TITLE **Making modulation of RFI tones *deterministic* is undesirable.**

PROJECTS RFI testing

SOURCE: KPN

AUTHORS: Rob van den Brink
Bas Gerrits

CONTACT: Rob F. M. van den Brink,
TNO Telecom
P.O. Box 421
2260 AK Leidschendam
The Netherlands

tel +31 70 4462389
fax: +31 70 4463166 (or +31 70 4463477)
e-mail: R.F.M.vandenBrink@telecom.tno.nl
the above name and e-mail address has changed since 1 jan 2003!

STATUS for (stopping) discussion

ABSTRACT Current xDSL standards require RFI tones to be random modulated with noise in a baseband up to 5 kHz. This to give the tones a spectral width, comparable with AM modulated radio stations. A sequence of recent contributions from Alcatel has asked to replace this by a deterministic modulation with five discrete tones, for the sake of simplicity. This contribution is to illustrate that such a change would be undesirable, be a significant step backward, without valid reasons, and opens the door to odd behavior during testing.

1. Why this contribution

The current standards require that RFI tones are to be modulated up to 5 kHz, to give these tones a spectral width comparable with AM modulated radio stations. This modulation prevents that RFI tests become no challenge at all for DMT modems under test, when their frequency happen to fell just in-between two DMT tones. The width of the modulation band ensures that whatever the frequency of the RFI tone will be, a band of 2×5 kHz will always be equally disturbed. Real environments, suffering from RF interference, do also suffer from a modulation *band* and not only from a single frequency.

The current standards have chosen that RFI tones are to be random modulated over the full band of interest. This makes it impossible for any current or future detection mechanism to lock-in into the frequency components of such an artificial RFI disturber. Such a lock-in could cause that modems are more or less immune for RFI tones in the test but loose performance in a real RFI disturbed environment.
One can argue about the precise shape, width and depth of this random modulation. This may improve the RFI test, as long as the full 2×5 kHz modulation band is "*filled*" with some spectrum, the RFI test remains a challenge for equipment under test.

It should be avoided that RFI tones are to be deterministic modulated, as proposed several times by Alcatel [1]. This will weaken the quality of the test, while the reasons given for that change are invalid.

2. Comparing random and deterministic modulation

The current xDSL standards specify the modulation of RFI tones in the time domain, while the discussions in the Alcatel's contributions [1] were given mainly in the frequency domain. Such a comparison is very difficult to follow, and that's why this discussion remained confusing so far.

In this contribution we compare both methods in the same domains, to highlight the differences.

Figure 1 shows how the RFI tones would look like at a spectrum analyzer, when tone frequencies and tone levels are chosen according to this example. Each tone has a "peak" in the middle, being the carrier frequency, and a noise band around it, being the modulation.
Figure 2 shows an exploded view of one such an RFI tone. This is the bandwidth that will be "filled" when the carrier is modulated with band-limited noise, that is white up to 5 kHz.

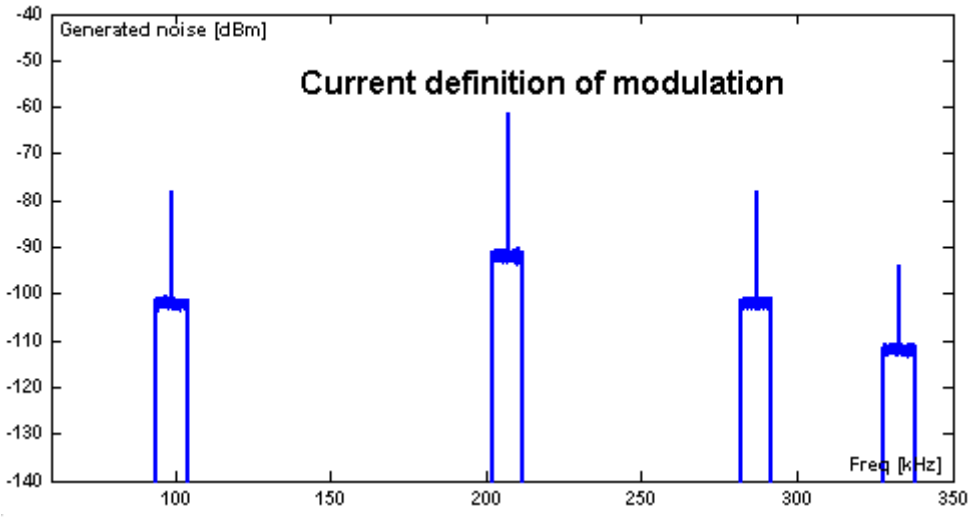

Fig 1

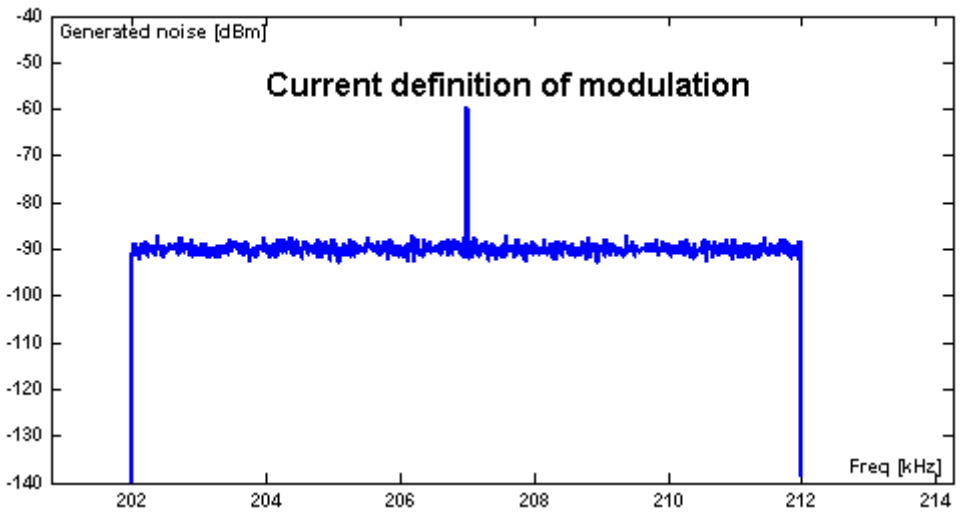

Fig 2

Suppose this RFI tone is to be generated with low-cost equipment, such as an Arbitrary Waveform Generator (AWG), having a simple memory that is no longer then 10.000 samples. By implementing the (time domain) formula for modulated RFI tones, specified in the various xDSL standards, the AWG will produce the required RFI tones. In short, it works as follows:

- evaluate (in software) the formula for a range of time samples in exactly the same way as the modulated RFI tones are specified in the standard
- this evaluation yields an array of numbers (in software)
- download that array of numbers into the memory of the AWG
- play back that memory periodically, and the required RFI tones occur as pseudo random noise.

Since ingress noise that is generated in this way will be pseudo random in nature (the memory is played back periodically), the cycle of this play back will cause that a spectrum analyzer will not show a white modulation band. Figure 4 shows what happens If noise is to be generated up to 1MHz, and the memory is only 10.000 samples long. The noise is constructed from equidistant frequency components, at 200 Hz spacing. So the modulation band is "filled" with about 50 frequency components. This is not perfect but probably sufficiently adequate

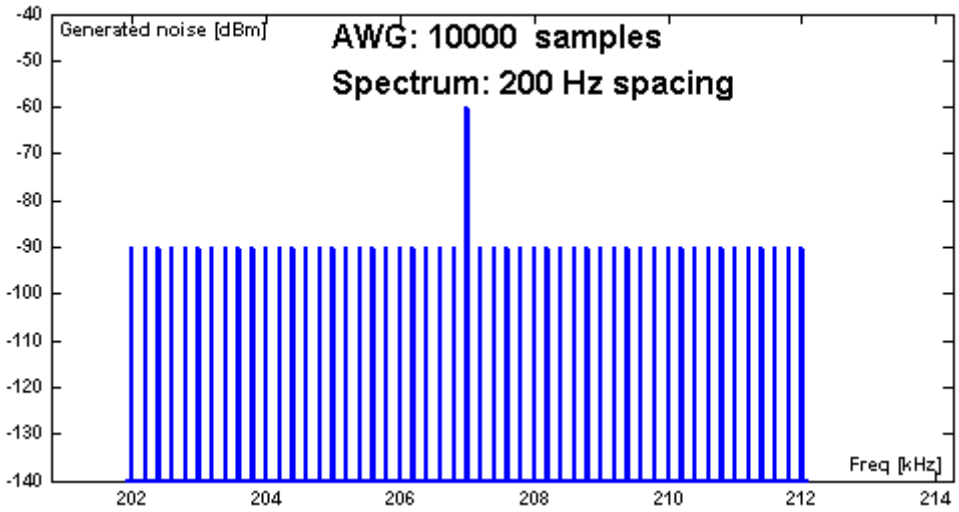

Fig 3

Figure 4 shows the same with a moderate AWG, with a memory of 100.000 samples. In this case you can hardly distinct between the individual frequency components. It is pretty close to "white"noise. With about 500 frequency components in a modulation band. So adequate ingress noise can be generated with even a moderate AWG. (today, a longer memory is no issue at all).

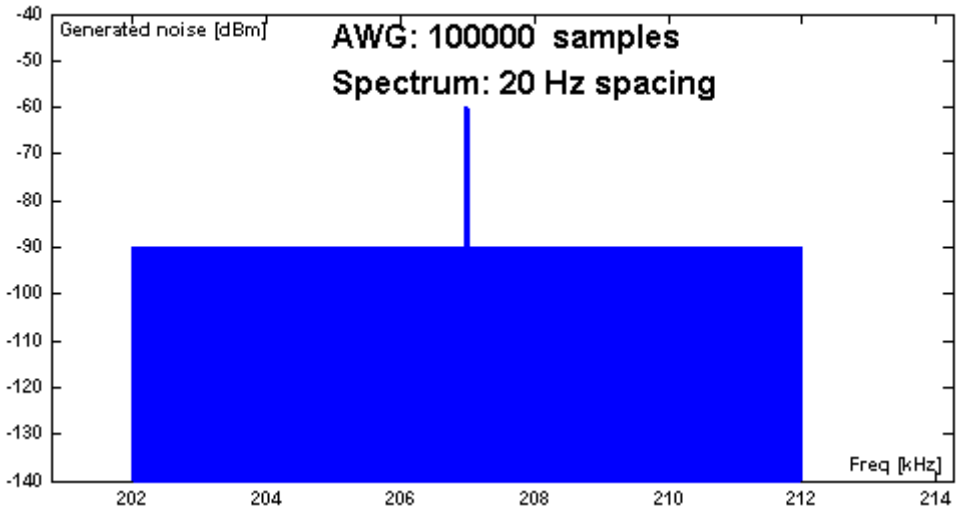

Fig 4

Figure 5 shows what the consequence is of using deterministic modulation, as being proposed by Alcatel in several contributions. These proposals are demanding for modulating the carriers with a few discrete tones (so no more than five tones).
The consequence is that only a very few frequency components are "scattered" around over the modulation band and this can cause ill-behaving test results.

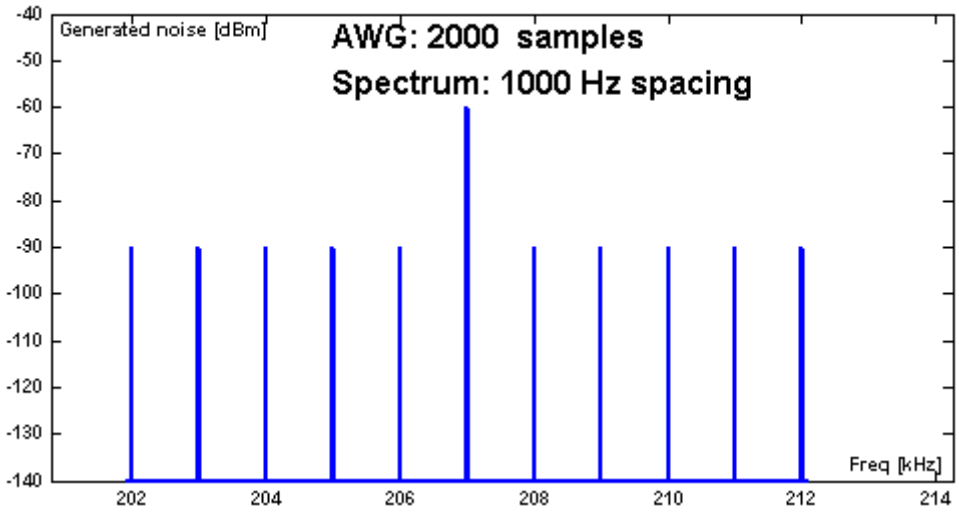

Fig 5

3. Conclusions

We demonstrated the difference between random modulated RFI tones (according to the current standards) and deterministic modulated RFI tones (proposed by Alcatel). The first one fills the modulation band with many frequency components, and the second one with only a very few. Changing the ingress noise in this way will be a significant step backward, and this is not acceptable for us.

We are open for improvement of the current specification, such as improving the spectral shape and time domain characteristics of the modulation noise (such as crest factor, slow time variations or whatsoever), but this should never cause that the modulation band will not be filled anymore with many frequency components.

If further improvement of the modulation will only result in an increase of complexity of the test equipment, but without a noticeable impact on the modems under test, we prefer to keep the specification as it is now. We believe that this is the best compromise between simple and adequate for the job.

4. References

[1] ETSI TM6 contribution 024T24, Alcatel, Darmstadt, nov 2002