NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Electrical and Electronic Engineering

AUDIO POWER AMPLIFIER

Graduation Project
EE- 400

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Lefkoşa - 2003

ACKNOWLEDGMENT

First, thanks to my god for giving me courage and ability in fulfilling my project. Then I would like to thank my project's advisor Assoc. Prof. Dr Adnan Khashman for his faithful guidance and his useful tips. In addition, I appreciate the nice supporting of Mr Kamil Dimililer in the practical working of the project.

Moreover, where the words are not enough to thank them "My Family". They have done a great job to push me through my education life. And thanks a lot to my dears brothers who encouraged me to complete my project. And I'm proud of being taught under a qualified teachers who showed me how to see the view of the engineering and to know the meaning of it.

ABSTRACT

Obviously one should take reasonable care in handling all components, especially nowadays when so many are of small size to be used in constructing the electronic projects.

Designer should design electronic products with having the verifying the aim of the electronic safety guidelines because different currents and voltages have different effect to human being.

There is difference between the audio amplifier and the other amplifiers types is in the amplifier frequency response. And the audio amplifiers can be classified in two categories as Single-stage audio amplifiers & Phase splitters.

The LM38ON has been a very popular device since it first became available to the home-constructor, and the reasons for this are its good quality output, and the very small number of discrete components needed to turn it into a practical audio amplifier.

This project briefly has a circuit of simple audio power amplifier using LM380N that provides an output of power of about 200 mW RMS and has an input sensitivity of about 50 mV RMS into 100 k for maximum output.

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INTRODUCTION

When people refer to "amplifiers," they're usually talking about stereo components or musical equipment. But this is only a small representation of the spectrum of audio amplifiers. There are actually amplifiers all around us. You'll find them in televisions, computers, portable CD players and most other devices that use a speaker to produce sound.

Amplifiers can be very complex devices, with hundreds of tiny pieces, but the basic concept behind them is simple. You can get a clear picture of how an amplifier works by examining the most basic components.

Amplifiers do not actually increase the strength of an electronic signal. What happens instead? The signal is copied and enlarged. There are different schemes for amplifying the signal. There are different classes of amplifiers. These classes are A, AB, and C. There have been some special classes such as G, created by Hatachi. Class H created by Soundcraftsman. Class D for the so-called digital amps and Class T for Tripath's digital amplifiers. [0]

Chapter 1: Presents the most important electronic components characteristics with explaining some essential concepts of the electrical safety guidelines.

Chapter 2: The single-state audio amplifiers and the phase splitters are explained with schematic diagrams.

Chapter 3: Contains general description about the LM380N with its practical characteristics also, it describes the circuit of the simple audio amplifier that has been built practically with its components.

Chapter 4: It explains the practical procedures that have been done in the simple audio amplifier circuit with its calculations and its components prices.

1. ELECTRONIC COMPONENTS

1.1 Overview

This chapter presents the most important electronic components characteristics, their properties and so many things related generally with circuitry. In addition, it contains essential concepts of the electrical safety guidelines. This chapter is also important due to the brilliance that it introduces about the careful handling for the electrical components.

1.2 Component Handling Precautions

Most constructors know that electrical components need careful handling but some, especially beginners, may not know just what may cause damage and what precautions to take. Obviously one should take reasonable care in handling all components, especially nowadays when so many are of small size, but certain components can be damaged by high voltage static charges. It is easy for these to occur without evidence of their presence, because they are generated by friction between insulating materials, and because so many different plastic materials with very low conductivity are in common everyday use. For instance, if I walk across the nylon carpet from the door of my study to the desk, I can accumulate a static charge of several hundred volts. It has been said in relation to humans that it is the current that kills, and you may have seen demonstrations in which sparks can be drawn from a person who has been charged from an electrostatic generator. However, it is the voltage that is lethal to electronic devices. Now some identifying of various components used in the electrical projects. [1]

1.2.1 Resistors

Resistors are electronic components used extensively on the circuit boards of electronic equipment. Resistors are usually used to limit current, attenuate signals, dissipate power (heating) or to terminate signal lines. Resistors are usually color coded with stripes to reveal their resistance value (in ohms) as well as their manufacturing tolerance.

Most important characteristics of a resistor are the resistance, tolerance of resistance and the power handling capacity. Resistors are generally available from the fractions of ohms up to several megaohms (higher value special components are also available). Most small general-purpose resistors have power handling capacity of around 0.25W. Most resistors used to be this type, and most electronics designs expect this kind of resistor unless the power rating is mentions. In typical circuits, you can nowadays see resistors with power handling of 0.125W up 1W. In addition, special power resistors are available, generally with power rating from few watt up to 50-100W. Highest power resistors are generally built to metal case that is designed to be connected to a heatsink.

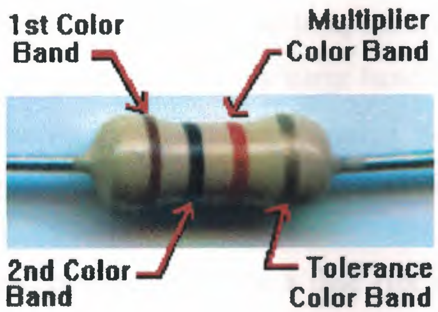


Fig.1.1- Resistor codes

The resistors are manufactured with some tolerance. For example, a typical resistor can have a 5% tolerance, which means that the resistance value can be 5% higher or 5% lower than what the color code indicated. There are special accurate resistors also available, for example resistors with 1% or better accuracy. [2]

There are many different resistor types that are characterized by the material they are made of and how they are constructed. Here are some details of different resistor types:

• Carbon film resistor: cheap general purpose resistor, works quite well also on high frequencies, resistance is somewhat dependent on the voltage over resistor (does not generally have effect in practice)

• Composite resistor: Usually some medium power resistors are built in this way. Has low inductance, large capacitance, poor temperature stability, noisy and not very good long time stability. Composite resistor can handle well short overload surges.

• Metal film resistor: good temperature stability, good long time stability, cannot handle overloads well.

• Metal oxide resistor: mostly similar features as metal film resistor but better surge handling capacity, higher temperature rating than metal film resistor, low voltage dependently, low noise, better for RF than wire wound resistor but usually worse temperature stability

• Thick film resistor: Similar properties as metal film resistor but can handle surges better, and withstand high temperatures.

• Thin film resistor: good long time stability, good temperature stability, good voltage dependently rating, low noise, not good for RF, low surge handling capacity

• Wire wound resistor: used mainly for high power resistors, can be made accurate for measuring circuits, high inductance because consists of wound wire.

In some applications, resistors are used like a fuse (for example in some power supplies and telecom applications). In those applications, the resistor burns up when it is overloaded. In this type of application non-flammable resistor are used to avoid the flames and risk of fire. If the application calls for non-flammable resistor (usually has white case), do not replace it with any other type. Sometimes special resistors designed to be used as fuses are called fusible resistors.

How to read Resistor Color Codes:

1- First the code:

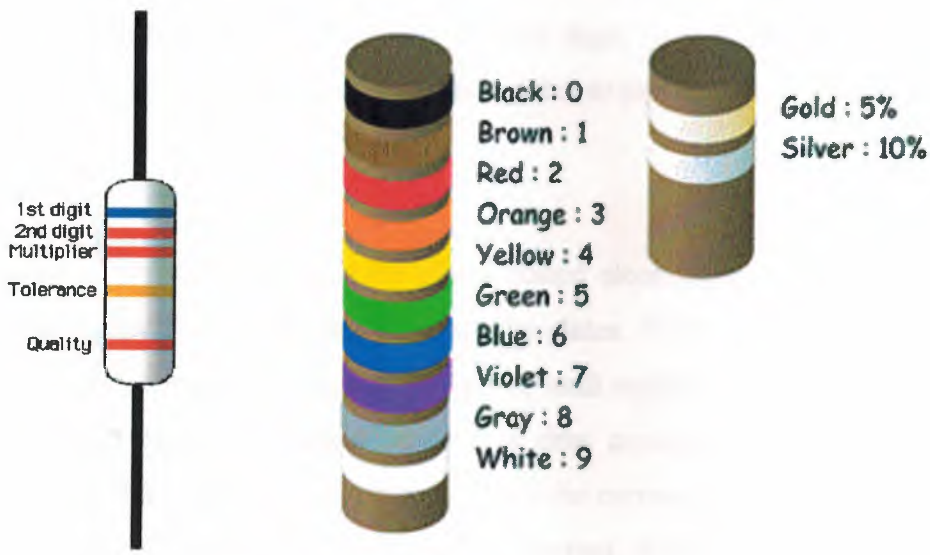


Fig.1.2 Resistors color coding concepts

2- How to read the 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 six.
- 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) 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.

1.2.2 Capacitors

A capacitor is simply two charged plates placed close together with a dielectric (non-conducting) material sandwiched between the plates. When a charge is applied to one plate, it repels charges on the opposite plate, until equilibrium is established. For direct current, the capacitor charges up with a time constant that depends on the capacitance value and the impedance through which the current flows into the capacitor. Once the capacitor is fully charged, no more current flows. This means that the capacitor is an effective block for direct current. For alternating current (like audio signals), the response is more complicated. The charge that develops on the capacitor depends on how fast the current is changing. It takes time for the charge to build up, and that time results in a frequency dependent delay (or phase shift) in the output signal.

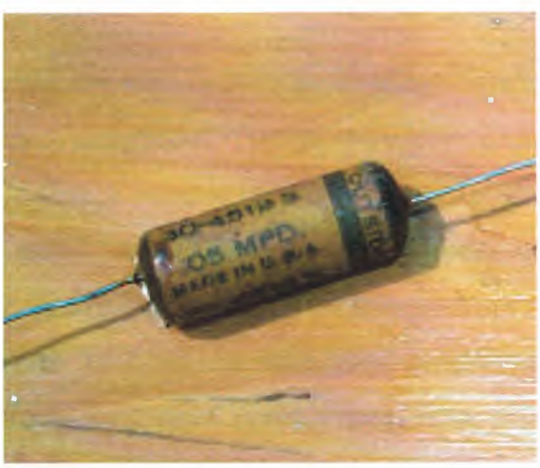


Fig.1.3 Capacitor

Capacitor device is often used to store charge in an electrical circuit. A capacitor functions much like a battery, but charges and discharges much more efficiently. A basic capacitor is made up of two conductors separated by an insulator, or dielectric. The dielectric can be made of paper, plastic, mica, ceramic, glass, a vacuum or nearly any other nonconductive material.

Capacitor electron storing ability (called capacitance) is measured in Farads. One Farad is actually a huge amount of charge (6,280,000,000,000,000,000 electrons to be exact), so we usually rate capacitors in microfarads (uF = 0.000, 001F) and Pico farads (pF = 0.000, 000,000,001F). Capacitors are also graded by their breakdown (i.e., smoke) voltage.

There are very many different capacitors. You have to realize that not all capacitors are equal. A 1uF ceramic definitely is NOT the same thing as a 1uF tantalum. You choose the device according to the application. [3]

Two 'parasitic' effects of capacitors are 'effective series resistance' (ESR) and series inductance. High ESR will cause power loss in higher-frequency applications (caps will get hot) especially in switching power supplies. High ESR also limits the effective filtering (your power supplies end up with more ripple). Except for very high frequency (multi-megahertz) applications, a high inductance isn't quite so critical.

The rated DC voltage is also very important. Usually it is a good idea to select capacitors rated at least 1.5 times or twice the maximum voltage you think they'll ever see. Temperature ratings also exist.

The most common types are ones built using standard capacitor plates + insulator and then there are electrolytic capacitors. Typical capacitors consist of some form of metal plates and suitable insulation material in between those plates. This insulation can be some form of plastic, paper, mica, ceramic material, glass or air (some physical separation between layers). Those metal plates used in capacitors are usually thin metal foils. This type of capacitors have usually very good propertied otherwise, but the available capacitance is usually quite small (usually goes from pF to few microfarads). This kind of capacitors can take easily DC at both polaritied and AC without problems. This type of capacitors is available with various voltage ratings from few tens of volts up to few kilovolts as ready-made components. For special application, same technique can be used for very high voltage capacitors.

Here is an overview of most common capacitor types:

- Ceramic: Fairly cheap but not available in really high capacitances - 2uF-10uF are about the max for any practical devices. Extremely low ESR. Surface mount devices have essentially no series inductance and are commonly used to bypass high-frequency noise away from digital IC's. Not polarized.
- Electrolytic: Cheapest capacitance per dollar, but high ESR. Mostly used for 'bulk' power supply. Typical values 1uF-5000+uF. Polarized. Fairly durable, but will literally explode if reverse-biased. Tolerances of +-10% and +-20% are not uncommon.
- Tantalum: The 'cadallac' of capacitors. Very low ESR (not as low as ceramic, though), very high capacitance values available, but expensive (10x electrolytic). Usually used where one might use electrolytics. Polarized.
- Polyester: Kind expensive, not very high capacitance values, ESR not too bad. Polyester capacitors have very stable temperature characteristics (capacitance change is very small as temperature changes). Used where stable capacitance is important like oscillators and timers. NOT polarized.

There are others, of course, such as 'X' caps made to connect directly across mains AC power supplies that literally 'heal' themselves after an overvoltage. There are also so called 'Y' capacitors, which are used in mains filters where they are connected between ground and live neutral connectors. Y-capacitors have special safety regulations related to them.

For power supply smoothing capacitor applications, where large capacitances are needed, aluminum electrolytic capacitors are the most common choice.

In audio applications, type of insulation material does make a difference. For audio applications IIRC, ceramic, high-end hifi people consider all paper, mica, electrolytic and tantalum inferior. The plastic-film kind (especially polystyrene) are the preferred dielectric in very high quality audio applications.

ESR acts like a resistor in series with a capacitor (thus the name Equivalent Series Resistance). This resister can cause circuits to fail that look just fine on paper and is often the failure mode of capacitors. While ESR is undesirable, all capacitors exhibit it to some degree.

Capacitors types:

Fig.1.4 ceramic-capacitor - Fig.1.5 polyester-capacitor - Fig.1.6 tantalum-capacitor

1.2.3 Semiconductor

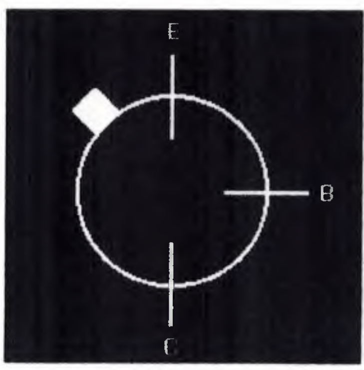
A semiconductor is a substance, usually a solid chemical element or compound that can conduct electricity under some conditions but not others, making it a good medium for the control of electrical current. Its conductance varies depending on the current or voltage applied to a control electrode, or on the intensity of irradiation by infrared (IR), visible light, ultraviolet (UV), or X rays.

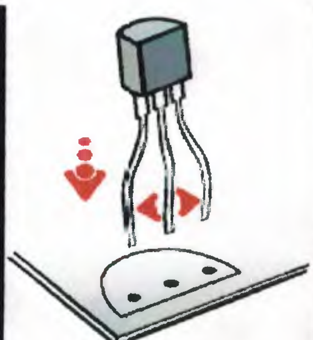
The specific properties of a semiconductor depend on the impurities, or *dopants*, added to it. An *N-type* semiconductor carries current mainly in the form of negatively charged electrons, in a manner similar to the conduction of current in a wire. A *P-type* semiconductor carries current predominantly as electron deficiencies called holes. A hole has a positive electric charge, equal and opposite to the charge on an electron. In a semiconductor material, the flow of holes occurs in a direction opposite to the flow of electrons.

Elemental semiconductors include antimony, arsenic, boron, carbon, germanium, selenium, silicon, sulfur, and tellurium. Silicon is the best known of these, forming the basis of most integrated circuits (ICs). Common semiconductor compounds include gallium arsenide, indium antimonide, and the oxides of most metals. Of these, gallium arsenide (GaAs) is widely used in low-noise, high-gain, and weak-signal amplifying devices.

A semiconductor device can perform the function of a vacuum tube having hundreds of times its volume. A single integrated circuit (IC), such as a microprocessor chip, can do the work of a set of vacuum tubes that would fill a large building and require its own electric generating plant.

Fig.1.6 Transistor-family-shot





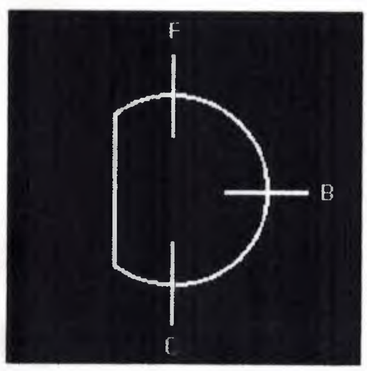


Fig.1.7 Transistor-metal - Fig.1.8 Transistor construction - Fig.1.9 Transistor-plastic

1.2.4 Integrated circuits

Integrated circuits are miniaturized electronic devices in which a number of active and passive circuit elements are located on or within a continuous body of material to perform the function of a complete circuit. Integrated circuits have a distinctive physical circuit layout, which is first produced in the form of a large-scale drawing, later reduced, and reproduced in a solid medium by high precision electro chemical processes. The term "integrated circuit" is often used interchangeably with such terms as microchip, silicon chip, semiconductor chip, and micro-electronic device.

1.2.5 MOSFET

MOSFET (metal-oxide semiconductor field-effect transistor, pronounced MAWS-feht) is a special type of field-effect transistor (FET) that works by electronically varying the width of a channel along which charge carriers (electrons or holes) flow. The wider the channel, the better the device conducts. The charge carriers enter the channel at the *source*, and exit via the *drain*. The width of the channel is controlled by the voltage on an electrode called the *gate*, which is located physically between the source and the drain and is insulated from the channel by an extremely thin layer of metal oxide.

A MOSFET can function in two ways. The first is known as *depletion mode*. When there is no voltage on the gate, the channel exhibits its maximum conductance.

Fig.1.10 MOSFET models

The MOSFET has certain advantages over the conventional junction FET, or JFET.

Because the gate is insulated electrically from the channel, no current flows between the gate and the channel, no matter what the gate voltage (as long as it does not become so great that it causes physical breakdown of the metallic oxide layer). Thus, the MOSFET has practically infinite impedance. This makes MOSFETs useful for power amplifiers. The devices are also well suited to high-speed switching applications. Some integrated circuits (ICs) contain tiny MOSFETs and are used in computers.

Because the oxide layer is so thin, the MOSFET is susceptible to permanent damage by electrostatic charges. Even a small electrostatic buildup can destroy a MOSFET permanently. In weak-signal radio frequency (RF) work, MOSFET devices do not generally perform as well as other types of FET.

1.2.6 Diodes

Diodes are non-linear circuit elements. Qualitatively we can just think of an ideal diode has having two regions: a conduction region of zero resistance and an infinite resistance non-conduction region. For many circuit applications, this ideal diode model is an adequate representation of an actual diode.

The behavior of a (junction) diode depends on its polarity in the circuit. If the diode is reverse biased (positive potential on N-type material), the current through the diode is very small. A forward-biased diode (positive potential on P-type material) can pass lots of current through it would much resistance (only a small voltage drop).

Diodes are very often used in power supplies for rectifying applications. A typical method of obtaining DC power is to transform, rectify, filter and regulate an AC line voltage. In power supply applications it is common to use a transformer to isolate the power supply from the 110 V AC or 230V AC line. A rectifier can be connected to the transformer secondary to generate a DC voltage with little AC ripple.

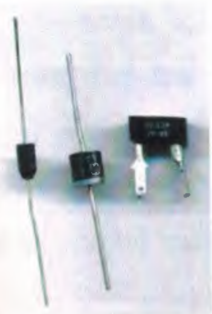


Fig.1.11 Diode technical shape – Fig.1.12 some diode models

There are several other types of diodes beside the typical junction diode. The Zener Diode is a special diode, where Zener breakdown occurs when the electric field near the junction becomes large enough to excite valence electrons directly into the conduction band. This means that a zener diode passes current through it in reverse direction when voltage is high enough (the zener voltage).

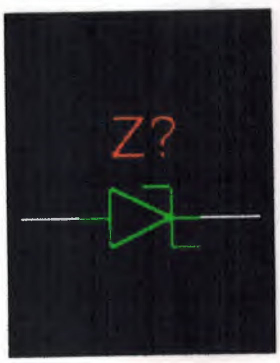


Fig.1.13 Zener diode

Zener diodes are typically used as voltage reference components in measuring circuits, as voltage regulators in some low power supplies and as over-voltage protection devices.

Light-emitting diodes (LED) emit light in proportion to the forward current through the diode. LEDs are low voltage devices that have a longer life than incandescent lamps. They respond quickly to changes in current (many can easily go up to 10 MHz). LEDs have applications as visible indicators in devices and in optical-fiber communication. LEDs produce a narrow spectrum of visible) many colors available) or infrared light that can be well collimated.

Fig.1.14 LED-board

Light-Sensitive Diodes indicate light of a proper wavelength. Photo-diodes or photocells can receive light signals. LEDs and photodiodes are often used in optical communication as receiver and transmitter respectively.

1.3 Electricity Safety Guidelines Information

Different currents and voltage have different effect to human being. Generally, the current is what determines the danger to human. The used voltage with some other things (for example skin resistance) generally determines what is dangerous and what not. Generally, the AC voltage in 40...50 Hz is very dangerous to human. A current that is less that 10 mA is not dangerous to most people. Alternating current (AC) in range of 70...110 mA and direct current (DC) in the range of 200...250 mA is considered to be very dangerous and lethal if it goes through the chest (where the heart is). The impedance of human from one hand-to-hand is generally in the range of 600...6000 ohms depending on the skin moisture level and the amount of current flowing. Voltages below 20V can be considered safe to touch (the current does not exceed 10 mA in normal conditions). If the skin is dry, voltages up to around 80V do not cause over 30 mA current. [5]

There are two classes of insulation:

- Class I: single insulation, which requires three core mains cable with earth.
- Class II: double insulation, which requires no earth.

Class I characteristics:

- Insulation between mains and every touchable part must withstand flashover voltage of 220V.
- The distance between mains voltage carrying parts and touchable parts must be at least 3 mm.
- All touchable conducting parts must be properly earthed.

Class II characteristics:

- Insulation between mains and every touchable part must withstand flashover voltage of 240V.
- The distance between mains voltage carrying parts and touchable parts must be at least 6 mm.

If you are designing electronics product you should aim for making your products class II. They are easier to sell abroad. If you need to provide the equipment as class 1 you should be very clear in the installation instructions of the correct methods for wiring the equipment to a supply.

When the power switch is not required?

Power on/off switch is not required if the power consumption of the equipments is less than 10W or if the equipment is intended for continuous use.

Three rules when working with line powered electronics equipments

- Rule 1: switch the power off
- Rule 2: work with one hand
- Rule 3: keep the other hand behind your back

When working with electronic devices (repairing etc.) switch then off and disconnect from the mains. When you need to test live circuits, use properly sheathed probes and power the device through protection device such as isolation transformer. When working with mains voltage or higher voltage, make sure that there is someone else in the room and that he or she knows what you are doing.

In normal operation electronics, devices are designed such that they are safe to use. The insulation inside electronics devices must be good enough to withstand the mains voltage and overvoltage links. Even though there is insulation, there is always some leakages and potential for failures.

Class I devices are designed to have grounded metal case, which keep the leakage out of reach and burns mains fuse if there is short circuit to case. Class II equipment is designed to work without grounding. They have thicker insulation in wires and components connected to mains. Leakage current from Class II equipment is limited low so that it is safe to touch, and I think we don't have to care of electric shock too much when using correctly designed Class II equipment alone.

1.4 Summery

In this chapter, plenty of information about some essential electronic components presented and illustrated clearly, in addition of the electrical safety guidelines section.

2. AUDIO AMPLIFIERS

2.1 Overview

In this chapter, the single-state audio amplifiers and the phase splitters are explained with schematic diagrams of several audio amplifiers will be shown and the functions of each of the components will be discussed.

2.2 Basic Audio Amplifiers Information

The difference between an audio amplifier and other amplifiers is the frequency response of the amplifier. The audio amplifier can be classified in two categories as Single-stage audio amplifier & Phase splitters. An audio amplifier has been described as an amplifier with a Frequency response from 15 Hz to 20 kHz. The Frequency response of an amplifier can be shown graphically with a Frequency response curve. Fig.2.1 is the ideal Frequency response curve for an audio amplifier. This curve is practically "flat" from 15 Hz to 20 kHz. This means that the gain of the amplifier is equal between 15 Hz and 20 kHz. Above 20 kHz or below 15 Hz the gain decreases or "drops off" quite rapidly. The Frequency response of an amplifier is determined by the components in the circuit. [6]

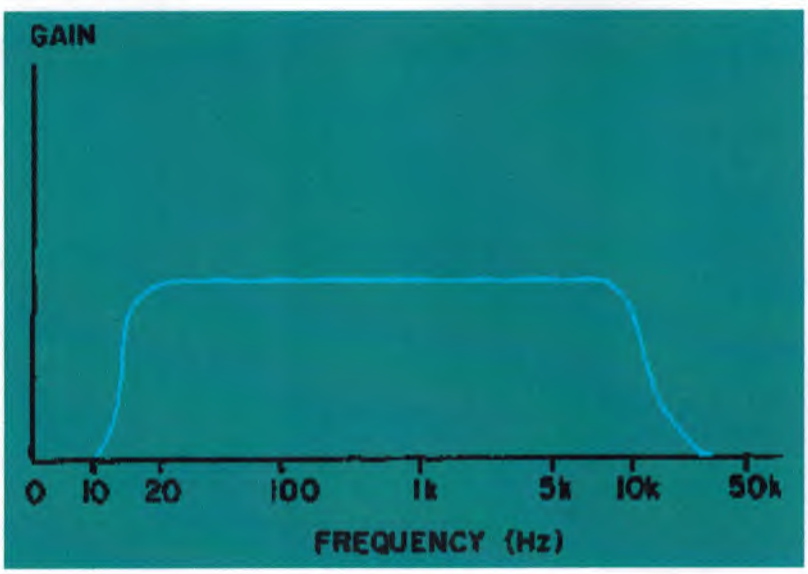


Fig. 2.1 Ideal Frequency response curve for an audio amplifier

The transistor itself will respond quite well to the audio frequency range. No special components are needed to extend or modify the Frequency response.

2.3 Single-Stage Audio Amplifiers

The first single-stage audio amplifier is shown in Fig.2.2. This circuit is a class A, common-emitter, RC-coupled, transistor, audio amplifier. C1 is a coupling capacitor that couples the input signal to the base of Q1. R1 is used to develop the input signal and provide bias for the base of Q1. R2 is used to bias the emitter and provide temperature stability for Q1. C2 is used to provide decoupling (positive feedback) of the signal that would be developed by R2. R3 is the collector load for Q1 and develops the output signal. C3 is a coupling capacitor that couples the output signal to the next stage. V_{CC} represents the collector-supply voltage. Since the transistor is a common-emitter configuration, it provides voltage amplification. The input and output signals are 180° out of phase. (The input and output impedance are both medium.)

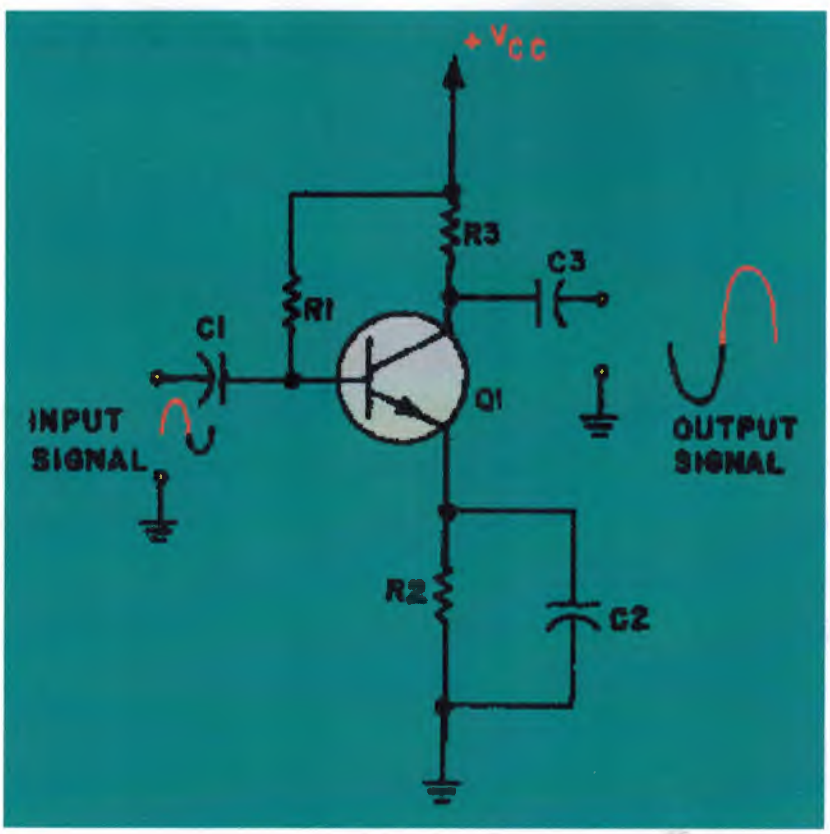


Fig. 2.2 Transistor audio amplifier

The second single-stage audio amplifier is shown in Fig.2.3. This circuit is a class A, common-source, RC-coupled, FET, audio amplifier. C1 is a coupling capacitor that couples the input signal to the gate of Q1. R1 is used to develop the input signal for the gate of Q1. R2 is used to bias the source of Q1. C2 is used to decouple the signal developed by R2 (and keep it from affecting the source of Q1). R3 is the drain load for Q1 and develops the output signal. C3 couples the output signal to the next stage. V_{DD} is the supply voltage for the drain of Q1. Since this is a common-source configuration, the input and output signals are 180° out of phase.

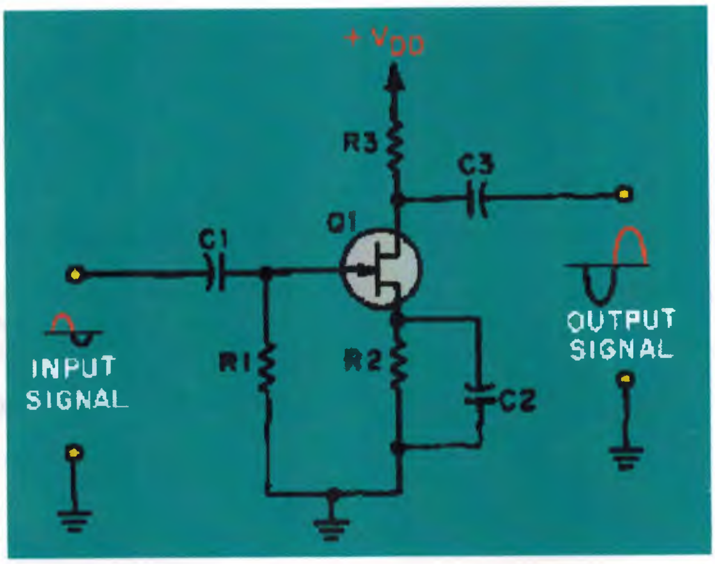


Fig. 2.3 FET audio amplifier

The third single-stage audio amplifier is shown in Fig.2.4. This is a class A, common-emitter, transformer-coupled, transistor, audio amplifier. The output device (speaker) is shown connected to the secondary winding of the transformer. C1 is a coupling capacitor, which couples the input signal to the base of Q1. R1 develops the input signal. R2 is used to bias the emitter of Q1 and provides temperature stability. C2 is a decoupling capacitor for R2. R3 is used to bias the base of Q1. The primary of T1 is the collector load for Q1 and develops the output signal.

T1 couples the output signal to the speaker and provides impedance matching between the output impedance of the transistor (medium) and the impedance of the speaker (low).

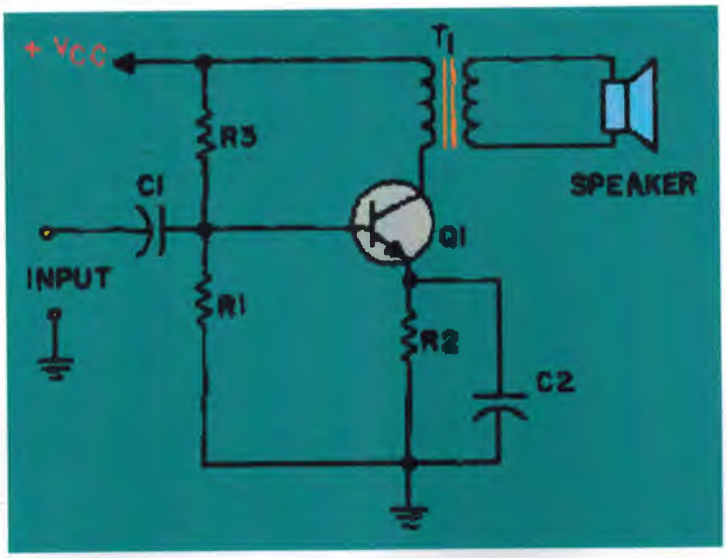


Fig.2.4 Single-stage audio amplifier

2.4 Phase Splitters

Sometimes it is necessary to provide two signals that are equal in amplitude but 180° out of phase with each other. The two signals can be provided from a single input signal by the use of a phase splitter. A phase splitter is a device that produces two signals that differ in phase from each other from a single input signal. Fig.2.5 is a block diagram of a phase splitter.

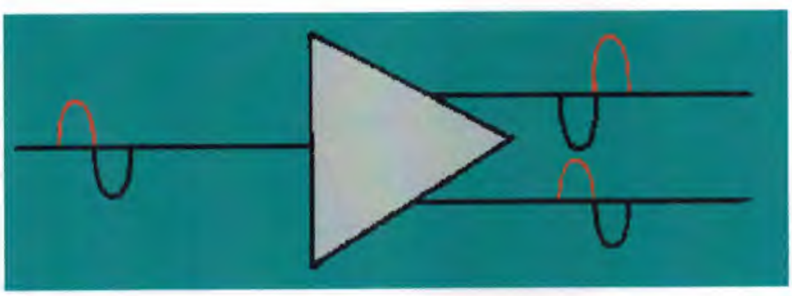


Fig.2.5 Block diagram of a phase splitter

One way in which a phase splitter can be made is to use a center-tapped transformer. As we know in the study of transformers, when the transformer secondary winding is center-tapped, two equal amplitude signals are produced.

These signals will be 180° out of phase with each other. Therefore, a transformer with a center-tapped secondary fulfills the definition of a phase splitter.

A transistor amplifier can be configured to act as a phase splitter. One method of doing this is shown in Fig.2.6

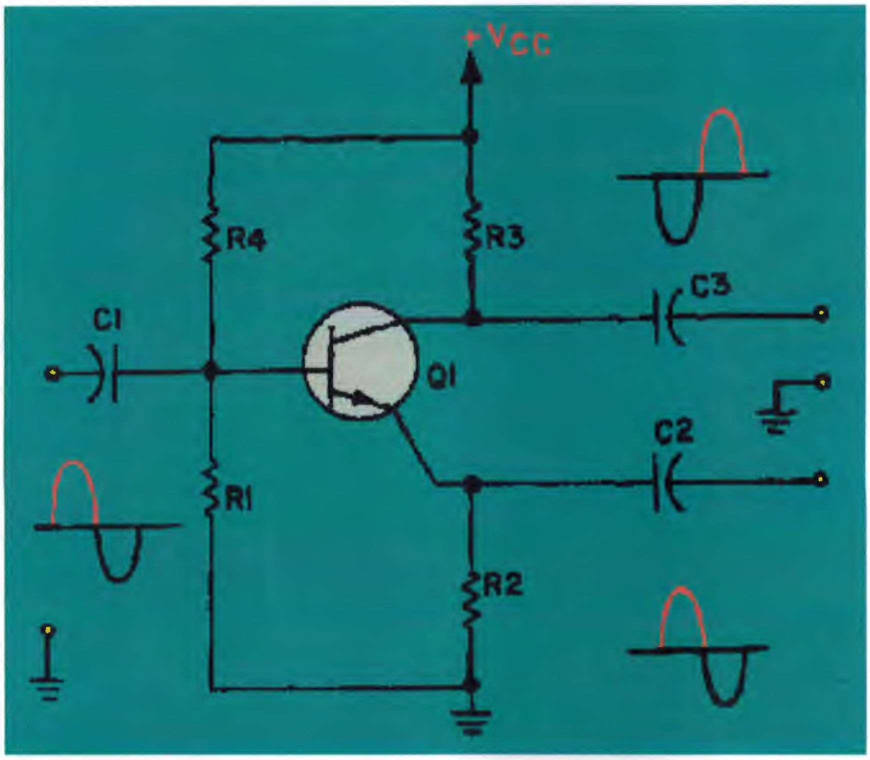


Fig.2.6 Single-stage transistor phase splitter

C1 is the input signal coupling capacitor and couples the input signal to the base of Q1. R1 develops the input signal. R2 and R3 develop the output signals. R2 and R3 are equal resistances to provide equal amplitude output signals. C2 and C3 couple the output signals to the next stage. R4 is used to provide proper bias for the base of Q1.

This phase splitter is actually a single transistor combining the qualities of the common-emitter and common-collector configurations. The output signals are equal in amplitude of the input signal, but are 180° out of phase from each other.

If the output signals must be larger in amplitude than the input signal, a circuit such as that shown in Fig.2.7 will be used. Fig.2.7 shows a two-stage phase splitter.

C1 couples the input signal to the base of Q1. R1 develops the input signal and provides bias for the base of Q1. R2 provides bias and temperature stability for Q1. C2 decouples signals from the emitter of Q1. R3 develops the output signal of Q1. Since Q1 is configured as a common-emitter amplifier, the output signal of Q1 is 180° out of phase with the input signal and larger in amplitude. C3 couples this output signal to the next stage through R4. R4 allows only a small portion of this output signal to be applied to the base of Q2. R5 develops the input signal and provides bias for the base of Q2. R6 is used for bias and temperature stability for Q2. C4 decouples signals from the emitter of Q2. R7 develops the output signal from Q2. Q2 is configured as a common-emitter amplifier, so the output signal is 180° out of phase with the input signal to Q2 (output signal from Q1).

The input signal to Q2 is 180° out of phase with the original input signal, so the output from Q2 is in phase with the original input signal. C5 couples this output signal to the next stage.

Therefore, the circuitry shown provides two output signals that are 180° out of phase with each other. The output signals are equal in amplitude with each other but larger than the input signal.

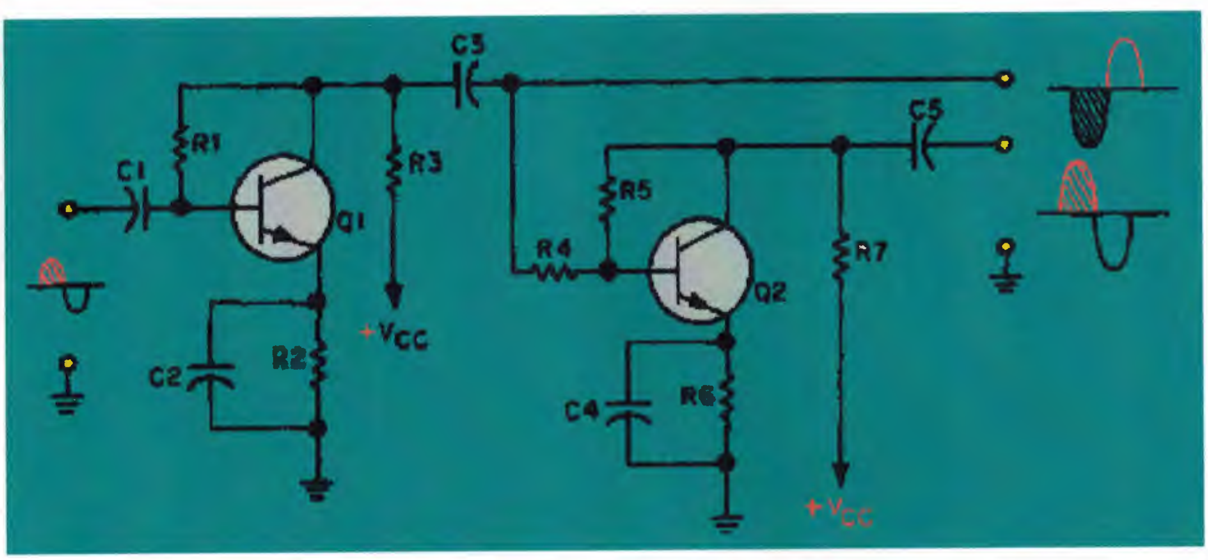


Fig.2.7 Two-stage transistor phase splitter

2.5 Summery

A proper classifying of the audio amplifiers has been illustrated with necessary basic information. Also explaining the frequency response on these amplifiers. In the next chapter, simple audio power amplifiers will be presented.

3. SIMPLE AUDIO POWER AMPLIFIER

3.1 Overview

This chapter contains general description about the LM380N with its practical characteristics. In addition, it describes the circuit of the simple audio amplifier that has been built practically with its components.

3.2 General Description

The LM380N has been a very popular device since it first became available to the home-constructor, and the reasons for this are its good quality output, and the very small number of discrete components needed to turn it into a practical audio amplifier. The LM380N is a power audio amplifier for consumer application. In order to hold system cost to a minimum, gain is internally fixed at 34 dB. A unique input stage allows inputs to be ground referenced. The output is automatically self-centering to one-half the supply voltage.

The output is short circuit proof with internal thermal limiting. The package outline is standard dual-in-line. A copper lead frame is used with the center three pins on either side comprising a heat sink. This makes the device easy to use in standard p-c layout.

Uses include simple phonograph amplifiers, intercoms, line drivers, teaching machine outputs, alarms, ultrasonic drivers, TV sound systems, AM-FM radio, small servo drivers, power converters, etc. A selected part for more power on higher supply voltages is available as the LM384. [7]

3.3 Connection Diagrams (Dual-In-Line Packages, Top View)

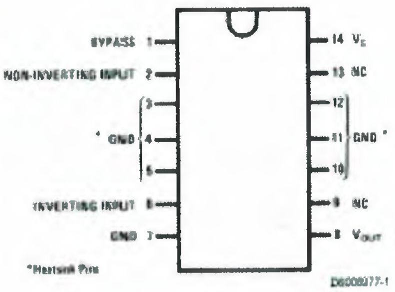


Fig. 3.1 Order Number LM380N

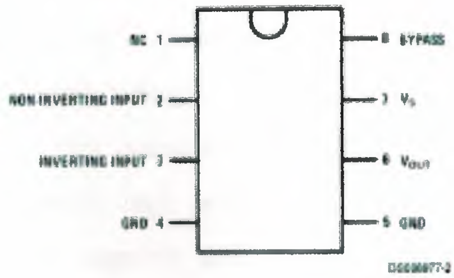


Fig. 3.2 Order Number LM380N-8

3.4 Block and Schematic Diagrams

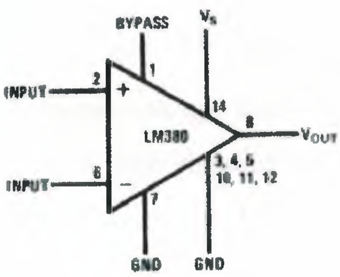


Fig.3.3: LM380N

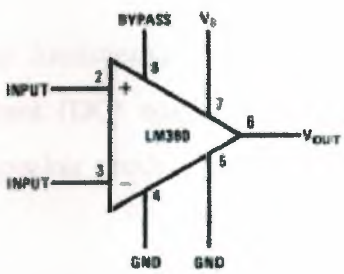


Fig.3.4: LM380N-8

3.5 Simple Audio Power Amplifier

This extremely simple circuit (see Fig. 3.5) provides an output of power of about 200 mW RMS (about equal in volume to a small or medium-size transistor radio) and has an input sensitivity of about 50 mV RMS into 100 k for maximum output. This enables the unit to be fed from a variety of signal sources, such as a crystal or ceramic pickup, radio tuner, etc.

The circuit is primarily intended as a simple one to demonstrate the properties of the LM38ON audio-power amplifier device, and it makes a very useful and inexpensive workshop amplifier if the circuit is built as a proper, cased project.

VR1 is the volume control, and the internal circuitry of the LM380N is such that no DC blocking capacitor is needed between the slider of VR1 and the input of the LM38ON (IC1) .A DC blocking capacitor is used at the input to VR1 through, so that any DC component that might be present on the input signal is blocked from the input of (ICl). IC1 has an internal bias circuit that gives a quiescent output voltage at the output terminal (pin 8) of nominally half the supply voltage. the AC input signal causes the output to swing positive and negative of this quiescent level by about plus and minus 3 volts or so , and this enables a reasonably high output power to be obtained without the output going fully positive or fully negative, and serious distortion being caused by clipping of the output waveform.

If a DC component on the input signal was allowed to reach the input of IC1 this would alter the quiescent output voltage of IC1, and could result in the output going almost fully positive or negative. Only a very small output power would then be possible without the signal becoming badly distorted.

Cl provides DC blocking at the output so that loudspeaker only receives the varying output voltage from IC1, and not the quiescent (DC) output voltage, which would Give a high standing current through the loudspeaker produce a very high level of current consumption.

The LM38ON has a class AB output stage, and this means that the average current consumption of the device (which is around 10 mA) remains virtually constant at low and medium output powers, but increases somewhat at high output powers. This gives reasonable battery economy, and a PP6 or larger 9-volt battery makes a suitable power source. There is some variation in the supply voltage due to variations in the 1oading on the battery by IC1 as the output power inevitably fluctuates quite rapidly and over a fairly wide range with any practical input signal .This can result in a loss of performance or instability, and decoupling capacitors C2 and C3 are included to prevent either of these occurring.

NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Electrical and Electronic Engineering

AUDIO POWER AMPLIFIER

Graduation Project
EE- 400

Student: Ibrahim Faza (991806)

Supervisor: Assoc. Prof. Dr Adnan Khashman

Lefkoşa - 2003

ACKNOWLEDGMENT

First, thanks to my god for giving me courage and ability in fulfilling my project. Then I would like to thank my project's advisor Assoc. Prof. Dr Adnan Khashman for his faithful guidance and his useful tips. In addition, I appreciate the nice supporting of Mr Kamil Dimililer in the practical working of the project.

Moreover, where the words are not enough to thank them "My Family". They have done a great job to push me through my education life. And thanks a lot to my dears brothers who encouraged me to complete my project. And I'm proud of being taught under a qualified teachers who showed me how to see the view of the engineering and to know the meaning of it.

ABSTRACT

Obviously one should take reasonable care in handling all components, especially nowadays when so many are of small size to be used in constructing the electronic projects.

Designer should design electronic products with having the verifying the aim of the electronic safety guidelines because different currents and voltages have different effect to human being.

There is difference between the audio amplifier and the other amplifiers types is in the amplifier frequency response. And the audio amplifiers can be classified in two categories as Single-stage audio amplifiers & Phase splitters.

The LM38ON has been a very popular device since it first became available to the home-constructor, and the reasons for this are its good quality output, and the very small number of discrete components needed to turn it into a practical audio amplifier.

This project briefly has a circuit of simple audio power amplifier using LM380N that provides an output of power of about 200 mW RMS and has an input sensitivity of about 50 mV RMS into 100 k for maximum output.

TABLE OF CONTENTS

INTRODUCTION

When people refer to "amplifiers," they're usually talking about stereo components or musical equipment. But this is only a small representation of the spectrum of audio amplifiers. There are actually amplifiers all around us. You'll find them in televisions, computers, portable CD players and most other devices that use a speaker to produce sound.

Amplifiers can be very complex devices, with hundreds of tiny pieces, but the basic concept behind them is simple. You can get a clear picture of how an amplifier works by examining the most basic components.

Amplifiers do not actually increase the strength of an electronic signal. What happens instead? The signal is copied and enlarged. There are different schemes for amplifying the signal. There are different classes of amplifiers. These classes are A, AB, and C. There have been some special classes such as G, created by Hatachi. Class H created by Soundcraftsman. Class D for the so-called digital amps and Class T for Tripath's digital amplifiers. [0]

Chapter 1: Presents the most important electronic components characteristics with explaining some essential concepts of the electrical safety guidelines.

Chapter 2: The single-state audio amplifiers and the phase splitters are explained with schematic diagrams.

Chapter 3: Contains general description about the LM380N with its practical characteristics also, it describes the circuit of the simple audio amplifier that has been built practically with its components.

Chapter 4: It explains the practical procedures that have been done in the simple audio amplifier circuit with its calculations and its components prices.

1. ELECTRONIC COMPONENTS

1.1 Overview

This chapter presents the most important electronic components characteristics, their properties and so many things related generally with circuitry. In addition, it contains essential concepts of the electrical safety guidelines. This chapter is also important due to the brilliance that it introduces about the careful handling for the electrical components.

1.2 Component Handling Precautions

Most constructors know that electrical components need careful handling but some, especially beginners, may not know just what may cause damage and what precautions to take. Obviously one should take reasonable care in handling all components, especially nowadays when so many are of small size, but certain components can be damaged by high voltage static charges. It is easy for these to occur without evidence of their presence, because they are generated by friction between insulating materials, and because so many different plastic materials with very low conductivity are in common everyday use. For instance, if I walk across the nylon carpet from the door of my study to the desk, I can accumulate a static charge of several hundred volts. It has been said in relation to humans that it is the current that kills, and you may have seen demonstrations in which sparks can be drawn from a person who has been charged from an electrostatic generator. However, it is the voltage that is lethal to electronic devices. Now some identifying of various components used in the electrical projects. [1]

1.2.1 Resistors

Resistors are electronic components used extensively on the circuit boards of electronic equipment. Resistors are usually used to limit current, attenuate signals, dissipate power (heating) or to terminate signal lines. Resistors are usually color coded with stripes to reveal their resistance value (in ohms) as well as their manufacturing tolerance.

Most important characteristics of a resistor are the resistance, tolerance of resistance and the power handling capacity. Resistors are generally available from the fractions of ohms up to several megaohms (higher value special components are also available). Most small general-purpose resistors have power handling capacity of around 0.25W. Most resistors used to be this type, and most electronics designs expect this kind of resistor unless the power rating is mentions. In typical circuits, you can nowadays see resistors with power handling of 0.125W up 1W. In addition, special power resistors are available, generally with power rating from few watt up to 50-100W. Highest power resistors are generally built to metal case that is designed to be connected to a heatsink.

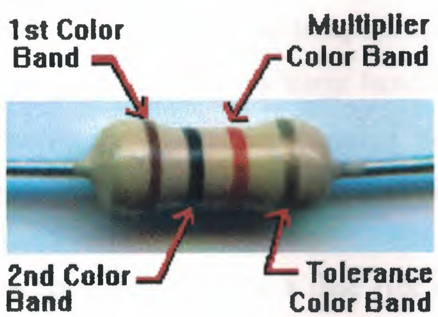


Fig.1.1- Resistor codes

The resistors are manufactured with some tolerance. For example, a typical resistor can have a 5% tolerance, which means that the resistance value can be 5% higher or 5% lower than what the color code indicated. There are special accurate resistors also available, for example resistors with 1% or better accuracy. [2]

There are many different resistor types that are characterized by the material they are made of and how they are constructed. Here are some details of different resistor types:

• Carbon film resistor: cheap general purpose resistor, works quite well also on high frequencies, resistance is somewhat dependent on the voltage over resistor (does not generally have effect in practice)

• Composite resistor: Usually some medium power resistors are built in this way. Has low inductance, large capacitance, poor temperature stability, noisy and not very good long time stability. Composite resistor can handle well short overload surges.

• Metal film resistor: good temperature stability, good long time stability, cannot handle overloads well.

• Metal oxide resistor: mostly similar features as metal film resistor but better surge handling capacity, higher temperature rating than metal film resistor, low voltage dependently, low noise, better for RF than wire wound resistor but usually worse temperature stability

• Thick film resistor: Similar properties as metal film resistor but can handle surges better, and withstand high temperatures.

• Thin film resistor: good long time stability, good temperature stability, good voltage dependently rating, low noise, not good for RF, low surge handling capacity

• Wire wound resistor: used mainly for high power resistors, can be made accurate for measuring circuits, high inductance because consists of wound wire.

In some applications, resistors are used like a fuse (for example in some power supplies and telecom applications). In those applications, the resistor burns up when it is overloaded. In this type of application non-flammable resistor are used to avoid the flames and risk of fire. If the application calls for non-flammable resistor (usually has white case), do not replace it with any other type. Sometimes special resistors designed to be used as fuses are called fusible resistors.

How to read Resistor Color Codes:

1- First the code:

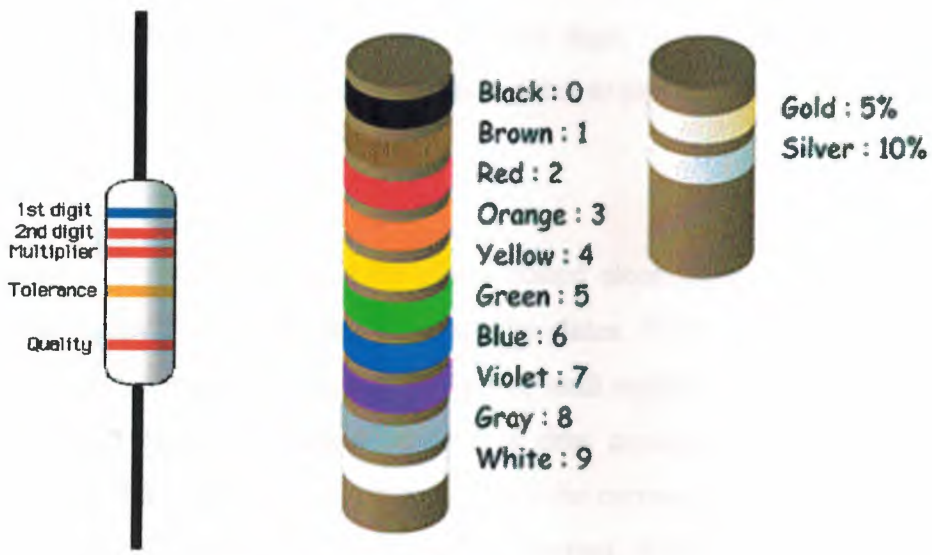


Fig.1.2 Resistors color coding concepts

2- How to read the 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 six.
- 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) 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.

1.2.2 Capacitors

A capacitor is simply two charged plates placed close together with a dielectric (non-conducting) material sandwiched between the plates. When a charge is applied to one plate, it repels charges on the opposite plate, until equilibrium is established. For direct current, the capacitor charges up with a time constant that depends on the capacitance value and the impedance through which the current flows into the capacitor. Once the capacitor is fully charged, no more current flows. This means that the capacitor is an effective block for direct current. For alternating current (like audio signals), the response is more complicated. The charge that develops on the capacitor depends on how fast the current is changing. It takes time for the charge to build up, and that time results in a frequency dependent delay (or phase shift) in the output signal.

Fig.1.3 Capacitor

Capacitor device is often used to store charge in an electrical circuit. A capacitor functions much like a battery, but charges and discharges much more efficiently. A basic capacitor is made up of two conductors separated by an insulator, or dielectric. The dielectric can be made of paper, plastic, mica, ceramic, glass, a vacuum or nearly any other nonconductive material.

Capacitor electron storing ability (called capacitance) is measured in Farads. One Farad is actually a huge amount of charge (6,280,000,000,000,000,000 electrons to be exact), so we usually rate capacitors in microfarads (uF = 0.000, 001F) and Pico farads (pF = 0.000, 000,000,001F). Capacitors are also graded by their breakdown (i.e., smoke) voltage.

There are very many different capacitors. You have to realize that not all capacitors are equal. A 1uF ceramic definitely is NOT the same thing as a 1uF tantalum. You choose the device according to the application. [3]

Two 'parasitic' effects of capacitors are 'effective series resistance' (ESR) and series inductance. High ESR will cause power loss in higher-frequency applications (caps will get hot) especially in switching power supplies. High ESR also limits the effective filtering (your power supplies end up with more ripple). Except for very high frequency (multi-megahertz) applications, a high inductance isn't quite so critical.

The rated DC voltage is also very important. Usually it is a good idea to select capacitors rated at least 1.5 times or twice the maximum voltage you think they'll ever see. Temperature ratings also exist.

The most common types are ones built using standard capacitor plates + insulator and then there are electrolytic capacitors. Typical capacitors consist of some form of metal plates and suitable insulation material in between those plates. This insulation can be some form of plastic, paper, mica, ceramic material, glass or air (some physical separation between layers). Those metal plates used in capacitors are usually thin metal foils. This type of capacitors have usually very good propertied otherwise, but the available capacitance is usually quite small (usually goes from pF to few microfarads). This kind of capacitors can take easily DC at both polaritied and AC without problems. This type of capacitors is available with various voltage ratings from few tens of volts up to few kilovolts as ready-made components. For special application, same technique can be used for very high voltage capacitors.

Here is an overview of most common capacitor types:

- Ceramic: Fairly cheap but not available in really high capacitances - 2uF-10uF are about the max for any practical devices. Extremely low ESR. Surface mount devices have essentially no series inductance and are commonly used to bypass high-frequency noise away from digital IC's. Not polarized.
- Electrolytic: Cheapest capacitance per dollar, but high ESR. Mostly used for 'bulk' power supply. Typical values 1uF-5000+uF. Polarized. Fairly durable, but will literally explode if reverse-biased. Tolerances of +-10% and +-20% are not uncommon.
- Tantalum: The 'cadallac' of capacitors. Very low ESR (not as low as ceramic, though), very high capacitance values available, but expensive (10x electrolytic). Usually used where one might use electrolytics. Polarized.
- Polyester: Kind expensive, not very high capacitance values, ESR not too bad. Polyester capacitors have very stable temperature characteristics (capacitance change is very small as temperature changes). Used where stable capacitance is important like oscillators and timers. NOT polarized.

There are others, of course, such as 'X' caps made to connect directly across mains AC power supplies that literally 'heal' themselves after an overvoltage. There are also so called 'Y' capacitors, which are used in mains filters where they are connected between ground and live neutral connectors. Y-capacitors have special safety regulations related to them.

For power supply smoothing capacitor applications, where large capacitances are needed, aluminum electrolytic capacitors are the most common choice.

In audio applications, type of insulation material does make a difference. For audio applications IIRC, ceramic, high-end hifi people consider all paper, mica, electrolytic and tantalum inferior. The plastic-film kind (especially polystyrene) are the preferred dielectric in very high quality audio applications.

ESR acts like a resistor in series with a capacitor (thus the name Equivalent Series Resistance). This resister can cause circuits to fail that look just fine on paper and is often the failure mode of capacitors. While ESR is undesirable, all capacitors exhibit it to some degree.

Capacitors types:

Fig.1.4 ceramic-capacitor - Fig.1.5 polyester-capacitor - Fig.1.6 tantalum-capacitor

1.2.3 Semiconductor

A semiconductor is a substance, usually a solid chemical element or compound that can conduct electricity under some conditions but not others, making it a good medium for the control of electrical current. Its conductance varies depending on the current or voltage applied to a control electrode, or on the intensity of irradiation by infrared (IR), visible light, ultraviolet (UV), or X rays.

The specific properties of a semiconductor depend on the impurities, or *dopants*, added to it. An *N-type* semiconductor carries current mainly in the form of negatively charged electrons, in a manner similar to the conduction of current in a wire. A *P-type* semiconductor carries current predominantly as electron deficiencies called holes. A hole has a positive electric charge, equal and opposite to the charge on an electron. In a semiconductor material, the flow of holes occurs in a direction opposite to the flow of electrons.

Elemental semiconductors include antimony, arsenic, boron, carbon, germanium, selenium, silicon, sulfur, and tellurium. Silicon is the best known of these, forming the basis of most integrated circuits (ICs). Common semiconductor compounds include gallium arsenide, indium antimonide, and the oxides of most metals. Of these, gallium arsenide (GaAs) is widely used in low-noise, high-gain, and weak-signal amplifying devices.

A semiconductor device can perform the function of a vacuum tube having hundreds of times its volume. A single integrated circuit (IC), such as a microprocessor chip, can do the work of a set of vacuum tubes that would fill a large building and require its own electric generating plant.

Fig.1.6 Transistor-family-shot

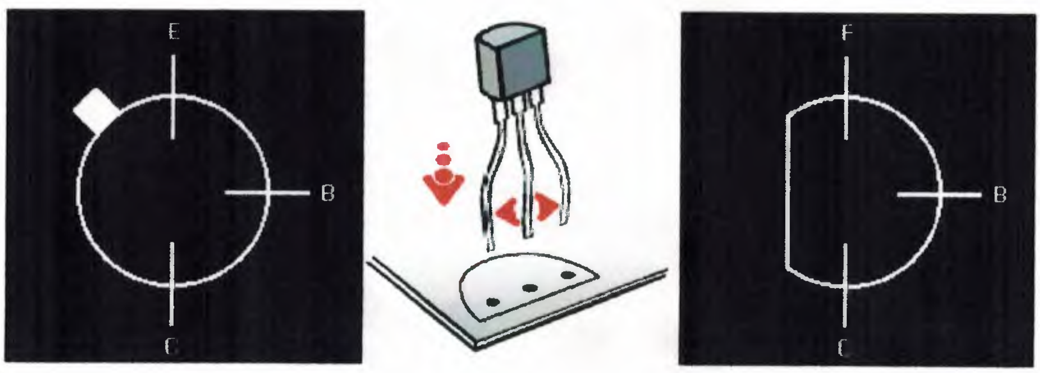


Fig.1.7 Transistor-metal - Fig.1.8 Transistor construction - Fig.1.9 Transistor-plastic

1.2.4 Integrated circuits

Integrated circuits are miniaturized electronic devices in which a number of active and passive circuit elements are located on or within a continuous body of material to perform the function of a complete circuit. Integrated circuits have a distinctive physical circuit layout, which is first produced in the form of a large-scale drawing, later reduced, and reproduced in a solid medium by high precision electro chemical processes. The term "integrated circuit" is often used interchangeably with such terms as microchip, silicon chip, semiconductor chip, and micro-electronic device.

1.2.5 MOSFET

MOSFET (metal-oxide semiconductor field-effect transistor, pronounced MAWS-feht) is a special type of field-effect transistor (FET) that works by electronically varying the width of a channel along which charge carriers (electrons or holes) flow. The wider the channel, the better the device conducts. The charge carriers enter the channel at the *source*, and exit via the *drain*. The width of the channel is controlled by the voltage on an electrode called the *gate*, which is located physically between the source and the drain and is insulated from the channel by an extremely thin layer of metal oxide.

A MOSFET can function in two ways. The first is known as *depletion mode*. When there is no voltage on the gate, the channel exhibits its maximum conductance.

Fig.1.10 MOSFET models

The MOSFET has certain advantages over the conventional junction FET, or JFET.

Because the gate is insulated electrically from the channel, no current flows between the gate and the channel, no matter what the gate voltage (as long as it does not become so great that it causes physical breakdown of the metallic oxide layer). Thus, the MOSFET has practically infinite impedance. This makes MOSFETs useful for power amplifiers. The devices are also well suited to high-speed switching applications. Some integrated circuits (ICs) contain tiny MOSFETs and are used in computers.

Because the oxide layer is so thin, the MOSFET is susceptible to permanent damage by electrostatic charges. Even a small electrostatic buildup can destroy a MOSFET permanently. In weak-signal radio frequency (RF) work, MOSFET devices do not generally perform as well as other types of FET.

1.2.6 Diodes

Diodes are non-linear circuit elements. Qualitatively we can just think of an ideal diode has having two regions: a conduction region of zero resistance and an infinite resistance non-conduction region. For many circuit applications, this ideal diode model is an adequate representation of an actual diode.

The behavior of a (junction) diode depends on its polarity in the circuit. If the diode is reverse biased (positive potential on N-type material), the current through the diode is very small. A forward-biased diode (positive potential on P-type material) can pass lots of current through it would much resistance (only a small voltage drop).

Diodes are very often used in power supplies for rectifying applications. A typical method of obtaining DC power is to transform, rectify, filter and regulate an AC line voltage. In power supply applications it is common to use a transformer to isolate the power supply from the 110 V AC or 230V AC line. A rectifier can be connected to the transformer secondary to generate a DC voltage with little AC ripple.

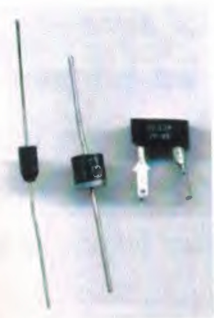


Fig.1.11 Diode technical shape – Fig.1.12 some diode models

There are several other types of diodes beside the typical junction diode. The Zener Diode is a special diode, where Zener breakdown occurs when the electric field near the junction becomes large enough to excite valence electrons directly into the conduction band. This means that a zener diode passes current through it in reverse direction when voltage is high enough (the zener voltage).

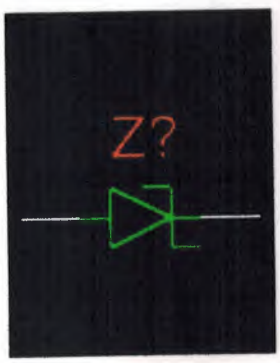


Fig.1.13 Zener diode

Zener diodes are typically used as voltage reference components in measuring circuits, as voltage regulators in some low power supplies and as over-voltage protection devices.

Light-emitting diodes (LED) emit light in proportion to the forward current through the diode. LEDs are low voltage devices that have a longer life than incandescent lamps. They respond quickly to changes in current (many can easily go up to 10 MHz). LEDs have applications as visible indicators in devices and in optical-fiber communication. LEDs produce a narrow spectrum of visible) many colors available) or infrared light that can be well collimated.

Fig.1.14 LED-board

Light-Sensitive Diodes indicate light of a proper wavelength. Photo-diodes or photocells can receive light signals. LEDs and photodiodes are often used in optical communication as receiver and transmitter respectively.

1.3 Electricity Safety Guidelines Information

Different currents and voltage have different effect to human being. Generally, the current is what determines the danger to human. The used voltage with some other things (for example skin resistance) generally determines what is dangerous and what not. Generally, the AC voltage in 40...50 Hz is very dangerous to human. A current that is less that 10 mA is not dangerous to most people. Alternating current (AC) in range of 70...110 mA and direct current (DC) in the range of 200...250 mA is considered to be very dangerous and lethal if it goes through the chest (where the heart is). The impedance of human from one hand-to-hand is generally in the range of 600...6000 ohms depending on the skin moisture level and the amount of current flowing. Voltages below 20V can be considered safe to touch (the current does not exceed 10 mA in normal conditions). If the skin is dry, voltages up to around 80V do not cause over 30 mA current. [5]

There are two classes of insulation:

- Class I: single insulation, which requires three core mains cable with earth.
- Class II: double insulation, which requires no earth.

Class I characteristics:

- Insulation between mains and every touchable part must withstand flashover voltage of 220V.
- The distance between mains voltage carrying parts and touchable parts must be at least 3 mm.
- All touchable conducting parts must be properly earthed.

Class II characteristics:

- Insulation between mains and every touchable part must withstand flashover voltage of 240V.
- The distance between mains voltage carrying parts and touchable parts must be at least 6 mm.

If you are designing electronics product you should aim for making your products class II. They are easier to sell abroad. If you need to provide the equipment as class 1 you should be very clear in the installation instructions of the correct methods for wiring the equipment to a supply.

When the power switch is not required?

Power on/off switch is not required if the power consumption of the equipments is less than 10W or if the equipment is intended for continuous use.

Three rules when working with line powered electronics equipments

- Rule 1: switch the power off
- Rule 2: work with one hand
- Rule 3: keep the other hand behind your back

When working with electronic devices (repairing etc.) switch then off and disconnect from the mains. When you need to test live circuits, use properly sheathed probes and power the device through protection device such as isolation transformer. When working with mains voltage or higher voltage, make sure that there is someone else in the room and that he or she knows what you are doing.

In normal operation electronics, devices are designed such that they are safe to use. The insulation inside electronics devices must be good enough to withstand the mains voltage and overvoltage links. Even though there is insulation, there is always some leakages and potential for failures.

Class I devices are designed to have grounded metal case, which keep the leakage out of reach and burns mains fuse if there is short circuit to case. Class II equipment is designed to work without grounding. They have thicker insulation in wires and components connected to mains. Leakage current from Class II equipment is limited low so that it is safe to touch, and I think we don't have to care of electric shock too much when using correctly designed Class II equipment alone.

1.4 Summery

In this chapter, plenty of information about some essential electronic components presented and illustrated clearly, in addition of the electrical safety guidelines section.

2. AUDIO AMPLIFIERS

2.1 Overview

In this chapter, the single-state audio amplifiers and the phase splitters are explained with schematic diagrams of several audio amplifiers will be shown and the functions of each of the components will be discussed.

2.2 Basic Audio Amplifiers Information

The difference between an audio amplifier and other amplifiers is the frequency response of the amplifier. The audio amplifier can be classified in two categories as Single-stage audio amplifier & Phase splitters. An audio amplifier has been described as an amplifier with a Frequency response from 15 Hz to 20 kHz. The Frequency response of an amplifier can be shown graphically with a Frequency response curve. Fig.2.1 is the ideal Frequency response curve for an audio amplifier. This curve is practically "flat" from 15 Hz to 20 kHz. This means that the gain of the amplifier is equal between 15 Hz and 20 kHz. Above 20 kHz or below 15 Hz the gain decreases or "drops off" quite rapidly. The Frequency response of an amplifier is determined by the components in the circuit. [6]

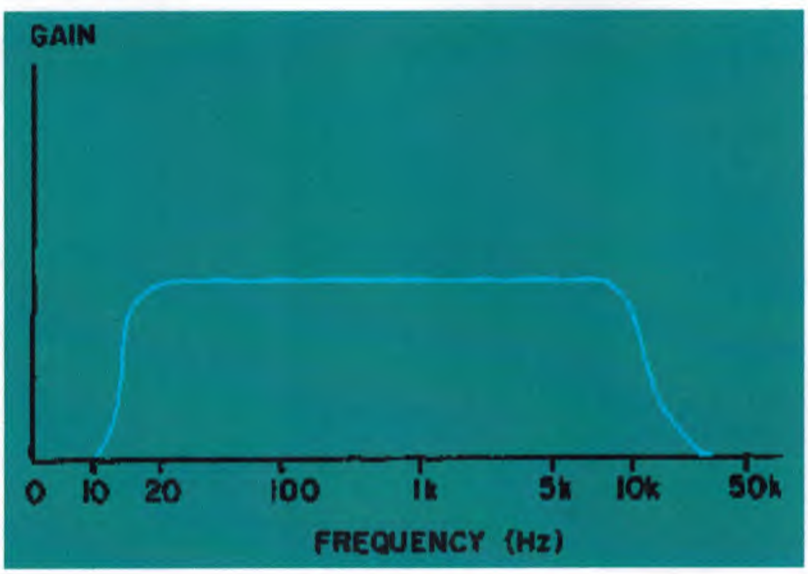


Fig. 2.1 Ideal Frequency response curve for an audio amplifier

The transistor itself will respond quite well to the audio frequency range. No special components are needed to extend or modify the Frequency response.

2.3 Single-Stage Audio Amplifiers

The first single-stage audio amplifier is shown in Fig.2.2. This circuit is a class A, common-emitter, RC-coupled, transistor, audio amplifier. C1 is a coupling capacitor that couples the input signal to the base of Q1. R1 is used to develop the input signal and provide bias for the base of Q1. R2 is used to bias the emitter and provide temperature stability for Q1. C2 is used to provide decoupling (positive feedback) of the signal that would be developed by R2. R3 is the collector load for Q1 and develops the output signal. C3 is a coupling capacitor that couples the output signal to the next stage. V_{CC} represents the collector-supply voltage. Since the transistor is a common-emitter configuration, it provides voltage amplification. The input and output signals are 180° out of phase. (The input and output impedance are both medium.)

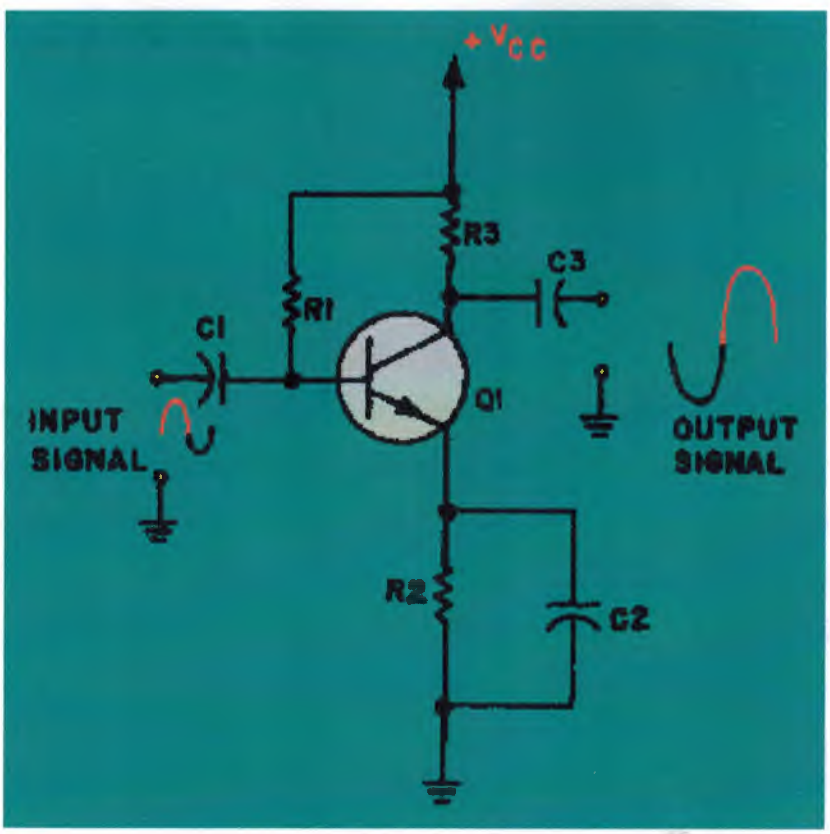


Fig. 2.2 Transistor audio amplifier

The second single-stage audio amplifier is shown in Fig.2.3. This circuit is a class A, common-source, RC-coupled, FET, audio amplifier. C1 is a coupling capacitor that couples the input signal to the gate of Q1. R1 is used to develop the input signal for the gate of Q1. R2 is used to bias the source of Q1. C2 is used to decouple the signal developed by R2 (and keep it from affecting the source of Q1). R3 is the drain load for Q1 and develops the output signal. C3 couples the output signal to the next stage. V_{DD} is the supply voltage for the drain of Q1. Since this is a common-source configuration, the input and output signals are 180° out of phase.

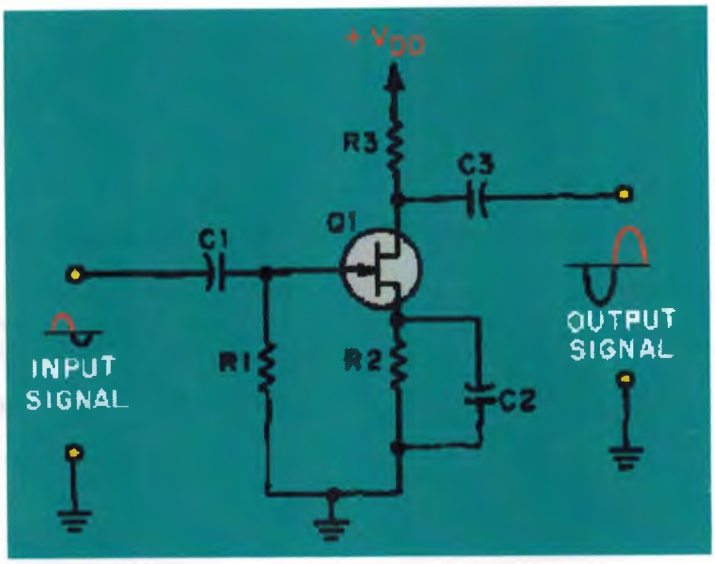


Fig. 2.3 FET audio amplifier

The third single-stage audio amplifier is shown in Fig.2.4. This is a class A, common-emitter, transformer-coupled, transistor, audio amplifier. The output device (speaker) is shown connected to the secondary winding of the transformer. C1 is a coupling capacitor, which couples the input signal to the base of Q1. R1 develops the input signal. R2 is used to bias the emitter of Q1 and provides temperature stability. C2 is a decoupling capacitor for R2. R3 is used to bias the base of Q1. The primary of T1 is the collector load for Q1 and develops the output signal.

T1 couples the output signal to the speaker and provides impedance matching between the output impedance of the transistor (medium) and the impedance of the speaker (low).

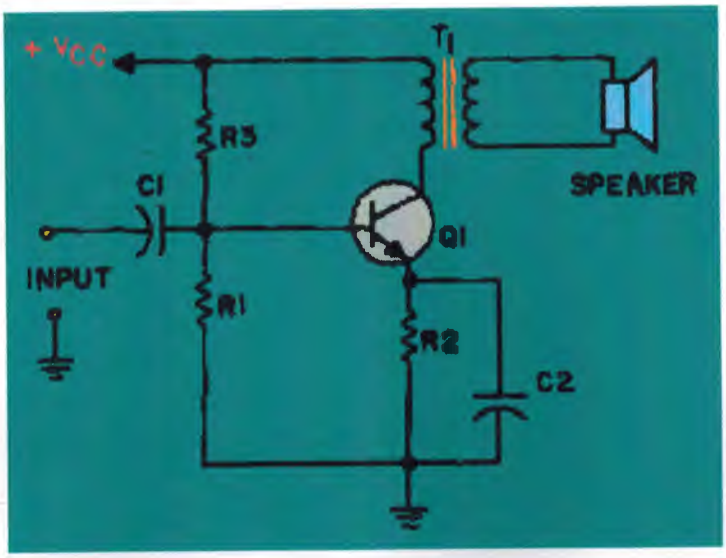


Fig.2.4 Single-stage audio amplifier

2.4 Phase Splitters

Sometimes it is necessary to provide two signals that are equal in amplitude but 180° out of phase with each other. The two signals can be provided from a single input signal by the use of a phase splitter. A phase splitter is a device that produces two signals that differ in phase from each other from a single input signal. Fig.2.5 is a block diagram of a phase splitter.

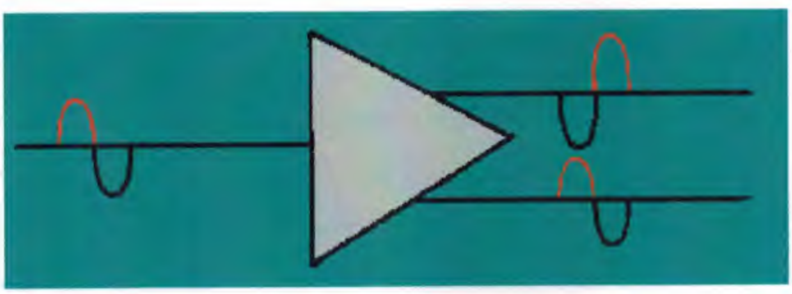


Fig.2.5 Block diagram of a phase splitter

One way in which a phase splitter can be made is to use a center-tapped transformer. As we know in the study of transformers, when the transformer secondary winding is center-tapped, two equal amplitude signals are produced.

These signals will be 180° out of phase with each other. Therefore, a transformer with a center-tapped secondary fulfills the definition of a phase splitter.

A transistor amplifier can be configured to act as a phase splitter. One method of doing this is shown in Fig.2.6

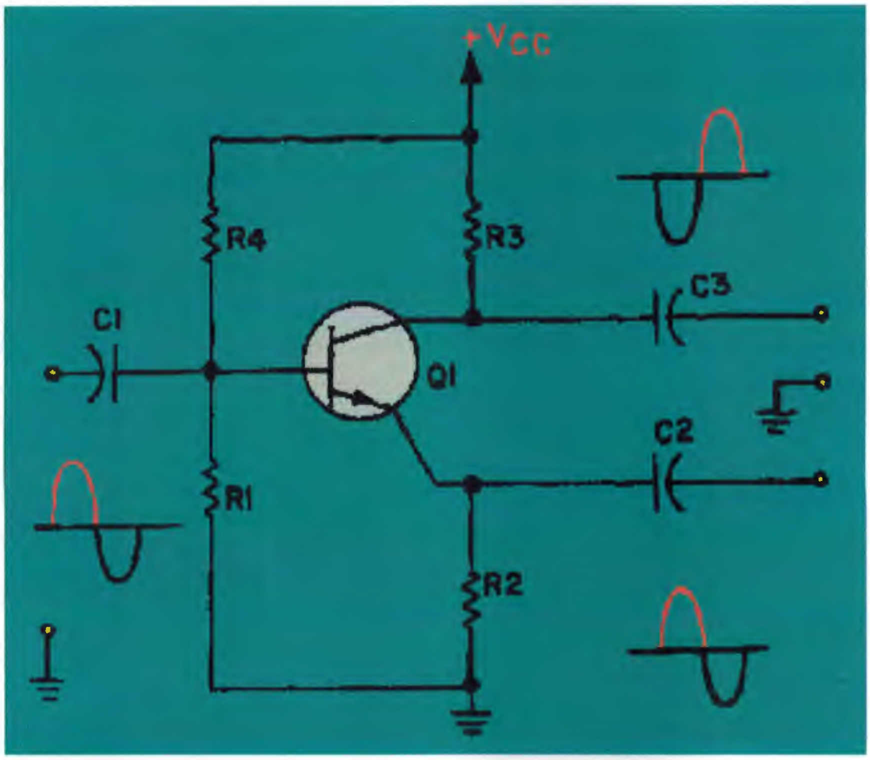


Fig.2.6 Single-stage transistor phase splitter

C1 is the input signal coupling capacitor and couples the input signal to the base of Q1. R1 develops the input signal. R2 and R3 develop the output signals. R2 and R3 are equal resistances to provide equal amplitude output signals. C2 and C3 couple the output signals to the next stage. R4 is used to provide proper bias for the base of Q1.

This phase splitter is actually a single transistor combining the qualities of the common-emitter and common-collector configurations. The output signals are equal in amplitude of the input signal, but are 180° out of phase from each other.

If the output signals must be larger in amplitude than the input signal, a circuit such as that shown in Fig.2.7 will be used. Fig.2.7 shows a two-stage phase splitter.

C1 couples the input signal to the base of Q1. R1 develops the input signal and provides bias for the base of Q1. R2 provides bias and temperature stability for Q1. C2 decouples signals from the emitter of Q1. R3 develops the output signal of Q1. Since Q1 is configured as a common-emitter amplifier, the output signal of Q1 is 180° out of phase with the input signal and larger in amplitude. C3 couples this output signal to the next stage through R4. R4 allows only a small portion of this output signal to be applied to the base of Q2. R5 develops the input signal and provides bias for the base of Q2. R6 is used for bias and temperature stability for Q2. C4 decouples signals from the emitter of Q2. R7 develops the output signal from Q2. Q2 is configured as a common-emitter amplifier, so the output signal is 180° out of phase with the input signal to Q2 (output signal from Q1).

The input signal to Q2 is 180° out of phase with the original input signal, so the output from Q2 is in phase with the original input signal. C5 couples this output signal to the next stage.

Therefore, the circuitry shown provides two output signals that are 180° out of phase with each other. The output signals are equal in amplitude with each other but larger than the input signal.

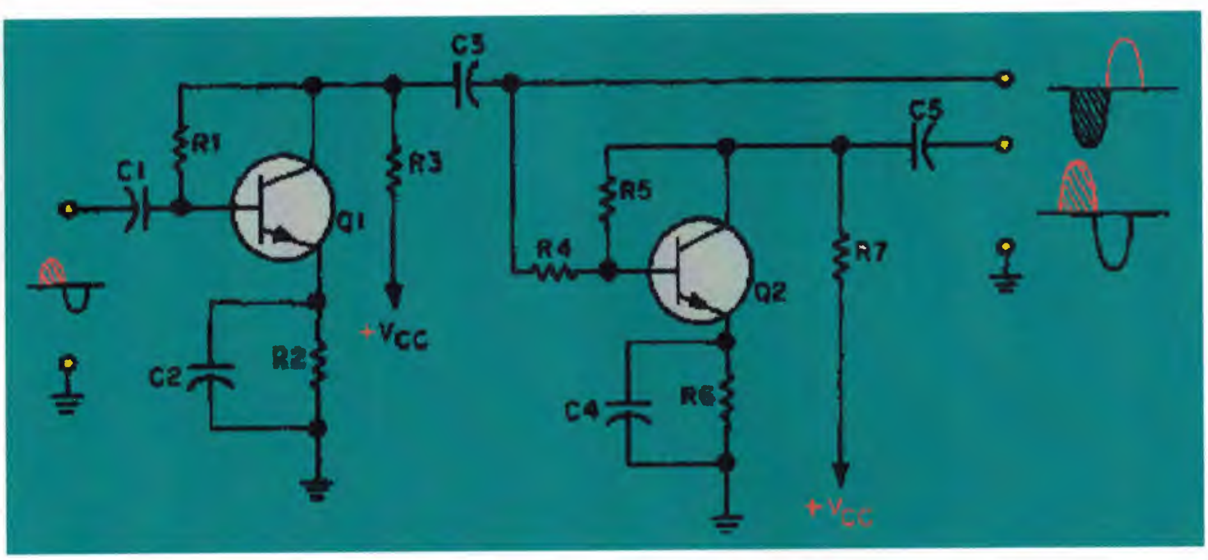


Fig.2.7 Two-stage transistor phase splitter

2.5 Summery

A proper classifying of the audio amplifiers has been illustrated with necessary basic information. Also explaining the frequency response on these amplifiers. In the next chapter, simple audio power amplifiers will be presented.

3. SIMPLE AUDIO POWER AMPLIFIER

3.1 Overview

This chapter contains general description about the LM380N with its practical characteristics. In addition, it describes the circuit of the simple audio amplifier that has been built practically with its components.

3.2 General Description

The LM380N has been a very popular device since it first became available to the home-constructor, and the reasons for this are its good quality output, and the very small number of discrete components needed to turn it into a practical audio amplifier. The LM380N is a power audio amplifier for consumer application. In order to hold system cost to a minimum, gain is internally fixed at 34 dB. A unique input stage allows inputs to be ground referenced. The output is automatically self-centering to one-half the supply voltage.

The output is short circuit proof with internal thermal limiting. The package outline is standard dual-in-line. A copper lead frame is used with the center three pins on either side comprising a heat sink. This makes the device easy to use in standard p-c layout.

Uses include simple phonograph amplifiers, intercoms, line drivers, teaching machine outputs, alarms, ultrasonic drivers, TV sound systems, AM-FM radio, small servo drivers, power converters, etc. A selected part for more power on higher supply voltages is available as the LM384. [7]

3.3 Connection Diagrams (Dual-In-Line Packages, Top View)

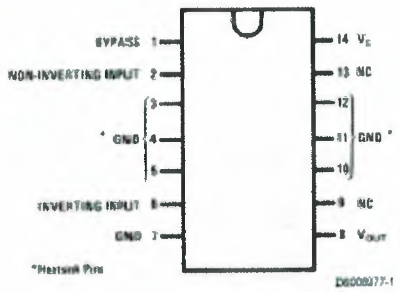


Fig. 3.1 Order Number LM380N

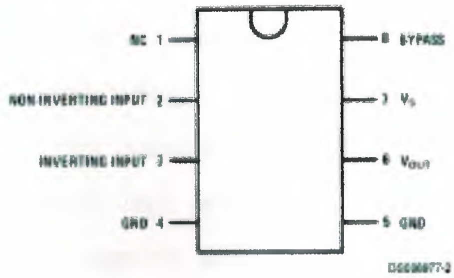


Fig. 3.2 Order Number LM380N-8

3.4 Block and Schematic Diagrams

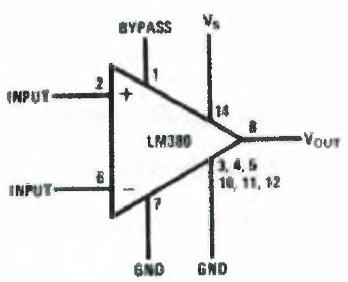


Fig.3.3: LM380N

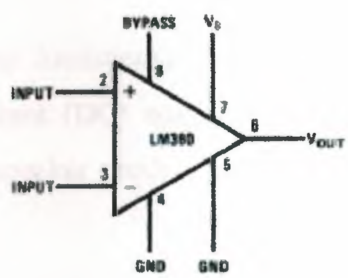


Fig.3.4: LM380N-8

3.5 Simple Audio Power Amplifier

This extremely simple circuit (see Fig. 3.5) provides an output of power of about 200 mW RMS (about equal in volume to a small or medium-size transistor radio) and has an input sensitivity of about 50 mV RMS into 100 k for maximum output. This enables the unit to be fed from a variety of signal sources, such as a crystal or ceramic pickup, radio tuner, etc.

The circuit is primarily intended as a simple one to demonstrate the properties of the LM38ON audio-power amplifier device, and it makes a very useful and inexpensive workshop amplifier if the circuit is built as a proper, cased project.

VR1 is the volume control, and the internal circuitry of the LM380N is such that no DC blocking capacitor is needed between the slider of VR1 and the input of the LM38ON (IC1) .A DC blocking capacitor is used at the input to VR1 through, so that any DC component that might be present on the input signal is blocked from the input of (ICl). IC1 has an internal bias circuit that gives a quiescent output voltage at the output terminal (pin 8) of nominally half the supply voltage. the AC input signal causes the output to swing positive and negative of this quiescent level by about plus and minus 3 volts or so , and this enables a reasonably high output power to be obtained without the output going fully positive or fully negative, and serious distortion being caused by clipping of the output waveform.

If a DC component on the input signal was allowed to reach the input of IC1 this would alter the quiescent output voltage of IC1, and could result in the output going almost fully positive or negative. Only a very small output power would then be possible without the signal becoming badly distorted.

Cl provides DC blocking at the output so that loudspeaker only receives the varying output voltage from IC1, and not the quiescent (DC) output voltage, which would Give a high standing current through the loudspeaker produce a very high level of current consumption.

The LM38ON has a class AB output stage, and this means that the average current consumption of the device (which is around 10 mA) remains virtually constant at low and medium output powers, but increases somewhat at high output powers. This gives reasonable battery economy, and a PP6 or larger 9-volt battery makes a suitable power source. There is some variation in the supply voltage due to variations in the 1oading on the battery by IC1 as the output power inevitably fluctuates quite rapidly and over a fairly wide range with any practical input signal .This can result in a loss of performance or instability, and decoupling capacitors C2 and C3 are included to prevent either of these occurring.

An additional decoupling capacitor can be added from pin 1 of IC1 to the negative supply, and this decouples the supply to the preamplifier stages of the device.

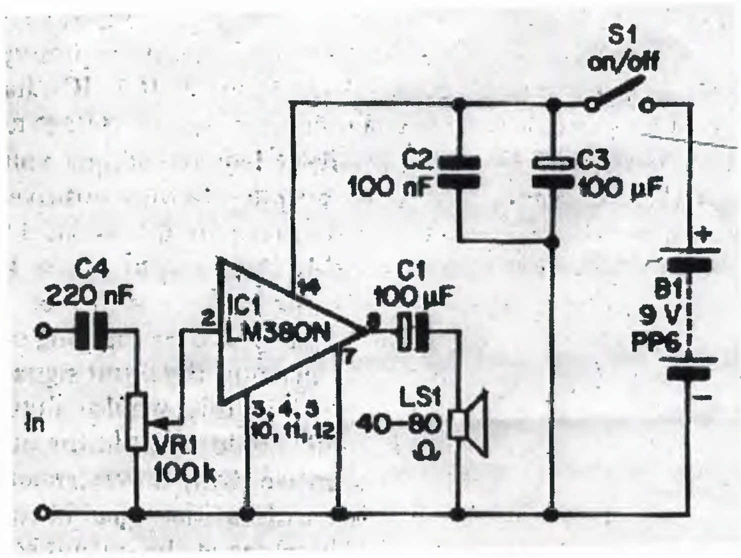


Fig.3.5 the circuit diagram of the simple audio amplifier

This is not normally necessary when the LM38ON is employed with a battery supply, and is a facility give a high standing current through the loudspeaker produce a very high level of current consumption.

An additional decoupling capacitor can be added from pin 1 of IC1 to the negative supply, and this decouples the supply to the preamplifier stages of the device.

This is not normally necessary when the LM38ON is employed with a battery supply, and is a facility that is normally only required when the device is used with a mains power supply that has high ripple content. You might be confused by the fact that one lead to IC1 in Fig. 3.5 is marked "3, 4, 5, 10, 11, and 12". This lead is marked with six pin numbers merely because these six pins are internally interconnected, and a connection to one of them is a connection to the other five.

The case should ideally be an all-metal type so that it screens the Circuitry from stray pick-up of mains hum and similar electrical signals, and the case should be earthed to the negative supply. With most types of audio socket, this chassis connection will be automatically provided through the earth lead to the socket. The test leads should use screened cable (the outer braiding connecting to the chassis of the amplifier).

An interesting feature of the LM38ON device is that it has two inputs, pin 2 is the non-inverting input and pm 6 is the Inverting input. An input signal to pin 6 produces a change in output voltage that is of the opposite polarity, whereas an input to pin 2 gives a change in output voltage that is of the same polarity as the input signal.

There is no audible difference between the two, and the fact that the signal is inverted through IC1 if the input at pin 6 is used is not really of any practical importance. The circuit works equally wel1 whichever of the two inputs is used and this fact can easily be demonstrated in practice.

3.6 Components for the project of Simple Audio-Power Amplifier

(Fig.3.5)

Resistors:

VR1 100 k log, carbon

Capacitors

C1 100µf 10 V electrolytic

C2 100µf polyester (brown, black, yellow, black, red)

C3 100µf 10 V electrolytic

C4 220nf polyester (red, red, yellow, black, red)

Semiconductor

IC1 LM38ON

Switch:

S1 SPST miniature toggle type

Battery:

B1 PP6 size 9 volt and connector to suit

Loudspeaker:

LS1 Miniature type having impedance in the range 40 to 80 ohms

Miscellaneous:

Verobloc

Control knob

Wire

3.7 Summery

In this chapter, we passed over important information about LM380N and learned in details the practical circuit about our simple audio power amplifier project.

4. PRACTICAL PROJECT CALCULATIONS

4.1 overview

This chapter contains some details about the amplifier's calculations (voltages, gain, power).and some hints about practical obstacles also contains project components prices.

4.2 Ohm's Law

Ohm's law is the most basic and most useful electrical equation. Simply stated Ohm's law is:

V=I*R Eqt.4.1

Where **V** is voltage measured in volts, **I** is current measure in amperes (amps) and **R** is resistance measured in ohms. Memorize this equation. You'll use it a lot in car audio. For example, if you need to figure out the current (amps) moving through a 12 volt, circuit and you know the resistance of the circuit is 4 ohms; the equation would look like this:

V = 12volts
I = unknown
R = 4 ohms

I = V/R or **I = 12/4** which is **I** = **3** amps

Another useful equation to know is the power equation:

P = V*I Eqt.4.2

(Power equals voltage multiplied by current or watts = volts * amps).

From this, we can substitute Ohm's law for any values we don't know. For instance if we need to know power but we only have amperage (**I**) and resistance (**R**) then we could substitute **I*R** in the power equation (because according to Ohm's law **V=I*R**) and get **P** = **I*R*I**.

4.3 Wiring

There are two ways to wire electrical components. In parallel or in series. Both are important to understand, especially when properly hooking up speakers to amplifiers.

4.3.1 Parallel Wiring

Parallel wiring is connecting components to a source so that they share the same voltage. To put that in a useful way, it would be connecting all of the speaker positive terminals to the positive terminal of the amplifier and connecting all of the speaker negative terminals to the negative terminal of the amplifier.

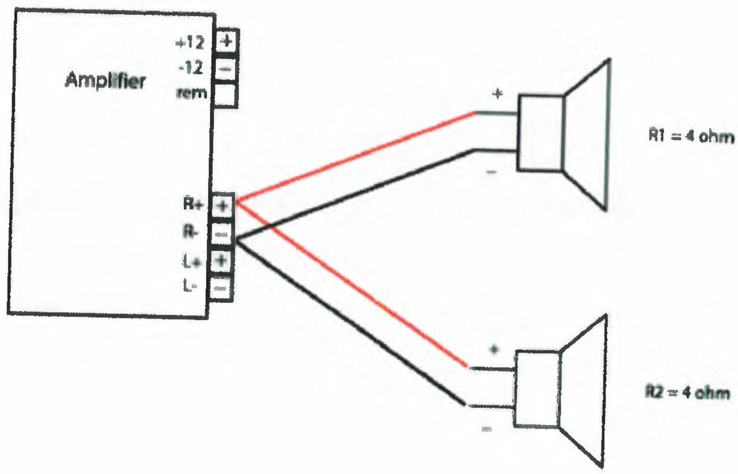


Fig.4.1: Parallel wiring

This increases the workload on the amplifier because more current will need to be supplied to this lower resistance (impedance). Parallel resistances (in this case 4 ohm speakers) will combine according to this equation:

$$1/R_t = 1/R_1 + 1/R_2 + 1/R_3 \ldots \qquad \text{Eqt.4.3}$$

Where **Rt** is the total resistance and **R1-R3** are the individual resistances. For our example, **Rt** will be the resistance at the amplifier's speaker outputs and **R1-R3** will be the resistances of the individual speakers. If we connect (2), four-ohm speakers (**R1** and **R2**) in parallel to an amplifier the total resistance will be:

1/**Rt** = 1/**R1** + 1/**R2** or 1/**Rt** = 1/4 + 1/4 or 1/**Rt** = 1/2

Inverting the equation we get **Rt** = 2 ohms.

Similarly if we connect (3) four-ohm speakers (**R1**, **R2**, and **R3**) we will get:

1/**Rt** = 1/**R1** + 1/**R2** + 1/**R3** or 1/**Rt** = 1/4 + 1/4 + 1/4 or 1/**Rt** = 3/4

Inverting the equation we get **Rt** = 4/3 or 1.33 ohms.

4.3.2 Series Wiring

Series wiring is connecting components to a source so that they share the same current. To put that in a useful way, it would be connecting the amplifier's positive terminal to the positive terminal of the first speaker and then connecting the negative terminal of the first speaker to the positive terminal of the second speaker and so on. The final speaker in the chain will have its negative terminal connected to the negative terminal of the amplifier.

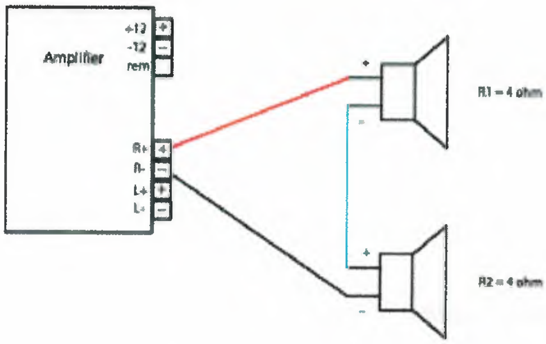


Fig.4.2: Series wiring

This decreases the workload on the amplifier because less current will need to be supplied to this higher resistance (impedance). Series resistances (in this case 4 ohm speakers) will combine according to this equation:

Rt = R1 + R2 + R3... .... Eqt.4.4

Where **Rt** is the total resistance and **R1-R3** are the individual resistances. For our example, **Rt** will be the resistance at the amplifier's speaker outputs and **R1-R3** will be the resistances of the individual speakers. If we connect (2) four-ohm speakers (**R1** and **R2**) in series to an amplifier the total resistance will be:

Rt = **R1** + **R2** or **Rt** = 4 + 4 or **Rt** = 8 ohms

Similarly if we connect (3) four-ohm speakers (**R1**, **R2**, and **R3**) we will get:

Rt = **R1** + **R2** + **R3** or **Rt** = 4 + 4 + 4 or **Rt** = 12 ohms

4.4 Input Sensitivities

Input sensitivities and their importance especially as to why 4-volt outputs on a head unit are better. Here is what an amp does: it takes its input and makes it larger so it can drive speakers. How much larger it can make the input signal is set by the input sensitivity and the maximum power output of the amp. You can turn the input sensitivity all the way up but that does not make the amp put out more power than its max, it just gets to that max level with a smaller input voltage. To see why 4 volt head units are better lets say we have 2 head units, model A puts out a 1 volt signal and model B puts out a 4 volt signal max. We are connecting these head units to a 25-watt amp. The amp puts out 10 volts.

Power = Voltage^2/Resistance = 10^2/4 = 25watts.

To get maximum output from head A, the gain needs to be 10 (10volts out per 1volt in, 10/1 = 10). Now let's say there's 0.1 volt of noise in the signal.

With our gain set at 10 with our input sensitivity control, we have amplified the noise to 1 volt. consider what happens with head B. The gain needs to be only 2.5 to get full output. We still get 10 volts of output but the noise is only 0.25 volts.

This noise level is 4 times lower than with head A. By using a higher voltage head unit you can set the gain on your amp lower and thus amplify less noise. Also let's say you left the input sensitivity set for a gain of 10 and you used 4-volt head unit at its max. If this did not make the input stage distort it would try to make the amp put out 40 volts (10*4) which would be 400watts! Obviously, the amp cannot do that and just hits its 25-watt limit. To set your input sensitivity, turn you amp's input sensitivity almost all the way down. Now start with your head unit at its lowest volume, turn it up until you hear distortion, and then back off some. Some head units will let you go to full volume without distorting the pre-amp level outputs. Now with your head unit putting out its max clean voltage, turn the input sensitivity up until you get to the loudest your system will play without distortion or the loudest you ever care to listen, whichever is lower. [8]

4.5 RMS Power

The power output of an amplifier should be roughly matched to what the amp will be used for and what speakers it will be driving. Oddly enough, the most common problem with matching speakers and amps is using an amp that is too weak to power the speaker. When an underpowered amp is used to power a speaker, the listener tends to turn the volume up higher in order to get more output of the amplifier. Eventually the amplifier runs into its limit and begins to distort. This distortion can cause the output from the amplifier to become DC for short periods and DC signals of even low power can destroy a speaker. Underpowering a speaker in this way can be more dangerous than overpowering it!

4.6 The Project Calculations:

Practically ... First, I did the connection of the project circuit simply in the Verobloc to test its components' working. Then I did the wilding in the brown board after that I made the testing of the circuit by inputing a signal of function generator set of 1000Hz to the circuit and having an output in the load speaker. In addition, I could get the voltages values (Input & output values) on the screen of a sinusoidal wave set for presenting the signals.

I connected the input signal of the function generator to the channel Y of the sinusoidal wave set, setting the volt/div = 2, I found the signal presented as 2.peak-to-peak (P/P) so that the input voltage can be calculated by:

Input Voltage= volt/div * P/P

= 2*2

Input Value = 4 V

In addition, I connected the output that comes from the Load Speaker to the channel X of the sinusoidal wave set, setting the volt/div = 2 and I found the signal presented as 6.25 peak-to-peak so:

Output voltage = 2*6.25 = 12.5 V, and this is the Max. output value that the output could be, even if I increase the input value or change the voltage supplying source value. So that we can calculate the gain of the amplifier circuit as following:

Gain (A) = Output Voltage / Input Voltage

A = O / I

A = 12.5 / 4 = 3.125 V

In order to increase the resistance of the speaker that I could have in my project, I put 56-ohm resistor in series with the speaker to have a resistance in the range of 40-80 ohm as required in the scheme. Therefore, the total resistance that we have in the speaker is equal to 4+56 = 60 ohm. The power of the speaker is equal to:

P = Output voltage^2 / resistance of the speaker

= 12.5^2 / 60 = 2.60 W

Nevertheless, the power of the amplifier is equal to:

P = supplied voltage^2/ resistance of the speaker

= 9 ^ 2 / 60 = 1.35 W

The following table 4.1 explains how the VR1 (variable resistor) affects on the output voltage signal practically:

VR1 Value (Ohm)	54.4	64	92
Output signal (V)	6.8	8	11.5

Table 4.1

The increasing in the supplied voltage in the circuit more than 12 V helps to burn the IC (LM380N) because it has a max. Level of Vcc value as 12 V shown in the Fig.4.3.

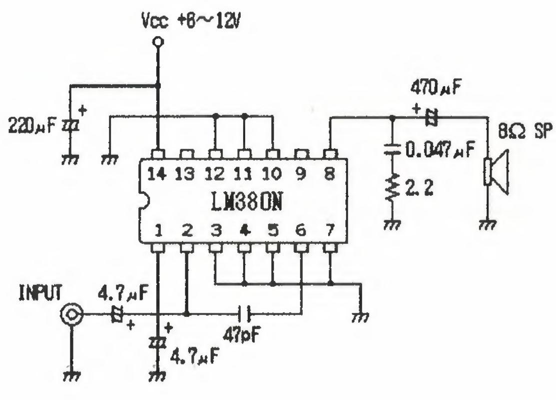


Fig.4.3:LM380N

4.7 The project components prices:

VR1 100 k log, carbon	**500.000TL**
C1 100µf 10 V electrolytic	**300.000TL**
C2 100µf polyester (brown, black, yellow, black, red)	**500.000TL**
C3 100µf 10 V electrolytic	**300.000TL**
C4 220nf polyester (red, red, yellow, black, red)	**500.000TL**
IC1 LM38ON	**3000.000TL**
S1 SPST miniature toggle type	**2.500.000TL**
B1 PP6 size 9 volt and connector to suit	**3000.000TL**
LS1 Miniature type having impedance in the range 40 to 80 ohms	**7000.000TL**
Verobloc	**11.600.000TL**
Control knob	**1000.000TL**
Wire (0.5 m)	**500.000TL**
Brown board	**4.700.000TL**
Total Price	**35.400.000TL**

4.8 Summery

In this chapter, we passed over related calculations with ohm's low and power low also the wiring concepts with its RMS power and it contained the project calculations with the prices of the electronic components that have been used.

CONCLUSION

A power amplifier takes an input signal, usually a preamp level signal, which has both low current and low voltage characteristics, and produces an output, which will have higher, and levels. The power supply available to the audio output in a head unit is limited. This means an audio signal is produced with a limited (by the battery voltage) voltage swing, and therefore a limited power output to the speaker.

In this project, plenty of information about some essential electronic components presented and illustrated clearly, in addition of the electrical safety guidelines section. Moreover, a proper classifying of the audio amplifiers has been illustrated with necessary basic information. Also explaining the frequency response on these amplifiers. In addition, of that, we passed over important information about LM380N and we learned in details the practical circuit about our simple audio power amplifier project. At last, we passed over related calculations with ohm's low and the power low, the wiring concepts with its and we could have a look over the project calculations with the prices of the electronic components that have been used.

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