A NEW RELIABILITY PREDICTION MODEL FOR TELECOMMUNICATION HARDWARE

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Abstract : An analysis of measured field failure rates of printed circuit boards has been done. The report shows that there is a correlation between production test statistics and field performance, for high-volume boards. This correlation is better than the one obtained for the prediction based on the part count method.
A new model for electronic reliability prediction has been proposed. It uses statistics from board and system tests performed at the production plant and the number of conductive layers on the board.

INTRODUCTION

The ability of a given system to operate correctly for a specified period of time is generally referred to as its reliability [1]. Why should manufacturers make reliability predictions on its products? Customers often require that a reliability prediction is made of new equipments. The system performance may be estimated based on reliability predictions of its parts. Maintenance costs and spare parts quantities need to be estimated as good as posible.

Understanding the real background for field failures will give better opportunities to implement effective product improvements and to come closer the to realisation of 'failure free electronics'.

METHOD

A number of high-volume boards from two markets and two production sites were selected. Field failure rates were correlated with predictions by the currently used "part count" method at Ericsson. Parameters that were believed to influence on the reliability were investigated. Finally, a prediction model was designed, based on technical parameters and available production-quality data.

PREDICTION OF ELECTRONIC SYSTEMS, "PART COUNT" METHOD

Each component in an electronic system is assigned a constant failure rate, ß. To predict a board's failure rate, the fault rates of the components are added, Eq. 1. This is known as the "part count" method. There has been criticism against this method for reliability prediction [2,3,4].

$$b_{\text{system}} = \sum_{1}^{n} b_{\text{component}} \qquad (1)$$

EXAMINATION OF THE PREDICTION MODEL USED AT ERICSSON TELECOM

A comparison between the predicted values, obtained with the "part count" method SYPREX and the current measured field reliability, FITS, (number of failures per 10^9 hours in operation) value was made; expressed as a deviation, Eq. 2.

$$\text{Deviation} = \frac{\text{predicted value}}{\text{FITS (measured value)}} \qquad (2)$$

The comparison is shown in figure 1 for the selected 56 high-volume boards from one market. The figure shows that the deviation of the predicted value from field statistics (FITS) is up to about 30 times.

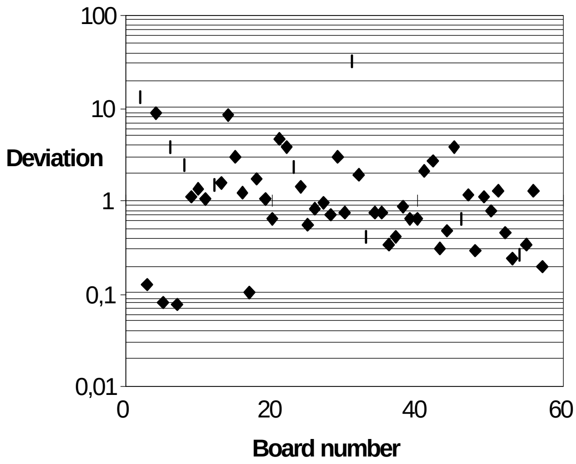
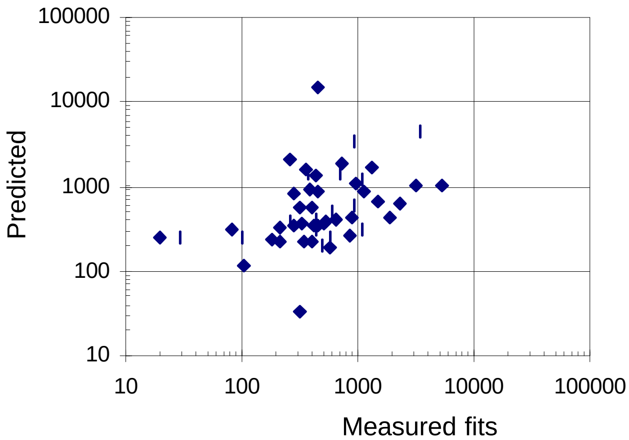


Figure 1 Deviation of predicted reliability for 56 high volume boards sorted in FITS order.



TECHNICAL PARAMETERS

Thirteen parameters likely to affect reliability were examined. To determine if a parameter influences reliability, the Mann-Whitney rank test was used [5]. The number of layers was the only one of these thirteen parameters that could be shown to influence reliability. This is proven with 99% confidence using the rank test.

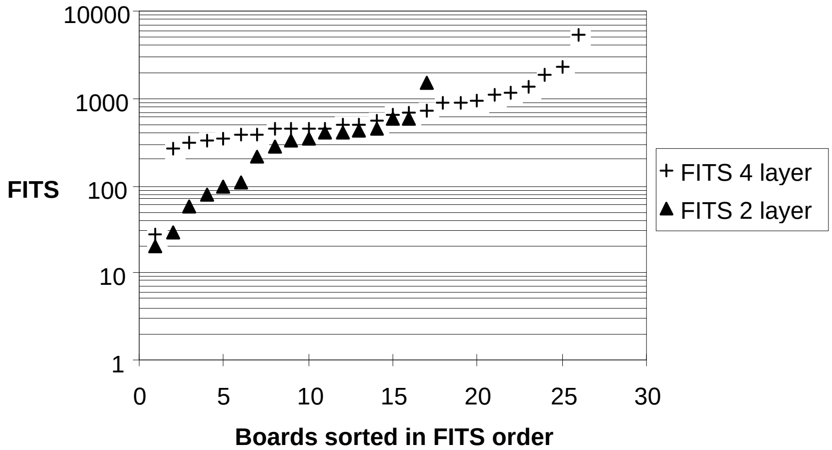


Figure 2 Number of layers on the board and reliability.

PROPOSED MODEL

In the proposed model a combination of failure levels (percentage) in board test, system test, and the number of layers on each board is used to estimate field reliability, Eq. 3. The board descriptor is calculated for each board, holding the factors a, b, c, and d constant.

$$\text{Board descriptor} = (a * \text{boardtest} + b * \text{systemtest} + c \oplus d\{\text{number of layers}\}) \quad (3)$$

The $\oplus$ symbol means that *either* c or d is added to the board descriptor, *depending* on the number of layers that the board has. The factors were selected in order to get the best possible correlation to field reliability. Equation 4 was designed using data solely from one market. The proposed model proved to support Eq. 4 when tested with data from another market and production site.

$$\text{Board descriptor} = (0{,}1 * \text{boardtest} + 1 * \text{systemtest} + (-0{,}24) \oplus 0{,}4\{\text{number of layers}\}) \quad (4)$$

In figure 3, field failure percentage after five years is compared with boards from the two markets, using Eq. 4. A linear curve fit that satisfies equation 5 is drawn in figure 3.

$$5Y\% = 1{,}48 * (\text{Board descriptor}) - 0{,}38 \quad (5)$$

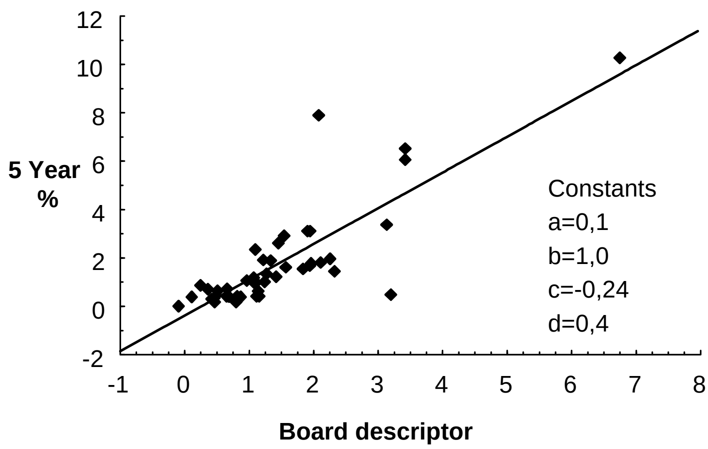


Figure 3 Failure percentage after five years, using boards from two markets.

DISCUSSION

Figure 3 shows that there is a correlation between production test statistics and measured field reliability. A new reliability prediction method for high volume boards is proposed, Eq. 4 and 5. It is based on tests carried out at the production plant and the fact that the reliability is influenced by the number of layers on the board. The difference in reliability between a two- and a four-layer board could be a measure of increased complexity. When data is available, the proposed model can be adjusted to include boards with even more layers and other parameters.

Field failure percentage may be specified (by customer requirements) for a new board under development. The proposed model could be used to determine maximum failure levels in board and system test using Eq. 4 and 5. When a number of boards are produced and tested, a comparison could be made between actual test results and specified. If actual test results are poor, actions can be taken to improve reliability *before* numerous boards are delivered to customers.

CAUSES OF ERRORS AND PROBLEMS WHEN USING THE PROPOSED MODEL

The major error cause is poor data quality in production-statistics and field-failure information.

When the curve obtained with the proposed model is used, predicted failure percentage might be outside the possible range (nonpositive). This occurs when production failure levels are *very* low, which according to the proposed model would mean excellent field reliability.

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