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Electronic Circuits: Analog and Digital Circuits

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Opinion Article

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ABOUT THE STUDY

Individual electronic components such as resistors, transistors, capacitors, inductors, and diodes are connected by conductive wires or traces through which electric current can flow to form an electronic circuit. It is a type of electrical circuit, and in order for it to be called electronic rather than electrical, at least one active component must be present. The combination of components and wires enables the execution of a variety of simple and complex operations, such as signal amplification, computation, and data transfer.

Circuits can be built from discrete components connected by individual wires, but it is much more common today to use photolithographic techniques to create interconnections on a laminated substrate (A Printed Circuit Board or PCB) and solder the components to these interconnections to create a finished circuit. The components and interconnections of an Integrated Circuit (IC) are formed on the same substrate, which is typically a semiconductor such as doped silicon or (less commonly) gallium arsenide.

An electronic circuit is typically classified as either an analogue circuit, a digital circuit, or a mixed-signal circuit (a combination of analogue circuits and digital circuits). The MOSFET is the most commonly used semiconductor device in electronic circuits (Metal-Oxide-Semiconductor Field-Effect Transistor).

Analog circuits

Analog electronic circuits are those in which current or voltage can vary continuously with time to represent information. Analog circuitry is made up of two basic building blocks: Series and parallel circuits. In a parallel circuit, all of the components are connected to the same voltage, and the current is divided among them based on their resistance. When the size of the circuit is comparable to a wavelength of the relevant signal frequency, a more sophisticated approach, the distributed-element model, must be used. Wires are treated as transmission lines with nominally constant characteristic impedance, and the impedances at the line's beginning and end determine transmitted and reflected waves. Circuits designed in this manner are distributed-element circuits.

Such considerations are typically relevant for circuit boards operating at frequencies above one Gigahertz (GHz); integrated circuits are smaller and can be treated as lumped elements at frequencies less than ten Gigahertz (GHz).

Digital circuits

Electric signals in digital electronic circuits take on discrete values to represent logical and numeric values. The information being processed is represented by these values. Binary encoding is used in the vast majority of cases: One voltage (typically the more positive value) represents a binary '1' and another voltage (typically a value near the ground potential, 0 V) represents a binary '0'. Digital circuits make extensive use of transistors, which are interconnected to form logic gates that perform Boolean logic functions such as AND, NAND, OR, NOR, XOR, and combinations thereof.

Latches and flip flops are circuits that have two or more metastable states and remain in one of these states until changed by an external input using transistors interconnected to provide positive feedback. As a result, digital circuits can provide logic and memory, allowing them to perform arbitrary computational functions. (Flip-Flop Memory is referred to as Static Random-Access Memory-SRAM). Dynamic Random-Access Memory (DRAM), which is based on the storage of charge in a capacitor, is also widely used.)

The design process for digital circuits differs significantly from that for analogue circuits. Because each logic gate regenerates the binary signal, the designer does not need to account for distortion, gain control, offset voltages, and other analogue design concerns. As a result, extremely complex digital circuits with billions of logic elements integrated on a single silicon chip can now be manufactured at a low cost. These digital integrated circuits are found in a wide range of modern electronic devices, including calculators, mobile phone handsets, and computers. Time delay, logic races, power dissipation, non-ideal switching, on-chip and inter-chip loading, and leakage currents become limitations to circuit density, speed, and performance as digital circuits become more complex.

Digital circuitry is used to build general-purpose computing chips like microprocessors as well as custom-designed logic circuits called Application-Specific Integrated Circuits (ASICs). FPGAs, chips with logic circuitry whose configuration can be changed after fabrication, are also widely used in prototyping and development.