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A Low-Cost Wireless Portable Printer

Based on a unidirectional infrared transmission path, this small thermal printer can provide hard copy of HP-18C and HP-28C calculations.

by David L. Smith and Masahiko Muranami

THE HP 82240A INFRARED PRINTER (Fig. 1) is a portable battery-powered thermal printer capable of printing a maximum of 24 columns of alphanumeric characters or 166 columns of continuous graphics per line. Designed for use with an HP-18C or HP-28C handheld calculator,[1,2] the information to be printed is transmitted to the printer by the calculator using an infrared beam. This transmission method is discussed in detail in the article on page 16.

The printer uses HP's standard 58-mm-wide black-printing thermal paper. The 2-inch-diameter, 80-foot-long roll will provide about 6000 lines of print. User controls include power, print intensity, and paper advance switches. The HP Roman8 character set is provided.

Power is supplied by four commercially available AA-size batteries and can be supplemented by an ac adapter with a common barrel-shaped plug. The unit can accept adapters with ac or dc output. With full power the printer is capable of printing 0.8 line per second. One set of fresh batteries will print up to one roll.

The HP 82240A measures approximately 7.25 inches long by 3.5 inches wide by 2.5 inches tall. It weighs about

Fig. 1. *The HP 82240A Infrared Printer is a battery-operated printer designed for use with the HP-18C and HP-28C Calculators. The need for connecting cables is eliminated by using an infrared beam for data transmission.*

one pound when loaded with a full paper roll and batteries. A manual, paper roll, and batteries are included with the printer.

Product Design

The components of the HP 82240A can be divided into several general categories (see Fig. 2): printer mechanism, printed circuit assembly, battery contacts, electrostatic discharge protection, and plastic parts.

The development time for the HP 82240A was rather short because of its scheduled announcement along with the HP-18C. One factor that enabled quick development was the decision to purchase an OEM printer mechanism. The mechanism was chosen for compactness, quiet operation, and graphics printing capability. Its cost accounts for one third of the total part cost of the printer. Testing was conducted to ensure acceptable life, environmental, and drop-survival performance. Based on qualification test results, the manufacturer agreed to modify the mechanism to meet our drop test and package drop test requirements.

Other parts such as switches, CPU, and interconnects were chosen for low cost and savings in development time.

Two battery springs were designed to connect the batteries to the printed circuit board. Nickel-plated beryllium copper was chosen for high strength and corrosion resistance. The 3.3-by-4.5-inch single-sided printed circuit board is a departure from recent double-sided and/or hybrid board technology used in HP's handheld products. Lower cost was the main reason for this decision.

Attention was paid to efficiency and manufacturability throughout the design process. A CAD/CAM system was used from initial layout to drawing generation. Components of the printer such as plastic parts, metal parts, and the printed circuit board were designed as wireframe models. To ensure proper interaction among the parts, purchased components such as the paper roll, batteries, printer mechanism, switches, photodiode, and ac socket were also recreated in the data bases. Where necessary, these models could be manipulated to determine feature locations and to check for fit and interferences. The rotating motion of the paper door, for example, was simulated to determine its pin location in the bottom case and its snap detail in the top case (see Fig. 3). Application of CAD/CAM methods to the design process greatly increased confidence that all components would perform together as intended.

Early in the design process, manufacturing engineering advised that parts allowing layered assembly were more desirable. An effort was made to design plastic parts that held components in place during assembly, thus eliminating as many two-handed operations as possible. The solution chosen uses snap fits and slip fits throughout the product and allows assembly from the bottom case up. The battery shorting bars and contacts snap into the bottom case to allow manipulation of the assembly without dislocating them. The ESD protection components and printed circuit assembly are located by screw bosses. The keycaps slip onto the switch actuators and the printer mechanism is secured. Two screws locate the mechanism within a small tolerance band to eliminate the possibility of paper jams. The ac adapter receptacle and infrared window snap into the bottom case, after which the top case is slipped over the whole assembly. Six screws hold the cases together to ensure acceptable drop performance. The cosmetically sensitive paper door and paper tear-off window are snapped into place at the end of the assembly process.

Custom tooling for plastic parts was another area in

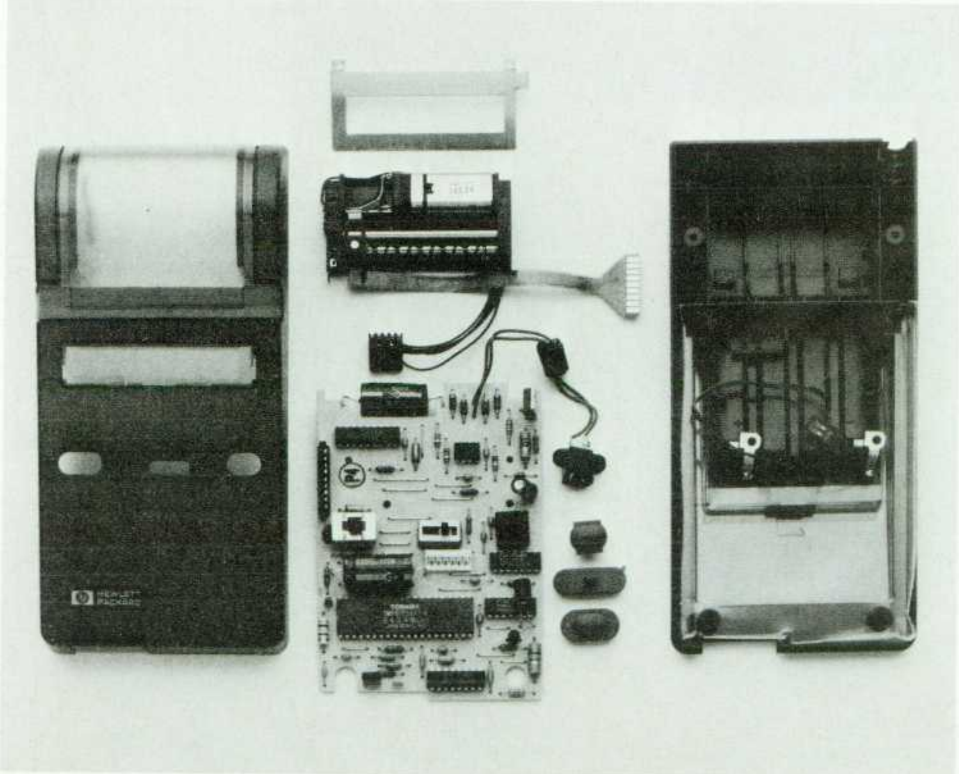

Fig. 2. *Components used in HP 82240A.*

which CAD/CAM played a major role. The plastic injection molds for the top and bottom case were built entirely using computer-aided-manufacturing techniques. The wireframe data base from R&D was transferred to a similar system in manufacturing. The mold designers used the part data base to create the mold data base. No part drawings were necessary, since the data base contained the required tooling information. Waterline locations, inserts, ejector plates and all electrode designs were completed on the system. The complex shape of the case parts would have made conventional calculations time consuming and difficult, but the system made number-checking trivial. Details such as the external radii along the intersection of a curved surface and a drafted plane were programmed and cut on a CNC (computerized numerical control) milling machine with great accuracy. With conventional techniques, milling such details exactly as the print specifies is nearly impossible and very time consuming. Complete tooling for the top and bottom case was manufactured in seven weeks, compared to quotes of nine to twelve weeks from outside vendors without CAD/CAM capability. Design modifications were also conveyed to the mold designers through the part data base. The hard-copy documentation for the top and bottom case was done after the molds were completed for production parts.

Because we lacked sufficient experience with single-sided printed circuit boards, manufacturing engineering gave considerable attention to the solderability and testing of the board. Design guidelines were first obtained from Roseville Terminal Division. The pad and trace design incorporates features designed for optimum solderability and strength in the finished product. Solder defect data was collected by conducting wave soldering experiments at Vancouver Division, from which design modifications were determined.

During development, the decision was made to transfer production to Singapore Manufacturing Division. A coordinated effort for a smooth transition was accomplished in several stages. First, assembly tooling was designed and built in Corvallis with the aid of Singapore engineers. Parts were sourced domestically, whether custom or commercially available. Lab prototypes were assembled in Corvallis. The results gave information upon which design improvements, tooling debug, and process refinement were based. Complete QA testing was conducted in Corvallis with a Singapore engineer, while some of the tests were duplicated in Singapore. Singapore then began procuring parts locally and initiated tooling for custom parts except plastic molds. Tooling and custom parts were shipped to Singapore for the production prototype build, for which Corvallis engineers were at hand. Finally, for production, the plastic molds were sent to Singapore.

Acknowledgments

Theresa Gibney conducted solderability experiments, coordinated assembly tooling, and designed the line both in Corvallis and Singapore. She also acted as liaison between the two sites. Marc Baldwin coordinated plastic tooling, texturing, and tool transfer. Other members of John Mitchell's manufacturing team contributed to assembly tooling. Gary Watts and Bill Peters designed the molds for the top case and bottom case. Burl Smith programmed the CNC milling machine. Singapore engineers David Shum and Tan Zing Chiou came to Corvallis to aid assembly tooling, line design, and procurement. Herbert Ting came to conduct product qualification. Other members of Ng Say Ban's manufacturing team contributed to the smooth transfer of production to Singapore. Procurement engineers both in Corvallis and Singapore were essential to the success of protoype builds.

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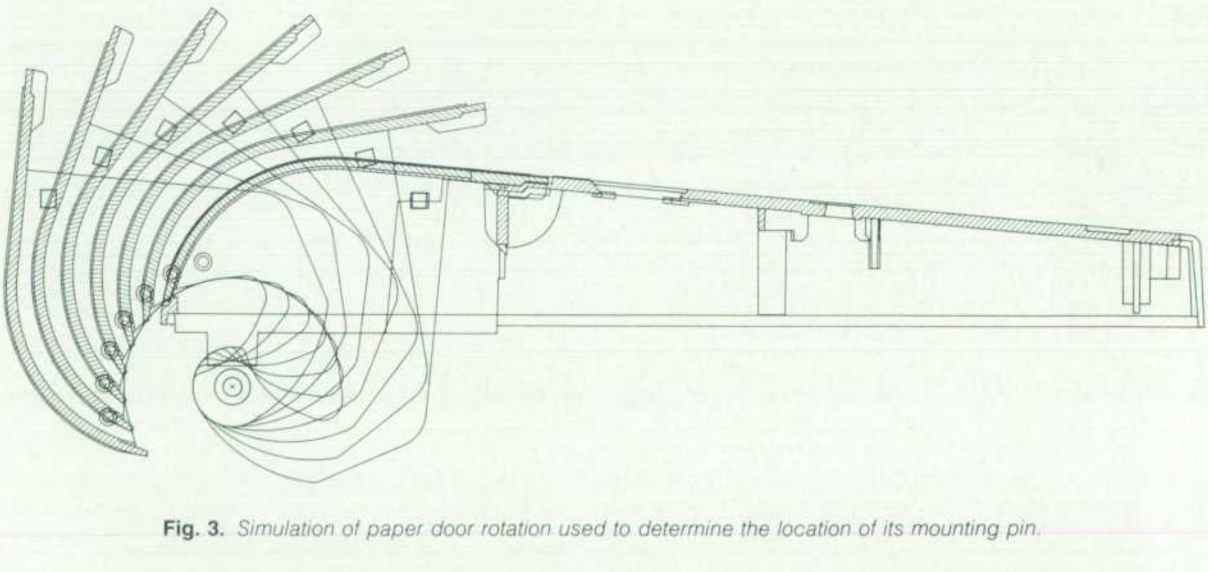

Fig. 3. *Simulation of paper door rotation used to determine the location of its mounting pin.*