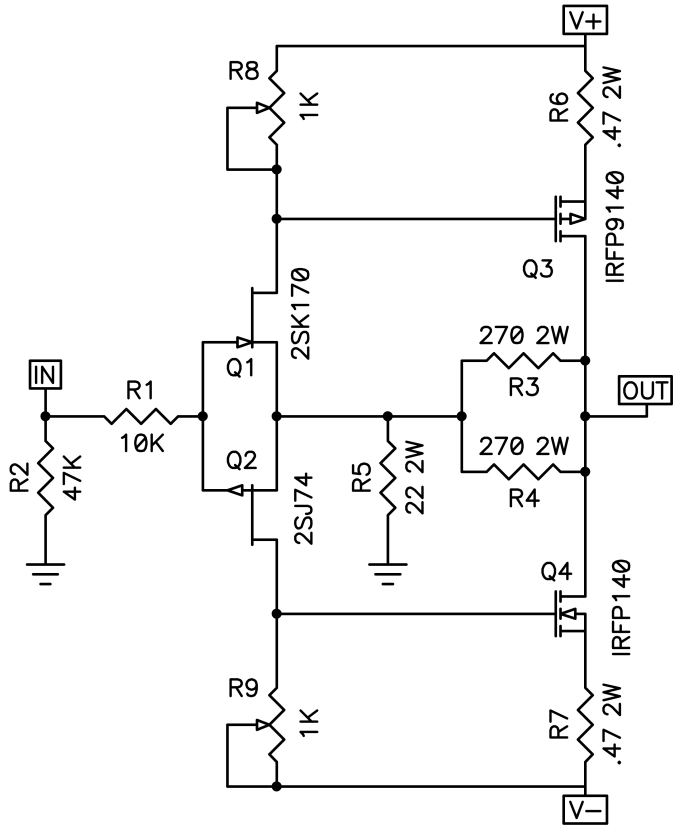
DIY F5M POWER AMPLIFIER

BY NELSON PASS

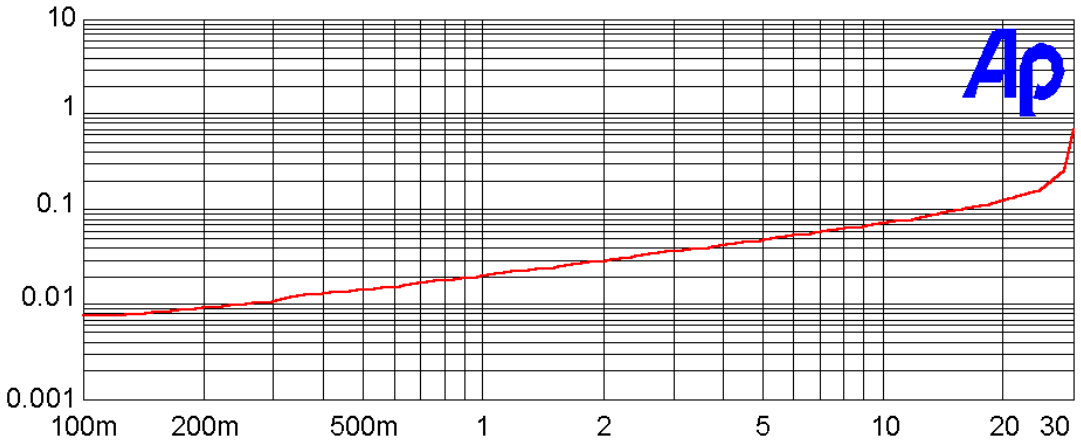
The original F5 amplifier was a commercial product made by First Watt in 2008, and like other FW projects, in a limited quantity. Also like other FW amplifiers it was relatively low power Class A, emphasizing simplicity and sonic quality. The design harkens back to the 2005 Profet amplifier from Selectronics, a classic kit which shares the two stage complementary CFA topology. As to differences, Profet used Toshiba lateral power Mosfets and the F5 ran vertical Mosfets biased at higher idle current, the result being more open loop gain, lower output impedance and lower distortion numbers.

In recreating the F5 for DIY enthusiasts as the F5m I decided to make it even simpler, without compromising the qualities which made the original popular. Here is the schematic:

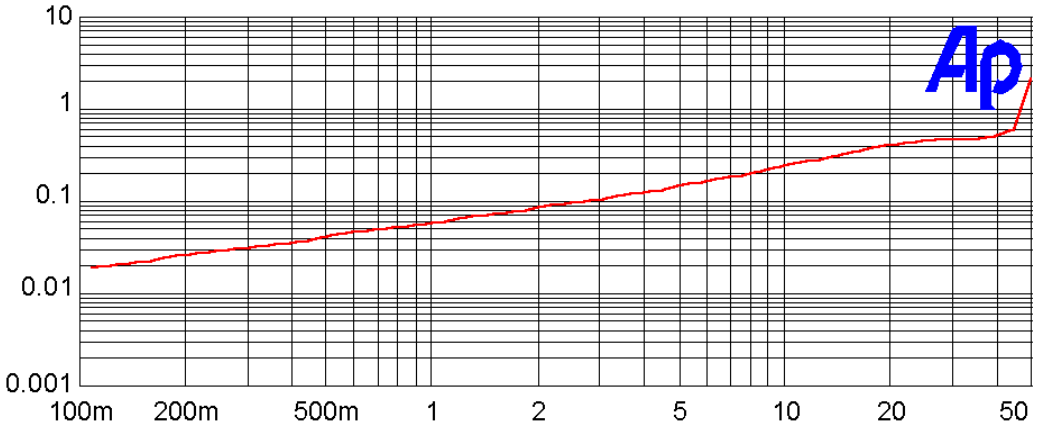


It's pretty simple – I suppose you could combine R3 and R4 into one resistor, but I didn't want to spring for 5 watt resistors. Any additional deletions would definitely create trouble. There are a couple performance differences between the F5 and the F5m, one being that I have allowed some negative phase 2nd harmonic into the sonic signature which has tended to be popular in FW amplifiers, a little more gain and variations in the output stage bias current depending on the supply voltage and heat sink size. The larger the heat sink, the higher the bias current and the lower the distortion.

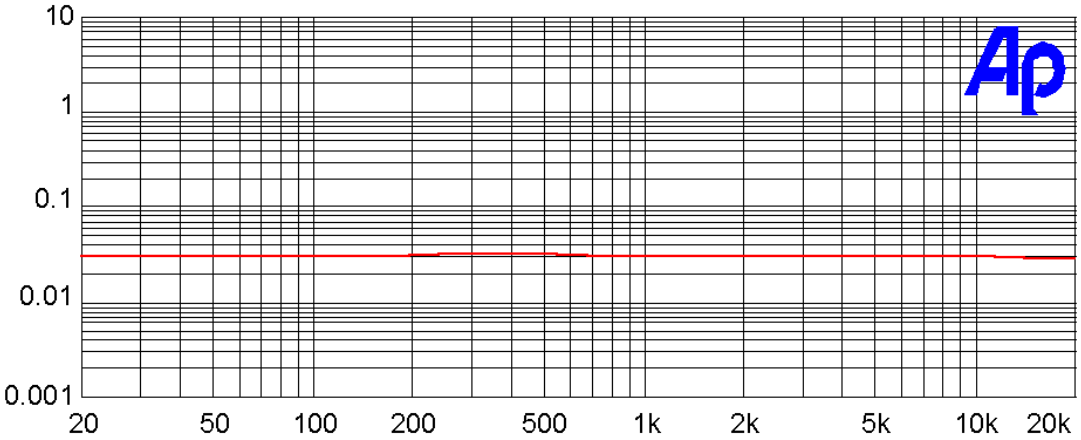
Since I mention distortion, here are some curves showing harmonic distortion with the amplifier channel biased at 1 amp current and +/- 24 volt supply rails. This is the curve at 1 khz into 8 ohms:



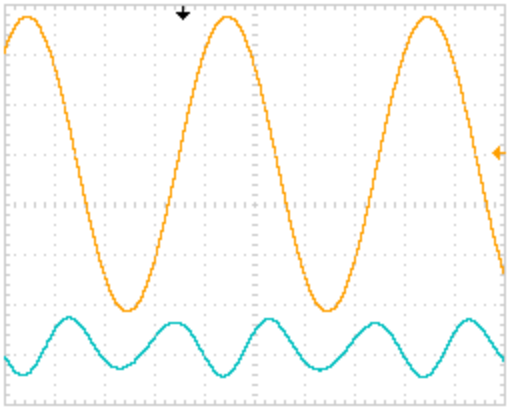
And below is the curve into 4 ohms:



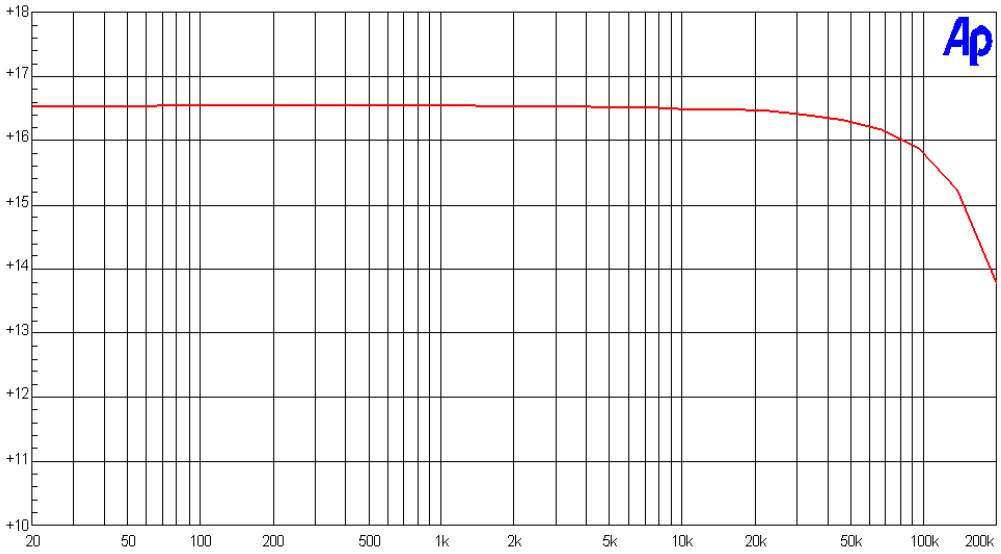
And distortion vs frequency at 1 watt, 8 ohms:



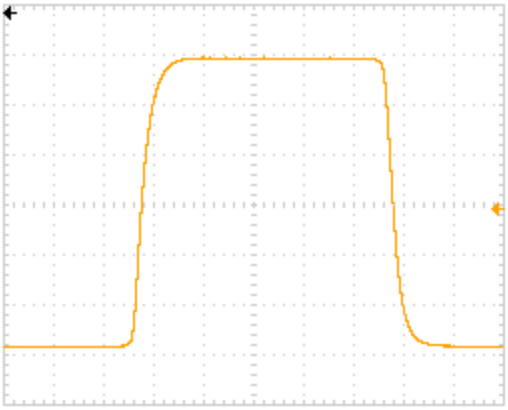
This image is the distortion waveform at 1 watt into 8 ohms, showing the negative phase 2nd harmonic characteristic:



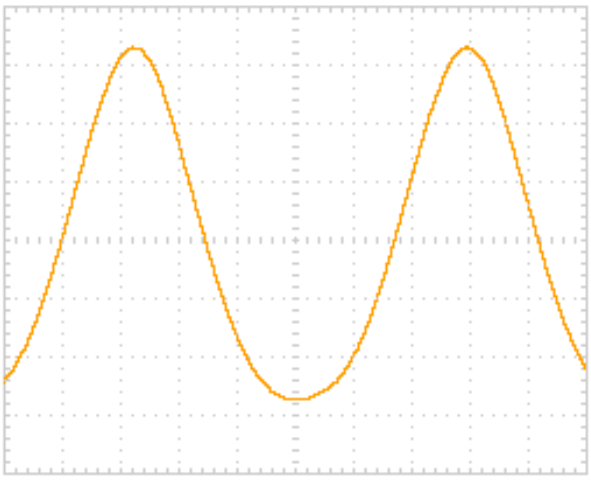
The dB gain vs frequency response:



And the 10 Khz square wave at 1 watt:

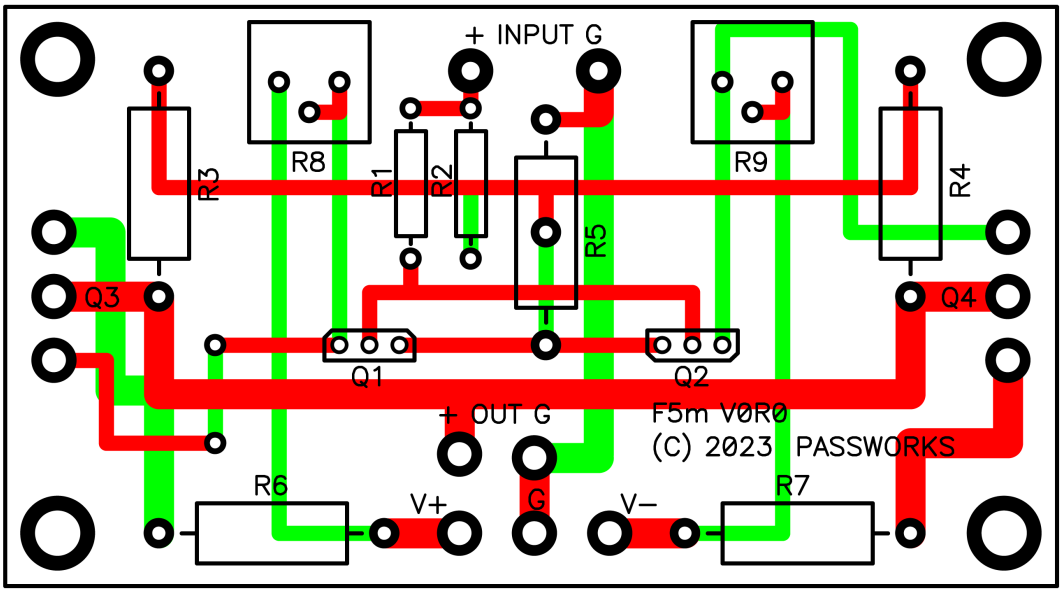


The amplifier takes advantage of the square law character of Field Effect Transistors to have a graceful transition from the Class A region for a wide range of bias levels, even when presented with high current into lower impedance. Here is the current waveform experienced by one half of the output stage as it approaches shutoff at 50 watt peak into 8 ohms:



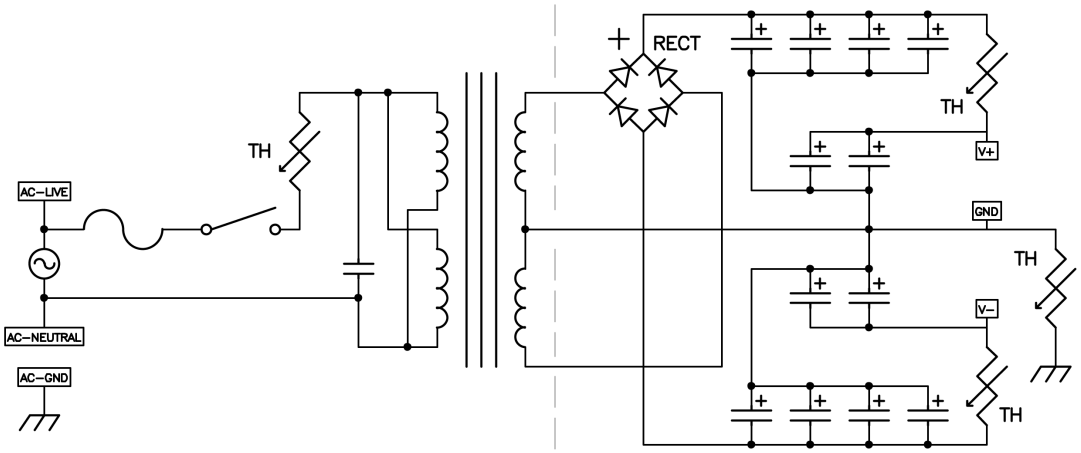
A couple more numbers, the input impedance is 47Kohm, the damping factor is about 50, and the output current is linear to about 5 amps peak, and the rise time is 5 microseconds.

By now perhaps you are thinking about building this amplifier. Here is an image of the channel board, with the red traces on top and green underneath:

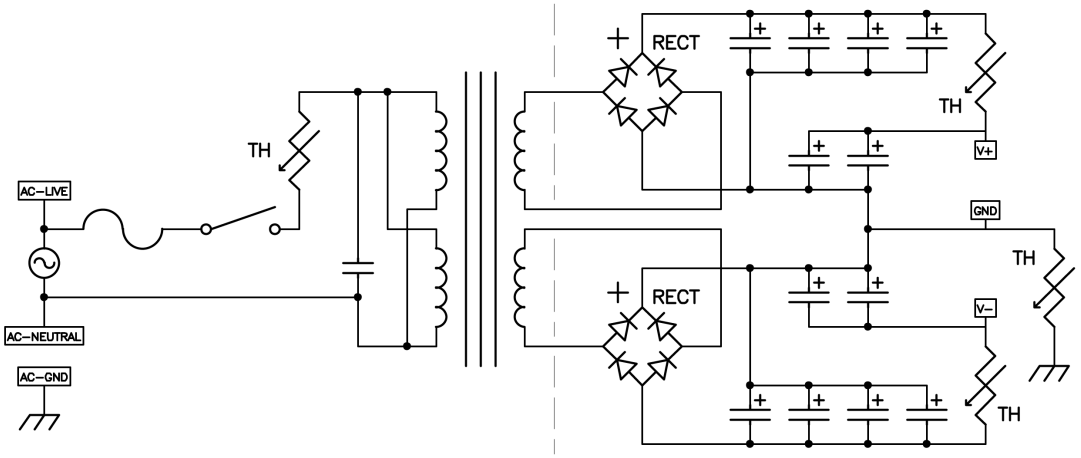


The output transistors Q3 and Q4 mount to the sink and circuit board. The board and power transistor mounts match the UMS standard for kits from the diyAudio store, but you can actually ignore the four mounting holes, as the power transistors are capable of holding the board up by themselves. Not that I recommend that..

The power supply circuit board which comes with the Essentials kit will accommodate two variations, with one or two chassis mount rectifier bridges. If your power transformer has a single center tap on the secondary, you would use the single rectifier.



If your transformer has dual secondaries you can use the circuit below.



The power Thermistors are used to suppress inrush at turn-on and also as RC filters on the capacitor banks to lower the noise on the rails seen by the channels. Also a Thermistor is useful for connecting circuit ground to chassis when you are trying to avoid ground loops while still maintaining a safety earth connection. The AC line fuse would be chosen at a rating lower than the current rating of the Thermistors.

AC power line as well as Input and output connectors, power switch and fuse are not included in the Essentials and Completion kits. The diyAudio store has some of these parts available separately, and in some cases you may have to rely on your own resources. I have had good success with Antek as a transformer supplier, and here are two of their transformers that have worked well:

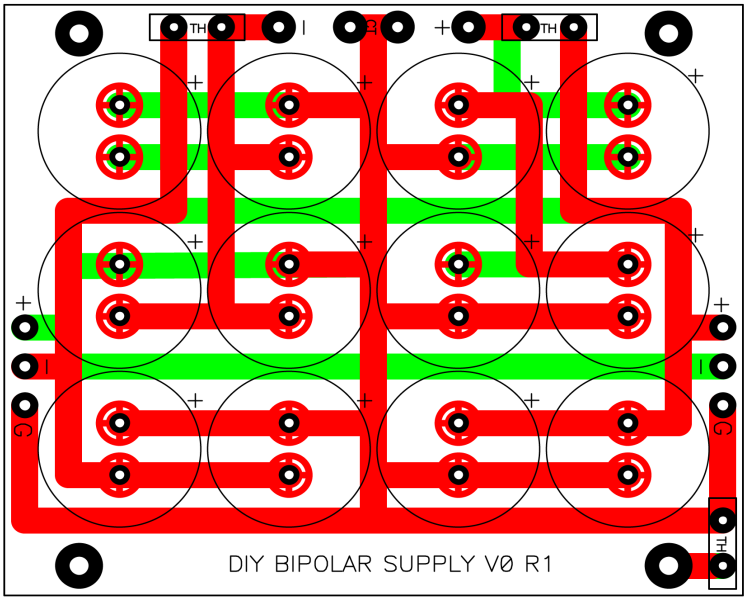
https://www.antekinc.com/as-2218-200va-18v-transformer/

https://www.antekinc.com/as-3218-300va-18v-transformer/

I should not need to mention that you are dealing with potentially lethal voltages on both the primary and secondary circuits, and you must take every precaution.

If you have any reservations or questions get some competent help.

The Essentials kit includes power supply board and the power supply caps as well as the thermistors used in RC filtering and coupling the circuit ground to chassis ground:



Here is the Bill of Materials for the two kits, the Essentials and Completion:

PRODUCT	DESC	QTY	MFR	VENDOR	PART #
F5M ESS	CH PCB	2			
F5M ESS	PS PCB	1			
F5M ESS	TOSH 2SJ74	2			
F5M ESS	TOSH 2SK170	2			
F5M ESS	IRFP140	2			
F5M ESS	IRFP9240	2			
F5M COMP	1K TRIM POTS	4	BOURNS	DIGIKEY	3386P-1-102LF
F5M COMP	RES 270 2W	4	VISHAY	DIGIKEY	BC270W-3JTB-ND
F5M COMP	RES 22 2W	2	VISHAY	DIGIKEY	AC03000002209JAC00
F5M COMP	RES .47 2W	4	VISHAY	DIGIKEY	AC03000004707JAC00
F5M COMP	RES 10K .4W	2		DIGIKEY	SFR2500001002JA500
F5M COMP	RES 47K .4W	2		DIGIKEY	SFR2500004702JA500
F5M COMP	CAPACITORS	12	EPCOS	DIGIKEY	B41231B7478M000
F5M COMP	RECTIFIER BRIDGE	2		DIGIKEY	4786-KBPC1506-ND
F5M COMP	THERM 5A 10OHM	3	EPCOS	DIGIKEY	495-76260-ND
F5M COMP	INSULATORS	4		DIGIKEY	BER1340-ND
F5M COMP	SPACER 3/8D X .25L X .14 ID	12		MCMASTER	94639A301
F5M COMP	SCREWS 6-32 X 5/8	4		MCMASTER	92196A144
F5M COMP	NUTS 6-32	4		MCMASTER	91841A007
F5M COMP	SCREWS M3 X 10mm	12		MCMASTER	91292A112
F5M COMP	WASHERS M3	4		MCMASTER	96505A111

Among the items not included in those two kits are the chassis, which are available separately from the store. I recommend considering these three, and here are the details of each. All three will fit the amplifier, and the big difference is the amount of heat sinking each offers.

	DISS 2U		DISS 3U		MDISS 3U	
PRICE	$169		$199		$189	
NAME	MM	INCH	MM	INCH	MM	INCH
SINK W	40	1.6	40	1.6	40	1.6
SINK H	80	3.1	120	4.7	120	4.7
SINK D	300	11.8	300	11.8	300	11.8
DEG C / W	0.56		0.44		0.44	
W @ 30C	54		68		68	
# DEV	2		2		2	
MAX W/DEV	27		34		34	
VOLTS V+ TO V-	48		48		48	
MAX BIAS	1.1		1.4		1.4	
CHASS HEIGHT	80	3.1	120	4.7	120	4.7
CHASS WIDTH	360	14.2	360	14.2	250	9.8
CHASS DEPTH	300	11.8	300	11.8	300	11.8

Having tested the heat sinks of each, I came up with a figure for how much power transistor dissipation each size sink will allow assuming a 30 deg C. temperature rise on the sinks.

The two potentiometers on each channel adjust the bias current and output DC offset. You will need a DC voltmeter to make the adjustment.

Start by turning the potentiometers fully counterclockwise for 0 bias.

My estimated maximum dissipation of each of the two output devices per channel is about 35 watts, so given my default +/-24V rails, I have calculated the maximum bias for each channel, which range from 1.1 to 1.4 amps. The bias is measured across R6 or R7, and is calculated, Voltage / 0.47 = bias amps For 1.1 amps the voltage is 0.52V and for 1.4 amps it is .80V. When initially adjusting a cold amplifier, you would set the bias at something like one half of these values and let it warm up (with the cover on), checking it every few minutes and adjusting it in half steps. After an hour or two you should be OK, but familiarize yourself with how that temperature feels over a longer term – you should be able to put your hand on top of the sink for 10 seconds without crying...

Well that's about it. DiyAudio member 6L6 will be doing his usual excellent video build guides online at diyAudio.com and you will find discussion and support in the Pass Labs forum at the same site. As well you can order the kits and auxiliary parts in the diyAudio store, and of course you can hardcore DIY it and source everything yourself.

When all else fails, my email is nelson@passlabs.com