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HART Based Flow Indicator Totalizer

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Abstract:

The Flow Indicator Totalizer accepts 4-20mA analog current signal from sensor. It processes the signal and displays the current flow rate per sec or min or hour and the total flow. This system works on PIC microcontroller. The PIC microcontroller acts as an interface between user and the field devices. Two relays are used for control on the process value. The system is programmable by user, user can set points, change the time and flow unit. This system is low cost, robust, any mounting position and low maintenance so that economic. The system is designed for fast and accurate measurement.

Our project is to make this system HART protocol enabled. HART is Highway Addressable Remote Transducer. The benefits of making the system HART protocol is that the system will communicate bi-directionally.

By using this protocol, system will be able to transmit and receive HART signal. The HART signal will not only carry flow rate information but also pressure, temperature and volume, on the same line.

Key words: HART Protocol, Flow Indicator Totalizer, PIC microcontroller

1. Introduction

Flow indicators and totalizers play an important role in any process industry. Quick and accurate measurement and control of a process value will improve the final product quality, reliability and reduce rejection. Process indication and control is therefore one of the prime considerations in any process industry. The Programmable Flow Indicator Totalizer is a Microcontroller based Process Indicator cum Controller with user friendly programming facility. The Programmable Flow Indicator Totalizer has been designed for fast and accurate measurement and control of process value. Linearization of signals provides high accuracy even for most nonlinear sensors. The instrument is designed using highly reliable electronic components. Process value is displayed directly in digits, giving better resolution.

The Programmable Flow Indicator Totalizer accepts 4-20mA as input along with digital signal. This enables two-way field communication to take place and makes it possible for additional information beyond just the normal process variable to be communicated to/from a smart field instrument. The HART Protocol provides two simultaneous communication channels: the 4-20mA analog signal and a digital signal.

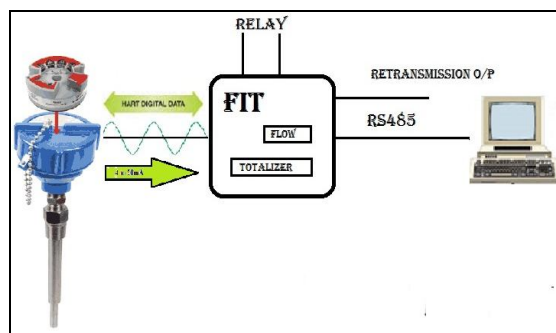


Figure 1: Functional Block Diagram

The rest of this paper is organized as follows:

Section 2 describes the basic ideas, section 3 describes typical system architecture of proposed system, section 4 described the design concept of HART, section 5 described the advantages of the project, section 6 describes the applications section 7 concludes the testing results and final section 8 concludes the paper and presents the issues for further work.

2. Motivation

Most automation networks in operation today are based on traditional 4-20mA analog wiring, HART technology serves a critical role because the digital information simultaneously communicated with the 4-20mA signal. Without it, there would be no digital communication.

There are around 70 companies, manufacturing Flow Indicator Totalizer in India, out of which around 29 companies are placed in Pune district. We studied the products of leading companies like NISHKO, RADIX etc and compared their product features with Company product.

After finalizing the project we did market survey. This product is manufactured and used national and international wide. So we studied the products of Indian companies and international companies. We compare the parameters of product of different leading companies with product parameters.

We observed that following parameters are additional in the leading companies:

- Alarm availability
- Time unit (in day, month)
- Wide range in baud rate
- Display (LCD OR LED)
- No. of set points
- Batch availability
- HART protocol enabled

From above observation and according to company's requirements we decided to add the following parameters in company's product:

- HART protocol
- Display (LED)
- No. set points (4).

3. System Architecture

This system typically has main four components: a transducer (the smart flow sensor), a microcontroller (a device that controls every action), a keypad (a device through which user can control) and a display. The fig. 1. shows the block diagram of Flow Indicator Totalizer system.

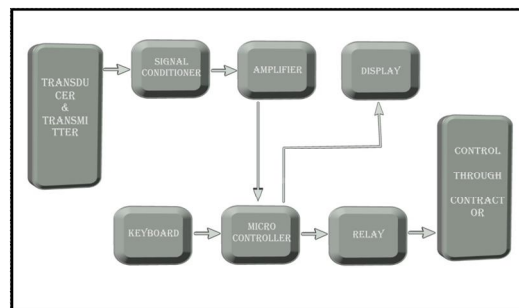


Figure 2: Block Diagram

- Transducer: This is externally connected to the instrument. It is a Smart sensor (HART enabled). Smart sensors are sensors with integrated electronics that can perform one or more of the function like two-way communication, makes decisions.
- HART Modem as Signal Conditioner: This circuit accepts the process signal from the sensor performs the necessary compensation and converts it into suitable signal level for ADC.
- ADC : This is a 12 bit successive approximation type ADC with inbuilt microcontroller .It accepts the analog input signal , converts it into digital data and feds it to the processor for further action.
- Microcontroller: This is the heart of the unit and is the interface to all the other peripherals. The transducer, membrane keypad, display, memory and output relay function under the command of microcontroller. We are using PIC18F45K80.
- Memory: There are two memory elements provided in the circuit. One is the EPROM for monitor program storage and the other is the NVRAM for storage of various users programmed parameters and process variables.
- Keypad: Feather touch membrane keys are provided on the front panel for user programming. These keys have features like long life, negligible contact bounce, ease of operation.

- Display: Front panel carries all the indications. This acts as an interface between user and CPU. We are implementing seven segment displays.
- Output relays: There are two relays one for each set point. In existing system there are 2 relays and 2 setpoints. In our project we are implementing 4 relays and 4 setpoints.
- RS232: Serial port is for communication with PC. In present system RS 232 is used for serial communication with PC, which is best for short-distance low-speed requirements. In our project we are implementing RS 485, which is for higher speeds over longer ranges or if duplex networking capability is required.

4. Design

FUNCTIONS OF HART MODEM (AD5700):

The AD5700-1 is single-chip solutions, designed and specified to operate as a HART FSK half-duplex modem, complying with the HART physical layer requirements. The AD5700-1 integrate all of the necessary filtering, signal detection, modulating, demodulating and signal generation functions, thus requiring few external components. The 0.5% precision internal oscillator on the AD5700-1 greatly reduces the board space requirements, making it ideal for line-powered applications in both master and slave configurations. The maximum supply current consumption is 115 μ A, making the AD5700-1 an optimal choice for low power loop-powered applications. Transmit waveforms are phase continuous 1200 Hz and 2200 Hz sinusoids. The AD5700-1 contain accurate carrier detect circuitry and use a standard UART interface.

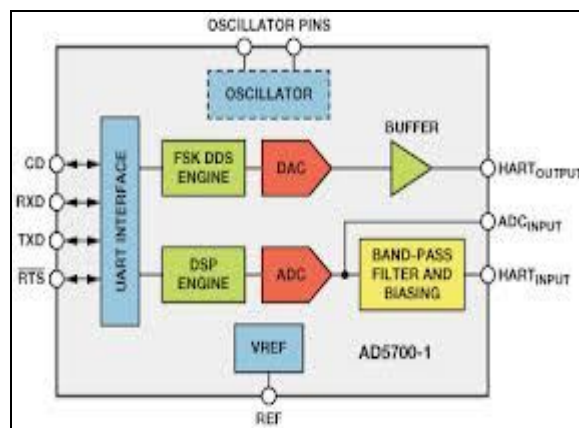


Figure 3: Functional Block Diagram AD5700

4.1. What is HART?

The HART (Highway Addressable Remote Transducer) Protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring system.

More specifically, HART is a bi-directional communication protocol that provides data access between intelligent field instruments and host systems. A host can be any software application from technician's hand-held device or laptop to a plant's process control, asset management, safety or other system using any control platform.

By using this protocol, system will be able to transmit and receive HART signal. The HART signal will not only carry flow rate information but also pressure, temperature and volume, on the same line.

4.2. How HART Works?

"HART" is an acronym for Highway Addressable Remote Transducer. The HART Protocol makes use of the Bell 202 Frequency Shift Keying (FSK) standard to superimpose digital communication signals at a low level on top of the 4-20mA.

This enables two-way field communication to take place and makes it possible for additional information beyond just the normal process variable to be communicated to/from a smart field instrument.

The HART Protocol communicates at 1200 bps without interrupting the 4-20mA signal and allows a host application (master) to get two or more digital updates per second from a smart field device. As the digital FSK signal is phase continuous, there is no interference with the 4-20mA signal.

General block diagram of PIC 18 microcontroller family

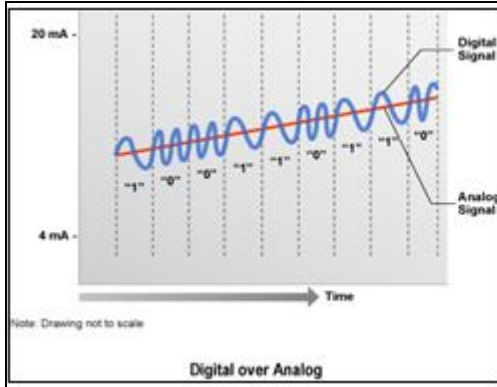


Figure 4: Frequency Shift Keying (FSK)

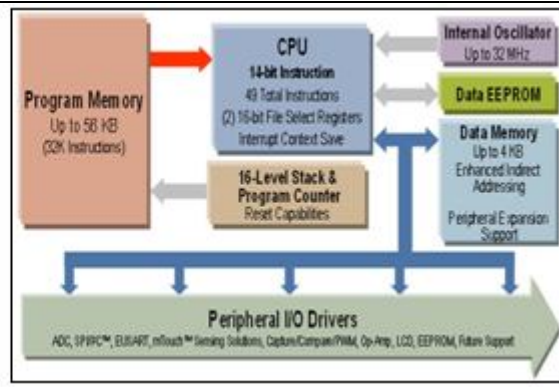


Figure 5: General Block Diagram of uc

5. Advantages

- We are using HART protocol which is the biggest advantage.
- Reduce Maintenance Cost.
- User friendly programming facility.
- Fast and accurate measurement and control of process value.

6. Applications

- Can be used in dams for water flow indication and control.
- Can be used in chemical labs.
- Can be used in industries where chemicals and oil are used.
- Can be used in petrol pumps.
- Used in chemical industry.
- Used in oil industry.
- Control monitoring.

7. Testing

Testing demonstrates that the hardware functions appear to be working according to specification, that behavioral and performance requirements appear to have been met. In addition data collected as testing is conducted provides a good indication of hardware reliability and some indication of hardware quality as whole. But testing cannot show absence of errors and defects, it can show accuracy and deviation in the measured value. These objectives are listed below

I/P (4-20mA)	I/P TO OP-AMP	O/P OF OP-AMP	ADC COUNT	DISPLAY
4mA	15mV	0.18V	0010	01lt/sec
12mA	33mV	1.04V	0513	50lt/sec
16mA	52.8mV	1.68V	768	74lt/sec
20mA	66mV	1.9V	1024	100lt/sec

Table 1: Test & Result Table

8. Conclusions and Future Work

Today, HART communication protocol is the global standard for sending and receiving digital information across analogue wires between smart devices and control or monitoring system. In addition, the introduction of wireless HART has significantly expanded the capabilities of the technology while maintaining compatibility with existing HART devices, tools and systems.

HART was primarily, intended to access remote or dangerous applications, where the superimposed communication could be used to configure devices.

However, when digital fieldbus communications became more widely used and accepted in the industry the use of HART communication also increased. Industries were able to make better use of the HART capabilities.

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