

Assignment 1 Joshua Beer

by Joshua Beer

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TIME SUBMITTED	20-DEC-2017 07:53PM (UTC+0000)	WORD COUNT	2882
SUBMISSION ID	80520330	CHARACTER COUNT	16802



Signals and Digital Communications

Signals and Modulation

Joshua Beer

PSDE5014

20/12/17

Word Count 2941

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1. Introduction, aims and objectives

The aims and objectives of this assignment are to analyse and manipulate a range of signals mathematically in both time and frequency domains and apply to analogue and digital communication systems and to demonstrate an understanding of the requirements of analogue and digital communications systems from theory and by practical testing or simulation.

This will be achieved by doing research into the development of radio and its effect, transmitters and receiver and analogue modulation techniques.

2. Research into radio systems

2.1 The development of radio since its invention

Since its invention, radio has developed vastly. The following research will be the main stages of development.

Early radio transmissions:

As early as 1885 inventors from around the world created and developed radio transmissions. This led to lots of arguments and claims of who actually invented radio.

As stated (Sterling & Kittross, 1990) "Radio technology started in 1864 when James Clerk Maxwell, a Scottish mathematician and physicist, theorized that when electricity passes through a wire, it gives off invisible waves under certain conditions. A young German named Heinrich Hertz proved this theory in 1887 and 1888."

It wasn't until later (1895) that wireless transmission was used to transmit radio signals, this allowed radio waves to travel over the distance of the Atlantic Ocean from Newfoundland to England. Although this was successful it had only transmitted the letter "S" in Morse code.

Developing for voice and music transmission:

As stated above, early radio transmission wasn't capable of transmitting voice or music transmission. This is because spark gap and arc transmitters did not have a high enough speed to generate the alternating current in order to create waves capable of carrying voice or music transmission.

In 1906 E. F. W. Alexanderson created the Alexanderson alternator which allowed the first radio broadcast of voice and music.

There was room for manoeuvre as by making the alternator bigger, the transmission strength would become more powerful but there were problems moving these and such smaller and lighter alternators were developed.

In 1915 the vacuum-tube transmitter was developed, this was portable and allowed them to be used in the First World War. These were used up until the 1950's when the transistor was developed.

Types of radio transmission:

There is AM/FM radio which is made up using waveforms and travels over specific frequencies, these take up more radio frequency per channel than DAB radio which uses binary to transmit data. This means there can be more radio channels per frequency as it is a more accurate way of sending data.

The future of radio is now DAB radio as it has a better quality than AM/FM (without the crackling) but at the moment the signal for DAB radio is weak.

2.2 The effect radio has had on the modern world

Amateur radio stations started in the 1900's which operated until World War I, when amateur radio stations were closed.

Radio was used in World War I to send weather reports to ships from designated stations. As stated above, radio transmissions were used as communication in World War I as radios were now portable enough to travel around. This allowed quick communication via ships and commanders where radios were available.

After the First World War, people started broadcasting messages and playing music over the radio frequencies. This was then monitored and decided that public broadcasting should be set up. This allowed the broadcasters to air news for big events such as election results.

The first frequency used by the BBC to broadcast radio transmissions was 1.5 KW and 3 KW in London. This is relatively low compared to today's standards which meant a lot of the country had poor to no reception. To solve this, 100 W relays were introduced to aid the problem.

By the 1950's VHF (very high frequency) radio transmission using FM (frequency modulation) was preferred. This system allowed car and roof aerials to pick up the transmissions along with the radios which were commonly built into TV sets.

These early radio channels were mostly by the BBC and consisted of limited channels (radio 1, 2, 3 and 4). This is when pirate radio was started in 1964 (Radio Caroline and Radio Atlanta). These commercial stations broadcast off the coast of Essex from ships which exploited a loophole in British law.

This led to the start of modern radio as we know it as local radio stations were then developed after pirate radio was outlawed in 1967. Radio frequencies were split or shared and allowed greater coverage for specific areas which allowed more local news and broadcasting.

In the mid 1980's commercial radio started to take off which allowed radio stations to make money by broadcasting advertisements, this is now modern radio as we know it with a mixture of public broadcasting and commercial radio stations.

2.3 Transmitter/receiver system to block diagram level

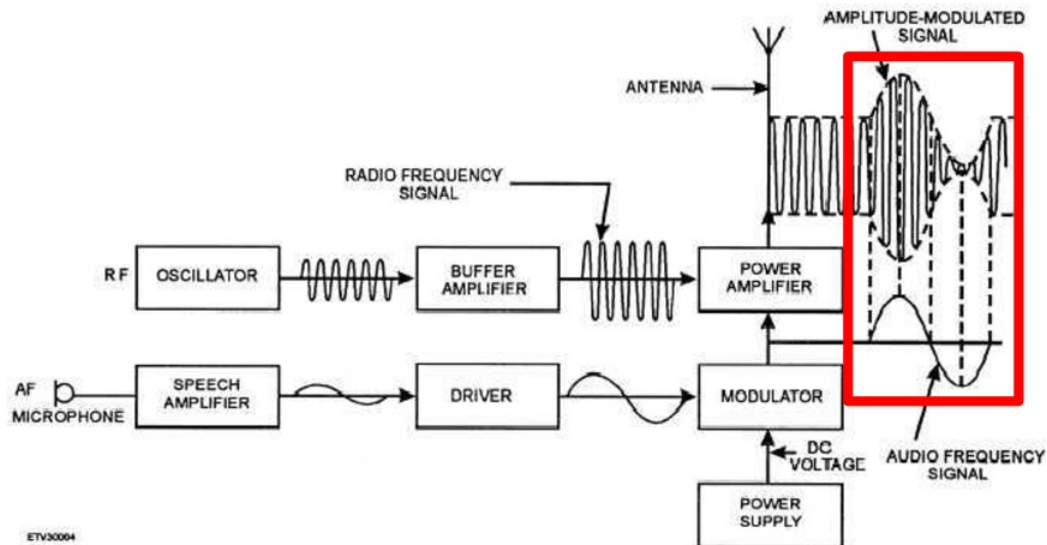


Figure 1 - AM Transmitter Diagram (2017)

The figure above shows an AM transmitter block diagram, this shows how the microphone uses the amplifier to convert the signal into electrical energy and then the driver and modulator amplifies the signal to carry the full signal. The power amplifier then combines the amplified frequency and the radio frequency signal to send the amplitude modulated radio signal but allows the signal to travel further as it is bigger but with the same amplitude.

This is show on the diagram and explains how the signal is then sent (Highlighted).

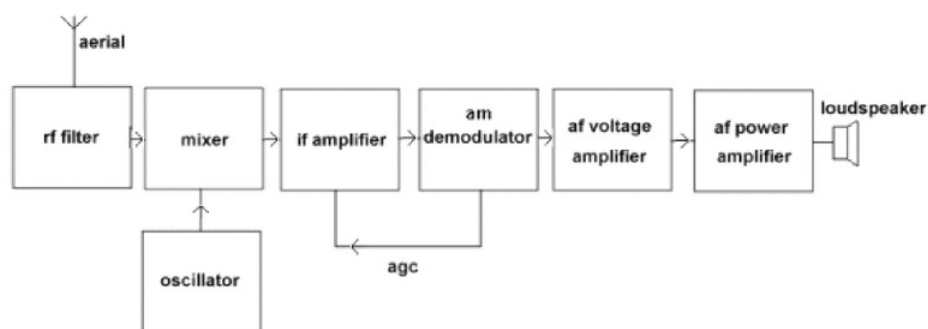


Figure 2 - AM Receiver Diagram (1999-2017)

Figure 2 above shows the AM receiver block diagram. The aerial receives the signal and which is chosen by the rf filter (choose radio station), this is then sent to the mixer along with the output from the oscillator. This is then sent to the if amplifier with a value of 455 KHz (this is always the same value no matter which radio station is selected). The AM demodulator which discards the rf carrier and keeps the desired radio signal, this then allows the voltage and power to be amplified and the final waveform to be transmitted to the listener via the speaker. If the mixer and carrier signal were not introduced before amplifying then a lot of noise would be introduced to the original signal and this is when the listener will hear crackling of the signal or no signal at all.

The FM transmitter is the same but instead of changing the amplitude of the signal, the transmitter is changing the frequency which is sent.

The FM receiver is the same as the AM receiver.

2.4 Analogue modulation techniques

There are three main types of analogue modulation and these are as follows:

- Amplitude Shift Keying (ASK)
- Frequency Shift Keying (FSK)
- Phase Shift Keying (PSK)

ASK is made by changing the amplitude of the carrier signal to reflect amplitude levels in the digital signal. The line encoding will determine the values of the analogue waveform to reflect the digital signal being carried, this is done by a digital high signal of 1 not affecting the signal whereas a low signal of 0 would make the signal zero.

The bandwidth B of ASK is proportional to the signal rate S .

$$B = (1+d)S$$

" d " is due to modulation and filtering, lies between 0 and 1.

FSK is made by the digital data stream changing the frequency of the carrier signal, f_c . The line encoding can determine the values of the analog waveform, this is done by a "1" representing $f_1 = f_c + \Delta f$, and a "0" representing $f_2 = f_c - \Delta f$.

The bandwidth of FSK is shown as: if the difference between the two frequencies (f_1 and f_2) is $2\Delta f$, then the required BW B will be:

$$B = (1+d)S + 2\Delta f$$

FSK can be coherent or non-coherent, this means that coherent will switch from one signal to the other on the same phase shift whereas the non-coherent will not be on the same phase shift.

Multi-level FSK is possible, similar to ASK, FSK can use multiple bits per signal. This means that when receiving the frequency there needs to be a provision to separate these frequencies and represent a different frequency each.

The bandwidth for FSK can be higher

$$B = (1+d)S + (L-1)/2\Delta f = LxS$$

Joshua Beer

PSK is made by varying the phase shift of the carrier signal to represent digital data, the bandwidth requirement, B is:

$$B = (1+d) \times S$$

PSK is much better and stronger than ASK as it isn't vulnerable to noise which changes the amplitude of the signal and thus affect ASK more.

2.5 An overview of the development of digital radio

As mentioned above DAB radio uses binary to transmit data. This means there can be more radio channels per frequency as it is a more accurate way of sending data.

The future of radio is now DAB radio as it has a better quality than AM/FM (without the crackling).

By digitising and compressing the AM/FM audio signals the DAB can be transmitted, this turns the modulations in the amplitude into 1s and 0s as with the frequency modulations into 1s and 0s. This as mentioned above is quality and allows more stations per frequency along with reducing the power and number of transmitters needed to cover a region.

Some radio channels coexist with AM/FM and DAB meaning they have both stations transmitting in digital and AM/FM, whereas there are certain stations which will only transmit in digital form. If a station is only transmitting in digital form it allows one wideband radio signal to carry a multiplex of several radio channels of various binary values as well as other forms of media. This means that for example, an internet app could be sending data which can be read and viewed at the same time as a radio signal which people can listen to. This is very useful for news broadcasting where people may want to listen live.

DAB channels can be sold and bought which allows the control of that frequency.

3. Experimental method

To work out the experimental method, the frequency modulation must first be found.
This is found below.

$$\Delta f_c = f_{\max} - f_c$$

$$\Delta f_c = 485\text{KHz} - 425\text{ KHz}$$

$$\text{Max frequency deviation} = 30\text{ KHz (60/2)}$$

$$B = \Delta f_c / f_s$$

$$30\text{ K} / 10\text{ K} = 3$$

mf	J0	J1	J2	J3	J4	J5	J6
3.0	0.26	0.34	0.49	0.31	0.13	0.04	0.01

By working out these values, it shows that the 3rd row on the Bessel function order table (above) should be used for the following calculations.

$$J_0 = 0.26 \times 375\text{ mV} = 97.5\text{ mV}$$

$$J_1 = 0.34 \times 375\text{ mV} = 127.5\text{ mV}$$

$$J_2 = 0.49 \times 375\text{ mV} = 183.75\text{ mV}$$

$$J_3 = 0.31 \times 375\text{ mV} = 116.25\text{ mV}$$

$$J_4 = 0.13 \times 375\text{ mV} = 48.75\text{ mV}$$

$$J_5 = 0.04 \times 375\text{ mV} = 15\text{ mV}$$

$$J_6 = 0.01 \times 375\text{ mV} = 3.75\text{ mV}$$

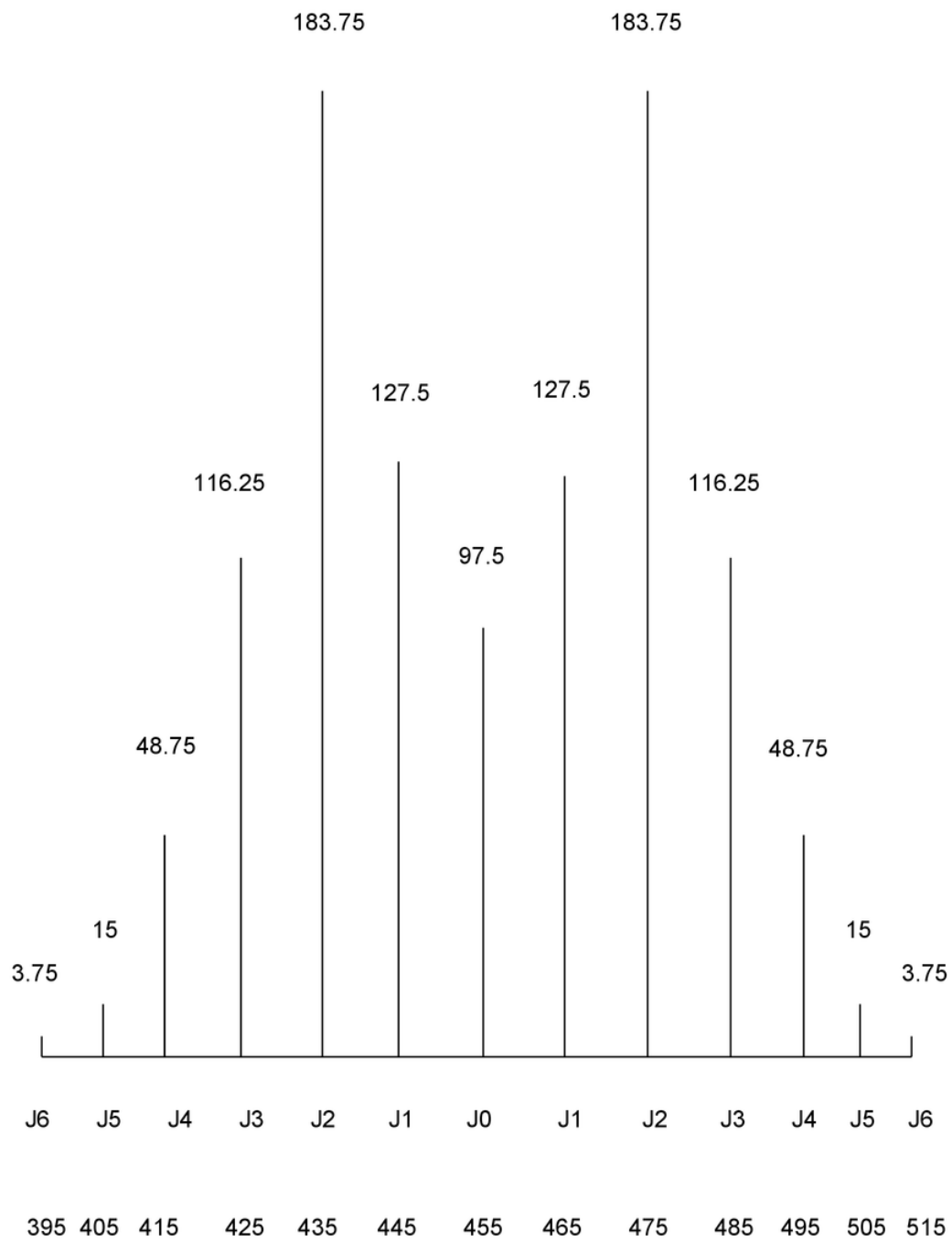


Figure 3 - Amplitude Spectrum Waveform Sketch

Figure 3 above shows the amplitude spectrum waveform sketched by using the calculations above. The sketch shows the bandwidth is 120 KHz and are spaced by 10 KHz each which is the modulating frequency. It also uses the amplitudes calculated and the values assigned to J0 – J6.

4. Testing and results

By testing the frequency modulated signal using a signal source and power supply module along with a picoscope the oscillations and frequency can be measured on the oscilloscope.

To gain the results the test equipment needs to be set to the following:

By setting the picoscope to channel A to show frequency and connecting 0dB output

Set the modulation generator to deliver a square-wave output at about 1 KHz with output amplitude at zero

Connect channel B and select show frequency peak to peak and connect to output of frequency modulator.

On the 52-100-A signal source module:

Set the attenuator to 0dB

Set control B sensitivity to max

Set the frequency control C to 455 KHz and then using the frequency meter set channel A frequency to 455 KHz also.

Set the modulation generator to 1 KHz at 6 Vp-p

This shows the change in frequency to be ± 100 KHz at 6 Vp-p. (Which is what it's set to)

Now the following results were obtained by reducing the Vp-p by 1 V each time.

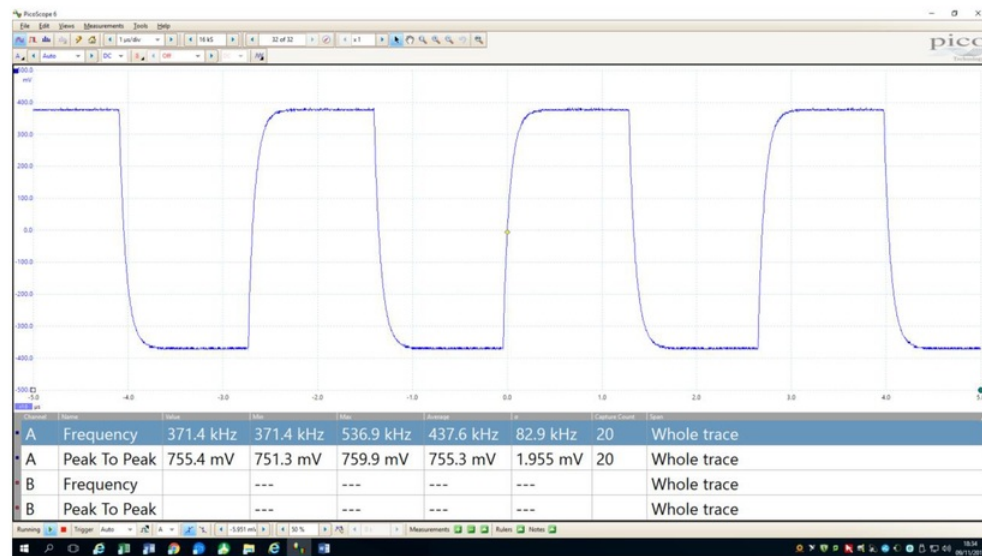


Figure 4 - 85 KHz at 5 Vp-p



Figure 5 - 70 KHz at 4 Vp-p

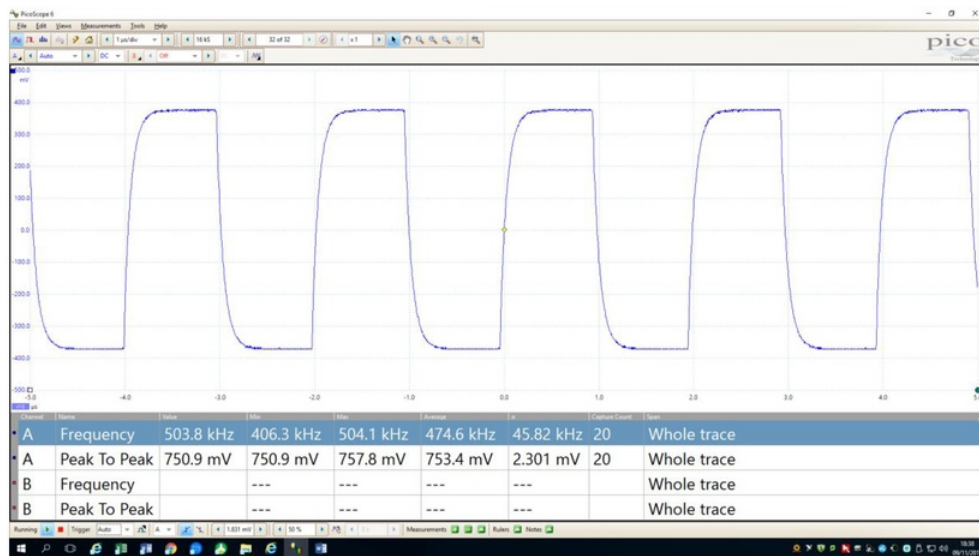


Figure 6 - 50 KHz at 3 Vp-p

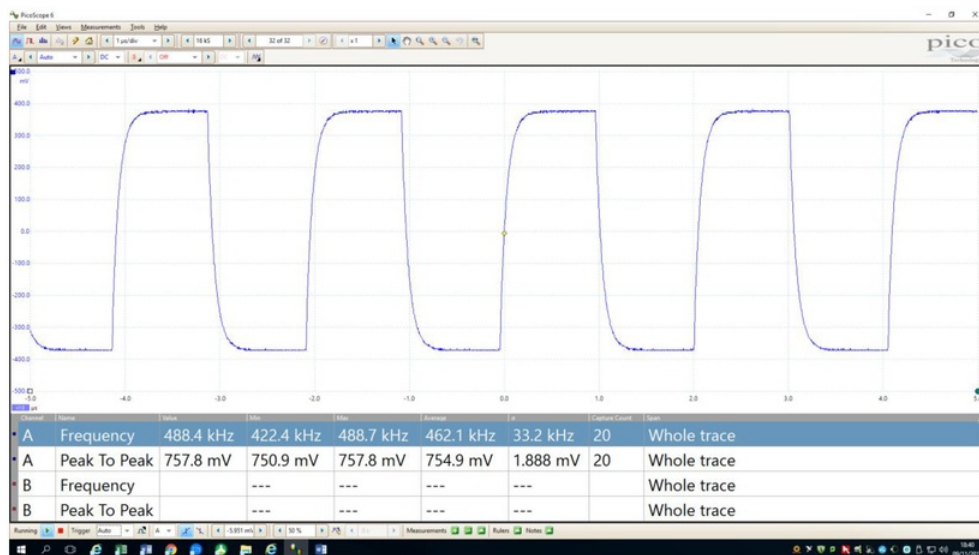


Figure 7 - 33 KHz at 2 Vp-p

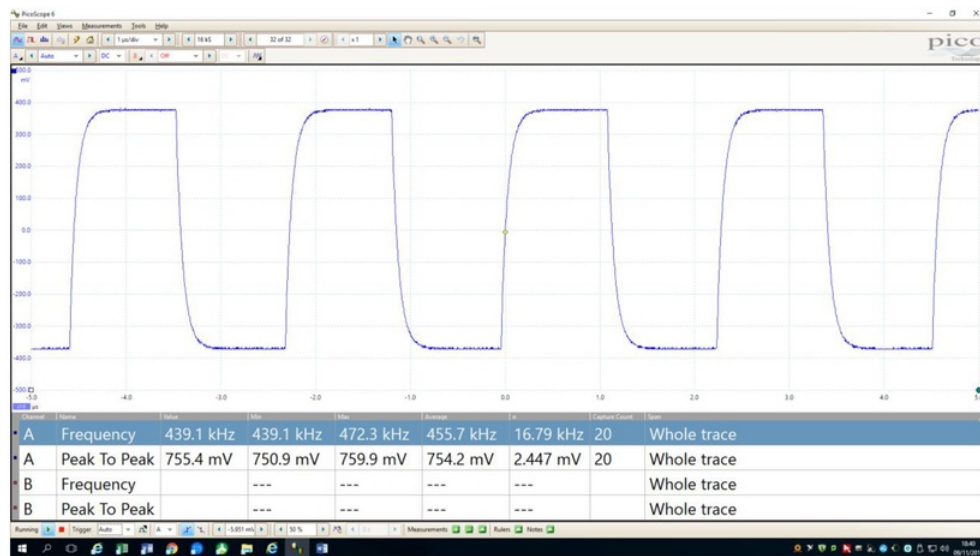


Figure 8 - 16 KHz at 1 Vp-p

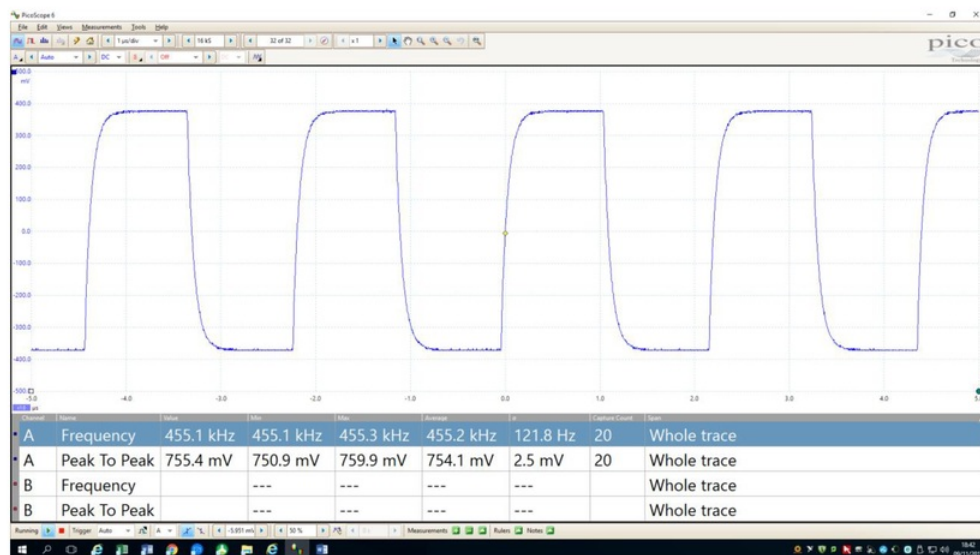


Figure 9 - 130 KHz at 0 Vp-p

These results are showing the frequency deviation which is caused by the amplitude of the carrier linearly affected the change in frequency.

This also shows the maximum frequency deviation (130 KHz) and the modulation index. These match up closely to the values calculated in the task above.

Now the modulation generator output must be adjusted so that the oscilloscope measures is as 6 Vp-p. Then adjust the B control on the signal source module until the deviation becomes exactly 60 KHz and leave the B controller alone.

The signal source module in set up so p-p control voltage from the modulation generator sets the frequency deviation as follows

6 Vp-p – 60 KHz

4 Vp-p – 40 KHz

2 Vp-p – 20 KHz

Working out the side frequencies the following must be done:

Do not adjust the B control value

Set the A control to 0.2

Leave manual frequency alone and C at 455 KHz.

Set the variable attenuator to 0dB

Set the output of the modulator to 20 KHz at 2 Vp-p (as above)

Now use the picoscope analyser to get the results.

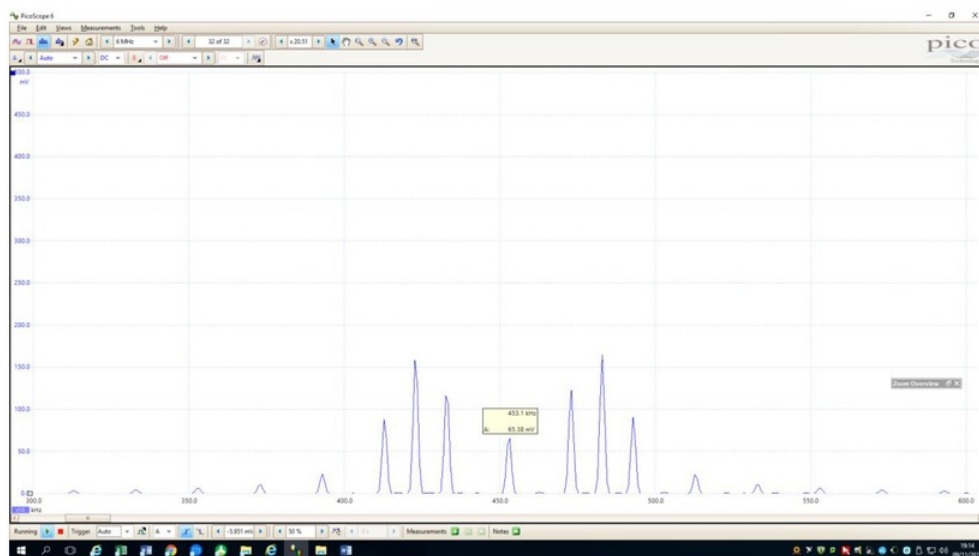


Figure 10 - 65 mV

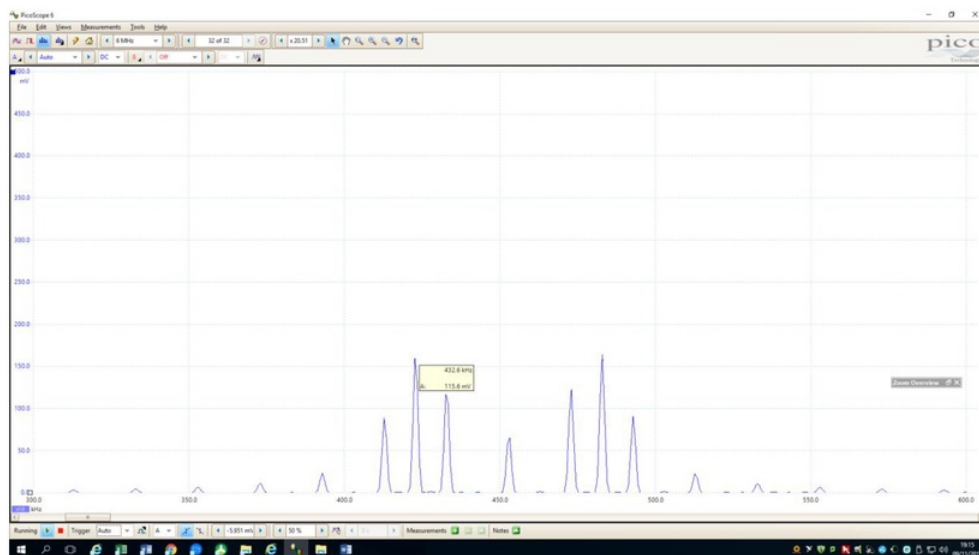


Figure 11 - 115 mV

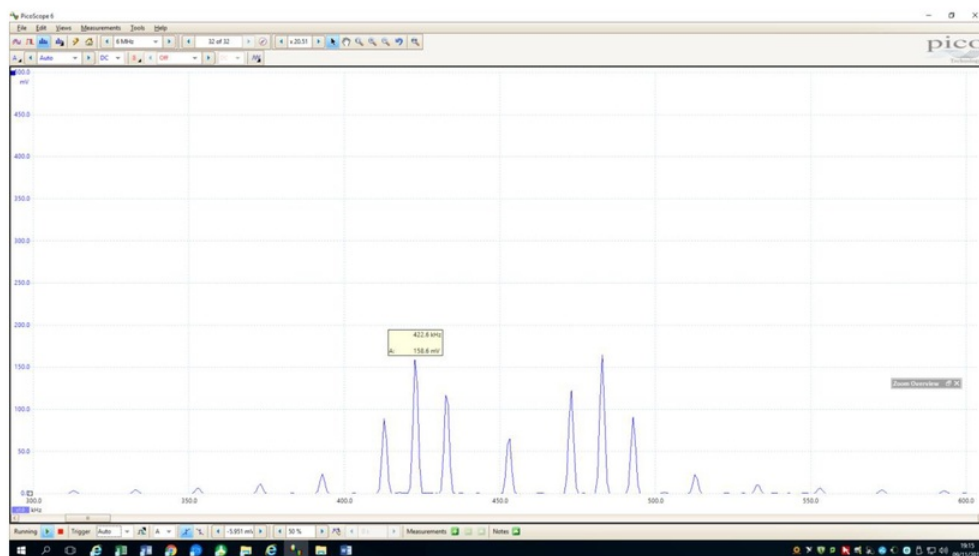


Figure 12 - 158 mV

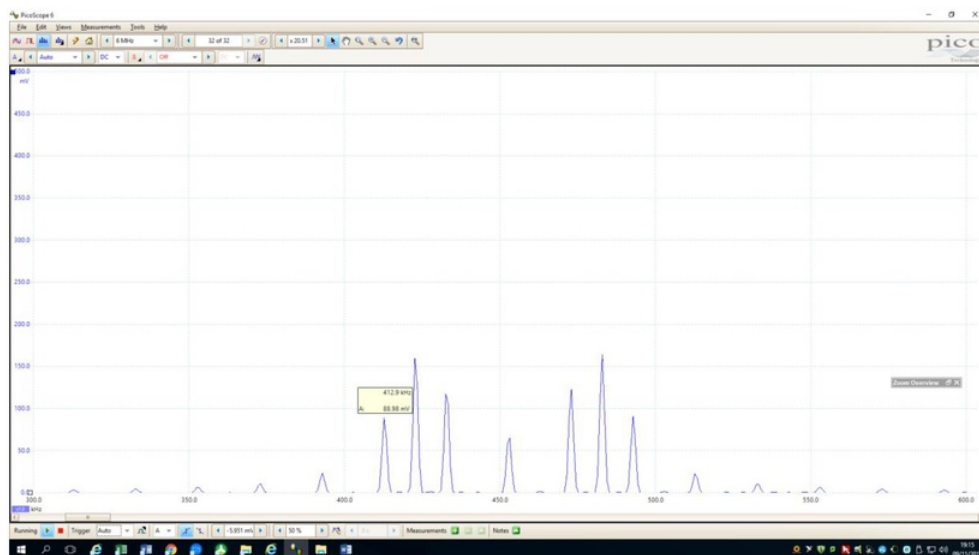


Figure 13 - 89 mV

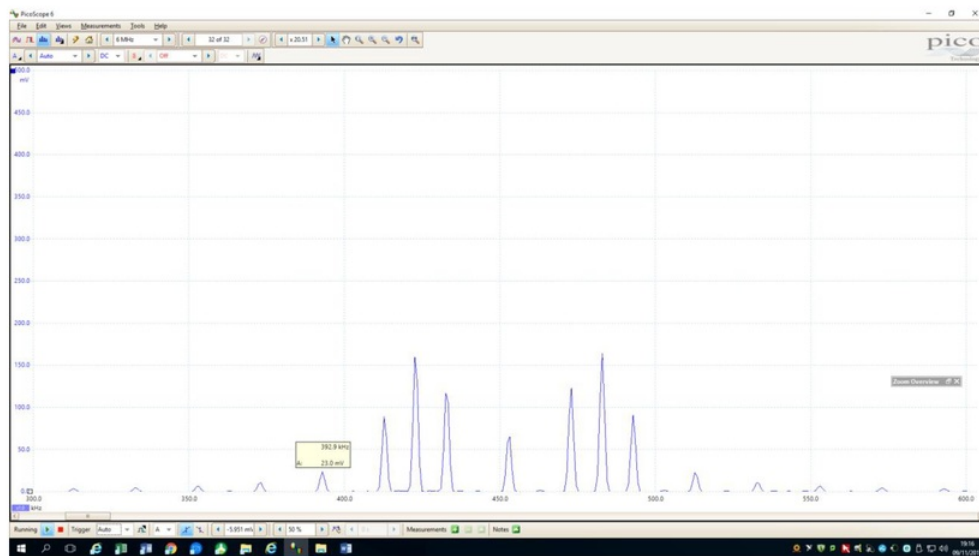


Figure 14 - 23 mV

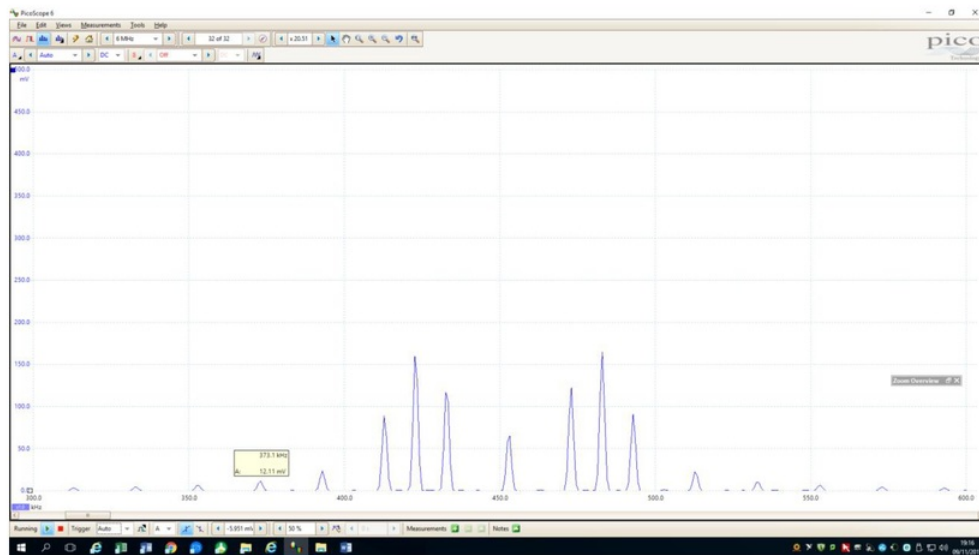


Figure 15 - 12 mV

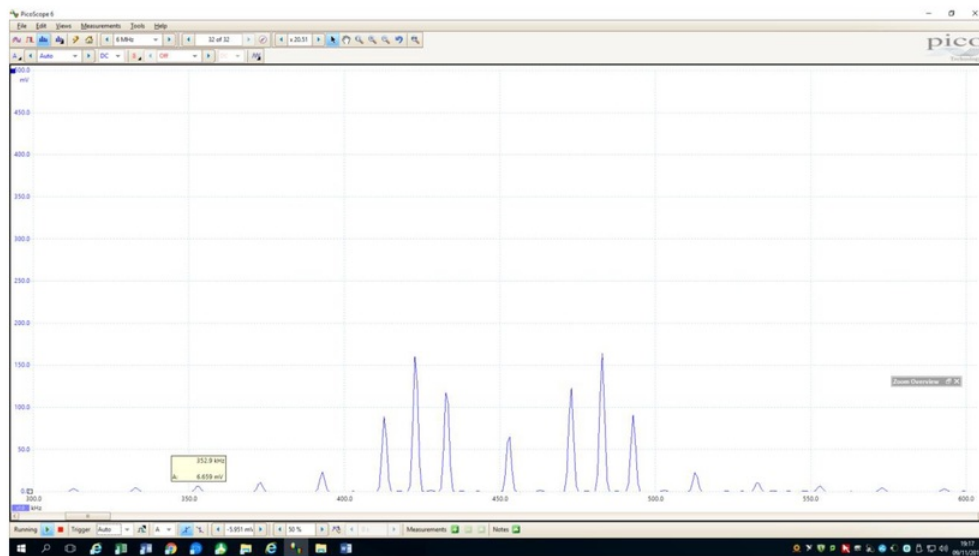


Figure 16 - 6 mV

These results start with J0 through to J6, these values are comparable to the values calculated in the task above.

Signal Frequency (KHz)	Voltage	Frequency Deviation (KHz)	Deviation Ratio	No. of Significant Pairs of Side Frequencies
20	2	20	1	3
	4	40	2	4
	6	60	3	5

The table above shows the various values of signal frequency and input voltage which were found through the practical experiment. Again this matches comparably to the values found in the task above.

5. Conclusion

By using the aims and objectives we can come to a conclusion of whether the assignment has been successful.

The aims and objectives of this assignment were to analyse and manipulate a range of signals mathematically in both time and frequency domains and apply to analogue and digital communication systems and to demonstrate an understanding of the requirements of analogue and digital communications systems from theory and by practical testing or simulation.

This was successful as stated above the results of the practical and calculated theoretical values are very close and therefore this part of the assignment has been a success

This will be achieved by doing research into the development of radio and its effect, transmitters and receiver and analogue modulation techniques.

The research has been a success because I have learnt a lot about radio and frequency modulation as a whole.

Therefore in conclusion the assignment has been successful.

6. References

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Assignment 1 Joshua Beer

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

53/100

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GRADING FORM: CSG-RUBIC

JOSHUA BEER**53****RESEARCH-INFORMED LITERATURE**

There was evidence of further reading and research with the inclusion of a reference list, however there was very little evidence of any in-text referencing. Your interpretation and understanding of the research was satisfactory although there were chunks of obviously cut'n'paste text. Your references list was difficult to gauge since you hadn't referred to it in the text, so it was not possible to check if the source was used. for this the task - the titles did however seem appropriate.

2**KNOWLEDGE AND UNDERSTANDING**

The knowledge and understanding of the subject demonstrated by this assignment was generally good. There were a few gaps in your knowledge of the basic principles and your understanding of the

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higher level concepts was demonstrated to a limited degree - you could have explained in more detail how the FM worked. The experiment was mainly a repeat of the handout and you wasted a lot of words typing out the instruction sheet. Further work – Your explanations need to be more detailed and written in a clear manner within the report.s.

ANALYSIS



Your analysis of the task was generally satisfactory, both in class and as shown in this assignment. You have demonstrated some analytical skills and your approach to the task was logical. You carried out a short analysis and a short conclusion. 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 were generally OK, you used the resources available appropriately when carrying out the experiment and you used appropriate options for testing and evaluating the circuit performance - albeit to a limited fashion. Testing generally lacked a lot of the required detail however and you should have included a comprehensive set of results for each stage.

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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 brief and lacked some detail. The report was well presented, with good diagrams in

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appropriate places, good sentence/paragraph structure and clear calculations.