Linear Transformers

(11.X1) Determine the voltage $V_o$ of the linear transformer given below. Ans: $V_o = 0.6\angle-90^\circ$ V

![Circuit for problem 11.X1](image)

Figure 11.X1: Circuit for problem 11.X1

(11.X2) In the linear transformer circuit below, calculate the input impedance and the current $I_1$. Take $Z_1 = (60 - j100)$ ohms, $Z_2 = (30 + j40)$ ohms, and $Z_L = (80 + j60)$ ohms. Ans: $Z_{IN} = 100.14\angle-53.1^\circ$ ohms, $I_1 = 0.5\angle113.1^\circ$ A

![Circuit for problem 11.X2](image)

Figure 11.X2: Circuit for problem 11.X2
Ideal Transformers

(15.60) Work for $N_1/N_2 = 10$ only: Ans: $V_{2\text{rms}} = 10 \, \text{V}$, $I_{2\text{rms}} = 0.1 \, \text{A}$, $P_L = 1 \, \text{W}$

(15.63) (a) $I_1 = 6\angle 30^\circ \, \text{A}$; $V_2 = 400\angle 0^\circ \, \text{V}$

(b) $P_{S1} = -519.6 \, \text{W}$ $P_{S2} = 519.6 \, \text{W}$

Power is taken from the voltage source and delivered to the current source

(c) $I_1 = 6\angle -150^\circ \, \text{A}$ $V_2 = 400\angle 180^\circ \, \text{V}$

$P_{S1} = 519.6 \, \text{W}$ $P_{S2} = -519.6 \, \text{W}$

Power is taken from the current source and delivered to the voltage source

(15.65) (a) $I_1 = 30\angle 0^\circ \, \text{A}$; (b) $I_1 = 10\angle 0^\circ \, \text{A}$
Determine the voltage $V_o$ of the linear transformer given below. Ans: $V_o = 0.6\angle -90^\circ \text{V}$

Assume currents $I_1$, and $I_2$ as shown above, write KVL equations around mesh 1 and mesh 2.

\[
\begin{align*}
(4 + j8) I_1 + jI_2 &= 6 \angle 90^\circ \\
-jI_1 + (10 + j5) I_2 &= 0
\end{align*}
\]

\[
\begin{bmatrix}
(4 + j8) & (10 + j1) \\
(0 + j1) & (10 + j5)
\end{bmatrix}
\begin{bmatrix}
I_1 \\
I_2
\end{bmatrix}
= \begin{bmatrix}
6 \angle 90^\circ \\
0
\end{bmatrix}
\]

$I_o = 0.06 \angle -89.4^\circ \text{A}$

$V_o = 10 I_2$

\[
V_o = 0.6 \angle -89.4^\circ \text{V}
\]
In the linear transformer circuit below, calculate the input impedance and the current $I_1$.
Take $Z_1 = (60 - j100)$ ohms, $Z_2 = (30 + j40)$ ohms, and $Z_L = (80 + j60)$ ohms.
Ans: $Z_{IN} = 100.14 \angle -53.1^\circ$ ohms, $I_1 = 0.5 \angle 113.1^\circ$ A

![Linear Transformer Circuit](image)

We have shown that

$$Z_{IN} = Z_1 + j20 + \frac{(WM)^2}{j40 + Z_2 + Z_L}$$

$$Z_{IN} = 60 - j100 + j20 + \frac{25}{j40 + 30j + 80j + 60}$$

$$Z_{IN} = 60 - j80 + \frac{25}{110 + j140}$$

$$Z_{IN} = 100.14 \angle -53.1^\circ \ \Omega$$

$$I_1 = \frac{50}{100.14 \angle -53.1^\circ} = 0.5 \angle 113.1^\circ \ A$$
Ideal Transformers

(15.60)

Consider the circuit below.

(a) Find the secondary voltage \( V_{2\text{rms}} \).

Find the secondary current \( I_2 \).

If \( N_1 / N_2 = 10 \)

\[
\begin{align*}
\text{Primary} & \quad 100 \, \text{V rms} \\
\quad & \quad 1:0.1 \\
\text{Secondary} & \quad 100 \, \Omega
\end{align*}
\]

Reflect the primary to the secondary.

\[
\begin{align*}
\text{Primary} & \quad 100 \, \text{V rms} \\
\quad & \quad (1)(10) \, \Omega \\
\text{Secondary} & \quad 100 \, \Omega
\end{align*}
\]

\[
V_{2\text{rms}} = 1000 \, V_{rms}
\]

\[
I_{2\text{rms}} = \frac{1000}{100} = 0.1 \, \text{A rms}
\]

\[
P_{100} = \left| I_{2\text{rms}} \right|^2 \times 100 = (0.1)^2 \times 100
\]

\[
P_{100} = 1 \, \text{W}
\]
Consider the circuit shown in the diagram below.

(a) Determine the values of $I_1$, $I_2$, $V_1$, and $V_2$.

(b) For each of the sources, determine the average power and state whether the power is delivered by or absorbed by the source.

(c) Move the dot on the secondary to the bottom end of the coil and repeat (a) and (b).

\[ V_1 = 200 \sqrt{2} \text{ V peak} \]

\[ V_2 = 2 \times V_1 = 400 \sqrt{2} \text{ V} \]

\[ I_2 = 3 \sqrt{2} \text{ A peak} \]

Reflect the secondary to the primary.

\[ n \times I_2 = 6 \sqrt{2} \text{ A} \]

\[ \frac{V_2}{V_1} = 2 \]

\[ I_1 = 6 \sqrt{2} \text{ A} \]

\[ V_2 = 2 \times V_1 = 400 \sqrt{2} \text{ V} \]
15.63 continue

(b) \[ P_1 = \frac{200 \times 6 \times \cos 30}{2} = 519.6 \text{ W} \]

This means that source 1 is supplying 519.6 W to the circuit source.

c) Reverse one of the dots. This makes the current source arrow point up, but still has value of 6 L30°.

1a) \[ I_1 = -6 L30 = 6 L180 \text{ A} \]

\[ V_2 = -2 V_1 = -400 V = 400 L180 \]

1b) \[ P_{1s} = \frac{200 \times 6 \times \cos (-180)}{2} = -519.6 \text{ W} \]

\[ P_{2s} = \frac{400 \times 6 \cos (180 - (-180))}{2} = 519.6 \text{ W} \]

Source 2 supplies 519.6 W to source 1.
Another way to find $I_1$ and $V_2$ is through analysis, no reflections.

Looking at the original transformer, we have for both sides up and $V_1, V_2, I_1, I_2$ as indicated

$V_1 = 200\,\text{V}$

$\frac{V_2}{V_1} = 2$

$V_2 = 2V_1 = 400\,\text{V}$

$\frac{I_1}{I_2} = +n = 2$

$I_1 = 2I_2 = 6\,\text{A}$
(15.65)

(a) Reflect the resistance and voltage source to the left in the circuit below, and find \( I_1 \).

(b) Repeat (a) but with one of the dots reversed.

\[
\begin{align*}
12 & \Rightarrow \frac{1}{n^2} = \frac{1}{12^2} = 4 \\
100 \text{V} & \\
100 \text{V} & \\
25 \text{V} & \\
\end{align*}
\]

\[
\begin{align*}
I_1 & = \frac{100 \text{V} + 50 \text{V}}{5} = 30 \text{A} \\
\text{Note reverse of polarity} \\
\end{align*}
\]

(b) Reversing one of the dots changes the polarity of the 25V voltage source.

\[
I_1 = \frac{100 \text{V} - 50 \text{V}}{5} = 10 \text{A}
\]