

PSDE5014 SGEE5005, Signals & Digital Comms Assignment 2018_19

by Phillip Rowe

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HND ELECTRICAL AND ELECTRONIC ENGINEERING

Signals and Digital communication

Signals and Modulation

Phillip Rowe

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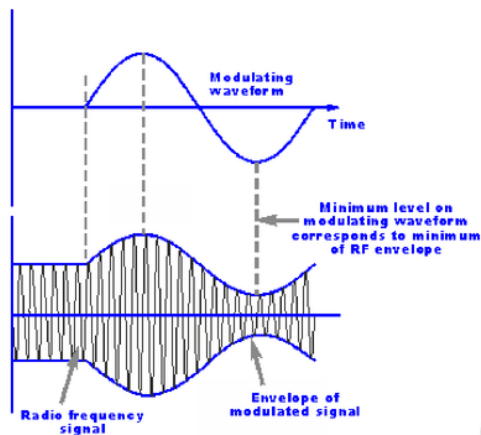
1. Executive summary

During this assignment there was extensive research into both AM and FM modulation techniques. Their applications were discussed and also how they work. Analog to digital convertors were also researched and their purposes. Different types of shift keying and also pulse modulations were investigated. The Pleisiosynchronous and Synchronous digital hierarchy were investigated and explained. There was then a practical investigation into frequency modulation in order to determine what the effects were of altering the amplitude and frequency at various times and what effects it has on the wave. The ADC practical involved investigating the differences between 4 bit and 8 bit ADCs and then finding out the effects of changing the amplitude and also the frequency at different times. All of these results were then critically evaluated in order to form a professional conclusion and to be able to relate the results gained in the practical to the research which was carried out.

2. Research into analogue and digital communication systems and techniques

Amplitude Modulation

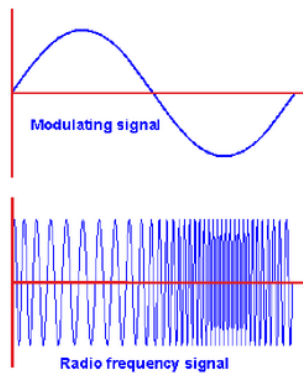
AM was something which was developed in the start of the 20th century. AM was the earliest modulation technique which was used in order to transmit voice. AM is used in electronic communications. With AM the amplitude of the carrier signal will vary based on the accordance of the message signal. Things such as phase and frequency remain constant. With AM the amplitude of both the positive and the negative half cycles of the carrier wave are changed with accordance to the signal. Amplitude modulation is carried out by an electronic circuit called a modulator. Below in figure 1 is an example of a transmitted AM waveform.



(Figure 1 - (Agarwal, 2015))

Frequency Modulation

FM modulation is carried out by changing the frequency of the carrier signal with accordance to the message signal. In FM the frequency of the signal will vary as the voltage of the modulation signal changes. This is also shown in figure 2 below. The other parameters like amplitude and phase will remain as a constant. FM is vastly used for things like radar, seismic prospecting and radios. With FM it provides a great benefit when it comes to cancelling noise as any FM with sufficient bandwidth will provide this advantage in cancelling the noise.

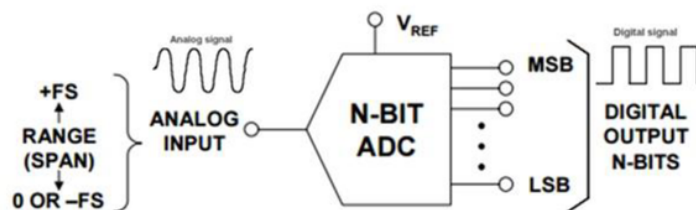


(Figure 2 - (Poole, Modulation types and techniques, 2013))

The amount in which the frequency signal will vary is a very important factor, this is called frequency deviation. The value of the frequency deviation is normally given in a number of KHz. With regards to his assignment the frequency deviation was worked out at the start of the assignment at a value of 40 KHz. The frequency deviation is a very influential when it comes to determining the actual bandwidth of the overall signal. Due to this factor the frequency deviation will be different in different applications, for example broadcast stations which are in the VHF(very high frequency) side of the spectrum around about 88.5 to 108 MHz will use very large values of deviation(around about $\pm 75\text{KHz}$). These are commonly known as WBFM (wideband frequency modulation). When these types of signals are used they are capable of carrying out very high quality transmissions but also have a very big bandwidth. Normally about 200 KHz is allowed for each wideband when using wideband transmissions. On the other hand for radio communications less bandwidth is used. NBFM (Narrowband frequency modulation) normally will used deviation values of around about $\pm 3\text{KHz}$. Since with radio communications the quality is not as important as other applications this means the bandwidth can be much narrower which will then have advantages with regards to the radio spectrum efficiency. Ideally in a FM wave the modulation index would ideally be less than one. This is because if it is greater than one then the top of the wave will start to get clipped off and you will lose part of that wave.

Analogue to digital convertors

Analog-to-digital conversion is an electronic process in which a continuously variable (analog) signal is changed, without altering its essential content, into a multi-level (digital) signal. (Rouse, 2015). Inputted into an ADC is a voltage which will vary among an infinite number of values. One example of this would be sine waves. These waves can represent human speech. Looking at an output of an ADC will consist of defined levels or states. These levels/states will always be in powers of two for example 2, 4, 8, 16 and so on. The digital signals will have two states and will be represented in binary. A normal telephone modem will use an ADC in order to convert the signal incoming from the twisted pair line into signals which the computer can understand. Below in figure 3 Is an example of a ADC.



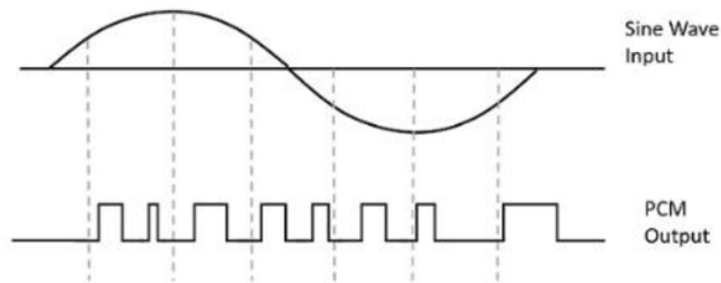
(Figure 3 - (Sobot,

2012)

One type of ADC is dial-up. A dial up modem works by taking digital information and then converting it into an analog signal which can travel through normal phone lines. The modem that is on the ISP side will take the analog signal it receives and then will convert it back to a digital signal. When converting a signal more than once it can cause degradation and can cause reduced speeds.

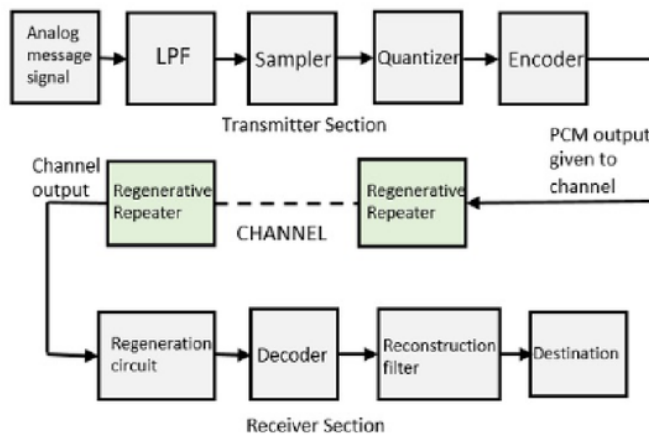
Pulse amplitude modulation and Pulse code modulation

PAM is the transmission of data which is done by varying the amplitude of the pulses. This is done in a timed sequence by electrical or electromagnetic pulses. There is an infinite amount of pulse amplitudes that are possible with analog PAM however, more commonly the number of pulses are a power of two so that the output signal can be digital. PCM is where a signal such as a sine wave input is converted into a binary sequence for example ones and zeros. Shown below in figure 4 is an example of pulse code modulation.



(Figure 4 (point, 2019))

The transmitter section of a PCM circuit consists of sampling, quantizing and also encoding. These are all performed in an ADC section. There is also a low pass filter in the circuit which prevents aliasing of the message signal. The receiver section of the circuit has basic operations such as regeneration of impaired signals, reconstruction and also decoding. Following below in figure 5 is a block diagram of the basic elements in a PCM circuit.

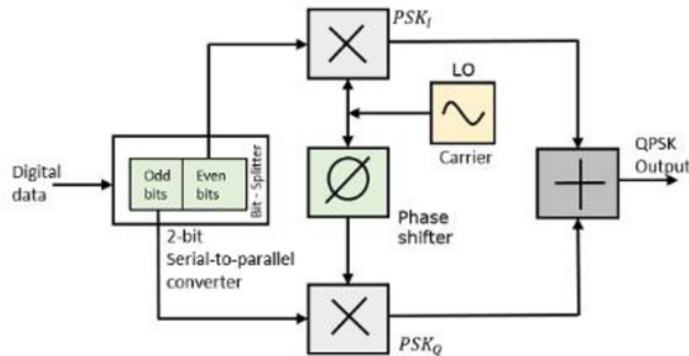


(Figure 5)

QPSK and QAM

The Quadrature Phase Shift Keying (QPSK) is a variation of BPSK, and it is also a Double Side Band Suppressed Carrier (DSBSC) modulation scheme, which sends two bits of digital information at a time, called as bigits. (point, 2019) The QPSK converts digital bits into bit pairs instead of a series of

digital stream as this allows space for other users. Following below is a QPSK modulator which makes use of a bit splitter, two multipliers which have a local oscillator, a 2-bit serial to parallel converter and finally a summing circuit, this is shown below in figure 6.



(Figure 6)

QAM is a signal in which two carriers shifted in phase by 90 degrees are modulated and the resultant output consists of both amplitude and phase variations. (Poole, radio electronics, 2015) One of the reasons for using QAM is because when straight amplitude modulated signals are used for example ones with double sideband and even ones with suppressed carriers, these can occupy twice the bandwidth of the modulating signal. This is seen as very wasteful when looking at the available frequency spectrum. When using QAM it restores the balance by using two independent double sideband suppressed carrier signals all in one spectrum as on ordinary double sideband suppressed carrier signal.

Plesiosynchronous and Synchronous digital hierarchy

The plesiochronous digital hierarchy (PDH) is a telecommunications network transmission technology designed for the transport of large data volumes across large scale digital networks. (Techopedia, 2010). The design of PDH will allow data to be streamed without the use of isochronous clocks to synchronize the signal exchanges. With PDH clocks they run at very close times but are not perfectly in time with each other so this means the signal arrival times could differ since the transmission rates will be linked to the rate of the clock.

Synchronous digital hierarchy is a known international technology standard which used LEDs or some lasers for synchronous optical fiber communication. The purpose of SDH development was to get rid of any synchronization problems and then also replace PDH systems for bulk telephone and data exchanges.

3. Experimental method

FM experiment

A 455kHz carrier has an amplitude of 375mV and is frequency modulated by a 10kHz square-wave signal of amplitude 2V. If the modulator has an FM transfer characteristic of 20kHz per volt.

Maximum frequency deviation and modulation index

$$\text{Frequency deviation} = \Delta f = 20\text{Khz} \times 2 = 40\text{Khz}$$

$$\text{Modulation index} = \frac{\Delta f}{f_s} = \frac{40\text{khz}}{10\text{khz}} = 4$$

Using the Bessel table below the calculations for the amplitude spectrum will be carried out.

x	Bessel-function order, n																
m_l	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}	J_{11}	J_{12}	J_{13}	J_{14}	J_{15}	J_{16}
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	—	—	—	—	—	—	—	—	—	—	—	—
2.41	0	0.52	0.43	0.20	0.06	0.02	—	—	—	—	—	—	—	—	—	—	—
2.5	−.05	0.50	0.45	0.22	0.07	0.02	0.01	—	—	—	—	—	—	—	—	—	—
3.0	−.26	0.34	0.49	0.31	0.13	0.04	0.01	—	—	—	—	—	—	—	—	—	—
4.0	−.40	−.07	0.36	0.43	0.28	0.13	0.05	0.02	—	—	—	—	—	—	—	—	—
5.0	−.18	−.33	0.05	0.36	0.39	0.26	0.13	0.05	0.02	—	—	—	—	—	—	—	—

$$J_0 = 0.375 \times 0.40 = 0.15V$$

$$J_1 = 0.375 \times 0.07 = 0.02625V$$

$$J_2 = 0.375 \times 0.36 = 0.135V$$

$$J_3 = 0.375 \times 0.43 = 0.16125V$$

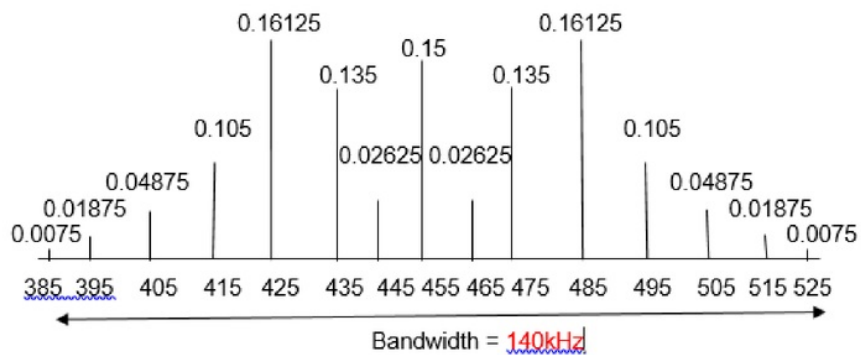
$$J_4 = 0.375 \times 0.28 = 0.105V$$

$$J_5 = 0.375 \times 0.13 = 0.04875V$$

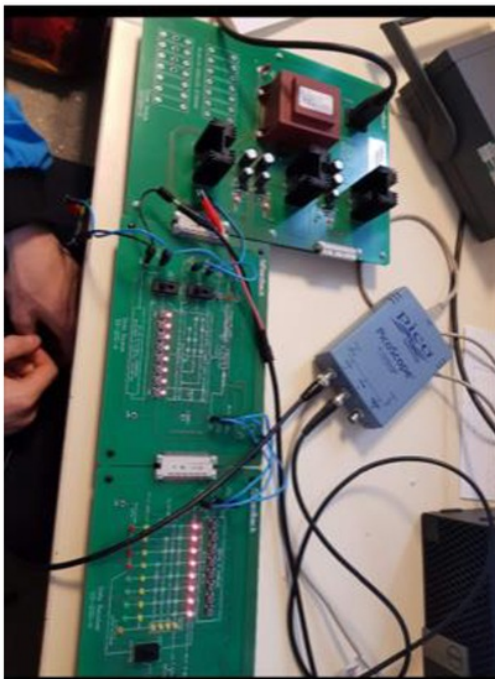
$$J_6 = 0.375 \times 0.05 = 0.01875V$$

$$J_7 = 0.375 \times 0.02 = 0.0075V$$

Components are spaced by the modulating frequency in this case it is 10KHz. Following below is the amplitude spectrum.



The FM practical was set up as shown below in figure 7 Channel A was set up to show the frequency in the measurements and the 0db output was connected to the signal source module. The modulation generator was set to deliver a square wave output at 1Hz. The amplitude was initially set to 0 and the input was connected to the Bx control. Channel B was set to show frequency and peak to peak measurements and then connected the output to the modulation generator.



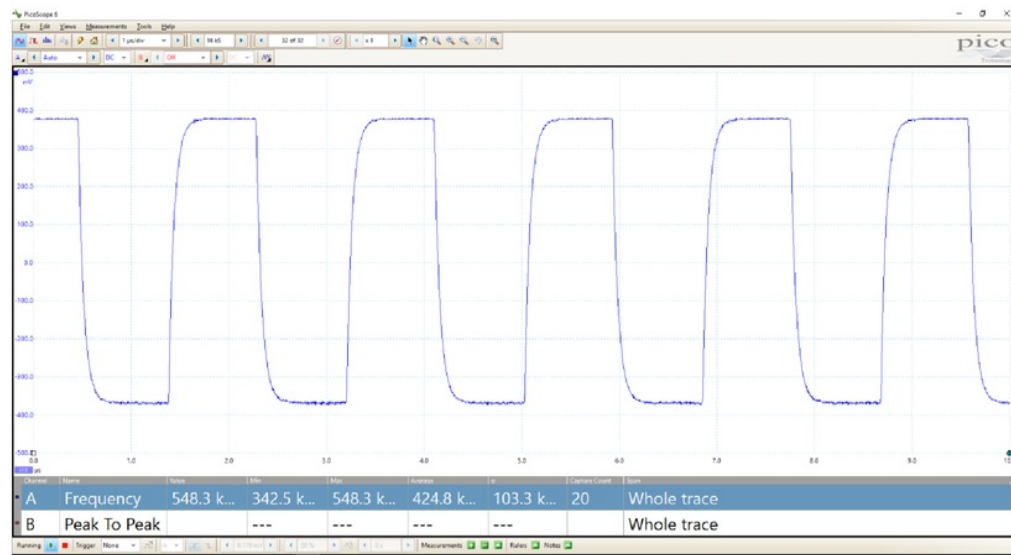
(Figure 7)

The following parameters were set up on the S2-100-A signal source module:

- Attenuator set to 0db
- Sensitivity control B set to Max

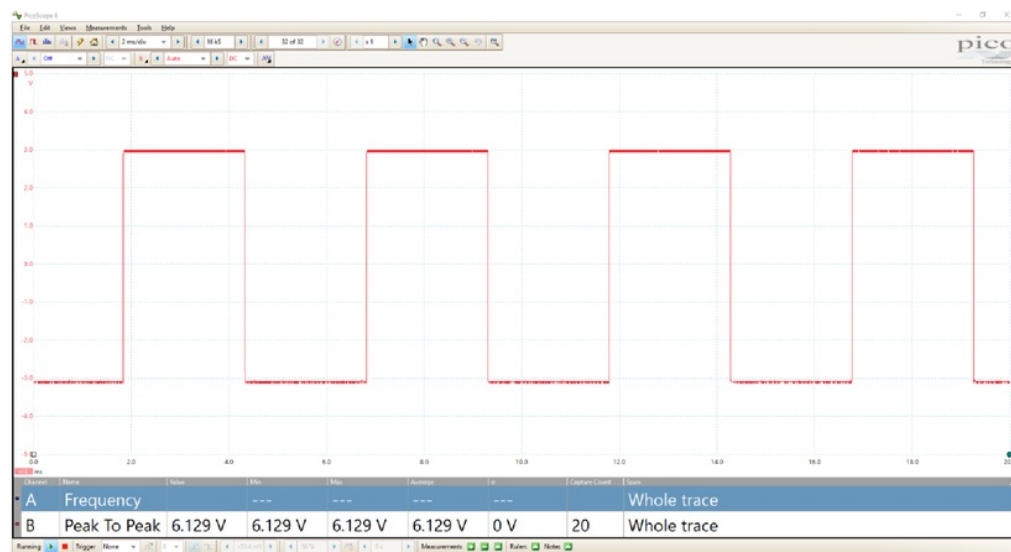
- Set the frequency control C to 455KHz
- Modulation generator set to 1Hz at 6vp-p

The frequency was temporally set 100KHz in order to get the 6vp-p. The frequency being set to 100KHz is represented below in figure 8.



(Figure 8)

Following below in figure 9 is the 6vp-p set up on the Pico Scope.



(Figure 9)

Looking at figure 8 of the frequency response on channel A the frequency is alternating between 342.5 KHz minimum and 548 KHz maximum frequency.

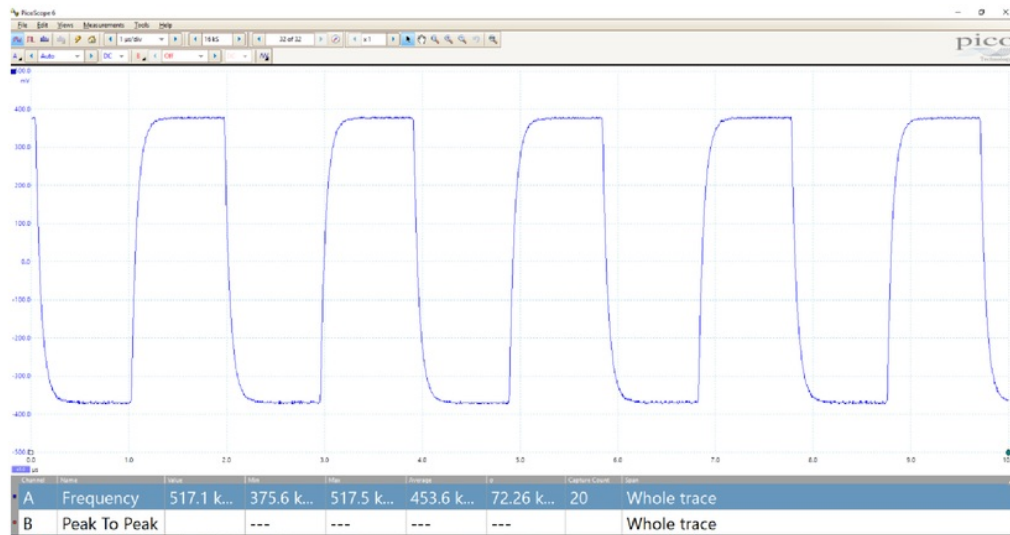
Now by looking at the carrier on channel A and reducing the amplitude of the modulation generator by 1v steps the following figures demonstrate what happens to the frequency deviation.

Following below in figure 10 is the 4vp-p set up.



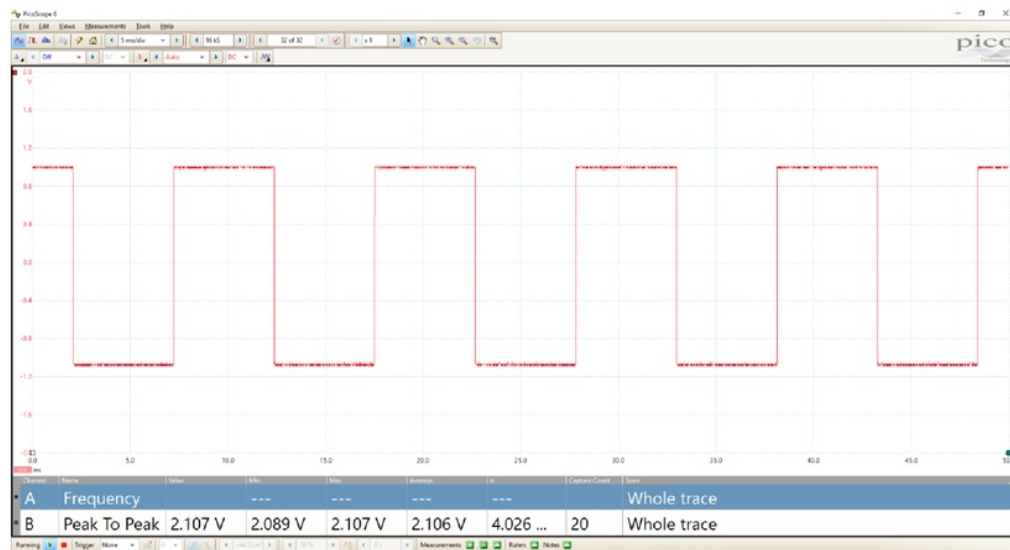
(Figure 10)

As shown below in figure 11 is the frequency response of 4vp-p, it can also be seen that the frequency deviation has reduced by 28KHz.



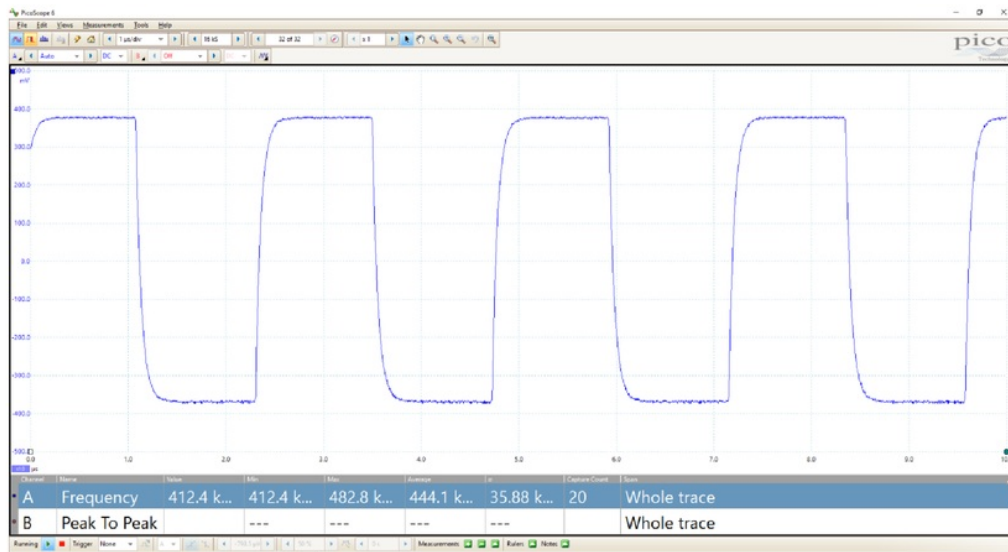
(Figure11)

As shown below in figure 12 The voltage has been set to 2vpk-p.



(Figure 12)

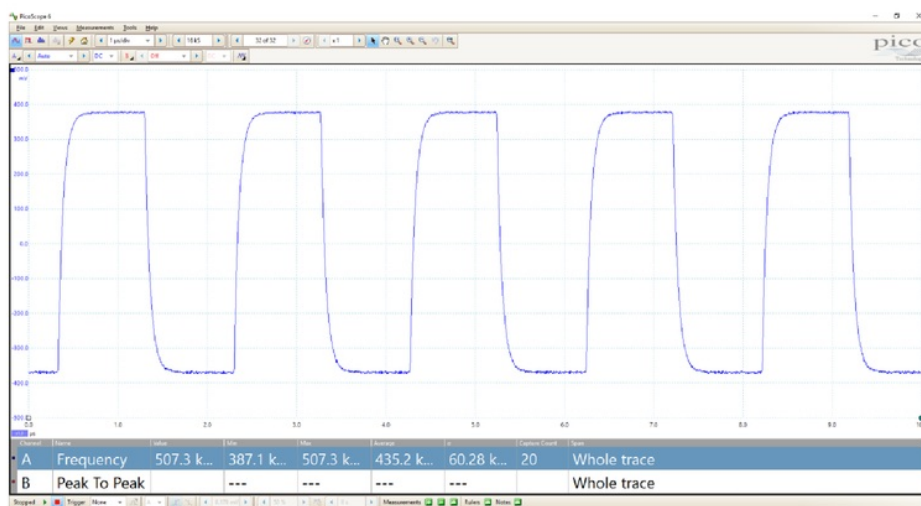
Below in figure 13 shows the frequency response of the updated voltage. The frequency deviation has now reduced to 35KHz.



(Figure 13)

To conclude from these results in above figures, by changing the amplitude the frequency will start to vary therefore this can change the frequency deviation.

The modulation generator output was set to measure 6vp-p. The B control on the signal source module was adjusted until the deviation was 60 KHz. This is represented below in figure 14.

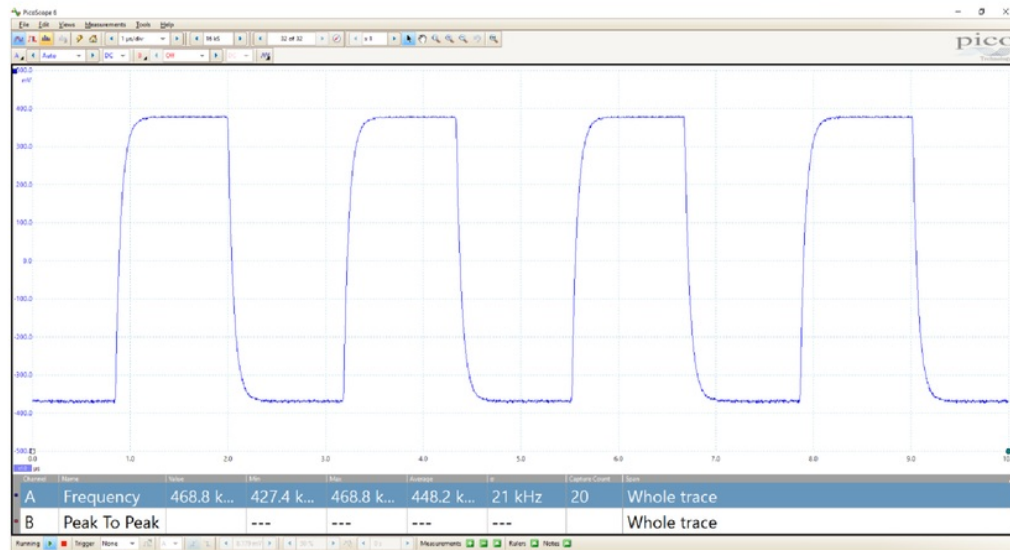


(Figure14)

Now that this adjustment has been made the frequency deviation has been set as followed:

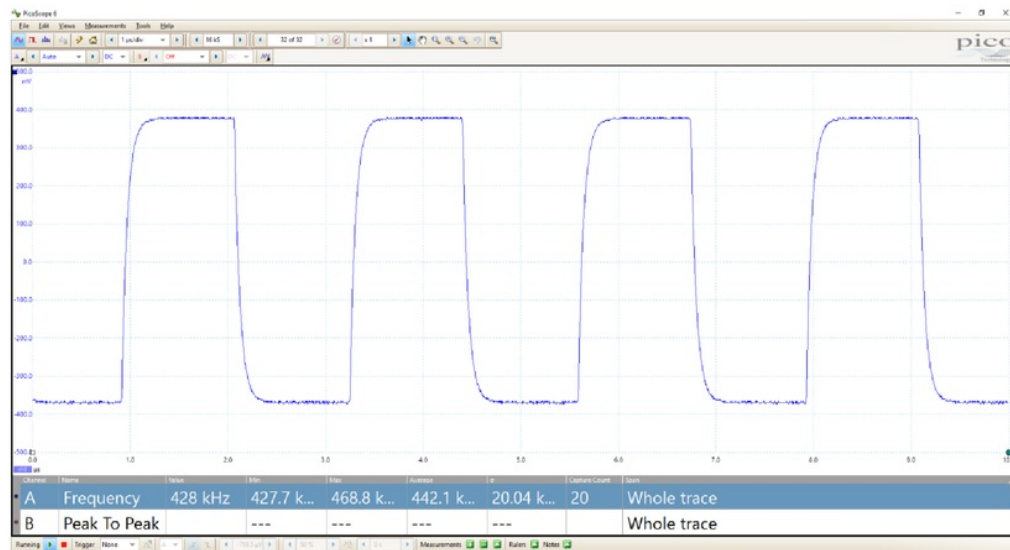
- 6vp-p – 60KHz
- 4vp-p – 40KHz
- 2vp-p – 20KHz

The frequency on the modulation generator was raised to 10Hz which is represented below in figure 15.



(Figure 15)

Following below in figure 16 the frequency has been set to 100Hz.



(Figure 16)

The frequency value reading on the meter cannot be truly related to its true frequency as it is changing too fast that it can't be seen by the human eye and also the Pico scope cannot keep up with the changes. The frequency deviation does not change as the peak to peak voltage is changed because the amplitude is responsible for the frequency deviation and then by varying the frequency the speed of the wave is changing.

Now the side frequencies will be displayed. Firstly the 52-100-A signal source module was set up with the following settings:

- The B control setting was left alone
- A control was set at 0.2
- Manual control C was left at 455KHz
- The variable attenuator was set to 0db
- The output of the modulation generator was set to 20KHz at 2vp-p
- The Pico Scope was set to spectrum analyser mode

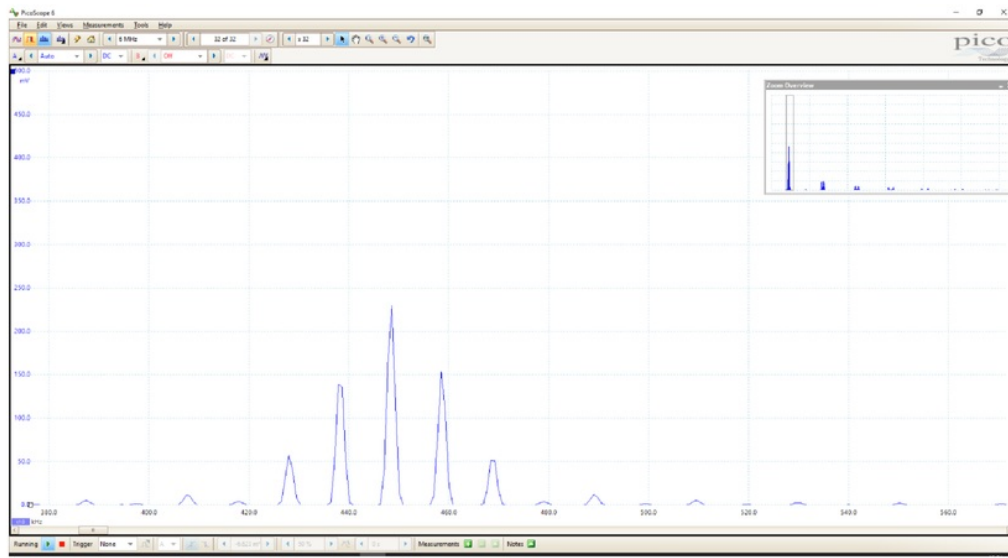
Following below in figure 17 is the initial spectrum analyser result.



(Figure 17)

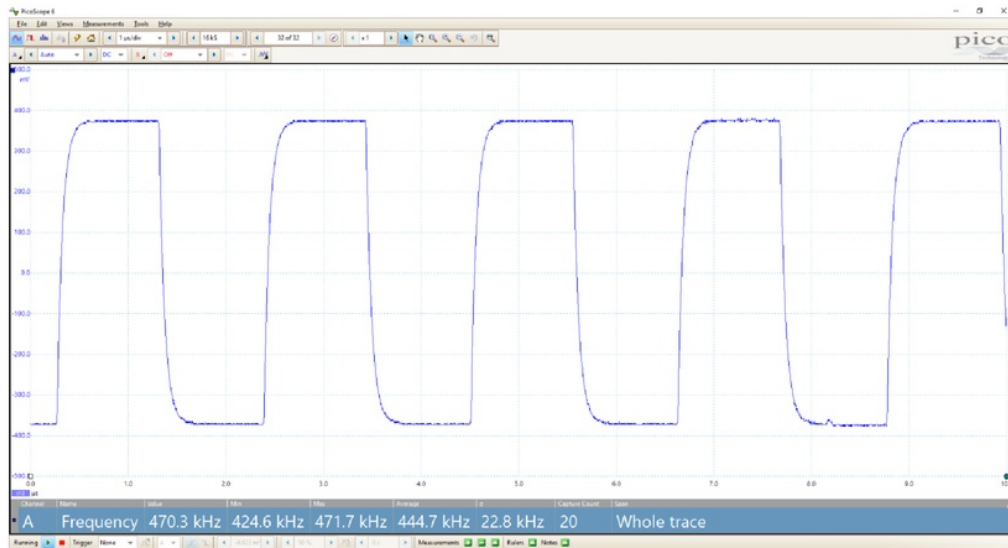
By using the mouse wheel to scroll in on the results around 450KHz the results are 0.464mv, 0.474mv and 0.484mv.

The input was then changed to 2vp-p which is shown below in figure 18.



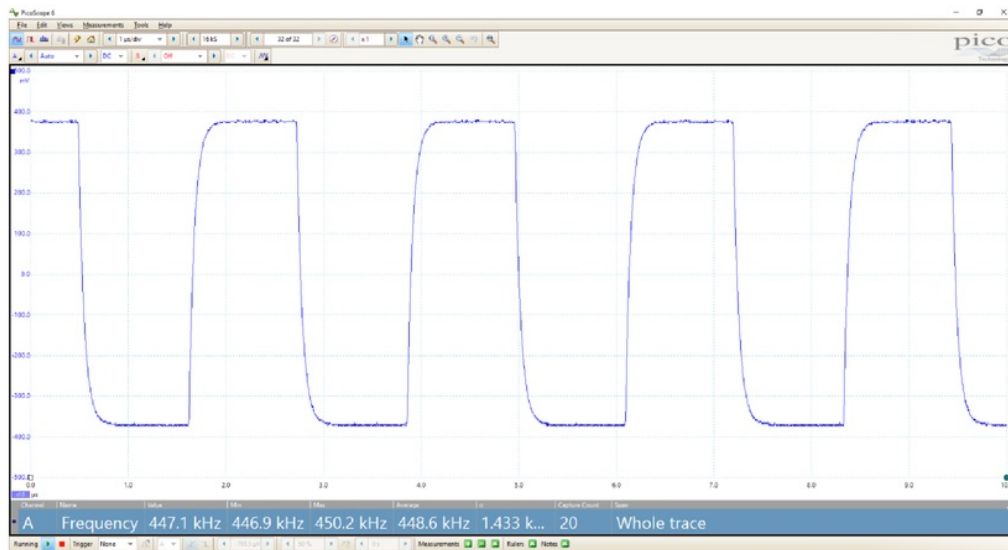
(Figure 18)

Following below in figure 19 is the frequency deviation of the spectrum shown in the previous figure. The frequency deviation is 22.8KHz



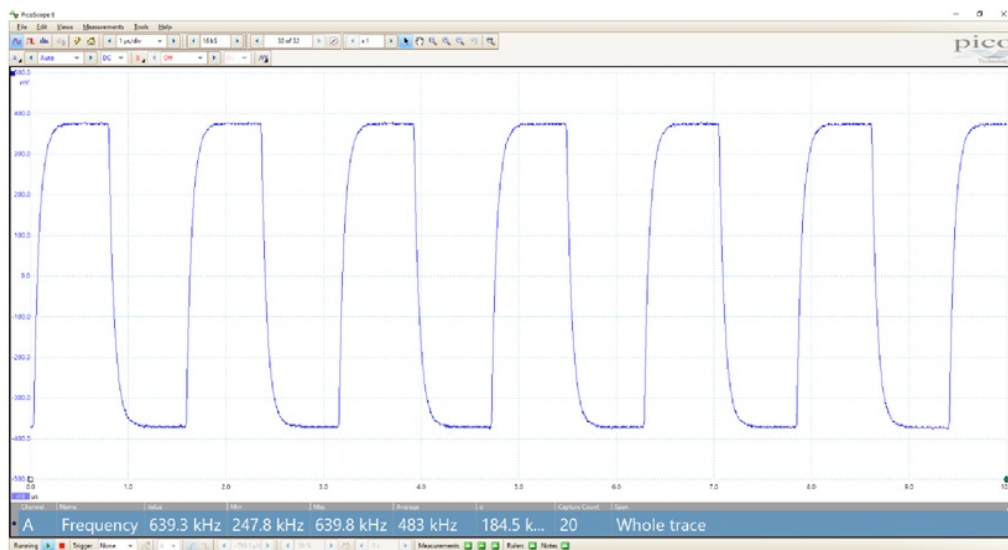
(Figure 19)

Following below in figure 20 is the minimum value for amplitude with the wave response. As seen in the figure the frequency deviation is 1.433 KHz.



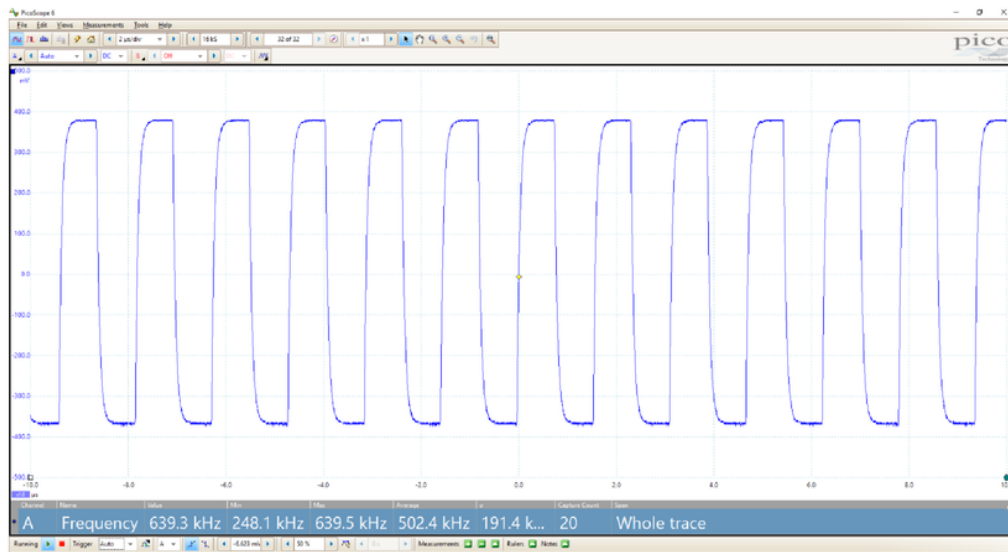
(Figure 20)

Below in figure 21 is showing the maximum value for the amplitude. Looking at the figure the value for the frequency deviation is 184.5 KHz.



(Figure 21)

By changing the frequency this will then make the rate of the change carrier change. This means that as the frequency is increased so is the rate of change of the carrier and the same affect if it is lowered. Below in figure 22 Shows a fast rate of change when the frequency is high.



(Figure22)

In order to accurately conclude and evaluate what affects the wave a table of various results were put together by performing some tests. These results are shown below in table 1.

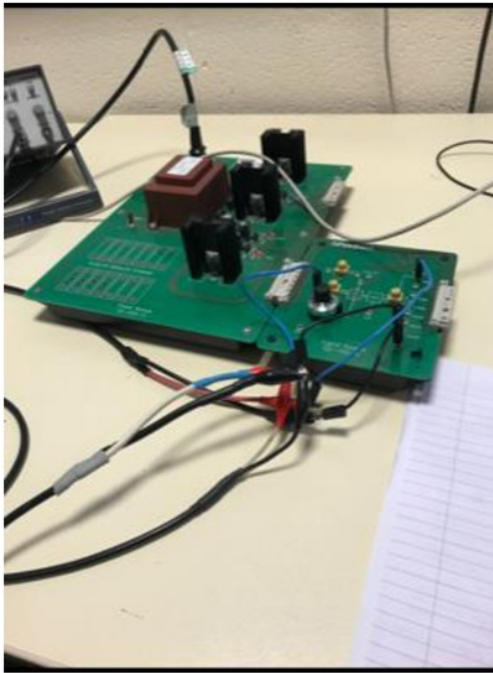
Signal Frequency	Voltage	Frequency deviation	Deviation ratio
20	2	20	1
	4	40	2
	6	60	3

(Table 1)

Looking at the table above there is a positive correlation with the varying peak to peak voltage of the wave and the frequency deviation. As the voltage is decreased then so is the frequency deviation. Concluding on the results from this practical by varying the frequency this will change the rate of change of the wave. Usually the amplitude is kept to a constant as this will keep the deviation constant which would keep the bandwidth to a set value for a specific application.

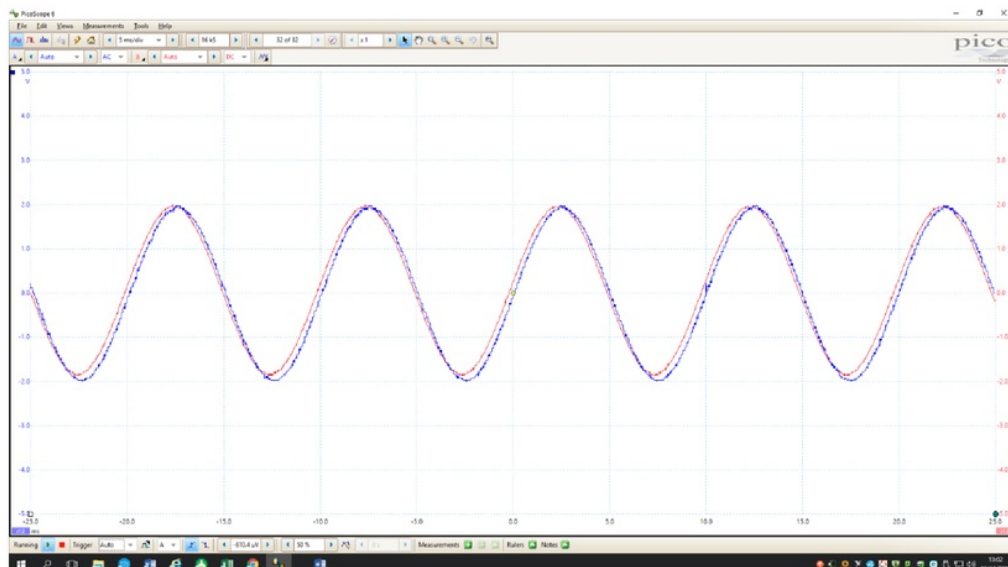
ADC Experiment

For this practical the ADC system was set up in order to look at the difference between an 4 bit and 8 bit ADC. Following below in figure 23 Is the practical set up.



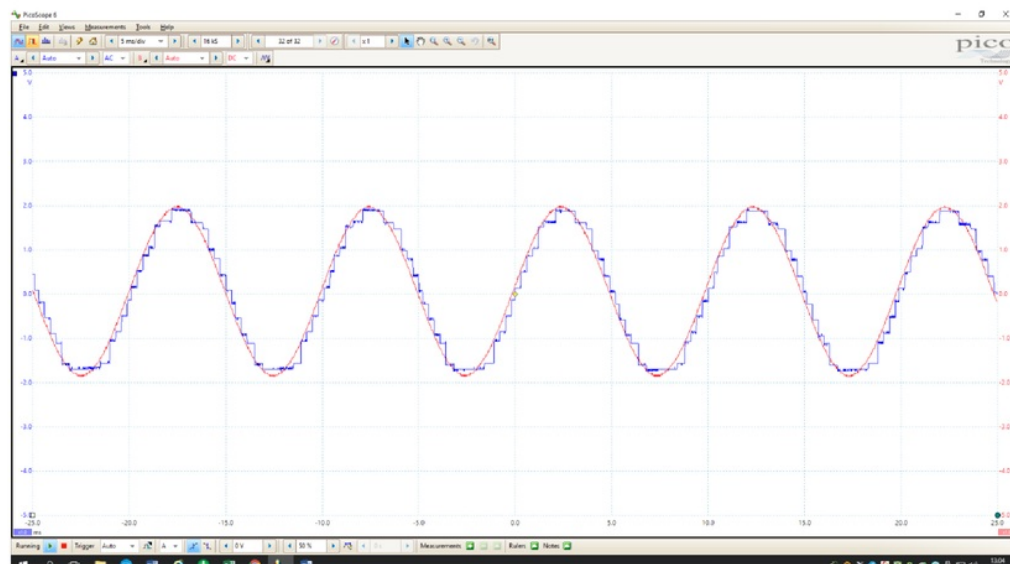
(Figure 23)

The ADC was set to 8 bits at 4vp-p with an input frequency of 100Hz. Following below in figure 24 is the wave response for the 8 bit ADC. Looking at the wave there are more points to make up the wave so the wave is a lot better with very little errors.



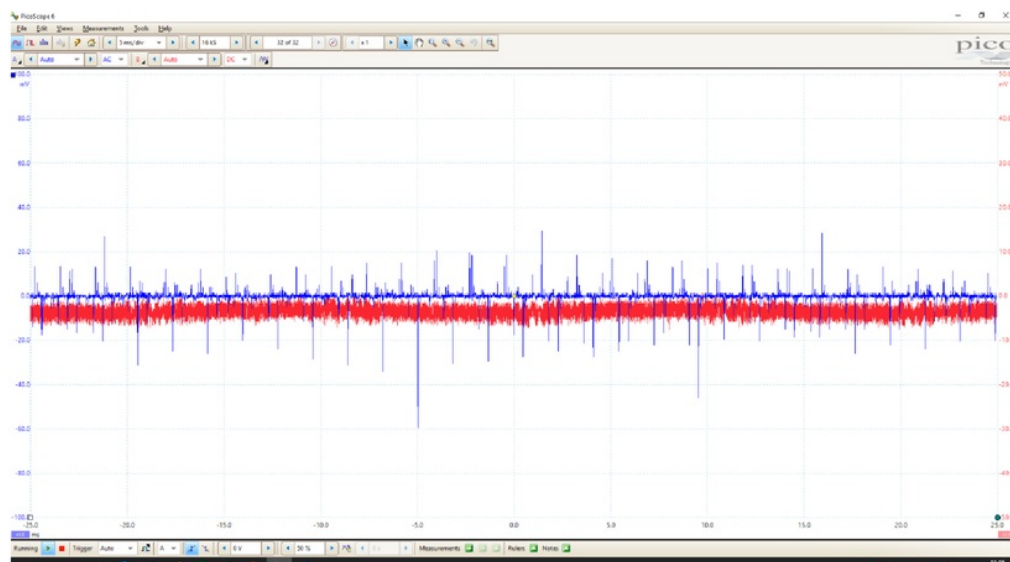
(Figure 24)

Following below in figure 25 is the response for the 4 bit ADC. This wave compared to the 8 bit wave is a lot worse as it has less sampling points therefore the wave is more staggered. This also means that the wave is also likely to have more errors.



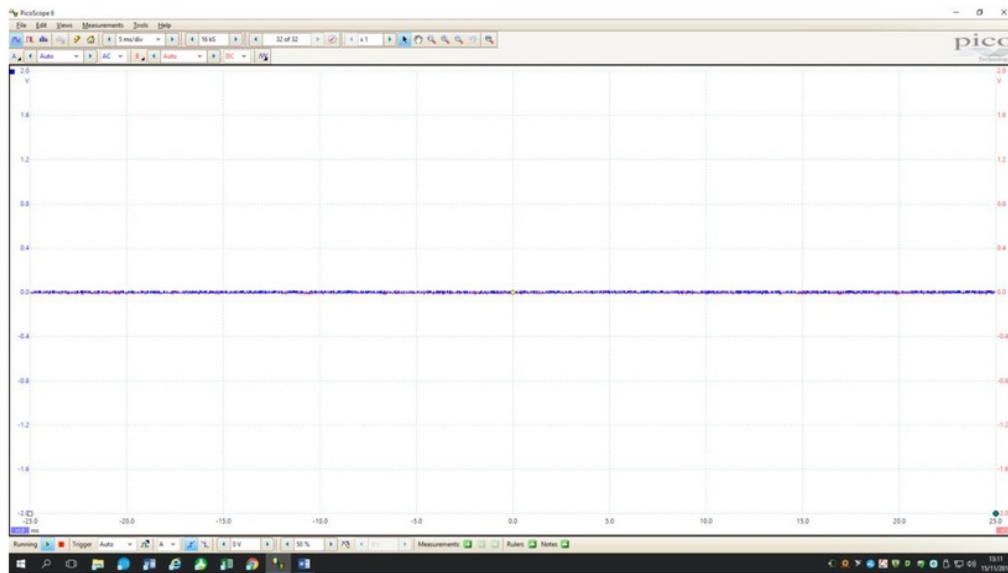
(Figure 25)

Now the input amplitude will be changed with the frequency held at a constant. Firstly this will be done for the 4 bit ADC. Following below In figure 26 is the standard output when there is nothing going in.



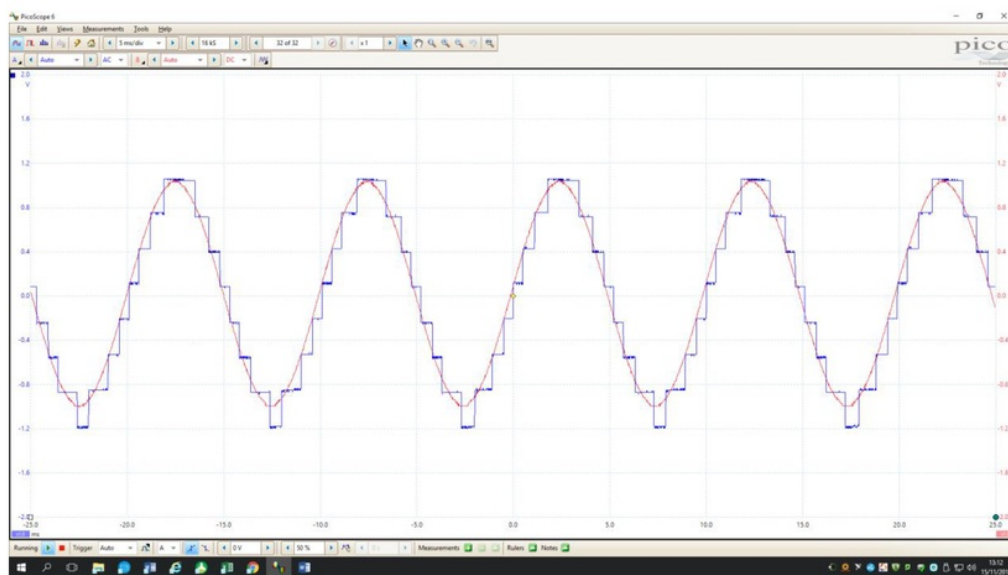
(Figure 26)

Now the 4 bit ADC was selected and the output is displayed below in figure 27. There is nothing being displayed as the amplitude is too low.



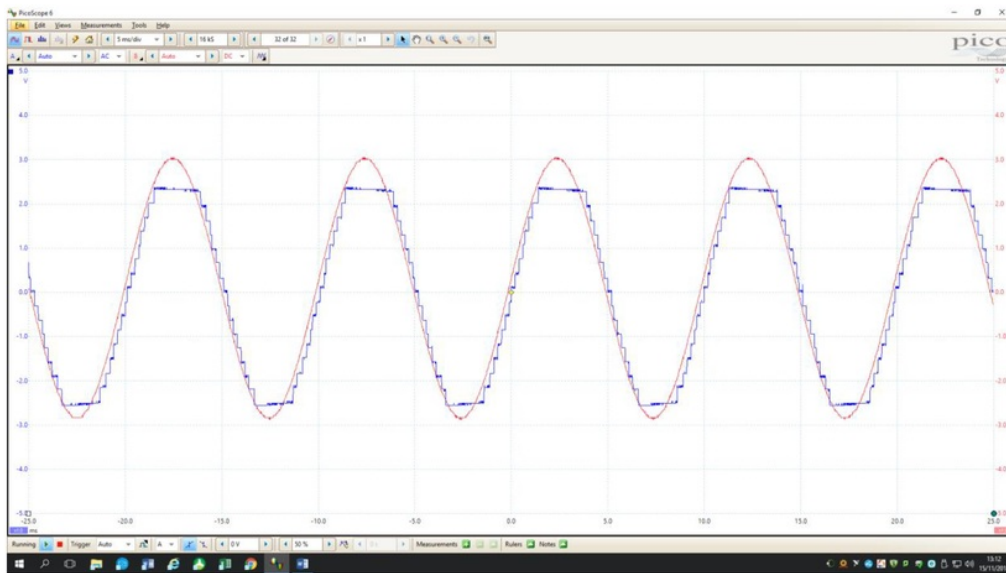
(Figure 27)

The voltage was then taken up to 2vp-p and below in figure 28 is the result of the updated response. This amplitude suits this response better as both of the waves are corresponding.



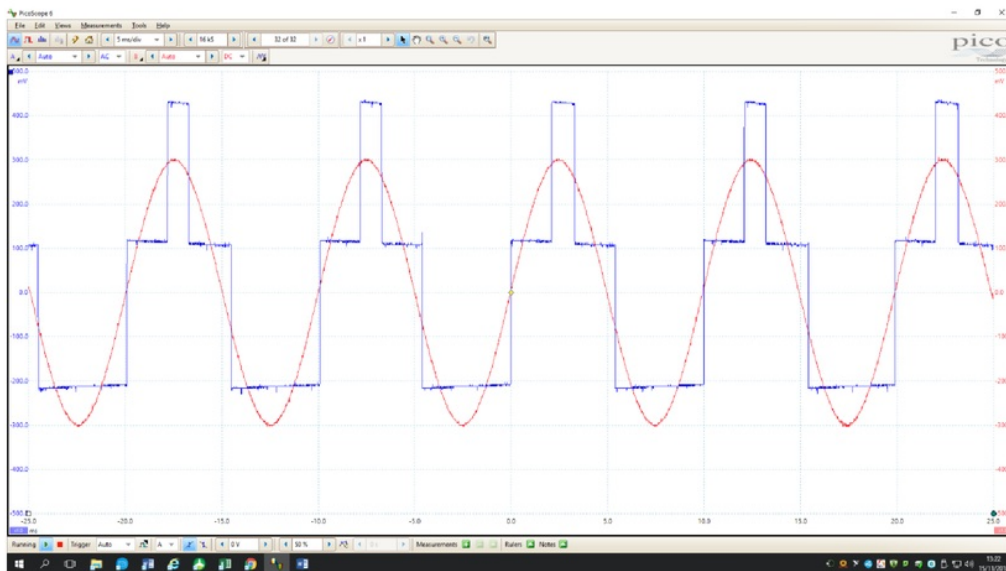
(Figure 28)

The final value of 6vp-p was set and the response can be seen in figure29.below. As seen below the amplitude is too high as in the process of transmission some of the wave would be lost. The wave is also not very good as it doesn't have as many bits to transmit the wave compared to the 8 bit ADC.



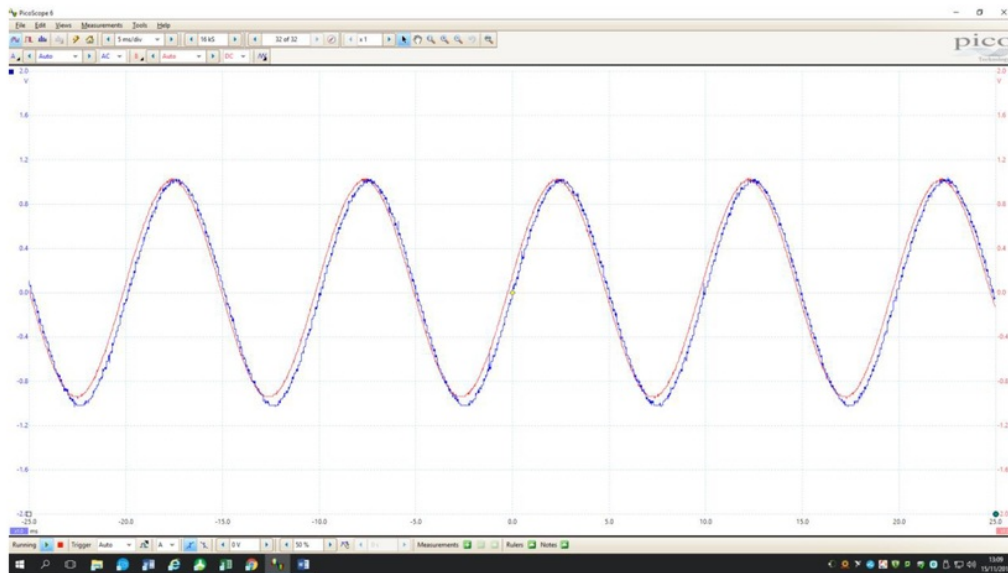
(Figure 29)

Quantisation is the amount of steps in the wave. At low amplitude there aren't many steps but as the amplitude is increased the amount of steps are increased but the resolution will stay the same. Resolution is the difference between one horizontal level and another. In this case it is from -200mv to 100mv which means the resolution is 300mv. This shouldn't change even when the amplitude increases. This is represented below in figure 30.



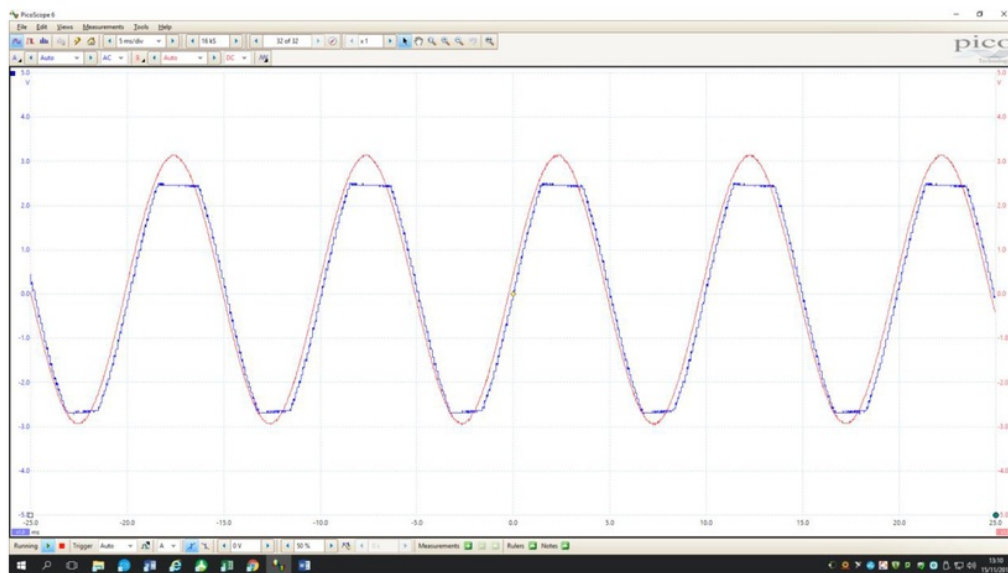
(Figure 30)

The above process was repeated for the 8 bit ADC. Following below in figure 31 is the 2vp-p response for the 8 bit ADC.



(Figure 31)

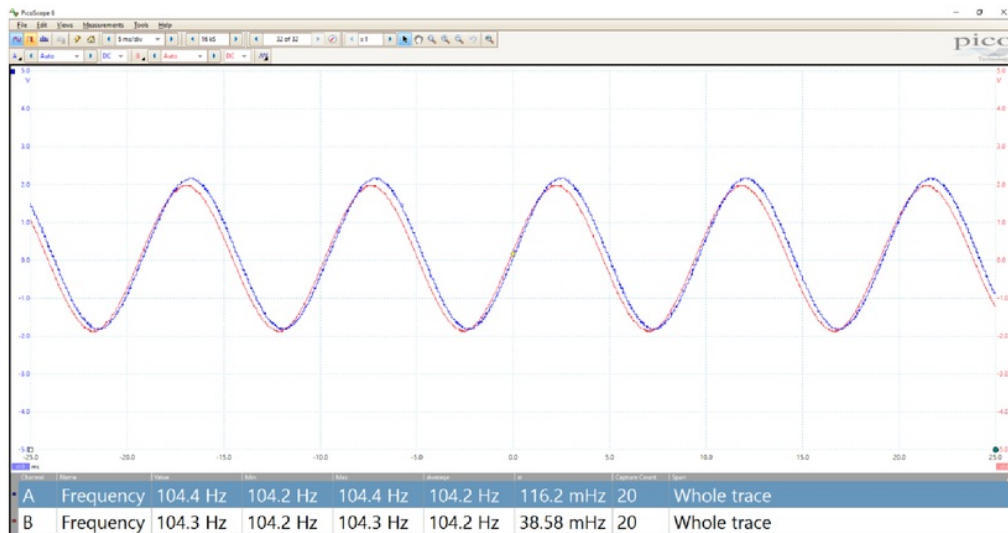
Below in figure 32 is the 6vp-p wave response.



(Figure 32)

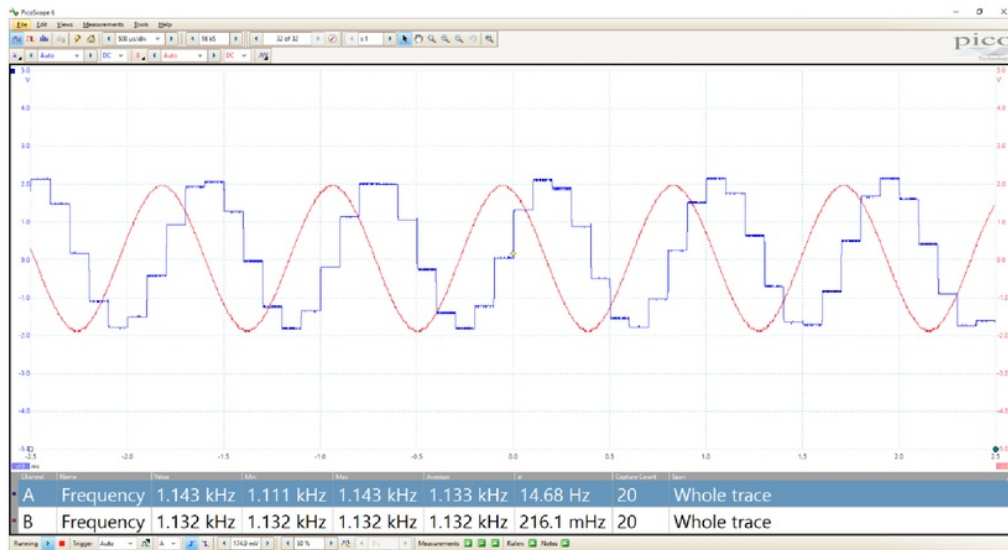
Comparing both of these waves there is a massive difference in the quality of the wave. This is because the 8 bit ADC will have 256 steps compared to the 4 bit which will have 16 steps. Although the levels are harder to see on the 8 bit ADC it still gives a better wave as there are more bits to represent the analog signals.

Now the effect of changing the frequency of the input will be shown while the amplitude will be kept constant. As shown below in figure 33 the frequency was set to 100 Hz at 4vp-p.



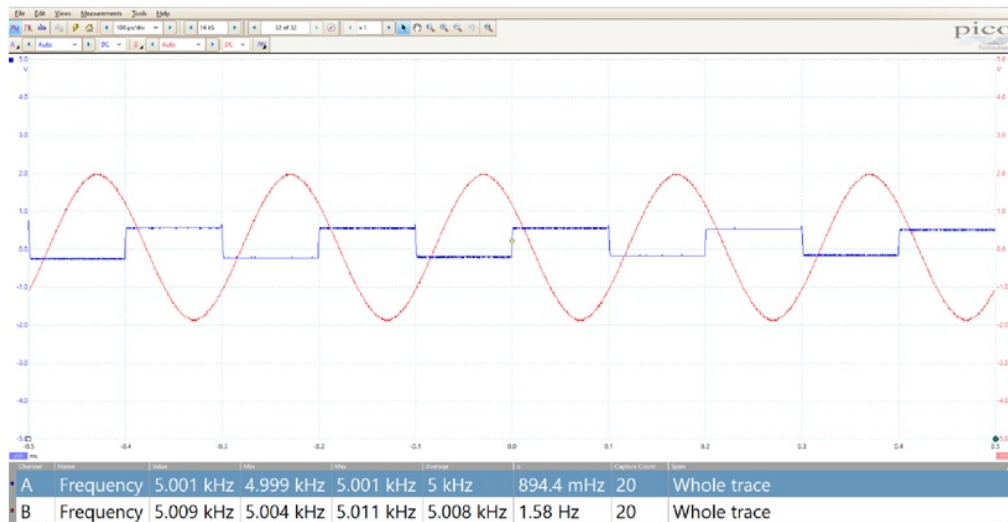
(Figure 33)

Following below in figure 34 is the frequency of 1 KHz for the 8 bit ADC. The following happens because the frequency is being increased it has less time to sample the wave. In lower frequencies the sampling takes place far too much.



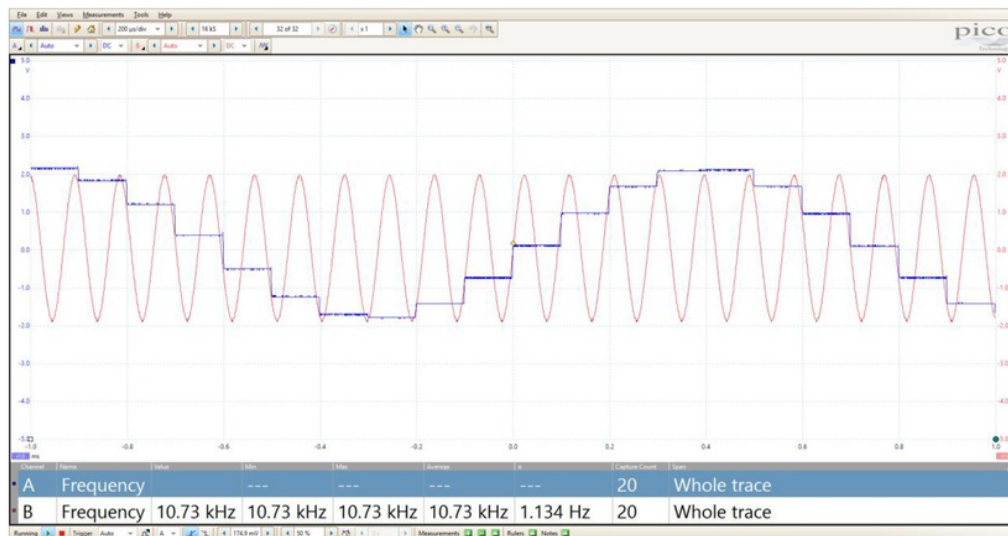
(Figure 34)

Following below in figure 35 is the frequency of 5 KHz. This is an example of the aliasing the wave so with the use of a capacitor it can be filtered into a normal sine wave again. Up to about 5 KHz the output frequency stays about the same as the input frequency however when you go above that it drops off.



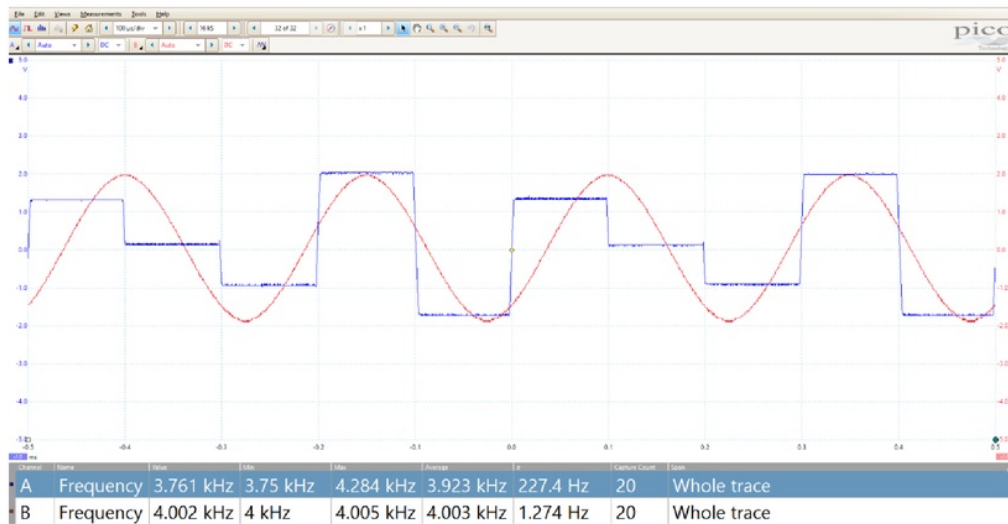
(Figure 35)

As shown below in figure 36 this represents an input frequency of 10 KHz. This also demonstrates even worse aliasing of the wave which is expected as the frequency is so high.



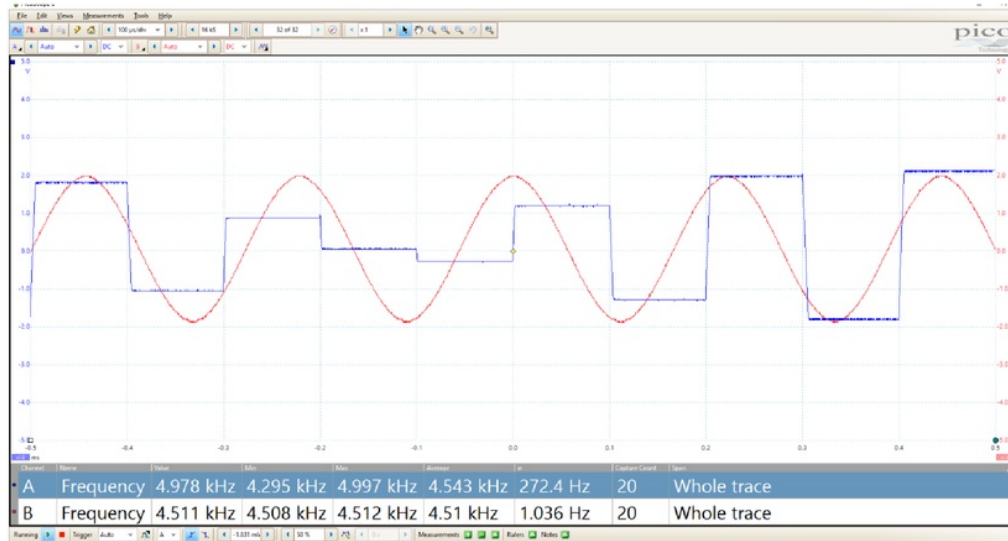
(Figure 36)

Following below in figure 37 the function generator has been set to 4 KHz. This was then moved up to 10 KHz in steps of 500 Hz and then steps of 1 KHz. Modulation signal frequency increases, the sidebands move further from the carrier.

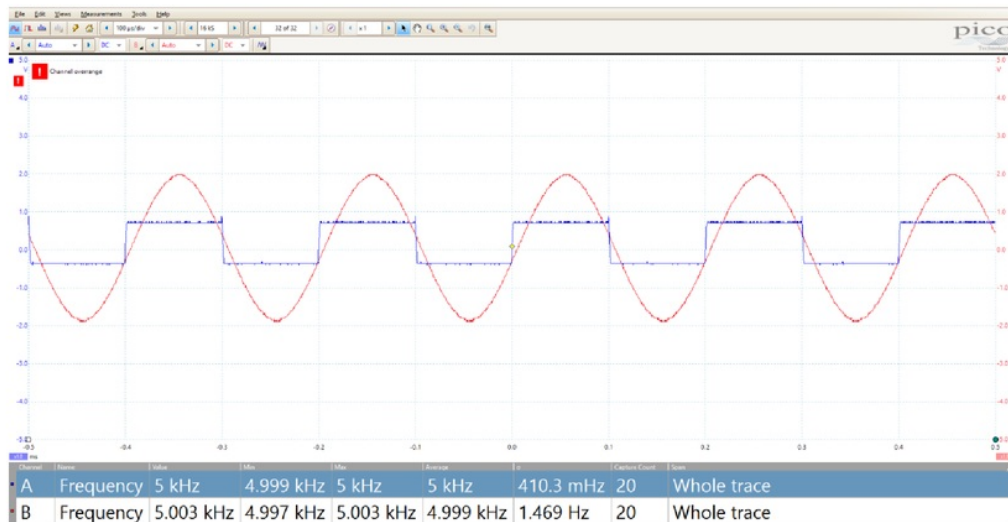


(Figure 37)

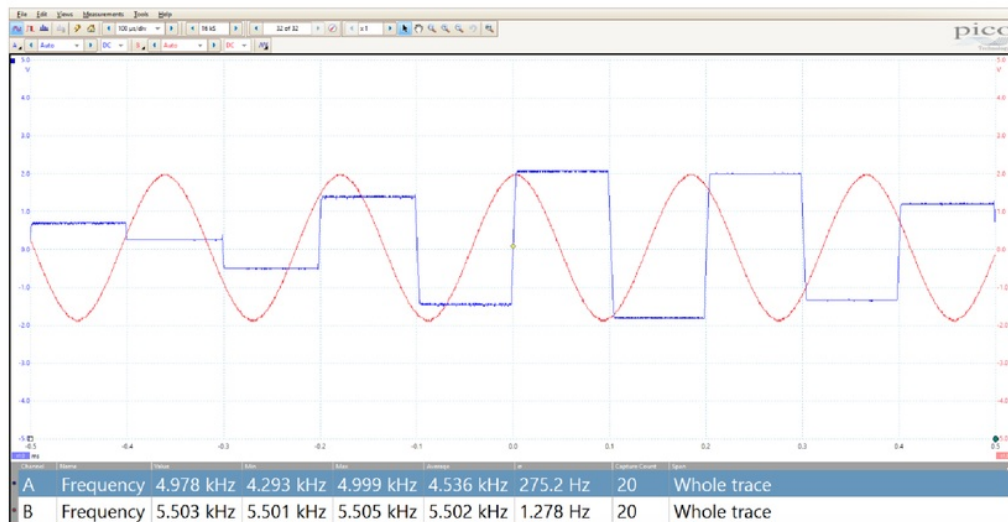
Below in figures 38, 39 And 40 there is very little change between 4 KHz to 7KHZ.



(Figure 38)

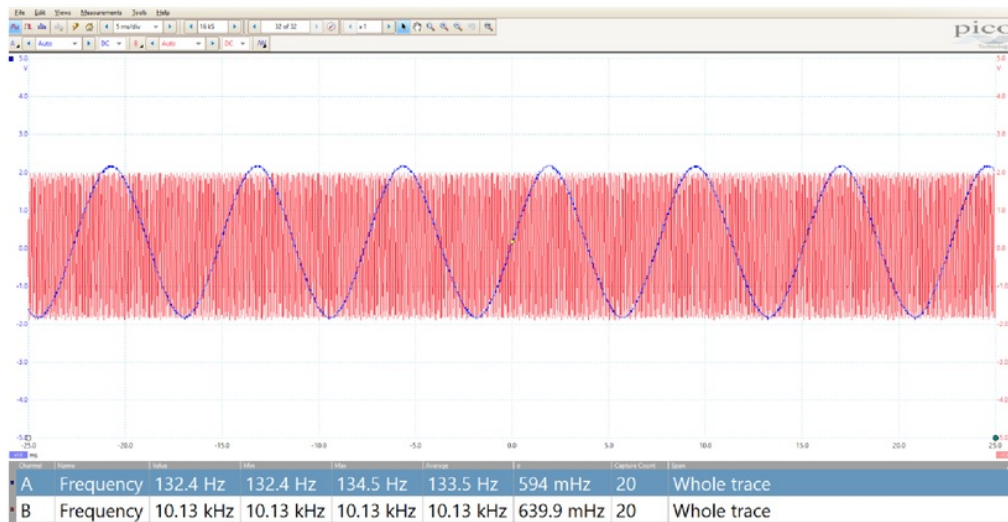


(Figure 39)



(Figure 40)

However when it gets to 7 KHz the changes start to show as the sampling rate is too fast and it cannot keep up. This is represented below in figure 41.



(Figure 41)

From this practical it can be concluded that by changing the amplitude and keeping the frequency the same can be linked with the quality of the message as when the amplitude is raised there is more steps in the wave so it is not as smooth. When the amplitude is kept the same and the frequency is varied the carrier wave will start to alias as the frequency is increased.

4. Conclusions and recommendations

To conclude all of the results gained from the research and practical with frequency modulation by changing the amplitude of the modulation generator this then effect the frequency deviation so as the amplitude is increased the frequency deviation also increases. When the frequency of the modulated wave is changed the rate of change of the wave also changes as it is increased so is the rate of change. With the ADC practical the relationship between the increasing the amplitude and the quality of the wave is proportional. As the amplitude is increased this increases the number of quantisation levels whilst the resolution stays the same. When the frequency is changed with amplitude modulation this starts to introduce aliasing when a certain frequency is reached. The conclusion on ADCs is that the higher bit ADC is better due to it having more bits which means it can have more bits to assign to quantisation levels. The recommendations for this assignment would be to repeat both practical tests in order to gather more results to gain a greater understanding of both topics. Reproducing results for the practical test would also give more results to talk about and draw more conclusions on.

5. Reference list and bibliography

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GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

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GRADING FORM: ASSIGNMENT RUBRIC 2018

PHILLIP ROWE

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ENGAGEMENT WITH LITERATURE



There was evidence of further reading and research with the inclusion of a reference list and appropriate in text referencing. Your interpretation and understanding of the additional research was good. Your references were appropriate to the task and your reference list was of an appropriate length for

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this assignment. Some of the sources were over-used and you should consider widening your range of sources for future assignments.

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 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.

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COGNITIVE AND INTELLECTUAL



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

Your application of practical skills for this task was



generally good. You used the resources available appropriately when carrying out the experiment and you used appropriate options for testing and evaluating the circuit performance. You managed to setup an effective circuit that functioned within the specification and achieved this by only asking for assistance when appropriate. Your results were comprehensive and allowed for a good conclusion to be attempted.

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TRANSFERABLE SKILLS FOR LIFE



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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