July 14, 2003

Commentary

Electrical wiring design needs EDA support

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July 14, 2003 (3:14 p.m. EST)

"Wiring is so fundamental to our society that we often forget it is a system unto itself. The aging of a wire system can result in loss of critical functions in equipment powered by the system or in loss of critical information regarding the operation of certain parts of the equipment...At the same time, new technologies and new materials need to be developed to make revolutionary improvements in wire system integrity and in the ability to identify problems before system failure. These technologies will create the wire systems of tomorrow."

-- National Science and Technology Council, Committee on Technology, Review of Federal Programs for Wire System Safety, November 2000.

Life is unimaginable without electricity, and the electrical systems that carry and distribute it. Miles of electrical wiring are present in homes we live in and buildings we work in — providing light, heating and cooling, and allowing us to operate a variety of equipment from telephones to the most highly automated machinery in factories or spaceships. Electrical systems bridge electrical, electromechanical, and electronic subsystems in machines, buildings, and vehicles.

The irony is that we rely on electrical systems more than ever, so that if they do fail, the consequences may be more catastrophic than ever. Thus along with the benefits of electrical systems, there are risks. One of these risks is that electrical systems may become unreliable or fail altogether, due to poor design, use of defective materials, incompatible components, improper installation, or simply false wiring.

If microprocessors are the brain of electrical systems, then interconnects surely represent the rest of the nervous system. Interconnects are an essential part of any electrical hardware system that provides power, control, and data distribution.

Although it plays a crucial role, the electrical system is usually the last component of a product to be designed. This creates various problems. For example, the compatibility and genders between connectors on the electronic box and interconnect cables are significant factors that are better

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accounted for before final assembly. The manual design process and delayed timing of electrical system design accelerate unrecoverable mistakes created by dealing with a large amount of data, especially when the production schedule slips.

Without automation, the manual design process could become difficult and frustrating, because the manual design process is based on trial, error, and numerous revisions. What if instead of frustration, the designer would have a choice to utilize an easy-to-use design tool that allows for the design of a product that will work the first time?

Automating the design process

A software solution to automate hardware electrical systems design, documentation, manufacturing, and procurement is a primary interest for interconnect technology and will be a significant improvement in existing design flow for EDA customers. What is interconnect technology? To answer this question let's define recognizable levels of interconnects inside an electromechanical system:

- *Level 1: Chip pads to IC package leads, e.g. wire bonds*
  Wire bonds are used to form preliminary bumps, which are then augmented by adding solderable bumps. Wire-bonded bumps are then formed on each pad. In the primary embodiment, the bonds have tails, with the total height of the bond and tail up to 30 mils. Wire bonds can be formed using either gold wire or solder wire.
- *Level 2: Component to PCB, e.g. DIP socket*
  A DIP socket is a dual-in-line IC package adapter soldered to the printed circuit board, and allows quick connection of components to the printed circuit boards.
- *Level 3: PCB to PCB, e.g. interconnect cable assembly or card edge connector*
  The typical “board to board” card edge connection is contained on a flash memory card or on a printed circuit board connected to the motherboard in personal computers.
- *Level 4: Sub-assembly to sub-assembly, e.g. interconnect cable assembly*
  All custom interconnect cable assemblies from a single-conductor power jumper to high-speed digital signal transmission assemblies are designed to provide signal and power distribution between sub-assemblies.
- *Level 5: Sub-assembly to input/output, e.g. interconnect cable assembly*
  In all products where these types of interconnects are specified, designers use round and flat cable assemblies. All of these cable assemblies must have minimal IR voltage drop and cross-talk, and provide EMI and RF immunity.
- *Level 6: System to system, e.g. interconnect cable assembly*
  Beside all the requirements explained above, these assemblies should have durable and robust mechanical and/or environmental protections. In some cases special protected systems are associated with cable assemblies in harsh environments.

The majority of interconnects are cable or harness assemblies. Surprisingly, the interconnects that comprise the majority are often marginalized on the “wish list” of EDA companies that develop tools for designers. Such tools can be independently installed as stand-alone applications, and have by-direction links with electrical and mechanical applications, or can be bundled together with electrical and/or mechanical software programs.

Let's characterize the general requirements for the development of an innovative CAD/CAE/CAM/PDM (Computer Aided Design/Engineering/Manufacturing and Product Data Management) tool that is fully compatible with a PLM (Product Lifecycle Management) system. First of all the tool should seamlessly provide design capabilities for cable and harness assemblies.

Cable and harness assemblies are defined by either signal or power applications. Signal applications are characterized by low current and voltage requirements. Power applications, in contrast, generally address higher current and, often, higher voltage requirements. All of this should be applicable to the layer of product design from Level 3 through Level 6, from top to bottom and vise versa. Subsequently it should fit the following areas:

- *Advanced Manufacturing and CAD/CAM:*
  Simulation, Control and Optimization
  Automation of Manufacturing
  Optimization of the process, Geometric Dimensioning, and Tolerancing
  Scheme for minimum rejection rate
- *Advanced Engineering:*
  Collaborative Product and Process Development
  Investigation of Optimal product Design, Control and Development
- Data management:
  Personnel management (Accessibilities, State control, Role assignment)
  Project management (Process control)
  File management (Version control, Data sharing, Notification, Product development document filing)

In order to address market needs, speed up the design process, and hence reduce product time to market, enterprise software packages must integrate various requirements spelled out above into one complete design flow, including conceptual hardware electrical system design, detail design, and manufacturer output.

This integration can be done by blending multiple techniques and CAD/CAE/CAM/PDM capabilities into a single environment. The techniques utilized in such a program must include knowledge-based systems, commonality between industries, and a clear understanding of system structure from the bottom up. When this is done a unique and powerful tool for hardware electrical systems design automation will be available, and can become a standard across the industries.

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