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IN REPLY REFER TO
3910
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From: Commander, Dahlgren Division, Naval Surface Warfare Center
To: Commander, Program Executive Office Aircraft Carriers (PMS312E)

Subj: CLARIFICATION ABOUT THE HISTORY AND USE OF THE NAVY FIBER OPTIC POWER (LOSS) BUDGET 3DB SAFETY MARGIN

Ref: (a) MIL-STD-2052A - FIBER OPTIC SYSTEMS DESIGN

1. Purpose. This letter is in response to the Carrier Network Working Group Action Item #09-B3 to provide the technical criteria used to establish the 3dB Safety Margin required in reference (a).

2. Background. Reference (a) provides detailed information, guidelines, procedures, and requirements for selecting and using fiber optic components to transmit fiber optic signals in Navy systems. Reference (a) is a standard practice that identifies the considerations used in the selection of the specific Navy fiber optic components and the performance of those components in the surface ship and submarine environments. Furthermore, reference (a) is the standard practice that provides detailed explanations of the fiber optic system design procedures. The power (loss) budget for fiber optic links included in reference (a) is briefly listed below:

a. Section 5.5 of reference (a) details methods for the calculation of a power (loss) budget for a fiber optic link. The methods discussed allow a system designer to evaluate the tradeoffs among the system link length, type of connections, number of connections, cable loss, and different transmitter and receiver combinations. The purpose of a loss budget is to ensure that sufficient optical power is delivered to the receiver over the anticipated life of the system.

b. Two methods of calculating a power (loss) budget for a fiber optic link are worse case and statistical. Both methods require the use of a safety margin for unexpected losses in the system link. The value utilized for the safety margin for either the worse case or statistical design for both Navy tactical and non-tactical applications shall be 3dB.

3. History of the Safety Margin. The history of the optical power (loss) budget safety margin included in reference (a) is described in the itemized list below.

a. Originally, and prior to the development of MIL-STD-2052, fiber optic industry recommended at least a 3dB safety margin. In technical papers and fiber optic design literature from the 1980s, the use of the 3dB was very prevalent. This gave rise to industry standards under the Telecommunications Industry Association (TIA), which called out the 3dB safety margin requirement (e.g., the original TIA-559).

b. At the same time industry standards were requiring the 3dB safety margin, the Department of Defense standardized on a requirement for a 10dB safety margin for tactical systems and a 6dB safety margin for non-tactical systems, which was documented in MIL-STD-188-111. Although MIL-STD-188-111 was intended for the Army's tactical ground-based data links, it served as the example for Navy shipboard tactical applications since the underlying logic and the complexities of the links were not that dissimilar.

c. In the late 1980s, TIA initiated an effort to bring together a comprehensive set of fiber optic design standards and completed the first one, TIA-526, in the early 1990s. TIA-526 served as the basis for the MIL-STD-2052. TIA-526 includes the 3dB safety margin requirement. Working in parallel, the Army reevaluated the margin requirements in MIL-STD-188-111 and also moved to the 3dB safety margin requirement.

d. Based on the maturity of the technology, the Navy also supported the move to the 3dB safety margin value for tactical and non-tactical systems and documented this in MIL-STD-2052. At the time, the Navy recognized that the 3dB safety margin would not be sufficient to cover all potential link anomalies in the worst case, but the 3dB value represented an acceptable risk to system non-availability.

4. What is Included in the 3dB Safety Margin? The following is not an exhaustive list of unexpected losses that are not directly included in the power budget, but the safety margin is expected to provide coverage of these and other sources of error. (NOTE: Not all of these issues are expected to occur at the same time, but combinations of these effects could be greater than the 3dB safety margin value currently required in MIL-STD-2052).

a. Passive device (connector) aging - Navy studies have shown up to 0.5dB degradation in connection losses over a full lifespan.

b. Optical fiber cable aging - minimal degradation, but nonzero.

c. Out of specification passive components - e.g., connection degradations due to dirt, wear, etc., that are correctable in the long term but present in fielded systems at any particular time.

d. Non-nominal power penalties induced by fiber optic receiver circuitry. Individual receivers can show optical power penalties in excess of those predicted by the power penalty models and can cause up to 1dB of optical loss.

e. Power penalty errors due to anomalous optical fiber bandwidth responses, especially for Navy fibers manufactured before 2004.

f. Optical link penalties not explicitly included in the optical power budget - depends on the specific technologies as the power budget calculations include (or exclude) specific penalties for specific technologies.

g. Environmental degradations in excess of the statistical environmental margin included in the power budget.

5. The Continued Use of the 3dB Safety Margin. The use of the 3dB safety margin is still recognized today as a sufficient safety margin value for Navy tactical and non-tactical systems. The 3dB safety margin is essentially a statistical representation of unexpected events that may occur during the life of the fiber optic system that cannot be accounted for in the optical power budget itself. Since many of the issues that the 3dB safety margin covers could certainly exceed 3dB, reducing this value is not viable for the Navy, even with technology advances. In order to reduce the safety margin further, the Navy would have to start explicitly budgeting for additional link degradations. Since there is not enough optical power available in the power budgets, performing explicit budgeting is not possible. The safety margin relies on statistics to average out all the additional degradations, such that they can be covered by the 3dB safety margin.

6. If you have any questions, please contact Mr. Michael S. Brown at (540)653-0626, michael.s.brown4@navy.mil or Mr. Robert Throm at (540)653-4203, robert.throm@navy.mil.

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