Chapter 1

Components, Quantities, and Units

Introduction

• This chapter will give you a preview of the types of things you will study throughout this book
Objectives

• Recognize common electrical components and measuring instruments
• State basic electrical and magnetic quantities and their units
• Use Scientific notation to express quantities
• Use engineering notation and metric prefixes to express large and small quantities
• Convert from one metric-prefixed unit to another

Resistors

• Resistors limit electrical current in a circuit
Capacitors

- Capacitors store electrical charge and are used to block dc and pass ac

Inductors

- Inductors, or coils, are used to store energy in an electromagnetic field
Transformers

- Transformers are used for ac coupling, or to increase/decrease ac voltages

Electronic Instruments
Electronic Instruments

- A DC power supply provides current and voltage to power electronic circuits
- A function generator provides electronic signals for our circuits
- A digital multimeter (DMM) can be used as a voltmeter, ammeter or ohmmeter, depending upon the function selected

Oscilloscope

- The oscilloscope is used for observing and measuring ac voltage signals in a circuit
- Digital storage scopes are able to store waveforms
- Some digital scopes are capable of performing analysis on waveforms
Digital Multimeter

• A digital multimeter (DMM) measures voltage, current or resistance, depending upon the function selected
  – A voltmeter is used to measure voltage across a component or circuit
  – An ammeter is used to measure current through a circuit
  – An ohmmeter is used to measure resistance

Electrical Units

• Letters are used in electronics to represent quantities and units
• The units and symbols are defined by the SI system
  – The term SI is the French abbreviation for System International
Electrical Units

<table>
<thead>
<tr>
<th>QUANTITY</th>
<th>SYMBOL</th>
<th>UNIT</th>
<th>SYMBOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>capacitance</td>
<td>C</td>
<td>farad</td>
<td>F</td>
</tr>
<tr>
<td>charge</td>
<td>Q</td>
<td>coulomb</td>
<td>C</td>
</tr>
<tr>
<td>conductance</td>
<td>G</td>
<td>siemens</td>
<td>S</td>
</tr>
<tr>
<td>current</td>
<td>I</td>
<td>ampere</td>
<td>A</td>
</tr>
<tr>
<td>energy</td>
<td>W</td>
<td>joule</td>
<td>J</td>
</tr>
<tr>
<td>frequency</td>
<td>f</td>
<td>hertz</td>
<td>Hz</td>
</tr>
<tr>
<td>impedance</td>
<td>Z</td>
<td>ohm</td>
<td>Ω</td>
</tr>
<tr>
<td>inductance</td>
<td>L</td>
<td>henry</td>
<td>H</td>
</tr>
<tr>
<td>power</td>
<td>P</td>
<td>watt</td>
<td>W</td>
</tr>
<tr>
<td>reactance</td>
<td>X</td>
<td>ohm</td>
<td>Ω</td>
</tr>
<tr>
<td>resistance</td>
<td>R</td>
<td>ohm</td>
<td>Ω</td>
</tr>
<tr>
<td>voltage</td>
<td>V</td>
<td>volt</td>
<td>V</td>
</tr>
</tbody>
</table>

Magnetic Units

- Letters are also used to represent magnetic quantities and units in the SI system

<table>
<thead>
<tr>
<th>QUANTITY</th>
<th>SYMBOL</th>
<th>UNIT</th>
<th>SYMBOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>flux density</td>
<td>B</td>
<td>tesla</td>
<td>T</td>
</tr>
<tr>
<td>magnetic flux</td>
<td>φ</td>
<td>weber</td>
<td>Wb</td>
</tr>
<tr>
<td>magnetizing force</td>
<td>H</td>
<td>ampere-turns/meter</td>
<td>A/m</td>
</tr>
<tr>
<td>magnetomotive force</td>
<td>F_m</td>
<td>ampere-turn</td>
<td>A t</td>
</tr>
<tr>
<td>permeability</td>
<td>μ</td>
<td>webers/ampere-turns-meter</td>
<td>WN/Atm</td>
</tr>
<tr>
<td>reluctance</td>
<td>R</td>
<td>ampere-turns/weber</td>
<td>A μ/Wb</td>
</tr>
</tbody>
</table>
Scientific Notation

• Scientific notation is a convenient method of expressing large and small numbers
• A quantity is expressed as a number between 1 and 10, and a power of ten

Example:
5000 would be expressed as $5 \times 10^3$ in Scientific notation.

Powers of Ten

• The power of ten is expressed as an exponent of the base 10
• Exponent indicates the number of places that the decimal point is moved to the right (positive exponent) or left (negative exponent) to produce the decimal number
**Engineering Notation**

Engineering notation is similar to Scientific notation, except that engineering notation can have from 1 to 3 digits to the left of the decimal place, and the powers of 10 are multiples of 3.

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**Metric Prefixes**

Metric prefixes are symbols that represent the powers of ten used in Engineering notation.

<table>
<thead>
<tr>
<th>METRIC PREFIX</th>
<th>SYMBOL</th>
<th>POWER OF TEN</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>pico</td>
<td>p</td>
<td>$10^{-12}$</td>
<td>one-trillionth</td>
</tr>
<tr>
<td>nano</td>
<td>n</td>
<td>$10^{-9}$</td>
<td>one-billionth</td>
</tr>
<tr>
<td>micro</td>
<td>μ</td>
<td>$10^{-6}$</td>
<td>one-millionth</td>
</tr>
<tr>
<td>milli</td>
<td>m</td>
<td>$10^{-3}$</td>
<td>one-thousandth</td>
</tr>
<tr>
<td>kilo</td>
<td>k</td>
<td>$10^{3}$</td>
<td>one thousand</td>
</tr>
<tr>
<td>mega</td>
<td>M</td>
<td>$10^{6}$</td>
<td>one million</td>
</tr>
<tr>
<td>giga</td>
<td>G</td>
<td>$10^{9}$</td>
<td>one billion</td>
</tr>
<tr>
<td>tera</td>
<td>T</td>
<td>$10^{12}$</td>
<td>one trillion</td>
</tr>
</tbody>
</table>
Example of Metric Prefix

Consider the quantity 0.025 amperes, it could be expressed as \(25 \times 10^{-3}\) A in Engineering notation, or using the metric prefix as \(25\ mA\)

Scientific notation vs Engineering notation

Consider the number: 23,000

In Scientific notation it would be expressed as: \(2.3 \times 10^4\)

In Engineering notation it would be expressed as: \(23 \times 10^3\)
Metric Unit Conversions

• When converting from a larger unit to a smaller unit, move the decimal point to the right
  \[0.52 \times 10^{-3} = 520 \times 10^{-6}\]
• When converting from a smaller unit to a larger unit, move the decimal point to the left
  \[1200 \times 10^{-9} = 1.2 \times 10^{-6}\]
• Determine the number of places that the decimal point is moved by finding the difference in powers of ten of the units being converted

Summary

• Resistors limit electric current
• Capacitors store electrical charge
• Inductors store energy in their electromagnetic field
• Transformers magnetically couple ac voltages, and may step these voltages up/down
Summary

- Power supplies provide current and voltage
- Voltmeters measure voltage
- Ammeters measure current
- Ohmmeters measure resistance
- Digital Multimeters (DMM) measure voltage, current and resistance

Summary

- Function generators provide electronic signals for our circuits
- An oscilloscope is used for observing and measuring voltages in a circuit
Summary

• Scientific notation expresses a number as one digit to the left of the decimal point times a power of ten
• Engineering notation expresses a number as one, two or three digits to the left of the decimal point times a power of ten that is a multiple of 3
• Metric symbols represent powers of 10 that are multiples of 3