EDGES MEMO #051

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To: EDGES Group
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Subject: Tests of AC240 spectrometer using out of band added noise

The level of systematics of the AC240 spectrometer after optimizing the sample frequency to 910 MHz are shown in Figure 5 of EDGES memo #27. For the case of switching between a 300K load and a load which simulates the sky noise the residuals after removing a 15 term polynomial are at 50 mK peak to peak in the range 110 to 200 MHz.

Tests of the same system using the standard sample of the 1 GHz plus the addition of added noise in the 10-50 MHz range show a large improvement to a level of about 10 mK peak to peak. In addition, it was found that using a sample rate of 1 GHz was needed to eliminate the effects of unbalance in the interleaved sampling.

Figure 1 shows the full spectrum of the sky simulator plus the out of band noise. Figure 2 shows the calibrated spectrum using 3-position switching before removing the polynomial. Figure 3 shows the effect of adding too much noise and Figures 4 and 5 show the effect of strong RFI.

The optimum level of the signal from the antenna compared with total power was determined by reducing the level of the signal until the noise level increases due to drift in the AC240 between switch cycles. The optimum was found to be around 8% in an environment of low RFI are the dominant systematics are due to the spurious signals in the AC240.

The dynamic range of the AC240 was also tested using the "two tone" test in which signals at 1150 and 160 MHz were injected each at 500,000K (32 dB above the 300 K noise) and the level of the intermodulation products (IP3) at 170 MHz and 140 MHz measured. In order to be sure the intermodulation was in the AC240 the output of each signal generator was filtered. The IP3 products dropped from about 10 K without added out of band noise to about 10 mK with out of band noise for a corresponding increase in dynamic range from 48 to 78 dB.

In summary, the performance of the AC240 operated as a 3-position switching spectrometer is greatly improved by the addition of out of band noise to "condition" the sampler.

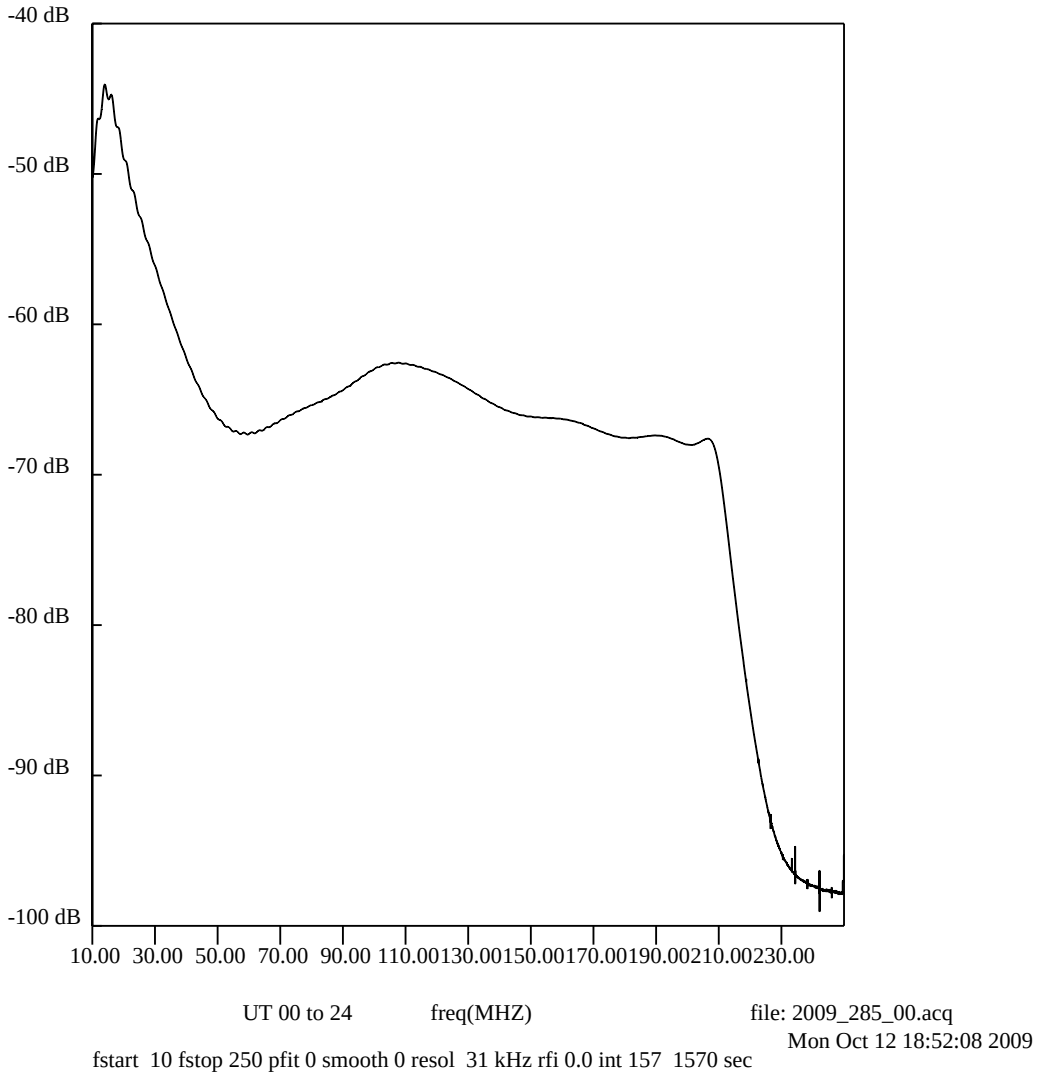


Figure 1. Spectrum of the added out of band noise peaking below 30 MHz, the simulated antenna spectrum peaking at about 110 MHz and the filter cut-off at 210 MHz.

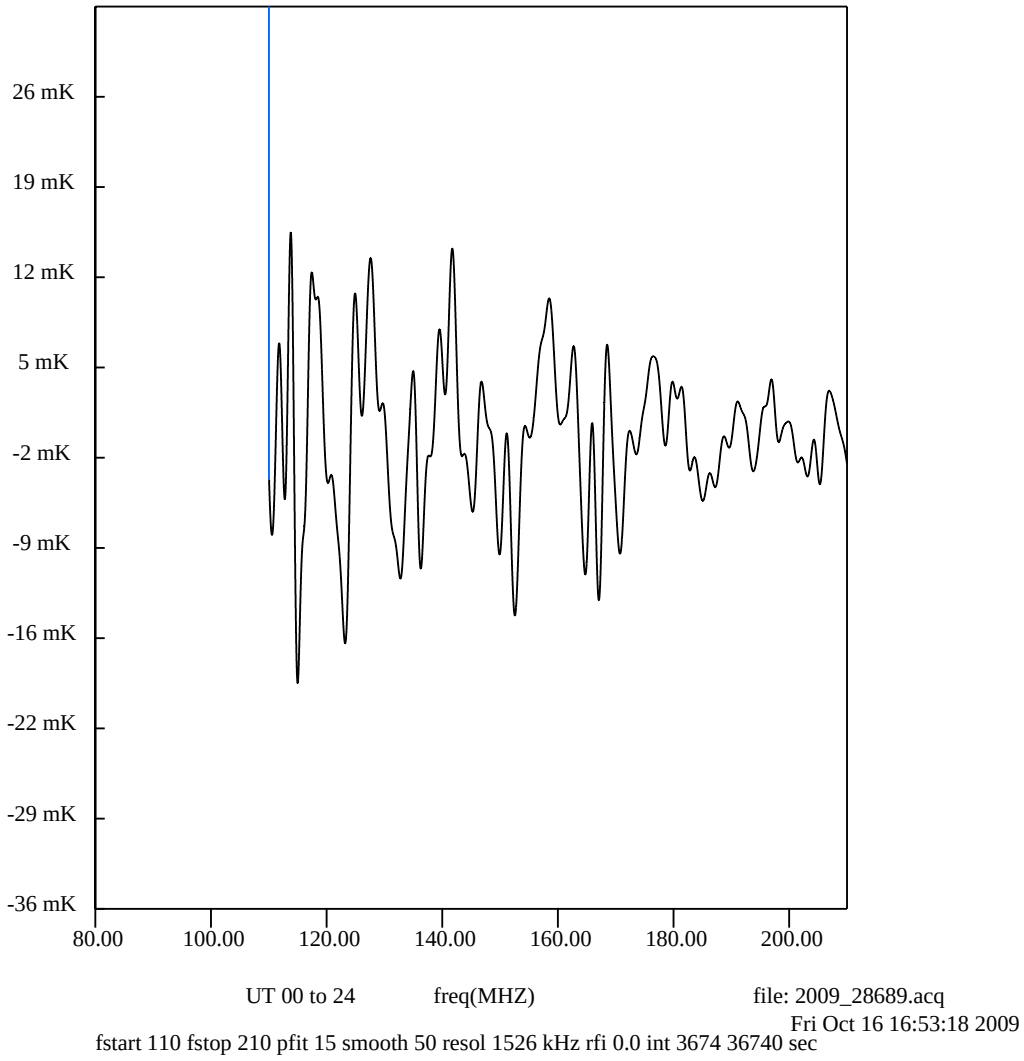


Figure 2. Spectrum of antenna ports using 3-position switching after removal of 15 term polynomial. The signal from the antenna port is 8% of the total power and the full-scale voltage setting on the AC240 was 0.5 volts. The rms is about 6 mK.

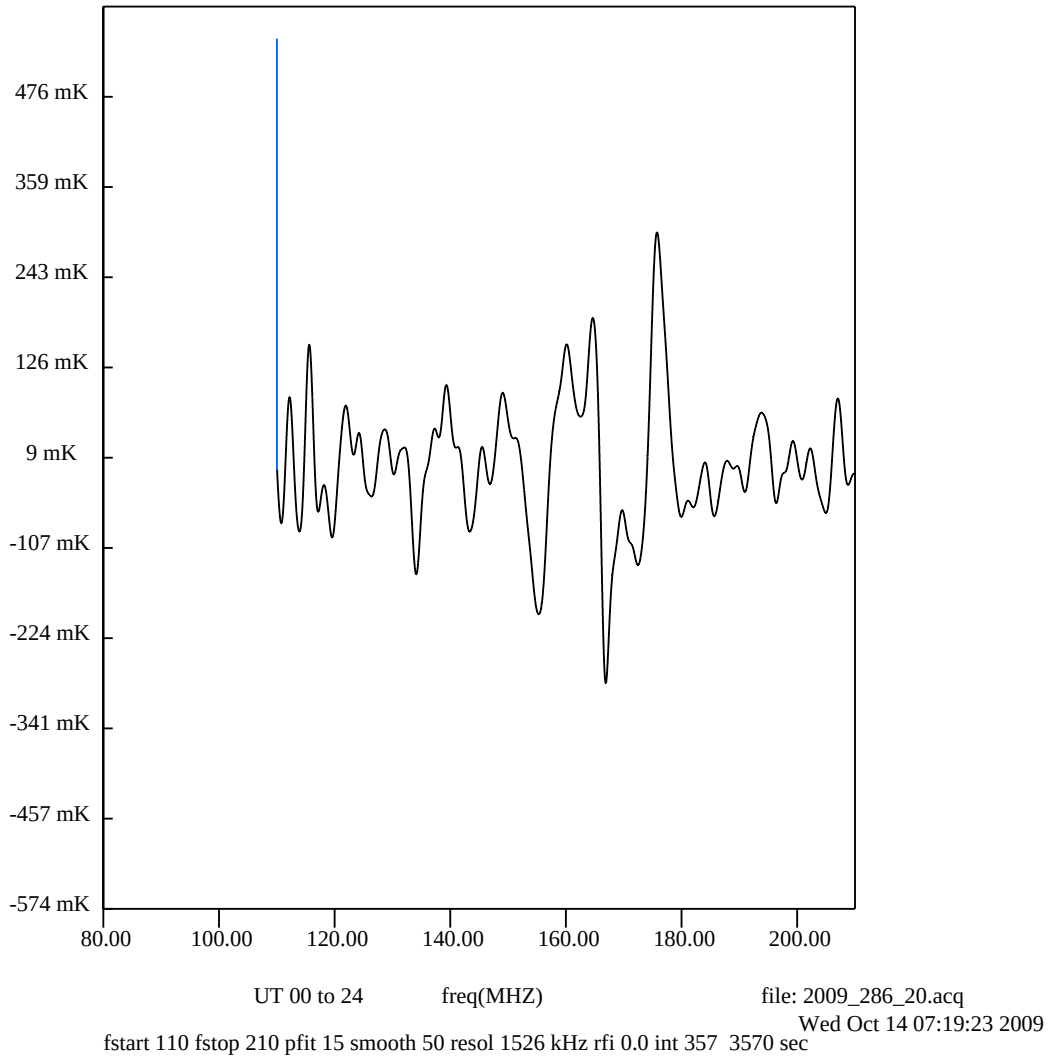


Figure 3. Same as figure 2 but with signal from antenna port reduced 20 dB so that the contribution is now only about 0.1. Although the systematics might be lower the spectrum is noisy (over 50 mK rms) because the system is not stable enough to remain constant from one switch cycle to the next. This shows that the signal should be at least a few percent of the total. That is the out of band noise should dominate but not be overwhelming.

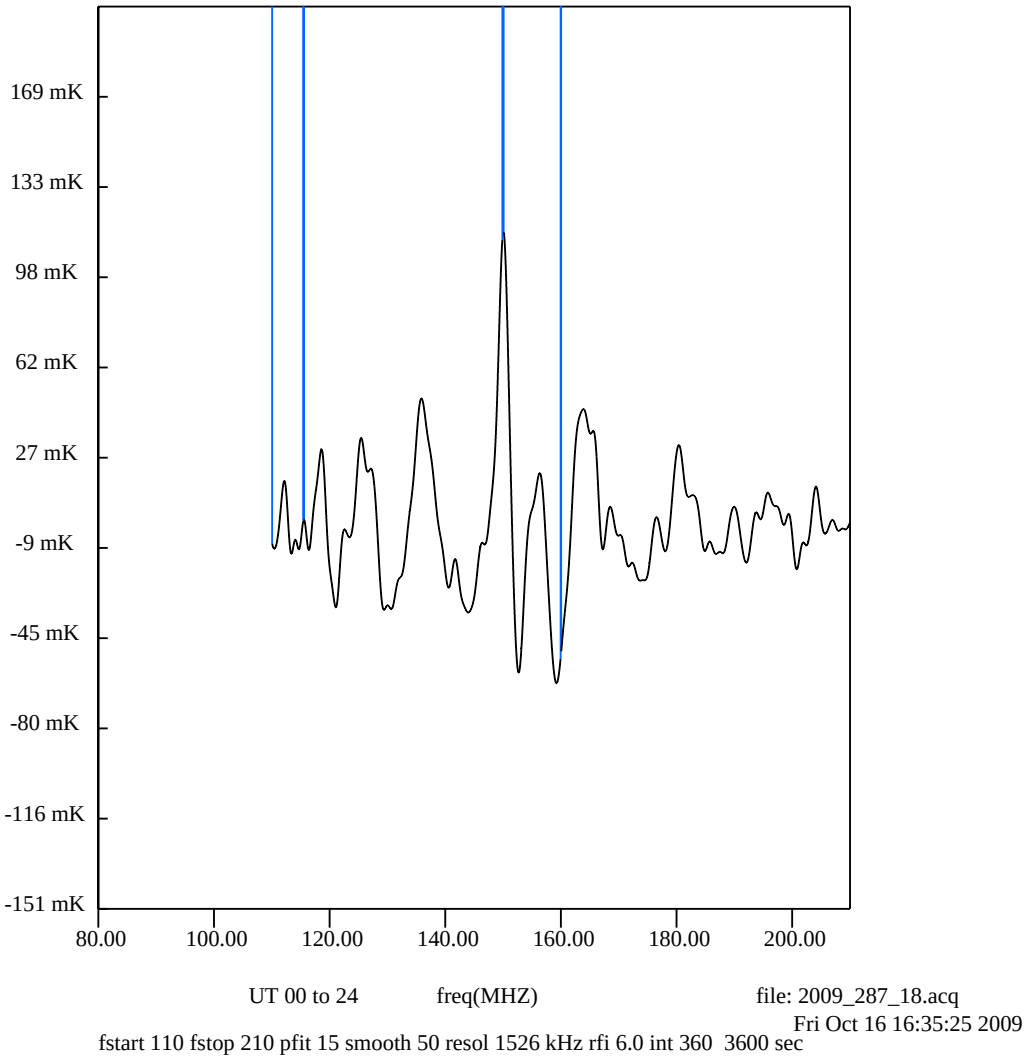


Figure 4. Spectrum with RFI is added at 150 MHz with power level 30 dB above the noise. In this case the signal contribution increased from 8 to 66%. The RFI, after removal, leaves residual of about 100 mK.

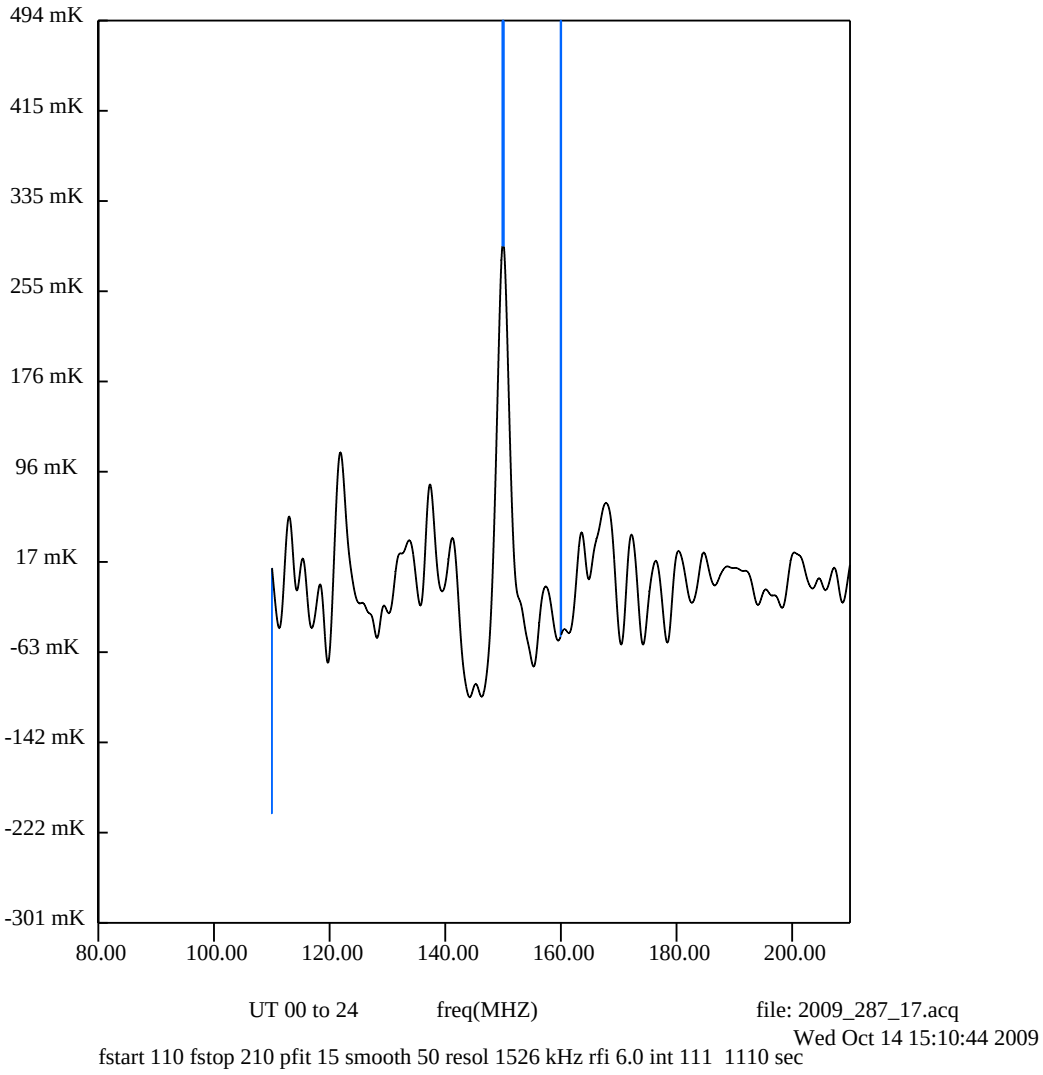


Figure 5. Same as figure 4 but without out of band noise so that the residual RFI, after removal, is over 200 mK.

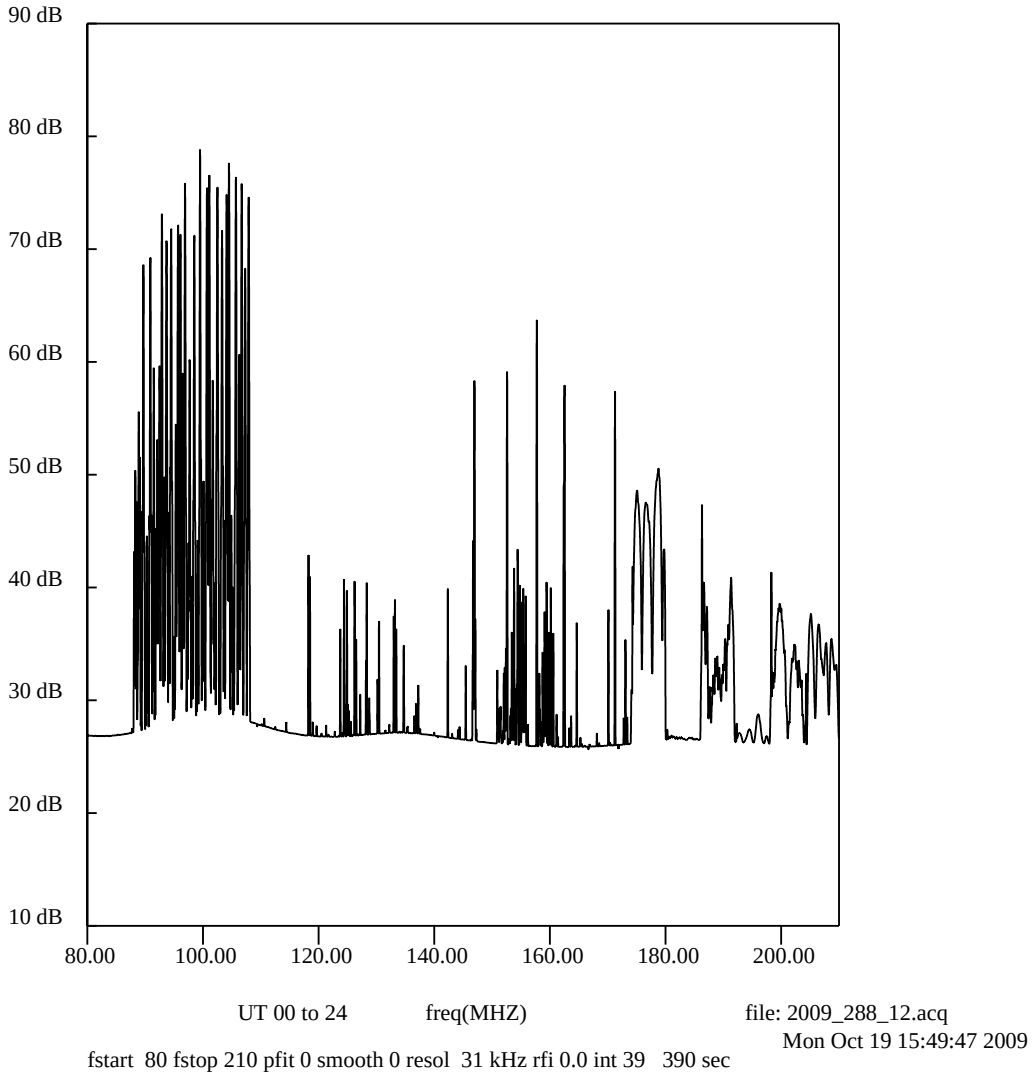


Figure 6. Spectrum at Haystack after adding 20 dB between the antenna and the LNA and another 20 dB as in Figure 3.