RFI MEMO #012

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To: RFI Group

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Subject: Extending the dynamic range of a spectrum analyzer

The dynamic range of a spectrum analyzer is limited by intermodulation distortion. These intermodulation products, which are generated in the mixer, can be reduced by lowering the input level to the mixer. For every dB reduction in the input the IP2 products drop by 2 dB and the IP3 products drop by 3 dB. There is no prefilter in front of the mixer the dynamic range is usually limited to the IP2 products the 1 dB drop in input signal level improves the dynamic range by 1 dB in an analyzer whose dynamic range is not limited by the noise floor. The noise floor can be effectively reduced by switching the input between the signals whose spectrum we want to measure and an ambient load and then calculating the difference spectrum. The noise floor reduction with load switching is given by

$$-10\log_{10} 2(\eta BT) = 5\log_{10}(\eta BT) - 3dB$$

Where B is the resolution bandwidth in Hz T is the integration time, and η is the spectral efficiency. A spectrum analyzer which uses a single scanning filter has a value of η approximately equal to the resolution bandwidth divided by the frequency span. For example consider a spectrum analyzer which scans a 1 MHz filter over a 1 GHz span in 100 seconds. In this case ηis 0.1% and the noise floor is reduced by 22 dB. If this analyzer is initially set-up with the IP2 intermodulation products at the noise floor to achieve a dynamic range of 60 dB then the input attenuator could be increased by 11 dB to drop the IP2 signals by 22 dB to equal the new noise floor from the load switching. In this case the dynamic range is increased from 60 dB by 11 dB to 71 dB. If the analyzer is limited by IP3 products to 60 dB a 7 dB increase in input attenuation accompanied by load switching will increase the dynamic range to 82 dB. In principle an analyzer that has multiple filters using FFT processing can have a spectral efficiency approaching unity. For example if the analyzer processes the 1 GHz bandwidth with double buffered 1024 point FFTs without any loss of data the noise floor with load switching, is reduced by 37 dB for a potential gain in dynamic range of 18 and 25 dB for the IP2 and IP3 limited cases respectively.

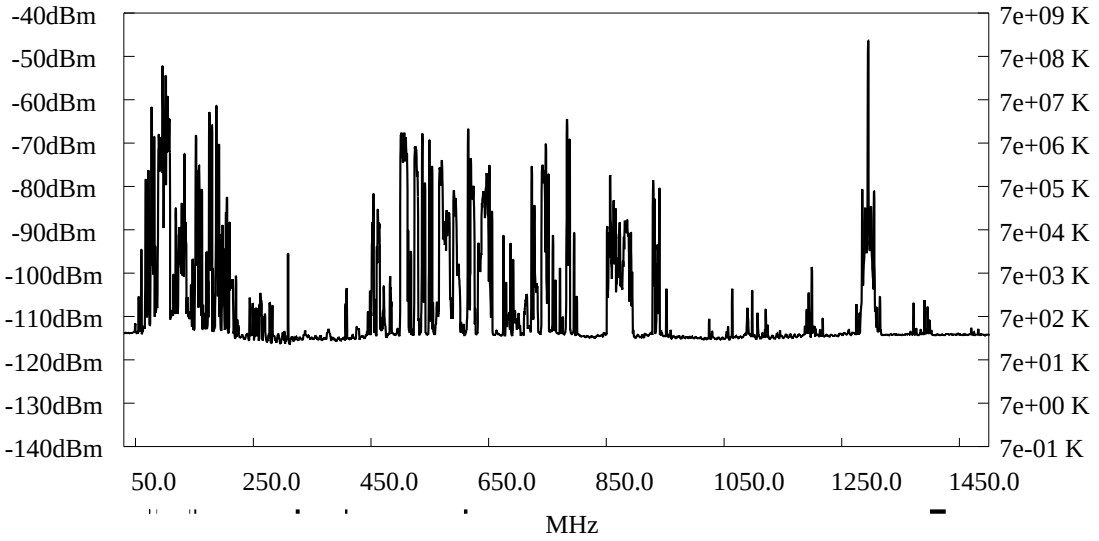

Figure 1. Spectrum with intermodulation products

Figure 1 shows the spectrum from the RFI monitor with an input attenuation of 6 dB and a 29 dB preamplifier. Notice the IP2 signals from the mixing of the Millstone 1295 MHz signal with the FM band. Figure 2 shows an expanded scale with the IM simulation.

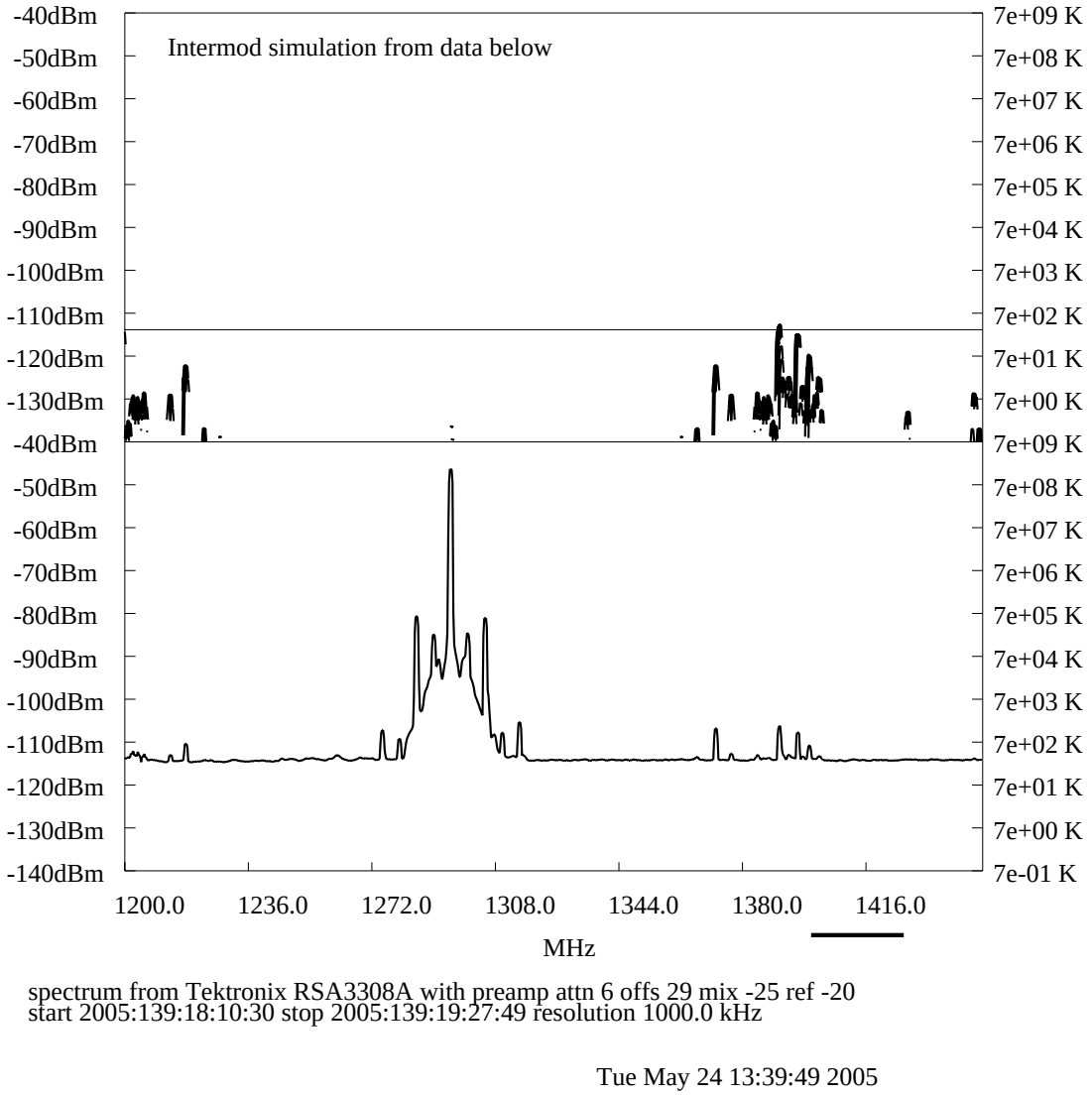

Figure 2. Expanded view of spectrum with intermodulation and simulation of intermodulation.

Figure 3 shows the improved dynamic range when the input attenuator is increased to 16 dB. [This memo is a DRAFT of something we might want to send in to a trade journal to advertise the need for spectral efficiency.]

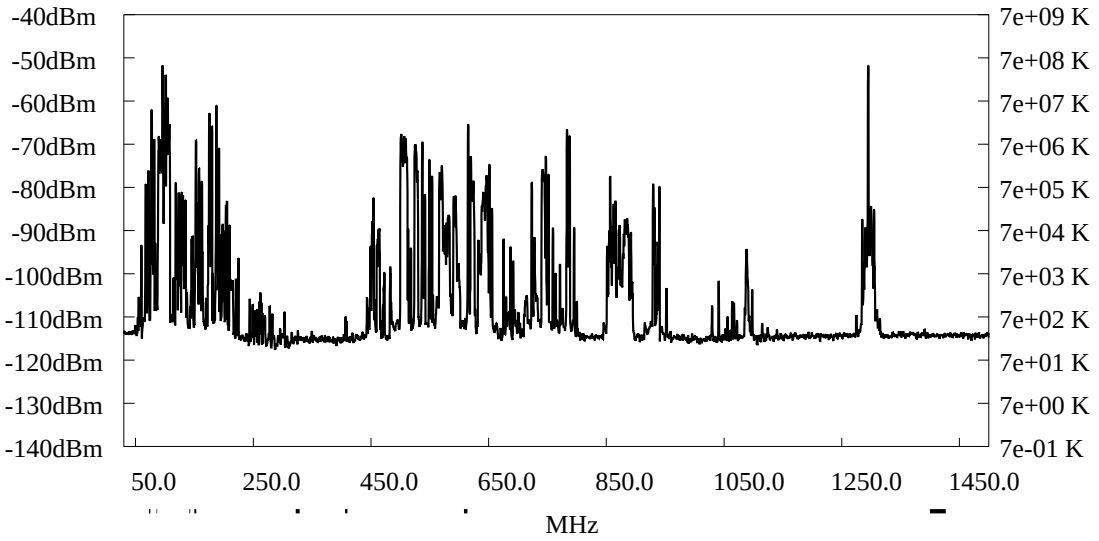

Figure 3. Spectrum with added attenuation before the mixer to improve the dynamic range.