http://www.outersound.com/osu/equipment/to-capacitors.html

Capacitors

What they are, What they do and How to change your filter caps

By Geoff Farina

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Disclaimer #1: Do not open up your amplifier unless you know what you are doing! Tube amps work with lethal voltages that can remain in the amp even after it is unplugged. If you don't know how to discharge filter caps and how to safely work on your amp, don't try it. If you or your amp die, I am not responsible.

Disclaimer #2: I'm no expert. I've learned only from blowing shit up, shocking myself, and a little research on the side. Don't trust me. Do research for yourself. Start with a reprint of the RCA Receiving Tube Manual from Antique Electronics (602.820.5411).

Zealots: capacitors are our friends. In this issue I will explain what they are, what they do, and finally how you can change your filter caps and make your amp have something most of us rarely experience: Real BASS!

What do they look like? That's the question that I wish someone answered for me when I fist became curious about this stuff. The most easily identifiable are the ones that look like little brown plain M&Ms, but there are also lots of other kinds as well: some look like little cylinders with obscure codes on them, the old Fender tone caps look like blue Good- N-Plenty's, others don't look like candy at all.

One thing that they all have in common is that they all have two leads, and they are marked with two codes: There is usually s voltage number on the cap, which designates the highest voltage the cap can handle. You will also see another code that designates is the amount of capacitance they are capable of, in fractions of *farads*, usually designated by units of 'mfd' or 'uF.' Even smaller fractions of farads, or picofarads, are designated by the unit 'pf'. Farads are units of capacitance, but don't worry about what this means now. Just remember that if you see any of these three abbreviations on a part, it's got to be a cap.

To got an idea of what caps do, I'm going to give you a bit of history and this will lead us to a basic understanding of what capacitance is and how it works. The capacitor story goes something like this: way back in the 1700's two smart guys at the University of Leyden in the Netherlands coated a glass jar with tin foil on the inside and the outside. The inside foil and outside foil were not connected. Then the jar was corked, and a metal rod was stuck through the cork so that it made contact with the foil on the inside. What was discovered was that the jar could be charged on the outside, and then later discharged by way of the metal rod through the cork: the two conductors that were separated by a fraction of an inch of glass were able to store a static charge. It had the capacity to store a charge, which is one of the many things that capacitors do.

These days your amplifier (and any other gear you have) has lots of different kinds of capacitors that do lots of different jobs, but basically they all evolved from the Leyden Jar, they all have two plates that are placed very close together, and separated by a nonconductive substance called a dielectric, just as the inside and outside tin surfaces on the Leyden Jar were separated from each other by the glass. These days the dielectric is no longer made of glass, but of other materials incuding some gelatinous material that tends to dry up after a while, as I will got to later.
How do they work? There's some heavy math, but in my opinion, the easiest way to think about capacitors and their characteristics is to think about the specific jobs they do in your amp. First of all, capacitors pass high frequencies and attenuate low frequencies. In essence, they are high pass

filters, and the greater the capacitance they have, the lower the frequencies they allow to pass through them. This is how the tone controls work on the amplifier. Your tone controls are a series of resistors that direct parts of your guitar signal through capacitors of certain values to control what frequencies are stopped, and which ones are let through.

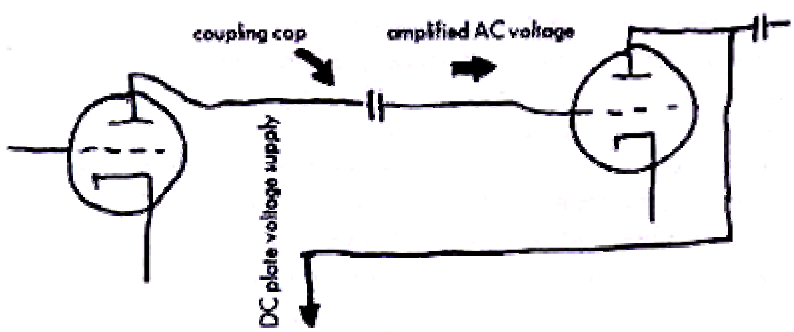
Because caps pass high frequencies, they are also used to suppress oscillations in amplifiers. Without getting too involved, this means that when an amplifier starts to freak out and squeal at high frequencies for whatever reason, capacitors can be used to bleed off the higher frequencies to ground, while the more usable part of the signal is allowed to continue through the circuit. This is just what happened in the seventies when Fender was trying to make their amps louder and cleaner. The new designs had a tendency to oscillate due to the new layout of the wiring that evolved after some of the components were changed around, and the transformers were made bigger. Engineers used caps to bleed off some of these annoying oscillations. Although this stopped the problem, most people say they give these amps a sterile sound because they also have a tendency to bleed off the higher harmonics that make tube amps sound good.

(Note... the high pitched ringing sound your amp usually makes is not parasitic oscillation. It is a microphonic preamp tube, a problem that is far more common. Here's how to tell the difference: pull the guitar cord out of the input jack. Turn it up really loud and smack it. Does it make the amp ring more or stop ringing? Yes? Then reach around back and tap on each preamp tube individually. The one that makes the sound needs to be replaced.)

Another important characteristic of caps is their ability to store a charge, as I mentioned before. They do this much like the battery in your Walkman, but for a much shorter time. What is really cool is that you can use them to store the signal voltage, instead of the power supply voltage that Duracells are usually used for. This can lead to all kinds of great stuff. Vibrato circuits often use caps this way. And have you got an old analog synth with a 'glide' or portamento control? It works by storing up the signal voltage of the key you press and slowly discharging it to the rest of the amplifier circuit.

Another valuable aspect of caps is that they pass AC and do not pass DC, much in the same way transformers block DC. This makes them the likely candidates for many jobs. Caps can get rid of AC by passing it to ground, or get rid of DC by stopping it at the crossroads. This is the case with coupling caps that are used to connect amplifier stages. Your amplifier is made up of many such stages, with the plate's output of the first tube going to the grid of the second, and so on. As you'll remember, the plate has a high DC voltage on it, and if this voltage ever got to the grid of the next tube, we'd be scraping you off the ceiling. So how do we keep this DC plate voltage separate from the amplified AC signal that we want to send to the next tube? With a capacitor of course, as shown in **Figure A**. Here, the capacitor passes the amplified AC voltage on to the grid of the next tube, but keeps the high DC plate voltage where it belongs.

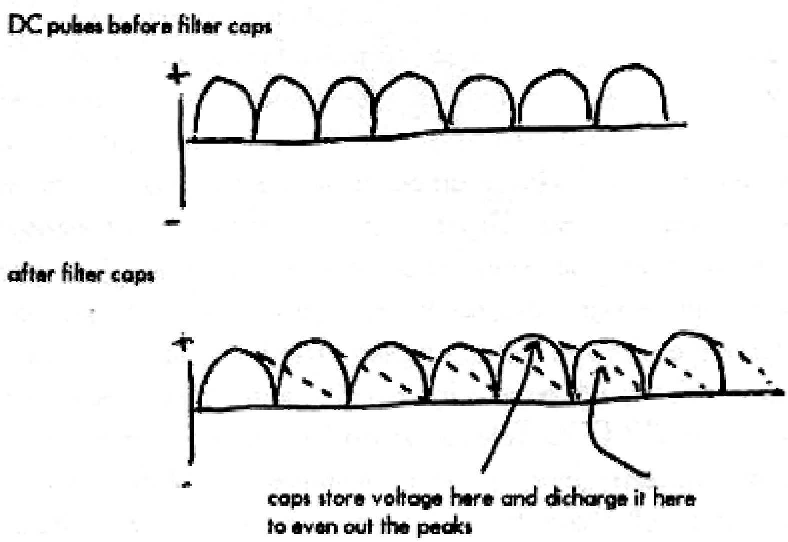
Figure A



Finally, we need to address a special kind of capacitor: the electrolytic. Basically, electrolytics have all the some characteristics as any other capacitor, except they're repolarized. This means that there is a negative lead and a positive lead, and that if you mix up the two, you're screwed. Usually the negative lead is marked, so this is pretty hard to botch up, but I've done it a few times.

One important job that these caps do is 'filter' out the AC component of the power supply voltage. As you probably know, the voltage in your wall outlet is 120 volts AC, and if we put 120 volts AC on any port of the tube, we're in deep trouble. So the amplifier needs a way to change this AC to the various DC voltages that the amp needs. The first stop is the rectifier tube, or the solid state rectifier that passes only one side of the wave and leaves us with DC pulses. The filter caps provide another part of this system by smoothing out the DC pulses to create pure DC. As you remember, caps store up voltage and then discharge it, and this is how filter caps work: they store up some of the 'pulse' and then discharge it as the pulse itself goes back toward ground, as in **Figure B**. In this way, the cap is providing the voltage in between the pulses of DC, and what comes out the other end is pure DC.

Figure B



Chances are, if you have an amp that has filter caps that are more than ten years old, they need to be changed. The dielectric in filter caps, as I mentioned earlier, is a gooey substance that dries up and stops working after ten years or so. When this dries up, your amp will develop a 60-cycle hum, lose volume, have mushy bass, and generally sound like most of the guitars you hear in the punk rock world. The good news is that you can change them and get all the good stuff back: more volume, real bass and you might even get rid of some of that hum. Here's what to do:

1) Find them and do not touch them. Clue: they are way bigger than any of the circuit board components, usually around the size of tubes. They are usually on the outside of the amp chassis with the transformers, not on the inside with the circuit board. In Fenders, they are usually under a pan in front of the tubes. In Marshalls, they are usually all combined into a big brownish-yellow cardboard tube. This tube really contains a few of them all rolled up into one convenient package.

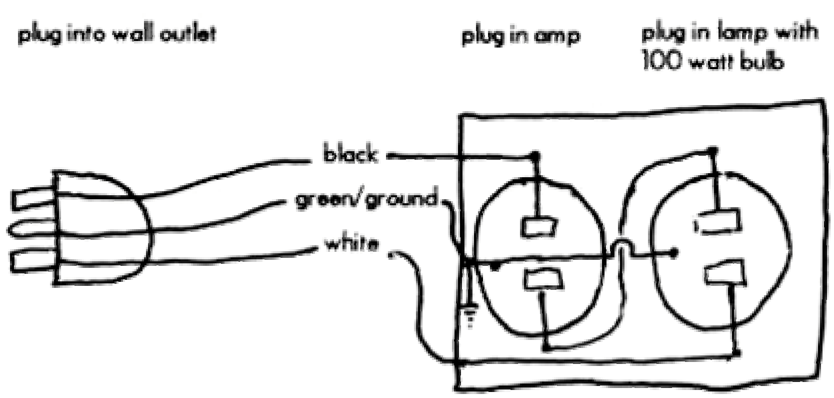
2) Do Not Touch Them! They Must First be Discharged! I can not stress this enough. I still have a small blistering burn on my finger from the filter caps in a tiny Fender Champ. A bigger amp can store enough voltage to stop your heart, unplugged. Here's how to discharge them: Unplug the amp, turn it on, and if it has a standby switch, turn that on as well. Connect one end of a jumper wire with alligator clips to pin 1 on any preamp tube, then connect the other end to the chassis (ground), essentially shorting pin 1 to ground. Keep this connection hooked up while you work inside the amp and allow a few minutes for any stored charge to bleed off before you start work.

3) Unsolder the caps and remember how they are connected, find replacements, and solder them in the same way. Use a pencil to remember where they go and what the polarities are! It can be really tricky to try to interpret this from a schematic because the wires are all under the fiberboard on a lot of amps. If you are replacing multi-caps, they might have six or more leads, so be careful. Replacements are hard to find from electronic warehouses because there is just not that much equipment out there anymore that requires large amounts of filtering. You will have better luck with Mouser, Antique Electronics or any of those warehouse-type places if your looking for smaller values, and of course the price will be right. But for bigger values and voltages you need to find a vintage guitar supplier, like Recycled Sound. The best place to look is in Vintage Guitar Magazine. Ignore all the stupid articles about this and that $12,000 Telecaster and go straight to the ads. There are at least five or ten companies like Hoffman and Kendrick that sell them. Expect to pay anywhere from $20- $50 to get what you need for bigger amps. Also, if you have a good store in your area that repairs old amps, you can usually get filter caps there.

How do you know what you need? Well, as I mentioned before, you need to get two things right: the voltage and the capacitance. Generally, you can use the same voltage or a higher than the originals and the capacitance must be in the some ballpark. For example, in a Twin, you might need something like three 20mfd/500v, and then two more 70mfd/350v. (Your caps might say '20uF' instead of '20mfd.' They are the same.) You might find replacement values that are a few mfd in either direction, which is fine as long as the voltages are at least as big as the old ones. Of course, you should always double check with the place you are buying them from. Most amp-parts suppliers that sell them list them as 'filter caps for 50w Marshalls', so it's pretty easy.

4) Charge them. When electrolytics are now, they must be brought up to voltage slowly as to properly form the dielectric and blah blah blah. I haven't decided if filter caps really need to be charged or not. Apparently Leo Fender never did. First you need a variac, or you need to **build a simple current limiter** (**figure C**). A variac is just what it sounds like: it varies the amount of AC you can send from a wall outlet to a device. They are great to have in general because if a fuse keeps blowing, you can run your amp at 12 volts and check all the voltages by multiplying what 28 you find by 10, and you won't blow the fuse because you're only drawing 1/10 of the current. Variacs start at around $175, but I got mine at the antique store for $10. So what if it only goes up to 110 volts! Junk stores with old radio parts are the best because hobbyists used to use them. If you have one, use it. Give it a few hours on some small voltage and then increase gradually. Be creative.

Figure C



If you don't have one, build a simple current limiter out of a three-prong extension chord, a lamp, and a 100-watt lightbulb. **(figure C)** This project is quite simple, **BUT IT DEALS WITH LETHAL VOLTAGESI DO NOT TOUCH THE BARE WIRES, AND INSULATE EVERYTHING BEFORE YOU PLUG IT IN!** The idea is to put the bulb in series with the amp, so that all the current must first go through the lightbulb before it goes through the amp. This way, the bulb will not glow until the amp is plugged in. When you have both plugged in, the bulb should not glow at its full Brightness because some of the current is being used up by the amp. This way, the amp doesn't get the full AC current and the caps are allowed to warm up at a lower voltage before they get the full wall voltage. When I did this before I found a variac, I gave it a couple hours and kept my eye on everything to make sure it didn't blow up.

5) Rock. If you changed and biased your power tubes and your driver tube you should have 100% more volume, less hum, and really firm bass after you change the caps. In fact, you'll be surprised how much you can got out of an amp this way.

Capacitor uF - nF - pF Conversion Chart

When reading schematics, repairing radios and buying capacitors, you often must convert between uF, nF and pF. Paper and electrolytic capacitors are usually expressed in terms of **uF** (**micro**farads). Short forms for micro farad include **uF**, mfd, MFD, MF and UF. Mica capacitors are usually expressed in terms of **pF** (**micromicro**farads) (picofarads). Short forms for micromicrofarads include **pF**, mmfd, MMFD, MMF, uuF and PF. A pF is one-millionth of a uF. In between a pF and a uF is a nF which is one-one thousands of a uF. Converting back and forth between uF, nF and pF can be confusing with all those darn decimal points to worry about. Below is a uF - nF- pF conversion chart. Just **print a copy and tape it to your workbench**....it will come in handy. Have fun with your radio restorations.

To use this table, just read across. For example, 1uF is same 1,000nF or 1,000,000pF.

uF/ MFD	nF	pF/ MMFD		uF/ MFD	nF	pF/ MMFD
1uF / MFD	1000nF	1000000pF(MMFD)		0.001uF / MFD	1nF	1000pF(MMFD)
0.82uF / MFD	820nF	820000pF (MMFD)		0.00082uF / MFD	0.82nF	820pF (MMFD)
0.8uF / MFD	800nF	800000pF (MMFD)		0.0008uF / MFD	0.8nF	800pF (MMFD)
0.7uF / MFD	700nF	700000pF (MMFD)		0.0007uF / MFD	0.7nF	700pF (MMFD)
0.68uF / MFD	680nF	680000pF (MMFD)		0.00068uF / MFD	0.68nF	680pF (MMFD)
0.6uF / MFD	600nF	600000pF (MMFD)		0.0006uF / MFD	0.6nF	600pF (MMFD)
0.56uF / MFD	560nF	560000pF (MMFD)		0.00056uF / MFD	0.56nF	560pF (MMFD)
0.5uF / MFD	500nF	500000pF (MMFD)		0.0005uF / MFD	0.5nF	500pF (MMFD)
0.47uF / MFD	470nF	470000pF (MMFD)		0.00047uF / MFD	0.47nF	470pF (MMFD)
0.4uF / MFD	400nF	400000pF (MMFD)		0.0004uF / MFD	0.4nF	400pF (MMFD)
0.39uF / MFD	390nF	390000pF (MMFD)		0.00039uF / MFD	0.39nF	390pF (MMFD)
0.33uF / MFD	330nF	330000pF (MMFD)		0.00033uF / MFD	0.33nF	330pF (MMFD)
0.3uF / MFD	300nF	300000pF (MMFD)		0.0003uF / MFD	0.3nF	300pF (MMFD)
0.27uF / MFD	270nF	270000pF (MMFD)		0.00027uF / MFD	0.27nF	270pF (MMFD)
0.25uF / MFD	250nF	250000pF (MMFD)		0.00025uF / MFD	0.25nF	250pF (MMFD)
0.22uF / MFD	220nF	220000pF (MMFD)		0.00022uF / MFD	0.22nF	220pF (MMFD)
0.2uF / MFD	200nF	200000pF (MMFD)		0.0002uF / MFD	0.2nF	200pF (MMFD)
0.18uF / MFD	180nF	180000pF (MMFD)		0.00018uF / MFD	0.18nF	180pF (MMFD)
0.15uF / MFD	150nF	150000pF (MMFD)		0.00015uF / MFD	0.15nF	150pF (MMFD)
0.12uF / MFD	120nF	120000pF (MMFD)		0.00012uF / MFD	0.12nF	120pF (MMFD)
0.1uF / MFD	100nF	100000pF (MMFD)		0.0001uF / MFD	0.1nF	100pF (MMFD)
0.082uF / MFD	82nF	82000pF (MMFD)		0.000082uF / MFD	0.082nF	82pF (MMFD)
0.08uF / MFD	80nF	80000pF (MMFD)		0.00008uF / MFD	0.08nF	80pF (MMFD)
0.07uF / MFD	70nF	70000pF (MMFD)		0.00007uF / MFD	0.07nF	70pF (MMFD)
0.068uF / MFD	68nF	68000pF (MMFD)		0.000068uF / MFD	0.068nF	68pF (MMFD)
0.06uF / MFD	60nF	60000pF (MMFD)		0.00006uF / MFD	0.06nF	60pF (MMFD)
0.056uF / MFD	56nF	56000pF (MMFD)		0.000056uF / MFD	0.056nF	56pF (MMFD)
0.05uF / MFD	50nF	50000pF (MMFD)		0.00005uF / MFD	0.05nF	50pF (MMFD)

0.047uF / MFD	47nF	47000pF (MMFD)		0.000047uF / MFD	0.047nF	47pF (MMFD)
0.04uF / MFD	40nF	40000pF (MMFD)		0.00004uF / MFD	0.04nF	40pF (MMFD)
0.039uF / MFD	39nF	39000pF (MMFD)		0.000039uF / MFD	0.039nF	39pF (MMFD)
0.033uF / MFD	33nF	33000pF (MMFD)		0.000033uF / MFD	0.033nF	33pF (MMFD)
0.03uF / MFD	30nF	30000pF (MMFD)		0.00003uF / MFD	0.03nF	30pF (MMFD)
0.027uF / MFD	27nF	27000pF (MMFD)		0.000027uF / MFD	0.027nF	27pF (MMFD)
0.025uF / MFD	25nF	25000pF (MMFD)		0.000025uF / MFD	0.025nF	25pF (MMFD)
0.022uF / MFD	22nF	22000pF (MMFD)		0.000022uF / MFD	0.022nF	22pF (MMFD)
0.02uF / MFD	20nF	20000pF (MMFD)		0.00002uF / MFD	0.02nF	20pF (MMFD)
0.018uF / MFD	18nF	18000pF (MMFD)		0.000018uF / MFD	0.018nF	18pF (MMFD)
0.015uF / MFD	15nF	15000pF (MMFD)		0.000015uF / MFD	0.015nF	15pF (MMFD)
0.012uF / MFD	12nF	12000pF (MMFD)		0.000012uF / MFD	0.012nF	12pF (MMFD)
0.01uF / MFD	10nF	10000pF (MMFD)		0.00001uF / MFD	0.01nF	10pF (MMFD)
0.0082uF / MFD	8.2nF	8200pF (MMFD)		0.0000082uF / MFD	0.0082nF	8.2pF (MMFD)
0.008uF / MFD	8nF	8000pF (MMFD)		0.000008uF / MFD	0.008nF	8pF (MMFD)
0.007uF / MFD	7nF	7000pF (MMFD)		0.000007uF / MFD	0.007nF	7pF (MMFD)
0.0068uF / MFD	6.8nF	6800pF (MMFD)		0.0000068uF / MFD	0.0068nF	6.8pF (MMFD)
0.006uF / MFD	6nF	6000pF (MMFD)		0.000006uF / MFD	0.006nF	6pF (MMFD)
0.0056uF / MFD	5.6nF	5600pF (MMFD)		0.0000056uF / MFD	0.0056nF	5.6pF (MMFD)
0.005uF / MFD	5nF	5000pF (MMFD)		0.000005uF / MFD	0.005nF	5pF (MMFD)
0.0047uF / MFD	4.7nF	4700pF (MMFD)		0.0000047uF / MFD	0.0047nF	4.7pF (MMFD)
0.004uF / MFD	4nF	4000pF (MMFD)		0.000004uF / MFD	0.004nF	4pF (MMFD)
0.0039uF / MFD	3.9nF	3900pF (MMFD)		0.0000039uF / MFD	0.0039nF	3.9pF (MMFD)
0.0033uF / MFD	3.3nF	3300pF (MMFD)		0.0000033uF / MFD	0.0033nF	3.3pF (MMFD)
0.003uF / MFD	3nF	3000pF (MMFD)		0.000003uF / MFD	0.003nF	3pF (MMFD)
0.0027uF / MFD	2.7nF	2700pF (MMFD)		0.0000027uF / MFD	0.0027nF	2.7pF (MMFD)
0.0025uF / MFD	2.5nF	2500pF (MMFD)		0.0000025uF / MFD	0.0025nF	2.5pF (MMFD)
0.0022uF / MFD	2.2nF	2200pF (MMFD)		0.0000022uF / MFD	0.0022nF	2.2pF (MMFD)
0.002uF / MFD	2nF	2000pF (MMFD)		0.000002uF / MFD	0.002nF	2pF (MMFD)
0.0018uF / MFD	1.8nF	1800pF (MMFD)		0.0000018uF / MFD	0.0018nF	1.8pF (MMFD)
0.0015uF / MFD	1.5nF	1500pF (MMFD)		0.0000015uF / MFD	0.0015nF	1.5pF (MMFD)
0.0012uF / MFD	1.2nF	1200pF (MMFD)		0.0000012uF / MFD	0.0012nF	1.2pF (MMFD)
0.001uF / MFD	1nF	1000pF (MMFD)	....	0.000001uF / MFD	0.001nF	1pF (MMFD)

http://www.arar93.dsl.pipex.com/mds975/Content/components01.html

LARGE CAPACITORS

Electrolytic
Probably the most common large capacity capacitor is the Electrolytic type. Most Electrolytic capacitors are clearly marked with the value of the capacitor in microfarads (uF), the polarity of the leads, and the working voltage. For this reason electrolytic capacitors are often the easiest capacitors to identify and use.

Most electrolytic capacitors will have clearly printed on the body something like" 220uF 50volts". It is very important to remember that most electrolytic capacitors are polarized i.e. the must be connected the correct way round in the circuit - to identify polarity these capacitors will generally have a (usually white) stripe down one side with a -ve sign to indicate that lead is to go only to the negative side of the circuit and the +ve lead will usually be longer than the -ve lead to help identification. Because DC is usually present in a circuit an electrolytic capacitor must be connected the right way round, if it is connected the wrong way round it may explode, so be careful!

Tantalum
Another type of capacitor that is available in large capacities is the Tantalum Bead type, they are much smaller than electrolytic capacitors and also usually have lower working voltages. Tantalum capacitors are also polarized and must be connected the right way round in the circuit. Modern tantalum bead capacitors have the value printed on the casing along with the voltage and polarity marking.

Older ones use a color code in the form of stripes and a spot. The top two stripes give the first two digits - using the colors in the table below, and the spot is the multiplier: Grey Spot = x 0.01 : White Spot = x 0.1 : Black Spot = x 1 . The third (bottom stripe) is the voltage marking - yellow being 6.3V; black being 10V; green being 16V; blue being 20V; grey being 25V; white being 30V and pink being 35V. The positive lead is the one on the right hand side when the spot is facing you.

SMALL CAPACITORS

Small value capacitors will be unpolarized and therefore can be connected into a circuit either way around. Many circuits specify small capacitors. They are available in a wide range of values, with the various polyester types and ceramic capacitors being popular choices. Some circuits may specify capacitor values in microfarads (uF), some in nanofarads (nF) while others may use picofarads (pF). The different and varied types of component marking used on capacitors can all be rather confusing!

PRINTED VALUES

Some capacitors simply have the value printed on them which sounds easy, but you have to know if the number is in microfarads, nanofarads or picofarads. It seems to be common that if, for example, a capacitor is marked 0.22 this means 0.22 microfarads (uF) and if the printed marking is, for example, 2n2 then this would be a 2.2nF (nanofarad) capacitor.

SIMPLE TWO DIGIT MARKINGS

Often the capacitor will simply be marked with a two digit number printed on the body such as "10" for example. This indicates that it is a 10pF capacitor. However you may find some capacitors marked "10n" and this capacitor will have a value of 10nF (ie 10,000pF), this is sometimes seen on polystyrene types and some resin dipped ceramics.

CODED THREE DIGIT MARKINGS

Many capacitors use a coded marking system, and it seems that the majority of modern capacitors that I have used in recent years fall in to this category, so here is a guide:

When we get our bag full of bits through the post, or eventually arrive home from the electronics shop with our little plastic bag full of components, keen to construct a circuit we will often find that many capacitors are marked with a three digit code such as "103" or "104" and some others have a three digit code plus a letter on the end such as "101K" or "102K". This can lead to a bit of 'head scratching' before construction of our exciting project can begin! Once we can familiarize ourselves with these codes or have a chart at hand then progress to the all important construction stage will be much swifter.

The capacitors marked with three digits are similar to resistors in that the first two digits need to be multiplied by the third digit in order to obtain the value in PICOFARADS (pF) as above. The letter is present to indicate the tolerance of the component. So 100 would be 10pF multiplied by zero i.e. 10pF. 103 is 10pF multiplied by 1000 ie 10,000pF or to put is another way 0.01 microfarads. 471K would be a 470pF capacitor with a 10% tolerance.

Help is at hand.....

To help make sense of all this and to be able to easily convert from nF to pF to uF etc. here's a very handy little table:

Remember that the code marking, when decoded, will provide the value in Picofarads (pF), but the table below shows you the values in microfarads (uF) and nanofarads (nF) too.

CODE / Marking	µF microfarads	nF nanofarads	pF picofarads
1RO	0.000001	0.001	1
100	0.00001	0.01	10
101	0.0001	0.1	100
102	0.001	1	1,000
103	0.01	10	10,000
104	0.1	100	100,000
105	1	1,000	1,000,000
106	10	10,000	10,000,000
107	100	100000	100,000,000

TABLE A

coded-decipher- value(pf)- value(nf)-value(uf)......coded-decipher- value(pf)- value(nf)-value(uf)

102	10+00	=1,000pf	1nf	.001uf	333	33+000	33,000pf	33nf	0.033uf
103	10+000	=10,000pf	10nf	.01uf	334	33+0000	330,000pf	330nf	0.33uf
104	10+0000	=100,000pf	100nf	.1uf	472	47+00	4,700pf	4.7nf	0.0047uf
222	22+00	=2,200pf	2.2nf	.0022uf	473	47+000	47000pf	47nf	0.047uf
223	22+000	=22,000pf	22nf	.022uf	502	50+00	5,000	5nf	0.005uf
224	22+0000	220,000pf	220nf	.22uf	503	50+000	50,000pf	50nf	0.05uf
332	33+00	3300pf	3.3nf	.0033uf	504	50+0000	500,000pf	500nf	0.5uf