ANALOG CIRCUIT PROJECT

GROUP – 1

TOPIC : DESIGN AN AUDIO AMPLIFIER USING 555 TIMER

TEAM MEMEBERS

ELECTRONICS AND COMMUNICATION ENGINEERING BRANCH

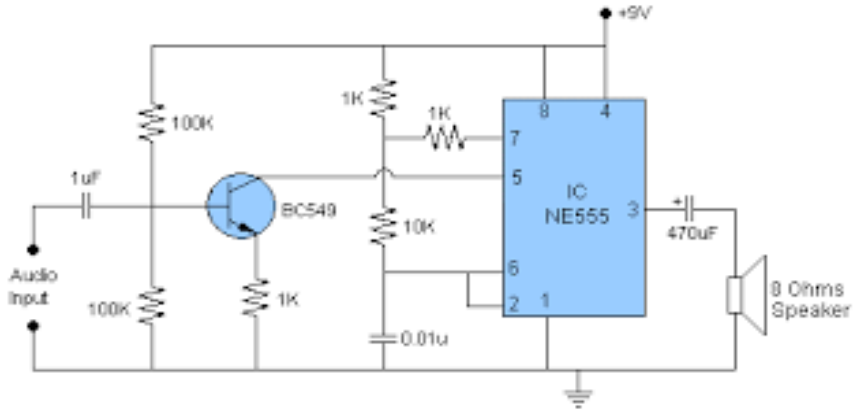
NAME	ENROLLMENT
SHARDA KUMARI	BT20EC001
SHASHANK SHEKHAR	BT20EC005
PRITI BHARTI	BT20EC017
NISHANT NITIN MISHRA	BT20EC019
VIRENDRA KUMAR	BT20EC021

INTRODUCTION

In this project we are describing the principle, design and operation of an audio amplifier using 555timer.This 555 timer generates a carrier signal which is modulated by the amplified audio signal to produce a modulated signal. This signal is used to drive a loudspeaker.

Audio amplifier is the basic circuit configuration that is required to amplify, the audio signal received through a device like a microphone or the audio signal that is to be transmitted out through a speaker/ Radio device/Wireless transmitter etc.

Abstract-Simulation of IC555 timer used as an audio amplifier is done in Multisim. The amplifying of input electrical signal and its Pulse Width Modulation by Timer 555 is done which produces a carrier frequency



suitable for modulation with input audio signal which will drive the Speaker. The input for simulation purpose is given a sine wave and resultant obtained wave is a square wave with varying width according to amplitude. This wave drives the speaker in Practical Application.

PRINCIPLE

It is based on the principle of audio amplification using operational amplifier and pulse width modulation using 555 Timer. The audio signal is amplified using low noise high input operational amplifier TL071 and is fed to the control pin of the 555 Timer. 555 Timer is used as an astable multivibrator producing an oscillating signal. This signal is modulated by the audio signal such that the width of the output pulse varies with respect to the voltage at the control pin (the audio signal), causing pulse width modulation.

COMPONENTS

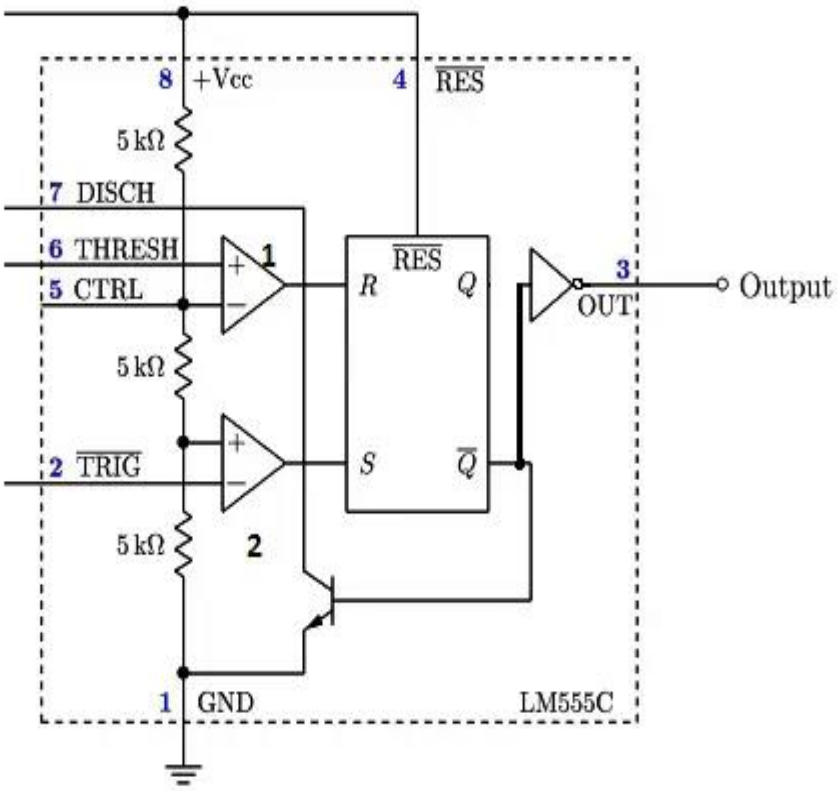
IC 555 TIMER

About

IC 555 TIMER is a well-known component in the electronic circles but what is not known to most of the people is the internal circuitry of the IC and the function of various pins present there in the IC. Let me tell you a fact about why 555 timer is called so, the timer got its name from the three 5 kilo-ohm resistor in series employed in the internal circuit of the IC.

IC 555 timer is a one of the most widely used IC in electronics and is used in various electronic circuits for its robust and stable properties. It works as square-wave form generator with duty cycle varying from 50% to 100%, Oscillator and can also provide time delay in circuits. The 555 timer got its name from the three 5k ohm resistor connected in a voltage-divider pattern which is shown in the figure below. A simplified diagram of the internal circuit is given below for better understanding as the full internal circuit consists of over more than 16 resistors, 20 transistors, 2 diodes, a flip-flop and many other circuit components.

The 555 timer comes as 8 pin DIP (Dual In-line Package) device. There is also a 556 dual version of 555 timer which consists of two complete 555 timers in 14 DIP and a 558 quadruple timer which is consisting of four 555 timer in one IC and is available as a 16 pin DIP in the market.



Internal Circuit Diagram of 555 IC

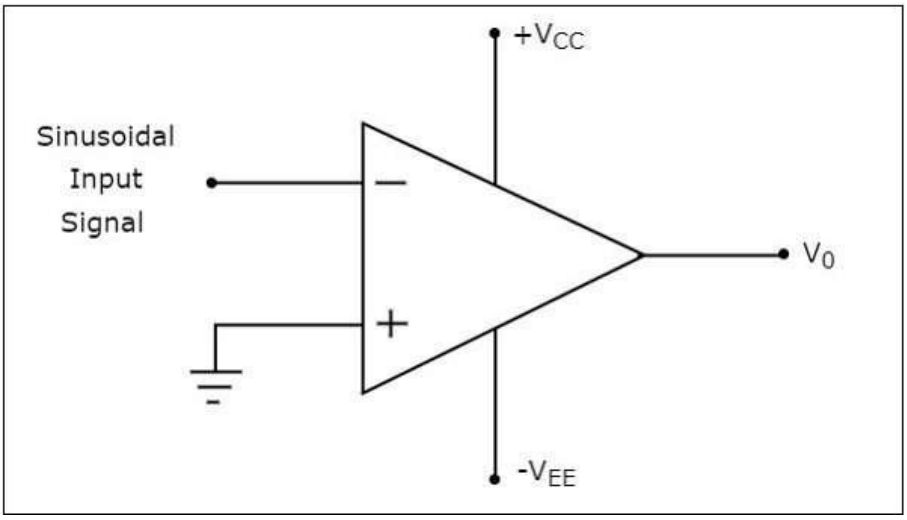
Basics Concepts

- · *Comparator*: The Comparator are the basic electronic component which compares the two input voltages i.e. between the inverting (-) and the non-inverting (+) input.

  If the voltage present at the non-inverting terminal of an op-amp is greater than the voltage present at its inverting terminal, then the output of comparator will be +Vsat. This can be considered as **Logic High** ('1') in digital representation.

  If the voltage present at the non-inverting terminal of op-amp is less than or equal to the voltage at its inverting terminal, then the output of comparator will be –Vsat–Vsat. This can be considered as **Logic Low** ('0') in digital representation.

  Also the input resistance of an ideal comparator is infinite.

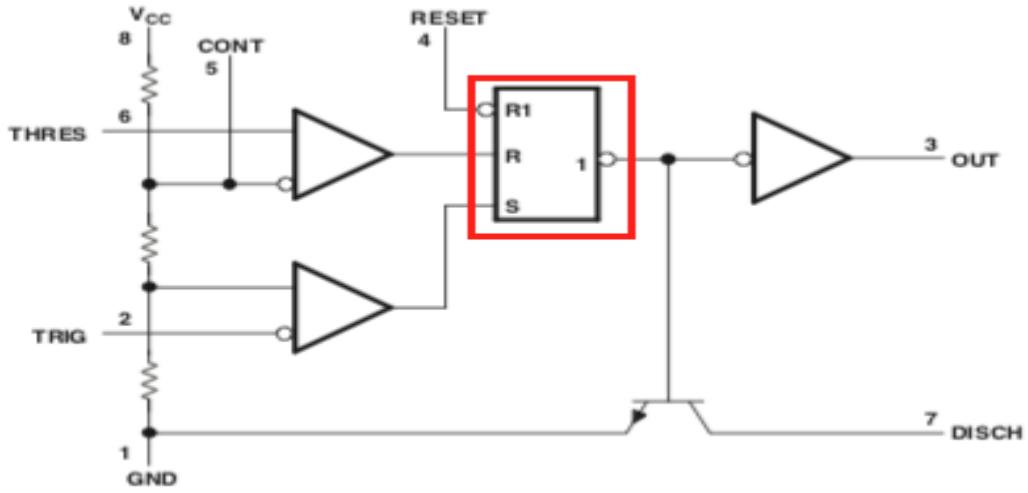


• *Voltage Divider*: As we know that the input resistance of the comparators is infinite hence the input voltage is divided equally between the three resistors. The value being $V_{in}/3$ across each resistor.

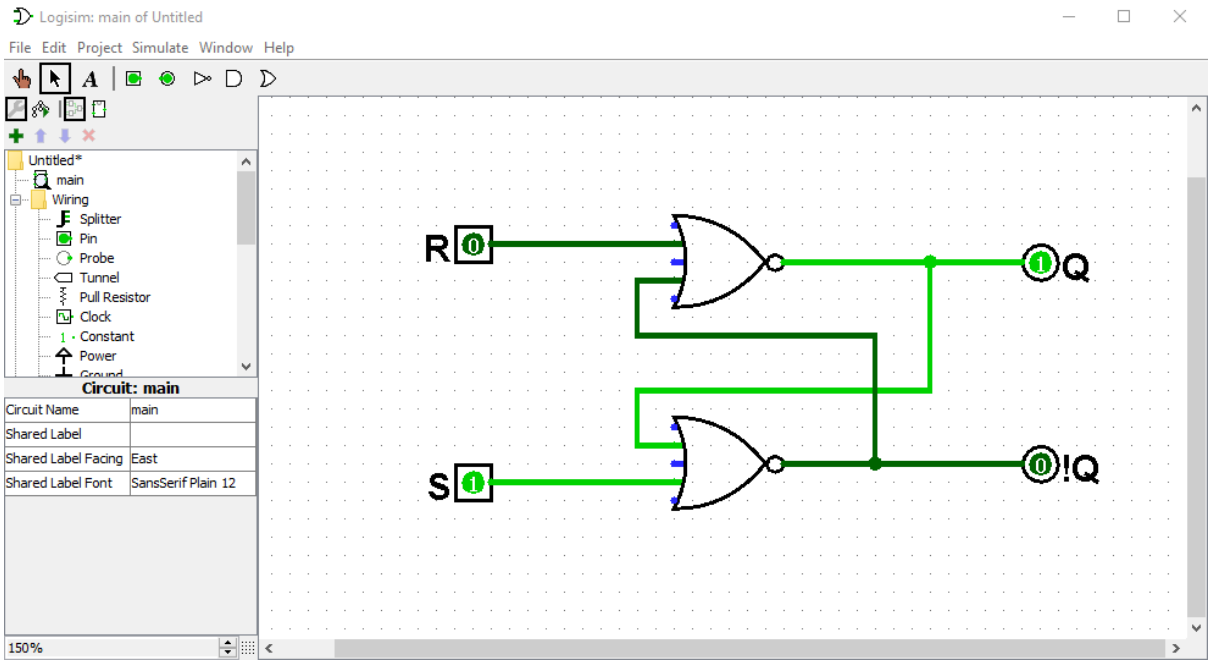
- *SR FLIP-FLOP IN TERM OF 555 TIMER*

A flip-flop is an electronic circuit that alternates between two output states. In a flip-flop, a short pulse on the trigger causes the output to go high and stay high, even after the trigger pulse ends. The output stays high until a reset pulse is received, at which time the output goes low.

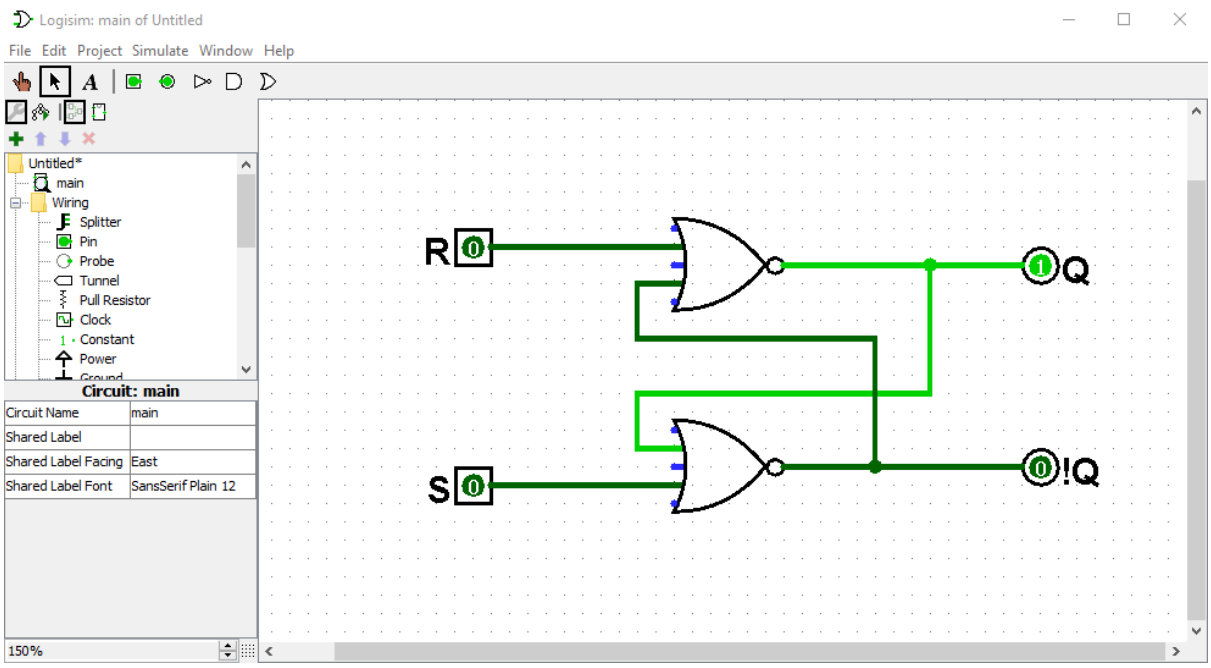
- **Pin 1** `GND` Ground.
- **Pin 2** `TRIG` Start of timing.
- **Pin 3** `OUT` Output signal. When output is active it switch to `HIGH` state.
- **Pin 4** `RESET` Reset timer. `LOW` state on this pin forces output to switch to `LOW` state.
- **Pin 5** `CONT` Controls internal comparator thresholds.
- **Pin 6** `THRES` End of timing input (when `THRES` > `CONT`).
- **Pin 7** `DISCH` Technically speaking: open collector output to discharge timing capacitor.
- **Pin 8** `VCC` Input supply voltage, in most cases from 5V to 15V.



The circuit can be made to change state by signals applied to one or more control inputs and will have one or two outputs. It is the basic storage element in sequential logic. Flip-flops and latches are fundamental building blocks of digital electronics systems used in computers, communications, and many other types of systems. All flip-flops can be divided into common types: the SR ("set-reset"), D ("data" or "delay"), T ("toggle"), and JK.



IN THIS IMAGE: S=1, R=0 to set Q.



IN THIS image: S=0, R=0 preserve previous state.

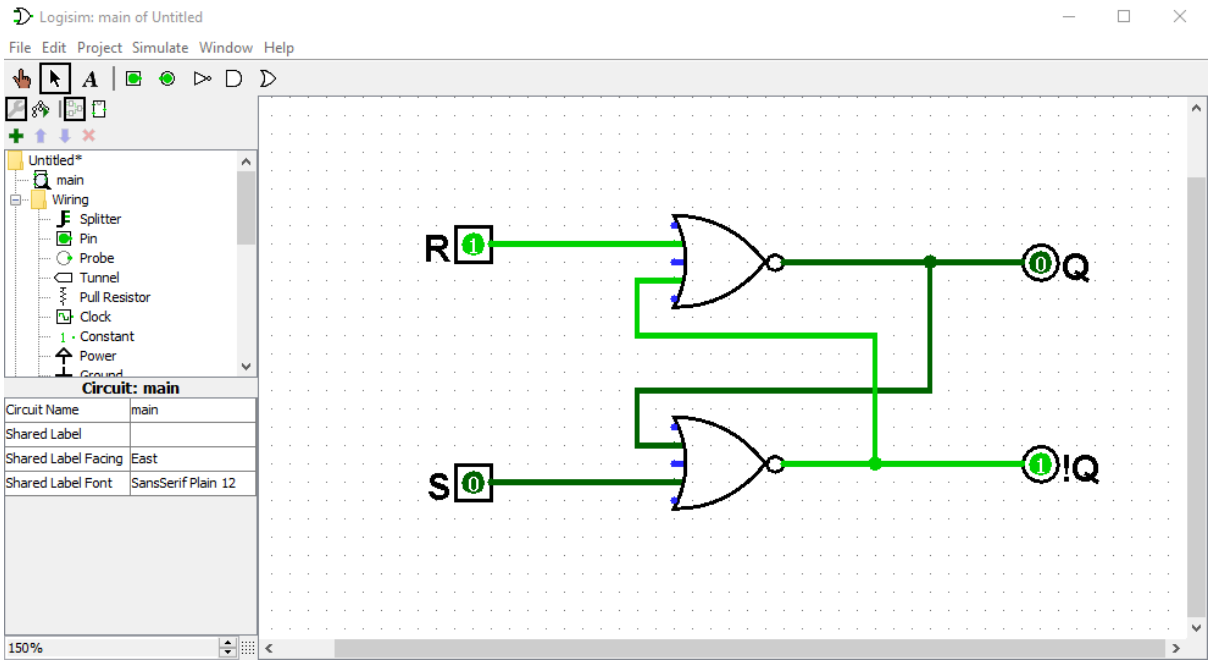


image: S=0, R=1 to reset Q.

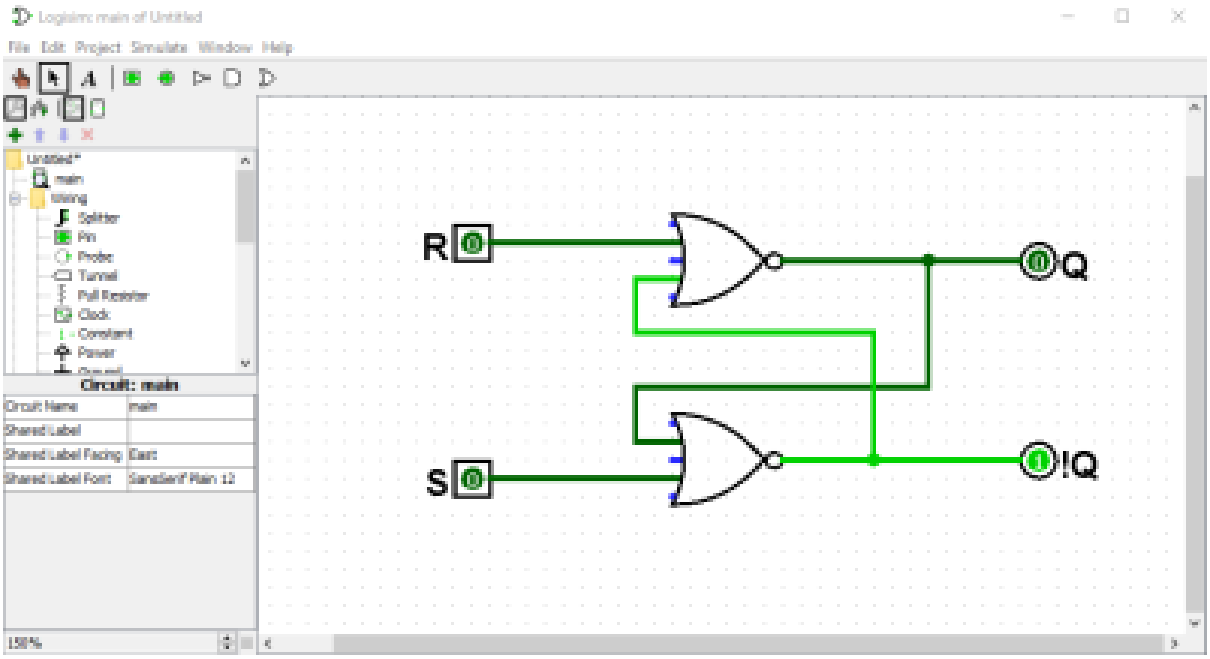


image: S=0, R=0 preserve previous state.

In case of SR, while the R and S inputs are both LOW, feedback maintains the Q and !Q outputs in a constant state, with Q the complement of !Q. If S is pulsed HIGH while R is held LOW, then the Q output is forced HIGH, and stays high when S returns to LOW; similarly, if R is pulsed HIGH while S is held LOW, then the Q output is forced LOW, and stays LOW when R returns to LOW.

The R = S = 1 combination is called a restricted combination or a forbidden state because, it breaks the logical equation Q = !Q (which is a consequence of internal structure, where two NOR gates are used).

In 555 chip SR flip-flop is used to remember the output states of voltage comparators.
The functions of its oins are as follows:

- **S -- set** -- high state set Q output to high state,
- **R -- reset** -- high state sets Q output to low state,
- **!R1 -- master reset** -- low state turns off Q output regardless of the state of the other two inputs,
- **Q -- flip-flop output**,
- **!Q -- negated output of the flip-flop** (opposite to Q).

Function of different Pins:-

1. **Ground**: This pin is used to provide a zero voltage rail to the Integrated circuit to divide the supply potential between the three resistors shown in the diagram.
2. **Trigger**: As we can see that the voltage at the non-inverting end of the comparator is $V_{in}/3$, so if the trigger input is used to set the output of the F/F to 'high' state by applying a voltage equal to or less than $V_{in}/3$ or any negative pulse, as the voltage at the non-inverting end of the comparator is $V_{in}/3$.
3. **Output**: It is the output pin of the IC, connected to the Q' (Q-bar) of the F/F with an inverter in between as show in the figure.
4. **Reset**: This pin is used to reset the output of the F/F regardless of the initial condition of the F/F and also it is an active low Pin so it connected to 'high' state to avoid any noise interference, unless a reset operation is required. So most of the time it is connected to the Supply voltage as shown in the figure.
5. **Control Voltage**: As we can see that the pin 5 is connected to the inverting input having a voltage level of (2/3) V_{in}. It is used to override the inverting voltage to change the width of the output signal irrespective of the RC timing network.
6. **Threshold**: The pin is connected to the non-inverting input of the first comparator. The output of the comparator will be high when the threshold voltage will be more than (2/3) V_{in} thus resetting the output (Q) of the F/F from 'high' to 'low'.
7. **Discharge**: This pin is used to discharge the timing capacitors (capacitors involved in the external circuit to make the IC behave as a square wave generator) to ground when the output of Pin 3 is switched to 'low'.

8. **Supply**: This pin is used to provide the IC with the supply voltage for the functioning and carrying of the different operations to be fulfilled with the 555 timer.

Basics of 555 Timer IC

Multivibrators find their own place in many of the applications as they are one of the most widely used circuits. The application may be household (domestic), industrial, access control, communication etc anyone. The multivibrators are used in all such applications as oscillators, as digital flip-flop, as pulse generator circuit, as delay generator circuit, as a timer and many more.

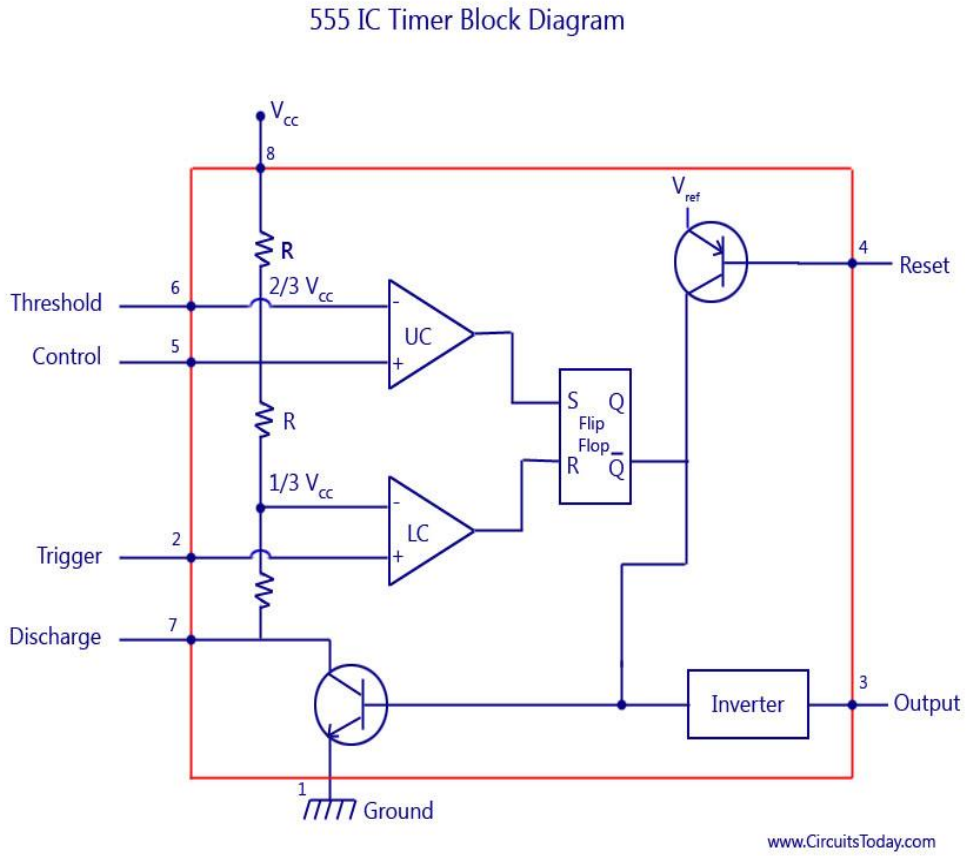
There are three types of multivibrators

1. **Astable multivibrator –** it has no stable state. It has two quasi stable states that automatically changes from one to another and back. So actually it changes from high to low state and low to high state without any trigger input after pre determine time.

{ 2. **Monostable multivibrator –** it has one stable state and one quasi stable state. It jumps into quasi stable state from stable state when trigger input is applied. It comes into stable state from quasi stable state after pre determine time automatically.

3. **Bistable multivibrator –** it has both stable states. Two different trigger inputs are applied to change the state from high to low and low to high.

All these three kinds of multivibrators can be easily made using transistors. But one IC is available that can be used as astable, monostable or bistable multivibrator and that is **IC555**.



IC **555** is the most versatile chip and it is (can be) used in all most every kind of application because of its multi functionality. Its 8 pin DIP or SOP package type chip with 200 mA direct current drive output. It's called mixed signal chip because there are analog as well as digital components inside. Its main applications are to generate timings, clock waveform, generate synchronizing signals, square wave oscillator, in sequential circuit and many more.

Working Principle

The internal resistors act as a voltage divider network, providing (2/3)Vcc at the non-inverting terminal of the upper comparator and (1/3)Vcc at the inverting terminal of the lower comparator. In most applications, the control input is not used, so that the control voltage equals +(2/3) V_{CC}. Upper comparator has a threshold input (pin 6) and a control input (pin 5). Output of the upper comparator is applied to set (S) input of the flip-flop. Whenever the threshold voltage exceeds the

control voltage, the upper comparator will set the flip-flop and its output is high. *A* high output from the flip-flop when given to the base of the discharge transistor saturates it and thus discharges the transistor that is connected externally to the discharge pin 7. The complementary signal out of the flip-flop goes to pin 3, the output. The output available at pin 3 is low. These conditions will prevail until lower comparator triggers the flip-flop. Even if the voltage at the threshold input falls below (2/3) V_{CC}, that is upper comparator cannot cause the flip-flop to change again. It means that the upper comparator can only force the flip-flop's output high.

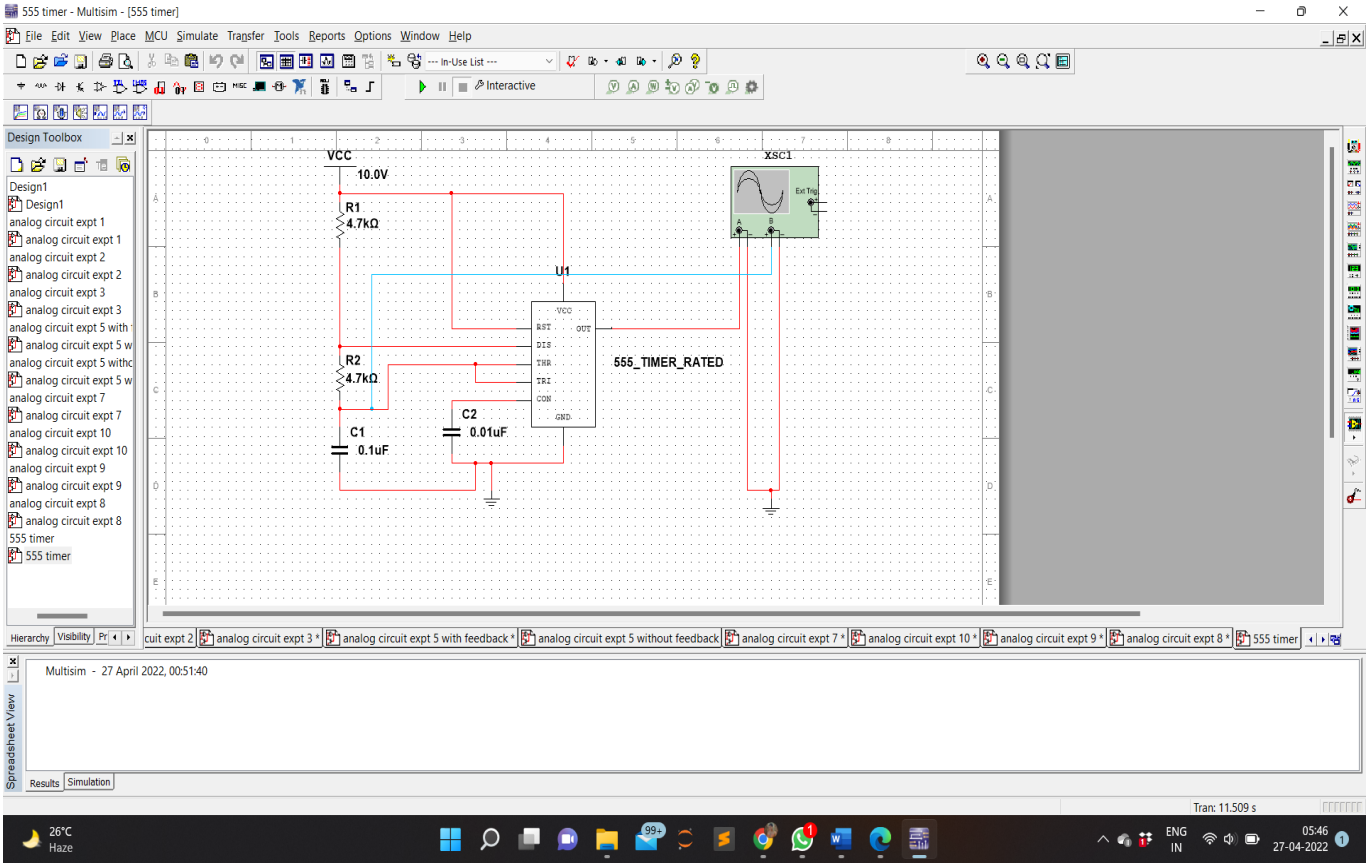
To change the output of flip-flop to low, the voltage at the trigger input must fall below + (1/3) Vcc. When this occurs, lower comparator triggers the flip-flop, forcing its output low. The low output from the flip-flop turns the discharge transistor off and forces the power amplifier to output a high. These conditions will continue independent of the voltage on the trigger input. Lower comparator can only cause the flip-flop to output low.

From the above discussion, it is concluded that for the having low output from the timer 555, the voltage on the threshold input must exceed the control voltage or + (2/3) V_{CC}. This also turns the discharge transistor on. To force the output from the timer high, the voltage on the trigger input must drop below +(1/3) V_{CC}. This turns the discharge transistor off.

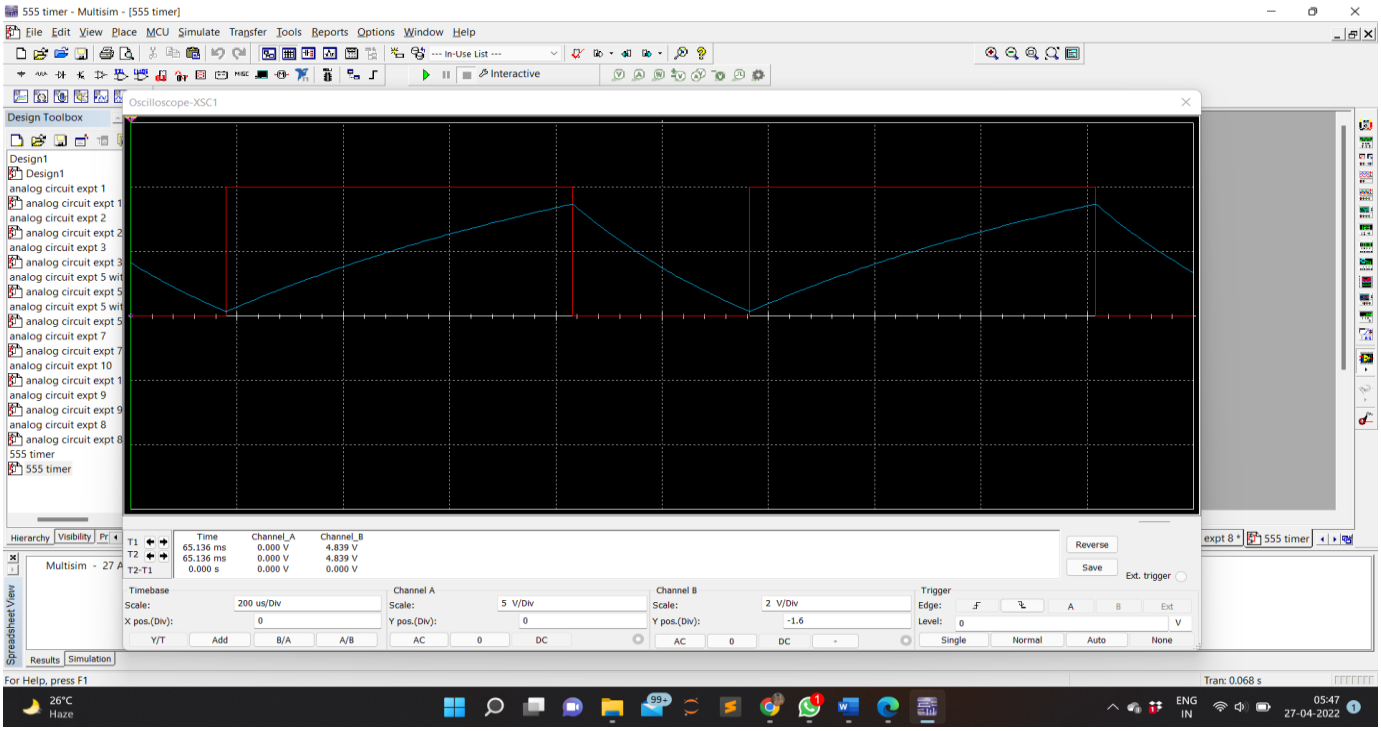
A voltage may be applied to the control input to change the levels at which the switching occurs. When not in use, a 0.01 nano Farad capacitor should be connected between pin 5 and ground to prevent noise coupled onto this pin from causing false triggering.

Connecting the reset (pin 4) to a logic low will place a high on the output of flip-flop. The discharge transistor will go on and the power amplifier will output a low. This condition will continue until reset is taken high. This allows the synchronization or resetting of the circuit's operation. When not in use, reset should be tied to +V_{CC}.

Circuit Diagram of 555 Timer as Astable Multivibrator



Waveform of 555 Timer as Astable Multivibrator



Some important features of the 555 timer

555 timer is used in almost every electronic circuit today. For a 555 timer working as a flip flop or as a multi-vibrator, it has a particular set of configurations. Some of the major features of the 555 timer would be,

- It operates from a wide range of power ranging from +5 Volts to +18 Volts supply voltage.
- Sinking or sourcing 200 mA of load current.
- The external components should be selected properly so that the timing intervals can be made into several minutes along with the frequencies exceeding several hundred kilohertz.
- The output pin of a 555 timer can drive a transistor-transistor logic (TTL) due to its high current output.
- It has a temperature stability of 50 parts per million (ppm) per degree Celsius change in temperature which is equivalent to 0.005 %/ °C.
- The duty cycle of the timer is adjustable.
- Also, the maximum power dissipation per package is 600 mW and its trigger pulse and reset inputs has logic compatibility.

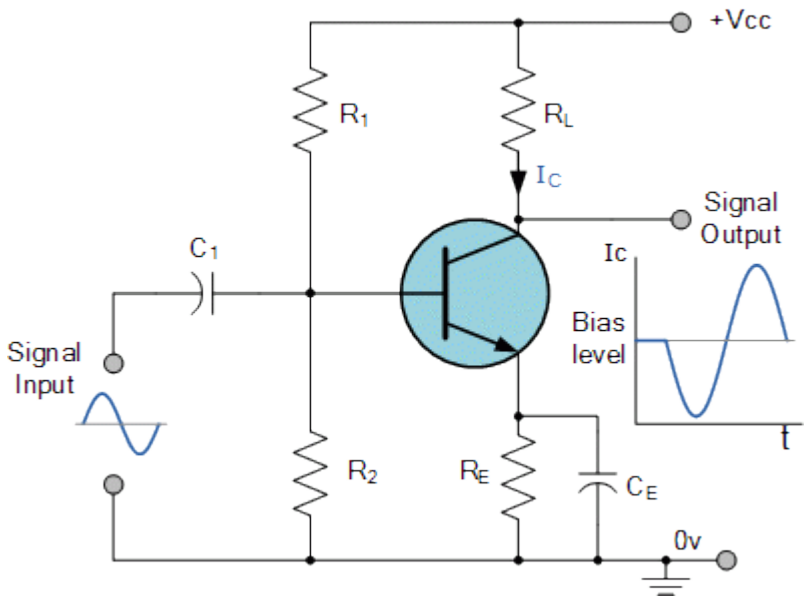
Uses of IC 555 Timer

The IC 555 timer is used in many circuits, for example One-shot pulse generator in Monostable mode as an Oscillator in Astable Mode or in Bistable mode to produce a flip/flop type action. It is also used in many types of other circuit for achievement of various purposes for instance Pulse Amplitude Modulatin (PAM), Pulse Width Modulation (PWM) etc.

TRANSISTOR

Audio amplifiers are based on solid-state transistors, especially the bipolar junction transistor (BJT) and the metal–oxide–semiconductor field-effect transistor (MOSFET). Transistor-based

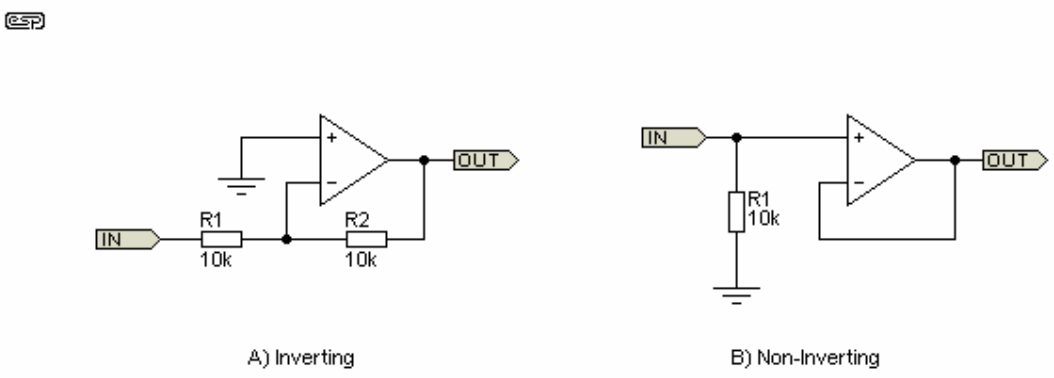
amplifiers are lighter in weight, more reliable and require less maintenance than tube amplifiers.



Operational Amplifier

Operational Amplifier commonly known as OpAmp is a linear device fundamentally used as voltage amplifier. The feedback components decide the function or operation. The circuit operates on dual power supply +Vcc and -Vee.

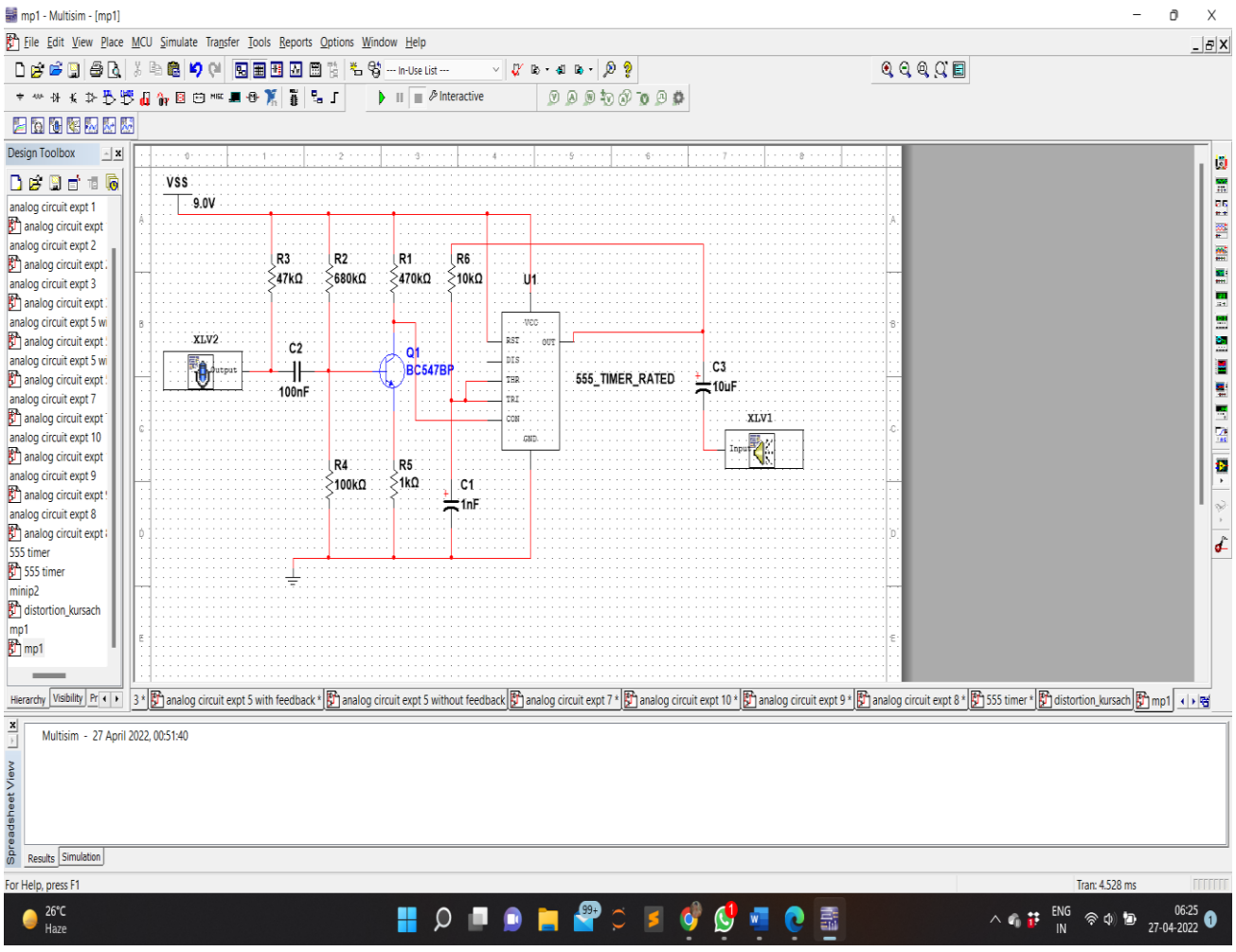
One input is called Non inverting(+) whereas other is called Inverting(-).The output is the difference between the two input signals applied at the terminals.



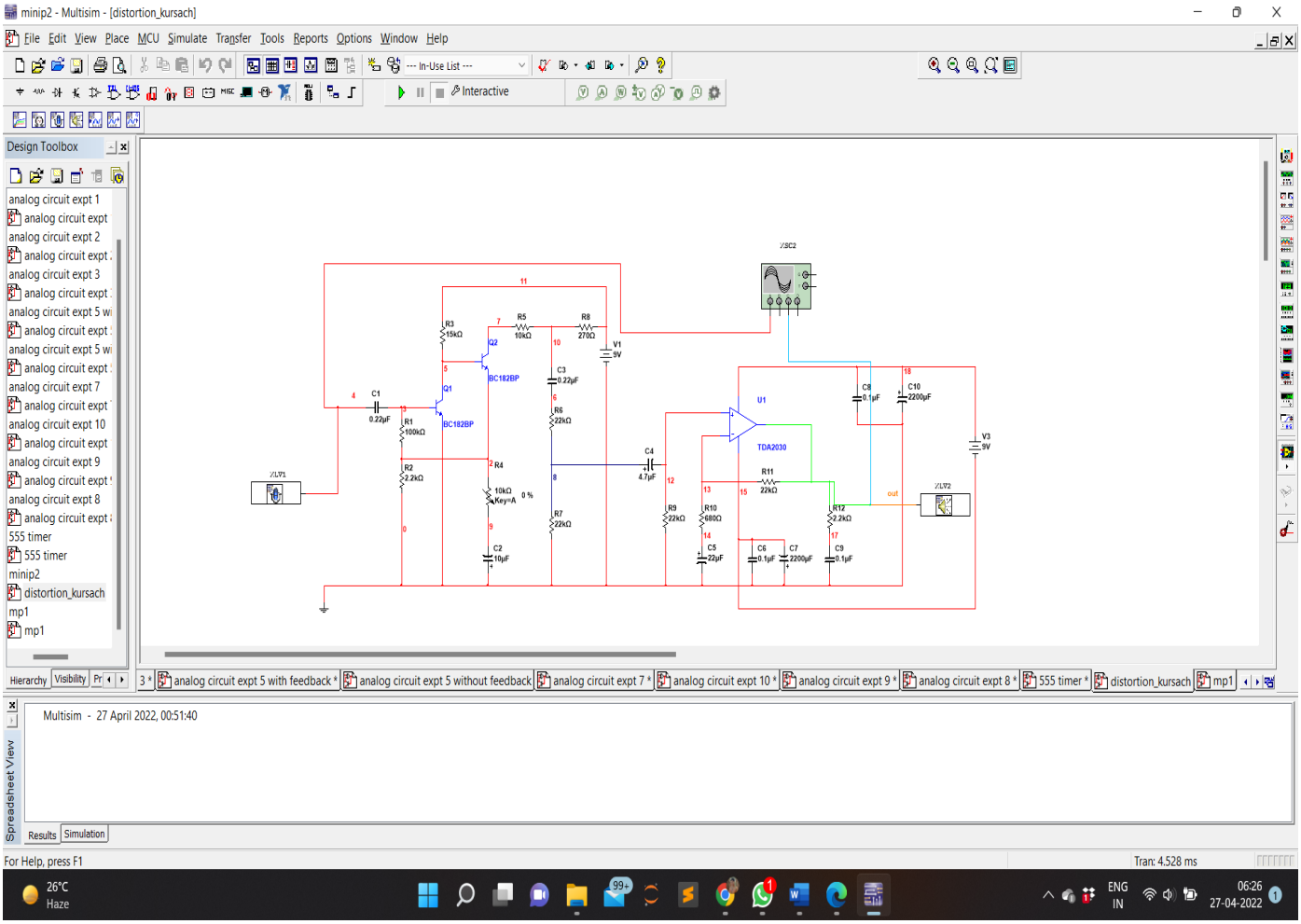
CIRCUIT DESIGN

This circuit is divided into two parts one is the Preamplifier circuit, which consists of a BC547 transistor, and the second part consists of an 8-ohm speaker and a 555 timer IC, which is oscillating in **Astable multivibrator mode**, with approx. 66KHz frequency. An astable multivibrator is a free-running oscillator that switches continuously between its two unstable states. With no external signal applied, the transistors alternately switch from cutoff to saturation state at a frequency that RC time constants of the coupling circuit determine. If these time constants are equal (R and C are equal) then a square wave will generate with a frequency of 1/1.4 RxC. Hence, an astable multivibrator is also a pulse generator or a square wave generator.

DESIGN 1



DESIGN 2



WORKING OF AUDIO AMPLIFIER

The circuit operation is divided into two segments – the pre amplifying (electric signal amplification) operation and the pulse width modulation operation. The amplifying operation is performed by the low noise operational amplifier TL071. The input audio signal is sensed using the microphone and converted to a low voltage electric signal. This low voltage AC signal is fed to the non inverting terminal of the OPAMP through an electrolyte capacitor of 1uF, which blocks the DC current of the audio signal.

This signal is amplified using the operational amplifier with a gain depending upon the values of feedback resistors. Here the OPAMP works

in linear mode so as to make the voltage at non inverting terminal equal to the output voltage using the feedback network. This amplified signal is then fed to the control pin of the 555 Timer through the capacitor (to remove the DC component) and the resistor. Here the 555 Timer works in the astable mode with the frequency of output signal determined by the combination of resistors R1 and C1.

However since here we are applying the control voltage, the width of the output pulse varies depending upon the control voltage. The carrier output signal produced by the 555 Timer is modulated by the audio voltage and the resultant modulated signal is used to the drive the loudspeaker. Here the loudspeaker does not responds to the high frequency signal, but rather to the DC value of the modulated signal and thus the audio signal appears amplified.

APPLICATIONS OF AUDIO AMPLIFIER

1. In the sound systems, these amplifiers are most widely used.
2. In various instruments that relate to music, these amplifiers are installed.
3. In the radio signals broadcasting these amplifiers are used.
4. The signal transmission for long-distance communication is the most amplifiers that are utilized.
5. For the wireless transmission of the signals, audio amplification is required.