DC Power Supply Reliability

Validating the MTBF Requirement

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One of the most widely used figures of merit when comparing the reliability of industrial DC power supplies is MTBF (Mean Time Between Failures). A power supply with a higher MTBF number stated on the specification sheet may be chosen over a competitor due to a perceived improvement in reliability. This notion can be far from the actual truth. Demonstrating the MTBF through actual field or experimental test data makes the calculated MTBF more plausible. This paper will examine the methods that can be used to correlate MTBF test data with the calculated values.

MTBF - Mean Time Between Failures
MTTF - Mean Time To Failure
DMTBF - Demonstrated Mean Time Between Failures

Test Methods

MTBF - The accumulation of field data is the most realistic way to determine an MTBF since actual product information is used, but it is not without its limitations. Given the many variables in gathering the product failures, the actual field returns data may not be accurately tracked resulting in incorrect MTBF data. Also, sufficient field return data for MTBF analysis can take months after the product is released.

DMTBF - Another statistical method that is based on a reliability model using an extended life test. The extended life test, known as DMTBF, verifies the MTBF calculation using cumulative life testing with the test conditions of the original MTBF calculation. The cumulative testing of a number of units accelerates the MTBF verification process. If the product is reliable, the DMTBF will result in data that closely tracks or may even surpass the published MTBF numbers. The latest compact, high efficiency SolaHD power supply designs use the statistical method of DMTBF during the product design verification test process.

Accelerated DMTBF - A method based on the extended life model accelerates the DMTBF testing by using more complex statistical methods. Utilizing high temperatures with load and power cycling accelerates basic extended life test duration.

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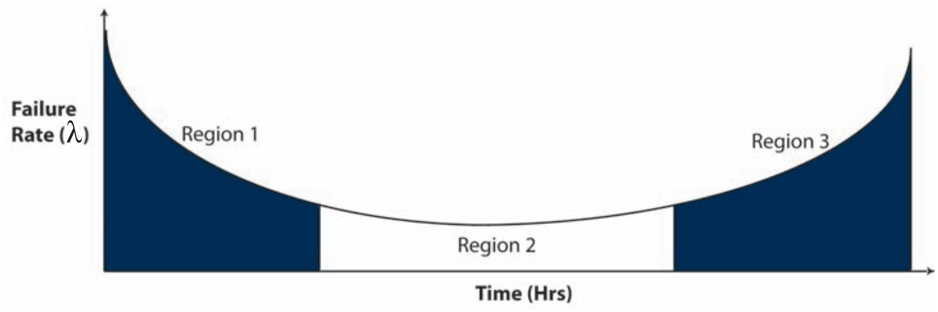
Reliability "Bathtub Curve"

Before presenting the extended life test process, lets review a few of the MTBF fundamentals. The most widely published reliability curve is known as the "bathtub" curve. This curve is made up of three regions that visually represents specific time lines for product reliability.



Region#1 represents the early failure rates of the product. These failures can be attributed to manufacturing defects, component defects, etc. Factory burn in processes will typically trap any of these defects before product is shipped to the customer.

The last region of the curve, Region#3, represents the wear out time of the product. It is at this stage in a products' life cycle where it no longer or minimally performs its intended function. This end of life point in a power supply can be due to the finite life of electrolytic capacitors or just accumulated product stress.

Region#2 represents the operating life of the product. Here is where the MTBF calculations apply. Another term commonly applied to this region relates to the Mean Time To Failure or MTTF. It can be shown that if the area under the curve in Region#2 has a constant failure rate, both MTTF and MTBF are equal. The MTBF term will be used in this paper.

MTBF Calculation

MIL217 and Bellcore methods use the statistical tools developed with component failure models. To obtain the initial MTBF, choose a calculation method based on the products requirements. Component data, ambient temperature, environmental conditions, operational stresses and operating voltages input into the MTBF tool. Once all of the individual component stresses are considered, MTBF can be calculated.

The result may vary based on the MTBF tool utilized. The MIL217 calculations often result in a lower MTBF than the Bellcore method. This is due to the more stringent military requirements where as the Bellcore method is based on commercially available components. Users may also modify the base failure rate levels according to their field experience which can result in enhanced MTBF numbers. When comparing various power supply calculations, its important to understand the methology used before comparing MTBF numbers.

Reliability Equation

The formula used in calculating a products' useful lifetime is:

λ rate
F in time (usually expressed as % failures
0 hours)

$R(t) = \exp(-\lambda t)$ where: $R(t) = 1-$ failure rate
$\lambda = 1/MTBF$
$t =$ operating time

This equation is based on an exponential distribution of a constant failure rate over a specified useful life. The specified useful life is the MTBF.

As an example, when t = MTBF, then R(t) = 0.368 or 36.8% (which means that with an operating time equal to the MTBF, a power supply will have a survival rate of 36.8%). Statistical testing strategies make use of the reliability equation and its derivatives to calculate and predict a products' useful life.

Extended Life Testing

SolaHD has chosen to use extended life testing with its latest high power density DIN rail mounted power supply designs. These additional tests are intended to provide confidence in the accurancy of the calculated MTBF number.

The extended life tests require a discrete number of units operated for a specific period of time that is determined by the power supply's useful life specification, typically the warranty period, and the calculated MTBF. All of the power supplies are operated under the same conditions.

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As an example, using the reliability equation with t = 5 years (43,200 hours) and an MTBF of 500,000 hours, one calculates the probability of a power supply's survival as 91.61% or as an FIT of .192%/1000 hours. Using the 91.61% survival rate and substituting nt for t in the reliability equation, one can calculate the number (n) of power supplies required for a test time (t) with an MTBF of 500,000 hours. If we want to accumulate the data over a test time of 3 months or 2,160 hours, a sample size of 20 power supplies will have to be used.

The latest high power density offerings from SolaHD were subjected to an extended life testing program. A number of units were powered up for several months and monitored for abnormal operation. After the test period, we are now able to conclude with 95% confidence that the calculated MTBF number is accurate.

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Other DMTBF Test Methods

To further accelerate the DMTBF process, one can operate the power supplies at an elevated temperature with power and load cycling. To allow for the statistical nature of the accelerated life tests, the reliability equation must be modified to include the probabilistic nature of the resulting data distribution. Thermal, power cycling and load stresses are accounted for with multiplicative coefficients applied to the reliability equation. The calculation of the required number of test units follows the previous example given for the extended life testing process. SolaHD is presently considering DMTBF test strategies that accelerate its reliability testing process.

SolaHD SDN-C

Conclusion

As DIN rail power supplies become more complex due to market demands for higher power density and increased efficiencies, the extended life testing methods become an important barometer in gauging the reliability of these products. SolaHD recognizes these trends in the power supply market and has established test guidelines within its design groups to ensure that the customer receives a highly reliable product. SolaHD has conducted DMTBF tests on its high power density SDN power supply series that have validated the MTBF calculations. If reliability is important, always insist on the DMTBF number as a basis for comparison.

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