

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Controlling an operation is a must in any industry or plant, in order to do that process control went through many stages to develop a control system that is efficient and simple enough to implement until the Distributed control system (DCS) was created using the analog 4-20 mA standard. Where the signals were analog and the information flowing in one direction only. Over the years the DCS was spread out and most of the industries were familiar with and counting on it. But the need for a new technology was anecessity . Until the evolving of the Filedbus technology that took the process control to a new era avoiding the limited capabilities and high costs of older analog technology.

The Fieldbus foundation, which was formed in 1994, set out a list of Fieldbus specifications under the name Foundation Fieldbus in 1998.since these specifications were established Fieldbus compatible products have continued to be successively released and subjected to field tests. So instead of using the traditional analog signals, the Fieldbus technology is all digital, serial, two way communications system that can be used to control different instruments with a single cable instead running separate individual cables that allow end users to achieve true distributed control.

Collaboration between a team from UTP electrical department and SKG 14 TP was formed to conduct basic interoperability test on the Fieldbus system supplied and installed by four vendors: Emerson, Honeywell, Foxboro &

Yokogawa. To provide a comprehensive guideline on the implementation of the respective technologies in PETRONAS OPU's [8]. There will be three tests to be conducted throughout that project which are Basic interoperability, Stress test and diagnostic capability. For the first stage, the focus will be on the basic interoperability tests.

1.2 Problem Statement

Since the Fieldbus is a relatively new technology, it encounters a number of problems as compared to the current systems which have been used for years and personnel become quite used to their type of problems. Thus this new technology is required to prove itself in the market place and gain credibility by overcoming those problems.

The limitation of Fieldbus capabilities can be summarized as follows:

- Interoperability & Interchangeability of the FieldBus System
- Deficiency in guidelines and information about the Fieldbus system
- Shortage in trained personnel for the field bus technology

The most significant problem is the Interoperability of the Fieldbus system. Interoperability means the device from one manufacturer should be able to interact with that of another manufacturer on a Fieldbus network without loss of functionality. But on the practical scale, the miscommunication between the devices still occurs, since each manufacturer developed its own protocol for his devices during the early implementation of the Fieldbus systems.

1.3 Objectives & Scope of Project

The main objective of this project is to overcome the difficulties faced by the fieldbus system by:

- Performing the basic interoperability test under the supervision of PETRONAS engineers using Honeywell host
- Testing foundation fieldbus devices of different, type and manufacturer to various Host manufacturers
- Define a standard protocol that all devices can follow, thus making it possible for products from different manufacturers to interoperate, that is, work with each other.
- Develop a full and effective guideline regarding the Fieldbus system as a reference for PETRONAS to implement efficiently in its plants and industries.
- Developing a plant model simple control loop.

The scope of testing will cover the basic interoperability test using Honeywell host , this will cover : Device commissioning and Decommissioning, Online device replacement, physical layer diagnostic, calibration check and trim And finally parameter download

CHAPTER 2

LITERATURE REVIEW

2.1 History of Fieldbus

In the 1940's, process instrumentation relied upon pressure signals of 3-15 psi for the monitoring of control devices. 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. The specific nature of the tasks to be controlled called for instruments and control methods to be custom designed. Refer to Figure 1

In the 1980's smart sensors began to be developed and implemented in a digital control, microprocessor environment. This prompted the need to integrate the various types of digital instrumentation into field networks to optimise system performance. And it became obvious that a Fieldbus standard was required to formalise the control of smart instrument.

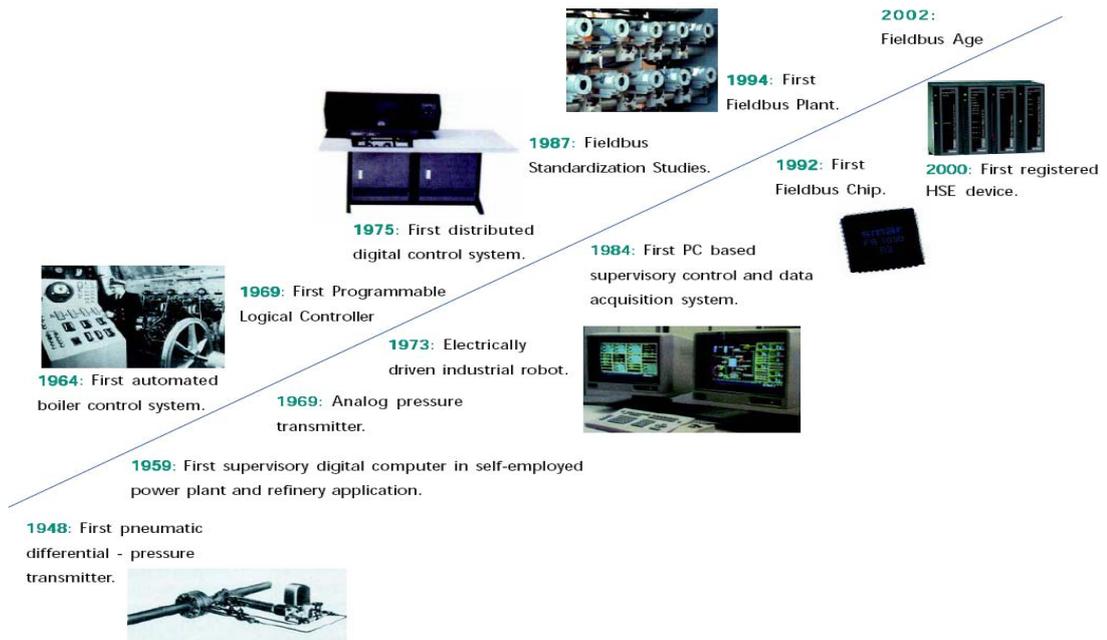


Figure 1: development of control systems

2.2 Fieldbus overview

Foundation Fieldbus technology is designed to provide a digital, two-way, multi-drop communication link between field devices [3] such as sensors, transmitters, actuators, and controllers, and various operator, engineering, and maintenance interfaces. Fieldbus as a digital replacement for 4-20mA analog communications is a simple concept, but it is significantly changing the way that users look at their processes while providing a flood of information from the field about both the devices and their associated processes.

Fieldbus devices are not limited to simply transmitting the process measurement, or even incrementally offering diagnostic and configuration information. Fieldbus is a sophisticated peer-to-peer control network. Each device on the network is an intelligent and interactive computer that monitors both the process and its own health. Fieldbus additionally allows process control at the device level, where elements of a control strategy can be executed in the field. For example, PID control may be executed in a transmitter or valve controller [1].

2.3 Fieldbus Advantages

Fieldbus as a new technology tried to overcome any problems encountered in the previous process control systems and provide the end user with many options as possible. As referred in[5]:

- providing access to more than a single data point of the field device
- serves to enable smart field devices due to the bidirectional data transfer
- Providing a means to calibrate and adjust remotely during operation without a need for hands-on access
- Enabling diagnostics and performance alarm while maintaining local memory of calibrations and service
- Improvement of accuracy and direct measurement of data since it's using digital transmission
- Doesn't depend upon control in the control room since field devices can act as controller of the whole operation on their own by restoring single loop integrity.
- Replacement of analog and digital (serial) point-to-point communication technology with much superior digital communication network for high speed ubiquitous and reliable communication within a harsh industrial environment.
- Enhanced data availability from smart field bus devices needed for advanced automation functions such as control, monitoring, supervision etc.
- Easy configurability and interoperability of system components leading to an easily installable, maintainable and upgradeable open system that leverages the computing and networking hardware and software solutions

In industrial automation systems, the field signals have been traditionally transmitted to the control room using point-to-point communication methods that employ analog technologies such as the 4-20 mA current loop.

Fieldbus is a standard for Local Area Network (LAN) of industrial automation field devices that enables them to intercommunicate. Typical Fieldbus devices are sensors, actuators, controllers of various types, such as PLCs, and DCS, and other computer systems such as human-machine interfaces, process management servers etc. It includes standards for the network protocol as well as standards for the devices on the network.

Fieldbus allows many input and output variables to be transmitted on the same medium such as, a pair of metallic wires, optical fibre or even radio, using standard digital communication technologies such as baseband time-division multiplexing or frequency division multiplexing. Thus sensors transmit the measured signal values as well as other diagnostic information; the controllers compute the control signals based on these and transmit them to actuators. Further, advanced features such as process monitoring can be carried out leading to increased fault tolerance. Online process auto-tuning can be performed leading to optimized performance of control loops. [9]

2.4 Difference between FieldBus & DCS

Table 1 shows the difference between Fieldbus & older technologies. It should be mentioned that Fieldbus becomes cost-effective only beyond a certain scale of operations.

Table 1: Comparison of Fieldbus with 4-20mA current loop [9]

Item No.	Specification	4-20mA	Fieldbus
1.	No. of devices per wire	1	32
2.	Qty. of data/variables per device	1	Up to thousands
3.	Control functions in field	No	Yes
4.	Device Failure Notification	Minimal (O/C, S/C)	Yes, detailed
5.	Signal degradation over wire	Possible	None
6.	Power distribution over wire	Yes	Yes
7.	Interchangeability of field devices	Yes	Yes (with some restrictions)
8.	Maximum run-length	2Km	1.9Km (5.7 Km with repeaters)
9.	Failure diagnosis	Technician reqd.	Operator informed at console
10.	Intrinsic safety	With barriers	With barriers
11.	Sampling delay	Vendor defined	User defined (within limits)

2.5 ISO OSI Model – The Basic Reference Model for Protocols

The International Standards Organization (ISO) developed the Open Systems Interconnection (OSI), Basic Reference Model in the late 1970s. Most fieldbus protocol descriptions and user documentation begin with a primer on the OSI model in the opening paragraphs. Some fieldbus protocols, incorporate all layers, or at minimum the Physical, Data Link and Application layers [10].

OSI Model			
	Data Unit	Layer	Function
Host Layers	Data	Application	Network process to application
		Presentation	Data representation and encryption
		Session	Interhost communication
	Segment/Datagram	Transport	End-to end connections and reliability
Media Layers	Packet	Network	Path determination and logical addressing
	Frame	Data Link	Physical addressing
	Bit	Physical	Media, signal and binary transmission

Figure 2: The ISO/OSI Reference Model[10].

2.5.1 The Physical layer

The fieldbus physical layer is OSI layer 1. Layer 1 receives encoded messages from the upper layers and converts the messages to physical signals on the fieldbus transmission medium.

Physical layer requirements are defined by the approved IEC 1158-2 and ISA S50.02-1992 Physical Layer Standards. Communications rates supported are 31.25 kbit/s, 1.0 Mbit/s and 2.5 Mbit/s. [15]

The fieldbus physical layer operating at 31.25 kbit/s is intended to replace the 4-20 mA analog standard currently used to connect field devices to control systems. Like the 4-20 mA standard, the FOUNDATION fieldbus supports single wire pair operation, bus powered devices, and intrinsic safety options.

Fieldbus has additional advantages over 4-20 mA because many devices can connect to a single wire pair resulting in significant savings in wiring costs.

Transmission technology (Physical Layer) of the PROFIBUS-PA can be characterized as follows:

- o Digital, synchronous bit data transmission.
- o Data rate 31.25 kbit/s.
- o Manchester coding.
- o Signal transmission and remote power supply with transposed two-wire cabling (screened/unscreened).
- o Remote power supply DC voltage 9V...32V.
- o Signal AC voltage 0.75 V_{pp}...1 V_{pp} (send voltage).
- o Line and tree topology.
- o Up to 1.9 km total cabling.
- o Up to 32 members per cable segment.
- o Can be expanded with maximum four repeaters.

2.5.2 Device descriptions

Each fieldbus device is described by a device description (DD) written in a special programming language known as Device Description Language (DDL). The DD can be thought of as a "driver" for the device.

The DD provides all of the information needed for a control system or host to interpret communications coming from the device, including configuration, and diagnostic information.

Any control system or host can communicate with a device if it "knows" the DD for the device. The host device uses an interpreter called Device Description Services (DDS) to read the DD for the device.

New FOUNDATION fieldbus devices can be added to the fieldbus at any time by simply connecting the device to the fieldbus wire and providing the control system or host can read the identification of the fieldbus device, including the DD identifier, over the fieldbus. Once the DD identifier is known, the host reads the DD from a CDROM and supplies the DD to DDS for interpretation.

The completion of the technical specifications for an interoperable fieldbus system is a major milestone in the history of automation. The FOUNDATION fieldbus specification was developed by a consortium of instrument and control system manufacturers that represent over 90% of the instrumentation and control systems provided to end-users worldwide. The specifications will allow many manufacturers to deliver a wide range of interoperable fieldbus devices. These devices will usher in the next major technology transition in process and manufacturing automation.[15]

2.6 Topology

Topology describes how devices are physically wired together. Fieldbus is a process control local area network used for interconnecting sensors, actuators, and control devices.

There are several wiring strategies for installing media for an industrial automation fieldbus network. The most beneficial fieldbus systems are ones that can comfortably support bus, star and/or tree type wiring topologies, without effecting capabilities. [10]

A **terminator** (T) is required at each end of the Fieldbus cable to avoid distorting signals and allow the twisted-pair cable to carry digital signals.

Power to the devices is provided by a power supply through a **power conditioner** (PC). The power conditioner is needed to separate a conventional power supply from the Fieldbus wiring so that the signals are not absorbed by the power supply.

A **host** or **H1** device is usually located in the control room. Its function is to Oversee the operation of the control system made up of devices connected by the Fieldbus network [2].

Table 2: Overview of various Fieldbus topologies [10].

Physical Topology	Common Medium	Protocol Type	Advantage	Disadvantage
Bus	Twisted Pair Coaxial Fiber	Serial Ethernet Token Passing	Easy to install and requires less cable.	Terminating resistors typically required and network shuts down if break in cable.
Star	Twisted Pair Fiber	Ethernet Token Passing Token Ring	Easy to install and no disruptions to network when connecting and removing nodes.	Requires more cable than linear topology and more expensive because of the cost of the concentrators.
Tree	Twisted Pair Coaxial Fiber	Ethernet	Flexible installation and point to point wiring of individual segments.	Limited segment lengths and if backbone breaks segments nodes attached are disabled.
Ring	Twisted Pair Fiber	Ethernet Token Ring	Each node has access to transmit and receive and larger networks easily supported.	One bad node or module can create problems for entire network and modifications can also have bad effects.

A) Bus Topology

A bus configuration has a main run of cable (called a trunk line), with drops off the trunk line. In medium and high speed networks there may need to be impedance matching terminating resistors at each end of the main line. The bus topology is by far the most common approach for implementing networks in automation applications.

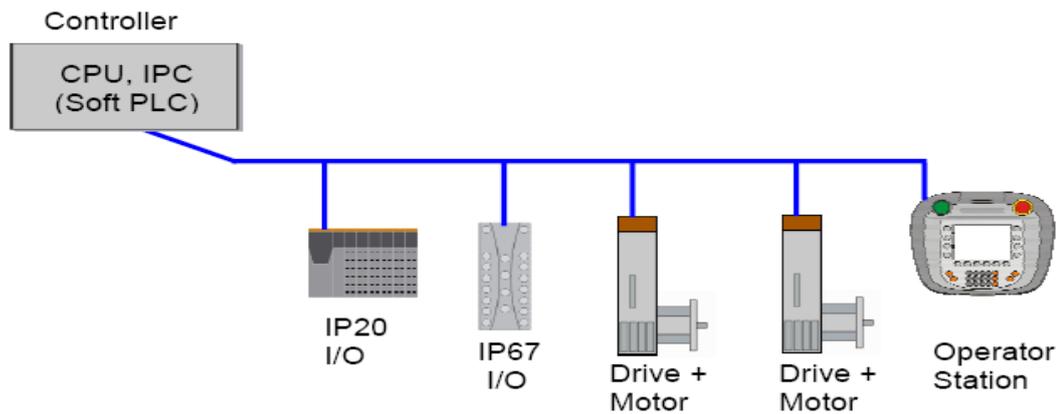


Figure 3: Typical bus Topology Configuration [10].

B) Star Topology

A star configuration has a central point and devices are connected in a point-to-point manner to the center. Typically the central point is the master and slaves are connected directly to the master. This type of network tends to be most flexible for installation.

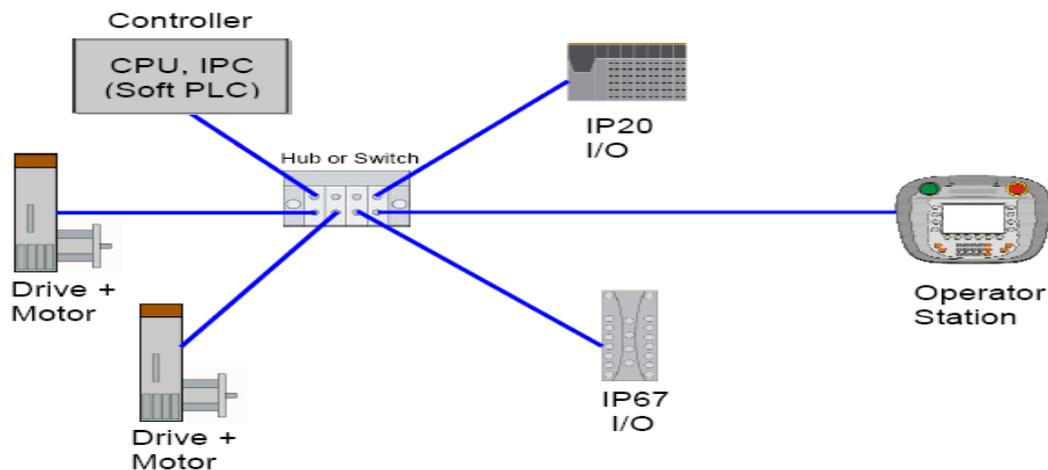


Figure 4: Typical Star Topology Configuration [10].

C) Tree Topology

A tree configuration combines features of a linear bus and star topology. It consists of a group of star- configured stations connected to a linear bus backbone cable. Tree topologies allow for expansion of an existing network, and enable machines or plants to meet their needs.

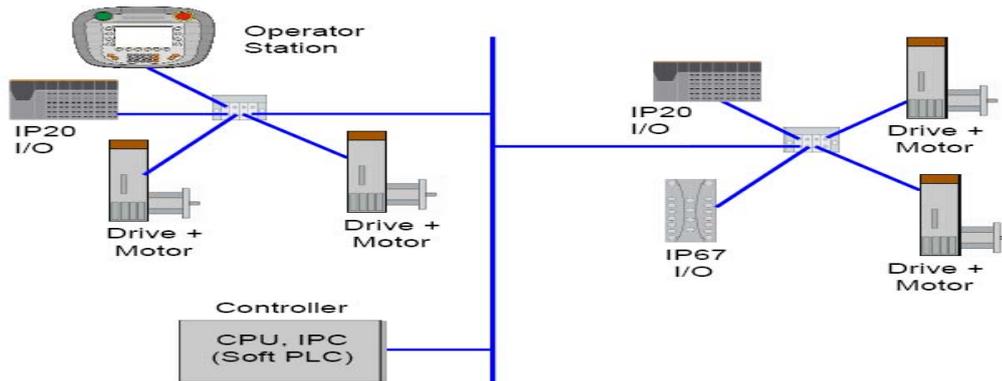


Figure 5: Typical Tree Topology Configuration [10].

D) Ring Topology

A ring configuration is a closed loop. Each device can access any other device using one of two possible paths. This topology has the advantage of being redundant, however at the hardware level such networks are more difficult to implement. With fieldbus systems that must use a ring topology, problems can occur when users think of new ideas for an extension after they are done laying cables for the network.

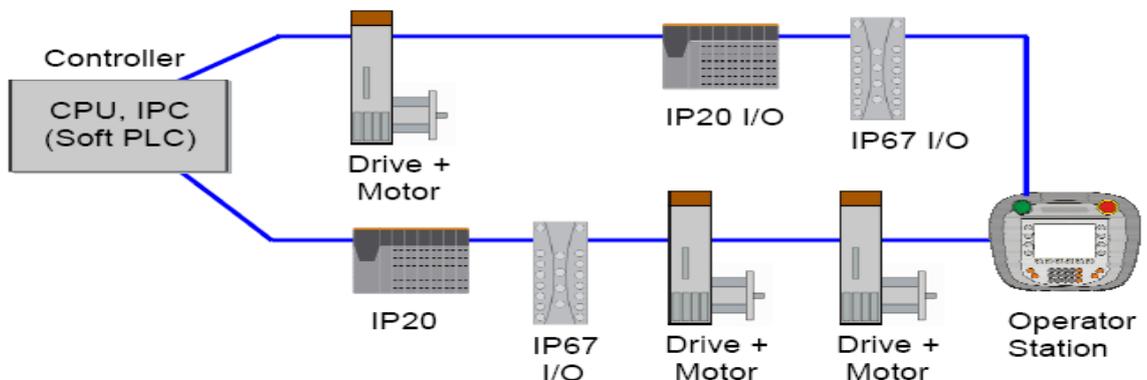


Figure 6: Typical Ring Topology Configuration [10].

2.7 H1 Technology Overview

Foundation Fieldbus H1 is a 31.25kbit/s digital multidrop communications standard connecting instruments together. It uses the layers 1,2 and 7 of the OSI Model.

There is an additional User Layer (which contains the Function Blocks) but this is not defined by the OSI Model.

The H1 Fieldbus Segment:

- Trunk + Spurs = Segment
- Trunk = Wiring between Terminators
- Spurs = Wiring between Trunk and devices

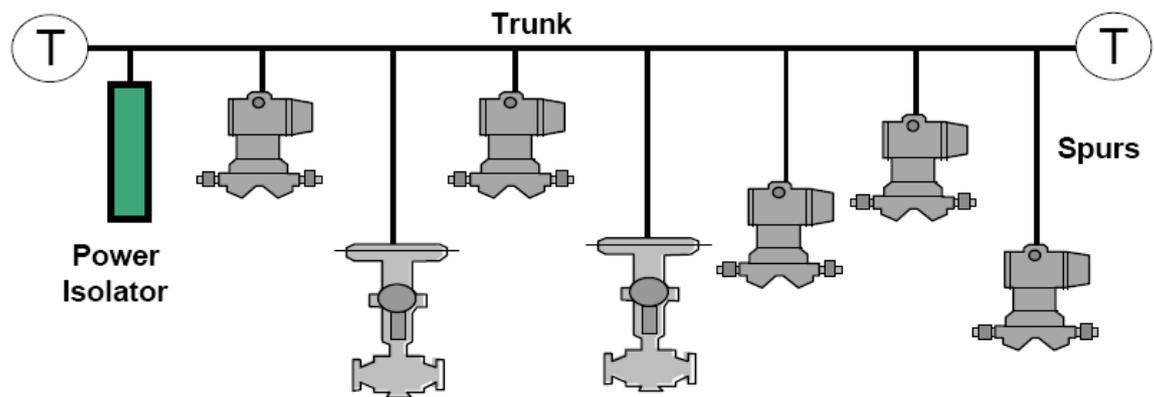


Figure 7: H1 Fieldbus Segment

The H1 Physical Layer can be either bus powered or non-powered and can be used in an intrinsically safe environment. The type A cable provides distances of up to a 1900 m segment without a repeater. It is possible to extend the distance using up to 4 repeaters per segment allowing $(4+1) * 32$ devices = 160 devices maximum per logical segment.

The H1 Data Link Layer supports three types of communication. These are:

The Publisher/Subscriber method which is a scheduled approach allowing linking of inputs and outputs to allow cyclic transfer of data between the different instruments on the bus. [11]

The Client/Server approach with unscheduled request/response is used for communications between the hosts and instruments.

Event notification or unscheduled multicast is used for alarming and trending.

The Link Active Scheduler (LAS) keeps the time synchronisation and handles the live List of communicating devices. There is also a back up so that if the LAS fail, another link master will become the LAS.

The User Layer comprises the Function Blocks, Device Descriptions and System Management. The most well known feature here is the function blocks which provide a consistent definition of inputs and outputs to allow interoperability of devices between different vendors' products.

2.8 HSE Technology Overview

This provides a high speed bus of 100 Mbit/s (or more) providing a huge increase in bandwidth and in addition providing redundancy. The HSE architecture is effectively an enhanced standard Ethernet model (IEEE 802.3). The HSE Application Layer contains the Dynamic Host Configuration Protocol (DHCP), Simple Network Time Protocol (SNTP) and Simple Network Management Protocol (SNMP). At the UserLayer is the HSE Management agent and Function Blocks. [11]

The use of redundancy is especially attractive as it uses off the shelf Ethernet hardware. Use of Ethernet Switches enables multiple paths to be set up so that failure of the primary path allows seamless transfer to the secondary path. layers and thus in helping one to achieve this.

CHAPTER 3

METHODOLOGY

3.1 Procedure Identification :

There are some procedures to be followed in order to carry out and implement the project. This is to ensure that the project can be accomplished within the given timeframe.

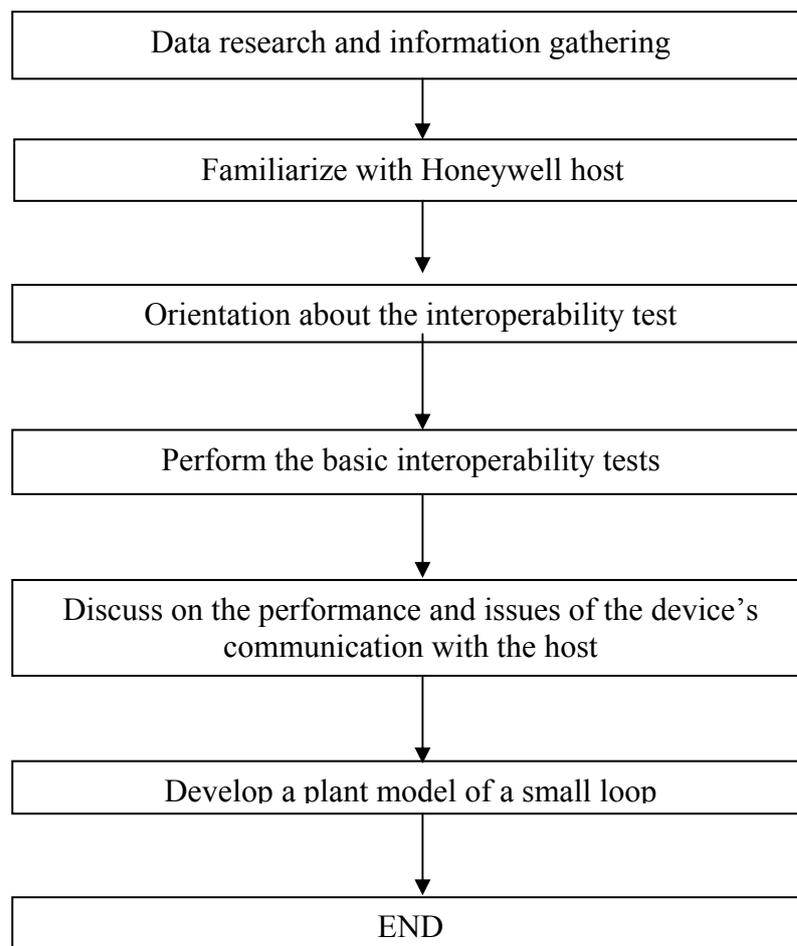


Figure 8: Project Flow Diagram

3.2 Interoperability Testing

The primary goal of interoperability testing is to validate the user layer, or the function block application of the FF field device. Interoperability Testing consists of two separate test systems: the Interoperability Test System (ITS) and Device Description Verification.[12]

Basic Interoperability Test for Honeywell system consists of:

1. Device Commissioning
2. Device Decommissioning
3. Online Device Replacement
4. Physical layer Diagnostic
5. Calibration Function Check

3.2.1 Procedures

Procedures for the above mentioned tests are discussed in details in the following tables.

Table 3: Procedures for Device Commissioning

Test 1: Device Commissioning	
1.1	Power up Host system at Cabinet 3.
1.2	Power up switch for MTL and P+F at Cabinet 2.
1.3	At the selector switch (front panel of Cabinet 2), select Honeywell for Segment 1 and Segment 2.
1.4	Click “Start”
1.5	Select “Programs”
1.6	Select “Honeywell Experion PKS”
1.7	Select “Configuration Studio”
1.8	Connect window will popup , select “UTPFSystem” ,click “Connect”

1.9	<p>Login to windows using the following username and password:</p> <p style="text-align: center;">Username: mngr Password: mngr1 Domain: <Traditional Operator Security></p>
1.10	Click OK.
1.11	Expand “UTPFFSystem”
1.12	Expand “Server”
1.13	Expand “UTPFFSVR”
1.14	Click “Control Strategy”
1.15	From “Process Control Strategy”, click “Configure Process Control Strategies” and a “Control Builder” window will popup
1.16	<p>At “Monitoring – Assignment”, check the status of C300_01 and FIM4_01.</p> <p><i>Note: Both should be in GREEN colour. In case of Controller in offline state for more than 120hours, the program needs to be restored. The state is marked by RED colour.</i></p>
1.17	<p>If at RED</p> <ul style="list-style-type: none"> -Right Click at ”C300_01” -Select “Checkpoint” -Select “Restore from checkpoint”. -A new window will pop up. <p style="padding-left: 40px;">Select the last saved checkpoint to be restored.</p> <p style="padding-left: 40px;">Click “Restore”</p> <p style="padding-left: 40px;">Start the controller by double clicking on controller “CEEC300_01”.</p> <p style="padding-left: 40px;">At “Main” tab, go to “CEE Command,” and select WARMSTART. Click YES.</p> <p style="padding-left: 40px;">Wait until all the icons turns Green.</p>
1.18	<p>From the “Monitoring-Assignment”,</p> <ul style="list-style-type: none"> - Expand “FIM4_01”

	<ul style="list-style-type: none"> - Expand “FFLINK_01” (the segment) - Check the status of the device base on the colour/ ‘?’ sign. <ul style="list-style-type: none"> RED : Already in the database but the system cannot detect BLUE: Idle / Inactive GREEN : Live device ‘?’ sign : Uncommissioned device - Double click on the device with the ‘?’ sign. - A window will be popup and select the device name. - Click “Commission Device Without Pre-Configuration” (Note: Take from device to segment), “User Authorisation” window will be popup, click “NEXT” until complete - Commissioning is successful when device turns GREEN. - Repeat steps for other devices.
1.19	<p>If the device unable to commission (device has two same tag ; 1 GREEN colour with ‘?’ sign , and the other tag RED colour)</p> <p>1.19.1 At “Monitoring-Assignment” (at the bottom of the window),</p> <ul style="list-style-type: none"> - Expand the “CEEC300_01” - Select the function block of device - Right click - Select “Inactivate” - Select “Selected item(s) and Content(s)” - A window will popup, click YES - Wait for seconds until the device tag turn to BLUE (Idle state) <p>1.19.2 At “Monitoring-Assignment”,</p> <ul style="list-style-type: none"> - Expand “CEEC300_01” - Select the BLUE device - Right click - Select “Force Delete” - BLUE device will be deleted

1.19.3 **At “Monitoring-Assignment”,**

- Expand “FIM4_01”
- Expand “FFLINK_01”
- Select RED device tag
- Right click
- Select “Force Delete”
- A window will popup, click “Continue”
- Click “Force Delete”
- RED device will be deleted

1.19.4 **At Project-Assignment”,**

- Expand “FIM4_01”
- Expand “FFLINK_01”
- Select device tag (device that need to be commission)
- Right click
- Select “Load”
- Click “Continue”
- Click OK

Note: Check the ‘Automatically change ALL control elements to the state selected in ‘Post Load State’ after load is completed’

1.19.5 **Open “Monitoring”, the device tag should turn to GREEN (already commissioned)**

1.19.6 **At Project-Assignment”,**

- Expand “CEEC300_01”
- Select function block of device
- Right click
- Select “Load”
- Click “Continue”
- Click OK

1.19.7	<p style="text-align: center;"><i>Note: Check the ‘Automatically change ALL control elements to the state selected in ‘Post Load State’ after load is completed’</i></p> <p style="text-align: center;">Commission of the device succeed.</p>
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Table 4: Procedures for Device Decommissioning

Test 2: Device Decommissioning	
2.1	<p>From “Monitoring-Assignment”,</p> <ul style="list-style-type: none"> - Expand “FIM4_01” - Expand “FFLINK_01” (segment 1) - Check the status of the device base on the colour/ ‘?’ sign. <ul style="list-style-type: none"> RED: already in the database but the system cannot be read BLUE: Idle / Inactivate GREEN: Live‘?’ sign: uncommissioned device
2.2	<p>From “Monitoring-Assignment”,</p> <ul style="list-style-type: none"> -Expand “CEEC300_01” -Select function block of the device -Right click -Select “Inactivate” -Select “Selected item(s)” -Click YES -Device will turned to BLUE -Right click at the BLUE function block -Select “Delete” -A window will popup, and click “Continue” -Click “ Delete Selected Object(s)” -Function block been deleted
2.3	<p>At “Monitoring-Assignment”,</p> <ul style="list-style-type: none"> - Expand “FIM4_01”

	<ul style="list-style-type: none"> - Expand “FFLINK_01” - Select device tag - Right click - Select “Force Delete” - “Force Delete: window will popup - Click “Continue” - Click “Force Delete”
2.4	Device will GREEN and with ‘?’ sign. It shows device decommission successfully

Table 5: Procedures for Online Device Replacement

Test 3: Online Device Replacement	
3.1	At “Monitoring-Assignment”, select the device that need to be replaced
3.2	<ul style="list-style-type: none"> - Click “Field Devices” (located at top of the window) <ul style="list-style-type: none"> ▪ Select “Device Replacement” ▪ Device Replacement Wizard window will popup ▪ Click NEXT ▪ Click “Yes,Upload” ▪ FF Device Replacement Wizard window will popup ▪ Wait for the device that need to be replaced been detected by the system
3.3	<ul style="list-style-type: none"> - At field site, the old device need to be disconnect and replace with the new device (For the testing: we replaced with the same device but with the new tag name and new address using 375 Field Communicator Device) <ul style="list-style-type: none"> ▪ Using 375 Field Communicator Device, connect the cable to the Fieldbus Port and Press ‘On’ button ▪ Select “Fieldbus Application” ▪ Select “Online”. (Note: The communicator will upload information on all

	<p>devices connected to the segment.)</p> <ul style="list-style-type: none"> ▪ Select the device ▪ Double click at the device ▪ Select “Details” ▪ Select “Physical Device Tag “ ▪ Change the tag name of the device ▪ Click OK ▪ Click “Send” ▪ Click YES and wait for the changes to be completed
3.4	At “Uncommissioned Replacement Device”, tick (√) at the new device that will be replace. Uncheck and check again in order for a box will be popup at the bottom of the box.
3.5	Click “Replace the Failed Device with the Uncommissioned Replacement Device”
3.6	FF Device Replacement Wizard- Verifying Replacement Device” window will pop up
3.7	Click “Continue”
3.8	Click OK <i>Note: Check for “Automatically change ALL highlighted control elements to INACTIVE/OUT_OF_SERVICE before load” and “ Automatically change ALL control elements to the state selected in “Post Load State” after load is completed”</i>
3.9	Click “Continue” and wait for the process
3.10	Click “Finish”
3.11	Device turn to GREEN and been commissioned as new device

Table 6: Procedures for Physical Layer Diagnostic

Test 4: Physical Layer Diagnostic	
4.1	Practice the device drop out testing
4.2	At the field site, disconnect a device

4.3	Open the Station window, click the “System” (at the bottom of the window in SYSTEM box)
4.4	Device alarm appear on the screen and blinking
4.5	Click “Acknowledge Page” button to acknowledge the alarm. Alarm will stop blinking
4.6	<p>Open the Control Builder window, at the “Monitoring-Assignment” window, monitor the status of the device</p> <p><i>Note: Before disconnect the device, device in GREEN. After disconnect the device, device turn to RED.</i></p> <ul style="list-style-type: none"> - At field site, connect device - At Station window, the device alarm will be gone - At Control Builder window, the device turn to GREEN

Table 7: Procedures for Calibration Function Checks

<p>Test 5: Calibration Function Checks</p> <p>(Carry out calibration function from the Host, 375 communicator or iAMS)</p>	
5.1	<p>Using Host:</p> <ul style="list-style-type: none"> - Type the name of the function block of the device at Command box - Click the details of the device (magnifying glass icon) - Data Acquisition Point Detail window will popup - Change system in “Engr” mode - <i>Note: At the bottom right of the window; Password: engr</i> - Click “Main”, change the Execution State to “Inactive” - Change to “Chart” window, AI block and DACA block will appeared. - Double click at DACA block - “Parameters[Monitoring]” will popup - Change the value for “PVEU Range Hi” and “PVEU Range Lo” - Close the “Parameters[Monitoring]” window - At “Main”, change the Execution State to “Activate” - Monitor at the faceplate. Range for the faceplate will be change

	<p>according to the previous changes</p> <ul style="list-style-type: none"> - Double click at the AI Block - “Parameter[monitoring] popup - In “Process”, change the Actual Mode to “ OOS” - Click “Ranges” - Change the XD_SCALE and OUT_SCALE - Click OK - Observe the device using the 375 Communicator. The changes of the device will be the same as the previous changes in the host
5.2	<p>Using 375 Communicator:</p> <ul style="list-style-type: none"> - At the field site, connect the 375 Communicator - Using the device, select “Fieldbus Application” - Select Online. <p style="text-align: center;"><i>*Note: The communicator will upload information on all devices connected to the segment.</i></p> <ul style="list-style-type: none"> - Select one device that needs to be rescaled. <p style="text-align: center;"><i>Note: the communicator will take some time to upload the device</i></p> <ul style="list-style-type: none"> - Select AI block. - Select “Quick Config”. Change Mode to “OOS” (previous mode in “Auto”). Change XD Scale (Transducer Block) and Output Scale. Click ‘Send’. Change mode back to “Auto”. <p style="text-align: center;"><i>Note: This step may be performed using other than “Quick Config” option.</i></p> <ul style="list-style-type: none"> - Monitor the faceplate and effect on the other devices. <p style="text-align: center;"><i>Note: Action by Host and Communicator cannot be performed on the same device at the same time. At one time, only either Host or the communicator may change the setting of the device.</i></p>

3.3 375 Field Communicator Host System Interoperability:

The 375 Field Communicator is designed to work both as a “Bench Tool” and as a “Field Tool”.

- As a Bench Tool, the 375 would typically be connected to one or more FOUNDATION™ fieldbus devices on the bench with no other host system connected to the segment.
- As a Field Tool, the 375 would be connected to a live FOUNDATION fieldbus segment in the field that is controlled by a Host Control System.

Normally (but not always) this Host Control System acts as the Link Active Scheduler (LAS) for the segment. When the 375 detects that there is a LAS on the segment, it joins the segment as a “guest”. For most operations, the Host Control System and the 375 should be able to co-exist on the FOUNDATION™ fieldbus segment with no problems. Other operations, such as changing the node address of a fieldbus segment, require careful coordination between the Host Control System and the 375. Some operations with the 375 are simply not advised if there is a Host Control System on the segment.

In light of all this, a set of Host System Interoperability Tests have been run with the 375. Initially, this complete set of tests has been run only with the DeltaV™ Host Control System from Emerson Process Management. These tests will be run with other Host Control Systems in the future and the results placed here.



Figure 9: 375 Field Communicator

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Results for Interoperability Testing using Honeywell Host

The Detailed Procedure for all the tests are discussed under **Chapter 3 (3.2.1 Procedures)**. The Test will be Running On Segment 1 : Pepperl + Fuchs.

4.1.1 Device Commissioning

4.1.1.1 Test Description

The test aims to check the proper steps to commission a device and to come up with guidelines on device commissioning. The commissioning process must not interrupt the system or affect other devices on the segment. For Basic Test, the scope covers the pre-registered devices. Commissioning of a new device will be covered in the Extended Test.

4.1.1.2 Summary of Method

1. Decommission a functioning device in the segment.
2. Commission the device following the Honeywell Work Instruction.

Table 8: *Result of the device commissioning*

	VENDOR	DEVICE NAME	COMMISSION	
			Successful Commission	TIME TAKEN
1	Rosemount	AT207	√	1 min. 25 sec.
2	Fisher	FV205	√	3 min. 2 sec
3	Rosemount	PDT204	√	3 min. 27 sec
4	Rosemount	PT202	√	4 min. 51 sec
5	Rosemount	TT203	√	4 min. 44 sec
6	Rosemount	TT201	√	4 min. 13 sec
7	Yokogawa	FT504	√	3min. 41 sec
8	Yokogawa	PDT501	√	3 min. 56 sec
9	Yokogawa	PT502	√	3 min. 38 sec
10	Yokogawa	TT503	√	3 min. 21 sec
11	Pepperl Fuchs	TT901	√	4 min. 5 sec
12	Pepperl Fuchs	VC902	√	2 min. 3 sec

4.1.2 Device Decommissioning

4.1.2.1 Test Description

To note the proper method of putting device in offline more i.e detaching the device from the segment. The process must make sure that host does not scan the detached device as error.

4.1.2.2 Summary of Method

1. Select device to be taken offline.
2. Inactivate device function block.
3. Delete function block.

Table 9: Result of the device Decommissioning

	VENDOR	DEVICE NAME	DECOMMISSION	
			Successful Decommission	TIME TAKEN
1	Rosemount	AT207	√	1 min. 24 sec.
2	Fisher	FV205	√	1 min. 19 sec
3	Rosemount	PDT204	√	2 min. 27 sec
4	Rosemount	PT202	√	2 min. 39 sec
5	Rosemount	TT203	√	2 min. 7 sec
6	Rosemount	TT201	√	4 min 5 sec
7	Yokogawa	FT504	√	1 min. 54sec
8	Yokogawa	PDT501	√	2 min. 15 sec
9	Yokogawa	PT502	√	1 min. 46 sec
10	Yokogawa	TT503	√	3 min. 18 sec
11	Pepperl Fuchs	TT901	√	1 min. 57 sec
12	Pepperl Fuchs	VC902	√	<1 min

4.1.3 Physical Layer Diagnostic

4.1.3.1 Test Description

It was carried out to ascertain that device failure would not affect the overall segment or any other healthy devices in the segment. This test is also to see whether signal is automatically recovered once the device is online.

4.1.3.2 Summary of Method

1. Disconnect the device cable from the segment and check the response from HMI.
2. Connect the device cable to the segment.
3. Repeat for all devices

Table 10: Result of the Physical Layer Diagnostic

Device Name	Drop-Out Response
<p>1. AT 207 (Vendor : Rosemount)</p>	<p><u>Initial condition:</u> at the <i>Control Builder (monitoring)</i>, the device displayed in green colour.</p> <p><u>Drop-out device:</u></p> <ul style="list-style-type: none"> i) <i>Control Builder(monitoring)</i>: The device displayed in red colour. ii) <i>Station (system)</i>: alarm displayed with the description “Device Off-Net”. <p><u>Plug-In Device:</u></p> <ul style="list-style-type: none"> i) <i>Control Builder(monitoring)</i>: The device displayed turn to green. ii) <i>Station (system)</i>: alarm displayed gone.
<p>2. FT 504 (Vendor : Yokogawa)</p>	<p><u>Initial condition:</u> at the <i>Control Builder (monitoring)</i>, the device displayed in green colour.</p> <p><u>Drop-out device:</u></p> <ul style="list-style-type: none"> i) <i>Control Builder(monitoring)</i>: The device displayed in red colour. ii) <i>Station (system)</i>: alarm displayed with the description “Device Off-Net”. <p><u>Plug-In Device:</u></p> <ul style="list-style-type: none"> i) <i>Control Builder(monitoring)</i>: The device displayed turn to green. ii) <i>Station (system)</i>: alarm displayed gone.
<p>3. FV 205 (Vendor : Fisher)</p>	<p><u>Initial condition:</u> at the <i>Control Builder (monitoring)</i>, the device displayed in green colour.</p> <p><u>Drop-out device:</u></p> <ul style="list-style-type: none"> i) <i>Control Builder(monitoring)</i>: The device displayed in red colour. ii) <i>Station (system)</i>: alarm displayed with the description

	<p>“Device Off-Net”.</p> <p><u>Plug-In Device:</u></p> <ul style="list-style-type: none"> i) <i>Control Builder(monitring)</i>: The device displayed turn to green. ii) <i>Station (system)</i>: alarm displayed gone.
<p>4. PDT 204 (Vendor : Rosemount)</p>	<p><u>Initial condition:</u> at the <i>Control Builder (monitoring)</i>, the device displayed in green colour.</p> <p><u>Drop-out device:</u></p> <ul style="list-style-type: none"> i) <i>Control Builder(monitring)</i>: The device displayed in red colour. ii) <i>Station (system)</i>: alarm displayed with the description “Device Off-Net”. <p><u>Plug-In Device:</u></p> <ul style="list-style-type: none"> i) <i>Control Builder(monitring)</i>: The device displayed turn to green. ii) <i>Station (system)</i>: alarm displayed gone.
<p>5. PDT 501 (Vendor : Yokogawa)</p>	<p><u>Initial condition:</u> at the <i>Control Builder (monitoring)</i>, the device displayed in green colour.</p> <p><u>Drop-out device:</u></p> <ul style="list-style-type: none"> i) <i>Control Builder(monitring)</i>: The device displayed in red colour. ii) <i>Station (system)</i>: alarm displayed with the description “Device Off-Net”. <p><u>Plug-In Device:</u></p> <ul style="list-style-type: none"> i) <i>Control Builder(monitring)</i>: The device displayed turn to green. ii) <i>Station (system)</i>: alarm displayed gone.
<p>6. PT 202 (Vendor : Rosemount)</p>	<p><u>Initial condition:</u> at the <i>Control Builder (monitoring)</i>, the device displayed in green colour.</p>

	<p><u>Drop-out device:</u></p> <p>i) <i>Control Builder(monitored)</i>: The device displayed in red colour.</p> <p>ii) <i>Station (system)</i>: alarm displayed with the description “Device Off-Net”.</p> <p><u>Plug-In Device:</u></p> <p>i) <i>Control Builder(monitored)</i>: The device displayed turn to green.</p> <p>ii) <i>Station (system)</i>: alarm displayed gone.</p>
<p>7.PT 502 (Vendor : Yokogawa)</p>	<p><u>Initial condition:</u> at the <i>Control Builder (monitored)</i>, the device displayed in green colour.</p> <p><u>Drop-out device:</u></p> <p>i) <i>Control Builder(monitored)</i>: The device displayed in red colour.</p> <p>ii) <i>Station (system)</i>: alarm displayed with the description “Device Off-Net”.</p> <p><u>Plug-In Device:</u></p> <p>i) <i>Control Builder(monitored)</i>: The device displayed turn to green.</p> <p>ii) <i>Station (system)</i>: alarm displayed gone.</p>
<p>8. TT 201 (Vendor : Rosemount)</p>	<p><u>Initial condition:</u> at the <i>Control Builder (monitored)</i>, the device displayed in green colour.</p> <p><u>Drop-out device:</u></p> <p>i) <i>Control Builder(monitored)</i>: The device displayed in red colour.</p> <p>ii) <i>Station (system)</i>: alarm displayed with the description “Device Off-Net”.</p> <p><u>Plug-In Device:</u></p> <p>i) <i>Control Builder(monitored)</i>: The device displayed turn to green.</p> <p>ii) <i>Station (system)</i>: alarm displayed gone.</p>
<p>9. TT 203</p>	<p><u>Initial condition:</u> at the <i>Control Builder (monitored)</i>, the device</p>

(Vendor : Rosemount)	<p>displayed in green colour.</p> <p><u>Drop-out device:</u></p> <p>i) <i>Control Builder(monitring)</i>: The device displayed in red colour.</p> <p>ii) <i>Station (system)</i>: alarm displayed with the description “Device Off-Net”.</p> <p><u>Plug-In Device:</u></p> <p>i) <i>Control Builder(monitring)</i>: The device displayed turn to green.</p> <p>ii) <i>Station (system)</i>: alarm displayed gone.</p>
10. TT 503 (Vendor : Yokogawa)	<p><u>Initial condition:</u> at the <i>Control Builder (monitoring)</i>, the device displayed in green colour.</p> <p><u>Drop-out device:</u></p> <p>i) <i>Control Builder(monitring)</i>: The device displayed in red colour.</p> <p>ii) <i>Station (system)</i>: alarm displayed with the description “Device Off-Net”.</p> <p><u>Plug-In Device:</u></p> <p>i) <i>Control Builder(monitring)</i>: The device displayed turn to green.</p> <p>ii) <i>Station (system)</i>: alarm displayed gone.</p>
11. TT 901 (Vendor : Pepperl + Fuchs)	<p><u>Initial condition:</u> at the <i>Control Builder (monitoring)</i>, the device displayed in green colour.</p> <p><u>Drop-out device:</u></p> <p>i) <i>Control Builder(monitring)</i>: The device displayed in red colour.</p> <p>ii) <i>Station (system)</i>: alarm displayed with the description “Device Off-Net”.</p> <p><u>Plug-In Device:</u></p> <p>i) <i>Control Builder(monitring)</i>: The device</p>

	<p>displayed turn to green.</p> <p>ii) <i>Station (system)</i>: alarm displayed gone.</p>
<p>12. VC 902 (Vendor : Pepperl + Fuchs)</p>	<p><u>Initial condition</u>: at the <i>Control Builder (monitoring)</i>, the device displayed in green colour.</p> <p><u>Drop-out device</u>:</p> <p>i) <i>Control Builder(monitoring)</i>: The device displayed in red colour.</p> <p>ii) <i>Station (system)</i>: alarm displayed with the description “Device Off-Net”.</p> <p><u>Plug-In Device</u>:</p> <p>i) <i>Control Builder(monitoring)</i>: The device displayed turn to green.</p> <p>ii) <i>Station (system)</i>: alarm displayed gone.</p>

4.1.4 Calibration Function Check

4.1.4.1 Test Description

Test how online parameter download is performed on the device. For Basic Test purpose, the parameter download was limited to change of device range using Host 375 Field Communicator and Advanced applications available in host system will be explored in Diagnostic Capability test.

4.1.4.2 Summary of Method

1. From the host system, set device mode to 'OOS' and make change to 'XD Range' and 'OUT Range'.
2. Change mode to 'Auto'. Record host response.
3. Repeat the test using 375 Field Communicator and iAMS

Table 11: *Result of the Calibration Function Check*

	VENDOR	DEVICE NAME	Successful Calibration	
			Change From Host	Change from Field(375 Communicator)
1	Rosemount	AT207	√	√
2	Fisher	FV205	√	√
3	Rosemount	PDT204	√	√
4	Rosemount	PT202	√	√
5	Rosemount	TT203	√	√
6	Rosemount	TT201	√	√
7	Yokogawa	FT504	√	√
8	Yokogawa	PDT501	√	√
9	Yokogawa	PT502	√	√
10	Yokogawa	TT503	√	√
11	Pepperl Fuchs	TT901	√	√
12	Pepperl Fuchs	VC902	√	√

4.1.5 Online Device Replacement

4.1.5.1 Test Description

The test was done to understand steps required to do an online device replacement. For Basic Test, it covers same device replacement i.e. the same device (same model) is used as the replacement.

4.1.5.2 Summary of Method

1. Device is removed from the segment.
2. Use wizard to perform device replacement

Table 12: Result of the online device Replacement

	VENDOR	DEVICE NAME	ONLINE DEVICE REPLACEMENT	
			Successful Replace	TIME TAKEN
1	Rosemount	AT207	√	4 min. 3 sec.
2	Fisher	FV205	√	6 min. 1 sec
3	Rosemount	PDT204	√	4 min. 38 sec
4	Rosemount	PT202	√	4 min. 32 sec
5	Rosemount	TT203	√	9 min. 10 sec
6	Rosemount	TT201	√	14 min 27 sec
7	Yokogawa	FT504	√	5 min. 31sec
8	Yokogawa	PDT501	√	4 min. 4 sec
9	Yokogawa	PT502	√	3 min. 23 sec
10	Yokogawa	TT503	√	7 min. 35 sec
11	Pepperl Fuchs	TT901	√	4 min. 2 sec
12	Pepperl Fuchs	VC902	√	9 min 15 sec

4.2 Process Control Loop

As Part of the project a plant design was required to be done, and for that simple control loops were developed , the graphical design for those loops was developed using Emerson Delta V Host.

Firstly, a transmitter PT502 was chosen from segment 1 for controlling over the FV205

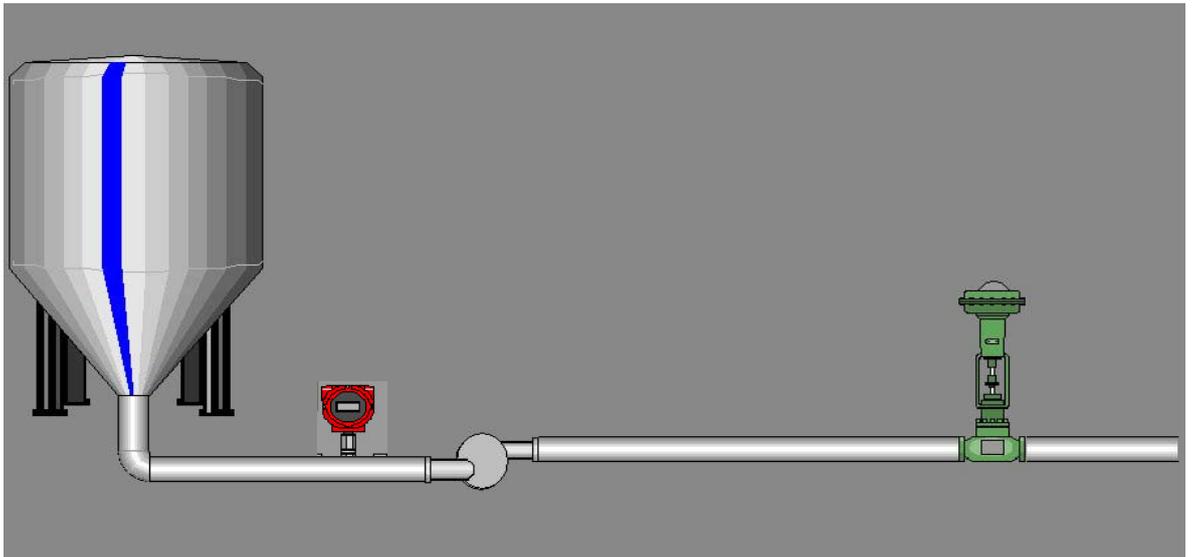


Figure 10: the pressure transmitter PT502 is used to monitor the pressure of the Tank.

For Better Understanding of the model ,the plant configuration figures are implemented using Honeywell Host (Control Bulider) and are attached in Appendix II,

It consists of four main blocks :

1. Analogue Input Block: Acts as the input source of data taken from the transmitter,
2. DACA block : Functions as a data acquisition block where data from the process is obtained and its also responsible for triggering alarms
3. PIDA block :responsible for PID trends and monitoring the controller performance using the trends given,

4. AO Block: It's the analogue output function block where execution at the output takes place,(in our case is the valve).

a) Model Parameter Estimation

I) Process Reaction Curve

The Pressure curve as in Fig. 11 obtained by using the process reaction curve method . the curve obtained was a first order process reaction curve. From this curve , some measurement can be made in order to obtain some parameters as the calculation below shows.

Measurements	Value
Change In Pertubation/ MV, σ	50%-40% = 10%
Change In Output/ PV, Δ	0.425 Bar
Maximum Slope , S	0.0125 Bar/S
Apparent Dead time , θ	47.4 sec
Calculations	Value
Steady state Process Gain, $K_p = \Delta / \sigma$	$\Delta / \sigma = 0.425 / 0.1 = 0.0425 \text{ bar}/\%$
Apparent Time Constant , $\tau = \Delta / S$ Or $\tau = 1.5 (t_{0.63\Delta} - t_{0.28\Delta})$	$\tau = \Delta / S = 0.425 / 0.0125 = 34 \text{ sec}$ or $\tau = 1.5 (t_{0.63\Delta} - t_{0.28\Delta}) = 1.5(78.16)$ $= 117 \text{ sec}$
Fraction Dead Time , $R = \theta / \tau$	$R = \theta / \tau = 47.4 / 34 = 1.39$ Or $R = \theta / \tau = 47.4 / 117 = 0.405$

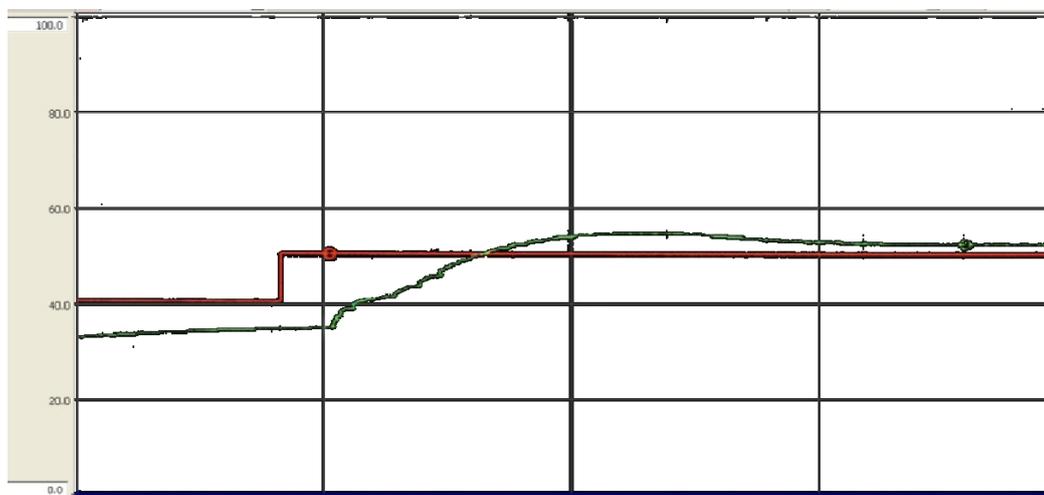


Figure 11: *Process Reaction Curve.*

B) Calculation of PID Controller Parameter

The controller tuning parameters based on cohen-coon open loop tuning correlations was calculated for the following modes :

- a) Proportional only (P-only)
- b) Proportional - Integral (PI)
- c) Proportional – Integral – Derivative (PID)

Tuning Parameters	P- only	PI
Proportional Gain , K _c	$K_c = [1/ (0.0405).(0.0425)] \cdot [1 + (0.405/3)] = 65.94$	$K_c = [1/ (0.0405).(0.0425)] \cdot [(9/10) + (0.405/3)] = 54.25$
Integral Time , T _I (Minutes/repeat)	T _I = 9999	T _I = (47.4) $[\{30+3(0.405)\} / \{9+20(0.405)\}]$ = 86.53
Derivative Time , T _D (Minutes/ Repeat)	T _D = 0	T _D = 0

Tuning Parameters	PID
Proportional Gain , K _c	$K_c = [1/ (0.0405).(0.0425)] \cdot [(4/3) + (0.405/4)] = 83.35$
Integral Time , T _I (Minutes/repeat)	T _I = (47.4) $[\{32+6(0.405)\} / \{13+8(0.405)\}]$ = 100.49
Deravative Time , T _D (Minutes/ Repeat)	T _D = (47.4) [1/ 11+2(0.0405)] = 16.05



Figure 12: *Process Response Curve for P-only*

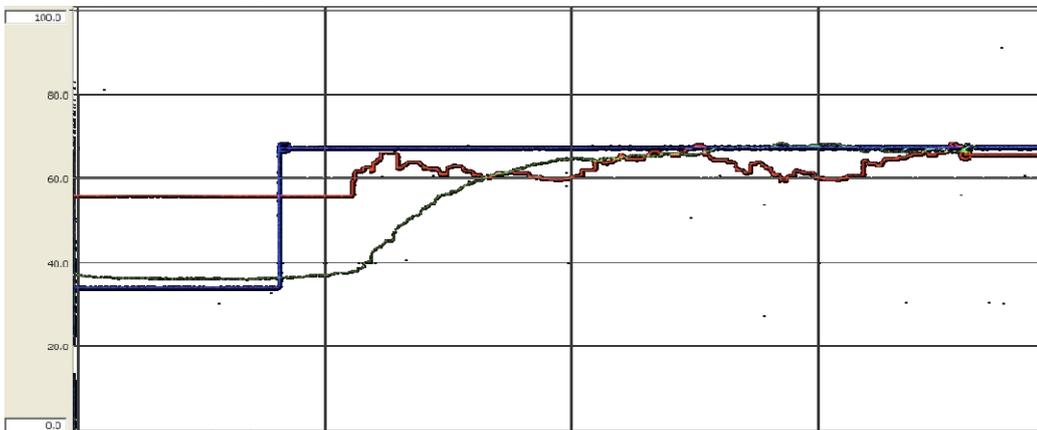


Figure 13: *Process Response Curve for PI*

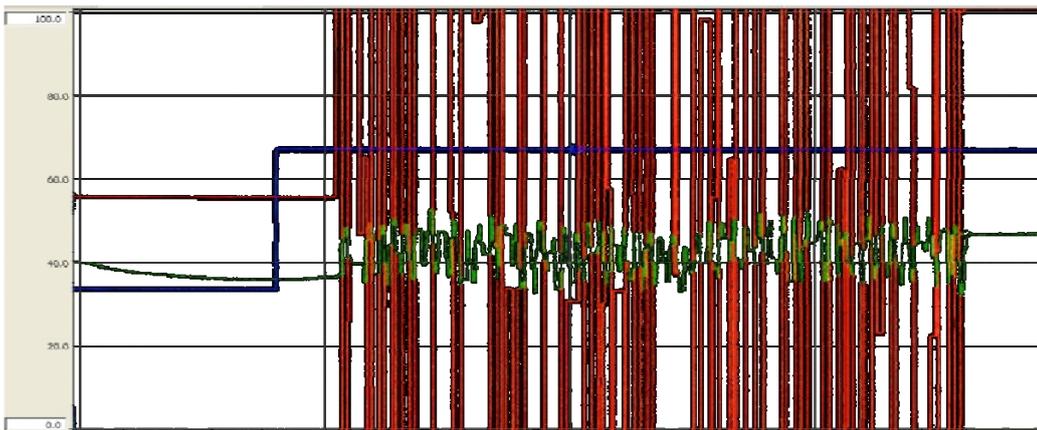


Table 14: *Process Response Curve for PID*

4.2.1 PID Controller

After getting the tuning parameters for every controller mode, each of them were tested and the curves were printed to evaluate the performance.

4.2.1.1 Proportional (P) :

The controller mode gives the decay ratio (DR) of 0.06 which can be conclude as stable process. Manipulated variable (MV) overshoot is not very high which is only 3.75% to reach the steady state. The proportional mode yields the fastest settling time, 270 seconds while the rise time is 37.9 seconds.

Figure 12(P.41) shows that the curve obtained had reduced the error since the curve nearly reach offset.

4.2.1.2 Proportional – Integral (PI) :

The DR for the PI mode is overdamped which shows that the process is stable . the MV overshoot is 0.125% which is the least compared to the other controller . the this means that the MV gives only a small response or overshoot to make the PV reach steady state . However, the settling time a bit large compared to proportional mode which is 350.5 seconds and the rise time is 113.7 seconds. The PI mode also result the curve to reach offset because of the integral mode.

4.2.1.2 Proportional – Integral – Derivative (PID) :

The PID mode gives the oscillating curves of PV and MV . Because of the DR and MV overshoot cannot be determined. From the pattern of the curves , the process can be evaluated as unstable Process which means that this controller mode cannot be used to control the pressure .this controller mode takes longer time to reach steady state which is 568.4 seconds but the shortest for the rise time, 4.7 seconds.

4.3 Discussion

The basic interoperability test is done for segment 1 of P+F which is comprises of 12 devices. The 12 devices were tested. The discussion will focus on each of the tests and the discussion of the test will be in term of the interoperability test consisting of the device decommissioning, device commissioning, online device replacement, physical layer diagnostic, and calibration check and any problems occurred during the tests.

4.3.1 Device Commissioning

All the devices can be fully commission and download. This means that all the devices does not need partial download to be perform. They can all be downloaded by segment. The time taken can be considered as short based on the whole 12 devices. Download action must be perform for the device to communicate with the host. The devices were successfully when through the segment download thus they do not need to undergo the partial download

4.3.2 Decommission

All the devices were managed to be decommissioned. However, only up to 4 devices can be decommissioned simultaneously, If the 5th devices being decommissioned, the system will experience the 'infinite delay'. This refers to the long time taken for the device to be changed to the offline mode. Normal time taken is less than 2 minutes but for this case, there is no action even after 30 minutes. In order to overcome this problem , we need to put any of the 4 decommissioned device under standby then the next device will be able to be decommissioned.

4.3.3 Calibration function checks

The calibration of the values for each device through host was done successfully. Each calibration just takes less than few seconds to show the outcome. The calibration function check is being done in two ways; simulate the input in the host and monitor the reading change from the 375 communicator or vice versa.

4.3.4 Physical layer Diagnostic

Failed device did not affect the segment healthiness or other devices on the Segment. System alarm was prompt out stating the device was off-line. The signal automatically recovered after the device was put back online i.e. no downloading was required. The system took 10 seconds to recover the signal. Alarms for the failed device returned to normal once the device was put back online and the initial alarm was acknowledged

4.3.5 Online Device Replacement

Built-in online device replacement wizard was able to detect suitable device that can be used as replacement. The wizard performed the decommissioning of the old device and commissioning of the new device. Time taken for device replacement for each device on each segments was 3-15 minutes. Online device replacement did not affect the fully functioning segment

4.3.6 Process Control Loop

A comparison between the performances of different controller modes to control the pressure of the process was made. The parameters to design the controller modes were obtained from the process reaction curve method. Some

calculations were done to get the proportional gain K_c , Integral Time T_i and derivative time for each controller. The performance of these controllers were evaluated via the curve obtained .

After each controller mode was evaluated , The Proportional- Integral mode was found to be the most stable to operate the pressure control.

CHAPTER 5

CONCLUSION

5.1 Conclusion

The tests were successfully conducted and had proven that the Honeywell host can communicate with all the tested devices from different vendors of Rosemount, Fisher, Yokogawa and Pepperl Fuchs which gives the opportunity for the end user to choose products from different manufacturers putting in consideration that they will be able to interoperate or work with each other perfectly. Furthermore this testing will be beneficial for future training of PETRONAS people in order to deepen the knowledge of the FF and for further development. Apart from the basic tests, a simple control was designed where the author learned and applied different control modes on the process.

5.2 Recommendations for Future work

In the next phase of the project it's recommended that:

- To apply the interoperability tests over a wider range of vendors to increase the efficiency of the Fieldbus system.
- To intensify the training sessions held by the vendors to allow better understanding of the system
- To provide the manufacturers with feedbacks resulting from the tests for better enhancement of the system and devices.
- To apply further test to ensure the reliability of the Fieldbus such as :
Extended test of the basic test , stress test , and diagnostic test.
- To Implement process control loops on other devices available in UTPFF plant

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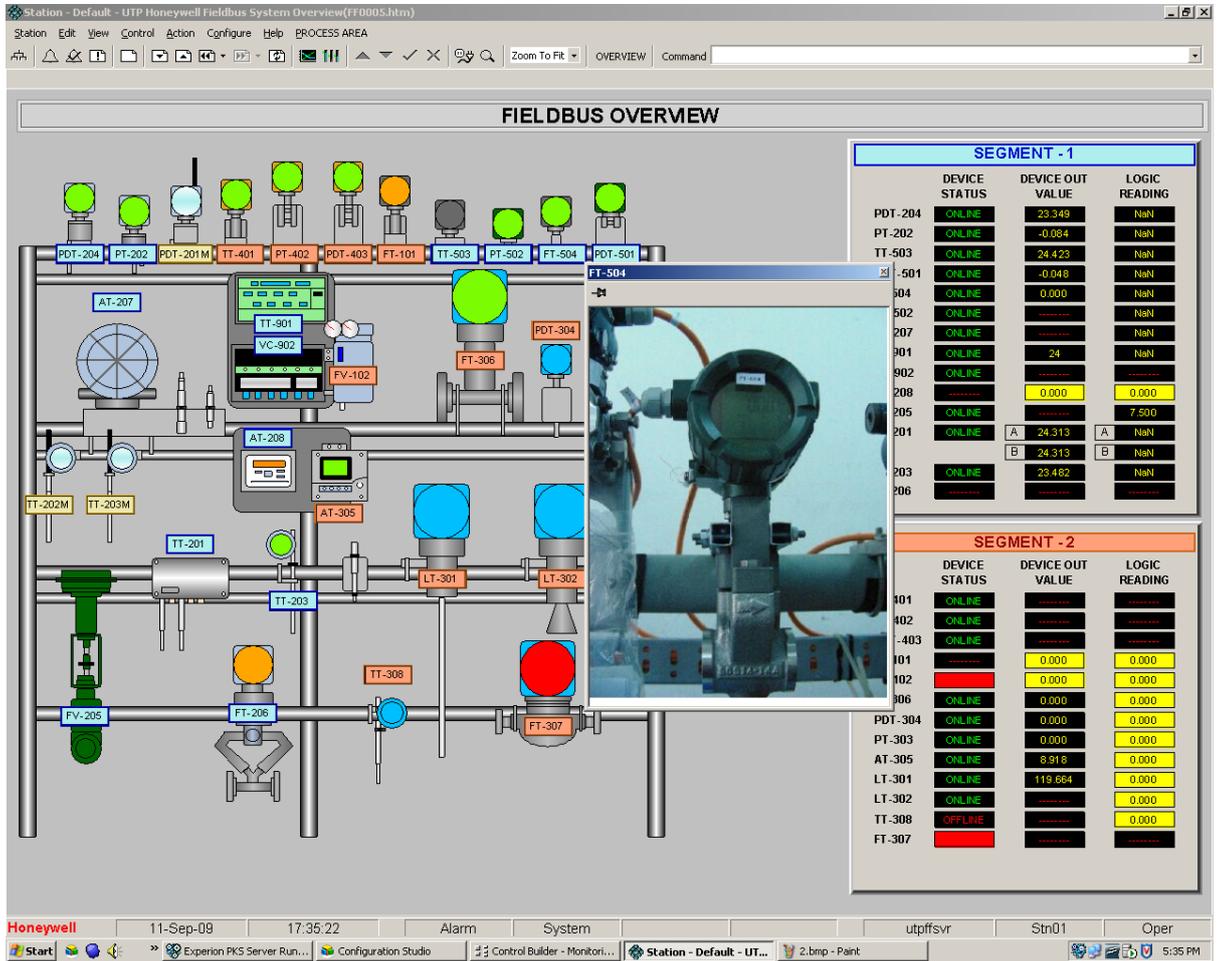
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APPENDICES

APPENDIX A

Transmitter PT502



APPENDIX B

Plant configuration for the plant model using PT502 at Honeywell Host

