

The DIY Sony VFET

by Nelson Pass

This is an addendum to the “Sony SIT AMP part 2” article is the second of a series presenting “Do-It-Yourself” audio power amplifiers using Static Induction Transistors (SITs), also known as VFETs. These are unusual transistors with a characteristic similarity to Triode tubes.

Here we are concerned with a modified version of the amplifier where we use only one pair of the VFET transistors per channel. The motivation for this is so that DIYers can build their own versions of the amplifier with the very limited quantities of the VFETs which are available.

To make this design more accessible, www.DIYAudio.com is offering a limited number of kits for this design including VFETs, pc boards, and hardware.

I refer you to previous articles (in pdf format) linked below. I recommend looking at these for background material.

[2015 Sony VFET Part 2](#)

[2014 Sony VFET Part 1](#)

[2013 Sony VFET 40 Year Commemorative Amplifier](#)

[2011 SIT Introduction](#)

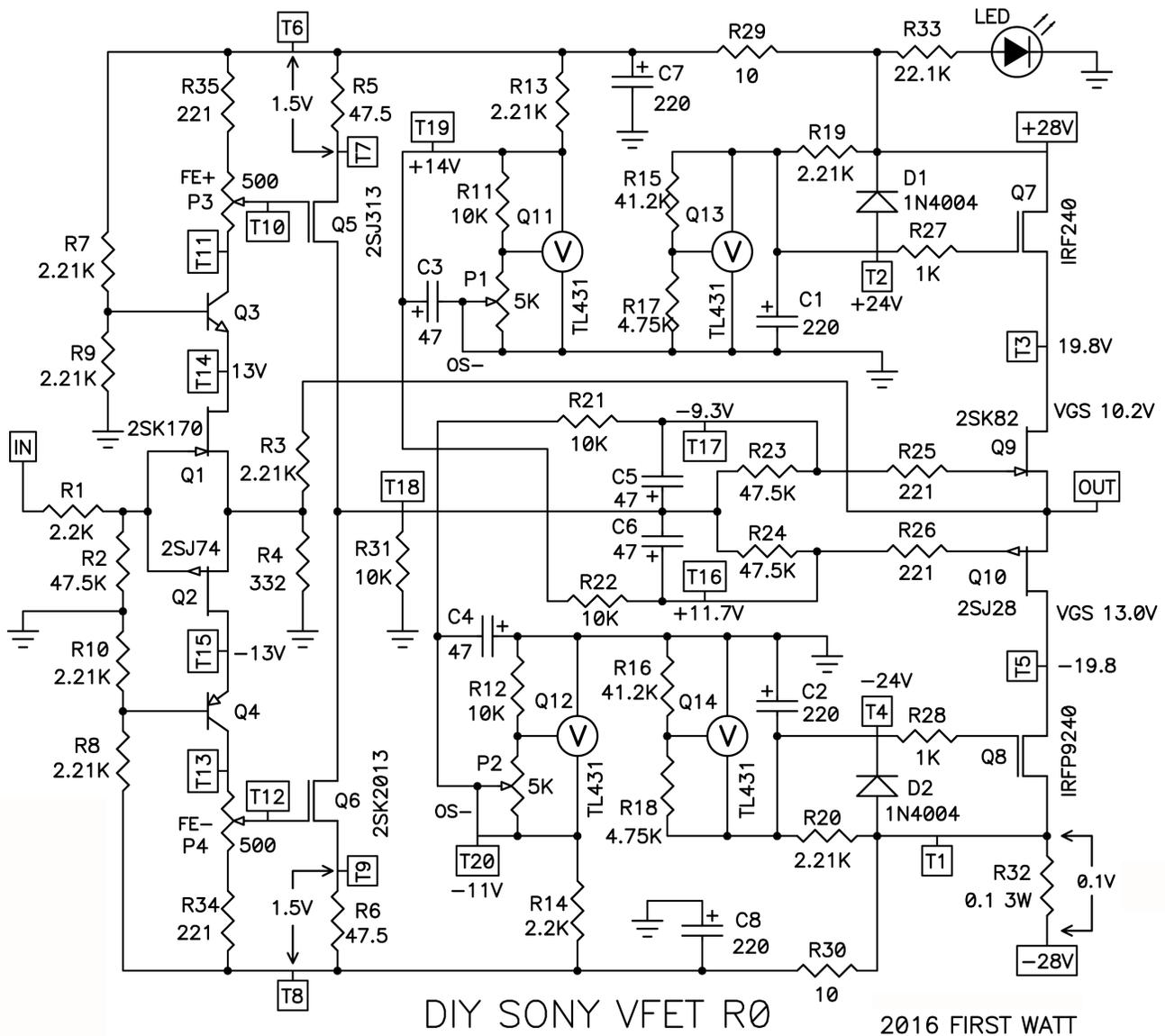
[2012 SIT Nemesis](#)

[2011 SIT-1 Owner's Manual](#)

[2011 SIT-2 Owner's Manual](#)

If you have absorbed the contents of the previous articles, you probably have a good picture of what is going on. This project is simply a simplification of the Part 2 article, and virtually all you can see their will apply to this project, so you will want to pay particular attention to that.

Here is the revised version of the circuit:



Comparing it to Part 2, you see that there is only one pair of the VFETs, that the input cascode transistors Q3 and Q4 are biased only by resistors, and that the regulators Q7 and Q8 are no longer bootstrapped by the output signal. Also, there is no longer a provision for no-feedback operation (we need the feedback here with the smaller output stage) and also no cascode feedback.

Although still complex, it is a simpler circuit than Part 2, and more likely to be successfully built. Numerous resistor and transistor values have been adjusted, no big deal.

Construction Notes:

As with Part 2, I used an ordinary First Watt type supply design, documented elsewhere, with 22 VAC transformer secondaries to provide +/-28 volts DC. 24 or 25 VAC will work fine, running a little hotter. Later we will discuss changes to resistor values for different rail voltages. Also we will be giving more organized test procedures to maximize the probability of success in that scary moment when the power is first applied.

This article pretty much assumes that you are using the kit supplied by DIYAudio. The VFETs provided with it are already tested and graded with a number which represents the bias voltage for 0.5 amps of current.

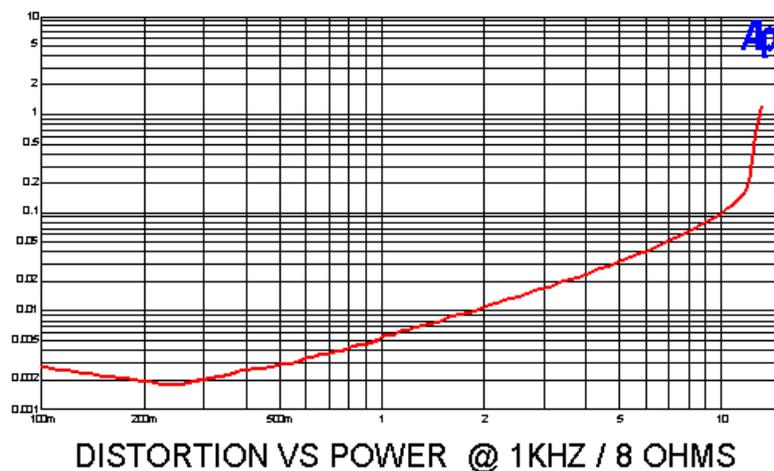
DIYaudio also offers a couple of chassis for this project, and the bracket which comes with the kit is designed to mount on one of their heat sinks.

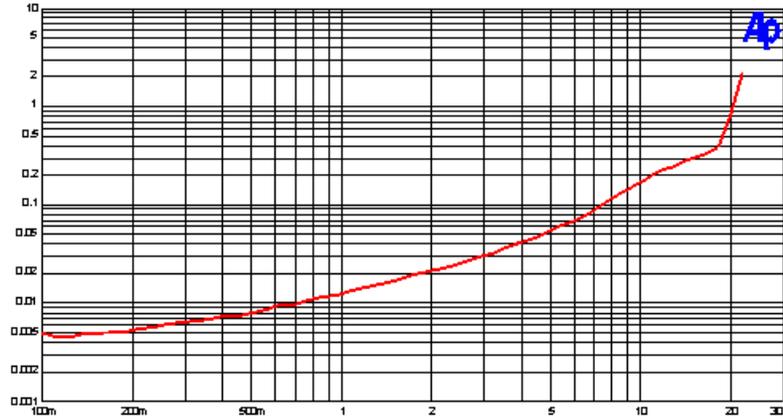
There is nothing unusual regarding the construction of this amplifier. All the usual cautions and advice about building power amplifiers apply. There will be a construction thread and build video by 6L6 in the Pass Labs forum at DIYAudio.

Performance Notes:

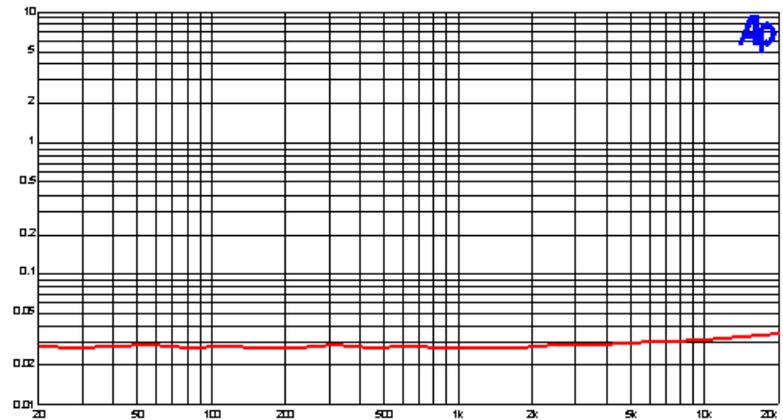
The amplifier delivers 15 watts into 8 ohms and 20 watts into 4 ohms. This is less power than Part 2, and reflects the single pair of VFETs. The open loop gain is about 36 dB without a load, and 35 dB with an 8 ohm load, and the closed loop gain is 16 dB. The output impedance is 0.18 ohms, a damping factor of 45.

Here are the curves:

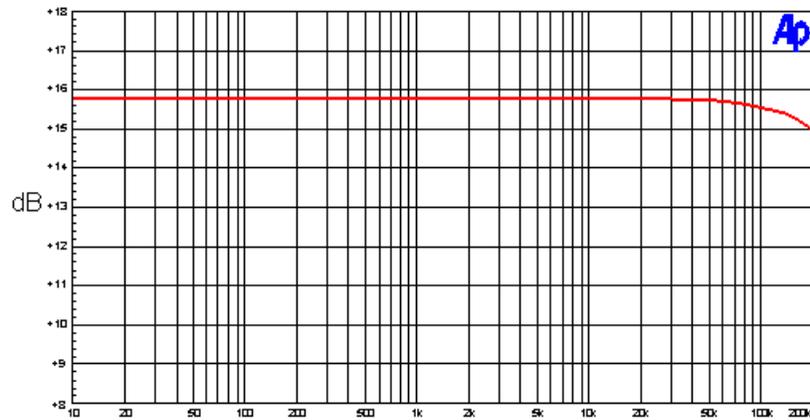




THD VS POWER @ 1KHZ / 4 OHMS

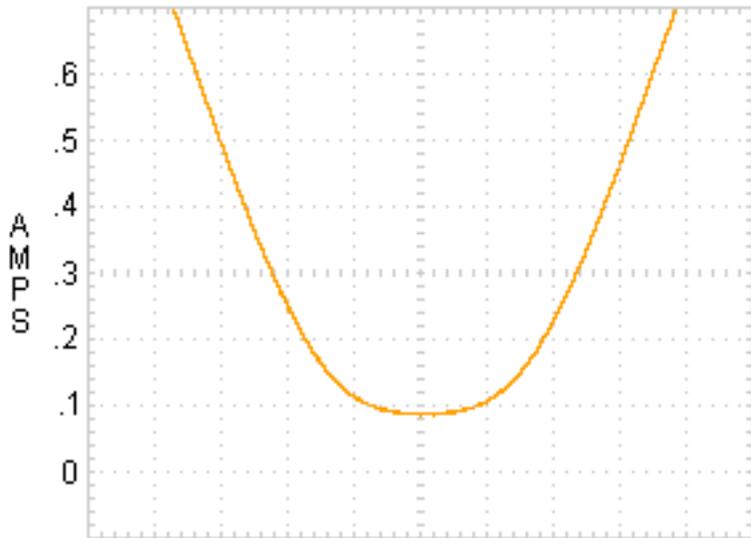


DISTORTION VS FREQUENCY @ 2W 8 OHMS



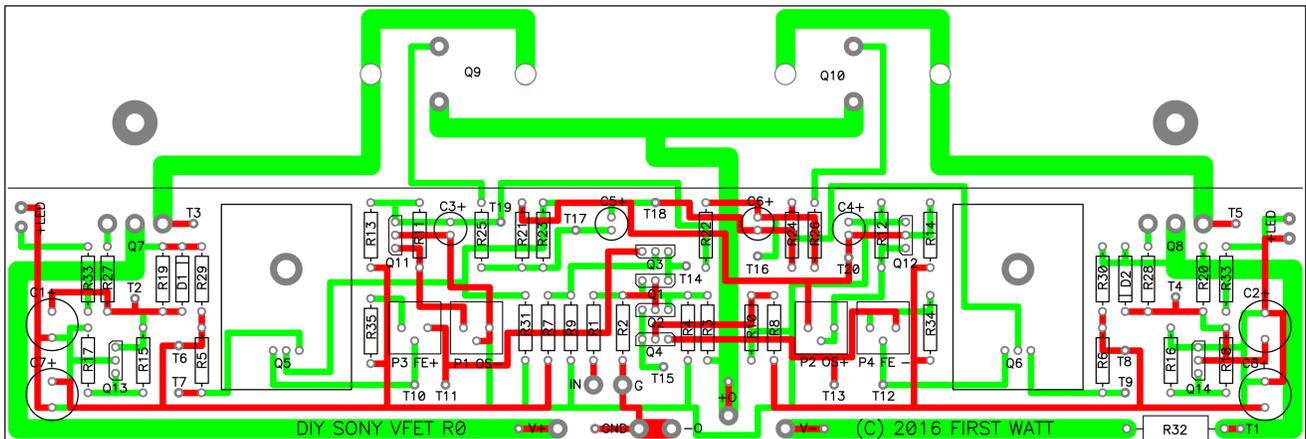
FREQUENCY RESPONSE

This is a curve showing the Class A envelope - current still going through the “unused” VFET at 15 watt rms (30 w peak) into 8 ohms. You can see that there is still about 100 mA bias left on the “unused half” of the amplifier at this point.



CURRENT THROUGH VFET @ 30W PEAK

For reference, this is the artwork for the circuit board supplied in the kit. Green is the bottom traces, red is the top. Component numbers, polarities, and voltage test points are silk screened in white on the top of the board.



TESTING NOTES

The following notes are intended as an aid to initial testing and adjustment of this advanced do-it-yourself project. It is assumed that the builder has the skills and knowledge to safely tackle a project like this and is prepared to take responsibility for the results.

PART 1 – TESTING THE RESISTORS

Here we will perform an early test to see if we have errors in resistor stuffing before we start putting in other parts. This will might just save us all sorts of trouble later on.

All resistors stuffed and soldered, no semiconductors or capacitors. All potentiometers set to halfway position. With digital ohmmeter, measure resistance between test points to about 5%. Don't get too excited if they aren't exact. Don't have an ohmmeter? Get one.

POINTS	OHMS	POINTS	OHMS
T6 – T11	680	T8 – T13	680
T2 – T6	2.1K	T1 – T4	2.1K
T6 – T7	47	T8 – T9	47
T6 – T19	1.9K	T8 – T20	1.9K
T12 – T13	250	T10 – T11	250
T6 – T10	430	T8 – T12	430
G – T18	7.5K	G – IN	49K
G – T19	3.9K	G – T20	3.9K
G – T17	11.3K	G – T16	11.3K
G – T2	4.9K	G – T4	4.9K
G – V+	3.1K	G – V-	3.1K

PART 2 – APPLYING POWER TO THE FRONT END

Circuit voltages with semis and capacitors stuffed – NO VFETs yet.

***** Pots P3 and P4 set fully counterclockwise *****

Power supply attached with $V+ = +28V$, $V- = -28V$.

See notes at end for other supply voltages.

Initial Voltages at test points:

POINTS	VOLTS	POINTS	VOLTS
G – T6	+28V	G – T8	-28V
G – T4	-24V	G – T2	+24V
T6 – T7	0V	T8 – T9	0V
T6 – T11	~ 5V	T8 – T13	~ 5V
G – T18	less than a few +/- volts (will adjust later)		
G – T14	+13V	G – T15	-13V
G – T19	~+12V	G – T20	~-12V
G – T17	~-10V	G – T16	~+10V

PART 3 - BIASING UP THE FRONT END

Assuming you acquired them from DIYAudio, your VFETs will have a V_{gs} rating written on them in tenths of volts (rating of 70 is 7.0 Volts, and rating of 101 is 10.1 Volts).

We want to set the voltages so the amplifiers comes up initially with low bias. The following voltages are reference to Ground.

Adjust P1 for T16 equals the V_{gs} of 2SJ28 + 1V (example: 68 wants +7.8V)

Adjust P2 for T17 equals the V_{gs} of 2SK82 – 1V (example: 92 wants -10.2V)

Now we are going to bias up the front end Mosfets. We will be looking at the voltage drops across R5 (T6 and T7) and R6 (T8 and T9) as well as the DC offset at T18 (relative to ground) while adjusting the trim pots P3 and P4

We are looking to achieve about 1.5 volts across R5 and R6 and close to 0 volts measured T18, which is the output of the front end circuit.

If your initial voltages across R5 and R6 with P3 and P4 counter-clockwise is above 1 volt, it is likely that either your Q1 and Q2 Jfets have particularly high I_{dss} values and/or your Mosfets Q5 and Q6 have a low V_{gs} . If you encounter this, I suggest that you note the voltage drop between T6 and T11 and also between T8 and T13 and ask for help on the DIYAudio Pass Labs forum. Do not continue to operate the circuit with R5 or R6 voltage drops above 2 V.

We start with P3 and P4 at counterclockwise positions which should be minimum bias, and ideally there will be no voltage across R5 and R6. If you have voltage drops between 0 and 1 volt, you are still fine. If the initial voltage is above 1 volt, skip to the end of Part 3.

We are now going to adjust P3 and P4 with the following rotating procedure:

Step 1 Check voltage across R5 (T6 to T7) and compare it to R6 (T8 to T9).

If the voltage across R5 is less than 1.2V and is lower than the voltage across R6, then adjust P3 clockwise to increase it by 0.1V otherwise go to Step 2

Step 2 Check voltage across R6 (T8 to T9) and compare it to R5 (T6 to T7).

If the voltage across R6 is less than 1.2V and is lower than the voltage across R5, then adjust P4 clockwise to increase it by 0.1V

Repeat until the voltages across R5 and R6 are both at 1.2V, matched as closely as you can get them.

At this point, the output voltage T18 should be fairly close to 0V. By tweaking the values of R5 or R6 very gently, you should be able to get T18 to be fairly close to 0V while holding the resistor drops at about 1.2V

At this point the circuit needs to warm up, and as it does the voltage across R5 and R6 (and thus the bias current of this stage) will rise a bit. If it climbs above 1.5V, it will need to be adjusted downward, and the output offset re-adjusted. If it doesn't rise to 1.5V, you can repeat the procedure to raise the value. Keep in mind that this is a good time to get these values and a low DC offset right. It becomes a little more complicated when the VFETs are installed and the feedback loop starts working.

Now readjust P1 and P2, as the adjustments of P3 and P4 will have slightly altered the voltages at T16 and T17.

Run it this way for a bit, and tweak the pots again for the desired voltages as outlined in this section, keeping in mind that each tweak will slightly alter the other values. Halfway adjustments are still recommended.

If it looks reasonably stable over a period of time, then we are ready for the final assembly and tests.

PART 4 INSTALLING VFETS AND ADJUSTMENT

At this point, you install the VFETs and prepare to fire up the amplifier.

The previous instructions were intended to help you isolate and solve problems in the circuit prior to this step to minimize the chance that the rare and expensive VFETs will not be damaged at this point.

If you have a Variac for this, you will want to use it, but keep in mind that it is only useful for providing a relatively low inrush current to the power supply capacitance – you cannot raise the AC line voltage too slowly or you risk having the VFETs draw too much current while the bias voltages are being established.

I suggest that you raise the AC line to voltage over a period of less than 5 seconds.

It's also a good idea to connect the channels up separately so that you are dealing with one at a time. Until things are working, one channel at a time gets power supply V+ and V-.

I also suggest that you start out with the lowest possible line fuse that can survive the modest inrush provided by the Variac. 1 amp fast blow is a good start, and has a reasonable chance of protecting the circuit.

If you don't have a Variac, you will probably need a higher value, but keep it at a minimum until you know the circuits are OK.

If the 1 amp fuse survives, take a look at the voltages across R32 on each channel (test points -28V to T1) With a little luck it will be less than 100 mV. If it is higher, shut it down, adjust P1 and P2 counterclockwise a bit and try again. If that doesn't work, then stop and get help.

Ideally, the R32 voltage drop will be about 50 mV or less, and you can move on to adjusting the output stage bias current and DC offset voltage. You do not need a load at the output for this.

For this procedure you will be adjusting P1 and P2 while keeping an eye on the voltage drop across the .1 ohm power resistor R32 and also on the DC offset voltage at the amplifier's output.

We will be looking to achieve 100 mV DC across R32 while also having close to 0 volts DC at the output. It's very helpful if you have two voltmeters, but you can do it with one. The target DC offset value will be 0 microvolts, but we will allow +/- 50 mV at the output. If you can do better, then that's good too.

Assuming that the voltage across R32 is less than 100 mV, you can adjust P1 and P2 in rotation much the same way as you did with P3 and P4. Don't try to just set it at the right value first time – these pots interact with each other, so go toward the desired values in small increments. With a little practice you will get the hang of it, and it does require patience, particularly as this has to be played with while the amplifier warms up – the values will drift a little with temperature.

If you are successful, and the amplifier runs for an hour or so without running away, either with the voltages across R5 and R6, or R32 or the DC offset at the output, then probably you are safe to hook up a loudspeaker and see how it sounds. If you need to tweak any of the pots, remember to do it in halfway steps, checking and adjusting the other bias values as you go along.

If you think you're ready to go, one last piece of advice: Start with cheap speakers.

(Note how much the amplifier improves their performance...)

NOTES ON SUPPLY VOLTAGES NOT +/-28V

This amplifier is designed to operate with voltages between about +/-26V DC and +/-30V DC.

If your supply is lower than this, you should adjust R15 and R16 down so that the R19 and R20 have at least 2 volts across them.

For example, if the supplies are +/-24V as measured at T6 and T8 (relative to ground) then the regulators Q13 and Q14 need to be set for 2 volts below that at 22V each.

To compute the new value of R15 and R16:

$$22V = 2.5V * (R15+4750 \text{ ohms})/4750 \text{ ohms}$$

$$22V * 4750 \text{ ohms} / 2.5V = R15 + 4750 \text{ ohms}$$

$$41800 \text{ ohms} = R15 + 4750 \text{ ohms}$$

$$R15 = 37050 \text{ ohms.}$$

You would pick the closest 1% resistor, which would be 36K or 36.5K for R15 and R16.

Other parts of the circuit are not very sensitive to supply values. Practically speaking, you should not try to make this amplifier with rail voltages below 20 volts, and above 32 volts.