

# MODULAR DEVICES INC

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## COTS solutions will be required for space power conversion

The present day average cost required to launch payloads into Earth orbit has been estimated to be in the \$10,000 per pound category. Reducing this cost to the \$100 per pound range has been a long time goal of many programs. This goal has not been achieved by any government sponsored programs. However, it is likely that breakthroughs may occur in the private sector, spurred by the Ansari X prize competition and like efforts.

Budgetary estimates for the present cost per pound of space qualified, radiation hardened DC/DC converters range from \$25,000 to \$100,000 per pound. This cost is not a major concern, given the high launch costs and the low hardware quantities. But how will the picture change if launch costs drop by two or three orders of magnitude?

If the long held dream of reasonable launch costs does come to fruition, there will be an overwhelming motivation by end users to commensurately reduce the cost of space capable power conversion components. This will also be aided by the increased unit quantities that lower launch costs will engender.

Radiation hardened DC/DC converters are assemblies of active and passive components. Although they may be built using 1970's style discrete techniques, most present day DC/DC converters are built as thick film hybrids or as surface mount assemblies. When designing this type of DC/DC converter, the design engineer relies on data

bases or RLAT (Radiation Lot Acceptance Tests) for knowledge about how the characteristics of the active piece part components move when total ionizing dose (radiation) is accumulating.

The design engineer must have complete knowledge of how the various parameters of each individual piece part vary when irradiated. This design method using the accumulated knowledge embodied in the results of previous data base tests and radiation lot acceptance testing must be followed regardless of whether the price of the piece parts are expensive or inexpensive.

Unfortunately, there is a built in propensity for this design process to select for expensive parts. In turn, these expensive parts result in expensive assemblies. How does this happen?

It happens in part because the people conducting radiation tests on components are, for the most part, not the same people who design the circuits that use the piece parts.

Many government and university facilities perform radiation tests on electronic components proposed for use in space. The results of these tests are then published or also appear in data bases accessible on the web.

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An examination of representative test results shows the detailed test conditions, test circuits and initial and final performance parameters. In almost every case, the pass/fail criteria are identical to the manufacturer's maximum data sheet limits for un-radiated parts.

Several companies offer the service of performing radiation lot acceptance tests on a commercial basis. Unless the customer provides specific test circuits and acceptance criteria, tested parts are also evaluated to the manufacturer's maximum data sheet limits for un-radiated parts.

The consequence of this testing methodology is that many candidate parts are unnecessarily eliminated from the circuit design engineer's consideration because existing data bases or RLAT tests give the often mistaken impression that the parts are unusable at the required radiation levels.

Many of the component types with "high marks" on the data bases or RLAT tests are parts that have been specifically designed to have minimal parametric shifts in the face of radiation effects. Unfortunately, these explicitly radiation hard parts tend to be produced in low volumes and have corresponding high costs.

If only the circuit design engineer had access to test results that showed results over a wider range, than just the manufacturer's maximum data sheet values. Of course, some part types will be non-functional at some point, but

many, many component types will still be functional, with degraded parameters.

This shows a path to achieving lower costs for radiation hardened DC/DC converters. Careful circuit design techniques, supported by a more inclusive radiation test methodology, will permit the circuit design engineer to overcome the parametric shifts of COTS type components to produce reliable results.

## Design Example:

Several years ago, Modular Devices, Inc. was contacted by physicists who were designing instrumentation for the Large Hadron Collider at CERN. They needed DC/DC converters that could operate in close proximity to the particle beam for many years. Since their instrument had many, many detection channels, a large number (approximately 2000) of DC/DC converters were required.

The radiation requirements were severe. However, the use of components with manufacturer's explicit radiation hardened performance was out of the question due to tight cost constraints.

A DC/DC converter module was designed at the 250 watt level. The low power control and regulation circuits were adapted from circuitry contained in MDI's radiation hardened hybrid DC/DC converter line. A highly efficient power stage was developed that incorporated planar magnetics. For the power switching function, a clamped topology was selected, allowing tight control of the FET drain to source voltages. A very large derating factor

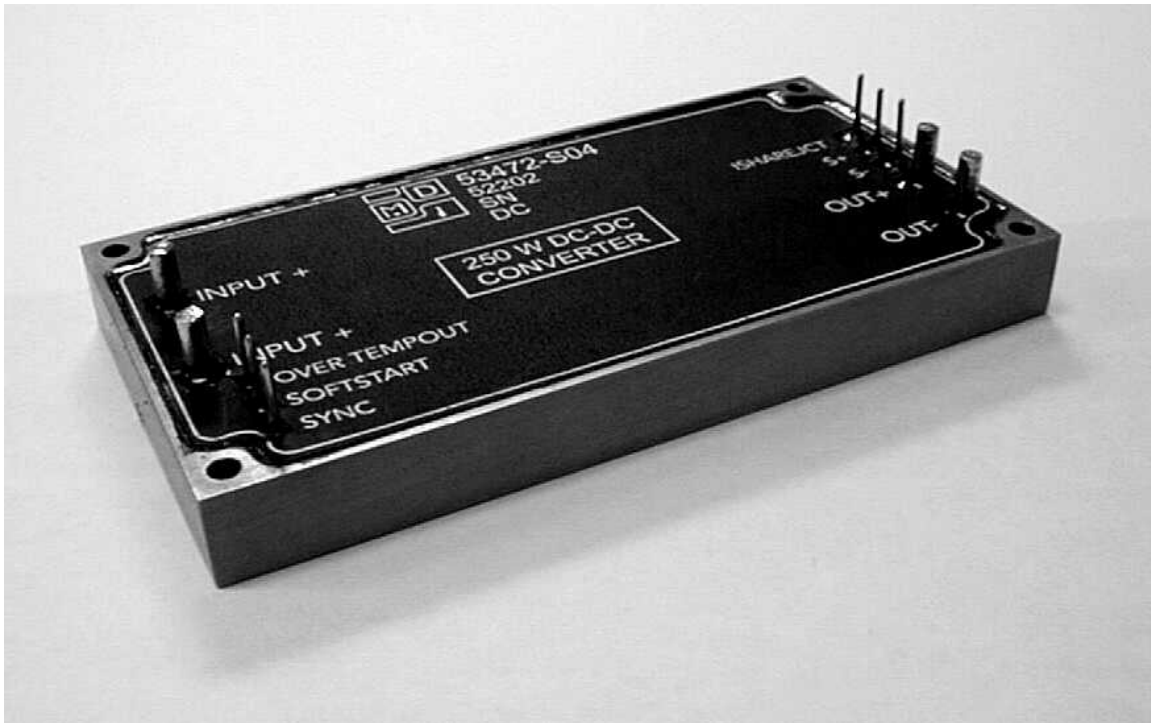
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was used in the selection of the FETs, allowing commercial FETs to withstand the single event effects of energetic particles.

The key components were radiation qualified by RLAT testing prior to use.

The modules were constructed with commercial techniques, on an aluminum clad board. The completed assembly was packaged in a housing, then encapsulated.



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The COTS radiation hardened module met the following parameters:

Cobalt 60 Total Ionizing Dose            300  
kRads

Neutron Fluence  
                   $2 \times 10^{14}$  neutrons per CM  
squared

SEU (protons)  
                   $1.33 \times 10^{12}$  protons per CM  
squared

(158 MEV protons)

## Conclusion

The involvement of the private sector in reducing transportation costs to space will ultimately bring about a dramatic reduction in the cost per pound of reaching earth orbit. This will then motivate the need for orders of magnitude reductions in the cost of all space capable electronic equipment, including DC/DC converters.

COTS components can be used to design and fabricate cost effective radiation hardened DC/DC converters. This has been demonstrated with actual production hardware.

To facilitate the use of COTS components, private industry, government agencies and universities doing radiation evaluations should test component parts to functional failure, not just to pre-radiation data sheet limits.

Circuit design engineers, assisted by computer circuit simulation, can then design DC/DC converter circuits that overcome the parametric component degradation caused by the radiation environment in space.