Chapter 1 - Introduction

Introductory Circuit Analysis

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1.1 The Electrical/Electronics Industry

- Technology and its effects on our lives
  - Healthcare and the arts
  - Computer simulations
- The Integrated Circuit (IC)
  - First developed in the late 1950's
- Understanding of fundamental concepts
  - Once understood, will not be replaced

1.2 A Brief History – The Beginning

- Physicists, chemists, mathematicians and even philosophers
- William Gilbert (static electricity)
- Otto von Guericke (first machine to generate large amounts of charge)
- Stephen Gray (transmitted electrical charge over long distances on silk thread)

A Brief History – The Beginning

- Charles DuFay (charges attract or repel)
- Pieter van Musschenbroek – 1745 (Leyden jar)
- Benjamin Franklin – 1752 (used the Leyden jar to prove lightning is an electrical discharge)
- Charles Coulomb – 1784 (force between charges)
- Luigi Galvani – 1791 (effects of electricity on animals)
- Alessandro Volta – 1799 (voltaic cell)

A Brief History – The Beginning

- Hans Christian Oersted – 1820 (foundation of electromagnetism)
- Georg Ohm – 1831 (Ohm's Law)
- Michael Faraday – 1831 (electromagnetic induction and condenser)
- James Clerk Maxwell – 1862 (electromagnetic theory of light)
- Heinrich Rudolph Hertz – 1888 (microwaves)
- Wilhelm Röntgen – 1895 (X ray)

A Brief History - The Age of Electronics

- Radio – the true beginning of electronics
- Thomas Edison and the Edison effect
- Guglielmo Marconi – the father of the radio
- Aleksandr Popov – first radio message
  - "Heinrich Hertz"
- John Ambrose Fleming –1904 (the first diode, Fleming's valve)
- Lee De Forest – 1906 (first amplifier)

A Brief History - The Age of Electronics

- Edwin Armstrong – 1912 (first regenerative circuit)
- Radio signals being transmitted across the U.S. – 1915
- Television
- Paul Nipkow – 1884 (electrical telescope)
- John Baird
  - 1927 (transmission of TV over telephone lines)
  - 1928 (transmission of TV over radio waves)
- NBC – 1932 (first commercial TV antenna installed)
- Color television – 1960s

A Brief History - The Age of Electronics

- Computers
- Blaise Pascal – 1642 (earliest computer system)
- Gottfried Wilhelm von Leibniz – 1673 (Leibniz wheel)
- Charles Babbage – 1823 (difference engine)
- IBM was formed – 1924
- ENIAC – 1946 University of Pennsylvania

A Brief History - The Solid-State Era

- Bell Telephone Laboratories –1947
  - Point-contact transistor
- First integrated circuit (IC) – 1958 - Texas Instruments
- First commercial grade IC – 1961 - Fairchild Corp.

1.3 Units of Measurement

- The numerical value substituted into an equation must have the unit of measurement specified by the equation

$$v=\frac{4000\text{ft}}{1\text{ min}}=4000\text{mi/h}$$ ✗ **Should be:** $$v=\frac{0.7576\text{ mi}}{0.0167\text{ h}}=45.37\text{mi/h}$$

- If a unit of measurement is applicable to a result or piece of data, then it must be applied to the numerical value

Units of Measurement

- Each quantity has the proper unit of measurement as defined by the equation
- The proper magnitude of each quantity as determined by the defining equation is substituted
- Each quantity is in the same system of units (or as defined by the equation)
- The magnitude of the results is of a reasonable nature when compared to the level of the substituted quantities
- The proper unit of measurement is applied to the result

1.4 Systems of Units

- Standard set of units for all nations
- Le Système International d'Unités – 1960
- Adopted by the Institute of Electrical and Electronic Engineers (IEEE) in 1965
- Adopted by USA Standards Institute in 1967
- The standards of some units are quite interesting
  - Meter
  - Kilogram

1.5 Significant Figures, Accuracy, and Rounding Off

- When writing numbers, consider:
  - format used
  - number of digits being included
  - unit of measurement to be applied
- Two type of numbers: exact and approximate
- Significant figures
- Adding approximate numbers
- Rounding off numbers

1.6 Powers of Ten

- Powers of 10
  - $1 = 10^0$ $1/10 = 0.1 = 10^{-1}$
  - $10 = 10^1$ $1/100 = 0.01 = 10^{-2}$
  - $100 = 10^2$ $1/1000 = 0.001 = 10^{-3}$
  - $1000 = 10^3$ $1/10{,}000 = 0.0001 = 10^{-4}$

Powers of Ten

- Addition and Subtraction
  - **When adding or subtracting numbers in a powers-of-ten format, be sure that the power of ten is the same for each number. Then separate the multipliers, perform the required operation, and apply the same power of ten to the result**

Powers of Ten

- Multiplication
  - **When multiplying numbers in the powers-of-ten format, first find the product of the multipliers and then determine the power of ten for the result by adding the power-of-ten exponents**

Powers of Ten

- Division
  - **When dividing numbers in the powers-of-ten format, first find the result of dividing the multipliers. Then determine the associated power for the result by subtracting the power of ten of the denominator from the power of ten of the numerator**

Powers of Ten

- Powers
  - **When finding the power of a number in the powers-of-ten format, first separate the multiplier from the power of ten and determine each separately. Determine the power-of-ten component by multiplying the power of ten by the power to be determined**

Powers of Ten

- Fixed-Point, Floating-Point, Scientific, and Engineering Notation
  - There are generally four ways in which numbers appear
    - Fixed-point
    - Floating-point notation
    - Scientific (standard) notation
    - Engineering notation

Powers of Ten

- Prefixes
  - **Specific powers of ten in engineering notation have been assigned prefixes and symbols**

1.8 Conversion Between Levels of Powers of Ten

- Convert kilohertz (kHz) to megahertz (MHz)
- Convert milliseconds (ms) to microseconds (μs)
- Convert kilometers (km) to millimeters (mm)

1.9 Conversion Within and Between Systems of Units

- Set up the conversion factor to form a numerical value of (1) with the unit of measurement to be removed from the original quantity in the denominator

- Perform the required mathematics to obtain the proper magnitude for the remaining unit of measurement

1.10 Symbols

TABLE 1.3

Symbol	Meaning
$\neq$	Not equal to $6.12 \neq 6.13$
$>$	Greater than $4.78 > 4.20$
$\gg$	Much greater than $840 \gg 16$
$<$	Less than $430 < 540$
$\ll$	Much less than $0.002 \ll 46$
$\geq$	Greater than or equal to $x \geq y$ is satisfied for $y = 3$ and $x > 3$ or $x = 3$
$\leq$	Less than or equal to $x \leq y$ is satisfied for $y = 3$ and $x < 3$ or $x = 3$
$\cong$	Approximately equal to $3.14159 \cong 3.14$
Σ	Sum of $\Sigma\,(4 + 6 + 8) = 18$
$\lvert\ \rvert$	Absolute magnitude of $\lvert a \rvert = 4$, where $a = -4$ or $+4$
$\therefore$	Therefore $x = \sqrt{4} \qquad \therefore x = \pm 2$
$\equiv$	By definition Establishes a relationship between two or more quantities

1.11 Conversion Tables

- Conversion tables are useful but frequent errors occur because the operations are not applied properly

- Establish mentally the magnitude for a quantity in the original set of units

- Anticipatory thinking will eliminate the possibility of mistakes

1.12 Calculators

- Must have a thorough and correct understanding of the process by which a calculator works
- Choose a calculator that has the ability to perform the functions you need (such as complex numbers)
- Initial settings
  - Format and accuracy
- Order of operation

1.13 Computer Analysis

- Computer usage has grown exponentially
- Language
  - C++, Basic, Pascal, and Fortran
- Software packages
  - Cadence's OrCAD PSpice 9.2, Electronic Workbench's Multisim, and MathSoft's Mathcad 2000