

## Low Cost Smart Sensors for an Intelligent Home

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**Abstract-** In this paper we propose a system able to monitor environmental parameters, to record information on SD card or to send relevant data remotely. The authors by this application demonstrate how to develop new smart sensors to be future used in intelligent buildings.

### I. Introduction

Smart home is an extension of modern electronic, information and communication technologies. The main objective of smart home research is to provide smartness to a dwelling facility for comfort, healthcare, security and energy conservation. Remote monitoring system is a common component of health smart home where telecommunication and web technologies are used to provide quick and proper medication to the patient from specialized assistance centre.

A home needs three things to make it smart:

1. Internal network wire, cable, wireless
2. Intelligent control gateway to manage the systems
3. Home automation products within the homes and links to services and systems outside the home. Some of the commonly used features in home automation are
  - Control of lighting.
  - Climate control of rooms.
  - Security and surveillance systems.
  - Control of home entertainment systems.
  - House plant watering system.
  - Overhead tank water level controllers.

Smart homes, the next gigantic leap in the field of home automation, have become an emerging research field in last few decades. Research on smart homes has been gradually moving towards application of ubiquitous computing, tackling issues on device heterogeneity and interoperability. A smart home adjusts its function to the inhabitants need according to the information it collects from inhabitants, the computation system and the context.

Sensors, multimedia devices and physiological equipments are core components to perceive information from home environment Infrared (IR) sensors, pressure sensors, magnetic contacts, passive and active Radio Frequency Identification (RFID) tags are used to track inhabitant location detection. Electrocardiogram (ECG), photoplethysmograph(PPG), temperature, spirometry, galvanic skin response, colorimetry and pulse measurement equipments are used to get physiological information from the patient. Camera and microphones provide audiovisual response from home user. Inhabitant can access the system through display panel.

Power line communication protocols are widely used for the connectivity of home appliances. Public telecommunication network with voice and text messaging service is involved to provide telecare facility from remote location. Videoconferencing is used as an interactive communication media between caregiver and the client. TCP/IP protocols of Ethernet network provide data connectivity for local and remote sites and locations. Ethernet protocols are also used to connect health-monitoring equipments and to provide data repository service. Algorithms from machine learning, data compression, statistics and artificial intelligent are employed to predict user behavior, detect activities of daily life (ADL) and location.

Smart home is mainly dedicated to provide health care, safety, security and monitoring service for patient and elderly. The house is equipped with sensors, cameras to track people and can trigger an alarm to a remote health care service provider in the case of emergency. Sophisticated physiological devices monitor heart rate, blood pressure, body temperature, ECG record and the patient is being observed from a distance location. Telecommunication service is used for communicating with service provider, relatives or neighbor and as a redundant acknowledgement method from the patient. For home comfort system, lighting, heating, doors, windows and home appliances are automatically controlled by ambient intelligence of smart home. Smart home also has significant contribution towards energy conservation by integration of energy meter with smart home.

Complex large-scale systems consist of a large number of interconnected components. Mastering the dynamic behavior of such systems, calls for distributed control architectures. This can be achieved by implementing control and estimation algorithms in several controllers. Associating computing (and communication) devices

with sensing or actuating functions, has given rise to intelligent sensors. These sensors have gained a huge success in the past ten years, especially with the development of neural networks, fuzzy logic, and soft computing algorithms.

The modern definition of smart or intelligent sensors can be formulated now as: 'Smart sensor is an electronic device, including sensing element, interfacing, signal processing and having several intelligence functions as self-testing, self-identification, self-validation or self-adaptation'. The keyword in this definition is 'intelligence'. The self-adaptation is a relatively new function of smart sensors and sensor systems. Self-adaptation smart sensors and systems are based on so-called adaptive algorithms and directly connected with precision measurements of frequency-time parameters of electrical signals.

The later chapters will give an elaborate view on why we should use intelligent sensors, intelligent sensor structure, characteristics and network standards.

## II. Experimental setup

SHT1x (including SHT10, SHT11 and SHT15) Humidity and Temperature Sensor IC is Sensirion's family of surface mountable relative humidity and temperature sensors. The smart sensors integrate sensor elements plus signal processing on a tiny foot print and provide a fully calibrated digital output. A unique capacitive sensor element is used for measuring relative humidity (HR) with (2) while temperature (temp) is measured by a band-gap sensor and calculated using (1). Both sensors are seamlessly coupled to a 14bit analog to digital converter and a serial interface circuit and can provide the measurement of dew point (Ro) as showed in (3). In next formulas the terms d1, d2, c1, c2, c3, m, Tn, t1 and t2 are constants. The description of comfort by means of knowledge of relative humidity and of ambient temperature is used in order to realize the comfort control module.

$$\text{temp} = d1 + d2 * \text{valT} \quad (1)$$

$$\text{HR} = c1 + c2 * \text{valH} + c3 * \text{valH} * \text{valH} \quad (2)$$

$$\text{Ro} = \text{Tn} * (\log(\text{RH}/100) + ((m * T) / (\text{Tn} + T))) / (m - \log(\text{RH}/100) - ((m * T) / (\text{Tn} * T))) \quad (3)$$

$$\text{HRtrue} = (T - 25.0) * (t1 + t2 * \text{valH}) + \text{HR} \quad (4)$$

The representation of measurements by means of linguistic scale provides abstract information that can be integrated in diagnosis, control or prediction systems based on symbolic coding. In the case of a predicted temperature above 25<sup>o</sup> C should be used humidity in apparent temperature calculation. If the temperature is below 10<sup>o</sup>C it must be combine with the wind speed in order to calculate the wind chill.

Communication with Arduino is made it by connecting the sensor GND pin to GND pin of the Arduino, VCC pin is connected to the Arduino 5V pin and the SCK and DATA pins of the sensor to two digital pins of Arduino.

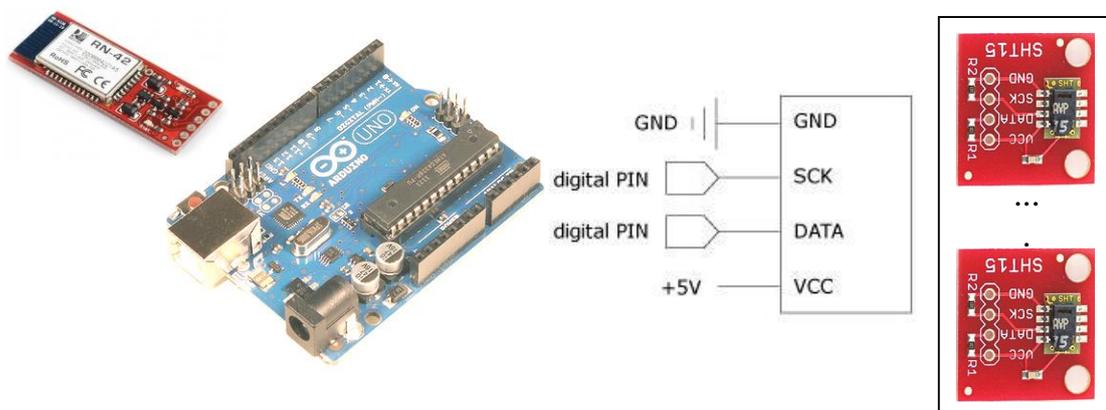


Figure 1. SHT and RN42 to Arduino connection.

The RN42 is a small form factor, low power, highly economic Bluetooth radio for OEM's adding wireless capability to Arduino. The RN42 supports multiple interface protocols, is simple to design in and fully certified, making it a complete embedded Bluetooth solution for different applications: cable replacement, measurement and monitoring systems, industrial sensors and controls, medical devices and intelligent home. In our application it make the connection between the user smart devices and Arduino in order to transmit data from SHTx sensors to a data base containing a number of users and their life style preferences in terms of thermal conditions.

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for anyone interested in creating interactive objects or environments.

One inconvenience of the SHTx is that it has a single address. This can be avoiding by using a multisensory system on the same Arduino.

Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using a programming language (based on Wiring) and a development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software running on a computer (e.g. Flash, Processing, MaxMSP).

We developed LabVIEW program for Arduino Uno board with one of the block diagrams showed in Figure 2. This allows configuration and data reading/writing from analog / digital input / output board channels.

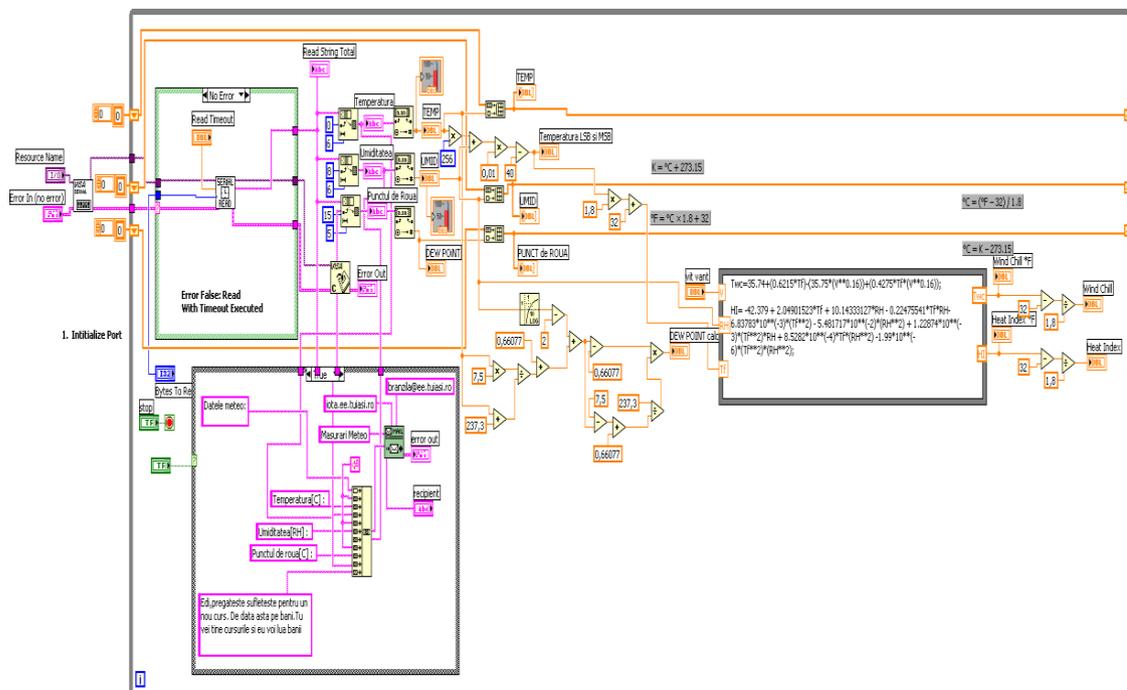


Figure 2. Block diagram for data reading from Arduino.

The program makes data acquisition from SHT11 sensor and LCD display. It display local the values of temperature, humidity and dew point, and then data is send it to the computer serial port. Virtual instrument makes it possible to calculate and display numeric or graphical form of the values of physical quantities and automatically send them in e-mail, to interested persons. Computer can signalize by lights and audible elements those exceeded limits.

### III. Conclusions

The work presented is part of this trend to use virtual instrumentation, in a sense of reducing the costs, flexibility and systems modularization. Using a Laptop and low cost hardware to process and measure signals, our solution allows rapid product development, resulting in quicker deployment to first intelligent home user and fast patient heart diseases assessment diagnoses. The LabVIEW software that we developed stands to serve as important tools for encourage smart buildings construction for any eco city.

## ACKNOWLEDGMENT

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