Interpretation of MTBF

Abstract: A widely used measure of product reliability is Mean Time Between Failure (MTBF). This is often used to compare the reliability of similar products from different vendors. However, MTBF is often not well understood and incorrect assumptions can lead to inaccurate conclusions. This paper discusses how to calculate and then interpret MTBF figures. It also gives the reader an insight into what to look for when comparing published MTBF figures from alternate vendors.

Calculation of MTBF:

To obtain the initial MTBF, choose a method based on the products requirements. This is typically a database of failure rates for various components. Component data, ambient temperature, environmental conditions, operational stresses and operating voltages can all be used to establish the failure rate for each component. Once all of the individual component stresses are considered, MTBF can be calculated. This is achieved by taking the accumulated failure rates for each component on your design. The result will vary based on the MTBF tool utilized. For example the MIL217 calculations often result in a lower MTBF to other methods. This is due to the more stringent military requirements, and higher failure rates applied. Users may also modify the base failure rate levels according to their field experience, which can result in a different MTBF number.

How to interpret a published MTBF figure:

Many will interpret that MTBF as the number of operating hours that will elapse before a unit fails. But this is not the case. It is the inverse of the failure rate.

So if we start with this definition, then

$$\mathbf{m} = \frac{\mathbf{1}}{\boldsymbol{\lambda}} \qquad \textbf{Equation (1)}$$

We can determine that

$$R_{(t)} = e^{-\lambda t} = e^{-\frac{t}{m}} \qquad \textbf{Equation (2)}$$

where
- $\mathbf{R_{(t)}}$ = reliability
- $\mathbf{e}$ = exponential (2.718)
- $\boldsymbol{\lambda}$ = failure rate
- $\mathbf{m}$ = MTBF

Thus

$$m = \frac{t}{\log_n\left(\frac{1}{R_{(t)}}\right)} \qquad \textbf{Equation (3)}$$

When **t/m = 1** i.e., after a time "**t**", numerically equal to the MTBF figure "**m**":

$$\mathbf{R_{(t)} = e^{-1} = 0.37} \qquad \textbf{Equation (4)}$$

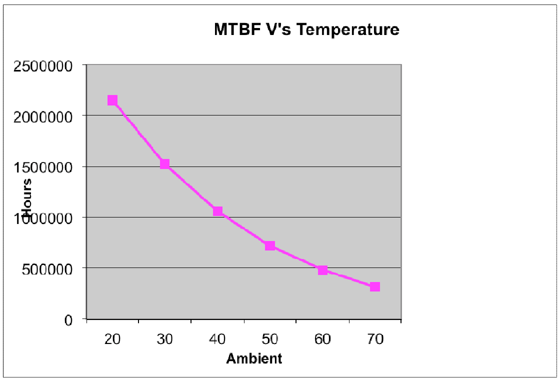
Equation (4) should be interpreted as follows:

- If a large number of units are considered, 37% of them will survive for as long as the published MTBF figure.
- For a single unit, the probability that it will work for as long as its MTBF figure, is 37%

Comparing MTBF's:

When comparing various MTBF calculations, it is important to understand the method that was applied. Ensure that you compare the database from which the failure rates are applied. Also review the operating conditions such as ambient and environmental conditions. Any changes in these will have a radical impact on the end figure (a decrease of 10°C ambient will result in the MTBF increasing by a factor of up the 2.5). Ensure that the conditions on which the MTBF figure has been calculated are identical, or you may misinterpret the results. MTBF is largely based on assumptions and definition of failure and attention to these details are paramount to proper interpretation.

Reliability will most often be specified in terms of Mean Time Between Failure (MTBF), with values extending up into the millions of hours. Equally important is the converter ambient or case temperature at which the specification applies. This number will vary from supplier to supplier. The actual converter reliability you will experience has a very strong dependence on the operating temperature in your system, as shown in Fig. 2.8. Consequently, you must adjust the published reliability data to reflect the operating conditions in your system before you have any meaningful projection of the actual expected reliability. The chapters on thermal design and reliability will assist with this process.



When selecting a converter and its supplier, it is important to understand the basis for their published reliability data. Some suppliers use test data such as field history or accelerated life tests. Others will use one of the generally accepted prediction methodologies such as MIL-HDBK, BelCore, internal component databases or comparison with similar models. All of these approaches can result in valid data. The most important thing is to have confidence in your supplier and in their prediction or testing methodology. This confidence is established based upon the supplier's reputation and on the nature of your interaction with their engineering and marketing people.

DC/DC converters tend to be more reliable than AC/DC converters. This is because they are functionally less complex, with only one power conversion stage. Even more importantly, they are implemented with extreme levels of integration, with low component counts, high quality materials and components and automated assembly processes. Reliability in the range of 1

to 5 million hours MTBF is achievable with the latest designs. AC/DC converters will have a smaller MTBF number due to the factors mentioned above and the inclusion of higher failure rate components such as fuses and fans. High quality AC/DC converters will have MTBF specifications in the range of 100 to 500 thousand hours.

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