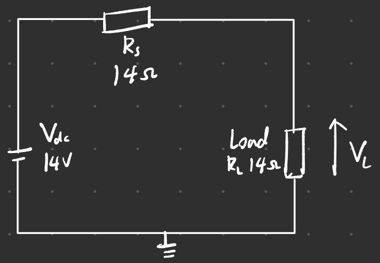
Q 1.1



$$I_L = \frac{14}{14+14} = 0.5\ A$$

$$V_L = 14 \times \frac{14}{14+14} = 7\ V$$

$$P_L = I_L^2 \times R_L = 0.5^2 \times 14 = 3.5\ W$$

Q 1.2

	Theoretical	Simulated
I_L	0.5A	0.5A
V_L	7V	7V
P_L	3.5W	3.5W

The theoretical and simulated results are matched.

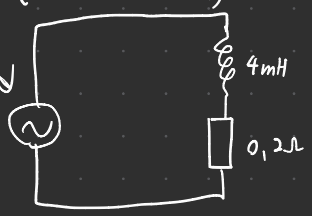
Q 1.3

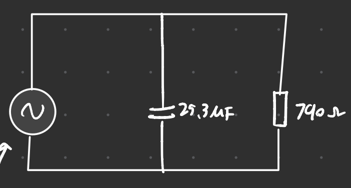
Stop Time : $200 \times 2ms = 0.4s$

Max time stamp: $\frac{1}{20} \times \frac{1}{500} = 0.1\ ms$

Q 1.4

$\sin(500 \times 2\pi t + 14 \times 1.414)$ V





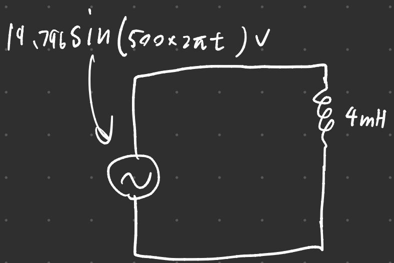
$\sin(1000\pi t + 14 \times 1.414)$ A

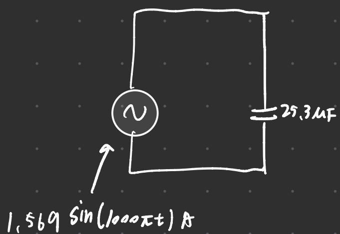
$$\tau = \frac{L}{R} = 0.02\ s$$

$$\tau = RC = 0.019987\ s$$

Both will reach steady-state before defined stop time, 0.4s

Q1.5 ignoring the added resistences.





$X_L = 2\pi \times 500 \times 0.004 = 12.57\,\Omega$

$I_{Rms} = \frac{14}{12.57} = 1.11A$

V_{Rms} is given $V_{Rms} = 14V$

$P_{L(t)} = \frac{19.796 \times 1.577}{2} = 15.609\,W$

$P_{avg} = 0$ caz of it's ideal inductor.

$I_{Rms} = 1.11\,A$

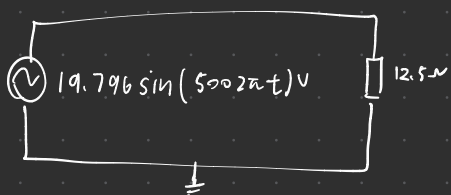
$X_C = \frac{1}{\omega C} = \frac{1}{3141.6 \times 25.3 \times 10^{-6}} = 12.5814\,\Omega$

$I_{LRms} = 1.11\,A$

$V_{L(Rms)} = I_{LRms} \times X_L = 13.9654\,V$

$P_{L(t)} = I_{Rms} \times V_{Rms} \times \cos(-90°) = 15.502\,W$

$P_{avg} = 0$ (ideal inductor)



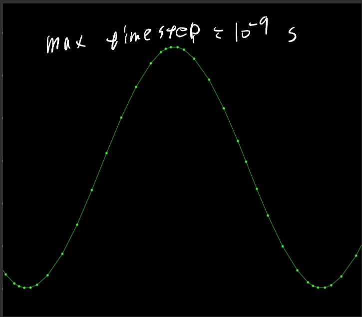
$I_{Rms} = \frac{V_{Rms}}{R} = \frac{14}{12.5} = 1.12A$

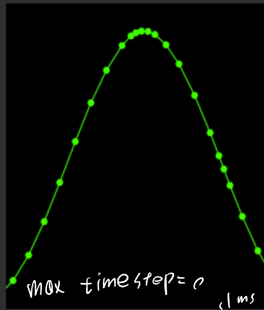
V_{Rms} is give, $V_{Rms} = 14v$

$P_{in} = V_{Rms} \times I_{Rms} = 14 \times 1.12 = 15.68\,W$

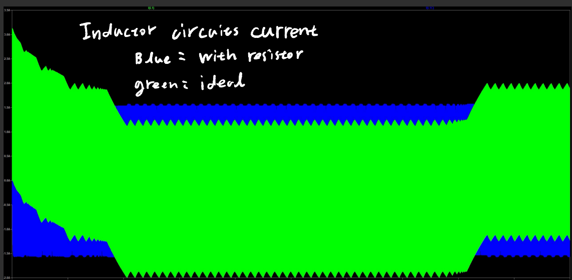
$P_{L(t)} = 14 \times \sqrt{2} \times 1.12 \times \sqrt{2} = 31.36\,W$

Q1.6



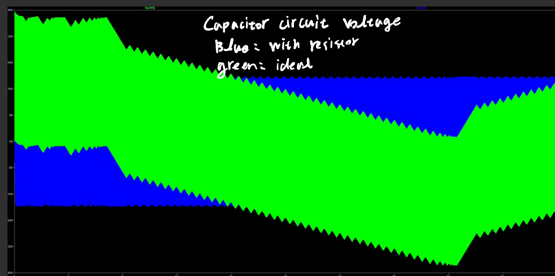


Q1.7



For ideal: $\because R = 0$

$\therefore \tau = \frac{L}{R} = \frac{L}{0} = \infty$



For ideal: $\because R = 0$

$\therefore \tau = C \times 0 = 0$

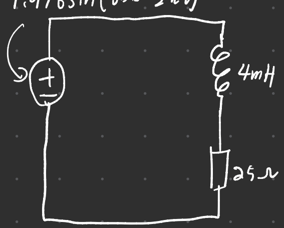
Q2.1

$$I_{max} = \frac{7.5\,VA}{12.6\,V} = 595.2381\ mA$$

$$I_{min} = \frac{2.5\,VA}{15.4\,V} = 162.3377\,mA$$

Q2.2

$1.976\sin(500\cdot 2\pi t)$



$$X_L = 2\pi \times 500 \times 4 \times 10^{-3} = 12.5664\ \Omega$$

$$Z_L = \sqrt{25^2 + 12.5664^2} = 27.9806\ \Omega$$

$$I_{L(Rms)} = \frac{V_{ac(Rms)}}{Z_L} = \frac{14}{27.9806} = 500.3465\,mA$$

$$|S| = 14 \times 500.3465 \times 10^{-3} = 7.0049\ VA$$

$$P = 25 \times (500.3465 \times 10^{-3})^2 = 6.2587\ W$$

$$Q = 12.5664 \times (500.3465 \times 10^{-3})^2 = 3.1459\ VAR$$

$$\begin{cases} \text{Simulated RMS voltage: } 13.877\ V \\ \text{Simulated RMS current: } 494.24\ mA \end{cases}$$

$$|S_{simulated}| = 13.877 \times 494.24 \times 10^{-3} = 6.8586\ VA$$

$$Q_{simulated} = \sqrt{S_{simulated}^2 + P_{simulated}^2} = \sqrt{6.8586^2 - 6.1174^2} = 3.1013\ VAR$$

Q2.3

$$X_L = 12.5664\ \Omega \qquad Z_L = \sqrt{12.5664^2 + 75^2} = 76.0455\ \Omega$$

$$I_{L(RMS)} = \frac{14}{76.0455} = 184.1\ mA$$

$$|S| = 14 \times 184.1 \times 10^{-3} = 2.5774\ VA$$

$$P = (184.1 \times 10^{-3})^2 \times 75 = 2.542\ W$$

$$Q = (184.1 \times 10^{-3})^2 \times 12.5664 = 0.4259\ VAR$$

$$I_{L(RMS)\ simulated} = 182.35\ mA \qquad V_{L(RMS)\ simulated} = 13.875\ V$$

$$P_{simulated} = 2.4948\ W \qquad |S_{simulated}| = 13.875 \times 182.35 \times 10^{-3} = 2.5301\ VA$$

$$Q_{simulated} = \sqrt{2.5301^2 - 2.4948^2} = 0.4212\ VAR$$

Q 3.1

Identidying the constrain :

$$I_{max} = 595.2381 \text{ mA} \quad \text{and} \quad P_{max} = 0.2 \text{ W}$$

Calculate $P_{s(max)}$:

$$R_{s(max)} = \frac{P_{max}}{I_{max}^2} = \frac{0.2}{(595.2381 \times 10^{-3})^2} = 0.5645 \, \Omega$$

Q 3.2

(Senario 1 : 7.5 VA at 12.6V)

$$I_{L(Rms)} = \frac{7.5VA}{12.6V} = \underline{\underline{595.2381 \text{ mA}}}, \quad X_L = 2\pi \times 500 \times 0.004 = 12.5664 \, \Omega$$

Total impendance required : $|Z_{total}| = \dfrac{12.6V}{595.2381 \times 10^{-3}} = 21.168 \, \Omega$

$$|Z_{total}|^2 = R_L^2 + X_L^2$$

$$R_L = \sqrt{|Z_{total}|^2 - X_L^2} = \sqrt{21.168^2 - 12.5664^2} = 17.0344 \, \Omega$$

$$V_{pk(Theo)} = I_{L(Rms)} \times R_s \times \sqrt{2} = 595.2381 \times 0.5645 \times 10^{-3} \times \sqrt{2} = \underline{\underline{0.4752 \text{ V}}}$$

$$P_{is} = P_{max} = (595.2381 \times 10^{-3})^2 \times 0.5645 = 0.2 \text{ W}$$

(Senario 2 : 7.5VA at 15.4V)

$$I_{L(Rms)} = \frac{7.5VA}{15.4V} = \underline{\underline{484.013 \text{ mA}}}$$

$$|Z_{total}| = \frac{15.4V}{484.013 \times 10^{-3}} = 31.8173 \, \Omega$$

$$R_L = \sqrt{31.6213^2 - 12.5664^2} = 29.2306$$

$$V_{is(Theo)} = 484.013 \times 10^{-3} \times 0.5645 \times \sqrt{2} = 0.3864\,V$$

$$P_{is(Theo)} = (484.013 \times 10^{-3})^2 \times 0.5645 = 0.1322\,W$$

(Senario 3: 2.5 VA at 15.4V)

$$I_{L(rms)} = \frac{2.5\,VA}{15.4\,V} = 162.3377\,mA \qquad |Z_{total}| = \frac{15.4}{162.3377 \times 10^{-3}} = 94.864\,\Omega$$

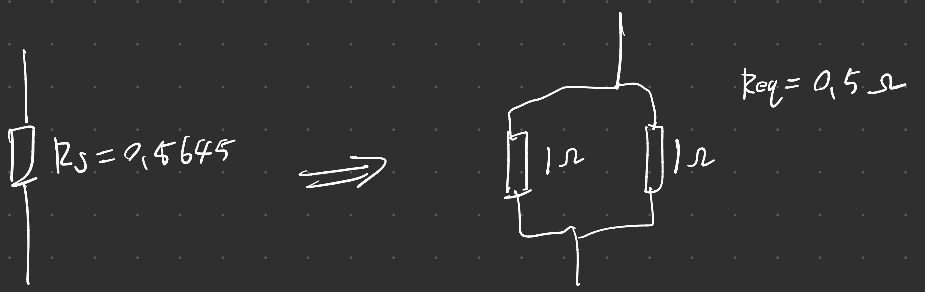
$$R_L = \sqrt{94.864^2 - 12.5664^2} = 94.028\,\Omega$$

$$V_{is(Theo)} = 162.3377 \times 10^{-3} \times 0.5645 \times \sqrt{2} = 0.1296\,V$$

$$P_{is(Theo)} = (162.3377 \times 10^{-3})^2 \times 0.5645 = 0.01488\,W$$

Q 3.3

Because the miniman resistor we can find in the lab is 1 ohm, so we need to use two resistors in parallel to approach to 0.5645



Q 4.1

In Q 2.1, I have calculated that max input voltage is 15.4 V_{rms}.
Target output voltage should be 2V (peak to peak), it means $V_{out(pk)}$ should be 1V.

$$V_{in(pk)} = 15.4 \times \sqrt{2} = 21.7789 \text{ V}$$

$$V_{out} = V_{in} \times \frac{R_b}{R_a + R_b} \quad \text{and} \quad \text{Ratio} = \frac{V_{out}}{V_{in}} = \frac{1}{21.7789} = 0.04592 = \frac{R_b}{R_a + R_b}$$

$$0.04592 R_a + 0.04592 R_b = R_b \Rightarrow 0.04592 R_a = 0.9541 R_b$$

$$R_a / R_b = \frac{0.9541}{0.04592} = \underline{\underline{20.7771}}$$

I pick $R_b = \underline{\underline{4.7k\Omega}}$ becuase it's large enough to limit power dissipation.

Given that $\frac{R_a}{R_b} = 20.7771$, $R_a \approx 97.65237 \text{ k}\Omega$

So I choose an E2 resistor close to $97.65237 k\Omega \Rightarrow R_a = 100k\Omega$

Check : $V_{out(pk)} = 21.7789 \times \frac{4.7k}{104.7k} = 0.9777$

However, my teammate proposed a better resistor combination, which is $R_a = 20k\Omega$ and $R_b = 1 k\Omega$.

It tured out the R_a/R_b to be : 20

And the output voltage will be: $V_{out(pk)} = 21.7789 \times \frac{1}{21} = 1.0371$

It slightly more deviate from 1V than 0.977 but it will be easier for calculation in the following design

Q4.2 I've picked that $R_a = 100k\Omega$ and $R_b = 4.7k\Omega$

(Senario 1 : 7.5VA at 12.6V)

R_L is calculated, $R_L = 16.4699\Omega$

$V_{ac(rms)} = 12.6 \times \sqrt{2} = 17.8191\,V$

Peak voltage, $V_{vs(pk,theo)} = 17.8191 \times \frac{1}{21} = \underline{0.8485\,V}$

Power Dissipation, $P_{vs} = \frac{V_{ac(rms)}^2}{R_a + R_b} = \frac{12.6^2}{21k} = \underline{\underline{7.56\,mW}}$

$P_{b(sim)} = 6.6955\,mW$ $\quad P_{vs(sim)} = P_{b(sim)} + P_{a(sim)} = 7.0090\,mW$

$P_{a(sim)} = 313.48 \times 10^{-3}\,mW$

(Senario 2 : 7.5VA at 15.4V)

$V_{ac(rms)} = 15.4 \times \sqrt{2} = 21.7789\,V$ $\quad V_{vs(pk)} = 21.7789 \times \frac{1}{21} = \underline{\underline{1.0371\,V}}$

$P_{vs(Theo)} = \frac{15.4^2}{21k} = \underline{11.2933\,mW}$

$P_{a(sim)} = 9.9925\,mW$ $\quad P_{vs(sim)} = P_{a(sim)} + P_{b(sim)} = \underline{\underline{10.4602\,mW}}$

$P_{b(sim)} = 467.66 \times 10^{-3}\,mW$

(Senario 3 : 2.5VA 15.4V)

$V_{ac(rms)} = 15.4 \times \sqrt{2} = 21.7781\,V$ $\quad V_{vs(pk)} = 21.7781 \times \frac{1}{21} = \underline{\underline{1.0371}}$

$P_{vs(Theo)} = \frac{15.4^2}{21k} = \underline{11.2933\,mW}$

$P_{a(sim)} = 10.012\,mW$ $\quad P_{vs(sim)} = P_{a(sim)} + P_{b(sim)} = \underline{\underline{10.4780}}$

$P_{b(sim)} = 468.99 \times 10^{-3}\,mW$