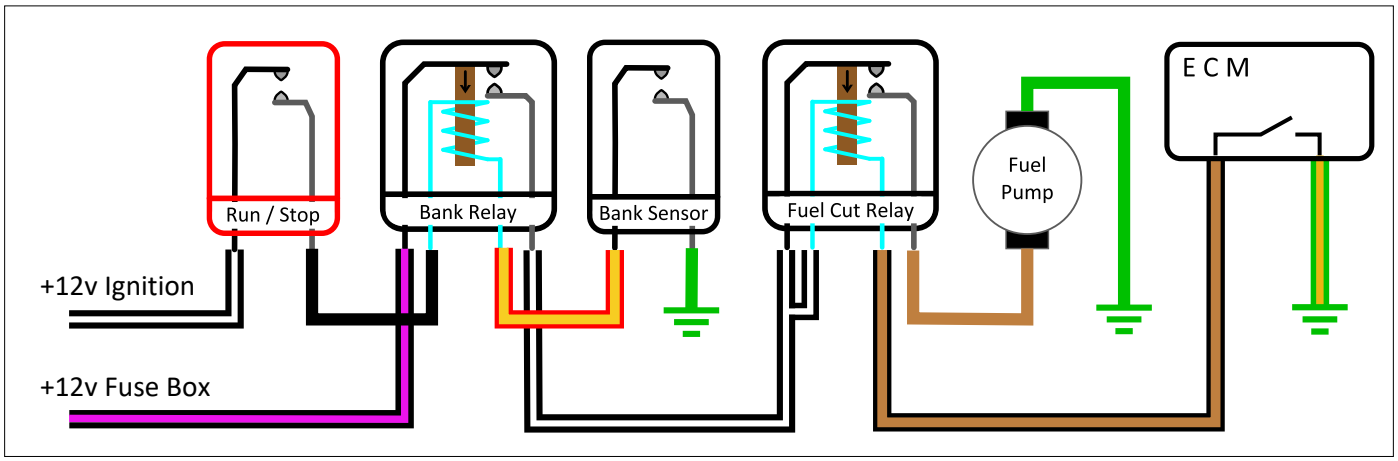
ST1300 - Fuel Pump Circuit

An Aid to Understanding

The diagram below is more of an aid to understanding, rather than an accurate circuit diagram. That is to say that one or two if the components are 'simplified' and are not 100% accurate. For example, the ECM is actually a very elaborate and expensive bit of electronics. Yet I have shown it as a simple switch - because for purposes of this explanation, it simply turns on or off part of the circuit.



The Run/Stop switch

Is correctly shown as a switch. It gets its power from a 10A fuse in the forward fuse box which in turn is supplied by power from the ignition switch which is powered from the 30A fuse in the starter relay. In case of issues, the first thing to do is to check that power is coming out of the run/stop switch. A quick way is to check the black wire of the Bank Angle Relay.

The Bank Angle Sensor

I have shown this as a simple switch because that is how it behaves as far as I am concerned. In fact it has 3 wires going to it - one of which is +12v from the ignition switch, another is a connection to earth. The third is the connection to the Bank Angle Relay. However it works, if the bike falls over, the connection through the bank angle sensor is broken.

The ECM

Is a computer. It does a lot of processing - taking a lot of different inputs and deciding what to do as a result. For the Fuel Pump Circuit above, it simply turns on or off the connection to earth of the black/brown lead from the fuel cut-off relay. Unless this connection to earth is made, the coil does not energise and the relay will not switch on.

The following are some of the other devices which affect this connection to earth in the ECM.

- HISS key present for bikes with HISS fitted (Europe and Australia)
- Clutch lever switch
- Side Stand switch
- Neutral switch

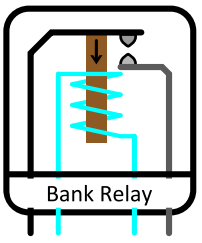
Operation of the Relay

A relay is simply a switch. It turns on an electrical circuit that is connected to the two outer Power Terminals.

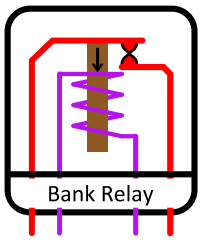
'The switch' is those two heavy duty contacts that you can see at the top of the diagram. The relays used in the fuel pump circuit on the ST1300 will switch on and off 20 Amps. (That's roughly 4 headlights).

The relay is activated by putting 12v onto one of the blue Coil leads, and connecting the other Coil lead to ground or to the negative post of the battery.

Some relays are activated as soon as the ignition key is turned, and they stay on until the key is removed. Others work momentarily - like a powerful horn button. The button activates the coil, the relay contacts connect and turn on the horn. As soon as the button is released, they contacts spring open and turn off the horn.



Relay switched off

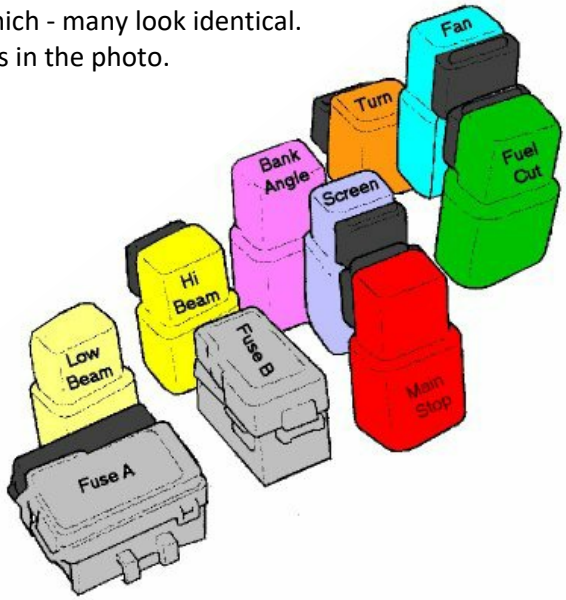


Relay switched on

More About the Relays in the Fuel Pump Circuit

Info taken from a UK ST1300 A9

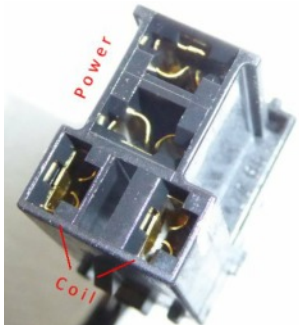
The bank or relays and fuse boxes are behind the left hand panel - easily accessed by removing 3 pan-head screws. The coloured diagram helps to identify which relay is which - many look identical.
The Bank Angle and Fuel Cut-Off relays are marked with coloured dots in the photo.



Having found the relays, it helps to know how they are connected.
The relays simply lift off the metal tab - there is no need to take the relay out of its shroud unless you want to.

These photos should help to identify the pins / sockets / rear of sockets and allow them to be compared with the symbols on the circuit diagram. There is a picture of the circuit diagram labelled Power and Coil on the next page.

Original Relay and Holder
Omron Part GBHN 1A4T RJ



Front view of the relay base.

Rear view of the relay base.

Showing the relay blades which plug into the base.

Important Note About Terminals.

The relay has two pairs of terminals - a pair for the '**Coil**' and a pair for the '**Power**' to the device to be switched.

The '**Coil**' terminals requires +12v and a ground to complete the circuit. This creates a magnetic field which causes the Power Contacts to meet - switching on the '**Power**' Circuit. On the ST1300 it doesn't matter which way the pair of wires for the coil are connected.

The '**Power**' terminals require +12v and a lead to the device to be switched on. On the ST1300, it doesn't matter which way round the two wires for the '**Power**' terminals are connected.

Testing a Relay in Situ.

You can test the relay using the terminals from the rear of the relay holder. That way the relay remains plugged in and you can tell which wire is which by referring to the circuit diagram. Connect the black probe to a good earth and make sure the meter reads +12v when you touch the red probe onto the +ve battery terminal. If not, find a better earth point for the black probe.

Start with the Fuel Cut-Off relay. Check the colour of the **Power** leads on the circuit diagram. And take a reading from each.

Note that the Fuel Pump is turned on for only 1-2 seconds after the ignition is turned on Make sure you take a reading immediately after turning on the ignition.

If both **Power** terminals show +12v, then the Fuel Cut-Off relay is switched on correctly so the relay has turned on correctly.

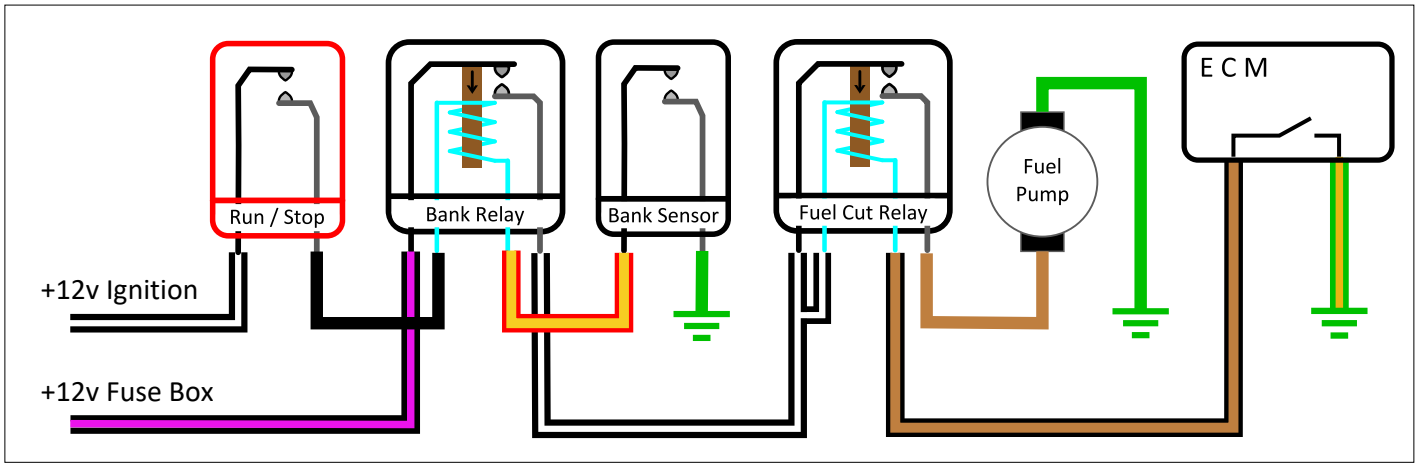
If both show 0 volts, then it is likely that the fault is before this relay - it is not getting power coming into it.

If one shows +12v and the other shows 0 volts, then the relay isn't turning on - so check the pair of **Coil** terminals. One should read 12v, one should read 0 volts. If they both show 12v, then the connection to earth is at fault. If they both show 0 volts, then the fault is in the 12v feed to the coil. It could be a switch, a wire, a fuse or another device - even another relay).

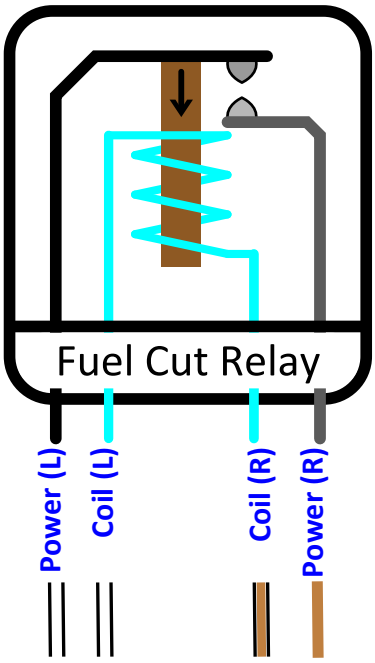
How the Relay is Wired

Comparison with the Circuit Diagram

Here is the circuit diagram from the first page, showing all of the components.



The Fuel Cut Off Relay - Circuit Diagram and the Real Thing



In my explanations that follow, I have used the terms '**Power**' and '**Coil**' to represent the two pairs of connectors. I use (L) and (R) to make clear to which terminal on the circuit diagram I am referring. So Power (L) refers to the left most pin of the relay. Coil (R) relates to the right hand coil connection.
See the Diagram on the left.

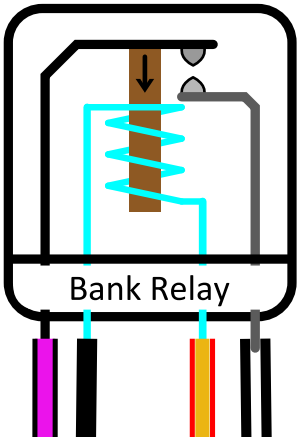
For the actual relay, no distinction between (L) and (R) is necessary. As long as the two **Power** wires are inserted in the top of the holder (the brown wire and the black/white wire) in the photo on the right, and the two **Coil** wires are inserted at the bottom (the brown/black wire and the other black /white wire), that is all that matters.

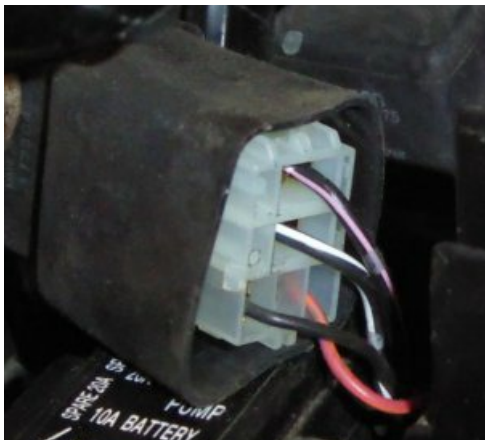
Some relays do care about the polarity of the pair of Coil wires, but those used in the ST1300 do not care. If the relays are replaced with ones that use diodes to protect the contacts you could run into trouble unless you first check the polarity of the wires going into the holder. (eg the photos on this page show the +ve wire going into the right hand terminal on one relay and the left on the other !)

The Bank Angle Relay and a photo of the rear of the relay holder from my ST1300A9.

Note that the **Power** pair of leads - the outer connections on the circuit diagram - are inserted in the top of the white fuse holder in the photo - the black / purple and the black / white leads.

The **Coil** leads - black and red/orange - are shown inserted into the bottom terminals in the photos.





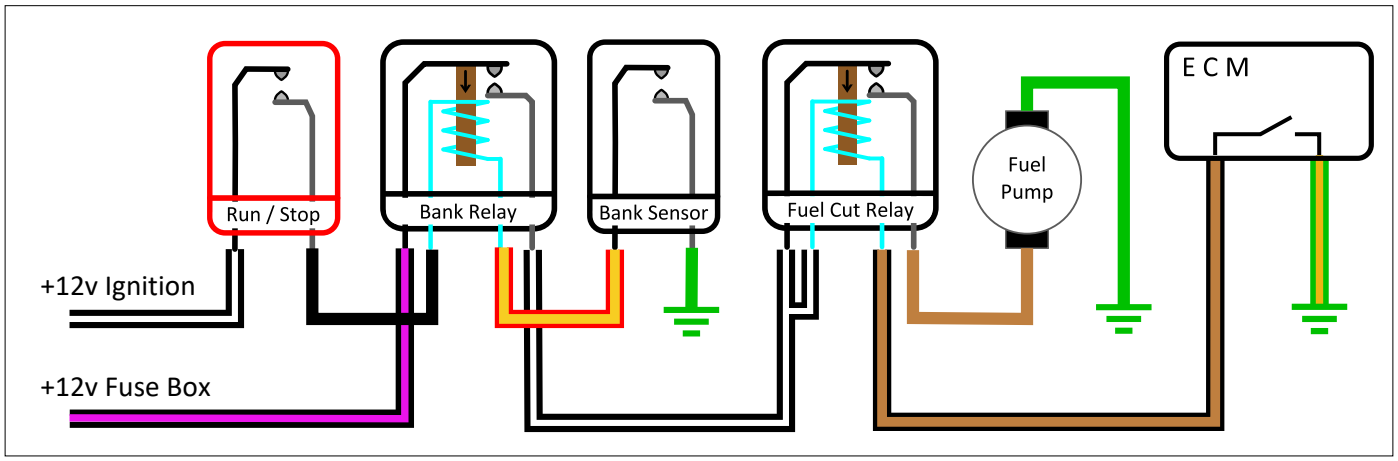
The Bank Angle Relay showing the rear connections.

Compare the leads in the photo to the leads on the diagram (far left).

The red/orange and the black wires are for the coil.

The purple/black and black/white leads are the Power leads which are switched by the relay.

The Fuel Pump Circuit Diagram

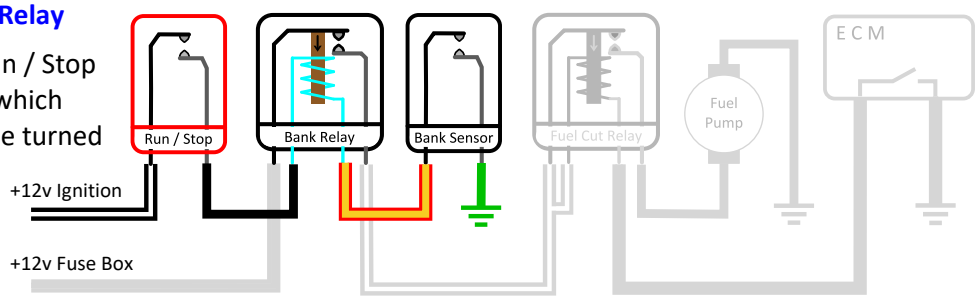


A quick overview.

The Fuel Pump circuit is about as complicated as they get. Here is a version extracted and redrawn from the circuit diagram. But it consists only of three simple circuits which anyone who has ever wired together a battery a bulb and a switch would be able to understand. The pictures and text below explains each separate circuit. The earth / ground symbol is where the circuit is connected to the -ve battery terminal - sometimes via the bike#s frame.

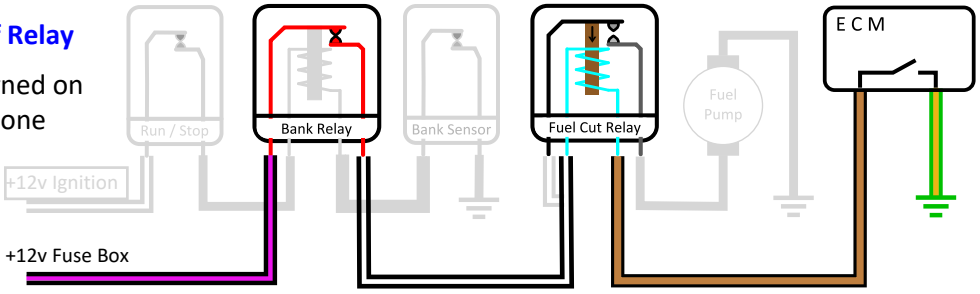
Circuit 1 - Turn on the Bank Angle Relay

A circuit with two switches: the Run / Stop switch and the Bank Angle Sensor which behaves like a switch. Both must be turned on in order to activate the coil in the Bank Angle Relay. When the coil is activated, the two contacts in the relay are forced together by the magnetic field that the coil creates.



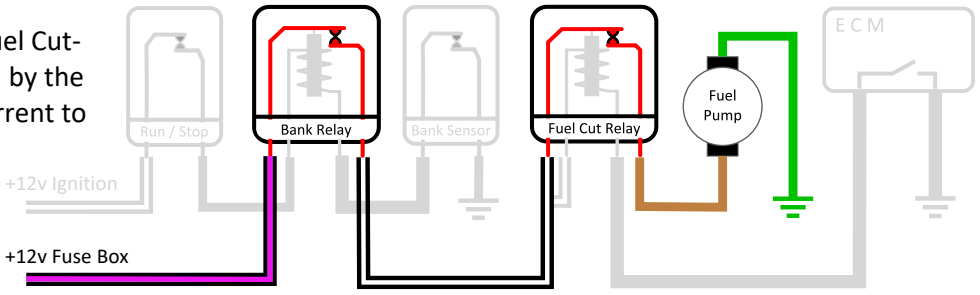
Circuit 2 - Turn on the Fuel Cut-Off Relay

The Bank Angle Relay is already turned on by Circuit 1, so this is a circuit with one 'switch' in the ECM. If the ECM allows it to be turned on, then the coil in the Fuel Cut-Off relay is activated, bringing together the two contacts.



Circuit 3 - Turn on the Fuel Pump

So the Bank Angle Relay and the Fuel Cut-Off Relay have both been activated by the previous circuits and they allow current to flow. There are no other switches in the circuit - so the Fuel Pump motor springs into life.



Note that the ST1300 frequently uses a switch on the negative side of the circuit - turning off the return to the negative battery terminal. If this switch is off, probing the circuit at different points with a volt meter will often show +12v on both sides of the component being tested.

Essential Tools

Nothing Much Required.

It's quite easy to diagnose faults in electrical circuits. All you need is a multimeter, an accurate circuit diagram, a pen and paper and a plan of action.

Its the last bit that requires the most effort - working out where the problems could be from the diagram, and finding ways of working systematically from one end to the other to verify at what point in the circuit the failure takes place.

I also have a pair of probes which are connected together - a means to provide an instant jumper to (say) provide 12v to a motor, or to bridge a suspect switch - to see if that eliminates the fault.

The multimeter needs to be set on a suitable range for motorbike electrics - DC voltage set to 20 (I have a choice of 2, 20, 200, 1000).

First thing to do is to check that you get a reading. Put the red probe on the +ve battery terminal, the black on the -ve. Make sure you get a reading of around 12v. It won't be exactly 12v though, but close enough.

Then do the same, but put the black probe on a suitable ground point. Somewhere on the frame, near to the bank of relays that you are going to be testing. Find somewhere that gives you almost the same reading that you got from the battery. If you can't find anywhere, then you have solved part of your problem Your connection from the battery to the frame needs cleaning up !

For most of the tests that I describe for the Fuel Pump Relay circuit, the object is to find out what voltage is present at a particular terminal. For this you need your black probe firmly connected to an earth point. Clamp it in place so that you have a free hand. You will then be putting the red probe into terminals that are visible from the rear of the relay holder, and noting the voltage. A probe like the ones in the photo will slip quite happily between the brass terminal and the plastic holder and stay in place.

Noting things down becomes important as by the end you will have quite a few readings. Keep referring back to the circuit diagram or your notes helps as well to make sure that you don't miss anything. There is nothing worse than starting at one end, getting to the other and not having found anything wrong because you mis-remembered a reading - or worse - jumping to the wrong conclusion about what you have just found. Do either of those and there is nothing else for it but to start again from scratch.

No - when taking the readings, don't think - just do it and note what you find. Then puzzle over your findings afterwards.

One final thought about testing voltage. If you are testing a relay coil there are two **Coil** terminals to probe.

The one going into the coil should have 12v on it.
The one leaving the coil should have 0 volts on it - because it is connected to earth / ground.

Sometimes, the one leaving the coil may be observed to have 12v on it. This will likely be due to the connection to whatever comes next (usually earth) has been disconnected, broke, corroded, etc. or the ECM may have turned it off; or the bank angle sensor may be tilted - both of these switch off the connection to ground.) You see 12 volts because the meter is reading the 12v going through the coil from the other terminal.

If the coil doesn't have a complete circuit, then the relay cannot switch the power circuit on the '**Power**' terminals.

It is not wise to go probing anything on the ECM / ECU particulary resistance. Testing for resistance puts a voltage through whatever you are testing, and some electronic components go pop if a voltage is applied the wrong way. Honda actually warn of this on instructions for their heated handlebar grips.

The Problems

Rather than bore you with explanations for every eventuality, I thought that a few worked examples would be of more use, so the following pages show 5 different problems.

Or that should be - 5 variations of the same problem - ie the Fuel Pump does not work.

For each, I have noted the reading on the voltmeter and presented them in a table with an indication of what the reading should be. I've also indicated whether this differs from what the reading should be.

Underneath, I have reproduced the components and coloured the wires where the reading is as expected. Purple for wires which trigger the relays, red for the main switched power. Where there is no power, the wire is shown as a pair of parallel lines.

Then a reproduction of the same circuit diagram that you have seen already, showing the cable colours.

There are two versions of this PDF file - one which has the answers at the bottom of the page, one that leaves a blank at the bottom of the page and puts the answers together on the back page.

Finally - an important point which I have mentioned before but you may have missed it. When testing the voltage on the brown lead and the brown / black lead, I have shown the values when the fuel pump would normally be turned on. However, the fuel pump turns on only when it is needed, and is turned off when it is not. So when the bike is sitting in the garage, the fuel pump is turned off. It comes on for a period of 1 or 2 seconds immediately after the ignition has been turned on, and then it turns off again - under control of the ECM.

You have to take the reading in those one or two seconds.

Problem 1

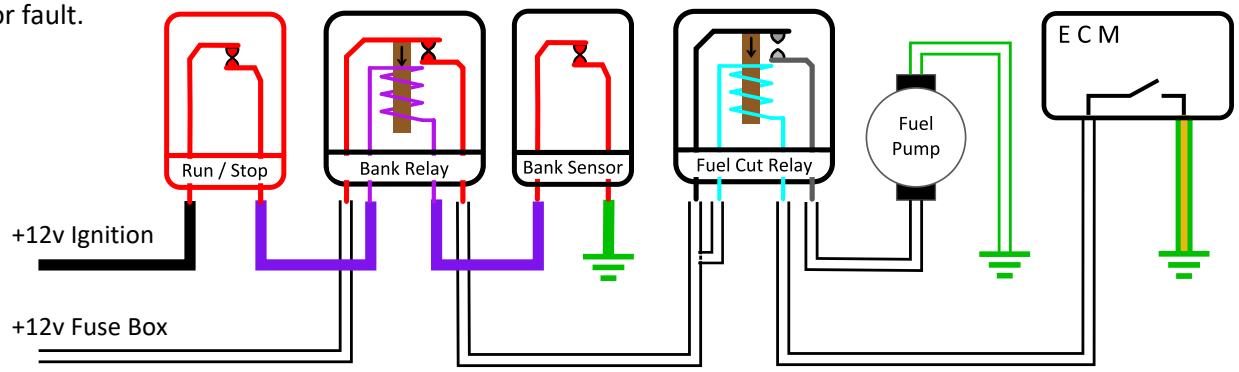
Symptom: Fuel pump does not spin when ignition is turned on.

Results of Probe Tests with a Voltmeter (Immediately after turning on ignition for Fuel Cut Off Relay)

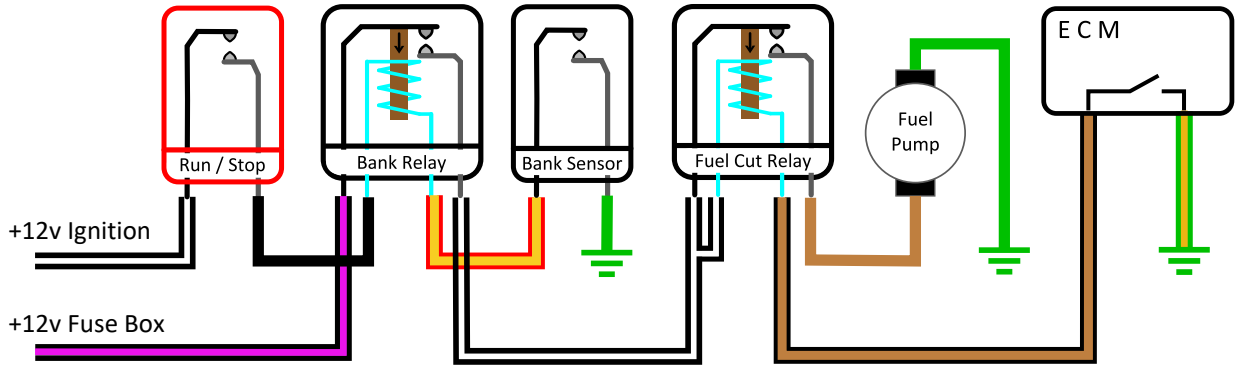
	Terminal	Wire	Result	Comment	
	Fuel Pump +ve	Brown	0 volts	Should be +12v	Fault
Fuel Cut Off Relay:					
	Power (L)	Black/White	0 v	Should be 12v	Fault
	Coil (L)	Black/White	0 v	Should be 12v	Fault
	Coil (R)	Black/Brown	0 v	Should be ~0. It goes to earth via ECM	
	Power (R)	Brown	0 v	Should be 12v when ign first turned on	Fault
Bank Angle Relay:					
	Power (L)	Black/Purple	0 v	Should be 12v	Fault
	Coil (L)	Black	12 v	Should be 12v	
	Coil (R)	Red/Orange	~0 v	0v - earthed via Bank Angle Sensor.	
	Power (R)	Black/White	0 v	Should be 12v	Fault

This circuit diagram shows whether or not the wire is conducting properly

- Solid Red for a live main cable
- Solid Purple for a live trigger cable
- Hollow for fault.



Circuit diagram showing the actual wire colours for reference



Suggested Answer: Problem 1

There is no power to the fuel pump brown lead. Nor is there voltage on the Fuel Cut-Off relay Power (R) Brown wire to the pump.

There is no power going into the Fuel Cut-Off relay on the Power (L) terminal with the Black/White wire.
This is because there is no power going out of the Power (R) terminal on the Bank Angle Relay via the Black/White wire.
There is no power coming in to the Bank Angle Relay on the Power (L) terminal - Black/Purple wire.

So although the Bank Angle Relay has been triggered, there is no power for the relay to switch on.

Check the fuse box and the Black/Purple wire - power comes from the '20A FI, Coil, Pump' fuse - which is fed from the 65A fuse on top of the battery.

Problem 2

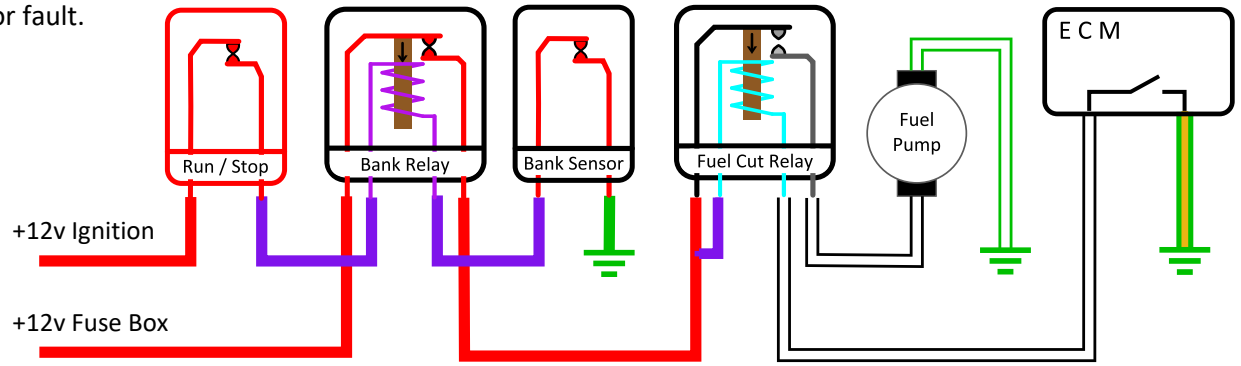
Symptom: Fuel pump does not spin when ignition is turned on.

Results of Probe Tests with a Voltmeter (Immediately after turning on ignition for Fuel Cut Off Relay)

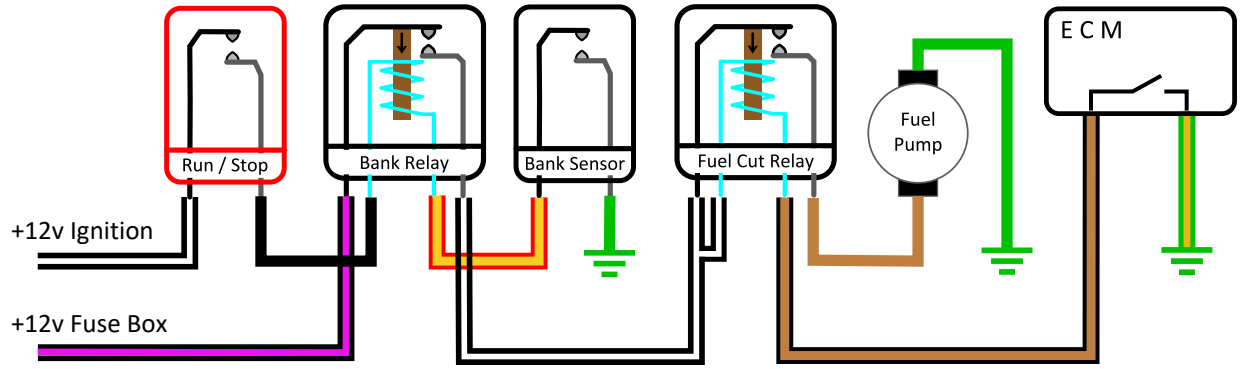
	Terminal	Wire	Result	Comment	
	Fuel Pump +ve	Brown	0 volts	Should be +12v	**Fault**
Fuel Cut Off Relay:					
	Power (L)	Black/White	12 v	Should be 12v	
	Coil (L)	Black/White	12 v	Should be 12v	
	Coil (R)	Black/Brown	12 v	Should be ~0. It goes to earth via ECM	**Fault**
	Power (R)	Brown	0 v	Should be 12v when ign first turned on	**Fault**
Bank Angle Relay:					
	Power (L)	Black/Purple	12 v	Should be 12v	
	Coil (L)	Black	12 v	Should be 12v	
	Coil (R)	Red/Orange	~0 v	OK - earthed via Bank Angle Sensor.	
	Power (R)	Black/White	12 v	Should be 12v	

This circuit diagram shows whether or not the wire is conducting properly

- Solid Red for a live main cable
- Solid Purple for a live trigger cable
- Hollow for fault.



Circuit diagram showing the actual wire colours for reference



Suggested Answer - Problem 2 - Faulty relay OR sensors attached to the ECM are preventing operation.

The fault can be identified at the fuel cut-off relay. Power is reaching the Power (L) Black/White wire, but it isn't passing it on to the Power (R) terminal, Brown wire. This is because the coil isn't triggering the relay to turn on.

The clue is that both of the coil terminals show +12v, which means that the circuit is 'broken' after the coil. If it was connected to earth (as it should be) then the Brown/Black lead would read 0v (or a very low voltage). The ECM has not permitted this circuit to continue to the ground connection. **But check this again during the first 2 seconds after turning on the ignition. The ECM turns it off after this.**

You can check this: If the Brown / Black wire on the Fuel Cut Relay Coil (R) terminal was briefly connected to earth, then that should energise the coil, the relay will click and the fuel pump will whirr into life. In which case there is nothing wrong with the circuit. The problem lies with other switches and sensors which feed into the ECM.

So start by checking the HISS system if fitted (perhaps no valid key), and then combinations of clutch lever switch, neutral switch, side stand switch. Or the relay could be faulty. The same relay is used in a number of places - check and do a switch to see if that fixes it.

Problem 3

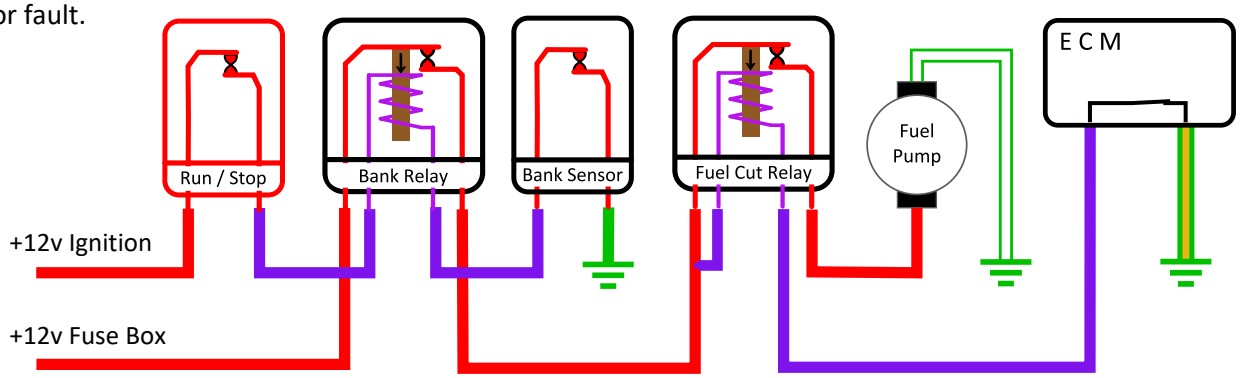
Symptom: Everything seems to check out, but fuel pump does not turn.

Results of Probe Tests with a Voltmeter (Immediately after turning on ignition for Fuel Cut Off Relay)

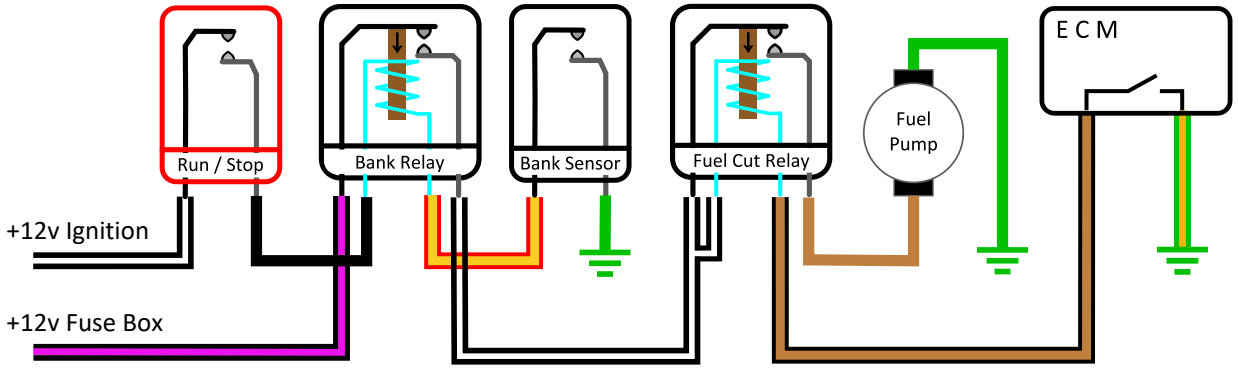
	Terminal	Wire	Result	Comment	
	Fuel Pump +ve	Brown	0 volts	Should be +12v	**Fault**
Fuel Cut Off Relay:					
	Power (L)	Black/White	12 v	Should be 12v	
	Coil (L)	Black/White	12 v	Should be 12v	
	Coil (R)	Black/Brown	0 v	Should be ~0. It goes to earth via ECM	
	Power (R)	Brown	12 v	Should be 12v when ign first turned on	
Bank Angle Relay:					
	Power (L)	Black/Purple	12 v	Should be 12v	
	Coil (L)	Black	12 v	Should be 12v	
	Coil (R)	Red/Orange	~0 v	Should be 0v - earthed via Bank Sensor	
	Power (R)	Black/White	12 v	Should be 12v	

This circuit diagram shows whether or not the wire is conducting properly

- Solid Red for a live main cable
- Solid Purple for a live trigger cable
- Hollow for fault.



Circuit diagram showing the actual wire colours for reference



Suggested Answer to Problem 3 - faulty ground, / negative battery connection

Apart from the fact that the fuel pump motor is not turning, everything is as it should be. For both trigger coils, one side is showing 12v, the other shows 0 or nearly 0, and power is getting through to the Fuel Pump brown lead.

We know that the ECM has turned on the route to earth, because the voltage on the Fuel Cut Off relay Power (R) terminal - brown/black wire is close to zero, rather than 12v. (**Checked within the first 2 seconds of turning on the ignition**)

The only thing that remains is the connection of the motor to earth. We tend to assume that this is OK, but it may be a corroded earth terminal. You could test this by bridging from the pump motor earth terminal to the -ve battery post. It will be a decent current, so you need a thick cable. Faulty earths can sometime carry low currents (eg when testing with an ohmeter), but they will fail when a larger current is required eg the fuel pump motor.

Problem 4

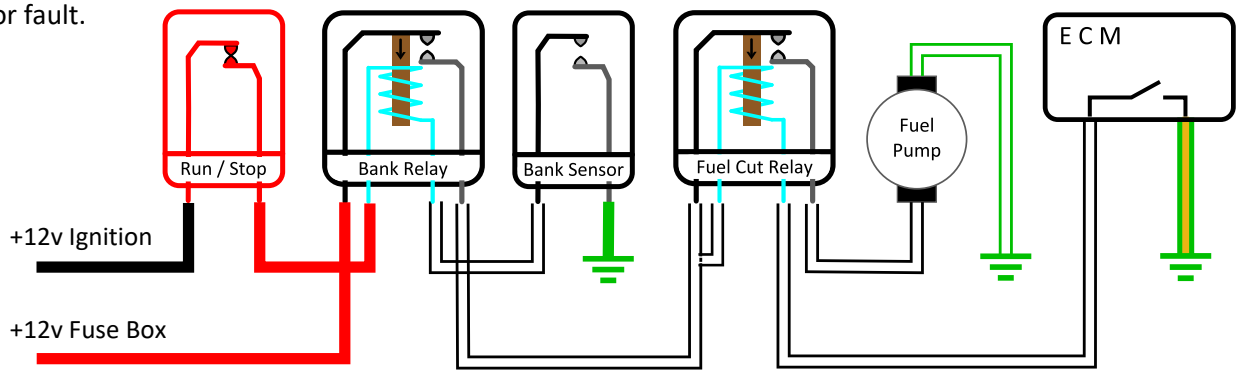
Symptom: Fuel Pump won't work, Fuel Cut Off Relay has no power.

Results of Probe Tests with a Voltmeter (Immediately after turning on ignition for Fuel Cut Off Relay)

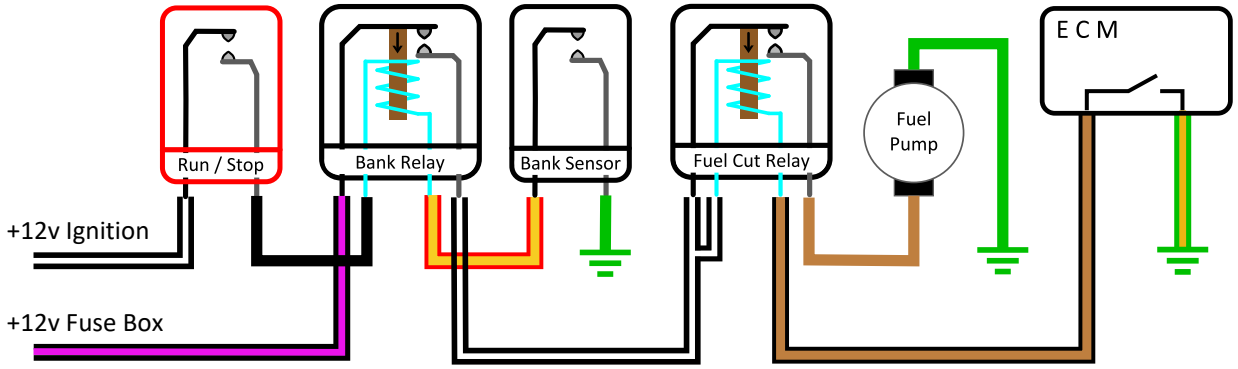
	Terminal	Wire	Result	Comment	
	Fuel Pump +ve	Brown	0 volts	Should be +12v	Fault
Fuel Cut Off Relay:					
	Power (L)	Black/White	0v	Should be 12v	Fault
	Coil (L)	Black/White	0 v	Should be 12v	Fault
	Coil (R)	Black/Brown	0 v	Should be ~0. It goes to earth via ECM	
	Power (R)	Brown	0 v	Should be 12v when ign first turned on	Fault
Bank Angle Relay:					
	Power (L)	Black/Purple	12 v	Should be 12v	
	Coil (L)	Black	12 v	Should be 12v	
	Coil (R)	Red/Orange	12 v	Should be 0v - earthed via Bank Sensor	Fault
	Power (R)	Black/White	0 v	Should be 12v	Fault

This circuit diagram shows whether or not the wire is conducting properly

- Solid Red for a live main cable
- Solid Purple for a live trigger cable
- Hollow for fault.



Circuit diagram showing the actual wire colours for reference



Suggested Answer to Problem 4 - There is an issue with the Bank Angle Sensor.

The fuel cut-off relay is dead on all 4 pins, so move on to what supplies its power - the Bank Angle Relay (BAR)

The BAR is getting 12v on the Power (L) Purple/Black wire. It is also getting 12v from the Run/Stop switch on the Black Coil (L) wire.

However, The BAR Coil (R) wire - Orange/Red is showing 12v. This should be connected to earth (earth via the Bank Angle Sensor) so it should be zero. If this is the fault, then connecting BAR Coil (R) Orange/Red to earth momentarily should cause the Bank Angle Relay to click on. If the temporary connection is in place when the ignition is turned on, the pump motor should whirr for a couple of seconds. (Assuming the motor earth is OK, which it may not be).

In which case, the Bank Angle Sensor is not behaving as it should, and not allowing a route to earth - so it could be corroded wires, faulty sensor, corroded or dislodged connector or the sensor itself has become tilted, giving the impression that the bike has fallen over.

Problem 5

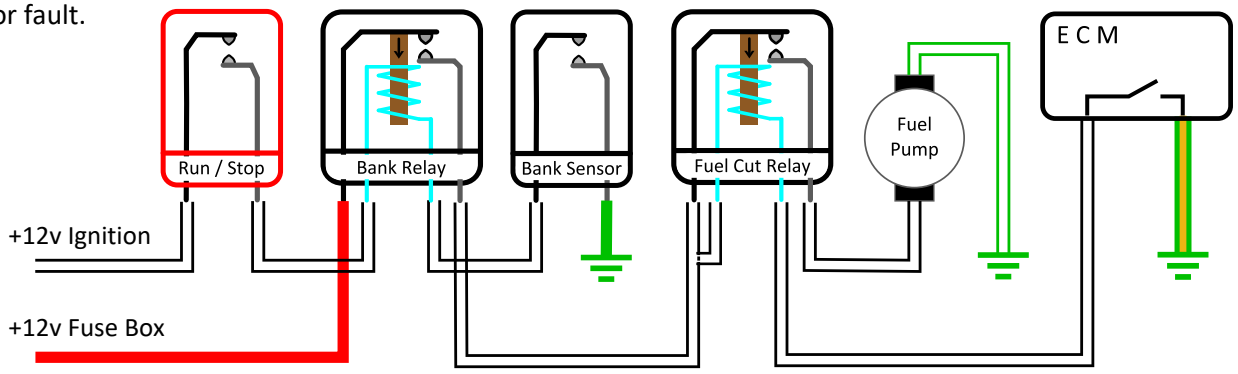
Symptom: Fuel Pump won't work, Everything seems to be dead.

Results of Probe Tests with a Voltmeter (Immediately after turning on ignition for Fuel Cut Off Relay)

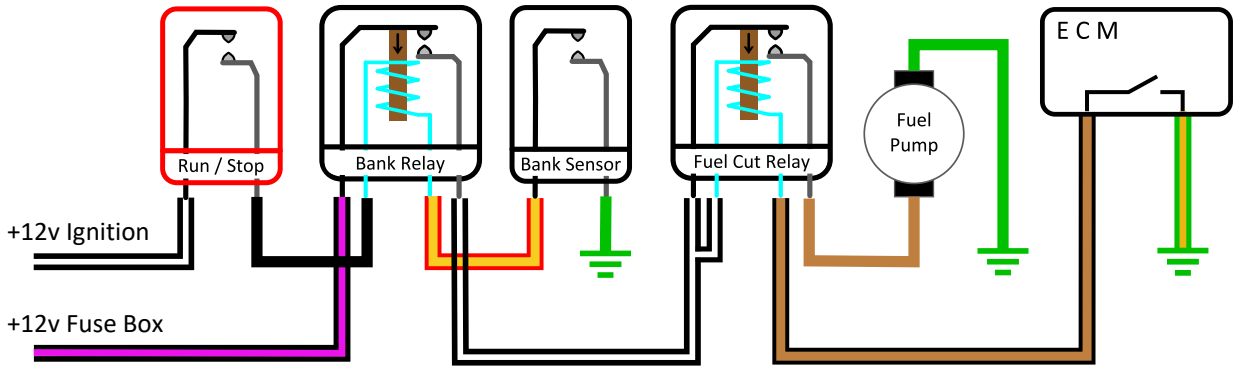
	Terminal	Wire	Result	Comment	
	Fuel Pump +ve	Brown	0 volts	Should be +12v	Fault
Fuel Cut Off Relay:					
	Power (L)	Black/White	0v	Should be 12v	Fault
	Coil (L)	Black/White	0 v	Should be 12v	Fault
	Coil (R)	Black/Brown	0 v	Should be ~0. It goes to earth via ECM	
	Power (R)	Brown	0 v	Should be 12v when ign first turned on	Fault
Bank Angle Relay:					
	Power (L)	Black/Purple	12 v	Should be 12v	
	Coil (L)	Black	0 v	Should be 12v	Fault
	Coil (R)	Red/Orange	0 v	Should be 0v - earthed via Bank Sensor	
	Power (R)	Black/White	0 v	Should be 12v	Fault

This circuit diagram shows whether or not the wire is conducting properly

- Solid Red for a live main cable
- Solid Purple for a live trigger cable
- Hollow for fault.



Circuit diagram showing the actual wire colours for reference



Suggested Answer to Problem 5 : Turn on the Run/Stop Switch - Check the fuses and ignition circuits.

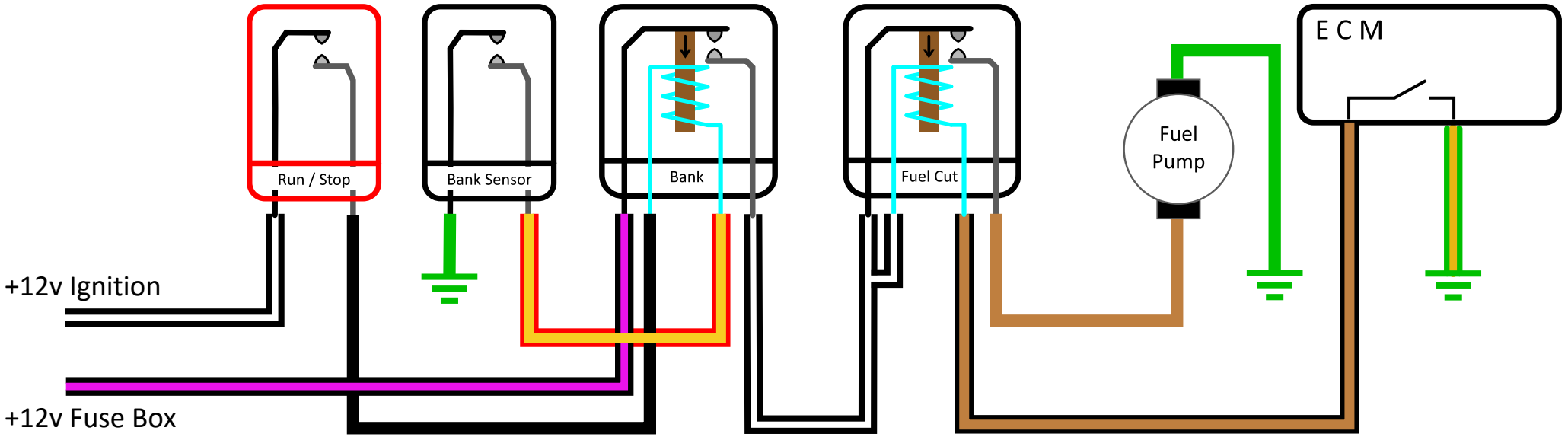
Well, the only thing getting power in this diagram is the Power (L) terminal Purple/Black wire on the Bank Angle Relay.

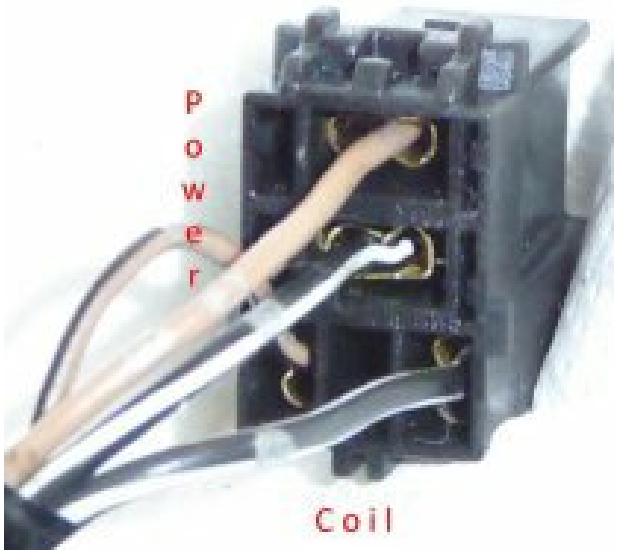
Nothing is coming in to the Coil (L) black wire on the Bank Angle Relay. Hmm. Someone has flicked the red switch !! Easily done.

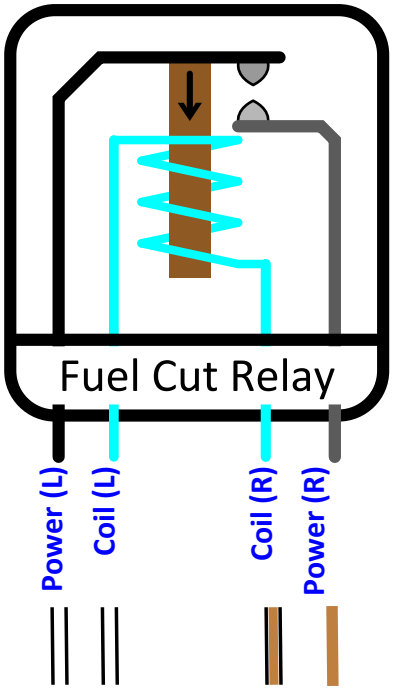
But suppose the switch was in the 'on' position, and no power was reaching that switch ?

Well it is fed from the forward fuse box - 10A fuse labelled 'Start / Eng Stop' **Fault**
That is fed from the ignition switch by turning the key to the run position (not 'acc')
That is fed from the 30A fuse built into the starter motor solenoid to the rear of the battery.

And if that doesn't reveal anything, check that the switch isn't faulty.







Garage Crib Sheet

jfheath for ST-Owners.com