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# Electronics 1 Part 1 (Quickstudy: Academic)

Quick Study ACADEMIC

## ELECTRONICS 1 PART ONE

PART 1 of FUNDAMENTALS OF ELECTRONIC DEVICES AND BASIC ELECTRONIC CIRCUITS

### CIRCUITS & SYSTEMS: BASIC DEFINITIONS

#### ELECTRONIC CIRCUITS

An electronic circuit is an information-bearing signal processing network formed by interconnections of passive components and/or active devices.

**Passive Components:** Resistor, inductor and capacitor.

**Active Devices:** (or energy source devices) — transistor, metal-oxide semiconductor, etc.

**Electronic System:** An arrangement of components (passive elements and/or active devices) with a specified input signal producing a defined output signal.

**Signal Processing:** Fundamentally, electronic circuits and systems process the input signal. Common processing includes:

- Amplification (magnification)
- Inversion
- Differentiation
- Filtering: Changing the relative magnitude of different frequency components of the signal
- Modulation: Substitution/modification of a particular part of the signal and polarity leads

**Other Electronic Circuits are:**

- Harmonic oscillators:** Produce sinusoidal wave forms of desired frequency, or, critical non-sinusoidal waveforms, their other outputs can produce non-sinusoidal wave forms such as square, triangular, etc.
- Digital circuits:** Specific circuits which handle digital wave forms; they can perform computational operations such as addition, subtraction, multiplication, etc. in binary form.

#### ELECTRICAL SIGNAL

Electrical signal is an information-bearing electrical entity (such as voltage or current) derived from a transducer (e.g. trans signal voltage derived from a microphone). Signal processing refers to processing the electrical signal in a predetermined manner so as to modify the nature of the information contained in it. Signal content can be represented by (Fig. 1):

- Thomson's equivalent circuit:** A signal source represented by a voltage generator  $v(t)$  in series with a source (internal) resistance  $R_s$ .
- Norton's equivalent circuit:** A signal source is depicted by a current generator with a short resistance  $R_p$ .

Electrical signal is characterized by:

- Amplitude, frequency and phase parameters. The signal is a time-varying function representing the wave-shape as a function of time. It can be periodic with a definite period  $T$ , or, it can be aperiodic. A complex waveform consists of several wave forms of different frequencies. A periodic signal with a complex structure of waveforms has a discrete spectrum of harmonics, i.e. sinusoidal wave forms of magnitudes as dictated by Fourier series expansion. An aperiodic waveform has a continuous spectrum of harmonic components or per Fourier integral transform.

Examples of signal representation by Fourier series and Fourier transform:

- A periodic, continuous, non-sinusoidal signal can be represented by a superposition of infinite number of harmonics (like and/or unlike wave forms, e.g. Fourier expansion of a square wave (Fig. 2)).
- A periodic, continuous, sinusoidal signal can be represented by a superposition of infinite number of harmonics (like and/or unlike wave forms, e.g. Fourier expansion of a square wave (Fig. 2)).

**Fourier Transform:**

$$Y(s) = \int_{-\infty}^{\infty} y(t) e^{-st} dt$$
$$y(t) = \int_{-\infty}^{\infty} Y(s) e^{st} ds$$

where  $s = \sigma + j\omega$ ,  $\sigma = \text{real part}$ ,  $\omega = \text{imaginary part}$ .

#### SIGNAL DISTORTION

Electrical signal processed by a circuit may undergo three types of distortion: amplitude distortion, frequency distortion and phase distortion.

**Amplitude distortion:** Also known as harmonic or non-linear distortion, this is caused by the nonlinear transfer function characteristics of the components/devices in the circuit (Fig. 3). That is, an input signal  $x(t)$  will be delivered at the output of the circuit as  $y(t) = a_0x(t) + a_1x^2(t) + a_2x^3(t) + \dots$ , where  $a_0, a_1, a_2, \dots$  are the coefficients of the nonlinear transfer function.

**Frequency distortion:** Also known as harmonic or non-linear distortion, this is caused by the nonlinear transfer function characteristics of the components/devices in the circuit (Fig. 4). That is, an input signal  $x(t)$  will be delivered at the output of the circuit as  $y(t) = a_0x(t) + a_1x^2(t) + a_2x^3(t) + \dots$ , where  $a_0, a_1, a_2, \dots$  are the coefficients of the nonlinear transfer function.

**Phase distortion:** This is caused by the nonlinear transfer function characteristics of the components/devices in the circuit (Fig. 5). That is, an input signal  $x(t)$  will be delivered at the output of the circuit as  $y(t) = a_0x(t) + a_1x^2(t) + a_2x^3(t) + \dots$ , where  $a_0, a_1, a_2, \dots$  are the coefficients of the nonlinear transfer function.

#### DIODES: IDEAL & PRACTICAL VERSIONS

**Ideal diode:** An ideal diode is a two-terminal, non-linear, unidirectional electrical element. Ideally, it conducts electricity in one direction and does not allow the current to flow in the opposite direction. Compared to Fig. 6, to see the current  $I$  — voltage  $V$  characteristic of a bilateral element (such as a resistor  $R$ ) and of an ideal diode.

**Practical diode:** In a practical diode, there is a small reverse current (called a leakage current) which flows in the reverse bias with its anode kept at positive (or anode relative to its other (cathode) terminal). In the reverse bias (anode being at negative potential with respect to cathode), there is a small reverse current (called a leakage current) which flows in the reverse bias, i.e. current is small. In the forward bias, i.e. anode is at positive potential with respect to cathode, there is a large forward current (called a forward current) which flows in the forward bias.

#### DIODES AS CIRCUIT ELEMENTS

**Basic applications of diodes:**

- Rectification
- Waveform clipping
- Diode as a switch
- Diode as a variable capacitor
- Diode as a variable inductor
- Diode as a variable resistor
- Diode as a variable capacitor
- Diode as a variable inductor
- Diode as a variable resistor

**Ideal Diode Switch:** An ideal diode switch is a two-terminal, non-linear, unidirectional electrical element. Ideally, a diode is a short-circuit element under forward bias and behaves as an open circuit when reverse biased. Its state is set by the magnitude of the voltage  $V$  across it. For  $V > 0$ ,  $I = \infty$  corresponding to short-circuit or off-state as illustrated in Fig. 7.

**Practical Diode Switch:** A practical diode switch is a two-terminal, non-linear, unidirectional electrical element. In the forward bias, it behaves as a short-circuit element. In the reverse bias, it behaves as an open circuit. Its state is set by the magnitude of the voltage  $V$  across it. For  $V > 0$ ,  $I = \infty$  corresponding to short-circuit or off-state as illustrated in Fig. 7.

**Half-wave Rectifier:** A diode can be used to rectify the alternating current (AC) voltage (or current) as a one-directional quantity. A simple half-wave rectifier is illustrated in Fig. 8. The current flows through the load resistor  $R_L$  only during positive half-cycle as the diode conducts (forward bias). During negative half-cycle, the diode is reverse-biased and no current flows through the load resistor  $R_L$ .



## Synopsis

Fundamentals of electronic devices and basic electronic circuits. As an engineer, tradesman or electronics student, this guide will help with over 50 diagrams and equations.

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I bought probably most of the QuickStudy guides over the years and they were almost always a big help both in and out of class. The several electronics guides were among my favorites. This one covers basic electronics as opposed to electricity and so deals with electronic devices like amplifiers, which it focuses on. Includes amplification, feedback, cascading, and more. You can't include everything of course in a little primer like this but the most important concepts get covered. These guides were durable, colorful, attractive, and fun to use. I have some that are going on decades old and the colors still haven't faded. In school they were almost constant companions in some of my courses. Overall another great little guide from BarCharts/QuickStudy.

Stashed this away for reference on projects if anything is forgotten or disputed. No longer need internet if its not available. The quality is good, but the amount of information is overwhelming. If you are going to actually be studying for a class, I recommend making your own study card in addition to buying this as there are many benefits to doing so.

It's legible, convenient, durable, water proof, etc. It's a handy little cheat sheet. I keep in a binder with the documents for a TI Nspire Calculator. I was kinda hoping that it would cover microwave transmission parameters. Some of that is on the Circuit Theory/Analysis card. Still, there was not much on the cards concerning practical impedance matching circuits. You just can't cram everything on a couple or three cards. All the basics are there. You should be able to derive the rest.

BarCharts are a great little reference. I would not recommend them as a study aid, but as a quick reference, they are great! I have used them for Chem, Physics, Electronics and Math. They are great for what they are.

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