DISCUSSION DOCUMENT

Radio-frequency Emission Standards; Should emissions from data transmission services be restricted to lower limits than are unintentional emissions?

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1) Summary

This paper puts forward the argument that lower limits should be applied to *exported* emissions - a term applied here to emissions associated with intended signals that are deliberately created for the purpose of carrying intelligence. This is because such emissions are different in kind to the *unintentional* emissions that have hitherto been the focus of EMC standards and so different statistical considerations apply.

2) The statistics behind EMC standards

2.1) Introduction

Emission standards such as CISPR22 - the standard now applied to Information Technology Equipment - have evolved over more than 60 years (BS800 Ed. 1 was published in 1937) and at every stage the intention has been to protect radio services. Many generations of engineers have worked on these standards and the working documents are mostly lost, but in the early 1980s the writer attended discussions of the European Computer Manufacturers EMC committee about a draft that eventually became the harmonised emission standard for Information Technology. At that time the Scandinavian Countries wanted tighter emission limits in the 100-200MHz band because they operated VHF TV broadcasting at a lower limit of field strength than did the rest of Europe, and tended to live in flats that would put Computers in closer proximity to TV aerials than the 10 metres "protection distance" - that is , the assumed separation of culprit and victim - that is also enshrined in the "Domestic and Light Industrial" EMC Standards. The equivalent distance is 30 metres for heavy industry.

2.2) Interference and UHF TV

As an example of the protection principle (but without specific reference to the lower-frequency xDSL & PLT since emissions below 30 MHz are measured differently) consider UHF analogue TV. The minimum field strength in the service area is approximately 65dBµV/m. [Ref. A]. Since a tolerable signal/interference ratio is about 45dB [Ref. Private communication from M J Culling, BBC Engineering], interference arriving at a chimney-mounted TV aerial should not be more than 65-45 = 20dBµV/m.

The domestic limits in the UHF TV band specified in the Generic Standard [Ref. B] and in the Information Technology Standard [Ref. C] are 37dBµV/m at 10 metres distance. This is 17 dB more than the TV user can tolerate.

Simplistically one should expect interference, but

- No allowance has been made for the benefit of aerial directivity.
- Not all viewers are near the edge of the service area.
- Some interferers are less visible than others by virtue of lack of synchronism.
- Not all electronic products emit on the TV channels that happen to be in local use.
- The culprit and victim may never be in use at the same time.

and on the other hand

- Not all TVs are used with outdoor aerials and well-shielded cables
- Not all electronic products are as much as 10 metres from the TV aerial

In summary there is a strong theoretical possibility of interference but this is greatly reduced by a number of widely-varying environmental circumstances. This calculation suggests that the Standard for radiated emission has evolved to provide a sensible set of limits that balance product cost against risk of interference in the environmental conditions of the time.

2.3) HF (0.15 to 30MHz) interference

In this frequency range where xDSL and PLT are of potential concern the world's commercial EMC standards all measure the interference voltages launched onto cables rather than radiated field since most electronic products are not physically large enough to radiate except via their cables. The culprit/victim analysis such as given above for radiated emission would be very difficult but the outcome would be similar and the environmental circumstances are similarly important.

3) The statistical differences between exported and unintentional emission

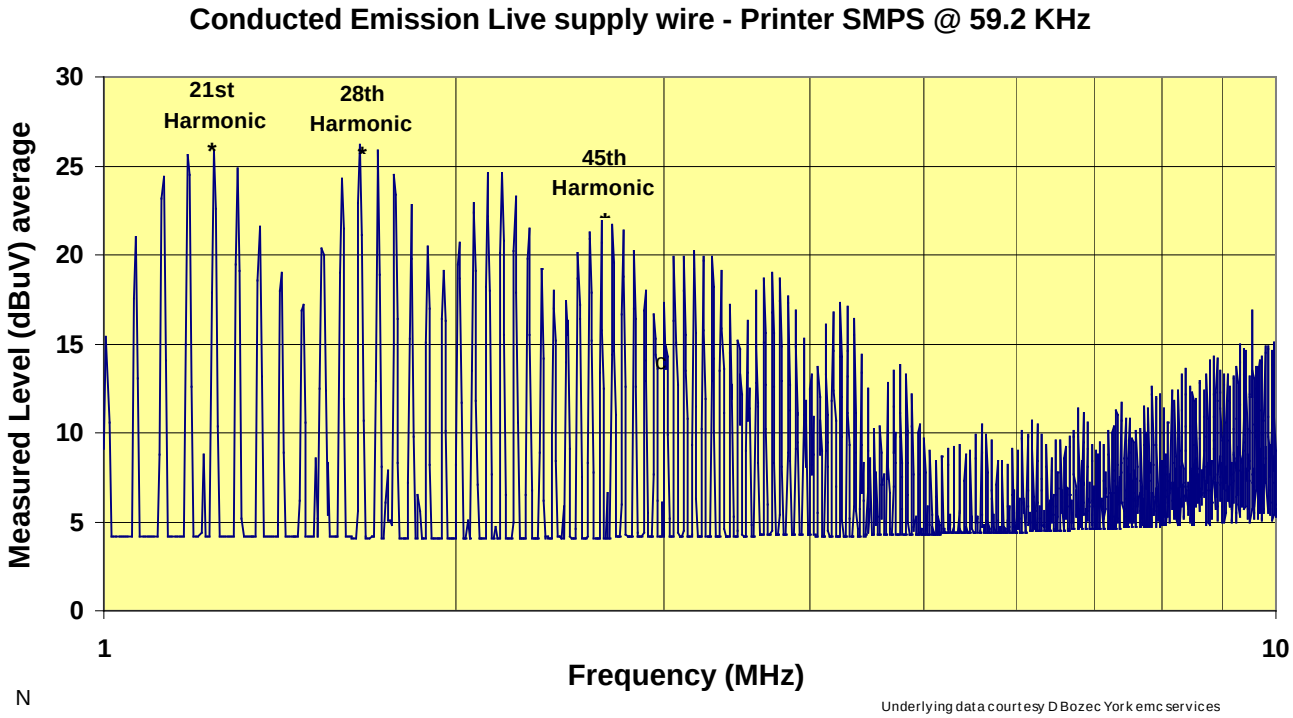
Data signals such as xDSL and PLT are deliberately exported from the equipment concerned and are different in kind to unintentional emissions for the reasons given below.

3.1) Power/frequency profile

The unintentional emission from a product is most unlikely to follow the limit line at all frequencies. It will have emissions at the frequencies used internally, together with their harmonics, coloured by resonance in its electronic or mechanical structure. The chart below [Ref. D] shows the harmonic emission into the supply cable of a typical switched-mode power supply across the central decade of the frequency range that is of interest for PLT. This particular product comfortably conforms to the domestic limits - but it is the relative levels that are of interest here. In this respect the SMPS chosen for the above analysis is typical: It is certainly neither the best or worst example of an electronic product, but it does embody the essential spectral distribution of most modern electronic products.

It will be seen that the peaks of emission are the distinct harmonics of the fundamental oscillation frequency of 59.2KHz. The 21st and 28th Harmonics are the strongest and at all other frequencies emission is lower. Analysis of this chart shows that the power in the 21st harmonic is 7.73µW and that in the 28th harmonic 8.28µW. By summing the voltages recorded in each 10KHz slice of this 9MHz spectrum the total power may be calculated as 233µW that is;

(Total power summed over 9MHz) / (Dominant line power) = 28.14 = 14.5dB



The design objective of an intentional data transmission system will be to achieve the maximum secure data rate. The multi-carrier transmission system that is naturally chosen for PLT and xDSL since it is so effective on ill-characterised physical channels allows the designer to optimise performance by filling the available spectral bandwidth with channels whose amplitudes are only just below the maximum voltage allowed. This will correspond to ***a constant voltage close to the limit in the Standard across the whole of the available frequency range.*** If this approach were applied with the same voltage as that of the principal lines in the figure above, then

(Total power summed over 9MHz) / (Power in single dominant 9KHz line) = 1000 = 30dB

Therefore, for the same worst-line power, the emitted ***exported*** interference power would be 15.5dB worse than the ***unintentional*** emission power of this SMPS.

The exported wide-band power is important for two reasons. It is an accurate measurement of the total emission into the environment – sometimes referred to as “electronic smog”- from the Equipment, and it is more representative of the effect of interference on the new broad-band radio services than is the interference voltage measured in a narrow bandwidth.

3.2) Bandwidth penalty

It may be concluded that **the *exported* emission voltage limits for broad-band emitters should be 15dB below the *unintentional* limit presently in the generic and IT standards.**

3.3) Time profile

As listed in 2.2) above, the present day incidence of interference complaints is reduced by the fact that the culprit and victim may never be in use at the same time.

However xDSL and PLT are always-on in the sense that carriers with idling modulation are present [for AxDSL Ref; Personal communication from M Wright of BT. For PLT Ref;. Report of R Page-Jones www.qsl.net/rsgb_emc/CRIEFFat %20Notes%20Version_1.html]

As an illustration the general public does not complain when a hair-dryer interferes with TV: It is evident that such a culprit is not going to be in use for very long.

CISPR14 [Ref E)] allows much higher emission limits for "discontinuous emissions" which are defined as those lasting less than 200mSeconds – whose disturbing effects will typically last about 1 second either in the case of an analogue radio listener or a digital TV viewer. The relaxation of limits is given as 20*LOG(30/N) dB for 0.2<=N<=30, where N is the click rate in clicks per minute. If the disturbance is observed for one-sixth of the time then N=10 and the allowed relaxation is 9.5dB.

Items in a domestic environment are almost never used for more than four hours out of 24, so an "always on" service such as PLT or xDSL occupies the spectrum for six times longer, and so should be subject to a corresponding 9.5dB lower limit emission.

In round figures a 10dB emission limit reduction should be applied to emissions lasting more than 4 hours a day.

3.4) Proximity profile

In 2.1) it was pointed out that EMC standards are based in part on the concept of a "protection distance" that is 10 metres for domestic and light industrial environments. This distance is generally regarded as the distance to other premises where any culprit would be outside the victim's control. It is acknowledged that a victim may need to take remedial action for interference problems within their own property.

It will be unusual to achieve 10 metres separation between receiving aerials and xDSL or PLT cables. Medium-wave radios invariably use internal ferrite-rod aerials, and are likely to be within a metre of either class of wired data service. A chimney- mounted FM radio or Private Mobile Radio aerial may be unavoidably close to an overhead power or telecommunications cable.

Worst of all, PLT must use a shared cable for hundreds of premises and for economic reasons will be without stop filters at the point of entry to these premises unless the Standards absolutely require this. Customers for electricity supply will have high-frequency data and the accompanying interference delivered whether they want it or not, and this interference will unavoidably be present on cabling very close to potential victim equipment – including in the domestic environment radio receivers with built-in ferrite rod and short whip antennae.

Standards already take into account the statistics of separation distance but the allowance cannot be sufficient for this extreme situation. For PLT the "protection distance" ought to be deemed to be 1.73 metres rather than 10 metres, leading to a **15dB penalty for exported emission onto a cable that may be routed over someone else's property**.

4) Conclusion

The above arguments support a limit reduction as follows

Factor	**xDSL**	**PLT**
3.2) Bandwidth penalty	15dB	15dB
3.3) Time profile	10dB	10dB
3.4) Proximity profile	0dB	15dB
Arithmetic sum	25dB	40dB

These are typical values of Parameters having a random distribution so the rms sum may be taken as an adjustment to the limit, thus;

18.0dB	**23.4dB**

For convenience in Standardisation these numbers may be further rounded as below.

According to this proposal, conducted emission limits for always-on data access signals should be limited to less than the existing figures in EN55022 by 15dB in the case of xDSL and by 20dB in the case of PLT.

5) References

A) **"Television reception the professional way"** *BBC Engineering Information Sheet 2107(2)9506*

B) **EN 61000-6-3:2001** Emission Standard for residential, commercial, and light industrial environments.

C). **EN 55022:1998** Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement.

D) Spreadsheet data supplied by D Bozec of York Electromagnetic Services. Published in a different format at emcYork 2003.

E) **EN55014-1:2000** EMC – Requirements for household appliances, electric tools and similar apparatus Part 1; Emission. Paragraph 4.2.2.2

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