ADVANCED ASSEMBLY

PCB ASSEMBLY CONSIDERATIONS WHEN DESIGNING FOR THE AEROSPACE INDUSTRY

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INTRO

With the number of aircrafts likely to double in the next two decades, printed circuit board (PCB) requirements are experiencing an increase in demand.

However, this industry has specific rules when it comes to designing, manufacturing, and assembling PCBs. The primary goal in aviation and aerospace industry is to build a product that will last at least 15-20 years without any failures. Therefore, reliability and zero failure rate are the key requirements.

RELIABILITY, RELIABILITY, AND MORE RELIABILITY

In circuit boards, reliability starts at the design and fabrication stages.

Often times, designers should avoid cutting-edge technology, and instead use standard technology that is proven to be reliable and is known to not fail.

For instance, although RoHS is the rage all over the world, and most manufacturers prefer to use processes that do not have any lead (Pb), most in the aviation and aerospace industry insists on using leaded materials for assembly and Hot Air Solder Levelling (HASL) with leaded solder. Their contention is using lead-free SMT components and subjecting them to the higher temperatures required by lead-free solder during reflow is going to add a substantial risk to the aerospace products. Therefore, for the aerospace industry, although one can use Electroless Nickel Immersion Gold (ENIG) for the PCB surface finish in place of HASL, for the assembly process using leaded material is essential.

THERMAL MANAGEMENT

Once a satellite goes up, there is no way to swap a defective board inside it for a good one. Therefore, failure due to heat buildup is not acceptable. Moreover, the lack of air precludes the use of convection cooling—a fan is of no use in removing heat in space. That leaves designers no choice but to use the natural properties of metal— conduction—to dissipate the unwanted heat from a source.

Although designs of 20-layer PCBs with 4-oz copper is a common feature in the aerospace industry, the heavy copper poses a substantial challenge for both fabrication and assembly. As polyimide is the most common material for use as a substrate, and it is a difficult resin system to work with, fabricating a multi-layer PCB with heavy copper and polyimide is a difficult task.

While the heavy copper does help to dissipate unwanted heat when the PCB is in active use, it also conducts heat away from the SMD terminals during the reflow soldering process when assembling it. Lack of heat does not allow the solder to melt and flow properly, resulting in a non-reliable joint. The assembly process has to compensate for this by having a longer pre-heat time, but this also increases the prospect of delamination as the copper traces now heat up to a higher temperature. Likewise, once the soldering process is over, the cooling time required is also more, which means the solder remains in a molten state longer than necessary. This may allow vibrations to displace the SMD components from their normal positions before the solder solidifies.

PROTECTING FROM THE ENVIRONMENT

Although some parts in an aircraft remain within a controlled environment such as in the cockpit, most of the electronics is exposed. For instance, the electronics in the fuselage, wings, and the engine have to face the extreme vagaries of temperature, pressure, and humidity. The only way to protect them is to encapsulate the electronics on the PCB after the assembly is over.

Some aircraft may have to operate in the desert heat in the Middle East, while another may have to operate from a base in Alaska. Moreover, the electronics has to work flawlessly when an aircraft moves from one environment to another. For instance, an aircraft flying at an altitude of 10,000 ft above sea level faces temperatures near about -50 degrees Celsius, compared to when it is sitting on the runway. Similarly, electronics in satellites may have to face zero-gravity in vacuum, and depending on their orbit, go from -50 degrees Celsius to +125 degrees Celsius.

Therefore, building a circuit board assembly for working in the aviation and aerospace industry requires it to pass through a vast set of testing processes to prove the design is reliable.

STANDARDS FOLLOWED

PCB assembly meant for aviation and aerospace industry must conform to IPC-A-610E Class 3 standards. The standard is meant for high-performance electronics products, while according to Class 3, the electronics products must provide continual performance in uncommonly harsh environmental conditions without downtime. This requires PCBs for military and aerospace follow special considerations during the design, fabrication, and assembly processes. Major considerations are as follows:

DESIGN CONSIDERATIONS

- Design the PCB for handling the maximum current load.
- Maintain 45-degree angles or less while routing on PCBs.
- Always shield the clock signal physically to keep it clean.
- Separate the low frequency components from the high frequency parts to avoid interference.
- Use only quality heat resistance material to withstand high temperatures.
- Use pre-layout simulation and impedance matching to make sure the PCB will work in real environments.
- Provide ample space for heat producing components.

FABRICATION CONSIDERATIONS

- Use only MIL-spec grade of components.
- Manufacture PCBs in conformance to MIL-PRF-55110, MIL-PRF-31032, and MIL-PRF-50884 standards.
- Use finishing material selected to support PCB performance in harsh environments.

ASSEMBLY CONSIDERATIONS

- Recheck the thermal profiles for reflow and wave soldering processes before assembly to avoid component damage and improper soldering.
- Solder all press-fit components to help avoid vibration.
- Pre-tin braided and stranded wires for better solderability.
- Always use thermal compounds for better heat conduction and dissipation.
- Use acrylic based sprays for conformal coating of PCBs.
- Always use ESD0 for ESD requirements.

ESD REQUIREMENTS

During PCB assembly it is essential to protect against electrostatic discharge from damaging electronic components. The protection required for PCB assemblies meant for aviation and aerospace industries is ESD Control Class 0, which is meant for electrostatic discharges greater than or equal to 100 V on the Human Body Model.

This is a more stringent ESD control program than the regular ESD control. It involves using wrist straps and footwear with improved grounding for assembly personnel, bonded grounds, work surfaces, and minimizing conductors. Extra precaution is necessary to ensure the PCB assembly process follows these conditions for total ESD compliance to the highest degree.

SPECIAL CONSIDERATIONS

Special projects of the aerospace and aviation industry may require step-by-step inspection and verification of all operations and sub-operations. For instance, printing solder paste on a surface mount pad may require following special internal procedures. These require assurance of dispensing only the certain specific amount of paste on the specific pad. The assurance comes from a paste height inspection machine that inspects and measures the paste height after the deposit.

Similarly, assurances may be required from multiple automated optical inspections all along other process as well. The aim is to ensure no irregularities can creep into the sub-system while building it, and the processes are stringently compliant to the MPI documents. For instance, advanced automated X-ray inspection helps in maintaining wire-bonding integrity.

PCB assembly conforming to AS9100 may require special processes ensuring product reliability and longevity. This may call for a separate line and associated workstations

complying with certain requirements. For instance, the OEM may require ESD0 compliance.

PCB ASSEMBLY BEST PRACTICES FOR THE AEROSPACE INDUSTRY

Following simple best practices help when developing and assembling for the aerospace and aviation industry. Some of them are as follows:

- Know the standards and regulations that are applicable
- Use the simulation capability in your PCB design software package
- Ensure the contract manufacturer is capable of meeting aerospace quality requirements
- Use only available and reliable components
- Know the tests required for the assembly

The aerospace and aviation industry follow standards such as AMS2750E, AS478N, AS5553A, AS9006A, AS9100D, AS9101E, and AS9102B. It is worth knowing which of the above standards and regulations are applicable for a specific job.

Complicated circuits often require multi-board and multi-layer boards that need to interact with each other. PCB design software packages with the capability to simulate temperature and power variations along with the ability to perform finite element analysis of hardness or strength offer definite advantages.

If you are using a PCB assembly partner for assembling your boards, it is essential to ensure they are capable of meeting aerospace quality and durability requirements. This may require scrutiny of their operational processes and quality control documentation to make sure they can assist you in meeting all the necessary compliances.

It is critical to use only high-quality components that meet and withstand the rigors of space environment. Take necessary steps to avoid using counterfeits. Ensure thesupply logistics causes no delays and/or production interruptions.

Aerospace and aviation electronics require extensive testing and knowing what specific tests are necessary is imperative. Make sure the necessary test equipment is available and fully operational, and the operators are well-trained to operate them.

CONCLUSION

Although the aerospace and aviation industry demand strict adherence to standards, it is not impossible to be an OEM for them, provided one follows the best practices mentioned above, and is willing to consider and undertake the special requirements the industry insists upon.

Reach out to us for a free pre-production assembly Q&A session with our engineers.

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