Task 1

Convert the following numbers to decimal:

Binary:

1. 00110101
2. 00001010
3. 00101111
4. 10001000

Hexadecimal:

1. 41
2. 61
3. 7A
4. FF

Task 1 Solution

The way to convert from binary to decimal is the same as convert from base-2 to base-10:

$00110101_2 = [(0) \cdot 2^7] + [(0) \cdot 2^6] + [(1) \cdot 2^5] + [(1) \cdot 2^4] + [(0) \cdot 2^3] + [(1) \cdot 2^2] + [(0) \cdot 2^1] + [(1) \cdot 2^0] = 53$

Binary:

1. 53
2. 10
3. 47
4. 136

The way to convert from hexadecimal to decimal is the same as convert from base-16 to base-10:

$41_{16} = [(4) \cdot 16^1] + [(1) \cdot 16^0] = 65$

Hexadecimal:

1. 65
2. 97
3. 122
4. 255

Task 2

What is the symbol of the following ASCII codes:

Hexadecimal:

1. 0A
2. 0D
3. 41
4. 61

Decimal:

1. 48
2. 49
3. 92

Task 2 Solution

Hexadecimal:

1. LF (Line feed, new line)
2. CR (Carriage return)
3. A
4. a

Decimal:

1. 0
2. 1
3. \

Task 3

Consider a byte which stores a signed number in the range -128 to 127. Negative numbers are represented as two's complement.

The binary representation of the number 3 is 00000011, while the number -3 is the two's complement 11111101.

What is the binary representation of the following numbers:

0, 1, 10, 16, 32, 64, -1, -2, -10, -16, -32, -64

Task 3 Solution

$$0 = 00000000_2$$
$$1 = 00000001_2$$
$$10 = 00001010_2$$
$$16 = 00010000_2$$
$$32 = 00100000_2$$
$$64 = 01000000_2$$

Since this is represented in a byte there are 8 bits.

Using two's complement to find the negative of the number. Invert the bits and add 1. For instance -1:

	00000001	= 1
¬	11111110	= -2
+1	11111111	= -1

Table 1: Two's compliment of 1

$$-1 = 11111111_2$$
$$-10 = 11110110_2$$
$$-16 = 11110000_2$$
$$-32 = 11100000_2$$
$$-64 = 11000000_2$$

Task 4

Task 4.a

Show with a truth table that

$$A + B + (A \cdot \overline{B}) = A + B$$
$$(A + B) \cdot (A + \overline{B}) = A$$

Task 4.b

Draw logical gates for both sides of de Morgan's laws

$$\overline{A + B} = \overline{A} \cdot \overline{B}$$
$$\overline{A \cdot B} = \overline{A} + \overline{B}$$

Task 4 Solution

Task 4.a Solution

We can see that column 3 and 5 are equal in Table 2.

A	B	A + B	$A \cdot \overline{B}$	$A + B + (A \cdot \overline{B})$
0	0	0	0	0
0	1	1	0	1
1	0	1	1	1
1	1	1	0	1

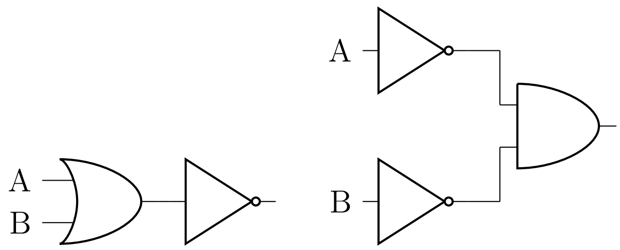
Table 2: Truth table for $A + B + (A \cdot \overline{B}) = A + B$

We can see that column 1 and 5 are equal in Table 3.

A	B	A + B	$A + \overline{B}$	$(A + B) \cdot (A + \overline{B})$
0	0	0	1	0
0	1	1	0	0
1	0	1	1	1
1	1	1	1	1

Table 3: Truth table for $(A + B) \cdot (A + \overline{B}) = A$

Task 4.b Solution



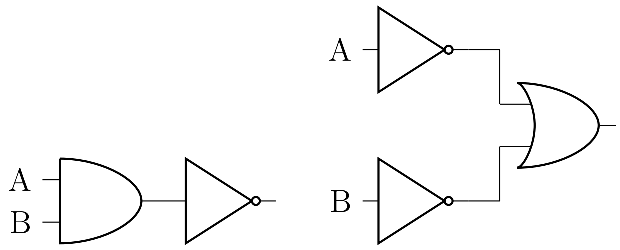
(a) $\overline{A + B}$ (b) $\overline{A} \cdot \overline{B}$

Figure 1: Logic gates for $\overline{A + B} = \overline{A} \cdot \overline{B}$

Task 5

Suppose that the three-phase voltages are in Figure 3 are:

$$v_a(t) = \sqrt{2} V_P cos(\omega t)$$
$$v_b(t) = \sqrt{2} V_P cos(\omega t - \frac{2\pi}{3})$$
$$v_c(t) = \sqrt{2} V_P cos(\omega t - \frac{4\pi}{3})$$



(a) $\overline{A \cdot B}$ (b) $\overline{A} + \overline{B}$

Figure 2: Logic gates for $\overline{A \cdot B} = \overline{A} + \overline{B}$

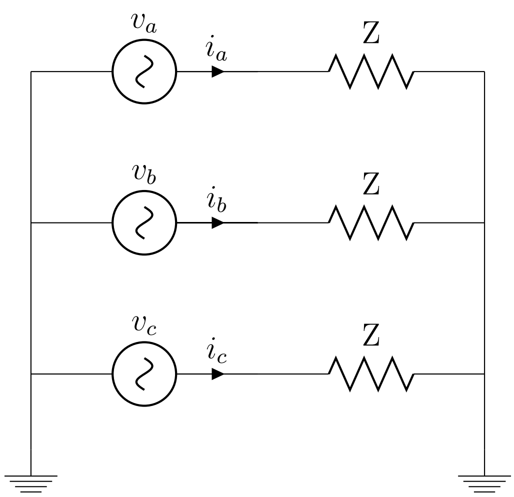


Figure 3: Three phase circuit

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While the phasor representations are:

$$\mathbb{V}_a(t) = V_P e^{j0}$$
$$\mathbb{V}_b(t) = V_P e^{-j\frac{2\pi}{3}}$$
$$\mathbb{V}_c(t) = V_P e^{-j\frac{4\pi}{3}}$$

Task 5.a

Suppose that the impedance is real and given by $\mathbb{Z} = 230\,\Omega$ and $V_P = 230\,\text{V}$. Find the current i_a, i_b and i_c and the corresponding phasors $\mathbb{I}_a$, $\mathbb{I}_b$ and $\mathbb{I}_c$.

Task 5.b

What is the power delivered to the impedances?

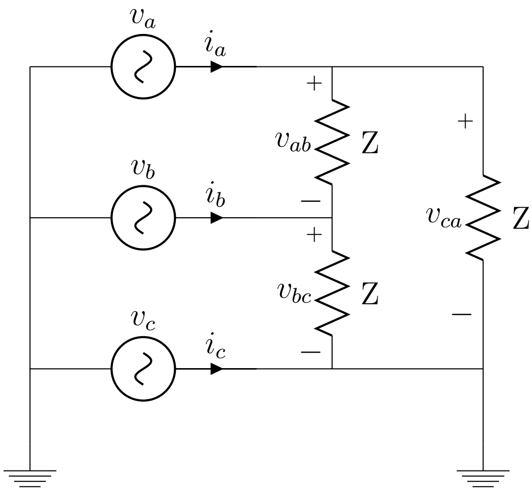

Figure 4: Three phase circuit

Task 5.c

Find v_{ab}, v_{bc} and v_{ca} and the corresponding phasors $\mathbb{V}_{ab}$, $\mathbb{V}_{bc}$ and $\mathbb{V}_{ca}$ in Figure 4.

Task 5.d

Find the currents i_{ab}, i_{bc} and i_{ca} and the corresponding phasors $\mathbb{I}_{ab}$, $\mathbb{I}_{bc}$ and $\mathbb{I}_{ca}$ with $\mathbb{Z}$ and V_P as given in Task 5.a.

Task 5.e

What is the power delivered to the impedances?

Task 5 Solution

Task 5.a Solution

Since $\mathbb{Z}$ is real we can use $v_a = \mathbb{Z} i_a$ with the same for b and c. This means that:

$$i_a(t) = \sqrt{2}\frac{V_P}{\mathbb{Z}}cos(\omega t) = \sqrt{2}\frac{230}{230}cos(\omega t) = \underline{\underline{\sqrt{2}cos(\omega t)}}$$
$$i_b(t) = \sqrt{2}\frac{V_P}{\mathbb{Z}}cos(\omega t - \frac{2\pi}{3}) = \sqrt{2}\frac{230}{230}cos(\omega t - \frac{2\pi}{3}) = \underline{\underline{\sqrt{2}cos(\omega t - \frac{2\pi}{3})}}$$
$$i_c(t) = \sqrt{2}\frac{V_P}{\mathbb{Z}}cos(\omega t - \frac{4\pi}{3}) = \sqrt{2}\frac{230}{230}cos(\omega t - \frac{4\pi}{3}) = \underline{\underline{\sqrt{2}cos(\omega t - \frac{4\pi}{3})}}$$

While the phasor representations are:

$$\mathbb{I}_a(t) = \frac{V_P}{\mathbb{Z}}e^{j0} = \frac{230}{230}e^{j0} = \underline{\underline{e^{j0}}}$$
$$\mathbb{I}_b(t) = \frac{V_P}{\mathbb{Z}}e^{-j\frac{2\pi}{3}} = \frac{230}{230}e^{-j\frac{2\pi}{3}} = \underline{\underline{e^{-j\frac{2\pi}{3}}}}$$
$$\mathbb{I}_c(t) = \frac{V_P}{\mathbb{Z}}e^{-j\frac{4\pi}{3}} = \frac{230}{230}e^{-j\frac{4\pi}{3}} = \underline{\underline{-e^{j\frac{4\pi}{3}}}}$$

Task 5.b Solution

$$P_a = V_a I_a = \sqrt{2}V_P cos(\omega t)\sqrt{2}cos(\omega t) = \underline{\underline{2V_P cos^2(\omega t)}}$$
$$P_b = V_b I_b = \sqrt{2}V_P cos(\omega t - \frac{2\pi}{3})\sqrt{2}cos(\omega t - \frac{2\pi}{3}) = \underline{\underline{2V_P cos^2(\omega t - \frac{2\pi}{3})}}$$
$$P_c = V_c I_c = \sqrt{2}V_P cos(\omega t - \frac{4\pi}{3})\sqrt{2}cos(\omega t - \frac{4\pi}{3}) = \underline{\underline{2V_P cos^2(\omega t - \frac{4\pi}{3})}}$$

Task 5.c Solution

$$v_{ab} = v_a - v_b = \sqrt{2}V_P cos(\omega t) - \sqrt{2}V_P cos(\omega t - \frac{2\pi}{3}) = \sqrt{2}V_P \cdot -2sin(\omega t - \frac{\pi}{3})sin(\frac{\pi}{3})$$
$$= \underline{\underline{-\sqrt{6}V_P sin(\omega t - \frac{\pi}{3})}}$$
$$v_{bc} = v_b - v_c = \sqrt{2}V_P cos(\omega t - \frac{2\pi}{3}) - \sqrt{2}V_P cos(\omega t - \frac{4\pi}{3}) = \sqrt{2}V_P \cdot -2sin(\omega t - \pi)sin(\frac{-\pi}{3})$$
$$= \underline{\underline{-\sqrt{6}V_P sin(\omega t - \pi)}}$$
$$v_{ca} = v_c - v_a = \sqrt{2}V_P cos(\omega t - \frac{4\pi}{3}) - \sqrt{2}V_P cos(\omega t) = \sqrt{2}V_P \cdot -2sin(\omega t - \frac{2\pi}{3})sin(\frac{-2\pi}{3})$$
$$= \underline{\underline{\sqrt{6}V_P sin(\omega t - \frac{2\pi}{3})}}$$

$$\mathbb{V}_{ab} = \mathbb{V}_a - \mathbb{V}_b = V_P(e^{j0} - e^{-j\frac{2\pi}{3}}) = \underline{\underline{\sqrt{3}V_P e^{j\frac{\pi}{6}}}}$$
$$\mathbb{V}_{bc} = \mathbb{V}_b - \mathbb{V}_c = V_P(e^{-j\frac{2\pi}{3}} - e^{-j\frac{4\pi}{3}}) = \underline{\underline{\sqrt{3}V_P e^{-j\frac{\pi}{2}}}}$$
$$\mathbb{V}_{ca} = \mathbb{V}_c - \mathbb{V}_a = V_P(e^{-j\frac{4\pi}{3}} - e^{j0}) = \underline{\underline{\sqrt{3}V_P e^{j\frac{-7\pi}{6}}}}$$

Task 5.d Solution

$$i_{ab} = \frac{v_{ab}}{\mathbb{Z}} = -\sqrt{6}\frac{230}{230}sin(\omega t - \frac{\pi}{3}) = \underline{\underline{-\sqrt{6}sin(\omega t - \frac{\pi}{3})}}$$
$$i_{bc} = \frac{v_{bc}}{\mathbb{Z}} = -\sqrt{6}\frac{230}{230}sin(\omega t - \pi) = \underline{\underline{-\sqrt{6}sin(\omega t - \pi)}}$$
$$i_{ca} = \frac{v_{ca}}{\mathbb{Z}} = \sqrt{6}\frac{230}{230}sin(\omega t - \frac{2\pi}{3}) = \underline{\underline{\sqrt{6}sin(\omega t - \frac{2\pi}{3})}}$$

$$\mathbb{I}_{ab} = \sqrt{3}\frac{230}{230}e^{j\frac{-\pi}{6}} = \underline{\underline{\sqrt{3}e^{j\frac{\pi}{6}}}}$$
$$\mathbb{I}_{bc} = \sqrt{3}\frac{230}{230}e^{j\frac{-\pi}{2}} = \underline{\underline{\sqrt{3}e^{-j\frac{\pi}{2}}}}$$
$$\mathbb{I}_{ca} = \sqrt{3}\frac{230}{230}e^{j\frac{-7\pi}{6}} = \underline{\underline{\sqrt{3}e^{j\frac{-7\pi}{6}}}}$$

Task 5.e Solution

$$P_{ab} = v_{ab}i_{ab} = -230\sqrt{6}sin(\omega t - \frac{\pi}{3})\sqrt{6}sin(\omega t - \frac{\pi}{3}) = \underline{\underline{-1380sin^2(\omega t - \frac{\pi}{3})}}$$
$$P_{bc} = v_{bc}i_{bc} = -230\sqrt{6}sin(\omega t - \pi)\sqrt{6}sin(\omega t - \pi) = \underline{\underline{-1380sin^2(\omega t - \pi)}}$$
$$P_{ca} = v_{ca}i_{ca} = 230\sqrt{6}sin(\omega t - \frac{2\pi}{3})\sqrt{6}sin(\omega t - \frac{2\pi}{3}) = \underline{\underline{1380sin^2(\omega t - \frac{2\pi}{3})}}$$