

Design and Development of Universal Sensor Interface Platform for IoT Applications

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Abstract - Universal sensor interface is a rapidly expanding area of research, which will inevitably in the current real life problems, this will lead to extraordinary changes. It is implemented with a number of High performance front end circuits for different types of sensors. This paper encompasses review of the concept of the universal platform for sensor interface. Incorporating UPSI provides high flexibility because it gives the facility of plug and play various types of sensor. The front end of the UPSI can be configured as per the connected sensor with the help of the processor and the firmware. Sensing elements can be directly connected without the need for extra circuits. There will be number of connector provided for analog and digital sensors. Analog sensors have a variety of types numerous transducers are available on the market with a multitude of different interfaces to provide measurements of all kinds. Mostly sensor outputs are in form of voltage output, current output, capacitive or resistive outputs, and various digital interfaces based on communication protocol such as, RS232, I2C, SPI, frequency and bus based interfaces. The presence of such a large number of different interfaces often makes the design and the realization of complex and distributed monitoring systems complex. Additionally, to plan solid and viable dispersed checking frameworks, other basic perspectives should be considered, for example, the exhibition and the dependability of the sensors utilized for the framework execution.

Index terms: UPSI, conditioned sensor, unconditioned sensor, resistive sensor, RS232 interface, sensitivity

I. INTRODUCTION

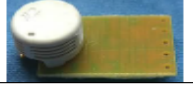
In the area of agriculture, indoor monitoring, gas level measurements and others, a new trend is emerging with low costs, energy efficiency, compactness and flexibility sensor nodes for dispersed sensing. An essential consideration in the design of universal multisensor based systems is flexibility and a high level of integration. Key component of the design are Sensor interfacing, signal conditioning and efficient signal processing. There are several sensors of various types in smart sensor based instruments types and having a variety of front ends. In order to meet the requirements of energy performance, compactness, low costs and superior intelligence, sensor signal processing has become increasingly important as new sensing technologies have been adopted on demand. Another important requirement in the universal system of sensors is sensor plug and play, defined by IEEE 1451.3 as a technology that will improve measurement accuracy and simplify use. Data acquisition complexity and total development costs decrease through the use of plug and go technology. There are several types of transducers available on the market, with a variety of interfaces that allow you to measure all manner of measurements. Typical frontend of the system is voltage input, current output, capacitive and resistive outputs, as well as a few digital interfaces such as RS-232, I2C, SPI, frequency and bus interface. In many cases, the design and realization of such a wide variety of interfaces are very complex. Furthermore, the reliability of sensors used for system implementation as well as their performance should also be considered in order to develop reliable and effective decentralized monitoring systems. A set of standard interfaces for different types of sensors and actuators is laid down in the IEEE 1451 Smart Transducer Interface Standards, with a view to supporting development and application of smart transducers into instruments. One member of this family, the IEEE 1451.4 standard specifies a Mixed Mode interface allowing an analogue analog general sensor signal to be merged with a Digital Interface which allows it to identify its sensors for plug and play operation. The various environmental sensing transducer (gas, temperature, humidity, light, pressure, etc) available in the market having heterogeneous front end, signal conditioning, electrical and mechanical specification. It is therefore essential that a universal, highly reconfigurable sensor interface be available for interfaces between large arrays of sensors by incorporating IEEE1451.3 features on the common platform without increasing development costs and design complexity. To interface heterogeneous sensors in a common platform system become bulky, power inefficient and least flexible. A solution known as a universal platform for sensors interface (UPSI) has been developed to overcome the above mentioned problem. The same reconfigurable connectors in a base can be interfaced with

this transducer, which has various topologies such as the conditioned, unconditioned, resistive, capacitive, current output and digital transducer. In order to address issues related to the interfaces of these sensors for environmental monitoring applications, UPSI was set up.

II.STUDY OF SENSORS

Table 1 frequently used environment monitoring

Sensor	Graphical Presentation	Sensor no	type	Required supply voltage	Nature of o/p
Carbon monoxide(CO)		TGS 4161	Solid electrolyte	VH 5.0±0.2V DC	Unconditioned non differential voltage o/p
Methane		TGS 6810	Catalytic	3.0±0.05V	Unconditioned (Differential voltage)
Hydrogen		TGS 821	tin dioxide (SnO ₂)	VH 5.0±0.2V AC or DC VC Max. 24V DC only Ps≤15mW	Resistive
Carbon monoxide(CO)		MQ 7	SnO ₂	VH (high)5.0 VH(low) 1.4v AC or DC	Resistive
Carbon monoxide(CO)		TGS 5342	Electrochemical-type	Not required	0.7~1.4nA/ppm
Oxygen		SK 25F	galvanic cell	Not required	0 to 10 mv 0 to 30% oxygen

Light		TSL235R	Semiconductor	2.7V	Frequency o/p
Light(Color)		ADJD-S371-QR999	Semiconductor	2.5 V	4 channel Digital o/p
Infrared Thermometer		MLX90614	IR sensitive Thermopile detector chip	5V	PWM output
Humidity		HH10D	Capacitive (C to F conversion)	3V	Frequency (5 to 10 KHz)
Humidity		SRhr233-C	Resistive	Typical 5V	1.9 to 920k
Barometric pressure sensor		BMP085	MEMS based sensor	3.5V	SPI
Barometric pressure sensor		BMP280	MEMS based sensor	3.5V	SPI
Temperature		DS18B20	Semiconductor	3-5.5V DC	Serial Digital
Temperature		LM35	Semiconductor	4-30v DC 60µA	Voltage

III. LITERATURE REVIEW:

Processing of output signals from all types of sensors is becoming increasingly critical as new sensor technologies are adopted and demands on signal processing, digital communications and local intelligence expand. These necessities make it vital that the sensor and its related electronics are considered as a systems and an increasing number of these systems desire to be clever or smart. Intelligent sensor interface is an unexpectedly increasing region of research, in an effort to unavoidably deliver remarkable modifications with inside the modern-day actual lifestyles problems.. On international level European patent EP1040322A1 they claim that a universal sensor interface system that utilizes a common hardware and software interface to drive many types of sensors. A variety of stimulation signals are generated that are transmitted to a plurality of sensors. The stimulation signals cause the sensors to generate response signals in the form of parametric measurements, which are then converted into a common format. The sensor reaction alerts are processed and output as usable inputs to a facts ingesting apparatus. During operation the host computer system or digital signal processor is programmed to analyse sensor response signals to detect sensor faults, help predict sensor failures, and determine if there has been a sensor error.

The universal sensor interface device is likewise able to notifying a device operator of wiring issues with a specific sensor or if a specific sensor is malfunctioning. Similarly a paper Published in: IEEE Transactions on Industrial Informatics (Volume: 10 , Issue: 2 , May 2014) by Qingping Chi ; Chairing Yan ; Chuan Zhang ; Zhibo Pang ; Li Da Xu says about the standard of IEEE1451.2 intelligent sensor interface specification is adopted for this design. It comprehensively stipulates the smart sensor hardware and software design framework and relevant interface protocol to realize the intelligent acquisition for common sensors. A new solution is provided for the traditional sensor data acquisitions. The device is combined with the newest CPLD programmable technology and the standard of IEEE1451.2 intelligent sensor specification. Performance of the proposed system is verified and good effects are achieved in practical application of IoT to water environment monitoring.

Yurish, Sergey. (2011). In his paper titled -A Simple and Universal Resistive-Bridge Sensors Interface. Sensors and Transducers. 10. 46-59. Briefs about Resistive-bridge sensors which are widely used in various sensor systems. Described in the article universal interface for resistive-bridge sensing elements and bridge-output-to frequency and/or duty cycle converters based on the designed Universal Sensors and Transducers Interface (USTI) integrated. It is based on a simple, cost effective three-point measuring technique and does not require any additional active components. The USTI IC is realized in a standard CMOS technology.

S. N. S. Baharudin and et al in their paper titled Universal Sensor Interface Circuits Performance Evaluation for Multi Sensor Systems which is published in International Journal of Scientific & Engineering Research says that Current applications require a combination of different sensors in single devices. Therefore, a sensor interface circuit that may acquire entry from diverse sensors is needed. To solve this problem, multi sensor interfaces or universal sensor interfaces have been introduced. This circuit can lessen the layout fee wherein it could intelligently examine and manner unique sensor application

IV. SURVEY OF WORK DONE IN THE RESEARCH AREA

A paper on high performance sensor interface gives idea regarding a low-cost and high-performance Universal Sensor Interface (USI). This device can provide accurate and reliable interfacing for capacitive sensors, platinum resistors, thermistors, resistive bridges, thermocouples, thermopiles, conductivity sensors and pH sensors. The interface converts the sensing-element signal into a period modulated signal (time interval), which is a microcontroller- and DSP-compatible signal. Optionally, the interface can be controlled via an SPI bus. An auxiliary temperature measurement is performed using a resistive temperature sensor. This feature enables compensation for temperature effect. Experimental results show that the interface has a resolution and linearity up to 14.8 bits and 13.5 bits with a measurement time of 100 ms.

The Universal Sensor Interface Chip (USIC) being developed within the EUREKA project JAMIE is such a device. The USIC has been designed as a flexible device and is intended to address the interfacing needs of the many industrial companies who cannot justify the development and production costs of dedicated mixed mode ASICs. The USIC includes all of the processing elements needed to produce many intelligent sensor systems and gives small and medium sized end users access to this growing market.

The development of a versatile sensor platform used for autonomous data acquisition. The key advantages of the platform are its compact design, implemented onboard sensors, standard interfaces to connect application specific sensors and subsequently simple installation and low costs for the preparation of a measurement task. The main aim for the sensor platform was to design a versatile, easy to operate measurement system that is capable of recording measurement data for various measurement tasks simultaneously and synchronizing the input of multiple sensors connected. A low power and minimally intrusive multi sensor network has been developed for health monitoring of elderly people. To save the power consumption of the unit, inactivity periods have been estimated using an algorithm during which the inactive sensor nodes are not polled by the central controller.

One of the paper studies some key technology of multifunctional sensor signal reconstruction. The multifunctional sensor signal reconstruction problem, presented a multifunctional sensor signal reconstruction method based on B spline and the extended Kalman filter. Simple systems generally use only a single sensor, fixed task. However for the intelligent system and autonomous system, found that a single sensor cannot satisfy the need of target recognition, and operating environment, especially in the uncertain environment.

The Goal of this literature study

1. Understanding of the conceptual meaning of sensor interfaces which are exist at international and national level
2. Investigate and review the use of universal platform for sensor interface applications in Internet of Things.
3. Conclusion on a number of suggestions with recommendations for compact and easy Implementation of universal platform for sensor interface applications based on literature survey with perspective of Internet of Things.

V.COMPONENT OF SYSTEM

The Universal platform for Sensor Interface (UPSI) can convert any generic sensor into a plug and play sensor (Figure 1). The configurable front-end of UPSI provide the platform to achieve the goal of multi sensor interface. The interface circuit is designed to accommodate various types of output signal, provide sensor driving, offset adjustment, data linearization and automatic gain to match the signals and sensitivities of different sensor elements.

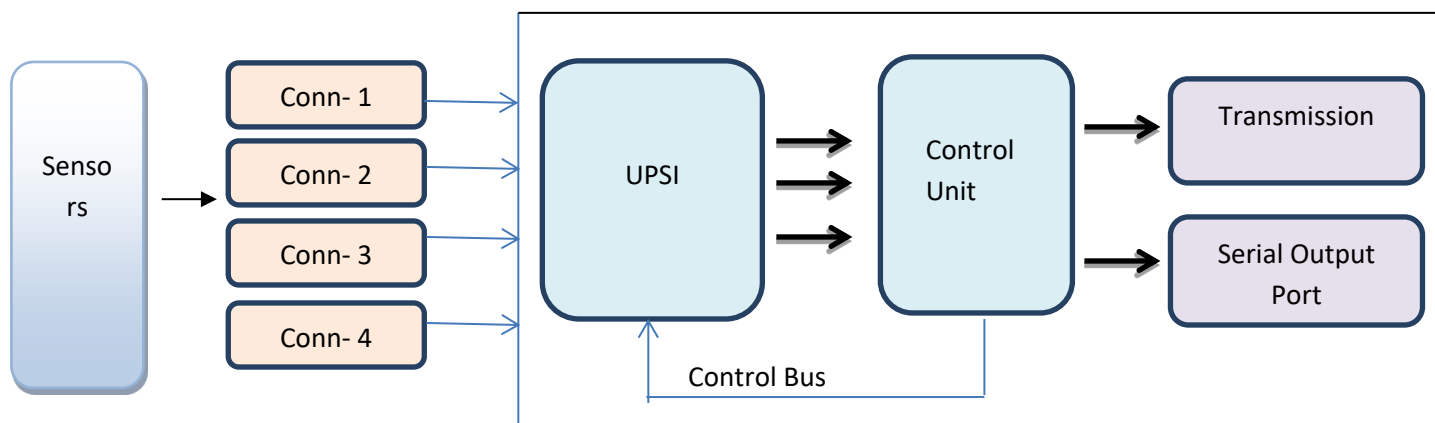


Figure 1. Universal Platform for sensor Interface

In this section, we will go through the key components and related technologies required for universal platform for sensor interface.

1. **Sensors:** Sensors are the foundation of any Internet of Things system. These sensors are used to measure intensity of light, temperature, soil moisture levels, humidity and atmospheric pressure, amongst different environmental conditions.
Connectors : The UPSI consists of four connectors; connectors 1 is dedicated for analog sensors such as conditioned, unconditioned, connectors 2 for resistive, capacitive, voltage and current output sensors, whereas connectors 3 is dedicated for digital sensors like RS232, SPI and connectors 4 for I2C sensors
2. **Processor:** The interface circuit is designed to accommodate various types of output signal, provide sensor driving, offset adjustment, data linearization and automatic gain to match the signals and sensitivities of different sensor elements. The trade-off between the measurement accuracy and the flexibility should be optimized so that the resulting system can be widely adaptable to the multi parameter system. Data received from sensors will be processed by microprocessor. The signal conditioning will be directly done by the processor which will also manages the other operations of the device. The processor will take care of signal conditioning as well transmit the data using Bluetooth module if required. For future, data of sensor will be stored in processor's memory for further analysis.
3. **Communication:** Wi-Fi, Bluetooth, Zigbee, and LoRaWAN are wireless communication technologies that are used to connect sensors and other devices to the internet. Transmission of data will be either wireless (Bluetooth) or in wired form using serial interface. This system can be used as standalone system due to wireless transmission

Universal Platform for sensor interface, on the other hand, may offer a viable answer to the sensor interfacing difficulties such as new sensor technology adopted on demand to meet the requirement of high intelligence, efficiency of power, compactness, and effectiveness of cost.

VI. CONCLUSION:

This paper deals with the design and development of UPSI. To provide a solution to convert various sensor signals to a standardized signal so that the complex conditioning circuit for different sensors is greatly simplified and it can be used in IoT application. The plug and play technology decrease the overall development cost and data acquisition complexity. Various transducers are available on the market with a multitude of different interfaces to provide measurements of all kinds. The concept of UPSI has proposed a highly flexible front end design for sensor node technology which reconfigures its hardware in self governing way to interface with a large range of distributed sensors to solve the multi-sensing challenge in many sensor based applications where different types of sensors are to be supported. This will help to eliminate error prone, manual entering of data and system configuration steps, ease the connection of sensors and actuators by wire line or wireless means.

VI. ACKNOWLEDGMENT:

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