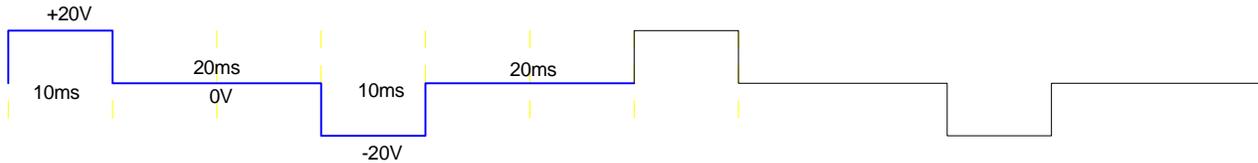


ECE 320 - Homework #7

DC to AC, SCR, Boolean Logic. Due Monday, March 2nd

DC to AC

1) Determine the efficiency of the following DC to AC converter (i.e. how much of the energy is in the 1st harmonic?). (on for 10ms (+20V), off for 20ms, on for 10ms (-20V), off for 20ms, repeat)



```
t = [0:0.001:6]';
V = 20*(t<1) - 20*(t>3).*(t<4);

T = 6;

a1 = 2*mean(V .* exp(-j*2*pi*t/T))

    a1 = 11.021407 - 6.3593637i

Pin = mean(V.^2);

    Pin = 133.24446

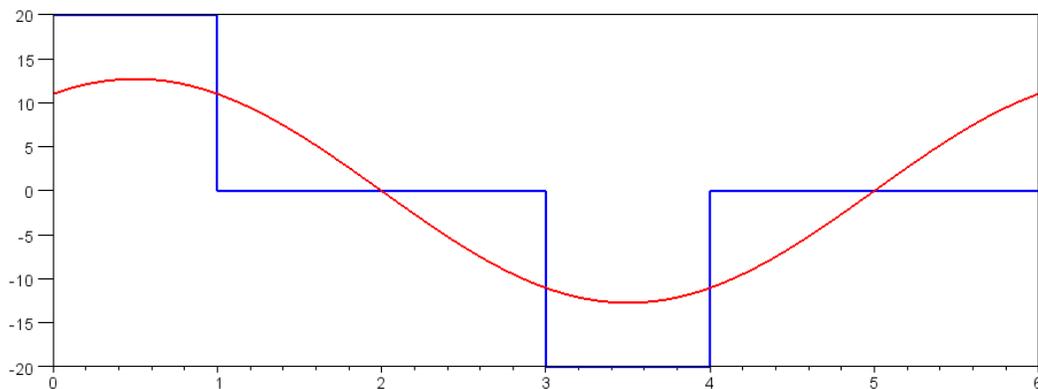
Pout = 0.5 * abs(a1)^2

    Pout = 80.956456

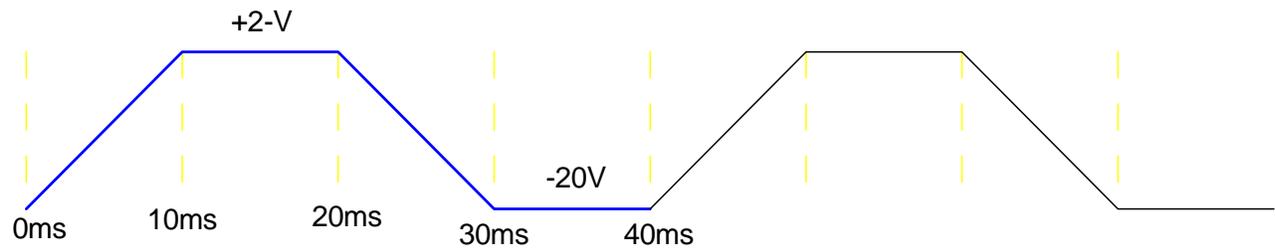
eff = Pout / Pin

    eff = 0.6075784

plot(t,V,t,real(a1 * exp(j*2*pi*t/T)))
```



2) Determine the efficiency of the following DC to AC converter (i.e. how much of the energy is in the 1st harmonic?).



```

t = [0:0.01:1]';
V1 = 40*t-20;
V2 = 0*t + 20;
V3 = 20 - 40*t;
V4 = 0*t - 20;
V = [V1;V2;V3;V4];

t = [1:length(V)]' / length(V) * 2 * pi;

a1 = 2*mean(V .* exp(-j*t))

a1 = - 16.371853 - 16.119191i

Pin = mean(V.^2)

Pin = 268.

Pout = 0.5 * abs(a1)^2

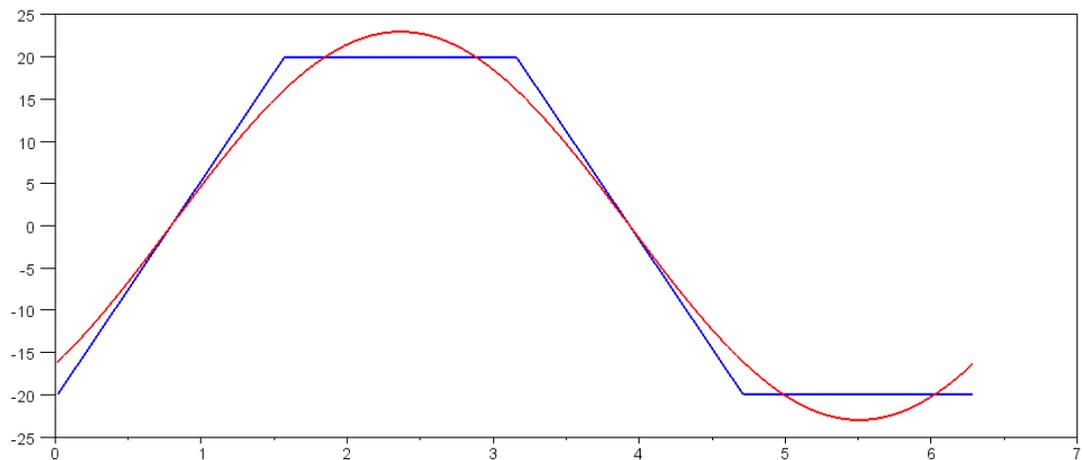
Pout = 263.93294

eff = Pout / Pin

eff = 0.9848244

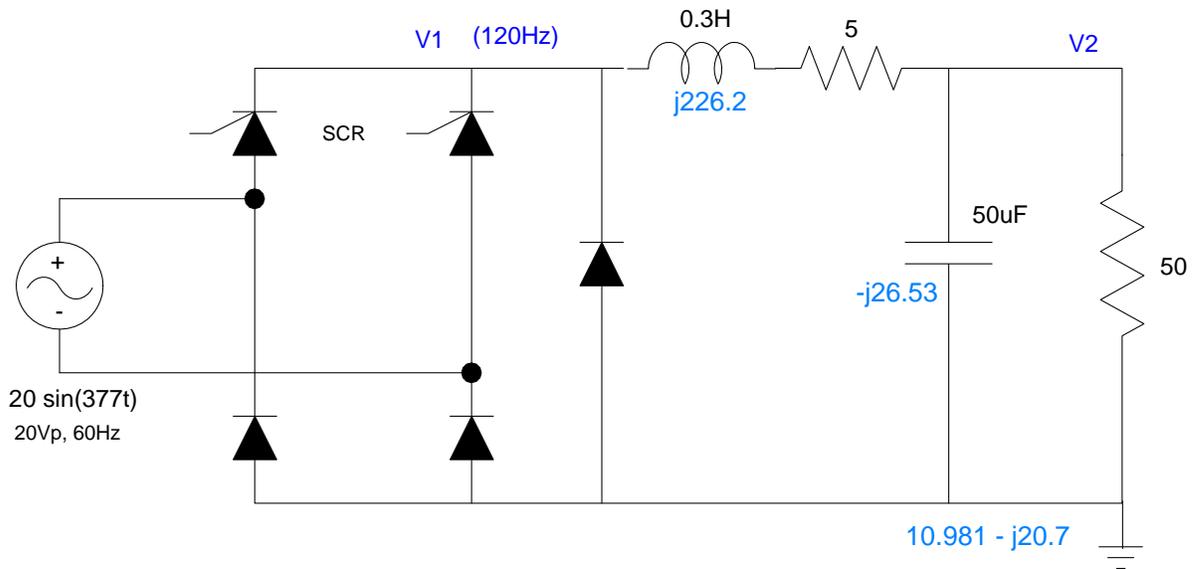
plot(t,V,t,real(a1 * exp(j*t)))

```



SCR

3) Assume a firing angle of 75 degrees. Determine the voltage at V1 and V2 (both DC and AC).



DC:

$$V_1 = \left(\frac{1 + \cos(75^\circ)}{\pi} \right) \cdot 19.3 - 0.7 = 7.033V$$

$$V_2 = \left(\frac{50}{50+5} \right) V_1 = 6.394V$$

AC:

$$V_1 = 19.3V_{pp}$$

$$V_2 = \left(\frac{10.981 - j20.7}{(10.981 - j20.7) + (5 + j226.2)} \right) \cdot 19.3V_{pp}$$

$$V_2 = 2.194V_{pp}$$

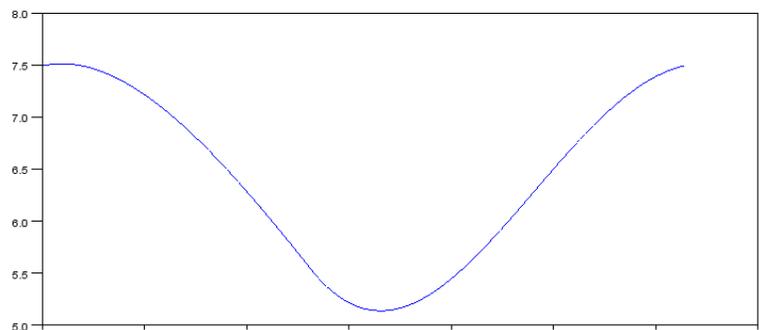
If you simulate this circuit

mean(V2)

6.3979185

max(V2) - min(V2)

2.3713101



4) Change this circuit so that

- The voltage at V2 is 7.50V (DC)
- With a ripple of 0.4Vpp

$$V_1 = \left(\frac{50+5}{50} \right) V_2 = 8.25V$$

$$V_1 = \left(\frac{1+\cos(\theta)}{\pi} \right) \cdot 19.3 - 0.7 = 8.25V$$

$$\theta = 62.816^\circ$$

The current ripple is 2.194Vpp with $C = 50\mu F$. To make the ripple 0.4Vpp

$$C = \left(\frac{2.194V_{pp}}{0.4V_{pp}} \right) \cdot 50\mu F$$

$$C = 274\mu F$$

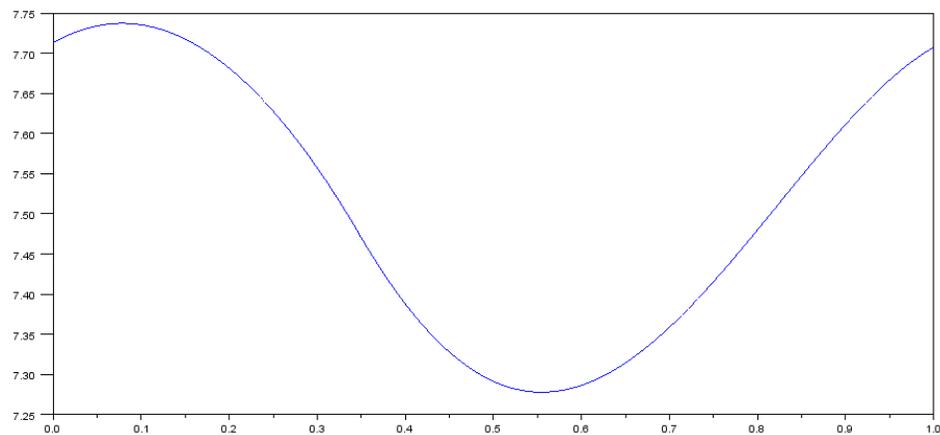
This results in

```
mean(V2)
```

```
ans = 7.5102431
```

```
max(V2) - min(V2)
```

```
ans = 0.4595707
```



V2(t) after 20 iterations

matlab code to simulate:

```

t = [0:0.001:1]';
V1 = 0*t;
IL = 0*V1;
VC = 0*V1;

dt = (1/120) / length(t);
L = 0.3;
C = 274e-6;

for n=1:20

    IL(1) = IL(1001);
    VC(1) = VC(1001);

    for i=1:1000

        theta = i/1000 * 180;

        if(theta < 62.816)
            V1(i) = -0.7;
        else
            V1(i) = 19.3*sin(theta*pi/180) - 0.7;
        end

        dIL = V1(i) - 5*IL(i) - VC(i);
        dVC = IL(i) - VC(i)/50;

        IL(i+1) = IL(i) + dIL*dt/L;
        VC(i+1) = VC(i) + dVC*dt/C;

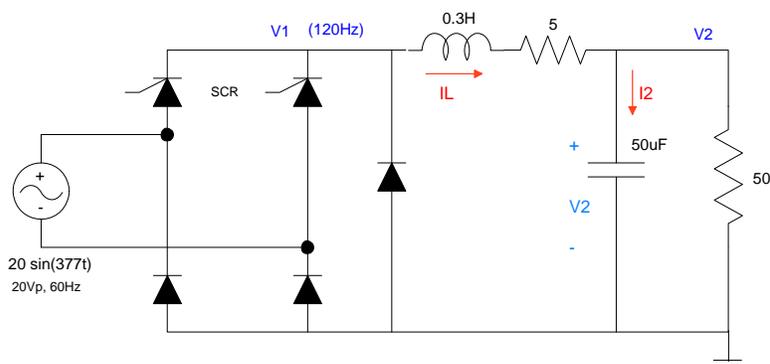
    end

end

plot(t,V1, t, VC);

end

```



The differential equations this circuit satisfies are:

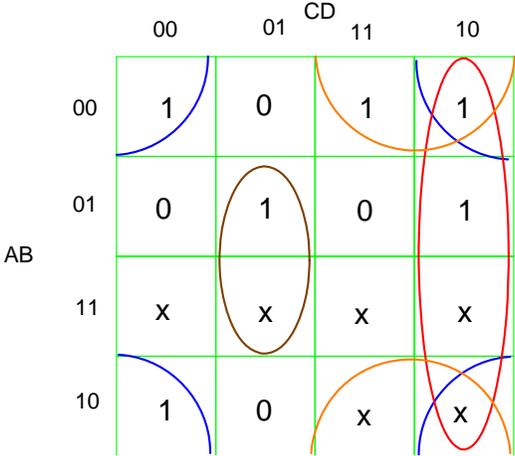
$$V_L = L \frac{dI_L}{dt} = V_1 - 5I_L - V_c$$

$$I_c = C \frac{dV_c}{dt} = I_L - \frac{V_c}{50}$$

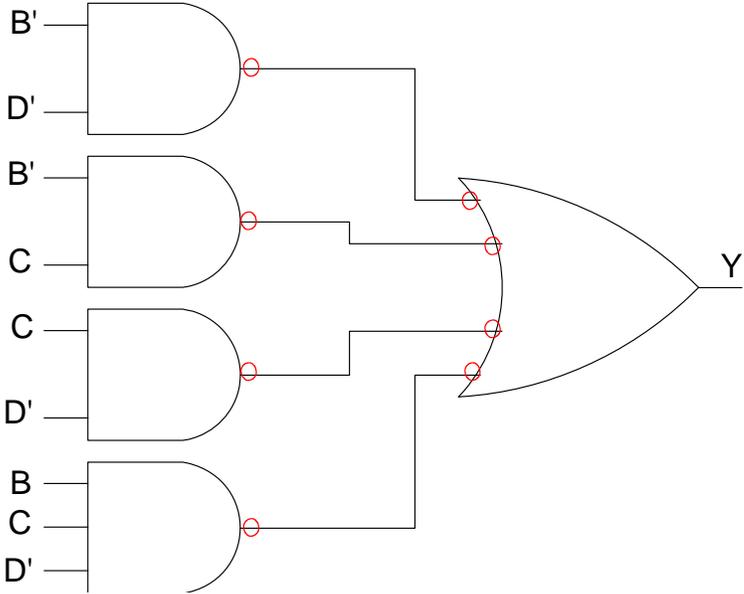
Boolean Logic:

5) Implement the following function using NAND gates (i.e. circle the ones)

| d(A,B,C,D) | | CD | | | |
|------------|----|----|----|----|----|
| | | 00 | 01 | 11 | 10 |
| AB | 00 | 1 | 0 | 1 | 1 |
| | 01 | 0 | 1 | 0 | 1 |
| | 11 | x | x | x | x |
| | 10 | 1 | 0 | x | x |

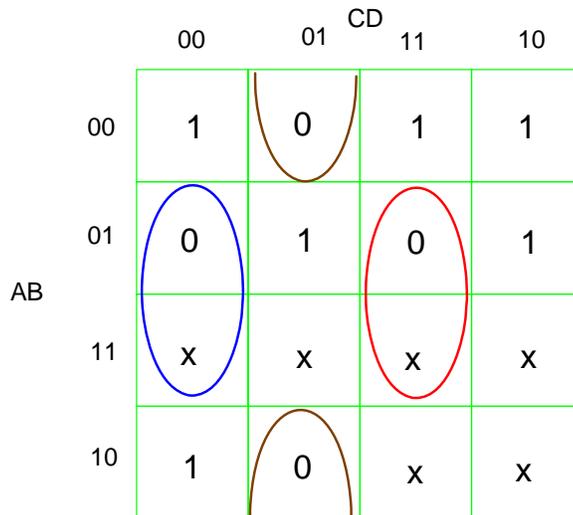


$$Y = B'D' + B'C + CD' + BCD'$$



6) Implement the following function using NOR gates (i.e. circle the zeros)

| d(A,B,C,D) | | CD | | | |
|------------|----|----|----|----|----|
| | | 00 | 01 | 11 | 10 |
| AB | 00 | 1 | 0 | 1 | 1 |
| | 01 | 0 | 1 | 0 | 1 |
| | 11 | x | x | x | x |
| | 10 | 1 | 0 | x | x |



$$Y' = BC'D' + B'C'D + BCD$$

Use DeMorgan's theorem

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

