CERTIFICATION OF APPROVAL

Implementation of Computer Control in Control Loop Process

by

Bari' Asyraf Bin Mohd Safian

A project dissertation submitted to the

Electrical and Electronics Engineering PrograMme

Universiti Teknologi PETRONAS

in partial fulfillment of the requirement for the

BACHELOR OF ENGINEERING (Hons)

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Approved by,

(Dr Nordin Saad)

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CERTIFICATION OF ORIGINALITY

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

BARI' ASYRAF B MOHD SAFIAN

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ABSTRACT

Process Control refers to the application of control technology components in order to achieve greater process stability, improved product specifications and yield, and to increase efficiency. In this work, in implementing a process control, Fieldbus technology is used on a simple control loop process. In definition, Fieldbus is a digital, two way communication link between controls where this technology is different with the 4-20mA Analog communication. The process control of desired plant is identified and depicted using P&ID. Then it is converted to the Function Block Diagram, by which the process control loop can be configured using SMAR SYSCON SYSTEM CONFIGURATOR & ICONICS GEN32 Enterprise Edition. All related instruments and devices are initialized and configured using the same application. Finally, the performance of the process control using Fieldbus communication is monitored.

ACKNOWLEDGEMENTS

I would like to praise Allah the Almighty, which gives me strength and helps me in completing my part of my Final Year Project. My deepest gratitude goes to Dr. Nordin Saad as kindly being my supervisor, guiding me to undergo this project.

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LIST OF ABBREVIATIONS

AI	Analog Input
AO	Analog Output
ARTH	Arithmetic
DCS	Distributed Control System
DDL	Device Description Language
DI	Discrete Input
DO	Discrete Output
FF	Foundation Fieldbus
FYP	Final Year Project
HMI	Human Machine Interface
HSE	High Speed Ethernet
I/O	Input/Output
OLE	Object Link Embedded
OPC	OLE for Process Control
UTP	Universiti Teknologi PETRONAS

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

This project mainly on application of computer based control system and the implementation of Fieldbus system in a process plant. In any process application and industry; Oil & Gas, pharmaceutical or petrochemical, monitoring the process performance is crucial in order to maintain its desired operating condition safely and efficiently.

The background of the study is based on the process control application in a plant. Each plant has it important process parameters i.e. pressure, temperature, flow and level. Process control is the method by which the input flow of processing plants is automatically controlled and regulated by various output sensor measurements. Process control can also describe the method of keeping processes within specified boundaries and minimizing variation within a process [1].

The study has been focusing on configuring the Fieldbus system with a pilot process plant using a PC (Personal Computer) as HMI (Human Machine Interface). It requires deep knowledge on the type of the process control and Fieldbus system.

1.2 PROBLEM STATEMENT

A control system is a system of integrated elements whose function is to maintain a process variable at a desired value or within a desired range of values. The control system monitors a process variable or variables, and then acts to maintain the desired system parameter.

In any process industry, good control is needed in order to achieve greater process stability, improved product specifications and yield, and to increase efficiency. Communication between control systems and instruments devices contributes major effect to good control criteria. The wide implementation of 4-20 mA analog in process control during past years proved that this technology must be improved or replaced due to its major disadvantages such as vast installation cost especially in wiring and termination; only single connection can be made between the controller and field device and single signal of transmission. In addition, it could not satisfy the modern need in process control that is to maintain a process at the desired operating conditions, safely and efficiently, while satisfying environmental and product quality requirements [2].

Fieldbus technology had been introduced mainly to improve the conventional 4-20 mA analog technology. Fieldbus is a bidirectional digital communication protocol for field devices. Fieldbus technology drastically changes process control systems and is gradually replacing the standard 4 to 20 mA analog technology that most current field devices employ [4]. It also used to satisfy all the needs in modern process control industries that become more stringent and challenging.

1.3 OBJECTIVES AND SCOPE OF STUDY

The main objective of this study is to develop computer based control system using Fieldbus system technology and to deepen knowledge on Fieldbus system. The focuses of the project are:

i. To implement digital, two way communication that will connect between host and field devices such as transmitter, valve etc.

ii. To provide a communication technology that has multidrop feature. This feature can be implemented by connecting multiple devices to a single Fieldbus network or segment.

The scopes of study of the process plant are:

i. Familiarization of hardware that will be used during the project, for example controllers, transmitters etc.

ii. Familiarization of software that will be used during the project (SMAR).

iii. Understand the function of Fieldbus system configuration.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION OF PROCESS CONTROL

2.1.1 Introduction

In process applications, monitoring the performance and safety of a production system is very crucial. Process control has become more important in the process industries, driven by vast competition, safety regulation and the need of quality product manufacturing. The primary objective of process control is to maintain a process at the desired operating conditions, safely and efficiently, while satisfying environmental and product quality requirements [2].

In practice, process control systems can be characterized as one or more of the following forms [3]:

- Discrete – Found in many manufacturing, motion and packaging applications. Robotic assembly, such as that found in automotive production, can be characterized as discrete process control. Most discrete manufacturing involves the production of discrete pieces of product, such as metal stamping [3].

- Batch – Some applications require that specific quantities of raw materials be combined in specific ways for particular durations to produce an intermediate or end result. One example is the production of adhesives and glues, which normally require the mixing of raw materials in a heated vessel for a period of time to form a quantity of end product. Other important examples are the production of food, beverages and medicine. Batch processes are generally used to produce a relatively low to intermediate quantity of product per year (a few pounds to millions of pounds) [3].

- Continuous – Often, a physical system is represented though variables that is smooth and uninterrupted in time. The control of the water temperature in a heating jacket, for example, is an example of continuous process control. Some important continuous processes are the production of fuels, chemicals and plastics. Continuous processes, in manufacturing, are used to produce very large quantities of product per year (millions to billions of pounds) [3].

Due to its importance, process control recently developed into a new era that is computer-based control systems. Without this technology, process control systems would be impossible to operate modern plants safely and profitably while satisfying product quality and environmental requirements [2]. Therefore, it is important to know and understand of modern process control application that is using computer-based control systems.

2.1.1 Cascade Process Control

A very common applied technique for rejecting the effects of disturbances is the cascade control. It uses deviation on the output of a system to influence an input/ correction back to the system. For example, a control valve is fitted with a positioner that measures the valve stem position and makes adjustment in the diaphragm pressure until the valve stem position equals the desired value / setpoint.

The purpose of using a positioner in the valve is to eliminate the effects of disturbance caused in the valve before it can affect the performance of primary loop. This process called cascade control where the valve positioner is known as the secondary loop while the main controller is known as the primary loop. This primary loop will sends a setpoint to the inner loop [2]

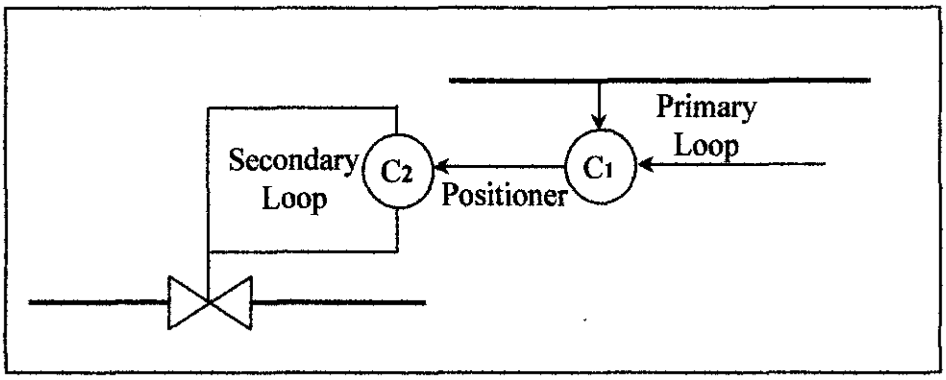


Figure 2-1 Cascade Control Architecture

The advantages of Cascade Control are:

i. Large improvement in performance when the secondary variable is much faster than primary variable.

ii. Simple technology with PID algorithm.

iii. Use of feedback at all levels. Primary variable has zero offset for "step-like disturbance".

iv. Plant operating personnel find cascade loops easy to understand and operate.

2.2 INTRODUCTION OF FIELDBUS SYSTEM

2.2.1 Introduction

In past years, process controls implemented 4-20 mA analog communication to control and monitor all process in plants and industries. An analog transmission is an information transmission technique using analog signals with a direct current of 4 to 20 mA. The topology, which is a one-to-one system, allows only one field device to be connected to a single cable. The transmission direction is one-way. Therefore, two different cables must be provided: one to acquire information from the field device, and the other to transmit control signals to the field device [4].

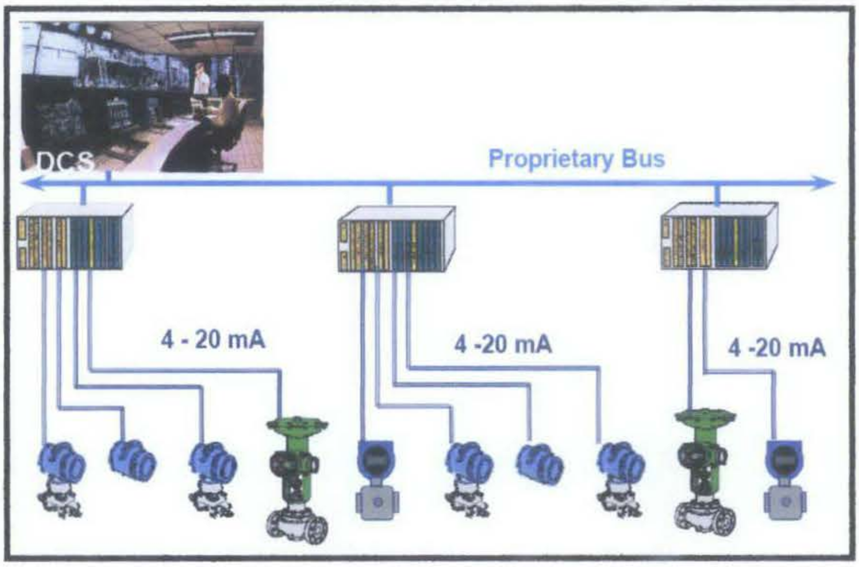


Figure 2-2 Analog 4-20mA system architecture

As engineers become aware of the importance of process control in process industries, they try to develop a new transmission technology to replace the conventional 4-20mA analog that has become almost obsolete. In 90's, Fieldbus communication technology had been introduced mainly to overcome the weakness of the conventional technology and to replace it in later time.

The Fieldbus communication technology, which is different from analog type, is a two way digital communication. It supports bidirectional communication, thus allowing more types and a larger amount of data to be transmitted in comparison to analog transmission and hybrid communication [4]. This communication removes the restriction which allows only one field device to be connected to a single cable in an analog transmission system. Multiple field devices can be connected to a single Fieldbus cable. Also, since this communication is internationally standardized, interoperability of field devices is guaranteed [4]. Interoperability means the system allows devices from different manufacturers are able to be installed in one controller, thus they can interact with each other without any conflict.

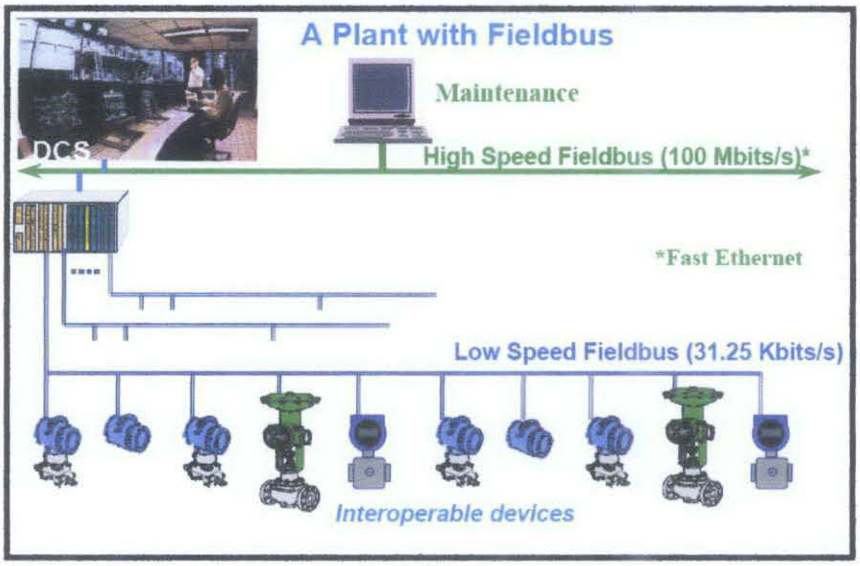


Figure 2-3 Fieldbus system architecture

2.2.2 OSI Model

It is helpful to describe Fieldbus system by using standard networking model like Open system Interconnect (OSI) model of communication. Consists of seven-layer model, it starts from physical layer and ends with application layer. This model explains how messages are built and transferred from a field device to control system and vice versa. The Fieldbus system is modeled after OSI model, but in a simpler ways.

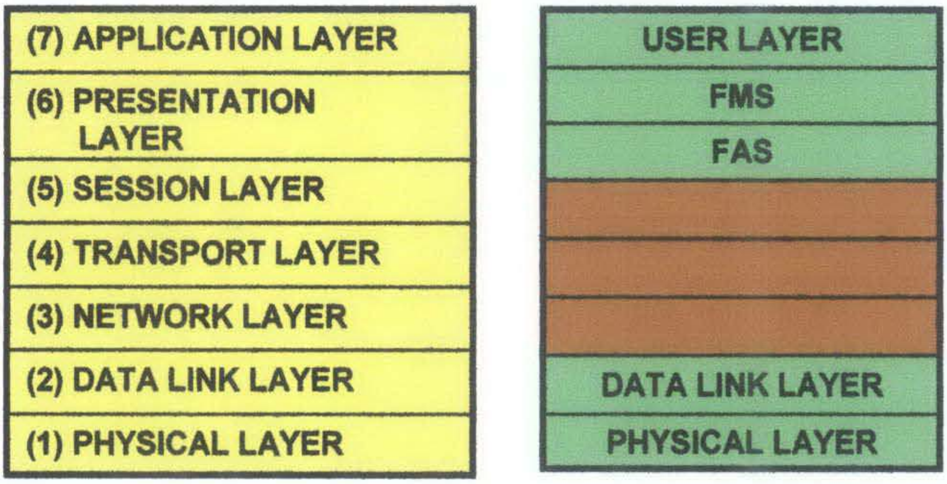


Figure 2-4 Comparison between OSI Model and Fieldbus Model

At the Fieldbus model, Physical Layer or H1 Physical Layer describes the communication speeds and cabling requirements. There are also guidelines on the implementation of power supply and the application of network terminators. Looking at the physical layer from an H1 perspective, the H1 low speed network is compatible with the IEC 61158.2 or the ISA S50.02 Fieldbus standards. The H1 runs at 31.25 kbps [8].

2.2.2 Fieldbus H1 Topologies

It defines on how the Fieldbus devices are connected in the field. There are several methods for networking schemes and each topology has different advantages and disadvantages.

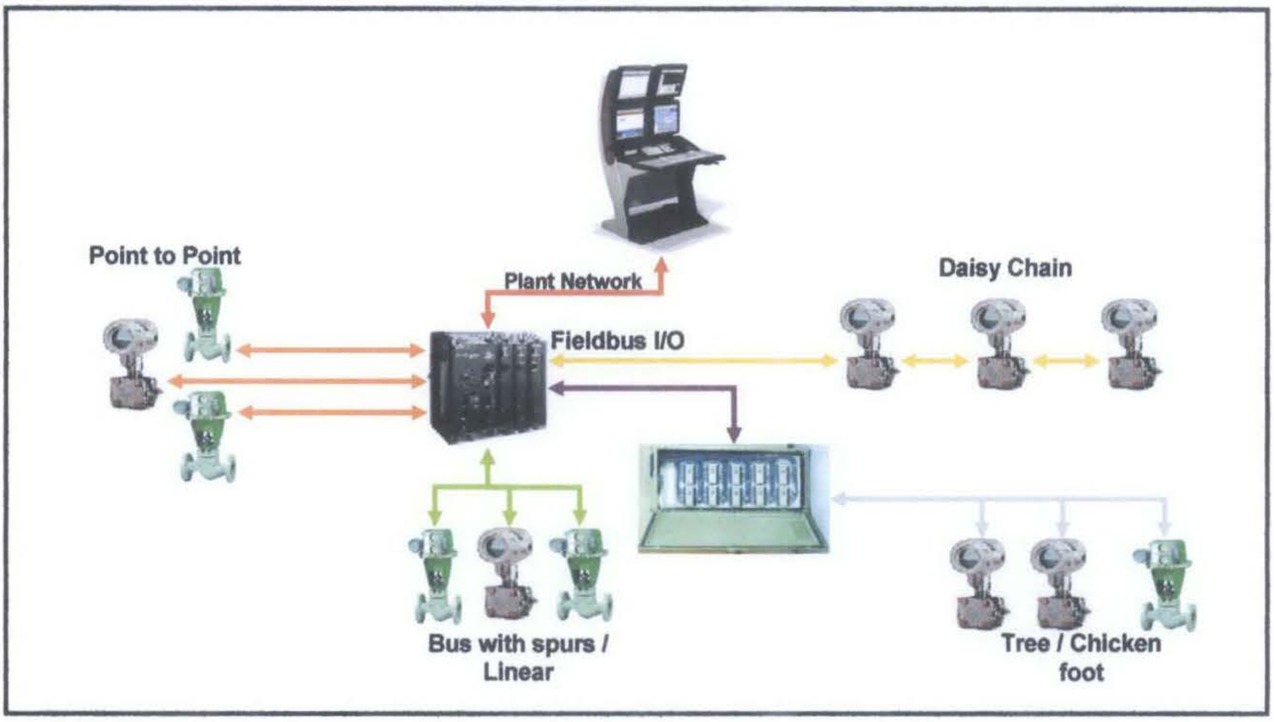


Figure 2-5 Fieldbus Network Topologies

i. Point to point topology

This method is reminiscent of conventional analog installations in that it has a home run from the host to each device [8]. Much of retrofitted installations can take advantage of this type of topology, but much of the benefit of true field communication is lost since each device must communicate to the host. In addition, new installation can be expensive as installing an analog system.

ii. Bus with spurs/ Linear

It employs a single trunk with smaller spurs or drops from the main trunk to each of the field devices. The specification recommends that each spur be a minimum one meter. In the instance that devices are spread over a large area of the process facility, a bus with spurs is a good choice. One disadvantage of this topology is the number of tees or splices that must be used to connect each field devices. These can cause reflections in the network as well as the potential for additional points of failure.

iii. Daisy Chain

Daisy chain is not recommended as an option when installing a Fieldbus segment. It is because it have inherent problem that if one device were to be removed from the segment or malfunction, the entire network will go down. The only advantage of this topology is it can use the maximum length available for the cable i.e. 1900 meters.

iv. Tree/Chicken Foot

It is a popular choice in many process facilities. Using a junction box keeps all splices at one location for easy troubleshooting. It alsc has some inherent fault tolerance since losing a splice or spur to a field device only alienates that device and the whole network will not get affected. One potential drawback is if the field devices are spread over a large area beyond the junction box a greater amount of wire will be required than using a bus with spurs.

2.3 INTRODUCTION TO FUNCTION BLOCK APPLICATION

2.3.1 Overview of Function Block

Function blocks are defined by their inputs, outputs, control parameters, and by the algorithm that operates on these parameters. Function blocks are identified using a name (Tag) and a numeric index. Tags provide a symbolic reference to function blocks. They are unambiguous within the scope of a Fieldbus system. Numeric indices are numbers assigned to optimize access to function blocks. As opposed to function block tags, which are global, numeric indices have meaning only within the application that contains the function block. Function block parameters define the inputs, outputs, and the data used to control function block operation. They are visible and accessible over the network. Additional parameters, called "contained within" parameters are used to define the private data of a function block. Although visible over the network, they may not participate in function block linkages [9].

2.3.2 Transducer Block

Transducer blocks insulate function blocks from the specifics of I/O devices, such as sensors, actuators, and switches. Transducer blocks control access to I/O devices through a device independent interface defined for use by function blocks. Transducer blocks also perform functions, such as calibration and linearization, on I/O data to convert it to a device independent representation. Their interface to function blocks is defined as one or more implementation independent I/O channels [9].

It provides the following features:

- Online measurement of block execution time
- Hardware revision
- Firmware revision
- Serial number of device
- Serial number of main board

2.3.3 Resource Block

Resource blocks are used to define hardware specific characteristics of function block applications. Similar to transducer blocks, they insulate function blocks from the physical hardware by containing a set of implementation independent hardware parameters.

This block contains data that is specific to the hardware that is associated with the resource. All data is modeled as Contained, so there are no links to this block. The data is not processed in the way that a function block processes data, so there is no function schematic. This parameter set is intended to be the minimum required for the Function Block Application associated with the resource in which it resides. Some parameters that could be in the set, like calibration data and ambient temperature, are more part of their respective transducer blocks.

The mode is used to control major states of the resource. O/S mode stops all function block execution. The actual mode of the function blocks will be changed to O/S, but the target mode will not be changed. Auto mode allows normal operation of the resource. IMan shows that the resource is initializing or receiving a software download. Parameters MANUFAC_ID, DEV_TYPE, DEV_REV, DD_REV, and DD_RESOURCE are required to identify and locate the DD so that Device Description Services can select the correct DD for use with the resource.

2.3.4 Analog Input Block

The Analog Input block takes the input data from the Transducer block, selected by channel number, and makes it available to other function blocks at its output. The AI block is connected to the transducer block through the CHANNEL parameter that must match with the following parameter in the transducer block:

- SENSOR_TRANSDUCER_NUMBER parameter for the TT302
- TERMINAL_NUMBER parameter for the IF302

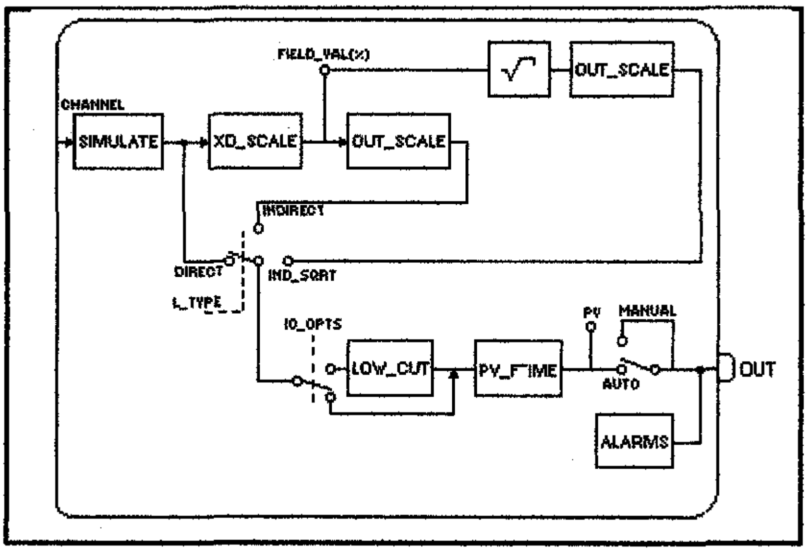


Figure 2-6 Analog Input Schematic

The CHANNEL parameter must be set to 1 (one) if the AI block is running in the LD302, and no configuration is necessary in the transducer block to connect it to the AI block. Transducer scaling (XD_SCALE) is applied to the value from the channel to produce the FIELD_VAL in percent. The XD_SCALE engineering units code and range must be suitable to the sensor of transducer block connected to the AI block, otherwise a block alarm indicating configuration error will be generated.

The L_TYPE parameter determines how the values passed by the transducer block will be used into the block. The options are:

Direct - the transducer value is passed directly to the PV. Therefore OUT_SCALE is useless.

Indirect - the PV value is the FIELD_VAL value converted to the OUT_SCALE.

Indirect with Square Root - the PV value is square root of the FIELD_VAL converted to the OUT_SCALE.

PV and OUT always have identical scaling based on OUT_SCALE.

The LOW_CUT parameter is an optional characteristic that may be used to eliminate noise near zero for a flow sensor. The LOW_CUT parameter has a corresponding "Low cutoff" option in the IO_OPTS bit string. If the option bit is true, any calculated output below the low cutoff value (LOW_CUT) will be changed to zero.

2.3.4 Analog Output Block

The Analog Output Block is a function block used by devices that work as output elements in a control loop, like valves, actuators, positioners, etc. The AO block receives a signal from another function block and passes its results to an output transducer block through an internal channel reference.

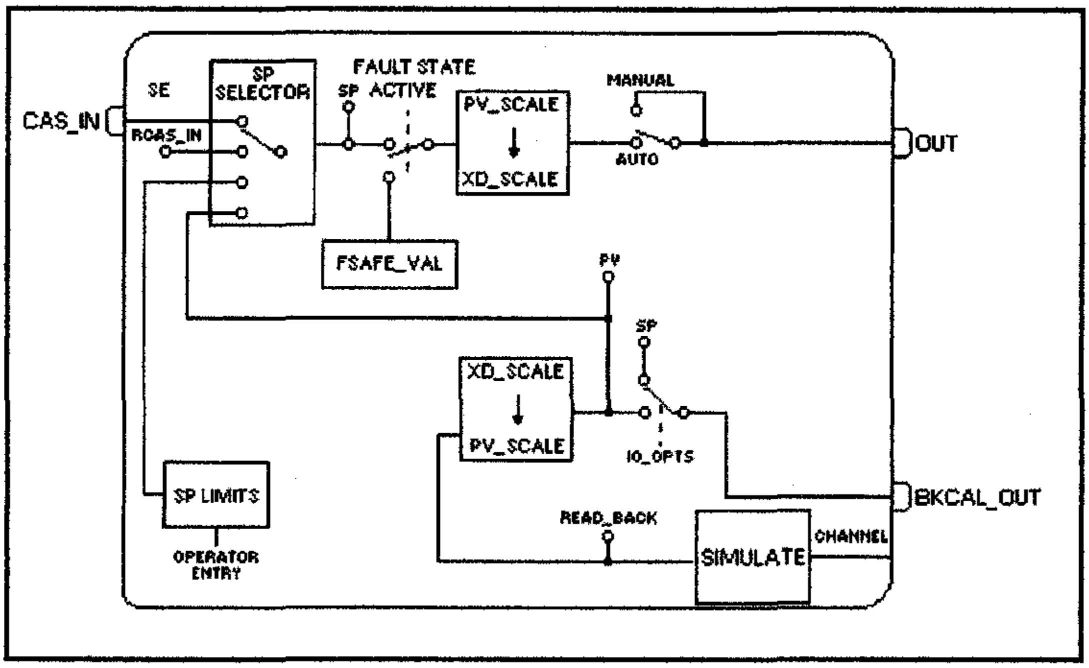


Figure 2-7 Analog Output Schematic

AO block is connected to the transducer block through the CHANNEL parameter that must match with the following parameter in the transducer block: TERMINAL_NUMBER parameter for the FI302 The CHANNEL parameter must be set to 1 (one) if the AO block is running in the FY302 or FP302, and no configuration is necessary in the transducer block to connect it to the AO block.

The SP value may be controlled automatically through a cascade or remote cascade control or manually by an operator. The PV_SCALE and XD_SCALE are used to do the scaling conversion of the SP. The transducer scaling (XD_SCALE) is used to convert percent of span to the number used by the transducer. This allows portions of the SP span to cause full span movement of the output. The bit "Increase to Close" in IO_OPTS allows the output to be inverted relative to the span of the input value.

2.3.4 PID Control Block

The PID block offers a lot of control algorithms that use the Proportional, integral and derivative terms. The algorithm of the PID is the non-iterative or ISA. In this algorithm, the GAIN is applied to all terms of the PID, and the Proportional and the Integral actuate over the error, and the derivative actuates over the PV value. Therefore user changes of SP will not cause bump in the output due to the derivative term when the block is in Auto. As long as an error exists, the PID function will integrate the error, which moves the output in a direction to correct the error. PID blocks may be cascaded when the difference in process time constants of a primary and secondary process measurement makes it necessary or desirable [9].

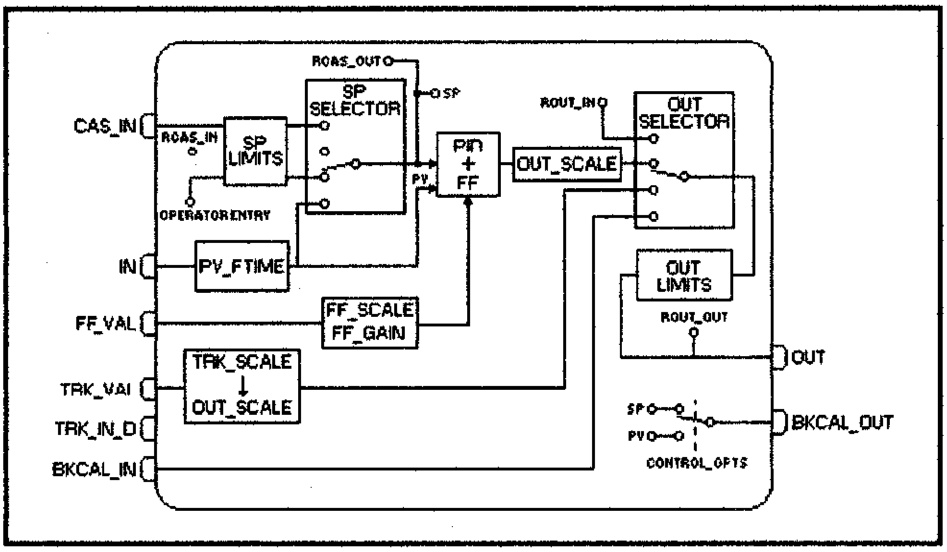


Figure 2-8 PID Control Schematic

2.3.4 Cascade Control

In a cascade, the upper control block provides an output value and status, which becomes the cascade input to the lower block. The lower block in the cascade provides an output value, which is communicated to the upper block as back-calculation input. Based on the following example, which is the most common form of cascade, it will be shown the process of cascade initialization [9]. There is a linked output and input pair involved in each of the different forms of cascade, as shown in the following table.

Mode	Forward	Backward
Cas	CAS_IN	BKCAL_OUT
RCas	RCAS_IN	RCAS_OUT
Rout	ROUT_IN	ROUT_OUT

Based on the following example, which is the most common form of cascade, it will be shown the process of cascade initialization.

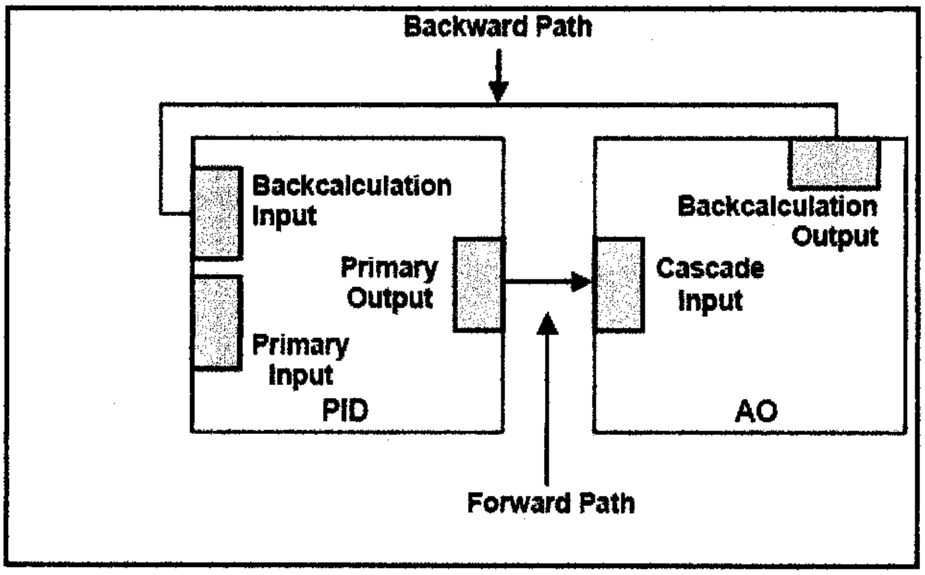


Figure 2-9 Cascade Common Form

There are four steps to complete a cascade initialization:

i. Not cascade mode – As the AO block is in Auto mode, the PID block is not calculating the output (OUT), it is just following the backward value (AO.BKCAL_OUT -> PID.BKCAL_IN).

PID

MODE_BLK.Target = Auto

MODE_BLK.Actual = IMan

OUT.Status = GoodC-Non-specific

AO

MODE_BLK.Target = Auto

MODE_BLK.Actual = Auto

BKCAL_OUT.Status = GoodC-Not Invited

ii. Initialize – The user changes the target mode of AO block to Cas, then the AO block sets

GoodC-IR in BKCAL_OUT. The value of BKCAL_OUT is the initial value for the PID starts to calculate. The AO block waits for the PID to set GoodC-IA in OUT, which is linked to AO.CAS_IN (PID.OUT ->AO.CAS_IN).

PID

MODE_BLK.Target = Auto

MODE_BLK.Actual = IMan

OUT.Status = GoodC-Non-specific

AO

MODE_BLK.Target = Cas

MODE_BLK.Actual = Auto

BKCAL_OUT.Status = GoodC-Initialization Request (IR)

iii. Initialization complete – The AO block goes to Cas, because the PID block sent GoodC-IA.

PID

MODE_BLK.Target = Auto

MODE_BLK.Actual = IMan

OUT.Status = GoodC- Initialization Acknowledge (IA)

AO

MODE_BLK.Target = Cas

MODE_BLK.Actual = Cas

BKCAL_OUT.Status = GoodC- Non-specific

iv. Cascade complete – The PID block changes the status of OUT from GoodC-IA to GoodC-NS.

PID

MODE_BLK.Target = Auto

MODE_BLK.Actual = Auto

OUT.Status = GoodC- Non-specific

AO

MODE_BLK.Target = Cas

MODE_BLK.Actual = Cas

BKCAL_OUT.Status = GoodC- Non-specific

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In order to satisfy the project requirements, several steps are taken and recorded. Initially, the author decided on project requirements and problem statements by performing researches and review on journal, books, internet and articles. This ensures that the concept of the project can be fully understood and thus all process throughout the project lifecycle will become easier.

After that, based on some previous experience in PETRONAS Carigali during his internship program, all materials related were compiled and studied. Some discussion with colleagues, lectures and engineers related with the project were made to get more information. The major concerns are on how to setup initialize and configure all the hardware using the software provided. Therefore, it is very important to fully understand the operation and implementation of the hardware and software and how they can benefit the projects.

3.2 PROJECT PLANNING

All steps and approaches discussed above are illustrated in Project Flow Diagram below:

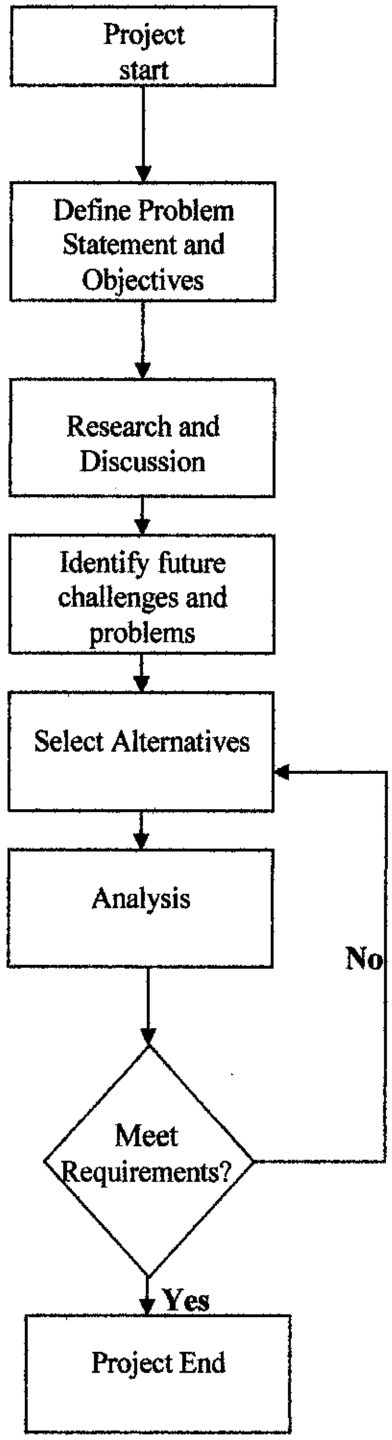


Figure 3.1: Project Flow Diagram

Then, the author planed on making the process control loop to the pilot plant. It can be depicted with the Process Flow Diagram below:

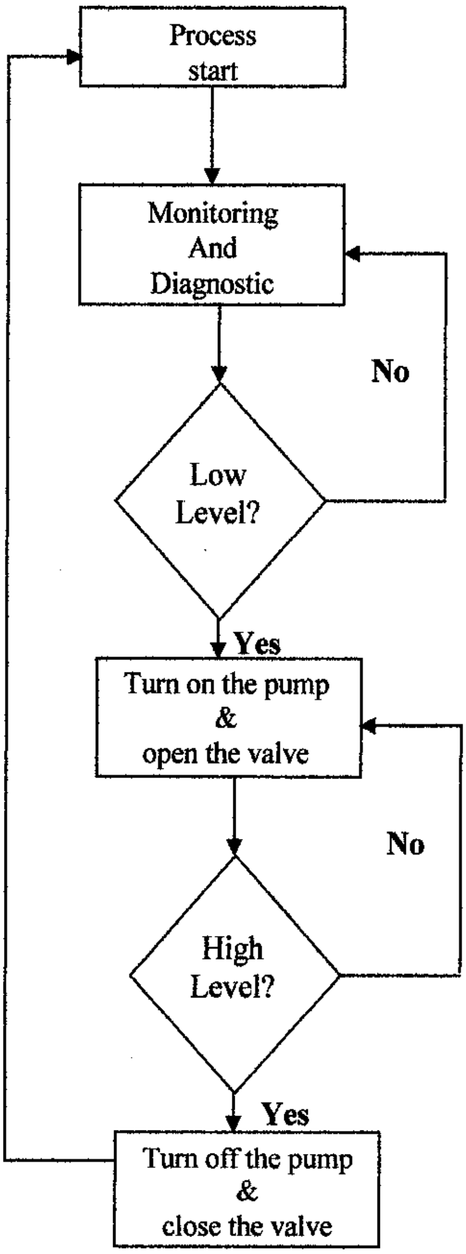


Figure 3.2 Process Flow Diagram

First, start the process of the pilot plant is initiated. The status of the closed tank is monitored and diagnosed by using the level transmitter. This transmitter will give the status of the process liquid level on the tank. When low level signal is indicated, the controller will give instruction to the pump to turn on and the valve to open thus the process liquid can fill up the closed tank. During the fill up, the level of the tank also being monitored and if the level is exceeded the requirements, the valve will be closed and the pump will be turned off.

3.3 HARDWARE AND SOFTWARE REQUIREMENTS

There are several hardware and software that is used in the project in order to accomplish the project. They are:

i. SMAR SYSCON System Configurator

It a software tool especially developed to configure, maintain and operate SMAR Fieldbus products line, by a Personal Computer with a Fieldbus interface. The friendly Human Machine Interface (HMI) of the SYSCON provides an efficient and productive interaction with the user. The use of the Fieldbus protocol provides interoperability between the system and each piece of equipment. The physical interface with the field network - the PCI (Process Control Interface) Board or the DFI (Fieldbus Universal Bridge) - is connected to a PC bus: equipment especially developed by SMAR for its Fieldbus line.

Configuration entry is completely graphical and object oriented. Function blocks are depicted as circles just like an ISA S5.1 P&I diagram. Tag and description of the block is displayed along with block input and output names. Additional illustrating graphics and clarifying annotations and descriptions can be added to illustrate concept or grouping. Configuration includes selection of devices and function blocks, linking and parameterization of the blocks.

ii. ICONICS GraphWorX32

GraphWorX32 is a Human Machine Interface (HMI) software packages for process control. It is a stand alone OPC client software package, providing a rich set of tools for creating animated graphics. This is where the visualization of the process is created for the Operator Interface. Using this software, all objects via function blocks can be embedded and linked to the application that created them. It also enhances the interface between host and field devices by providing supported mechanism to communicate data between devices and devices or host and devices.

iii. SMAR FIELDBUS BRIDGE DFI302.

It is a multifunction hardware component which includes all of hardwares and softwares needed to manage, monitor, control, maintain and operate a plant. DFI302 is a single, integrated unit of interface, linking device, bridge, controller, gateway, Fieldbus power supply and Distributed I/O system.

Features:

i. Tight integration with intelligent devices and software.
ii. Employs open Fieldbus and OPC standards.
iii. Connects through conventional I/O Modbus Communication.
iv. Full redundancy and fault isolation.
v. High information throughput.

The Fieldbus Bridge DFI302 consists of several modules, i.e.:

i. DF50 Power Supply for backplane

- Input: 90-264 VAC.

- Output: 5VDC (Backplane power supply) and 24VDC (External Use).

ii. DF51 Processor Module for DFI302

- 1 x 10Mbps Ethernet and 4 x Fieldbus H1 channels at 31.25Kbps.

iii. DF52 Power Supply for Fieldbus

- Input: 90-264 VAC.

- Output: 24VDC.

iv. DF53 Power Supply Impedance for Fieldbus (4 ports)

- To ensure no short circuit between the power supply and the communication signal of the Fieldbus.

iv. SMAR LD302 Pressure (Gauge & Differential) Transmitter.

SMAR LD302 Pressure Transmitter are designed for differential, absolute and gauge pressure, level and flow measurements. It is based on a proven digital capacitance sensor providing reliable operation an high performance. The LD302 is part of SMAR complete series of Fieldbus devices.

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

v. SMAR TT302 Temperature Transmitter.

SMAR TT302 Temperature Transmitter provides measurement of temperature using RTDs or Thermocouples, but also can accept other sensors with resistance or mV output.

Features:

- Digital LCD display (Optional)
- Basic accuracy of 0.02%
- Self Diagnostic
- Dual Channel
- Universal input accept several Thermocouples, RTDs, mV and Ohm

vi. SMAR FY302 Valve Positioner.

The Fieldbus 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 advance control schemes.

Features:

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

vii. Hub

The hub is used in switching and connecting network between Host device and the Fieldbus Configuration system. it automatically establishes what addresses are on which port. The hub support multichannel capability that connects several networks together so that the communication between ports can occur simultaneously without interfering each other.

viii. Host Device

It is usually a personal computer (PC) with special integrated software (SYSCON SYSTEM CONFIGURATOR AND ICONICS GEN32) that is located in the control room that controls the process configuration. Its function is to configure, monitor and control the operation of control system made up from the pilot plant.

CHAPTER 4

RESULTS AND DISCUSSION

Throughout the first semester, several steps referred to the process flow diagram have been accomplished, mainly on researches and data compilation. At the earlier stage of the work, several issues such as designing Project Flow Diagram, performing researches of Process Control and Fieldbus technology and project objectives have been accomplished.

After the study have been completed, the author moved to the next; doing some experiments to get some initial results. These results were analyzed and used for further project development. In the final semester, the author started the initialization and configuration of the computer based control system using Fieldbus system. By using two main softwares i.e. SMAR SYSCON System Configurator and ICONICS GEN32 (Including GRAPHWORX, TRENDWORX AND ALARMWORX) and all instruments and equipments, the system was developed.

4.1 RESEARCHES

During few early weeks of semester, the author had made researches on various kinds of sources such as library and internet for any kind of articles, journals and books related with his project. Also some discussion with the lecturers, senior students and engineer were made to find any useful information regarding the project.

The results of the researches are listed below:

i. What is Fieldbus?

- It is a digital, two-way, multi-drop communication link among intelligent field devices and automation systems.

- Multi- drop communication means Fieldbus can connect multiple field instrument devices to the controller with single cable using various kinds of topologies.

ii. What are the advantages of using Fieldbus instead of the conventional 4-20 mA analog communication technology?

- The advantages of using Fieldbus are:

a) Cost saving in terms of wiring installation and field devices commissioning.

b) Provide diagnostic access to the devices. It can provide the status of a device and make sure the value given is whether valid or not.

c) The introduction of interoperability of devices.

- This "interoperability" term means it allows devices from different manufacturers are able to be installed in one controller, thus they can interact with each other without any conflict.

iii. How can we implement Fieldbus technology on process control loop?

- We can implement Fieldbus technology on process control loop by connecting all the devices related such as valves and transmitter to the controller via fieldbus cable.

- After that, all the devices must be initialized and configured so that it can be read by the controller.

- Using the software provided, a process control loop will be built using function block diagram as per desired by operator.

iv. How do we insert process loop drawing into the software?

- Firstly, the process control must be drawn to get the idea on how to make the process control works. One of the way to draw is using P&ID.

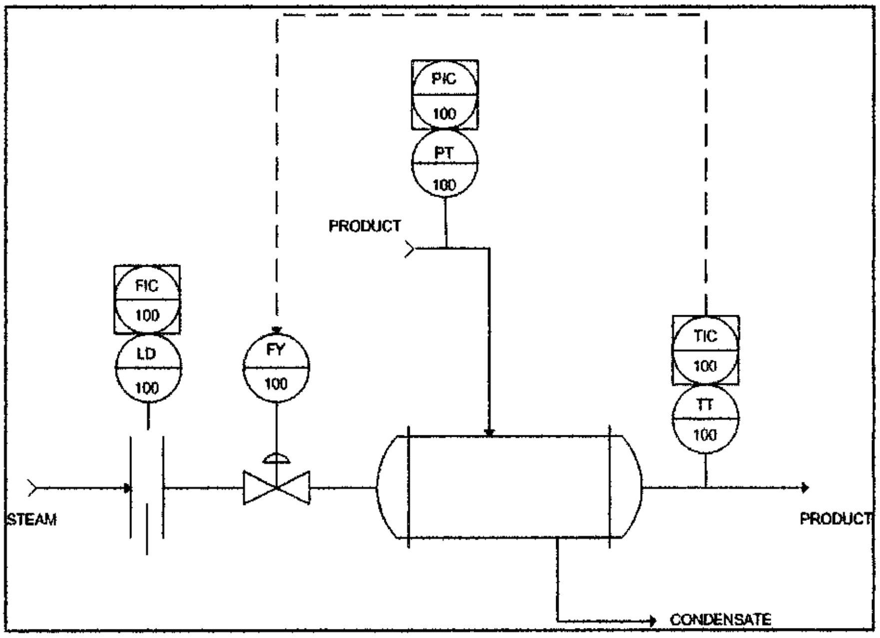


Figure 4.1: An example of P&ID

- After that, the drawing will be converted to Function Block Program. Function Block Program is an integral part of Fieldbus system. It is used to control and monitoring a process system. An example of Function Block Diagram is shown:

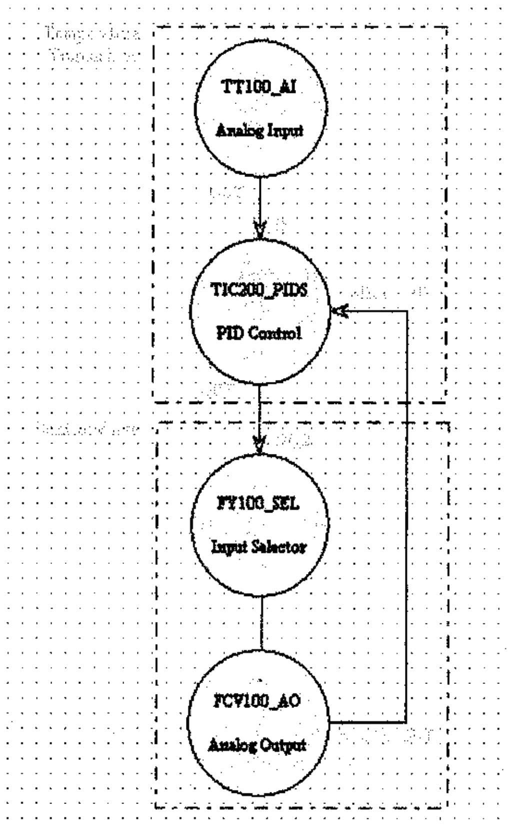


Figure 4-2: Example of Function Block Diagram [5]

4.2 INITIAL EXPERIMENT

For the initial experiments, 2 objectives must be met. The objectives are:

i. To identify the process control loop of the pilot plant.

ii. To know all the instruments and field devices used in the pilot plant.

As the results, the devices that will be used are:

i. SMAR FIELDBUS BRIDGE DFI302.

ii. SMAR LD302 Pressure (Gauge & Differential) Transmitter.

iii. SMAR TT302 Temperature Transmitter.

iv. SMAR FY302 Valve Positioner.

v. Hub

vi. Host Device

4.3 CONFIGURATION AND SIMULATION

4.3.1 System Configuration

Using SYSCON SYSTEM CONFIGURATOR, Fieldbus configuration system was developed and configured using SMAR Fieldbus products line. Personal computer was used as a host device with a Fieldbus interface. The PC physical interface with the field network is by the PCI (Process Control Interface) board or the DFI (Fieldbus Universal Bridge) connected to a PC bus via hub.

Firstly, new project was started after running the software. The communication setting was set for SMARDFIOLEServer.0 node as being used to connect between field instrument and host. Usually, this node is the default node for the connection. Then, communication initialization was done by click at the green "ON" button at the toolbar.

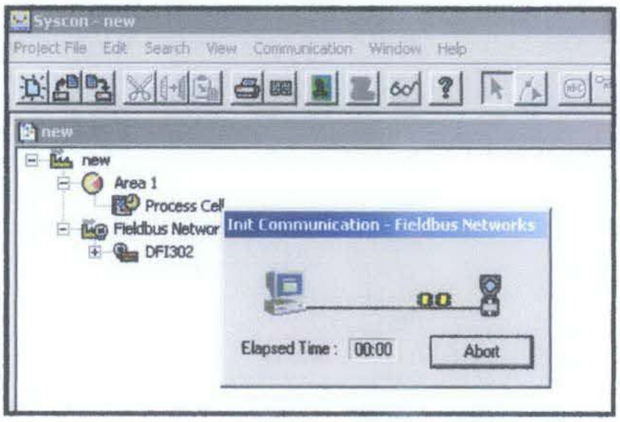


Figure 4-3: Communication Initialization window

SYSCON software has two main work areas that are Logical Plant named as Area 1 and the Physical Plant named as Fieldbus Networks. The uploading from the field was being done in Physical Plant. The uploading process was started by right clicked the Fieldbus Network and select upload. Then all active Fieldbus networks will appear as in diagram below:

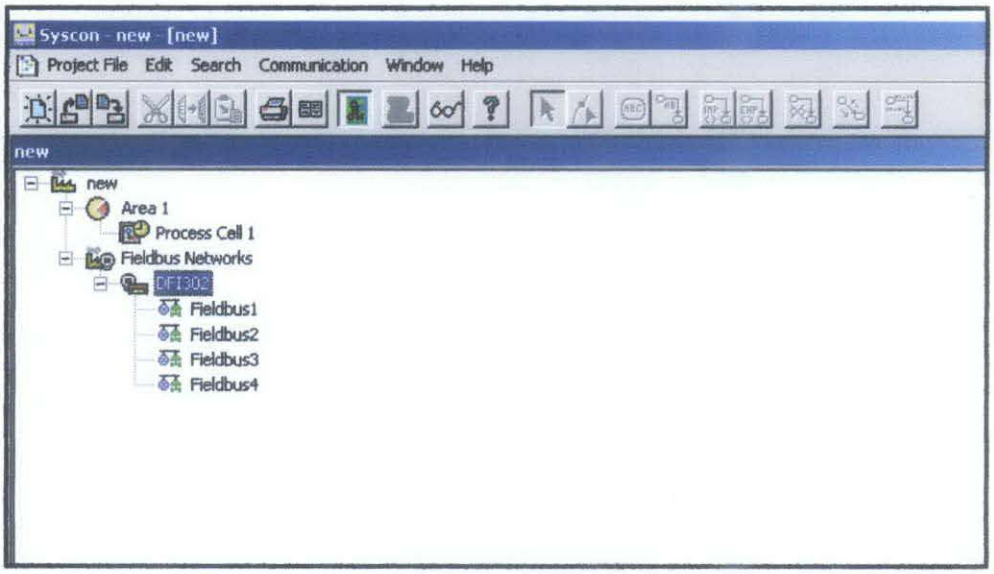


Figure 4-4: Active Fieldbus Networks

The first Fieldbus network was selected and all the field devices from the plant were uploaded to the network.

Figure 4-5: Uploading Fieldbus devices

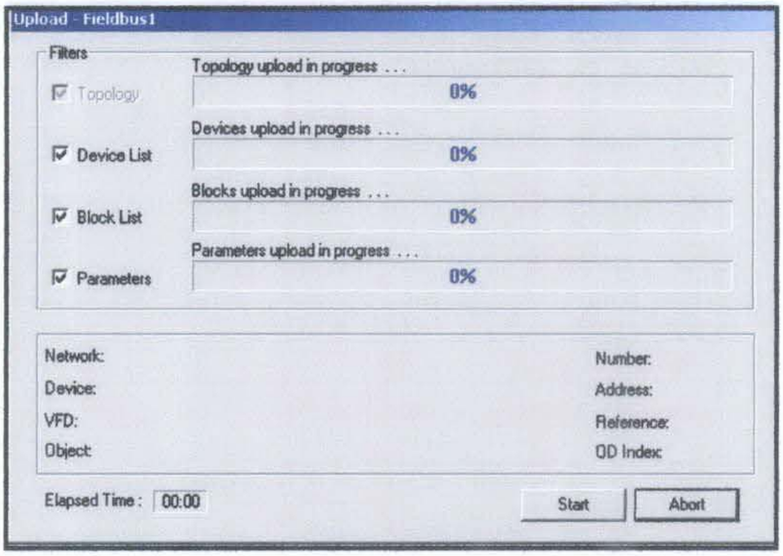


Figure 4-6: Uploading window

All live devices with their function blocks will appear in the Fieldbus network. Each device had its own unique address or Device ID that will be used to communicate between the host and the process loop.

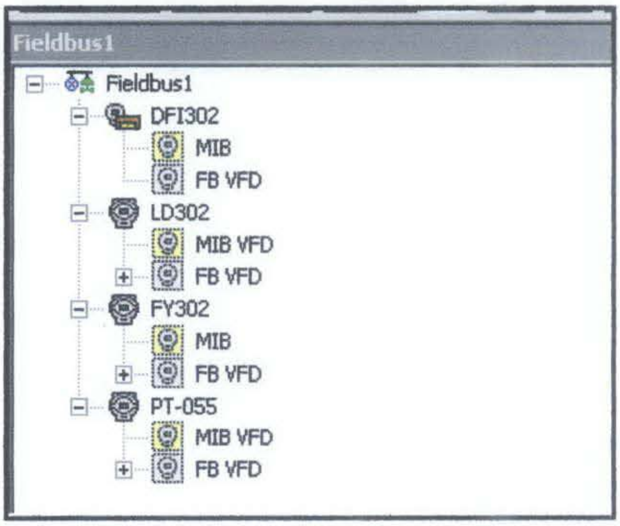


Figure 4-7: Active devices and Function Blocks

Specific function blocks also been added and configured to the respective field devices:

i. Control Valve with Positioner Fy302 –

- Analog Output Block
- Resource Block
- Transducer Block
- Display Block

ii. Level Transmitter LD302

- PID Control Block
- Analog Input Block
- Display Block
- Transducer Block
- Resource Block

iii. Temperature Transmitter TT302

- PID Control Block
- Analog Input Block
- Display Block
- Transducer Block
- Resource Block

iv. Gauge Pressure Transmitter PT055

- Resource Block
- Display Block
- Transducer Block

Each block from each device will be configured based on the process control requirement. The process control selected was Cascade control. The criteria for cascade control are:

i. Pressure Transmitter (LD302):

AI BLOCK (TT302):

MODE_BLK.TARGET= AUTO

PID BLOCK (TT302)

MODE_BLK.TARGET= AUTO

PV_SCALE= 0-100 psi

OUT_SCALE= 0-200 kg/h

ii. Level Transmitter (LD302):

AI BLOCK (LD302):

MODE_BLK.TARGET= AUTO

L_TYPE= indirect, square root

XD_SCALE=0-200 inH20

OUT_SCALE= 0-200 kg/h

PID BLOCK (LD302)

MODE_BLK.TARGET= CAS

PV_SCALE= 0-200 kg/h

OUT_SCALE= 0-100%

iii. Valve Positioner (FY302)

AO BLOCK (LD302)

MODE_BLK.TARGET= CAS

PV_SCALE= 0-100%

OUT_SCALE= 3- 15 psi

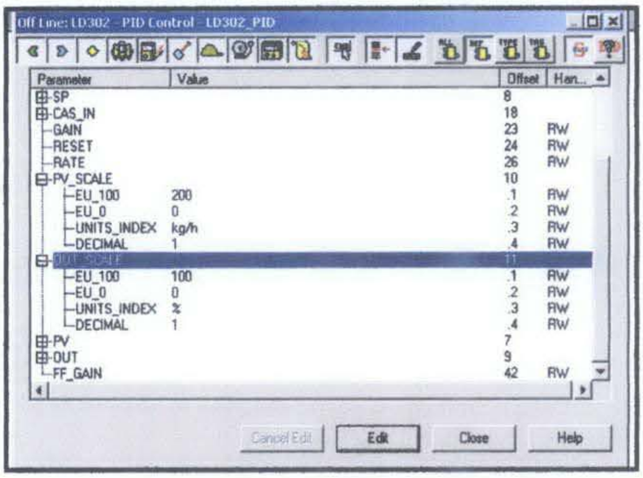
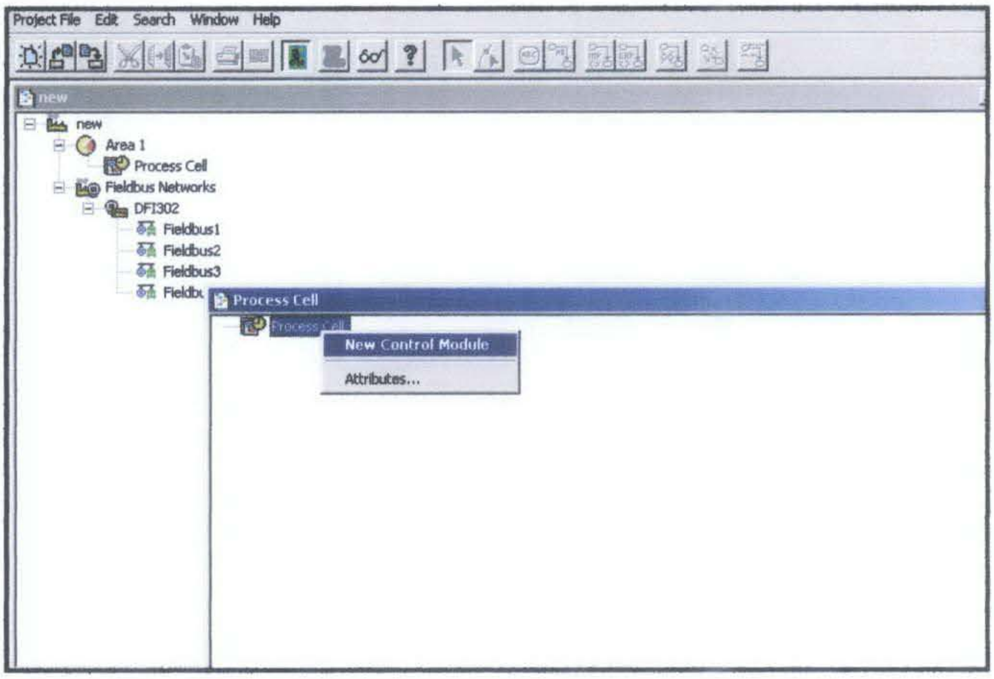


Figure 4-8: Function Block configuration

4.3.2 Control Strategy

Next step was to develop control strategy for the Fieldbus configuration system. Control strategy was done by linking and parameterizes required function blocks to design cascade control. In the Area 1, right click and select New Process Cell. Then New Control Module was selected; where in this area will be the control strategy being developed.

The Control Module was filled by selected function blocks. It was done by dragging the function blocks to the Control Module.



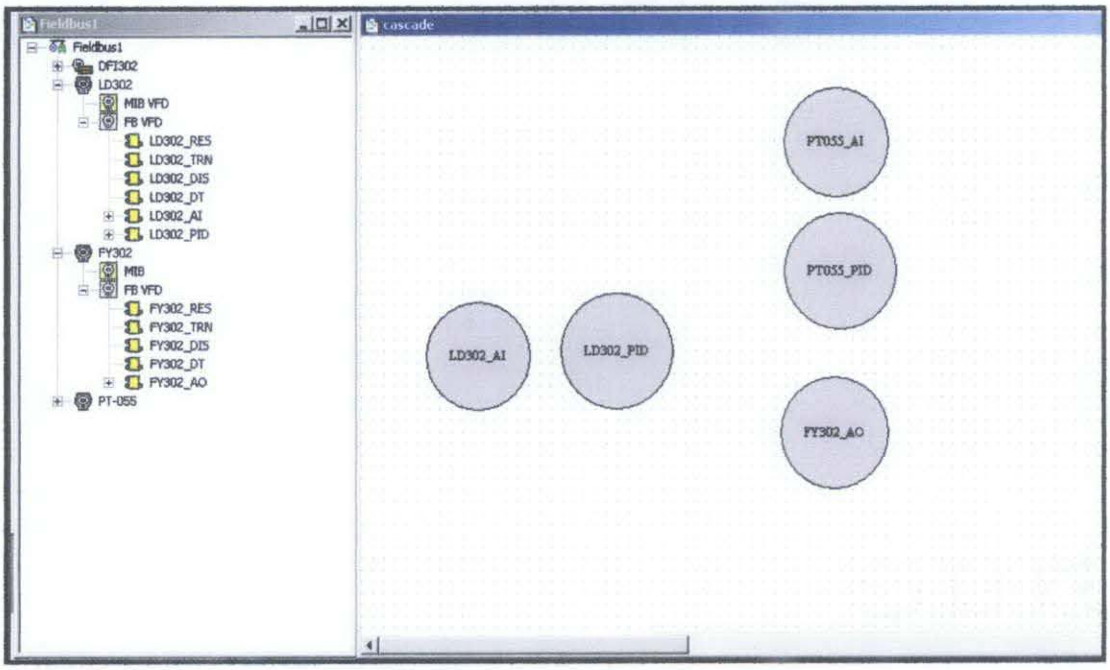


Figure 4-9: Developing control strategy

In the Control Module work area, the blocks were connected with the link icon according to the function block created.

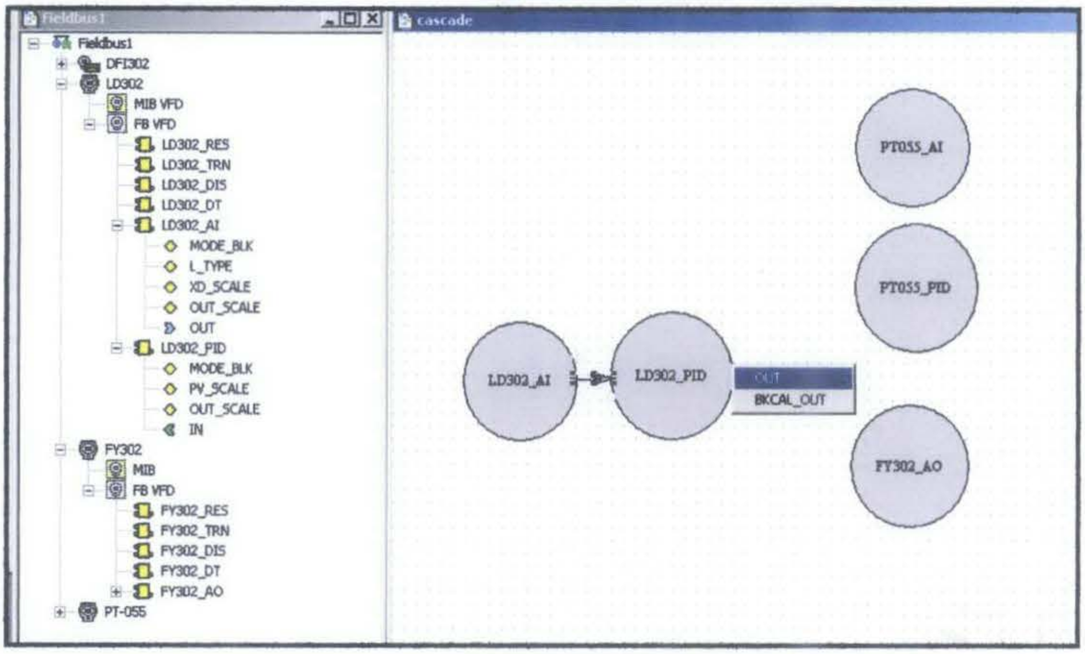


Figure 4-10: Linking up function blocks

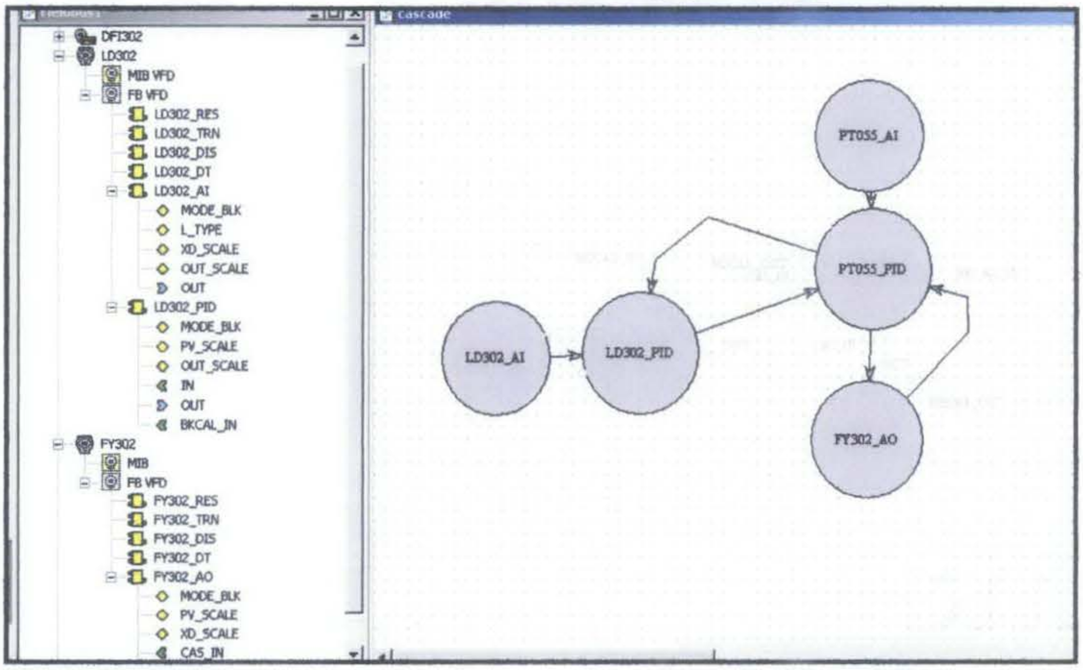


Figure 4-11: Completing Cascade control strategy

4.3.3 Downloading to the process plant

After all configurations were done, it was downloaded to the process plant. Right click to the Fieldbus Network and select download, and download process began.

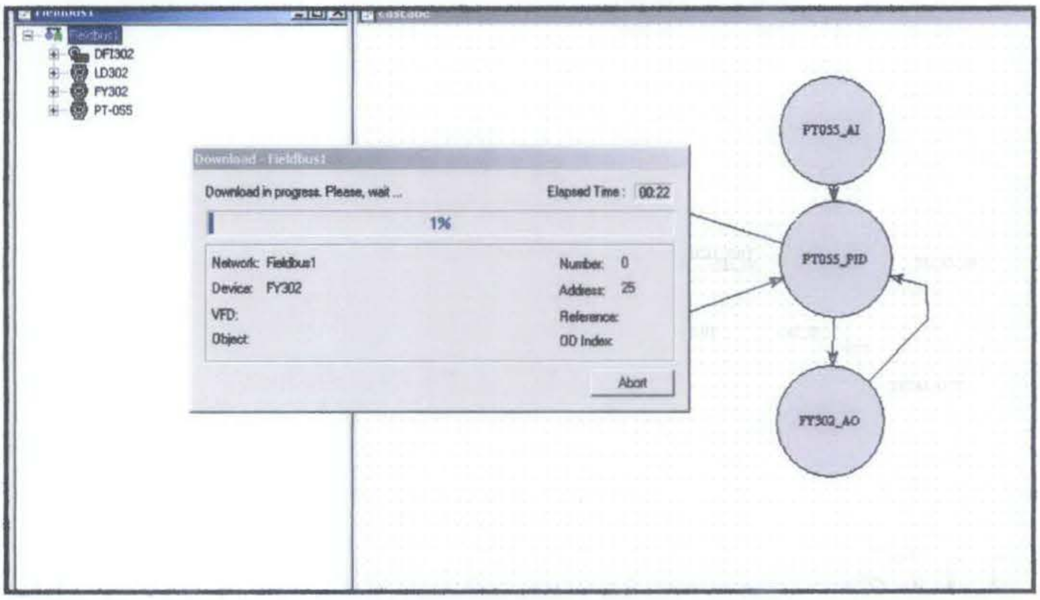


Figure 4-12: Downloading configuration to the process plant

To check whether the system was running good, right click the device block and select Online Characterization. All quality supposed to be in Good condition

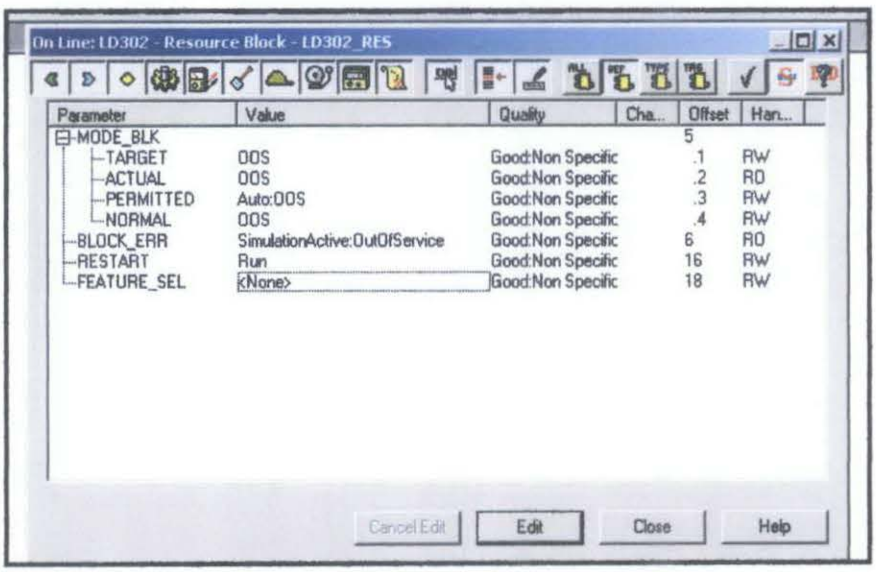


Figure 4-13: Good condition of device

4.3.4 Creating OPC database

OLE (Object Link Embedded) for Process Control or OLE was developed so that all data stored in the host can be monitored and controlled in the PC host. Before the interface was done, all data in the system configured before will be exported to the server (in case it had been done, it will be updated).

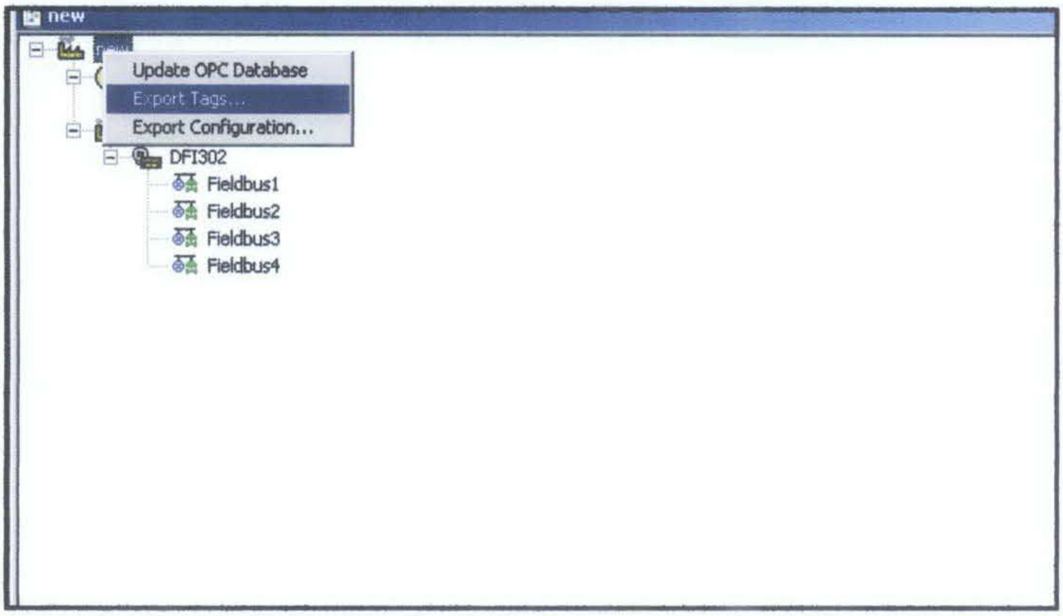


Figure 4-14: Exporting tags to the server

Then, at start menu, GenBroker Configurator was selected (inside ICONICS GENESIS-32 Folder) in order to obtain continuous data.

4.3.5 GraphWorX32 Setup

The monitoring and diagnostic can be done remotely via host device. By using GraphWorX32, the process visualization interface was developed, which it allows screens to be totally customized for the user interface.

It showed the overview of the process plant with selection button to select the control loop strategy to be applied to the process. After opening the GraphWorX32, all the devices from the process plant were drawn.

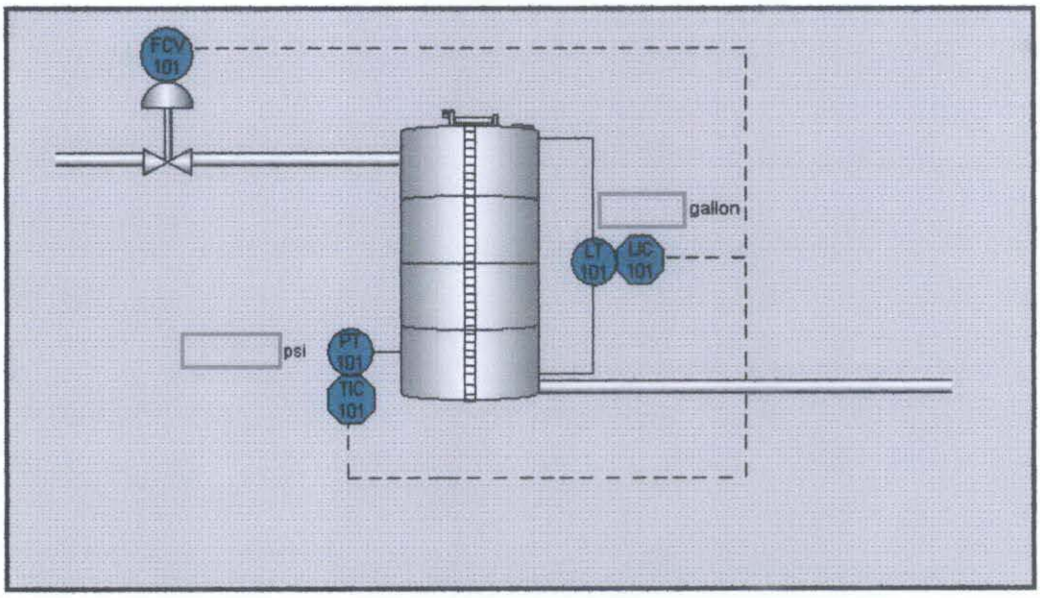


Figure 4-15: Drawing the process plant interface

4.4 DISCUSSION

The topology used in the process plant gave a problem during the Fieldbus configuration system development. The major disadvantage of daisy chain topology is, when one of the devices was down or set to be removed, the entire network will go down. During the configuration, the temperature transmitter TT302 could not been detected and thus this created an instability at the Fieldbus network. When the system tried to upload all active devices from the pilot plant, it could not detect the temperature transmitter; though the connection of the transmitter had been checked several times.

Another problem encountered was the developed project could not be saved as a file, thus creating problem to create it once over again. When the project was tried to be loaded back, all devices went undetected thus it must be created from the start.

CHAPTER 5

CONCLUSION & RECOMMENDATION

5.1 FIELDBUS OVERVIEW

5.1.1 The real Fieldbus.

In the plant technology today, many buses designed for plants control mistakenly called as "fieldbus" thus created confusion with the real fieldbus. The fact is the "fieldbus" properly applies only to buses with technical correspondence to the IEC/ISA SP50 fieldbus standard, such as FOUNDATION FIELDBUS. In this project, this type of fieldbus was used.

Fieldbus technology was developed to help solve problems, to make plant runs better and to make better measurements. In traditional or legacy systems that use 4-20mA current loops, a single device is connected to a pair of wires and power supply. This is a point to point communication mode. In a fieldbus network, multiple devices may be connected to a single fieldbus, each of which communicating to each other in different devices connetion topologies i.e. point to point, daisy chain, trees or chicken foot or bus with spurs.

Besides providing field-level control, the fieldbus system also has HSE (High Speed Ethernet) as control level network that takes the place of remote I/O networks. In this project, much detail focused on the Low Speed Fieldbus or known as Fieldbus H1.

5.1.2 Fieldbus system vs 4-20mA system

The most significant benefit Fieldbus system gives is the cost reduction in term of wiring and terminations. In traditional 4-20mA systems each instruments have their own cable that connected to the host devices. If the system has hundreds devices, it also has hundreds of wires. In many instances a multi paired cable would run throughout different areas of the plant to provide connectivity. In the event of an Intrinsically Safe (IS) installation, traditional systems required an IS barrier for each pair of wires [8]. In a Fieldbus implementation, several devices can be connected to a single segment. In addition, in IS application only one IS barrier is required per segment. Therefore, a reduction in the cost of wiring and instrically safe barriers is realized.

Fieldbus system provides the ability to distribute control functionality across multiple devices. In 4-20mA system, point to point topologies have a singular relationship with host systems [8]. The host will retrieve information collectively from the devices and compile this information for use in the final control of other devices. For Fieldbus, all devices are connected on one segment, thus they can communicate each other without any intervention from the host system.

Perhaps the big difference between 4-20mA system and Fieldbus system is Fieldbus system provides diagnostic benefits for its devices, thus it increase the flow of information in the loop. In the traditional 4-20mA system, typically an analog value would be read representing all important parameters such as temperature, pressure and level. For Fieldbus system, the temperature value that is being read not only provides value but there is also a status message that accompanies the data, which indicates the quality of the value. This provides diagnostic information to validate the measurement value. It also can show that the measurement is good value or bad value. When a device shows bad value, means that whether the device is having a problem or it's time to be maintained has come. This great benefit that is not available in traditional 4-20mA system.

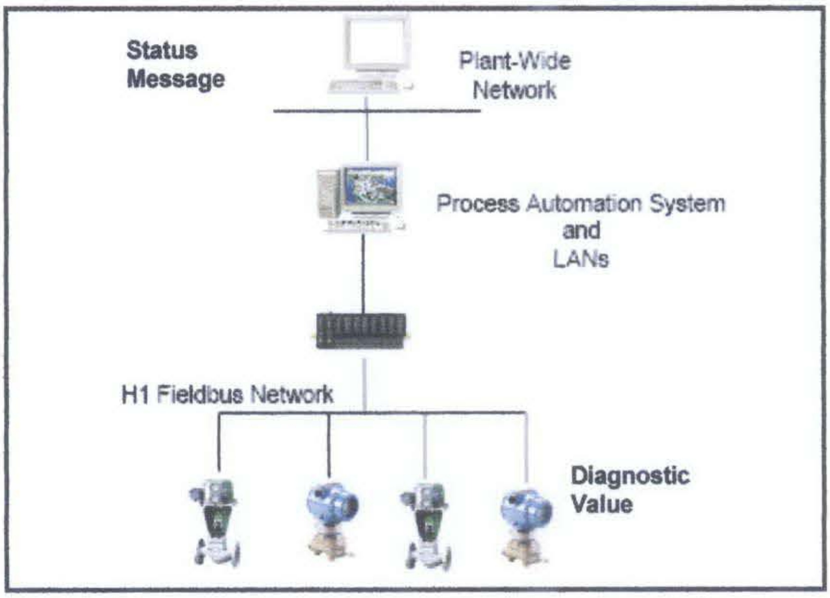


Fig 5.1: Fielbdus system with network diagnostic benefits

5.2 CONCLUSION

Fieldbus networks are designed to provide highly reliable bi-directional communications between sensors and actuators and a control system in any process control application. One of the objectives for fieldbus is to be the digital replacement for analog 4-20mA transmission of process variables in the process industries. An example of implemented low-speed fieldbus networks is FOUNDATION Fieldbus H1.

The motivation to this project is to learn deeply about Fieldbus technology and able to build Fieldbus system configuration for a process plant using all hardware and software required.

During the testing and simulation, all required configuration setting for the system were completed. But a problem was encountered during one of the process, which is during the downloading of all configurations to the pilot plant. The configuration could not be downloaded to the pilot plant, thus the control mechanism could not be done.

Since all available devices was managed to be uploaded from the pilot plant, the system can only monitor the status of the devices but couldn't put any control to the pilot plant.

Deep research was done and studied in order to search the cause of the problem and concluded that it came from the field devices connection topologies. The plant was using daisy chain topology, which this type of connection is not recommended as an option when installing fieldbus segment. It is because daisy chain has inherent problem that if one device were to be removed or broke down, the entire network would go down. Although it offers very long network connection runs (1900 meters), but many engineers prefer to use tree or chicken foot topologies. The author also found that one of the field device could not be detected in the Fieldbus System Configurator (Fieldbus Temperature Transmitter TT302) thus strengthened his conclusion.

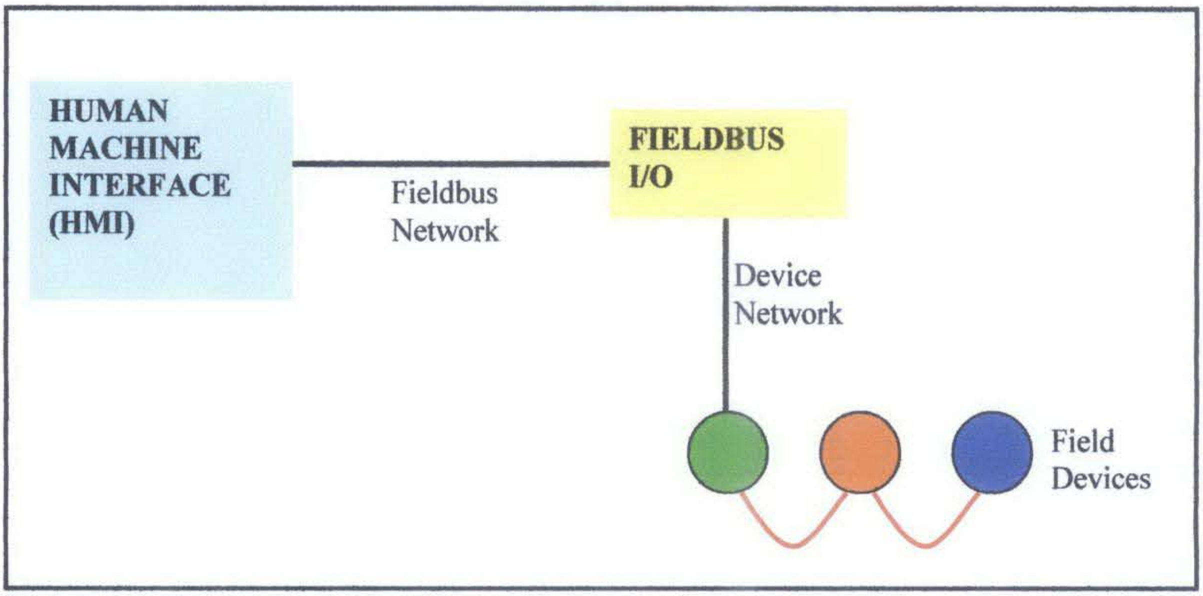


Fig 5.2: Daisy Chain Devices Network Topologies

5.3 RECOMMENDATION

The Fieldbus system still has a lot to be improved especially in the interoperability of the system. It has been developed by different vendor in the control system industries, thus creating big competition in the system development. Non profit organization such as Fieldbus FOUNDATION set up standard guidelines regarding this system, and it is to be followed by all the control system developer. All parties, from end user to developer must working together to develop the technology that is open, interoperable system.

The new process plant that will arrive hopefully can be a good learning process for future students who are interested in the Fieldbus technology. This opportunity can not be let away since this system has a lot to offer for future engineer. All the system parameters, topologies used, communication specification and system design must be studied thoroughly to obtain a better result.

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