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Multiple sensors fault detection and monitoring system using PIC, GSM, and IoT

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Abstract - The integrity of sensors is critical to the safe and profitable operations of industrial processes. The slightest sensor variation can have a rippling effect on production rate, scrap, and waste. It can also lead to dangerous accidents that can cause serious harm. We propose Multiple sensors fault detection and monitoring system using PIC, GSM, and IoT that will closely monitor the multiple sensors. If any sensors show abnormal behavior, it will send the message to the admin with the help of the GSM module, and with the help of a dedicated app admin can control the system running on those sensors. Sensors used in this system are humidity & Temperature, Distance, and gas. If any of the sensors is not working completely, it will directly turn off the system thereby notifying the admin via message.

Keyowrds: GSM, IOT, Sensors, Fault detection, PIC, NodeMcu, AT commands.

I. INTRODUCTION

Many autonomous systems are usually equipped with sensors to sense the surrounding environment. The sensor readings are interpreted into beliefs upon which the robot decides the way to act. Unfortunately, sensors are susceptible to faults. These faults might lead to task failure. GSM-based multiple sensors fault detection and monitoring system using PIC and IoT will detect the fault of sensors with the help of electrical signals received by the sensors. Our proposed system will compare the sensors reading with the admin maximum threshold readings and show the updates of sensors on LCD, and if the sensor behaves abnormally, it will alert the user by various indications and send the message to the admin mobile. Admin can control the system with the dedicated application from mobile. This system will help the admin to monitor the fault of the sensors automatically on a real-time basis. It also can be used for sensor integrity testing.

The main objectives of the paper are

A) To create the multiple sensor fault detection and monitoring system.
B) To get real-time alert message when sensor shows faulty readings with the help of GSM.
C) Interface the mobile application with the system running on sensors with the help of IoT.
D) If the sensor is completely damaged or no action is taken by the admin, turn off the system automatically.

The complete paper has been organized in different sections as

Section 2: Block and circuit diagram
Section 3: Propose algorithm flow
Section 4: Explains the hardware and software requirements
Section 5: Discussion of implemented results
Section 6: Conclusion
Section 7: References

II. BLOCK DIAGRAM AND CIRCUIT DIAGRAM

The proposed block diagram of the system is shown in fig.1. It has Multiple sensors such as HC-SR04, MQ-2, and DHT11 as an input to PIC 18F2520. Rf transceiver is also connected with PIC. Output is observed with help of LEDs, buzzer, LCD, and servo motor. Message is sent to the admin with the help of GSM module. NodeMcu ESP8266 is used to interface mobile application with the system running on the sensors. RF Transceiver sends maximum and minimum values of the sensors to be monitored to the PIC 18F2520. PIC compares the sensors reading. If sensors show faulty readings or abnormal behavior, it indicates the user by various means such as LCD, buzzer, LEDs and message will be sent to the admin. Admin can take the further action by controlling the system with the help of mobile application using nodemcu ESP8266.

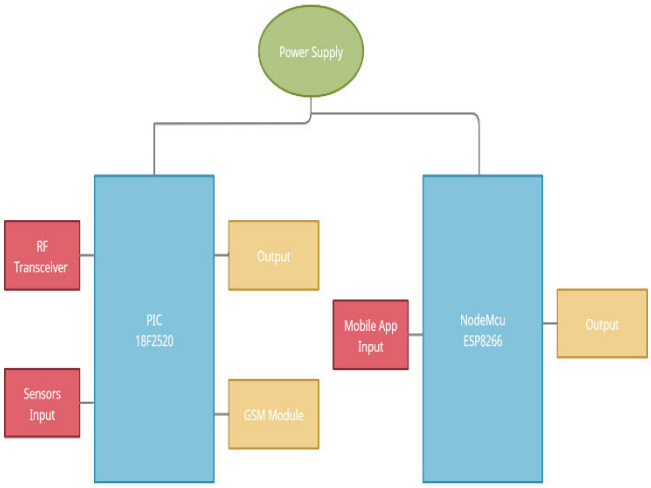


Fig 1. Block diagram of Multiple Sensors fault detection and monitoring system using PIC, GSM, and IoT

III. PROPOSED ALGORITHM FLOW

The proposed flow of the algorithm is given in Fig 2.

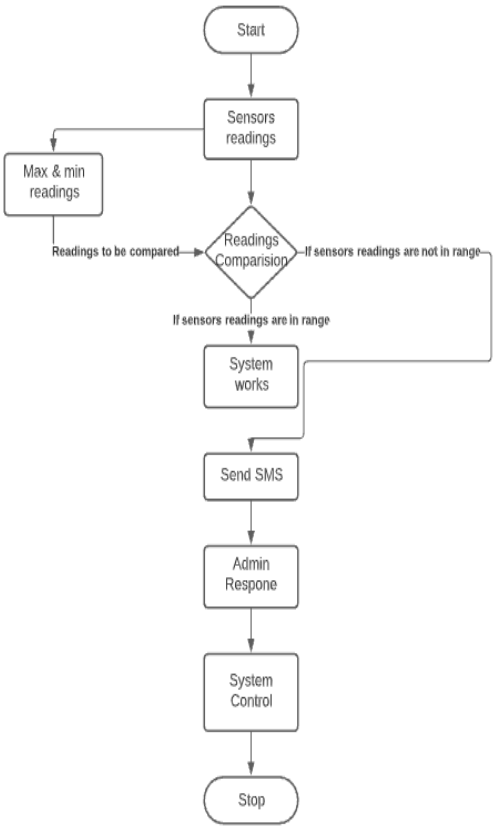


Fig 2. Flow chart of a designed system

Flow of the designed system can be understood by the following steps.

Step 1: System is started when the power supply of 5v is applied to the circuit.

Step 2: Maximum and minimum required sensor readings are calibrated in PIC with the help of RF transceiver and PC interface.

Step 3: If the readings taken from the sensor matches with the readings received from the admin, System works properly. If the readings do not match, there is fault in the system.

Step 4: Message in real time will be sent to the admin informing about the faultiness of the specific sensor.

Step 5: Admin can control the system with the help of mobile application using IoT.

Step 7: If the sensor fault is severe, system gets turn off automatically.

IV. HARDWARE AND SOFTWARE REQUIREMENTS

1. Hardware

1.1 Microcontrollers

1.1.1 PIC 18F2520

Fig 3. Pic 18F2520 Microcontroller

• C Compiler Optimized RISC Architecture
• Operating speed of the pic is up to 64 MHz clock operation - 62.5 ns minimum instruction cycle
Memory
• Up to 64 KB Flash Program Memory
• Up to 4 KB Data SRAM Memory
• Up to 1 KB Data EEPROM
Operating Characteristics
• Operating Voltage Range: -
1.8V to 3.6V (PIC18LF25/26K83) –
2.3V to 5.5V (PIC18F25/26K83)
• Temperature Ranges for Industrial is-40°C to 85°C - Extended: -40°C to 125°C

1.1.2 NodeMcu ESP8266

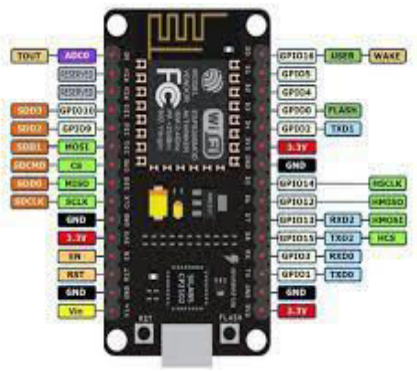


Fig 4. NodeMcu ESP8266

• It is 32-bit RISC CPU Xtensa LX106.
• It operates on 3.3V though its input range is 7-12V.
• It has 16 digital I/O pins and one analog input pin.
• It has 1 UARTs, 1 SPIs, 1 I2Cs.
• NodeMcu has a flash memory of 4MB and SRAM of 64 KB
• It runs at the clock speed of 80MHz.
• US-TTL supportedCP2102 is included onboard in nodemcu.

1.2. Sensors

1.2.1 DHT-11 Sensor

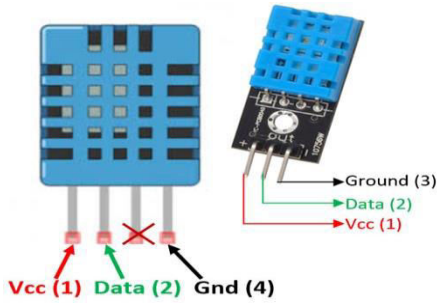


Fig 5. DHT-11 Sensor

The DHT11 is commonly used as temperature and humidity sensor. This sensor has NTC and an 8-bit microcontroller to output the values of temperature and humidity as serial data. This sensor is additionally factory calibrated and hence it is easy to interface with other microcontrollers.
This sensor can measure temperature ranging from 0°C to 50°C and humidity ranging from 20% to 90% with an accuracy of ±1°C and ±1%.

1.2.2 HC-SR04 Sensor

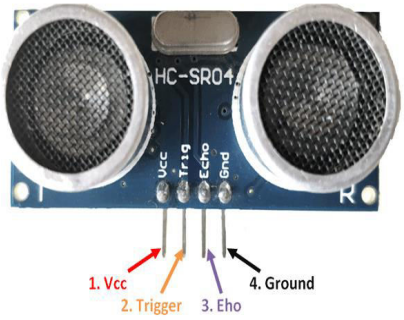


Fig 6. HC-SR04 Sensor

This sensor provides 0.02m to 4m of non-contact measurement functionality with a ranging accuracy that can reach up to 3mm. Each HC-SR04 module includes an ultrasonic transmitter, a receiver, and a control circuit.
This sensor has additional control circuitry that can prevent inconsistent "bouncy" data depending on the application.
There are only four pins present in the HC-SR04 they are: VCC (Power), Trig (Trigger), Echo (Receive), and GND (Ground).

1.2.3 MQ-2 Sensor

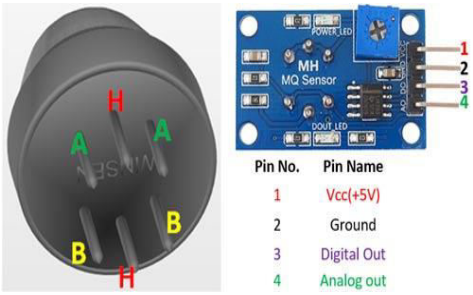


Fig 7. MQ-2 Sensor

• Operating Voltage of MQ-2 is +5V.
• It can be used to measure or detect LPG, Alcohol, Propane, Hydrogen, CO and even methane.
• Its analog output voltage ranges from 0V to 5Vand digital output voltage ranges from 0V or 5V (TTL Logic).
• It has Preheat duration of 20 seconds.
• It can be used as a Digital or analog sensor.
• The Sensitivity of Digital pin can be varied using the potentiometer present on the circuit.

1.3 HC12 RF TRANSCEIVER MODULE

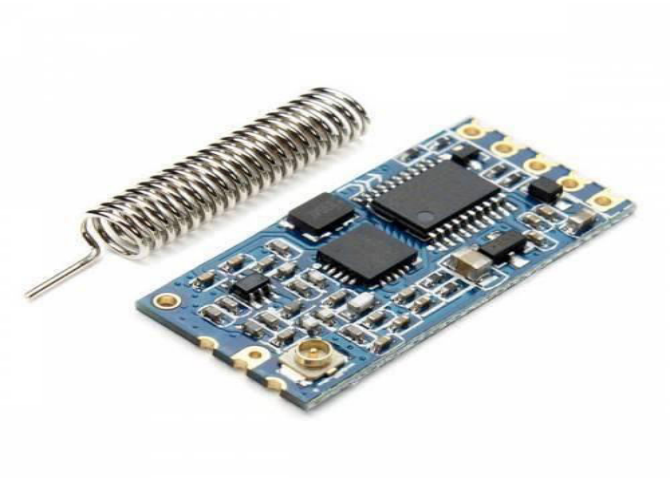


Fig 8. HC12 RF Transceiver module

• It has long-distance wireless transmission (1,000m in open space/baud rate 5,000bps in the air)
• Working frequency range of RF transceiver module id 433.4-473.0MHz, up to 100 user selectable communication channels.
• It has Maximum 100mW or 20dBm transmitting power (8 levels of power can be set)
• There are three working modes, adapting to different application situations.
• It has built-in MCU, it performs communication with external device through serial port
• Working frequency: 433.4MHz to 473.0MHz
• Supply voltage: 3.2V to 5.5VDC
• Serial baud rate: 1.2Kbps to 115.2Kbps
• Receiving sensitivity: -117dBm to -100dBm
• Transmit power: -1dBm to 20dBm
• Interface protocol: UART/TTL

1.4 LCD 16 x 2

Fig 9. Actual image of System LCD 16x2

- It operates 4.7V to 5.3V
- It consumes current of 1mA without backlight
- It has alphanumeric LCD display module which means it can display alphabets and numbers
- It consists of two rows and each row can print 16 characters.
- Each character is built by a 5×8-pixel box in LCD 16x2.
- It can work on both 8-bit and 4-bit mode
- It is also capable todisplay any custom generated characters

1.5 USB to TTL converter

Fig 10. USB to TTL converter

- It is stable and reliable chipset CP2102.
- It has USB specification 2.0 compliant with full speed 12Mbps.
- It contains Standard USB type A male and TTL 6pin connector.
- USB to TTL converter has 6pins for 3.3V, RST, TXD, RXD, GND & 5V.
- Operates at baud rate of300 bps to 1.5 Mbps
- IT contains Byte receive buffer; 640 bytes transmit buffer.
- It supports Hardware or X-On/X-Off handshaking.
- Event character Line break transmission is supported.
- In TTL, USB suspend states supported via SUSPEND pins.
- Its temperature ranges from -40 to +85.

1.6 GSM MODULE

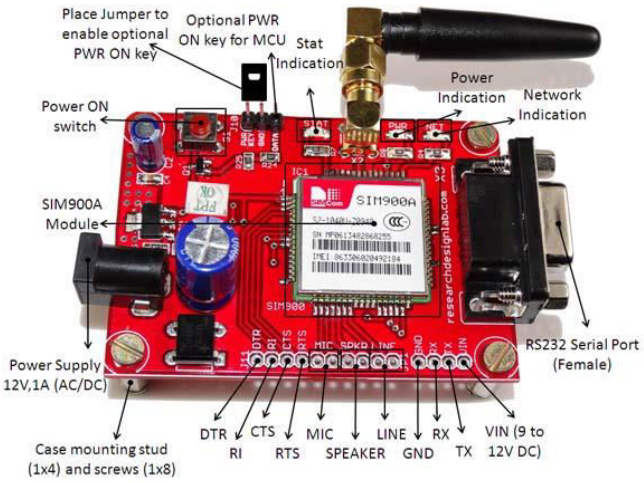


Fig 11. GSM module

- The Global System for Mobile Communications is a standard developed by the European Telecommunications Standards Institute to describe the protocols for second-generation digital cellular networks used by mobile devices such as mobile phones and tablets.[4]
- It Supports Quad-band: GSM850, EGSM900, DCS1800 and PCS1900
- We can Connect onto any global GSM network with any 2G SIM
- With the help of this module we can make and receive voice calls using an external earphone & electret microphone
- We can also send and receive SMS messages
- This module is also capable of sending and receiving GPRS data (TCP/IP, HTTP, etc.)
- It has facility of scan and receive FM radio broadcasts
- Transmit Power Details:
  - Class 4 (2W) for GSM850
  - Class 1 (1W) for DCS1800
- Serial-based AT Command Set is used.
- This module has U.FL and SMA connectors for cell antenna
- Full-size SIM card can be inserted in this module

2. SOFTWARE

2.1 MPLAB X IDE

MPLAB is an Integrated Development Environment (IDE) which is a free, integrated toolset for the development of embedded applications employing Microchip's PIC® and dsPIC® microcontrollers. MPLAB IDE runs as a 32-bit application on MS Windows®, is easy to use and includes a host of free software components for fast application development

and super-charged debugging. MPLAB IDE also serves as a single, unified graphical user interface for additional Microchip and third-party software and hardware development tools. Moving between tools is a snap and upgrading from the free software simulator to hardware debug and programming tools is done in a flash because MPLAB IDE has the same user interface for all tools. In this system we have used MPLAB IDE to write embedded C code for PIC microcontroller.[12]

2.2 Arduino IDE

Fig 12. Arduino IDE logo

The Arduino Integrated Development Environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in functions from embedded C and C++. It is used to write and upload and debug the programs to Arduino compatible boards, but also, with the help of third-party cores, other vendor development boards. In this system, arduino IDE is used to write the code for NodeMcu ESP8266.

2.3 Visual Studio Code

Visual Studio Code is a source-code editor made by Microsoft for Windows, Linux and macOS. Its features include support for debugging, syntax highlighting, intelligent code completion, snippets, code refactoring, and embedded Git. Framework of .net is created with the help of Visual studio code.

V. Result and Discussion

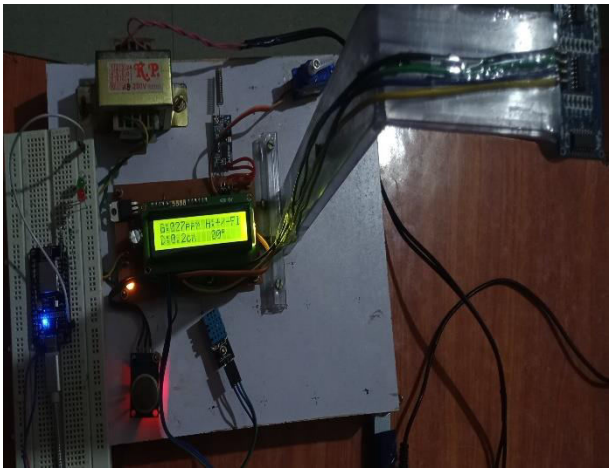
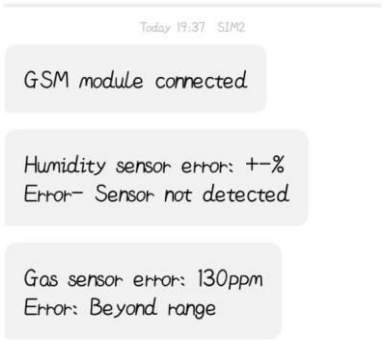


Fig 13. Hardware representation of the proposed system

Multiple sensors fault detection and monitoring system using PIC, GSM, and IoT are created to solve the sensors integrity problem. This system also can be used for testing multiple sensors at one time.

On LCD real-time values of Gas concentration in parts per million(ppm), Humidity value in percentage(%), Distance value in centimeter(cm), and temperature value in Degree Centigrade can be observed as shown in fig 9.

With the help of AT commands and GSM module, SMS alert can be sent to the admin in real-time. Fig 14. Shows the SMS example sent to the admin.



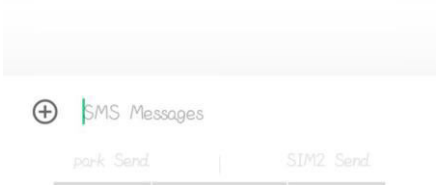


Fig 14. SMS example sent to the admin by GSM module.

Fault in the sensors can be caused by the following two measure reasons

1. Sensor gets damaged when exposed to extreme conditions or when input voltage range goes beyond limits.
2. Cable break /lead breakage, broken connectors, and damaged cable insulation can cause errors in sensor readings.

When the sensor do not fall in the range of admin-defined readings, the GSM module will send the message as real-time sensor reading with the error message as beyond range. If the sensor cables break or one of the sensor cables gets disconnected, the GSM module will send the message as-Sensor not detected.

Once the admin receives the message from the system, he can take the necessary action with the help of a dedicated mobile application as shown in fig 15. The mobile application is connected with the NodeMcu with the WIFI. We created mobile application with the help of the MIT app inventor website. The exhaust fan, Conveyor

belt, Air cooler in the application is depicted by white, red, and green LED respectively.

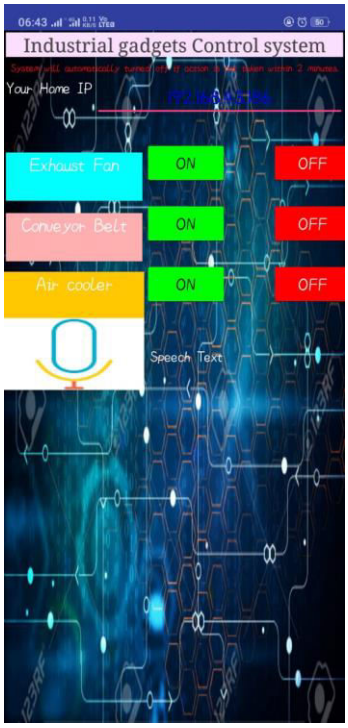


Fig 15. Snapshot of mobile application created to control the system running on sensors

VI. CONCLUSION

The proposed system in the paper not only provides the facility to monitor the multiple sensors continuously but also provides the facility to take the necessary action if the fault is detected. With the help of this system, Losses caused due to the faultiness of the sensor can be prevented and Harmful accidents can be averted. This system can be implemented in the engineering students' practical labs to test the sensors integrity. It also can be used in the green house management system to monitor the sensors in real-time and in continuous manner.

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