TALL AND LONG components - bring them on!

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Is your pick & place process capable?
Know your capability

The use of fine-pitch components, accompanied by the transition to lead-free, will force PCB manufacturers to learn more about their pick-and-place machines’ capabilities. This article describes a method for inexpensive, in-house capability measurements, comparable to those of pick-and-place machines' capabilities. This article describes a method for lead-free, will force PCB manufacturers to learn more about their pick-and-place machines' capabilities.

Requirements and Defects

Originally, quality was identical to remaining within tolerance limits. If you fall within these limits you can be satisfied, with no incentive to try to improve the production process. Figure 1 shows target value (T), an upper specification limit (USL) and a lower specification limit (LSL). The overhang shows loss suffered due to failure to meet tolerance requirements. A product that lies just over the LSL will be approved, while one just below the LSL is rejected. It is not completely satisfactory that two almost-identical products are evaluated differently.

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Variation — A Cause of Losses

There are many causes for variations in a process. We usually separate causes of variation that can be identified from those that cannot. There is a natural “background noise” that consists of many small and essentially unavoidable causes of variation. These causes are called “chance causes of variation.” Sometimes specific causes of variation occur, such as incorrect material or damaged tools; and these causes are known as “systematic” causes. A process that only has chance causes of variation is said to be in statistical control, or stable. Equipment and production methods work as well as possible, and if you want to reduce variation further, you often need new investments. A process that is in statistical control can be brought out of control by situations such as incorrect material. Systematic variation often has a few causes, and usually new investments are not needed to correct the error. To control systematic variation, we use SPC. To be able to detect the presence of systematic causes of variation, you must model the process as it appears when only chance causes are present. Depending on what the data look like and the purpose of the analysis, chance causes of variation can be modeled in various ways. Keep in mind, however, that each model is a compromise between being realistic and being manageable.

Models for Random Variation

If X represents the position of the 0201 component in the previous example and all systematic causes of variation are eliminated, the position can be modeled as an average plus a random variation.

\[ X = \mu + \epsilon \]

\[ \epsilon \sim N(0, \sigma^2) \]

In our case, with W = 0.3 mm and P = 100%–140% of W, assume that P = W = 0.3 mm, and that \( \epsilon \) = 0. We then have the following specification limits for the placement of the 0201 component:

\[ CL = \frac{P}{2} + \epsilon \]

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Class 1, 2, 3

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In SPC, normal distribution most likely will be assumed for the data.

Note that not all stochastic variables normally are distributed. If instead we had modeled the number of functioning components on the printed board, then a binomial distribution would have been preferable. The main reason for the usability of the normal distribution is the Central Limit Theorem, stating that the distribution of a sum of many independent stochastic variables tends to be normal, even when the distribution of each individual variable is non-normal. As stated, variation in a production process often is caused by many small, essentially unavoidable causes, and can be modeled using normal distribution. If $X$ is distributed normally, the average value $µ$ and standard deviation $σ$ can be calculated.

Figure 1.1 shows the distribution for a normal distribution with average $µ$ and standard deviation $σ$.

The normal distribution has two parameters, the mean $µ$ and the standard deviation $σ$. The mean represents the central tendency of the data, while the standard deviation measures the spread of the data. A normal distribution is bell-shaped and symmetric, with the mean, median, and mode all equal.

The normal distribution is used extensively in statistics and probability theory due to its properties. For example, for a normally distributed random variable $X$, the probability of $X$ falling within a range $[a, b]$ can be calculated using the cumulative distribution function $\Phi$ as:

$$\Phi(b) - \Phi(a)$$

where $\Phi(x)$ is the cumulative distribution function of the standard normal distribution.

For a random variable $X$ with mean $µ$ and variance $σ^2$, the standardized variable $Z = \frac{X - µ}{σ}$ follows a standard normal distribution with mean zero and variance one.

The normal distribution is used in many areas of science and engineering, such as signal processing, finance, and quality control, for modeling phenomena with continuous variables. It is also used as a reference distribution in hypothesis testing and confidence interval estimation.

Process Control – Eliminate Systematic Variation

If a process is in statistical control and something happens to the process, the problem needs to be identified and corrected. One way of discovering sudden problems is by using a control chart. This technique is based on selecting random samples at regular intervals and calculating the average and standard deviation of the data. The average value and standard deviation are calculated as:

$$\bar{X} = \frac{\sum X_i}{n}$$

$$σ = \sqrt{\frac{\sum (X_i - \bar{X})^2}{n-1}}$$

where $X_i$ represents the value of the $i$th sample, $n$ is the number of samples, and $\bar{X}$ is the average value.

If a process is in statistical control, there is a risk that the control chart will give a warning by chance. One common way to design a control chart is to use warning limits three standard deviations away from the average value $µ$. For example, if the average value is 100 with a standard deviation of 10, the warning limits are 70 and 130.

Process Capability – Reduce Random Variation

Even if a process is free of systematic errors, and thus in statistical control, it does not mean that it can deliver products that fulfill customer requirements. A process in statistical control does not necessarily fulfill the specifications, and an uncontrolled process can fulfill tolerance requirements. To link SPC with specification limits, we will introduce a concept known as "process capability." Process capability is a measure of how well a process is able to produce products that are in accordance with the customer requirements.

Process capability is often assessed by using a process capability index (PCI) or a process capability ratio (PCR). The PCI is defined as the ratio of the specification limits to the process variability, while the PCR is defined as the ratio of the process variability to the specification limits.

In the IPC-9850 capability test method, the capability indexes are calculated as:

$$\text{PCI} = \frac{USL - LSL}{6σ}$$

$$\text{PCR} = \frac{σ}{1.5}$$

where $USL$ is the upper specification limit, $LSL$ is the lower specification limit, and $σ$ is the standard deviation.

The PCI is a measure of how well the process is capable of meeting the customer requirements, while the PCR is a measure of how well the process is capable of maintaining the variability.

Process variation can be categorical and non-categorical. Categorical data refers to data that can be divided into distinct categories, such as pass/fail or good/bad. Non-categorical data refers to data that can be measured on a continuous scale, such as length or weight.

There are different types of process variation, such as random variation and systematic variation. Random variation is due to factors that are not under control, while systematic variation is due to factors that are under control.

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where $USL$ is the upper specification limit, $LSL$ is the lower specification limit, and $σ$ is the standard deviation.

The capability index $Cpk$ is calculated as:

$$Cpk = \min\left(\frac{USL - \bar{X}}{3σ}, \frac{\bar{X} - LSL}{3σ}\right)$$

where $\bar{X}$ is the average value and $σ$ is the standard deviation.

If $Cpk > 1.33$, the process is capable of meeting the customer requirements.

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Conclusion

With the introduction of new, advanced fine-pitch components and lead-free processes, accuracy requirements will increase. Pick-and-place machines are pushed to their capability limits, and it becomes necessary to gain a deeper understanding of the statistical aspects of the assembly process. Traditional three-sigma value found in data sheets will not be enough to predict whether a piece of equipment can produce to specification – or just produce lots of rejects.

Because the qualification of the IPC-9850 glass plate, the pick-and-place machines built-in vision system can be used instead of an expensive CMM. Manufacturers who begin to gain knowledge about SPC and capability measurements, and develop in-house methods for characterizing their processes, will be one step ahead of the competition when lead-free, ultra-fine-pitch components become commonplace.  

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Tall and long components – bring them on!

Many components today are complex and come in such limited quantities that there is no room for error. If you’re concerned about accurately handling the components of the future, the new MY-Series Extended Component Range (ECR) model is the solution.

With the ECR you get a machine that can place virtually any component – from extremely small 01005s and small-pitch QFPs to complex CCGAs and surface-mounted connectors.

Extending MY-Series even further

The ECR model virtually eliminates manual assembly by extending the range of components that can be handled by a MYDATA machine. It’s available in all MY-Series machine sizes, with feeder capacity ranging from 96 to 256. And since it can be configured with any T-Series conveyor, it is suitable for high-mix production as well as the challenges of large-board assembly.

ECR key benefits

- High placement accuracy to IPC 9850 standard
- Comprehensive component range from 01005 to 40 mm tall and 132 mm long components
- Benefit of shared feeders, software, spare parts and training
- Virtually eliminate all manual component assembly

Place those tough components – accurately

The ECR handles tall and long components with ease. The redesigned and elevated X-beam, together with the Linuscan Front Light vision system and Midas mounthead, give it a unique capability. This configuration means that the ECR model can safely handle up to 40 mm high components and 132 mm long connectors – components that otherwise require manual placement. Easy and complex components like CCGAs and BGAs can be placed accurately by the ECR. The specifications have proven to be very competitive – only a few pick-and-place machines can mount the same range in one machine as a MYDATA ECR machine.

Have you got true SMT Flexibility?

In the high-mix segment, top speed is irrelevant. What matters is flexibility. At MYDATA, we’ve identified six key ingredients you need to achieve true flexibility in surface mount production.

Find out more at www.mydata.com

1. Full range of component handling

The starting point for truly flexible production is the ability to handle and place a full range of components on virtually any board. This includes everything from 01005 and CSP/FCC components on up to complicated BGA and QFP-types. With the trend towards miniaturization and odd-shaped components, it’s essential to have an all-in-one placement machine.

2. Smart feeder system

Loading feeders can be time-consuming. But not with a flexible feeder system. With feeders as small as a ballpoint pen, tape reels can be loaded in a matter of seconds. A modular magazine system eliminates bulky carts and makes it easy to change between feeders, trays or sticks. Plus, intelligence functions ensure that components are never loaded incorrectly.

3. Any shape or size PCB handling

The ability to handle PCBs of any shape and size – from small boards to giant backplanes – is another key aspect of flexible production.

4. Actual throughput

For years, our industry has focused on top speed. But in a high-mix environment, the only issue that matters is how many boards you produce by the end of the day.

5. Integrated software suite

Wouldn’t it be nice if you could transfer CAD files, extract management data and pre-program your next job – all with the machine still running? This is our software philosophy in a nutshell. It’s about getting your placement machine to do as many things as possible without slowing down your productivity.

6. Customization & customer support

Ultimately, our greatest challenge is to anticipate your needs. One aspect of this is technical. The other is human. At MYDATA, we’re proud of our ability to back up customers when they need it most. Whether that means providing 24-hour support, or tailor-made placement tools, we’re here to anticipate your needs.

Download software and documentation

You can now download software updates and get your hands on a lot of useful user documentation via our Interactive Support website.

Having access to documentation will enable you to find answers to common questions you might have when using MYDATA products. The information that has been released includes all MYDATA manuals, maintenance guides, release notes and schematics. Certain installation guides and application guides are also available. The software downloads available are updates for CADConv, MYLabel, MYPlan, MYSpeed and the MY500 JPSys system software.

To get the documentation and software go to the MYDATA Interactive Support website http://support.mydata.com and click on “Manuals & Guides” or “Software downloads”. If you haven’t yet got an account to access the Interactive Support please contact your local sales office, details of which can be found on the MYDATA website.
MYDATA has launched the “Rock the Process Tour”, featuring its new screenless jet printer – the MY500. After its highly successful debut at the Productronica tradeshow in November, the MY500 jet Printer is now on display at locations throughout Europe – enabling busy and time-conscious manufacturers to take a closer look. The MYDATA crew will demo the machine together with a MY12E, which also attracted attention during Productronica for its ability to handle virtually any component and board size.

The Rock the Process Tour will continue until June 2006. The truck tour will stop at more than 30 cities in 10 countries, including France, Spain, the U.K., the Netherlands, Finland, Italy, Portugal, Estonia, Denmark, Germany and the Czech Republic.

MYDATA automation AB develops, manufactures and supplies flexible and cost-effective surface mount equipment. MYDATA automation and Agilis are registered trademarks of MYDATA automation AB. The following products and accessories are also trademarks of the company: MY19, MY15, MY12 and MY9; MYSynergy; T5; T6; HYDRA Speedmount; Midas; MYDATA Tray Exchanger (TEX); MYDATA Standard Vision System (SVS); MYDATA Assembly Process Management (MPM) including TPSys; CAD Conversion, MYLabel, MYCam, MYSpeed, Equinox and MYLink.

Worldwide events calendar
MYDATA will be represented at the following events:

- **ROADSHOW FRANCE** .................................. MAY 15-19
  - Representative: MYDATA France
  - Location: Roadshow truck
- **ROADSHOW SPAIN** ..................................... MAY 22-26
  - Representative: A.B. Electronic Devices / MYDATA
  - Location: Roadshow truck
- **ROADSHOW PORTUGAL** ................................ MAY 29-30
  - Representative: A.B. Electronic Devices / MYDATA
  - Location: Roadshow truck
- **SMITECHPACKAGING 2006, GERMANY** ............. MAY 30
  - Representative: MYCON / MYDATA
  - Location: Exhibition Centre Nuremberg
  - Website: http://www.sm-te-pack.com
- **ROADSHOW CZECH REPUBLIC** ......................... JUNE 05-09
  - Representative: MF Electronics / MYDATA
  - Location: Roadshow truck
- **NEPCON SOUTH CHINA / SMT SOUTH CHINA 2006** .......... AUGUST 29-SEP 03
  - Representative: MYDATA Asia
  - Location: Shenzhen International Convention & Exhibition Centre, Shenzhen, China. Booth: 2H03
- **EBM INTERNATIONAL ENGINEERING FAIR** .......... SEP 18-22
  - Representative: MF Electronics / MYDATA
  - Location: Brno Exhibition Centre, Czech Republic
- **ASSEMBLY TECHNOLOGY EXPO** ........................ SEP 26-28
  - Representative: MYDATA Inc
  - Location: Donald E. Stephens Convention Center, Rosemont (Chicago), IL USA
  - Website: http://www.altepo.com
- **GLOBELECTRONICS 2006** ................................ OCT 10-13
  - Representative: MYDATA Asia
  - Location: Suntec Singapore
  - Booth: Hall 401-404 booth L20
- **MATELEC** ................................................ OCT 24-28
  - Representative: A.B. Electronic Devices / MYDATA
  - Location: M adrid, Spain