Design, Construction and Testing of JP Low Cost Wireless Public Address System

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***Abstract*---** **It has become inevitable there would be communication and due to the extrinsic limitation of the human voice, the public address system came to being. A public address or "PA SYSTEM" is an electronic amplifying system with a mixer, amplifier and loudspeakers, used to strengthen a given sound, e.g. a person making a speech, pre-recorded music, and distributing the sound throughout a venue. The human voice or sound signal is passed through a microphone, which converts the sound energy to electrical energy, the electrical energy signal being transmitted is being received and amplified by the amplifier circuit. The amplifier's output is fed into the loudspeaker which converts the electrical energy back to the original form but in an amplified state. Based on the procedures adopted, and the tests carried out, the specific findings include a range of 100.2MHz of transmission from a 9V DC battery, and a clear sound produced from the microphone. The work indicated that the practical JP Low cost wireless public address system requiring a low power can be designed and constructed.**

Keywords: **Microphone, Electronic amplification system, Public address system, Receiver and Radio**

I. INTRODUCTION

A public address system (PA system) is an electronic system comprising microphones, amplifiers, loudspeakers, and related equipment. It increases the apparent volume (loudness) of a human voice, musical instrument, or other acoustic sound source or recorded sound or music. PA systems are used in any public venue that requires that an announcer, performer, etc. be sufficiently audible at a distance or over a large area. Typical applications include sports stadiums, public transportation vehicles and facilities, and live or recorded music venues and events. A PA system may include multiple microphones or other sound sources, a mixing console to combine and modify multiple sources, and multiple amplifiers and loudspeakers for louder volume or wider distribution. Simple PA systems are often used in small venues such as school auditoriums, churches, and small bars. PA systems with many speakers are widely used to make announcements in public, institutional and commercial buildings and locations—such as schools, stadiums, and passenger vessels and aircraft. Intercom systems, installed in many buildings, have both speakers throughout a building, and microphones in many rooms so occupants can respond to announcements. Public address system and Intercom systems are commonly used as part of an emergency communication system. The term sound reinforcement system generally means a PA system used specifically for live music or other performances.

A public address system allows you to broadcast information to a large group of people, whether you are giving a speech or playing live or recorded music. Public address systems typically consist of input sources, preamplifiers, control and monitoring equipment, and loudspeakers. Input sources refer to the microphones that provides a sound input for the system. These input sources are fed into the preamplifiers. The pre amplified signals are then passed into the audio power amplifiers. These amplifiers will amplify the audio signals to an adequate speaker line level. In view of the above, one can now say that the public address system is an electronic amplification system used for communication in public areas. Microphone is a device that converts sound waves into electrical waves. Sometimes colloquially called a micro mike is an acoustic-to-electric transducer or sensor that converts sound into an electrical signal. Microphones are used in many applications such as telephones, hearing aids, live and recorded audio engineering, in radio and television broadcasting and in computers for recording voice, and for non-acoustic purposes such as ultrasonic checking. The sensitive transducer element of a microphone is called its element. Since a wireless microphone is used in this project; a wireless microphone is one in which communication is not limited by a cable. A transmitter is extremely important equipment and is housed in the broadcasting station. Its purpose is to produce radio waves for transmission into space. The important components of a transmitter are microphone, audio amplifiers, oscillator and modulator. It usually sends its signal using a small FM radio transmitter to a nearby receiver connected to the sound system, but it can also use infrared light if the transmitter and receiver are within sign of each other. The transmitter is responsible for taking in the signal from the microphone, modulating it, and transmitting it to the receiver using radio waves.

II. MATERIALS AND METHOD

2.1 Materials

The components used in our design are easy to find and easy to implement. The circuit designing and implementing part can also be done using Copper Clad Board (CCB).

Transistor: $(2N3904)$

Resistors: $10k\ ohm, 27k\ ohm, 470\ ohm$

Microphone (Condenser Mic)

Capacitors: $22\mu f, 0.01\mu f\ (103), 10pf.$

9 Volts Power supply DC Battery, Bread board, Copper clad board (CCB), Soldering Iron, Soldering lead, F.M radio receiver, Multi-meter and Jumper Wires.

i. Microphone

Microphone is a transducer, which converts sound energy to electric energy. It consists of parallel plate capacitor which has one plate as fixed and other plate being movable. The movable plate is called diaphragm. When sound strikes diaphragm it starts moving, thus in turn changing capacitance of capacitor, which in turn results in flow of variable current.

ii. Transistor (2N3904)

Transistor 2N3904 is a medium gain general-purpose transistor. It is widely used for low power amplification. It has transition frequency of around 300 MHz with a minimum current gain of 100 Ampere.

2.2 Methods

The system is made up of the transmitter which is incorporated in the microphone; and the receiver unit, the tone control and mixer unit, the audio amplifier unit and the loudspeaker.

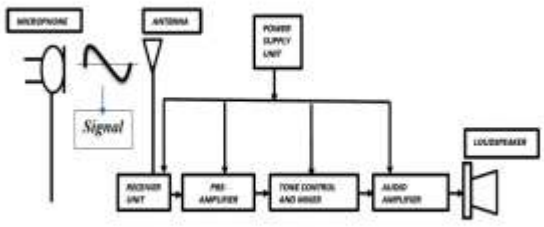

Figure 1: Block Diagram of Public Address System

Each of these sections is explained below:

i. Microphone

Microphone is a transducer, which converts sound energy to electric energy. It consists of parallel plate capacitor which has one plate as fixed and other plate being movable. The movable plate is called diaphragm. When sound strikes diaphragm it starts moving, thus in turn changing capacitance of capacitor, which in turn results in flow of variable current.

ii. Signal

A signal is an electrical or electromagnetic current that is used for carrying data from one device or network to another. It is the key component behind virtually all: Communication. Computing.

iii. Antenna

An antenna is a transducer that converts radio frequency (RF) fields into alternating current or vice versa. There are both receiving and transmission antennas for sending or receiving radio transmissions. Antennas play an important role in the operation of all radio equipment. They are used in wireless local area networks, mobile telephony and satellite communication. Antennas have an arrangement of metallic conductors with an electrical connection to receivers or transmitters. Current is forced through these conductors by radio transmitters to create alternating magnetic fields. These fields induce voltage at the antenna terminals, which are connected to the receiver input. In the far field, the oscillating magnetic field is coupled with a similar oscillating electric field, which defines electromagnetic waves capable of propagating the signal for long distances.

Radio waves are electromagnetic waves that carry signals through air at the speed of light without any transmission loss. Antennas can be Omni-directional, directional or arbitrary.

iv. Receiver Unit

In radio communications, a radio receiver, also known as a receiver, wireless or simply radio is an electronic device that receives radio waves and converts the information carried by them to a usable form. It is used with an antenna. The antenna intercepts radio waves (electromagnetic waves) and converts them to tiny alternating currents which are applied to the receiver, and the receiver extracts the desired information. The receiver uses electronic filters to separate the desired radio frequency signal from all the other signals picked up by the antenna, an electronic amplifier to increase the power of the signal for further processing, and finally recovers the desired information through demodulation.

v. Pre-Amplifier

A preamplifier (preamp or "pre") is an electronic amplifier that converts a weak electrical signal into an output signal strong enough to be noise-tolerant and strong enough for further processing, or for sending to a power amplifier and a loudspeaker. Without this, the final signal would be noisy or distorted. They are typically used to amplify signals from analog sensors such as microphones and pickups. Because of this, the preamplifier is often placed close to the sensor to reduce the effects of noise and interference.

vi. Tone Control and Mixer

Tone control is a type of equalization used to make specific pitches or "frequencies" in an audio signal softer or louder. It can be used in any audio system and it is able to boost or attenuate the audio spectral content at low, mid and high frequencies in the range of -16 to +16db. While **Mixer** is the process of combining multitrack recordings into a final mono, stereo or surround sound product. In the process

of combining the separate tracks, their relative levels (i.e. volumes) are adjusted and balanced and various processes such as equalization and compression are commonly applied to individual tracks, groups of tracks, and the overall mix. In stereo and surround sound mixing, the placement of the tracks within the stereo (or surround) field are adjusted and balanced.

vii. Audio Amplifier

An audio amplifier is an electronic device that increases the voltage, current, or power of a signal. Amplifiers are used in wireless communications and broadcasting, and in audio equipment of all kinds. They can be categorized as either weak-signal amplifiers or power amplifiers.

viii. Power Supply Unit

A power supply unit (or PSU) converts mains AC to low-voltage regulated DC power for the internal components of a computer. Modern personal computers universally use switched-mode power supplies.

ix. Loudspeaker

A loudspeaker (or speaker) is an electroacoustic transducer; a device which converts an electrical audio signal into a corresponding sound.

2.3 Construction and Materials Used

The materials used in testing the circuit are:

i. *Bread Board:* This is a platform you can use to build and test electronic circuits, usually without having to do any soldering. Certain parts of the breadboard are wired together so that electricity can flow from component to component in orderly rows.
ii. *Jumper Wires:* They are simply wires that have connector pins at each end, allowing them to be used to connect two points to each other without soldering. Jumper wires are typically used with breadboard, copper clad board (CCB) and other prototyping tools in order to make it easy to change a circuit as needed.
iii. *Battery:* This source dc supply is 9volts high watt battery.
iv. *Cutter:* This is to cut connecting wires and components to size.
v. Insulation Tape
vi. Complete Pliers Set
vii. Screw Driver
viii. *Digital Multi-meter:* This is a multi-purpose electrical measuring instrument use to test for various parameter in an electrical circuit.

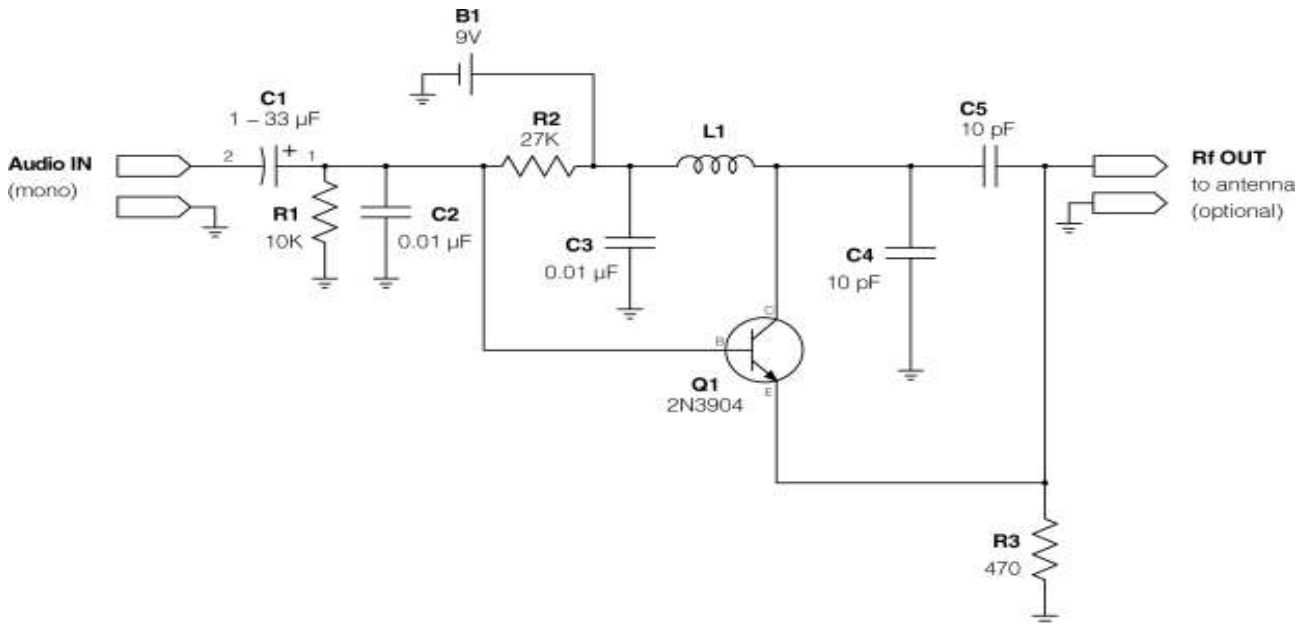

Figure 2: Overall Circuit Diagram

2.4 Description of Circuit

The circuit basically operates in 4 steps. Firstly, a condenser microphone takes input, the amplifier does amplification, the amplified signal is modulated with frequency being generated by LC oscillator and finally antenna transmits the signal. The inductor L1 and capacitor C3 forms an oscillating tank circuit along with the transistor 2N3904. As long as the current exits across the inductor coil L1 and the capacitor C3, the tank circuit will oscillate at the resonant carrier frequency for FM modulation. Where as Capacitor C4 acts as a negative feedback to the oscillating tank circuit. The modulated signal

from the antenna is radiated as radio waves at FM frequency band. Antenna is nothing but a simple copper wire of 30cm or more long.

2.5 Input Stage

Inside the microphone, a capacitive sensor diaphragm is present. It vibrates according to the air pressure changes and generates AC signals. The C3 and C2 can be thought of as a frequency-dependent resistor (called reactance). The Capacitor C2 separates microphone from transistor. Speech consists of different frequencies and the capacitor impedes them. The net effect is that C2 modulates the current going into the transistor. Using a large value for C2 reinforce bass (low frequencies) while smaller value boost treble (high frequencies).

2.6 Tank Circuit

The Inductor and capacitor together form an oscillating tank circuit or a resonant circuit oscillating at frequency given by,

$$f = \frac{1}{2\pi\sqrt{L \times C}}$$

Where, L & C are values of Inductor and Capacitor forming tank circuit respectively. Here L1 and C4 forms an oscillating tank circuit with frequency = 100.2 MHz

2.7 Design Calculation

i. Transmitter Distance (d)

From the Global Positioning System (GPS), using the fields Area measurement software, a total population distance of the transmission of $1.200km = 1200m$was obtained as the total range to be covered by the transmitter.

ii. *The required output power P_w of the wireless public address system.*

Using the formula $\mathrm{P}_w = \frac{\mathrm{E}^2 \times \mathrm{d}^2}{30}$

Where $E = 20\mu v = 20 \times 10^{-6} v, d = 1200m$

$$\therefore \textit{The distance } (d) \textit{ will be } 1200m$$

P_w = Public address system transmitted power

$$\mathrm{P}_w = \frac{(20 \times 10^{-6})^2 \times (1200)^2}{30}$$

$$\mathrm{P}_w = \frac{5.76 \times 10^{-4}}{30}$$

$$\therefore \mathrm{P}_{\boldsymbol{w}} = 1.92 \times 10^{-5}\ mw$$

When measuring a transmitter output, the measurements must be made in the far field, the power received per unit area from an isotropic antenna is calculated from the following equation.

$$\mathrm{P}_r = \frac{\mathrm{P}_w}{(4\pi d^2)}$$

Where P_r = received power

P_w = Public address system transmitted power

d = distance from public address system in meters

$$\mathrm{P}_w = 1.92 \times 10^{-5}\ mw, d = 1200m \textit{ and } \mathrm{P}_r = ?$$

$$\mathrm{P}_r = \frac{1.92 \times 10^{-5}}{(4\pi \times 1200^2)}$$

$$\mathrm{P}_r = \frac{1.92 \times 10^{-5}}{1.80 \times 10^7}$$

$$\therefore \mathrm{P}_r = 1.06 \times 10^{-12}\ mw$$

$\therefore 1.06 \times 10^{-12}\ mw$ is the received from the wireless public address system.

$$\mathrm{E}_{fs} = \frac{\sqrt{(30\mathrm{P}_w)}}{d}$$

where E_{fs} *is the field strength in* v/m,

P_w is the transmitted power from the wireless public address system and d is the distance from the wireless public address system in meters.

$$\mathrm{P}_w = 1.92 \times 10^{-5} mw, d = 1200m \textit{ and } \mathrm{E}_{fs} = ?$$

$$\mathrm{E}_{fs} = \frac{\sqrt{(30 \times 1.92 \times 10^{-5})}}{1200}$$

$$\mathrm{E}_{fs} = \frac{\sqrt{5.76 \times 10^{-4}}}{1200}$$

$$\therefore \mathrm{E}_{fs} = 2 \times 10^{-5}\ {}^{v}/_{m}$$

$\therefore 2 \times 10^{-5}\ {}^{v}/_{m}$ is the field strength in the wireless public address system.

The one stage circuit in figure 2 works from a $9V$ battery, its output frequency was measured to be $100.2MHz$. The final common emitter stage of this circuit, develops power in the tank circuit, which is transferred to the antenna, most of the power is developed in the coil, there are three ways to calculate this

$$\mathrm{P} = \frac{\mathrm{V}^2}{Z} \qquad (1)$$

$$P = VICos\theta \qquad (2)$$

$$\mathrm{P} = \mathrm{I}^2 V \qquad (3)$$

In the circuit, V_E (voltage emitter) was measured at $2V$ across the $470 - ohm$ emitter resistor.

As $\mathrm{I}_E = I_C$then collector current is:

$$\mathrm{I}_E = \frac{\mathrm{V}_E}{\mathrm{R}_E}$$

Where $\mathrm{V}_E = 2V$

$$R_E = 470\ ohm\ or\ 0.47k$$

$I_E = \frac{2\ V}{0.47\ K} = 4.255\ mA$

This value will be substituted for the ac collector current. The impedance of the tank circuit is now found. At resonance the impedance is given by the following equation, where R is the DC (Direct Current) resistance of the coil in the tank circuit. R(resistor) was measured at 0.1 ohm.

$$Z = \frac{L}{CR}$$

Where, C is capacitor, R is resistor and L is inductor

$L = 0.15\mu H = 0.15 \times 10^{-6} H$

$C = 10 \times 10^{-12}, R = 0.1$ ohm

$$Z = \frac{0.15 \times 10^{-6}}{10 \times 10^{-12} \times 0.1}$$

$$Z = \frac{0.15 \times 10^{-6}}{1 \times 10^{-12}}$$

$$\therefore Z = 150k$$

III. RESULTS

The outcome of this research gave rise to a wireless public address system equipment with a robust search and discover capabilities in terms of radio transmission. Figure3. Shows the picture of the device.

Figure 3: JP Low Cost Wireless Public Address System.

3.1 Testing

The implemented circuit is further tested. To test the transmitter, the tank circuit is tuned properly so that frequency generated can be easily modulated with message signal. Now, both the JP wireless public address system and receiver are switched on. The receiver is tuned to 100.2 MHz and voice signal is being transmitted. Instantly the voice signal is heard clearly at the receiver. Furthermore, to check the range of transmitter, a constant voice signal is applied or a music signal can also be applied as well at input and receiver is moved away from the JP wireless public address system slowly. As distance increased, the impact of noise started dominating our message signal. Also, as our JP wireless public address system is producing a low power signal, output can be obtained clearly in a radius of 100m effectively.

IV. CONCLUSION

Conclusively, from this research work which is aimed at modulating frequency with the aid of a transmitter, we were able to transmit a human voice and also from a phone and laptop after going through several tests. The human voice transmitted, was received at output on 100.2 MHz with a low power output and with an antenna at 10 meters above the ground was able to transmit to a distance of 1200 meters, provided conditions are favorable for wireless transmission. This shows that locally designing, construction and packaging of JP wireless public address system requiring low power input can be carried out successfully.

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