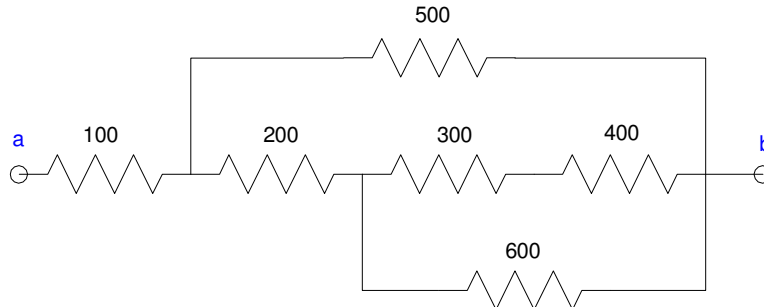


ECE 320 - Homework #1

ECE 211 Review, Phasors, 555 Timers

Resistors in series and parallel

1) Find the resistance R_{ab}



Several ways to do this. Using Matlab (hand calculator also works)

```
>> R1 = 300 + 400
```

```
R1 = 700
```

```
>> R2 = 1 / (1/R1 + 1/600)
```

```
R2 = 323.0769
```

```
>> R3 = R2 + 200
```

```
R3 = 523.0769
```

```
>> R4 = 1 / (1/R3 + 1/500)
```

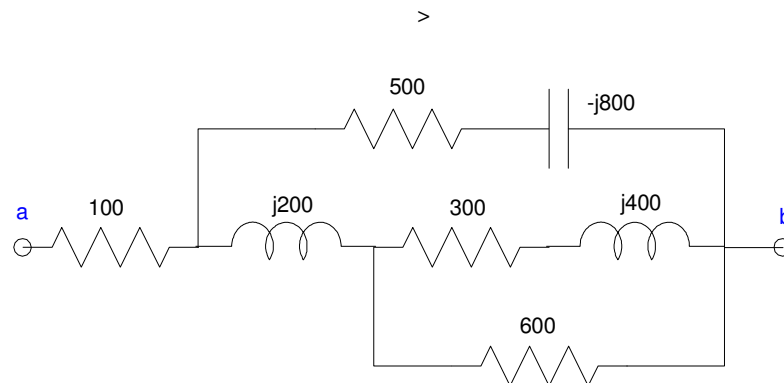
```
R4 = 255.6391
```

```
>> Rab = 100 + R4
```

```
Rab = 355.6391
```

```
>>
```

2) Find the impedance, Z_{ab}

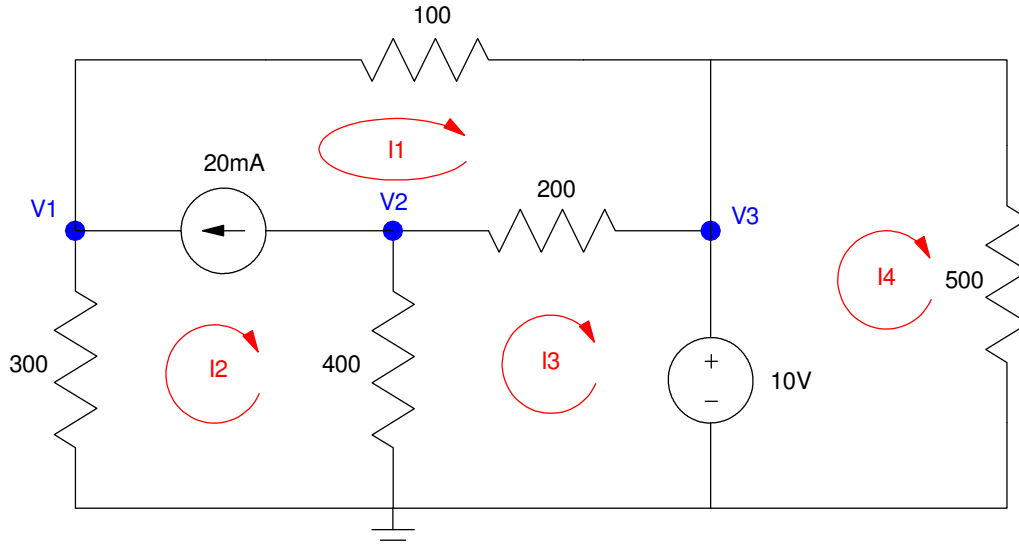


Again, using Matlab (hand calculator also works)

```
>> Z1 = 300 + 400j
Z1 = 3.0000e+002 +4.0000e+002i
>> Z2 = 1 / (1/Z1 + 1/600)
Z2 = 2.6598e+002 +1.4845e+002i
>> Z3 = Z2 + 200j
Z3 = 2.6598e+002 +3.4845e+002i
>> Z4 = 1 / (1/Z3 + 1/(500-800j))
Z4 = 4.2094e+002 +1.9781e+002i
>> Zab = Z4 + 100
Zab = 5.2094e+002 +1.9781e+002i
>>
```

Voltage Nodes & Current Loops

3) (Voltage Nodes): For the following circuit



a) Write the voltage node equations

$$V_3 = 10$$

$$\left(\frac{V_1 - V_3}{100}\right) - 0.02 + \left(\frac{V_1}{300}\right) = 0$$

$$0.02 + \left(\frac{V_2}{400}\right) + \left(\frac{V_2 - V_3}{200}\right) = 0$$

b) Solve using Matlab (or similar program)

group terms

$$V_3 = 10$$

$$\left(\frac{1}{100} + \frac{1}{300}\right) V_1 - \left(\frac{1}{100}\right) V_3 = 0.02$$

$$\left(\frac{1}{400} + \frac{1}{200}\right) V_2 - \left(\frac{1}{200}\right) V_3 = -0.02$$

Put in matrix form

$$\begin{bmatrix} 0 & 0 & 1 \\ \left(\frac{1}{100} + \frac{1}{300}\right) & 0 & \left(\frac{-1}{100}\right) \\ 0 & \left(\frac{1}{400} + \frac{1}{200}\right) & \left(\frac{-1}{200}\right) \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 10 \\ 0.02 \\ -0.02 \end{bmatrix}$$

Solve using Matlab

```
>> A = [0,0,1 ; 1/100+1/300,0,-1/100 ; 0,1/400+1/200,-1/200]
```

A =

```
      0      0      1.0000
0.0133      0     -0.0100
      0     0.0075     -0.0050
```

```
>> B = [10;0.02;-0.02]
```

B =

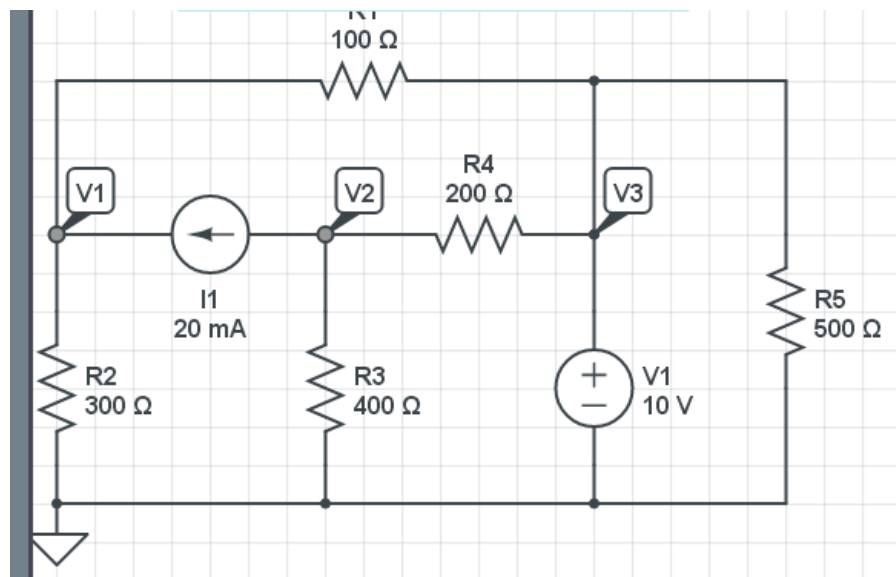
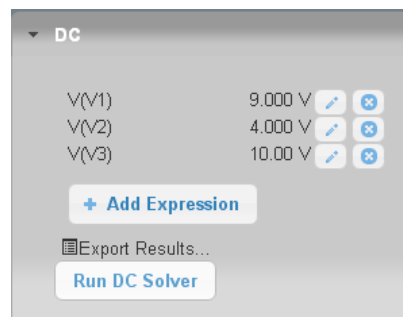
```
10.0000
 0.0200
-0.0200
```

```
>> V = inv(A)*B
```

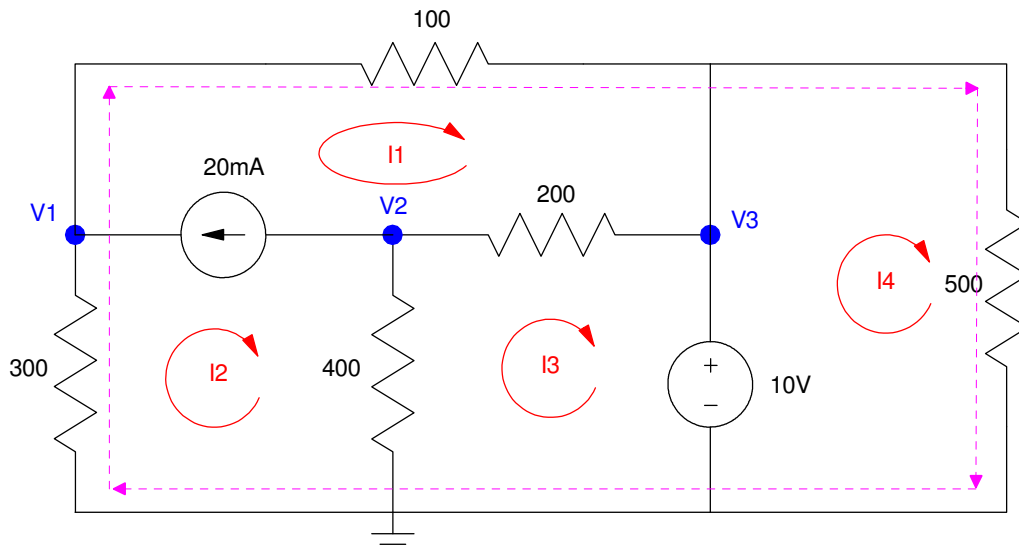
V =

```
V1    9.0000
V2    4.0000
V3   10.0000
```

c) Check your answers in CircuitLab (or similar circuit simulator)



4) (Current Loops) For the following circuit



a) Write the current loop equations

$$I_1 - I_2 = 20mA$$

$$400(I_3 - I_2) + 200(I_3 - I_1) + 10 = 0$$

$$-10 + 500I_4 = 0$$

$$300I_2 + 100I_1 + 500I_4 = 0 \quad \text{superloop}$$

b) Solve using Matlab (or similar program)

group terms

$$I_1 - I_2 = 20mA$$

$$-200I_1 - 400I_2 + 600I_3 = -10$$

$$500I_4 = 10$$

$$300I_2 + 100I_1 + 500I_4 = 0$$

Place in matrix form

$$\begin{bmatrix} 1 & -1 & 0 & 0 \\ -200 & -400 & 600 & 0 \\ 0 & 0 & 0 & 500 \\ 100 & 300 & 0 & 500 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \end{bmatrix} = \begin{bmatrix} 0.02 \\ -10 \\ 10 \\ 0 \end{bmatrix}$$

Solve in Matlab

```
>> A = [1,-1,0,0 ; -200,-400,600,0 ; 0,0,0,500 ; 100,300,0,500]
```

```
    1    -1     0     0
 -200  -400   600     0
     0     0     0   500
    100   300     0   500
```

```
>> B = [0.02 ; -10 ; 10 ; 0]
```

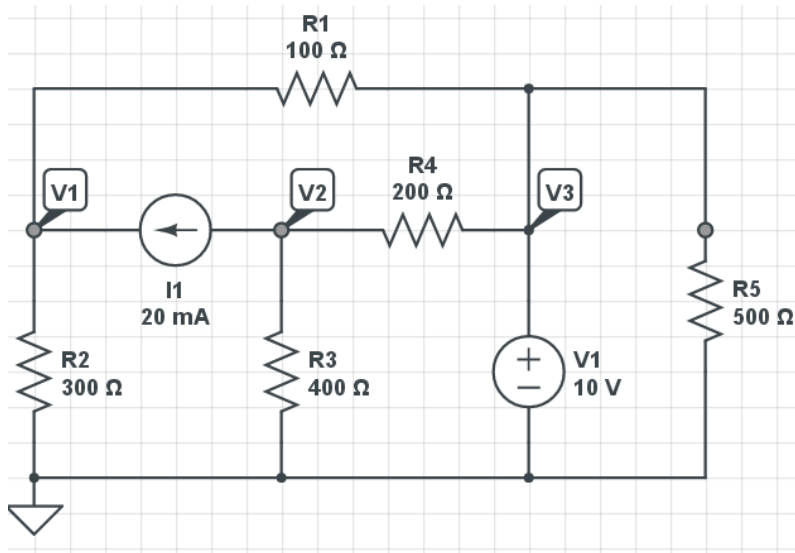
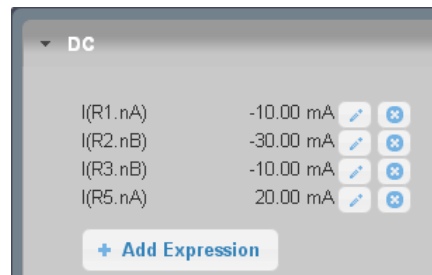
```
    0.0200
 -10.0000
    10.0000
         0
```

```
>> I = inv(A)*B
```

```
I1    -0.0100
I2    -0.0300
I3    -0.0400
I4     0.0200
```

c) Check your answers in CircuitLab (or similar circuit simulator)

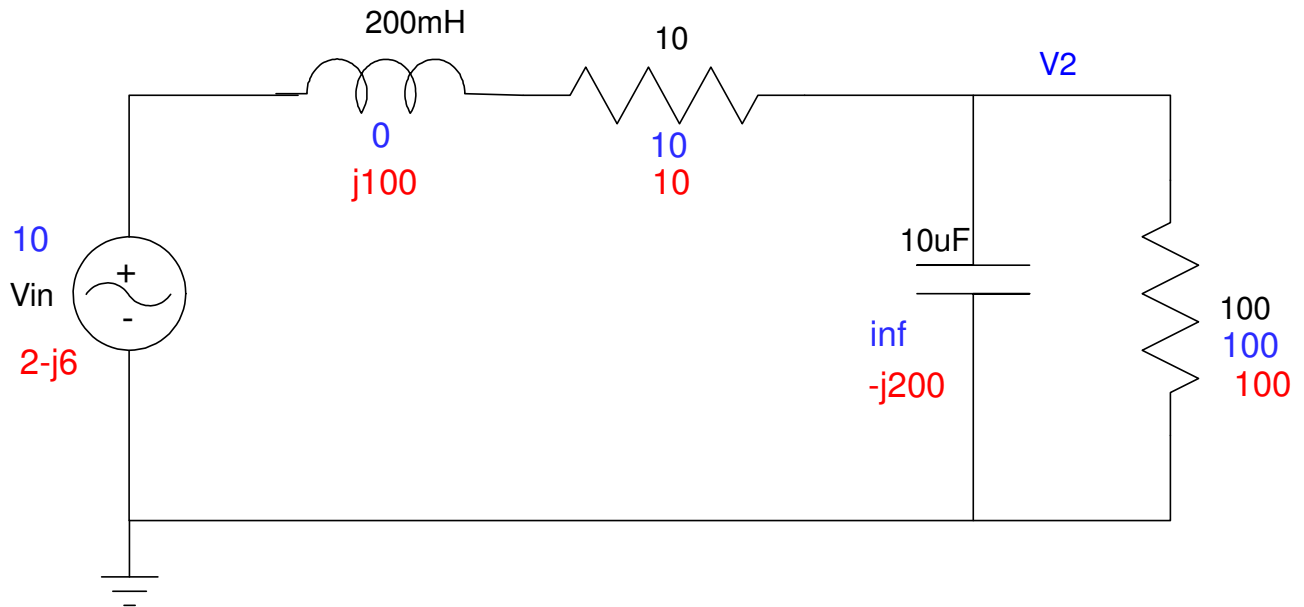
note: $I(R3) = I3 - I2 = -10\text{mA}$



5) Assume V_{in} contains a DC and 500 rad/sec signal:

$$V_{in} = 10 + 2 \cos(500t) + 6 \sin(500t)$$

a) Determine the voltage, V_2 , using phasor analysis



DC Analysis (blue)

$$V_{in} = 10$$

$$V_2 = \left(\frac{100}{100+10} \right) 10 = 9.091 V$$

meaning $V_2(t) = 9.091$

AC Analysis (red)

$$V_{in} = 2 - j6$$

$$L \rightarrow j\omega L = j100$$

$$C \rightarrow \frac{1}{j\omega C} = -j200$$

$$100 \parallel -j200 = 80 - j40$$

$$\left(\frac{(80-j40)}{(80-j40)+(10+j100)} \right) (2-j6) = -3.487 - j3.897$$

meaning $V_2(t) = -3.487 \cos(500t) + 3.897 \sin(500t)$

The total answer is DC + AC

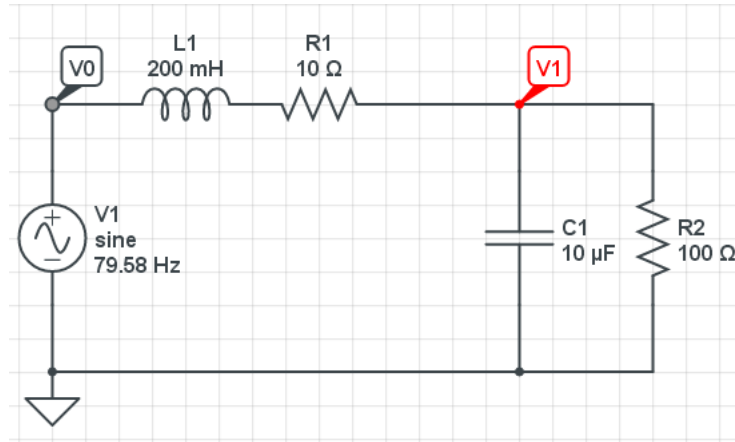
ans $V_2(t) = 9.091 - 3.487 \cos(500t) + 3.897 \sin(500t)$

6) Determine the voltage V2 using CircuitLab

- Compare CircuitLab's results to your calculations in problem #5

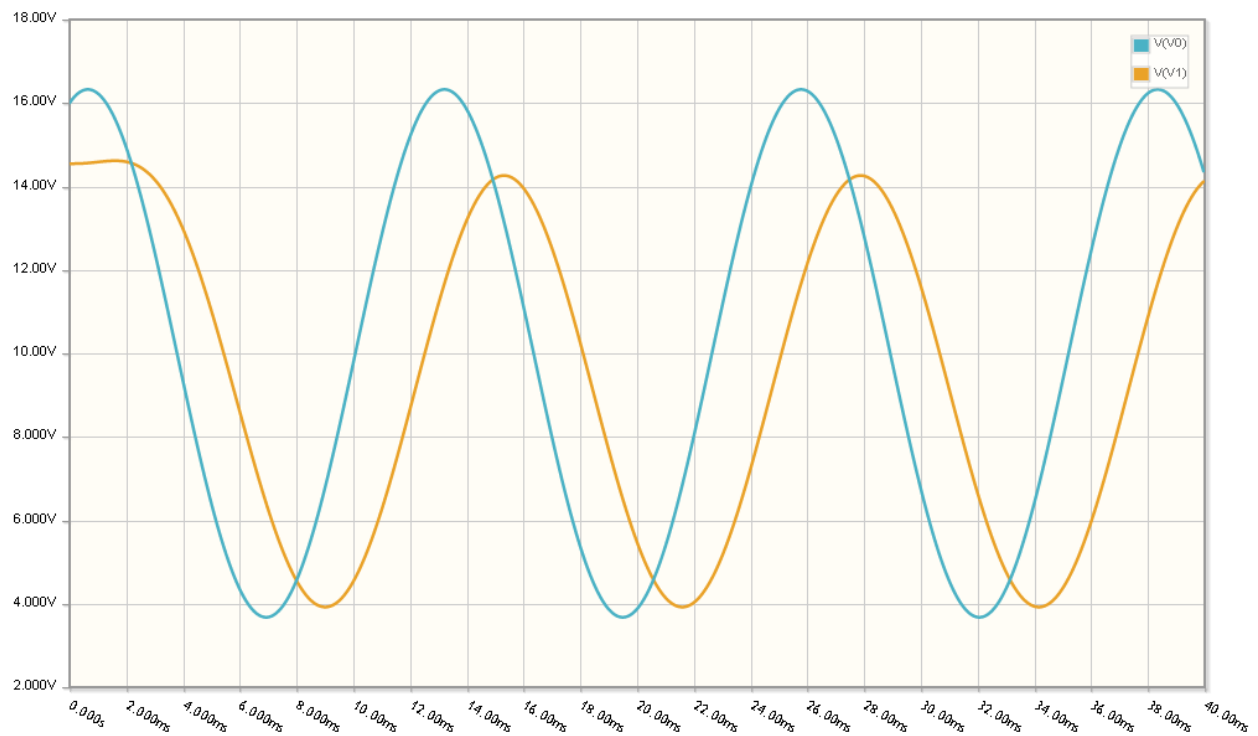
500 rad/sec = 79.58Hz

$$\omega = 2\pi f$$



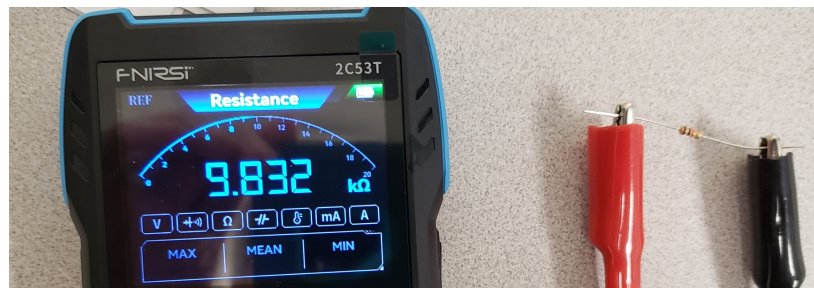
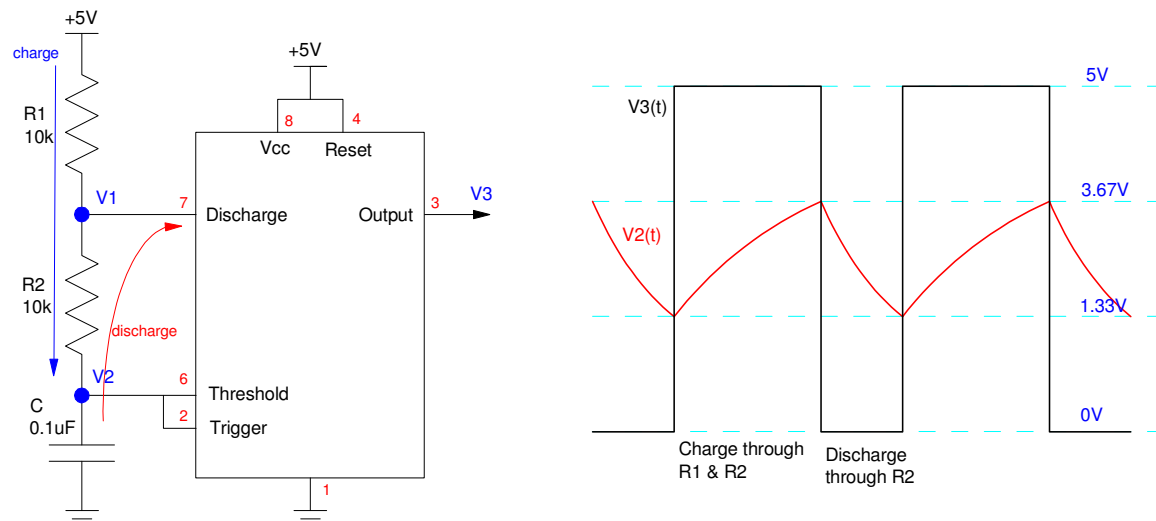
Running a time domain simulation for 3 cycles

- The output (orange) has a peak-to-peak voltage of 10V (vs. 10.46V_{pp} calculated)
 $2 * |-3.487 - j 3.897| = V_{pp} = 10.46V_{pp}$
- The output (orange) has an average voltage of 9.2V (vs 9.091V)

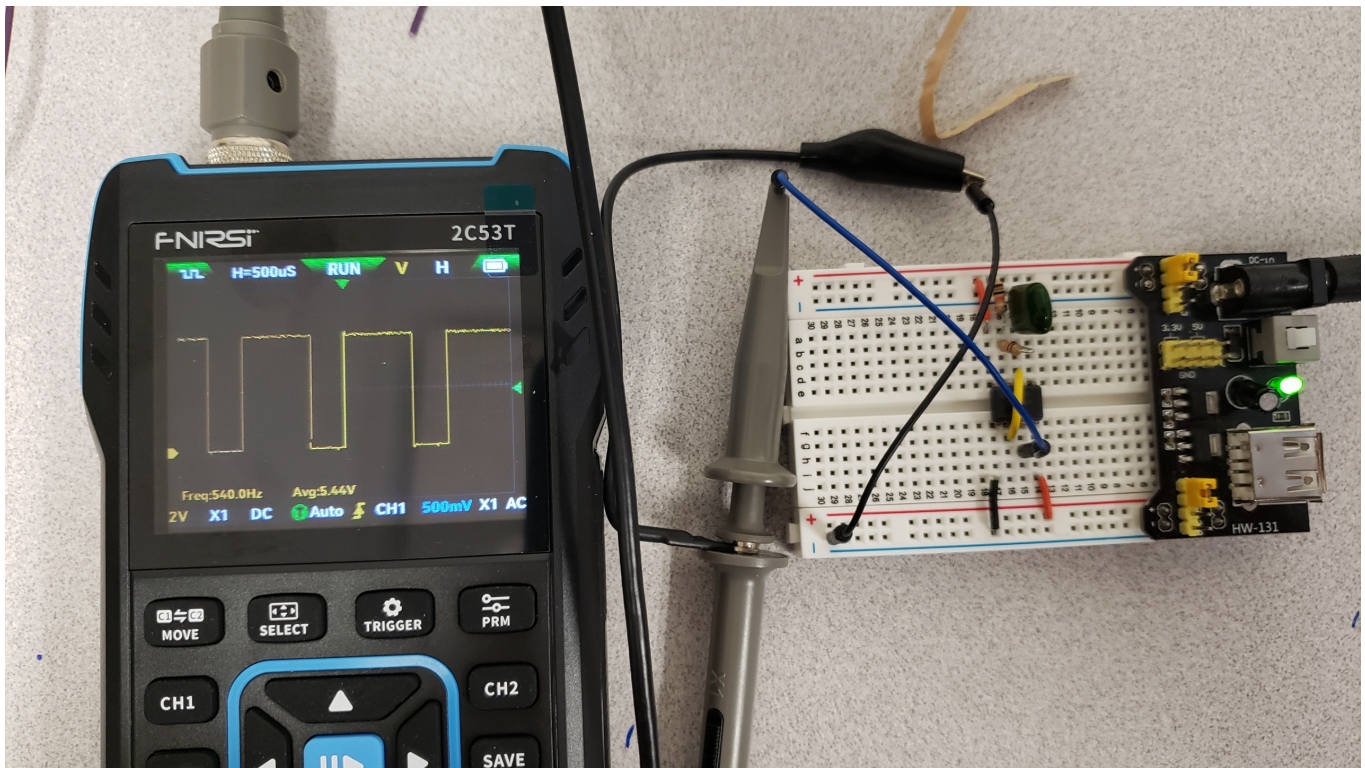
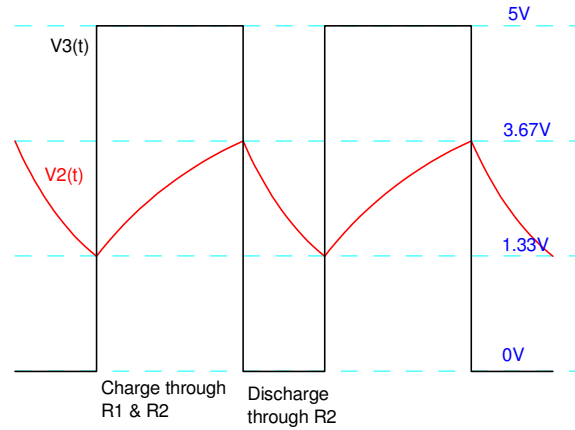
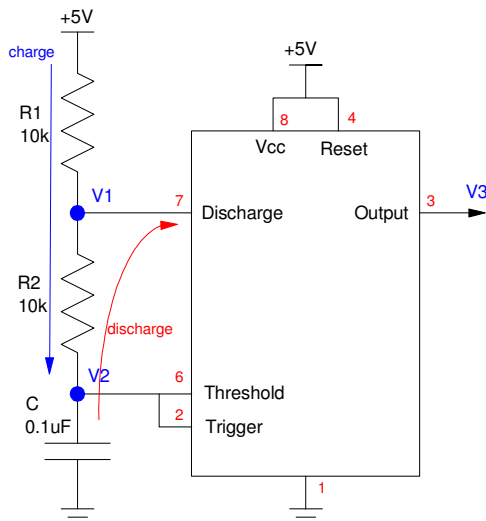


Lab (over)

7) Using your FNIRSI multimeter, measure the resistance of R1, R2, and C (two 10k resistors and a 0.1uF capacitor)



- 8) Build the following 555 timer circuit with your lab kit
- Include a photo of your breadboard circuit for full credit



Calculations:

$$T = (R_1 + 2R_2) \cdot C \cdot \ln(2)$$

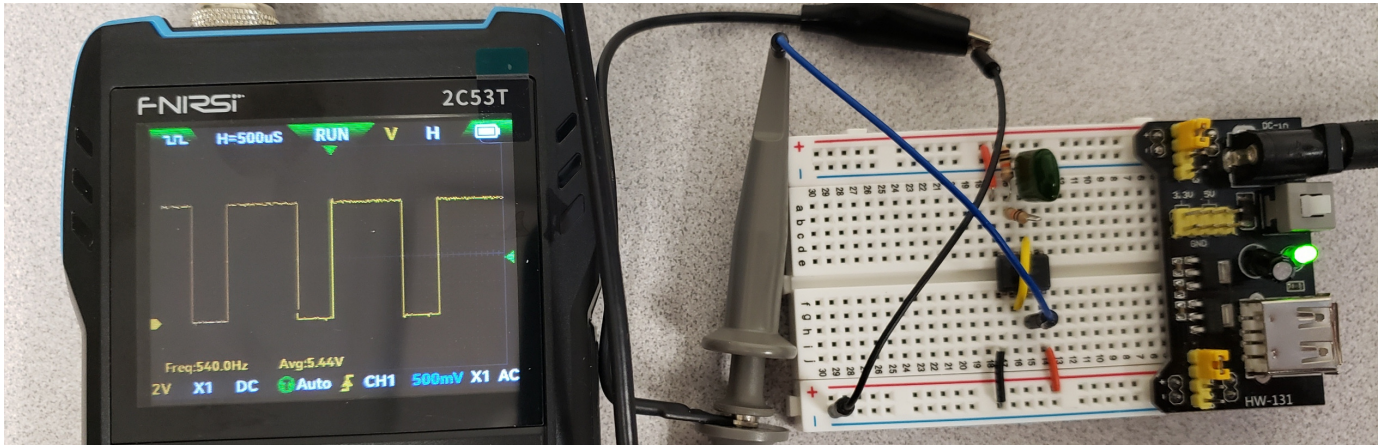
$$T = 1.8293ms$$

$$f = \frac{1}{T} = 546.65Hz$$

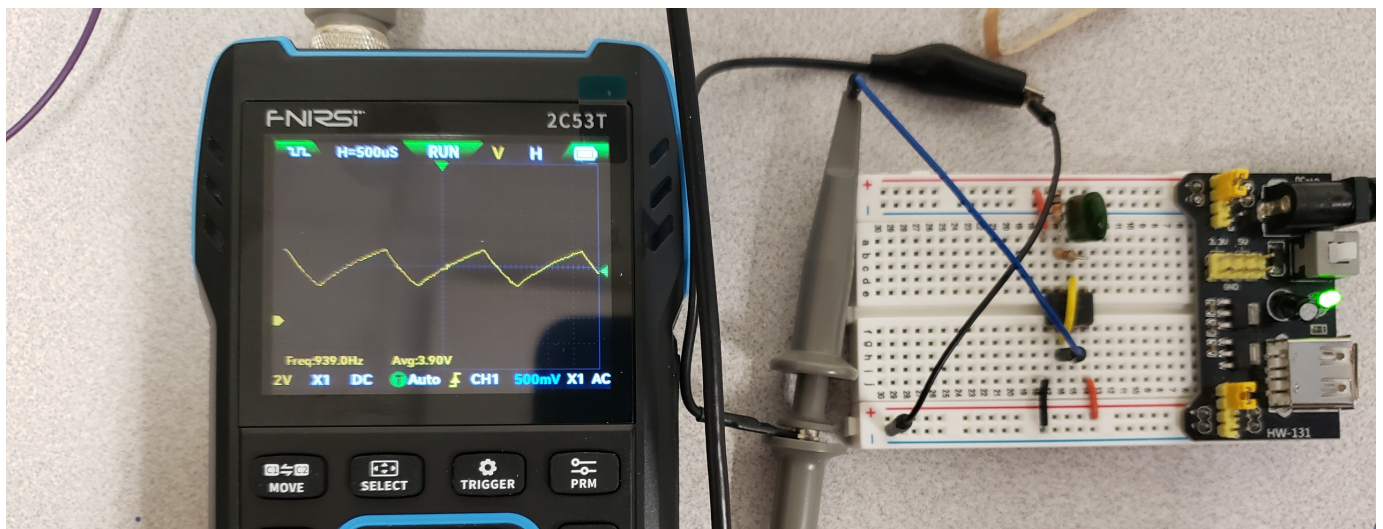
$$measured = 540.0Hz$$

9) Using your FNRSI multimeter in oscilloscope mode, record the signal at

- Pin 3 (Output - a square wave), and
- Pin 6 (Threshold - a charge / discharge waveform)
- Include a photo of the signal on your multimeter



Output (pin 3)



Threshold (pin 2)