FOUNDATION FIELDBUS INTEROPERABILITY TESTING

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ELECTRICAL & ELECTRONICS ENGINEERING
UNIVERSITI TEKNOLOGI PETRONAS
JUNE 2009

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by

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FINAL REPORT

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

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Electrical & Electronics Engineering Programme
Universiti Teknologi PETRONAS
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Bachelor of Engineering (Hons)
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Approved by,

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Project Supervisor

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.

Hanisah bt. Hassan

ABSTRACT

This report is to discuss about the research and testing of Basic Interoperability Testing for Foundation Fieldbus system. The Foundation Fieldbus is the new protocol that used in the PETRONAS process plant. Since that, PETRONAS personnel get lack of training in handling this new system. Devices that used in Foundation Fieldbus system can not work or interoperate with the devices from different manufacturers. This project is to perform the interoperability testing and the result will be used as the reference for Foundation Fieldbus system for PETRONAS personnel that handling this new system. Besides, the purpose of this project is to find out interoperability devices with the manufacturers system. The methodology towards achieving the objectives includes the theoretical and technical research, and testing the system and devices. Research and understanding of the project is very important. Some procedure needs to follow to get the desired result and accuracy and consistency of the result need to take to the consideration. The specific system need to conduct for the basic interoperability testing is Honeywell system. The tasks that should be done under this Basic Interoperability Test are device commissioning, device decommissioning, online device replacement, physical layer diagnostics, calibration function checks, and online parameter downloads. From this test, all the devices that had been tested were successfully done. The research for the Foundation Fieldbus should continuously perform to improve the system from time to time and the analysis of result and reports will use for a future research.

ACKNOWLEDGEMENT

First and foremost, I would like to express my deepest gratitude to my supervisor, Dr. Rosdiazli B. Ibrahim, for his continuous supports, guidance, encouragement and concerns throughout the whole process of making this thesis possible.

I also would like to express greatest appreciation to Ms. Syaimaa Bt. A Rahim, Instrumentation & Control Executive from PETRONAS Group Technology Solutions, Ms. Siti Hawa Hj Mohd Tahir, Lab Technologist Plant Process, Universiti Teknologi PETRONAS and all of my coursemates that play an important role in this project. Without their guidance and valuable information, this thesis would not be completed in time.

My appreciation also goes to Universiti Teknologi PETRONAS especially Electrical and Electronics Engineering Department, for endowing me with essential skills to excel in theoretical and technical works. Last but not least, thanks to my friends and family who have been supporting me throughout this Final Year Project.

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CHAPTER 1
INTRODUCTION

1.1 Background Of Study

This project is intended to perform the interoperability testing of Foundation Fieldbus system for PETRONAS by using Honeywell system for Segment 1 devices. There are two segments in Foundation Fieldbus Lab. Segment 1 consists of 12 devices that come from three different manufacturers which are Yokogawa, Rosemount and Pepperl + Fuchs. The Foundation Fieldbus Interoperability Testing involved of University Technology of PETRONAS (UTP) team and the Skill Group (SKG) 14 team. Four vendors have been supplied the Foundation Fieldbus system and installed in the laboratory. The vendors are Foxboro, Honeywell, Yokogawa, and Emerson. All the tests will be conducted by 8 UTP's students which divided to perform tests on different vendors. The test for Basic Interoperability Testing takes 8 months to complete.

1.2 Problem Statement

Basically, the communication protocols that are widely used is 4-20mA analogue current loop for implementing process control system in PETRONAS. This protocol was using individual pair of wires to cabling each instrument and actuator to be connected to the instrumentation control room. However,PETRONAS are now trying to use a compatible digital communication standard which provides the maximum benefits to end user, which is Foundation Fieldbus. For this new protocol system, multiple devices connected using shared wired-pairs cable to the control room over the bus network. Foundation Fieldbus have some limitation that PETRONAS need to overcome.

1.2.1 Lack of training in handling Foundation Fieldbus System

Since Foundation Fieldbus system is still new in PETRONAS, the personnel that handling Foundation Fieldbus system is still lack of knowledge and need more training about this new system.

1.2.2 Interoperability

The products from different manufacturers designed for one protocol cannot work with those designed for another. Thus, the end user can not mix and match the devices from different vendors. Foundation Fieldbus need standardization to make sure products from different manufacturer can interoperate with each other.

1.3 Objectives

The objectives of this project are

- To perform the interoperability testing and the result will be used as the reference for Foundation Fieldbus system for PETRONAS personnel that handling this new system.
- To have standardization and all devices can follow this standard and the products from different manufacturer are possible to interoperate or work with each other.

1.4 Scope Of Study

The scope of study includes the research and builds the understanding of the Foundation Fieldbus topology and the type of devices that will be used in this test. Other scopes include studying how to conduct the basic interoperability test which are consist of assist the instrument procedure, perform the test, compile the result of the test and analysis the result. The specific system need to conduct for the basic interoperability testing is Honeywell system.

CHAPTER 2
LITERATURE REVIEW

2.1 History Of Fieldbus

Foundation Fieldbus is one of the communications protocol and is a digital and two way communications system. The Foundation Fieldbus is the upgraded communications protocol from the 4-20mA standard [5]. The Foundation Fieldbus was created in 1994 and a combination of two major industry fieldbus organizations which are Interoperable Systems Project Foundation (ISP) and WorldFIP/North America [6]. At the early used of Foundation Fieldbus, every vendor invented its own protocol and independently used. The products could only work with other products from the same vendor. Because of this, the end user can not select the devices from different manufacturers since different vendor have a specialization in different area. The standardization had been decided by the industry experts by working on vendor independent device standard in 1985 [5]. Being tied to a single manufacturer will make the cost higher and no longer a problem by having standardization in Foundation Fieldbus system.

2.2 Advantages Of The Foundation Fieldbus

2.2.1 The information can be communicated on a single cable [5].

The millions of information can be communicated along just one network cable. Using analog signal, it is not possible to extract much more information for each devices and it was impossible to transmit remotely anything other than simple I/O. For the digital communications, the DCS and PLC controllers can be placed away from the control room in a main room.

2.2.2 Saving cost for the cabling and construction. [5].

Foundation Fieldbus reduces the wiring cost because less cable is used compare to conventional systems. Since there is less cable to be installed, the man power used to do the installation is smaller than required for conventional systems.

2.2.3 Less maintenance work [5].

For the Foundation Fieldbus system, detailed device diagnostics is one of the important feature for the operators. Operators can remotely check and quickly detect the problem that caused by the device or the process. The time and cost saved because maintenance workers only send to the field when it is really needed. For the conventional system, the maintenance workers always sent to the field to check the devices without knowing the exact problems.

2.3 Interoperability

2.3.1 Standard User Layer [5].

Devices need to have a same physical user layer standard to be connected on a single cable. Figure below shows the differences between OSI (Operation System Interconnect) Model and Fieldbus Model. User application layer or standard user layer only defined in Fieldbus Model. Many devices in the market use ethernet but they do not use a standard user layer .The data can be transmitting successfully from the devices to another device, but without physical user layer standard, the meaning of the data can not be understood. Besides that, the transmitting of the data for the Fieldbus Model were faster than the OSI Model because the Fieldbus Model only have three layer compare to seven layer for the OSI Model.

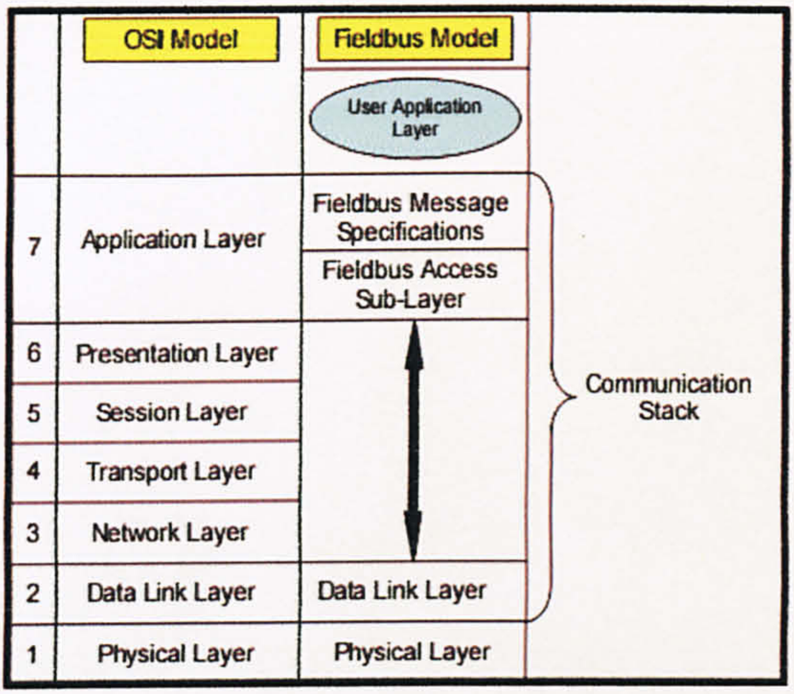

Figure 1: OSI Model and Fieldbus Model

Different manufacturers have different user layer protocol for the Foundation Fieldbus devices. The protocols were restored in user application layer during interoperability testing. Thus, the devices can be communicated with other devices from different manufacturers.

2.3.2 Device Description (DD) File

Device Description (DD) is the file that containing information of the device and manufacturer will provided the device description for each devices. The DD file works as a 'certification birth' for the devices. The system or host need to upload the DD file for each of the devices to make sure the system can recognize that particular devices [5]. The Electronic Device Description (EDD) for Foundation Fieldbus consists of a standard language normalized by IEC 18042- Electronic Device Description Language (EDDL), a compiler for EDDL and a interpreter named DDS (Device Description Services) [18].

2.4 Foundation Fieldbus Topology

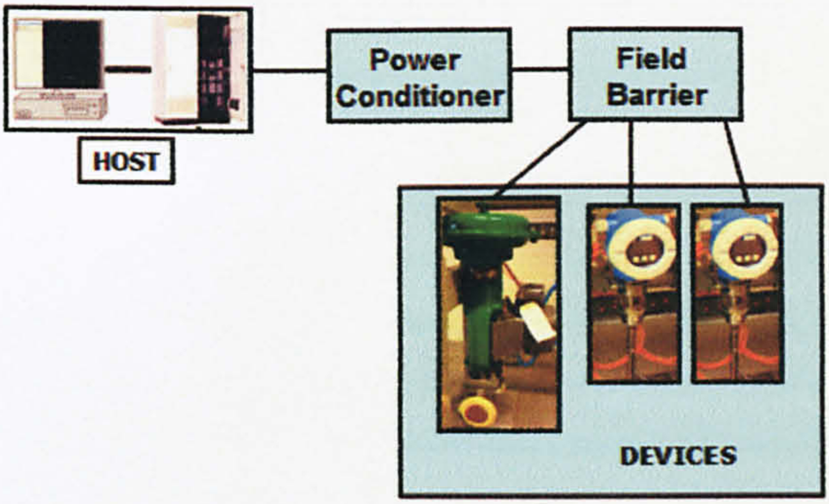

Figure 2 : Foundation Fieldbus architecture

Figure above shows the Foundation Fieldbus architecture consists of the workstation, panel, power conditioner, field barrier and the devices. This workstation or system from different host will connect to the panel which is the place for controller and the I/O Card. The type of the I/O Card used for the Foundation Fieldbus is H1 Card.

There are two type of power conditioners that will used in this Foundation Fieldbus Interoperability Test which are from two different manufacturers; MTL and Pepperl + Fuchs. The power conditioner connected to the field barrier using trunk cable. This test shall use chicken foot topology as this topology will be the standard practice in PETRONAS. For the real plant, the Foundation Fieldbus devices can be Intrinsically Safe (IS) Entity, FISCO type, FNICO type and High Power Trunk Concept.

2.4.1 Chicken Foot Topology

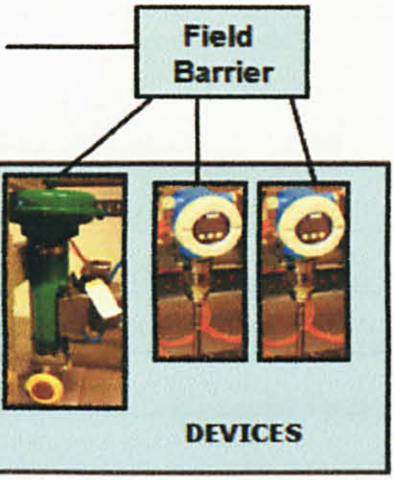

Figure 3 : Chicken Foot Topology (field barrier)

The chicken foot topology is use for this test and this topology consists of single cable connected to the devices through field barrier [15]. The maximum length of the spurs is important if using this topology [12]. The recommended maximum length for the spurs is 30m for Intrinsically Safety installation [12]. The benefit of using this topology is it is easier in assigning and configuring the devices to the network or segment [12].

2.5 Foundation Fieldbus Devices

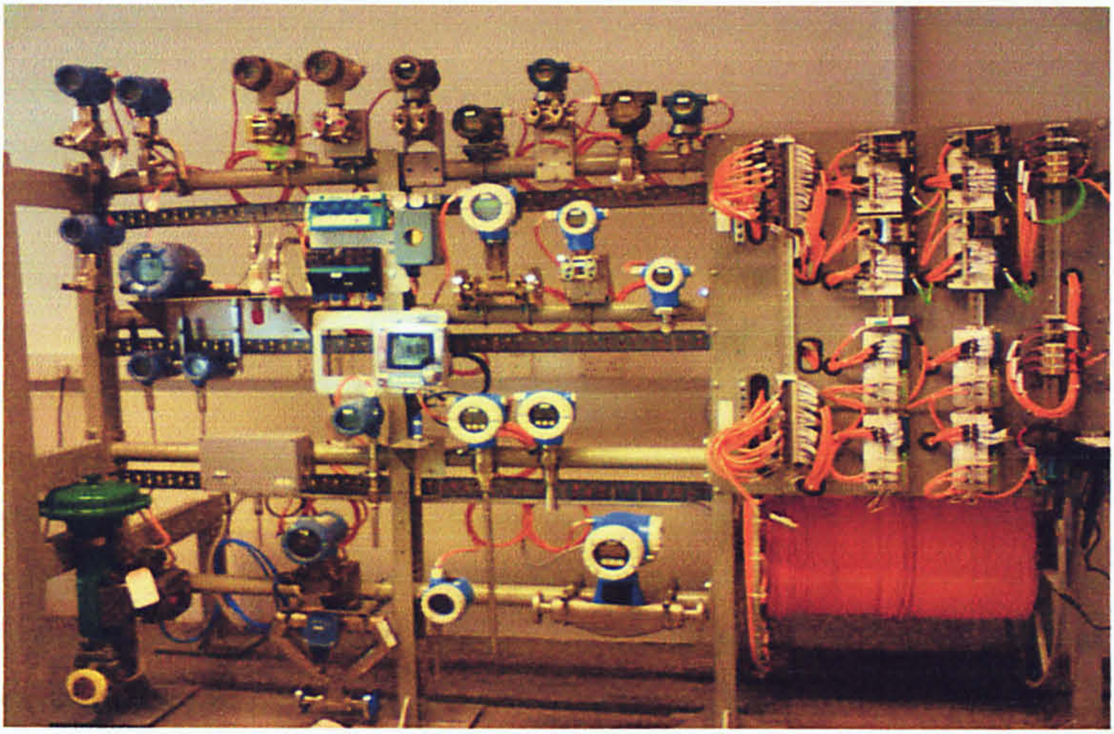

Figure 4 : Foundation Fieldbus Devices In The Laboratory Test

Figure above shows all the devices that had been installed in the laboratory test. The Foundation Fieldbus devices can have one of these type; IS Entity, FISCO, FNICO, and High Power Trunk Concept. However, all the devices in this test will be used the High Power Trunk Concept.

2.6 Intrinsically Safety (IS) Fieldbus (in Hazardous Area)

To install and design the Fieldbus devices in the explosion hazardous area, the long cable length is needed and the type of application must be taken into consideration [14]. Energy can be reducing in the hazardous area by placing the barriers between the power conditioner to devices [14].

2.6.1 Entity

The Entity is the method that used the Intrinsically Safety parameters to validate and install the devices It also need to considered the cable capacitance and inductance.
The recommended safety parameters is U_0=24V, I_0=250mA, and P_0= 1.2W for the power supplies [14]. A disadvantage of this concept is, only a few power supplies that match with the Entity. Besides that, the cost for this IS Entity is high.

2.6.2 FISCO (Fiedlbus Intrinsically Safe Concept)

It is one of the methods for validation and installation. There is only one power supply permitted per fieldbus segment and other devices are power drains [14]. FISCO is to be said the easiest method for validation and installation and allows many field instruments operate compared to Entity [14]. However, it is still not achieve the 32 possible devices as in the fieldbus standard. Besides, there is no power supply redundancy since there is only one single power supply per segment.

2.6.3 High Power Trunk Concept

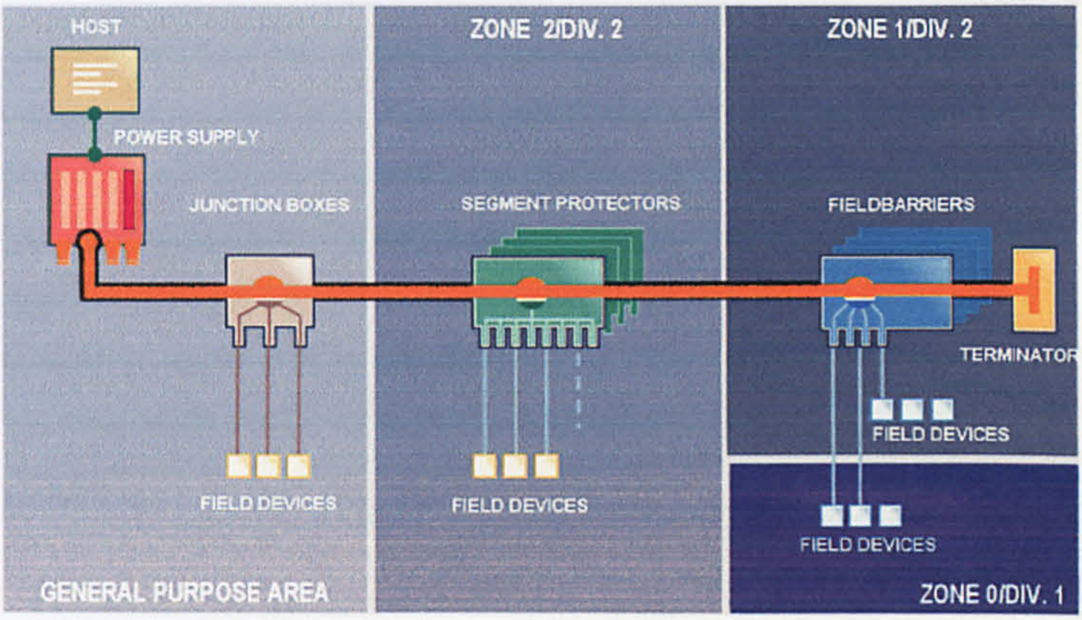

Figure 5 : High Power trunk for any hazardous area [14]

This method is the best method for validation and installation because of its low price and simpler to design. The energy's delivered on the fieldbus trunk for the High Power Trunk not limited for explosion protection close into the hazardous area . In the hazardous area, the energy-limiting wiring interfaces are used to distribute the energy to the field instrument [14]. Besides that, field barrier acts as distribution interfaces. The benefit of the high power trunk is it allows a large number of devices per segment [14].

CHAPTER 3
METHODOLOGY

3.1 Project Work Flow

The flow chart below shows the work flow to achieve the objective of the project.

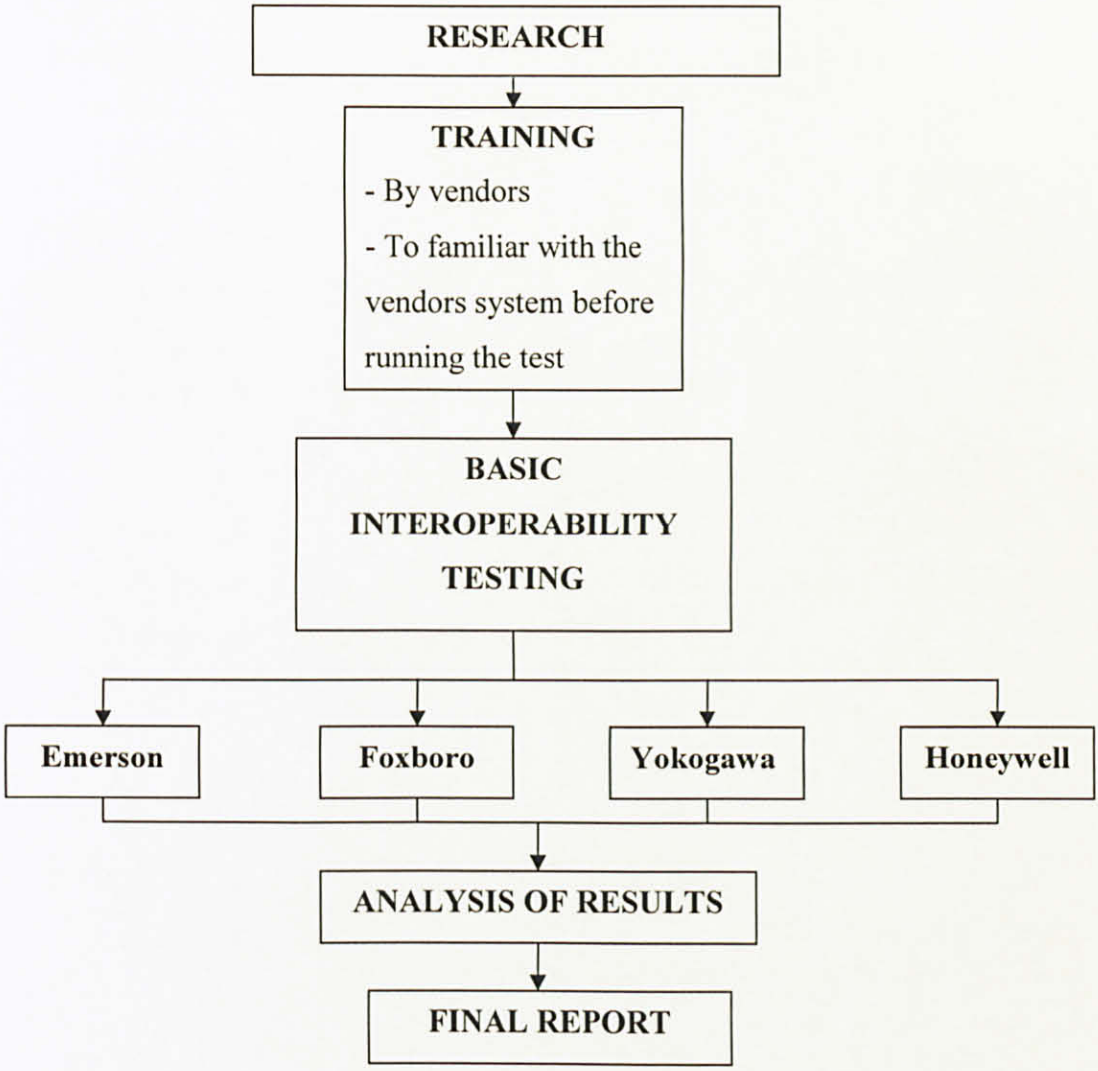

Figure 6 : Project Work Flow

Table 1 : Project Planning and Activities

ACTIVITIES\MONTH	SEPT 2008	OCT 2008	NOV 2008	DEC 2009	JAN 2009	FEB 2009
Research						
1st Vendor (Emerson) Training And Testing						
2nd Vendor (Foxboro) Training And Testing						
3rd Vendor (Yokogawa) Training And Testing						
4th Vendor (Honeywell) Training And Testing						
Analysis The Report						
Foundation Fieldbus Final Report						

Table 1 shows the planning for the project and activities that need to be done. The planning of the duration for this project is 6 month, starting from September 2008 and end on February 2009. However, due to some error, some system need to do the retest and the project planning had been delayed.

3.2 Basic Interoperability Testing for Honeywell system.

On 12 January 2009 until 14 January 2009, Honeywell had conducted the training for their system to be used for Foundation Fieldbus Interoperability Testing. Basic Interoperability Testing for Honeywell system consists of:

1) Device Commissioning
2) Device Decommissioning
3) Physical Layer Diagnostic (Drop Out Test)
4) Calibration Function Check
5) Online Device Replacement

3.2.1 Test Equipment

1) Foundation Fieldbus Emerson 375 HART Communicator
2) Workstation (Honeywell Experion system)
3) Devices from different vendor (Test Bench)

Figure 7: Emerson 375 HART Communicator

3.2.2 Procedure

Procedure for this five tests that submitted to the PETRONAS team is in Appendix A.

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 "UTPFFSystem" ,click "Connect"
1.9	Login to windows using the following username and password: *Username: mngr* *Password: mngr1* *Domain: <Traditional Operator Security>*
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	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.*
1.17	At RED colour: - Right Click at "C300_01" - Select "Checkpoint" - Select "Restore from checkpoint". - A new window will pop up. *Select the last saved checkpoint to be restored.* *Click "Restore"* *Start the controller by double click the controller "CEEC300_01".* *At "Main" tab, go to "CEE Command," and select WARMSTART.* *Click YES. Wait until all the icons in Green.*
1.18	From the "Monitoring-Assignment": - Expand "FIM4_01" - Expand "FFLINK_01" (the segment) - Check the status of the device base on the colour/ '?' sign. *RED : Already in the database but the system cannot be read* *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 turn to GREEN. - Repeat steps for other devices.
1.19	If the device unable to commission (device has two same tag ; 1 GREEN colour with '?' sign , and the other tag RED colour). **1.19.1 At "Monitoring-Assignment" (at the bottom of the window),**

	- 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) **1.19.2 At "Monitoring-Assignment",** - 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 colour device tag - Right click - Select "Force Delete" - A window will popup, click "Continue" - Click "Force Delete" - RED device will 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 **Note: Check the 'Automatically change ALL control elements to the state selected in 'Post Load State' after load is completed'* **1.19.7 Commission of the device succeeds.**

Test 2: Device Decommissioning	
2.1	From "Monitoring-Assignment", - Expand "FIM4_01" - Expand "FFLINK_01" (segment 1) - 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*
2.2	From "Monitoring-Assignment", - 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	At "Monitoring-Assignment", - Expand "FIM4_01" - 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 (device decommission successfully).

Test 3: Physical Layer Diagnostic	
3.1	Practice the device drop out testing
3.2	At the field site, disconnect a device
3.3	Open the Station window, click the "System" (at the bottom of the window in SYSTEM box)
3.4	Device alarm appear on the screen and blinking
3.5	Click "Acknowledge Page" button to acknowledge the alarm. Alarm will stop blinking.
3.6	3.6 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* - At field site, connect device - At Station window, the device alarm will be gone - At Control Builder window, the device turn to GREEN

Test 4: Calibration Function Check (Carry out calibration function from the Host, 375 communicator or iAMS)	
4.1.1	Using Host: - 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 *Note: At the bottom right of the window; Password: engr* - 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 according to the previous changes - 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
4.1.2	Using 375 Communicator: - At the field site, connect the 375 Communicator - Using the device, select "Fieldbus Application" - Select Online. **Note: The communicator will upload information on all devices connected to the segment.* - Select one device that needs to be rescaled. *Note: the communicator will take some time to upload the device* - 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". *Note: This step may be performed using other than "Quick Config" option.* - Monitor the faceplate and effect on the other devices. *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.*

Test 5: Online Device Replacement	
5.1	At "Monitoring-Assignment", select the device that needs to be replaced
5.2	Click "Field Devices" (located at top of the window) - 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
5.3	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)
5.4	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 devices connected to the segment.) - 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
5.5	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.
5.6	Click "Replace the Failed Device with the Uncommissioned Replacement Device"

5.7	"FF Device Replacement Wizard- Verifying Replacement Device" window will pop up
5.8	Click "Continue"
5.9	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 Load State" after load is completed"*
5.10	Click "Continue" and wait for the process
5.11	Click "Finish"
5.12	5.11Device turn to GREEN and been commissioned as new device.

CHAPTER 4
RESULTS AND DISCUSSIONS

4.1 Result for Basic Interoperability Testing using Honeywell system

4.1.1 Device Commissioning

Procedure for this test is in **Test 1: Device Commissioning** under **Chapter 3 (3.3.2 Procedure)**.

Table 2 : Result for Device Commissioning

Tag Name	Device Vendor	Successful Commission	Time Taken
AT 207	Rosemount	✓	1 min 20 secs
FV 205	Rosemount	✓	3 min
PDT 204	Rosemount	✓	3min 23 secs
PT 202	Rosemount	✓	4 min 57 secs
TT 203	Rosemount	✓	4 min 43 secs
TT 201	Rosemount	✓	4 min 18 secs
FT 504	Yokogawa	✓	3 min 40 secs
PDT 501	Yokogawa	✓	3 min 50 secs
PT 502	Yokogawa	✓	3 min 35 secs
TT 503	Yokogawa	✓	3 min 21 secs
TT 901	Pepperl Fuchs	✓	4 min 5 secs
VC 902	Pepperl Fuchs	✓	2 min 3 secs

Table above shows the result of the device commissioning for segment 1. All the devices successfully download without any problem. At the system, the observation had been done. Before commission the devices, there are "?" sign at the device icon in the host and the "?" sign gone when devices successfully commissioned. The purposes of this test are:

- To test how well the FF startup procedure for a completely new system.
- To investigate the user friendliness and less steps for loading wizard.

4.1.2 Device Decommissioning

Procedure for this test is in **Test 2: Device Decommissioning** under **Chapter 3 (3.3.2 Procedure)**.

Table 3 : Result for Device Decommissioning

Tag Name	Device Vendor	Successful Decommissioning	Time Taken
AT 207	Rosemount	✓	1 min 25 secs
FV 205	Rosemount	✓	1 min 11 secs
PDT 204	Rosemount	✓	2min 29 secs
PT 202	Rosemount	✓	2 min 36 secs
TT 203	Rosemount	✓	2 min 3 secs
TT 201	Rosemount	✓	4 min
FT 504	Yokogawa	✓	1 min 51 secs
PDT 501	Yokogawa	✓	2 min 12 secs
PT 502	Yokogawa	✓	1 min 44 secs
TT 503	Yokogawa	✓	3 min 15 secs
TT 901	Pepperl Fuchs	✓	1 min 59 secs
VC 902	Pepperl Fuchs	✓	<1 secs

Table above shows the result of the device decommissioning for Segment 1. All the device successfully decommissioning. After decommissioning, the devices had been commission back one by one. The time taken to decommission the device had been note down. The times to decommission the device VC 902 only take less than 1 second. This is because the device VC 902 did not have function block. After successfully decommission, the "?" sign at the device in the system will pop up.

The purposes of this test are:

- To check whether the steps to decommission the device is complex or not.
- To look up the effect on the host and other device

4.1.3 Physical Layer Diagnostic (Device Drop Out)

Procedure for this test is in **Test 3: Physical Layer Diagnostic** under **Chapter 3 (3.3.2 Procedure)**.

Table 4: Result for Physical Layer Diagnostic

Device	**Drop-out Response**
1. AT 207 (Vendor : Rosemount)	**<u>Initial condition</u>**: at the *Control Builder (monitoring)*, the device displayed in green colour. **<u>Drop-out device</u>**: - *Control Builder(monitoring)*: The device displayed in red colour. - *Station (system)*: alarm displayed with the description "Device Off-Net". **<u>Plug-In Device:</u>** - *Control Builder(monitoring)*: The device displayed turn to green. - *Station (system)*: alarm displayed gone.
2. FT 504 (Vendor : Yokogawa)	**<u>Initial condition</u>**: at the *Control Builder (monitoring)*, the device displayed in green colour. **<u>Drop-out device</u>**: - *Control Builder(monitoring)*: The device displayed in colour. - *Station (system)*: alarm displayed with the description "Device Off-Net". **<u>Plug-In Device:</u>** - *Control Builder(monitoring)*: The device displayed turn to green. - *Station (system)*: alarm displayed gone.

3. FV 205 (Vendor : Fisher)	**<u>Initial condition</u>**: at the *Control Builder (monitoring)*, the device displayed in green colour. **<u>Drop-out device</u>**: - *Control Builder(monitoring)*: The device displayed in red colour. - *Station (system)*: alarm displayed with the description "Device Off-Net". **<u>Plug-In Device:</u>** - *Control Builder(monitoring)*: The device displayed turn to green. - *Station (system)*: alarm displayed gone.
4. PDT 204 (Vendor :Rosemount)	**<u>Initial condition</u>**: at the *Control Builder (monitoring)*, the device displayed in green colour. **<u>Drop-out device</u>**: - *Control Builder(monitoring)*: The device displayed in red colour. - *Station (system)*: alarm displayed with the description "Device Off-Net". **<u>Plug-In Device:</u>** - *Control Builder(monitoring)*: The device displayed turn to green. - *Station (system)*: alarm displayed gone.
5. PDT 501 (Vendor : Yokogawa)	**<u>Initial condition</u>**: at the *Control Builder (monitoring)*, the device displayed in green colour. **<u>Drop-out device</u>**: - *Control Builder(monitoring)*: The device displayed in red colour.

	- *Station (system)*: alarm displayed with the description "Device Off-Net". **Plug-In Device:** - *Control Builder(monitoring)*: The device displayed turn to green. - *Station (system)*: alarm displayed gone.
6. PT 202 (Vendor :Rosemount)	**Initial condition**: at the *Control Builder (monitoring)*, the device displayed in green colour. **Drop-out device**: - *Control Builder(monitoring)*: The device displayed in red colour. - *Station (system)*: alarm displayed with the description "Device Off-Net". **Plug-In Device:** - *Control Builder(monitoring)*: The device displayed turn to green. - *Station (system)*: alarm displayed gone.
7.PT 502 (Vendor : Yokogawa)	**Initial condition**: at the *Control Builder (monitoring)*, the device displayed in green colour. **Drop-out device**: - *Control Builder(monitoring)*: The device displayed in red colour. - *Station (system)*: alarm displayed with the description "Device Off-Net". **Plug-In Device:** - *Control Builder (monitoring)*: The device displayed turn to green. - *Station (system)*: alarm displayed gone.

8. TT 201 (Vendor :Rosemount)	**<u>Initial condition</u>**: at the *Control Builder (monitoring)*, the device displayed in green colour. **<u>Drop-out device</u>**: - *Control Builder(monitoring)*: The device displayed in red colour. - *Station (system)*: alarm displayed with the description "Device Off-Net". **<u>Plug-In Device:</u>** - *Control Builder(monitoring)*: The device displayed turn to green. - *Station (system)*: alarm displayed gone.
9. TT 203 (Vendor :Rosemount)	**<u>Initial condition</u>**: at the *Control Builder (monitoring)*, the device displayed in green colour. **<u>Drop-out device</u>**: - *Control Builder(monitoring)*: The device displayed in red colour. - *Station (system)*: alarm displayed with the description "Device Off-Net". **<u>Plug-In Device:</u>** - *Control Builder(monitoring)*: The device displayed turn to green. - *Station (system)*: alarm displayed gone.
10. TT 503 (Vendor : Yokogawa)	**<u>Initial condition</u>**: at the *Control Builder (monitoring)*, the device displayed in green colour. **<u>Drop-out device</u>**: - *Control Builder(monitoring)*: The device displayed in red colour. - *Station (system)*: alarm displayed with the description "Device Off-Net". **<u>Plug-In Device:</u>** - *Control Builder(monitoring)*: The device displayed turn to

	green. - *Station (system)*: alarm displayed gone.
11. TT 901 (Vendor : Pepperl + Fuchs)	**Initial condition**: at the *Control Builder (monitoring)*, the device displayed in green colour. **Drop-out device**: - *Control Builder(monitoring)*: The device displayed in red colour. - *Station (system)*: alarm displayed with the description "Device Off-Net". **Plug-In Device:** - *Control Builder(monitoring)*: The device displayed turn to green. - *Station (system)*: alarm displayed gone.
12. VC 902 (Vendor : Pepperl + Fuchs)	**Initial condition**: at the *Control Builder (monitoring)*, the device displayed in green colour. **Drop-out device**: - *Control Builder(monitoring)*: The device displayed in red colour. - *Station (system)*: alarm displayed with the description "Device Off-Net". **Plug-In Device:** - *Control Builder(monitoring)*: The device displayed turn to green. - *Station (system)*: alarm displayed gone.

Table above shows the result for the physical layer diagnostic (device drop-out test). The purpose of this test is to test the two way communication from device to the host and from the host to the device. All the device successfully done and no problem occurred during the test for this segment. The purpose of this test is just to see the diagnostic feature in a system only.

4.1.4 Calibration Function Check

Table 5: Result for Calibration Function Check

Tag Name	Device Vendor	Successful Calibrate	
		Change from host	Change from field(using 375 Communicator)
AT 207	Rosemount	✓	✓
PDT 204	Rosemount	✓	✓
PT 202	Rosemount	✓	✓
TT 203	Rosemount	✓	✓
TT 201	Rosemount	✓	✓
FT 504	Yokogawa	✓	✓
PDT 501	Yokogawa	✓	✓
PT 502	Yokogawa	✓	✓
TT 503	Yokogawa	✓	✓
TT 901	Pepperl Fuchs	✓	✓

For this test, 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. When the device range for transducer scale (XD_SCALE) and output scale (OUT_SCALE) is changed at the field (using 375 communicator), the range at the host automatically changed (observe at the AI function block). The purpose of this test is:

- To test the effectiveness of the steps for calibration as per wizard available

4.1.5 Online Device Replacement

Table 6 : Result for Online Device Replacement

Tag Name	Device Vendor	Successfully Replace	Time Taken
AT 207	Rosemount	✓	4 min
FV 205	Rosemount	✓	6 min 2 secs
PDT 204	Rosemount	✓	4 min 39 secs
PT 202	Rosemount	✓	4 min 30 secs
TT 203	Rosemount	✓	9 min 18 secs
TT 201	Rosemount	✓	14 min 52secs
FT 504	Yokogawa	✓	5 min 38 secs
PDT 501	Yokogawa	✓	4 min 2 secs
PT 502	Yokogawa	✓	3 min 25 secs
TT 503	Yokogawa	✓	7 min 32 secs
TT 901	Pepperl Fuchs	✓	4 min 4 secs
VC 902	Pepperl Fuchs	✓	9 min 13 secs

Table above shows the result for the online device replacement. All the device at Segment 1 successfully replaced. From the observation, at the Control Builder (monitoring), the device displayed in red colour when the device was taken out at the field. The devices then turn back to green colour when the device had been replaced.

4.2 Discussion

Result for the training and testing for Emerson and Foxboro system is in **Appendix A**. The testing for these two systems was conducted by another team member. The Basic Interoperability Testing for Honeywell system for Segment 1 successfully done and there is no problem occurred during the test. For the Device Commissioning Test, devices that come from different manufacturers; Rosemount, Yokogawa and Pepperl Fuchs were successfully commissioned using Honeywell host. However, this test can only performed for one device at the same time. It will take a long time to finish commissioned all the devices. For the Device Decommissioning Test, the observation had been done in the system. At Control Builder (monitoring window), the '?' sign appeared next to the GREEN device. The device was completely been decommissioned. This test also can only performed for one device at the same time. The purpose of Physical Layer Diagnostic test is to test the two way communication from device to the host and from the host to the device.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

At the end of this project, PETRONAS would discover the Foundation Fieldbus technology theoretically and practically. The Foundation Fieldbus Interoperability Testing is very important for PETRONAS to get the procedure and the results to be references on Foundation Fieldbus System. The Basic Interoperability Testing for HONEYWELL system was successfully done. All the devices can interoperate with each other and the host can communicate with all devices from different manufacturers. There are many advantages of using Foundation Fieldbus system. By having interoperability testing, all the devices can follow this standard and the products from different manufacturer are possible to interoperate or work with each other. The end user also can have a choice in choosing devices from different manufacturers. The research for the Foundation Fieldbus should continuously perform to improve the system from time to time. Besides, the analysis of result and reports should be done properly because it will use for a future research.

5.2 Recommendation

Basic Interoperability Testing consists of system from different suppliers; Honeywell, Yokogawa, Emerson and Foxboro. These four suppliers had conducted training to the PETRONAS team and UTP's team. However, the training did not cover all the project scope. Thus, the team that had been attached to perform the tests will face a problem in handling the system. Suppliers should give detail training about their system. Personnel from suppliers also should join the testing to assist the team in using the system.

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APPENDIX A

10.1.7 Expand "Physical Network" (Add figure).

10.1.8 Expand "Control Network".

10.1.9 Expand "CTRL1".

10.1.10 Expand "I/O".

10.1.11 Expand "CO2".

10.1.12 Right click at "P01" (Note: Port 1 of H1 card). Select "Download" and click "Fieldbus Port".

10.1.13 Establish the communication with fieldbus devices (initial download).

10.1.13.1 A pop-up "Confirm Partial Download" will appear. Select 'Yes' to confirm.

10.1.13.2 Two new pop-ups will appear. At "Select Additional Objects to Download", click "Check All" to check all objects. Click 'OK'.

10.1.13.3 Repeat step 10.1.16 to download Port 2 (P02).

10.1.14 Perform individual device download in the following manner if step cannot be establish.

10.1.14.1 Right click at selected device under "P01".

10.1.14.2 Select "Download".

10.1.14.3 Click "Fieldbus Device".

10.1.14.4 A pop-up "Confirm Partial Download" will appear. Select *'Yes' to confirm.*

10.1.14.5 At "Select Additional Objects To Download", click "Check All" to check all objects. Click 'OK'.

10.1.14.6 Repeat steps for other devices.

10.1.15 View through the Host HMI and record response of the host for each fieldbus device.

10.1.15.1 At "DeltaV Operate (Run)", click "Overview" icon.

10.1.15.2 Call-up faceplate of each device.

10.1.15.3 Call-up faceplate of each device.

10.1.15.4 Faceplate will appear. Acknowledge alarm, if any.

10.1.15.5 If alarm clears, then device has been commissioned successfully.

APPENDIX B

1. Result For Training and Testing using Emerson System

On 3rd and 4th September 2008, Emerson had conducted the training about their system which is DeltaV. DeltaV is one of the Emerson products for the Distributed Control System. The DeltaV System can divided into two; DeltaV Hardware and DeltaV Software. DeltaV Software consists of DeltaV Operate and DeltaV Explorer. DeltaV Operate in run mode is used for the operator to view and operate the process while the configure mode is used to create and edit the DeltaV graphic.

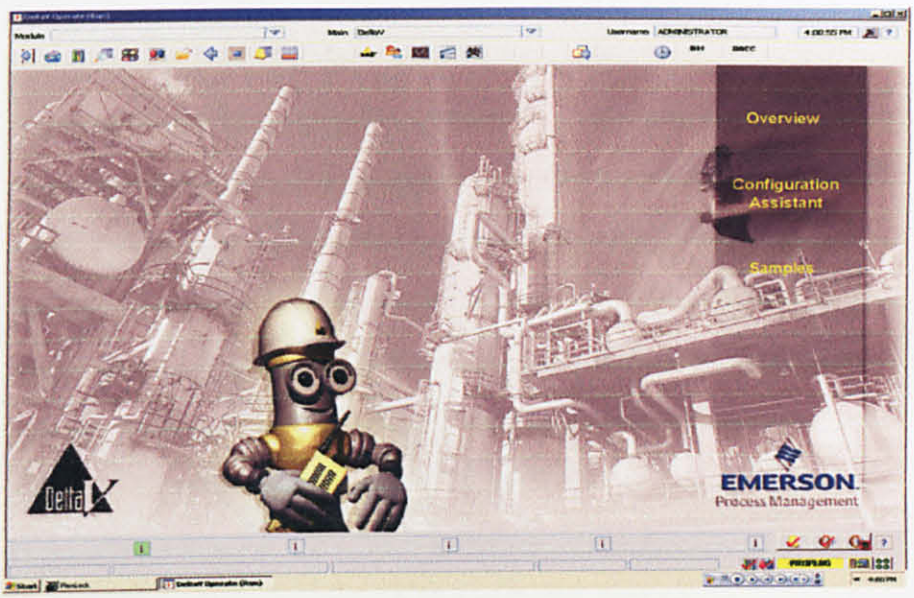

Figure 1 : DeltaV Operate (in run mode)

DeltaV Explorer consists of plant area and control module. Control module is placed under the plant area and assigned to the correct controller. It consists of the algorithms that define the control system behavior. To do the maintenance for the controller, the controller needs to decommission first before it can take out from the panel. Faceplate is the popup picture that contains the graphics and controls necessary to perform normal control. It can control and monitored the I/O point at the Terminal Block in the panel from this faceplate. Figure below show one example of the faceplate.

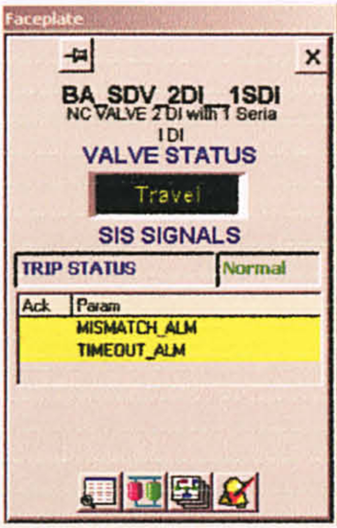

Figure 2 : Faceplate

There are 28 devices need to be test. However, for this Basic Interoperability Testing for the first vendor, Emerson, only 23 devices are used. 5 devices can not be tested because Emerson did not provide fully license.

Device Commissioning Test

Table 1 : Result for Device Commissioning Test

No	Device Name	Full Download	Partial Download	Time Taken(minute)
1	TT201	✓	None	2.12
2	PDT 204	✓		
3	FV 205	✓		
4	PDT 501	✓		
5	PT 502	✓		
6	TT 503	✓		
7	TT 901	✓		
8	VC 902	✓		
9	FT 504	✓		

The purpose for this test is for the device maintenance and to check how well the Foundation Fieldbus startup procedure of a completely new system works. This test can used fully download or partial download. Fully download is for downloaded all the devices at the same time while partial download is for downloaded the devices one by one. By using partial download, the test will takes time to finish it. The time taken for the fully download is 2.12 minutes.

Device Decommissioning Test

Table 2 : Result for Device Decommissioning Test

No	Device Name	Address	Offline Address	Standby Address	Time Taken (minute)
1	TT201	22	248	233	<1
2	PDT 204	25	250	241	<1
3	FV 205	26	251	240	<1
4	PDT 501	30	249	236	>12
5	PT 502	31	Nil	234	>12
6	TT 503	32	Nil	234	<1
7	TT 901	34	248	237	<1
8	VC 902	35	249	239	<1
9	FT 504	33	nil	238	>12

The purpose for the device decommissioning test is same with the device commissioning test. Before can do the decommissioning, the device need to offline first, then put it under standby mode. However, after offline 4 devices, the 5^{th} device will take an infinite delay to offline. To overcome this problem, one of the 4 offline devices need to put under standby mode, then can continue to decommission. This system can only have 4 devices for offline at one time.

Table 3 : Result for Online Device Replacement

No	Device Name	Time	Time Taken(minute)	Successful	Other Affected	Note
1	TT 201	9.51-10.00	49	✓	No	
2	PDT 204	10.02-10.08	6	✓	No	PT 202 display in the box
3	FV 205	10.09-10.13	4	✓	No	
4	PDT 501	10.23-10.29	6	✓	No	Tag name display PDT 502
5	PT 502	10.14-10.21	7	✓	No	Tag name display PT 501
6	TT 503	10.30-10.34	4	✓	No	
7	TT 901	10.35-10.39	4	✓	No	
8	VC 902	10.40-10.43	3	✓	No	
9	FT 504	10.44-10.48	4	✓	No	

This online device replacement test tested the effect of the new device that been introduced to Foundation Fieldbus system. The response between host and devices had been observed. There are some error had been detected during this test. When PDT 204 is taken out and put it back, PT 202 displayed in the box instead of PDT 204. PDT 501 and PDT 502 tag name at the host system is different from the devices. This problem is from the vendor itself. The address of the host is different from the address of the devices

Physical Layer Standard

Table 4 : Result for Physical Layer Diagnostic

Tag Name	Current (mA)									
	2 Terminator		3 Terminator		4 Terminator		5 Terminator		6 Terminator	
	High	Low	High	Low	High	Low	High	Low	High	Low
TT201	439	332	312	244	234	186	186	146	146	107
PDT204	722	508	488	381	361	303	293	234	234	195
FV205	713	508	508	391	391	303	303	244	225	176
PDT501	654	478	439	332	332	284	254	205	205	166
PT502	605	459	439	342	293	234	225	186	186	146
TT503	625	469	449	352	303	244	234	186	186	156
TT901	644	478	459	352	342	264	244	195	186	186
VC902	654	478	478	361	352	283	283	215	205	166
FT504	635	478	459	352	342	264	244	195	195	156

Table above shows the result of the physical layer diagnostic test. The purpose of this test is to check the voltage drop if there more than two terminators. The condition of the Foundation Fieldbus is, it needs to have at least two terminator. From the result, the current is reduced when more terminator connected to the segment.

Calibration Function Check

This test is to observe the changing at the range of the devices and the faceplate at the host. There are two linearization types of the devices which are direct and indirect. For the direct devices, the XD_SCALE need to have the same range with the OUT_SCALE. The XD_SCALE is the range at the devices and OUT_SCALE is the range at the faceplate. For indirect linearization type, the XD_SCALE range should be different with the range at OUT_SCALE.

Online Parameter Download

The purpose of this test is to make sure all the devices can be downloaded successfully from the system/host and can read the parameter changes. The observation had done when the calibration function check had conducted. After make a change in XD_SCALE and OUT_SCALE, the control module of the devices need to download. All the devices had successfully downloaded and the changes successfully detected.

2. Result for Training and Testing using Foxboro System

On 20th, 21st, 22nd of October, Foxboro had conducted the training about their system which is IACC or IA Series System. During the training, the familiarization of the IACC system is done. The remaining 5 devices did not have fully license from vendor. In this system, Foxview is the mode for the operator to view and operate the process while the Foxdraw is for editing and create the graphic. During the training, the trainees need to create one graphic using the IACC software. Figure below shows the result of the graphic that had been created during the training.

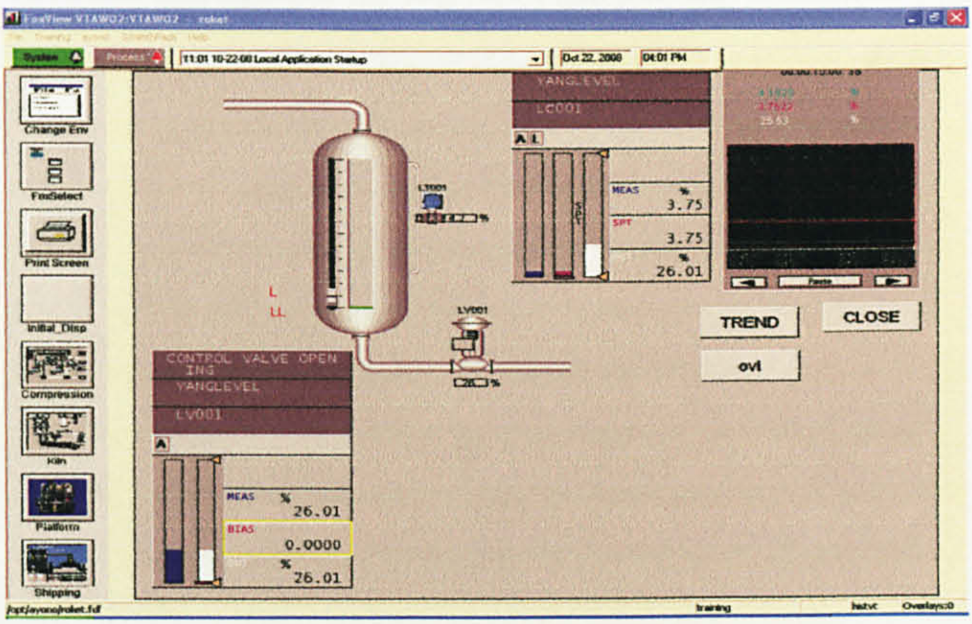

Figure 10 : Result from the Foxboro training