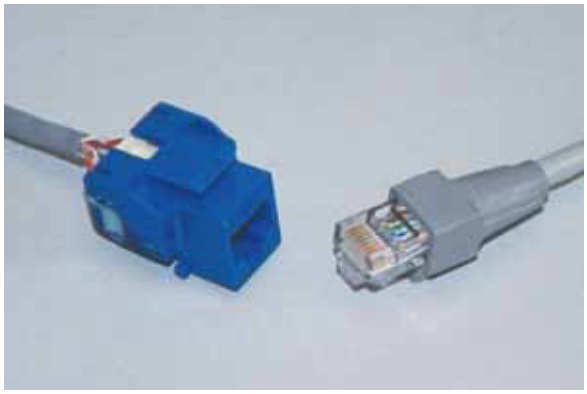
Installation Scorecard 66 Punchdown Block

Below is a "scorecard" for UTP installation. Check off "√" when you have correctly completed each step; repeat the step if it is a "X" until it is done correctly. If you have a mentor or instructor, have them provide feedback.

Process Step	Completed		Comments or Mentor/Instructor Feedback
	√	X	
Conducts parts inventory			
Strip cable jacket to appropriate length			

Separate wire pairs, then wires			
Align wires per color code			
Insert wires in block			
Punchdown wires, remove scrap			
Place connecting block on 110 block			
Seat connecting block w/PD tool			
Strip 2nd cable jacket to length			
Separate wire pairs, then wires			
Align wires per color code			
Insert wires in connecting block			
Punchdown wires, remove scrap			

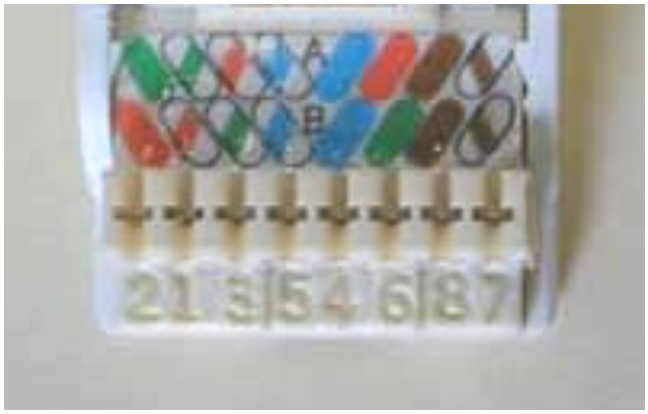
Terminating Jacks with 110 punchdowns

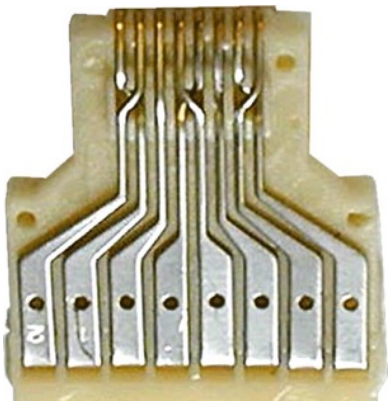


Modular jacks are used with Cat 5, 5e, 6 or 6A cable to provide for a termination at the end of the cable for connection at the work area or for patching in a telecom closet. Modular jacks use IDC connections, with either termination like 110 blocks or with a simple cut and crimp operation using molded parts of the jack itself. The cut and crimp styles are made by many manufacturers, each one slightly different, but everyone makes 110 type terminations, so we'll focus on those.

Now that you know how to use the punchdown tool on 110 blocks, you will use the same tool to terminate the cable at the jack. You will need the following items:

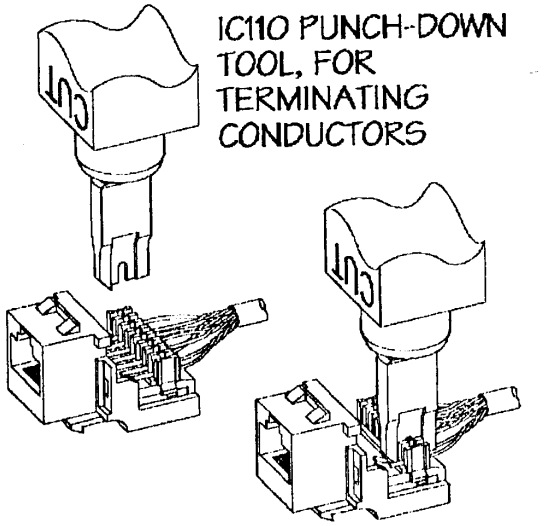
cable jacket stripper
punchdown tool with the 110 blade
hand-holder for the jack
one modular jack





NOTE: *While the jacks all will terminate in 568A or 568B terminations (and USOC for that matter), they generally have color coding on the back of the jack to show you how to order the wires for termination. BE CAREFUL! The jacks usually include both 568A and 568B color coding (and it's small!), So be sure you use only the correct coding for that jack and don't get confused halfway through the job. Also since they often have "twists" inside the connector to reduce NEXT, the order of the wires on the back of the jacks is sometimes different from the normal order and from a RJ45 plug! Make sure you know you have the wires correctly ordered according to the jack requirements!*

Exercise:
Tools required: Jacket stripper, cable cutter on crimp tool and punchdown tool with 110 blade (CUT side), small screwdriver. (optional, hand holder for jack.)



Drawing courtesy of International Connectors and Cable Corp.

1. Find the end of the cable in the Training board near the outlet
2. Strip off about 2 inches of the jacket
3. For each pair, untwist just enough wire to place each wire in the punchdown slot. Remember it must be untwisted less than 1/2 inch**.**
4. Punchdown the wire to terminate it and cut off the excess wire
5. Repeat for all other wires.
6. Snap on the protective covers provided.

Once you have terminated one end of the cable, insert the jack into the outlet and snap it into place as shown below. Then repeat the process to terminate the other end of the cable and snap that jack into its outlet.

Hands-On Worksheet
Terminating UTP Cable – 110 Punchdown Jacks

Complete this worksheet

Name:_____

1. Why are the color codes for jacks different from punchdown blocks?

2. What is the maximum amount of untwist that can be allowed for each pair?

Installation Scorecard UTP Jack (110 Punchdown)

Below is a "scorecard" for UTP installation. Check off "√" when you have correctly completed each step; repeat the step if it is a "X" until it is done correctly. If you have a mentor or instructor, have them provide feedback.

Process Step	Completed		Comments or Mentor/Instructor Feedback
	√	X	
Conducts parts inventory			
Strip cable jacket to appropriate length			
Separate wire pairs, then wires			
Align wires per color code			
Insert wires in jack			
Punchdown wires, remove scrap			
Snap cover on wires			

Terminating RJ-45 8 pin modular plugs

The final hands-on exercise is to make two patch cables to complete the 568 "channel". In most networks, you buy patchcords made in a factory because making patchcords is difficult, but in a pinch, you can easily make your own. You will see that straightening all the wires and keeping them in proper order for the plug is not easy. Patchcords are usually stranded wire and require different plugs for solid or stranded wire with different styles of IDC contacts.

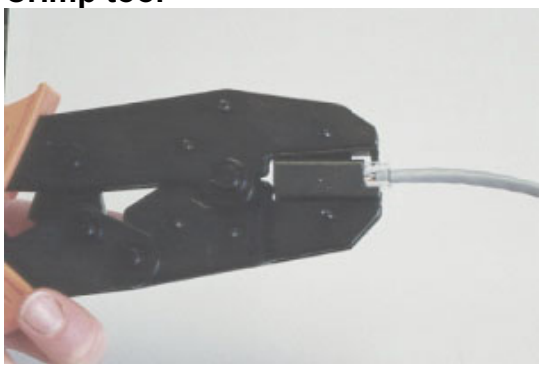
We'll use the cable and modular connectors provided to make two of our own patchcords.

Most 8 pin modular plugs use the same termination process. You will strip the cable jacket, untwist the wire pairs, align the wires according to the proper color code for the termination style (568A, 568B, USOC, etc.), cut to 1/2 inch length, inset in the connector and crimp to set the IDC connectors.

Exercise

Tools: Jacket stripper, modular connector crimper
Materials: 1 meter (3 feet) Cat 5, 5e, 6 cable, modular connector

Crimp tool

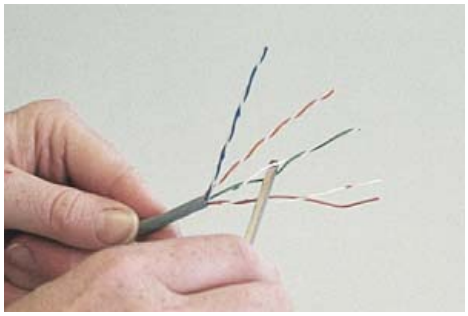


The crimp tool and the replaceable jaws for different connectors are sold separately. One set of jaws is for 8 pin modular connectors and the other is for type F coax connectors. Make sure the proper jaws are installed before beginning the exercise.

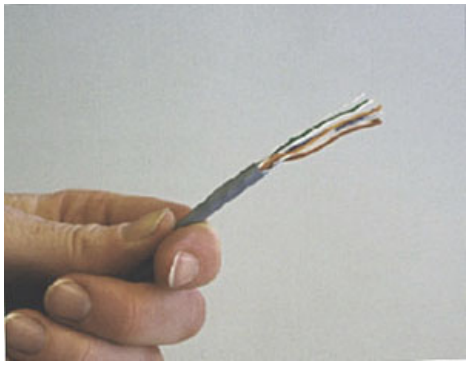
This is a ratcheting crimper which forces you to complete the crimping cycle once started, insuring complete crimping on each cycle. If it is necessary to stop the crimp cycle before completed, there is a trigger between the handles that can release the jaws. Push the lever toward the jaws to release.

Use the jacket stripper to strip approximately 2 inches of jacket off the cable.

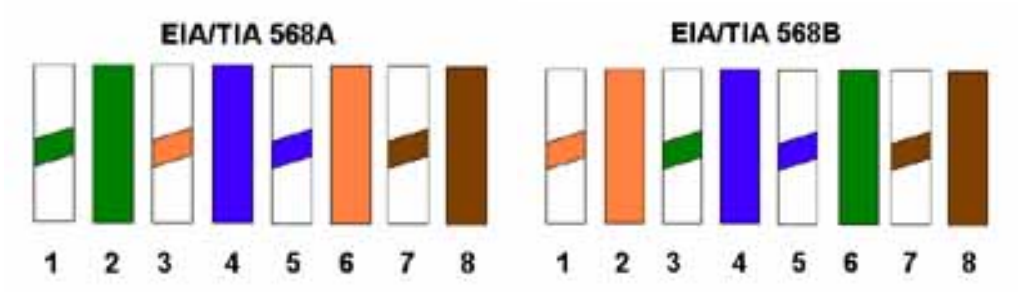
Separate the pairs by fanning them out.



Use a small screwdriver to untwist the pairs by inserting the screwdriver between the wires in the pair near the cut end of the jacket and pull outward, untwisting the wires. Use your fingers to straighten the wires as much as possible.

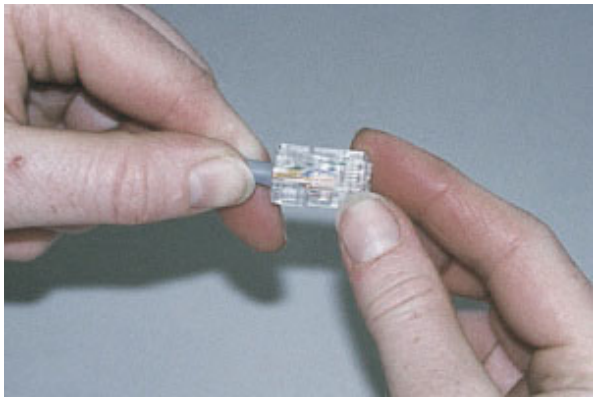


Place the wires in color coded order for a 568A or 568B connector, as below:



When you have aligned the wires correctly, hold them flat between your fingers and wiggle them back and forth to make them as flat and straight as possible.

Using the crimp tool, cut the wires to 1/2 inch length. Make sure the wires do not get out of order!

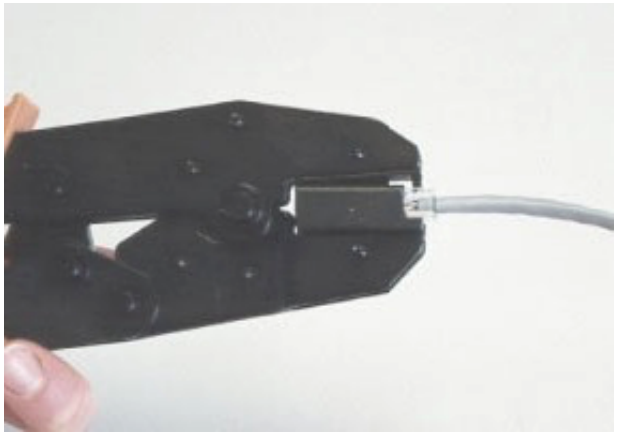


Place the connector onto the cable by inserting the wires into the connector channels and sliding them all the way in. Make sure the wires butt up against the inside front wall of the connector.

Crimping Modular Connectors

Attach the proper jaws to the crimp tool. Follow the directions for the particular type of coax connector you are using. F connectors usually have only one crimp for the connector body. BNC and some other connectors require crimping a center contact first, before crimping the connector body to the cable.

Place the assembled connector into the larger crimp slot, made for the RJ45. Be sure to load the connector with the key side down and insert it fully. When the connector is properly positioned, squeeze the tool handles to allow one full ratchet cycle until the tool completely closes and opens again.



To remove the connector after crimping, press down on the connector key and pull the connector out of the tool. Finally, inspect the completed crimp. All pins should be fully crimped and of the same height.

Repeat the process on the other end of the cable to produce a patchcord. Then make several more patchcords to use in testing your cabling installation.

Hands-On Worksheet

Terminating UTP Cable – Modular Plugs

Complete this worksheet

Name:_____

1. Why are most patchcords purchased not made in the field?

2. What is the difference in plugs for solid and stranded wire?

3. What is the advantage of a “ratcheting crimper”?

Installation Scorecard UTP Plug (110 Punchdown)

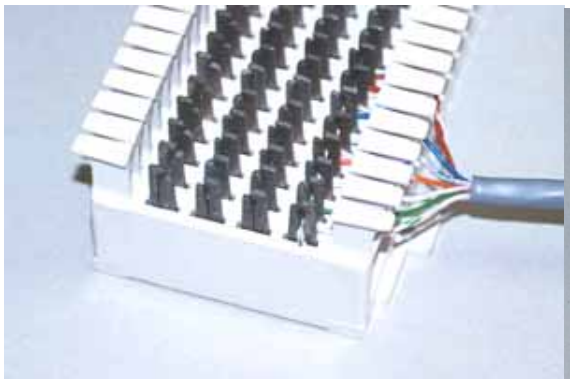
Below is a “scorecard” for UTP installation. Check off “√” when you have correctly completed each step; repeat the step if it is a “X” until it is done correctly. If you have a mentor or instructor, have them provide feedback.

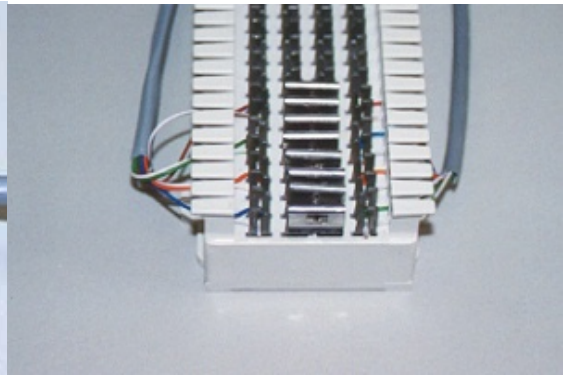
Process Step	Completed		Comments or Mentor/Instructor Feedback
	√	X	
Conducts parts inventory			
Strip cable jacket to appropriate length			
Separate wire pairs, then wires			
Flatten wires			
Align wires per color code			
Cut wires to 1/2” (13mm)			
Insert wires in plug			
Crimp the plug			
Repeat for other end of cable			
Test cable with wiremapper			

Terminating Cat 3 Cable with a 66 Block

The Cat 3 installation for telephones is almost exactly like the Cat 5, 5e, 6 for LANs, except we will use a “Type 66” block. We specify a shorter length of Cat 3 cable for this exercise, which will be connected to the telephone outlet jacks to provide an end to end connection.

The 66 block has rows of four punchdown positions, with each side being a permanently connected pair. In use, the outside positions are used to terminate cable pairs, while the inside positions are used to terminate cross-connect wires. If the connection is directly across the row, a bridging clip can be used to save wiring time.



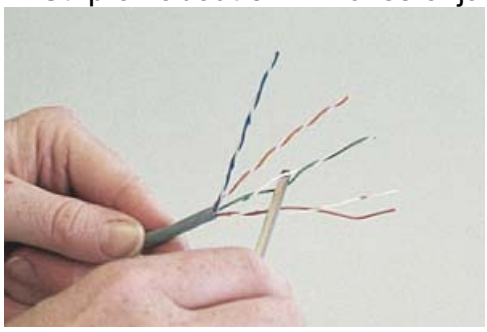


Since we are terminating for telephone connections over Cat 3, not LAN cabling, we can allow more untwisted wire without harming the performance of the cabling. Remember, this only applies to cabling that is for telephone service only, and is never intended for LAN usage!

The procedure for terminating the 66 block is as follows:

Tools:
Jacket stripper
Punchdown with 66 blade

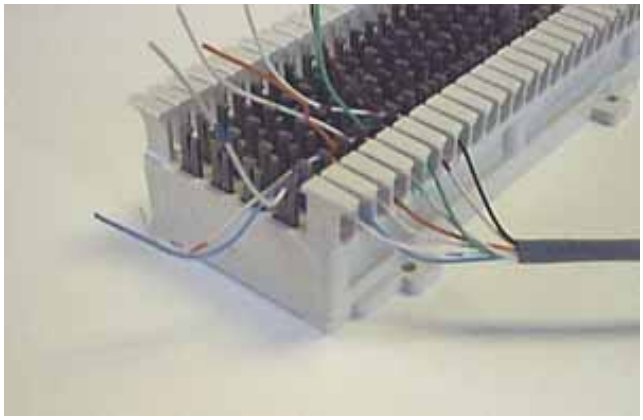
1. Identify the Cat 3 cable in the training box
2. Strip off about 3 - 4 inches of jacket



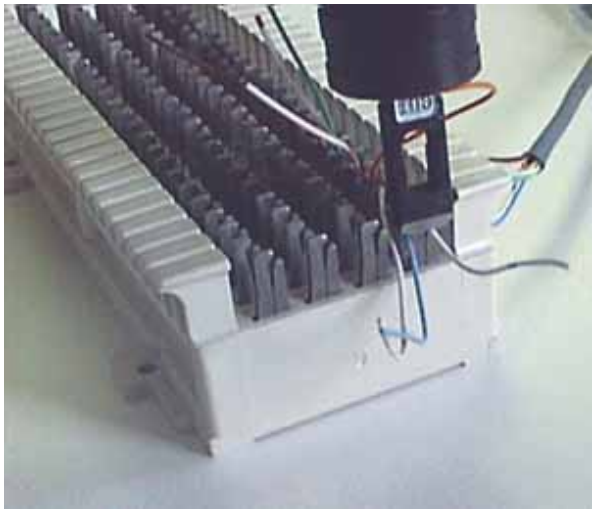
3. Untwist the pairs but keep pairs together

4. Following the color code above, punch down each wire into a position on the end of one row on the block.

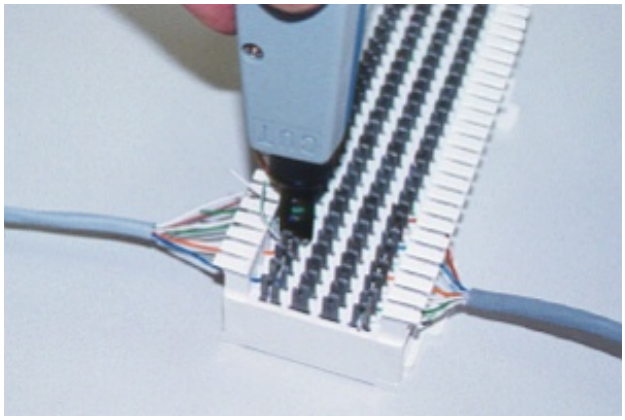
The punchdown tool works almost exactly like it did on the 110 block. Make sure you use the 66 blade end that says cut, so it will cut off the excess wire. And make sure the cut side is on the side of the position that has the excess wire to be cut off!



Untwist the wires an adequate amount, and hook the wire into the top of the IDC contact on the 66 block. Punchdown with the tool to set the contact and cut the excess wire.

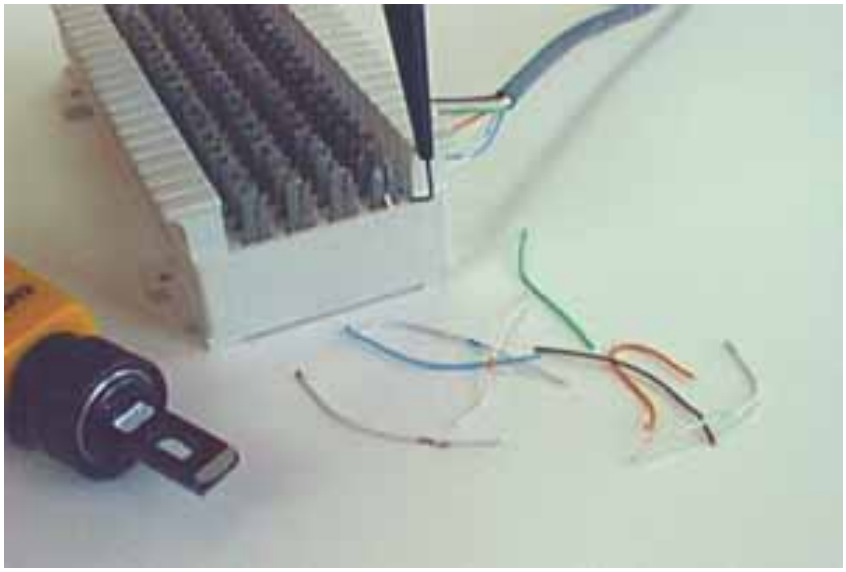


After you have terminated one end of the Cat 3 cable to the 66 block, terminate the other Cat 3 cable to the position on the other side of the block with the color-coded wires in the same rows.



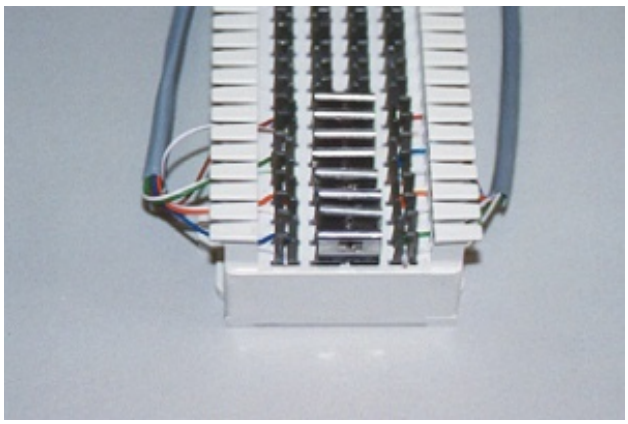
Spudger

The “spudger” is an essential tool for working with wires in a punchdown block. It has a wire hook on one end for moving and pulling wires off the punchdown contacts and a plastic end that can be used to push wires around. It can be used to repair opens by pushing on the wires and shorts by moving wires around.



Cross-connecting

Now you can use bridging clips to connect the rows to complete the connection. Optionally, and if you want more practice doing punchdowns, you can cut a one foot length of cable, pull out the wires, untwist them, then use them to punch down on the inner positions as cross-connect wires.



Terminating Cat 3 Outlet Jacks

Following exactly the same procedure as the Cat 5, 5e and 6 jacks, terminate the Cat 3 cable into the jacks provided and snap them into the outlet plates in the telephone position.

Note: Descriptions of other terminating types

Some manufacturers have developed terminations for jacks and patch panels that do not require punchdowns. They have built in IDC terminations that merely require stripping the jacket, cutting the wire to length and inserting it in the proper receptacle. A simple push on a block or crimp with pliers sets the IDC connector with no other tools.

Each of these blocks is unique, but similar. If you use them, read the manufacturer's directions carefully and follow them exactly to insure proper termination.

Hands-On Worksheet

Terminating UTP Cable – 66 Punchdown Blocks

Complete this worksheet

Name:_____

1. The 66 block has for contacts across. What is the purpose of each?

2. What is a bridging clip? What is an alternative to its use?

3. What is a spudger tool used for?

Installation Scorecard 66 Punchdown Block

Below is a “scorecard” for UTP installation. Check off “√” when you have correctly completed each step; repeat the step if it is a “X” until it is done correctly. If you have a mentor or instructor, have them provide feedback.

Process Step	Completed		Comments or Mentor/Instructor Feedback
	√	X	
Conducts parts inventory			
Strip cable jacket to appropriate length			
Separate wire pairs, then wires			
Align wires per color code			
Insert wires in block			
Punchdown wires, remove scrap			
Strip 2nd cable jacket to length			
Separate wire pairs, then wires			
Align wires per color code			
Insert wires in block			
Punchdown wires, remove scrap			
Make connection by bridging clips or wires			

Testing Cabling

There are 3 different types of UTP cable testers. A wiremapper checks that all the connections have been made properly and pinouts are correct on both ends of the cable – minimum acceptable test for cabling. A verifier checks wiremap then tests the cable using simulated network signals to see if it can transmit data properly. The cabling certifier is the most comprehensive tester that checks all performance parameters specified in standards documents. Cable certifiers are the most expensive but provide the most data on the cabling, starting with wiremapping, and then test to the relevant industry performance standards for the cabling category. Certifers may be required by installation contracts to prove the installation meets industry standards. If you have a certifier when doing this exercise, follow the directions to test the cables you build in the hands-on labs.

Now you have completed the cables on the training board, we will test them. you will need a wiremapper cable tester to test for wire map. If you have access to a Cat 5, 5e or 6 certification tester, you can use it too.

Test Equipment Operation

The wiremapper is a simple, one button instrument that will check the cables for all the normal wiremapping problems encountered in UTP wiring, including split pairs. It does not test for Cat 5, 5e or 6 compliance for certification. You need a "Cable Certifier" for testing to these specifications. If you have one available, use it to test your work.

Tools: The Wiremapper

The first test of any network is "wiremap" or proper connections. Most wiremap errors are simply improper termination of wires during the termination process, usually by confusing color codes.

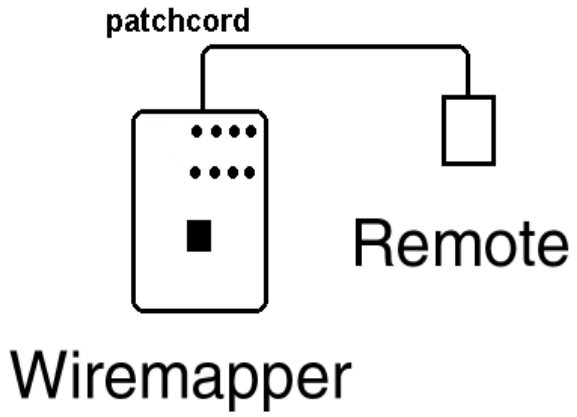
The wiremapper tests for all the wire mapping faults found in UTP cabling, including opens and shorts, reversed pairs, crossed pairs and split pairs. The LEDs display indicates the problem and the pair(s) at fault by the front panel LEDs. The Wiremapper tester usually consists of the instrument itself, a remote unit and several short Cat cables to allow connections to either plugs or jacks.

Testing with the wiremapper

Refer to the instructions provided with your wiremapper for specific instructions on its use.

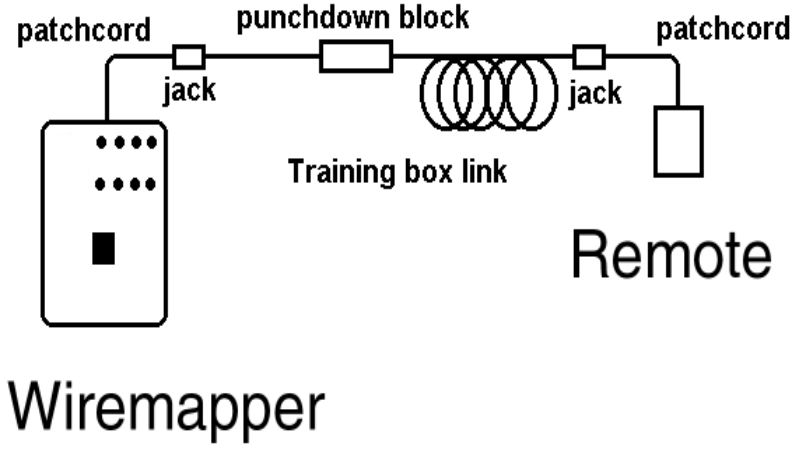
Testing patchcords

To test the wiremapper and your test patchcords, connect the wiremapper directly to the remote with one of your patchcords and press the test button.



Training Board Link Testing

To test your cabling network created using the training board, connect the wiremapper and the remote to each end of the cables by using the test patchcords to connect into the jacks at either end of the training board. Push the test button and test for correct wire connections.

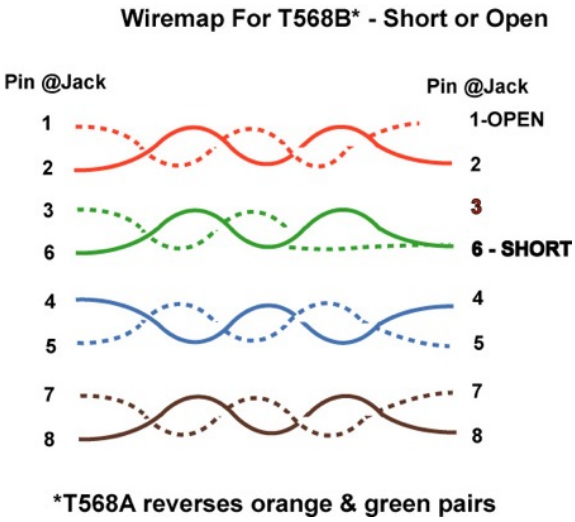


Troubleshooting problems

If the wiremapper indicates you have a problem with a cable or a link, here are what the errors mean (with diagrams of the problems applied to a 568A connection):

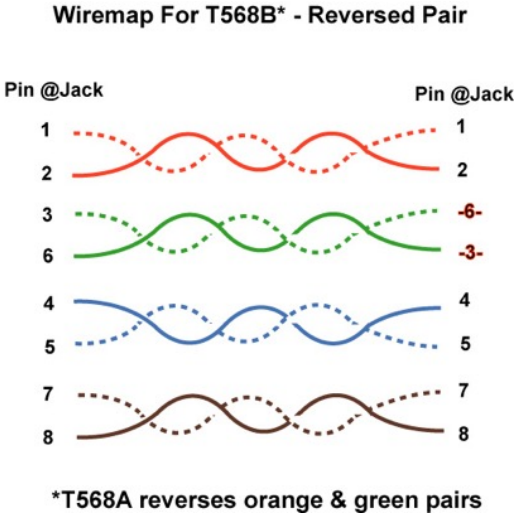
Shorts or Opens

These indicate a short where two conductors are accidentally connected or an open where one or more wires are not connected to the pins on the plug or jack. Opens can also occur due to cable damage. Most shorts and opens will occur at the connections. Physical examination of the connections should find the fault. If possible, disconnect the cables in a link to help find the location. A time domain reflectometer (TDR) test will show the distance to the fault to assist in its location.



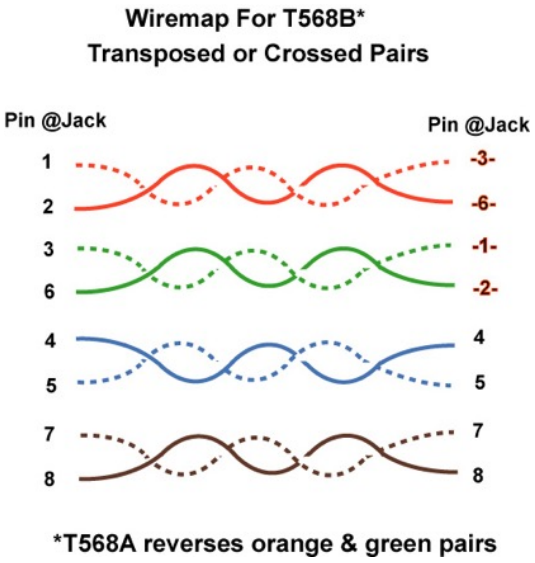
Reversed Pairs

Reversed pairs with the conductors (tip and ring) reversed on one end of the pair. Reversal can occur at any connection, so look for the correct wire color coding at every termination point. Since it involves reversing white and a color, it should be easy to find.



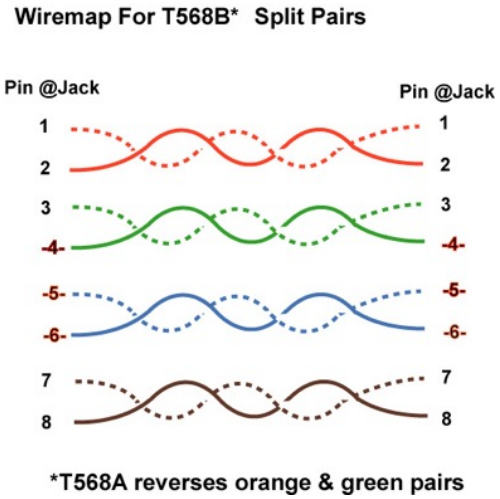
Transposed Or Crossed Pairs

Transposed or crossed pairs where both conductors of one pair are reversed with both conductors of another pair at one end. If you see a crossed pair error involving pairs 2 and 3, it may be that the link has a mixture of 568A and 568B terminations, as these two terminations differ by the reversal of these two pairs.



Split Pairs

A wiremapper may provide basic connection information, but some faults like split pairs may not show up in their wire map – check the instructions of the tool you are using. Split pairs are where one wire each of two pairs are reversed on <u>both</u> ends. This is impossible to find with a normal wiring verifier, since the wire map is correct, that is the pin corrections are correct, but the wires are not in proper pairs. It can only be detected in a crosstalk (NEXT) test, where the unbalanced pairs can be detected. The wiremapper sends a 10 MHz signal down the pairs to find split pairs.



Troubleshooting wire map problems

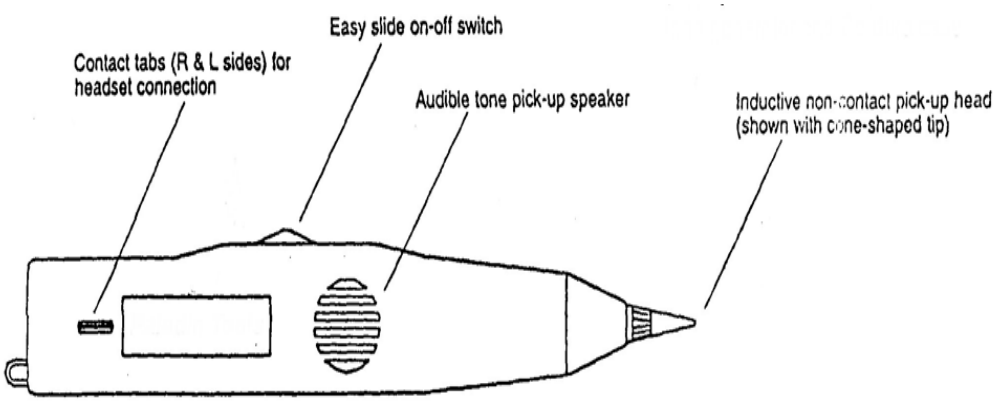
Some errors are easier to trace than others. Most problems require simply rechecking all terminations in sequence. If you have a "certifying" tester or a TDR (time domain reflectometer), it will give you a distance to opens and shorts. If you see a crossed pair error involving pairs 2 and 3, it may be that the link has a mixture of 568A and 568B terminations, as these two terminations differ by the reversal of these two pairs. If pair 1 is *reversed* and everything else is in error, a USOC pinout might be involved somewhere. If you see split pairs, it's likely that a jack has been terminated with the pair 1-2-3-4 sequence used on a punchdown block instead of T568A or T568B pinout.

Category 5, 5e, 6 or 6A Testing

If a "certifying" tester is available, test your cable link with it. This tester does much more than a wire map, measuring length, attenuation, crosstalk (NEXT, or near-end crosstalk), and ACR (attenuation crosstalk ratio) per EIA standards. Refer to the FOA textbook or CPCT class PPT slides on Cat 5, 5e, 6 & 6A testing for a complete explanation of all these tests.

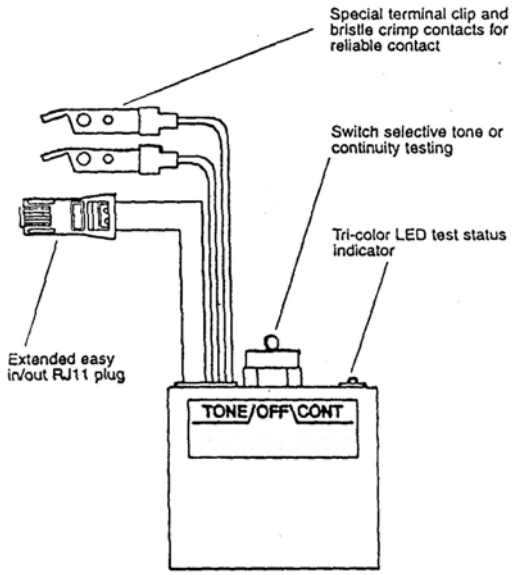
Toner and Telephone Test Set

The "Toner" is used to inject a tone into the cabling and use it for tracing and identifying wires. In addition, the Tone Generator can be used for testing standard phone lines for correct connections.



1568 Speaker probe hand-held wand

Tone Generator And Test Source (Background With Test Leads)



1569 Tone generator and test source

Polarity Testing With Tone Generator

1. Set the function select switch to the "OFF" position.
2. Connect the red test lead to the "ring" side of the circuit and the black lead to the “tip" side of the circuit.
3. If the polarity is correct, the LED will show green. If the polarity is reversed, the LED will show red.

Continuity Testing With Tone Generator

1. Set the function select switch to the "CONT" position.
2. When the test leads are connected across the circuit,- the LED will show green if there is a path of continuity. If the circuit is open, the LED will show red.

Tone generator/probe testing

1. Set the function select switch to the ”0N" position.

2. The generator is factory set to provide an alternating tone signal to the lines at 500 and 1000 Hz. To change to a continuous 1000HZ tone, open the unit and set the tone select slide switch on the circuit board to the "cont" position.

3. Connect the RJ11 phone connector into the telephone cable socket or connect the red and/or black test leads to the wire to be tested. The RJ-11 plug will fit into RJ-45 Jacks also.

4. Use the probe to trace the signal(s) through the cable to the termination panel or termination point. If an open exists, then the tone will end at the open point. If a short exists, the tone will transmit to the shorted wire(s).

Hands-On Worksheet

Testing UTP Cable

Complete this worksheet

Name:_____

1. What instrument is used to check for correct connections? What causes most connection problems?

2. What is the most likely cause of cross pairs?

3. If you terminate a jack with punchdown block color codes, what error will you have?

4. What does a toner do?