WIRELESS HEARING ASSISTANCE

Mini Project Report

Submitted by

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Bonafide Certificate

This is to certify that the mini project report entitled **"Wireless Hearing Assistance"** submitted by Ananya Sasikumar (JYANEEC008), Jayasree P R (JYANEEC047), Keerthana K (JYANEEC060) and Kironraj O P (JYANEEC062) in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Electronics and Communication Engineering is a bonafide record of the work carried out under our guidance and supervision at Jyothi Engineering College, Thrissur.

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Abstract

The aim of the project is to develop a wireless hearing assistance to be used in specialized applications. It can be used for speech understanding, to differentiate important speech (such as a teacher's voice in a classroom), and for communication in cars and auditoriums, etc. The basic principle behind the circuit is frequency modulation. Frequency modulation (FM) has several advantages over amplitude modulation (AM), which is used in an alternate form of radio broadcasting. The most important of these advantages are:

- The system has greater freedom from interference and is static-free.
- FM broadcasts operate in the upper VHF and UHF frequency ranges, where there is less noise than in the MF and HF ranges occupied by AM broadcasts.
- Due to guard bands between commercial FM stations, there is less adjacent-channel interference than in AM.
- In FM, all the transmitted power is useful, whereas in AM most of the power is carrier power, which does not contain any information.
- Greater transmission efficiency.
- In wireless or radio communication, a message is transmitted through open space by EM waves called radio waves. An FM transmitter radiates a modulated carrier signal. The transmitter converts the message signal into a form suitable for transmission over the channel. In FM modulation, this is achieved by varying the frequency of the carrier wave in accordance with the message signal.

The circuit of the FM transmitter is simple and has a range of 30 m to 100 m. Commercial FM radio stations are assigned frequencies between 88 and 108 MHz, which is the range used for transmission. It is a portable audio transmitter that can be used to transmit FM waves so that the signal can easily be picked up on a mobile phone, radio, etc. It is very small, approximately the size of a 9 V battery. The circuit works on the principle of frequency modulation to transmit audio signals captured by the microphone. It uses a BC548 transistor to amplify the signal and then frequency-modulate it. Being tiny and powered by just 9 V, the transmitter circuit can thus be used as a hearing aid.

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1. Introduction

The wireless hearing assistance is basically an FM transmitter. An FM transmitter transmits the audio signal on a carrier wave by frequency modulation. It is a low-power radio transmitter that broadcasts a signal from a portable device to a standard FM radio. The signal is transmitted over an FM broadcast frequency band so that it can be picked up by any nearby radio. This allows the portable device to make use of louder and better sound quality for various applications in everyday life, without using a wired connection. Being low-powered, this transmitter typically has a short range of 30–100 meters, depending on the quality of the antenna, receiver, obstructions, and elevation.

FM transmission is done through the process of audio pre-amplification. The audio wave is then modulated and transmitted by the antenna. After that, the transmitted signal is received by the receiver (radio) and demodulated to hear the audio. These signals lie in the range of 88 to 108 MHz.

An FM system is a wireless system designed to help someone identify and understand speech in noisy situations and over distances of up to 30 meters (100 feet). Some FM systems work together with hearing aids, while others are designed for those with normal hearing.

It works like this: the person speaking wears or holds a transmitter microphone (or places it in the middle of the group). This transmitter picks up important speech sounds and uses harmless radio waves to send them to one or more FM receivers, which a child wears behind the ear (for example, connected to their hearing aid).

The child hears the speaker's words directly in their ears, without any distracting background noise, allowing them to enjoy and participate fully in every conversation.

1.1 Advantages

- The circuit is small and can be easily used.
- The circuit can be easily constructed at low price.
- It has noiseless reception.
- Operating range is quite large.
- It is less affected by buildings and can be received indoors.
- The efficiency of transmission is very high.
- Waves at higher frequency can carry more data than waves at lower fre-

quency.
- Smaller geographical interference between neighboring stations.

1.2 Applications

- FM transmitters are commonly used to broadcast a stationary audio source.
- It can also be used as a simple cordless mike for educational institutions.
- It can be used for commercial and non-commercial broadcasting.
- It is also used in homes for parental control and care of babies.
- Used in private security services and field work for communication.
- Can also be used for spying purposes.
- It is useful as a simple cordless mike.

1.3 Objective

- To understand the basic concept of wireless communication.
- To implement a wireless hearing assistance.
- To enhance practical skills such as soldering, PCB implementation and circuit testing.

2. Literature Survey

Wireless hearing aids make use of FM modulation, one of the angle modulation techniques. This modulation technique is so common nowadays that it can be found in any commercial radio. Several projects and research efforts have been carried out on this topic since its introduction in 1931.

Due to the rapid development of integrated circuits (ICs), most FM transmitters and receivers today are constructed and designed using modulator and demodulator IC chips. The use of ganged inductors and capacitors can also be found in modern radio sets.

Several projects have been carried out on hearing aids using FM modulation. A few of them are described below.

2.1 Hearing Aid Using IR Audio Link

A typical IR communication system includes an infrared source, such as infrared lasers and LEDs, with specific wavelengths. The transmission medium used for IR communication is vacuum, atmosphere, and optical fibers. In IR communication, the IR rays are detected using photo diodes or photo transistors. The output signal from these detectors is very small and is not able to drive the speakers directly; hence amplifiers are used to amplify the signal so that it can drive the speakers.

Disadvantages

- The transmission using infrared rays is of short range.
- It can only be used for line-of-sight communication.
- IR signals get interfered with by other IR sources.

2.2 Hearing Aid Circuit

This hearing aid circuit project, or small listen booster, performs a simple function similar to that of a common audio amplifier. The design starts with a preamplifier circuit to increase the volume from the microphone that receives the audio signals. A power amplifier is then used to boost the signal further before it drives the headphone.

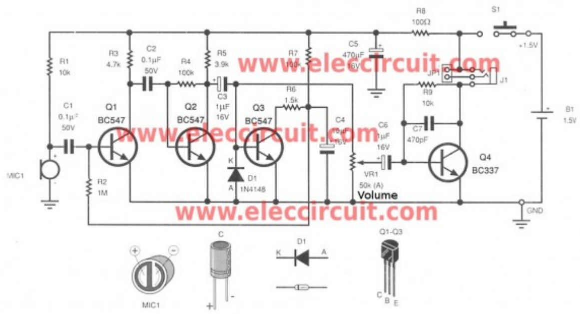


Figure 2.1: Hearing aid circuit

The number of transistors used in this circuit is large, and hence the circuit becomes complex when compared to our single-transistor circuit.

2.3 Inductive Hearing Aid

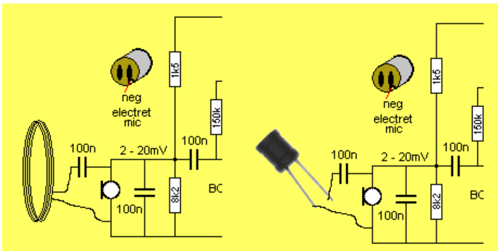


Figure 2.2: Inductive hearing aid circuit

An inductive hearing aid has a coil connected to the front end of the amplifier in place of a microphone. This coil picks up electromagnetic radiation, similar to a radio transmission but at a much lower frequency.

Disadvantages

1. The transmitting range for an audio loop is very short compared to RF transmission.
2. Even though the energy is electromagnetic radiation, it is at a very low frequency and the signal carries very little energy.
3. In most cases, the receiver (the hearing aid) must be situated within the loop or a very short distance away.
4. The transmitting and receiving coils must be in the same plane to achieve the greatest range.
5. The transmitting coil requires at least 50 turns for better transmission [3].

The circuits mentioned above have several disadvantages. Our aim was to develop a portable wireless hearing assistance of the size of a 9 V battery. The simple FM transmitter circuit used here reduces the complexity of the above circuits while still providing the same transmission range with good noise clarity. In the circuit, a single transistor forms the heart of the modulator; capacitors and handmade inductors are used to generate the carrier frequency. This portable transmitter becomes very useful when the power supply to a hall goes off during a speech – even in the absence of a working public-address speaker, the audience can listen to the speech by tuning a radio on their mobile phones. It can also be used in cars and auditoriums (along with a receiver). The mini transmitter and receiver, when connected to a cradle, can help in taking care of babies. This is an enormous advantage for a deaf person, as the volume level in a church or meeting place is often quite low compared to someone talking directly to them. The compact size, low cost and easy implementation make our wireless hearing transmitter unique.

3. Proposed Methodology

The main aim of the project is to provide hearing assistance for children. Many children who wear hearing aids still have difficulty hearing and understanding a parent's or teacher's words when there is a lot of background noise or the distance is large. This communication challenge also applies to many normal-hearing children who suffer from concentration-related disorders such as Attention Deficit Hyperactivity Disorder (ADHD) or Auditory Processing Disorder. Children often get frustrated because they cannot always understand speech. They struggle to engage with groups of family and friends, or find it difficult to follow conversations in noisy classrooms.

Wireless Hearing Assistance works on the basic principle of FM modulation. The circuit used here helps in improving communication. Group activities and mealtimes pose a real challenge for children with hearing loss or attention-related problems, due to the complex mix of chatter, background noise, tabletop bangs, and clinking cutlery and glasses. An FM system cuts out this distracting noise, helping a child identify and respond to what is being said. A personal FM system can improve a child's ability to communicate normally by cutting through distracting noise from group activities and overcoming the effects of distance on speech understanding.

3.1 Overcoming Challenging Situations

Children with more severe hearing loss can often only understand speech if they can also lip-read at the same time. An FM system "bridges the gap," bringing speech sounds directly into the child's ears and helping out when lip reading is not possible. Children with hearing issues find it easier to respond to a coach's instructions when they can hear these commands directly, wherever they are on the field of play.

FM transmitters plug straight into any multimedia device's audio-out jack, letting a child hear sounds such as TV programmes, MP3s, video games, and educational software via their FM receivers, without needing to turn up the volume.

Children often struggle to hear and understand conversation during car journeys due to the high background noise level. With FM, the difference is remarkable – often turning a previously unhappy child into a serene and responsive traveler.

When the noise level increases, students with hearing loss or attention issues often struggle to differentiate important speech sounds – such as the teacher's voice – from the surrounding noise. In these situations, FM technology is a real advantage, as it helps students better hear and respond to the teacher's directions, improving their performance as a result.

FM technology can transmit crystal-clear speech sounds over distances of up to 30 m, meaning teachers no longer need to raise their voices to be heard and understood. Students with more severe hearing loss often lip-read in order to understand what the teacher is saying; with a personal FM system, such speech clues are no longer required – the student can hear and understand the teacher regardless of which direction they are facing.

3.2 Block Diagram

In wireless or radio communication, a message is transmitted through open space by EM waves called radio waves. An FM transmitter radiates a modulated carrier signal. The transmitter converts the message signal into a form suitable for transmission over the channel. In FM modulation, this modification is achieved by varying the frequency of the carrier wave in accordance with the message signal.

Figure 3.1: Block diagram of proposed circuit

3.2.1 Microphone

Figure 3.2: Condenser mike

The microphone captures audio signals as electrical signals. The mechanical vibrations are converted into electrical signals, but their amplitude is not enough to drive a speaker directly.

3.2.2 Modulator

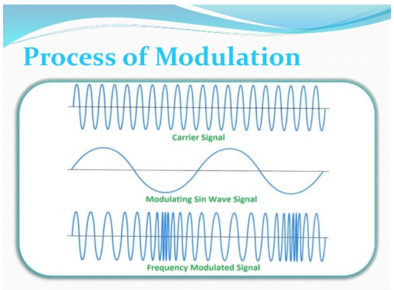


Figure 3.3: Inductor and trimmer capacitor

The modulator modifies the signal into a form suitable for transmission over the channel. Modulation may be defined as the process by which some characteristic of a signal, called the carrier, is varied in accordance with the instantaneous value of another signal, called the modulating signal. Signals containing information or intelligence are referred to as the modulating signal; this information-bearing signal is also called the baseband signal. The carrier frequency is greater than the modulating frequency. The signal resulting from the process of modulation is called the modulated signal.

Modulation is basically of two types:

- Continuous Wave Modulation
- Pulse Modulation

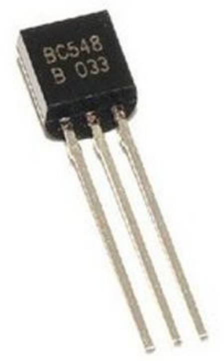


Figure 3.4: FM modulation

3.2.2.1 Frequency Modulation

Frequency modulation is a continuous-wave modulation technique. It is a type of angle modulation in which the instantaneous frequency is varied linearly with a message or baseband signal about an unmodulated carrier frequency. In FM, the frequency deviation is proportional only to the amplitude of the message signal, regardless of its own frequency.

Need for modulation / benefits of modulation

1. **Practicality of the antenna.** In the modulation process, the low-frequency audio signal at a radio station is translated to a higher-frequency spectrum, i.e., the radio-frequency range. These higher radio frequencies, having a small wavelength, act as a carrier for the audio frequencies (the modulating signal). Thus the required antenna height is much reduced and becomes practical.
2. **To remove interference.** If audio signals from different stations were transmitted over the same range of 20 Hz to 20 kHz, the programmes would get mixed up. To avoid this, each station is allocated a band of frequencies to keep the various signals separate. This also overcomes the drawback of poor radiation efficiency at low frequency.
3. **Reduction of noise.** With the help of several modulation schemes, the effect of noise can be minimised [4].

3.2.3 Amplifier

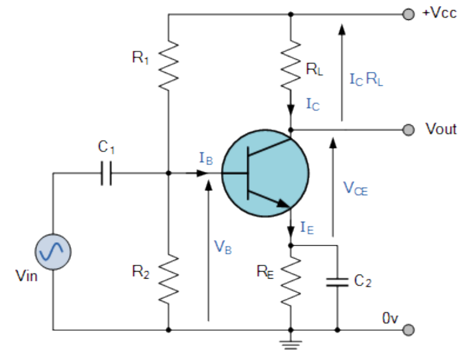


Figure 3.5: BC548 transistor

The signal is amplified before being connected to the speaker. This circuit is based around the BC548, an NPN transistor. After the modulation process, the generated FM signal is attenuated; hence amplification of the signal is necessary.

BC548 is a general-purpose silicon NPN bipolar junction transistor used for amplification and switching purposes. Its current gain may vary between 110 and 800, with a maximum DC current gain of 800. Its equivalent transistors are 2N3904 and 2SC1815, although these have different lead assignments. The variants of BC548 – 548A, 548B and 548C – differ in current gain range and other characteristics.

The transistor terminals require a fixed DC voltage to operate in the desired region of their characteristic curves; this is known as biasing. For amplification applications, the transistor is biased such that it is partly on for all input conditions – the input signal at the base is amplified and taken at the emitter. BC548 is used in a common-emitter configuration for amplifiers [5].

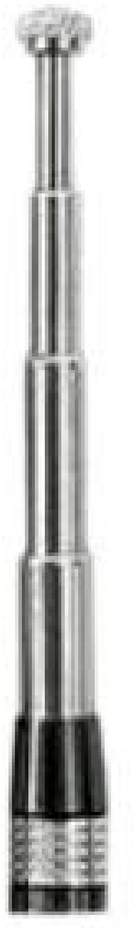


Figure 3.6: Common emitter amplifier

The single-stage common-emitter amplifier circuit shown above uses what is commonly called "voltage divider biasing." This biasing arrangement uses two resistors as a potential-divider network across the supply, with their center point supplying the required base bias voltage to the transistor. Voltage-divider biasing is commonly used in the design of bipolar-transistor amplifier circuits.

3.2.4 Antenna

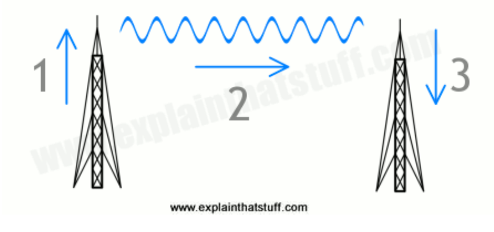


Figure 3.7: Antenna

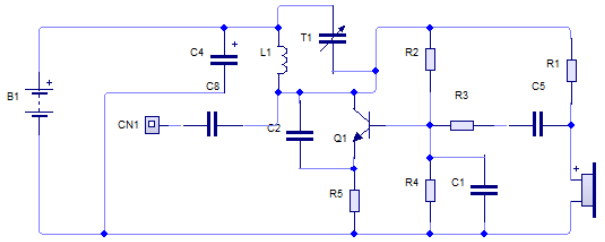


Figure 3.8: Antenna transmission

In wireless or radio communication, a message is transmitted through open space by electromagnetic waves called radio waves. Radio waves are radiated from the transmitter into open space through a device called an antenna. An antenna (aerial) is considered a region of transition between a transmission line and space. Antennas radiate, couple, concentrate and direct electromagnetic energy in the desired direction. An antenna may be isotropic (also called omni-directional) or anisotropic (directional). While choosing an antenna, many electrical, mechanical and structural aspects must be taken into account, including radiation pattern, gain, efficiency, impedance, frequency characteristics, shape, size, weight, appearance, and economic reliability.

High efficiency and high gain are the basic requirements of a transmitting antenna. Antennas may vary in size from a few millimeters to thousands of feet; 1-D linear arrays and 2-D planar arrays with lengths or diameters of tens of kilometers operate at the lower edge of the frequency spectrum [6].

3.3 Circuit Diagram

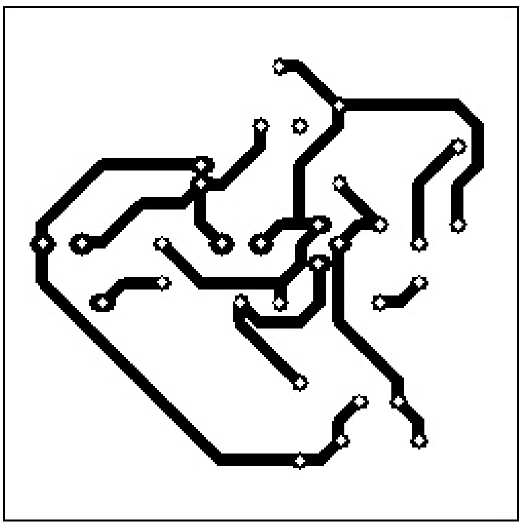


Figure 3.9: Circuit diagram

In telecommunications, frequency modulation (FM) conveys information over a carrier wave by varying its frequency. FM is commonly used at VHF radio frequencies for high-fidelity broadcasts of music and speech. Throughout the world, the broadcast band falls within the VHF part of the radio spectrum; usually 87.5–108.0 MHz is used to transmit and receive FM signals.

Design Considerations

The performance of an FM transmitter depends on two important aspects:

1. Tuning of the FM transmitter to the desired frequency – even a slight change in the coil specification or the variable-capacitor value can shift the output to a harmonic frequency instead of the 88–108 MHz FM band.
2. The length of the antenna used to transmit the signal.

The important parameters for optimum performance of an FM transmitter are:

1. Transmitter frequency, output power, and range of transmission.
2. Antenna length.
3. Coil diameter, length, number of turns, and gauge of the wire used for coil winding.

The circuit diagram shown above is that of a single-transistor FM transmitter with a range of 30–50 feet and 100–125 mW output, adapted from the single-transistor spy-bug design in [3]. The design details of each component are as follows.

3.3.0.1 1. Condenser MIC

The condenser MIC is used to pick up sound signals. The diaphragm inside the MIC vibrates according to air-pressure changes and generates AC signals. R1 adjusts the current through the MIC and thus determines its sensitivity. The condenser MIC should be directly soldered onto the PCB to obtain maximum sensitivity; sleeving the MIC inside plastic tubing can enormously increase its sensitivity.

3.3.0.2 2. Decoupling Capacitors

C5, the first decoupling capacitor, impedes the different frequencies of the speech signal. C1 modulates the current to the base of the transistor. The C5 capacitor isolates the microphone from the base voltage of the transistor and allows only alternating-current (AC) signals to pass.

A large-value capacitor induces bass (low frequencies), while a low-value one gives treble (high frequencies). Capacitor C1 (0.01 μF) acts as the decoupling capacitor. Capacitor C2 across transistor T1 keeps the tank circuit vibrating.

As long as current exists across inductor L1 and the trimmer capacitor, the tank circuit (coil–trimmer) vibrates at the resonant frequency; if it vibrates for a long time, the frequency decays due to heating. The presence of capacitor C2 prevents this decay. A capacitor between 4 and 10 pF is necessary here.

3.3.0.3 3. Resistors

R1 restricts the current through the MIC. The voltage divider R2 and R4 limits the base current of T1, and R5 forms the emitter current limiter. The given values are chosen for the BC548 transistor.

3.3.0.4 4. Transistor

BC548 is a general-purpose silicon NPN bipolar junction transistor used for amplification and switching purposes. Its current gain may vary between 110 and 800, with a maximum DC current gain of 800. Its equivalent transistors are 2N3904 and 2SC1815, which have different lead assignments. The variants of BC548 – 548A, 548B and 548C – differ in current-gain range and other characteristics.

The transistor terminals require a fixed DC voltage to operate in the desired region of their characteristic curves (biasing). For amplification applications, the transistor is biased so that it is partly on for all input conditions; the input signal at the base is amplified and taken at the emitter. BC548 is used in a common-emitter configuration for amplifiers, with voltage-divider biasing being the commonly used mode. For switching applications, the transistor is biased so that it remains fully on when there is a signal at its base, and completely off in the absence of one.

3.3.0.5 5. Inductor

The inductor used in the circuit is a handmade coil made from 22 SWG (Standard Wire Gauge) enameled copper wire. The length, inner diameter, and number of turns are the important parameters to be considered while making the inductor – these determine whether the inductor resonates in the 88–108 MHz FM band. For this circuit, the coil radius was selected as 0.26 inches (outer diameter) and 0.13 inches (inner diameter). The coil can be wound around a screwdriver of the same diameter to obtain a 5-turn coil, 0.2 inch long. The coil is then removed from the screwdriver, the enamel is removed from the tips, and the wire is soldered close to the transistor.

The inductance of the coil can be calculated using the formula:

$$L = \frac{n^2 r^2}{9r + 10x} \tag{3.1}$$

where r is the inner radius of the coil, x is the length of the coil, and n is the number of turns. The resulting value of L is in microhenries.

3.3.0.6 6. Trimmer Capacitor

A small button-type variable capacitor, with a value of 22 pF, can be used to adjust the resonant frequency of the tank circuit. The variable capacitor and the inductor coil form the tank circuit (LC circuit) that resonates in the 88–108 MHz band. In the tank circuit, the capacitor stores electrical energy between its plates while the inductor stores magnetic energy in its windings. The resonant frequency can be calculated using the formula:

$$f = \frac{1}{2\pi\sqrt{LC}}\ \text{Hz} \tag{3.2}$$

where f is the frequency in hertz, C is the capacitance of the trimmer in farads, and L is the inductance of the coil in henries.

Tank Circuit

Every FM transmitter needs an oscillator to generate the radio-frequency (RF) carrier wave. The name "tank" circuit comes from the ability of the LC circuit to store energy for oscillations – the purely reactive elements, C and L, simply store and return energy to the system. In the tank (LC) circuit, the BC548 transistor and the feedback 10 pF capacitor are the oscillating components. The feedback signal makes the base–emitter current of the transistor vary at the resonant frequency; this causes the emitter–collector current to vary at the same frequency. This signal is fed to the aerial and radiated as radio waves.

Antenna

A plastic wire or telescopic aerial can be used as the antenna. The length of the antenna is very important for transmitting the signal over the suitable range. As a rule, the antenna length should be $\frac{1}{4}$ of the FM wavelength. To determine the length of the antenna, the following relations are used:

$$\text{Speed of light} = \text{Frequency of oscillation} \times \text{Wavelength} \quad (\text{km/s}) \tag{3.3}$$

$$\text{Wavelength} = \frac{\text{Speed of light}}{\text{Frequency}} \quad (\text{m}) \tag{3.4}$$

$$\text{Antenna length} = 0.25 \times \text{Wavelength} \quad (\text{m}) \tag{3.5}$$

Using this relation, the required antenna length can easily be calculated. For the circuit described above, an antenna 25–28 inches long is sufficient.

3.3.1 Components Used

Table 3.1: Components required

Item	**Specification**	**Quantity**
Transistor	BC 548	1
Condenser Mic	2 pin	1
Inductor	4 turn, 22 SWG	1
Trimmer Capacitor	22 pF	1
Supply	9 V	1
Antenna	–	1
Resistor	10 kΩ	1
Resistor	15 kΩ	1
Resistor	4.7 kΩ	2
Resistor	47 Ω	1
Capacitor	0.01 μF	2
Capacitor	10 pF	1
Capacitor	0.001 μF	1
Capacitor	2.2 μF / 50 V	1
Connecting wires	–	As required

4. Implementation and Result

4.1 Hardware Implementation

4.1.1 PCB Fabrication

Printed circuit boards are electronic circuits created by mounting electronic components on a non-conductive board and creating conductive connections between them. Circuit patterns are created using both additive and subtractive methods. The conductive circuit material is generally copper, although aluminium, nickel, chrome and other metals are sometimes used. There are three basic varieties of printed circuit board – single-sided, double-sided, and multi-layered – and the spatial density required, along with the circuit complexity, determines the type of board produced. Printed circuit boards are used in the manufacture of business machines and computers, as well as communication, control, and home-entertainment equipment.

Production of a printed circuit board involves the plating and selective etching of a flat copper circuit supported on a non-conductive sheet of plastic. Production begins with a sheet of plastic laminated with a thin layer of copper foil. Holes are drilled through the board using an automated drilling machine; these holes are used to mount electronic components and to provide a conductive path from one layer to another. Following drilling, the board is scrubbed to remove fine copper particles left by the drill – the resulting rinse water can be a significant source of copper waste, so the particulate copper is typically removed by filtration or centrifuge, allowing the rinse water to be recycled back to the scrubber.

The steps involved in PCB fabrication are:

1. **Board cleaning before pattern transfer.** After choosing the copper-clad laminate, it should be cleaned. Cleaning the copper-clad board prior to resist application is an essential step in any PCB process using an etch or plating resist.
2. **Screen printing.** Screen printing is the process by which the conductor pattern on the film master is transferred onto the copper-clad laminate.
3. **Etching.** The final copper pattern is formed by selectively removing all unwanted copper not protected by the etch resist. For small-scale PCB production, ferric chloride is used as the etchant because it is very simple to use.
4. **Drilling.** After etching, component-mounting holes are drilled in the PCB.

The usual hole size is 0.8 mm, and for larger components such as presets and power devices the size is 1.2 mm. Once the required number of holes of specified dimensions have been drilled, the components are mounted on the PCB.

5. **Component mounting.** Components are mounted on the PCB in a way that minimizes cracking of solder joints due to mechanical stress – for example, by bending the axial component leads to guarantee good retention of the component while introducing minimum stress on the solder joint.
6. **Soldering.** Soldering is the process of joining metals using a lower-melting-point metal or alloy at the joining surface.

Printed circuit boards are certainly the most important element in the fabrication of electronic equipment; the design of a properly laid-out PCB determines many of the limiting properties with respect to noise immunity, as well as the fast-pulse, high-frequency and low-level characteristics of the equipment. High-power PCBs, in turn, require a special design strategy. The first step in producing a printed circuit board is to obtain its layout from the circuit diagram; computer-aided design (CAD) techniques are used for this, with diagrams drawn directly on a graphics workstation. The software then checks for any design and layout-rule errors. After correcting any errors, the layout is finalized, and based on this layout, the printed circuit board is fabricated from copper-clad laminate.

4.1.2 PCB Layout

Figure 4.1: PCB Layout

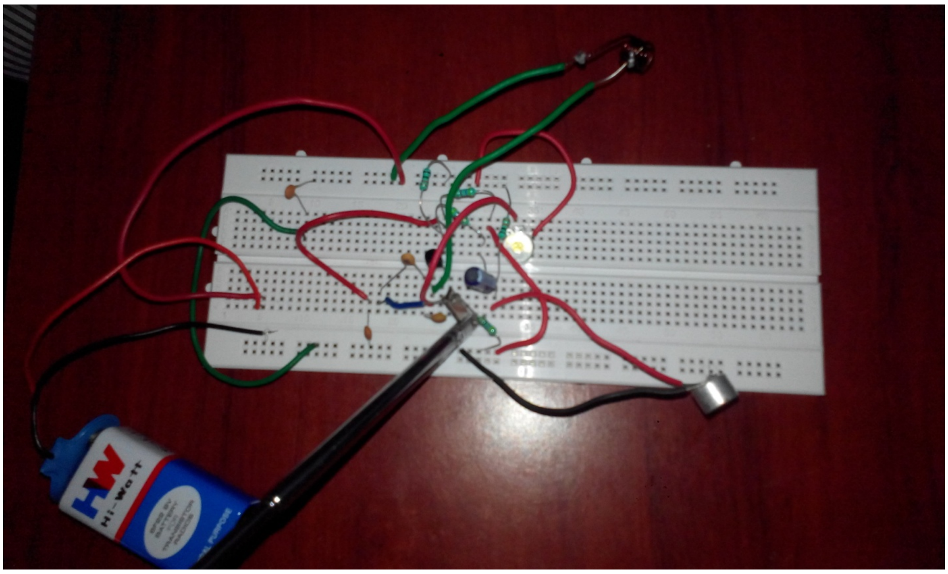
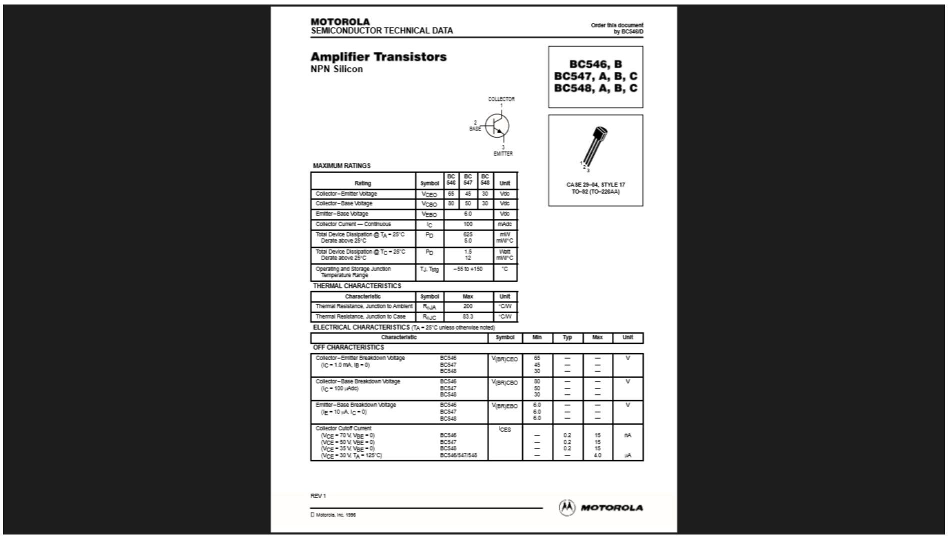


Figure 4.2: PCB Fabrication

4.1.3 Circuit in Breadboard



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SEMICONDUCTOR TECHNICAL DATA

Order this document by BC546/D

Amplifier Transistors
NPN Silicon

BC546, B
BC547, A, B, C
BC548, A, B, C

MAXIMUM RATINGS

Rating	Symbol	BC 546	BC 547	BC 548	Unit
Collector–Emitter Voltage	V_{CEO}	65	45	30	Vdc
Collector–Base Voltage	V_{CBO}	80	50	30	Vdc
Emitter–Base Voltage	V_{EBO}	6.0			Vdc
Collector Current — Continuous	I_C	100			mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0			mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector–Emitter Breakdown Voltage (I_C = 1.0 mA, I_B = 0)	BC546 BC547 BC548	$V_{(BR)CEO}$	65 45 30	— — —	— — —	V
Collector–Base Breakdown Voltage (I_C = 100 μAdc)	BC546 BC547 BC548	$V_{(BR)CBO}$	80 50 30	— — —	— — —	V
Emitter–Base Breakdown Voltage (I_E = 10 μA, I_C = 0)	BC546 BC547 BC548	$V_{(BR)EBO}$	6.0 6.0 6.0	— — —	— — —	V
Collector Cutoff Current (V_{CE} = 70 V, V_{BE} = 0) (V_{CE} = 50 V, V_{BE} = 0) (V_{CE} = 35 V, V_{BE} = 0) (V_{CE} = 30 V, T_A = 125°C)	BC546 BC547 BC548 BC546/547/548	I_{CES}	— — — —	0.2 0.2 0.2 —	15 15 15 4.0	nA μA

REV 1

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Figure 4.3: Circuit in breadboard

4.1.4 Implementation on Breadboard

1. Connect the resistors, transistor and capacitors as shown in the circuit diagram (Fig. 3.9) on the breadboard.
2. Wind the inductor from 22 SWG copper wire (4 turns) on a screwdriver with 0.26 inch outer diameter and 0.13 inch inner diameter (0.2 inch long).
3. Remove the enamel from the tip of the inductor and solder it to the connecting wires, to fix it on the breadboard.

4. Connect one end of the inductor to the collector of transistor BC548, and the other end to the 9 V supply.
5. Connect the antenna to the end of capacitor C3 (the end not connected to the inductor).
6. Connect a condenser mike such that the negative end is grounded and the positive end connects to the junction of R1 and C5.
7. Connect a 9 V battery.
8. Use a battery-operated FM pocket radio to receive the signal transmitted by the FM transmitter circuit.
9. Place the FM radio half a meter away from the transmitter and tune it to the 88–108 MHz range.
10. Produce a sound near the mike – if the tank circuit is properly tuned, the sound will be heard on the radio receiver.
11. Adjust the shaft of the trimmer capacitor and check again whether the sound is clearer than before.
12. If the sound clarity is good, fix the inductor coil with glue to prevent further frequency variation.

The wireless FM transmitter can now be used as a hearing aid.

4.2 Problems Faced

- Difficulty in maintaining equal spacing between the inductor windings.
- Difficulty in attaining a stable tuned frequency.
- Implementation on the breadboard was difficult due to stray capacitance.
- Interference of noise.

5. Conclusion

The project demonstrates how FM can help people hear effectively. The system designed is wireless, and it helps a person understand and identify speech in noisy situations and over distances of up to 30 m (100 feet). The FM system aids understanding even when the listener cannot see the speaker's face. Wireless hearing assistance can help any person with an auditory processing disorder – in short, the circuit used here helps in improving communication.

The circuit can be combined with an automatic level control circuit to adjust the volume as needed, so that each person can set the volume to a level that is comfortable for them.

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[6] J. D. Kraus, *Antennas*, 2nd Edition.

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A. Appendix

A.1 Datasheet

The datasheet for the BC548 NPN transistor used in the circuit, giving its pinout, absolute maximum ratings, electrical characteristics and h_{FE} classification, is reproduced on the following pages [7].

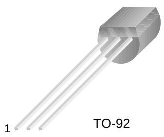
FAIRCHILD
SEMICONDUCTOR®

BC546/547/548/549/550

BC546/547/548/549/550

Switching and Applications

- High Voltage: BC546, V_{CEO}=65V
- Low Noise: BC549, BC550
- Complement to BC556 ... BC560



TO-92
1. Collector 2. Base 3. Emitter

NPN Epitaxial Silicon Transistor

Absolute Maximum Ratings T_a=25°C unless otherwise noted

Symbol	Parameter	Value	Units
V_{CBO}	Collector-Base Voltage : BC546 : BC547/550 : BC548/549	80 50 30	V V V
V_{CEO}	Collector-Emitter Voltage : BC546 : BC547/550 : BC548/549	65 45 30	V V V
V_{EBO}	Emitter-Base Voltage : BC546/547 : BC548/549/550	6 5	V V
I_C	Collector Current (DC)	100	mA
P_C	Collector Power Dissipation	500	mW
T_J	Junction Temperature	150	°C
T_{STG}	Storage Temperature	-65 ~ 150	°C

Electrical Characteristics T_a=25°C unless otherwise noted

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Units
I_{CBO}	Collector Cut-off Current	V_{CB}=30V, I_E=0			15	nA
h_{FE}	DC Current Gain	V_{CE}=5V, I_C=2mA	110		800	
V_{CE} (sat)	Collector-Emitter Saturation Voltage	I_C=10mA, I_B=0.5mA I_C=100mA, I_B=5mA		90 200	250 600	mV mV
V_{BE} (sat)	Base-Emitter Saturation Voltage	I_C=10mA, I_B=0.5mA I_C=100mA, I_B=5mA		700 900		mV mV
V_{BE} (on)	Base-Emitter On Voltage	V_{CE}=5V, I_C=2mA V_{CE}=5V, I_C=10mA	580	660	700 720	mV mV
f_T	Current Gain Bandwidth Product	V_{CE}=5V, I_C=10mA, f=100MHz		300		MHz
C_{ob}	Output Capacitance	V_{CB}=10V, I_E=0, f=1MHz		3.5	6	pF
C_{ib}	Input Capacitance	V_{EB}=0.5V, I_C=0, f=1MHz		9		pF
NF	Noise Figure : BC546/547/548 : BC549/550 : BC549 : BC550	V_{CE}=5V, I_C=200μA f=1KHz, R_G=2KΩ V_{CE}=5V, I_C=200μA R_G=2KΩ, f=30~15000MHz		2 1.2 1.4 1.4	10 4 4 3	dB dB dB dB

h_{FE} Classification

Classification	A	B	C
h_{FE}	110 ~ 220	200 ~ 450	420 ~ 800

Typical Characteristics

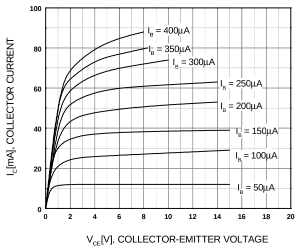


Figure 1. Static Characteristic

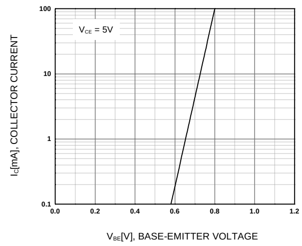


Figure 2. Transfer Characteristic

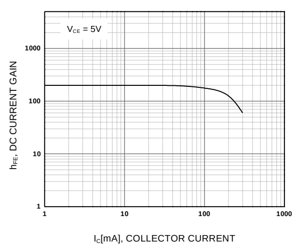


Figure 3. DC current Gain

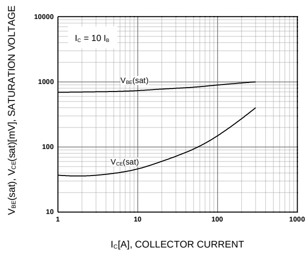


Figure 4. Base-Emitter Saturation Voltage Collector-Emitter Saturation Voltage

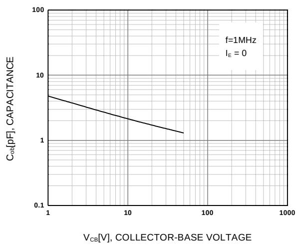


Figure 5. Output Capacitance

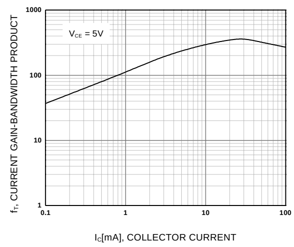
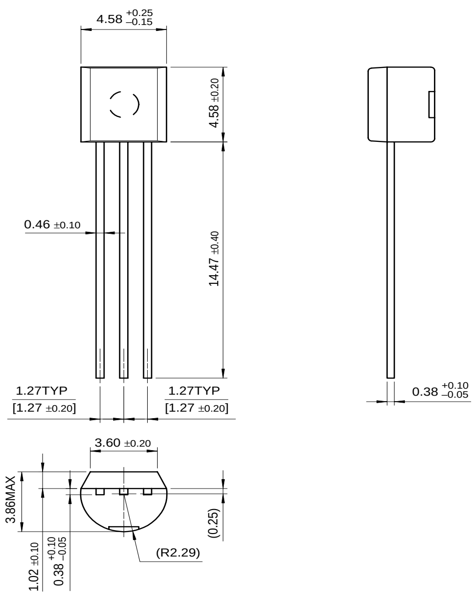


Figure 6. Current Gain Bandwidth Product

BC546/547/548/549/550

Package Dimensions

TO-92



Dimensions in Millimeters

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DOME™	GlobalOptoisolator™	MICROWIRE™	QS™	SyncFET™
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