Electronics

- Involves the use of devices and circuits to control the flow of electric current to achieve some purpose.
- These circuits contain:
  - Resistors, capacitors, inductors...
  - Electronic devices: diodes, transistors (non-linear devices)...
- These devices are termed *solid state.*
The transfer of power from its generation point to its point of use may be done by using:

- AC – alternating current.
- DC – Direct current.

Most electronic circuit require DC as a source of power in order to operate.
Analog and Digital Systems

- **Signal** – a voltage or current varied over time in order to encode and transmit information.
- Electronic systems may be classified by the type of signal they process.
  - Analog.
  - Digital.
Analog Signals

Signals that vary continuously with time.

(a) Analog signal

Varies continuously and can assume any level
Analog Systems

This systems handle analog signals and these signals may be complex or periodic. Note that a complex signal can be shown to be composed of a number of sinusoidal signals.
Sinusoidally Varying Signals

$v(t) = A \sin(\omega t + \theta)$
- $A =$ amplitude.
- $\omega =$ angular frequency (radians per second).
- $\theta =$ phase angle.

Frequency in Hertz is given by the following relation:
- $f = \frac{\omega}{2\pi}$
Digital Signals

Signals that switch between discrete levels over time.

(b) Digital signal
Pulses

Classified as:
- Positive.
- Negative.
Serial and Parallel

The transmission of information may be classified as:

- Serial – when the information is transmitted over a single line.
- Parallel – when the information is transmitted over several lines simultaneously.
Amplifiers and Gain

Amplifiers are electronic circuit used to increase the amplitude of signal. This signal may be a voltage or current.

The gain of a voltage amplifier is determined by the following ratio:

\[ A_v = \frac{|v_o|}{|v_i|} \]
Decibels

The gain of an amplifier is sometimes expressed in decibels (db), which is defined by:

\[ A_v(\text{db}) = 20 \log A_v \]
Frequency Response

The way in which the gain varies as the frequency of a sinusoidal input signal is changed.
Half-power Frequencies

The high and low frequencies where the gain is reduced by a factor of 0.707 from the midband value are termed:

- $f_{LO}$ - low-corner frequency.
- $f_{HI}$ - upper-corner frequency.

These are the half power frequencies.

\[ 3 \text{dB} = 20 \log \left( \frac{1}{\sqrt{2}} \right) \]
Bandwidth

The difference in frequency between the upper-corner frequency and the lower-corner frequency.
Modulation and Demodulation

- Modulation is the process used to encode information on an analog signal.
- Demodulation is the process used to extract information from an analog signal.
- Modem – *modulator-demodulator.*
Modulation and Demodulation

A signal may be encoded with:
- Amplitude modulation;
- Frequency modulation;
- Phase modulation
Amplitude Modulation

In amplitude modulation the amplitude of the carrier wave is changed by the information to be transmitted.
Amplitude Modulation

\[ v_c(t) = V_c \sin(\omega_c t) \]
\[ v_m(t) = V_m \sin(\omega_m t) \]
\[ \omega_m \ll \omega_c \]
\[ v_{AM}(t) = [V_c + V_m \sin(\omega_m t)]\sin(\omega_c t) \]
\[ v_{AM}(t) = V_c \left[ 1 + \frac{V_m}{V_c} \sin(\omega_m t) \right] \sin(\omega_c t) \]

Modulation Index : \( m = \frac{V_m}{V_c} \)
\[ v_{AM}(t) = V_c \sin(\omega_c t) + mV_c \sin(\omega_m t)\sin(\omega_c t) \]
\[ v_{AM}(t) = V_c \sin(\omega_c t) + m \frac{V_c}{2} \cos((\omega_c - \omega_m) t) - m \frac{V_c}{2} \cos((\omega_c + \omega_m) t) \]
Upper and Lower Sidebands

The previous result showed that the amplitude modulation had a frequency component at the carrier frequency and two components with the information at the \((\omega_c + \omega_m)\) and \((\omega_c - \omega_m)\) frequencies. These are called the upper and lower sidebands.
Encoding and Decoding

- Encoding is the process used to encode information on a digital signal.
- Decoding is the process used to extract information from a digital signal.
Digital Systems

- Digital systems use circuits with binary logic which are represented by voltages, and sometimes currents, that switch between one of two possible levels.
- These levels are called:
  - Logic 0 – low level;
  - Logic 1 – high level.
- A *bit*, binary digit, is a single unit of digital information.
Digital Systems

A series of bit that represent some information is termed a *digital word*.

- Nibble = 4 bits;
- Byte = 8 bits;
- Word = 16 bits;
- Double word = 32 bits;
- Quad word = 64 bits.
Digitizing Analog Signals

- This is the process of converting an analog signal into a digital one.
- An analog signal varies continuously over time while a digital signal varies at discrete points in time.
Digitizing Analog Signals

Sampling Rate:
- Number of times the signal is sampled each second.
- Minimum sampling rate, also known as the Nyquist frequency, is twice the maximum frequency of the signal being sampled.

$$f_s \geq 2f_m$$
Digitizing Analog Signals

Resolution is the number of zones for quantization. The number of bits each sample will be represent with.

- $Z = 2^n$ where $n$ is the number of bits.
Logic Gates

- Most basic digital device.
- Electronic circuits that has one or more inputs that accept voltage level corresponding to logic 0 and logic 1 signals and produce an output that is a function of the current input values.
- Any digital function can be realized with just three types of gates, the AND, OR and NOT gates.
Logic Gates

- **AND gate**
  - Inputs: 00, 01, 11
  - Outputs: 00, 01, 11

- **OR Gate**
  - Inputs: 00, 01, 11
  - Outputs: 00, 01, 11

- **Inverter**
  - Input: 0, 1
  - Output: 1, 0