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Works Cited

Diffen, 2012. *AM vs. FM*. [Online]

Available at: https://www.diffen.com/difference/AM_vs_FM

[Accessed 8 February 2024].

Electronics Tutorials, 2024. *Analogue to Digital Converter*. [Online]

Available at: <https://www.electronics-tutorials.ws/combination/analogue-to-digital-converter.html>

Heavy.AI, 2022. *Frequency Modulation*. [Online]

Available at: <https://www.heavy.ai/technical-glossary/frequency-modulation#:~:text=With%20AM%2C%20the%20strength%20of,order%20to%20incorporate%20sound%20information.>

[Accessed 8 February 2024].

McHugh, B., 2021. *Evaluating ADC and DAC Performance Characteristics*. [Online]

Available at: <https://www.electronicdesign.com/technologies/analog/article/21165089/per-vices-corp-evaluating-adc-and-dac-performance-characteristics>

[Accessed 8 February 2024].

UStudy Initiative, 2008. *Successive Approximation ADC..* [Online]

Available at: <http://www.ustudy.in/node/6502>

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1. Executive Summary

This assignment required research into amplitude and frequency modulation. Following that, Experiment 1 was performed, which required calculations to be compared to the results of the practical tests. The FM waveforms were shown on the test apparatus that was used to conduct the practical tests. After then, the results were analysed. The second experiment involved analysing ADCs. For example, consider the difference in conversion quality between four and eight bit converters. The relationship between the input signal frequency and the ADC sampling rate, as well as the importance of matching the input signal amplitude to the device's range. These trials were evaluated, and the results were compared to the established theory.

2. Frequency Modulation

Research

Amplitude and Frequency Modulation

When looking at both amplitude and frequency modulation, the following characteristic must be considered.

Bandwidth;

The bandwidth used by AM signals is larger than that of FM signals. This is because the sidebands containing the modulating information must be accommodated in addition to the carrier signal. Carson's rule states that the occupied bandwidth in AM is twice the maximum modulating frequency.

FM signals have a smaller bandwidth than AM signals. This is due to the fact that FM only needs room for the carrier frequency and a small number of sidebands. The maximum frequency variation from the carrier determines the bandwidth of an FM transmission.

Signal Quality;

Compared to FM signals, AM signals are more prone to noise and fading. The amplitude of the signal might be distorted by noise, which lowers the quality of the audio that is demodulated. One of the reasons AM is less frequently utilised for high-fidelity audio transmission is its susceptibility to noise.

Compared to AM transmissions, FM signals are more resilient to noise and interference. The demodulated signal is not significantly affected by noise-induced amplitude changes since the information is contained in the frequency variations. For applications like high-quality audio transmission, where signal fidelity is essential, FM is therefore preferred.

Applications;

FM signals are more resistant to interference and noise than AM broadcasts. Noise-induced amplitude changes have minimal effect on the demodulated signal because the frequency variations carry the information. FM is consequently recommended for applications where signal fidelity is crucial, such as high-quality audio transmission.

Broadcast radio frequently uses FM modulation, especially when transmitting high-fidelity audio in the FM broadcast spectrum. Additionally, it is utilised in two-way radio communication systems that depend heavily on the rejection of noise and interference, such mobile phones and walkie-talkies.

(Heavy.AI, 2022) (Diffen, 2012)

Experiment 1

Experiment 1 involves frequency modulation. A 455kHz carrier has an amplitude of 375mV and is frequency modulated by a 10kHz sine-wave signal of 2V amplitude. For this experiment, the FM transfer frequency will be 20kHz per volt.

The maximum frequency deviation (Δf) was calculated using the equation below.

$$\Delta f = \text{modulator transfer characteristic} * \text{message amplitude}$$

$$\Delta f = 20 * 2 = 40\text{KHz}$$

The modulation index (m_f) was then calculated using the equation below.

$$m_f = \frac{\Delta f}{m_f} = \frac{40}{10} = 4$$

Having calculated the modulation index, the component amplitude values could be calculated using the Bessel Table below in conjunction with the following equation.

$$\text{Amplitude} = EC * J_n$$

Modulation	Sideband amplitude															
Index	Carrier	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0.00	1.00															
0.25	0.98	0.12														
0.5	0.94	0.24	0.03													
1.0	0.77	0.44	0.11	0.02												
1.5	0.51	0.56	0.23	0.06	0.01											
2.0	0.22	0.58	0.35	0.13	0.03											
2.40483	0.00	0.52	0.43	0.20	0.06	0.02										
2.5	-0.05	0.50	0.45	0.22	0.07	0.02	0.01									
3.0	-0.26	0.34	0.49	0.31	0.13	0.04	0.01									
4.0	-0.40	-0.07	0.36	0.43	0.28	0.13	0.05	0.02								
5.0	-0.18	-0.33	0.05	0.36	0.39	0.26	0.13	0.05	0.02							
5.52008	0.00	-0.34	-0.13	0.25	0.40	0.32	0.19	0.09	0.03	0.01						
6.0	0.15	-0.28	-0.24	0.11	0.36	0.36	0.25	0.13	0.06	0.02						
7.0	0.30	0.00	-0.30	-0.17	0.16	0.35	0.34	0.23	0.13	0.06	0.02					
8.0	0.17	0.23	-0.11	-0.29	-0.10	0.19	0.34	0.32	0.22	0.13	0.06	0.03				
8.65373	0.00	0.27	0.06	-0.24	-0.23	0.03	0.26	0.34	0.28	0.18	0.10	0.05	0.02			
9.0	-0.09	0.25	0.14	-0.18	-0.27	-0.06	0.20	0.33	0.31	0.21	0.12	0.06	0.03	0.01		
10.0	-0.25	0.04	0.25	0.06	-0.22	-0.23	-0.01	0.22	0.32	0.29	0.21	0.12	0.06	0.03	0.01	
12.0	0.05	-0.22	-0.08	0.20	0.18	-0.07	-0.24	-0.17	0.05	0.23	0.30	0.27	0.20	0.12	0.07	0.03

Figure 1 - Bessel Table

The values used and calculated are shown below.

Bandwidth (KHz)	Bessel Coefficient	Amplitude (mV)
385	0.02	7.5
395	0.05	18.75
405	0.13	48.75
415	0.28	105
425	0.43	161.25
435	0.36	135
445	0.07	26.25
455	0.4	150
465	0.07	26.25
475	0.36	135
485	0.43	161.25
495	0.28	105
505	0.13	48.75
515	0.05	18.75
525	0.02	7.5

Table 1 -Values Calucated

From these values an Amplitude-Frequency graph could be created.

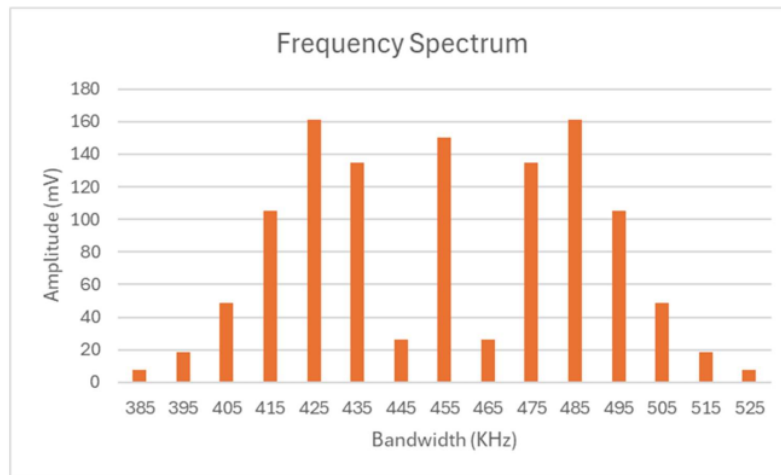


Figure 2 - Theoretical Frequency Spectrum

Experiment

A practical experiment was carried out to determine whether the calculated values matched. The setup for the test equipment is shown below.

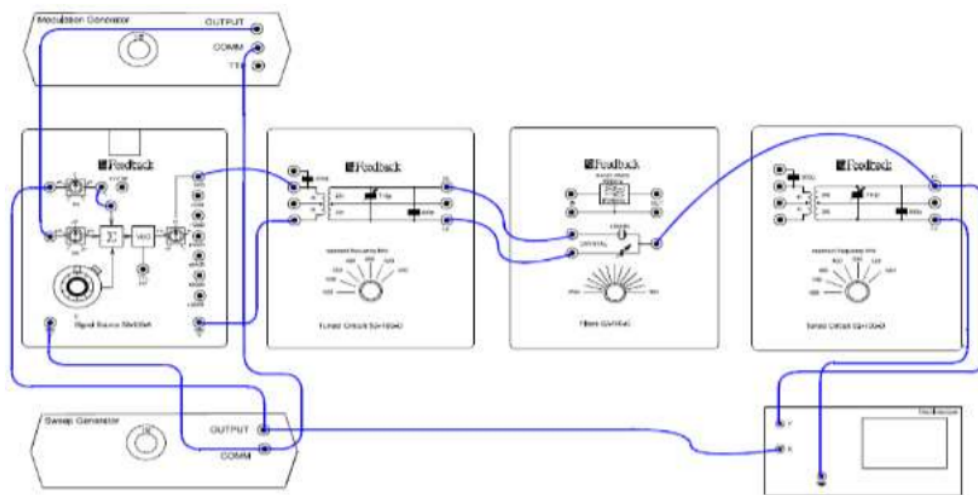


Figure 3 - Layout of experimental kit

Firstly the frequency spectrum was measured after the setting the frequency control C to the approximate position for 455 kHz of the above equipment, then using the frequency meter, the frequency shown on Channel A was set to 455 kHz as accurately as possible. The frequency modulation was set to 10KHz and the amplitude was set to 2V. The observed spectrum is as follows.

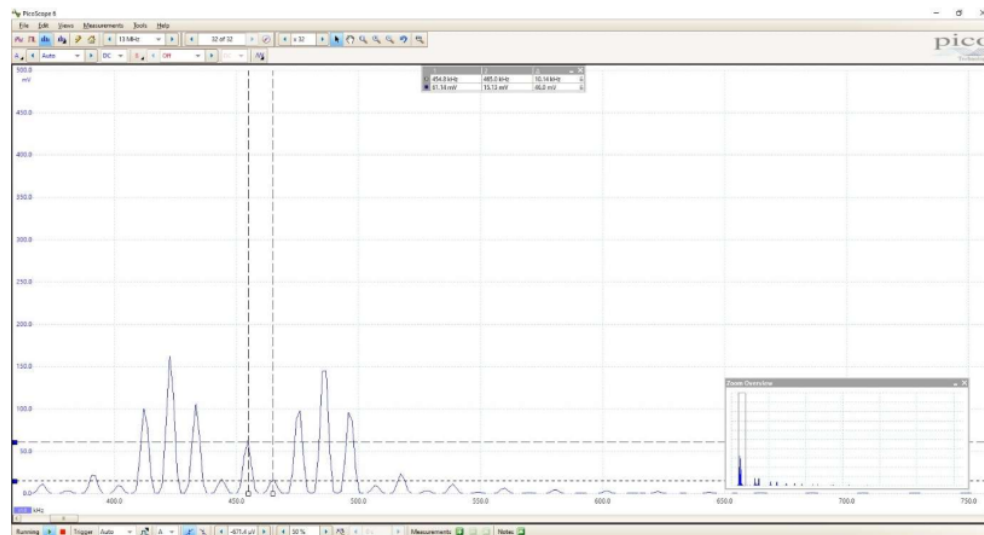


Figure 4 - Frequency Spectrum @10KHz

As can be seen, the amplitude of the centre frequency of 455Khz does not match that of what was calculated using the Bessel coefficients. This can be put down to human error whilst carrying out the experiment. However, the side frequencies match up to what was calculated.

Next the carrier wave centre frequency of 455kHz with a deviation of 32KHz was measured

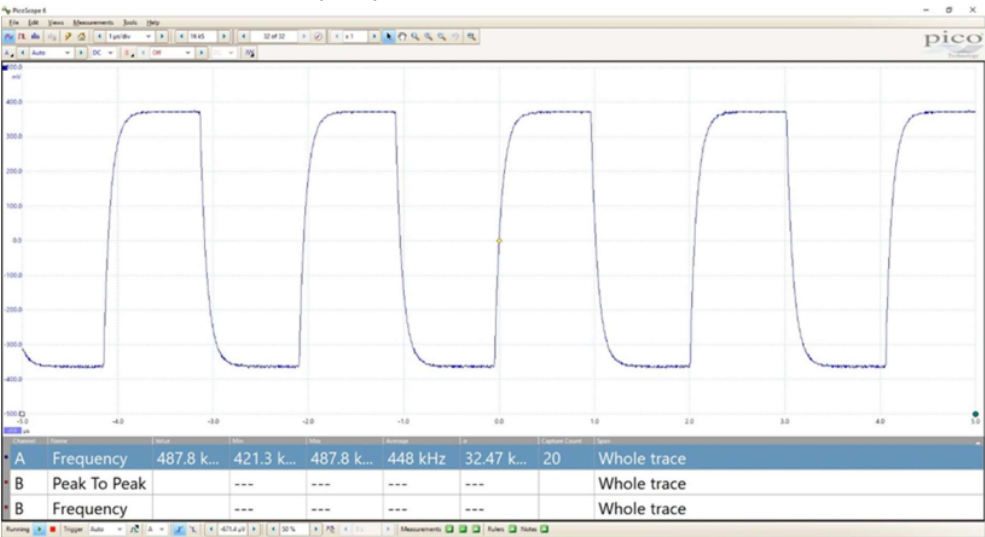


Figure 5 - Carrier Wave @10KHz

The 2V peak to peak message wave was then measured at 10KHz, the observed wavelength can be seen below.

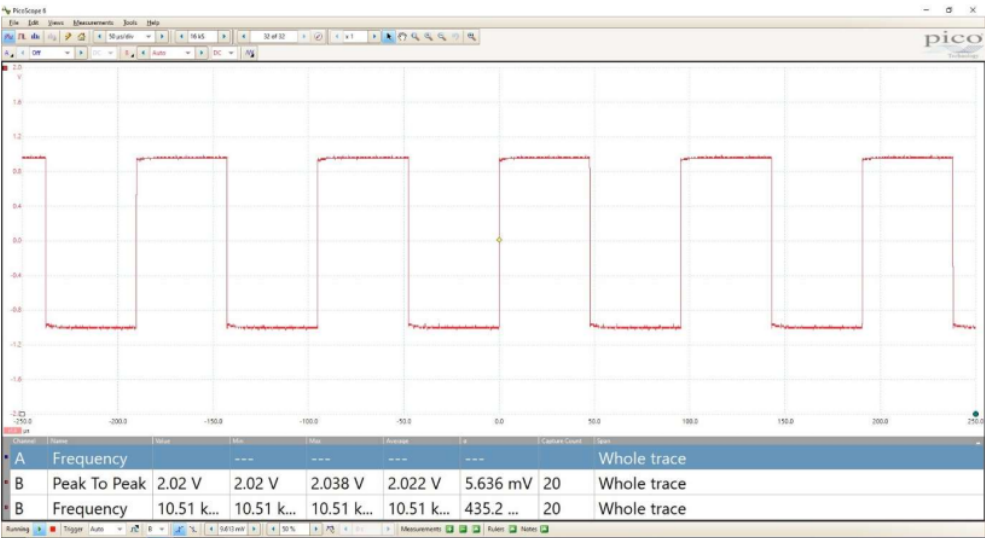


Figure 6 - Message Wave @10KHz

Next the frequency modulation was set to 5KHz and the frequency spectrum was graphed. From the graph it can be said that as the modulation is reduced, the centre frequency is greatly reduced compared to what is seen at the 10KHz modulation frequency. It can also be seen that the Amplitude of the side frequencies is also reduced. The observed wavelength can be seen below.

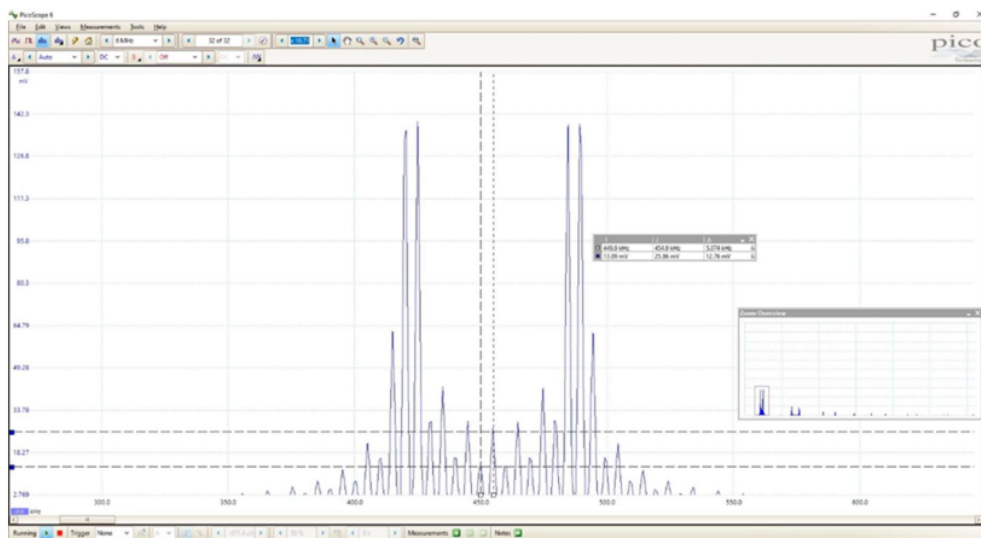


Figure 7 - frequency spectrum @5KHz

Next the carrier waves centre frequency was measured at 5KHz modulation frequency. As can be seen from the observed waveform below, there is little difference compared to what can be seen at 5KHz.

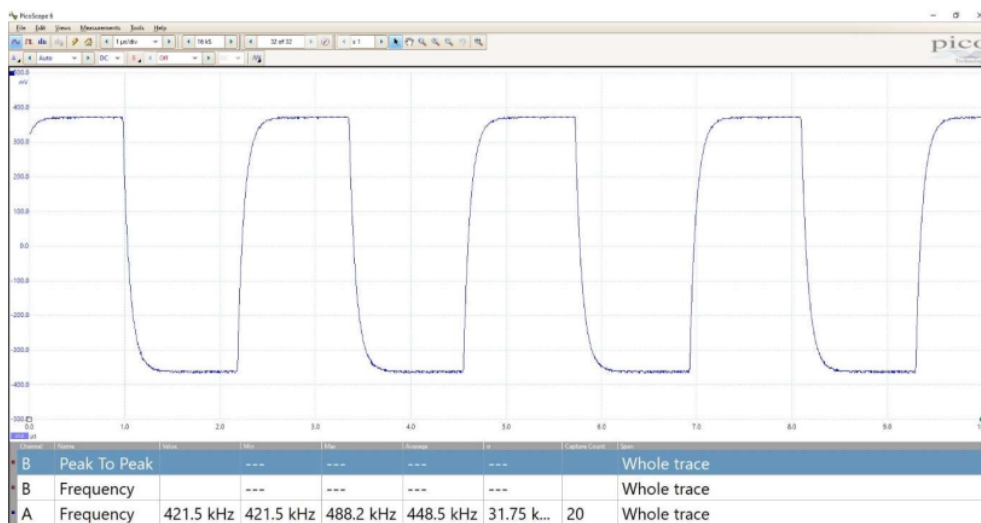


Figure 8 - Carrier wave @5KHz

Finally the message frequency was measured at 5KHz. As can be seen from the observed waveform below the only change observed is that of the frequency.

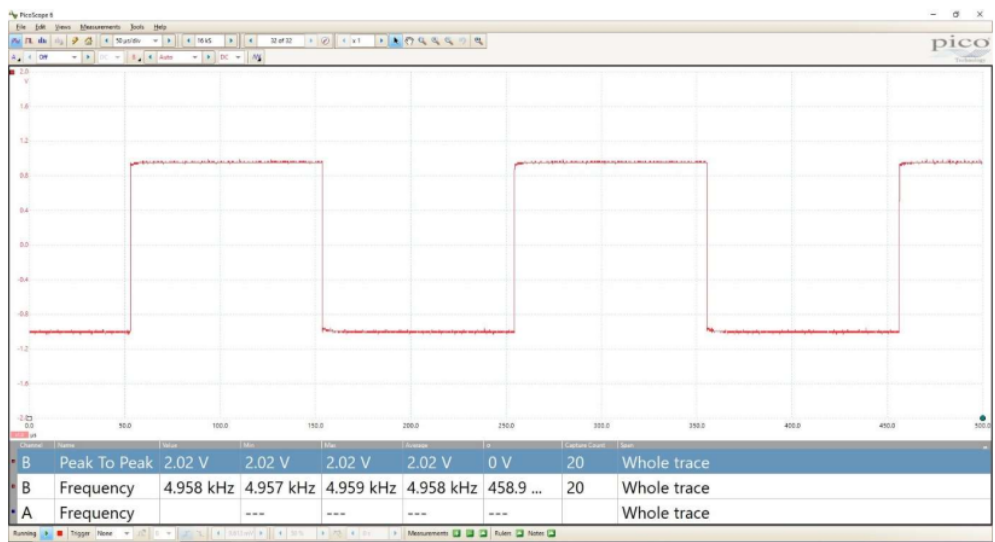


Figure 9 - Message wave @5KHz

3. Analogue to Digital Conversion

Research

Analogue to Digital Converters (ADCs) convert a variable value of an analogue signal at a given time interval into a digital value that may be utilised by software. The resolution, or number of samples per second, determines how accurate the conversion outcome will be. The analogue input of an ADC is measured against a reference voltage or current.

An improved representation of the original waveform signal can be achieved with a higher resolution ADC since it contains more bits to represent the analogue values. The Successive Approximation Register (SAR) architecture is a widely used ADC that can attain high sample rates and is available in several resolutions ranging from 8bit to 18bit, with an 8-bit providing 256 discrete output levels, and an 18bit providing 262144 discrete output levels. (Electronics Tutorials, 2024) (UStudy Initiative, 2008)

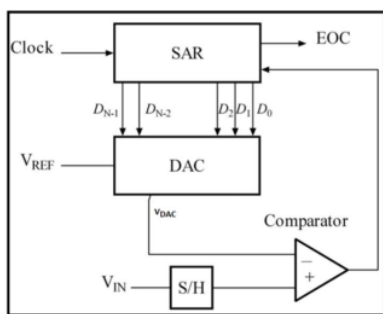


Figure 10 - SAR Architecture

The fundamental architecture of a SAR is depicted above, along with the key parts that enable the ADC to process every bit while giving the comparator feedback so that it can determine the value of the next input.

The frequency at which an ADC samples its analogue input signal and generates digital output samples is known as its sampling rate. Usually, it is expressed in hertz (Hz) or samples per second (SPS).

The Nyquist-Shannon sampling theorem states that the sampling rate needs to be at least twice the input signal's highest frequency component (Nyquist frequency) in order to reconstruct a signal accurately. Therefore, in order to prevent aliasing and precisely capture the dynamics of the signal, the sampling rate needs to be selected with care.

Increased sample rates enable the ADC to record input signals that change more quickly and retain more information in the digital output.

An ADC's voltage range is the range of input voltages it can handle without clipping or saturation. It establishes the highest and lowest voltages that are precisely digitised.

The minimum and maximum input voltages that match the full-scale range of the ADC's digital output are commonly used to define the voltage range.

An ADC's voltage range should be equal to or greater than the range of the analogue input signals that it is meant to digitise. Saturation or clipping may happen if the input voltage is higher than the ADC's operating range. This can result in information loss and distortion. (McHugh, 2021)

Experiment 2

For this task, an investigation will be carried out into the behaviour, requirements and limitations of ADCs by using the Feedback experimental kit as shown below.

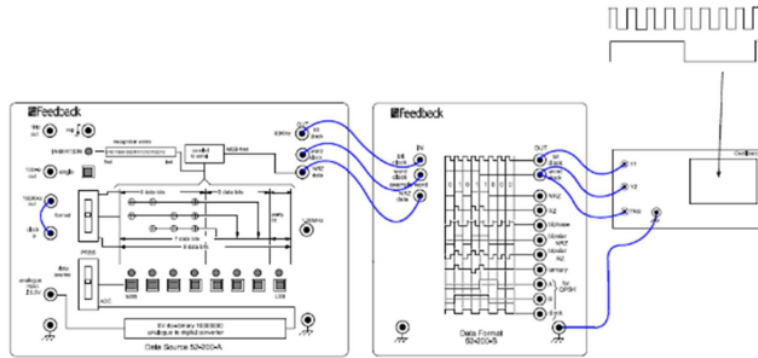


Figure 11 - Experimental Kit layout

The investigation will look into the differences in conversion quality between 4-bit and 8-bit convertors, the significance of matching the amplitude of the input signal to the ADC's range, the significance of the relationship between the ADC's sampling rate and the input signal frequency, and the validity of the Nyquist Criterion.

Effect of changing the number of bits

Firstly, measurements on the Pico Scope were set to provide the input and output frequencies off the ADC, as well as the peak-to-peak voltage of the input. The zero DC offset of the signal generator was adjusted on the data source switch was set to ADC on the corrected data switch was set to uncorrected on the data receiver. during the experiment it was ensured thought the data source module under data receiver module were both set to the same number of bits.

The ADC was then set to 4 bits on the input frequency generated was set to 100 Hertz at 4 volts peak to peak. The observed results can be seen below.

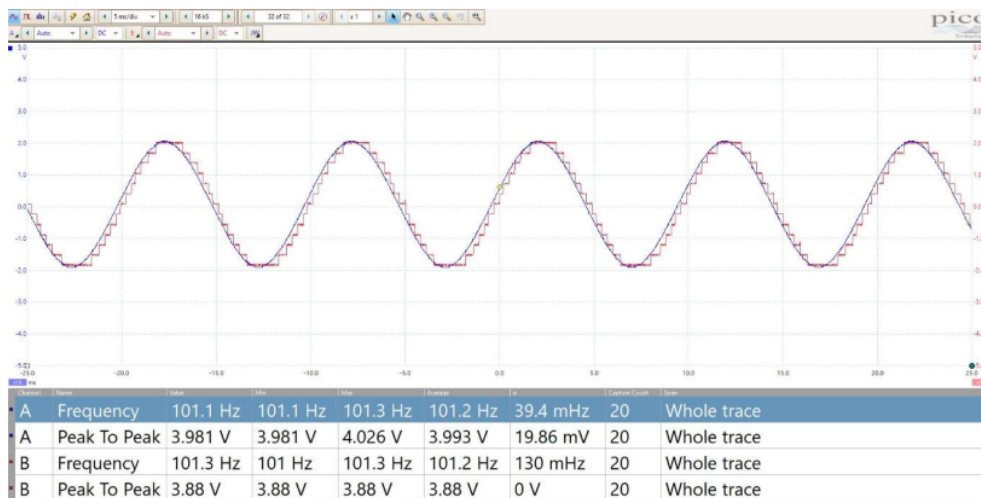


Figure 12 - ADC test 1

The ADC was then set to 8 bits on the observed results can be seen below.

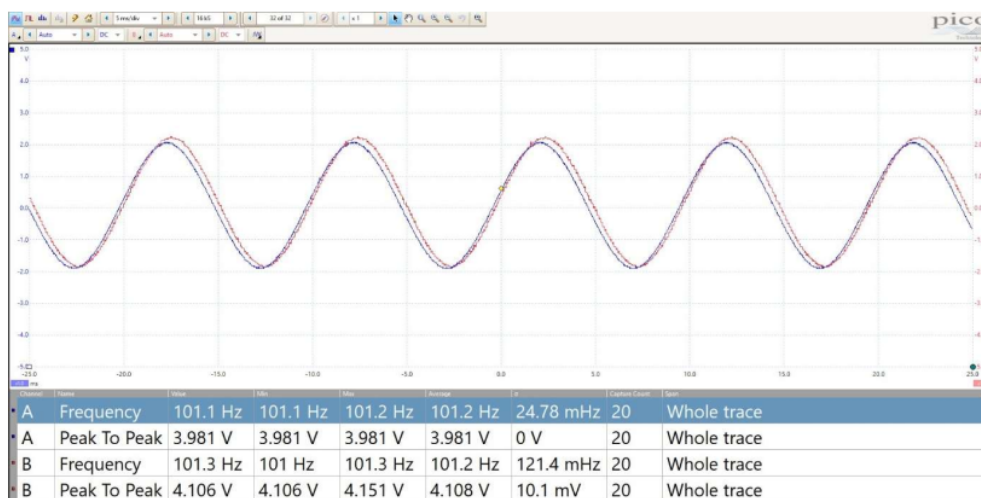


Figure 13 - ADC test 2

As can be seen from the above results, the most noticeable difference is the increase in resolution. Moving from a 4-bit to an 8-bit ADC effectively doubles the number of digital output values. This means that the ADC can represent finer voltage increments, resulting in greater accuracy in transforming the analogue signal into digital. Also, it can be seen that the higher resolution of the 8-bit ADC has improved noise reduction and accuracy than the lower-resolution 4-bit ADC. Thus, it can be said that more bits enable the ADC to distinguish smaller changes in the input signal and provide a more accurate representation of the analogue waveform.

Effect of changing the input amplitude

The next step was to set the ADC back to 4 bits, then set the input frequency to 100 hertz and the amplitude was reduced to a minimum. The observed output, which can be seen below, shows that the reduction of the amplitude to a minimum greatly reduces the resolution of the 4-bit ADC.

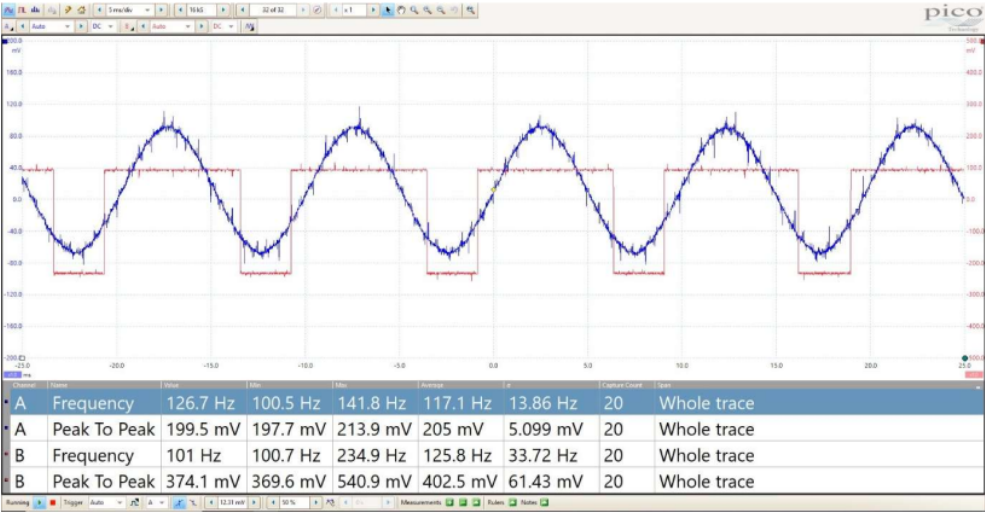


Figure 14 - ADC test 3 p1

The amplitude of the observed waveform was then slowly increased to 6 volts peak to peak, the results can be seen in the appendix, figures .

As can be seen from the above results, as the amplitude of the input signal increases from its minimum value, the ADC's effective resolution improves. At its minimum amplitude, the ADC may only use a small percentage of its available digital output levels, resulting in coarse resolution and limited accuracy. However, as the input amplitude increases, more digital output levels become available, improving the ADC's resolution and accuracy.

This method was then repeated with the ADC set to 8 bits, the observed output with the amplitude set minimum at 8 bits can be seen below.

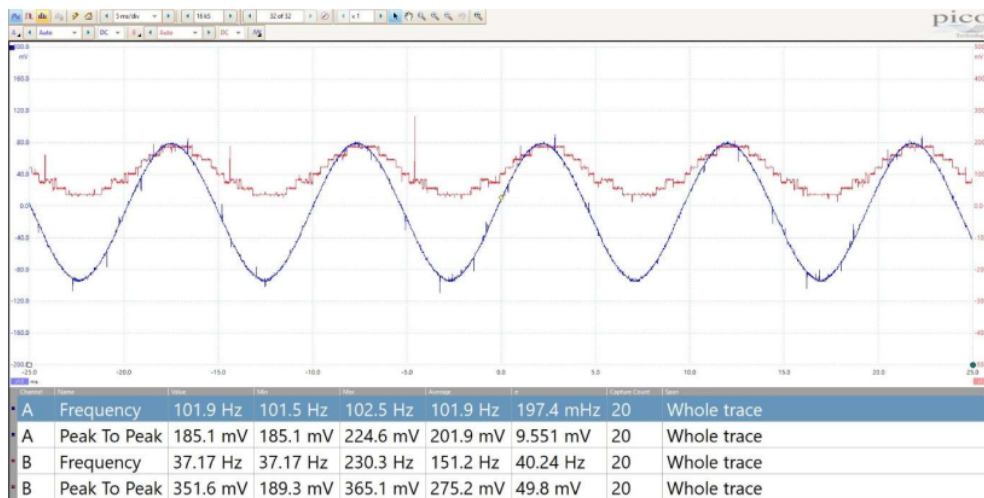


Figure 15 - ADC test 4 p1

The amplitude of the observed waveform was then slowly increased to 6 volts peak to peak, the results can be seen in the appendix, figures 19-12.

As can be seen from the above figures, the results are similar to that of the 4-bit ADC. However, it is clear that the 8-bit ADC once again offers a significantly higher resolution than that of the 4-bit ADC. Thus, it can be said that increasing the amplitude of the 8-bit ADC significantly increases the precision of the output waveform as the 8-bit ADC is able to utilise a larger number of digital output levels. This was as expected based on the results that were seen when changing the number of bits.

Effect of changing the input frequency

In order to observe this the input frequency was set to one kHz at 4 Volt peak to peak. The frequency was then increased to 4KHz in 1KHz intervals, frequency observed at each step can be seen in the appendix figures 22-25.

From the four kHz, the frequency was then increased in 200Hz steps up to 6kHz the observed waveforms can be seen in the appendix figures 26-35. Then from 6KHz, the frequency was increased further to 10KHz in 1KHz steps, the observed output can also be seen in the appendix figures 36-39.

As can be seen from the results, the waveforms differ greatly from that of the effect of changing the input amplitude. As the frequency increases, missed samples or under sampling starts to occur. As the ADC's sampling rate is insufficient to fully capture the frequency of the input signal, some samples begin to be missed, resulting in inaccuracies and gaps in the output waveform. It can also be seen that from 1KHz to 4KHz there is some slight aliasing that occurs in as there is distortion in the digitised output waveform where it starts out being somewhat accurate at 1KHz to becoming significantly less so at 4KHz, this trend continues through to 4.8KHz. However, at 5KHz it could be said that the distortion is reduced but with a significantly lower resolution than what was seen at 1KHz. Past 5KHz and up to 10 kHz the under sampling begins.

In order to better visualise the changes throughout the experiment, the time that passes per division of the graphing tool could have been increased.

4. Conclusions

During this assignment, analogue and frequency modulation were investigated, including the technical characteristics of amplitude and frequency modulation, as well as the technical characteristics of ADCs, including the number of bits, sampling rate, and voltage range. These issues were researched, and the results were used in experiments to demonstrate the theory and ensure that the experiments were carried out accurately. The experiments offered for an improved understanding of how to set up test equipment to monitor a frequency modulated signal and ADCs. Understanding how to employ calculation to generate theoretical values and then compare them to practical data. A practical experiment on ADCs was performed to assess the effect of changing the number of bits on the ADC. An 8-bit ADC proved to be much more precise than a 4-bit ADC. This is supported by the graphs shown in the practical and study. The second experiment included altering the input amplitude on a 4- and 8-bit ADC. This technique indicated that the output signal improved when the input amplitude matched the range of the ADC. The third experiment looked at the effects of changing the input frequency while keeping the amplitude constant. This showed that the most accurate output signal was half of the ADC's sample rate, which was 5KHz. This experiment showed that there are three elements to consider when choosing an ADC. This is the number of bits in the ADC. The greater the number of bits, the more levels, resulting in a more precise output signal. The second factor is the ADC range, which should be proportional to the input amplitude to provide the most accurate output signal.

5. Appendix

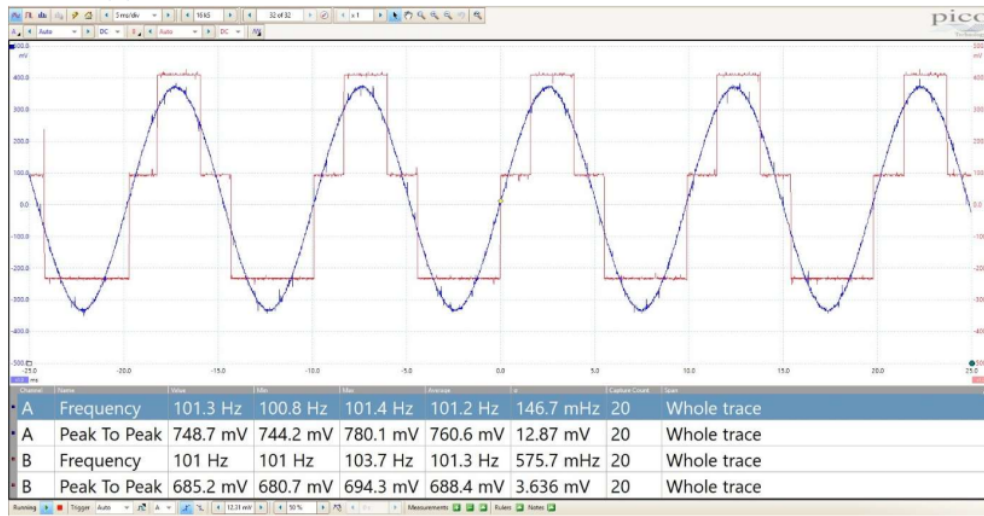


Figure 16 - Test 3 p2

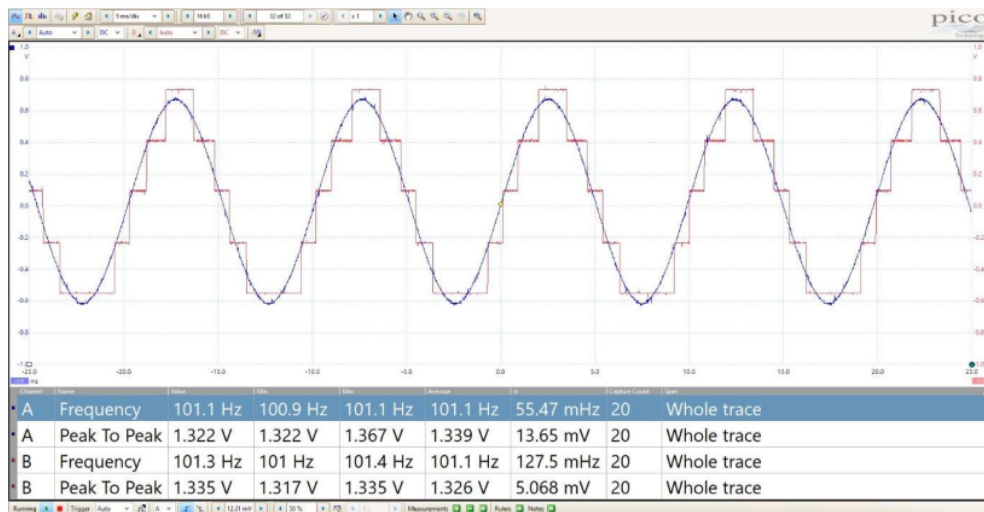


Figure 17 - Test 3 p3

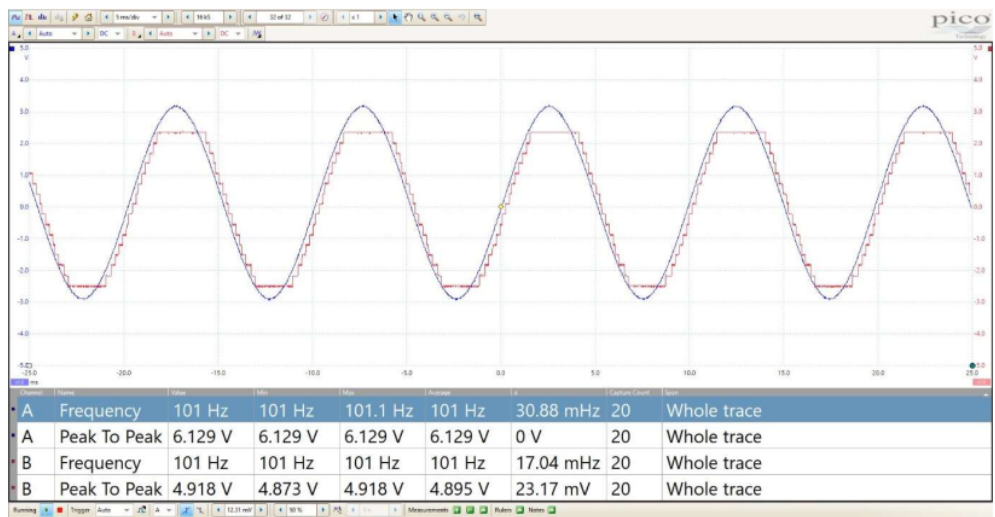


Figure 18 - Test 3 p4

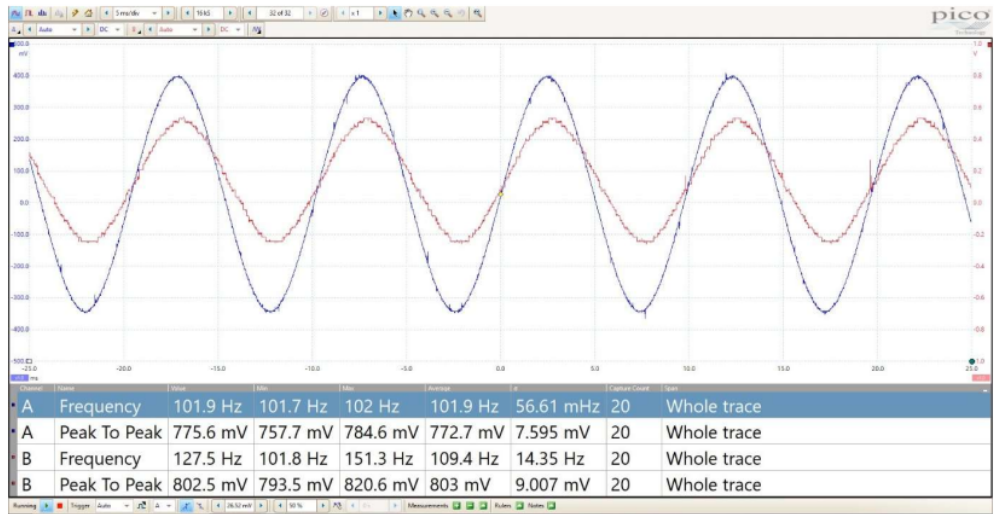


Figure 19 – ADC test 4 p2

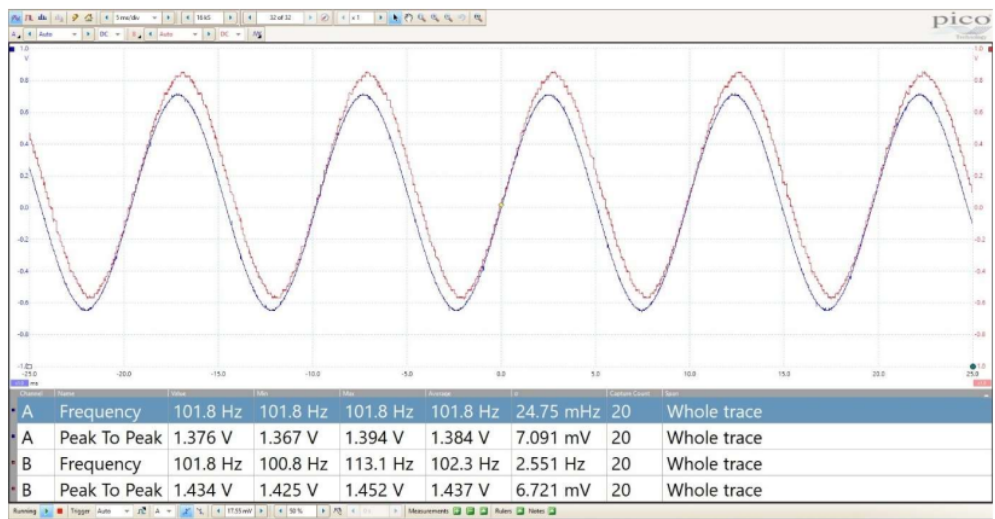


Figure 20 - ADC Test 4 p3



Figure 21 - ADC test 4 p4

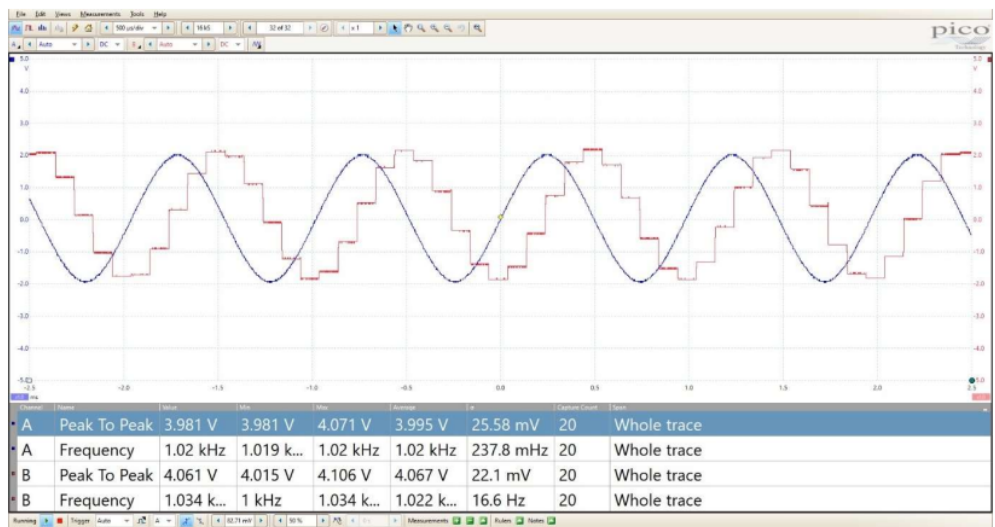


Figure 22 - 1KHz

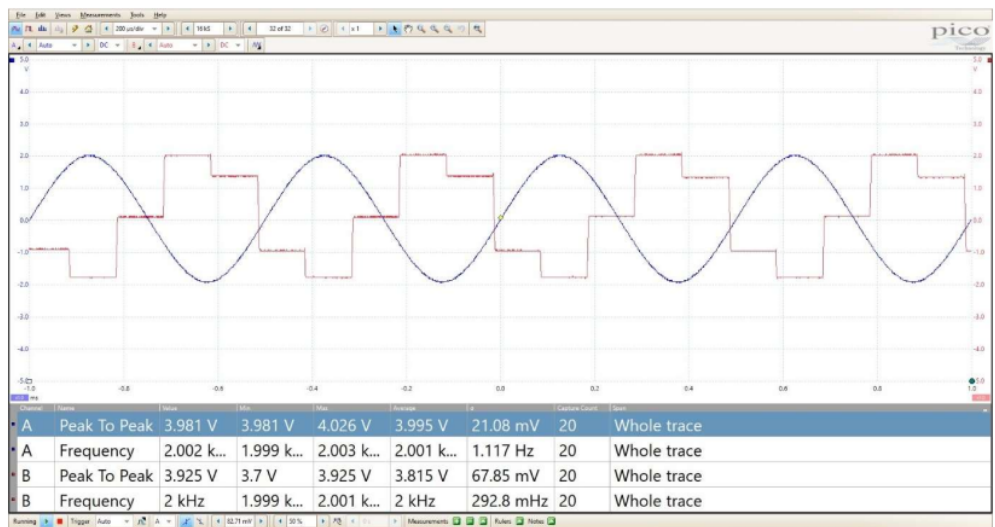


Figure 23 - 2KHz

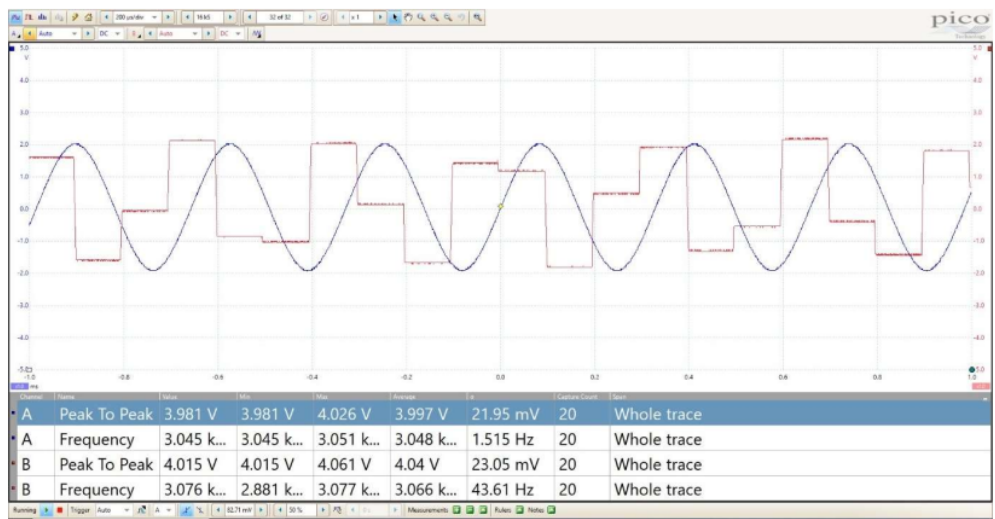


Figure 24 - 3KHz

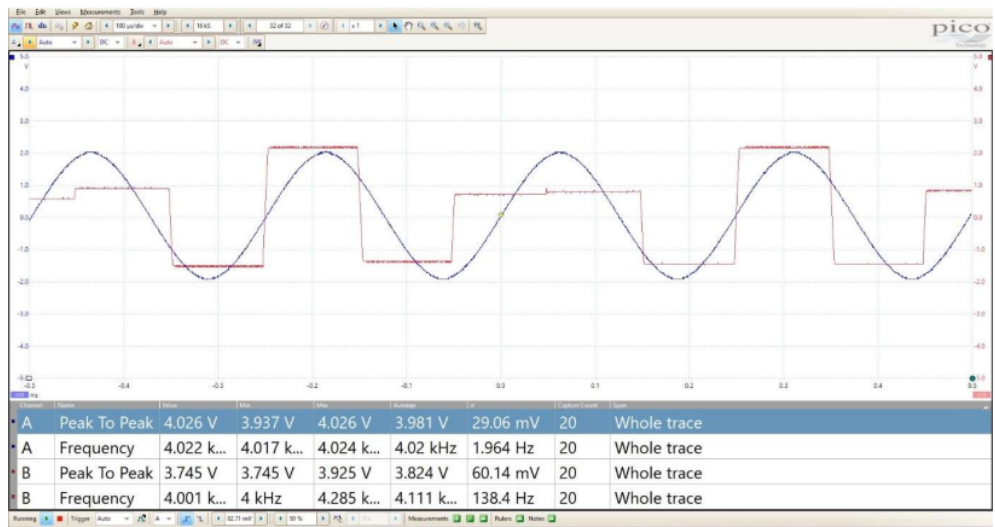


Figure 25 - 4KHz

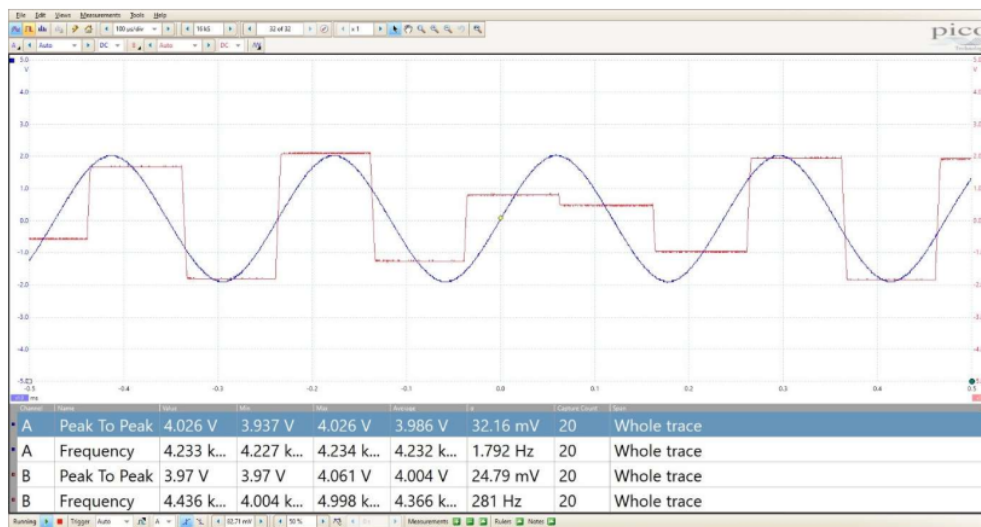


Figure 26 - 4.2KHz

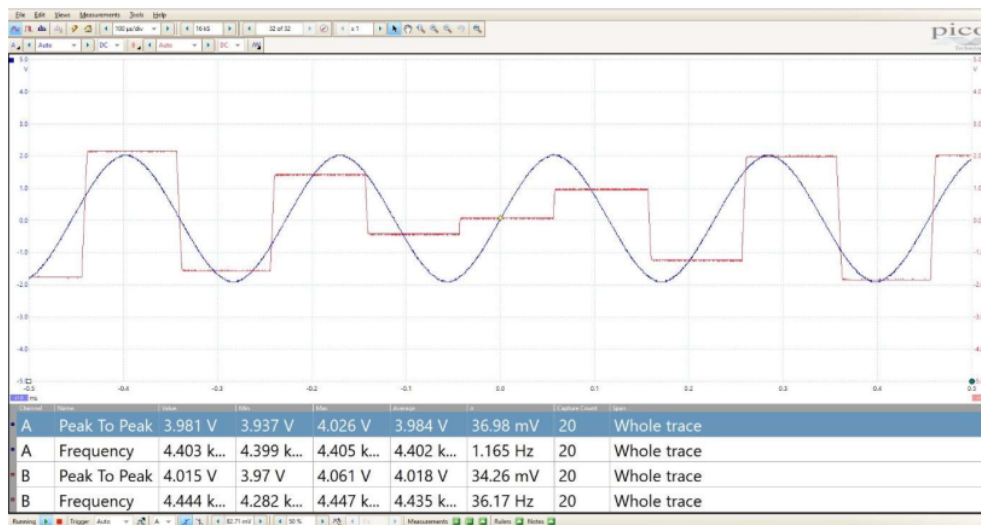


Figure 27 - 4.4khz

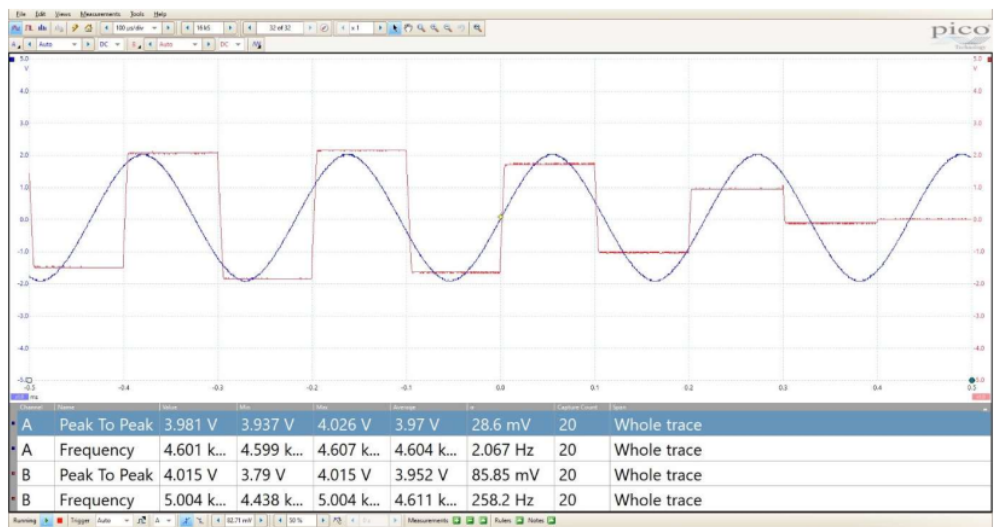


Figure 28 - 4.6khz

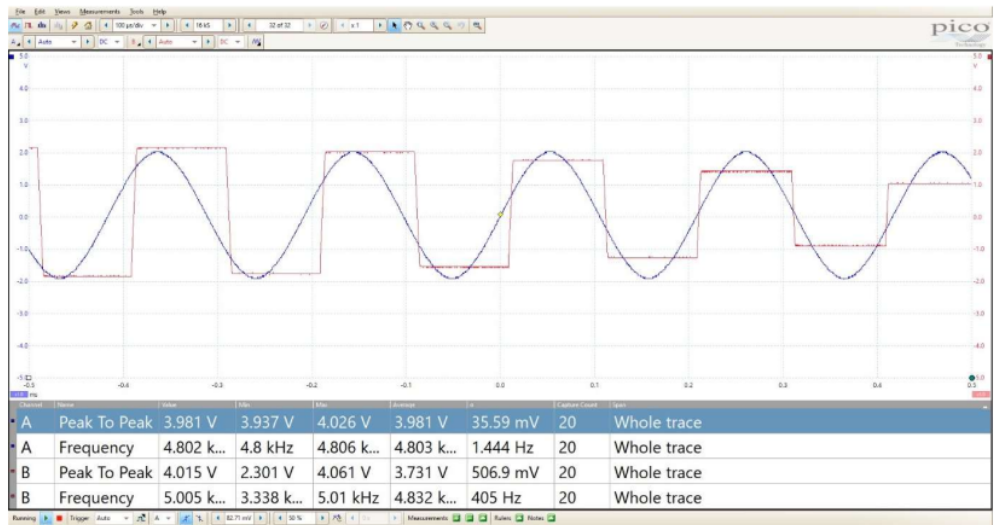


Figure 29 - 4.8khz

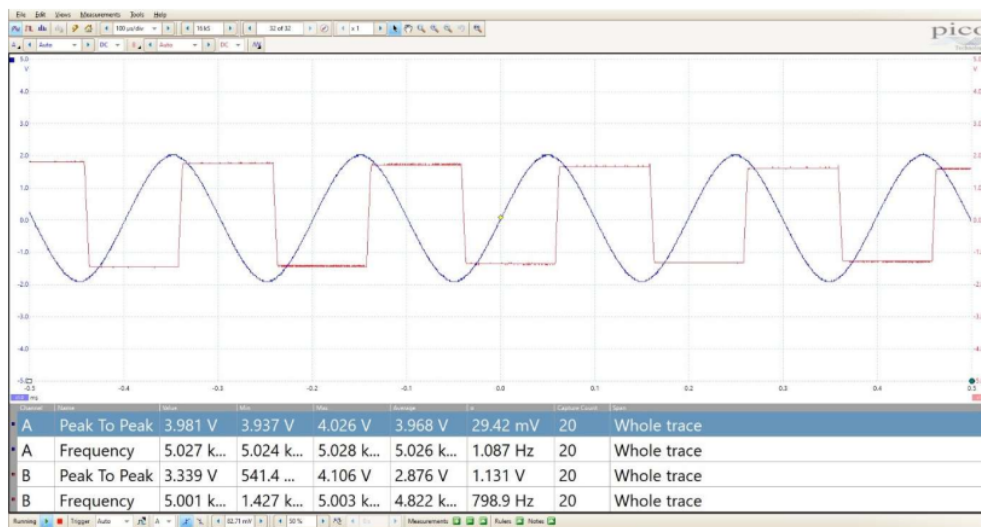


Figure 30 - 5khz

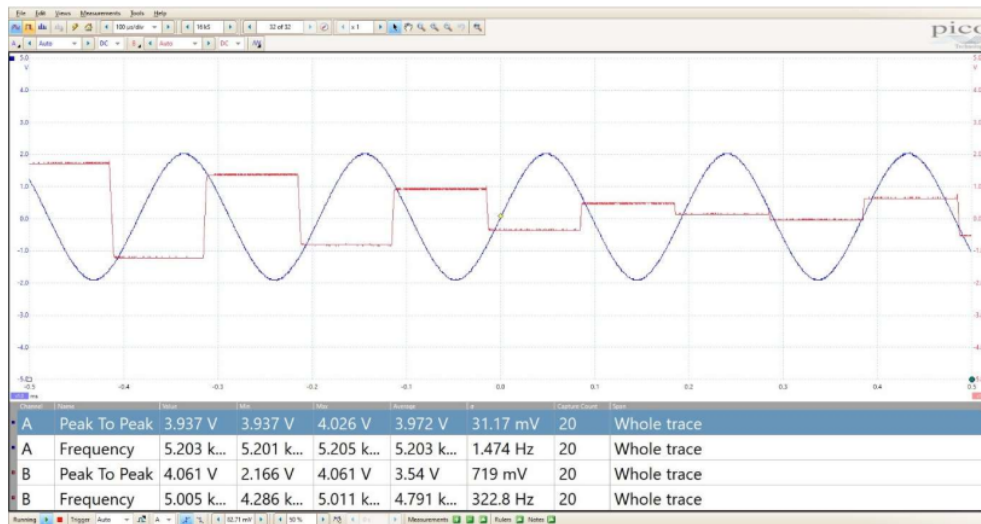


Figure 31 - 5.2khz

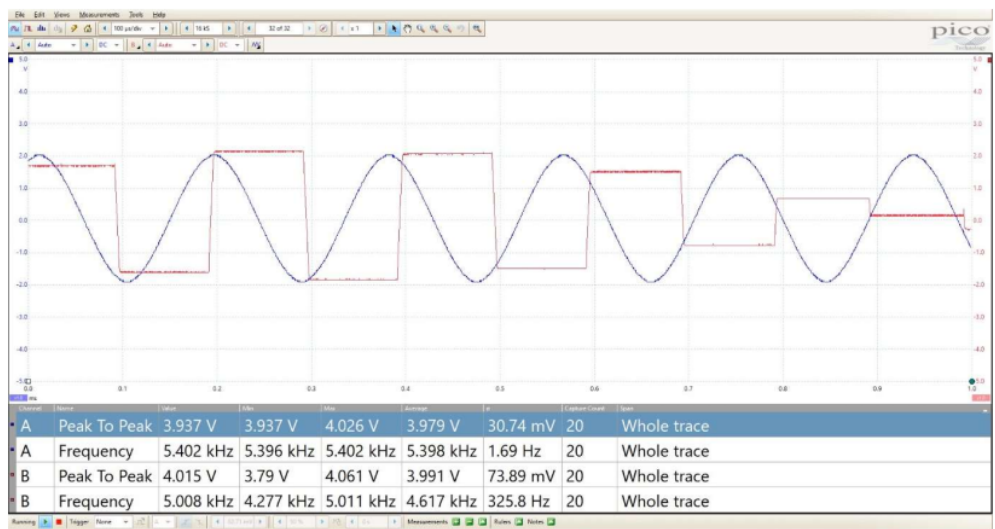


Figure 32 - 5.4khz

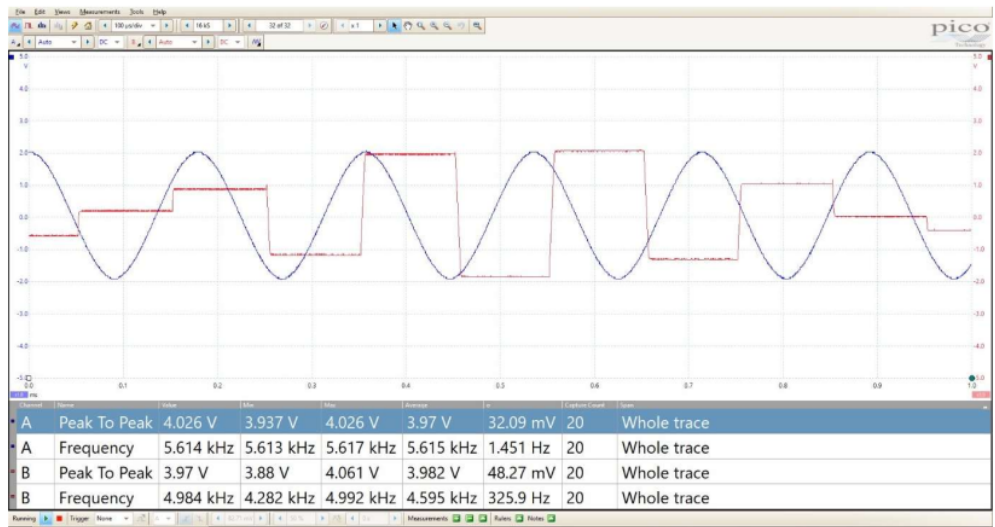


Figure 33 - 5.6khz

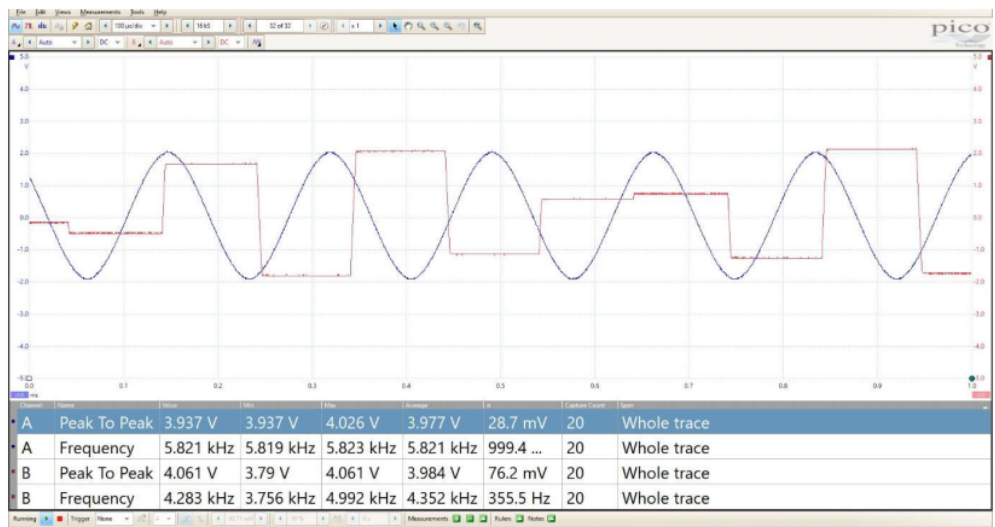


Figure 34 - 5.8khz

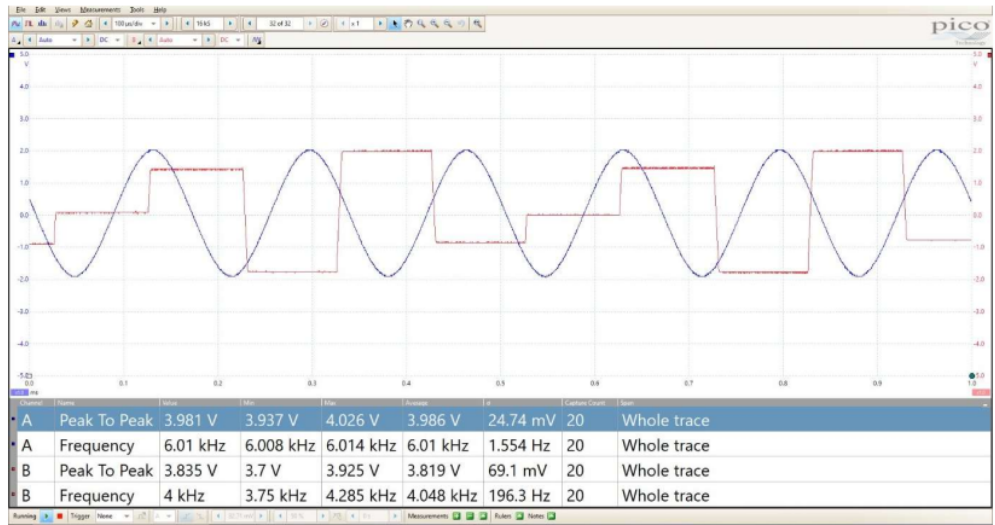


Figure 35 - 6khz

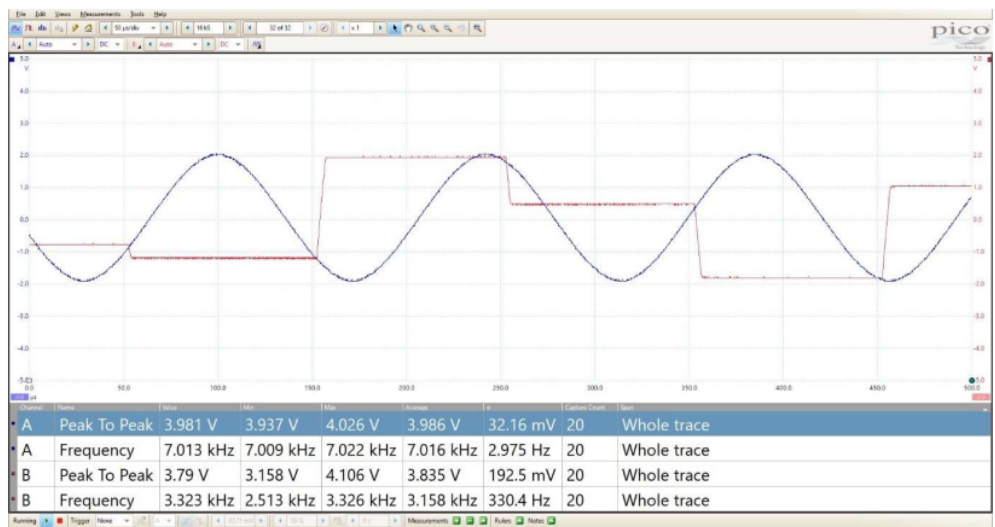


Figure 36 - 7khz

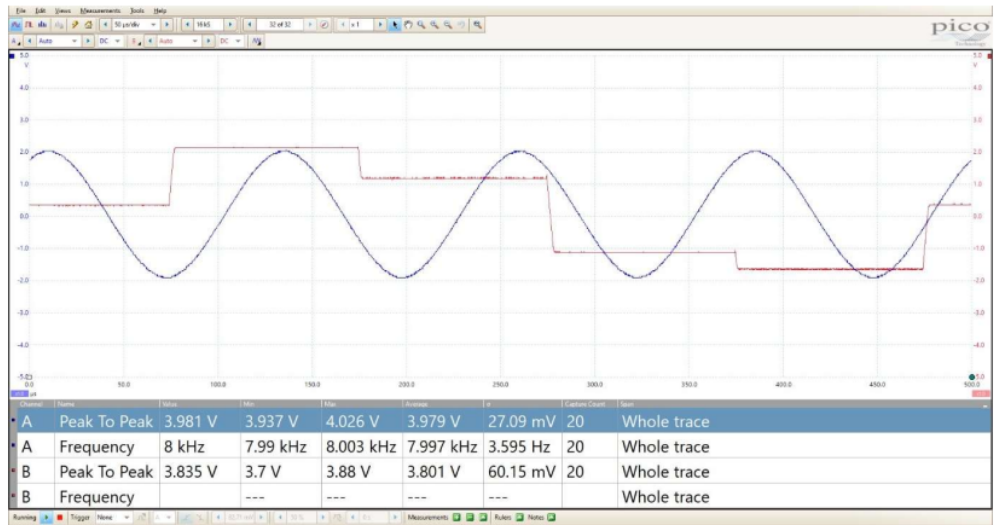


Figure 37 - 8khz

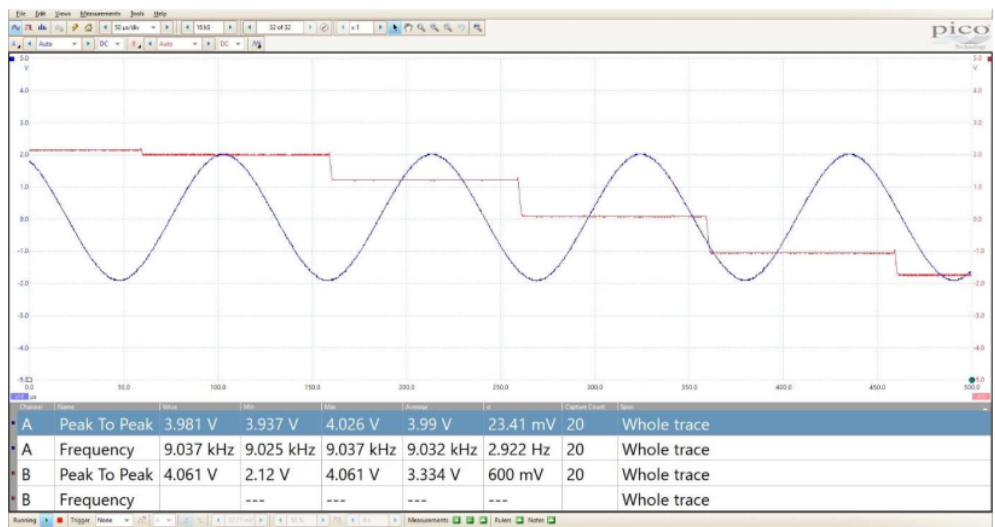


Figure 38 - 9khz

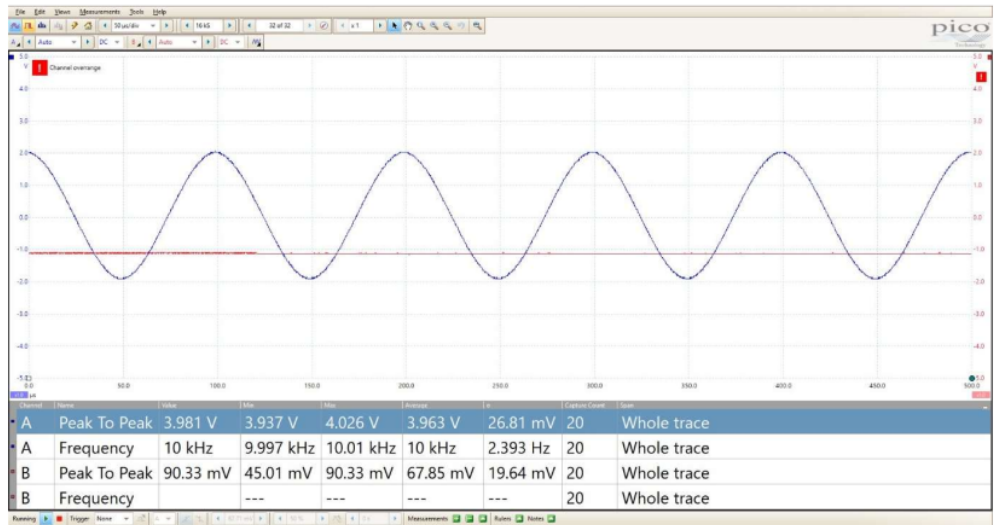


Figure 39 - 10khz

FINAL GRADE

GENERAL COMMENTS

70/100

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GRADING FORM: CSG-RUBIC

IWAN GRIFFITHS

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RESEARCH-INFORMED LITERATURE



There was some evidence of further reading and research and your interpretation and understanding of the additional research was satisfactory and demonstrated an underlying appreciation of the subject. Your references still rely on a small selection of mostly credible sources

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and you need to be more consistent with your referencing conventions e.g. citing diagrams as well as text.

KNOWLEDGE AND UNDERSTANDING



The knowledge and understanding of the subject demonstrated by this assignment was generally very good. There were few gaps in your knowledge of the basic principles and your understanding of the higher level concepts was demonstrated to a high degree. You have demonstrated a competent critical understanding of the main concepts and expanded your knowledge beyond that contained in the course notes.

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ANALYSIS



Your explanation of the experimental procedure was good and the conclusions showed that you can interpret quantitative and qualitative data, although this was often descriptive. You could have evaluated the results and specified whether they concurred with theory suggesting reasons for any discrepancies. You have however demonstrated good analytical skills and your approach to the task was logical. Arguments made in the conclusions were mostly valid and demonstrated a good understanding of the topic. Further work – in your conclusion, you should relate the results to the original specification and to accepted theory.

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PRACTICAL APPLICATION AND DEP.



Your application of practical skills for this task was generally very good. 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 both circuits functioned within the specification and achieved this by only asking for assistance when appropriate thus demonstrating some advanced problem solving skills. Your results were comprehensive and allowed for a detailed conclusion to be attempted.

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SKILLS FOR PROFESSIONAL PRAC.



Your written report was generally well written in a coherent and fluent manner that contained most of the required detail, although it lacked the depth of explanation required in places. Avoid the use of photographs and/or scans of hand-written notes and utilise the available word count more effectively. You need to be more selective with where you put diagrams and graphs, only put those essential for the explanation in the report, the rest can be referred to in the appendix.

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