CHAPTER 6 : SUMMARY AND FUTURE SCOPE

6.1 SUMMARY

The role of sensors is very vital in all fields of engineering and industries for the purpose of measurement, monitoring, recording, and control. In virtually every field of application we find sensors that transform real-world data into electrical form. Today many groups around the world are investigating advanced sensors capable of responding to a wide variety of measurands. Recent years have witnessed the excellent progress in the field of sensors. The cost-effective processing of sensor signals has become increasingly critical with the more widespread use of complex control instrumentation and intelligent sensor systems [1]. A universal sensor interface that would work with a wide range of sensors that have different output signal formats would greatly streamline the ability of users to integrate different types of sensors into their systems or applications. A sensor with a universal interface would, moreover, have greater "plug-and-play" capability and be more easily incorporated in a wider range of applications. For example, resistive bridge-output pressure sensors, force sensors, position sensors, rotational speed sensors [2].

In order to design signal conditioning circuits for various types of sensors and to design a universal intelligent sensor interface system, initially a review is made on sensors and their classification scheme, various techniques of signal conditioning, circuit simulation, various types of available sensor interfaces provided by different vendors, and microcontrollers. The comparison is also made amongst commercially available both integrated as well as discrete types of sensor interfaces regarding number of sensors at input, provision of various types of outputs and the speed. It is essential to design a universal sensor interface which accepts various sensors on one side and provide various
types of outputs viz. (1) Analog 0-5 V  (2) 4-20 mA (3) Digital parallel port (4) RS-232C protocol (5) GPIB. The most important part of design of such system is to design signal conditioning circuits for various sensors.

In case of sensor, as there is a change in the input physical parameter, there is a change in electrical output which may be in a form of a change in resistance, capacitance, inductance, d.c. or a.c. voltage, etc. The output of sensor needs to be modified by a signal conditioner. In the present work the Pspice is used to design signal conditioning circuits for various eight types of sensors. The performance of circuits was verified by applying various test inputs. The circuits are so designed so that as the input parameter, for a particular range, changes the output changes from 0-1V. The user has to set the position of DIP switches according to the range of measurement and use of particular type of sensor and then he must plug signal conditioning circuit into a base unit consisting of microcontroller, V to I converter, PGA, analog to digital converter and RS 232C protocol. The output of signal conditioning circuit is connected to programmable gain amplifier (PGA). The microcontroller is used to set the gain of PGA according to range of measurement and type of sensor. The PGA output is always 0-5V variation and is converted into digital form by using 12 bit analog to digital converter for the purposes of processing, transmission, display and storage. The RS 232C protocol is used to transmit this digital data to the PC or smart instruments for storage or further processing.

Theoretical understanding, designing of signal conditioning circuits and universal sensor interface, use of microcontroller, has been the major thrust of activities.
6.2 APPLICATIONS

For practical utility of any sensor it is important to tailor its performance according to the need of the application. The present system provides interface for commonly used sensors which are useful in both the scientific research and industrial processes interacting basically with control systems, process instrumentation, etc. The universal sensor interface represents a complete signal processing capability for data acquisition systems designed to support a wide range of sensor applications. Following section discusses various applications of designed sensor interface.

1. Universal sensor interface is useful in different disciplines of science and engineering, such as automated target recognition, automatic landing guidance, remote sensing, monitoring of manufacturing processes, robotics, and medical applications [3].

2. By connecting suitable sensors, it can be used to measure temperature, pressure, relative humidity, light, resistance, current, power, speed, vibration…in fact, anything that you need to measure [4].

3. Perhaps the most common physical quantity that today’s data-acquisition systems are expected to monitor is temperature. Thermocouples are the most ancient, popular rugged temperature sensors available with a wide temperature range. Further, for absolute temperature measurement, additional temperature sensors like resistive temperature detectors (RTDs) or thermistors have to be incorporated in the signal conditioning circuit. Thermistor, at their wide use for temperature monitoring, control and compensation, in almost every conceivable field like home appliances, manufacturing industries, bio-medical, transportation and security, making them the most suitable choice for remote sensing applications. Disc thermistors are the most popular and the applications include automotive temperature sensing required
mostly for engine coolant, transmission fluid, engine oil, air, and other fluids [5]. These thermal sensors are ideal for temperature sensing on heat sinks and for thermal control of alarms or fans. SMD thermistors are ideal for temperature compensation in compact circuits such as

- LCD displays;
- battery charging circuits;
- automotive remote sensors; and
- power transistor stabilization, etc.

4. NTC thermistor or RTD elements for applications requiring long life in a demanding environment, including medical equipment, analytical instruments, food equipment, and process chemical uses [6].

5. LVDT sensors can be applied in almost all engineering applications covering civil, mechanical, petrochemical, power generation, production, aerospace, defense, and much more. They can be used on production lines to automatically gauge products for quality control and product sorting. In the power generation and petrochemical industries they can be used, for example, as servo position feedback on actuated equipment such as valves and dampers, or for measuring turbine casing expansion. Submersible units can be used in marine and offshore mining applications [7].

6. In today's high-tech world of motor racing, winning depends on the performance of components such as displacement sensors. These sensors are widely used in Formula One racing and other racing series to control and monitor a number of critical control functions that will trim a few tenths of a second off a car's lap time - this being the difference between success and failure! The use of displacement sensors and a computerized data logging system or a universal sensor interface, allow the race engineer to perfect the performance of a racecar for individual circuits during pre-race practice.
Throttle control in Formula One is a closed loop electro-hydraulic system (fly-by-wire) that requires a displacement sensor on the driver's pedal and one on the actuating mechanism mounted on the engine. This arrangement allows faster acceleration and also preserves the engine life by restricting over revving during a race. The sensor mounted on the clutch actuating mechanism is a special design short stroke LVDT (linear variable differential transformer). LVDT Sensors are often used on clutch actuation and for monitoring brake disc wear. One of the area’s in motor sport where the displacement sensor is having a lot of success is in suspension movement measurement. All race car's are effected by the slightest change in the suspension set up, so the more information a racer has, the more chance they have of winning. Hydraulic fluid level measurement is also achieved using displacement sensors mounted in the fluid reservoirs. This measurement is made using either a linear potentiometer or LVDT depending on the signal conditioning available in the electronics system. Formula one racing is probably the most demanding automotive application for control and measurement sensors. General vehicle manufacturers also take advantage of the latest technology to help develop modern cars and trucks. Typical applications include sensors for positioning systems in machine building, speed control of rollers in the converting industry and feedback sensors in robotics [8].

7. Capacitive sensing devices are ideal for a wide range of high-performance instrumentation and sensing applications, from blood pressure monitors and glucose analyzers to position sensors for automobiles and industrial corrosion analysis systems [9].

8. The universal sensor interface can be used in fields [10] such as
   a. Automotive (for Combustion Control, Engine Performance Control, Physical Sensors)
   b. Military (for Chemical Agents)
c. Commercial and Food Industry (for Process Control, Food
Freshness, Industrial)
d. Agricultural and Environmental (for Combustion Emissions
Monitoring, Water Quality, Work Place Monitoring).

9. From commercial airliners to most military vehicles, sensors are
employed for a variety of applications including landing under
adverse weather conditions, “seeing” through smoke, fog, etc.,
viewing the surrounding area at night under very low light
conditions and guiding missiles to their targets [11].

10. A variety of sensors are currently used in e-noses (The objective of
an electronic nose (e-nose) is to mimic the human olfactory system
to enable artificial detection of odours and odour concentration.),
these sensors work on the physical properties of conductivity,
piezoelectricity, capacitive-charge coupling, fluorescence, chemo-
luminescence, molecular spectrum, atomic mass spectrum and
transmitted light spectrum (Nagle et al., 1998) [12].

11. Juice extracting mill efficiency measurement unit: It is essential to
measure the actual power consumed by the cane-crushing mill.
There is no instrument available at present to measure the power
directly consumed by the cane-crushing mill individually. The
power transmitted through any shaft is directly proportional to the
angle of twist produced in the shaft and rotational speed of the shaft.
This can be expressed as Power $\alpha$ Angle of twist $\times$ Rotational
speed. By knowing the speed and the rotational speed of the shaft,
the power transmitted through the shaft can be calculated. An
optoelectronic system based on laser beam is used to detect the
voltage proportional to the angle of twist produced in the tail bar.
The displacement of source and the variation of detector amplifier
output voltage from 0-250 mV is already reported [13]. This
variation in voltage can be converted into 0-5V and 4-20 mA current
variation. So the designed interface can be used for this application after making the signal conditioning circuit for this application.

12. Study of effect of soil variations of sensitivity of ceramic soil moisture sensor: Automatic drip irrigation has become very popular in agriculture because this technique offers a proven method for considerably reducing the wastage of water in fields. If it is to be introduced, it is imperative to find the optimum level of moisture in the soil for a given variety of crop [14]. A ceramic soil moisture sensor with the variation of output voltage from 0-300 mV with time from 0-1000 sec is already reported [15]. This variation can be amplified and converted into current, digital output or can be send to PC by using the universal sensor interface.

13. Low cost humidity sensor: The measurement of humidity sensor is a very common problem. A parallel plate type of capacitor with top comb electrode has been used [16]. Response of the sensor was found to vary from about 10 nf to 45 nf for humidity range of 50% to 70% RH. This variation in capacitance may be converted into a voltage by using a signal conditioner. The universal sensor interface may be used to convert the change in voltage into current, parallel data and may be transferred to PC.

14. Thick film resistive gas sensor: The use of resistive adsorption based sensor has been increasing at an outstanding rate in last few years for variety of purposes such as detection of smoke, oxidizing or reducing gas, humidity, etc. The variety of the material has been used for sensing of the gases. The sensor, obtained by screen printing, of tin oxide is used [17]. The variation of resistance change of 0-350Ω with temperature of the sample in air is already reported [18]. This resistance variation can be converted into voltage by proper use of signal conditioner and then universal sensor interface may be used to convert this variation into current, digital data or may be send to PC.
15. Moisture meter for rubber insulators: Moisture in the rubber can affect its thermal and electrical properties. The rubbers particularly those having silica as one of the constituents, absorb moisture and affect the operation of the system. Therefore determination of the moisture in the rubber becomes important which is done using half bridge method. As moisture in the rubber increases its resistance increases. This change in output voltage varies from 0-5 V as % moisture in vulcanized rubber samples changes from 0 to 7 % changes [19]. So the present instrument can be used for this application after making the signal conditioning card for this application.

6.3 DIRECTION FOR FUTURE SCOPE

Present work particularly deals with the development of a versatile intelligent instrument that reduces the burden of the system designer. The user has to only set the position of DIP switches, present on the sensor specific signal conditioning module, for selection of type and range of measurement and then he has to plug the module in the base unit. Depending upon the need he can use the required outputs, which are provided. If user wants to use the sensor, whose interface is not provided in this system, then he has to only design a signal conditioning circuit for that sensor. The universal sensor interface system has an advantage of connection of 8 different types of sensor. No external signal conditioning is required. The microcontroller controls the overall operation of the system intelligently. The present system is slow in acquiring number of samples per second as compared to commercial available interface cards.

The performance of the said system can be improved by increasing the number of sensors connected to the system. This is possible by using 4 bit sensor select code instead of 3 bit as shown in table 4.2 and 4.3. Further, the speed of the present system can be
improved by using a faster ADC. The present system also does not provide a GPIB interface. The use of special chips used for this interface can fulfill the requirement.

REFERENCES


