EMC Filters

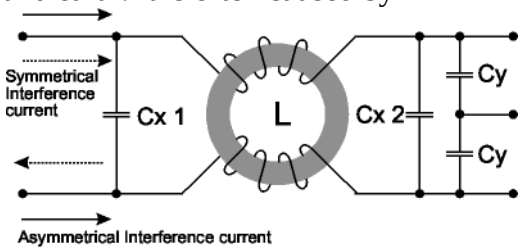
Filters work by providing an impedance mismatch between the power line and the equipment, which reflects the generated noise back to its source. In order to maximize the impedance mismatch the choice of filter circuit should take into account the impedances of the source and load.

The main components inside the filter are chokes, capacitors and resistors.

The capacitors oppose the AC flow of electrons more at lower frequencies and less at higher frequencies. Inductors on the other hand react against the rate of change of current; they are more effective at opposing AC flow of electrons at higher frequencies. Therefore, a combination of series connected inductors and shunt connected capacitors is chosen to provide suppression over a wide frequency spectrum. The resistors serve to discharge the capacitors when the supply is disconnected and for damping resonances. The enclosure is normally produced from metal to provide good earth bonding.

Above right a typical REO filter built into metal enclosure (lid removed). The main components; capacitors and inductors can be clearly seen.

The filter circuit is designed to contend with two types of noise. There is ***COMMON MODE NOISE***, which manifests itself as a current in phase in the live and neutral conductors and returns via the safety earth. This produces a noise voltage between live/neutral and earth. It is often caused by capacitive coupling to the case earth. The other is ***DIFFERENTIAL MODE NOISE*** produced by current flowing along either the live or neutral conductor and returning by the other. This produces a noise voltage between the live and neutral conductors.



The chokes fall into two groups; current compensated or common mode and series or differential mode types. The current compensated choke has two or three windings on a toroidal core. The direction of each winding is chosen to give an opposing current flow, hence balancing the flux. The result is that a much smaller choke can be used. Furthermore, the common mode currents, which are in phase in the two or three conductors, have an additive effect, thus presenting higher impedance against the common mode noise.

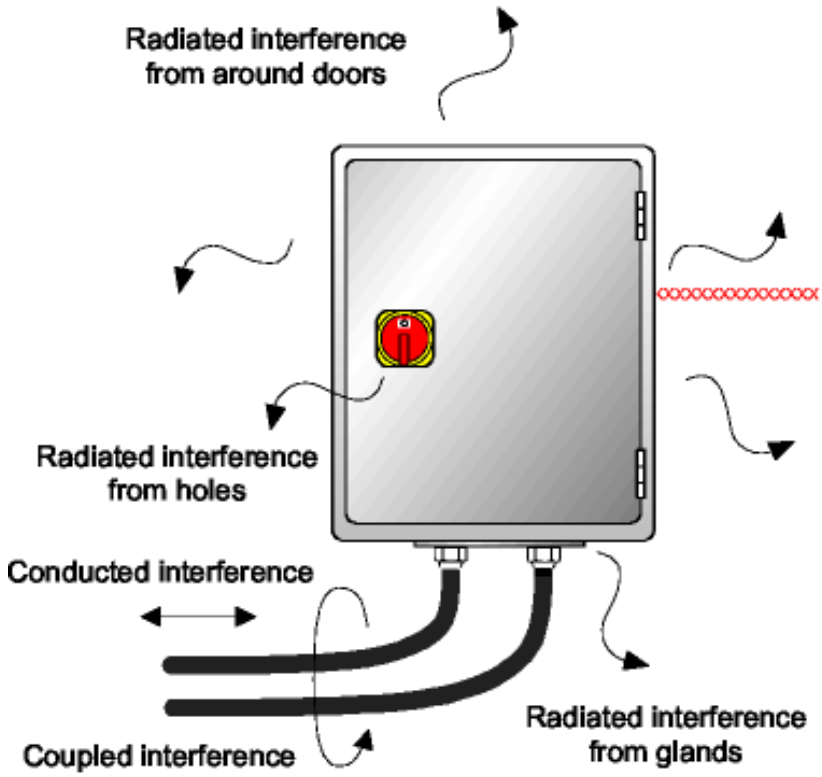
The differential mode chokes are larger due to the higher current handling requirement. Using a core made from a highly permeable material will reduce its size.

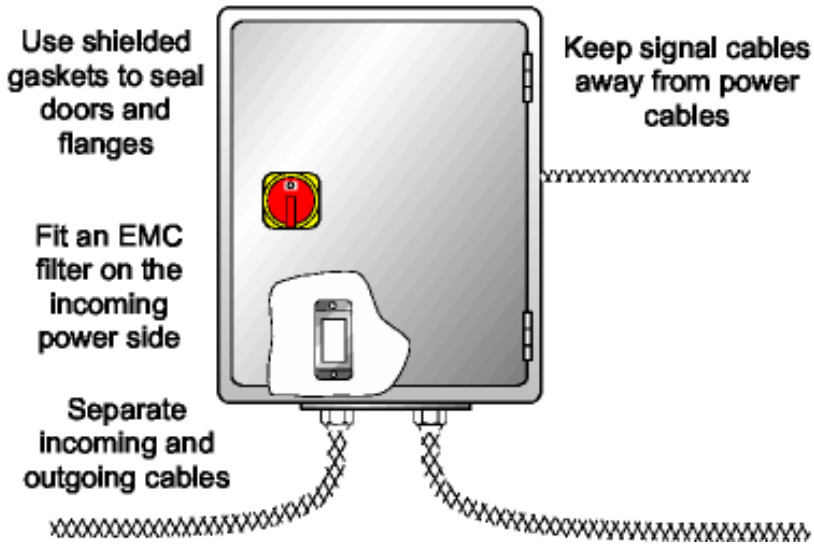
Capacitors also fall into two groups; X Class and Y Class. The X Class capacitors are connected between live and neutral, or between phases, to reduce differential noise. They are tested to withstand mains voltage. Y Class capacitors on the other hand are more critical because they are connected between live/neutral and earth to reduce common mode noise. Because of this they have to be tested to ensure that they cannot fail to short circuit. Needless to say they are more expensive.

For higher levels of attenuation, several stages of chokes and capacitors can be added and this is known as a multi-stage filter.

REO-USA, Inc. 3250 North Post Road, Suite 132 Indianapolis, IN 46226
Phone (317) 899-1395 Fax (317) 899-1396
www.reo-usa.com info@reo-usa.com

Another important factor is the earth leakage current. The larger the Y Class capacitor the more the 50 Hz current that will leak to earth, raising the potential of the filter enclosure. The maximum permissible leakage current depends on the application but to give an indication; the maximum protective earthing conductor current for handheld equipment it is 0.25 mA. Equipment that is permanently connected to the mains supply may have a leakage current of up to 3.5mA. Industrial equipment normally has higher leakage current limits (up to 5%) but in each case particular care must be taken to ensure that local earthing regulations are observed.





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