

HART Communication Based Universal Data logger

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Abstract: Highway Addressable Remote Transducer(HART) Communication based Universal Data logger has been designed through which we can measure & monitor different parameter like temperature, pressure, voltage etc in different hazardous processes. The aim of this research work is to design a real-time Measurement system, which is able to measure parameters such as pressure, temperature, voltage and calibrate them with standard specification to form a current loop. i.e. 4-20mA using HART communication in order to avoid destruction of any work unit in industry or chemical laboratories.

Keywords: Highway addressable remote transducer(HART), Data Logger, K-type sensor, WIKA A-10, GLCD.

I. Introduction

Highway Addressable Remote Transducer(HART) is one of the communications protocols used in industrial plant automation. HART is the best solution for obtaining value-added device and distinct information in digital form while holding compatibility with legacy 4mA-20mA automation architectures. HART is a communication protocol for industrial process measurement and application. HART is an open and independent standard from suppliers. It is the world's most widely used protocol in the data processing industry using thousands of HART-based products available from many manufacturers. This is called a hybrid protocol because it combines analog and digital communication. Analog signals can transmit additional information about the digital signal fed to a standard 4mA-20mA current loop. When using an analog signal, information is transmitted only in one direction either from the host (input) or host (device) to the device (output). Digital information can travel in two directions with HART.

This paper is planned as follows: Section II provides reviews about previous techniques of HART Communication and Data Logger. Section III provides the Methodology which describes the distributed measurement system in brief. Section IV shows the block diagram and its description. Section V consists of Hardware Description used in the project. Section VI shows the implementation of Data logger Unit, HART Unit and actual Interfacing of GLCD. The conclusion and future scope is mentioned in Section VII and Section VIII respectively.

II. Literature Survey

K. Cheng, et al. [1] structured a remote HART configurator, which depends on HAA-5191 and Raspberry Pi. HART modem module utilized is HAA-5191. It associates the HART field gadget with any microcontroller which supports UART. The Raspberry Pi interconnects the HART modem to the Internet through Wi-Fi or Ethernet. This lets clients remotely design the HART field gadget through the Internet.

J. Ledvina, et al. [2] structured equipment that limits current utilization with the goal that the module is controlled by a 4-20mA current circle. Correspondence between the Hart and the estimating gadget is actualized as shared access to the I2C EEPROM and FRAM. The chosen working framework is a free RTOS, which enables you to perform assignments dependent on occasions and utilize preemptive arranging.

C. Patrascioiu, et al. [3] have structured three sections. The initial segment exhibits the standard of estimating the pH of an answer matter, the transducer structure and of the connector utilized. The second part is committed to the examination going for the utilization of PACTware programming condition for the arrangement and checking of the pH transducer working by utilizing the HART convention. The last part is bound to the introduction of the examination work for the elaboration of the observing and control framework utilizing Labview programming.

Jian-Ming Liao, et al. [4] portrayed that remote HART innovation gives a vigorous remote convention to full scope of procedure estimation and resource the board applications. Remote HART is a remote work organize correspondence convention for procedure robotization applications

.Y. Wang, et al. [5] Developed a brilliant gadget correspondence module dependent on the HART convention – A valuable HART experience for savvy gadgets. As indicated by pragmatic natural necessities, the creator presents thoughts of hacking. The plan of equipment and programming for HART convention correspondence framework was presented and broke down. This paper gives discourse about how to understand the counter obstruction of HART convention programming. Additionally, the gadget troubleshooting and test work is presented toward the finish of this paper.

Thompson, et al. [6] have portrayed minimal effort, low power utilization advanced information lumberjack equipped for autonomous activity for extensive stretches of time has been created. Its motivation was for temperature estimation (0.1o goals), yet any voltage in the range 0-5V can be estimated. The lumberjack can record up to 8 channels of 10-bit information and store information in 512Kbyte of on-board memory.

In 2010, **Rajmond, et al. [7]** planned an information procurement framework that exchanged logged information by the DAQ framework to PC, which is in charge of information stockpiling and flag investigation. The UI, to enable the client to design the estimation framework and select among different information examination calculations, was worked in LabView.

Mazidi, et al. [8] examined the outline of PIC microcontroller. Microcontrollers and chip are broadly utilized in installed framework items. An installed item utilizes a microcontroller to complete one undertaking and one errand as it were. Notwithstanding the portrayal of criteria for picking a microcontroller, the interfacing with this present reality gadgets, for example, LCDs, ADCs, sensors and console is depicted in detail. At last; they talked about the issue of interfacing outer recollections, both RAM and ROM.

III. Methodology

First physical parameters like pressure, temperature, voltage, & current are sensed using different sensors. After sensing these parameters they are fed to the signal conditioning circuit which manipulates the incoming input signal in such a way that meets requirements of the next stage for further processing. Now a multiplexer is used to select one of parameter from the four channel as per the user's choice. The working of multiplexer & signal conditioning circuit is controlled by the PIC24 controller. For the user to enter his choice, we will be using a touch panel that will be interfaced to the microcontroller externally. The data is transferred from PIC24 to HART Modem through UART Communication. The communication between DAC and PIC24 takes place using SPI.

IV. Block Diagram

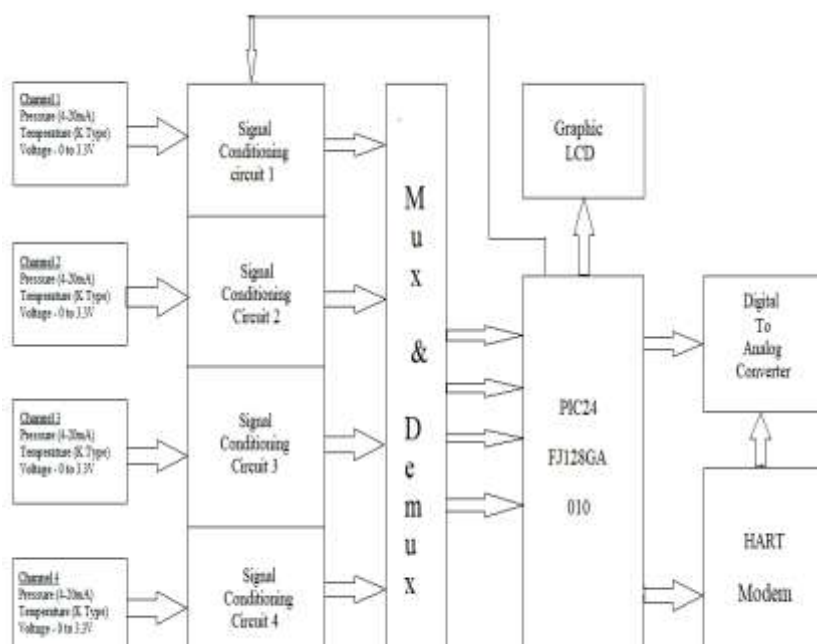


Fig 1: Block diagram

Block diagram description of Fig 1.

The distributed measurement system consists of:

- Four channels with physical parameters which are to be measured
- Signal conditioning circuit for respective input parameters
- Multiplexers and de-multiplexers for selecting any one channel out of four
- Analog-to-digital Converter,
- Microcontroller (PIC24),
- GLCD

At very first physical parameters like pressure, temperature, voltage, & current are sensed using different sensors. After sensing these parameters they are fed to the signal conditioning circuit which manipulates the incoming input signal in such a way that meets requirements of the next stage for further processing. Now a multiplexer is used to select one of parameter from the four channel as per the user's choice. The working of multiplexer & signal conditioning circuit is controlled by the PIC24 controller. For the user to enter his choice, we will be using a touch panel that will be interfaced to the microcontroller externally. By using touch panel the user will enter their choice. The user entered data is given to the microcontroller. According to user's entered choice the corresponding parameters selected by multiplexer will be converted into digital form using analog to digital converter. Now using the concept of SPI serial communication the output of ADC will be stored in the memory of controller for further usage. This project deals with current loop generation using HART Module & DAC unit. At the output of DAC we get a current loop 4-20mA.

V. Hardware Description

Sensors: A sensor converts the physical parameters like (temperature, pressure, humidity etc.) into a signal which can be measured electrically.

The sensors used in this system to detect the input signals are explained as follows:

Temperature Sensor (K-type thermocouple):

It is used as temperature sensor for measurement and control and can also be used to convert temperature gradient into electricity. Type K Thermocouple provides widest operating temperature range.

- Temperature range:
 - Thermocouple grade wire: -270 to 1260 degree Celsius
 - Extension wire: 0 to 200 degree Celsius
 - Sensitivity: 41µV/ degree Celsius

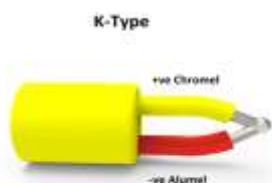


Fig 2: K-type Thermocouple

Pressure Sensor (WIKA A-10):

Wika A-10 is the piezoresistive pressure sensor which is the very first product of MEMS technology and works on the principle of piezoresistive effect that is change in the electrical resistivity of a semiconductor material or metal when mechanical strain is applied. The pressure sensor converts the mechanical pressure or strain into proportional electric signal.

- Pressure ranges: 0-15psi upto 0...10000psi
- Signal output: 4-20mA, 0-10V, 0-5V



Fig 3: WIKA A-10

PIC Microcontroller (PIC24FJ128GA010):

Features:

- Operating Voltage Range of 2.0V to 3.6V
- Modified Harvard Architecture
- 8 MHz Internal Oscillator
- 10-Bit, Up to 16-Channel Analog-to-Digital Converter
- Five 16-Bit Timers/Counters with Programmable Prescaler
- Two I2C modules Support Multi-Master/Slave mode and 7-Bit/10-Bit Addressing



Fig 4: PIC24FJ128GA010

Low Power HART Modem AD5700:

The AD5700 are single-chip solutions, designed and specified to operate as a HARTFSK half-duplex modem, complying with the HART physical layer requirements.

- 1.71 V to 5.5 V power supply
- 1.71 V to 5.5 V interface
- -40°C to +125°C operation
- 4 mm × 4 mm LFCSP package
- HART physical layer compliant
- UART interface



Fig 5: HART IC

Serial Input, Loop-Powered, 4mA to 20mA DAC:

The AD5421 is a complete, loop-powered, 4 mA to 20 mA digital-to-analog converter (DAC) designed to meet the needs of smart transmitter manufacturers in the industrial control industry. The DAC provides a high precision, fully integrated, low cost solution in compact TSSOP and LFCSP packages.

Graphical LCD (mikroe-240):

The MIKROE-240 is a graphic LCD Display Board with touch screen.

- 128*64 GLCD Board

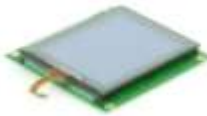


Fig 6: GLCD Display

OrCAD: OrCAD is a proprietary software tool suite used primarily for electronic design automation (EDA). The software is used mainly by electronic design engineers and electronic technicians to create electronic schematics and electronic prints for manufacturing printed circuit boards.

VI. Implementation



Fig 7.1: Data Logger (Back)



Fig 7.2: Data Logger (Front)

Fig 7.1 , 7.2 shows the PCB design with component mounting.

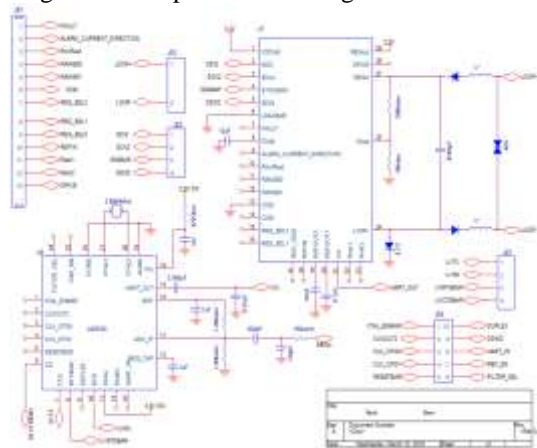


Fig 8: Schematic Diagram (HART Unit)

Fig 8 shows the schematic diagram of HART Unit designed in ORCAD comprising of HART modem, DAC connectivity with Pic24FJ128GA010.

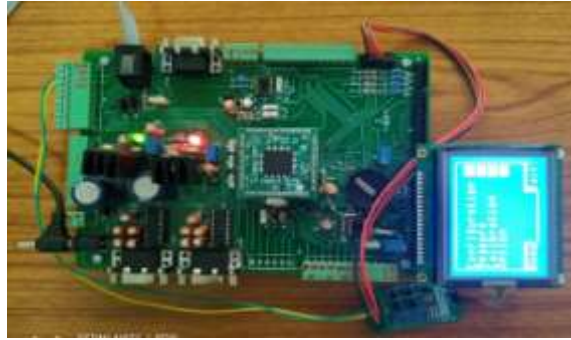


Fig 9: GLCD Display

Fig 9 shows the GLCD Display, displaying options such as Configuration, Measure and Calibration after interfacing with PIC24FJ128GA010.

VII. Conclusion

HART communication protocol is based on Bell 202 telephone communication standard and operates using the FSK principle. The digital signal is made up of two frequencies-1200 Hz and 2200 Hz representing bits 1 and 0. It continuously validates the integrity of control information. It ensures accuracy of the system data and detect any deviation between device and system. It gives additional information in multi variable devices. We developed a HART communication based distributed measurement system through which we measure and monitored parameters like temperature, pressure etc. for a period of time. During configuration phase, the data logger will search for a wireless network or device while it is physically connected to the PC.

VIII. Future Score

This designed system can further include wireless transmission of loop current to the receiver which is in remote area via wireless adaptor. This system can communicate with controllers such as Programmable Logic Controllers (PLC) or Distributed Control System (DCS). This loop current can be given to PID Controllers to control various applications in industrial control system.

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