ECE 320 - Homework #7

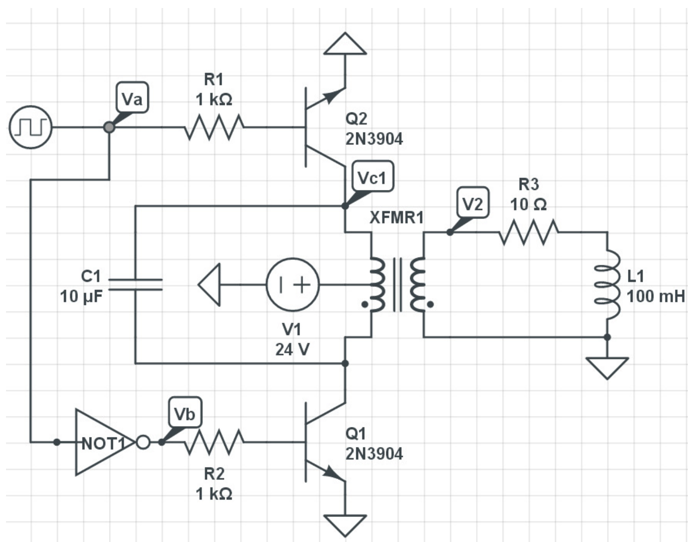
DC to AC, SCR, Boolean Logic. Due Monday, Octiber 11th

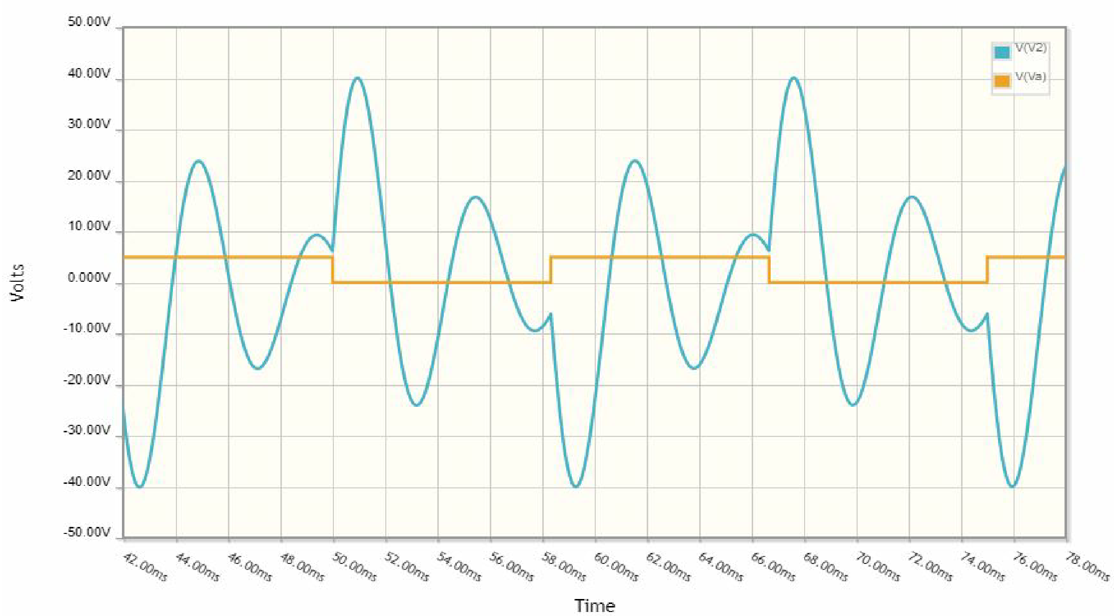
DC to AC

1) Let

- A = 0V / 5V square wave, 60Hz, 0 degree time delay
- B = 0V / 5V square wave, 60Hz, 180 degree time delay
- C1 = 10uF

Determine using CircuitLab the voltage V2 (i.e. the votlage across a DC motor, modeled as a 10 Ohm & 100mH load)



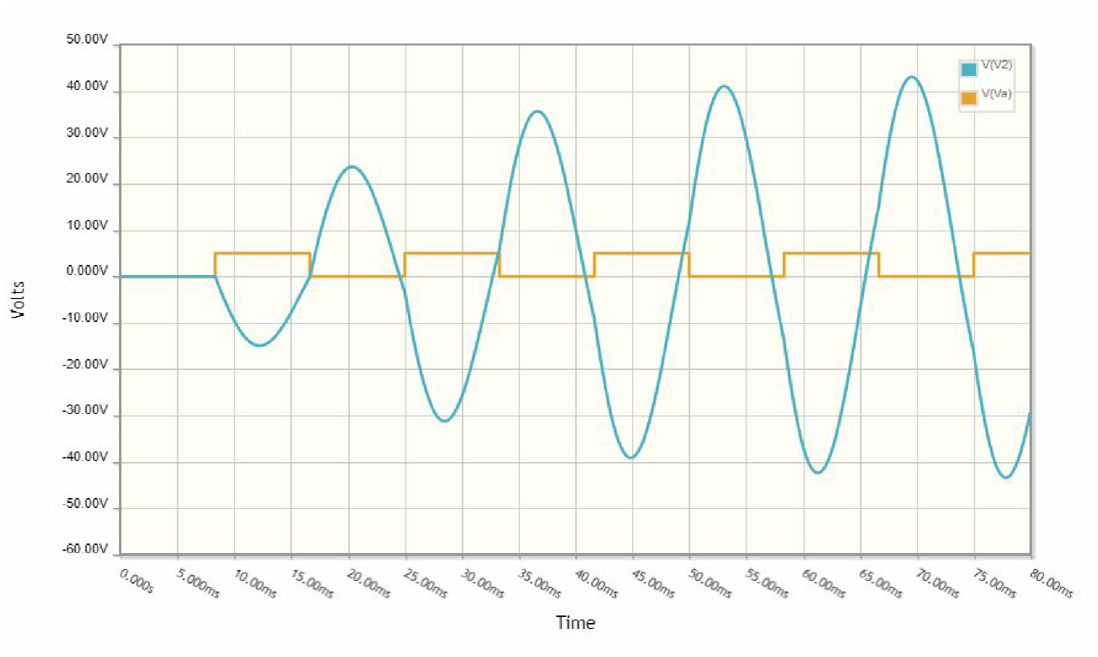


2) Adjust C1 so that the voltage across the motor is as close to a sine wave as possible (trial and error)

In theory, resosnance is

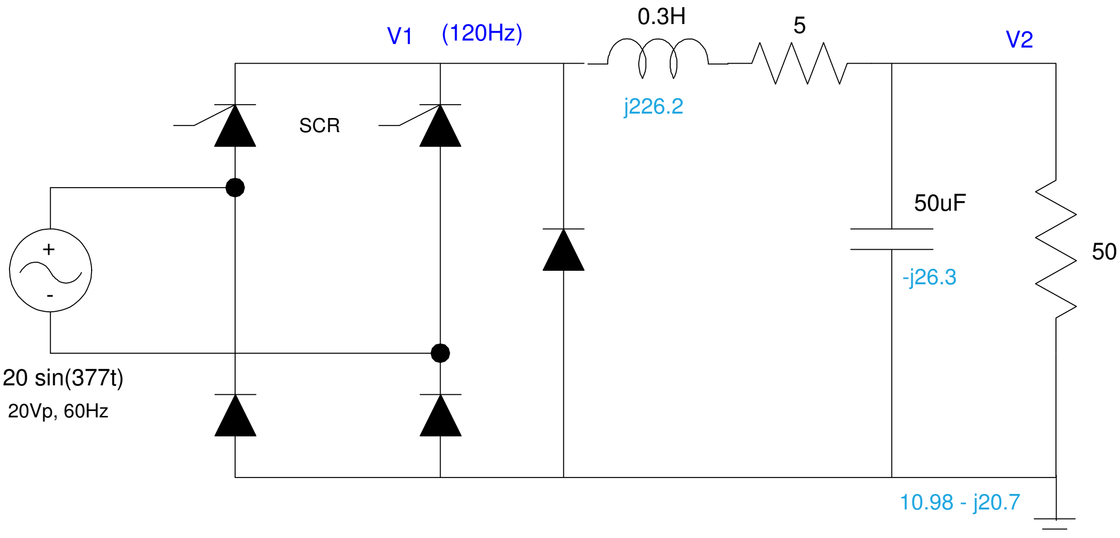
$$\omega = \frac{1}{\sqrt{LC}}$$

For 377 rad/sec (60Hz), L = 0.1H, C = 70uF. Adjusting to get a sine wave, C = 120uF



SCR

3) Assume a firing angle of 45 degrees. Determine the voltage at V1 and V2 (both DC and AC).



DC Analysis:

$$V_1(DC) \approx \left(\frac{18.6+0.7}{\pi}\right) \cdot (1+\cos(45^0)) - 0.7$$

$$V_1(DC) \approx 9.787V$$

$$V_2(DC) = \left(\frac{50}{50+5}\right) V_1(DC) = 8.799V$$

AC Analysis (120Hz = 754 rad/sec)

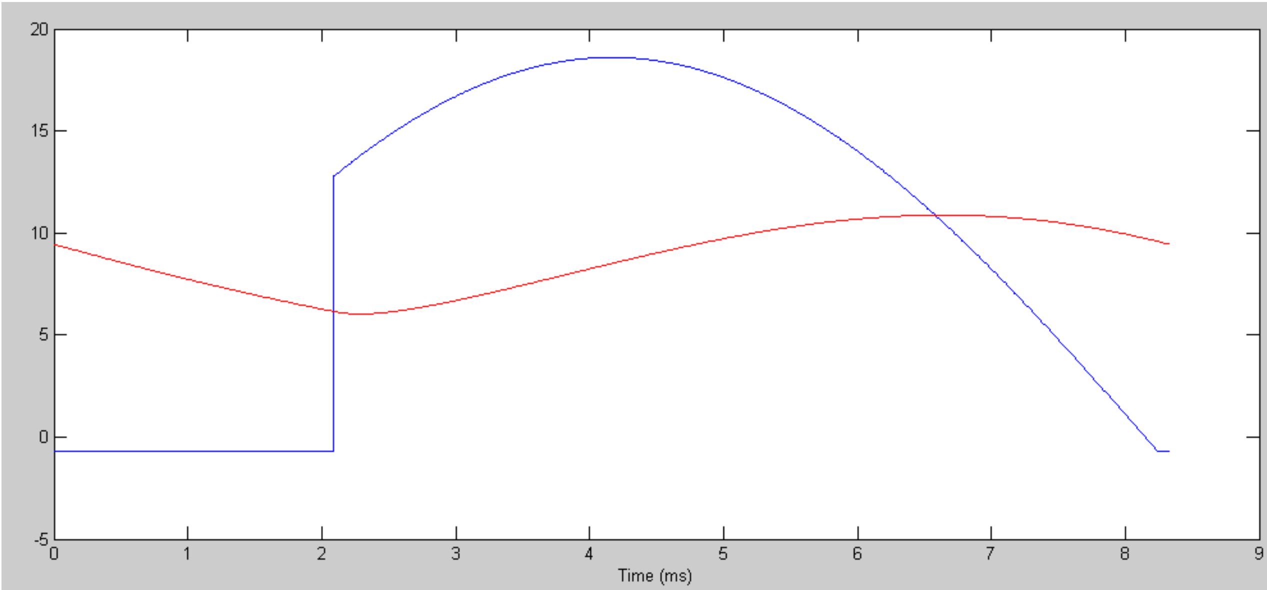
$$V_1(AC) \approx 18.4V - (-0.7V) = 19.3V_{pp}$$

$$V_2(AC) = \left(\frac{(10.98-j20.7)}{(10.98-j20.7)+(5+j226.2)}\right) 19.3V_{pp}$$

$$V_2(AC) = 2.194V_{pp}$$

Simulation Results (problem 5)

```
>> DC = mean(V2)
   8.7647

>> Vpp = max(V2) - min(V2)
   2.3669
```



4) Change this circuit so that

- The voltge at V2 is 10.00V (DC)
- With a ripple of 500mVpp

$$V_2(DC) = 10V$$

$$V_1(DC) = \left(\frac{50+5}{50}\right) V_2 = 11.00V$$

$$11.00V = \left(\frac{18.6+0.7}{\pi}\right) \cdot (1 + \cos(\theta)) - 0.7$$

$$\theta = 25.25^0$$

Without C2, the ripple is

$$V_2(AC) = \left(\frac{50}{50+(5+j226)}\right) 19.3V_{pp}$$

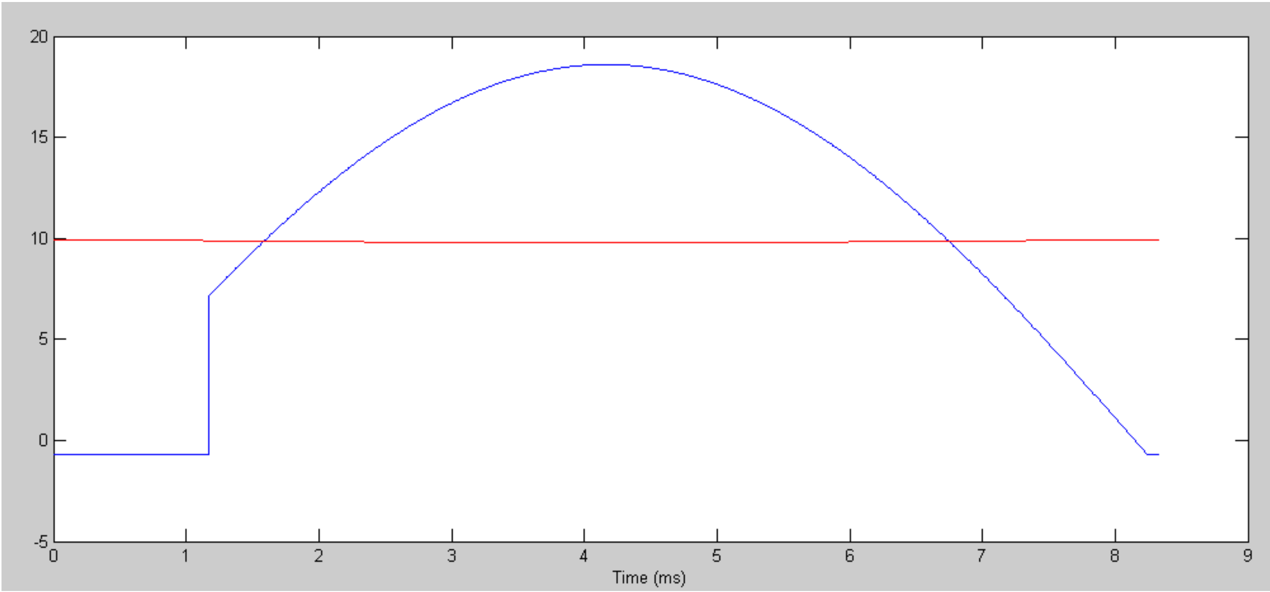
$$V_2(AC) = 4.14V_{pp}$$

To make the ripple 15x smaller, make the impedance of the capaitor 15x smaller than R

$$\left|\frac{1}{j\omega C}\right| = \left(\frac{0.5V_{pp}}{4.14V_{pp}}\right) 50\Omega = 6.02\Omega$$

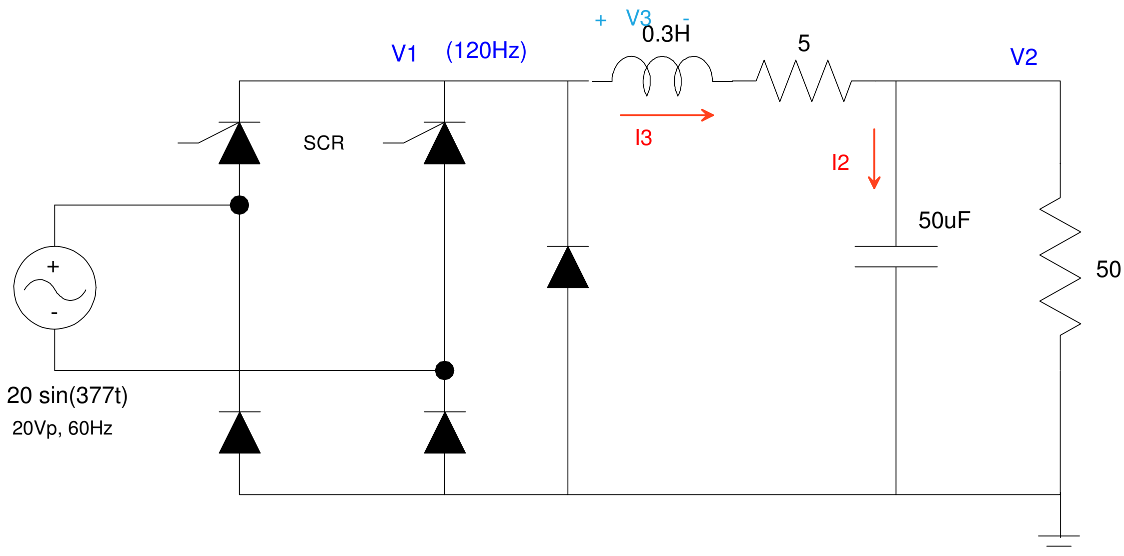
$$C_2 = 220\mu F$$

```
> DC = mean(V2)
    9.8405

>> Vpp = max(V2) - min(V2)
    0.732
```



5) Simulate this circuit in Matlab by

- Writing the differential eqautions which describe this circuit (state variables: IL and Vc)
- Specify V1(t) as a full-wave rectified sine wave, clipped at X degrees (from problem #4)
- Use numerical integration to find V2(t)



The differential equations that describe this circuit are than:

$$I_2 = CsV_2 = I_3 - \frac{V_2}{50}$$

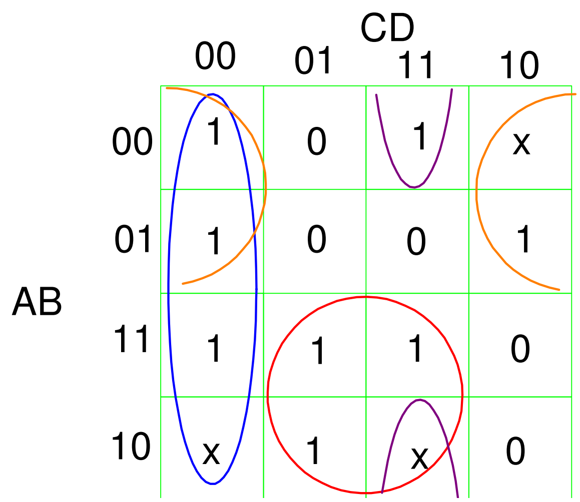
$$V_3 = LsI_3 = V_1 - 5I_3 - V_2$$

Matlab Code:

```
t0 = [0:0.001:1]';
angle = t0*180;
% firing angle
Fire = 45;

V0 = abs(20*sin(t0*pi));
V0 = V0 - 1.4;
V0 = max(-0.7, V0);

V0 = V0.*(angle > Fire) - 0.7*(angle <= Fire);
t = t0 / 120;
dt = t(2) - t(1);

plot(t,V0);

V2 = 0;
I3 = 0;
V2 = 0*t;
I3 = 0*t;
L = 0.3;
C = 5e-6;

npt = length(t);

% itterate for 100 cycles to reach steady state
for n=1:100
    I3(1) = I3(npt);
    V2(1) = V2(npt);

    for i=1:length(t)-1
        dI3 = (V0(i) - 5*I3(i) - V2(i))/L;
        dV2 = (I3(i) - V2(i)/50) / C;

        I3(i+1) = I3(i) + dI3*dt;
        V2(i+1) = V2(i) + dV2*dt;
    end

    plot(t*1000,V0,'b',t*1000,V2,'r');
    xlabel('Time (ms)')
    pause(0.1);
end
```

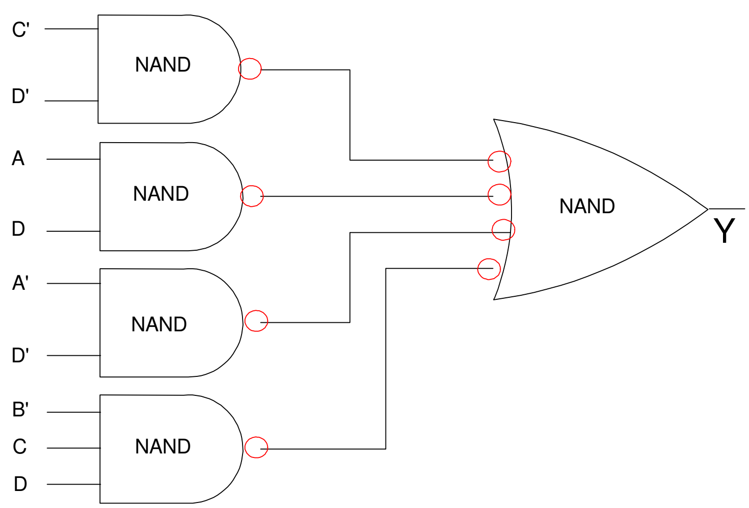
Boolean Logic

6) Design a circuit to implement Y using NAND gates



Y = C'D' + AD + A'D' + B'CD

Using NAND gates



7) Design a circuit to implement Y using NOR gates

AB \ CD	00	01	11	10
00	1	0	1	x
01	1	0	0	1
11	1	1	1	0
10	x	1	x	0

$$Y' = A'C'D + A'BD + ACD'$$

using DeMorgan's Theorem

$$Y = (A + C + D')(A + B' + D')(A' + C' + D)$$

Using NOR gates: