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PIPE Line Monitoring using IoT

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Abstract:
A pipe inspection robot is device that is inserted into pipes to check for obstruction or damage. These robots are traditionally manufactured offshore, are extremely expensive, and are often not adequately supported in the event or malfunction. This had resulted in associated environmental services limited. A New Zealand utilize of this equipment, facing significant periods of down time as they wait for their robots to be the repaired. Recently, they were informing that several robots were no longer supported. This project was conceived to redesign the electronics control systems one of these PIR, utilizing the existing mechanical platform. Requirements for the robot were that it must operate reliably in confined, dark and wet environments and provides a human wears with a digital video feed of the internal status of the pipes. There robot should as much as possible incorporate off the shaft components, cheap, and potentially onsite repair. This project details the redesign and constructions of such robots. It employees there electronic boards integrated with mechanical components and provides video feedback via custom graphical interface although at the prototypes state the electronics has been successful with cost of less than a length of the original robot purchase prize. In this system the pipeline in industries is going to be monitored by ultrasonic sensor, gas sensor, soil sensor. It will acquires the damage occurred by the artificial or natural damage conditions during construction and clashes. The acquire data are send to an server using GSM

Keywords: PIR, PIPE INSPECTION ROBOTS

1. INTRODUCTION:

Pipeline systems deteriorate progressively over time. Corrosion accelerates progressively and long term deterioration increases the probability of failure (fatigue cracking). Limiting regular inspecting activities to the "scrap" part of the pipelines only, results ultimately into a pipeline system with questionable integrity. The confidence level in integrity will drop below acceptance levels. Inspection of presently uninspected sections of the pipeline system becomes a must. This project provides information on the "robotic inspection technology". Pipelines are proven to be the safest way to transport and distribute Gases and Liquids. Regular inspection is required to maintain that reputation.

The larger part of the pipelines system is accessible by In-Line Inspection Tools but this access is limited to the section in between the launching and receiving traps only. Unfortunately, corrosion does not have this limitation. The industry looks for means of inspecting these in-accessible pressure holding piping systems, preferably, without interrupting the operations. It is a fact that sufficiently reliable and accurate inspection results can only be obtained by direct pipe wall contact/access. If that is not feasible from the outside, we have to go inside. Since modifying pipeline systems for In-Line Inspection is mainly not practical, PIPE INSPECTION ROBOT pursues development of ROBOTIC inspection services for presently in-accessible pipeline systems. Robotics is one of the fastest growing engineering fields of today.

Robots are designed to remove the human factor from labor intensive or dangerous work and also to act in inaccessible environment. The use of robots is more common today than ever before and it is no longer exclusively used by the heavy production industries. The inspection of pipes may be relevant for improving security and efficiency in industrial plants. These specific operations as inspection, maintenance, cleaning etc. are expensive, thus the application of the robots appears to be one of the most attractive solutions. Pipelines which are tools for transporting oils, gases and other fluids such as chemicals, have been employed as major utilities in a number of countries for long time.

Recently, many troubles occur in pipelines, and most of them are caused by aging, corrosion, cracks, and mechanical damages from the third parties. So, continuous activities for inspection, maintenance and repair are strongly demanded .The robots with a flexible (adaptable) structure may boast adaptability to the environment, especially to the pipe diameter, with enhanced dexterity, maneuverability, capability to operate under hostile conditions. The wheeled robots are the simplest, most energy efficient, and have the best potential for long range. Loading the wheels with springs, robots also offer some advantages in maneuverability with the ability to adapt to in-pipe unevenness, move vertically in pipes, and stay stable without slipping in pipes. These types of robots also have the advantage of easier miniaturization. The key problem in their design and implementation consists in combining the capacity of self-moving with that of self-sustaining and the property of low weight and dimension. A very important design objective is represented by the adaptability of the in-pipe robots to the inner diameters of the pipes. Currently, the applications of robots for the maintenance of the pipeline utilities are considered as one of the most attractive solutions available Pipe Inspection Robot is shown in Figure 1.1.

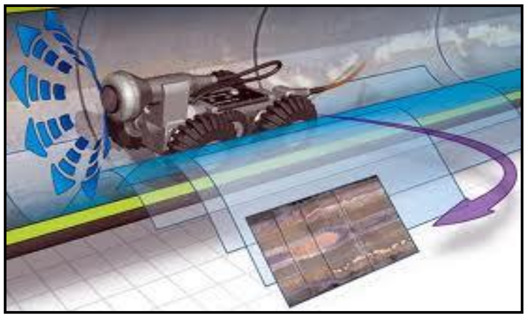
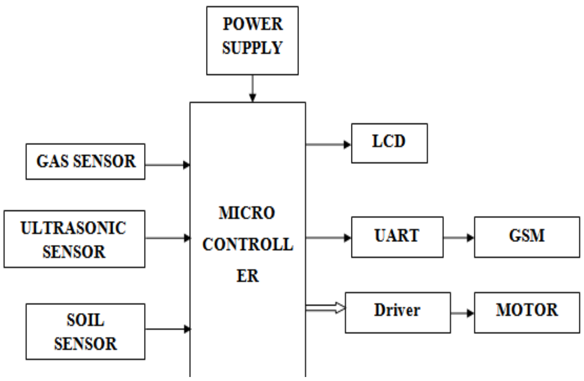
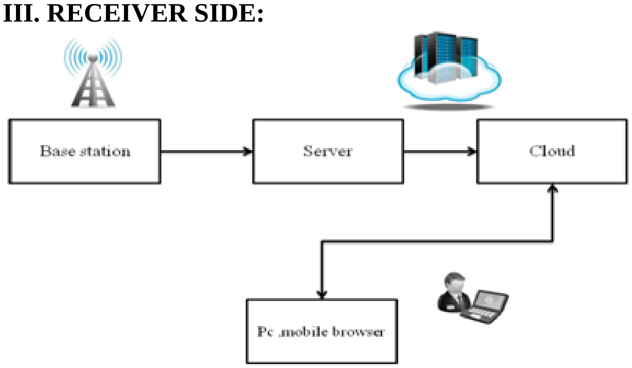


Figure.1. Pipe inspection robot

II. BLOCKDIAGRAM:

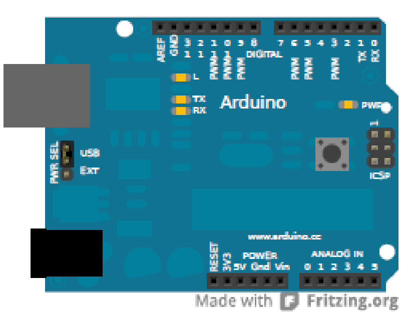


III. RECEIVER SIDE:



IV. ARDUINO:

A micro-controller is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/ output peripherals the important part for us is that a micro-controller contains the processor (which all computers have) and memory, and some input/output pins that you can control. (often called GPIO – General Purpose Input Output Pins).



We will be using the Arduino Uno board. This combines a micro-controller along with all of the extras to make it easy for you to build and debug your projects. The Uno is a microcontroller board based on the Atmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.. You can tinker with your UNO without worrying too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again. “Uno” means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards.

ULTRA SONIC SENSORS:

Our ultrasonic rangefinder is capable of allowing the user to determine his or her distance from an object or wall.When deciding on what type of project to design and construct, we decided that we wanted to create something that would have some practical use in life. Many groups in the past created video games, but we wanted to be different. We considered issues such as safety, user interface, and ease of use, and came up with the idea of making an ultrasonic rangefinder. A rangefinder can be used in various applications such as a measuring device or an obstacle detection device.

SOIL MOISTURE SENSORS:

Soil moisture sensors measure the volumetric water content in soil. Since the direct gravimetric measurement of free soil moisture requires removing, drying, and moisture sensors measure the volumetric water content indirectly by using some other property of the soil, such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for the moisture content. The relation between the measured property and soil moisture must be calibrated and may vary depending on environmental factors such as soil type, temperature, or electric conductivity. Reflected microwave radiation is affected by the soil moisture and is used for remote sensing in hydrology and agriculture. Portable probe instruments can be used by farmers or gardeners.

Hardware design:

The hardware for the rangefinder can be broken down into three functional units, the receiving circuit, the transmitting circuit, and the MCU circuit. The receiver and transmitter circuits can work independently of the MCU, which made testing with a signal generator quite useful. This allowed one of us to work on the hardware while the other worked on the software independently and not require one to be dependent on the other for testing. At the heart of the receiver circuit is one of the ultrasonic transducers. The transducer converts an incoming sound wave and converts it into a voltage signal. This signal needs to be cleaned of noise, amplified, and turned into a TTL-type signal for the MCU. The signal from the transducer is fed through a capacitor to filter out noise and then through a voltage divider to center the signal at 2.5 volts. From here, the signal needs to be amplified to guarantee true TTL .levels. Initially, this was attempted using an LM358 op-amp. However, the LM358 could not switch fast enough and was unable to create a clean square wave. At the suggestion of Prof. Land, we tried using a 74HC04 high speed CMOS inverter as a high gain linear amplifier. Initially, we used resistor values of 1 M ohm and 100 k ohm to achieve a gain of 10. This created voltage levels well beyond +5 volts and resulted in a clipped signal at the output. This, however, is actually desired because the output now represented a more of a square wave than a sine wave. The output of the inverter was then fed into a (CD4069) Schmitt trigger to convert it into a true TTL square wave. The input of the Schmitt trigger was connected to ground using a 22 pF capacitor to clean the signal from noise. The output of the Schmitt trigger can now be fed into the MCU as the received pulse. .During testing, however, we noticed that this did not quite create a nice clean square wave and was influenced greatly by noise. To combat this, we changed the gain of the inverter amplifier by replacing the 100 k ohm resistor with a 10 k ohm resistor for a gain of 100. We then fed the signal through three cascaded Schmitt triggers to clean up the signal much more than previously.

There is a single 22 pF capacitor on the input of the last Schmitt trigger to ground Unlike the receiver circuit, which tries to generate a TTL square wave, the transmitter circuit starts with a TTL square wave. This square wave is generated by the MCU as a series of pulses. The goal of the transmitting circuit is to amplify the pulse train enough so that it can travel a significant distance and reflect back towards the receiver. Again, we had initially tried using a LM358 op-amp running into the same switching problems. We then tried using a 2N3904 BJT sourced by 9 volts at the collector as a simple switch. This ended up not working because the transducer did not create a DC path for current to flow through the BJT.

In the end, a LM311 high-speed comparator was used as the amplifier. In the spec sheet, an example of a zero-crossing detector was given. Changing that to a 2.5 volt-crossing detector was just a matter of changing the negative input terminal to 2.5 volts instead of GND and the VCC- pin to GND instead of -5 volts. By supplying the LM311's VCC+ pin with +18 volts, we were able to get high gain for the square wave generated by the MCU to transmit through the transducer. Unfortunately, the high gain caused by the +18 volt supply also amplified noise in the circuit. The source of this noise is still unknown, but is likely due to the physical locations of the various circuits on the solder board. Many wires were crossing each other and are the likely culprit. As such, the amplified noise gave rise to incorrect readings by the receiver circuit. When we dropped the supply voltage back down to +9 volts, the range and accuracy of the device improved.

Software design:

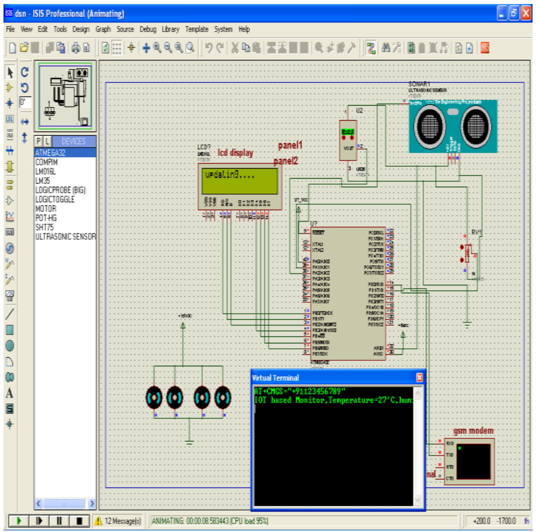
The program for the rangefinder essentially does two things: 1) transmit a 40 kHz pulse, and 2) detect when the pulse is received. All that was needed to be done was to count the time that passed between the time of transmission of the ping and the reception of the pong. There were also 3 modes of operation: normal mode, change sample number mode, and calibration mode. In order to generate the ping and count the time between ping and pong, we used two of the MCU's timers. Timer1 was running at 40 kHz in PWM mode to generate a square wave for transmission using PortD.5. Timer0 was running at 250 kHz. Timer0's purpose is to calculate time between the send pulse and the receive pulse. In normal operation, the user pushes a button to send out the ping. The MCU then counts the number of ticks it takes before the receiver detects the pong. The number of ticks is then divided by a factor of two to represent the number of millimeters between the device and the object. As stated earlier, multiple distance samples are taken and then averaged to create more accurate readings. We noticed during testing that using one sample (or only a few) gave erroneous measurements due to picking up random noise spikes. By increasing the number of samples to a minimum of 50, we obtained pretty accurate measurements. The average of all the measurements is then displayed on the 7 SEGMENT DISPLAY. In addition, normal mode also displays the speed of the device relative to a stationary object. The speed is determined by using the distance values of the middle sample and the last sample using the dx/dt formula mentioned earlier.

The 7 SEGMENT DISPLAY displays the measured distance in millimeters and the speed in millimeters/second In the sample number changing mode you can change how many samples you want to take with a minimum number of samples being 50. This is to allow you to get a more precise measurement taking more measurements and eliminating randomness. Calibration mode is used in cases when the speed of sound may differ from that at sea level. Factors such as altitude and humidity can affect the speed of sound. To maintain correct measurements, the user places the device exactly 5 centimeters from a flat wall or object. By pressing the pulse button, a pulse is sent out and received by the device. The MCU then uses the time between ping and pong to calculate the new number of ticks per meter.

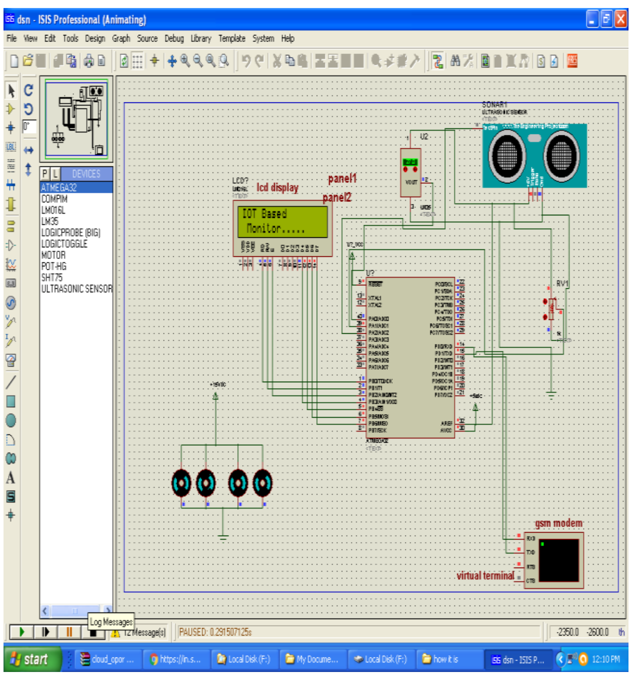
The MCU uses this value for all future measurements until the device is power off. The code was very straightforward in theory. The transducers that we used operate at 40 kHz. We first attempted to use a clock running at 80 kHz to toggle a port pin to generate a 40 kHz square wave. This did not work as well as expected. When we hooked up the port pin to the oscilloscope for testing, we noticed that the output was not an ideal 40 kHz square wave. To get around this we decided to use the PWM mode of Timer1. We configured the timer to toggle OC1A on compare match so we could pull a 40 kHz square wave off PortD.5. This seemed to solve the problem of producing a 40 kHz square wave from a port pin.

To change the number of pulses in each pulse sequence for transmission we just turned on and off the toggle at certain times. Another tricky part of the program was the timing and accuracy. As mentioned earlier, we programmed a timer tick to be 250 kHz. This translates roughly to 1.36 millimeters per second. To get the right distances required some floating point arithmetic. Finally knowing where to start and stop the counter clock was a bit tricky. We did not want to count any useless ticks that did not represent when the pulse was actually sent. These useless ticks are a result of the MCU performing other operations such as floating point calculation and conditionals.

V. SIMULATION OUTPUT:



VI. SIMULATIONS RESULTS:



VII. CONCLUSION:

Robots play an important role in inside pipe-network maintenance and their repairing. Some of them were designed to realize specific tasks for pipes with constant diameters, and other may adapt the structure function of the variation of the inspected pipe. We addressed the design and development of a pipe crawler for inspection of water pipes. A description of its working principle, design details, and practical aspects are provided. As a future step, we look to further increase in driving speed in order to improve the pipe inspection efficiency. The types of inspection tasks are very different. A modular design was considered for easily adapted to new environments with small changes. Presence of obstacles within the pipelines is a difficult issue. In the proposed mechanism the problem is solved by a spring actuation and increasing the flexibility of the mechanism. The robot is designed to be able to traverse horizontal and vertical pipes. Several types of modules for pipe inspection minirobot have been presented. Many of the design goals of the Pipe inspection robot have been completely fulfilled.

VIII. ACKNOWLEDGEMENT:

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