FOUNDATION FIELDBUS INTEROPERABILITY TEST, SYSTEM CONFIGURATION AND LOOP DESIGN OF FLOW, PRESSURE AND TEMPERATURE PLANT (EMERSON DELTAV)

Ayuni Yazib[1], Nordin Saad[2]

[1] *Electrical and Electronic Engineering*
Universiti Teknologi PETRONAS
Bandar Seri Iskandar, 31750 Tronoh, Perak Darul Ridzuan, Malaysia
Tel: +6019-9523052, E-mail: yuni86@gmail.com

[2] *Electrical and Electronic Engineering*
Universiti Teknologi PETRONAS
Bandar Seri Iskandar, 31750 Tronoh, Perak Darul Ridzuan, Malaysia
Tel: + 605-3687835, E-mail: nordiss@petronas.com.my

Abstract

This project, FOUNDATION Fieldbus Interoperability Test, System Configuration and Loop Design (Emerson) is to perform the technical verification and interoperability of every FOUNDATION Fieldbus host and devices. The hosts involves in this project are Emerson, Yokogawa, Foxboro and Honeywell. This project is collaboration with PETRONAS SKG14. The current issue in the control system industry is the interoperability of the FOUNDATION Fieldbus among the vendors. In other words, the devices with different system can not communicate to each other. FOUNDATION Fieldbus is interoperable; however, the manufacturer must meet the standard in order to achieve the interoperability. The stress test and Diagnostic test will be carried out to test on the interoperability of the devices among these four hosts. From the basic test done, FOUNDATION Fieldbus is user friendly and can be operated by non-communication expert such as operator. This project architecture is divided to two segments which is Segment 1 and Segment 2. This report is focusing on Segment 2 only. The Stress test and Diagnostic test can not be performed due to the delay from PETRONAS SKG 14. As a result, the basic test is important to understand the system before proceeding with Stress test and Diagnostic test.

Keywords:

FOUNDATION Fieldbus, Emerson DeltaV, interoperability

Introduction

Fieldbus is a digital, serial and bi-directional communication protocol. It interconnects devices such as actuators, sensors, discrete devices with the controllers in the field. It enables basic control and I/O to be moved to the field devices and control can be executed by the smart device itself. This can be done by FF technology using the function blocks, Device Descriptions (DD) and Capability File (CF). Function blocks reside in the FOUNDATION Fieldbus devices contain information needed for online control function in the field.

FOUNDATION Fieldbus architecture

FOUNDATION Fieldbus allows multiple types of instruments connected to one single cable, called a **segment**. This segment carried digital signal for communication and DC power. Maximum length of this segment is 1900m per segment. The calculation of the maximum length of segment is as in the Figure 2. This one segment can connects up to 32 FOUNDATION Fieldbus devices but in practice only twelve to sixteen devices only in use due to the current limiting couplers. **Spur** is a branch line from the segment that used to distribute the devices along the segment and also act as final circuit. The maximum length can be up to 120m. **Terminator** is placed at each end of the segment that functions to prevent the distortion and signal loss due to the reflection of the signal and to obtain the voltage mode signal on the segment. The architecture of FOUNDATION Fieldbus can be laid out in three **topologies** which are bus with spur, daisy chain and tree. In this project, the topology used is tree. Below is the FOUNDATION Fieldbus architecture for this project.

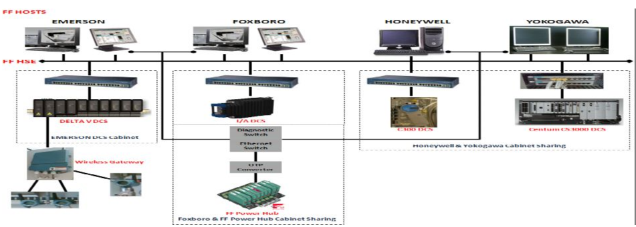

Figure 1: FOUNDATION Fieldbus Network Architecture

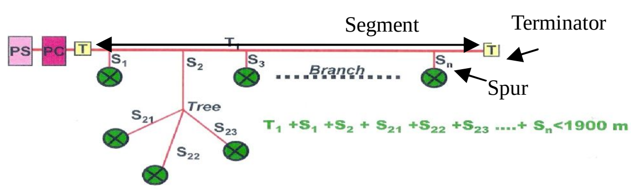

Figure 2: Segment, spur, topology and terminator

H1 physical layer

The H1 physical layer was based on the OSI model as in Figure 3. **Physical layer** is a layer to provide connection to communication media. **Communication layer** used the concept of non-collision based communication protocol that uses LAS to synchronize the digital communication signals on a FOUNDATION Fieldbus segment. **User layer** level is where the data formats and semantics are defined that allow the devices to execute the data and perform the control.

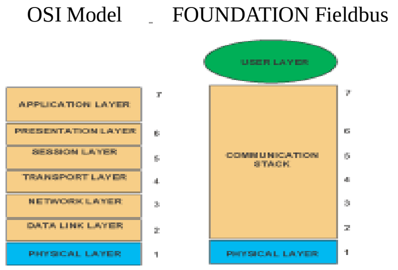

Figure 3: H1 physical layer

Methodology

This project consists of two parts which are the Basic test and control loop design.

Basic test

Basic test consists of six subtests which are:

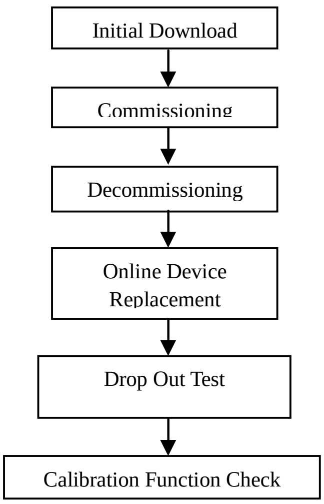

Figure 4: Flowchart of Basic Test

The initial download can be done either by segment (port) or partially at the device. In this test, the device that cannot be downloaded via segment is downloaded partially.

Commissioning done by dragging the device from the 'Decommission Fieldbus Device' to the device tag name and complete the commission wizard.

Decommission can be done by right click the device and select 'Decommission' and select 'Take Offline'. Select the device under the 'decommission Fieldbus Device', right click and select 'Place In Standby'.

Online device replacement can be done by removing the device cable from the fully functioning system and right click at the selected device and select 'Replace'. Then the process will proceed with decommissioning. Then, reattach the device and proceed with the commissioning device.

Drop out test procedure is similar to the online device replacement test. However, in this test, the time taken for the alarm of each device is recorded.

Calibration function check test is done by using host (workstation) and 375 Field Communicator. The upper and lower limit of XD_SCALE and OUT_SCALE of each device were change and the response is recorded.

Control loop design

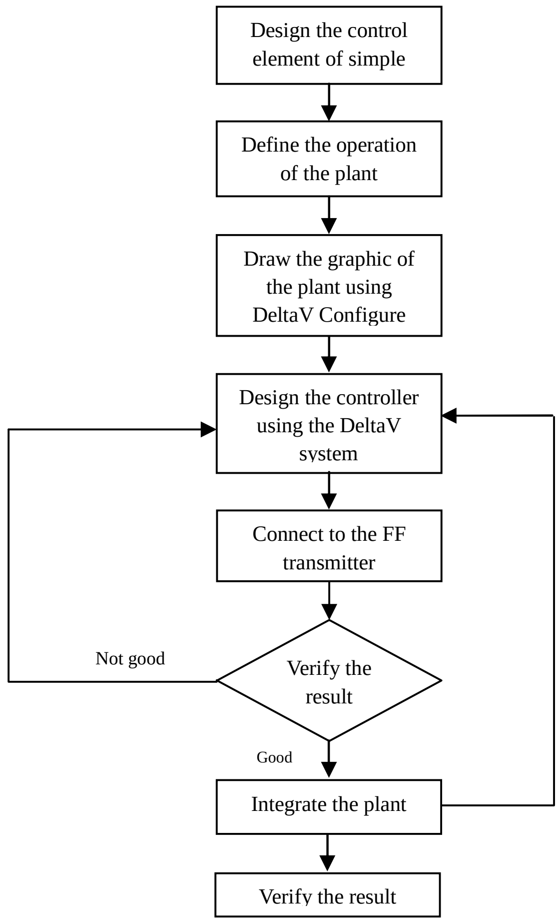

Figure 5: Flowchart of Control Loop Design

In designing the control loop, the flow chart in Figure 5 shows that first is to design the control element for a simple plant such as the flow, pressure and temperature. The operation of the plant is defined after determining those control elements. Next is to draw the graphic of the plant design using the DeltaV Configure and proceed with the controller design using DeltaV system. The testing of the plant would be done by downloading the controller (software) design to the hardware (FF transmitter). The result would be verified and if the FF transmitter did not function according to the simulation, then the logic of controller need to be checked. If the hardware and software did communicate well, the test will be proceeded to integrate the plant to make it looping. The procedure is repeated as in Figure 5.

Tools and Devices

The software used is DeltaV system that has features such as:

- DeltaV Configure mode
- DeltaV Run
- DeltaV Explorer
- DeltaV Diagnostic
- DeltaV Control Studio

The hardware used in this project are as below:

- 375 Handheld Communicator

Table 1: list of devices in Segment 2

No.	Descriptions	Device Name
1	FOXBORO Intelligent Electronic D/P Cell Transmitter	FT101
2	FOXBORO Intelligent Positioner (Intrinsically Safe)	FV102
3	E&H Guided Wave Radar Level Transmitter	LT301
4	E&H Radar Level Transmitter	LT302
5	E&H Pressure Transmitter	PT303
6	E&H Differential Pressure Transmitter	PDT304
7	E&H pH Analyser	AT305
8	E&H Prowirl Vortex Flowmeter	FT306
9	E&H Promass Coriolis Mass Flowmeter	FT307
10	E&H Temperature Transmitter	TT308
11	HONEYWELL Temperature Transmitter RTD Sensor with Thermowell	TT401
12	HONEYWELL Pressure Transmitter	PT402
13	HONEYWELL Differential Pressure Transmitter	PDT403

Result

The result of this project consists of two parts which are the Basic test and control loop design.

Basic test

The initial download test result shows that all devices can be downloaded either through segment or partial download except for FT307 and MTLADM1. The time taken for initial download is approximately 10.53 minutes. Besides that, there are several devices that their alarm can not be acknowledged.

All devices can be commission except for FT 307 and MTLADM1. The time taken for each device to commission is about 1.13 minutes and the full download take about 13 minutes while the partial download of each device take times of 2 minutes in average. After commissioning, all the device tag in the DeltaV Operate is green.

The device that cannot be commission which is FT 307also can not be decommissioning. The time taken for each device to decommission is about 1.25 minutes. As the device being decommissioned, the device tag in the graphic is changed to yellow.

All the devices in Segment 2 can be replace online. After removing the cable from the terminal block, the tag in the graphic must changed to yellow first before clicking for replace or else the device cannot be replace. There are two alarms that need to be acknowledged in this test which are Module Alarm (Red) and Communication Alarm (Yellow).

In the drop out test, all the alarm of each device can be acknowledged with the difference time taken. However there are certain device alarms that still appear but not blinking even after acknowledged. While the PDT 403 was being taken out, the alarm of TT 308 appear to be blinking.

All the devices can be calibrated using the host but not all device can be calibrated using the 375 Communicator.

Control loop design

Based on the P&ID in Figure 6, the graphic of Flow, Pressure and Temperature plant as in Figure 7 was drawn using the DeltaV Operate Configure. This plant is going to be control by developing the control system using DeltaV and will be connected to the device provided in the lab. The devices that will be used are Pressure Transmitter, Temperature Transmitter, Flow Transmitter and valve as stated in the P&ID.

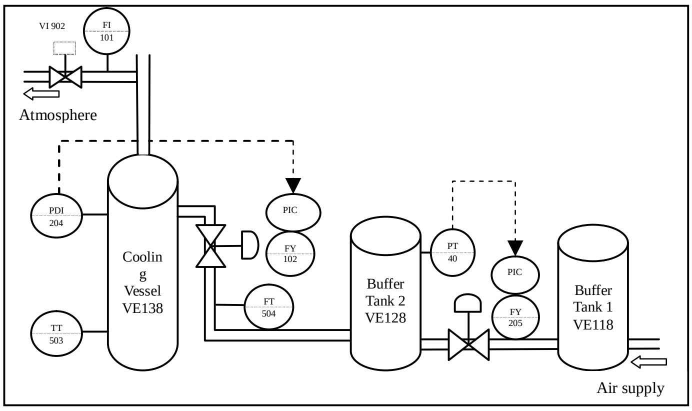

Figure 6: Flow, Pressure and Temperature plant P&ID

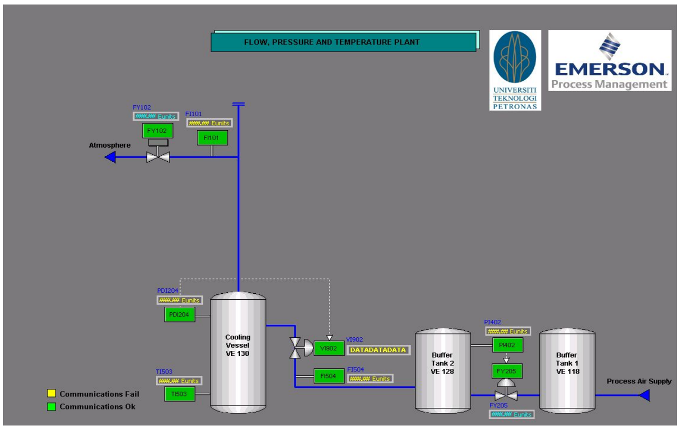

Figure 7: Flow, Pressure and Temperature plant in DeltaV Operate Configure

Discussion

The discussion of the result obtained via the project is consists of two parts which are the Basic test and control loop design

Basic test

This test was done on 12 devices from Segment 2. However, there are some devices in the segment are failed to be tested due to the DD file constraint and there are also some devices are not attached to the segment.

FT 307 cannot be downloaded because it is detached from the segment while MTL is a power conditioner that did not need to be downloaded but it required a channel for its power device diagnostic feature. The alarm can not be acknowledged because the system is already detected the online device but the device itself was not updated with this information. The initial download needs to be performed every time host being switched as to register the device to the selected system.

Commissioning was performed to make sure that all devices is functioning and can be recognized by the host. In this test, all the devices can be fully commission and download either by segment or partial download. Download must be performed for the device to communicate with the host. The time taken for the device to commission is considered short indicates that all the devices are in good condition. Furthermore, all the device tag is green in the DeltaV Operate indicates that the commissioning is successful and the devices can be recognized by the host. No devices being interrupt during the commissioning. It means that commissioning device can be done during the fully functioning system.

Decommission is performed when to remove the device either for maintenance or to change the corrupted device. In this test, all the devices can be fully decommission. The time taken can be considered as short and in normal condition as it less than 2 minutes. Placing the decommission device on standby mode is necessary before the device can go online. The device decommissioning can also de done during the fully functioning system because it does not disturb other devices in the segment.

Online device replacement test is to prove that the device can be removed online and after reattach to the segment and completing the commission, the device can function well. The device might be replaced because of the corruption of old device or maintenance. However, the new device must have the same DD file as the old one. In this test, as the device tag in the graphic change to yellow, the device is removed. Since all the alarm can be acknowledged, all the devices being replaced can be recognized by the host after completing the wizard. The replacement also not interrupts the whole process and other devices in the segment.

The drop out device in this test shows that the failure of one device in the segment is not affecting the segment performance or other device. The alarm appears to inform the user of the disconnected device. The alarm will be normalized after reattach the device to the segment. The alarm appear but it is not blinking is because the alarm had been normalized but the condition of the device is not back to normal yet. While replacing the device, the other alarm device appears because of while removing the cable, the hand might touch the other loose device cable and alarm appears.

The calibration function check is used to change the output range of the device. This test proved that the output range can be change via host at Control Studio and 375 Field Communicator at the field. Any changes done to the device is automatically detected by the system. During the test, there are some of the devices cannot be calibrated via 375 Field Communicator because of their DD files were not loaded or updated by the vendor in the 375 communicator. Thus the data cannot be retrieving from the device.

Control loop design

The plant obtained in Figure 7 is not a loop control. A simple plant is design to be controlled first. After succeeding with the simple design, then the plant will be integrated to be loop. The logic to the devices has been taken from the logic of FFIT. The main idea is to create the logic, but due to the limitation of privilege and hardware that is in terms of the termination, the logic cannot be created.

Plant Operation

The plant in Figure 7 consists of two buffer tanks, VE 118 and VE 128 that functioned to supply regulated, compressed air to the cooling vessel, VE 138. As more the air supplied entering the VE128, the pressure inside the vessel will be increase. In order to ensure safety, the compressed air will be controlled by using the valve, FY205. The air from the source will be supplied through the VE 118 to the VE 128. The PT402 at VE 128 will measure the pressure inside the tank and the signal will be sent to the controller. If the pressure measured is over the high limit, the signal will be sent to the valve to decrease the opening in order to maintain the pressure within the specified range. This operation is also goes to the controller at the FY102 which is to maintain the pressure inside the cooling vessel VE 138.

In order to ensure safety, which is one of the control objectives, the flow of the output will be controlled. The flow transmitter, FI101 will measure the flow rate of the compressed air and sent the signal to the controller, FIC. If the flow measured by the FI101 is less than the low limit, the controller, FIC will sent the pneumatic signal to the valve, VI902 to increase the opening so that the compressed air can be flown out to the atmosphere. Figure 7 shows the graphic of the plant that had been drawn using DeltaV Configure and Figure 8 is the graphic in DeltaV Run mode that going to be used by the operator in monitoring the running of the plant. For example, the Analog Input of TT503 will show the display of the temperature in the VE138 and if it is over the low or high limit, the block will be blinking in red color. The set point can be set at the faceplate of the device.

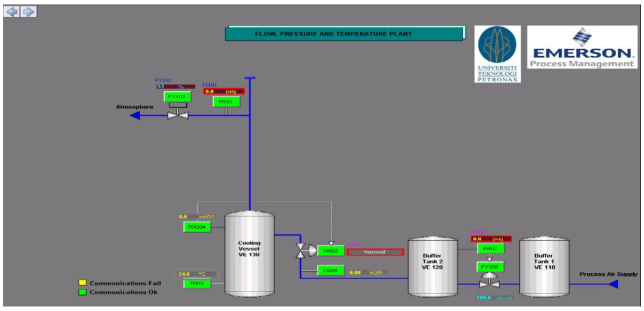

Figure 8: Flow, Pressure and Temperature plant in DeltaV Operate Run

Conclusion

This project was aimed to do research on the FOUNDATION Fieldbus interoperability in collaboration with PETRONAS SKG14. In running the project, the basic test managed to give better understanding on the FOUNDATION Fieldbus system, it characteristics as well as its communication system. However, the interoperability limitation of the FOUNDATION Fieldbus still can not be solved because the project can not be proceeding with stress test and diagnostic test due to the delay from the PETRONAS SKG14. The design of a Flow, Pressure and Temperature plant was done but there are some limitation occurs in terms of privilege and hardware. The outcome of this project will be used as a resource for developing standards and guidelines for implementation in PETRONAS Groupwide.

Recommendation

This project can be expanded and obtained an efficient result with some recommendation as below:

1. The enhancement of scheduling, so that the delay in performing the test would not be too long.
2. Provide one team of the UTP student to in charge or cooperate in doing the testing rather than the FYP students.
3. Provide more training in terms of hardware rather than only software, so that the research on this project can be done efficiently by the students.

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