

Study of Amplitude Modulation Transmitter

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Abstract:- This project deals with the design and implementation of a simple amplitude modulation transmitter using colpitts oscillator principle to transmit a low power AM transmitter, typically used as short range linkage between a microphones and the audio amplifier modules. The project will also enable other listeners and other correspondents to tune and receive the same information via all sorts AM receivers at the same oscillation frequency of the oscillator.

1. INTRODUCTION

Generally in communication and information processors, Amplitude Modulation (AM) is a technique used in electronic communication, most commonly for transmitting information via a radio carrier wave (Newkirk et al., 2004; Karl et al., 2004; Quist et al., 2004). AM works by varying the strength (amplitude) of the carrier in proportion to the waveform being sent. That waveform may, for instance, correspond to the sounds to be reproduced by a loudspeaker. This contrasts with frequency modulation, in which the frequency of the carrier signal is varied, and phase modulation, in which its phase is varied, by the modulating signal. In amplitude modulation, the amplitude or "strength" of the carrier oscillations is what is varied. For example, in AM radio communication, a continuous wave radio-frequency signal (a sinusoidal carrier wave) has its amplitude modulated by an audio waveform before transmission. The audio waveform modifies the amplitude of the carrier wave and determines the envelope of the waveform. In the frequency domain, amplitude modulation produces a signal with power concentrated at the carrier frequency and two adjacent sidebands. Each sideband is equal in bandwidth to that of the modulating signal, and is a mirror image of the other. Standard AM is thus sometimes called "double-sideband amplitude modulation" (DSB-AM) to distinguish it from more sophisticated modulation methods also based on AM (Newkirk and Rick 2004).

AM radio technology is simpler than frequency modulated (FM) radio, Digital Audio Broadcasting (DAB) and satellite radio. An AM receiver detects amplitude variations in the radio waves at a particular frequency. It then amplifies changes in the signal voltage to drive a loudspeaker or earphones. The earliest crystal radio receivers used a crystal diode detector with no amplification, and required no power source other than the radio signal itself. AM radio signals can be severely disrupted in large urban centers by metal

structures, tall buildings and sources of radio frequency interference (RFI) and electrical noise, such as electrical motors, fluorescent lights, or lightning. As a result, AM radio in many countries has lost its dominance as a music broadcasting service, and in many cities is now relegated to news, sports, religious and talk radio stations. Some musical genres – particularly country, oldies, nostalgia and ethnic music – survive on AM, especially in areas where FM frequencies are in short supply or in thinly populated or mountainous areas where FM coverage is poor. The early experiments in AM transmission, conducted by Fessenden, Valdemar Poulsen, Ernst Ruhmer, Quirino Majorana, Charles Herrold, and Lee De Forest, were hampered by the lack of a technology for amplification. The first practical continuous wave AM transmitters were based on versions of the Poulsen arc transmitter invented in 1903, and the huge, expensive Alexanderson alternator, developed between 1906-1910. The modifications necessary to transmit AM were clumsy and resulted in very low audio quality. Modulation was usually accomplished by a carbon microphone inserted directly in the antenna wire. The limited power handling ability of the microphone severely limited the power of the first radiotelephones. At the receiving end, the unamplified crystal radio receivers then in use could not drive loudspeakers, only earphones, so only one member of a family could listen at a time (Wiki, 2010).

This project will explain firstly the AM radio transmitter experiment, involving the explanation of the aim and objectives of what the experiment entails. Then the report will go on to discuss the equipment used for this experiment and also the method which was used to construct both parts of the experiment. Finally the report will conclude with the results which were obtained and then an explanation of the results to conclude the experiment. The report will then lead on to discuss the AM transmission demonstration in which the aim, objectives, equipment, method and results will also be explained for this experiment. The report will then

conclude with a conclusion which will involve a discussion to how both experiments went on. The structure of the report will be as said above allowing both experiments to be explained in details.

2. EXPERIMENTAL

In this experimentation, I will describe the methods used to apply voice signals to a carrier wave by the process of amplitude modulation transmitter. Therefore, according to this project an AM transmitter can be divided into two major sections based on the frequencies at which it operates: Radio-frequency (RF) and Audio-frequency (AF) units. The RF unit is the section of the transmitter used to generate the RF carrier wave while the AF unit is the section of the transmitter used to generate AF carrier wave.

COMPLETE CIRCUIT DESIGN FOR THE RESEARCH CIRCUITS DIAGRAM OF AM TRANSMITTER

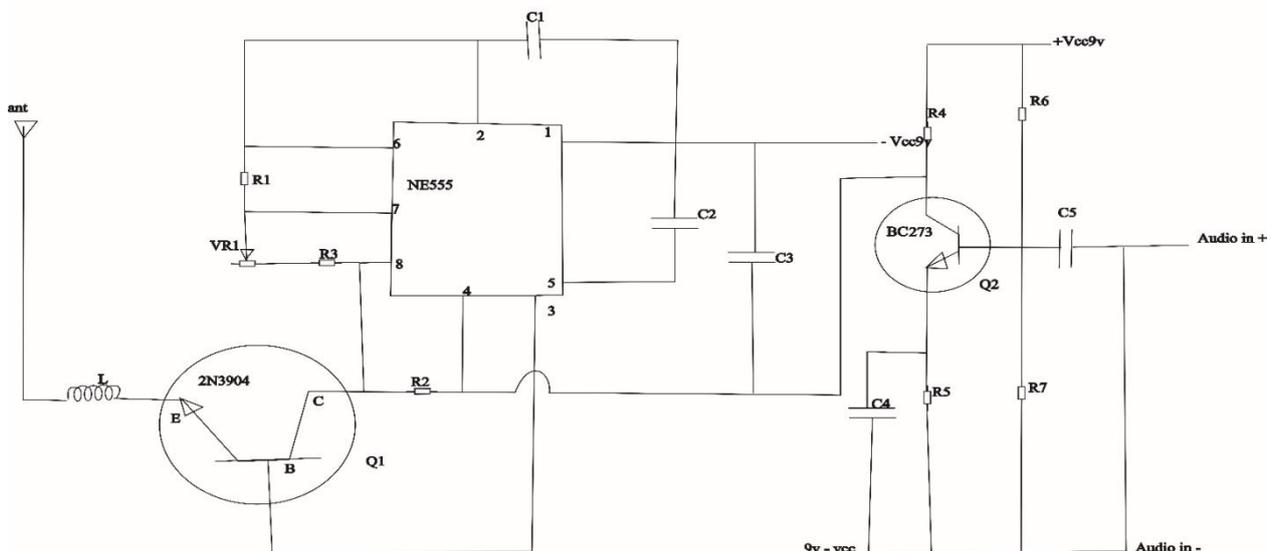


Figure showing circuit diagram used.

3.1 PRINCIPLE OPERATIONS OF OSCILLATOR

The oscillator C1 and C2 are used as a voltage divider which also serve as smoothening device. R2 which is connected from C3 to collector serve as a voltage limiter and voltage differentiator. Generally Q1 serves as a final amplifier in the oscillator because it burst the signal or amplifies the signal before sending it to the antenna for transmission.

Inductor L1 function as a coupler because it couple or connect the antenna with the final amplifier which is Q1 but the main function of the induction is to increase the frequency of the oscillator at output. R1 and R3 also serve as a current differentiator. The 555 timer functions as a main oscillator in the circuit.

3. DESIGN DISCRIPTION

The circuit is divided into two parts in constructing the project viz:

The oscillator: will provide the carrier signal, and is responsible of carrying the sound through the air to be received in any nearby receiver. This part includes transistor Q1, IC, resistors, inductor and capacitor. The capacitor will be used to change the frequency of the carrier signal. Both inductor and capacitor will mainly be used to make the oscillation.

The amplifier: a Bipolar Junction Transistor (BJT) Common Emitter amplifier was used to amplify the sound signal. The input sound signal will be provided through the base, and the output will receive signal from the collector. The amplified signal will receive an input through the oscillator. This part is built around transistor Q2.

CALCULATION

The colpitts equation is used to determine the frequency of the oscillator as follows:

$$F = \frac{1}{2\pi\sqrt{LC}}$$

Where C is the total capacitor and L is the inductor

Data

$$C1 = 0.102\mu F$$

$$C2 = 0.103\mu F$$

$$L1 = 5\mu H$$

By using capacitor in series we now have. C is given as:

$$C = \frac{C1 * C2}{C1 + C2}$$

$$C = \frac{0.102 * 0.103}{0.102 + 0.103}$$

$$C = 0.5125 \times 10^{-6}$$

$$C = 5.125 \times 10^{-7} F$$

From the colpitts equation

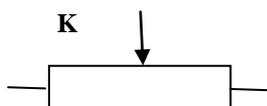
$$F = \frac{1}{2\pi\sqrt{LC}}$$

By substituting the values into the equation we now have;

$$F = \frac{1}{2 * 3.142\sqrt{5\mu H * 5.125 \times 10^{-7} F}}$$

The frequency of the oscillator is now F= 99.40 kHz

3.2 Potentiometer



The circuit potentiometer which is a variable resistor vary the loudness of the amplifier but the most function of it in this circuit is to help the oscillator or the transmitter to increase the signal of the frequency in the oscillator. This also comprise of some resistive element that are commonly used to control electrical devices such as volume or audio equipment, a sliding contact (wiper) that moves along the element, making good electrical contact with one part of it, electrical terminals at each end of the element, a mechanism that moves the wiper from one end to the other, and a housing containing the element and wiper for turning.

3.3 AMPLIFIER OPERATIONS

C5 serves as a coupling capacitor that connect the audio input RF and the power amplifier. It also smooth the audio input R6 and R7 which serve as voltage divider. Q2 which is the amplifier that amplifies the audio coming in to it. It then amplifies then it gives a high audio sound at its output which is connected to the C3 while R4 serve as a blocking resistor because it protects the amplifier against positive feedback. It is connected to the collector so that it gives high impedance. It also serve as voltage divider. R5 is used to protect the circuit against negative feedback which is connected to the emitter of the transistor Q2. C4 it used to store current so that it gives a required current at the output. C3 functions as a coupling capacitor because it connect the amplifier to the oscillator.

3.4 ANTENNA

3.4.1 Antenna



The antenna is the transmitter. It transmits the signal or the frequency as IF at the sending end. Nevertheless, antenna in a communications system is specialized as a transducer that converts incoming electromagnetic fields into alternating electric currents having the same frequencies (receiving antenna), or converts an alternating current at a specific frequency into an outgoing electromagnetic field at the same frequency (transmitting antenna). An antenna can be a simple wire or rod, or a complicated structure. Thousands of geometries and specifications are possible. The optimum antenna type for a given situation depends on the communications frequency, the distance to be covered,

3.4.2 Inductor



Inductor L1 functions as a coupler because it couple or connect the antenna with the final amplifier which is Q1 but the main function of the induction is to increase the frequency of the oscillator at its output. An inductor is also called a coil or reactor, with passive two-terminal electrical component which resists changes in electric current passing through it. It consists of a conductor such as a wire, usually wound into a coil. When a current flows through it, energy is stored temporarily in a magnetic field in the coil. When the current flowing through an inductor changes, the time-varying magnetic field induces a voltage in the conductor.

VOLTAGE REGULATION UNITS

As a result of the 9V requirement of the circuit components used, it is sufficient to use a 9V battery so that it can provide up to 1A load current and has in the circuit to prevent damage in the overheating/excess handling capacity of the chip, improving its working condition. The power supply unit +9V is tested for the output voltage under no-load and full-load conditions.

Under no-load, the voltage of the +9V supply was measured to be 8.94V. At full-load, the voltages was measured as 8.83V.

Voltage Regulation (V.R) is given as;

$$V.R = \frac{V_{NL} - V_{FL}}{V_{NL}} \times 100 \%$$

Where,

V_{NL} = No-load Voltage

V_{FL} = Full-load Voltage

For the unit's operating on +9V,

$$V.R = \frac{9.89 - 9.41}{9.89} \times 100 \% = 4.03 \%$$

S/N	DISCRIPTION	COMPONENT LABEL	QUANTITY
1	555 Timer	IC	1
2	NPN Transistor(2n3904)	Q1	1
3	NPN Transistor(BC547)	Q2	1
4	Capacitor 103uf	C2 & C3	2
5	Capacitor 102uf	C1	1
6	Capacitor 100uf	C4	1
7	Capacitor 4.7uf	C5	1
8	Wires		
9	Resistor 1kΩ	R1 & R3	2
10	Resistor 10kΩ	R2	1
11	Resistor 4.7kΩ	R4 & R7	2
12	Resistor 100Ω	R5	1
13	Resistor 5.6kΩ	R6	1
14	Potentiometer 10kΩ	VRI	1
15	Male audio jack		1
16	Receiver		1
17	Antenna	Ant	1
18	Inductor coil 5uH	L1	1
19	9volt battery		1

3.5 TABLE OF COMPONENT USED

3.6 COMPLETE OVER VIEW OF THE COMPONENT ARRENGEMENT AND CASEN



Figure1. Showing component arrangement

4. TESTING AND RESULT

4.1 TESTING

To test the AM radio transmitter, simply set the antenna next to your AM radio receiver (Alarm clock) tuned to approximately 600 KHz. Then play with the potentiometer until you can hear your music on your radio. If you hear weird sounds when you turn the potentiometer and do not hear the audio signal that means your audio signal is not on and your transmitter is working.

Otherwise try these for troubleshooting:

Is there power applied to the transmitter?

Is the audio signal on?

Then by turning the potentiometer signal will be received.

This is called amplitude modulation transmitter

4.2 THE SIGNAL WAVEFORM

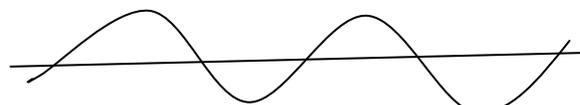


Figure1. Signal to be modulated e.g. speech or music

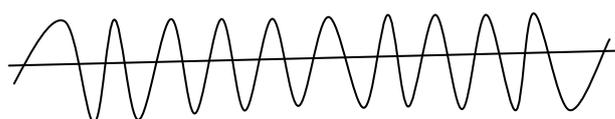


Figure2. Carrie radio signal of high frequency

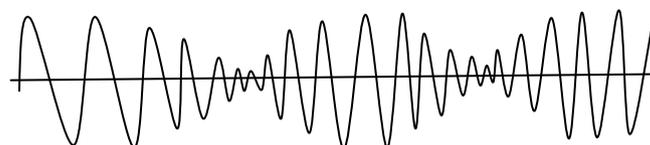


Figure3. Carrier wave amplitude modulated by speech or music information

4.3 MAINTANANCE OF AMPLITUDE MODULATION TRANSMITTER

PRECAUTIONS:

- i. The AM transmitter system is not waterproof. Avoid driving through puddles, rain, wet grass, or

- mud. If water gets into the transmitter it could damage it.
- ii. Do not operate the transmitter with low batteries or you could lose control of it. After the battery power drops below a certain point, the transmitter will continue out of control. Indications of low battery power include slow operation, sluggish.
 - iii. If the transmitter is too close to the receiver (within 3-feet), you may experience erratic radio system operation.
 - iv. Fluorescent lighting and steel building structures have been known to cause radio interference therefore avoid transmitting at the region of fluorescent light.

5. RESULT

The radio transmitter I made can only transmit at frequencies from 110 KHz to 480 KHz. The AM radio band is from 520 KHz to 1610 KHz. Harmonics is essential to be able to hear audio signals transmitted from my radio transmitter.

6. CONCLUSION

The aim of the project is to design and implement simple AM transmitter. Having realized the device and found working properly based on its design and relatively cheap components involved in its realization, the aim of the project can be said to be achieved. The project can be used as an effective linkage between offices, rooms, gates etc. for passing out information's.

REFERENCE

- [1] A.P.Godse and U.A.Bakshi (2009). Communication Engineering. Technical Publications. p. 36. ISBN 978-81-8431-089-4. <http://www.instructables.com/id/Easy-AM-Transmitter>
- [2] Adams, Mike (2011). Lee de Forest: King of Radio, Television, and Film. US: Springer. pp. 99–101. ISBN 1461404185.
- [3] Bray, John (2002). Innovation and the Communications Revolution: From the Victorian Pioneers to Broadband Internet. Inst. of Electrical Engineers. pp. 59, 61–62. ISBN 0852962185.
- [4] Belrose, John S. (September 1994). "Fessenden and the Early History of Radio Science". The Radio scientist (IEEE) 5 (3). Retrieved September 10, 2013. On Inst. of Electrical and Electronic Engineers, Canada website
- [5] Bertrand, Ron (2011). "Reading 30: AM Transmitters and Receivers". Online Radio and Electronics Course. Arcade archive. Retrieved September 10, 2013.
- [6] Barr, Michael. "Pulse Width Modulation," Embedded Systems Programming, September 2001, pp. 103-104.
- [7] Davis, L. J. (2012). Fleet Fire: Thomas Edison and the Pioneers of the Electric Revolution. Sky horse Publishing Inc. ISBN 1611456592.
- [8] "De Forest, Lee", Sterling, Christopher H.; Cary O'Dell, Michael C. Keith, Ed. (2011). The Biographical Encyclopedia of American Radio. Rout ledge. pp. 94–96. ISBN 0415995493.
- [9] "Fessenden, Reginald", Sterling, Christopher H.; Cary O'Dell, Michael C. Keith, Ed. (2011). The Biographical Encyclopedia of American Radio. Rout ledge. pp. 136–139. ISBN 0415995493.
- [10] Frederick H. Raab, et al. (May 2003). "RF and Microwave Power Amplifier and Transmitter Technologies - Part 2". High Frequency Design: p. 22.
- [11] "Herrold, Charles D.", Sterling, Christopher H.; Cary O'Dell, Michael C. Keith, Ed. (2011). The Biographical Encyclopedia of American Radio. Rout ledge. pp. 169–170. ISBN 0415995493. Greb 2003, Charles Herrold, Inventor of Radio Broadcasting, p. 150
- [12] Hilmes, Michele (2011). Network Nations: A Transnational History of British and American Broadcasting. Routledge. p. 6. ISBN 0415883857.
- [13] Jim Cox (2009). American Radio Networks: A History. McFarland. pp. 5–. ISBN 978-0-7864-5424-2.
- [14] Jeffrey S. Beasley New Mexico State University and Gary M. Miller Modern electronic communication eighth edition (2006) ISBN-81-203-3045-5
- [15] Klooster, John W. (2009). Icons of Invention: The Makers of the Modern World from Gutenberg to Gates. ABC-CLIO. pp. 399–400. ISBN 0313347433.
- [16] King Fahd University of Petroleum and Minerals Electrical Engineering Department (2006)AM Transmitter By:AhmadQutb Al-Deen, SalehNaser Al-Mutawa
- [17] Louis E. Frenzel Communication electronics (third edition 2009) ISBN 0-02804837-7 Laurence Gray and Richard Graham (1961). Radio Transmitters. McGraw-Hill. p. 141
- [18] "Lee De Forest as Early Radio Broadcaster" on De Forest.com website excerpted from Adams, Mike (1996). "The Race for the Radiotelephone: 1900-1920". The AWA Review (Antique Wireless Association) 10: 78–119.
- [19] Lee, Thomas H. (2004). Planar Microwave Engineering: A Practical Guide to Theory, Measurement, and Circuits, Vol. 1. Cambridge Univ. Press. p. 11. ISBN 0521835267.
- [20] Newkirk, David and Karl Quist, Rick (2004). Mixers, modulators and demodulators. In D. G. Reed (ed.), the ARRL Handbook for Radio Communications (81st ed.), pp. 15.1–15.36. Newington: ARRL. ISBN 0-87259-196-4.
- [21] Richter, William A. (2006). Radio: A Complete Guide to the Industry. Peter Lang. p. 12. ISBN 0820476331.
- [22] Roy Blake (2002) electronic communication system 2nd edition. Website
- [23] Robert M. Rector 2006. google search
- [24] Silver, Ward, ed. (2011). "Ch. 15 DSP and Software Radio Design". The ARRL Handbook for Radio Communications (Eighty-eighth Ed.). American Radio Relay League. ISBN 978-0-87259-096-0.

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- [25] Silver, Ward, ed. (2011). "Ch. 14 Transceivers". The ARRL Handbook for Radio Communications (Eighty-eighth Ed.). American Radio Relay League. ISBN 978-0-87259-096-0.
- [26] Sarkar, T. K.; Robert Mailloux; Arthur A. Oliner; M. Salazar-Palma; Dipak L. Sengupta (2006). History of Wireless. John Wiley & Sons. pp. 373–374. ISBN 0471783013.
- [27] "Superheterodyne Receivers". ES310: Introduction to Naval Weapons Engineering. Federation of American Scientists. 1998. Retrieved September 10, 2013.
- [28] Street, Sean (2002). A Concise History of British Radio, 1922-2002. Kelly Publications. pp. 17–24. ISBN 1903053145.
- [29] "The First Radio Broadcast". The Sydney Morning Herald (Sydney, Australia: Fairfax Media). March 29, 1939. p. 19. Retrieved 27 September 2013.
- [30] Greb 2003, Charles Herrold, Inventor of Radio Broadcasting, p. 155
- [31] "The process of combining two frequencies in a nonlinear device and producing new frequencies is called mixing, modulating, heterodyning, beating, or frequency conversion" Bureau of Naval Personnel (1973). Rate Training Manual 0087-C: Basic Electronics. Courier Dover Publications,. p. 338. ISBN 0486210766.
- [32] Verghese, George; HariBalakrishnan (2013). "Ch. 14: Modulation and Demodulation, p. 189,192". Lecture Notes - Introduction to EECS 2: Digital Communications Systems. Electrical Engineering Dept., Massachusetts Institute of Technology. Retrieved September 10, 2013