Chapter 4
Reliability Analysis

Inexperienced engineers typically neglect reliability issues when designing. Reliability parameters are sometimes not known, and as a result the development engineer often maximizes them, "to be on the safe side." However, the resulting excessive costs often require a redesign. On the other hand, when reliability data for a system are provided, they raise questions on the required reliability of the system's individual components.

This chapter explains the mathematics needed to perform reliability analysis and introduces the primary reliability parameters, which a development engineer must be familiar with today (Sects. 4.1 and 4.2). The so-called bathtub curve of failure rates is applied for the reliability of electronic systems; understanding the middle of this curve, which represents a constant failure rate, is critical in practice. The reliability parameters for electronic systems are easily calculated by applying this constant failure rate, which is associated with an "exponential failure distribution" (Sect. 4.3). The failure modes of electronic components are described in Sect. 4.4. We show how the required reliability parameters for individual components and modules can be determined by applying the exponential failure distribution to these failure modes (Sects. 4.5 and 4.6). In addition, we show how the system reliability can be calculated from the reliability of individual components.

Finally, Sect. 4.7 contains recommendations for upgrading the reliability of electronic systems.

4.1 Introduction

Function and reliability are the two most important factors impacting system quality. An electronic system should fulfill its required *functions* based on given parameters (output/response values) within defined boundaries. *Reliability* is a measure of the performance of these functions over a given period. The parameter

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boundaries are determined by the predefined operating modes and conditions of usage, along with maintenance, storage, and transportation.

High reliability is especially important for electronic systems in industrial equipment, where a device failure often results in production loss or rejects. The associated costs in such cases may be higher than the initial outlay for the defective system.

We will show later how the product *price* increases as the reliability increases. The price increase associated with increased reliability is, however, offset by a reduction in extra costs for the customer for maintenance and repair during the product lifetime. Thus, customer costs can be *optimized* by examining the relationship between the overall costs and system reliability (Fig. 4.1).

If there is a loss of reliability, *maintenance costs* may exceed customer expectations or the proposed manufacturer guarantee and warranty costs. In addition, the business's reputation may also suffer and it may lose customers if the reliability of its products is lower than that of its competitors' products. On the other hand, if a product's reliability exceeds market expectations, without offering additional technical benefits, it can become so expensive that it is not profitable to manufacture.

Against this backdrop of cost efficiency, a product need not be overly reliable. Rather, the development engineer should aim to minimize overall costs by seeking reliability that fits the purpose. There are exceptions to this rule, however. Maximum reliability is required in aerospace engineering, for example, as maintenance and repair are extremely difficult, if not impossible. The same applies to healthcare systems: health and safety risks and environmental concerns prohibit cost cutting.

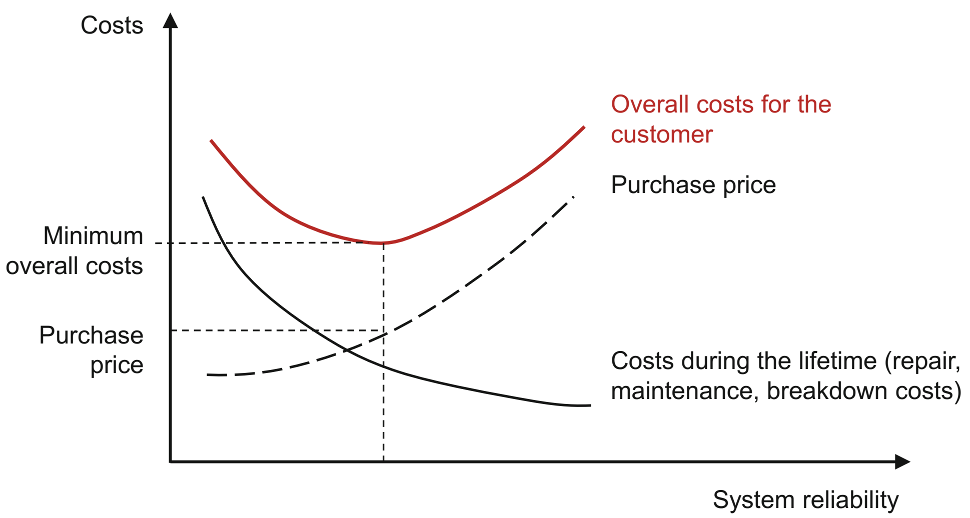

Fig. 4.1 Achieving cost efficiency by examining the relationship between the overall costs and system reliability. The increased reliability associated with higher purchase prices is offset by a reduction in repair and maintenance costs, resulting in an overall cost optimum at specific (to-be-aimed-for) reliability values

Reliability data are always future oriented. The proper functioning of a system can only be predicted with a specific probability, as the reliability parameters are stochastic (random). Nevertheless, every development engineer needs to define the target reliability level for the system at hand.

The functionality, accuracy, processing power, etc. of electronic systems are constantly improving. At the same time, due to these increased levels of complexity, there is also an increased risk of systems becoming prone to failure. These factors cause a conflict of interests. A culture of reliability is needed to accompany systems throughout their entire life cycles. Reliability must be designed "into the systems," starting with product planning, and on through component selection and the system design itself, to fabrication and quality control. Since reliability should be "designed in," it should be considered a strategic task. (In contrast, maintenance, keeping components and systems functioning, is considered a tactical task.)

The engineer remains responsible for reliability when the product moves from engineering into production. The developed system is also tested "in the field," as the product is still under warranty and the manufacturer guarantees the quality of its product for the customer. Failures, which are not random failures, must be carefully assessed for a period of several years. The development engineer remains responsible for the reliability parameters and calculations even years after the design and development is complete.