Relialibty and Control of Wireless Data Acquisition System for Natural Gas Pipeline Network

Mohamed S. Zaghloul , Mohamed M. M. Omar ,and Moataz E. Mohamed

Abstract—In the normal system for gas supply we have different nodes through the path. Each node is controlled by a hand pump for on/off status. The proposed system, in this paper, offers two parallel paths at each node where there is a two solenoid controlled by the remote station. This control is done through data transmitted from a pressure sensing switch nearby solenoid. The data measured from each pressure switch is sent wireless to control central using zigBee.The control central reply back with a suitable control order for the two parallel paths to overcome the problem may be faced.

Index Terms— ZigBee, Data transmission, natural gas, Wireless control, Arduino, control system, system reliability

1 INTRODUCTION

No one can deny the important role played by supplies to maintain reliable supply of gas for all customers without any drop.

Gas/Hydraulic actuators are most normally used for automating valves located in gas transmission pipelines. These pipelines typically run hundreds of miles through inhospitable and undeveloped areas where no low pressure pneumatic instrument air or high pressure hydraulic supply lines are available. Gas/Hydraulic actuators use the pressurized gas in the pipeline as their power source. Since gas under pressure is a potential source of explosion, Gas/Hydraulic operators use an oil barrier to ensure that clean, non-explosive hydraulic fluid is used to drive the actuator rather than using the high-pressure gas directly. we found that there a lot of problem in controlling of valve (closing valves in emergency) may be switched and set locally or remotely by System Control and Data Acquisition (SCADA)[1].

SCADA is the one of the systems that can be utilized to achieve the required efficiency [2], in old valves as shown in Figure 1, that exist at pipeline as these valves are working from a long time and have no spare parts in the market for maintain. We found that the control panel which used in Solenoid actuator Valves is very simple in maintenance and can get Spare Parts from local market.

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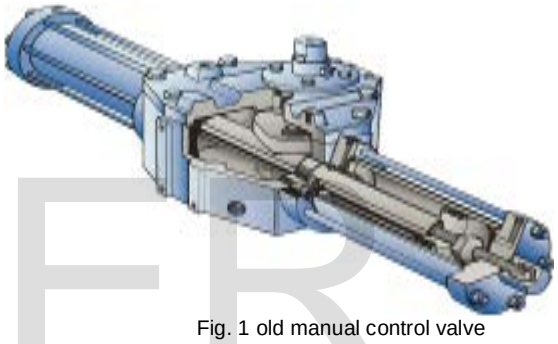

Fig. 1 old manual control valve

We will use Arduino & ZigBee module for this operation.

ZigBee module help to implement systems connecting between valves room of natural gas distribution pipelines and one control center called (control room).. We put the ZigBee module which is connected to programmable Logic Controller (PLC) connected to valve. We program the PLC to send data collected from valves room by ZigBee module to control center which is placed in the ZigBee module in the control center site, which receives the message.

It is proposed to design, develop and make a wireless network connected to a valve room using ZigBee model, for connecting to a Central Monitoring Station (CMS) through ZigBee model related to the field and sends them to a central monitoring station.

2 SYSTEM OPERATIONS

The working principle of Panel is feeding Pressurized power gas from the pipeline is piped into the top of a tank partially filled with hydraulic fluid. The power gas pushes the hydraulic fluid out of the bottom of the tank and into the actuator's cylinders as shown in Figure 2. The pressurized hydraulic fluid forces a piston to move. The movement of

the piston is then either used directly or indirectly to actuate the valve [3] [4].

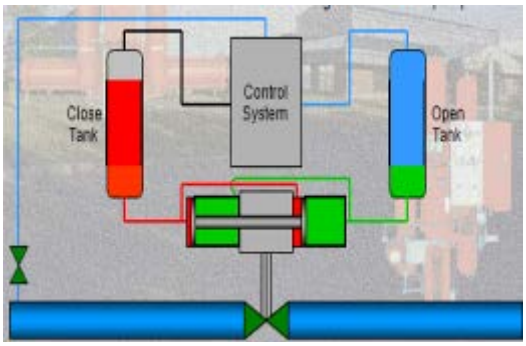

Fig. 2 Show the mechanism for hydraulic pressure.

By using two tanks (gas/hydraulic tanks) each with an independent hydraulic supply piped into opposite sides the actuator's piston, we are able to open the valve by pressurizing the 'Open' gas/hydraulic tank with power gas and venting the 'Close' gas/hydraulic tank to atmosphere and vice versa. The control schematic shows the mainline valve being stroked to its open position as shown in Figure 3.

3 Operation Principle of Suggested Modification

3.1 Solenoid Valve Specification

Pneumatic solenoid valve is engineered to work with high-pressure gas so, the reliability of the system is increased. The pneumatic valves in Aluminum alloy actuator body and controls for exceptional corrosion resistance and low temperature applications. The basic control system of the solenoid valve consists of a double 3 ways, 2 position control valve which is normally piloted by 2 solenoid valve for remote control, one for closing and one for opening. It is also possible to locally operate this valve by means of 2 levers, one for closing and one for opening as shown in Figure 4,5. The solenoid enclosures and the junction box are weather and explosion proof in accordance with ATEX standard [5].

Fig. 3 Valve (actuator valve) in gas line


Fig. 4 Complete Control system with solenoid valves

3.2 Solenoid Valve Connections

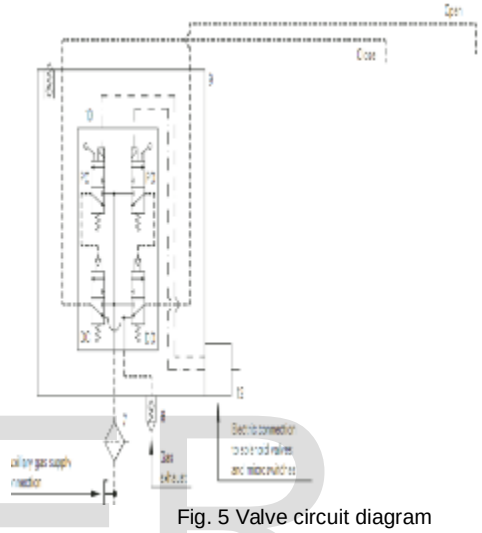
Fig. 5 Valve circuit diagram

Item 7 refer to Gas filter / condensate Separator
Item 8 refer to Gas exhaust
Item 9 refer to control valve enclosure
Item10 refer to double Solenoid valve with manual override
PC-pilot Solenoid valve, manual override to close
PO-pilot Solenoid valve, manual override to open
DC- pneumatic pilot spring return valve to close
DO - pneumatic pilot spring return valve to open

3.3 Suggested Modification

Max. Operating pressure is the pressure required to produce the maximum rated torque of a double acting actuator as shown in Figure 6.

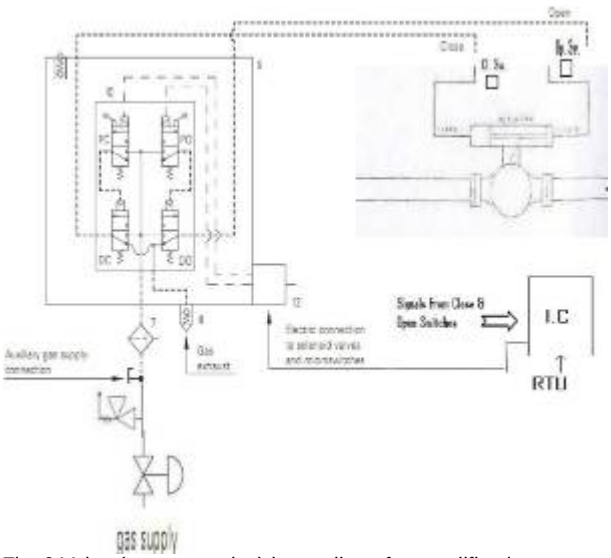

Fig. 6 Valve (actuator valve) in gas line after modification

In case of closed operation, a 24 Volt dc (latched) will be supplied to PC by interface cabinet (also PC can be worked manually by lever), then PC will allow the gas to flow to DC. The DC will change its status, allowing the gas to flow to the Piston so, the valve start to close. after the valve is fully close , a closed signal (from closed switch) will permit the interface cabinet (already exist in the field) to remove latched 24 Volt from PC , as a result the DC will return to its normal status and the Pressurized gas at the piston will be vented . The same method will be applied in case of opening the valve. These valves can be work manually by hand pump.

3.4 DATA ACQUISITION SYSTEM

The operator can monitoring & control all gas pipelines data and status of any valves as shown in Figure 7 , and then can change the status remotely as he can acknowledge it by SCADA[6] as shown in Figure 8.

SCADA is designed to monitor the process of pressure to compare these values for the set value when the applied value is reaches the set an alarm is activated [7], [8].. When sensing either 'low' for set point pressure the switch is

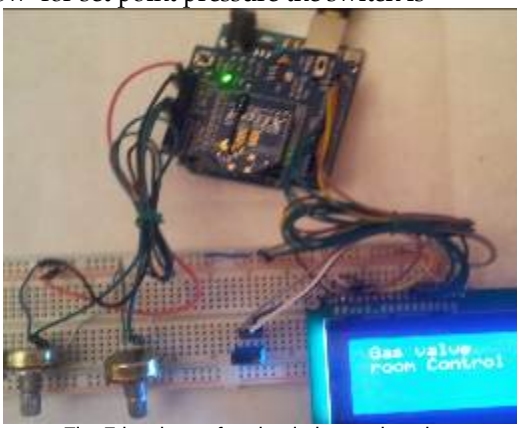

Fig. 7 hardware for simulation and testing

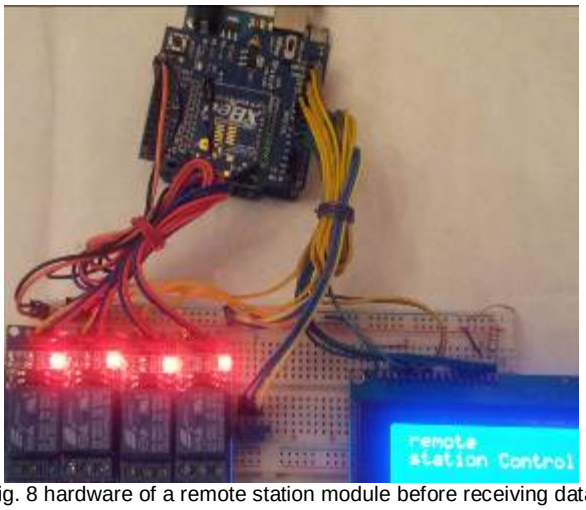

Fig. 8 hardware of a remote station module before receiving data

Actuated (normal open or normal close) at pressure very low for the normal situation of the gas pipelines, this situation happens when the pipeline is broke, in this situation the operator can monitor and control all data and the status of any transmitter and valve. To control this situation at the right time. Operator can be comparing to the pressure and to the set point and connected to SCADA. When the pressure exceeds the set point send a low pressure as shown in Figure 8 alarm signal is sent to SCADA & microcontroller or (PLC) and when the pressure is still decreasing to a second set point a low pressure alarm signal is sent to the ZigBee model (this situation is un controllable & unstable) ZigBee module in the local station(valve room) sends this signal (wireless in our case) to the ZigBee module in the remote station and then sent to the microcontroller, in this case the microcontroller or (PLC) can give order(closed command) as shown in Figure 9 to the solenoid of the valve to be closed until the situation is controlled & stable and the microcontroller or (PLC) can give the order (open command) to the solenoid of the valve to be open(by pass line) as shown in Figure 10. When the operator want change a status of valve, this action is directed to the destination at the PLC placed in the control center. The PLC sends corresponding message for this order via ZigBee module connected to it to the ZigBee module in the valve room.

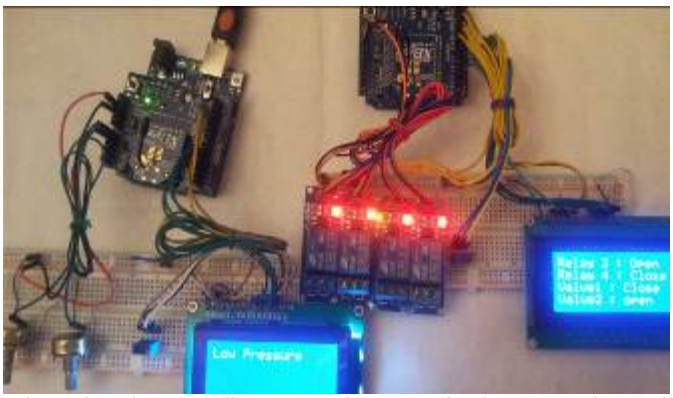

Fig. 9 The microcontroller at gas valve rooms for data comparison at low pressure

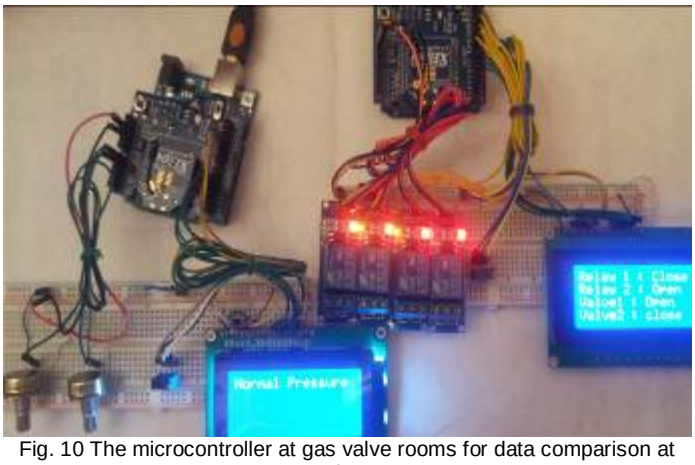

Fig. 10 The microcontroller at gas valve rooms for data comparison at normal pressure

4 VALVE ROOM AND REMOTE STATION INTERACTION

Data will be collected from sensor and valve in the valve room and connected to the microcontroller via arduino card and adding to that local display (LCD) is added used to monitor the output value of the pressure before transmission. The microcontroller scans this value (the time put in Program) and sends it to another site in the control room which to follow the valve room. An operator in the control room monitors the gas stations and valve room of gas pipelines through the SCADA system then controls the valves (relay modules) in the gas stations and valve room remotely.

The changes in the gas like (valve closed) is fed to the control room via passing these data to micro controller then fed it to transmitter which transmit the changes to control room trough the transmission system.

The operator can monitor all valve room data and the status of any switch or sensor and then can adjust it remotely or acknowledge it as shown in Figure11 [9].

A wireless system for monitoring reduces the number of facilities and personnel needed, but always provide Flexibility in system in term of distance or location and reducing the overall system cost [10],[11].

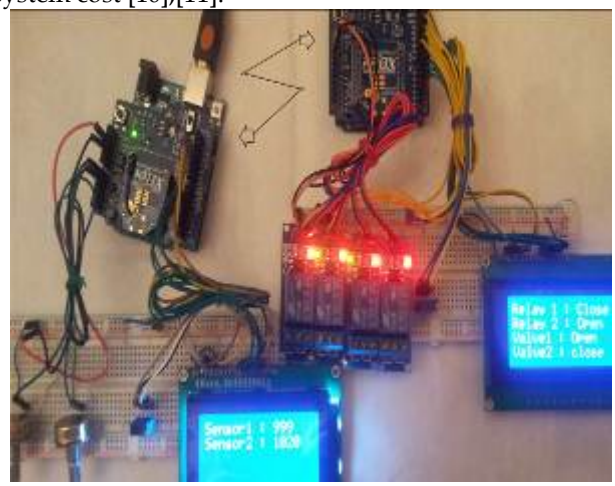

Fig. 11 Data transmission using a Zigbee module

5 ZIGBEE MODULE

The ZigBee S2 protocol is 1mW with a wire antenna.

The ZigBee module can be found in two modules module S1 and module S2 as shown in figure 12, there is no great difference in characteristic between both modules, the difference is that in S2 it use wireless stack instead of 802.15.4 which is good for a mesh technology and low power usage. Also many XBee is difficult for point to point but good for a mesh technology [12],[13].

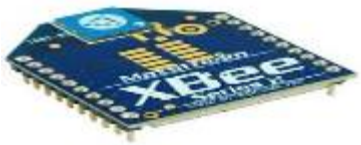

Fig. 12 ZigBee module

6 CONCLUSION

This paper has described the design and implementation of a wireless network for gas pipeline distribution system. The system is always flexible, extendable, and fully adaptable to user needs. The simplicity of ZigBee model, the reliability of electronic components, the feature of the sensor network, the processing speed, the reduced costs, and the ease of installation are the features that characterize the proposed system, which presents itself as an interesting engineering and commercial solution according to the comparison with other technologies demonstrated. The wireless sensor networks are a very powerful and suitable tool to be applied in this application of multi-parameter measuring, monitoring and sending wireless communication using ZigBee model. A continuous auditing and performance monitoring is also done. The design system can be used as standalone for case studies, such as the planning of shutdowns or new investments and thus, it can be recommended to operations personnel made.

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