Title: Real Time Dynamic Application of Part Average Testing (PAT) at Final Test

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Abstract

The application of Part Average Testing (PAT) during semiconductor final test is typically applied to population data from numerous batches, called static PAT limits. This can lead to excessively wide distributions compared to batch by batch estimates. This paper will explain a method that allows the application of PAT limits dynamically using the specific distribution of the batch being tested. It also will look into PAT solutions used for distributions that are not Gaussian.

INTRODUCTION

PAT limits are well established in the automotive industry. They are used to separate parts that are different than what is "normally" being produced. That is to say they screen out the outliers from the typical population. The Automotive Electronics Council document AEC-Q001 defines the standard for application of PAT limits in the automotive industry. The strict methodology of this document works fine when you are producing widgets and when typical machining processes are known to be Gaussian in nature and the output can be serialized for later selection. But in the modern final test process, devices are tested and then immediately put onto tape and reel for shipment to the customer. You must make your decision just after the individual unit is tested. In addition, in RF module manufacturing it is not unusual to have other than Gaussian distributions including ones that are highly skewed or bimodal in nature. Because of these issues the standard methods for application of PAT limits would lead to over rejection or worse yet, under rejection.

IMPLEMENTATION

We have addressed these issues in a custom test shell that runs between the native environment and the user GUI on everything from ASL and LTX ATE's as well as custom rack and stacks. This shell handles all statistical calculations as well as binning and data logging.

The basic method follows closely to AEC-Q001 in that the first 20 devices are tested using the normal static limits. At this point a good estimate of the "robust" mean and standard deviation of key parameters can be calculated. Using these estimates, PAT limits for the batch are applied (Figure 1).

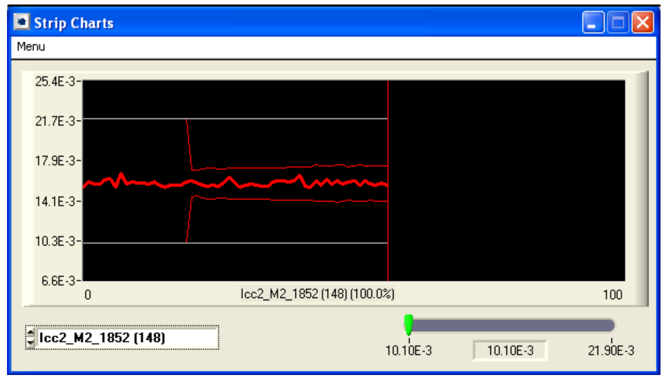

Figure 1: Trend chart showing PAT limits applied after testing 20 devices.

The shell continues to refine the estimate as more devices are tested until the sample size reaches 200. Then a moving average of the last 200 devices is used for the "robust" estimates. In this way the limits move dynamically to allow for small system drifts due to socket wear without adversely effecting yield. To put it another way, the shell is answering the basic question of if any given device is different from the last 200.

The "robust" mean and standard deviation is calculated after applying an outlier filter described in the introduction section of CSMantech 2012 paper, *A Robust, Non-Parametric Method to Identify Outliers and Improve Final Yield and Quality*. This method is key to handling non-Gaussian distributions found in RF module production and testing.

As testing continues any device that passes all spec limits but fails any dynamic limit will be binned to a separate failure bin for retest and failure analysis as appropriate. The first parameter that failed dynamic limits is logged in the data file along with the limits that were applied at the time of testing. In addition, dynamic limit yield by parameter is also tracked for Pareto and future Statistical Bin limit application.

In addition to the shell development that went into this process, a dashboard was developed to help with initial limit setting.

This dashboard allows the import of historic batch data and facilitates enabling or disabling dynamic limits for any given parameter and the number of standard deviations for which the limit is set. This helps to minimize arbitrary yield loss while allowing for concentration on key quality parameters.

RESULTS

This system has been implemented on multiple platforms and products. Early results show a small yield loss as expected. But devices that have otherwise passed the static specification limits but were clearly outliers from the main population have been effectively screened out to both keep them from shipment to the customer and to analyze for ongoing yield improvements (Figure 2).

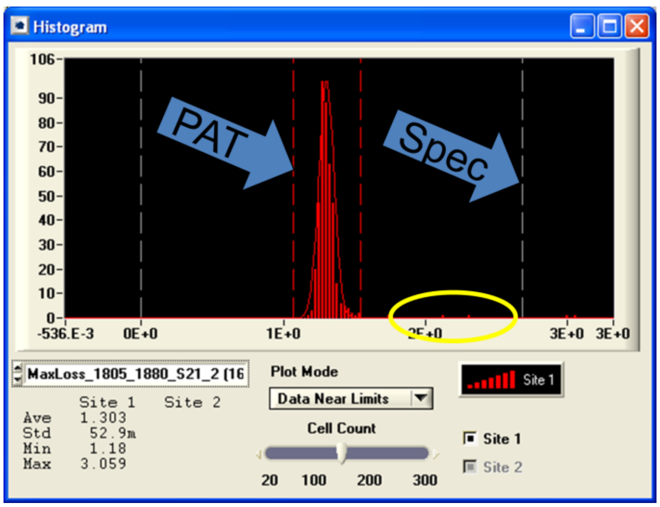

Figure 2: Devices circled passed static test limits but failed PAT limits and were effectively screen out.

REFERENCES

[1] Automotive Electronics Council doc, AEC-Q001, *Guidelines for Part Average Testing.*

[2] N. Patterson, *A Robust, Non-Parametric Method to Identify Outliers and Improve Final Yield and Quality* , 2012 GaAs MANTECH Digest, pp. 59-61, April 2012.

ACRONYMS

PAT: Part Average Testing