TECH TIP 2: INTRODUCTION TO INTERFERENCE SUPPRESSION Almag

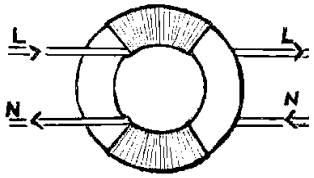
SUMMARY

Filtering to meet emc requirements is now an essential requirement for many types of power electronic equipment.
Two types of noise signal, common-mode and series-mode, are normally present, which require radically different types of suppression chokes to provide efficient filtering.
The suppression of emc, within the range 0.15MHz to 30MHZ, should not be confused with the reduction of supply harmonics, which requires filtering within the range 0.1kHz to 5kHz.

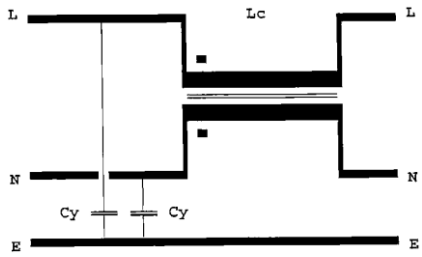
COMMON-MODE NOISE SUPPRESSION

Common-mode noise results from interference currents flowing from line to earth or neutral to earth. A major source of these currents is leakage capacitance from the switching element to an earthed heatsink.
The particular nature of this interference, occuring from L-E and N-E but not from L-N, allows the use of two phase-cancelling "bucking" windings. These are arranged so that the main phase currents are cancelled in the choke, and therefore give no line frequency magnetisation of the magnetic core.

This allows the use of high permeability ferrite cores or flat-loop amorphous cores, which can then give very large values of common-mode inductance, 0.5mH to 30mH^{+} according to current rating, in a small size.



These large values of inductance are required to maintain the LxC product required for filtering, where the values of "Y" capacitor that can be connected from L-E and N-E are severely restricted by earth leakage current requirements.



Chokes : 1-ph Almag WB series

Chokes : 3-ph Almag WT series

Winding : Phase cancelling,
0.5mH-30mH per phase

Cy : 2.2nF-22nF, limited by earth leakage

Although the magnitude of the harmonics of the switching voltage waveform will decrease as the interference frequency increases, the capacitive impedance also reduces with frequency, allowing interference currents to be generated at frequencies well into the MHz band.
This requires the use of a suppression choke which will also maintain its inductance/impedance to high frequencies, achieved by using selected grades of ferrite core material with single-layer windings where possible to minimise the choke self-capacitance.

A two-stage filter can be used to provide higher suppression in the more demanding types of application, using two common-mode chokes of differing resonant frequencies.

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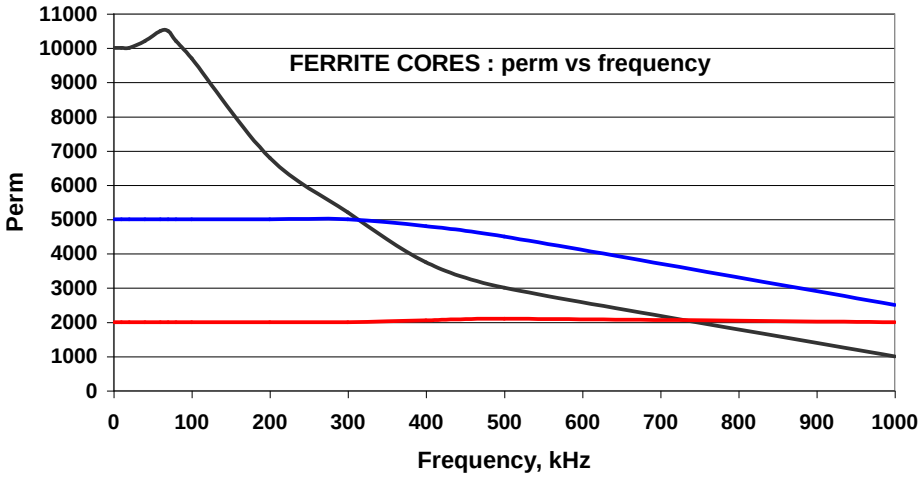
COMMON-MODE NOISE SUPPRESSION (contd.)

Very high permeability grades of ferrite core can be used to give a high inductance per turn, providing increased suppression in some applications, but the following limitations should be considered:-

1) The inductance of these high permeability cores starts to decrease at frequencies of typically 0.1-0.5MHz, with a reduced suppression effectiveness in the MHz band. The choke can still give extra suppression in the critical 0.15Mz-0.3MHz band.



2a) A saturation effect occurs in common-mode chokes caused by imperfect cancellation of the phase currents, and by common-mode capacitor earth leakage currents. This effect is more pronounced on higher permeability materials.

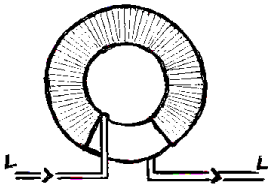
2b) This effect must be particularly taken into account where the phase currents are very "peaky", for instance because of electrolytic storage capacitor charging currents.

2c) The effect is also more apparent at higher temperatures, around 80-100°C, due to a combination of a progressive reduction in ferrite core saturation flux density and an increase in core permeability.

SERIES-MODE (DIFFERENTIAL) SUPPRESSION

Series-mode noise is generated by interference currents flowing from line to neutral. A particular example is the fast current rise in phase-angle control circuits, where harmonics of the repetition frequency extend well into the 0.15MHz to 30MHz conducted emc band. Series-mode noise is also usually present on the input to SMPSUs (switched mode power supplies), but can be at a level some 10dB to 20dB below the common-mode noise level.

As series-mode noise appears on line and neutral simultaneously, the phase-cancelling technique cannot be used, and the magnetic core used must be able to maintain inductance in the presence of the full phase current.



This is a very severe requirement in equipment with very high peak currents, such as the capacitor charging currents on an SMPSU input. Soft saturation, distributed-gap cores are normally used, using iron powder, Hi-Flux powder or the latest Super-MSS sendust material.

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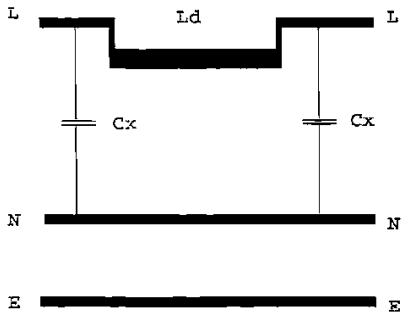
SERIES-MODE (DIFFERENTIAL) SUPPRESSION (contd.)

For further details of these powder core materials and the Almag choke ranges, please ask for a copy of our TECH TIP 1.

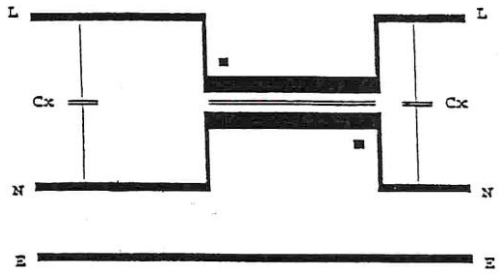
As the harmonics of the switching waveform generally fall away as the interference frequency increases, it is often possible to accept an amount of choke self-capacitance and use a multi-layer winding to achieve the required inductance from the relatively low permeability of the powder cores.
Inductance values of 0.1mH to 3mH are normally adequate, as the values of "X" capacitor that can be used from L-N can be quite high at 0.01uF to 1uF, depending on the constraints in the particular equipment.



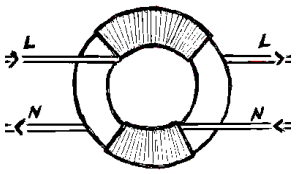
Chokes : Almag type WD, WE, WH, WP, WK or WKF

Winding : single, 0.05mH-3mH
Core : Low permeability powder
Iron powder 33u-85u
Hi-Flux 26u-160u
Super-MSS 60u-125u
Cx : 0.022uF-1uF. May need bleed resistor

It is often an advantage to split the "X" capacitor to form a pi-network around the series-mode choke, as this can give increased suppression for a given total value of capacitance.
Increased suppression may be achieved by using a series-mode choke in both line and neutral.



A phase-adding choke on a single core can also be used.
It is important to maintain isolation between the windings, which can be be achieved by winding on opposite halves of a toroidal powder core.



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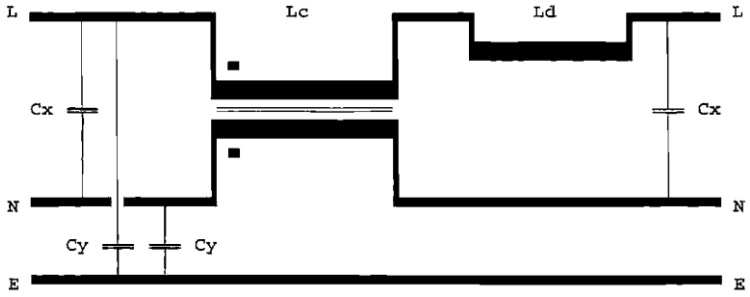
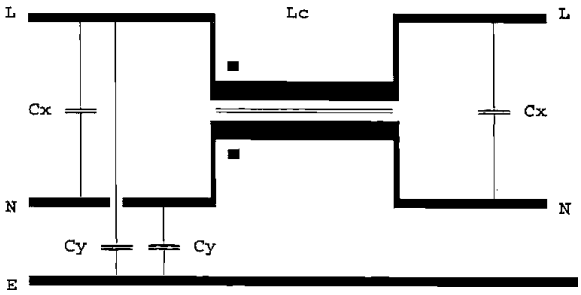
COMBINED FILTER CIRCUIT : COMMON-MODE & SERIES-MODE

In many applications, for instance the input to an SMPSU, both common-mode and series-mode noise need to be suppressed by a combination of the two types of filter circuit.



COMBINED FILTER CIRCUIT : COMMON-MODE & LIMITED SERIES-MODE

Where the series-mode noise is about 20dB lower than the common-mode noise, as in some SMPSUs, it is possible to use the leakage inductance of the common-mode choke to provide a reduced level of series-mode suppression.
It is then normal practice to split the "X" capacitor to form a pi-network around the suppression choke to give increased suppression for a given total capacitance value.



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