Automatic test setup checks thermal resistance

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Measuring the thermal resistance of microelectronic devices is usually a tedious one-device-at-a-time operation—it takes a long time to calibrate temperature-sensitive elements, to apply power to individual devices for long stabilization periods, and to calculate the thermal resistance. But with the technique described here, testing time can be cut significantly so that the thermal resistance of 40 devices can be determined in the time it previously took to measure just one device.

The equipment primarily includes an automatic dc digital IC tester, a special sequencer circuit, a modified oven setup, a liquid bath, and a high-current power supply.

The sequencer allows the thermal resistance of a large number of devices to be measured almost simultaneously. As noted in the block diagram (a), three 4-line-to-16-line decoder/demultiplexers interpret the program inputs from the automatic IC tester. These decoders provide a total of 40 output lines, one for each device being tested. Each output feeds a NAND inverter gate, a relay driver transistor, and a double-pole single-throw relay.

The circuit of (b) shows the hookup between the relay and the device under test, which, in this case, is a simple resistor/diode die. When a relay is activated by a program input, its contacts switch from their normally closed position to a normally open one. The test sequence here is designed to find diode slope with changing temperature, as well as forward voltage drop both before and after a power soak period.

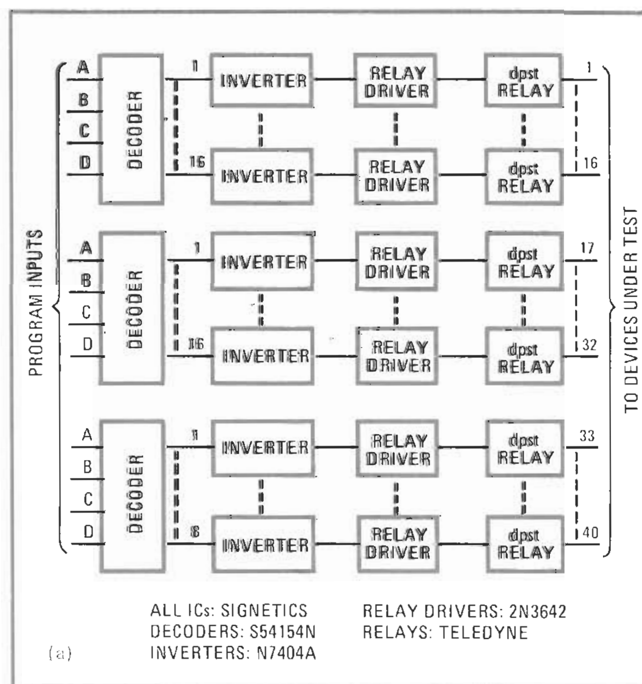
Forward voltage drop is measured at six temperatures covering the expected operating temperature range, and diode slope is measured without any supply voltage applied. The dies are then brought to a specified test temperature for initial forward-voltage readings, before being exposed to a power soak period of 15 minutes. (This is long enough to allow the devices to stabilize at a constant junction temperature.) At the end of the soak period, each device is sequentially removed from the external "soak" supply and re-energized by an internal supply to determine what forward voltage it has because of power dissipation.

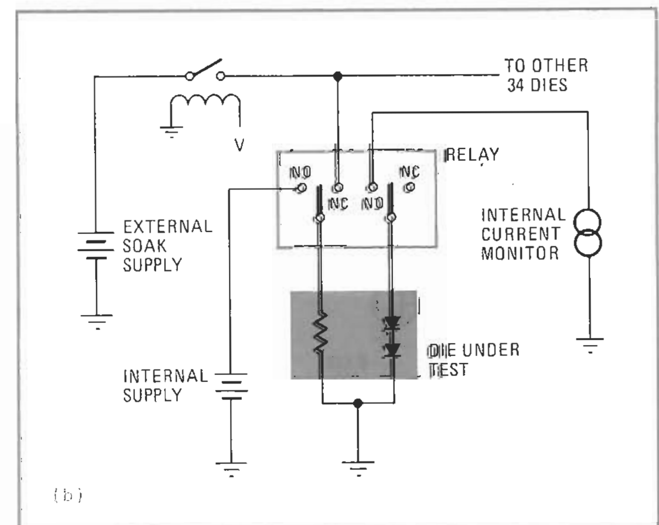
All the information needed to compute the slope and thermal resistance of each device is now available: the forward voltage at six temperatures, the initial forward voltage at a specified test temperature, the power applied, and the final forward voltage due to heating from the power applied.

The photos show the special door used for mounting the dies and their holders; it fits the oven and the tub employed for the liquid bath. To find the thermal resistance between a device's junction and ambient temperature, the door is placed in the oven. To measure thermal resistance between junction and case temperatures, the door is placed upside down in the liquid bath. The sequencer circuit is also mounted on the door, but can be removed by disconnecting the edge connectors on the front of the door.

The bath is made up of a stainless-steel tub that rests on two hot plates. Cooling is achieved by forcing carbon dioxide through copper tubing at the bottom of the tub. To obtain high temperatures, from 25°C to 125°C, the liquid used is ethylene glycol; for cold temperatures, from 25°C to -55°C, the liquid is Freon.

Only the extreme tips of the leads to the devices under test should be soldered, so that little or no heat sinking is provided by the solder joints. Also, it is a good idea to put cutouts in the pc board around the holder for each test device, to improve the flow of air and liquid around it. □





Sequencing circuitry. Sequencer (a) enables the thermal resistance of 40 devices to be determined at the same time in response to program commands from an automatic tester. In this case, resistor/diode dies (b) are measured for slope and forward voltage drop.