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Audio Power Amplifier EE-400

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Viva Palestine.

Viva Arabic Nation.

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ABSTRACT

Audio power amplifier is one of the most important devices in the entertainment world, where it's impossible to get an excellent loud sound without it. Where it's used to sense (audio playback device) output signal, and produce a larger version of the same signal.

The amplification of the audio signal can be achieved with placing an IC on the terminals of the loud speakers, but because the IC doesn't do all the work, there must be some external components, where the combination of the IC and the components will form the Audio Power Amplifier.

The project aim is designing an (AB-stereo) audio power amplifier, with minimum number of components, to amplify the audio signal as max as possible with the best sound quality.

Additionally, to understand the configuration and the specification of the used IC (TDA2005) .Last but not least is to get some experience in the electronic hardware projects.

CHAPTER ONE

INTRODUCTION

Amplifier is a component or device intended to sense a signal and produce a larger version of that signal. In general, any amplifying device is limited by available power, frequency response, and device maximums for voltage, current, and power dissipation. The project Main subject is about how to amplify the audio signal as big as possible, with less electrical components.

In this project, the first chapter will be introducing Electronic component, and it will go through the most commonly components used in hardware projects and the way they function and how they must be connected. In the end of this chapter there will be some of the guide lines that each electrical engineer should apply in his life.

The second and Main chapter will be about class AB stereo audio power amplifier, for quality hi-fi applications using a TDA2005 module. And it will introduce the TDA2005 features and pin configuration among with its schematic diagram. Then the circuit construction, operation, and schematic diagram, among with its components and specification will be represented

Going through this project, will lead to the right path in analysing and understanding the characteristics of the electrical circuits and components, especially the IC"s, and all of that will give an idea about the practical part of my major. The Main aims of this project are:

1_to amplify the audio signal as big as possible, with less electrical components.

2_ to understand the electronic components that are commonly used in hardware projects like some semiconductors, capacitors and resistors.

3_ understanding the characteristic of the audio amplifier circuit, and the specification and the configuration of TDA2005.

4_ provide my self with enough knowledge that I will use in the practical work, and will help me in the future in my career.

5_learn how the student can protect his self and the circuit during its constructing.

CHAPTER TWO

ELECTRONIC COMPONENTS

2.1 Overview

This chapter includes an introduction to electronic components like some semiconductors, capacitors and resistors. Additionally safety guidelines for electronic projects will be presented.

2.2 Electronic Components

Electronics gets its name from the electron, a tiny particle which forms part of all atoms, which, as everybody knows, make up everything in the world. Atoms contain other types of particles - protons and neutrons - but it is the electrons which will be interesting us here.

Electrons and protons have the electrical property of charge. Protons have positive charge and electrons have negative charge and they normally balance each other out. We don't really need to know what charge is. It's just a property like weight or color, but it is this property which makes the whole of electronics happens. But keep in mind the fact that opposite charges attract and similar charges repel.

When electrons move together in a unified way we say there is a current flowing. Electrons are actually moving all the time in materials like metals but moving in a random disordered way. A current is when they all move together in one particular direction.

When you touch a lift button having walked across a synthetic carpet and you feel a shock that is electrons flowing through you to the ground. That's all a current is, simply the movement of electrons in a particular direction.

Electrons can't flow through every material. Materials that allow a current to flow easily are called conductors. Materials that don't allow a current to flow are called non-

conductors or insulators. Metals are the most common conductors, plastics are typical insulators.

Conductor's	non-conductors
Gold	plastic
Copper	wood
Carbon	air

Copper is a good conductor. Copper tracks are used on the printed circuit boards to connect the components together. Solder is another good conductor. The solder makes the actual join between the leg of the component and the track.

The plastic that a printed circuit board is made of is an insulator. Currents can only flow up and down the copper tracks and not jump from one to another. For the same reason wires are surrounded by plastic coatings to stop them conducting where they shouldn't.

There are certain materials that are between the two extremes of conductor and non-conductor; we will come to them later.

A battery supplies the 'force' that makes the electrons move. This force is called the voltage. The bigger the voltage the more force. Mains electricity which is 240 volts is more powerful than an ordinary 9 volt battery.

Currents are measured in amps, and voltages are measured in volts (after the scientists Ampere and Volta). Voltages are sometimes called potential differences, or electromotive forces, but we won't use these terms here.

There is a big confusion for many people as to the difference between voltage and current. They talk about so many volts going through something when they really mean amps. So let's think about things in a different way.

Imagine water flowing through a pipe filling up a pond. The water represents the electrons and the pipe represents the wire. A pump provides the pressure to force the water through the pipe. The pump is the battery. How much water flows out the end of the pipe each second is the current. How hard the water is being pumped is the voltage.

A narrow pipe will take a long time to fill the pond, whereas a broad pipe will do it much faster using the same pump. Clearly the rate of flow depends on the thickness of the pipe. So we have the situation where the same voltage (pump pressure) can give rise to different currents (flow rate) depending on the pipe. Try to guess what the thickness of the pipe represents in this model of things (answer later).

An electric current requires a complete path - a circuit - before it can flow. In a circuit with a battery, the battery is both the starting flag and the finishing line for the electrons. A chemical reaction in the battery releases electrons which flow around the circuit and then back into the battery. The battery keeps the current flowing, feeding electrons in at one end and collecting them at the other. It takes energy to do this and so after a while the battery wears out.

Current flows into a component and the same amount of current always flows out of the component. It is not 'used up' in any way. As the current passes through components things happen (an LED lights up for instance).

2.2.1 Resistors

Electrons move more easily through some materials than others when a voltage is applied. In metals the electrons are held so loosely that they move almost without any hindrance. We measure how much opposition there is to an electric current as resistance.

Resistors come somewhere between conductors, which conduct easily, and insulators, which don't conduct at all. Resistance is measured in ohms after the

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discoverer of a law relating voltage to current. Ohms are represented by the Greek letter omega.



Think back to the model of water flowing in a pipe. The thickness of the pipe must represent the resistance. The narrower the pipe the harder it is for the water to get through and hence the greater the resistance. For a particular pump the time taken to fill the pond is directly related to the pipe thickness. Make the pipe twice the size and the flow rate doubles, and the pond fills in half the time.

The resistors used in the kits are made of a thin film of carbon deposited on a ceramic rod. The less carbon the higher the resistance. They are then given a tough outer coating and some colored bands are painted on.

The main function of resistors in a circuit is to control the flow of current to other components. Take an LED (light) for example. If too much current flows through an LED it is destroyed. So a resistor is used to limit the current.

When a current flows through a resistor energy is wasted and the resistor heats up. The greater the resistance the hotter it gets. The battery has to do work to force the electrons through the resistor and this work ends up as heat energy in the resistor. An important property to know about a resistor is how much heat energy it can withstand before it's damaged. Resistors can dissipate about a 1/4 Watt of heat (compare this with a domestic kettle which uses up to 3 000 Watts to boil water).

It's difficult to make a resistor to an exact value (and in most circuits it is not critical anyway). Resistances are given with a certain accuracy or tolerance. This is expressed as being plus or minus so much of a percentage. A 10% resistor with a stated value of 100 ohms could have a resistance anywhere between 90 ohms and 110 ohms. The resistors are 5% (that's what the gold band means) which is more than enough accuracy.

Real resistances vary over an enormous range. In the Lie Detector there is a 1000000 ohms resistor alongside a 470 ohms resistor. In circuit diagrams you will often see an 'R' instead of omega to represent ohms. This is a convention that dates from before the days of computers and laser printers when Greek letters were rarely found on typewriters. The letter 'k' means a thousand and its position shows the position of the decimal point.

Here are some examples:

20R = 20 ohms

20k = 20 kilo ohms = 20000 ohms

5k5 = 5.5 kilo ohms = 5 500 ohms

During manufacture, a thin film of carbon is deposited onto a small ceramic rod. The resistive coating is spiraled away in an automatic machine until the resistance between the two ends of the rod is as close as possible to the correct value. Metal leads and end caps are added; the resistor is covered with an insulating coating and finally painted with colored bands to indicate the resistor value. Carbon film resistors are cheap and easily available, with values within $\pm 10\%$ or $\pm 5\%$ of their marked or 'nominal' value. Metal film and metal oxide resistors are made in a similar way, but can be made more accurately to within $\pm 2\%$ or $\pm 1\%$ of their nominal value. There are some differences in performance between these resistor types, but none which affect their use in simple circuits.

Wire wound resistors are made by winding thin wire onto a ceramic rod. They can be made extremely accurately for use in MultiMate's, oscilloscopes and other measuring equipment. Some types of wire wound resistors can pass large currents without overheating and are used in power supplies and other high current circuits.

2.2.1.2 Resistor Color Code

First find the tolerance band, it will typically be gold (5%) and sometimes silver (10%).Starting from the other end, identify the first band - write down the number associated with that color; in this case Blue is 6.Now 'read' the next color, here it is red so write down a '2' next to the six. (you should have '62' so far.)Now read the third or 'multiplier' band and write down that number of zeros.

In this example it is two so we get '6200' or '6,200'. If the 'multiplier' band is Black (for zero) don't write any zeros down. If the 'multiplier' band is Gold move the decimal point one to the left. If the 'multiplier' band is Silver move the decimal point two places to the left. If the resistor has one more band past the tolerance band it is a quality band. Read the number as the '% Failure rate per 1000 hour' This is rated assuming full wattage being applied to the resistors. (To get better failure rates, resistors are typically specified to have twice the needed wattage dissipation that the circuit produces).



Some resistors use this band for temco information. 1% resistors have three bands to read digits to the left of the multiplier. They have a different temperature coefficient in order to provide the 1% tolerance.

At 1% the temperature coefficient starts to become an important factor. at +/-200 ppm a change in temperature of 25 Deg C causes a value change of up to 1%.

2.2.1.3 Resistors in Series and Parallel

In a series circuit, the current flowing is the same at all points. The circuit diagram shows two resistors connected in series:



It doesn't matter where in the circuit the current is measured; the result will be the same. The total resistance is given by:

$$R_{\text{total}} = R_1 + R_2$$

The next circuit shows two resistors connected in parallel:



Parallel circuits always provide alternative pathways for current flow. The total resistance is calculated from:

$$R_{\text{total}} = \frac{R_1 \times R_2}{R_1 + R_2}$$

This is called the product over sum formula and works for any two resistors in parallel. An alternative formula is:

$$\frac{1}{R_{\text{total}}} = \frac{1}{R_1} + \frac{1}{R_2}$$

This formula can be extended to work for more than two resistors in parallel, but lends itself less easily to mental arithmetic. Both formulae are correct.

2.2.1.4 Variable Resistors

Unsurprisingly, variable resistors are resistors whose resistance can be varied. The variable resistors (called presets) have a metal wiper resting on a circular track of carbon. The wiper moves along the track as the preset is turned. The current flow through the wiper; and then; through part of the carbon track. The more of the track it has to go through the greater the resistance.



The presets have three legs. The top leg connects to the wiper and the other two legs to the two ends of the track. Generally only one of the track legs is actually used. Variable resistors are used in circuits to vary things that need changing, like volume etc.

2.2.2 Capacitors:

An electronic component that stores an electronic charge and releases it when required, it comes in a huge variety of sizes and types for use in regulating power as well as for conditioning, smoothing and isolating signals. Capacitors are made from many different materials, and virtually every electrical and electronic system uses them.

Capacitors act like tiny storage batteries made of two plates separated by a thin insulator or sometimes air. When one plate is charged negative and the other positive, they build up a charge that remains when the current is removed. When its power is required, the circuit is switched to conduct current between the two plates, and the capacitor releases its charge.



In general, a capacitor consists of two metal plates insulated from each other by a dielectric. The capacitance of a capacitor depends primarily upon its shape and size and upon the relative permittivity ε_r of the medium between the plates. In vacuum, in air, and in most gases, ε_r ranges from one to several hundred.

One classification of capacitors comes from the physical state of their dielectrics, which may be gas (or vacuum), liquid, solid, or a combination of these. Each of these classifications may be subdivided according to the specific dielectric used. Capacitors may be further classified by their ability to be used in alternating-current (ac) or directcurrent (dc) circuits with various current levels.

Capacitors are also classified as fixed, adjustable, or variable. The capacitance of fixed capacitors remains unchanged, except for small variations caused by temperature fluctuations. The capacitance of adjustable capacitors may be set at any one of several discrete values. The capacitance of variable capacitors may be adjusted continuously and set at any value between minimum and maximum limits fixed by construction. Trimmer capacitors are relatively small variable capacitors used in parallel with larger variable or fixed capacitors to permit exact adjustment of the capacitance of the parallel combination.

Made in both fixed and variable types, air, gas, and vacuum capacitors are constructed with flat parallel metallic plates (or cylindrical concentric metallic plates) with air, gas, or vacuum as the dielectric between plates. Alternate plates are connected, with one or both sets supported by means of a solid insulating material such as glass, quartz, ceramic, or plastic. Gas capacitors are similarly built but are enclosed in a leak proof case. Vacuum capacitors are of concentric-cylindrical construction and are enclosed in highly evacuated glass envelopes.

The purpose of a high vacuum, or a gas under pressure, is to increase the voltage breakdown value for a given plate spacing. For high-voltage applications, when increasing the spacing between plates is undesirable, the breakdown voltage of air capacitors may be increased by rounding the edges of the plates. Air, gas, and vacuum capacitors are used in high-frequency circuits. Fixed and variable air capacitors incorporating special design are used as standards in electrical measurements.

Solid-dielectric capacitors use one of several dielectrics such as a ceramic, mica, glass, or plastic film. Alternate plates of metal, or metallic foil, are stacked with the delectric, or the dielectric may be metal-plated on both sides.

A large capacitance-to-volume ratio and a low cost per microfarad of capacitance are chief advantages of electrolytic capacitors. These use aluminum or tantalum plates. A paste electrolyte is placed between the plates, and a dc forming voltage is applied. A current flows and by a process of electrolysis builds up a molecule-thin layer of oxide bubbles on the positive plate. This serves as the dielectric. The rest of the electrolyte and the other plate make up the negative electrode. Such a device is said to be polarized and must be connected in a circuit with the proper polarity. Polarized capacitors can be used only in circuits in which the dc component of voltage across the capacitors exceeds the crest value of the ac ripple.

Another type of electrolytic capacitor utilizes compressed tantalum powder and the baking of manganese oxide (MnO_2) as an electrolyte. Non polarized electrolytic capacitors can be constructed for use in ac circuits. In effect, they are two polarized capacitors placed in series with their polarities reversed.

Thick-film capacitors are made by means of successive screen-printing and firing processes in the fabrication of certain types of microcircuits used in electronic computers and other electronic systems. They are formed, together with their connecting conductors and associated thick-film resistors, upon a ceramic substrate. Their characteristics and the materials are similar to those of ceramic capacitors.

Thin-film dielectrics are deposited on ceramic and integrated-circuit substrates and then metallized with aluminum to form capacitive components. These are usually single-layer capacitors. The most common dielectrics are silicon nitride and silicon dioxide.



When electric charge accumulates on the plates, an electric field is created in the region between the plates that is proportional to the amount of accumulated charge. This electric field creates a potential difference $V = E \cdot d$ between the plates of this simple parallel-plate capacitor.



The electrons within dielectric molecules are influenced by the electric field, causing the molecules to rotate slightly from their equilibrium positions. The air gap is shown for clarity; in a real capacitor, the dielectric is in direct contact with the plates.



The capacitor's capacitance (C) is a measure of the amount of charge (Q) stored on each plate for a given potential difference or *voltage* (V) which appears between the plates:

$$C = \frac{Q}{V}$$

In SI units, a capacitor has a capacitance of one farad when one coulomb of charge causes a potential difference of one volt across the plates. Since the farad is a very large unit, values of capacitors are usually expressed in micro farads (μ F), nano farads (nF) or Pico farads (pF).

2.2.3 Semiconductors

Semiconductors are insulators that have a few loose electrons. They are partly able to conduct a current.

The free electrons in semiconductors leave behind a fixed positive charge when they move about (the protons in the atoms they come from). Charged atoms are called ions. The positive ions in semiconductors are able to capture electrons from nearby atoms. When an electron is captured another atom in the semiconductor becomes a positive ion.

These behaviors can be thought of as a 'hole' moving about the material, moving in just the same way that electrons move. So now there are two ways of conducting a current through a semiconductor, electrons moving in one direction and holes in the other. There are two kinds of current carriers.

The holes don't really move of course. It is just fixed positive ions grabbing neighboring electrons, but it appears as if holes are moving.



In a pure semiconductor there are not enough free electrons and holes to be of much use. Their number can be greatly increased however by adding an impurity, called a donor. If the donor gives up some extra free electrons we get an n-type semiconductor (n for negative). If the donor soaks up some of the free electrons we get a p-type semiconductor (p for positive). In both cases the impurity donates extra current carriers to the semiconductor.

In n-type semiconductors there are more electrons than holes and they are the main current carriers. In p-type semiconductors there are more holes than electrons and they are the main current carriers. The donor atoms become either positive ions (n-type) or negative ions (p-type).



The most common semiconductors are silicon (basically sand) and germanium. Common donors are arsenic and phosphorus.

When we combine n-type and p-type semiconductors together we make useful devices, like transistors and diodes and silicon chips.

2.2.3.1 Transistors

Transistors underpin the whole of modern electronics. They are found everywhere - in watches, calculators, microwaves, hi-fi's. A Pentium(tm) computer chip contains over a million transistors.

Transistors work in two ways. They can work as switches (turning currents on and off) and as amplifiers (making currents bigger). We'll only be looking at them as switches here. To understand them as amplifiers would involve a little mathematics.

Transistors are sandwiches of three pieces of semiconductor material. A thin slice of n-type or p-type semiconductor is sandwiched between two layers of the opposite type. This gives two junctions rather than the one found in a diode. If the thin slice is ntype the transistor is called a p-n-p transistor, and if the thin slice is p-type it is called a n-p-n transistor. The middle layer is always called the base, and the outer two layers are called the collector and the emitter.

We will consider the (more common) n-p-n transistor here, as used in the circuits. In a n-p-n transistor electrons are the main current carriers (because n-type material predominates).

When no voltage is connected to the base then the transistor is equivalent to two diodes connected back to back. Recall that current can only flow one way through a diode. A pair of back-to-back diodes can't conduct at all.

If a small voltage is applied to the base (enough to remove the depletion layer in the lower junction), current flows from emitter to base like a normal diode. Once current is flowing however it is able to sweep straight through the very thin base region and into the collector. Only a small part of the current flows out of the base.

The transistor is now conducting through both junctions. A few of the electrons are consumed by the holes in the p-type region of the base, but most of them go straight through.

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The difference between PNP and NPN transistors is that NPN use electrons as carriers of current and PNP use a lack of electrons (known as "holes"). Basically, nothing moves very far at a time.

One atom simply robs an electron from an adjacent atom so you get the impression of "flow". It's a bit like "light pipes". In the case of "N" material, there are lots of spare electrons. In the case of "P" there aren't. In fact "P" is gasping for electrons.

Now we can see how a transistor acts as a switch. A small voltage applied to the base switches the transistor on, allowing a current to flow in the rest of the transistor.



2.2.3.2 Diodes

A diode is like a one way valve for electrical current. Current can flow in one direction, and will be blocked in the other direction up to the diodes rated breakdown voltage.

Diodes of all types have two connections, an anode (A) and a cathode (K). With the exception of zener diodes, conventional current flow can only pass from the anode to the cathode and will always suffer a small drop in EMF. (usually about 0.6V) This effect is called forward voltage drop, forward because it occurs when the diode is forward biased.

A diode is often said to be forward biased or reverse biased, which can be quite confusing if you're not in the know. When the voltage on the anode is greater than the voltage on the cathode by the diodes forward voltage drop, current will flow from the anode to the cathode and the diode is said to be forward biased. If the difference between A and K is less than the forward voltage drop the diode will not conduct, voltages less than the forward voltage drop are therefore lost.

Likewise, when the voltage on the cathode is greater than the voltage on the anode the diode is said to be reverse biased and will not conduct. (With the exception of zener diodes)

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The four most common diode types are pictured below:



2.2.3.2.1 Power Diodes:

Diodes designed to withstand heavy loads are called power diodes. The most commonly used power diode is the 1N400x. (Where "x" is any number, e.g. 1N4004, 1N4001... etc) The 1N400x has a maximum rating of 1A and a voltage rating which varies with "x" but is almost always several hundred volts. 1N400x diodes all have a forward voltage drop of ~0.6V, as do most power diodes.

Power diodes are usually used in power supplies (for AC rectification or reverse power supply protection) but can be used in any situation where the "one way valve" operation of any diode is required with large current capacity.

2.2.3.2.2 Signal Diodes

Signal diodes have a different physical construction from other diode types in order to achieve very low forward voltage drops, commonly used is the modern equivalent of a "cats whisker" diode, where the diode junction is created by a thin wire resting on a semiconductor, this sort of diode is used to "detect" (rectify) AM radio signals without eliminating the signal like a power diode would.

Signal diodes work just like power diodes, but without the larger forward voltage drop. Use a signal diode to pass signals which are close to or less than 0.6V.

2.2.3.2.3Zener Diodes

Zener diodes are an exception to the diode rule. They pass forward current like a normal diode with a standard ~0.6V forward voltage drop, but will only block reverse current up to the "zener voltage" which is specific to individual parts. When the zener is exceeded while reverse biasing the diode, the diode junction will conduct and the excess voltage will appear on the anode. (i.e. the zener voltage is also the "reverse voltage drop")

This unusual behavior can be used to clamp a voltage level in a circuit. If the zener diode is connected with it's anode to ground and the cathode to the positive supply, voltages in excess of the zener voltage of the diode will be shorted to ground and not appear on the positive rail. This can also be applied to logic inputs to protect sensitive integrated circuits from voltage spikes or incorrect connections.



For more robust spike protection, place a small capacitor across the zener to absorb the transient voltages which can occur as the zener diode conducts. The larger the capacitor the more effective the circuit will be, but it will also have more effect on the rise time of voltages applied. If the circuit is required to pass high frequency signals, (like serial data) then capacitors should be smaller so they don't interfere with the signal timing.

2.2.3.2.4 Light Emitting Diodes

LEDs are diodes which glow a certain color when forward biased. The intensity with which they glow is roughly proportional to the current allowed to pass through the diode junction. LEDs typically have larger forward voltage drops than other diodes and require current limiting as the diode junction can only withstand small amounts of current. (~30mA) When a LED passes excessive current it will glow off color and heat up. If a red LED is glowing orange, it's about to open circuit and become useless plastic.

As this type of diode is more often used for emitting light than as a diode, much emphasis is placed on the visual appeal of most LEDs. You can get just about any color you want, in a variety of sizes and profiles, or even with more than one diode in the same package. Below is a picture of a tri-color LED in a standard 5mm package. The colors are red, green and blue and can be pulse width modulated to obtain just about any color.



Figure 2.14: Light emitting diodes.

Because LEDs can only withstand small amounts of forward current, they should always be used with a series resistor. The correct resistor for the voltage being used can be calculated with ohm's law.

2.2.4 Batteries

Battery is electric device that converts chemical energy into electrical energy, consisting of a group of electric cells that are connected to act as a source of direct current.

Batteries provide the power for the circuits, the source of this power is a chemical reaction; chemicals within the battery react with each other and release electrons, these electrons flow around the circuit connected to the battery and make things happen.

Electrons flow out of the negative terminal of the battery, through the wires and components of the circuit, and then back into the positive battery terminal.

It takes energy to do this and so eventually all the energy in the battery is used up. Occasionally the acid in the battery messily leaks out before it has been used and the battery has to be discarded.

2.2.5 Loudspeaker

A loudspeaker, or speaker, is an electromechanical transducer which converts an electrical signal into sound. The term loudspeaker is used to refer to both the device itself, and a complete system consisting of one or more loudspeaker drivers (as the individual units are often called) in an enclosure.

The loudspeaker is the most variable element in an audio system, and is responsible for marked audible differences between systems.



Figure 2.14: Loud speaker.



The lead wires as shown are for illustration purposes. Commonly the voice coil wires are soldered to the lead wires and the soldered joints are glued to the diaphragm, close to the dust-cap periphery.

2.2.6 Switches

A switch is a device for changing the course (or flow) of a circuit. The prototypical model is a mechanical device (for example a railroad switch) which can be disconnected from one course and connected to another. The term "switch" typically refers to electrical power or electronic telecommunication circuits. In applications

where multiple switching options are required (e.g., a telephone service), mechanical switches have long been replaced by electronic variants which can be intelligently controlled and automated.

The switch is referred to as a gate when abstracted to mathematical form. In the philosophy of logic, operational arguments are represented as logic gates the use of electronic gates to function as a system of logical gates is the fundamental basis for the computer, i.e., a computer is a system of electronic switches which function as logical gates.



Figure 2.16: Switches types

A selection of modern electrical switches Bottom, left to right: common household wall switch, miniature toggle switch, in-line switch, push-button switch, rocker switch, micro switch. Top, left to right: circuit breaker, mercury switch, wafer switch, DIP switch, surface mount switch, reed switch.

2.2.7 The schematic Symbols



2.3 Safety Guidelines

1- Before using any electrical instrument, read the data sheet, and then use it in the circuit.

2- When we connect it in any circuit, be careful with the polarities of the power source.

3- Be careful with chip pins (IC) when we plant them in the board not to break them.

4- Watch out of breaking the electrical components (capacitors, resistors and led) while placing them in the circuit.

5- Make sure that the transistor pins (base, emitter, and collector) not to break and mix them which causes damage to the transistor.

6- Its very important to discharge capacitors in equipment before working on the circuits, because large capacitors found in many laser flash lamps and other systems are capable of storing lethal amounts of electrical energy and pose a serious danger even if the power source has been disconnected.

7- Be careful when shifting probes in a live/active circuit, be sure to shift using only one hand: It is best to keep the other hand off other surfaces and behind your back.

8- When you are working on a design project and planning to work for higher voltage equal to or greater than 50 volts, notify your instructor and obtain their approval before proceeding.

9- Turn off the power source after we finished using it.

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CHAPTER THREE



AUDIO AMPLIFIRE DESIGN

3.1 Overview

This chapter will talk about the construction and the operation of a class AB stereo for quality hi-fi applications using a TDA2005 module, and it will go through the circuit components and specification.

3.2 Audio power amplifier

This circuit [Fig.3.4] is a class AB stereo audio power amplifier for quality hifi applications using a TDA2005 module. It has a minimum of external components. The module has output current protection and thermal protection. This circuit produces an excellent sound. The supply voltage required for it is 9V-18V DC at 1 to 2 Amps.

Maximum output power will only be obtained with a power supply of at least 2A at 15V DC, and using 2 Ohm speakers or 2 by 4 Ohm speakers in parallel.

However approximately 4W/ch. can be obtained with only a 15V DC, 1A supply into 40hm loads.

The power supply should be well filtered to reduce mains hum, the on board capacitors alone are not enough for this purpose but are necessary to ensure stability, and extra filtering is unnecessary if operating from battery.

3.3 TDA2005 Features

- 1_ short circuit protection
- 2_Thermal protection
- 3_Low power consumption
- 4_Good stability
- 5_Gain is internally set to 31dB

3.3.1 TDA2005 Pin configuration

As any IC, TDA2005 has many pins, where each pin has its own function and connection. It consists of 11 legs as shown in figure [3.1], each five on a side. And the table below shows the suitable kind of connection for each pin:

Pin number	Pin name
]	INPUT +1
2	INPUT +2
3	SVRR
4	INPUT -2
5	INPUT +2
6	GND
7	BOOTSTRAP 2
8	OUTPUT 2
9	+VS
10	OUTPUT 1
11	BOOTSTRAP 1

Table 3.1: Pin configuration



The figure [3.2] shows a picture of TDA2005, as we can see that its quiet small, and don't take any space in the circuits, and its easy to be placed on any board.



3.3.2 TDA2005 Schematic diagram



Figure 3.3: TDA2005 Inner Schematic diagram

3.3.3 TDA2005 specification

These are the TDA2005 specification:

Ta	able 3.2: TDA2005 Specification
1_Power Supply	9-18V at 1-2 A
2 Power output	>6W RMS/ch.at 40hm 16V DC supply
	>4W RMS/ch.at 40hm 12V DC supply
3_THD	<0.1% @ 1W, 40hm
	0.018% at 1W RMS @ 4 ohm and +15V supply
4_Frequency resp	onse ~15 Hz to 50 kHz, -3 dB
5_S/N ratio	>80 dBA
6_Input level	~160 mV for full output
7_Gain	~31 dB maximum

3.4 Circuit construction

Following the printed circuit overlay with the reference to the circuit diagram where necessary. While placing the electrical component it was important to add the lowest height components to the board, starting with the resistors.

And to avoid any damage in the capacitors, or other part of the circuit, it was so important to get the electrolytic capacitors in the correct way around all parts in their correct positions.

And it was necessary to connect the power supply to earth, so it reduces earth current on the board and the lowers the distortion by a worthwhile amount. The circuit how ever will perform adequately without it.

3.4.1 Circuit operation

The C4-5 are input coupling capacitors and block DC, as do C9-13 which are the output coupling capacitors, and C8-12 which block DC from the feedback loop to the differential inputs.

R2-3 and R4-5 set the level of feedback. C9/R6 and C13/R7 provide a high frequency load for stability where loudspeaker inductive reactance may become excessive. C1-2 provides power supply decoupling or filtering.

The gain is equal to 1 + (R2/R3) = 1 + (R4/R5) = 37, or 31dB, minus any input attenuation. Reducing the feedback resistors R3 and R5 may increase the gain. The maximum supply voltage circuit is 18V. Checking the polarity before connecting to the circuit to the power supply voltage is important.

Some trouble were found in getting this circuit to work, but after checking all the external wiring, and making sure that there is no shorts and checking all the components positions and orientation, and confirming all wires joints and being certain that there are no dirty joints, the circuit worked smoothly, with no problems.

3.4.2 Circuit Schematic diagram

Constructing any circuit is impossible without its schematic diagram, where each value of any component should be shown on it, or at least each component should be represented with a number which is connected to a table that shows the specific numbered component value.

The figure below stands for my audio power circuit, it consists of an nine resistors (including two variable resistors) with values varied between 10hm up to 120 k Ohm, and thirteen capacitor with values between 2.2 uf up to 2200 uF, and one IC (TDA2005).

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IN1-IN2 stands for the circuit audio signal input, and (J1 1-JL 2) stand for circuit DC input voltage, and J3 1-J3 3 stands for the circuit signal output.



3.4.3 Circuit components

This circuit was constructed with minimum number of components, and the table below shows the number of each kind of the component, and the value of each of them. Where it needed an nine resistors (including two variable resistors) with values varied between 10hm up to 120 k Ohm, and thirteen capacitor with values between 2.2 uf up to 2200 uF, and one IC (TDA2005).

The Resistors		
R1	Brown Red Yellow	120Kohm 1/2W 5%
R2-4	Brown Red Red	1.2Kohm 1/2W 5%
R3-5	Orange Orange Black	33 ohm 1/2W 5%
R6-7	Brown Black Gold	1 ohm 1/2W 5%
RV1	Red Brown Orange	2X10Kohm Log. Pot
The Capacitors	:	
C1-C9-13	100nF 100V MKT	
C2	220uF 25V	
C3	10uF 25V	
C4-5	2.2uF 25V	
C6-10	100uF 25V	
C7-11	2200uF 16V	
C8-12	220uF 25V	
Terminal block	:	
J1	2 Pole Terminal Block	
J2-3	3 Pole Terminal Block	
IC :	· · · · · · · · · · · · · · · · · · ·	
IC 1	TDA2005	

Table 3.3: Circuit components

3.4.4 Photo for the completed circuit



Figure 3.5: Photo showing the complete circuit of TDA2205 audio amplifier

CONCLUSION

This project included three chapters, first chapter was an introduction to the project, and it went through the entire project briefly. In the second chapter the electronic components that are commonly used in hardware projects are presented, and how they function and the way they must be connected.

The last chapter presented comprehensive general information on the stereo amplifier circuit, and it went through the specification of the TDA2005, and the circuit construction and operation. By applying the safe guide line in chapter one, the circuit worked smoothly with no problems at all.

The Maine aims of this project were to amplify the audio signal as big as possible, with less electrical components. And to understand the electronic components that are commonly used in hardware projects like some semiconductors, capacitors and resistors. Plus understanding the characteristic of the audio amplifier circuit, and the specification and configuration of TDA2005, and learn more about how I can protect my self and the circuit during constructing it. Last thing was to provide my self with enough knowledge that I will use in the practical work that will help me in the future in my career.

I found out that approximately 4W/ch. can be obtained with only a 15V DC, 1A supply into 40hm loads. However to get the best sound quality the power supply should be well filtered to reduce mains hum, the on board capacitors alone are not enough for this purpose but are necessary to ensure stability, and extra filtering is unnecessary if operating from battery.

A small suggestion for further improvement, I think that it can be achieved on TDA2005, by decreasing its space, and decreasing the needed input power, for less power consumption and more space on board.

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