Digital Stopwatch with Light Sensor Circuit

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Abstract

Digital stopwatch with light sensor circuit that can count from 00 to 99 seconds is built in this work. The circuit can be mainly divided into four parts. One is light sensor circuit which produces high pulse or low pulse depending on light detecting. The second part is pulse generator circuit to produce the pulse of one hertz frequency. The other two parts are the counter that counts the actual counting of the seconds and the display unit. The combination of 1Hz pulse generator IC 555, counter IC 4518B, two seven-segment decoder/driver ICs 4511, and two seven-segment displays serve as a complete two-digit counter/display system. The output 1Hz pulse frequency gives as a digital clock and by using hold switch and reset switch; it can be used as a digital stopwatch.

Key words: Light sensor, Pulse generator, Counter, Display

Introduction

Digital electronics is the most popular science. One of the most common requirements in digital equipment is counting and the most common counting requirements have to do with time. Counters are required for various counting ranges and in all sorts of circumstances. Counters are important in so many applications. Some are specifically designed to count in decimal mode, while others count in binary and still others have selectable counting ranges.

To count or measure the time intervals among several events, stopwatch is used. Many circuits of stopwatches have been designed in so many electronics. A very common requirement in modern electronics is that of displaying alphanumeric characters. Digital watches, pocket calculators, digital multi-meter and frequency meters are all examples of devices that use such displays. In most practical application, seven-segment display is used to a given visual indication of the output states of digital ICs such as decade counter and latches, etc.

Many different kinds of counter ICs have been designed with TTLs and CMOS logic families. In this research work, digital stopwatch is designed and constructed by using light sensor circuits and CMOS ICs. This system is widely used in daily life and also extremely useful in education and electronics laboratories.

The main parts of the system are sensor, pulse generator, counter and display unit. This system has numerous advantages such as high speed, high accuracy and easy operation. It can be used to count from 00 to 99 seconds. Only 9 V power supply is applied to operate the whole circuit. The block diagram of the whole system is shown in figure (1).

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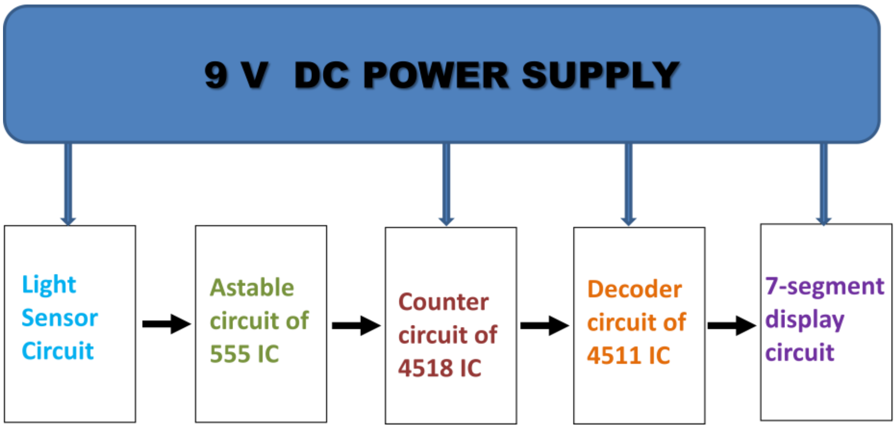


Figure (1) Block diagram of the whole system

Light sensor circuit

Light dependent resistors, LDRs, are often used in circuits where it is necessary to detect the presence or the level of light. They can be described by a variety of names light dependent resistor (LDR), photo-resistor or even photo cell (photocell) or photoconductor. A photo-resistor or light dependent resistor is a component that is sensitive to light. When light falls upon it, the resistance is changed. The LDR's resistance varies from about 10 MΩ in total darkness to about 150 Ω in bright light.

A simple circuit of light operated switch or light sensor circuit is shown in figure (2). With the LDR covered or in darkness, the potential at the base terminal of the transistor is high enough for the transistor to conduct and hence the collector output is low. When a light shines on the LDR, the potential at the base falls and the collector output is high. The output of sensor voltage is fed to the pulse generator as supply.

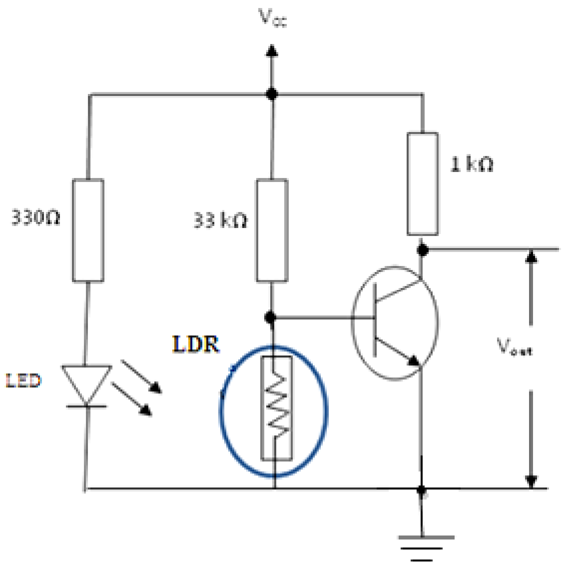


Figure (2) Simple light sensor circuit

Pulse generator circuit

555 timer IC is composed of two comparators, a flip flop, a discharge transistor and resistive voltage divider and it has 8-pins dual in line package as shown in figure (3). The 555 timer IC is a versatile and widely used device because it can be configured in two different modes as either in monostable multi-vibrator or as an astable multi-vibrator. Among these operations, the astable operation is used in this circuit. In astable mode of operation, the threshold input is connected to trigger input. The external components R_1, R_2 and C_1 form the timing network that sets the frequency of oscillation. The capacitor C_2 connected to the control input is strictly decoupling and has no effect on the operation. When the sensor output is high, the capacitor C_1 is uncharged and thus the trigger voltage is at 0 V. This causes the output of the lower comparator to be high and the output of upper comparator to be low, forcing the output of flip- flop and thus the base of transistor Q_1 is low and keeping the transistor off. Now, C_1 begins charging through R_1 and R_2 (Floyd, 2006)

When the capacitor voltage reaches $^1/_3$ of sensor output voltage, the lower comparator switches to its low output state, and when the capacitor voltage reaches 2/3 of sensor voltage, the upper comparator switches to its high output state. This resets the flip-flop, causes the base of Q_1 to go high, and turns on the transistor. Another charging cycle begins, and the entire process repeats. The result gives rectangular wave output which duty cycle depends on the values of R_1, R_2 and C_1. The frequency of oscillation is given by

$$f = \frac{1.44}{(R_1 + 2R_2)C_1}.$$

As in the above formula, when the resistance value of variable resistor R_2 is approximately 67 kΩ, the 1Hz pulse frequency is generated. The pulse frequency can be varied by changing the resistance value of variable resistor R_2.The astable operation of 555 timer IC for 1 Hz frequency is shown in figure (4).

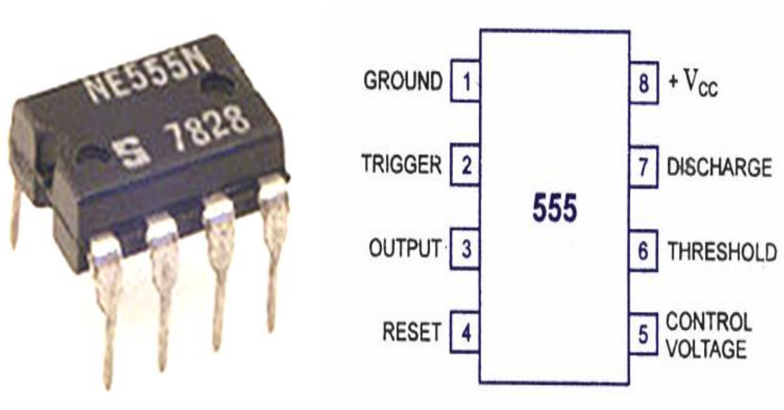


Figure (3) Pin configuration of 555 Timer IC

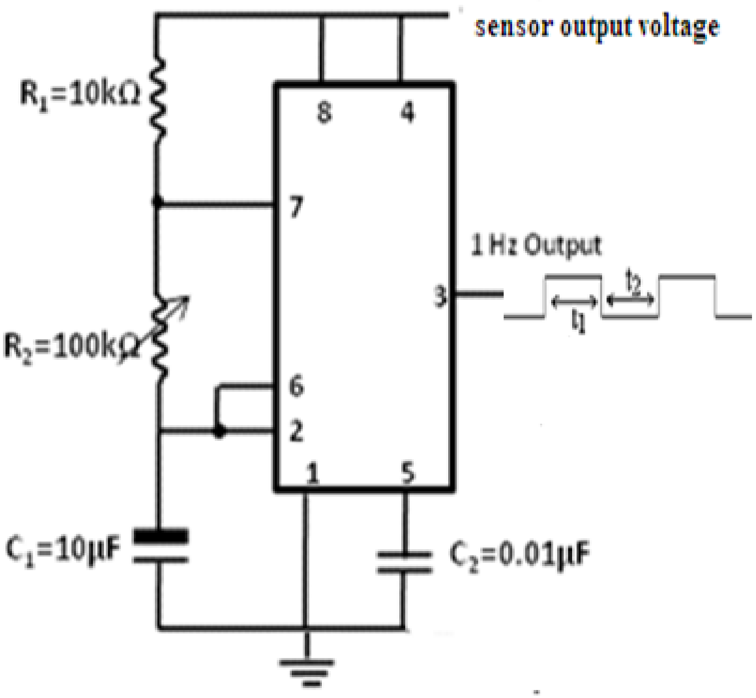


Figure (4) Circuit Diagram of astable operation of 555 Timer IC

Counter section

The signal of 1Hz, which has been taken from the generator, is imported to a BCD counter IC4518B. The IC 4518B is virtually divided into two segments. One counts the units of the seconds, while the other the decades. The generator pulse is imported to the part which counts the units. The IC 4518B dual BCD counter is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. Each consists of two identical, independent, internally synchronous 4-stage counters. Functional diagram of 4518B IC and 4-bit synchronous decade counter are shown in figures (5) and (6).

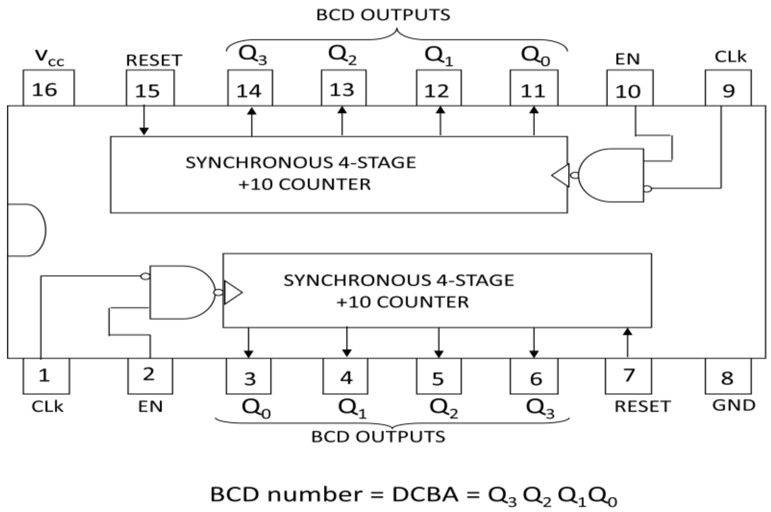
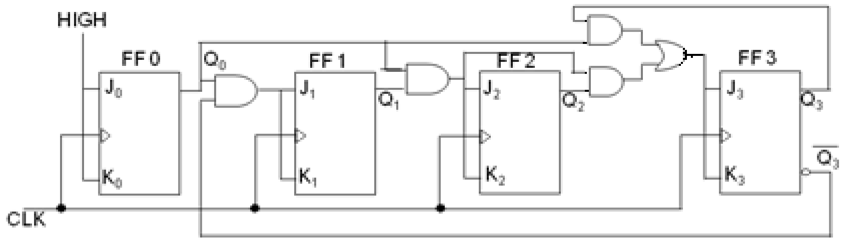
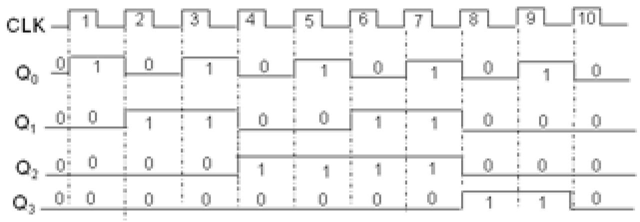


Figure (5) Functional Diagram of 4518B IC



(a) Logic diagram



(b) Timing diagram

Figure (6) Four bit synchronous decade counter

For normal operation, the 1Hz clock signal is imported to the clock inputs of IC4518B, with the enable input held high. The reset input should be low. Counting advances as the clock signal becomes high (on the rising-edge).

In order to raise the first display by 1, every 10 seconds, 4011 NAND gate IC is used. By using this, the first display will be triggered, only when the first counter has been counted to (1001) or decimal 9. That is from 1001 to 0000, and we have a descending pulse, as the last digit descends from logical 1 to logical 0 and triggers the BCD counter of the decades. When the decades display becomes 9, the circuit goes to the next state, which is zero, and the counting begins once more. The circuit design for counter section is shown in figure (7).

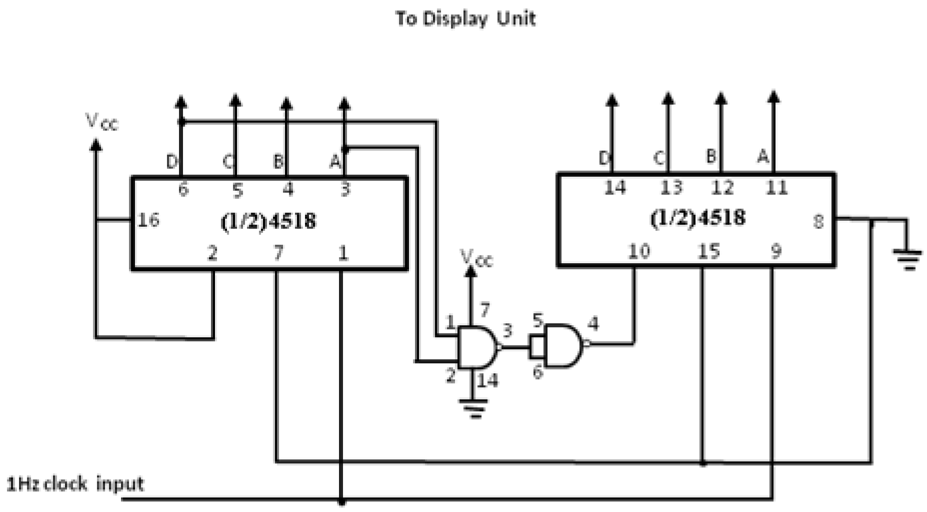


Figure (7) Circuit Design for Counter Section

Display units section

In this section, there are two parts: one is two seven segment display driver ICs 4511 and the other one is two seven segment displays. The integrated circuits 4511 are BCD to 7 segment drivers. Their sole purpose is to translate the BCD information of IC 4518, to a code understandable by the 7 segment displays. Display test and blank input are active-low so they should be high for normal operation. When display test is low, all the display segments will light (showing number 8). When blank input is low, the display will be blank (all segments off). The store input should be low for normal operation. The circuit design for display units section is shown in figure (8) (Marston, 1996a & 1996b).

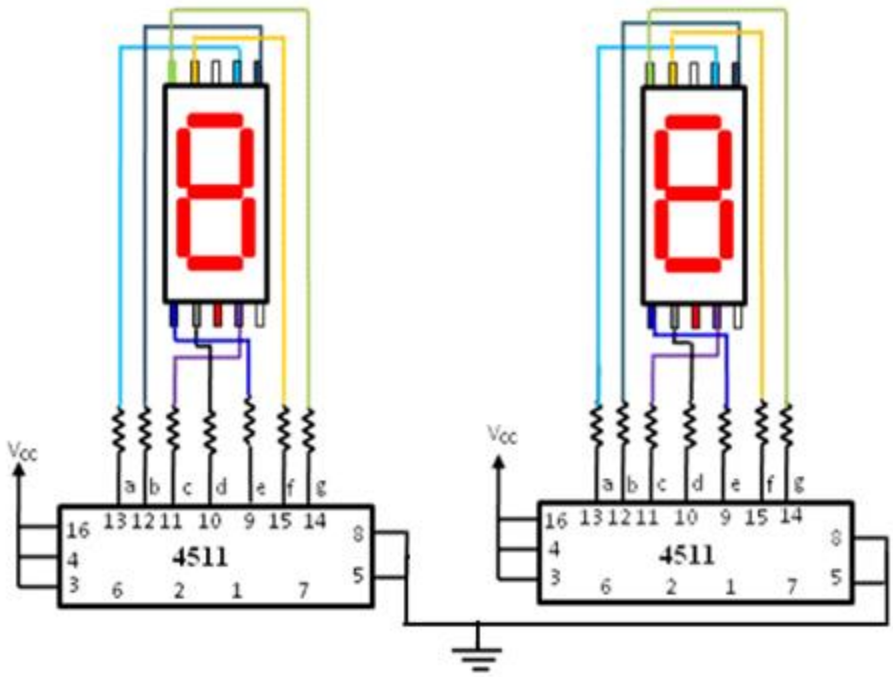


Figure (8) Circuit Design for Display Units Section

Operation of the System

The complete circuit diagram of digital stopwatch with light sensor and photograph of it in ready state to start the counting are shown in figures (9) and (10). There are two switches in this system: one is reset switch S_1 for ready and clear configurations and the other is hold switch S_2 for start and stop configurations. To start the counting for event duration, switch S_1 can be used for ready configuration. When the switch S_1 is pushed to the ready state, it will be ready to count the event duration. It will display the (00) in the seven segment displays. When the light incident on the LDR, the collector output voltage is high and the pulses are generated. These pulses are input to a four-bit BCD (Binary-Coded Decimal) value, and energize the proper output lines to form the corresponding decimal digit on the 7-segment LED display. Of two types of displays a common cathode display is required for 4511 IC. The BCD inputs are designated A, B, C, and D in order from least-significant to most-significant. Outputs are labeled a, b, c, d, e, f, and g, each letter corresponding to a standardized segment designation for 7-segment displays. Of course, since each LED segment requires its own dropping resistor, seven 1kΩ resistors must be placed in series between the 4511's output terminals and the corresponding terminals of the display unit.

When a HIGH is applied to a segment input, the LED is turned on and there is current through it, then the appropriate outputs a-g becomes high. When the LDR is covered, the counting will stop. At that time, it will display the time period for event duration. Then, it can be set clear and counting can restart again.

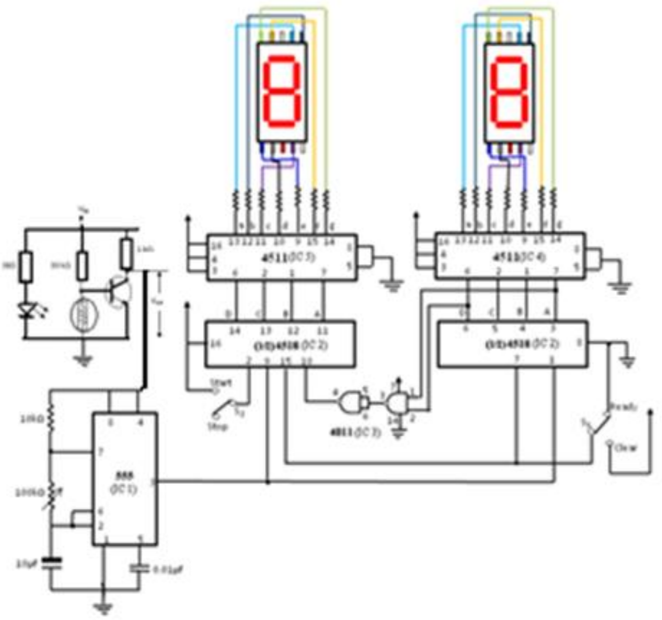


Figure (9) Circuit Diagram of the Whole System

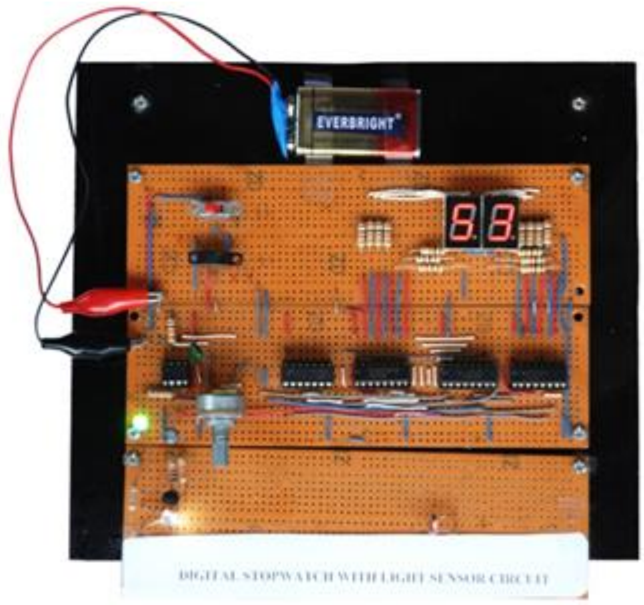


Figure (10) Photograph of the Complete System

Discussion and Conclusion

This system is very commonly used in racing competitions and other gaming activities. It can be used for single event timing, a warning signal and play an audio file. This system is a versatile and flexible multifunctional. This circuit can be measured the time interval for any two events. Measuring range for time interval is 00 to 99 seconds and since two seven-segment displays are used instead of pointer, it is more exact measurement than the ordinary clock.

It can be used as timer circuit to control the other circuits such as water pumping circuit and switching devices as a function of time. Besides it can also be used to measure exact period of any events in various sports. Moreover, this circuit can be used as teaching aids device for under graduate students and post graduate students in practical sections such as measuring the period of Simple Pendulum experiment and measuring the time taken for the motion of two objects in Atwood Machine experiment. The electrical components and devices used in this system are very cheap and available in local market and it can be constructed easily by students.

Acknowledgements

We would like to thank Dr. San Linn, Acting Rector, Hinthada University, and Dr. Aung Win, Pro-Rector, Hinthada University, for their kind permission to carry out this research work. We are also thankful to Dr. Ohnmar Hlaing, Professor, Head of Department of Physics, Hinthada University, for her valuable suggestions and encouragement in carrying out this work.

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Websites

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