# Kit Builders Guide

## Recommended Tools, Test Instruments, Soldering, Wiring & Assembly



## WORKSPACE

Before beginning the construction of your project is essential that you

1. Establish the proper workspace,
2. Obtain the minimum basic tools,
3. Familiarize yourself with their proper use, and
4. Review the associated document thoroughly before you begin.

This preparation will make the difference between a fun project and a series of frustrating experiences. With poor tools you will consistently find yourself in the position of compensating for the shortcomings of your tools rather than focusing on the details of your project.

The proper workspace is critical. It should be located in an area where you will be able to retain until the project is completed. Choosing a kitchen table or other shared area where you will be required to "put away" your project between sessions is a recipe for mistakes. In respect to Murphy's Law, assume you will need the workspace much for twice the projected timeframe. Choose a well lighted and temperature controlled area where you will be comfortable. Find a comfortable chair that will permit you to work slightly above your project.

## RECOMMENDED TOOLS

There are tools that are essential and others that are convenience. If you plan to build one project annually, then investing in the convenience tools may be a bit of extravagance. But if you will be building several projects annually then many of the convenience tools begin to fall into the essential category. The tables indicate which category I believe each should be classified. A good stable of soldering / desoldering tools is essential. These will be the tools you use most frequently and therefore I urge you to follow my recommendations.

| DESCRIPTION | CATAGORY | POSSIBLE SOURCE(S) |
|---|---|---|
| Soldering Equipment | | |
| Solder Station (Basic ~ $50) | Essential | MCM # 21-3475 |
| Solder Station, Temp Control (~ $140) | Convenience | MCM # 96-030 |
| Solder Sucker (~ $20) | **Essential** | MCM # 21-4699 |
| Solder Wick (~ $3) | **Essential** | MCM #21-1280 |
| Solder, Rosin (Non Residue ~ $20) | **Essential** | MCM #21.1570 |
| Soldering Aids (~ $4) | Convenience | MCM # 21.665 |
| Pliers | | |
| Miniature (4") Long Nose, Serrated | Essential | MCM # 22-575 |
| Standard (6") Long Nose, Serrated | Essential | MCM # 22-815 |
| Slip Joint Type | Essential | MCM # 22-820 |
| Wire Stripper | Essential | MCM # 22-3775 |
| Wire Cutters | | |
| Diagonal | Essential | MCM #22-540 |
| Shear (Low Profile) | Essential | MCM # 96-1183 |
| Heavy Duty | Convenience | MCM # 22-1705 |
| Miscellaneous | | |
| RCA Input Shorting Plugs | Essential | See Text |
| Electrical Tape | Essential | MCM # 108-3375 |
| Test Clip Leads | Essential | MCM # 21-3315 |
| Wire, 20 ga, Silver / Copper / Teflon | Essential | CAE #TWK |

| | | |
|---|---|---|
| Contact Cleaner (Deoxit Gold) | Essential | MCM # 200-040 |
| Heat Sink Compound | Near Essential | MCM # 20-1975 |
| Wire Wrap & Gun | Convenience | MCM # 21-3554 & 21-3230 |
| Heat Shrink Tubing Assortment | Convenience | MCM # 95-570 |
| Crimping Tool | Convenience | MCM # 22-120 |
| Small File Set | Convenience | MCM # 22-1440 |
| Standard Screwdriver Set<br>Flat Blade & Phillips<br>Jewelers Screwdriver Set | Essential | Sears, Quality Hardware Outlet |
| Small Socket Driver Set | Essential | Sears, Quality Hardware Outlet |
| Hex Key Wrench Set | Essential | Sears, Quality Hardware Outlet |
| Adjustable Wrench<br>Small (4")<br>Large (12") | Essential | Sears, Quality Hardware Outlet |
| Hand Drill (1/4" or 3/8")<br>Drill Bit Set (to ½") | Essential | Sears, Quality Hardware Outlet |
| | Convenience | |
| Locking Clamps | Convenience | Sears, Quality Hardware Outlet |

## RECOMMENDED TEST INSTRUMENTS

Once your project is assembled, it will be necessary for you to perform some of the tests specified and perhaps calibrate the unit as defined in the instructions. Furthermore, should you encounter a problem, a good basic digital voltmeter (with resistance) is essential. Also an AC Variac (essentially a variable line voltage supply source) will prove very useful as a diagnostic tool. Additional instruments such as a signal generator oscilloscope, and power supply are helpful but may not be necessary. As with the tools above, should you plan to build several kits annually, the "convenience" instruments begin to fall into the essential category.

You can easily spend thousands of dollars on your test equipment. Unfortunately (or fortunately depending on your perspective) there are many sources of test equipment. From e-bay and hamfests through retail outlets you could spend 3 to five times the amount for what is essentially the same unit.

You could choose to purchase new equipment from an authorized dealer. This is clearly the low risk approach however is will command the most premium price. In this case I'd recommend MCM electronics (800-543-4330, www.mcmelectronics.com). They offer Wavetek, Fluke & Tektronix gear at non bargain prices. In contrast they offer some generic (Temna) brands with comparable specifications at of course comparatively good prices. This is tempting but it simply is not in the same league as the name brand equipment.

Personally, I'd rather do a little research and purchase higher quality gear from a "reconditioned" supplier. They offer fully guaranteed and fully reconditioned and calibrated test gear at less than new but nonetheless premium prices. You could save more money and try some lesser known reconditioned test gear suppliers. A personal recommendation is AST Global Marketing (800-216-7159,www.a-mall.com/testlist.com) in Pennsylvania. I have purchased perfect equipment from them at the most competitive prices available. Good service as well.

Another source is e-bay. I have had both good and bad experiences with e-bay. My advice – look at the prices of recently completed items and read the ad carefully. Be sure that the item is returnable if it does not meet the description as stated.

Finally there are the hamfests where it is possible to find the best bargains - but at a risk. Be sure to get the name of the seller and his / her address and phone number. Some sellers will tell you that it is being sold “as is” - avoid this unless you know exactly what you are doing. Even an on the spot demo may fail to reveal all of the hidden problems. The risk is high but so are the possible rewards. Probably the best advice is to secure a genuine opportunity to return the item should it not meet condition as advertised

| DESCRIPTION | MIN SPECS | CATAGORY |
|---|---|---|
| Digital VOM<br>Radio Shack #22-810 (Minimum @ $20)<br>Wavetek #10-XL (Moderate @ $50)<br>Wavetek # 27XT (Premium @ $120)<br>Alternate - Used Fluke 8000A @ $40 | 0.5% Accuracy<br>Diode Junction Test<br>Capacitance (Not Essential)<br>Good Test Probes | Essential |
| Power Variac<br>MCM # 72-110 Recommended | 5 Amps w/ Built In Ammeter | Near Essential |
| Oscilloscope<br>Used Tektronix 465 Series Recommended | 20MHz Bandwidth<br>Dual Channel<br>Triggered Sweep<br>Probes (10:1) | Useful |
| Tube Tester<br>Used B&K 707 or 747 | | Useful |
| Old SS Stereo Receiver & Test Speakers | 10 to 50 WPC<br>(Fuse the Speakers @ .5 A) | Useful |
| Test Oscillator (or Function Generator)<br>Used HP 204C Recommended<br>Alternate - Used Wavetek Function Generator | 10 Hz to 100 KHz | Useful |
| Power Supply<br>Low Voltage<br>High Voltage (Lamda Model 71) | <br>+/- 15 VDC Variable, 5 VDC<br>0-500VDC @ 200 mA | <br>Convenience<br>Convenience |
| AC Millivoltmeter<br>Used HP 400F Recommended | 1 mV Full Scale | Convenience |
| Frequency Counter | 20 Hz - 100 MHz | Convenience |
| Transistor Tester | Signal & Power Bipolars<br>J-FET’s & MOS-FET’s | Convenience |
| Capacitance Meter | 20pf - 1000 uF | Convenience |
| Distortion Meter<br>Used HP 331A Recommended | 0.01 Full Scale | Convenience |

## SOLDERING

CAE products have been designed to incorporate the finest circuitry, components, grounding techniques, and power supply technology to deliver the finest audible performance and long term reliability. However, the audible and measured performance of your project will depend upon many elements under your control.

One major factor is the workmanship you will exercise during assembly. And in that area the most important is the quality of the individual soldering connections. This includes both those made at the component lead pc board interface and those associated with the interconnecting wiring. Good connections are essential for long term reliability and world class audible performance. If you follow the techniques

outlined here you can rest assured. On the other hand shortcuts will negate the significant investments you have made elsewhere from components to esoteric tubes and the like.

That being said, proper solder connections are not difficult but it is advisable to observe a few tips & precautions:

1. Use a high quality soldering pencil (refer to the tools section for recommended brands). Set it to approximately 700 to 800 degrees (F).
2. Keep a small damp sponge handy (include with quality irons suggested) and wipe it clean immediately before making any connection. The iron must have a bright shiny tip to insure complete heat transfer.
3. Sometimes it may be necessary to add a small amount of solder to "wet" the tip and aid the thermal transfer to the connection.
4. Always use high quality 60/40 rosin core solder. You will have the best results with the major suppliers - Multicore, Kester, or Edsyn. Never use acid core or any separate flux. Silver solder is also not recommended.
5. Never use a soldering "gun" – the weight, size and uncontrolled temperature will at best insure a poor connection and, at worst, likely a damaged pc board.
6. Never "butter" partially melted solder on the joint – this is a useless effort. A good connection will appear bright and shiny because the solder flows into every crevice when the parts have reached the proper temperature. Poor connections appear dull or are covered by a "ball" of solder.
7. Once the solder connection has been made any movement must be avoided until the solder fully solidifies. If the connection is not shiny suspect it.
8. Remember – the connections will be made by the solder, not by the mechanical connection to the terminal. Usually the wire is half looped through the lug and hooked into place. Some rightly prefer to just place the wire through the hole and rely on the stiffness of the wire to hold it in place during the soldering process. Eyelet connections are a prime example of this type of connection.
9. When you have to desolder old connections to reclaim a part or terminal it is very possible that you will encounter highly oxidized surfaces presenting a strong obstacle to proper heat transfer. In this case, simply add a small amount of new solder to bridge the area between the iron and the old connection you are attempting to desolder. Once the solder is fully molten place your solder sucker strategically to remove as much of the solder as possible. You may need to perform this more than once to completely remove all of the old (and the new) solder.
10. When soldering wires, never strip more than ¼" of insulation from the end of the wire unless otherwise instructed. Always "tin" wires before you solder them. To "tin" a wire, apply a small amount of solder to the wire. You should be able to see the individual strands of the wire. BTW, we always use Teflon insulated stranded wire. It is very tolerant of the heat required to make a good solder connection and (being stranded) is tolerant of flexing.
11. It is also imperative that the elements being soldered be relatively clean. (You should be getting the idea by now that cleanliness is a good thing.) Rosin based solder has powerful chemicals that when heated do a pretty good job of cutting through component and pc board oxides. But this takes time and heat. And the longer you are required to heat the junction to dissolve oxides the more the risk that you will physically damage the pc board foil or melt the insulation on the wire. (BTW if you use Teflon insulation this latter problem is eliminated.) To minimize these problems, I recommend a simple cleaning step with the leads of components. This involves using your mini long nose pliers (should have serrated tips) to scrape off the thin layer of oxide. Place the component lead at the body of the part in the jaws of your mini long nose pliers and with a little force pull the pliers away from the component body (with a little practice this will become second nature). Do this two or three times to cover the circumference the lead

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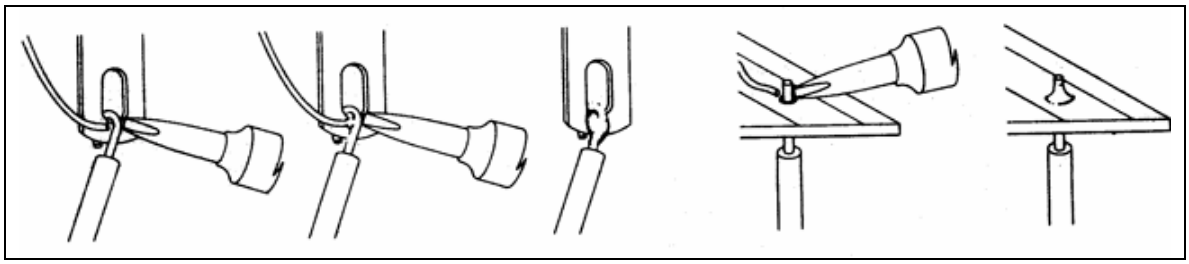


OK then – here are the four simple steps:

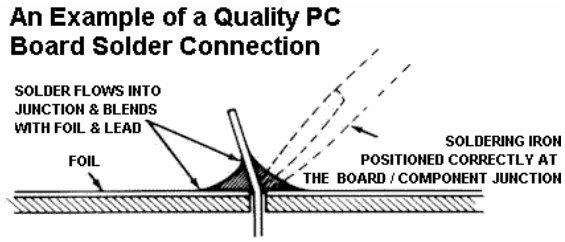
1. Loop the wire being soldered into the hole (pc board) or lug to make a good mechanical connection. The items being soldered should be in a relatively stable position such that once competed there is no possibility of jarring or relative movement between the soldered elements
2. After you have made a good mechanical connection, get your soldering pencil, wipe its tip and then place its tip in the junction so that you provide to the two items you wish to solder. The idea is to heat both.
3. After a few seconds, apply solder to the junction. It should melt immediately and flow smoothly around both surfaces. Don't attempt to swamp the connection with solder – apply just enough solder to cover the connection.
4. Observe the action of the flux it really aids the process however try not to spend too much time making the connection which will evaporate all of the flux.
5. Allow the connection to cool undisturbed
6. Replace your soldering iron in its holder.

OK, that's it. Actually it is much simpler that it sounds.

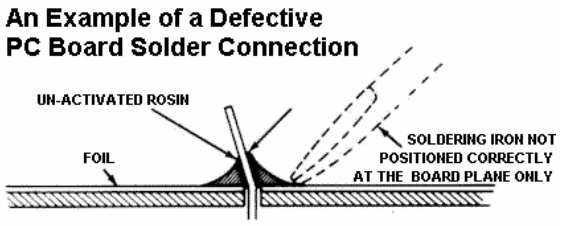
If you are new to this, take the time to practice on some scrap pc boards and terminals until you feel confident.

When soldering high density PC boards or near IC pins, it is very common to form a solder bridge. This is when a connection of solder forms between to adjacent pins. Many hours have been dedicated to troubleshooting and many components destroyed as well as a result of this “minor” error. I would suggest that at the conclusion of each component connection (or certainly at the completion of one board) you stop to visually inspect each connection. Look for both cold solder connection and bridges. A small magnifying glass is very useful to examine each connection in detail. This care is a valuable investment with playback in both trouble free start up and long term reliability. If you find a bridge or a poor solder connection, use your solder sucker (or solder wick on small pads) to remove the solder and then resolder. You will find that the tinning action of removing the solder from the first connection will make the re-soldering much easier.

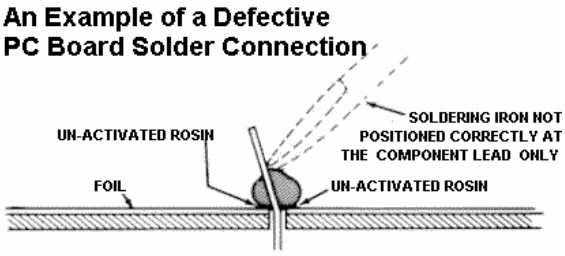
Heat the component lead and foil at the same time. Apply solder a few seconds later to the heated junction on the other side. It should flow easily into the junction and fill the gaps between the foil and component lead.



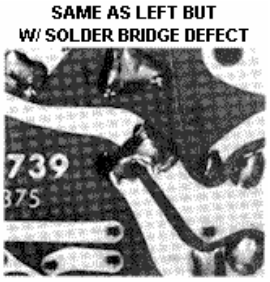

This defect occurs when the temperature of the component lead has not reached the melting temperature of the solder. This type of defect is difficult to spot. Usually you will notice the lead is loose. If this happens, use some solder wick to remove the solder and try again. Be careful not to apply too much heat to the foil.




Another defective solder joint. Here the temperature of the foil has not reached the solder melting temperature. This one is very easy to spot as it is characterized by a “ball” appearance of the solder and of course the component will be able to move in the direction of the component lead. Once again use some solder wick to clean up and try again.




An example of a pc board showing a solder bridge. The left photo is correct - no defect whereas the right photo shows the same position on the pc board but with a solder bridge defect in place. Bridges are more likely in high density areas such as IC leads. I recommend you use a magnifying glass to visually examine each connection carefully after each component especially the high density types.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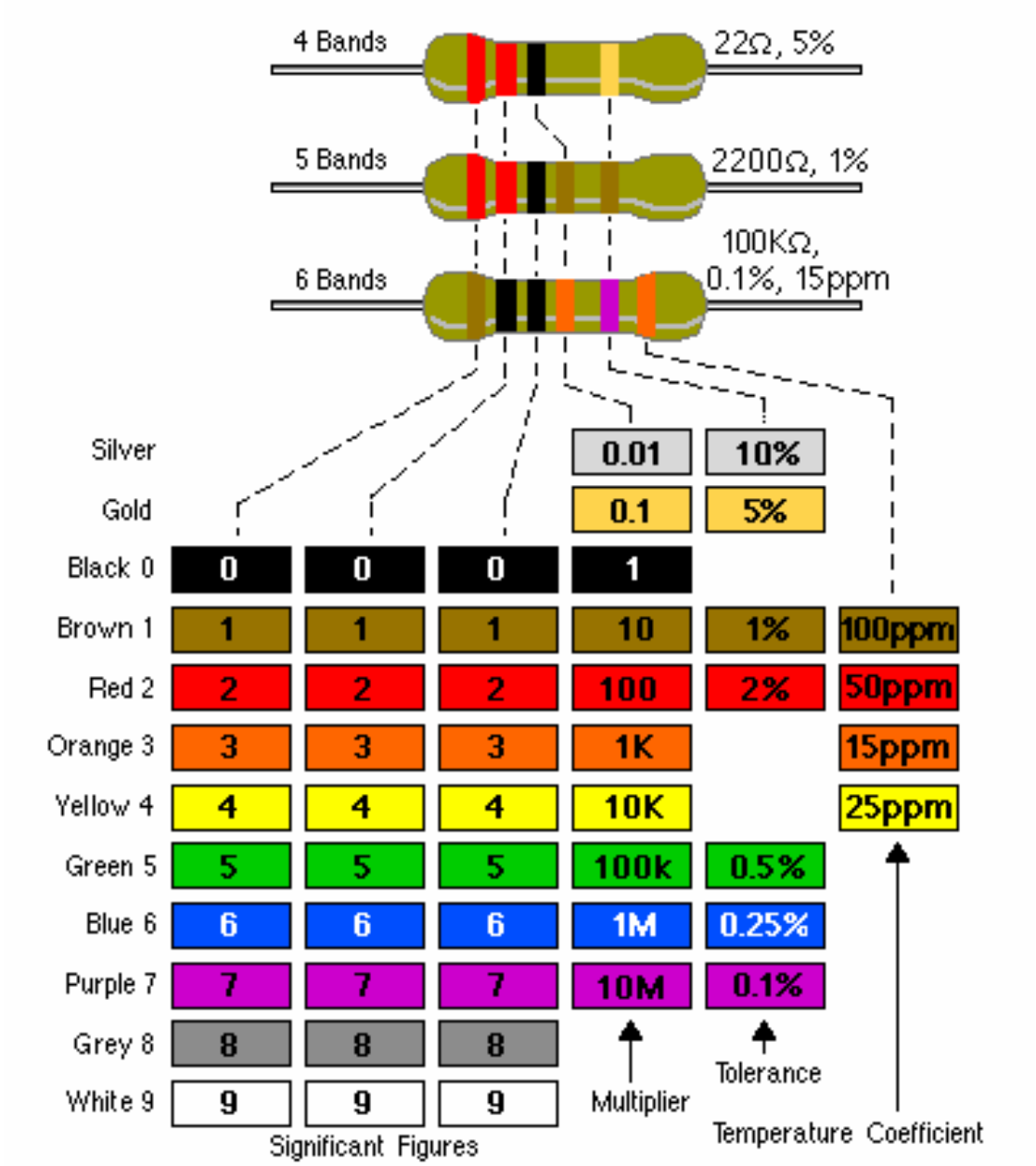
## RESISTOR COLOR CODE




Resistor Color Code System

# Kit Builders Guide

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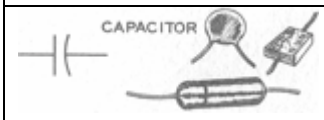
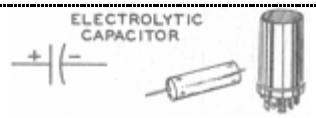
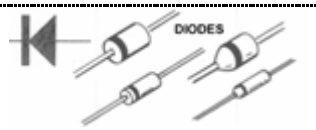
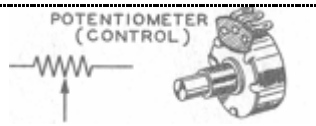
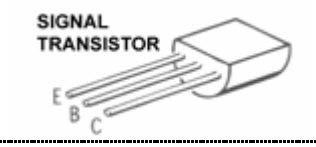
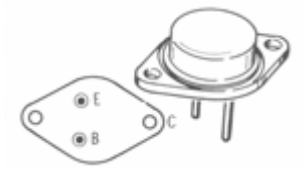
# COMPONENT IDENTIFICATION

| APPEARANCE | NOTES |
|---|---|
|  | Signal capacitors (film, mica, ceramic) are sized in units of microfarads (10E-6), nanofarads (10E-9), or picofarads (10E-12) with an associated voltage rating. They are typically not polar. When replacing capacitors, you may substitute with the same capacitance and a higher (but not lower) voltage rating. |
|  | Electrolytic capacitors are typically used when a large capacitance (> 1.0 microfarad) is required. Electrolytic capacitors are polar – that is there is a correct orientation for insertion and accordingly electrolytic capacitors always have a symbol indicating either a positive (+) or negative (-) terminal. Note- inserting electrolytic capacitors incorrectly can lead to an explosion – always double check your work and be certain that you have installed the capacitor correctly. |
|  | Diodes (also called rectifiers) cause current to flow in one direction only and as such are definitely polar. Note that selenium rectifiers are common in vintage tube circuits and have the appearance of a stack of parallel plates. You may replace selenium rectifiers with newer silicon types as shown on the left. |
|  | Fuses are used to protect associated circuitry from excessive current. There are basically two types – quick trip and slow trip. Fuses are sized in amps signifying the approximate current flow where the device will trip. **Never** exceed the manufacturers rating – you will harm the associated electronic circuit. |
|  | Potentiometers (pots) are variable resistors. Pots, like resistors, are rated in ohms, Kohms (X1000), and Megohms (X 1,000,000). Power ratings for pots used in typical tube circuits will be less than ½ watt although higher power pots are sometimes used. |
|  | This is a TO-92 transistor. It is used to amplify or buffer small currents (up to about 30ma). |
|  | This is a TO-220 device. It can be a low power transistor, Power MOS-FETs or IC regulator. The leads shown relate to a bipolar transistor. |
|  | This is a TO-3 device. It is a high power device that can carry large currents and is typically mounted on a heatsink (but not always). It can house a power transistor or high power regulator (typically used to power high current sections such as filament supplies). |
|  | Resistors are used to limit current. Resistors are sized in resistance (Ohms, Kohms, and Megohms) and power (Watts). Typical power ratings for resistors encountered in tube circuits are ½, 1, 2, and 3 watts. The higher the power the larger the body of the resistor. Resistors can be fabricated from several materials including carbon, deposited metal films, and wound wire. Each type has a particular use in tube circuits however metal film types are usually higher |

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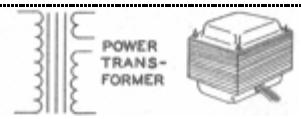
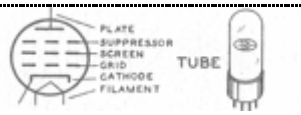
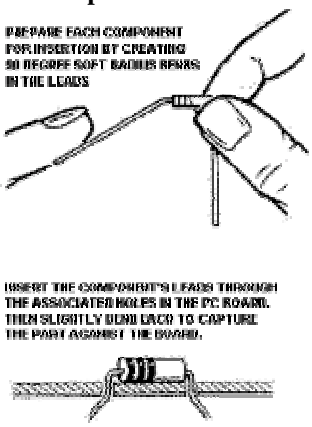
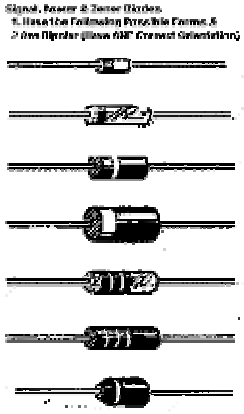
|---|---|
| | performance (at least electrically). |
|  | Power transformers convert the 110VAC from your electrical outlet to one or more AC voltages necessary to operate your amplifier. Each of these voltages is generated from "secondary" windings. Some of these "secondary" voltages are much lower and much higher (up to 1200 VAC) than the 110VAC from your outlet. |
|  | Vacuum tubes are used to rectify (like the diodes above) and amplify. Amplifiers use triodes (three elements plus the filament) and tetrodes (four or five elements). The diagram to the left is a tetrode – the triode version would not include the suppressor and screen elements. |

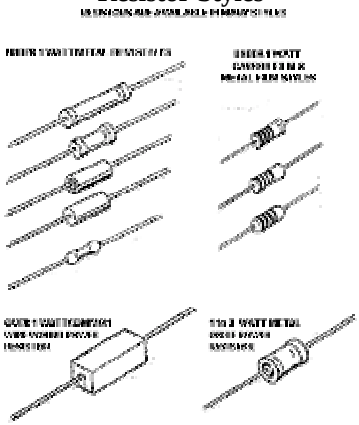
**Component Insertion**



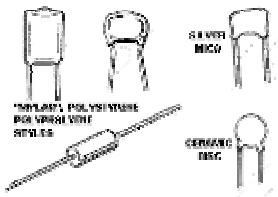

**Diode Styles**



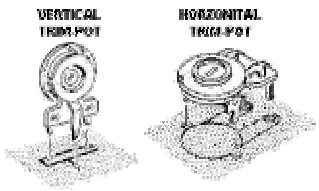
**Resistor Styles**



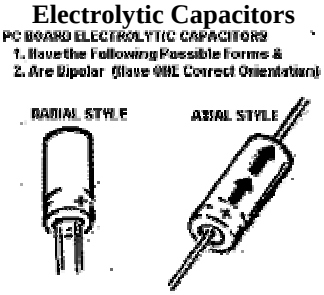
**Mylar Capacitor Types**



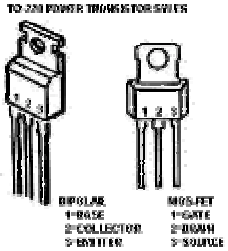

**Trimpot Types**



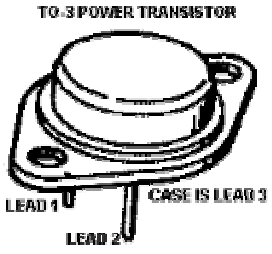

**Electrolytic Capacitors**




**Power Transistors & MOS- FETS, TO-220 Style**




**Power Transistor, TO-3 Package**



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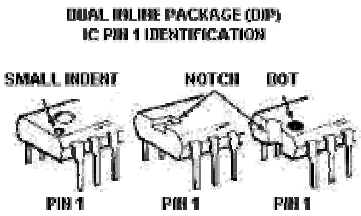
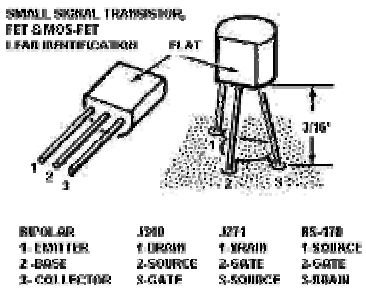
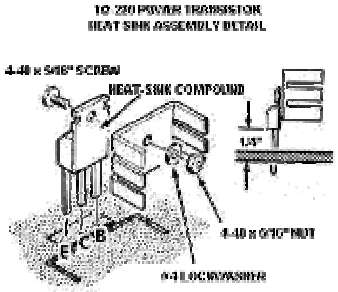
### IC DIP Orientation



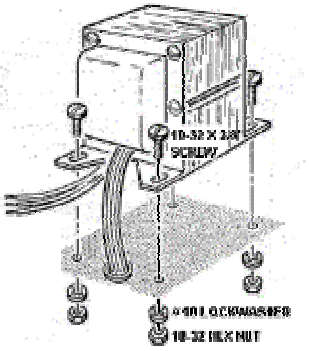

### Small Signal Transistor



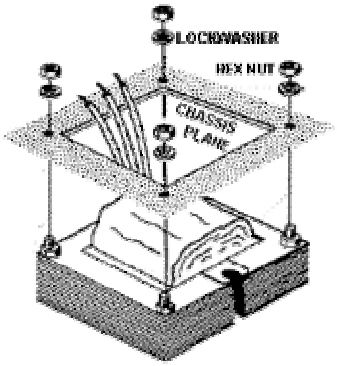

### TO-220 HeatSink Assy




### Chassis Surface Power Transformer Install

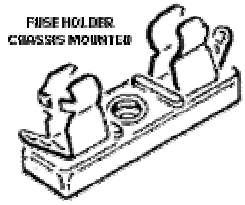



### Through Chassis Power Transformer Install

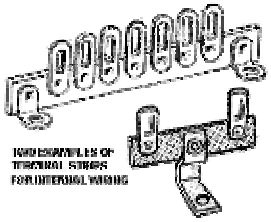


**Chassis Mount Component Illustrations**

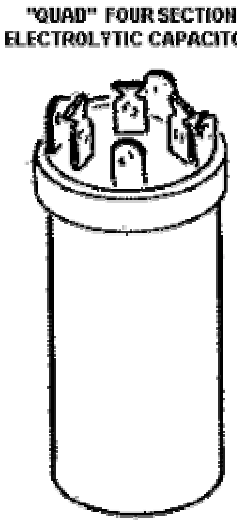
**Fuse Holder**



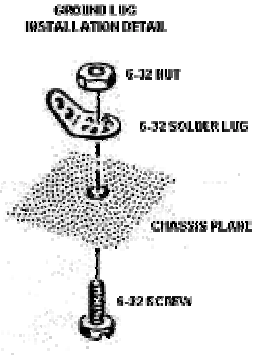

**Terminal Strips**



**Dyna "Quad" Capacitor**




**Ground Lug Installation**




**Line Cord Installation Illustration**