

TECHNICAL CONSIDERATIONS]

Understanding Terminology

Technical Considerations

Conducted Emissions Testing

Custom Filter Capabilities



Understanding Terminology

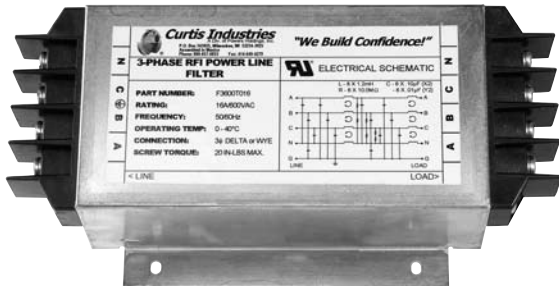
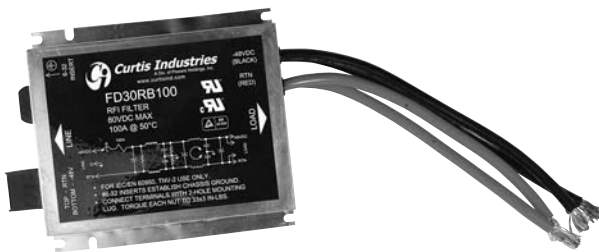
Curtis Industries, a leading manufacturer of superior-quality electronic and electrical components and assemblies for more than 70 years, offers a complete line of RFI power line filters designed to help your equipment meet FCC and CE requirements on conducted EMI.

Radio frequency interference (RFI) is unwanted noise generated by a wide variety of electronic and electrical devices. Governments of most industrial

countries, including the United States, Canada and the European Union have enacted guidelines on emitted RFI.

Curtis designs quality into every product and then tests for quality by specification compliance, including hipot, component value, grounding and leakage, on a 100% production basis. We employ a rigorous component qualification program with thorough incoming and on-line inspection procedures. Our computer-controlled 100% safety and performance testing to demanding customer requirements is your assurance of the highest quality RFI filters available today.

This section provides you with some basic knowledge on terminology and technical information helpful in solving your noise emission in power circuits. For additional information visit our website at www.curtisind.com.



TECHNICAL CONSIDERATIONS

Definitions

Attenuation: The decrease in intensity or absorption of electromagnetic energy. Expressed in dB.

Conducted Interference: Electromagnetic signals entering a device through direct connection.

Emissions: The level of electromagnetic disturbances equipment causes to its environment.

Filter: Remove electrical noise or interference from the power line by cleaning up the sine wave.

Immunity: The level to which equipment is immune to electromagnetic disturbances in its environment

Impedance: Opposition to the flow of electrical current when a given voltage is applied.

Inductor: Passive component that produces a voltage proportional to the change in current. Measured in Henrys.

Insertion Loss: The electromagnetic signal loss resulting from the insertion of a filter in a transmission line. Expressed in dB.



What is RFI?

Radio frequency interference (RFI) is the radiation or conduction of radio frequency energy (or electronic noise) produced by electrical and electronic devices at levels that interfere with the operation of adjacent equipment. Frequency ranges of most concern are 10 kHz to 30 MHz (conducted) and 30 MHz to 1 GHz (radiated).

What causes RFI?

The most common sources include components such as switching power supplies, relays, motors and triacs. These devices are found in a wide variety of equipment used in industrial, medical, white goods, and building HVAC equipment.

What are the types of RFI?

An electrical or electronic device emits RFI in two ways:

- **Radiated RFI** is emitted directly into the environment from the equipment itself.
- **Conducted RFI** is released from components and equipment through the power line cord into the AC power line network. This conducted RFI can affect the performance of other devices on the same network.

How can RFI be controlled?

- **Radiated RFI** is usually controlled by providing proper shielding in the enclosure of the equipment.
- **Conducted RFI** can be attenuated to satisfactory levels by including a power line filter in the system.

The filter suppresses conducted noise leaving the unit, reducing RFI to acceptable levels. It also helps to lower the susceptibility of the equipment to incoming power line noise that can affect its performance.

What is the government's role in regulating RFI?

Governments and safety agencies of major industrial countries, including the United States, Canada, and the European Union have established noise emission regulations that are focused on digital and other electronic equipment. The most important of these guidelines are FCC CFR 47 (Parts 15 and 18) in the United States and CISPR 11, 14 and 22 in the European Union.

FCC CFR 47 (Part 15) regulates the RF

interference of electronic computing devices, defined as any electronic device or system that generates and uses timing signals or pulses at a rate in excess of 10,000 pulses (cycles) per second and uses digital techniques. This definition includes telephone equipment that utilizes digital techniques and any device or system that generates and uses radio frequency energy for the purpose of performing data-processing functions such as electronic computations, operations, transformations, recording, filing, sorting, storage, retrieval or transfer.

FCC regulations are broken down into **Class A** computing devices marketed for use in commercial, industrial or business environments, and **Class B** devices intended for use in a residential environment.

The European Union has harmonized the various national regulations and has established the international standards CISPR 11, 14 and 22. CISPR 11 covers industrial, scientific and medical equipment. CISPR 14 covers electrical and thermal appliances and tools. CISPR 22 covers information technology equipment.

In addition to governmental regulations, safety agencies worldwide have established guidelines for all electrical/electronic components. These include UL, CSA and TUV. They are designed to protect against shock and fire hazard.

How do RFI power line filters work?

Consisting of a multiple-port network of passive components arranged as a dual low-pass filter, the RFI filter attenuates radio frequency energy to acceptable levels, while permitting the power frequency current to pass through with little or no attenuation. Their function, essentially, is to trap noise and to prevent it from entering or leaving your equipment.

RFI is conducted through a power line in two modes. Asymmetric or **common mode** noise occurs between the line and ground. Symmetric or **differential mode** is measured from line to line. See the selection guide on page 2 under "Performance."

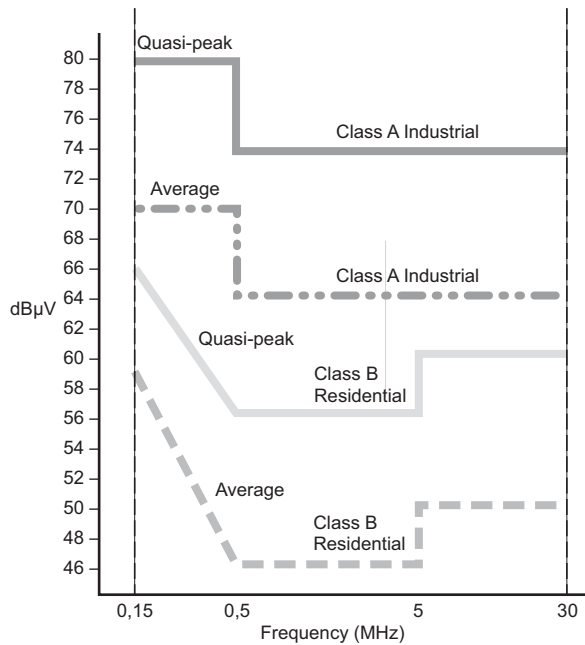


Technical Considerations

Meeting Emissions Standards

The emissions limits that a piece of equipment must meet will depend on the intended market for that piece of equipment. If there is more than one market, more than one emission standard may have to be met. This can have a substantial effect on the circuit, size, and cost of a filter. Standards like the CISPR's or the FCC Rules Part 15 have frequency limits of 150 kHz to 30 MHz.

FCC 15 AND CISPR CONDUCTED EMISSION LIMITS DIGITAL EQUIPMENT



EMI measurements are generally made using Spectrum Analyzers with Average or Quasi-Peak detectors in accordance with methods described in CISPR 16. Quasi-Peak differs from Average measurements by weight-averaging the peaks into the total.

Equipment meeting these specifications can utilize a filter with a fairly high cutoff frequency. Other standards like FCC 18 with a low frequency limit of 10 kHz will result in the equipment using lower cutoff filters. As might be expected, the lower the cutoff frequency, the larger the physical size and the higher the cost of the filter.

Conducted RFI Susceptibility

The problem of susceptibility can be extremely difficult to deal with because the amplitude and frequency of the offending RF noise are seldom known and are often intermittent. If the malfunction can be duplicated by isolating the equipment from the power line with LISN's

(Line Impedance Stabilization Network) and using signal generators to inject RF of varying amplitude and frequency, some insight can be gained as to the nature of the problem. However, the criteria for acceptable performance will have to be decided upon so that a filter yielding this level of performance can be obtained from the test procedure. Unfortunately, this still does not eliminate the need for final testing in the actual operating environment which, in many cases, occurs in the field.

Selection of a suitable filter can best be based on the type of power supply or input impedance of the equipment and on the mode of the offending RFI noise.

Noise Modes

Power line filters attenuate noise in two different modes.

Common Mode: Also known as line-to-ground noise measured between the power line and ground potential.

Differential Mode: Also known as line-to-line noise measured between the lines of power.

Power line filters are designed to attenuate either one or both modes of noise. The need for one design over another will depend on the magnitude of each noise type present. The attenuation is measured in dB (decibels) at various frequencies of signal.

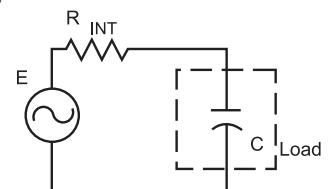
Circuit Configuration

Power line RFI filters are generally built with two or three-pole filter networks. As the number of poles and the corresponding component count increases, the cost will increase also. Trying to typify an equipment's impedance as either high or low for purposes of filter selection may not be successful. If it is a complex impedance, it could probably be low at some frequencies, high at others, and some intermediate value at still other frequencies.

Although we have been generally successful in recommending a two-pole network for linear power supplies and three-pole networks for switching power supplies and synchronous motors, you should not limit your testing to just one circuit type if either additional circuit performance or lower cost is desired. Consider the following: If the equipment looked strictly capacitive, the performance of a two-pole network would be reduced to that of a single-pole filter.

Figure 1a.

A signal source (E) with its internal impedance driving a capacitive load.



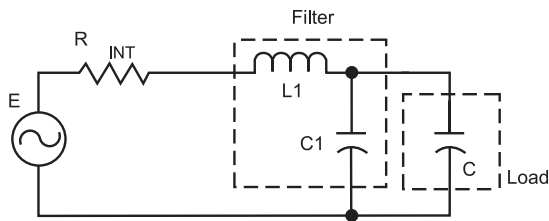
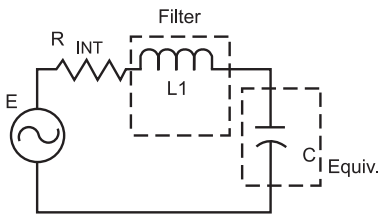


Figure 1b.

The same circuit as in Figure 1a, with the addition of a 2-pole low pass filter. Notice filter capacitor C1 is in parallel with the capacitive load.

Figure 1c.

Combining capacitor C1 in Figure 1b, with the load results in this circuit configuration.



The filter has been reduced to one inductive element, L1.

Obviously a three-pole filter would be preferred for maximum performance. Likewise, if the equipment looked strictly inductive, the performance of a three-pole network would be reduced to that of a two-pole network.

Figure 2a.

A signal source with its internal impedance driving an inductive load.

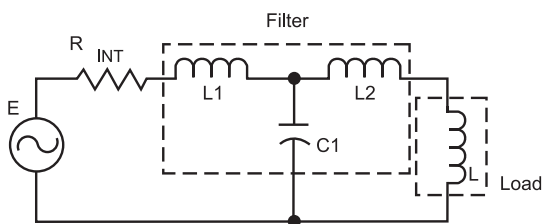
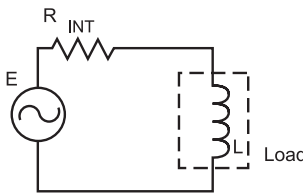


Figure 2b.

The same circuit as in Figure 2a, with the addition of a 3-pole low pass filter. Notice filter inductance L2 is in series with the inductive load.

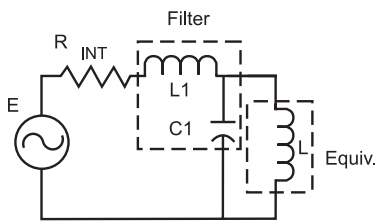


Figure 2c.

Combining inductor L2 in Figure 2b, with the load results in this circuit configuration, the filter has been reduced to two effective elements, L1 & C1.

Undoubtedly the two-pole filter would be a more economical choice with probably equal performance in this application. Since the equipment is not likely to be equivalent to either one of these simple cases, the only way to find the best cost-effective solution is to test the filters in your equipment and base your judgement on these test results.

Leakage Current

The maximum leakage current that a device is allowed depends on the requirements of the particular safety agency involved. Here, selection of the filter is quite easy since either the filter is designed to meet a given level or it is not. Although there is no compromise when it comes to safety specifications, it should be understood that for a given level of performance, as the leakage current is reduced, the physical size of the package will increase. Curtis medical filters have a very low leakage current.

Insertion Loss

DO NOT use the insertion loss specifications to make your final decision. Power line filters are two-terminal pair passive networks whose attenuation characteristics can be defined by a complex transfer function. How that transfer function will react in a particular system and at specific frequencies will depend on the complex impedances connected to each side of the filter. The equipment impedance and the impedance of the power line, even if a 50 ohm LISN (Line Impedance Stabilization Network) is being used during emission testing, will not generally be equal to the resistive 50 ohms used during insertion loss measurements. Therefore, the performance of the filter in the equipment cannot be related to the published insertion loss data.

Minimum Insertion Loss

Do not be alarmed that the insertion loss figures we have published may be of lower value than those of our competition. You will only find guaranteed minimum insertion loss figures in this catalog, without any mention of typical values.

Insertion loss test data measured in a 50 ohm system is a valuable incoming inspection tool to assure you that consistent product is being shipped. The only figures of any importance are those that specify the criteria for acceptance or rejection of that product, and those figures are the minimum values.



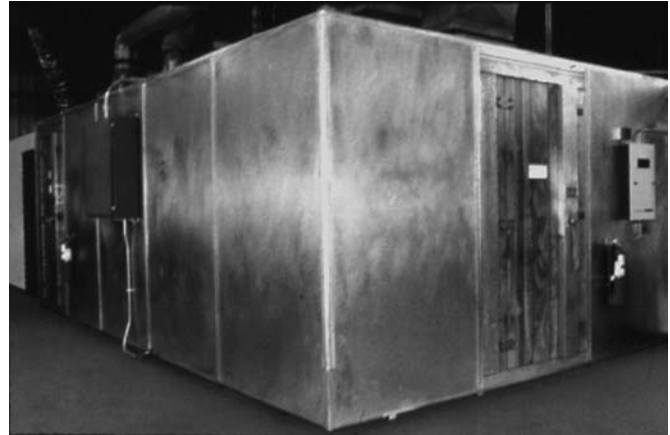
RFI/EMI Conducted Emissions Testing

Curtis offers full RFI/EMI conducted emissions testing services for manufacturers who must produce equipment in accordance with FCC and CE standards.

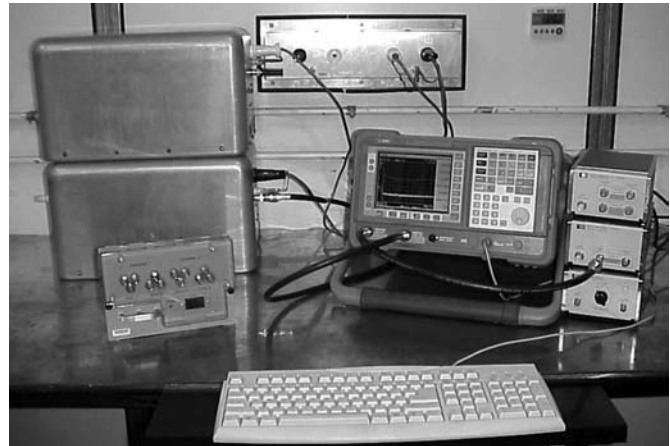
Curtis testing facilities consist of a laboratory equipped to test and evaluate EMI characteristics of equipment that must comply with FCC Part 15 and/or CISPR standards. With these facilities, Curtis can provide manufacturers with greater assistance in the selection of RFI/EMI filters to help them meet the necessary emission levels.

Isolated Environment Enhances Test Capabilities

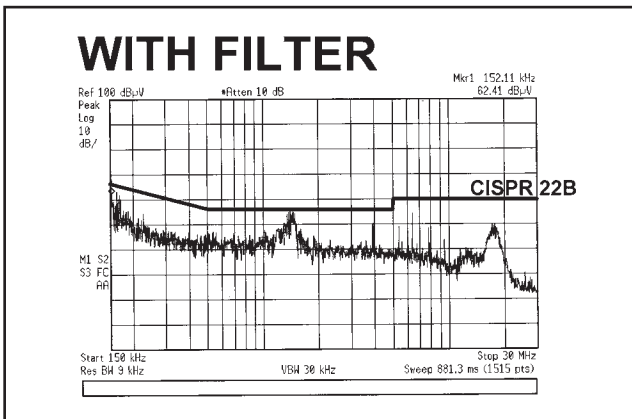
- Totally isolated environment for both equipment under test and test instrumentation provided by separate chambers.
- RF screen room shielded against magnetic, electric and plane wave field per MIL-STD-285.
- Specially constructed line impedance stabilization networks (LISN) for FC Part 15 and CISPR testing.
- Sensitive, reliable automatic measurement and recording of conducted emissions data from 10 KHz to 1 GHz.
- Computer-controlled Agilent E7402A Spectrum Analyzer with associated amplifiers and attenuators.
- Agilent E7402A graphics capabilities allow quick generation of hard copies of emissions test results.



The Curtis screen room provides complete RFI isolation for equipment under test and the test instrumentation.



Computer-controlled test equipment assures fast turnaround on RFI emissions testing.



Fast Pre-Compliance Test Results

Computer-generated graphics and test reports provide the customer with fast turnaround on all testing.

On-site RFI filter design/applications engineers are available to assist in evaluating test results and to determine cost-effective solutions to conducted emissions problems before going to agencies.

Please contact your local Curtis representative or the factory sales staff to coordinate pre-compliance testing of your equipment at Curtis Industries.



Curtis can provide environmental testing to demonstrate performance and survival in harsh conditions.



Custom Filter Capabilities *We Build Confidence!*

Curtis has the capability to modify any of our standard filters or to work with you from design to delivery on a completely custom filter to meet your exact mechanical and electrical requirements. The Curtis Filter Engineering Team, drawing from our extensive knowledge and experience, is fully equipped and qualified to consult with you on your RFI and EMI emission control problems. Curtis has the ability to test your equipment in our technologically advanced screen room to help you select the proper filter for your application.



Information We Need From You

Specifications:

* Rated Voltage: _____ * Line Frequency: _____

* Rated Current: _____ * Max. Temperature: _____

Current Overload: _____ Humidity Range: _____

Max. Leakage Current (Each Line to Ground) _____

Dimensions: _____

Terminal Type: Input (Line): _____

Output (Load): _____

Mounting Torque (Panel-Mount Models Only): _____

Test Specifications:

Hipot Test: Line to Ground: _____ VAC for One min.

Line to Line: _____ VDC for One min.

Insulation Resistance: _____

* Minimum Insertion Loss (50Ω Circuit):

	Frequency (MHz)						
	.01	.15	.5	1	5	10	30
CM							
DM							

Organization Approvals: UL _____ CSA _____ TUV _____ Other _____

Company Name: _____ Contact: _____

E-mail Address: _____ Phone Number: _____

** Required*

Curtis Contact Information

E-mail: sales@curtisind.com

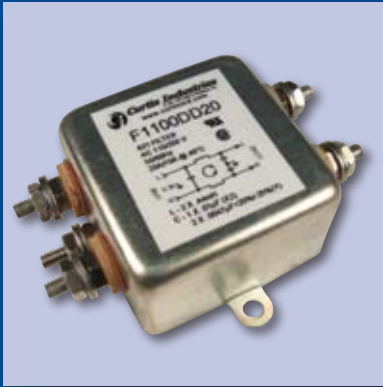
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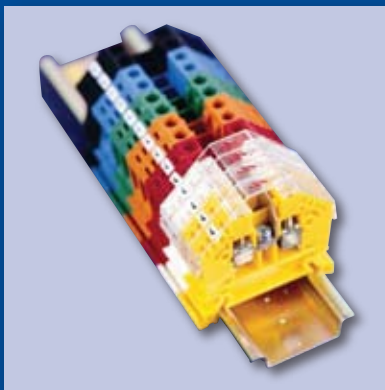
RFI Filters



Filtered Power Entry



Custom Filters



DIN Rail

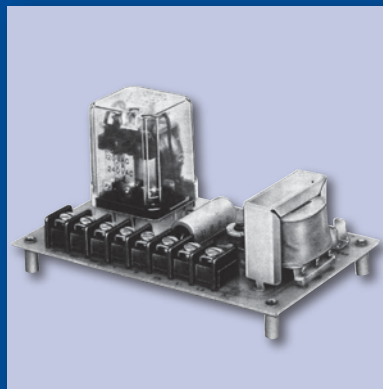
Curtis Family of Products



Terminal Blocks



PCB Mount Blocks



Liquid Level
Controllers



Custom Terminal Blocks



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