Keyboards for μP-based systems grow in versatility, performance

The push is on in keyboard technology, and the major pressure's coming from the need to communicate with the fast-growing world of microprocessor-controlled systems and devices. There's quite a range out there—from high-speed, data-entry terminals to household range-oven controls. The demands sound familiar: Lower cost, better performance and higher reliability for keyboards of all sizes, shapes and capabilities. Keyboard manufacturers are meeting these demands in a number of ways:

- More intelligence, providing better performance and a variety of user options, is being incorporated into keyboards through the use of custom LSI chips and microprocessors.
- Keyboard costs are being reduced, while performance is being improved, by the development of new key-switch designs tailored to low-cost, highly automated production methods.
- Cost/performance-competitive versions of capacitive and membrane keyboards are emerging as dominant industry trends.

Options easy with μPs

LSI technology and microprocessors, being applied to a broad number of keyboards, are providing advantages to both the manufacturers and OEM users. The manufacturer can offer a wide variety of options, from a "bare bones" unit to an on-board μP that can be programmed to carry out unique customer requirements.

The customer benefits because he can choose how to allocate the cost of the system electronics—keyboard plus, say, video terminal. And with a μP on the keyboard, the user may be able to unload some peripheral duties on it, or even provide some missing functions. That will help greatly to reduce over-all design costs.

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Associate Editor

Adapting μPs to keyboard technology has been rapid, as illustrated by Honeywell's Micro Switch Division (Freeport, IL), the first to introduce a full-function intelligent keyboard that combined an 8-bit single-chip microcomputer with 103 Hall-effect key modules.

"A year ago," says Joe E. Bailey, keyboard engineering manager at Micro Switch, "our keyboard electronics was provided by custom NMOS and CMOS devices, plus off-the-shelf logic." But the custom chip designs made it difficult and expensive to respond quickly to varying customer demands for keyboard changes as systems were developed.

Today, Micro Switch is solving this problem—it's universally agreed that the keyboard business itself is custom—by applying Intel's 8048 and other MCS 48 components. Depending on what the user wants, different chips in the MCS 48 family are used on the keyboard.

For the low-cost end of the line, Micro Switch applies the 8021. Erasable, programmable EPROMs are also used as well as standard mask-programmable devices.

The keyboard itself, designed by Micro Switch for intelligent and distributed-processing terminal applications, demonstrates the power of a μP in keyboard applications. The board can be programmed to interface with any 8-bit bus and can operate as a three-state I/O device in either a polled or interrupt mode. Data duration and strobe can be adjusted to meet special needs. The key-code output is fully programmable, and can also perform any of the shift, repeat or control functions.

Mode priority and assignment can be changed, and auto-repeat key assignments and repeat rate modified. Multiple-character storage on a first-in-first-out basis can be regulated by size. And pressing particular keys will generate character output. Moreover, the serious-output word format and baud rate can be tailored to user requirements.

The MCS 48 family is a good choice over a relatively unfamiliar custom μP, because most keyboard customers are already using one of the common 8-bit μCs. In addition, the family can operate on a common 8-bit bus line.

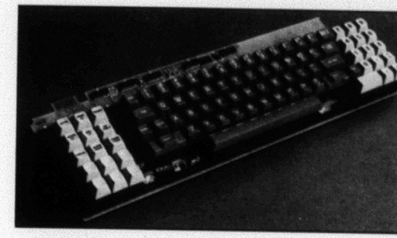
Diagnostics appearing with μPs

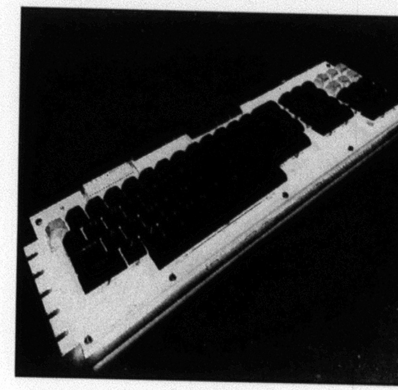
Besides infusing keyboards with useful intelligence, keyboard μPs are offering themselves as diagnostic tools. Aware of the high cost of service calls, terminal manufacturers are designing diagnostic routines and capabilities into the terminal itself. And this added capability is involving the keyboard. For example, it's not unusual for a diagnostic program to request that a keyboard generate two or three special characters, when power is applied to the system, to indicate that all is working properly. A microprocessor under software control makes this easy.

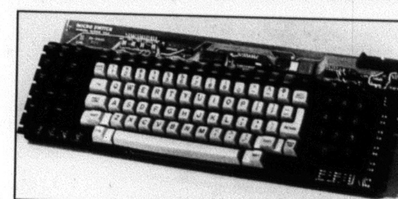
Such diagnostics are being designed not only into terminals and other sophisticated keyboard equipment, but also into equipment as mundane as microwave ovens.

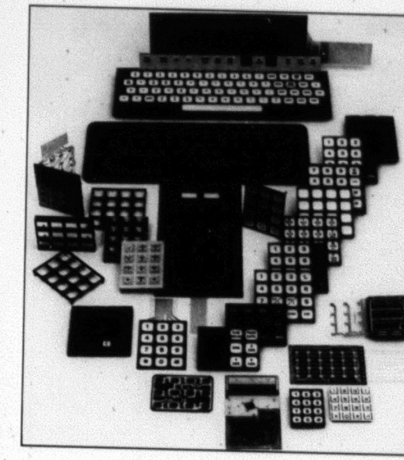
One leading manufacturer of consumer-oven and range controls, Robertshaw Controls (Holland, MI), has recently developed a control for an expensive line of microwave ovens. This Universal Microwave Control features a touch-type membrane keyboard for operating a 4-bit μP, which has 130 standard strappable options using the same ROM. Incorporated self-diagnostic routines can be accessed from the control-panel keyboard.

Another offshoot of the μP-technology invasion into the keyboards is the









The intelligent Hall-effect keyboard (lower left) incorporates Intel's 8048 single-chip μC. This permits the keyboard, by Micro Switch, to interface with a variety of computer terminals. The key-code output is programmable.

A hard-wired microprogrammed encoder chip (center left) in this Cherry capacitive keyboard converts the keyswitch signals into a standard-coded 8-bit format. The chip has special features, such as a noise-immunity circuit.

A custom "universal" keyboard-scan encoder (upper left) on this saturable-core assembly by Cortron, identifies the location of a key with a binary-coded output instead of the key's alphanumeric designation.

The most versatile and generally the lowest-cost of all keyboards is the elastomeric membrane type (above), which can be fabricated in thin touch-type panels or as a full-key, alphanumeric device. Keyboards are by Chomerics.

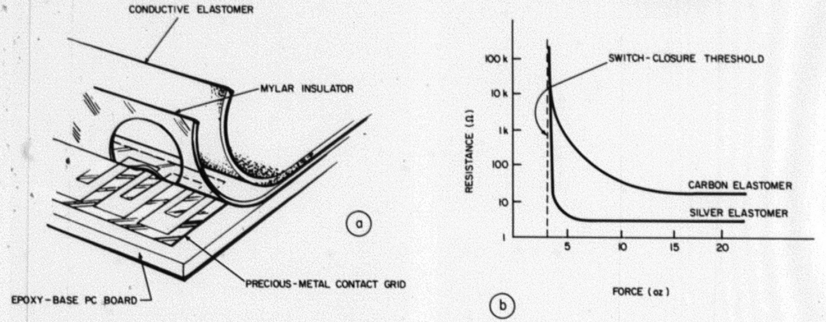
rise to power of capacitance-keyswitch technology. It's now a potential leader in high-volume keyboard applications. The problem hasn't been with the keyswitch structures—they're low-cost and reliable, simply one small plate moving towards one or two others. But these plusses have been blunted by the relatively high cost of oscillator, sensing amplifier and serial-scanning electronics, much of which contained discrete elements. For example, the first generation of capacitance keyswitch interface technology employed serial scanning techniques with multiple discrete components, which were slower than what's required for most of today's n-key roll-over keyboards.

But now, cost comes down while speed goes up with a 40-pin IC that allows a capacitive keyboard to interface directly with μPs. Developed by C.P. Clare in conjunction with General Instrument's Microelectronics Div. (Hicksville, NY), the Byte-Wide is used with an on-board 8048 or 8021 to provide an intelligent unit, supplied by Clare. Or, Clare will offer a capacitive keyboard with just the Byte-Wide, which can then be used with a customer's 8021, 8048 or 3870 (Mostek).

The Byte-Wide, a multilayer I^2L device that requires but one 5-V dc supply, minimizes microcomputer overhead and allows the μC to better serve other system functions. It does this by sampling the status of each keyswitch and stores it in memory. The information can then be scanned and read out, eight bits at a time.

This capability also gives higher throughput rates and n-key roll-over at no extra cost. In addition, electronic keyswitch hysteresis, designed into the Byte-Wide, prevents an operator from "teasing" a key by partially depressing it.

Another way to reduce the cost of capacitive keyboard electronics is shown by Cherry Electrical Products (Waukegan, IL), which uses a special, custom encoder chip plus a sense amplifier. The encoder converts the ca-



Membrane-keyboard switches are constructed (a) using a PC board, Mylar insulator with holes for contact areas, and a conductive elastomer sheet on top. Operating characteristics of this Flex Key design can be varied (b) by putting either carbon or silver filling in the elastomer sheet. Silver gives the lower on-resistance.

pacitive keyswitch signals first into analog, then into digital, and then converts them to a standard encoded format of eight data bits. Two additional data bits are available for customer options.

The custom chip, which Cherry calls a hard-wired microprogrammer rather than a μP, incorporates special features such as

- A noise-immunity circuit to discriminate between a valid key depression and noise.
- Externally adjustable keyboard-scan times (as low as 10 μs per key).
- Built-in electronic hysteresis, which prevents a double signal should an operator slightly release key pressure and then push down harder.

Redesign reduces cost

Keyboard cost can also be reduced by redesigning the keyswitch and board elements themselves to reduce production expense or by designing lower-cost keyboards from scratch. The impetus for this comes from the large volume users, which inhabit the lower-cost brackets.

Micro Switch has been able to reduce the costs of its Hall-effect keyboards by around 10% by scouring production details. Its 3T keyboard, so called because it uses a three-terminal Hall-effect module rather than a previous four-terminal unit, has a single-sided PC board rather than the two-sided, plated-through PC board formerly used. The reason for this is that the company invested substantially in wire-insertion equipment that provides wire crossovers automatically, and replaces the second, plated side of a PC board with hard-wired crossovers.

The 3T-module design also saves money by omitting one connection. Moreover, though packaged smaller than the 4T module, it can be stacked 16 in a row in a space that could fit just 10 4T modules. And instead of using two magnets that had to be hand-assembled into a key plunger, the 3T module uses one magnet that's automatically molded into a plunger.

Meanwhile, to compete in low-cost markets, Clare has turned to a new low-profile alphanumeric keyboard that uses small, micromotion pancakes containing cricket-type switches. Soon to be marketed, it has been specifically developed for a conversational type terminal—one which is portable and is operated intermittently and slowly—instead of for high-speed data entry terminals, where reliability is critical. The dome switches won't live nearly as long as reed or capacitive switches, which are expected to last through 100-million operations. And the micromotion keyboard feels somewhat like that of a Texas Instruments' calculator—stiff.

Another kind of keyswitch is coming down in cost. The saturable-core device being used by the Cortron Division of Illinois Tool Works (Chicago) in its latest Series III Solid State keyboards, has one instead of two magnets in the moving key element. In addition, the keyswitch package has been redesigned for automated assembly.

A custom LSI "universal" keyboard scan encoder works with 8048 and 8041 μPs in different versions of Cortron keyboards. The LSI chip gives a 7-bit binary-coded signal that indicates the position or location of the actuated key station. The first four bits scan in the X direction, while the last three bits scan in the Y direction, providing up to 127 unique key position codes.

Membrane keyboards versatile

Low cost has always been the trademark of membrane-type keyboards: They were developed for calculators and other low-cost applications. But this hasn't stopped them from improving in reliability and extended operating lifetimes. Today, their range of applications is wide enough to include telephones and military control panels.

Membrane technology currently falls into two separate areas of use: for digital touch-panel type keyboards, and for full-key-travel applications in alphanumeric keyboards. However, the real growth in use stems from incorporating these touch-type keyboards into products and equipment that never used keyboards before: consumer appliances, sewing machines, washing machines, blenders and food processors.

For top-of-the-line home appliances, glass has historically been preferred for touch-panel controls by the home user. But Fred Bauer, general manager of service at Robertshaw Controls, points out that membrane keyboards interface rather simply with the microprocessors going into ovens and ranges.

Glass keyboards must be used where grease and heat are encountered, as with a range, and when surfaces have to be scrubbed with soap-filled steel wool pads. But Chomerics (Woburn, MA) is developing membranes with greater abrasion resistance and higher gloss, to better compete with glass.

At the same time, full-travel alphanumeric keyboards, the latest development in membrane technology, are designed to fulfill a low-cost market requirement that requires key life lasting just 25 to 50-million operations. Such boards are essentially touch-panel membranes with keys mounted on top.

Both Chomerics and Flex Key (Gloucester, MA) have recently produced versions. At present, Chomerics is supplying the keyboard without encoding electronics. Flex Key, on the other hand, is producing a full-travel device with Intel 8748 programmable μPs for prototype models, and is now preparing masks for the 8021, which will be used in production versions.

Wayne Friedrichs, Flex Key vice president, envisions these keyboards in data-entry terminals such as point-of-sale systems, where the customer requirement is only a few thousand keyboards a year. For much higher quantities, he recommends as more cost-effective a "bare bones" keyboard with the electronics integrated in the terminal.

All this rush to more sophisticated keyboards and electronics has overshadowed the basic electromechanical switch, in which two conductors pressed together make a contact. But electromechanical keyswitches are still very much alive and highly marketable.

Low-travel keyboards using contacts of gold-on-gold are finding increased use, says Tom Odderstol, marketing manager of Refac Electronics Corp. (Winsted, CT), which manufactures this proprietary type of keyboard. Standard designs for Refac's Wild Rover PCK series of touch-switch keyboards are 12 and 16-key, but a new 10-key, gold-on-gold design for a tuner-input keyboard for a major TV manufacturer is uniquely suited for tuner-input applications. ■■

Standard keyswitch types give broad selection range

Standard keyboard types, except for elastomeric, membrane types, are assemblies of individual keyswitch modules, interconnected through PC-board wiring. Each has its pros and cons:

■ *Keyswitches with mechanical contacts*—the electromechanical types—are low-cost and simply constructed. Usually nonsealed, they are subject to contact contaminations from dust and other unwanted influences such as spilled coffee.

Although contact bounce is an inherent problem, these keyswitches can be used with bounce-eliminator electronics. Gold contacts provide the best operating life, between 5 and 10-million operations.

■ *Reed-type keyswitches* have contacts of sealed-in-glass reed relays, which are closed and opened by moving a small magnet up to or away from the reed. Because these elements are sealed, contacts can't be contaminated.

The reeds are tiny and have a high, natural resonant frequency, which makes for short bounce times. The reeds make a high-reliability keyboard with operations in the 50 to 100-million range.

■ *Saturable-core keyswitches* unsaturate a toroidal transformer by displacing a small magnet or magnets, when the key top is depressed. In an unsaturated state, or on state, the energy from a local high-frequency oscillator is coupled through the transformer to provide an output. In the saturated, or off state, coupled energy drops to low values, so on and off states are indicated electrically.

Like reeds, saturable-core keyswitches are highly reliable and provide lifetime on the order of 50 to 100-million operations.

■ *Hall-effect keyswitches*, made exclusively in the U.S. by Micro Switch, move a magnet on a plunger assembly to or from an IC Hall transducer chip, which produces isolated outputs that reduce encoding-logic complexity. Neither an oscillator nor an amplifier is required, but the chip does draw dc current in both operating and standby modes.

Hall-effect keyswitches are extremely reliable, good for 100-million operations or better.

■ *Capacitive keyswitches* are mechanically simple. A plate's moving on the end of the keyswitch plunger increases the capacitive coupling between one or two other plates connected between an oscillator and an amplifier. The coupled level output, substantially higher than the uncoupled, thus indicates on and off states, somewhat like saturable-core operation. And like Hall-effect keyswitches, these keyswitches will last for more than 100-million switching operations.

■ *Membrane-type keyswitches*, the lowest-cost and best known for their use in touch-type keyboards for calculators and kitchen appliances, typically have a conductive pattern on a board overlaid with a Mylar film containing holes. These holes permit a conductive-elastomer sheet to penetrate, under finger or key-plunger pressure, and make contact with that portion of the conductive pattern underneath.

The keyboard assembly can be made very thin, and the contact system sealed off by bonding the edges of the assembly together with adhesives. Depending upon the particular design, reliability can run from good to excellent, with operating cycles of a few to 100-million possible.