Design and Construction of a Simple but Efficient and Cost Effective Amplitude Modulated Transmitter Using Locally Available Materials

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ABSTRACT

This work is an exploration of the design foundation and construction of an AM Transmitter. An AM transmitter controls the transmitting and broadcasting of signals that supports information conveyance in the AM Bandwidth. A brief introduction of the concept of AM transmission is followed by detailed discussion of design and construction. The discussion is organized under the 5 stages of the AM transmitter unit, namely; Power supply, Audio Amplification, carrier wave oscillation, modulation, and the RF Power Amplification Stages.

Keywords: AM Transmitter, Audio Amplification, Modulation, Carrier, Demodulation, etc.1

1.0: INTRODUCTION

Modulation is the process by which voice, music and other "intelligence" is added to the radio waves produced by a transmitter. The different methods of modulating a radio signal are called modes. An unmodulated radio signal is known as "A Carrier" [1]. When you hear "dead air" between songs or announcements on radio station you are "hearing" the carrier. While a carrier contains no intelligence, you can tell it is being transmitted because of the way it quiets the background noise on your radio [2].

A device that performs modulation is known as a modulator and a device that performs the inverse operation of a modulator is known as a demodulator (sometimes detector or demodulator). A device that can do both operations is a modem. [1], [3]

In amplitude modulation, the strength (amplitude) of the carrier from a transmitter in varied according to how a modulating signal varies. [4].

When you speak into the microphone of an AM transmitter (broadcasting on a frequency between a frequency range of 530 to 1700 KHz), the microphone converts your voice into a varying voltage. This is used to vary the strength of the transmitters output. Amplitude modulation "adds power" to the carrier, with the amount added depending on the strength of the modulation voltage. [2]. Amplitude modulation results in three separate frequencies being transmitted:

- The original carrier frequency
- A lower sideband (LSB) below the carrier frequency

- And an Upper sideband (USB) above the carrier frequency. [4]

The side bands are "mirror images" of each other and contain the same intelligence. [5]. When an AM signal is received, these frequencies are combined to produce the sounds you hear. Each sideband occupies as much frequency space as the highest audio frequency being transmitted. If the highest audio frequency being transmitted is 5 KHz, then the total frequency space occupied by an AM signal will be 10 kHz (the carrier occupies negligible frequency space). [1], [3]

2.0: TYPES OF MODULATION

There are three (3) types of modulation, namely Amplitude modulation, frequency modulation and phase modulation also known as indirect frequency modulation. Amplitude Modulation is further explained below.

2.1.: AMPLITUDE MODULATION (AM)

In amplitude modulation (AM), the information signal is mixed with the carrier signal in such a way to cause the AMPLITUDE of the carrier to vary at the frequency of the information signal[4].

3.0: BACKGROUND REVIEW AM TRANSMITTER

AM was the dominant method of broadcasting during the first eighty years of the 20th century and remains widely used into the 21st century.

AM radio began with the first, experimental broadcast on Christmas Eve of 1906 by Canadian experimenter Reginald Fessenden, and was used for small-scale voice and music broadcasts up until world war I. San Francisco, California radio station KCBS claimed to be the direct descendant of KQW, founded by the radio experimenter Charles "Doc" Herrold, who made regular weekly broadcast in San Jose, California as early as June of 1909. On that basis KCBS has claimed to be the world's oldest broadcast station and celebrated its 100th anniversary in the summer of 2009. The great increase in the use of AM radio came late in the following decade as radio experimentation increased worldwide following World War 1. The first licensed commercial radio services began on AM in the 1920s. XWA of Montreal, Quebec (later CFCF, now CINW) claims status as the first commercial broadcaster in the world, with regular broadcasts commencing on May 20, 1920. The first licensed American radio station was started by Frank Conrad, KDKA in Pittsburgh, Pennsylvania. Radio programming boomed during the "Golden Age of Radio" (1920s-1950s) Dramas, comedy and all other forms of entertainment were produced, as well as broadcast of news and music. [6].

4.0 : DESIGN EXPLORATION AND CONSTRUCTION

This deals with the analysis of the circuit of AM transmitter and the generation of values for strategic mode voltage. Considering all the factors ranging from the amplitude modulation theory to the individual transmitter stages and the electronic component properties, it is now possible to have a look at the complete AM design. The

design covered includes diagrams and a brief explanation how it works (7)

4.1: RESEARCH DESIGN

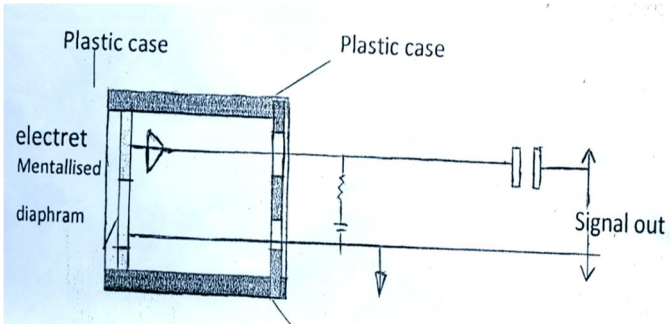
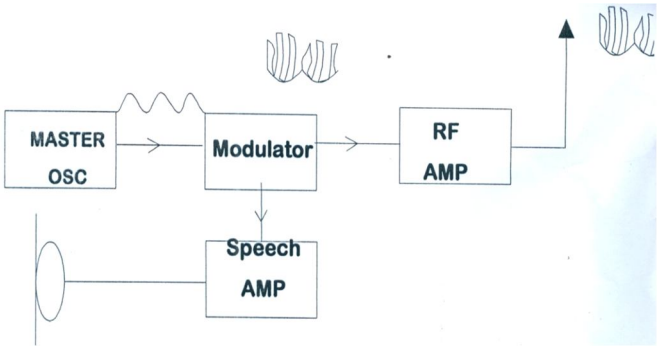


Fig.1: The Schematic diagram of an AM Transmitter

Foremost, the AM transmitter to be discussed was tested with a microphone as the input device.

4.2: THE MICROPHONE ELEMENT

Fig .2 The Microphone element.



The input can be a microphone or a programmed input (i.e. a DVD), but for space constraint, the microphone as an input device is chosen to be used for the discussion, for this project however a DVD player was also used as the input device. [8].

The AM transmitter constructed is made up of 5 stages, the first stage is;

4.3 : THE POWER SUPPLY STAGE.

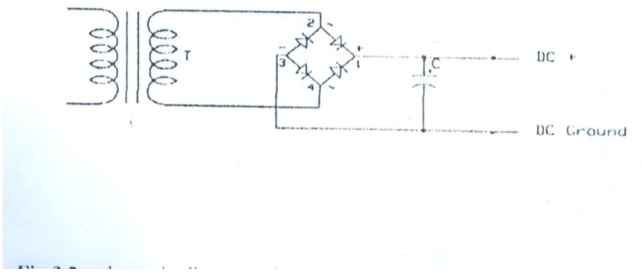


Fig.3 The Power Supply Sketch.

This stage comprises of a step down transformer which steps down power from 240VAC mains supply to 12VAC and thereafter rectifies and filters the resultant current such that it will be ripple free.

The ideal voltage input would have been a 9v battery, but due to high decrease in the voltage across the circuit (i.e. voltage drop) the power supply is sole, this implies that the device can only function with 220-240VAC 50Hz. For a constant operation of the device, It relies on utility power supply (PHCN) and standby power supply (Generator). In achieving the aim posited herein before, a step-down transformer of 12 volts rated was incorporated into the circuit to step down the mains voltage from 220VAC to 12 VAC. [5].

A 4 layer Diode (rectifier) D_1-D_4 IN 4001 was incorporated to act as bridge rectifiers (shown as D_1 in the circuit) converting the AC to DC voltage. Capacitor (electrolytic types) C_1 and C_2 were used to smooth (i.e. to filter the ripples) the DC which was fed into a voltage regulator IC which determines a 12 volts regulated voltage. The

resulting D.C voltage charges c_1 and C_2 to its r.m.s value such that the value of the DC voltage is given by [9]

$V_{dc} = V_{ac}$ (2 ½)

=12(2 ½) = 16.97 V_{dc}

[12] The essence of the regulated voltage is to reduce distortion which is generated by the AC power supply Diode D_2 is an LED (Light emitting diode) which was incorporated to signify when the supply voltage is in use.Also connected is a D_2 with series resistor R_1 (i.e. D_5 was limited with a series resistor R_1) across the regulated DC power supply R_1 acts as a current limiting resistor to D_2, the value is given by:

$R_t = V_S - V_d \div 1$ max

Where:

$V_s = V_{dc}$= 16.97 given

V_d = voltage drop by diode = 1.6v

1 max = Maximum load current of LED = 20mA

then Relay R'$_1$ coil is connected across the circuit output. This was done to enable the relay contact switch 'on' the 220volts of the utility power supply or standby power supply. The Diode D_2 is connected across the coil of the relay to prevent back emf flow into the circuit. The next stage is the audio amplifying stage. [10]

4.4: The Audio Amplifying Stage

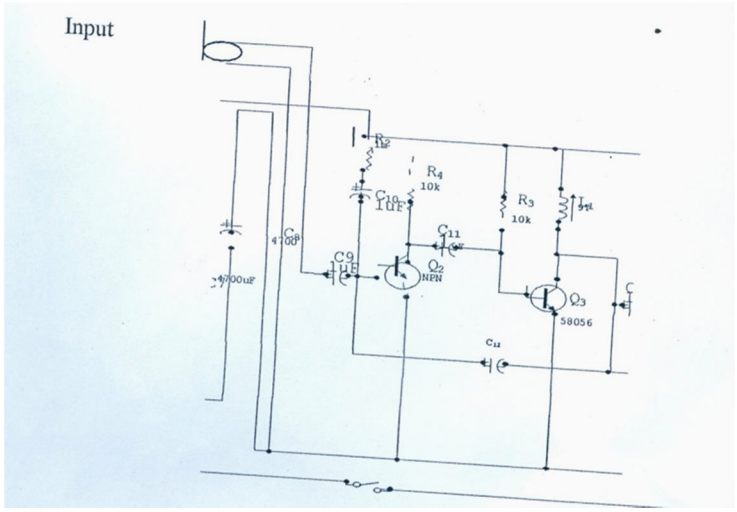


Fig 4. Audio Section of an AM Transmitter Circuit

The audio amplifier comprises of an input device (mic or programmed input) and 2 transistors Q_2 and Q_3. The programmed input is the input for the audio signal. The signal passes through capacitor C_9 to the transistor Q_2 and is amplified in the first stage by this transistor. The output passes through capacitor C_{11} and this is further amplified by transistor Q_5.

This amplifier is responsible for increasing the strength of audio signal. The audio signal is usually weak but comes out strengthened. [11]

Using

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

F_c =1 ÷ (2x3. 142x0.01x0.000181659)

F_c = 1 ÷ (0.000001141)

= 876,424

= 876 KHz

4..6: THE MODULATION NETWORK STAGE

It is here that the process of mixing the audio signal and the carrier wave goes on. This process is called modulation.A coupling capacitor C15 was used to send the modulated signal to the transistor Q5 to boost the amplitude of the signal. The modulator changes the strength of the radio waves to match the loudness of the music or voice we want to transmit.

4.7: RF POWER AMP OUTPUT STAGE

Here the amplifying transistor Q5 was used as a convertor of DC power to AC power, since the variation of collector current at the drive frequency provides an alternating component of voltage across the load impedance and thus provides output power.

The ratio of AC power produced to the DC power supplied is the conversion efficiency. It is usually desirable to operate with a maximum possible efficiency having regard to

The amount tolerable distortion of the wave form of the voltage being amplified. The R.F. amplification output follows the modulator stage of the transmitter.

The RF amplifier was used to push the modulated signal on air through the antenna. I monitored the sent signal via a radio receiver which I tuned to demodulate the height of the antenna.

5.0: CIRCUIT DESIGN CONSTRUCTION

The final circuit is an incorporation of all the individual circuits. A multi-tester is used to determine the polarities of the devices used. More so, it was of great importance to measure the voltage and resistance of some of the devices.

The circuit is built first on a bread board, before transferring to a final circuit board (i.e. Vero board).

9 resistors was used of varying resistance and 15 capacitors of varying voltage inductance and 5 transistors in the construction and design of the circuit. The components were properly connected and soldered.

5.1: ASSEMBLING

After completion and testing of the circuit . It was cased, taking openings for the power source, the antenna, and the points for the mic or programmed inputs into consideration. This assembling was done in order to ensure that all the stages worked together as a circuit.

5.2: DEVICE OPERATION

The electric charge travels up and down the wire antenna, causing radio waves to be emitted from the wire. These radio waves are picked up by the Am radio, amplified and used to make the speaker cone move back and forth creating sound.

On the transmitter, the sound source is connected to the transformer instead of to a

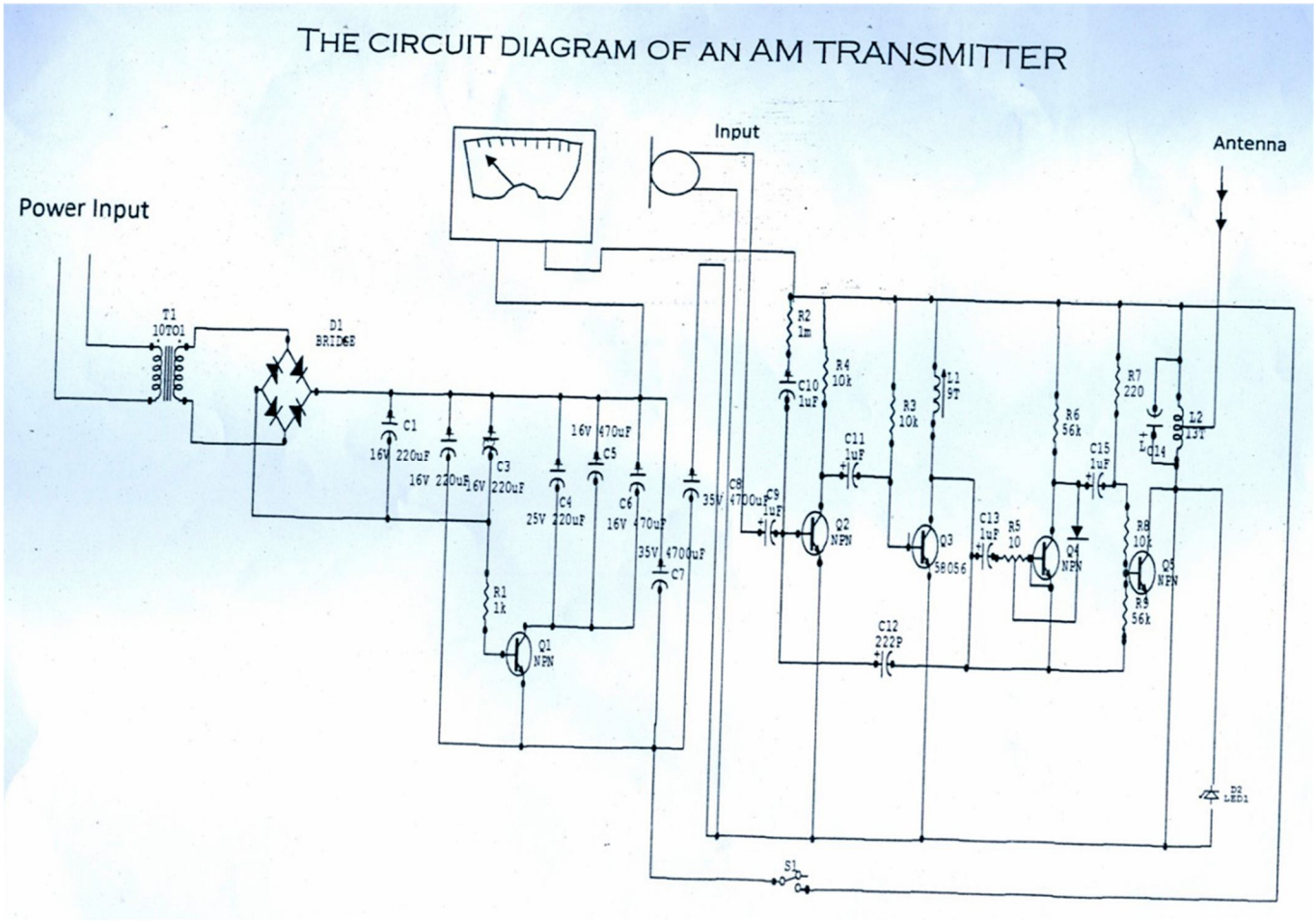


Fig 5; Circuit diagram of an AM Transmitter.

speaker. The transformer is connected to the power supply of the oscillator. The sound source causes the transformer to add and subtract power from the oscillator, just as it would have pushed and pulled on the speaker.

As the power to the oscillator goes up and down, the power of the electricity in the antenna goes up and down also. The voltage is no longer simply 12 volts. It is now varying between 0 volts and 13 volts, because the power from the transformer adds and subtracts from the power of the AC supply. The varying power in the antenna causes radio waves to be emitted. The radio waves follow the same curves as the waves in the antenna.

Since some of the little pushes are stronger than others they move the speaker in the receiver more than the weaker ones. We hear this variation as sound.

The sound is a faithful reproduction of the original sound wave at the transmitter

If the transmitter is plugged into the AC supply for a few minutes and held near an AM radio, turned to a frequency of about

876 KHz, you should hear the sound source in the AM radio. Adjust the volume controls on the sound source and on the AM radio to get the best sound.

CONCLUSION

A simple efficient and cost effective amplitude modulated transmitter has been designed and constructed using locally available materials.

The device has single power source for effective performance which makes use of a regulated 12volts dc supply.

It is a device that every broadcasting house, advertising agents, commercial and business associated body could use.

This device also has application in many kinds of commercial and private areas. The device is useful in information transmission in communication

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