CEC Continuing Education Center

DesignNews

Exploring Electronic Circuits with Breadboards, AI Circuit Analysis, and Simulators

DAY 2: Electronic Circuit Schematic Diagrams – KiCad and Microcap

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Webinar Logistics

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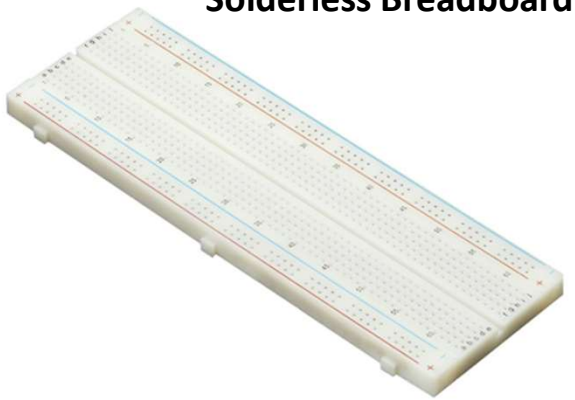
Dr. Don Wilcher

Visit ‘Lecturer Profile’ in your console for more details.

Course Kit and Materials

Adafruit Parts Pal Kit

Solderless Breadboard



Jumper Wires: Male to Male

Solderless Breadboard Power Supply

Research Perspective

"Breadboards are widely used in early-stage circuit prototyping since they enable users to rapidly try out different components and to change the connections between them" (Zhu et al., 2020).

Agenda:

- The Purpose of Electronic Circuit Schematic Diagrams In Industry
- Introduction to Micro-Cap
  a) Layout of the Micro-Cap Software Environment
  b) Build and Simulate a 555 Timer Astable Multivibrator Circuit Activity
- Introduction to KiCAD
  a) Layout of the KiCAD Software Environment
  b) Drawing a 555 Timer Astable Multivibrator Electronic Circuit Schematic Diagram Activity

The Purpose of Electronic Circuit Schematic Diagrams in Industry

Due to these factors, electronic circuit schematic diagrams play an important role in the industry.

- Provide a clear visual representation of how components in a circuit are connected.
- Allowing for easier understanding of products of
  a) design.
  b) communication.
  c) troubleshooting.
  d) analysis of complex electrical systems.
- Enabling engineers and technicians to quickly grasp circuit functionality.
- Identify potential issues without needing to examine the device itself physically.

The Purpose of Electronic Circuit Schematic Diagrams in Industry. . .

Key benefits of Electronic Circuit Schematic Diagrams in Industry.

- Improved communication- Standardized symbols and layouts for clear communication of circuit designs.
- Design and Planning – Schematics allow engineers to visualize and plan circuit layouts before physical construction begins.
- Troubleshooting – Schematic Diagrams help technicians to identify the source of electronic circuit problems.
- Simulation and Analysis – Schematic Diagrams can be used as input for computer simulations. Allowing circuit behavior to be tested under specific conditions.
- Documentation – Schematic Diagrams preserve design details and facilitating future modifications or maintenance.

Question 1

Schematic diagrams can be used as output for computer simulations.

a) True

b) False

Introduction to Micro-Cap Software

- Is a freeware analog and digital circuit simulator that provides an interactive environment for electronic engineers to build and simulate virtual designs.
- The software was designed by Spectrum Software.
- Spectrum Software shuttered the company's domain in July 2019.
- Spectrum Software's website went offline in early 2023.
- Micro-Cap Software can be obtained from archive.org.
- Version 12 can be obtained from the following web link: https://archive.org/details/mc12cd_202108.

Introduction to Micro-Cap Software. . .

Micro-Cap is a powerful software tool that can be used to:

- build circuits.
- explore circuit operations.
- learn about circuits.
- perform sensitivity analysis.
- worst case analysis.
- transient analysis.
- create macro-model functions of specific circuits.

Although software is no longer supported, the features listed are important in the design and analysis of electronic circuits.

Introduction to Micro-Cap Software. . .

What is a Macro-model?

A compact circuit that emulates the behavior of a real circuit or device without modeling each of its elements.

Question 2

Micro-Cap software was designed by

a) Simply Software
b) Software Simply
c) Software Spectrum
d) Spectrum Software

Introduction to Micro-Cap Software. . .

Macro-model Examples

AMP

This block provides a simple linear amplifier. Its definition is:

$$V_{Out}(t) = gain\ V_{In}(t)$$

The function is implemented with the AMP macro:

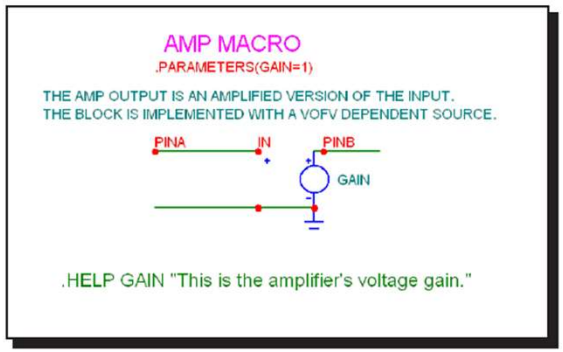


Figure 25-3 AMP macro circuit

The single input parameter, GAIN, multiplies the input to produce an amplified output. This implementation uses a simple linear dependent VOFV source. It could have been done with a Function source or a Spice poly source. In general, the simplest type of source that will perform the function is preferred.

PID Controller

The PID (Proportional-Integral-Derivative) controller is a common feedback mechanism used within closed loop control systems. The controller automatically adjusts a variable to keep a specified measurement at a set point. It can be found in temperature, flow, and position control applications. The macro employs other math function macros, SUB, AMP, INT, DIF, and SUM.

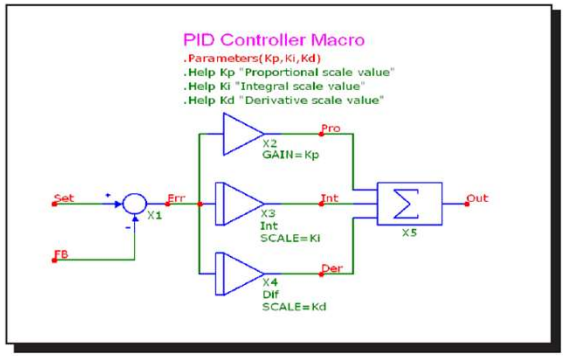


Figure 25-33 PID Controller macro circuit

Parameter	Definition
KP	Proportional scale value
KI	Integral scale value
KF	Derivative scale value

Introduction to Micro-Cap Software. . .

Macro-Model Examples

555

The 555 is a model of the ubiquitous 555 timer circuit. Its circuit is as follows:

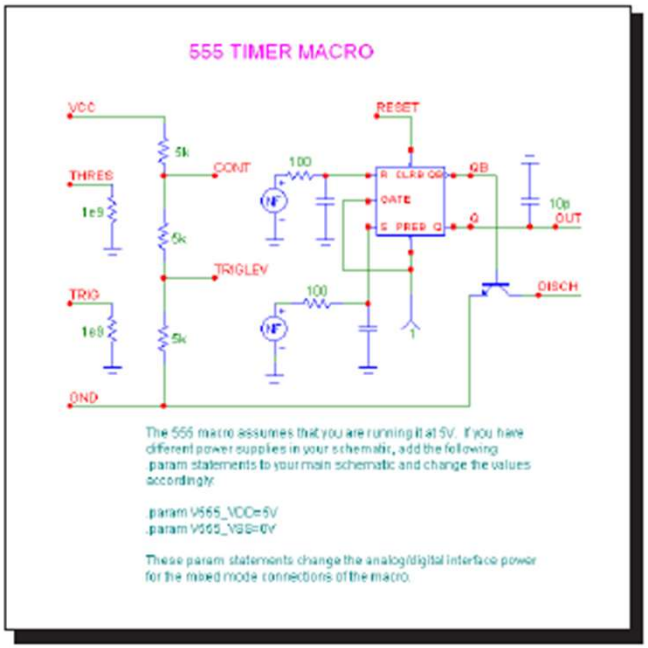


Figure 25-57 555 macro circuit

Introduction to Micro-Cap Software. . .

Macro-model Examples

555

The 555 is a model of the ubiquitous 555 timer circuit. Its circuit is as follows:

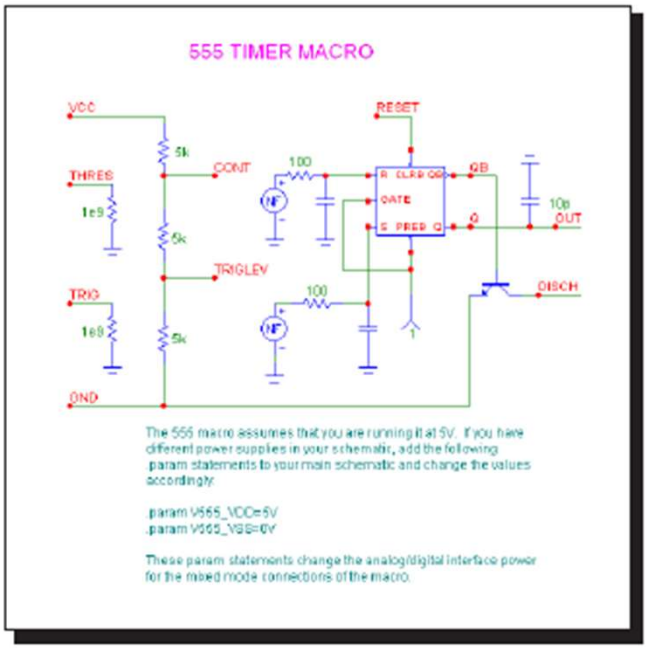
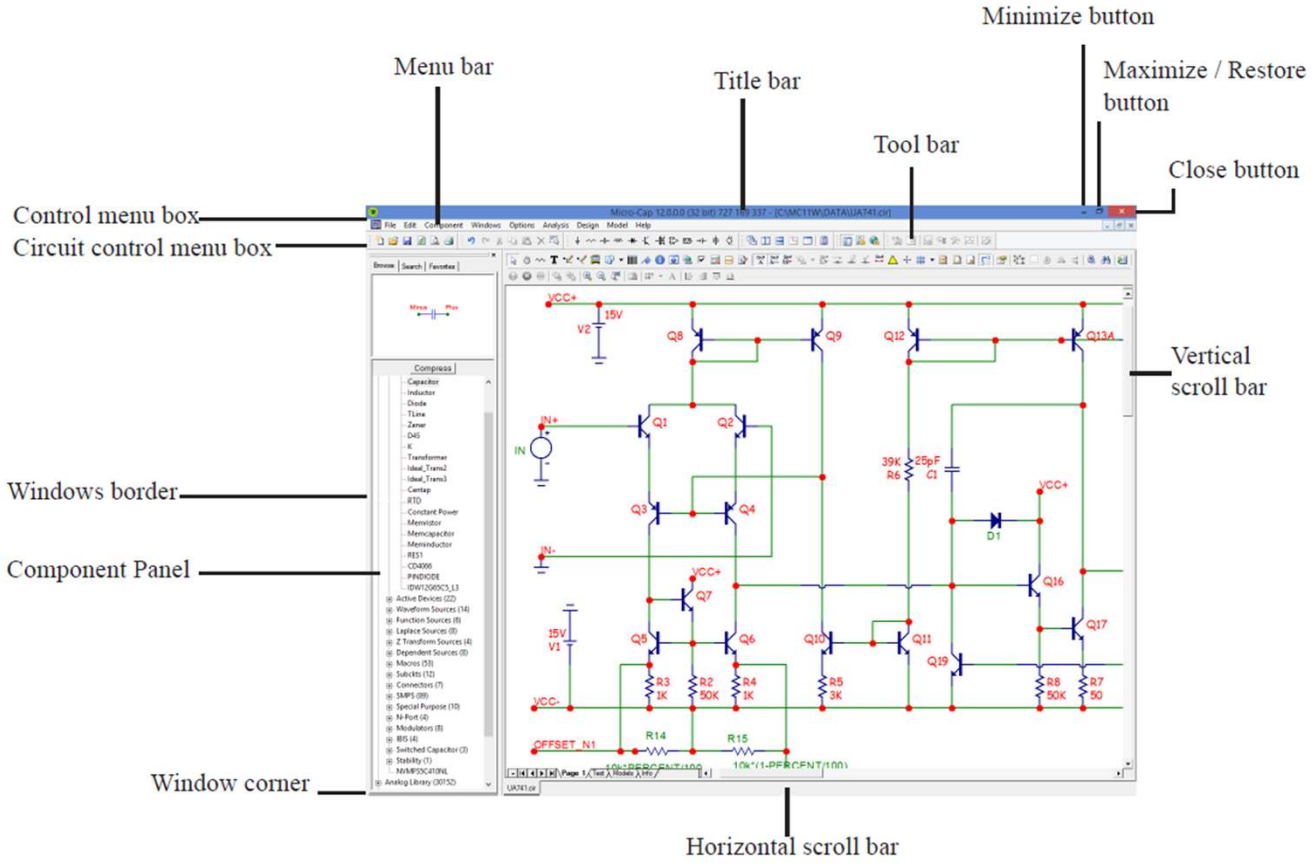


Figure 25-57 555 macro circuit

Layout of Micro-Cap Software Environment



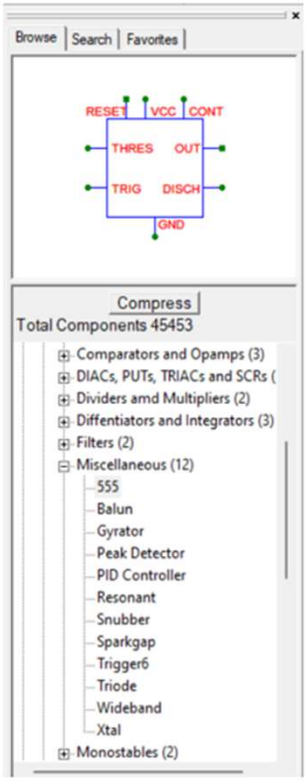
Question 3

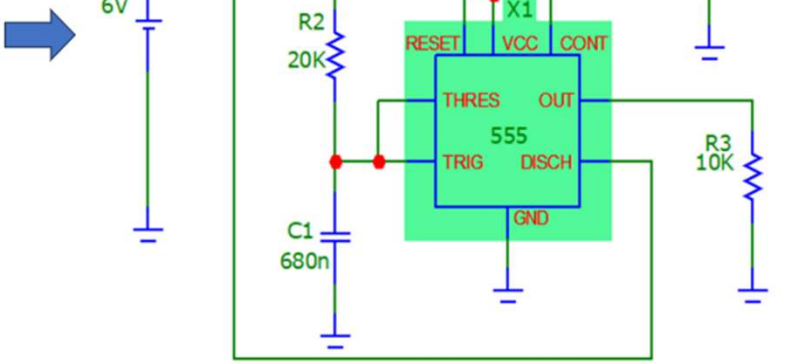
In reviewing slide 14, the AMP block provides a simple linear amplifier defined by a:

a) picture
b) text
c) mathematical equation
d) none of the above

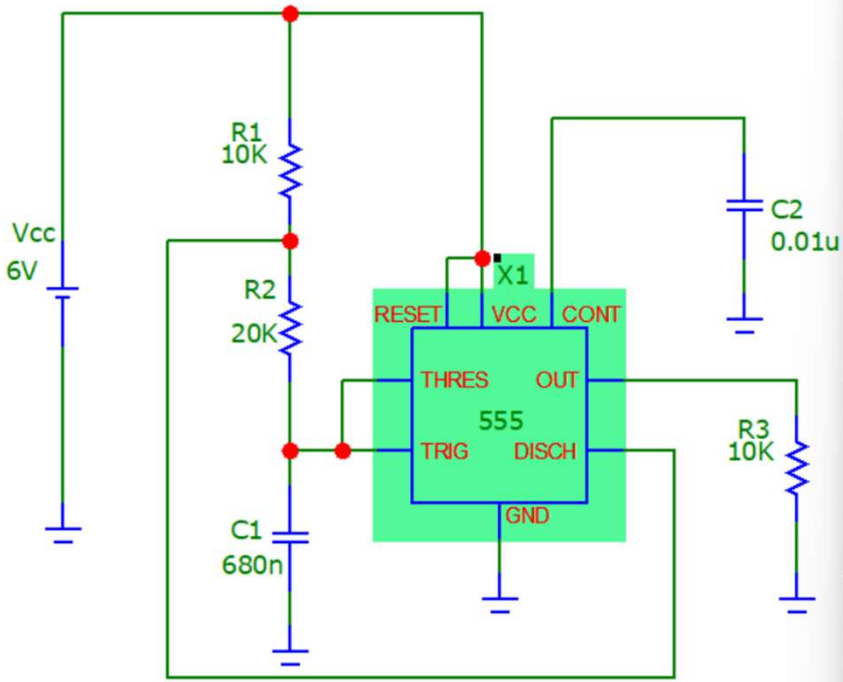
Build and Simulate a 555 Timer Astable Multivibrator Circuit Activity

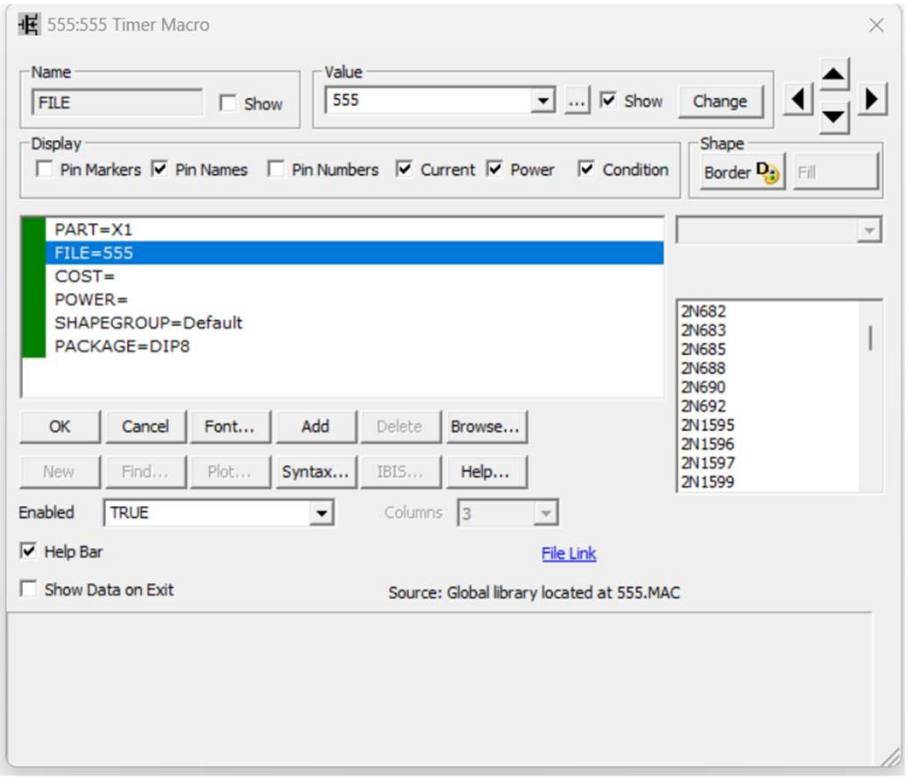
Adding a 555 Timer





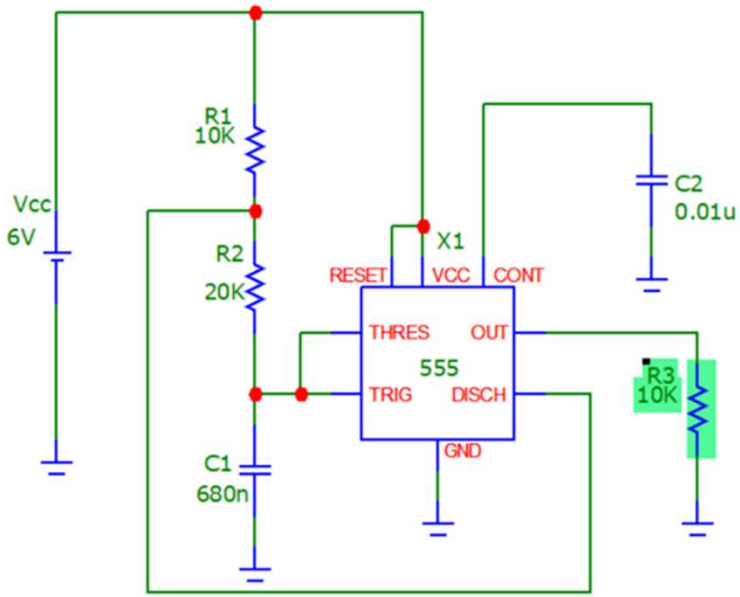
Build and Simulate a 555 Timer Astable Multivibrator Circuit Activity. . .

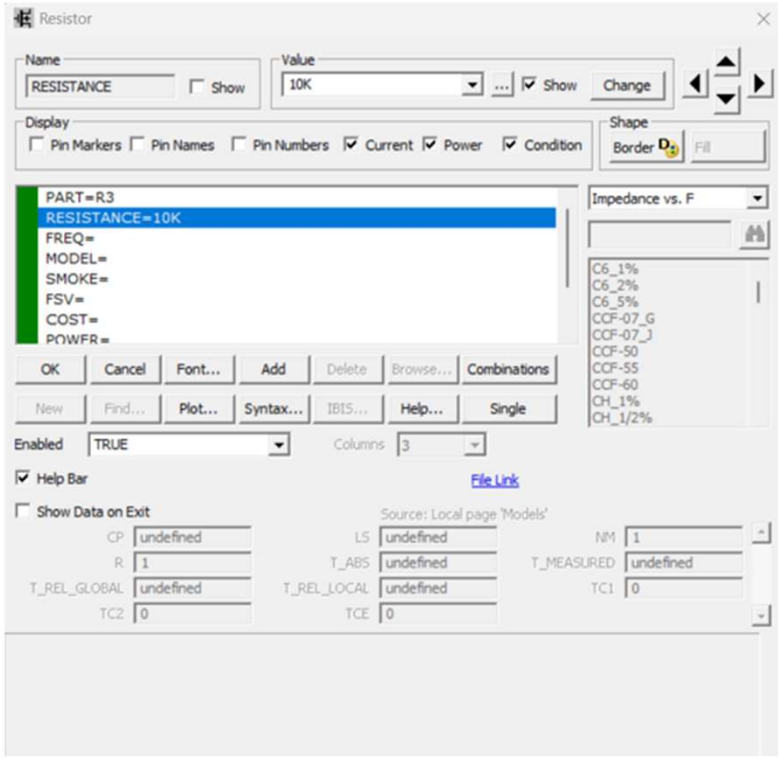




Adding a 555 Timer. . .

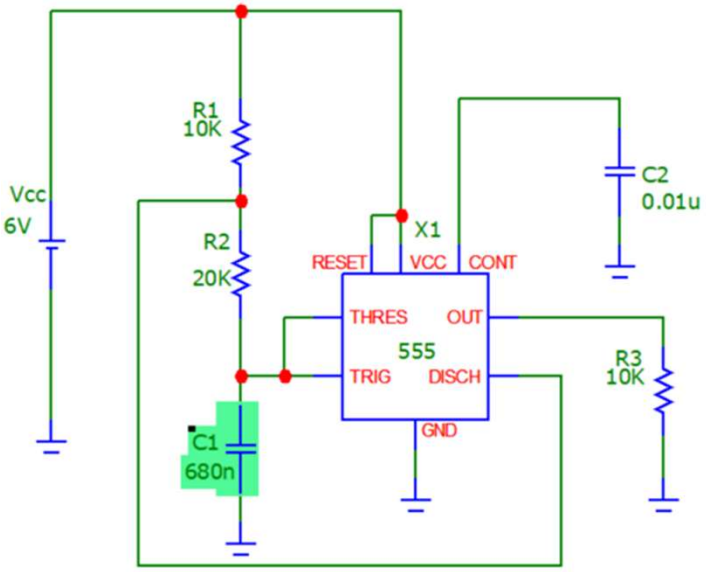
Build and Simulate a 555 Timer Astable Multivibrator Circuit Activity

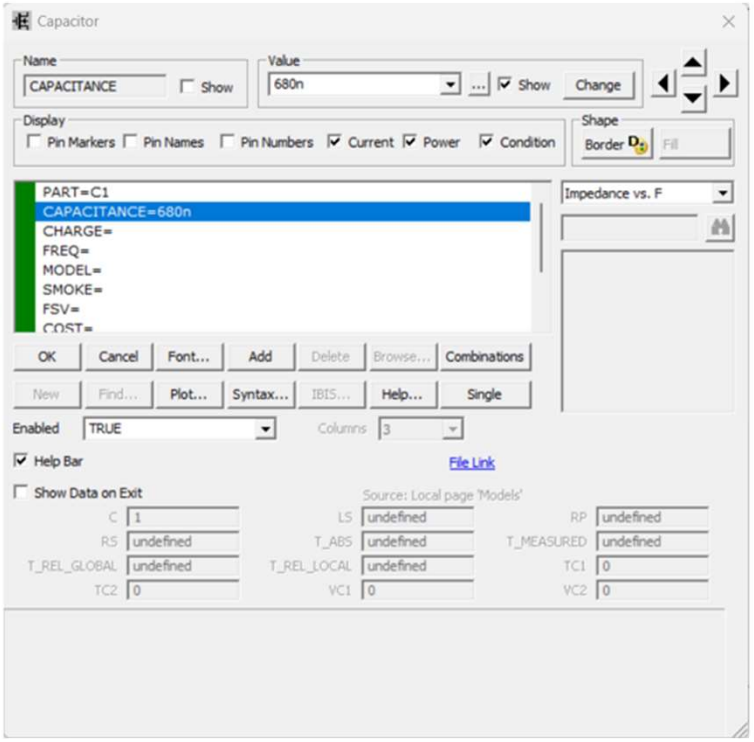




Adding an output load resistor

Build and Simulate a 555 Timer Astable Multivibrator Circuit Activity…





Adding the trigger capacitor

Build and Simulate a 555 Timer Astable Multivibrator Circuit Activity. . .

Before simulating the 555 Timer Astable Multivibrator circuit, perform the following analysis. Determining the output frequency (**f**) of the 555 Timer Astable Multivibrator circuit.

f = 1/**Ttotal**
= 1/23ms
= 43.4Hz

Where:

f is the frequency
Ttotal is the total time

tlow = 0.693+**R2C1**
= 0.693 + (20KΩx680nF)
= 9ms

thigh = 0.693**(R1 + R2)C1**
= 0.693(10KΩ+20KΩ)680nF
= 14ms

Ttotal = tlow+thigh
= (9 +14)ms
=23ms

Question 4

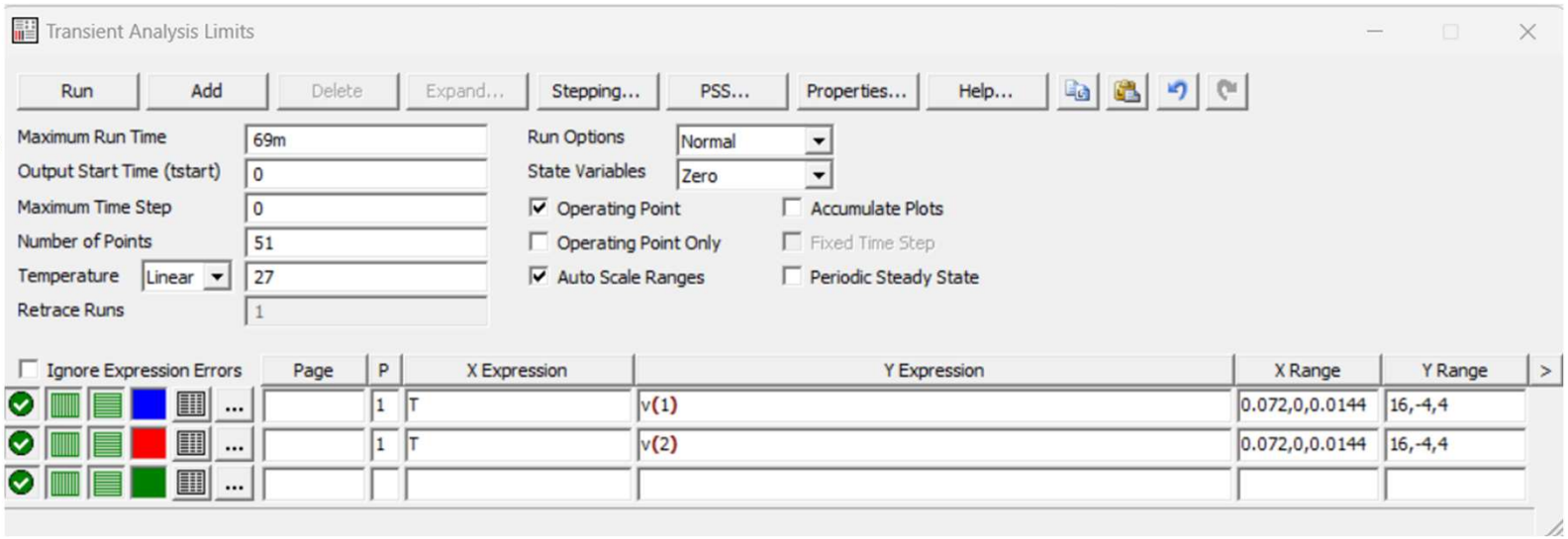
What output frequency is produced with an R2 value of 10KΩ for a 555 Timer Astable Multivibrator circuit?

a) 500Hz
b) 700Hz
c) 1.45KHz
d) 1.410KHz

Build and Simulate a 555 Timer Astable Multivibrator Circuit Activity. . .

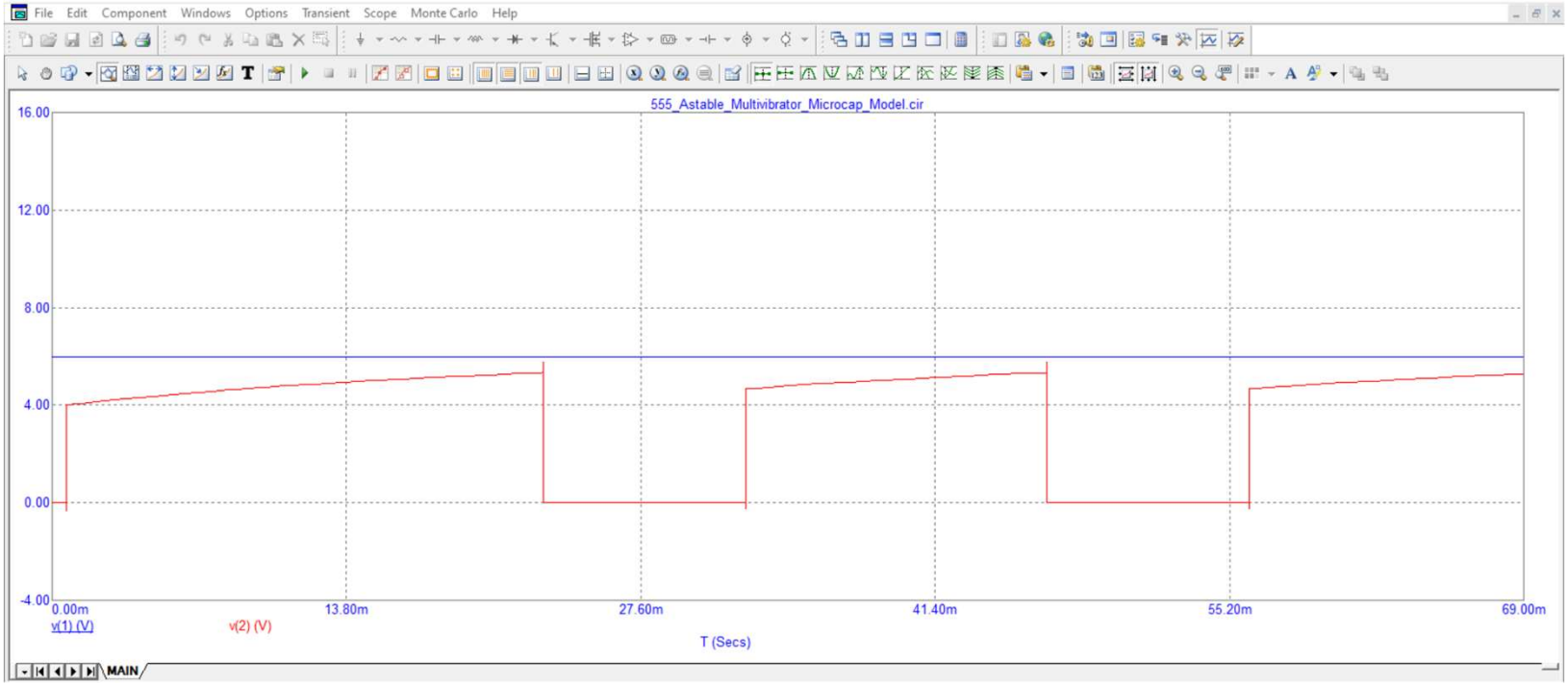
Set the time in simulation using 23ms as the timebase. To display 3 cycles of the squarewave output, the maximum time will be 69 ms. Go to Analysis (the top toolbar), and select Transient. Analysis>Transient. Click the Run button to execute the simulation.

Add 69ms Here!



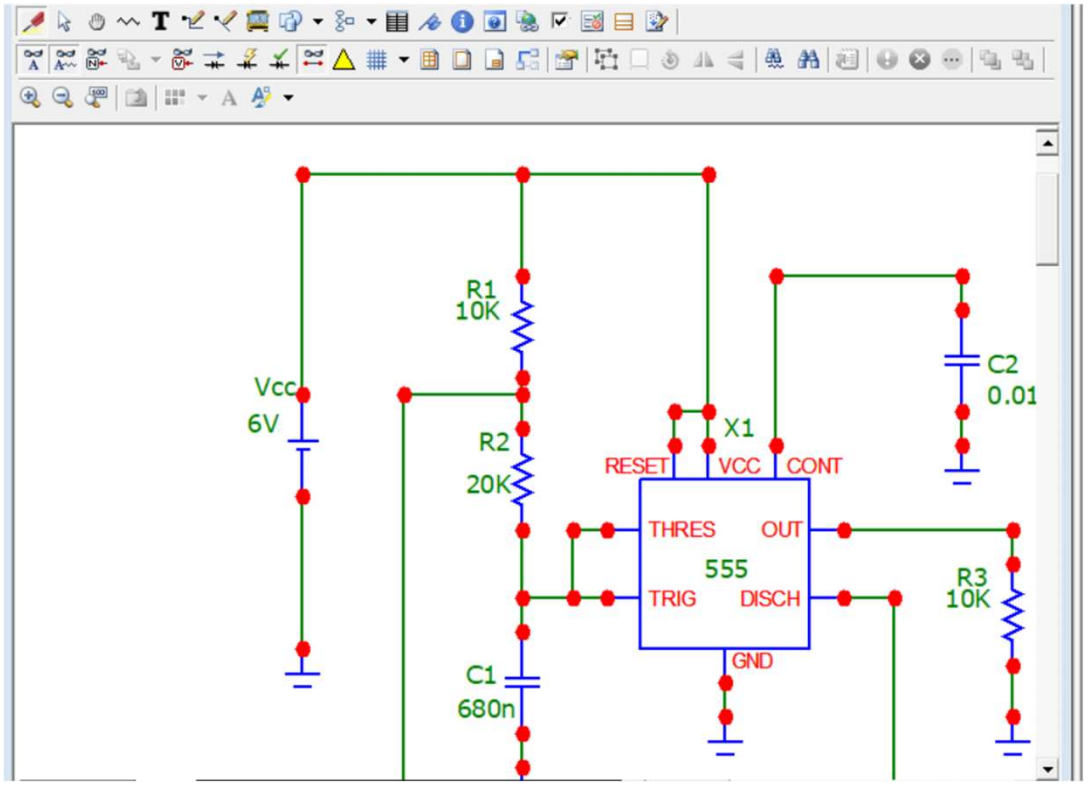
Build and Simulate a 555 Timer Astable Multivibrator Circuit Activity…

Simulation Results: Exit out of the simulation, Click Transient then Exit Simulation.
Transient>Simulation



Build and Simulate a 555 Timer Astable Multivibrator Circuit Activity. . .

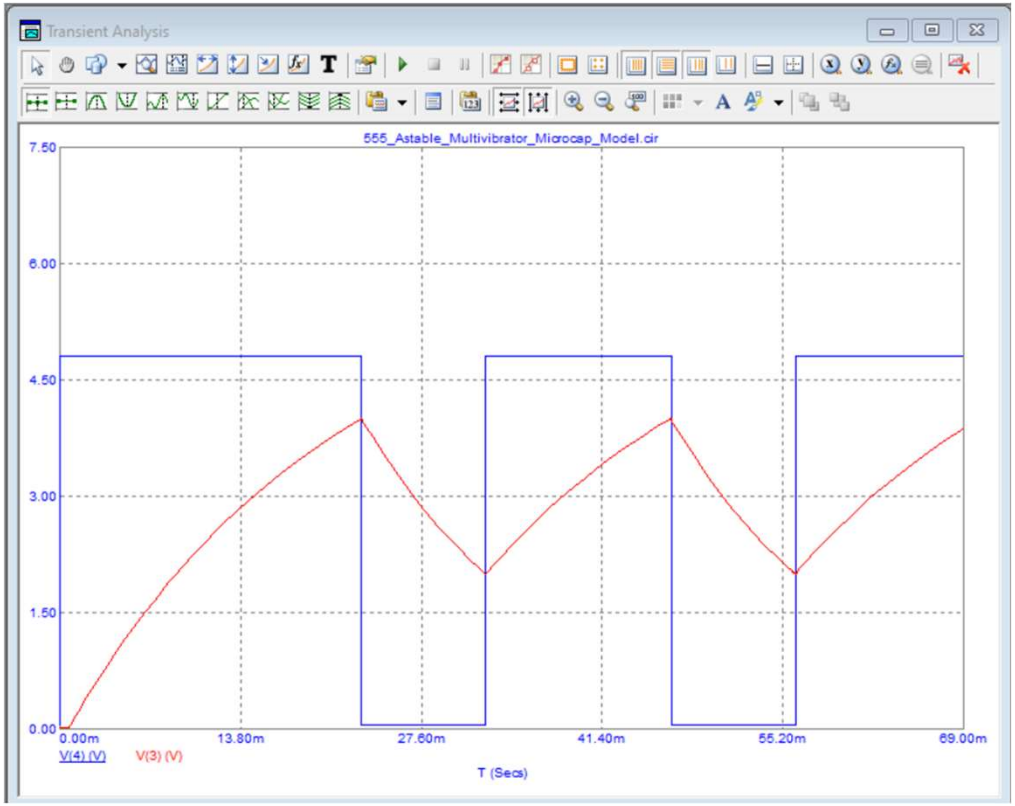
To obtain multiple circuit points (nodes) for probing voltages use, Analysis >Probe Transient.



Build and Simulate a 555 Timer Astable Multivibrator Circuit Activity…

Results of Analysis >Probe Transient.

a) 555 Timer Astable Multivibrator Squarewave output
b) Charging/Discharging of the 680nF (C1) capacitor



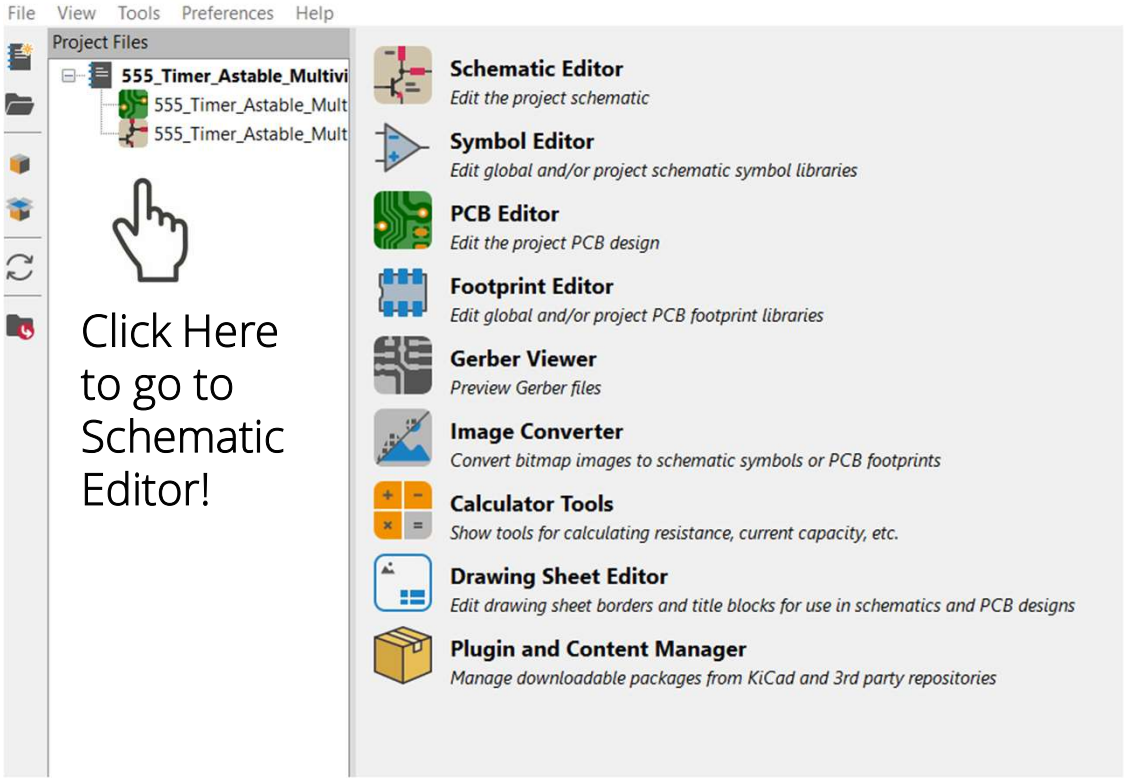
Introduction to KiCad Software

- Is a free software suite for Electronic Design Automation (EDA).
- The software facilitates the design and simulation of electronic hardware for Printed Circuit Board (PCB) manufacturing.
- The software features an integrated environment for:
  a) schematic capture.
  b) PCB layout.
  c) manufacturing file viewing
  d) ngspice (open-source SPICE) simulation
  e) engineering calculation

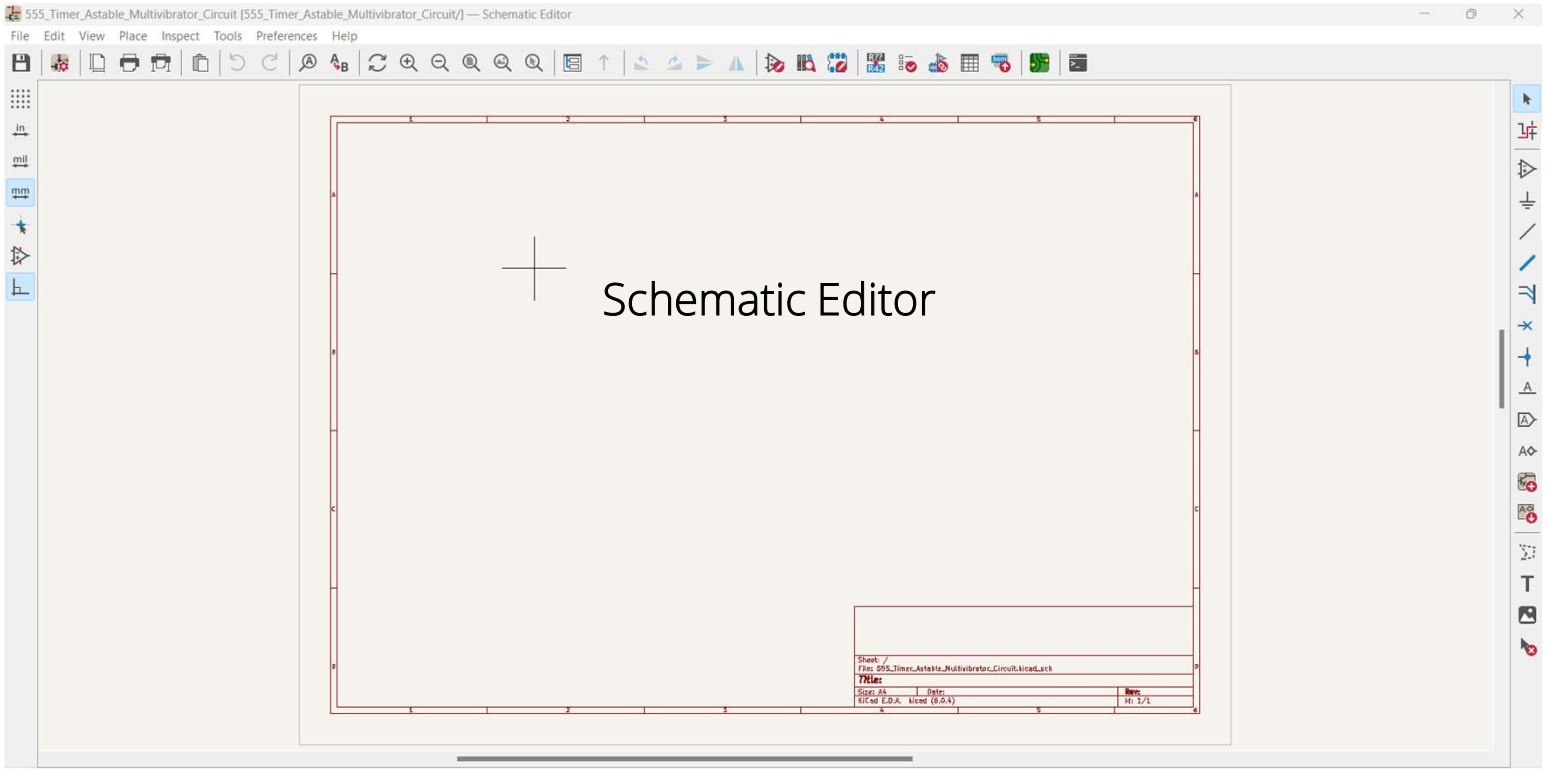
Note:
SPICE is Simulation Program with Integrated Circuit Emphasis

Layout of KiCad Software Environment. . .

File >New Project



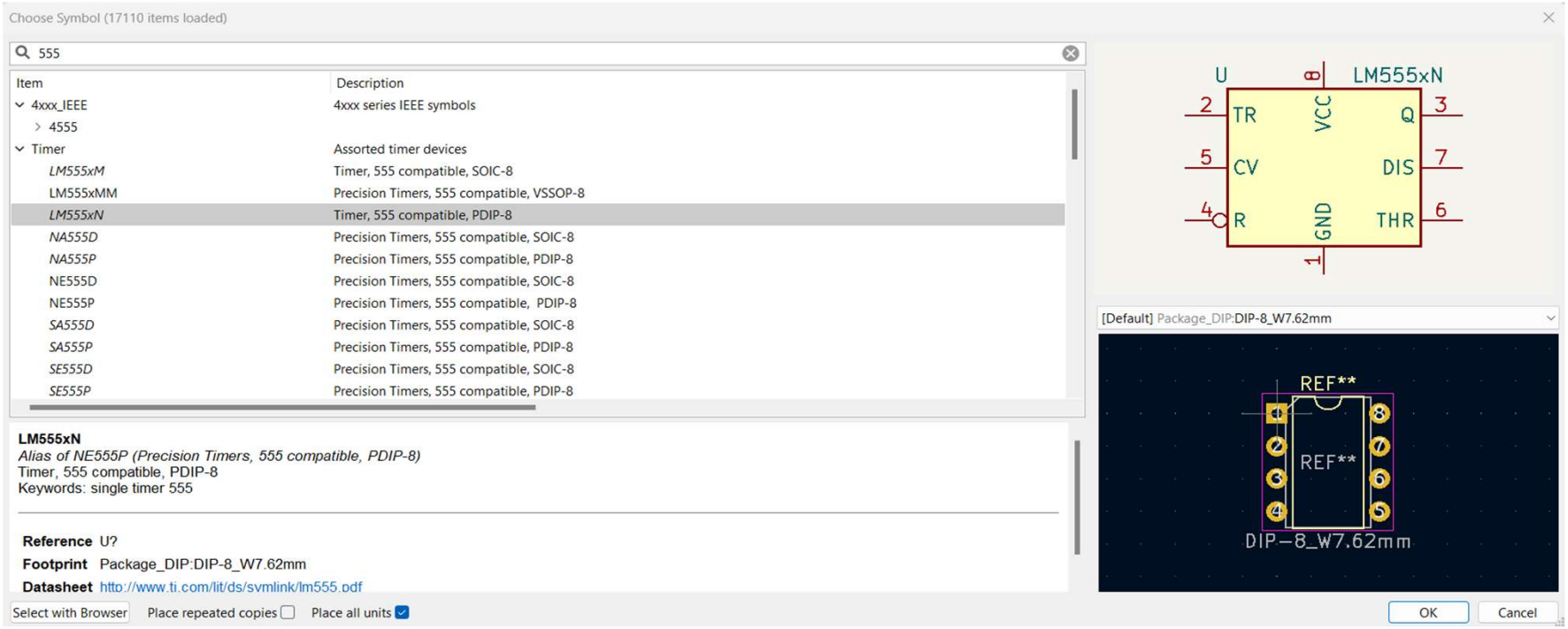
Layout of KiCad Software Environment. . .



Click Here to obtain the component library!

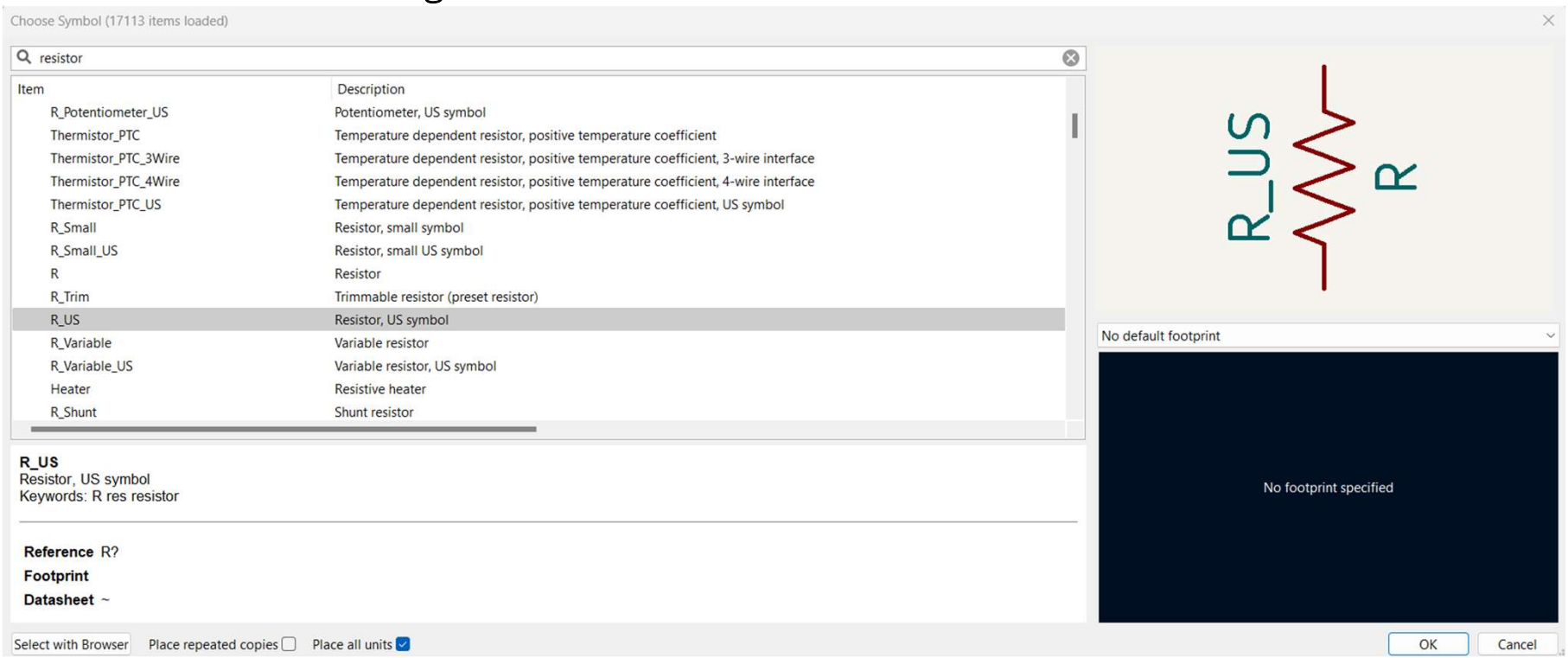
Drawing A 555 Timer Astable Multivibrator Electronic Circuit Schematic Diagram Activity . . .

Adding the 555 Timer IC to the Schematic Editor



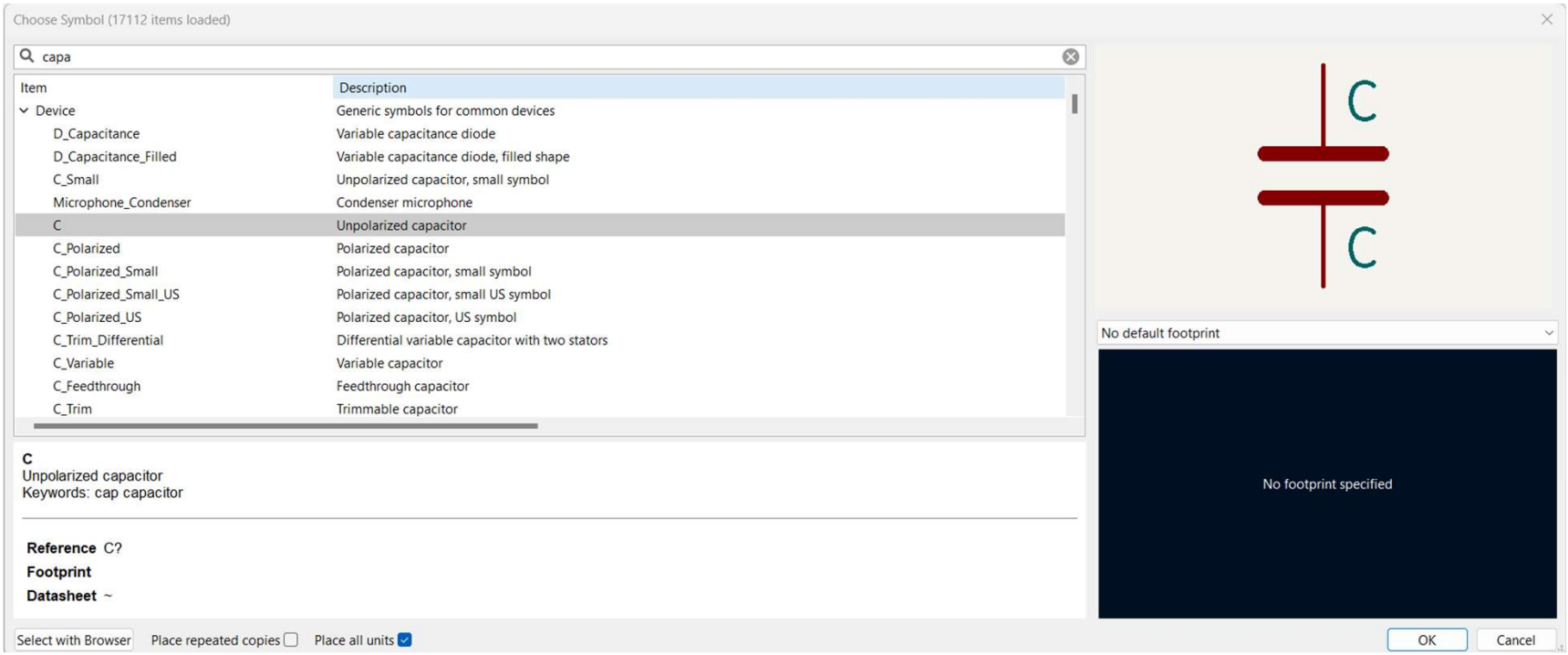
Drawing A 555 Timer Astable Multivibrator Electronic Circuit Schematic Diagram Activity . . .

Adding a resistor to the schematic editor



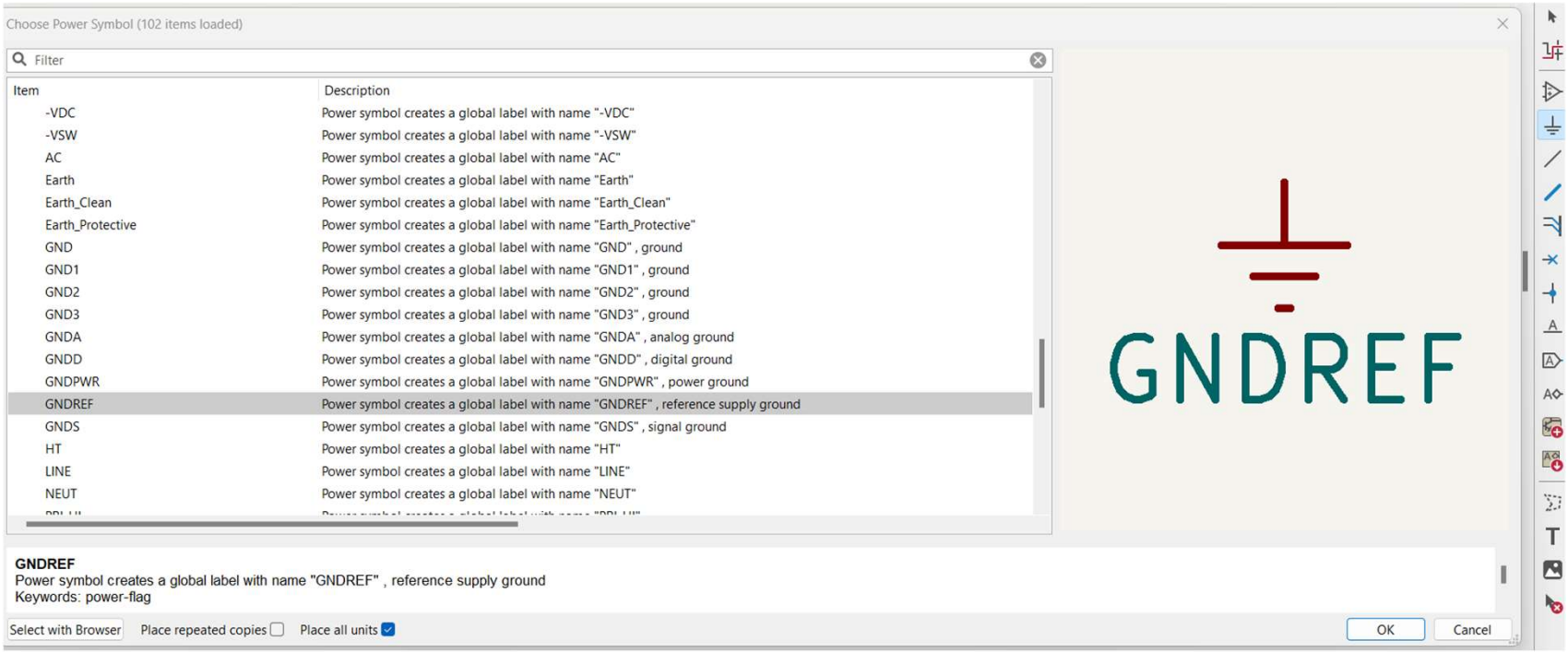
Drawing A 555 Timer Astable Multivibrator Electronic Circuit Schematic Diagram Activity . . .

Adding a capacitor to the schematic editor



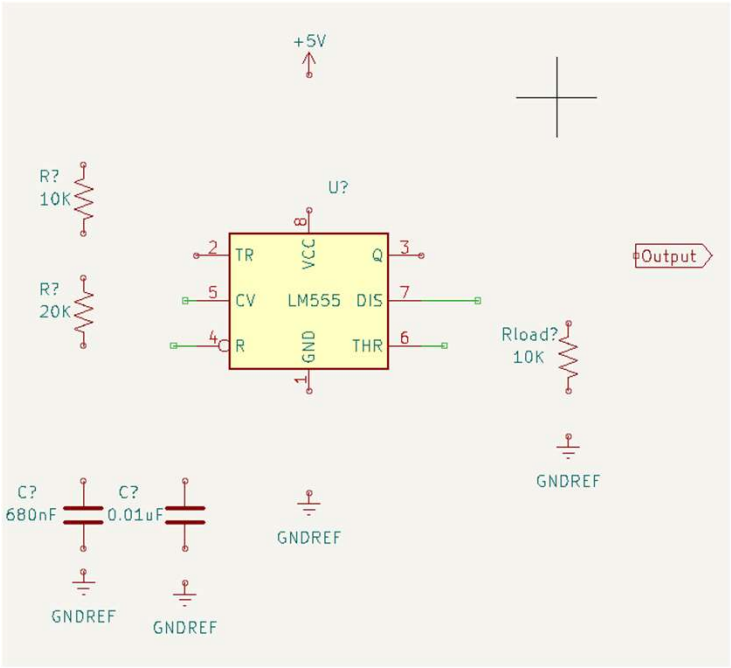
Drawing A 555 Timer Astable Multivibrator Electronic Circuit Schematic Diagram Activity . . .

Placing a ground onto the schematic editor



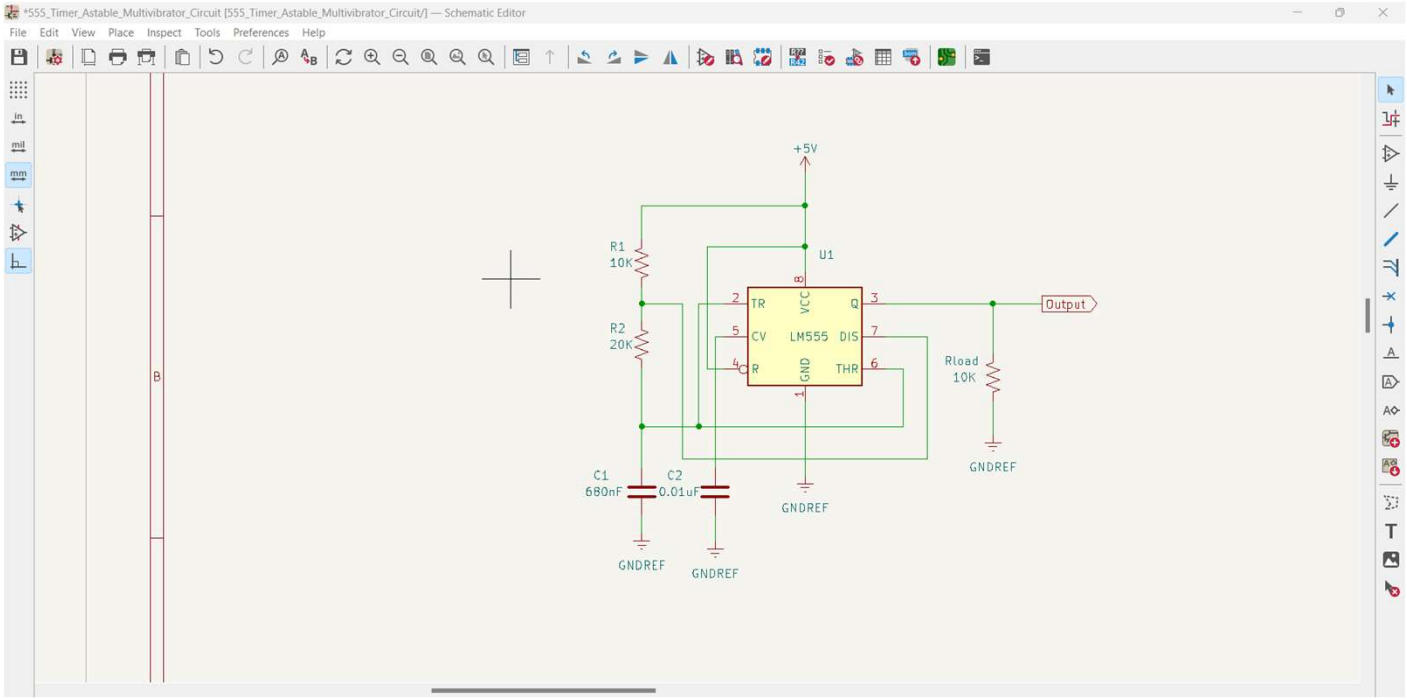
Drawing A 555 Timer Astable Multivibrator Electronic Circuit Schematic Diagram Activity . . .

Orientation and location of the 555 Timer Astable Multivibrator Electronic components on to Schematic Editor.



Drawing A 555 Timer Astable Multivibrator Electronic Circuit Schematic Diagram Activity . . .

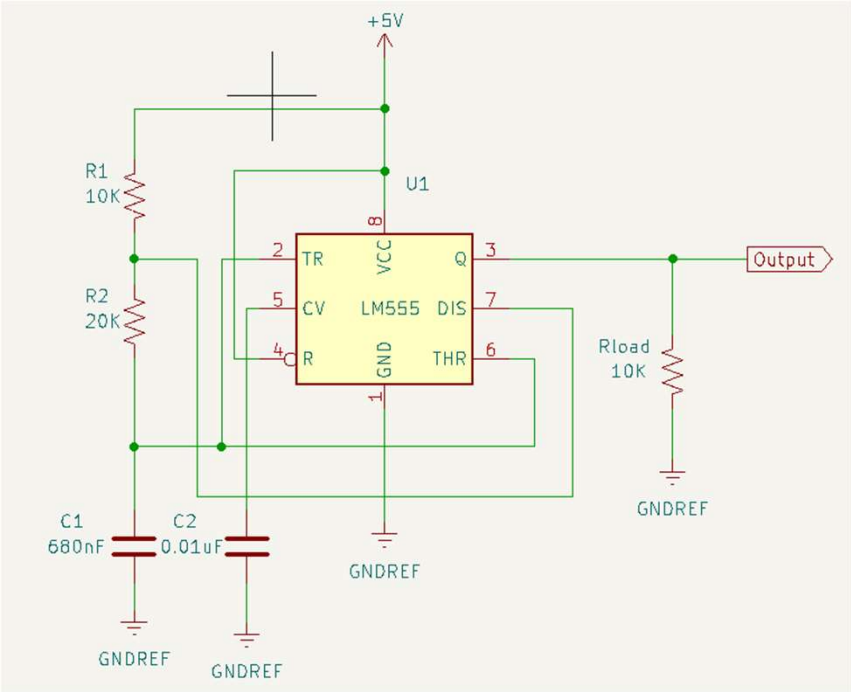
The completed 555 Timer Astable Multivibrator Electronic Circuit Schematic Diagram



Wiring the circuit components using the wire tool

Drawing A 555 Timer Astable Multivibrator Electronic Circuit Schematic Diagram Activity . . .

The completed 555 Timer Astable Multivibrator Electronic Circuit Schematic Diagram



Question 5

What symbol is used to obtain parts to place on the KiCad Schematic editor?

a) resistor
b) line
c) gnd
d) operational amplifier

Thank you for attending

Please consider the resources below:

Kicad. (n.d.). *Getting started with kicad 6.0*. https://docs.kicad.org/6.0/en/getting_started_in_kicad/getting_started_in_kicad.html

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