Chapter 16

EMI CONTROL IN COMPONENTS

Previous chapters have addressed topics such as cabling, grounding, shielding, and filtering that represent EMI problems between sources and victims. This chapter and Chapter 17 will examine the essence of EMC, namely, EMI-control techniques that are applied at component, circuit, and equipment levels.

Fundamentals are stressed. Basic building-block elements of resistors, inductors, capacitors, insulators, conductors, diodes, and logical components are reviewed with regard to their role in EMI problems and control techniques. Several sections on transient-producing devices are included, with discussion of EMI control in transformers, relays, solenoids, motors, and generators. Since these devices also produce significant magnetic fields, flux leakage control provided by shielding is considered. The chapter ends with a discussion of EMI problems and control in fluorescent lamps.

R, L, AND C COMPONENTS

This section discusses potential EMI problems and control techniques that are employed in fabricating and using resistors, inductors, and capacitors. It is shown that these fundamental passive electronic parts in reality do not behave at their stated values (8), especially at high frequencies, because of parasitic inductance and capacitance. Under certain conditions, their performance degrades at frequencies as low as 1 MHz, or even lower. Thus, filters, for example, often do not perform as expected at frequencies equal to ten times the filter cutoff frequency, and amplifiers may exhibit out-of-band parasitic oscillations and spurious responses. These phenomena result from the nonideal nature of components that manifests itself at high frequencies.

Resistors (6, 8)

The resistors considered here are: carbon composition, deposited carbon-composition film, pyrolytic carbon film, metal film, wirewound, microelectronic, and special purpose. The type of resistor to be used is determined by
considerations of resistance, wattage, cost, compactness, precision, distributed capacitance, distributed inductance, life, and internal noise. Composition resistors may be of the pellet or filament type, and are made of finely divided carbon and a binder pressed into a slug with leads embedded in each end. The slug is then enclosed in a phenolic or other case, and the resistor body is molded. In some cases, the resistor is enclosed in a ceramic tube with cement covering both ends. The filament type has the carbon and binder mixture coated on the outer surface of a glass tube with the leads inserted therein. A phenolic tube is then molded around the resistor body.

**Resistor Characteristics.** Carbon or metal fixed-film resistors are usually made by depositing a controllable thickness of resistive material in a continuous film into a base. The resistor body is then covered with a plastic or epoxy. The geometry of film resistors enhances their high-frequency characteristics when they are used at typical frequencies up to several hundred megahertz.

A microelectronic resistor is a thin layer of silicon on a base or metal placed over a semiconductor. Close spacing increases capacitance and coupling leakage. The small size limits available resistances, and undesired semiconductor junctions may be formed.

Any covering on the resistor body acts as a thermal barrier as well as protection against moisture. Thus, dissipated energy is conducted primarily by the leads. Special metal jackets are made to help heat energy to leave the resistor body. Bifilar winding of a wirewound resistor reduces internal inductance because adjacent turns carry currents in opposite directions. However, adjacent turns may exhibit appreciable shunt capacity, and capacitive currents are likely to have adverse effects on RF applications. The Ayrton-Perry winding is preferred, as each resistor is constructed of two parallel windings in opposite directions; the turns cross each other at points of zero (i.e., minimum) potential difference. A typical Ayrton-Perry resistor wound on a cylindrical spool exhibits 1% of the inductance of a conventional spool-wound power resistor.

A composition resistor can exhibit an AC resistance that is lower than its DC values. This characteristic, known as the Boella effect, is primarily due to the shunting effect of distributed capacitance that results from the large number of conducting particles mixed with the dielectric material. To reduce this effect, resistors with a minimum amount of dielectric material are used to minimize the value of the dielectric constant and associated loss factors. Decreasing the resistor cross section and increasing the resistor length, as in the filament type of resistor, minimizes this problem. Because of the greater amount of dielectric used to construct resistors of higher value, the higher-value resistors exhibit a greater percentage of change in value than the lower-value resistors.