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Welcome to the documentation that accompanies the third in a series of Podcasts done for the members of www.mycockpit.org in association with FSBreak, Vybhav and me

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These Podcasts are designed to help new builders or those who want to simply expand their experience from what they have now. I apologise in advance to more experienced builders if I have simplified the explanations somewhat, but that was my intention. We all started somewhere and I thank you for your understanding.

In this Episode, we are going to be covering simple electronics. That is using simple circuits to switch something on and off or start and stop something. All references in this discussion, will be about low voltage D.C. (direct current). Direct Current is two potentials, a Positive and a Negative (or Gnd). Unlike A.C. (alternating current) where the two poles cycle between the two potentials, The two D.C. potentials remain constant as the Positive and Negative.

Quick 'Rule of Thumb', in D.C. the current will flow from Positive to Ground. Some components like LED's are 'Pole Sensitive'. That means that they have to be connected the right way round or they will not work.

So, the first question is where do we get our Power from?. Well below is a picture of your new 'best friend'. This is an ATX Computer Power Supply. They are Regulated, Stable and have built in Overload and Short Circuit protection. And the best bit is they are cheap :o))



Here's a link to the Wikipedia Page about Power Supplies

[http://en.wikipedia.org/wiki/Power_supply_unit_\(computer\)](http://en.wikipedia.org/wiki/Power_supply_unit_(computer))

This type of Power Supply is going to give you 3.3v, 5v and 12v. Look at the Multipin Plug in the image. Colour Coding is as follows.....

ORANGE is 3.3v

RED is 5v

YELLOW is 12v

BLACKS are Ground

GREEN is the Switch.

To turn the Power Supply On and Off, simply connect the GREEN wire to any Black and the unit starts. Break the connection and the unit stops. Or if your PSU has an ON/OFF switch like the one in the diagram, then simply solder the GREEN and a Black wire together and use that.

By combining any of the Coloured wires (our Positive) with any of the Black wires, we now have a D.C. Voltage Supply of 3.3, 5 or 12volt.

Definition: **CONTINUITY** What this means is that we have a continuous circuit all the way between two points. That can be from the power supply to your LED or motor thru several components like a switch, a diode, a resistor etc. or simply across a component.

OK, we have our power source, but what are we going to do with it? Well let's look at some simple components first and then we'll bring them all together to make some simple circuits.

SWITCHES

Right, a switch is a simple component that is going to make or break the continuity. Simply put, it is going to turn something on or off.

There are several types of switches. Toggle Switches, Push To Make, Push to Break, Rotary etc.

SPST

 **SPST**... Single Pole Single Throw. A Simple On/Off Switch that has two contacts to simply make and break the continuity.



SPDT

SPDT... Single Pole Double Throw. A two position switch having 3 terminals. The centre being the common. In one position, continuity is between the A terminal and the common and in the other position, continuity is between the B terminal and the common. Can be used as either a simple On/Off by only connecting the common and one of the terminals or for directing continuity two different ways I.e lighting two different LED's or sending two different Joystick button presses to a controller card. This type of switch is also available in a 'Centre OFF' variant. So it will be a SPDT-Centre Off switch. May also be referred to as a SPDTCO. Micro switches are usually SPDT.



DPST

DPST Double Pole Single Throw. This is basically two separate SPST switches in one housing. This now allows the control of two continuity circuits with one switch. For example, one side of the switch can turn on and off the voltage to an LED and the other side can be connected to a joystick controller as a button.

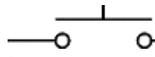


DPDT

DPDT Double Pole Double Throw. Going one step further, this switch is two SPDT switches in one case. It will have 6 terminals on the back, the centre ones being the common's. Can be used for controlling upto 4 LED's or upto 4 Joystick buttons or even two of each. These switches are also available in a Centre Off variant - DPDTCO.

MOMENTARY SWITCHES... Some Toggle switches have a momentary action. That is they do not actually click into a given position, they merely make the connection and then break it when released, returning to the central OFF position. This will normally be defined in the description as (ON). For example an SPDT momentary switch would be ON-OFF-(ON) or (ON)-OFF-(ON).

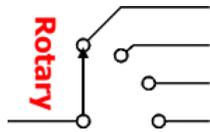
And talking of Momentary switches



PUSH TO MAKE This is a simple 'push to make' switch. When the button is pressed, there is continuity through the switch which allows current to flow. And once released, the continuity is broken causing flow to stop. Can be applied to any function requiring a simple on/off action.



PUSH TO BREAK Not as popular as Push To Make Switches, but I'm sure somebody somewhere will have a use for it. Works completely opposite to the Push To Make. When in its rest position, continuity is on across the switch. But when it's pressed the continuity is broken.



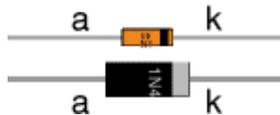
ROTARY SWITCHES The final switch type we are going to look at is a Rotary Switch. These are available in a multitude of different pole/way variations. For Example 1 pole 12 way, 2 pole 6 way, 3 pole 4 way and 4 pole 3 way. Purpose of this type of switch is to allow continuity to be steered over several connections. A good example is starter switches where the continuity can be sent to several recipients.



Here's some common types of switches (L to R) SPST Toggle, SPDT Miniature Toggle, Some Push To Make Switches and a Typical Rotary Switch. There are some weird and wonderful switch types out there. When you get a bit more experienced, go exploring. Most vendors publish a data sheet telling you about that switch. Read through it to get a handle on what it does. Using different types of switches can really expand what you can do.

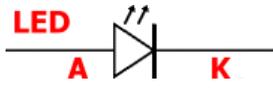


DIODES... Ok, we've all heard about diodes, but what are they? To make it easy, think of a diode as a 'one way valve' for current flow. That is your current will flow one way thru the diode, but not the other way. Remember that with D.C. current flows from the positive to GND? Diodes are therefore 'pole sensitive'. Look at the circuit symbol of the diode. The two ends of the diode are labelled A & K. The A stands for ANODE and the K stands for CATHODE. Again looking at the symbol, the current flows from the ANODE to the CATHODE. Or to put it another way, the current flows in the direction of the arrow and think of the solid line as a wall. So any current trying to flow in the reverse direction comes up against the wall and can't go any further.



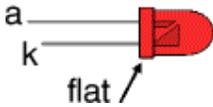
Some things to know about diodes. Because diodes are 'pole sensitive', they are usually marked at the CATHODE side as shown in the image. This then means that it becomes easy to identify the CATHODE by the banding that is printed or marked on the casing.

When using diodes, there will be a voltage drop across them of about 0.7 volts. So, if you connect the ANODE to 5vdc, you will have a voltage of 4.3vdc on the CATHODE side being delivered to your component. Just bear this in mind when driving LED's because the resistor needed to protect the LED can be a lower value (more later).

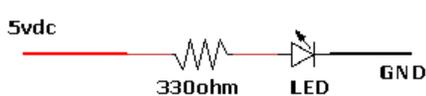


LED's... Light Emitting Diode, that's what LED stands for. As it's name suggests, it is indeed a diode that emits light. Being a type of diode, it is again 'pole sensitive'. It acts exactly the same way as a standard diode, but the current is used to produce light which it emits (notice the arrows in the circuit symbol).

So, you have to connect it the right way round or it's just not going to play ball. It's relatively easy to identify the ANODE & CATHODE on an LED. Standard type LED's will have two pins coming out of them. The longer leg is the ANODE (+) and the shorter leg is the CATHODE (GND). Most mass produced LED's will also have a flat on the CATHODE side of the casing to aid identification. Right, now we know how to hook up an LED, there are some considerations to take into account first.

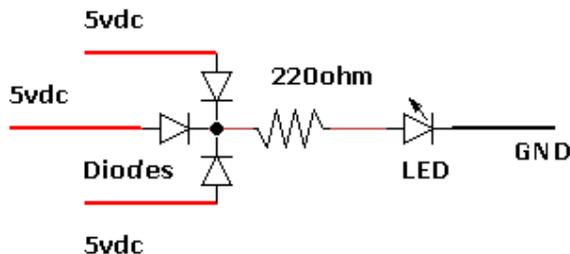


Most standard LED's that you can buy over the counter will have a forward voltage of approx. 2.2volts(depends on the colour). Connecting an LED to a higher voltage will burn out the LED. Therefore it is important to reduce the voltage to a level that the LED can be driven at. We do this by connecting a resistor in series in the positive delivery to the LED.



Unless you have a good understanding of Ohm's Law, here's a couple of examples for you. The circuit on the left has an LED and a 5vdc supply. 5vdc is going to blow the brains out of the LED, so a resistor is connected in series to protect the LED and ensure it gets the correct amount of juice. That resistor is 330ohm.

The circuit on the right is also connected to a 5vdc supply. But see there is a diode also in the line? Now remember there is a voltage drop across a diode, so that means we can reduce the value of the resistance needed to protect the LED. That resistor is only 220ohm.



Now why do we need to put a diode in the circuit I hear you ask, well we may want to light that LED from two or more sources as in the example on the left.

Some things to know about LED's.....

Not ALL LED's have a forward voltage of 2.2v. Some LED's are

available with a built in resistor that will allow you to connect directly to 5v or 12v etc. Read the data sheet or the information that the vendor gives you at point of sale to satisfy yourself exactly what the LED can safely handle.

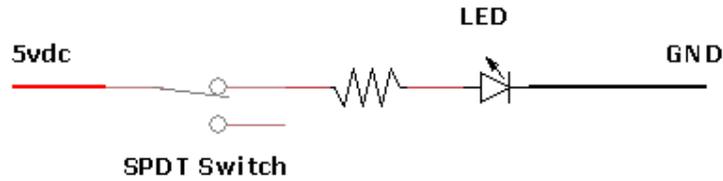
Resistors.... The above examples are intended as a 'Rule of Thumb'. By all means experiment with resistors if you feel the LED is not bright enough (more on this lower down). I have now started to use 220ohm in circuits like the one on the left and as low as 180ohm in circuits like the right one.

MCD..... Most Datasheets will give you a value of the MCD. What this means is that it is a value of the brightness of the LED at a given current. So, it follows that the higher the MCD, then the brighter the LED is going to be. An LED with a MCD value of 80@10ma is going to be brighter than an LED with an MCD of 32@ 10ma.

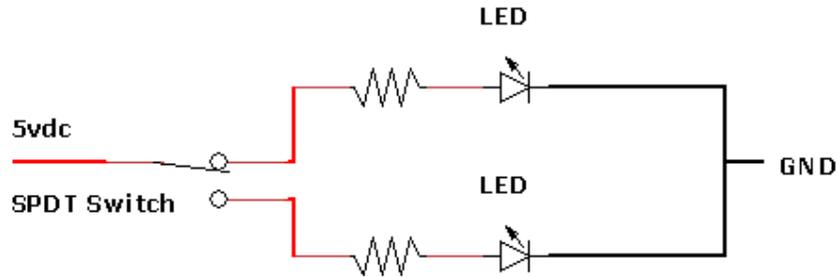


Never connect two LED's up in parallel. It's going to give you problems. Usually the lower value LED only will light. Always connect multiple LED's in series.

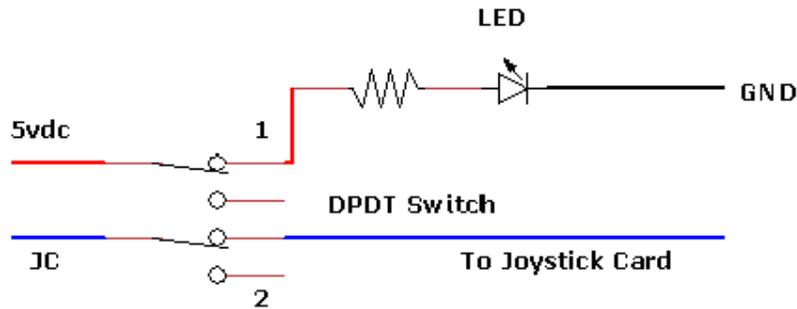
OK, here's some examples.....



Simple On/Off circuit that lights the LED when the switch is turned to the on position.



Simple circuit that lights each LED in turn when the switch position is changed. Using a 'Centre Off (SPDTCO), will isolate both LED's when the switch is in the OFF position.

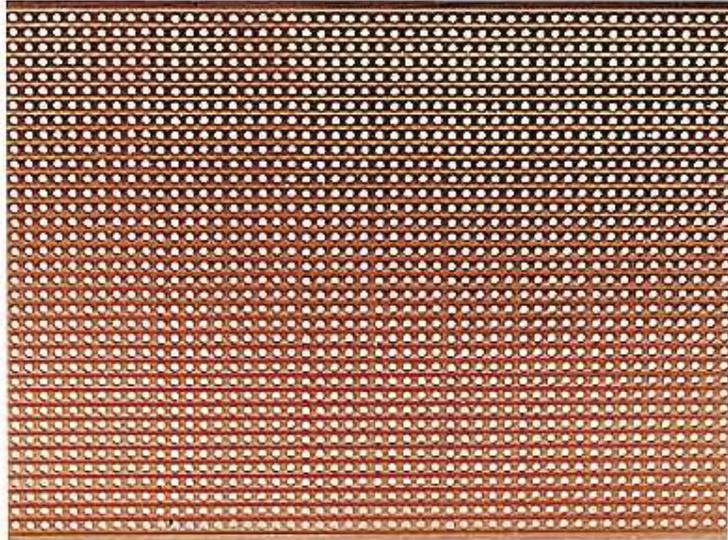


Taking it up one level, here's an example of using a DPDT switch (two separate switches in one case) to turn on an LED and also send a continuity (or button pressed) signal to a Joystick or controller card.

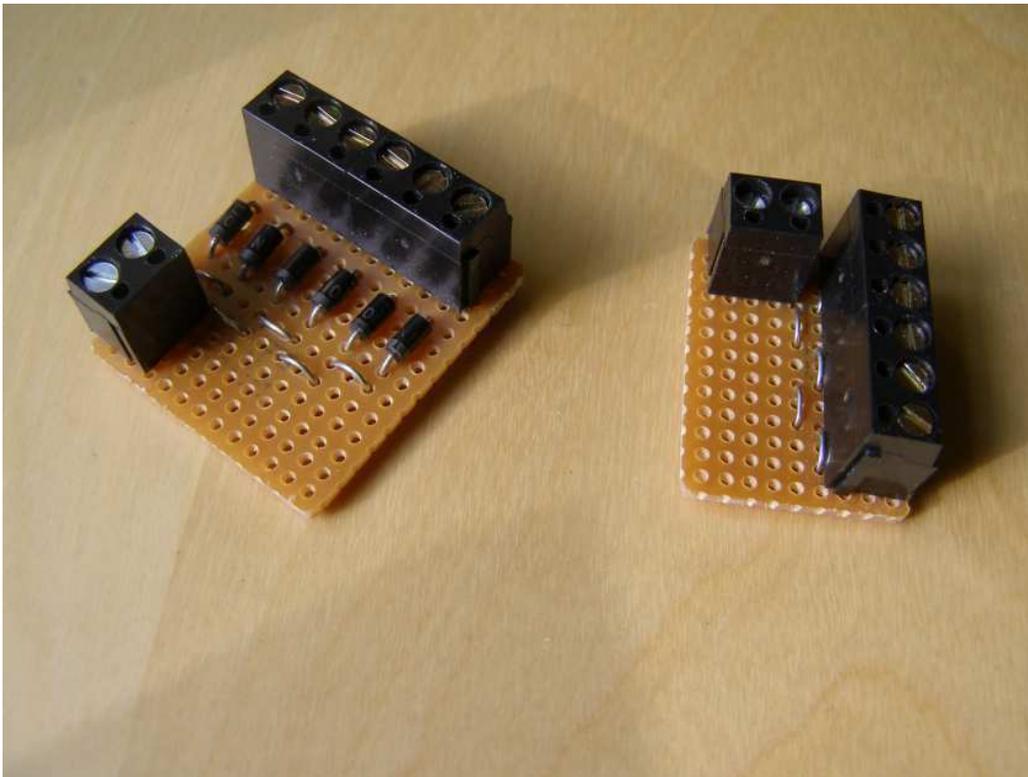


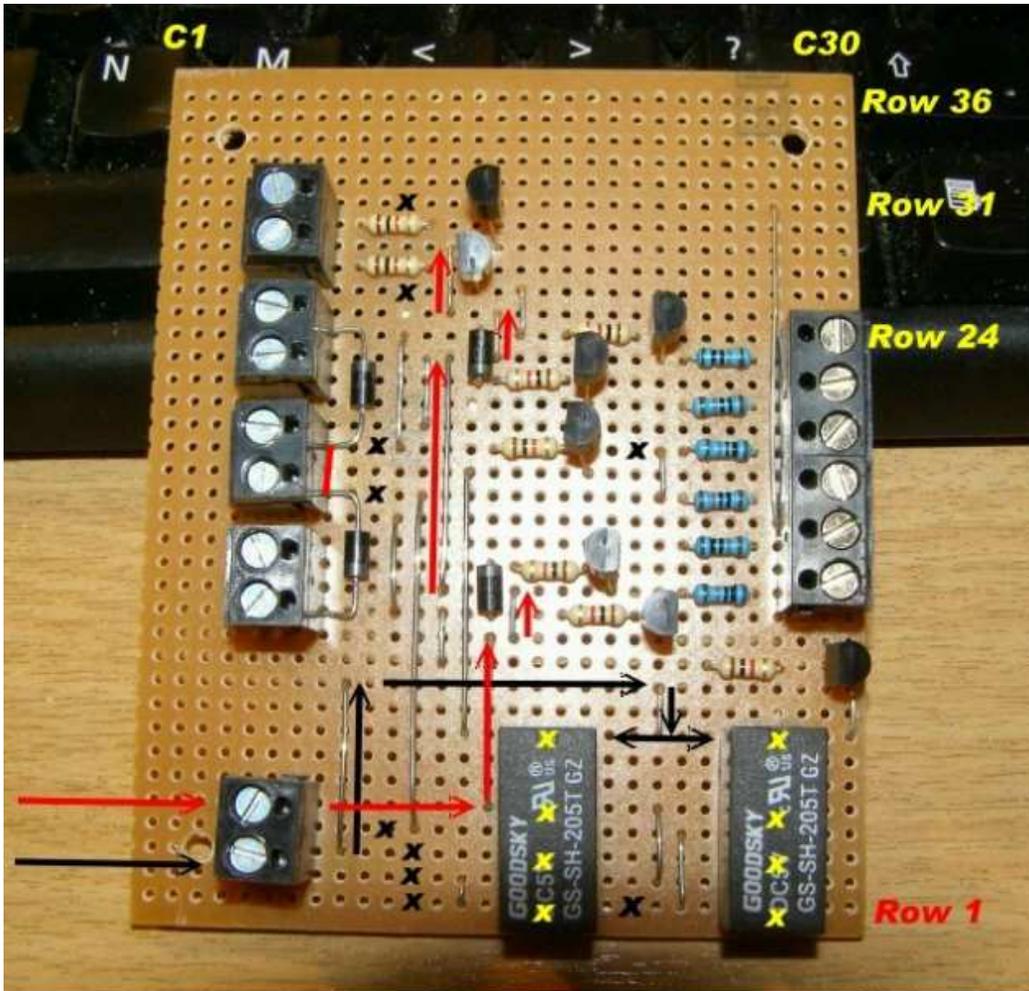
Just a quick word about **RESISTORS**..... Think of a Resistor as a current regulator. Resistors restrict the flow of electric current. So the greater the resistance, the less current flow that goes thru it. Resistors are NOT 'pole sensitive', they can be connected anyway round.

The value of the resistor is colour coded onto the body as in the above image. For more information about interpreting these codes, do a 'Google' on resistor colour codes. But generally your local electronics shop or on-line vendor will sell them in packs of a given value. 'Rule of Thumb' here. For most simple circuits, .25w resistors will be fine. But get some .5w ones as well just in case you want to try doing something more adventurous :o))



VERO BOARD & STRIPBOARD..... I love it. Let's you build your own circuits onto a solid base. What this board has is a series of copper strips running down one side of it to which components can be soldered. The strips can be cut and linked together using bridging wires to form all sorts of simple or complicated circuits. The holes in the strips have a spacing of 2.54mm (or 1/10th of an inch). Most common components seem to have this dimension (or a multiple thereof) for their pin spacing. So most common components will fit straight onto this type of board. Very easy to cut to size because the board can be cracked across a line of holes and then cleaned up. Tracks can be cut where needed easily. I use a 3mm drill to break the track. Here's a couple of examples.....





Ideal for making 'breakout boards' or joystick button Matrix boards. The top image shows some Matrix Boards I made for a friend using a BU0836 standard board which required diodes for the permanently on switches (R) and one for the momentary on switches (L) which did not require diodes.

The second and third images are more complicated circuits. But I showed them just to give you an idea what can be done. The middle one is the prototype I made to handle the Eng Gen Off Bus, Source Off & Transfer Bus Off Logic before I started using PIC's. The bottom circuit is my original APU control board using 555 timer chips to light the proper annunciators and then make the APU available after a given time.



Potentiometers.... Ok, above are two examples of everyday, easily available Potentiometers. The one on the left is a rotary and the one on the right is a slider. Potentiometers are available in a huge range of different values, but for our purpose, usually 10kohm or 100kohm values are what we should be using. Pots are also referred to as being either 'Linear' or 'Logarithmic'. Again for our purpose, keep it simple, Linear is just what we need. Linear Pots change their value evenly as the shaft is rotated.

So, how does a pot work? Look at the pot on the left and you'll see it's got three solder pins. Inside the Pot is a track, usually made of carbon or a ceramic/metal mix. The two outer pins on the pot will be joined to either end of this track. The centre pin, which is connected to the shaft and rotates with it, is called the wiper. The wiper moves along the track and in doing so, changes the resistance.

For most of our purposes, a 5vdc and GND supply is connected to the 2 outer pins and a third wire is connected to the centre pin.

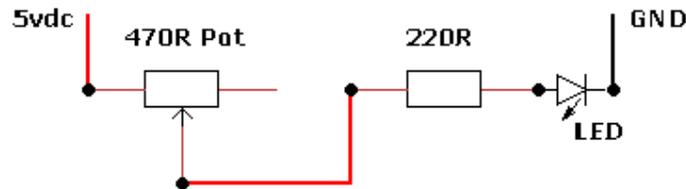
Now remembering Volts,Current,Resistance and Mr Ohm. As the Wiper moves along the track, resistance changes, so that change is reflected and read by the Wiper connection and that's how your Joystick, Controller Card and Computer knows where the position of the pot is at any given time.

Things to Know About Pots..... Always try to use Pots of the same value in a project.

Use all 10k or all 100k. That's not 'set in stone', but makes for good practise.

Ok, you connected your Pot up and it works back to front. No worries, simply swap the 5vdc and GND wires and 'way to go'.

Pots can also be used as 'dimmers' for small applications

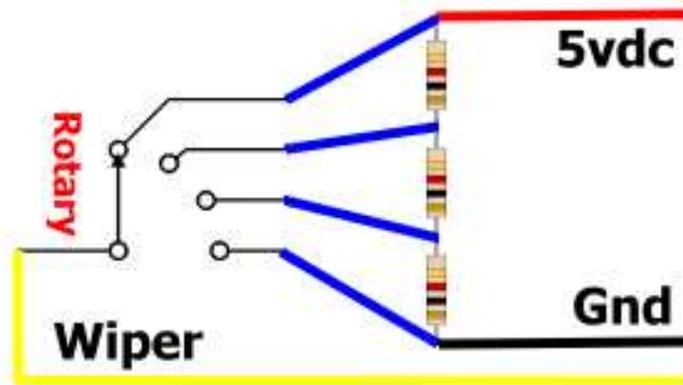


A simple Pot can also be used as a rheostat. Because of the changing resistance along the track, it then becomes possible to control the current flowing to a device. By simply connecting your 5vdc supply to one of the outer pins of the pot and the wiper, you get to control the amount of current available to your LED (for example). In the above diagram, when the Pot is at one end of it's travel 470Ohm resistance is applied (plus the 220Ohm at the resistor, total 690Ohm). The LED will not light. But move the wiper to the other extreme and no resistance is applied across the Pot and only the protection resistor is applying control. The LED will light. Now rotate the Pot slowly in the opposite direction and watch what happens :o))

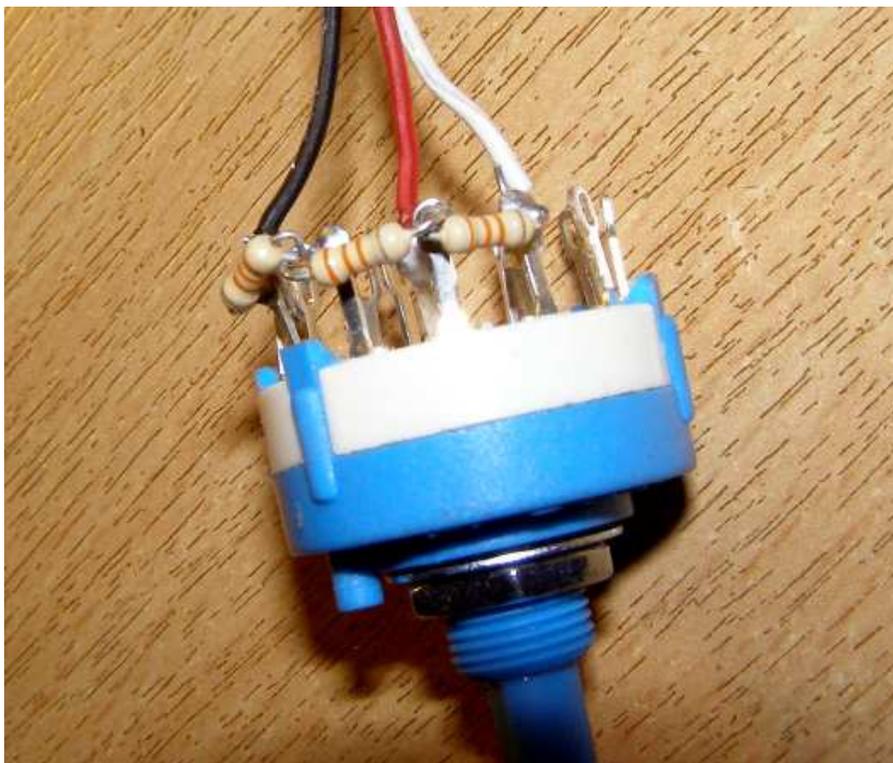
I use this technique for the Zone Temp LED's on my Overhead.

Laddering Resistors

Here's a technique I learned from a colleague (quite a few years ago). Ok, so we know a potentiometer is a 'variable resistance' which changes as we rotate the pot. For example and to make it simple, a 100kohm pot changes it's resistance from 0 to 100kohm over it's range. So it follows that at a third of the way along it's track it's resistance is 33kohm and at two thirds along the resistance is 66kohm. With me so far ? Well if we use a rotary switch and connect each pin together using 33kohm resistors as in this example, it then becomes possible to 'emulate' the resistances at any given point on it's rotation.



Using the above example, this is how it works. Let's assume we were going to use a 100kohm pot for an axis. Can be anything Brakes, Flaps etc. That would give us a 100kohm range over the pot. But by using a rotary and 3 x 33kohm resistors, the same end result is achievable. Lets say you have a 4 position flaps lever (Cessna anyone?). This is an accurate way to ensure you get UP, Flap1, Flap2 and Flap3. Then if you use FSUIPC, you can use the action functions in the Axis assignment menu to assign commands or even action one of your own macro's.



So, I hope this little discussion has given you something to chew on and hopefully got you thinking about trying to do something with a few components. It's a great feeling when you turn on a switch and something happens, especially when what you think is going to happen, actually does :o))

Once you discover simple electronics, trust me you'll want to do more. It's a real challenge learning what components do and then applying what you've learnt into practise.

Look up 555 Timer Chips and what they can do. Have a look at Logic Chips to have your circuits make decisions and it's going to lead you to PIC's. It's an amazing world, but we all have to start somewhere. Thanks for your time.

Get yourself a circuit drawing utility. All the examples in this document have been done using TINYCAD. It's free to download, has a very good library of components and I find it very good for drawing out circuits before I put the Soldering Iron to work. You can download it here: <http://tinycad.sourceforge.net/>

Need a Stripboard Image to plan your circuit? Get one here:
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