Silicon Carbide (SiC) MOSFETs

With the development of the (SiC) MOSFETs, I have found them to be superior to the switching MOSFETs we have been using for LF and MF amplifiers. The new devices I've tested are manufactured by Onsemi and GeneSiC.

G3R60MT07D $11.56 GeneSiC--750V drain 43 amps

G3R40MT12D $17.52 GeneSiC—1200V drain 45 amps

NTHL060N090SC1 $12.77--Onsemi--900V drain 46 amps. **Note NVHL060N090SC1 is the same device just a newer production.**

After testing all three devices, I will list the results for the NVHL060N090SC1, and G3R60MT07D as the same, because both perform equally well in the circuit. These devices are a close drop-in for the IRFP250n, but a much superior device. Test results for the G3R40MT12D listed separate.

Test results NTHLL060N090SC1 & G3R60MT07D

- Efficiency 94%
- Linear operation good, stable idle current, improvement over the IRFP250. The IRFP250 requires a thermistor to control current runaway.
- With the high drain voltage, it's not necessary to have a snubber for the drain pulse.
- Will operate at low and high voltages (25v-70v in my testing). Test results shown below with a single NTHL060N090SC1 at 475 kHz.
- 25V 100 watts out
- 35V 200 watts out
- 43V 300 watts out
- 49V 400 watts out
- 55V 500 watts out
- 59V 550 watts out 9.8 Amps, drain pulse 360V.
- 63V 600 watts out
- 68V 700 watts out 11.1 Amps, drain pulse 412V.

Test results G3R40MT12D

- Efficiency 91%
- Linear operation good, stable idle current.
- 13.8V 40 watts out, *A good voltage for test and circuit optimization.*
- 25V 141 watts out
- 30V 200 watts out
- 35V 260 watts out
- 43V 380 watts out
- 49V 470 watts out
- 55V 586 watts out 11.7 amps, 346 volt drain pulse
- 59V 630 watts out
- Will go higher but stopped test at 59V

The output L2, C2 impedance matching network requires a 7.4uh coil and a 18500pf capacitor for 475 kHz in my circuit for the NTHL060N090SC1 and the G3R60MT07D, but the G3R40MT12D required the same 6.4uh as the IRFP250.

The drain DC circuit L1, C1 is a 12uh and 6800pf same as the IRFP250.

Feedback circuit for Linear operation is 3K 5 watt in series with a .1uf capacitor. I found these on Amazon and there non inductive. uxcell 10Pcs 3K Ohm Resistor, 5W 5% Tolerance Metal Oxide Film Resistors Part # a19041800ux0200

Idle current for Linear is between 100-150 ma.

Gate drive 15V, for all three, the IRFP250 requires 10V

I have not detected any startup or dropout oscillation's as seen with the IRFP250.

Notes

- When driving these SiC MOSFETS with a driver like the TC4427 apply +15 Vdd to the driver.

- When running over 250 watts I recommend stacking two T-130-2 cores for L2 and L3, use #16 wire. This will help with the core heating problem and increased power out. A cooling fan pulling air across L2 also helps.

- With any of these devices I recommend that you test and optimize the circuit at 25Vdc before increasing to higher voltage/power.

- When I converted my non-linear 2200 amp I'm still using the TC4427 but with only one SiC MOSFET not two in parallel. I changed the driver regulator from 10V to 15V.

- Add a TVS 18V diode, P6KE18A from gate to ground to protect the gate from over voltage spikes. Highly recommended in the linear mode.

A final note

I have converted my 630 and 2200 amps to the Onsemi NTHLL060N090SC1, and on the air test have shown excellent results. The GeneSiC G3R40MT12D, 1200V 45A, is a beast but comes at a higher cost, $17.52. If the added cost is not a problem, it would be my first choice of the three devices, but the other two are just as good for our use in LF MF amplifiers. The G3R40 is the true drop-in for the IRFP250, but the circuit mod for the other two are simple. Some of the new SiC MOSFETS require 20-25 vote gate drive but the ones I have listed here are 15-volt drive. Something to watch out for if researching others.

SSB voice operation. The SiC MOSFETS does not have the true linear ramp like the IRFP250 but seem to work ok under test. The output looks like the amplifier is under compression, making the linear operation a power curve, so keep the mike gain low to reduce compression. Also when operating SSB the modulation frequency peaks up to 3khz moving the transmit frequency out of resonance with the antenna system. This can cause high reflected spikes. I have found that its best to run reduced voltage when operating voice to keep the drain dissipation below the maximum rating of the G3R40 MOSFET, and the SWR spikes low. 36V

or below seems to be a good level. This will give you around 200 watts' peak output. Nonlinear modes like wsjt-x, cw, with 15v gate drive you can push this device to over 600 watts and the drain dissipation will be well under the maximum. This is a problem with any switching MOSFETS, when the gate drive is reduced the Drain dissipation goes up.

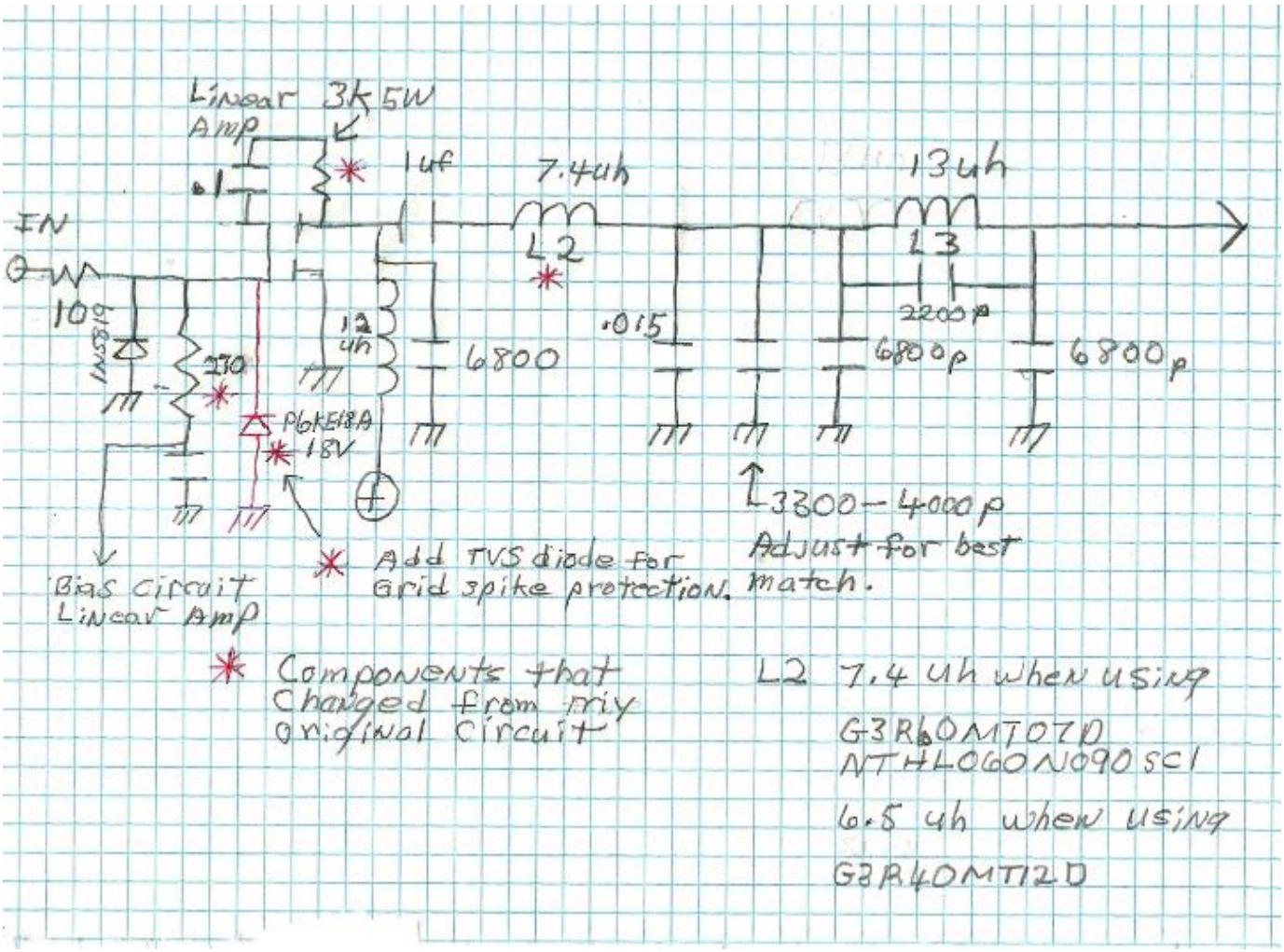
Any questions about these devices or coil/circuit data drop me an email. QRZ, WB4JWM or Slack DM.

On Semiconductor, PDF file on SiC MOSFETS

https://www.mouser.com/pdfDocs/TND6237-D.PDF

See print for circuit changes

10/12/2021


Linear 3k 5W
Amp
.1
1uf
7.4uh
L2
13uh
L3
IN
100
1N5819
270
12 uh
6800
P6KE18A
18V
.015
2200p
6800p
6800p
3300-4000p
Adjust for best match.
Add TVS diode for Grid spike protection.
Bias circuit
Linear Amp
* Components that Changed from my original circuit
L2 7.4 uh when using
G3R60MT07D
NTHL060N090SC1
6.5 uh when using
G2R40MT12D