

DIY SONY VFET AMPLIFIER OS2 – GOT VFETS?

OUTPUT STAGES FOR 2SK60 and 2SJ18

By Nelson Pass 3/11/22

Introduction

Limited as it was to about 180 stereo amplifiers, last year's release of designs around the Sony 2SK82 and 2SJ28 Vfet power transistors seems to have been a great success. Unfortunately, that was the total of my supply of these precious parts, and not likely to be repeated. However, numerous DIYers also purchased them from the same source in Singapore many years ago, and in addition others have salvaged them out of old Sony amplifiers. Some of those are the same 2SK82 and 2SJ28's and others are 2SK60 and 2SJ18. Same chips, but there are twice as many inside the 2SK82/2SJ28, so the result is not quite the same.

For those of you who have any of these parts I now present revised versions for both N and P polarities which will serve 2SK82/2SK60 or 2SJ28/2SJ18 types and any other TO-3 parts of similar function (even Mosfets!), although the emphasis will be on the single-die N channel 2SK60 and P channels 2SJ18.

This pair of output stage circuits will bear a lot of similarity to last year's offering, but are more flexible. In tackling this project you will want to make reference to the very similar designs from last year, as detailed in the following two articles:

https://www.firstwatt.com/pdf/art_diy_sony_vfet_pt1.pdf

https://www.firstwatt.com/pdf/art_diy_sony_vfet_pt2.pdf

Also there are discussion and build guides (usually by member 6L6) to be found in the Pass Labs forum at www.diyAudio.com. Questions that are not addressed in this piece will no doubt be addressed by the community there.

Note that these are just the follower output stages of a power amplifier. There are numerous front end circuits for this now, not just the ones from last year, as well as variations in power supply filters. The original designs still work, but you have lots of choices compatible with this effort as well as last year's. You may even find it worthwhile to drive these output stages directly from a preamp – they have a high input impedance, but no voltage gain, only current gain.

Additional pieces on the subject of VFETs and SIT transistors:

https://www.firstwatt.com/pdf/art_sony_vfet_pt1.pdf

https://www.firstwatt.com/pdf/art_sony_vfet_pt2.pdf

https://www.firstwatt.com/pdf/art_sony_vfet_40yr.pdf

https://www.firstwatt.com/pdf/art_sit_nemesis.pdf

<https://www.firstwatt.com/sit1.html>

<https://www.firstwatt.com/sit2.html>

https://www.firstwatt.com/pdf/art_sit_intro.pdf

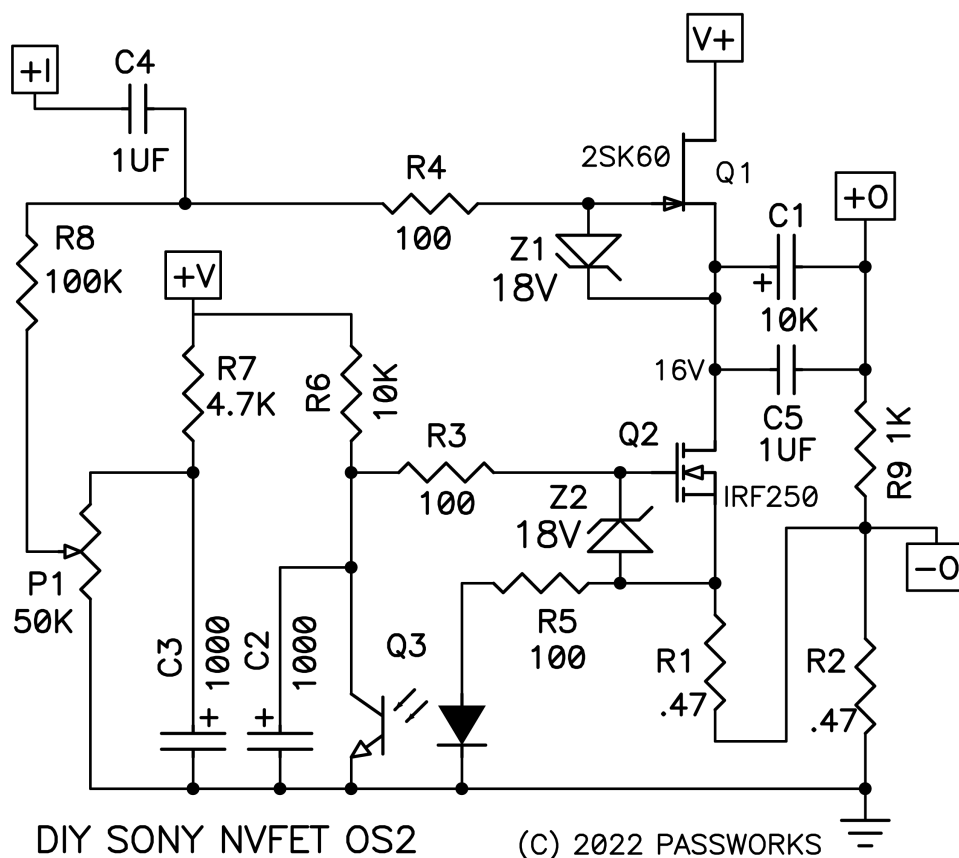
The biggest difference between these N and P channels and last year's versions is that the current source which biases the VFET into Class A operation can be adjusted for gain. The original was a constant current source and did not contribute gain to the output circuit. The current sources for this version can be set to 0 gain (constant current) or higher, where the current source contributes to the output AC current.

There is an interesting reason for this. The dual die 2SK82 and 2SJ28 have a character which is largely optimized around an 8 ohm load, where the variations of current (I_{ds}) vs voltage (V_{ds}) for the device work out nicely. Having half the chip hardware inside, the 2SK60 and 2SJ18 has a preference for 16 ohms.

To get the behavior we want, we will fool the 2SK60 and 2SJ18 into thinking that the load is higher impedance by giving the current source some gain with small topology variations. They resemble last year's circuits, but you will see that the power resistors attached to the Source pins of the IRF250 current source transistors have been split and the speaker connection is tapped between them. This tap can be adjusted by varying the relative values of the two resistors, leaving the sum of the resistance the same, and the minus output to the loudspeaker is connected to this point.

The result is that when output current from the Vfet goes through the speaker, and it flows into this tap and varies the current of the IRF250 Mosfet current source, supporting the output of the Vfet, and making it behave as if the load impedance is higher.

Here is the schematic for the 2SK60 N channel version:

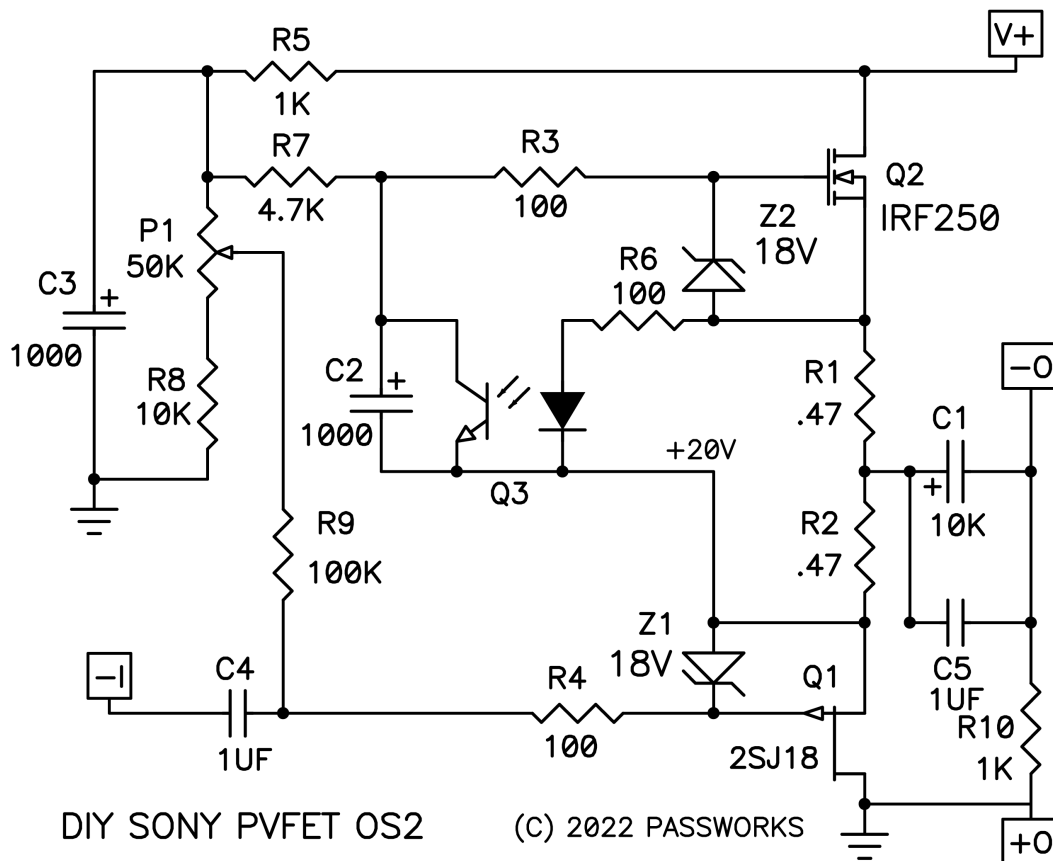


Q1 is the Vfet follower device and Q2 is the current source. R1 + R2 determine the DC bias current and the ratio of R1 and R2 sets the AC gain. The for R1 = 1 ohm and R2 = 0, the current is constant. As seen, the transistor Q2 will contribute about 40%, and this is the value chosen for 2SK60, although you can choose a different ratio.

Q3 is used to set the DC current by controlling the voltage across R1 + R2 for about 1.2V DC. Potentiometer P1 is used to set the DC output voltage, which is +16 VDC measured on the case of the IRFP250 transistor. We want about 19 Volts from Drain to Source on the VFET, and that 16V is what's left over.

Note that like its predecessor the polarity on the input is positive, as is the live output. This N channel version gives the desired harmonic character when operated with the signal in phase on both the input and output. The downside of the N channel version is that it's power supply rejection is lower, and so requires a quieter V+ supply. Also, it has a larger turn-on/off thump. The fixes for these are more elaborate power supply filtering, and in addition to the original design you will find at least one more at diyAudio.com in the Pass Labs forum.

And here is the 2SJ18 P channel version:



Like the N channel 2SK60 it is biased by a current source, although this setup is different, a Mu-Follower complementing a Follower (MUFF). We still also have largely the same result, with R1 + R2 setting the DC current and their ratio setting the AC, again at about 40% contribution from the current source and fooling the 2SJ18 into thinking that the load impedance is higher. Again setting R1 at 0 makes the current source constant, as with the 2SJ28 version.

Again we see P1, in this case used to set the DC output voltage, but this time it is 20V referenced to ground, and again leaves 16 volts for the current source given a 36 volt supply.

Unlike the N channel version the signal polarity on the input is negative, as is the live output. This P channel version gives the desired harmonic character when operated with the signal in phase on both the input and output. No one will stop you from using any signal polarity you like – and you should feel free to try it differently.

And here we have the Bill of Materials – note that they are not identical.

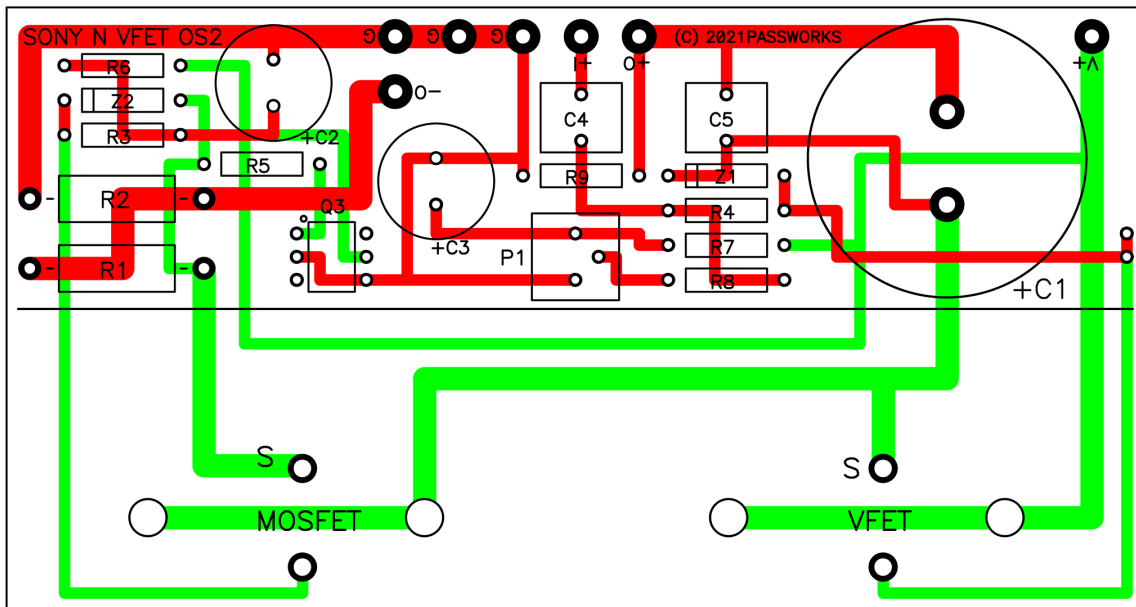
DIY SONY VFET OS2 N CHANNEL - BILL OF MATERIALS

N CH REF #	QTY	DESCRIPTION	VENDOR	PART #
MOSFET TO-3	2	IRF250		
Q3	2	OPTO ISOLATOR - LITE ON	DIGIKEY	160-1304-5-ND
Z1, Z2	4	ZENER DIODE 18V	DIGIKEY	1N5248BFSTR-ND
P1	2	TRIM POT 25K BOURNES	DIGIKEY	3386P-253LF-ND
R1, R2	4	RESISTOR 0.47 OHM 3W	DIGIKEY	A138414TB-ND
R3, R4, R5	6	RESISTOR 100 OHM .4W	DIGIKEY	PPC100YCT-ND
R7	2	RESISTOR 4.7K OHM .4W	DIGIKEY	PPC4.75KYCT-ND
R6	2	RESISTOR 10K OHM .4W	DIGIKEY	PPC10.0KYCT-ND
R8	2	RESISTOR 100K OHM .4W	DIGIKEY	PPC100KYCT-ND
R9	4	RESISTOR 1K OHM .4W	DIGIKEY	PPC1.00KYCT-ND
C1	2	CAPACITOR 10000 UF 50V	DIGIKEY	604-1050-ND
C2, C3	4	CAPACITOR 1000 UF 50V	DIGIKEY	1189-4212-ND
C4, C5	4	CAPACITOR 1 UF FILM		
#6 SCREW	8	#6-32 SCREW .5"L (TO-3 MOUNT)		
#6 NUT	8	#6-32 LOCKNUT (TO-3 MOUNT)		
SPACER	8	NYLON SPACER #6 HOLE .25"D X .25"L		
PC BOARD	2	PCB		
TO-3 INSULATOR	4	THERMAL PAD		
BRACKET	2	CHANNEL BRACKET		

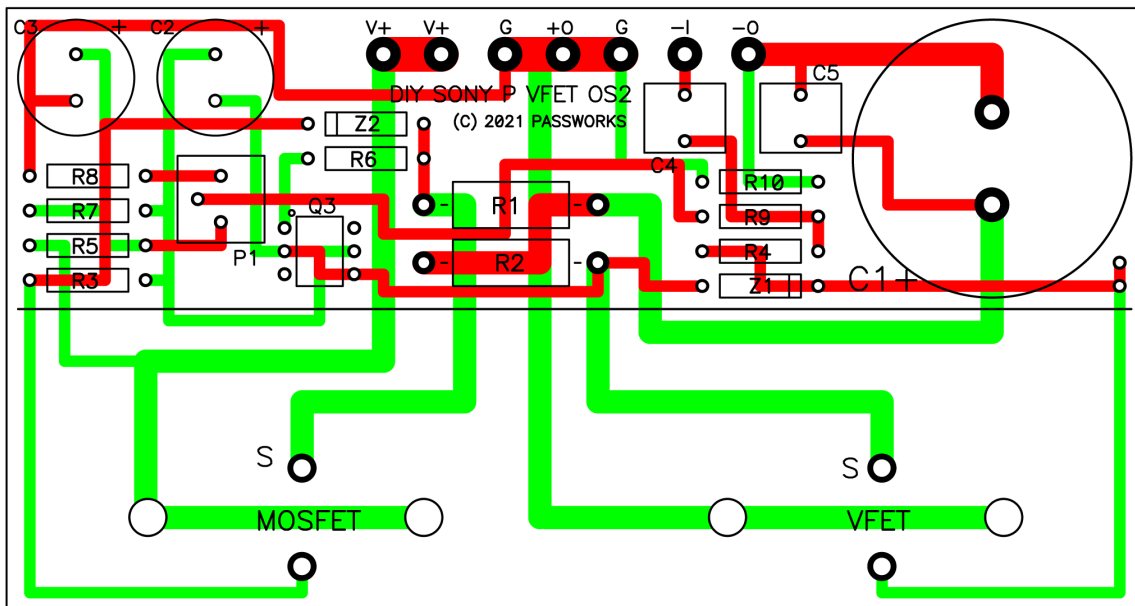
DIY SONY VFET OS2 P CHANNEL - BILL OF MATERIALS

P CH REF #	QTY	DESCRIPTION	VENDOR	PART #
MOSFET TO-3	2	IRF250		
Q3	2	OPTO ISOLATOR - LITE ON	DIGIKEY	160-1304-5-ND
Z1, Z2	4	ZENER DIODE 18V	DIGIKEY	1N5248BFSTR-ND
P1	2	TRIM POT 25K BOURNES	DIGIKEY	3386P-253LF-ND
R1, R2	4	RESISTOR 0.47 OHM 3W	DIGIKEY	A138414TB-ND
R3, R4, R6	6	RESISTOR 100 OHM .4W	DIGIKEY	PPC100YCT-ND
R7	2	RESISTOR 4.7K OHM .4W	DIGIKEY	PPC4.75KYCT-ND
R8	2	RESISTOR 10K OHM .4W	DIGIKEY	PPC10.0KYCT-ND
R9	2	RESISTOR 100K OHM .4W	DIGIKEY	PPC100KYCT-ND
R10	4	RESISTOR 1K OHM .4W	DIGIKEY	PPC1.00KYCT-ND
C1	2	CAPACITOR 10000 UF 50V	DIGIKEY	604-1050-ND
C2, C3	4	CAPACITOR 1000 UF 50V	DIGIKEY	1189-4212-ND
C4, C5	4	CAPACITOR 1 UF FILM		
#6 SCREW	8	#6-32 SCREW .5"L (TO-3 MOUNT)		
#6 NUT	8	#6-32 LOCKNUT (TO-3 MOUNT)		
SPACER	8	NYLON SPACER #6 HOLE .25"D X .25"L		
PC BOARD	2	PCB		
TO-3 INSULATOR	4	THERMAL PAD		
BRACKET*	2	CHANNEL BRACKET		

The circuit boards, red is top layer, green is bottom:



DIY SONY N CHANNEL VFET PC BOARD

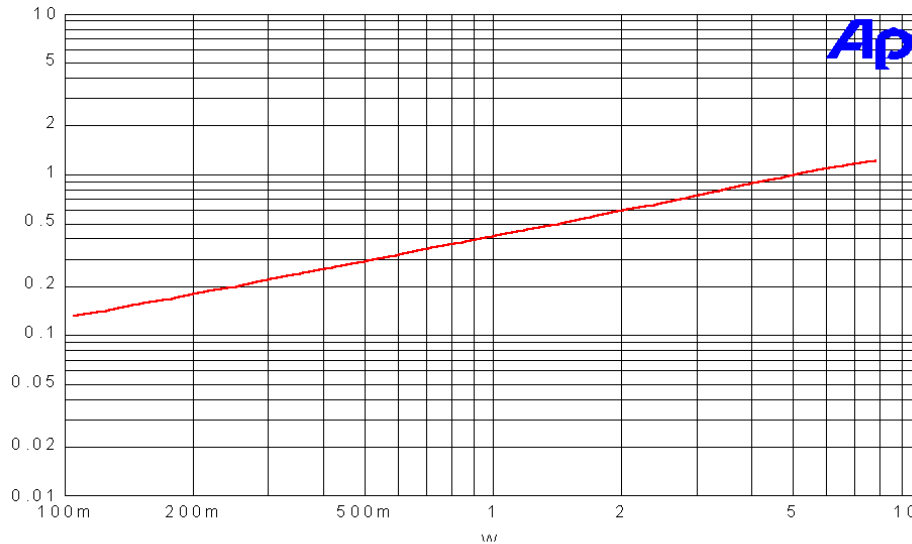


DIY SONY P CHANNEL VFET PC BOARD

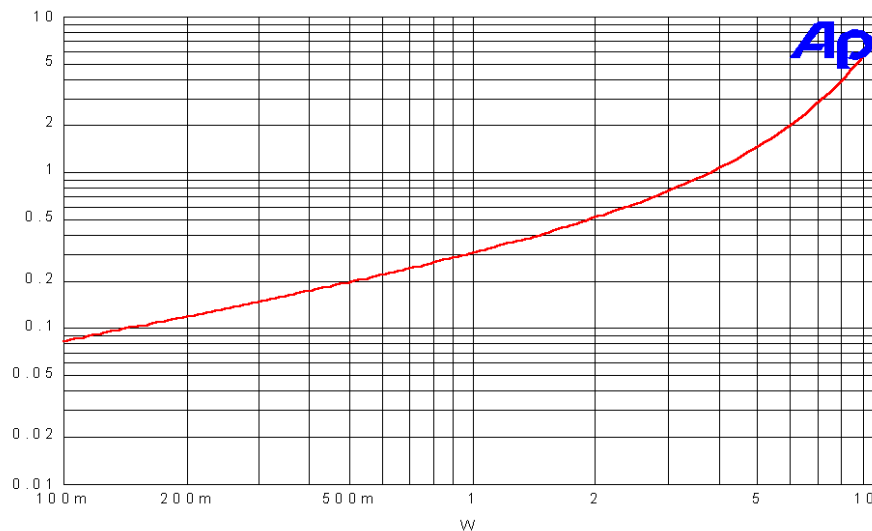
Like last year's project you will want to note that the brackets are not identical, so when you go to mount the boards to them, check that they will mount attractively in the chassis with component sides up. Do this before you mount the power transistors. Also, don't use too much force tightening the transistors down, and after you mount the power transistors check with an ohmmeter for shorts through the silicone insulators from transistor case to bracket.

You can use the diagrams from the original articles for the wiring connections, noting that on the earlier boards the signal inputs are labeled D+ or D- and on these boards they are called out as I+ and I-, otherwise no difference.

No bragging rights without some curves: 2SK60 N channel



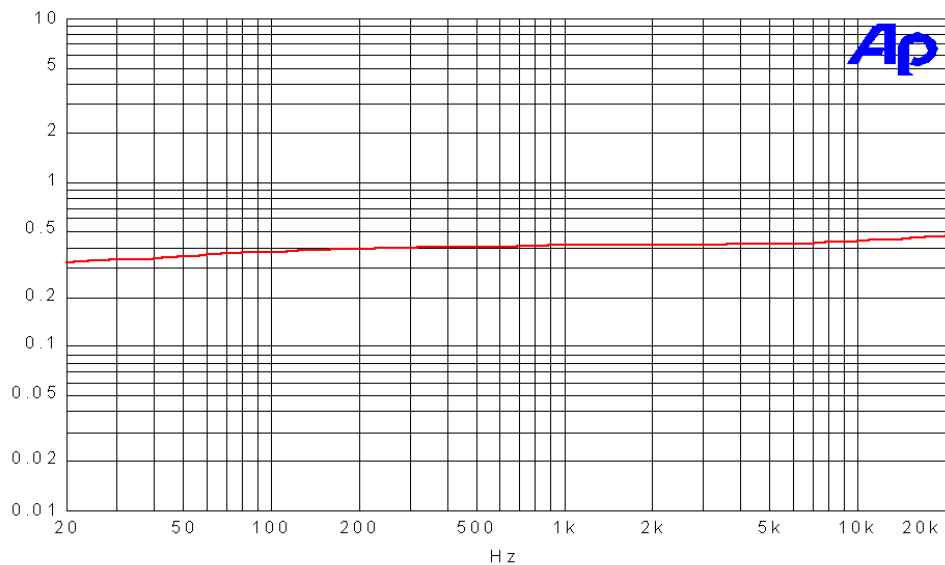
DIY SONY OS2 N VFET WITH 2SK60 - DISTORTION VS POWER @ 8 OHM



DIY SONY OS2 N VFET WITH 2SK60 - DISTORTION VS POWER @ 4 OHM

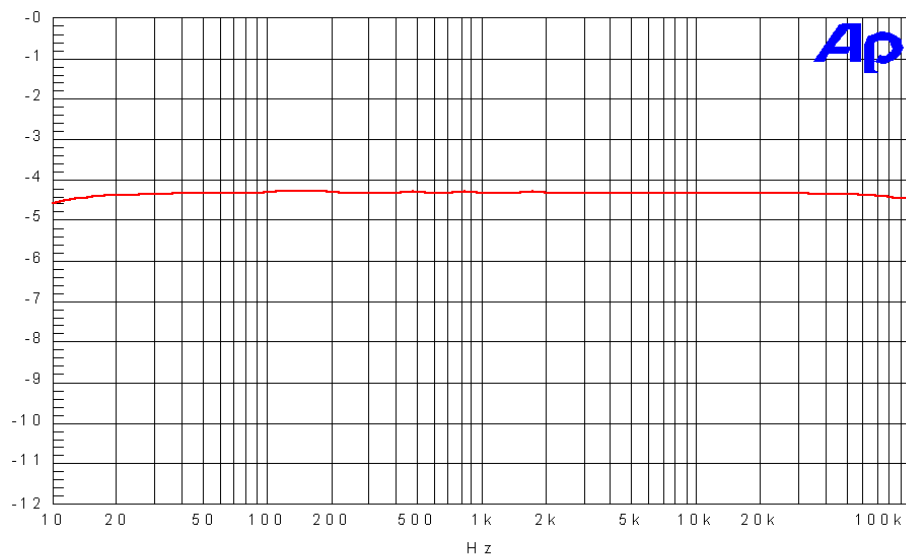
The distortion for 8 ohms is nicely negative phase 2nd harmonic into loads at 8 ohms and above, but as the impedance goes down to 4 ohms you will see more 3rd harmonic creeping in.

Distortion vs frequency:



DIY SONY OS2 N VFET WITH 2SK60 - DISTORTION VS FREQ @ 1 WATT

Frequency response:

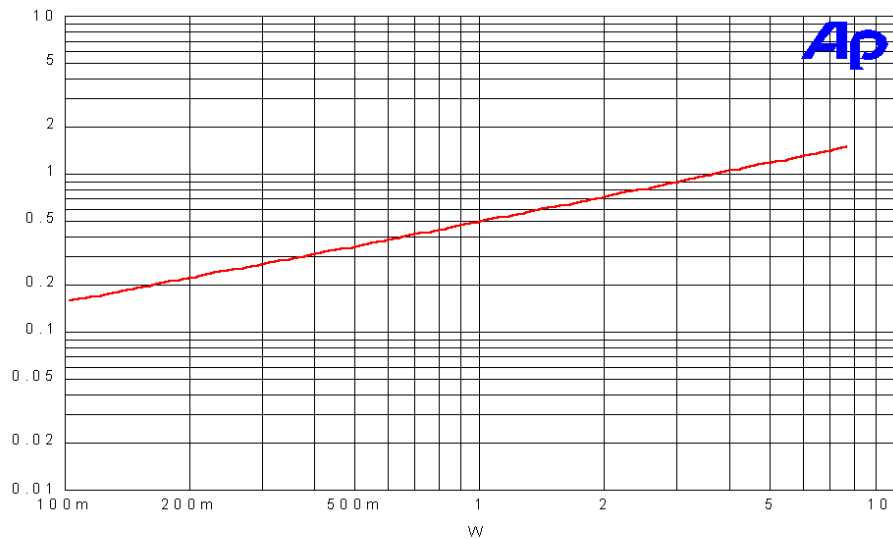


DIY SONY OS2 N VFET WITH 2SK60 - FREQUENCY RESPONSE

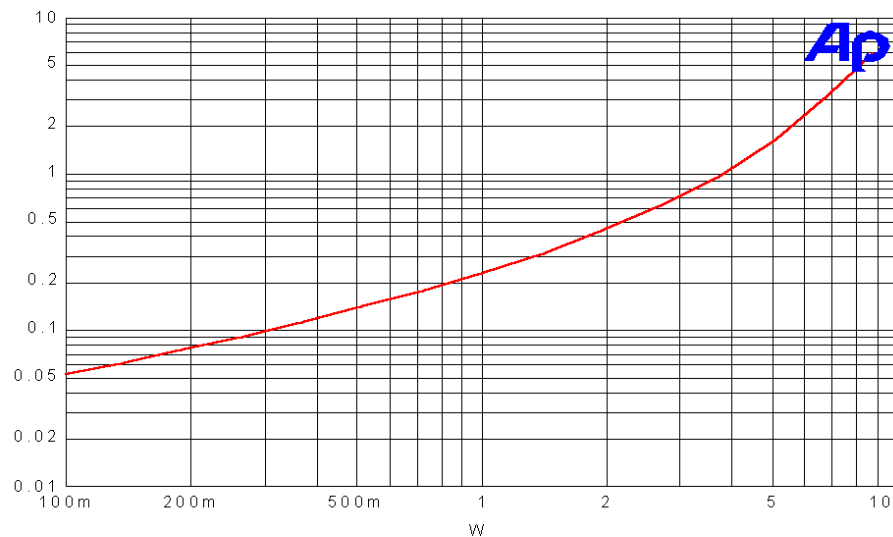
You will note that both output stages have about 4 dB of voltage loss, a function of both the damping factor and also the low Drain impedance of the VFET.

Measured damping factor of both output stages is about 4. All these figures vary a bit from part to part and also power supply and bias current. These figures are as shown on the schematics here, operated without feedback.

Curves for 2SJ18:



DIY SONY OS2 P VFET WITH 2SJ18 - DISTORTION VS POWER @ 8 OHM



DIY SONY OS2 P VFET WITH 2SJ18 - DISTORTION VS POWER @ 4 OHM

The distortion vs frequency and response curves of the P channel version are virtually identical to the N, and so are not shown here.

So there we have it. There are 75 stereo kits of each of these two designs going into the “store” at www.diyAudio.com as well as support to be found on the Pass Labs forum there. There are plans for additional quantities of TO-3 based versions of this and also TO-247 (plastic) versions.