UNIVERSAL TEST BENCH FOR SENSORS WITH REAL-TIME MONITORING

[1]Muskan Bhusal, [2]Pragya Pandey, [3]Joshitha Soans, [4]Mahalakshmi S, [5]Siddesha K
ECE Department,
Dr. Ambedkar Institute of Technology, Bengaluru, India

Abstract: ***This paper describes about the test setup established to test the working of ultrasonic, temperature and infrared sensor. With the increase in number of sensors being introduced to the market, it is cumbersome to determine the sensor with the greatest accuracy. Laboratories are filled with many sensors of the same type and functionality and when the application involved demands a sensor with high precision and accuracy, it becomes a difficult task for the user to select the one best out of these. One has to sit and calculate the readings of the sensor against the actual value for each and every sensor. The proposed system is a portable instrument which enables the user to test various sensors readings against the required accuracy level and also facilitates real time monitoring of sensors data to determine the stability in readings.***

Index Terms **- Accuracy, Arm processor, Sensors testing, Python.**

I. INTRODUCTION

Sensors are the "organs of observation" in any domain, be it proximity sensor in a cell phone or a photoelectric sensor in automation industry. Sensors basically find the application in detecting and measuring four main parameters i.e. physical, mechanical, chemical and electromagnetic properties. Sensors play a vital role in introducing new functionalities. Sensors form an integral part of many electronic applications. With the introduction of many new sensors it has been possible to ease the human task. The rapid development in automation industry is apparently due to the additional capabilities brought in the sensor industry. Global competition highly demands an economical, efficient and optimized processes. None of these demands can be imagined without sensors and measuring technology, and neither can the advancements in standards of quality persist without the testing technology. The electronic circuit designing itself takes most of the manufacturing time due to the rapid development in sensors and transducers. Manufacturers cannot afford to delay it further in the process of debugging and validation of the sensor functionalities. Currently instrumentation labs are filled with different boards for different sensors and transducers. If you need to test ten sensors, you will have to use ten different boards which increases the investment cost. A dedicated hardware and software are used for each of these sensors which would be very difficult to carry. The test bench proposed here is a device of the size of a laptop to which various sensors are interfaced. One can carry it anywhere and can be utilized to quickly and easily evaluate any sensor.

It eases the task of testing and determining the best suitable sensor out of many by simply plugging in the sensor to be tested with the device through a specific port. The Test Bench can be used as a laboratory equipment which gives students a setup to get practical knowledge about sensors. It provides a detailed introduction to how electronic sensors work, the signals they produce etc. The basic idea behind this Test Bench is to have a single device to test and verify the features, functions and characteristics of various sensors. The main objective is to reduce cost and time by testing various sensors under one roof.

Ports are allocated for each type of sensors. Any sensor to be tested can be plugged in to the device and its output can be compared with the expected output. Hex keypad is used to enter the expected reading or the exact value and also the required percentage accuracy. Controller then evaluates the acceptable range of sensor reading and the sensor output is tested against this specified acceptable range of values to check whether it falls within the specified accuracy level or not. LCD is used to display all the operations being performed.

II. SYSTEM ARCHITECTURE

ARM architecture-based processor is used for the system. The ARM7TDMI-S is a general purpose 32-bit microprocessor, which is widely used these days in building many SOCs for many consumer electronics products. It offers high performance and very low power consumption. The ARM architecture is based on Reduced Instruction Set Computer (RISC) principles. Instruction set in RISC is quite simpler than Complex Instruction Set Computer (CISC) architecture. Due to its reduced instruction set it uses less chip space and produces more efficient code.

The NXP (founded by Philips) LPC2148 microcontroller is used which is an ARM7TDMI-S based high-performance 32-bit RISC Microcontroller with Thumb extensions. It has 512KB on-chip flash ROM which can be programmed through In-System Programming (ISP) and In-Application Programming (IAP). It has 32KB on-chip static RAM. Two 10bit ADCs with 14 channels are used to convert the analog input from sensor readings into digital with the measurement range of 0 V to VREF V. It has two UARTs, one with full modem interface. CPU clock is the system clock which is up to 60 MHz it also has On-chip crystal oscillator and On-chip PLL. Since the system needs to be portable, there is a facility for viewing test report on 16*2 LCD. It displays the sensor reading and the entered value through keypad. Later it displays message based on whether the sensor reading lies within the acceptable range of values.

Arduino Uno which is based on the ATmega328P microcontroller is used to communicate serially with the PYTHON software which uses the serial data and plots the graph.

1. Microcontroller performs the following functions:
   - Interface with all the sensors and scan the slots to detect sensor data
   - Display the switches allocated for testing different sensor
   - Interface with keypad to receive the input for required accuracy and expected value
   - Convert analog input to digital output with inbuilt ADC.
   - Display the test results on LCD
2. The motherboard has slots allocated for each sensor. One can plug and play sensors anytime by making the required connections with the port pins.
3. Arduino UNO is used an interface to send sensor data serially to the software to plot the real time characteristics of the sensor.
4. Two different sensors like working and non-working sensors can be connected to Arduino UNO to compare between their characteristics.

III. METHODOLOGY

Lpc2148 microcontroller is the heart of the system which monitors operation of all the peripherals. Ports are allocated for each sensor. Sensor to be tested can be connected to the allocated port and the corresponding switch should be pressed to start the operation. The main block diagram is as shown in fig 1.

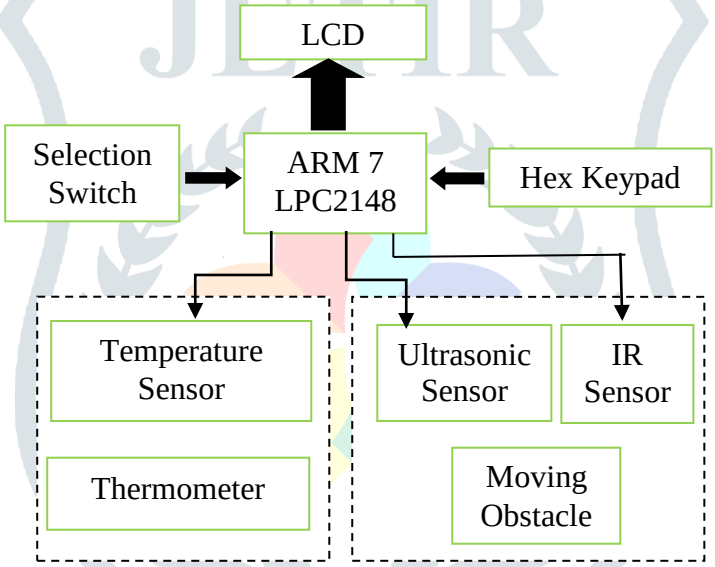

Fig. 1 Block Diagram

Actual values of temperature and obstacle distance can be obtained from thermometer and measurement scale attached to the measurement scale respectively. Hex keypad enables the user to enter the actual value and required accuracy. Sensor reading is compared with the acceptable range as calculated using accuracy and actual value and subsequently message is displayed regarding the suitability of the sensor based on comparison results.

Sensor data is plotted in real time and compared with the reference sensor to verify the stability in sensor readings. Plotting of the sensor data is done by connecting the sensor to Arduino UNO. Coding for graph plotting is done in Python. Serial library in Python enables the program to communicate serially with Arduino and receives the sensor reading serially. Further the received data is utilized by the Python software for plotting. The actual flowchart of the system working is given in fig2.

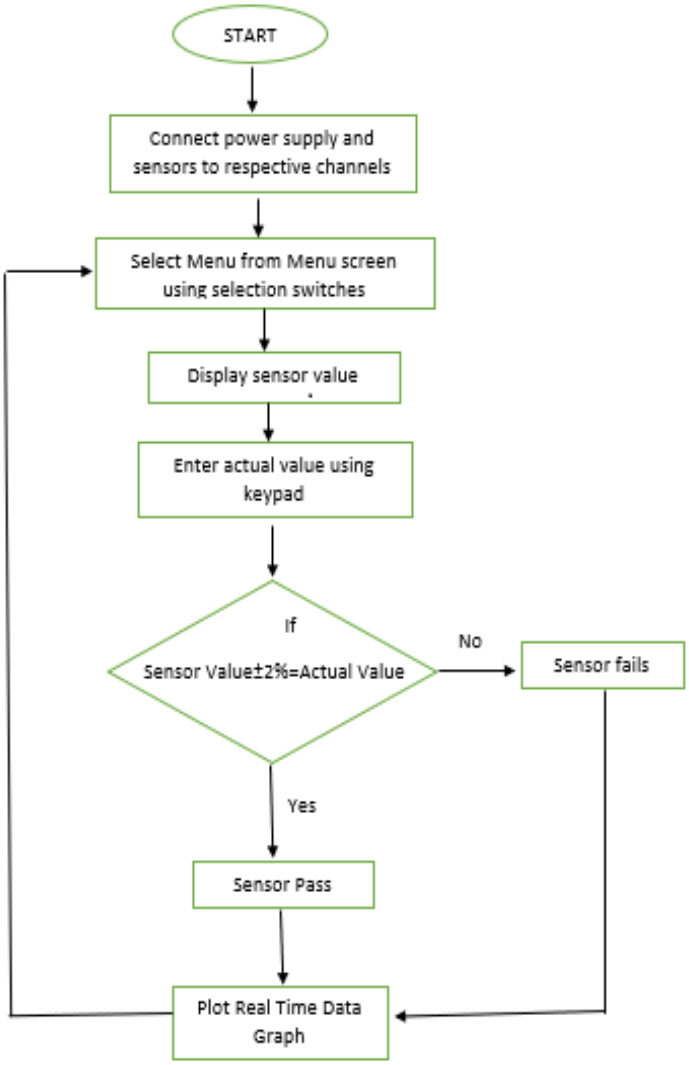

Fig. 2 Flow Chart

IV. RESULT AND DISCUSSION

16*2 LCD Display is interfaced with the microcontroller which displays the message. First it shows the ports for each sensor, displays the reading and then asks the user to enter actual value and desired accuracy and later displays the message about the suitability of sensor.

Fig 3. Messages showing the readings and the suitability of the sensors

A. REAL TIME PLOTTING OF CHARACTERISTICS WITH ARDUINO USING PYTHON

Table 1. Readings of working and non-working

Actual distance(cm)	Working ultrasonic sensor reading(cm)	Non-Working ultrasonic sensor reading(cm)
4	5	0
6	6	0
8	8	0
13	12	0
15	15	0
19	18	0
22	22	0

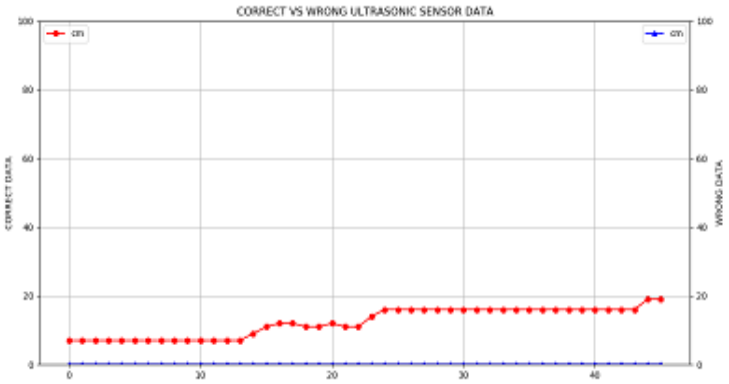

Fig 4. Plot of working vs non-working ultrasonic sensor.

Correct ultrasonic sensor tracks the change in position of the obstacle as shown by red color and output of non-working sensor does not vary with the position of the obstacle and the same is shown in blue color.

Table 2. Readings of two temperature sensors

Actual temp. as measured by thermometer (in °C)	Reading of temp sensor 1(in °C)	Reading of temp sensor 2(in °C)
20	19.2	16.6
27	26.3	22
33	33.5	31
.43	41.9	39.4
55	53.8	50.6
63	62.1	60.1
84	83.4	79.6

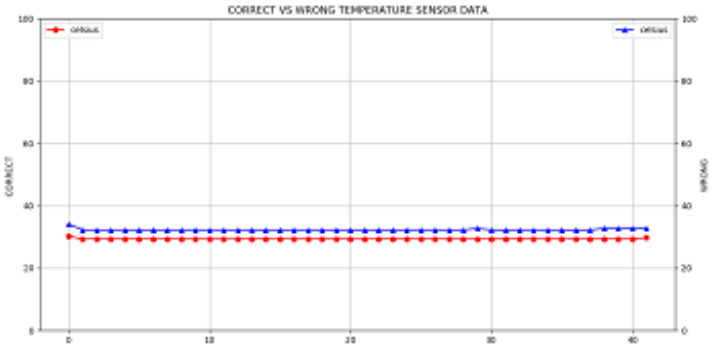

Fig. 5. Plot of two different temperature sensors.

Here the reading of wrong sensor is offset by some value with respect to standard sensor which represents the error.
The major applications where the setup can be used are:
Laboratory

1. Test various sensors
2. Study the characteristics of sensor

Industry

1. Data loggers
2. Environmental monitoring

V. CONCLUSION

The system proposed can be used as low cost and powerful equipment to test and evaluate the accuracy of various sensors against the actual value of the physical parameters in concern. The system gives practical knowledge about the working of the sensor and the various physical parameters that do or do not affect the same. The system helps in using the best suited sensor according to the accuracy required for the particular application easing the workload of scientists, engineers and students.

REFERENCES

[1] Riva, Marco; Piergiovanni, Schiraldi, Luciano; Schiraldi, Alberto (January 2001), "Performances of time-temperature indicators in the study of temperature exposure of packaged fresh foods", Packaging Technology and Science 14 (1): 1–39,
[2] Singh, J; Singh, Burgess (July 2007), "Measurement,
Analysis, and Comparison of the Parcel Shipping Shock and Drop Environment of the United States Postal Service with Commercial Carriers", JOTE 35 (3)
[3] C. A. Grimes, E. C. Dickey, and M. V. Pishko (2006), Encyclopedia of Sensors (10-Volume Set), American Scientific Publishers. ISBN 1-58883-056-X
[4] Sensors - Open access journal of MDPI

[5] Clifford K. Ho, Alex Robinson, David R. Miller and Mary J. Davis. Overview of Sensors and Needs for Environmental Monitoring. Sensors 2005, 5, 4-37
[6] Scott R. Burge Dave A. Hoffman Mary J. Hartman and Richard J. Venedam. Automated Ground-Water Sampling and Analysis of Hexavalent Chromium using a ―Universal‖ Sampling/Analytical System. Sensors 2005, 5, 38-50
[7] MCP9800 Temperature Sensor Demo Board, http://www.microchip.com
[8] Ambient Light Sensor Development Kit, http://www.vishay.com
[9] Wireless hydrogen sensor
[10] Sensors and Actuators - Elsevier journal
[11] Automated Deformation Monitoring system
[12] Droid's Sensors -adware for droid sensors
[13] RuiWang and Shiyuan Yang, Senior Member, IEEE
[14] David Brash, ―The ARM Architecture Version", ARM White Paper, January 2002
[15] The ARM Architecture Leonid Ryzhyk leonidr@cse.unsw.edu.au June 5, 2006
[16] Brian W. Kernigan and Dennis Ritchie, ―The C Programming Language (ANSI)", Prentice Hall, second edition, 2001
[17] ARM System Developer's Guide Designing and Optimizing System Software by A. N. Sloss, D. Symes, C. Wright, J. Rayfield, Elsevier 2004.