COMMERCIAL FILTER CONNECTORS PROVIDE LOW-COST EMI CONTROL

INTRODUCTION

Due to the proliferation of microprocessors and other digital devices, it was inevitable that problems from radio frequency interference (RFI) and electromagnetic interference (EMI) would arise. The problem with "signal pollution," or the "EMI problem," was addressed by the Federal Communications Commission in Docket #20780 which established limits on high-frequency electronic emissions. These standards had to be met by manufacturers by October 1983.

Although connectors are passive components, in hybrid form as filter connectors they can play an important role in the suppression of electronic pollution. These filter connectors are fast becoming a proven and cost-effective method to control EMI in computer applications. With built-in, low-pass filters, the connectors prevent external EMI from compromising system performance and data integrity, protect against damage and downtime due to electrostatic discharge, and help meet FCC requirements. The latest filter connectors can also withstand physical shock just as well as traditional connectors that do not have built-in filter networks. This feature allows these devices to be used in military and other high-reliability applications, as well as to meet specifications that call for frequent insertion and withdrawal.

Typically, filter connectors use a straightforward low-pass filter network that filters out or attenuates spurious high-frequency signals. It also allows the frequencies essential to system operation to pass relatively unrestricted, with minimal attenuation.

The basic component of this type filter network is a capacitor. The value of the capacitor determines the cutoff frequency below which signals are passed, and above which noise or spurious signal currents are attenuated. The degree of noise filtering is determined by the insertion-loss characteristics of the network—the higher the capacitance value, the lower the cutoff frequency where signals start to be attenuated.

Filter connectors require capacitors with low-power factors for maximum amount of space. For this reason, the connector industry is turning more and more to chip capacitors made of barium titanate (identical to those used in hybrids and surface-mounted printed circuit assemblies) for the construction of the networks in filter connectors.

Since the network is housed in the connector body, a typical filter connector is generally longer than an equivalent nonfilter connector. However, some recently introduced filter connectors for computer and telecommunications applications are the same size as the standard connectors they are designed to replace. This same size is made possible by the use of chip capacitor filter networks. In addition, these newer filter connectors are physically compatible with nonfilter devices; they are fully interchangeable in terms of both mating and mounting. This is important in computer systems where retooling a port opening to accept a filter connector is often time-consuming and expensive.

Many types of network circuits can be used for controlling EMI. They consist of various combinations of inductive, capacitive and resistive elements. Pi- and T-shaped configurations, as well as LRC and CLR combinations and C and L elements by themselves, have all been used successfully. However, the most common networks for filter connectors are Pi and C types.

Insertion-loss characteristics are the primary electrical difference between the two types, with the Pi network having a higher insertion loss than a C network with identical overall circuit capacitance. The Pi configuration is more expensive, but generally provides a greater degree of filtering.

Pi networks are more limited than C networks in the amount of capacitance that can be effectively applied. Pi networks top out at about 10,000 pF, whereas C networks can be designed with at least five times more capacitance, which allows a lower cutoff frequency.

Most actual interference problems encountered in computer applications occur at relatively low frequencies—between 20 and 200 MHz. This part of the spectrum includes the EMI generated by the oscillators found on many micro-processor boards. The EMI emitted over this frequency range can be attributed to either the fundamental frequency of the oscillator or its harmonics.

Since most computer applications can be satisfied by the filtering networks of the C network, the vast majority (perhaps 95 percent) of applications can be served by connectors with filters based on this design. The C networks are more easily and cost-effectively applied in commercial systems. Pi-network applications are generally restricted to military systems, where cost is not as great a factor as it is in the commercial applications, and to systems with very high frequency EMI problems.

C-NETWORK ADVANTAGES

The C network, since it consists of only a single standard barium-titanate chip capacitor, is the most inexpensive filter circuit. It can be built less expensively than the more complex Pi network, which requires a ferrite core inductor and an additional capacitor.

Some of the more advanced filter connector designs using C networks are being packaged with spring members rather than solder to connect the capacitor. This concept, called stress-isolation packaging, is gaining popularity because the stress-isolated filters can withstand physical shock much better than connectors that have rigidly soldered leadless capacitors.

The result is more reliable operation and, for the first time, filter connectors that do not require special handling either on the production line or during use. The additional testing that manufacturers often recommend for a connector that has been dropped or jarred will no longer be required, thus adding to the filter connector's cost-effectiveness in a production setting.

ESTABLISHING SPECIFICATIONS

The OEM designer's first step in developing connector specifications is to determine filtering requirements which include minimum insertion-loss levels, maximum capacitance value, and signal passband. As with any component, it is important not to overspecify requirements. As a general guideline, the more critical the filtering requirement, the more costly is the connector. If a C network filter satisfies the requirements of the application, a more expensive Pi network should not be used.

Designers should also consider the advantages of using connectors that have nonrigid capacitor connections. Barium-titanate chip capacitors are leadless ceramic components that fracture or crack under physical stress. Since all commercial filter connectors employ this type capacitor, it should be mounted with nonrigid connections so that it will not be damaged when dropped or jarred. A well-designed connector can withstand a drop of 5 feet onto concrete with no damage to the filter network.

Nonrigid connections can also prevent the introduction of electrical noise caused by piezoelectric effects. In applications that damage stability over a wide temperature range, it can be advantageous to specify filters made of negative-positive, zero-temperature-coefficient (NPO) materials. Filters with poor dielectric materials in the capacitor can be electrically unstable with changes in temperature. Unlike chip capacitors, tubular capacitors are generally not available in NPO materials, and they are too large to be used in most filter connectors.

Another area of concern is the grounding of the filter connector's shell. Here, a low-impedance ground path is necessary for maximum protection against noise.

TYPICAL APPLICATION

A typical application where a filter connector is particularly cost-effective is a computer connected to a peripheral such as a printer. The connecting cable is the standard, unshielded type used for RS-232 interfaces, with a conventional D-subminiature connector at each end.

Unfortunately, tests show that the cable radiates beyond FCC limits for Class B computing equipment. There are two methods by which this radiation can be reduced. The offending interconnect can simply be replaced with a shielded cable assembly, which must then be grounded at the connectors, and thereby increases the cost of the system. The cost-effective alternative is to use a filter connector which will directly replace the conventional connector on the computer. This approach will add less to the total system cost. In some connectors, a C network filter configuration is actually contained within the body of the connector which mounts directly on the housing of the computer or peripheral.

If the filter were placed in the cable mount portion of the connector that plugs into the adapter, it would be possible for a user to swap out a filtered cable and use an unfiltered one instead. Thus, by an inadvertent act, the purpose of the filter would be defeated. Good design calls for equipment to have connectors integrated so the filters cannot be removed by the end user.

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