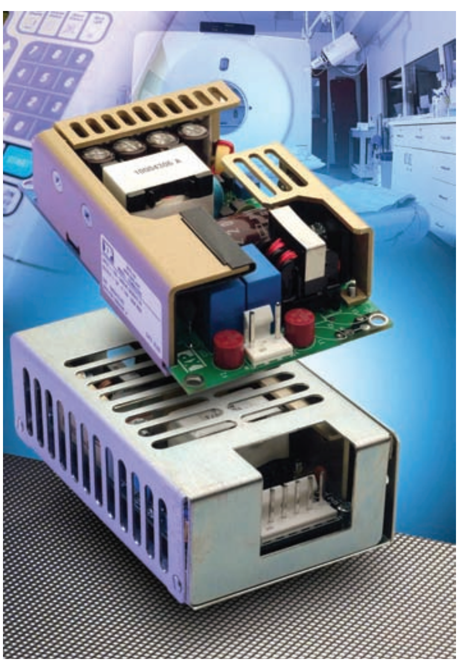
MTBF: misquoted and misunderstood

Reliability is one of the most important factors that a designer needs to consider when specifying components or subsystems – particularly when the component in question is the power supply on which an entire assembly relies. And yet reliability figures are possibly the most ambiguous on any datasheet – including those for power products.



Mean operating time between failures (MTBF) is the most familiar way of specifying reliability. But even this simple measure can be misquoted and misunderstood. Datasheet producers use the term very loosely (sometimes deliberately, sometimes inadvertently); and, because the term means different things to different people, it is possible that engineers will misinterpret what they read, even when it is "true" in the strictest sense.

Furthermore, it is essential to remember that MTBF for new products is necessarily an estimate. Without a substantial history of deployment in the field, manufacturers and purchasers have to fall back on indirect evidence: knowledge of previous designs; calculations of expected failure rate given the known reliability of the components that make up the product in question; or, at best, accelerated life testing. Because of these ambiguities, it is worth stepping back and taking time to define the meaning of various terms that are frequently used in discussions of reliability.

The most fundamental concept in reliability is a graph known colloquially as “the bathtub curve” (see figure 1). This is a chart of the statistical failure rate per unit time (λ) throughout the life of a product. At the beginning of the curve is an area called the “infant mortality period” – for electronic components and assemblies usually less than 200 hours – in which λ is high due to the impact of manufacturing defects and marginal components. This is followed by a long period of useful life, during which λ is low and constant. Finally, the “bathtub” shape is completed by a wear-out period beyond the intended useful life of the product, in which Ï increases rapidly with time.

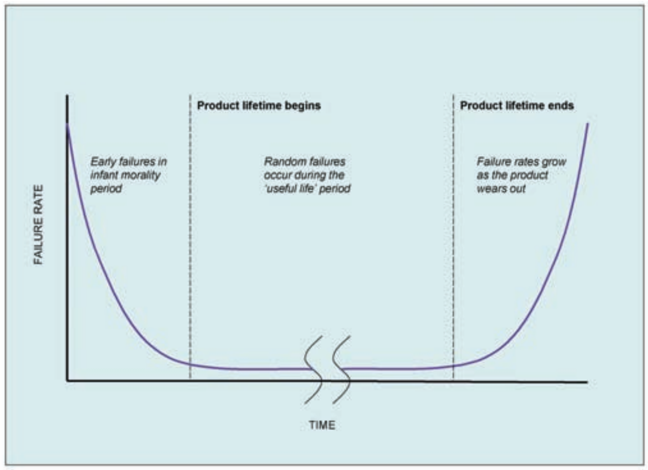


Figure 1

Strictly speaking, the term MTBF applies to equipment that is going to be repaired and returned to service – in practice, it is more or less universally equated with a related measure, MTTF (mean time to failure), which is the inverse of the failure rate during the useful life (in terms of the bathtub curve, that equates to 1/λ).

So, the MTBF gives a statistical indication of the failure rate that can be expected during the useful life period. The higher the MTBF, the closer the bathtub curve gets to zero in its middle portion. Manufacturers can use MTBF (and/or MTTF) to plan service requirements, repairs under guarantee and spares stocking strategies.

What MTTF and MTBF do not do is predict the useful life (or service life) of the product – the length of time between the end of infant mortality and the start of wear-out. If this seems counterintuitive, consider items which might have a very high MTBF, but a very short service life: a guided missile, for instance, is not “in service” for very long, but must be extremely reliable. The death rate for 25-year-old humans is about 0.1% per year – equating to an “MTBF” of 800 years – but few of us can expect to achieve a comparable “service life”.

Even those who are clear about what MTBF represents are often less clear about the numerical implications of the specifications that they read. Assuming that failures occur randomly during the useful life of a product, they can be described as an exponential distribution. So the probability of the product operating after time, t, will be given by:

R(t) = e-Ït = e-t/MTBF

We can calculate that the probability of a given unit operating without failure beyond the MTBF (setting t = MTBF) is approximately 37%: not, as many people might expect, 50%. Similar calculations can be used to show that an MTBF of 500,000 hours (approximately 57 years) gives a 95% chance of failure-free operation for just three years.

If the above calculations make it seem a little unfair that manufacturers should “headline” their datasheets with MTBF figures, it should also be noted that observed failure rates are generally much lower than predicted failure rates. This highlights the difficulty for manufacturers launching new products, which have no choice but to use predictive methods – themselves not originally intended to provide an absolute measure, but to enable comparisons to be made when designing and specifying. Such predictions are calculated by combining reliability figures (from a database) for the components used within the product in question, to produce an overall expected failure rate. There are two ‘standard’ sets of conditions under which MTBF is often quoted. The first is documented in a handbook known as ‘MIL-HDBK-217’; the second is based on the Bellcore (Bell Communications Research) methodology.

Whether predicted, measured in the field or deduced from accelerated life testing, operating and environmental conditions will dramatically affect MTBF, so it is vital for the designer to ensure that these are standardised to allow accurate comparisons. Recent data from the European Power Supply Manufacturers Association emphasised how important this is: it showed, for instance, that MIL-HDBK-217 and Telcordia calculations can diverge by as much as an order of magnitude in their results. Differences can be caused by many factors. The two techniques may simply apportion different failure rates to the same components: and when the end product has few components this may make the results very sensitive to differences across methods. The same arguments apply to accelerated life testing: although there is a standard assumption that MTBF will halve for every 10°C rise in ambient temperature, the engineer cannot allow such assumptions to remain implicit.

Today's electronic components and assemblies achieve reliability figures undreamed of in the past. Even so, designers cannot take this reliability for granted. Armed with a basic understanding of the principles of reliability, engineers can make sense of conflicting and confusing specifications. With consistency and care as the watchwords, there is no reason to suppose that reliability will not continue to increase in the future.

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