

Myriad Design – FET Matcher V7 – Construction Guide

V3.1 September, 2018 – For FET7V3DS02 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 :

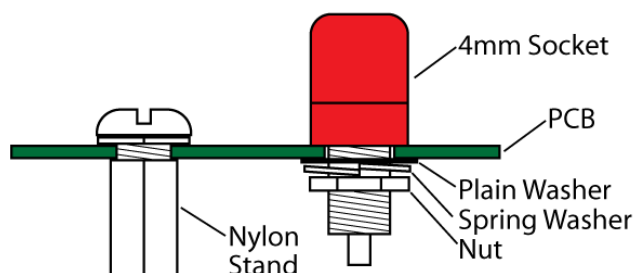
Designation	Description	Marking
PCB	FET Matcher V7 - printed circuit board	FET7V3DS02
R1, R2, R3A	1/4W resistor - 10k	See Note 1
R3B	1/4W resistor - 4k7	
R4	1/4W resistor - 3k3	
C1	47uF electrolytic capacitor	
C2, C4	100nF ceramic capacitor	100n or 104
C3	10uF electrolytic capacitor	
D1	BAT43 Schottky 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	OPA2244PA
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.

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.

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 8 (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 5 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 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).

14. Switch off and connect a multimeter (set to d.c. mA) to the I_{dss} terminals and ensure SW3 is set to 'IN'. 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 10mA 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. You may wish to use an analogue milliammeter if you are characterising high I_{dss} 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 $V_{gs(off)}$ in excess of $\pm 10V$, 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.

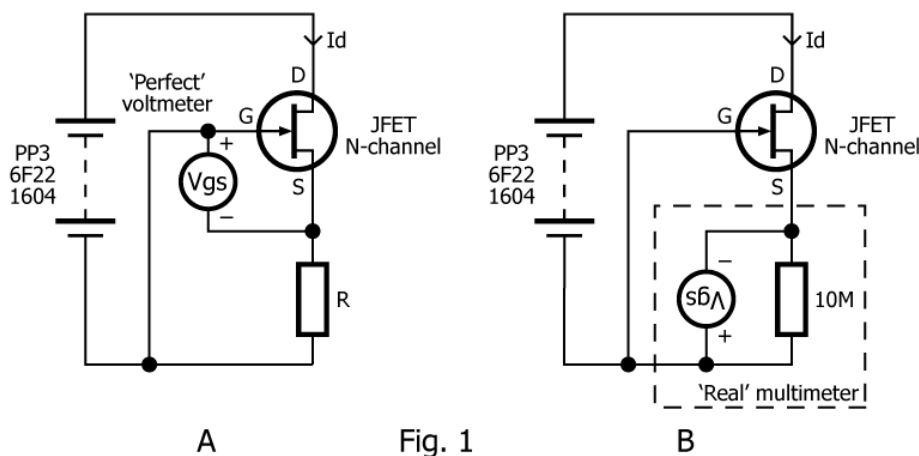
Using the FET Matcher

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.



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 JFET 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 $V_{gs}(off)$.

For practical purposes, we measure $V_{gs}(M)$ 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 $V_{gs}(M)$:

- 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. Measurement of $V_{gs}(k)$ is achieved using a circuit topology suggested by RG Keen at www.geofex.com.

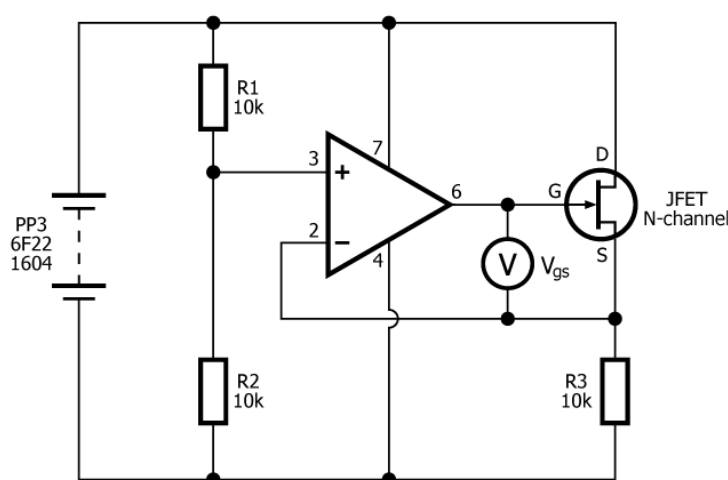


Fig. 2

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 (R_{ds}), 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 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. Note that the diagram above shows pinout for OPA244 (single op-amp version which is now obsolete in DIP package).

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.

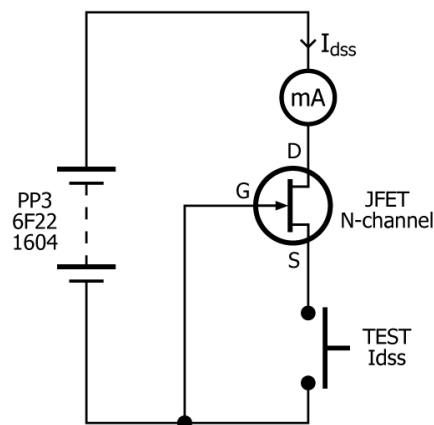


Fig. 3

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.

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:

- The battery may not be able to deliver the current demanded by the JFET and thus lead to an inaccurate I_{dss} reading. If you are testing JFETs with significant I_{dss} (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 I_{dss} of a device under test is above 8mA or so, you will likely not be able to get consistent and exactly repeatable I_{dss} 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 immune from being affected by electro-magnetic interference (EMI). In particular, if the $V_{gs}(M)$ reading changes when you move your hand close to the PCB then EMI is affecting your readings. C4 serves to reduce sensitivity to environmental interference. You are encouraged to build a shielded enclosure for your tester if you experience issues with interference.
3. I_{dss} varies with V_{ds} . 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.

Toubleshooting

We have sold hundreds of testers and have had very positive results. Occasionally, however, we get emails from customers indicating they have a problem with their tester. We go through a process of asking the customer to send photographs of their build for our evaluation and the problem is usually one of the following issues:

- Poor solder joints. The JFET tester is a piece of test equipment and must be built with the utmost care to ensure there are no dry joints.

Can't test Idss:

- You must be careful to ensure that all components are inserted in the correct orientation. This includes the "Test Idss" switch, which has a flat to match the silkscreen legend. If you have this switch 180° out, it **will** work. However, if you have it 90° out, it **will not** work.
- You must test your multimeter to ensure it can measure current in the mA range. Many people have blown the fuse in their multimeter but didn't know. You can use a resistor (between 1k0 and 10k, nominally 4k7) connected between D and S on the ZIF socket. When you press "Test Idss", you should get a reading of about 2mA with a 9V supply. If the current is zero, then you likely have a problem with your multimeter.

Finally, you must be confident you have good quality JFETs. We have had customers trying to use their JFET matcher for the first time and the only JFETs they have available are a dodgy batch of 2SK170 or 2N5457 they go off the internet. Please ensure you test the meter using a known good JFET. You can test any JFET for Vgs(off) and Idss using a multimeter, a breadboard and a 9V battery. You are encouraged to do so if you are having problems with your newly-built JFET matcher.

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