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A Consideration of Error Probability in Multilevel Reliability Verification

To establish an innovative technical product like a wind turbine, a photovoltaic plant, an electric automobile etc. in the market, among several key characteristics its reliability has to be comparable with that of conventional products. Otherwise, customers' acceptance of the new technology would not be sufficient to achieve the breakthrough and economical success.

Thus, reliability engineering starts early in the development process - where the physical product is still not available - with analysis and simulation activities. Reliability risks which cannot be covered adequately with virtual methods have to be mitigated by physical tests. Depending on the development stage, such tests cover single components, subsystems or instances of the complete product. While component tests are carried out relatively fast and cheap they are usually not representative as they not encounter the full variety of stress caused by interactions with neighbor components in the product and environmental conditions in real usage. These shortcomings of component tests will be compensated with more expensive subsystem and time-consuming product tests.

To meet the given reliability target for the complete product, corresponding verification targets for each development level have to be derived. They are used to determine level-specific appropriate verification test programs. Then, the demonstrable reliability of a single test program is a non-quantifiable conservative lower confidence bound for the corresponding survival probability as far as no failures will be observed.

This presentation discusses some important facts to consider when test programs carried out in different development levels are summarized in order to evaluate the verification and to estimate the reliability of the complete product. In particular, the accumulation of error probability in multilevel verification tests can in general only be determined based on prior assumptions about the real reliability of the product. A computer simulation experiment with practically relevant data shows the accuracy the reliability estimation and the sensitivity regarding the prior assumptions.

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