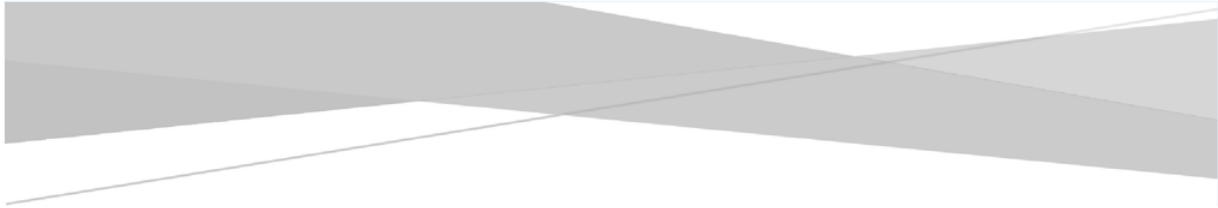


Assignment 1

by Nathan Smith

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HND ELECTRICAL & ELECTRONIC ENGINEERING

PSDE 5014 SIGNALS AND DIGITAL COMMUNICATIONS

ASSIGNMENT 1 SIGNALS AND MODULATION

Nathan Smith

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1. Introduction, aims and Objectives

This assignment will look into the signals and modulation and radio systems. The first objective is carrying out research into the development of radio systems along with its effect to the modern world and modulation techniques; the research also looks at digital radio development. The assignment then moves onto a practical and experimental section where the objective was to prove a set of calculated carrier results matched up to an experiment results with the same values used. The assignment is set into seven parts as stated in the assignment brief.

2. Research into Radio Systems (investigation of wireless communication)

2.1 The development of radio since its invention

Radio based its development on two other systems, the telephone and the telegraph, as these systems share similar technology. Radio systems first started as “wireless telegraphy” The name “radio” can relay to the speech or sound that is emitting or to the actual device we are listening to these sounds from. For both the application they all stemmed from the finding or discovering of “radio waves” or “electromagnetic waves” which have the abilities to transmit data through the air such as speech, voice and music. (Bellis, 2017)

Radio was first discovered mathematically by James Clerk Maxwell, he published his findings in many papers but it wasn't proved until 1887 when Heinrich Hertz carried out a series of experiments. These very first radio findings were found using a simple transmitter system which contained a spark gap across an induction coil and an antenna which was built with a loop of wire.

Around 1896 developments were made in radio transmissions by Marconi who set up experiments to send radio signals over water. During 1896 he set up an experiment stretching over the 14km Bristol Channel and successfully transmitted radio waves. Following on from this in 1901 Marconi had success with the first transatlantic radio transmission across the Atlantic ocean with stations set up in Polhi in Cornwall England and a Cape Cod in Massachusetts USA. Both sites were hit by storms and the site in USA was relocated to Newfoundland, on the 12th of December 1901 the letter 'S' was received from England. (Anon., 2017)

1904 came the next major development with Professor Ambrose Fleming who invented the diode valve. This diode valve was created to solve the problem of the weak detectors used in radio receivers. The diode valve consisted of two elements, the first consisting of a heated element in an evacuated bulb made from glass and a second elements inserted in the bulb but wasn't heated. The current would only flow in one direction with electrons leaving the heated cathode and flowing towards the second's element called the anode. In 1906 the diode was taken a step further by De forest who invented the triode by adding an additional element and calling the device an Audion. This triode was then taken in 1912 and used as an amplifier by De forest which potential was seen to be used and a repeater in long distance telephone circuits.

When the “triode” was confirmed to be an amplifier this impacted the performance of the receiver as it made the signals incoming a lot bigger by amplifying them. This amplification allowed more distant or weaker stations to be heard greatly improving radio transition. In order to produce enough gain though, a series of valves were required, these value were very expensive so other ways to solve this problem were required. In 1913 a regenerative detector was introduced which involved the use of positive feedback and resulted in significant improvements in the levels of gain that could be achieved, the amount of feedback could be adjusted to a point of oscillation and this greatly increased to gain and selectivity.

During World War One the demand to further the performance of radio technology was greatly required. The TRF receiver had a major improvement of performance but still needed improving, a new form of direct conversion receiver was introduced which solved some of the problems but still needed improving. The autodyne was introduced which used the TRF valve differently to produce an oscillator and mixer, this optimised the circuit and improved radio transmission.

Transistor radios came next, these were introduced in the 1940's and are perfect for use on medium and long wave forms. Field effect transistors were introduced and semiconductor technology was introduced to take over from valves.

In the 21st century radio technology has greatly improved, digital signal processing are carried out through an analogue intermediate frequency and through mathematical manipulation the signal can convert to digital. Today's radios consist of integrated circuits which are of high performance but low power, which are still based of the principles of the superhet discovered back in 1918. (Anon., 2017)

2.2 The effect it has had on the modern world

Radio transition has had a great positive effect on the modern world. Cables were expensive and very vulnerable so data sharing through cables was not a viable and reliable way to transit information and was almost impossible over long distances.

Radio transition enables people to communicate over vast distances without the need for any physical materials except for sending and receiving radio transition.

People all over the world were now able to communicate and during the world wars, radio transition was used to relay information to military and civilian personnel which aided the military and in some ways helped to win the wars. In the modern world radio technology has vastly improved and radios have a positive effect impacting people daily from relaying information about news or advertising to transmitting the latest music and current affairs.

2.3 A transmitter/receiver system to block diagram level

A radio transmitter and receiver block diagram is shown below in figure 1, this demonstrates the communication of radio signals by radiating waves through a transmitter system and then collecting or receiving these waves in a receiver.

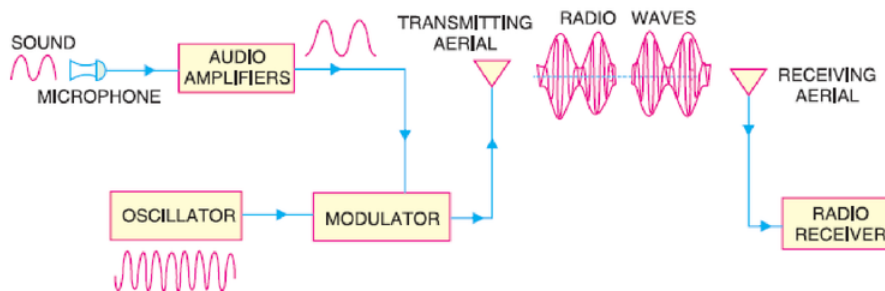


Figure 1: Transmitter Receiver Block Diagram

Above shows the main parts of the transmitter and receiver system, the transmitter creates radio waves which are transmitted into space. The transmitter can include components like modulators, oscillators, microphones and amplifiers.

The audio amplifiers steps up or amplifies the signal coming from the microphone and then sends it to modulator to render the modulation. The microphone converts a sound wave into an electrical wave, as a sound is created to the microphone it generates an audio electrical signal which is the same as the frequency of the original signal.

The modulator receives a signal from the audio amplifier which are then superimposed to a set value, these resultant waves become modulated waves. The modulator permits the audio signal transmission at the carrier frequency. The oscillator creates a large frequency signal, this becomes a carrier wave. The antenna will transmit the radio waves into all directions, these waves are electromagnetic waves and are send to the receiving antenna.

The receiver collects these waves and when they are receives to the antenna they induce a small emf. This voltage is sent to the receiver of the radio were the waves are amplifies and the signal is taken from these through demodulation. The signal then gets amplified again through and audio amplifier and send to the speaker to revert back to sound waves. (Coleg Sir Gar, 2017)

2.4 Various analogue modulation techniques

Amplitude modulation

(Anon., 2017) States that, "Amplitude Modulation or AM is the process of varying the instantaneous amplitude of a carrier signal accordingly with instantaneous amplitude of message signals, thus if $m(t)$ is the message signal and $c(t)=A\cos\omega t$ then AM signal $f(t)$ is written as";

$$F(T)=A\cos\omega t+m(t)\cos\omega t$$

$$F(T)=[A+m(t)]\cos\omega t$$

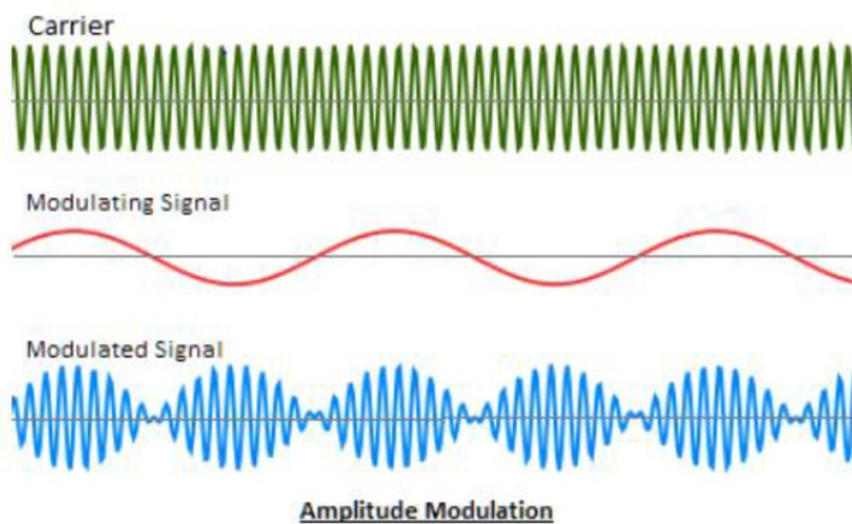


Figure 2: Amplitude Modulation

The advantages of AM is that it's the most basic and easy to use modulation type and the components for the receiver and transmitter systems are more cost effective. The disadvantages are that it is very susceptible to noise which may affect the transmission.

Frequency Modulation

(Anon., 2017) States, "FM or frequency modulation is the process of varying the instantaneous frequency of a carrier signal accordingly with instantaneous amplitude of a message signal. Thus, if $m(t)$ is the message signal and $c(t)=A\cos\omega_c t$ then FM signal will be";

$$F(t) = A\cos(\omega_c t + k_f \int m(a) da)$$

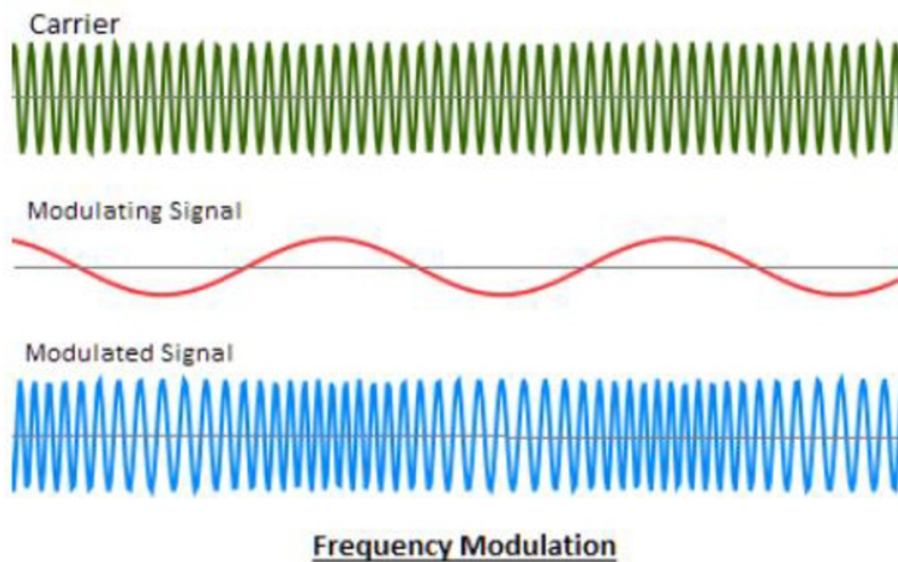


Figure 3: Frequency Modulation

The advantages of FM are that not noise through the channels are caught with demodulation and modulating systems, and the disadvantages are that the circuit that is needed for modulation and demodulation is more complex.

Phase modulation

(Anon., 2017) States that, "PM or phase modulation is the process of varying the instantaneous phase of carrier signal accordingly with instantaneous amplitude of message signal. Thus if $m(t)$ is the message signal and $c(t)=A\cos\omega_c t$ the PM signal will be";

$$F(t)= A\cos(\omega_c t+k_p m(t))$$

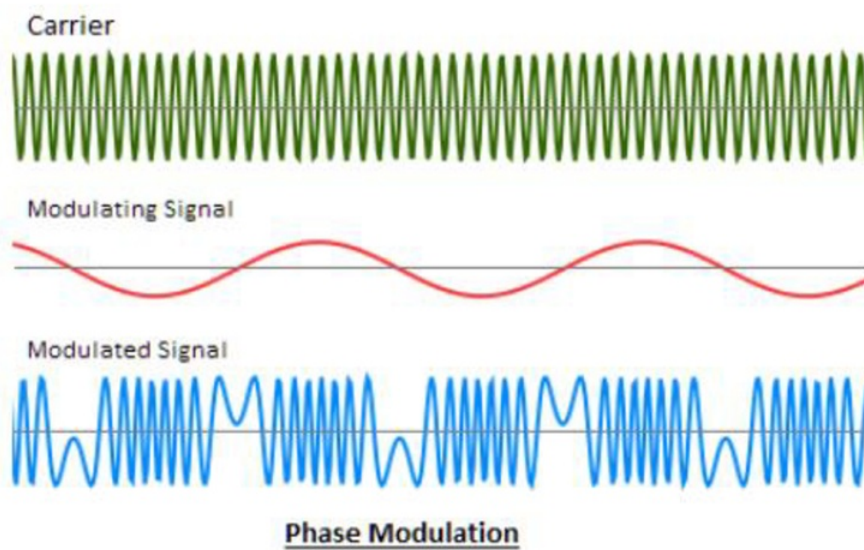


Figure 4: Phase Modulation

The advantages of Phase modulation are that the modulation and demodulation do not catch or receive any channel noises, and the disadvantages are that circuits needed in PM are more complicated than that used in AM and FM.

2.5 An overview of the development of digital radio.

Digital radio is a relatively new advancement in radio technology it was first put under development in the early 80's but was first seen in operation in the mid 90's. Digital radio operates a lot better than a FM or AM radio as it operates more efficiently. The digital signal does not have as much interference through noise so provides a cleaner transmission, the digital signal differs to the FM and AM signal in that if the reception of the signal drops the transmission stops fast as opposed to the AM and FM signals fading slowly.

Digital radio has come a long way since its development and by the mid 2000's over 500 million people were in areas covered by a digital radio signal. Today there is over 2,000 digital radio services worldwide showing a massive move forward in radio development.

(Woodford, 2017) States, "To help avoid interference, a digital radio signal travels on a huge, broad band of radio frequencies about 1500 times wider than those used in analogue radio". "The transmitter send program signals broken into fragments and coded in numbers." "The transmitter sends each fragment many times to increase the chances of it getting through."

3. Experimental Method

1)

For this part of the assignment the modulation index and maximum frequency deviation were required to be calculated for a frequency modulation practical of a 455kHz carrier. The carrier has an amplitude of 375mV and it is frequency modulated by a 10kHz square wave signal with an amplitude of 1.5v. The carrier was will vary between 425-485kHz.

$$\text{Carrier frequency} = \frac{f_{\max} + f_{\min}}{2}$$

$$= (485 - 425)/2 = \underline{30\text{kHz}}$$

$$\text{Frequency deviation } (\Delta f_c) = f_{\max} - f_c$$

$$= 485 - 455 = \underline{30\text{ kHz}}$$

$$\text{Modulation index } = \beta = \Delta f_c / f_s = 30/10 = 3$$

Using the Bessel table below, figure 5, the amplitudes are calculated as shown below. The carrier frequency is the found using the above equation. To find out which row to use we use the deviation index as above, this is found as the change in carrier caused by modulation which is the 30 kHz as above, we then find the modulation index which is the frequency deviation divided by the frequency modulated which is 10, this gives the modulation index of 3. This means we use row for the value 3 on the chart below to times the carrier amplitude with as shown below.

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	—	—	—	—	—	—	—	—

Figure 5: Bessel Table

The results are shown below which will be used to input into the amplitude spectrum also below and in figure 6.

$$J0 = -0.26 \times 375\text{mv} = 97.5\text{mv}$$

$$J1 = 0.34 \times 375\text{mv} = 127.5\text{mv}$$

$$J2 = 0.49 \times 375\text{mv} = 183.75\text{mv}$$

$$J3 = 0.31 \times 375\text{mv} = 116.25\text{mv}$$

$$J4 = 0.13 \times 375\text{mv} = 48.75\text{mv}$$

$$J5 = 0.04 \times 375\text{mv} = 15\text{mv}$$

$$J6 = 0.01 \times 375\text{mv} = 3.75\text{mv}$$

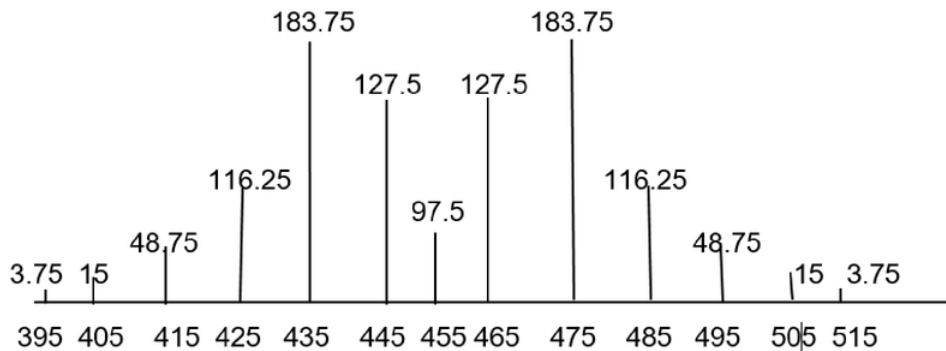


Figure 6: Calculated Amplitude Spectrum and Side Frequencies

The next step was to carry out a practical investigation using the apparatus provided by the college and the practical activity 6 worksheet for direction on setting up the equipment.

The experiment consisted of using a power supply module, a signal source board and a picoscope which provides an oscilloscope and a frequency meter. The next step was to carry out the testing and results of the practical which is shown below in the next section.

4. Testing and Results

Using the practical activity worksheet the practical calculations could be confirmed by using the equipment and setting the variables to the task description values. The worksheet was followed and the experiment was set up to correctly to input variables to determine what effects the system.

The first step was to find out what effect reducing the amplitude of the modulation generator will have on the frequency deviation. The value of 5v p-p was used first and the result of $\pm 85\text{kHz}$ was shown as the frequency deviation, as shown below in figure 7.

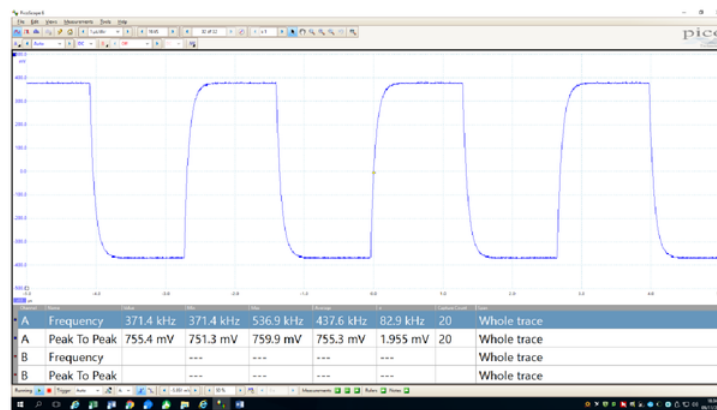


Figure 7: 5V p-p frequency Deviation

This was repeated by dropping the amplitude of modulation by 1v unit the value of 0v, at 0v the frequency deviation was at $\pm 130\text{Hz}$ which is a very small value. By carrying out this task it was proved that the frequency deviation is determined by changing the peak to peak voltage or a change in the amplitude of the message.

The next stage was to test if the deviation changed when the peak to peak voltage is the same. This was done by setting the deviation of the system to 60 KHz as explained in the practical sheet. The signal source was now set up to show; 6V p-p = 60 kHz, 4V p-p = 40 kHz and 2V p-p = 20 kHz, the frequency of the modulation generator was changed to 10 KHz and then to 100 kHz. This proved the value displayed on the frequency meter was not sensibly related to the true frequency as it was moving too quickly. This also proved that deviation moved quicker when then peak to peak voltage stayed the same.

To display the side frequencies was the next stage, this involved changing the system as the work sheet and setting out picoscope to its spectrum analyser mode. The side frequencies are shown below in figure 8, with the values set as per the sheet to a manual frequency control of 455 kHz, the variable attenuator set to 0dB and the output modulation generator set to 20 kHz at 2V p-p.

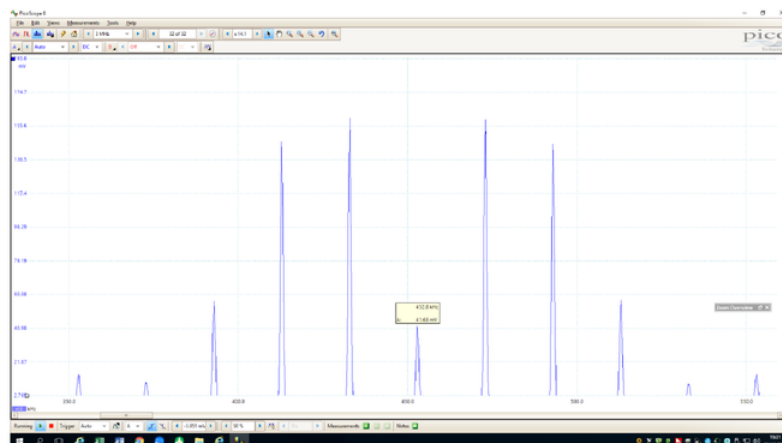


Figure 8: 2V p-p Side Frequencies

The frequency was changed from 20 to 40 and then to 60 with an increasing voltage and shown that the deviation ratio increases with a changing frequency. If we increase the frequency the number of significant pairs of side increases. This experiment showed that the carrier signal can be modulated by changing it frequency in accordance with the signal and the side bands can be changed depending on the amplitude and frequency.

The next stage was to verify the results gained in the practical part of the assignment brief by inputting the values of a 455 kHz manual frequency, amplitude of 375mV, frequency modulated by a 10 kHz square wave signal of amplitude 1.5v. The carrier wave varies between 425 kHz and 485 kHz. The experiment was set up to show this and the results were shown below in figures to prove the calculations carried out above. The Bessel table was used as stated above in the practical section to gain the values to be entered into the system.

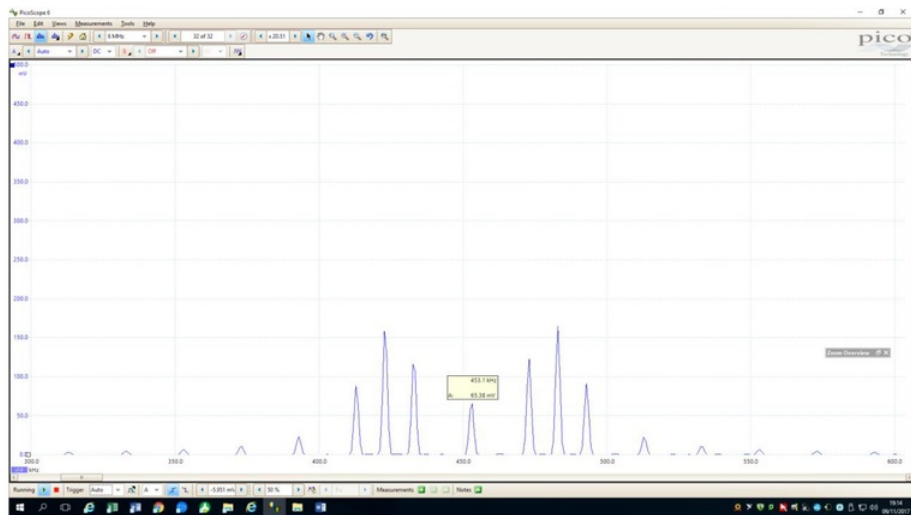


Figure 9: 65mV

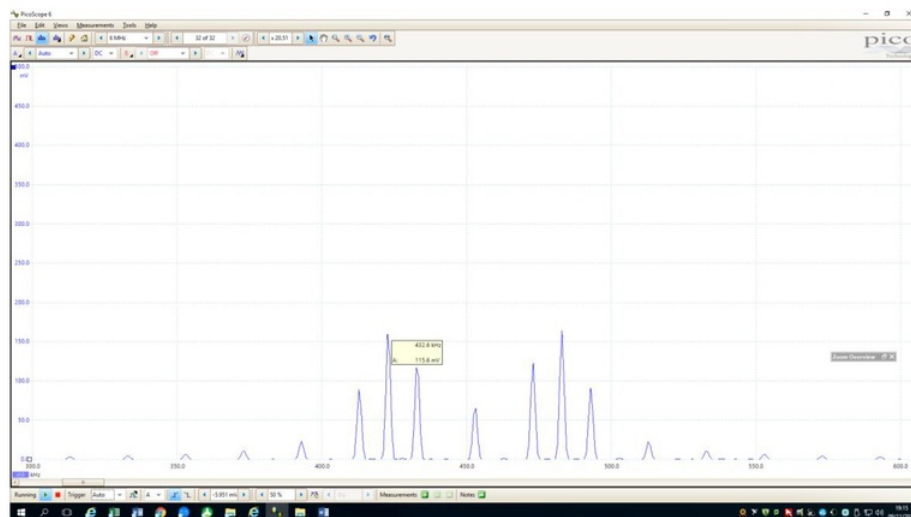


Figure 10: 115mV

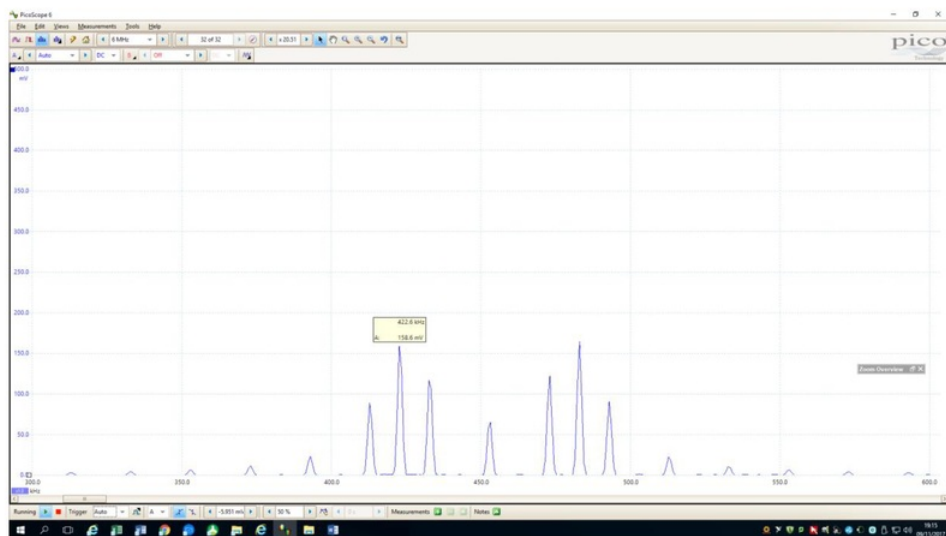


Figure 11: 158mV

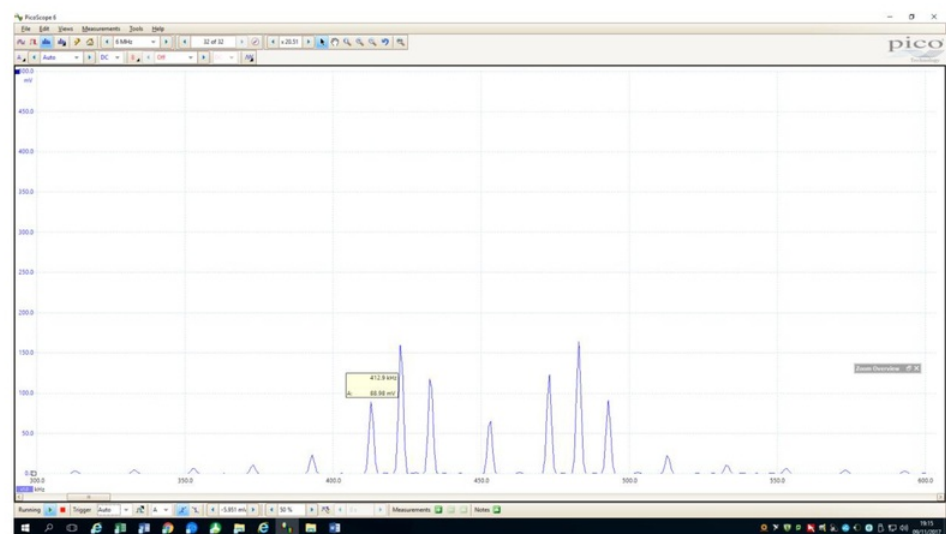


Figure 12: 89mV

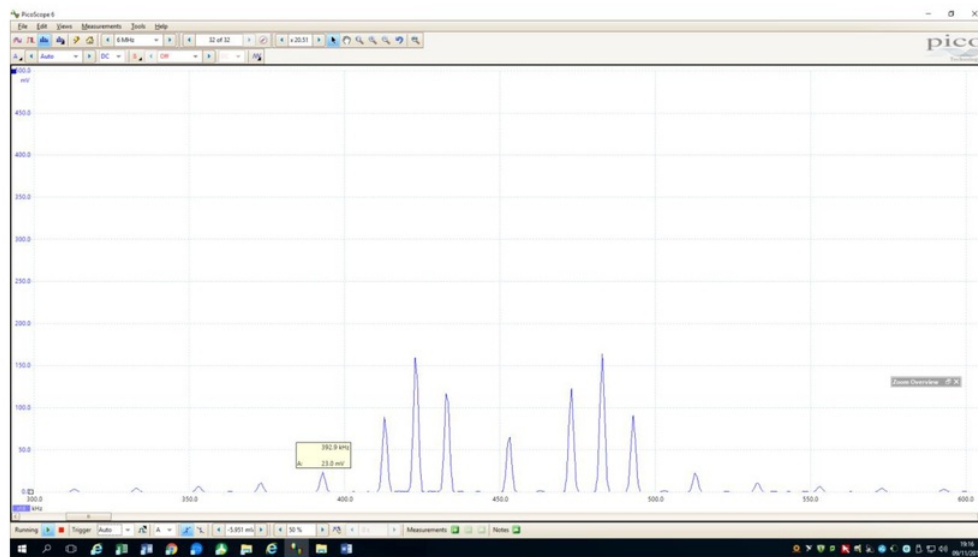


Figure 14: 23mV

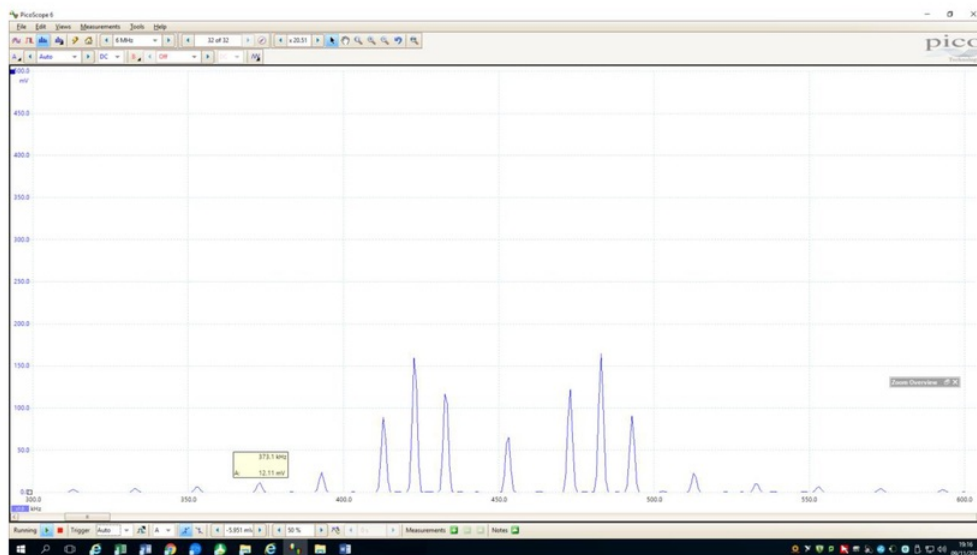


Figure 13: 12mV

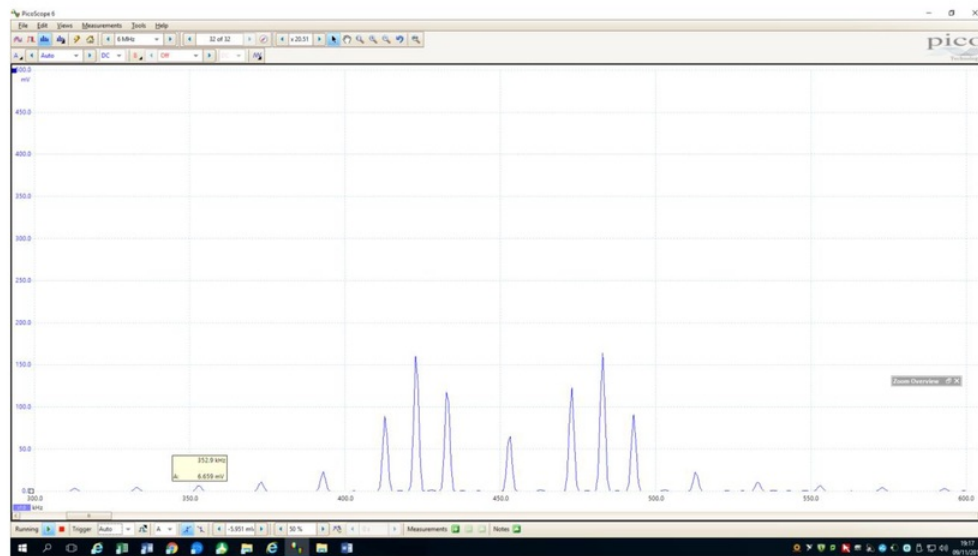


Figure 15: 6mV

The above results show a slight deviation from the calculated value but equipment calibration could be the cause of this, the values shown though shown the same side frequency shape and bandwidths proving the experiment proved the practical calculations a success and it worked as predicted.

5. Conclusions

The assignment proved that through research carried out the importance of the radio since being invented. The radio has been a great success through many long years of development and many tests. Without radio many key historical events may not of happened and the world could of been a lot different place to it is today, the research has shown a block diagram of a radio system and how it has been developed and improved but still uses the same basic principles to get us the quality of radio we have today. The digital radio has been investigated also and shown that it is a leap forward in radio technology providing cleaner and stronger radio.

The practical and testing parts of the assignment looked at calculating a carrier with given values and then testing these values on a physical experiment to prove the results. The experiment showed that effect that frequency and amplitude have on the signal and also showed that the FM source provides improved immunity from interfering signals as opposed to an AM source.

The results calculated and the results proved in the experiment were similar and only not exact due to calibration issues, the proved a success and provided results as we would expect in the assignment.

6. Reference list and Bibliography

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

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Assignment 1

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

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GRADING FORM: CSG-RUBIC

NATHAN SMITH**67****RESEARCH-INFORMED LITERATURE**

There was some evidence of further reading and research from credible and reliable sources. Your interpretation and understanding of the additional research was good and demonstrated an underlying appreciation of the subject. Your reference list however is no use unless it is referred to in the text, you started off well enough but need to include more in-text references - especially for diagrams

7**KNOWLEDGE AND UNDERSTANDING**

The knowledge and understanding of the subject demonstrated by this assignment was generally good. There were very few gaps in your knowledge of the basic principles and your understanding of the higher level concepts was demonstrated to a limited degree - you could have explained in more detail how FM worked and how the results of your experiment illustrated the basic principles of FM.

22**ANALYSIS**



Your explanation of the experiment was good, however the conclusions lacked some detail. You could have evaluated the results in more detail 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. Further work – in your conclusion, you should relate the results to the original specification and to accepted theory.

10

PRACTICAL APPLICATION AND DEP.



Your application of practical skills for this task were generally OK, you used the resources 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.

21

SKILLS FOR PROFESSIONAL PRAC.



In this assignment you have demonstrated skills in working individually and also collaboratively. Your written report was of an appropriate length, you could however be more efficient with your word count. The report was well presented, with good diagrams in appropriate places, good sentence/paragraph structure and clear calculations.

7