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How To Bias A Valve Guitar Amplifier

Transistors, FET's, diodes, IC's (integrated circuits) and electronic valves (also called tubes) are all active electronic components. In an audio amplifier the job of an active electronic component is to amplify or otherwise actively manipulate. To use a water analogy, an active component is a bit like a water tap on a large and powerful water pipe, it allows a small force (the tap knob) to control a much larger force (the water in the pipe). The job of an amplifier is to take a small signal and make it large enough to control a loudspeaker or with the water analogy to take a little wiggle on the tap to make a much larger but controlled wiggle in the water supply. All active electronic components require bias to operate. Solid state bi-polar transistors are normally dead ducks and need to be actively biased-on to make them do useful work (pass water), electronic valves are like a wide open tap (passing all of the available water) and need to be actively biased down or off to make them do useful work. This document deals only with biasing of valves in guitar amplifiers.

To bias a valve into a useful zone, the input grid pin needs to be more negative than the cathode pin. In a valve guitar amplifier there are two basic types of valves, pre-amp valves and output valves. Pre amp valves are usually used in self biasing (also called "auto biasing") circuits, this simply means that the cathode is fitted with a resistor and that this resistor allows the cathode voltage to rise above the ground referenced input grid. The higher the cathode voltage rises the more the valve is biased off and the more negative the input grid appears to the cathode. These circuits are called self biasing (or auto biasing) as they find their own level and then stay there. Auto biasing can be used for output valves as well but this technique is wasteful of output power and so is so is usually only used for smaller amplifiers.

Output valves in guitar amplifiers of 30 watts and under are often used with auto biasing circuits, however once we move above this power level then it is much more desirable and power efficient to use a dedicated output bias circuit. Some guitar amplifiers use a "fixed" bias circuit, this is a dedicated bias circuit but is not adjustable, the manufacturer assumes that you will always use the valves that they specify and that you will be happy with the bias level that they have chosen. Fixed bias circuits can be modified to make them adjustable, however it is not the scope of this document to show you how to do this (this sort of mod should only be attempted by an alert technical person).

There are several methods of adjusting bias in valve amplifiers. The best method is to use a dedicated "bias probe", these are expensive and rare. There are other methods including measuring the current and operating voltage of the valve and calculating the dissipation (you have to mindful of the total dissipation of the valve, hence a current and voltage calculation). The method that I like to use is documented in "The Tube

Amp Book" by Aspen Pittman of Groove Tubes. Naturally as with all biasing methods there are pluses and minuses and there are fans and detractors

First up, you need a non inductive resistive dummy load that is the correct impedance for the amplifier and can handle the expected power levels. Second up, you need an audio signal generator that can output a clean 2KHz sine wave at about 100mv RMS. Thirdly you need an oscilloscope (commonly called a CRO) and suitable oscilloscope probe (with a X10 switch). It is also wise to be armed with a digital multimeter.

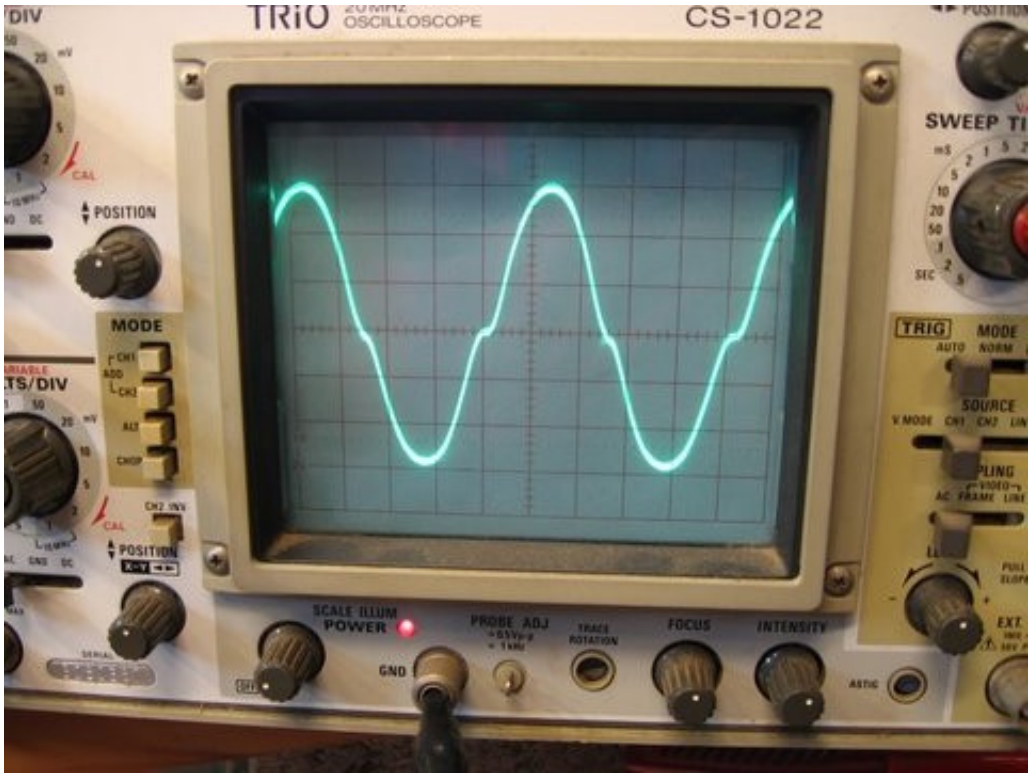
The above shows my guitar amp dummy load, this box contains 4 x 8 ohm 100 watt non inductive resistors, in Australia these can be purchased from Wagner Electronic Services in Sydney (most audio repair people have an account with WES). Each of the two channels in the box can be switched for 4, 8 and 16 ohms.

Preparation :

It is critical that a valve amplifier always has a load when being operated, failure to do so can and will result in damage to the output transformer if the output level is clipped. A valve amplifier with a speaker load or dummy load can safely be driven hard into clipping without damage. As this bias method relies on driving the amplifier into clipping a suitable dummy load must be used.

Plug the output of the amplifier into the dummy load. Set the dummy load to the correct impedance for the amplifier, this is important and failure to do this will result in an incorrect bias setting. Connect the CRO probe to the dummy load, I use the X10 switch on the probe and rarely connect the earth clip as the earth path is usually already connected via the mains earth. I tend to always connect a multimeter between chassis and the bias circuit output and measure and note the bias voltage before and

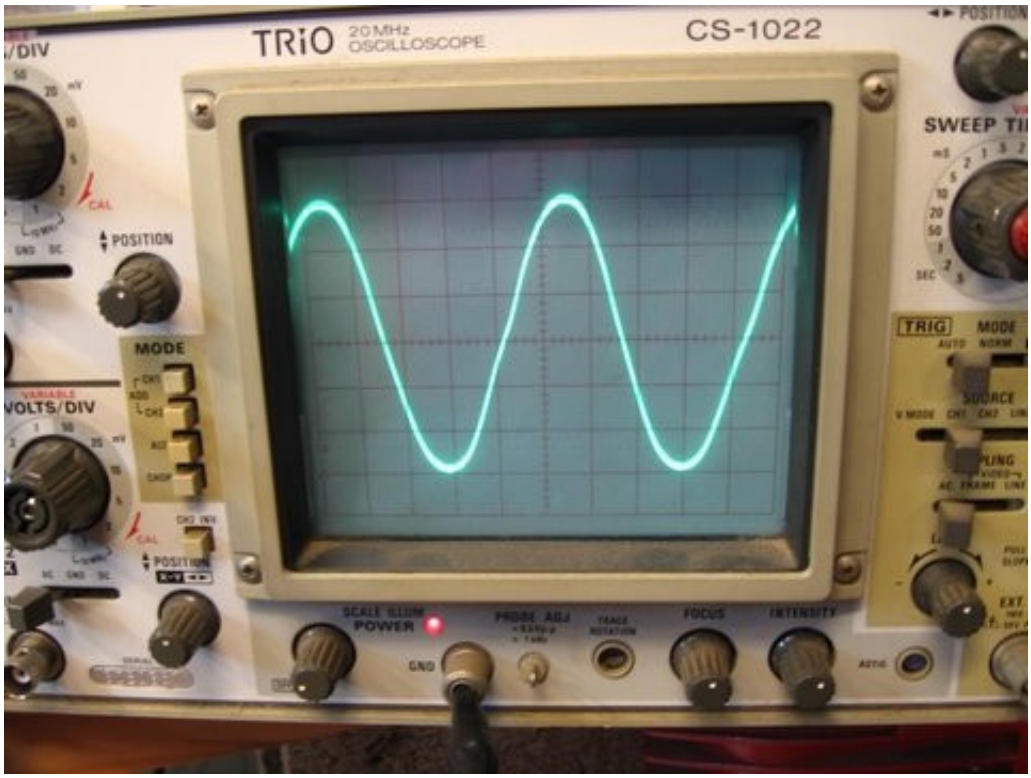
after adjustment (take care not to short out the bias, to do so will destroy the output valves). Turn on the amplifier. Feed a 2KHz 100mv RMS test tone into the “low” input of the amplifier (on a Fender Twin this is any input 2). Adjust the tone controls to about 50%, set the master volume to max. Turn up the input volume pot until the amplifier is only just under clipping. You should now have an image of a sine wave on the oscilloscope.



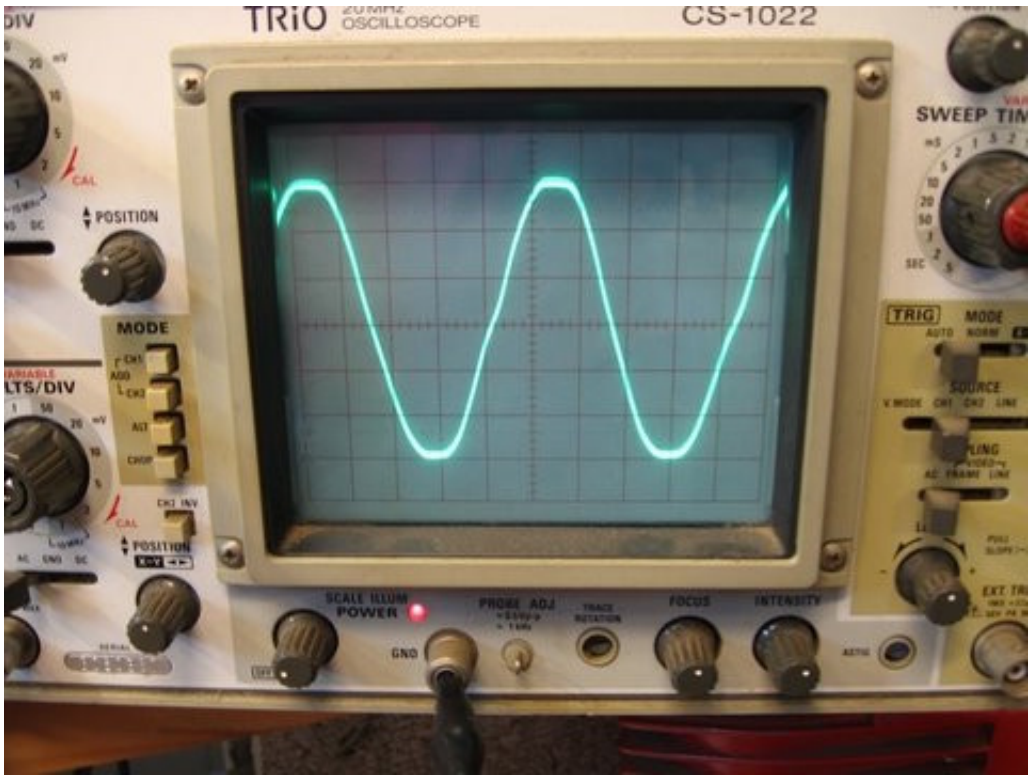
The above shows a guitar amplifier where the output valves are over-biased. As mentioned earlier, the higher the bias in a valve amp the less that the output valves can conduct. The amplifier as shown above has a lot of crossover distortion (the point where one valve hands off to the other), it is running “cold” and will not sound very good (it will be dull and lifeless).

The secret of a great sounding valve guitar amplifier is to balance the bias just slightly out of the safe “cold” zone and slightly into the potentially hazardous “hot” zone. Biasing too far into the “hot” zone results in reduced valve life and the potential for valve meltdown (when they go cherry red). Biasing too far into the “hot” zone has no sonic benefits, there is a very definite sweet spot right between the two zones.

Take note that the gain of the output valves will change while you are adjusting the bias voltage (this is due to the “variable Mu” effect). You have to ride the input volume knob to keep the amplifier just on the edge of clipping while you are turning the bias pot.



The above image shows the same amplifier with correct bias. The output is shown just under the clipping point, you can just see a small kink in the sine wave at the crossover point (the mid point between the +ve and –ve peaks). This kink should disappear when the output level is dropped away from the clipping point. This is the sweet spot where good tone occurs. There is no need to eliminate the kink completely but it should only be noticeable just on or just over the edge of clipping.



The above shows the same amplifier and the same correct bias point. The level has now been increased to push the amplifier harder into clipping and the crossover kink is now more obvious. As mentioned, the crossover kink should pretty much disappear when the level is dropped below clipping when the correct bias point has been set.

This method of biasing is not trouble free. It is important that the bias is set with the amplifier running into the correct load. There are some amplifiers that will not bias up correctly with this method and obviously the valves must be in good condition otherwise any sag that they have will show up as a false crossover kink.

This biasing method will show the relative matching of the output valves, if the crossover kink is not in the centre it can mean that the output valves are not well matched or that the valves are worn. A non centred kink can also indicate a fault condition and so some experience and skill is required to correctly diagnose a non centred crossover kink problem.

It is important that the front end of the amplifier is not clipping, so make sure that you have your 2KHz tone source plugged into a low sensitivity input and that a clean channel has been selected. If an amplifier has a proper insert point you can feed the tone source in here, though you will probably need a much higher level than 100mv to push the output stage to the edge of clipping.

Good luck and take extreme care if mucking about with valve amplifiers. Never assume that the power supply discharge resistors are working, always assume that the unit under test is dangerous unless proven safe (even if powered off for several weeks). Don’t attempt to bias a valve amplifier unless you have a reasonable level of competence around relatively high voltage electronics.

Regards, Warren Huck, 10/09/07