Six Sigma

Cabot Microelectronics
A MESSAGE FROM OUR CEO

Cabot Microelectronics is firmly committed to embracing Six Sigma as a way of life throughout our business. Ingrained in our business strategy, Six Sigma is essential to achieving progress in our strategic focus areas:

- Grow Profitably
- Improve Productivity
- Improve Quality
- Innovate in Technology and Business
- Get Closer to Customers
- Cultivate a Winning Culture

At CMC, quality means totally understanding customer requirements, adopting a team concept, doing the job right the first time, and striving for continuous improvement. Six Sigma involves and empowers all of us to design the best products and to improve our existing processes and services to achieve maximum customer satisfaction.

We face challenges from increased competition for our customers, budget pressures, and rapid development of new technologies. Our challenges can no longer be solved incrementally. We need to focus on understanding our customers' needs better and the real-world conditions in which they perform. We must all work smarter, not just harder.

Six Sigma will help us achieve breakthrough performance. Becoming a Six Sigma company will enable us to develop the right products at the right time and to improve processes to improve cycle time, reduce defects, and increase customer satisfaction. Your support of our Six Sigma efforts will help position CMC long-term as the preferred provider of advanced polishing and surface modification solutions.

Regards,

Bill Noglow

WHAT IS SIX SIGMA?

Six Sigma means many things:

- A Symbol - a Greek letter/mathematical character
- A Metric - measurable
- A Benchmark - a best practice
- A Vision - where you want to be
- A Method - for higher quality
- A Tool - applicable to any business process
- A Goal - what you want to achieve
- A Value - quantifiable
- A Philosophy - a way of work
- A Strategy - a key business plan

Six Sigma is a disciplined methodology for measuring and managing projects in a cost- and data-driven manner that relies heavily on statistical measures and process mapping tools.

The goal of Six Sigma is zero defects and improved customer satisfaction, which are achieved by applying powerful tools at the right time during product/process design and improvement. Use of the Six Sigma DMAIC improvement methodology allows us to achieve improvements for existing products and processes. Six Sigma also guides us, through the Design for Six Sigma methodology, in identifying critical customer requirements and determining how to satisfy those requirements.

How does Six Sigma performance relate to reality? What does 99% Good look like? Here are some typical activities that everyone can relate to and how they perform.
WHAT IS SIX SIGMA?

Would you be able to live with this level of performance?

3.8 Sigma
99% Good

- 20,000 lost articles of mail per hour.
- Unsafe drinking water for almost 15 minutes each day.
- 5,000 incorrect surgical operations per week.
- Two short or long landings at most major airports each day.

Now here are those same activities at a Six Sigma level of performance. As a consumer, which would you choose?

Six Sigma
99.99966% Good

- Seven articles lost per hour.
- One unsafe minute every seven months.
- 1.7 incorrect operations per week.
- One short or long landing every five years.

Six Sigma is about radical business improvement and laser focus on delivering what the customer needs, when they need it.

DMAIC METHODOLOGY

DMAIC is the acronym used to describe the process for Six Sigma improvement activities. DMAIC is one of the methods followed to realize Six Sigma benefits (the other, PIDO V, is covered in the next section). So what does DMAIC stand for?

Define
Measure
Analyze
Improve
Control

Each phase of a DMAIC project seeks to answer a key question about the process or product being improved. The tools that are used to help answer these questions can vary, and no two projects look exactly alike in this regard. Each project must answer these questions in the appropriate phase:

Define: “How do I bound the problem?” The answer to this question is in the scope and charter of the project. A properly defined project, with a scope that is not too large to be accomplished in 4-6 months nor too small as to prevent achieving the goal, is a key for success of a DMAIC project.

Measure: “What is the current process capability?” In order to understand what the potential for improvement is in the beginning and how much improvement has been achieved in the end we must know how our process performs today. A
key part of understanding our current process capability is understanding the role that the measurement system plays in the variation we see. Poor measurement system capability can make it difficult or impossible to determine what variation is inherent to the process and what variation is in the measurement.

**Analyze:** "What are the root causes of today's problems?" In the analyze phase, we seek to determine the key root causes for variation and how much we can reduce them. This is expressed in a term called "Entitlement". Entitlement is the best performance the process can deliver, usually determined by identifying a particular period of data that shows excellent performance. Our goal is to drive the process to perform at this level or better all of the time.

**Improve:** "How do I fix the underlying causes of variation?" The improve phase is where we start to test, model, and implement the improvements that we believe will help us achieve entitlement. During this phase, we monitor process performance very carefully for signs of improvement. Also during this phase, the process stakeholders begin to take ownership of the solutions along with the project team.

**Control:** "How do I control the underlying causes of variation?" This phase is about "sustaining the gains" achieved during the improve phase so that we can maintain the new, higher levels of performance. Process stakeholders should have full ownership of the improved process during this phase.

**PIDOV** is an acronym for the steps in a Design for Six Sigma (DFSS) project. The goal of a DFSS project is to design a product or process that meets all of the customer requirements and is capable of meeting Six Sigma levels of quality. A successful DFSS project addresses potential problems during product definition, design, development and validation instead of after the product has been launched. DFSS is the proactive version of a DMAIC project. If done well, there should be very little to "fix" using DMAIC projects.

DFSS projects invest a higher level of resources into a project at the earliest stages to reduce problems later on.

The PIDOV model divides a DFSS project into the following phases:

**Plan:** Enable the project and team to succeed. Key outputs are a market assessment,
DESIGN FOR SIX SIGMA AND PIDOV

Lean manufacturing is a set of methodologies or techniques that complement Six Sigma and are used to improve quality, optimize flow, eliminate waste and reduce inventory and costs in a process or system. The various tools and techniques that comprise lean manufacturing each address one or more of the process improvements listed by focusing on particular aspects of the overall operation. For example, quality can be improved by eliminating errors that occur within a process and thus, a mistake-proofing technique such as Poka-Yoke can be employed to help eliminate the source of the error and improve overall yield or consistency in the operation. There are many lean tools available in the industry today and only a few are described within this section. Additional lean tools and terms are listed in the glossary for reference.

Value Stream Mapping (VSM):
A value stream map (VSM) uses simple graphics or icons to show the sequence and movement of information, materials and actions in a particular value stream. The value stream is defined as all of the activities that must occur to design, produce and deliver particular products and/or services to a customer. The VSM helps to identify the value-added and non-value-added activities in a process and enables easy identification of sources of waste. One important term used in VSM is takt time which represents available daily production time divided by customer demand and is the target rate for production to ensure proper delivery without over-production i.e., waste.
Visual Management (5S):
Visual management is a set of techniques that help a company achieve a clear, clean, safe and organized workplace through establishing visual order. With visual order in place, work processes are cleaner, more efficient and organized, and costs can be reduced with elimination of waste such as motion and inventory. Visual management is also referred to as 5S, which is derived from the Japanese approach to workplace organization and housekeeping. 5S utilizes visual techniques to further simplify tasks and enhance process efficiency. The steps of 5S represent the methodology for implementing visual order:

S1 – Sort through/Sort out – eliminating excess items/materials not needed
S2 – Scrub – Clean the workplace
S3 – Secure safety – ensure the workplace is safe for operation
S4 – Select locations – Optimize locations and flow to eliminate motion waste
S5 – Set locations – Ensure everything has a place and everything is in its place

Theory of Constraints (TOC):
The Theory of Constraints (TOC) is a lean management philosophy that stresses removal of constraints to increase throughput while decreasing inventory and operating expenses. Basically, TOC looks at the entire operation and determines the weakest link or constraint then applies techniques to manage the constraint and increase output while minimizing variation. A specific technique of TOC is Drum-Buffer-Rope (DBR). DBR controls the flow of materials through the plant in order to produce products in accordance with market demand with a minimum of manufacturing lead time, inventory and operating expenses. The definitions of Drum, Buffer and Rope are:

- Drum - A schedule for the constraint.
- Buffer – This is the time provided for parts to reach the protected area. The protected areas are the Drum, the due-dates and the assemblies of constraint parts with non-constraint parts.
- Rope - A schedule for releasing raw materials to the floor. The Rope is derived according to the Drum and Buffers; its mission is to ensure the proper subordination of the non-constraints

DBR is based on the TOC logistics approach and the TOC five steps of focusing which are as follows:
1. Identify the system constraint(s).
2. Decide how to exploit the system constraint(s).
3. Subordinate everything else to the above decisions.
4. Elevate the system constraint(s).
5. If, in the previous steps, a constraint has been broken, go back to step one, but do not allow inertia to cause a system constraint.

TOC, specifically DBR, allows the plant to manage the bottleneck operation(s) and prevent overproduction, minimize inventories and reduce operating costs.

Total Productive Maintenance (TPM):
Total Productive Maintenance (TPM) is a series of methods that ensures every piece of equipment in a production process is always able to perform its
LEAN CONCEPTS

required function. It involves a team based approach
to improving equipment performance through five key
goals:

- Improve equipment effectiveness – Targets im-
  proving Overall Equipment Effectiveness (OEE)
  which is comprised of three main aspects of equip-
  ment performance: availability, performance effi-
ciency, and quality rate.

- Achieve autonomous maintenance - Allow the
  people who operate equipment to take responsibili-
  ty for, at least some, of the maintenance tasks.

- Plan maintenance - Establish a systematic ap-
  proach to all maintenance activities.

- Train all staff in relevant maintenance skills.

- Achieve early equipment management: The aim is
to move towards zero maintenance through main-
tenance prevention.

TPM works to reduce losses at the equipment such
as work stoppages,
downtime from break-
down or changeover,
yield losses due to start-
up or shut-down, and
defects due to equip-
ment failures.

NOTE: There are many
lean manufacturing
methodologies available
and these are only a few.
The glossary in this
guide contains additional
lean terms and methods
as reference.

Black Belt (BB): A project team leader who is
trained and certified in the Six Sigma breakthrough
methodology and advanced statistical tools.

Capability: The ability of a process to stay within
specifications and on target.

Capability Index: Examples are Cpr and Cpk
which are respectively a measure of the spread of
the process in terms of the specification and a
measure of both the spread of a process and its
setting in terms of the specification. Can also be
used to compare processes to each other.

Cause and effect matrix: Also called a fish
bone diagram used to determine the critical proc-
ess inputs that influence the key output variable.

Champion: An upper level business leader who
facilitates the leadership, implementation, and de-
ployment of the Six Sigma initiative.

Cost of poor quality: Cost associated with
poor quality products or services. Example: prod-
uct inspection, sorting, scrap, rework and field com-
plaints. But, moreover, the cost associated with
what we call the lost opportunity (late delivery, lost
customer loyalty, lost sales, etc).

Critical to Quality (CTQ): Parameters in the
process or product that have a significant impact on
product performance.

Defect: Any characteristic that deviates outside of
specification limits or customer requirements.

Design for Six Sigma (DFSS): A template for
product development where resources are front-
loaded to minimize in-production design changes.

Design of experiments (DOE): A structured,
organized method for determining the relationship
between factors (Xs) affecting a process and the
output of that process (Y).
**KEY TERMS**

**DMAIC:** A type of Six Sigma project conducted using a combination of tools through five phases: Define, Measure, Analyze, Improve, Control.

**Failure Modes and Effects Analysis (FMEA):** A systematic approach to predict problems and provide a system of ranking so the most likely failure modes can be addressed.

**First pass yield:** The percentage of acceptable output of a process after fixes, rework and remanufacture are completed.

**Gage R&R:** Gage repeatability and gage reproducibility testing or validation of measurement system.

**Gage repeatability:** The variation in measurements obtained with a measurement instrument when used several times by one appraiser while measuring the identical characteristic on the same part.

**Gage reproducibility:** The variation in the average of the measurements made by different appraisers when measuring the identical characteristic on the same part.

**Green Belt (GB):** A project team member or leader who is trained and certified in the Green Belt curriculum.

**Just-in-Time (JIT):** Manufacturing method where downstream operations pull required parts needed from upstream operations at the required time.

**Kaizen:** Japanese term for incremental improvement.

**Kanban:** Stocking technique using containers, cards and electronic signals to facilitate one-piece process flow.

**Key process input variable (KPIV):** One of the vital few process input variables that have the greatest effect on the output variable(s) of interest. They are associated with "X's" of the process.

**Key process output variable (KPOV):** The output variable(s) of interest are associated with the "Y's". May be process performance measures of product characteristics.

**Master Black Belt (MBB):** A person who is an "expert" in Six Sigma breakthrough techniques and project implementation. Master Black Belts play a key role in training and coaching Black Belts.

**Measurement system:** The complete process used to obtain measurements. It consists of the collection of operations, procedures, gages and other equipment, software and personnel used to assign a number or value to the characteristic being measured.

**Minitab:** The main statistical software package used by the Black Belts and Green Belts.

**Normal distribution:** A bell-shaped curve of probabilities that describe many natural processes.

**One-piece flow:** Producing one unit at a time, as opposed to producing in large lots.

**Poka-Yoke (mistake-proofing):** Designing a potential failure or cause of failure or mistakes out of a product or process.

**Probability:** The chance of an event happening or a condition occurring in a random trial.

**Process:** The combination of people, equipment, materials, methods and environment that produce output—a given product or service. It is the particular way of doing something.
**Process map:** A step-by-step pictorial sequence of a process showing process inputs and process outputs.

**Process spread:** The extent to which the distribution of individual values of the process characteristic (input or output variable) vary; often shown as the process average plus and minus some number of standard deviations. Other related measures of spread include the range and variance.

**Quality Function Deployment (QFD):** A systematic process used to focus on customers and determine true customer requirements.

**Sigma:** A letter in the Greek alphabet which is used to describe a unit or value of efficiency in processes and procedures. A Sigma rating shows the ability of a process to perform without defects. The higher a Sigma rates, the lower the incidence of defects.

**Six Sigma:** A Six Sigma company achieves fewer than 4 defects per million opportunities.

**Specification:** The engineering requirement or customer requirement for judging acceptability of a particular characteristic.

**Sponsor:** A manager responsible for a Six Sigma project who has local responsibility and accountability to the process being improved by the Six Sigma team.

**Standard deviation:** The most common measure of the variability of a set of data.

**Statistical control:** The condition describing a process from which all special/assignable causes of variation have been eliminated and only common/random causes remain. Applies to both the mean (location) and range.

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**Takt time:** How often product needs to be produced in order to meet customer requirements, based on the rate of sales. Takt time is calculated by dividing the customer demand rate by the available working time per day.

**Theory of Constraints (TOC):** Lean management theory that focuses on optimizing throughput by identifying and removing or managing constraints in a process or system.

**Total Productive Maintenance (TPM):** A series of methods that ensures every piece of equipment in a production process is always able to perform its required tasks.

**Value Stream Mapping:** A tool used to focus on the value of a product from a customer perspective, encompassing every process required to plan, schedule, manufacture, and ship the product.

**Variation:** Difference between individual measurements. Differences are attributed to common and/or special causes.

**Visual Management (5S):** A method of creating a clean and orderly workspace that exposes waste and errors.
FOR FURTHER INFORMATION

Please send an email to

Six Sigma

in Lotus Notes