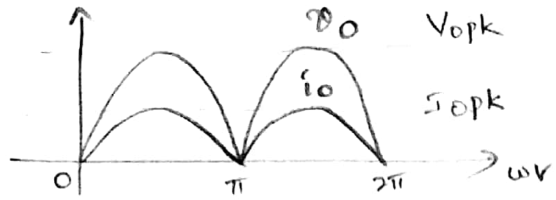
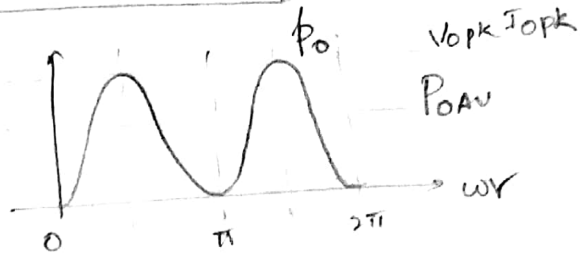
1

a)





Average power dissipated in the resistor $= \frac{V_{opk} I_{opk}}{2} = \frac{V_{opk}^2}{2R}$

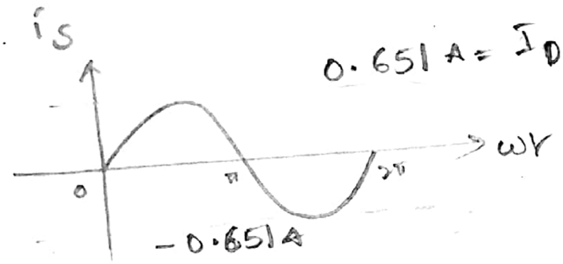
$R = 5\Omega$

$\Rightarrow \frac{V_{opk}^2}{2R} = 105.8\,W \Rightarrow V_{opk}^2 = 1058 \Rightarrow V_{opk} = 32.569\ V$

$\Rightarrow$ RMS voltage across each half of the secondary $= \frac{V_{opk}}{\sqrt{2}} = 23V$

$\Rightarrow \frac{N_1}{N_2} = \frac{230}{23} = 10$ (8) $\frac{N_2}{N_1} = \frac{1}{10}$ and $I_{opk} = \frac{32.569}{5} = 6.51\,A$

b)



$0.651\,A = I_{opk} \frac{N_2}{N_1}$

c) PIV = 2 × Peak voltage across secondary $= 2 \times 32.569 = 65.05\ V$

$\Rightarrow I_{D1\,AV} = \frac{I_{opk}}{\pi} = 2.07\,A$

with a safety factor of 2

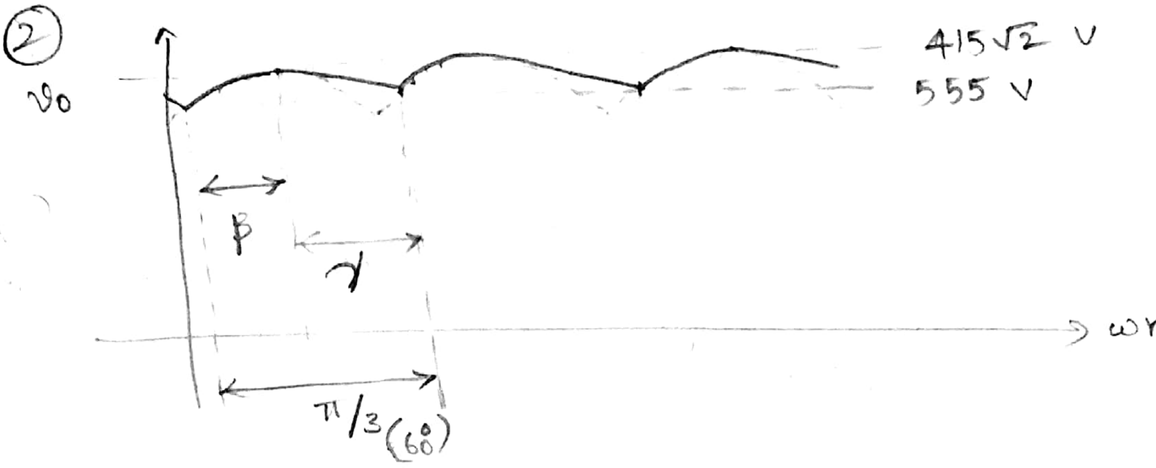
$[150V, 5A]$ diode is chosen

d) Loss in each diode $= I_{D1AV} \times 0.8 = 1.656W$

Total loss $= \underbrace{2\,W}_{\text{Transformer}} + \underbrace{(2 \times 1.656)}_{\text{Diodes}} = 5.312W.$

Scanned by CamScanner

(2)



$$\sin^{-1}\left(\frac{555}{415\sqrt{2}}\right) = \sin^{-1}(0.946) = 71.02^\circ$$

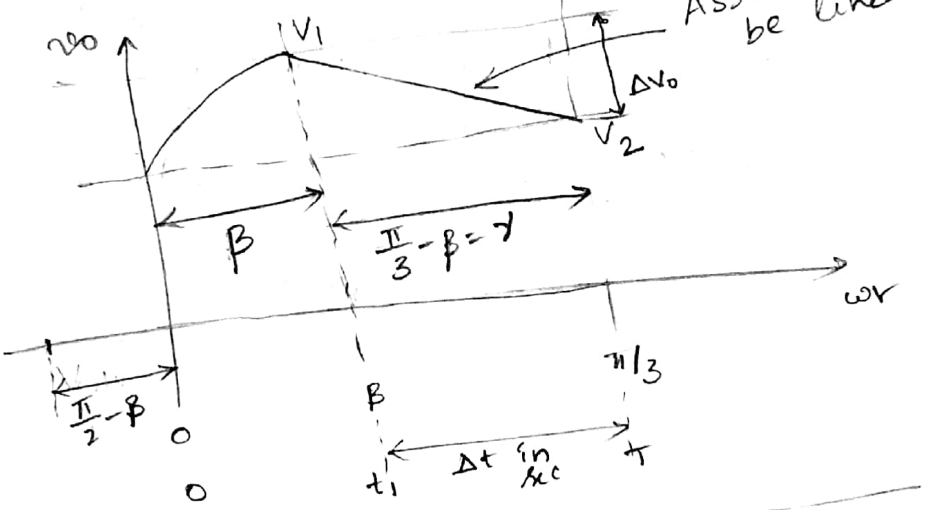
$$\Rightarrow \beta = 90^\circ - 71.02^\circ = 18.98^\circ$$

$$\Rightarrow \text{exponential fall time } \Delta t = \frac{(60 - 18.98)}{360^\circ} \times 20\times10^{-3}$$

$$= 2.28 \text{ ms}$$

Average power delivered to load (resistor)

$$P_{OAV} = \frac{V_{ORMS}^2}{R}$$



For $0 < \omega t < \beta$

$$v_o = V_1 \sin\left[\omega t + \left(\frac{\pi}{2} - \beta\right)\right]$$

for $\beta < \omega t < \frac{\pi}{3}$

$$v_o = V_1 - \frac{\Delta V_o}{\Delta t}(t - t_1)$$

$$= V_1 - \frac{\Delta V_o}{\Delta \omega t}(\omega t - \omega t_1)$$

$$= V_1 - \frac{\Delta V_o}{\gamma}(\omega t - \beta)$$

$$V_{ORMS} = \sqrt{\frac{1}{T}\int_0^T v_o^2(t)\, dt} = \sqrt{\frac{1}{\pi/3}\int_0^{\pi/3} v_o^2(\omega t)\, d\omega t} \rightarrow \int_0^{\beta},\ \int_{\beta}^{\pi/3}$$

$$\int_0^{\beta} v_o^2(\omega t) = \int_0^{\beta} V_1^2 \cos^2(\omega t - \beta)\, d\omega t = V_1^2 \int_0^{\beta} \frac{1 + \cos(2\omega t - 2\beta)}{2}\, d\omega t$$

$$= \frac{V_1^2}{2}\left[\beta + \left(\frac{\sin(2\omega t - 2\beta)}{2}\right)\Bigg|_0^{\beta}\right]$$

$$= \frac{V_1^2}{2}\left(\beta + \frac{\sin 2\beta}{2}\right) \longrightarrow (A_1)$$

Scanned by CamScanner

$$\int_{\beta}^{\pi/3} v_0^2(\omega t)\, d\omega t = \frac{1}{3}\Delta\omega t\left(V_1^2+V_2^2+V_1V_2\right)$$

$$= \frac{1}{3}\left(\frac{\pi}{3}-\beta\right)\left(V_1^2+V_2^2+V_1V_2\right) \longrightarrow A_2$$

$V_1 = 415\sqrt{2} = 586.9\,V$
$V_2 = 555\,V$
$\Delta V_0 = 31.9\,V$
$\gamma = \frac{41.02\times\pi}{180} = 0.72$
$\beta = \frac{18.98\times\pi}{180} = 0.33$
$\sin\beta = 0.3252$
$\sin 2\beta = 0.615$
$\cos\beta = 0.946$

$$V_{ORMS} = \sqrt{\frac{3}{\pi}\int_0^{\pi/3} v_0^2(\omega t)\, d\omega t} = \sqrt{\frac{3}{\pi}\left(A_1 + A_2\right)}$$

$$A_1 = \frac{V_1^2}{2}\left(\beta + \frac{\sin 2\beta}{2}\right) = \frac{415^2\times 2}{2}\left(0.33+0.31\right) = 110224$$

$$A_2 = \frac{1}{3}\gamma\left(V_1^2+V_2^2+V_1V_2\right) = \frac{1}{3}\times 0.72\left(\left(415\sqrt{2}\right)^2+555^2+415\sqrt{2}\times 555\right) = 234769$$

$$\Rightarrow V_{ORMS} = 573.97\,V.$$

$$P_{OAV} = \frac{V_{ORMS}^2}{R} \Rightarrow 8000 = \frac{573.97^2}{R} \Rightarrow R = 41.18\,\Omega$$

Calculation of the value of 'C' - by energy balance

change in energy stored in the capacitor (ΔE_{cap}) = energy consumed by the load resistor (E_{load}) } During voltage fall

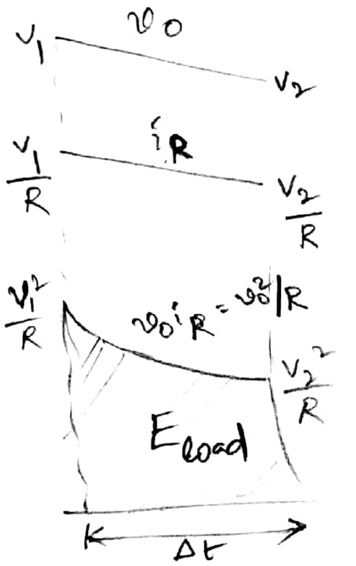
$$\frac{1}{2}C\left(V_1^2 - V_2^2\right) = \frac{1}{3}\Delta t\,\frac{\left(V_1^2+V_2^2+V_1V_2\right)}{R}$$

$$\Rightarrow \frac{1}{2}C\left[\left(415\sqrt{2}\right)^2 - 555^2\right] = \left[\frac{1}{3R}\right]\times 2.28\times 10^{-3}\times\left(\left(415\sqrt{2}\right)^2+555^2+555\times 415\sqrt{2}\right)$$

$$\Rightarrow RC = 0.0408\ \text{sec}$$

$$R = 41.18\,\Omega$$

$$\Rightarrow C = 990.8\,\mu F = 0.9908\,mF$$



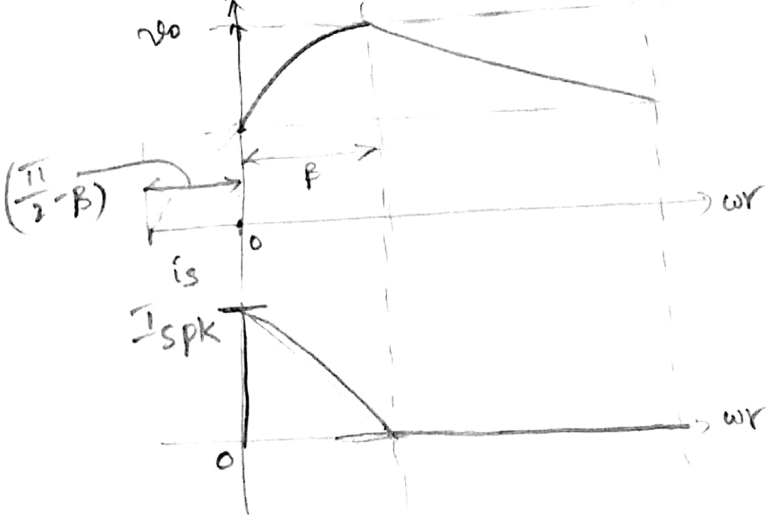
$$= \frac{\gamma}{2\pi}\times 20\,ms$$

$$= \frac{41.02}{360}\times 20\times 10^{-3}$$

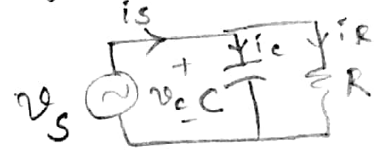
$$= 2.28\ ms.$$

Scanned by CamScanner

Peak input current



$0 < \omega t < \beta$



$$i_s = i_c + i_R$$

$$= C\frac{dv_s}{dt} + \frac{v_s}{R}$$

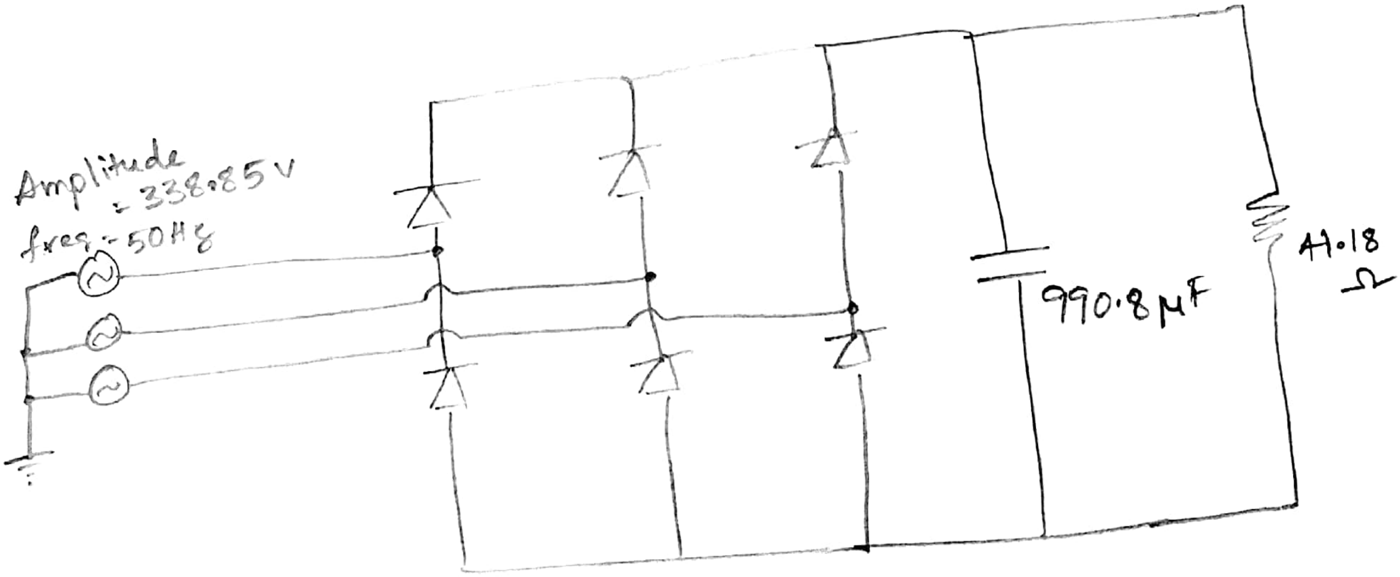
$$= \omega C V_1 \cos\left[\omega t + \left(\frac{\pi}{2}-\beta\right)\right] + \frac{V_1 \sin\left[\omega t + \left(\frac{\pi}{2}-\beta\right)\right]}{R}$$

At $\omega t = 0^\circ$, $i_s = I_{spk}$

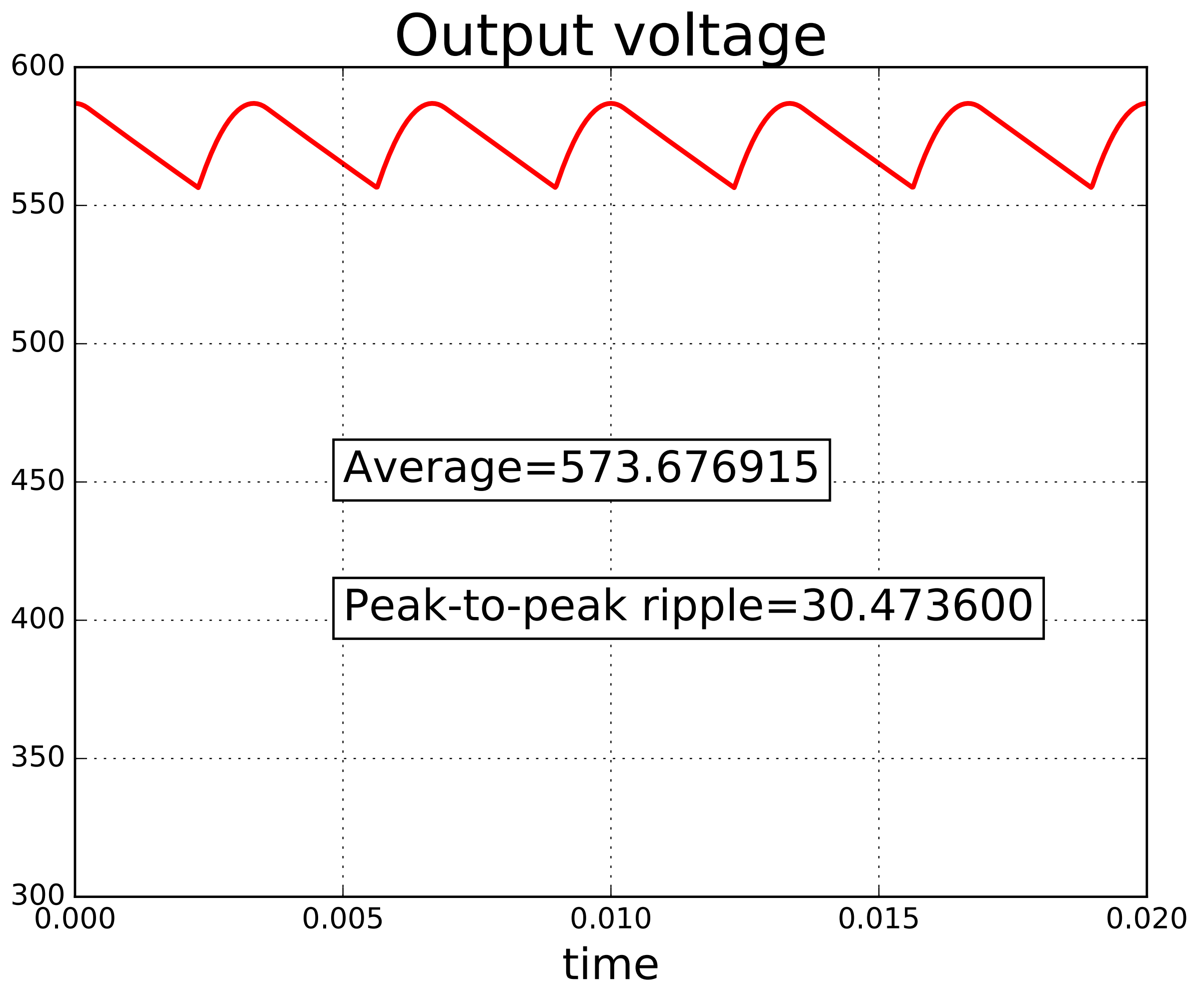
$$\Rightarrow I_{spk} = \omega C V_1 \sin\beta + \frac{V_1 \cos\beta}{R}$$

$$I_{spk} = (2\pi \times 50 \times 990.8 \times 10^{-6} \times 415\sqrt{2} \times 0.3252) + \left(\frac{415\sqrt{2} \times 0.946}{41.18}\right) = 72.9\ A$$

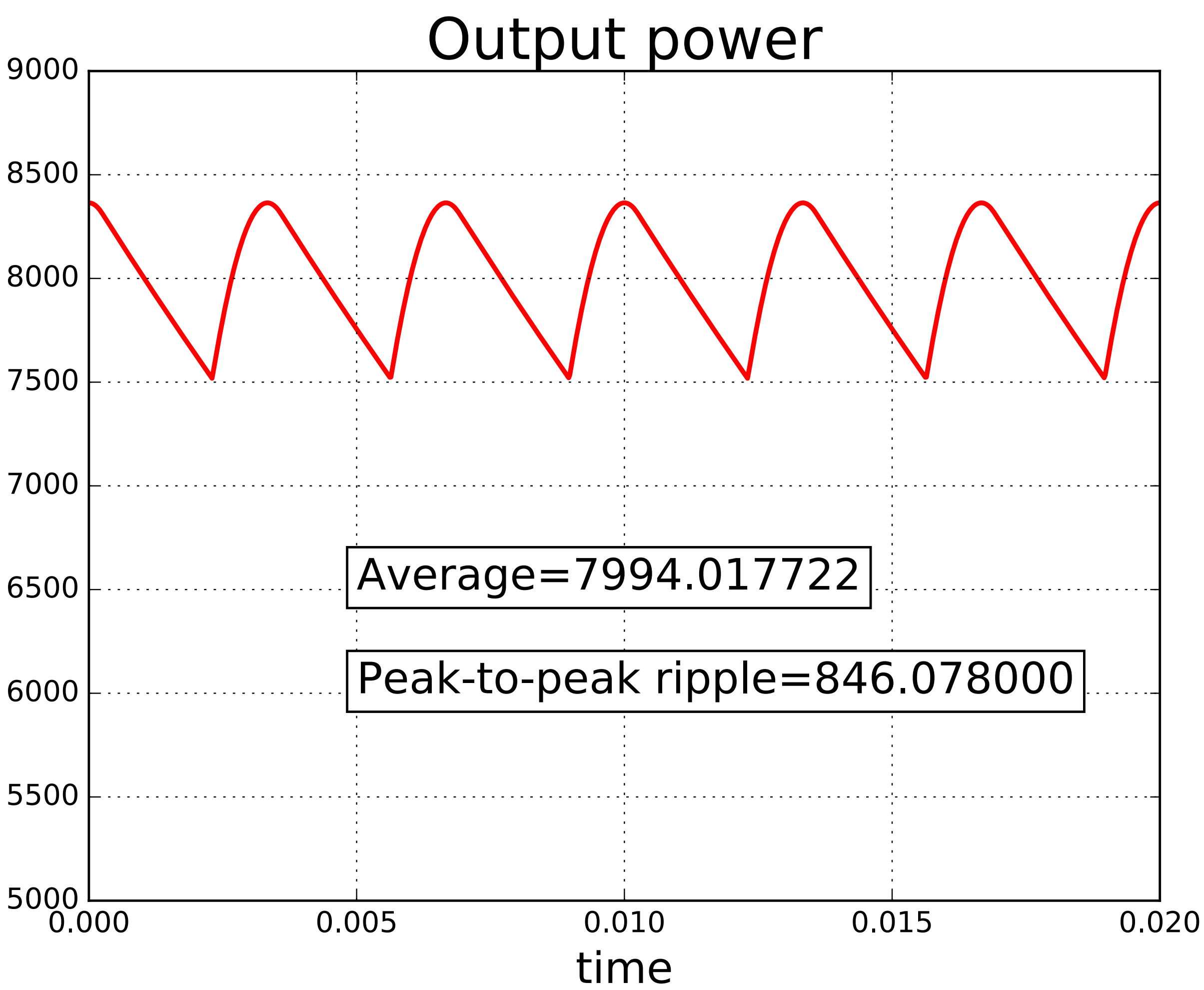
Simulated circuit:



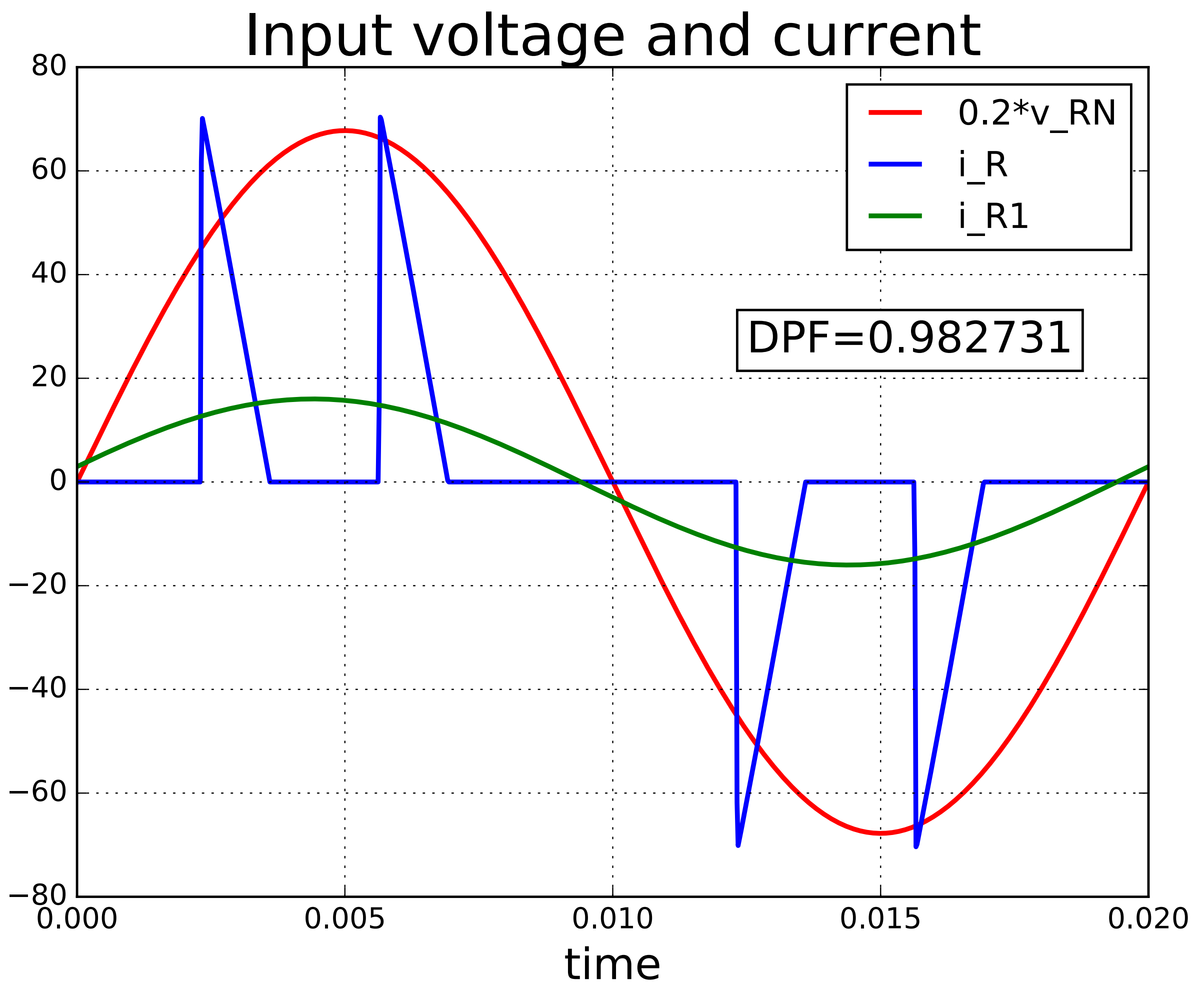
Scanned by CamScanner

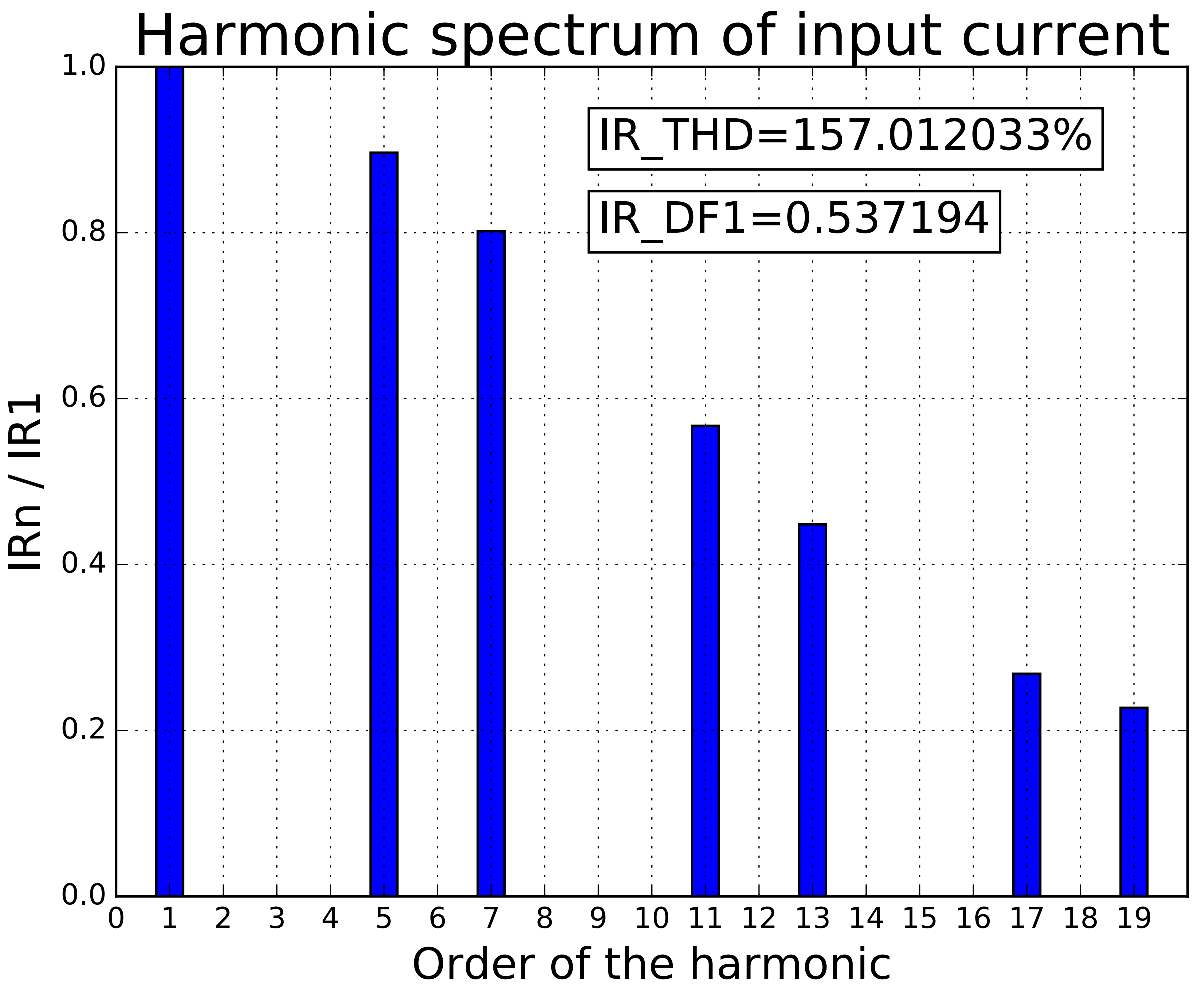


Output voltage
600
550
500
450
400
350
300
0.000
0.005
0.010
0.015
0.020
time
Average=573.676915
Peak-to-peak ripple=30.473600



Output power
9000
8500
8000
7500
7000
6500
6000
5500
5000
0.000
0.005
0.010
0.015
0.020
time
Average=7994.017722
Peak-to-peak ripple=846.078000


Input voltage and current
0.2*v_RN
i_R
i_R1
DPF=0.982731
80
60
40
20
0
−20
−40
−60
−80
0.000
0.005
0.010
0.015
0.020
time


Harmonic spectrum of input current
IR_THD=157.012033%
IR_DF1=0.537194
IRn / IR1
1.0
0.8
0.6
0.4
0.2
0.0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Order of the harmonic