MANSI UNIYAL
19EE10039
Experiment 4

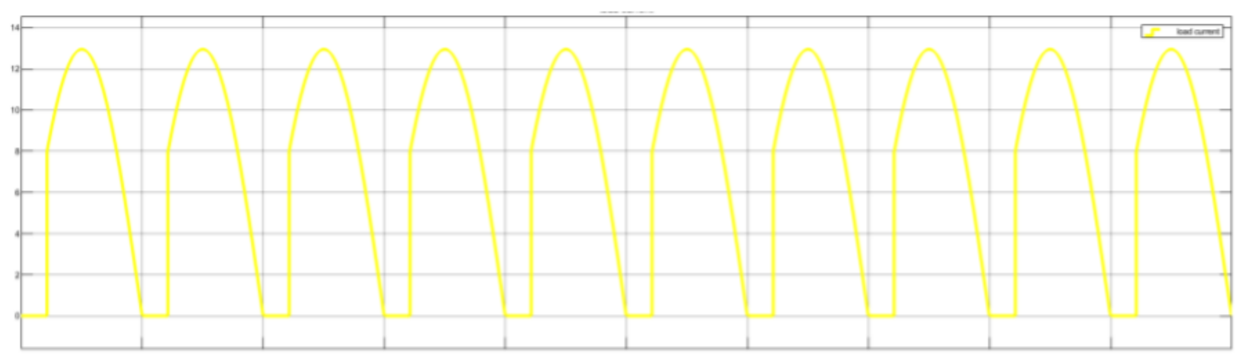
PART A: TRIGGERING CIRCUIT

Section 1:
1.

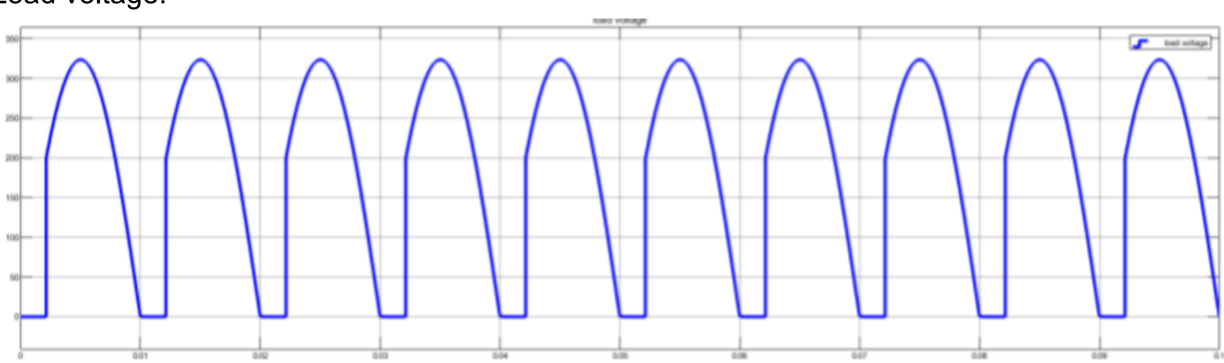
$$P_n = 4\,VA, f_n = 50\,Hz, V_1 = 230\,V, R_1 = 6.9\,\Omega, L_1 = 7.1\,mH,$$
$$V_2 = 3.605\,V, R_2 = 1.7\,m\Omega, L_2 = 2.1\,\mu H,$$
$$R_m = 600\,\Omega\,, L_m = 1.145\,H$$

Vo = 185V and Vin (RMS) = 230V
$Vout$= (Vm/π)*(1+cos α)
α = cos^−1 ((185$*\pi$)/(230√2) − 1)
So, the firing angle = 38.1 degrees
Vref = 3.605 √2 * cos α = 4.107 V
Vout(avg) =183.8 V

Load current:

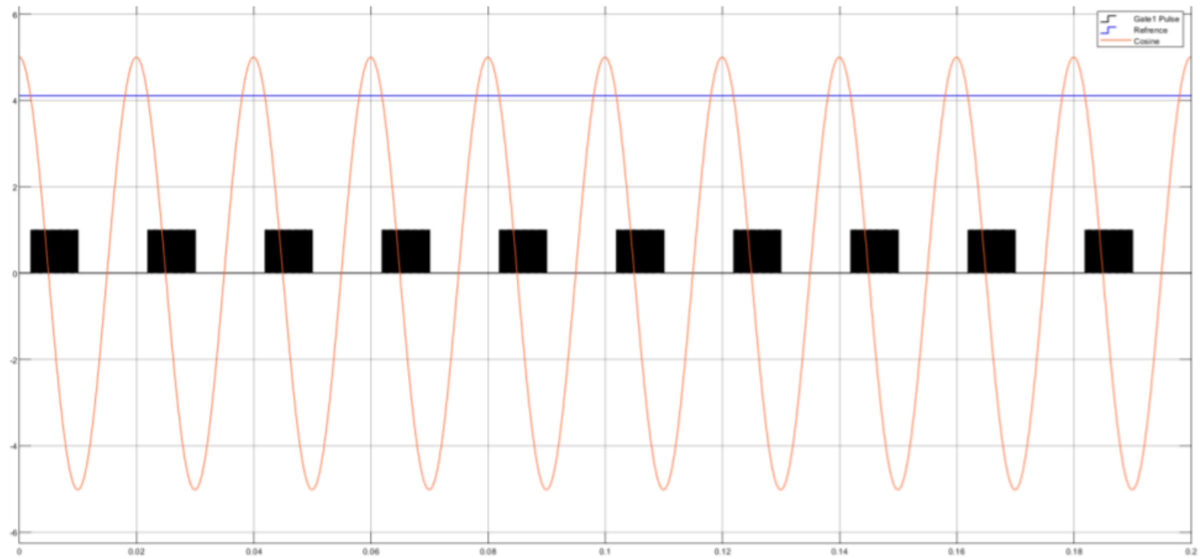


Load voltage:

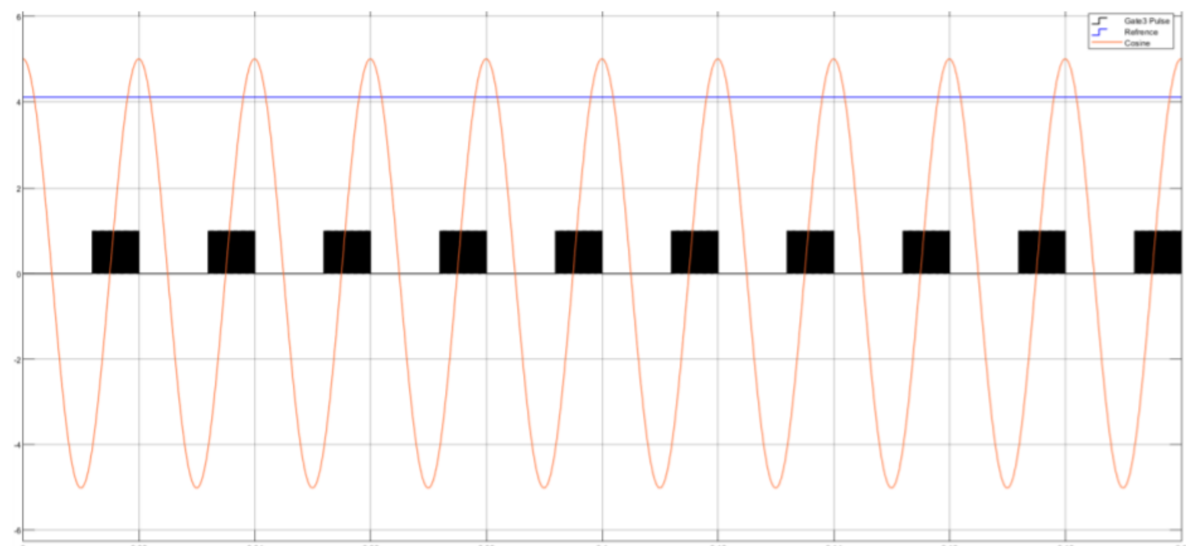


2.

Gate Pulse 1 w.r.t the cosine and reference signal:



Gate Pulse 3 w.r.t the cosine and reference signal:



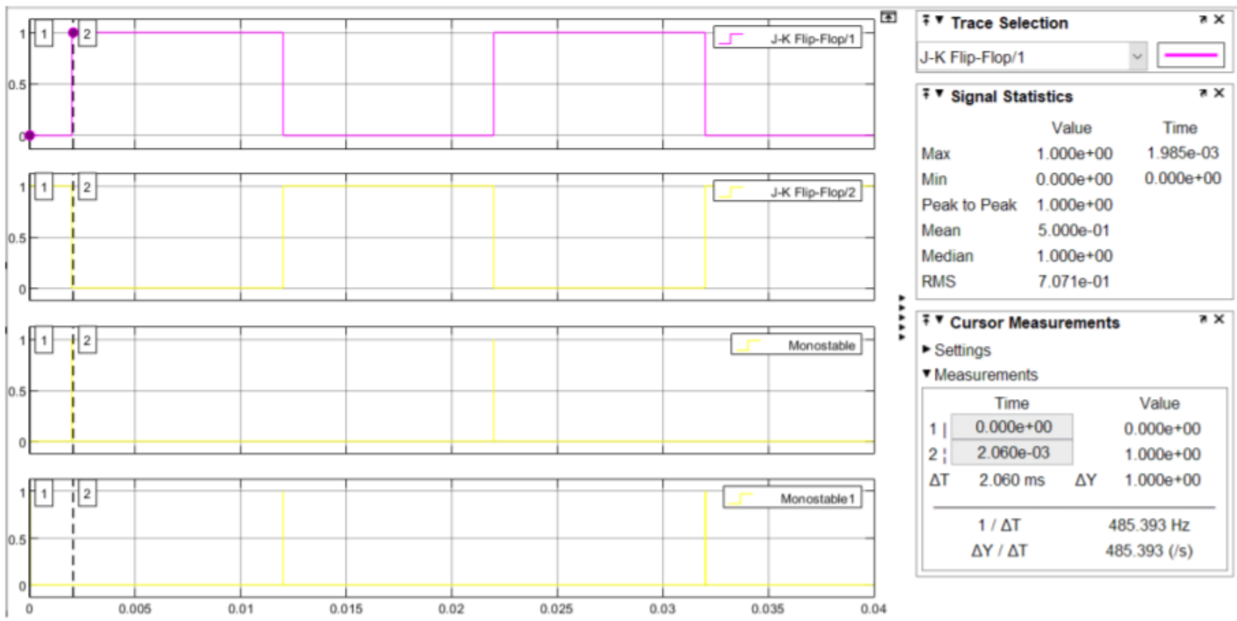
Observation:

- Thyristor 1 triggers when Vin is in the +ve half cycle after firing angle α.
- Thyristor 3 triggers when Vin is in the -ve half cycle after firing angle α.

3.

Firing time = 2.060 ms

Firing angle = 37.08 degree



Section 2:

Pulse transformer specifications: $L_m = 1.5mH$, $L_{lp} = L_{ls} = 20\mu H$, $R_{pri} = R_{sec} = 0.8\ \Omega$, $R_{core} = 400\ \Omega$, $N_1:N_2 = 1:1$

Auxiliaries Specifications: $V_{cc} = 20$ V, $R_p = 10\ \Omega$, $R_g = 20\ \Omega$, $R_{gk} = 10\ \Omega$

1.

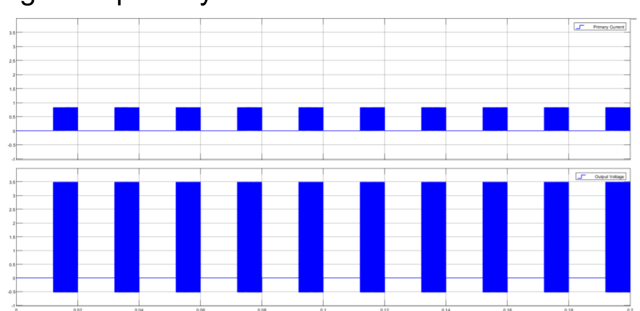
$VCC \times Tpulse = VZ \times Tdemag$

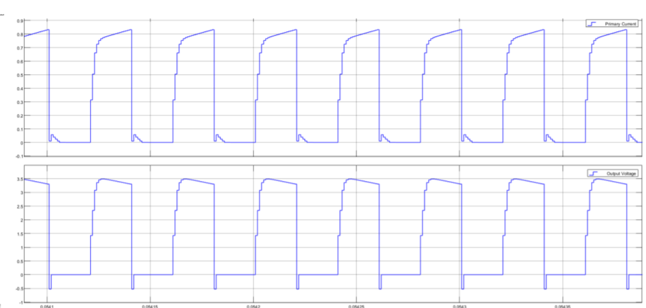
$Tpulse$ is 50% of the time period

Duration of $Tdemag$ is 30% of the time period of the gate pulse generated by the control circuit Vzener= 33.34V

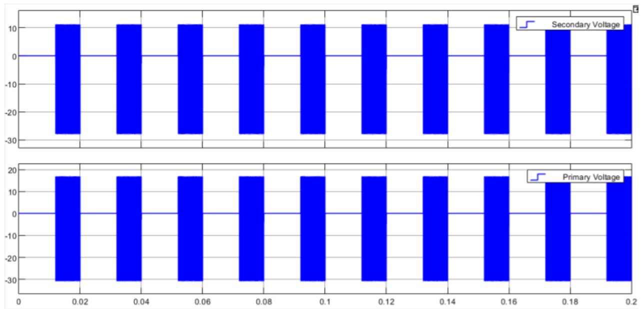
2.

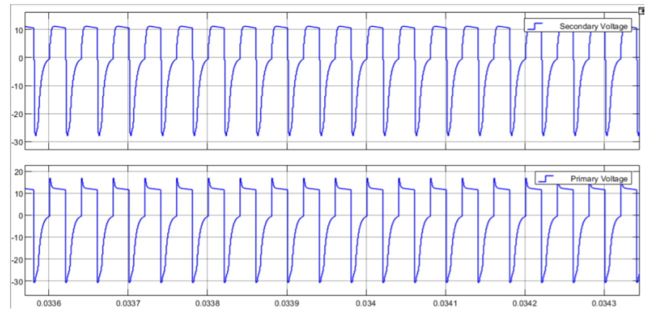
Vgk and primary current:





Primary Voltage and Secondary Voltage:





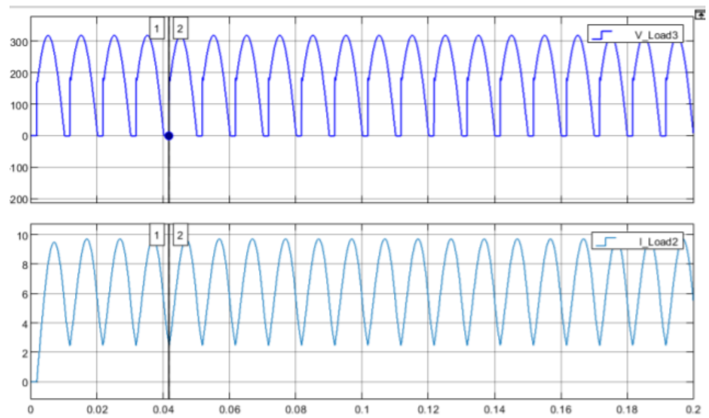
PART B: FULL CONTROLLED CONVERTER

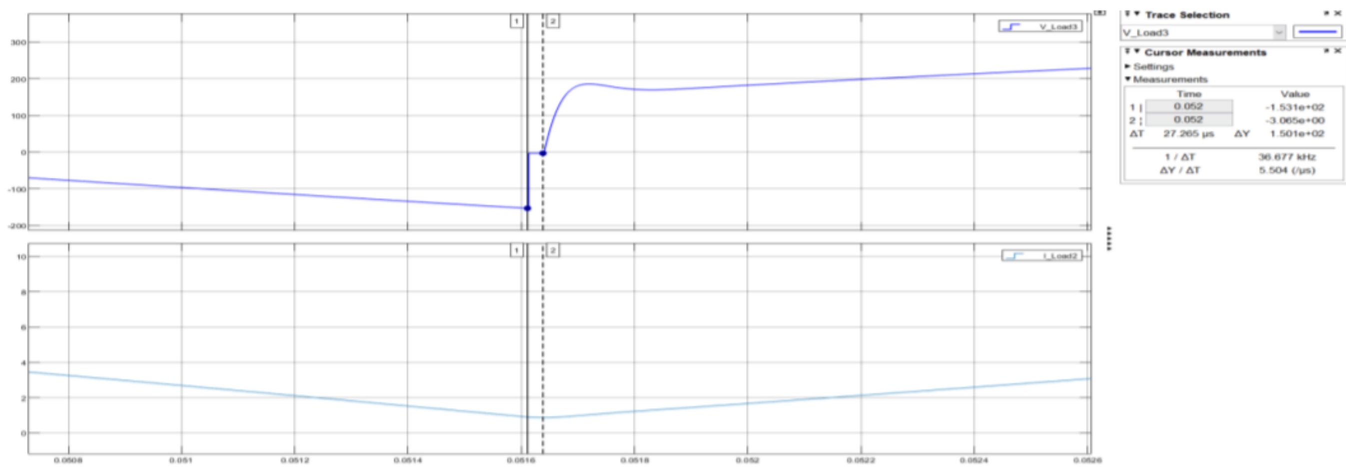
1.
Without source inductance and freewheeling diode for L= 60 mH.
Vin = 230V
α=30
$Vout = \frac{2\sqrt{2}}{\pi} * 230 *(\cos 30) = 179.33V$
$RLoad = \frac{179.33}{8} = 22.42\ \Omega$
$Vref = 3.605 * \sqrt{2} * \cos 30 = 4.414V$
VDC = 183.8V
IDC = 8.32A

2.
With 2.5 mH source inductance,
VDC = 183.8V
IDC = 8.32A
Overlap angle (μ) = (360/20ms)*(27.380us) = 0.49

3.
Voltage drop due to source inductance: (179.1-177.9) V = 1.2 V 4.

4.
With Freewheeling diode in the same circuit:

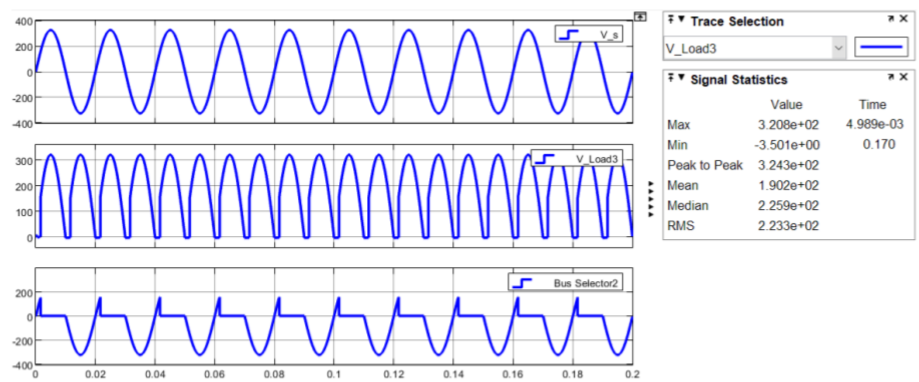




Parameter	Load voltage (V) Ideal case	Load voltage (V) With source inductance	Load voltage (V) With source Inductance and freewheeling diode
Firing angle (Degree)	30	30	30
Average load Voltage (V)	183.9	183.8	183.8
Average load Current (A)	8.32	8.316	8.31
Input rms current (A)	9.98	9.94	9.948
Fundamental Input current	13.86	13.84	13.84
Distortion factor	0.9998	0.99984	0.9998

THD (%)	19.59%	18.07%	18.15%
Dpf	0.867	0.866	0.866
Pf	0.867	0.866	0.867
P1 (W)	2202.248	2202.25	2202.24
Q1	997.6	998.87	1030.77
S1	1971.43	1945.78	2002.85

PART C: Asymmetric half-controlled converter
5.
$Vout$ = (Vm / π)*(1+cos α) = 193.2V
a)
For firing angle α = 30°,
Simulated average Vout =190.2 V



b) Thyristor 1 (RMS value) = 4.658 A
Thyristor 3 : RMS value = 4.722 A
Diode 2 (RMS value) = 4.855 A
Diode 4 (RMS value) = 4.839 A

c)
Source reactance drop of 5% of rated line voltage
The firing angle α = 30°.
Vm = 0.95*230* 2 = 309 V
$Vout$ = (Vm / π)*(1+cos α) = 183.54 V

2.

Given : R = 30 Ω, L = 60mH, α = 45°,

Without Free Wheeling Diode

```
Sampling time      = 1e-06 s
Samples per cycle = 20000
DC component      = 0.02662
Fundamental       = 8.59 peak (6.074 rms)
THD               = 19.19%

   0 Hz  (DC):          0.03     270.0°
  10 Hz                 0.05     254.7°
  20 Hz                 0.05     239.4°
  30 Hz                 0.05     224.1°
  40 Hz                 0.05     208.9°
  50 Hz  (Fnd):         8.59     -28.5°
  60 Hz                 0.04     179.3°
  70 Hz                 0.04     165.2°
  80 Hz                 0.04     151.9°
  90 Hz                 0.04     139.3°
 100 Hz  (h2):          0.03     127.8°
 110 Hz                 0.03     116.2°
 120 Hz                 0.03     105.4°
 130 Hz                 0.03      95.0°
 140 Hz                 0.03      84.7°
 150 Hz  (h3):          0.98      68.3°
 160 Hz                 0.02      64.0°
 170 Hz                 0.02      53.6°
 180 Hz                 0.02      43.1°
 190 Hz                 0.02      32.7°
 200 Hz  (h4):          0.02      23.0°
 210 Hz                 0.02      12.1°
 220 Hz                 0.02       1.9°
 230 Hz                 0.02      -8.1°
 240 Hz                 0.02     -17.9°
```

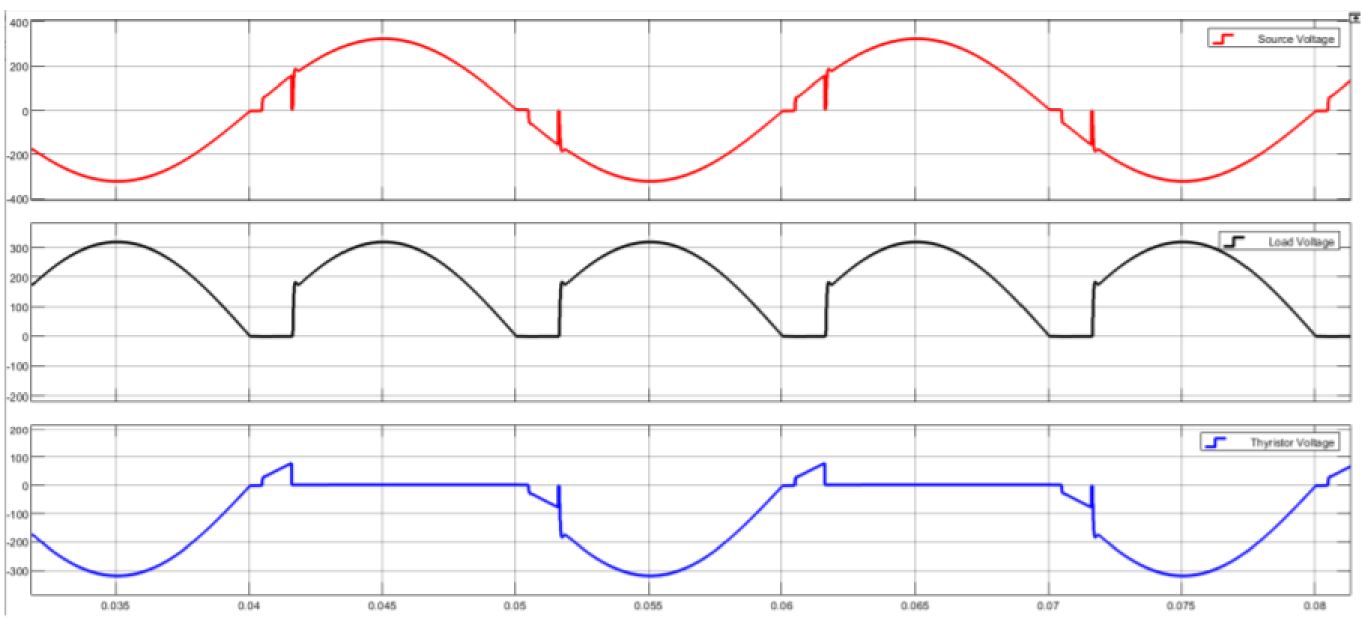
With Free Wheeling Diode :

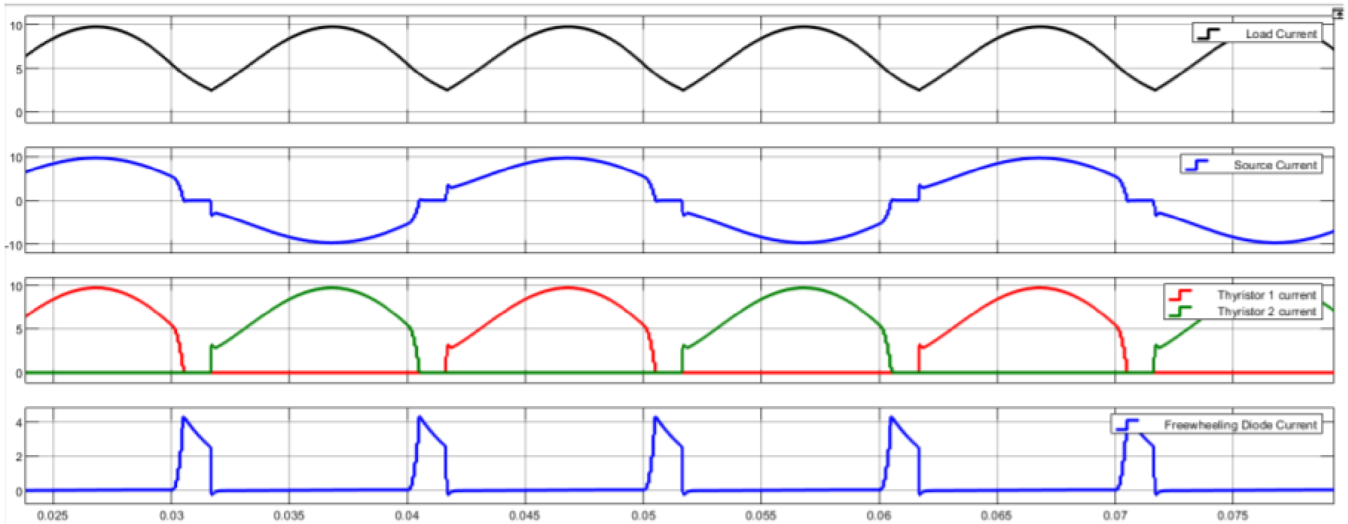
```
Sampling time      = 1e-06 s
Samples per cycle = 20000
DC component      = 0.02701
Fundamental       = 8.584 peak (6.07 rms)
THD               = 19.13%

   0 Hz  (DC):          0.31%     270.0°
  10 Hz                 0.61%     254.7°
  20 Hz                 0.60%     239.4°
  30 Hz                 0.59%     224.1°
  40 Hz                 0.57%     208.9°
  50 Hz  (Fnd):       100.00%     -28.3°
  60 Hz                 0.52%     179.3°
  70 Hz                 0.48%     165.3°
  80 Hz                 0.45%     151.9°
  90 Hz                 0.42%     139.3°
 100 Hz  (h2):          0.40%     127.8°
 110 Hz                 0.36%     116.2°
 120 Hz                 0.34%     105.4°
 130 Hz                 0.32%      95.0°
 140 Hz                 0.30%      84.6°
 150 Hz  (h3):         11.27%      68.3°
 160 Hz                 0.28%      63.9°
 170 Hz                 0.27%      53.5°
 180 Hz                 0.26%      43.0°
 190 Hz                 0.25%      32.6°
 200 Hz  (h4):          0.24%      22.9°
 210 Hz                 0.23%      11.9°
 220 Hz                 0.22%       1.8°
 230 Hz                 0.21%      -8.3°
 240 Hz                 0.20%     -18.1°
```

DISCUSSIONS:

QS1.





QS. The study between full-controlled and Asymmetric half-controlled converter in terms of load voltage, source current, power factor, THD.

Ideal cases considered : For a Full controlled converter :
R = 22.4 OHM , L = 60mH, Vin(RMS) = 230 V ,50hz, α=30°
Asymmetric half controlled converter :
R = 22.4 OHM , L = 60mH, Vin (RMS) = 230 V ,50hz, α=30°

Asymmetric Half Controlled gives a greater output voltage and an improved power factor as compared to the Full-Controlled. Asymmetric Half Controlled gives a greater output voltage and an improved power factor as compared to the Full-Controlled.

Parameters	Full-Controlled	Asymmetric Half Controlled
Load Voltage(AVG)(in V)	179.2	190.8
RMS Source Current (in A)	8.452	8.61
THD (%)	11.55	17.66
Power factor	0.843	0.918
Displacement factor	0.845	0.934

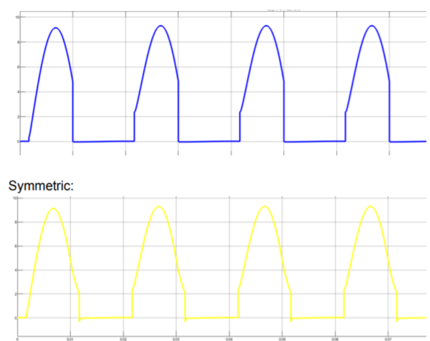
QS. Why a train of pulses are used to turn on the thyristor instead of a single pulse?
The following are the reasons we use a train of pulses to turn on the thyristor instead of a single pulse:

If we hold the gate trigger voltage for a longer duration, it will cause huge dissipation of power within the thyristor and thus draw excess power from the circuit.
The thyristor may not latch on with the first firing pulse at the start of a conduction interval, as the current may not reach the minimum holding current.
Hence, we need to keep triggering on until it latches on.

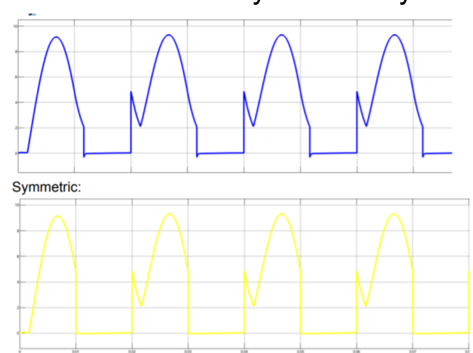
QS. List key differences between asymmetric and symmetric semi-controlled rectifiers.

While the load current and the load voltage waveforms come out exactly the same for both the rectifiers, a difference in the Diode and Load current is observed.

Thyristor Currents: Asymmetric/Symmetric:



Diode Currents: Asymmetric/Symmetric:



Observation :

- The conduction time for thyristor is more in symmetrical topology, thus higher RMS and average thyristor currents.
- The conduction time for the diode is less in symmetrical topology, thus lower RMS and average diode currents.
- From conduction time periods, we can also say that the average and RMS thyristor current is symmetrical configuration is higher. So SCR's current rating should be higher in a symmetrical configuration.
- The average and RMS diode current in asymmetrical configuration is higher. So, the diode current rating should be higher in asymmetrical configuration. The freewheeling path in symmetrical configuration is through a (thyristor-diode) combination, and in asymmetrical configuration is through a (diode-diode) combination. This is because during freewheeling, devices belonging to the same leg will conduct in both configurations.