HW#2: Design a Digital Stopwatch with Start/ Stop and Reset Functions

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Course: Smart Electronics System Design Paradigm

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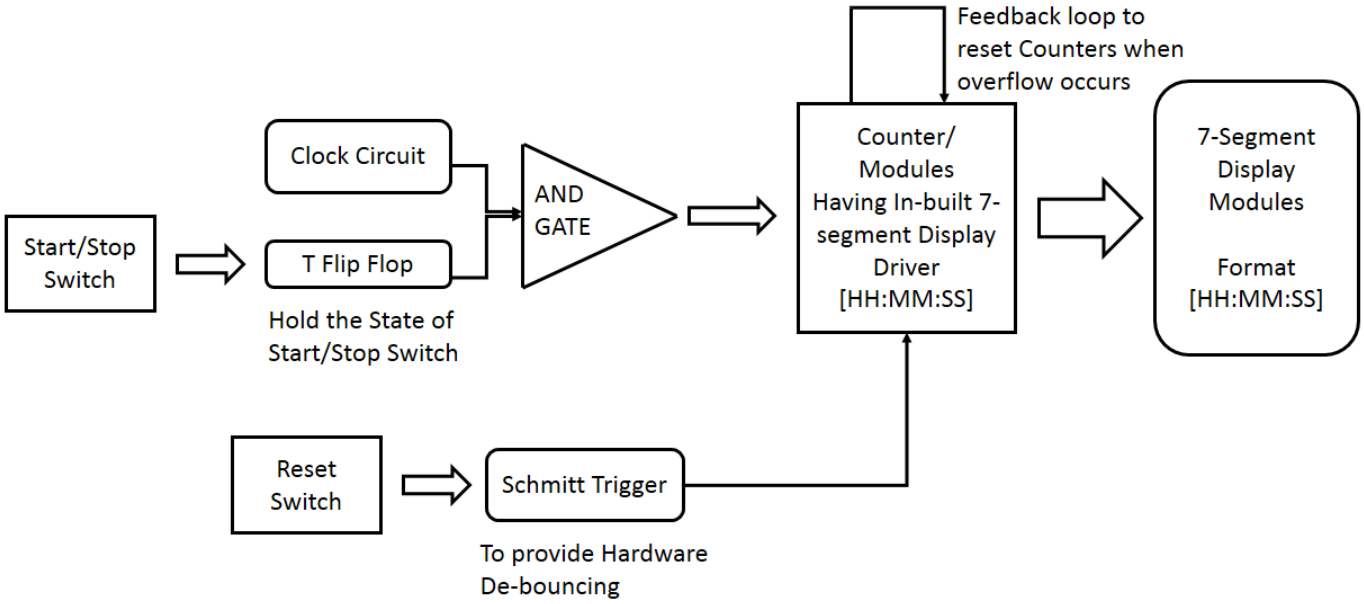
AIM: Goal of this design project is to design a digital stopwatch using non-programmable ICs and should demonstrate full functionality of a digital stop watch, this design is given to have a thorough understanding of design principles and make note of facts which have to be taken care of while designing electronic systems e.g. handling switch de-bouncing in hardware, design toggle switches having state hold feature.

Flow Chart of Design Statement



Flow Diagram of Digital Stop Watch built using non-programmable IC's

Block wise description of all section is given below:

1. **Clock Generating Block (NE555 Timer)**

   NE-555 is driven in astable multivibrator mode governed by design equations as stated below. This block is used to generate 1Hz clock to drive out stop watch circuit. The clock fed in to first counter circuit is provided through an AND gate controlled a switch to START and STOP the stop watch. A T-Flip Flop is used to toggle polarity of this switch which controls the CLOCK feeding. This whole step of including T-FF is to avoid any glitches in the switching action. So in this way clock will be provided to stop watch when output from T Flip Flop is high.

Circuit Diagram for NE-555 Timer IC in astable mode is shown below.

$$F=\frac{1.44}{(R1+2R2)C1} \qquad D=\frac{(R1+R2)}{(R1+2R2)}$$

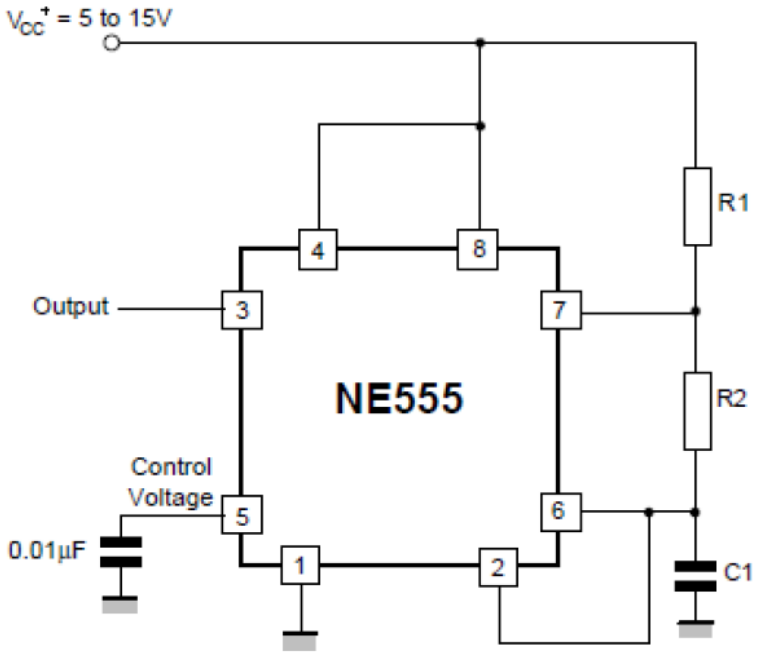
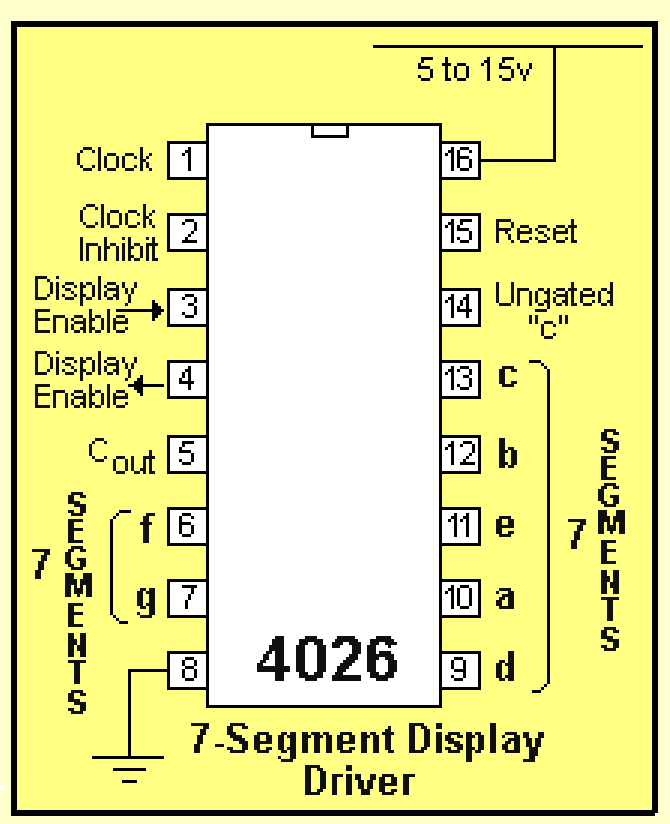


Figure: IC NE555 in Astable mode.

2. Counter circuit IC4026

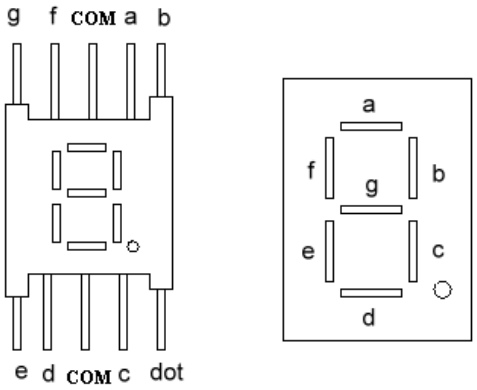
This block consists of six decade counters used with a purpose of doing the counting action in HH:MM:SS having 24 hourly display pattern. This also consists of IC4082 quad input AND gate to do the counter reset based on sequence match e.g. resetting seconds counter after 59 and hours counter after 24. The first counter in this block is driven by 1Hz clock from NE555 timer IC. This block is also having a common RESET function in order to reset all the counters with a same push button. This function is implemented by feeding overflow reset and RESET through a dual input OR gate in to Pin No. 15 of all the counters.

The labelled Pin diagram of CD4026 is shown below.



3. 7 Segment Modules

Six 7-segment modules are used to display stop watch action in HH:MM:SS format. Having 7 control signals for 7 LEDs and all the LEDs are connected with 100 ohm series resistor to limit the current being fed in to these LED segments.



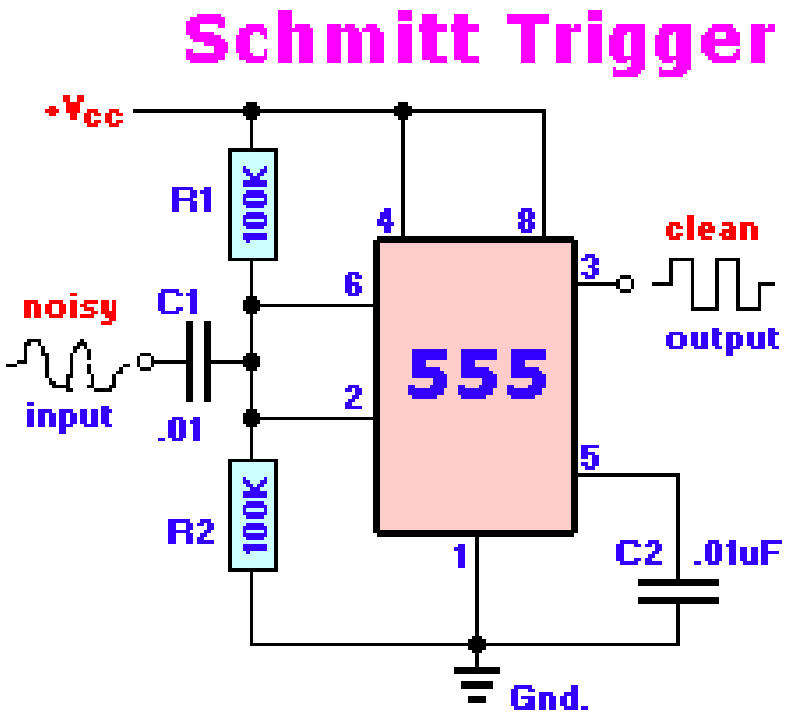
Seven-Segment Display

4. Schmitt Trigger Based RESET Function

Schmitt Trigger based Reset is used to avoid any glitches in the reset action and to provide hardware de-bouncing.

The circuit is closed whenever the normally open switch is momentary closed. When the switch is released, the contacts separate and open the circuit. The contacts are designed to be springy, so that the switch will return to its open state immediately upon being released. The same springy characteristic of the contacts that enables the switch to function in this way creates a new problem - when the switch is released, the contacts have a tendency to bounce and make a series of very short open / closed pulses called switch bounce or “chatter”. This problem can be very pronounced when using the momentary pushbutton switch as a digital logic input in a circuit. The result can be a very erratic or seemingly random functioning of the switch. “Switch de-bouncing” is the term for the technique to correct and compensate for mechanical switch bounce. There are both software and hardware methods to accomplish this. Here hardware de-bouncing has been used.

This circuit actually takes an input signal and maintains the output for a certain time period and then goes back to low state.



5. **Power Supply**

   Power supply to all pins and also un-invoked pins is fed through standard signal inputs which are mounted using a standard BERG connector to +5V and GND.

6. **ICs**

   - IC CD4026: Decade Counter IC is used for counter action. Another important fact is that it also contains inbuilt BCD to 7-segment driver for controlling 7-segment displays.

     External inputs given to this counter are: clock from clock circuit (containing a timer, T flip flop, AND gate, switch), Reset through OR gate, ground and +5V supply. Output of this counter is connected to the seven segment display modules.
   - IC 7408: This is quad dual-input AND gate IC being used for controlling START/STOP function of this stop watch.
   - NE555: This is used for Schmitt trigger as well as for generating clock for counter circuit. This is used to implement hardware de-bouncing while doing reset function as explained above.
   - IC 4027: This is a JK FF being used to implement T-FF for controlling START/STOP switch. This is required to maintain the state of Start/Stop function.
   - IC 74HC32N: This IC is a dual-input OR gate IC used to control provide dual reset function to counter ICs. One is through overflow due to counters and second is due to manual resets.
   - IC 4092N: This IC is used to do the overflow action whenever a minute counter reaches 59 or hour counter reaches 24 this will make a reset.

     NB: All these ICs are available in local markets.

7. **Alternative Approach**

   Currently this design is implemented using non-programmable ICs and due to that this seems to be quite complex. Similar design can be implemented using any low cost microcontroller to do this counting and other functions (Start/Stop and Reset). This design will be far simpler in terms of board design and also in terms of debugging. But this design will require six external bcd-7segment driver ICs (BC7447) to drive six 7-segment displays.

8. **Future work or Possible Improvements**

   I am sure if some further improvement is possible apart from an efficient SMPS based power supply to power this up. I have tried to cover all design aspects which are best known to my knowledge.

STOP Watch Circuit