Initial ARGUS Measurement Results

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Introduction

This report illustrates some initial measurement results from the new ARGUS system [1]. Its main focus is on simple measurements of the ARGUS system, and is not intended to be a detailed analysis. The document is broken into two sections - the first presents measurements of a single tone, and the second measures the system stability.

1 DDC Data Measurements

The measurements made in this section use the following test setup: a test tone generated by a HP8752C network analyzer is split eight ways and fed into the ARGUS RF inputs. The tone has a frequency of 1.5729855 GHz and a power of -20dBm (measured using a spectrum analyzer.) The tone passes through a variable attenuator (16dB to 106dB) and then is antenuated another 12dB through a 8-way splitter. The output tone is then in the range of -48dBm to -138dBm. The LO frequency is set to 1572MHz.

In this section capture results from the DDC processor are shown. The DDC is configured to have a decimation of 200 ($5 \times 20 \times 2$) which reduces the output data rate to 20 MSPS/200 = 100 kSPS. The BW of the output data is set to a little over 80kHz using the DDC FIR filter. DDC data can be captured from all channels simultaneously using the ARGUS system. All the DDCs have their digital LO set to 1MHz - thus the expected output frquency is 1.5729855 GHz - 1572 MHz - 1 MHz = -14.5 kHz. Results for the DDC sample captures are discussed below:

Figure 1(a&b) A capture of 1024 complex DDC samples is shown in this Figure. The IQ-trajectories are perfectly circular due to the digital LO in the DDC. The RF input power for this capture is set to -48dBm.

Figure 2(a) The 1024 complex samples are converted into the frequency domain using FFT (with a Bartlett window.) The tone appears at a frequency of -14.5kHz. Note the phase noise of the network analyzer can be seen at the base of the tone.

Figure 2(b) The RF input power is decreased in steps of 10dB, taking a measurement at each power level. The power of the tone in the FFT spectrum is then recorded at each power level. The range of power where the tone is visible above the system noise is approximately 80dB. Given that the ADCs are 8-bit the expected dynamic range is around 42dB, plus the DDC decimation gain of $10 \log_{10} 200 = 23$dB, plus the additional gain of 30dB using a length 1024 FFT, a total of 95dB.

Figure 3(a&b) Finally the gain and phase is plotted against time. The power difference between channels is less than 2dB. Note that 1024 samples is equivalent to 1024/100k=10.2ms. All channels appear to have a similar amount of power noise which probably suggests it comes from the network analyzer. The phase of each channel is also shown with reference to channel-0. The phase spread is approximately 76 degrees, or 4cm (at 1573MHz) which is possibly due to the different cable lengths in the splitter network. The phase of each channel is constant with time.

2 ARGUS System Stability

The stability of the system can be measured by integrating FFT results and measuring the variance. In this experiment the input to the 8-way splitter is terminated and large blocks of DDC data recorded. The number of DDC data points recorded was 10 blocks of 1 MS, a total of 10 MS (320Mbytes of data!) This represents approximately 100 seconds of data, although the data took approximately 330 seconds to record (for each acquisition it takes 10 seconds to get the DDC data (@100kSPS), 12 seconds to write to disk (32Mbyte/12≈3Mbyte/second), and 11 seconds to display.)

In Matlab the data is broken in to 1024 sample blocks (a total of 10240 FFTs) and integrated. After each integration the variance of the data (in the pass-band) is calculated. No base-line correction is used since the pass band is approximately flat over this relatively small band width. The DDC spectrum after 10240 integrations shown in Figure 4. The variance as a function of FFT integrations is shown Figure 5. After approximately 5000 integrations (or, approximately 50 seconds) half of the channels start to deviate from the ideal 1/(number of FFTs) line.

Summary and Conclusions

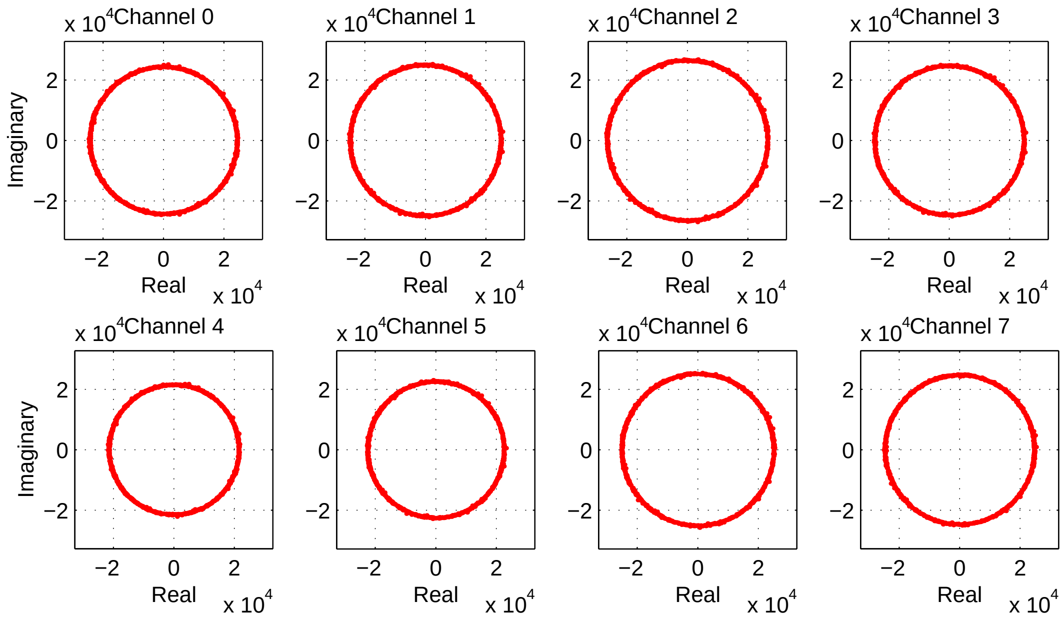
This report has presented and analyzed some initial measurements made with the new ARGUS system. The DDC results indicated that the system is performing well with the expected gain in dynamic range. The stability tests reveal that the system is capable of integrations of up to 50 seconds. However, components such as the low noise amplifier [2] and ampli-filter [3] not integrate yet, so these tests will be repeated.

References

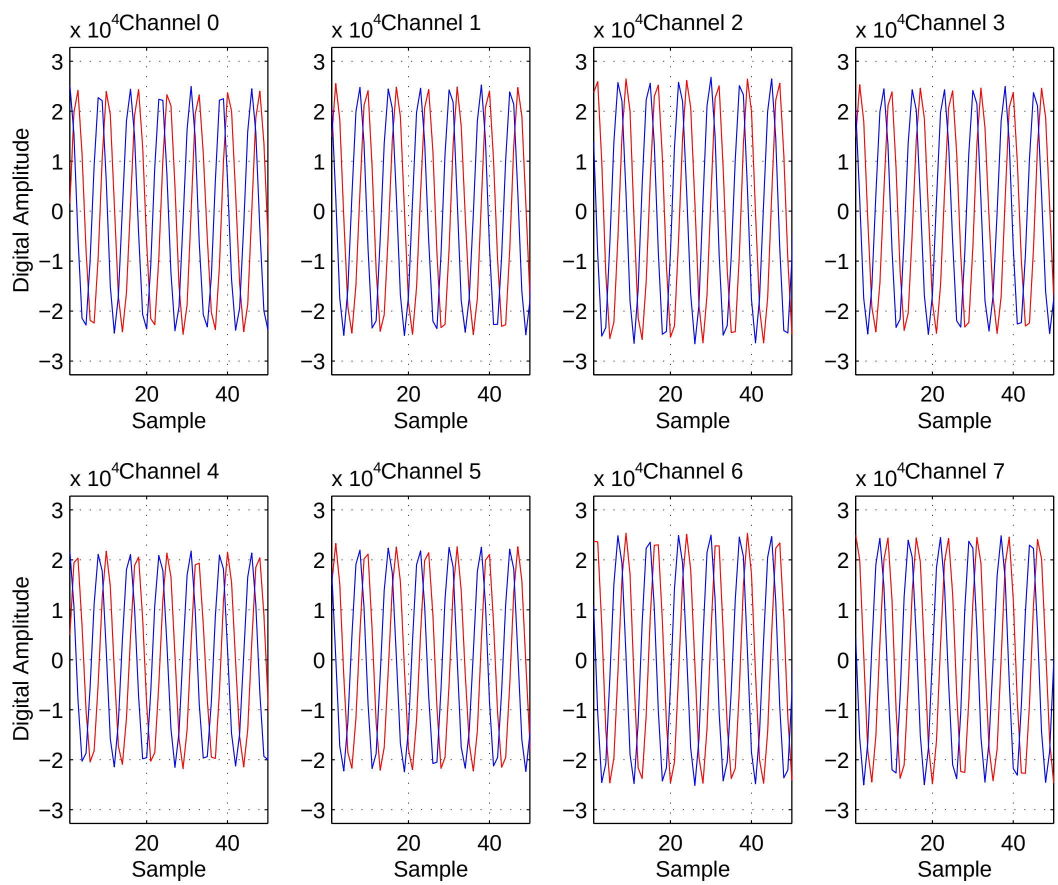
[1] G. A. Hampson and S. W. Ellingson, "A New Argus Direct Conversion Receiver and Digital Array Receiver/Processor," October 3 2002. http://esl.eng.ohio-state.edu/~swe/argus/gah_arch.pdf.

[2] S. W. Ellingson, "A 1-GHz Highpass PHEMT Low-Noise Amplifier (Rev. 1)," October 6 2002. http://esl.eng.ohio-state.edu/~swe/argus/lna2_1.pdf.

[3] S. W. Ellingson, "A Low-Cost L-Band Line Amplifier," September 9 2002. http://esl.eng.ohio-state.edu/~swe/argus/rfb.pdf.

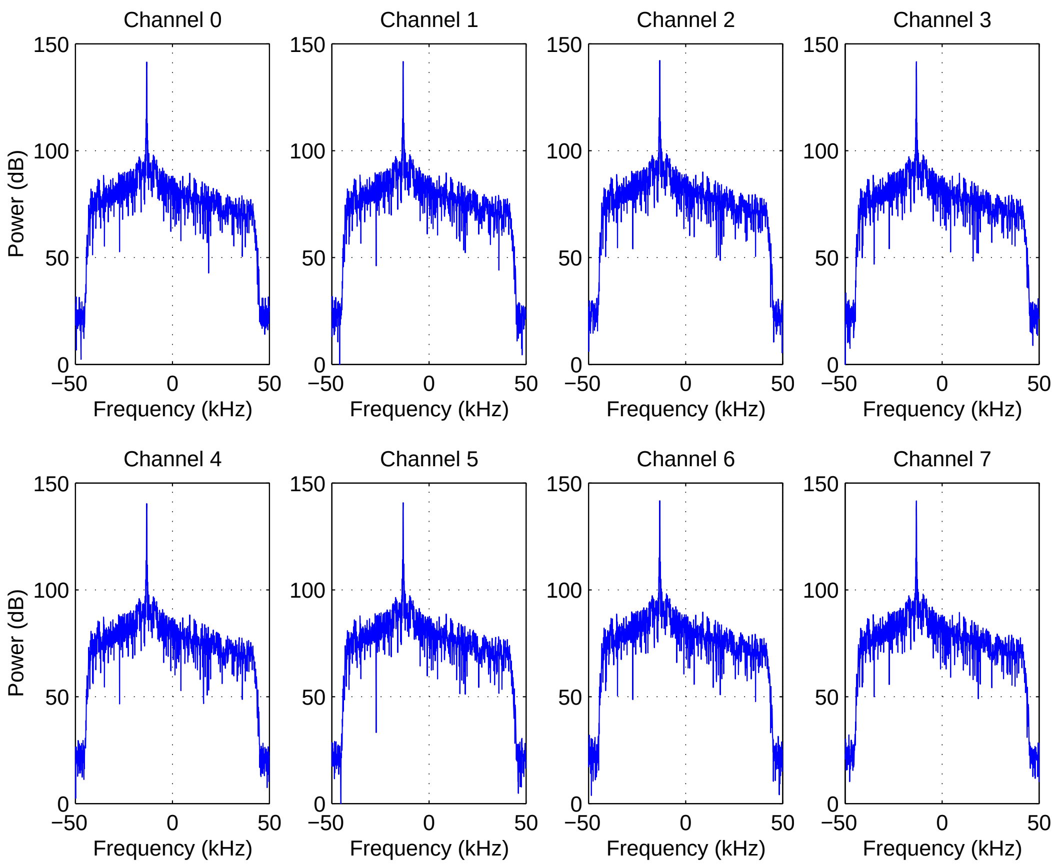


(a) Complex Waveforms

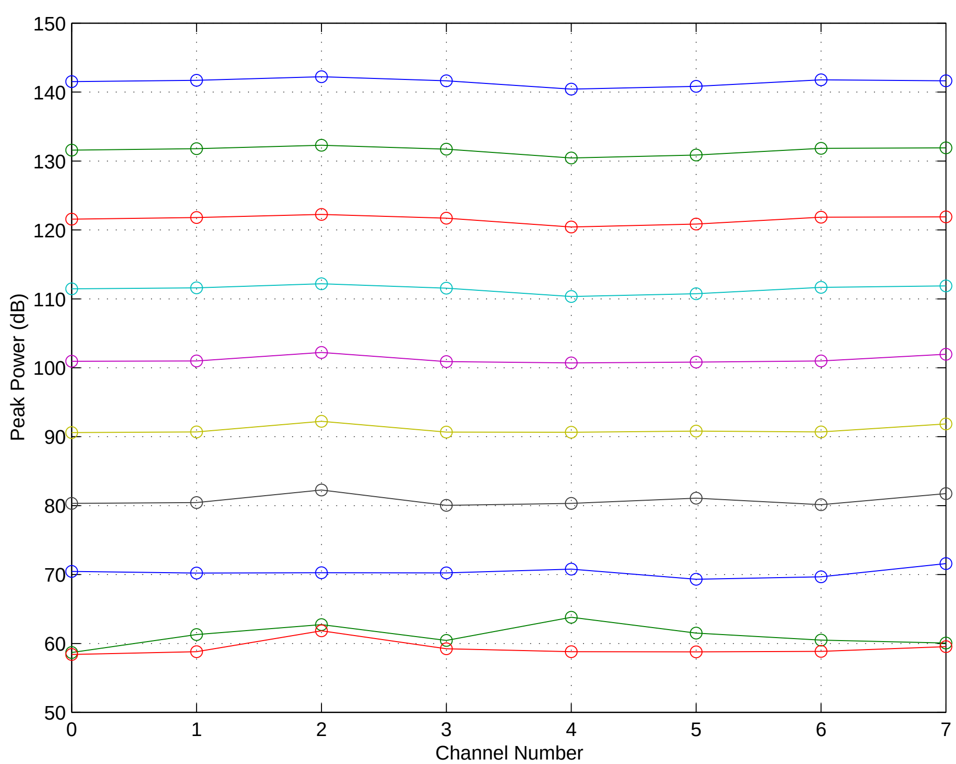


(b) Time domain representation

Figure 1: 1024 complex DDC samples are simultaneously acquired using the 8-channel ARGUS system. The data is illustrated using (a) IQ plots and (b) time domain plots (the first 50 samples.) In this measurement the output frequency of the data is -14.5kHz. The RF input power is -48dBm in this measurement.

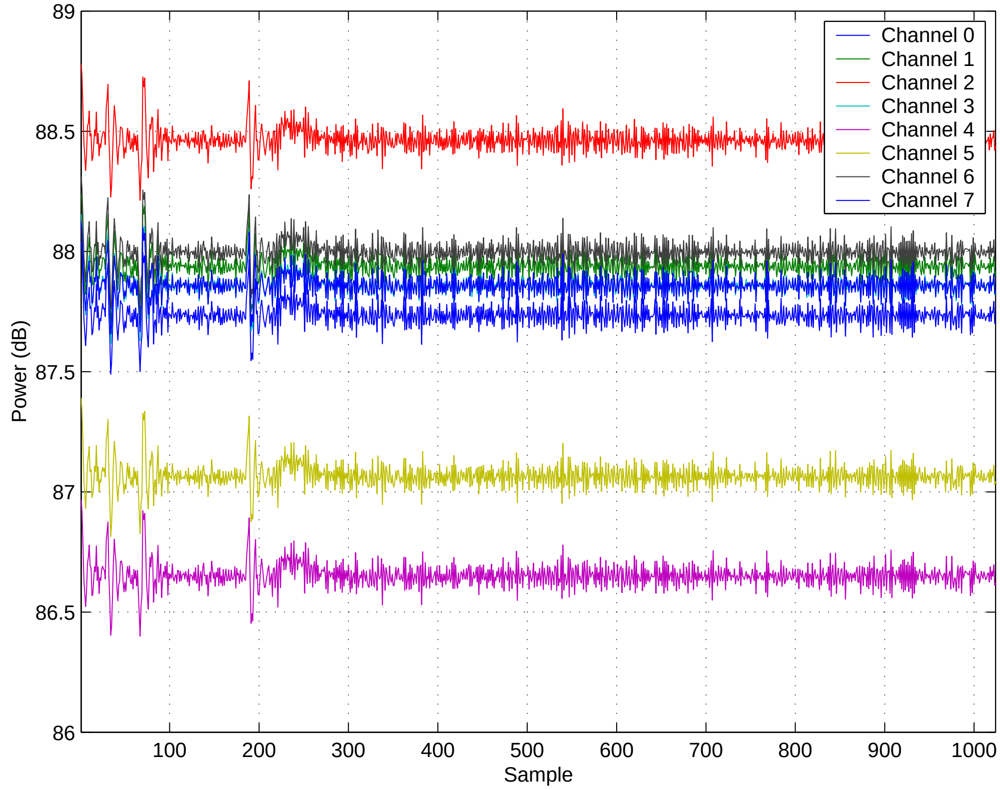


(a) 1024-point FFT Spectra

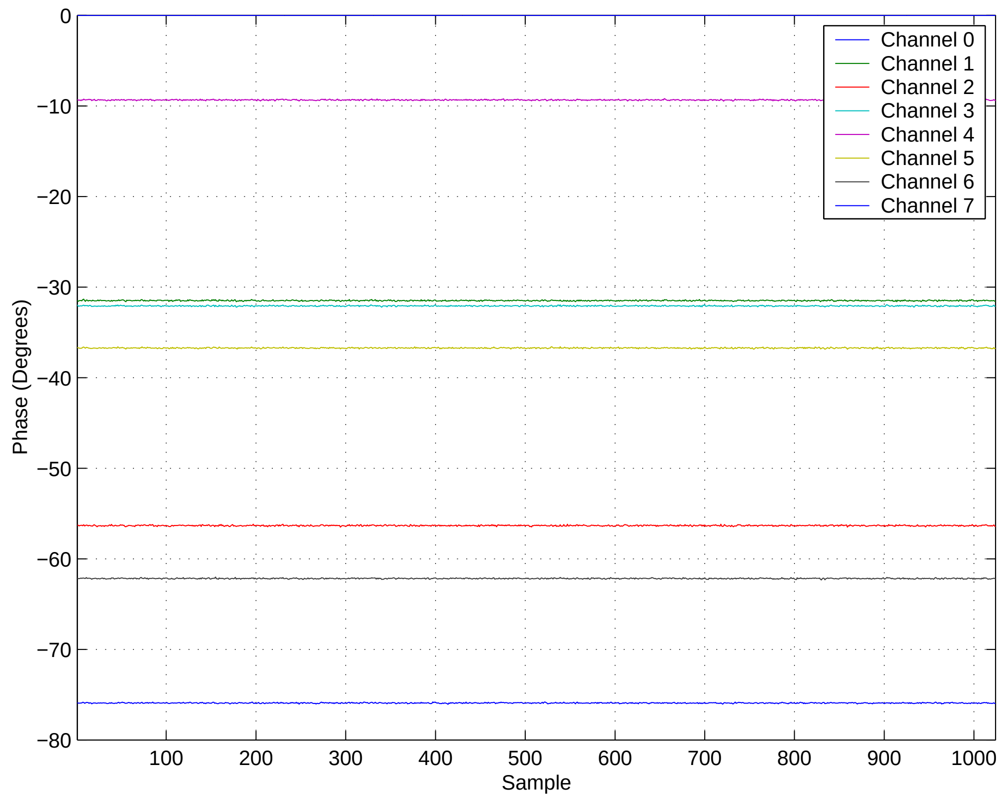


(b) Dynamic Range Results

Figure 2: (a) FFT spectra of the raw samples captured in Figure 1. (b) Peak power measured for an input tone of varying power (-48dBm to -138dBm, in steps of 10dB.)

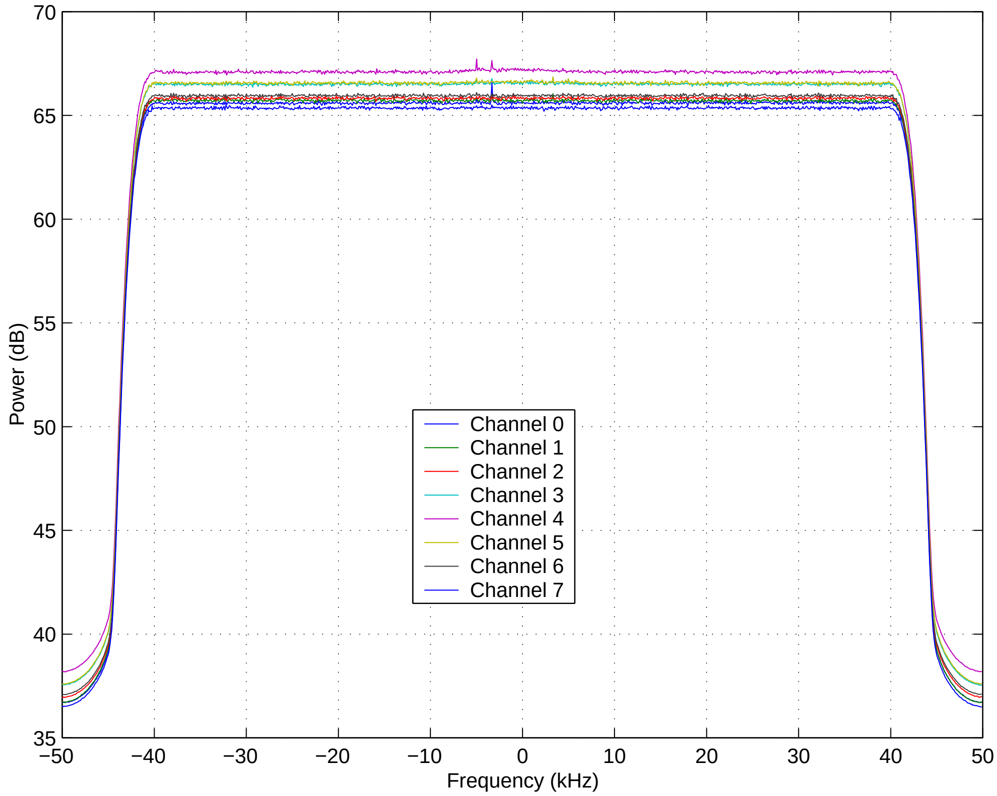


(a) Time Domain Magnitude Measurement

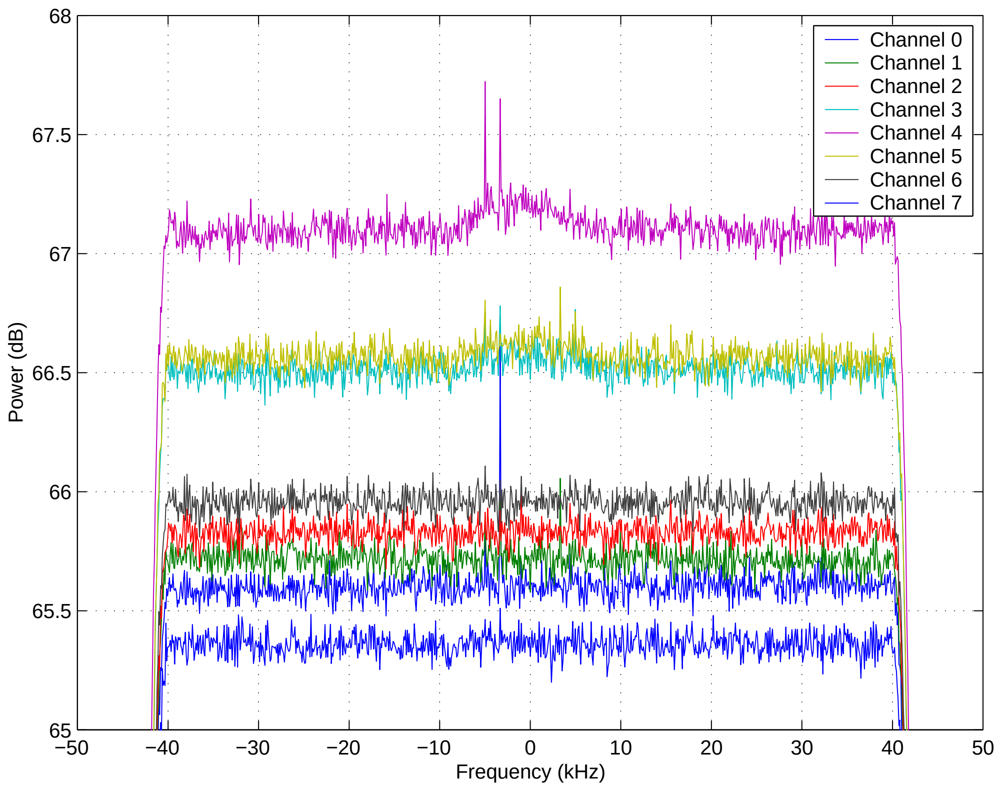


(b) Time Domain Phase Measurement

Figure 3: Gain and phase variations over time of the ADC data. 1024 samples is equivalent to 1024/100kHz=10.24ms. Note that channels are sampled simultaneously.



(a) DDC Baseline after 10240 FFT Integrations



(b) Close up of the DDC Baseline after 10240 FFT Integrations

Figure 4: Integration results from the ARGUS system: 10 mega-samples of DDC data is recorded and analyzed. Here 10240 integrations of 1024-point FFT data is shown.

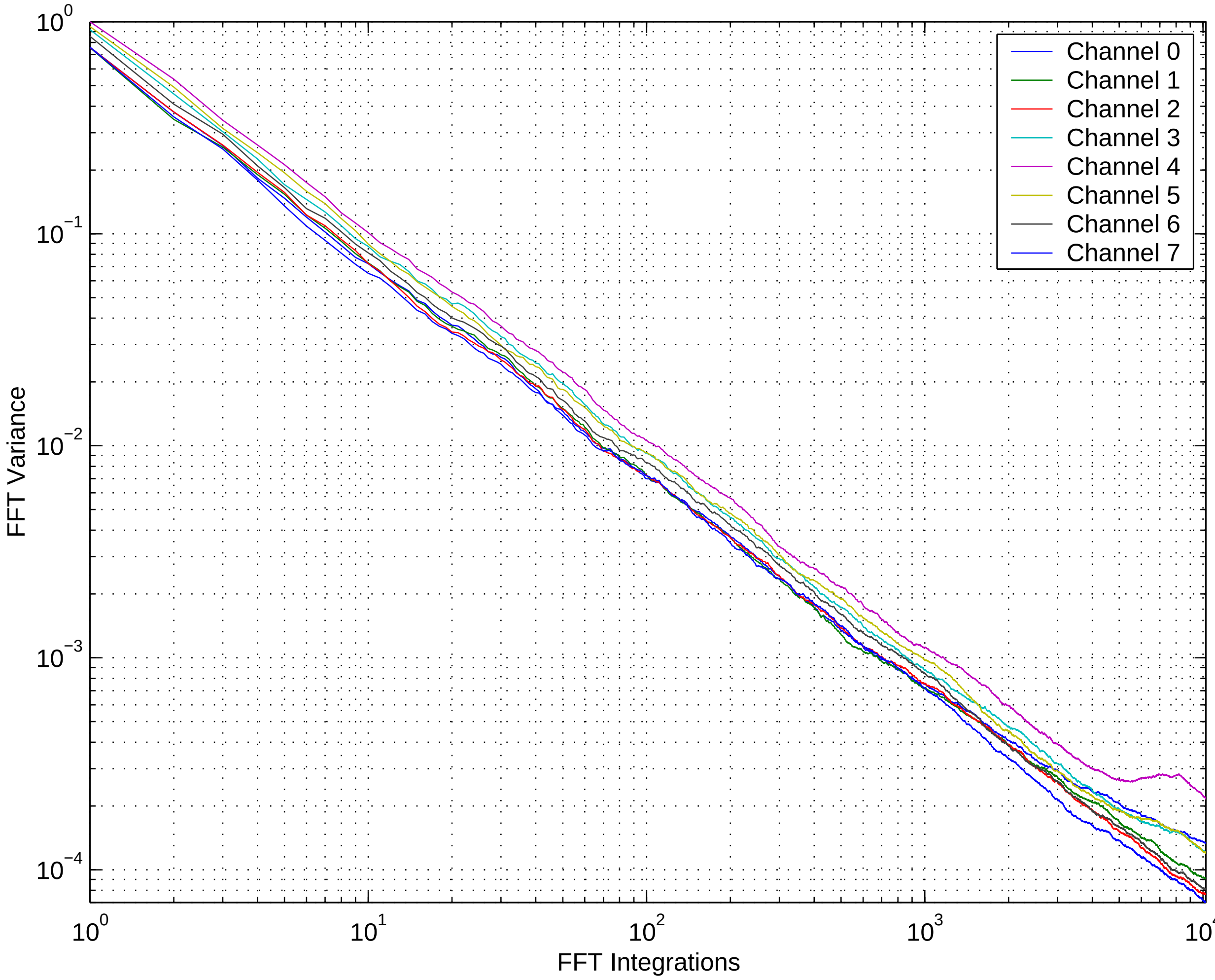


Figure 5: ARGUS variance test: 10 mega-samples of DDC data is recorded and analyzed. In Matlab the data is broken in to 1024 sample blocks (a total of 10240 FFTs) and integrated. After each integration the variance of the data (in the pass-band) is calculated. No base-line correction is used since the pass band is approximately flat over this relatively small band width. The graph indicates that the ARGUS system is stable up to 5000 FFT integrations (approximately 50 seconds.) In this graph the maximum variance of channel-4 has been used to normalize all channels (i.e., they are not individually normalized.)