Test Synopsis for Optical Networks Inc. Parallel Fiber Optic Data Bus (PFODB)  
Proton SEE and Dose/Damage test at UCDavis Feb 4-5, 1998

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INTRODUCTION
The objective of this test was to perform proton single event effect (SEE) and total ionizing dose/radiation damage characterization of a novel Parallel Fiber Optic Data Bus (PFODB) developed under a NASA SBIR by Optical Networks Inc. The PFODB is a 12-wide fiber optic link (i.e., 12x12 parallel configuration) with a maximum throughput per channel of 125 Mbps (limited by a PECL IC in the transmitter circuit and not by the optical components). Thus, a maximum aggregate system bandwidth of over 1 Gbps is possible. The link operates at 1300nm utilizing a laser in its transmitter circuit and a III-V based detector in its receiver.

Testing was being performed to two spaceflight requirement levels:
- the New Millenium Programs Earth Observer 1 (EO-1) which has a 30 krad(Si) requirement, and
- a generic level of near 100 krad(Si).

We will not discuss dose equivalence for ionizing and non-ionizing contributions. Dose discusses herein will be for ionizing equivalents of tested proton fluences.

TEST DESCRIPTION
There are 2 cards per system (transmitter - T and receiver - R). We counted bit errors on individual channels (links) during testing as well as tracking power supply current consumption.

Testing was performed with a Naval Research Laboratory (NRL) –based test setup utilizing BCP bit error rate (BER) test equipment. Pseudo-random data was utilized.

One should note that by changing Vcc for the transmitter laser, the optical power output would change accordingly (lower Vcc = lower optical output power). The majority of the testing was performed with a nominal power output.

Two test boards were utilized, each containing receivers and transmitters. Brief board information is cited below.

<table>
<thead>
<tr>
<th>Board #</th>
<th>Mfr</th>
<th>Part #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2</td>
<td>Optivision</td>
<td>PFORX12</td>
<td>Receiver</td>
</tr>
<tr>
<td>1,2</td>
<td>Optivision</td>
<td>PFOTX12</td>
<td>Transmitter</td>
</tr>
</tbody>
</table>

Note: there is also a BiCMOS logic device on the transmitter board that was explored for it’s characteristics.

   TI   SN74ABT16244ADL

All tests were performed with the board at normal incidence to the beam line and at the prime incident proton energy of 62.5 MeV.

TEST FACILITY
Testing was performed at the University of California at Davis Crocker Nuclear Laboratory (CNL). Prime energy of 62.5 MeV external to the device package was utilized.

Proton flux: 2E8-1E9 p/cm2/sec  
Proton fluence: 1E10-2.2E11 p/cm2/test run.
TEST RESULTS – Optical modules
For the EO-1 level,
- no bit errors were observed when 30 krad(Si) of protons was placed on either the transmitter or receiver portions of the PFODB. Icc also remained at nominal levels.

For the generic level after ~85 krad(Si) exposure of the receiver, two items should be noted:
- Icc for the receiver test board had increased by 1.4 mA., and
- Several “bursts” or clusters of bit errors occurred. This phenomenon is unexplained at this time, but only occurred while the device was being irradiated. Devices appeared to be functional at 100 krad(Si).

Reducing the laser power output, did not affect the measured number of bit errors (i.e., as long as the optical link margin was above threshold, the BER was nominal).

TEST RESULTS – TI ABT logic
Testing was only performed to the 30 krad(Si) level. No apparent system degradation was noted, however two bursts of errors were noted. The receiver under use at the time had been irradiated with 100 krad(Si) and is more than likely the cause of the errors. Previous heavy ion testing on similar technology ABT logic family devices showed a threshold linear energy transfer (LET) indicating no proton SEE sensitivity.

CONCLUSIONS
For EO-1, we recommend usage of this system for its proton SEE and dose/damage characteristics.

For generic usage, we recommend the PFODB usage with a slight reservation due to the burst error anomaly from the receiver after 85 krad(Si) irradiation. Further analysis and/or testing is recommended.

ACKNOWLEDGEMENTS
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