DIY JFET Mic Preamp and Beyond!

by Scott Hampton

Back in July/August of 2002, I offered up a tube mic preamp circuit here in *Tape Op*, and provided a kit for a limited time to assist in building it, through my company Hamptone. For all of you I scared off with subtle warnings about hi voltage and serious death, this project may be more your speed. My goal was to design an extremely simple solid-state circuit that sounded great, but was inexpensive and easy to build. Tube circuits inherently get more complicated because of power supply requirements, whereas the circuits shown here can all be run off a DC wall wart. First I will describe how a JFET (junction field effect transistor) works and why I chose it as the amplifying device. Second, I will show a circuit implementing the JFET in a simple class A gain stage with a voltage follower. Last, we will use the gain stage in three applications: an instrument preamplifier, a microphone preamplifier, and a line mixer. The JFET amp shown here can be applied to a variety of other applications including condenser microphones. It will be my intent to keep this more oriented toward practical application rather than going heavily into technical detail. So fire up your soldering irons, let's DIY!

N CHAN JFET AMP vs TRIODE

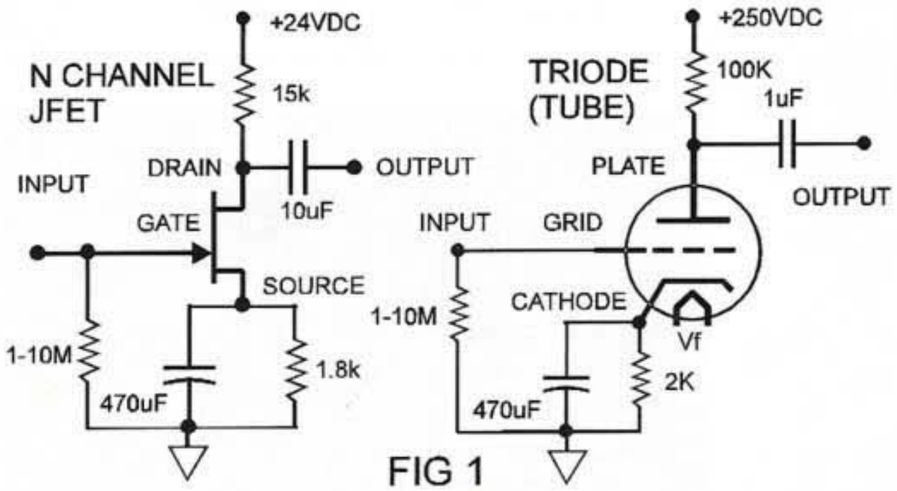

FIG 1

THE SOLID STATE TUBE: Figure 1 shows two class A amplifiers, one designed with an N channel JFET, the other a triode vacuum tube. Though the supply voltage and some component values are different, the overall circuits are identical. In fact, the N channel JFET behaves like a triode; a voltage controlled current source (or sink in this circuit). A change in voltage on the gate, produces a change in current through the drain. This change in current across the 15k resistor results in a voltage that is an amplified version of the input, and out of phase. In contrast, a transistor is a current controlled current source. By nature, JFETs and triodes have a very high input impedance, meaning they require almost no current to drive their inputs. JFETs also saturate in a soft way very similar to triodes. When listening to the JFET circuit side by side the equivalent triode circuit (with the same transformers), it's surprising how similar they sound. The tube circuit has more headroom, and a bigger presence in the bottom end, but the JFET amp is very clean in the upper end, and has a very flat and tight low end. I actually like it better than the tube circuit as a bass DI (if forced to go direct). With the proper gain structure on the front end, the JFET amplifier can deliver a very accurate and musical sound. The fun starts when you overdrive the shit out of it. The distortion characteristics of the JFET based mic preamp are just as useful (if not more) than its merit as a clean and accurate mic preamp. And jumpering one JFET mic preamp into another, and working the two pads and volume controls, unleashes a palette of sonic evil.

JFET GAIN MODULE: Figure 2 shows the 2N5457 N channel JFET circuit in figure 1 with an output stage added. The signal is applied to the gate of the JFET, and the output is taken off the Drain (amplified and inverted in phase). A 50-ohm resistor has been added that is not bypassed by the 470 µf cap, which reduces the third harmonic by about 20dB. The NPN transistors act as a voltage follower providing the output drive, with near unity gain. The dc voltage on the drain is slightly above the supply, and directly biases the MPSA14 Darlington transistor. A Darlington is used to minimize the loading on the 2N5457 (Darlington transistors have a much higher input impedance). The ZTX653 is a generic NPN transistor acting as an active load (beta = 100 min). Since the output also has roughly 1/2 the supply voltage on it, a coupling capacitor on the output is required to block the DC but allow the audio signal to pass. This is a key component and worth a few extra bucks for a good quality polypropylene capacitor or better.

JFP GAIN MODULE

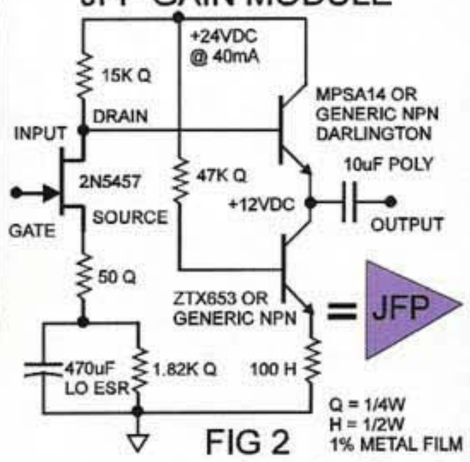

FIG 2

The output impedance of the voltage follower is a function of the 47 kilo-ohm resistor on the base of the ZTX653. If this resistor is too big, the output will not have enough drive and will be clipped on one 1/2 of the waveform. On the opposite end of the spectrum, if you make it too small, more power will be dissipated than is needed in the output devices. The value shown provides adequate drive for typical line inputs, with or without the 1:1 output transformer.

There are as many ways to buffer a signal as there are signals, so I leave it up to the reader to explore more esoteric designs if desired. The one shown here works great, and in my opinion is not compromised in any way just because of its simplicity. This circuit (figure 2) will from here on be referred to as the JFP (JFET preamp) and represented by the purple triangle. The input impedance of the JFP is basically the value of resistance on the gate to ground, and can be as high as 1000Mohms. The gain is approximately +26 dB, with the signal at the output being out of phase with the input.

INSTRUMENT PREAMP

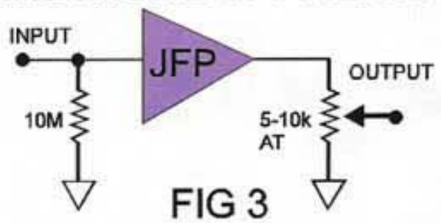

FIG 3

SIMPLE INSTRUMENT PREAMP: Putting a pot on the output of one JFP stage, you have a perfect preamp for hi impedance transducer pickups, or a nice gain stage to push a guitar amp a bit. Figure 3 shows the external components required. You can also cascade two (or more) stages with volume pots on each stage giving "pre" and "master" gain controls like a guitar amp. With the "master" at full (the pot is basically out of the circuit), the output level is set by the "pre" control providing an undistorted output. When the "pre" is set to full and the output level is set by the "master" control, the signal is pleasingly distorted. The JFET produces a distortion that is more aggressive than a tube, but still musical. Keep in mind if you use a single stage, the output is inverted in phase since each JFP is a single class A inverting amplifier.

MICROPHONE PREAMPLIFIER

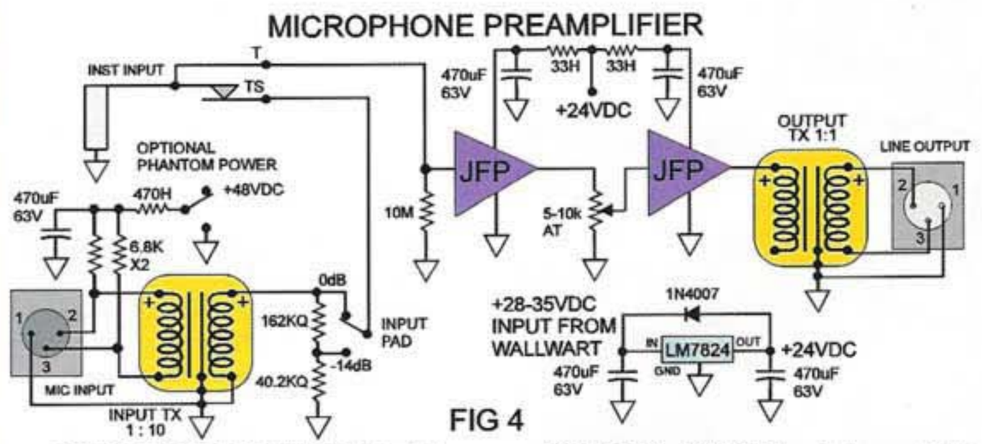

FIG 4

MICROPHONE PREAMPLIFIER: Adding an input transformer, DI jack, and a pad produces a mic preamp (shown in figure 4). Two JFP stages are cascaded to provide the necessary gain, with the level control between them. A 600:600 ohm transformer can be added to the output of the second JPF stage to provide a true balanced output, but it is not necessary if cable runs aren't too long. A 1:10 input transformer is used to provide the necessary balanced mic input matching, with a 14 dB pad on the secondary. I chose to place the pad here because most transformers have more than enough headroom for typical mic signals, transformers often sound good pushed a bit, and it does not degrade the S/N ratio as bad compared to placing it on the primary side. The DI jack bypasses the input transformer and goes straight to the input of the first JFP stage. Optional phantom power is also shown. If you refer back to the DIY tube mic preamp project in the July/August 2002 issue of *Tape Op*, you will notice the JFET-based mic preamp is identical in layout to the tube circuit, the only difference being the gain stages.

I built a two channel version of this with transformers on both the input and output, run from a 24 VDC 500 mA wall wart (shown in photo). Most unregulated power supplies output voltage is rated at a given load current. If you draw less than the rated value, the voltage will tend to be higher. The 24 VDC wall wart I used actually puts out almost 31VDC under the load of two mic preamp channels (approximately 165 mA). Because there is extra voltage, a LM7824 linear regulator was added to clean up the power. The regulator requires only 3 external parts, and an input of +28 VDC to 35 VDC to regulate properly. To decouple the two stages and filter the power further, a 33 ohm resistor and 470 µf cap LP filter was added to each JFP gain stage.

LINE LEVEL MIXER: Figure 5 shows an N into 1 mixer, where N is the number of inputs. Each line input goes directly into a 10 K AT (audio taper) pot. The output of each pot goes through a 150 K resistor then connects together to form a summing node. The loss of the summing network increases the more channels you add; the overall gain with the JFP is shown. Since the JFP gain stage is inverting, the output transformer is wired out of phase, so the input and output are in phase. A 600:600 ohm transformer can be added to each input if balanced inputs are required. If more channels are desired or more overall gain, an additional JFP stage is needed. In this case, wire the summing node directly to the input of the first JFP stage, and the master volume between the two JFP stages just like in the mic preamp (figure 4). It is important for noise reasons to keep the summing resistors as close to the JFP input as possible, and shield this circuit from noise sources.

My 16 channel Tube/JFET mixer has aux busses based on this design (L/R bus is tube). There are 4 auxiliary busses with 20 inputs each (16 channels sends, 4 aux returns) using two JFP stages as described in the previous paragraph and it works beautifully. If you look at the schematic to most modern mixers, you will find your signal path littered with op amps and coupling capacitors. On my 32-channel board I used to own (manufacturer I will leave nameless), a tape input passed through 8 op amps to get to a line output (12 with the EQ in!). Each op amp internally contains multiple stages and negative feedback to control the gain - bottom line, a lot of stuff. The day I saw that was the day I started designing a mixer. The sonic difference between 8-12 op amps and two discrete class A gain stages is dramatic; perhaps the reason discrete class A boards are so sought after.

For more info including parts lists and kit options, check out my website: *www.Hamptone.com* Good luck!

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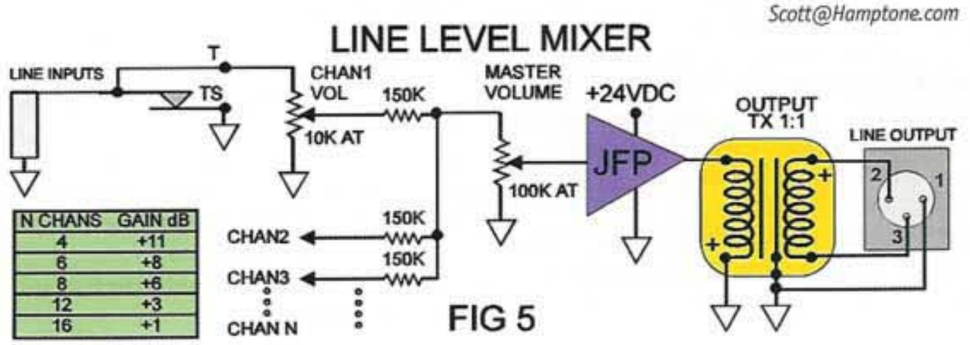
LINE LEVEL MIXER



N CHANS	GAIN dB
4	+11
6	+8
8	+6
12	+3
16	+1

FIG 5