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Amewornu, E.M. (2015) Design and Construction of Wireless Speaker Using Bluetooth. In: Mojekwu, J.N., Ogunsumi,L.O., Ojigi,L.M., Atepor, L., Thwala,D.W., Sackey,S. Awere E., and Bamfo-Agyei, E. (Eds) African Journal of Applied Research .(AJAR) Journal, Vol.1,No.1 ISSN 2408-7920 January 2015, Cape Coast, Ghana. 413- 428

DESIGN AND CONSTRUCTION OF WIRELESS SPEAKER USING BLUETOOTH

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ABSTRACT
This paper focuses on design and construction of 2.4 GHz wireless system, to transmit stereo audio from a 3.5 mm jack to play on a speaker. The transmitter will convert the audio from analog to digital with an Analog-to-Digital Converter (ADC) and transmit this digital data via a 2.4 GHz transmitter. The aim of the project is to design a system that will receive wireless stereo audio from a source and give an output useful for both indoor and outdoor purposes. The objectives of the project are to design and construct a low power transmitter so that it can be powered with 9V battery or PSU and be small and portable and to produce enough power to speakers to have "loud" music while limiting noise and distortion. The stereo amplifier used in this design is the MAX98400A Class D amplifier. An available class AB linear amplifier is an option for this project, but the higher-efficiency Class D amplifier consumes less power and dissipates much less heat. This amplifier exhibits a high 107-dB signal-to-noise ratio (SNR). This design uses a Nokia BH-214 Bluetooth stereo headset. It has the 3.5-mm audio connector, making it very easy to take audio signals from a headset's printed-circuit board (PCB) and feed signals to the stereo audio amplifier.
Keywords: Design; Construction; Wireless; Speaker; Bluetooth

INTRODUCTION

Wireless communication has grown rapidly over the years with the invention of various technologies. Goldsmith (2005) and Shafi *et al.* (2002) also explained wireless communication to involve the transmission of electromagnetic waves representing either voice or data through open space from one point to the other.
Communication system according to Anderson (2001) consists of three main parts namely the sending end, the transmission medium and the receiving end. The basic elements of a communication system are as shown in figure 1. The source and the transmitter forms the sending end (which converts the original signal into electrical

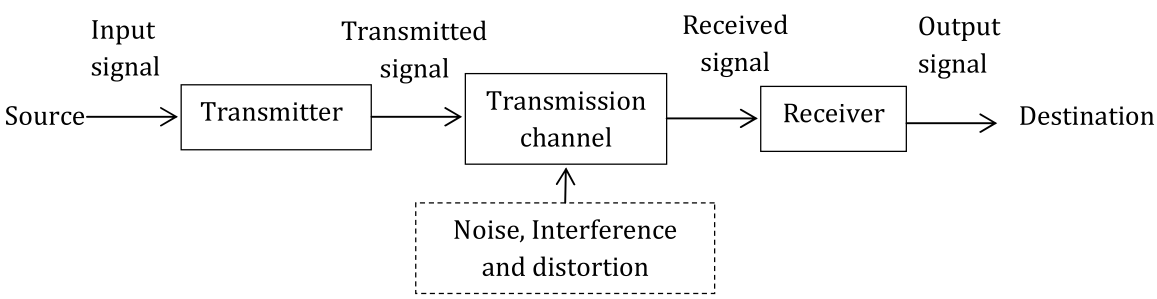

Figure 1 Elements of a communication system.

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signal) while the transmission channel (the atmosphere in the case of wireless communication) represents the medium which transmittes the electrical signal and the receiver and the destination combines as the receiving end (which reconvert the electrical signal into the original for of signal). The destination refers to the transducer used as interface between human and the electrical demodulated signal.
Rappaport *et al*, (2002) noted that the industry has expanded from cellular phones and pagers to Personal Communication Systems (PCS), wireless local area networks (WLANs), and broadband wireless services that can provide voice, data, and full-motion video in real time. Anderson *et al*, (2002) argued that in order for the visions of 3rd and 4th generation of wireless communication standards to be realized, system design engineers must have a thorough understanding of the wireless channels in which these devices operate.
According to Houghton (1999), a speaker refers to an electro acoustic transducer that convert electrical audio signal as its input signal to sound as it output signal. A complete speaker system may consist of an enclosure including one or more drivers depending on the sound pressure level or accuracy level required. Individual drivers are responsible for the reproduction of different frequency ranges. Green and Holman (2010) pointed out the various speaker drivers as subwoofer (for very low frequencies), woofer (low frequencies), mid-range speaker (middle frequencies) and tweeters (high frequencies).These various types of speakers are connected to signal source with wires which can be complex depending on the number of speakers involve.

Problem Statement

The complexity of wiring a number of speakers increase with the number of speakers involved. The set up home theatres with multiple speakers for outdoor purposes can be very challenging due to the number of speakers that may be involves. The connecting speakers' way in the back of a room for instance requires the navigation wires around objects or through walls can become a time consuming task. Also, disconnecting an operating speaker located outside when it is raining can be a problem and time consuming.
Speakers use two wiring points to connect to the source of the signal. This is done by using binding posts or spring clips on the back of the enclosure. The improper phase (speaker and amplifiers should be of the same phase) connection of the speaker wires can be responsible for speaker not operating as expected.
This work is to design a wireless speaker that will help minimize time and difficulty associated with connecting wires to the speakers. With increasing popularity of home theatre setups with multiple speakers, the use of wireless speakers is convenient.

Aim

The aim is to design a system that will receive wireless stereo audio from a source and give an output useful for both indoor and outdoor purposes.

Objectives

The objectives are as follow:

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- To design and construct a low power transmitter so that it can be powered with 9V battery or PSU and be small and portable.
- To produce enough power to speakers to have “loud” music while limiting noise and distortion.

Research Questions

The research questions for the project work are as follows:

- What are the wireless technologies available for the transmission of audio signal?
- What audio signal output will be appropriate for both indoor and outdoor use?

THEORETICAL FRAMEWORK OF SOUND

According to Houghton (1999), Sound is a mechanical wave that is an oscillation of pressure transmitted through a solid, liquid, or gas, composed of frequencies within the range of hearing. Sound also travels through plasma. Sound is a sequence of waves of pressure that propagates through compressible media such as air or water. (Sound can propagate through solids as well, but there are additional modes of propagation). Sound that is perceptible by humans has frequencies from about 20 Hz to 20,000 Hz. In air at standard temperature and pressure, the corresponding wavelengths of sound waves range from 17 m to 17 mm.

According to Fahy and Gardonio (2007) when sound is moving through a medium that does not have constant physical properties, it may be refracted (either dispersed or focused). The perception of sound in any organism is limited to a certain range of frequencies. For humans, hearing is normally limited to frequencies between about 20 Hz and 20,000 Hz (20 kHz), although these limits are not definite. The upper limit generally decreases with age. Other species have a different range of hearing. For example, dogs can perceive vibrations higher than 20 kHz, but are deaf to anything below 40 Hz. As a signal perceived by one of the major senses, sound is used by many species for detecting danger, navigation, predation, and communication. Earth's atmosphere, water, and virtually any physical phenomenon, such as fire, rain, wind, surf, or earthquake, produces (and is characterized by) its unique sounds. Many species, such as frogs, birds, marine and terrestrial mammals, have also developed special organs to produce sound. In some species, these produce song and speech.

Also according to Green and Holman (2010) humans have developed culture and technology (such as music, telephone and radio) that allows them to generate, record, transmit, and broadcast sound. The scientific study of human sound perception is known as psychoacoustics. The mechanical vibrations that can be interpreted as sound are able to travel through all forms of matter: gases, liquids, solids, and plasmas. The matter that supports the sound is called the medium. Sound cannot travel through a vacuum. Sound is transmitted through gases, plasma, and liquids as longitudinal waves, also called compression waves. Through solids, however, it can be transmitted as both longitudinal waves and transverse waves. Longitudinal sound waves are waves of alternating pressure deviations from the equilibrium pressure, causing local regions of compression and

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rarefaction, while transverse waves (in solids) are waves of alternating shear stress at right angle to the direction of propagation.

Speaker

According to Houghton (1999) speaker is an electro acoustic transducer that produces sound in response to an electrical audio signal input. The term loudspeaker may refer to individual transducers called DRIVERS or a complete speaker system consisting of an enclosure including one or more drivers. Most speakers employ more than one driver, particularly for higher sound pressure level or maximum accuracy. Individual drivers are use to reproduce different frequency ranges. The drivers are subwoofer (for very low frequencies), woofer (low frequencies), mid-range speaker (middle frequencies), and tweeters (high frequencies) (Green and Holman 2010).

Wireless speakers generally fall into two categories: infrared and radio frequency. Infrared, like a television remote control, beams a signal to the speakers. The disadvantage of this setup is occasional dropouts of sound. Since infrared requires a direct line of site, and any objects in the way can prevent the wireless speakers from receiving. Other wireless speakers use radio frequency waves to transmit the signal. And while the signal can pass through objects, some static can interfere with the sound just like when listening to the radio or when using a cordless telephone (Shafi *et al.,* 2002).

Types of Wireless Communication Systems

Shafi *et al.,* (2002) defined wireless communication technology as any method of communication possible without a direct physical connection between the two parties, largely describing systems based on radio waves. The first wireless communication systems came into use at the end of the 19th century, and the technology has matured significantly over the intervening years. Today, many types of devices use wireless communication technology, allowing users to remain in contact even in remote areas.

Radio

Shafi *et al.,* (2002) acknowledged that open radio communication was one of the first wireless technologies to find widespread use, and it still serves a purpose today. Portable multichannel radios allow users to communicate over short distances, while citizen's band and maritime radios provide communication services for truckers and sailors. Ham radio enthusiasts share information and serve as emergency communication aids during disasters with their powerful amateur broadcasting equipment, and can even communicate digital data over the radio spectrum.

Cellular

Cellular networks use encrypted radio links, modulated to allow many different users to communicate across a single frequency band. Because individual handsets lack significant broadcasting power, the system relies on a network of cellular towers, capable of triangulating the source of any signal and handing reception duties off to the most suitable antenna.

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Satellite

Satellite communication is another wireless technology that has found widespread use in specialized situations. These devices communicate directly with orbiting satellites via a radio signal, allowing users to stay connected virtually anywhere on Earth. Portable satellite phones and modems feature more powerful broadcast and reception hardware than cellular devices due to the increased range, and are correspondingly more expensive. For semi-permanent or permanent installations, such as outfitting a ship for satellite communication, a more traditional communication system may link to a single satellite uplink, allowing multiple users to share the same broadcast equipment.

Wi-Fi

According to Gartrell, (2005) Wi-Fi is a form of low-power wireless communication used by computers and hand-held electronic devices. In a Wi-Fi setup, a wireless router serves as the communication hub, linking portable devices to a wired internet connection. These networks are extremely limited in range due to the low power of the transmissions, allowing users to connect only within close proximity to a router or signal repeater. Wi-Fi is common in home networking applications, allowing users to link devices without running lengths of cable, and in commercial applications where a business may provide wireless Internet access to their customers. Wi-Fi networks may be free to use, or their owners may secure them with passwords and access restrictions.

Overview of Speakers

According to Stallings (2004) wireless speakers are very similar to traditional (wired) loudspeakers, but they receive audio signals using radio frequency (RF) waves rather than over audio cables. Wireless speakers are composed of two units: a main speaker unit combining the loudspeaker itself with an RF receiver, and an RF transmitter unit. The transmitter connects to the audio output of any audio devices such as hi-fi equipment, televisions, computers, mp3 players, etc. An RCA plug is normally used to achieve this. The receiver is positioned where the listener wants the sound to be, providing the freedom to move the wireless speakers around without the need of using cables. The receiver/speaker unit generally contains an amplifier to boost the audio signal to the loudspeaker; it is powered either by batteries or by an AC electric outlet. Batteries may last for three to four hours; some wireless speakers operate on rechargeable batteries. The signal frequency range used by wireless speakers is generally the same as that used by cordless telephones — 900 MHz. The RF signal can traverse walls and floors/ceilings. Most manufacturers claim the signal transmits over a range of 150 to 300 feet. Many wireless speakers feature variable transmission frequencies (channels) that can be set using a tuning knob to overcome potential RF interference with other nearby wireless devices such as cordless phones or baby monitors.

Also according to Shafi *et al.,* (2002) different types of wireless speakers are designed for specific needs: Stereo speakers can deliver both Left and Right stereo channels in a single speaker. Speakers designed specifically for outdoor use have a robust casing;

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manufacturers claim these are weatherproof. Home theatres utilize a specialized set of speakers in which only the rear speaker/s are wireless, while the front speakers are wired. Wireless speakers receive considerable criticism from high-end audiophiles because of the potential for RF interference with other signal sources like cordless phones as well as for the relatively low sound quality some models deliver. Despite the criticism, wireless speakers have gained popularity with consumers and a growing number of models are actively marketed.

RESEARCH METHODOLOGY

The research strategy is based on experiment; several tools and components were used to design and construct the design and construct the wireless speaker using Bluetooth.
The screwdriver was used to drive screws and bolts. The potentiometer was used in measuring the potential (voltage) in the circuit. Soldering iron was used in soldering the components used in the build-up. It supplied heat to melt the solder so that it could flow into the joint between two work pieces. Heating was achieved electrically, by passing an electric current (supplied through an electrical cord or battery cables) through a resistive heating element. Soldering lead (solder) was used to join together components. Solder is fusible metal alloy used to join together metal work pieces and having a melting point below that of the work pieces. Digital Multimeter was used to measure the voltage, current and resistances of the components. The multimeter conducted tests of AC/DC voltage, DC current, resistance, transistor, diode and battery.
The power supply unit was mounted just inside the back of the case. The side of the PSU facing outside the case has a male, three pronged port that a power cable, connected to a power source, plugs into. There was also often a power switch and a power supply voltage switch. Large bundles of coloured wires extended from the opposite side of the power supply unit into the speaker. Connectors at the opposite ends of the wires connect to various components inside the speaker.
The Bluetooth stereo headset acted as a bridge, delivered the audio signal from the handheld device to a stereo audio amplifier and created a wireless stereo audio system. Bluetooth device is widely used for short-range voice transmission. While it can be used for data transmission, the short range (due to using low power to reduce battery drain) is a limiting factor.
Light emitting diodes, commonly called LEDs, are real unsung heroes in the electronics world. They are illuminated solely by the movement of electrons in a semiconductor material, and they last just as long as a standard transistor.
A capacitor (originally known as condenser) is a passive two-terminal electrical component used to store energy in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors separated by a dielectric (insulator). Capacitors are commonly used in electronic devices to maintain power supply while batteries are being changed. (This prevents loss of information in volatile memory.)
A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. The current through a resistor is in direct proportion to the voltage across the resistor's terminals.

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A push-button or simply button is a simple switch mechanism for controlling some aspect of a machine or a process. Buttons are typically made out of hard material, usually plastic or metal. The surface is usually flat or shaped to accommodate the human finger or hand, so as to be easily depressed or pushed. Buttons are most often biased switches, though even many un-biased buttons (due to their physical nature) require a spring to return to their un-pushed state.

Putting the Bluetooth Audio System together

Bluetooth headsets typically employ fairly small, 8Ω speakers. By connecting the audio signal from a Bluetooth headset to an external 2amplifier, it's possible to amplify the signal. The Bluetooth stereo headset then acts as a bridge, delivering the audio signal from the handheld device to a stereo audio amplifier, creating a wireless stereo audio system. This system is based on a stereo Class D audio amplifier, which drives a pair of 8-Ω speakers. The output power requirement is $200W_{RMS}$ (10 W_{RMS} per channel). Measuring rms output power isn't the optimal way to determine an amplifier's output power, since rms doesn't really reveal much about an amplifier's true performance. Therefore, in this project, rms output power refers to the average sine-wave power into a resistive load. Consequently, rms output power is used mainly for comparative purposes. The 20 W_{RMS} translates to 40-W peak output power. To achieve 10-W_{RMS} per channel into 8-Ω speakers, the minimum supply voltage (V_{RMS}) needs to be:

$$V_{RMS} = \sqrt{\text{Output Power}_{RMS} \times \text{Speaker Impedance}} = \sqrt{10W \times 8\Omega} = 8.94V \qquad (1)$$

For peak output voltage, this translates to:

$$V_{PEAK} = V_{RMS} \times \sqrt{2} = 8.94V \times \sqrt{2} = 12.64\ V_{PEAK} \qquad (2)$$

Equations 1 and 2 show that a 9-V supply voltage would be enough to achieve 10-W_{RMS} output power per channel. However, this design uses a 12-V supply voltage, which allows some room for the power-supply unit's (PSU) output voltage to drop during a heavy load. An isolated PSU with a 12-V output voltage utilizes a low-cost LED driver voltage supply. These supplies are readily available from any electronics store. It's a matter of choosing a PSU that matches the output power. As an aside, most people don't relate to "20-W_{RMS} total output power." For comparison, think about low-cost car audio amplifiers or low-cost portable audio "boom-box" products. They're often advertised as providing 40-W total output power, but this is normally peak output power that translates to 200-W_{RMS} output power. Low-cost car audio amplifiers typically don't incorporate a step-up dc-dc converter, so they use 15V from the car's battery to drive the speakers. Actually, a car's battery voltage is about 13.8 V, but that's not important here. Any headset with a 3.5-mm audio connector will do the trick. This design uses a Nokia BH-214 Bluetooth stereo headset. It has the 3.5-mm audio connector, making it very easy to take audio signals from a headset's printed-circuit board (PCB) and feed signals to the stereo audio amplifier. An On/Off switch and indicator LEDs are needed as well. These signals need to be taken from the Nokia headset. Some signals come from outside the Nokia headset's PCB. As a result,

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a few wires must be soldered to that PCB to enable signal transmission. The front cover of the headset is opened by gently squeezing with a small screwdriver at the right corners, top and bottom. The plastic faceplate is removed and then the keyboard rubber is also removed. The part containing the PCB from the bottom enclosure is gently pulled. With the front cover open, make some extra room for wires by clipping off some plastic from the cover. Also remove the light guide and the plastic enclosure for the On/Off switch. Procedures will vary for other headsets.
Working from the headset, solder off the On/Off-switch, the bicolor LED, blue LED, and battery wires all on the Bluetooth headset. Remove the battery from the PCB. Now solder wires to the On/Off switch pads. Then solder a wire to the bicolor LED common anode pad. Solder a wire to the blue LED anode pad. Finally, solder wires to the battery pads. Use the thinnest wires that you can find, and note the wires' colours for future reference. Three more wires need to be soldered to the headset. Solder the green LED cathode, red LED cathode, and blue LED cathode to resistors. Now there should be wires for the following signals:
1.Two wires for the Bluetooth headset's On/Off switch
2.Three wires for the green and red bicolor LEDs (i.e., the common anode, green cathode, and red cathode)
3.Two wires for the blue LED (anode and cathode)
4.Two wires for the battery terminals (for 3.6 V from the LDO)

When all wires are soldered to the PCB, gently put the headset back together. Close the enclosure with caution, because it's very easy to detach a pad from the PCB by pulling the wire. After modifications, the headset will look the same but with wires extending from outside the headset.

Assembling the System
Finally, the system is assembled into an industrial 200 by 400mm waterproof wooden enclosure. Many different layouts can be employed to assemble the PSU, stereo Bluetooth headset, audio amplifier, switches, and LEDs into an enclosure. Make sure that no cables cross the headset's Bluetooth antenna, since that can reduce the Bluetooth range. The system should not be mounted very near other wireless transmitters. For example, it should not be positioned beside a wireless local-area network (WLAN) router, because those transmissions can interfere with the headset's reception. The amplifier in this design features a high 32.9-dB power-supply rejection ratio (PSRR), which eliminates the need for a tightly regulated power supply.
Nonetheless, be sure to choose a PSU with reasonably good output-voltage regulation. In practice, that means one should not use the lowest-cost PSU available. Perhaps the hardest part of building this system involves soldering wires to the LED indicator pads located on the Nokia BH-214 PCB. If you have any doubts about soldering these wires, change to an enclosure with a transparent front cover. Then the stereo Bluetooth headset would be mounted sideways to make indicator LEDs visible through the front cover. Thus, there's no need to remove the LED indicators from the PCB. The wires for the On/Off switch and

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the wires to the battery pads still must be soldered to the headset's PCB. That's much easier than soldering for the LED indicators. Also, the power-on LED is optional. If it's mounted, a series resistor must be used to limit LED current. When the LEDs are supplied from the 3.6-V LDO output and the LED forward voltage equals 1.8 V with, for example, an 8-mA LED current, then the series resistor would be:

$$R_{LED} = \frac{3.6\ V - 1.8\ V}{8\ mA} = 220\Omega$$

Block Diagram

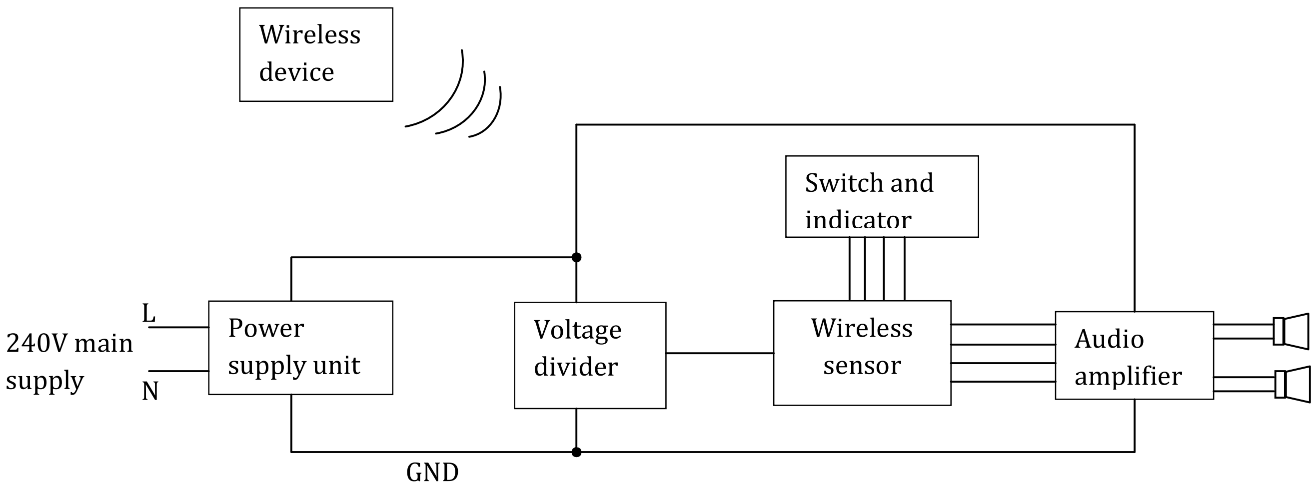

Fig 2 Block diagram of Bluetooth Speaker system

Description of block diagram

The transmitter will convert the audio from analog to digital with an Analog-to-Digital Converter (ADC) and transmit this digital data via a 2.4 GHz transmitter. The receiver will receive the digital data with minimal loss, and reconstruct the analog signal with a Digital-to-Analog Converter (DAC). The receiver will pass this audio signal through an audio equalizer to control the frequency response of the low, mid and high bands. A power amplifier will then be used to amplify the audio signal and play it through speakers. This design uses a Class D audio amplifier. Perhaps, if a Class AB linear amplifier is used in the design instead, the system will be much less efficient. A Class AB linear amplifier operating under same conditions will have approximately 50% less efficiency than the Class D device, meaning that there will be 10W of dissipated (wasted) power in the amplifier. Therefore, a fairly large heat sink would be required for thermal protection. When we consider how much power a Class AB amplifier would waste in this application, it is easier to understand why the term "RMS output power" is misleading. Assume that two amplifiers, a Class D and a Class AB amplifier, are delivering the same $20W_{RMS}$

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output power. In our example, the MAX98400A will dissipate 3.5W and a Class AB amplifier will dissipate 10W. Thus, even when the RMS output power *seems* to be the same, the Class AB amplifier cannot deliver as much power to the speakers because it is wasting so much power. In the end, less power translates to considerably less sound.

CALCULATION

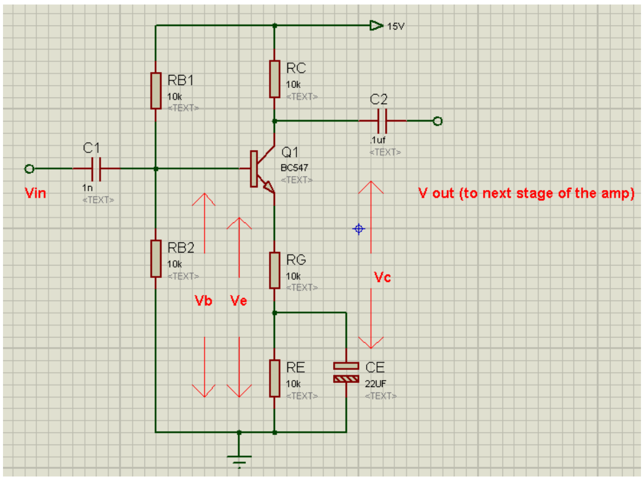

Figure 3 typical single-transistor amplifier circuit.

Figure 2 illustrates a typical single-transistor amplifier circuit. This arrangement is often called the common emitter amplifier because the input voltage to the transistor appears between the base & emitter, and the output voltage appears between the collector & emitter.

In order to build a working amplifier for the project, a suitable values for resistors Rb1, Rb2, Rc and Re must be chosen. For now, assume that Rg=0 (i.e. it is a piece of wire). We will want to choose a value for Rg later, but for now we'll worry about everything else.

A good start for choosing the components is to make just three assumptions and use them as 'rules' unless we know better:—

1. The base-emitter voltage will always be about 0.6 Volts (or ¬0.6 for a PNP TRANSISTOR).
2. The current gain (the hfe value) will be a few hundred.
3. The large hfe value means that Ib<Ic , so we can assume that Ic = Ie.

Looking at the transistor characteristic curves we will see that, although Vbe does depend upon Ib , over most of the measured range it is around 0.6 Volts or so. The hfe of the transistor will probably be somewhere in the 200 — 600 range. So these approximations are a moderately good place to start in the absence of any better information.

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The resistors in the amplifier circuit will determine the steady bias voltages and currents, , , etc. The capacitors in the circuit are used to control the effects of a.c. signals. Start off by ignoring the capacitors as they don't affect the way the actual transistor operates. We can therefore work out all the resistor values, etc, without bothering about them.
The circuit is driven by a +15V power line and the collector-emitter voltage is applied via the two series resistors, Rc& Re. multiple for the above circuit is cascaded to for the main circuit.

RESULTS AND DISCUSSION

Results

The stereo audio amplifier incorporates a linear voltage regulator (MAX16910) that converts a 12-V supply to 3.6 V. The LDO output, which can have a voltage between 3.4 V and 4.2 V, connects to the headset's battery terminals. This device has 30-V (max) input voltage and built-in thermal and overload protection. With the R1 and R2 values, the LDO's output voltage will be about 3.8 V. The MAX98400A amplifier needs few external components for its function. Its gain is selected with SV1 and SV2. Gain tops out at 32.9 dB, which equals 44.2 V/V:

$$GAIN_{MAX[dB]} = 32.9\ dB$$

$$GAIN_{MAX[\frac{V}{V}]} = 10^{\frac{32.9}{20}} = 44.2\frac{V}{V}$$

Selecting maximum gain occurs when connector SV1 is open and connector SV2 pins 1 and 2 are connected together. Therefore, with a 12-V supply voltage and 44.2-V/V gain, the maximum input signal that can be used without clipping and distortion to the output signal becomes:

Table 1 Gain settings for the MAX98400 Stereo Audio Amplifier

MAX98400A STEREO AUDIO AMPLIFIER GAIN SETTINGS			
SV1	SV2	Gain (dB)	Gain (V/V)
2-3	2-3	9	2.8
Open	2-3	13	4.5
1-2	2-3	16.7	6.8
2-3	Open	20.1	10.1
Open	Open	23.3	14.6
1-2	Open	26.4	20.9
2-3	1-2	29.8	30.9
Open	1-2	32.9	44.2

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$$\text{INPUT}_{\text{SIGNAL[MAX]}} = \frac{12\ \text{V}}{44.2\ \frac{\text{V}}{\text{V}}} \approx 270\ \text{mV}$$

When this Bluetooth audio system is used in a very warm ambient temperature and the audio amplifier is delivering its highest possible output power, nothing will be damaged or destroyed. There are always electromagnetic interference (EMI) issues to consider when using a Class D amplifier in a design. If a system needs long speaker cables (over 1m), it would be good to use a ferrite bead mounted to the speaker cable to reduce radiated emissions.

Discussion

The stereo amplifier used in this design is the MAX98400A Class D amplifier. An available class AB linear amplifier is an option for this project, but the higher-efficiency Class D amplifier consumes less power and dissipates much less heat. This amplifier exhibits a high 107-dB signal-to-noise ratio (SNR). Speakers can be connected directly to the amplifier's outputs without an output filter and without big, bulky dc-blocking capacitors. This latter point is very important. Traditional Class D amplifiers require an output filter to recover the audio signal from the amplifier's output. The MAX98400A relies on the inherent inductance of speaker coil to recover the audio component of the square-wave output. Thus, eliminating the output filter and dc-blocking capacitors saves considerable space on the PCB. The stereo audio amplifier incorporates a linear voltage regulator (MAX16910) that converts a 12-V supply to 3.6 V. The LDO output, which can have a voltage between 3.4 V and 4.2 V, connects to the headset's battery terminals. This device has 30-V (max) input voltage and built-in thermal and overload protection. With the R1 and R2 values, the LDO's output voltage will be about 3.8 V. The MAX98400A amplifier needs few external components for its function. Its gain is selected with SV1 and SV2. Gain tops out at 32.9 dB, which equals 44.2 V/V.

The amplifier contains an integrated clipping-limiter circuit that prevents output clipping distortion. Without that circuit, the headset's input signal would otherwise need to be adjusted to 270 mV (max) at maximum gain to ensure that the audio amplifier's output signal isn't clipped and distorted at maximum volume. Alternatively, the MAX98400A's gain can be lowered by choosing different settings for SV1 and SV2. Thermal issues must be considered, too. With a 12-V supply voltage and a 4-Ω load, the amplifier's efficiency with 20-W_{RMS} output power is about 85%. The power dissipated in the amplifier can be calculated as:

$$P_{\text{DISSIPATION}} = P_{\text{OUT}} \times \frac{100\% - \text{Efficiency}}{\text{Efficiency}} = 20\ \text{W} \times \frac{100\% - 85\%}{85\%} = 3.5\ \text{W}$$

CONCLUSION AND RECOMMENDATION

Bluetooth headsets typically employ fairly small, 8Ω speakers. By connecting the audio signal from a Bluetooth headset to an external amplifier, it's possible to amplify the signal.

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The Bluetooth stereo headset then acts as a bridge, delivering the audio signal from the handheld device to a stereo audio amplifier, creating a wireless stereo audio system. This system is based on a stereo Class D audio amplifier, which drives a pair of 8-Ω speakers. The output power requirement is $200W_{RMS}$ ($10\ W_{RMS}$ per channel). However, this design uses a 15-V supply voltage, which allows some room for the power-supply unit’s (PSU) output voltage to drop during a heavy load. An isolated PSU with a 15-V output voltage utilizes a low-cost LED driver voltage supply. The transmitter will convert the audio from analog to digital with an Analog-to-Digital Coveter. This design uses a Nokia BH-214 Bluetooth stereo headset. It has the 3.5-mm audio connector, making it very easy to take audio signals from a headset’s printed-circuit board (PCB) and feed signals to the stereo audio amplifier. An On/Off switch and indicator LEDs are needed as well. These signals need to be taken from the Nokia headset. Some signals come from outside the Nokia headset’s PCB.
The Nokia headset needed to be modified. Since some signals come from outside the headset's PCB, a few wires needed to be soldered to that PCB to enable signal transmission. The front cover of the headset was opened by gently squeezing with a small screwdriver at the right corners, top and bottom. The plastic faceplate is removed and then the keyboard rubber is removed afterwards. The part containing the PCB is pulled from the bottom enclosure. Wires were soldered to the On/Off switch pads. Then a wire was soldered to the bicolor LED common anode pad. A wire was also soldered to the blue LED anode pad. Finally, wires were soldered to the battery pads. The thinnest wires were used and noted the colours of wires for future reference. When all wires were soldered to the PCB, the headset was put back together. And then the enclosure was closed with caution, since it was very easy to detach a pad from the PCB by pulling the wire

Recommendation

There is a need for researchers to improve upon it such as removing the battery from the headset and then connecting wires to the battery pad together with the PSU so that on switching the system on, the headset would be charged as well without charging the headset separately.

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