GaAs Amplifier PCB V1.0 manual and assembly notes

GM4ISM 2024

VDD and 12V

If VDD for the amplifier is Between 8V and 15V and the –V generator requires 5V in, then the 5V regulators are OK and the Solder Link adjacent to Q3 Source can be made (solder bridge) The 12V input, J5 need not be used.

If VDD is outside this range, omit the bridge by Q3 and use J5 to supply the board with +12V as well

Selection of the Switching FET Q3

This is a P Channel FET used as a high side switch. It needs to have a low rDS(on) value if significant current is required and no heatsinking is envisaged. Values less than 0.02Ω are generally good. Its voltage rating VDS should be twice VDD

Depending on the maximum gate voltage VGS and the switching voltage of the device to achieve optimum rDS(on), R6 will need to be selected to suit. For 10V VGS and a 10V VDD 10 Ω will suffice. For 10V VGS and a 28V VDD 10 kΩ will be needed as VGS max is often about 20V

PCB has component layout for a simple snubber circuit (C16,C17 and R8) but so far this has not been found necessary and is unpopulated.

VDD switching current.

If the switching FET is PCB mounted, the current rating will be limited by FET dissipation and by the tracks and DC connectors used

The tracks are good for about 4A mean (rating is temperature rise related). Molex KK254 connectors for which the PCB is sized are rated at only 2.5A (I have used them on this board at 5A as a test and they were OK short term)

Note Dupont type 2.54mm header pins are rated to 1A max!

PCB mounted screw terminals are available (Rated 10A eg Mouser 538-39773-0002) (Rated 4A eg RS 790-1098) or you could solder wires on.

I tested the PCB with a SUD45P03-15 (D Pak was a little awkward to fit but that was what I had to hand) and was switching 15V into a slightly inductive load at a little over 5A, with no heating issues over a 1 Hour period of continuous current.

LED Current. Depending on voltages used, the LED indicators will need suitable values for R5, and especially R7 and R9 that may differ from the schematic values eg for 28V VDD R9 would have to be about 5.6kΩ for a LED at 4.5mA. The LED current is limited by R9 for a 100% duty cycle, as a 1206 Surface mount resistor is only rated at 0.125W.

I use a blue LED for D2 (-Ve voltage indicator) and it needs only a few mA so for R7 I recommend 1kΩ for -5V and 3.3 kΩ for -12V

Note R5, R7, R9 and R6 are all 1206 size surface mount so that they can be fitted / changed more easily.

The LED can be driven from either the -5V pin3 or the 'Unregulated' pin4 on J7. This is selected on a jumper JP1 which is bridged on the PCB linking pads 1-2 selecting regulated by default. Cut the fine bridge track between pads 1 and 2 and solder bridge 2-3 for the unregulated (eg ICL7660) output

Negative voltage generators

The PCB can accommodate the following devices and more.

U1 ICL7660 (5V, 5V out) supplied with 5V from by U6 (78M05 D-Pak) OR   U2 78L05 (TO-92) dependant on 5V current requirement.

Note C2 is only required if ICL7660 is used

OR

U3 CRE1S1212SC (12V in -12V out) supplied from 12V input, followed by U4 79L05 or 7905 if -5V is required as well

OR

Murata NCS1S12xxSC (available with 3.3, 5,12V outputs) supplied from 12V input

OR

Traco TEA 1 series (Not E),   Recom RFM Series   (U3 Left hand set of 4 holes)

OR, with minor PCB alteration

Traco TBA 2 series (Single rail) or TEA-1xxxxE with 1 cut on the PCB (Cut track linking Pin 7 to Pin 4, before fitting the device!)

PCB Pin 3 and Pin 7 to ground (Pin 6 is convenient for Pin 7, Pin 5 to Pin 4 ***The device Pin 1 goes in PCB hole Number 2*** (PCB Pin1 is unused)

IMPORTANT

If 5V input DC-DC converter modules are used for U3, ***you must CUT the track adjacent to Pin1 of J4 (no solder mask here) and link pins 2 and 3*** This disconnects the 12V line to J4 Pin 1 (DC input to U3)

Negative Voltage detection and protection.

The primary purpose of the switch in VDD is to allow a degree of protection for the amplifier should the –Ve bias supply fail.

The board uses an external input for the –Ve supply it senses (J7 Pin2)

The board outputs the –Ve supply to the amplifier on J7 pin 3 or 4 (Pin 1 is ground)

Ideally the –V supply is looped round at the amplifier end so that even a loose cable or broken wire will be detected as loss of the –Ve supply and will mute the VDD supply.

On the header of J7 (Dupont type) Pin2 can be cut slightly shorter than the rest so that the sense line breaks before the outgoing supply lines

The sense line is connected to one end of a 10K potentiometer, RV1. The other end is connected to VDD in (+V). The wiper is connected to Q1 base via 4.7 kΩ

The potentiometer can be set so that the VDD supply un-mutes at a suitable level of –Ve bias , eg -4V if the supply is -5V nominal.

Be aware that changes to VDD change the mute point!

Caution

Detecting a –Ve voltage greater than 5V means the pot could be set such that the transistor is subject to a –V voltage in excess of VEBO maximum ratings (typically 6V for a small bipolar transistor) If this is that case :-

Either wire, a 2.7V Zener diode from the base of Q1 to ground (Cathode to Base) This is not implemented as a component position on this version of the PCB

Or cut the track between J7 pin 2 and RV1 (before fitting the potentiometer and fit a small 1/4W 4.7 kΩ resistor between these points on the back of the board. This prevents the base being presented with as high a voltage at the end of the potentiometer range.

These will not interfere with the mute cct but will protect the transistor Q1

Once set up, the VDD supply will not be passed through unless the –Ve rail is present and correct.

Switching VDD Off is also possible by grounding J2 Pin4. This can be used to provide PTT controlled power (inverted logic) any short cct device applied here will mute the VDD line. This pin is pulled high to VDD via a 4.7kΩ resistor.

Examples include relay contacts eg back contacts on an RF antenna changeover relay, over temperature alarm, open collector inhibits from other equipment. Multiple mule ccts can be applied to the same pin

Do not connect logic level or other controlling voltages, they wont work!

A Selection of possible suitable P Channel FETS (PCB is designed for TO-220)

SUP70101EL (TO-220) 100V 120A rDS(on) 0.010Ω dissipates 1W at 10A £2.33 @Mouser

SUP60061EL (TO-220) 80V 150A rDS(on) 0.0058Ω dissipates 0.58W at 10A £2.95 @Mouser

SQM40081EL (D-Pak) 40V 50A rDS(on) 0.0085Ω dissipates 0.58W at 10A £1.24 @Mouser

SQM40061EL (D-Pak) 40V 100A rDS(on) 0.0051Ω dissipates 0.51W at 10A £1.42 @Mouser

SQM40031EL (D-Pak) 40V 120A rDS(on) 0.0030Ω dissipates 0.3W at 10A £2.24 @Mouser

SUD45P03-15 (D-Pak) 30V 13A rDS(on) 0.0150Ω dissipates 1.5W at 10A £2.24 @Mouser

For information, some calculations and measurements of device temperatures was attempted, based on datasheet figures.

I ***estimate*** worst case thermal resistance of these devices to air with no heatsink to be in the order of 60C/W

With a double sided metal sheet heatsink of 4 sq cm in free air this may drop to 40C/W or better

Datasheets suggest 30-40C/W is typical of a PCB mounted device on 1 sq inch of 1 oz copper

With 100% duty cycle, running with a case temperature of 70C in an ambient of 30C, 40C/W allows for 1W dissipation

The SUP70101EL will manage that temperature at 60C/W heatsinking with about 660mW dissipation at a current of over 8A

The SUD45P03-15 will manage that temperature at 60C/W heatsinking at a current of over 6.5A

Measured temperature rise was 23C for this device at 5A, confirming thermal resistance to be about 60C/W

To maintain a 40C temp rise max, rDS(on) must be lower than 0.026 Ω for 5A and 60C/W heatsink,

For 4 A, rdS(on) can be 0.04 Ω

For 2 A, rdS(on) can be 0.16 Ω

For 1 A, rdS(on) can be 0.64 Ω