

2118459

by Cerys Joseph

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Executive Summary

First test was a to carry out a test for a 455 kHz carrier wave that has an amplitude of 375mV. The wave has a frequency modulation of 10kHz sine-wave signal that has a 2V amplitude. The calculations were carried out with the same value to see how close the simulated values to the calculated values. The second test that was carried out was an ADC, there is a difference in analysing and the importance of the input signal between the 4-bit and the 8-bit. Once the test is completed, the results can be analysed.

FM

1. Research

Frequency modulation and amplitude modulation are used to send data using a method of changing the carrier signal. The biggest difference between the modulations is the FM the frequency carrier wave is changed to send the data, whereas the AM the carrier wave is changed according to the data needed. (BYJU'S, N/A)

Amplitude modulation broadcasts at lower carrier frequencies, by doing that the signal can be transport for longer distances. They can also be bounced off the ionosphere. However, the frequency modulation has larger bandwidth than AM radios, this helps gives better sound quality. (BYJU'S, N/A) AM and FM work in a similar way to each other, the AM has strength of the signal varies in order to incorporate the sound information required whereas FM the current changes direction per second for the carrier signal is varied to incorporate the sound information. (HEAVY.AI, 2023)

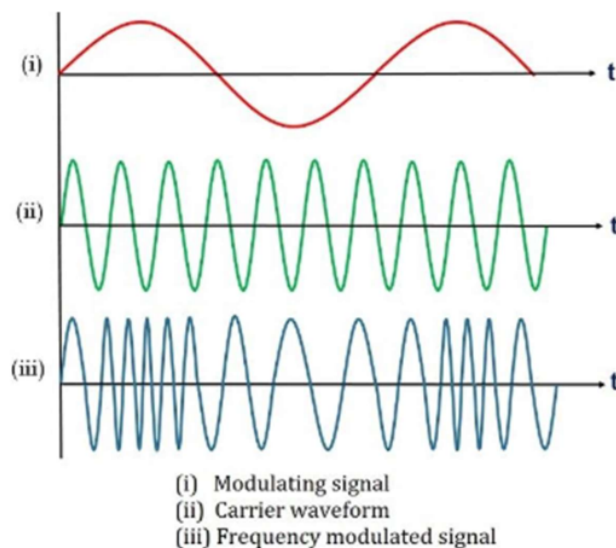


Figure 1 Signal Waves (HEAVY.AI, 2023)

Amplitude is the distance of the maximum vertical displacement of the wave from its mean positioning. For example, the larger the amplitude, the higher the energy will be. In sound the amplitude will be the magnitude of compression and the expansion experienced by the medium of the sound wave travelling through it. (BYJUS, 2023) There are three main types of AM, a single sideband modulation, double sideband-suppressed carrier modulation, and vestigial sideband modulation. If the amplitude of the carrier wave is varied with the modulating signal, this is known as amplitude modulation. This is needed for high range transmission, avoiding overlapping of signals and for quality of transmissions. For an effective communication using AM the length of the antenna should be $\lambda/4$ times the modulating signal. (BYJU'S, 2023)

The carrier wavelength is altered in FM, the number of waves per second that is modified or the frequency. This change is done to match the carrier's wave frequency to the message signal. (Collimator, 2023)

2. Planning and Reflection

First thing that will be done is to start the calculations from the values that are given in the assignment, the carrier wave has a 455kHz with an amplitude of 375mV. The frequency modulation of 10kHz has a sine-wave signal with a 2V amplitude. After the calculations are complete then the equipment can be safely set up for the frequency modulation test to be completed. Once the values are measured on the test equipment then they can be compared to the calculated values.

3. Method 1 – Frequency Modulation

For this assignment, the 455kHz carrier wave has an amplitude of 375mV. It also has a frequency modulation by a 10kHz sine-wave signal with a 2V amplitude. When the modulator has an FM transfer characteristic of 20kHz per volt, the calculations are shown below:

The carrier frequency is calculated by, $\frac{F_{MAX} + F_{MIN}}{2}$, so when all the values are added into the formula it will look like, $\frac{520 + 480}{2}$. The carrier frequency is then worked out to be 500KHz, this value is then used in the formula to find out the maximum frequency deviation. The maximum frequency deviation is calculated by the formula, $F_{MAX} - F_C$, so the frequency deviation for this would be 520 – 500, which will give an answer of 20KHz.

The modulation index is worked out by the formula, $\frac{dfc}{fm}$. When the values are placed into the formula it looks like, $\frac{40kHz}{10kHz}$ this will give the answer of 4. The component amplitudes can be calculated using the Bessel Table.

β	J0	J1	J2	J3	J4	J5	J6	J7	J8
0.00	1.00	—	—	—	—	—	—	—	—
0.25	0.98	0.12	—	—	—	—	—	—	—
0.50	0.94	0.24	0.03	—	—	—	—	—	—
1.00	0.77	0.44	0.11	0.02	—	—	—	—	—
1.50	0.51	0.56	0.23	0.06	0.01	—	—	—	—
2.00	0.22	0.58	0.35	0.13	0.03	—	—	—	—
2.40	0.00	0.52	0.43	0.20	0.06	0.02	—	—	—
2.50	-0.05	0.50	0.45	0.22	0.07	0.02	0.01	—	—
3.00	-0.26	0.34	0.49	0.31	0.13	0.04	0.01	—	—
4.00	-0.40	-0.07	0.36	0.43	0.28	0.13	0.05	0.02	—
5.00	-0.18	-0.33	0.05	0.36	0.39	0.26	0.13	0.05	0.02

Figure 2 Bessell Table

J0	$0.375 * 0.4$	$= 0.15$
J1	$0.375 * 0.07$	$= 0.02625$
J2	$0.375 * 0.36$	$= 0.135$
J3	$0.375 * 0.43$	$= 0.16125$
J4	$0.375 * 0.28$	$= 0.105$
J5	$0.375 * 0.13$	$= 0.04875$
J6	$0.375 * 0.05$	$= 0.01875$
J7	$0.375 * 0.02$	$= 7.5 * 10^{-3}$

This figure is a graph of data in the table above, this figure will give us a rough idea the shape of the frequency that will be measured from the values.

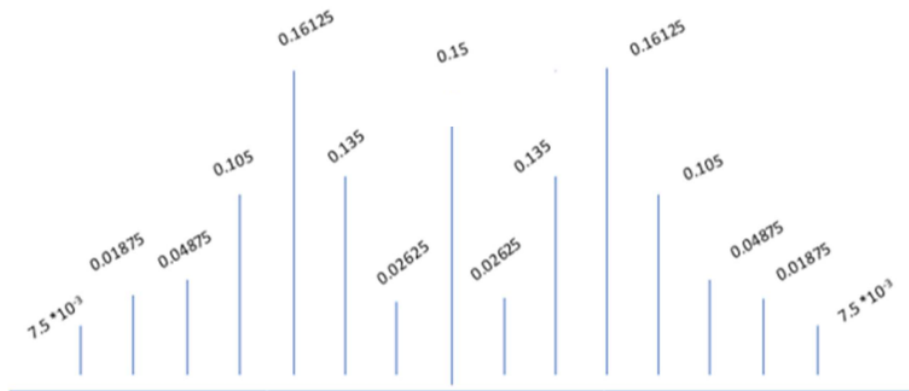


Figure 3 Calculation Graph

The figure 3 what the data above looked like after the information was put into the equipment. When looking at both graphs the measured data has a similar shape to the calculated data, in both graphs the data has a peak in the middle then dips. After that the data increases then slowly decreases.

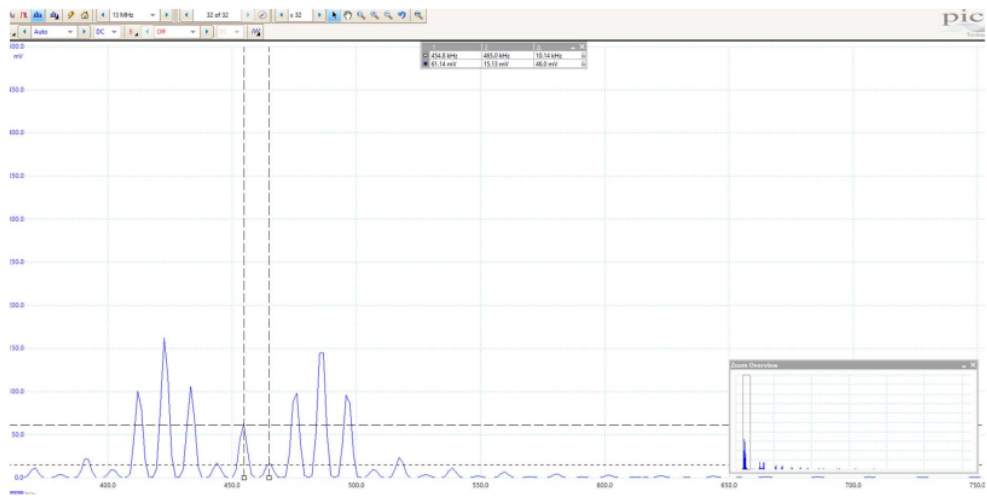


Figure 4 Frequency Spectrum

In screenshot 4 it shows channel B which is the 10kHz message wave, the wave is the peak to peak for 2 volts. As seen in the channel B peak to peak column the value is 2.022V and in the column below it shows the frequency is 10.51kHz.

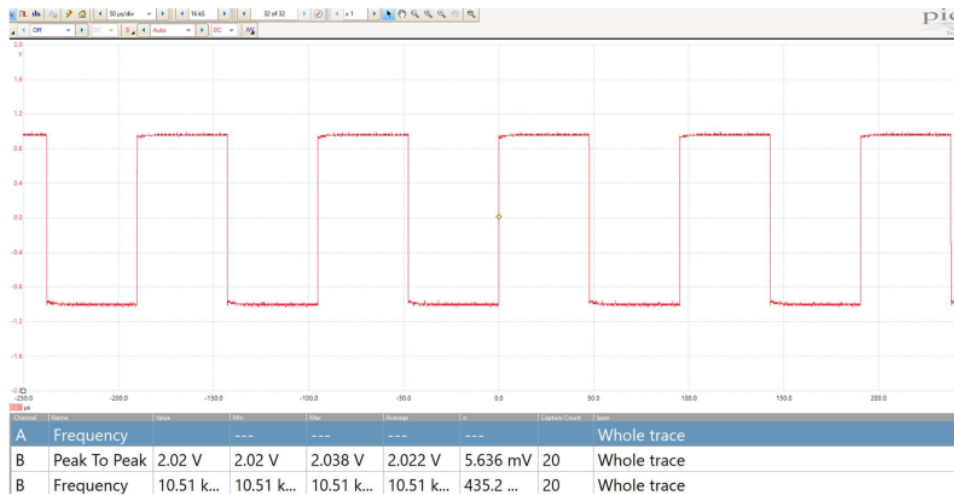


Figure 5 2 Volt Peak to Peak 10kHz message wave

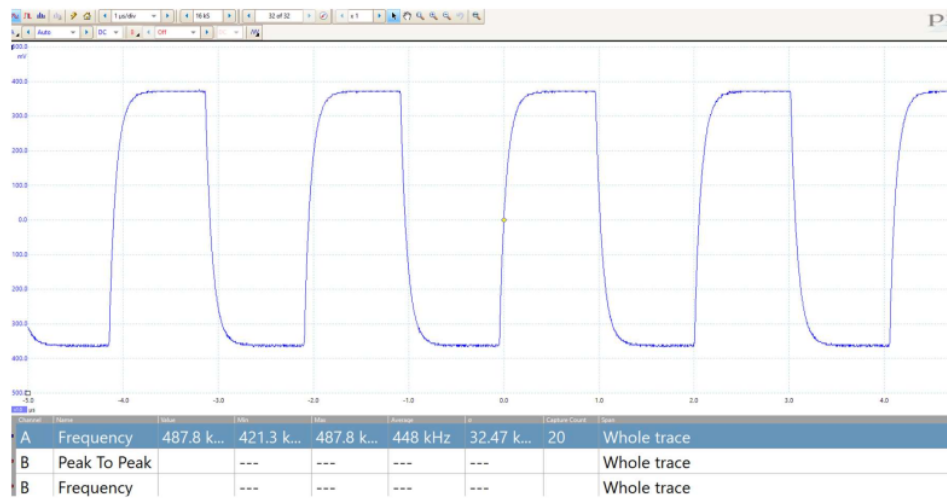


Figure 6 Carrier Wave Centre Frequency of 455kHz, 32kHz

In the screenshots 6, 7 and 8 is the second test and the simulated graph looks the similar to calculated graph. The middle peaks to around 0.15 then drops, after dropping the frequency then increases to around 0.16.

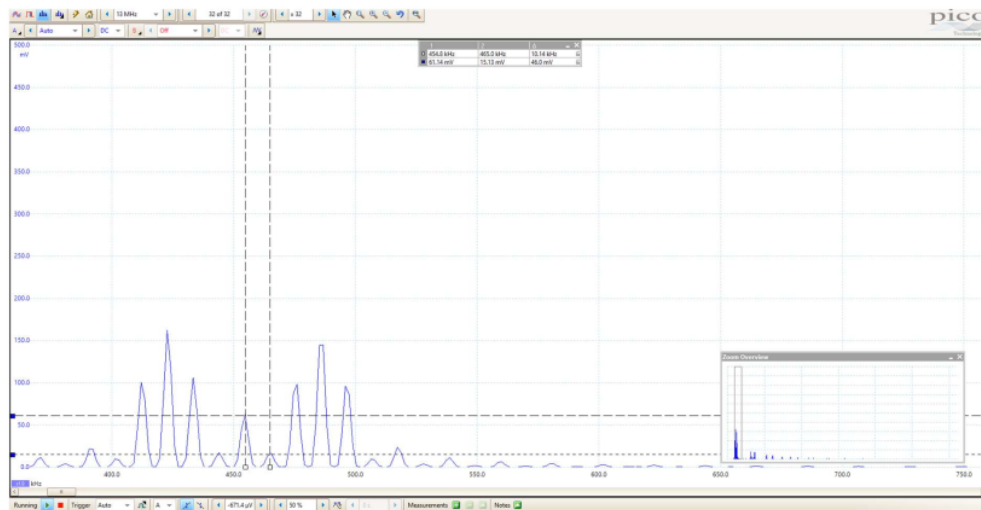


Figure 7 Frequency Spectrum Change

The 5kHz carrier wave is shown below in screenshot 7, channel A is the blue line. In screenshot 8, the red line is channel B the frequency is 5kHz and the peak to peak value is 2V. As can be seen in the screenshot the red line goes up to the 2V value.

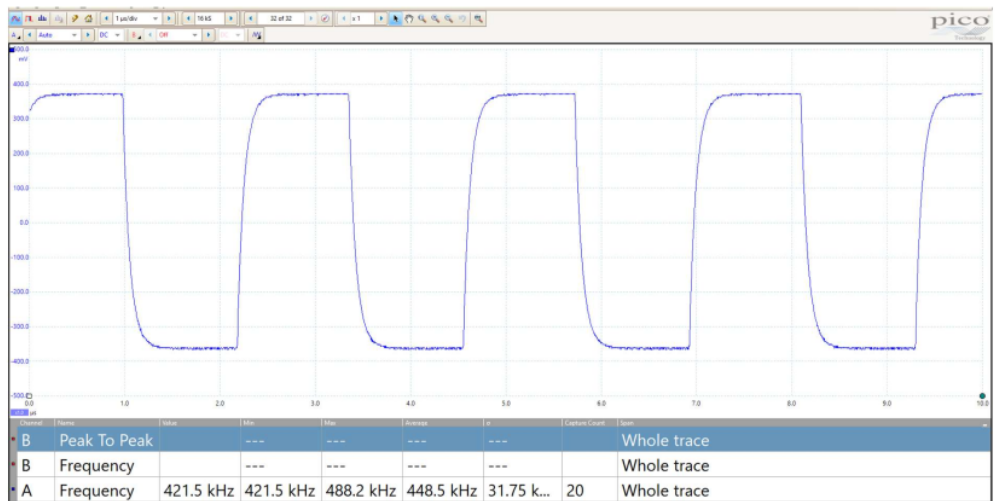


Figure 8 5kHz Carrier wave

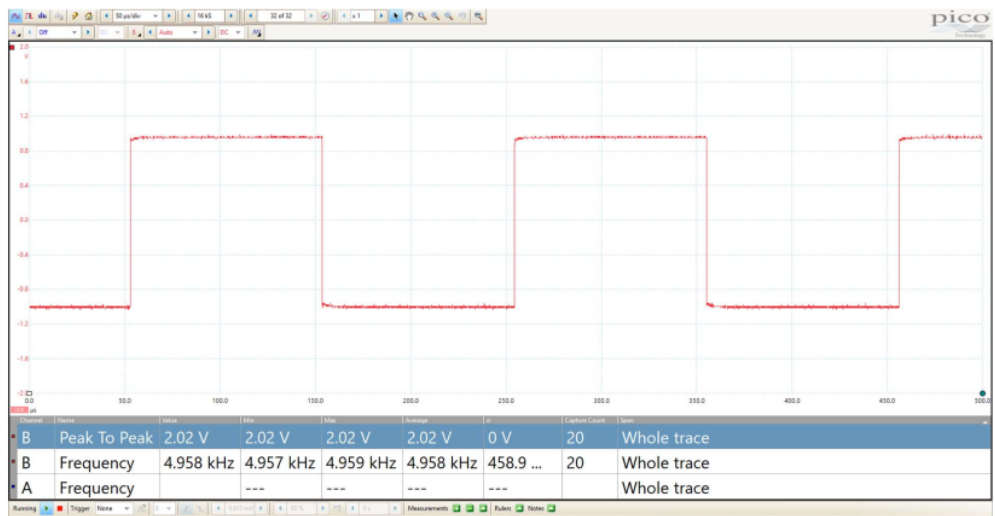


Figure 9 Frequency from 10 to 5kHz

4. Results

The Frequency from 10 to 5 kHz

	Frequency	Peak-To-Peak
Channel A	---	---
Channel B	4.958 kHz	2.02 V

5 kHz Carrier Wave

	Frequency	Peak-To-Peak
Channel A	448.5 kHz	---
Channel B	---	---

Carrier Wave Centre Frequency 455 kHz

	Frequency	Peak-To-Peak
Channel A	448 kHz	---
Channel B	---	---

2V Peak-To-Peak of a 10 kHz Message Wave

	Frequency	Peak-To-Peak
Channel A	---	---
Channel B	10.51 kHz	2.022 V

5. Analysis

When looking at the results the data shows that the calculated and simulated results look similar as shown in the diagram and the simulated screenshot. The shape of the graphs shows the increases and the decreases of the data. The 10 kHz message wave has a peak-to-peak value of 2.022V and the frequency is shown to be 10.51 kHz.

ADC

1. Research

The analog to digital converter, ADC, this takes an analog wave as the input and then converts it to a digital output form. (ElectronicDesign, 2021) Most modern microcontrollers have built in ADC converters, it's normally 10 or 12 bits, which has 1024 to 4096 quantisation levels. When the user program can take several hundred microseconds to complete the conversation. (ScienceDirect, 2022)

For Flash Method an AD convertor uses 2^N-1 comparators, this is for a 2^N converter, to compare the signals with reference voltages. The feature of the analogy signals is converted into digital ones, this makes sample and hold circuit unnecessary. The sampling is extremely fast conversion, sampling frequency above 1GHz. The larger size and power consumption limits resolution to around 8 bits. (ROHM, 2024)

The Pipeline Method consists of several successive stages, which include sample and hold circuit, digital error correction, and low-resolution ADC/DAC. A delta sigma is a device that consists of oversampling modulator which will feed very high-rate signal into a decimation/digital filter, this produces high-resolution and will slow a digitally encoded waveform. (ElectronicDesign, 2021)

The Approximation Method compares with the sampling analog input with the output in succession, it starts with the MSB. The analog input signal is sampled, S and H. A successive register, which is designed to supply an appropriate digital code to the internal DAC, the most significant bit is set to '1'. The digital value from the SAR will be converted to analog values by the DAC. The sampled input voltage is compared with the DAC output voltage and the digital conversion is then completed by repeating the operation up to LSB.

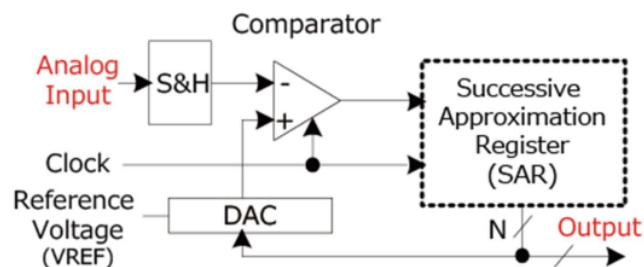


Figure 10 Comparator Graph

The characteristic of this type is high resolution conversion, up to 18 bits. (ROHM, 2024) The characteristics need to be assessed and evaluated before they are designed into the circuit, the basic ones are speed, resolution, accuracy, and dynamic range.

2. Planning and Reflection

The first that was done was to set up the equipment safely, then the frequency modulation test can be carried out. The amplitude of the carrier 375mV then it will be compared to the calculated results. The next test that needs to be done is the ADC. The difference between 4-bit and 8-bit is analysed and the importance of the input signal matching the amplitude will be analysed.

3. Method 2 – Analogue to Digital Conversion

The 4-bit convertor has a frequency of 39.4mHz with a peak to peak of 19.86mV in channel A and has a frequency of 130mHz with a peak to peak of 0V in channel B. The difference in the frequency in the 4-bit results is 90.6mHz between channel A and channel B and the difference between channel A and B on the 8-bit results is 96.62. The results shown that the equipment works better with the 4-bit settings oppose to the 8-bit settings as the data is better transmitted as efficiently as possible. The 4-bit has 64 distinct characters, a 95% accuracy rate and a 48% overall speed up rate. Whereas the 8-bit has 256 characters, a 95.4% accuracy rate and a 39% overall speed up rate. So even though the 8-bit has a better signal it is slower at getting the signal to where it needs to be.

4. Results

100Hz mV for a 4-bit

	Channel A Frequency	Channel A Peak to Peak	Channel B Frequency	Channel B Peak to Peak
2 nd	101.2 Hz	101.1 Hz	101 Hz	117.1 Hz
3 rd	760.6 mV	1.339 V	6.126 V	205 mV
Bottoming Out	101.3 Hz	101.1 Hz	101 Hz	125.8 Hz
Bottomed Out	688.4 mV	1.326 V	4.895 V	402.5 mV

100Hz mV for an 8-bit

	Channel A Frequency	Channel A Peak to Peak	Channel B Frequency	Channel B Peak to Peak
2 nd	101.9 Hz	101.8 Hz	101.8 Hz	101.9 Hz
3 rd	772.7 mV	1.384 V	6.039 V	201.9 mV
Bottoming Out	109.4 Hz	102.3 Hz	101.9 Hz	151.2 Hz
Bottomed Out	803 mV	1.437 V	5.189 V	275.2 mV

Effect of changing the input frequency, 200Hz to 6kHz

	Channel A Frequency	Channel A Peak to Peak	Channel B Frequency	Channel B Peak to Peak
4.2 kHz	4.232 kHz	3.986 V	4.366 kHz	4.004 V
4.4 kHz	4.402 kHz	3.984 V	4.435 kHz	4.018 V
4.6 kHz	4.604 kHz	3.97 V	4.611 kHz	3.952 V
4.8 kHz	4.803 kHz	3.981 V	4.832 kHz	3.731 V
5 kHz	5.026 kHz	3.968 V	4.822 kHz	2.876 V
5.2 kHz	5.203 kHz	3.972 V	4.791 kHz	3.54 V
5.4 kHz	5.398 kHz	3.979 V	4.617 kHz	3.991 V
5.6 kHz	5.615 kHz	5.615 V	4.595 kHz	3.982 V
5.8 kHz	5.821 kHz	3.977 V	4.352 kHz	3.984 V
6.0 kHz	6.01 kHz	3.986 V	4.048 kHz	3.829 V

Effects of changing the Input Frequency, 1 kHz to 10kHz

	Channel A Frequency	Channel A Peak to Peak	Channel B Frequency	Channel B Peak to Peak
7 kHz	7.016 kHz	3.986 V	1.158 kHz	3.835 V
8 kHz	7.997 kHz	3.979 V	---	3.801 V
9kHz	9.032 kHz	3.99 V	---	3.334 V
10 kHz	10 kHz	3.963 V	---	67.85 mV

5. Analysis

The 100Hz 4-bit screenshot, figure 11, shows channel A as the blue sinewave and the channel B show as the red square-wave. The frequency of channel A is 101.2Hz and has a peak-to-peak value of 760.6mV and channel B has a frequency of 101.3Hz and a peak-to-peak value of 688.4mV. This shows a two-step in the waveform, the steps shown are an error in the sinewave. The third step has a frequency of 101.1Hz in both channels A and B and a slight difference of 0.013 between the peak to peaks in channel A and B. The waveform is as close as it can be with the errors that are occurring in channel B. At around 4.895V peak to peak for a frequency of 101Hz for channel B, the sinewave starts to bottom out. This is shown as the red line, which is channel B, starts to flatten at the top and the bottom of each wave. When frequency of channel A is 117.1Hz with a peak to peak of 205mV and the frequency of channel B is 125.8Hz with a peak to peak of 402.5mV the sinewave completely bottoms out, this will cause the channel B line to change into steps and channel A to stay as a sinewave.

With the input amplitude being low, the 4-bit square-wave will switch into a sinewave for the 8-bit. For the 100Hz 8-bit screenshot is figure 15, shows that channel A has a frequency of 101.9Hz with a peak to peak of 772.7mV and channel B has a frequency of 109.4Hz with a peak to peak of 803mV. The channel B waveform is smaller than the channel A, however when the voltage increases to 1.384V for channel A and 1.437V for channel B, the channel B waveform is nearly identical to channel A waveform with channel B being slightly off apart from some parts of the waveform where it matches. The waveform starts to bottom out when the peak to peak reaches 201.9mV on channel A and 275.2mV on channel B, there are lots of steps in the sinewave around these values with the odd spike occurring throughout. It bottoms out when the peak to peak reaches 6.039V for channel A and 5.189V for channel B, the waveform of channel B goes back to matching channel A however the top and bottom of the waveform are flat.

When the input frequency is set to 1kHz then channel A is a sine-wave and channel B has a step square-wave, the frequency is 1.034kHz with a peak to peak of 4.061V. Then when the frequency was increased to 2kHz on channel A it is still a sine-wave. However, the step square wave of channel B is still the same except there's more of a gap between each of the steps. The peak to peak is 3.925V. When the input is increased to 3kHz, channel A is still the same as before. However, channel B has more gaps between each step, the peak-to-peak value is 4.015V. Then when the input frequency is changed to 4kHz, then channel A is the same and channel B is move of a square-wave. The peak to peak of channel B is 3.74V.

When the frequency for channel A is increased to 7kHz, there is a sine-wave for channel A, whereas for channel B the wave has a step square-wave. The peak-to-peak value for channel B is 3.981V with a frequency of 7.013kHz. When the channel A frequency has been increased to 8kHz the sine-wave is still the same. However, the channel B does not have a value, this could be out of the range that the software can measure. The wave itself increases too just over 2V then decreases in steps. When the frequency of channel A has been increased to 9kHz the sine-wave doesn't change. However, the channel B still does not

have a value and is starting to level out. When the frequency of channel A is increased to 10kHz, it is still a sine-wave. However, at 10kHz the channel B has levelled out and has 'channel overrange.'

6. Evaluation

The results for the 100Hz, 4-bit test the channel A value was 101.2Hz with a peak-to-peak value of 760.6mV. Channel B has a frequency of 101.3Hz with a peak-to-peak value of 688.4mV. These values show there's a two-step in the waveform, these steps show an error in the waveform. The third step in the sinewave will occur when the frequency is at 101.1Hz in both channel A and B, there's a difference of 0.013. For the errors which have occurred in channel B it is the closes that the waveform can get, then at around 4.895V the sinewave starts to bottom out. The sinewave bottoms out at around 125.8Hz with a peak-to-peak of 402.5mV.

The 4-bit square-wave will change to sinewave when changing to the 8-bit as the input amplitude is low. This change can be seen in the 100Hz 8-bit screenshot, the channel A frequency is 101.9Hz and a peak-to-peak of 772.7mV while channel B has a frequency of 109.4Hz and a peak-to-peak of 803mV. When looking at the two waveforms it can be seen that channel A is larger than channel B, after the increase in voltage the channel B can be seen to be nearly identical to the channel A. At around the 201.9mV for channel A and 275.2mV for channel B the waveform starts to bottom out, which can be seen as loads of steps in the sinewave. When the peak-to-peak reaches 6.039V then the waveform bottoms out, the bottomed out can be shown as the top and bottom curves being flat.

7. Conclusion

The 100Hz, 4-bit starts to bottom out with a peak-to-peak of 4.895V and completely bottoms out with a peak-to-peak of 4.895V with a frequency of 125Hz. However, the 100Hz, 8-bit starts to bottom out with a peak-to-peak of 201.9mV, channel A, and a peak-to-peak of 275.2mV, channel B. The 8-bit completely bottoms out 6.039V as shown by the flat sections of the curve.

To improve the assignment, it could go to a higher number of bits so there's a wide range of data that we can compare. For example, 16-bit or 32-bit, to see what happens to the sinewave when the number of bits is increased.

Citation List

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Appendix

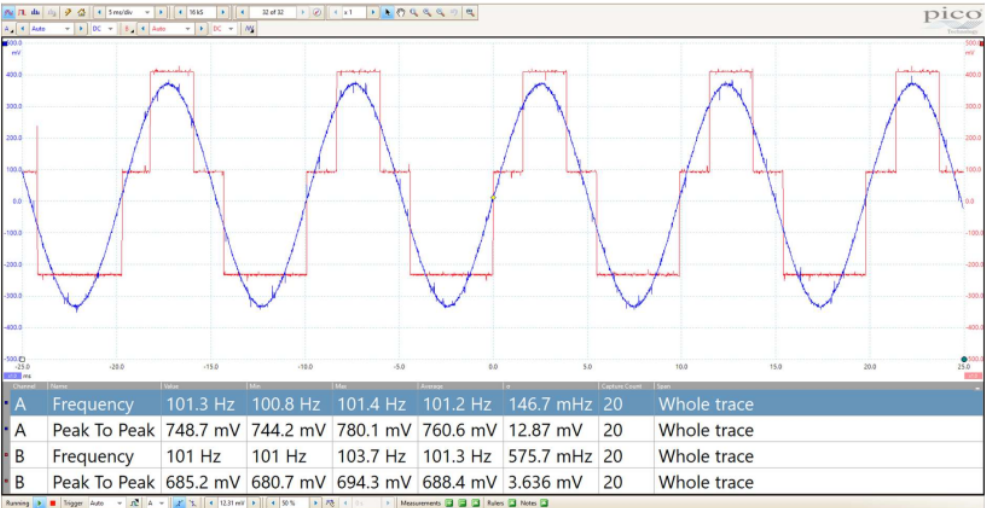


Figure 11 100 Hz mV, Second Step (4-bit)

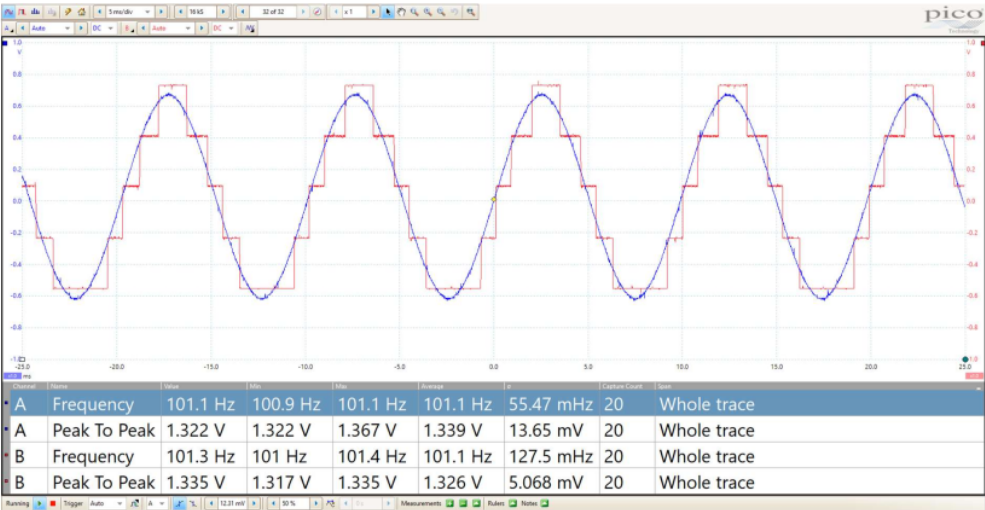


Figure 12 100Hz mV, Third Step (4-bit)

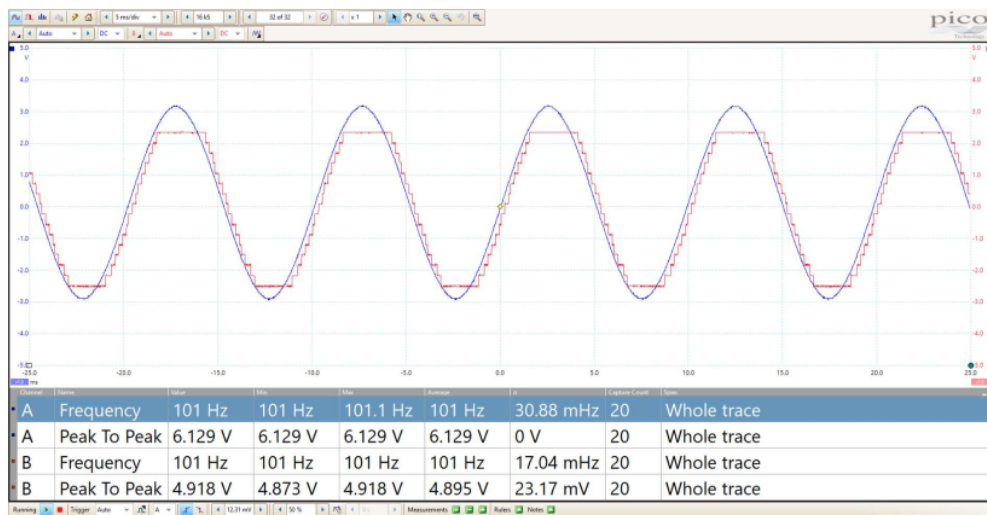


Figure 13 100 Hz mV, Bottoming Out (4-bit)

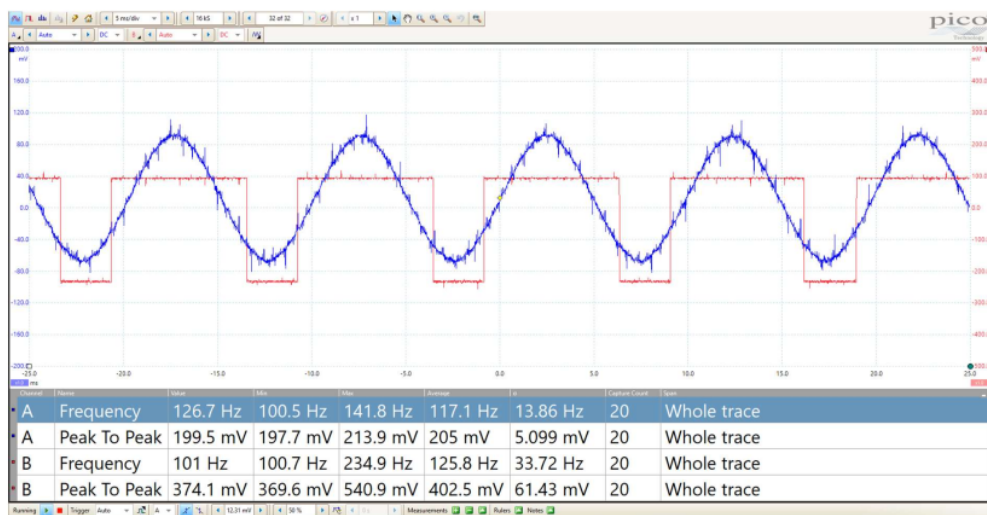


Figure 14 100 Hz mV, Bottomed Out (4-Bit)

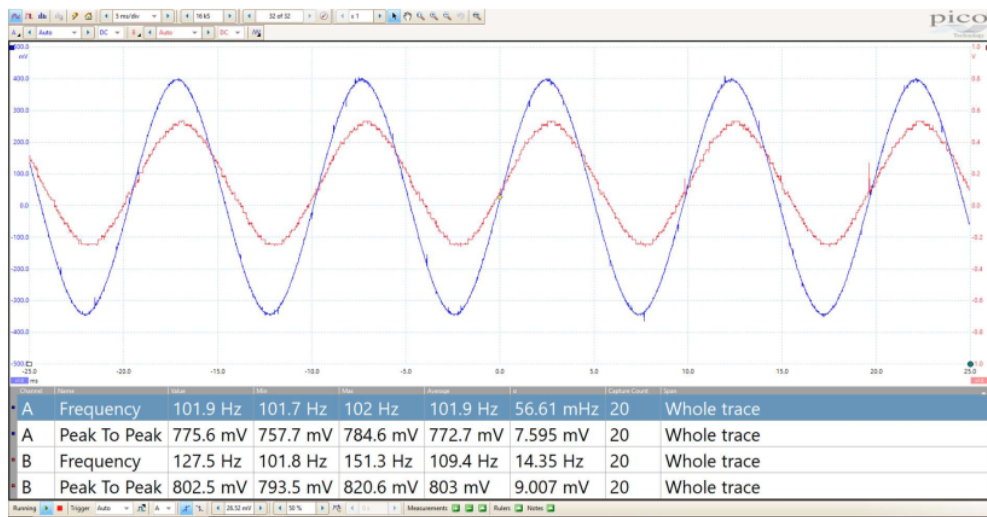


Figure 15 100 Hz mV, Second Step (8-Bit)

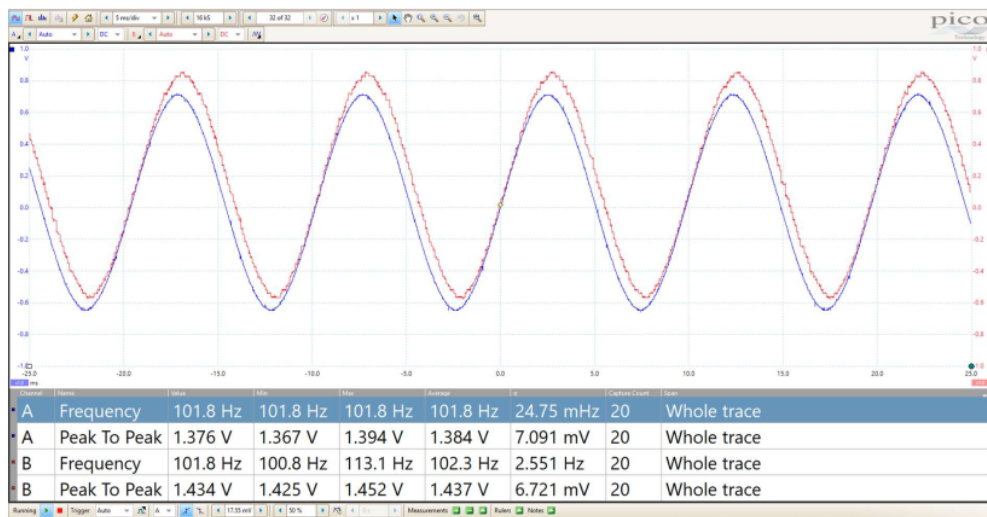


Figure 16 100 Hz mV, Third Step (8-Bit)

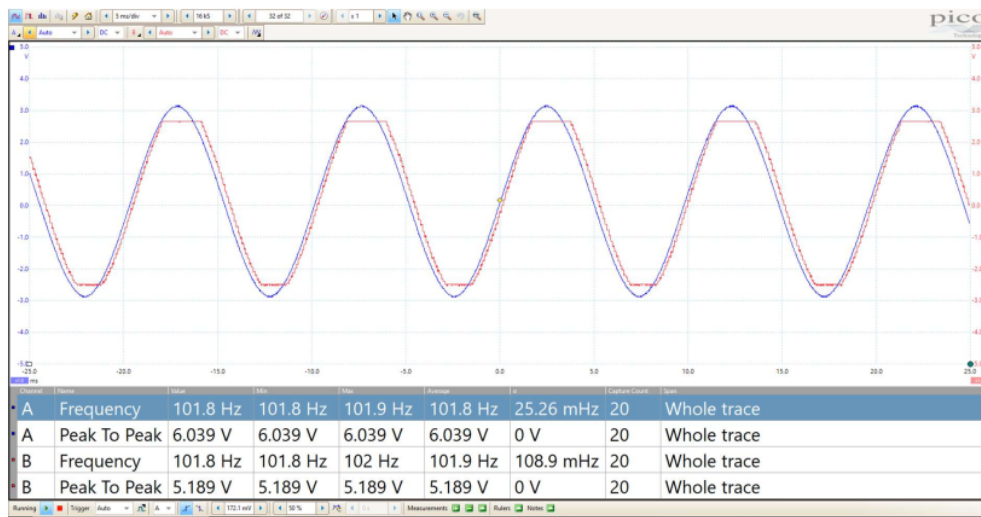


Figure 17 100 Hz mV, Bottoming Out (8-bit)

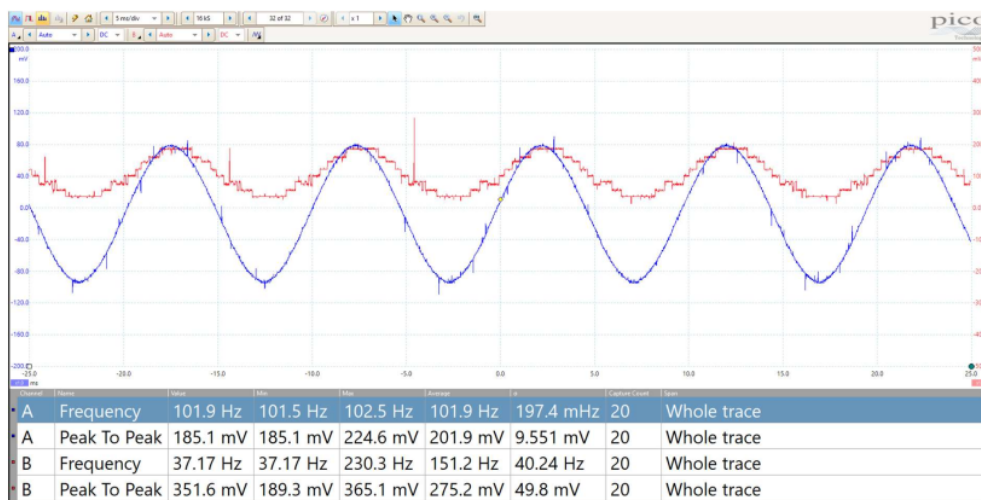


Figure 18 100 Hz mV, Bottomed Out (8-bit)

FINAL GRADE

GENERAL COMMENTS

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GRADING FORM: CSG-RUBIC

CERYS JOSEPH**49****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 sources

4**KNOWLEDGE AND UNDERSTANDING**



The knowledge and understanding of the subject demonstrated by this assignment was generally adequate. The circuits worked and the explanation of how this was achieved was included, but only to a descriptive level, there was little evidence of any critical understanding. Your report lacked depth and detail at times and didn't really extend your

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knowledge beyond that contained in the course notes. Further work – Research results need to be in much more detail and written in a more logical and clearer way.

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.

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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.

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SKILLS FOR PROFESSIONAL PRAC.



In this assignment you have demonstrated skills in working individually and also collaboratively. Your written report was generally good and contained most of the required detail, it was also written in a coherent and logical way. The available word count was in the main effectively used.

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