DIY FRONT END 2022

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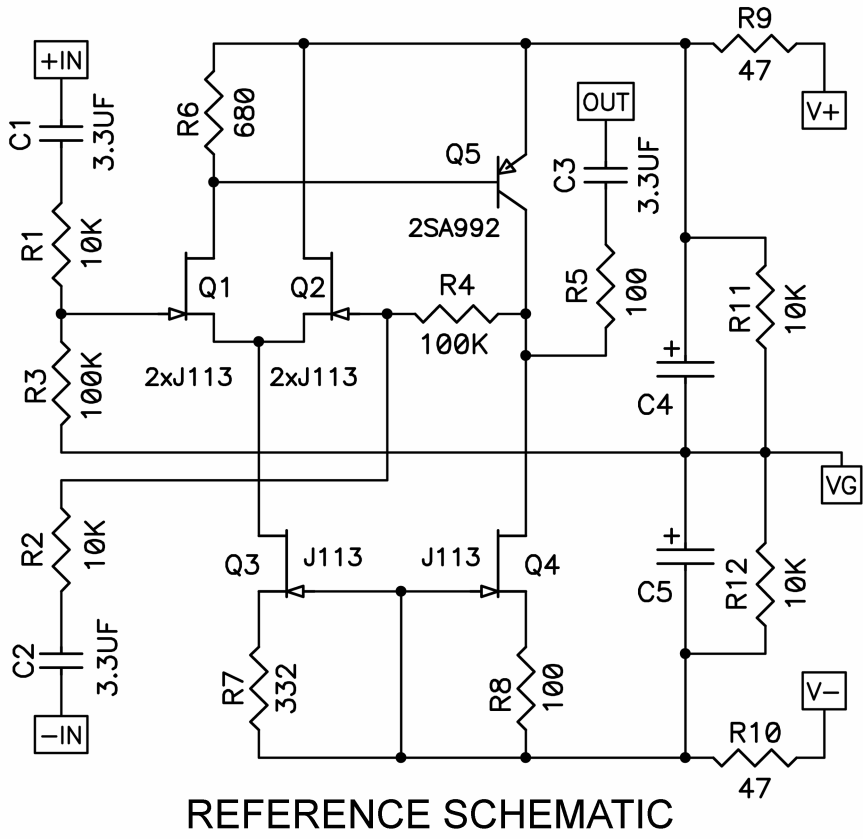
Among the appreciations of DIYers is stuff that works *simply, well, and cheap*, not necessarily in that order. This project is an effort to assemble these elements into a discrete gain stage that can be used as the front end for modest power amplifiers or as a general audio gain circuit. I waved the schematic at the camera during the 2022 Burning Amp Festival and now (before the villagers with torches arrive at my doorstep) I present the DIY Front End 2022.

Here is the schematic of the reference build, the one you almost saw at BAF. It's a simple example of an op-amp type circuit – a pair of differential input transistors Q1 and Q2 driving a PNP transistor Q5 in Common Emitter mode, forming a single-ended Class A amplifier. Both stages are biased by Jfets Q3 and Q4 operating as constant current sources.

As shown here, the circuit operates with a gain of 10 with dual supplies and balanced inputs, but there are numerous options for single-ended input, single-ended supplies and gain. The power supply filter can also create a virtual ground for single-ended supply operation with either V+ or V- referenced to a Ground.

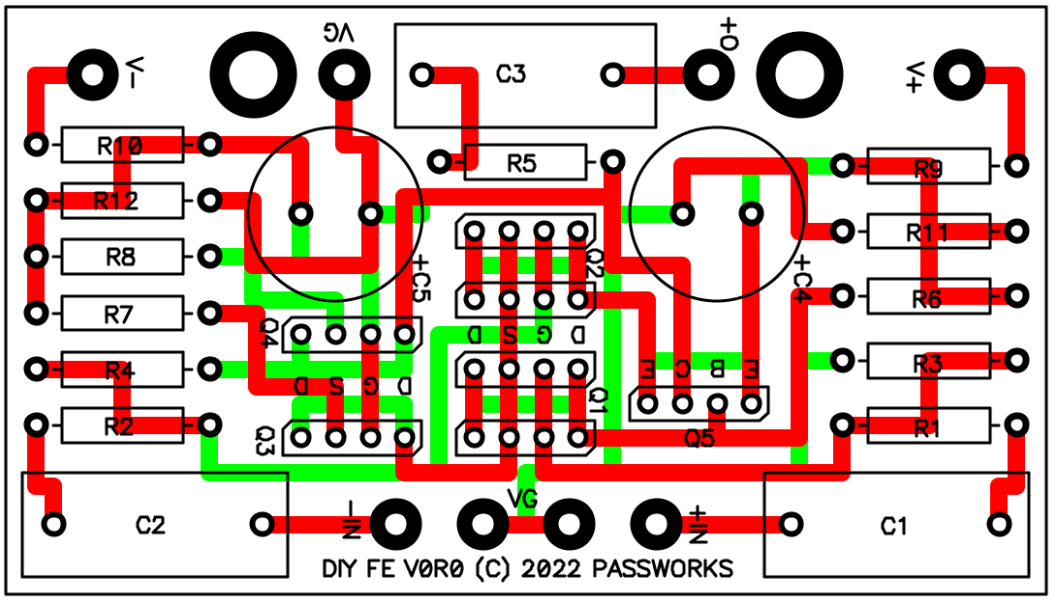


REFERENCE SCHEMATIC

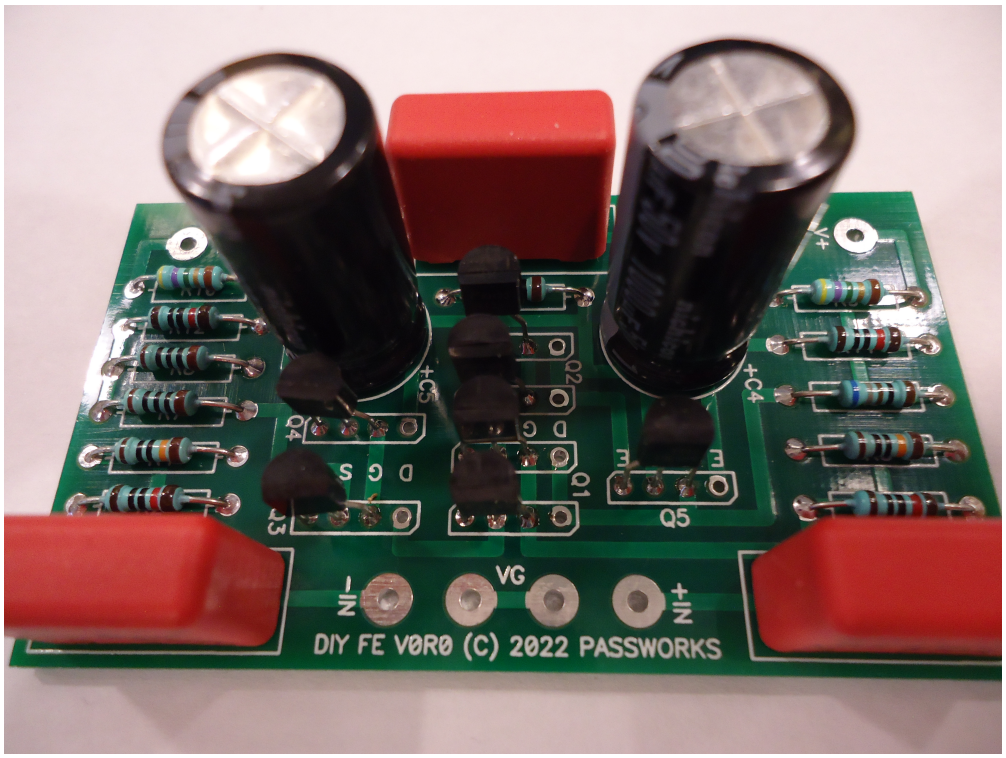
As shown the circuit uses cheap J113 Jfet transistors and also a KSA992 Bipolar transistor. The KSA992 is very inexpensive but has perfectly fine performance (no compromise there) and the J113's are not as great as the Toshiba 2SK170's (at maybe 20 times the price) but this is not an issue for the constant current sources Q3 and Q4.

For the input stage we can improve the performance by paralleling the J113's, which increases the transconductance and lowers the distortion and noise. The pc board artwork also has hole patterns for 2SK170's and other Jfets, and later we will see some curves.

Here is an image of the double sided circuit board showing the top in red and bottom in green. It's dimensions are 1.7” x 3” with mounting holes spaced at 1.575”.



And a photo of a finished board:



Here is the Bill of Materials for the reference design:

DIY FE 2002 REFERENCE DESIGN BOM – 2 CHANNELS

PART #	DESC	QTY	COMMENT
Q1 – Q4	J113 N JFET TRANSISTOR	12	MATCHED TO Vp TO R7 AND R8
Q5	2SA992 PNP TRANSISTOR	2	DIGIKEY KSA992 FBTA
C1 - C3	3.3 UF CAPACITOR POLYPROP – WIMA	6	MOUSER MKS4-3.3/63/10P15
C4 – C5	1000 UF CAPACITOR 25V ELECTROLYTIC	4	DIGIKEY 493 10989-3-ND
R1, R2	10K OHM RESISTOR .5W 1% METAL FILM	4	
R3, R4	100K OHM RESISTOR .5W 1% METAL FILM	4	
R3, R4 *	10K OHM RESISTOR .5W 1% METAL FILM	4	ALTERNATE VALUE UNITY GAIN
R5, R8	100 OHM RESISTOR .5W 1% METAL FILM	4	R8 MATCHED TO Vp OF J113
R6	682 OHM RESISTOR .5W 1% METAL FILM	2	
R7	332 OHM RESISTOR .5W 1% METAL FILM	2	MATCHED TO Vp OF J113
R9, R10	47.5 OHM RESISTOR .5W 1% METAL FILM	4	
R11, R12	10K OHM RESISTOR .5W 1% METAL FILM	4	

The “Essentials” kit from the store at diyAudio contains a pair of the circuit boards, transistors, and the selected values for R7 and R8 to give the reference value for the Vp pinch-off voltages of the matched Jfets.

The balanced input version assumes R1=R2 and R3=R4, and the gain is set by R3/R1. Unity gain is achieved by R1=R3. You can run the input unbalanced/single-ended with arbitrary resistor values and by attaching the -IN to ground.

To run the circuit with bipolar (dual) supplies, you would attach pad VG as ground, and run the circuit as shown in the schematic.

To run the circuit with a V+ single-ended supply, set R10 at 0 ohms and treat the V- as ground. With a single supply V-, you would short R9 and treat the V+ as ground. The circuit itself doesn't mind, and in both cases the power supply filter circuit will continue to work and also generate a mid-point virtual ground for the circuit. As the inputs and outputs are coupled by polypropylene film caps, there are no DC offset issues.

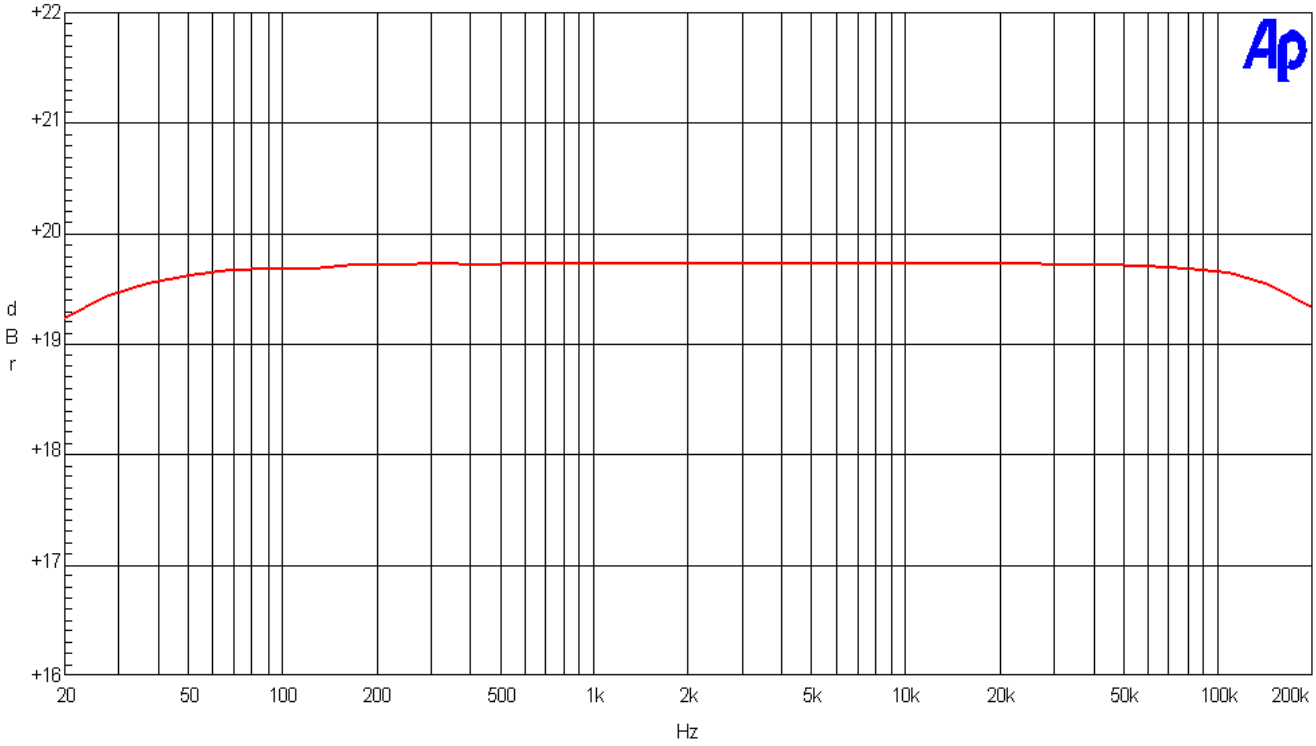
Now all this may sound complicated, but I have entrusted the details to diyAudio member 6L6's build guides, and of course there will be questions answered and problems solved on the “DIY FE 2022” thread at www.diyaudio.com in the Pass Labs forum.

There will be a two channel “Essentials” kit in the store at diyAudio consisting of 2 pc boards, 12 matched J113 Jfets, 2 KSA992 bipolars and 4 resistors matched to the Jfets.

The choice of additional resistors and capacitors is yours. The circuit is designed to operate either as a line level gain stage with a maximum output of 15V rms or as the front end of a modest follower output stage to a maximum of about 30 watts single-ended or 120 watts with a bridged output. The J113 and KSA992 have been shown to stand up to 70 volts maximum in testing, but I am suggesting that a 50 volt supply is appropriate and allows use of 2SK170 type and other Jfets as well.

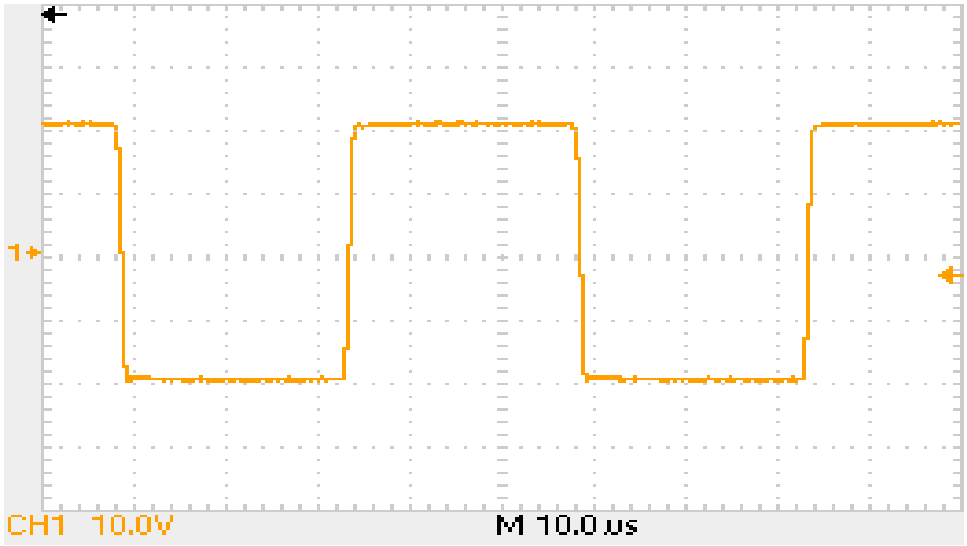
With one exception, the following curves show the performance of the single-ended supply version with balanced inputs and a gain of 10, with an output load of 10 Kohm and 1000 pF capacitance.

Below is the frequency response:

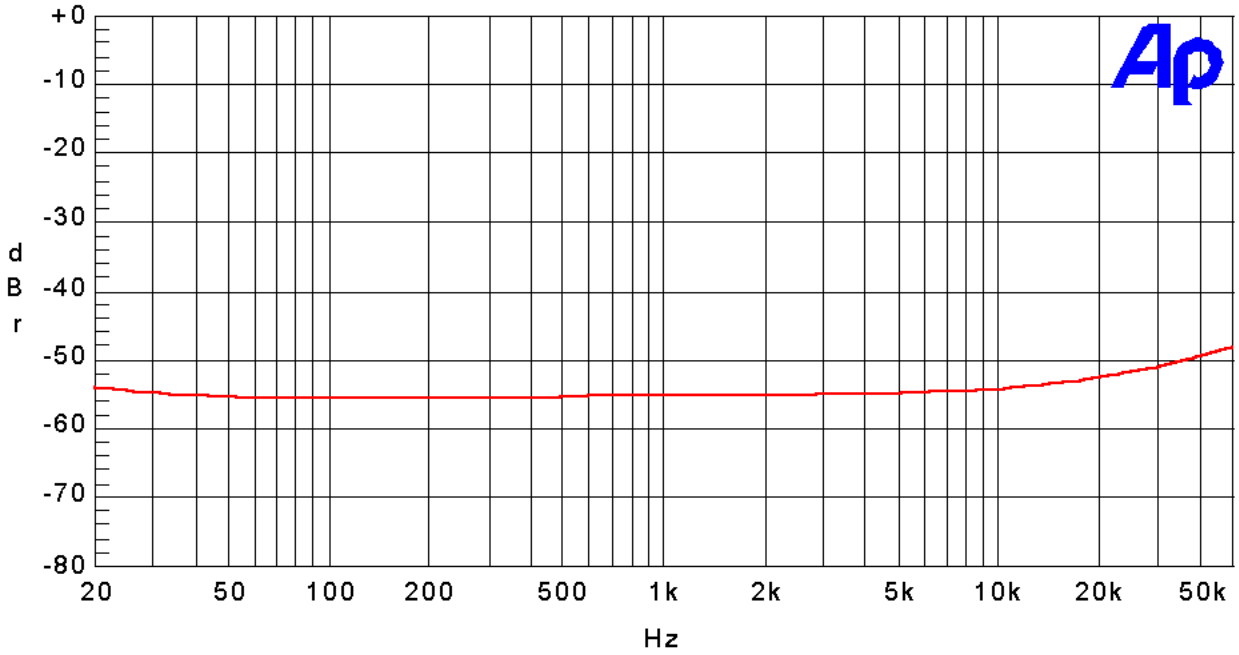


FREQUENCY RESPONSE - 1V OUT, 10 KOHM + 1NF LOAD

The square wave response at 20 Khz, 40 volts peak to peak:

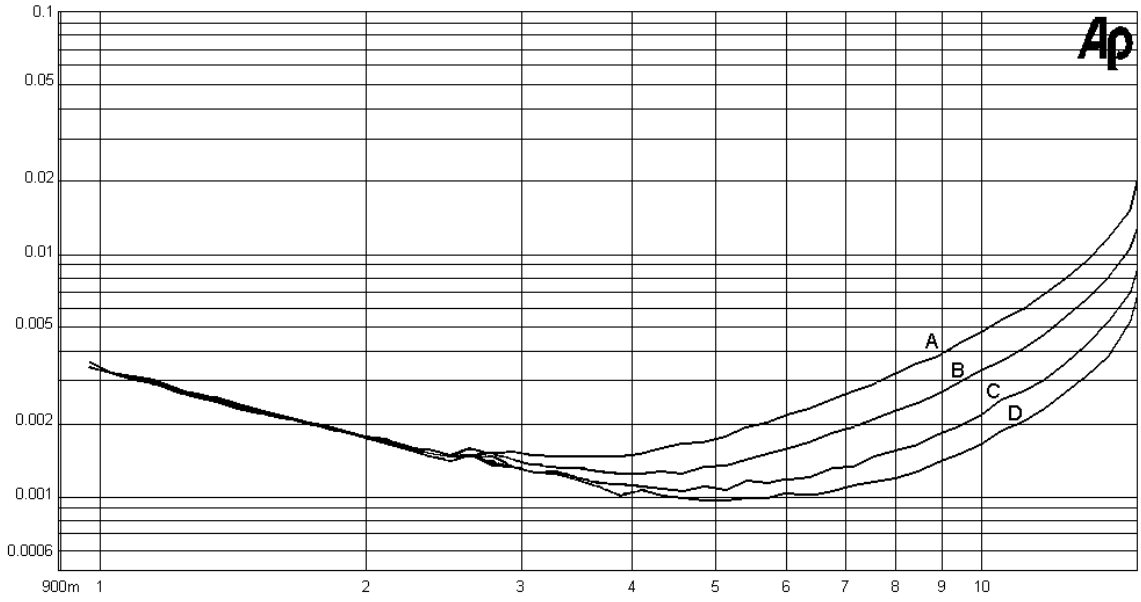


The balanced input Common Mode Rejection Ratio (CMRR) of the reference circuit, achieved with a gain of 20 dB and 1% tolerance resistors:



BALANCE INPUT - COMMON MODE REJECTION

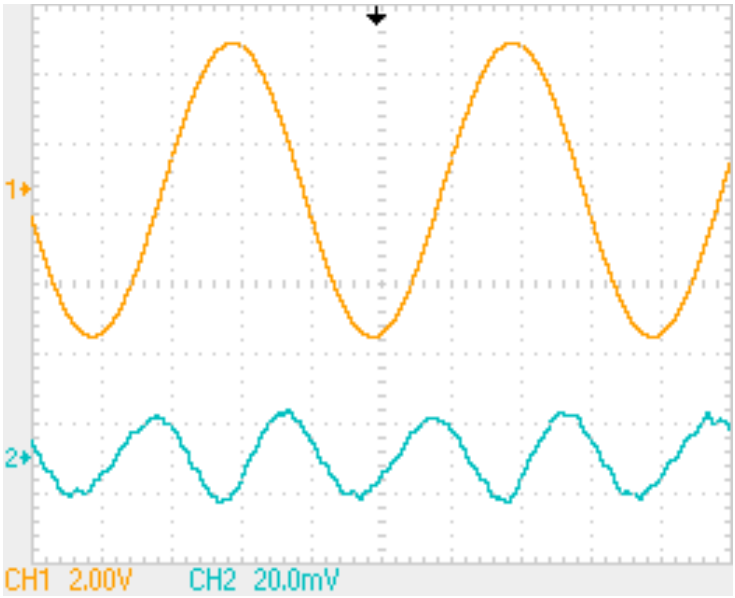
Here are some distortion vs output curves for the reference circuit:



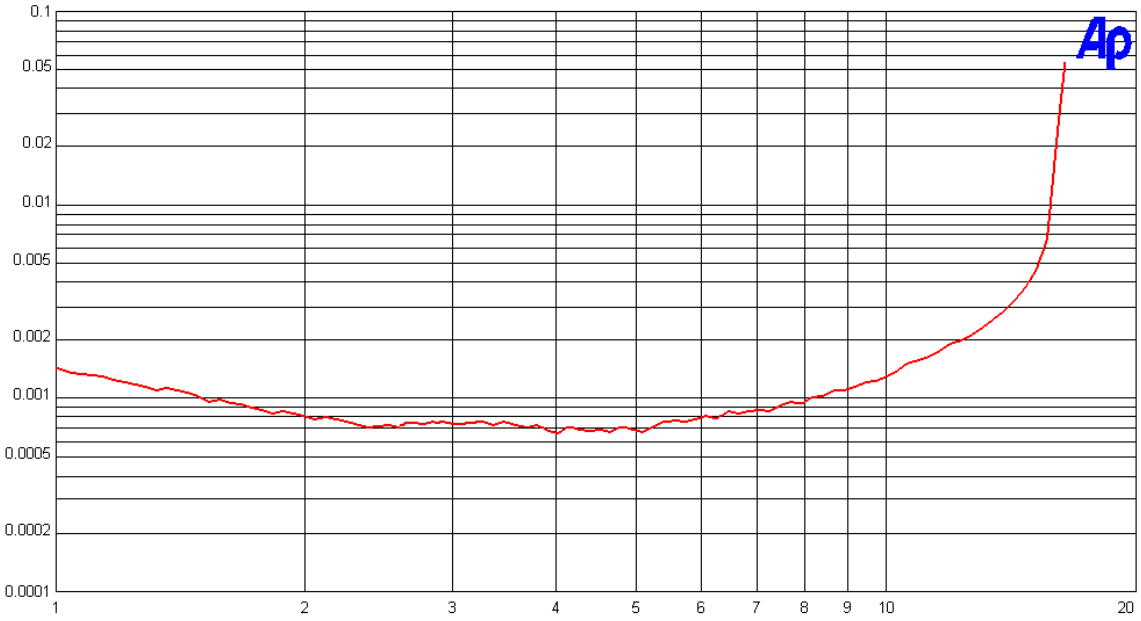
DISTORTION VS OUTPUT VOLTAGE - 1 KHZ, 10K+1NF LOAD

Curve A is the distortion with a single pair of J113 inputs, B is with 2 parallel pairs, C is one pair of 2SK170, and D is with two parallel pairs of 2SK170.

Here is what the distortion waveform looks like with the reference circuit, showing a “negative phase” 2nd harmonic distortion character. This varies with loading and other choices, but is a good example of the performance of single-ended Class A circuits.



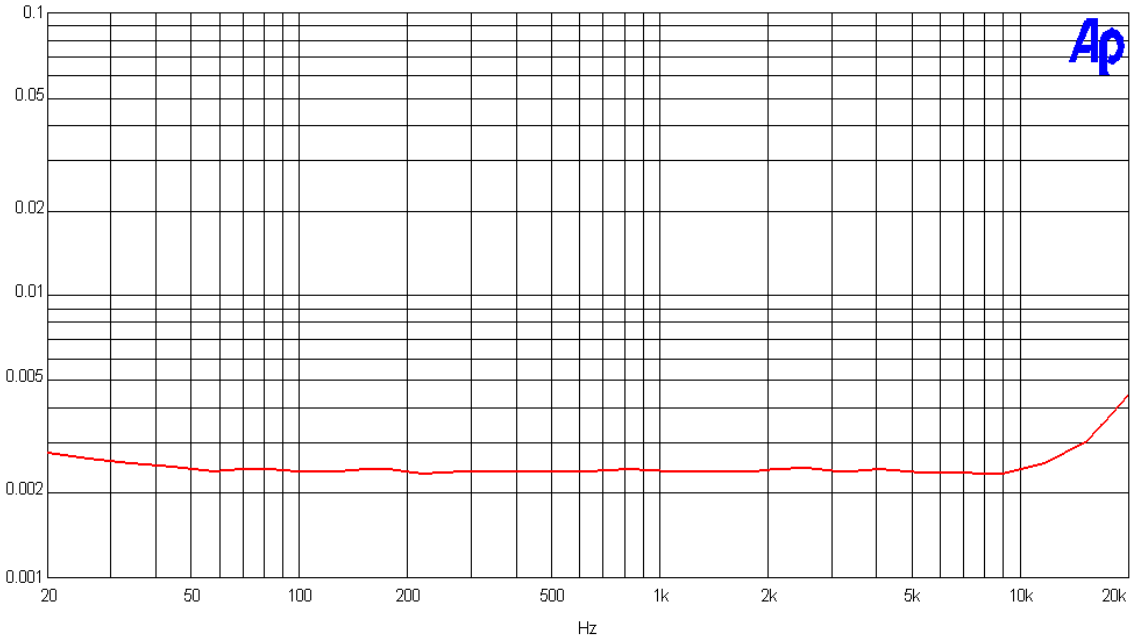
The reference circuit has a gain of 10, but if you set the gain to unity (+)1 you benefit from the additional feedback, and the distortion falls proportionally:



DISTORTION WITH BALANCED UNITY GAIN

This amplifier is also happy running with phase inverted gain if you simply drive the -IN with the signal and ground the +IN connection.

The distortion vs frequency is quite good and there are no frequency compensation capacitors needed for stability. The graphic below displays this at 10 dB gain, and the rise at the top frequency is due to the 1 nF capacitive loading at the output.



DISTORTION VS FREQUENCY - 2.8V OUT, 10K + 1NF LOAD

Conclusion

And there we have it. I started out trying for *simple, good, and cheap* as a means for luring in would-be DIYers, and I expect it will do that. At the same time, to my surprise the performance exceeded expectations, so I will amend *good* to *excellent*.

The basic circuit works fine as a line level preamp or balanced to single-ended converter, and can be adapted into other projects without the power supply filter or coupling capacitors, no problems. Some of you may want to adapt it into other projects with your own artwork - feel free to do that.

A bit later I will have some nice little power amplifier projects that can use this, but you will also notice that there are already several simple Class A follower output stages in the threads of the Pass Labs forum at diyAudio.com that will fit.

And remember, it's Entertainment, not Dialysis.

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