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45-50

- ① RESEARCH WAS DISTORTED
- ② FM EXPERIMENT SEEM TO HAVE GONE AWAY. RESULTS WERE NOT CLOSE TO THAT EXPECTED.
- ③ ADC WAS BETTER, BUT DID HAVE EXTRA TURNED THAT DIDN'T SEEM NECESSARY.
- ④ RESULTS AND ANALYSIS WERE INACCURATE AT TIMES
- ⑤ CONCLUSIONS WERE FAR TOO DESCRIPTIVE AND DIDN'T CRITICALLY ANALYSE THE MAIN POINTS. MORE FM OR ADC
- ⑥ PRESENTATION COULD BE IMPROVED, FAR TOO MANY DIAGRAMS IN THE REPORT. MORE COULD BE DELETED THE REF. PUT IN THE APPENDIX. ONLY PUT NECESSARY DIAGRAMS IN THE REPORT ITSELF.

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1. Executive Summary

Two practical experiments were carried out to compare results with the established theory. Research was carried out to provide an evaluation of amplitude and frequency modulation techniques and an evaluation of the development of digital communication techniques. The topic areas were, analogue to digital convertors (ADC's), PAM and PCM techniques and Synchronous Digital Hierarchies (SDH). Research was carried out to gather the necessary information to compare with results. Experiment one was frequency modulation. Firstly, the writer determined the maximum frequency deviation and calculated the modulation index. Secondly, ~~the writer calculated~~ the required amplitude values using the Bessel Table and sketched the spectrum of this wave indicating the bandwidth and waveform. The college provided a Feedback Instruments pack 'Analogue Communications Systems'. Thirdly, ~~the writer displayed~~ the side frequencies and ~~determined the bandwidth~~ on a spectrum analyser. Fourthly, the writer measured the Bessel co-efficients. The writer took regular screen shots at different intervals during the tests. Lastly, ~~the writer compared~~ the practical results with the theory. Experiment 2 was the Analogue to Digital Conversion. The writer used the feedback Ltd experimental kit and connected it as demonstrated according to the instructions. The writer noted the behaviour, requirements and limitation of the ADC. Firstly, the writer noted the differences in the quality of conversion between 4 and 8 bit convertors. Secondly, the writer noted why it is important to match the amplitude of the input signal to the range of an ADC and why the relationship between the input signal frequency and the sampling rate of the ADC's is important. The writer investigated the validity of the Nyquist Criterion. Secondly, the writer used the Feedback Ltd experiment and carried out various tests at different peak to peak voltages and different frequencies at 4 and 8-bit ranges to make conclusions and recommendations.

3RD PERIOD, PAST TENSE IS BEST.
JUST AVOID 'THE WRITER' ALTOGETHER.

2. Research into analogue and digital communication systems and techniques

2.1 An evaluation of amplitude and frequency modulation techniques

Radio signals carry information. The information is in the form of audio and data. It is used to modulate a single frequency known as the carrier. The information superimposed into the carrier forms a radio signal which is transmitted to the receiver. The information is removed from the radio signal and reconstituted in its original format, which is known as demodulation. There are several different varieties of modulation and can be seen in three categories, amplitude modulation, frequency modulation and phase modulation. FM – Frequency Modulation is the form of angle modulation where the $f_i(t)$ instantaneous frequency is varied on a linearly basis with the $m(t)$ baseband signal, as seen by: $(10) f_i(t) = 12\pi \int m(t) dt = f_c + k_f m(t)$ Frequency modulation, it is the frequency rather than the amplitude of the carrier wave that is made to vary in proportion to the varying amplitude of the modulating signal. Frequency modulation can be achieved by varying the capacitance of a resonant LC circuit in a given transmitter, (Meyers, 2001). In Amplitude Modulation, voltage or power level of the information signal changes the amplitude of the carrier in proportion, see figure 45. If there is no modulation, the AM carrier is transmitted on its own. When the modulating information signal or the sine wave is applied, the carrier amplitude will increase and decrease in accordance. The carrier frequency remains constant during the AM, (Louis E. Frenzel, 2018).

THE FIRST REFERENCE IS TO
FIGURE 45? WHY NOT PUT
THEM IN ORDER.

2.2 An Evaluation of the development of digital communication techniques

2.2.1 Analogue to digital convertors (ADCs)

Analogue to Digital Converters are an electronic device that converts ~~a~~ a continuous analogue input signal to binary. ADC's work in two stages, sampling and quantising and encoding. The sampling rate depends on clock frequency. It uses Nyquist Criterion. It increases sampling rate, which increases accuracy of conversion. There is also the possibility of aliasing. See figure 46 for sampling examples and figure 47 for the sampling and Nyquist Criterion formulas. Aliasing is where the high and low frequency samples are indistinguishable. Results in improper conversion of the input signal is present when Nyquist Criterion is violated. It is present even when $f_s > 2 \times f_{\text{max}}$. It is prevented through the use of low-pass (anti-aliasing) filters. See figure 48 for aliasing example. Quantising and encoding approximates a continuous range of values and replaces it with binary numbers. Error is created between input voltage and output binary representation, it is also dependent on the resolution of the ADC. See figure 49 for an example of quantising and encoding. Resolution, maximum value of quantisation error. Error is reduced with more available memory. Increasing the resolution improves the accuracy of the conversion. See figures 50 and 51 and examples of resolution, (Gar, n.d.).

2.2.2 PAM and PCM techniques

Pulse Amplitude Modulation, the amplitudes of regularly spaced rectangular pulses alter with the instantaneous sample values of the continuous message signal in a form of one to one. This method of modulation is illustrated in figure 52. Diagrams a, b and c represent a message signal, the pulse carrier, and the corresponding PAM wave, (Haykin, 2003). The PAM system can be seen as a switch that closes every T_s seconds for Δ seconds, and stays open. The PAM signal is the multiplication of continuous time signal $x(t)$ by a periodic signal $p(t)$ consisting of pulses of width Δ , amplitude $1/\Delta$ and period T_s . Therefore, $x \text{ PAM}(t)$ consists of narrow pulses with the amplitudes of the signal within the pulse width, for narrow pulses, the pulse amplitude is determined by the signal amplitude of the sampling time, this is known as flat-top PAM. For small pulse width Δ , the PAM signal is $x \text{ PAM}(t) = x(t)p(t) =$

$\frac{1}{\Delta} \sum_m x(mT_s)[u(t - mT_s) - u(t - mT_s - \Delta)]$. As a periodic signal $p(t)$ is represented as a

Fourier Series, $p(t) = \sum_{k=-\infty}^{\infty} P_k e^{jk\Omega_0 t}$ $\Omega_0 = \frac{2\pi}{T_s}$, (Luis F. Chaparro, 2019).

RELEVANCE ?

Pulse Code Modulation is a digital scheme for transmitting analogue data. It can convert analogue signals into digital form. With PCM, it is achievable to digitise all forms of analogue data, including video, voice and music, (Vijay K, 2007). If each digital word has n binary digits, then $M = 2^n$ unique words is achievable and every coded word had an amplitude level. This is known as quantising, which, instead of using an exact sample of analogue waveform value, the sample is substituted by the nearest possible value corresponding to one of the code words, (Perez, 1998). One of the main advantages of pulse code modulation is that the message in PCM is a train of pulses of equal height which can be regenerated as many times along the propagation path, this is because the information is not reliant on the exact height and shape of the pulses, but is more reliant on identifying whether the pulse is there or not. The pulse which has deteriorated in shape and size can be recognised at the receiver as the presence of a pulse or presence of a bit. Before the pulses in a pulse train become so distorted that the error-free decision between 1's and 0's becomes difficult, the pulse train is then regenerated to its original form and resent as if it were the original message, see figure 53, (Plonus, 2020).

2.2.3 Synchronous Digital Hierarchy (SDH)

SDH and SONET (Synchronous Optical Network) are a group of fibre-optic transmission rates that can transport digital signals with different capacities, (Consortium, n.d.). The synchronous digital hierarchy is a standard for multiplexing together low rate digital traffic channels into higher rate channels so that these low rate channels may be more efficiently transported around a telecommunications network. SDH has developed into a comprehensive set of standards which meet all aspects of a telecommunications transport network. SDH can transport isochronous traffic channels and is on layer one of the ISO seven layer OSI protocol hierarchy. SDH is based on a hierarchy of continuously repeating, fixed length frames, just like PDH. The effects of the full range of SDH standards cover a wider area of telecommunications due to their general applicability. The existence of SDH optical interface specifications will lead to their use in a range of non-SDH applications, due to the dearth of competing standards, (Matthews, 1993).

THE RESEARCH DOESN'T FLOW OR READ WELL. IT IS MORE A COLLECTION OF LOOSELY RELATED FACTS. YOU HAVE ALSO INCLUDED THINGS WHICH ARE WELL BEYOND THE REMIT AND THEREFORE LACK CONTEXT.

3. Experimental method for experiment 1

$$\text{Modulation index} = \frac{\Delta f_c}{f_m}$$

FM = Frequency of the message, 10kHz

Δf_c = Maximum frequency deviation.

20kHz per volt, therefore, $20\text{kHz} \times 2 = 40\text{kHz}$

$$\text{Therefore, modulation index} = \frac{40\text{kHz}}{10\text{Hz}} = 4$$

@ 455kHz = $E_c \times J_0 = 375\text{mv} \times 0.40 = 0.15\text{V}$ or **150mV**

@ 445 and 465kHz = $E_c \times J_1 = 375\text{mv} \times 0.07 = 0.02625\text{V}$ or **26.25mV**

@ 435 and 475kHz = $E_c \times J_2 = 375\text{mv} \times 0.36 = 0.135\text{V}$ or **135mV**

@ 425 and 485kHz = $E_c \times J_3 = 375\text{mv} \times 0.43 = 0.16125\text{V}$ or **161.25mV**

@ 415 and 495kHz = $E_c \times J_4 = 375\text{mv} \times 0.28 = 0.105\text{V}$ or **105mV**

@ 405 and 505kHz = $E_c \times J_5 = 375\text{mv} \times 0.13 = 0.04875\text{V}$ or **48.75mV**

@ 395 and 515kHz = $E_c \times J_6 = 375\text{mv} \times 0.05 = 0.01875\text{V}$ or **18.75mV**

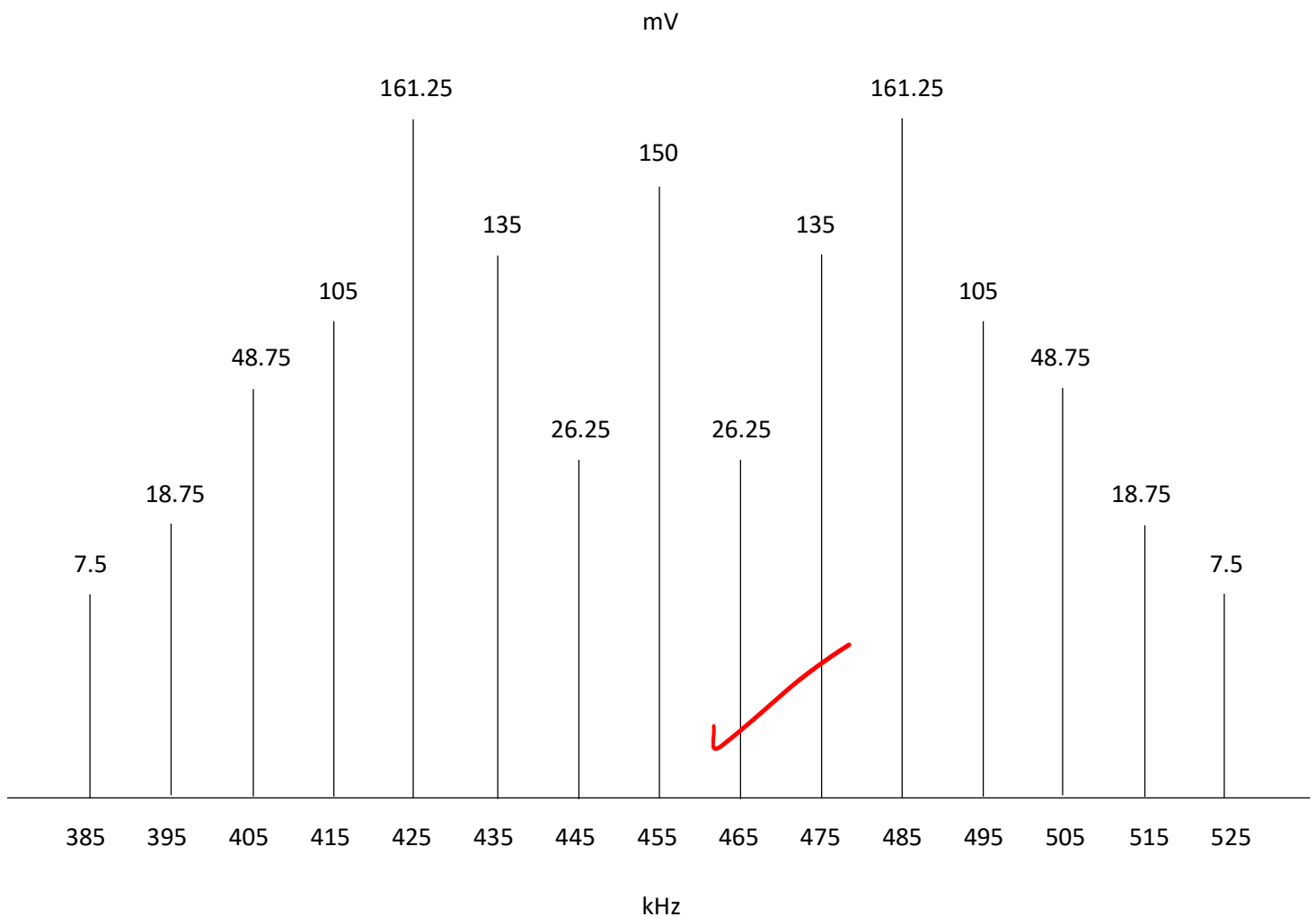
@ 385 and 525kHz = $E_c \times J_7 = 375\text{mv} \times 0.02 = 7.5\text{mV}$

Appendix.

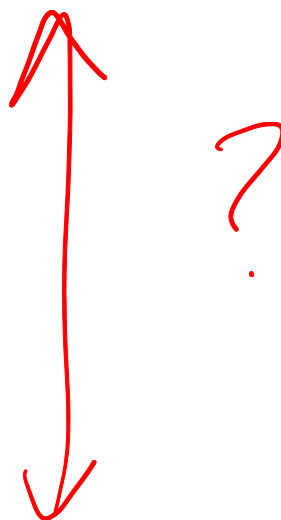
Bandwidth = 525 – 385

Bandwidth = 140KHz

Figure 1 Spectrum Analyser



The spectrum analyser measures the magnitude of an input signal against the frequency, (Tektronix, n.d.). The frequency is on the horizontal X axis and the amplitude on the vertical Y axis, (Awati, n.d.). Its primary function is to measure the strength of the spectrum of known and unknown signals. It reveals details about the signal that would otherwise be unknown, such as the efficiency and performance of the equipment producing the signal, (Techopedia, n.d.).



4. Testing, results and analysis for experiment 1

Figure 2 1V peak to peak with a minimum frequency reading of 441.3kHz and a maximum of 465kHz at 390mV.

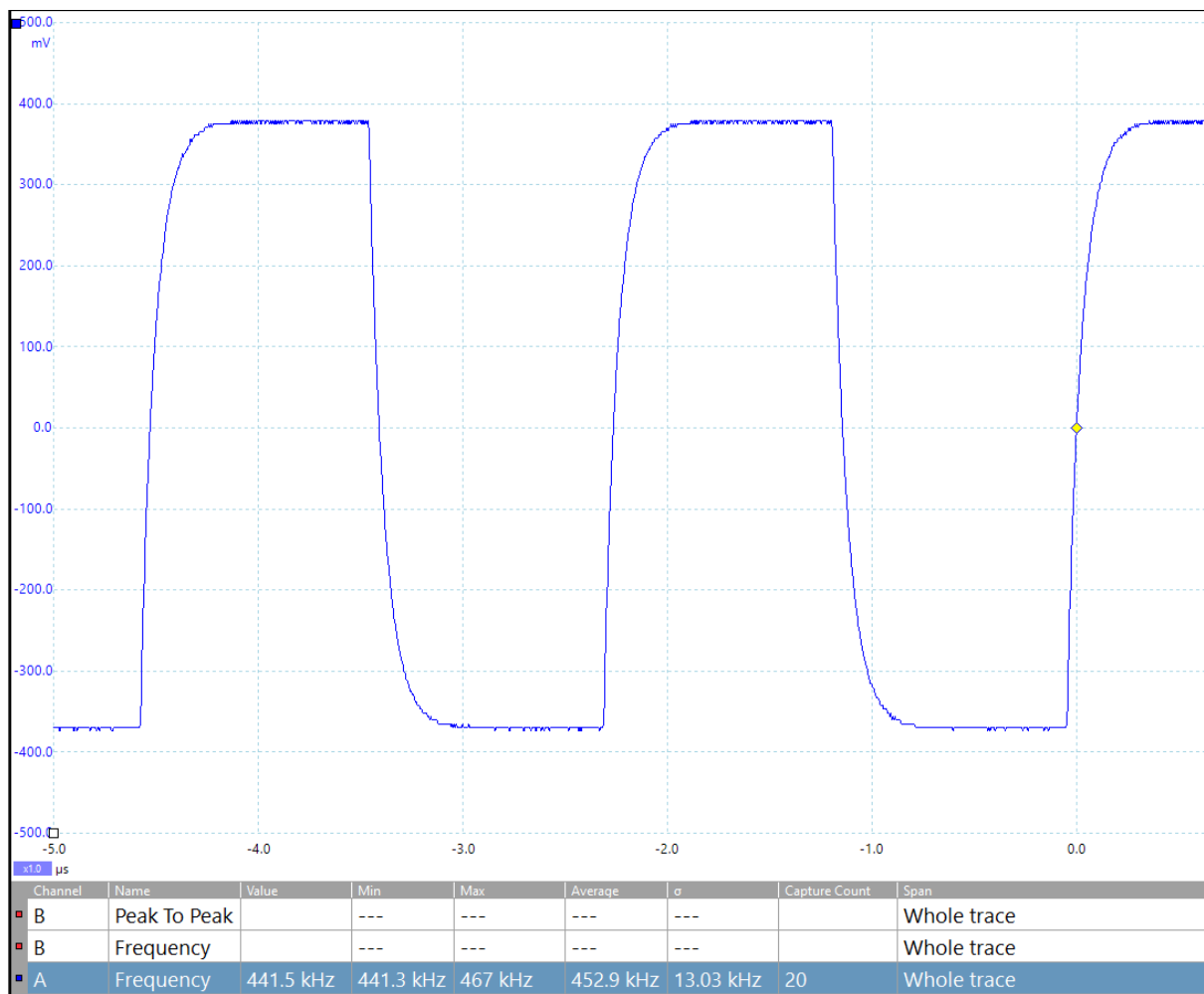


Figure 3 2V peak to peak with a minimum frequency reading of 428kHz and a maximum of 479.6kHz at 390mV.

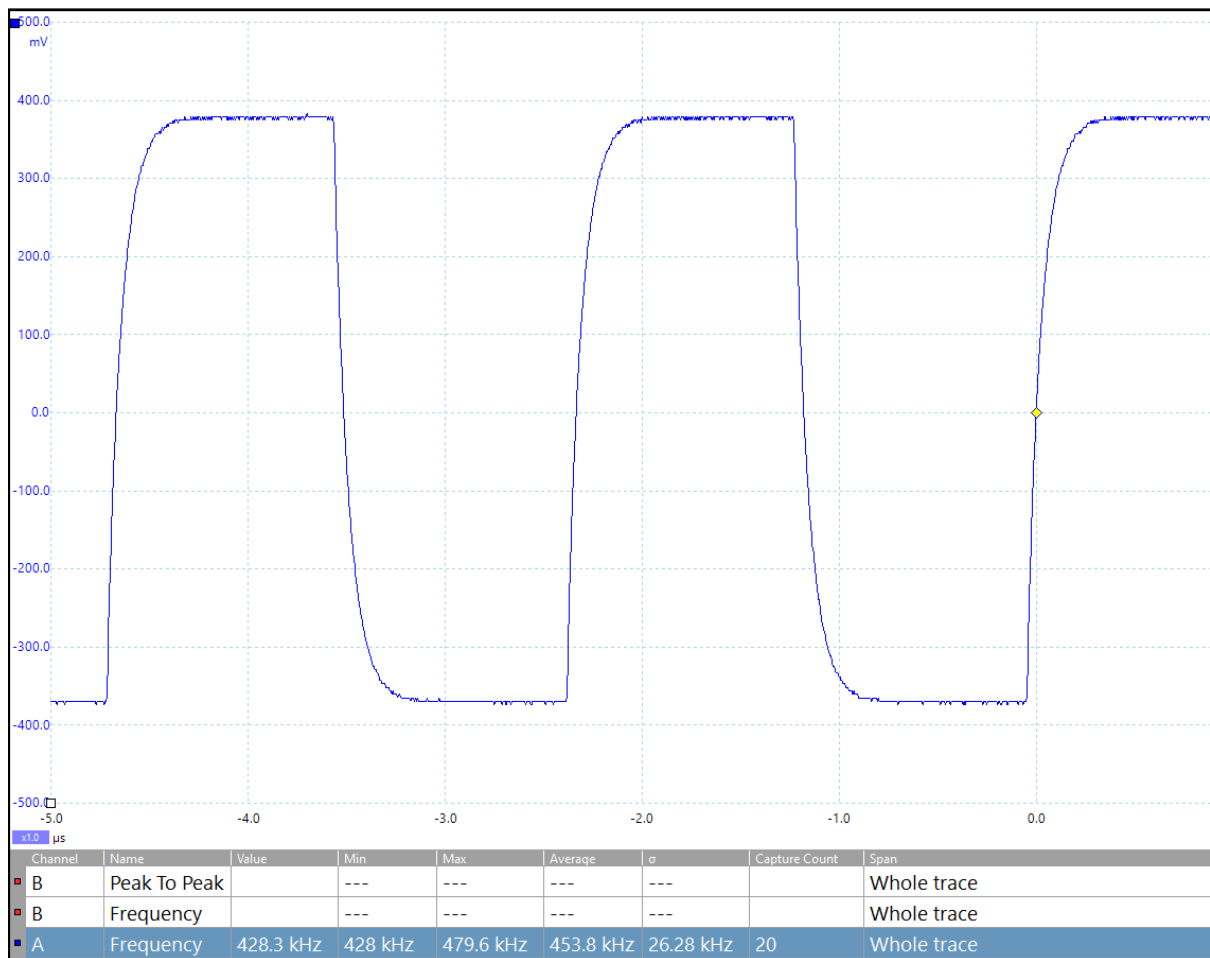


Figure 4 3V peak to peak with a minimum frequency reading of 414.3kHz and a maximum of 492.6kHz at 390mV.

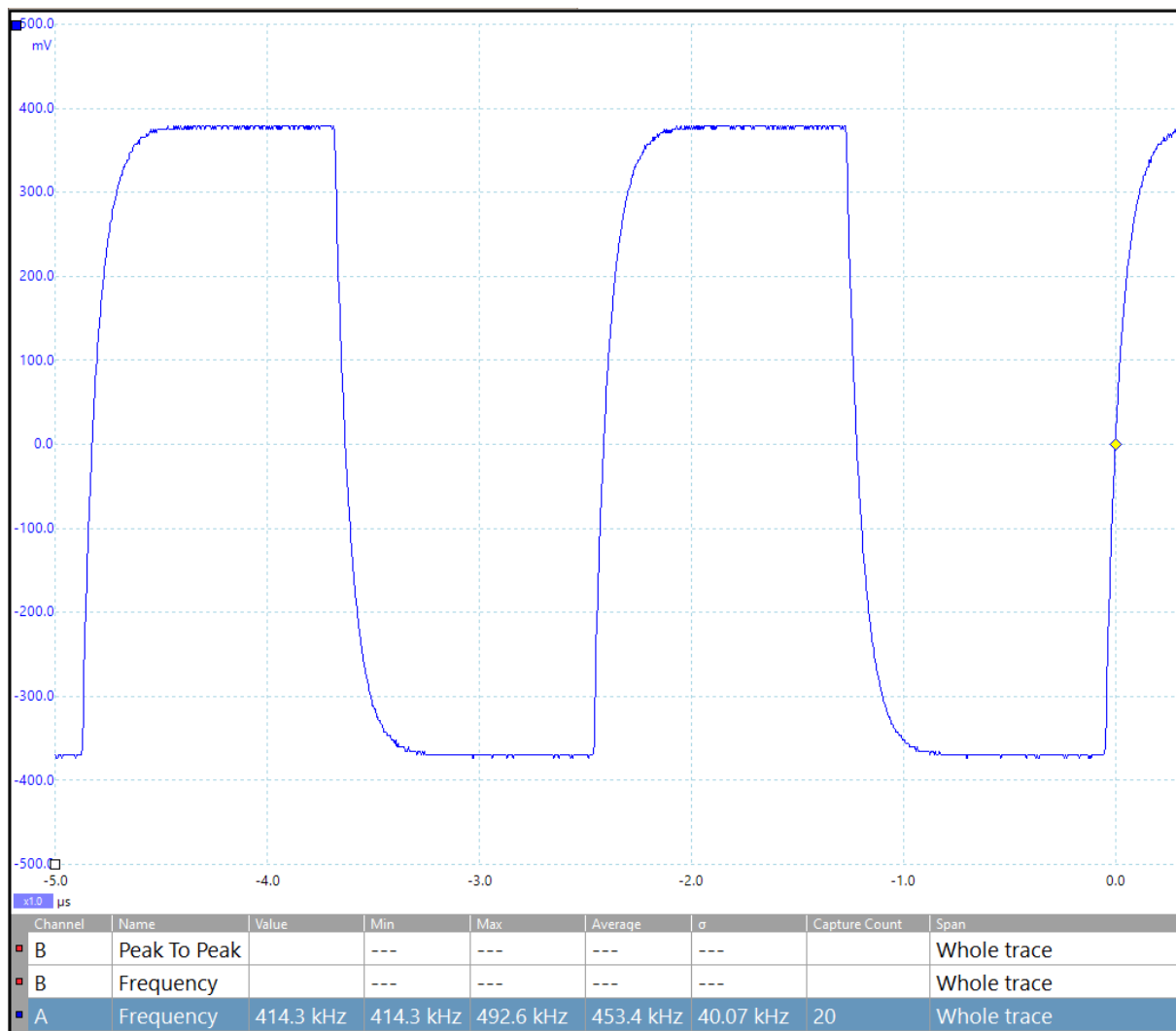


Figure 5 4V peak to peak with a minimum frequency reading of 401.6kHz and a maximum of 504.7kHz at 390mV.

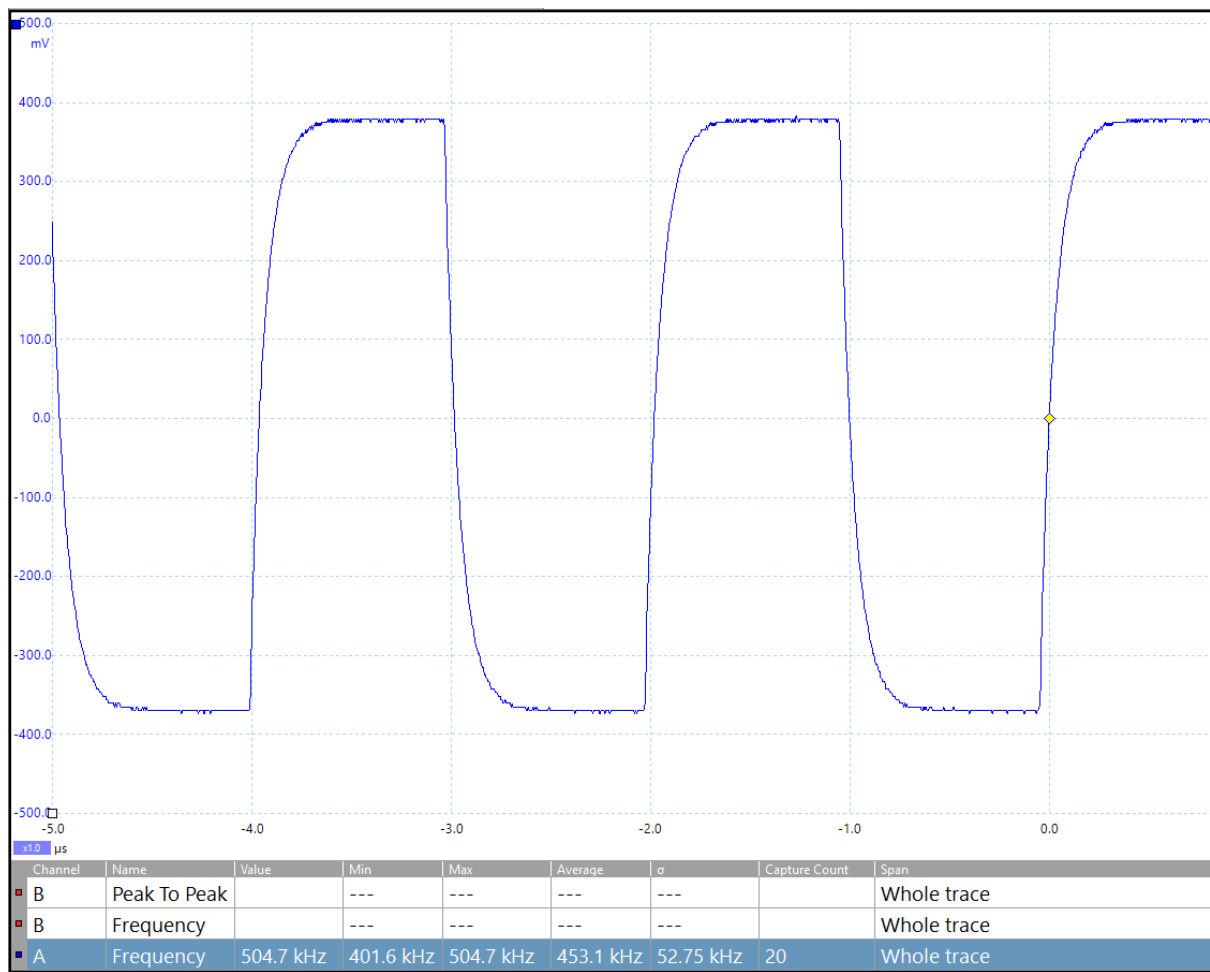
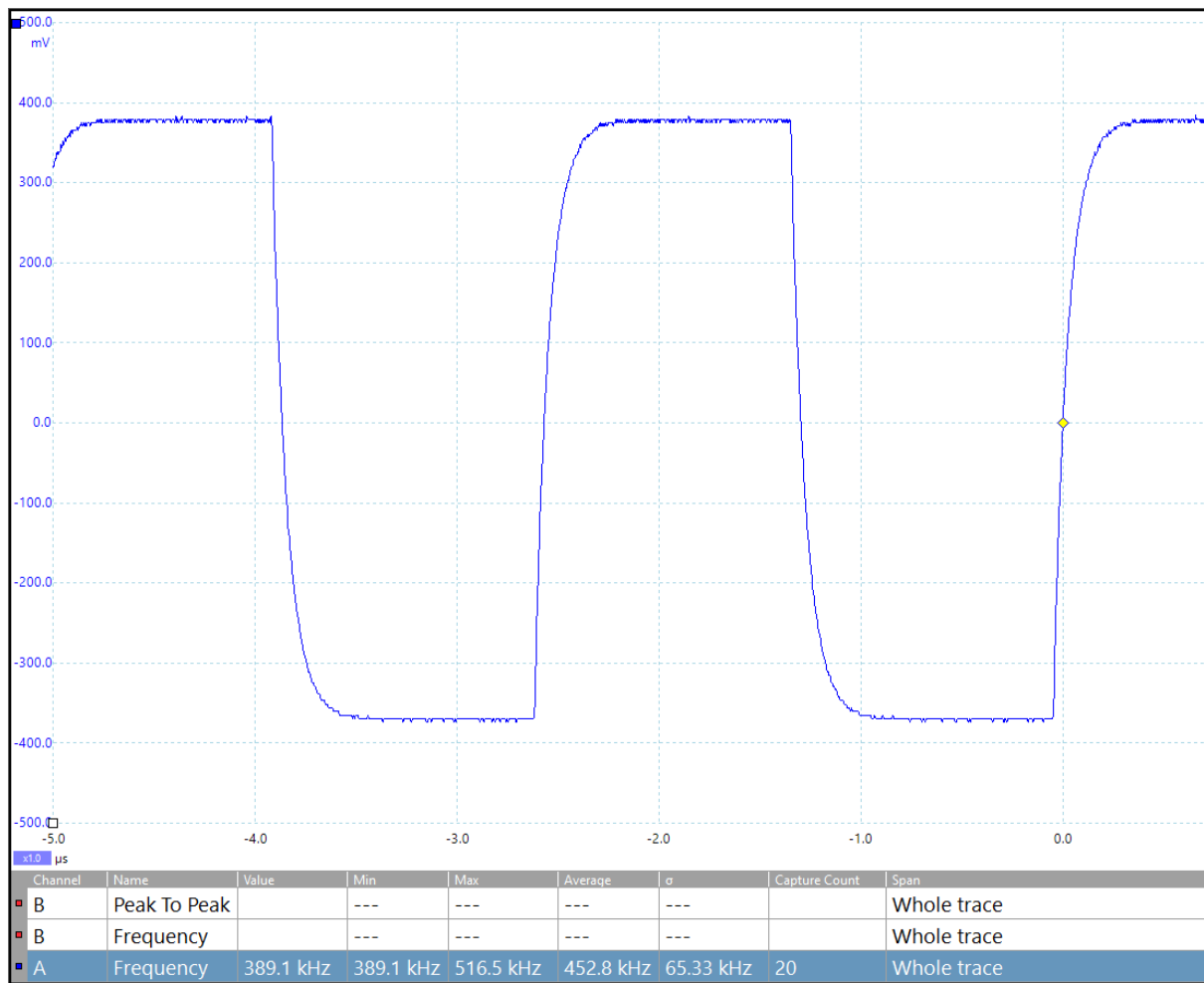


Figure 6 5V peak to peak with a minimum frequency reading of 389.1kHz and a maximum of 516.5kHz at 390mV.



WHY HAVE 5 LARGE
DIAGRAMS HERE - APPENDIX
IS RM BETTER.

Figure 7 6V peak to peak with a minimum frequency reading of 374.9kHz and a maximum of 529.8kHz at 390mV.

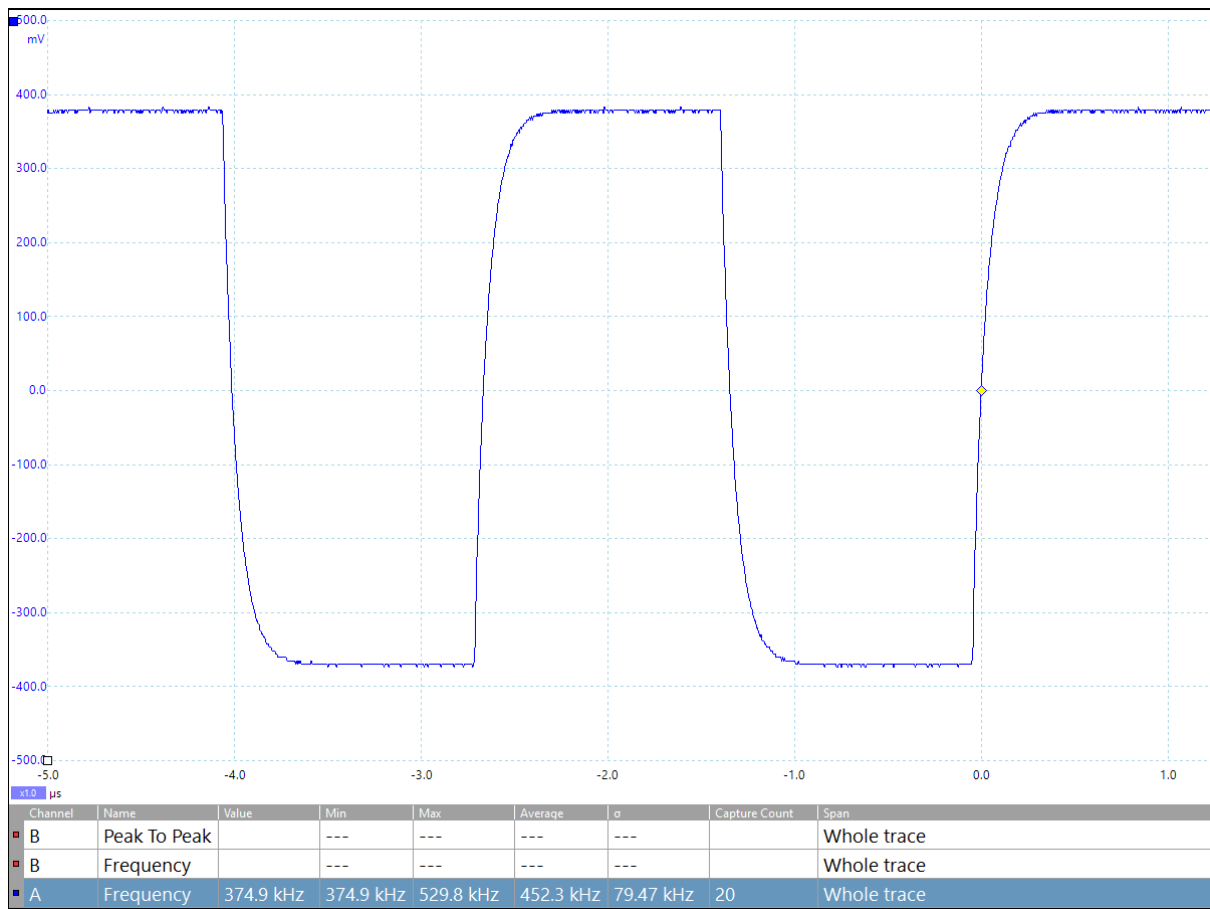
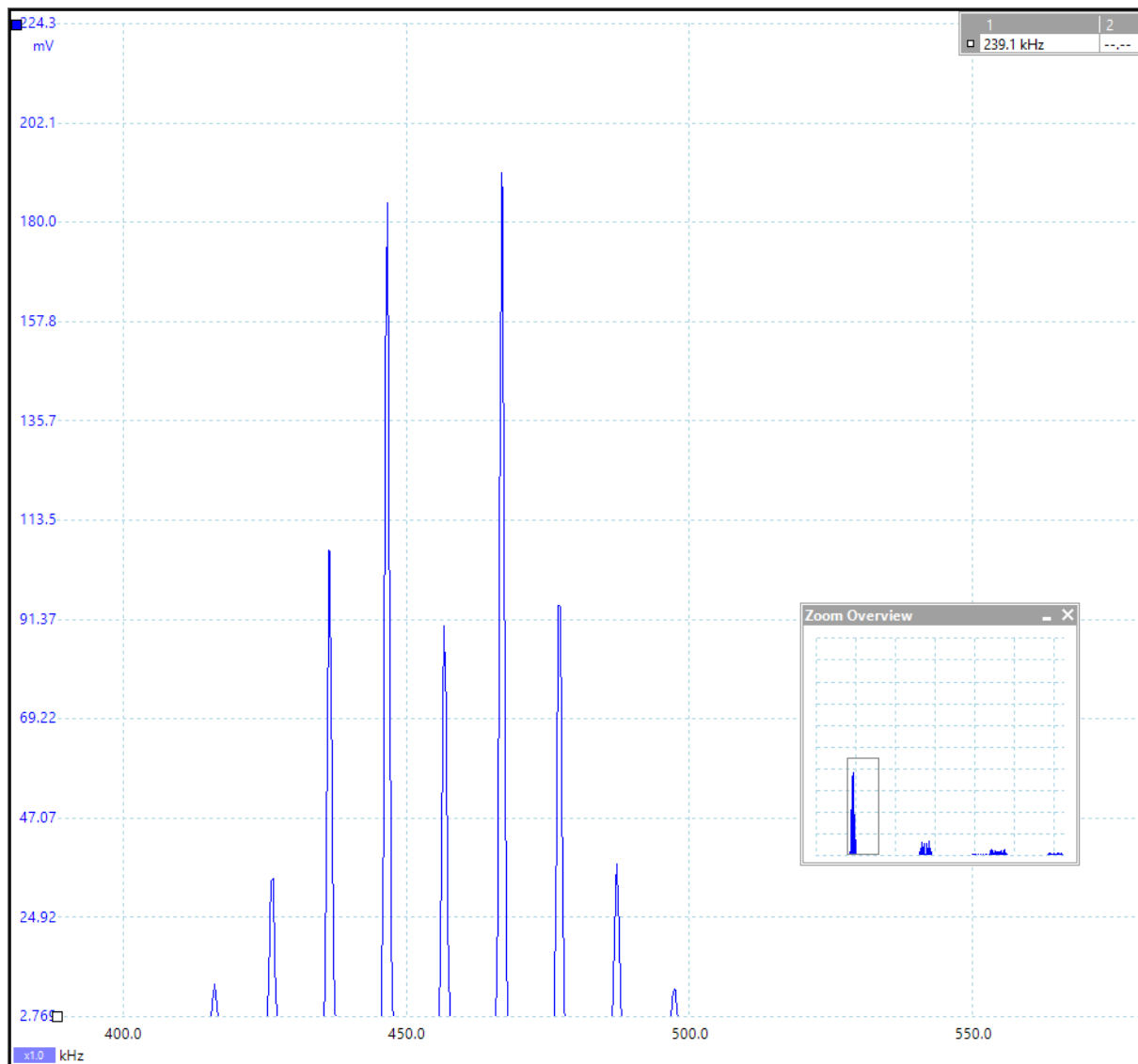


Figure 8 spectrum analyser



Practical Spectrum Analyser Results	
kHz	mV
415	7
425	35
435	110
445	182
455	91
465	190
475	92
485	35
495	7
Bandwidth = 495 – 415 = 80kHz	

@ 415 and 495kHz = 7mV

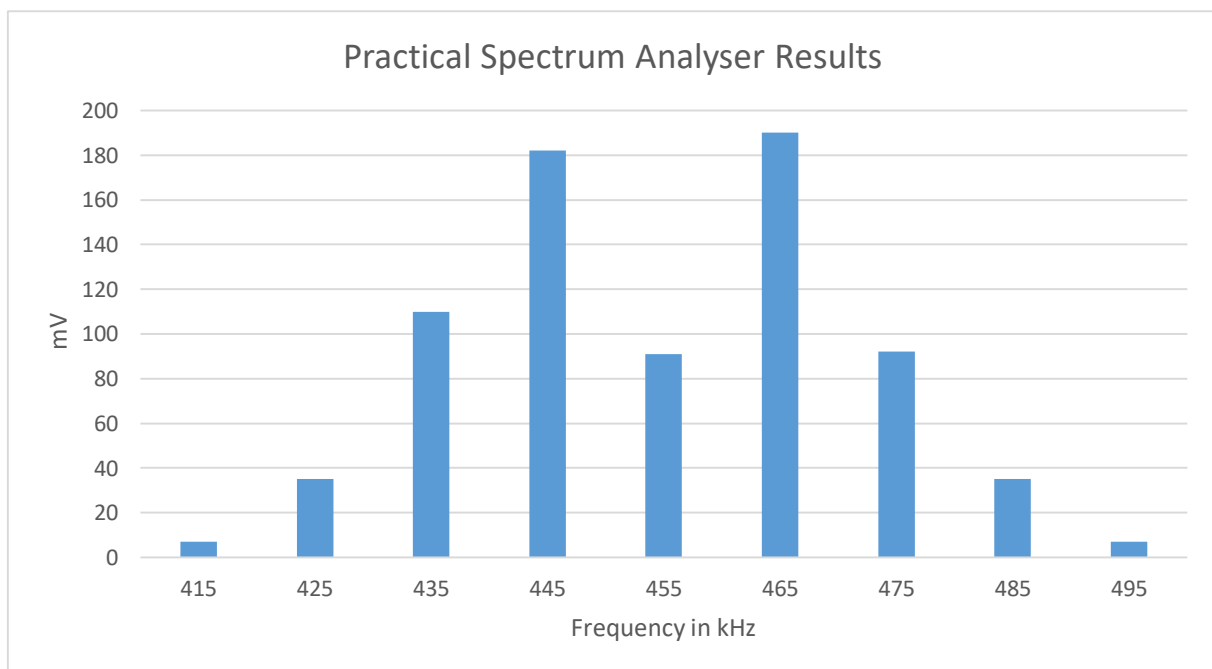
@ 425 and 485kHz = 35mV

@ 435kHz = 110mV and 475kHz = 92mV

@ 445kHz = 182mV and 465kHz = 190mV

@ 455kHz = 91mV

Figure 9

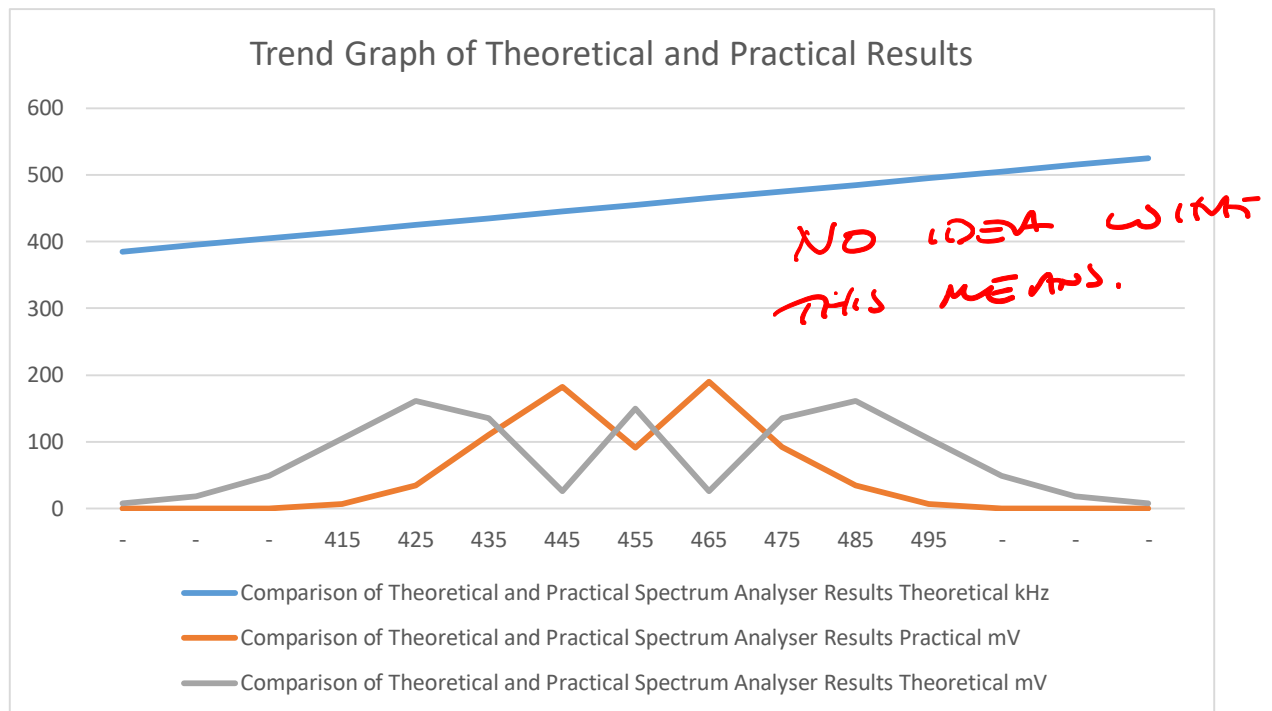


The practical spectrum analyser, figure 9 has a small bandwidth of just 80kHz. The different ranges of frequency have different mV readings, for example, 435Khz has 110mV and 475kHz has 92mV. Theoretically that specific frequency range should have the same mV reading, but this is not the case here, however, they are close. Frequency range 435 and 475kHz are 18mV apart and 445kHz and 465kHz are 8mV out. The other frequency ranges, 415 to 495kHz and 425 to 485kHz are approximately the same. These results are estimations and are not entirely accurate, but rather approximations based on the graph.

Comparison of Theoretical and Practical Spectrum Analyser Results			
Practical	Theoretical	Practical	Theoretical
kHz		mV	
-	385	-	7.5
-	395	-	18.75
-	405	-	48.75
415	415	7	105
425	425	35	161.25
435	435	110	135
445	445	182	26.25
455	455	91	150
465	465	190	26.25
475	475	92	135
485	485	35	161.25
495	495	7	105
-	505	-	48.75
-	515	-	18.75
-	525	-	7.5
Bandwidth			
Practical		Theoretical	
80kHz		140kHz	

SOMETHING WRONG HERE.
 YOUR EXPERIMENT CAN'T
 HAVE BEEN SET UP CORRECTLY.

Figure 10



Based on the comparison results it is clear that the practical and theoretical bandwidths are different. The theoretical bandwidth was nearly double the size to that of the practical spectrum analyser. It is clear that the mV readings of the practical and theoretical results do not match. Throughout the different frequencies the practical and theoretical mV readings are opposing each other. Where the trend lines cross is where the mV match. However, the mV are not out by a wide margin. The theoretical and practical results will never be exactly the same, there will always be discrepancies due to equipment calibration and equipment precision.

5. Experimental method for experiment 2

5.1 The differences in the quality of conversion between 4 and 8 bit convertors.

4 bit converters have 16 levels, it has low accuracy, whereas an 8-bit convertor will have ~~250~~ ²⁵⁶ levels, far better accuracy. The 4-bit ADC will have a resolution of one part in 15, ($2^4 - 1$), where the 8-bit ADC will have a resolution of one part in 255, ($2^8 - 1$). Therefore, an ADC takes an unknown continuous analogue signal and converts it into an 'n' bit binary number of 2^n bits, (Tutorials, n.d.). The accuracy of a converter refers to how many bits, from conversion to conversion, are repeatable, (Tips, n.d.). Figure 11 shows the 8-bit ADC and figure 12 shows the 4-bit ADC, both at 100Hz at 4V peak to peak. The 8-bit ADC shows a more accurate response than the 4-bit ADC. The digital output of the 8-bit ADC is not distorted and is exactly the same to the analogue input signal, whereas the 4-bit ADC, the digital output is distorted. This proves that the 8-bit ADC is more accurate than the 4 bit. This is because the 4 bit only has 16 levels, whereas the 8-bit has 250 levels. The 8-bit binary number is greater than the 4-bit binary number. The more levels, the greater the accuracy.

RESEARCH

5.2 The importance of matching the amplitude of the input signal to the range of an ADC

During this experiment figures 13 -26 show tests carried out on 4 and 8-bit ADC's with the frequency held constant and the amplitude increased from 0V to 6V peak to peak. Firstly, the 4-bit ADC, figures 13 to 19. Figure 13 shows a ADC sine wave at 100Hz and a 0V peak to peak there is no digital output. Figure 14 shows the ADC sine wave with 1V peak to peak. The area between the red digital steps and the blue line indicates an amount of distortion of the original signal. By using more steps, or digital values and bits, it is possible to reduce the distortion and the digital copy gets closer to representing the true signal. Figure 14 does display a fair amount of distortion to that of the original signal. Figure 15 shows the ADC at 2V peak to peak and the distortion has decreased from that of the 1V. Figure 16 shows the ADC at 3V peak to peak and the distortion has decreased from that of the 2V. Figure 17 shows the ADC at 4V peak to peak and there is a very good digital output, nearly identical to that of the original signal. Figure 18 shows the ADC at 5V peak to peak and the digital output has not changed much. Figure 19 shows the ADC at 6V peak to peak and the digital output is worse, it is not reaching the 6V peak to peak range. The ideal result was the 4V peak to peak. The 4-bit only has a maximum of 16 levels. The maximum number a 4-bit binary number can represent is 15. These levels are then divided between 0-6V peak to peak. Due to the ADC only being 4-bits it has a lower accuracy to that of an 8-bit, so the digital output signal will never match the analogue input signal perfectly. There needs to be more steps. The best results were obtained when the 4-bit and 8-bit ADC were at an amplitude of 4V peak to peak, as seen in figures 17 and 24. This is where the digital output matches the analogue input signal best, this is why the amplitude is important.

4-bit ADC Resolution Response		
V peak to peak range	Resolution	Figure
0V	+/- 200mV	13
1V	+/- 1V	14
2V	+/- 2V	15
3V	+/-2V	16
4V	+/-5V	17
5V	+/-5V	18
6V	+/-5V	19

The table above shows that as the voltage is reaching 4V the resolution increases.

Secondly, the 8-bit ADC, figures 20-26. Figure 20 shows that at 0V there is no output as was seen in figure 13. Figures 21 to 24 shows that as the peak voltage is drawing to 4V, the digital output is exactly the same or very close to the analogue input. This shows that the analogue signal coming in is the same to the digital output, which is the ideal. The 8-bit ADC is far more accurate than the 4-bit, so that as why the 4-bit ADC even at 4V, the digital output was distorted. As was seen in the 4-bit ADC and as figures 18 to 19 and 25 to 26, when the voltage exceeds 4V, the digital response starts to level off at the top and bottom of the sine wave.

5.3 Why the relationship between the input signal frequency and the sampling rate of the ADC is important and consequently investigate the validity of the Nyquist Criterion.

To demonstrate this, an experiment was carried out on an 8-bit ADC at 4V peak to peak. Three frequency decades were measured at 100Hz, 1kHz and 10kHz. Figure 27 shows the 100Hz frequency response and the output frequency matches the input frequency of 100Hz, so the analogue input and digital output are the same at 4V peak to peak. It is sampling a full sine wave at every 12.5ms. This is a perfect response. Figure 28 shows the frequency at 1kHz. Due to the frequency being 10 times the amount, it is sampling every 2.5ms, again the digital output matches the analogue input. Figure 29 shows the frequency at 10kHz. The generator can only record frequencies up to 10kHz. Any higher than that the readings don't correspond. This is what we see in figure 29. The input frequency is 10kHz, but the output frequency is 259.2Hz. The ADC is 10,000 samples a second.

Sampling		
Input Frequency	Output Frequency	Figure
100Hz	100Hz	27
1kHz	1kHz	28
10kHz	259.2Hz	29

*You need to show more results,
especially between 4 and 6 kHz.*

In the experiment, the generator was set to 4kHz and the frequency was increased to 6kHz in 200Hz steps and then increased at 1kHz steps to 10kHz, see figures 30-44.

ADC is 10,000 samples/second. Sampling at twice the input frequencies, 5kHz is the maximum sample rate in 10,000 samples/second because $5\text{kHz} \times 2 = 10,000$. After 5kHz, e.g. 6kHz the input does not correspond to the output. The table below shows the theoretical results to prove this and the 'Frequency sampling test' table, which shows the results from figures 30-44 also prove this theory. After an input of 5kHz the output frequency does not correspond.

Sampling Theorem	
Input	Output
1kHz	1kHz
2kHz	2kHz
3kHz	3kHz
4kHz	4kHz
4.2kHz	4.1kHz
4.4kHz	4.3kHz
4.6kHz	4.4kHz
4.8kHz	4.7kHz
5kHz	4.8kHz
6kHz	2kHz

WHY 2 TABLES?



Frequency Sampling Test		
Figure Number	Input Frequency	Output Frequency
30	4kHz	5kHz
31	4.2kHz	4.2kHz
32	4.4kHz	4.3kHz
33	4.6kHz	4.3kHz
34	4.8kHz	5kHz
35	5kHz	5kHz
36	5.2kHz	5kHz
37	5.4kHz	5kHz
38	5.6kHz	4.3kHz
39	5.8kHz	4.3kHz
40	6kHz	4kHz
41	7kHz	3kHz
42	8kHz	No Frequency
43	9kHz	No Frequency
44	10kHz	259.2Hz

The table shows that as the frequency exceeds 5kHz, according to the Nyquist Criterion rule, a continuous analogue signal is sampled at discrete intervals, $t_s = 1/f_s$, which must be chosen to ensure an accurate representation of the original analogue signal. It is clear that the more samples taken, the faster sampling rates the more accurate the digital representation, (Kester, n.d.). See figure 54 for an example of Nyquist Criterion. From 4kHz to 5kHz there is a very accurate representation of the original analogue signal. Nyquist criteria is defined as a graphical technique used in control engineering for determining the stability of a dynamic system. When the frequency rises above 5kHz the frequency response becomes unstable, but between 4kHz to 5kHz there is a stable response.

6. Testing, results and analysis experiment 2

Figure 11 8-bit ADC at 100Hz at 4V peak to peak

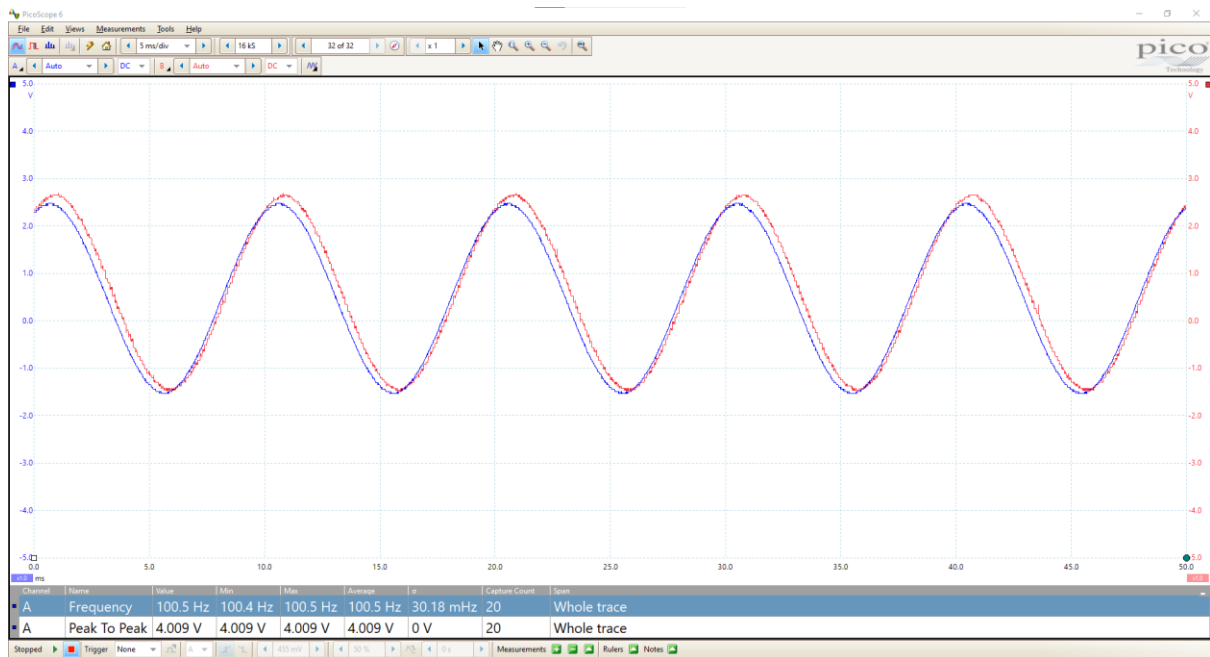


Figure 12 4-bit ADC at 100Hz at 4V peak to peak

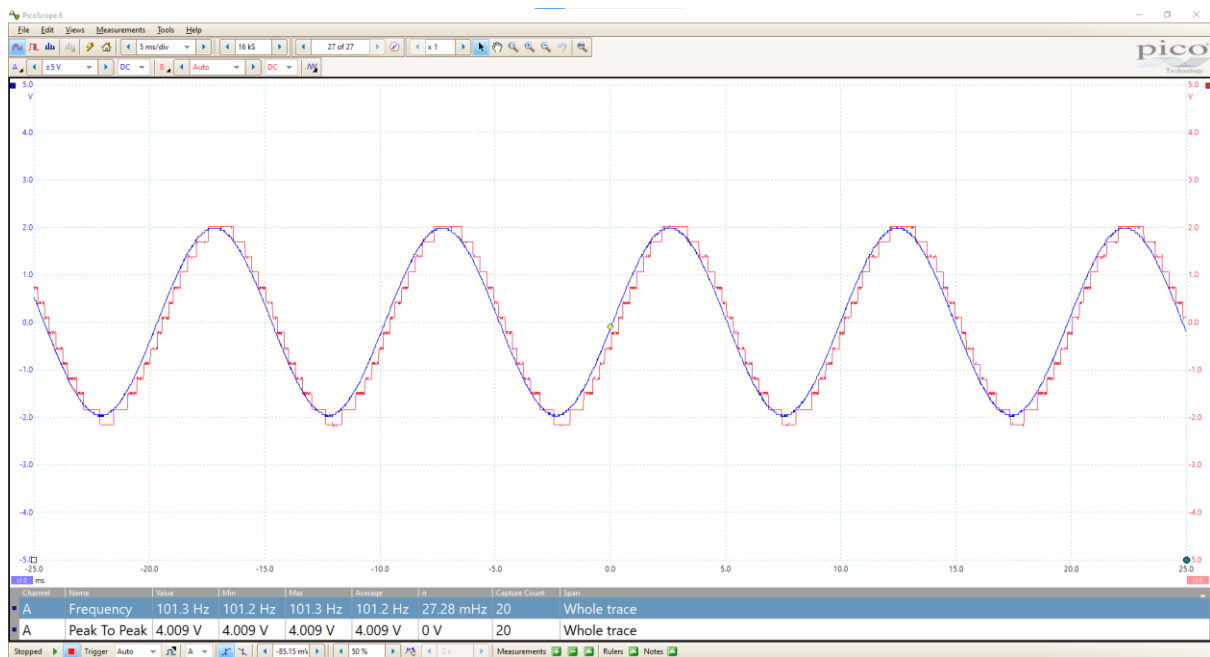


Figure 13 4-bit ADC at 100Hz at 0V peak to peak.

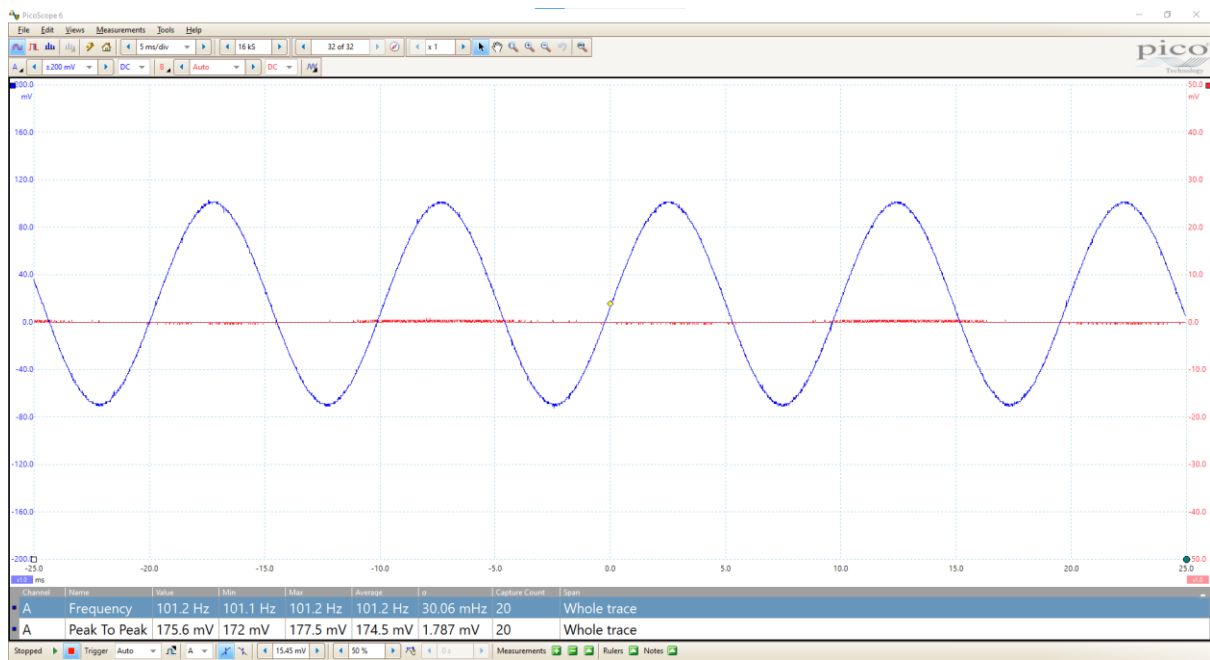


Figure 14 4-bit ADC at 100Hz at 1V peak to peak

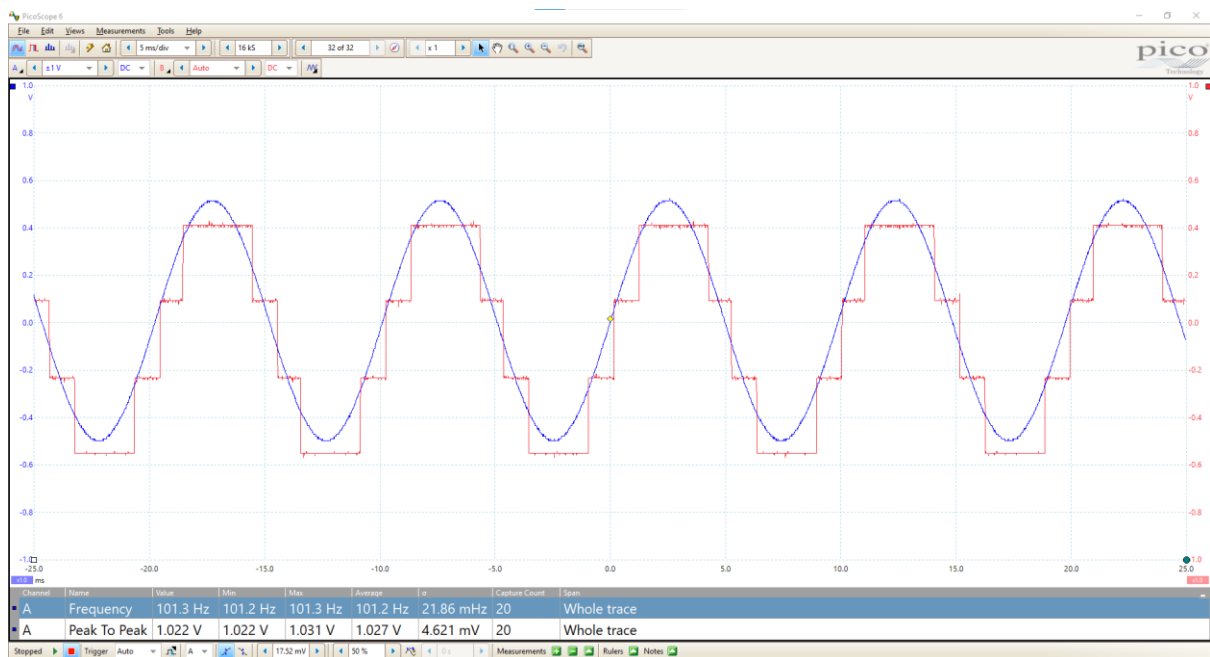


Figure 15 4-bit ADC at 100Hz at 2V peak to peak

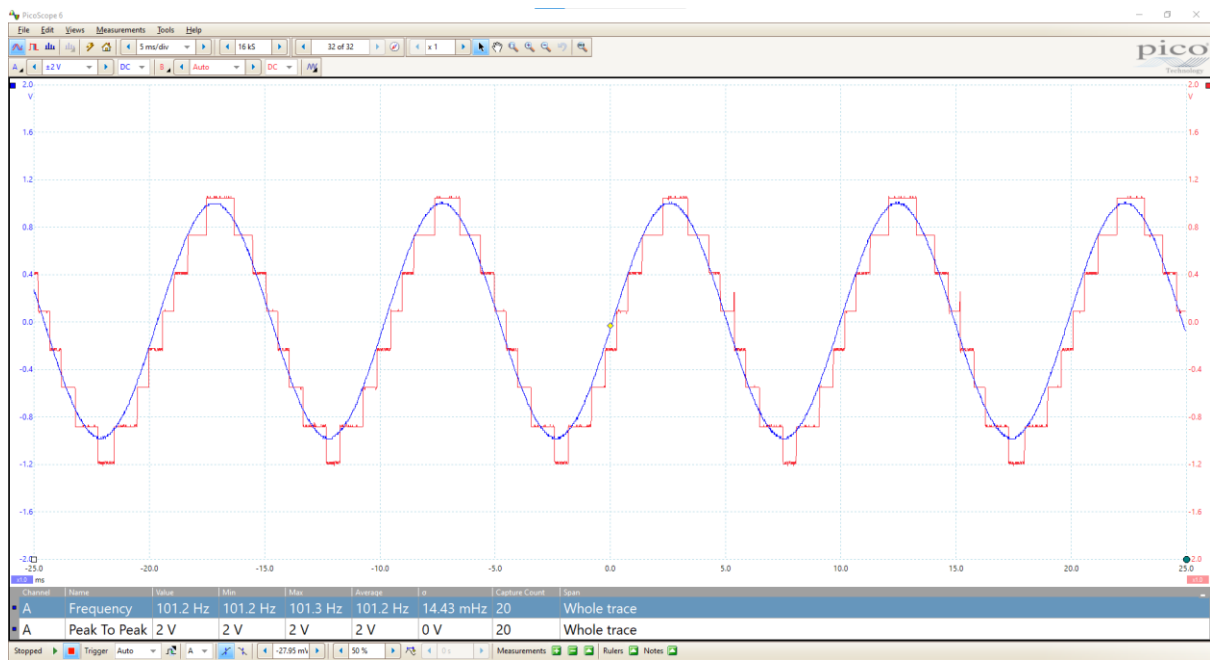


Figure 16 4-bit ADC at 100Hz at 3V peak to peak

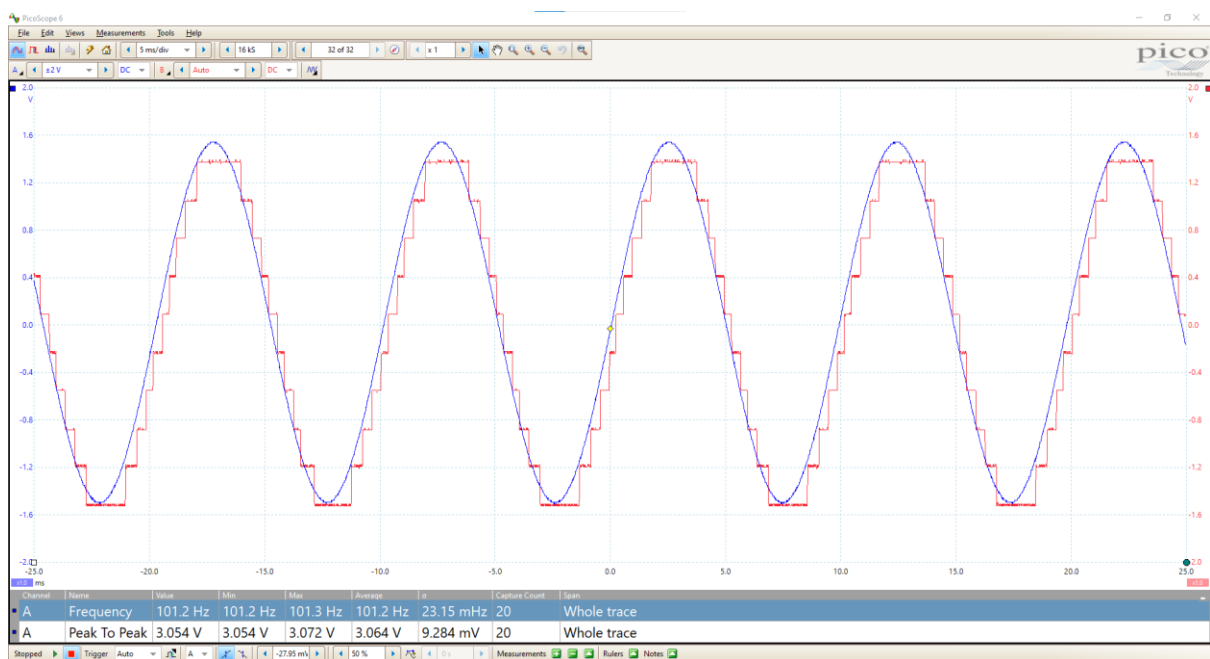


Figure 17 4-bit ADC at 100Hz at 4V peak to peak

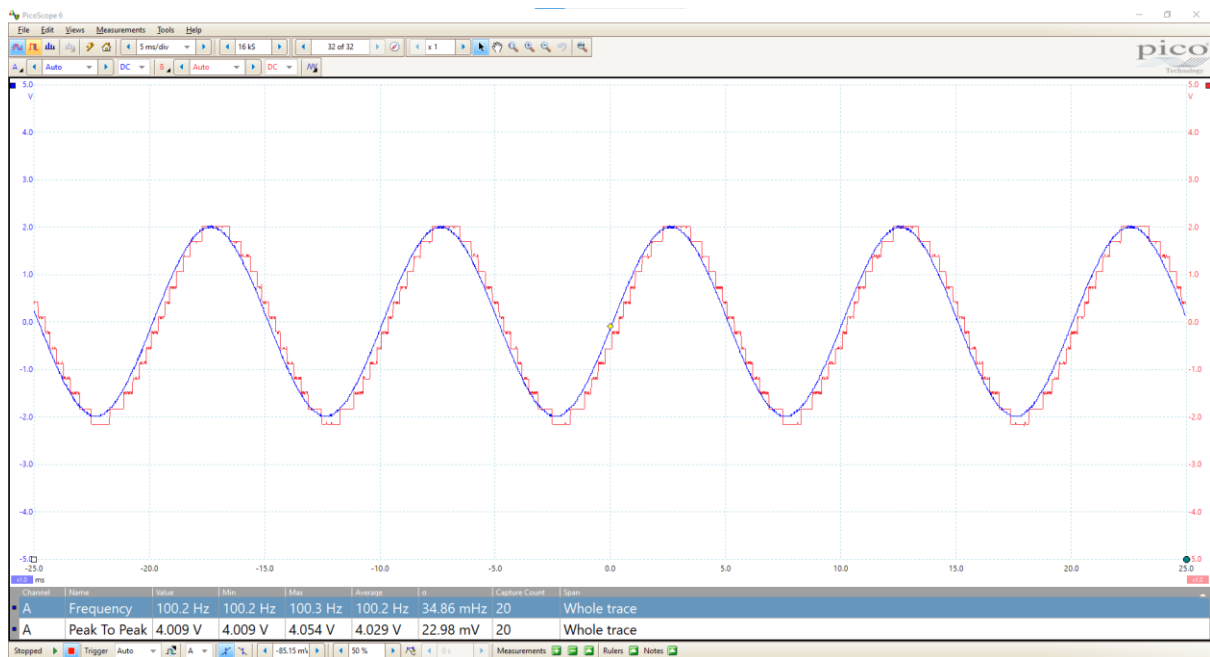


Figure 18 4-bit ADC at 100Hz at 5V peak to peak

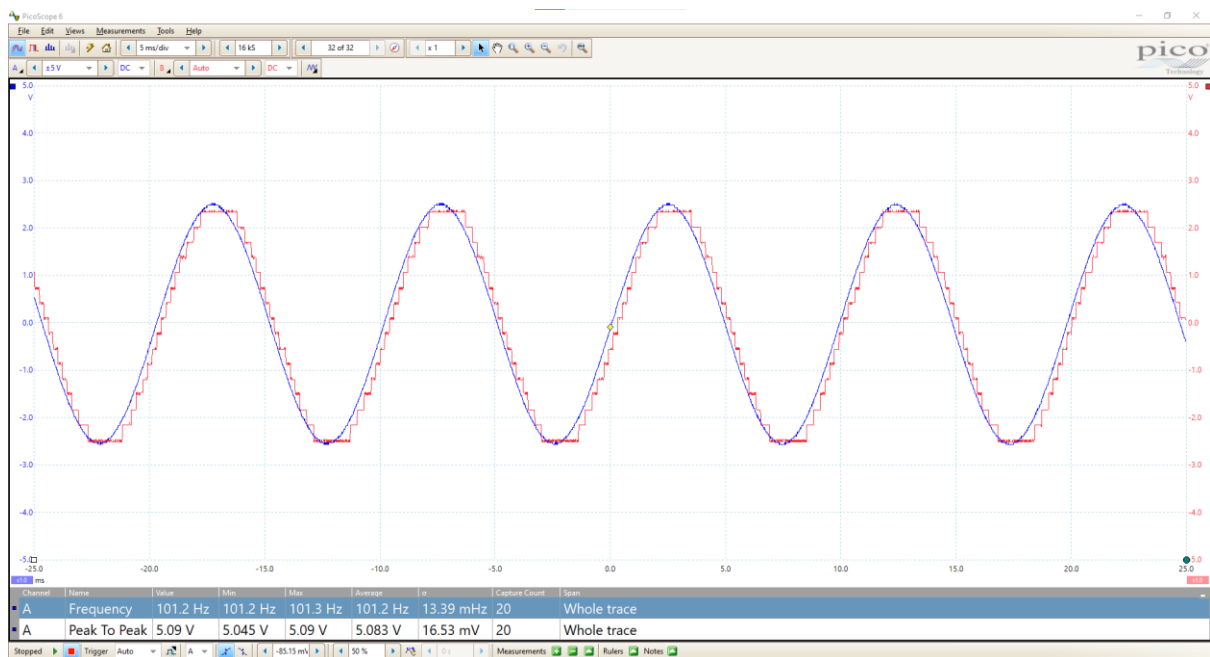


Figure 19 4-bit ADC at 100Hz at 6V peak to peak

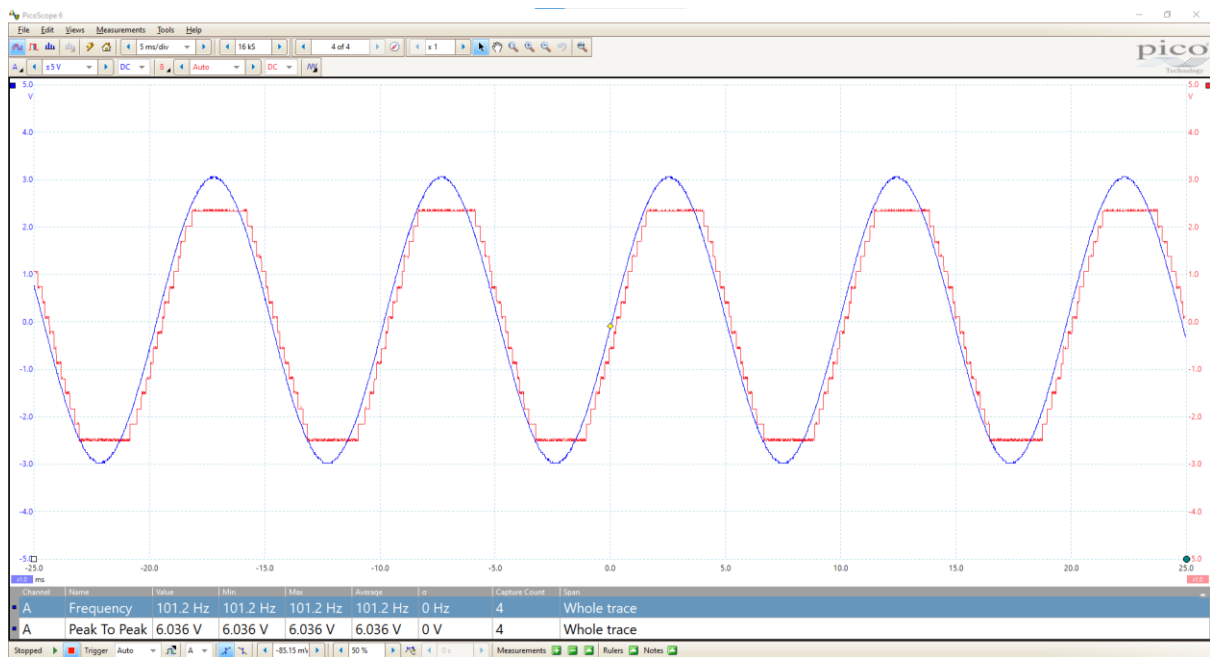


Figure 20 8-bit ADC at 100Hz at 0V peak to peak

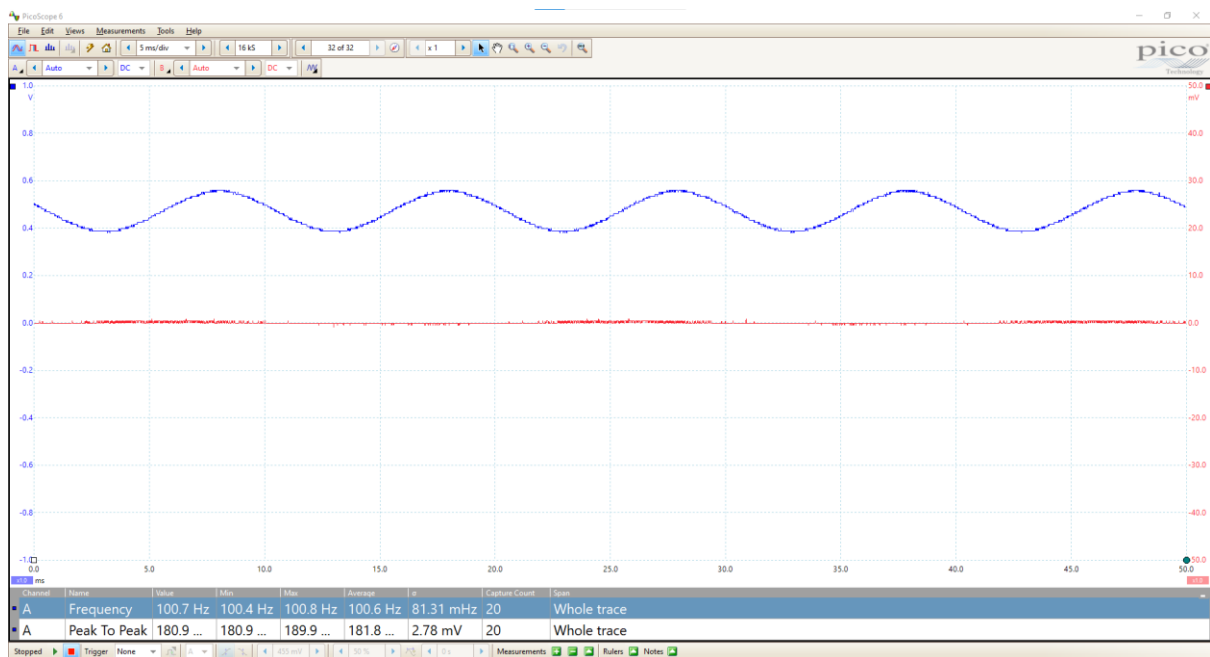


Figure 21 8-bit ADC at 100Hz at 1V peak to peak

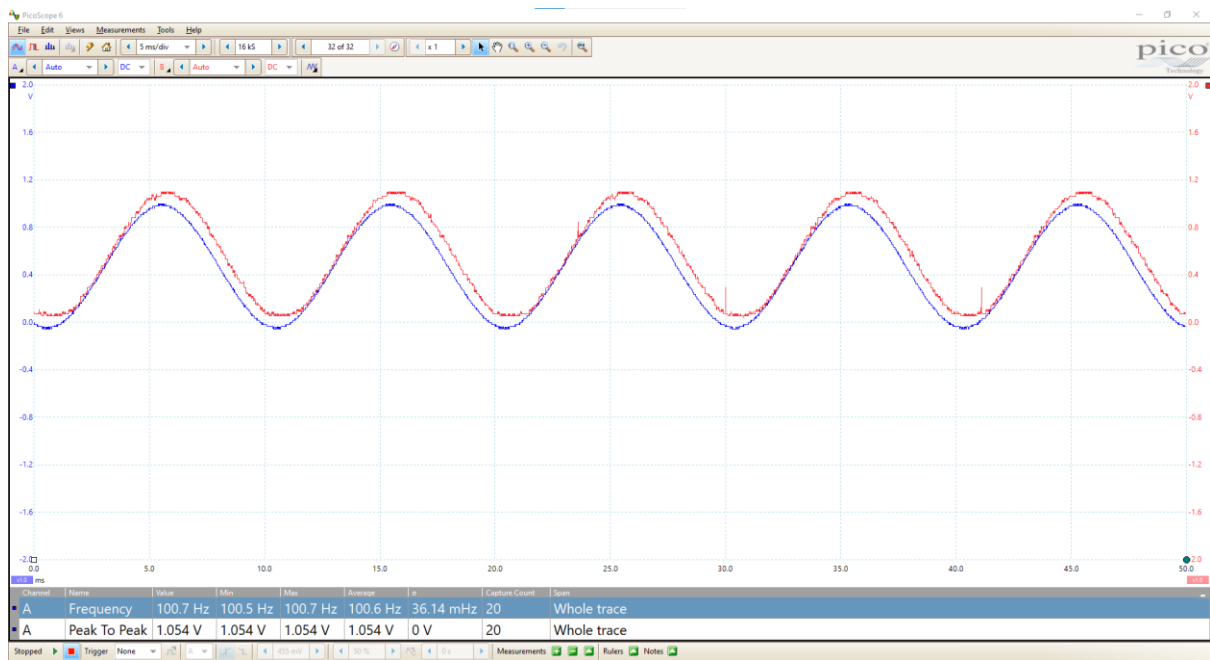


Figure 22 8-bit ADC at 100Hz at 2V peak to peak

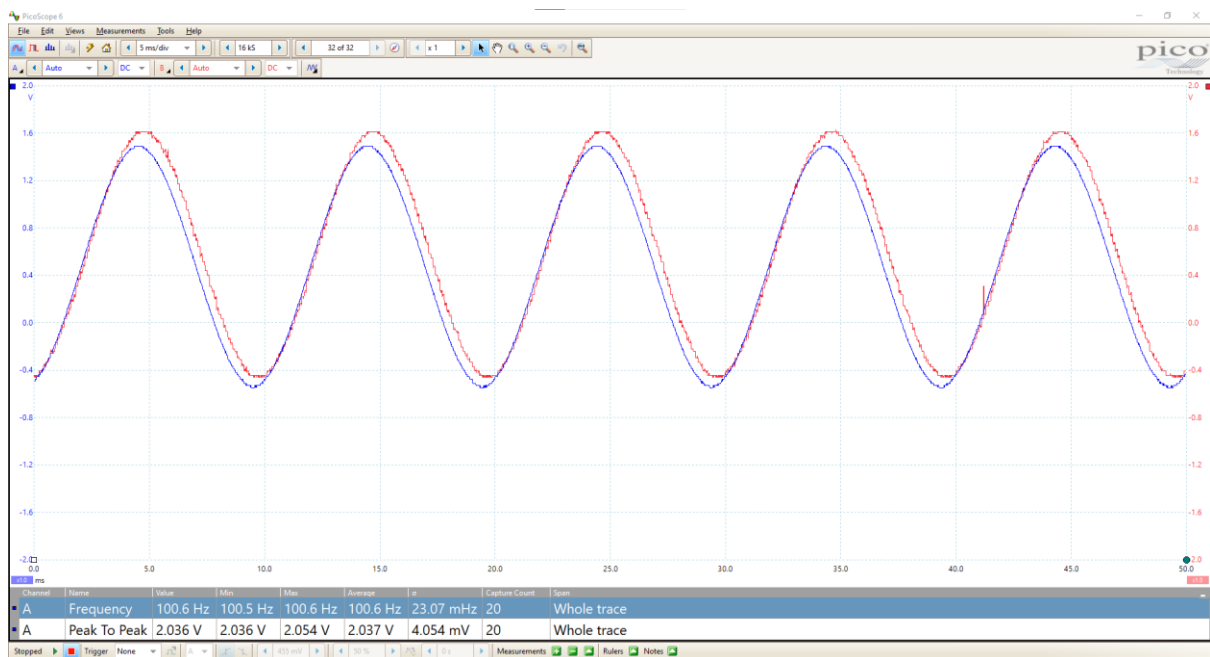


Figure 23 8-bit ADC at 100Hz at 3V peak to peak

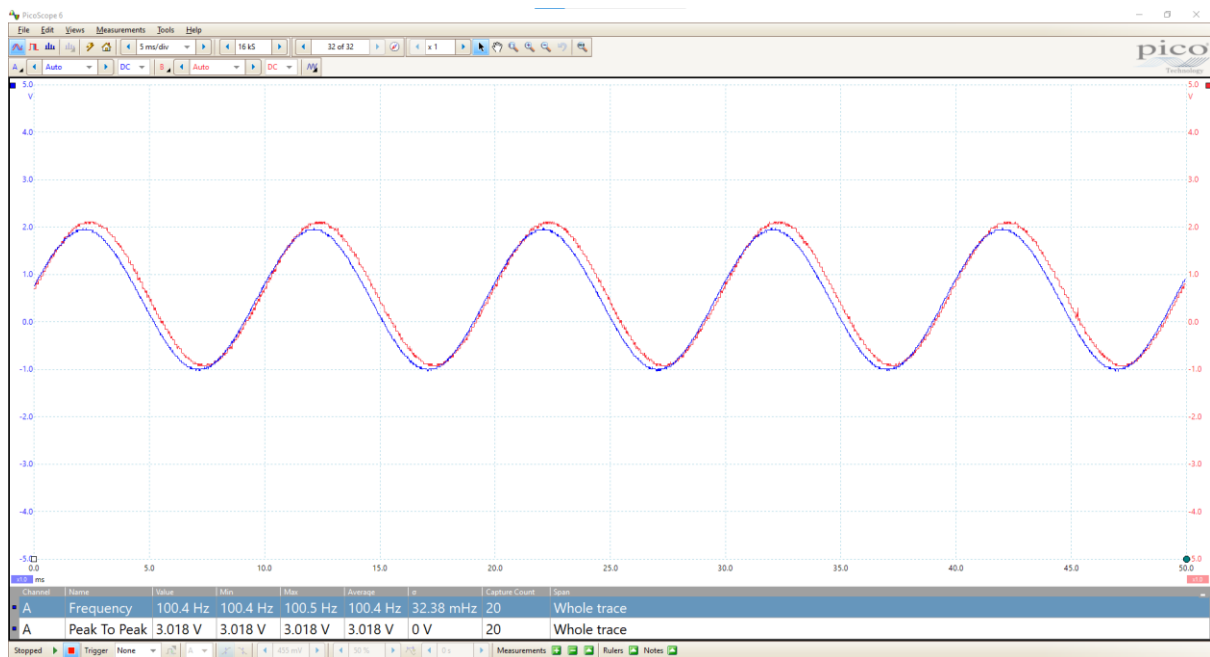


Figure 24 8-bit ADC at 100Hz at 4V peak to peak

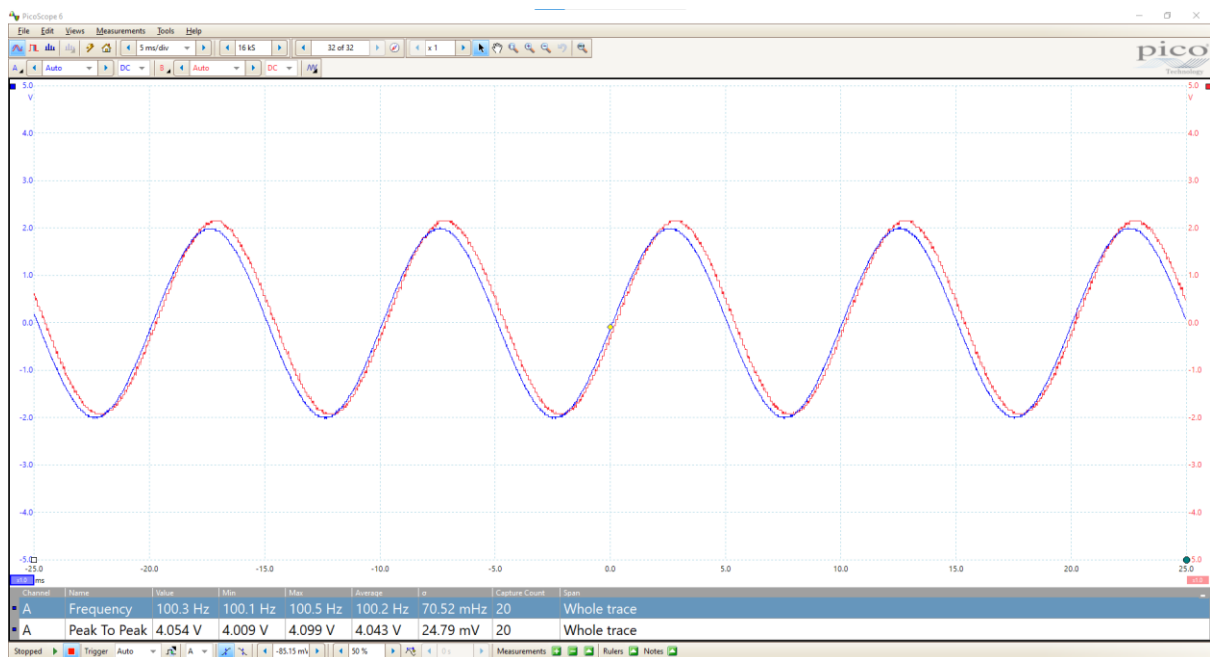


Figure 25 8-bit ADC at 100Hz at 5V peak to peak

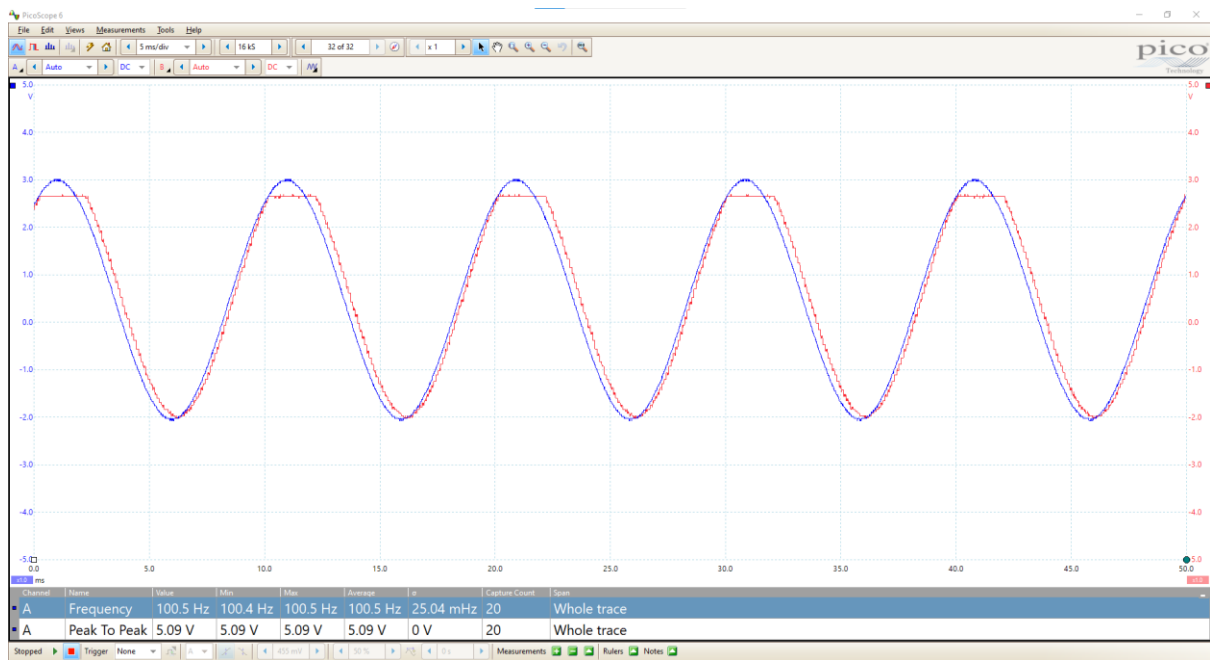


Figure 26 8-bit ADC at 100Hz at 6V peak to peak

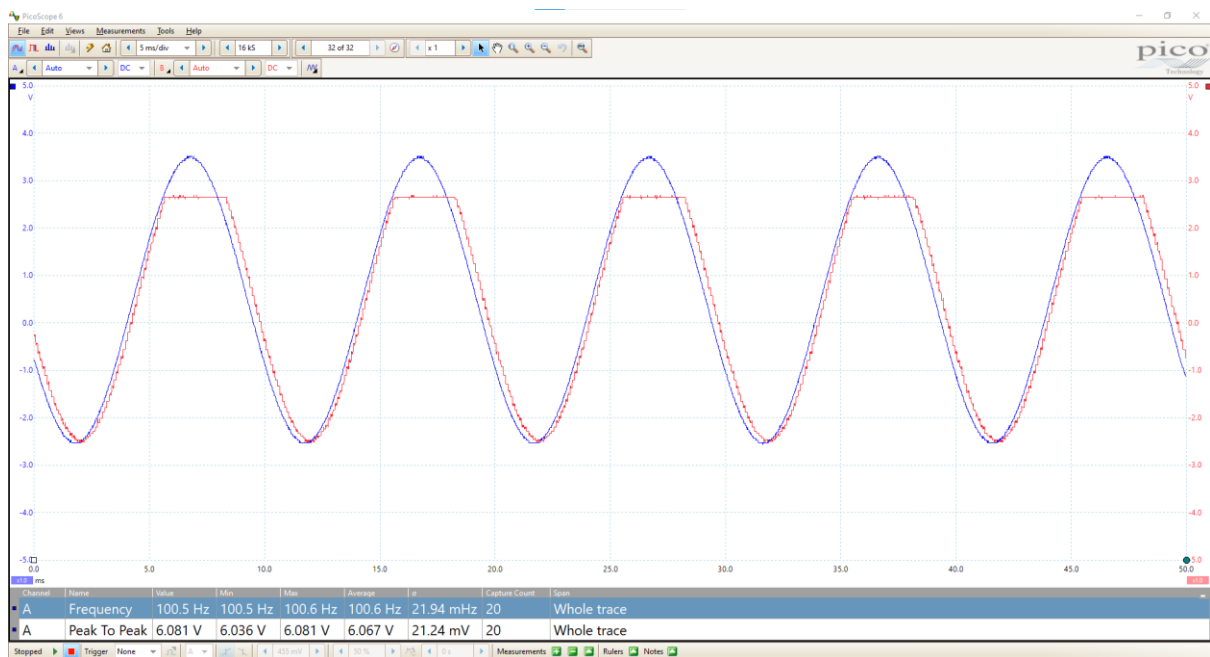


Figure 27 8-bit ADC at 100Hz at 4V peak to peak, 1st decade

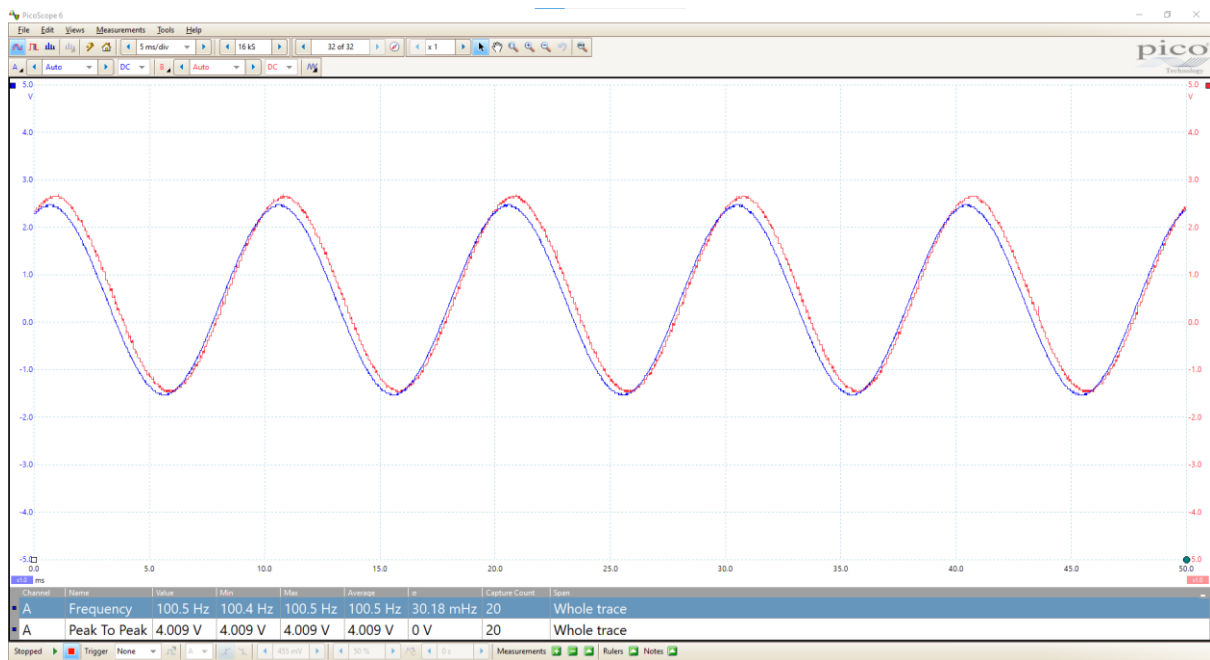


Figure 28 8-bit ADC at 1kHz at 4V peak to peak, 2nd decade

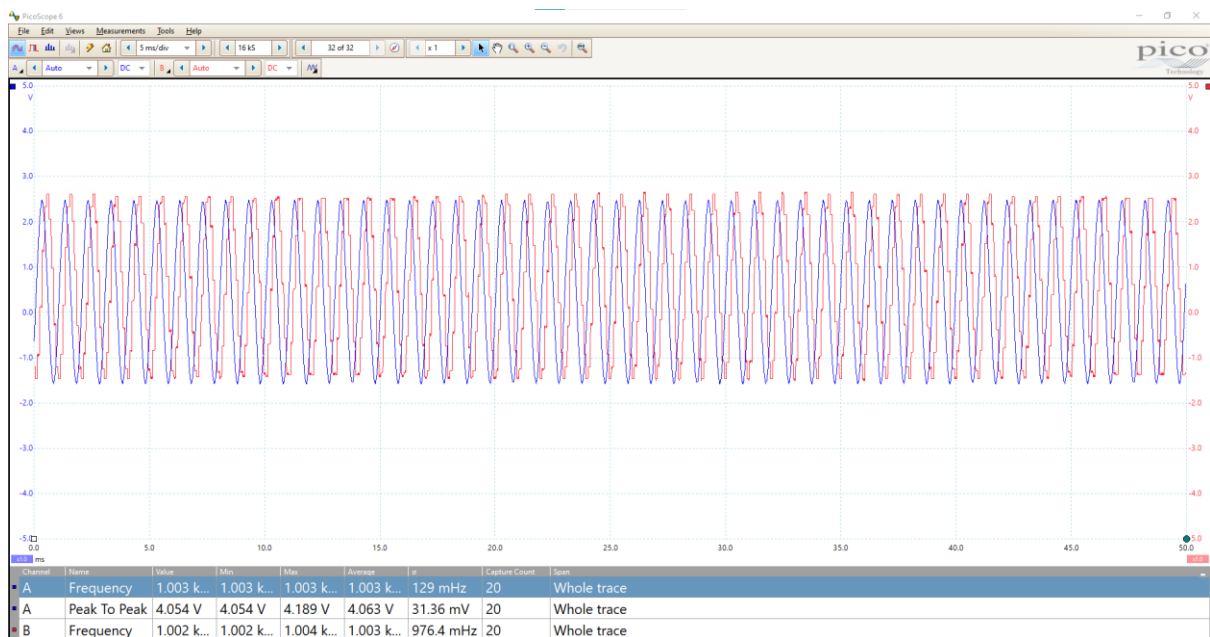


Figure 29 8-bit ADC at 10kHz at 4V peak to peak, 3rd decade

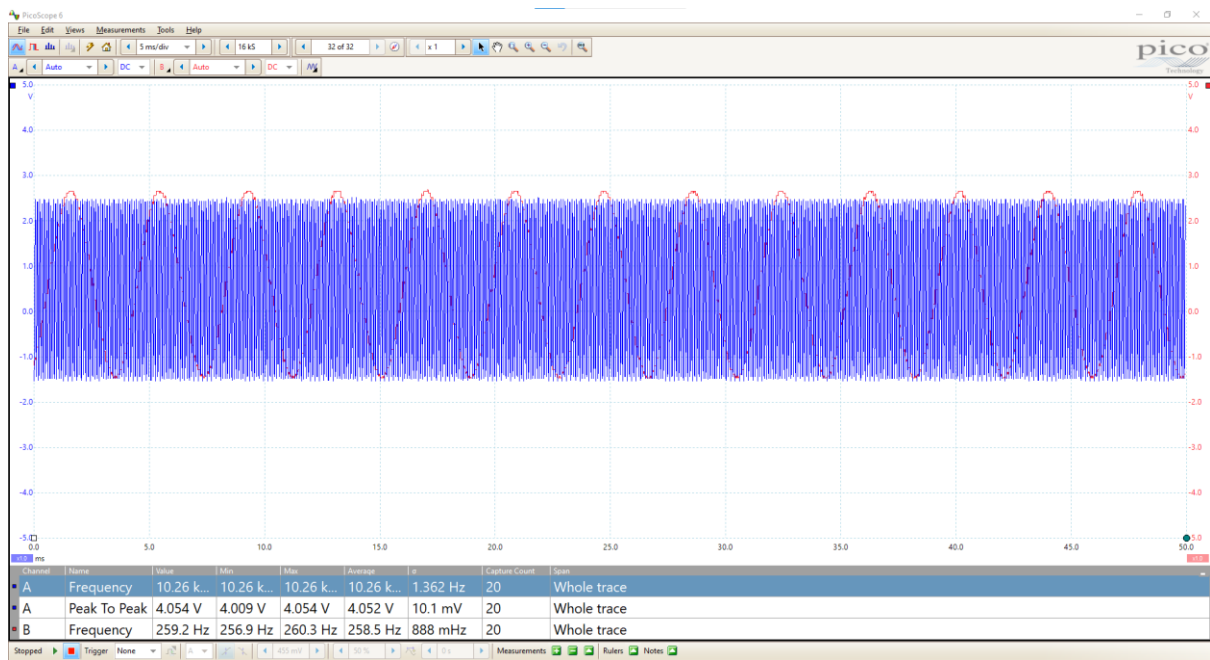


Figure 30 8-bit ADC at 4kHz at 4V peak to peak.

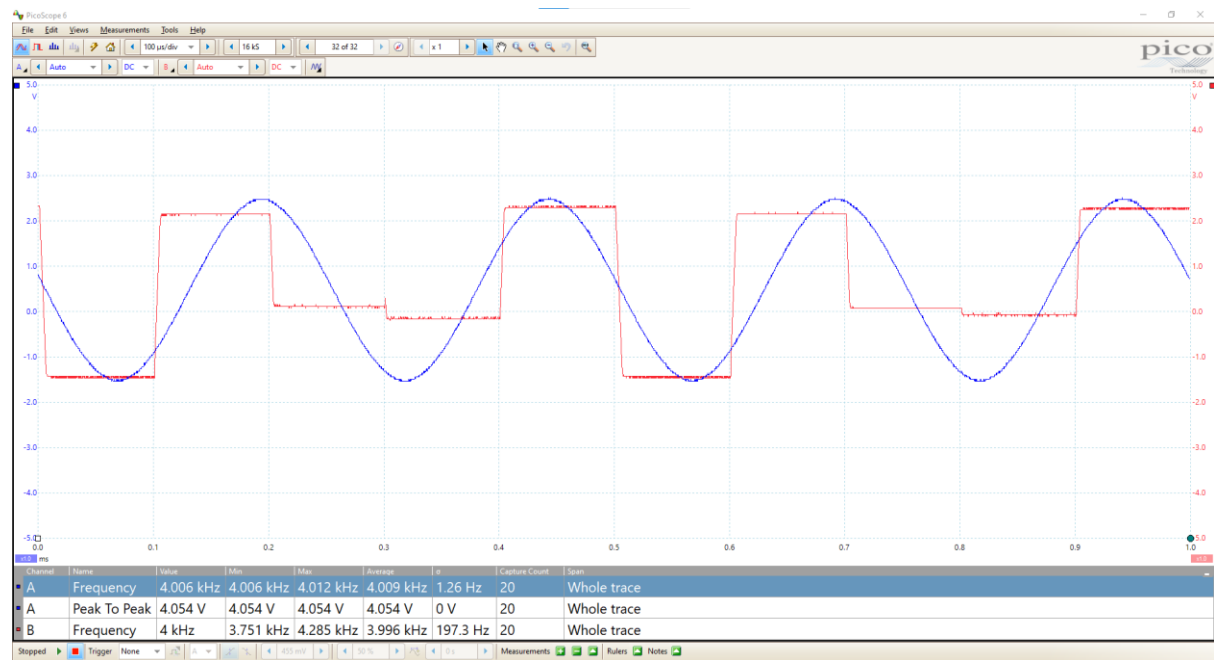


Figure 31 8-bit ADC at 4.2kHz at 4V peak to peak.

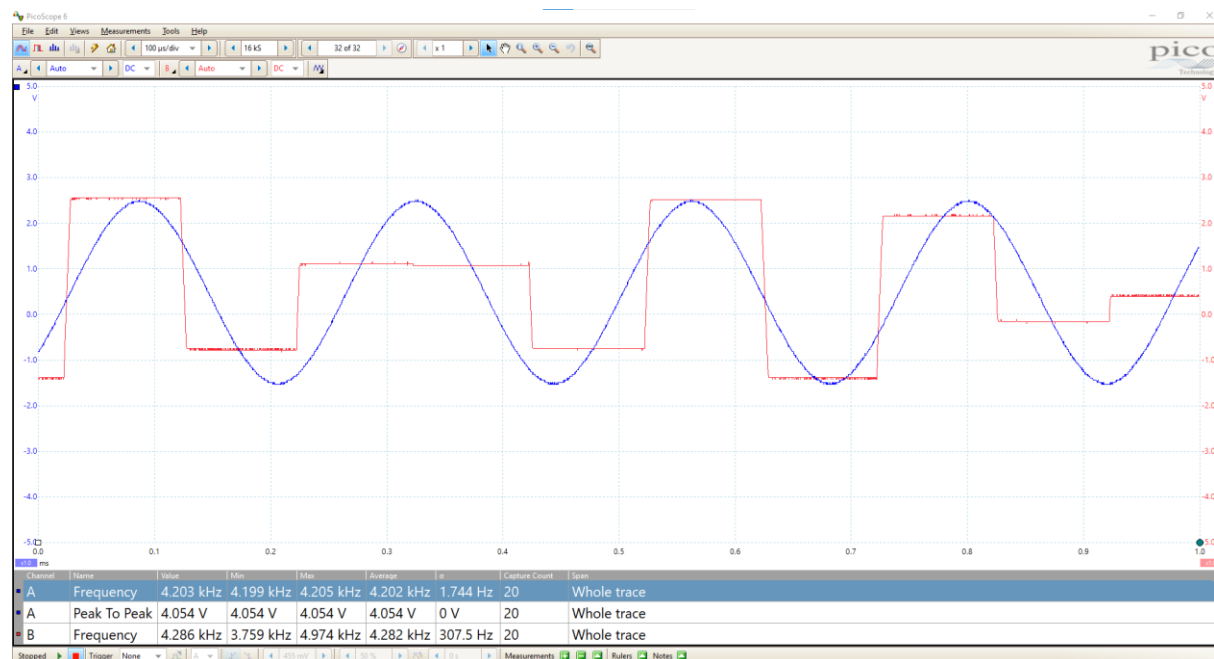


Figure 32 8-bit ADC at 4.4kHz at 4V peak to peak.

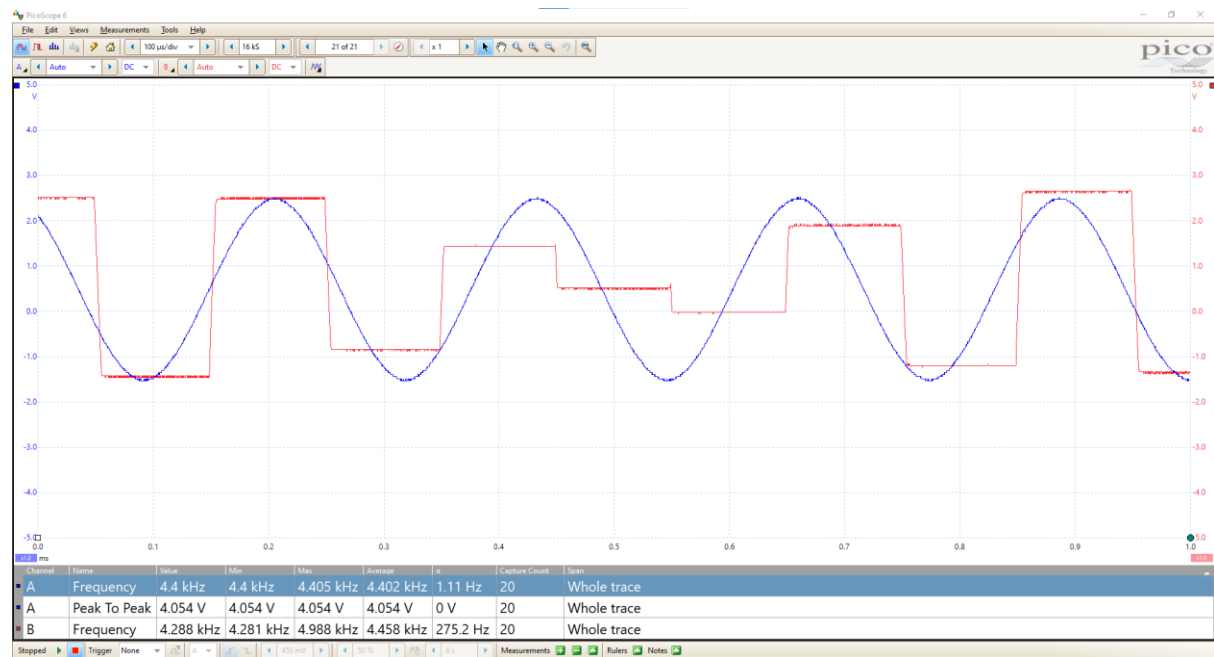


Figure 33 8-bit ADC at 4.6kHz at 4V peak to peak.

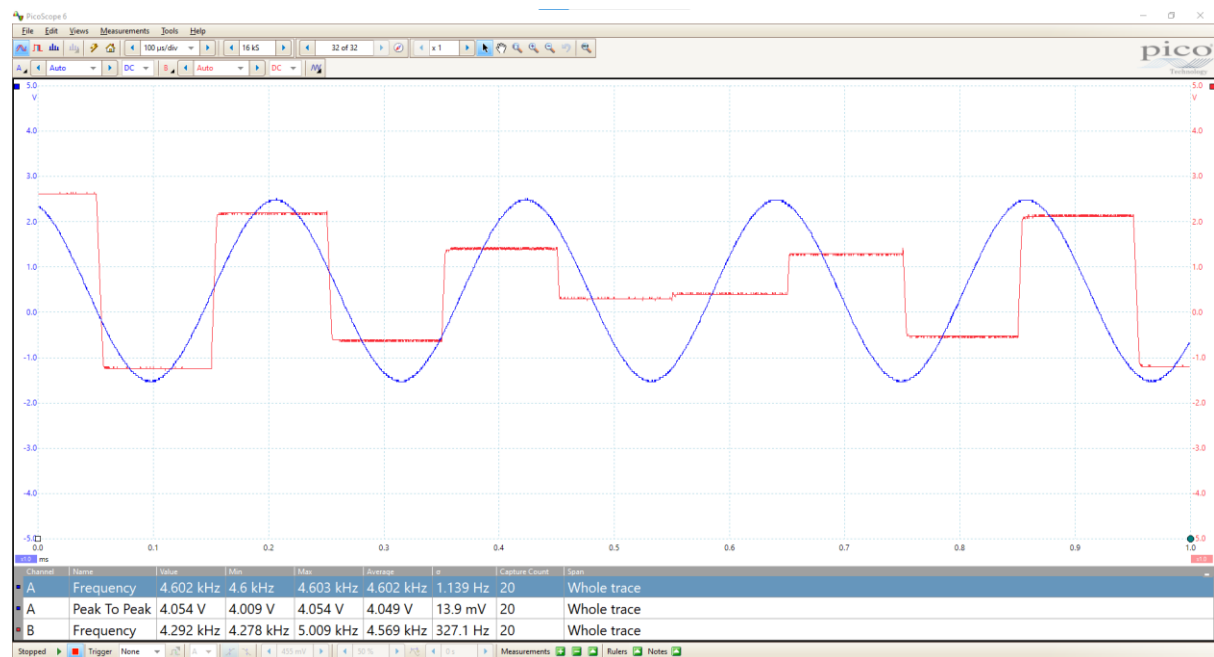


Figure 34 8-bit ADC at 4.8kHz at 4V peak to peak.

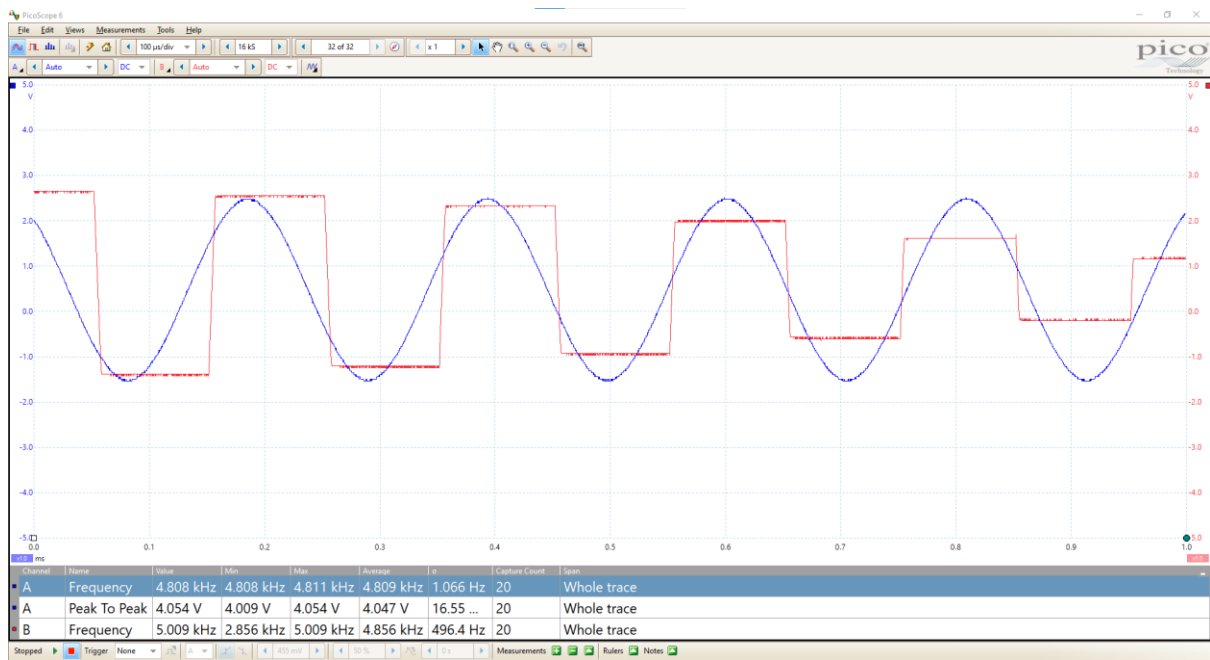


Figure 35 8-bit ADC at 5kHz at 4V peak to peak.

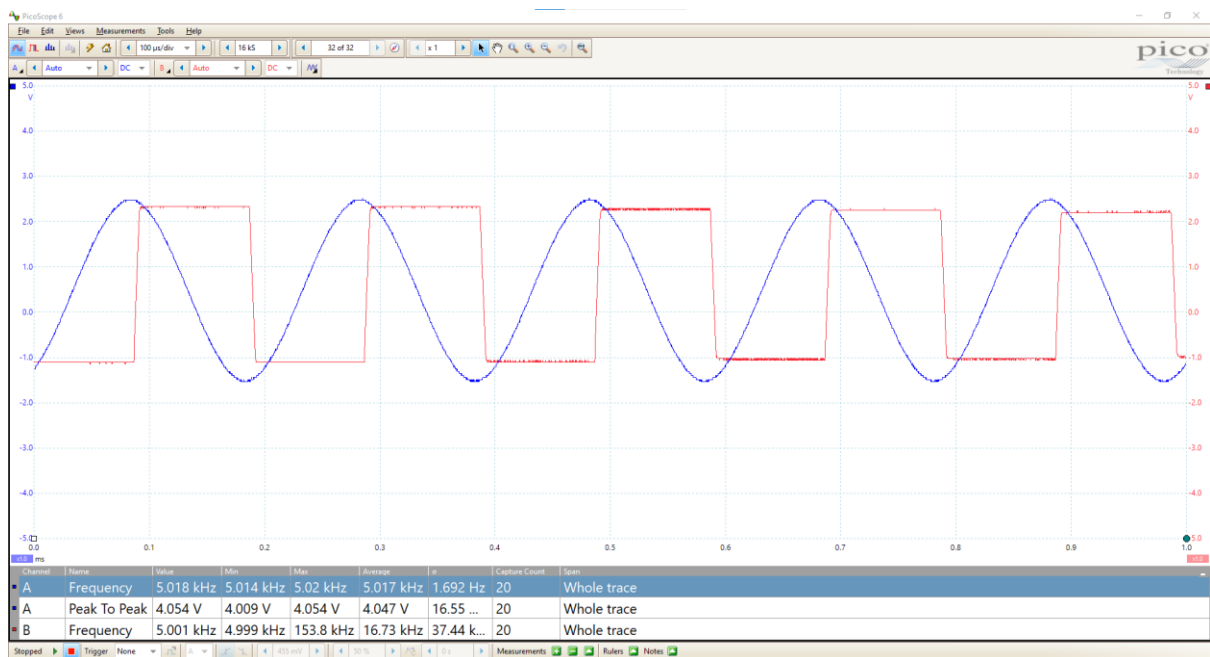


Figure 36 8-bit ADC at 5.2kHz at 4V peak to peak.

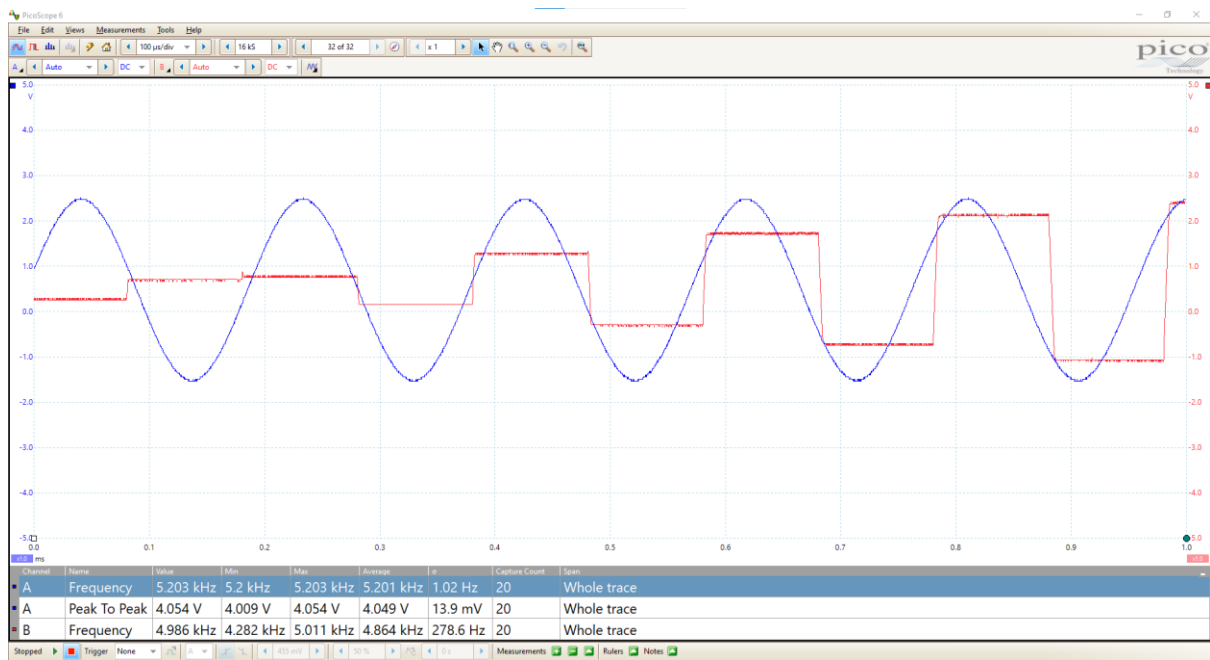


Figure 37 8-bit ADC at 5.4kHz at 4V peak to peak.

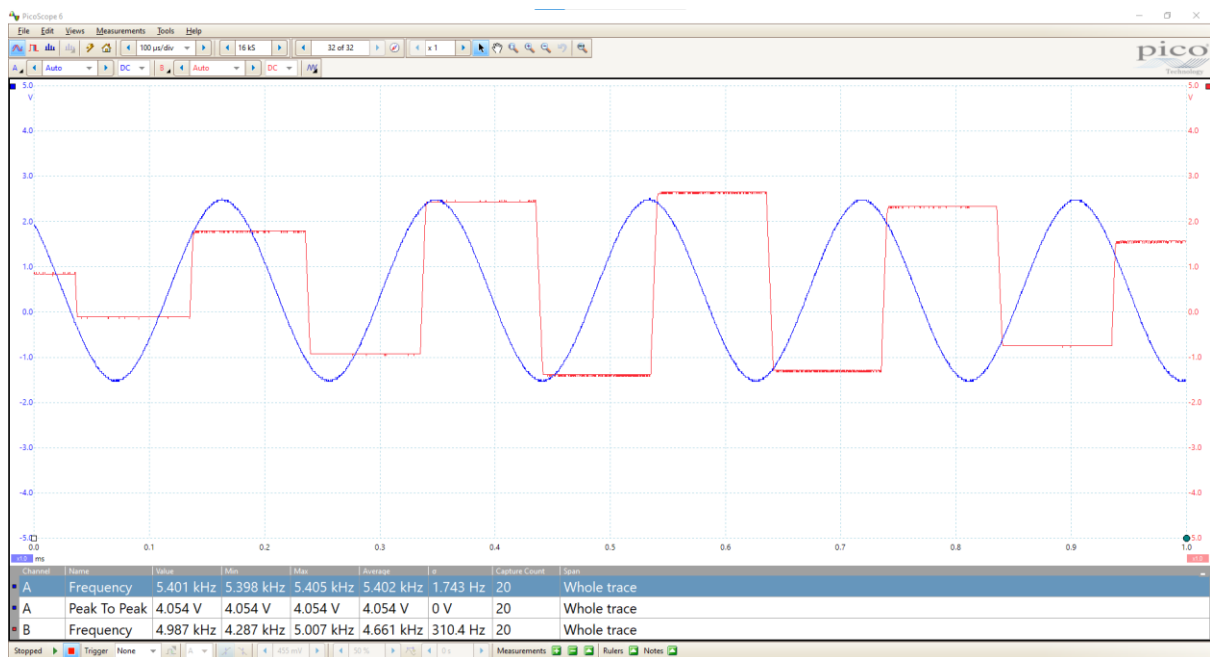


Figure 38 8-bit ADC at 5.6kHz at 4V peak to peak.

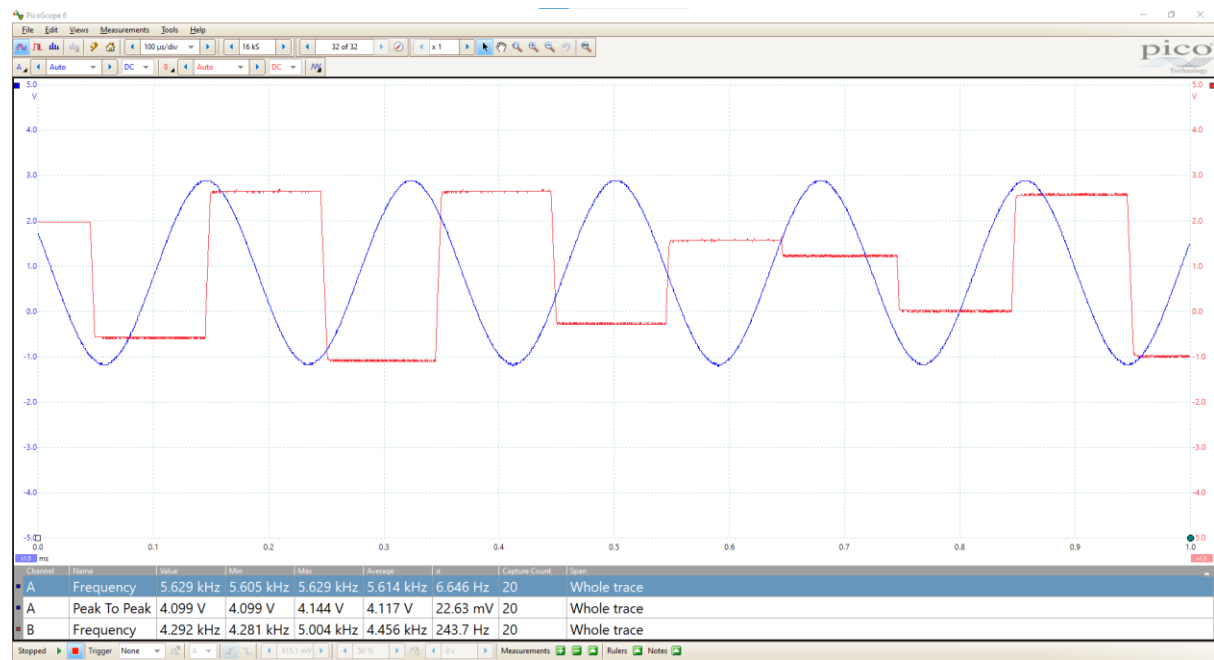


Figure 39 8-bit ADC at 5.8kHz at 4V peak to peak.

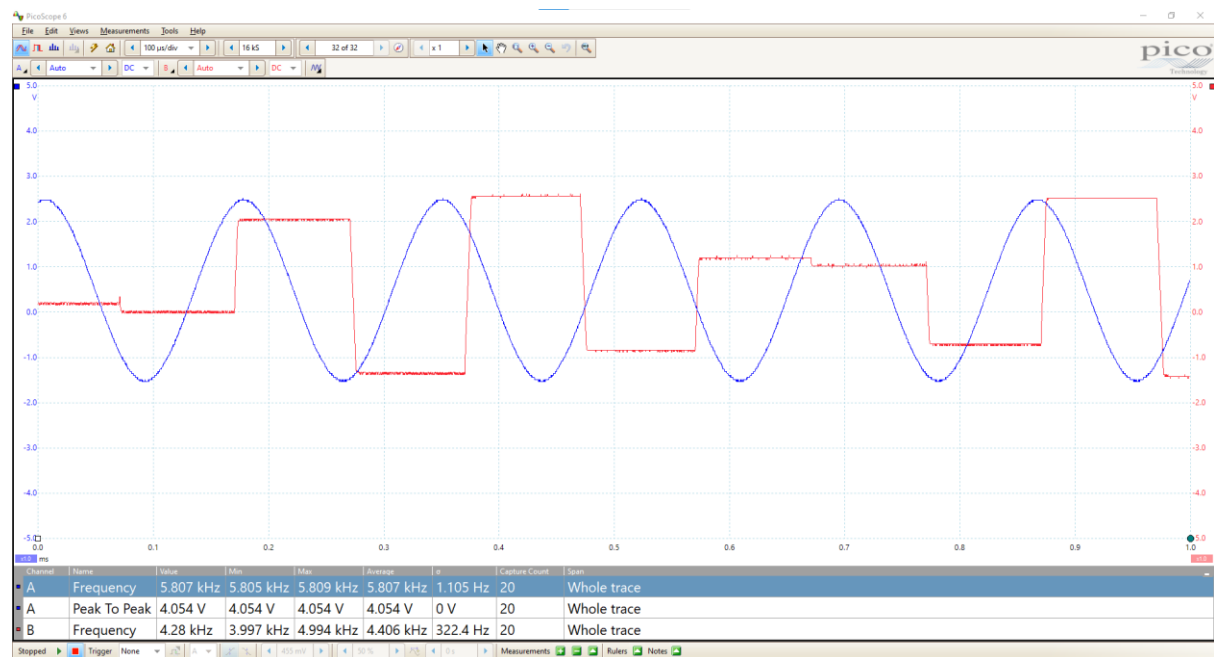


Figure 40 8-bit ADC at 6kHz at 4V peak to peak.

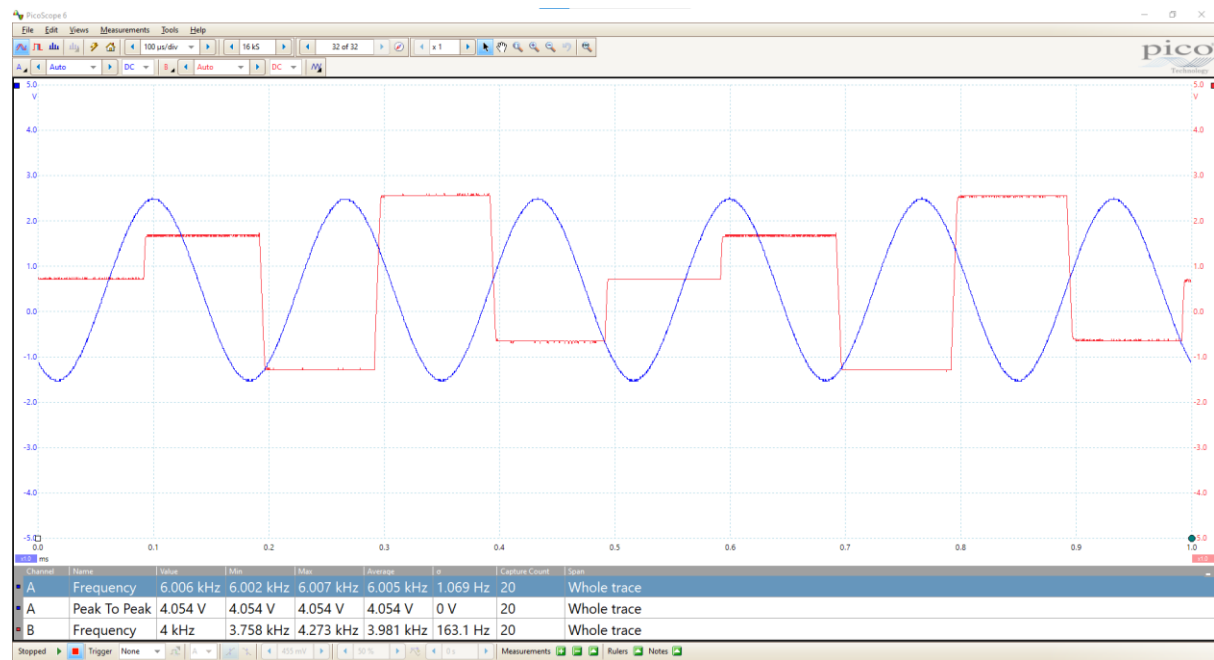


Figure 41 8-bit ADC at 7kHz at 4V peak to peak.

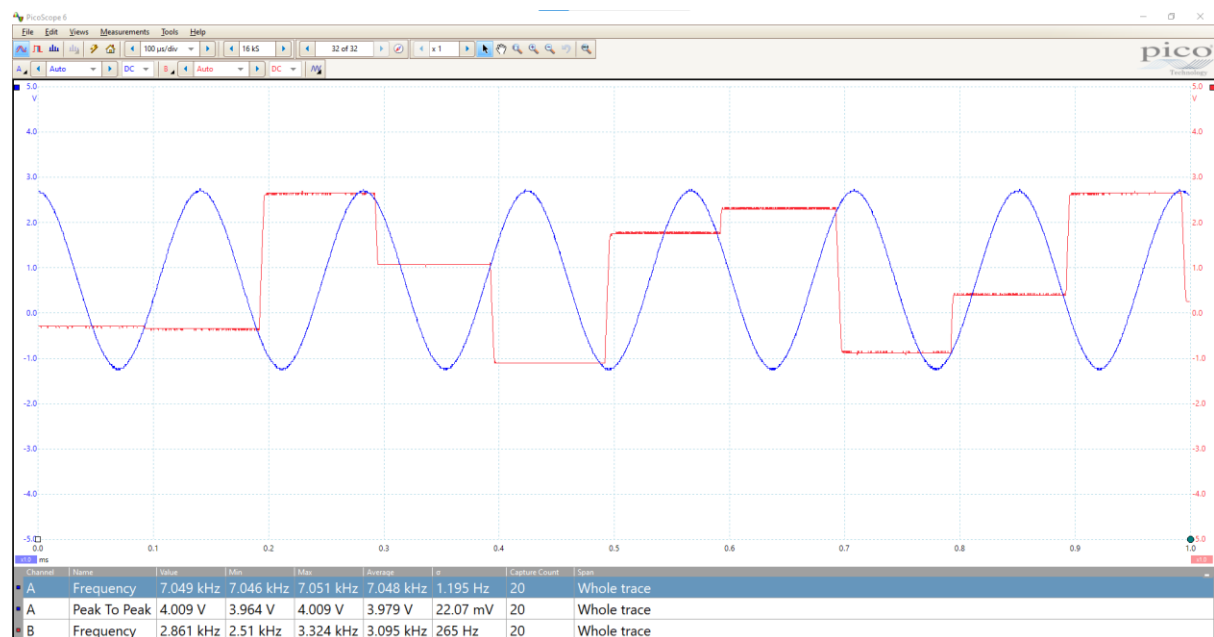


Figure 42 8-bit ADC at 8kHz at 4V peak to peak.

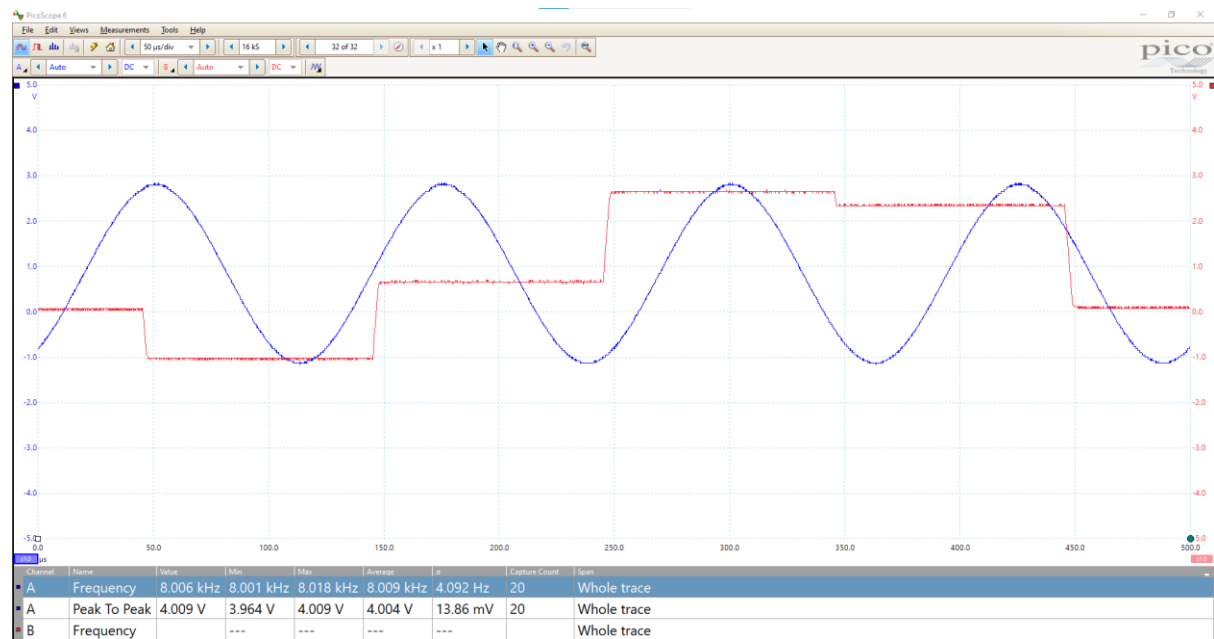


Figure 43 8-bit ADC at 9kHz at 4V peak to peak.

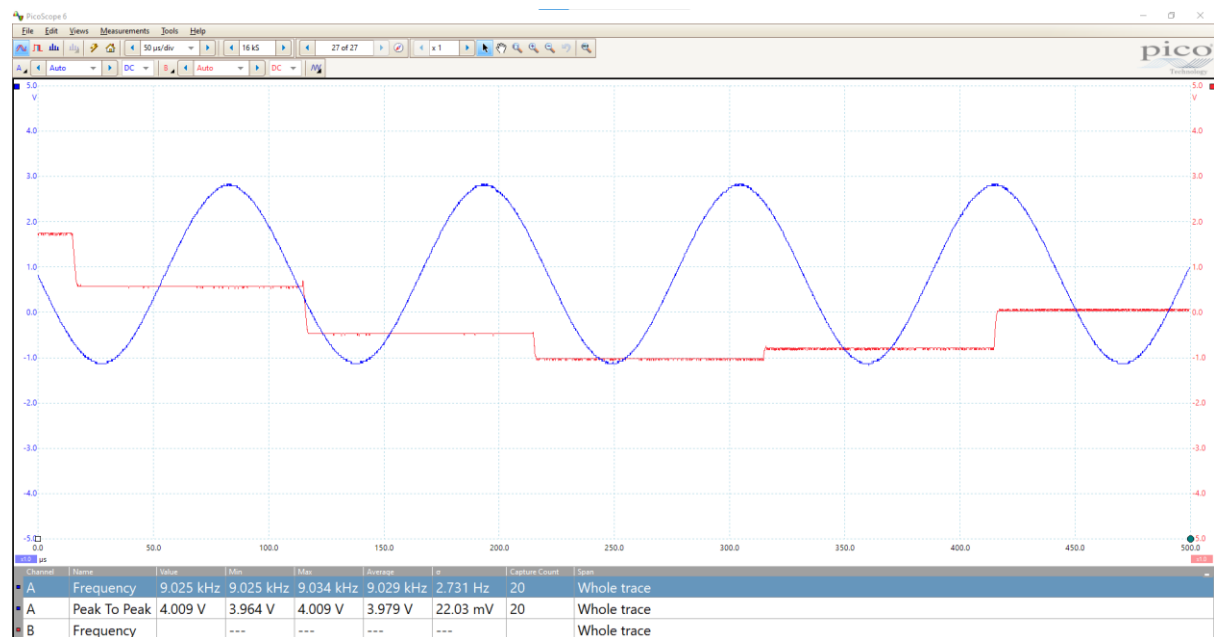
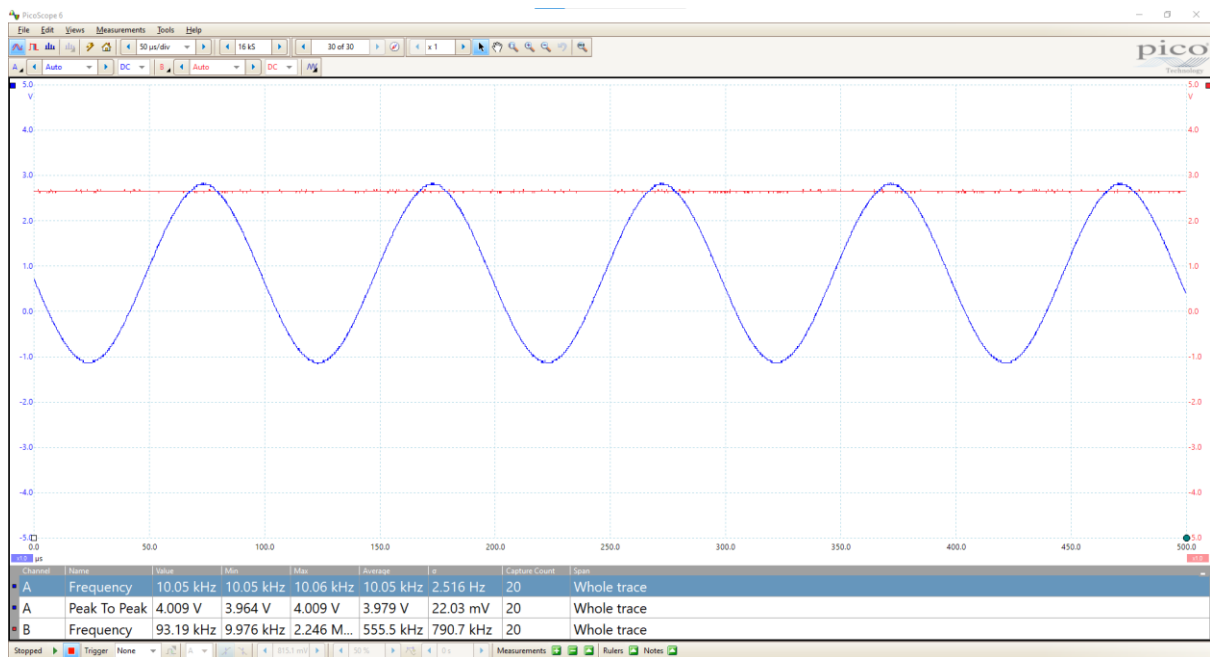


Figure 44 8-bit ADC at 10kHz at 4V peak to peak.



FAR TOO MANY DIAGRAMS, MOST
SHOULD BE IN THE APPENDIX AS WELL.

7. Conclusions and recommendations

In experiment 1 with regards to the frequency modulation, the theory and formulas obtained provided the modulation index and the frequency of the message. The theoretical and practical spectrum analysers did not match. The theory will never match the practical exactly, the theory should provide a rough idea as to how the practical results will respond. This is due to discrepancies and accuracy of software/equipment. If equipment has not been calibrated, accurate results will not be obtained. The Pico scope is dated and not up to date, this will have an effect on the final outcome. The Pico scope software may not be cable of providing precise measurements and provide results to the nearest digit. However, the practical spectrum analyser was not far off the theoretical values, this is what was expected. From the ADC practical test, figures 11 and 12 show the difference in the quality of conversion between the 4 and 8-bit convertors. The theory made it known that the 8-bit ADC is far more accurate than that of the 4-bit ADC and this was seen in the 4 and 8-bit ADC test, where both ADC's have the same frequency and peak to peak voltage. Figures 13 to 26 show the effect of changing the input amplitude for an 8 and 4-bit ADC with the frequency held constant. Figures 13 and 16 shows the importance of selecting the correct amplitude. It was seen that the best results were obtained at 4V peak to peak, figures 13-26 shows that at 4V peak to peak the digital output matched that of the analogue input. This was the case with the 8-bit ADC, however, since the 4-bit ADC is not as accurate as it has fewer levels, even at 4V peak to peak the digital output was slightly distorted to that of the analogue input signal. Figures 27 to 44 shows the effects of changing the frequency of the input with the amplitude held constant. The test proves that the input frequency matches the output frequency until the input frequency exceeds 5kHz, after this the output frequency does not correspond to the input frequency. This is what was expected from the theory.

Recommendation include widening the evaluation and looking at different types of AM such as DSB-SC's, SSB and VSB.

WHY? WE ARE INVESTIGATING FM!

TOO DESCRIPTIVE AND NOT ENOUGH CRITICAL
ANALYSIS.

8. Reference list and bibliography

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9. Annexe for diagrams, data sheets, results tables etc

Figure 45 Amplitude Modulation

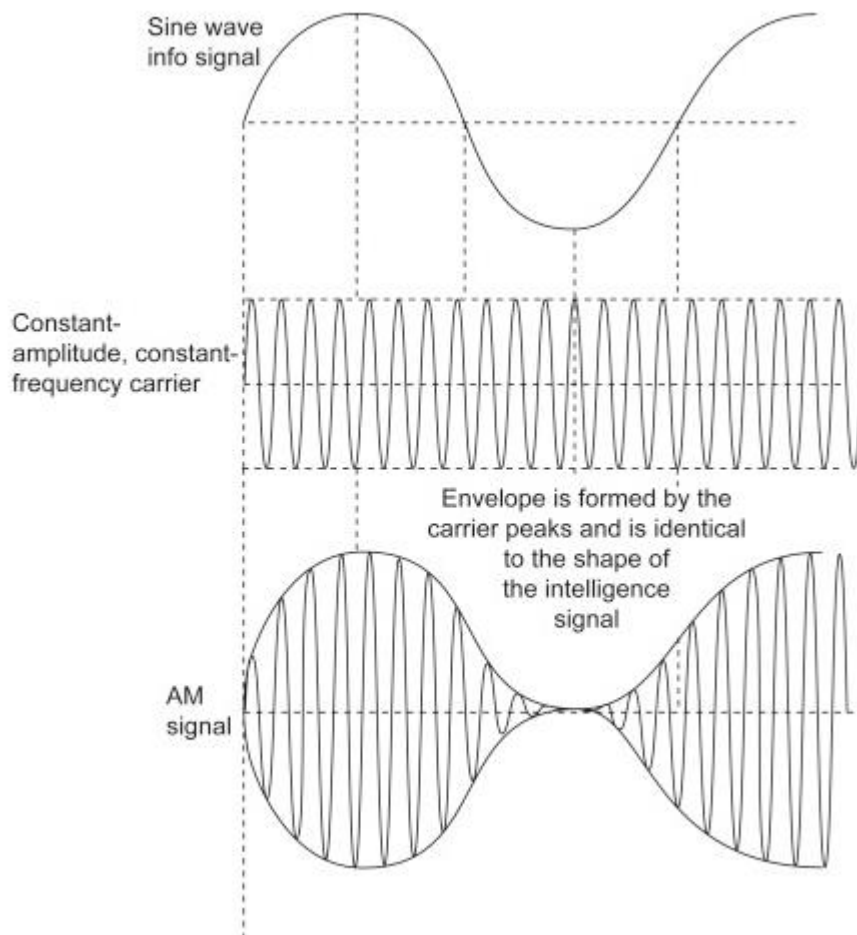


Figure 46 Sampling Examples

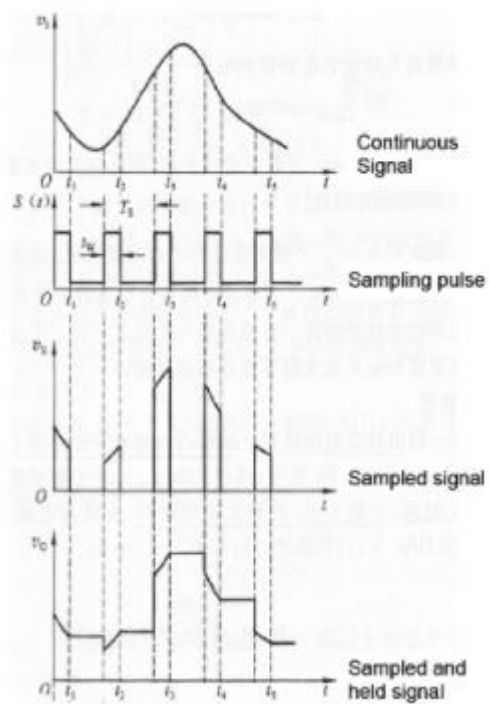


Figure 47 Sampling formulas

Sampling Signal: T_w

Sampling Period: $T_s = \frac{1}{f_s}$

Nyquist Criterion: $f_s > 2 * f_{\max}$

Figure 48 Aliasing example

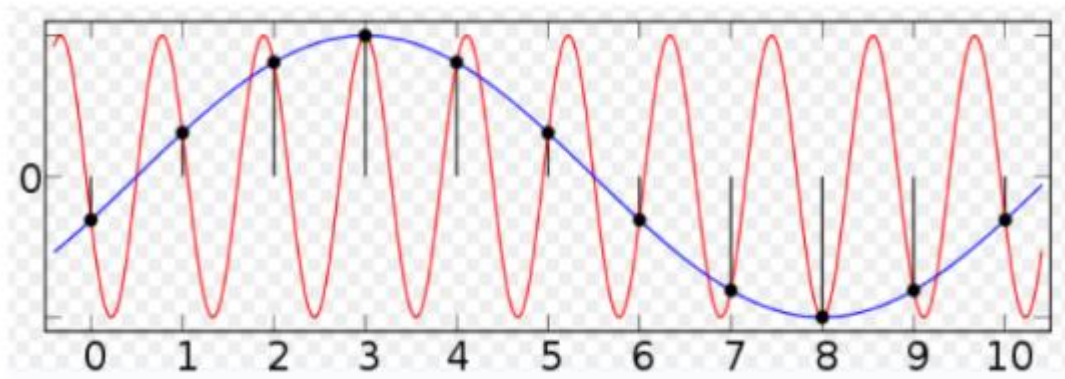


Figure 49 Examples of quantising and encoding

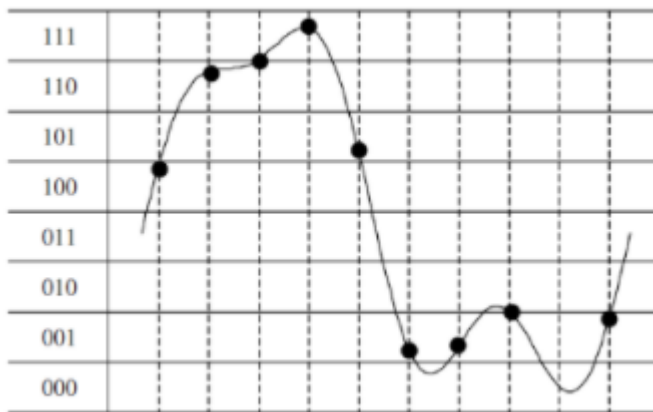


Figure 50 Resolution example

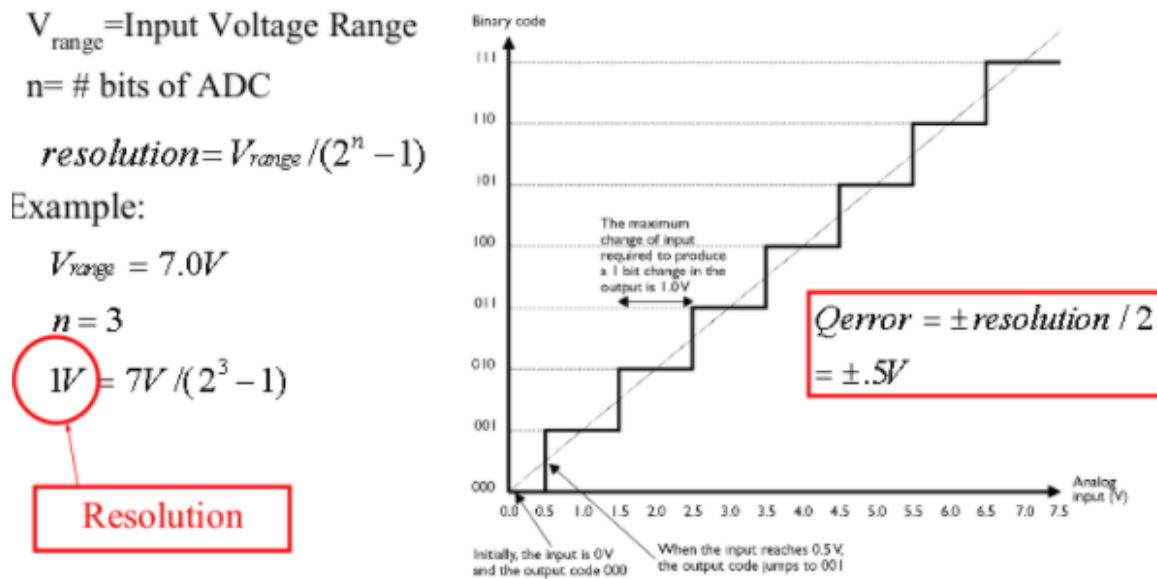


Figure 51 Resolution example

Resolution (bits)	Discrete states	Binary weight	Value of Q for 10 V FS	S/N ratio in dB
4	16	0.0625	0.625 V	34.9
6	64	0.0156	0.156 V	46.9
8	256	0.00391	39.1 mV	58.1
10	1024	0.000977	9.76 mV	71.0
12	4096	0.000244	2.44 mV	83.0
14	16384	0.0000610	610 μ V	95.1
16	65536	0.0000153	153 μ V	107.1

Minimum voltage step recognized by ADC

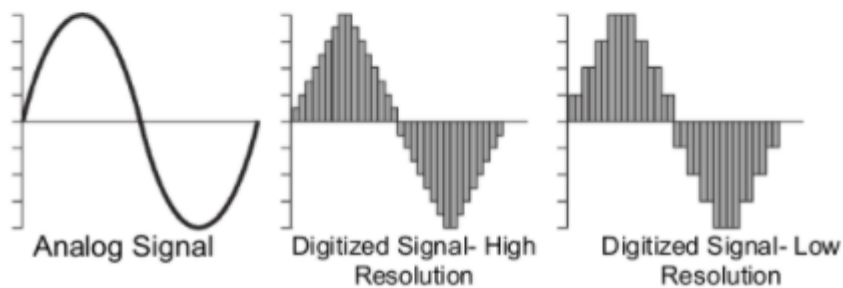


Figure 52 PAM

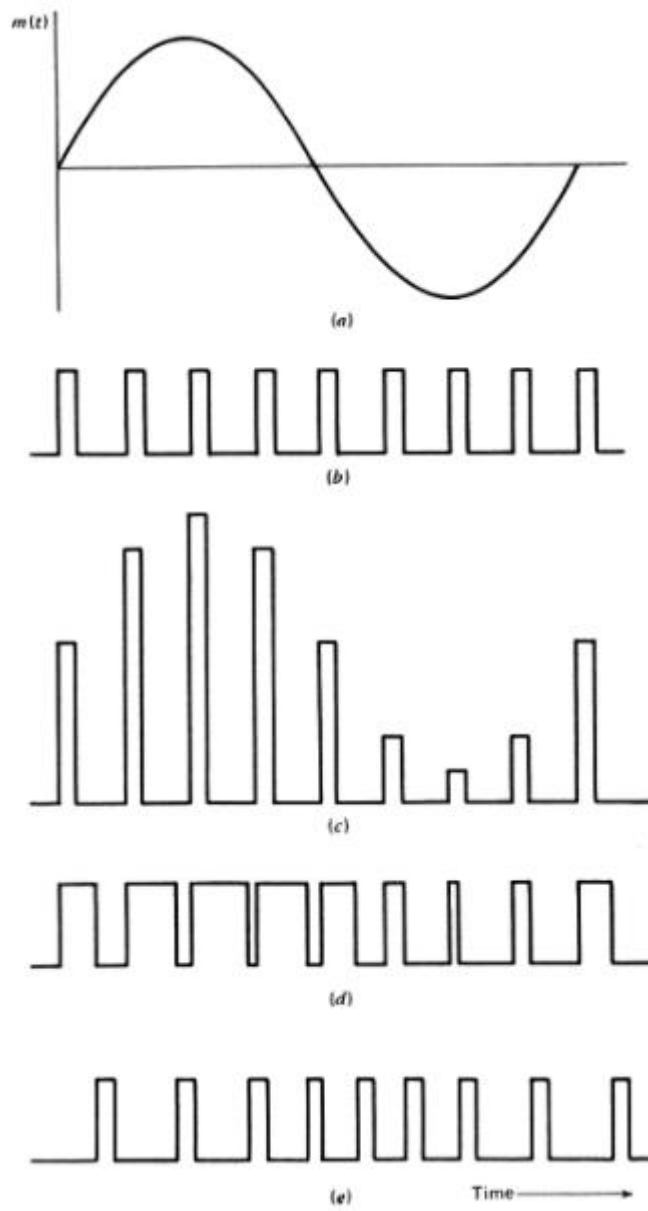


Figure 53 PCM

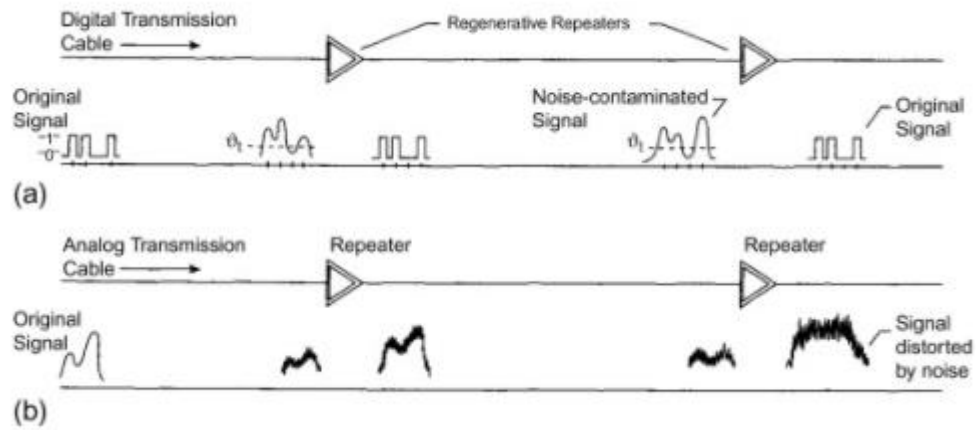
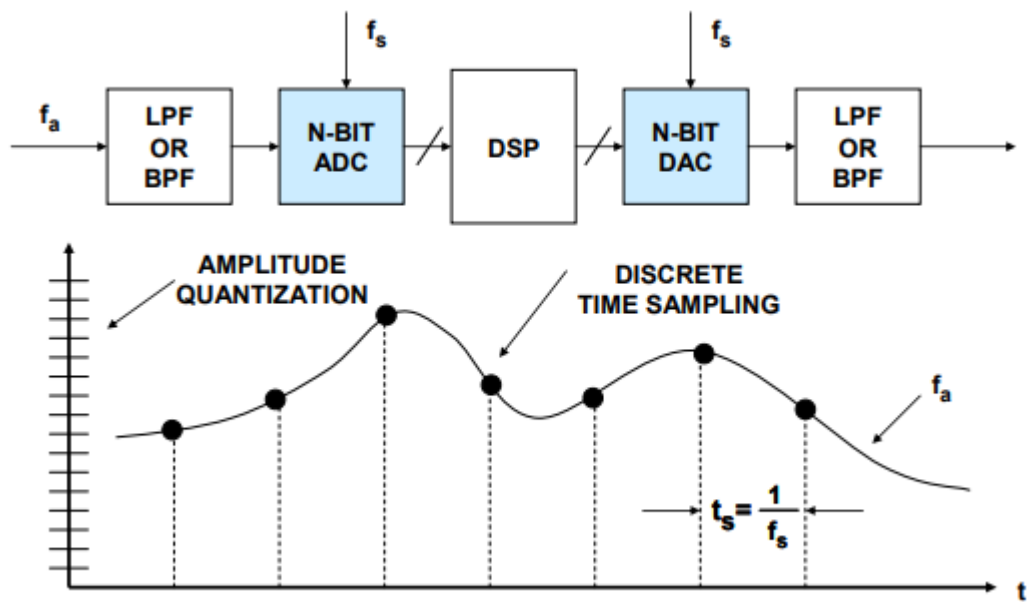


Figure 54



FINAL GRADE

GENERAL COMMENTS

Instructor

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GRADING FORM: CSG-RUBIC

SEAN PARRY

43

RESEARCH-INFORMED LITERATURE



There was some evidence of further reading and research and your interpretation and understanding of the additional research was OK. The sources referenced were insufficient at this level given the amount of potential research areas for this assignment and relied on a small selection of mainly inappropriate and non-authoritative

4

sources. You also need to include more in-text citations using the Harvard reference system.

KNOWLEDGE AND UNDERSTANDING



The knowledge and understanding of the subject demonstrated by this assignment was generally superficial and lacked critical understanding. The report lacked a lot of the required detail and contained significant inaccuracies and too much irrelevant material. Additionally, your understanding of most of the basic principles as well as the higher level concepts was not shown. Further work - There were a few omissions and misunderstandings throughout the task, which could be read up on for future reference. Explanations need to be written in much more detail and written in a more logical and clearer way.

14

ANALYSIS



Your analysis of the task was mainly descriptive and superficial and lacked a lot of the required detail. Your conclusions were also mainly descriptive and there were several instances of flawed understanding. There was little evidence of critical analysis with most results accepted uncritically as fact and without explaining the underlying principles. You did however demonstrate some basic analytical skills and your approach to the task was logical.

12

PRACTICAL APPLICATION AND DEP.



Your application of practical skills for this task was generally adequate. You used the resources appropriately when conducting both experiments and you used appropriate options for testing and evaluating the circuit performance. You managed to confirm that the results of both experiments were within the specification and achieved this by only asking for assistance when appropriate thus demonstrating some basic problem solving skills. Your results were adequate and allowed for a reasonable conclusion to be attempted.

9

SKILLS FOR PROFESSIONAL PRAC.



Your written report was reasonably well presented in terms of content and layout and was mostly structured in a coherent way, however you should be much more selective and consistent in which diagrams go in the report and which go in the appendix.

4