

Title: DIGITAL CLOCK

Goals: Introduction to digital circuits. Learn to build a square wave generator with a Schmitt-Trigger inverter; to use a decimal (BCD) counter, and to use a display decoder for an LED display.

Background:

This is a digital clock with only two output digits counting seconds up to 59. The first stage of the circuit is a Schmitt-Trigger oscillator (U4) that generates a square wave at a frequency of 1 Hz. The output signal is applied to a decimal (BCD) Up-Counter (U1), i.e. it counts from 1 to 9, returns back to 1 and continues. The number transition occurs at the falling edge of the clock signal because the clock signal is applied to the Enable input of the counters (E) and the actual clock input is grounded (CLK). Please refer to the datasheet of these integrated circuits for description of their detailed operation. The outputs of the flip-flops in the decimal counters are decoded by BCD-to-7-Segment Decoders (4511, U3 for seconds and U2 for ten seconds). This decoder converts the outputs of the BCD counter into other combination of high and low voltages at the seven outputs (A through G) such that we can read them as number on the 7-Segment-Common-Cathode LED Displays. The common cathode of all the LEDs in the display should be connected to the ground as shown. A resistor is used to limit the current flowing through each LED segment. The function of D1 and D2 is to make the counters return to zero by resetting both at the count of 60.

Assignment:

1. Pick an arbitrary value for R1 between 100kOhm and 1MOhm. Calculate the capacitor C1 value to obtain 1 Hz from the square wave oscillator using the following equation:
 $f = 1 / (0.69 \times R1 \times C1)$.
2. Build the entire circuit and ask the instructor to come and check the circuit connection.
3. Power the circuit as shown by the instructor.
4. Measure the oscillator frequency (U4) by connecting its output to the oscilloscope. Adjust the frequency by changing R1 to make it exactly 1 Hz on the oscilloscope screen.
5. Check if the decimal numbers appear from 1-9 on the first LED display and 0-5 on the second at intervals of 1 sec.
6. Does the number return to 0 after 59?
7. Now replace R1 with half of its value. Is the counting speed doubled ?
8. Do the following on the display decoder, one at a time, while observing the display:
 - a. Connect the BL input to the ground
 - b. Connect the LT input to the ground
 - c. Connect the LE input to the positive supply
9. Change the order in which the 4511 outputs are connected to the display and have fun!!!
10. Change the order in which the 4518 outputs connected to 4511 and observe the order of counting. Can you explain the change?
11. In your report, include:
 - a. Calculations of square wave frequency,
 - b. Basic operation of the frequency dividers (binary and decimal counters, i.e. 4040 and 4518 respectively)
 - c. Basic operation of the BCD decoders (e.g. 4511) and the LED displays
12. Disconnect the circuit and place the components where they belong in their boxes.