



WEMS ELECTRONICS

**EMI/EMC Filters:
A Technical Presentation**

TOPICS OF DISCUSSION

- Back To Basics
- EMI Modes Propagation
- Military EMI Specifications
- Cylindrical Style Filters
- Bolt Style Filters
- Solder-In Style Filters
- Multicircuit Filter Assemblies

TOPICS OF DISCUSSION

- Common Mode & Differential Mode Interference
- Hermetically Sealed Space Level Bolt Style Filters
- MIL-PRF-28861 “S” Level Requirements And Problems
- WEMS Electronics Quality Programs
- Review Of Source / Specification Control Drawings
- More Information On EMC / EMI
- Introduction to WEMS Electronics

BACK TO BASICS

- EMC: Electromagnetic Compatibility – The Goal
- EMI (RFI): Electromagnetic Interference – The Menace

Electromagnetic Compatibility, the ability for multiple electronic systems and subsystems to operate and perform together in a variety of hostile environments, without interfering with each other, is the goal and can be achieved through prudent EMC design practices that often requires the use of EMI filters.

EMI MODES OF PROPAGATION

CONDUCTED EMI: Electromagnetic interference that exits or enters a piece of equipment via conduction on the power line.

Common Mode Interference: Interference which is present as a common potential between ground and all power lines. Also referred to as asymmetric interference.

Differential Mode Interference: Interference which is present as a potential between individual power lines. Also referred to as symmetric interference.

EMI MODES OF PROPAGATION

RADIATED EMI: Electromagnetic interference that is transmitted or radiated (similar to an antenna), and exits or enters a piece of equipment via this radiation.

This EMI can emanate directly from the system (through the housing) or via the interconnecting cables that are acting like dipole antennas.

MILITARY EMI SPECIFICATIONS

MIL-STD-461 (462, 463): A joint service military specification that limits the level of conducted and radiated emissions (EMI) emanating from subsystems and systems. This specification also establishes minimum levels of conducted and radiated susceptibility including EMP and line transients (spikes).

Conducted Emissions (designated CE) are measured over a specified frequency range using a LISN (line impedance stabilization network). Earlier revisions of MIL-STD-461 used a RF current probe or a LISN depending on the applicable test method specified.

MILITARY EMI SPECIFICATIONS

Conducted Emission requirements are applicable to input / output power lines (AC and DC) and to signal / interconnecting lines depending of the class of equipment.

Conducted Emission measurements do not discriminate between common mode and differential mode interference and take into consideration both “Broadband” and “Narrowband” emissions.

MILITARY EMI SPECIFICATIONS

Radiated Emissions (designated RE) are series of measurements over a specified frequency range using a variety of antennas and take into consideration both “Broadband” and “Narrowband” emissions. The exact frequency ranges are determined by the class of equipment under test.

Conducted Susceptibility tests (designated CS) are a series of tests where RF signals, including spikes and transients, are injected on / into the power lines and signal / interconnecting lines to determine the threshold level of susceptibility of the unit under test.

MILITARY EMI SPECIFICATIONS

Radiated Susceptibility tests (designated RS) are a series of tests where the unit under test is subjected to radiated fields (v/m) to determine the threshold level of susceptibility of the unit under test.

Both Conducted and Radiated Susceptibility levels are determined by the class of equipment as specified in MIL-STD-461.

MILITARY EMI SPECIFICATIONS

EMI filters are bi-polar by design and therefore not only do they reduce the amount of conducted interference (CE) they also provide protection against unwanted RF signals (CS), including spikes and transients. This is achieved through circuit selection and sometimes-using transient suppressors.

EMI filters do not “meet” MIL-STD-461. EMI filters help to cause systems to comply with the requirements of MIL-STD-461 by reducing the conducted emissions, and sometimes radiated emissions, and by protecting the system from outside interference.

MILITARY EMI SPECIFICATIONS

There are numerous commercial EMI Specifications including the FCC (US), CSA (Canada), CISPR (France), and VDE (Germany). These agencies regulate the EMI emissions for commercial devices and in some cases safety requirements as well.

Although the basic principles are the same as the Military Specifications, the test methodology is completely different and therefore the results cannot be compared to MIL-STD-461. Additionally, these specifications only address Conducted and Radiated emissions and do not specify susceptibility requirements.

WEMS OFFERS THE FOLLOWING TYPES OF FILTERS

- Cylindrical style filters
- Bolt style filters
- Solder – in filters
- Multicircuit filters and filter assemblies
- Hermetically sealed space level bolt style filters



CYLINDRICAL STYLE FILTERS

CYLINDRICAL STYLE HIGHLIGHTS

- Rugged discoidal ceramic capacitor construction
- Cylindrical and button styles available
- Hermetically sealed on both ends. Epoxy seals available
- Standard body sizes available
- Available circuits: “C”, “L”, “T”, “ π ”
- Wide variety of filtering performance to choose from
- MIL-PRF-15733 and MIL-PRF-28861 QPL equivalents
- Mounting hardware supplied



BOLT STYLE FILTERS

BOLT STYLE HIGHLIGHTS

- Rugged discoidal ceramic capacitor construction
- Standard thread sizes available: 4-40, 8-32, 10-32, 12-32
- Available circuits: “C”, “L”
- 4-40 thread size available in “C” circuit only
- Hermetically sealed in 12-32 thread size
- MIL-PRF-15733 and MIL-PRF-28861 QPL equivalents
- Mounting hardware supplied



SOLDER - IN FILTERS

SOLDER - IN STYLE HIGHLIGHTS

- High temperature construction
- Withstands 300°C installation temperatures
- 0.128 inch diameter
- 0.165 inch diameter
- 0.250 inch diameter
- 0.400 inch diameter
- Available circuits: “C”, “L”
- Hermetically sealed on either end

MULTICIRCUIT FILTER ASSEMBLIES

All Multicircuit filter assemblies are custom designed and engineered to satisfy specific customer requirements. The requirements can be in the form of an existing Source Control or Specification Control Drawing or can be developed by WEMS to satisfy the customer's precise needs.

Years of packaging experience have provided solutions to the most challenging filter assembly requirements.

MULTICIRCUIT FILTER ASSEMBLIES

Construction:

- Fabricated or machined metallic and non-metallic housings
- Hermetic or non-hermetic assemblies containing up to 300 circuits
- Unique mounting schemes

Finish Options:

- Electro-tin plated, gold plated, anodized, chem film, painted
- Any other as specified by the customer

MULTICIRCUIT FILTER ASSEMBLIES

Input / Output Terminations:

- Military or commercial connectors
- Solder terminals, turret terminals or eyelet
- Screw terminals using ceramic or insulative bushings
- PWB mounting
- Flex cables
- Coaxial cables
- Fiber optic cables
- Wires with or without lugs or terminals
- Wire harness
- Any combination of the above

MULTICIRCUIT FILTER ASSEMBLIES

Circuit Types:

- Effective filtering up to 10 GHz
- Common mode filtering elements
 - Common mode inductors, Line to ground capacitors
- Differential mode filtering elements
 - Differential mode inductors, Line to line capacitors

MULTICIRCUIT FILTER ASSEMBLIES

Surge Protection

- Lightning
- HERF
- Transient
- EMP

MULTICIRCUIT FILTER ASSEMBLIES

Other Components:

Many types of non-filtering components can be incorporated into a multicircuit filter assembly.

- Fuses
- Switches
- Relays
- Receptacles
- Hybrids
- Resistors
- Diodes

MULTICIRCUIT FILTER ASSEMBLIES

Voltage Ratings:

- Multiple DC ratings up to 1000 VDC
- Multiple AC ratings up to 440 VAC, 50 Hz to 400 Hz
- DC, AC and data lines in the same package

Current Ratings:

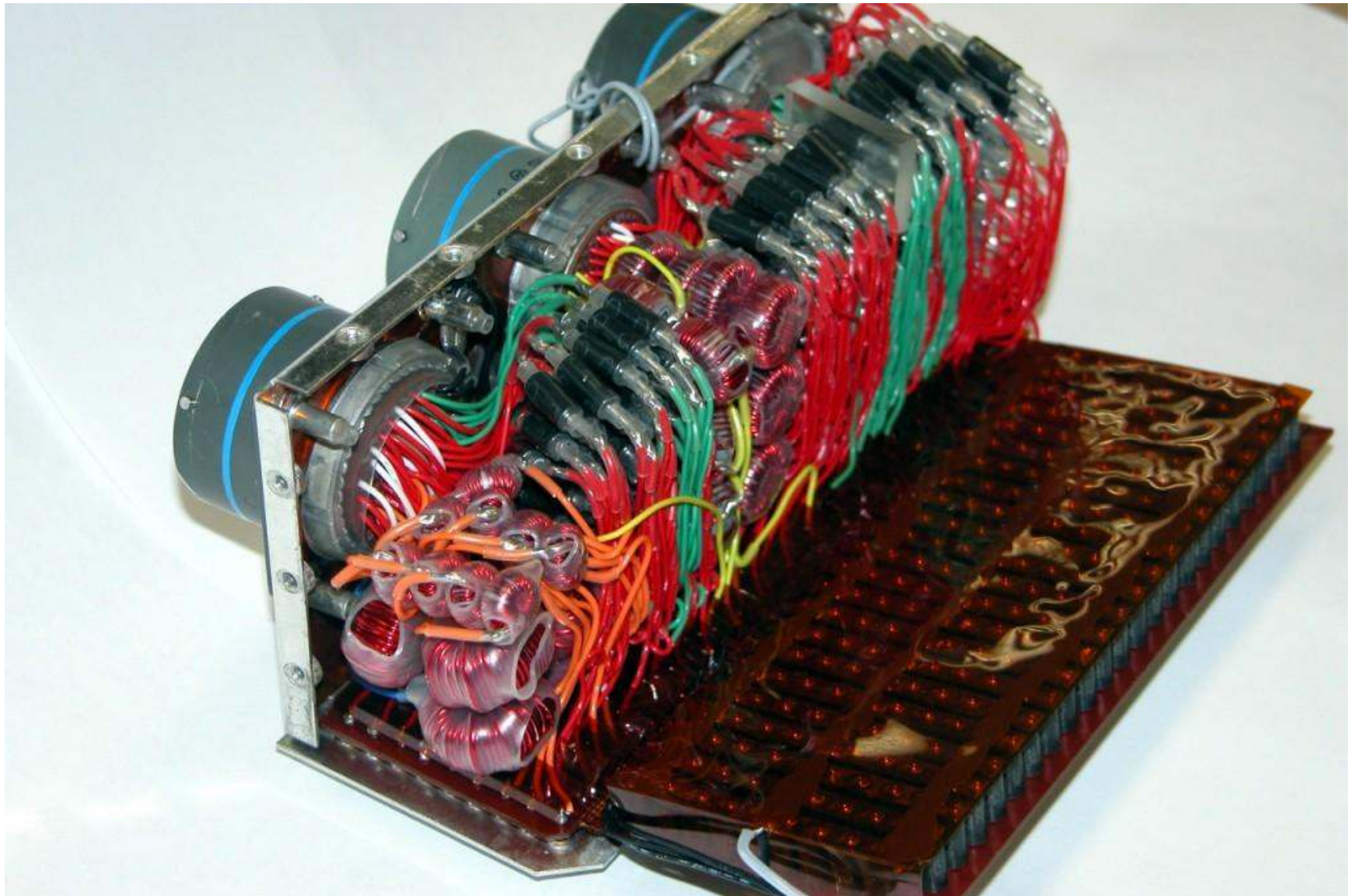
- Multiple ratings up to 200 amperes, AC or DC

Higher voltage and current ratings will be reviewed on an individual basis due to unusual requirements i.e. corona and reactive current.

MULTICIRCUIT FILTER ASSEMBLIES

Reliability:

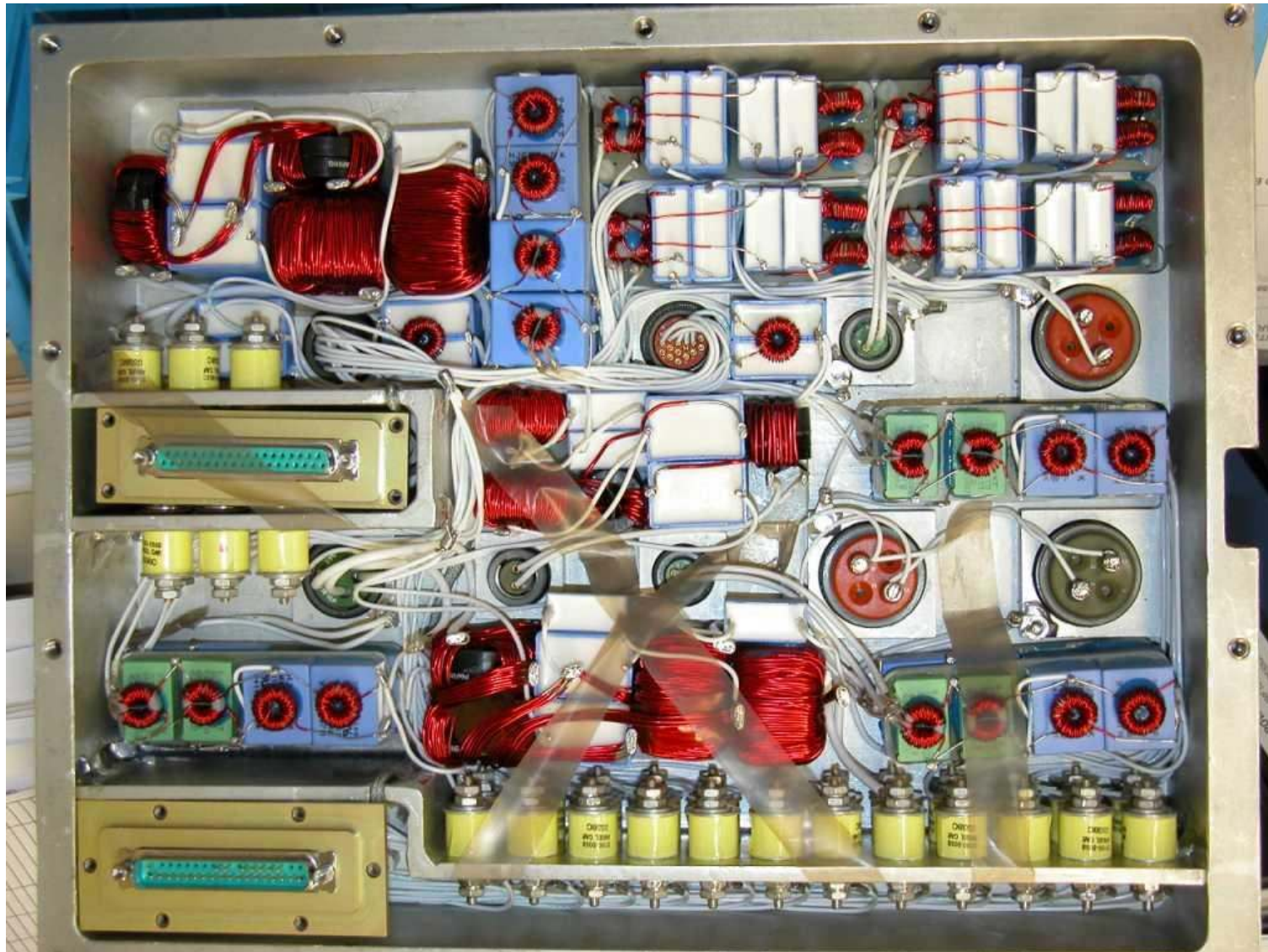
- MIL-STD-202
- MIL-PRF-15733
- MIL-PRF-28861
- MIL-C-123
- UL
- CSA
- FAA / PMA
- Or as required by the customer



298 MULTI CIRCUITS FILTER FOR C-17



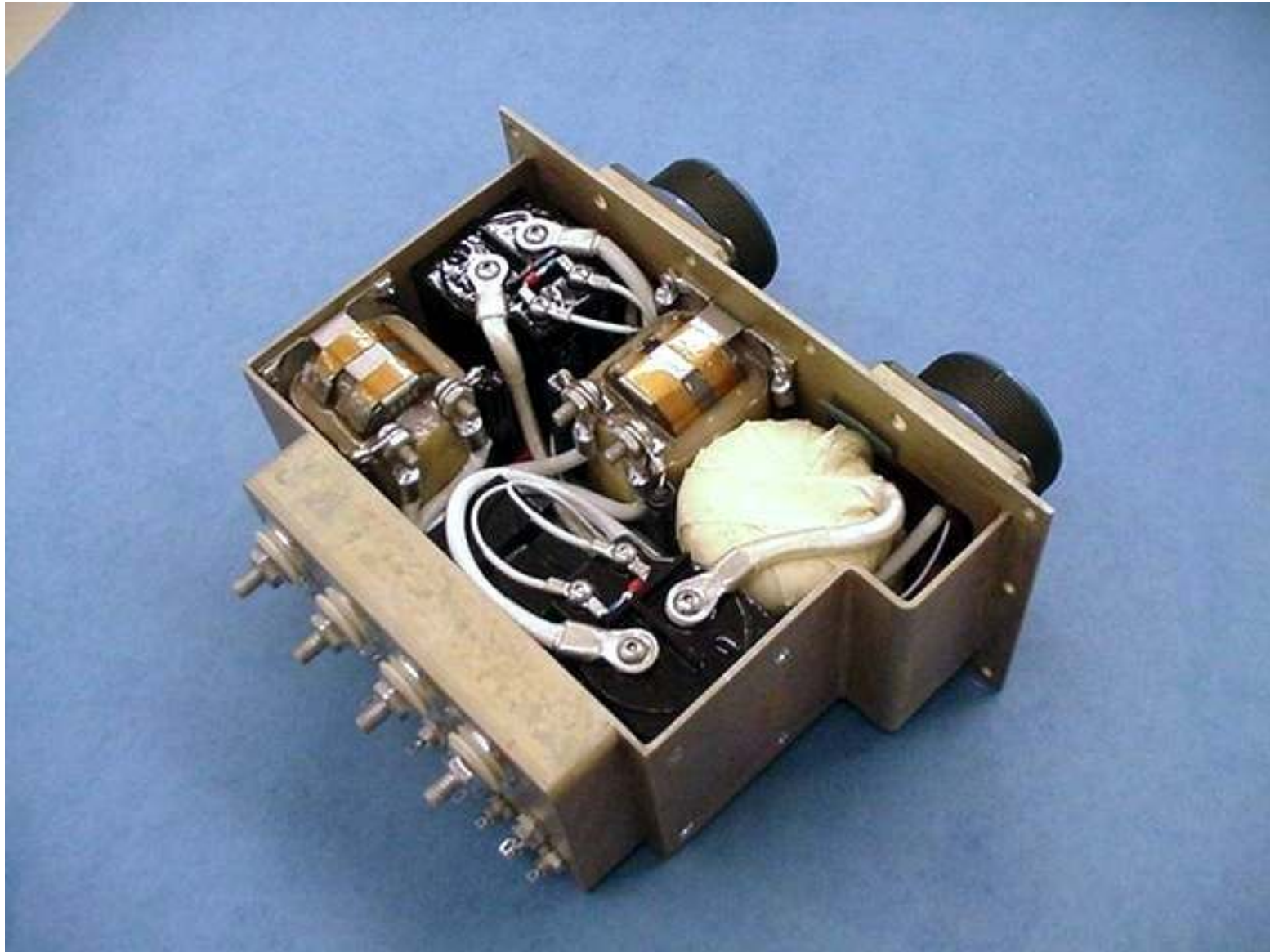
AC/DC FILTER FOR ROTORCRAFT CENTRAL POWER SUPPLY



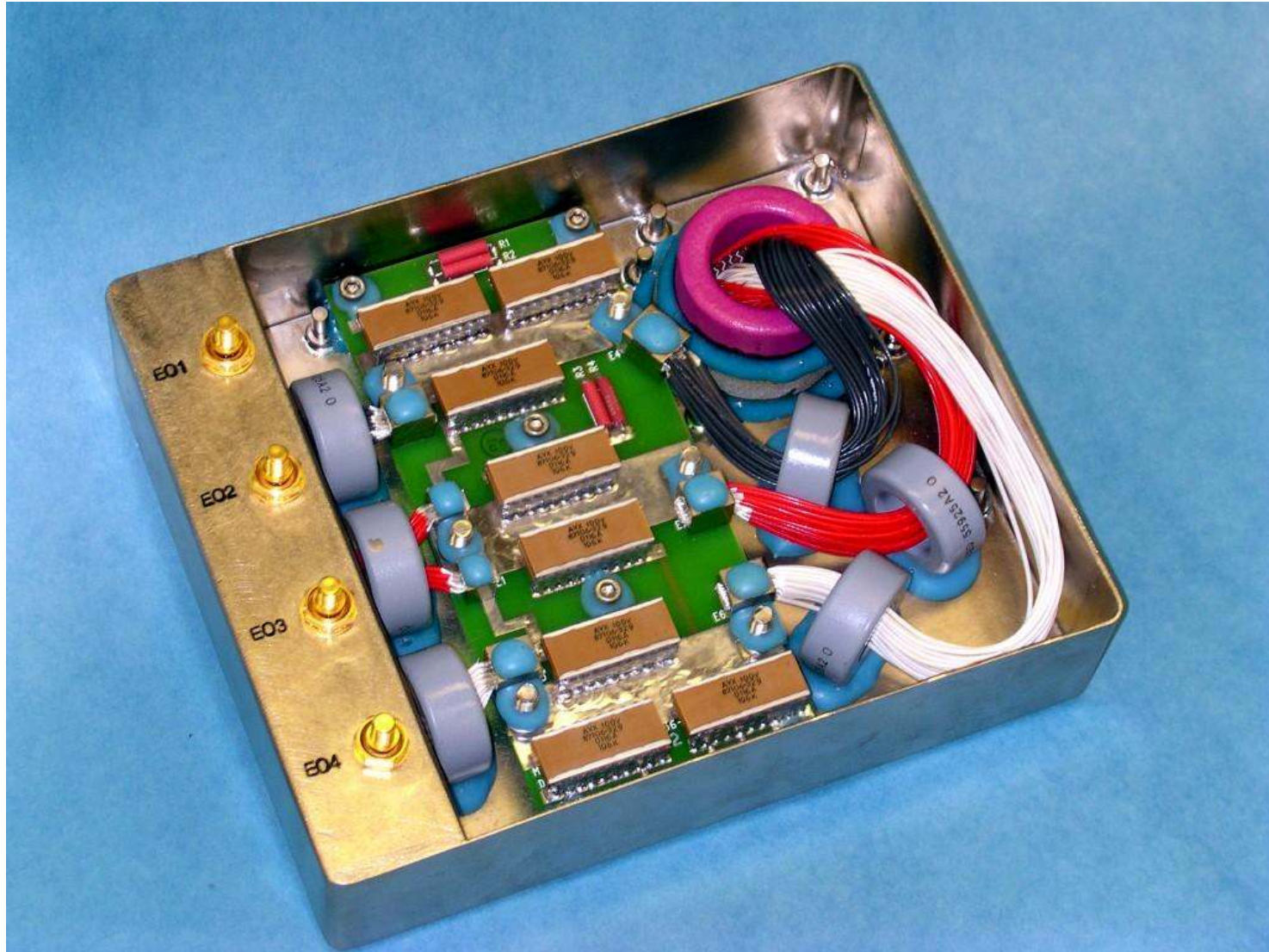
DC FILTER FOR CLASSIFIED PROGRAM



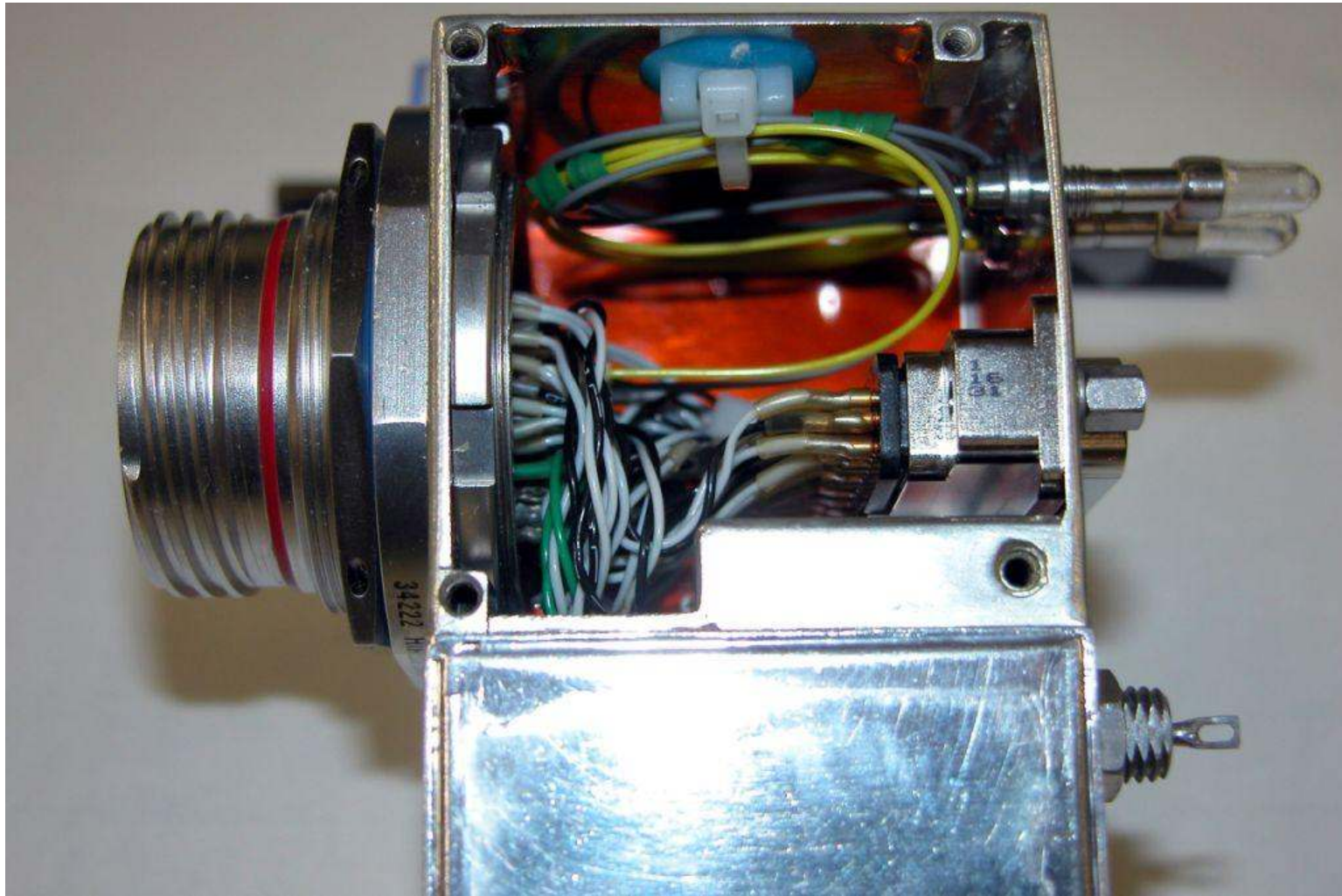
AC TO DC FILTER FOR AIRBUS A380



POWER UNIT FILTER FOR F22 RAPTOR



DC FILTER FOR CLASSIFIED SATELLITE PROGRAM



DC FILTER WITH SEPARATE FIBER OPTIC
COMPARTMENT FOR PHALANX

NEW HERMETICALLY SEALED SPACE LEVEL BOLT STYLE FILTER

- MIL-PRF-28861 space level requirements and problems
- Current styles available
- Current design and construction for a π circuit
- WEMS space level bolt style filter (U.S. patent 6,816,033 B2)
- WEMS design and construction for a π circuit
- Conclusion

MIL-PRF-28861 "S" LEVEL REQUIREMENTS AND PROBLEMS

- Group B "S" Level requires 41 test samples
- Zero failures are permitted
- One failure and the entire lot of filters is scrapped
- 22 samples are subjected to a 1,000 hour life test at + 125° C
- Insulation resistance (IR) after life is the test that is most likely to fail due to flux residue from the soldering process
- Multiple soldering operations increase the chance of a failure
- Current styles have as many as 4 solder operations

CURRENT STYLES AVAILABLE

- 4 - 40 thread - epoxy sealed on both ends
- 8 - 32 thread - epoxy sealed on both ends
- 10 - 32 thread - epoxy sealed on both ends
- 12 - 32 thread - epoxy sealed on both ends
- 12 - 32 thread - hermetically sealed on both ends
- Available circuits : “ C ”, “ L ”, π per MIL-PRF-28861
- Voltage and current ratings per MIL-PRF-28861

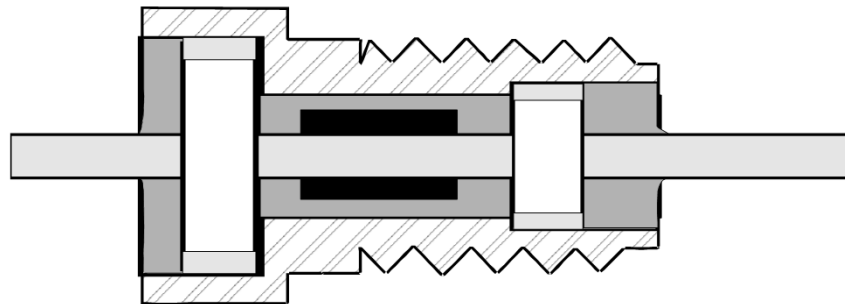
CURRENT DESIGN AND CONSTRUCTION

- Discrete monolithic discoidal ceramic capacitors per MIL-C-123
- Discrete ferrite beads
- Resin epoxy seal on both ends except for 12 - 32 style
- Case and leads are gold , silver, or electro-tin plated
- Cold rolled steel case
- Half / hard copper leads

CURRENT DESIGN AND CONSTRUCTION

π CIRCUIT

A discrete capacitor is soldered into the hex portion of the screw body. A lead is then soldered into the ID of the capacitor. The unit is cleaned and a ferrite bead is then inserted into the screw body portion and located in place with epoxy. A discrete capacitor is then soldered in place at the screw body end. The filter is then cleaned thoroughly to remove all flux and both ends are filled with epoxy. However, it is impossible to remove all the flux in the inner cavity where the ferrite bead is located.



WEMS SPACE LEVEL BOLT STYLE FILTER U.S. PATENT 6,816,033 B2

- 4 - 40 thread - hermetic seal on one end , epoxy seal on other
- 8 - 32 thread - hermetic seal on one end , epoxy seal on other
- 10 - 32 thread - hermetic seal on one end , epoxy seal on other
- 12 - 32 thread - hermetically sealed on both ends
- Available circuits : “ C ”, “ L ” and π per MIL-PRF-28861
- Voltage and current ratings per MIL-PRF-28861

WEMS DESIGN AND CONSTRUCTION

U.S. PATENT 6,816,033 B2

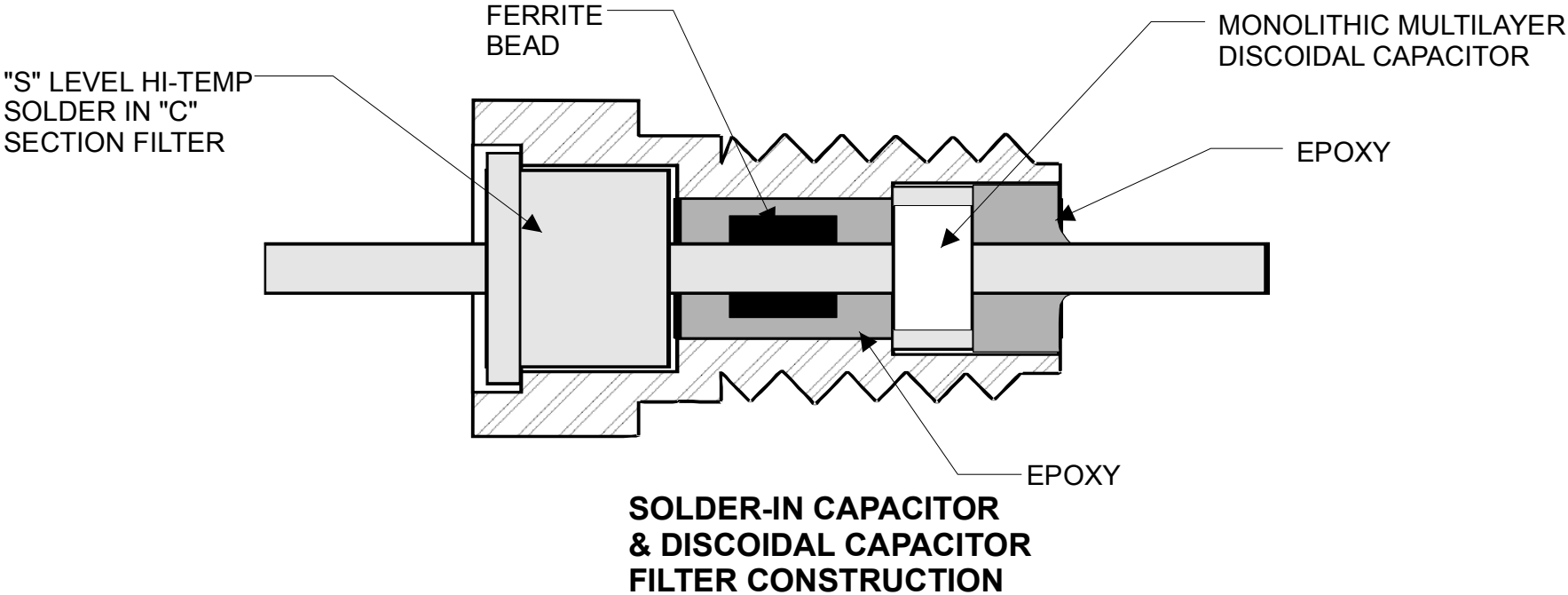
- Discrete “S” level hermetically sealed solder-in style filter
- Discrete monolithic discoidal ceramic capacitors per MIL-C-123
- Discrete ferrite beads except for 12 - 32 style
- Resin epoxy seal on one end except for 12 - 32 style
- Case and leads are gold , silver, or electro-tin plated
- Cold rolled steel case
- Iron-nickel alloy leads

WEMS DESIGN AND CONSTRUCTION

U.S. PATENT 6,816,033 B2

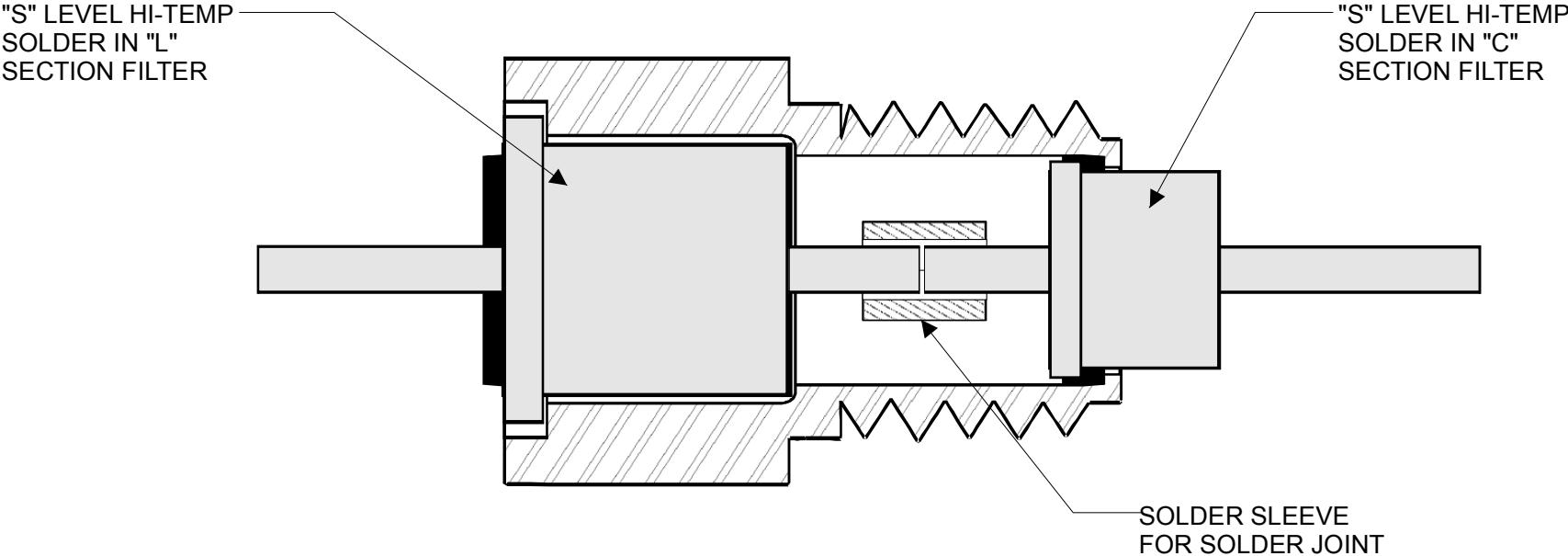
π CIRCUIT

ASSEMBLY PROCESS



WEMS DESIGN AND CONSTRUCTION U.S. PATENT 6,816,033 B2

ASSEMBLY PROCESS



**SOLDER-IN CAPACITOR
FILTER CONSTRUCTION**

CONCLUSION

By using pre-screened “S” level solder-in style filters at one end of the bolt style filter, or both ends for 12 - 32 thread size, the number of capacitor soldering operations are reduced, or completely eliminated, thereby increasing the probability of successfully complying with the Group “ B “ IR requirements of MIL-PRF-28861.

WEMS ELECTRONICS - QUALITY

The WEMS Quality Assurance system is compliant with a diverse range of systems and product specifications

- ISO 9001:2008
- AS 9100 C
- MIL-PRF-15733
- MIL-PRF-28861
- MIL-I-45208
- MIL-Q-9858A
- IPC / EIA J-STD-001
- IPC-A-610
- UL / CSA SURVEILLANCE
- FAA / PMA SURVEILLANCE

OTHER SERVICES OFFERED BY WEMS

- Filter circuit design and analysis
- Filter packaging, layout, new designs and recommendations
- Prototyping / first article
- EMI test assistance
- Environmental tests and recommendations
- Filter Source Control / Specification Control drawings
- Acceptance Test Procedures
- Qualification Test Procedures
- Turnkey / Box Build assemblies

SOURCE / SPECIFICATION CONTROL DRAWINGS (SCD)

A well written SCD will insure that you, THE CUSTOMER, will receive production filters guaranteed to meet or exceed the performance required for system EMC compliance based on months of design effort. A poorly written SCD will result in . . .well it's anybody's guess. The following, as a minimum, should be taken into consideration when writing a SCD.

- Applicable military specifications and other documents
- Operating voltage, frequency (be careful of de-rating pitfalls)
- Operating current (be careful of de-rating pitfalls)

SOURCE / SPECIFICATION CONTROL DRAWINGS (SCD)

- Leakage current at what voltage and frequency
- Operating temperature range
- Filter housing and finish
- Hermetically sealed or not
- Input and output terminations
- Mechanical requirements, mounting, weight etc.
- Electrical schematic
- Individual Inductors

Core material and core size by part number

Number of turns and wire size

Inductance at what voltage and frequency

SOURCE / SPECIFICATION CONTROL DRAWINGS (SCD)

- Individual Capacitors

 - Voltage rating (be careful of de-rating pitfalls)

 - Feed-through or bypass

 - Ceramic (NPO, X7R, Z5U), film, tantalum, other

 - Capacitance at what voltage and frequency

- Filter Electrical tests and test methods

 - Insulation resistance; line-to-line and line-to-ground

 - DWV (Hi-pot); line-to-line and line-to-ground

 - Inductance; differential and common mode

 - Capacitance; line-to-line and line-to-ground

 - DC Resistance / voltage drop

 - Insertion loss; full load or no load

SOURCE / SPECIFICATION CONTROL DRAWINGS (SCD)

- Environmental requirements
 - Burn-in; temperature, voltage, duration
 - Thermal Shock; temperature range and number of cycles
 - Vibration; random or sine
 - Shock; pulse, g's
 - Other (be careful not to specify a non-compatible test)
- Qualification inspection
 - Qualification Testing; Group "B" and/or Group "C"
 - Quality Conformance Inspection; Group "A" or other
- Inspection lot size; AQL or 100%
- Data reporting; attributes or variable

INTRODUCTION TO WEMS ELECTRONICS

Established in 1959, WEMS Electronics has created an extensive state-of-the art manufacturing complex located a few miles south of Los Angeles International Airport in Hawthorne, California. To serve the worlds most demanding customers, WEMS has invested heavily in a modern 80,000 square foot facility and experienced personnel.

Taking full advantage of corporate vertical integration, the WEMS Filter Group manufactures high reliability input power line, output power line, and signal line filters intended for military, aerospace, space, and high end industrial / commercial applications.

WEMS ELECTRONICS - EMI FILTER GROUP

The vast majority of filters manufactured by WEMS Electronics are to customer Specification Control and Source Control Drawings. What is presented in WEMS EMI / RFI Filter Group catalog is basically MIL-PRF-15733 and MIL-PRF-28861 type product.

Most of the discrete filters that we now manufacture are modified QPL products procured to customer drawings or are totally new products for specific applications.

WEMS is a manufacturer of EMI filters. We are NOT a ceramic or film capacitor company that also happens to build filters.

WHO TO CONTACT AT WEMS

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