state of solid state

Microprocessors are inching their way into home appliance applications. Here's a look at how the TMS1100 is teamed up with triacs to control a microwave oven.

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THYRISTORS ARE TOUGH COMPONENTS. Silicon-controlled rectifiers and triacs are more damage-resistant than other semiconductors because their regenerative latching mechanism switches them rapidly through the dangerous half-on, high-dissipation region. Thyristors (especially the versatile triac) are unbeatable in AC power switching applications. Their use in industrial control systems is not new, but their recent availability in low-cost plastic packages is responsible for their growing application to home appliances. Thyristors are present in the horizontal-deflection systems and remote power on-off controls of TV receivers. They are also found in microwave ovens, where moderate amounts of power are switched and modulated. They have proved to be more dependable than relay contacts and conventional transistors.

Microcomputers, too, have moved from their industrial beginnings into the appliance market. The control microcomputer is an inexpensive IC, the result of thousands of hours of human endeavor and accomplishment. Single-IC microcomputers such as the Texas Instruments TMS1000 contain the central processing unit (CPU), a small amount of RAM (*R*andom-*A*ccess *M*emory) and a substantial block of ROM (*R*ead-*O*nly *M*emory).

Microwave cooking is generally a time-sequential procedure. Each time interval has a different heat setting. Combining a microcomputer with triacs in an oven-controller system eliminates many objections to such an ecologically attractive appliance. The factory presetting of popular cooking procedures and easy user programming of special sequential operations are just two possibilities of such a combination.

Figure 1 shows the partial schematic of a microwave oven-control system built around the TMS1100, a single-IC microcomputer with 2048 eight-bit words of ROM. The ROM is factory-programmed to carry out the control-function algorithms designated by the oven manufacturer. The design approach is competitive with discrete control-logic circuitry, and is more reliable because of the product's reduced component count.

The control system's primary function is to properly activate the oven's power-consuming heat and air-circulation portions: The magnetron, the broiler heating coil and the lamp and fan, shown on the left-hand side of Fig.1. Each element is connected in series with the AC power line and a controlling thyristor. The triacs are chosen to handle the individual circuits' current requirements: the TIC263 controlling the magnetron is rated at 25 amp, the TIC246 is rated at 16 amp and supplies from 5 to 10 amp to the heater element, and the TIC206, rated at 3 amp, supplies about 1 amp to the lamp and the fan.

A triac is the equivalent of two SCR's connected back to back. It can be triggered by either positive or negative gate voltage with respect to main terminal No. 1 (the axial lead merging with the gate lead), although the sensitivity is different depending on the power source and trigger polarities. The triac triggering pulse must only be long enough to insure regenerative latching. This minimum pulse-width requirement varies from about 2 to 20 μs depending on the level of gate overdrive for those triacs shown in Fig. 1. If the gate drive is discontinued by the time the AC signal waveform reverses its polarity, so that the triac current is reduced below its holding current, the triac turns off. Radio frequency interference is minimized if turn-on is restricted to zero crossings of the power-line cycle. In Fig. 1, the three TIS92 emitter-follower transistors supply the turn-on gate current. The series resistors between the emitter of the transistors and the triac gates determine the gate current. These resistors generally supply twice the nominal current to take care of tolerance and temperature variations.

The signals on the triac gate and the driver-follower transistors are referenced to one side of the AC power line. For safety and to prevent power-line or SCR-induced transients from damaging or causing incorrect computer operation, it is necessary to isolate the power circuitry from the processor circuitry and operator controls. Optical couplers are a natural choice for this isolation because only light and high-resistance leakage paths exist between the input and output sides of the circuit. An internal LED provides photon coupling to a phototransistor; a higher LED current provides more light and more current drive to the phototransistor base. Standard couplers provide a voltage isolation of 2.5 kV. Note that the three TIL111 optical coupler inputs are driven by microcomputer outputs R7, R8 and R9. These outputs are controlled by the ROM program permanently stored in the TMS1100 to trigger the triacs in response to predetermined sequences or by direct front-panel control. The SETR and RSTR instruction mnemonics correspond to the machine language codes controlling the status of these outputs.

The controls and displays are directly interfaced to the microcomputer through outputs R_0—R_6, outputs O_1—O_3 and inputs K_1, K_2, K_4 and K_8. The TMS1976 capacitive touch-control IC converts touch into logic levels.

The column being scanned is selected by outputs R_2, R_4 and R_6 under program control, and the six parallel panel outputs feed the TMS1100 through inputs K_1, K_2, K_4 and K_8. Since these inputs are the only microcomputer inputs, they must be shared by other oven functions, including the safety features and temperature-sensing input. These other inputs are strobed by the R outputs not used to scan the touch panel. The LED oven display is multiplexed by driving the segments from microcomputer outputs O_0, O_1, O_2, O_3 and O_4. In this case, the binary computer outputs are decoded by the SN7447 BCD-to-7-segment decoder/driver. The TMS1100 includes a PLA (*P*rogrammable *L*ogic *A*rray), which in some applications is programmed for 7-segment display decoding.

The other LED oven-function indicators are scanned by outputs, R_4, R_5 and R_6 and driven by outputs O_0–O_3. Keyboard scanning is done with the same R outputs used by the display. The input sense instruction (mnemonic KNEZ) can be used to detect an input switch condition, then jump to a routine that determines which input (or inputs) has been activated and respond to it. Then, a few milliseconds or so after the interruption, the program can continue with the display-scan routine.

For additional information on thyristor gating for microprocessor applications, write for *Bulletin CA-191* from Texas Instruments Incorporated, Inquiry Answering Service, Box 5012, M/S 308 (Attn: CA-191), Dallas, TX 75222. **R-E**

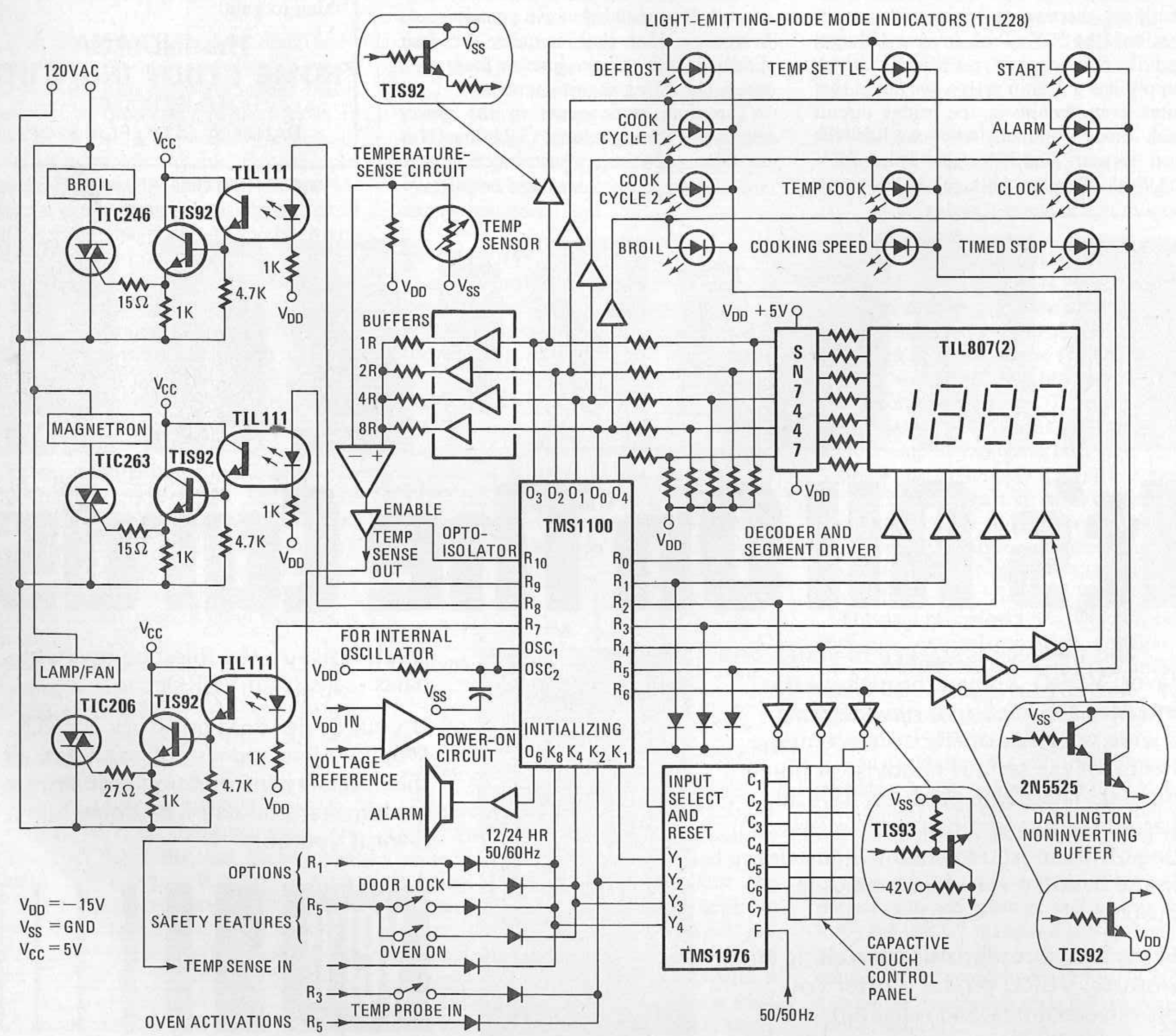

FIG. 1—MICROWAVE OVEN CONTROL system based on Texas Instruments TMS1100 8-bit microprocessor.