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The Definitive Guidebook for Component Engineering

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This series of papers present the organization and disciplines of the Components Engineer, (CE). The author’s intention is to provide a comprehensive reference for any individual or company concerned with the development of the department and the ongoing responsibilities of the Components Engineer.

To ensure the most comprehensive coverage, the author assumes that the reader is “new” to the subject. However, both basic and advanced discussions will be presented. It may be argued that various companies have different interpretations of the department’s roles, but a well-designed Components Engineering department will complement almost every other department within the R&D and Manufacturing environment. The CE will be in high demand as a result of the proper execution of his/her responsibilities. Most important of all is the recognition that Components Engineering is a support discipline and thereby contributes through various support functions to complete projects efficiently, on time, and at “least cost”.

Components Engineering is an amazingly challenging and invigorating discipline. The job variety is endless and the technology is forever advancing, providing a rich opportunity to learn about technologies, manufacturing processes, devices, systems, and methodologies for test and analysis.

This is a character producing occupation. Because of the criticality of components to designs, the CE will not have time to daydream. The CE will be “interrupt” driven, and he or she will be consulted and required by Purchasing personnel who need lower cost parts. Engineers, Project Coordinators, and Program Managers will need part numbers and part-specific information to proceed with their individual assignments. CE support request come from all departments and directions, including finance and risk management. In addition, the Manufacturing Process and Sustaining Engineering people who are facing line-down situations at the Factory often consult with the Components Engineer. This is where the CE, the Manufacturing Engineers, and Process Engineers become the heroes who “Save the day!”, not to mention critical parts of their own anatomies. Department heads choose your Components Engineer carefully. Look for a person who is highly organized, even-tempered, diplomatic, tenacious, detail oriented, and LOVES THIS PROFESSION.

Components Engineering Essentials – Part 1

This paper can be used as a guideline for setting up a Components Engineering Department. It contains the nuts and bolts information required to execute the job functions. Included in subsequent papers are suggested forms, procedures, and flowcharts detailing the processes used to execute each CE task. There are discussions about component types, circuit functions, failure modes, the CE inspection tools, test equipment, and a basic understanding of how each component type works…and fails. Reliability Prediction Methodologies and Environmental Testing and Quality Assurance are also covered in additional discussions.

A sample database-organizing scheme is included that lists the most common component types, with suggested format guidelines for the descriptors for each type of device. The author has also attempted to create a most commonly used abbreviation set for the identification of the various parameters that might be included in the database parametric description of a component.

Guidelines for creating and maintaining a Specification Control Document, (SCD) or a Source Control Drawing, (also SCD) are included. Various companies refer to similar documents with different acronyms. The latter “SCD” may be called a “PSD”, (Purchasing Specification Drawing). The purpose and function of the two documents are defined by the unique documentation needs of each company. Different individuals or entire departments within the company may refer to the same document using various names. The Components Engineer will undoubtedly discover that there are as many variant names for standard documents as there are companies. The author has attempted to clear up the confusion by focusing on the purpose and suggested content of each type of document rather than trying to identify the unique nomenclature assigned by each company.

Software and Hardware tools play a powerful role in maintaining a Components Engineering department. Database management will be discussed as well as common electronic record formats such as Portable Document Format, (PDF), and various graphics creation and capture techniques. A basic understanding of common business application software is assumed.
Sub-part One – Basic Functions

Components Engineering is the engineering discipline concerned with the function of component selection, testing, and analysis with emphasis on reliability, availability, suitability, affordability, and traceability.

Breaking this down to individual sections we can further define these as follows:

**Component selection:** The task of identifying a “correct” component for the circuit. This may involve an understanding of how the circuit works and extrapolating the correct parametric for a device, or it may involve identifying the device from a given “list” of parameters. The latter case may be presented to the Component Engineer as: “I need a low drop-out regulator that can handle 500 milliamps with a 5V input voltage and 3.3V out.” The Component Engineer must know what additional questions to ask the Design Engineer in order to expedite the selection of the right part. The CE needs to know if there is a package preference, a mounting configuration, an operating temperature consideration, a size constraint, or any number of other factors that may effect the final selection.

**Testing:** Screening is often required to verify that a device meets the manufacturer’s specifications and functions as expected in the design in process or existing circuit under test, (CUT). This can be as simple as verifying a resistor value and tolerance on an LCR meter (Inductance/Capacitance/Resistance), or as involved as qualifying a higher-level purchased assembly that has hundreds of critical parameters. An example of this may be a television tuner/modulator that has to be measured on all 125 channels for signal-to-noise (SN) ratio, picture quality, audio quality, stability, and a host of other concerns that will determine the end user’s experience.

**Analysis:** The Components Engineer will be involved in Failure Mode Effect Analysis (FMEA) when a component is found to be the cause of a failure in a circuit. Every failure must be examined for “Root Cause” in order to understand the fundamental reason for the failure. Until this is understood, there can be no assurance that the failure will not occur again. To say a component failed because of excessive electrostatic discharge, (ESD) does not delineate the full causation of the failure. How much of a charge is needed to destroy the device? What was the source of the ESD? How did the charge reach the component? Is the circuit protected against ESD? These questions and a many others must be asked in order to determine the ultimate “fix”. In one case, the manufacturer of the part may discover the trace in the integrated circuit connected to the protection diode was over-etched in the manufacturing process; resulting in a lower current handling capacity than specified. In another, the root cause might be that one of the Input connectors did not have the correct interrupt rating for a polyswitch designed to “open” the circuit before passing the ESD along to the more sensitive components.

**Reliability:** Reliability is the property of a device or circuit that determines if the component will function as designed for an expected amount of time under stated worst-case operating conditions. The Components Engineer is concerned with three basic components of reliability: Infant Mortality, Useable Life, and Wear Out. All three will be discussed in later papers. The Component Engineer will be involved in calculating the reliability often expressed in MTBF or “Mean Time Between Failure”. In most cases the manufacturer will issue a “FIT” number, (One failure per billion device hours).

**Availability:** If a component is perfect for the circuit, but is made of “unobtanium”, (unavailable) then all of the work up to this point is to no “avail”. Much of the work of the Components Engineer involves identifying multiple alternate components and sources for every device. The reason is obvious. If a circuit is designed with parts that cannot be found in quantity, the manufacturing process comes to a halt and will not be continued until the circuit can be redesigned or another substitute component is identified. For this reason, the CE must work with the supplier directly or the Purchasing department to determine availability before any other CE task is initiated.

**Suitability:** This criterion concerns more than just the physical form, fit, and functions of the component, but has to do with business issues that without some investigation may not be obvious at the time of selection. The supplier may not be reliable, the datasheet designates “PRELIMINARY” status, the manufacturer is attaching royalties or license fees that may escalate the product cost beyond marketability or cash flow management capabilities, there may be minimum buy quantities that are unrealistic for low volume, high mix operations, and any of a myriad other business related applications that should be addressed and resolved in a concurrent review with all affected departments.
Affordability: This is the “overall” cost associated with the component under consideration. One of the responsibilities of the Components Engineer is to analyze the system with an eye towards best performance at high reliability figures at the lowest possible cost. The Components Engineer does not typically decide features of the end product, but with rare exception, given the same time-to-market window, additional features translate to additional costs. Contrariwise, the Components Engineer may find a part that costs the same or a bit more, but adds extended features that will give the sales force an edge over competing products. But, if a more expensive part is selected that has additional features that are not critical to marketability, then the better choice may be to scale back on the design and select a less costly component with the minimum feature set. Affordability looks at the marketplace and decides if the company is going to get the most return for their investment.

Traceability: Components and products are always changing. Manufacturers may or may not send out a Product Change Notice (PCN), every time a form, fit, or function change is implemented by the manufacturer. The Design Engineers may not be aware of “End of Life” announcements, IC die revisions, or mechanical dimension changes that could affect the performance or physical or electrical form factor fit to the product as previously designed-in. The Components Engineer has to stay current with every component in a product assembly. This means every component should have a Specification Control Document, (SCD) or a Purchasing Specification Document, (PSD) that includes revision level control and all Manufacturer or Vendor change notices associate with the part. The Components Engineer is responsible to see that the change notifications are proliferated throughout all departments concerned as early as possible. Examples of these forms will be shown in a subsequent section. 

A Components Engineer’s role in product development, sustainability, anticipation and planning for eventual market obsolescence is critical to the long-term survival of the product. Later, we will discuss where the CE fits into each stage of a product’s life cycle. From design concept to product introduction and through follow-on support efforts, the Components Engineer’s responsibilities underpin the integrity of both processes and procedures essential to the Company’s reputation and viability; primarily dependent upon continuing product reliability and the market’s continuing demand.

End of Part One

The following subjects are covered in subsequent papers.