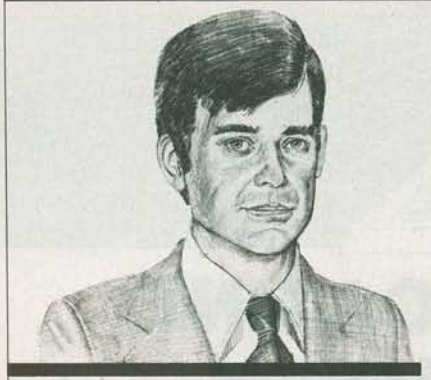

Introducing the Varistor

By Forrest M. Mims, III

THE varistor, a nonlinear resistor that does not obey Ohm's law, is one of those wonderfully simple components whose operating principles are not yet fully understood. What is understood is that the varistor is well-suited for protecting electronic circuits from transient voltage surges.

The current through a standard resistor is directly proportional to the voltage across the resistor. The current through a varistor, however, varies according to the *n*th power of the voltage, where *n* is from 2 to 25. Figure 1 is a curve of the voltage versus current characteristics of a typical varistor.

Varistors are made from silicon carbide or metallic oxides, yet their construction more closely resembles that of a resistor than a semiconductor device. Metal oxide varistors, for example, are made from powdery grains of zinc oxide and small amounts of other metal oxides. The zinc-oxide powder is pressed and sintered to form ceramic discs. The discs are coated on opposite sides with silver to provide solderable contact regions.

The varistor's voltage and current handling capacities are determined, respectively, by the thickness and width of the disc. The size of the zinc-oxide grains also determines the varistor's voltage rating.

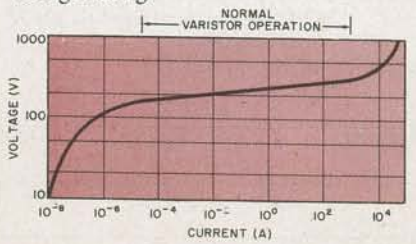

Fig. 1. Varistor V/I characteristic.

Varistors are primarily used to protect electronic circuits from transient voltage surges. They are particularly useful for protecting computers from power surges that cause memory errors or even loss of memory contents.

As shown in Fig. 1, the operation of a varistor resembles that of two back-to-back zener diodes. When the voltage across the varistor is below its rated continuous voltage, the varistor is in a high-impedance state. When the voltage exceeds the rated level, the varistor suddenly begins to conduct and its formerly very high impedance falls to a few ohms.

Voltage transients can be caused by power-line surges, lightning, switch arcing, component failures, and the sudden removal of a voltage across a transformer, inductor, or relay coil. Figure 2, for example, shows a relay coil connected through a switch to a power supply. When the switch is opened, the field in the coil collapses and induces a series of high-voltage spikes across the coil terminals. The varistor serves to short to ground the spikes having an amplitude above the varistor's voltage rating.

A New Pair of Low-Voltage Varistors. Recently General Electric added to its line of GE-MOV^{R} II metal-oxide varistors two new low-voltage devices designed specifically to protect TTL integrated circuits from transient voltage spikes. Designated V8ZA1 and V8ZA2, the two varistors are rated for a continuous voltage of 5.5 V. The V8ZA1 is rated for a maximum clamping voltage of 22 V at 5 A and a peak transient current of 100 A. The V8ZA2 is rated for a maximum clamping voltage of 20 V at 5 A and a peak transient current of 250 A.

Figure 3 is a photograph of the V8AZ2 next to a 28-pin dual-in-line package IC. General Electric claims the new varistors perform better in overstress situations than competing silicon devices. Another advantage is low cost. In large quantities, the General Electric devices sell for only 35 cents each.

Incidentally, in addition to its low-voltage varistors, General Electric also manufactures an entire line of high-voltage, high-current devices. For example, the B-series device shown in Fig. 4 next to a low-voltage varistor can protect industrial electrical systems from transients with peak currents of 70,000 A and energy levels up to 10,000 joules. At 200 A, the maximum clamping voltage of this device is 7.8 kV.

For more information about metal-oxide varistors, contact a General Electric distributor or write the company

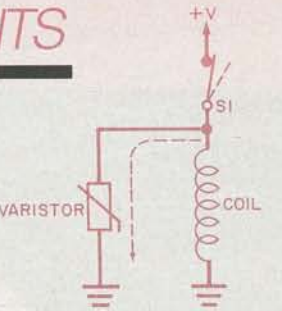

Fig. 2. Varistor voltage clamp.

(GE, Semiconductor Products Department, Auburn, NY 13021). General Electric has recently published the third edition of its excellent applications manual on varistors, "Transient Voltage Suppression" (1982). The manual is GE publication number 400.3, and it sells for $5.00. The company also offers (prices unspecified) design kits that include a low-voltage GE-MOV II varistor.

Varistor Operating Precautions. When exposed to voltage or current transients above its peak ratings, a varistor may fail. General Electric's varistor literature describes a possible consequence being " . . mechanical rupture of the package accompanied by expulsion of package material in both solid and gaseous forms." An explosion by any other name is still an explosion. For this reason, if overstress conditions are expected, it would be wise to fuse the varistor or to mechanically shield it from other components and people.

A New 12-MHz Microcomputer. The Z8 is an 8-bit, 40-pin, single-chip microcomputer designed for use as a general-purpose controller for disk drives, terminals, printers, etc. The Z8 contains a 144-byte register file. Four registers in the file are dedicated I/O ports, 16 are status and control indicators, and the remaining 124 are reserved for general-purpose, user-definable applications. The Z8 also contains a full duplex (bidirectional) UART and two programmable 8-bit counter/timers.

Traditional microprocessors include a single accumulator register, but each of the Z8's general-purpose registers

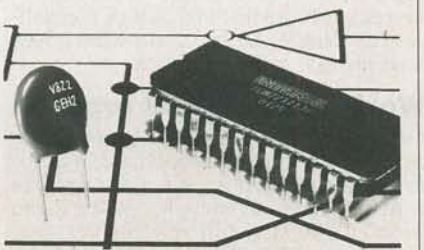

Fig. 3. GE's new varistor (left) is designed to protect TTL circuits.

can be used as an accumulator. They can also be used as address pointers, index registers, and other functions. Zilog claims this flexibility of its register oriented architecture "... permits over 30% higher code densities than primitive accumulator designs and allows appreciably reduced development time."

Until recently, the Z8 was available only in an 8-MHz version. Now, Zilog, Inc. (Components Marketing, 1315 Dell Ave., Campbell, CA 95008) has introduced a 12-MHz version of this popular single-chip microcomputer. Seven specific versions of the new computer are available. The Z8611 is the standard 40-pin computer containing 2K or 4K bytes of internal, mask-programmed ROM. The Z8613 Protopack is a 40-pin prototype development version with a self-contained 24-pin socket for direct interface to 2K or 4K bytes of erasable programmable ROM (EPROM). The Z8681 is a ROM-less version that replaces the internal ROM with alternative combinations of I/O lines and bus capabilities. The Z8671 includes on-chip Tiny BASIC.

Prices for the new 12-MHz Z8 chips are only slightly higher than the 8-MHz versions. For example, in large quantities the 8-MHz Z8611 is under $10, while the 12-MHz version of the same chip is under $12.

World's Brightest LEDs? Japan's Stanley Electric Co., Ltd. (LED Sales Section, 2-9-13, Nakameguro, Meguro-ku, Tokyo 153, Japan) has recently been running full-page ads in electronics trade magazines claiming "The World's Brightest LEDs." These new GaAlAs LEDs are claimed to emit 500 millicandelas and to be some 8 times more intense than conventional GaAsP LEDs driven at the same forward current.

Regular readers of this column will recall that GaAlAs is the ternary alloy used so successfully to make very powerful near-infrared emitters. Stanley, incidentally, also makes high-power GaAlAs near-infrared emitters.

Is a 500 millicandela LED really the world's brightest? Among the brightest conventional GaAsP red LEDs is Hewlett-Packard's 5082-4650 series (Hewlett-Packard Components, 640 Page Mill Road, Palo Alto, CA 94304). The 4655 is encapsulated in clear, diffused epoxy and at 10 mA of forward current has a luminous intensity of typically 4 millicandelas. The 4658, the same diode encapsulated in clear, *non*-diffused epoxy, has a luminous intensity of 24 millicandelas. At 20 mA, the 4658 has a luminous intensity of more than 60 millicandelas.

From Stanley's advertisement, its new diode apparently delivers 500 millicandelas when driven at 50 mA. By extrapolation, therefore, it has approximately five times more luminous intensity than the Hewlett-Packard LED when both diodes are operated at the same forward current.

GaAlAs is certainly placing a new light on both visible and near-infrared diode emitters. Several LED makers were quick to offer high-power GaAlAs near-infrared emitters when they first became available a few years ago. It is likely, therefore, that other companies will soon offer the new high-power visible-red GaAlAs diodes.

More High-Speed CMOS Chips. National Semiconductor (2900 Semiconductor Dr., Santa Clara, CA 95051) and Motorola (Box 20912, Phoenix, AZ 85036) continue to add new members to their jointly developed 54HC/74HC high-speed CMOS family. Among the latest National entries are the MM54HC139/MM74HC139 dual 2- to 4-line decoder, the MM54HC164/MM74HC164 8-bit serial-in/parallel-out shift register, and the MM54HC00/MM74HC00 quad 2-input NAND gates.

These new high-speed CMOS chips are considerably faster than conventional CMOS and easily approach or even exceed TTL speeds. For example, the 54HC164/74HC164 features a typical operating frequency of 50 MHz and a typical propagation delay (clock to Q output) of only 19 ns. Its supply voltage range is 2 to 6 V, and maximum standby current is 80 μA.

Fig. 4. The high-energy varistor at left protects against transients having peak currents of 70,000 amperes and energies of 10,000 joules.

I'm not aware of a mail order dealer that stocks these new high-speed CMOS chips, but you can be sure they will become widely available as more circuit designers learn about their excellent specifications. Their price may at first be quite a bit higher than conventional chips, however. For example, the 54HC00/74HC00 packaged in a plastic dual-in-line package now sells for 51 cents in quantities of 100 or more. Their high performance, however, more than makes up for the increased cost.

A New Fiber-Optic Record. British Telecom has established a new record for the world's longest fiber-optic telecommunications link. The system's cable links London and Birmingham and is nearly 130 miles long. The system employs second-generation LEDs that emit at 1.3 micrometers. First generation LEDs emit in the 800-900-nanometer range and are therefore subject to more attenuation when used as sources for low-loss fibers.

Thanks to the 1.3-micrometer LEDs used in this system, the cable has an attenuation of only 1.5 dB per kilometer. This increases the repeater spacing from 5 miles for a first generation system to about 6 miles.

Regular followers of fiber-optic developments should be aware that British Telecom's new system will hold the distance record for only a limited time. Developments in this field occur so rapidly that their record may be surpassed before this column is published.

Wanted: New Product Information. Information about the solid-state components and products described in this column is gleaned from news releases, phone calls to and from manufacturers, technical papers published in scholarly journals, and articles printed in electronics trade publications. If *you* work for a company, university, or research institution involved in solid-state product or component developments not yet described in this column, please ask your public relations department to place Solid-State Developments on its mailing lists. News releases, preferably accompanied by black-and-white photos, should be mailed to my attention, Solid-State Developments, COMPUTERS & ELECTRONICS, One Park Avenue, New York, NY 10016. While it will be impossible to use or acknowledge receipt of all such information, *all* news releases will be reviewed, and those having high interest to readers will be considered for inclusion in future columns. Meanwhile, thanks to all of you for your help in broadening this column's data base. ◇