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I MID TERM EXAMINATION 2018 (MECHATRONICS) Subject code & Name: 6ME3A

MM: 20 Time: 1.30Hr

Student Instructions:-
1.Use pencil for diagrams.
2.All questions carry equal marks.
3.Attempt Any four questions.

Q.1 What is a sensor? Explain type of sensors.

Ans:-There are numerous definitions as to what a sensor is but I would like to define a Sensor as an input device which provides an output (signal) with respect to a specific physical quantity (input).
The term “input device” in the definition of a Sensor means that it is part of a bigger system which provides input to a main control system (like a Processor or a Microcontroller).
Another unique definition of a Sensor is as follows: It is a device that converts signals from one energy domain to electrical domain. The definition of the Sensor can be understood if we take an example in to consideration.

Classification of Sensors

The list of different types of sensors that are commonly used in various applications. All these sensors are used for measuring one of the physical properties like Temperature, Resistance, Capacitance, Conduction, Heat Transfer etc
Temperature Sensor
Proximity Sensor
Accelerometer
IR Sensor (Infrared Sensor)
Pressure Sensor
Light Sensor
Ultrasonic Sensor
Smoke, Gas and Alcohol Sensor
Touch Sensor
Color Sensor
Humidity Sensor
Tilt Sensor
Flow and Level Sensor
We will see about few of the above mentioned sensors in brief. More information about the sensors will be added subsequently. A list of projects using the above sensors is given at the end of the page.
Tmperature Sensor :-One of the most common and most popular sensor is the Temperature Sensor. A Temperature Sensor, as the name suggests, senses the temperature i.e. it measures the changes in the temperature.
In a Temperature Sensor, the changes in the Temperature correspond to change in its physical property like resistance or voltage.

There are different types of Temperature Sensors like Temperature Sensor ICs (like LM35), Thermistors, Thermocouples, RTD (Resistive Temperature Devices), etc.
Temperature Sensors are used everywhere like computers, mobile phones, automobiles, air conditioning systems, industries etc.
A simple project using LM35 (Celsius Scale Temperature Sensor) is implemented in this project: TEMPERATURE CONTROLLED SYSTEM.
Proximity Sensors
A Proximity Sensor is a non-contact type sensor that detects the presence of an object. Proximity Sensors can be implemented using different techniques like Optical (like Infrared or Laser), Ultrasonic, Hall Effect, Capacitive, etc.

Some of the applications of Proximity Sensors are Mobile Phones, Cars (Parking Sensors), industries (object alignment), Ground Proximity in Aircrafts, etc.
Proximity Sensor in Reverse Parking is implemented in this Project: REVERSE PARKING SENSOR CIRCUIT.
Infrared Sensor (IR Sensor)
IR Sensors or Infrared Sensor are light based sensor that are used in various applications like Proximity and Object Detection. IR Sensors are used as proximity sensors in almost all mobile phones.
There are two types of Infrared or IR Sensors: Transmissive Type and Reflective Type. In Transmissive Type IR Sensor, the IR Transmitter (usually an IR LED) and the IR Detector (usually a Photo Diode) are positioned facing each other so that when an object passes between them, the sensor detects the object.
The other type of IR Sensor is a Reflective Type IR Sensor. In this, the transmitter and the detector are positioned adjacent to each other facing the object. When an object comes in front of the sensor, the sensor detects the object.
Different applications where IR Sensor is implemented are Mobile Phones, Robots, Industrial assembly, automobiles etc.
A small project, where IR Sensors are used to turn on street lights: STREET LIGHTS USING IR SENSORS.
Ultrasonic Sensor
An Ultrasonic Sensor is a non-contact type device that can be used to measure distance as well as velocity of an object. An Ultrasonic Sensor works based on the properties of the sound waves with frequency greater than that of the human audible range.
Using the time of flight of the sound wave, an Ultrasonic Sensor can measure the distance of the object (similar to SONAR). The Doppler Shift property of the sound wave is used to measure the velocity of an object.
Arduino based Range Finder is a simple project using Ultrasonic Sensor: PORTABLE ULTRASONIC RANGE METER.
The following is a small list of projects based on few of the above mentioned Sensors.
Light Snsor – LIGHT DETECTOR USING LDR
Smoke Sensor – SMOKE DETECTOR ALARM CIRCUIT
Alcohol Sensor – HOW TO MAKE ALCOHOL BREATHALYZER CIRCUIT?
Touch Sensor – TOUCH DIMMER SWITCH CIRCUIT USING ARDUINO.

Q.2 Explain analog to digital conversion and its basic elements.

Ans :-

Digital to Analog Converter

In modern life, electronic equipment is frequently used in different fields such as communication, transportation, entertainment, etc. Analog to Digital Converter (ADC) and Digital to Analog Converter (DAC) are very important components in electronic equipment. Since most real world signals are analog, these two converting interfaces are necessary to allow digital electronic equipments to process the analog signals. an example, ADC converts the analog signal collected by audio input equipment, such as a microphone, into a digital signal that can be processed by computer. The computer may add sound effect such as echo and adjust the tempo and pitch of the music. DAC converts the processed digital signal back into the analog signal that is used by audio output equipment such as a speaker.

A DAC can be constructed by using a Summing Amplifier and a set of resistors R, 2R, 4R and 8R as its inputs, Figure 2. The resistors are scaled to represent weights for the different input bits.

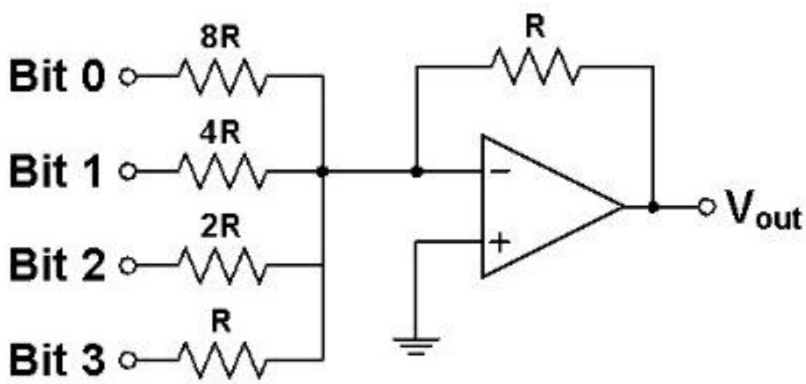


Figure 2: A Summing Amplifier functioning as a simple DAC

The resistor with the lowest value R corresponds to the highest weighted binary input Bit 3 (MSB) [23 = 8], and 2R, 4R, 8R correspond to the binary weights of Bit 2 (22 = 4), Bit 1 (21 = 2), and Bit 0 (LSB) [20 = 1] respectively. The relationship between the digital inputs (Bit 0 to Bit 3) and the analog output VOUT is as follo

$$V_{OUT} = -V_{ref}\left(\frac{1}{1}Bit3 + \frac{1}{2}Bit2 + \frac{1}{4}Bit1 + \frac{1}{8}Bit0\right)$$

where V_{ref} is the Reference Voltage of the circuit. Assuming the value of V_{ref} as 5 V, the Analog Output Voltages corresponding to the Digital Input Codes is shown in Table 1.

Digital Input Code				Analog Output Voltage
Bit 3	Bit 2	Bit 1	Bit 0	(V)
0	0	0	0	0.000
0	0	0	1	-0.625
0	0	1	0	-1.250
0	0	1	1	-1.875
0	1	0	0	-2.500
0	1	0	1	-3.125
0	1	1	0	-3.750
0	1	1	1	-4.375
1	0	0	0	-5.000
1	0	0	1	-5.625
1	0	1	0	-6.250
1	0	1	1	-6.875
1	1	0	0	-7.500
1	1	0	1	-8.125
1	1	1	0	-8.750
1	1	1	1	-9.375

Table 1: The Analog Output Voltages corresponding to the Digital Input Codes with V_{ref} = 5 V

Table 1: The Analog Output Voltages corresponding to the Digital Input Codes with Vref = 5 V

Analog to Digital Converter

In electronics, an Analog to Digital Converter (ADC) is a device for converting an analog signal (current, voltage etc.) to a digital code, usually binary. In the real world, most of the signals sensed and processed by humans are analog signals. Analog-to-Digital conversion is the primary means by which analog signal are converted into digital data that can be processed by computers for various purposes, Figure

There are many types of ADC for different applications. The most inexpensive type of ADC is a Successive-Approximation ADC. The transfer curve of a 4-bit ADC. Inside a Successive-Approximation ADC, a series of digital codes, each corresponds to a fix analog level, are generated successively by an internal counter to compare with the analog signal under conversion. The generation is stopped when the analog level becomes just larger than the analog signal. The digital code corresponds to the analog level is the desired digital representation of the analog signal.

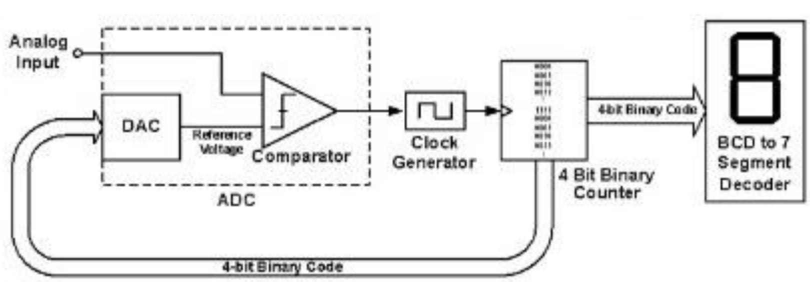


Figure 1: Block diagram of the 1-Digit Voltmeter

The Resolution of a converter is expressed in the number of Bit. For an ADC, the Resolution states the number of intervals or levels which can be divided from a certain analog input range. An n-bit ADC has the resolution of 1 / 2n. For example, the Resolution of a 16-bit ADC is 1 / 65536, since 216 = 65536. If the measuring voltage range is 10 V, then this input range can be resolved into 10 V / 65536 = 0.153 mV precision.
The Speed of a converter is expressed by the Sampling Frequency. It is the number of times that the converter samples the analog signal, its unit is Hertz (Hz). In audio signal processing, Sampling Frequencies of 44 kHz, 22 kHz and 11 kHz are mostly used. Using 44 kHz Sampling Frequency means the converter is sampling the analog audio signal and doing analog to digital conversion at 44000 times per second. The higher the Sampling Frequency, the lower the distortion and the better the sound quality.
ADCs are used virtually everywhere, whenever an analog signal has to be transported, it is processed and stored in digital form. They are always used together with different transducers to convert physical sense and measurement such as temperature, pressure, humidity, speed, vibration, sound, picture etc. in digital signal for further processing by microprocessor.
A Voltmeter is a measuring instrument for measuring the Voltage between two points in an electric circuit.
This Exhibit is a simple application of the ADC for measuring the value of an analog input. Figure 1 is its block diagram. The 1-Digit Voltmeter consists of an ADC, a Clock Generator, a 4-bit Binary Counter, a BCD to 7-Segment Decoder and a 7-Segment LED Displa
The operation flow is as follow
Initially, the DAC Reference Voltage is set to zero, which is smaller than the Analog Input, therefore the Comparator outputs a signal to enable the Clock Generator.
The Binary Counter receives the Clock Signal and increases the Binary Code, from $(0000)_2$ towards $(1111)_2$.
The DAC converts this 4-bit Binary Code into a new Reference Voltage.
This Reference Voltage is compared to the Analog Input again. If it is still smaller than the Analog Input, the above cycle continues. If it is larger than the Analog Input, the Comparator will change its output and disable the Clock Generator, the Binary Counter stops increasing, and the conversion of the Analog Input to a Binary Code is done.
This resulting Binary Code is the one that causes the DAC to produce an analog voltage that is as close as to the analog input as possible without exceeding it.
This Binary Code is fed to the BCD to 7-Segment Decoder to drive the 7-Segment LED to display the 1-digit decimal value.

Q.3. Define micro electro mechanical system.

Ans:- Micro-Electro-Mechanical Systems (MEMS) is the integration of mechanical elements, sensors, actuators, and electronics on a common silicon substrate through the use of micro fabrication technology.

Microelectronic integrated circuits (ICs) can be thought of as the "brains" of systems and MEMS augments (its decision-making capabilities) its "eyes" and "arms". They allow micro systems to sense and control the environment. In its most basic form, the micro sensors gather information from the environment through measuring mechanical, thermal, biological, chemical, optical, and magnetic phenomena; then the micro electronics process the information derived from the sensors and through some decision making capability directs the micro actuators to respond by moving, positioning, regulating, pumping, and filtering, thereby, controlling the environment for some desired outcome or purpose.

While the electronics are fabricated using integrated circuit (IC) process sequences (e.g., CMOS, Bipolar, or BICMOS processes), the micromechanical components are fabricated using compatible "micromachining" processes that selectively etch away parts of the silicon wafer (the micro structures)or add new structural layers to form the mechanical and electromechanical devices.

Impact of MEMS

Since MEMS devices are manufactured using batch fabrication techniques, similar to ICs, unprecedented levels of functionality, reliability, and sophistication can be placed on a small silicon chip at a relatively low cost. MEMS technology is enabling new discoveries in science and engineering:

- A Polymerase Chain Reaction (PCR) micro-systems-for DNA amplification and identification
- Micro-machined Scanning Tunneling Microscopes (STMs), biochips-for detection of hazardous chemical and biological agents
- Micro-systems for high-throughput drug screening and selection.
- MEMS devices are emerging as product performance differentiators in numerous markets wherever electromechanical systems are currently functioning
- MEMS devices are extremely small (e.g. MEMS has enabled electrically-driven motors smaller than the diameter of a human hair to be realized), many processes from automobiles, to gas turbines, anything mechanical can have performance boosted by MEMS

A New Manufacturing Technology

MEMS technology is not just about size, and it’s not about making things out of silicon. (Even though silicon possesses excellent materials properties making it an attractive choice for many high-performance mechanical applications–e.g. the strength-to-weight ratio for silicon is higher than many other engineering materials allowing very high bandwidth mechanical devices to be realized). Instead, MEMS is a manufacturing technology—a new way of making complex electromechanical systems using batch fabrication techniques similar to the way integrated circuits are made and making these electromechanical elements along with electronics.

MEMS is an extremely diverse technology that potentially could significantly impact every category of commercial and military products. Already, MEMS is used for everything ranging from in-dwelling blood pressure monitoring to active suspension systems for automobiles. The nature of MEMS technology and its diversity of useful applications make it a far more pervasive technology than even integrated circuit microchips.

MEMS blurs the distinction between complex mechanical systems and integrated circuit electronics. Historically, sensors and actuators are the most costly and unreliable part of a macro-scale sensory-actuator-electronics system.. Since MEMS devices are manufactured using batch fabrication techniques, similar to ICs, unprecedented levels of functionality, reliability, and sophistication can be placed on a small silicon chip at a relatively low cost. As a breakthrough technology, allowing unparalleled synergy between hitherto unrelated fields of endeavor such as biology and microelectronics, many new MEMS applications will emerge, expanding beyond that which is currently identified or known.

MEMS technology is based on a number of tools and methodologies, which are used to form small structures with dimensions in the micrometer scale (one millionth of a meter).

There are three basic building blocks in MEMS technology, which are(1) the ability to deposit thin films of material on a substrate—Deposition , (2) to apply a patterned mask on top of the films by photolithographic imaging—Lithography, and (3) to etch the films selectively to the mask--Etching.

Deposition

One of the basic building blocks in MEMS processing is the ability to deposit thin films of material. Usually the thin film has a thickness between a few nanometers to about 100 micrometer. MEMS deposition technology can be classified in two groups:

(1) Depositions that happen because of a chemical reaction. These processes exploit the creation of solid materials directly from chemical reactions in gas and/or liquid compositions or with the substrate material. The solid material is usually not the only product formed by the reaction. Byproducts can include gases, liquids and even other solids.

(2) Depositions that happen because of a physical reaction. Common for all these processes are that the material deposited is physically moved on to the substrate. In other words, there is no chemical reaction which forms the material on the substrate. This is not completely correct for casting processes, though it is more convenient to think of them that way.

Lithography

Lithography in the MEMS context is typically the transfer of a pattern to a photosensitive material by selective exposure to a radiation source such as light. A photosensitive material is selectively exposed to radiation (e.g. by masking some of the radiation or not).

If the resist is placed in a developer solution after selective exposure to a light source, it will etch away one of the two regions (exposed or unexposed). If the exposed material is etched away by the developer and the unexposed region is resilient, the material is considered to be a positive resist. If the exposed material is resilient to the developer and the unexposed region is etched away, it is considered to be a negative resist.

The pattern of the radiation on the material is transferred to the material exposed, as the properties of the exposed (positive resist) and unexposed regions (negative resist) differs this technique is capable of producing fine features in an economic fashion, a photosensitive layer is often used as a temporary mask when etching an underlying layer, so that the pattern may be transferred to the underlying layer.

Etchin

In order to form a functional MEMS structure on a substrate, it is necessary to etch the thin films previously deposited and/or the substrate itself. In general, there are two classes of etching processes:

1. Wet etching where the material is dissolved when immersed in a chemical solution

2. Dry etching where the material is sputtered or dissolved using reactive ions or an etching agent. The dry etching technology can split in three separate classes called reactive ion etching (RIE), sputter etching, and vapor phase etching.

Q.4 Explain the role of control system in mechatronics.

Ans:-
Mechatronics is attracting more and more attention. The term is used for a wide variety of applications. Sometimes it is even used for applications that, judged by a more narrow definition, hardly can be seen as a mechatronic system. The Industrial Research and Development Advisory Committee of the European Union, (IRDAC, 1986) has formulated a general accepted definition of mechatronics:
"The term 'mechatronics' refers to a synergistic combination of precision engineering, electronic control and systems thinking in the design of products and manufacturing processes. It is an interdisciplinary subject that both draws on the constituent disciplines and includes subjects not normally associated with one of the above."
Essential in this definition is the 'systems approach'. This implies that the system is designed and optimised as a whole and not in sequential steps. However, not every design made by means of a systems approach is a mechatronic design. By concentrating on a limited application area, a mechatronic designer should have the domain-specific knowledge that enables him to realise really advanced products. Mechatronic design also implies teamwork.

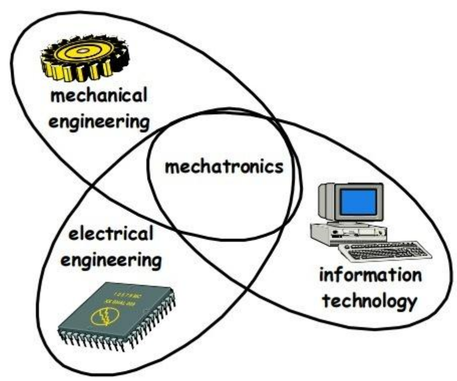


Figure 1 Mechatronics is a synergistic combination of mechanical and electrical engineering and information technology

The flexibility introduced by the combination of precision mechanics and electronic control has allowed the development of CD-ROM players, running at speeds more than 30 times faster than the original audio CD's. A new way of thinking was necessary to come to such a new solution. On the other hand, the CD player is still a sophisticated piece of precision mechanics. No electronic memory device can compete yet economically with the opto-mechanical storage capabilities of the CD and its successor the DVD. But this may change rapidly. Nowadays, electronic buffers with a memory capacity of up to 10 seconds, allow the use of these devices during outdoor exercises, such as jogging. The first devices that deliver CD-quality sound and use only solid state electronics in combination with powerful data compression techniques have become available already. In the packing industry, many devices still rely on, for instance, gravity to get a certain behaviour of the product and the packing material. Such systems are sensitive to disturbances. In addition, a new packing requires a redesign or at least readjustment of the machine. By implementing active motion control, a more reliable, faster and more flexible device can be constructed.

If an aeroplane should have stable flight properties under pure manual control, the design possibilities are limited. When under all circumstances the presence of an automatic controller as a support system for the pilot is accepted, implying that it should be as reliable as the rest of the construction, aerodynamically more efficient designs become feasible. Other good examples of mechatronic systems can be found in automotive applications such as ABS, electronic stabilisation systems and active suspension systems as well as automated highways. Mechatronic Design

Mechatronics is more a way of thinking than a completely new discipline. It still needs advanced knowledge of specialists from different disciplines who meet each other in a mechatronic design team. Mechatronics is a design philosophy. It has been mentioned in the introduction that it is important to make a design from a systems approach in order to get the best possible performance. But it is not realistic, nor needed to invent the wheel again and again, because time to market is an important issue. Mechatronic designs of production machines can help to react faster to market demands. A flexible production line that can be reconfigured by means of software is much easier to adapt than conventional lines that require that mechanical devices be manually reconfigured. But also in the design stage of products and production means, time to market is an important issue. By developing proper tools and knowledge bases, existing knowledge can be made available to less experienced designers. Such knowledge bases should not only be filled with standard solutions for mechanical components, but also with proper CAD tools and mathematical models of these components and with control structures suited for certain classes of problems. The knowledge base could also contain standard software modules that have been tested well; thus enabling the automatic generation of code for a computer based controller. One may doubt whether the design process could ever be done automatically. Although the power of computational intelligence is increasing rapidly, the human creativity can not yet be beaten by a computer. But providing the human designer with proper tools can considerably increase his productivity.

2.1 Tools for modelling, simulation and controller design Simulation can play an important role in the process of designing mechatronic systems. With computer simulation alternative designs can be compared and evaluated without the cost involved with building real prototypes. Simulation tools used in control engineering are mostly based on a block diagram representation of the underlying mathematical model. These models have a direct connection with the transfer functions of the various components of the system. If necessary, they can be extended with non-linearities. For the design of mechatronic systems transfer functions and block diagrams are often not the most appropriate models. A basic assumption in a block diagram is that the different blocks do not influence each other's properties, or that any interaction between the blocks has been accounted for in the parameters. This implies that they cannot easily be replaced by other system components. Another problem is that the parameters of various physical components appear in various combinations and at various locations in the block diagram. Unless there is a supporting system available that automatically relates the different parameters of the mechanical system to the parameters of the block diagram, investigating the effects of parameter changes becomes a tedious job.

In the Control Laboratory at the University of Twente a software package (20-sim) has been developed that supports the modelling and simulation with bond graphs, in addition to the use of equations and block diagrams. Versions 3 of this program also supports iconic diagrams and object orientation. The latter enables to start with a simple design, using only basic functions of the various components. When the design process proceeds, more complex representations of the component can be incorporated in the model, and their effect on the system behaviour can be examined. A model of a component is thus not fixed. It can have various shapes. The models are polymorphic i.e. they can have various levels of detail. Also viewing the system in various representations or in multiple views can help to get a good insight in the properties of the system (Figure 4). Among these various representations are: representations in the frequency domain, time domain, differential equations, bond graphs, iconic

diagrams and block diagrams as well as more fancy representations like stereo views as found in virtual reality. 20-sim 3.0 can automatically generate (linear) state space descriptions from the simulation code. This allows the use of tools like Matlab for further analysis, control system design and generating other representations. Demo versions of 20-
sim are available from the web.
Examples

A few examples of mechatronic designs of projects that were recently carried out in the Control Laboratory of the Faculty of Electrical Engineering of the University of Twente will be shortly discussed here. All these projects were performed in the multidisciplinary Environment of the Cornelis J. Drebbel Institute for Systems Engineering (formerly MRCT), a cooperation of the faculties of Electrical Engineering, Mechanical Engineering, Applied Mathematics and Computer Engineering.

Q.5 Write Applications of Mechatronics.

Ans:-

- Production line automation: A manufacturing setting is designed as a chain process whereby one stage leads to the next. Most such systems use belts to move products and materials during the process. Mechatronics makes it possible to automate the process by incorporating devices like barcode readers, imaging and sound processors along the line. For example, a packaged product can have its manufacture and expiry dates stamped in and recorded while on the belt.
- Measuring devices: A manufacturing process is only good if the end products come out in the right shapes, sizes, weight, and quality. In that case, installing intelligent sensors, testing and calibration systems at the required points goes a long way in ensuring that. All this falls within the realm of mechatronics.
- Control systems: In any effective manufacturing line, there must be measures put in place to ensure that the installation operates at its optimum level. That makes dealing with factors like pressure and temperature a priority. Thanks to mechatronics, this can be done very easily through sensors and response mechanisms that work to monitor and maintain the desired operating conditions. For example, a sensor can trigger the turn on of the cooling system when the temperature builds to a certain degree.

Q.6 Explain Fuzzy System?

Module overview. *The idea of a fuzzy system is introduced in this module. Its main components are described and discussed in detail using examples. The results from the fuzzification module drives the rule base. The fuzzy inference machine is developed which solves the reasoning. The methods to transform the fuzzy results of the reasoning process to crisp data is shown in detail. The mainstream in the fuzzy system of this module is the Mamdani approach which needs the defuzzification step, but the Takagi-Sugeno-type of fuzzy system is also introduced which avoids defuzzification.*

Module objectives. *When you have completed this module you should be able to:*

1. Design a fuzzy system.
2. Fuzzify input information.
3. Describe a fuzzy inference machine using fuzzy sets.
4. Defuzzify results from the reasoning process.

Module prerequisites. *Fuzzy sets.*

In the previous section, elementary fuzzy terms and fuzzy logic operations have been introduced. In this section, the application to the treatment of rule-based knowledge follows. For this a rule-based fuzzy system is needed, containing a rule base and a reasoning algorithm, which is used to process crisp or fuzzy input values $x_i, i = 1, \ldots, n$ to a crisp or fuzzy output value y, see Figure 16.1.

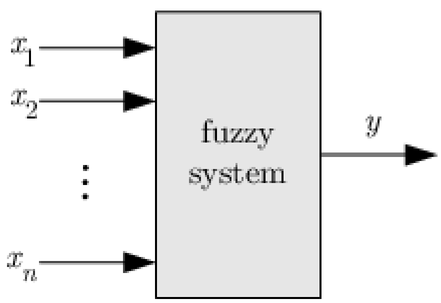


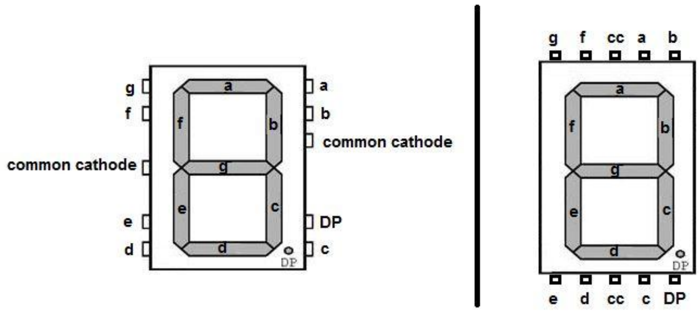
Figure 16.1: Rule-based fuzzy system with n inputs and one output

Using multiple inputs and one output implies no restriction as a multi-input-multi-output fuzzy system can always be decomposed into multiple systems according to Figure 16.1. Such systems are the basis for the realisation of fuzzy controllers. As there are mostly crisp input values x_i from measurements and for controllers only a crisp output y, a fuzzy system must contain additional components, fuzzification and defuzzification.

Q.7 Explain Seven segment display with example.

A seven-segment display is commonly used in electronic display device for decimal numbers from 0 to 9 and in some cases, basic characters. Use of light emitting diodes (LEDs) in seven segment displays made it more popular, whereas of late liquid crystal displays (LCD) displays have also come into use. Electronic devices like microwave ovens, calculators, washing machines, radios, digital clocks etc. to display numeric information are the most common applications. Let's take a look at the 7 segment display pinout to have a better understanding.

7 segment display pinout



A 7 segment display is made of seven different illuminating segments. These are arranged in a way o form numbers and characters by displaying different combinations of segments. The binary information is displayed using these seven segments. LED or light emitting diode is P-N junction diode which emits the energy in the form of light, differ from normal P-N junction diode which emits in the form of heat. Whereas LCD use properties of liquid crystal for displaying and do not emit the light directly. These LED's or LCD's are used to display the required numeral or alphabet.

Types of 7 segments

There are basically 2 types of 7 segment LED display. Common Anode: All the Negative terminals (cathode) of all the 8 LEDs are connected together. All the positive terminals are left alone. Common Cathode: All the positive terminals (anode) of all the 8 LEDs are connected together. All the negative thermals are left alone.

Working on 7 segments

Seven segment devices are generally made up of LEDs. These LEDs will glow when they are forward biased. Intensity of the LEDs depends on forward current. So, sufficient forward current has to be provided to these LEDs to glow with full intensity. This is provided by the driver and is applied to the seven segments.

Number	**g f e d c b a**	**Hex code**
0	1000000	C0
1	1111001	F9
2	0100100	A4
3	0110000	B0
4	0011001	99
5	0010010	92
6	0000010	82
7	1111000	F8
8	0000000	80
9	0010000	90

Table: Display numbers on a seven segment display in common anode configuration

Things change for common cathode configuration.

Number	**g f e d c b a**	**Hex Code**
0	0111111	3F
1	0000110	06

2	1011011	5B
3	1001111	4F
4	1100110	66
5	1101101	6D
6	1111101	7D
7	0000111	07
8	1111111	7F
9	1001111	4F

Table: Display numbers on a seven segment display in common cathode configuration

A sample interfacing of the 7 segment display to Arduino uno is provided for reference.