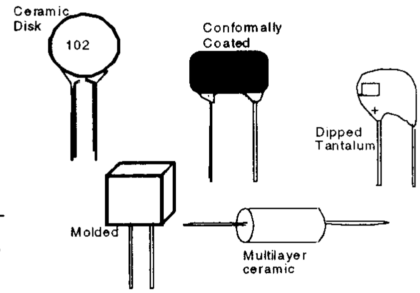
THE CAPACITORS.



Picture a piece of window glass with a sheet of aluminum foil on each side; connect a lead wire to each sheet and that would make a decent capacitor. The capacitor's purpose is to store electrons and/or to allow alternating current (such as audio or Radio Frequencies) to flow while not permitting Direct Current (DC) to pass.

Capacitors come in many varieties and we show the more popular types here. Sometimes the markings on capacitors can be very cryptic. Here is a chart showing commonly used values and how they may be marked. Note that one picofarad is .001 nanofarad and so on. A 100 picofarad capacitor could be marked with 100 ,an *underlined* number "100". OR it may be marked ".1nF" and so on.

Do you understand how a 100P capacitor is equal to a .1nF capacitor? This should be fairly clear to you from the last chapter's explanation.

Markings on capacitors vary and may be tough to figure out, causing confusion. But if you see a number *underlined* it is telling you that the value is in picofarads; and you can bank on that. A capacitor marked 43 is definitely forty-three picofards.

A .01ufd capacitor may also be marked in picofarads in a way. The maker could mark it 103 which means ten with three more decimals behind it or 10,000 pico farads. Make sense?

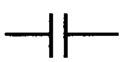
What is confusing is that one maker could mark a capacitor .01ufd and another mark the same value 103; both mean the same thing.

Note in the chart that we show the values that are equivalent to each other. When they use a code, such as 224, the significant value is in the first two numbers and the "four" indicates that you add four zeros behind it. So, this is a 220,000 picofarad capacitor which equals .22microfarad (ufd.) and so on. The chart should help a great deal with your understanding the system.

pico	nano	micro	code
1pF	.001nF	.000,001uF	*A Bar under*
4.7pF	.0047nF	.000,0047uF	*the number means*
10pF	.01nF	.000,01uF	*the value is in*
22pF	.022nF	.000,022uF	*pico farads*
100p	.1nF	.000,1uF	110
330pF	.33nF	.000,33uF	331
1000pF	1.0nF	.001uF	102
8200pF	8.2nF	.0082uF	822
10,000pF	10nF	.01uF	103
33,000pF	33nF	.033uF	333
100,000pF	100nF	.1uF	104
220,000pF	220nF	.22uF	224
1,000,000pF	1,000nF	1.0uF	105
4,700,000pF	4,700nF	4.7uF	475
10,000,000pF	10,000nF	10.0uF	106

You may see a clear marking such as **.01ufd** which could not be more clear. But when you see some other number, its time to start thinking about the "code" used in marking these little devices.

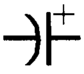
Polarity



schematic symbol

Most of the small capacitors such as those shown in the illustration at the top of the page do not care which direction they face in the circuit. Ceramic disks and "Monoblock" or monolithic can be in a circuit facing either direction. And the ceramic is certainly the most commonly used part. However, you need to watch for polarity markings on the part and *on your schematic and on your PC board layout.* A tantalum capacitor will have a "+" sign and you need to be sure that the part is installed facing the right direction.

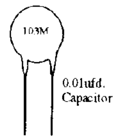
We will show you the Electrolytic capacitor in the next section and those *definitely* need to installed facing the right direction or the circuit will not work. When you see a symbol on the schematic such as the one to the left (with a "plus" sign) then you know that the part is definitely *POLARIZED* and that the part absolutely must be placed in the circuit facing the right direction. Look on the part for a polarity marking that will tell you which lead wire is the "plus" and which is the "minus" or negative lead. Match the marking on the part with the marking on the PC board or schematic and you will have the part installed correctly.



More on Capacitors

Number	Multiply by:
0	None
1	10
2	100
3	1000
4	10,000

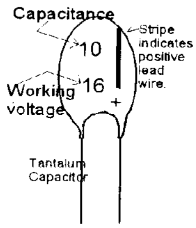
Remember that "code" marked capacitors (a marking such as 102, or 104 , or 224 etc.) have TWO Significant digits in the first part of the code and the third number is the MULTIPLIER. This last number tells you how many zeros need to be added. Remember that the value is always in picofarads (unless clearly marked such as .01ufd or .01 microfarad).



Using The chart to your right may be faster than figuring out the code. Note the .01ufd. capacitor illustration. And note the "103M" marking. The first two digits (the '1' and the '0') are actually numbers (*significant digits*), in this case ten. But the third digit is always a code for a multiplier. And here is the chart so you know what to multiply by. See how it works?

The chart on the previous page can give you the value of caps marked 102 and 104. See if you understand the system. (Put simply, the code simply indicates how many zeros to "add".)

The Tantalum capacitor....Here is one that must be inserted facing the right direction; or it won't work and may even explode with a "POP". Note that the tantalum is clearly marked with its value and working voltage.



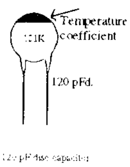
Tolerance codes

Letter	if <10 pF	if >10 pF
B	± 0.1 pF	-
C	±0.25 pF	-
D	±0.5 pF	-
E		±25%
F	±1 pF	±1%
G	-	±2%
H	-	±2.5%
J	-	±5%
K	-	±10%
M	-	±20%
P	-	-0 / +100%
S	-	-20 +50%
W	-	-0 +200%
X	-	-20 + 40%
Z	-	-20 + 80%

CAPACITOR TOLERANCE

Did you notice That the ceramic capacitor shown above was marked *103M*? Note the letter "M". This is another code to tell us the tolerance of the device, in this case it is ±20%. Here is one more chart showing all of the different tolerance markings that you may run into. There are over a dozen different tolerance values. When you replace a bad or missing capacitor, keep in mind that you can always remove a sloppy value and replace it with a 'really tight' value, such as ±2%

Temperature Coefficient



We almost hesitate to mention Temperature Coefficient in a beginners book; it probably won't be of much use but then again, if we did not mention it, it may cause some confusion. On the left is an illustration of a 120 pfd. ("one-hundred twenty pico farad") capacitor. This one has a color code indicating the temperature coefficient of the device; see the Temp Coefficient Chart for that.

The temperature coefficient is only sometimes of great importance, such as in a frequency controlling section of a transmitter or some such. A capacitor can be designed in such a way that it will hold very close to its value even when the temperature inside the circuit's case rises quite a bit. A close tolerance and 'tight' temp coefficient may be necessary to help keep the circuit from "drifting" and getting off-frequency. (So that you don't find channel three showing up on channel four etc.)

You can look up the meaning of temperature coefficients later on in life. But, in brief, "NPO" means "negative/positive/zero" and is an indication of high stability, usually good for circuits such as Variable Frequency Oscillators (VFO's). When you need to know more, check your library as we don't want to get more involved here.

The reason that "tight" tolerance capacitors and very stable NPO type capacitors are not used universally is that they are simply not necessary and their high cost would increase the cost of all kinds of electronic equipment with no increase in performance. However, you may see some of the expensive audio equipment, video equipment and so on using NPO values in places that cheaper makers do not use them. Sometimes quality parts, that will contribute to stability and performance, are hidden from view except in the price tag of a piece of equipment.

Color	Temperature Coefficient		Color	Temperature Coefficient
Black	NPO		Blue	N 470
Brown	N030/N033		Violet	N 750
Red	N075/N080		Gray	--
Orange	N 150		White	P 100
Yellow	N 220		Red & Violet	P100
Green	N 330			

Note: any capacitor is going to be made of two conducting materials with a dielectric between them to keep them apart electrically. The conductor in an electrolytic may simply be aluminum foil, the dielectric a sheet of plastic. The conductors in a variable capacitor are usually aluminum plates and the dielectric is the air between the plates.

Working Voltage

The working voltage of a capacitor is easy to understand. If a part says that the working voltage (or WV) is 200 volts, then you may use it for any voltage LESS than that. For example, if a part is marked 16WVDC, then you may certainly use it in a twelve volt circuit. A capacitor is more accurate, however, if the circuit and the working voltage are not too far apart; a capacitor marked 50 WV could be used (in a pinch) in a 12 volt circuit but the capacitor marked 16 volts will be closer to its value in farads than the fifty volt unit when used at 12 volts. Electrolytics will vary somewhat in value as the voltage varies. Often, you won't be able to notice a difference. Usually, we use a capacitor with a WV just a bit higher than the circuit's voltage unless we just don't have one and then we try the larger WV capacitor. Sometimes it will make the circuit work wrong (such as audio circuits) but it can't do damage.

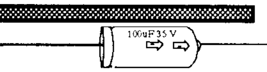
Wattage

You will recall that we showed some different 'wattage' resistors in the resistor section. While capacitors need to be used at their peak working voltage, or below that voltage, a resistor has a power rating rather than a voltage rating.

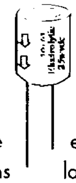
Just remember that you may use a 1/2 watt resistor in circuit up to 1/2 watt but when it creeps above 1/2 watt, switch to a 1 watt resistor; the value in ohms does not change.

Most of the time, the schematic will tell you what wattage is needed. It is OK to use a bigger wattage to replace a smaller wattage.

The Electrolytic Capacitor



The electrolytic is definitely a polarize part; meaning: you need to be sure to place it on a circuit board facing the correct direction. The negative lead is usually identified and the circuit board layout or the schematic will show a "+" plus mark and/or the "-" negative. These marks will be located on a PC board by the hole for each lead wire.



Electrolytics are usually marked clearly in microfarad and won't be hard to identify. Sometimes the lead wires come out of one end and this is called a radial lead electrolytic. The leads may come out of opposite ends of the "tube" (top right), and this is called an axial lead electrolytic. It does not matter which style you use as long as the value in microfarads is correct and you use the correct working voltage capacitor (or one that is bigger; read the Working Voltage section above if you did not do so already).

The symbol for an electrolytic , shown to the left, will always indicate which lead is positive or negative or both. The negative lead on the capacitor must go the negative in the hole on the PC board marked negative and the schematic will also show the polarity. Finally; note that one of the two sides of the capacitor is shown as a curved line; often both sides having a straight line and don't worry about it. This is just a variation in symbols from older styles to newer and does not change anything. (Note below is a variable symbol drawn with two straight lines and an arrow; if one line were curved, nothing is changed.)

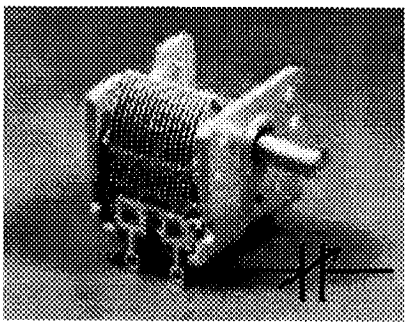
The Variable Capacitor

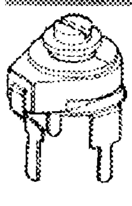
With the invention of radio, the tuning device that we have used to select the radio station has been the variable capacitor. Solid-state devices are rapidly replacing them in many circuits, but chances are the tuning device in your Walkman or other portable is still a variable capacitor.

You may find variable capacitors in circuits such as the clock circuit in your computer or the oscillator in an FM microphone.

A variable capacitor has two metal plates separated by a dielectric, which could be mica or plastic but might be air. Often, a number of metal plates are used on each side to obtain the needed capacitance in a smaller space. The upper photo on the right is a good example of this.

The 'variable' has no polarity, connect it facing either direction. You'll probably see your first one if you build a radio receiver kit. Most FM transmitter or microphone kits tune using a small variable capacitor.





Above, typical radio tuning variable capacitor. Left, a trimmer variable capacitor (screwdriver adjustable).

CONDENSER is sometimes used to mean capacitor, especially in older texts. The terms ***condenser*** *and* ***capacitor*** *mean the same thing.*

Note that the symbol for the variable capacitor is a capacitor symbol with the addition of the arrow to indicate that the part is adjustable.

Designs vary ; adjustment may be made by turning a knob, which is connected to a shaft that in turn moves the plates. Or you may see a slot for a screwdriver or a tuning tool. There are quite a few variations in designs and a peek inside a couple of radios will will give you a better idea of what they look like. Some variables are completely encased in a plastic housing with the tuning shaft and connection lugs protruding. Some simply move the plates closer or further apart to change capacitance. §