CASE STUDY

Digital scopes: assembly in record time

PRODUCT: 11401, 11402 oscilloscopes
MANUFACTURER: Tektronix Inc.
SCOPE: digital, simple-to-use instruments for complex measurements
CONCEPT: November 1982
AVAILABLE: October 1986
CHIEF DESIGNERS: Tom Rousseau, engineering; Walter C. Ventgen, manufacturing

Many of today's engineers and scientists first saw a Tektronix oscilloscope in an undergraduate college laboratory. They feel they have grown up with Tek scopes. But in doing their own growing up, the laboratory oscilloscopes made by nearly all instrument companies have become complex and, as a result, time-consuming and very expensive to assemble.

One of the exceptions to that trend is the 11400 line of digitizing oscilloscopes from Tektronix Inc., Beaverton, Ore. It is complex by virtue of being fast and having many advanced functions, but it can be assembled in 45 minutes. By contrast, a predecessor, the 7854 digitizing scope, took 9 hours to assemble.

Simplicity through complexity

Tom Rousseau, project manager for the 11400 series, and his design engineers faced a difficult problem. Their job was to design scopes that would be even more complex than the 7854, with its more than 200 knobs and buttons to control 250 functions. To make the new line easy for engineers to use, the 11401 and 11402 were to be programmable instruments with soft buttons, touch screens, and extensive onboard diagnostics. All told, the approach mandated 0.75 megabyte of firmware. Yet the time to assemble the oscilloscopes had to be cut drastically.

The biggest savings lie in the designs of the printed-circuit boards and the way they are connected. The complexity of the 11400 series circuit boards requires dense component placement, so surface-mounted components were called for wherever possible. To keep assembly time down, the design called for maximum use of machine insertion. As a result, boards were laid out with components oriented in a common direction to facilitate machine insertion, and they were spaced to accommodate the insertion heads.

Where surface-mounted components are not used, the designers selected components housed in DIP, TO-5, and other packages with leads exiting from the bottom, which favors automatic insertion. Components were further selected and arranged to minimize the number of insertion heads required and the number of times the heads had to be changed.

Another concern was the extensive cabling between boards on the 7854, which made cable installation a time-consuming and error-prone task. On the 11400 series, most cables are replaced by card cages and back planes; the few cables that remain are indexed to prevent incorrect connection.

The digital design of the 11400 scopes helps speed final factory calibration. All but one of the 200 calibration constants in the 11400 series are done automatically. Laser trimming of resistors has largely replaced the classic trim pot, and most of the calibrations that remain are adjustments for the CRT.

Before the design of the 11400 scopes got under way, Al Peecher, then manufacturing manager (now retired), and Greg Rogers, then engineering manager for the Laboratory Instruments Division, decided to bridge the traditional separation of engineering and manufacturing.

Previous experience had indicated that designers often used components and board layouts that defied machine insertion. "Engineering would design it so it worked," said scope codesigner Walter C. Ventgen, "and Manufacturing would spend two years redesigning it so it could be made at a profit." Peecher and Rogers reversed this trend by stationing a group of manufacturing engineers in the design engineering area to make sure manufacturing requirements were incorporated.

One major change in design practice came at the board prototyping stage. The standard procedure at Tektronix, as in most of the electronics industry, had been to hand-assemble prototype boards in the engineering department. A working prototype verified the design but it usually looked nothing like the production board. The 11400 team made it a rule that all prototype boards would be assembled by the manufacturing department. As a result manufacturing was able to catch many potential assembly problems at an early stage.

—Kenneth I. Werner

Board designs featuring uniaxial placement and careful spacing of selected components made machine insertion possible for nearly 90 percent of the components in the Tektronix 11401/402 digitizing oscilloscopes, compared with about 50 percent in its predecessor, the 7854. The difference is striking in the display controller boards of the 7854 [top] and the 11401/402 [bottom]. The orange components are the ones that must be hand-inserted.