EET103 Electrical Circuits I

Final Project: 555 Timer Monostable Circuit with Relay Control – Part 1

Name: ___________________________________

Introduction

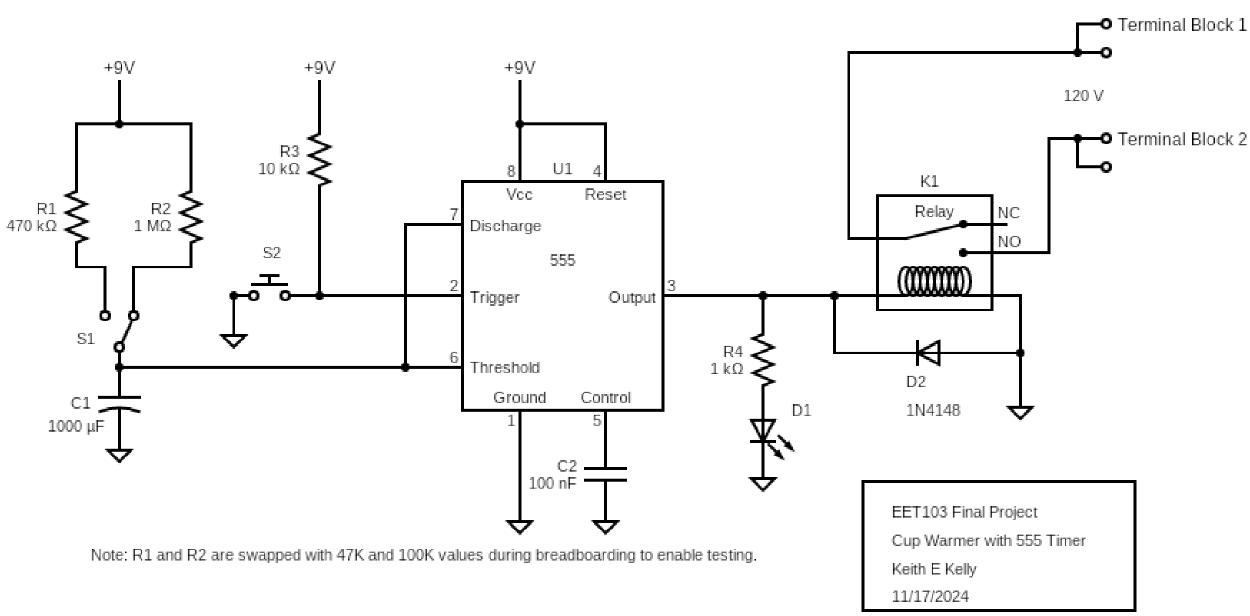
This capstone project will guide students through the design and construction of a 555 timer monostable multivibrator circuit to control a relay that switches 120V AC to an off-the-shelf cup warmer. The project consists of three phases: breadboard build, perfboard build, and final assembly.

The introductory phase focuses on reviewing the schematic diagram, understanding the RC time constant and one-shot duration calculations, and setting up for a breadboard demonstration. The breadboard phase will use a 5V power supply, while the final perfboard build will transition to a 9V battery. Students will substitute specific resistor values during the breadboard phase to facilitate faster testing.

Key goals include:
- Reviewing the schematic diagram and design goals.
- Demonstrating the RC timing and digital trigger functionality on a breadboard.
- Preparing for safe handling of 120V AC power in the final assembly.

Theory of Operation

1. As a class, we will review the function of the 555 timer as an asynchronous multivibrator (one-shot).



2. Complete the following Component Identification Table. R1 and D2 are provided as examples.

Designator	**Component Name**	**Component Purpose**
R1	Charging Resistor	One of two resistors that along with C1 set up the RC timing for the one-shot.
R2		
C1		
S1		
R3		
S2		
U1		
D1		
R4		
K1		
D2	Flyback Diode	A semiconductor device connected across an inductor to protect other components from voltage spikes.

Breadboard Phase

The breadboard phase involves step-by-step assembly and validation of the circuit. Each stage includes an instructor check to evaluate functionality and professional construction techniques.

Step 1: Power Supply

1. Place an 8-pin socket in the center section of the breadboard to ensure room for the RC and trigger circuits on the left side and the output circuit on the right side.
2. Connect power from the +V rail to the Vcc supply pin 8 and the Reset pin 4.
3. Connect ground from the ground rail to pin 1.
4. Connect a 0.1 µF capacitor between the control input (pin 5) and ground.
5. Energize the circuit and use a DMM to validate power is applied to pins 8 and 4.

_________ Instructor Check: Validate power connections, clean wiring practices, and correct placement in the center section.

Step 2: RC Timing Circuit

1. Use a 100K resistor (R1) and a 47K resistor (R2) connected through an SPDT selector switch (S1) to the 1000 µF capacitor (C1).
2. Build the RC timing circuit on the leftmost section of the breadboard.
3. Apply the capacitor voltage to the 555 timer socket: threshold input (pin 6) and discharge (pin 7).
4. Use a DMM to measure and display the voltage as the capacitor charges when power is applied.
5. Demonstrate RC timing with S1 switched to both positions using the DMM:
    a. When S1 connects the 47K resistor (R2) to the 1000 µF capacitor (C1):
        i. $\tau = R * C = 47{,}000 * 0.001 = 47$ seconds.
        ii. After 1 τ, the capacitor voltage will reach 63% of the supply voltage (just over 3V).
    b. When S1 connects the 100K resistor (R1) to the 1000 µF capacitor (C1):
        i. $\tau = R * C = 100{,}000 * 0.001 = 100$ seconds.
        ii. After 1 τ, the capacitor voltage will reach 63% of the supply voltage.
6. Students will measure and observe the capacitor voltage as it charges in each position of the S1 switch using the DMM, validating the RC timing behavior.

_________ Instructor Check: Validate RC timing functionality with DMM for both S1 positions.

Step 3: Digital Switch

1. Connect a 10K pull-up resistor (R3) and a push button switch (S2) to pin 2 of the socket.
2. Demonstrate the digital switch function.
7. Explain the pull-up function of R3 and the active low trigger signal created when S2 is pressed.

_________ Instructor Check: Validate trigger functionality and student explanation.

Step 4: Output Circuit

1. Connect the output (pin 3) to the relay coil: pin 1 of the coil to pin 3 and pin 8 of the coil to ground.
2. Add an LED (D1) in parallel with the relay coil, using a 1K current limiting resistor.
3. Connect a DMM across the N.O. relay output.
4. Energize the output by connecting pin 3 of the socket to the supply voltage.
5. Note: the relay will not close when a 5 volt source is applied. Use the bench supply to apply 9 volts to the output on pin 3. You should hear the relay activate and the N.O. relay outputs close. Use your DMM to validate that N.O. outputs are closed with 9 volts applied to the output pin.

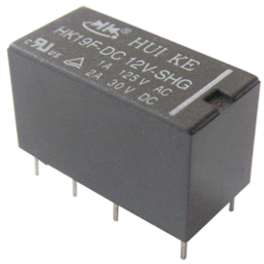
_________ Instructor Check: Validate relay operation and LED indicator functionality.

Step 5: Final Integration and Testing

1. Insert the 555 timer IC into the socket.
2. Connect the DMM to measure continuity across the N.O. relay output.
3. Move the S1 switch to both positions to demonstrate delay selection.
4. Ensure the circuit layout follows a left-to-right flow: RC charging circuit on the left, trigger input in the center-left, 555 timer in the center-right, and output relay and LED on the far right.
5. Check timing and recall that the relay is not “pulled in” with the 5-volt source provided on the breadboard. The final build uses the 9-volt battery as the source.

__________ Instructor Check: Validate functionality and professional organization of the breadboard layout.

HK 19F SUBMINIATURE DIP RELAY



Features

- 2 Form C configuration
- High switching capacity: 125VA/60W
- Bifurcated contacts
- Epoxy sealed for automatic-wave soldering and cleaning
- Environmental friendly product (RoHS compliant)
- Outline Dimensions: (20.2 x 10.0 x 12.0) mm

■ CONTACT DATA

Contact Form	2C
Contact Material	Silver Alloy
Contact Ratings	1A 125VAC /2A 30VDC
Max Switching Voltage	250VAC/125VDC
Max Switching Current	2A
Max Switching Power	125VA /60W
Contact Resistance	100MΩ(at 1A 6VDC)
Electrical Life	1X10^{5}Ops(30Ops/min)
Mechanical Life	1X10^{7}Ops(300Ops/min)

■ GENERAL DATA

Insulation Resistance		100MΩ 500VDC
Dielectric Strength	Between coil & contacts	1000VAC 1min
	Between open contacts	600VAC 1min
Operate Time		Max. 6ms
Release Time		Max. 4ms
Temperature Range		- 30℃ to +70℃
Shock Resistance	Functional	98m/s^2 (10g)
	Destructive	980m/s^2 (100g)
Vibration Resistance		10 to 55Hz 1.5mm
Humidity		40% to 85% RH
Weight		Approx. 5g
Safety Standard		CUL TüV

■ COIL DATA

Nominal Voltage (VDC)	Coil Resistance at 20℃ ± 10%(Ω)				Max Operate Voltage (VDC)	Min Release Voltage (VDC)	Max Applicate Voltage (VDC)
	0.15W	0.20W	0.36W	0.45W			
3	60	45	25	20	2.25	0.30	3.90
5	167	125	70	56	3.75	0.50	6.50
6	240	180	100	80	4.50	0.60	7.80
9	540	405	225	180	6.75	0.90	11.70
12	960	720	400	320	9.00	1.20	15.60
24		2880	1600	1280	18.00	2.40	31.20

ORDERING INFORMATION

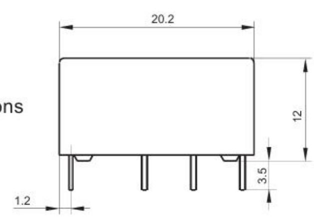
HK19F - DC 6V - S D 2C X X

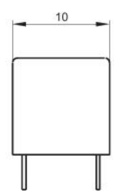
Special request code	G:RoHS
Mounting termination	NIL:PCB
Contact Form	NIL:2C
Coil Power	NIL:0.36W D:0.15W H:0.2W L:0.45W
Type of Sealing	F: Flow Solder Type S: Plastic Sealed Type
Coil Voltage	3V,5V,6V,9V,12V,24V
Coil Type	DC
Type	HK19F

OUTLINE DIMENSIONS, WIRING DIAGRAM AND PC BOARD LAYOUT

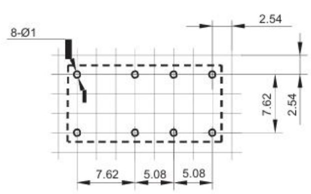
Unit: mm

Outline Dimensions

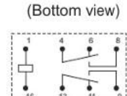




PCB Layout
(Bottom view)



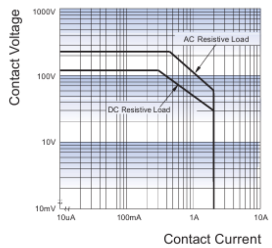
Wiring Diagram
(Bottom view)



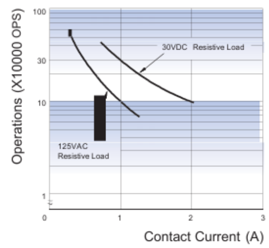
Remark: 1) In case of no tolerance shown in outline dimension: outline dimension ≤1mm, tolerance should be ±0.2mm; outline dimension >1mm and ≤5mm, tolerance should be ±0.3mm; outline dimension >5mm, tolerance should be ±0.4mm.
2) The tolerance without indicating for PCB layout is always ±0.1mm.
3) The width of the gridding is 2.54mm.

CHARACTERISTIC CURVES

MAXIMUM SWITCHING POWER



ENDURANCE CURVE



Notice

1) To avoid using relays under strong magnetic field which will change the parameters of relays such as pick-up voltage and drop-out voltage.
2) The relay may be damaged because of falling ot when shocking conditions exceed the requirement.
3) Regarding the plastic sealed relay, we should leave it cooling naturally untill below 40̊ C after welding, then clean it and deal with coating remarkably the temperature of solvents should also be controlled below 40̊ C.Please avoid cleaning the relay by ultrasonic, avoid using the solvents like gasoline, Freon, and so on, which would affect the configuration of relay or influence the environment.
4) About preferable condition of operation, storage and transportation, please refer to "Explanation to terminology and guidetines of relay".

Disclaimer

This datasheet is for the customets' reference. All the specifications ate subject to change without notice.
We could not evaluate all the performance and all the parameters for every possible application. Thus the user should be in a tight position choose the suitable product fot their own application. If thete is any query, please contact Everway for the technical service. However it is the user's responsibility to determine which product should be used only.