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INDUSTRIAL PROCESS MONITORING AND ALERT SYSTEM USING WIRELESS TECHNOLOGY

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ABSTRACT

Effective measurement and monitoring of process parameters like pressure, flow etc is essential for scientific applications and in process industries. In process monitoring and control, measurements like pressure, flow are acquired through sensing elements and transmitted to control station for operation and management. Wired sensors have been extensively utilized for this purpose but difficult to augment and maintain and not suited for harsh environments. In order to overcome the complexities in wired networks, Wireless Sensor Network technology is an emerging alternative. The wireless network provides significant benefits in cost, ease of deployment, flexibility and convenience. The use of wireless technology can assist the industry to overcome the limitations of wired networks. In the process Industry, the critical measurement needs to be monitored by 24x7 basis. Conventional system for round the clock monitoring is complex. Wireless communication technology is the solution for continuous monitoring in any critical areas. Alert system is required in process industries to generate mobile SMS alerts to the concerned in case of any abnormalities.

This paper presents implementation of Monitoring & Alert system of critical process parameters in the process industry using wireless technology. The system was designed, implemented and validated. Process parameters like Pressure & Flow data was monitored through wireless modem, alert message using GSM technology was verified and validated.

KEYWORDS

Process Monitoring, Wireless Sensor Networks, GSM, SCADA.

1.0 INTRODUCTION

Plant knowledge is essential for the process industry in order to improve process operations. Now a day's process systems are automated in order to overcome criticalities and to avoid human interfaces. Automated systems have less manual interventions which drastically increase the flexibility, reliability and accuracy. Automation based on advanced electronics technologies yields fruitful results in every aspect.

Recently for scientific and research community, wireless sensor networks are in top priority. Wireless capabilities add convenience and cost savings to process measurement and control. By removing the wired interfaces between the components, realization of systems are faster, easier, and less expensive. Wireless technology facilitates data transmission as well as most wireless equipment interfaces are can be easily interfaced to other equipments either through USB or Ethernet.

Online monitoring of measurements located in remote locations from control room facilitates uninterrupted operation in the process plants and industries.

Why use wireless?

Wireless networks can assist the process industry to gather data from processes predict maintenance of equipment, increase workforce efficiency through plant wide network connectivity solutions. Wireless technology is attractive as it eliminates the problems associated with wired networks like Pre-planning requirements, higher installation and maintenance costs.

Key benefits of wireless technology:

- Wear and tear free data transfer
- Lower installation and maintenance costs

2.0 SYSTEM REPRESENTATION

System realization for acquisition & transmission of process parameters through wireless mode represents as follows.

In the sensing element side, the process data such as pressure, flow etc., are converted into digital by means of ADC in the microcontroller unit. These signals are transmitted to control station through wireless mode using RF module. In the control station, the RF module receives the data, converts and transfers to the PC. SCADA was developed to monitor the data in real time. It also generates alarm, when the process data exceeds the threshold limit. Also it generates mobile SMS alert using GSM module to the concerned for necessary action.

The figure 1 & 2 shows block schematic for Transmitter & Receiver units.

2.0.1Transmitter End:

The transmitting node consists of Pressure Transmitter, Vortex Flow meter, Processing circuits, RF Transceiver, Signal converters, GSM modem etc.

- Pressure Transmitter output (4-20mA) & Vortex Flow meter output (4-20mA) are converted into voltage signals, since the microcontroller unit accepts voltage inputs.
- For data transmission, the analog output is fed to Arduino Development Board which converts to digital signal by means of built in 10 bit ADC.
- The microcontroller in the Arduino generates TTL output, whereas the RF modem accepts RS232 serial signal. Using TTL to RS232 converter the signal is converted and posted to RF modem.
- The serial data is transmitted by means of RF modem at the throughput data rate of 9600 bps. The data rate can be extended upto 115200 bps. But the transmission range is reduced to half with the increased data rate.
- For generating alert messages, the analog output is also connected to Arduino Development Board which in turn connected to GSM Modem (with SIM) via TTL to RS232 converter.

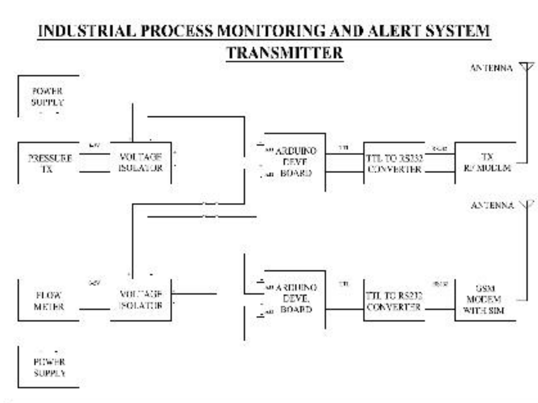

Figure 1. Transmitter section for Data & Message communication

2.0.2 Receiver End:

The receiver section consists of RF module, Server PC, LAN backbone etc.

- At the receiver side, the RF Modem receives the data which is transmitted by the RF modem at the transmitter end.
- The RF modem at the receiver end is interfaced with PC for Graphical display in the Monitoring Centre.
- The Interface PC (data rate 9600 bps) in Monitoring Centre is connected to the Local Area Network and measurements can be monitored through any PC in that network.

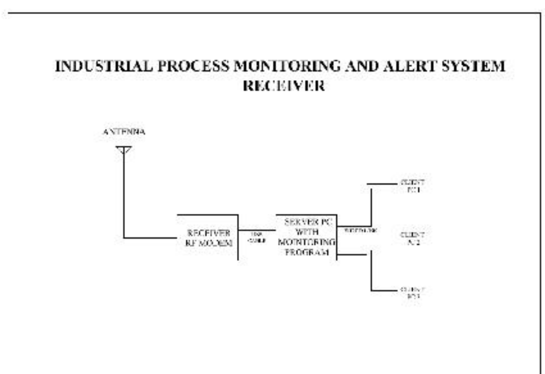

Figure 2. Receiver section for monitoring purpose at Control station

2.0.3 Description of the Hardware units:

A. PRESSURE TRANSMITTER:

A pressure transmitter is a transducer that converts pressure into an analog electrical signal. The conversion of pressure into an electrical signal is achieved by the physical deformation of strain gauges which are bonded into the diaphragm of the pressure transmitter. The strain will produce an electrical resistance change proportional to the pressure.

Figure 3. *Pressure Transmitter*

B. VORTEX FLOW METER:

A Vortex flow meter is a flow measurement device best suited for flow measurements where the moving parts caused problems in the process. Vortex flow meters operates based on karman vortex street theory and adopts piezoelectric crystal to detect the burble frequency of the fluid caused by flowing through the triangular prism in the pipeline and then measure the flow of fluid.

Figure 4. *Vortex Flow meter*

C. RF TRANSCEIVER:

The XTend RF Module provides reliable delivery of critical data between remote devices. It provides a long range, low cost wireless solution. The module transfers a standard asynchronous serial data stream, operates within the ISM 900 MHz frequency band and sustains up to 115.2 Kbps data throughput. Its transmit power is software adjustable from 1mW to 1W.

Technical specifications:

- Supply Voltage : 2.8V to 5.5V
- Spread spectrum : FHSS
- Modulation : FSK
- Encryption : 256 Bit
- Range (Indoor) : 14Km
- Range (Outdoor) : 40Km
- Data rate : 9600 bps to 115200 bps
- Receiver sensitivity: -110dBm at 9600 bps.

Figure 5. *RF Transceiver*

Addressing:

Each RF packet contains addressing information. Receiving module inspects the hopping channels (HP parameter), Vendor Identification number (ID parameter) and Destination address (DT parameter) contained in each RF packet.

Address recognition:

In the RF modules, transmissions can be addressed to a specific module or group of modules using the Destination address. A destination module will only accept a packet if it determines the packet is addressed to it. The receiving module makes this determination by inspecting the destination address of the packet and comparing it to its own address.

Security:

The XTend module utilizes FHSS (Frequency Hopping Spread Spectrum) agility to avoid interference by hopping to a new frequency on every packet transmission or re-transmission. FHSS is a method of transmitting radio signals by rapidly switching a carrier among many frequency channels, using a pseudorandom sequence known to both transmitter and receiver. Spread-spectrum signals are difficult to intercept. A spread-spectrum signal may simply appear as an increase in the background noise to a narrowband receiver. An eavesdropper may have difficulty intercepting a transmission in real time if the pseudorandom sequence is not known.

Encryption:

AES 256 bit Encryption standard is implemented in XTend RF module. The Advanced Encryption Standard (AES) is a specification for the encryption of electronic data established by the U.S. National Institute of Standards and Technology (NIST) in 2001. The algorithm described by AES-256 is a symmetric-key algorithm uses key size of 256 bits, meaning the same key is used for both encrypting and decrypting the data.

D. ARDUINO DEVELOPMENT BOARD:

The Arduino Uno is a microcontroller Board based on the ATmega328. The ATmega 328 is an Atmel 8-bit AVR RISC based microcontroller. It has 14 digial input/output pins, 6 analog inputs, 16MHz crystal oscillator etc. It contains every thing needed to support the microcontroller. The Arduino Uno can be powered via the USB connection or with an external power supply. The Atmega328 has 32KB of flash memory for storing code. It has also 2 KB of SRAM and 1 KB of EEPROM. The ATmega328 provides UART TTL(5V) serial communication which is available on the Rx and Tx Pin.

Arduino is an open source microcontroller development board. It consists of uC and IDE used to develop software & download to the physical board.

Technical specifications:

- H/w version : Arduino UNO R3
- Input Voltage : 7-12V
- Microcontroller : ATmega328
- Analog Inputs : 6
- Digital I/O pins : 14
- ADC : 10 Bit
- Communication : UART

Figure 6. *Arduino Development Board*

Figure 7. *ATmega328 microcontroller*

E. GSM MODEM:

GSM Modem is a class of wireless MODEM devices that are designed for communication of a computer with the GSM network. The modem needs AT commands for communicated through serial port. It accepts any GSM network operator SIM card. It is having internal TCP/IP stack to enable connect with internet via GPRS. The modem is designed with RS232 level converter circuitry, which allows to directly interfacing PC serial port.

Technical specifications:

- Frequency : 900MHz
- Input voltage : 4.5V to 12V
- Modem Interface : RS232 Serial
- Data rate : 9600 bps
- Communication : UART

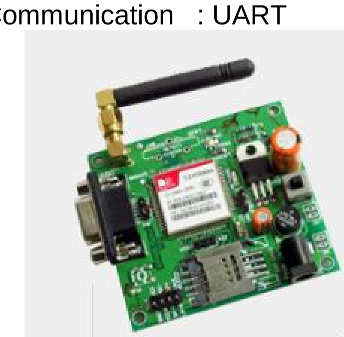

Figure 8. *GSM Modem*

F. TTL TO RS 232 CONVERTER:

It is a dual RS232 receiver/transmitter using only +5V power supply. It has 4 level translators, two of which are RS232 transmitters that convert TTL/CMOS inputs levels into RS232 outputs. The other two level translators are RS232 receiver that converts RS232 inputs to 5V TTL/CMOS level.

When MAX232 IC in the converter receives a TTL signal, it changes TTL logic 0 to between '+3 and +15V' and change TTL Logic 1 to between' -3 and -15V', and vice versa for converting from RS2323 to TTL.

Figure 9. *TTL to RS232 converter*

3.0 TRANSMITTER KIT

The following figure shows the interfacing circuitry for the transmitter section.

Figure10. *Interfacing of Arduino Development Board and RF Transceiver*

Figure11. *Interfacing of Arduino Development and GSM Modem*

4.0 SYSTEM VALIDATION

Pressure Transmitter:

Pressure Transmitter of range 6 MPa is interfaced with the microcontroller unit. The 4-20mA input signals are simulated using HART communicator.

Flow meter:

Vortex Flow meter of range 34 L/s is interfaced. The 4-20mA input signals are simulated using HART communicator.

5.0 REMOTE END DISPLAY

RF Transceiver at remote end is configured & connected to COM port of host computer via RS232 cable. Data received by host computer is shown on the Graphical Display developed in Visual Basic 6. Color change and audio alarming to alert the concerned when the process value reaches threshold level is implemented.

5.0.1 Display mimic

Mimic at remote end when the pressure and Flow value are within the limit is given as below.

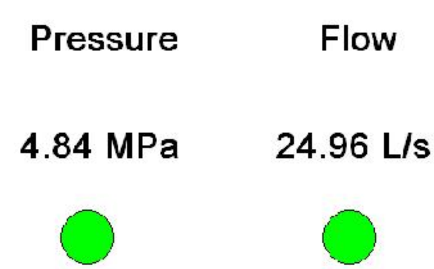

Figure 12. *Mimic Display at Normal condition*

Mimic at remote end when the pressure and Flow value are exceeds the threshold limit is given as below.

Figure 13. *Mimic display at Abnormal Condition*

6.0 RESULTS AND DISCUSSION

6.0.1 Pressure Measurement:

A) Recorded Data:

The Table.1 gives the data recorded through wireless modem for the corresponding simulated input signal. *Max error observed is 0.03 MPa only.*

Input Signal (mA)	Expected O/P (MPa)	Measured O/P (MPa)	Error (Mpa)
4	0.00	0.01	0.01
8	1.50	1.48	0.02
12	3.00	2.97	0.03
16	4.50	4.48	0.02
20	6.00	5.97	0.03

Table 1. *Recorded Data for Pressure Measurement*

B) I/O Characteristics:

The graph for the Input Current (mA) Vs Expected Output (MPa) and Measured Output (MPa) for the pressure measurement is given below. The curve is linear over the entire range.

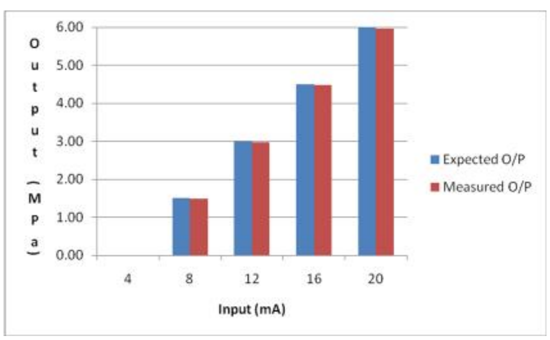

Figure14. *Graph for Pressure Measurement*

6.0.2 Flow meter Measurement:

A) Recorded Data:

The Table.2 gives the data recorded through wireless modem for the corresponding simulated input signal. *Max error observed is 0.2 l/s*

Input Signal (mA)	Expected O/P (l/s)	Measured O/P (l/s)	Error (l/s)
4	0	0.14	0.14
8	8.5	8.46	0.04
12	17	16.85	0.15
16	25.5	25.30	0.20
20	34	33.89	0.11

Table 2. *Recorded Data for Flow measurement*

B) I/O characteristics:

The graph for the Input Current (mA) Vs Expected Output (l/s) and Measured Output (l/s) is given below. The curve is linear over the entire range.

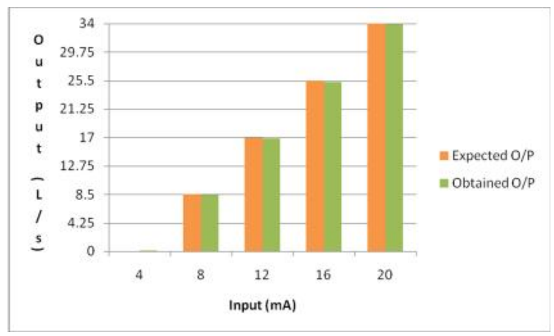

Figure 15. *Graph for Flow measurement*

7.0 MOBILE SMS ALERT

When the measurement exceeds the threshold limit, SMS message was sent to the registered mobile numbers from GSM Modem to alert the concerned.

Figure 16. *Mobile SMS alert*

8.0 CONCLUSION

"Industrial Process Monitoring and Alert System using Wireless technology" was designed, implemented and validated. Remote end mimic display program with audio alarm was developed. Program for message communication also developed and tested. Process parameters like Pressure & Flow data was monitored through wireless modem at a distance of 500mtr with obstacles, alert message using GSM technology was verified and validated.

9.0 FUTURE SCOPE

Now the system implemented here is one to one single system ie pressure transmitter & flow meter are kept in same location. Testing are under progress to implement process monitoring of field elements at different location and monitoring at centralized area. Also data transmission range can be extended by using high gain antennas replacing the existing antenna in RF Transceiver & keeping RF module at sufficient height by implementing line of sight transmission.

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