## **CHAPTER ONE**

## COMPONENTS, QUANTITIES, AND UNITS, SCIENTIFIC & ENGINEERING NOTATIOS

## **Objectives:**

- To recognize electronics components.
- Identify magnetic, electrical quantities, units.
- Express quantities in scientific notation.
- Express quantities in the metric scale.
- Convert from one metric unit to another.

## **1-1 Circuit Elements:**

Circuit elements are divided into two categories:

- a- Passive elements.
- b- Active elements.

## **1-1.1 Passive Elements:**

The passive elements are:

- a- Resistor.
- **b-** Capacitor.
- **c-** Inductor.

The Quantity for the **resistor** is the **resistance** and it is measured in the **ohms** units. That for the **capacitor** is the **capacitance** and it is measured in the **Farads** units and that for the **inductor** is the **Inductance**, and it is measured in the **Henrys** units.

The symbols of all three elements are as shown in Figure 1-1.





1-1. b. Capacitor



1-1. c. Inductor

## FIGURE 1-1. Passive elements symbols.

## **1-1.2 Active Elements:**

Active elements range from components such as a diode, to other elements such as the bipolar junction transistor (BJT), field effect transistor (FET). Other elements are the silicon controlled rectifier (SCR), varactor, operational amplifier (Op-Amp) and many more. Active elements do not have any measurement units. Some active element symbols are as shown in Figure 1-2.



1-2. a. Diode



1-2. b. Operational Amplifier



1-2. c. Bipolar Junction Transistor (BJT) 1-2. d. Field Effect Transistor (FET)



FIGURE 1-2. Active elements symbols.

## **1-2 Electronics Instruments:**

Electronics instruments range from voltage sources such as **power supplies** and **function generators** to measuring instruments such as the **voltmeter**, **ammeter**, **ohmmeters**, and **oscilloscopes**.

**Power supplies** are used to supply DC voltages to the whole electronic circuit (hence the name power supply). **Function generators** on the other hand are used to supply waveform signals such as sine waves, rectangular waves, and triangular waveforms. As for measuring instruments, the **voltmeter** is used to measure DC and AC voltages, the **ammeter** is used to measure DC and AC currents while the **ohmmeter** is used to measure resistances. The **oscilloscope** on the other hand is used to measure and display voltage waveforms and in some advanced oscilloscopes measure and display current, frequency, duty cycle and differences between two voltages and two current levels. Those advanced oscilloscopes have memory functions where you can store waveforms for later displays or printing.

Other measuring devices include Logic analyzers, Spectrum analyzers and frequency counters.

Figure 1-3 shows a variety of electronics instruments.

## **1-3** Electrical Units:

Of very high importance in electronics is the measurement of quantities. An example of a quantity is the capacitance which has the symbol C and is measured in Farads units symbolized as F. Table 1-1 lists the most common electrical quantities along and their SI units and symbols.

Quantity	Description	Quantity Symbol	Basic Unit	Unit Symbol
Resistance	An element that resists current flow	R	Ohm	Ω
Conductance	The opposite of a resistance	G	Siemens	S
Capacitance	An electric field storage element	С	Farad	F
Inductance	A magnetic field storage element	L	Henry	Н
Reactance	The AC ohmic value of a capacitance or an inductor	Х	Ohm	Ω
Impedance	The ohmic value of a combination of resistance, capacitance, inductor	Z	Ohm	Ω
Voltage	The potential difference between two circuit nodes	V	Volt	V
Current	The current passing through a circuit branch	Ι	Ampere	Α
Energy	The energy supplied by a voltage source or consumed by a load	E, W	Joule	J
Power	The rate of energy(power) supplied by a voltage source or consumed by a load	Р	Watt	W
Charge	The charge stored in an electric field	Q	Coulomb	С
Frequency	The repetition speed of a waveform	F	Hertz	Hz
Time	Absolute or differential time	t	Second	S

# Table 1-1. Electrical quantities and units (Partial Listing).1-4Scientific Notation and Metric Units:

It is always the case when working with quantities; you will encounter a wide range of values with decimal points. For example, in electronics you will get a value of **0.00000024** just as easily as you would get a value of **240000000**. To easily express these values in such a way they are meaningful, the Scientific notation is used. This scientific notation expresses numbers in powers of 10.

The power value is directly proportional to how the decimal point is moved around the number. Every time the decimal point is moved to the right, the power of the 10 is decremented by 1 and every time it is moved to the left, the power of the 10 is incremented by 1.

Going back to the numbers shown above, in scientific notation, the **0.00000024** number could be expressed as  $2.4 \times 10^{-7}$ . This is done by moving the decimal point 7 places to the right. On the other hand, the **240000000** could be expressed as  $2.4 \times 10^8$ . This is done by moving the decimal point by 8 places to the left.

The format for a scientific notation number is  $x.yyyy \times 10^{m}$  where x is a non-zero value and m is the power of the 10 which could be either positive or negative.

## **1-4.1** Scientific Notation Math:

## 1-4.1.1 Addition:

When adding two numbers expressed in scientific notation, the following rules should be applied:

- The two numbers should have the same power of 10.
- Perform the addition while ignoring the 10 and its power.
- Place the sum and replace the 10 and its power.

## **1-4.1.2 Subtraction:**

When subtracting one number from another, the following rules should be applied:

- The two numbers should have the same power of 10.
- Perform the subtraction while ignoring the 10 and its power.
- Place the difference and replace the 10 and its power.

## **1-4.1.3 Multiplication:**

When multiplying two numbers expressed in scientific notation, the following rules should be applied:

- Obtain the product of the two base numbers while excluding the powers of 10.
- Algebraically add the powers of the 10s to obtain a sum of the powers.
- Place the product of the base numbers and replace the 10 and its sum of powers.

## 1-4.1.4 Division:

When dividing two numbers expressed in scientific notation, the following rules should be applied:

- Obtain the quotient of the two numbers while excluding the power of 10.
- Algebraically subtract the divisor (denominator) power from the dividend (numerator) power to obtain the difference of the powers.
- Place the quotient and replace the 10 and its difference of powers.

## Example 1-1:

Add  $4.5 \times 10^6$  to  $2.8 \times 10^8$ .

## **Solution:**

This could be solved in either one of two methods:

*First method:* Convert to a power of 8.

- 1- Convert the  $4.5 \times 10^6$  to  $0.045 \times 10^8$ .
- 2- Add 2.8 to 0.045 = 2.845.
- 3- Replace the 10 and its power to obtain  $2.845 \times 10^8$ .

*Second method:* Convert to a power of 6.

- 1- Convert the  $2.8 \times 10^8$  to  $280 \times 10^6$ .
- 2- Add 280 to 4.5 = 284.5
- 3- Replace the 10 and its power and convert back to scientific notation to obtain  $2.845 \times 10^8$ .

Example 1-2:

Add 0.0000000375 to  $2.8 \times 10^{-9}$ .

## Solution:

This could be solved in either one of two methods:

*First method:* Convert to a power of -9.

- 1- 0.0000000375 is the same as 0.0000000375 ×10<sup>o</sup>
- 2- Convert the 0.00000000375 to its scientific notation to obtain  $3.75 \times 10^{-9}$ .
- 2- Add 3.75 to 2.8 = 6.55
- 3- Replace the 10 and its power to obtain  $6.55 \times 10^{-9}$ .

## Second method: Convert to decimal notation.

- 1- Convert the  $2.8 \times 10^{-9}$  to 0.000000028.
- 2- Add 0.0000000375 to 0.000000028 = 0.0000000655.
- 3- Convert the 0.0000000655 to  $6.55 \times 10^{-9}$ .

Example 1-3: Subtract 0.0000087 from 0.000009.

## **Solution:**

This could be solved in either one of two methods:

*First method:* Convert to a scientific notation power of -7.

- 1- Convert the 0.00000087 to  $8.7 \times 10^{-7}$ .
- 2- Convert the 0.000009 to  $90 \times 10^{-7}$ .
- 3- Subtract 8.7 from 90 = 81.3.
- 4- Replace the 10 and its power to obtain  $81.3 \times 10^{-7}$ .

Second method: Subtract in decimal form first and then convert to a power of -7.

- 1- Subtract 0.00000087 from 0.000009 = 0.00000813.
- 2- By moving the decimal 7 places to the right, convert to  $81.3 \times 10^{-7}$ .

## Example 1-4:

Subtract  $28 \times 10^7$  to  $45 \times 10^8$ .

**Solution:** 

This could be solved in either one of two methods:

## *First method:* Convert to a power of 8.

- 1- Convert the  $28 \times 10^7$  to  $2.8 \times 10^8$ .
- 2- Subtract 2.8 from 45 = 42.2.
- 3- Replace the 10 and its power to obtain  $42.2 \times 10^8$ .

## *Second method:* Convert to a power of 7.

- 1- Convert the  $45 \times 10^8$  to  $450 \times 10^7$ .
- 2- Subtract 28 from 450 = 422.

Replace the 10 and its power to obtain  $422 \times 10^7$ .

## Example 1-5:

Multiply  $1.5 \times 10^7$  by  $2.8 \times 10^2$ .

## **Solution:**

- 1- Obtain the product of the two numbers while excluding the power of 10 to get:  $1.5 \times 2.8 = 4.2$ .
- 2- Algebraically add the powers of the 10s to obtain a sum of the powers to get: 7 + 2 = 9.
- 3- Place the product (4.2) and replace the 10 and its sum of powers ( $10^9$ ) to get:  $4.2 \times 10^9$ .

## Example 1-6:

Multiply  $0.0000068 \times 10^{-5}$  by  $3.5 \times 10^{2}$ .

#### Solution:

- 1- First convert the decimal into scientific notation format. This will convert 0.0000068 to  $6.8 \times 10^{-6}$ .
- 2- Obtain the product of the two numbers while excluding the power of 10 to get:  $6.8 \times 3.5 = 23.8$ .
- 3- Algebraically add the powers of the 10 to obtain a sum of the powers to get: -6 5 + 2 = -9.
- 4- Place the product (23.8) and replace the 10 and its sum of powers to get:  $23.8 \times 10^{-9}$  which can also be expressed as  $2.38 \times 10^{-8}$ .

## Example 1-7:

Divide  $7.5 \times 10^7$  by  $1.5 \times 10^2$ .

## **Solution:**

- 1- Obtain the quotient of the two numbers while excluding the power of 10 to get:  $7.5 \div 1.5 = 5$ .
- 2- Algebraically subtract the divisor (denominator) power from the dividend (numerator) power to obtain the difference of the powers. This will result in: 7-2=5.
- 3- Place the quotient and replace the 10 and its difference of powers to get:  $5 \times 10^5$

## Example 1-8:

Divide  $3.7 \times 10^{-3}$  by  $14.8 \times 10^{2}$ .

## **Solution:**

- 1- Obtain the quotient of the two numbers while excluding the power of 10 to get:  $3.7 \div 14.8 = 0.25$ .
- 2- Algebraically subtract the divisor (denominator) power from the dividend (numerator) power to obtain the difference of the powers. This will result in: -3 - (-2) = -3 + 2 = -1.
- 3- Place the quotient and replace the 10 and its difference of powers to get:  $0.25 \times 10^{-1}$  or  $2.5 \times 10^{-2}$ .

## **1-4.2** Metric Prefixes:

Electrical and Electronics applications most often utilize the use of metric units. These metric units have metric prefixes in such a way that adjacent metrics prefixes are separated by a factor of  $1000 (10^3)$  or  $0.001(10^{-3})$ . The factor is 1000 when moving from a higher value prefix to its lower adjacent prefix. It is 0.001 when moving from a lower prefix to its adjacent higher prefix.

The most utilized metric prefixes are shown in Table 1-2.  $5 \times 10^{-9}$  V = 5 nV

Metric Prefix Name	Value Notation	Engineering Notation	Prefix Symbol
Femto	One Quintillionth	10 <sup>-15</sup>	f
Pico	One Trillionth	10 <sup>-12</sup>	р
Nano	One Billionth	10 <sup>-9</sup>	n
Micro	One Millionth	10 <sup>-6</sup>	μ
Milli	One Thousandth	10 <sup>-3</sup>	m
Basic prefix	One	$10^{\circ} = 1$	Any basic unit.
Kilo	One Thousand	10 <sup>3</sup>	K
Mega	One Million	$10^{6}$	М
Giga	One Billion	10 <sup>9</sup>	G
Tera	One Trillion	10 <sup>12</sup>	Т

## Table 1-2. Metric prefixes and their symbols.

Referring to table 1-2 and keeping in mind the engineering notation, one can express any number by using the proper metric prefix for it. For example, a current value of 0.02 A (Amperes) can be expressed in engineering notation as  $20 \times 10^{-3}$  A. When referencing Table 1-2 this indicates that it is a current value of 20 mA.

Any electronic or electrical value can be expressed in either metric unit format or engineering notation. The way it expressed is a matter of preference or requirement. Converting between metric units and engineering notations is essential in expressing values in such a way it is understood without any doubt. The chart shown in Table 1-3 serves as a good reference to convert between metric units and engineering notations. Conversion Illustrations are shown in examples 9 through 15. For these examples, refer to Table 1-1 to identify the units used.

Math Operation, Division or Multiplication									
This Direction — multiply									
This Direction  divide									
Т	G	М	Κ	Basic	m	μ	n	р	f
10 <sup>12</sup>	10 <sup>9</sup>	10 <sup>6</sup>	$10^{3}$	$10^{0}$	$10^{-3}$	$10^{-6}$	10 <sup>-9</sup>	10 <sup>-12</sup>	$10^{-15}$

## Table 1-3. Metric unit and scientific notation conversion chart.

#### Example 1-9:

- a- Convert 0.5 k $\Omega$  to  $\Omega$  (**Resistance**. Basic unit is **ohms**).
- b- Convert  $0.5 \text{ k}\Omega$  to  $G\Omega$  (**Resistance**. Basic unit is **ohms**).

#### **Solution:**

a - Referring to table 1-3, the unit movement is to the right. This means that to convert from  $k\Omega$  to  $\Omega$ , a multiplication process must take place. Between the  $k\Omega$  and the  $\Omega$  prefixes there is 1000. The multiplication is by 1000 or  $10^3$ . Therefore:

 $0.5 \text{ k}\Omega = 0.5 \times 1000 = 500 \Omega \text{ or:}$ 

 $0.5 \,\mathrm{k}\Omega = 0.5 \times 10^3 \,\Omega\,.$ 

b - Referring to table 1-3, the unit movement is in the left direction. This means that to convert from k $\Omega$  to G $\Omega$ , a division process must take place. Between the k $\Omega$  and the G $\Omega$  prefixes there is 1000 × 1000. The division is by 1000000. Therefore:

 $\begin{array}{l} 0.5 \ k\Omega \ = 0.5 \div 1000000 = 0.0000005 \ G\Omega \ or; \\ 0.5 \ k\Omega \ = 0.5 \times 10^{-6} \ G\Omega \, . \end{array}$ 

#### Example 1-10:

Convert 250 k $\Omega$  to M $\Omega$ . (**Resistance**. Basic unit is **ohms**)

#### **Solution:**

Referring to table 1-3, the unit movement is in the left direction. This means that to convert from  $k\Omega$  to  $M\Omega$ , a division process must take place. Between the  $k\Omega$  and the  $M\Omega$  prefixes there is 1000. The Division is by 1000 or a multiplication by  $10^{-3}$ . Therefore: 250  $k\Omega = 250 \div 1000 = 0.25 M\Omega$  or: 250  $k\Omega = 250 \times 10^{-3} M\Omega$ .

## Example 1-11:

Convert 0.075 mA to nA. (Electric current. Basic unit is Amperes)

#### **Solution:**

Referring to table 1-3, the unit movement is in the right direction. This means that to convert from mA to nA, a multiplication process must take place. Between the mA and the nA prefixes there is  $1000 \times 1000$ . The multiplication is by 1000000 or  $10^3 \times 10^3 = 10^6$ . Therefore:

 $0.075 \text{ mA} = 0.075 \times 1000 \times 1000 = 75000 \text{ nA or:}$ 

 $0.075 \text{ mA} = 0.075 \times 10^6 \text{ nA} = 75 \times 10^3 \text{ nA}.$ 

#### **Example 1-12:** Convert 0.000067 mF to pF. (**Capacitance**. Basic unit is **Farad**)

#### **Solution:**

Referring to table 1-3, the unit movement is in the right direction. This means that to convert from mA to nA, a multiplication process must take place. Between the mA and the nA prefixes there is  $1000 \times 1000 \times 1000$ . The multiplication is by  $1000000000 \text{ or } 10^3 \times 10^3 \times 10^3 = 10^9$ . Therefore:  $0.000067 \text{ mF} = 0.000067 \times 1000 \times 1000 \times 1000 = 67000 \text{ pF or:}$  $0.000067 \text{ mF} = 0.000067 \times 10^9 \text{ nA} = 67 \times 10^3 \text{ nA}$ 

## Example 1-13:

Convert 200 nF to µF. (Capacitance. Basic unit is Farad)

## **Solution:**

Referring to table 1-3, the unit movement is in the left direction. This means that to convert from nF to  $\mu$  F, a division process must take place. Between the nF and

the  $\mu$  F prefixes there is 1000. The division is by 1000 or  $10^3$  (same as

multiplying by  $10^{-3}$ ). Therefore:

 $200 \text{ nF} = 200 \div 1000 = 0.2 \ \mu \text{ F or:}$ 

 $200 \text{ nF} = 200 \times 10^{-3} \mu \text{ F}$ 

#### Example 1-14:

- a- Convert 387000  $\mu$  V to V. (Voltage. Basic unit is Volt).
- b- Add 3 V to 275 mV, express the answer in mV.

## **Solution:**

a- Referring to table 1-3, the unit movement is in the left direction. This means that to convert from  $\mu$  V to V, a division process must take place. Between the  $\mu$  V and the basic unit V prefixes there is 1000 × 1000. The division is by

1000000 or  $10^6$  (same as multiplying by  $10^{-6}$ ). Therefore: 387000  $\mu$  V = 387000 ÷1000000 = 0.387 V or:

 $387000 \ \mu V = 387000 \times 10^{-6} V = 387 \times 10^{-3}$ 

b- To express the answer in mV, the Volts value must be converted into mV. Referring to Table 1-3, the unit movement is in the right direction. This means that to convert from V to mV, a multiplication process must be performed. Between the basic unit V and the mV prefixes there is 1000. The Multiplication is by 1000 or  $10^3$ . Therefore:

 $3V = 3 \times 1000 = 3000 \text{ mV or:}$ 

Adding:  $3000 \text{ mV} + 275 \text{ mV} = 3275 \text{ mV} = 3275 \times 10^{-3} \text{ V}$ 

## Example 1-15:

Subtract 1300 pF from 0.0022 µ F (Capacitance. Basic unit is Farad).

## **Solution:**

In order to perform the subtraction, the two units must be identical. Either the pF is to be converted to  $\mu$  F or the  $\mu$  F is to be converted to pF.

## - *Converting from* $\mu$ *F to pF*:

Referring to table 1-3, the unit movement is in the right direction. This means that to convert from  $\mu$  F to pF, a multiplication process must take place. Between the  $\mu$  F and the pF prefixes there is 1000 × 1000. The multiplication is by 1000000 or 106 m s

10<sup>6</sup> Therefore:

 $0.0022 \ \mu F = 0.0022 \times 1000000 = 2200 \ pF.$ 

Adding the two numbers yields: 2200 pF + 1300 pF = 3500 pF.

## Converting from pF to $\mu$ F:

Referring to table 1-3, the unit movement is in the left direction. This means that to convert from pF to  $\mu$  F, a division process must take place. Between the pF and

 $\mu$  F prefixes there is 1000 × 1000. The division is by 1000000 or 10<sup>6</sup> (same as

multiplying by  $10^{-6}$  Therefore:

 $1300 \text{ pF} = 1300 \div 1000000 = 0.0013 \ \mu \text{ F}.$ 

Adding the two numbers yields:  $0.0022 \ \mu F + 0.0013 \ \mu F = 0.0035 \ \mu F$ .

## **1-5 Engineering Notation:**

From examples 9 through 15, notice that the scientific notation for some of the answers was expressed in multiples of three. This was done on purpose to introduce the student to a derived notation called the engineering notation. In engineering notation, powers of 10 are only expressed in multiples of three such as that seen in Table 1-2.

## **1-6 Prefix Multiplication & Division:**

Most often, when dealing with electronics analysis and calculations, multiplications, and divisions of various electrical quantities with different prefixes occur. Table 1-4 and Table 1-5 can be used to expedite the calculation process and provide the prefix answer without the need to enter the prefix corresponding powers of 10 into the calculator.

Prefix	Т	G	Μ	K	Basic	m	μ	n	р
Т	10 <sup>24</sup>	<b>10</b> <sup>21</sup>	10 <sup>18</sup>	<b>10</b> <sup>15</sup>	Т	G	Μ	K	Basic
G	<b>10</b> <sup>21</sup>	<b>10</b> <sup>18</sup>	<b>10</b> <sup>15</sup>	Т	G	М	K	Basic	m
Μ	10 <sup>18</sup>	10 <sup>15</sup>	Т	G	М	K	Basic	m	μ
K	10 <sup>15</sup>	Т	G	М	K	Basic	m	μ	n
Basic	Т	G	М	K	Basic	m	μ	n	р
m	G	М	K	Basic	m	μ	n	р	f
μ	М	K	Basic	m	μ	n	р	f	10-18
n	K	Basic	m	μ	n	р	f	10-18	10-21
р	Basic	m	μ	n	р	f	10-18	10 <sup>-21</sup>	10-24

Table 1-4. Metrics prefixes multiplication table. Note: Basic refers to thebasic unit with no prefix.

Prefix	Т	G	Μ	K	Basic	m	μ	n	р
Т	Basic	m	μ	n	р	f	10-18	10-21	10-24
G	K	Basic	m	μ	n	р	f	<b>10</b> <sup>-18</sup>	10-21
М	М	K	Basic	m	μ	n	р	f	10 <sup>-18</sup>
K	G	Μ	K	Basic	m	μ	n	р	f
Basic	Т	G	М	K	Basic	m	μ	n	р
m	<b>10</b> <sup>15</sup>	Т	G	М	K	Basic	m	μ	n
μ	10 <sup>18</sup>	10 <sup>15</sup>	Т	G	Μ	K	Basic	m	μ
n	<b>10</b> <sup>21</sup>	10 <sup>18</sup>	10 <sup>15</sup>	Т	G	М	K	Basic	m
р	<b>10</b> <sup>24</sup>	<b>10</b> <sup>21</sup>	10 <sup>18</sup>	<b>10</b> <sup>15</sup>	Т	G	Μ	K	Basic

Table 1-5. Metrics prefixes division table (Row1 elements ÷ Column1elements). Note: Basic refers to the basic unit with no prefix.

## **1-7 Unit Multiplication & Division:**

Some basic unit multiplications and divisions are so common which warrants listing them. The following are such listing:

## **Multiplications:**

a- $\mathbf{\Omega} \times A$	$\mathbf{A} = \mathbf{V}$	$(Ohms \times Amperes = Volts).$
b- $\mathbf{A} \times \mathbf{V}$	$V = \mathbf{W}$	(Amperes $\times$ Volts = Watts).
c- $\mathbf{A} \times \mathbf{S}$	$\mathbf{S} = \mathbf{C}$	(Amperes ×Seconds = Coulombs).
d- $\mathbf{W} \times \mathbf{S}$	S = J	(Watts $\times$ Seconds = Joules).

## **Divisions:**

a- $\mathbf{V} \div \mathbf{\Omega} = \mathbf{A}$	(Volts $\div$ Ohms = Amperes).
b- $\mathbf{V} \div \mathbf{A} = \mathbf{\Omega}$	(Volts $\div$ Amperes = Ohms).
$c-\mathbf{W} \div \mathbf{A} = \mathbf{V}$	(Watts $\div$ Amperes = Volts).
$d-\mathbf{W} \div \mathbf{V} = \mathbf{A}$	(Watts $\div$ Volts = Amperes).
$e - C \div S = A$	$(Coulombs \div Seconds = Amperes).$
$f - C \div A = S$	$(Coulombs \div Amperes = Seconds).$
$g - J \div W = S$	(Joules $\div$ Watts = Seconds).

$h - J \div S = W$	(Joules $\div$ Seconds = Watts).
$i - J \div Q = V$	(Joules $\div$ Coulombs = Volts)

This concludes Chapter one theory. See next for pertaining solved problems.

## **1-8 Solved Problems:**

## 1) Complete the following table:

ROW	QUANTITY	UNIT	ABBREVIATION	SYMBOL
1	Current			
2		Volts		
3			R	
4	Frequency			
5				$\mathbf{W}$

## Solution:

## **For row 1 in the table:**

The quantity is the current. The unit for the current is the Ampere. The abbreviation for the current is I. The symbol for the current is A.

## For row 2 in the table:

The quantity is the voltage. The unit for the voltage is the Volt. The abbreviation for the voltage is V. The symbol for the voltage is V.

## For row 3 in the table:

The Quantity is the resistance. The unit for the resistance is the Ohm. The abbreviation for the resistance is R. The symbol for the resistance is  $\Omega$ .

## For row 4 in the table:

The Quantity is the frequency. The unit for the frequency is the Hertz. The abbreviation for the frequency is f. The symbol for the frequency is Hz.

## For row 5 in the table:

The Quantity is the Power. The unit for the power is the Watt. The abbreviation for the power is P. The symbol for the power is W.

Therefore, when completed, the table will be:

ROW	QUANTITY	UNIT	ABBREVIATION	SYMBOL
1	Current	Ampere	Ι	Α
2	Voltage	Volts	V	$\mathbf{V}$
3	Resistance	Ohm	R	Ω
4	Frequency	Hertz	F	Hz
5	Power	Watt	Р	W

## 2) Convert the following numbers to the scientific notation form:

<b>a-</b> 254	<b>b-</b> 300 × 10 <sup>2</sup>	<b>c-</b> 13,650,000,000
<b>d-</b> 0.0000657	<b>e-</b> $0.0035 \times 10^{-2}$	<b>f-</b> 687.5 × 10 <sup>-3</sup>

## Solution:

Remember that scientific notation is expressed as powers of 10. Also, moving the decimal to the left by one place causes the power of 10 to increment by 1 while moving it to the right causes the power to decrement by 1 as well.

**a**- 254 is the same as 254.0 and also the same as  $254.0 \times 10^{0}$  since  $10^{0} = 1$ . Therefore we could move the decimal point to the left by 2 places thereby causing the result to be  $2.54 \times 10^{2}$ .

**b**-  $300 \times 10^2$  is the same as  $300.0 \times 10^2$ , following the rules above, this can be converted to  $3.0 \times 10^4$ .

**c-** 13,650,000,000 is the same as 13,650,000,000.0 ×10<sup>0</sup>. By moving the decimal point 10 places to the left, the power of 10 will increment by 10. Therefore the number expressed in scientific notation will be **1.365** × 10<sup>10</sup>.

**d-** For 0.0000657 is the same as  $0.0000657 \times 10^{0}$ . Moving the decimal point by 6 places

to the right, the power of the 10 would decrement by 6 as well. Therefore, the number expressed in scientific notation will be  $6.57 \times 10^{-6}$ .

e- For  $0.0035 \times 10^{-2}$ , could be expressed as  $3.5 \times 10^{-5}$  by moving the decimal place to the right by 3 places while subtracting 3 from the power of the 10.

**f**- For  $687.5 \times 10^{-3}$ , the decimal point could be moved to the left by 2 places while adding 2 to the power of the 10. The number expressed in scientific notation will be  $6.875 \times 10^{-1}$ .

## 3) Convert the following into engineering notation format:

<b>a-</b> 684 ohms	<b>b-</b> $525 \times 10^{2}$ Amps	<b>c-</b> 13,650,000,000 Ohms
<b>d-</b> 0.0000950 Volts	<b>e-</b> $0.0035 \times 10^{-3}$ Volts	<b>f-</b> 723.5 × $10^{-3}$ Amps

## **Solution:**

Remember that engineering notation is nothing more than scientific notation where the powers of the 10 are simply multiples of 3 including the zero. Such powers which are most common are listed in the following table:

Metric Prefix Name	Scientific Notation also known as Engineering Notation	Symbol
•••••	•••••	•••••
Femto	10 <sup>-15</sup>	f
Pico	10 <sup>-12</sup>	р
Nano	10 <sup>-9</sup>	n
Micro	10 <sup>-6</sup>	μ
Milli	10 <sup>-3</sup>	m
Basic prefix	$10^{\circ} = 1$	Any basic unit
Kilo	10 <sup>3</sup>	K
Mega	10 <sup>6</sup>	М
Giga	109	G
Tera	10 <sup>12</sup>	Т
•••••	••••	•••••

Table 1-4. Engineering notation powers of 10.

Technically, as long as the answers are expressed in powers of 3, they are represented in the engineering notation format. However, the choice of the power must be made in such a way it makes sense in the context of the subject at hand. Finally, the same rules apply as far as the movement of the decimal point and its correspondence to power of 10 adjustments.

- **a-** 684 is the same as  $684.0 \times 10^{0}$ , so moving the decimal point to the left by 3 places corresponds to the addition of a 3 to the power of 10. Therefore, the answer is  $0.684 \times 10^{0+3}$  or  $0.684 \times 10^{3}$  which when expressed in a prefix format is 0.684 Kilo or simply put **0.684 K**.
- **b-**  $525 \times 10^{-4}$  is the same as  $525.0 \times 10^{-4}$ , so moving the decimal point one place to the left corresponds to adding a 1 to the power of 10. Therefore, the answer  $52.5 \times 10^{-4} + 1$  or  $52.5 \times 10^{-3}$  which when expressed in a prefix format is 52.5 milli also expressed as **52.5 m.**
- c- 13,650,000,000 Ohms is the same s 13,650,000,000.0 × 10<sup>0</sup>, so moving the decimal point 9 places to the left corresponds to adding a 9 to the power of 10. Therefore the answer is  $13.65 \times 10^9$ . This expressed in a prefix format is **13.65 G** $\Omega$ .
- **d** 0.0000950 Volts is the same as  $0.0000950 \times 10^{0}$  Volts. This could also be expressed as  $95.0 \times 10^{-6}$  Volts. This is done by moving the decimal point 6 places to the right while subtracting 6 from the power of 10. Therefore, the answer is  $95.0 \times 10^{-6}$  Volts. This when expressed in a prefix format is 95 milli volt or simply **95 mV**.
- e-  $0.0035 \times 10^{-3}$  Volts could also be expressed as  $3.5 \times 10^{-6}$  Volts. This is done by moving the decimal point 3 places to the right while subtracting 3 from the power of 10. When expressed in a prefix format, the answer is 3.5 micro volts or simply  $3.5 \mu V$ .
- **f**  $723.5 \times 10^{-3}$  is simply 723.5 milli Amps or simply **723.5 mA**.

# 4) Re-write each number in scientific notation format expressing each number as one between 1 & 10 times a positive power of 10:

**a**- 4000 **b**- 300 **c**- 750000 **d**- 60000

## Solution:

In order to express each number as a single digit, the decimal point has to move to the left until that digit is reached. Recall that every time the decimal is moved to the left by one place, the power of 10 must be incremented by 1. **a-** 4000 is the same as  $4000.0 \times 10^{\circ}$ . So in this case to get a 4 (number between 1 & 10), the decimal has to move to the left 3 places. Consequently, the power of 10 has to be incremented by 3. Therefore:

 $4000 = 4.0 \times 10^{0+3} = 4 \times 10^{+3} .$ 

**b-** 300 is the same as  $300.0 \times 10^{\circ}$ . So in this case to get a 3 (number between 1 & 10), the decimal has to move to the left 2 places. Consequently, the power of 10 has to be incremented by 2. Therefore:

 $300 = 3.0 \times 10^{0+2} = 3 \times 10^{+2}$ .

**c**- 750000 is the same as 750000.0 × 10<sup>**0**</sup>. So in this case to get a 7.5 (number between 1 & 10), the decimal has to move to the left 5 places. Consequently, the power of 10 has to be incremented by 5. Therefore: **750000** = **7.5** × 10<sup>**0**+5</sup> = **7.5** × 10<sup>+5</sup>.

**d-** 60000 is the same as 60000.0 × 10<sup>**0**</sup>. So in this case to get a 6 (number between 1 & 10), the decimal has to move to the left 4 places. Consequently, the power of 10 has to be incremented by 4. Therefore: **60000** = **6.0** × 10<sup>**0**+4</sup> = **6** × 10<sup>+4</sup>.

5) Re-write each number in scientific notation format expressing each number as one between 1 & 10 times a negative power of 10:

<b>a-</b> 0.04	<b>b-</b> 0.3
<b>c-</b> 0.000086	<b>d-</b> 0.009

## Solution:

In order to express each number as a single digit, the decimal point has to move to the right until that digit is reached. Recall that every time the decimal is moved to the right by one place, the power of 10 has to be decremented by 1.

**a**- 0.04 is the same as  $0.04 \times 10^{\circ}$ . So in this case to get a 4 (number between 1 & 10), the decimal has to move to the right by 2 places Consequently, the power of 10 has to be decremented by 2. Therefore: **0.04 = 4.0** × 10<sup>o-2</sup> = 4 × 10<sup>-2</sup>.

**b-** 0.3 is the same as  $0.3 \times 10^{\circ}$ . So in this case to get a 3 (number between 1 & 10), the decimal has to move to the right by 1 place. Consequently, the power of 10 has to be decremented by 1. Therefore:

 $0.3 = 3.0 \times 10^{0-1} = 3 \times 10^{-1}$ .

**c**- 0.000086 is the same as  $0.000086 \times 10^{\circ}$ . So in this case to get an 8.6 (number between 1 & 10), the decimal has to move to the right by 5 places. Consequently, the power of 10 has to be decremented by 5. Therefore: **0.000086 = 8.6 × 10^{\circ-5} = 8.6 × 10^{-5}**.

**d-** 0.009 is the same as  $0.009 \times 10^{\circ}$ . So in this case to get a 9 (number between 1 & 10), the decimal has to move to the right by 3 place. Consequently, the power of 10 has to be decremented by 3. Therefore:

 $0.009 = 9 \times 10^{0-3} = 9 \times 10^{-3}$ .

## **6)** Express the following power of 10 numbers into regular decimal numbers:

<b>a-</b> $2 \times 10^{2}$ .	<b>b-</b> $8.5 \times 10^{4}$ .
<b>c-</b> $1.8 \times 10^{-2}$ .	<b>d-</b> $425 \times 10^{-5}$ .

#### **Solution:**

In order to express each number as a regular decimal number, the power of the 10 has to be reduced or increased to 0, since  $10^{0} = 1$ . Recall that every time the power of 10 is decremented by 1, the decimal point moves to the right by one place. On the other hand every time the power of 10 is incremented by 1, the decimal point is moved to the left by one place.

**a**-  $2 \times 10^2$  is the same **as**  $2.0 \times 10^2$ . Therefore, decrementing the power of 10 from 2 to 0 results in moving the decimal point two places to the right. Consequently:  $2 \times 10^2 = 2.0 \times 10^2 = 20.0 \times 10^1 = 200.0 \times 10^0 = 200$ .

**b-**  $8.5 \times 10^{4}$  is converted to a regular decimal following the same approach in part "a". Therefore, decrementing the power of 10 from 4 to 0 results in moving the decimal point four places to the right. Consequently:  $8.5 \times 10^{4} = 85.0 \times 10^{3} = 850.0 \times 10^{2} = 8500.0 \times 10^{1} = 85000 \times 10^{9} = 85000$ .

c-  $1.8 \times 10^{-2}$  is converted to a regular decimal by first increasing the power of the 10 to 0. This is done by incrementing the power by 2. Therefore, incrementing the power of 10 from -2 to 0 results in moving the decimal point two places to the left. Consequently: **1.8**  $\times 10^{-2} = 0.18 \times 10^{-1} = 0.018 \times 10^{0} = 0.018$ .

**d-** 425 × 10<sup>-5</sup> is converted to a regular decimal by first increasing the power of the 10 to 0. This is done by incrementing the power by 5. Therefore, incrementing the power of 10 from -5 to 0 results in moving the decimal point five places to the left. Consequently:  $425 \times 10^{-5} = 425.0 \times 10^{-5} = 42.5 \times 10^{-4} = 4.25 \times 10^{-3} = 0.425 \times 10^{-2} = 0.0425 \times 10^{-1} = 0.00425 \times 10^{0} = 0.000425.$ 

## 7) Perform the following scientific notation addition operations:

<b>a</b> - $(83 \times 10^5)$ + $(2.5 \times 10^6)$	<b>b-</b> $(4 \times 10^{2})$ + $(25000 \times 10^{-3})$
<b>c-</b> $(375 \times 10^{-5}) + (260 \times 10^{-6})$	<b>d-</b> $(500 \times 10^{-2}) + (0.002 \times 10^{-3})$

#### **Solution:**

When adding numbers expressed in the scientific notation format, the best approach is to have the numbers added expressed as having the same power of 10. After that, the addition operation is simply a straight addition.

**a-**  $(83 \times 10^5) + (2.5 \times 10^6)$  could be either expressed as  $(8.3 \times 10^6) + (2.5 \times 10^6)$  or as  $(83 \times 10^5) + (25 \times 10^5)$ . Either way, the addition becomes a straight one. This will yield answers as:

 $(8.3 \times 10^{6}) + (2.5 \times 10^{6}) = 10.8 \times 10^{6} \text{ or } (83 \times 10^{5}) + (25 \times 10^{5}) = 108 \times 10^{5}.$ 

**b-**  $(4 \times 10^2) + (25000 \times 10^{-3})$  also could be expressed as  $(400000 \times 10^{-3}) + (25000 \times 10^{-3})$  or as  $(4 \times 10^2) + (0.25 \times 10^2)$ . Now that the two numbers added have the same powers of 10, the addition becomes a straight one. This will yield the following answers as:

 $(400000 \times 10^{-3}) + (25000 \times 10^{-3}) = 425000 \times 10^{-3} \text{ or } (4 \times 10^{2}) + (0.25 \times 10^{2}) = 4.25 \times 10^{2}.$ 

**c**-  $(375 \times 10^{-5}) + (260 \times 10^{-6})$  again could be expressed as  $(3750 \times 10^{-6}) + (260 \times 10^{-6})$  or as  $(375 \times 10^{-5}) + (26 \times 10^{-5})$ . With the powers of 10 the same, the addition then will be a straight one. Therefore the answers are:

 $(3750 \times 10^{-6}) + (260 \times 10^{-6}) = 4010 \times 10^{-6} \text{ or } (375 \times 10^{-5}) + (26 \times 10^{-5}) = 401 \times 10^{-5}.$ 

**d**-  $(500 \times 10^{-2}) + (0.002 \times 10^{-3})$  could also be expressed as  $(0.005 \times 10^{-3}) + (0.002 \times 10^{-3})$  or as  $(500 \times 10^{-2}) + (200 \times 10^{-2})$ . With the powers of 10 the same, the addition then will be a straight one. Therefore the answers are:

 $(0.005 \times 10^{3}) + (0.002 \times 10^{3}) = 0.007 \times 10^{3} \text{ or } (500 \times 10^{-2}) + (200 \times 10^{-2}) = 700 \times 10^{-2}.$ 

## 8) Perform the following scientific notation subtraction operations:

<b>a</b> - $(83 \times 10^5)$ - $(2.5 \times 10^6)$	<b>b</b> - $(4 \times 10^{2})$ - $(25000 \times 10^{-3})$
<b>c</b> - $(375 \times 10^{-5})$ - $(260 \times 10^{-6})$	<b>d</b> - $(500 \times 10^{-2})$ - $(0.002 \times 10^{-3})$

#### **Solution:**

When performing subtractions expressed in the scientific notation format, the best approach is to have the numbers added expressed as having the same power of 10. After that, the addition operation is simply a straight subtraction.

**a**-  $(83 \times 10^5)$  -  $(2.5 \times 10^6)$  could be either expressed as  $(8.3 \times 10^6)$  -  $(2.5 \times 10^6)$  or as  $(83 \times 10^5)$  -  $(25 \times 10^5)$ . Either way, the subtraction becomes a straight one. This will yield answers as:

 $(8.3 \times 10^{6}) - (2.5 \times 10^{6}) = 5.8 \times 10^{6} \text{ or } (83 \times 10^{5}) - (25 \times 10^{5}) = 58 \times 10^{5}.$ 

**b**-  $(4 \times 10^2)$  -  $(25000 \times 10^{-3})$  also could be expressed as  $(400000 \times 10^{-3})$  -  $(25000 \times 10^{-3})$  or as  $(4 \times 10^2)$  -  $(0.25 \times 10^2)$ . Now that the two numbers have the same powers of 10, the subtraction becomes a straight one. This will yield the following answers as:

 $(400000 \times 10^{-3}) - (25000 \times 10^{-3}) = 375000 \times 10^{-3} \text{ or } (4 \times 10^{-2}) - (0.25 \times 10^{-2}) = 3.75 \times 10^{-2}.$ 

**c**-  $(375 \times 10^{-5})$  -  $(260 \times 10^{-6})$  again could be expressed as  $(3750 \times 10^{-6})$  -  $(260 \times 10^{-6})$  or as  $(375 \times 10^{-5})$  -  $(26 \times 10^{-5})$ . With the powers of 10 the same, the subtraction then will be a straight one. Therefore the answers are:

 $(3750 \times 10^{-6}) - (260 \times 10^{-6}) = 3490 \times 10^{-6} \text{ or } (375 \times 10^{-5}) - (26 \times 10^{-5}) = 349 \times 10^{-5}.$ 

**d-**  $(500 \times 10^{-2}) - (0.002 \times 10^{-3})$  could also be expressed as  $(0.005 \times 10^{-3}) - (0.002 \times 10^{-3})$  or as  $(500 \times 10^{-2}) - (200 \times 10^{-2})$ . With the powers of 10 the same, the subtraction then will be a straight one. Therefore the answers are:

 $(0.005 \times 10^{3}) - (0.002 \times 10^{3}) = 0.003 \times 10^{3} \text{ or } (500 \times 10^{-2}) - (200 \times 10^{-2}) = 300 \times 10^{-2}.$ 

## 9) Perform the following scientific notation multiplications:

a- $(8 \times 10^{-2}) \times (5 \times 10^{-5})$	b- $(2.5 \times 10^{3}) \times (4 \times 10^{2})$
$c - (1.45 \times 10^{-9}) \times (4.0 \times 10^{-3})$	d- $(0.6 \times 10^{-4}) \times (5 \times 10^{7})$

## **Solution:**

When multiplying numbers expressed in scientific notation, the multiplication is performed in two steps; first simply multiply the numerical numbers with each other and obtain a product. Next, when multiplying the 10s and their power, simply add the powers of the 10s.

**a-** For  $(8 \times 10^{-2}) \times (5 \times 10^{-5})$ , the numerical numbers are 8 and 5. Therefore their product is 40. Next, the powers of the 10s which are -2 and -5 are added together to yield -7. Therefore, the whole product is  $40 \times 10^{-7}$ .

**b-** For  $(2.5 \times 10^{3}) \times (4 \times 10^{2})$ , the numerical numbers are 2.5 and 4. Therefore their product is 10. Next, the powers of the 10s which are 3 and 2 are added together to yield - 5. Therefore, the whole product is  $10 \times 10^{5}$  or simply  $10^{6}$  which is also 1000,000.

**c-** For  $(1.45 \times 10^{-9}) \times (4.0 \times 10^{-3})$ , the numerical numbers are 1.45 and 4. Therefore their product is 5.8. Next, the powers of the 10s which are -9 and 3 are added together to yield -6. Therefore, the whole product is  $5.8 \times 10^{-6}$ .

**d-** For  $(0.6 \times 10^{-4}) \times (5 \times 10^{7})$ , the numerical numbers are 0.6 and 5. Therefore their product is 3. Next, the powers of the 10s which are -4 and 7 are added together to yield 3. Therefore, the whole product is **3.0** × **10**<sup>3</sup>.

## **10) Perform the following scientific notation divisions:**

a- $(125 \times 10^6) \div (25 \times 10^2)$	b- $(0.006 \times 10^{8}) \div (2400 \times 10^{3})$
$c - (400 \times 10^{-7}) \div (5 \times 10^{2})$	d- $(5000 \times 10^{-2}) \div (2.5 \times 10^{-4})$

#### **Solution:**

When dividing numbers expressed in scientific notation, the division is performed in two steps; first simply divide the numerical numbers with each other and obtain a quotient. Next, when dividing the 10s and their power, simply subtract the denominator power of 10 from the numerator power of 10.

**a-** The  $(125 \times 10^6) \div (25 \times 10^2)$  operation is performed as dividing the numerical parts and subtracting the denominator power of 10 from the numerator power of 10. This will yield an answer of  $(125 / 25) \times 10^{6-2}$  which will give an answer of  $5 \times 10^4$ .

**b-** The  $(0.006 \times 10^{8}) \div (2400 \times 10^{3})$  could also be expressed as  $(600 \times 10^{3}) \div (2400 \times 10^{3})$ . <sup>3</sup>). The division operation is again performed as dividing the numerical parts and subtracting the denominator power of 10 from the numerator power of 10. This will yield an answer of  $(600 / 2400) \times 10^{3-3}$  which will give an answer of  $0.25 \times 10^{9} = 0.25$ .

**c-** The  $(400 \times 10^{-7}) \div (5 \times 10^{2})$  operation also is performed as dividing the numerical parts and subtracting the denominator power of 10 from the numerator power of 10. This will yield an answer of  $(400 / 5) \times 10^{-7-2}$  which will give an answer of **80** × 10<sup>-9</sup>.

**d-** Just like the preceding solutions, the  $(5000 \times 10^{-2}) \div (2.5 \times 10^{-4})$  operation is performed as dividing the numerical parts and subtracting the denominator power of 10 from the numerator power of 10. This will yield an answer of  $(5000 / 2.5) \times 10^{-2}$  - <sup>(-4)</sup> which will give an answer of  $2000 \times 10^2 = 200,000 = 2 \times 10^5$ .

## **11) Perform the following conversions:**

a- $(285 \times 10^{2})$	converts to:	× 10 <sup>5</sup> .
b- $(345000 \times 10^4)$	converts to:	× 10 <sup>8</sup> .
$c - (0.0075 \times 10^{6})$	converts to:	$\times 10^{2}$ .
d- $(-0.06 \times 10^{-2})$	converts to:	$ \times 10^{-5}. $
$e - (200.78 \times 10^{-4})$	converts to:	× 10 <sup>-6</sup> .

## Solution:

The solution to this problem is nothing more than moving the decimal point the proper number of places while adjusting the power of 10 until the desired power of 10 is reached.

**a**-  $(285 \times 10^2)$  converts to: \_\_\_\_\_\_  $\times 10^5$ . For this problem, the power of 10 is incremented by 3 from  $10^2$  to  $10^5$ . Corresponding to that, the decimal point has to move to the left by 3 places in order to offset the change in the power of 10. Therefore:

## $285 \times 10^{2}$ converts to: $0.285 \times 10^{5}$ .

**b-** (( $345000 \times 10^4$ ) converts to: \_\_\_\_\_\_  $\times 10^8$ . For this problem, the power of 10 is incremented by 4 from  $10^4$  to  $10^8$ . Corresponding to that, the decimal point has to move to the left by 4 places in order to offset the change in the power of 10. Therefore:

## $345000 \times 10^{4}$ converts to: $34.5 \times 10^{8}$ .

**c**-  $(0.0075 \times 10^{6})$  converts to: \_\_\_\_\_\_  $\times 10^{2}$ . For this problem, the power of 10 is decremented by 4 from 10<sup>6</sup> to 10<sup>2</sup>. Corresponding to that, the decimal point has to move to the right by 4 places in order to offset the change in the power of 10. Therefore:

## $0.0075 \times 10^{6}$ converts to: $75 \times 10^{2}$ .

**d-**  $(-0.06 \times 10^{-2})$  converts to:  $\times 10^{-5}$ . For this problem, the power of 10 is decremented by 3 from  $10^{-2}$  to  $10^{-5}$ . Corresponding

to that, the decimal point has to move to the right by 3 places in order to offset the change in the power of 10. Therefore:

## -0.06 × 10<sup>-2</sup> converts to: $-60 \times 10^{-5}$ .

e-  $(200.78 \times 10^{-4})$  converts to: \_\_\_\_\_\_\_\_\_  $\times 10^{-6}$ . For this problem, the power of 10 is decremented by 2 from  $10^{-4}$  to  $10^{-6}$ . Corresponding to that, the decimal point has to move to the right by 2 places in order to offset the change in the power of 10. Therefore:

 $(200.78 \times 10^{-4})$  converts to:  $20078 \times 10^{-6}$ .

# **12)** Express each of the following electrical quantities in engineering notation format using the proper abbreviation and symbol:

a- A resistance of 200,000 ohms.

b- A frequency of 400 hertz.

c- A current of 20 milli amperes.

d- A voltage of 12.5 volts.

## Solution:

For a list of abbreviations and symbols, refer back to Table 1-1 (Electrical quantities and units).

a- A resistance of 200,000 ohms is abbreviated as  $\mathbf{R} = 200,000 \Omega$  or  $\mathbf{R} = 200 \times 10^3 \Omega$  or  $\mathbf{R} = 200 \text{ K}\Omega$ .

**b-** A frequency of 400 hertz is abbreviated as  $\mathbf{F} = 400 \text{ Hz}$ .

**c-** A current of 20 milli amperes is abbreviated as **I = 20 mA**.

**d-** A voltage of 12.5 volts is abbreviated as V = 12.5 V.

# **13**) Express each of the following electrical quantities in engineering notation format using the proper abbreviation and symbol:

- a- An inductance of 0.00075 henrys.
- b- A capacitance of 2 micro farads.
- c- A power of 3.5 watts.
- d- A charge of 60 coulombs.

## **Solution:**

**a-** An inductance of 0.00075 henrys is abbreviated as  $L = 0.00075 H \text{ or } L = 0.75 \times 10^{-3} H$  or L = 0.75 mH.

**b-** A capacitance of 2 micro farads is abbreviated as  $C = 2 \mu F$ .

**c-** A power of 3.5 watts is abbreviated as **P** = **3.5 watts**.

**d-** A charge of 60 coulombs is abbreviated as  $\mathbf{Q} = \mathbf{60} \mathbf{C}$ .

## **14) Multiply the following quantities:**

a- 6 mA  $\times$  2.5 K $\Omega$ . b- 4.25  $\mu$ A  $\times$  8 G $\Omega$ . c- 8.25 $\mu$ A  $\times$  8 KV. d- 9.75 A  $\times$  10 mS. e- 8 nW  $\times$  12.5 mS.

## **Solution:**

a- 6 mA  $\times$  2.5 K $\Omega$ . Using the prefix multiplication Table 1-4 and the unit's multiplications yield:  $6 \times 2.5 = 15.$   $m \times K = Basic unit.$  $A \times \Omega = V.$ 

Therefore, the result for the multiplication is:  $6 \text{ mA} \times 2.5 \text{ K}\Omega = 15 \text{ V}$ .

b- 4.25  $\mu$ A × 8 GΩ. Using the prefix multiplication Table 1-4 and the unit's multiplications yield:

Therefore, the result for the multiplication is:  $4.25\mu A \times 8 G\Omega = 34 \text{ KV}$ .

 $6 \text{ mW} \div 1.5 \text{A}$ . Again using the prefix multiplication Table 1-4 and the unit's multiplications yield:

$$\begin{split} 8.25\times8 &= 66.\\ \mu\times K &= m.\\ A\times V &= W. \end{split}$$

Therefore, the result for the multiplication is:  $8.25\mu A \times 8 K\Omega = 66 mV$ .

d- 9.75 A  $\times$  10 mS. Using the prefix multiplication Table 1-4 and the unit's multiplications yield:

 $9.75 \times 10 = 97.5$ . Basic Unit  $\times m = m$ . A  $\times$  S = C.

Therefore, the result for the multiplication is:  $9.75A \times 10 \text{ mS} = 97.5 \text{ mC}$ .

e- 8 nW  $\times$  12.5 mS. Using the prefix multiplication Table 1-4 and the unit's multiplications yield:

$$\begin{split} 8\times 12.5 &= 100.\\ n\times m &= \mu.\\ W\times S &= J. \end{split}$$

Therefore, the result for the multiplication is:  $8 \text{ nW} \times 12.5 \text{ mS} = 100 \text{ pJ}$ .

## **15) Divide the following quantities:**

 $\begin{array}{l} a\text{-} \ 6 \ mW \div 1.5 A, \\ b\text{-} \ 72 \ V \div 8 \ M\Omega, \\ c\text{-} \ 68 \ \mu W \div 8 \ KV, \\ d\text{-} \ 9.75 \ mV \div 10 \ mA, \\ e\text{-} \ 8 \ nJ \div 12.5 \ mS, \\ f\text{-} \ 46.5 \ \mu J \div 3.75 \ \mu W, \\ g\text{-} \ 25 \ C \div 2 \ S, \end{array}$ 

#### **Solution:**

a-  $6 \text{ mW} \div 1.5 \text{A}$ . Using the prefix division Table 1-5 and the unit's division yield:

 $6 \div 1.5 = 4$ m ÷ Basic unit = m. W ÷ A = V.

Therefore, the result of this division operation is  $6 \text{ mW} \div 1.5\text{A} = 4 \text{ mV}$ .

b- 72 V  $\div$  8 MΩ. Using the prefix division Table 1-5 and the unit's division yield:

 $\begin{array}{l} 72 \div 8 = 9.\\ Basic unit \div M = \mu.\\ V \div \Omega = A. \end{array}$ 

Therefore, the result of this division operation is 72 V  $\div$  8 M $\Omega$  = 9  $\mu$  A.

c-  $68\mu W \div 8 \text{ KV}$ Using the prefix division Table 1-5 and the unit's division yield:

$$\begin{split} & 68 \div 8 = 8.5. \\ & \mu \div K = n. \\ & W \div V = A. \end{split}$$

Therefore, the result of this division operation is  $68\mu W \div 8 \text{ KV} = 8.5 \text{ nA}$ .

d- 9.75 mV  $\div$  10 mA.

Using the prefix division Table 1-5 and the unit's division yield:

 $9.75 \div 10 = 0.975.$   $m \div m = Basic unit.$  $V \div A = \Omega.$ 

Therefore, the result of this division operation is 9.75 mV  $\div$  10 mA = 0.975  $\Omega$ .

e- 8 nJ  $\div$  12.5 mS. Using the prefix division Table 1-5 and the unit's division yield:

$$\begin{split} &8\div 12.5=0.64,\\ &n\div m=\mu\\ &J\div S=W. \end{split}$$

Therefore, the result of this division operation is  $8 \text{ nJ} \div 12.5 \text{ mS} = 0.64 \mu\text{W}$ .

f- 46.5  $\mu$ J ÷ 3.75  $\mu$ W. Using the prefix division Table 1-5 and the unit's division yield:

 $\begin{array}{l} 46.5 \div 3.75 = 12.4 \\ \mu \div \mu = Basic \ unit. \\ J \div W = S \end{array}$ 

Therefore, the result of this division operation is  $46.5 \ \mu\text{J} \div 3.75 \ \mu\text{W} = 12.40 \ \text{S}$ .

g- 25 C  $\div$  2 S Using the prefix division Table 1-5 and the unit's division yields:

 $25 \div 2 = 12.5.$ Basic unit  $\div$  Basic unit = Basic unit.  $C \div S = A.$ 

Therefore, the result of this division is  $25 \text{ C} \div 2 \text{ S} = 12.5 \text{ A}$ .

## This concludes Chapter One.