Chapter 14
Recent Advancements in Smart Sensors and Sensing Technology

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ABSTRACT
The chapter presents the design and development of very low cost planar sensors and sensing systems for measuring fat contents in meat, leather quality assessment, food quality, and biomedical application such as cancer detection, agriculture, and RFID based detection systems. The sensors comprise planar passive microwave integrated circuits in the forms of microstrip meander lines, mesh and inter-digital capacitance. The sensors are excited with voltage controlled oscillators (VCOs) and power supply units. A data acquisition system based on a microcontroller and an op-amp based interfacing circuits complete the sensing system. The results of various characteristics parameters of samples are presented and compared with the results from expensive conventional measurement set up. These low cost sensors bring benefits in the sensing technology with novel and accurate concepts.

INTRODUCTION
The sensors and sensing technology plays a crucial role in our day-to-day life. Sensors and associated measuring instrumentation circuits pose a challenge towards the development of a low-cost intelligent sensing system. Sensors are a significant part of complex and sophisticated systems of modern technology. It will be difficult to achieve the purpose of any modern system or process control without use of any forms of sensors. In recent times, a significant amount of research work is undertaken to develop smart and intelligent sensor system for different novel applications. J. Schmalzel et. al. (Schmalzel, Figueroa, & Morris, 2005) have reported an implementation of a prototype intelligent rocket facility, the results of which established a basis for future advanced development and validation using the rocket test stand facilities at Stennis Space Center. In health
management systems, smart sensor components play key roles in providing the distributed intelligence needed to perform diagnosis of overall health of the people. A wireless visual sensor comprising of a low-cost greyscale camera as the sensing hardware and BlueTooth (BT) 100-m slave module as the transmission hardware has been reported in (Ferrigno, Pietrosanto, & Paciello, 2006). The sensor is quite efficient in terms of cost, energy saving and bandwidth for image transfer. Usually the camera based sensor systems are not able to provide internal characteristics of the system though in recent times depth camera has now been reported. A low-cost, high performance displacement sensor has been presented in (Toth & Meijer, 1992). The system has been implemented with simple electrodes, an inexpensive microcontroller and linear capacitance-to-period converter. For the sensing system sometime excitation for the sensors pose design challenges. The excitation part of the sensor as reported in (Toth et al., 1992) is not very clearly explained as this can be challenging in many applications. A low-cost, smart capacitive angular-position sensor with simple, stable and reliable characteristics has been reported in (Li & Meijer, 1995), (Li, Meijer, de Jong, & Spronck, 1996) and (Li, Meijer, & de Jong, 1997). Interfacing the sensors signals to a microprocessor or to a microcontroller pose a challenge. A novel smart interface for voltage-generating sensors has been reported in (Li, Meijer, & Schnitger, 1998). A smart and accurate interface for resistive sensors has been reported in (Li & Meijer, 2001). If the sensors provide DC signals as in for thermocouple types, the problem of interfacing is not so severe. It is important that the signal from the sensors should also have the condition signals, which provide rudimentary information necessary for fault detection and isolation in sensor systems (Amadi-Echendu & Zhu, 1994). Such rudimentary information should be very significant in the development of an intelligent measurement system. An interface circuit for a differential capacitance transducer has been described in Mochizuki, Masuda, & Watanebe (1998) which allows high-accuracy signal processing with standard components. In Patra, Kot, & Panda (2000), a scheme of an intelligent capacitive pressure sensor using an artificial neural network has been proposed. A complete solution to connect an IEEE 802.11-based sensor with a wireless network has been presented in (Ferrari, Flamini, Marioli, & Taroni, 2006). An overview of significant development of methods, structures, manufacturing technologies, and signal processing characterizing today’s sensors and sensing systems has been presented in (Kanoun & Trankler, 2004). Most of the common magnetic sensing methods have been described and the underlying principles governing their operation have been highlighted in (Lenz & Edelstein, 2006).

This chapter reports the development work which was carried out at Massey University, New Zealand over the last few years. The idea behind the research works is to design and develop of a low-cost intelligent sensing system for variety of applications. The whole chapter is divided into 4 sections. After the introduction in the first section, the design issues towards a low-cost sensing system will be discussed. The next section discusses the development of different sensing systems for wide variety of applications. The following section deals with the issues of developing intelligent systems. The last section concludes with future possibilities.

**DESIGN ISSUES TOWARDS A LOW COST SENSING SYSTEM**

A low-cost sensing system is always desirable in many applications. A sensing system is comprised on three main parts: Sensors; an Excitation system; and a Data Acquisition system as shown in Figure 1.

A sensor is a passive device which changes its physical parameters in response to the environment. As for an example, a humidity sensor re-