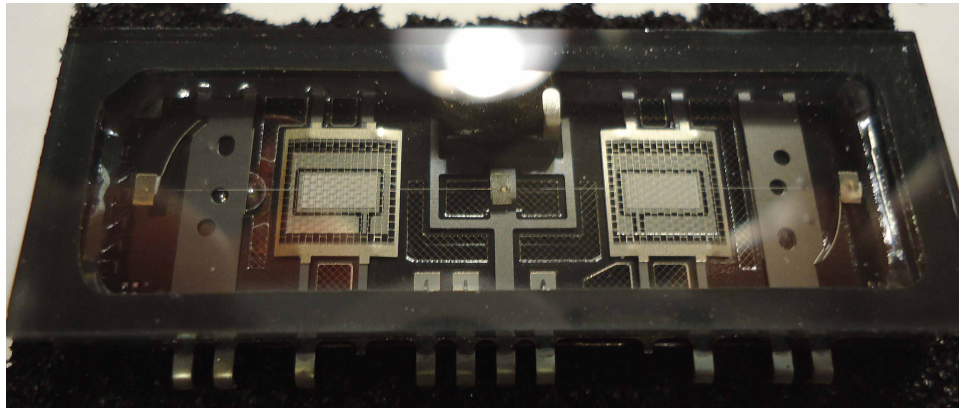
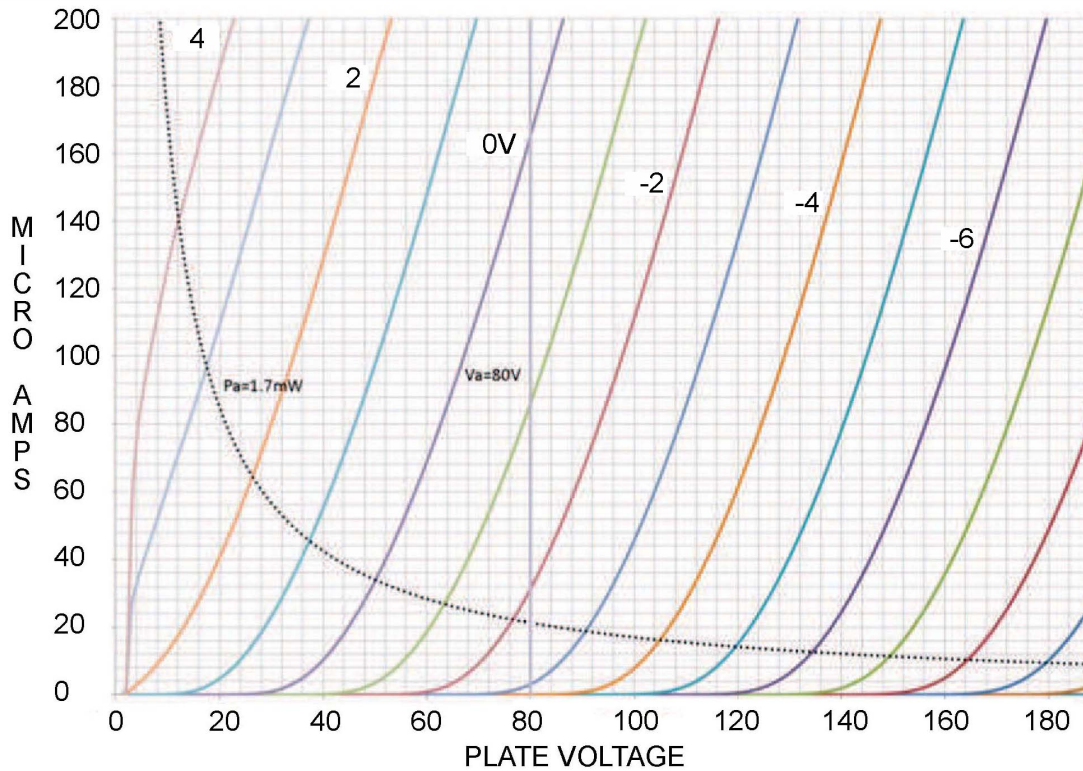


The DIY Nutube Preamp

At the Burning Amp Festival 2017 I presented a version of a preamp using the Korg Nutube dual Triode. It is similar to the example circuit provided by Korg, different mostly in the use of Jfet constant current sources instead of bias by resistors. The Nutube is about the size of a 40 year old 8088 microprocessor and is made of glass, allowing a view of the interior:



It's an actual tube, with the visible detail of the glowing Cathode. The characteristic of the Nutube is the familiar Triode, as seen here:



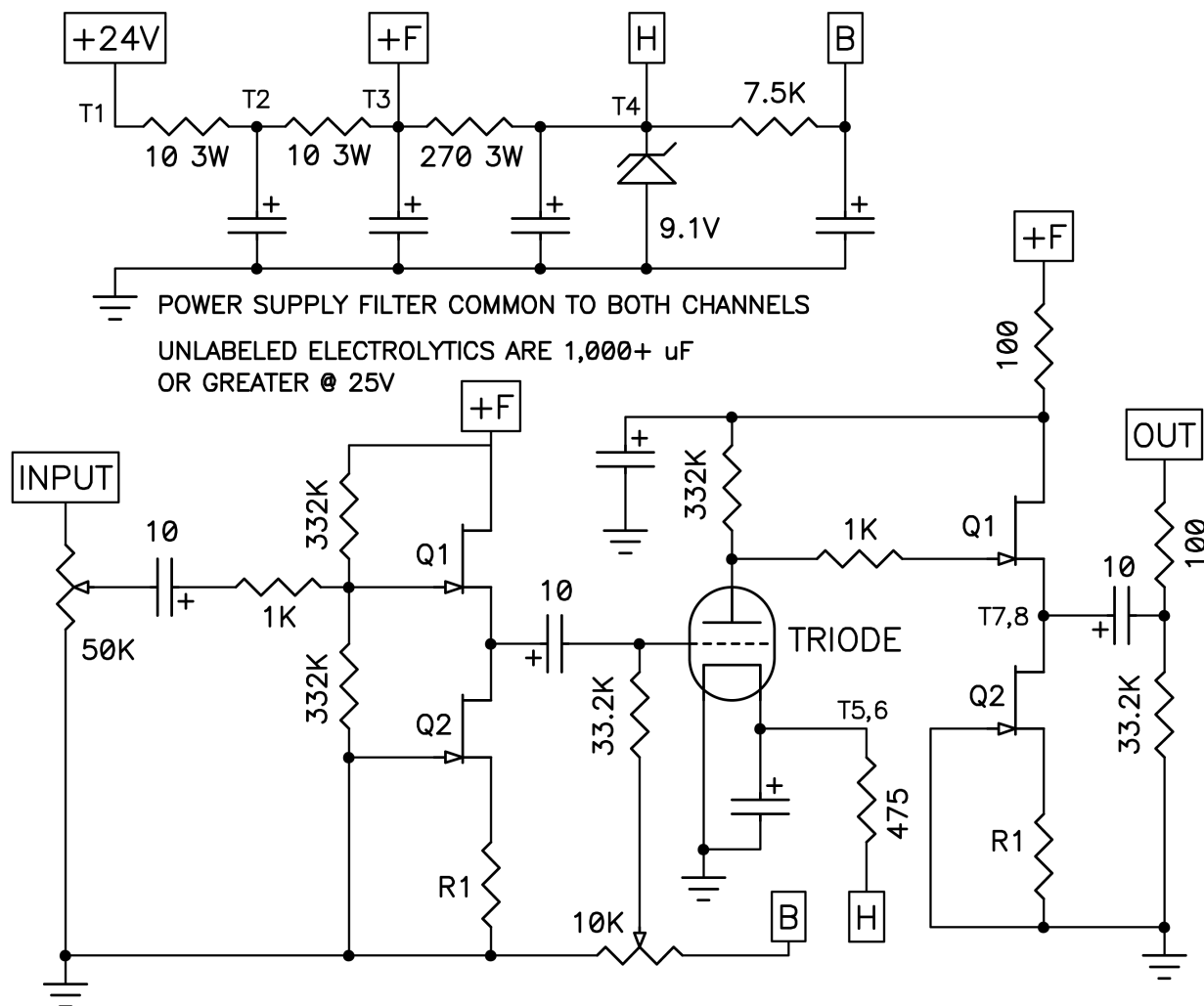
KORG NUTUBE CURVES

Besides pure novelty, the attraction of the Nutube in an audio circuit is the Triode character, allowing adjustment of the distortion by operating the device in a specific voltage/current load line. For a given amount of current through the tube there is a point at which the square law effects of Cathode current and Plate voltage cancel, nulling out 2nd harmonic distortion and leaving 3rd harmonic. This is the lowest output distortion setting.

If you increase the Plate voltage, the circuit takes on a positive phase 2nd harmonic distortion character, and if you lower the Plate voltage it has negative phase 2nd harmonic. These distortions increase as you adjust the Plate voltage farther from the null point.

This being mostly just the DIY assembly documentation, I refer you also to another discussion about 2nd harmonic: http://www.firstwatt.com/pdf/art_h2.pdf

Here is the schematic of the preamp, showing one channel and the power supply:



KORG NUTUBE DIY PREAMP
V1 R0 (C) 2018 PASSWORKS

ONE CHANNEL SHOWN
JFETS = MATCHED J113 OR
2SK170 / LSK170 / 2SK370

The power source is a “wall wart” type external supply, providing regulated 24V and rated at 0.50 Amps current. The preamp will draw about 60 mA in operation, although the extra current rating of the switching supply gives us the initial current to charge the filter capacitors at turn-on. As some switchers have protection which prevents the charging of the caps, it is important to test the specific power supply with the circuit. The specified Triad supply meets this requirement, and is cheap and fairly quiet. The additional filtering takes noise down to a few micovolts. Node +F provides current to the Jfet and Nutube gain stages, H provides current to drive the Cathode heaters of the Nutube, and B provides Grid bias voltage. The Zener diode regulates the DC value for H and B of 9 volts.

The preamp can be made to work with other supply voltages, but you will find yourself adjusting resistors and also needing a distortion analyzer to set the Nutubes for the desired distortion character. Easier to use 24V. If you use a linear power supply, you will want to have it regulated, as we need a constant DC value regardless of AC line voltage.

You will see two sets of buffers in the circuit - at the input and output. The Nutube has a lower input impedance than regular Triodes, and an input buffer allows operation with a high impedance volume control, as with the 50K pot in the schematic. The output impedance of the Nutube Plate and 332K resistor is quite high, on the order of 100 Kohms or more, so an output buffer is appropriate.

In this design, the buffers consist of Jfet followers operated without feedback and biased by matched Jfets used as constant current sources. Depending on the Jfets, the buffered output impedance of the preamp is 140 ohms to 170 ohms (including the 100 ohm output resistor).

The PC board is set up to accommodate a variety of Jfets and has corresponding holes for the parts, being that they have different pin-outs. The JQ1,Q2 is used for the Fairchild J113's and the KQ1,Q2 fits the 2SK170, 2SK370, and LSK170 Jfets.

Q1 and Q2 transistors are selected for specific I_{dss} values, and the R1 values are matched to the Q2 Jfets. For J113 parts, the I_{dss} of Q1 is set to be equal to current through Q2, and with the 2SK parts it is matched and the value of R1 is zero. The kits are provided with selected J113's, and note that Q1/Q2 are not interchangeable. The use of the other parts involves matched I_{dss} values ranging from about 4 to 8 mA.

The 10 uF input and output capacitors are intended to be the “audio grade” types offered by Elna or Nichicon. You are of course welcome to customize these as you like. Lowest practical values are about 1 uF.

None of the passive parts are critical, but it is important to feed the proper current through the heaters, about 17 to 18 mA through the 475 ohm resistors. Too much current will cause the cathode to glow red, and that is not a good thing for reliability.

You will notice various test points T1 - T8 which are referenced on the circuit board for the project for the purpose of testing and adjusting the completed circuit.

Selection and matching is very useful for adjustment of the Nutube's bias without a distortion analyzer. For this circuit the amount and phase of the 2nd harmonic depend on the Plate voltage of each channel of the Nutube which are adjusted by the potentiometers.

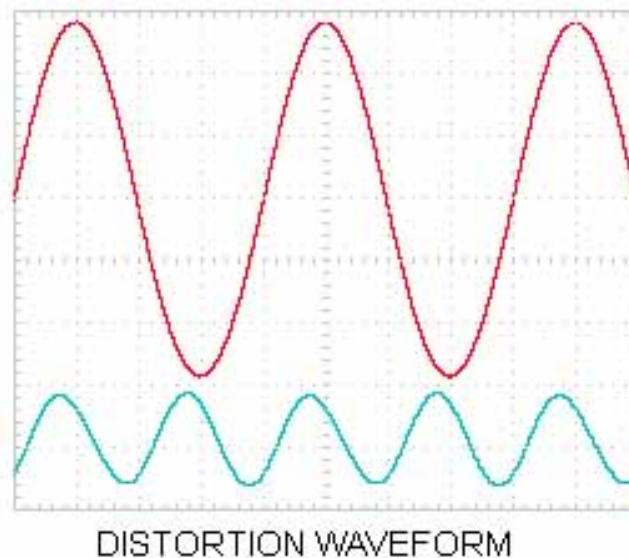
Because the impedance of the Plate loaded into a 332 Kohm resistor is very high, your average multimeter will load it down, giving an incorrect Plate voltage when you measure it. Instead, we will measure the Source voltage at pins 7 and 8 and count on the small difference voltage between the Gate and Source of the output follower Jfet to tell us the Plate voltage.

For this reason we will operate the follower Jfets at I_{dss} , the current at which the Gate and Source are at the same voltage. This is accomplished by selection and matching.

The reference settings for the circuit give the following distortion curve:

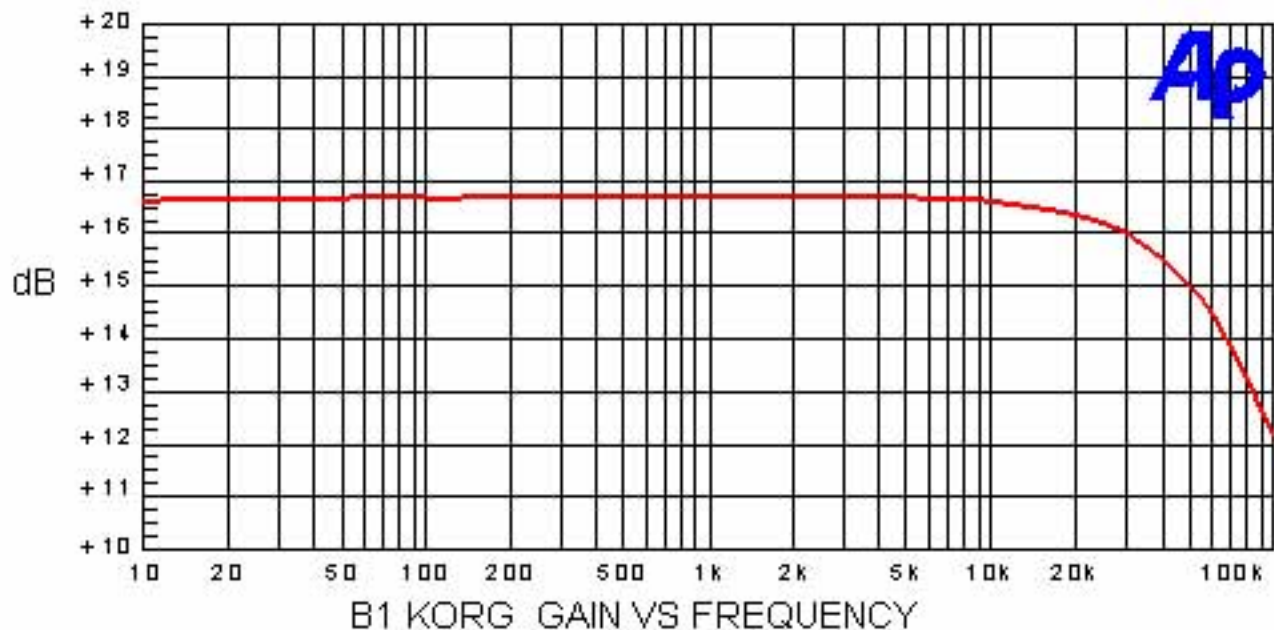


Below are the fundamental and distortion waveforms at 1 volt output, showing a positive phase 2nd harmonic (lower trace)



I describe positive phase second as being the harmonic having a positive distortion peak on lined up with either a positive or negative peak on the fundamental.

Here is the frequency response of the circuit:



You will note that the response is about 3 dB down at 80 KHz, the result of the high Plate resistance and the capacitance of the output buffer. Also note that the circuit as presented has a little over 16 dB of gain, and happily functions as a preamp with a logarithmic input potentiometer.

The circuit can be adjusted for lower or higher distortion via the bias pots on the circuit board, and the reference values afford 1.5% thd at 1 volt output. At this setting it generates higher 2nd harmonic values as the output voltage is increased to a maximum of about 5 volts.

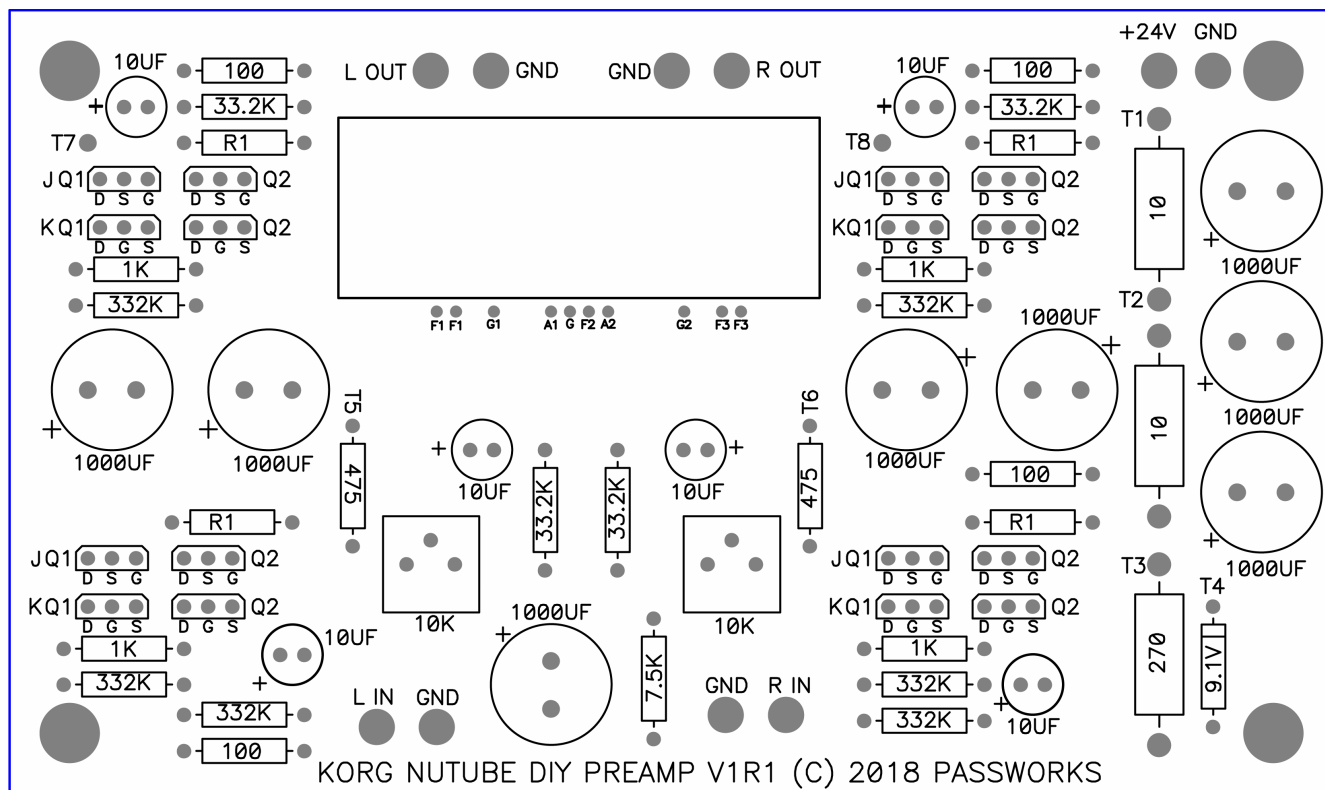
The input impedance is roughly the value of the input pot, and the output impedance is about 140 ohms (2SK/LSK Jfets) to 170 ohms (Fairchild Jfets).

It has been noted that the Nutube is a bit microphonic, and if you tap on it, you can hear it in the speakers. Not recommended that you mount it on top of your speaker. Korg recommends some sort of foam damping pad underneath the Nutube, but I will say that I have not found this to be an issue.

Also, the circuit has a turn-on turn-off thump. You can leave it on, and it draws .06 amps at 24V, and it won't impact your electric bill. Alternatively, you can be sure to turn it on first and turn it off last in the system.

Base kit offers circuit board and selected Fairchild Jfets. You can obtain the 2SK or LSK types independently - they should be matched for 3 to 8 mA Idss and used with R1 = 0 ohms.

Here is the pc board showing the location of the components:



Parts on the board besides the Nutube:

QTY	DESCRIPTION	DIGIKEY #
2	RESISTOR 10 OHM 3W	P10W-3BK-ND
4	RESISTOR 100 OHM .4W	PPC100YCT-ND
1	RESISTOR 270 OHM 3W	P270W-3BK-ND
2	RESISTOR 475 OHM .4W	PPC475YCT-ND
4	RESISTOR 1K OHM .4W	PPC1.00KYCT-ND
1	RESISTOR 7.50 KOHM .4W	PPC7.50KYCT-ND
4	RESISTOR 33.2K OHM .4W	PPC33.2KYCT-ND
6	RESISTOR 332K OHM .4W	PPC332KYCT-ND
2	TRIM POT 10K BOURNES	3386P-103LF-ND
8	CAPACITOR 1000 UF @ 25V	493-15476-ND

6	CAPACITOR 10 UF 25V	604-1050-ND
1	ZENER DIODE 1N4739 9.1V	1N4739AFSCT-ND
4	Q1 N CHANNEL JFET	SUPPLIED
4	Q2 N CHANNEL JFET	SUPPLIED
4	R1 BIAS RESISTORS	SUPPLIED
1	TRIAD WSU240-0500-13	237-2249-ND

Construction hints:

I like to bend all the resistors to .5" spacing, stuff them on the board and solder the other side with the resistors pressed flat against the work surface. Then I go on to taller parts. When it's time to do the Jfets I have the board flat on the work surface and set them in the holes, and solder just one of the pins while trying to align the transistor nicely, and then I solder the remaining pins from the other side. Lot easier that way and comes out neat.

Then the supply caps and lastly the Nutube. With that we want to put a temporary spacer between the tube and the pcb and line it up flat, then soldering a few pins to keep it that way while soldering the underside. Some people use 2 sided sticky tape or something to permanently hold the Nutube, especially if it's going to be shipped, I have used hot glue, works just fine. If you aren't worried about shipping or dropping the preamp, then you can let the Nutube be held horizontally by just its pins.

IMPORTANT CAVEAT:

The first batch of boards, the V1R0, is missing a short trace on the underside of the board. You, the intrepid DIYer are expected to fix this as part of your experience here. You can use a snipped-off piece of resistor lead to bridge the two points as shown here.



Sorry about that. If you have V1R1 or later, it has been corrected.

If you are a novice at these things, you will want to consult the always excellent build guides presented by diyAudio's member 6L6. As I write this he is putting one together....

Initial Power Up:

Put the adjustment pots at the center position.

Connect the 24V supply

Look at the Nutube - the Cathodes should lite up as blue in about 3 seconds or so. If they are orange or red, unplug the power supply immediately - there is too much bias current.

With a voltmeter referenced to Ground (all 4 mounting holes are at ground) measure:

T1 = 24V approximate

T3 = 23V approximate

T4 = 9V

If these values are good within .5V you should be OK. If not, carefully check your circuit for errors.

T5 and T6 should be at about 0.6 VDC This is the bias to the Cathode heaters.

T7 and T8 are adjusted by the on board pots for each channel. They should be set to 10 volts and allowed to sit for a bit, while the tube warms up.

After a few minutes and no smoke, we adjust the T7 and T8 voltages as follows:

Voltage at 12 VDC is approximately the 2nd harmonic null point where we get about .3 % distortion in 3rd harmonics. As we go lower we start getting positive phase 2nd harmonic, and it will hit 1.5% at 1 volt AC output with about 9.5 VDC on the T7 or T8 test points. Voltages higher will give negative phase second harmonic.

This is a reasonable calibration - 0.1V either way changes the distortion by about 0.1%

Clockwise on the pot from the null spot makes for less Plate voltage, and positive phase second harmonic, counterclockwise makes for more negative phase second harmonic.

If you have a distortion analyzer which gives you the percentage but not the phase, then just start out with the Plate voltage high (CCW pot) and turn it clockwise to the point where it is minimum, and then go further for + phase, or back up for - phase.

The reference setting for this project, are 9.5V on T7 and T8, which gives a positive phase at about 1.5% at 1 volt output. You are free to set it elsewhere.

Operation:

There are a couple of points to consider, a primary one being, "What setting do I want?"

That would be whatever makes you happy, but to help you get there, here are some tips:

Remember that the preamp is phase-inverting. In order to get the correct absolute phase coming out of the speaker you must invert the phase after the preamp. The easiest place to do this is at the loudspeaker. Of course if you prefer it out of phase, that's fine with me.

When you invert the phase of the output of the Nutube to get correct phase, then you invert the phase of the second harmonic as well, and now it becomes negative phase second.

This is often what we want, but not always. Routinely people describe negative phase second harmonic distortion as having a deeper sound stage and a magnified illusion of placement of instruments in that depth. Positive phase second harmonic distortion is often described as more up close, intimate and perhaps more detailed.

Let's be clear. To the extent that it works, it's just a psycho-acoustic trick. It doesn't work for everyone, and is not as good on complicated music, where IM distortion is more of a problem.

IMHO it's also trick that doesn't like to be over-done. Some people like to sweeten up their analytical sounding amplifiers with a tube preamp, but you might find that this circuit plus a SET (or even a SIT) amplifier is too much of a good thing.

With a little effort and good luck it will sound great.

Your results may vary, but remember that we are here to have some fun - It's entertainment, not *dialysis*.

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