Electronic Circuit Board Design Reliability Lessons Learned

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Figure 1. Typical Circuit Board

Introduction

Here are some design tips for reliability with respect to shock and vibration environments.

Circuit Board Mounting

Boards should be securely mounted in their enclosures using positive locking devices. The mounting and geometry should usually be designed to make the board as stiff as possible, to increase the natural frequency, and to minimize relative displacement.

Note that piece parts are sensitive to the board flexing which tends to have higher displacement amplitudes at lower natural frequencies. This deflection causes bending

stresses in the solder joints and lead wires which may result in fatigue failure per Reference 1.

On the other hand, the box or enclosure should be mounted to the "next higher assembly" via isolators, if possible, to attenuate the shock and vibration energy flow into the circuit board.

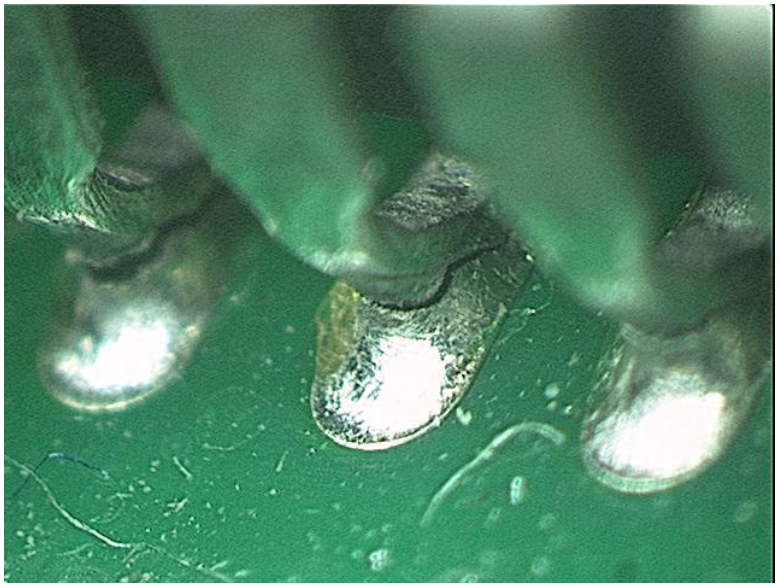

Figure 2. Cracked solder Joints for Piece Part with "J leads"

Sockets

Sockets are often used to mount IC chips to circuit boards. Unfortunately, chips in socket mounts can easily detached from circuit boards that are exposed to shock and vibration.[1] Or an IC may experience an intermittent open due to vibration even if it remains in the socket.

Ideally, IC chips would be soldered directly to circuit boards. The desire to allow for upgrading the CPU and RAM requires a socket approach, however. On the other hand, the furious rate of technological change would seem to make "upgrade-ability" of an existing system a moot point. The consumer must typically buy a whole new computer system to run the latest operating system and software.

[1] The author personally experienced this problem many years ago with a numeric coprocessor chip in a 386 computer.

Crystal Oscillators

Crystal oscillators can shatter when exposed to shock and vibration. Care should be taken to choose an oscillator that has been designed and tested to withstand shock and vibration.

Staking

Piece parts should staked to the circuit board with an RTV or epoxy compound to protect the part from detaching, as shown in Appendix A. A solder connection alone does not necessarily preclude detachment. This is particularly important for large components such as DC-to-DC converters.

Coating

Ideally, a layer of thick conformal coating should be applied to each board. This layer adds damping. It also protects against shorting due to stray solder balls. Unfortunately, the coat makes rework difficult.

Piece Part Locations

The highest deflection will usually occur at the center of the circuit board. This zone should be reserved for smaller, lighter parts. Heavier parts should be mounted along the outer perimeter.

Fasteners

Fasteners may come loose during vibration environments. Screws must be torqued properly during assembly. In addition, lockwashers should be used to maintain preload. A thread-locking adhesive may also be used.

A power screwdriver can induce shock pulses. Use a manual screwdriver if practical.

References

1. D. Steinberg, Vibration Analysis for Electronic Equipment, Third Edition, Wiley, New York, 2000.
2. H. McLean, HALT, HASS and HASA Explained, Accelerated Reliability Techniques, ASQ Quality Press, Milwaukee, Wisconsin, 2009.

APPENDIX A

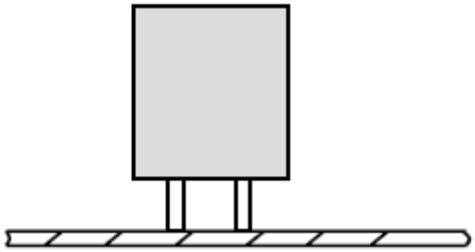

Figure A-1. Crystal Oscillator Mounted on Circuit Board, Typical Mounting Method

The oscillator's structural response is similar to a cantilever beam. Resonant excitation may occur during shock and vibration. High stress levels may develop in the crystal and in the leads as a result.

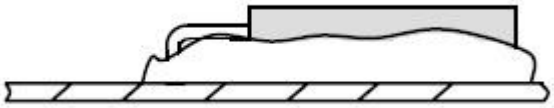

Figure A-2. Crystal Oscillator Mounted on Circuit Board, Improved Mounting Method

The oscillator is bent over so that it is parallel to the board. Then it is staked down with an RTV or epoxy compound. Furthermore, a Mil-Spec oscillator should be used rather than a commercial unit.