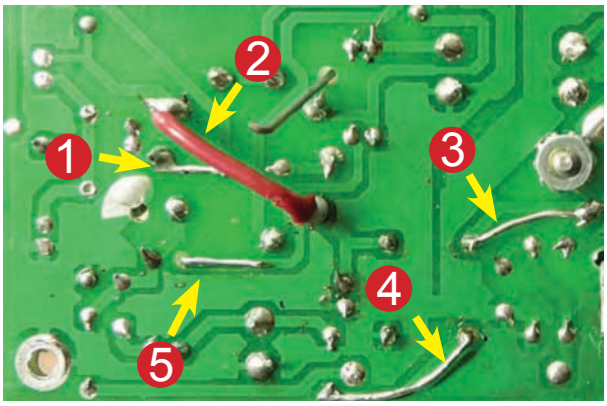
Tips 'n Tricks for
Working on PCBs

A PCB (printed circuit board) begins life as a solid sheet of thin copper foil across a backing material made of epoxy resin. Then, using a photographic process, a circuit is imprinted onto the foil and all unnecessary copper is etched away. What's left are copper foil "traces" that take the place of wires. To prevent shorts, PCBs are laminated with a colored insulating material (green for the ***AC4tv***) that functions just like the shielding around insulated wire. Although PCBs may be many layers thick, the PCB used in the ***VOX AC4tv*** is single-layered, which makes it easier to work on or modify.

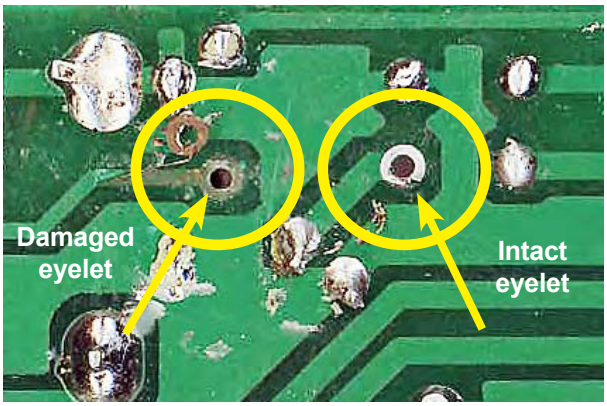
PCBs cost substantially less to produce than their predecessors, i.e. *point-to-point* circuit boards. And are used by amp manufacturers to maintain affordable prices for consumers.

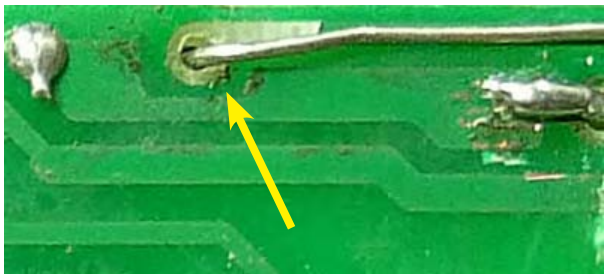
On a PCB components are often attached to the top of the board and then soldered from the back via pass-through conductive "eyelets" where they follow the traces that make up the circuit.

Asian-made PCBs are typically not as resilient as those made in the west. Therefore they're likely to require patching and repair work as you make the ***Upgrade***. This is normal, and easy to do – as long as you know a few tricks.



Various examples: 1. Jumper. 2. Jumper. 3. Trace repair (jumper soldered from terminal to terminal on same trace). 4. Trace repair (ditto). 5. Damaged eyelet repair (lead is soldered to a revealed trace).





Repair to a damaged eyelet: The lead from component bypasses the damaged eyelet and is soldered to either a revealed trace or another terminal on the same trace (as in this example).

Revealing a Trace: Sometimes we need to "reveal" traces so that the PCB can be modified or repaired. An easy way to do this is to take a sharp knife or *Exacto* and carefully scrape away the lamination to "reveal" the copper foil under it. Use high-grade (99%) Isopropyl alcohol and a Q-tip to clean these new contacts before soldering to them.

How to Repair Damaged Eyelets: The PCB's conductive eyelets are easily damaged and

Continued on next page ➔

often just fall off in the process of making repairs and modifications. If this happens the easiest workaround is to reveal about 1/8” of trace material (near the eyelet hole on the same circuit) and solder the component’s lead connection directly to that.

Or, if there’s a nearby soldered connection on the same trace, you can use the component’s lead to jumper directly to the terminal.

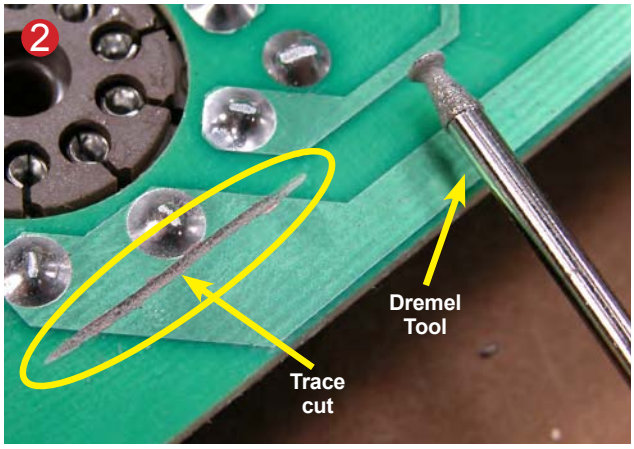
If an eyelet is damaged or missing or the trace material around it is very thin, then you may consider soldering a reinforcement jumper across it.

How to Cut a Trace: A “trace” is the conductive strip (foil) on a printed circuit board. It has a very thin laminate or lacquer layer over it. Cutting a trace is like clipping a wire. Use a box knife, *Exacto* knife or a *Dremel Tool* with a cutting or grinding edge attachment to make the cuts.

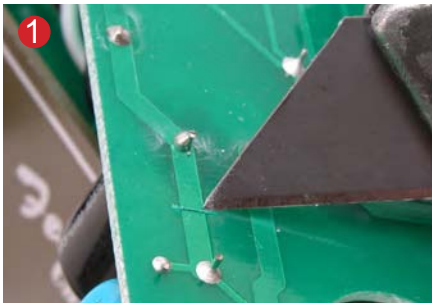
Various examples: This photo shows a cut trace, and a component lead jumpered and soldered to a revealed trace. It’s best to not drill a hole directly into a trace. Instead make the hole off to the side of the trace and then, as in this example, solder the component’s leg to the trace.

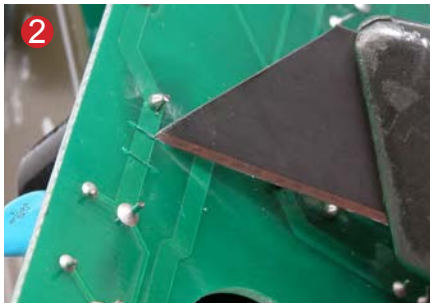
A *trace cut* severes the embedded metal laminent on a PCB. The purpose of a *trace cut* is to modify or re-route the electrical flow of the circuit.

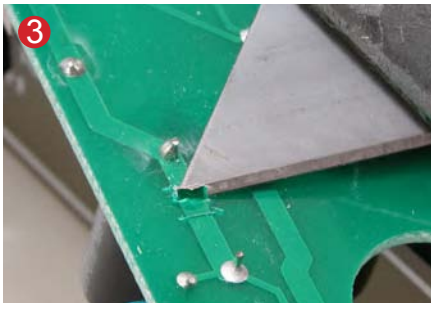
Here’s two different ways to cut a trace:

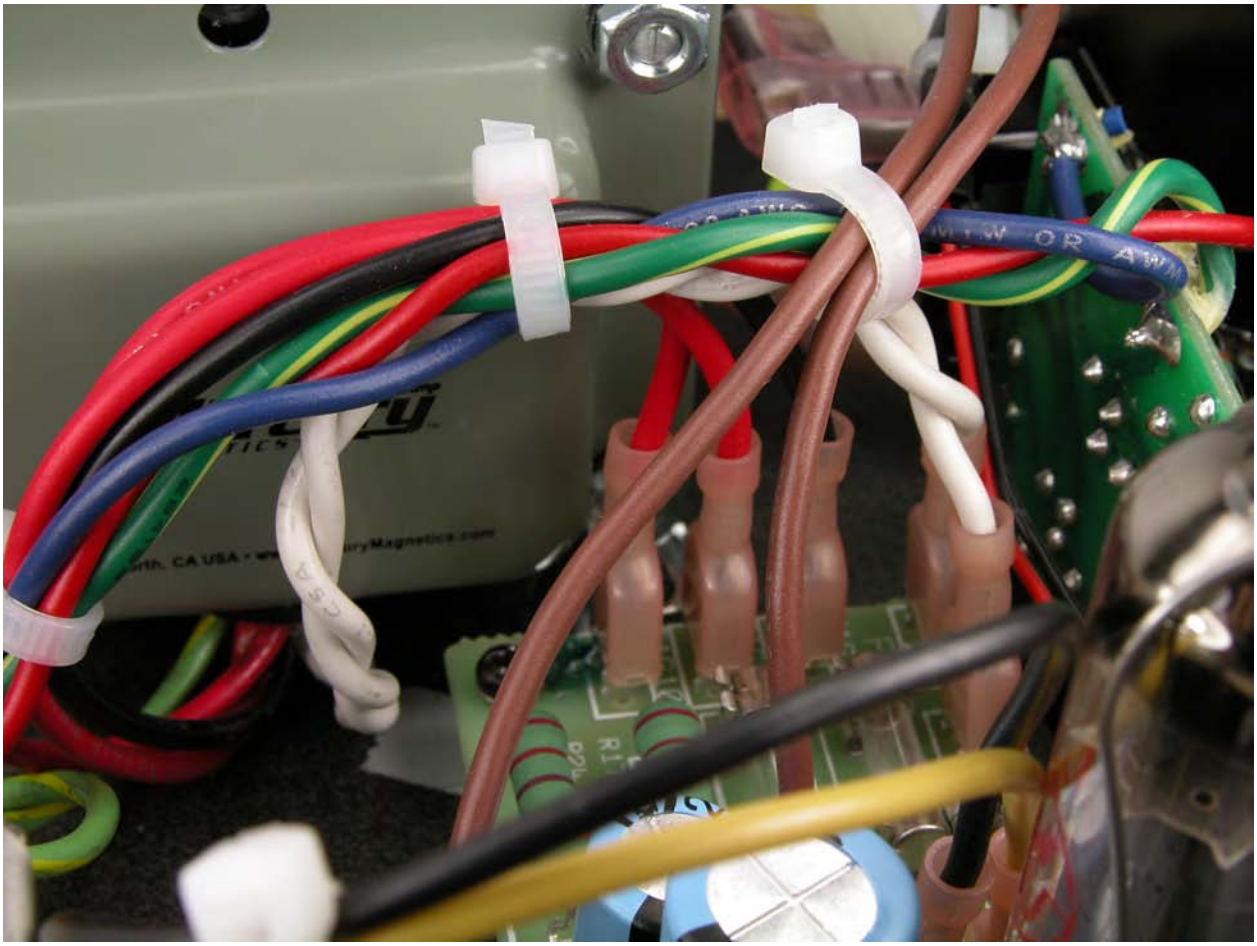


OR









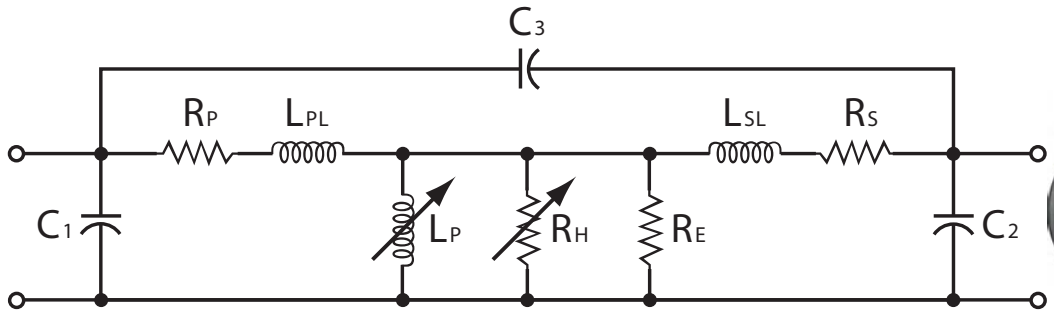
About the Filament Supply Leads

The PT (power transformer) with the ***Mercury Upgrade Kit*** for the ***AC4tv*** has two white leads (wires) coming from the *secondary* side (but NOT the single white lead coming from the *primary*) of the casing. See the power transformer's diagram at the front of this manual for clarification. The two white *secondary* leads are the "filament supply leads." The ***filament supply leads*** are the *only* wires that must be twisted together.

This photograph shows a twisting pattern that you should aim for. Consistent, even twisting is important. Ideally about 10 twists per inch. Cable tie these leads as high off the Main PCB as possible, and as close as possible to both the power transformer. This will minimize amp noise and hum.

The Output Transformer Circuit

Mercury's circuit equivalent of an Output Transformer



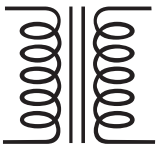
C_1	Primary Self Capacitance	L_P	Primary Inductance
C_2	Secondary Self Capacitance	R_P	Primary Resistance
C_3	Interwinding Capacitance	R_S	Secondary Resistance
L_{PL}	Primary Leakage Inductance	R_E	Core Eddy Current Losses
L_{SL}	Secondary Leakage Inductance	R_H	Core Hysteresis Losses

"Blessed are the Tone Makers"

The above circuit reveals the properties of an audio *output transformer*. The transformer is a *reactive* component—its values change depending upon the information feeding it. Transformers for tube-based electric guitar amps are designed to *intentionally provoke* the tubes into distortion—the polar-opposite of demands of *hi-fi*. The best guitar tone comes from harnessing and *manipulating* the inherent flaws of the imperfect transformer. This is where art meets science in our pursuit of great guitar tone.

—Sergio Hamernik

Consider the above *vs.* this typical dummied-down transformer symbol



DANGER! READ ME!

DISCHARGE THOSE FILTER CAPS!!!!!

The following is a collection of notes on discharging Filter Capacitors

Compiled by the staff at ***Mercury Magnetics***

DISCHARGING CAPACITORS – The filter capacitors in an amp will retain a charge for quite some time after the amp is shut off and unplugged. It is a good idea to make sure your amp is safe to work on. One way is to take a wire with an INSULATED alligator clip on each end, clip one end to a good ground point, and the other to one of the plate leads for the first stage preamp tube. Another method would be to put a 100K, 5W or more resistor in line of these two clips by attaching one end to ground (first), then the other to the filter caps themselves. NEVER SHORT THEM OUT DIRECTLY!

BE THE ONE-ARMED TECHNICIAN – There will come a time when you have to work on a chassis that is running. When doing so, if possible clip one of your meter's test leads to ground, and use only one hand to probe the circuit, keeping the other in your pocket, *etc.* That way if you DO take a shock, your heart is not in line of the path of least resistance – in one arm and out the other. When you ABSOLUTELY must use two hands, be EXTREMELY CAREFUL, and use common sense, but PLEASE try to avoid these situations!

* * *

"Filter" caps can store ***fatal*** amounts of electrical current. The caps are connected near the rectifier and are part of the power supply, and aid in converting AC to DC. In fact, they are a standard component in any power supply.

If you're completely lost, and don't understand this, DON'T MODIFY YOUR AMP. You haven't enough knowledge to work on high voltage/current circuits safely.

Several ways to discharge caps:

FIRST, UNPLUG THE AMP! (But that doesn't make it safe!)

THEN, take a screwdriver or a jumper and short the capacitors leads.

– OR jumper the power amp tube plate pin to ground for a minute or so (Class A, single power tube only)
– OR jumper the positive (+) lead of each large cap to ground for several seconds. A jumper with a built-in resistor (10K or so) will help prevent sparks here.

Some or all of these methods may result in a spark. Obviously, your flesh can act as a jumper also.

It's NEVER a good idea to touch amp circuitry when it's switched on. And don't work on amps in bare feet, or on a damp basement floor.

* * *

Letting the capacitors discharge slowly is preferable to having them do it all at once through your body while you're poking around inside the amp. Having the supplies you need on hand makes the job go faster.

You'll want screwdrivers, contact cleaner (you can use *Gunk* brand choke and carburetor cleaner or *WD-40*), a toothbrush and – unless you own an air compressor – an aerosol can of compressed air – soldering supplies and a volt/ohm meter (learn how to use them!).

Start by unplugging the amp from the wall, the speakers from the amp, and removing the amp chassis from the case. For Fender amps, removing the chassis involves unscrewing the upper back case panel, then unscrewing the chassis from the top of the case. Put the screws, nuts, and lock washers where they won't get lost.

With the chassis out of the case, you can locate the filter capacitors you'll want to avoid touching as you perform the tune-up. These will be cardboard cylinders (usually orange or tan or vintage Fenders) with "+" printed near one terminal. It's also a good idea to steer clear of wiring connected to the power transformer because it's a discharge path for the filter capacitors.

If you haven't given the capacitors a couple of days to discharge – or if you just want to be cautious – you can use a short length of insulated wire with alligator clips on the ends to discharge them. First, make certain that the amp is unplugged. Attach one alligator clip to a capacitor's positive (+) lead, then touch the other clip to the amp chassis several times. Repeat the procedure for each capacitor marked with a voltage (VDC) rating higher than 25. The time spent on this precaution can spare you from a numbing electric shock that you'll remember long after the amp is back together.

How to Discharge a Power Capacitor in Tube Amp

by Kevin Krause
eHow contributing writer

To be able to properly test and troubleshoot your tube amplifier with a multimeter it is important to discharge the capacitors located in the amp's power section to avoid false readings. Capacitors act as short-term batteries, storing a charge that can be called on by other components. This charge will remain in the capacitor even after the amp has been powered off, and can produce misleading voltage readings along circuit paths. Because of the high level of the stored power in the capacitor, safe discharging is a must.

Things you'll need:

1. High wattage resistor
2. Alligator clip
3. Copper wire
4. PVC tube or dowel rod
5. Soldering iron
6. Solder
7. Multimeter

Instructions

Level of difficulty: Moderate

Step 1: Strip about 1/4 inch of insulation off each end of a 2-foot length of insulated copper wire, and solder one end of the wire to one of the leads of a high wattage resistor. The resistance required can be determined by adding 5 to 50 ohms per volt of the capacitor's rating. For instance, a 100V capacitor would require a resistor rated anywhere from 500 to 5k ohms.

Step 2: Attach the other end of the wire to an alligator clip.

Step 3: Solder the free lead of the resistor to a short piece of bare copper wire.

Step 4: Tape the resistor and bare copper wire to one end of a length of non-conductive material, such as PVC tubing or a dowel rod. Make sure enough of the copper wire is exposed to act as a contact point.

Step 5: Attach the alligator clip to one of the capacitor's leads. Be sure the amplifier is completely powered off before doing so.

Step 6: Touch the bare wire end of the PVC tube or dowel rod to the other lead of the capacitor. It is very important to not touch any of the exposed leads or wires at this time. Hold the bare wire on the lead for at least several seconds to fully discharge the capacitor.

Step 7: Test the capacitor with a multimeter to be sure all voltage has been safely removed.

Discharging Capacitors in a Guitar Tube Amp

Take pride in how safe you can be.
You can't play guitar or build amps if you're dead.

You may have heard various horror stories about things inside amps that can store a charge that can kill you. Well, it's true! However, those dangerous voltages can be easily drained in just a few minutes, so take your time and don't rush.

It is absolutely vital that we drain the filter capacitors in the DC power supply before working on any guitar amplifier. These often hold a charge of several hundred volts, which is potentially deadly. Capacitors can hold their charge for a long time, even with the power off and the amp unplugged. It's very important that we learn to properly "drain" this residual voltage so that we may safely work on the inside of our amplifiers.

What You'll Need:

Filter Capacitor Discharge Tool

1. **Safety glasses.** Always use safety glasses. If you wire a capacitor in backwards there is a very good chance that it will explode in your face.

2. **Digital multi-meter.** Capable of reading 500 volts DC.
3. **Capacitor discharge tool.** A jumper wire consisting of alligator clips on the ends, with a resistor in series in the middle of the jumper.
4. **Needle nose pliers.** With very good insulation on the handles for holding the alligator clips of the capacitor discharge tool.

Always make sure your tools are in good condition. If there's any question, replace them. Cracked insulation is one of the first things to check, and check often.

Turn the power switch OFF, and place the standby switch in the ON position. This isn't the same as having your amp "on standby."

Always unplug the amp from the wall. Unplugging from the wall will not drain the filter capacitors completely, but again this is for our own safety. Unplugging is the equivalent to "locking out" before working on a downed machine.

Because filter caps are almost always of the electrolytic type, they're "polarized" and therefore have a positive and negative end. We can identify the positive or negative ends by looking for the "polarity indicator" printed on the cap's side.

Our first objective is to check for residual voltage with a multi-meter. In some cases most of the voltage may have already been drained. Many amplifiers will incorporate "bleeder" resistors, which will drain the capacitor charge automatically in a few minutes after the amp is turned off. Don't depend on this resistor to do the job. Never assume the caps have been drained to a safe level without checking with a reliable multi-meter.

Here's a couple of ways to measure the residual voltage contained in the filter capacitors. Note that these are also equally valid for draining the caps:

1. **Across the capacitor**.
2. **From the positive side of the cap to the chassis**. This is essentially the same as draining "across" the caps since the negative side is at the same electrical potential as the chassis.
3. **From the chassis to a tube pin**. This can be done at pin 3 of any power tube, or pins 1 or 6 of any preamp tube. By shorting the chassis to the correct pin the caps will be forced to drain through the plate load of that tube. This prevents sparking from high current.

IMPORTANT NOTE, HOW NOT TO DO IT: In old electronics books they tell you to use a screw driver with an insulated handle to short out the caps. "Shorting" with a screwdriver will almost instantly drain the caps to zero volts, causing sparks from high current. This is not acceptable. If there are several hundred volts stored in the caps, be prepared for a nice sized spark. It will most likely leave a black mark on the chassis, and in extreme cases, partially weld the screwdriver to the chassis.

Now we're ready to start testing and discharging

Set your multi-meter to read DC voltage. Adjust the meter's range so that it's above 500 volts. Clip the black lead of your multi-meter to the chassis. Using only one hand, with the other hand far from the chassis (preferably in your pocket or behind your back), measure the DC voltage across one of the filter capacitors. You can adjust the meter's range down if you can't get a clear reading. Any DC voltage readings less than 5 volts are harmless, so the amp can be safely worked on, but do a double check of all the caps just to make sure. If not we must drain off the residual voltage with a resistor until it is safe.

Use a resistor value somewhere between 10K and 100K, with a power rating of 5W or so (a high power rating is not really necessary for heat dissipation reasons, but mainly because the higher power resistors are physically more robust and won't tend to break). The larger the resistor value, the longer it will take to discharge. If your capacitors do not have a dangerously high voltage, say around 30 volts, feel free to use a smaller 1K 1 Watt resistor.

Now take your capacitor discharge tool and clip one side to the chassis. Always clip to the chassis ground first before connecting to the circuit. If you clip to the circuit first you will have a hot wire hanging out of your amp, which is very dangerous. Once you have one side clipped to the chassis, take your needle nose pliers with good insulation on the handles and hold the alligator clip that will go to the circuit with the needle nose pliers.

Clip this to pin 1 or 6 of the first preamp tube. This seems to be the safest way of discharging the capacitors. If you're working on the first preamp tube socket, then clip your discharge tool to pin 1 or 6 of the second preamp tube. Wait a few minutes (about 5 minutes, if the amp has bleeder resistors this time will be shorter) then, while the discharge tool is still in place recheck all the capacitors with your multi-meter and keep that other hand behind you. Keep checking until the voltage has reached a safe level. Note: This procedure must be done every time you turn the amp on then off.

> Remember to remove the discharge tool before powering on the amp. Make it a bright color like

yellow and maybe put a piece of shiny tape on it to make it more visible. You can even put a fuse in series with the resistor on the discharge tool in case you forget to remove it.

Filter capacitors are wired in parallel, so draining one should drain them all, but never assume. Always recheck for residual voltage in every filter capacitor until there's absolutely no doubt in your mind that all are drained.

Less than 5 volts is safe, but I prefer to drain mine to 1 volt for peace of mind. Don't be surprised if you find the capacitors slowly recharging themselves. This phenomenon is known as dielectric absorption and is quite normal in electrolytic capacitors. The filter caps shouldn't recharge to a lethal level, but leave the discharge tool in place while working on the amp.

A few final notes:

1. Never work on an amp if you're tired, fatigued, frustrated or intoxicated.
2. Never work while distracted.
3. Never work on an amp around small children. There are just too many dangers involved to take that chance.
4. Try to have a plan in case something does go wrong. You might consider asking someone in your household to take a CPR class.
5. Take your time and don't rush.
6. Use common sense.

http://tubenewbie.com/discharge_capacitors.html

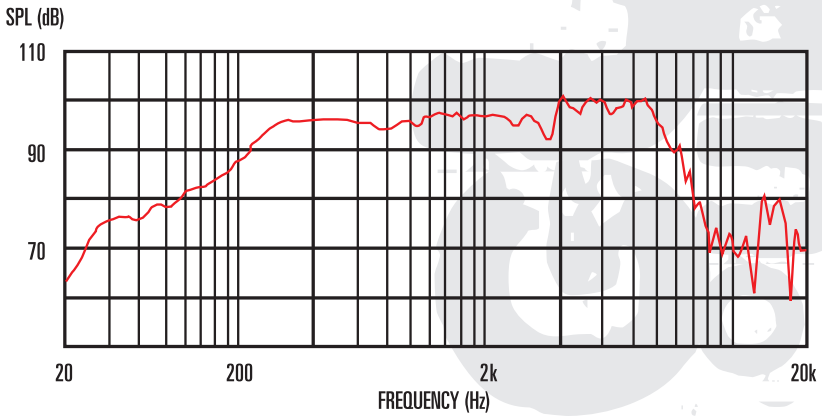
CELESTION GUITAR LOUDSPEAKERS

G10 GOLD

Following the great reviews we received for the Gold 12", we realised there was also a need for a speaker that conveyed the Alnico mellowness of the original Blue, with the speed and response of a 10" driver.

The G10 Gold is the ultimate 10" speaker, blending unmistakable Alnico class with a rich low-end, creamy mid-range and vintage chiming top-end. Springy, warm, revealing and highly expressive, it can be used singly or in pairs to add a classy sheen to any amp, or in a 4x10 configuration for higher volume depth, warmth and shimmer, with less of the boom associated with 4x12 cabinets.

8 FREQUENCY RESPONSE



GENERAL SPECIFICATIONS

Nominal diameter	10", 254mm
Power rating	40W
Nominal impedance	8 Ω & 1 5 Ω
Sensitivity	98dB
Chassis type	Pressed steel
Voice coil diameter	1.75", 44.5mm
Voice coil material	Round copper
Magnet type	Alnico
Frequency range	80-6000Hz
Resonance frequency, Fs	80Hz

MOUNTING INFORMATION

Diameter	10.1", 256mm
Overall depth	5.3", 135mm
Magnet structure diameter	4.7", 119mm
Cut-out diameter	9.0", 229mm
Mounting slot dimensions	0.25 x 0.43", 6.5 x 11mm
Number of mounting slot	8
Mounting slot PCD	9.6", 244mm
Unit weight	5.9lb, 2.7kg

Celestion International Ltd, Claydon Business Park, Great Blakenham, Ipswich, IP6 0NL, England
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