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Workstation Requirements for Printed Wiring Boards Design

By

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ABSTRACT

This article presents an overview of the requirements of workstations which are used in the design of printed wiring boards (PWB)s. Weaknesses in the current usage of workstations in the design process are discussed and a solution is is suggested whereby functionally specific clustered workstations are tied to an intelligent working data base to form a workstation environment tailored to the engineering design process.

INTRODUCTION

The PWB provides the structure to mechanically support, thermally manage and electrically connect circuit components. As the density, speed, and resulting heat dissipation of microelectronic circuit components increases, and as new technologies, such as fine line and surface mount [6], enable more components to be placed on a PWB, the utilization of computer-aided design (CAD) workstations with heuristic decision support (DS) capabilities is required in the design process. Design operations which can be effectively handled using CAD and DS systems include: the capture and verification of electrical schematic data, component placement, wire routing, thermal analysis, vibrational analysis, reliability analysis, design and tolerance checks, the generation of manufacturing data and computer numerical control tapes, and documentation [1,5]. However, even with current implementations of dedicated CAD and DS systems, the design process can take up to 12 weeks from initiation to completion, without any guarantee of a reliable final product [2,3].

CURRENT DESIGN ISSUES AND PRACTICES

PWB design requirements arise from a variety of interdisciplinary areas including electrical and mechanical engineering, mathematics and computer science. One of the most complex and critical tasks in PWB design is the placement of microelectronic components on a PWB. The following placement criteria have been identified:

- wire buildup in the routing channels on the board must be kept within tolerable bounds
- signal cross-talk must be eliminated without undue use of expensive shielding techniques
- signal echoes must be eliminated
- thermal reliability constraints obtained from heat dissipation values based on the actual power dissipation of the components must be satisfied
- radiation reliability constraints must be satisfied
- vibrational and thermal modes which can induce solder, component or board failures must be eliminated
- the manufacturability, testability and maintainability of the PWB must be insured

In general, each of these tasks are dependent, but have the property that the analysis can be accomplished concurrently. Since the tasks require specific analysis capabilities, individual workstations appropriate to the specific tasks can be used.

By examining the requirements which arise from the component placement task, it becomes apparent that the current state-of-the-art in the design of printed wiring boards leaves a great deal of room for improvements. Computer assisted engineering and computer aided design are nearly always applied in a rather unsophisticated manner inherited from the days prior to CAE and CAD.

CAD workstations typically lack appropriately sophisticated data management capabilities. For PWB design, a global data base with a complete range of components, their attributes and qualifiers requires a separate management system which can be directly interfaced to the various analysis workstations in a relational data base mode. On the other hand, working data bases which are specific to a particular PWB design, and form a relational subset of the global data base (i.e. only attributes needed for the task) should be resident in the workstation which is executing that task. As a result, the transfer, interpretation, and conversion from one functional task to another will be minimized.

The data base issue is complicated by the fact that traditionally the PWB design groups have their own software tools for their own particular piece of the overall design project. The different groups do not interact, employing instead a linear design approach whereby tasks are passed from one division to another. This is primarily a consequence of the development of separate, non-integrable and complex functional operations. There is seldom any concurrent processing and often there is little iteration outside a division, since a failure at any stage can rarely be handled.

The electrical engineers have tools for schematic and logic design, and simulation. They pass a netlist to the layout group which proceeds to place the components on the board using algorithms which aim for 100% routability. The placement is then sent to mechanical engineering groups which perform a thermal analysis in order to flag exceptionally hot components. The mechanical engineering group may also execute a vibrational analysis of the PWB, primarily to determine if board stiffeners should be added. The results of these analyses may then be sent to the reliability group which should check the design for reliability, maintainability, and cost. If the layout fails any of these checks, the reliability group then proceeds to "negotiate" with the layout and/or the electrical groups. Unfortunately, by this time the board has been routed, and the effort (and cost) to go back and change any components or their placement is prohibitive. For example, thermal reliability analysis is typically executed near the end of the PWB analysis/design process. If the board fails to meet to meet specified guidelines, components must be re-arranged. However, components cannot be re-arranged without affecting the wire length constraints required to meet critical timing paths. As a result, a PWB with minimum total wire length, providing the necessary heat dissipation and acceptable thermal reliability is difficult to achieve [7,8,9,10].

Finally, current design systems do not have the capabilities to incorporate the knowledge of an intelligent PWB system designer [4]. Although an engineer is often required to aid in the operation of a particular design task, the interdisciplinary system design requires that the knowledge gained from each step in the design process, as well as constraint information be used in the design process.

A NEW APPROACH TO PWB DESIGN

The "perfect" PWB design workstation might be defined as a system which efficiently 'integrates' and optimizes (as a multi-variable problem) all the functional operations in the design process. However, there are a number of reasons why this approach is presently not feasible. First, a single workstation cannot efficiently handle all the design criteria. In most cases, design requirements and constraints are developed during the design process and require some human interface with an experienced engineer. Second, once an initial placement of the components has been given, many of the design processes can and should be implemented concurrently [12]. Third, the analysis routines generally require specific computer functionality such as extensive floating point capabilities for the numeric processing needed in mechanical engineering analysis, integer processing and high resolution graphics needed for routing analysis, and high I/O capabilities needed for reliability and global data base management. For these reasons, an environment of task dependent workstations clustered around a decision support system [11] which holds the component placement working data base is the most suitable (Figure 1). This design system intelligently interfaces rather than integrates the various PWB workstations and associated analysis tasks, can be adapted to a wide range of different and changing technologies without excessive re-programming or re-configuring and can be efficiently executed.

In this configuration of workstations, PWB design characteristics can be monitored and the appropriate design operations can be run concurrently on machines suited for the specific operations. Concurreny of operation is of key importance because of the design economics. For example, using a 32 bit Arithmetic Processing Unit (APU), and a well known state of the art software package, it can take up to 90 hours to satisfy 70% routing of a VHSIC board with approximately 100, 320 pin gate arrays. The remaining 30% can take as much as 1000 man hours to complete. Thermal analysis for this type of board can be completed in less than 45 minutes, while the thermal reliability analysis can be completed in 15 minutes assuming that a readily accessible data base exists. Vibrational analysis typically takes about 10 hours of executive time, assuming finite element analysis which incorporates linearly elastic pin connections. It is apparent from this example that a linear approach can no longer be tolerated since the costs in time are so large, especially if a modification is required. Using concurrency, routing, thermal and thermal reliability analysis, and vibrational analysis can be initiated together. Then process "states" can be examined to measure the progress of the design until a satisfactory state is reached. While this will probably not result in the optimal thermal or vibrational reliability design, optimal reliability is usually not required. Instead, reliability limits which meet design specifications must be satisfied.

This approach requires that the individual workstations (Figure 2) use heuristics rather than algorithmic techniques to interface between computational routines. This provides the designer with flexibility in that the PWB design can be modified by changing the manner in which the working data base handles the results of the computational analysis by simply modifying the rules. Furthermore, the modularity of this approach allows a variety of different technologies to be integrated without excessive re-programming. The advantages to modular problem solving are well known and documented. Modularity allows computational routines to be appended, placed in suspension during the design process, or omitted.

CONCLUSION

With the complex electronic systems of today containing hundreds of components on a PWB, the design of PWBs has become a difficult problem requiring an integrated approach. A workstation environment which combines the various disciplines involved in PWB design can be invaluable in making integrated design viable especially if it allows for concurrency, flexibility and modularity of the design tasks.

ACKNOWLEDGEMENT

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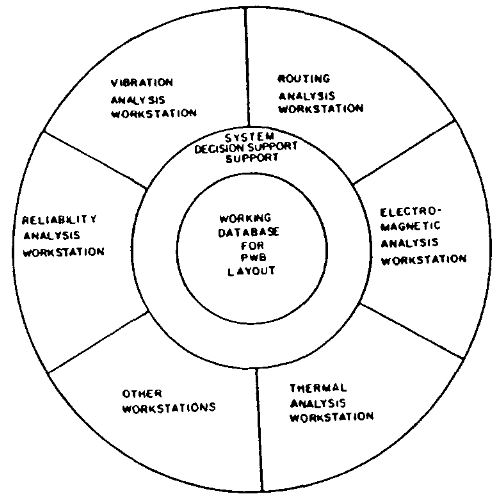

Figure 1: Clustered Workstation Architecture

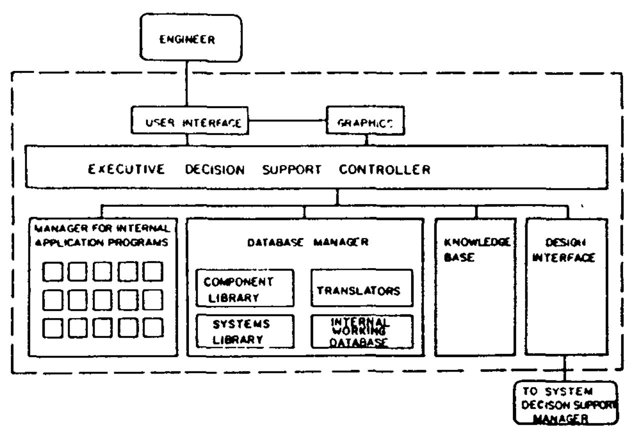

Figure 2: Individual Analysis Workstation Architecture