Podcast 008 – Electrical system

Hello and welcome again to another Boeing 737 Talk where we'll take a look at my least favourite technical system, electrics. Together with Mark we'll try and make some sense of this quite tricky subject, well for me anyway and hopefully up all our knowledge points a bit. I would say that, if possible, have a schematic of the system nearby for reference to help cement the overall picture. In writing this podcast we've come to realise that there's too much information to fit into one without you either at best losing a bit of interest, or quite possibly even falling asleep so we'll split this into two more digestible episodes. In this first one we'll look at an overview, the Batteries, the Standby system, the APU generator, some load shedding and circuit breakers. In the second we'll focus solely on the main AC system. We're not going to list which systems come off which busses or you really would be asleep and possibly us too, but we will mention some as we go.

We'll start with the basics and a reminder that we're talking about the 737NG after discussing the Max recently. Onboard we have both AC and DC power. Our primary sources for AC power are two 90KVA engine driven IDG generators which supply three phase 115V, 400 cycle AC. We can also produce AC from the APU generator and the Ground power unit. DC is primarily produced by converting that AC power via transformer rectifiers or TR's and battery chargers. When AC power sources are lost, we have batteries that provide back up and emergency power.

There are two basic principles of the 737 electrical system. Firstly, there is no paralleling of the AC sources of power and secondly the source of power being connected to a transfer bus automatically disconnects an existing source.

Let's talk about these batteries first. Our Main battery consists of a 24v DC Nickel Cadmium battery located in the E&E compartment. Voltage ranges from 22-30V with a 48Ah rating. Following a loss of engine driven generators, a fully charged battery will provide power for a minimum of 30mins. Most NG's will also have the Auxiliary Battery fitted giving a total back up of 60 minutes.

The Auxiliary battery is of the same type as the main but is isolated from the electrical system in normal operations. It will operate in parallel to the main battery when the main battery is powering the standby system.

The main Battery can be used to start the APU alone, usually we'd use Transfer Bus #1. If we do use the main battery the battery charger will disconnect to prevent overloading of the battery charger. Each APU start takes approximately 6.7Ah or 4.2mins of battery power which is something to bear in mind when attempting an APU start at high altitude and part of the reason it is not recommended to battery start above 25,000ft as multiple attempts may be required.

One Battery I'll quickly mention that can often be forgotten is the Fuel Shut Off Valve Battery. This is a stand-alone battery that always makes sure we have power to close both the Engine Spar Valves and the APU Fuel Shut Off Valve. It is a backup for the normal Hot Battery Bus source.

The 73 has three Battery Buses. The most important being the hot battery bus, then the switched hot battery bus and then finally the battery bus.

The Hot Battery Bus normally receives power from the main battery or battery charger. I like to remember some of its functions by the fact that it's Hot so needs extinguishing! Yep you guessed it, it supplies power for our extinguishers. The Switched Hot battery bus becomes energised by selecting the Battery Switch to on hence it's called switched. It powers numerous systems as a DC emergency power source including the L&R ADIRU's. The Battery Bus receives power from the main Battery or from TR3 and is energised by putting the Battery switch to On OR the Standby power switch to Bat. The battery bus has the heaviest DC users connected.

In a loss of both generators' situation, as well as the three buses we have just mentioned the DC standby bus will also be powered.

Here we'll mention a couple of the possible indications you can have on the Electrical panel. Firstly, the amber ELEC light only comes on on the ground and indicates a problem in the DC or standby power system. You can also get an amber BAT DISCHARGE light which is combined with the master caution and ELEC annunciator. This indicates excessive Battery current output of either 5amps for 95 seconds, 15amps for 25 seconds or 100amps for 12 seconds.

This leads us on nicely to charging them back up. This is done funnily enough by the battery charger. These chargers however have two functions to give you more to remember. When Battery Voltage drops below 23V they go into charging mode although this is inhibited when the fuelling panel is open or the APU is being started. The other mode of the main battery charger is Transformer Rectifier mode which is where they spend most of their time. Once the primary charge cycle is complete in TR mode the main battery charger powers loads connected to the hot battery bus and switched hot battery bus.

The main battery charger is powered through AC ground service bus 2 with the auxiliary charger powered through AC ground service bus 1.

As we've covered the batteries first, I think we'll take a look at the Standby Power system now. This system is there so that essential systems are still powered for us to safely complete the flight even in the event off a loss of all AC power sources. As well as our three battery buses already mentioned we have the standby AC and standby DC buses powered giving us 5 in total. Also, part of the standby system are the main and auxiliary batteries along with the static inverter providing the AC for the AC standby bus.

In normal operations the guarded standby power switch is in AUTO and the battery switch ON. This allows alternate power sources in case of partial power loss as well as complete transfer to the battery if all normal power is lost. Normally the AC standby bus is powered from AC transfer bus 1 and the DC standby bus through DC BUS 1 via TR1, TR2 and TR3 with the battery bus powered by TR3.

When we come down to our alternate power of just the batteries with the standby power switch in AUTO the AC standby bus is powered from the batteries via the static inverter with the other 4 buses getting their power directly from the batteries.

The standby power switch itself allows for automatic or manual control of power to the standby buses. In AUTO switching from normal to alternate power occurs if power from either AC transfer bus 1 or DC bus 1 is lost. Positioning the switch to Bat overrides automatic switching and places the AC standby bus, DC standby bus and battery bus on battery power irrespective of the battery switch position.

Positioning the standby power switch to off de-energises both the AC and DC standby busses and illuminates the STANDBY POWER OFF light. The parameters for this light are if either of these standby busses or the battery bus see a voltage drop below 100v AC or 17.5v DC for more than two seconds.

A standby power Control unit or SPCU controls the standby power relays and ensures only one source, Batteries or AC power sources, power the standby system at a time.

There is a list in OM-B Volume 2 under electrical system description 6.20.14 of all significant equipment that operates with all generators inoperative that is well worth a read through.

Our normal source of DC comes through the conversion of the 115V AC to 28V DC through Transformer Rectifier Units or TR's. We have 3 duly called TR1, TR2 and TR3. TR1 is powered by Transfer Bus 1 and provides power to DC bus 1. TR 2 is powered by transfer bus 2 and yes you guessed it supplies DC bus 2 and TR3 normally receives power from Transfer bus 2 but is backed up from Transfer bus 1 and normally supplies power to the battery bus. They are connected in parallel through the cross bus tie and any two TR's are capable of supplying the total connected load.

The cross bus tie relay automatically opens, isolating DC bus 1 from DC Bus 2 at glideslope capture during a flight director or autopilot ILS approach. This prevents a single failure from affecting both navigation receivers and FCC's. The relay will also open by selecting the Bus transfer switch to OFF.

The associated amber light TR UNIT will illuminate on the ground with any TR fault and can be identified through the rotary switch on the overhead AC and DC Metering panel. Turn through the TR's and the one that shows 0 Volts, and 0 Amps has malfunctioned.

In-flight the light will illuminate when either TR1 has failed or TR1 and TR2 together have failed. The QRH will then warn you not to use the AFDS approach mode during an ILS approach. This is because when the cross tie relay opens on glideslope capture you'd lose either DC bus 1 or DC bus 2 which would disconnect both autopilots.

To finish up here let's just look at the APU generator and a quick load shedding and Circuit Breaker review.

The APU starter Generator provides aircraft AC power when the APU has been started. It operates at 12,000 RPM and can be started and used up to 41,000ft. It supplies 90KVA up to 32,000ft and linearly decreases to 66KVA at 41,000ft due to load capabilities at low air density.

The APU start sequence is determined by the Electronic Control Unit or ECU which is powered by the switched hot battery bus. That is why the Battery switch must be on to operate the APU and also why if you turn that switch off when the APU is running it will shut down. This is not recommended as you won't achieve the 1-minute cooling cycle.

When APU RPM reaches +-95% the ECU commands the blue APU GEN OFF BUS light to illuminate meaning we can now use the APU for electrical load.

On take off you do have an Auto generator online function that will allow the respective Generators to take over should the APU fail.

Load shedding allows electrical current to maintain within limits by removing electrical loads in a priority order. The Bus Control Power Unit automatically controls load shedding. As we've just been talking about it, we'll look at the APU load shedding first.

On the ground, if an overload occurs then the Galley and main busses are deenergised until back within limits. You can attempt to restore the galley and main busses by moving the CAB/UTIL switch to OFF then ON.

In flight, if the APU is the only source of electrical power, all galley and main busses are shed automatically. If the load still exceeds limits, then the IFE busses are too shed.

If on a single Engine generator, the sequence will go. Firstly, the galley and main busses on XFR bus 2. Then if needed the Galley and main busses on Transfer bus 1 and the finally the IFE busses.

As you may have guessed we're not going to go through each Circuit Breakers on todays, or any day's podcast. Briefly, the Panels behind the FO are called P6 and behind the Captain are P18. First officers would remember this by the fact that captains are paid 3 times more, perhaps Captains would think of it as them being worth 3 times more!

The very top of the panel on each side tend to contain Navigation related things such as FMC's, Radio, Weather Radar and ADIRU to name a few with the lower panels tending to be more focused on aircraft systems such as Hydraulics, Anti ice, Fuel, Landing gear etc.

And that's that! I hope you enjoyed the first part of this refresher on the aircraft Electrical system and have learned something new, I know we certainly have. We'll be back soon with the exciting sequel involving our main AC power sources, so don't forget the popcorn. Or the cheese board.

Thanks again for listening and please do continue the talk over on our various social media sites. For now, from us both, fly well and stay safe.