IMPLEMENTATION OF FEEDFORWARD AND PID CONTROL STRATEGIES ON CONTROL LOOP FIELDBUS FOUNDATION PROTOCOL

By

HAFFIZZULL RAHMAN BIN MD YUSUB

FINAL PROJECT REPORT

Submitted to the Electrical & Electronics Engineering Programme
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

Universiti Teknologi Petronas
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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Approved by,

(Dr. Nordin bin Saad)
Project Supervisor.

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

December 2006

CERTIFICATION OF ORIGINALITY

This is certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or person.

Haffizzull Rahman bin Md Yusub

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ABSTRACT

This report is intended to discuss the project undertaken to design, analyse and fabricate a simple control loop using a fieldbus foundation protocol. The first control systems used mechanical and pneumatic controllers and were designed merely to achieve stability rather than economic performance. Later in the 1970s, distributed control system (DCS) emerged to replace the conventional technology. In DCS, a central processor controls all parameters however, it has limitation in term of reliability, robustness and cost. This lead to the introduction of network communication for industrial process known as the fieldbus system replacing the DCS architecture by enabling distribution of control function to equipment in the field such as sensors, controllers and actuators. In this project configuration and implementation procedure for the development of fieldbus process loop is presented involving three process variables that are the temperature, pressure and level together with PID and feedforward control strategies. The methodology towards accomplishing the project includes the theoretical and technical research, the installation and commissioning, the configuration network of fieldbus protocol together with HART protocol, the troubleshooting, operation and maintenance, and the analysis of the fieldbus advantages and benefits. The findings demonstrates the benefits of the fieldbus system in term of cost saving, data quality and quantity, simpler and better controllability.

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LIST OF ABBREVIATIONS

psi	Pounds per Square Inch.
CV	Controlled Variable
DCS	Distributed Control System
DDC	Direct Digital Control
DV	Disturbance Variable
HART	Highway Addressable Remote Transmitter
HMI	Human Machine Interface
I/O	Input/Output
IEC	International Electrotechnical Commission
ISA	Instrument Society of America
MV	Manipulated Variable
OLE	Object Linking and Embedding
OPC	OLE for Process COntrol
P&ID	Piping and Instrument Diagram
PETRONAS	Petroliam Nasional Bhd
PID	Proportional, Integral and Derivative
PV	Process Variable
RTD	Resistive Temperature Detector
SCADA	Supervisory Control and Data Acquisition

CHAPTER 1
INTRODUCTION

This chapter describes the background study of this project, problem statement, objective and scope of study.

1.1 Background of Study

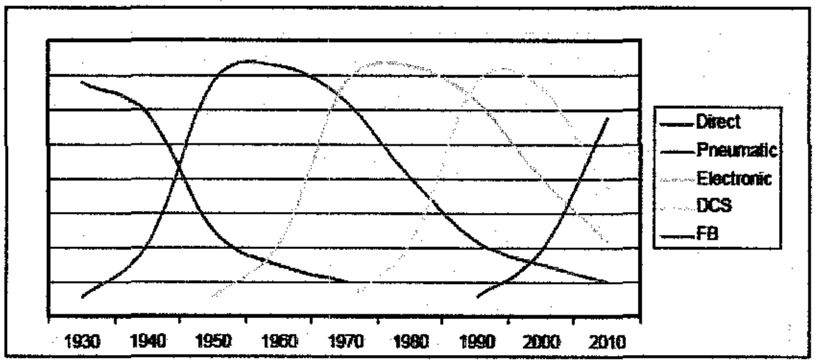


Figure 1-1: Evolution of Control System Architecture

During the pneumatic era in the 1940's, process instrumentation relied upon pressure signals of 3-15 psi for the monitoring of control devices. The controller was located in the field and operated locally. All plants were run conservatively for stability rather than economic and efficiency performance.

In the 1960's, the 4-20 mA analogue signal standard was introduced for instrumentation. Despite this standard, various signal levels were used to suit many instruments which were not designed to the standards specification. The development of digital processors in the 1970's sparked the use of computers to monitor and control a system of instruments from a central point which led to the introduction of Programmable Logic Controller (PLC-1972) and Distribution Control Systems (DCS-1976) architecture.

Smart sensors began to be developed and implemented in a digital control, microprocessor environment during the 1980's. This prompted the need to integrate the various types of digital instrumentation into field networks to optimise system performance. Figure 1-1 illustrates the evolution timeline of the control system architecture from the pneumatic era to fieldbus system. The fieldbus system is different from any other communication protocol, because it is designed to resolve process control applications instead of just transfer data in a digital mode

1.2 Problem Statement

Direct Digital Control (DDC-1962) used current loop where it becomes easier to bring a signal from transmitter in the field to central controller in the control room and then back to the field again. Because all functions were concentrated into a computer, the entire system would fail if there were even a single fault. Later, the DCS (Distributed Control System) was introduces and provide a great improvement over the DDC where the controls were distributed over several smaller controllers that shared the task.

As shown in Figure 1-2, a DCS normally consists of four different tiers of networking, each with different technology; device manager, I/O subsystem, controllers and plant wide integration to business applications in order to achieve the distribution functions [8]. All these levels of hardware, software and networking results in complicated and costly control system.

Due to the rising of production and processing costs, stiff competitions and globalization of market economies, increasing attention has been placed on the fieldbus system as the platform to provide efficient and flexible plant. The major advantage of the fieldbus and the one that is most attractive to the end user is its reduction in capital costs. The savings attained by the user stem from three main areas, initial savings, maintenance savings, and savings due to improved systems performance. The need to design, configure and implement of fieldbus system is important to allow a study on the benefits and limitations of the system itself. Presently, there are not many university has been developed own control process plant using fully fieldbus foundation technology for the training and demonstration purposes.

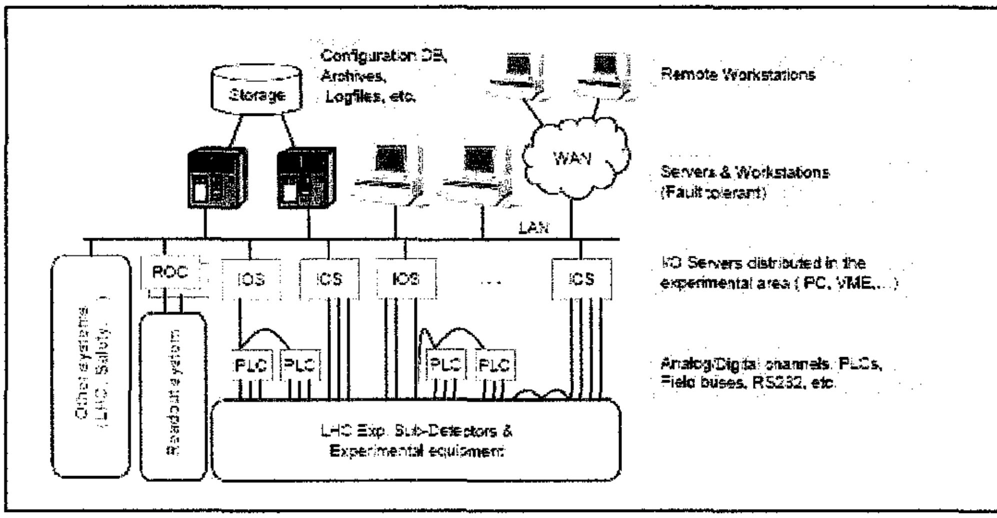


Figure 1-2: DCS System with Multilevel Tiers

1.3 Objectives

Motivated by several setbacks of the DCS system and benefits of the foundation fieldbus focused in the oil and gas industry, this project aims to find the answers on the flexibility, economical issues and efficiency that this system can offers. Importantly, this technology is new in the process and industrial instrumentation where different aspects of the fieldbus problems still need to be addressed. Particularly, this technology has been the main focus by PETRONAS to be implemented in the platforms and refineries to achieve a simpler and better controllability system. In this project, a typical process control loop with several control variables such as temperature, pressure and level are selected to be controlled by a fieldbus network. This work would provide a succinct familiarization to the fieldbus system that would be used for improving the issues related to a fieldbus system.

The main objective of this project is to develop a Foundation Fieldbus control system and to enhance knowledge in Fieldbus system. The focuses of the project are:

- To design a simple control loop (feedforward and PID) using various field instrument and to be controlled via Foundation Fieldbus system
- To commission a test platform based on the fire water pump system using both HART and Foundation Fieldbus control system

The following outlines the scope of study on the design, configuration and implementation of fieldbus system:

- Detail familiarization on the fieldbus system
- Analyzing the deficiency of current controller system such as conventional PID, HART and to be compared with fieldbus system
- Designing a simple control loop using several measurement devices such as temperature, level and pressure with feedforward control strategy
- Establish a fieldbus network by device installation and measurement
- Commissioning a test platform based on the onshore fire water pump system
- Trouble shooting the test platform for any fieldbus connection failure

CHAPTER 2
LITERATURE REVIEW/THEORY

2.1 Introduction of Fieldbus

Fieldbus is a generic-term which describes a new digital communications network which is used in industry to replace the existing 4 - 20mA analogue signal. The network is a digital, bi-directional, multidrop, serial-bus, communications network used to link isolated field devices, such as controllers, transducers, actuators and sensors. Each field device has low cost computing power installed in it, making each device a 'smart' device. Each device will be able to execute simple functions on its own such as diagnostic, control, and maintenance functions as well as providing bi-directional communication capabilities. With these devices not only will the engineer be able to access the field devices, but they are also able to communicate with other field devices. In essence fieldbus will replace the centralised control networks with distributed-control networks. Therefore fieldbus is much more than a replacement for the 4 - 20mA analogue standard. [2]

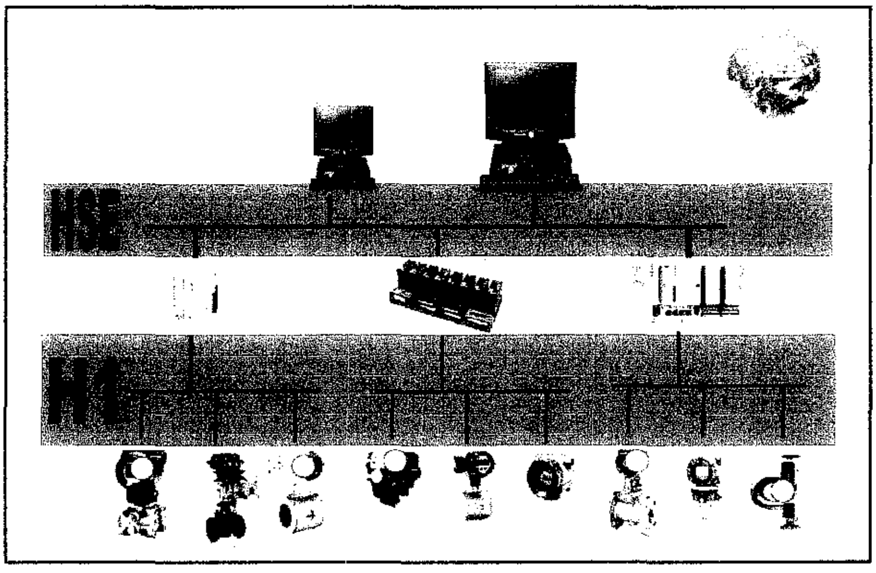


Figure 2-1: Foundation Fieldbus Network

Fieldbus uses the three layers of Open Systems Interconnection (OSI) model as a basis of the technology. The layers are physical layer, data layer and application layer. The physical layer and data link layer is network-oriented layer that will transport data from one location to another. The application layer is user-oriented layer that provide the user with access to the network system in an appropriate form. The foundation fieldbus has an additional comprehensive user layer for the interoperability purposes.

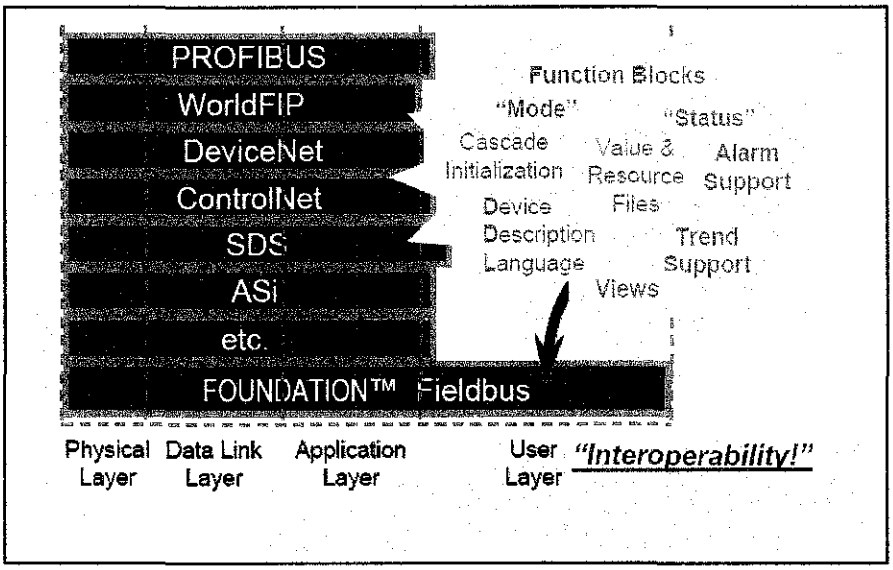


Figure 2-2: Comparison of buses communication layer

2.2 Advantages of fieldbus

The fieldbus has a multitude of advantages that the end users will benefit from. The major advantage of the fieldbus and the one that is most attractive to the end user is its reduction in capital costs. The savings attained by the user stem from three main areas, initial savings, maintenance savings, and savings due to improved systems performance [2].

Initial Savings

One of the main features of the fieldbus is its significant reduction in wiring. Each process cell requires only one wire to be run to the main cable, with a varying number of cells available. The cost of installing field equipment in a fieldbus system is thus significantly reduced. Installation costs are further reduced due to the fact that the fieldbus it is a multi-drop rather than point-to-point system and the multidrop network can offer a 5:1 reduction in field wiring expense.

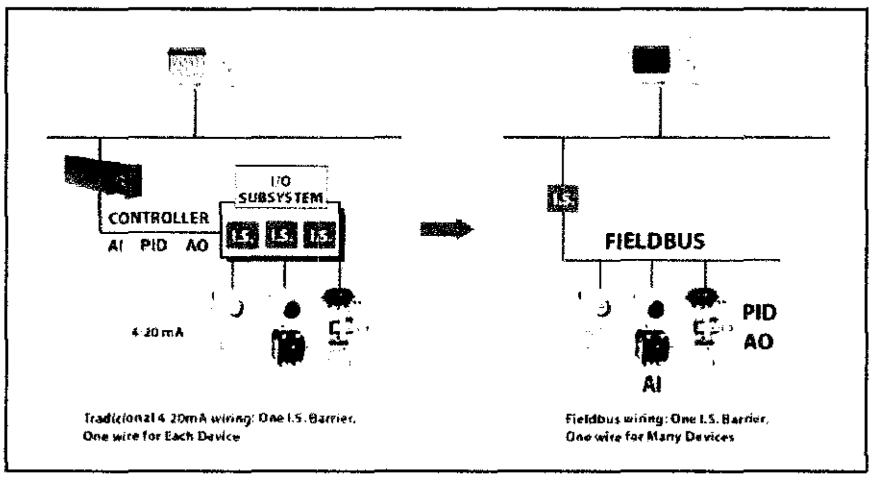


Figure 2-3: Comparison of wiring system

Maintenance Savings

The fieldbus system is less complex than a conventional bus systems implies that there will be less overall need for maintenance. With the fieldbus system, it is possible for the operators to easily see all of the devices included in the system and to also easily interpret the interaction between the individual devices. This will make discovering the source of any problems and carrying out maintenance much simpler, and thus will reduce the overall debugging time.

The debugging and maintenance of the system will also be enhanced due to the fact that fieldbus enables online diagnostics to be carried out on individual field devices. The online diagnostics include functions such as open wire detection and predictive maintenance and simplify tasks such as device calibration.

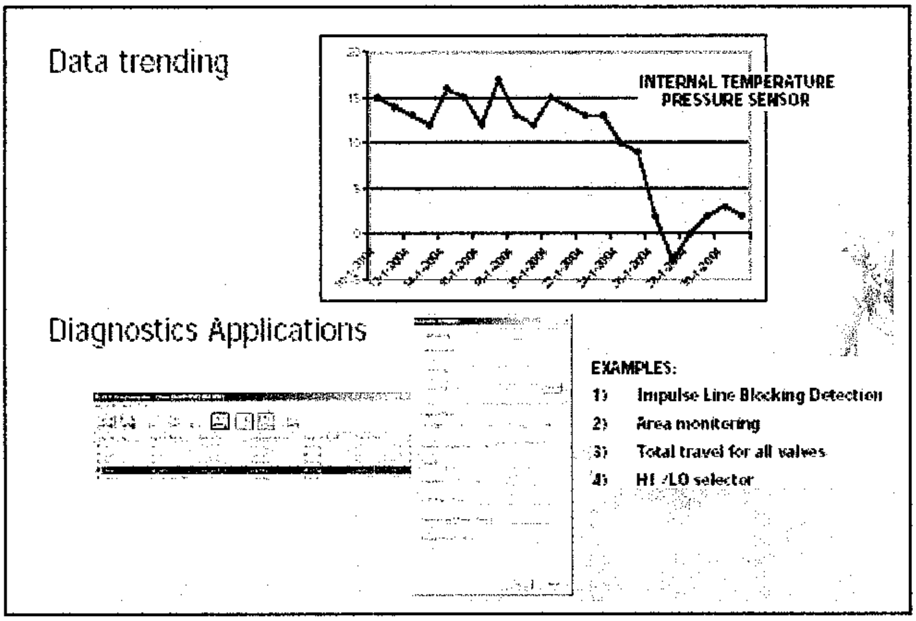


Figure 2-4: Diagnostic capability of fieldbus

Improved Systems Performance

System performance is enhanced with the use of fieldbus technology due to the simplification of the collection of information from field devices. Measurement and device values will be available to all field and control devices in engineering units. This eliminates the need to convert raw data into the required units and will free the control system for other more important tasks. The reduction in information complication will allow the development of better and more effective process control systems.

Interoperability

The special features of foundation fieldbus is the interoperability capability. Talking the advantage of using the digital signal compared to analog signal, device from various suppliers can be attached to the same bus. The analogy of this system is same as a printer which is connected to a Local Area Network (LAN) for the used of several host computers. In order to access the printer, a driver needs to be installed first in each computer in order to recognize the printer. But instead of using driver, a Device Description (DD) file is used to retrieve data from different manufacturer. The DD file can be uploaded from the internet for free.

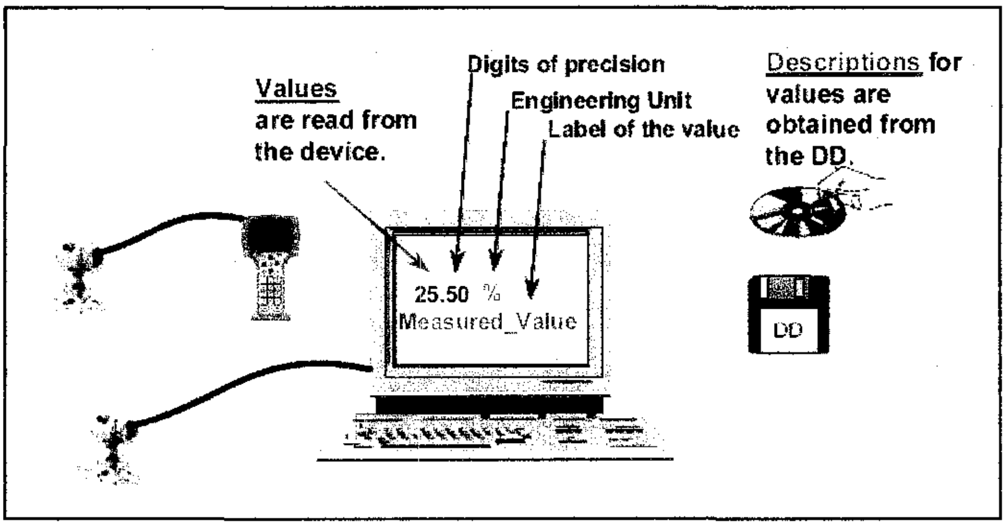


Figure 2-5: Interoperability capability

2.3 Fieldbus Topologies

There are several possible topologies for fieldbus networks. This section will illustrate some of these possible topologies and discuss some of the characteristic of each. In the interest on clarity and simplicity, power supplies and terminators are omitted from the diagrams in this section

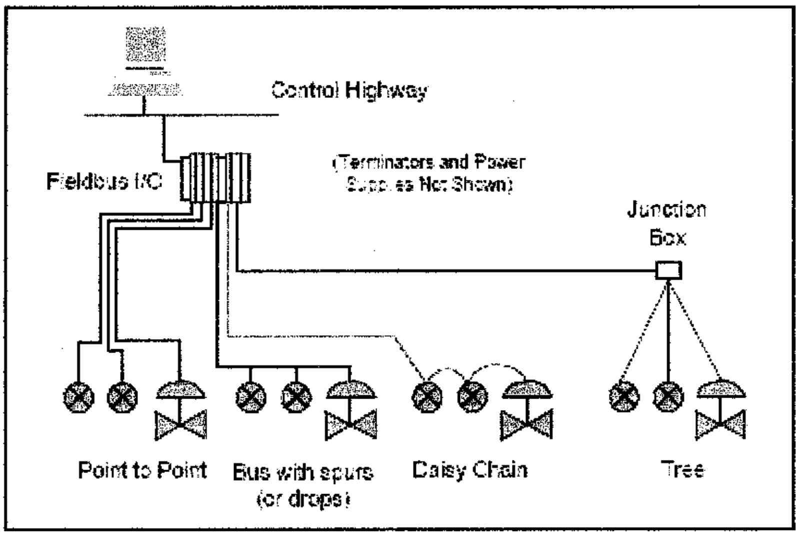


Figure 2-6: Possible Fieldbus Topology

2.3.1 Point-to-Point Topology

This topology consists of a segment having only two devices. The segment could be entirely in the field: a transmitter and a valve operating independently, with no connection between each other. Alternatively, it could be a field device connected to a host system. This configuration is often used for the fact that is has only one control device or one measurement per segment. As a result, it does not take advantage of the multi device per segment capability of the fieldbus network. (See Figure 2-7) [4]

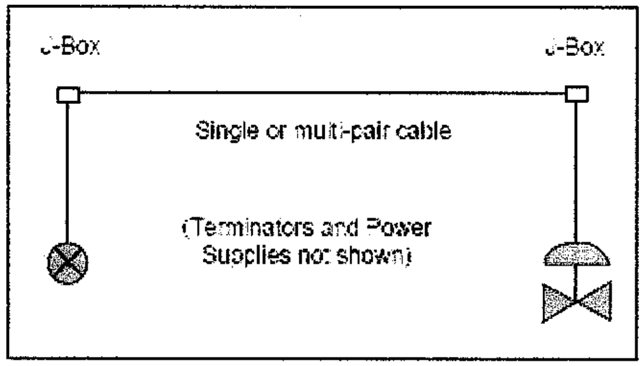


Figure 2-7: Point-to –Point Topology

2.3.2 Bus with Spurs Topology

For bus topology, the fieldbus devices are connected to the bus segment through a length of cable called a spur. A spur can vary in length from 1 meter to 120 meters. A spur that is less than 1 meter in length is considered a splice. The advantage of bus topology is that it minimizes the amount of cable that is required to connect the devices. However, because several junction boxes are required for the spurs, there will be many connections.

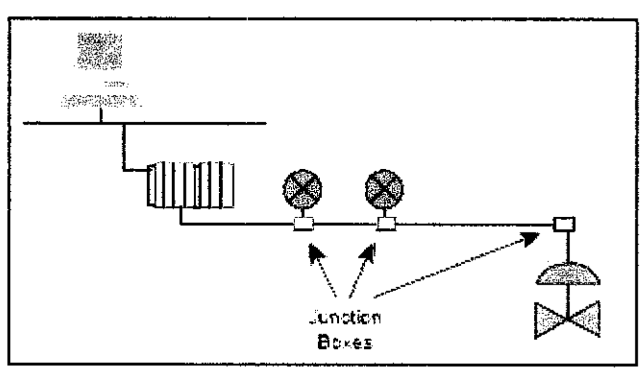


Figure 2-8: Bus with Spurs Topology

2.3.3 Daisy-Chain Topology

With this topology, the fieldbus cable is routed from device to device on this segment, and is interconnected at the terminals of each fieldbus device. Installations using this topology should use connectors or wire practices such that disconnection of a single device is possible without disrupting the continuity of the whole segment.

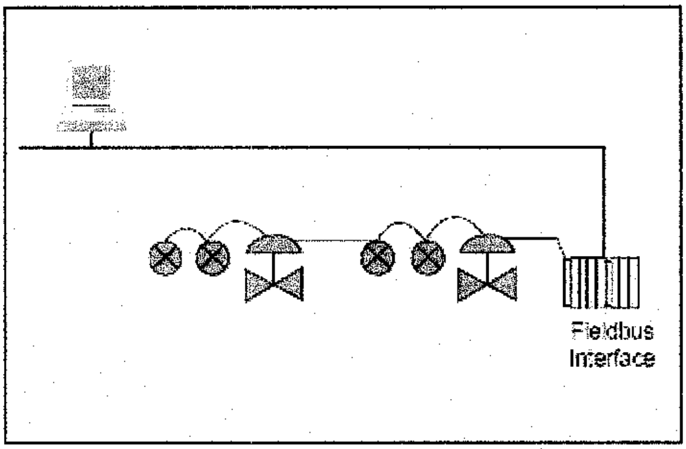


Figure 2-9: Daisy-Chain Topology

2.3.4 Tree Topology

The tree topology, devices on a single fieldbus segment is connected via individual twisted wire pairs to a common junction box, terminal, marshalling panel or I/O card. This topology can be used at the end of a home run cable. It is practical if devices on the same segment are well separated, but in the general area of the same junction box. When using this topology, the maximum spur length must be taken into consideration.

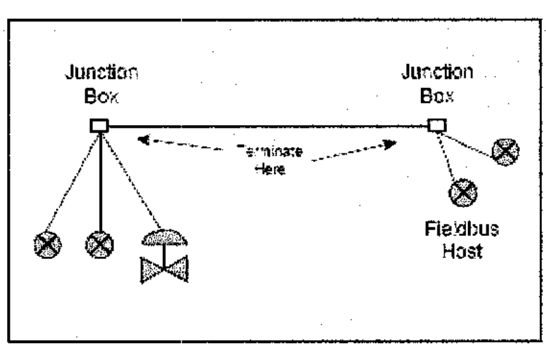


Figure 2-10: Tree Topology

CHAPTER 3
METHODOLOGY/PROJECT WORK

3.1 Project Work

This chapter is intended to describe the project flow in the development of the test rig to be used in this project. The following sections introduce the work flow which could be simplified in a flowchart as shown in Figure 3-1.

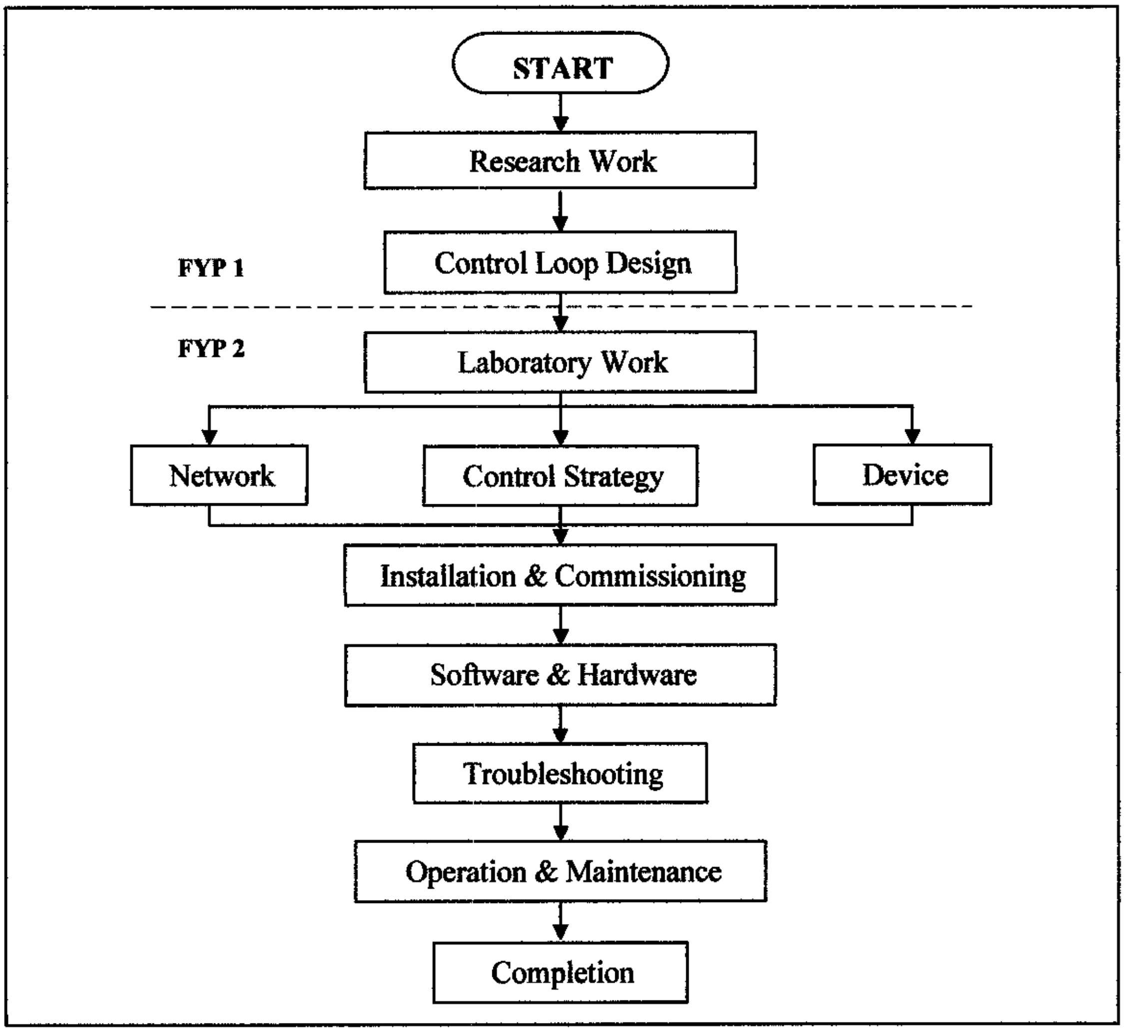


Figure 3-1: The project flow diagram

3.1.1 Research and Information Gathering

The main objective of this project is to build a fieldbus network process loop and this requires research and literature review to be conducted. Having done the industrial internship at PETRONAS Carigali Sdn. Bhd. the author obtained valuable information on fieldbus from major vendors such as Yokogawa, Emerson and Honeywell. The research scopes include:

- Fieldbus history and the evolution of control system technology
- Fieldbus Foundation definition, functionality and working its principle
- Installation, commissioning and configuration of the fieldbus system

3.1.2 Control Loop Design

The control loop is to be designed based on the real fire water pump system in a platform. The system is to be implemented using various field instruments such as transmitters and valves.

3.1.3 Installation, Commissioning and Configuration

After the system design is completed and the instruments have been selected, the device is installed and commissioned with regards to the system manual and based on the designed schematic.

3.1.4 Troubleshooting, Maintenance and Operation

Several test and calibration need to be done to ensure the connectivity of the fieldbus system. The operation is remotely monitored, controlled and maintained in real time application.

3.2 Tools Required

The equipments are available as loose instruments n the Process/Instrumentation Laboratory of Electrical and Electronics Department, UTP. The field devices and basis components utilized the SMAR Foundation Series 302. Generally, the hardware and software required to implement a fieldbus system in a segment are:

- Cable
- Terminators
- Power supplies
- Measurement and control devices
- Host devices
- Configuration and operation software

3.2.1 Cable

Various types of cables are useable for fieldbus. The Table 1 contains the type of cable identified by the IEC/ISA Physical Layer Standard.

The preferred fieldbus cable is specified in the IEC/ISA Physical Layer Standard, Clause 22.7.2 for performance testing, and it is referred to as type "A" fieldbus cable. This cable will most probably be used in new installations.

Other types of cables are also available to be used for fieldbus wiring. The alternate preferred fieldbus cable is a multiple, twisted pair cable with an overall shielded (Type B) fieldbus cable. This cable can be used in both new and retrofit installations where multiple field buses are run in the same area if the user's plant.

A less preferred fieldbus cable is a single or multiple, twisted pair cable without any shield, (type C) fieldbus cable. The least preferred fieldbus cable is a multiple conductor cable without twisted pairs, but with overall shield (type D). These cables will mainly used in retrofit applications with limitation in the fieldbus distance. [4]

TABLE 1: Fieldbus Cable Types and Maximum Lengths

Type	Cable Description	Size	Max Length
Type A	Shielded, twisted pair	#18 AWG (.8 mm2)	1900 m (6232 ft.)
Type B	Multi-twisted-pair with shield	#22 AWG (.32 mm2)	1200 m (3936 ft.)
Type C	Multi-twisted pair, without shield	#26 AWG (.13 mm2)	400 m (1312 ft.)
Type D	Multi-core, without twisted pairs and having an overall shield	#16 AWG (1.25 mm2)	200 m (656 ft.)

3.2.2 Terminal Blocks

Terminal blocks can be the same terminal blocks used in the 4-20mA system. The terminal blocks typically provide multiple bus connection, such that a device can be wired to any set of bus terminals.

Figure 3-2 indicates one method of connection and terminating a fieldbus segment to several field devices at a junction box using the type of terminal blocks that have been used in the past. Today, there are terminal block systems especially designed for fieldbus to make wiring considerably easier.

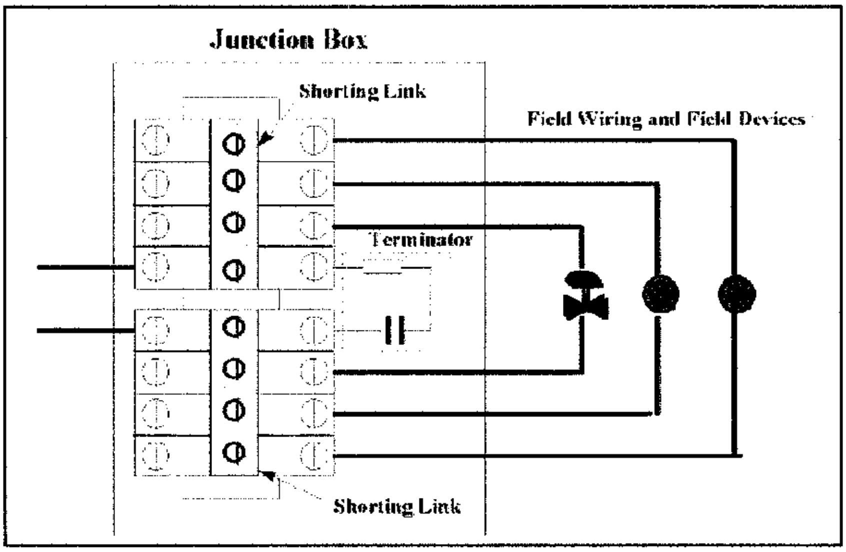


Figure 3-2: Terminal Blocks in Field Mounted Junction Box

3.2.3 Terminators (BT302)

Figure 3-3: Fieldbus Terminator

A terminator is an impedance matching module used at or near each end of a transmission line. A terminator is needed at each end of the fieldbus network segment. The terminator prevents distortion and signal loss, and are typically purchased and installed as a preassembled, sealed module. [5] The terminator has the following functions:

- **Prevent signal reflection**

  The communication signal bounces back when it reaches the end of the wire, potentially distorting itself

- **Signal current shunt**

  A device transmits by rapidly changing the current in the network, either by changing its power consumption or injecting a current. The terminator converts the current change produced by a transmitting device into a voltage change across the entire network that is picked up by all devices as the means for receiving the signal

3.2.4 Host devices

Figure 3-4: A Host Computer

A host computer usually a main computer with special integrated software that is located in the control room that controls the process configuration. Its function is to manage, monitor, control, maintaining and operate the operation of the control system made up of devices connected by the fieldbus network. From the fieldbus network, it can be connected to other computer or other monitoring devices.

3.2.5 Switch

A network switch is a networking device that performs transparent bridging (connection of multiple network segments) at full wire speed in hardware. It has intelligence to examine the Ethernet destination address for the message and only transmit the message on that one corresponding port. They automatically establish what addresses are on which port. The switch supports multiple simultaneous operations that connect several networks together. As a result, communication between other ports can occur concomitantly without any interfering problem.

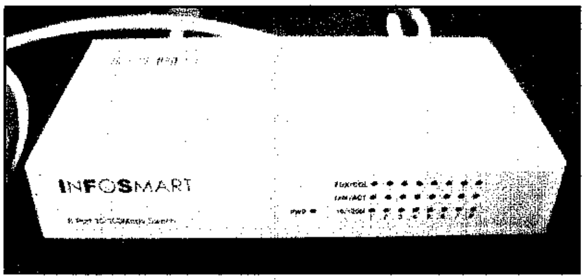


Figure 3-5: 8 Ports10/100Mbps Switching Hub

3.2.6 Close and Open Tank

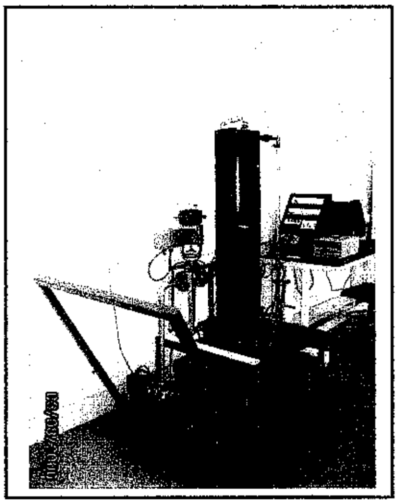


Figure 3-6: Open Tank

The close and open tanks are used in this project to implement the design system that using both HART and Foundation Fieldbus protocol. Based on the fire water pump system, the open tank will fill by the standby water while the close tank fills with water under certain pressure. Both tanks are made by fiber glass material and attached on the wheels for easy storing and transportable.

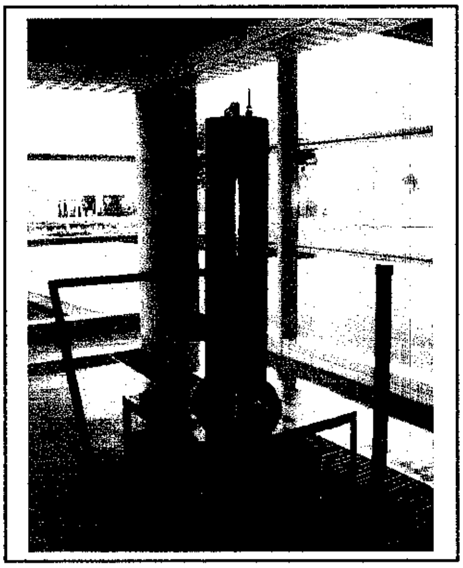


Figure 3-7: Close Tank

3.2.7 *System Configurator (SYSCON)*

The SYSCON is a software tool especially developed to configure, maintain and operate the SMAR fieldbus products line, by a Personal Computer with a fieldbus interface. The software includes the functions:

- **System and device configuration**

  Possible to communicate with all devices in the network, assign tags, configure the control strategy, adjust parameters and download a configuration.

- **System maintenance**

  This function communicates with all field instruments and accesses information about instrument manufacturer, materials of construction and ranges. It allows for transducer calibration and controller tuning.

- **System operation**

  Indication of variables, historical trends and alarm logs can be retrieve by this function. The parameters and settings can be changed which is ideal tool for plant commissioning.

Figure 3-8: System Configurator (SYSCON)

3.2.8 ICONICS GraphWorX32

It is a software solution of OLE for Process Control (OPC) based Client for HMI, SCADA and control. Object Linking and Embedding (OLE) is a compound document standard developed by Microsoft Corporation. It enables objects creation with one application and then link or embeds them in a second application. Embedded objects retain their original format and links to the application that created them. OPC is a standard based approach for connecting controllers and I/O devices with HMI client application (e.g. graphics trending). It enhances the communication of data between device to device and device to host.

Two ICONICS application will be used in this project which is GraphWorx32 and ControlWorx32. GraphWorx32 is used to create animated graphics for control display in host computer. This is where the visualization of the process is created for the operator interface. ControlWorx32 is a control application to perform plant control. [6]

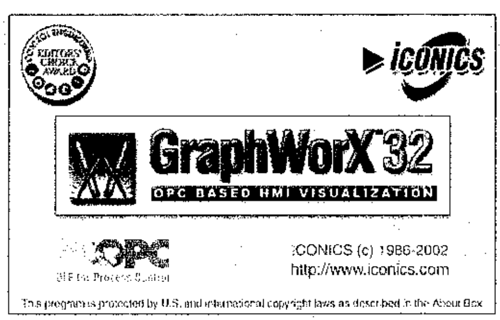


Figure 3-9: GraphWorX32

3.2.9 Fieldbus Universal Bridge (DFI-302)

The DFI-302 is a single integrated unit with functions of interfacing, linking device, bridge, controller, power supply and distributed I/O system [7]. Concisely, DFI-302 is a multifunction hardware component necessary to manage and control the fieldbus plant. The modules that available in the DFI-302 include:

TABLE 2 : DFI-302 Hardware Components

Series	Description	Specification
DF01	Rack with 4 slots	Backplane
DF02	Terminator	End terminator for the last rack
DF50	Power supply for backplane	Input: 90-264 VAC, Output: 5VDC (backplane power supply) and 24VDC (external use)
DF51	DFI-302 processor module	1 x 10Mbps Ethernet and 4 x fieldbus H1 channels at 31.25Kbps.
DF52	Power supply for fieldbus	Input: 90-264VAC, Output: 24Vdc
DF53	Power supply impedance for fieldbus (4 ports)	To ensure no short-circuit between the power supply and the communication signal on the fieldbus.

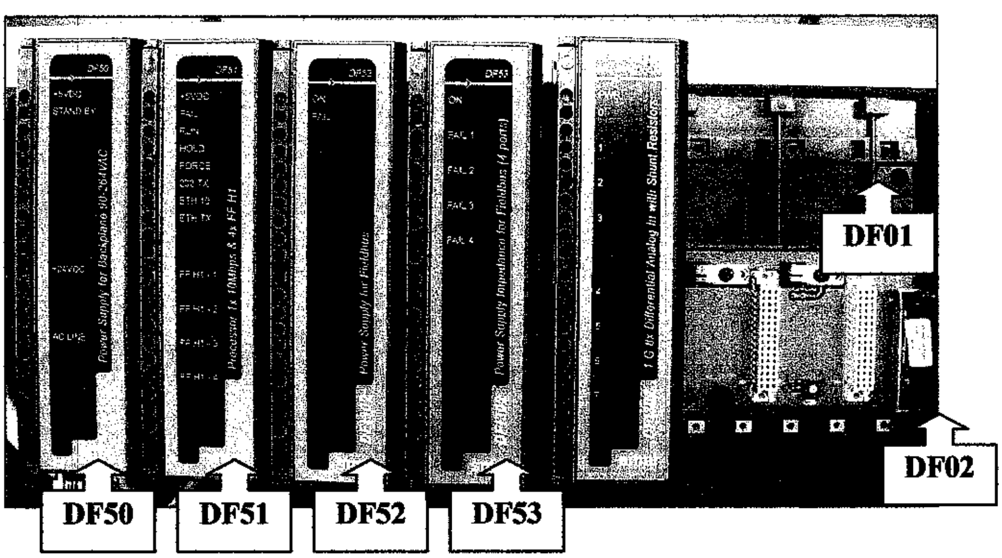


Figure 3-10: Fieldbus Universal Bridge

3.2.10 HART Communicator

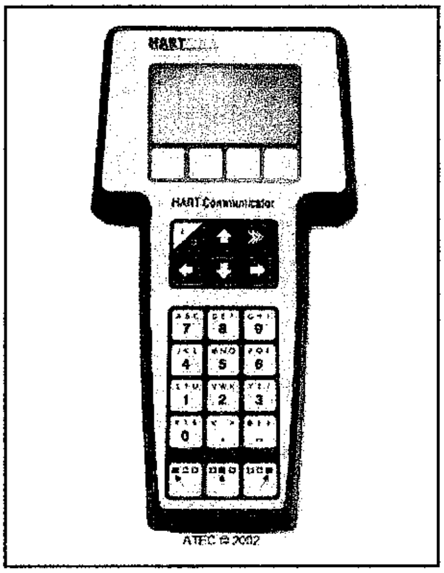


Figure 3-11: HART Communicator

The HART Communicator is a hand-held interface that used to provide a common communication link to all HART compatible, microprocessor based instrument. Calibration of the HART instrument is done using the HART communicator. Tag name, upper and lower range is set in the HART communicator and sent to the devices. The HART Communicator interfaces with any HART-compatible device from any wiring termination point using 4-20 mA loop, provided a minimum load resistance of 250 ohms present between the communicator and power supply. It uses the Bell 202 frequency shift key (FSK) technique of high frequency digital signals superimposed on a standard transmitter current loop. Because of the total high frequency signal voltage added to the loop amounts to zero, communication to and from HART-compatible device does not disturb the 4-20 mA signal [9].

3.2.11 *CA100 Calibrator*

Figure 3-12: CA100 Calibrator

In this project, the CA 100 source device is used in order to supply a virtual temperature to the transmitter. This device is connected to the temperature transmitter at the same terminal as the output from thermocouple prop is established. The thermocouple output prop is detached and the temperature source is supplied by CA100 to the temperature transmitter.

3.2.12 *YS136 Yokogawa Controller*

A controller can monitor and affect the operational conditions of a system. The operational conditions are typically referred to as output variables of the system which can be affected by adjusting certain input variables. For the HART partition, YS136 controller is used in order to manage the control valve for the inlet of open tank (tank 1). The values from pressure transmitter are transferred to the controller and perform calculation for the valve to react. By using this controller, the percentage open of control valve can be controlled both automatically and manually.

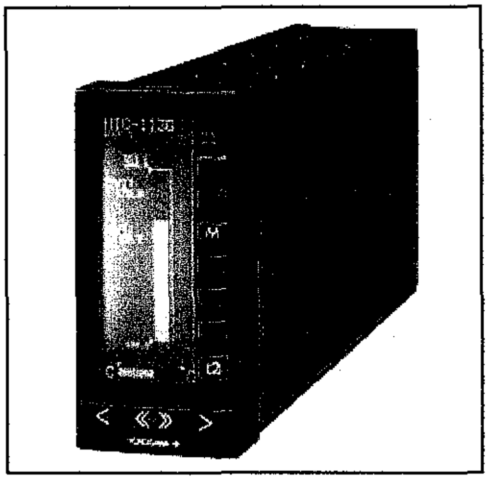


Figure 3-13: Yokogawa controller

3.2.13 UR1000 Recorder

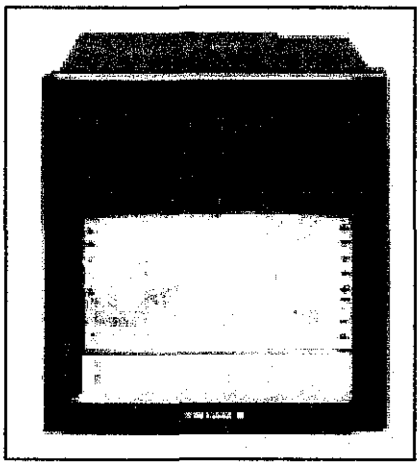


Figure 3-14: Yokogawa recorder

The uR1000 is a 4 channel paper chart recorder with a 110mm chart span, capable of measuring voltage, thermocouples and RTD's. The recorder is connected at the 4-20 mA loops and displayed the voltage that represents the level of open tank (open tank). The trend of the voltage is printed on paper for the history log purposes.

3.2.14 Measurement and Control Devices

Below is the list of equipment, measurement and control devices used in the test platform. The technical specifications for each device are attached in Appendix A.

3.2.14.1 Fieldbus Valve Positioner (FY-302)

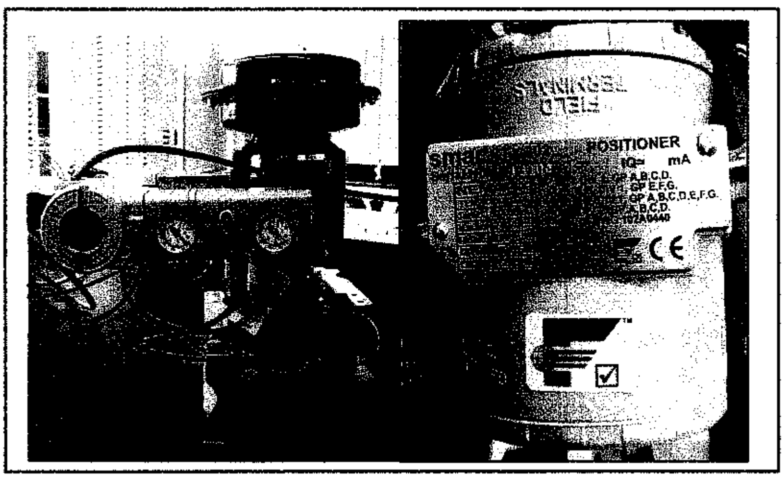


Figure 3-15: Control Valve and Valve Positioner

The fieldbus valve positioner offers position sensing without any mechanical contact, virtually eliminating wear-and-tear and subsequent degradation. The FY302 directly senses longitudinal or rotary movement based on the Hall Effect. The position signal may also be used in advanced control schemes. [10]

Features:

- Low air consumption
- Direct, non-contact position sensing
- Valve characteristics change with software cams
- Wide range of function blocks
- Network master capability

3.2.14.2 Fieldbus Temperature Transmitter (TT-302)

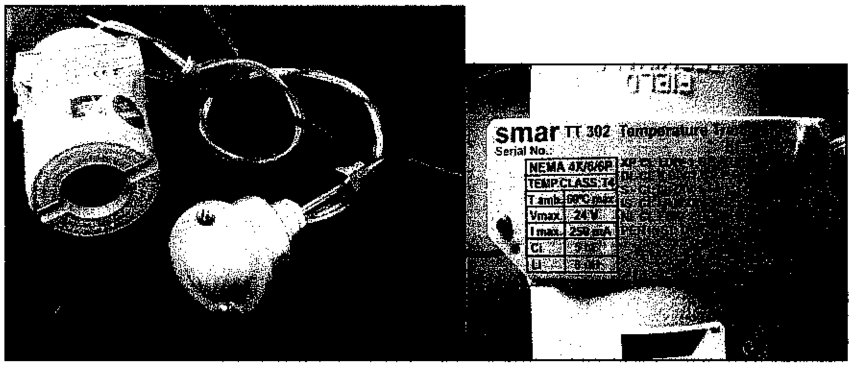


Figure 3-16: Temperature transmitter

The TT302 fieldbus temperature transmitter provides measurement of temperature using RTDs or thermocouples and also other sensors with resistance or mV output. But, in this project the CA100 calibrator is used to generate a virtual temperature for the transmitter. A single TT302 model can accept various sensors, wide ranges, and single-ended or different measurements. It provides an easy interface between the field and control room. [10]

Features:

- Digital LCD display (optional)
- Basic accuracy of 0.02%
- Self-diagnostics
- Dual channel
- Universal input accepts several thermocouples, RTDs, mV and Ohm

3.2.14.3 Fieldbus Pressure Transmitter (LD-302 Series)

The LD302 Series fieldbus pressure transmitters are intended for differential, absolute and gauge pressure; level; and flow measurements. The LD302 Series is based on a field-proven digital capacitance sensor providing reliable operation and high performance. The LD302 is part of SMAR's complete series of fieldbus devices. [10]

Features:

- 0-125 Pa to 0-40 Mpa
- 0.075% accuracy of calibrated range
- Accepts range from URL to URL/120
- Wetted parts in 316 SS, Hastelloy and Tantalum
- Self-diagnostics

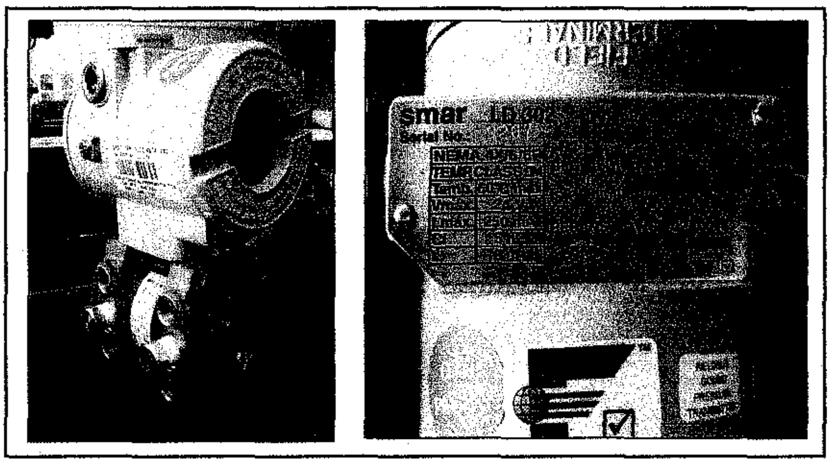


Figure 3-17: Differential Pressure Transmitter

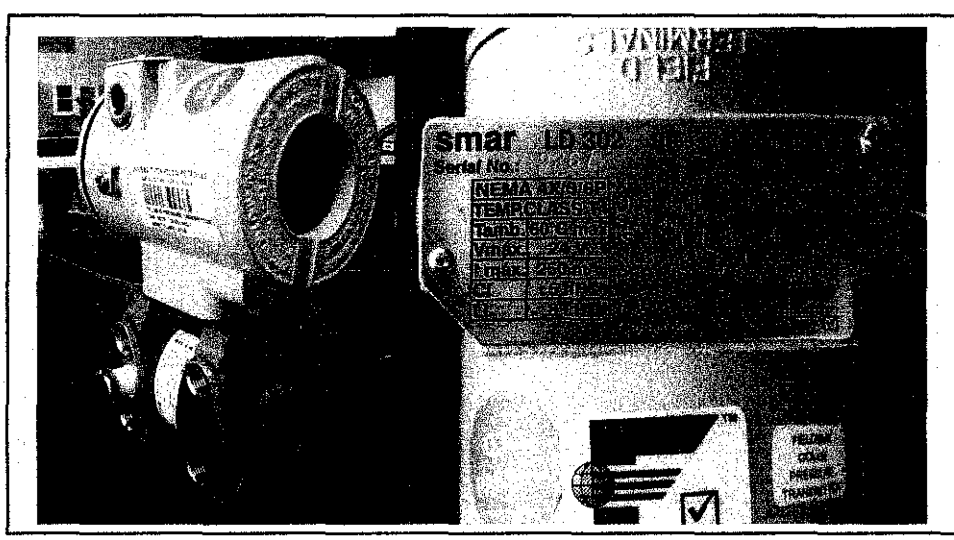


Figure 3-18: Gauge Pressure Transmitter

CHAPTER 4
PROCESS PLANT AND CONTROL STRATEGIES

4.1 Petrobras Platform P-36 Explosion, Brazil

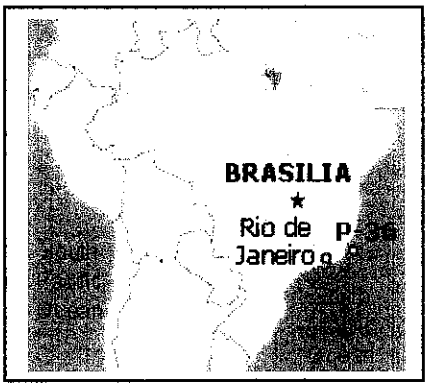


Figure 4-1: Platform P-36 Location

The Petrobras Platform 36 (P-36) was located in the deepwater Roncador Field in the northern Campos Basin area, some 125 km off the coast of Brazil. Campos Basin is the largest oil reserve in Brazil, covering an area of over 100,000 km^2 and was discovered in 1976. The Roncador Field, discovered in 1996, covers an area of 111 km^2 and has a sea depth varying from 1,500 to 1,900 m.

The P-36 was transformed from a drilling rig, known as Spirit of Columbus, into a floating production facility with a processing capacity of 180,000 barrels per day. It was a moderately sized semi-submersible platform with two submerged pontoons supporting four large columns which in turn supported the main deck housing the production facility.

As typical for semi-submersible platforms, the P-36 was floating on the sea by buoyancy and had no physical support to the seabed. It was positioned on the surface of the sea by an anchoring system. The P-36 had been in production since May 2000 and had an oil production rate of around 80,000 barrels at the time [11].

4.1.1 The explosion and fire

In the first hour of 15 March 2001, three explosions occurred in the starboard aft column of the Petrobras Platform P-36, causing the fire and flooding of the platform. The platform sank into the water of approximately 1360 m deep on 20 March 2001.

The incident was initiated by the rupture of the Emergency Drain Tank (EDT) in the starboard aft column due to excessive pressure at 00:22 on 15 March 2001. The rupture caused damage to various equipment and installations, leading to the flooding of water, oil and gas into the column. Emergency Firefighting Service was sent to the area. After 17 minutes, the dispersed gas caused fire, causing a major explosion which 11 crews been killed in the incident. The explosion also resulted in serious physical damage to the platform.

Of the 175 people on board, 165 were successfully evacuated including a person who was seriously burned and died 1 week later. The continuous flooding finally destabilised the P-36 and it sank five days later.

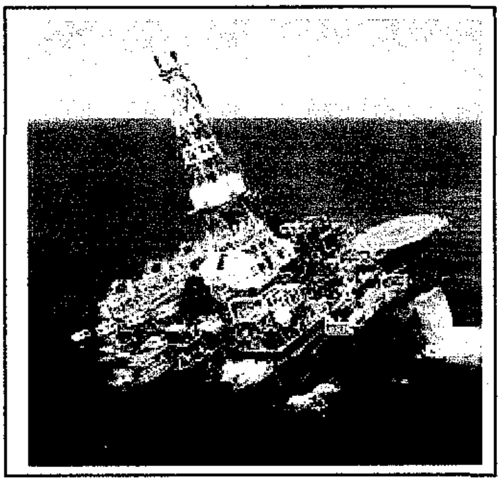


Figure 4-2: Platform P-36 after explosion
Source: http://www.mace.manchester.ac.uk/

4.2 Fire Water Pump Control System

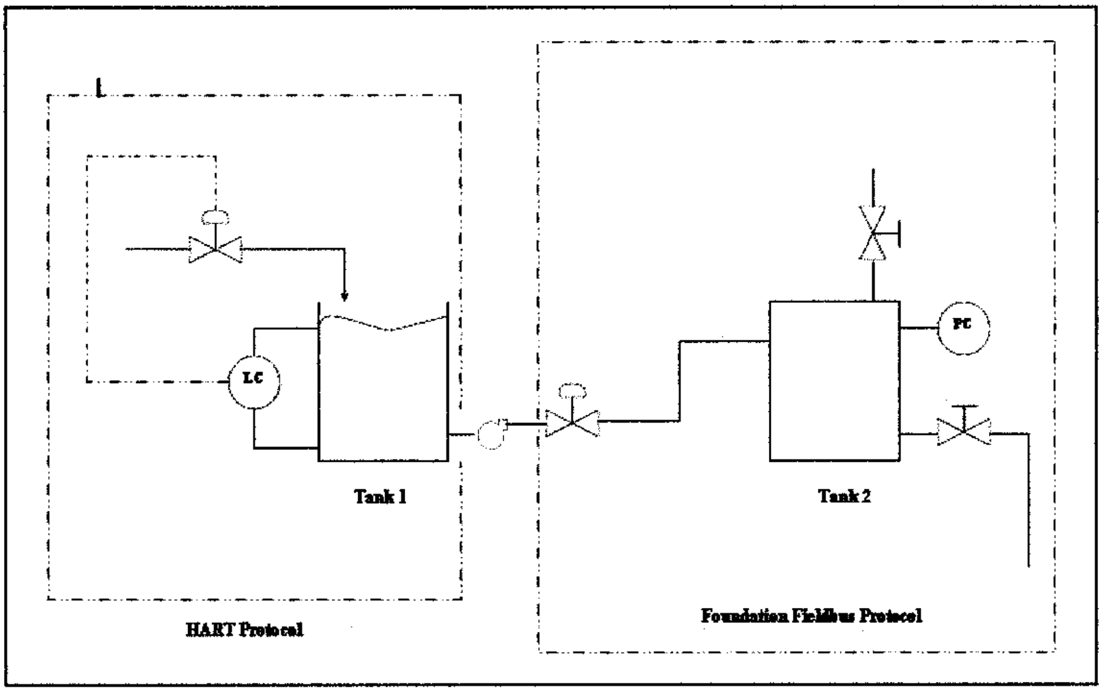


Figure 4-3: P&ID of process loop design

Triggered with the safety system on a plant, the control loop design is based on the fire water pump system. Referring to the Figure 4-3, the control process consists of 2 tanks; one is an open tank while the other one is a close tank. The design is based on availability of devices in the laboratory. This process loop consists of all instrument devices such as control valve, level transmitter and pressure transmitter.

The constraint of the Fieldbus devices resulted to the use of HART protocol in the control loop design. The HART protocol is used for tank 1 while for the tank 2 it is fully foundation fieldbus equipped. Instead of using the Foundation Fieldbus protocol, the combination of HART protocol fulfills a part of this project objective to show the advantages of the Foundation Fieldbus in term of robustness, better controllability, saving cost and compatibility with other system.

When designing a process loop, we need to consider eight (8) criteria of control objectives in order to place the controller and transmitter, and they are:

- Safety
- Environmental protection
- Equipment protection
- Smooth operation
- Production quality
- Profit
- Monitoring and diagnosis

In Figure 4-3, the location of the pressure and level transmitter has been specified based on the requirement of the control objective. The level controller at tank 1 for example ensures the safety and smooth operation of the process. It prevents the tank to overflow by controlling the inlet flow to the tank and at the same time maintaining the level for use in the next process.

4.3 HART - what is it?

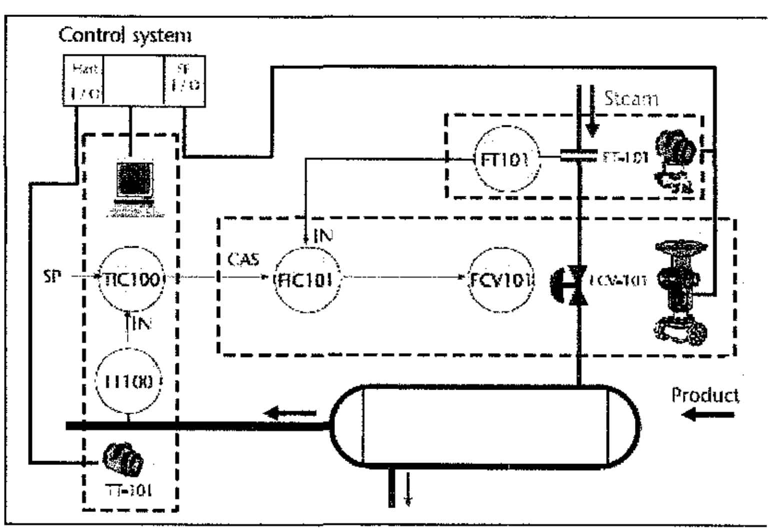
Devices using HART communication technology hit the market early 1980s. The HART Communication Foundation estimated that there are 10 million HART devices in service throughout the world today. [3]

In HART devices, data are delivered via digital signaling "superimposed" on top of the traditional 4-20 mA current loop used to return (or send) the process variable (PV). The communication speed for HART signaling is 1.2 Kbps. With HART devices, the PV is always being derived from the 4-20 mA signals despite the fact that the PV is also available as part of the digital data provided by the device. In fact, many HART devices installed today still use the PV and ignore the digital data provided by the HART protocol. On the other hand, HART protocol does not allow several devices to be connected in series in the same current loop, thus providing digital data from each device.

Table 3: Characteristics of HART and Foundation Fieldbus

Characteristic	HART	Foundation Fieldbus
Uses 4-20 mA for providing PV	Yes	No
Data provided via digital signaling	Yes	Yes
Type of communication	Master / Slave	Token passing
Bus speed	1200 bps	31,25 kbps
Remote configuration / calibration	Yes	Yes
Provides device diagnostics	Yes	Yes
Multi-drop configurations	Yes (limited)	Yes
Approximate number of devices in service	10,000,000	300,000
Suitable for intrinsically safe application	Yes	Yes
Non-proprietary / vendor neutral	Yes	Yes
Supports control in the field	No	Yes

Similar I/O interfaces would connect the HART loops and the fieldbus segments to the control system computer. In such configuration, it would be typical for the fieldbus I/O interface to connect to multiple multidrop fieldbus segment with multi devices on each segment. The HART I/O would typically be wired so each HART device connects to a separate channel on the HART I/O interface.



A simple cascade control loop shows the FT101 and FCV101 are fieldbus function blocks located in fieldbus devices FT-101 and FCV-101, respectively. TT100 and TIC100 are non-fieldbus function blocks located in the control system PC. TT-101 is a HART device providing the input to the TT100 AI function block. The trick is for the control system to convert the output of the conventional TIC100 function block into a fieldbus output, so it can provide a cascade input to the FIC101 fieldbus function block contained in fieldbus device FT101.

Figure 4-4: HART and fieldbus control system

The design of the process control is based on the actual process of firewater pump system. This system mainly designed for the plant as the fire fighting system where the operation needs to be 100% accurately functions, as the environment is hazardous and flammable.

This process loop consists of two tanks where the open tank reacts as a standby water tank while the close tank mainly operates during the processing of the system. All the instrument devices react to the situation for the smooth process of the system.

The algorithm of this process loop requires a set point is place for the level of tank 1, the open tank. Water from the supply fills up the open tank until reaching the set point. This inlet flow is controlled by the control valve, based on the reading of the level transmitter value. If it is below the set point, valve will be opened and fill up the tank. If it reached the set point, the valve will be closed. For the safety reason, an overflow outlet will be places at the most top of the tank.

A pump and a foundation fieldbus control valve is attached at the outlet of the open tank which is connected to the close tank, tank 2. The outlet flow of the tank 1 will be controlled by the control valve based on the reading from the pressure sensor at the close tank. Water fills up the close tank until it reaches a certain value of pressure that is set by the user. If the pressure drops below the set point, the valve will be opened and water flows into the tank. If the pressure achieves the set point, the valve will be closed and stop water from flowing into the tank. To make sure that the water in tank 2 is not overflowed, the system is enhanced by introducing a level transmitter. The control valve to tank 2 reacts not only to the pressure but also the level of tank 2.

In the real application, the outlet of the close tank will be attached to the sprinkler However, in this project it is replaced by the shower where the flow is controlled by the hand valve due to budget constrain. Although this design used the HART protocol, but for the critical loop the Foundation Fieldbus protocol is the choice.

4.4 Control Strategy Design and Configuration

The process loop has numerous inputs and outputs that will be used to provide information for the next process (see Figure 4-5). All the inputs and outputs signals are important in order to have the desired product that is maintaining the pressure of a close tank at a certain set point.

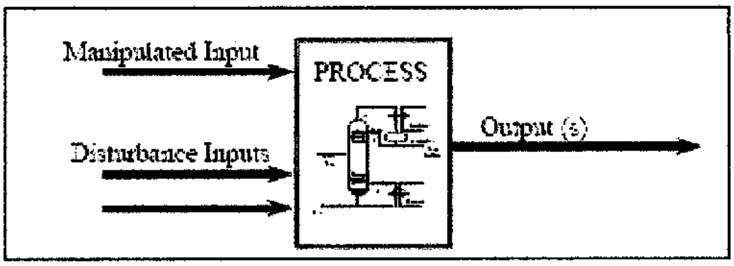


Figure 4-5: Diagram of a certain process

The inputs can be generally:

- **Disturbances.**
  Disturbances are variables that fluctuate and cause the process output to move from the desired operating value (setpoint). A disturbance could be a change in flow, temperature of the surroundings, pressure etc. Disturbance variables (DV's) can normally be further classified in terms of measured or unmeasured signals.

- **The manipulated variable (MV).**
  This is the variable chosen to affect control over an output variable. As the output is being controlled it is normally referred to as the controlled variable (CV). On a typical chemical process there are generally many CV's and MV's.

The objective of a control system is to keep the CV's at their desired values (or setpoints). This is achieved by manipulating the MV's using a control algorithm.

4.4.1 PID Controller

A proportional-integral-derivative controller (PID controller) is a common feedback loop component in industrial control systems. The controller compares a measured value from a process with a reference setpoint value. The difference or "error" signal is then being processed to calculate a new value for a manipulated process input. The new value takes the process measurements value back to its desired setpoint. Unlike the simpler control algorithms, the PID controller can adjust process inputs based on the history and rate of change of the error signal, which gives more accurate and stable control.

A control loop consists of three parts:

1. Measurement by a sensor connected to the process,
2. Decision in a controller element,
3. Action through an output device ("actuator") such as a control valve.

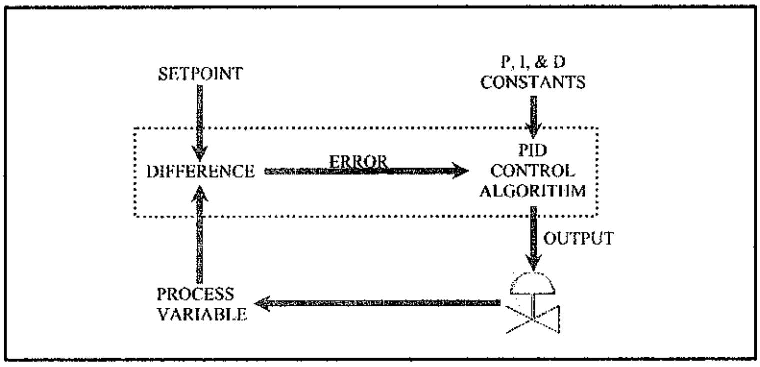


Figure 4-6: PID controller

The controller reads a sensor, subtracts this measurement from a desired value i.e., the "setpoint" and determines an "error". It then uses the error to calculate a correction to the process's input variable so that the correction will remove error from the process's output measurement. It then adds the correction to the process's input variable to remove errors from the process's output.

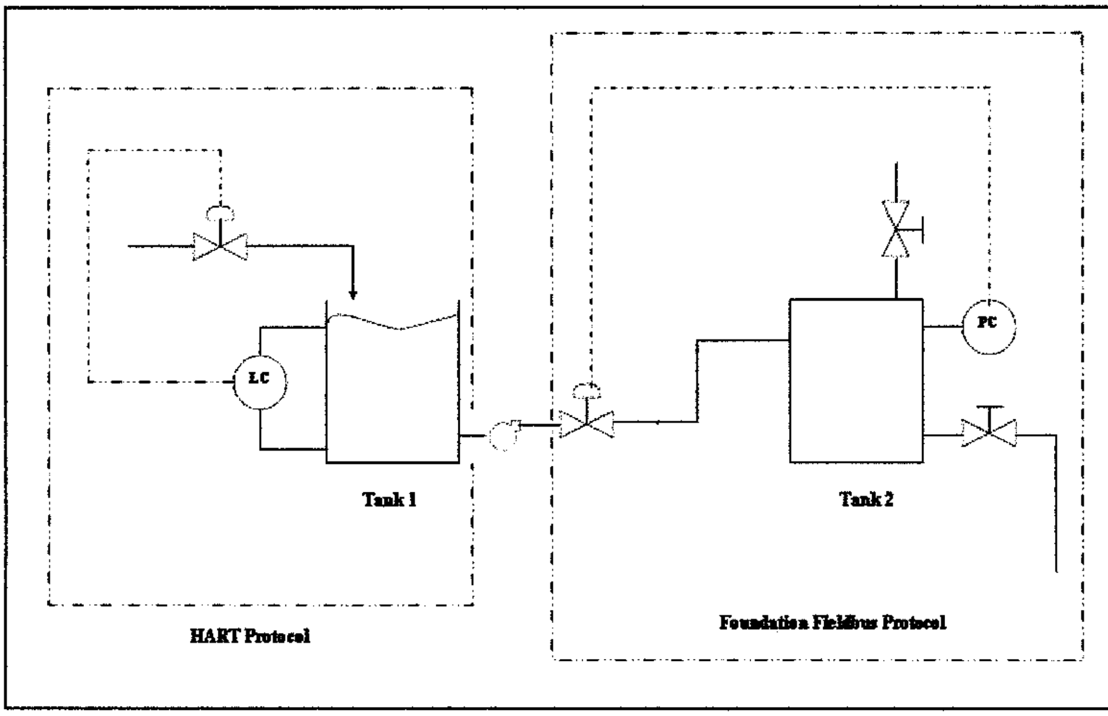


Figure 4-7: PID controller with feedback loop

In this project, when using the feedback control loop with PID controller, the opening of the control valve is controlled by the amount of the pressure in the tank. For a given set point, if the pressure drops below the set point, the valve will be opened to fill up the tank and vice versa. For example, the decreasing of the pressure of tank 2 will increase the opening of the valve of the inlet of close tank to maintain the desired pressure.

The same reasoning goes to the level controller. When the water of tank 1 reaches the set point, the control valve at the feed will be closed in order to prevent more feed going to the tank. If the level drops below the set point, it will give a feedback signal to the controller and give order to the valve whether to open wider, or smaller. This process will be repeated until the set point is achieved.

4.4.2 Feedforward Control

Feedforward differ from the feedback. Feedforward uses the measurement of an input disturbance to the plant as additional information for enhancing single-loop PID control performance [1]. This measurement provides an "early warning" that the control variables will be upset some time in the future. With this warning, the feedforward controller has opportunity to adjust the manipulated variable before the controlled variable deviates from its set point.

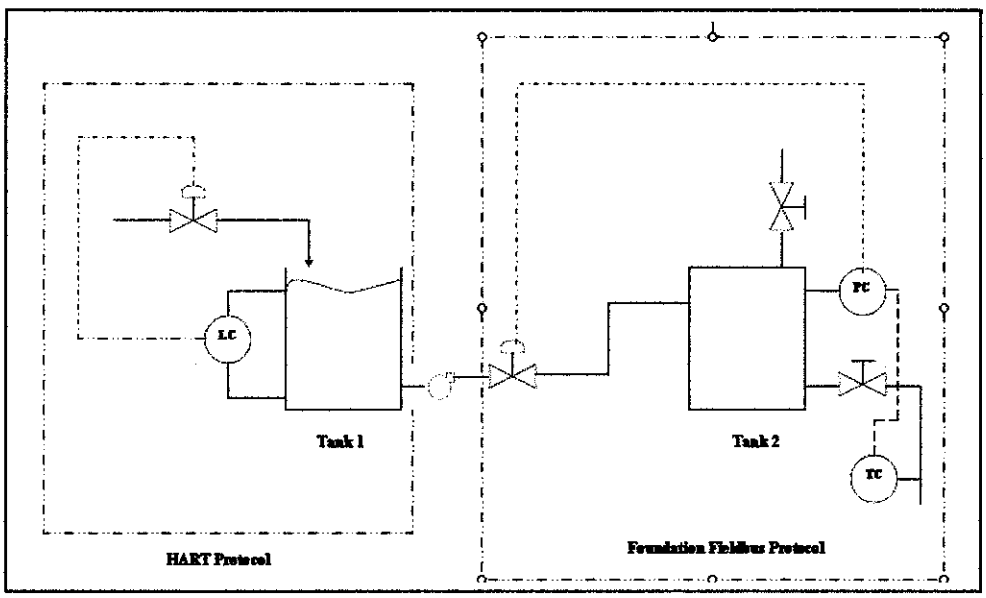


Figure 4-8: Feedforward Control

Applying feedforward requires an additional temperature controller to be attached at the output of tank 2. Both outputs of temperature and pressure controller will be the set point to control the opening and closing of the inlet control valve of tank 2 (see Figure 4-8). What actually happen in this control design is that when there is a fire and which result the increasing of temperature and will be sensed by the temperature controller. Before the pressure drop due to the water goes sprinkler in this case the opening of hand valve, the output from the temperature sensor will send signal to the controller to give early warning to the valve to open. In this case, the pressure would drop slightly lower compared if there is the feedback loop alone. This will enhance the control ability of the controller.

4.4.3 Ratio Control

Ratio control differs from the feedback. Ratio control is used to ensure that two or more flows are kept at the same ratio even if the flows are changing. [1] For this project, ratio control is used for measuring the ratio of pressure and flow in order to enhance single-loop PID control performance. In this control strategy, the pressure is set at a certain value. The amount of inlet flow of tank 2 will be control by the ratio controller. After the pressure has achieved the set point, the valve will be closed and no more flow to tank 2.

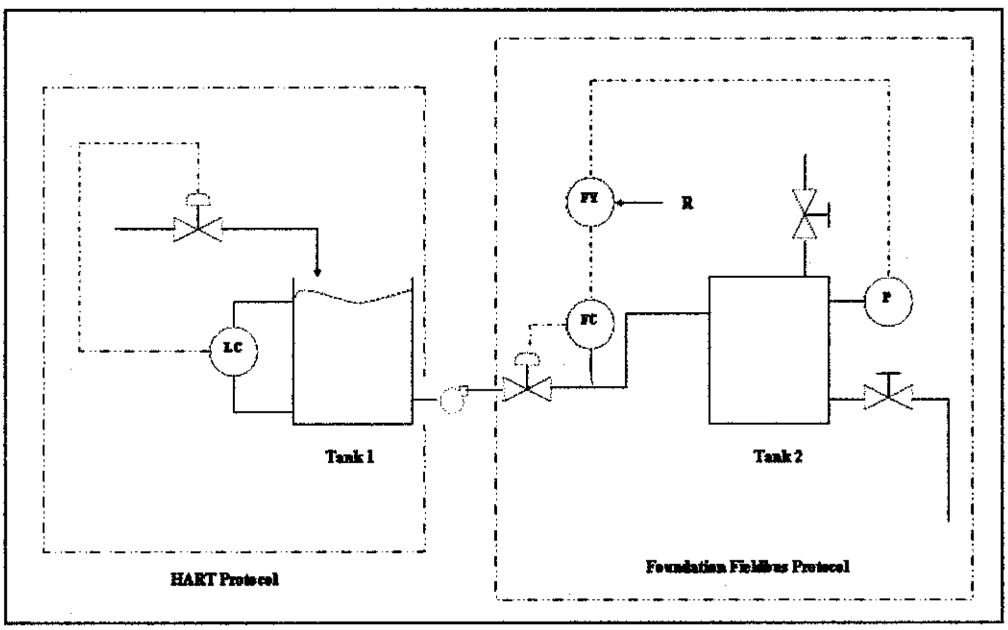


Figure 4-9: Ratio Control

Applying ratio control needs to have a flow controller to be attached with the pressure transmitter of tank 2. Both the outputs of flow and pressure controller will be the set point to control the opening and closing of the inlet control valve of tank 2, depending on the certain amount of ratio (see Figure 4-9).

4.4.4 Cascade Control

Cascade control is one of the most successful methods for enhancing single-loop control performance. In cascade control, the output of the primary loop will be the set point for the secondary loop. Referring to the Figure 4-10, the temperature controller is the primary while the flow controller is the secondary. The output of the temperature controller will be the set point of the flow controller, the secondary. [1]

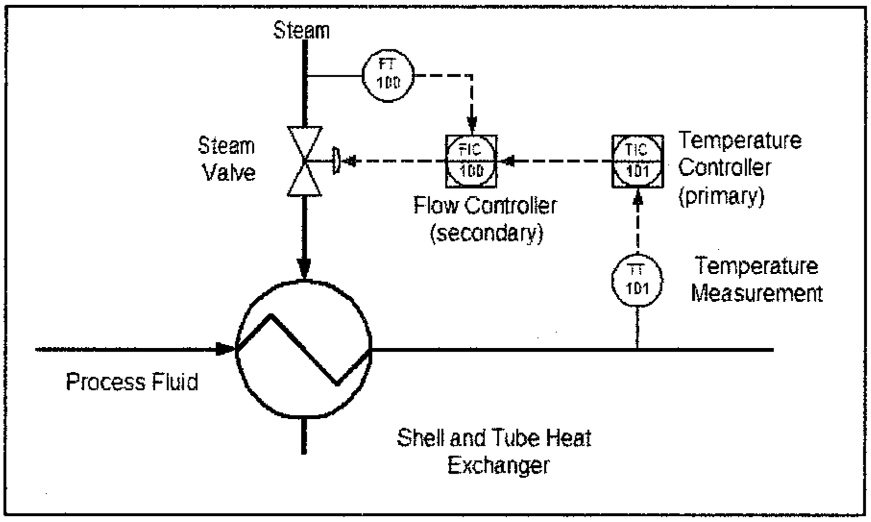


Figure 4-10: Cascade Control

Reasons for cascade control include:

- Allow faster secondary controller to handle disturbances in the secondary loop.
- Allow secondary controller to handle non-linear valve and other final control element problems.
- Allow operator to directly control secondary loop during certain modes of operation (such as startup).

Requirements for cascade control:

- Secondary loop process dynamics must be at least four times as fast as primary loop process dynamics.
- Secondary loop must have influence over the primary loop.
- Secondary loop must be measured and controllable.

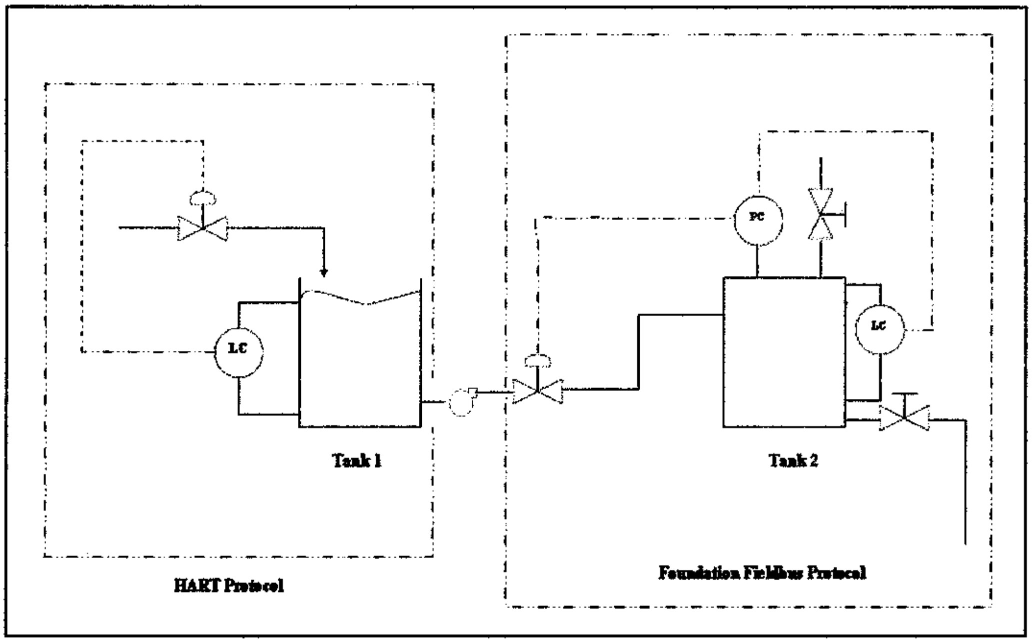


Figure 4-11: Cascade Control in the process design

Figure 4-11 shows the arrangement where the level controller is the primary loop and the pressure controller is the secondary loop. The output from the level controller will be the set point to the pressure controller. In this case, instead of using single loop only, having both pressure and level measurement will increase the control performance of the system. The advantage of having the level controller is if there is any leakage in the close tank, the water level will not exceed the limit because the priority is set to the level rather than pressure itself.

In the first draft design, a flow transmitter will be put at the inlet of tank 2 and be cascaded with the pressure controller. But, as been informed by the lab technician, there is no spare part of orifice plat that can be use in this project. Due to this problem, the design has been changed by using the level controller.

CHAPTER 5
INSTALLATION AND COMMISSIONING

5.1 Decommissioning Existing Plant

In this project, older plants were upgraded with the fieldbus system. The plant consists of two tanks; open and close tank. Both tanks were used for demonstrating the level measurement using the conventional instrument devices. All the transmitter and control valve need to be decommissioning in order to suit our foundation fieldbus instruments. Some of the existing tubes and pipes are being reused as this project requires the level controller strategies for both tanks.

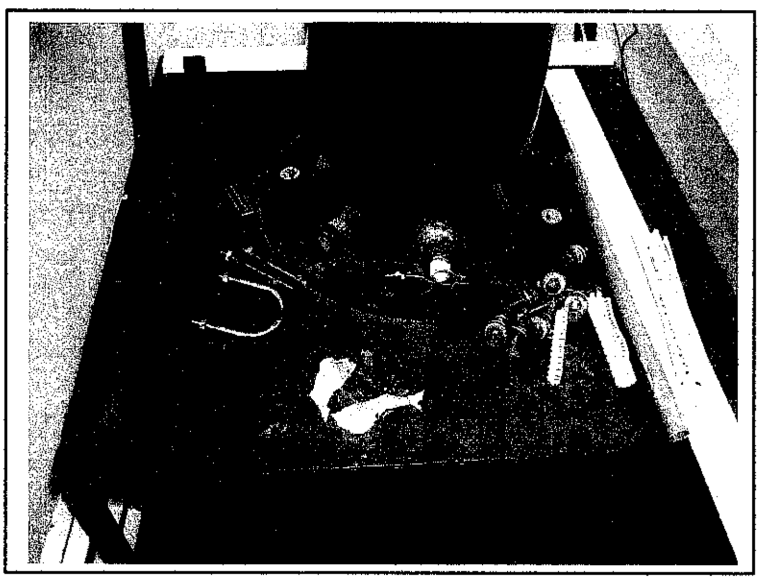


Figure 5-1: Decommissioning process

5.2 Painting Process

The trolleys that support both tanks are rusty due to the effect of corrosion. Because of that, the tanks are painted with oil base painting which is red-orange in color same as the function of fire water pump system. The painting process become easier as all devices have been detach from the plant.

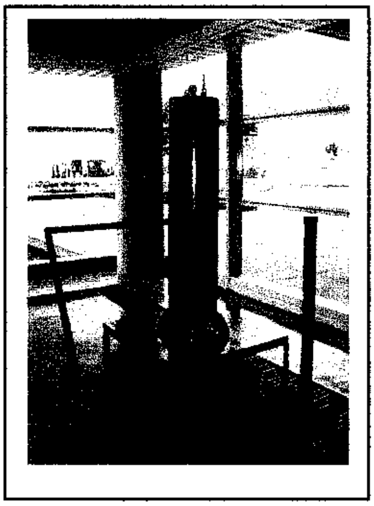


Figure 5-2: Painted Platform

5.3 Hardware and Piping Installation

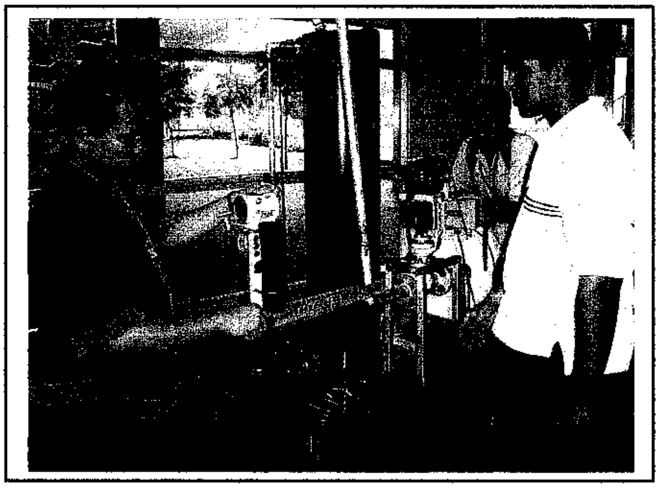


Figure 5-3: Piping and hardware installation

In this project two tanks, two control valves, three differential pressure transmitter, two pumps and two hand valves need to be connected to imitate a fire water pump system. The pipe that has been used is the galvanic type. For the manifold, 10mm cuprum tubing was used together with the joints. The tubing is connected from the differential pressure transmitter to the tank and familiarization of bending technique during the internship is useful throughout the commissioning of all instrument devices.

5.4 Network Installation

This project used both HART and foundation fieldbus protocol of network communication. For the fieldbus network it has two wires used for both communication and power supply. The devices are connected in parallel, thus it is possible to connect or remove device while the bus is running. Each segment of the fieldbus network has to have two terminators, one in each end. In this network, the power supply, host end terminator and host interface have been integrated into a single device, DFI-302 to simplify wiring in the panel. There are two methods in supplying power to the devices; bus powered and non bus-powered. Bus-powered devices take power from the bus. The non bus-powered devices get power over separates wire. For the HART network, the measuring device is supplied by external power source while for the final element such as control valve, the signal is produced by the controller itself.

5.4.1 *Establishing Loop Connections for HART Network Wiring*

The controller, recorder, power supply, temperature transmitter, control valve, 250Ω resistance decade box and differential pressure transmitter are used in establishing the loop connections. To establish the HART connection loop, the wiring steps to be conducted are:

i. The positive and negative terminal of the differential pressure transmitter is connected with a wire as shown in Figure 5-4

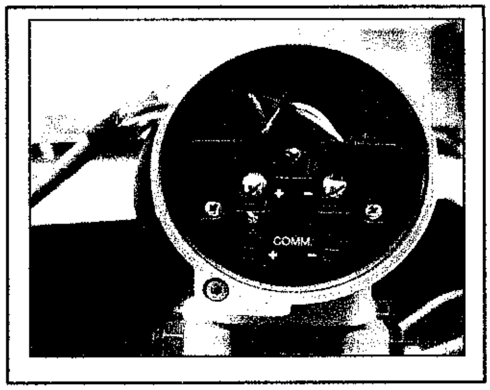


Figure 5-4: Wiring connection at the differential pressure transmitter

ii. At the power supply (**Figure 5-5**), the ground terminal (white jumper) is connected to the ground terminal of the controller. The positive supply (red wire) is connected to the positive terminal of the differential pressure transmitter.

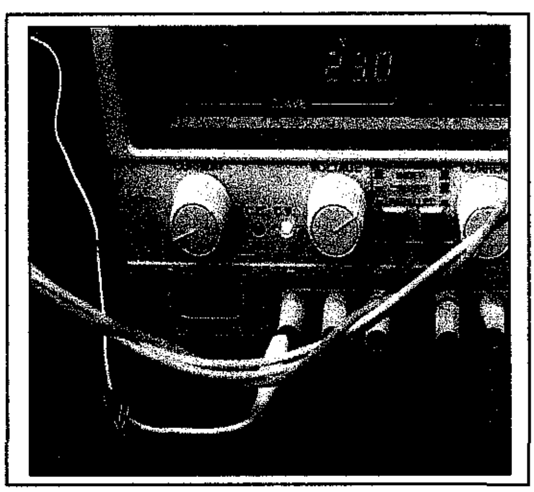


Figure 5-5: Wiring connection at the power supply

iii. **Figure 5-6** shows the connections made at the controller. Terminals 1 and 2 (in red shape) are the positive and negative terminals for Process Variable (PV) input, respectively. The range of input is to be between 1 to 5 Vdc. The blue shape highlights the terminals 22 and 23, which represent the positive and negative terminals of manipulated variable (MV) output 1, respectively. The output range is in between 4 to 20 mA.

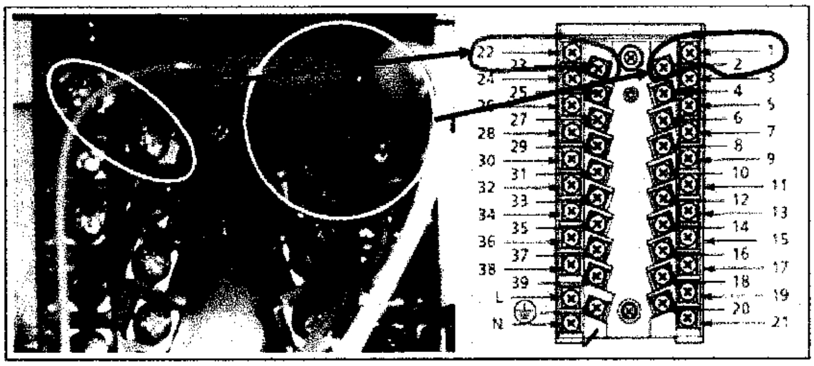


Figure 5-6: Connections at the controller (backside)

The positive terminal of the PV input is connected to the ground terminal of the differential pressure transmitter (yellow jumper). The other connection (white jumper) for the positive terminal comes from the ground terminal of the resistance decade box. For the negative terminal, it is connected to the ground terminals of the resistance box (green jumper) and power supply (red jumper). The wiring from MV output is connected to the positioner valve as shown in **Figure 5-7**.

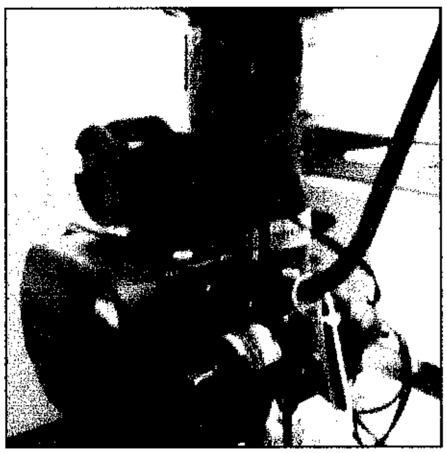


Figure 5-7: Wiring from controller into the control valve

iv. **Figure 5-8** shows the connections at the backside of the recorder. Input terminal of channel 1 is used, as circled by the white and red oval in the figure.

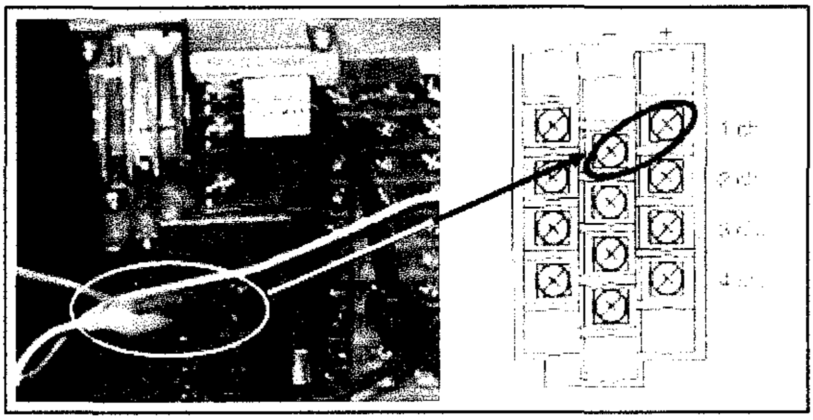


Figure 5-8 Connections at the recorder (backside)

The positive terminal (green jumper) and negative terminal (yellow jumper) is connected to the positive and negative terminal of the resistance decade box, respectively. With these connections, the positive terminal of the recorder is also connected to ground terminal of the transmitter and negative terminal is connected to the ground terminal of the power supply.

v. **Figure 5-9** shows the connections at the decade box.

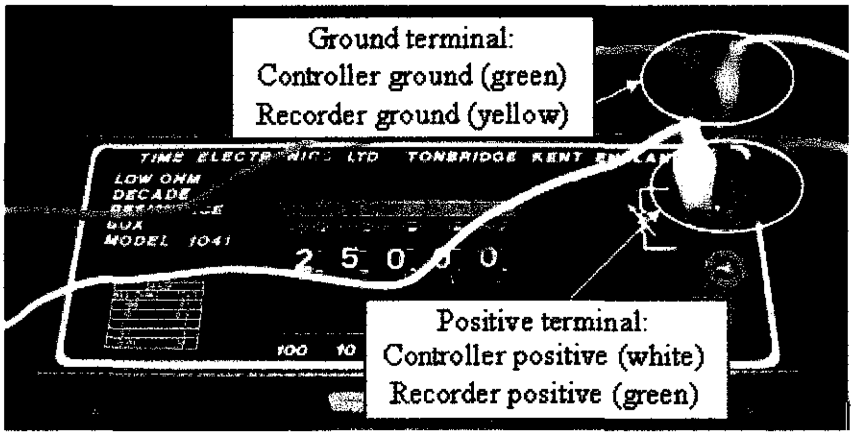


Figure 5-9 Connections at 250Ω Resistance Decade Box

vi. The complete connections described for HART network can be represented into loop drawing as Figure 5-10.

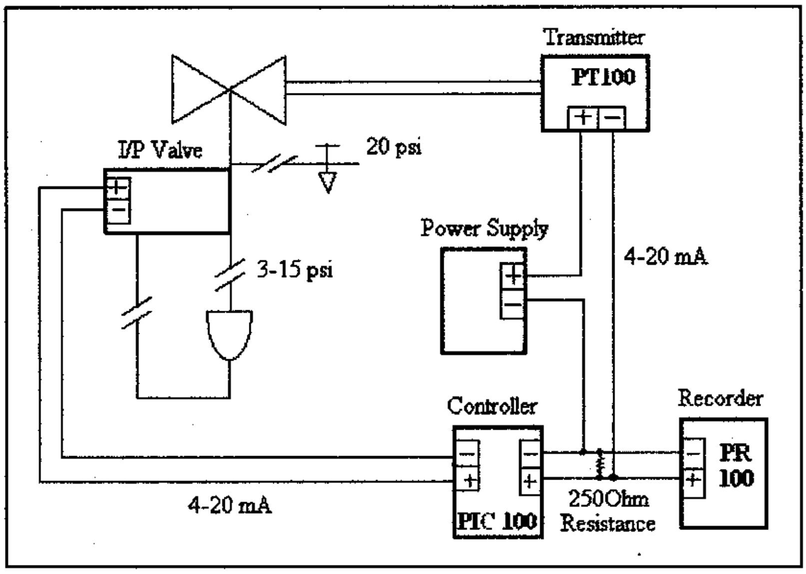


Figure 5-10: Loop drawing designed for HART network

5.4.2 *Foundation Fieldbus Network Wiring*

The test platform of fire water pump comes with Daisy-Chain topology as shown in Figure 5-11. This fieldbus topology applies end-type terminator for the following reasons. The primary function of the terminator is to convert the transmit current to a voltage that can be received. According to the standard, the current must be modulated with amplitude between ±7.5 mA AC to ±10 mA AC (Smar is using ±8mA). When the fieldbus signal traveling down the wire reaches the end, it is faced with a change in impedance from the characteristic impedance of the wire to the infinite impedance of open air. This will cause a part of the signal power to be reflected back up through the wire. The reflected signal interferes with the oncoming "real" signal. If the reflected signal is powerful enough, it may distort the "real" signal such that the communication does not work. The terminator has the same impedance as the cable such that when placed at the end the fieldbus signal sees no change in impedance and hence there is no reflection. It is also clear that the terminator must be at the end of the wire to really work.

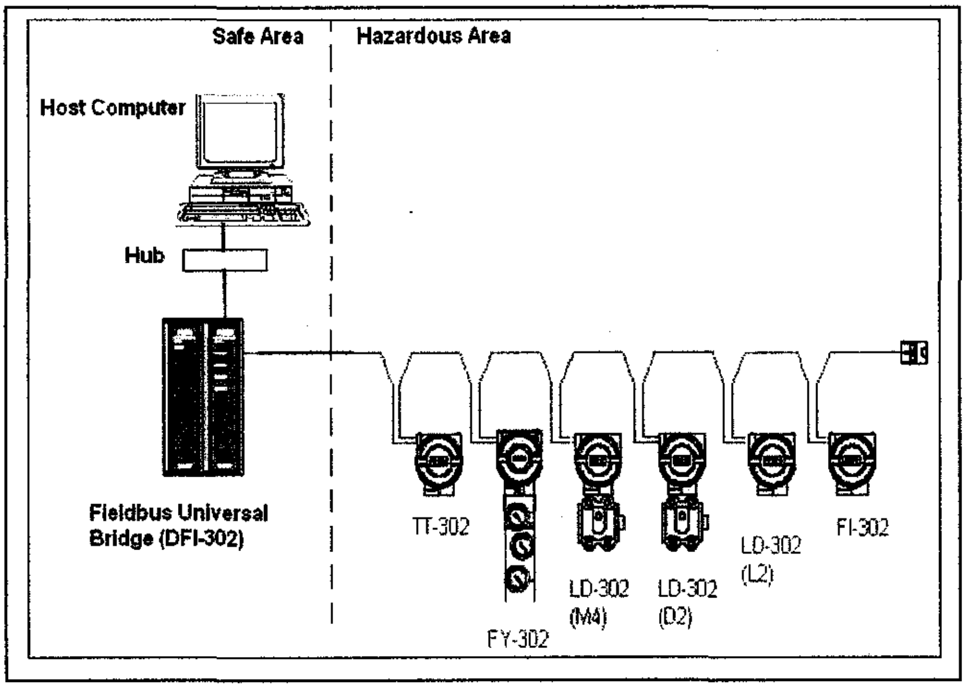


Figure 5-11: Daisy-Chain Topology

To establish the fieldbus topology, the wiring steps to be conducted are:

i. The Electrical Connection Cover is released by rotating the cover anti-clockwise. Signal wires must be kept separate from sources and noise. Because of the polarized signal and bus-powered devices the polarity of the connection must be under consideration. The devices are all connected in parallel, thus colour-coded crimp is used to unite all negative terminal in same node and all positive terminal in the other node.

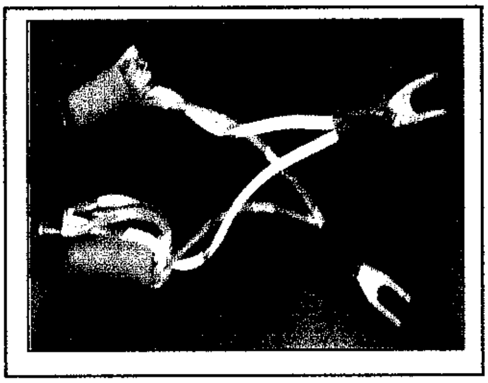


Figure 5-12: Colour-coded crimp

ii. Using the Daisy-Chain topology needs the cable to be connected from device to device meaning that the possibility if a device disconnected and interrupted other device are high. Therefore the same conduit for "in" and "out" wires is used in order to enable removal of device without disconnecting entire bus (see Figure 5-13).

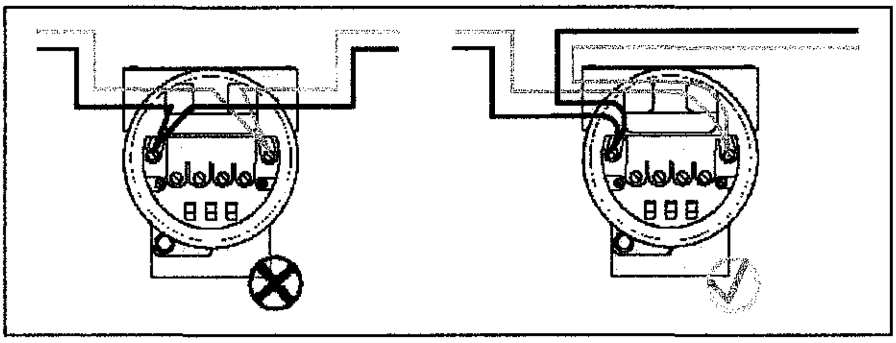


Figure 5-13: Daisy-Chain Wiring

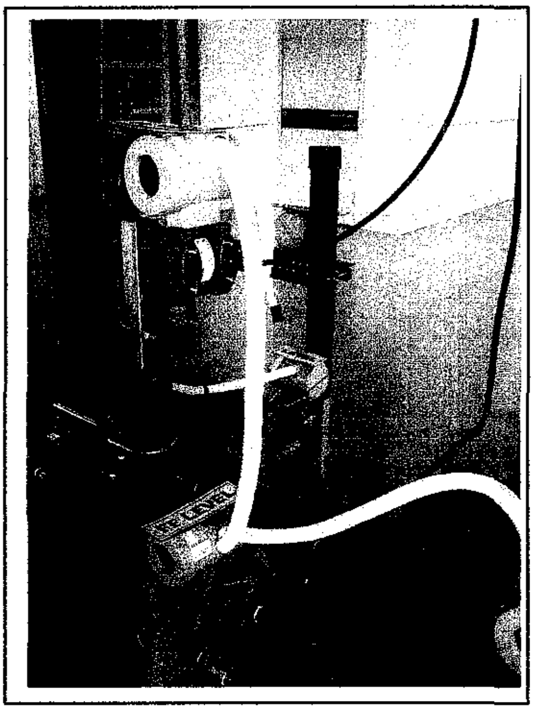


Figure 5-14: Daisy-Chain Topology Implementation

CHAPTER 6
SYSTEM CONFIGURATION AND INTERFACING

6.1 Foundation Fieldbus Configuration

In the fieldbus system, it requires the engineer to configure the network and also the control strategies together with the devices. This objective is achieved by using the SYSCON (System Configurator) which is a software tool developed to configure, maintain and operate especially for the SMAR Fieldbus products line, using a personal computer (PC) as a host with a Fieldbus interface.

The configuration process starts by creating a file for the workspace. It can be divided into two parts; The Logical Plant and the Physical Plant. In the logical plant where the logic part of the system is kept such as the connection function blocks while for the physical plant, the configuration of the fieldbus network been made for all field devices installed in the segment. Then the configuration of the field device and control strategies can be established by initializing the communication between devices and host PC, uploading the fieldbus network, commissioning the device, design the control strategies in function block and downloaded back the configuration in the devices.

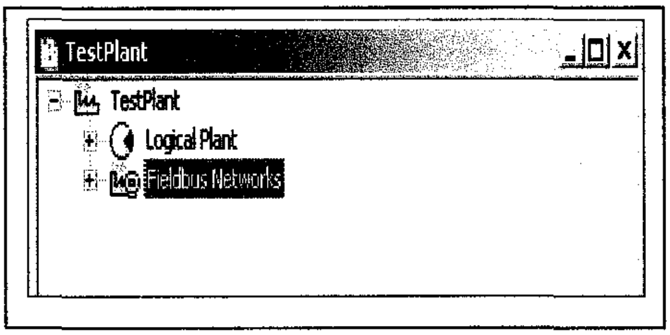
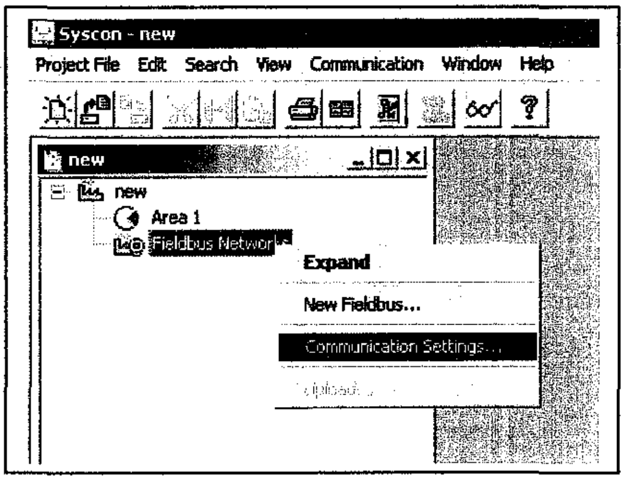


Figure 6-1: SYSCON Main Window

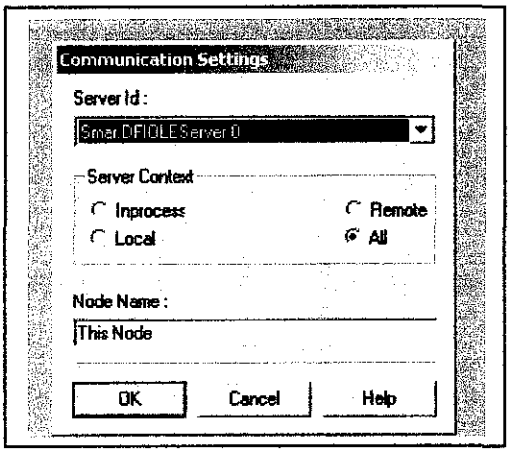
6.1.1 Initializing Device Communication

The initialization of device communication is significant for the SYSCON to detect the fieldbus network. Below are the steps taken to initialize the online communication:

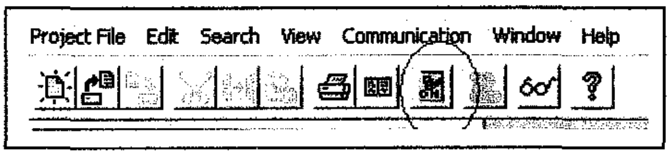
i. The communication setting is selected in the popup menu activated by right clicking Fieldbus Network icon as the following figure.



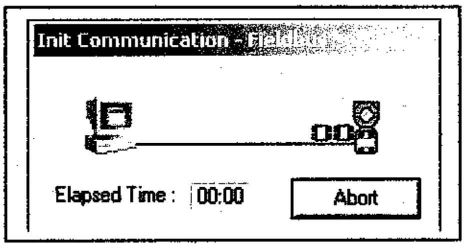
ii. The server ID is set to Smar.DFIOLEServer.0 in the communication setting dialog box.



iii. The ON Button in the toolbar is clicked.



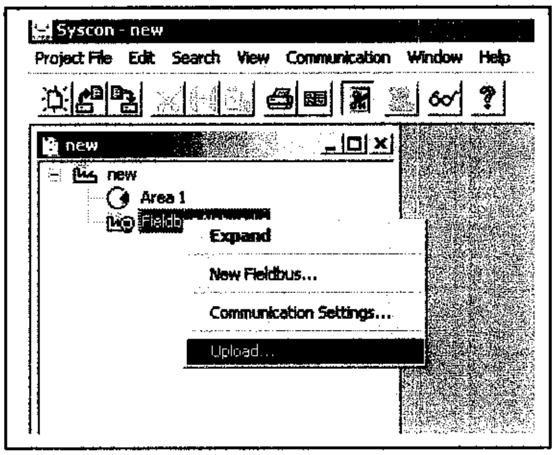
iv. The communication initializing window will popup and the bridges installed in the computer is attached to the configuration software.



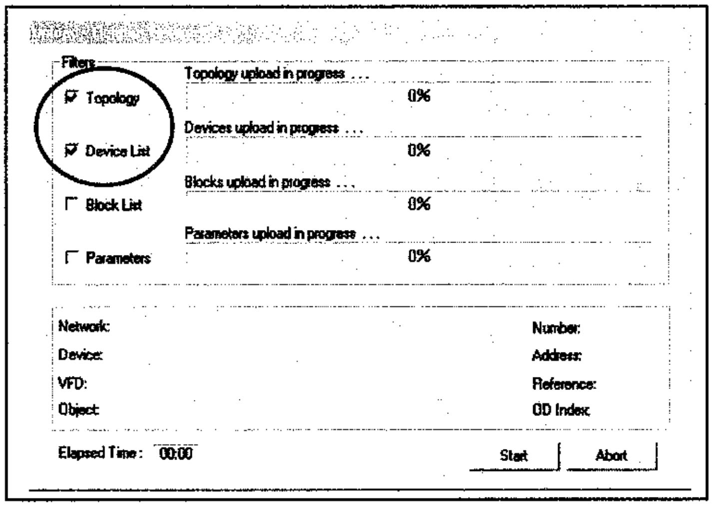
6.1.2 Uploading Fieldbus Networks and Devices

The online communication has been initialized in the previous part. The device topology and device list is needed to be uploaded for the configuration process. Below are the procedures to upload the device to the Physical Plant.

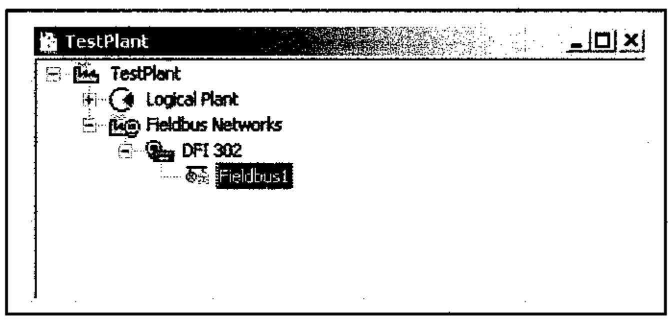
i. The Fieldbus Network is right clicked in order to activate the popup menu. The Upload icon is selected in order to upload the devices list into the network



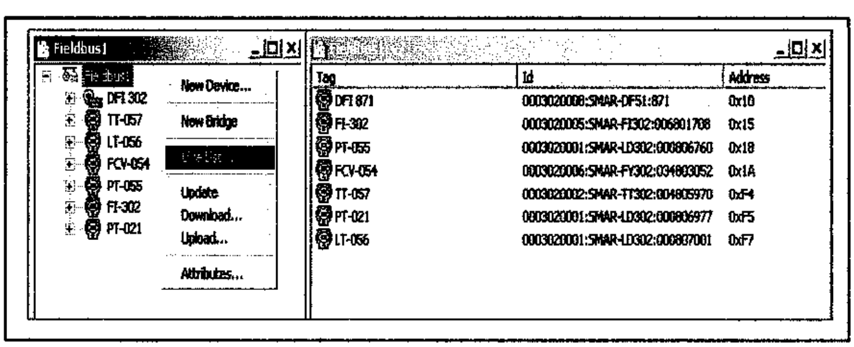
ii. After the Upload-Fieldbus Network box appeared, the Topology and Device List is checked in the filters selection before the Start button is pressed.



iii. The Fieldbus 1 icon is double clicked to open the network that being used. In the Fieldbus 1 window, the popup menu is activated and Live List is selected.



iv. This window will popup and show each devices address and its unique device identifier ID



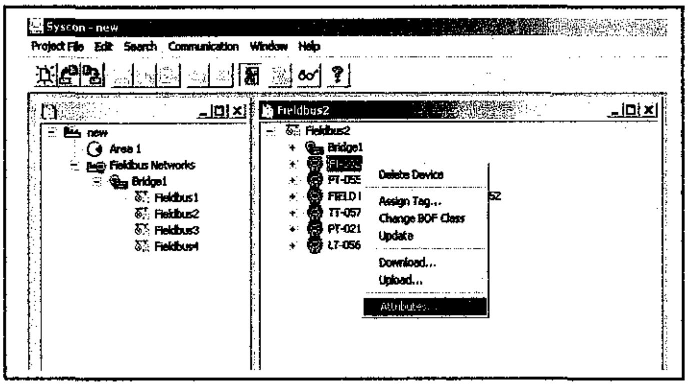
6.2 Device Commissioning

One of the advantages using Foundation Fieldbus is the device can be easily commissioned from the control room. The DFI-302 is automatically assigned node address assignment for each device.

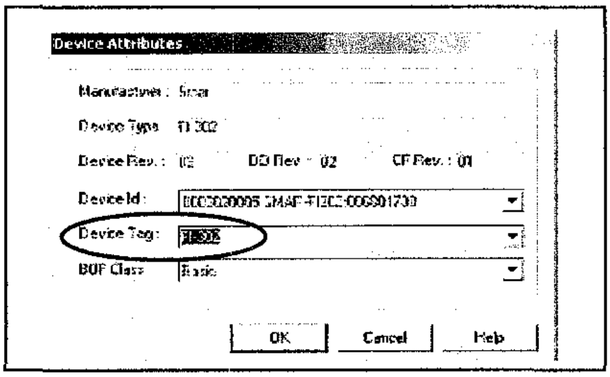
6.2.1 Changing Device Attribute

The attributes for each device are unique and assigned by the manufacturer in order to ovoid network conflict. This unique attribute serves the foundation fieldbus to be interoperability where devices from other manufacturer can work together in the same network connection. Below are the procedures to change the device attribute:

i. The popup menu is activated by right clicked on any device in the Fieldbus window and attribute is selected from the list



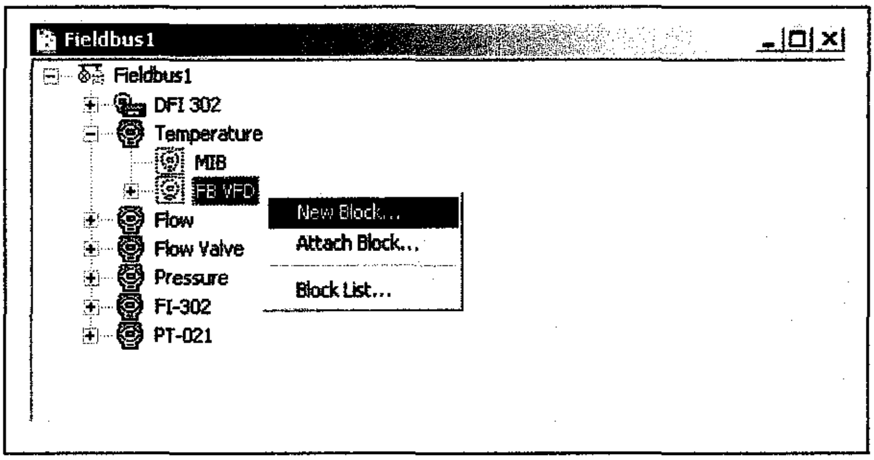
ii. The Device Attribute box is appeared. Only Device Tag is allowed to be changed by the user due to the product line and network conflict protection taken by manufacturer.



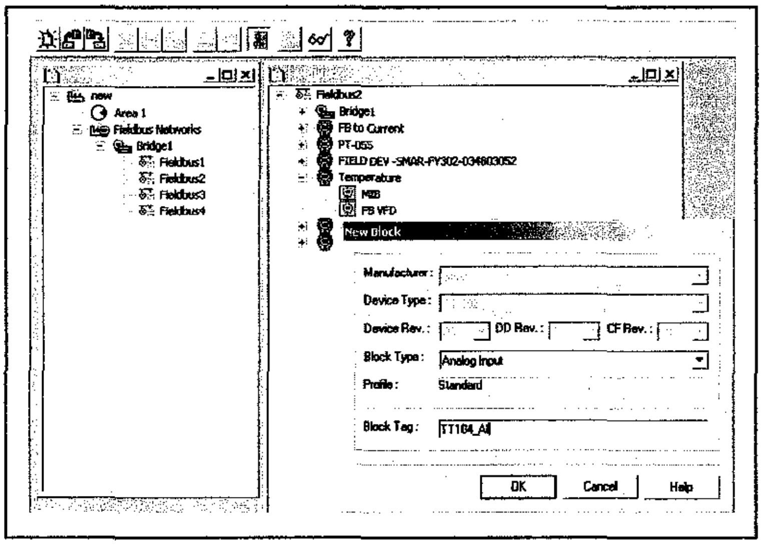
6.2.2 Creating the Function Block

By linking several function blocks, various control strategies can be implemented in the fieldbus network. A device is allowing the selection up to 20 function block per device. Below are the steps to add blocks for a device.

i. To add a new block, the popup window is activated with the right mouse button at the FB VFD. The icon new block is selected as seen in the following picture.



ii. The new block windows will popup. The block type is selected from the menu and tagged using preferred name.

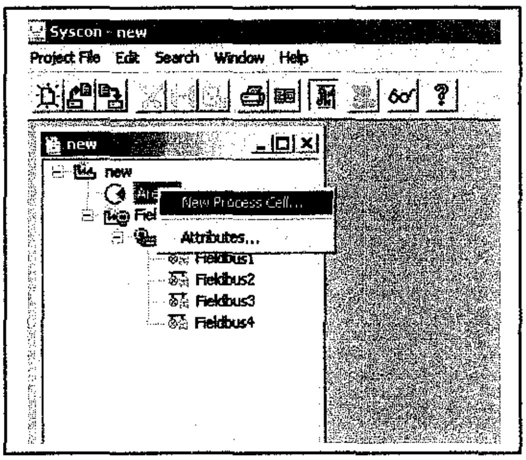


6.3 Creating the Control Strategies

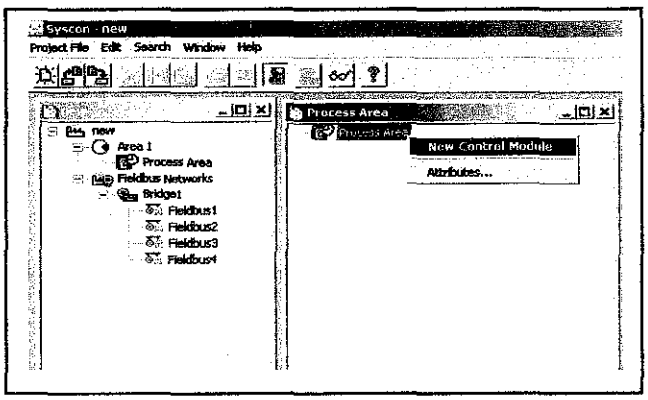
The control strategies to be implemented in this project are created and configured in the logical plant area window. Two control strategies have been combined together to individually control the process of heat exchanger. The control strategies involved are:

a. Single loop feedback control
b. Feed forward and feedback control

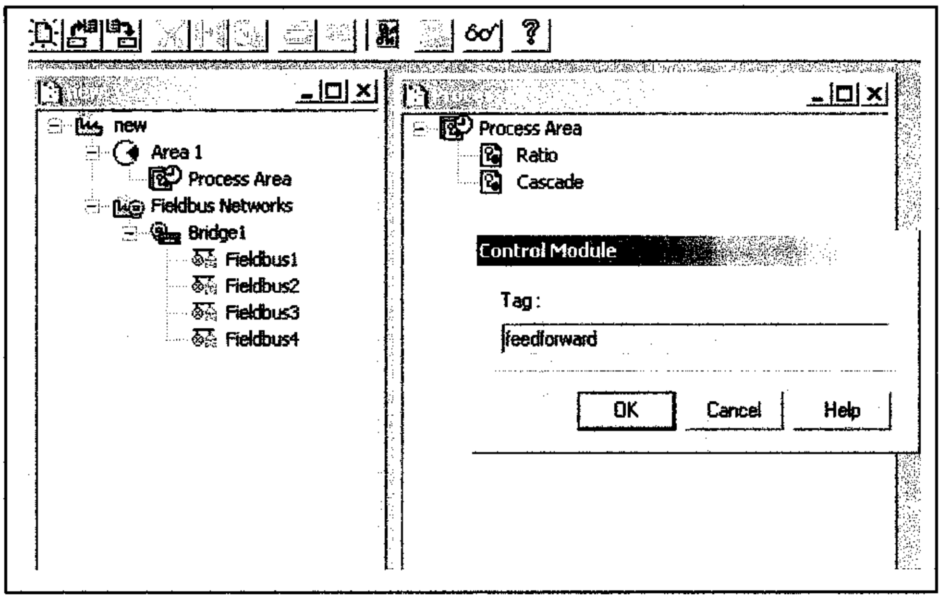
i. New Process Cell is created under the Logical Plant by activated the shortcut menu with the right mouse button. New process cell tab is selected and Process Area window is appeared.



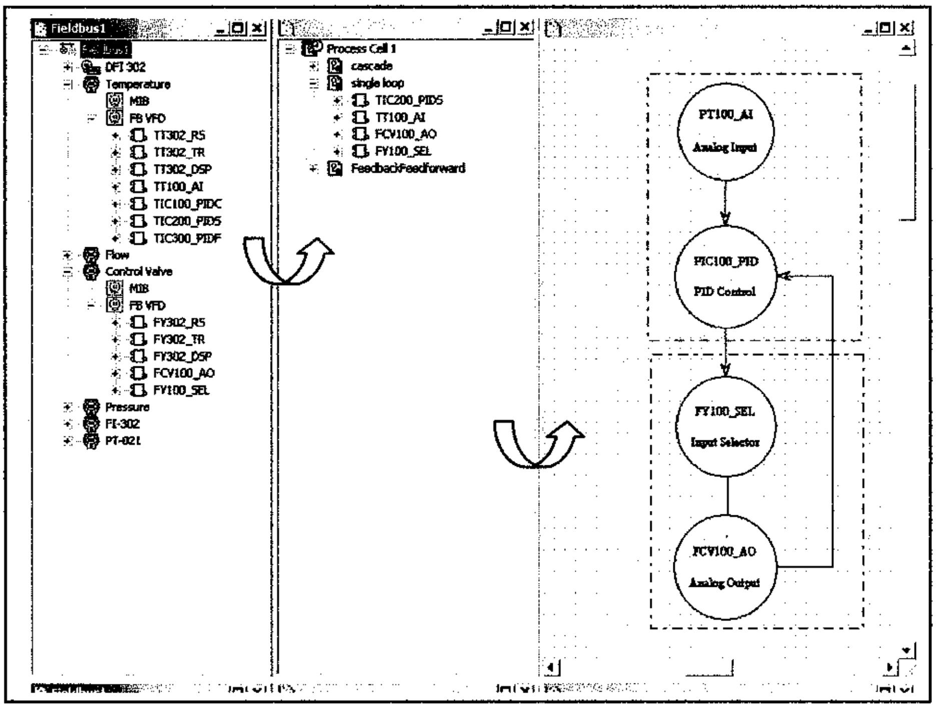
ii. In the Process Area window, the shortcut menu is again activated with the right click mouse button. The New Control Module tab is selected to create a control strategy.



iii. The Control Module windows will popup and the tag for each control strategy can be created



iv. The specific control module is clicked to open the working area. Three windows are opened together as shown in figure below. The desired block is dragged from the Bridge 1 window to the Process Area and to the desired Control Module window. All the blocks are connected with the link icon according to the control strategies designed.



6.3.1 Single Loop Feedback Control Function Block

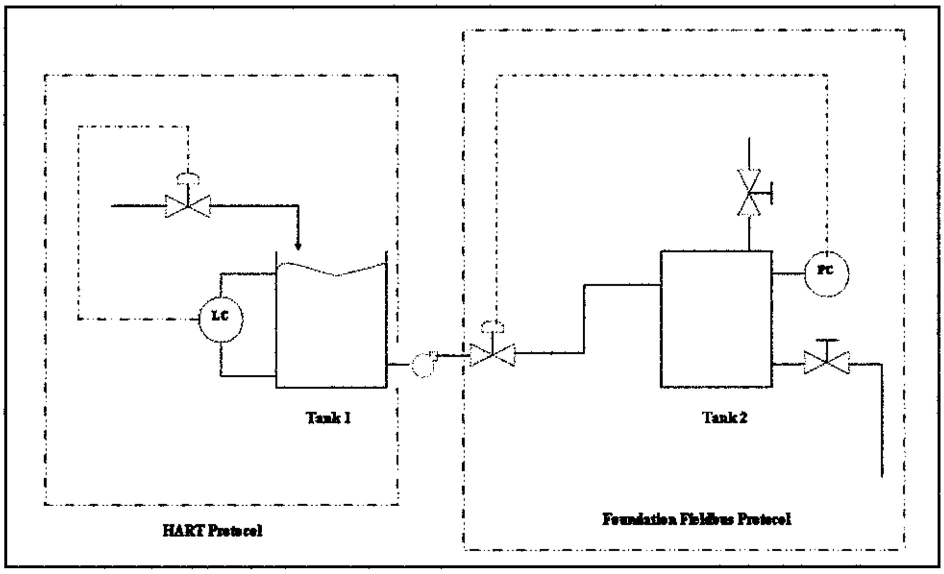


Figure 6-2: P&ID of Single Loop Feedback Control

Feedback control strategy is one of the process control used in this project. The disadvantage of this control strategy it is only depending on a single transmitter to provide the response back to the controller valve. This control scheme involve only pressure transmitter and control valve and does not take into consideration of any other process variable.

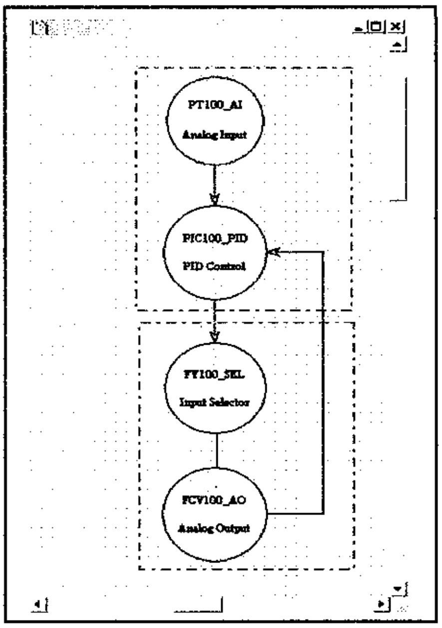


Figure 6-3: Function Block of Single Loop Feedback Control

6.3.2 Feedforward Control Function Block

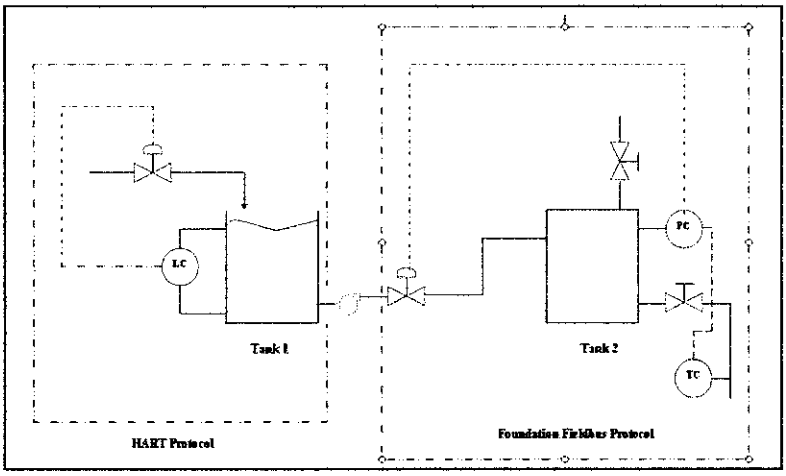


Figure 6-4: P&ID of Feedforward Control

In feed forward control, an input disturbance is measured to determine an adjustment to an input manipulated variable before the controlled variables deviates from its set point. In this project, the temperature sensor giving the early warning to the system that a fire might occur and the pressure of tank 1 will drop as the fire fighting is operated. However, feedforward control alone cannot eliminate the steady state offset. Hence, feedforward is combined with feedback control as each has important advantages that compensate for deficiencies of the other. The major advantage of feedback control is that it reduces steady-state zero offset to zero for all disturbances.

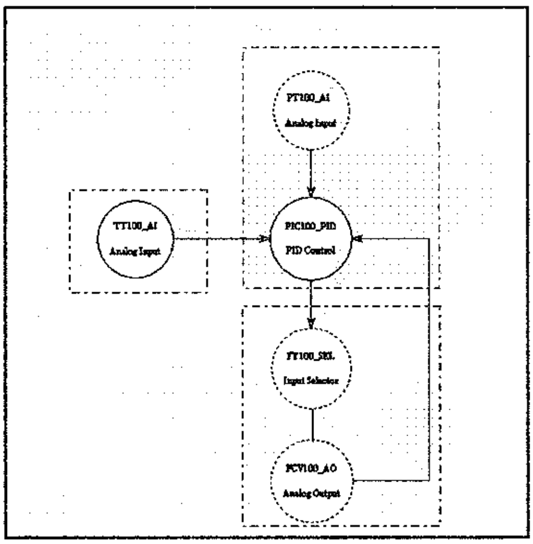


Figure 6-5: Function Block of Single Loop Feedback Control

CHAPTER 7

FIELDBUS SAVINGS AND BENEFITS

7.1 Data Quality and Quantity

7.1.1 Increase quality of product

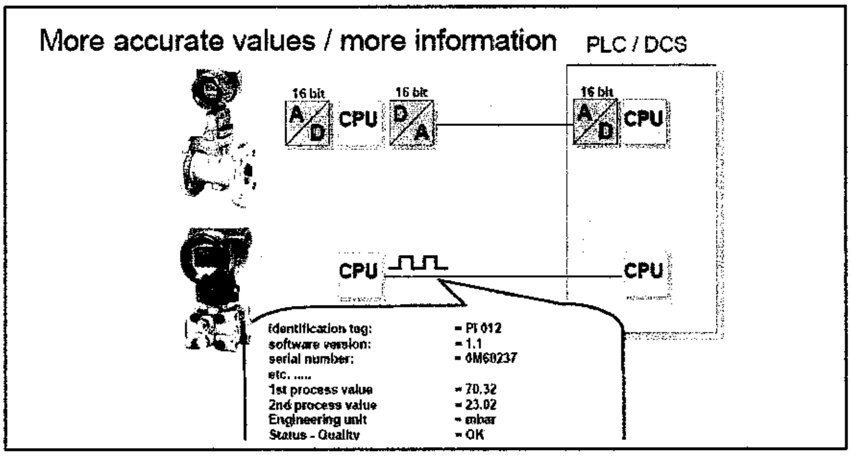


Figure 7-1: HART and Fieldbus Data Transfer

Figure 7-1 illustrates the HART and foundation fieldbus data transferring from the field device to the PLC or DCS. Looking to the HART signal, there are 3 times conversion from A/D or D/A before reaching the controller. These phenomena will increase the distortion of the signal making the signal less accurate and result to the decrease of data quality. Having the inaccurate data to be processed in the controller will result the final element to react inefficiently to the process loop. As the conclusion, the product produce will less quality and decrease the profit of the company.

Different from using the foundation fieldbus technology, it has increased the resolution and less distortion of the data transferred due to reducing of data conversion. The data or measurement from the fieldbus device is higher in term of accuracy taking the advantage of digital signaling. This will result to the increasing of product quality and at the same time rising the productivity owing to the precise data that been processed in the controller.

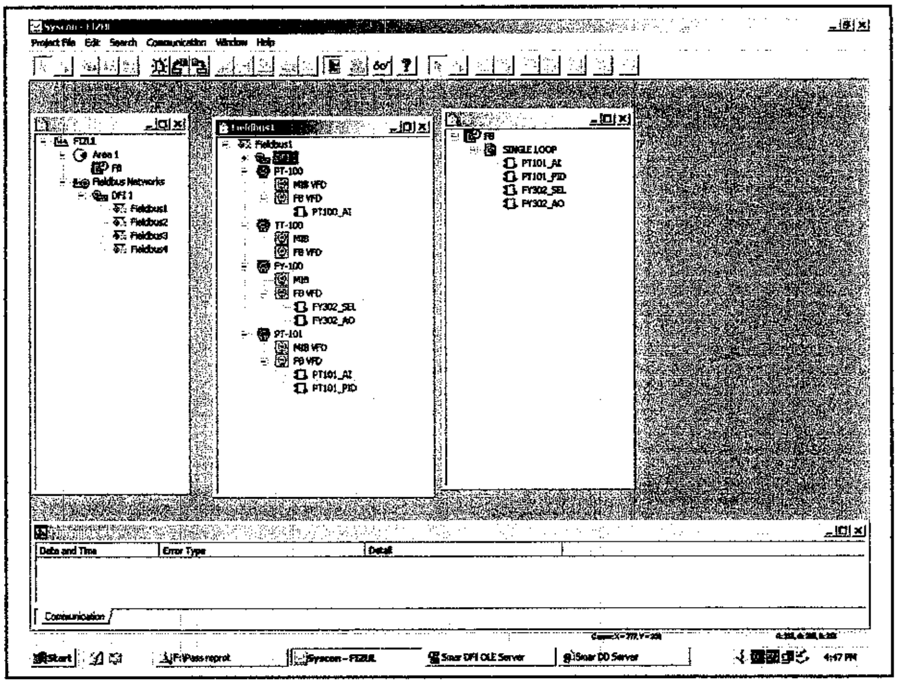


Figure 7-2: Online Configuring

As shown in figure 7-2, the entire configuration of this project is done online for the foundation fieldbus while for the HART portion it is all done in the field. It is much easier to calibrate the device in the control room rather to go to the plant. This is due to the benefit of using the digital communication network where many data can be transferred not only the measurement values but also for configuration purposes.

7.2 Decrease Total Cost

7.2.1 Hardware reduction

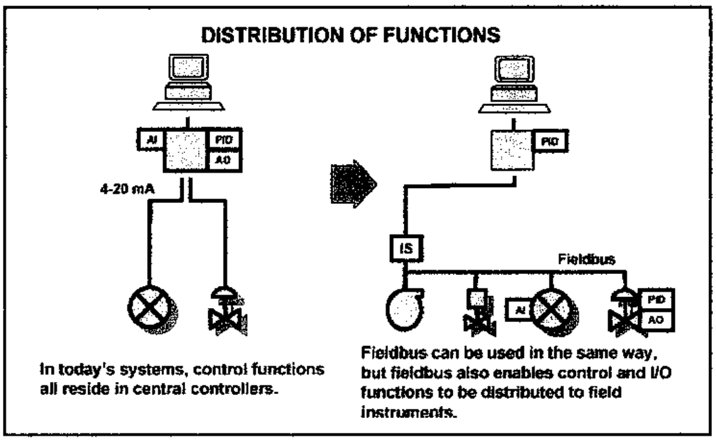


Figure 7-3: Conventional and Fieldbus Control Loop

As shown in Figure 7-3, sensors and actuators for the conventional control loop were hardwired to the controller using an individual dedicated pair of wire. For the foundation fieldbus control loop, each device can be attach to the bus and result to the hardwire reduction.

In term of the IS barrier used in the control loop, using the conventional control system each segment need to be attach with IS but for foundation fieldbus technology, IS barrier is only used at the line before connecting to the controller. Figure 7-3 points up the shift of control system functions to the field level. Such implementation reduces the I/O cards and control equipment needed such as card files, cabinet and power supply.

As shown in Table 4 is the cost comparison between conventional control loop and foundation fieldbus protocol. Although the transmitter and the valve for the foundation fieldbus is much higher, but by using fieldbus 30% of the total cost of this project can be reduced. The wiring for fieldbus is lower compared to the conventional system and by using the foundation fieldbus protocol less device is needed to complete this project.

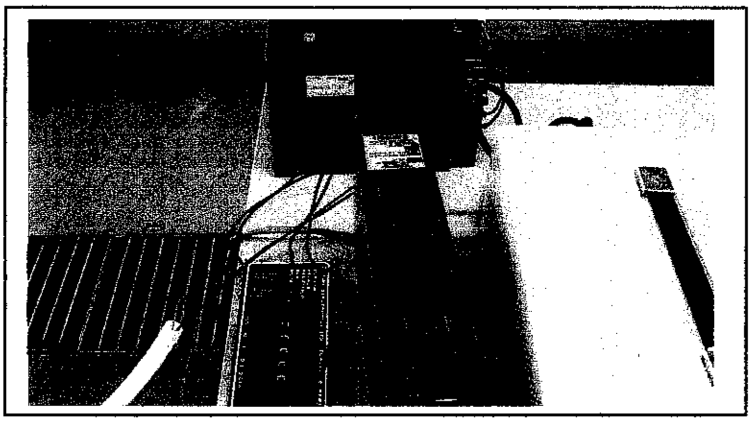


Figure 7-4: Wiring connection using HART

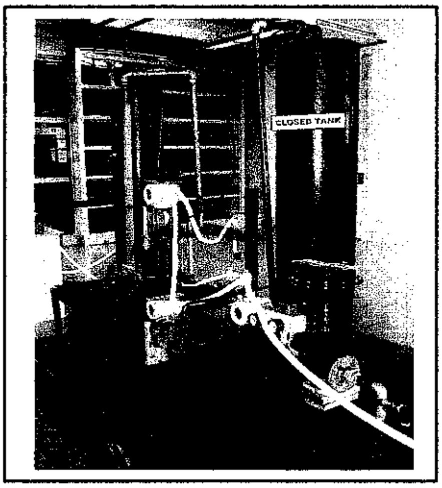


Figure 7-5: Wiring connection using Foundation Fieldbus

TABLE 4: Cost Estimation for Conventional and Fieldbus System

	Conventional (RM)	Fieldbus (RM)
Power Supply	200	120
Interface	280	640
Wiring and Fittings	5 600	1 160
Valve	2 260	4 100
Transmitter	2 200	2 500
Standalone PC	NA	3 000
Hub	NA	500
Terminator	NA	200
Controller	2 100	NA
Recorder	2 900	NA
Decade Box	1 500	NA
Labor Cost	2 040	1 400
TOTAL	**19 080**	**13 620**

7.2.2 Maintenance cost reduction

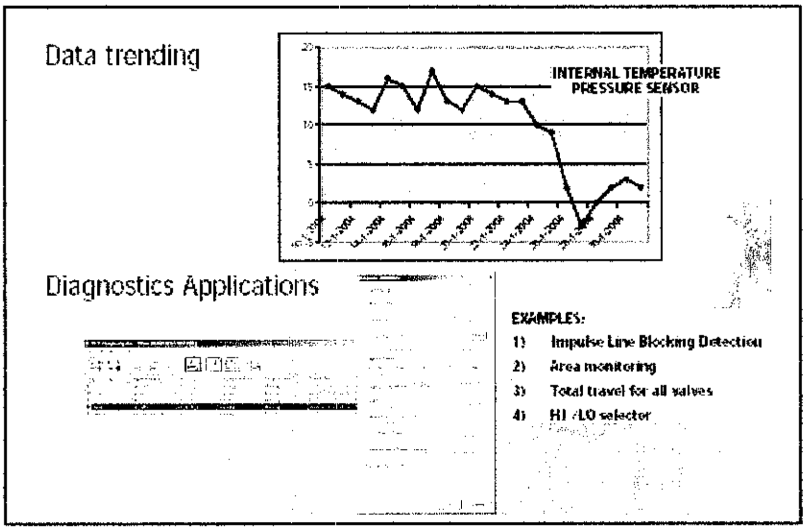


Figure 7-6: Diagnostics capability

Successful process automation is enabling refiners to increase productivity, improve asset utilization and increase the quality of the product. Using the conventional control system only provides the information of control variables but by using foundation fieldbus more data can be transferred because of the digital communication system.

The foundation fieldbus devices have the self diagnostic capability and will alert the operator if the device needs to be replacing at a certain time. This prediction maintenance feature allowed the operator to search for spar or stocks. Using the maintenance software can reduce the maintenance cost because all the maintenance activities can be done in the control room instead to be checked in the field manually.

CHAPTER 8
CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusion

This project is focusing on the implementation of the foundation fieldbus technology. Foundation Fieldbus is an all-digital, bi-directional, multidrop, serial-bus, communications system that serve as the base-level sophisticated network for plant or factory automation environment. Fieldbus technology is already changing the way systems performs control. Some users have gone toward using fieldbus in their plant, whereas others have implemented a full scale fieldbus system. In oil and gas industry, many companies in the world including PETRONAS have implemented fieldbus foundation in their designs. It has been stipulated that the fieldbus has credibility over DCS in terms of hardware installation, wiring, communication speed, data quantity and quality, maintenance and devices interoperability.

The aim of this project is to design, configure and implement a loop process using the fieldbus devices, controller and actuator together with HART protocol system. Only through a project like this we are able to truly see the advantages and benefits of fieldbus technology in enhancing the performance of plant process control and be compared with the conventional control system. Control strategies, especially the feedforward and PID control were implemented and have found to be very effective in monitoring and control the system.

This project has shown that by using the foundation fieldbus, 30% of the total cost can be reduced due to the less wiring and device used to complete this project. Benefit of two-way communication between the controller and transmitter by using foundation fieldbus making the configuration and commissioning process easier and reduce the time consumption.

8.2 Recommendation

Familiarization on fieldbus equipments was achieved throughout the completion of this project. Currently, most of the fieldbus devices only supported PID control, cascade control, feedforward control and feedback control. For the future work, the implementation of state-space model for control strategies can be looking forward as it can increase the controllability in term of performance and stability.

One of the fieldbus benefit is the interoperability of this technology or the availability of foundation fieldbus to work with together with other manufacturer devices in the same network connection. As for the recommendation for future work, this existing plant can be connected with multiple manufacturer devices in order to have a familiarization of the benefit that foundation fieldbus claim in term of interoperability.

By using foundation fieldbus innovation control system technology, the users are allowed to connect up to 32 devices per segment or bus. But, all the way trough the research for this project, there are experts who claim that only 8 devices can be attached to the single bus due to the power consumption constrains. This problem can be taken under consideration for enhancing this project for future work by implementing the redundancy power supply to the segment.

The work presented in this dissertation has contributed to a solid understanding of the procedure for configuring and implementing a foundation fieldbus system. The test plant commissioned provides wide avenues for other research scope to address different aspect of issues pertaining to the fieldbus technology.

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APPENDICES

APPENDIX A

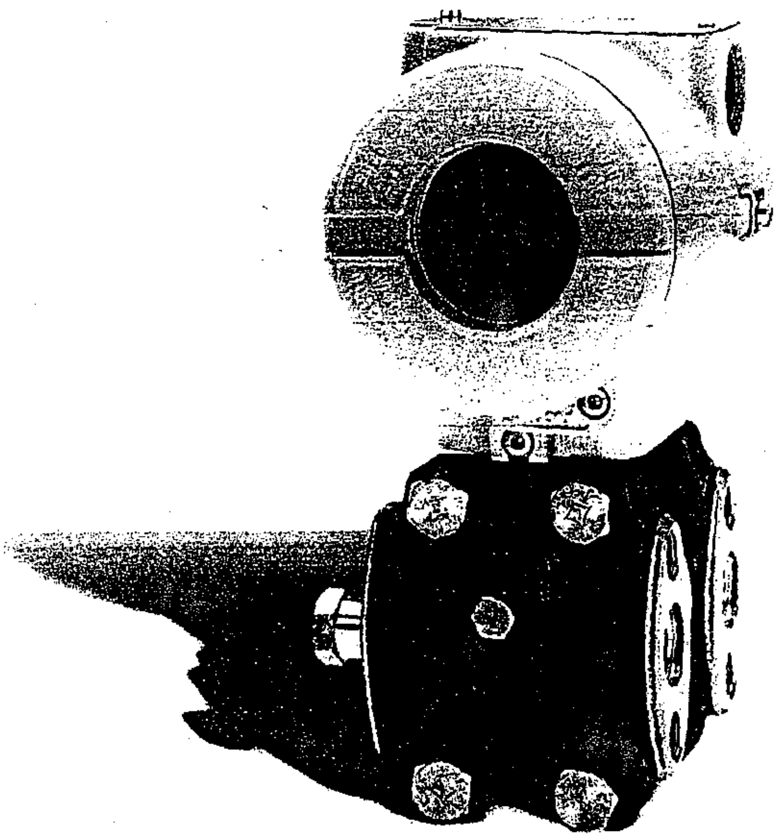
FIELDBUS DEVICES FEATURES

LD302 Series
FIELDBUS PRESSURE TRANSMITTERS

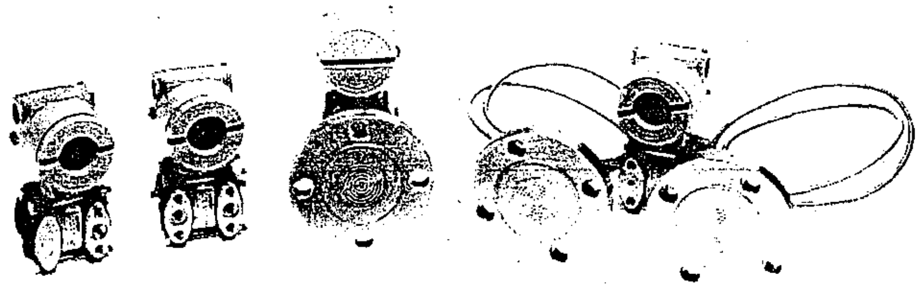
FOUNDATION

Features

- 0 ~125 Pa to 0 ~ 40 MPa.
- (0 ~0.5 inH_2O to 0 ~ 5800 psi).
- 0.075% accuracy of the calibrated range.
- Accepts calibration from URL to URL/40.
- Wetted parts in 316 SS, Hastelloy, Tantalum.
- Digital LCD display (optional).
- Configuration through FIELDBUS communication from a PC or by the local adjustment switches (should be used the display).
- Instantiation and deletion of function blocks.
- Totally digital; sensor, electronics and communication.
- Self diagnostics.
- Weather proof, explosion proof and intrinsically safe.
- Network master capability.



APID	*ADVANCED PID* – It has all the standard features plus: bumpless or hard transfer from a "manual" mode to an "automatic" mode, bias. Adaptive gain, PI sampling, dead-band for error, special treatment for error, ISA or parallel algorithm.
ARTH	*ARITHMETIC* – This calculation block provides some pre-defined equations ready for use in applications as flow compensation, HTG, ratio control and others.
INTG	*INTEGRATOR* – It integrates a variable in function of the time. There is a second flow input that may be used for the following applications: net flow totalization, volume/mass variation in vessels and precise flow ratio control.
ISEL	*INPUT SELECTOR* – This block has four analog inputs that may be selected by an input parameter or according to a criterion as first good, maximum, minimum, middle and average.
CHAR	*SIGNAL CHARACTERIZER* – It has capability for two signal characterization based on the same curve. The second input has an option for swapping "x" to "y", providing an easy way to use the inverse function, that may be used in signal characterization of read-back variables.
AALM	*ANALOG ALARM* – This alarm block has dynamic or static alarm limits, hysteresis, temporary expansion of alarm limits on step setpoint changes to avoid nuisance alarms, two levels of alarm limits and delay for alarm detection.
TIME	*TIMER* – This block has four discrete inputs that are processed by combination logic. The selected timer processing type operates on the combined input signal to produce a measurement, delay, extension, and pulse or debounce.
LLAG	*LEAD-LAG* – This block provides dynamic compensation of a variable. It is used normally in a feed-forward control.
OSDL	*OUTPUT SELECTOR / DYNAMIC LIMITER* – It has two algorithms: - Output selector – selection of output by a discrete input. - Dynamic limiter – this algorithm was developed specially for double cross limit in combustion control.
CT	*CONSTANT* – It provides analog and discrete output parameters with constant values.
DENS	*DENSITY* – This block has a special algorithm to calculate the density in different types of engineering units: Plato degree, INPM and others.



Overpressure and Static Pressure Limits	From 3.45 kPa abs. (0.5 psia)* to: 8 MPa (1150 psi) for range 1. 16 MPa (2300 psi) for ranges 2, 3, 4 & 5. 32 MPa (4600 psi) for models H5 & A5. 40 MPa (5800 psi) for model M5. 52 MPa (7500 psi) for model M6. * except the LD302A model. For ANSI/DIN Level flanges (LD302L models): 150 lb Flanges : 6 psia to 275 psi at 100 °F. 300 lb Flanges : 6 psia to 720 psi at 100 °F. 600 lb Flanges : 6 psia to 1440 psi at 100 °F. PN10/16 : -60 kPa to 2,8 MPa at 38 °C. PN25/40 : -60 kPa to 9 MPa at 38 °C. These overpressures will not damage the transmitter, but a new calibration may be necessary. Flange Test Pressure: 60 MPa (8570 psi).
Humidity Limits	0 to 100% RH.

Performance Specifications

Reference conditions: range starting at zero, temperature 25 °C (77 °F), atmospheric pressure, power supply of 24 Vdc, silicone oil fill fluid, isolating diaphragms in 316L SS and digital trim equal to lower and upper range values.

Accuracy	±0.075% of span (for span ≥ 0.1 URL). ±0.0375 [1+ (0.1 URL/SPAN)]% of span (for span <0.1 URL). For range 5 and 6, Absolute models, diaphragms in Tantalum, Monel or fill fluid in Fluorolube: ±0.1% of span (for span ≥ 0.1 URL). ±0.05 [1+ (0.1 URL/SPAN)]% of span (for span <0.1 URL). For Absolute - range 1: ±0.2% of span Linearity, hysteresis and repeatability effects are included.
Stability	±0.1% of URL for 24 months for ranges 2, 3, 4, 5 & 6. ±0.2% of URL for 12 months for range 1 & L models. ±0.25% of URL for 5 years at 20 °C temperature change and up to 70 bar of static pressure.

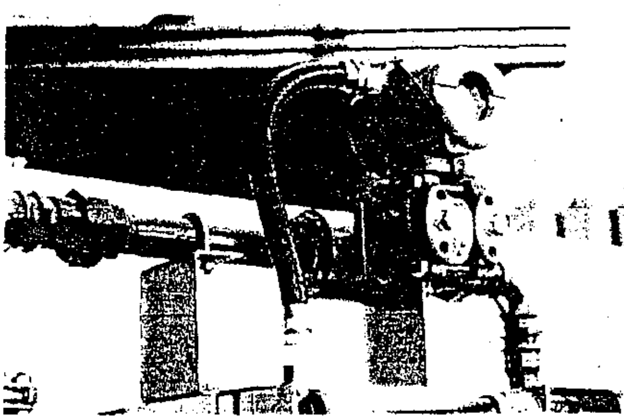
- Electronic Housing
  Injected aluminum with polyester painting or 316 SST (NEMA 4X, IP67).
- Blank Flange
  Plated carbon steel, when the wetted flange is made of this same material, and 316 SST in the other cases.
- Level Flange (LD302L) Material
  316 SST.
- Fill Fluid
  Silicone or Fluorolube Oil.
- Cover O-Rings
  Buna N.
- Mounting Bracket
  Plated carbon steel with polyester painting or 316 SST. Accessories (bolts, nuts, washers and U-clamp) in carbon steel or 316 SST.
- Flange Screws, Bolts and nuts
  Plated carbon steel, Grade 7 or 316 SST.
- Identification Plate
  316 SST.

Mounting

a) Flange mounted for models LD302L.
b) Optional universal mounting bracket for surface or vertical/ horizontal 2"-pipe (DN 50).
c) Via bracket on manifold valve (Optional).
d) Directly on piping for closely coupled transmitter/ orifice flange combinations.

Approximate Weights

3.15 kg (7 lb): all models, except level transmitters.
5.85 to 9.0 kg (13 lb. to 20 lb): level transmitter depending on the flanges, extension and materials.



Description

The TT302 is from the first generation of Fieldbus devices. It is a transmitter mainly intended for measurement of temperature using RTDs or thermocouples, but can also accept other sensors with resistance or mV output such as: pyrometers, load cells, resistance position indicators, etc. The digital technology used in the TT302 enables a single model to accept several types of sensors, wide ranges, single-ended or different measurement and an easy interface between the field and the control room and several interesting features that reduce considerably the installation, operation and maintenance costs. The transmitter accepts two channels, i.e., two measurements. This reduces the cost per channel.

The TT302 is part of Smar's complete 302 series of Fieldbus devices. Fieldbus is a complete system enabling distribution of the control function to equipment in the field.

Using Fieldbus technology, with its capability to interconnect several devices, very large control schemes can be constructed. In order to be a user friendly, the function block concept was introduced. The user may now easily build and overview complex control strategies. Another advantage is adding flexibility, the control strategy may be edited without having to rewire or change any hardware.

The need for Fieldbus implementation in small as well as large systems was considered when developing the entire 302 series of Fieldbus devices. They have the common features of being able to act as a master on the network and be locally configured using a magnetic tool, eliminating the need for a configurator or console in many basic applications.

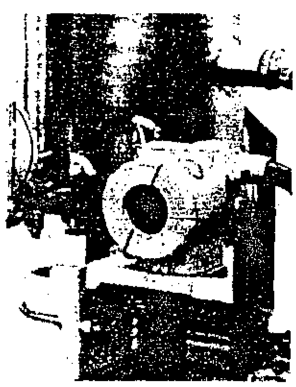
Function Blocks Table

BLOCK	
RES	*RESOURCE* – This block contains data that is specific to the hardware that is associated with the resource.
TRD	*TRANSDUCER BLOCK* – This block converts the primary variables of the physical I/O devices into the proper enginnering
DSP	*DISPLAY TRANSDUCER* – This block configures what process variables of the function blocks will be displayed in the device LCD panel.
DIAG	*DIAGNOSTICS TRANSDUCER* – It provides online measurement of block execution time, check of links between blocks and other features.
AI	*ANALOG INPUT* – This block takes the input data from the transducer block and makes it available to other function blocks. It has scaling conversion, filtering, square root and low cut.
PID	*PID CONTROL* – This standard block has a lot of valuables features as setpoint treatment (value and rate limiting), filtering and alarm on PV, feed-forward, output tracking and others.

Technical Characteristics

Functional Specifications

Inputs Signal	See following table for options.
Output Signal	Digital only. Foundation™, 31.25 kbit/s voltage mode with bus power.
Power Supply	Bus powered: 9 - 32 Vdc. Current consumption quiescent 12 mA.
Indicator	Optional 4½-digit numerical and 5-character alphanumerical LCD indicator.
Hazardous Area Certifications	Explosion proof, weather proof and intrinsically safe (CENELEC and FM standards).
Temperature Limits	Ambient: -40 to 85 °C (-40 to 185 °F). Storage: -40 to 100 °C (-40 to 212 °F). Display: -10 to 60 °C (14 to 140 °F) operation. -40 to 85 °C (-40 to 185 °F) without damage.
Humidity Limits	10 to 60% RH.
Turn-on Time	Approximately 10 seconds.
Update Time	Approximately 0.2 second.
Configuration	Basic configuration may be done using local adjustment magnetic tool if device is fitted with display. Complete configuration is possible using remote configurator.



Physical Specifications

Electrical Connection	1/2-14 NPT, Pg 13,5 or M20 x 1,5 metric.
Material of Construction	Injected low-copper aluminum with polyester painting or 316 Stainless Steel housing, with Buna N 0-rings on covers (NEMA 4X, IP67).
Mounting	Can be attached directly to the sensor. With an optional bracket can be installed on a 2" pipe or fixed on a wall or panel.
Weight	Without display and mounting bracket: 0.80 kg. Add for digital display: 0.13 kg. Add for mounting bracket: 0.60 kg.

		2, 3 or 4 WIRES				DIFFERENTIAL			
SENSOR	TYPE	RANGE (°C)	RANGE (°F)	MINIMUM SPAN (°C)	ACCURACY (°C)	RANGE (°C)	MINIMUM SPAN (°C)	RANGE (°F)	ACCURACY (°C)
RTD	Cu10 GE	-20 to 250	-4 to 482	50	±1.0	-270 to 270	-454 to 518	50	±2.0
	Ni 120 DIN	-50 to 270	-58 to 518	5	±0.1	-320 to 320	-544 to 608	5	±0.5
	Pt50 IEC	-200 to 850	-328 to 1562	10	±0.25	-1050 to 1050	-1858 to 1922	10	±1.0
	Pt100 IEC	-200 to 850	-328 to 1562	10	±0.2	-1050 to 1050	-1858 to 1922	10	±1.0
	Pt500 IEC	-200 to 450	-328 to 842	10	±0.25	NA	NA	NA	NA
	Pt50 JIS	-200 to 600	-328 to 1112	10	±0.25	-850 to 850	-1498 to 1562	10	±1.0
	Pt100 JIS	-200 to 600	-328 to 1112	10	±0.25	-800 to 800	-1408 to 1472	10	±1.5
THERMO-COUPLE	B NBS	+100 to 1800	+212 to 3272	50	±0.5*	-1600 to 1600	-2848 to 2912	60	±1.0*
	E NBS	-100 to 1000	-148 to 1832	20	±0.2	-1100 to 1100	-1948 to 2012	20	±1.0
	J NBS	-150 to 750	-238 to 1382	30	±0.3	-900 to 900	-1588 to 1652	30	±0.6
	K NBS	-200 to 1350	-328 to 2462	60	±0.6	-1550 to 1550	-2758 to 2822	60	±1.2
	N NBS	-100 to 1300	-148 to 2372	50	±0.5	-1400 to 1400	-2488 to 2552	50	±1.0
	R NBS	0 to 1750	32 to 3182	40	±0.4	-1750 to 1750	-3118 to 3182	40	±2.0
	S NBS	0 to 1750	32 to 3182	40	±0.4	-1750 to 1750	-3118 to 3182	40	±2.0
	T NBS	200 to 400	-328 to 752	15	±0.15	-600 to 600	-1048 to 1112	15	±0.8
	L DIN	-200 to 900	-328 to 1652	35	±0.35	-1100 to 1100	-1948 to 2012	35	±0.7
	U DIN	-200 to 600	-328 to 1112	50	±0.5	-800 to 800	-1408 to 1472	50	±2.5

* Not applicable bellow 440°C
NA Not applicable.

Reliable and flexible

Elimination of many mechanical parts seen in other positioners has a number of advantages. Higher reliability as there are fewer parts that wear, safer as there are less moving parts, more accurate as there is less dead-band from mechanical imprecision.

Position sensing is done without any mechanical contact virtually eliminating wear and tear and subsequent degradation. FY302 directly senses longitudinal or rotary movement based on the Hall effect. The position signal may also be used in advanced control schemes.

Valve characteristics, action, absolute and rate-of-change limits, etc. are altered in software instead of a mechanical cam and spring, changing, action or characteristics between linear, equal percentage, hyperbolic (quick opening) or a freely configurable table may be done remotely by the click of a bottom. These and other software capabilities make the FY302 extremely flexible.

Self diagnostics

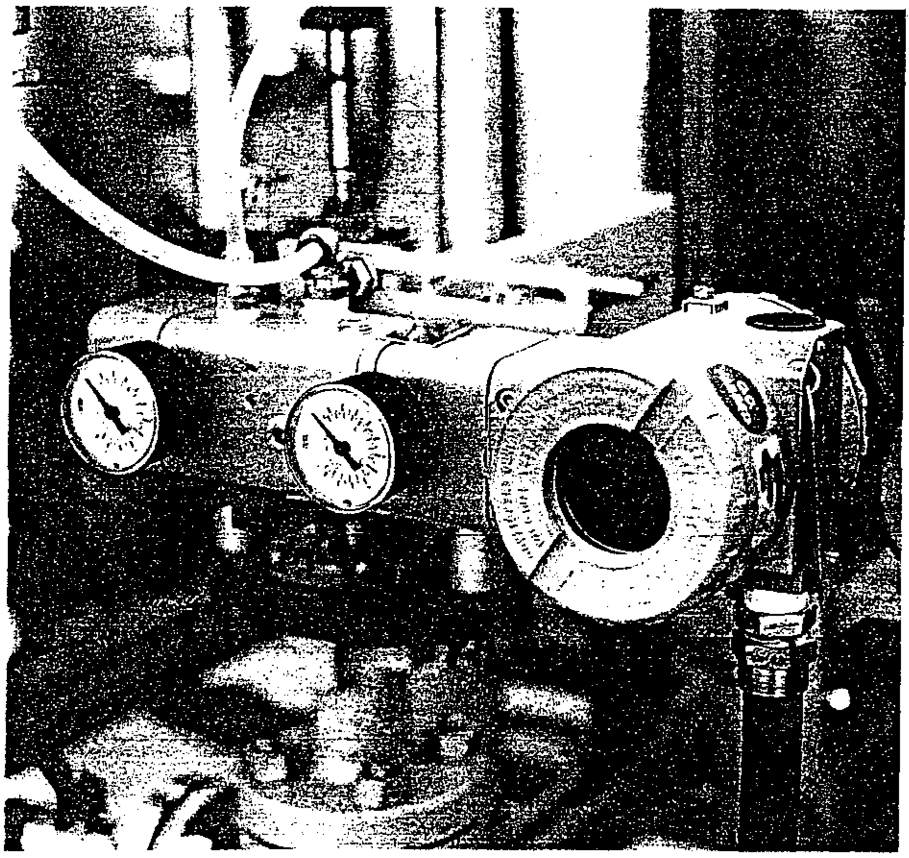
The continuous self diagnostics of the positioner issues alerts for a range of hardware and software failures and problems with the positioner or valve immediately, enabling maintenance personnel to pinpoint errors instantly or even before they can cause any harm. The diagnostic data may also be accessed on demand.

The benefit for the operator to get this information without having to bring the valve or positioner in to a workshop for testing is obvious. The time that can be saved by not having to test only a few units is enormous.
Diagnostics enables you to quickly determine if a process problem is due to the valve/ positioner or not, without having to do several field visits. Production can get back in operation in minutes.

The diagnostics functions are also suitable for preventive maintenance such as detection of increasing valve dead-band and "stick-slip" operation.

There is also software limit switche for travel, which automatically alerts the operator.

TIME	*TIMER* - This block has four discrete inputs that are processed by combination logic. The selected timer processing type operates on the combined input signal to produce a measurement, delay, extension, and pulse or debounce.
LLAG	*LEAD-LAG* - This block provides dynamic compensation of a variable. It is used normally in a feed-forward control.
OSDL	***OUTPUT SELECTOR / DYNAMIC LIMITER*** – It has two algorithms: - Output selector – selection of output by a discrete input. - Dynamic limiter – this algorithm was developed specially for double cross limit in combustion control.
CT	*CONSTANT* - It provides analog and discrete output parameters with constant values.



Perfomance Specifications

Resolution	≤ 0.1% F.S.
Repeatibility	≤ 0.1% F.S.
Hysteresis	≤ 0.2% F.S.
Consumption	0.25 Nm^3/h (0.15 scfm) at 1.4 bar (20 psi) supply. 0.70 Nm^3/h (0.40 scfm) at 5.6 bar (80 psi) supply.
Output Capacity	46.7 Nm^3/h (28 scfm) at 5.6 (80 psi) supply.
Ambient Temperature Effect	0.8%/20°C do span.
Supply Pressure Effect	Negligible.
Vibration Effect	15-150 Hz at 2 g. 150-2000 Hz at 1g. Reference SAMA PMC 31.1 - 1980, Sec. 5.3, Condition 3, Steady State.
Electro-Magnetic Interference Effect	Designed to comply with IEC 801 and European Standards EN50081 and EN50082.

Physical Specifications

Electrical Connection	1/2 -14 NPT, Pg 13,5 or M20 x 1,5.
Pneumatic Connections	Supply and output: 1/4 - 18 NPT. Gage: 1/8 - 27 NPT.
Material of Construction	Injected low copper aluminum with polyester painting or 316 Stainless Steel housing, with Buna-N O-rings on cover (NEMA 4X, IP67).
Weight	Without display and mounting bracket: 2.7 kg. Add for digital display: 0.1 kg.

APPENDIX B

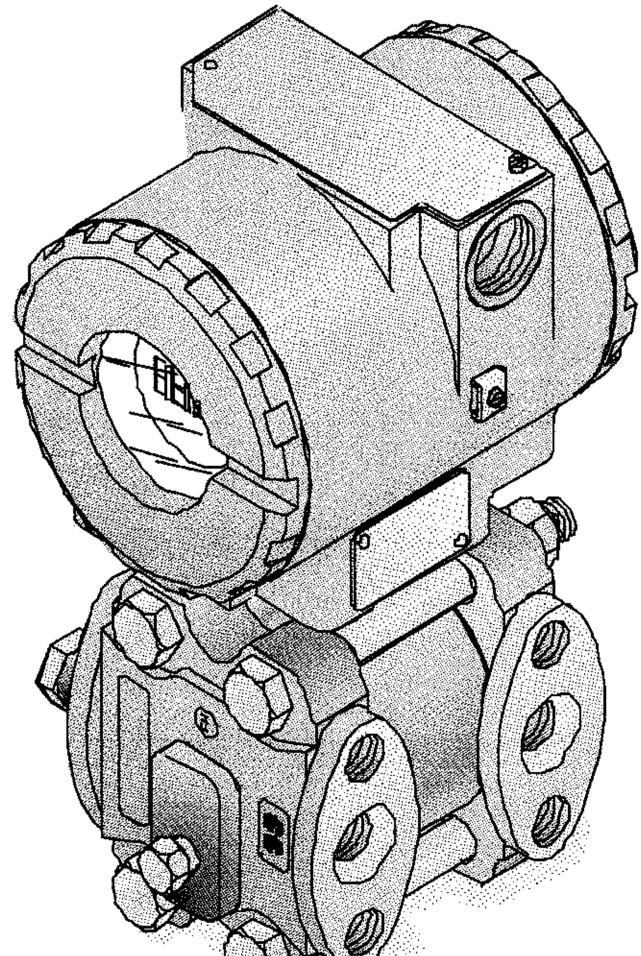
FIELDBUS PRESSURE TRANSMITTER MANUAL

LD302 -

FIRST IN FIELDBUS

OPERATION & MAINTENANCE INSTRUCTIONS MANUAL

FIELDBUS PRESSURE TRANSMITTER



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D302

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Configuration

One of the many advantages of Fieldbus is that device configuration is independent of the configurator. The **LD302** may be configured by a third party terminal or operator console. Any particular configurator is therefore not addressed here.

This section describes the characteristics of the blocks in the **LD302**. They follow the Fieldbus specifications, but in terms of transducer blocks, the input transducer block and display, they have some special features on top of this.

ransducer Block

Transducer block insulates function block from the specific I/O hardware, such as sensors, actuators. Transducer block controls access to I/O through manufacturer specific implementation. This permits the transducer block to execute as frequently as necessary to obtain good data from sensors without burdening the function blocks that use the data. It also insulates the function block from the manufacturer specific characteristics of certain hardware.

By accessing the hardware, the transducer block can get data from I/O or passing control data to it. The connection between Transducer block and Function block is called channel. These blocks can exchange data from its interface.

Normally, transducer blocks perform functions, such as linearization, characterization, temperature compensation, control and exchange data to hardware.

low to Configure a Transducer Block

Each time when you select a field device on **SYSCON** by instantiating on the Operation menu, automatically you instantiate one transducer block and it appears on screen.

The icon indicates that one transducer block has been created and by clicking twice on the icon, you can access it.

The transducer block has an algorithm, a set of contained parameters and a channel connecting it to a function block.

The algorithm describes the behavior of the transducer as a data transfer function between the I/O hardware and other function block. The set of contained parameters, it means, you are not able to link them to other blocks and publish the link via communication, defines the user interface to the transducer block. They can be divided into Standard and Manufacturer Specific.

The standard parameters will be present for such class of device, as pressure, temperature, actuator, etc., whatever is the manufacturer. Oppositely, the manufacturers specific ones are defined only for its manufacturer. As common manufacturer specific parameters, we have calibration settings, material information, linearization curve, etc.

When you perform a standard routine as a calibration, you are conducted step by step by a method. The method is generally defined as guide line to help the user to make common tasks. The **SYSCON** identifies each method associated to the parameters and enables the interface to it.

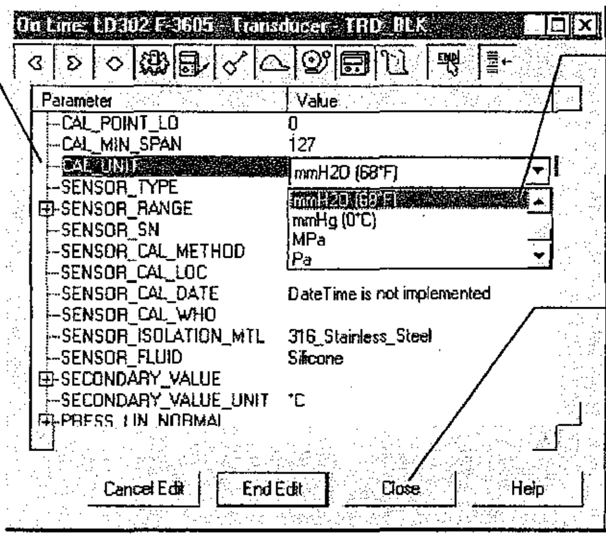
’ressure Trim - LD302

Via SYSCON

It is possible to calibrate the transmitter by means of parameters CAL_POINT_LO and CAL_POINT_HI.

First of all, a convenient engineering unit should be chosen before starting the calibration. This engineering unit is configured by CAL_UNIT parameter. After its configuration the parameters related to calibration will be converted to this unit.

The parameter CAL_UNIT should be configured according to the Engineering Unit wished for calibrating the device.



The Engineering Units can be choosen from the Pressure Units list box

After the selection this key should be pressed to complete the

Figure 3.2 - LD302 SYSCON – Transducer Configuration Screen

The following engineering unit's codes are defined for pressure according to Foundation Fieldbus® standard:

UNIT	CODES
InH2O a 68°F	1148
InHg a 0°C	1156
ftH2O a 68°F	1154
mmH2O a 68°F	1151
MmHg a 0°C	1158
Psi	1141
Bar	1137
Mbar	1138
g/cm2	1144
k/cm2	1145
Pa	1130
Kpa	1133
Torr	1139
Atm	1140
Mpa	1132
inH2O a 4°C	1147
mmH2O a 4°C	1150

WARNING

It is recommendable that a convenient engineering unit be chosen by means of parameter XD_SCALE of the Analog Input Block, considering that the range limits of the sensor must be respected, these being 100% and 0%.

It is also recommendable, for every new calibration, to save existing trim data in parameters CAL_POINT_LO_BACKUP and CAL_POINT_HI_BACKUP, by means of parameter BACKUP_RESTORE, using option LAST_TRIM_BACKUP.

'ia Local Adjustment

In order to enter the local adjustment mode, place the magnetic tool in office "Z" until flag "MD" lights up in the display. Remove the magnetic tool from "Z" and place it in orifice "S". Remove and reinsert the magnetic tool in "S" until the message "LOC ADJ" is displayed. The message will be displayed during approximately 5 seconds after the user removes the magnetic tool from "S". Let's take the upper value as an example:

Apply to the input a pressure of 5,000mmH_2O.
Wait until the pressure of readout of parameter P_VAL (PRIMARY_VALUE) stabilizes and then actuates parameter UPPER until it reads 5,000.

NOTE

Trim mode exit via local adjustment occurs automatically should the magnetic tool not be used during approximately 16 seconds.

Keep in that even when parameters LOWER or UPPER already present the desired value, they must be actuated so that calibration is performed.

Limit Conditions for Calibration:
For every writing operation in the transducer blocks there is an indication for the operation associate with the waiting method. These codes appear in parameter XD_ERROR. Every time a calibration is performed. Code 0, for example, indicates a successfully performed operation.

Upper:
SENSOR_RANGE_EUO < NEW_UPPER < SENSOR_RANGE_EU100 * 1.25
Otherwise, XD_ERROR = 26.
(NEW_UPPER - PRIMARY_VALUE) < SENSOR_RANGE_EU100 * 0.1
Otherwise, XD_ERROR = 27.
(NEW_UPPER - CAL_POINT_LO) >CAL_MIN_SPAN * 0,75
Otherwise, XD_ERROR = 26.

NOTE

Codes for XD_ERROR:
16: Default Value Set
22: Out of Range.
26: Invalid Calibration Request.
27: Excessive Correction.

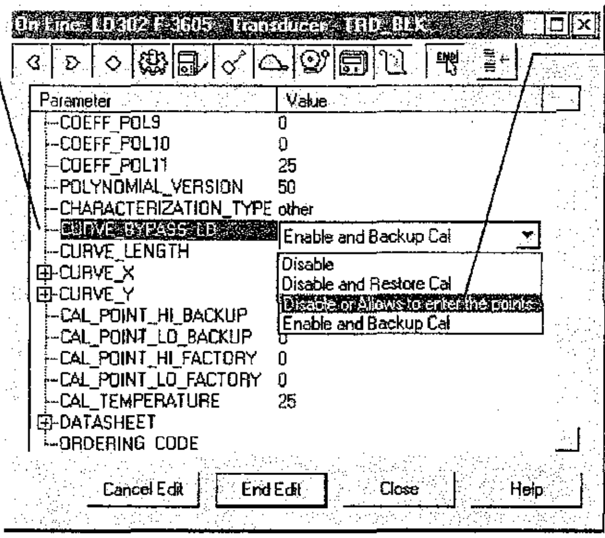
haracterization Trim

It is used to correct the sensor reading in several points.

Use an accurate and stable pressure source, preferably a dead-weight tester, to guarantee the accuracy must be at least three times better than the transmitter accuracy. Wait for the pressure to stabilize before performing trim.

The sensor characteristic curve at a certain temperature and for certain ranges may be slightly nonlinear. This eventual non-linearity may be corrected through the Characterization Trim.

This parameter activates or deactivates the Characterizatio n Curve after the points have been configured.



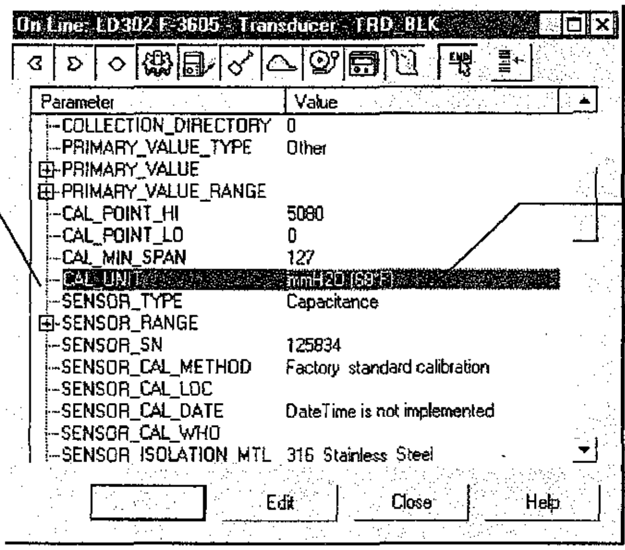
By the list box the user can enable or disable the Characterization Curve, enter the points, restore or backup the curve entered. This parameter should be used preferable by a method of calibration.

Figure 3.6 - The Characterization Curve Configuration

׳ensor Information

The main information about the transmitter can be accessed selecting the Transducer block icon option as shown on the Figure 3.10 - Creating Transducers and Function Blocks. The sensor information will be displayed as shown below.

This parameter assigns the E.U. for all parameters related to calibration methods. Normally, they start their names with CAL_



The appropriate calibration unit can be choosen by selecting the Engineering Units available for each type of Transducer Block

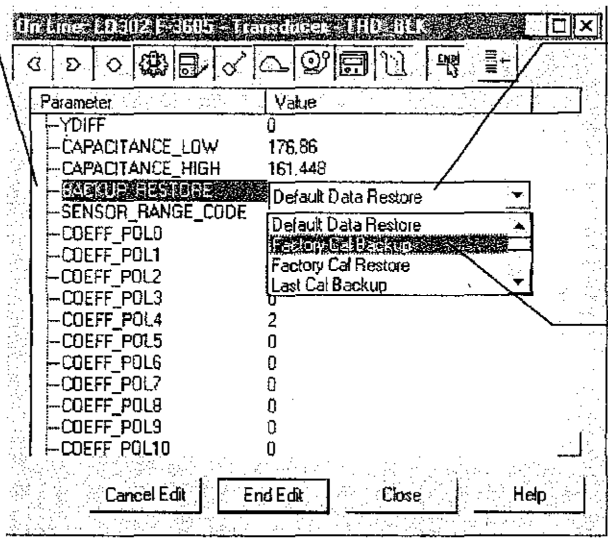
Figure 3.7 - Transducer Block - Sensor Information

Only application dependent options defined by combo boxes can be changed. (E.g. Flange Type, O' Ring Material, etc.) And the others are only factory configured (e.g. Sensor Isolating Diaphragm, Sensor Fluid, etc.).

emperature Trim

Write in parameter TEMPERATURE_TRIM any value in the range -40°C to +85°C. After that, check the calibration performance using parameter SECONDARY_ VALUE.

This parameter is used to save or restore the default, factory or user configuration stored at the sensor module.



By selecting the options contained in the list box, operations of backup and restore data in the sensor module can be

Using its option, the user can save his last calibration settinas.

Figure 3.9 - Transducer Block - Backup/Restore

ransducer Display – Configuration

Using the SYSCON is possible to configure the Display Transducer block. As the name described it is a transducer due the interfacing of its block with the LCD hardware.

The Transducer Display is treated as a normal block by **SYSCON**. It means, this block has some parameters and those ones can be configured according to customer's needs. (See the Figure 3.10 – Creating Transducers and Function Blocks.

The customer can choose the parameters to be shown at LCD display, they can be parameters just for monitoring purpose or for acting locally in the field devices by using a magnetic tool.

all parameters and their respective values, which shall be configured in accordance with the necessity of being locally adjusted by means of the magnetic tool. All values shown on the display are default values.

There are seven groups of parameters, which may be pre-configured by the user in order to able, a possible configuration by means of the local adjustment. As an example, let's suppose that you don't want to show some parameters; in this case, simply write an invalid Tag in the parameter, Block_Tag_Param_X. Doing this, the device will not take the parameters related (indexed) to its Tag as a valid parameters.

Definition of Parameters and Values

Block_Tag_Param
This is the tag of the block to which the parameter belongs to use up to a maximum of 32 characters.

Index_Relative
This is the index related to the parameter to be actuated or viewed (0, 1, 2...). Refer to the Function Blocks Manual to know the desired indexes, or visualize them on the SYSCON by opening the desired block.

Sub_Index
In case you wish to visualize a certain tag, opt for the index relative equal to zero, and for the sub-index equal to one (refer to paragraph Structure Block in the Function Blocks Manual).

Mnemonic
This is the mnemonic for the parameter identification (it accepts a maximum of 16 characters in the alphanumeric field of the display). Choose the mnemonic, preferably with no more than 5 characters because, this way, it will not be necessary to rotate it on the display.

Inc_Dec
It is the increment and decrement in decimal units when the parameter is Float or Float Status time, or integer, when the parameter is in whole units.

Decimal_Point_Numb.
This is the number of digits after the decimal point (0 to 3 decimal digits).

Access
The access allows the user to read, in the case of the "Monitoring" option, and to write when "action" option is selected, then the display will show the increment and decrement arrows.

Alpha_Num
These parameters include two options: value and mnemonic. In option value, it is possible to display data both in the alphanumeric and in the numeric fields; this way, in the case of a data higher than 10000, it will be shown in the alphanumeric field.

In option mnemonic, the display may show the data in the numeric field and the mnemonic in the alphanumeric field.

In case you wish to visualize a certain tag, opt for the index relative equal to zero, and for the sub-index equal to one (refer to paragraph Structure Block in the Function Blocks Manual).

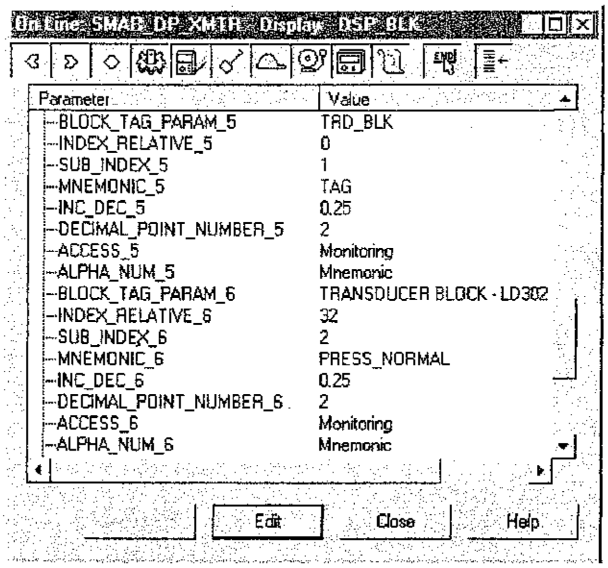


Figure 3.13 - Parameters for Local Adjustment Configuration

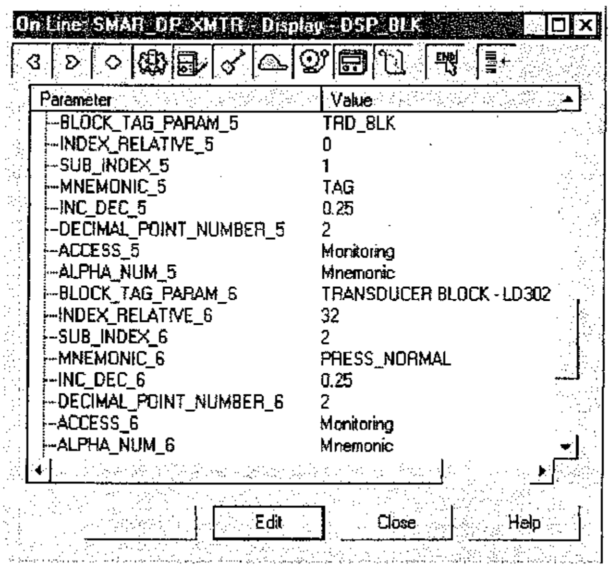
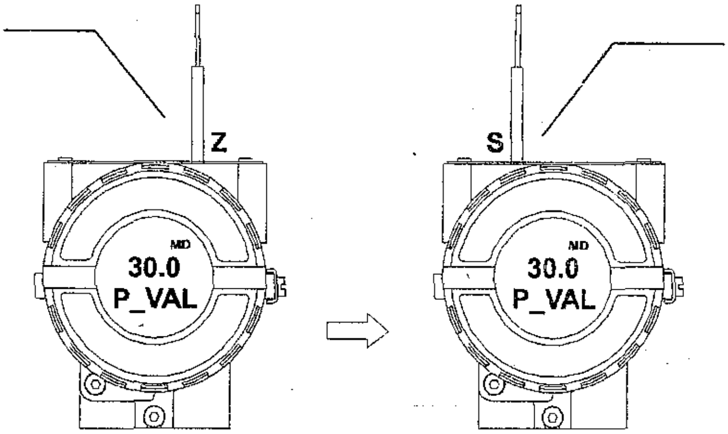


Figure 3.14 - Parameters for Local Adjustment Configuration

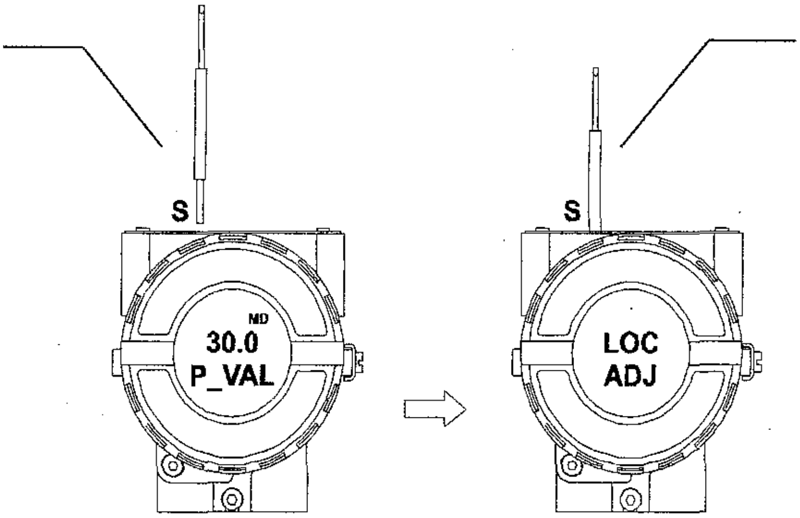
In order to start the local adjustment, place the magnetic tool in orifice Z and wait until letters MD are displayed.



Place the magnetic tool in orifice S and wait during 5 seconds.

Figure 3.16 - Step 1 - LD302

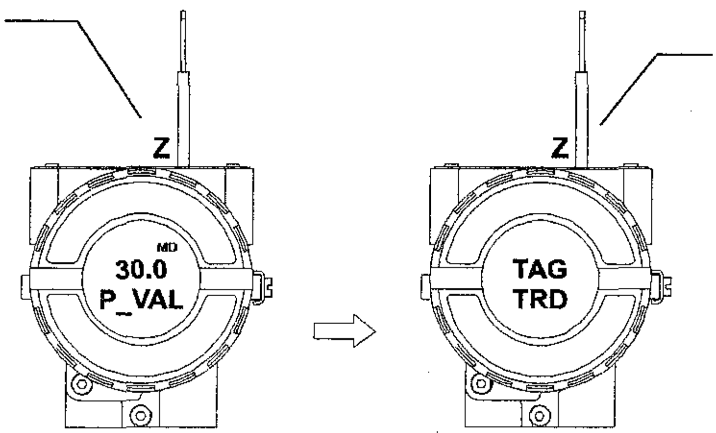
Remove the magnetic tool from orifice S.



Insert the magnetic tool in orifice S once more and LOC ADJ should be displayed.

Figure 3.17 - Step 2 - LD302

Place the magnetic tool in orifice Z. In case this is the first configuration, the option shown on the display is the TAG with its corresponding mnemonic configured by the SYSCOM. Otherwise, the option shown on the display will be the one configured in the prior operation. By keeping the tool inserted in this orifice, the local adjustment menu will rotate.



In this option the first variable (P_VAL) is showed with its respective value (if you to want that it keeps static, put the tool in S orifice and stay there.

Figure 3.18 - Step 3 - LD302

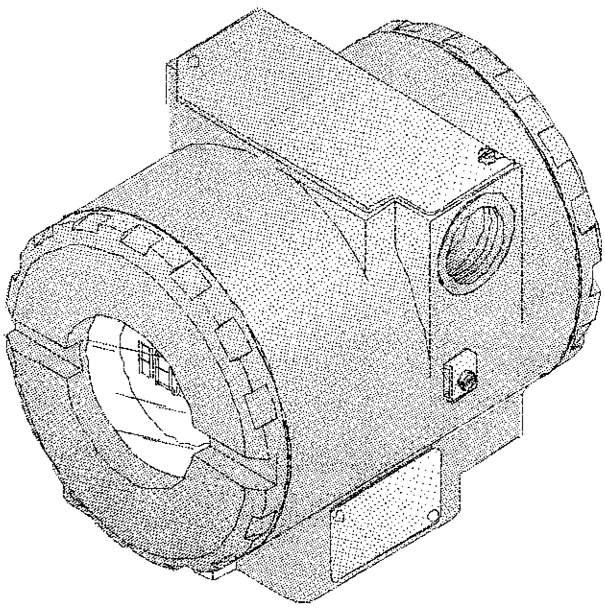
APPENDIX C

FIELDBUS TEMPERATURE TRANSMITTER MANUAL

TT302 - smar
FIRST IN FIELDBUS

OPERATION & MAINTENANCE
INSTRUCTION MANUAL

FIELDBUS TEMPERATURE TRANSMITTER



UNE / 02
TT302
ERSION 3

OUNDATION

TT32FME

Configuration

One of the many advantages of Fieldbus is that device configuration is independent of the configurator. The **TT302** may be configured by a third party terminal or operator console. Any particular configurator is therefore not addressed here.

The **TT302** contains two input transducer blocks, one resource block, one display transducer block and other function blocks.

For explanation and details of function blocks, see the "Function Blocks Manual".

ansducer Block

Transducer block insulates function blocks from the specific I/O hardware, such as sensors, actuators. Transducer block controls access to I/O through manufacturer specific implementation. This permits the transducer block to execute as frequently as necessary to obtain good data from sensors without burdening the function blocks that uses the data. It also insulates the function block from the manufacturer specific characteristics of certain hardware.

By accessing the hardware, the transducer block can get data from I/O or passing control data to it. The connection between Transducer block and Function block is called channel. These blocks can exchange data from its interface.

Normally, transducer blocks perform functions, such as linearization, characterization, temperature compensation, control and exchange data to hardware.

›w to Configure a Transducer Block

The transducer block has an algorithm, a set of contained parameters, it means, you are not able to link these parameters to other blocks and publish the link via communication, and a channel connecting it to a function block.

The algorithm describes the behavior of the transducer as a data transfer function between the I/O hardware and other function block. The set of contained parameters defines the user interface to the transducer block. They can be divided into Standard and Manufacturer Specific.

The standard parameters will be present for such class of device, as pressure, temperature, actuator, etc., whatever is the manufacturer. Oppositely, the manufacturers specific ones are defined only for its manufacturer. As common manufacturer specific parameters, we have calibration settings, material information, linearization curve, etc.

When you perform a standard routine such as calibration, you are conducted step by step by a method. The method is generally defined as guideline to help the user to make common tasks. The **SYSCON** identifies each method associated to the parameters and enables the interface to it.

›nsor Transducer Number

The Sensor Transducer Number associates the sensor to the transducer. It can be set to one up to two, in case of dual sensor.

›nsor Wiring

The **TT302** accepts up to two sensors and may operate in one of three modes:

- Single channel single sensor measurement
- Dual channel dual sensor measurement
- Single channel dual sensor differential measurement.
- Single channel dual sensor backup measurement.

mper Configuration

In order to work properly, the jumpers J1 and J3 located in the **TT302** main board must be correctly configured.

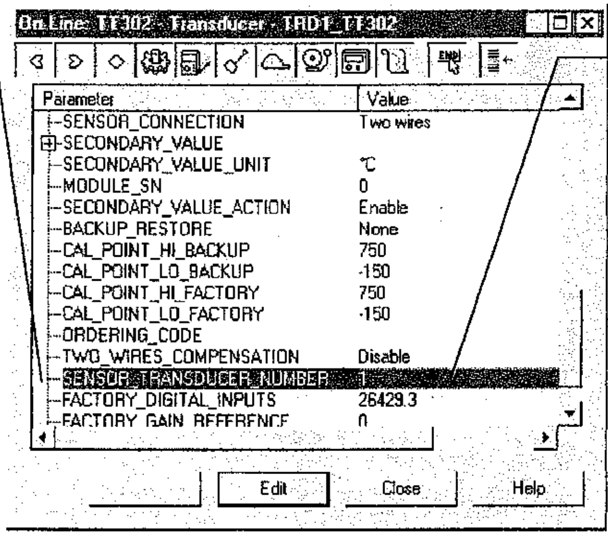
J1 is responsible to enable the AI block simulate mode.

W1 is responsable to enable the local adjustment.

nsor Configuration

It is necessary to configure the transducer number allocated to its task. The parameter SENSOR_TRANSDUCER_NUMBER should be configured to 1.

This parameter sets the transducer number, according to the type of temperature measurement.

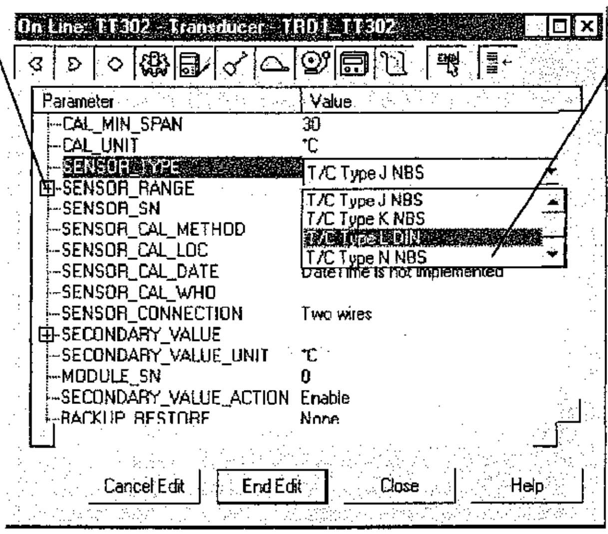


This parameter could be 1 or 2, for indicating respectively first or second transducers.

Figure 3.2 - Temperature Calibration - TT302

It is possible to configure connection and sensor type by means of parameters SENSOR_TYPE and SENSOR_CONNECTION. The connection and sensor types available are listed in the tables Table 3.1 - Sensor Type Table and Table 3.2 - Type of Connection Table, as well as the corresponding value.

This parameter selects the type of sensor connection. The options here will depend on Sensor Type chosen as described above.



This list contains the number of wires available for each type of sensor.

Figure 3.3 - Temperature Calibration - TT302

CONNECTION
DOUBLE TWO WIRE
TWO WIRE
THREE WIRE
FOUR WIRE

Table 3.2 - Type of Connection Table

w to Connect Two Sensors

Transmitter series **TT302** are capable of operating simultaneously with two sensors, using two transducer blocks, if necessary. Configuration types in two sensors operation are as follows:

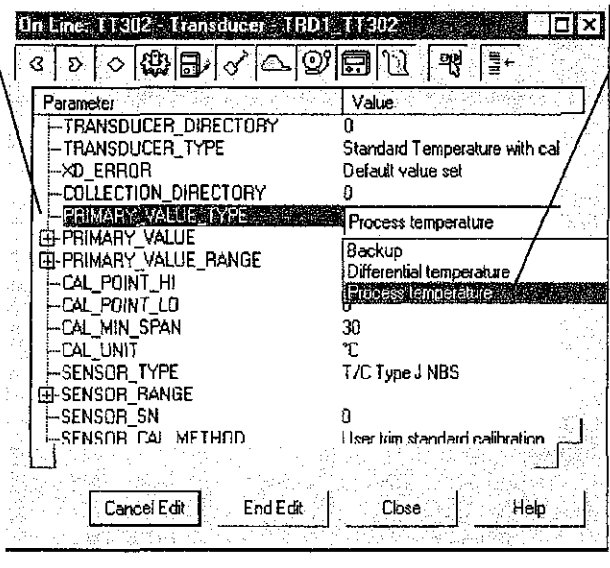
Differential – In this case there is only one transducer. Transducer output is the difference between the readout of sensor 1 (between terminals 3 and 4) and the readout of sensor 2 (between terminals 2 and 4).

Backup – In this case there is only one transducer.
Should the first sensor (between terminals 3 and 4) open, the second sensor (between terminals 2 and 4) will supply the signal to the transducer.

Double - In this case there are two transducers. Each sensor provides a signal to its respective transducer.

In order to be able to operate with sensors in the backup or differential modes, the user shall actuate parameter PRIMARY_VALUE_TYPE. In order to operate with double sensors, the user shall actuate parameter SENSOR_CONNECTION.

This parameter sets the type of calculation sh ould be done for each transducer.



This list contains the Simple, Backup and Differential type of temperature calculation.

Figure 3.5 - Temperature Calibration - TT302

mpensation of Lead Resistance for RTD or Ohm

When 2 - wire resistive sensors are used, the readout is not a very accurate because of the resistance of leads connecting sensor to transmitter. In order to reduce this error, it is possible to configure the transmitter to compensate for a constant lead resistance by means of parameter LEAD_RESISTANCE_VALUE.

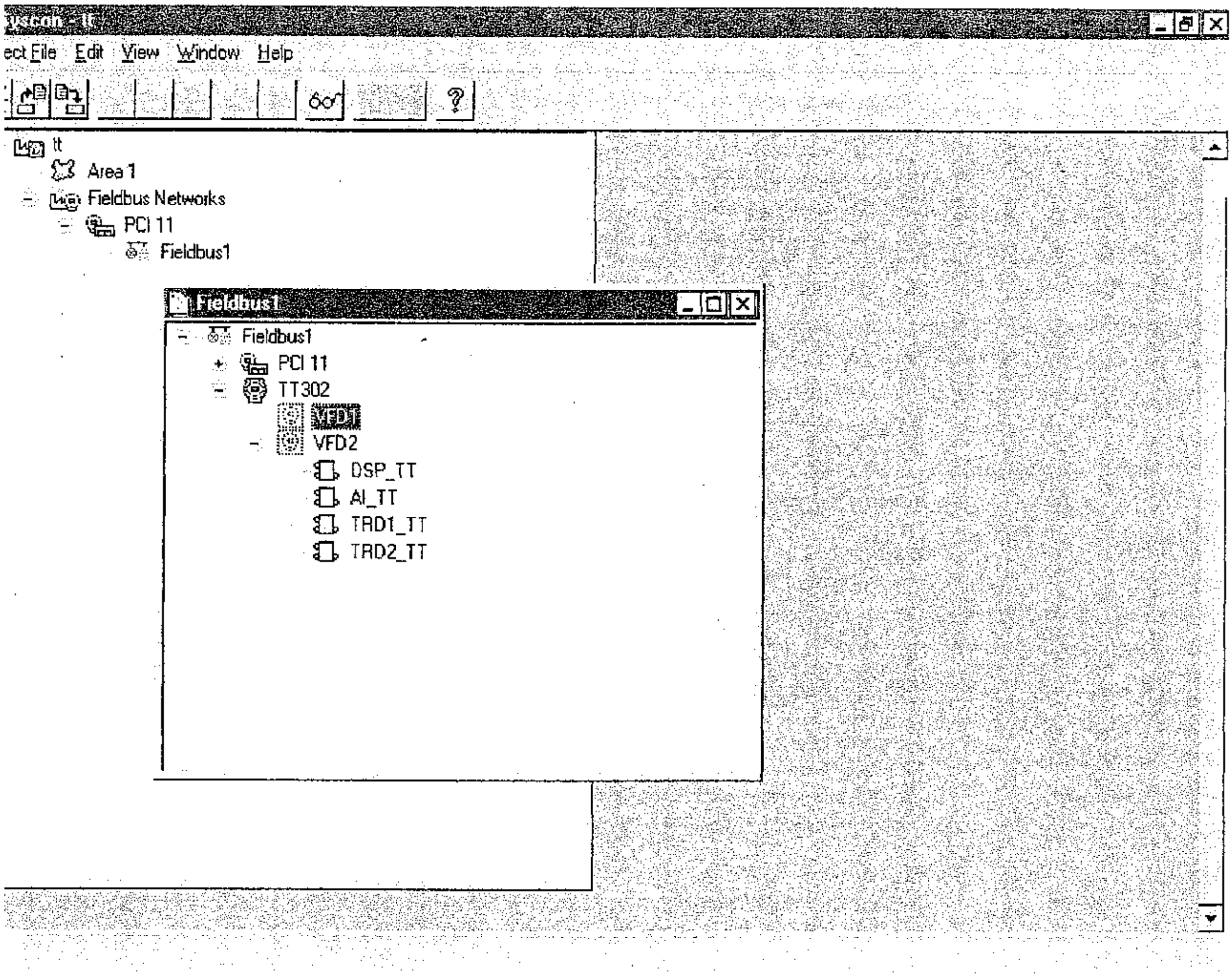


Figure 3.6 – Creating Transducers and Function Blocks

splay Transducer Block

The local adjustment is completely configured by **SYSCON**. It means, the user can select the best options to fit his application. From factory, it is configured with the options to set the Upper and Lower trim, for monitoring the input transducer output and check the Tag. Normally, the transmitter is much better configured by **SYSCON**, but the local functionality of the LCD permits an easy and fast action on certain parameters, since it does not rely on communication and network wiring connections. Among the possibilities by Local Adjustment, the following options can be emphasized: Mode block, Outputs monitoring, Tag visualization and Tuning Parameters setting.

The interface between the user is described very detailed on the "General Installation, Operation and Maintenance Procedures Manual". Please take a detailed look in that manual in the chapter related to "Programming Using Local Adjustment". The resources on the transducer display, as well as for all the **Series 302** field devices from SMAR, has the same methodology to handle with it. So, since the user has learned once, he is capable to handle all kind of field devices from SMAR.

All function block and transducers defined according Foundation Fieldbus™ have a description of their features written on binary files, by the Device Description Language.

This feature permits that third parties configurator enabled by Device Description Service technology can interpret these features and make them accessible to configure. The Function Blocks and Transducers of Series 302 have been defined rigorously according the Foundation Fieldbus specifications in order to be interoperable to other parties.

In case you wish to visualize a certain tag, opt for the index relative equal to zero, and for the sub-index equal to one (refer to paragraph Structure Block in the Function Blocks Manual).

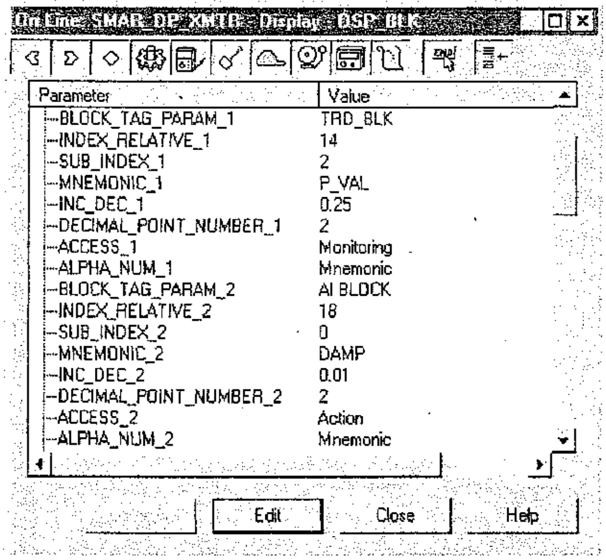


Figure 3.7 - Parameters for Local Adjustment Configuration

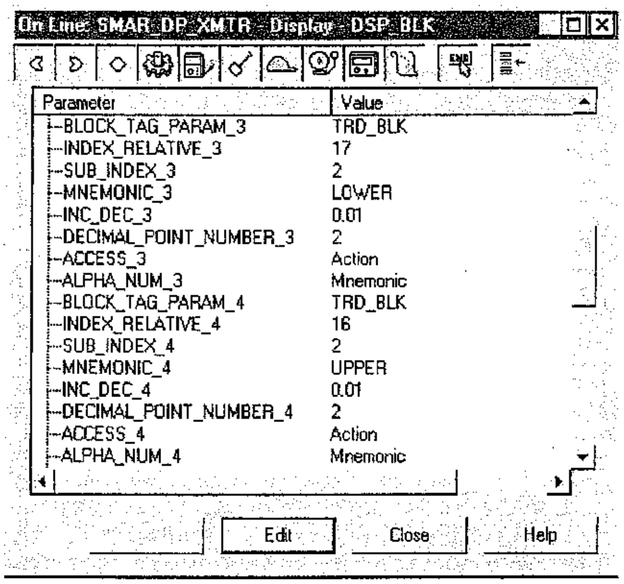
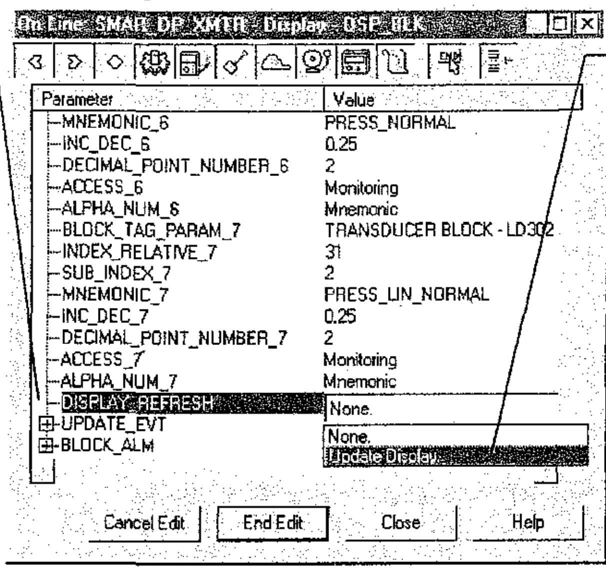


Figure 3.8 - Parameters for Local Adjustment Configuration

his parameter
pdates the local
djustment
rogramming tree
onfigured on each
evice.



The option "update" should be selected in order to execute the upgrade of local adjustment programming tree.

After its step all the parameters selected will be show on the LCD display.

Figure 3.11 - Parameters for Local Adjustment Configuration

'ogramming Using Local Adjustment

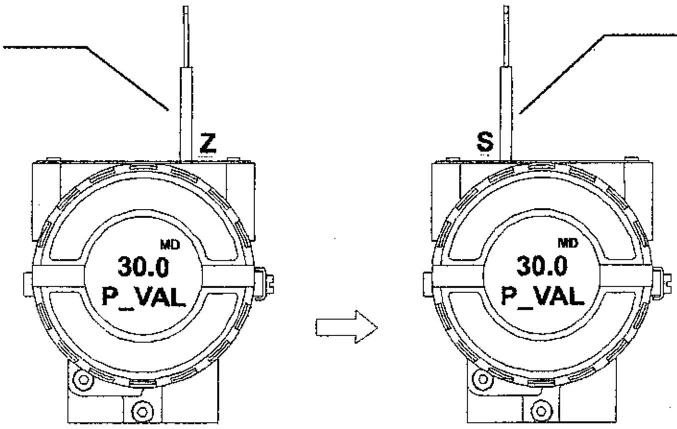
The transmitter has two holes for magnetic switches activated by the magnetic tool located under the identification plate.

This magnetic tool enables adjustment of the most important parameters of the blocks.

The jumper W1 on top of the main circuit board must be in place for this function to be enabled and the transmitter must be fitted with the digital display for access to the local adjustment. Without the display the local adjustment is not possible.

cal Programming Tree

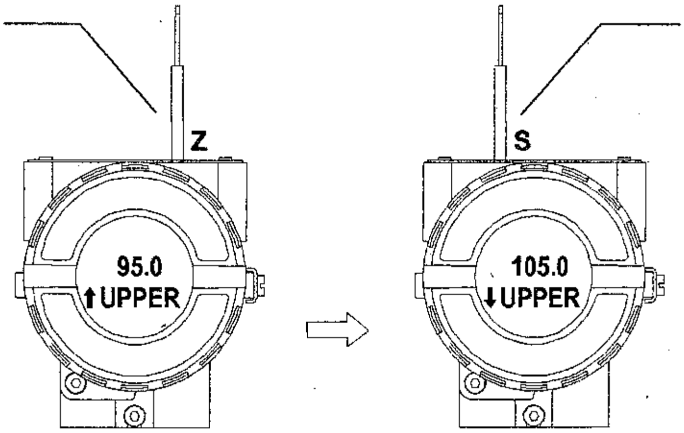
In order to start the local adjustment, place the magnetic tool in orifice **Z** and wait until letters **MD** are displayed.



Place the magnetic tool in orifice **S** and wait during 5 seconds.

Figure 3.12 - Step 1 - TT302

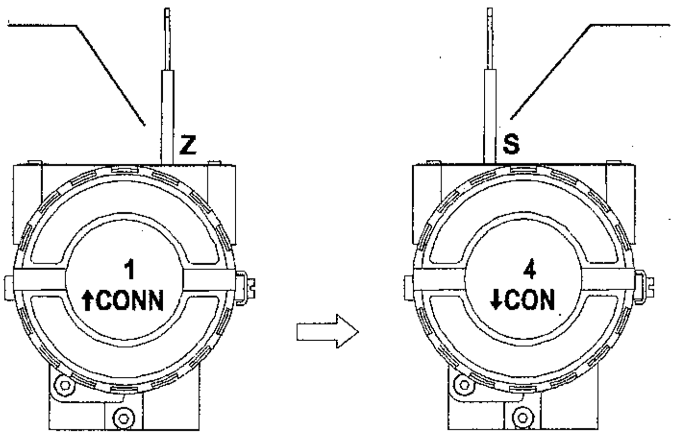
In order to range the upper value(upper), simply insert the magnetic tool in orifice S as soon as upper is shown on the display. An arrow pointing upward (↑) increment the value and an arrow pointing downward (↓) decrements the value. In order to increment the value, keep the tool insert in S up to set the value desired.



In order to decrement the upper value, place the magnetic tool in orifice Z to shift the arrow to the downward position an then, by insetting and keeping the tool in orifice S, it is possible to decrement the upper value.

Figure 3.16 - Step 5 - TT302

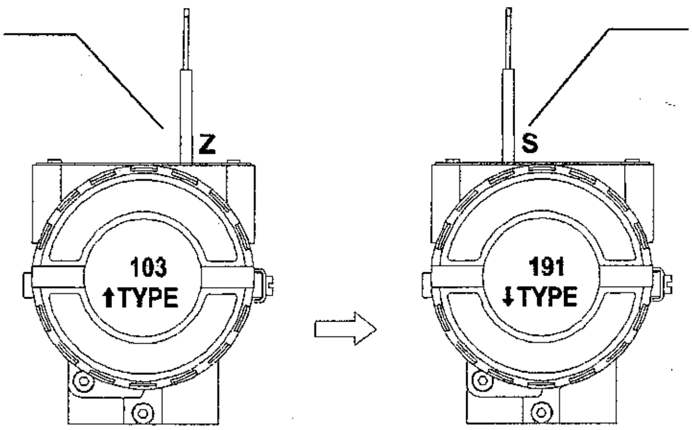
In order to configure the connection(CONN), simply insert the magnet tool in orifice S as soon as CONN is shown on the display. An arrow pointing upward (↑) increment the value and an arrow pointing downward (↓) decrement the value. The number over CONN mnemonic is the value corresponding of the table xx. See it to do the correct choice of the connection value.



In order to decrement the upper value, place the magnetic tool in orifice Z to shift the arrow to the downward position an then, by insetting and keeping the tool in orifice S, it is possible to decrement the upper value.

Figure 3.17 - Step 6 - TT302

In order to configure the connection(TYPE), simply insert the magnet tool in orifice S as soon as TYPE is shown on the display. An arrow pointing upward (↑) increment the value and an arrow pointing downward (↓) decrement the value. The number over TYPE is the value corresponding of the table YY. See it to do the correct choice of the connection value.



In order to decrement the upper value, place the magnetic tool in orifice Z to shift the arrow to the downward position an then, by insetting and keeping the tool in orifice S, it is possible to decrement the upper value.

Figure 3.18 - Step 7 - TT302

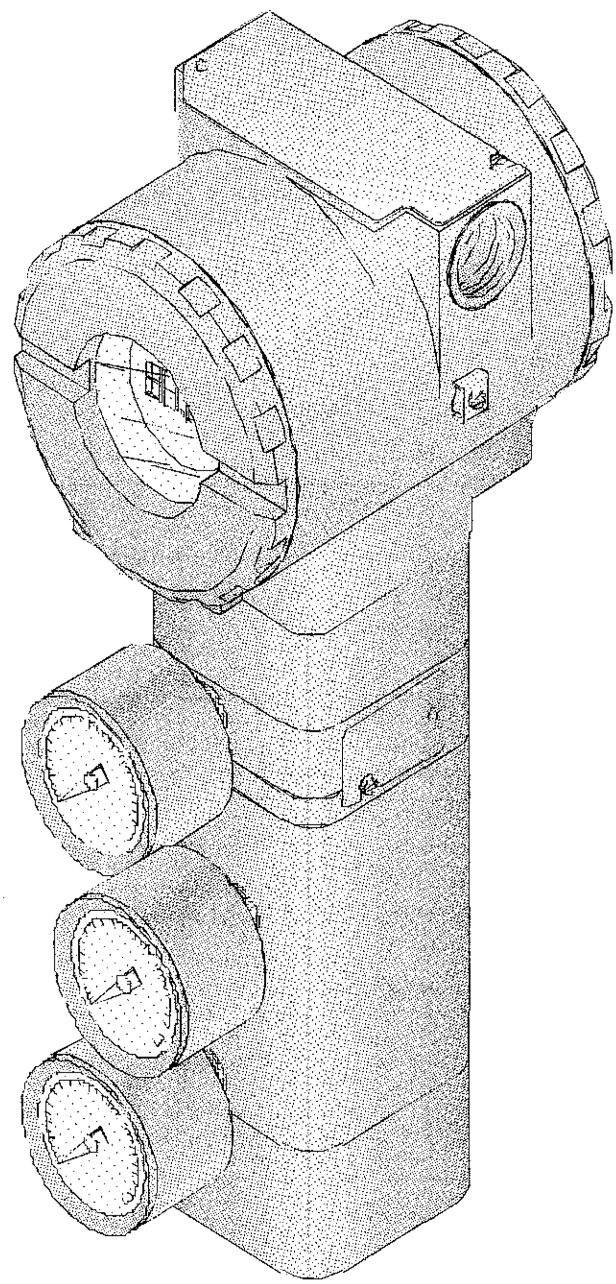
APPENDIX D

FIELDBUS VALVE POSITIONER MANUAL

FY - 302

OPERATION & MAINTENANCE INSTRUCTIONS MANUAL

FIELDBUS VALVE POSITIONER



FIRST IN FIELDBUS

MAR / 02

FY302

VERSION 3

FOUNDATION

F Y 3 2 F M E

Configuration

One of the many advantages of Fieldbus is that device configuration is independent of the configurator. The **FY302** may be configured by a third party terminal or operator console. Any particular configurator is therefore not addressed here.

The **FY302** contains one output transducer block, one resource block, one display transducer block and function blocks.

Function Blocks are not covered in this manual. For explanation and details of function blocks, see the "*Function Blocks Manual*".

nsducer Block

Transducer block insulates function block from the specific I/O hardware, such as sensors, actuators. Transducer block controls access to I/O through manufacturer specific implementation. This permits the transducer block to execute as frequently as necessary to obtain good data from sensors without burdening the function blocks that use the data. It also insulates the function block from the manufacturer specific characteristics of certain hardware. By accessing the hardware, the transducer block can get data from I/O or passing control data to it. The connection between Transducer block and Function block is called channel. These blocks can exchange data from its interface.

Normally, transducer blocks perform functions, such as linearization, characterization, temperature compensation, control and exchange data to hardware.

w to Configure a Transducer Block

The transducer block has an algorithm and a set of contained parameters.

The algorithm describes the behavior of the transducer as a data transfer function between the I/O hardware and other function block. The set of contained parameters, it means, you are not able to link them to other blocks and publish the link via communication, defines the user interface to the transducer block. They can be divided into Standard and Manufacturer Specific.

The standard parameters will be present for such class of device, as pressure, temperature, actuator, etc., whatever is the manufacturer. Oppositely, the manufacturers specific ones are defined only for its manufacturer. As common manufacturer specific parameters, we have calibration settings, material information, linearization curve, etc.

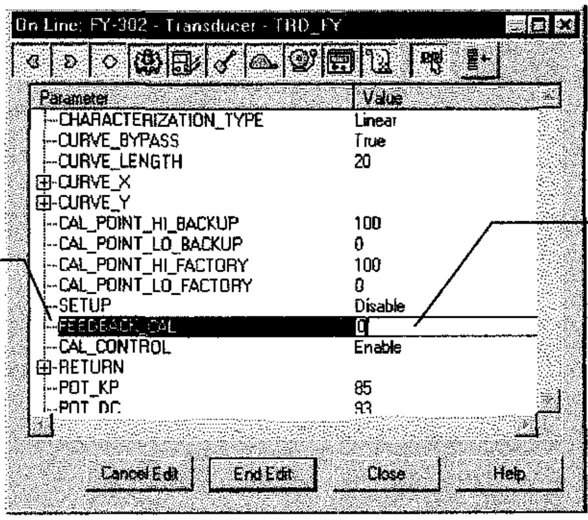
When you perform a standard routine as a calibration, you are conducted step by step by a method. The method is generally defined as guide line to help the user to make common tasks. The SYSCON identifies each method associated to the parameters and enables the interface to it.

libration

It is a specific method to make the calibration operation. It is necessary to match the source of reference applied to or connected to the device with the desired value. At least four parameters should be used to configure this process: CAL_POINT_HI, CAL_POINT_LO, CAL_MIN_SPAN, and CAL_UNIT. Those parameters define the highest and lowest calibrated values for this device, the minimum allowable span value for calibration (if necessary) and the engineering unit selected for calibration purposes.

Check the position showed in the local indicator and if it is different of 0% write it in the parameter FEEDBACK_CAL. Repeat this operation until it reads 0%.

rameter should be set
e actual position of
uring the calibration
ure.

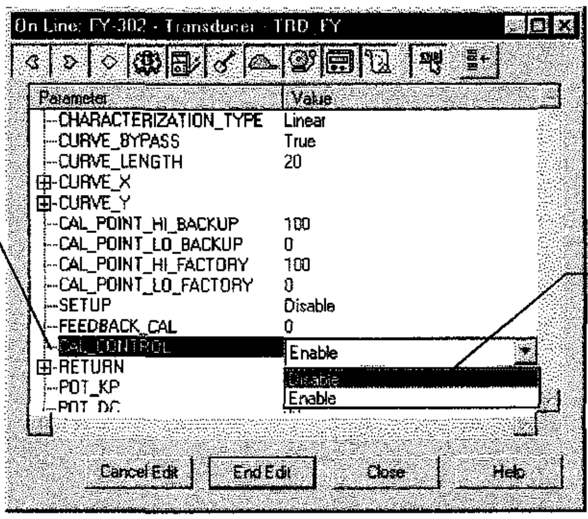


The value should be entered here. Note that its value can be a negative number depending on the actual position of valve.

Figure 3.3 - Calibrating of Trim 0%

You should finalize the calibration method writing "Disable" in the parameter CAL_CONTROL.

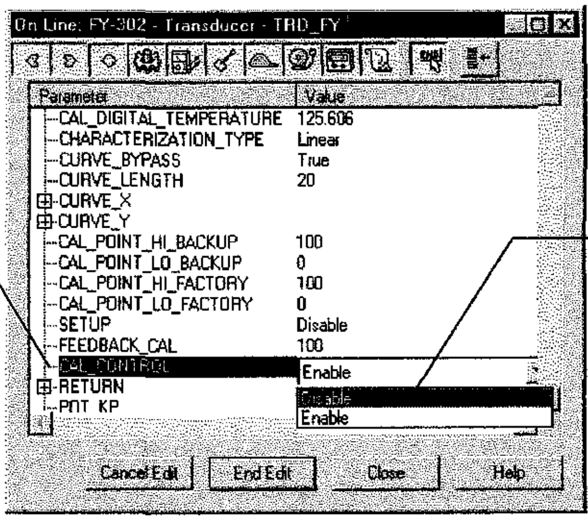
rameter ends the
tion procedure.



The enable option indicates that the calibration process is being done. In order to finalize its procedure, the user should set it to disable.

Figure 3.4 – Ending Finishing Calibration Procedure

In order to end the trim procedure, select disable in parameter CAL_CONTROL



is parameter
ds the calibration
ıcedure.

The enable option indicates that the calibration process is being done. In order to finalize its procedure, the user should set it to disable.

Figure 3.7 - Ending the Trim procedure

NOTE

It is convenient to choose the unit to be used in parameter XD_SCALE of the Analog Output Block, considering that positioner limits shall be observed, it means 0% and 100%.

It is also recommendable, for every new calibration, to save the existing trim data in the parameters CAL_POINT_LO_BACKUP and CAL_POINT_HI_BACKUP, by means of parameter BACKUP_RESTORE, using option LAST_CAL_ BACKUP.

splay Transducer Block

The local adjustment is completely configured by SYSCON. It means, the user can select the best options to fit his application. From factory, it is configured with the options to set the Upper and Lower trim, for monitoring the input transducer output and check the Tag. Normally, the transmitter is much better configured by SYSCON, but the local functionality of the LCD permits an easy and fast action on certain parameters, since it does not rely on communication and network wiring connections. Among the possibilities by Local Adjustment, the following options can be emphasized: Mode block, Outputs monitoring, Tag visualization and Tuning Parameters setting.

The interface between the user is described very detailed on the "*General Installation, Operation and Maintenance Procedures Manual*". Please, read carefully at this manual in the chapter related to "*Programming Using Local Adjustment*". It is significantly the resources on this transducer display, also all the Series 302 field devices from SMAR has the same methodology to handle with it. So, since the user has learned once, he is capable to handle all kind of field devices from SMAR.

All function block and transducers defined according *Foundation Fieldbus™* have a description of their features written on binary files, by the *Device Description Language*. This feature permits that third parties configurator enabled by *Device Description Service* technology can interpret these features and make them accessible to configure. The Function Blocks and Transducers of Series 302 have been defined rigorously according the Foundation Fieldbus specifications in order to be interoperable to other parties.

In order to enable the local adjustment using the magnetic tool, it is necessary to previously prepare the parameters related with this operation via **SYSCON** (System Configuration).

In case you wish to visualize a certain tag, opt for the index relative equal to zero, and for the sub-index equal to one (refer to paragraph Structure Block in the Function Blocks Manual).

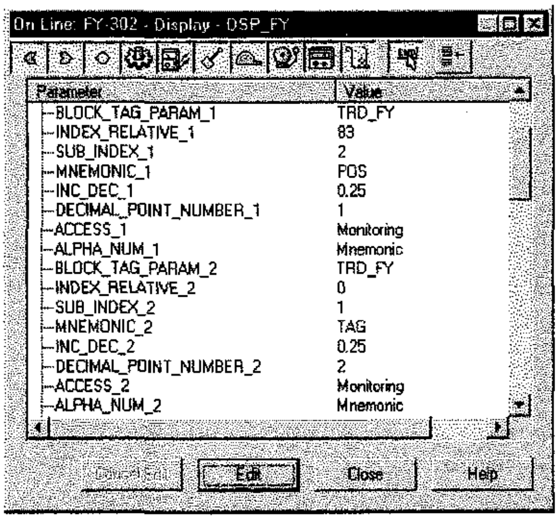


Figure 3.8 - Parameters for Local Adjustment Configuration

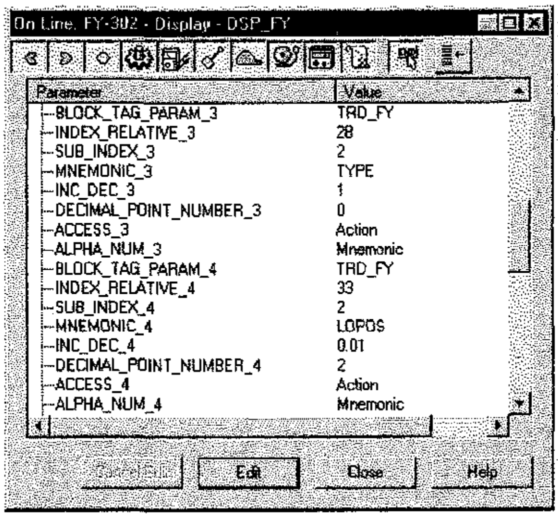


Figure 3.9 - Parameters for Local Adjustment Configuration

Browse to parameter "LOPOS". After that in order to start the calibration, the user shall activate parameter "LOPOS" with the help of the magnetic tool placed in "S". For example, it is possible to enter 0%. When the magnetic tool is removed from "S", the output will be set to a value close to the desired value. The user shall then browse the tree up to parameter FEED (FEEDBACK_CAL), and actuate this parameter by placing the magnetic tool in "S" until reaching the value obtained from the position reference.

The user shall continue to write in this parameter until it reads 0% or the desired lower position value. Browse up to parameter "UPPOS". After that, in order to start the calibration, the user shall actuate parameter "UPPOS" by placing the magnetic tool in "S". For example, it is possible to enter 100%. When the magnetic tool is removed from "S", the output will be set to a value close to the desired value. The user shall them browse the tree up to parameter FEED (FEEDBACK_CAL), and actuate this parameter by placing the magnetic tool in "S" until reaching the desired value.

The user shall write in this parameter until it reads 100% or the desired upper position value.
The LOWER and UPPER should be different.

LIMIT CONDITIONS OF CALIBRATION	
LOPOS (Lower Position)	Always equal 0%
UPPOS (Upper Position)	Always equal 100%
FEED	- 10% =< FEED =< 110%, otherwise XD_ERROR = 22

NOTE

Codes for XD_ERROR:
16: Default Value Set
22: Out of Range
26: Invalid Calibration Request
27: Excessive Correction

to-Setup

This process is necessary to find the position values at which the valve is considered fully open or close. This operation can be done using the **SYSCON** or the Local Adjustment. The **FY302** automatically finds the fully open and closed positions of a valve, but the user may also set a narrower range of operation should he like to. Before making the Auto-Setup, select the type of valve through the parameter VALVE_TYPE choosing between "Linear or Rotary" options.

The setup operation can be started writing "Enable" on the parameter SETUP, so the positioner will execute immediately the operation of auto-setup for approximately 2 to 5 minutes depending on the type of valve, other configured parameters and function blocks used in the positioner.

The process will be finished when the SETUP parameter will indicate "Disable" automatically during the operation of reading.

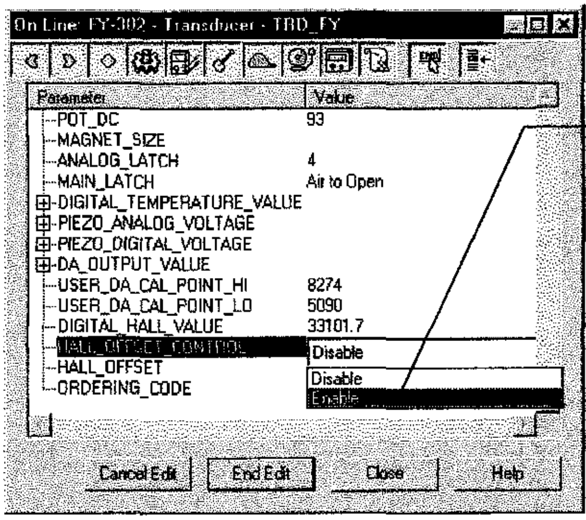
NOTE

This operation should be performed off-line or with the process shut down to be sure that the plant operation is not disturbed, due the valve will be moved between the fully open and close points in order to reach the better adjustment.

After the AUTO-SETUP operation the user should adjust the ZERO and SPAN positions, writing on the parameters CAL_POINT_LO and CAL_POINT_HI. Please, look for POSITION TRIM in this manual.

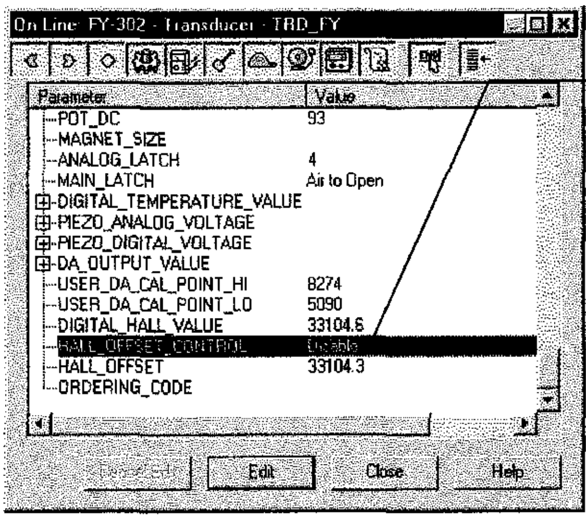
ll's Offset Compensation Without Magnet

Before installing the magnet to the positioner, write "Enable" on the parameter HALL_OFFSET_CONTROL and wait until the SYSCON 302 set it back to "Disable" indicating end of its process of Hall's Offset compensation.



The HALL OFFSET CONTROL operation is initiated writing "Enable" on its parameter

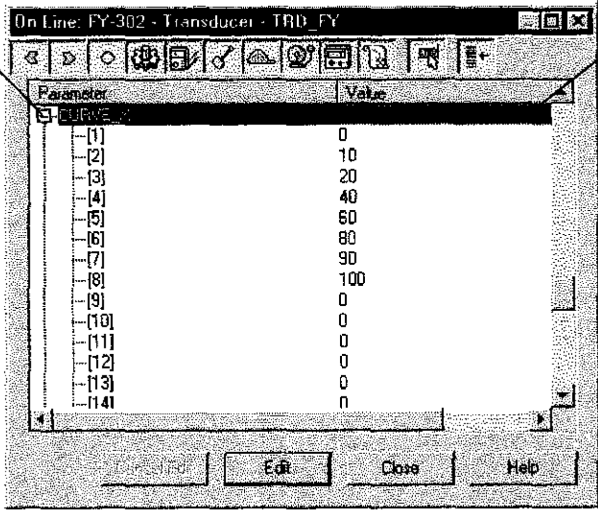
Figure 3.14 - Enabling the Hall's Offset Compensation



The "Disable" indicates that the HALL OFFSET CONTROL operation is completed.

Figure 3.15 - Disabling the Hall's Offset Compensation

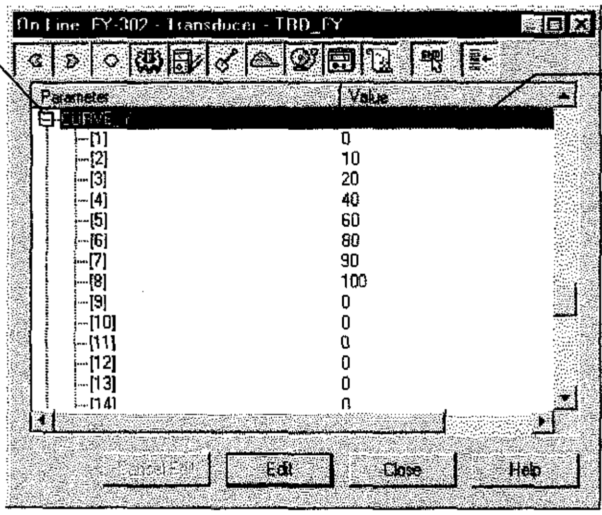
This parameter contains the coordinates X



These values are in percentage of Position Value before the Curve

Figure 3.17 - Configuring the Table for Flow Characterization - X points

This parameter contains the coordinates y

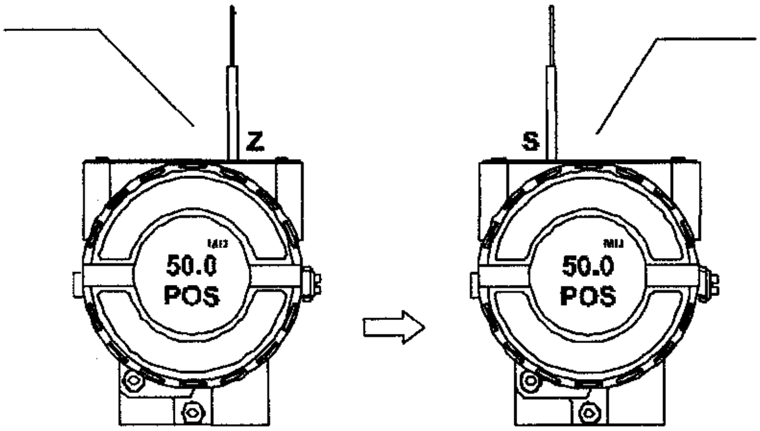


These values are in percentage of Position Value after the Curve

Figure 3.18 - Configuring the Table for Flow Characterization - Y points

gramming Using Local Adjustment

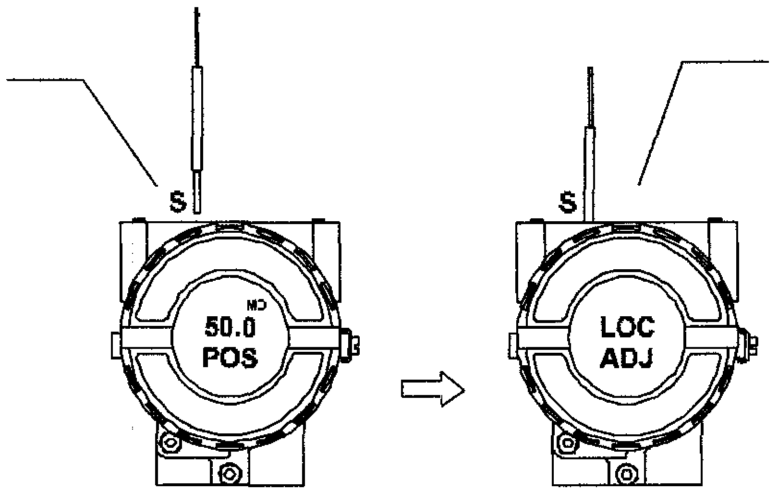
1 order to start the
ocal adjustment,
lace the magnetic
ool in orifice **Z** and
vait until letters MD
re displayed.



Place the
magnetic tool in
orifice **S** and wait
during 5 seconds.

Figure 3.21 - Step 1 - FY302

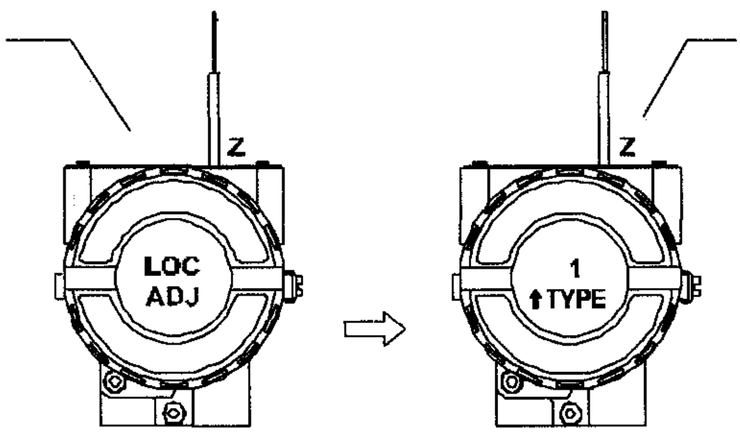
Remove the
nagnetic tool
rom orifice **S**.



Insert the magnetic
tool in orifice **S**
once more and
LOC ADJ should be
Displayed.

Figure 3.22 - Step 2 – FY302

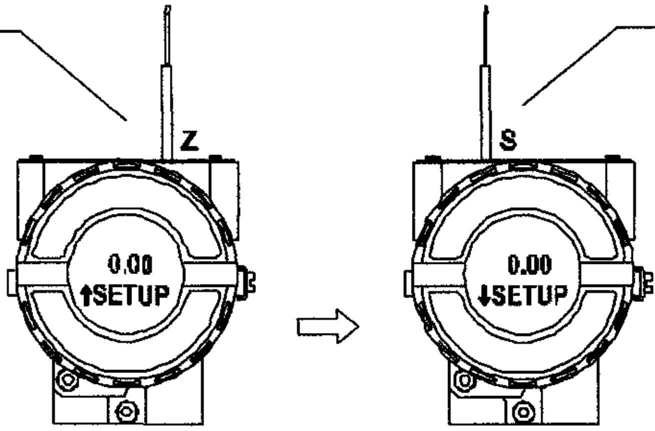
Place the magnetic
ool in orifice **Z**. In
case this is the first
configuration, the
option shown on the
display is the TAG
with its corresponding
mnemonic configured
by the SYSCOM.
Otherwise, the option
shown on the display
will be the one
configured in the prior
operation. By keeping
the tool inserted in
this orifice, the local
adjustment menu will
rotate.



In this option TYPE,
is indicated by the
numbers 1 or 2,
which respectively
represent Linear or
Rotary valves.

Figure 3.23 - Step 3 - FY302

'his option
nplements the
uto setup of the
'alve, that is, the
ower and upper
osition points of
he valve. When
etup displays 0
zero), it indicates
hat the setup is
lisabled.



Insert the magnetic tool in orifice S and enter the value 1. After this, the auto setup will be started and a flashing message with the word SETUP will show in the display of the positioner. After this process finishes, the local adjustment returns to normal operation.

Figure 3.27 - Step 7 - FY302

NOTE

Every time the AUTO SETUP is used it is necessary to save it via SYSCON, and to write in the Backup-Restore parameter of the transducer block the sensor Data Backup option.

This Local adjustment configuration is a suggestion only. The user may choose his preferred configuration via SYSCON, simply configuring the display block. (refer to paragraph Display Transducer Block)