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

PROJECTS SDSL + ADSL + VDSL

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STATUS for decision

ABSTRACT Ingress noise is modelled for SDSL, ADSL and VDSL performance tests as a set of discrete frequencies (RFI-Tones). Each tone is modulated (as already described for VDSL) but the specification of how it should be modulated is not clear and unambiguous enough. This proposal provides literal text that replaces the current text for SDSL, ADSL as well as VDSL. It is based on our preliminary proposal in WD02 from Monterey, but is slightly modified to line up with VDSL.
This revision improves the description of topics that are still for further study.

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 in amplitude (AM) 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, ADSL and VDSL. The text completes the proposed functional description of RFI test (TD44, Infineon, Monterey meeting, dec 2000) and refers to the updated figure in that TD44.
The actual number of carriers, their frequency and their amplitude is beyond the scope of this contribution.

<u>**LITERAL TEXT PROPOSAL**</u> (applicable to SDSL, ADSL and VDSL)

***.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 **<TBD>** dBm can occur on telephone lines in the distant vicinity of broadcast AM transmitters. The noise is typically dominated by the closest **<TBD>** or so transmitters to the victim wire pair.

The ingress noise signal for differentional mode impairment (or common mode impairment) is a superposition of random modulated carriers (AM). The total voltage $U(t)$ of this signal is defined as:

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

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

- U_k - The voltage U_k of each individual carrier is specified in table [x] as power level P (dBm) into a resistive load of R=135Ω. Mark that spectrum analysers will detect levels that are slightly higher then the values specified in table [x] when their resolution band width is set to 10 kHz or more, since they will detect the modulation power as well.
- f_k - The frequency f_k of each individual carrier is specified in table [x]. Their values do not represent actual broadcast frequencies but they are chosen in such a way that they cover a frequency range that is relevant for the xDSL modem under test, and that the harmonic relation between the carriers is minimal.
- φ_k - The phase offset φ_k of each individual carrier shall have a random value that is uncorrelated with the phase offset of each other carrier in the ingress noise signal.
- m - The modulation depth m of each individually modulated carrier shall be m=0.32, to enable a modulation index of at least 80% during the peak levels of the modulation signal $m \times \alpha_k(t)$.
- $\alpha_k(t)$ - The normalized modulation noise $\alpha_k(t)$ of each individually modulated carrier shall be random in nature, shall be Gaussian distibuted in nature, shall have an RMS value of $\alpha_{rms}=1$, 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.
  <u>NOTE</u>: The possible need for specifying a more sophisticated distribution function than the Gaussian distribution function is subject for further study.
- Δb - The modulation width Δb of each modulated carrier shall be at least 2×5 kHz. This is equivalent to creating $\alpha_k(t)$ from white noise, filtered by a low-pass filter having its cut-off frequency at $\Delta b/2$ = 5 kHz. This modulation width covers the full modulation band used by AM broadcast stations.
  <u>NOTE</u>: The precise specification of the spectral shape requirements of the modulation signal is for further study.

The ingress noise generator may have two distinct outputs, one contributing to the differential mode impairment, and the other one to common mode impairment.

*<u>NOTE</u>. The question if the differential mode and common mode signals are (partly) correlated or fully uncorrelated is **for further study**. The amount of correlation between differential and common mode signals is related to the frequency domain variations within a 10 kHz span of cable balance of real cables.*

TABLE [x] WITH POWER LEVELS IS NO PART OF THIS PROPOSAL