

## Myriad Design – FET Matcher V7 – Construction Guide

V1 December, 2014

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

Designation	Description	Marking
PCB	FET Matcher V7 - printed circuit board	FET7V1DS04
R1, R2, R3A	1/4W resistor - 10k	See Note 1
R3B	1/4W resistor - 4k7	
R4	1/4W resistor - 3k3	
C1	47u 35V electrolytic capacitor	
C2	10n ceramic capacitor	10n or 103
C3	10u 50V electrolytic capacitor	
D1	BAT43 Schottky diode	BAT43 or BAT42 or BAT85
D2	3mm LED RED	
D3	3mm LED AMBER/YELLOW	
D4	3mm LED GREEN	
U1	OPA244 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 or BLUE	
J6	14 way ZIF Socket	
J7	3-pin 0.1" SIL header	
-	8-pin DIL socket	
-	0.1" Jumper	
Qty 4	M3 x 6 screw with washer	
Qty 4	M3 nylon standoff	
Qty 4	M6 spring washer	
-	Knob	
-	Battery clip	
-	Self-adhesive pad for battery	
-	Quick start guide	

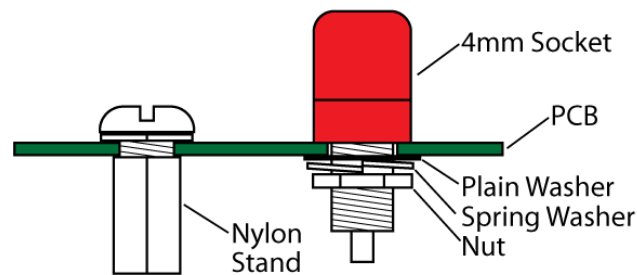
<sup>1</sup> Some resistors may be 4-band and some 5-band. See: <http://stompville.co.uk/ResistorColourCodes.pdf>

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.



6. The 4mm sockets J2-J5 may be fitted in two different ways to give isolated or un-isolated mounting. In this case, mount them un-isolated. Insert the entire body assembly into the hole then fit the plain washer followed by the spring washer and the locknut.



7. 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.

8. 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 of the PCB legend. If you have cut the leads of the LED and lost track of which was the shorter lead, solder it in anyway. No damage will be done if it is fitted the wrong way round. However, if it fails to light when selected, you will need to reverse it.

9. You are advised to test the assembled board without fitting the op-amp and without a JFET installed. 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.

10. 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.

11. 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'.

12. Switch on and observe the voltage  $V_{gs}$ . 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  $V_{gs(k)}$ . Note that the absolute value of  $V_{gs(k)}$  should be lower in magnitude than  $V_{gs(M)}$ . For example, if you measured  $V_{gs(M)}$  at -1.6V,  $V_{gs(k)}$  might be -1.3V (i.e. closer to zero).

13. Switch off and connect a multimeter (set to d.c. mA) to the  $I_{dss}$  terminals and ensure SW3 is set to out. Set SW2 to  $I_{dss}$  and press the 'TEST  $I_{dss}$ ' button. The multimeter will show the  $I_{dss}$  of the JFET. The value should be positive for an N-channel JFET. If the  $I_{dss}$  is greater than about 15mA you will notice the  $I_{dss}$  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  $I_{dss}$  current is above 20mA,  $I_{dss}$  will likely fall faster than the multimeter updates and it will be difficult to get a confident reading.

14. 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 35V d.c. However, as JFETs tend not to have  $V_{gs(off)}$  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  $V_{dg(max)}$  of the JFET will withstand the applied voltage. Many JFETs have a  $V_{dg(max)}$  of 25V.

## Using the FET Matcher

### Measuring $V_{gs}$

The instrument can measure two values of  $V_{gs}$ , which we call  $V_{gs}(k)$  and  $V_{gs}(M)$ . 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  $V_{gs}(off)$ .

#### $V_{gs}(M)$

$V_{gs}(off)$  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  $V_{gs}(off)$ , we connect the gate to ground and introduce a source resistor to raise the source above ground, making it more positive than the gate.

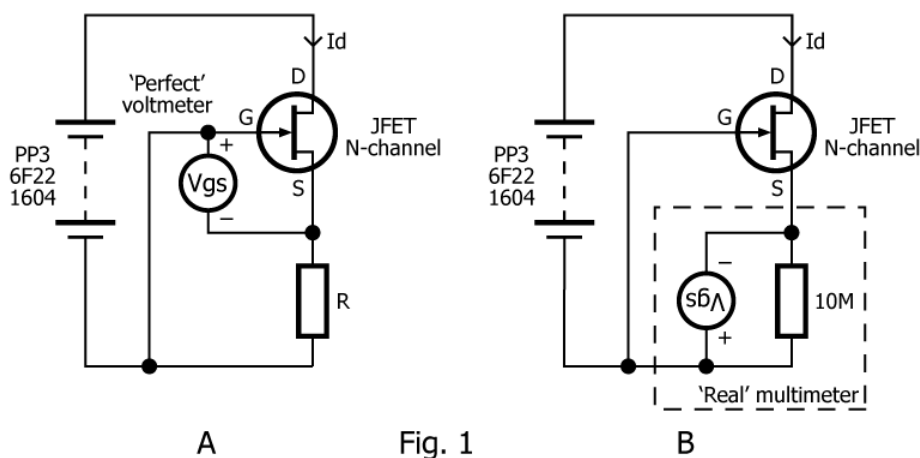


Fig. 1

In Fig 1 A, we introduce a source resistor  $R$ . Current  $I_d$  flows in the circuit generating a voltage across the resistor equal to  $R \times I_d$ . 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  $I_d$  increases  $V_{gs}$  which turns the JFET off thus reducing  $I_d$ . The circuit will naturally achieve a stable equilibrium.

If we make  $R$  very high,  $I_d$  is necessarily very low and the JFET will settle with a  $V_{gs}$  practically the same as  $V_{gs}(off)$ .

We measure  $V_{gs}(M)$  using the circuit of Fig 1 B. Here a real-world digital voltmeter is modelled 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 $V_{gs}(M)$ :

- Switch power off
- Select ' $V_{gs}(M)$ ' 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  $V_{gs}(V)$  sockets
- Set multimeter to measure d.c. Volts
- Switch power on
- Note  $V_{gs}$  reading on multimeter

Notes:

- If the actual  $V_{gs}(M)$  of the JFET is higher than the battery voltage you will not get an accurate reading

### $V_{gs}(k)$

$V_{gs}(k)$  gives a value for  $V_{gs}$  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. This measurement is achieved using a circuit topology suggested by RG Keen at [www.geofex.com](http://www.geofex.com).

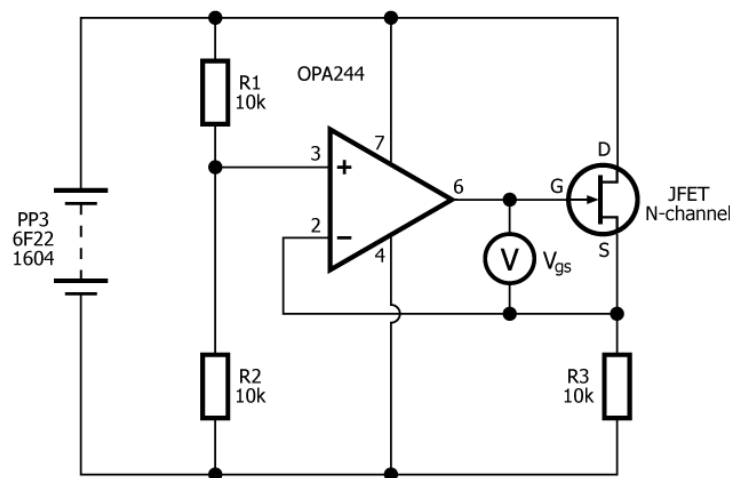


Fig. 2

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 - 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  $R_{ds}$  is 10k Ohms (i.e. equal to the value of R3).

Because pin 3 of the op-amp is held at  $\frac{1}{2}V_{cc}$ , the output can only bias the JFET if the absolute value of  $V_{gs}(k)$  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 OPA244 op-amp. The OPA244 is more expensive than a TL071 but it has the advantage of having rail-to-rail output voltage swing and low input offset voltage.

### Procedure for measuring $V_{gs}(k)$ :

- Switch power off
- Select ' $V_{gs}(k)$ ' 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  $V_{gs}(V)$  sockets
- Set multimeter to measure d.c. Volts
- Switch power on
- Note  $V_{gs}$  reading on multimeter

Notes:

- If the magnitude of  $V_{gs}(k)$  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 $I_{dss}$

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.  $I_{dss}$  is the current which flows when the gate is held at the same potential as the source.

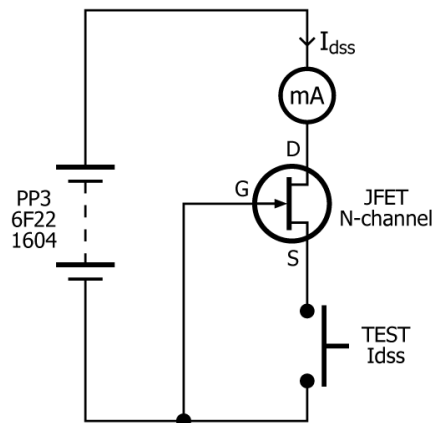


Fig. 3

If  $I_{dss}$  is greater than about 15mA you will notice  $I_{dss}$  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  $I_{dss}$  current is above 20mA,  $I_{dss}$  will likely fall faster than the multimeter updates and it will be difficult to get a confident reading. Note that JFET manufacturers characterise  $I_{dss}$  by applying short pulses of current to avoid heating effects in the device.

Note that the current flowing in the JFET is largely independent of the applied drain voltage and JFETs may be used as a form of constant-current source/sink.

**Procedure for measuring  $I_{dss}$ :**

- Switch power off
- Select ' $I_{dss}$ ' on rotary selector switch
- Select JFET Type N-channel or P-channel
- Insert JFET into ZIF socket
- Connect an ammeter to  $I_{dss}$  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  $I_{dss}$  button
- Note  $I_{dss}$  reading on ammeter

## Notes:

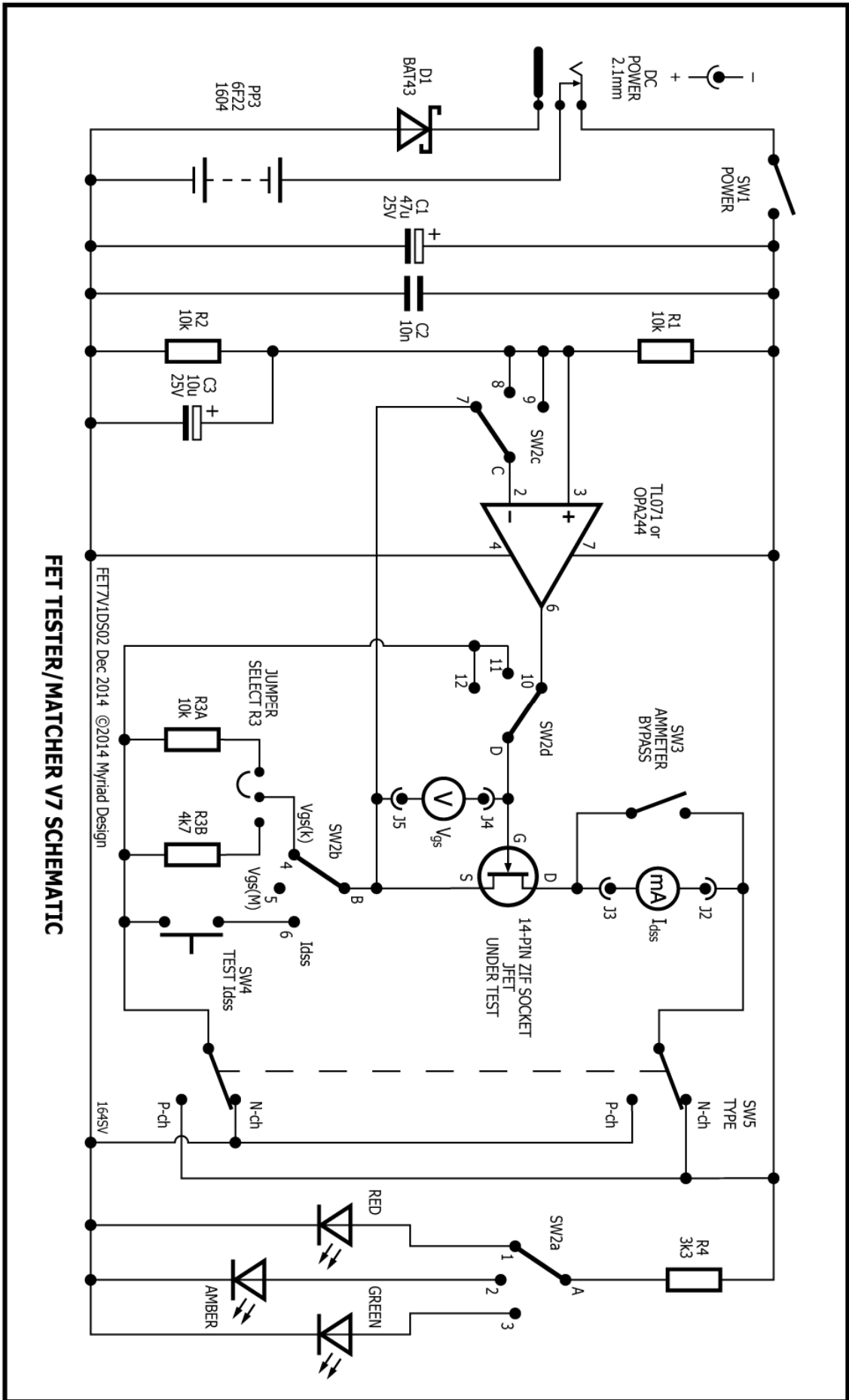
- If the battery is flat it may not be able to deliver the current demanded by the JFET and thus lead to an inaccurate  $I_{dss}$  reading.

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**FET TESTER/MATCHER V7 SCHEMATIC**

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