TITLE **Text proposal for modulating the Ingress noise generator**

PROJECTS ADSL + SDSL

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STATUS for decision

ABSTRACT Ingress noise is modelled for ADSL & SDSL performance tests as a set of discrete frequencies (RFI-Tones). Each tone is modulated (like in VDSL) but the specification of how it should be modulated is not clear and unambiguous enough. This proposal provides literal text that repelaces the current text.

Problem to be solved

To complete the description of what (synthetic) ingress noise shall be generated by the "Broadcast RF noise generator", details about how the RFI tones are to be *modulated* have to be solved. This modulation represents a property of real broadcast transmitters that are modulated by voice and music.

Why complicating the ingress noise generator by modulation?

The main purpose of using modulated RFI tones in a xDSL performance test is to prevent that the test with (synthetic) ingress noise can be faked. Unmodulated RFI tones can be cancelled by subtracting a similar tone that is locked in phase (and amplitude) to the incoming tone. This will work to pass succesfully a poorly designed performance test but will fail as soon as real RFI ingress noise is applied to the xDSL modem under test.
By using carriers with *random* modulation, the (synthetic) ingress noise cannot be predicted any more in advance and the test gives a much better insight into how an xDSL modem under test will behave under realistic ingress noise.

Solution

There is no need to find the most accurate statistic representation for voice and music. It is plausible that the use of modulated RFI tones has only a minor *additional* impact on the xDSL performance degradation. So if the RFI tones are modulated with noise that is more or less Gaussian distributed, the modulation noise is relatively simple to generate, while the ingress noise test becomes good enough. Even the question how realistic it is if the carrier is occasionally overmodulated (>100%) during a peak value of the modulation noise is assumed to be irrelevant. It will have hardly no additional impact on the performance degradation of the xDSL modem under test.
The only thing that is left, is a desciption of this noise in terms of modulation depth and modulation width, so that test equipment can be build in a *reproducable* way.

The text below is a full text proposal to describe the "Broadcast RF noise generator" G5. It is intended to replace the full text that is currently used for SDSL and ADSL. The text completes the proposed functional description of RFI test (TD44, Infineon, this meeting) and refers to the updated figure in that TD44. All figure and table numbers, however, refer to the ADSL draft, so the numbering has to be modified for inclusion in the SDSL standard as well.
The actual number of carriers, and the frequency and amplitude of each carrier is beyond the scope of this contribution.

LITERAL TEXT PROPOSAL (refers to ADSL, but applies to SDSL as well)

5.3.3.5 Broadcast RF noise generator [G5]

The broadcast RF noise generator represents the discrete tone-line interference caused by amplitude modulated broadcast transmissions in the SW, MW and LW bands, which ingress into the cable. These interference sources have more temporal stability than the amateur/ham interference (see sub clause 5.3.3.6) because their carrier is not suppressed. Ingress causes differential mode as well as common mode interference.
Power levels of up to –40 dBm can occur on telephone lines in the distant vicinity of broadcast AM transmitters. The noise is typically dominated by the closest 10 or so transmitters to the victim wire pair.

This ingress noise generator has two outputs, one contributing to the differential mode impairment, and the other one to common mode impairment (see figure 9, generator G5). The ingress noise signal at each output is a superposition of random modulated carriers (AM). The total voltage U(*t*) of this signal is defined as:

$$U(t) = \sum_{k} U_k \times cos(2\pi \cdot f_k \times t + \varphi_k) \times (1+\alpha_k(t))$$

The individual components of this ingress noise signal U(*t*) are defined as follows:

- The frequency f_k of each carrier is specified in table 7. Their values do not represent actual broadcast frequencies but they are chosen in such a way that they cover a range up to 1 MHz, and that the harmonic relation between the carriers is minimal.
- The amplitude U_k of each carrier is specified in table 7 as power level (dBm) into a resistive load of 135Ω. Mark that spectrum analysers will detect slightly higher levels then specified in table 7 when their resolution band width is set to10 kHz or more, since they will then detect the modulation power as well.
- The modulation noise $\alpha_k(t)$ of each modulated carrier shall be random in nature, shall be close to Gaussian distibuted, shall have a crest factor of 2,5 or more, and shall be uncorrelated with the modulation noise of each other modulated carrier in the ingress noise signal.
- The RMS modulation depth of each modulated carrier shall be 32%, to enable a modulation index of at least 80% during the peak levels of the modulation signal. This is equivalent to setting the RMS amplitude of $\alpha(t)$ at 0,32.
- The modulation width of each modulated carrier shall be at least 2×9 kHz. This is equivalent to creating $\alpha(t)$ from filtered white noise by using a low-pass filter having its cut-off frequency at 9 kHz.
- The phase offset φ of each carrier shall have a random value that is uncorrelated with the phase offset of each other carrier in the ingress noise signal.

NOTE. The question if the differential mode and common mode signals are (partly) correlated or have to be fully uncorrelated is ***for further study***. The rapid fluctuations in the frequency domain of cable balance in real cables may give rise to fully <u>un</u>correlated differential and common mode ingress noise.

<Table 7, as it is now>