

CONSTRUCTION OF A LOW-POWER RATING FM TRANSMITTER RADIO WITH AUDIO CONSOLE FOR COMMUNITY BROADCAST AND SECURITY ALERT

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Abstract—The security challenges experienced in different communities of Nigeria require initiatives from every stakeholder, hence the development of this miniaturized FM transmission console for information dissemination within a localized community. The early transmitter for radio broadcasting was so bulky and laborious that they occupied large space and heavy circuitry. The circuits were mainly designed with valves and other active components, which are responsible for the large size. With the advent of semiconductor materials such as transistors and integrated circuits, electronic equipments are now becoming miniaturized such that small transmitters are now becoming handy and compact. In line with this, a complete radio broadcasting equipment that is compact and locally designed is constructed in this research. The system units are of two categories namely: the audio console for processing voice with music mixer and the transmitter unit where the center frequency is generated. This project is aimed at serving community such as Estates or villages for broadcasting urgent information using a small radio broadcasting FM transmitting at 107.0 MHz with a power rating of 1 watt and covers a distance of 1 kilometer irrespective of directivity. The output audio signal was tested for different hours of the day and production was received with noticeable voice output. The radio broadcasting transmitter can also be used to disseminate information within large industries, hospitals and

universities. The constructed device is recommended for security alerts in areas where security challenges are currently taking place in the Nigeria.

Keywords—Transmitter, audio console, modulator;

I. INTRODUCTION

Communication is the system of exchanging information in form of voice, images, writings, video and the likes, over a space from one place to another. The information exchanged is termed signal during the transmission procedure. Through this process, humans have expressed their feelings, thoughts and ideas to one another. It is therefore a way for people to understand and convey messages through medium space [1],[2]. Communication can be grouped as either verbal or nonverbal. Saying verbal, we mean to say the information is expressed through the spoken word, which is the easier way to relay the information. Nonverbal classification involves facial expression, writing, and hand gestures; humans have developed signs and symbols in communicating this way [3], [10]. At large scale, verbal means of communication is prevalent since the ideas are easily relayed while the nonverbal way requires signs and symbols assigned by the sender and the receiver. It is however suggested that both the sender and the receiver of the information must understand the symbols they assigned, else the process becomes void and the objective is defeated.

In the time past, humans use face-to-face conversation as the primary way of relaying their ideas and thoughts. As time progresses, they realized this type of communication is difficult to attain with distance[7], [8],[13]. As the gap between the sender and receiver increases, the process of expressing the information becomes totally difficult. Since verbal communication over long distance is almost unattainable, people learned to use non-verbal languages through the use of letters, symbols and figures[5][6]. With this development, the limitation of distance is extended to a few kilometers. However, the need for satisfactory communication over much longer distances in several miles arises when people from different nations across the globe tend to connect with each other. The world of communications took a big leap in the late nineteenth century when electricity was discovered. From that time, communications become highly developed, making conversation over long distances very possible. Thus electronic communication is the transmission, reception, and processing of information between two or more locations with the use of electronic circuits. The basic components of electronic communication system are the transmitter, communication channel or medium, receiver, and noise. Analog signals (such as human voice) or digital signals (binary data) are inputted into the system, processed in the electronic circuits for transmission, and then decoded by the receiver. The system is said to be reliable and effective only when errors are minimized in the process [4].

II. DESIGN ANALYSIS

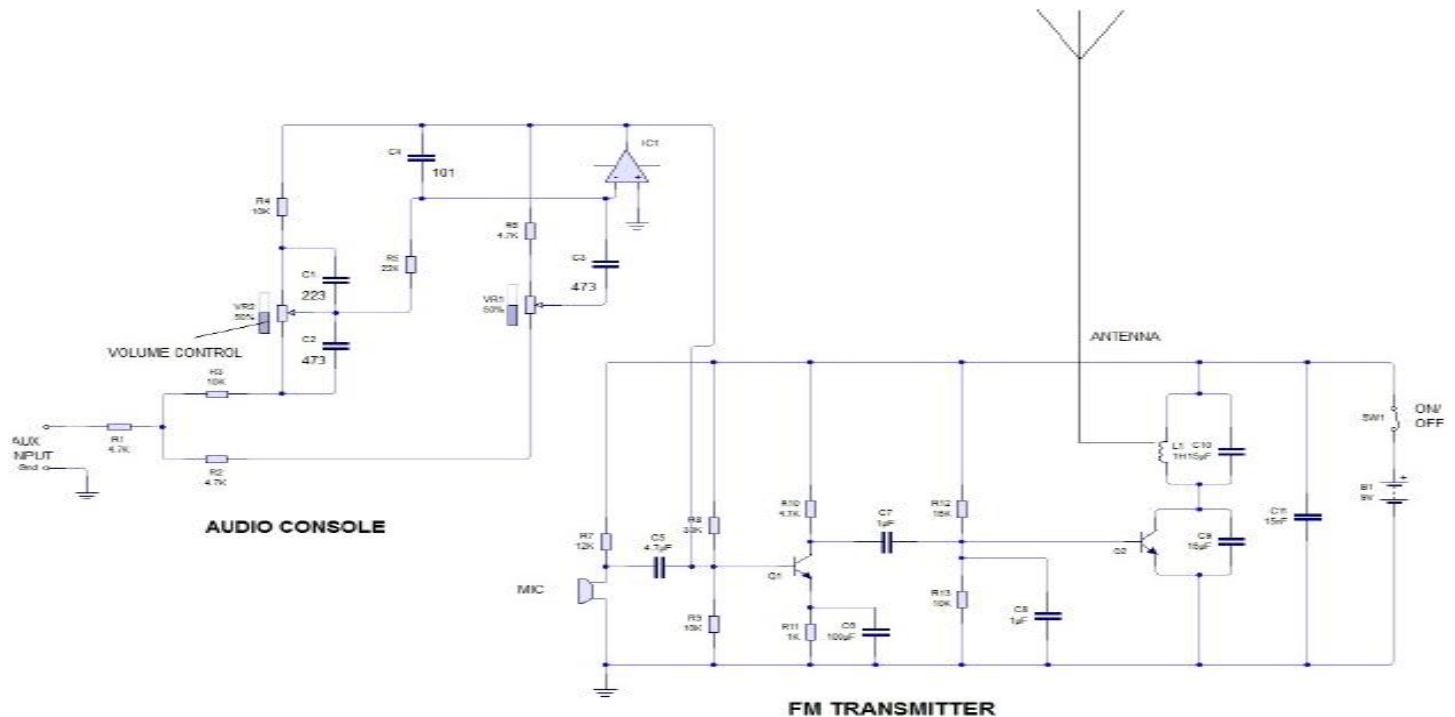


Figure 1 Schematic diagram of operation of audio console

A. The operation of the Audio Console

Figure 1 shows the audio console has two input jack the mic and the auxiliary respectively. The variable resistor 100k (vri) is capable of balancing or setting the gain of the two inputs. When Vri is set to allow more mic input, more mic input will be sent to the pro-amp stage or only mic input if auxiliary is not allowed at all and vice versa. The auxiliary input could be a tape recorder, when all of the input is selected equally both are sent to the pre-amp and Via the power Amp. The output of the power Amp is sent to the transmitter. The method allows transmission of the human voice with little or no background music and also a transmission of music or both at the same time without interference. This is an advancement in the common FM microphone and portable transmitter which is currently in use.

B. Broadcast Frequency Modulation

Standard broadcast FM uses a 200 khz bandwidth for each station. The maximum allowed deviation around the carrier is $\pm 75\%$ and 25khz guard bands at the upper and lower ends are also provided. The carrier is required to maintain $\pm 2\text{khz}$ stability. An infinite number of side frequencies are generated during frequency modulation but their amplitude gradually decreases as you move away from the carrier. In other words, the significant side frequencies exist up to $\pm 75\text{khz}$ around the carrier and the guard bands ensure that the adjacent channel interference will not be a problem.[15]

Since full deviation is 75 khz, that is 100% modulation. By definition, 100% modulation in FM is when the deviation is the full permissible amount. recall that modulation index mf is $M_f = \text{deviation} / \text{intelligence signal}$ So that the actual modulation index at 100% varies inversely with the intelligence frequency.

C. Tuned Circuit Calculation

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

Where; F= carrier frequency n=107MHz, $\pi = 3.142$, L = Inductance of inductor in the tuned circuit, C= Capacitance of the capacitor in the tuned circuit = 30 pf,

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

$$LC = \left(\frac{1}{2\pi F}\right)^2$$

$$L = \frac{\left(\frac{1}{2\pi F}\right)^2}{C}$$

$$L = \frac{\left(\frac{1}{2 \times 3.142 \times 107 \times 10^6}\right)^2}{30 \times 10^{-12}}$$

$$L = 0.0737H$$

D. Power Density

The power density (in watt per square meter) at wave front is inversely proportional to the square of the distance, r (in meters) from its source, with respect to the originally transmitted power pt stated mathematically;

$$\frac{P_t}{4\pi r^2} \quad (3)$$

Where; Transmitter power = 1 watt, = 3.142, r = 100m radius
power density = 7.95×10^{-6}

E. Characteristics Impedance

The strength of the electric field ϵ (in volts per meter) at a distance r from a point source is given by

$$\epsilon = \sqrt{30 P_t / r} \quad (4)$$

where P_t is the original transmitted power in watts

$$\epsilon = 0.52$$

F. Mic input calculation

Current input to the mic = $\frac{9V}{12k\Omega}$, 47 μ f is input capacitor

$$\text{Input impedance } X_c = \frac{1}{2\pi f c} \quad (5)$$

$$\frac{1}{2\pi \times 20 \times 10^3 \times 47 \times 10^{-6}} = 0.169$$

G. Preamplifier stage

The base resistors are used as voltage dividers, Input voltage = 9v, R4 and R3 are in series

I through R4 and R3

$$= \frac{V}{R_3 + R_4} \quad (6)$$

$$\frac{9}{33k + 10k}$$

$$I = 2.0930 \times 10^{-4}$$

Voltage at the base of Q1

$$I \times R_3 = \frac{V}{R_3 + R_4} \times R_3$$

$$\frac{9}{33k + 10k} \times 10k$$

$$= 2.0930 \times 10^{-4} \times 10^4$$

$$= 2.0930V$$

Capacitor C_5 is used to connect the transistor Q_1 to ground at signal frequency. Its impedance at low signal level is X_c at

$$20H_z = \frac{1}{2\pi f c}$$

$$= \frac{1}{2\pi \times 20 \times 100 \times 10^{-6}}$$

$$X_c \text{ at } 20 \times 10^3 = \frac{1}{2\pi f c}$$

$$= 7.96\Omega$$

R3 and R6 are use to bias the transistor Qz

R3 = 4.7k, R6 = 1k Ω

For transistor Q1

$$I_c/I_b = h_{fc}$$

I_c is collector current, I_b is base current, h_{fc} is gain of the transistor at maximum input signal = $I_c/I_b \approx$

200 for s9014 transistor at maximum input signal

Vemitter is $V_b - 0.6V$ for silicon transistor

$$V_b = \frac{V}{R_3 + R_6} \times R_3 \quad (7)$$

$$= 9 \times 10^{-3} V$$

$$V_c = \frac{V}{R_3 + R_6} \times R_3 - 0.6V$$

$$= 0.591$$

$$I_c = \frac{V_c}{R_c} = \frac{R_c}{1k\Omega} = \frac{V_c}{1 \times 10^3}$$

$$= 5.91 \times 10^{-4} mA$$

$$I_e \approx I_c$$

Voltage at the collector of Q1 is $I_c \times R_c = I_c \times 4.7k\Omega$

This voltage is the DC bias setting of the transistor Q1 at no signal input

C1 is a coupling capacitor

Impedance is given as $1/2\pi f c$

$$\frac{1}{2\pi \times 1 \times 10^{-6} \times 20} \text{ to } \frac{1}{2\pi \times 1 \times 10^{-6} \times 20 \times 10^3}$$

$$= 7.96 \text{ohms}$$

2.8 Modulator stage design

R7 and R8 are use to bias the base of transistor Q2 ,R7 and R8 are in series

$$\text{Current I through R7 and R8} = \frac{V}{R_7 + R_8} = \frac{9}{15 \times 10^3 + 10 \times 10^3}$$

$$= 3.6 \times 10^{-4}$$

DC voltage applied to the base is given by

$$\frac{V}{R_7 + R_8} \times R_8$$

$$= \frac{7}{15 \times 10^3 + 10 \times 10^3} \times 10 \times 10^3$$

$$= 3.6$$

Capacitor C6 is use to ground the input stage of the transistor Q2 for input signal

$$\text{Its impedance is } \frac{1}{2\pi f c}$$

$$\frac{1}{2\pi \times 20 \times 10^{-6} \times 20} \text{ to } \frac{1}{2\pi \times 20 \times 10^{-6} \times 20 \times 10^{-3}}$$

$$= 3.97 \times 10^5 \text{ohms}$$

C8 is use to filter any form of noise signal on the power supply

C8 = 15µf recommended

III. CONSTRUCTION

The construction implies the physical implementation of the designed paper work. It was carried out with the electrical connections of all the components in their respective units of the design to achieve desired output. The first step involved the layout of the calculated values of all the associated components. Then the layout was constructed on the bread board. This has the advantage of components to be fixed in and removed at will without any damage to the circuit. At this point extreme care was taken not to break the terminals of the components employed since there was this tendency for fixing and removing them in order to sit the made design and more importantly achieve the design output. Connecting wires were used to interconnect the components where necessary. The circuit was then transferred to the Vero-board for permanent soldering as shown in figure 2 and figure 3.

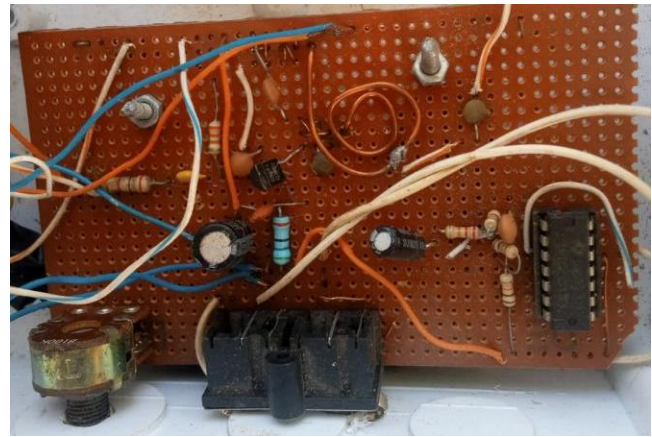


Figure 2: Veroboard connection of audio console



Figure 3: Internal layout of the Constructed audio console

The wiring involved joining components with aid of an electric soldering iron.. The construction started from the power supply unit where a 9 Volts dc battery was used, to the transmitting antenna unit of stainless foldable FM antenna and to the casing as shown in figure 4. During soldering, care was taken to avoid dry joint by ensuring that the soldering iron was hot enough and that the components were properly cleaned before soldering.



Figure 4: Complete outlook of the audio console

IV. CONCLUSION

The designing aim to transmit standard FM signal at frequency of 107.0MHz standard broadcast

FM uses 200kHz bandwidth for each station was successful and the only limitation is the transmitter power of 1 watt. This will limit the range of the transmitted signal. This miniature transmitter is easy to construct and its transmissions can be picked up with FM radio transistor. It has a range of up to 1000 meters radius or more depending on the line-of-sight, obstructions by large buildings and vegetation.. It could be used for room monitoring, nature research, conferencing lecture hall, intra- community broadcasting and for students of mass communication department as a practicing device.

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