

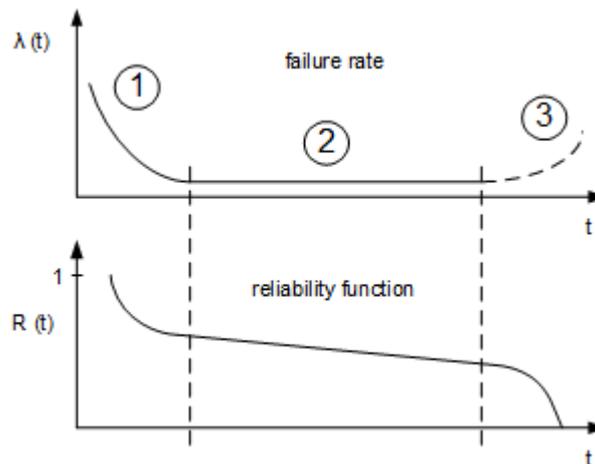
**Topic:**

- How is reliability calculated for maxon controllers?
- Where to find the MTBF value of maxon controllers?

**Lösung:**

**Failure rate (FIT or λ-value)**

Each component has a failure rate curve in the shape of a bath tube, called Weibull distribution. In the first phase, one finds the early failure due to weakness in the materials, quality variations in production, handling mistakes and spurious, unconfirmed failures. In the second phase, the admissible failures are defined, usually with a constant rate over time. In this second phase, the standard failure rates for electronics components are defined and calculated. Phase 3, the deterioration phase, is hardly relevant for electronic components.



$$R(t) = e^{-\int_0^t \lambda(t) dt}$$

Assuming that the failure rate λ is approximately constant, the equation can be simplified as follows:

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

**MTBF (= Mean Time Between Failure):**

The MTBF value (= Mean Time Between Failure) is defined as the time between two errors of an assembly or device. Typical values lie between 300'000 and 1'200'000 hours. Failure rates are identified by means of life testing experiments and experience from the field. The MTBF results from the inverse FIT or  $\lambda$  values. Summing the MTBF values of single components or subassemblies gives the MTBF of the full system. A large influence comes from the ambient conditions such as temperature variations, vibrations, and so on. Therefore, MTBF values are determined with the help of manuals that include these conditions.

$$MTBF = \int_0^{\infty} R(t) dt = \int_0^{\infty} e^{-\lambda t} dt = \frac{1}{\lambda} \quad [h]$$

$$\frac{1}{MTBF_{System}} = \frac{1}{MTBF_{component1}} + \frac{1}{MTBF_{component3}} + \frac{1}{MTBF_{component2}} + \lambda_{component4} + \dots \left[ \frac{1}{h} \right]$$

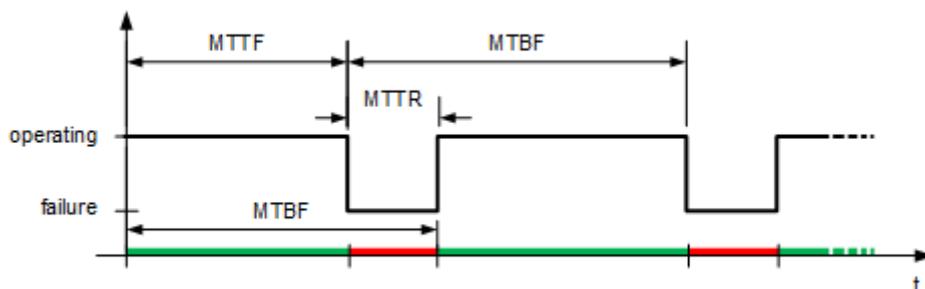
**MTTF (= Mean Time To Failure):**

The term MTTF (= Mean Time To Failure) differs only slightly from MTBF. It is used for systems that cannot be repaired; the device directly enters the recycling process.

**MTTR (= Mean Time To Repair):**

MTTR is the average time needed for repair (= Mean Time to Repair). Besides the time for repairing, it includes the time for failure analysis as well.

**MTBF, MTTF, MTTR: Overview**



<b>maxon motor control</b>		
maxon motor ag Brünigstrasse 220 CH – 6072 Sachseln <a href="http://www.maxonmotor.com">www.maxonmotor.com</a>	<b>Reliability Analysis,  Failure rate, MTBF</b>	Version: 1.00 (Engl.) Author : WJ Date : 2019-02-15

### Defining MTBF with manuals

Manuals are used to get realistic MTBF values close to the later experience in the field. They are based on international standards such as:

- IEC 62380
- MIL-HDBK-217F
- Siemens SN 29500..

Based on parts lists, the MTBF value is calculated for each part, considering as well external factors such as ambient temperature, humidity or stress.

### Calculating of maxon controllers

Producers of electronic components identify the effective FIT-value with so-called accelerated tests according to the Arrhenius law. These FIT-values are preferred for calculating the MTBF of maxon controllers, because they allow a more accurate calculation than the general values from handbooks. Active components have a predominant influence on the resulting MTBF-value of a product. That is the reason why we calculate with these effective FIT-values. The remaining passive components are calculated according to the MIL-HDBK-217F handbook. This finally means that the specified total MTBF-value match very precisely the reality.

### MTBF value specified in maxon manuals

The MTBF value is specified in the chapter "Specifications / Standards" of the "Hardware Reference" corresponding to the controller.

Example: Extract of chapter "2.5 Standards" of the "EPOS4 Module-Compact 24-1\_5 Hardware Reference.pdf" manual:

<b>Reliability</b>	<b>MIL-HDBK-217F</b>	Reliability prediction of electronic equipment Environment: Ground, benign (GB) Ambient temperature: 298 K (25 °C) Component stress: In accordance with circuit diagram and nominal power Mean Time Between Failures (MTBF) <ul style="list-style-type: none"> <li>• Module: 611'610 hours</li> <li>• Compact CAN: 326'977 hours</li> <li>• Compact EtherCAT: 279'388 hours</li> </ul>
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**Conclusion:**

The values of the analysis must be considered as pure statistical values. For the development engineer, these values allow to validate the failure rates of the complete system; in order to select other components if necessary or to start a redesign. The MTBF value should not be confused with the minimum service life of a system.

**Units of the most important parameters:**

F	Service life	[h]
$\lambda$ or FIT	Failure rate (Failure per Time)	[1/h]
f	Probability density of failure	[%/h]
R	Probability of survival	[%]
MTBF	Mean Time Between Failure	[h]
MTTF	Mean Time To Failure	[h]
MTTR	Mean Time To Repair	[h]

Source:

Gottschalk, Armin: Qualitäts- und Zuverlässigkeitssicherung elektronischer Bauelemente und Systeme, ISBN, 978-3-8169-2680-1