

5.1 SOUND SYSTEM

NUR HIDAYAH BT MAT NOR

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ABSTRACT

5.1 Sound System is a project of 'Projek Sarjana Muda (PSM)' that includes the knowledge of the electronic specifically in circuit operation. This project requires designing and constructing the hardware for the sound system based on power amplifier, treble and bass. It will have FIVE (5) sound system speakers together with a subwoofer (5.1 channels). There are 8 circuits of amplifiers which includes the bass (low frequency) and treble (high frequency). The circuit will filter and channel the high and low frequency to the appropriate speaker. This will utilize the use of microprocessor and the speakers will collect the sound signals from CD player / tape player and Auxiliary system. 5.1 project is suitable for the sound system at home or a room with a scope area of 6×4 metre and with the audience of 5 to 8 audiences such as a family. From this project, the information and knowledge about the audio system and circuit involved will be analyzed like the output power and current required, the suitable speaker used, and the impedance for the speakers, before choosing the power amplifier circuit that will be used to amplify the treble and base output for both side (left and right). Then, the output from amplifier will be sending to the speaker to produce the sound needed.

ABSTRAK

“ 5.1 Sound System “ adalah satu projek yang dibina sebagai memenuhi syarat “ Projek Sarjana Muda (PSM) “ yang mengambil kira pengetahuan tentang operasi litar elektronik. Projek ini memerlukan rekaan dan binaan untuk perkakasan sistem bunyi berdasarkan kepada litar penguat, treble dan bass. Ia mempunyai 5 sistem pembesar suara (speakers) dan satu subwoofer (5.1 channels) bersama dengan 6 litar termasuk treble dan bass. Litar ini berfungsi untuk menapis dan menyalurkan frekuensi tinggi dan rendah kepada pembesar suara yang sesuai. Pada keadaan ini, mikropemproses akan digunakan dan pembesar suara berfungsi untuk mengumpul/memungut isyarat bunyi dari pemain CD/pemain pita dan sistem auxiliary. Projek ini adalah bersesuaian digunakan untuk sistem bunyi dirumah atau dibilik yang mempunyai keluasan 6×4 meter bersama dengan 5 hingga 8 orang pendengar /penonton. Selain daripada itu, melalui projek ini juga pengetahuan dan maklumat mengenai sistem audio dan litar yang terlibat dapat diketahui dan dianalisis seperti kuasa keluaran dan arus yang diperlukan, pembesar suara yang bersesuaian, dan impedans pembesar suara yang bersesuaian sebelum litar penguat dipilih dan digunakan sebagai penguat kepada keluaran treble dan bass bagi kedua-dua bahagian kiri dan kanan. Keluaran daripada penguat akan dihantar kepada pembesar suara untuk mengeluarkan suara yang diperlukan / diingini.

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CHAPTER I

INTRODUCTION

1.1 Project introduction

5.1 Sound System is a project that will design FIVE (5) sound system together with a subwoofer (5.1 channels). Hence, there are 3 pre amplifier circuits which include the bass (low frequency) and treble (high frequency) that will be built in this project. Besides that, there are 5 power amplifier circuits that will amplify the output from pre amplifier for both sides (left and right) before the signal is sending to the speaker to produce the sound needed. The speaker used in this project is 8Ω speaker. The input for this system is from the CD player / tape player and Auxiliary system. This project is suitable to implement at home or a room with a scope area of six times four metres and with the audience of 5 to 8 audiences such as a family.

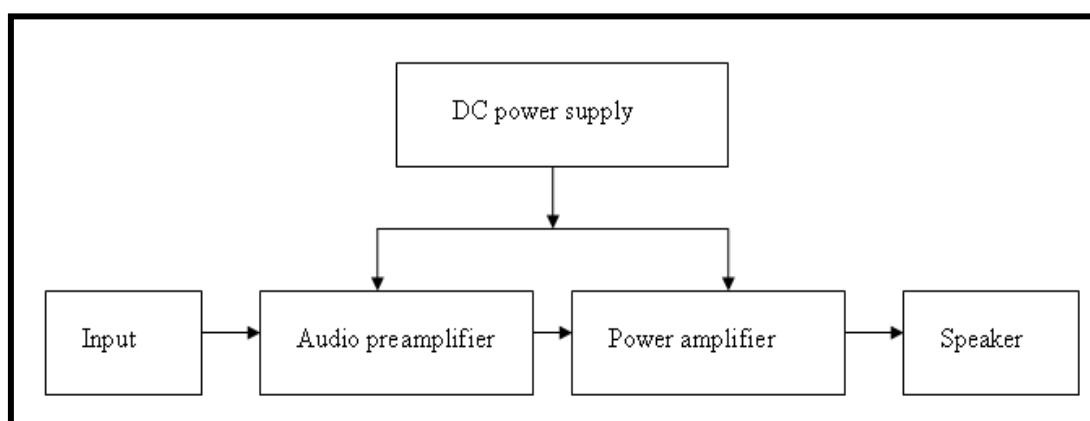


Figure : 1.1 Block diagram of 5.1 Sound System

In sound system, power amplifiers are the bridge between loudspeakers and the rest of any sound system like showed in Figure 1.1. Power amplifiers are large-signal amplifiers. It means that a much larger portion of load line is used during signal operation than in a small-signal amplifier. In a small-signal amplifier, the ac signal moves over a small percentage of the total ac load line. When the output signal is larger and approaches the limits of the ac load line, the amplifier is a large-signal type. Power amplifiers are normally used as the final stage of a communications receiver or transmitter to provide signal power to speakers or to a transmitting antenna. In this project, a power amplifier circuit used can generate an output of 100W. The circuit consist the transistors, resistors, diodes and capacitors. The type of amplifier used is a Darlington class AB push-pull amplifier. When the push-pull is used, the load resistance is relatively small. An 8ohm speaker is a common load for a class AB push-pull amplifier. A push-pull amplifier using Darlington transistors can be used to increase the input resistance presented to the driving amplifier and avoid reducing the voltage gain. [3]

For the treble and bass circuit (pre amplifier), it acts like a two band equalizer. Treble circuit controls the higher frequencies of sound, and bass controls the lower frequencies of sound. The treble and bass circuit will be included in all of the circuits used for this project. [4]

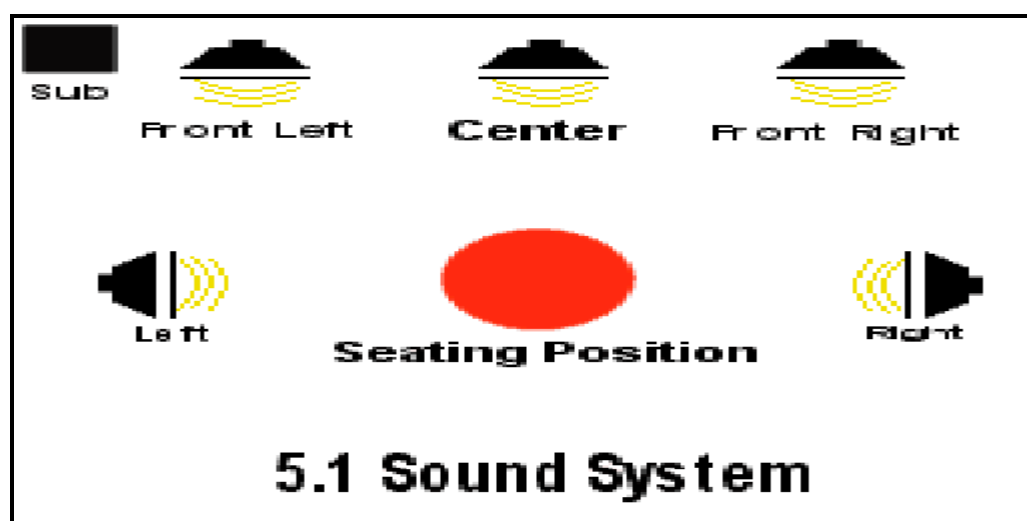


Figure 1.2 : Position of the speaker

1.2 Objectives of the project

- 1) To learn about the audio system and the circuit needed.
- 2) To be familiar with the audio power amplifier.
- 3) To improve the troubleshooting of the electronic circuit.
- 4) To design and implement the 5.1 sound system circuit.
- 5) To be familiar with the simulation of 5.1 sound system circuit.

1.3 Problem statement

This project is about a sound system at home or a room with a scope area of six times four metres. It is suitable for a group of audience of five to eight. There are three circuits used for this project which includes the low (bass) and high (treble) frequency circuit and the power amplifier circuit. Both circuits will control the tone/sound and the power amplifier will amplify it input to be sent to the speaker.

1.4 Scope of work

As the scope of the project, it must be noted that an undergraduate project, it is not expected to be perfect design. There must be a border, in which the student should attain to fulfill the requirement of the project. This project scope is list as below:

- 1) To search for information from reliable resources.
- 2) To study and analyze the information and choose the suitable circuit for the project.
- 3) To design the circuit :
 - i. Low frequency circuit
 - ii. High frequency circuit
- 4) To simulate the circuits.
- 5) To troubleshoot and implement the circuit.

1.5 Project methodology

This part will explain about the path that has been taken until the hardware realization. First, before start the project, the information and knowledge about 5.1 sound system must be analyzed and gain. This will be under the first method called literature review. The information about the circuit and project is found from the internet, books, journal, thesis and others. From the sources, the aspects involved with this project like circuit used, the suitable speaker used, the output power and current required and the impedance for the speakers can be determined. Following that, the comparison between the companies involved in this field had been made. For example, Pioneer and Sony company. The characteristics that are compared will be the features of the product, the power output provided, the equipment used and the price. Then, the best one will be choose as a reference to the project.

The main circuit in this project is divided into two; preamplifier circuit that will include the bass and treble circuit; and the power amplifier circuit. For preamplifier circuit, it has to function as the equalizer of the sound. This circuit will control the low and high frequency of the sound. In this circuit the main component is the IC LM348, that is quadruple, independent, high-gain, internally compensated operational amplifiers. Both of the circuit (bass & treble) will use it.

For power amplifier, it is function to amplify the signal to 100watt and then sent it to the speaker. There is a few types of amplifier design that is commonly used in the audio system such as class A amplifier, B amplifier and AB amplifier. These three types had their own special characteristics. For class A, it is a straightforward common-collector amplifier. In class A amplifier, the transistor must be conducting for the whole of the cycle. It is biased sufficiently to keep it on continuously, even during the negative half of the cycle. In general, class A amplifier show little distortion. The type of amplifying device used has no bearing on the class. Class A amplifier may base on BJTs, FETs, valves, Darlington pairs and several other devices. [6]

In class B amplifier, the excessive waste of power of the class A may be eliminated by using two transistors, one to handle positive going excursions of the signal and the other to handle the negative going excursions. This design is known as push-pull operation. The amplitude of the harmonics in the output of class B is much greater than the class A. For class AB amplifier, it is not really a separate class of its own, but a combination of A and B. If an amplifier is biased into Class B, and then the bias further increased, it will enter AB. For outputs below a certain level both output devices conduct, and operation is class A. At higher levels, one device will be turned off completely as the other provides more current, and the distortion jumps upward at this point as AB action begins. Class AB is less linear than either A or B. [6]

Then, base on the type of amplifier, the circuit needed for power amplifier will be designed. The main component used in power amplifier circuit is power transistor, capacitor and resistor. During the designing, the two stage power amplifier is used. For the input stage, there is a circuit called differential pair amplifier will be used. For the last stage, the circuit used is complementary push-pull amplifier class AB transistor combined with the Darlington amplifier.

Next, the simulation using the MultiSim will take part to verify the functionality of the circuit. From the result of simulation, the signal will be compared to the reference result of the reference circuit to see the different between it. If any difference appears, the circuit has to be modified and find the error. Lastly, the circuit will be troubleshoots and tested before hardware mounting process. In the testing stage, the circuit involved is power supply circuit, high and low frequency circuit, and power amplifier circuit. The case for the entire circuit is designed where it will have space for cd, tape player and auxiliary system.

1.6 Working flow chart

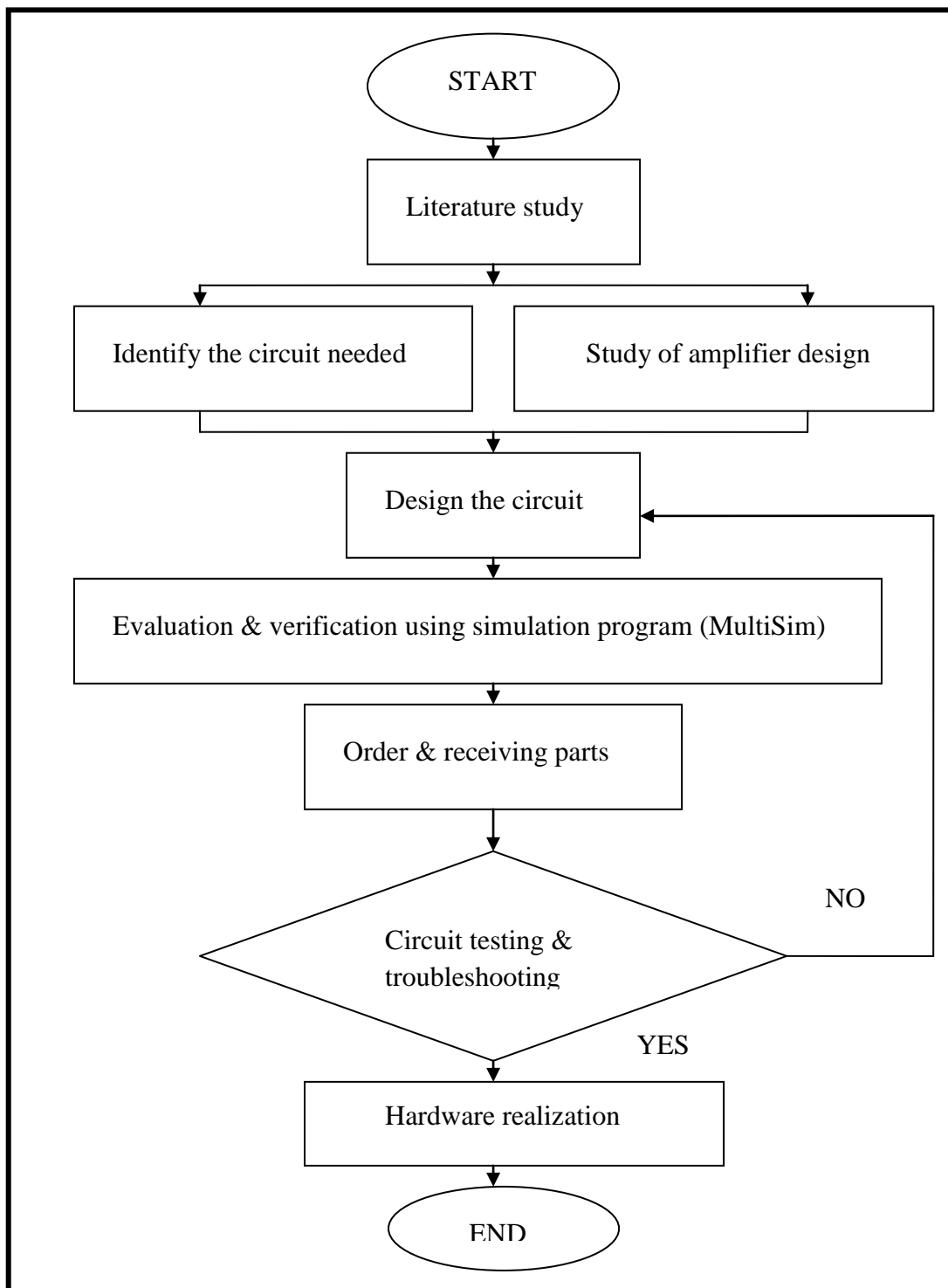


Figure 1.3 : Flow chart

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

The sound system consists of four main components: the input (the microphone, MiniDisc, cassette tape players, CD player), audio preamplifier, the power amplifier, and the speakers. To use the sound system to its fullest potential, the understanding of its components is necessary. One way of explaining a system is in terms of the signal path, which refers to the path the signal (the electrical form of the sound) gets from the recording system to the audience. The signal usually begins at either the MiniDisc player or the cassette deck, the microphone. These devices serve as your inputs. All of your input devices feed the preamplifier, which includes the tone control (treble bass circuit). Using the preamplifier, the electric signal is sent to the right places at the right volumes. [4]

From the preamplifier, the signal will go through the power amplifier to amplify the line level signal into a higher level signal powerful enough to drive a speaker. The speakers convert the electrical signal into vibrations which we hear as sound. [4]

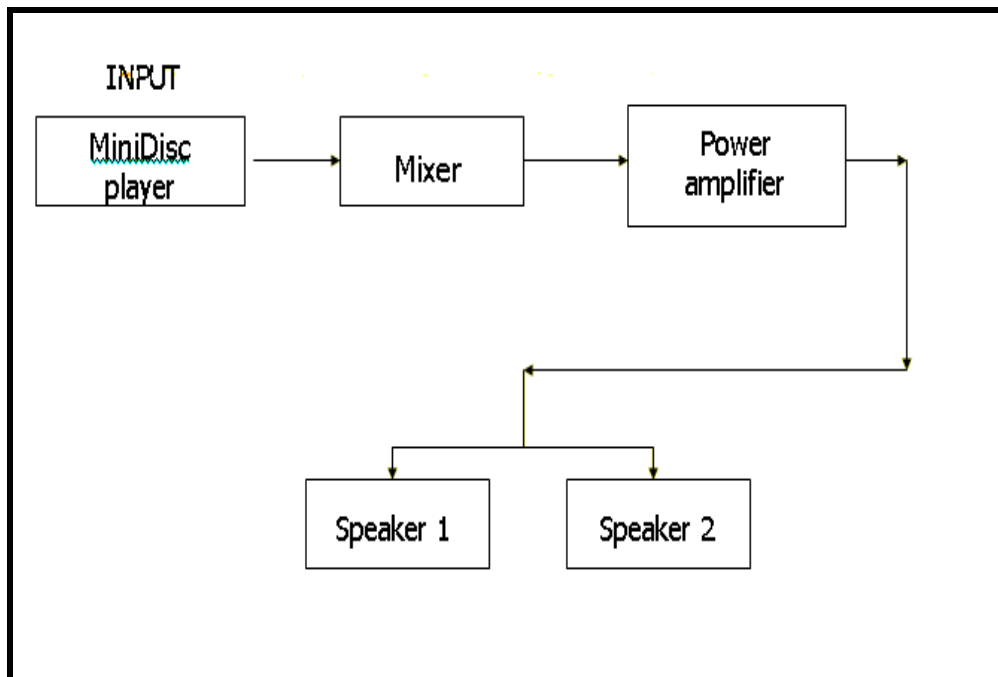


Figure 2.1 : Sound system block diagram

2.2 Pre-amplifier

A preamplifier (preamp), or control amp in some parts of the world, is an electronic amplifier which precedes another amplifier to prepare an electronic signal for further amplification or processing. In general, the function of a preamp is to amplify a low-level signal to line-level. A list of common low-level signal sources would include a pickup, microphone, turntable or other transducer. Equalization and tone control may also be applied. In a home audio system, the term 'preamplifier' may sometimes be used to describe equipment which merely switches between different line level sources and applies a volume control, so that no actual amplification may be involved. [11]

Other definition for preamp is the signal processing part of an amplifier. This means it's the section of the amplifier that allows you to plug in sources such as tuner

and CD player. It's also the section that allows you to change volume and possibly to change treble and bass settings. So it's a glorified switch with volume pot. [11]

2.3 Power amplifier

The term "power amplifier" is a relative term with respect to the amount of power delivered to the load and/or sourced by the supply circuit. In general a power amplifier is designated as the last amplifier in a transmission chain (the output stage) and is the amplifier stage that typically requires most attention to power efficiency. Power amplifiers are large-signal amplifiers. In a small-signal amplifier, the ac signal moves over a small percentage of the total ac load line. When the output signal is larger and approaches the limits of the ac load line, the amplifier is a large-signal type. The purpose of an amplifier is to make an electronic signal bigger without affecting the electronic device in any other way. [3]

Most power amplifier has two channels, a left and a right. The input signal assigned to an amplifier determined the speaker component connected to the output. The number of speaker components connected to an amplifier channel depends on the electrical resistance (ohms) of the speaker component and the way they are wired. The speakers can be wired in series or parallel. The total resistance of speakers wired in series is calculated by summing the values of the speakers. A speaker cabinet with two 8-ohm speakers wired in series would put a load of 16 ohms on an amplifier. The resistance of speakers wired in parallel is a little more difficult to calculate. The values of the speakers are multiplied and the total is divided by the sum of the values. A cabinet with two 8-ohm speakers wired in parallel would put a load of 4-ohms on an amplifier ($8 \times 8 = 64$; $64 \div 16 = 4$). The amount of power that an amplifier delivers depends on output load. The lower the speaker's resistance (ohms), the higher the output power (watts), and the greater the amplifier's power, the cleaner is the sound. [2]

Power amplifiers usually are set with the volume full up; most level adjustments are made by the controlling the system. The amplifiers are the last components to be switched on in the signal path and the first to be switched off, because any electronics in the chain that are powered up while connected in line will cause a loud, possibly damaging click through the speakers. [2]

There are three stages in power amplifier. The first being a transconductance stage or input stage (differential voltage in, current out), the second a transimpedance stage (current in, voltage out) and the third a unity-voltage-gain output stage. The second stage clearly has to provide all the voltage gain and it is called as voltage-amplifier stage or VAS. [2]

2.3.1 Input stage

The input stage of an amplifier performs the critical duty of subtracting the feedback signal from the input, to generate the error signal that drives the output. It is almost invariably a differential transconductance stage; a voltage-difference input results in a current output that is essentially insensitive to the voltage at the output port. In this circuit, the differential pair transistor is used as the input stage of the amplifier because of its low DC offset. Apart from its inherently lower offset due to the cancellation of the V_{be} voltages, it has the important added advantage that its standing current does not have to flow through the feedback network. However a second powerful reason, which seems less well-known, is that linearity is far superior to single transistor input stages. [2]

2.3.1.1 Differential pair transistor

A differential amplifier has two inputs instead of only one and its function is to amplify the difference between the two inputs. There are two terms of mode for the differential pair. First is the differential mode that describes the normal operation

of an amplifier in detecting and amplifying the difference in potential between its two inputs. The second term is common mode. Common mode implies that both sides of the amplifier are identical. They both have the same supply voltages and the resistors and transistor used in both sides of the amplifier should have identical performance. [5]

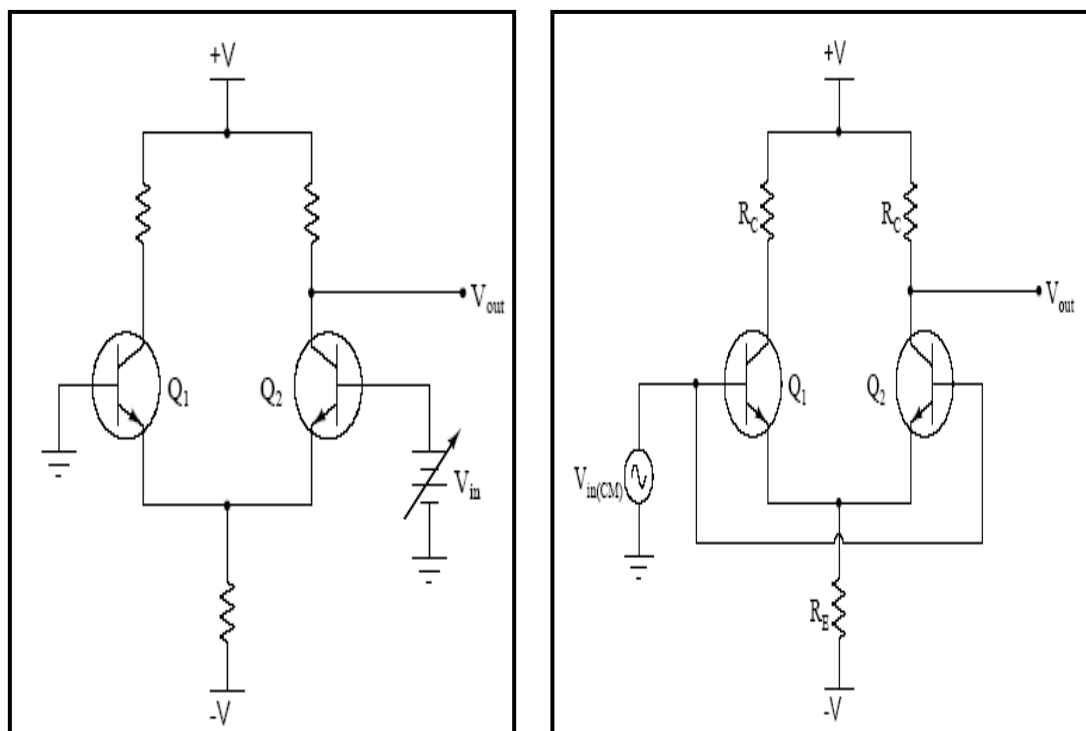


Figure 2.2 : Differential pair transistor

2.3.2 VAS stage

The Voltage-Amplifier Stage (VAS) has often been regarded as the most critical part of a power amplifier, since it not only provides all the voltage gain but also must give the full output voltage swing. (The input stage may give substantial transconductance gain, but the output is in the form of a current). [2]

In this stage, the circuit involves is Darlington pair with current mirror diodes bias. The Darlington pair consists of BJTs connected as Figure 2.3.