Aerospace Corporation

Questions & Answers

29 March 2001

1. What is the best way to shock-mount the printed circuit boards?

   Shock mounting is not really necessary if the PCB is properly designed and large parts are secured to the board with adhesive. Be certain to make the board stiff enough so it cannot 'oil can'.

2. What is the best axis to orient printed circuit boards on with respect the launch direction?

   The axis is generally not critical especially with small boards.

3. What material should be used as a conformal coating on the PCBs?

   Conformal coating is generally not recommended except as an electrical insulator to prevent shorts in the event a piece of loose conductive material contacts the board. Conformal coating will not prevent out-gassing.

4. How well do through-hole PCBs hold up as compared to surface-mount?

   Through-hole PCBs have been the standard until recently when surface mount technology was developed. Both technologies have their own characteristic points of failure but if designed correctly, both are acceptable for use in satellites.

5. What is most likely to be damaged on a surface mount PCB during launch?

   Components with insufficient pad area or poor mounting are likely to fly off the board. Use a drop of epoxy beneath components to mechanically secure them. Make pads as large as possible. Testing using a shake table is mandatory.

6. Are there certain types of surface mount components that are known to have problems surviving a launch?

   None in particular, provided that the pads are large enough and they are properly secured to the board.

7. Should we be concerned about a failure of the actual copper traces on the PCB and, if so, what precautions should be taken to minimize a failure (i.e., trace width, board thickness, copper weight, number of layers)?

   Thickness: >0.062"
   Trace Width >10mil
   Trace Isolation >10mil
   Power and ground planes are mandatory to prevent ground bounce and should be the two center layers.
   Have one signal plane for horizontal traces and another for vertical on the outside layers.
   Do not use blind vias, it prohibits access to test points.
   Minimize trace lengths by intelligently placing components.
   Do not autoroute PCBs.
   Leave >20mil space between edge of board and any copper to prevent shorts.
   Avoid placing traces beneath components.
   Make traces as wide as possible.

8. Are there guidelines for determining acceptable PCB specifications?

   Refer to IPC275, MIL-STD-275, and MILP55110. I am currently attempting to obtain these specs.

9. Does most FR4 outgas?

   No. FR4 has been PCB material of choice for space missions and does not significantly outgas.

10. What type of wire should be used within the satellite?

    Choose a wire that has been designated "flight wire" for optimal results. The wire should have many strands, avoid high tin content (prevents 'tin whiskers'), and be careful with insulation materials such as Teflon, which can become displaced from the conductor (cold flow). Refer to MIL-STD-975, PPL15, PPL18.

11. What type of epoxy should be used to secure wire and sensors within the satellite?

    For our purposes, any two-part epoxy should work just fine.

12. What other precautions need to be taken to prevent wire connections within the satellite from failing during launch?

    Provide strain relief at connection points.

13. Should we be concerned about radiation damage on a mission of less than one-month duration?

    No, the probability of a radiation event that could cause damage is low for that mission duration.

14. What concerns should we have with regard to radiation damage on any mission?

    Certain technologies are susceptible to radiation. For long-term missions you can examine the odds of a radiation event occurring and you can reduce your risk by using non-susceptible technologies or radiation hardened products.

15. Are there any simple precautions that can be taken to reduce the effects of radiation on key components (i.e., EEPROM)?

    It's all about component selection. Fused link PROMs are not as susceptible as EEPROMs to single upset radiation damage.

16. Are there any consumer grade clock crystals that are known to survive launch conditions?

    Most types of crystals will survive launch. Make sure to test the specific crystal on a shake table prior to launch.

17. How well do the typical surface mount crystals survive launch conditions?

    There are no particular concerns with surface mount crystals.

18. Are specialized high durability crystals used or are there other alternatives?

    This should not be an issue. An off-the-shelf crystal should work in any application. Swept crystals are ideal, in that they are less susceptible to radiation.

19. What deployable antenna schemes seem to yield the best results and have the least chance of failure?

    Carpenter tape style antennas have worked well in the past.

20. Have compact, non-deployable antennas ever been tested or successfully used on a picosat mission?

Patch antennas were used on the picosat that were etched from copper clad FR4. They had very poor gain though.

21. What are the five most common points of failure in a picosat?

    Mechanical failure has occurred on sliding surfaces (i.e. during testing, a picosat welded itself to the deployer due to vibration and the failure of a protective coating called Dichronite. It is recommended that all sliding surfaces be hard-anodized and then coated with Hard Tuff E20. Other isolated failures have resulted from poor design.

22. What, if anything, can be done to prevent temperature extremes within the cube or reduce the extent of thermal cycling?

    Thermally isolate electronics from cube to prevent conduction of heat both into the electronics and out.

23. Are there any tricks, tips, or precautions in the assembly of a surface mount PCB in order to maximize its durability?

    Place a small amount of epoxy beneath each component during assembly.

24. How do conformal coatings affect the heat dissipation of components?

    Unanswered.

25. What components need to be hermetically sealed?

    None in particular.

26. What material should be used to adhere solar panels to aluminum?

    Flight approved (low-volatility) silicone. Torrseal is a hard epoxy that works well. Flight approved silicone can be used as a flexible adhesive.

27. How are picosat solar panels generally constructed?

    No answer.

28. What kind of solder is used to make connections directly to silicon solar cells?

    Use a conductive epoxy to attach leads. Kapton rigid flex with conductive traces can be used in place of wire.

29. Are space rated solar cells commercially available?

    Don't worry about whether the cells are space rated for relatively short missions.

30. What techniques have been used to deploy picosat antennas on past missions?

    Hot wire, electro/thermo wax actuator, devices relying on sublimation (moth balls).

31. What type of thread-lock compound should be used?

    Some variety of Loctite has been used before. (no details available as to type)

32. What types of polymers are acceptable for space use, and which are generally not?

    Any polymer that does not outgas significantly is acceptable. Aerospace Corporation used Delrin in their picosat

33. Does nylon degrade in space, and if so, what causes the degradation?

    Nylon is not known to degrade under vacuum. Nylon has been used as structural parts on previous missions.

Notes: They recommended that the assembled cube be milled to final tolerances and that the parts should be indexed so that the parts are always reassembled the same way in which they were milled.

They see Kapton as a good material, specifically in making flex connections, and for other applications as well.

Delrin was used for the shock-mounting and thermal isolation within their picosat.

If possible, take steps to increase radar visibility to enable tracking of satellite by NORAD. Their picosat wasted a large part of its power source when it beaconed for three days because it could not be located to command the beacon off.

It would be helpful to measure the exit velocity of the satellites from the deployer to aid in initial tracking.

Watchdog timers should be used as the first line of defense against microprocessor latch-up. Additionally, it was suggested that the current consumption could be monitored and the processor reset upon over-current detection.