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<b>From:</b>	<b>Man o'Blues</b>		
<b>Date:</b>	7/18/2002 8:04 PM		
<b>Subject:</b>	<b>Help needed with MOSFET source followers</b>		

Hi all,

I think I'm ready to try using a pair of IRF 820's as source followers to drive the outputs in my BF clone, as per R.G. Keen's article at:

<http://www.geofex.com/tektips.htm>

The article seems straightforward, but I could really use some implementation advice specific to my amp, whose power section is set up as follows:

- \* Standard AB763 12AT7 LTPI but with 47K plate loads.
- \* B+ nodes are: 410V/screens, reverb, and trem, 330V/PI and 260V/preamp section
- \* 100K/100K bias resistors
- \* -36V bias voltage (derived from PT's 50V bias supply)
- \* 6V6GT outputs

Questions (for now):

1. Which B+ supply node do I use for the MOSFET drain (plate), and why?
2. What is the best way to derive the high negative voltage for the cathodes? Note: I get 425V B+ from the rectifier plate. Also, the PT's 2A/5V filament winding is unused, if this can be used at all.
3. I adjust the -ve supply so I get -36V on the cathodes, right?
4. How do I bias the grid (gate) of the MOSFET?
5. I seem to recall some previous posts here about blowing MOSFETS in this application if not done properly. Is there anything else I need to add that's not mentioned in the R.G.'s article?

I've never handled any ss devices, so mucho TIA for any tips on the above!

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<b>From:</b>	<b>Stan Bailey</b> ( <a href="mailto:whipzippy@aol.com">whipzippy@aol.com</a> )		
<b>Date:</b>	7/19/2002 6:36 PM		
<b>Subject:</b>	<b>Re: Help needed with MOSFET source followers</b>		

Since this passed by the more knowing individuals on this forum, I'll take a crack at it.

*1. Which B+ supply node do I use for the MOSFET drain (plate), and why?*

I just tapped off one of the b+ nodes (PI) and decoupled it with a 10K and cap. Why? Because it's quick and easy :O)

*2. What is the best way to derive the high negative voltage for the cathodes? Note: I get 425V B+ from the rectifier plate. Also, the PT's 2A/5V filament winding is unused, if this can be used at all.*

For the source V- you could use a real small 5-6 volt transformer with it's secondaries hooked up to your 5V filament windings. Make sure your V+ and V- to the Drain and Source doesn't exceed the MOSFETs D-S Voltage.

*3. I adjust the -ve supply so I get -36V on the cathodes, right?*

I think you leave your existing bias intact, and hook up one leg to it's own Mosfet gate through a 100R-220R to prevent oscillations. After you connect everything as shown on schematic, just adjust bias as you did before. The source follower will "follow" the bias input voltage.

*4. How do I bias the grid (gate) of the MOSFET?*

I believe it will self bias to about 3 volts?

*5. I seem to recall some previous posts here about blowing MOSFETs in this application if not done properly. Is there anything else I need to add that's not mentioned in the R.G.'s article?*

I always have problems with Mosfets if I don't put a 12V zener connected from gate to source for protection.

I have done the direct coupling thing with both tube and fets. As others have stated, I really can't hear the difference between the two topologies. Anyway, I have a few threads saved to disk. Just e-mail me.

Good luck,  
Stan

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<b>From:</b>	<b>Shea</b> ( <a href="mailto:stmoxon@earthlink.net">stmoxon@earthlink.net</a> )		
<b>Date:</b>	7/20/2002 10:07 PM		
<b>Subject:</b>	<b>Re: Help needed with MOSFET source followers</b>		

I was the one who blew MOSFETS, but I didn't use any zeners to limit the gate-source voltage. That probably was the problem, or part of it.

I rectified the negative voltage from the HT winding. I'm thinking about using a different method that will give a lower voltage. Maybe I'll use a 1:1 isolation tranny that I haven't been using.

Shea

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<b>From:</b>	<b>R.G.</b>		
<b>Date:</b>	7/21/2002 3:38 PM		
<b>Subject:</b>	<b>Re: Help needed with MOSFET source followers</b>		

Lemme take a shot. I've never done an AB763, so this will reflect my approach to it, not experience with that amp.

*1. Which B+ supply node do I use for the MOSFET drain (plate), and why?*

IRF820's are rated for a max Vds of 500V. You have to have a B+ supply that can supply all the necessary current to the 820's and still make the drain-source voltage under 500V even under moderate overvoltage, say about 10-15% to allow for line voltage variation. This is the wrong place to start the design, though, as the 820's need to be designed to make the output tube grids happy, then make the drain voltage right.

2. *What is the best way to derive the high negative voltage for the cathodes? Note: I get 425V B+ from the rectifier plate. Also, the PT's 2A/5V filament winding is unused, if this can be used at all.*
3. *I adjust the -ve supply so I get -36V on the cathodes, right?*

\*This\* is the place to start the design.

You have to have the source of the MOSFET be able to sit at -36V, and swing to several volts positive to get into positive grid voltage on the output tubes. That means that they have to be able to swing the same amount of voltage negative on the other half cycle of signal to be able to turn the off-side tube off.

So the minimum minus supply for the MOSFET sources has to be at least twice the existing bias supply, plus a bit more to cover the odd cases. The minus supply needs to be at least -80v (about) and maybe a few more, so -100V would be good. -90 might work, depends on exactly how far you have to drive the output tubes to get them to cut off.

Note that this analysis is for a marginal-Class-A amp. The deeper you run the amp into AB, and the closer to B you get, the less negative bias swing you need. A pure class B amp would only need about -40V. But for average class AB, lets say -75 to -80V.

Having done that, we have eaten 80V from the available Vds on the MOSFET. So the drain supply for the MOSFET can't be more than 500V-80V = +420V without killing the MOSFET from overvoltage. You could use a higher voltage MOSFET (they're available up to about 1kV) or just a lower B+. Anything safely under 420 will work. The minimum is probably about 40V-50V to allow the MOSFET to pull positive. So, any drain voltage from 40V up to 300V is OK. The higher this voltage, the more heat wasted in the MOSFET.

This voltage supply has to provide enough current to pull the source-follower resistors and positive grid current up to the most-positive drive voltage. For the 10K resistors listed, that's going to be about  $(-Vs - 10V)/10K$ . Typical values might be  $(-80V-10V)/10K = 9ma$  plus grid current of a few ma. Call it 12ma. The grid resistors dissipate  $(-80V - (-36V)) * 0.012A = 0.528W$ , so you need 1W resistors there. This happens once for each MOSFET, so you could need 24ma of supply current. Notice that the source resistors are the majority of the current, so you might be able to up the source resistors to 22K or even 47K. The higher the resistor, the lower the off-state drive; however, those would probably be good enough. I selected 10K as a good high performance driver. 47K source resistors would require only about 5ma per side, 10ma total. Actually, that's conservative, as only one side will be at max current at a time. You might get by with 50-75% of that if you're on a tight current-budget.

That current has to come from the + supply on the drain of the MOSFETs. So you need something that can provide 10 to 12ma of current at no less than 40V at max current, and no more than 300V at minimum current. The simplest way to do that is with a resistor-zener supply from the main B+. You make the resistor drop your 420V to 40V under max current:  $(420V-40V)/24ma = 15.833K$ . You have the zener eat all the current when the voltage hits 300V:  $420-300 = 120V$ ;  $I_{zener} = 120V/15.833K = 7.6ma$ ; so you need a 300V, 2.3W zener minimum. Any zener between +40V and +300V that can eat the no-load current at that voltage will do. I would use an amplified zener with another MOSFET.

Which brings up another way to do this. Use a second MOSFET with its drain tied to +420, its gate tied to one of the lower preamp voltages, like maybe the +260V preamp section, and its source tied to the drain of the actual source follower MOSFET. Now the upper MOSFET does the heavy lifting on the power supply. Hmmm. I hadn't thought of that one. I'll have to draw that up. It's a neat trick. The reference supply is just that, a reference. The gate of the power supply MOSFET will not load your preamp power supply. I'll have to draw that one up.

The -Vs supply has to be able to eat all the current that the B+ supply lets through, too.

4. *How do I bias the grid (gate) of the MOSFET?*

Use the old bias pots where the pots are shown in the article. In this case, you do the same job you used to do - measure the power tube current and twiddle the knob until the power tube currents are right. However, because the MOSFETs are enhancement devices, the actual voltage on the MOSFET gates will be about 1-3V higher than the voltage used to be when it drove the power tube grid directly. You won't notice this; just bias for power tube currents.

5. *I seem to recall some previous posts here about blowing MOSFETs in this application if not done properly. Is there anything else I need to add that's not mentioned in the R.G.'s article?*

Tie a 12V 1/2W zener anode to source, cathode to gate on all the MOSFETs to protect from transients.

I'll do some more drawing. You bring up some good design questions for people not as accustomed to just making things up as they go along. Thanks for the questions, and watch for the additional info.

R.G.

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<b>From:</b>	<b>Cornbread</b>		
<b>Date:</b>	7/21/2002 4:37 PM		
<b>Subject:</b>	<b>Re: Help needed with MOSFET source followers</b>		

Excellent info! Wow. I would love to see you write some articles on applications of Mosfet's in tube amps.

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<b>From:</b>	<b>kg (<a href="mailto:ride5000@ride.ri.net">ride5000@ride.ri.net</a>)</b>		
<b>Date:</b>	7/21/2002 11:03 PM		
<b>Subject:</b>	<b>Re: Help needed with MOSFET source followers</b>		

have you been to his home page? i believe it's part of the reading list:

<http://www.geofex.com/>

there are articles on applications of all kinds of transistor circuits, as well as everything else.

ken

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<b>From:</b>	<b>R.G.</b>		
<b>Date:</b>	7/22/2002 12:21 AM		
<b>Subject:</b>	<b>Re: Help needed with MOSFET source followers</b>		

I did some introspection and came up with a much more end to end set of circuits to do the MOSFET follower grid drive. Most of the complexity is in the power circuits, of course.

I used a source follower on the positive side with a second MOSFET's gate tied to +100V. This provides clean +100 to the follower MOSFETS to drive the gates.

I did a rectifier/filter/MOSFET active zener to make regulated -100V for the source side.

I'll get it drawn up. I think the whole mess of four MOSFETs and power resistors, filters, etc. can fit onto a neat small PCB or two.

R.G.

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**From:** Stan Bailey ([whipzippy@aol.com](mailto:whipzippy@aol.com))

**Date:** 7/22/2002 4:42 AM

**Subject:** Re: Help needed with MOSFET source followers

Also, you may want to check out the BUZ80A. 800V @4Amps. Mouser part# 511-STP4NB80 \$1.64  
Stan

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