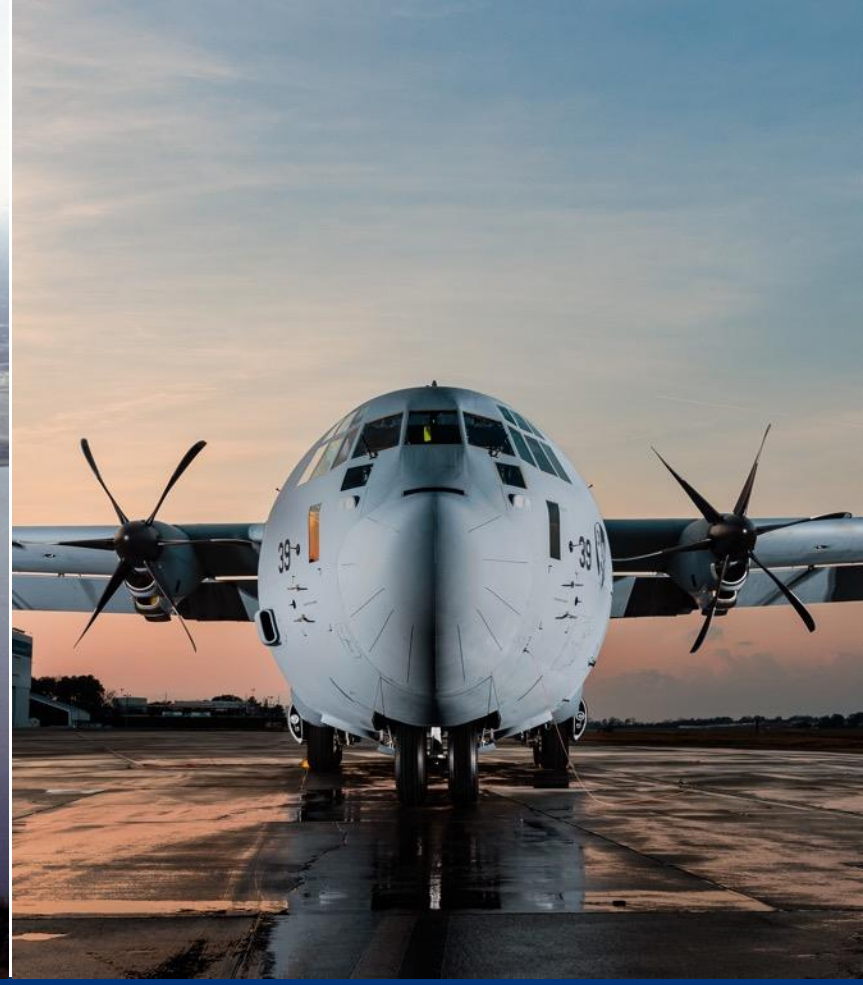

Electrical Bonding & Best Practices

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Electrical Bonding: What is it?

One of our goals as designers and maintainers is to protect (airborne, ground and support) systems from electromagnetic effects. These effects encompass Electromagnetic Compatibility (EMC), Electromagnetic Interference (EMI), lightning, static electricity, Radio Frequency Compatibility (RFC), Electromagnetic Pulse (EMP), electrical bonding and grounding.

Electrical Bonding is a practice that helps to provide that protection as well as protection of personnel.

Definitions:

- **Bond** – Any fixed union existing between two objects that results in electrical conductivity between the two objects. Such union occurs either from physical contact between conducting surfaces of the objects or from the addition of a firm electrical connection between them.
- **Grounding** – The bonding of an equipment case, frame or chassis to an object or vehicle structure to ensure a common potential. The connection of an electric circuit or equipment to earth or to some conducting body of relatively large extent serves in place of earth.
- **Electrical bonding** – Measures that are implemented for management of electrical current paths and/or control of voltage potentials to ensure system performance and to protect personnel. Bonding provisions need to be compatible with other requirements imposed on the system for corrosion control.

Electrical Bonding: Classes

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Classes – Electrical bond joints are assigned or categorized into one (or more) categories:

CLASS	OHMS	APPLICATION
A	0.0025	Antenna Installations (with and without counterpoise)
C	0.0025	Joints carrying power or discrete return current • Explosive areas (e.g., fuel tanks) have additional constraints
H	0.1	Personnel shock hazard • Applies to voltages greater than 30 volts • Ensures circuit protection activates in the event of a power fault
L	0.0025	Lightning – Must carry high currents
R	0.0025	Radio Frequency (RF) Potentials – Minimizes RF potentials across this joint • Usually low currents unless it is also part of a current path
S	1.0	Static Charge – Ensures that accumulating charge will bleed away • Caused by airflow or moving liquids – Can cause sparks or personnel shock

Electrical bond joints often address more than one class (e.g., equipment racks; structural components)

Electrical Bonding: Is There a Problem?

Electrical bonding problems can display some very unusual symptoms or abnormal behaviors.

The symptoms may at first appear to “not make any sense.”

- Example: Sometimes equipment is no longer operating consistently in a single-sided mode; responds to differential mode (signals).

Intermittency makes the troubleshooting process much more challenging.

My problem is intermittent... Is it a software bug... an EMI issue... or a bad electrical bond?

- **Software bugs –** Will materialize consistently (if aircraft is properly set up). It should happen reasonably often (same procedures, same user actions). Although, some functions may be probabilistic (vs. deterministic) due to sampling rate, event quantity and/or persistence.
- **EMI –** Is less consistent. Troubleshoot until you find the source (emitter) that caused the receiver to squawk. Sources can be transmitters, large currents or a re-radiating high impedance lines.
- **Bonding –** Often systemic problems, multiple unrelated systems and may occur only in flight (zero-G, negative-G unloading).

Electrical Bonding: Maintainer's Perspective

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When might I have an electrical bonding problem?

- Equipment is being repeatedly damaged (in the same location)
- Displayed values (on Heads Down Display (HDD)) are "odd," or erratic (read: bouncing around) or out of specification
- Multiple pieces of equipment failed or squawked an Advisory, Caution and Warning System (ACAWS) annunciation at the same time
  - Timing can be staggered due to acquisition times and persistence requirements coded in software
- Unrelated equipment is misbehaving
- Many of the failing components are located...on the same rack (aircraft vs. schematics)
- Behavior only occurs in flight and cannot be duplicated on the ground
- Days, weeks or months go by before symptoms reappear?!
- Radio communications (analog stages) are noticeably noisy or contain more static than usual
- Corrosion is evident in other corners of the aircraft...due to aircraft age or high maritime use
- Did a single Line Replaceable Unit (LRU) (repeatedly) fail...and then "it went away" (i.e., its local bond joint was unintentionally corrected)?

Ask your aircrews questions!

Electrical Bonding: What Could go Wrong?

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Does the joint use a full fayed surface...or a spot bond?

- A fully fayed interface of the two mating pieces may leave a lot of metal area unprotected (by primer and paint) against corrosion.
  - Bond joints are always a compromise between electrical conductivity and corrosion protection.
  - Which concern is more important depends on the location and application.
  - If the exposed area is too large, conductive sealants will be used. But these are more sealant than conductive.
- A spot bond can result in a “paint well,” wherein the metal does not cinch together and make metal-to-metal contact. Remember:
  - Fasteners shift
  - Fastener threads corrode
  - Cannot be used for a stack of 3 or more pieces

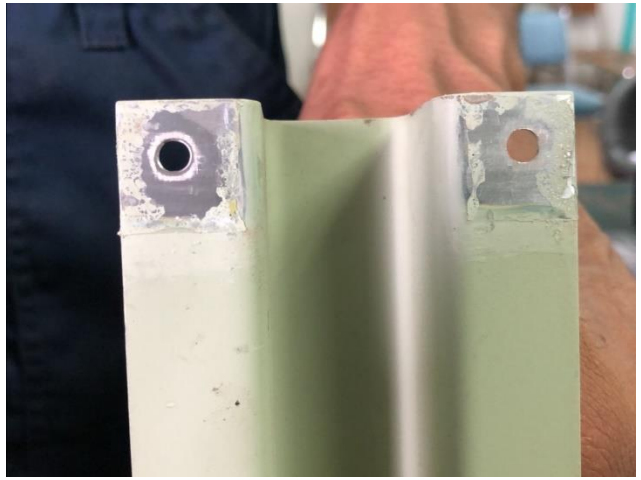
Electrical Bonding: What Else?

Is corrosion or contamination affecting the integrity of the bond joint?

- Upper right picture shows a typical “hat channel” used for equipment (LRU) support.
- Lower right picture shows corrosion of the bond joint (and perhaps some wicking of touch-up paint). After the paint dried, it could serve as a mechanical shim giving humidity an ingress pathway.
- Lower left is a Electrical Control & Supply (EC&S) Rack C-bracket

Reduced conductivity may be due to:

- Oxidation (Al_2O_3 is insulative)
- Wicked up paint (during assembly)
- Dust or dirt
- Particulate from fretting



Electrical Bonding: Don’t Panic!

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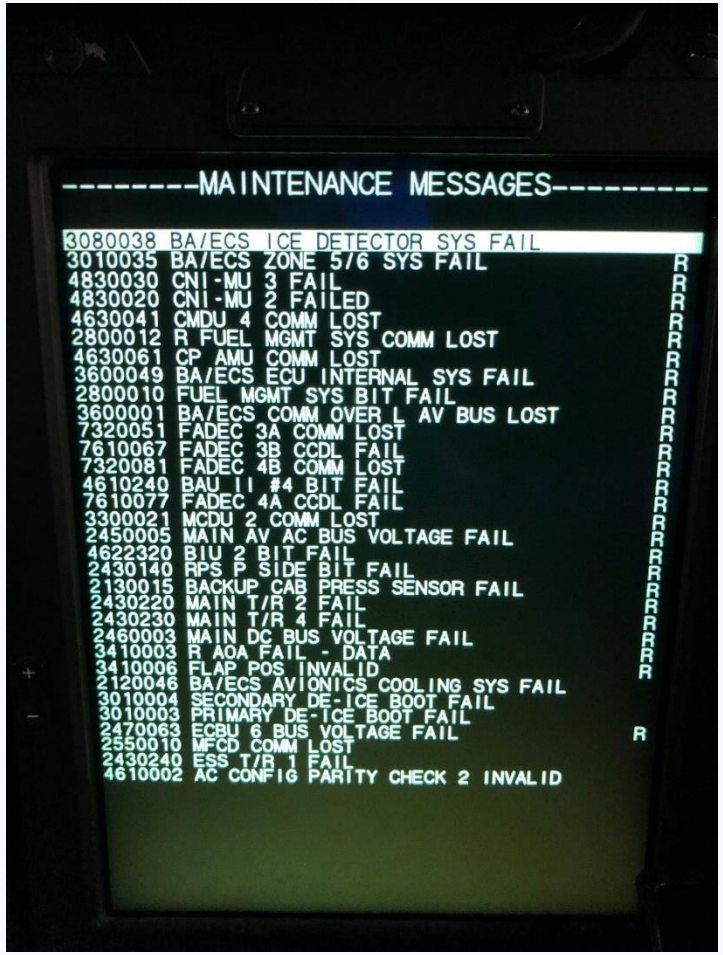
Does your aircraft’s Maintenance Page look like this?



- There are a lot of items that failed. Do not start trying to fix things in list order... The ICE DETECTOR can wait.
- Inspection shows the loss of power conversion equipment (e.g., MAIN T/R 2 FAIL). When a power bus is lost, other equipment will be reported as “failed.”
- When a power bus is lost, other equipment will stop communicating with it is a Mission Computer (MC) or Bus Interface Unit (BIU) (e.g., Color Multi-functional Display Unit (CMDU) 4 COMM LOST).
- Clues? “R” implies the equipment recovered. Look at the debrief and see if it failed/recovered multiple times.
  - Only once – Could be an EMI event
  - More – Possibly a bad bond joint (...or worse, intermittent)
- Start with the racks or shelves containing the power conversion equipment, then the data accumulators (i.e., MC, BIU, Bus Adaptor Unit (BAU))

Electrical Bonding:Additional Information

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Reference Documents

- MIL-B-5087(B) – Military Specification for Bonding, Electrical and Lightning Protection, for Aerospace Systems
- MIL-STD-1818 – Military Standard, Electromagnetic Effects, Requirements for Systems
- MIL-STD-464(C) – Department of Defense Interface Standard, Electromagnetic Environmental Effects, Requirements for Systems (see the Appendix)

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