The Boeing electronic computer aided design system

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PROBLEM

A large percentage of the cost of most DOD-contracted programs is concerned with the concept development, circuit design, packaging, test and fabrication of electronic systems and subsystems. The application of Computer Aided Design (CAD) concepts to facilitate these operations can significantly reduce cost and minimize flow time in the design, fabrication and test of end item hardware.

OBJECTIVE

The fundamental objectives of CAD are to reduce cost and minimize flow times in the design and factory production of electrical hardware. This calls for identification of areas in the equipment design, packaging, test and fabrication processes that are operationally and economically adaptable to computerized techniques and the specification and development of those techniques.

SYSTEM DESCRIPTION

The following is a brief description of the Electronic Computer Aided Design (E/CAD) system in use at The Boeing Company.

E/CAD system description

Some of the factors making the development of electronics systems a lengthy and time-consuming process relate to the sheer mass of detail work that must be performed. Examples are: the drafting and checking of logic diagrams, the tabulation of electrical parametric data (time delays, logic states, voltages, etc.), evaluation to verify electronics designs and functional test sequences, the assignment of logic elements to integrated circuit packages (allocation) and of integrated circuit packages to printed circuit boards (partitioning), placement of circuit packages on the boards, boards in card cages or drawers, and the production of documentation to convey fabrication details to the shop. This accumulation of data during development of a product is an essential procedure, from preliminary design analysis through manufacturing.

To facilitate efficient transfer of data, the E/CAD system was designed to ensure that the programs do not communicate directly with each other but through common groups of data residing in the design data base. This facilitates the addition of new software programs to the system. A separate Data Base Utility program is provided to allow the user to add user-prepared data to the data base and to store and control data.

The Boeing E/CAD System is schematically represented in Figure 1. The rectangular boxes represent programs that are operational on Company computers, while the oval-ended boxes represent manual design functions and are entry points into the system. The programs are divided into two categories: design validation (including analysis, simulation and functional test) and packaging. Analog analysis, digital analysis, Computer Simulator, logic simulator, and digital functional test comprise the design validation programs. They assist the user in converting the data represented by a schematic or logic diagram into a format that can be used by the E/CAD System and provide aids to detect and correct logic errors in the system design. The Logic Simulator program assists the engineer in performing detailed logic simulation (design verification) of digital assemblies, including automatic worst case timing analysis. The Digital Functional Test program aids in the efficient development of high quality functional tests. Also included are post-processing programs which translate the test output data to releasable documentation and format the data for use on automatic test equipment. In addition, numerous analog circuit analysis programs (e.g., ISPICE, CIRCUS, SCEPTRE) and thermal analysis programs (e.g., BETA) are utilized but are not currently integrated into the E/CAD system.

The Packaging Interface program is the interface between design validation and packaging design. User-supplied packaging information (the assignment of logic devices to parts and parts to assemblies) is combined with the design description from the analysis programs. The Packaging Inter-
The face program ensures against incompatibilities between logic design and packaging design information, determines all signals that must be brought to the connectors on the assembly, automatically assigns pin numbers for all logic devices, and generates pin-node data for use by the packaging programs and the functional test patterns for producing the final test program package.

The packaging programs are divided into two major categories: printed circuit board design and backplane design. Design of a printed circuit board (PCB) is accomplished with a combination of large-scale computer and small midicomputer with interactive graphics. The PCB editor utilizes packaging design information in addition to the data from the Packaging Interface program. Packaging design information (design rules, pad sizes, spacing, optional part placement, etc) is entered into the system, processed, and edited to correct errors. The resulting information is used for interactive placement of components and automatic routing of conductors. Once automatic routing is completed, options are provided for manual intervention and modification of conductor routes by means of the interactive graphics console (Figure 2). Automatic checking for connection and dimensional spacing violations is a part of the software system. Once board layout is completed, necessary information is generated to drive plotters to produce assembly drawing and photo master artwork and a control tape for numerically controlled drilling is produced. The assembly drawing, photo master artwork, and drill tape, when combined with other manually prepared instructions, are used to produce the finished printed circuit board.

The second major category of packaging programs is backplane design, which involves point-to-point wiring predominantly by wire wrap. This packaging technique is used for two general categories of assembly design: digital logic assemblies and PCB connector backplanes. Wire wrap assembly of digital logic assemblies usually proves to be more cost effective than PCB's in applications such as breadboards and small-quantity production runs. The shop aids
necessary to wire the assembly are produced from the wiring program in the form of a punched tape and a computer listing. This tape and listing are used by the shop for fabrication. The wiring program also places data on the data base for use by a documentation program to produce a complete wire book. The wire book contains necessary information to identify the wiring on an assembly and maintain unit configuration control. The documentation program, in turn, places data on the data base for use by the DITMCO Test-Postprocessor program, which generates a test tape for the DITMCO test equipment to check for open or shorted circuits in the completed wiring assembly.

Utilization within boeing

The E/CAD system has been in development since late 1970. An overall system approach was selected and capabilities added on a modular basis. The E/CAD system is used on all major electronic design and development activities within The Boeing Company. To date, approximately 2,000 PCB's and 700 wired assemblies have been designed using these capabilities. The average PCB is four to six layers and the average wired assembly has in excess of 1,000 wires. Cost savings/avoidance to date are in excess of 10 million dollars.