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Mean Time between Failure (MTBF)

MTBF values

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1 Background Information to MTBF

1.1 General

What is this about?

The Mean Time Between Failures (MTBF) is a statistical mean value for error-free operation of an electronic device. The specification of this statistical value in years often leads to it being wrongly interpreted as the service life of the component. Therefore, below we will show you

- What is to be understood by service life and MTBF.
- How to use the MTBF to determine the probability of failure.

What is to be understood by service life?

The service life is the time for which the device or component is designed to function. This, therefore, is the time up to the beginning of the wear-and-tear phase through a physical law or aging due to chemical reactions. In the case of devices with electromechanical parts (relays), the service life is mainly defined by the number of operations and the load connected.

What is to be understood by MTBF?

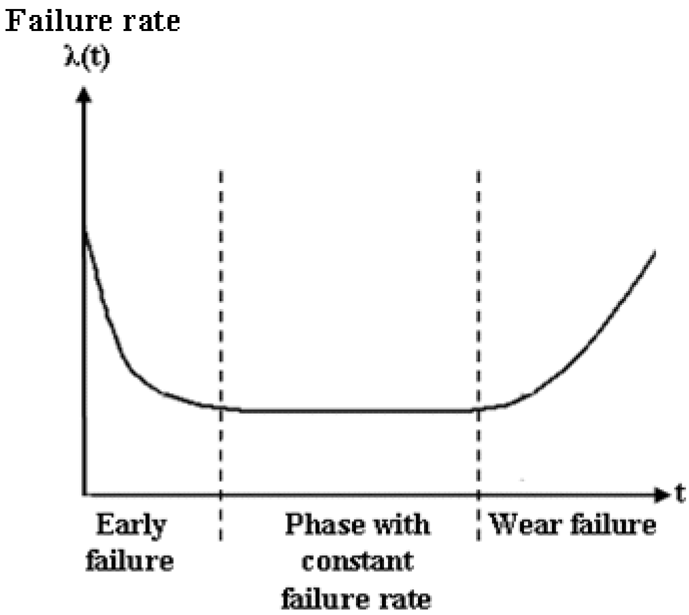
The MTBF does not apply to an individual component, but is a statistical mean value for the average time between two failures during the normal working life. The MTBF always refers to the phase with constant failure rate (i.e. without early or wear failures (see "bathtub curve" figure)).

The higher the MTBF, the less often the component concerned fails and the more reliable it is. According to DIN 40041, reliability is understood to be the "the property of an entity to fulfill its reliability requirements during or after a given time span under given application conditions". You must note here that in addition to the MTBF value, the environment and operating conditions (in particular temperature), the failure criteria and the duration of the value's validity must be specified and taken into consideration. If a device is operated under conditions beyond its specification (e.g. at extremely high ambient temperatures or subject to a massive EMC load), then the MTBF values are no longer valid and large numbers of failures might occur.

1.2 Failure Rate and Probability of Failure

Bathtub curve

The reciprocal value of the MTBF that is a measure for the reliability of a component is the failure rate λ. Plotting of the statistical failure rate λ over time t gives the bathtub function shown below (bathtub curve).



Failure rate

Failure rates have the dimension of 1/time unit. The term FIT (failures in time) is also often used for individual components. This describes a failure rate with reference to a relevant time base: 1 FIT = 10^{-9} h^{-1}.

The early failure phase is mainly characterized by defective components that are identified during manufacture and in the end are not available to the user. The wear failure phase is defined mainly by the wear and tear of the components. The phase with the constant failure rate is the useful life of the component. During this time you can assume a defined (constant) failure of the components.

Probability of failure

An exponential distribution is used to define the probability of failure of electronic and electromechanical components. The following holds:

$F(t) = 1 - e^{-\lambda t}$

Where

- $F(t)$ is the probability of failure
- λ is the failure rate in 1/time unit (1/h, for example)
- t is the observed service life (h, for example)

This correlation applies only for the phase of constant failure rate in the bathtub curve, i.e. for λ = constant. Under these conditions, the relationship below holds for the MTBF:

$MTBF = 1 / \lambda$ or $\lambda = 1 / MTBF$

If you now replace the failure rate λ in $F(t)$, you get the following result:

$F(t) = 1 - e^{(-t/MTBF)}$

Thus, you can easily calculate the probability of failure from the MTBF specified by the manufacturer and an assumed constant failure rate.

Example

After one year's delivery, there are 20,000 components in the field with an MTBF of 60 years. How high is the probability of failure of the components?

With $F(t) = 1 - e^{(-1/60)}$ where t=1a and MTBF=60a the result is:

$F(t) = 0.0165$, which means that the probability of failure of the components is 1.65%. For the assumed 20,000 components this means that from the statistical point of view 330 components may fail within one year. However, practice has shown that with electronic components in particular, there are much less failures.