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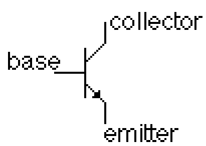
Question 1 – Describe to a 12 year old how transistor works and why is so important in applications around us.




Typical transistor packages

The essential usefulness of a transistor comes from its ability to use a small signal applied between one pair of its terminals to control a much larger signal at another pair of terminals. This property is called gain. A transistor can control its output in proportion to the input signal, that is, can act as an amplifier. Or, the transistor can be used to turn current on or off in a circuit like an electrically controlled switch, where the amount of current is determined by other circuit elements.

In electronics, a **transistor** is a semiconductor device commonly used to amplify or switch electronic signals. A transistor is made of a solid piece of a semiconductor material, with at least three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals changes the current flowing through another pair of terminals. Because the controlled (output) power can be much larger than the controlling (input) power, the transistor provides amplification of a signal. The transistor is the fundamental building block of modern electronic devices, and is used in radio, telephone, computer and other electronic systems. Some transistors are packaged individually but most are found in integrated circuits.

The design of a transistor allows it to function as an amplifier or a switch. This is accomplished by using a small amount of electricity to control a gate on a much larger supply of electricity, much like turning a valve to control a supply of water.

Transistors are composed of three parts – a base, a collector, and an emitter. The base is the gate controller device for the larger electrical supply. The collector is the larger electrical supply, and the emitter is the outlet for that supply. By sending varying levels of current from the base, the amount of current flowing through the gate from the collector may be regulated. In this way, a very small amount of current may be used to control a large amount of current, as in an amplifier. The same process is used to create the binary code for the digital processors but in this case a voltage threshold of five volts is needed to open the collector gate. In this way, the transistor is being used as a switch with a binary function: five volts – ON, less than five volts – OFF.

Semi-conductive materials are what make the transistor possible. Most people are familiar with electrically conductive and non-conductive materials. Metals are typically thought of as being conductive. Materials such as wood, plastics, glass and ceramics are non-conductive, or insulators. In the late 1940's a team of scientists working at Bell Labs in New Jersey, discovered how to take certain types of crystals and use them as electronic control devices by exploiting their semi-conductive properties. Most non-metallic crystalline structures would typically be considered insulators. But by forcing crystals of germanium or silicon to grow with impurities such as boron or phosphorus, the crystals gain entirely different electrical conductive properties. By sandwiching this material between two conductive plates (the emitter and the collector), a transistor is made. By applying current to the semi-conductive material (base), electrons gather until an effectual conduit is formed allowing electricity to pass The scientists that were responsible for the invention of the transistor were John Bardeen, Walter Brattain, and William Shockley. Their Patent was called: "Three Electrode Circuit Element Utilizing Semiconductive Materials."

Question 2 - Characterize using the following criteria –

Projected rather than 3D
Serial, rather than batch or continuous
Top-down rather than bottom-up

Laser machining, Mechanical machining, E-beam machining and plastic molding

Laser machining – projected rather than 3D
Serial, rather than batch or continuous
Top-down rather than bottom-up

Laser cutting is a technology that uses a laser to cut materials, which is used in the production line and is typically used for industrial manufacturing applications. Laser cutting works by directing the output of a high power laser, by computer, at the material to be cut. The material then either melts, burns, vaporizes away, or is blown away by a jet of gas leaving an edge with a high quality surface finish.

Mechanical machining - projected rather than 3D
Serial, rather than batch or continuous
Top-down rather than bottom-up

Conventional machining, one of the most important material removal methods, is a collection of material-working processes in which power-driven machine tools, such as lathes, milling machines, and drill presses are used with a sharp cutting tool to mechanically cut the material to achieve the desired geometry.

E-beam machining and plastic molding - projected rather than 3D
Serial, rather than batch or continuous
Top-down rather than bottom-up

Electron-beam machining (EBM) is a machining process where high-velocity electrons are directed toward a work piece, creating heat and vaporizing the material. Applications of this process are annealing, metal removal, and welding. EBM can be used for very accurate cutting of a wide variety of metals.

Question 3 –

The following dimensional-mass-density analysis is relevant:

$$Volume \cdot Density = Mass$$

$$Mass \cdot \left(\frac{Avogadro's\_Number}{AtomicMass} \right) = Number\_of\_Atoms$$

$$\frac{Number\_of\_Atoms}{Deposition\_Rate} = Time$$

Atomic mass: 107.8682
Density(25^{o}C)=10.50g/cm^{-3}
Avogadro’s number: 6.02*10^{23} (reference to grams)
Volume=100micrometer*1micrometer*1micrometer
=0.01cm*0.0001cm*0.0001cm=1*10^{-10}cm
Deposition rate=1 atom per second

Mass=1.05*10^{-9}g
Number of atoms=5.86*10^{12}atoms
Time=5.86*10^{12}seconds
Alternative method: use atomic radius of 1.4Angstrom