ECE 320 - Homework #7

DC to AC Converter, SCR. Due Monday February 27th, 2017

1) Determine the Fourirer Series approximation for the following waveform out to 5 terms

$$V(t) \approx a_0 + a_1 \cos\left(\frac{2\pi}{T}t\right) + b_1 \sin\left(\frac{2\pi}{T}t\right) + a_2 \cos\left(\frac{4\pi}{T}t\right) + b_2 \sin\left(\frac{4\pi}{T}t\right)$$

First, input V(t) into Matlab:

```
>> t = [0:0.001:4]';
>> V = 0*t;
>> V(1:1000)= 1;
>> V(1000:2000) = 8;
>> V(2000:3000) = 1;
>> V(3000:4000) = -6;
```

Now, find the Fourier coefficients. Just to show off, take it out to 20 terms:

```
function [c] = four20( x )

N = length(x);

t = [1:N]' /N * 2 * pi;

a = zeros(20,1);    % cos() terms
b = zeros(20,1);    % sin() terms

for n=1:20
    a(n) = sum( cos(n*t) .* x ) / (N/2);
    b(n) = sum( sin(n*t) .* x ) / (N/2);
end

c = a - j*b;

end
```

The DC terms (a0) is:

```
>> DC = mean(V)

    0.9980
```

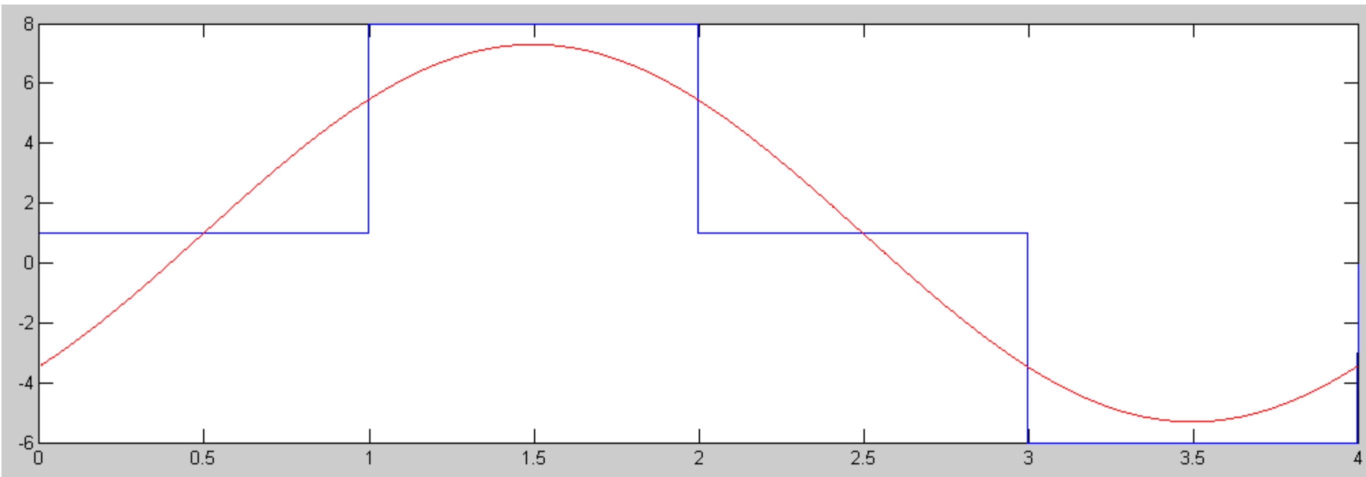
The other 20 terms are:

```
>> c = four20(V);
>> N = [1:20]';
>> [N,real(c),imag(c)]
```

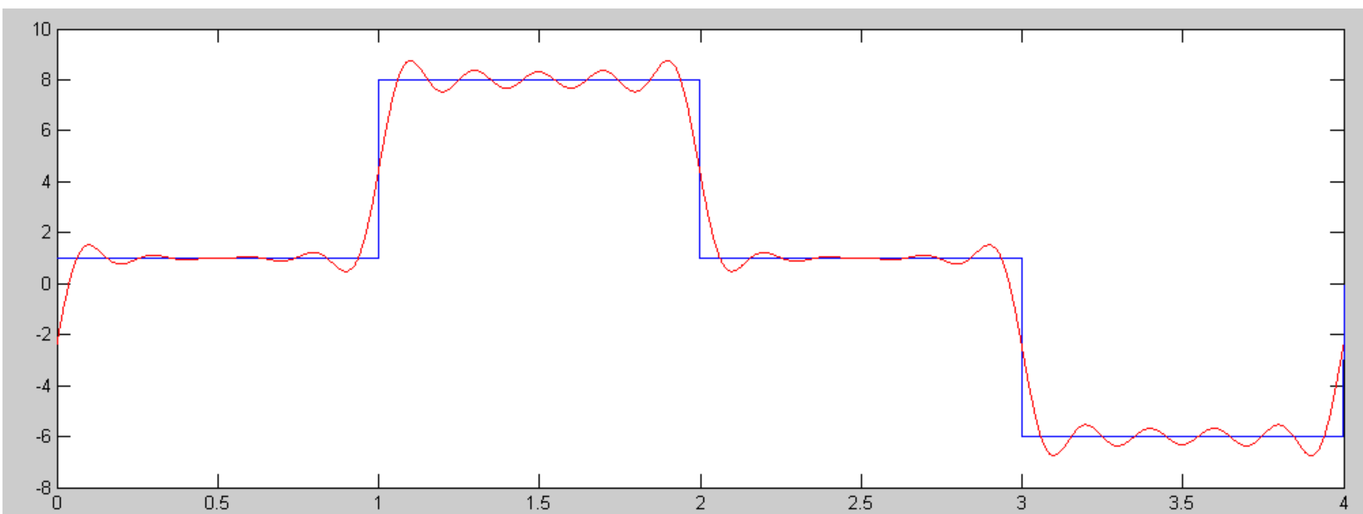
harmonic	cos()	-sin()
1.0000	-4.4516	-4.4633
2.0000	-0.0005	0.0000
3.0000	1.4902	-1.4784
4.0000	-0.0040	-0.0000
5.0000	-0.8865	-0.8983
6.0000	-0.0005	0.0000
7.0000	0.6413	-0.6296
8.0000	-0.0040	-0.0000
9.0000	-0.4904	-0.5021
10.0000	-0.0005	0.0000
11.0000	0.4098	-0.3981
12.0000	-0.0040	-0.0001
13.0000	-0.3380	-0.3498

Checking, plot V(t) along with it's Fouier expansion out to N terms

```
Yf = 0*t + DC;
for n = 1:20
     Yf = Yf + real(c(n))*cos(n*t*pi/2) - imag(c(n))*sin(n*t*pi/2);
     end
y20 = Yf;
```



Fourier Series expansion out to 1st harmonic



Fourier Series Expansion out to the 20th harmonic

2) How much of the energy in this waveform is in its 1st harmonic (the 250Hz term)?

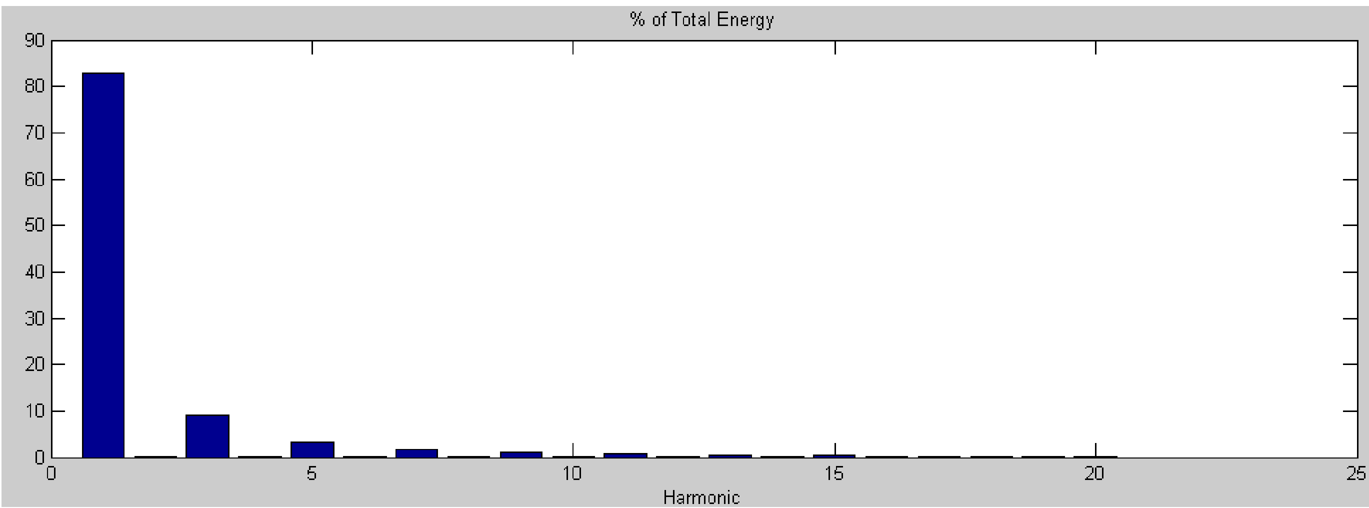
```
>> mean(y1.^2) / mean(V.^2)

    0.8181
```

81.81 % of the energy is in the 1st harmonic

In terms of Watts

$$P = \frac{1}{2}V_p^2 = \frac{1}{2}(4.44^2 + 4.44^2) \qquad \text{(sine and cosine term)}$$

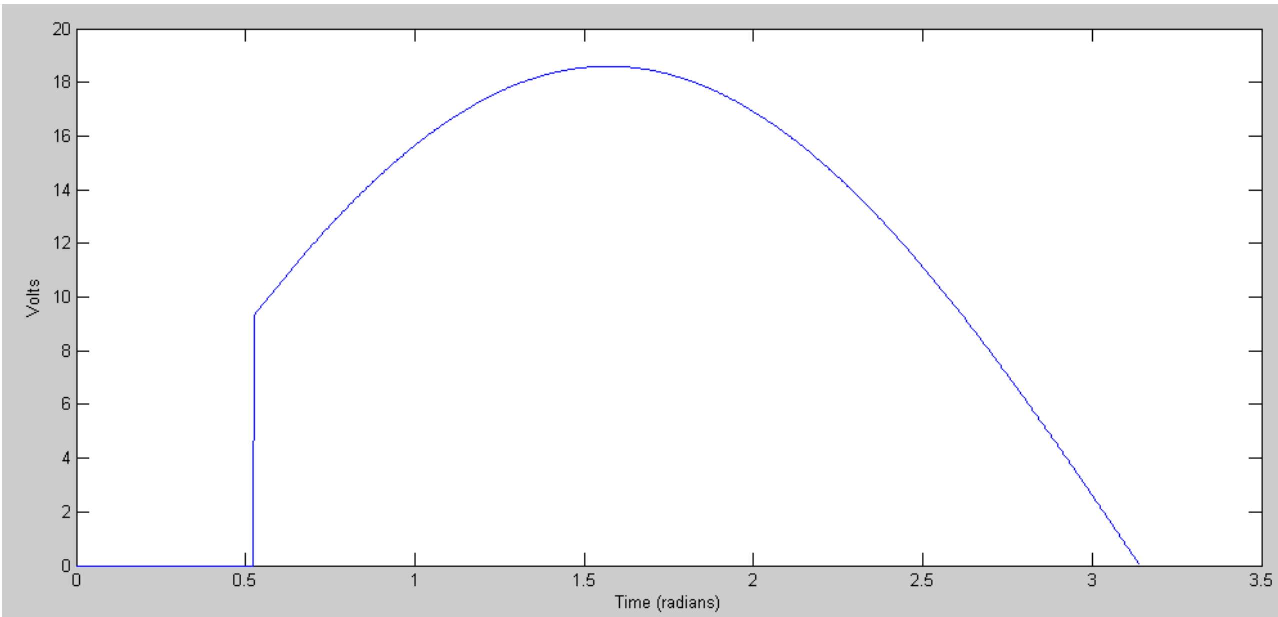
$$P = 19.71W$$



3) Assume a firing angle of 30 degrees. Determine

- The DC voltage at V2 and
- The peak-to-peak ripple at V2

```
t = [0:0.001:1]' * pi;
y = 18.6*sin(t);
y = y .* (t > pi/6);
plot(t,y);
DC = mean(y)

   11.0384

>> Vpp = max(y) - min(y)

   18.6000
```



Going through the filter:

DC Analysis: The inductor and capacitor don't affect the DC signal.

Y = 11.0384V

AC Analysis: The inductor and capacitor do affect the AC (120Hz) term, however

$$L \rightarrow j\omega L = j754\Omega$$

$$C \rightarrow \frac{1}{j\omega C} = -j26.5\Omega$$

The resistor and capacitor in parallel are

$$100\Omega || -j26.5\Omega = 25.6\angle -75^0$$

By voltage division then

$$V_2 = \left(\frac{25.6\angle -75^0}{25.6\angle -75^0 + j754}\right) V_1$$

$$V_2 = (0.0352\angle -164^0) V_1$$

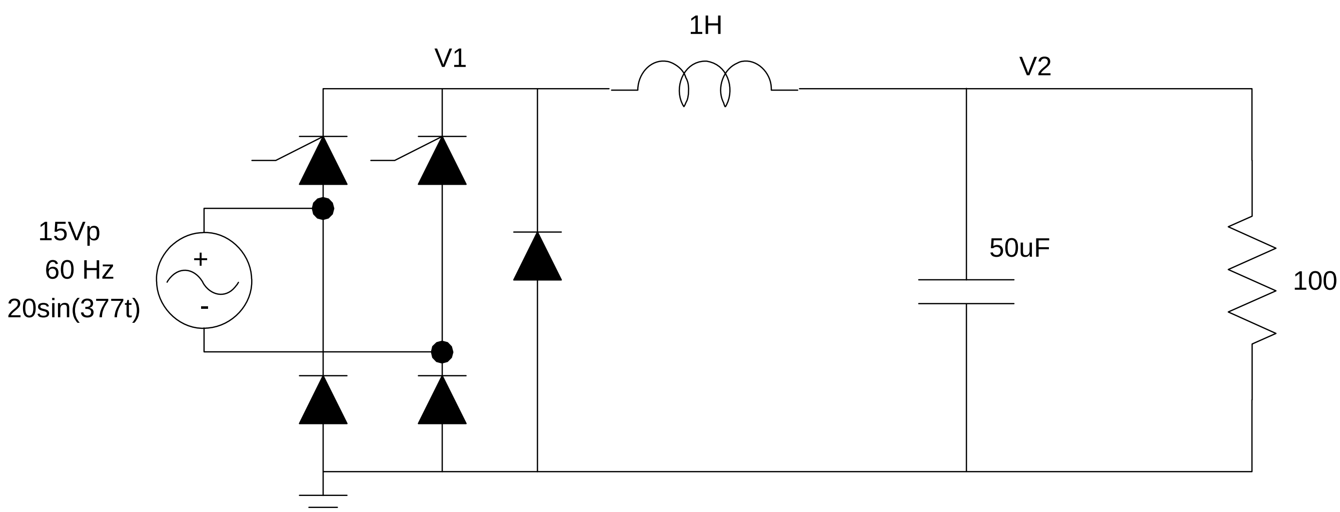
$$V_2 = (0.0352\angle -164^0) \cdot 18.6V_{pp}$$

$$V_2 = 0.653V_{pp}$$

Putting it together:

V2 = 11.0384VDC with a ripple of 0.653Vpp

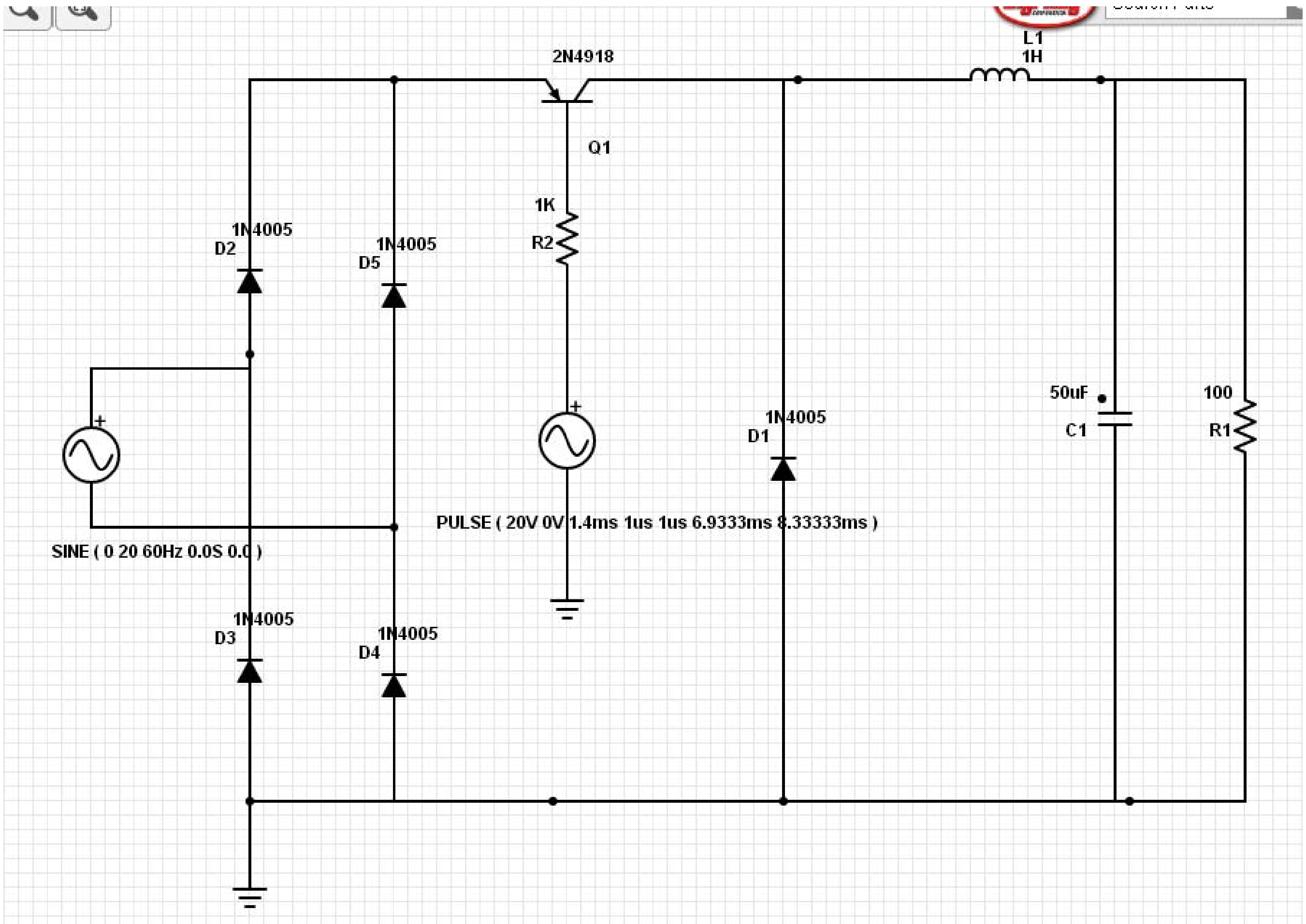
4) Simulate this circuit in PartSim to verify your results from problem #3



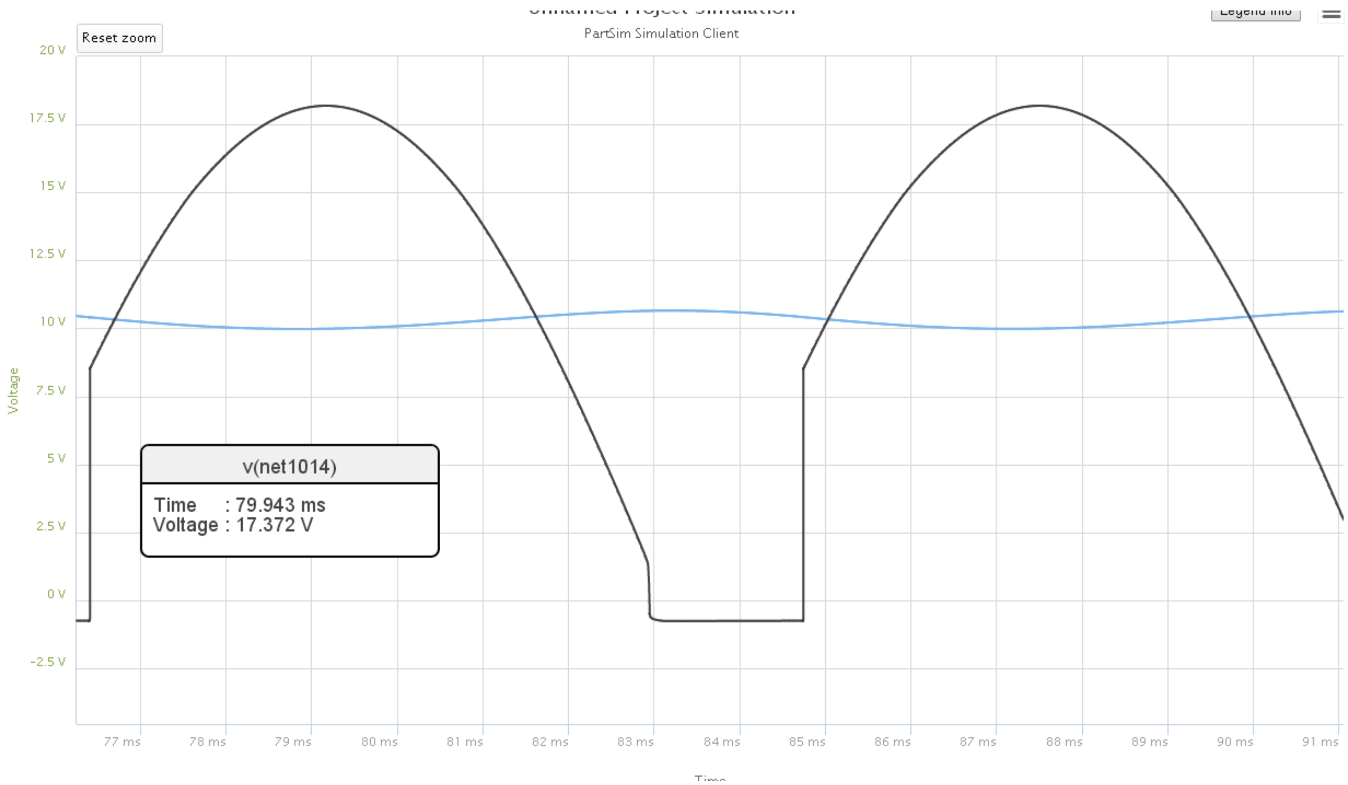
AC to DC Converter for problem 3 and 4. The firing angle is 30 degrees.

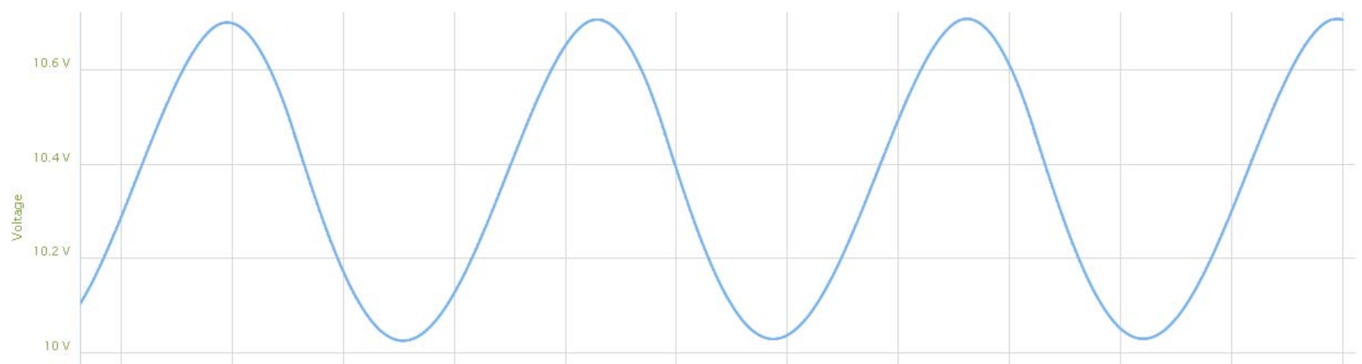
First, input it into PartSim. SCR's are not available and I had problems getting a PNP/NPN to work, so a PNP transistor was used as an on/off switch

- 0V at the base is on
- 20V at the base is off



The voltages at the diode (D1) and loar (R1) are:





	Calculated	Simulated	Error
Vavg (DC)	11.0384V	10.365V	0.67V
Vpp (AC)	653mVpp	680mVpp	+3.9%