Hazardous Gas Pipeline Leakage Detection Based on Wireless Technology

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Abstract: The paper describes the performance and functional characteristics of Arm based wireless sensor node in monitoring the parameters such as CO2, temperature, humidity and light around the pipeline structure. The system is deployed to monitor any deviations in these parameters with the standard atmospheric values eventually alert the user even to a remote location. The proposed system is an ARM based wireless sensor node and it has the features of continuous monitoring of specified parameters with easy deployment procedures and increase the battery lifetime. Wireless connectivity is obtained by ZIGBEE module which enables data transmission of the system to the remote location. The sensor node consists of various sensors to monitor the values of CO2 concentration, percentage of temperature and relative humidity each sensor outputs are amplified by the gain amplifier. The maximum gain of an amplifier is selected to obtain the reference voltage of the analog to digital converter (ADC). The filter circuit is added with the output of the gain amplifier to reduce the noise level of the amplified output. The filtered analog signals are given as inputs to the 10Bit ADC modules of the micro controller. The sensor node is successfully tested for the distance of 100 ft without any data loss. The individual sensors such as Carbon-di-Oxide, Temperature and Humidity are calibrated and deployed for the Estimation of hazarourdous gas pipe line leakage. The signal conditioning circuit for the individual sensor has been designed eventually tested. A ten byte of data frame is formed and its data fields are allocated to each measured parameter.

Key words: Arm7 controller, Sensors, GPS module, ZIGBEE wireless technology.

I. Introduction

Industries are using gases like CO2, Oxygen, Nitrogen, Methane etc and commercializing it based on the requirements. Gas pipelines take part of vital role in transmission and distribution of gases in industrial and domestic purposes. Leakage of hazardous gas pipelines modifies the percentage of gas contents in the atmospheric air and causes undesirable effects in the environment. In Proposed system used to monitor the concentration of CO2 and the percentage of humidity and temperature in the atmosphere in the randomly selected locations in the pipeline.

II. The Hardware System

Micro controller: This section forms the control unit of the whole project. This section basically consists of a Microcontroller with its associated circuitry like Crystal with capacitors, Reset circuitry, Pull up resistors (if needed) and so on. The Microcontroller forms the heart of the project because it controls the devices being interfaced and communicates with the devices according to the program being written. ARM7TDIM: ARM is the abbreviation of Advanced RISC Machines, it is the name of a class of processors, and is the name of a kind technology too. The RISC instruction set, and related decode mechanism are much simpler than those of Complex Instruction Set Computer (CISC) designs.

Liquid-crystal display (LCD) is a flat panel display, electronic visual display that uses the light modulation properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images or fixed images which can be displayed or hidden, such as preset words, digits, and 7-segment displays as in a digital clock. They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements.

GPS: The Global Positioning System (GPS) is a satellite-based navigation system that sends and receives radio signals. A GPS receiver acquires these signals and provides you with information. Using GPS technology, you can determine location,
velocity, and time, 24 hours a day, in any weather conditions anywhere in the world—for free.

**ZIGBEE:** ZIGBEE is a new wireless technology guided by the IEEE 802.15.4 Personal Area Networks standard. It is primarily designed for the wide ranging automation applications and to replace the existing non-standard technologies. It currently operates in the 868MHz band at a data rate of 20Kbps in Europe, 914MHz band at 40Kbps in the USA, and the 2.4GHz ISM bands Worldwide at a maximum data-rate of 250Kbps.

**Temperature sensor:** Temperature sensors are devices used to measure the temperature of a medium. Examples of this include maintaining the temperature of a chemical reactor at the ideal set-point, monitoring the temperature of a possible runaway reaction to ensure the safety of employees, and maintaining the temperature of streams released to the environment to minimize harmful environmental impact.

**Co Sensor:** They are used in gas leakage detecting equipments in family and industry, are suitable for detecting of LPG, i-butane, propane, methane, alcohol, Hydrogen, smoke.

**Humidity sensor:** Humidity is the amount of water vapor in the air. In daily language the term "humidity" is normally taken to mean relative humidity. Relative humidity is defined as the ratio of the partial pressure of water vapor in a parcel of air to the saturated vapor pressure of water vapor at a prescribed temperature. Humidity may also be expressed as absolute humidity and specific humidity. Relative humidity is an important metric used in forecasting weather. Humidity indicates the likelihood of precipitation, dew, or fog. High humidity makes people feel hotter outside in the summer because it reduces the effectiveness of sweating to cool the body by preventing the evaporation of perspiration from the skin.

**Light sensor:** We use the light sensor to measure the light intensity in the environment.

### III. Design of Proposed Hardware System

The sensor node consists of various sensors to monitor the values of CO2 concentration, temperature and relative humidity. The sensors to be embedded with the system are listed in Table 1. Each sensor outputs are amplified by the gain amplifier [7]. The maximum gain of an amplifier is selected to obtain the reference voltage of the analog to digital converter (ADC). The filter circuit is added with the output of the gain amplifier to reduce the noise level of the amplified output. The filtered analog signals are given as inputs to the 10Bit ADC modules of the micro controller. Low power micro controller is contributed for computations, conversion and data transmission of the proposed system. The input power supply required to operate the micro computer is 3.3V.

![Fig.1.Block diagram of Transmitter section](image1)

![Fig.2.Block diagram of Receiver section](image2)

The current drawn by the micro controller is 11μA at run mode. Thirteen number of 10-bit ADC modules support the extension of the existing design; SPI module and ZIGBEE compatibility are the key features which are used by the proposed system. The 10bit ADC of the micro controller converts the analog input signal from the sensor module into digital value within the range between 0 and 1024. Computations are used for the conversion of digital values to its respective engineering units.

### IV. Board Hardware Resources Features

**ZIGBEE Technology**

ZIGBEE is a new wireless technology guided by the IEEE 802.15.4 Personal Area Networks standard. It is primarily designed for the wide ranging automation applications and to replace the existing non-standard technologies. It currently operates in the 868MHz...
band at a data rate of 20Kbps in Europe, 914MHz band at 40Kbps in the USA, and the 2.4GHz ISM bands Worldwide at a maximum data-rate of 250Kbps. The ZIGBEE specification is a combination of Home RF Late and the 802.15.4 specification. The specification operates in the 2.4GHz (ISM) radio band - the same band as 802.11b standard, Bluetooth, microwaves and some other devices. It is capable of connecting 255 devices per network. The specification supports data transmission rates of up to 250 Kbps at a range of up to 30 meters. ZIGBEE’s technology is slower than 802.11b (11 Mbps) and Bluetooth (1 Mbps) but it consumes significantly less power. 802.15.4 (ZIGBEE) is a new standard uniquely designed for low rate wireless personal area networks. It targets low data rate, low power consumption and low cost wireless networking, and its goal is to provide a physical-layer and MAC-layer standard for such networks. Wireless networks provide advantages in deployment, cost, size and distributed intelligence when compared with wired networks. This technology allows users to set up a network quickly, and allows them to set up networks where it is impossible or inconvenient to wire cables. Wireless networks are more cost-efficient than wired networks in general. Bluetooth (802.15.1) was the first well-known wireless standard facing low data rate applications. The effort of Bluetooth to cover more applications and provide quality of service has led to its deviation from the design goal of simplicity, which makes it expensive and inappropriate for some simple applications requiring low cost and low power consumption. These are the kind of applications this new standard is focused on. It’s relevant to compare here Bluetooth and ZIGBEE, as they are sometimes seen as competitors, to show their differences and to clarify for which applications suits each of them. The data transfer capabilities are much higher in Bluetooth, which is capable of transmitting audio, graphics and pictures over small networks, and also appropriate for file transfers. ZIGBEE, on the other hand, is better suited for transmitting smaller packets over large networks; mostly static networks with many, infrequently used devices, like home automation, toys, remote controls, etc. While the performance of a Bluetooth network drops when more than 8 devices are present, ZIGBEE networks can handle 65000+ devices.

GPS
Global Positioning System (GPS) technology is changing the way we work and play. You can use GPS technology when you are driving, flying, fishing, sailing, hiking, running, biking, working, or exploring. With a GPS receiver, you have an amazing amount of information at your fingertips. Here are just a few examples of how you can use GPS technology.

- Know precisely how far you have run and at what pace while tracking your path so you can find your way home.
- Pinpoint the perfect fishing spot on the water and easily relocate it.
- Get the closest location of your favorite restaurant when you are out-of-town.
- Find the nearest airport or identify the type of airspace in which you are flying.

![Fig.3. Pin diagram of X-Bee Transceiver](image)

**What is GPS?**

The Global Positioning System (GPS) is a satellite-based navigation system that sends and receives radio signals. A GPS receiver acquires these signals and provides you with information. Using GPS technology, you can determine location, velocity, and time, 24 hours a day, in any weather conditions anywhere in the world—for free.

GPS formally known as the NAVSTAR (Navigation Satellite Timing and Ranging). Global Positioning System originally was developed for the military. Because of its popular navigation capabilities and because you can access GPS technology using small, inexpensive equipment, the government made the system available for civilian use. The USA owns GPS technology and the Department of Defense maintains it. GPS technology requires the following three segments.

- **Space segment.**
- **Control segment.**
- **User segment**

**Space Segment**

At least 24 GPS satellites orbit the earth twice a day in a specific pattern. They travel at approximately 7,000 miles per hour about 12,000 miles above the earth’s surface. These satellites are spaced so that a GPS receiver anywhere in the world can receive signals from at least four of them.

- Each GPS satellite constantly sends coded radio signals (pseudorandom code) to the
earth. These GPS satellite signals contain the following information.

- The particular satellite that is sending the information.
- Where that satellite should be at any given time (the precise location of the satellite is called ephemeris data).
- Whether or not the satellite is working properly.
- The date and time that the satellite sent the signal.

The signals can pass through clouds, glass, and plastic. Most solid objects such as buildings attenuate (decrease the power of) the signals. The signals cannot pass through objects that contain water (such as underwater locations). The GPS satellites are powered by solar energy. If solar energy is unavailable, for example, when the satellite is in the earth’s shadow, satellites use backup batteries to continue running. Each GPS satellite is built to last about 10 years. The Department of Defense monitors and the satellites to ensure that GPS technology continues to run smoothly for years to come.

**Control Segment**

The control segment is responsible for constantly monitoring satellite health, signal integrity, and orbital configuration from the ground control segment includes the following sections:

- Master control station
- Monitor stations
- Ground antennas

**Monitor Stations**

At least six unmanned monitor stations are located around the world. Each station constantly monitors and receives information from the GPS satellites and then sends the orbital and clock information to the master control station (MCS).

**Master Control Station (MCS)**

The MCS is located near Colorado Springs in Colorado. The MCS constantly receives GPS satellite orbital and clock information from monitor stations. The controllers in the MCS make precise corrections to the data as necessary, and send the information (known as ephemeris data) to the GPS satellites using the ground antennas.

**Ground Antennas**

Ground antennas receive the corrected orbital and clock information from the MCS, and then send the corrected information to the appropriate satellites.

**User Segment**

The GPS user segment consists of your GPS receiver. Your receiver collects and processes signals from the GPS satellites that are in view and then uses that information to determine and display your location, speed, time, and so forth. Your GPS receiver does not transmit any information back to the satellites.

**Temperature Sensor - The LM35**

The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in °C).

**The LM35 - An Integrated Circuit Temperature Sensor**

- You can measure temperature more accurately than a using a thermistor.
- The sensor circuitry is sealed and not subject to oxidation, etc.
- The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage be amplified.

**Working of LM35:**

1. It has an output voltage that is proportional to the Celsius temperature.
2. The scale factor is .01V/°C
3. The LM35 does not require any external calibration or trimming and maintains an accuracy of +/-0.4 °C at room temperature and +/- 0.8 °C over a range of 0 °C to +100 °C.
4. Another important characteristic of the LM35DZ is that it draws only 60 microamps from its supply and possesses a low self-heating capability. The sensor self-
heating causes less than 0.1 °C temperature rise in still air.
The LM35 comes in many different packages, including the following.
- TO-92 plastic transistor-like package,
- T0-46 metal can transistor-like package
- 8-lead surface mount SO-8 small outline package
- TO-202 package. (Shown in the picture above)

CO SENSOR:

Product Description
They are used in gas leakage detecting equipments in family and industry, are suitable for detecting of LPG, i-butane, propane, methane, alcohol, Hydrogen, smoke.

Fig. 6. CO Sensor

Advantages
- Voltage output
- High sensitivity
- Long stability
- Good selectivity
- Effective technical service

OPERATION PRINCIPLE:
The surface resistance of the sensor Rs is obtained through effected voltage signal output of the load resistance RL which series-wound. The relationship between them is described:

\[ R_s \Delta R_L = (V_c - V_{RL}) / V_{RL} \]

Fig. 5 shows alterable situation of RL signal output measured by using Fig. 2 circuit output signal when the sensor is shifted from clean air to carbon monoxide (CO), output signal measurement is made within one or two complete heating period (2.5 minute from high voltage to low voltage).
Sensitive layer of MQ-7 gas sensitive components is made of SnO2 with stability, So, it has excellent long term stability. Its service life can reach 5 years under using condition.

SENSITIVITY ADJUSTMENT
Resistance value of MQ-7 is difference to various kinds and various concentration gases. So, when using these components, sensitivity adjustment is very necessary. we recommend that you calibrate the detector for 200ppm CO in air and use value of Load resistance that( RL) about 10 KΩ(5KΩ to 47 KΩ). When accurately measuring, the proper alarm point for the gas detector should be determined after considering the temperature and humidity influence. The sensitivity adjusting program:

a. Connect the sensor to the application circuit.
b. Turn on the power; keep preheating through electricity over 48 hours.
c. Adjust the load resistance RL until you get a signal value which is respond to a certain carbon monoxide concentration at the end point of 90 seconds.
d. Adjust the another load resistance RL until you get a signal value which is respond to a CO concentration at the end point of 60 seconds.

LDR: LDRs or Light Dependent Resistors are very useful especially in light/dark sensor circuits. Normally the resistance of an LDR is very high, sometimes as high as 1000 000 ohms, but when they are illuminated with light resistance drops dramatically.

Fig. 7. LDR sensor
The animation opposite shows that when the torch is turned on, the resistance of the LDR falls, allowing current to pass through.

**Humidity sensor:** Humidity [7] is the amount of water vapor in the air. In daily language the term "humidity" is normally taken to mean relative humidity. Relative humidity is defined as the ratio of the partial pressure of water vapor in a parcel of air to the saturated vapor pressure of water vapor at a prescribed temperature. Humidity may also be expressed as absolute humidity and specific humidity. Relative humidity is an important metric used in forecasting weather. Humidity indicates the likelihood of precipitation, dew, or fog. High humidity makes people feel hotter outside in the summer because it reduces the effectiveness of sweating to cool the body by preventing the evaporation of perspiration from the skin.

**Product name:** macromolecule Humid resistance sensor (GY-HR10X), it’s a new kind of humid resistance sensor, it has wide range of humidity, fast respond, high-sensitivity, stable and reliable performance, consistency characteristics.

![Fig.8. Humidity sensor](image)

V. Conclusion

The functionalities and performance of PIC18LF4620 based wireless sensor node has been evaluated by interfacing the same with various sensors. The sensor node is successfully tested for the distance of 100 ft without any data loss. The individual sensors such as Carbon-di-Oxide, Oxygen, Temperature and Humidity are calibrated and deployed for the estimation of hazardous gas pipe line leakage. The signal conditioning circuit for the individual sensor has been designed eventually tested. A ten byte of data frame is formed and its data fields are allocated to each measured parameter.

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