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SIMPLE BIAS MONITOR FOR TUBE AMPS

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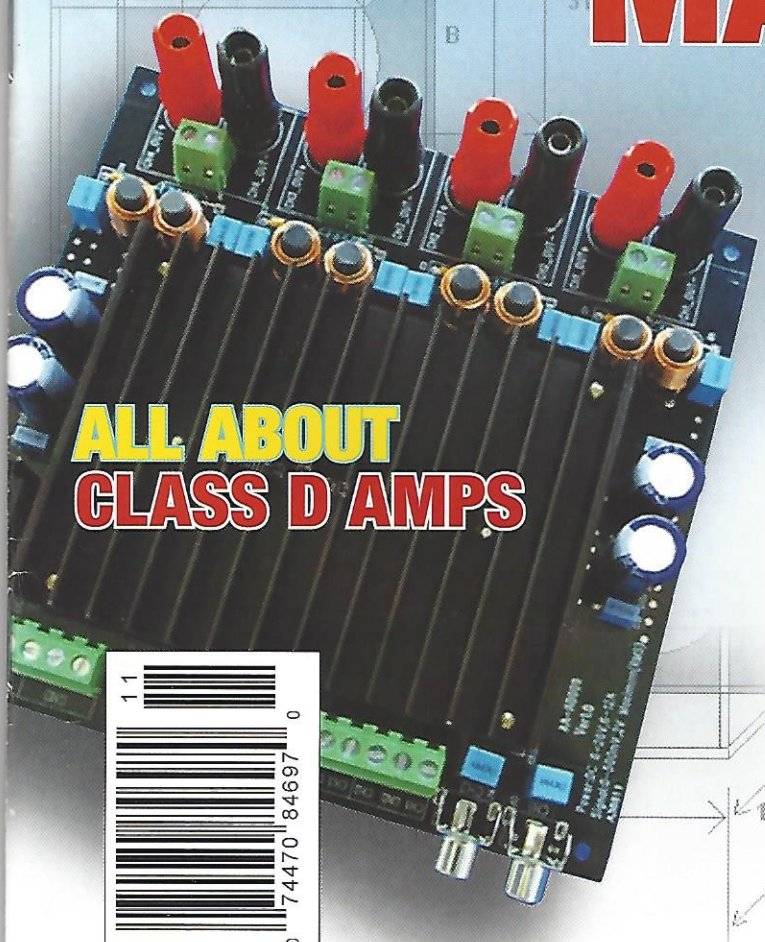

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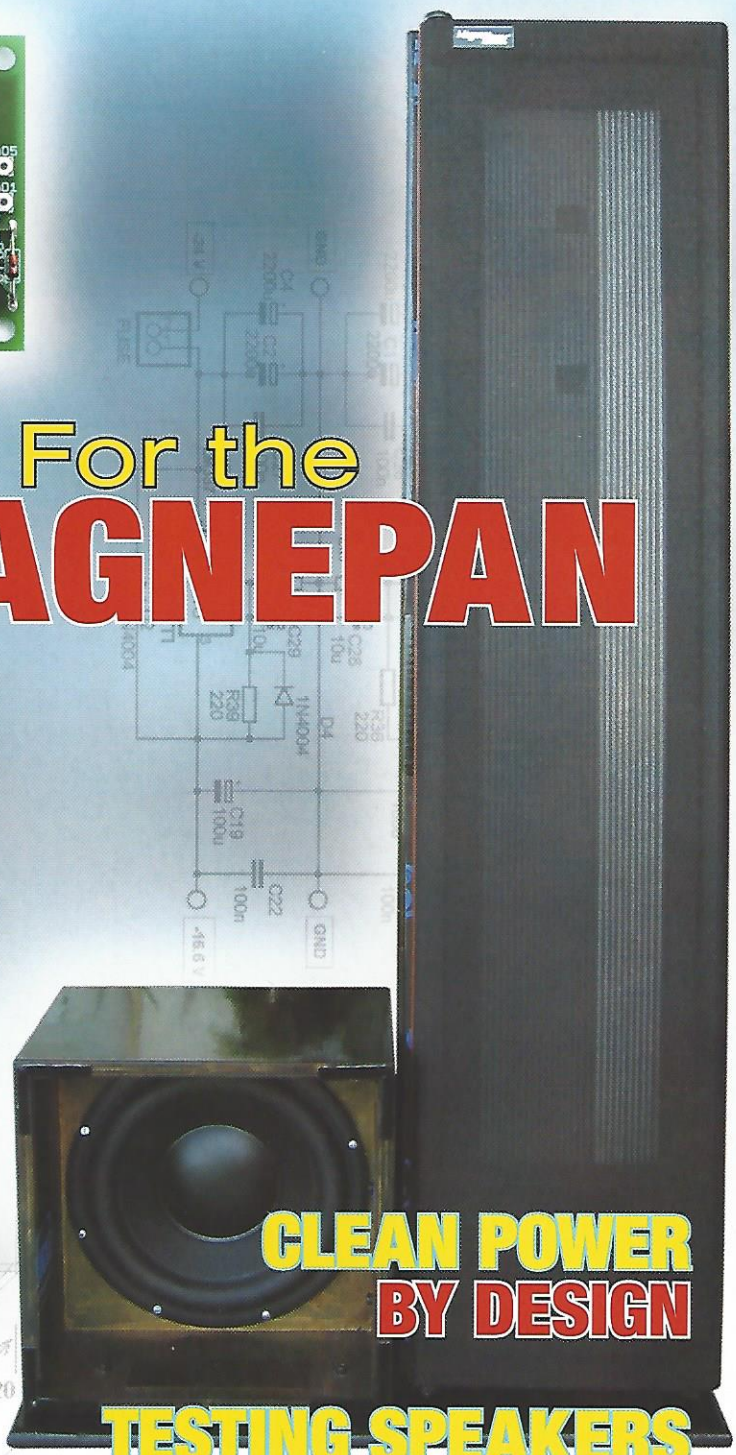

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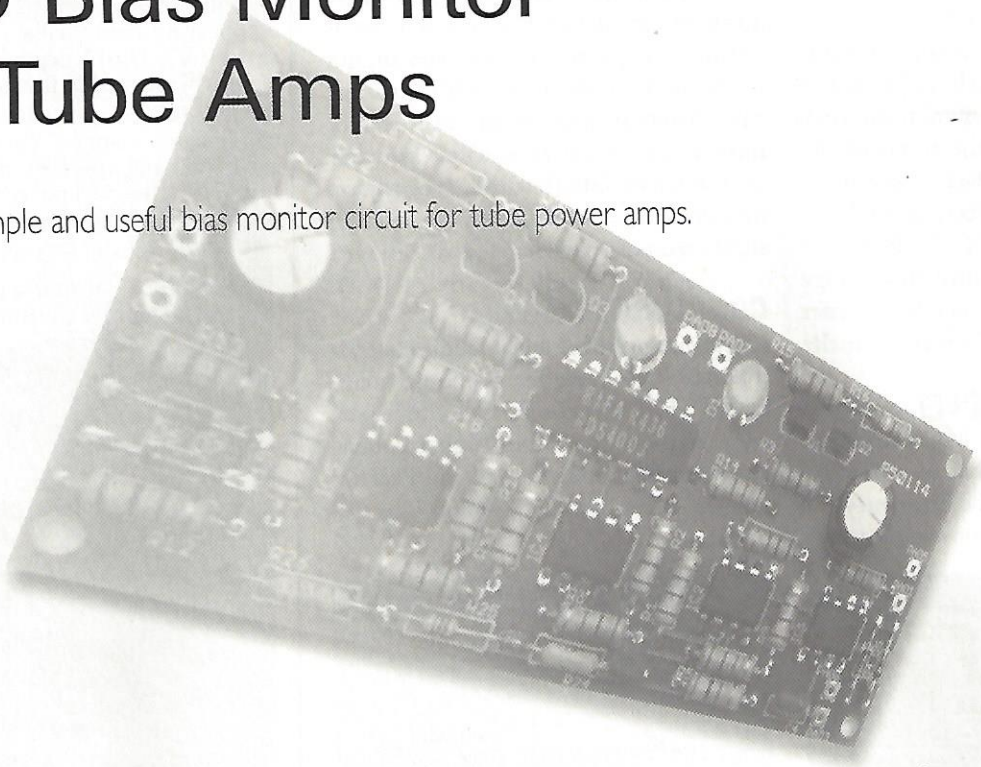
By Scott Reynolds

LED Bias Monitor for Tube Amps

Here's a simple and useful bias monitor circuit for tube power amps.



This small circuit, which may be of interest to *audioXpress* readers, is a bias monitor for tube power amplifiers, consisting of a window comparator, some simple logic gates, and a bi-color LED. It indicates visually whether the tube bias current is within some user-determined range. A number of such circuits have been published over the years in *audioXpress*, *Glass Audio*, and *Audio Amateur*, but this one is versatile enough so you can add it to almost any new or existing tube amp.

Tube power amps that use fixed bias require occasional readjustment due to tube and component aging and line voltage variation. A pronounced drift in the required bias voltage is often the first sign that a tube needs replacement. The most common way of monitoring the bias current is by a test point that you can measure with a handheld multimeter. But I find this is often inconvenient, especially when the test points are inaccessible or the amp is located where I don't keep a meter. It's much more convenient if the amp can monitor itself.

MONITOR CIRCUIT

The circuit in **Fig. 1** is designed to do just that. Comparators IC1 and IC2 form a window comparator that can monitor the voltage drop across a current-sensing resistor in the tube cathode circuit, as shown in **Fig. 2**. For one of my amps, the tube is a KT88, which I bias at 50mA cathode current, and which equates to a 0.5V drop across the 10Ω current-sensing resistor. I decided that I wanted an indication when the current fell below 45mA or rose above 55mA.

In **Fig. 1**, the window edges are set by a voltage divider consisting of R26, R25, and R24, which divide the output of a 1.23V precision reference diode D2. If the input voltage is between 0.45 and 0.55V, the output of IC2 is high and the output of IC1 is low, which makes the output of logic gate IC3B low, and the LED D1 glows green. If the voltage is outside that range, the output of IC3B is high and D1 is yellow. You can set the lower and upper window edges *VL* and *VH* between 0 and 1.23V by changing the voltage divider resistors R24-R26, according to the formulas

$$V_L = 1.23\left(\frac{R_{26}}{R_{24}+R_{25}+R_{26}}\right) \quad \text{and}$$

$$V_H = 1.23\left(\frac{R_{25}+R_{26}}{R_{24}+R_{25}+R_{26}}\right)$$

You can also set them up to 2.5V by using the 2.5V version of reference diode D2.

Resistor R4 and capacitor C1 form a low-pass filter so that fast signal voltages across the cathode resistor don't affect the bias monitor. But sustained large signals will raise the average voltage across the cathode resistor, so the bias monitor is only accurate under no-signal or low-signal conditions. In practice, music signals don't seem to affect the indication.

Diodes D4 and D5 prevent a large transient above 5V or below ground from damaging the comparators. Feedback resistors R7 and R9 (and R6 and R1) add a few mV of hysteresis to ensure positive switching action at the window edges. The TTL output of IC3B may be useful elsewhere in your system; in one of my amps, a timer shuts down the power if the bias is out of range for a prolonged period.

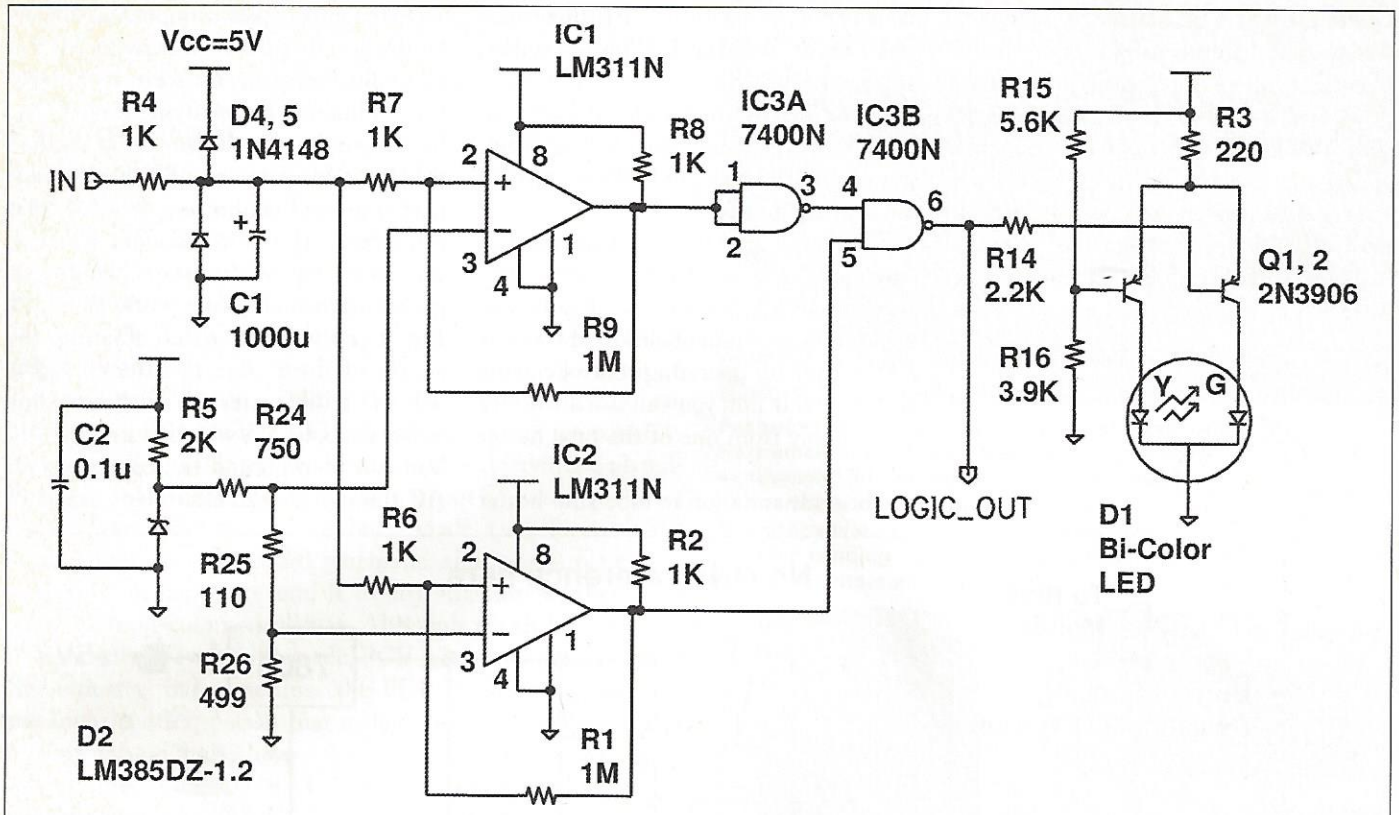


FIGURE 1: Bias monitor schematic. The PCB shown in *Photo 1* contains two bias monitor circuits, but R5, C2, D2, R24, R25, and R26 are common to both.

SIMPLIFIED VERSION

My original prototype was more complicated, with multiple comparator windows and a four-LED display for each tube. While that was useful for designing and testing a new amplifier, it was much fancier than it needed to be and had too many LEDs. This design has just one bi-color LED per tube. Although it is intended mainly for monitoring, you can even use it to set bias. Turn down the bias current until the LED turns yellow, noting the position of the bias potentiometer. As the bias is turned up, the LED turns green and then yellow again; you can set the bias pot halfway between the two trip points.

The circuit requires only a filtered and regulated 5V ground-referenced supply, at about 15mA per monitor. My homemade audio equipment almost always has a 5V supply for operating control circuits and timers. If not, you can usually derive a 5V supply from one of the tube heater supplies.

The wide variation in tube amp heater arrangements makes it impossible for me to give specific advice on deriving 5V, but I can give one general caveat. If the supply is obtained by rectifying a 6.3V AC heater winding as shown in **Fig. 3**, then the AC side of the rectifier bridge can't have a ground connection or a DC bias connection. In many cases, for instance, the center tap of the heater winding is grounded, which won't work in **Fig. 3**. But if the winding is left floating, the action of the bridge rectifier in **Fig. 3** will cause the center tap of the winding to be at about 4V, which is usually OK. You can then ground the center tap for AC through a small electrolytic capacitor

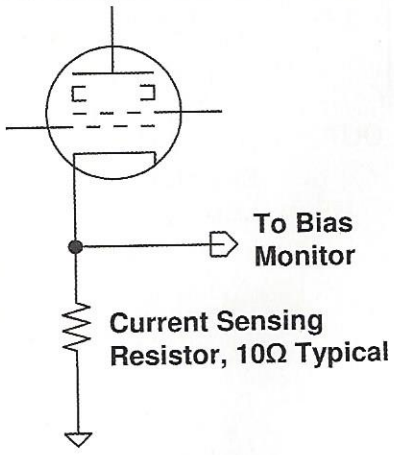


FIGURE 2: Output tube with current-sensing resistor.

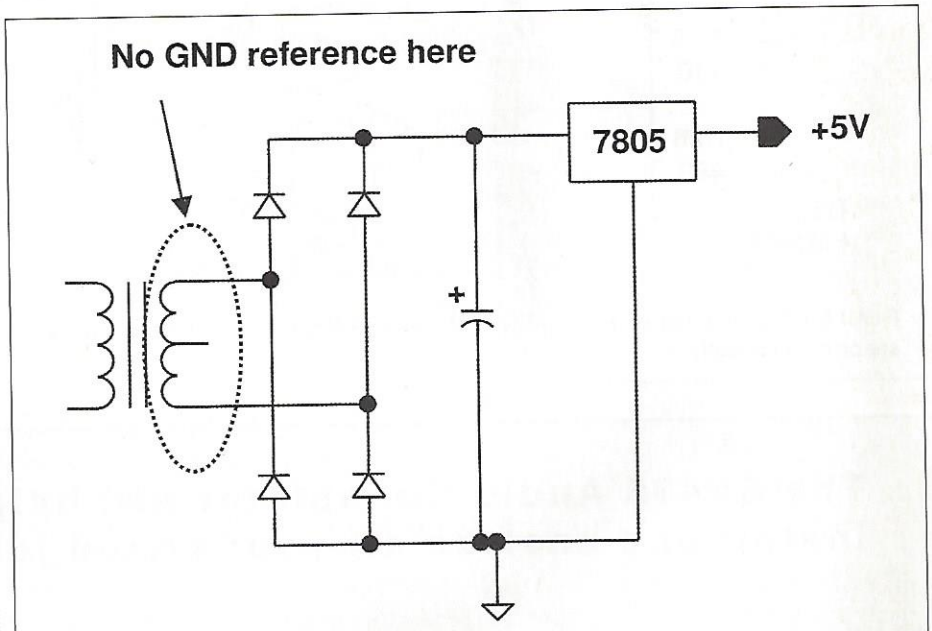


FIGURE 3: Possible power supply arrangement for bias monitor.

TABLE 1 Parts List

Component Description	Digi-Key #	Part #Reference
1000µF elec., 10V or more (2)		C1 (C2)
0.1µF film, 10V or more		C4
G/Y Bi-color LED (2)	160-1714-ND	D1 (D3)
LM385Z-1.2 precision reference diode	LM385Z-1.2NS-ND	D2
1N4148 Si diode (4)	1N4148FS-ND	D4-5 (D6-7)
LM311N comparator (4)	LM311NFS-ND	IC1-2 (IC4-5)
7400N	296-14641-5-ND	IC3
2N3906 (4)	2N3906FS-ND	Q1-2 (Q3-4)
1MΩ (4)		R1, R9 (R11, R19)
220Ω (2)		R3 (R22)
1kΩ (10)		R2, R4, R6-8 (R10, R12-13, R17-18)
2kΩ		R5
2.2kΩ (2)		R14 (R20)
3.9kΩ (2)		R16 (R23)
5.6kΩ (2)		R15 (R21)
750Ω, ¼ or ½W, 1%		R24
110Ω, ¼ or ½W, 1%		R25
499Ω, ¼ or ½W, 1%		R26

Part numbers in parenthesis are for the second monitor. All resistors are ¼ or ½W, 5%, carbon film, except as noted. Digi-Key part numbers are given for the semiconductors, but these are very common parts, and you can use components from any vendor.

to reduce hum and noise. If you are in doubt, it is best to add a small transformer for the 5V supply. Digi-Key and Mouser stock some very tiny ones these days.

CIRCUIT BOARDS

The bias monitor is straightforward to build on a piece of perforated board or a general-purpose prototyping board. The parts list is in **Table 1**. But to make the monitor compact and easy to add to my amps, I designed a 3.9″ × 1.7″ double-sided PCB (**Photo 1**), which contains two of the monitor circuits shown in **Fig. 1**, for the two tubes in a push-pull amp. I usually solder the two LEDs on the back of the board and mount it on the front panel of the amplifier chassis, so that the LEDs can protrude directly through LED mounting clips on the panel.

The PCB is a silk-screened board with solder-mask, plated-through holes, and fine lines, so it is not practical for most amateurs to make it at home, but I made a zip file with the Gerber files, an exact board schematic, and a parts placement diagram. I'm happy to send it to any amateur for their own personal (non-commercial) use. Although it can be expensive to have only a few boards made, PCB fabrication is a competitive industry, and sometimes the PCB fabrication houses on the Internet offer specials that make it quite reasonable. It pays to shop around. I also have a few boards left that I'm willing to sell to other readers. You can contact me by e-mail at scott@tavishdesign.com.

With this bias monitor, I no longer need to look at my power amps and wonder whether the bias is still in range. Nor do I need to go to the trouble of finding a meter, pulling the amp out of my equipment rack, and checking the bias, only to find that it is still OK. I've found that the monitor is simple and compact enough to be added unobtrusively to almost any amp.

Old Colony Sound Lab often makes available printed circuit boards in support of magazine projects if there is sufficient reader interest. To indicate your interest level in PCBs for this project, contact Old Colony Sound Lab at 603-924-9464, 603-924-9467 (fax), or custserv@audioXpress.com (e-mail). Availability decisions are usually made in about two-three months—watch Old Colony ads for further developments. aX

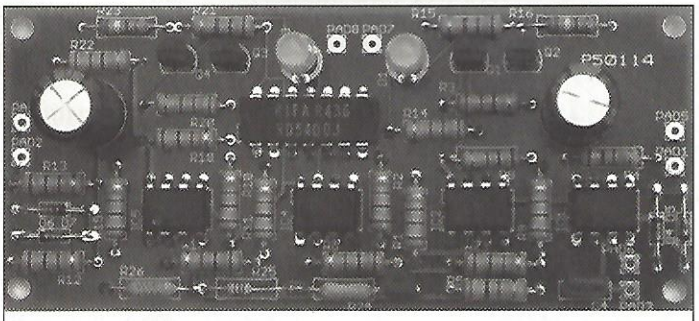


PHOTO 1: Printed circuit board (3.9″ × 1.7″) containing two bias monitors and the common voltage reference circuit. Although the two LEDs are shown here on the top (component) side of the board, I usually mount them on the back (see text).