Checkpoint 3

M835083

1) The highest signal frequency that could be measured correctly was 1,5 KHz. The reason as to why a higher frequency could not be correctly sampled was that the sample frequency was approaching the Nyquist frequency of the ADC given it's current Sampling frequency of $\approx$ 4 KHz.

The nyquist frequency is given by $f_{Nyquist} = \frac{1}{2}\gamma$ where γ is the sampling rate of the ADC

As the nyquist frequency is exceeded, the ADC can no longer fully reconstruct the signal frequency from the generator.

2) When a waveform is undersampled, the resulting waveform is affected by data loss. While this causes many issues on the resultant signal, the most apparent is aliasing. This occurs when two signals being sampled ~~are~~ are indistinguishable & results in the reconstructed signal being different from the original sample being sampled. In our case, the ~~sample~~ signal being undersampled results in there being occasional signal ~~drops~~ loss (reduced amplitude) in the reconstructed signal. Note that in the example figure provided the aliasing is minor (& hence so are the signal losses) as the signal frequency is only 0,1 KHz above the observed Nyquist frequency. Were the signal frequency to be $\gg \gamma$, then the aliasing on the reconstructed signal would be more apparent.

3) The callibration plot shows a linear relation between the ~~Measured~~ ~~ob~~ measured voltages from the signal generator (measured using an oscilloscope) & the observed voltages (measured using the ADC). This was also confirmed by producing an optimized best fit curve using the ~~to~~ curve_fit method from scipy, which resulted in a ~~fit that~~ fitted curve which follows the data points consistently & produced a best fit function of: $y = mx + c$ where $m = 1,33(11)$ and $c = -0,6(2)$

These coefficients are 2 to 3 σ away from the theoretical best fit of $m=1$ & $c=0$. This however can be more closely achieved using more sample points in the curve_fit function method.

When looking at the residual plot we see what seems like a random scatter above and below the x axis (although it is not easy to tell as there are only 4 data points) & there seems to be no systematic curvature in the residuals. As a result, we can conclude (with the limited data points that we have) that the ADC did a good job @ reconstructing the signals. Note that a majority of the error bars did not cross the x axis & therefore are not 1σ from their expected value, though this is likely due to the selection of the error in the measured voltage ($\delta V = 0{,}05V$) rather than an issue w/ the ADC.

We can use the optimized best fit line as a calibration plot to improve future data from the ADC. In order to do this, we would use the following function obtained through this process to find the new calibrated data:

$$\boxed{V_{calibrated}(V_{measured}) = 1{,}33 \cdot V_{measured} - 0{,}6}$$

As mentioned previously, the calibration plot can be improved by using more data points in the curve fit function. Additionally, extra polynomial terms can be added to the model function, along w/ more optimization parameters to improve the calibration function. e.g: $V_{cal} = ax^3 + bx^2 + cx + d$.