

NOTES ON EMC STANDARDS, ASPECTS AND SOLUTIONS

1.0 Present EMC Standards

There are standards that need to be complied for Electro Magnetic Compatibility – e.g. EU 336/89.

Figure 1 shows maximum limit of conducted Electro Magnetic Interference (EMI) set by the FCC and VDE for equipment used in industrial, commercial and residential equipment (not medical). The EMI noise frequency ranges from 10Khz to 30Mhz.

To compare against these limits, the *conducted noise* is measured by means of a specified impedance network called LISN (Line Impedance Stabilisation Network). Standard for radiated EMI are also specified by various agencies.

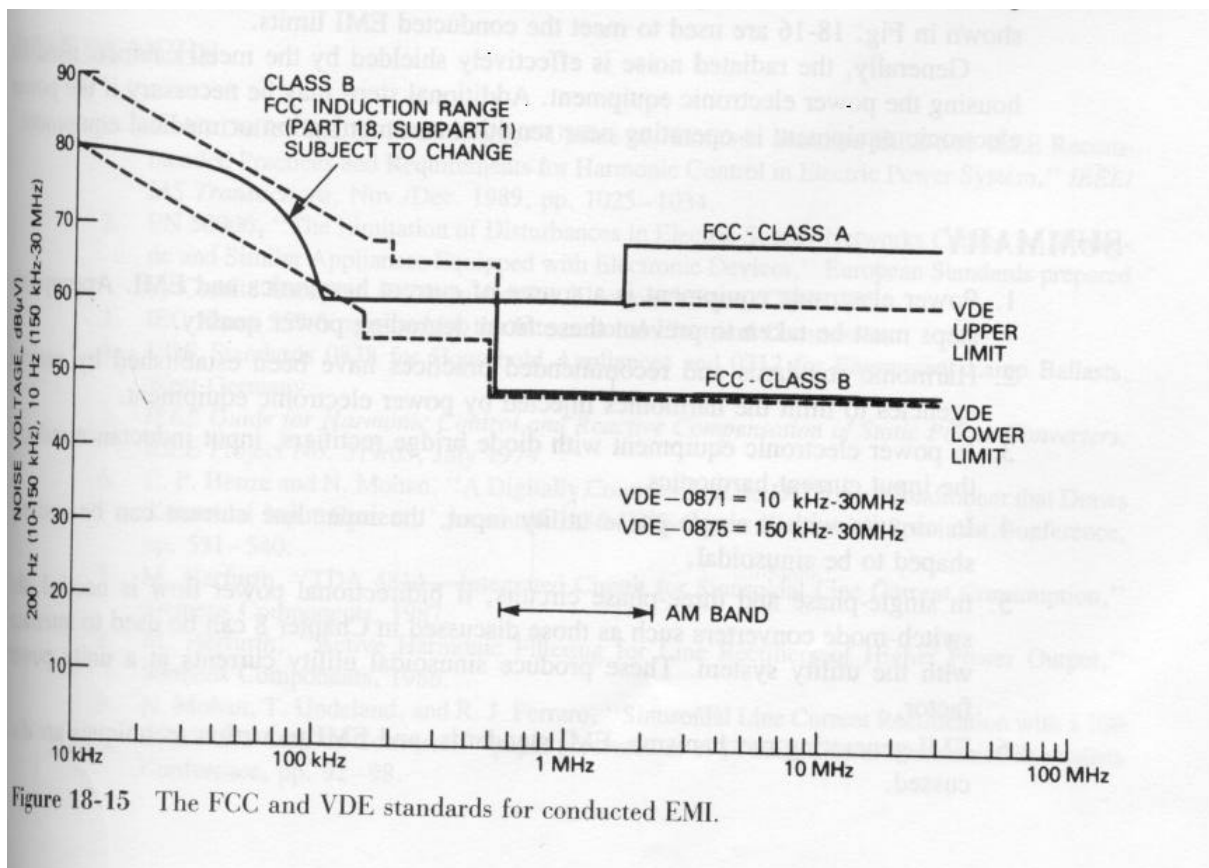


Figure 18-15 The FCC and VDE standards for conducted EMI.

Figure 1

2.0 Origins of high frequency EMI

Common sources of EMI in power electronics systems are:

- Rectifying diodes,
- Switching components (IGBTs)
- High frequency transformers and chokes.
- Circuit layouts (high dv/dt long wires, high dv/dt wide loops, high current wires)
- Mechanical switches bouncing

2.0 Radiated and Conducted EMI/RFI

There are two forms of EMI/RFI propagation of interest as shown in Figure 2:

- Electromagnetic radiated E and H waves.
- Conducted Interference on supply lines and interconnecting wires.

Radiated interference is normally minimised, as a result of layout and wiring practices required to reduce leakage inductance. Typically the high frequency current loops will be short and twisted pairs will be used where possible. Transformers and chokes will be screened to reduce radiated magnetic fields. Screen box or enclosure will often be used.

Furthermore the techniques applied to minimised conducted interference will also reduce radiated noise.

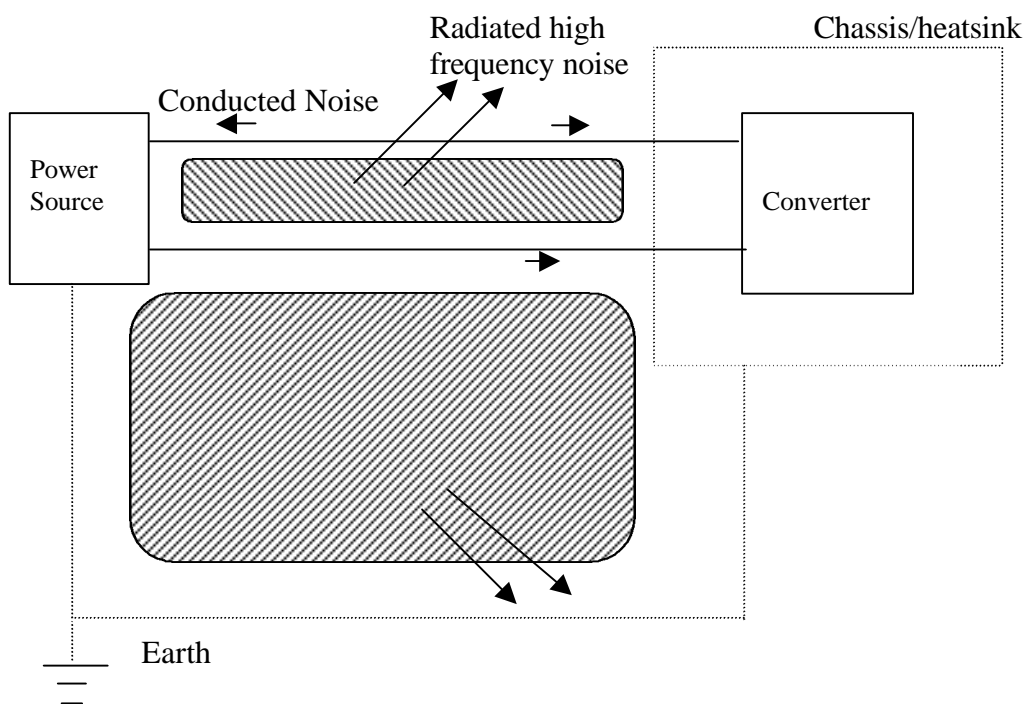


Figure 2

In general, the followings are observed:

- EMI are propagated both as conducted and radiated
- Noise currents flow through connecting wires
- Loops and wires act like antennas producing radiated EMI
- Loops and wires also receive EMI
- Therefore, EMI are radiated as well as picked-up by loops and wires.

4.0 Powerline Conducted-mode Interference

Two major aspects of conducted interference will be considered:

4.1 Differential-mode interference (series mode)

Component of RF noise which exists between any two supply or output lines. In SMPS, this would be live to neutral, line to line at the input. At the output, noise exists between the positive and the negative lines.

4.2 Common Mode interference

Component of RF noise which exists on any or all supply or output lines with respect to the common ground plane (chassis, box heatsink).

5.0 Propagation of EMI

EMI/RFI can propagate mainly by two ways:

- Capacitive coupling
- Inductive coupling

5.1 Capacitive Coupling

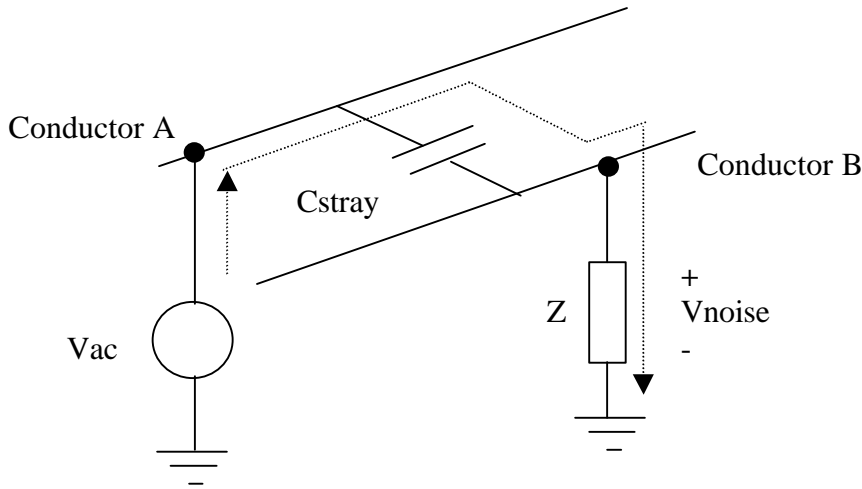


Figure 3

- Capacitive coupling between conductors causes parasitic currents
- Noise voltage increase with frequency. Higher frequency means more high frequency harmonics flow through the capacitor.
- Two wires with 2mm diameter and spaced by 1cm shows about 0.1pF/cm of parasitic capacitance.

5.2 Inductive Coupling

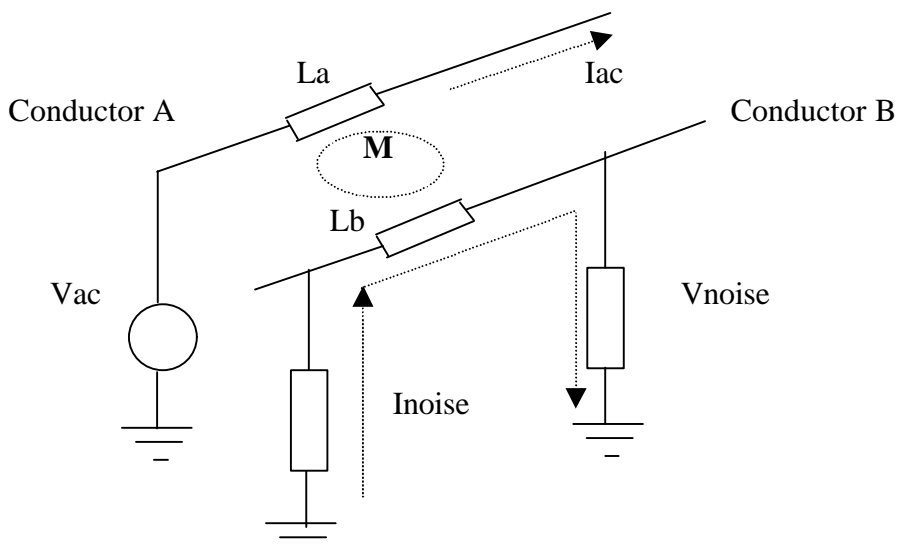


Figure 4

- Magnetic coupling between conductors causes parasitic induced voltages
- Noise current increases with frequency.
- Two wires with 2mm diameter and spaced by 1cm, shows about 10nH/cm of parasitic inductance.

6.0 Corrective Methods

- Improved Circuit layouts – ground planes
- Shielding of noisy components and wires
- Position of magnetic components
- EMI Filters

7.0 EMI Filters

7.1 *Differential Mode Filters*

Example: single-phase system.

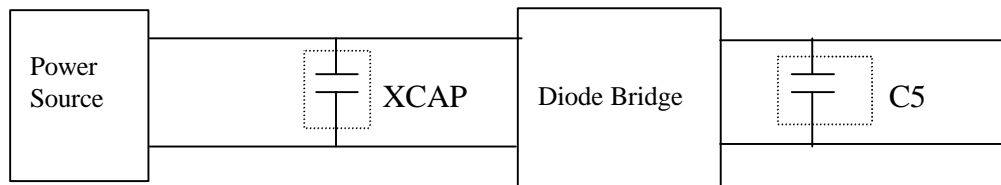


Figure 5

7.1.1 *X-CAP*

Main harmonic filter is normally known as X-CAP. It should be rated for the switching frequency and its harmonics, i.e. it will absorb all harmonics multiple of switching frequencies.

Say switching frequency is 20KHz, then for 10-ohm reactance, we need X-CAP to be 0.8uF.

7.1.2 *Additional X-CAPs (C5).*

C5 is a smaller X-cap. It should be placed after the diode rectifier but before the main capacitor filter.

XCAP should be the special class X suppression capacitor type (see Farnell Section 8 under topic Filter and Suppression pp. 508-510). X-Caps are mostly metalised polyester and paper type.

7.2 Common Mode filters

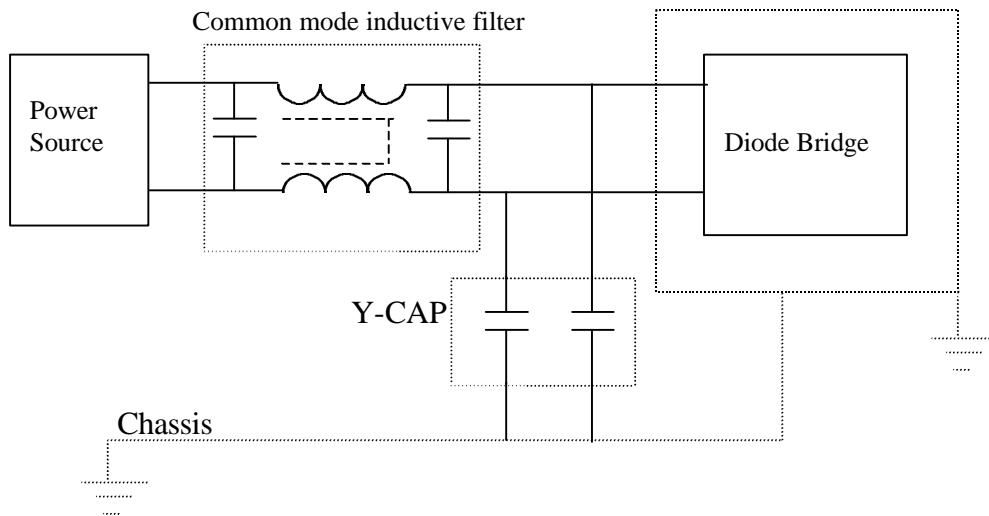


Figure 6

7.2.1 Y-CAP

Y-CAPs are used to bypass the high frequency noise from flowing to the earth. Its value is restricted by different **safety regulations**, e.g.

Country	Specifications	Ground Leakage Current limit	Maximum value of X-CAP
USA	UL 478 (Industrial, domestics)	5mA; 120V/60Hz	0.11uF
USA	UL 1283 (more sensitive equipment)	0.5-3.5mA; 120V/60Hz	0.011-0.077uF
UK	BS 2135	0.25-5mA; 250V/50Hz	0.0032-0.064uF

To minimise inductor and filter size, the largest decoupling Y-CAP capacitor permitted by the regulations should be used.

7.2.2 Common mode inductors

This is special type of inductor. It must attenuate common mode noise signal. Therefore it must have high inductance for common mode. However it need to carry large 50Hz current. In that sense, high inductance in not at all desirable for 50Hz.

This conflicting requirements are fulfilled by using phased inductor; i.e. two windings on L1 are phased such that they provide maximum inductance for common mode currents but cancelling the inductance (making it minimum) of the series mode (or the 60Hz) current.

To provide the maximum inductance on the smallest core, a high-permeability core material must be used. This is in contrary to the conventional 50Hz choke designs, whereby low permeability core or air-gap is used. This is to prevent saturation.

The phasing effectively prevents the core from saturating for the normal 50Hz differential line current, as these flow in apposite phase, each winding, eliminating the 50Hz induction.

The performance of L1 for common mode is quite different. Common mode noise appears on both supply lines at the same time with respect to the ground plane. The large shunt YCAP helps to ensure that the noise amplitude will be the same on both lines where they connect to the inductor. The two windings are now in phase for this condition, and both windings behave as one, providing a large common-mode inductance. Using high permeability ferrite toroid, the effective inductance for the common-mode inductors can be quite high, typically several milihenrys.

Note:

EMI filters are readily available as a complete part (refer to Farnell Catalogue Section 8, pp 492). They are, however, very expensive.

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