Rajasthan Institute of Engineering & Technology, Jaipur

M.Tech. I mid Term Examination

Session: 2017-18

II Sem Production Engineering
MECHATRONICS (6ME3A)
Solution

Time: -2 Hrs. **[Maximum Marks: -25]**
Minimum marks :- 13

Instructions to Candidates: -

1. **No provision for Supplementary answer book.All Question carry equal marks.**

Q.01. What do you mean by Mechatronics system? Enlist the Scope & Application of Mechatronics.

Ans.01 Mechatronics is a multidisciplinary field of science that includes a combination of mechanical engineering, electronics, computer engineering, telecommunications engineering, systems engineering and control engineering. As technology advances, the subfields of engineering multiply and adapt .Mechatronics' aim is a design process that unifies these subfields. Originally, mechatronics just included the combination of mechanics and electronics, therefore the word is a combination of mechanics and electronics; however, as technical systems have become more and more complex the definition has been broadened to include more technical areas.

The word "mechatronics" originated in Japanese-English and was created by Tetsuro Mori, an engineer of Yaskawa Electric Corporation. The word "mechatronics" was registered as trademark by the company in 1971.Mechatronics defins as "approach aiming at the synergistic integration of mechanics, electronics, control theory, and computer science within product design and manufacturing, in order to improve and/or optimize its functionality".

Scope :-

The profession of mechatronics includes technicians and engineers. They design and maintain automated equipment. Technicians and engineers work in laboratories, offices or on-site manufacturing plants. The goal is to produce safe and efficient automated equipment. Technicians primarily maintain machinery, while engineers are more concerned with design and development of components and products.

Application

- Machine vision
- Automation and robotics
- Servo-mechanics
- Sensing and control systems
- Automotive engineering, automotive equipment in the design of subsystems such as anti-lock braking systems
- Computer-machine controls, such as computer driven machines like CNC milling machines, CNC waterjets, and CNC plasma cutters

- Expert systems
- Industrial goods
- Consumer products
- Mechatronics systems
- Medical mechatronics, medical imaging systems
- Structural dynamic systems
- Transportation and vehicular systems
- Mechatronics as the new language of the automobile
- Computer aided and integrated manufacturing systems
- Computer-aided design
- Engineering and manufacturing systems
- Packaging
- Microcontrollers / PLCs

Q.02 Explain the Microprocessor used in mechatronic system..

Ans.02 A microprocessor is a computer processor which incorporates the functions of a computer's central processing unit (CPU) on a single integrated circuit (IC), or at most a few integrated circuits.[2] The microprocessor is a multipurpose, clock driven, register based, digital-integrated circuit which accepts binary data as input, processes it according to instructions stored in its memory, and provides results as output. Microprocessors contain both combinational logic and sequential digital logic. Microprocessors operate on numbers and symbols represented in the binary numeral system.

The integration of a whole CPU onto a single chip or on a few chips greatly reduced the cost of processing power, increasing efficiency. Integrated circuit processors are produced in large numbers by highly automated processes resulting in a low per unit cost. Single-chip processors increase reliability as there are many fewer electrical connections to fail. As microprocessor designs get better, the cost of manufacturing a chip (with smaller components built on a semiconductor chip the same size) generally stays the same.

Microprocessor is defined “as a silicon chip embedded with a Central Processing Unit or CPU. It is also referred to as a computer's logic chip, micro chip, and processor”. Before microprocessors, small computers had been built using racks of circuit boards with many medium- and small-scale integrated circuits. Microprocessors combined this into one or a few large-scale ICs. Continued increases in microprocessor capacity have since rendered other forms of computers almost completely obsolete (see history of computing hardware), with one or more microprocessors used in everything from the smallest embedded systems and handheld devices to the largest mainframes and supercomputers.

The internal arrangement of a microprocessor varies depending on the age of the design and the intended purposes of the microprocessor. The complexity of an integrated circuit (IC) is bounded by physical limitations of the number of transistors that can be put onto one chip, the number of package terminations that can connect the processor to other parts of the system, the number of interconnections it is possible to make on the chip, and the heat that the chip can dissipate.

Advantages of Microprocessors is that these are general purpose electronic processing devices which can be programmed to execute a number of tasks. These are used in personal computers as well as a number of other embedded products. There are no disadvantages as such but when compared tofixed logic devices or certain ASICs (application specific intergrated circuits), there is a need to program Microprocessors and write software/firmware when used in embedded applications.

Q.03 What do you mean by Sensors & Transducers? Enlist the types of transducers used in mechatronic system.

Ans.03 The main difference between sensor and transducer is that a transducer is a device that can convert energy from one form to another, whereas a sensor is a device that can detect a physical quantity and convert the data into an electrical signal. Sensors are also a type of transducers.

Sensors

In general sensors are the electronic module that detect and monitor physical or chemical phenomenon whereas actutors are ones those produces mechanical motion, force and torque. Sensing can be broadly defined as energy transduction processes that results in perception, whereas actuation is energy transduction precosses that produce action.The quality of a sensor depends on how weak a signal it can "pick up". Minimum discernible signal describes the lowers signal that can be picked up by a sensor. Merely having the ability to register weak signals is not good enough either: the sensor should also have the ability to distinguish that signal from the noise. The term sensitivity describes a sensor's ability to do this. Resolution of a sensor describes how good the sensor is at differentiating between two different levels of the signal.

Transducer

Transducer is a device which converts one form of energy into another. So sensors are, in fact, a type of transducer. However, transducers also consist of devices that convert energy into other forms, such as actuators. An actuator is something that can convert a different form of energy into motion.A transceiver is a device that both detects and gives out signals.

Types of Sensors

(1) Based on the quantity being measured

- Temperature:Resistance Temperature Detector (RTD), Thermistor, Thermocouple
- Pressure: Bourdon tube, manometer, diaphragms, pressure gauge
- Force/ torque:Strain gauge, load cell
- Speed/ position: Tachometer, encoder, LVDT
- Light:Photo-diode, Light dependent resistor

(2) Active and passive sensors

(3) Analog and digital sensor

(4) Inverse sensors

Transducer Types

(1) Piezoelectric Transducer

(2) Pressure Transducer

(3) Temperature Transducer

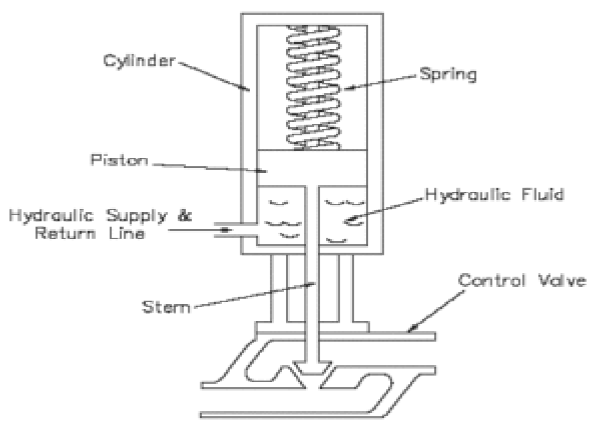
(4)Ultrasonic Transducer

Q.04 **Differentiate between Hydraulic & Pneumatic actuation System.Write down advantages of Hydraulic Actuation System.**

Ans.04 **Hydraulic actuator**

A hydraulic actuator consists of cylinder or fluid motor that uses hydraulic power to facilitate mechanical operation. The mechanical motion gives an output in terms of linear, rotatory or oscillatory motion. As liquids are nearly impossible to compress, a hydraulic actuator can exert a large force. The drawback of this approach is its limited acceleration.

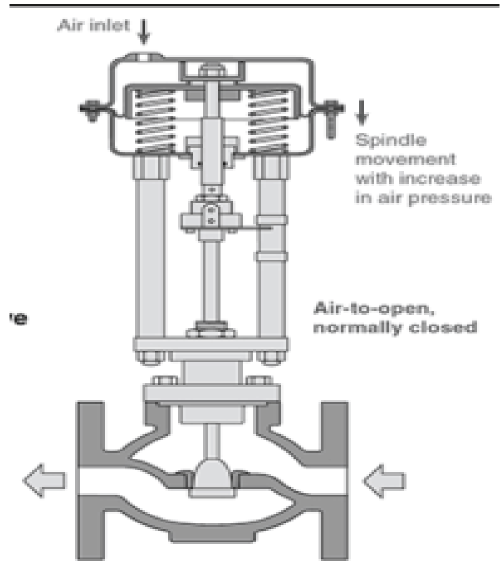
The hydraulic cylinder consists of a hollow cylindrical tube along which a piston can slide. The term *single acting* is used when the fluid pressure is applied to just one side of the piston. The piston can move in only one direction, a spring being frequently used to give the piston a return stroke. The term *double acting* is used when pressure is applied on each side of the piston; any difference in pressure between the two sides of the piston moves the piston to one side or the other.



Pneumatic Actuator

A pneumatic actuator converts energy formed by vacuum or compressed air at high pressure into either linear or rotary motion. Pneumatic energy is desirable for main engine controls because it can quickly respond in starting and stopping as the power source does not need to be stored in reserve for operation. Moreover, pneumatic actuators are safer, cheaper, and often more reliable and powerful than other actuators.[4]

Pneumatic actuators enable considerable forces to be produced from relatively small pressure changes. These forces are often used with valves to move diaphragms to affect the flow of liquid through the valve.



Advantages of Hydraulic Actuation Systems

Variable Speed and Direction: Most large electric motors run at adjustable, but constant speeds. It is also the case for engines. The actuator (linear or rotary) of a hydraulic system, however, can be driven at speeds that vary by large amounts and fast, by varying the pump delivery or using a flow control valve. In addition, a hydraulic actuator can be reversed instantly while in full motion without damage. This is not possible for most other prime movers.

Power-to-weight ratio: Hydraulic components, because of their high speed and pressure capabilities, can provide high power output with vary small weight and size, say, in comparison to electric system components. Note that in electric components, the size of equipment is mostly limited by the magnetic saturation limit of the iron. It is one of the reasons that hydraulic equipment finds wide usage in aircrafts, where dead-weight must be reduced to a minimum.

Stall Condition and Overload Protection: A hydraulic actuator can be stalled without damage when overloaded, and will start up immediately when the load is reduced. The pressure relief valve in a hydraulic system protects it from overload damage. During stall, or when the load pressure exceeds the valve setting, pump delivery is directed to tank with definite limits to torque or force output. The only loss encountered is in terms of pump energy. On the contrary, stalling an electric motor is likely to cause damage. Likewise, engines cannot be stalled without the necessity for restarting.

Q.05 Explain the Analog to digital conversion process .Describe the types of A/D converter.

Ans.05 Analog-to-digital conversion

It is an electronic process in which a continuously variable (analog) signal is changed, without altering its essential content, into a multi-level (digital) signal.

The input to an analog-to-digital converter (ADC) *c*onsists of a voltage that varies among a theoretically infinite number of values. Examples are sine waves, the waveforms representing human speech, and the signals from a conventional television camera. The output of the ADC, in contrast, has defined levels or states. The number of states is almost always a power of two -- that is, 2, 4, 8, 16, etc. The simplest digital signals have only two states, and are called binary. All whole numbers can be represented in binary form as strings of ones and zeros.

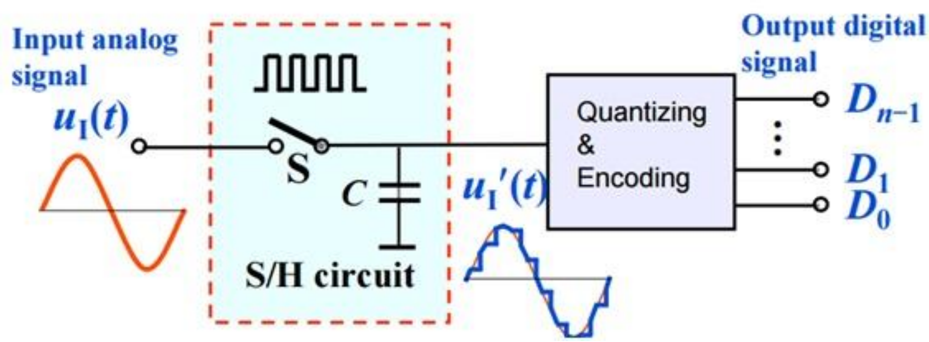
Digital signals propagate more efficiently than analog signals, largely because digital impulses, which are well-defined and orderly, are easier for electronic circuits to distinguish from noise, which is chaotic. This is the chief advantage of digital modes in communications. Computers "talk" and "think" in terms of binary digital data; while a microprocessor can analyze analog data, it must be converted into digital form for the computer to make sense of it.

A typical telephone modem makes use of an ADC to convert the incoming audio from a twisted-pair line into signals the computer can understand. In a digital signal processing system, an ADC is required if the signal input is analog.

ADC PROCESS

Mainly there are two steps for the analog to digital conversion:

1. S/H: Sampling and holding
2. Q/E: Quantizing and Encoding



Sampling and Holding

An analog signal continuously changes with time, in order to measure the signal we have to keep it steady for a short duration so that it can be sampled. We could measure the signal repeatedly and very fast, and then find out the right time scale. or we could measure the signal at different timings and then average it. Or preferably we can hold the signal for a specific duration and then digitize the signal and sample the value. This is done by a sample and hold circuit. For, at least the time required for digitization, it keeps the value stable.

Quantizing and Encoding

On the output of (S/H), a certain voltage level is present. We assign a numerical value to it. The nearest value, in correspondence with the amplitude of sampling and holding signal, is searched. And this value cannot be just any value, it should be from a limited set of possible values. It depends on the range of the quantizer and the range in given in a power of 2 i,e 2^n ($2^8 = 256$, $2^{10=}1024$ etc).

After identifying the closest value, a numerical value is assigned to it and it is encoded in the form of a binary number. The binary encoded numbers generated by quantizer are represented by ‘n’ bits. The resolution of an ADC can also be denoted by ‘n’ bit.The figure shows the whole conversion process:

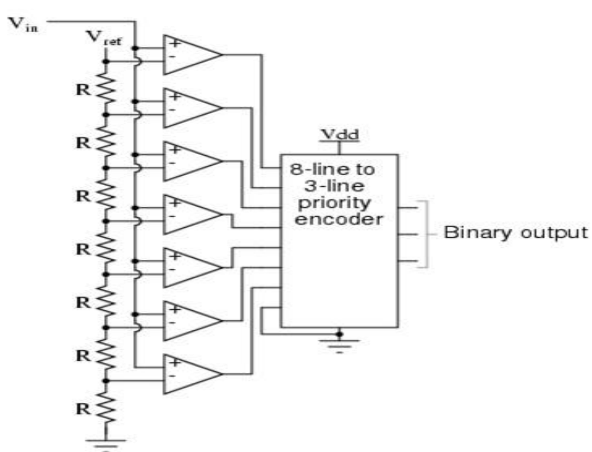
The values achieved after the quantization and encoding process cannot be said to be thoroughly accurate. These are only the approximations of the real world values. The accuracy of the quantizer highly depends on the resolution of the qunatizer, greater the resolution, more accurate the values will be.The ADC resolution is limited by a number of constraints, out of which, time is a major issue. If the set of possible values, from which the closest value is to be searched, is greater, then it will surely take more time.

Types of Analog to digital converters

1. Flash Analog to Digital converter.
2. Dual slope Analog to Digital converter.
3. Successive Approximation Analog to Digital Converter.

FLASH ADC

Flash ADC is one of the simplest ADCs. It is also known as the parallel ADC converter.It consists of a number of comparators. An encoder circuit is connected at the output of the comparators which gives us binary output. A flash ADC circuit of 3-bits is shown.



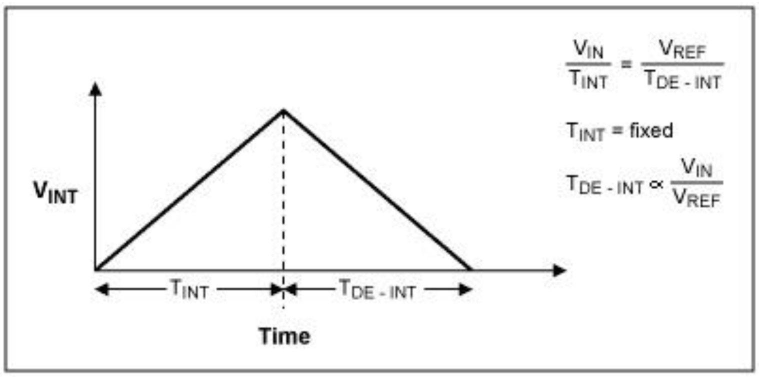
flash ADC

Vref is the reference voltage; if the analog value at the input becomes greater than the reference voltage then the comparator output will be high.Flash converter is the most efficient of all the converters in terms of speed. But the number of comparators increases as the number of bits increases. We would require 7 comparators for 3-bit and 15 comparators for 4-bits. This is the weakness of flash ADC.

But a flash converter can produce a non-linear output which is an additional advantage.

DUAL SLOPE ADC

A dual slope integrator first integrates and then disintegrates a voltage signal. It integrates an unknown voltage for a fixed time and disintegrates for variable time using a reference voltage.

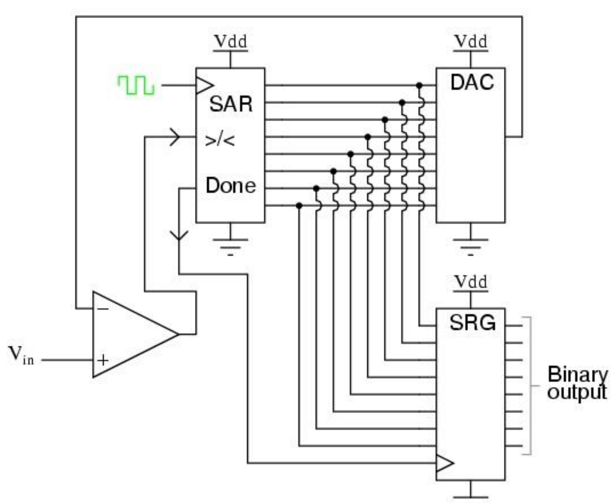


Dual-slope integration

The main advantage is that the error occurring in a component during the integration is cancelled out during the phase of de-integration.Figure below shows a dual slope converter block diagram:

SUCCESSIVE APPROXIMATION ADC

This ADC does not count in the binary sequence, this register starts with the most significant bit and finishes at the least significant bit. The comparator’s output is continuously monitored and compared with the analog signal input. This strategy gives much faster results.



SUCCESSIVE APPROXIMATION ADC