ON POWER FEEDLINE FILTERS

The first *ITEM* article on a realistic and scientifically sound approach to the often misunderstood topic of power line filters appeared in 1977, as "Progress in EMC Filters". It was based on the following:

(a) a broad statistical data base of interface impedances encountered in the real world of U.S. 60 Hz systems and on

(b) appropriate worst-case calculations made transparent with matrix theory.

The significant finding of this combination of empiry and theory was the peculiar phenomenon that filter behavior is most critical in the transition band (between passband and stopband) where ringing and/or insertion gain can cause severe system malfunction.

The 1979 *ITEM* reprinted this article as appendix to a paper "Worst Case Filter Measurements". It said that CISPR is working on two alternate methods as standards for worst case filter measurements, either based on:

(a) a British paper (assuming the source impedance to be zero), measuring the Thevenin and transfer impedances, or on

(b) a US position paper (see Schlicke's paper discussed above), employing 0./100 Ohm (& reverse) interfaces for the frequncy range of 1 to 100 kHz.

Above 100 to 200 kHz, the otherwise highly uncritical 50/50 Ohm interface per Mil-Std-220A is acceptable provided and only if the transition band measurement is satisfactory (negligible insertion gain and sufficient insertion loss at 150 kHz). If this important additional condition is disregarded or not met, reliance on Mil-Std-220A alone gives a false sense of safety concerning filter and systems performance. And any "assurance" and/or protestation to the contrary tries to negate the legitimate concern of the filter user who must see the filter as an integral part of the system into which it is placed.

At the time of writing this article, the standard under discussion is not finalized because, in the opinion of the author, too many agencies are involved. Thus, in the interim, there is still the urgent need to get a handle on the seemingly so perplexing problematique of powerline filtering operating into indeterminate and/or switching interface impedances. This became most obvious in the discussion that followed Schlicke's overview talk "What is needed for Progress in EMC?", an invited paper given at the "Major Workshop for Decision Makers in Industry and Government on Causes, Effects and Regulations of Electromagnetic Pollution", NBS, Gaithersburg Md., Nov. 1978. While users of filters complained that they never knew for sure whether a filter would work or would not ring, some filter manufacturers maintained that they meet existing standards they consider to be adequate. It seems that outdated concepts die slower the longer they have been alive. But in the long run, facts catch up with unjustifiable opinion. One cannot predict the behavior of a system under critical conditions from behavior observed under extremely uncritical conditions (50/50 Ohms). In this context it is rather encouraging that some filter manufacturers are already introducing losses at (nota-bene) low frequencies (2 to 200 kHz).

The following briefly recapitulates the author's opinion for essential criteria for assuredly good performance of filters operating into indeterminate and/or switching interface impedances:

(a) Multi-section filters have always good stopband performance provided resonances in the filter elements themselves are absent or dampened by lossy structures (HF losses).

(b) Low-frequency losses must be introduced in the transition band to suppress ringing and/or insertion gain, both being very detrimental to satisfactory system performance. Most power feedline filters have their transition band in the 2 to 200 kHz range where losses can be realized by eddy-currents or hysteresis in the magnetic cores or by adding resistors.

(c) Even though standards for worst case measurements are not yet issued, the filter user is not left 'hanging in the air'. A simple ringing test, sketched in the 1979 issue of *ITEM* is practically sufficient to avoid disappointment by filter malfunction, provided point (a) is also met.

(d) Naturally, if the operating conditions are such that the interface impedances are constant and known, one can optimize the filter for these particular conditions. But how often do such ideal conditions occur in a large system?

For more information, see Ch. VIII of Schlicke's book ELECTROMAGNETIC COMPOSSIBILITY.

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