

FOUNDATION FIELDBUS INTEROPERABILITY TESTING

By

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FINAL REPORT

Submitted to the Electrical & Electronics Engineering Programme
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CERTIFICATION OF APPROVAL

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Approved:



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UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

June 2009

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 the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.



Yang Hajarul Aira binti Ahmad Kamal

ABSTRACT

Foundation Fieldbus is known as the smart protocol that is a combination of digital communication simultaneously superimposed on a conventional 4-20mA signal [1]. Back to the past of the fieldbus, there were a problem on lack of interoperability occurred. There were so many different protocols in the market and the product could only work with other product from the same vendor. PETRONAS as the established company will apply this fieldbus technology in its plants. A Foundation Fieldbus system is already been installed at level 1, building 23 in University Technology PETRONAS. With collaboration from vendors from Emerson, Honeywell, Yokogawa, and Foxboro, PETRONAS team and UTP students, a Foundation Fieldbus Interoperability Testing will be conducted. The objectives of the testing are to get a PETRONAS Technical Standard on the Foundation Fieldbus system and come out with a report on the results from interoperability testing that will be the reference for system in PETRONAS. In order to achieve the objectives above, three different tests will be done through the Foundation Fieldbus Interoperability Testing which is Basic Interoperability Test, Stress Test and Diagnostic Capability. The results and data will be recorded. Due to the time constraint, the UTP team only managed to complete the Basic Interoperability Test until February 2009. The other two tests will be complete by the next group of UTP team. In the next chapter, there will be a detail on the training and procedure of the different system conducted by Emerson, Foxboro, Yokogawa and Honeywell, in order to proceed with the interoperability test. But the author will only focus on the Honeywell system. At the same time, there will be information on the Foundation Fieldbus architecture.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Fieldbus is a digital communications system which interconnects “field” equipment such as sensors, actuators and controllers together on a single network [3]. This technology has been widely applied to the producing fields, and it implements the bidirectional, serial, and multipoint communications. Nowadays, there are various kinds of fieldbus in the world market such as Foundation Fieldbus, PROFIBUS, LonWorks [7]. The desired system architecture made the protocol different from each other [1].

Known as the smart protocol, the Foundation Fieldbus system is completely digital and identical wiring used [1]. In PETRONAS, this technology is one of the new technologies to be apply in the field. So, with conducting the testing, the standardization of the Foundation Fieldbus system with four different vendors will be achieved. Along with this project, a Foundation Fieldbus Interoperability Test will be conducted as scheduled.

1.2 Problem Statement

Based on the history of the fieldbus, there were a problem on lack of interoperability occurred. There were so many different protocols in the market and the product could only work with other product from the same vendor. This previous system had created a limited range for the vendor to provide all parts a site required [1].

Once the system had been purchased the plant was essentially “locked in” by the manufacturer, the user must remember the system supplier had no longer had any competition, replacement parts and extras would be much costlier than they were for the first time [1].

The other factor that made the development of the fieldbus technology is the eagerness of the people nowadays to see the existing technology with the national standards adopted as the international fieldbus by some companies. This factor contributed to the delay in the ratification of the single fieldbus standard. Parts of both Foundation Fieldbus and PROFIBUS, through not HART, are elements of this standard, but devices of these two types cannot communicate with each other since the protocols are not compatible [1].

The lack of experienced engineer in Foundation Fieldbus is also one of the reasons for the testing needs to be conducted. PETRONAS needs more engineers to be able to work with this new technology in the future.

1.3 Objective and Scope of Study

Foundation Fieldbus Interoperability Testing is been conducted with collaboration of PETRONAS group and four different vendors. The test is used to verify correct implementation of the user layer function blocks and device descriptions. The foundation fieldbus will issue a certification mark for the device after the test is successfully completed. The mark assures the end user that the tests were completed and the device will interoperate on the fieldbus.

At the end of the project, a report from interoperability testing will be the reference for good technical practice of the Foundation Fieldbus system and it will be applied by PETRONAS OPUs in oil and gas facilities and refineries. The test also been conducted in order to achieve the PETRONAS Technical Standard n Foundation Fieldbus system.

The test will be done only for the Foundation Fieldbus application and the chicken foot topology will be used as the PETRONAS standard practice. The test will covered 3 tests as well which are Basic Interoperability test, Stress Test and Diagnostic capability of the system. The device that will be used for the testing shall be intrinsic safety, IS entity and FISCO type. Due to the time constraint, there will be a basic interoperability test only been done until the end of the February 2009.

CHAPTER 2

LITERATURE REVIEW

2.1 HART Communication System

The conventional way to communicate the devices is known as Highway Addressable Remote Transducer (HART) communication which modulated as an AC signal superimposed onto the 4-20mA DC signal. The digital communication and analog signal can hence be used simultaneously, which makes it possible to do configuration, diagnostics, checks while the device is operating in the control loop. This conventional system is unable to predict and identify the faults in cabling and devices. But, the Foundation Fieldbus system is one of the intelligent technology systems which able to predict, detect and identify faults. The signal in HART communication is in frequency range that is filtered out by most analog devices. This allows the device to operate normally undisturbed by HART signal [1].

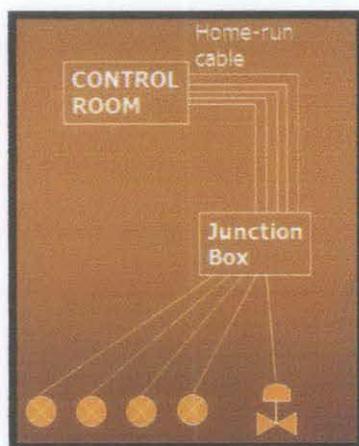


Figure 1: Conventional system

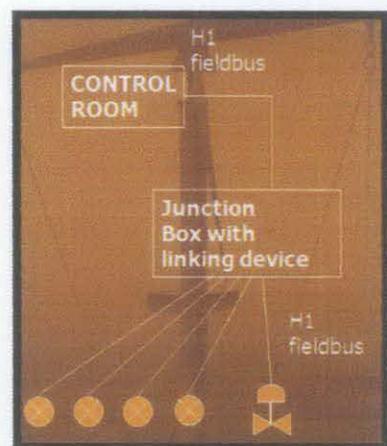


Figure 2: Foundation Fieldbus system

For the topology, HART communication protocol is using point-to-point wiring in order to use the traditional two-wire 4-20 mA DC current loop. The DC power supply also can be used. Hence, the resistance in the current loop, which often provided by input shunt resistors, must be 230 ohm or greater for the HART signaling to work. HART network can be connected up to two masters at the same time. The interface must be connected between the field device and resistor in order to make the communication work out. If the interface had been connected between power supply and the resistor, there will be no communication because the signal is short circuited by the power supply [1].

Since the analog devices are wired in series, the system will causes a voltage drop over each. The responsible person (technician), must ensure that the power supply is sufficient for the total resistance of cable and the input shunts otherwise there will not be sufficient operating voltage for the field device when the current is at its maximum [1].

2.2 Foundation Fieldbus

Fieldbus is a digital technology with the two-way communication systems that allow end users to achieve true distributed control, thereby freeing valuable plant resources for real-time production control. This system is been used to improve the existing 4-20 mA analog signals. Each of the field devices has low cost computing power installed in it; it makes each of the devices an intelligent device. The device is able to execute the simple functions on its own. For example, the fieldbus device is capable on diagnostic, control, and maintenance functions as well providing bi-directional communication capabilities. The system can communicate with the other field device as well.

The fieldbus is now widely accepted as the valuable communication method between industrial control systems and field instruments, and rapidly becoming the method of choice for communication between process control systems and field

instrumentation [6]. There are hundreds of different Fieldbus protocols, such as PROFIBUS, FOUNDATION Fieldbus and etc. Both of the FOUNDATION Fieldbus and PROFIBUS have large installed bases so it is unlikely that either will disappear in the near future [6].

As for the fieldbus network, it has two wires used for both communication and power supply to bus-powered devices. All the network devices are connected in parallel. In that case, the system is able to connect or remove a device while the bus is running. For each segment of the fieldbus network, there are two terminators located at each end of the trunk. Terminator is used to prevent signal reflection and subsequent communication errors. The other function is to convert the current change produced by a transmitting device into a voltage change across the entire network that is picked up by all the devices as means for receiving the signal [1].

For the topology, this Foundation Fieldbus Interoperability testing is using tree topology which also known as chicken foot topology. In chicken foot topology, a main cable called “trunk” typically runs from marshalling panel near the control room out into the field until reaches the last devices, passing all the devices along the way. From the main trunk, shorter wires called “spurs” connect the individual devices and the terminator are mounted at the ends of the trunk. For every segment of the network, a repeater had been used and each can have several spurs. The chicken foot topology can minimizes the amount of cable required to connect the devices. However, since several junction boxes are required for the spurs, there will be many connections. The terminator is typically mounted in the furthest junction box along the trunk [1].

The trunk in chicken foot topology runs into the field where it branches out into the individual devices from a single junction box as shown in figure 3. For the field-end terminator, it is mounted in the junction box itself. This topology minimizes the number of connections, but the cable length will be longer, especially if the devices are not practically close together [1].

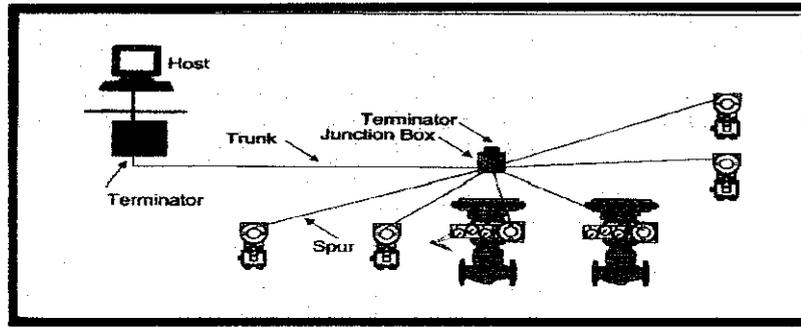


Figure 3: Tree topology with field-end terminator where trunk ends and spurs branch out

There are other topologies that had been applied at the plants such as point-to-point topology, bus topology and daisy chain topology. Point-to-point topology consists of a network having only two devices. The network could be entirely in the field (e.g. a transmitter and valve, with no connection beyond the two) or it could be a field device connected to a host system for control or monitoring. The bus topology consists of Fieldbus devices are connected to a trunk through a length of cable called a spur. Point-to-point and bus topology is not a good economical choice. Meanwhile for daisy chain, this topology is not reliable for the Fieldbus network because the devices difficult to be added or remove from a network/segment without disruption to other devices in the same network/segment. [16]

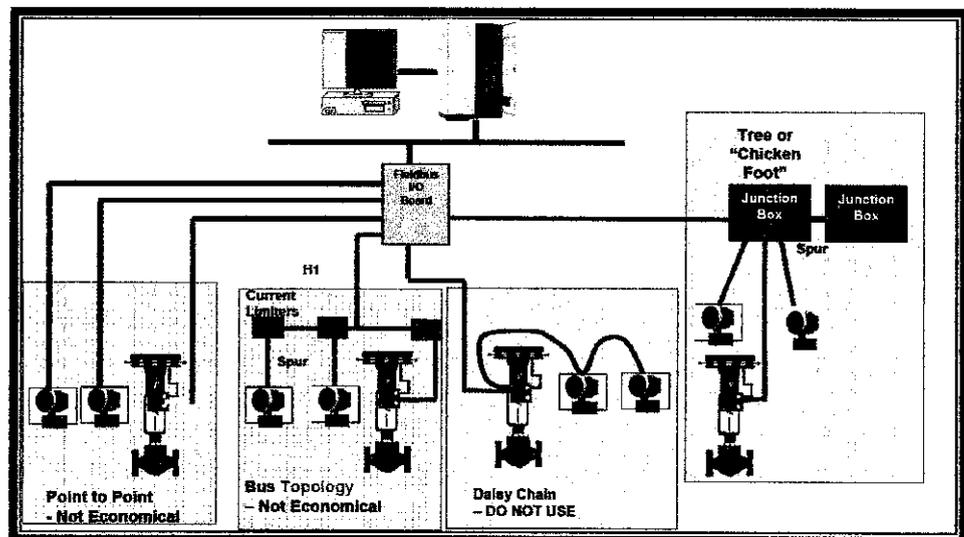


Figure 4: Types of topologies

2.3 How Fieldbus Work

The communication networks, which are HART and Foundation Fieldbus are the serial communication protocols. The Foundation Fieldbus has a bidirectional communication which mean that a device able to transmit and also receive, but not at the same time. All of these three networks are all based on the Open System Interconnection (OSI) reference model as defined in ISO 7498 standard. The messages had been passed through all the layers and each layer performing a set of function. As for layer 1 in figure 5, it is the physical media of data communication, normally a wire. Meanwhile above layer 7 is the device function called the User Layer. The User layer function as measurement, actuation, control or operator interface in a host. This layer is where the data formats and semantics are defined to allow devices understand and able to act intelligently on the data, thereby, achieving the real interoperability. For the fieldbus, the remaining layers in OSI Layers such as layer 3,4,5 and 6, are not be used [16]. A message makes it way down through the layers in the transmitting device, over the wires and then up through layers in the receiving device. For the requested message, the device attends to it and responds by passing a message back the opposite way [1].

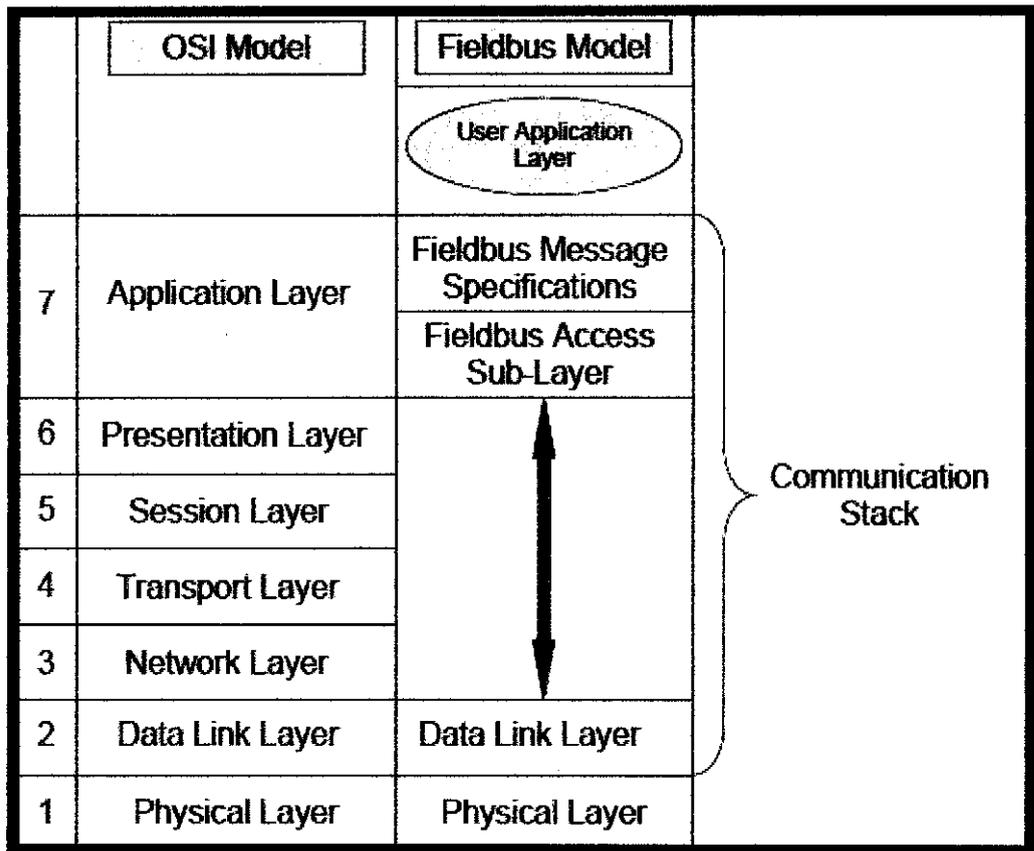


Figure 5: Open System Interconnect model and Fieldbus model

2.4 The Interoperability Test

In order to achieve the interoperability for the fieldbus devices, all the layers must be able to interoperate. The foundation required that each of the fieldbus resident devices must successfully complete several formal tests to ensure that all layers interoperate. The tests are Physical Layer Test, Conformance Test and also Interoperability Test. In the project, the Interoperability Test is been highlighted. An interoperability tester is used to verify correct implementation of the user layer function blocks and device descriptions [3].

To test the interoperability of a fieldbus system (which is “plug and play” devices), the hosts need to be connected to an assigned H1 segment. Then, the segments will be swapped between hosts and the connectivity tests re-run. As the result, the segments could be swapped between different hosts, with 100% of the Device Description (DD) files working correctly [14].

After completed all the tests successfully, the Foundation Fieldbus will issue a certification mark for the device. The mark assures the end user that all of the tests were completed and the device will interoperate on the fieldbus [3].

2.5 Advantages of Foundation Fieldbus

The fieldbus has a plenty of advantages that the end users will benefit from. The major advantage of the fieldbus and the most attractive to the end user is the reduction in costs. [13]. The fieldbus has additional advantages over 4-20mA because many devices can connect to a single wire pair resulting in significant savings in wiring costs [3]. Instead of reducing the wiring requirements, the fieldbus also decrease the installation and equipment costs as well [14].

The other advantage that can get from the fieldbus technology is by delivers system self-diagnostics which can support predictive/preventive the plant maintenance. Through fieldbus device and subsystem interoperability, users can remove the constraints of proprietary network architectures. The technology's "plug and play" ease-of- use also simplifies network expansion and device selection, and allows users to take advantage of "best-in-class" measurement and control solutions.

2.6 Disadvantages of Foundation Fieldbus

The primary disadvantage for the Foundation Fieldbus is the system has a higher initial cost of the field instruments compare to the HART. The field control can reduce the number of controllers required for the DCS, but difficult to accept for the first installation. Field control is capable of replacing 80 to 90 percent of the controls formerly done in the shared controllers of the DCS. The reduction in wiring cost and the reduced cost of the DCS is far more than compensates for the higher initial cost of the field instruments [13].

For the network reliability, the Foundation Fieldbus facing the risk on losing one loop of control and a few other measurements on the segment if the H1 segment cable is been cut. This situation will be happen if the system is been designed for the single loop integrity [13].

CHAPTER 3

METHODOLOGY

3.1 Basic Interoperability Test

This project aims to build a Foundation Fieldbus Interoperability Test which will be conducted through the project until the end of February 2009. The Basic Interoperability testing is about to make sure the device is functioning between the host and device. In the project, an observation of the effects of different revision of DD files between host and field devices will be done. The test also includes a bus health inspection, which will be the team task on getting the communication error statistic and its effects.

The Basic Test covers five (5) major tasks to be completed using the test bench of the Foundation Fieldbus. The test bench include four (4) hosts, 28 devices, high power trunk concept, three (3) cabinets been used and the other monitoring diagnostic systems. The tasks are Device Commissioning, Decommission, Online Device Replacement, Physical Layer Diagnostic, and Calibration Function Checks.

For Device Commissioning, the objective is to check whether the host is able to read data from the fieldbus device and to note the time taken for the commissioning to accomplish. At the same time, the Device Commissioning is used to tell how well the FF startup procedure (*to be referenced*) of a completely new system works. Extra steps needed to make the system function will be noted. This will gauge the difficulty level of commissioning of a FF system.

Meanwhile, for the Device Decommissioning, it is used for maintenance and also for replacement the new device. At the end of the task, each of the devices must successfully decommission.

The next test is Online Device Replacement. After the decommissioned is done and the system is ready for the commissioning of the new device, the cable will be plug in to the location and the system will automatically commission the device. The task is needed to test the effects of an unknown device being introduced into a FF system. The host must also be able to read the data from the fieldbus device. The task must cause no major interruptions.

For the Physical Layer Diagnostic, there are several method can be used such as scaling using the parameters and also drop out cable method. If testing using parameters is been applied, the 375 communicator is needed to get the readings of the noise, voltage and also the current for each devices. But for the drop out cable method, the testing will only focus on the alarm after the cable has been pulled out. The task is used to ensure that physical layer is performing at optimum level. At the end of Physical Layer Diagnostic, the parameters shall match with the Foundation Fieldbus system guideline.

Lastly, for Calibration Function Checks, the test needs the team to come out with the guideline for the Operations personnel on the calibration requirements unique to foundation fieldbus devices and Host. The essential steps is been registered when carrying calibration of the handheld communicator. In the tasks, the calibration from the Host, 375 communicator or iAMS must be carrying out.

The project flow is as follows:

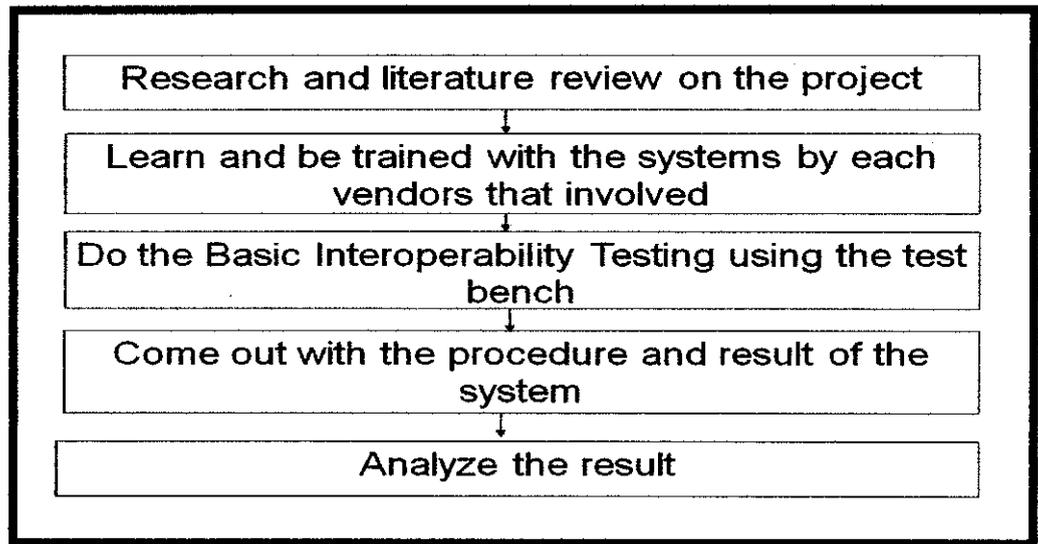


Figure 6: Project Work Flow

Before start the Basic Interoperability Testing, research and literature review on the project will done to gain more knowledge in the theory of the Foundation Fieldbus itself. Next, training from all vendors, such as Emerson, Foxboro, Yokogawa and Honeywell will be conducted based on the schedule. The training is conducted to teach and train the team to use their system for the testing. Then, the Basic Interoperability Testing will be conducted by applying the vendor's system and the test bench provided. There will be a procedure needs to be written parallel with the testing. The results from the testing will be recorded. Finally, the results will be analyzed by the team from UTP site and also PETRONAS team. At the end of February 2009, the team should complete the final report for the Foundation Fieldbus Interoperability Test.

3.2 Tools

Below are the equipments that required for the Foundation Fieldbus Interoperability Testing, they are for the test bench, test equipments and for safety purposes.



Figure 7: Test bench with 28 devices

- UTP FF Laboratory comprises of:
 - four Hosts, two segments, 28 devices and using High Power Trunk concept



Figure 8: Cabinets

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Familiarization of Emerson system

4.1.1 *DeltaV System*

DeltaV is the system which been used for testing by Emerson, one of the vendor which involve in the Foundation Fieldbus Interoperability Testing. A course of DeltaV system had been conducted for two days (3- 4 September 2008) located at the system's room at building 23, UTP. The main objective of conducting the course is to expose the team with the DeltaV system. Plus, the team will be prepared to install DeltaV and perform system startups, understand process reactions to partial downloads, process reaction to loss and also restoration of power.

As the introduction, the lesson began with exposing the team to the DeltaV Hardware and Software applications. The course also provides a session on ways to install and uninstall the hardware of the DeltaV itself. Next, the lesson continued on the way of login on to a DeltaV Workstation. Then, the lesson covered the way to install the carrier controller and power supply, power up the system and become familiar with the LED's. The team also been taught on installing the IO carrier and IO cards as well.

After that, the lesson was based on performing a system startup by commissioning a controller, then upgrading the controller and I/O card firmware. A configuration download and familiarization with LED indication also been performed

during the lesson. In the lesson, there was also a familiarization on the process reaction to loss and restoration of power. Plus, it also covered the creation of a process graphic and the way on a value configured from control module to display on the process graphic.

The process and system alarms visible on the operator display and the way on clearing them also been covered in the training. Last but not least, the lesson also highlighted on the how to simulate the connecting of the valve, transmitter and pump to the system, and then create the control modules to operate them.

4.1.2 Basic Interoperability Testing

EMERSON is the first host that proceeds with the test for the Foundation Fieldbus. Two (2) of the UTP student had been assigned to the EMERSON Host Device Basic Test. As the host of the project, training had been conducted in order to achieve the desired results at the end of the tests. The DELTA V training was been held as mentioned above. The objective of the training is to expose the team with the DeltaV system.

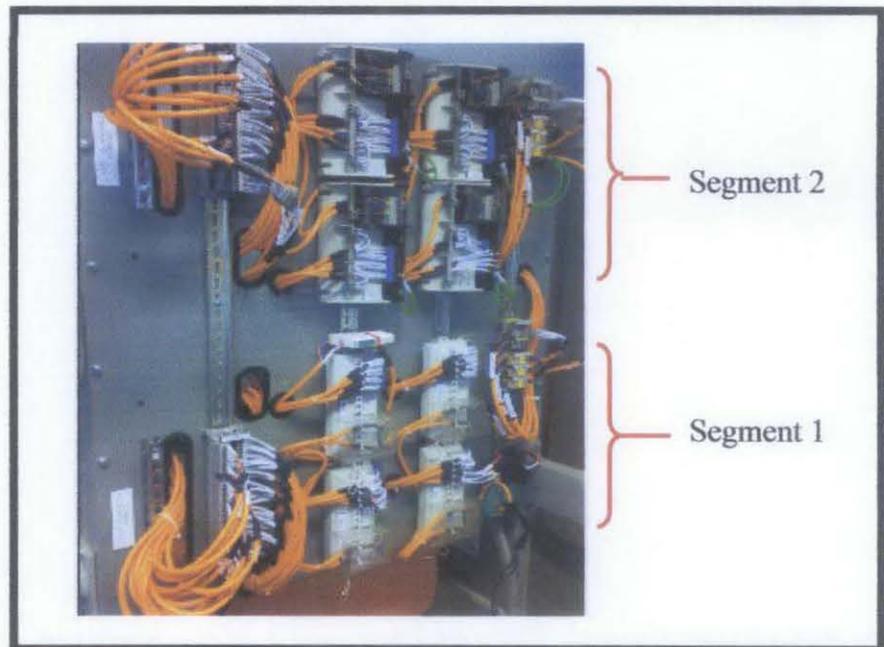


Figure 10: Two segment of the Test Bench

The procedures and the results for the tests had been completed by the other team member as shown in Appendix I.

4.2 Familiarization of FOXBORO System

The next host which is FOXBORO, had already completed their training for the system. The training was held on 20th until 22nd October 2008, at the same place where the Test Bench Foundation Fieldbus been installed. The objective of the training is to make sure the team familiarize with their system. In the training, the FOXBORO team guides all the participants to draw, adding the menu in the system, and etc. Figure 11 shows one of the results through the 3 days training. All the procedures and the results had been attached at Appendix II as reference.

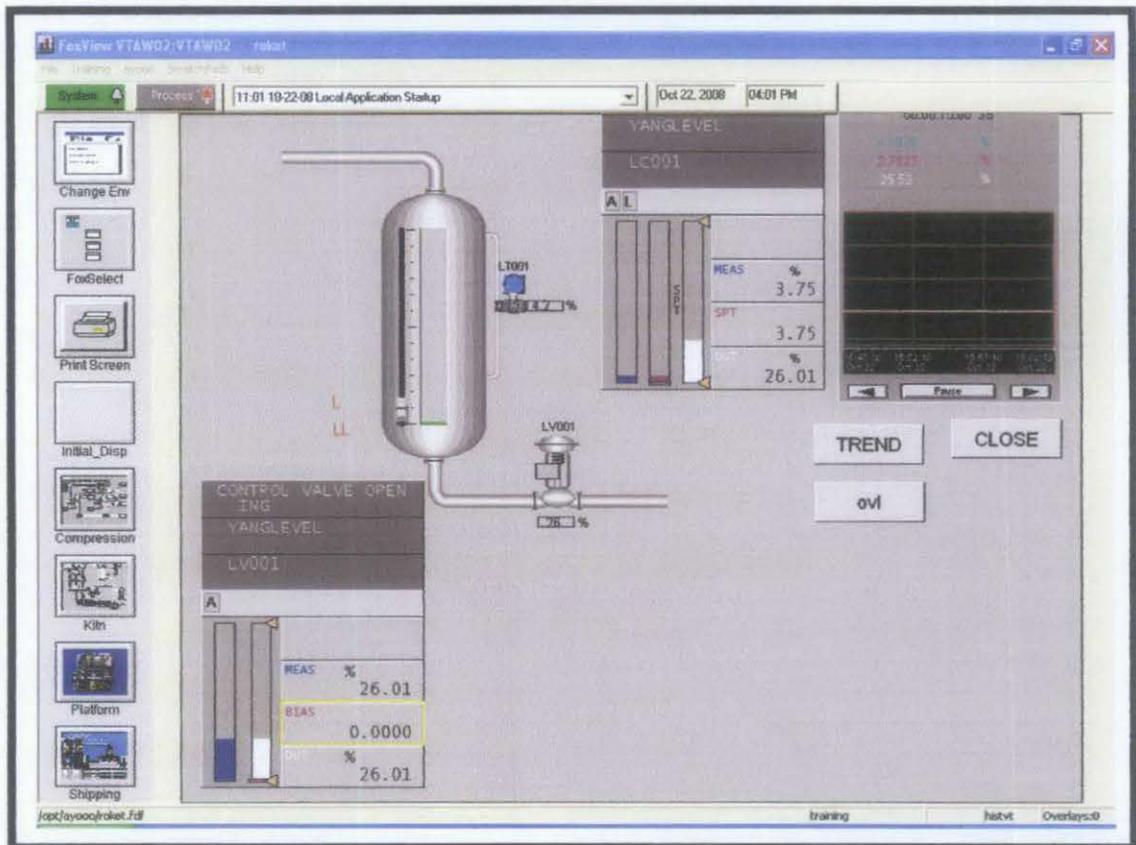


Figure 11: One of the exercise in the FOXBORO training

4.3 Familiarization of YOKOGAWA System

For YOKOGAWA system, the training began on 16th December 2008 and end at 18th December 2008. The three days training had been fulfilled with the basic of Foundation Fieldbus and the familiarization of the system. The system also been used for the Basic Interoperability Testing. The tests had been conducted for more than a week. The procedures and results for all the tests using the YOKOGAWA system can be refer at Appendix III.

4.4 Familiarization of HONEYWELL System

Honeywell system is the final host that needs to be tested using the test bench provided in a room at level 1, Building 23, Universiti Teknologi PETRONAS. Before the interoperability testing been conducted, all the students in charge for the project, together with the engineers, were having a three days training (12-14 January 2008) from Mr. Nik , the engineer from Honeywell. The objectives were to get familiar with the system and at the same time to gain the knowledge of the new technology of Foundation Fieldbus. The basic interoperability testing for Honeywell system took 2 weeks to complete for both of the segments.

4.4.1 Device Commissioning

Below are the steps to launch the Configuration Studio (in order to start the Honeywell system):

1. Click "Start"
2. Select "Programs"
3. Select "Honeywell Experion PKS"
4. Select "Configuration Studio"
5. Connect window will popup , select "UTPFFSystem" ,click "Connect"
6. Login using
 - a. Username: mngr
 - b. Password: mngr1

- c. Domain: <Traditional Operator Security>
7. Click OK
8. Expand “UTPFFSystem”
9. Expand “Server”
10. Expand “UTPFFSVR”
11. Click “Control Strategy”
12. From “Process Control Strategy”, click “Configure Process Control Strategies” and a “Control Builder” window will popup
13. At “Monitoring – Assignment”, check the status of C300_01 and FIM4_01.
 *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.
14. If at RED,
 - a. Right click at C300_01
 - b. Select “Checkpoint”
 - c. Select “Restore from checkpoint”.
 - d. A new window will pop up.
 - e. Select the last saved checkpoint to be restored.
 - f. Click “Restore”.
 - g. Start the controller by double click the controller “CEEC300_01”.
 - h. At “Main” tab, go to “CEE Command,” and select WARMSTART. Click YES. Wait until all the icons in Green.

For commission a device, there are the steps that must be considered. They are:

1. From the “Monitoring-Assignment”,
 - a. Expand “FIM4_01”
 - b. Expand “FFLINK_01” (the segment)
 - c. Check the status of the device base on the colour/ ‘?’ sign.

RED: already in the database but the system cannot be read

BLUE: Idle / Inactivate

GREEN: Live device

'?' sign: uncommissioned device

2. Double click on a device with the '?' sign,
3. A window will be popup and select the device name
4. Click "Commission Device Without Pre-Configuration" (Note: Take from device to segment), "User Authorisation" window will be popup, click "NEXT" until complete
5. Commissioning is successful when device turn to GREEN

***if the device unable to commission** (device GREEN colour with '?' sign only)

1. At "Project-Assignment",
 - a. Expand "FIM4_01"
 - b. Expand "FFLINK_01"
 - c. Select device
 - d. Right click
 - e. Select "Load"
 - f. Click "Continue"
 - g. Click OK ***Note: Check the 'Automatically change ALL control elements to the state selected in 'Post Load State' after load is completed'*
2. At "Project-Assignment",
 - a. Expand "CEEC300_01"
 - b. Select function block of the device
 - c. Right click
 - d. Select "Load"
 - e. Click "Continue"
 - f. Click OK ***Note: Check the 'Automatically change ALL control elements to the state selected in 'Post Load State' after load is completed'*
3. At "Monitoring-Assignment", device turn to GREEN without '?' sign

***if the device unable to commission (device has two same tag; 1 GREEN colour with '?' sign, and the other tag RED colour):**

1. At "Monitoring" (at the bottom of the window),
 - a. Expand the "CEEC300_01"
 - b. Select the function block of device
 - c. Right click
 - d. Select "Inactivate"
 - e. Select "Selected item(s) and Content(s)"
 - f. A window will popup, click YES
 - g. Wait for seconds until the device tag turn to BLUE (Idle state)

2. At "Monitoring-Assignment",
 - a. Expand "CEEC300_01"
 - b. Select the BLUE device
 - c. Right click
 - d. Select "Force Delete"
 - e. BLUE device will deleted

3. At "Monitoring-Assignment",
 - a. Expand "FIM4_01"
 - b. Expand "FFLINK_01"
 - c. Select the RED colour device tag
 - d. Right click
 - e. Select "Force Delete"
 - f. A window will popup, click "Continue"
 - g. Click "Force Delete"
 - h. RED device will deleted

4. At "Project-Assignment",
 - a. Expand FIM4_01
 - b. Expand FFLINK_01

- c. Select device tag (device that need to be commission)
 - d. Right click
 - e. Select “Load”
 - f. Click “Continue”
 - g. Click OK ***Note: Check the ‘Automatically change ALL control elements to the state selected in ‘Post Load State’ after load is completed’*
5. Open “Monitoring”, the device tag should turn to GREEN (already commissioned)
6. At “Project-Assignment”,
- a. Expand CEEC300_01
 - b. Select function block of device
 - c. Right click
 - d. Select “Load”
 - e. Click “Continue”
 - f. Click OK ***Note: Check the ‘Automatically change ALL control elements to the state selected in ‘Post Load State’ after load is completed’*
7. Commission of the device succeed

****if there is no loop of the device at CEEC300_01, create the loop for the device**

1. Open the “Control Builder” window
2. At “Project-Assignment”,
 - a. Expand CEECC300_01
 - b. Select any device (Note: Require to choose other device in order to copy the connection between AI block and DACA block)
 - c. Right click

- d. Select "Copy"
 - e. "Name New Function Block(s)" window will popup
 - f. Change the destination for the "Tag Names" and "Items Names", with the device's loop that need to be create
 - g. Click "Finish"
3. At "Project-Assignment",
- a. Expand "Unassigned"
 - b. New loop will be created in the "Unassigned"
 - c. Click and drag the new loop from Unassigned to "CEEC300_01"
 - d. Expand "CEEC300_01"
 - e. Double click the new loop. AI block and DACA block will be appeared.
 - f. Delete the AI block (Note: Since it is the copy of the other device's AI block)
4. At "Project-Assignment",
- a. Expand "CEEC300_01"
 - b. Expand the new loop
 - c. Search the AI of the device loop
 - d. Click and drag the AI in the new loop into the "Project" window
 - e. Connect OUTVALUE of the AI block to the input of the DACA block (double click at the OUTVALUE arrow, then single click to the DACA block)
 - f. Click "Save"
5. At "Project-Assignment",
- a. Expand "CEEC300_01"
 - b. Select the new loop
 - c. Right click
 - d. Select "Load"
 - e. A window will popup and click "Continue"

f. Click OK ****Note: Check the 'Automatically change ALL control elements to the state selected in 'Post Load State' after load is completed'**

6. At "Monitoring-Assignment", new loop will be create successfully in "CEEC300_01"

Table 1: Result for the device commission of Segment 2 using Honeywell system

No.	Device name	Fully Download	Time Taken
1.	LT301	√	<1 min
2.	LT302	√	<1 min
3.	PT303	√	<1 min
4.	PDT304	√	<1 min
5.	AT305	√	<1 min
6.	FT306	√	<1 min
7.	FT307	X	-
8.	TT308	√	<1 min
9.	TT401	X	-
10.	PT402	√	<1 min
11.	PDT403	√	<1 min
12.	FT101	√	<1 min
13.	FV102	√	<1 min
14.	MTLADM1	√	<1 min

All of the devices in segment 2 were successfully been commissioned without any problem occurred except for FT307 and LT 401. Both of the unable to commission device are in out of service condition. There is no power supply go through the devices. This initial device commissioning took less than 1 second to be completed by using Honeywell system.

4.4.2 Decommission

Next, the procedures for the device decommissioning using Honeywell system are:

1. From the “Monitoring-Assignment”,
 - a. Expand “FIM4_01”
 - b. Expand “FFLINK_01” (segment 1)
 - c. Check the status of the device base on the colour/ ‘?’ sign.
RED: already in the database but the system cannot be read
BLUE: Idle / Inactivate
GREEN: Live
‘?’ sign: uncommissioned device

2. At “Monitoring-Assignment”,
 - a. Expand CEEC300_01
 - b. Select function block of the device
 - c. Right click
 - d. Select “Inactivate”
 - e. Select “Selected item(s)”
 - f. Click YES
 - g. Device will turned to BLUE
 - h. Right click at the BLUE function block
 - i. Select “Delete”
 - j. A window will popup, and click “Continue”
 - k. Click “ Delete Selected Object(s)”
 - l. Function block been deleted

3. At “Monitoring-Assignment”,
 - a. Expand FIM4_01
 - b. Expand FFLINK_01
 - c. Select device tag
 - d. Right click

- e. Select "Force Delete"
- f. "Force Delete" window will popup
- g. Click "Continue"
- h. Click "Force Delete"

4. Device will GREEN and with '?' sign. It shows device decommission successfully.

Table 2: Result for the device decommission of Segment 2 using Honeywell system

No.	Device name	Decommission	Time taken
1.	LT301	√	1 min 38 sec
2.	LT302	√	1 min 16 sec
3.	PT303	√	3 min 50 sec
4.	PDT304	√	2 min 35 sec
5.	AT305	√	2 min 19 sec
6.	FT306	√	1 min 33 sec
7.	FT307	X	-
8.	TT308	√	1 min 19 sec
9.	TT401	X	-
10.	PT402	√	1 min 15 sec
11.	PDT403	√	1 min 23 sec
12.	FT101	√	1 min 14 sec
13.	FV102	√	1 min 30 sec
14.	MTLADM1	√	1 min 28 sec

Above is the complete result for the segment 2, decommission testing using the Honeywell system. All the devices are able to decommission and commission. The process only took 2 to 4 minutes to complete the test. There was no problem occurred during the testing.

4.4.3 *Online Device Replacement*

For online device replacement, the procedures are:

1. At “Monitoring-Assignment”, select the device that need to be replaced
2. Click “Field Devices” (located at top of the window)
 - a. Select “Device Replacement”
 - b. Device Replacement Wizard window will popup
 - c. Click NEXT
 - d. Click “Yes,Upload”
 - e. FF Device Replacement Wizard window will popup
 - f. Wait for the device that need to be replaced been detected by the system
3. 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)
 - 375 Field Communicator Device
 - i. Using the device, select “Fieldbus Application”
 - ii. Select “Online”. (Note: The communicator will upload information on all devices connected to the segment.)
 - iii. Select the device
 - iv. Double click at the device
 - v. Select “Details”
 - vi. Select “Physical Device Tag “
 - vii. Change the tag name of the device
 - viii. Click OK
 - ix. Click “Send”
 - x. Click YES and wait for the changes to be completed

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.
5. Click “Replace the Failed Device with the Uncommissioned Replacement Device”
6. “FF Device Replacement Wizard- Verifying Replacement Device” window will pop up
7. Click “Continue”
8. Click OK ***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*
9. *Load State” after load is completed”*
10. Click “Continue” and wait for the process
11. Click “Finish and Device turn to GREEN and been commissioned as new device

Table 3: Result for the online device replacement of Segment 2 using Honeywell system

No.	Device name	Time taken	Successful	Other affected?	Remarks
1.	LT301	3 min 58 sec	√	NO	Unable to replace at the beginning, but success after proceed with extra procedure
2.	LT302	3 min 48 sec	√	NO	Unable to replace at the beginning, but success after proceed with extra procedure
3.	PT303	9 min 45 sec	√	NO	Unable to replace at the beginning, but success after proceed with extra procedure
4.	PDT304	8 min 18 sec	√	NO	Unable to replace at the beginning and the second attempt, but success after proceed with extra procedure
5.	AT305	8 min 33 sec	√	NO	Unable to replace at the beginning and the second attempt, but success after proceed with extra procedure
6.	FT306	9 min 44 sec	√	NO	Unable to replace at the beginning, but success after proceed with extra procedure
7.	FT307	-	X	-	-
8.	TT308	8 min 4 sec	√	NO	Unable to replace at the beginning and the second attempt, but success after proceed with extra procedure
9.	TT401	-	X	-	-
10.	PT402	3 min 8 sec	√	NO	Unable to replace at the beginning, but success after proceed with extra procedure
11.	PDT403	2 min 28 sec	√	NO	Unable to replace at the beginning, but success after proceed with extra procedure

12.	FT101	3 min 33 sec	√	NO	Unable to replace at the beginning, but success after proceed with extra procedure
13.	FV102	3 min 53 sec	√	NO	Unable to replace at the beginning, but success after proceed with extra procedure

The procedures had been followed accordingly, but the all the tag name for all devices cannot be change. The 375 communicator was unable to change the tag name for the selected devices. An error occurred and it mentioned that another host been detected in the 375 Communicator. As the solution, a switch for Honeywell in segment 2 (at Cabinet 2) had been switched off in order to able for the 375 communicator to change tag name. Then, switch on the cabinet. The steps for Device Replacement using the Honeywell system had been followed. Device changed to the active mode (Green device) and replacements for a new device succeed.

But for AT305, PDT304 and TT308, the devices still cannot be replace successfully after change the device tag (in 375 Communicator). The devices still in inactive mode (RED device) and new device that been replaced in uncommission mode (“?” sign). So, to solve the new problem, function block and of the device in “Monitoring-Assignment” must be deleted. At “Project-Monitoring”, the device was “Load” in order for the device in active mode. Then, a switch for Honeywell in segment 2 (at Cabinet 2) had been switched off in order to able for the 375 communicator to change tag name. Then, switch on the cabinet. The steps for Device Replacement using the Honeywell system had been followed. The replacements for a new device succeed after the system changed to the active mode (Green device).

4.4.4 Physical Layer Diagnostic

Meanwhile, for the drop out cable, the work instructions are as below:

1. At field site, disconnect a device
2. Open the Station window, click the “System” (at the bottom of the window in SYSTEM box)
3. Device alarm appear on the screen and blinking
4. Click “Acknowledge Page” button to acknowledge the alarm. Alarm will stop blinking
5. Open the Control Builder window, at the “Monitoring-Assignment” window, monitor the status of the device
 (*Note: Before disconnect the device, device in GREEN. After disconnect the device, device turn to RED)
6. At field site, connect device
7. At Station window, the device alarm will be gone
8. At Control Builder window, the device turn to GREEN

Table 4: Result for the drop out cable testing of Segment 2 using Honeywell system

Device Name	Drop-out Response
AT305	<p><u>Initial condition:</u> At the Control Builder (monitoring), the device displayed in green colour.</p> <p><u>Drop-out device:</u> i) Control Builder(monitoring): The device displayed in red colour. ii) Station (system): alarm displayed with the description “Device Off-Net”.</p> <p><u>Plug-In Device:</u> i) Control Builder(monitoring): The device displayed turn to green. ii) Station (system): alarm displayed gone.</p>
FT101	<p><u>Initial condition:</u> At the Control Builder (monitoring), the device displayed in green colour.</p>

	<p><u>Drop-out device:</u></p> <p>i) Control Builder(monitored): The device displayed in red colour. ii) Station (system): alarm displayed with the description “Device Off-Net”.</p> <p><u>Plug-In Device:</u></p> <p>i) Control Builder(monitored): The device displayed turn to green. ii) Station (system): alarm displayed gone.</p>
FT306	<p><u>Initial condition:</u></p> <p>At the Control Builder (monitored), the device displayed in green colour.</p> <p><u>Drop-out device:</u></p> <p>i) Control Builder(monitored): The device displayed in red colour. ii) Station (system): alarm displayed with the description “Device Off-Net”.</p> <p><u>Plug-In Device:</u></p> <p>i) Control Builder(monitored): The device displayed turn to green. ii) Station (system): alarm displayed gone.</p>
FV102	<p><u>Initial condition:</u></p> <p>At the Control Builder (monitored), the device displayed in green colour.</p> <p><u>Drop-out device:</u></p> <p>At Control Builder(monitored): The device displayed in red colour. At Station (system): alarm displayed with the description “Device Off-Net”.</p> <p><u>Plug-In Device:</u></p> <p>At Control Builder(monitored): The device displayed turn to green. At Station (system): alarm displayed gone.</p>
LT302	<p><u>Initial condition:</u></p> <p>At the Control Builder (monitored), the device displayed in green colour.</p> <p><u>Drop-out device:</u></p> <p>At Control Builder(monitored): The device displayed in red colour. At Station (system): alarm displayed with the description “Device Off-Net”.</p> <p><u>Plug-In Device:</u></p> <p>At Control Builder(monitored): The device displayed turn to green. At Station (system): alarm displayed gone.</p>
LT301	<p><u>Initial condition:</u></p>

	<p>At the Control Builder (monitoring), the device displayed in green colour.</p> <p><u>Drop-out device:</u></p> <p>i) Control Builder(monitoring): The device displayed in red colour. ii) Station (system): alarm displayed with the description “Device Off-Net”.</p> <p><u>Plug-In Device:</u></p> <p>i) Control Builder(monitoring): The device displayed turn to green. ii) Station (system): alarm displayed gone.</p>
PDT304	<p><u>Initial condition:</u></p> <p>At the Control Builder (monitoring), the device displayed in green colour.</p> <p><u>Drop-out device:</u></p> <p>i) Control Builder(monitoring): The device displayed in red colour. ii) Station (system): alarm displayed with the description “Device Off-Net”.</p> <p><u>Plug-In Device:</u></p> <p>i) Control Builder(monitoring): The device displayed turn to green. ii) Station (system): alarm displayed gone.</p>
PDT403	<p><u>Initial condition:</u></p> <p>At the Control Builder (monitoring), the device displayed in green colour.</p> <p><u>Drop-out device:</u></p> <p>i) Control Builder(monitoring): The device displayed in red colour. ii) Station (system): alarm displayed with the description “Device Off-Net”.</p> <p><u>Plug-In Device:</u></p> <p>i) Control Builder(monitoring): The device displayed turn to green. ii) Station (system): alarm displayed gone.</p>
PT303	<p><u>Initial condition:</u></p> <p>At the Control Builder (monitoring), the device displayed in green colour.</p> <p><u>Drop-out device:</u></p> <p>i) Control Builder(monitoring): The device displayed in red colour. ii) Station (system): alarm displayed with the description “Device Off-Net”.</p> <p><u>Plug-In Device:</u></p> <p>i) Control Builder(monitoring): The device displayed turn to green. ii) Station (system): alarm displayed gone.</p>

PT402	<p><u>Initial condition:</u> At the Control Builder (monitoring), the device displayed in green colour.</p> <p><u>Drop-out device:</u> i) Control Builder(monitoring): The device displayed in red colour. ii) Station (system): alarm displayed with the description “Device Off-Net”.</p> <p><u>Plug-In Device:</u> i) Control Builder(monitoring): The device displayed turn to green. ii) Station (system): alarm displayed gone.</p>
TT308	<p><u>Initial condition:</u> At the Control Builder (monitoring), the device displayed in green colour.</p> <p><u>Drop-out device:</u> i) Control Builder(monitoring): The device displayed in red colour. ii) Station (system): alarm displayed with the description “Device Off-Net”.</p> <p><u>Plug-In Device:</u> i) Control Builder(monitoring): The device displayed turn to green. ii) Station (system): alarm displayed gone.</p>

There was no problem occur during the drop out cable testing been conducted. All the devices in segment 2 were successfully tested. There were also no other device affected when each of the cable of the device had been drop out. Alarms for all the devices work well in the system.

4.4.5 Calibration Function Checks

And the procedure for the final interoperability test, calibration function checks are as shown below:

1. Using 375 Communicator
 - a. At field site, connect the 375 Communicator
 - b. Using the device, select “Fieldbus Application”
 - c. Select “Online”. (Note: The communicator will upload information on all devices connected to the segment.)

- d. Select one device that needs to be rescaled. (Note: The communicator will take some time to upload the device)
- e. Select AI block.
- f. Select “Quick Config”. Change Mode to “OOS” (prev mode in “Auto”). Change XD Scale (Transducer Block) and Output Scale. Click Send. Change mode back to “Auto”.
- g. Monitor the faceplate and effect on the other devices

2. Using Host

- a. Type the name of the function block of the device at Command box
- b. Click the details of the device (magnifying glass icon)
- c. Data Acquisition Point Detail window will popup
- d. Change system in “Engr” mode (*Note: At the bottom right of the window; Password: engr)
- e. Click “Main”, change the Execution State to “Inactive”
- f. Change to “Chart” window, AI block and DACA block will appeared.
- g. Double click at DACA block
- h. “Parameters[Monitoring]” will popup
- i. Change the value for “PVEU Range Hi” and “PVEU Range Lo”
- j. Close the “Parameters[Monitoring]” window
- k. At “Main”, change the Execution State to “Activate”
- l. Monitor at the faceplate. Range for the faceplate will be change according to the previous changes
- m. Double click at the AI Block
- n. “Parameter[monitoring] popup
- o. In “Process”, change the Actual Mode to “ OOS”
- p. Click “Ranges”
- q. Change the XD_SCALE and OUT_SCALE
- r. Click OK
- s. Observe the device using the 375 Communicator. The changes of the device will be the same as the previous changes in the host

Table 5: Result for the calibration function checks of Segment 2 using Honeywell system

Device Name	Response using Host	Responses using 375 Communicator
LT301	-	Error occurred in 375 Communicator. It stated that 'Unable to load DD'. Device unable to change the value of the scale
LT302	-	Error occurred in 375 Communicator. It stated that 'Unable to load DD'. Device unable to change the value of the scale
PT303	-	Error occurred in 375 Communicator. Device unable to change the value of the scale
PDT304	-	Error occurred in 375 Communicator. It stated that 'Unable to load DD'. Device unable to change the value of the scale
AT305	-	Error occurred in 375 Communicator. It stated that 'Device upload aborted'. Device unable to change the value of the scale
FT306	At the AI function block, the range of the transducer scale (XD_SCALE) and the output scale (OUT_SCALE) is changed	The range of transducer scale (XD_SCALE) and the output scale (OUT_SCALE) is changed at 375 Communicator
FT307	Device in offline mode	-
TT308	-	Error occurred in 375 Communicator. It stated that 'Device upload aborted'. Device unable to change the value of the scale
TT401	Device in offline mode	-
PT402	At the AI function block, the range of the transducer scale (XD_SCALE) and the output scale (OUT_SCALE) is changed	The range of transducer scale (XD_SCALE) and the output scale (OUT_SCALE) is changed at 375 Communicator

PDT403	At the AI function block, the range of the transducer scale (XD_SCALE) and the output scale (OUT_SCALE) is changed	The range of transducer scale (XD_SCALE) and the output scale (OUT_SCALE) is changed at 375 Communicator
FT101	At the AI function block, the range of the transducer scale (XD_SCALE) and the output scale (OUT_SCALE) is changed	The range of transducer scale (XD_SCALE) and the output scale (OUT_SCALE) is changed at 375 Communicator
FV102	-	Error occurred in 375 Communicator. It stated that 'Device upload aborted'. Device unable to change the value of the scale

Referring to the table 5, only four devices are able to complete the testing successfully. They are FT306, PT402, PDT403, and FT101. When the device range for transducer scale (XD_SCALE) and output scale (OUT_SCALE) is changed using Host, the range at the field automatically changed by observe it using 375 communicator device. Meanwhile, when the device range for transducer scale (XD_SCALE) and output scale (OUT_SCALE) is changed at the field by using 375 communicator device, the range at the host automatically changed. Observation can be done at the AI function block.

Hence, for AT 305, FV102 and TT308, the error reading mentioned that the device upload been aborted and the devices unable to change the value of the scale. As for LT301, LT302 and PDT304, the error reading stated that the system unable to load DD file. The further actions will be taken by the executives of PETRONAS in charge.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

With the advantages of the fieldbus technology, PETRONAS, the operating companies will make a step forward in upgrading their system. Overall, the project is achieving the main objectives which are come out with a report from interoperability testing and the report will be the reference for the Foundation Fieldbus system in PETRONAS' OPU's in oil and gas production facilities, refineries, gas processing plants, chemical plant, marketing facilities or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization. At the same time, the test also been conducted in order to achieve the PETRONAS Technical Standard in Foundation Fieldbus system.

5.2 Recommendations

As mentioned in the previous chapter, the FF Interoperability Testing will carry out three different tests for the system which are Basic Interoperability Test, Stress Test and Diagnostic Capability Test. But due to the time constraint, and the test also take quite a long time to complete, there will be only Basic Interoperability Test will be conducted. This test will be due on February 2009. During the testing, there were several problems did occur and took a long time to be solved. The expertise from the vendor's company should come to check the result from the testing several times in order for the project to achieve the accurate results and at the same time we can reduce the time spend for the tests. Since the Basic Interoperability Testing is already completed, a discussion with the managers in PETRONAS had been arranged.

As the output from the discussion, an extended test is required to be accomplished and been conducted by the engineers themselves. An extended test is needed for the addition information on the testing itself. As future improvement, the people who in charge to complete the other two remain tests should be more alert when conducting the test in order to reduce the human error.

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APPENDIX I

EMERSON System

The procedures and results using Emerson system are as below:

1. *Device Commissioning*

Here are the steps for the device commissioning testing:

1. The EMERSON host system (Cabinet 1) and switch for MTL and P+F (both at Cabinet 2) had been powered up to start the commissioning.
2. Emerson had been selected for Segment 1 and Segment 2 at the selector switch located at the front panel of Cabinet 2
3. Next, login to windows using the following username and password.
Username: Administrator
Password : deltav
4. Then, Flexlock appeared and DeltaV Operate had been clicked to open the operator viewing station by using following username and password.
Username: Admin
Password : deltav
5. After that, the Deltav Explorer had been opened. And the Physical Network, Control Network, CTRL1, I/O, CO2 had been expended.
6. After clicked at P01 (port 1 of H! card), Download and Fieldbus Port had been selected. The communication with the fieldbus devices is then been established.
7. For the device that cannot be established, the individual device download had been performed.
8. The respond of the host for each fieldbus device can view through the host HMI and recorded as well.
9. The device commissioning is success if the alarm clears.
10. The alarm can be acknowledged after the appearance of the face plate.
- 11.

Result for Device Commissioning of Segment 1 (Emerson system)

	Device name	Fully Download
1	TT201	√
2	PDT204	√
3	FV205	√
4	PDT501	√
5	PT502	√
6	TT503	√
7	TT901	√
8	VC902	√
9	FT504	√
10.	FT206	X
11.	FT208	X

Refer to table above, it clearly shows that all the device is successfully commissioning without any problem occur. Two devices are unable to commission. It is because both of the devices have no power supply.

2. *Decommission*

For the proper procedure, the device that will be decommission had been selected. By using DeltaV system, ‘Decommission’ had been chosen after right click to the device and ‘Take Off-line’ been selected. Then, the status of the device had been checked in DeltaV Operate. At “Decommissioned Fieldbus”, the device tag been selected, right click and “Place in Standby” been choose. Placing the decommissioned device on standby mode is necessary before the device can go online.

Result for the Device Decommissioning of Segment 1 (Emerson system)

	Device Name	Address	Offline Address	Standby Address	Time Taken (minute)
1.	TT201	22	248	233	< 1
2.	PDT204	25	250	241	< 1
3.	FV205	26	251	240	< 1
4.	PDT501	30	249	236	< 1
5.	PT502	31	nil	234	> 12
6.	TT503	32	nil	234	> 12
7.	TT901	34	248	237	< 1
8.	VC902	35	249	239	< 1
9.	FT504	33	nil	238	> 12
10.	FT206		-	-	-
11.	AT208		-	-	-

Based on the results above on table above, it shows that at the first four devices, the decommissioning complete successfully below 1 minute. But at the 5th device and the 6th, the system took more than 12 minutes to complete. It happened because the system only allows 4 devices to decommission at 1 time. For the 7th device, the offline address had been change to the 1st device’s offline address. At the

same time, the 1st device's address had been changed to the standby address. As the result the 7th device can be decommissioning with time below 1 minute.

3. *Online Device Replacement*

Below is the result for the Segment 1 only:

Result for the Online Replacement of Segment 1 (Emerson system)

	Device name	Time taken (sec)	Successful	Other affected?
1.	TT201	9	√	NO
2.	PDT204	6	√	NO
3.	FV205	4	√	NO
4.	PDT501	6	√	NO
5.	PT502	7	√	NO
6.	TT503	4	√	NO
7.	TT901	4	√	NO
8.	VC902	3	√	NO
9.	FT504	4	√	NO
10.	FT206	-	X	-
11.	AT208	-	X	-

By referring to the table above, it shows that all the devices for Segment 2 are successfully been replace by using the Decommission and commission of the device except for FT206 and AT208. The device took 3 to 9 seconds to complete the replacement. The replacement does not affect any device and the system.

4. *Physical Layer Diagnostic*

In the testing, we identify the terminator at the last field barrier. The communicator was been connect to the terminal. The communicator will inform if the cable is not connected properly. We select “Start” and then select “OK”. The screen will now show the mentioned diagnostic features. Ensure all values are within acceptable region by selecting on the parameter and select “Help”.

Here are the steps for the testing:

1. Segment 1 is connected to the two terminators
2. All readings had been recorded. (DC voltage, low frequency noise, signal level of each device).
3. Adding 1 more terminator by switch it on. Now the segment is been connected to three terminators.
4. The reading had been taken.
5. Continue the test, with adding another terminal until exceed 6 terminals for the test.
6. All the steps above been repeated for the segment 2.
7. At the end of the test, connect the segments back to two terminators only

Result for the Physical Layer Diagnostic of Segment 1 (Emerson system)

Device name	Device Add.	2		3		4		5		6	
		Terminator (mA)									
TT201	16	439	332	312	244	234	186	186	146	146	107
PDT204	22	723	566	488	381	361	303	293	234	234	195
FV205	25	713	508	508	391	391	303	303	244	225	176
PDT501	26	654	478	439	332	332	284	254	205	205	166
PT502	30	605	459	439	342	293	234	225	186	186	146
TT503	31	625	469	449	352	303	244	234	186	186	156
TT901	32	732	537	527	410	391	312	273	215	215	176
VC902	33	644	478	459	352	342	264	244	195	186	186
FT504	34	654	478	478	361	352	283	273	215	205	166
	35	635	478	459	352	342	264	244	195	195	156

Above are the results for the Physical Layer Diagnostic for 2, 3, 4, 5 and 6 terminators involved. We can conclude that if we increase the number of terminator, the current will decrease as well and this is not good for the process performance and readings.

5. *Calibration Function Checks*

Below are the complete procedures using the Host:

1. From “Exploring DeltaV”, expand “Physical Network”.
2. Expand “Control Network”.
3. Expand “ CTRL1”
4. Expand “ Assigned Modules”
5. Select control module of the device that need to be rescaled
6. Right click on the module and open using “Open Online with Control Studio”.
7. Select AI Block from the main page
8. Refer to the “Parameter” on the bottom left.
9. Under “Operating”, double click “mode”. Mode properties will popup.
10. Change “Target” to “Out of Service”
11. Refer to Index. Change the XD_SCALE and OUT_SCALE (randomly select any value)
12. Change “Target” back to “Auto”
13. Monitor the effect on the other devices/ Host

Below are the complete procedures using the 375 Communicator:

1. Use Fieldbus Application in 375 Communicator
2. Select Online. The communicator will upload information on all devices connected to the segment
3. Select one device that needs to be rescaled.

Note: the communicator will take some time to upload the device

4. 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”
5. Monitor the faceplate and effect on the other devices.

For the iAMS :

Note: The rescale cannot be performed using Emerson AMS

Result for the Calibration Function Check of Segment 1 using Host (Emerson)

	Device Name	Linearization Type	Successfully Rescaled	Effect on other Devices
1	PDT204	Indirect	Yes	No
2	PDT501	Indirect	Yes	No
3	PT502	Direct	Yes	No
4	TT503	Direct	Yes	No
5	TT901	Direct	No	No
6	FT504	Direct	Yes	No

Each of the devices has different linearization type. Some device has direct linearization type, some has indirect linearization type. It depend on how the device been manufactured. Based on the result in table, all of the transmitter successfully been rescaled except for TT901. The reason is still unknown. All of the devices did not affect any of the other devices when calibration testing is running.

APPENDIX II

FOXBORO System

The procedures and results using Foxboro system are as below:

1. *Device Commissioning*

Below are the work instructions for the Foxboro system for the device commissioning:

1. Switch on Foxboro
2. Turn on PCs for Foxboro System. I/A Series System will appear (FoxView).
3. Turn Selector Switch of 2 segments to Foxboro.
4. At FoxView, select System tab. It will open System Management Display Handler. Click "CP003" and select "Config" button. Click "FBM00B" and select "Next Level". Select the port no and view the status of all the devices.
5. Record the time taken to download all devices in both segments (Port 1 and Port 2).
6. Record failed devices, any special steps and ease of initial download.
7. The steps repeats for each devices

All the devices for both segments had been initial commission successfully. Below are the results for the devices on segment 1 only.

Result for the initial device commissioning of Segment 1 (Foxboro system)

No.	Device name	Fully Download
1.	FT206	X
2.	TT503	√
3.	PDT501	√
4.	PT502	√
5.	TT201	√
6.	PDT204	√
7.	FV205	√
8.	AT207	√
9.	AT208	X
10.	TT901	√
11.	VC902	√
12.	PT202	√
13.	TT203	√
14.	FT504	√

Based on the above results, it clearly showed that there are two devices unable to be commissioned. It is because there is no power through the devices (FT206 and AT208).

2. *Device Decommission*

Here are the next procedures for the device decommissioning:

1. Open IACC Application, select Network tab and expand Configuration
 - a. Expand HPS001
 - b. Expand SW0001
 - c. Expand CP0003
 - d. Expand FBM00B (FBM228)
 - e. Expand iom228r_FBM00B
 - f. Expand FBM00B (ECB202)
2. Select device to be decommissioned
3. Precaution: right click, select properties
 - a. Check device type, device revision, port, DD rev
 - b. Note all related information in the result template.
4. Right click at the device to be deleted. Click "Delete". Proceed until device is deleted.
5. Download the changes made:
 - a. Right click at CP0003, and choose Download. Follow the instructions
6. Check this action has been performed successfully.
 - a. IACC. Make sure the device has been deleted from the list.
 - b. At FoxSelect, click Options, choose Refresh All. Ensure the device is mark as undefined or is deleted from the list.
 - c. At FoxView. Go to Instrument Skid page, ensure the device had been deleted.
 - d. At FoxView, select System tab. It will open System Management Display Handler
 - i. Click "CP003" and select "Config" button. Click "FBM00B" and select "Next Level". Select the port no and check the device is no longer in the database.
 - e. If any of these do not indicate that the device has been deleted, record the status in the result template,

- f. Ensure that while decommissioning the selected device, other devices are not affected.

The results for the device decommissioning of segment 1 as shown in table.

Result for the device decommissioning of Segment 1 (Foxboro system)

No.	Device name	Decommission	Time taken (minute)
1.	FT206	X	-
2.	TT503	√	< 1
3.	PDT501	√	< 1
4.	PT502	√	< 1
5.	TT201	√	< 1
6.	PDT204	√	< 1
7.	FV205	√	< 1
8.	AT207	√	< 1
9.	AT208	X	-
10.	TT901	√	< 1
11.	VC902	√	< 1
12.	PT202	√	< 1
13.	TT203	√	< 1
14.	FT504	√	< 1

Based on above results, it shows that all the devices in segment 1 were successfully been decommission except for FT206 and AT208. There was no power supply for those two devices.

3. *Online Device Replacement*

The procedures for the online device replacement are as below:

1. Open IACC Application, select Network tab and expand Configuration
 - a. Expand HPS001
 - b. Expand SW0001
 - c. Expand CP0003
 - d. Expand FBM00B (FBM228)
 - e. Expand iom228r_FBM00B
 - f. Expand FBM00B (ECB202)
2. Right click at the FBM00B (ECD202) and select “New Child Device”.
 - a. Select device and change the port number accordingly. Note: If the step is missed, the port number can be changed later. Click OK.
 - b. Rename the device to the original name.
3. Select Plant tab, choose the manufacturer name and double click at the device model. A function block will appear.
 - a. Click at Network tab, drag the device and drop it beside the AI function block.
 - b. Draw the connection from Input_1 (device block) to the From_Fld1 (AI block)
 - c. Download the changes made. Right click at CP0003, and choose Download. Follow the instruction
4. Check this action has been performed successfully.
 - a. IACC. Make sure the device has been added from the list.
 - b. At FoxSelect, click Options, choose Refresh All. Ensure the device has been added to the list.
 - c. At FoxView. Go to Instrument Skid page, ensure the device had been added.
 - d. At FoxView, select System tab. It will open System Management Display Handler

- i. Click “CP003” and select “Config” button. Click “FBM00B” and select “Next Level”. Select the port no and check the device has been added. It will appear in cyan
- ii. Select the device. Click Equipment Change and choose Enable Comms.
- g. If any of these do not indicate that the device has been added, record the status in the result template,
- e. Ensure that while commissioning the selected device, other devices are not affected.

Refer to table below as the results for segment 1,

Result for the online device replacement of Segment 1 (Foxboro system)

No.	Device name	Time taken (sec)	Successful	Other affected?
1.	FT206	-	X	-
2.	TT503	< 10	√	NO
3.	PDT501	< 10	√	NO
4.	PT502	< 10	√	NO
5.	TT201	< 10	√	NO
6.	PDT204	< 10	√	NO
7.	FV205	< 10	√	NO
8.	AT207	< 10	√	NO
9.	AT208	-	X	-
10.	TT901	< 10	√	NO
11.	VC902	< 10	√	NO
12.	PT202	< 10	√	NO
13.	TT203	< 10	√	NO
14.	FT504	< 10	√	NO

All the devices in segment 1 were successfully been replaced except for the FT206 and AT208. The online replacement only took less than 10 seconds to be completed. There was no other devices had been effected during each of the device replacement testing.

4. *Physical Layer Diagnostic*

For physical layer diagnostic, drop out cable testing is been applied. Below are the procedures for the testing.

1. Using fieldbus communicator (375 Field Communicator)
 - a. Connect the cable to the Fieldbus Port (Ensure Fieldbus logo can be seen)
 - b. Press “On” button.
2. Identify terminator at the last field barrier. Connect the communicator to the terminal. Ensure the polarity is correct (red is positive, black is negative). The communicator will inform if the cable is not connected properly.
3. On the communicator screen, select Foundation Fieldbus Application.
4. Select Fieldbus Diagnostic. The screen will show DC Voltage, noise and signal level.
5. Select “Start” and then select “OK”. The screen will now show the mentioned diagnostic features. Ensure all values are within acceptable region by selecting on the parameter and select “Help”.
6. Terminator
 - a. Segment 1 is now connected to two terminators.
 - b. Record all the readings (DC voltage, low frequency noise, signal level of each device).
 - c. Switch on another terminator. The segment is now connected to three terminators.
 - d. Record all readings.
 - e. Repeat step c and d until have the maximum of 6 terminators.
 - f. Repeat step a- e for segment 2.

- g. At the end of the test, connect the segments back to two terminators only.

7. Device drop out

- a. Take out one device cable connected to the segment. Record the response of the segments (device should be marked as offline and other devices should not be affected).
- b. Repeat for all devices.

The results for the testing had been shown in table.

Result for the drop out testing of Segment 1 (Foxboro system)

No.	Device name	Alarm displayed?	Other affected?
1.	FT206	√	-
2.	TT503	√	NO
3.	PDT501	√	NO
4.	PT502	√	NO
5.	TT201	√	NO
6.	PDT204	√	NO
7.	FV205	√	NO
8.	AT207	√	NO
9.	AT208	√	-
10.	TT901	√	NO
11.	VC902	√	NO
12.	PT202	√	NO
13.	TT203	√	NO
14.	FT504	√	NO

Refer to the results, the alarm for both devices (FT206 and AT208) already been displayed before all the testing been conducted.

5. *Calibration Function Check*

Below are the procedures for the calibration function check testing using Foxboro system.

1. Using Host

- a. At FoxSelect, click device manufacturer and double click at the selected device/tag number. (To open the Block Detail Display at FoxView)
- b. At FoxView, note the original transmitter range defined.
- c. Change from Auto mode to OOS mode by clicking the OOS Switch. Note: No changes can be made if the device is on Auto mode.
- d. At IACC, click at Plant tab. Choose the manufacturer and double click at the selected the device.
- e. The CSD will appear. Double click at the AI block, the Properties window will appear.
- f. At the Standard tab, change the XD_Scale and OUT_Scale (@100 and @0). Choose any value.
- g. After changing the parameters, click Apply and then Download. Follow through the instructions.
- h. Change the OOS mode to Auto mode again.
- i. At FoxView, ensure the changes are displayed. Record the range in the result template.

2. Using 375 Communicator

- a. Use Fieldbus Application in 375 Communicator.
- b. Select Online. The communicator will upload information on all devices connected to the segment.
- c. Select one device that needs to be rescaled. Note: the communicator will take some time to upload the device.
- d. Select AI block. Select "Quick Config". Change Mode to "OOS" (prev mode in "Auto"). Change XD Scale (Transducer Block) and Output Scale. Click Send. Change mode back to "Auto".
- e. Monitor the faceplate and effect on the other devices.

Result for the drop out testing of Segment 1 (Foxboro system)

No.	Device name	Alarm
1.	FT206	already shown at Alarm Manager because it is in red colour.
2.	TT503	-
3.	PDT501	alarm displayed at Alarm Manager in OOS mode. After changing it back to AUTO mode and acknowledge the alarm, alarm at Alarm Manager can be disappeared
4.	PT502	alarm displayed at Alarm Manager in OOS mode .After changing it back to AUTO mode and acknowledge the alarm, alarm at Alarm Manager can be disappeared.
5.	TT201	alarm displayed at Alarm Manager in OOS mode .After changing it back to AUTO mode and acknowledge the alarm, alarm at Alarm Manager can be disappeared.
6.	PDT204	no alarm when change to OOS mode
7.	FV205	alarm displayed at Alarm Manager in OOS mode. After changing it back to AUTO mode and acknowledge the alarm, alarm at Alarm Manager can be disappeared.
8.	AT207	alarm displayed at Alarm Manager in OOS mode .After changing it back to AUTO mode and acknowledge the alarm, alarm at Alarm Manager can be disappeared.
9.	AT208	already shown at Alarm Manager because it is in red colour.
10.	TT901	-
11.	VC902	This device in OOS mode.
12.	PT202	alarm displayed in OOS mode at Alarm Manager.After changing it back to AUTO mode and acknowledge the alarm, alarm at Alarm Manager can be disappeared
13.	TT203	alarm displayed at Alarm Manager in OOS mode .After changing it back to AUTO mode and acknowledge the alarm, alarm at Alarm Manager can be disappeared.
14.	FT504	-

Refer to result above, it shows that most of the device in segment 1 able to be tested using the Foxboro system. The alarm is been displayed at the Alarm Manager in OOS mode. If the system is changing back to AUTO mode and acknowledge the alarm, the alarm at Alarm Manager will disappear.

APPENDIX III

YOKOGAWA System

The procedures and results using Yokogawa system are as below:

1. *Device Commissioning*

The procedure for the device commissioning for Yokogawa system are as below:

1. Power up Host system at Cabinet 3.
2. Power up switch for MTL and P+F at Cabinet 2.
3. At the selector switch (front panel of Cabinet 2), select Yokogawa for Segment 1 and Segment 2.
4. Login to windows using the following username and password:
5. Username: Administrator
6. Password: vigilance
7. Launch Yokogawa CENTUM CS3000 "System View" from the Start Menu.
8. Expand "UTP"
9. Expand "FCS0101" (Note: Controller)
10. Expand "IOM"
11. Expand "NODE1"
12. Expand "8ALF111"
13. Double click at "8ALF111-1" (Note: Port 1 of H1 card) and "Fieldbus Builder" window will open.
14. Right click on "8ALF111-1" on the left hand-side of the window. Select "Load to Device" and choose "Initial Download".
15. Click "OK" to continue the Initial Download". Wait until loading is completed which will take about an hour for each segment.
16. Establish the communication with fieldbus devices (initial download).
 - a. A pop-up "Download to FCS" will appear. Select OK to confirm.
 - b. Repeat step 10.1.12 to download Port 2 (8ALF111-2)

17. Perform individual device download in the following manner if step 10.1.15 cannot be establish.
 - a. Check the "System Alarm" status at the system message window toolbar. Select "System Status".
 - b. Check the controller symbol. Make sure no cross mark sign appear on the status. (Note: Not communicating with the host).
 - c. Check the status lamp at the Controller. Make sure the "HRDY", "RDY" and "CTRL" lamp is in green. (Note: HRDY is for processor card , RDY is for both hardware and software and CTRL is for duplex FCS).
 - d. If RDY light is in RED, select FCS0101 and click "Load".
 - e. Choose "Offline Download to FCS" and click OK to confirm.
 - f. If successful, the "HRDY" , "RDY" and "CTRL" lights will turn to green.
 - g. Repeat steps for other devices.
18. View through the host HIS and record response of the host for each fieldbus device.
 - a. At "Fieldbus Builder", select "Tools" and right click on "Display Device Information".
 - b. Device Live List Panel will appear. Observe and record the status of each device on each segment.
 - c. Check on the graphic overview and see the status.
 - d. Acknowledge all alarms that appear in the Alarm Window Toolbar.
 - e. If alarm clears, then device has been commissioned successfully.
 - f. If alarm does not clear, click "Process Alarm" icon at the Window Toolbar and note down the error message displayed in the "message" window.
 - g. Check faceplate for all devices.
 - h. Refer to Step 17 to attempt recovery of failed devices. If not successful, note down the affected device(s).

Result for the initial device commissioning of Segment 2 using Yokogawa system

No.	Device name	Fully Download	Remarks
1.	LT301	√	Successfully been commissioned
2.	LT302	X	Commission aborted, update process been interrupted
3.	PT303	X	Commission aborted, update process been interrupted
4.	PDT304	X	Commission aborted, update process been interrupted
5.	AT305	X	Commission aborted, update process been interrupted
6.	FT306	X	Commission aborted, update process been interrupted
7.	FT307	X	Device offline
8.	TT308	√	Successfully been commissioned
9.	TT401	X	Device offline
10.	PT402	X	Commission aborted, update process been interrupted
11.	PDT403	X	Commission aborted, update process been interrupted
12.	FT101	√	Successfully been commissioned
13.	FV102	X	Commission state not found in the project
14.	MTLADM1	√	Successfully been commissioned

Only a few of the device in segment 2 can be initially commissioned. There were a lot of problem occurred during the testing, Most of the devices' process had been aborted by the system and the update process had been interrupted. Since there were so many failures in the system, the person who in charge for the segment 2 by using YOKOGAWA system, should redo the device commissioning testing again.

2. *Decommission*

Next, for the decommission testing, the procedure are as below:

1. At "Fieldbus Builder", select any device to be decommissioned.
2. Take note of the Device ID and properties i.e. tag name, address, parameter.
3. Right click at the device, select "Device Delete".
4. Click on "Download"
5. Check the alarm status at the graphic as well as the device live list. Note that this action should only affect the decommissioned device and check for any other alarm that appears. Acknowledge the alarm.
6. To open the device Live List, from Fieldbus Builder, selects "Tools" and then chooses "Display Device Information".
7. Check that the Host must be able to see devices that are connected to the respective segment.
8. Scan the segment to ensure the device is fully decommissioned i.e. not in the loop.

Result for the device decommissioning of Segment 2 using Yokogawa system

No.	Device name	Decommission	Time taken (seconds)	Remarks
1.	LT301	X	-	Alarm appeared
2.	LT302	X	-	Alarm appeared
3.	PT303	√	14	Decommission success
4.	PDT304	√	20	Decommission success
5.	AT305	X	-	
6.	FT306	√	14	Decommission success
7.	FT307	X	-	Device offline
8.	TT308	√	11	Decommission success
9.	TT401	X	-	Device offline
10.	PT402	√	11	Decommission success
11.	PDT403	√	18	Decommission success
12.	FT101	√	17	Decommission success
13.	FV102	√	11	Decommission success
14.	MTLADM1	X	-	

Based on the above results, the table shows most of the devices in segment 2 were successfully been decommissioned. For FT307 and TT401, the devices were in offline state. Meanwhile, for the case of LT301 and LT302, both of the devices able to decommission but the alarm appeared during the decommission testing. According to the proper decommission of the device, the alarm should not appear and it can show that the activity is safe.

3. *Online Device Replacement*

Here are the procedure for the next test which is online device replacement testing.

1. This test is to check the device replacement step. This test would only be done on the same device.
2. At Fieldbus builder window, select device to be replaced.
3. Delete the **Device ID** of the device.
4. Select “Device Registration” and click “Device ID acquisition.” A new device ID will appear in Green color.
5. Go to File and click “Download”. Checkbox will appear and select the related tag from checkbox.
6. “Download to FCS” box will appear and click “Yes”.
7. The Device ID will become Black indicates that the replacement is successfully performed.
8. Record the response of the host and other devices in the system.

Result for the online device replacement of Segment 2 using Yokogawa system

No.	Device name	Time taken (sec)	Successful	Other affected?
1.	LT301	12	√	NO
2.	LT302	10	√	NO
3.	PT303	-	X	-
4.	PDT304	-	X	-
5.	AT305	11	√	NO
6.	FT306	16	√	NO
7.	FT307	-	X	-
8.	TT308	-	X	-
9.	TT401	-	X	-
10.	PT402	12	√	NO
11.	PDT403	28	√	NO
12.	FT101	11	√	NO
13.	FV102	13	√	NO
14.	MTLADM1	-	X	-

Based on the results above, there are several of the devices in segment 2 using the Yokogawa system unable to replace. For further action, the testing will be re do after finish with the testing on Honeywell system.

4. *Physical Layer Diagnostic*

Below are the complete procedures for the physical layer diagnostic testing using Yokogawa system. The procedure also included the working instruction of the drop out cable testing.

1. Using fieldbus communicator (375 Field Communicator):
 - a. Connect the cable to the Fieldbus Port (Ensure Fieldbus logo can be seen)
 - b. Press “On” button.

2. Identify terminator at the last field barrier. Connect the communicator to the terminal. Ensure the polarity is correct (red is positive, black is negative). The communicator will inform if the cable is not connected properly
3. On the communicator screen, select Foundation Fieldbus Application.
4. Select Fieldbus Diagnostic. The screen will show DC Voltage, noise and signal level.
5. Select "Start" and then select "OK". The screen will now show the mentioned diagnostic features. Ensure all values are within acceptable region by selecting on the parameter and select "Help"
6. Terminator:
 - a. Segment 1 is now connected to two terminators
 - b. Record all the readings (DC voltage, low frequency noise, signal level of each device)
 - c. Switch on another terminator. The segment is now connected to three terminators
 - d. Record all readings
 - e. Repeat the step 10.4.6.3 and 10.4.6.4 until have the maximum of 6 terminals.
 - f. Repeat step 10.4.6.1 to 10.4.6.6. for segment 2.
 - g. At the end of the test, connect the segments back to two terminators only
7. Device drop out:
 - a. Take out one device cable connected to the segment. Record the response of the segments (device should be marked as offline and other devices should not be affected)
 - b. Repeat for all devices.
8. From a fully functioning fieldbus system with all cabling and screening properly terminated, record for 24 hrs a period of time any alarm or event of the bus under control environment.

5. Calibration Function Checks

For the final interoperability test for Yokogawa system, the calibration function checks carry out the function from the host, 375 communicator and EWS.

1. Using Host (PRM):
 - a. On Plant Resource Manager, Choose "Network" tab.
 - b. From "Plant", expand "Centum".
 - c. Expand "UTP".
 - d. Expand "FCS0101".
 - e. Expand "Node 01"
 - f. Expand "Slot 08 – ALF111"
 - g. Select device either from "CH1" for Segment 1 or "CH2 for Segment 2 that need to be rescaled.
 - h. Select "Parameter" tab
 - i. Double click "<Show Actual Parameter>"
 - j. For non-Yokogawa device, **Parameter Manager** will be used. Select "AI01" tab.
 - i. Click "Update Device Values"
 - ii. Change the XD_SCALE and OUT_SCALE (randomly select any value)
 - iii. Click "Download Checked Parameters"
 - k. For Yokogawa device, **DTM Works** will be used. Click on "Easy Setup"
 - i. Select "Analog Input 1"
 - ii. Change "Target" to "OOS"
 - iii. Refer Index. Change the Transducer Scale and Output Scale (randomly select any value). Press "Enter" for every change on the scale.
 - iv. Change "Target" back to "Auto"
 - v. Select "Device" tab, and click on "Download to Device".
 - l. Go to EWS Centum, and makes the same changes to the corresponding function block detail in the control drawing.
 - m. Monitor the effect on the other device

2. Using 375 Communicator:
 - a. Use Fieldbus Application in 375 Communicator
 - b. Select Online. The communicator will upload information on all devices connected to the segment
 - c. Select one device that needs to be rescaled. Note: the communicator will take some time to upload the device
 - d. 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".
 - e. Monitor the faceplate and effect on the other devices.

3. Using EWS (Centum):
 - a. Open "System View" and Expand "UTP"
 - b. Expand "FCS0101"
 - c. Expand "Function Block"
 - d. Select "DR0007" to open control drawing for Segment 1, or "DR0008" for Segment 2.
 - e. Right click "FF-AI" block and choose "Properties"
 - f. Change the "Low limit value" and "High Limit value" (randomly any value). Then, click OK.
 - g. Right click "PVI" block and choose "Properties"
 - h. Change the "Low limit value" and "High Limit value" (randomly any value). Click OK.
 - i. Select "File" tab and click "Download"
 - j. Click Yes when "Download to FCS" box appear.
 - k. Monitor the effect on the other devices/ Host
(Note: Rescale using Centum EWS will affect only the OUT_scale at both 375 and PRM)

As the results, most of the device in segment 2 unable to be tested. So, the person who in charge should repeat the test after finished with the Honeywell system testing.