EEE 3101: Digital Logic and Circuits

DIGITAL AND ANALOG SIGNALS

Course Teacher: Nafiz Ahmed Chisty

Associate Professor, Department of EEE & CoE
Head (UG), Department of EEE
Faculty of Engineering
Room# DNG03, Ground Floor, D Building
Email: chisty@aiub.edu
Website: http://engg.aiub.edu/
Website: www.nachisty.com

DIGITAL AND ANALOG SIGNALS

Signals carry information and are defined as any physical quantity that varies with time, space, or any other independent variable. For example, a sine wave whose amplitude varies with respect to time or the motion of a particle with respect to space can be considered as signals. A system can be defined as a physical device that performs an operation on a signal. For example, an amplifier is used to amplify the input signal amplitude. In this case, the amplifier performs some operation(s) on the signal, which has the effect of increasing the amplitude of the desired information-bearing signal.

Signals can be categorized in various ways; for example discrete and continuous time domains. Discrete-time signals are defined only on a discrete set of times. Continuous-time signals are often referred to as continuous signals even when the signal functions are not continuous; an example is a square-wave signal.

A digital system is the one that handles only discrete values or signals. Any set that is restricted to a finite number of elements contains discrete information. The word digital describes any system based on discontinuous data or events. Digital is the method of storing, processing and transmitting information through the use of distinct electronic pulses that represent the binary digits 0 and 1. Examples of discrete sets are the 10 decimal digits, the 26 letters of the alphabet etc. A digital system would be to flick the light switch on and off. There's no 'in between' values.

Advantages of digital signals

The usual advantages of digital circuits when compared to analog circuits are:

Noise Margin (resistance to noise/robustness) : Digital circuits are less affected by noise. If the noise is below a certain level (the noise margin), a digital circuit behaves as if there was no noise at all. The stream of bits can be reconstructed into a perfect replica of the original source. However, if the noise exceeds this level, the digital circuit cannot give correct results.

Error Correction and Detection : Digital signals can be regenerated to achieve lossless data transmission, within certain limits. Analog signal transmission and processing, by contrast, always introduces noise.

Easily Programmable : Digital systems interface well with computers and are easy to control with software. It is often possible to add new features to a digital system without changing hardware, and to do this remotely, just by uploading new software. Design errors or bugs can be worked-around with a software upgrade, after the product is in customer hands. A digital system is often preferred because of (re-)programmability and ease of upgrading without requiring hardware changes.

Cheap Electronic Circuits : More digital circuitry can be fabricated per square millimeter of integrated-circuit material. Information storage can be much easier in digital systems than in analog ones. In particular, the great noise-immunity of digital systems makes it possible to store data and retrieve it later without degradation. In an analog system, aging and wear and tear will degrade the information in storage, but in a digital system, as long as the wear and tear is below a certain level, the information can be recovered perfectly. Theoretically, there is no data-loss when copying digital data. This is a great advantage over analog systems, which faithfully reproduce every bit of noise that makes its way into the signal.

Disadvantages:

The world in which we live is analog, and signals from this world such as light, temperature, sound, electrical conductivity, electric and magnetic fields, and phenomena such as the flow of time, are for most practical purposes continuous and thus analog quantities rather than discrete digital ones. For a digital system to do useful things in the real world, translation from the continuous realm to the discrete digital realm must occur, resulting in quantization errors. This problem can usually be mitigated by designing the system to store enough digital data to represent the signal to the desired degree of fidelity. The Nyquist-Shannon sampling theorem provides an important guideline as to how much digital data is needed to accurately portray a given analog signal.

Digital systems can be fragile, in that if a single piece of digital data is lost or misinterpreted, the meaning of large blocks of related data can completely change. This problem can be diminished by designing the digital system for robustness. For example, a parity bit or other error-detecting or error-correcting code can be inserted into the signal path so that minor data corruptions can be detected and possibly corrected.

Digital circuits use more energy than analog circuits to accomplish the same calculations and signal processing tasks, thus producing more heat as well. In portable or battery-powered systems this can be a major limiting factor.

Digital circuits are made from analog components, and care has to be taken to all noise and timing margins, to parasitic inductances and capacitances, to proper filtering of power and ground connections, to electromagnetic coupling amongst data lines. Inattention to these can cause problems such as "glitches", pulses do not reach valid switching (threshold) voltages, or unexpected ("undecoded") combinations of logic states.

A corollary of the fact that digital circuits are made from analog components is the fact that digital circuits are slower to perform calculations than analog circuits that occupy a similar amount of physical space and consume the same amount of power. However, the digital circuit will perform the calculation with much better repeatability, due to the high noise immunity of digital circuitry.

Reference:

Mixed contents from books by Floyd; Mano.

Thanks