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Wireless Smart Sensor Platform

P. V. Shekdar
Department of Electronics and Telecommunication Engineering, Government College of Engineering, Amravati, Maharashtra, India
prasadshekdar.0601@gmail.com

S. R. Hirekhan
Department of Electronics and Telecommunication Engineering, Government College of Engineering, Amravati, Maharashtra, India
hirekhan.sunil@gcoea.ac.in

***Abstract*—Today, wireless sensor networks (WSN) are potentially one of the most important technologies of the 21st century. The utilization of wireless sensor based control systems have been augmented to a very great extent due to reduced cost, better power management, ease in maintenance, and effortless application in remote and hazardous areas [1]. In the context of this paper, review of Smart Sensor system is presented and discussed many features such as history, development, need of smart sensor, followed by their successful exploitation in many industrial applications such as monitoring, control, maintenance, security and so on.**

***Key Words*— IEEE 1451.4, IEEE 1451.2, Smart Sensor, Transducer Electronics Data Sheet, Wireless Sensor Network.**

I. INTRODUCTION

Prior to the discovery of microelectronics, transducers were being used for data acquisition of various physical quantities such as temperature, pressure, distance, etc. The field of data acquisition has continuously grown starting from early days of point-to-point wired links for communication to the current Ethernet, a wired communication for networking industrial systems [6]. In the industrial monitoring and control field, requirement of the industry control techniques grows day by day. There are disadvantages to conventional situation Based Monitoring analytical Maintenance systems, in which the information is read by periodic "walk-around" data collection. The walk-around structure requires a human to periodically "walk" the path taking data manually for later analysis. This method requires a continuous labor presence which puts humans in hazardous area for operating machinery. Therefore, if it is required to collect certain data and carry out wiring work in many rugged-conditions, uneasy to reach; the traditional monitoring system is obviously uneconomic and unreasonable. Industry control has been changed from the traditional field control to a remote control model, powerful Internet and the wireless telecommunication [5, 7].

Existing industrial control and monitoring systems have to use a significant portion of their expenditure in cable installation and the maintenance costs associated with moving and replacing cables during machinery maintenance and re-configuration. As the number of wireless and self-configuring devices increases, the wireless coverage footprint expands and removes the need for cable connectivity. There are several reasons why wires may be inconvenient and expensive such as High installation cost, High maintenance costs, Failure rate of connectors, Trouble shooting - hardwired systems. On the other hand, the cost for using wireless systems has, and is continuing to decrease especially in the installation and maintenance areas. Many hundreds of meters of cable can be saved for an industrial application by going with a wireless solution. Costs are saved from the installation of the cables as well as the cost of the cables themselves. Also there are no wire net line equipments for real-time control in some industrial fields such as metallurgy, mine, etc., which forces wireless telecommunication technique for the development in the distance monitoring field [7, 5]. Instrumentation applications are open or closed loop control applications, involving sensors and actuators, where the objective is to control certain parameters (e.g., speed and position), or state of the system. All the system elements may always be in communication with each other, requiring real-time performance and their effect on the control parameters is defined. Predictive-maintenance involves tracking the state of equipment or machine or system, and to take action, if they enter a restricted state. In event based monitoring, a violation condition is specified strictly and an event of which initiates the system to perform a pre-defined action such as recording the violation and/or issuing an alert [1]. A compressed and moderately inexpensive RF coupled sensor system with better performance and long battery life will create a standard modification in machinery maintenance and control.

The organisation of this paper is as follows. Section 2 covers related work on sensor networks and specific idea for diverse function of smart sensor technology in industrial field. Future applications of smart sensor are mentioned in brief in section 3. Section 4 reports the conclusion on the survey.

II. RELATED WORK

This section represents an overview of smart sensor, wireless sensor networks with available wireless technologies. Wireless devices are constructed with three major sections: data acquisition, data transportation, and data presentation. Data acquisition is the acquiring of data of interest. The data may be physical, biological such as a person's pulse rate, blood pressure or data on the environment such as gas level concentrations. Data transportation is moving data items of interest from a source device, such as a gas sensor, to a destination device like a display or database. Data presentation is the displaying of the acquired data in some practical form [10].

A. Wireless Sensor Network

The growth of wireless sensor networks was stimulated by military applications such as battlefield surveillance. They are now used in many industrial and civilian application areas, including industrial process monitoring and control, machine health monitoring, environment and healthcare applications, temperature and traffic control. A WSN is a rich domain that involves both hardware and system design. It consists of sensor devices that are "small in size and able to sense, process data, and communicate with each other, typically over an RF channel". Their purpose is to collect and process data from the environment, produce a detection event and then forward the information to a specific destination. A WSN consists of separately distributed sensors to cooperatively monitor physical or environmental conditions, such as temperature, pressure, sound, vibration, flow, level, viscosity, density [4].

Wireless sensor network enables connectivity and intelligence for sensor applications that will provide a variety of applications, including wireless data acquisition, machine monitoring and maintenance, smart buildings and highways, environmental monitoring, site security, automated on -site tracking of expensive materials, safety management, and in many other areas. A general WSN protocol consists of the application layer, transport layer, network layer, data link layer, physical layer, power management plane, mobility management plane and the task management plane. Currently two standard technologies are available for WSN: ZigBee and Bluetooth. Both operate within the Industrial Scientific and Medical (ISM) band of 2.4 GHz, which provides license free operations, huge spectrum allocation and worldwide compatibility [12]. There are nearly unlimited numbers of WSN that have different technology considerations such as frequencies, sampling rate, topologies, sensor to use, etc.

B. Smart Sensor

A sensor (also called detector) is a device that converts a physical quantity into an electronic signal which can be read by an observer or by an instrument. There are various primary sensors such as pressure sensor, temperature sensor, accelerometer sensor, etc. Sensor technology plays a key role in situational awareness. Sensors are needed to measure the critical parameters of the human, environment and machines.

A smart sensor cannot be defined in a specific way. The term Smart Sensor was actually invented in the mid-1980 [6], and since then it has got a variety of meanings from various researchers. "Smart sensor is a sensor which performs more than what is expected from it to do" which is a very broad definition. In another way, "when a sensor can communicate over a digital communication network, either wired or wireless" can also be called as smart sensor. The most acceptable definition of smart sensor is "when a primary sensor such as pressure sensor, accelerometer sensor, ultrasonic distance detector is interfaced with a smart sensor interface unit which consist of an Analog to Digital Converter (ADC), microcontroller, and includes feature as communication capability and provides some internal signal conditioning such as linearization, on board diagnostics that provide information to monitor the system is called as smart sensor" [6, 10]. The smart sensor system is as shown in Fig. 1.

There is one more form of smart sensor called 'smart plug & play Transducer Electronic Data Sheet (TEDS) sensor'. This is a sensor which is obtained just by embedding TEDS into the device in cost effective manner. IEEE1451 is a standard for smart sensor. The 1451.4 standard is implemented primarily because the requirement for a few of the higher level standards, particularly 1451.1 and 1451.2, is beyond the capability of the technology at present. It is fairly simple to embed a small piece of memory within the sensor. It is very difficult to place a system such as an analog to digital (A-D) or digital to analog (D-A) converter, a microprocessor or a microcontroller inside a sensor, since the size of the sensor has to be increased to contain the same. There is also a consideration for the amount of power that is necessary to operate the system. Hence, placing the data sheet on a small piece of memory is a more practical approach.

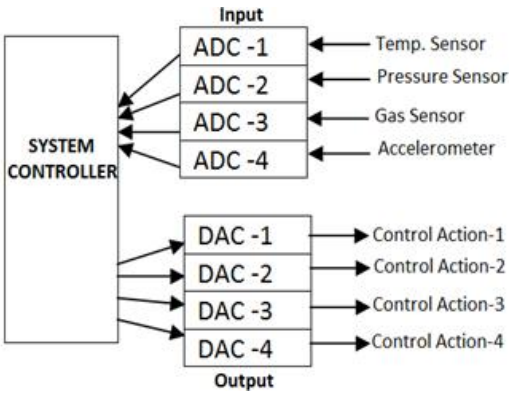

Figure 1. Smart sensor system

The newly approved IEEE1451.4 standard for smart sensor defines the smart sensor as "a sensor that provides function beyond those necessary for generating a correct representation of a sensed data. This function typically simplifies the integration of the transducer into applications in a networked environment", was developed to define a flexible, standard interface that would enable any smart sensor from any manufacturer to connect to a multi-node network of smart sensors. The traditional smaller sensor companies that are not successful in integrating several technologies observed that fundamentally the IEEE 1451.2 plug and play concept was an easy means of obtaining a smart sensor [10]. Therefore, instead of being worried about integrating network communications and other complicated technologies they are able to manufacture a smart sensor by embedding the TEDS in a Dallas chip that costs only a couple of dollars

per chip, these companies can now call their sensors, Smart sensors.

The smart sensor network can be compared to "fixed-wireless", where the equipment is static, but uses wireless technology for communication. Design issues must be considered for such a sensor network, which is being used for industrial applications are:

System building: A hierarchical system building technique enhances the system flexibility, robustness and reliability.

Fault tolerance: Service guarantee is required in the communication system in the form of a confidence level.

Energy efficiency: As energy-saving is a critical issue in the industrial organization, the system set up must be designed with energy minimization techniques.

Multiple interface requirements: The system to be designed must be interfaced with any number nodes and performance should not get affected due to some physical parameters such as distance between the nodes, surrounding environment conditions.

Connectivity: Multiple sensor networks may be connected through sink nodes, along with existing wired networks.

Operability in harsh environments: Robust sensor design integrated with high levels of fault tolerance and network reliability enable the use of sensor networks in dangerous and strange environments.

The smart sensor acquires physical, biological or chemical input then converts the measured value in digital format in the units of measured attribute and transmits that measured information to the computer monitoring point. The main objective of the smart sensor platform is to craft a general purpose hardware interface for various types of sensors and a central data processing and controlling infrastructure to implement the applications for industrial monitoring and control. The anticipated smart sensor platform consists of a collection of sensors, and actuators communicating with the central control unit using standard RF-links. The model design for smart sensor is shown in Fig.2.

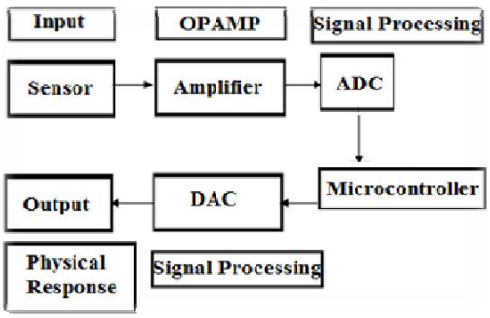

Figure 2. Model design for smart sensor (Source: 6)

Smart Sensor System Components are Sensors, Microcontroller, Communication device, power supply [1].

The sensors found in industrial applications used for data communication produces the output in analog form. The Smart Sensor Interface interprets sensor's signal which is in the analog form, and converts it into digital data/commands through ADC. The digital data extracted by the hardware interface has to be bound in a predefined manner and processed to convert it into useful information. This task is implemented by microcontroller. This digitized information is then transmitted to the central processing and controlling unit by using RF transceiver module. Depending upon the area of the manufacturing plant the RF module can be chosen. Thereafter depending upon the data received, the central processing and controlling unit takes the required action.

III. Future Applications

Smart sensor systems effectively correspond to a new generation of sensing capacity. The design of smart sensor systems can have an idealistic impact on several applications in hazardous environment and in industrial monitoring and control field such as safety hazard detection and warning regarding the possible upcoming problems, environmental monitoring, health monitoring and medical diagnostics such as food safety and biological hazard detection, industrial aerospace and vehicle applications like tire pressure monitoring system for car safety [11]. Smart sensor platform can allow systems to monitor themselves and respond to varying conditions. The integration of sensors and algorithms can be used for early warning fire detection or any number of sensor based applications. The smart sensor system approach can achieve distributed sensor systems acquiring information from multiple locations to improve the overall understanding of system conditions.

IV. Conclusion

A survey on using smart sensor technology in industrial process monitoring and control is provided in this paper. First, the existing monitoring and control scheme for industrial applications are explored, following with a review of the advantages of adopting Smart sensor technology in industrial control field. The smart sensor provides a general purpose hardware interface for various sensors to develop a standard platform with 'plug -and-play' capability to support hardware interface and communication need of multiple sensors in order to reduce the human efforts. These dynamic features of smart sensors can provide the critical data to the end user in a more rapid, reliable, robust, economical and efficient way.

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AUTHOR'S PROFILE

P. V. Shekdar

received the bachelor's degree in Electronics and Telecommunication engineering from SSGM College of Engineering, Shegaon, Maharashtra, India and currently pursuing M. Tech in Electronic System and Communication. from Govt. College of Engineering, Amravati, Maharashtra, India.

S. R. Hirekhan

received the bachelor's and master's degree from Marathwada University, Aurangabad. Currently he is an Associate Professor at Government College of Engineering, Amravati, Maharashtra, India with over a 20 years of experience in teaching field. His current areas of research are Digital Design and Embedded Systems.