The City College of New York

School of Engineering

EE22100 Electrical Engineering Laboratory I

Spring Semester

Lab Report Experiment #7

Digital Clock

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INTRODUCTION:

In this lab, we will be implementing seven-segment numerical displays and various types of digital Integrated circuits (ICs), counters, and gates to build a 12-hour or 24 hours digital clock. Digital integrated circuits (ICs) allow designers of electrical circuits to implement a wide variety of logical, combinatorial, sequential, and other functions. This lab will be using ICs that contain less than a few hundred transistors each and are called ASICs. SSIC stands for 'small scale integrated circuits.

We will design a clock using 3, two-digit, common anode "LED seven segment display", BCD display driver, and cascading counters. The clock will either get a clock signal from the function generator or a timing generator. Then the counters will output 4-bit binary code decimal to display drivers, which will then produce output 7-bit binary output to light up the corresponding digit. A detailed explanation is given under the procedures/technical discerption.

PROCEDURES/ TECHNICAL DISCERPTION:

This section will describe parts of the clock, the display, the display driver, the counter, and the timing generator.

Seven Segment Display:

The 7-segment displays are seven LEDs lined up in a particular pattern. In this case, we're all familiar with the number '8' shape. Each of the seven LEDs is called a segment because when illuminated the segment forms part of a numerical digit (both Decimal and Hex) to be displayed. An additional 8th LED is sometimes used for indication of a decimal point (but we are not using it in this experiment). This display module contains 18 pins placed on the top and bottom of the display. The pins (1-4, 15-18) are for the left digit, and pins (5-9, 10-12) are for the right digit. Pin 14 and 13 are for the power for the left and right digits respectively as shown below.

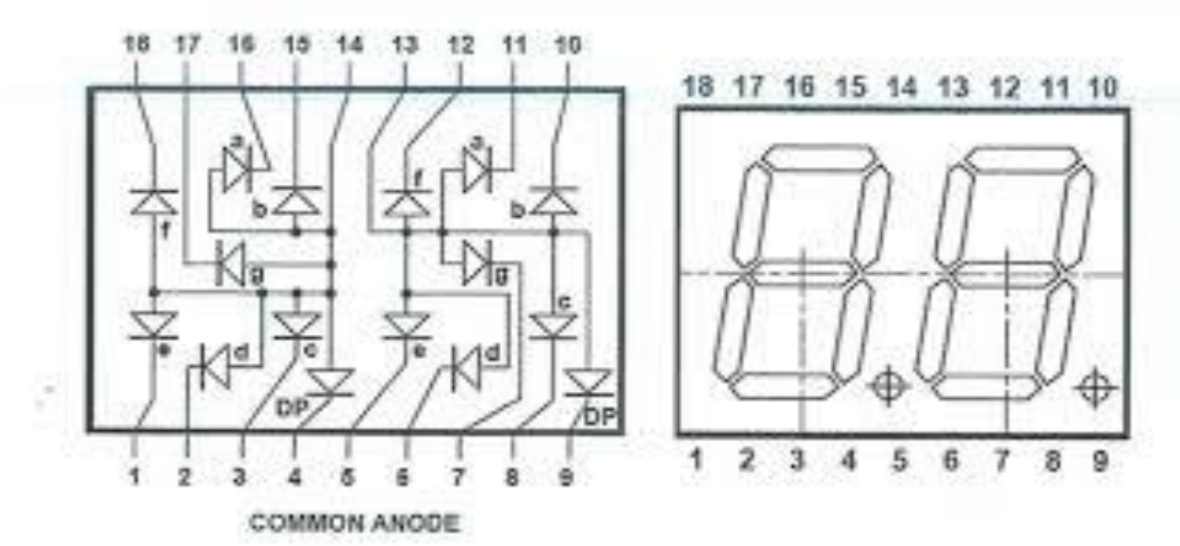

Figure 1: internal of the 7-segment display and pin setup

There are different types of 7-segment displays, we are using a common anode, which means that the anode (positive) side of all the LEDs is connected, as we can see in the top figure. Each segment is named with the letters a to g. For example, If you want to display the number one, segments b and c need to be lit up. The latter corresponds to the output of BCD to display the decoder.

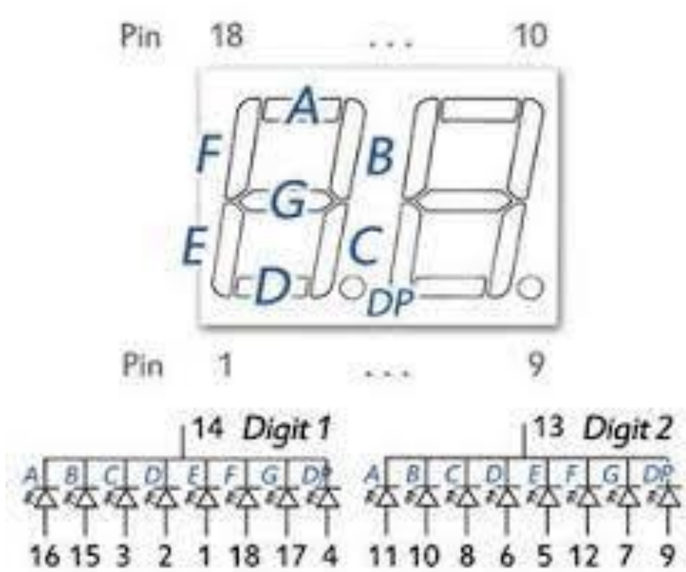

Figure 2: top view and pinout and segment symbol of the display.

BCD to 7-Segment Display Decoders (display driver):

There are several commonly used binary codes. The one that will be used in the clock design is Binary coded Decimal (BCD). BCD is used when binary numbers are used to represent or display decimal digits. The display decoder takes 4-bit binary input (representing a digit) and converts it into 7-bit output connected to the corresponding segment. Figure 3 shows the table of binary input and out and the corresponding number. For example, to display decimal digit 4, the input would be 0100 and the output would be 0110011. Although 4-bit binary can represent 0 to 15, for our case we will ignore those.

Decimal Digit	Input lines				Output lines							Display pattern
	A	B	C	D	a	b	c	d	e	f	g	
0	0	0	0	0	1	1	1	1	1	1	0	0
1	0	0	0	1	0	1	1	0	0	0	0	1
2	0	0	1	0	1	1	0	1	1	0	1	2
3	0	0	1	1	1	1	1	1	0	0	1	3
4	0	1	0	0	0	1	1	0	0	1	1	4
5	0	1	0	1	1	0	1	1	0	1	1	5
6	0	1	1	0	1	0	1	1	1	1	1	6
7	0	1	1	1	1	1	1	0	0	0	0	7
8	1	0	0	0	1	1	1	1	1	1	1	8
9	1	0	0	1	1	1	1	1	0	1	1	9

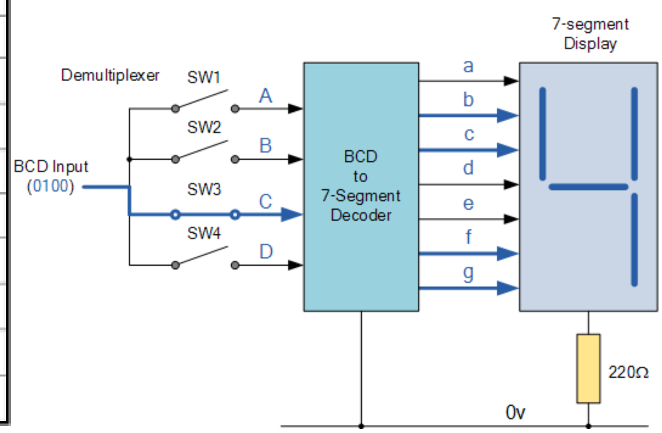

Figure 3: Decimal digit to binary conversion table and example diagram.

We will be using provide IC with part number CD4543, this IC does not require any resister and signals when unwanted input is given. The driver is also a common anode, thus Phase Must be 1 to reverse. An internal circuitry bit complex, but specially built for 7-segment displays. The circuit diagram is shown below. Following the pinout of the IC, we connect pins 1,6, and 16 to power (Vdd), and pin 7 and 8 to ground. The input pins are 2 to 5, and output pins are pins 9 to 15 (a to e in order but f and g are swapped).

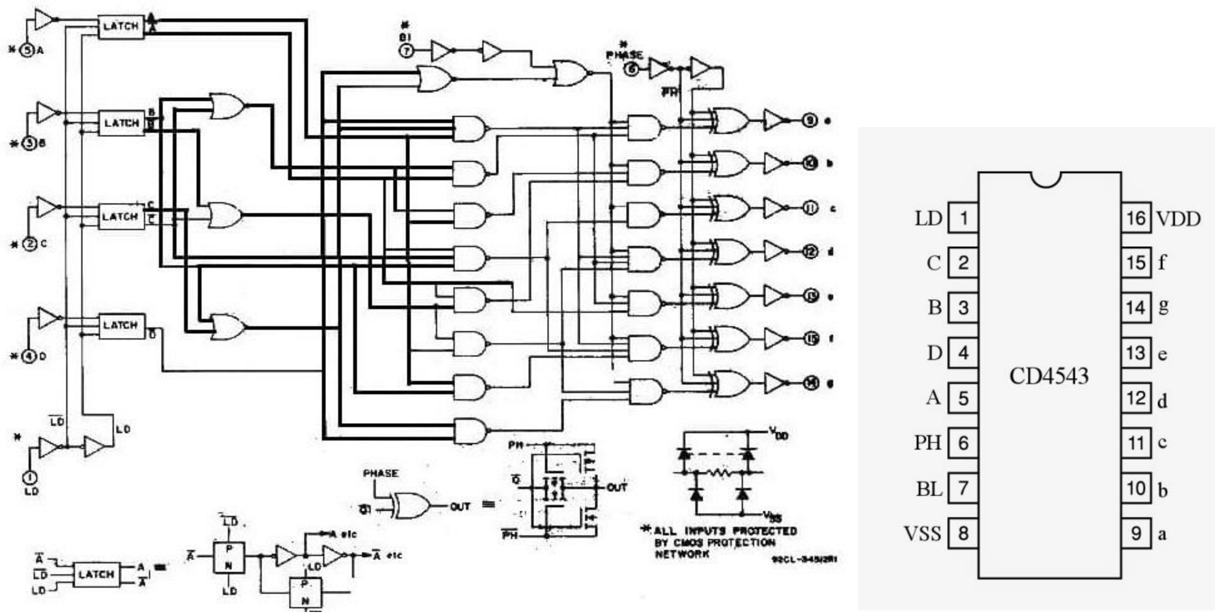

Figure 4: BCD-to-7-segment display driver CD4543 logic circuit diagram and pin layout.

The Counters:

For the counters, two separate kinds of chips were used. The 4510 was used for the hour's display, and the 4518 was used for the minutes and hours displays. Both chips serve a similar function. They count up until a certain number and then reset. However, the 4510 can customize which number you reset back down to. This is desirable for the hours display because we want it to count from one to twelve, not zero to twelve. For the minutes and hours displays, which we want to count from 00 to 59, this ability to customize what number the reset returns to is not necessary. Thus, the 4518 was chosen for inclusion in the lab kit. The 4518 cannot customize the return value but can control two 4543 chips (and their corresponding two 7 segment displays) compared to the 4510's ability to control only a single 4543 chip (and corresponding display).

These functions were made possible by using a 4081 quad AND gate chip which takes two inputs and produces an output when both inputs are high. For example, setting one and gate to trigger off of a 0001 and 0111 signal coming from the 4518 chips forces the hour's display to reset when the first digit is 1 and the second digit attempts to change to 3.

The first 4518 receives the clock signal and counts from 00 to 59. When it reaches 59, it resets to 0 after the next second passes and passes the clock signal onto the minutes counter, the other 4518. The 4518 repeats the same process for the hour's counters, the two 4510s. Below attach a diagram of the cascading counters and connection to the driver.

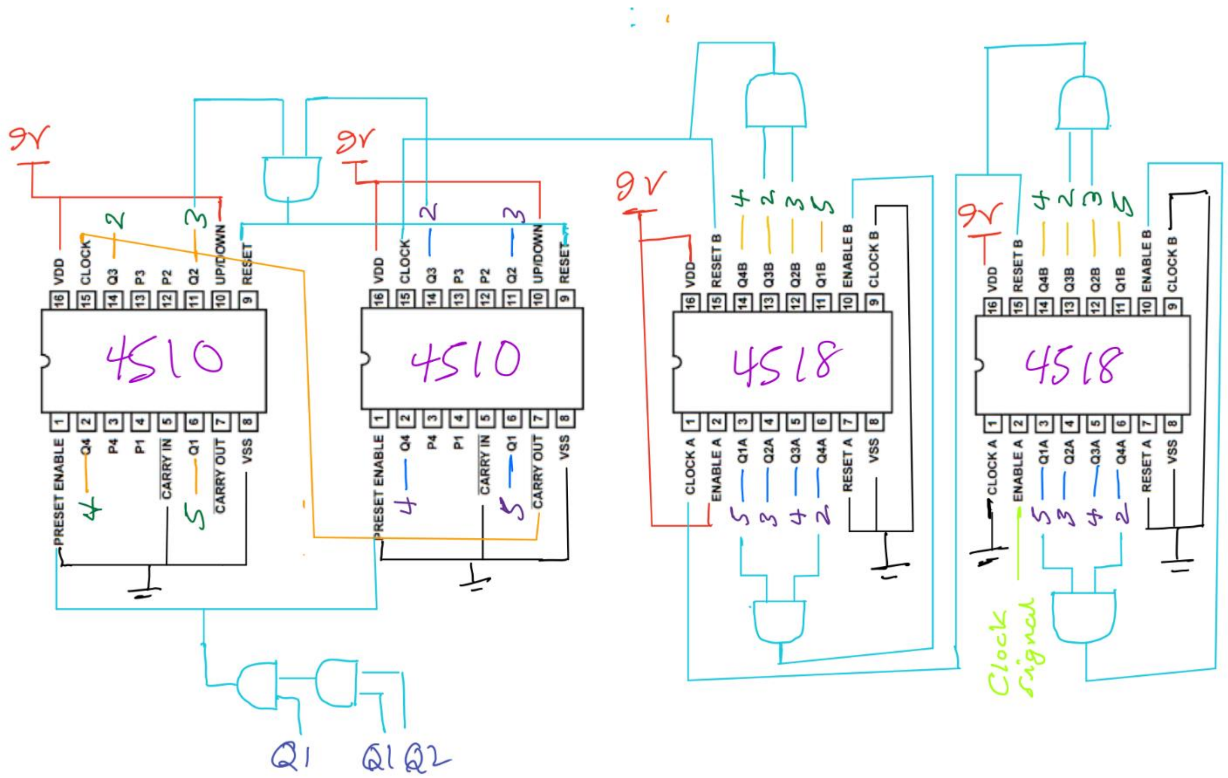

Figure 5: Cascade counter of CD4510 and 4518 and present enable for hour. The number shown corresponds to the display driver input PINs.

Generating the clock signal:

The time base generator was first simulated by using a function generator set to a square sine wave output and later by installing a 32,768 Hz quartz crystal onto the breadboard. A 32.768 Hz crystal was chosen because lower frequencies (such as the 16Mhz quartz crystal) provide less accurate timekeeping and are also bulkier. Two capacitors and two resistors were used to buffer and protect the crystal and to step down the voltage. The output from the crystal was passed to a 4069-amplifier chip, which was then routed to a pair of 4520 chips to divide the clock signal down to 1 second. This output was then linked up to the clock input of the first 4518 chip (for the seconds counter). Below is the circuit diagram.

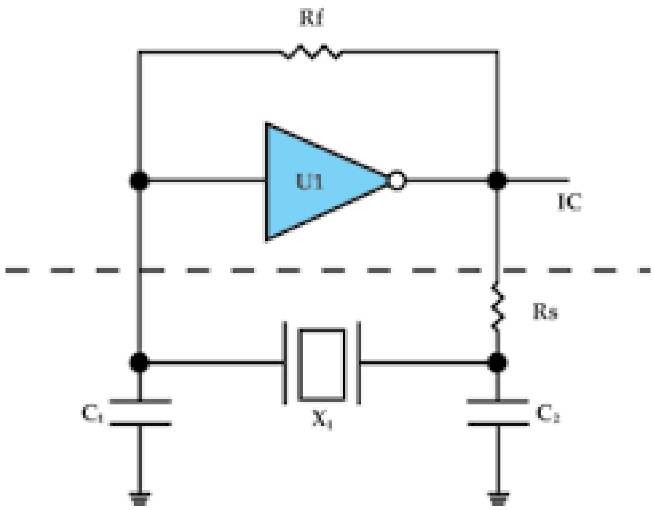

Figure 6: A time-based generator that will output 1 Hz clock signal to drive the counters. Rf = 10MOhms, Rs = 330kOhms, C1 and C2 = 33nF, X1 = 32768 crystal oscillator, and U1 is CD4069 logic inverter and several CD4020 IC binary counter to configured to divide by 32768 = 2^15.

DATA TABLES AND FIGURES:

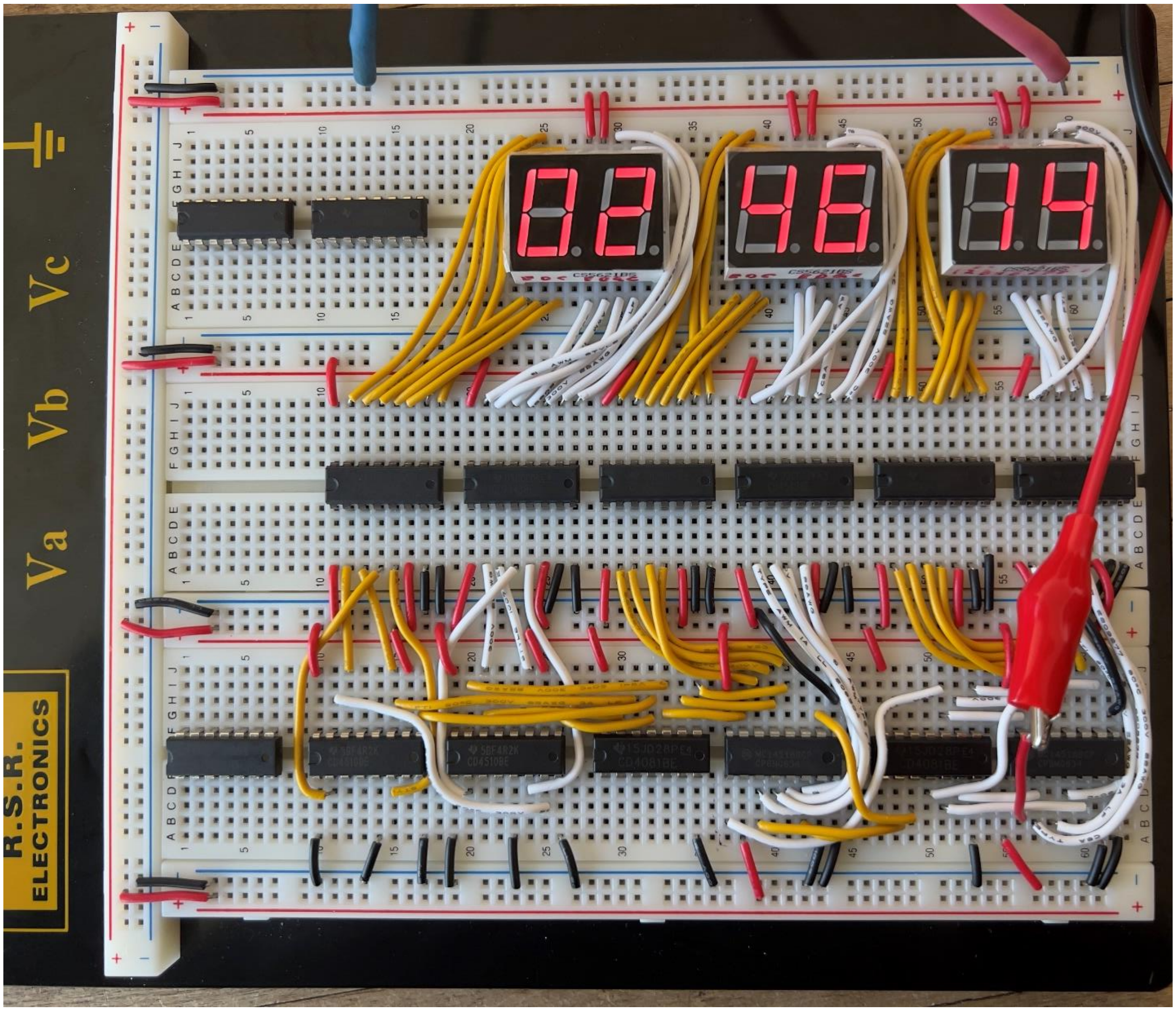

Figure 7: Prototype of the digital clock. The top row contains 2 cd4520 for the timing generator and 3 double-digit 7-segment displays, the middle row contains 6 cd4543(BCD to &-segment display decoders). Bottom row consistency of cd4069 logic inverter, 2 cd4510 (BCD pre-settable counter), and 2 cd4518 (Dual 4-bit BCD counter with asynchronous RESET). And 2 CD4081 quad AND gates.

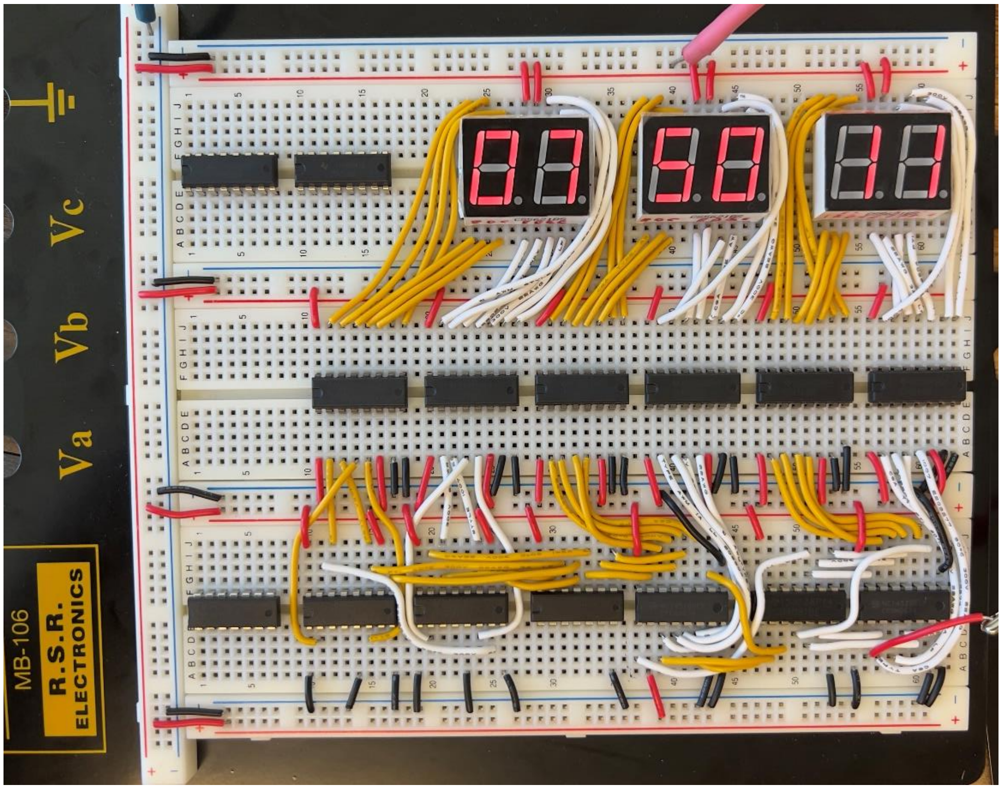

Figure 8: complete clock with a clock signal for the function generator

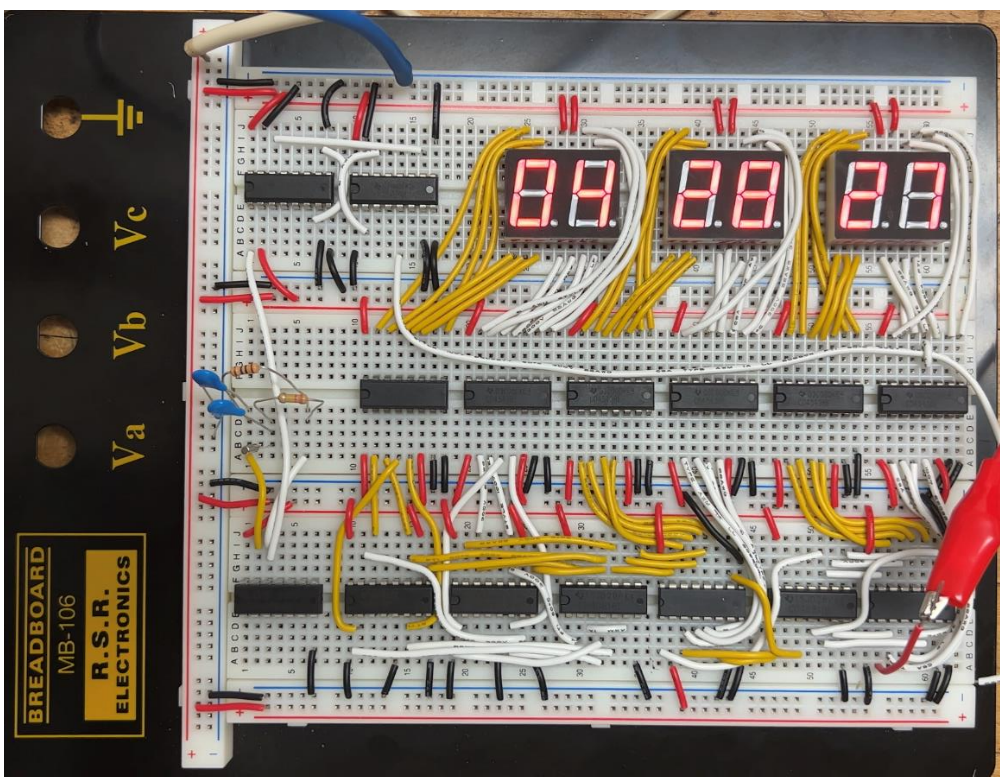

Figure 9: Complete clock with time base generator for digital clock

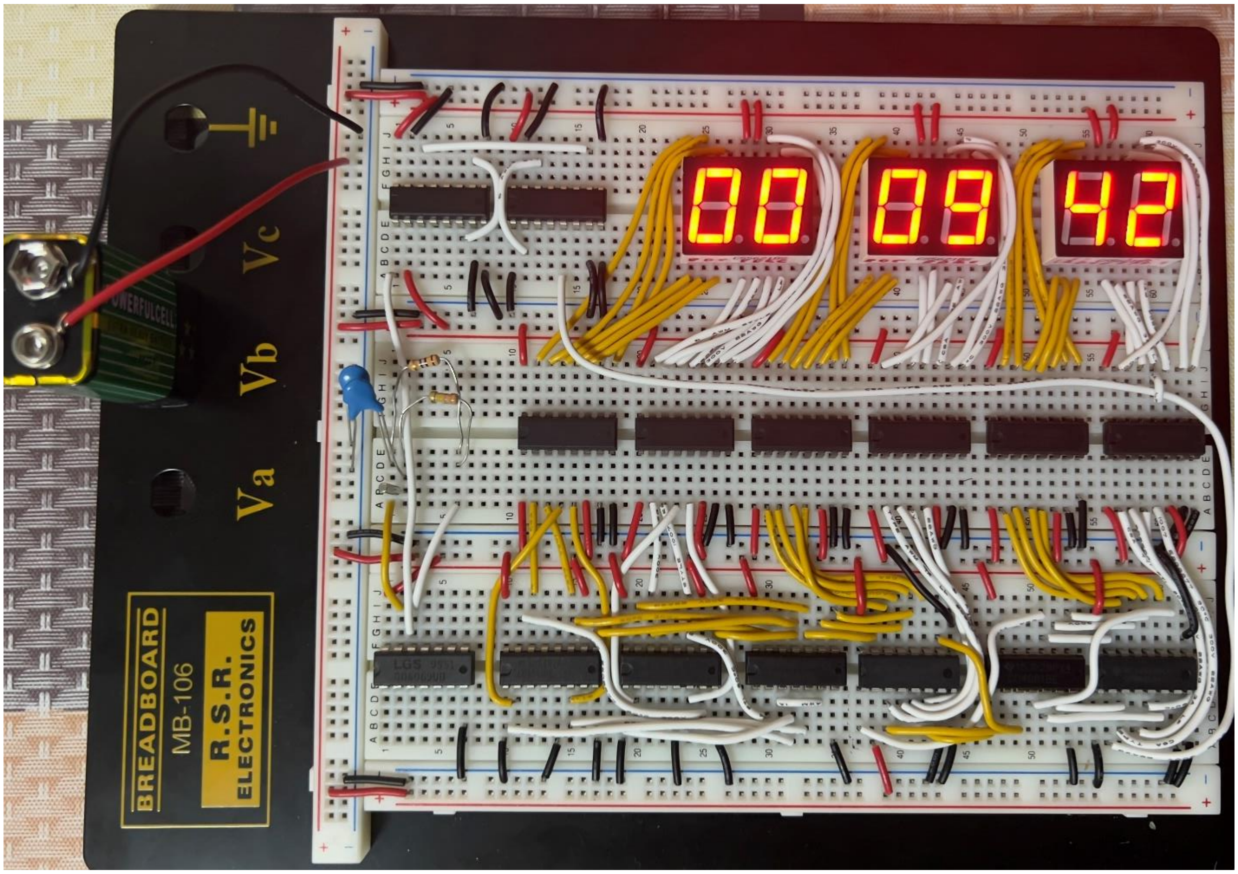

Figure 9: Complete clock with time base generator for digital clock and powered by 9v battery

QUESTIONS AND ANSWERS:

How long will this thing run on 9V or AAA batteries?

A 9V battery is the same as 6 x 1.5 V or 6 AA battery. This clock would be better off attached to a wall power supply since a 9V power supply will not run it for very long likely an hour or less. According to the datasheet, the typical forward current per LED is 20mA, and we have 6 digits with 8 segments each. This totals to 960mA if all 8 segments on all six digits were lit continuously. Although only a few segments per digit may be lit at a time during normal operation, if we assume that half the segments are on and half are off, resulting in, say, a 500mA current draw, it will still have a very limited operating time--a 9V battery only has between 400-600mAH. The logic portion of the clock draws very little current compared to the LED displays, so long as all the unused inputs of the chips are properly grounded. An LLCDis a common choice for projects such as this because it draws much less current than LED display types such as the ones we used.

CONCLUSION:

In this lab, we were introduced to integrated circuits (ICs) and learned about BCD to 7-segment display decoder and its functionality. Learned about counters and how they can be used to make the digital clock and many others. Used logic gates to make cascading counters. Made a clock signal generator using a crystal oscillator and counters. Learn about the 7-segment display. Although the clock does not have any time-setting functionality, it can be implemented using the 4053 IC chip. Due to lack of space in the protoboard, we left this part. I was successful in creating a digital clock that can run on a 9V battery and just using ICs.