Electronic Circuits

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SIMPLY EASY LEARNING

About the Tutorial

This tutorial explains the very basic circuits in Electronics and Communications. The circuits mentioned in this tutorial are mostly related to the applications of diodes.

The components mentioned in Basic Electronics tutorial have their applications seen here. Almost all the important **diode circuits** are covered in this tutorial.

Audience

This tutorial is intended for beginners in the field of Electronics and Communications and hence, it would be useful for most students. It has been designed keeping in mind the requirements of beginners who are interested in learning the functionalities of basic circuits used in Electronics and Communication.

Prerequisites

The readers should have elementary knowledge regarding electronic components to make the most of this tutorial, however it is not a necessity. If you want to refresh your knowledge on the construction, working, and applications of electronic components, then please go through our Basic Electronics tutorial first.

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Table of Contents

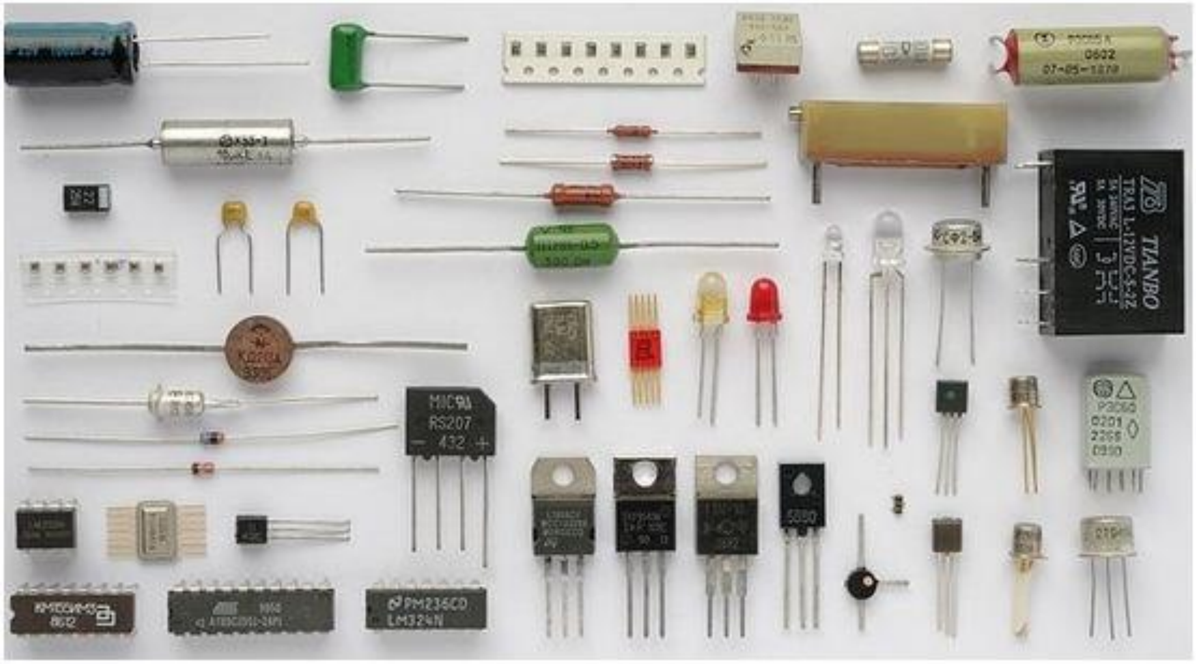
1. Electronic Circuits – Introduction

In Electronics, we have different components that serve different purposes. There are various elements which are used in many types of circuits depending on the applications.

Electronic Components

Similar to a brick that constructs a wall, a component is the basic brick of a circuit. A **Component** is a basic element that contributes for the development of an idea into a **circuit** for execution.

Each component has a few basic properties and the component behaves accordingly. It depends on the motto of the developer to use them for the construction of the intended circuit. The following image shows a few examples of electronic components that are used in different electronic circuits.



Just to gather an idea, let us look at the types of Components. They can either be **Active Components** or **Passive Components**.

Active Components

- Active Components are those which conduct upon providing some external energy.
- Active Components produce energy in the form of voltage or current.

- **Examples**: Diodes, Transistors, Transformers, etc.

Passive Components

- Passive components are those which start their operation once they are connected. No external energy is needed for their operation.
- Passive components store and maintain energy in the form of voltage or current.
- **Examples**: Resistors, Capacitors, Inductors, etc.

We also have another classification as **Linear** and **Non-Linear** elements.

Linear Components

- Linear elements or components are the ones that have linear relationship between current and voltage.
- The parameters of linear elements are not changed with respect to current and voltage.
- **Examples**: Diodes, Transistors, Transformers, etc.

Non-linear Components

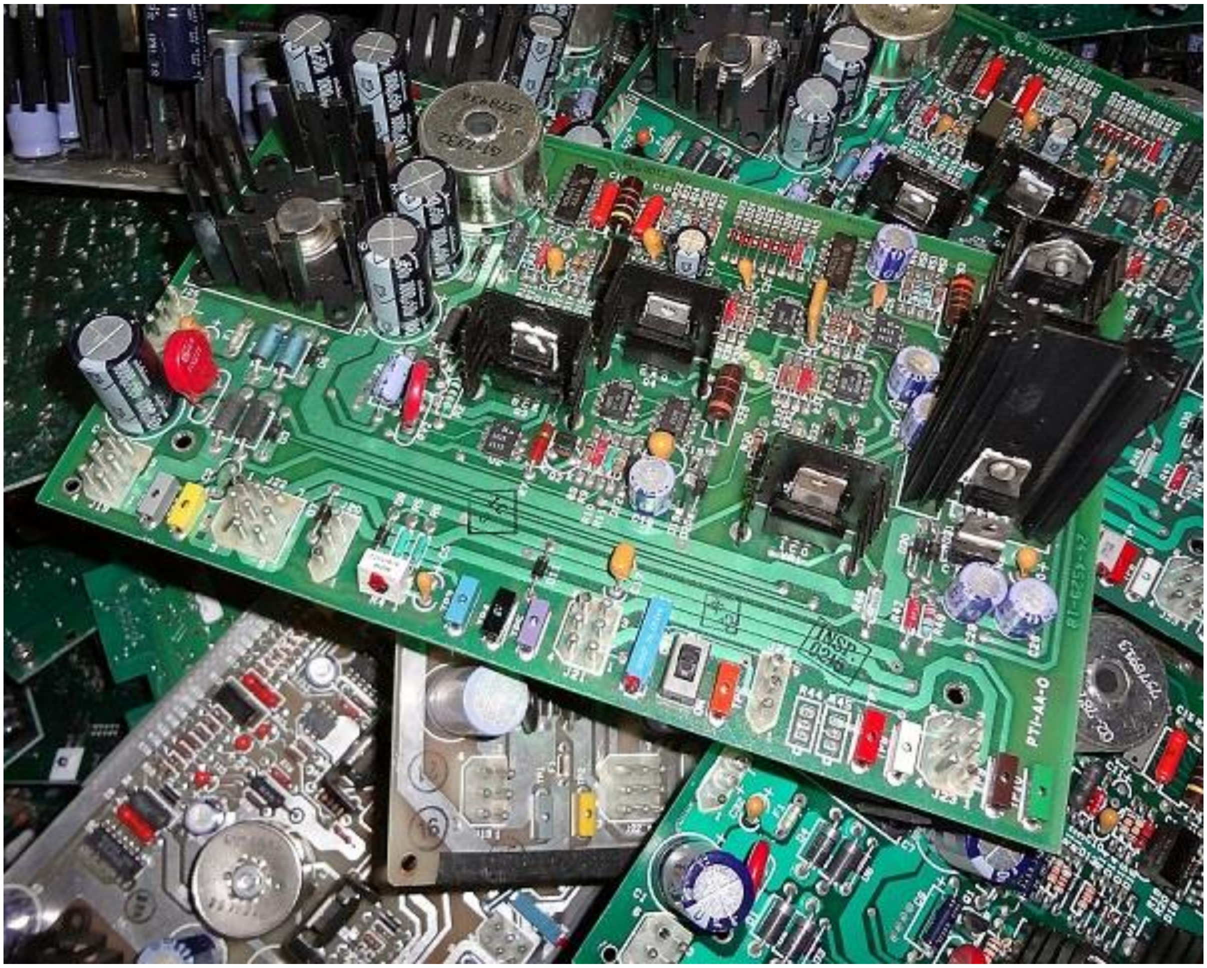
- Non-linear elements or components are the ones that have a non-linear relationship between current and voltage.
- The parameters of non-linear elements are changed with respect to current and voltage.
- **Examples**: Resistors, Capacitors, Inductors, etc.

These are the components intended for various purposes, which altogether can perform a preferred task for which they are built. Such a combination of different components is known as a **Circuit**.

Electronic Circuits

A certain number of components when connected on a purpose in a specific fashion makes a **circuit**. A circuit is a network of different components. There are different types of circuits.

The following image shows different types of electronic circuits. It shows Printed Circuit Boards which are a group of electronic circuits connected on a board.



Electronic circuits can be grouped under different categories depending upon their operation, connection, structure, etc. Let's discuss more about the types of Electronic Circuits.

Active Circuit

- A circuit that is build using Active components is called as **Active Circuit**.
- It usually contains a power source from which the circuit extracts more power and delivers it to the load.
- Additional Power is added to the output and hence output power is always greater than the input power applied.
- The power gain will always be greater than unity.

Passive Circuit

- A circuit that is build using Passive components is called as **Passive Circuit**.

- Even if it contains a power source, the circuit does not extract any power.
- Additional Power is not added to the output and hence output power is always less than the input power applied.
- The power gain will always be less than unity.

Electronic circuits can also be classified as **Analog**, **Digital**, or **Mixed**.

Analog Circuit

- An analog circuit can be one which has linear components in it. Hence it is a linear circuit.
- An analog circuit has analog signal inputs which are continuous range of voltages.

Digital Circuit

- A digital circuit can be one which has non-linear components in it. Hence it is a non-linear circuit.
- It can process digital signals only.
- A digital circuit has digital signal inputs which are discrete values.

Mixed Signal Circuit

- A mixed signal circuit can be one which has both linear and non-linear components in it. Hence it is called as a mixed signal circuit.
- These circuits consist of analog circuitry along with microprocessors to process the input.

Depending upon the type of connection, circuits can be classified as either **Series Circuit** or **Parallel Circuit**. A Series Circuit is one which is connected in series and a **parallel circuit** is one which has its components connected in parallel.

Now that we have a basic idea about electronic components, let us move on and discuss their purpose which will help us build better circuits for different applications. Whatever might be the purpose of an electronic circuit (to process, to send, to receive, to analyze), the process is carried out in the form of signals. In the next chapter, we will discuss the signals and the type of signals present in electronic circuits.

2. Electronic Circuits – Signals

A **Signal** can be understood as "a representation that gives some information about the data present at the source from which it is produced." This is usually time varying. Hence, a signal can be a **source of energy which transmits some information**. This can easily be represented on a graph.

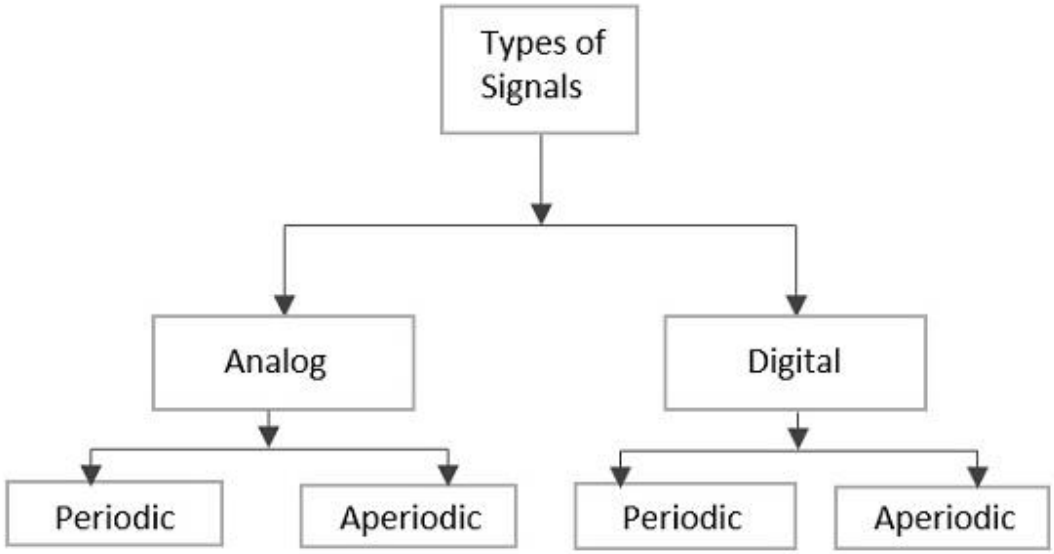
Examples

- An alarm gives a signal that it's time.
- A cooker whistle confirms that the food is cooked.
- A red light signals some danger.
- A traffic signal indicates your move.
- A phone rings signaling a call for you.

A signal can be of any type that conveys some information. This signal produced from an electronic equipment, is called as **Electronic Signal** or **Electrical Signal**. These are generally time variants.

Types of Signals

Signals can be classified either as Analog or Digital, depending upon their characteristics. Analog and Digital signals can be further classified, as shown in the following image.



Analog Signal

A continuous time-varying signal, which represents a time-varying quantity, can be termed as an **Analog Signal**. This signal keeps on varying with respect to time, according to the instantaneous values of the quantity, which represents it.

Digital Signal

A signal which is **discrete** in nature or which is **non-continuous** in form can be termed as a **Digital signal**. This signal has individual values, denoted separately, which are not based on previous values, as if they are derived at that particular instant of time.

Periodic Signal & Aperiodic Signal

Any analog or digital signal, that repeats its pattern over a period of time, is called as a **Periodic Signal**. This signal has its pattern continued repeatedly and is easy to be assumed or to be calculated.

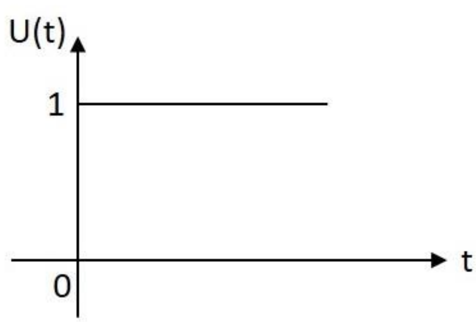
Any analog or digital signal, that doesn't repeat its pattern over a period of time, is called as **Aperiodic Signal**. This signal has its pattern continued but the pattern is not repeated and is not so easy to be assumed or to be calculated.

Signals & Notations

Among the **Periodic Signals**, the most commonly used signals are Sine wave, Cosine wave, Triangular waveform, Square wave, Rectangular wave, Saw-tooth waveform, Pulse waveform or pulse train etc. let us have a look at those waveforms.

Unit Step Signal

The unit step signal has the value of one unit from its origin to one unit on the X-axis. This is mostly used as a test signal. The image of unit step signal is shown below.

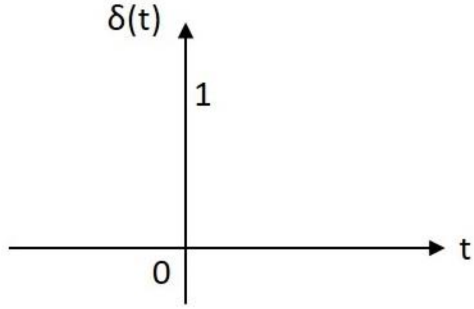


The unit step function is denoted by **u(t)**. It is defined as

$$u(t) = \begin{cases} 1 & t \geq 0 \\ 0 & t < 0 \end{cases}$$

Unit Impulse Signal

The unit impulse signal has the value of one unit at its origin. Its area is one unit. The image of unit impulse signal is shown below.



The unit impulse function is denoted by **δ(t)**. It is defined as

$$\delta(t) = \{ \begin{matrix} \infty & if & t = 0 \\ 0 & if & t \neq 0 \end{matrix}$$

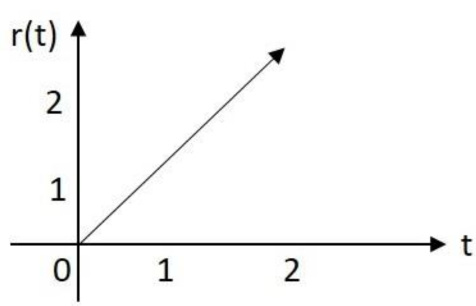
$$\int_{-\infty}^{\infty} \delta(t) d(t) = 1$$

$$\int_{-\infty}^{t} \delta(t) d(t) = u(t)$$

$$\delta(t) = \frac{du(t)}{dt}$$

Unit Ramp Signal

The unit ramp signal has its value increasing exponentially from its origin. The image of unit ramp signal is shown below.



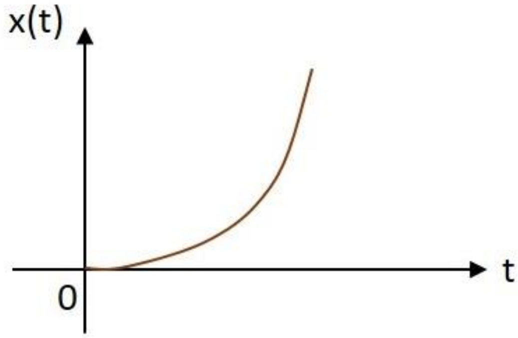
The unit ramp function is denoted by **u(t)**. It is defined as:

$$\int_0^t u(t)d(t) = \int_0^t 1\, dt = t = r(t)$$

$$u(t) = \frac{dr(t)}{dt}$$

Unit Parabolic Signal

The unit parabolic signal has its value altering like a parabola at its origin. The image of unit parabolic signal is shown below.



The unit parabolic function is denoted by **u(t)**. It is defined as

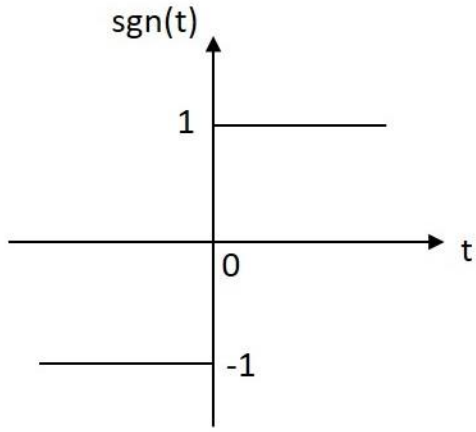
$$\int_0^t \int_0^t u(t)dtdt = \int_0^t r(t)dt = \int_0^t t.dt = \frac{t^2}{2}dt = x(t)$$

$$r(t) = \frac{d\,x(t)}{dt}$$

$$u(t) = \frac{d^2\,x(t)}{dt^2}$$

Signum Function

The Signum function has its value equally distributed in both positive and negative planes from its origin. The image of Signum function is shown below.



The Signum function is denoted by **sgn(t)**. It is defined as

$$sgn(t) = \begin{cases} 1 & for \quad t \geq 0 \\ -1 & for \quad t < 0 \end{cases}$$

$$sgn\ (t) = 2u(t) - 1$$

Exponential Signal

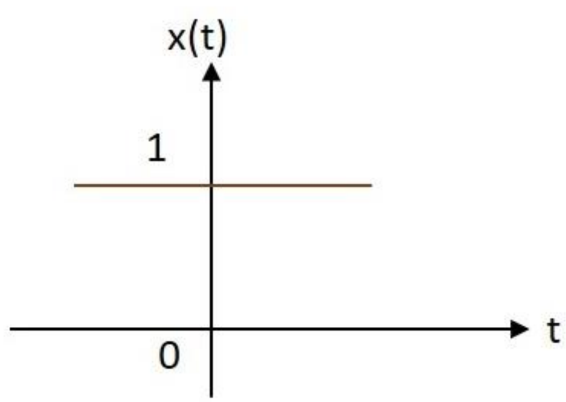
The exponential signal has its value varying exponentially from its origin. The exponential function is in the form of:

$$x(t) = e^{\alpha t}$$

The shape of exponential can be defined by α. This function can be understood in 3 cases.

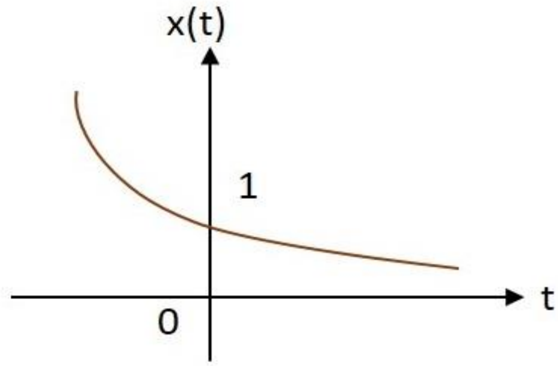
Case 1:

If $\alpha = 0 \rightarrow x(t) = e^0 = 1$



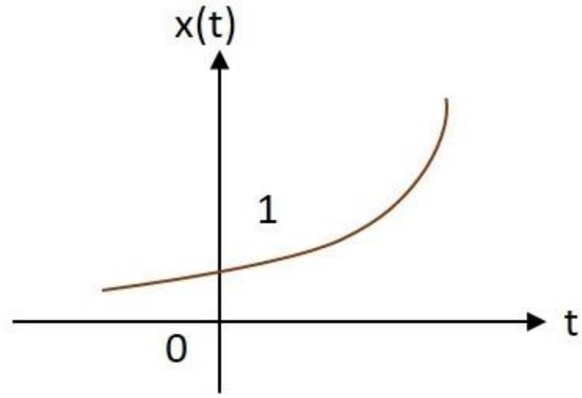
Case 2:

If $\alpha < 0$ then $x(t) = e^{\propto t}$ where $\propto$ is negative. This shape is called as **decaying exponential**.



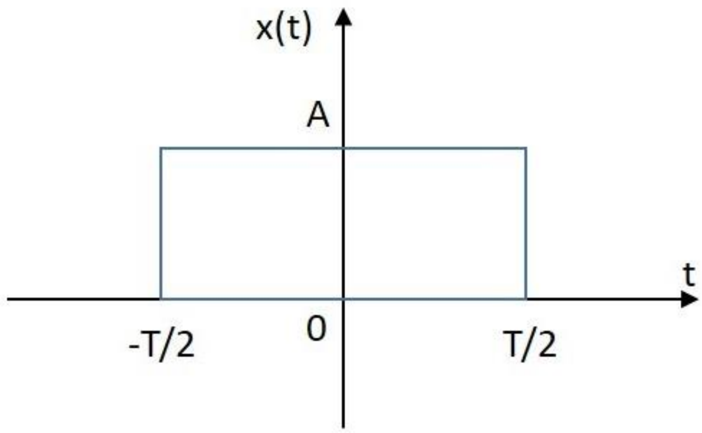
Case 3:

If $\alpha > 0$ then $x(t) = e^{\propto t}$ where $\propto$ is positive. This shape is called as **raising exponential**.



Rectangular Signal

The rectangular signal has its value distributed in rectangular shape in both positive and negative planes from its origin. The image of rectangular signal is shown below.



The rectangular function is denoted by **x(t)**. It is defined as

$$x(t) = A\,rect\left[\frac{t}{T}\right]$$