Main Template

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1 Introduction

1.1 Categorization of Components

Rather than trying to understand full circuits at once, it is easier to break them into two groups: **passive** components and **active** components.

Passive Components **1.1**

Passive components are ones that don't require any power supply to operate. For example, a resistor or a capacitor are both passive components.

Active Circuits **1.2**

Active components require power to operate. In other words, they need to be connected to a power supply to function. Logic gates (74LSXX) are active since they require a power supply.

Another way to divide components is between **linear** and **non-linear**.

Linear Components **1.3**

Linear components are... They also can be subdivided into components that store energy (capacitors and inductors) and components that dissipate energy (resistors).

Non-Linear Components **1.4**

...

1.2 Overview of Concepts

1.2.1 Charge and Current

Charge **1.5**

Charge (Q) is an electrical property of the atomic particles of which matter consists, measured in coulombs (C).

$$Q(t) = \int i(t)\,dt$$

When charged particles move in space over time, such as throughout a wire in a circuit, an electrical current is generated.

Electric Current **1.6**

Electric current (I) is the time rate of change of charge, measured in amperes (A).

$$i(t) = \frac{dQ}{dt}$$

Current is simply a rate of change of a charge, and thus the two are related as the others' derivative/integral.

1.2.2 DC vs. AC

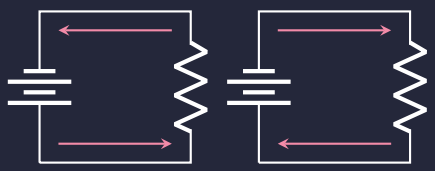
Direct Current **1.7**

A direct current (dc) flows only in one direction and can be constant or time varying.

There are two ways of describing the *direction* in which the electrons flow in a direct current: **conventional flow** and **electron flow**. Both are shown in Figure 1.

Alternating Current **1.8**

An alternating current (ac) is a current that changes direction with respect to time.



(a) Conventional (b) Electron

Figure 1: Electron Flow in Direct Currents

Voltage **1.9**

Voltage (or *potential difference*) is the energy required to move a unit charge form a reference point (-) to another point (+), measured in Volts (V).

$$v(t) = v_b - v_b = \frac{dw}{dQ} = \frac{dE}{dQ}$$

1.2.3 Power and Energy

Power **1.10**

Power is the time rate of expending or absorbing energy measured in watts (W). It is the rate of change of energy.

$$p(t) = \frac{dE}{dt} = \frac{dE \cdot dQ}{dt \cdot dQ} = \frac{dE}{dQ} \cdot \frac{dQ}{dt}$$
$$p = v \cdot i$$

Energy **1.11**

Energy is the capacity to do work measured in Joules (J).

$$E(t) = \int p(t)\, dt$$

Again, these two values are related as the derivative/integral of the other.

1.3 Circuit Elements

Ideal Independent Source **1.12**

An ideal independent source is an active element that provides a specified voltage or current that is completely independent of other circuit elements.

Ideal Dependent Source **1.13**

Also called an *Ideal Controlled Source*, this is an active element in which the source quantity is controlled by another voltage or current.

There are four types of dependent sources:

1. Voltage Controlled Voltage Source (VCVS)
2. Voltage Controlled Current Source (VCCS)
3. Current Controlled Voltage Source (CCVS)
4. Current Controlled Current Source (CCCS)

1.4 Basic Laws

1.4.1 Ohm's Law

Ohm's Law states that the voltage V across a resistor is *directly* proportional to the current I flowing through the resistor.

Ohm's Law **1.1**

$$R = \rho \cdot \frac{l}{A}$$

When there is current flowing through a wire with resistance approaching zero, a **short circuit** is created. Conversely, an **open circuit** is where the resistance in a circuit approaches infinity.

Resistance and conductance are inversely related. It is the ability of an element of conduct electric current; it is measured in mhos or siemens (S).

1.4.2 Nodes, Branches, Loops

Branch **1.14**

Represents a single element in a circuit such as a resistor or power supply.

Node **1.15**

The point of connection between two or more branches.

Loop **1.16**

A loop is any *closed* path in a circuit. Generally, loops are defined as the smallest possible path.

By analyzing the nodes connection branches of a circuit, elements can be found to be in parallel or in series.

Parallel **1.17**

Elements are in parallel if they share two nodes.

Series **1.18**

Elements are in series if they *exclusively* share a node.

It is possible for elements to be neither in series or in parallel. These situations aren't problematic, but require somewhat different techniques to analyze.

1.4.3 Kirchhoff's Laws

Kirchhoff's Current Law **1.19**

Kirchhoff's Current Law (KCL) states that the algebraic sum of currents entering a node (or a closed boundary) is zero:

$$\sum_{n=1}^{N_{branch}} i_n = 0$$

Kirchhoff's Voltage Law **1.20**

Kirchhoff's Voltage Law (KVL) states that the algebraic sum of all voltages around a closed path is zero:

$$\sum_{m=1}^{M_{branch}} v_m = 0$$