

Hermetic seals are qualified via various methodologies including helium testing and dye penetrant. The purpose of both types of tests is to detect and measure leakage under pressure. The dye penetrant method has the advantage of revealing the exact location of a leak, while Helium testing measures overall leakage within the hermetic device. In both types of tests, a pressure differential between the internal volume of the package and the external environment is created.

The resultant pressure gradient causes the helium or liquid dye to diffuse through the

connector shell, contacts and/or glass seals. Quantitative and qualitative measurements are then taken using appropriate sensing instruments. Glenair MIL-DTL-38999 qualified hermetic connectors are rated to 1×10^{-6} cc/second maximum helium leakage rate.

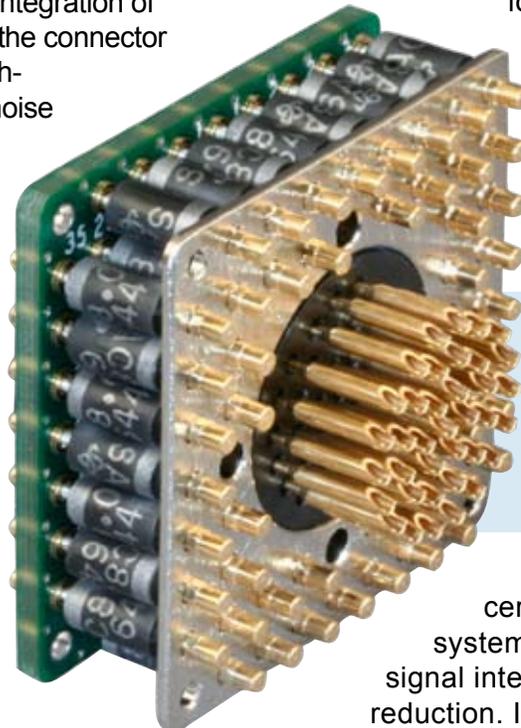
As with other connector classes, customers may specify the connector coupling style (threaded, bayonet, solder mount, etc.) pin or socket count and layout, contact termination type (solder cup, flat eyelet or PCB termination), conductive or non-conductive finish, polarization and so on.

EMI/EMP Filter Connectors

“Filtering” or suppression of electromagnetic noise within the connector package is reliably accomplished through the integration of capacitors and diodes into the connector to segregate interfering high-frequency or high voltage noise from the desired lower frequency signals. The capacitors strip off the interfering noise from the signal as it passes through the filter device. While various types of capacitor filters are available, perhaps the most widely applied is the Planar Array type.

Planar Arrays are extremely effective at filtering high-frequency interference. Planar Array designs utilize ceramic capacitor arrays and ferrite inductors which externally surround each contact, and may be supplied in a single monolithic block to fit into any connector

size or shape. Planar arrays may be fabricated with different capacitive values on individual pins for additional flexibility in achieving the desired level of EMC. Diodes are used to clamp the voltage below a certain value, thereby protecting the electronic circuitry. They are typically integrated into the connector using a small printed circuit board.



Ferrite elements and capacitors can be integrated into any connector package envelope.

Using filter technology has certain advantages to the electrical system engineer, including improved signal integrity as well as size and weight reduction. In addition, filters can be incorporated into an interconnect system late in the research and development process—for example after an unforeseen emission problem has been detected. In every filter application the signal levels

and frequency bands must be well understood in order to select the appropriate mode or type of filter technology.

For example, electronic equipment used by avionic systems typically spans the electromagnetic spectrum from a few kilohertz to several gigahertz. At the low end, Omega Navigation, which is used to fix aircraft position within a network of ground based transmitters, operates in the frequency range of 10 to 14 KHz. VHF Omnidirectional Range Finders (VOR) are radio beacons used in point-to-point navigation. They operate from 108 to 118 MHz. Glideslope Systems used during landings operate in the 328 to 335 MHz range. Distance-Measuring Equipment (DME), which gauges the space between the aircraft in the sky and ground-based transponders operate at frequencies of just over 1 GHz.

Clearly, potential EMI in the application environment described above covers a broad

range of frequencies. Filter modes and types are consequently specified according to the EMI frequency ranges which are the source of the actual signal degradation and the operating frequency of the affected device. Certain electrical circuit criteria are also germane to filter selection, including:

- Capacitance Value
- Working Voltage
- Surge Voltage
- Dielectric Withstand Voltage
- Insulation Resistance
- Transient Protection

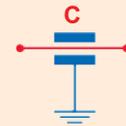
Filter connectors appropriate for use in applications such as those referenced above are broadly identified as 'low-pass' filters (i.e. they let low frequency signals pass through and attenuate higher frequencies). The attenuation curve can

COMMON FILTER CONNECTOR TYPES

Glenair supplies filter connectors in the following electrical configurations: C, L-C, C-L, and Pi. The following general values may be used in type selection: Single element filter connectors sporting either a single capacitor or inductor yield an insertion loss characteristic of 20dB per decade, dual element filters (capacitor plus an inductor) 40dB per decade, and triple element filters 60dB per decade. Selection is based primarily on source and load impedances but may also be influenced by the level of attenuation required at various frequencies. Please consult the factory for assistance in evaluating insertion loss values.

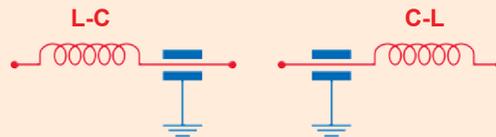
C Filter

Single capacitor with low self inductance. This configuration is generally used to attenuate high frequency signals. The simple design allows high-frequency EMI to discharge to ground via the surrounding electromagnetic field.



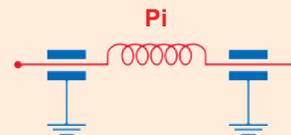
L-C or C-L Filter

Single capacitor combined with an inductive element. It is commonly used in a circuit with a both a low impedance source and a high impedance load or a low impedance load and a high impedance source. The inductive element should face the low impedance.



Pi Filter

Dual capacitors with a single inductive element positioned between them. The Pi filter provides exceptional high-frequency performance due to its sharper rolloff and is typically used when both source and load impedances are high.

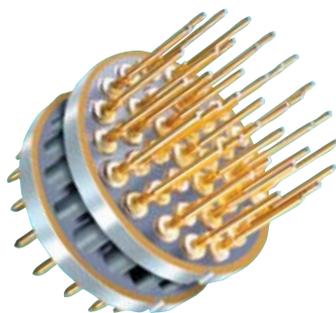


MIL-DTL-38999 Type Filter Connectors Overview



be shaped using different filter types (different configurations of capacitors and inductors). These types include: Pi Filter, L-C or C-L Filter, and C Filter. These filter connector types are characterized by their relative abilities to filter noise according to capacitance, voltage values and load impedances. The simplest design is the "C", which consists of a single capacitor inserted between the signal line and ground.

While most EMI filter connectors can be used in a working temperature environment from -55° to 125° C, selected designs are optimized for higher operating temperatures. Hermetic filter connectors provide the ultimate protection. The hermetic glass fused design protects the filter assembly while maintaining very low leakage rates.



A multiway planar array filter device, assembled with its ferrite elements and connector contacts, ready for insertion into the connector shell. The flexible design allows for different capacitive values on individual pins as well as the integration of hybrid contacts such as optical termini.

Prior to shipping a filtered connector, Glenair offers extensive testing, qualification and burn-in options. Tests range from a simple capacitance (C), insulation resistance (IR), and dielectric withstanding voltage (DWV), to more elaborate options such as RF insertion loss, dissipation factor, Zener/TVS diode test, ground resistance, voltage conditioning and thermal shock.

The Glenair factory, provided with the system attenuation and frequency values, relevant electrical specifications, and connector configuration details, can design an effective filter device for every application (to get started, use the checklist found in the filter connector section of this catalog). In addition to the MIL-DTL-38999 type filter products cataloged in this book, Glenair is able to supply filter technology in virtually any connector package

including our own Series 80 "Mighty Mouse," Mil-C-24308, and MIL-DTL-83513 products. Hybrid electrical/optical filter connectors and hermetic filter designs are a specialty.

Multilayer Ceramic Planar Capacitor Arrays

Planar, multi-layer ceramic capacitive filters offer reduced size and improved performance compared to discrete discoidal or tubular capacitors. Planar array filter devices have the advantage, especially when compared to capacitive filters integrated at the circuit board level, of being bidirectionally effective at attenuating unwanted noise travelling into and out of equipment enclosures.

As mentioned, the planar array can be designed with different capacitive values on individual pins, and pin groupings, and can also be selectively equipped with surge protection diodes. The ability to accommodate such Transient Voltage Suppressions (TVS) diodes to protect against voltage spikes from transient sources such as EMP, lightning or Electrostatic Discharge (ESD) is an additional strength of the planar array design.

The planar array package can also easily accommodate ferrite elements to add inductance to the filter device. For these reasons and more, the planar array is the most common filter type specified in military aerospace and other high-performance applications. The planar array consists of multiple layers of ceramic dielectric separated by individual sheets of a ceramic tape material screen-printed with a pattern of metal electrodes. The exact configuration of the electrodes—their combined capacitance values, positions vis-a-vis individual contacts, selective grounding to the connector shell, etc.—determines the EMI attenuation properties of the filter device. After the layer-cake of dielectric materials and conductive elements is assembled, it is fired at high temperature to create a unified, monolithic structure. The planar array is fabricated such that the capacitor positions align exactly to the pin layout positions of the connector. When combined with inductive



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A ferrite elements, TVS diodes or other special circuitry, the final assembly is ready for insertion into the connector shell. The incorporation of filter elements into a standard cylindrical or rectangular connector will necessarily increase the overall length of the package. The extra real estate is usually added to the inside-the-box (non-mating) side of the connector receptacle. Another approach is to attach a connector adapter, or go-between, outfitted with the filter device, to the connector plug. This approach has the advantage of not requiring any dimensional changes in box design or receptacle connector package.

Often, custom-configured planar arrays, with unique capacitive elements and values, are required to effectively address complex EMI problems such as might be encountered in an avionics bay or in the body of a missile. But many EMI problems can be satisfactorily addressed with standard catalog product designs. As critical EMI problems are often discovered late in the development process—perhaps only after equipment has been installed for use—it is critical that both standard catalog products as well as non-standard designs are delivered with the fastest possible turnaround. Glenair is committed to meeting the most aggressive delivery requirements for planar array type filter connectors.



Glenair can apply a broad range of custom shell configurations, filter values, TVS technologies—even hybrid fiber optic contacts—into any MIL-DTL-38999 type connector package, including bulkhead feed-thrus and connector savers.

Insertion Loss Evaluation

Insertion loss is an important specification to consider in the selection of filter connectors. Insertion loss is a measure of the degradation experienced by a signal when a device, such as a connector, is inserted into the transmission path.

When a filter element performs its job of stripping signal noise from a transmission line, it may attenuate a portion of the desired signal as well. Measured in decibels (dB), insertion loss should be minimized in sensitive electronic systems which may operate at extremely low current levels. Typically, some amount of insertion loss is considered acceptable to accomplish the necessary signal selectivity, since the signal can always be re-amplified post-filtering. However, in many applications, too large a loss may ultimately result in the unacceptable degradation of system performance.

The evaluation of insertion loss is performed over a specific frequency range—i.e., a spectrum that extends from one limiting frequency to another. The intent being to measure signal degradation for each filter type across the actual operating frequencies of the equipment under consideration. Note that each filter type may yield different (theoretical and actual) insertion loss values depending on the specific capacitance and inductance [pF] ratings of the filter elements. Effective EMI/EMP filtering is, therefore, a balance between the purposeful attenuation of signal noise and the unfortunate degradation of signal strength—both conditions directly attributable to the insertion of the filter device into the system.

Sensible EMC design should, as a consequence, always incorporate conventional grounding and shielding of interconnect cabling and equipment housings in anticipation of unexpected EMI problems. The tables on the opposite page explain predictable insertion loss [dB] for each filter type (C, L, and Pi), at the available capacitance ratings [pF] across a common frequency range [MHz].

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C



INSERTION LOSS

Frequency	Insertion Loss, dB Minimum, 25°C						
	A	B	C	D	E	F	G
1 MHz	6	5	3	–	–	–	–
10 MHz	24	23	16	8	4	–	–
100 MHz	41	39	35	28	21	10	5
500 - 1000 MHz	50	49	46	41	34	23	17

CAPACITANCE

Filter Class	Capacitance
X	80000 – 120000 [pF]
Y	40000 – 60000 [pF]
Z	30000 – 45000 [pF]
A	19000 – 28000 [pF]
B	16000 – 22500 [pF]
C	9000 – 16500 [pF]
D	4000 – 6000 [pF]
E	1650 – 2500 [pF]
F	400 – 650 [pF]
G	200 – 300 [pF]

Pi



INSERTION LOSS

Frequency	Insertion Loss, dB Minimum, 25°C						
	A	B	C	D	E	F	G
1 MHz	10	8	5	1	–	–	–
10 MHz	40	35	25	14	8	2	0.8
100 MHz	62	60	57	50	40	15	13
500 - 1000 MHz	66	62	60	58	52	32	22

CAPACITANCE

Filter Class	Capacitance
X	1600000 – 240000 [pF]
Y	80000 – 120000 [pF]
Z	60000 – 90000 [pF]
A	38000 – 56000 [pF]
B	32000 – 45000 [pF]
C	18000 – 33000 [pF]
D	8000 – 12000 [pF]
E	3300 – 5000 [pF]
F	800 – 1300 [pF]
G	400 – 600 [pF]

APPLICATION NOTES

- Standard voltage rating is 500 V DWV.
- Insertion loss values quoted are for 50Ω impedance and no load condition.
- Classes X, Y and Z are 250 V DWV. Consult factory for additional information.
- Some shell configurations may require extra length for classes X, Y and Z.



Custom Options in Filtered Connectors

Glenair MIL-DTL-38999 type filter connector designs may be optimized for use in a wide range of application environments including avionic systems, down-hole drilling and logging devices, network-centric ground warfare systems, and missile and satellite/space applications. Common electrical customizations include unique capacitance values on individual lines, electrostatic discharge designs, transient voltage suppression diodes, grounded holes and feed-throughs, as well as the incorporation of customer-specified filter architectures including Pi, C, L-C, C-L and T configurations.

Non-standard packaging options in EMI/EMP filter connectors include:

- Hybrid Fiber Optic/Electrical Contacts
- Dual-Flange PCB Mount Designs
- Composite Thermoplastic Shell Materials
- Variable Length PCB Tails
- Piggy-Back Crimp Contacts
- EMI Grounding Fingers and Gaskets
- In-Line, Feed-Through, Plug and Other Shell Styles

EMP and Transient Voltage Suppression

Electromagnetic Pulse (EMP) refers to intense radio frequency pulses produced by nuclear explosions at high altitudes. Other names for this phenomenon are Nuclear EMP (NEMP), and High-Altitude EMP (HEMP). Like other forms of electromagnetic interference, EMP can have a destructive effect on sensitive electronic devices, if the EMP grounds to an unshielded cable and passes into the electronic device.

EMP hardened equipment is designed to protect vital communications at a time when unhardened devices are likely to fail. Thus it is standard for many military applications to proactively protect certain devices from EMP. This is accomplished, in part, by the integration of Transient Voltage Suppression technologies into the connectors that service the device.

Transient Voltage Suppression (TVS) technologies are designed to shunt voltage transients directly to ground before such surges can damage sensitive electronic equipment. Individual TVS diodes as well as diode modules may be incorporated directly into the filter connector package to provide optimal protection for either individual contacts or groups of contacts without significant increases in connector size or weight. Individual circuit protection diodes and diode modules are available for all connector types and are routinely stocked by Glenair to reduce lead-times. Individual diodes and modules may be screened and tested prior to assembly to ensure reliable performance. Field maintenance and repair of damaged diodes is also possible as both individual diodes and diode modules are easily removed from the connector package. RTCA DO-160 and other electrical performance standards now define acceptable benchmarks for withstanding electromagnetic pulse, lightning strike, or other induced voltage surges in high-reliability systems. Glenair designs all TVS equipped filter connectors to conform to the RTCA DO-160 standard.

Composite Connectors and Lightning Strike

Composite thermoplastic materials, such as the 30% glass filled polyetherimide (PEI) used in Glenair's MIL-DTL-38999 Series II Wall Mount Receptacle Connector have been tested for mechanical and electrical survivability to direct and indirect lightning strike. At issue is the ability of the composite connector shell to maintain its electrical continuity in the event of an intense voltage surge resulting from lightning strike.

In testing in accordance with MIL-STD-1344, items are subjected to waveform 1 and 5B using a high current generator. Items must remain functional without degradation of the unit's electrical performance, including filtering elements and TVS diodes and modules. Waveform 1 and 5B are applied starting at 3Ka increasing to 20Ka checking continuity measurements at set intervals. Waveform 1 is additionally subjected to an oscillatory wave starting at 30Ka and increasing in 10Ka steps until failure in continuity is measured.

While larger composite connector shell sizes (12 to 24) conform to MIL-STD-1344, smaller sizes (8 and 10) fail the test. Customers should select alternative materials, aluminum or stainless steel, when specifying small connector shell sizes in applications subject to lightning strike.



Glenair composite connectors and backshell are tested IAW MIL-STD-1344 lightning strike.

Soldering

Our filter connector engineers are frequently asked about any special handling procedures that are required when soldering PC Tail and Solder-cup contacts. At issue is the potential to damage filter elements due to the high heat of the soldering process. The short answer is that any trained and qualified operator can complete the operation without any special precautions. While it certainly can't hurt to take some basic precautions such as preheating the connector or utilizing a heat sink on individual contacts, our tests have revealed that, under normal conditions, the temperature of the ceramic filter array is not radically raised during solder termination of the contacts. Even in tests where we used a solder iron temperature of 350°C and an extremely long 'touch time' of 90 seconds, no adverse effects were observed. In fact, temperature at the ceramic remained well below 100°C at all times.



Hermetic Filter Connectors

Hermetic class EMI/EMP filter connectors are available throughout our complete range of MIL-DTL-38999 type filter connector products in both Pi and C from 400 pF to 56000 pF. Select either class H2 (stainless steel, electroless nickel), or class XM (composite, electroless nickel).

Hermetic connectors with EMI/EMP filtering are specified for applications as divergent as submarines, orbiting satellites, oil-patch logging equipment or medical devices that require both filtering elements and hermeticity. In addition to their EMI management function, the connectors are deployed to resist moisture ingress in

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underground applications and to withstand pressure differentials in vacuum chambers, laboratory equipment and commercial and military aircraft. Hermetic filter connectors are constructed from a core component-set that includes the connector shell, the planar array filtering device, a vitreous glass insert and the necessary interfacial sealing.

Shells may be machined from stainless steel or Kovar®, an iron-nickel-cobalt alloy with a coefficient of expansion closely balanced to

the glass inserts. Contacts used in hermetic connectors must be fabricated from high-grade materials that can withstand high-heat, and bond effectively to the vitreous glass seal.

Glennair offers both standard hermetic/filter products compatible with standard MIL-DTL-38999 plugs as well as non-standard designs with unique filter values or voltage suppression technologies. Our goal is to always provide the fastest turnaround in the industry. Please consult the factory for unique packaging requirements.

Filter Module Elements

