SPECTRUM CONTROL™

Design Guide

EMI PROTECTION

Engineer's Guide to Circular Filtered Connectors

Everything you need to know about designing high performance circular connectors with integral EMI Filters.

Circular Connectors

Electromagnetic Interference (EMI) is unwanted electrical energy in electronic circuits caused by an outside source. EMI can range from nuisance background static on voice communications to the catastrophic failure of entire electronic systems.

Wires and cables act as efficient radio antennas and the most direct path for EMI to enter or exit a device is through its wiring. Filtered connectors provide the highest level of EMI rejection by filtering the wire interface at the point of entry. Filtered connectors are available in the same mechanical configuration as unfiltered connectors.

Emissions from switch-mode power supplies, brushed motors, and digital circuits will cause interference on nearby radio receivers for voice communications, radio navigation, GPS, and broadcast radio and TV. EMI filtered connectors are an effective way to meet emission limits and reduce harmful radio interference.

Low-level analog signals like those in temperature, pressure, voltage, and current sensors will routinely fail immunity testing. They are particularly susceptible to high-level EMI from local radio transmitters like radar and voice communication and their immunity will be significantly increased with EMI filtered connectors. Mission-critical digital circuits that require high-level EMI hardening will also benefit from filtered connectors.

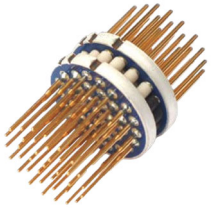
Advantages of Filtered Connectors

Filtered connectors have three main advantages over discrete filters: weight, footprint, and cost. A single EMI filtered connector can replace up to 128 discrete filters. The physical size of a filtered connector is equivalent to an unfiltered connector with only a marginal weight increase. Although an EMI filtered connector is higher cost than an unfiltered connector, the total BOM is significantly lower, particularly for high line count applications.

Construction of a Filtered Connector

Although EMI filtered connectors are custom products with limitless variations in capacitance per line, their design and manufacturing are standard and repeatable. Externally, a filtered connector looks the same as an unfiltered MIL-qualified connector. The same seals and rigid inserts provide the same environmental protection. Spectrum Control's EMI Filtered circular connectors utilize in-house planar capacitors and ferrite beads to achieve the desired frequency response.

- Soldered construction
- Rugged design
- Superior high-frequency performance up to 10 GHz



Construction of a Planar Capacitor

The construction of a planar capacitor is very similar to a chip capacitor. As shown in Figure 1, multiple layers of ceramic tape are stacked, and an electrode pattern is screened onto the tape at a designated location.

After stacking, the capacitor is cut to size, and holes are drilled. The planar capacitor is then fired at approximately 1300°C. Once fired, the capacitor is terminated (metalized) to facilitate upper level assemble processes. The product of this process is an array of individual capacitors assembled into a single ceramic disc (i.e., a 128-line planar capacitor has 128 individual capacitors). The discs themselves range in diameter from ~1/4" to 1-1/4" and are approximately 1/16" thick. This approach results in a very durable compact package.

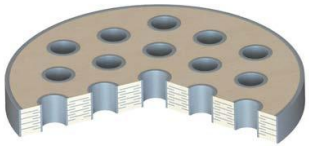


Figure. 1

- Insulated and ground line options
- Selective loading and custom capacitance values
- Designed and manufactured in the USA

Input Impedance (2)	Circuit Type	Output Impedance (2)
LOW	C Type	HIGH
	Pi Type	
	L Type	LOW
HIGH	T Type	
	L Type	HIGH

Figure. 2

Choosing the Right Filter

A noise suppression filter should match the impedance of the system it is to be used in. Figure 2 illustrates how to choose the circuit type required to match your system and maximize filter performance.

AC and DC power lines typically need broadband filtering due to switch-mode power supplies and voltage-switching regulators. In contrast, digital data line filtering must be carefully selected to prevent waveform distortion that stops circuit operation. Analog signals and lower data rate digital lines can achieve higher levels of performance with Pi filters that include a ferrite between two capacitors. LC filters with one capacitor and one ferrite, and T filters with a ferrite on each side of a capacitor are also available. EMI Filtered connectors for high-speed data lines such as Ethernet, USB, and HDMI are available with insulated pins. For systems that require ultra-low capacitance, but still require some attenuation, connectors are available with ferrite beads only.

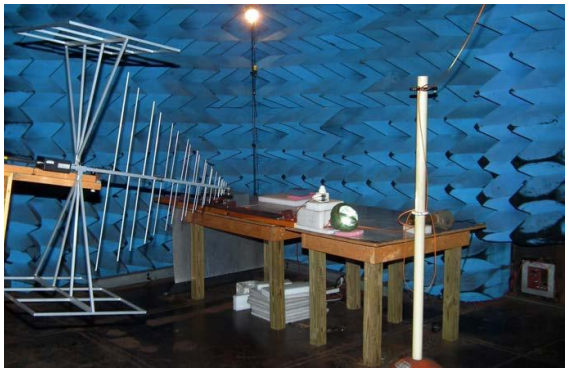
Rapid turn-around from prototype to production

1 Source Control Drawing
Quick review of customer requirements

2 Design
EMI experts with state-of-the-art engineering tools and methods

3 Prototype
In-house machining and ceramic manufacturing for quick response

4 Production
Vertically integrated manufacturing for control and best-in-class lead times



EMC Test Lab

Spectrum Control has an on-site EMC Test Lab with a semi-anechoic chamber and iNARTE-certified staff that can perform industry-standard pre-compliance testing. Conducted and radiated emissions and immunity measurements can be made quickly and accurately to identify out-of-spec conditions and offer filter solutions.

Spectrum Control Filtered Connectors

Spectrum provides filtered versions of MIL-DTL-38999, MIL-DTL-26482, MIL-DTL-83723, Mil-DTL-5015, MIL-DTL-24308, and MIL-DTL-55116.

Custom mechanical configurations and selectively loaded EMI filter options are available. Typical configurations have pin or socket contacts with either solder cups or pc tails. Crimp removable and custom cabling can be added to any connector.

To learn more about design considerations for EMI filtered military and high-reliability connectors, contact Spectrum Control.

Custom filtered connectors in as little as 14 weeks.

Shell materials: aluminum, stainless steel, composite

Finishes: nickel, olive drab cadmium (OD CAD), black nickel zinc, nickel Teflon

Sealing: environmental, hermetic

Transient survival and suppression: "lightning withstand designs for transient environments (up to DO160 Level III & IV)"

Quality Acceptance Test Specifications

All EMI filtered connectors undergo extensive testing to ensure that all product meets specification requirements. Many of the tests are performed 100% by computer-controlled test sets including capacitance, dissipation factor, dielectric withstanding voltage, and Insulation resistance as routine. Others are tested on a sample basis as applicable. Test plans can be configured to specific customer requirements.

Qualification/special testing - Spectrum has a fully qualified test laboratory and can provide additional acceptance testing upon the customer's request. This could be a one-time qualification exercise or ongoing periodic testing.

MKTG-AA-1-A3-01