LEDA Memo: 8 Bit Sampling of LWA Data

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1 Summary

In order to determine the suitability of an 8 bit ADC for sampling LWA data, we analyzed data taken every 15 minutes over a 24 hour period from 6 LWA dual pol stands. The data was captured using the currently available 12 bit ADCs. The following plots and statistics were produced using all of the captured data.

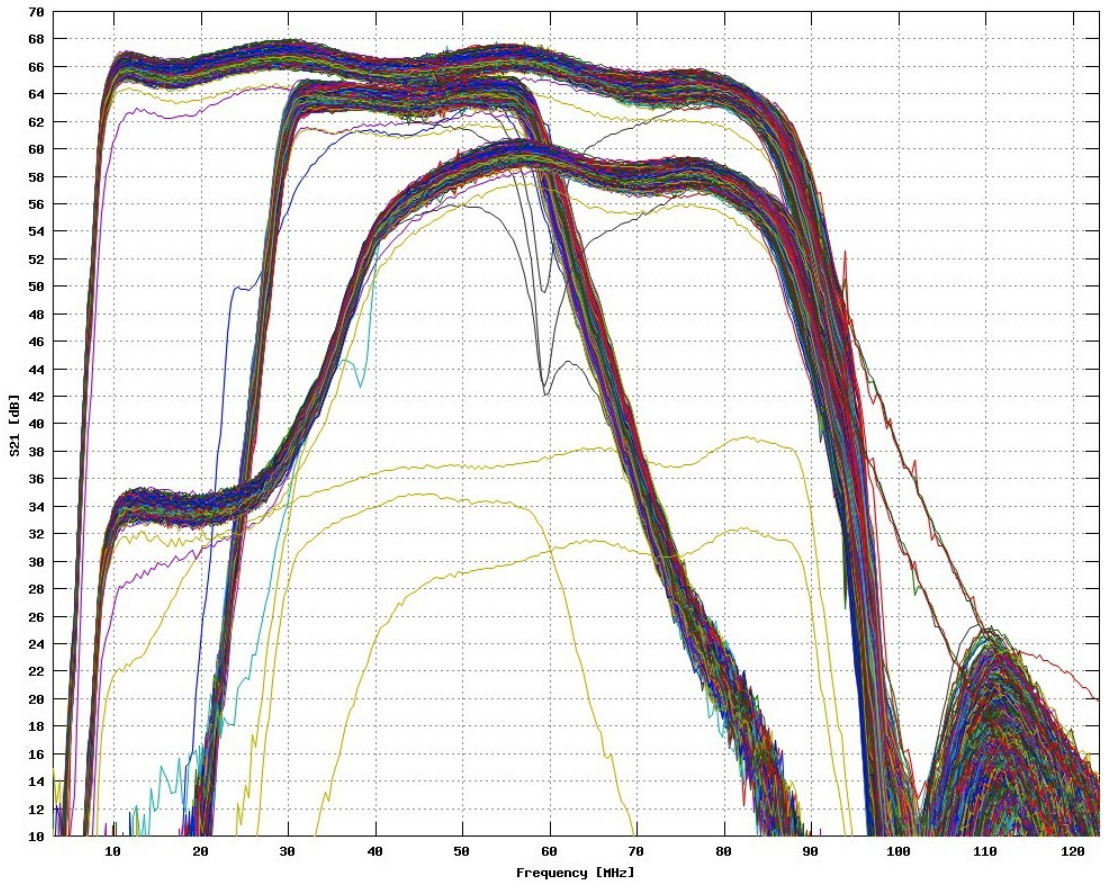

Figure 1: ARX filter response. Refer to the memo "Manufacturing Tests of the Analog Receiver (ARX) Boards" for more information on the filters.

Figure 1 shows the frequency responses of all the available LWA filters. The "split bandwidth" filter set that was selected for this experiment has a main passband from 40 to 90 MHz, and an attenuated passband from

10 to 40 MHz (the staircase passband shown in figure 1). The filter was configured as follows:
Filter Config: Split Bandwidth, ARX setting of "0"
Split Bandwidth Attenuation: 24 dB (maximum), ARX setting of "15"
First Attenuator: 16 dB (out of 30 dB), AT1 = "08"
Second Attenuator: 12 dB (out of 30 dB), AT2 = "06"

Analysis of the data showed that at least 97% of the samples lie within the range $[-128, 128)$. Therefore, without adjusting any gains there would be $< 3\%$ error due to saturation using an 8 bit ADC. If the ADC gain is set so that the RMS is 20, the error rate of the ADC gets even lower. With the sampled data rescaled, saturation would only occur in $< 0.001\%$ of the samples using an 8 bit ADC (an error rate of 10^{-5}).
Based on this analysis, we recommend using an 8 bit ADC to sample LEDA data from the LWA. If the gains are adjusted appropriately, there will be very little loss due to saturation.

Stand	RMS	samples $\in [-128, 128)$	samples $\in [-128, 128)$ with RMS = 20
$Stand001X$	34.118798	99.9896%	99.9998%
$Stand001Y$	28.544380	99.9988%	99.9999%
$Stand010X$	55.174325	98.0064%	99.9997%
$Stand010Y$	46.112851	99.4528%	99.9999%
$Stand054X$	43.717739	99.6627%	99.9996%
$Stand054Y$	47.889111	99.2436%	99.9999%
$Stand248X$	26.123759	99.9996%	99.9998%
$Stand248Y$	30.7075512	99.9988%	100.0000%
$Stand251X$	58.756399	97.0939%	99.9996%
$Stand251Y$	58.047033	97.2851%	99.9997%
$Stand258X$	27.404131	99.9993%	99.9998%
$Stand258Y$	28.3805394	99.9995%	100.0000%

2 Histograms

The rest of the memo contains histograms of the data from each stand-pol. Each histogram is shown in linear and log scale, to highlight the peakedness and short tails of each distribution. The blue bars highlight the samples that could be represented with 8 bits without gain adjustment. The yellow bars show the samples that would not saturate if the gain was adjusted so that the RMS is 20. The log plots of the data emphasize the short tails in the histogram, showing that adjusting the gain will be an effective way to reduce the saturation rate.

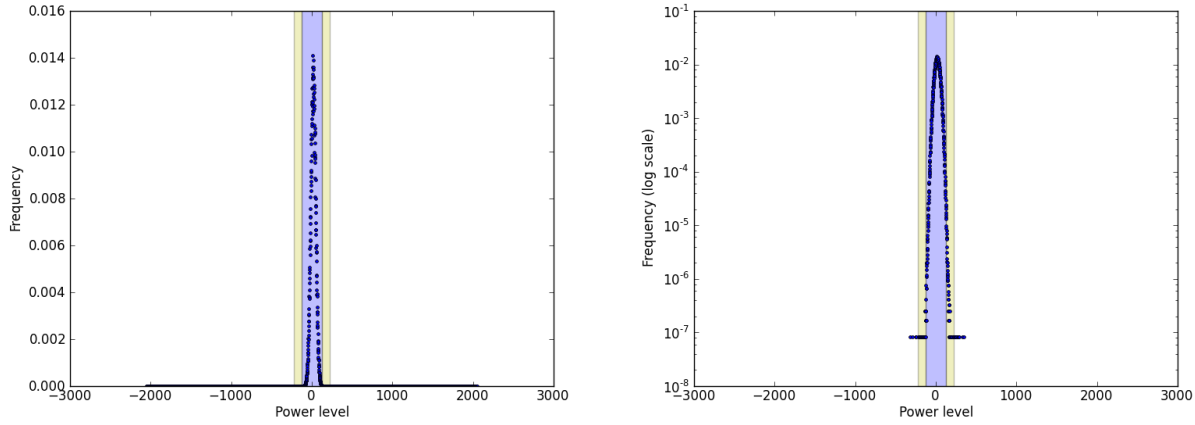

Figure 2: Data from Stand001X. RMS is 34.1188 Samples used : 3792000000. If the RMS is unchanged 99.9896 percent of the samples will lie within [-128,128). With an RMS of 20, 99.9998 percent of the samples will lie within [-128,128).

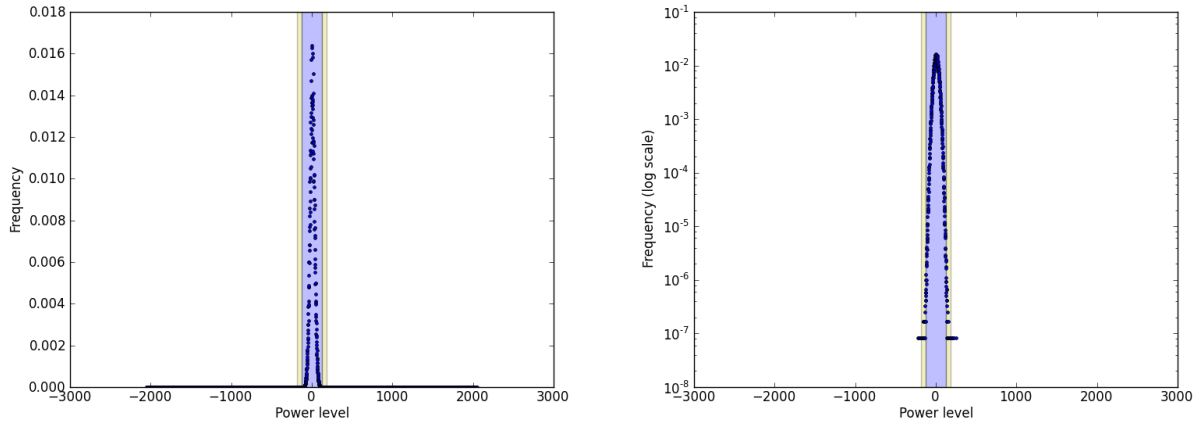

Figure 3: Data from Stand001Y. RMS is 28.5444 Samples used : 3792000000. If the RMS is unchanged 99.9988 percent of the samples will lie within [-128,128). With an RMS of 20, 99.9999 percent of the samples will lie within [-128,128).

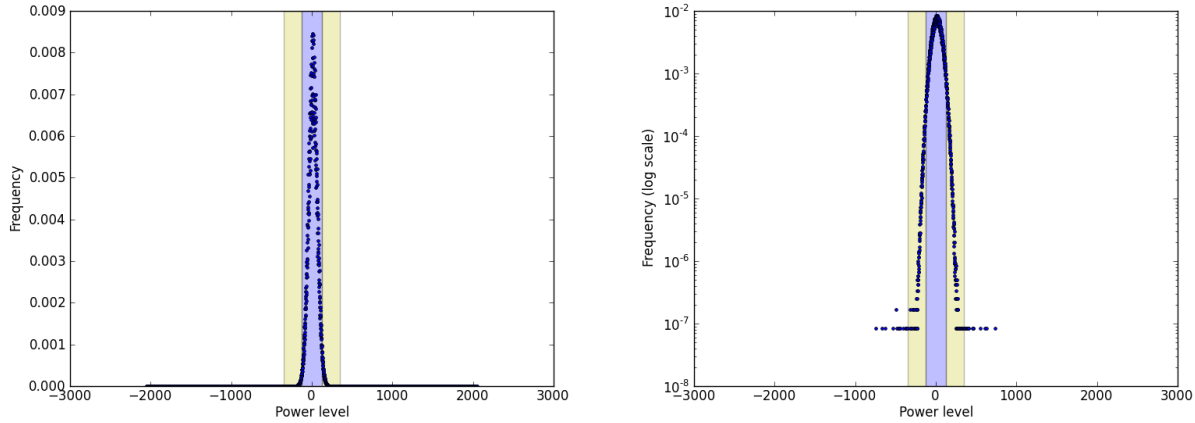

Figure 4: Data from Stand010X. RMS is 55.1743 Samples used : 3792000000. If the RMS is unchanged 98.0064 percent of the samples will lie within [-128,128). With an RMS of 20, 99.9997 percent of the samples will lie within [-128,128).

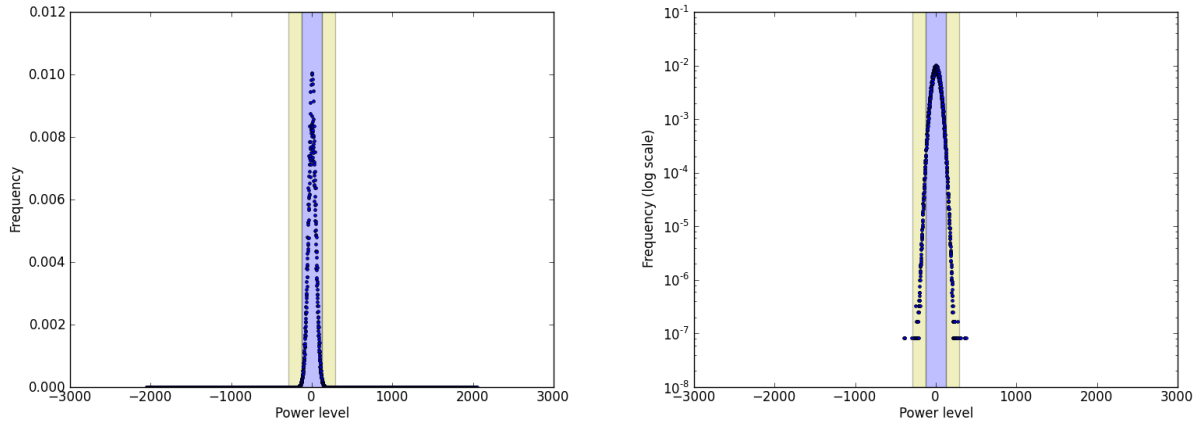

Figure 5: Data from Stand010Y. RMS is 46.1129 Samples used : 3792000000. If the RMS is unchanged 99.4528 percent of the samples will lie within [-128,128). With an RMS of 20, 99.9999 percent of the samples will lie within [-128,128).

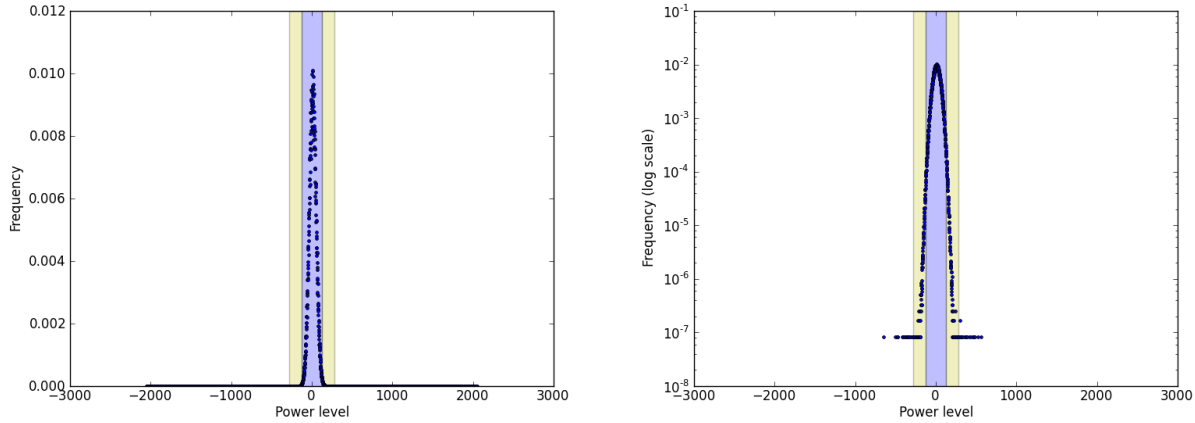

Figure 6: Data from Stand054X. RMS is 43.7177 Samples used : 3792000000. If the RMS is unchanged 99.6627 percent of the samples will lie within [-128,128). With an RMS of 20, 99.9996 percent of the samples will lie within [-128,128).

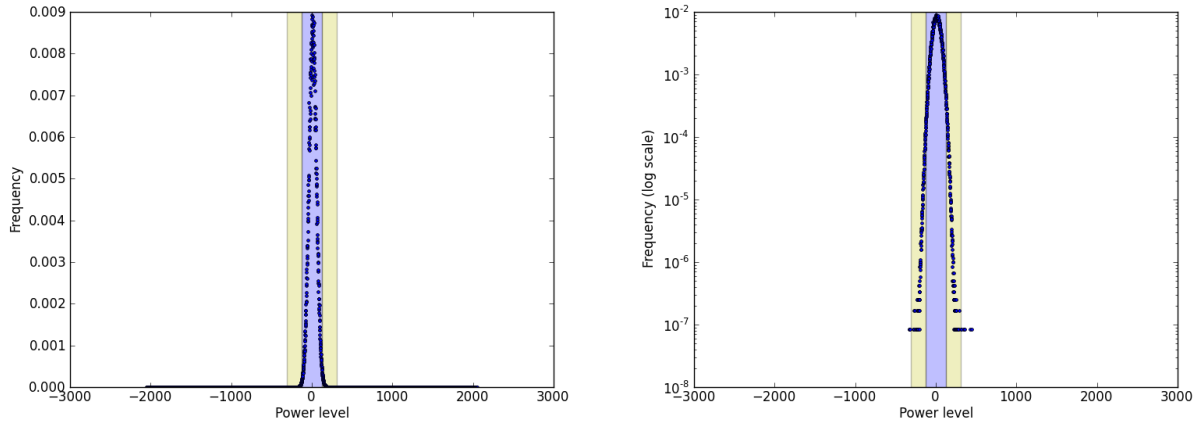

Figure 7: Data from Stand054Y. RMS is 47.8891 Samples used : 3792000000. If the RMS is unchanged 99.2436 percent of the samples will lie within [-128,128). With an RMS of 20, 99.9999 percent of the samples will lie within [-128,128).

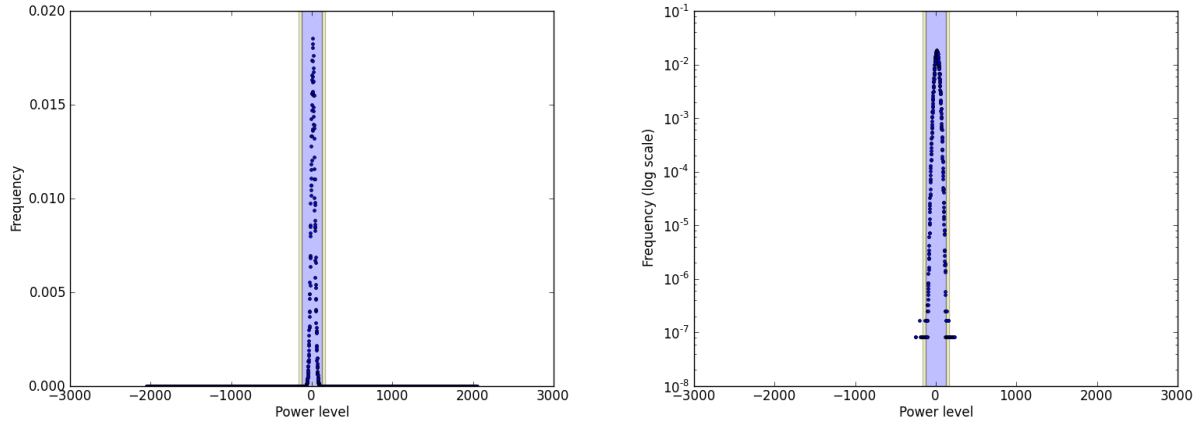

Figure 8: Data from Stand248X. RMS is 26.1238 Samples used : 3792000000. If the RMS is unchanged 99.9996 percent of the samples will lie within [-128,128). With an RMS of 20, 99.9998 percent of the samples will lie within [-128,128).

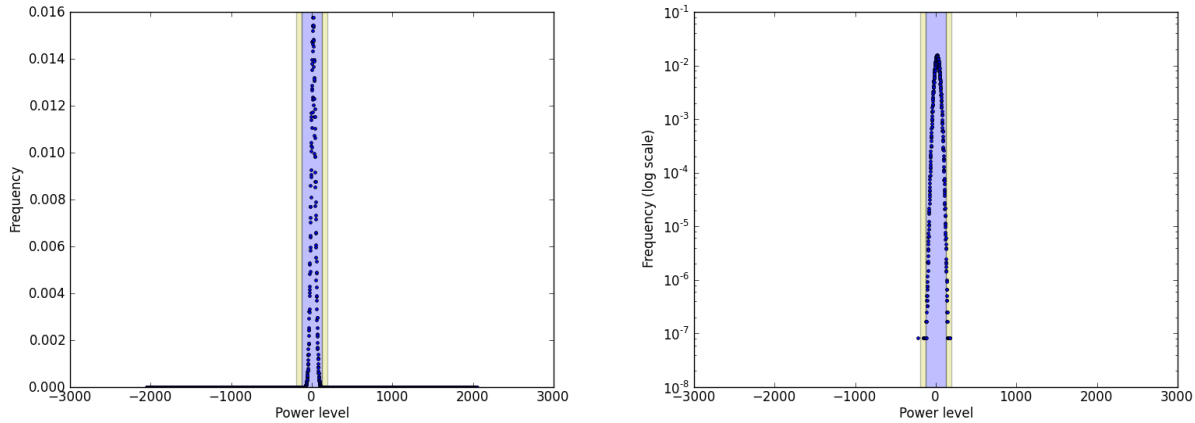

Figure 9: Data from Stand248Y. RMS is 30.7076 Samples used : 3792000000. If the RMS is unchanged 99.9988 percent of the samples will lie within [-128,128). With an RMS of 20, 100.0000 percent of the samples will lie within [-128,128).

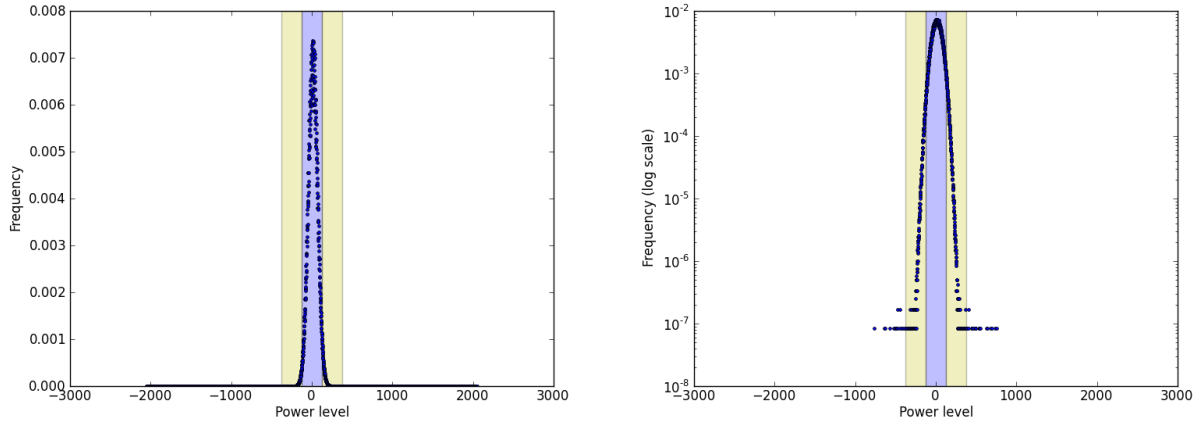

Figure 10: Data from Stand251X. RMS is 58.7564 Samples used : 3792000000. If the RMS is unchanged 97.0939 percent of the samples will lie within [-128,128). With an RMS of 20, 99.9996 percent of the samples will lie within [-128,128).

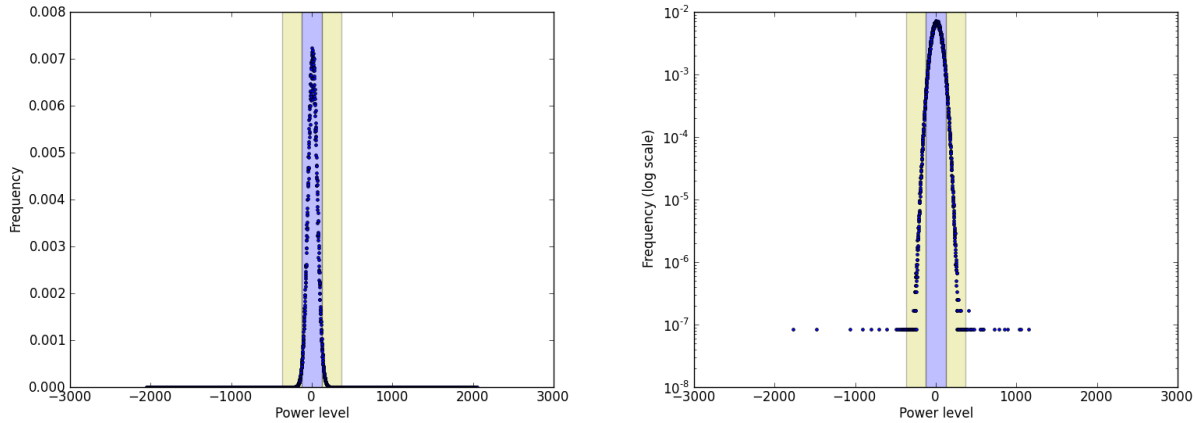

Figure 11: Data from Stand251Y. RMS is 58.0470 Samples used : 3792000000. If the RMS is unchanged 97.2851 percent of the samples will lie within [-128,128). With an RMS of 20, 99.9997 percent of the samples will lie within [-128,128).

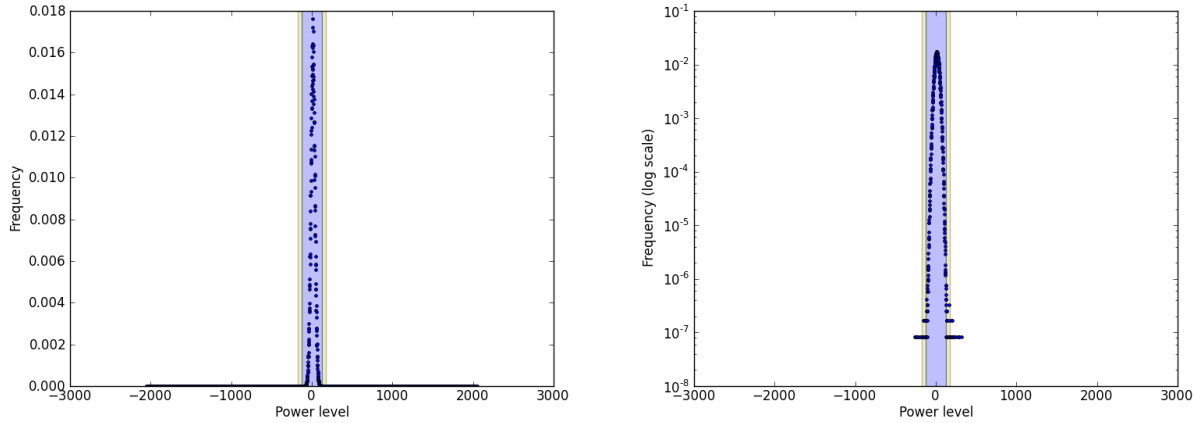

Figure 12: Data from Stand258X. RMS is 27.4041 Samples used : 3792000000. If the RMS is unchanged 99.9993 percent of the samples will lie within [-128,128). With an RMS of 20, 99.9998 percent of the samples will lie within [-128,128).

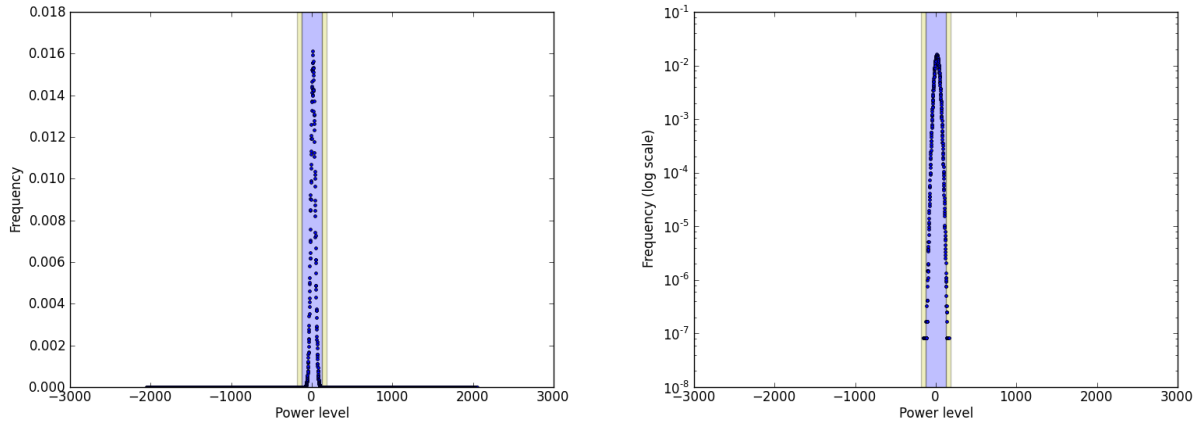

Figure 13: Data from Stand258Y. RMS is 28.3805 Samples used : 3792000000. If the RMS is unchanged 99.9995 percent of the samples will lie within [-128,128). With an RMS of 20, 100.0000 percent of the samples will lie within [-128,128).