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NAVSO P-3641: Navy Power Supply Reliability Design & Mfg Guidelines (NAVMAT P4855-1)

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4.6 ENVIRONMENTAL STRESS SCREENING

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There is a very large database which clearly indicates that subjecting electronic hardware to thermal cycling and random vibration is a very effective method of eliminating workmanship and component defects and providing the ultimate user with very reliable equipment. See Reference 30. This process has been defined as Environmental Stress Screening (ESS). A case history of the thermal cycle screen and resultant measured reliability of a high- reliability, low-voltage power supply is presented in "Thermal Cycle Screening of Militarized Power Supplies." See Reference 25.

RECOMMENDED ESS PROCEDURE

The minimal requirements for performing ESS on power supplies should be implemented in the following sequence:

(1) Parametric testing

(2) Random vibration with continuous monitoring

(3) Thermal cycling with continuous monitoring

(4) 100% parametric testing per the customer Acceptance Test Procedure (ATP).

The above ESS process applies to all low-voltage power supplies and high-voltage power supplies. High-voltage power supplies should be subjected to the additional ESS detailed in Section 5.5 of this publication.

RANDOM VIBRATION

There are two general types of random vibration recognized for the screening process; i.e., pure random and pseudo or quasi-random. Either type is acceptable. Random vibration should be done prior to performing the thermal cycle portion of ESS. The power supply should be operational, fully loaded (resistive) and continuously monitored. The profile and levels of the random vibration are approximately 6 grams (guidelines are provided in NAVMAT P-9492). The power spectral density versus frequency is illustrated in that publication. The vibration should be applied to a minimum of two axes for 10 minutes per axis. At least one of the axes should be perpendicular to the plane of any PWB/MIBs in the power supply.

The data gathered during random vibration screening of militarized digital avionics, and used in the development of these requirements, was examined in "Random Vibration Screening of Six Militarized Avionic Computers." See Reference 26. A comprehensive guide to ESS is provided by "Environmental Stress Screening for Assemblies." See Reference 27.

THERMAL CYCLING

Twelve thermal cycles are required in accordance with the profile in Figure 4-1. The last two cycles must be failure-free. The temperature limits are:

(1) High Temperature

The chamber ambient conditions should be such that the average temperature measured at the surface of the components of the power supply is a maximum temperature of +55ºC during fully operational (power-on) conditions.

(2) Low Temperature

The chamber ambient conditions should be such that the average temperature measured at the surface of the components of the power supply is a minimum temperature of -55ºC with the power off.

(3) Thermal Rate of Change

The average rate of change of temperature at the surface of the components should be at least 5ºC per minute, with 15ºC per minute providing optimum results.

(4) Thermal Stability

The power supply should be considered to have reached thermal stability at the high- or low-temperature portions of the thermal cycle when the component with the greatest thermal inertia has a rate of change of less than 5ºC per hour, or is within 5ºC of the ambient temperature of the chamber. To achieve this stability in as short a time as possible, the cooling fans should operate continuously during the cool-down part of the cycle.

In order to validate that the above thermal conditions are achieved, a thermal survey should be performed under the required temperature and duty cycle to identify the component of greatest thermal inertia and establish the time/temperature relationship between it and the chamber air.

The 3-hour thermal cycle shown in Figure 4-1 is a typical example for power supplies. The power supply should be turned on (energized) under full load (characterized) conditions at the start of the temperature transition from low to high temperature; this is defined as the cold-start condition. Except for planned on/off cycling lasting no more than a few minutes, the power supply should then be operated continuously until thermal stability is reached. During the transition from high to low temperature the power supply should be turned off and remain de-energized until the start of the transition from low to high temperature.

Provision for ESS temperature ranges should be incorporated in the design specification. For the purpose of ESS, it is required that the power supplies be turned on at the end of the cold soak period of the thermal cycle. This provides the maximum thermal shock and stimulates the failure of weak components and elements. It has been observed that most failure mechanisms occur during the transition, with power on, from low to high temperature. The power supply would not be expected to operate within its performance criteria until its temperature rises above that specified for power-on operating conditions by the customer specification.

The power supply should be turned off for no less than one minute, at least four times during the thermal cycle: twice when the chamber ambient is between low temperature and 0ºC, and twice at high temperature after thermal stability has been reached. The input power should be applied and removed in an abrupt manner, as by a relay or mechanical switch.

POWER SUPPLY LOADING

Each output of a power supply should have a static (characterized) load equal to the maximum rated load. This load should be applied to the power supply during all ESS.

SPARES

Power supplies and/or their assemblies that are delivered as spares should be subjected to the same ESS as the original assemblies.

FAILURE DATA AND CORRECTIVE ACTION

A reliability program should be implemented to collect and analyze the data from ESS, determine the failure mechanism and implement corrective action.

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