Computer Bits

By Hal Chamberlin

ELECTRICAL NOISE

ELECTRICAL noise is a major problem in home computers. Generated within a computer itself, it can, in many cases, interfere with nearby radio and TV reception and even with the computer's own operation! Many unexplained home-computer malfunctions can, in fact, be traced to external noise. Since microcomputers are usually more prone to electrical-noise problems than large mainframe computers, let us explore the various sources of noise and their effect on personal-computer operation and suggest some methods of reducing or eliminating the problem.

Power-Line Noise. Of all environmental noise sources, power-line noise is perhaps the best understood and most easily suppressed. High-frequency spikes and "hash" generated by motors, switches, lamp dimmers, and lightning are the most troublesome types of power-line noise. Measured at a wall outlet, this noise can be several hundreds or even thousands of volts in amplitude. Fortunately for computer power supplies, however, the noise pulses are only a few microseconds in duration, so energy content is actually quite low.

Nearby lightning strikes, of course, would generate spikes of the highest amplitude, but strikes a mile or more away can also cause trouble. This noise appears on an oscilloscope as a rapid-fire series of narrow high-voltage spikes. It can enter the power system either from a direct strike on power-distribution equipment or by induction. Since power lines may be strung overhead for long distances, they efficiently pick up electrostatic and electromagnetic fields radiated by lightning strikes and conduct the resulting spikes into the computer owner's home.

Probably the power-line noise with the next highest amplitude is created by switching off an inductive appliance, allowing energy stored in the magnetic field of an inductive device to suddenly release as the field collapses. For a few dozen microseconds, a very high voltage is built up and may arc across the open switch contacts, feeding a high-voltage pulse with a fast rise time into the power line. Ac induction motors and transformers—even those in fluorescent lamp fixtures—are the most highly inductive. Large motors, such as those used in refrigerators and air conditioners, create an electrical noise even when they switch on because an internal starting winding switches off when they reach operating speed. Industrial plants with hundreds of very large motors and transformers constantly switching on and off present particularly hostile electrical environments for computers.

While the foregoing sources are responsible for occasional high-amplitude spikes on the power line, universal motors (those with brushes) and lamp dimmers generate lower-amplitude, but more continuous, noise. The obvious source of noise in universal motors originates with armature brushes that constantly spark during motor operation. Lamp dimmers with silicon-controlled rectifiers (SCRs) or triacs generate a small amount of noise on every alternation of the ac line because of the rapid turn-on characteristics of these semiconductors.

One might reasonably ask how power-line noise can get into a computer's logic circuitry if its very-narrow pulse widths cannot pass through the power transformer and rectifier diodes to actually change the dc supply voltages (large power-supply filter capacitors prevent this). It is *capacitively* coupled from the power supply's primary wiring directly into the regulated dc output wiring and then into the logic. In some computers with the primary wiring routed close to the logic circuitry, noise bypasses the power supply altogether and couples directly into the logic. It is not difficult to visualize how even a fraction of a picofarad of coupling capacitance can transfer more than 1 volt (the typical noise-immunity specification for most TTL and MOS logic) of the original 1000-volt spike into the logic circuitry and possibly cause an error. (Note: most computers are sensitive to noise only during part of their bus and memory cycles; hence, it is possible for the computer to ignore the majority of noise spikes.)

Preventing power-line noise from entering a computer is relatively easy—simply use a noise filter between the ac outlet and computer's line cord. Filters are most effective if located inside the computer's cabinet, right at the point where the power cord enters. Even if installed at the plug end of the computer's line cord, however, they can be very helpful in excluding power-line noise.

While filters are available from a number of sources, you might want to make your own filter circuit. A good power-line filter consists basically of two L-section low-pass r-f filters (to provide both common- and transverse-mode noise rejection), with inductors designed to handle several amperes of continuous current. Metal-oxide varistors (MOVs) are included to prevent possible damage from direct local lightning strikes but do not otherwise contribute to filtering out noise. (MOVs act like high-power zener diodes, shorting out electrical spikes that exceed about 300 volts in amplitude.)

A properly grounded three-wire ac outlet and computer line cord are required for *any* noise filter to function properly. With non-grounded outlets, filtering efficiency will be very low and current leakage through the filter's capacitors could create a mild shock hazard.

Ac-line filters cannot cope with problems caused by low-frequency power surges and dips. Unlike noise spikes, surges and dips are long enough in duration for them to affect the computer's dc voltages. The only defense against this type of noise is a wide line-voltage range computer power supply or an expensive external ac voltage regulator.

Electrostatic Discharge. As you know, a tremendous static-electricity charge can be built up on your body simply by walking across a carpeted or plastic-tiled floor—expecially in very-low-humidity environments. When you reach for any metal, even without coming into physical contact, the charge almost instantly dissipates into what you touch. If what you touch is the cabinet of your computer, the rapid discharge can cause a running program to crash and, at its worst, even damage components in your computer.

Static discharges make a tremendous amount of electromagnetic noise. Charges of 5000 to 10,000 volts are not unusual and, when discharged through a typical body impedance of 100 ohms, can flow at peak currents of 50 to 100 amperes. Coupled with typical rise times of 10 nanoseconds, this creates incredible noise amplitudes.

To guard against electrostatic-discharge noise problems, a computer system must be designed from the ground up to be resistant. The best defense is to make all exterior packaging from insulating material, such as plastic. Then nothing in the system is exposed for you to discharge to and static-discharge problems are avoided. Fortunately, most manufacturers realize this problem and house their computers in plastic cabinets. But peripherals, such as disk drives and particularly printers almost always have exposed metal parts.

While plastic cabinets bestow immunity against direct static discharges, they provide no shielding for the powerful electromagnetic fields created by discharges to other metal in the vicinity of the computer. Hence, in practice, system crashes may be just as common as with metal-cased computers. The ideal cabinet would be metal encased in plastic. This would not only just about eliminate the static problem, but it would also prevent noise generated by the logic *inside* the computer from escaping and interfering with nearby radio and TV reception.

If you buy a static-sensitive computer, there are several steps you can take to reduce the incidence of crashes. The easiest is to keep the computer in an environment with concrete floors and to wear leather-soled shoes. You can also obtain an antistatic floor mat or carpeting with metal threads woven throughout if you cannot move your computer out of a carpeted area. Too, use of a humidifier in the room in which your computer is located will reduce the intensity of static discharges.

In really tough cases, a 2-watt resistor of 1 megohm or more can be attached at one end to your computer's, disk drive and printer cases. Then, when you approach your equipment, merely touch the free lead of the resistor first to safely bleed off any accumulated static charge. ◇