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# Electronics 1 Part 1 (Quickstudy: Academic)

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## 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 electronic device, signal processing networks formed by interconnections of passive and active electronic components.

**Power Circuits:** Resistive, capacitive and inductive.

**Active Circuits:** (using active devices): Transistors, metal-oxide-semiconductors, etc.

**Electronic Systems:** An arrangement of components (active elements, and passive devices) with a specified input-output process or a defined function.

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

- Amplification (magnification)
- Filtering
- Differentiation
- Integration
- Modulation
- Demodulation
- Filtering: Changing the relative magnitude of different frequency components of the signal.
- Rectification: Selection/selection of a particular part of the signal or pulses.
- Peak Detection Circuits
- Harmonic oscillators: Product sinusoidal wave forms of different frequency, as, termed as subharmonic oscillations, their other versions can produce non sinusoidal wave forms such as square, triangular, etc.
- Digital Circuits: Circuits that perform digital operations such as addition, subtraction, multiplication, etc. in binary form.

**ELECTRICAL SIGNAL**

An electrical signal is an information-bearing electrical entity (such as voltage or current) derived from a transducer (e.g. voice signal voltage) defined by a unique waveform. Signal processing is concerned with electrical signal as it is received in order to decide the meaning of the information contained in it. Signal current can be represented by Fig. 1.

**Hartmann's equivalent circuit:** A voltage generator  $V$  is series with a source resistance  $R_s$  and a load resistance  $R_L$ .

**Fourier's representation:** The signal  $v$  is represented by a voltage  $v = v_0 \sin(\omega t + \phi)$  where  $v_0$  is amplitude,  $\omega$  is angular frequency and  $\phi$  is phase. The signal  $v$  is a time-varying function representing a periodic wave form. The frequency  $f$  is a function of time. It can be periodic with a definite period  $T$ , or, it can be aperiodic. A complex wave form is a periodic sum of several waves. Some of these waves are periodic and some are aperiodic. A periodic wave form has a discrete spectrum of harmonics, conversely wave forms of magnitude are related to Fourier series expansion. An aperiodic function has a continuous spectrum of harmonics, conversely a per-foresce integral transform.

**Expansion of signal represented by Fig. 2:**

Fourier series and Fourier transform

A periodic signal can be represented by a superposition of infinite number of harmonic components of different frequencies. The frequency of the fundamental component is called fundamental angular frequency.

Fourier expansion of a square wave (Fig. 2)

$v = \frac{4V_0}{\pi} \left[ \sin(\omega t) + \frac{1}{3} \sin(3\omega t) + \frac{1}{5} \sin(5\omega t) + \dots \right]$

**Fourier Transform:**  $V(f) = \int_{-\infty}^{\infty} v(t) e^{-j2\pi ft} dt$

**CONTINUOUS FOURIER TRANSFORM**

$v(t) = \int_{-\infty}^{\infty} V(f) e^{j2\pi ft} df$

**SIGNAL DISTORTION**

Distortion of signal processed by a circuit may undergo three types of distortion: amplitude, phase and distortion due to noise.

**Amplitude Distortion:** Also known as harmonic or overdrive distortion, this is caused by the nonlinear transfer function characteristic of the components delivered in the circuit (Fig. 3). That is, an input signal  $v_i$  will be non-linearly converted in the circuit  $v_o = A(v_i) = A_0 + A_1 v_i + A_2 v_i^2 + A_3 v_i^3 + \dots$ , where  $A_0, A_1, A_2, \dots$  are constants. If the input signal is a pure sine wave, the frequency signal, the output will create higher harmonic components in square, cubic, etc., etc. As a result, the output signal wave shape will be non-distorted (waveform distortion).

**Fig. 4**

**Amplitude Distortion**

$v_o = A(v_i) = A_0 + A_1 v_i + A_2 v_i^2 + A_3 v_i^3 + \dots$

**Frequency Distortion:** Due to the presence of reactive ( $iC$ ) and resistive ( $R$ ) elements in the circuit, a complex signal component of a spectrum of several frequency components will have varying of its components, although the maximum frequency of input signal is constant. As a result, the output frequency plot is as shown in Fig. 5. The distortion of a quartz crystal filter (QCF) starts at high (HF) and low (LF) frequencies, as, for example, due to low reactance of the shunt capacitance  $C_0$  and high resistance of series capacitance  $C_0$  respectively.

**Fig. 5**

**Frequency Distortion**

$v_o = A(v_i) = A_0 + A_1 v_i + A_2 v_i^2 + A_3 v_i^3 + \dots$

**Phase Distortion:** Considering the input and output signals, their relative phase angle  $\phi$  again decided by  $C$  circuit. If  $C$  is present in the circuit, then their phase difference is frequency dependent. For a complex input signal with a spectrum of several frequencies, the output signal will have a different phase in different frequencies. This is called dispersion of the circuit when plotted against frequency, as shown in Fig. 6. Except over a range of frequencies, dispersion of the circuit will reflect apparently to frequency, as shown in Fig. 7. For example, dispersion of the circuit will appear to be zero at low frequencies due to series and shunt inductor and capacitor, respectively, and to be high at high frequencies due to shunt and series inductive elements, if present.

**NOISE**

Note: An undesired entity introduced to the signal in the circuit, either caused by various other elements of the circuit. Noise is a random fluctuation and affects the quality of the signal. The noise level should be minimized (high signal-to-noise ratio).

**Fig. 6**

**Dispersion of a Filter**

**Fig. 7**

**Dispersion of a Resonator**

**Fig. 8**

**Half-Wave Rectifier**

**CIRCUIT DEVICES**

**DIODES: IDEAL & PRACTICAL VERSIONS**

**1. Ideal:**  $i = \frac{v}{R}$  (Fig. 9)

**2. Practical:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 10)

**3. Zener:**  $v = v_z$  (Fig. 11)

**4. Varactor:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 12)

**5. Schottky:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 13)

**6. Avalanche:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 14)

**7. Varicap:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 15)

**8. Diode Switch:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 16)

**9. Zener Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 17)

**10. Varactor Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 18)

**11. Schottky Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 19)

**12. Avalanche Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 20)

**13. Varicap Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 21)

**14. Diode Switch:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 22)

**15. Zener Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 23)

**16. Varactor Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 24)

**17. Schottky Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 25)

**18. Avalanche Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 26)

**19. Varicap Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 27)

**20. Diode Switch:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 28)

**21. Zener Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 29)

**22. Varactor Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 30)

**23. Schottky Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 31)

**24. Avalanche Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 32)

**25. Varicap Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 33)

**26. Diode Switch:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 34)

**27. Zener Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 35)

**28. Varactor Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 36)

**29. Schottky Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 37)

**30. Avalanche Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 38)

**31. Varicap Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 39)

**32. Diode Switch:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 40)

**33. Zener Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 41)

**34. Varactor Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 42)

**35. Schottky Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 43)

**36. Avalanche Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 44)

**37. Varicap Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 45)

**38. Diode Switch:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 46)

**39. Zener Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 47)

**40. Varactor Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 48)

**41. Schottky Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 49)

**42. Avalanche Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 50)

**43. Varicap Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 51)

**44. Diode Switch:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 52)

**45. Zener Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 53)

**46. Varactor Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 54)

**47. Schottky Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 55)

**48. Avalanche Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 56)

**49. Varicap Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 57)

**50. Diode Switch:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 58)

**51. Zener Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 59)

**52. Varactor Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 60)

**53. Schottky Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 61)

**54. Avalanche Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 62)

**55. Varicap Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 63)

**56. Diode Switch:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 64)

**57. Zener Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 65)

**58. Varactor Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 66)

**59. Schottky Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 67)

**60. Avalanche Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 68)

**61. Varicap Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 69)

**62. Diode Switch:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 70)

**63. Zener Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 71)

**64. Varactor Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 72)

**65. Schottky Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 73)

**66. Avalanche Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 74)

**67. Varicap Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 75)

**68. Diode Switch:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 76)

**69. Zener Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 77)

**70. Varactor Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 78)

**71. Schottky Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 79)

**72. Avalanche Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 80)

**73. Varicap Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 81)

**74. Diode Switch:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 82)

**75. Zener Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 83)

**76. Varactor Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 84)

**77. Schottky Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 85)

**78. Avalanche Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 86)

**79. Varicap Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 87)

**80. Diode Switch:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 88)

**81. Zener Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 89)

**82. Varactor Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 90)

**83. Schottky Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 91)

**84. Avalanche Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 92)

**85. Varicap Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 93)

**86. Diode Switch:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 94)

**87. Zener Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 95)

**88. Varactor Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 96)

**89. Schottky Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 97)

**90. Avalanche Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 98)

**91. Varicap Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 99)

**92. Diode Switch:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 100)

**93. Zener Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 101)

**94. Varactor Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 102)

**95. Schottky Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 103)

**96. Avalanche Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 104)

**97. Varicap Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 105)

**98. Diode Switch:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 106)

**99. Zener Diode:**  $i = i_0 (e^{v/v_t} - 1)$  (Fig. 107)

**100. Varactor Diode:**  $v = v_z + \frac{1}{2} C_0 v^2$  (Fig. 108)

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## 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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husband loves them He says great learning/reference tool

Great reference!

basic

High quality and delivered on time.

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.

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