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Xtreme Outer Space Boards

Written by Robert Tarzwell

The information in this book is current to March 2009. As material specifications and manufacturing practices change and evolve, please ensure you are using up to date information.

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One of the most amazing things I have seen Robert Tarzwell do, and there are many, is the day he told the owner of a twenty million dollar board shop that he could take a walk through his shop and come up with savings of at least half a million dollars. The owner took him up on his challenge. Bob walked through the shop and came up with a list of things that the owner could do to save money; all in about an hour's time frame. A few months later when I was again talking to that owner I asked him if he had ever followed any of Bob's suggestions from the walk that day. *"Oh yes,'* he answered with enthusiasm, *"We took all of them and the only thing he was wrong about was that we actually are realizing savings larger than he predicted."*

Bob Tarzwell is truly one of the Printed Circuit Board industry's technology gurus. With his grasp of today's technology and his insight into the technologies of tomorrow, he is the real "go-to" person for anyone who is looking for the right direction to take their company. Bob has that unique ability to take very complicated problems and come up with elegant and seemingly simple solutions. Whether you are talking about learning how to produce the absolutely best four layer board in the most cost efficient way possible, or talking about fabricating a circuit board with one mil lines and spacing, Bob is literally the only person in the industry that I know of who can get it done.

Not being technical myself, Bob is the person I go to when I am working with a client who has a new technology and I need it explained to me. Bob will talk to the client for me and then come back and explain the technology in way that makes it so clear to me that I not only understand it but then can proceed to do my job of helping the client sell it. There are not many people who can do that.

As A Wang once said, *"The true sign of a genius is someone who can take something very complicated and make it simple enough for everyone to understand."* And this surely applies to Bob Tarzwell.

Dan Beaulieu
President
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Chapter 1

Overview of Xtreme Outer Space Boards

Many potential problems face a printed circuit board in a spacecraft orbiting our world. The first problem to design around is vibration; at take off the G loading can exceed 100 Gs with many large instantaneous vibration peaks hitting 1000Gs. The vibration is severe and constant for 5 to 10 minutes. For the designer a serious shaker table research program will be needed to properly ensure a large safety margin.

Second, the wide variation in temperature extremes can be very detrimental to a printed circuit card and its components which means, we need to improve the reliability of the vias and laminate. Design parameters such as expected min and max temperature excursions as well as number of expected cycles need serious consideration. Most circuitry is protected with special ceramic insulation and gold foils, to reduce the temperature swings however even then the temperature can vary widely.

Additional problems await the printed circuit in space, the vacuum will cause the board to continue expelling volatiles. These volatiles are accelerated (17,000 miles per hour) by the high voltage plasma fields and can easily damage sensitive optical pieces or other parts of the craft. It has been recorded in the 80’s that out gassed particles from a PCB board went right through a chip and damaged the space craft.

When I made boards for outer space work, I selected the prepreg for maximum glass content to limit the amount of out gassing epoxy glue used. The laminate material was also selected for minimum out gassing properties; I found BT epoxy one of the lowest for out gassing while still having good process ability factors. Also I use the Metcron series 1755 and 1566 from Panasonic,

The cores and boards were processed through a special manufacturing process to remove the volatiles and significantly reduce out gassing. To limit moisture absorption by the finished PCB during shipping and storage the boards must be sealed in vacuum packed sulfur free plastic and shipped.

One of the most significant problems facing today's space circuits is the destruction of the dielectric material from plasma and corona. As the spacecraft orbits the earth it cuts magnetic lines of force very quickly, generating very significant voltages on the spacecrafts skin and components.

Since plasma interactions generally result in vehicle surfaces charging negatively, an intense ion bombardment and sputtering of the metal results. Spacecraft surfaces usually consist of thermally controlled coatings that also serve as poor electrical conductors. The most common outer material is anodized aluminum, which is subject to dielectric breakdown. Anodized aluminum does not create an effective faraday shield to properly dissipate the large voltage potential generated by the spacecraft.

Because the aluminum skin allows a high voltage e field to develop inside the spacecraft any high field points will generate a corona. If the voltage field is high enough, particles in the environment will be disrupted and possibly expelled with significant force and speed to penetrate components and damage the silicon chips. Several satellites have been lost this way during periods of extreme solar flares. The radiation generated by this large E signature field is significantly strong enough to cause particle type acceleration to amazing speeds.

Special shielding and artificial atmosphere may be needed to control the field generated. As the pressure is lowered to 0 Torr levels voltage arc or corona is generated at a very low level of 40 Volts/mil

The potential for an arc is catastrophic in a spacecraft; the large lightweight tanks of hydrogen and oxygen have a potential problem of modular leakage. This leakage, when combined with corona or an arc, can cause the spectacular destruction of the spacecraft.

N.A.S.A. has learned by hundreds of thousand of hours of detailed research experiments, and from hands on, standard design practices developed over years of operation. N.A.S.A and thee sub contractors have a very detailed and stringent set of specifications to pass to qualify for outer space PCB.

Power supplies in outer space of 100 Volts are considered high voltage with the potential to arc or corona due to the low atmospheric pressure and the plasma fields which may surround it.

If you are designing or manufacturing a circuit for space application I strongly suggest you spend time with the aerospace boys and girls to find out as much as you can about the expected environment and conditions to properly ensure a large safety margin.

To assist in passing out gassing tests or to lower the figure even further we need to clean the edge of the board, to remove nay small partial off the edge I take 600 grit sand paper and sand the edges smooth, then wipe with IPA, twice. The sanding eliminates before the test any fine whiskers and fiber acquired during processing. Note this also works for flame test for UL approval, I always sand the edges and round the sharp points before sending a sample to UL.

Chapter 2

Manufacturing Xtreme Outer Space Boards.

For all the secrets in manufacturing outer space low out gassing PCB buy my book

Xtream outer space boards