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Delay Timer (Relay driver) for home electrical appliances

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ABSTRACT

Delay timer (relay driver) for home electrical application has been successfully designed, constructed and tested. The result shows the timer can keep an appliance working for a time period between 2 and 40 minutes. And in the delay off mode the timer can work for several hours. It can conveniently be use to run a load of 2,500W.

Key words: Delay timer, 555 timer, home electrical appliances.

INTRODUCTION

Semiconductors are materials whose electronic properties are intermediate between those of metals and insulators. These intermediate properties are determined by crystal structure bonding characteristics and electronic energy band. Unlike metals, semiconductor has both positive (holes) and negative (electron) carriers of electricity whose densities can be controlled by dopping the pure semiconductor with chemical impurities during crystal growth [1-3].

Semiconductors are indispensable in modern technology primarily because their properties are fundamental to the operation of photovoltaic devices such as solar cell, transistors, and related devices.[4]

According to quantum mechanics, electrons, in isolated atom can have only specific discrete energy levels. When atoms are brought close together as in a lattice of a crystal, the electronic energies of the individual atoms are grouped in energy bands.[5-7]

The valence band is the highest filled band, which corresponds to the ground state of the outermost or valence electrons in the atom. There is the conduction band which is the lowest energy band. The conduction band is separated from the valence band by an energy gap or forbidden band. The electrical characteristics of a material are determined by the position of the electrons in the allowed bands. The nature of the band and energy gap varies with the type of materials [8] .

Electrons in crystals are arranged in energy bands separated by regions in energy where no wave like electron orbital exists. Such forbidden regions are called energy gaps or band gaps, and result from the interaction of the conduction electron waves with the ion core of the crystal. The crystal behaves as a metal if one or more bands are partly filled and as a semiconductor or a semimetal if all the bands are entirely filled.

Metals are characterized by high electrical conductivity and a large number of the electrons in a metal must be free to move about, usually one or two per atom called conduction electrons. Electrical properties of metals are determined by the shape of the Fermi surface. The Fermi surface is defined as the surface of constant energy E_f in K space. It separates the unfilled orbital from the filled ones at absolute zero.

These electrons move within the solid as a result of the overlap of state functions. On application of electric field, they are accelerated into higher energy states with subsequent increase in velocity. This gives rise to a net charge transport and hence electric current.

Metals with high crystalline imperfections of electrons tend to have high resistivity as collision of electrons with lattice ions reduce the average velocity while those with extremely good perfect crystalline have low resistivity since charge transport is increased.

In a constant electric field E, the current density is

$$J = nqv \quad (1)$$

The electrical conductivity is given as

$$J = \sigma E \quad (2)$$

So that

$$\sigma = (ne^2 \tau)/ M^* \quad (3)$$

The electrical resistivity ρ is defined as the reciprocal of conductivity so that,

$$\rho = M^*/ne^2\tau \quad (4)$$

where M* is the effective mass of the electron, n is the number of electrons of charge e and τ the collision time.

Semiconductors are electronic conductors with electrical resistivity values in the range of 10^2 t0 10^9 μcm at room temperature.

At absolute zero, the conduction band is empty and is separated by an energy gap example from the filled valence band. As the temperature is increased, electrons are thermally excited from the valence band to the conduction band. (Kittle 1976)

The objective of this work is to design and construct a simple device that can be used to monitor or time the usage of some home electrical appliances.

MATERIALS AND METHODS

We used the 8-pin 555 timer wonder chip that can be used to build many circuits with just few external components. A box is used for the circuit symbol for the 555 with its pins arranged to suit the circuit diagram. The 555 chips come in different manufacturer names. A popular version of the 555 timer is the NE555 produced by Fairchild. Others include LM555C (National), CA555 (RCA), LC7555 (Sanyo), HA17555 (Harris) etc.

The chip was operated with a voltage supply $+V_{cc}$ or V_s in the range of 4.5 to 15V and a maximum of 18V. The timer chip can be operated in three distinct modes. The Astable, produce a square wave, while Monostable, produced a single pulse when triggered and the Bistable which is a simple memory that can be set and reset [9]. Some of the applications of the timer chip (555) include lamp flasher, relay driver (delay timer), metronome etc [10-11]. The monostabe mode of operation was used in this work and the relay driver application was tested.

Figure 1[11], shows the circuit symbol of the 555 chip. The circuit build up operates in the monostable mode. Timing period starts when the trigger input pin 2 is less than V3 of the supply voltage +Vcc. This is achieved by momentarily pressing switch S1. Hence the output pin3 becomes high and the capacitor C1 begins to charge through the resistor R1. C1 is a combination of capacitors arranged parallel to each other. Any further trigger impulse at pin2 is ignored once the time period is in progress.

Pin 6, is the threshold input that monitors the voltage across the charging capacitor C1 and once this is over the output becomes low. Immediately the discharge pin7 is connected to ground, thus discharging the capacitor and ready for the next trigger.

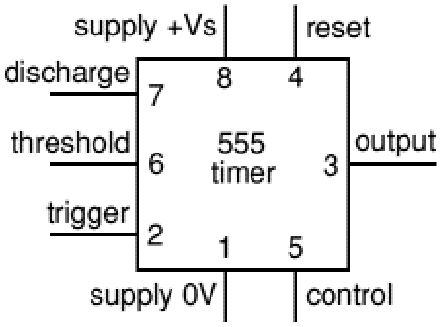

Fig.1 circuit symbol / pinout diagram for the 555 chip

During the time period when the output pin3 is high, the signal is fed to the base of transistor Q1 through resistor R3 which biases the transistor to switch on and hence the relay is energized connecting the load to the mains supply 230Vac. When the time period is over, the transistor switches off, de-energizing the relay which in turn cuts off the load from the mains. When timing is in progress diode D1 is on. The output voltage at pin3 is approximately equal to the supply voltage. The reset input pin4 overrides all other input, which implies that the timing may be cancelled at any point in time by connecting reset switch S2 to ground.

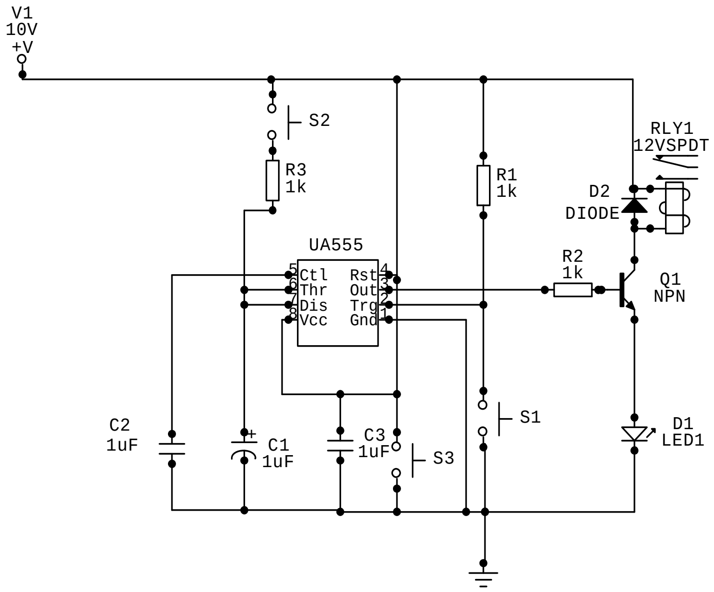

Fig.2: circuit diagram for the delay timer.

Figure 2 is the circuit diagram used to carry out the research at Covenant University Ota. A monostable circuit produces just a single pulse when triggered. It is called MONOstable because it is only stable in just one state; that is LOW output. The HIGH output is only temporarily stable.

The duration of the pulse is known as the time period T. This was determined by the values of the resistor R1 and capacitor C1. This time period is given by the relation

$$T = 1.1*R1*C1 \quad (5)$$

where T is the time period in seconds, R1 is the resistance in ohms while C1 is the capacitance in farad.C1, is a combination of capacitors in parallel arrangement to give the different timing range. A rotary switch is used to select the different time range.

The range of time period is only an approximation for each of the stages. With perfect components the maximum time period for each of the stages is as shown in table 1. But due to problem of charge leakage exhibited by electrolytic capacitors, their actual value may vary by as much as ± 30% of their rated value. Hence there is an extension in the time range.

For example, a capacitor whose rated value is 100µF theoretically may have its practical value between 70 µF and 130 µF. This will give a time period of 143 seconds instead of 120 seconds.

The device can also be used to keep an electrical or electronic appliance working for an extended time period of hours. This ability was obtained in the delay off mode, which is achieved by opening the switch S3.

RESULTS AND DISCUSSION

Table.1 Expected time period for different stages using equation 5.

STAGE	C1(μF)	R1(MΩ)	TIME PERIOD(S)	TIME PERIOD(min)
1	100	1	110	2
2	200	1	220	4
3	538	1	592	10
4	1100	1	1210	20
5	2200	1	2420	40

Table. 2 Obtained time period for different stages

STAGE	C1(μF)	R1(MΩ)	TIME PERIOD(S)	TIME PERIOD(min)
1	100	1	99	1.65
2	200	1	211	3.52
3	538	1	600	10.00
4	1100	1	1265	21.00
5	2200	1	2310	38.50

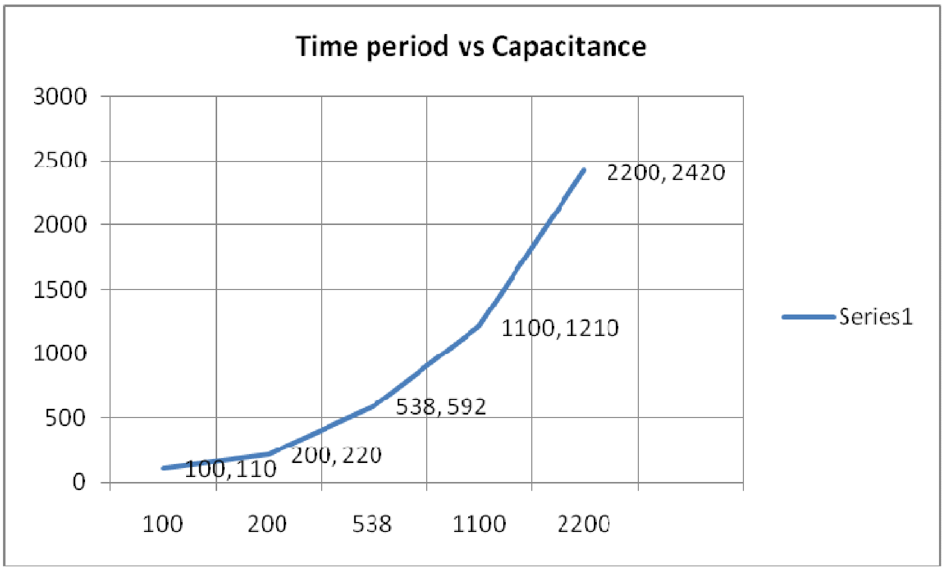

Fig.3: Graph representing expected time delay.

This device can easily be used to time electrical appliances like pressing iron, boiling ring, room warmer, electric cooker and other electrical appliance which ordinarily are not fitted with a timing circuit. The electrical load that the device can control via the relay depends on the load the relay can conveniently accommodate. The choice of relay used can accommodate a maximum load of 2,500W.

Table 2 is the actual representation of how the device works. It shows slight variations from the expected delay period shown in Table.1 and fig.3 for all the stages. This variation is due to charge leakage exhibited by electrolytic capacitors.

From fig.4, it was observed that increase in the capacitance value in each of the stages resulted in an eventual increase in the delay time period keeping the unit working

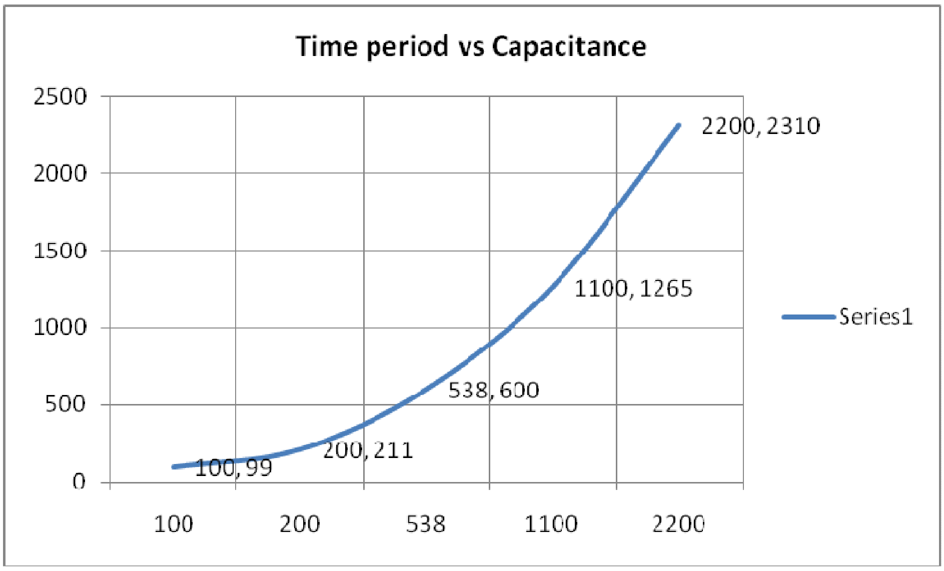

Fig.4 : Graph representing obtained time delay

CONCLUSION

A delay timer for home appliances has been successfully designed, constructed and tested. The unit has five stages representing five different times for delay period. It has a time range of 1.65 to 38.5 minutes, and can run for hours when set to the delay off mode. It can power a maximum of 2,500W of load

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