Wiring The Boeing 737NG Overhead Panel v1.2 (provisional)

Changes 12/08/06….Added Annex 1 about dual operation of LED's (some are fed from 2 sources)

Thank you for reading this document. Part of the reason for writing it is that I had to learn a lot and the notes I made helped me understand this very complex switching circuit. So by sharing this knowledge and experience, I hope to make life easier for the next colleague who undertakes a project like this.
This is a provisional file and there will be mistakes, so thank you for your understanding. Any comments, corrections or useful advice will be very favourably received.

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GENERAL DISCUSSION & OPTIONS.

I am forever being asked questions about how I am going to implement the Overhead, it's switching and control of the PMDG 737NG. So, I have decided to document my progress (and my failures) hopefully to educate, entertain and inform other builders.
My invitation goes out to anyone who can show me a better way to do it because just because I did it this way, does not mean it's the best way. So, your input (as long as it is constructive) is welcomed.
Now we all know that to control any aircraft in MSFS, we have to use either a keystroke, a Joystick Button or Axis such as for the Aileron, Elevator and Throttle etc. Or the dreaded Mouse Click.
There is of course internal codes and routines within the program or add-on aircraft itself that developers do not generally make available. That is indeed the case with the PMDG and it's Overhead Panel. This Panel is purely controlled by Mouse Clicks.
However, I have overcome this problem by utilising Luciano Napolitano's excellent Key2Mouse utility that allows me to send a keystroke thru a keyboard encoder which results in a pre-configured mouse click on the corresponding switch on my overhead panel. Result a fully operational Overhead Panel that controls and emulates the PMDG software Overhead Panel. See the article about 'Controlling Your PMDG From Hardware Switches' on the Overhead Page at www.737ng.co.uk
Now the problem arises that we have to have all the Annunciators operating in Harmony with the PMDG Panel. Here goes ……..

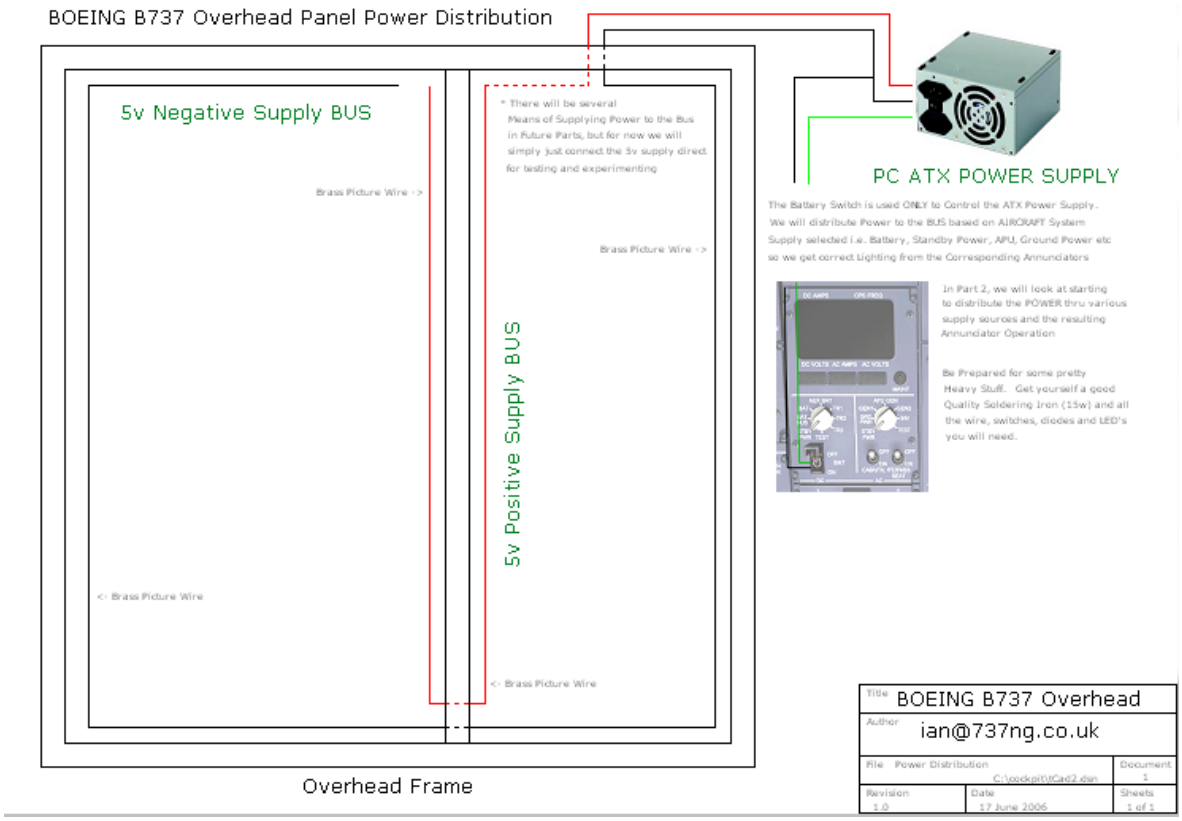
The standards that I have used in this project are
All switching is in the Positive Line.
All LED's for the Annunciators are 5vdc at 2000mcd (a measure of how much light they emit. The higher the number, the more light is emitted) with built in resistance, so no soldering separate resistor – saves time.
All switches are 'Break Before Make' but that's to do with the Keyboard Encoder and not the illumination (the action of the switch changing from one set of contacts to the other can be so fast that the keyboard encoder can miss the switching action).

Then the question arises of 'How Complex and Realistic Do I Want To Make it?'
Obviously we are all looking for the simple, cost effective and most realistic way to get it 100%. However unless you spend Mega Bucks or buy a real 737NG, that is like the quest for the Holy Grail. What you have to do is be realistic about your expectations. I will be happy with 90% realism because I have built this cockpit to enjoy. It is theoretically possible to control every system and switch on the Panel. However, my main concern is to focus on the systems that are directly concerned with the correct operation of flying it and keeping it in the air. So heating, aircon and cabin pressurisation will the last things I think about.
And my second consideration is to balance, cost/simplicity/expectation when 'working in' a system.

Sources Of Power
There are various sources of Power on the 737NG. These are:
1. Batteries
2. Ground Power
3. Auxiliary Power Unit Generators
4. Engine Driven Generators

And for your information there are two types of Power, the D.C System at 24-28 volts and the A.C. System at 115 volts 3 phase. But of course this has no bearing on this document because I will be using 5 & 12vdc.

Distributing The Power Around The Overhead Panel.
Now we all know that any electrical circuit needs to deliver two potentials, a negative and a positive, to drive the components we are using. This project is a very complex circuit of switching voltages and directing them where we want them based on certain conditions.
Each LED will require a negative and positive supply to operate. That is going to be one hell of a lot of wires going everywhere. So the easy solution was to distribute the power around the Overhead Frame via two BUSSES. One was for the negative which will be needed just about everywhere on the panel and one was for the positive which will accept the supply from the various means of delivery and distribute it to points where it will be needed.



Above is a copy of Drawing One which you can get from my Overhead Page at www.737ng.co.uk

So how did we get the Power onto the Main BUSSES?

THE POWER SUPPLY UNIT
Ok so we have got as far as the Overhead Panel. I have just spent a whole month researching the behaviour and operation of the Unit, so I can form a basis for how far and how complex I want to make it.

Remembering that we have these cockpits to fly them, not spend 2 hours setting it up for a 20 minute flight. And also remember that in a real 'office' the workload is shared which generally means a short setup for flight time, where you will be doing everything for yourself.
Obviously simplicity is my main concern, but this panel is probably the most complex part of your cockpit with which you want to introduce realism and interactivity.
So I have decided to initially focus on the important units on the panel and then go onto supplementary boards after I have successfully integrated the controls that matter.

What I am going to do is use a PC Power Supply to give me both a 5v d.c. and 12v d.c. supply for the LED's and the Cooling Fans/Lighting.
Just about every Computer in the World will have one of these, but if you do not have access to a scrap or unused Computer, you can buy one from any good Computer Shop. Just ask them for an ATX Power Supply Unit. Prices range from GB£20 (about US$34). Get the highest power output you can, because you will be driving quite a lot of LED's from the 5v and the cooling fans and the Floods from the 12v supply. A 350 watt unit is ideally recommended.
Right then, the mains power is generally supplied by a 3 pin 'Kettle Lead'. You know the type, it is quite universal, used on Kettles, Computers, Power Supply Units etc. This will supply the A.C. 'Mains Power' to the ATX Power Supply Unit.
The ATX Power Supply is basically an Electrical Apparatus for TRANSFORMING AC power to DC power and reducing the voltage from the Mains Power Voltage to a stabilised and constant 12 volt and 5 volt supply.
It also incorporates 'Short' and 'Overload' protection circuits, so if you 'Goof', no problem, it lets you try again.
Now on the other end is a 'Plate Full of Spaghetti' coming out. This is the Wiring Harness. Remember it is designed to power a PC and not the Overhead Panel on a 737NG. But we are a pretty smart bunch, so lets put it to good use.




Starting from the Left, you must identify the following output plugs. 1. 6 pin Aux. Connector. 2.MOLEX P4 12v connector. 3. 4 Pin Standard MOLEX connector and finally 4. The ATX Motherboard connector (ATX-2 Plugs have 4 extra pins). But what we are interested in are the following COLOURED WIRES.
Green = On/Off Switch
Red = 5v + Positive for normal LED Operation
Orange 3.3v + Positive for LED 'Dim' State (to be implemented later)
Yellow 12v + Positive
Black 5 & 12v – Negative. (It does not matter which is which, because the Positive Potential will only request the matching negative potential, so use any Black Lead as your Negative Supply).
These are the conventions I have used in this document. If you see a red lead, it will be 5v, if you see a yellow lead, it will be 12v etc. All voltages are of course D.C. or direct current.

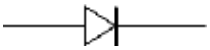
TIP. What I did was to open up the Power Supply and 'tidy up' the outputs so all I had leaving the case was the GREEN Lead, 5 Black Leads, 2 Red and 2 Yellow.

SWITCHING THE POWER SUPPLY UNIT ON & OFF

If you look on the ATX Motherboard connector, you will see a single GREEN wire attached to it. This GREEN wire controls the switching of the power supply.
Join the GREEN wire to any BLACK wire and the power supply will turn on. Break the contact and the power supply will turn off.
So, this is how we will control the Power to the Overhead Panel. By inserting a Rocker Switch between the GREEN and any BLACK wire, power is controllable.

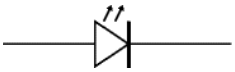
SYMBOLS USED.

DIODE

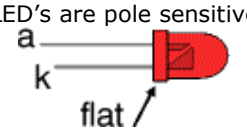


This is a common diode. Basically it is a one way valve for current. The arrow (anode) will indicate the direction of flow and think of the black line (cathode) as a brick wall. Current can flow from the anode to the cathode, but not the other way round.
Diodes are usually marked with a black line to indicate the cathode side.
A very cheap component which works wonders.

LED

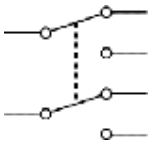


LED or Light Emitting Diode.
LED's are pole sensitive



Like a diode, power can only flow one way, from the Anode to the Cathode. To help you identify these, the anode is longer than the cathode and the cathode side generally has a flat edge.
ALWAYS use LED's with built in resistance made by KINGBRIGHT.

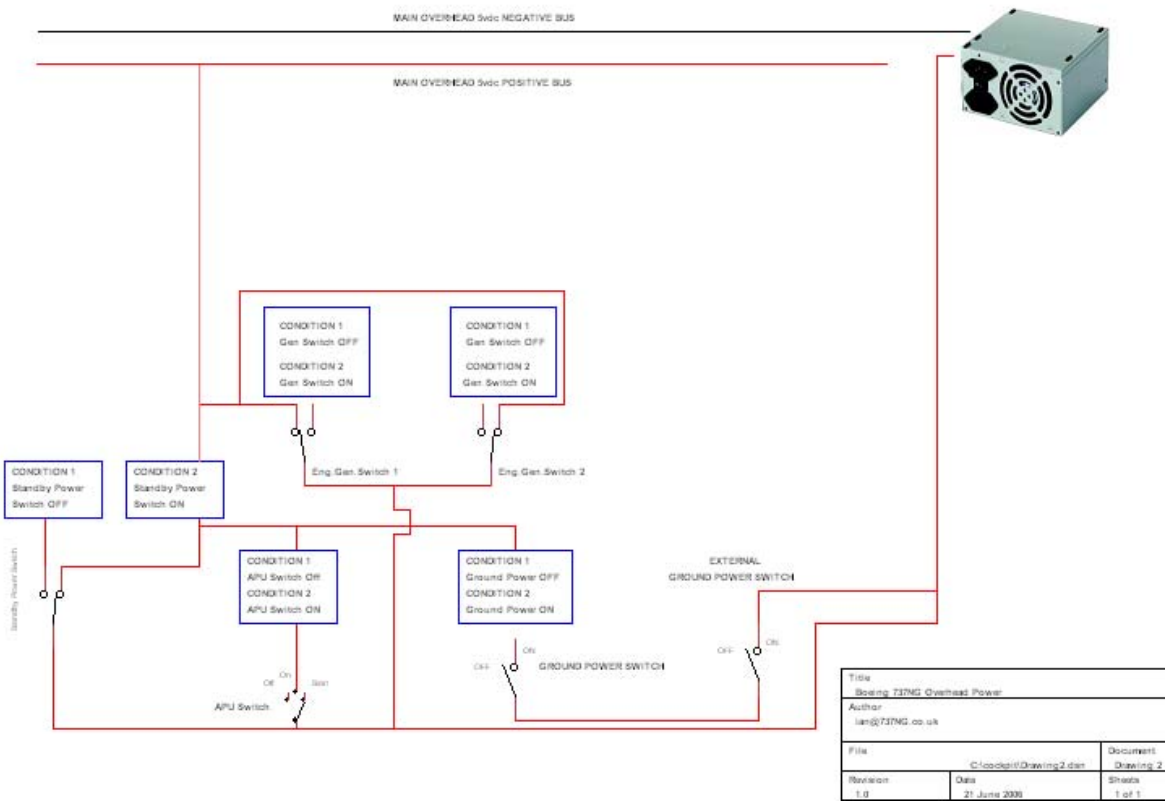
SWITCH



Switches come in all types and sizes. Single Pole, Double Pole, Momentary On etc. Basically you have to decide what you want a switch to do and then select the corresponding type. But if you are using a Keyboard encoder, you have to make sure you get 'Break before Make' Type otherwise the switch action may be faster than your KB encoder reads!

The VARIOUS SOURCES OF ELECTRICAL POWER

Standby Power – One of the 'Switching' Circuits to Give Correct Annunciation. See Standby Power Desc.
1. Battery – Very Simple to Implement – SEE BATTERY POWER
2. Ground Power – Again Very Simple to Implement – SEE GROUND POWER
3. APU - Simple Delivery, SEE APU POWER
4. Engine Generators – SEE ENGINE GENERATORS POWER

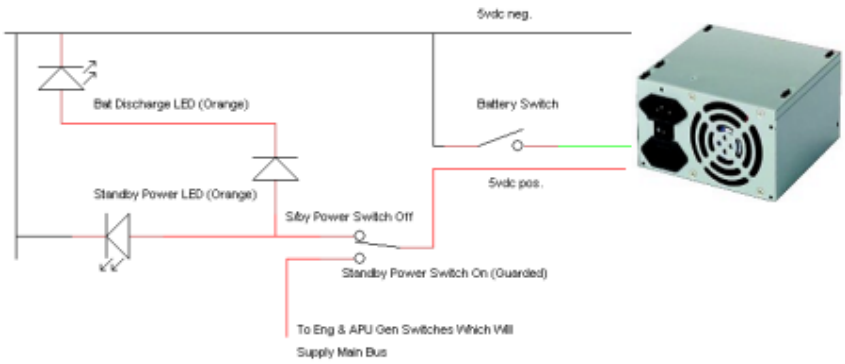


Above is a copy of Drawing Two that you can get from my Overhead Page at www.737ng.co.uk

1. BATTERY POWER

Below is a basic diagram of how I have wired the battery switch. The GREEN and BLACK wires are sent to the corresponding wires on the POWER SUPPLY, thus turning it on and off when the switch is operated.
When the Hot Battery Bus is made live, it powers up essential services only.
What actually happens when you turn on the Battery Supply, is certain Exterior Lighting, Interior Cockpit Lighting, Communication Equipment and the PFD,ND and EICAS Displays come 'live'.
Look at Your PMDG Overhead Panel in a 'Cold & Dark' state. Once you turn on Battery Power see how things light up? You now have the PFD/ND Displays and your radios have gone live.
CONDITION. When the Battery is switched on, there is a discharge from the battery so the Bat Disch Light on the Metering Panel needs to be illuminated. You may even want to illuminate the TR UNIT Annunciator as well as sometimes happens. In addition, the Standby Power Annunciator has to advise it's state, either on or off.

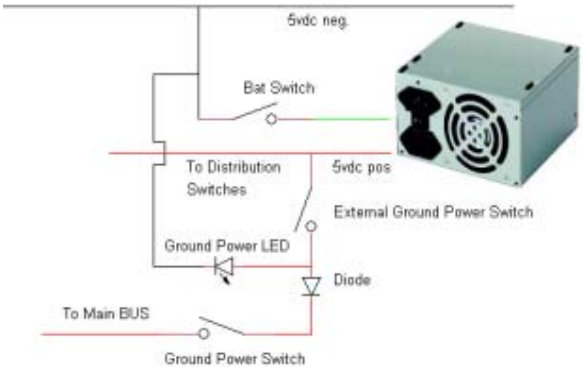
SOLUTION.



Ok, this is what has happened so far. We have thrown the battery switch on, the Power Supply has started and is delivering 5v to the Standby Power Switch which is in it's BAT Position. The 5v+ is being directed to the Battery Discharge, TR UNIT and Standby Power OFF Annunciators which are lit. When the Standby Power Switch is thrown to AUTO (Guarded), power is redirected to the Eng. Generator Switches which will become part of the switching circuit (but not yet). The reason we have a diode in the line to the Bat Disch.LED is because we will be feeding it from the generator switches as it needs to stay illuminated until the gens are brought ON-BUS. This stops the power from arriving at the S/by Power LED.

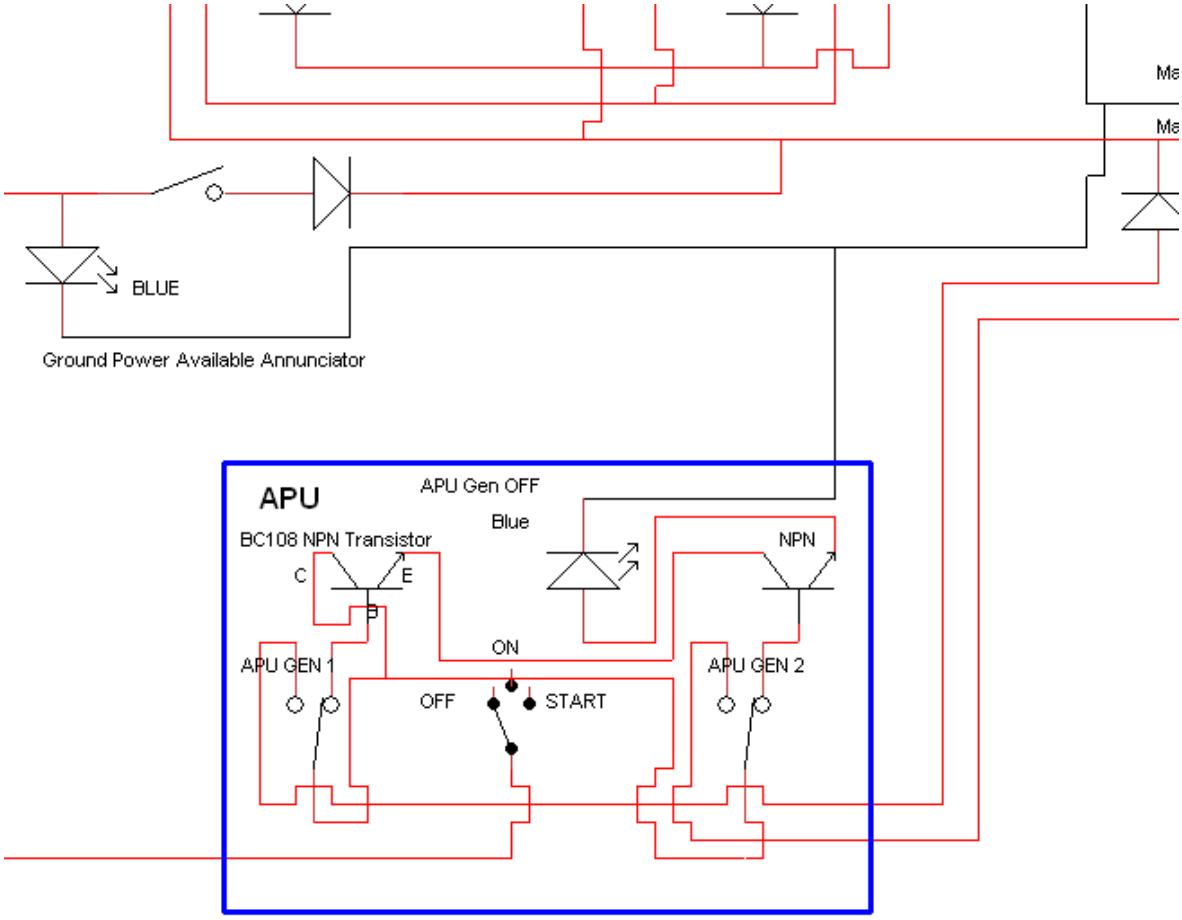
2. GROUND POWER

So here we are sat on the Ground having just turned on the batteries so we can see what we are doing. Then along comes this nice man who has just seen the Nav Lights come on and knows we are in here. So he taps on the window and says 'Want the Ground Power Guv?'. Yeah, great. So off he goes and gets plugged in. On the overhead, a Blue Annunciator comes on that says 'GND POWER AVAILABLE' .
CONDITION When Ground Power is available and meets the Aircraft Quality and Reliability Standards, the Annunciator announces the fact. Below the annunciator is the Ground Power Switch which is 3 position (centrally Sprung on the real thing) OFF /Centre/Momentary ON. What I have used is a simple 3 position switch to simplify things without resorting to relays. As there is generally Air also available (for the Bleed Systems/Start etc) – which we are not going to get involved in, lets just assume we have it.
Once the Ground Power is available, there is sufficient 115v and 28v coming in to power the whole aircraft. So the easiest way to apply Ground Power is to direct it straight to the BUS, thus allowing Full Power Distribution to the Overhead and the Aircraft.
SOLUTION Simple installation. The man with the Power Truck is simply replaced with an External Switch when on, sends 5v to the Ground Power Switch, Lighting the GND POWER AVAILABLE LED on its way. The Ground Power Switch when OFF isolates this supply and when ON sends the power direct to the Main BUS allowing Full use of Power Switches and Annunciators. The diode is used to prevent feedback to the G/Power LED if the switch is left in the ON position.



3. APU POWER

This is where it starts to get a little bit more complicated :o)



Above is the section lifted from the Overhead Power Circuit Diagram Drawing 3 which you can get from the OVERHEAD Page at my website www.737ng.co.uk

Lets talk about it in detail.

CONDITION

When the APU is started, its generators are capable of supplying both AC ,DC and Bleed Air to the system. If the Generator switches are turned off, that power is not being directed into the aircraft electrical system. So an annunciator on the Panel will be illuminated BLUE. Once either generator switch is turned to the ON position, the BLUE annunciator is extinguished and 5vdc + is directed to the BUS.

SOLUTION

The Battery Switch is turned on which starts the Power Supply. 5v+ is fed direct to the APU Start Switch. In The OFF Position, no power is fed to the APU Gen.Switches. In the start position, I use Key2Mouse to actuate the PMDG APU start and once running, I switch it to the ON position. This directs 5v to the APU Gen.Switches. If they are both OFF, the Power is fed to the APU GEN OFF BUS Annunciator thru 2 switching transistors (type BC108). If either is turned on, power is fed to the Main BUS, breaking the circuit to the switching transistors, thus extinguishing the annunciator. (My thanks to Erwin van Steen for pointing me in the right direction on this one).

4. Eng.GENERATOR POWER

Below is the section lifted from the Overhead Power Circuit Diagram Drawing 3 which you can get from the OVERHEAD Page at my website www.737ng.co.uk

When the Bat Switch is turned on, power from the Power Supply is directed to the Standby Power Switch. In the OFF Position, you can see that the voltage is directed to light the S/B Power OFF Annunciator and also the BAT DISCH and TR UNIT LED's. When the S/B Power switch is turned on (Guarded Position), the 5vdc+ is directed to the Eng. Generator Switches. With the Eng.Gen Switches in the OFF Position, power is directed to the Eng Gen OFF BUS Annunciators and also as the Gens are not feeding the system, there is still a Bat Discharge, so we still have the LED Illuminated.

As soon as we bring the Eng Gens on BUS, Power is directed away from the LED's, thus extinguishing them and it is directed to the main BUS.

CONDITION

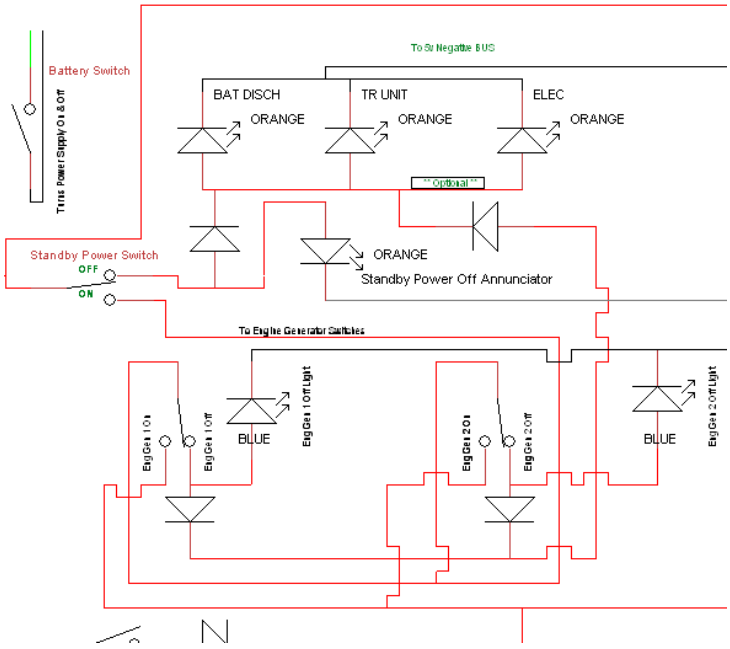
Lets assume that we have gone thru basic 'Power Up' by turning on the battery, selecting Standby Power into The Auto Position and that we have either Ground Power or the APU feeding into the system for engine start. With power being supplied to the Eng.Gen. switches, in their off position they will feed their corresponding BLUE Annunciator and if required the BAT Disch LED.
Once they are switched on BUS the power is directed away from the annunciators and to the main BUS.

SOLUTION

The Battery Switch is turned on which starts the Power Supply. Power is directed to the Eng.Gen Switches via the S/By Power switch. In the OFF Position, they illuminate the Eng Gen OFF (Blue) Annunciators and the Bat Disch LED's. In the ON position the Annunciators are extinguished and power is fed to the BUS.
Known Limitation….. Strictly Speaking, with an External Power supply to the Aircraft, when the Eng.Gen switches off BUS, the Bat Dish Light will not illuminate. I know how to do this, but again, it is not a priority. An updated circuit diagram will be made available when I have developed the circuit for the 'Final Build'.

IN CONCLUSION

Ok, so we have an operational Overhead which works reasonably well. The actual hardware switching of the software is 100% accurate. However, there are some limitations to the exact operational performance on the annunciator switching. But I have tried to use simple components which are cheap and effective.
I can get the switching of annunciators closer to the real thing, but time is a very expensive commodity and it has to be put to good use.
So this is the provisional setup. I have to add that it will not be the final version because I have discovered relays which will allow me to introduce the 'Source Off' LED's on the Transfer Panel and will allow me to control the Bat Discharge LED correctly.
So please understand that this is just part of the R&D process. And of course if there is anybody out there who can help me out, please get in touch.



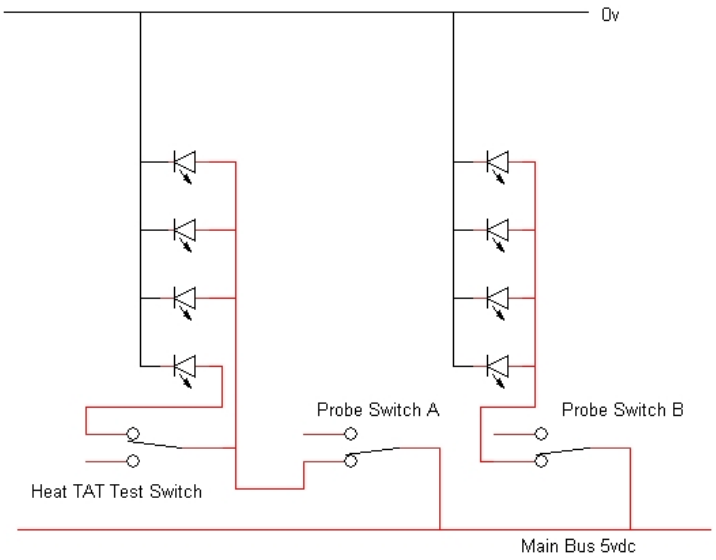
Thank you for your time and I hope this document has both instructed and informed you. And that it also got you thinking.

Ian P.Sissons OSWESTRY England August 2006 v1.2

ANNEX 1 12th August 2006. Power to LED's from Second Source.

From the e-mails I have been getting, it has become clear that there may be some confusion in how some of the LED's are illuminated. For example, with both engines stopped and only Battery or Ground Power available, some Warning Annunciators are lit irrespective of switch position. OK, this means that the LED has to be powered from a second source. Here is an example showing how this is done.

Here is a simple switching circuit Representing the Temperature Probe and Heat Test Switch Panel. The Panel has 3 switches, A,B and Heat TAT Test. There are 2 banks of 4 annunciators each representing a particular probe and it's state. The lower left annunciator is connected to a Test switch which when operated extinguishes the annunciator (if all is well). Probe annunciators are illuminated when the Probe Power if off. Consequently in this diagram, all 8 annunciators will be lit. Yet if the TAT test switch is operated, the Temp Test annunciator will be extinguished as we expect.



Now with the introduction of 3 diodes, it becomes possible to light the LED's from 2 sources. It is possible to use just the one between the 2 banks of annunciators but I always like to cover my ass when feeding power in from a second source to prevent voltage loopback, hence the 2 diodes between the Main Bus and the switches.
So in this example, all the annunciators are extinguished. However, if the RECALL/TEST/Generators Inactive source is connected to the circuit, all 8 annunciators will light with no voltage loopback reaching the Main Bus, eliminating the risk of erroneous lighting of other LED's.
More on the RECALL/TEST/Gen Off Bus Circuit later, I have to go to the supermarket :o)