Myriad Design – FET Matcher V7 – Construction Guide

V3.0 June, 2018 – For FET7V3DS01 boards

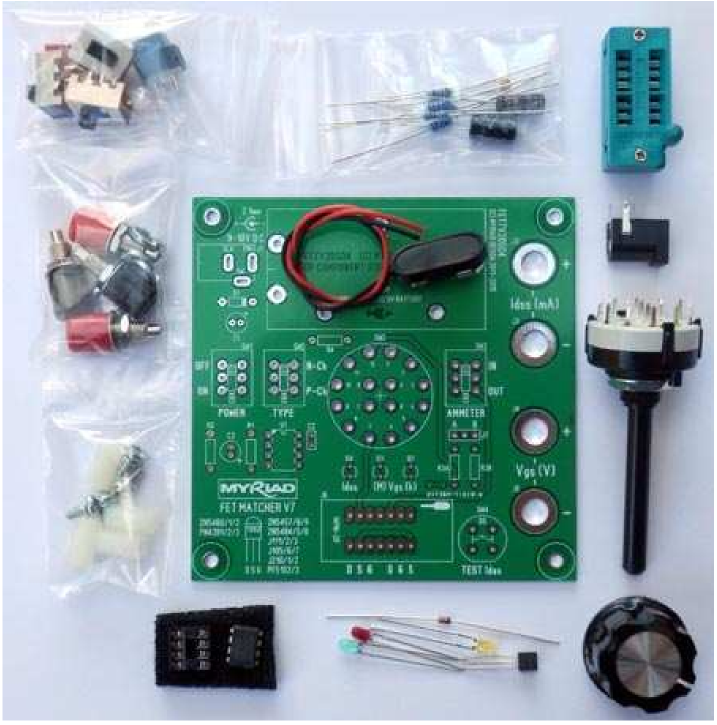
1. The package should include the following items. If any of the items are missing from the package, please contact sales@stompville.co.uk :

Designation	Description	Marking
PCB	FET Matcher V7 - printed circuit board	FET7V3DS01
R1, R2, R3A	1/4W resistor - 10k	See Note 1
R3B	1/4W resistor - 4k7	
R4	1/4W resistor - 3k3	
C1	47uF electrolytic capacitor	
C2, C4	100nF ceramic capacitor	100n or 104
C3	10uF electrolytic capacitor	
D1	BAT43 Schottky diode	BAT43 or BAT42 or BAT85
D2	3mm LED RED	Cathode is shorter leg
D3	3mm LED AMBER/YELLOW	Cathode is shorter leg
D4	3mm LED GREEN	Cathode is shorter leg
U1	OPA2244 operational amplifier	
SW1, 3, 5	PCB Slide switch	
SW2	4-pole, 3-way rotary switch	
SW4	PCB tactile switch	
J1	2.1mm DC power inlet	
J2, J4	4mm banana socket RED	
J3, J5	4mm banana socket BLACK	
J6	14 way ZIF Socket	
J7	3-pin 0.1” SIL header	
Qty1	8-pin DIL socket	
Qty1	0.1” Jumper	
Qty 4	M3 x 6 screw with washer	
Qty 4	M3 nylon standoff	
Qty 4	M6 spring washer	
Qty1	Knob	
Qty1	Battery clip	
Qty1	Self-adhesive pad for battery	
Qty1	Quick start guide	

[1] Some resistors may be 4-band and some 5-band. See: http://stompville.co.uk/ResistorColourCodes.pdf

2. It is assumed that you have some experience of soldering and building of simple kits and are confident to build the FET matcher. If not, there are many relevant tutorials and videos on the internet. Please spend some time familiarising yourself with construction and soldering techniques.

3. Note that U1 and the JFETs you will test are electrostatic sensitive devices and should be handled with care. If you have an ESD protective wristband, use that. If not, wear clothes made of natural materials (e.g. cotton), regularly touch your finger to an earthed (grounded) metal object (such as a central-heating radiator) and do not handle the sensitive devices any more than you have to. In particular, don’t remove them from the electrostatic protective package until you are ready to fit them to the board.

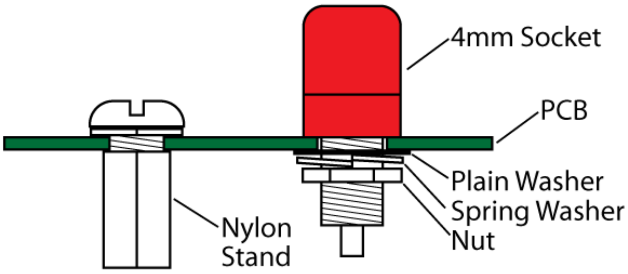


4. Solder the items to the PCB according to the silk-screen legend, checking and ensuring that you insert each component in the correct orientation.

5. Switches SW1, SW3, SW5 may be fitted either way round. If you wish, you can hack the PCB traces to change the power switch to suit the North American convention (i.e. 'up' is on).

6. You will need to cut down the shaft of SW2 before soldering SW2 to the board. This switch is rotationally symmetrical and will fit in any of four positions. You do not need to match up the switch sections A, B, C, D with the PCB legend. When fitting the knob, set the switch to the middle position and line up the knob accordingly before tightening the screw.

7. The 4mm sockets J2-J5 should be fitted in accordance with the diagram below. Ensure the metal body of the socket is tightly screwed to the plastic part then insert the entire body assembly into the hole. Fit the plain washer followed by the spring washer and the locknut. There is no need to solder the sockets in place and this is not recommended in any case.



8. Note that provision on the PCB has been made for a 9V battery holder. This is not supplied in the kit. A battery clip and self-adhesive pad are supplied in lieu.

9. Note that the LEDs must be connected the correct way round. The shorter lead of the LED is the cathode and is shown by the flat side on the PCB legend.

9A. Note that C4 acts to stabilise the reading for Vgs and must be soldered to the underside of the board in accordance with the diagram on the quickstart guide.

10. You are advised to test the assembled board without fitting the op-amp and without a JFET inserted. Connect a battery and switch on. Switch SW2 between its three positions. The LED corresponding to each position should light. If not, check your soldering and if necessary reverse any LED which does not light.

11. Using a multimeter, check the d.c. voltage between pins 7 (positive) and 4 (negative) on the op-amp socket. This voltage should be the same as the battery voltage. Move the positive probe to pin 3 and measure the voltage, which should be half the battery voltage.

12. Switch off and insert the op-amp into its socket and a JFET into the ZIF socket. Set SW2 to the middle position. Set SW5 according to the polarity of the JFET. Connect a multimeter set on d.c. voltage to J4 and J5. If you have another multimeter to hand, set it to d.c. mA and connect it to J2 and J3. If you have an ammeter in circuit, set SW3 to 'IN'. If no ammeter is present, set SW3 to 'OUT'.

13. Switch on and observe the voltage Vgs. For an N-channel JFET this should be negative. Make a note of the value. Ensure that the jumper on J7 is set to position A and set SW2 to measure Vgs(k). Note that the absolute value of Vgs(k) should be lower in magnitude than Vgs(M). For example, if you measured Vgs(M) at -1.6V, Vgs(k) might be -1.3V (i.e. closer to zero).

14. Switch off and connect a multimeter (set to d.c. mA) to the Idss terminals and ensure SW3 is set to 'IN'. Set SW2 to Idss and press the 'TEST Idss' button. The multimeter will show the Idss of the JFET. The value should be positive for an N-channel JFET. If the Idss is greater than about 10mA you will notice the Idss falling as you watch the multimeter. This is because the current flowing in the JFET is warming it up and thereby increasing its resistance. If the Idss current is above 20mA, Idss will likely fall faster than the multimeter updates and it will be difficult to get a confident reading. You may wish to use an analogue milliameter if you are characterising high Idss JFETs.

15. If you wish to use a power adaptor to power the unit, the power unit should have a nominal voltage of 9-18V d.c. with centre-hole negative (preferably regulated). Note that you can use a supply up to 24V d.c. However, as JFETs tend not to have Vgs(off) in excess of +/- 10V, there is no need to go higher than an unregulated 18V supply which will likely have a supply voltage in excess of 21V under the minimal load the tester places on the supply. Also if you connect a power supply in excess of 18V d.c. nominal, ensure that the voltage rating *Vdg(max)* of the JFET will withstand the applied voltage. Many JFETs have a *Vdg(max)* of 25V.

Using the FET Matcher

Measuring Vgs

The instrument can measure two values of *Vgs*, which we call *Vgs(k)* and *Vgs(M)*. The 'k' is a reminder that the circuit resistance is kilohms and the 'M' that the resistance is megohms. *Note that neither of these values represent the true Vgs(off).*

Vgs(M)

Vgs(off) is the potential difference (voltage) between the gate and the source when the resistance of the drain-source channel is infinity. For an N-channel JFET, the gate must be negative with respect to the source to turn the JFET off. To test for *Vgs(off)*, we connect the gate to ground and introduce a source resistor to raise the source above ground, making it more positive than the gate.

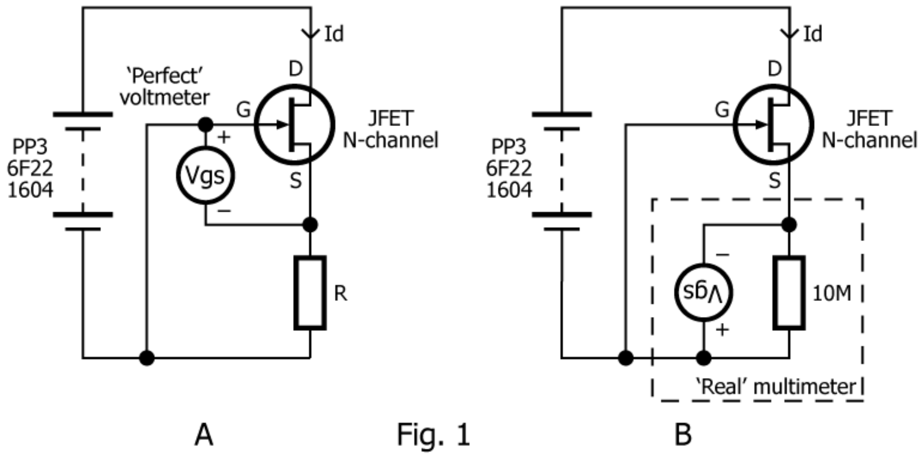


Fig. 1

In Fig 1 A, we introduce a source resistor *R*. Current *Id* flows in the circuit generating a voltage across the resistor equal to *R* x *Id*. This makes the source positive with respect to the gate and the FET is partially switched off.

There is negative feedback at play where increasing current *Id* increases *Vgs* which turns the JFET off thus reducing *Id*. The circuit will naturally achieve a stable equilibrium.

If we make *R* very high, *Id* is necessarily very low and the JFET will settle with a *Vgs* practically the same as *Vgs(off)*.

For practical purposes, we measure *Vgs(M)* using the circuit of *Fig 1 B*. Here a real-world digital voltmeter is represented as a perfect voltmeter (i.e. one with infinitely high impedance) in parallel with a 10M Ohm resistor (which is usually the case for a real-world digital multimeter).

This is equivalent to circuit A – a perfect voltmeter (infinitely high impedance) along with a value for *R* of 10M Ohms.

Note that it is important to check that your multimeter has a 10M Ohm input impedance when measuring d.c. volts. You can check the instruction manual or manufacturer's website or you can simply connect it directly to another multimeter set to measure Ohms. Some bench multimeters have a very-high-input-impedance mode. This will likely not give useful results.

Procedure for measuring Vgs(M):

- Switch power off
- Select 'Vgs(M)' on rotary selector switch
- Select JFET Type N-channel or P-channel
- Insert JFET into ZIF socket
- Select Ammeter 'OUT' on SW3 if no ammeter is present
- Connect digital multimeter with 10M Ohm input impedance to Vgs(V) sockets
- Set multimeter to measure d.c. Volts
- Switch power on
- Note Vgs reading on multimeter

Notes:

- If the actual *Vgs(M)* of the JFET is higher than the battery voltage you will not get an accurate reading

Vgs(k)

Vgs(k) gives a value for *Vgs* when the resistance of the drain-source channel of the JFET is of a middling value (say 10k). This is important in *phaser* guitar-effect designs such as the MXR phase 90 where a JFET is used to modify the resistance in an RC network. Measurement of *Vgs(k)* is achieved using a circuit topology suggested by RG Keen at www.geofex.com.

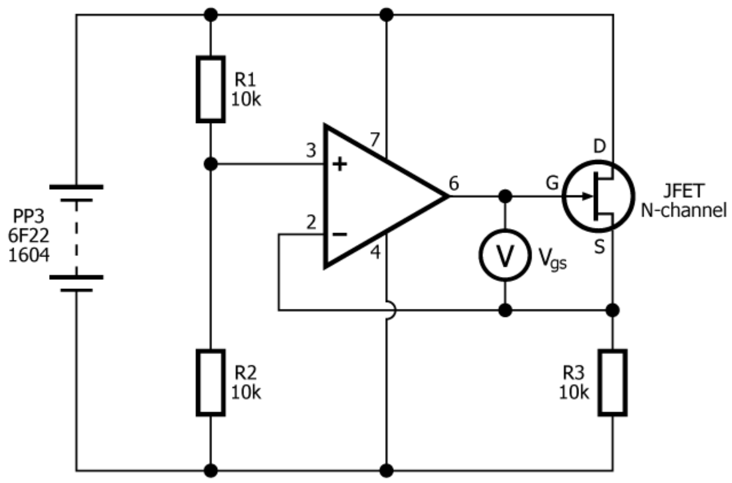


Fig. 2

R1 and R2 form a potential divider that fixes the op-amp's non-inverting input at half the battery voltage. The JFET drain-source channel may be modelled as a simple resistance (*Rds*), so the JFET and R3 also form a potential divider. The circuit will balance when the op-amp's differential input voltage is zero. If the voltage at pin 2 is the same as pin 3, the JFET/R3 potential divider must be equivalent to the R1/R2 potential divider. Hence the output of the op-amp biases the JFET so that its *Rds* is 10k Ohms (i.e. equal to the value of R3).

Because pin 3 of the op-amp is held at ½Vcc, the output can only bias the JFET if the absolute value of *Vgs(k)* is less than half of the battery voltage. Also, many standard op-amps (such as TL072, RC4558) can not drive their output anywhere near the supply rails. This design uses an OPA2244 op-amp. The OPA2244 is more expensive than a TL072 but it has the advantage of having rail-to-rail output voltage swing and low input offset voltage.

Procedure for measuring Vgs(k):

- Switch power off
- Select 'Vgs(k)' on rotary selector switch
- Select JFET Type N-channel or P-channel
- Set the jumper on J7 to 'A' or 'B' as required
- Insert JFET into ZIF socket
- Select Ammeter 'OUT' on SW3 if no ammeter is present
- Connect digital multimeter with 10M Ohm input impedance to Vgs(V) sockets
- Set multimeter to measure d.c. Volts
- Switch power on
- Note Vgs reading on multimeter

Notes:

- If the magnitude of *Vgs(k)* of the JFET under test is higher than half the battery voltage you will not get an accurate reading

Note that the design has provision for alternative values for R3. The standard value is 10k (R3A). An (arbitrary) alternative value of 4k7 (R3B) is supplied in the kit. R3B could notionally be replaced with any value between (say) 100 Ohms and 100k Ohms.

Measuring Idss

JFETs require a potential difference between gate and source to turn off. If the gate is held at the same voltage as the source, the JFET will be fully on and the resistance of the drain-source channel will be at a minimum. *Idss* is the current which flows when the gate is held at the same potential as the source.

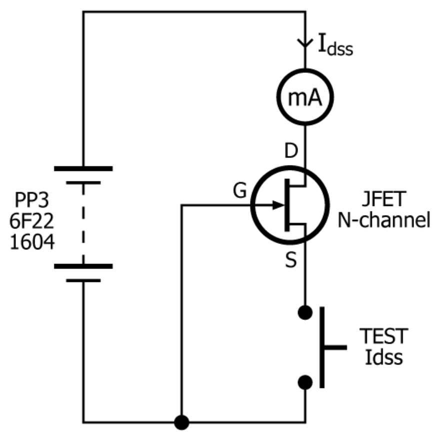


Fig. 3

If *Idss* is greater than about 15mA you will notice *Idss* falling as you watch the multimeter. This is because the current flowing in the JFET is warming it up and thereby increasing its resistance. If the *Idss* current is above 20mA, *Idss* will likely fall faster than the multimeter updates and it will be difficult to get a confident reading. Note that JFET manufacturers characterise *Idss* by applying short pulses of current to avoid heating effects in the device.

Procedure for measuring Idss:

- Switch power off
- Select 'Idss' on rotary selector switch
- Select JFET Type N-channel or P-channel
- Insert JFET into ZIF socket
- Connect an ammeter to Idss terminals (don't forget to re-plug your multimeter leads)
- Select Ammeter 'IN' on SW3
- Set ammeter to measure d.c. mA
- Switch power on
- Press TEST Idss button
- Note Idss reading on ammeter

Notes:

- The battery may not be able to deliver the current demanded by the JFET and thus lead to an inaccurate *Idss* reading. If you are testing JFETs with significant *Idss* (i.e. more than a few mA) you should consider using a mains power supply as a matter of course.

Important Notes

1. The tester can be used to test a JFET (i.e. check for operation within published parameters) or can be used to identify matched sets of JFETs. Note that when matching JFETs, the results you get will depend on the input impedance of the voltmeter, the burden voltage of the ammeter, the supply voltage, the internal impedance of the battery, room temperature, etc. Also, if the *Idss* of a device under test is above 8mA or so, you will likely not be able to get consistent and exactly repeatable *Idss* readings as JFETs have significant temperature coefficient of resistance. Therefore, when matching JFETs, you should be looking for devices that give the same readings on the same day/hour under the same conditions and with the same test set-up. Do not try to find a match for a device you tested last week ; re-test it today and use today's figures as the basis for finding a match.

2. The tester is not immume from being affected by electro-magnetic interference (EMI). In particular, if the *Vgs(M)* reading changes when you move your hand close to the PCB then EMI is affecting your readings. You need to move your test rig to the kitchen table or the potting shed or some place where there is less interference - or you could build a shielded enclosure for your tester.

3. *Idss* varies with *Vds*. If you are using the tester to select a JFET to act as a constant current source then you need to set the supply voltage to the same voltage the JFET will see in the application circuit.

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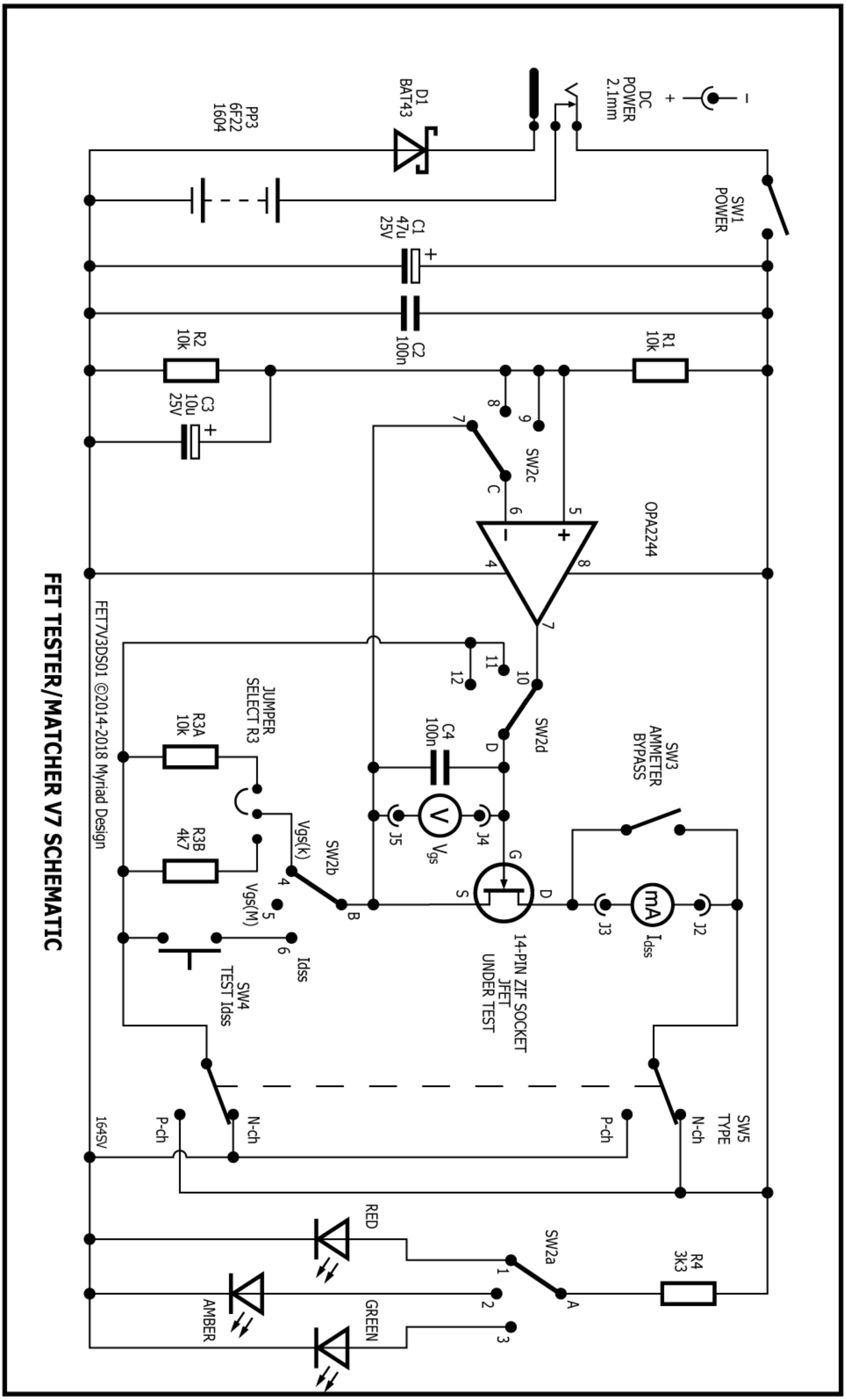
FET TESTER/MATCHER V7 SCHEMATIC
FET7V3DS01 ©2014-2018 Myriad Design
DC POWER 2.1mm
SW1 POWER
D1 BAT43
PP3 6F22 1604
C1 47u 25V
C2 100n
R1 10k
R2 10k
C3 10u 25V
SW2c
OPA2244
SW2d
C4 100n
SW3 AMMETER BYPASS
JUMPER SELECT R3
R3A 10k
R3B 4k7
SW2b
Vgs(k)
Vgs(M)
Idss
J2
J3
J4
J5
V_{gs}
I_{dss}
14-PIN ZIF SOCKET JFET UNDER TEST
SW4 TEST Idss
SW5 TYPE
N-ch
P-ch
164SV
SW2a
R4 3k3
RED
AMBER
GREEN