FOUNDATION FIELDBUS INTEROPERABILITY TESTING
(YOKOGAWA & SMAR)

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ELECTRICAL & ELECTRONICS ENGINEERING
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by

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CERTIFICATION OF APPROVAL

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Muhammad Bin Kamarul Baharin

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TRONOH, PERAK

June 2010

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.

Muhammad bin Kamarul Baharin

ABSTRACT

Fieldbus is a bi-directional, fully digital and multidrop communications network used in process industry to link instrument between field devices and also the control system. FOUNDATION Fieldbus can be flexibly used in process automation applications. The potential of using fieldbus network is that, more information can be communicated on a single cable, communication speed can be increased and the overall cost of installation and wiring can relatively be reduced. The current scenario on the FOUNDATION Fieldbus is that, there are many vendors developing the technology but with no standard operating procedures. The intention is to replace the existing conventional 4 – 20mA analogue control system with fieldbus technology. Hence the main objective of this project is to ensure that different types of hosts could support different types of fieldbus devices by performing interoperability testing of FOUNDATION Fieldbus. The testing are aligned with FFT SKG 14th team project from PETRONAS GTS (PETRONAS Group of Technology Solution) which includes three types of testing namely, the basic interoperability test, stress test and diagnostic test. However, the scope of this project is to perform basic interoperability test using Yokogawa system as a host. This work also covers a comparison study with another different host (SMAR) for this basic interoperability test. Results and findings of the project in the end will be documented. Eventually, the documentation will be utilised as a guideline for PETRONAS Link Companies.

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LIST OF ABBREVIATIONS

AI	Analogue Input
CNF	Connection Failure
DCS	Distributed Control System
DD	Device Description
DP	Decentralized Philosophy
EWS	Engineering Work Station
FF	Foundation Fieldbus
FFIT	Foundation Fieldbus Interoperability Testing
FMS	Factory Management System
HMI	Human Machine Interface
HART	Highway Addressable Remote Transmitter
HSE	High Speed Ethernet
IEC	International Electrotechnical Commission
IOP	Input open
ISA	Instrument Society of America
ISP	Interoperable System Project
LAN	Local Area network
LAS	Link Active Scheduler
OOS	Out of services
OSI	Open System Interconnection
PA	Process Automation
PGTS	PETRONAS Group of Technology Solution
PLC	Programmable Logic Controller
PRM	Plant Resource Manager
TCP	Transmission Control Protocol
IP	Internet Protocol

CHAPTER 1
INTRODUCTION

1.1 Background of Study

In the early stages of process control, many DCS in plants use 3 – 5 psi pneumatic signals and 4 – 20 mA analogue control system which is the conventional method. Currently, research and testing on fieldbus are been conducted to slowly replace the existing conventional technology [1]. Fieldbus is a bi-directional, fully digital communication network that enables the connection of multiple field instruments or devices, processes and operator stations [2].

The capability of a device from different manufacturers to interact and communicate between each other without Host interaction is called interoperability. Industrial process plants nowadays use various kinds of instrument devices from different manufacturers and sometimes need to communicate with different control system host [3]. Thus fieldbus is implemented to overcome the problems and slowly replacing the existing technology.

1.2 Problem Statement

Normal practice in the industry is where the control system connects field devices and the controller via long cables to the control room, entering marshalling rack, controller and finally the Human Machine Interface (HMI). This leads to high usage of cables as well as not practical maintenance purposes. At the same time current scenario on the FOUNDATION Fieldbus, there are many vendors developing on the technology but with no standard procedures for implementations. Furthermore, it is an open and integrated architecture, thus problems such as the followings might occur:

i. Different vendors could have different interpretations of the FOUNDATION Fieldbus specifications due to the freedom to implement its own functions and features and too many protocols and devices from different vendors.
ii. Different types of field devices may not communicate well with the system(s) due to limitations and constraints.

With the implementation of fieldbus technology, it enables the instrument devices to be connected to each other as well as control system hosts from different manufacturers to interact and communicate on the fieldbus network.

1.3 Objectives and Scope of Studies

The objectives of the interoperability testing of FOUNDATION Fieldbus project are:

i. To verify different type of hosts that could support different type of fieldbus devices manufactured by different type of vendors.
ii. To perform interoperability testing of FOUNDATION Fieldbus focusing on basic test using Yokogawa and SMAR systems.
iii. To perform a comparison analysis between both hosts.

The scope of this project is to focus on two hosts, the Yokogawa using CENTUM CS3000 as its software and the SMAR using SYSCON as its software.

1.4 Significance of project

The interaction between field devices and hosts needs further research and testing (Interoperability Testing) before it can be implemented. Thus, the project is an effort from PETRONAS GTS and UTP to contribute in developing its own standard of procedures from different system vendors (Yokogawa, Honeywell, Emerson and Foxboro) in running and implementing this new technology especially for PETRONAS Link Companies around the world. In addition, this project aims to provide knowledge and act as a training documents for future learners from UTP also PETRONAS staffs.

CHAPTER 2
LITERATURE REVIEW

2.1 History of Fieldbus

Fieldbus technology initially started during 1970s with the first attempt to distribute control functionalities to the field level instead of centralizing it in one location. In the 1980s, considerable effort went into developing a digital communication standard for field devices. The members of the ISA's SP50 committee spent years defining technical requirements and building consensus for a digital fieldbus leading to process control suppliers started working on their own proprietary digital communication standards.

In late 1994, two suppliers' consortiums – the InterOperable Systems Project (ISP) and WorldFIP North America merged to form the Fieldbus Foundation. Foundation technology was created to replace incompatible networks and systems with an open, fully integrated architecture for information integration and distributing real-time control across the enterprise. The followings are some of the milestones achieved:

i. Completion of the preliminary specifications draft of H1 May 1995
ii. Demonstration of H1 technology at Monsanto Chocolate Bayou, October 1996
iii. Registration of the first H1 fieldbus products, September 1998
iv. Completion of High Speed Ethernet (HSE) draft preliminary specifications, September 1999
v. Registration of the first HSE linking devices, May 2001
vi. Demonstration of HSE and Flexible Function Blocks (FFBs) at ISP Lima, May 2005

vii. Completion of SIF protocol specifications, 2005

viii. Demonstration of SIF Technology at Shell Global Solutions, Amsterdam, May 2008

Beginning in May 2006, the Fieldbus Foundation and NAMUR, an international user association for automation technology in the process industries, collaborated on enhancing the Fieldbus technology. Considering the NAMUR NE107 (Self Monitoring and Diagnosis of Field Devices) recommendations for diagnostic profiles support, the Fieldbus Foundation developed a profile specification enhancing organization and integration of device diagnostics within FOUNDATION Fieldbus systems [4].

2.2 Overview of FOUNDATION Fieldbus

Fieldbus network system is now expending in the industry. There are several methods to modify and upgrade an existing plant using the conventional technology to fieldbus technology. First is the conventional wiring can either be modified into a bus line and second is to replace it with a shielded bus cable, if required. The essential objectives in fieldbus technology are to reduce installation costs and ease commissioning work. In addition, the technology is also able to simplify planning as well as improving the operating reliability of the system due to additional performance features [4].

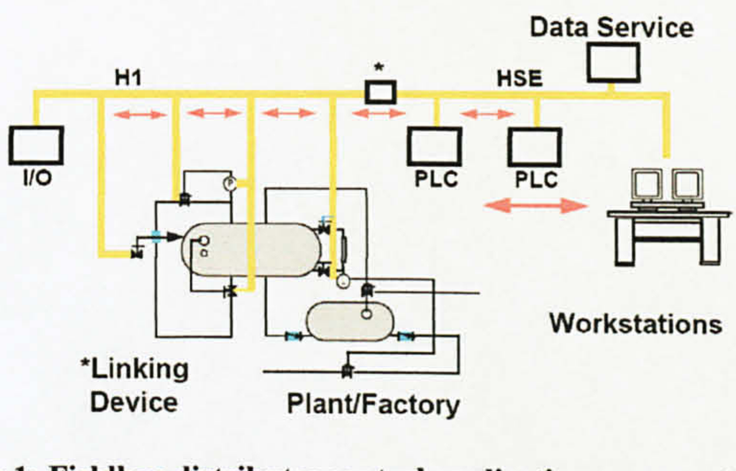

Figure 1: Fieldbus distributes control application across network[5]

FOUNDATION Fieldbus is an open system. It is also an integrated total architecture for information integration. FOUNDATION Fieldbus is an all-digital, serial, two-way communication system. It can carry a lot of information and the speed of information rate transfer is fast. H1 (31.25 kbit/s) interconnects "field" equipment such as sensors, actuators and input and output card (I/O).

HSE (100 Mbit/s) (High Speed Ethernet) provides integration of high speed controllers (such as PLCs), H1 subsystems (via a linking device), data servers and workstations. FOUNDATION Fieldbus is the only protocol with the built-in capability to distribute the control application across the network (Figure 1). Examples of subsystems are burner management, shut down systems, compressor control tank farms etc. the 'linking device brings data from one or H1 fieldbus networks directly onto the HSE backbone [5].

2.3 FOUNDATION Fieldbus Communication Layer

Figure 2 shows a comparison between both communication layer for Open Systems Interconnect (OSI) Model and Fieldbus Model. These layers explain the communication protocol for the model to communicate information.

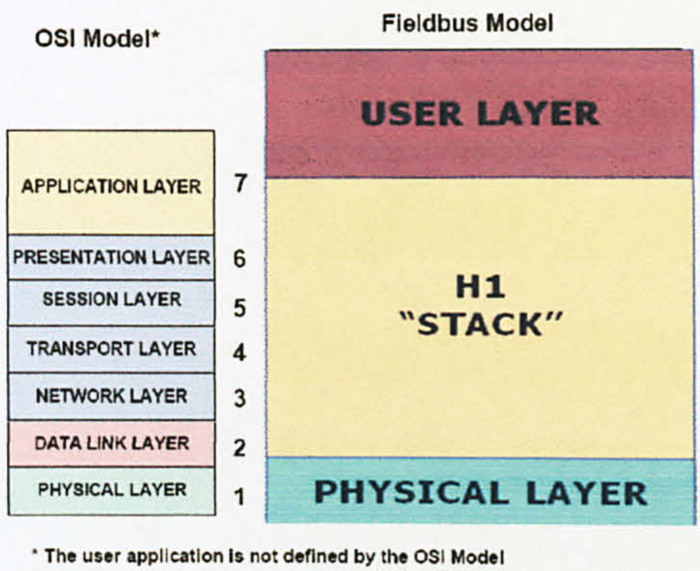

Figure 2: OSI Model compared to Fieldbus Model [5]

The Open Systems Interconnect (OSI) layered communication model is used to model these components (Figure 2). The Physical Layer is OSI layer 1. The Data Link Layer (DLL) is OSI layer 2. The Fieldbus Message Specification (FMS) is OSI layer 7. The Communication Stack comprises of layers 2 and 7 in the OSI model. The fieldbus does not use OSI layers 3, 4, 5 and 6. The Fieldbus Access Sublayer (FAS) maps the FMS onto the DLL.

The User Application is not defined by the OSI model. The FOUNDATION Fieldbus specifies a User Application model, significantly differentiating it from other models. Each layer in the communication system is responsible for a portion of the message that is transmitted on the fieldbus [5].

FOUNDATION Fieldbus H1 technology consists of:

i. *Physical Layer* – basically this layer converts messages into physical signals, requires certified physical devices approved by IEC and ISA standard such as for the trunk cable, power conditioner and field barrier.
ii. *Communication/H1 "Stack,"* – controls Acyclic communications where it communicates non-control data Cyclic communications, communicates function block data and also coordinates function block execution across the bus. H1 Stack also supports client/server model (unscheduled Request/Response), publisher/subscriber model (scheduled Data Acquisition) and Event Notification (Unscheduled Multicast).
iii. *User Application Layer* – is configured to achieve the desired functional control strategy where it consists of the following features:
    a. Standard Function Blocks: Gives consistent definition of data for integrated & seamless distribution of functions in field devices from different suppliers
    b. System Management: Deterministic scheduling of Function Blocks

c. Device Descriptions (DD): Allows the host system to operate the device without custom programming which is the 'key to interoperability'

d. Common file Format: Allows the host system to configure the system off line

2.4 Fieldbus Topology

There are four commonly used fieldbus topologies, namely point-to-point topology, bus with spurs topology, daisy chain topology and tree topology. These topologies are used depending on the plant situations and conditions.

2.4.1 Point to point topology

Point-to-Point Topology (Figure 3) consists of a network having 2 devices where it could be in the plant (e.g. transmitter and a pump with no connection between both) or it could be a field device connected to a host (for monitoring and control). Simple point-to-point (host and one device per bus segment) is not usually used as it has only one measurement OR control device per segment (as in 4 – 20 mA). As a result it does not take advantage of the multi-device-per-bus-segment capability.

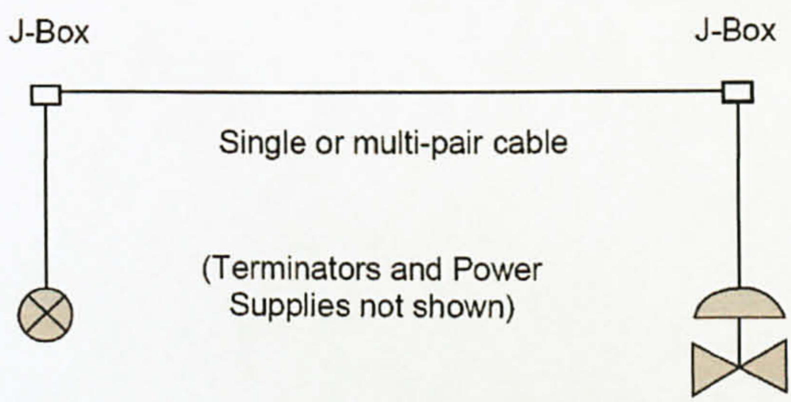

Figure 3: Point to point Topology [6]

2.4.2 Bus with spurs topology

Bus with spurs topology (Figure 4) uses a single bus to connect between devices and spurs directly or in other word it is connected to a multi-drop bus segment through a length of cable called spur. More than one device can be connected to each spur. Each technology is technically acceptable but not generally a good economic choice. Bus with spur topology should be used in new installation areas that have low density of devices.

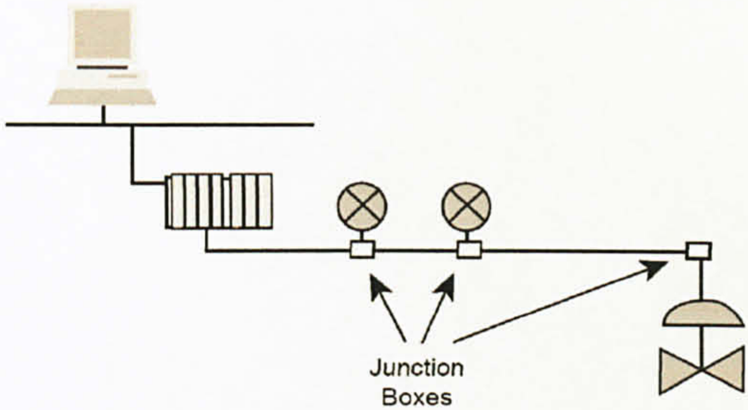

Figure 4: Bus with Spurs Topology [6]

2.4.3 Daisy-Chain topology

Daisy-chain topology (Figure 5) consists of a segment/network that is routed from device to device where it is connected to terminals of the fieldbus device. This topology is impractical due to its maintenance complexity.

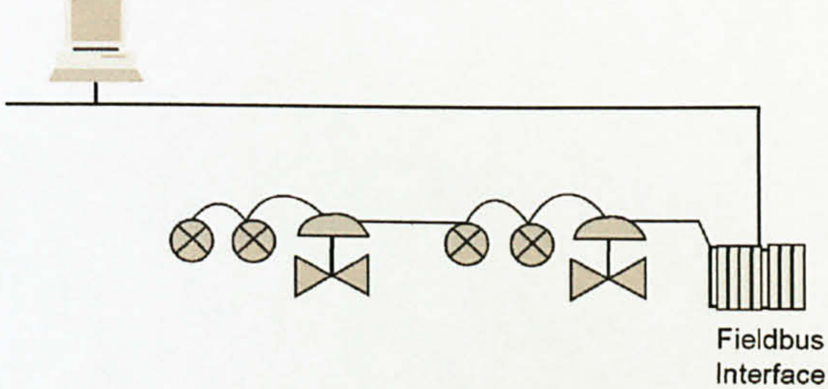

Figure 5: Daisy Chain Topology [6]

2.4.4 *Tree topology*

This tree topology (Figure 6) consists of a fieldbus segment connected to a common junction box to form a network. Practically it can be used at the end of the cable. It is more practical if the devices on the same segment are separated well from the junction box. It is also practical to be implemented if the devices on the same segment are well separated but in general area of the junction box, the maximum spur lengths must be considered.

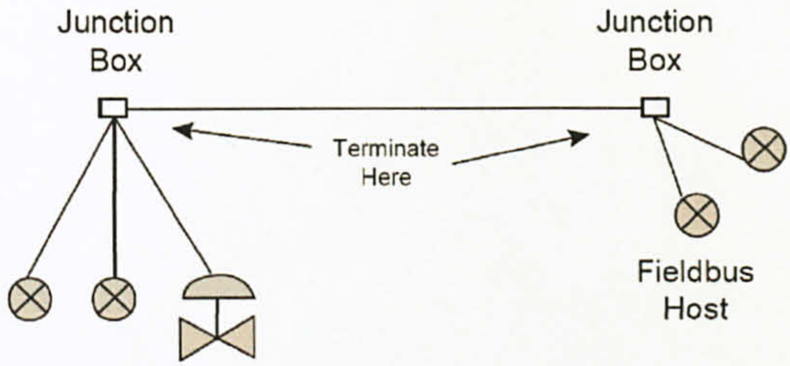

Figure 6: Tree Topology [6]

2.5 How Fieldbus Works

Instruments in analogue control systems produce 4 – 20 mA output signals that travel from the remote distillation column, tank or process unit to the control room, marshalling rack, remote I/O concentrator or RTU over twisted pair cables. Similarly, 4 – 20 mA control signals travel from the control system to valve actuators, pumps and other control devices. Hundreds, sometimes thousands, of cables snake their way through cable trays, termination racks, cabinets, enclosures and conduit (Figure 7).

Figure 7: Traditional 4 – 20mA field wiring [7]

The availability of low cost, powerful processors suitable for field instrumentation now opens the way to remove the bulk of these cables at the same time increase data rate transfer from the plant.

Instead of running individual cables, fieldbus also allows multiple instruments to use single cable, called "trunk" or "segment," (Figure 8); each instrument connects to the cable as a "drop". However these instruments require relevant software and interface for segment connectivity in order for them to provide fieldbus communication capabilities.

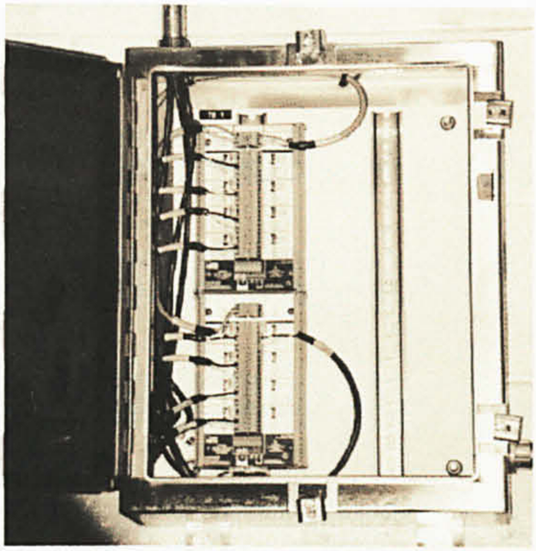

Figure 8: Fieldbus installation substantially simplifies wiring [7]

Figure 8 shows a fieldbus trunk or segment (either FOUNDATION Fieldbus H1 or PROFIBUS PA). It is single twisted pair wire that can carry both digital signals and DC power. This fieldbus trunk or segment that can connect up to 32 fieldbus devices (temperature, flow, level and pressure transmitters, smart valves, actuators, etc.) to a DCS or similar control system. Most of these devices are 2-wire bus-powered units requiring 10 to 20mA. However for high current draw applications, 4-wire fieldbus devices are preferable.

The fieldbus segment begins at an interface device at the control system. For FOUNDATION Fieldbus H1 (FF) system, the interface is called H1 card, for PROFIBUS PA system (PA), it is called PROFIBUS DP/PA segment coupler. In terms of signal wiring and power requirements for the segment, FF and PA are identical have following specification:

i. Minimum device operating voltage of 9V.
ii. Maximum bus voltage of 32V.
iii. Maximum cable length of 1900m (shielded twisted pair).

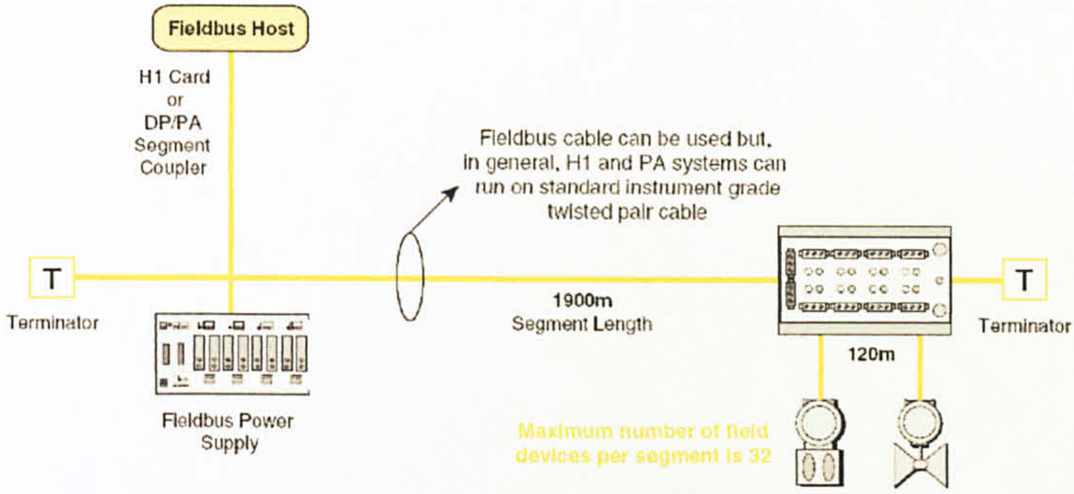

Figure 9: Typical Fieldbus segment and its operation [7]

Figure 9 shows a typical fieldbus segment. Its DC power are required by the bus is normally sourced through the fieldbus power supply or "power conditioner". This prevents high frequency communications signal from being short circuited by the DC voltage regulators. However typical power conditioners that have a range of 350 to 500 mA usually incorporate isolation to prevent segment-to-segment cross talk. Correspondingly for PAs, their "segment coupler" usually incorporates power conditioning components. However for FF segments, their power conditioners are separate from H1 interface card and are often installed in redundant pairs to improve the overall reliability.

When calculating the number of devices that can fit on a fieldbus segment, a user must take into account the maximum current requirement of each device and the length of the segment (because of voltage drops along the cable). The calculation is a simple Ohm's law problem, with the aim of showing that at least 9V can be delivered at the farthest end of the segment, after taking into account all the voltage drops from the total segment current. For example, driving 16 devices at 20 mA each requires 320 mA, so if the segment is based on 18AWG cable (50 Ohms/km/loop) with a 25V power conditioner, the maximum cable length is 1000m to guarantee 9V at the end connection. Note that many users also specify an appropriate safety margin on top of the 9V minimum operating voltage, to allow for unexpected current loads and adding additional devices [7].

2.6 Advantages and Disadvantages

Fieldbus like any other technology also have advantages and disadvantages where both should be looked into for further improvements to ensure the reliability for it to be installed in the plant.

Some of the advantages of using fieldbus are as follows [8].

i. It provides information to the host about their operational condition.
ii. The calibration of the devices can be performed remotely.
iii. The regulatory control is interchangeable between host system and the field devices.

The followings are some of disadvantages of installing fieldbus:

i. For existing plants, installation of fieldbus may lead to a mixture of analogue and digital signals.
ii. Advance tools are required for this advance technology such as laptops with appropriate diagnostic software's which are costly.

2.7 New Developments

2.7.1 Fieldbus safety

Fieldbus system is relatively safe. It allows users to use specific function blocks to create safety logic controls within the system. It also ensures accuracy of timing and efficiency of data transmission as well as integrity of communication between devices. This allows users to uses the developed safety blocks when unnecessary shut down occurs. Conversely for most other busses, 'black channel' models are used. This however requires the user to developed communication protocols from scratch which could introduce unforeseen trivial mistakes that could lead to unforeseen circumstances [9].

2.7.2 Electronic Device Description Language (EDDL)

Electronic Device Description Language (EDDL) is the base technology for FOUNDATION Fieldbus protocols by defining a significant part of their User Layer. Unfortunately it has limitations where the original EDDL contains little support for the graphics leading to the interface. This also limits the degree of integrations between the field devices and the host. However the level of integration and information that could be presented to the user varies between each installation depending on the host used. To overcome these limitations, EDDL is used by FDT/DTM (Field Device Tool/Device Type Manager) because it allows the user to explore or develop their own new specific function blocks. Hence, allows the user to 'look and feel' the device information for other than the Process Variables (PV) and relate signals, such as those used to configure and calibrate the device [9].

2.8 Interoperability

Interoperability is the central theme of Fieldbus. It authorizes users to "mix and match" between field devices and host system from the different vendors and manufacturers while maintaining specific operations. The ability to operate multiple devices, independent of manufacturer, in the same system, without loss of minimum functionality is called interoperability. Also the system is able to work together with field devices [10].

Interoperability allows users to design, build and maintain Fieldbus system easily by transferring data in standard format among the system builder and device vendors. Various tools are needed for Fieldbus to communicate and transfer data. One of these tools, is DD (Device Description) is a technology that allows interoperability to be achieved effectively. The interoperability of these tools that are used for Fieldbus engineering can be accomplished by using value files. For example, if there is an off-line configuration tool and downloader or an uploader that can understand the value files, any such tools can be used. Interoperability can also be realized by keeping the external interface provided as the value files, even if the tools are developed by different vendors [11].

CHAPTER 3
METHODOLOGY

3.1 Procedure Identification

Figure 10 shows the methodology used to execute this project and Appendix F shows the whole project Gantt chart for FYP 1 and 2.

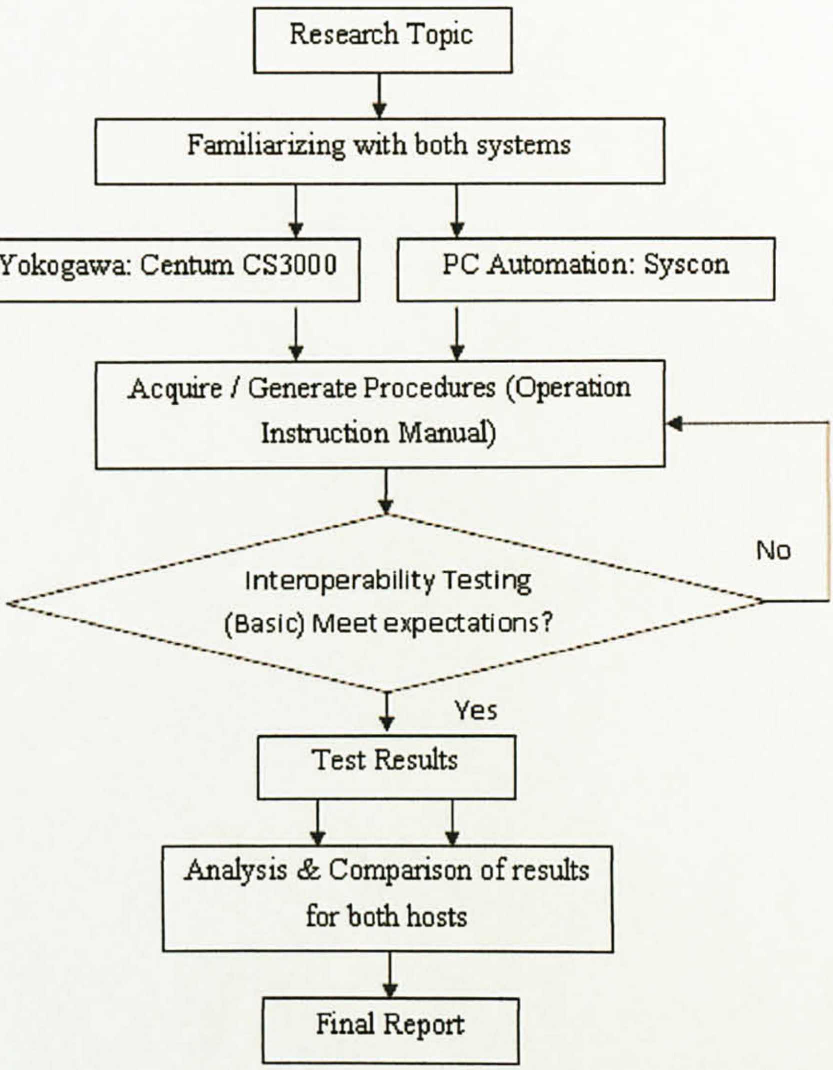

Figure 10: Project Flow Chart

3.2 YOKOGAWA Basic Test

There are several sub tests under the basic interoperability testing for YOKOGAWA system [12].

3.2.1 Initial Download

Initial download needs to be performed every time when host changing is carried out. This is to ensure that all devices are properly recognized by the new host loaded with the identified host configuration and are also updated with current data.

3.2.2 Device Decommissioning

The test aims to note the proper method of putting device in offline mode i.e. detaching the device from the segment. The tester has to ensure that the host does not scan the detached device as error.

3.2.3 Device Commissioning

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

3.2.4 Online Device Replacement

The test aims to develop the steps required to perform online device replacement. For Basic Test, the scope only covers for similar device replacement i.e. the same device is used as the replacement.

3.2.5 Drop Out Test

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

3.2.6 Calibration Function Check

Calibration function check basically testing how online parameter download is performed on the device. For this basic test purpose, the parameter download is limited to change of device range using host, 375 Field Communicator and iAMS (Instrument Asset Management System).

3.3 SMAR Basic Test

There are several tests to be performed under basic test for SMAR system.

3.3.1 Initial Download

First part of the testing is to initialize the communication of network. These are procedures to be followed. First is to click the 'On-line' button on the main toolbar to initialize the communication. A video clip below the 'On-line' button should appear for a few seconds. During this time, ***Syscon*** identifies and associates any bridge and fieldbus channels from the configuration to the real plant. ***Syscon*** indicates the bridges and devices included in the project configuration are not associated to the physical equipments, or whether a device is not communicating properly to the network [13].

3.3.2 Device Commissioning and Decommissioning (assigning tag Number for each device)

This part of the test performs online device commissioning and decommissioning. Basically, it disconnects the device from the network, reconnect it and assign automatically a tag number for the specific device. The procedures are explained in the following paragraph.

At the Fieldbus Window, Right click to each of the devices and select Assign Tag. This allows the system to assign the connected devices to the system to be registered or assign a tag name for the specific device. In average, it takes about less than 1 minute for each device to be assigned while after that, it needs to be normalized in order for the device to be commissioned back [13].

3.3.3 Drop Out Test

This is a test carried out to check whether a field device has communication failure or is in disconnection mode. Since, this involves tremendous amount of calculations, a workstation is used to expedite the required results. Field devices are disconnected physically from the network by disconnecting the power supply cable at the device. Firstly, the field device has to be physically disconnected from the network. To do this, the cable inside the transmitter has to be loosened like for transmitter, it was done by opening its rear cover. This automatically cuts the power supply. Then, the display at workstation showing communication failure or disconnection mode is observed.

3.4 Analysis and Comparison

Even though there is a comparison for both hosts, this project does not conduct the test based on equality of the same field devices. For both hosts, they have a different set of testing setup. Thus the project performed analysis and comparison for both hosts based on the testing concept and general features of host display. Analysis and comparison are done mostly on the following aspects:

- Basic test and time response of the test
- User friendly

3.5 Tools and Equipment Required

The testing uses the following tools:

- Yokogawa system, Centum CS3000
- Foundation Fieldbus Interoperability Testing Facilities, UTP
- SMAR system, SYSCON
- Pilot Plant 3, Plant Process Control Laboratory, UTP
- 375 Field Communicator
- FBT-6 Fieldbus Monitor

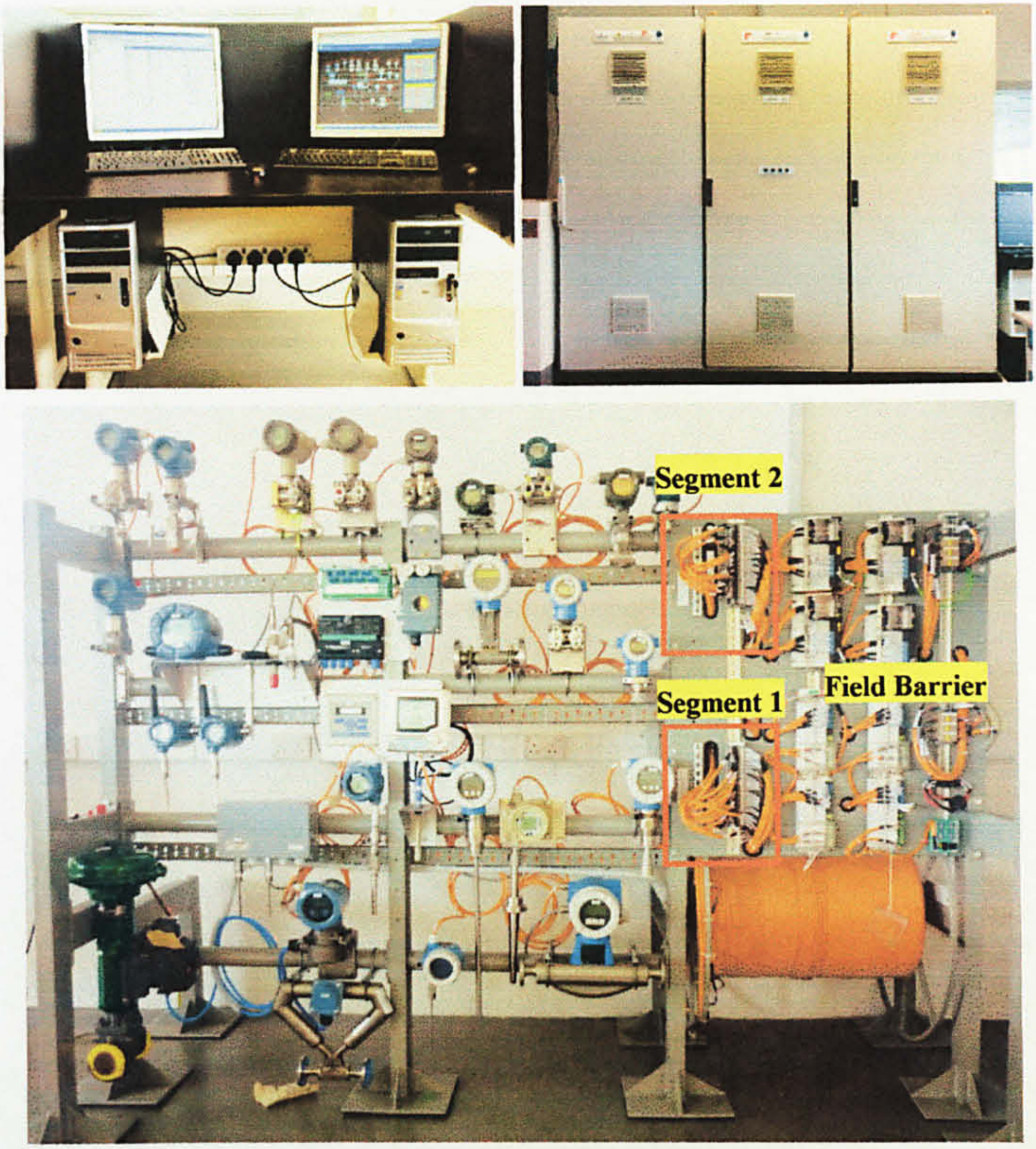

Figure 11: Foundation Fieldbus Training Facilities (Yokogawa Workstation, Marshalling Cabinet, Field Devices)

Figure 11 shows the Foundation Fieldbus Training Facilities consisting of the work station, marshalling cabinet containing the host and power supply conditioner and the testing rig. The field devices are installed at the testing rig consisting of various types of transmitters (level, pressure, temperature and flow), ph analyzer and actuator.

The right part of Figure 11 shows two segments of the network, segment 1 and 2. The following Tables 1 and 2 shows the list of devices in segment 1 and 2 together with the vendors' name.

Table 1: List of devices in Segment 1

	DEVICETAG	ADDRESS	MANUFACTURER
1	TT201	22	ROSEMOUNT
2	PT202	23	ROSEMOUNT
3	TT203	24	ROSEMOUNT
4	PDT204	25	ROSEMOUNT
5	FV205	26	FISHER
6	FT206	27	MICRO MOTION
7	AT207	28	ROSEMOUNT
8	AT208	29	ROSEMOUNT
9	PDT501	30	YOKOGAWA
10	PT502	31	YOKOGAWA
11	TT503	32	YOKOGAWA
12	TT901	34	Pepperl and Fuchs (P+F)
13	VC902	35	Pepperl and Fuchs (P+F)
14	FT504	33	YOKOGAWA

Table 2: List of devices in Segment 2

	DEVICE TAG	ADDRESS	MANUFACTURER
1	LT301	22	E+H
2	LT302	23	E+H
3	PT303	24	E+H
4	PDT304	25	E+H
5	AT305	26	E+H
6	FT306	27	E+H
7	FT307	28	E+H
9	TT308	29	E+H
8	TT401	30	HONEYWELL
10	PT402	31	HONEYWELL
11	PDT403	32	HONEYWELL
12	FT101	33	FOXBORO
13	FV102	34	FOXBORO
14	MTLADM1	35	MTL

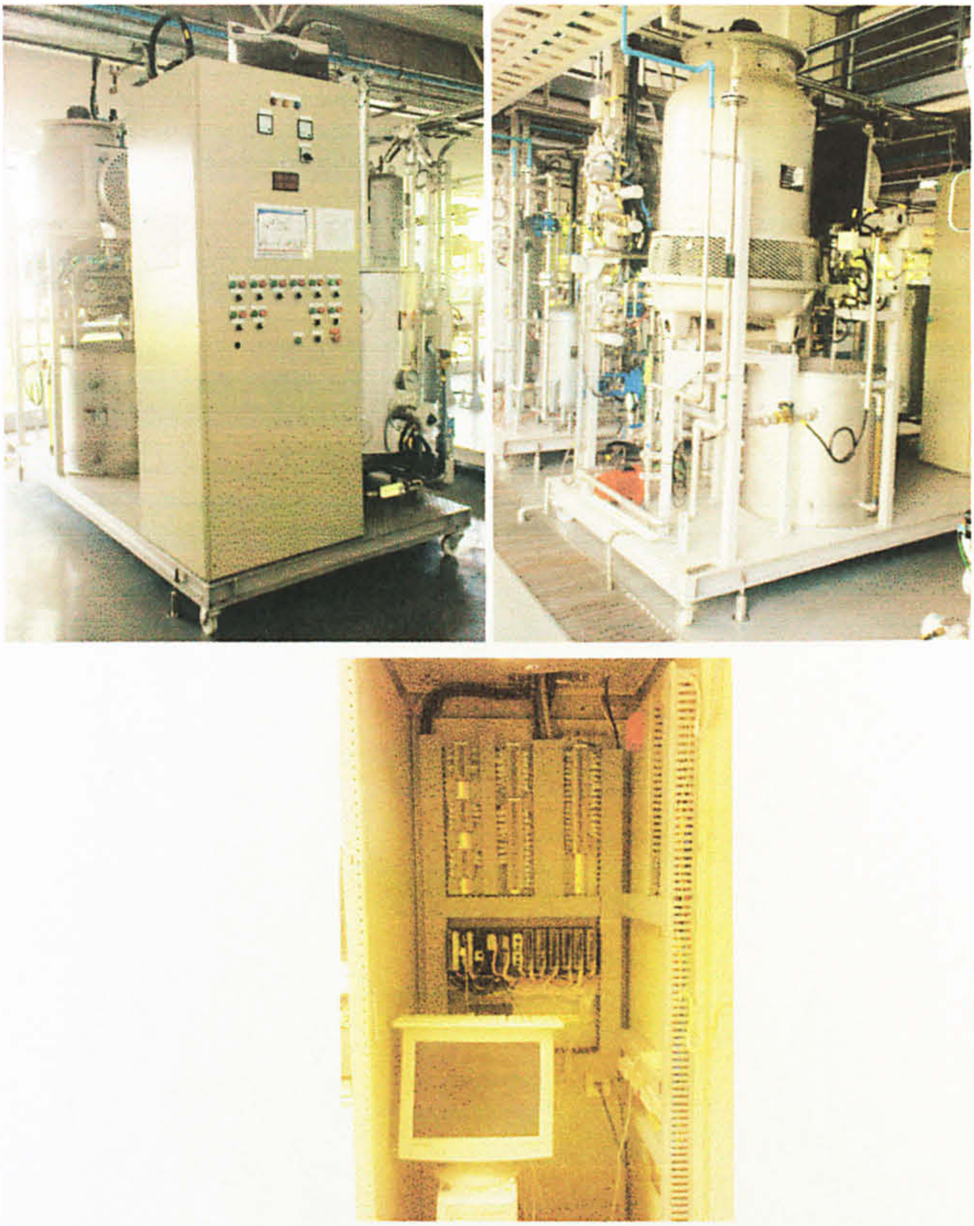

Figure 12: Pilot Plant 3 in Plant Process Control System Laboratory

Figure 12 shows Pilot Plant 3 located in Plant Process Control System Laboratory consists the actual live plant, the host and work station. Pilot Plant 3 consists of 2 segments. Table 3 shows segment Fieldbus 3 and Table 4 shows segment Fieldbus 4.

Table 3: List of Devices in Segment Fieldbus 3

	DEVICE TAG	ADDRESS	MANUFACTURER
1	LT-362	Error	SMAR
2	PT-322	0x18	SMAR

Table 4: List of Devices in Segment Fieldbus 4

	DEVICE TAG	ADDRESS	MANUFACTURER
1	LT-322	0x1B	SMAR
2	TT-331 / TT-332	0x1C	SMAR
3	TT-333 / TT-334	0x1D	SMAR
4	FT-331	0x19	SMAR
5	FY-331	0x20	SMAR
6	FT-364	0x18	SMAR
7	FY-364	0x21	SMAR
8	FT-323	0x1E	SMAR
9	FY-323	0x1A	SMAR

CHAPTER 4
RESULTS AND DISCUSSION

This chapter discusses basic test results for Yokogawa System, basic test results for SMAR System, problems and challenges encountered in this project.

4.1 Basic test for Yokogawa System

4.1.1 Initial Download

The testing rig in the Foundation Fieldbus Laboratory is connected to all hosts (Yokogawa, Emerson, Honeywell and Foxboro). Appendix A shows a simplified diagram of the system connection in the Foundation Fieldbus Laboratory and the switching hosts. Only one host can be used at a time for a specific segment. However, it could only control the system for a particular segment at a time.

Thus, initial download need to be performed each time when there are changes of host. This is to ensure that all devices are recognized and online for communication by the new host, loaded with identified host configuration and updated with current data. Both segments 1 and 2 are switched to YOKOGAWA host at selection switch. Segment 1 initial download takes 50 minutes while segment 2 takes 45 minutes. The time taken for initial download depends on the number of devices in each segment. Appendix B shows the result status after the initial download and equalization on each device.

However, some of these devices still have the equalization symbol even after the equalization process has already been done. This is because there is a mismatch in the block structure. Figures 13 and 14 show the graphics before and after initial download for Yokogawa system.

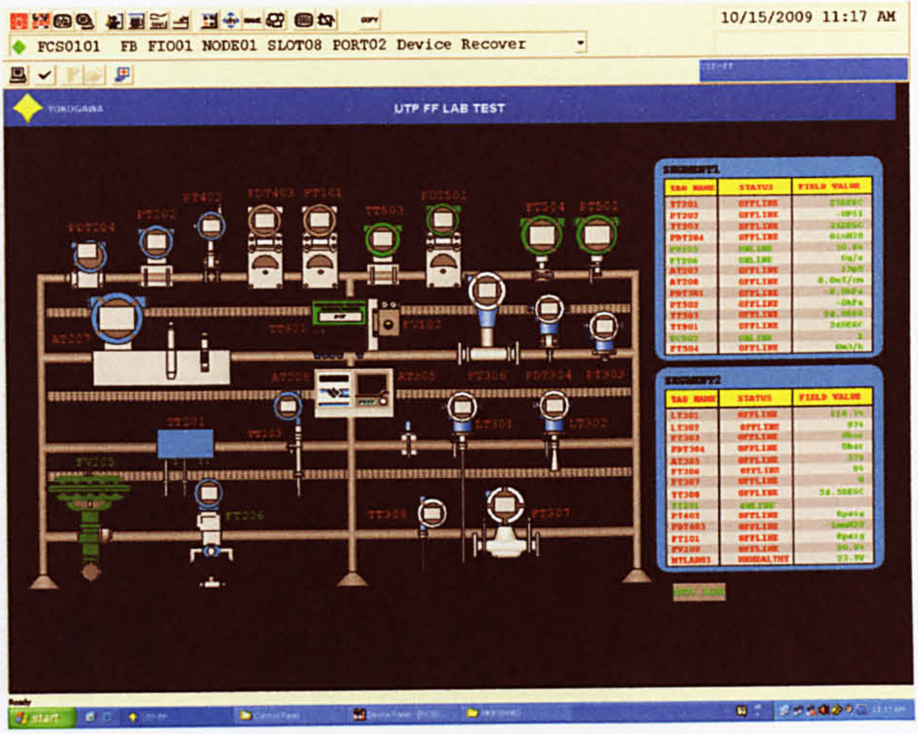

Figure 13: Graphic before Initial Download (Yokogawa)

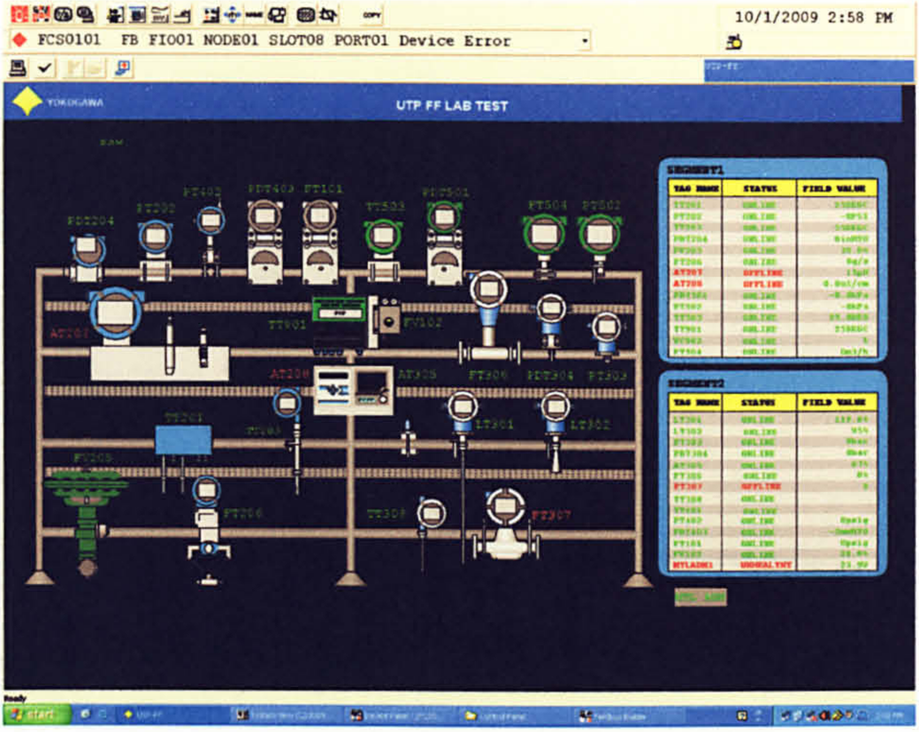

Figure 14: Graphic after Initial Download (Yokogawa)

4.1.2 Device Decommissioning

Decommission causes the device to be in offline mode and detaches the device from the segment. There are two ways to decommission the devices that are by clearing the address and tag name. The first 5 of the devices on each segment are decommissioned by clearing the address. When "address clear" option is chosen, the original address is cleared and temporary address is assigned to the device. The time taken for each device decommission is 10s. The device status changed to offline, AI block to CNF and PVI block to IOP. The host limits the number of devices to be decommissioned to occupy the temporary address. The decommissioned devices are not allowed to exceed 4 units due to limited temporary address. The fifth decommissioned device can not be detected from the device panel.

After commissioning the devices, other 5 devices are then decommissioned by clearing the tag name where this method deletes both the address and tag. The temporary address is then assigned to the device. The device status change to offline, AI block status to CNF and PVI block status to IOP. The time taken for each device decommission is 30s. Temporary address also limits to 4 devices only. It follows the Foundation Fieldbus standard that reserves 4 addresses as the temporary address. Refer to Appendix C for the device decommissioning results.

4.1.3 Device Commissioning

Commissioning puts the device in online mode and attaches the device to the segment. However, the tester has to be careful not to interrupt the system or affects other devices on the segments. The commissioning involves 3 steps that is from the device panel, followed by assigning the tag name and address and lastly, equalization.

Firstly, the device is commissioned at the device panel and the time taken is 1s. The device statuses at live list changes from decommission status to commission status. The graphic status, AI block status and PVI block status still remain unchanged. The device still uses the temporary address and after assigning a new address, the device temporary address changes to a new assigned address. The graphic status, AI block status and PVI block status still remain unchanged. Lastly, after equalizing the device, the graphic changes from offline to online, AI block status from CNF to NR and PVI block status from IOP to NR. Equalization is an operation that matches the information devices in the project database and the information of devices on the FF-H1 bus. There are few devices that cannot be equalized due to mismatch in block structure. Refer to Appendix C for decommissioning and commissioning results.

4.1.4 Online Device Replacement

The test aims to develop steps required to perform the online device replacement. The device is replaced with the same device used before. The devices' ID is permanently removed from the Fieldbus Builder. Then, new device ID acquisition is performed to obtain the new device ID. Green colour indicates that the downloading process is successful while, black indicates that the online device replacement is successful. Both segments 1 and 2 obtain the same device ID before deleting the previous device ID. Refer to Appendix D for online device replacement results.

4.1.5 Drop Out Test

Drop out test aims to ensure that device failure does not affect the overall segment and healthy devices in the segment. This test is also to see whether signal is automatically recovered once the device is online. The device cable is disconnected from the segment and the response is checked from the HMI (human machine interface) host. As a result, the device appears offline while other devices are not affected.

The device changes to offline mode when the cable is disconnected and automatically returns to online when the cable reconnected. During disconnection of the device, the AI block status changes from NR to CNF while, PVI block status changes from NR to IOP. The alarm triggers after 10s of device drop out. Device is then normalized after 30s reconnection and the AI block status changes from CNF to NR while PVI block status changed from IOP to NR. No downloading is required when reconnecting the device. All alarms related to the fail device are cleared once the device is reconnected. Refer to Appendix E for drop out test results.

4.1.6 Calibration Function Check

This check is to test whether online parameter download is performed on the device. The device range is changed using Engineering Work Station, EWS, 375 Field Communicator and host (PRM). When rescaling device from EWS, changes are made to XD_SCALE and OUT_SCALE from the Functional Block Detail Builder. When rescaling the device via 375 Field Communicator and PRM, the AI block is set to OOS mode and changes are made to XD_SCALE and OUT_SCALE.

The device is rescaled using EWS and the changes are observed by 375 Field Communicator and PRM. After rescaling and downloading, the changes are updated within AI block of the device as well as PRM. From HMI graphics, the OUT_SCALE is updated at AI block faceplate while high and low limit values are updated at PVI faceplate.

The devices are then rescaled using 375 Field Communicator and the changes were observed by EWS and PRM. After rescaling from 375, the device needs to be updated and equalized at the Function Block Detail Builder. Then, the new rescaling value changes at EWS. The device is then rescaled using PRM and the changes are observed by 375 Field Communicator and EWS. The device also needs to be updated and equalized at Function Block Detail Builder after rescaling from PRM. Refer to Appendix F for calibration function check/online parameter download.

4.2 Basic Test for SMAR System

4.2.1 Initial Download

The same concept of Initial Download is also performed to the SMAR system. All devices are downloaded into the host. The status of devices is online after the download. The communication of devices with the host is healthy. The download process takes 20 minutes.

4.2.2 Device Commissioning and Decommissioning (assigning tag Number for each device)

The tags and addresses assigned are the same as before and after the test. The following Tables 5 and 6 show the results of Tag Assigned to all Fieldbus devices for Pilot Plant 3, the tables also shows the time taken for assigning tag and normalizing the devices. While assigning its tag number, these devices are disconnected automatically and commissioned back.

Table 5: Time taken to assign tag and normalize Segment Fieldbus 3

Device Tag	Address	Assign Tag	Normalize
LT-362	Error	Error	Error
PT-322	0x18	44s	12s

Table 6: Time taken to assign tag and normalize for Segment Fieldbus 4

Device Tag	Address	Assign Tag	Normalize
LT-322	0x1B	49s	60s
TT-331 / TT-332	0x1C	41s	34s
TT-333 / TT-334	0x1D	46s	53s
FT-331	0x19	48s	31s
FY-331	0x20	39s	80s
FT-364	0x18	47s	42s
FY-364	0x21	47s	36s
FT-323	0x1E	46s	31s
FY-323	0x1A	49s	77s

In general, all devices can be assigned with a tag number without any errors. During the assignment, the device displays a failure in connection, or in other words, the devices are disconnected. The significance of giving a tag number is for the system and human interface to recognise each device and make it easier to design a project or a loop for it.

4.2.3 Drop Out Test

All devices can be physically detached from the network by unplugging the power supply cable from the field devices except for the LT-362. The result is immediate, it is represented by a 'red cross' icon on the display when the device is unplugged. This is shown in Figure 15 and 16 before and after the drop out test.

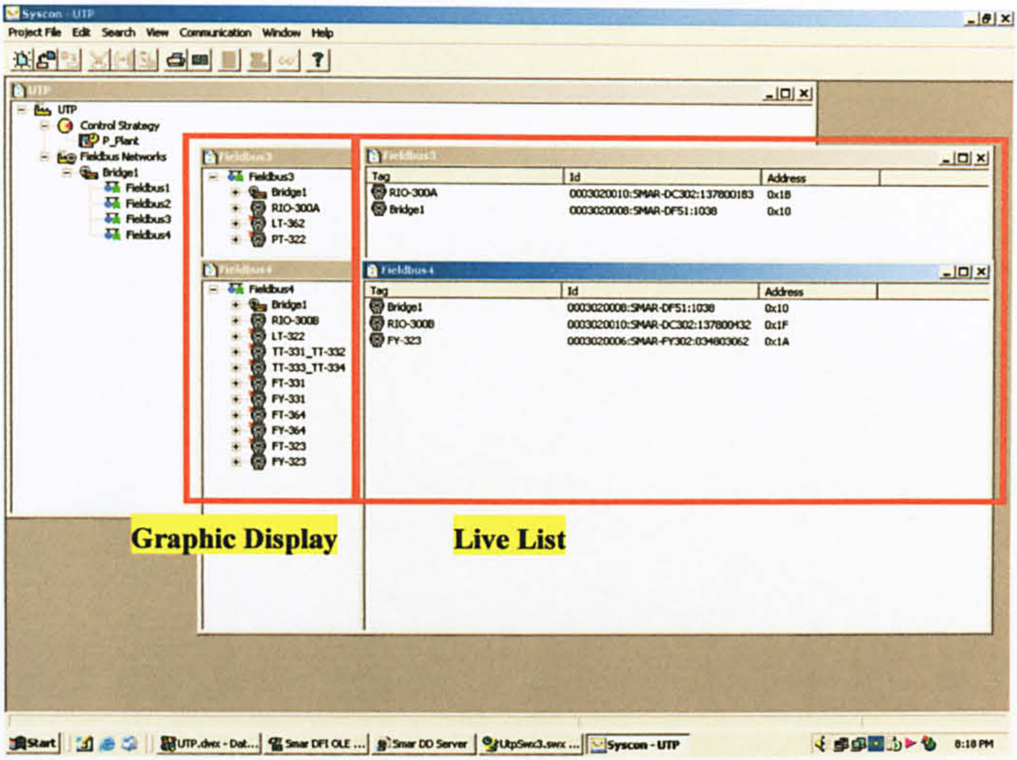

Figure 15: Graphic Display for Drop Out Test, after devices are dropped out (SMAR: Pilot Plant 3)

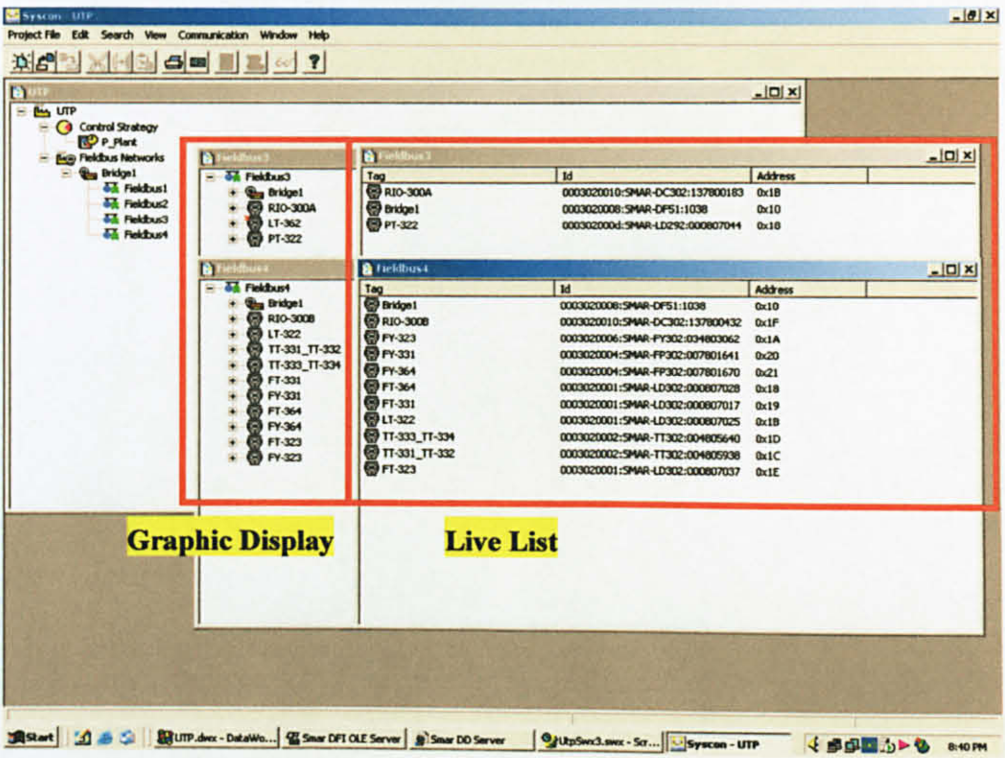

Figure 16: Graphic Display for Drop Out Test, after devices are normalized (SMAR: Pilot Plant 3)

4.3 Discussion and comparison of tests and hosts

Discussion and comparison are separated into several criteria while Table 7 summarises the differences Yokogawa and SMAR hosts.

Table 7: Comparison of tests and hosts

Criteria	**Yokogawa**	**SMAR**
Basic Test and time response	- **Initial Download** Tests are successful, and the average time taken for each device to be downloaded is 3 minutes and 45 seconds - **Device Commissioning & Decommissioning** Centum CS3000 can perform commissioning and decommissioning separately. Also, the test could perform in two ways, by deleting devices' tag or address. - **Online device replacement** Yokogawa have this testing feature. - **Drop out test** The test was successful. The test gives immediate response on the display.	- **Initial Download** Tests are successful, and the average time taken for each device to be downloaded is 1 minute and 50 seconds - **Device Commissioning & Decommissioning** For this version of Syscon software, commissioning and decommissioning has to be performed simultaneously while tagging assigning are carried out. - **Online device replacement** SMAR does not have this testing feature. - **Drop out test** The test was successful. The test gives immediate response on the display.

	- **Calibration function check** The test was successful.	- **Calibration function check** The test was unsuccessful because the testing part cannot be identified.
User friendly of host	- **Graphic Display** It is user friendly. Setting of the testing rig can be drawn in the system, devices could be seen directly and located on the testing rig. The graphic can be seen in Figure 13 and 14. - **Live List** CENTUM CS3000 can show the status of the device (healthy, failure or disconnected – Figure 17). It allows operators to see what is happening to each device and make a problem easier to be solved.	- **Graphic Display** It is not that user friendly. Devices are listed downwards (Figure 15 and 16). Location of the devices in the plant can not be located exactly on the graphic display. - **Live List** SYSCON can only show devices that are connected to the host and can not show the status of other devices. It does not allow the operators to identify what is going on and thus make the problems difficult to be solved.

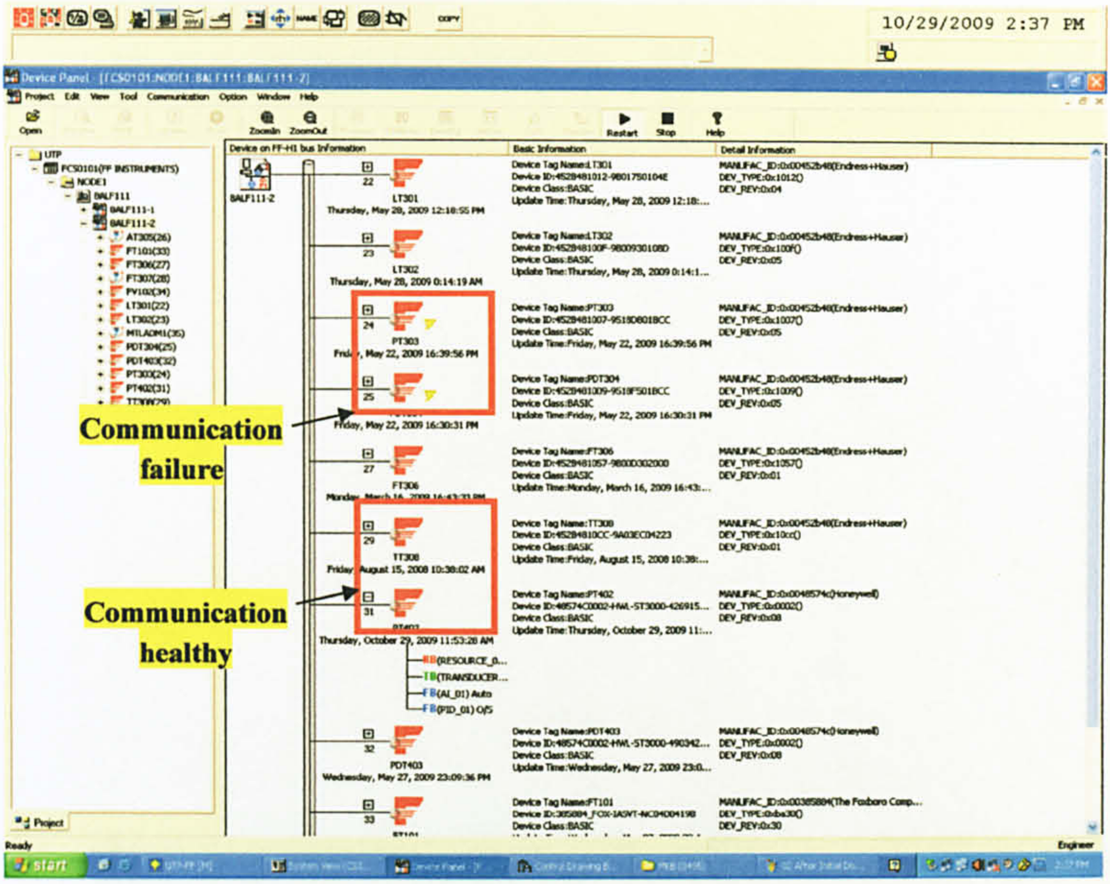

Figure 17: Live List (Yokogawa)

Figure 17 shows the 'live list' communication status for Yokogawa where it is healthy, fail or disconnected. The disconnection status is represented by a 'red cross' icon on the device display.

4.4 Problems and Challenges Faced

This section highlights some of problems and challenges faced in this project due to the testing.

i. Yokogawa software instruction manual is not user friendly. Quite sometimes is required to be spent to really digest and understand the software system. (Thanks to the Yokogawa engineers who have personally help the author to understand the system).

ii. The present SMAR system that is being used for this project for testing for this project does not have a user manual. However the author was given with a newer version of user manual. These prove to be difficult because the author has to inter and extrapolate information from the manual to suite the present SMAR system.

iii. The author has to face with the scheduling situation in using the work station for the testing work of this project. This is because the available work station has to be shared with other students. However the author has tried to install the software in a different work station but unfortunately it was unsuccessful due licensing limitation.

iv. For SMAR system, the author has to face with a scheduling situation in using the available work station for the testing work of this project. This is because the available work station is being shared with other students that are using it for other testing work.(The author tried to install the software in a separate work station unfortunately the installation was unsuccessful due to licensing limitations).

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Based on the basic test performed, the results for Yokogawa show that the system is interoperable between host and various field devices manufactured by different manufacturers. Basic test for SMAR shows that the host and field devices can communicate well but the ability of interoperability of the host to support different manufacturers of field devices cannot be identified. To a certain extent, the author has successfully tabled out the fundamental procedures to be followed for the interoperability testing procedures for both hosts. It is hoped that these "procedures" can serve as a basis for future testing activities especially for PETRONAS Link Companies & others in general. Comparing between both Yokogawa and SMAR systems, Yokogawa are preferable for industrial applications due to its testing features. Furthermore, the software display is more users friendlier in terms of applications and usages.

Also it can be concluded that from this project, fieldbus technology has great potential in testing activities especially in signal interoperability and communication protocols.

5.2 Recommendations

The followings are some recommendations from the author for future works in the field of signal interoperability and communication protocols.

i. This project has shown that the potentials of fieldbus technology is beyond doubt will be the future systems of signal interoperability and communication protocols. Thus, the author would like to suggest that, this project should be further continued to further explore its potentials such as the benefits of stress and diagnostic testing.

ii. This project focuses on the potentials of 4-host test system. Hence, the author would like to recommend exploring the potentials of the 4-host testing systems by connecting these systems to the fieldbus pilot plants located in Plant Process Control Laboratory.

iii. Due to time constraint, the SMAR system was not fully explored for comparison purposes with YOKOGAWA system in this work. It will be good if this unfinished work be explored further so that more useful results can be obtain to achieved a more conclusive and better understandings of the systems.

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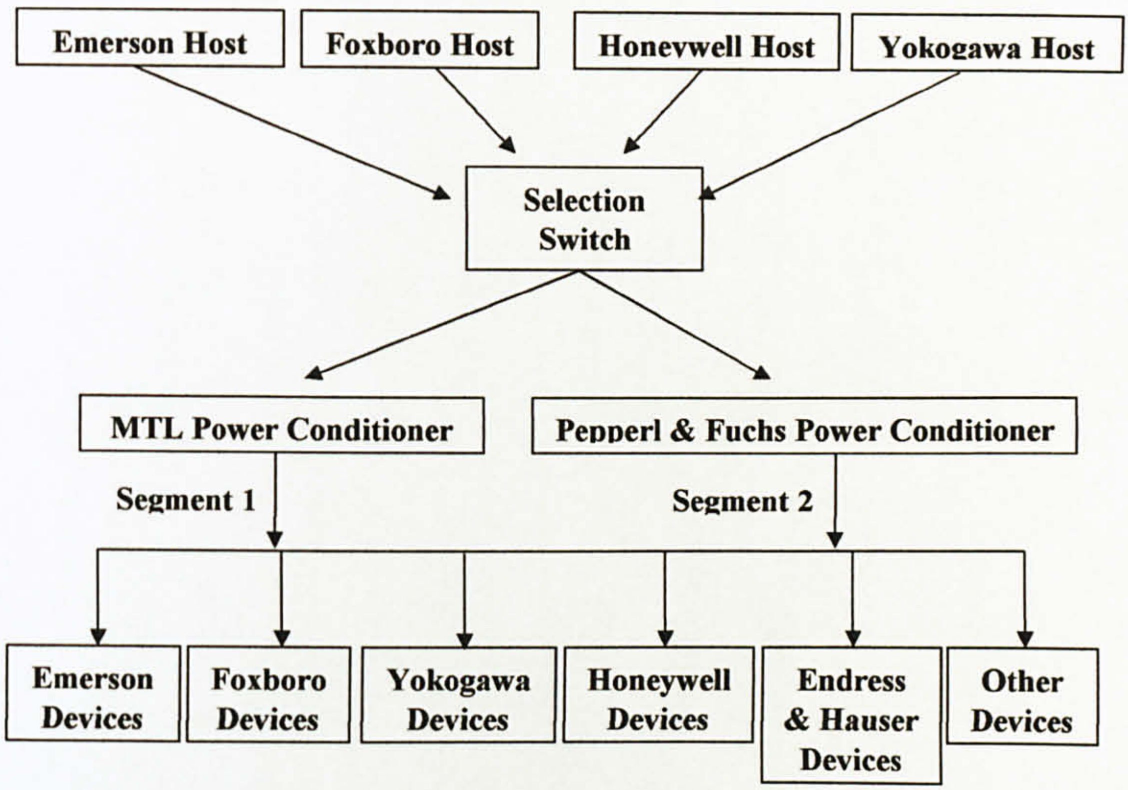
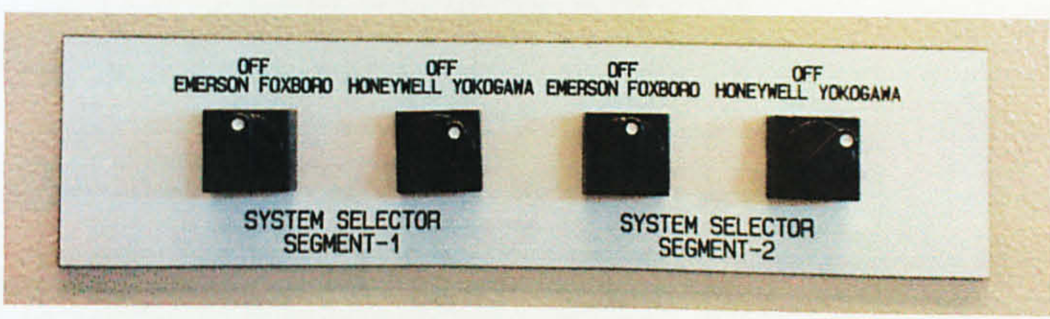
APPENDICES

APPENDIX A: SIMPLIFIED BLOCK DIAGRAM OF THE SYSTEM CONNECTION IN FOUNDATION FIELDBUS LABORATORY AND HOST SWITCHING





APPENDIX B: INITIAL DOWNLOAD

Segment	Device	Status			Remarks
		Live List	Graphic	Device	
1	TT 201	Decommission	ONLINE	ONLINE	-
	PT 202	Commission	ONLINE	ONLINE	-
	TT 203	Commission	ONLINE	ONLINE	-
	PDT 204	Commission	ONLINE	ONLINE	-
	FV 205	Commission	ONLINE	ONLINE	-
	FT 206	Not found	OFFLINE	OFFLINE	Not Powered
	AT 207	Commission	OFFLINE	ONLINE	Graphic and device status does not tally because mismatch in range of pH
	AT 208	Not found	OFFLINE	OFFLINE	Not Powered
	PDT 501	Commission	ONLINE	ONLINE	-
	PT 502	Commission	ONLINE	ONLINE	-
	TT 503	Commission	ONLINE	ONLINE	-
	TT 901	Commission	ONLINE	ONLINE	-
	VC 902	Commission	OFFLINE	OFFLINE	Not Powered
	FT 504	Commission (not equalize)	ONLINE	ONLINE	Cannot be equalized because mismatch in block structure
2	LT 301	Commission	ONLINE	ONLINE	-
	LT 302	Commission	ONLINE	ONLINE	-
	PT 303	Commission	ONLINE	ONLINE	Cannot Equalized
	PDT 304	Commission	ONLINE	ONLINE	Cannot Equalized
	AT 305	Commission	ONLINE	ONLINE	-
	FT 306	Commission	ONLINE	ONLINE	-
	FT 307	Not found	OFFLINE	OFFLINE	Not Powered
	TT 308	(not found in project)	ONLINE	ONLINE	Not in Database
	TT 401	Not found	ONLINE	ONLINE	Not Powered
	PT 402	Commission	ONLINE	ONLINE	-
	PDT 403	Commission	ONLINE	ONLINE	-
	FT 101	Commission	ONLINE	ONLINE	-
	FV 102	Commission	ONLINE	ONLINE	-
	MTLADM 1	Not found	UNHEALTHY	-	MTL diagnostics tools.

APPENDIX C: DEVICE DECOMMISSIONING AND COMMISSIONING

Decommissioning using address clear

Segment	Device	Decommission Sequence	Time Taken(s)	Address		Status		Block status		Remarks
				Device	Temporary	Live List	Graphic Status	AI	PVI	
1	PDT204	1	15	25	251	Decommission	OFFLINE	CNF	IOP	Address is cleared after decommission and the device is assigned to new address (temporary address)
	TT503	2	22	32	248	Decommission	OFFLINE	CNF	IOP	
	AT207	3	12	28	249	Decommission	OFFLINE	CNF	IOP	
	TT201	4	12	22	250	Decommission	OFFLINE	CNF	IOP	
	PT202	5	12	23	248	Decommission	OFFLINE	CNF	IOP	System only provides 4 temporary addresses. After decommission the device disappear from Live List even though it is in decommission state - because not enough temporary address to assigned to PT202. PT202 is assigned to temporary address after commissioning 1 of the decommissioned device earlier (TT503). PT202 take the temporary address of TT503.
2	LT301	1	13	22	248	Decommission	OFFLINE	CNF	IOP	Address is cleared after decommission and the device is assigned to new address (temporary address)
	LT302	2	12	23	251	Decommission	OFFLINE	CNF	IOP	
	PT303	3	10	24	250	Decommission	OFFLINE	LL	IOP	
	PDT304	4	12	25	249	Decommission	OFFLINE	LL	IOP	
	AT305	5	11	26	248	Decommission	OFFLINE	CNF	IOP	System only provides 4 temporary addresses. After decommission the device disappear from Live List even though it is in decommission state - because not enough temporary address to assigned to AT305. AT305 is assigned to temporary address after commissioning 1 of the decommissioned device earlier (LT301). AT305 take the temporary address of LT301.

Commissioning using address clear

Segment	Device	Commissioning					Assigning Address				Equalize				Remarks
		Time Taken (s)	Status		Block Status		Time Taken (s)	Status	Block Status		Time Taken (s)	Status	Block Status		
			Live List	Graphic	AI	PVI		Graphic	AI	PVI		Graphic	AI	PVI	
1	TT503	1	Commission	OFFLINE	CNF	IOP	106	OFFLINE	CNF	IOP	97	ONLINE	NR	NR	The device only changes its status from OFFLINE to ONLINE after it is commission and equalize.
	TT201	2	Commission	OFFLINE	CNF	IOP	99	OFFLINE	NR	IOP	145	ONLINE	NR	NR	
	PDT204	2	Commission	OFFLINE	CNF	IOP	104	OFFLINE	CNF	IOP	103	ONLINE	NR	NR	
	AT207	2	Commission	OFFLINE	OOP	IOP	99	OFFLINE	OOP	IOP	98	OFFLINE	OOP	IOP	The status does not change to ONLINE even though it is already commission - because the device is not equalize
	PT202	2	Commission	OFFLINE	CNF	IOP	93	OFFLINE	CNF	IOP	107	ONLINE	NR	NR	The device only changes its status from OFFLINE to ONLINE after it is commission and equalize.
2	LT301	1	Commission	OFFLINE	CNF	IOP	123	OFFLINE	CNF	IOP	82	ONLINE	NR	NR	
	LT302	1	Commission	OFFLINE	CNF	IOP	89	OFFLINE	CNF	IOP	111	ONLINE	NR	NR	
	PT303	1	Commission	OFFLINE	LL	IOP	118	OFFLINE	LL	IOP	47	OFFLINE	LL	IOP	The status does not change to ONLINE even though it is already commission - because the device is not equalize
	PDT304	1	Commission	OFFLINE	LL	IOP	122	OFFLINE	LL	IOP	47	OFFLINE	LL	IOP	
	AT305	1	Commission	OFFLINE	CNF	IOP	88	OFFLINE	CNF	IOP	220	ONLINE	NR	NR	The device only changes its status from OFFLINE to ONLINE after it is commission and equalize.

Decommissioning using tag clear

Segment	Device	Decommission Sequence	Time Taken(s)	Address		Status		Status			Remarks
				Device	Temporary	Live List	Graphic Status	AI	AO	PVI	
1	FV205	1	29	26	248	Decommission & not found in the project	OFFLINE	-	CNF	OOP	Address and tag name of the device is cleared after decommission and the device is assigned to new address (temporary address). Clear tag method deletes the tag name of the device and also automatically deletes the device address without selecting the address clear option. The status "not found in the project" appears in Live List because the tag name of the device is deleted.
	PT202	2	28	23	249	Decommission & not found in the project	OFFLINE	CNF	-	IOP	
	PDT501	3	22	30	250	Decommission & not found in the project	OFFLINE	CNF	-	IOP	
	TT901	4	45	34	251	Decommission & not found in the project	OFFLINE	CNF	-	IOP	
	TT203	5	171	24	248	Decommission & not found in project	OFFLINE	CNF	-	IOP	System only provides 4 temporary addresses. After decommission the device disappear from Live List even though it is in decommission state because not enough temporary address to assigned to TT203. TT305 assigned to temporary address after commission 1 of the decommissioned device earlier (FV205). TT203take the temporary address of FV205
2	FT306	1	18	27	248	Decommission & not found in project	OFFLINE	CNF	-	OOP	Address and tag name of the device is cleared after decommission and the device is assigned to new address (temporary address). Clear tag method deletes the tag name of the device and also automatically deletes the device address without selecting the address clear option. The status "not found in the project" appears in Live List because the tag name of the device is deleted.
	PT402	2	25	31	251	Decommission & not found in project	OFFLINE	CNF	-	IOP	
	PDT403	3	23	32	249	Decommission & not found in project	OFFLINE	CNF	-	IOP	
	FT101	4	73	33	250	Decommission & not found in project	OFFLINE	CNF	-	IOP	
	FV102	5	182	34	248	Decommission & not found in project	OFFLINE	-	CNF	IOP	System only provides 4 temporary addresses. After decommission the device disappear from Live List even though it is in decommission state because not enough temporary address to assigned to FV102. FV102 is assigned to temporary address after commission 1 of the decommissioned device earlier (FT306). FV102 take the temporary address of FT306

Commissioning using tag clear

Segment	Device	Commissioning						Assigning Address and Tag					Equalize					Remarks
		Time taken(s)	Status		Block Status			Time taken(s)	Status	Block Status			Time taken(s)	Status	Block Status			
			Live List	Graphic	AI	AO	PVI		Graphic	AI	AO	PVI		Graphic	AI	AO	PVI	
1	FV205	1	Commission	OFFLINE	-	CNF	OOP	97	OFFLINE	-	CNF	OOP	109	ONLINE	-	NR	NR	The device only change it status from OFFLINE to ONLINE after it is commissioned and equalized. The status does not change to ONLINE even though it is already commission because the device is not equalized. Both tag and address can be assigned using tag assignment.
	PDT501	1	Commission	OFFLINE	CNF	-	IOP	103	OFFLINE	CNF	-	IOP	105	ONLINE	NR	-	NR	
	TT901	1	Commission	OFFLINE	CNF	-	IOP	93	OFFLINE	CNF	-	IOP	93	ONLINE	NR	-	NR	
	PT202	1	Commission	OFFLINE	CNF	-	IOP	93	OFFLINE	CNF	-	IOP	91	ONLINE	NR	-	NR	
	TT203	1	Commission	OFFLINE	CNF	-	IOP	94	OFFLINE	CNF	-	IOP	93	ONLINE	NR	-	NR	
2	FT306	1	Commission	OFFLINE	LL	-	IOP	127	OFFLINE	LL	-	IOP	170	ONLINE	NR	-	NR	
	PT402	1	Commission	OFFLINE	LL	-	IOP	88	OFFLINE	LL	-	IOP	88	ONLINE	LL	-	NR	
	PDT403	1	Commission	OFFLINE	LL	-	IOP	97	OFFLINE	LL	-	IOP	93	ONLINE	NR	-	NR	
	FT101	1	Commission	OFFLINE	CNF	-	IOP	92	OFFLINE	CNF	-	IOP	86	ONLINE	NR	-	NR	
	FV102	1	Commission	OFFLINE	-	CNF	OOP	91	OFFLINE	-	CNF	OOP	91	ONLINE		NR	NR	

APPENDIX D: ONLINE DEVICE REPLACEMENT RESULTS

Segment	Device	Acquisition Time(s)	Device ID		Graphic Status		Download Time(s)	Remarks
			Before	After	Before	After		
	TT201	22	0011510848-FR-TEMP-0x214E6C27	0011510848-FR-TEMP-0x214E6C27	ONLINE	ONLINE	550	-
	PT202	10	0011513051032208120613-020060507	0011513051032208120613-020060507	ONLINE	OFFLINE	306	Lack of system update. Device ONLINE in several days
	TT203	9	0011513144-TMP-0x23511C27	0011513144-TMP-0x23511C27	ONLINE	OFFLINE	274	
	PDT204	10	0011513051032208074316-020060493	0011513051032208074316-020060493	ONLINE	OFFLINE	387	
	FV205	10	0051006000FisherDVC0070208100218	0051006000FisherDVC0070208100218	ONLINE	ONLINE	237	-
	FT206	-	-	-	-	-	-	Not Powered
1	AT207	27	5241494085-5081pH/ORP-Ox8548C431	5241494085-5081pH/ORP-Ox8548C431	OFFLINE	OFFLINE	199	Cannot Equalized
	AT208	-	-	-	-	-	-	Not Powered
	PDT501	10	594543000CJ0017515	594543000CJ0017515	ONLINE	ONLINE	239	-
	PT502	10	594543000CJ0017516	594543000CJ0017516	ONLINE	ONLINE	340	-
	TT503	9	5945430005S1003598	5945430005S1003598	ONLINE	ONLINE	252	-
	TT901	9	502B460003-01517169585037	502B460003-01517169585037	ONLINE	OFFLINE	321	Lack of system update.
	VC902	9	502B460001-01108172711042	502B460001-01108172711042	ONLINE	ONLINE	190	
	FT504	10	5945430006D0002728	5945430006D0002728	ONLINE	ONLINE	191	-
	LT301	9	452B481012-9B01750104E	452B481012-9B01750104E	ONLINE	ONLINE	225	-
	LT302	8	452B48100F-9B00930108D	452B48100F-9B00930108D	ONLINE	ONLINE	205	-
	PT303	9	452B481007-9518D801BCC	452B481007-9518D801BCC	OFFLINE	OFFLINE	372	Cannot Equalized
	PDT304	8	452B481009-9518F501BCC	452B481009-9518F501BCC	OFFLINE	OFFLINE	429	Cannot Equalized
	AT305	8	452B48108F-9A109705G00	452B48108F-9A109705G00	ONLINE	ONLINE	356	-
	FT306	8	452B481057-9B00D302000	452B481057-9B00D302000	ONLINE	ONLINE	615	-
	FT307	-	-	-	OFFLINE	-	-	Not Powered
2	TT308	-	-	-	ONLINE	-	-	Not in Database
	TT401	-	-	-	ONLINE	-	-	Not powered
	PT402	7	48574C0002-HWL-ST3000-4269154912	48574C0002-HWL-ST3000-4269154912	ONLINE	ONLINE	122	-
	PDT403	8	48574C0002-HWL-ST3000-4903423400	48574C0002-HWL-ST3000-4903423400	ONLINE	ONLINE	120	-
	FT101	9	385884_FOX-IASVT-NC04D0419B	385884_FOX-IASVT-NC04D0419B	ONLINE	ONLINE	123	-
	FV102	9	385884240183/031884	385884240183/031884	ONLINE	ONLINE	206	-
	MTLADM1	-	-	-	UNHEALTHY	-	-	MTL Diagnostics Tools

APPENDIX E: DROP OUT TEST

Segment 1

Device	Disconnect the Cable								Connect the Cable								Remarks
	Block Status				Status		Alarm	Time taken(s)	Block Status				Status		Alarm	Time taken(s)	
	AI	AO	PVI	DO	Graphic	Live List			AI	AO	PVI	DO	Graphic	Live List			
TT201	CNF	-	IOP	-	OFFLINE	Not exist	TT201AI1 - CNF TT201AI3 - CNF	3.3	NR	-	NR	-	ONLINE	Not exist	TT201AI1 - NR TT201AI3 - NR	47.9	
PT202	CNF	-	IOP	-	OFFLINE	Not exist	PT202AI1 - CNF	15.1	NR	-	IOP	-	OFFLINE	Not exist	PT202AI1 - CNF	26.4	
TT203	CNF	-	IOP	-	OFFLINE	Not exist	TT203AI1 - CNF TI203 - IOP	4.5	NR	-	NR	-	ONLINE	Not exist	TT203AI1 - NR TI203 – NR	28.8	
PDT204	CNF	-	IOP	-	OFFLINE	Not exist	PDT204AI1 - CNF	12.4	NR	-	IOP	-	OFFLINE	Not exist	PDT204AI1 - NR	13.6	
FV205	-	CNF	OOP	-	OFFLINE	Not exist	FY205 - OOP FV205AO1 - CNF	4.2	-	NR	-	-	ONLINE	Not exist	FY205 - NR FV205AO1 - NR	39.2	
FT206	-	-	-	-	-	Not exist	-	-	-	-	-	-	-	Not exist	-	-	Not Powered
AT207	OOP	-	IOP	-	OFFLINE	Not exist	AT207AI1 - CNF	13.8	NR	-	NR	-	ONLINE	Not exist	AT207AI1 - NR	25.8	
AT208	-	-	-	-	-	Not exist	-	-	-	-	-	-	-	Not exist	-	-	Not Powered
PDT501	LL	-	IOP	-	OFFLINE	Not exist	PDT205AI1 - CNF PDI501 - IOP	4.7	LL	-	NR	-	ONLINE	Not exist	PDI501 - NR	11.3	
PT502	CNF	-	IOP	-	OFFLINE	Not exist	PT502AI1 - CNF PI502 - IOP	9	NR	-	NR	-	ONLINE	Not exist	PT502AI1 - NR PI502 - NR	22.7	
FT504	CNF	-	IOP	-	OFFLINE	Not exist	FT504AI1 - CNF FI504 - IOP	5.2	NR	-	NR	-	ONLINE	Not exist	FT504AI1 - NR FI504 - NR	18.8	
TT901	IOP	-	IOP	-	OFFLINE	Not exist	TT901AI1 - CNF TI901 - IOP	16.1	IOP	-	NR	-	ONLINE	Not exist	TI901 - NR	23.9	
VC902	-	CNF	-	CNF	OFFLINE	Not exist	VC902DO1 - CNF	13.4	-	-	-	NR	OFFLINE	Not exist	VC902DO1 - NR	10.6	
TT503	CNF	-	IOP	-	OFFLINE	Not exist	TT503AI1 - CNF TI503 - IOP	3.6	NR	-	NR	-	ONLINE	Not exist	TT503AI1 - NR TI503 - NR	22.8	

Segment 2

Device	Disconnect the Cable								Connect the Cable								Remarks
	Block Status				Status		Alarm	Time taken (s)	Block Status				Status		Alarm	Time taken (s)	
	AI	AO	PVI	DO	Graphic	Live List			AI	AO	PVI	DO	Graphic	Live List			
LT301	CNF	-	IOP	-	OFFLINE	Not exist	LT301AI1 CNF LI301 IOP	6.26	NR	-	NR	-	ONLINE	Exist	LT301AI1 NR LI301 NR	49.5	-
LT302	CNF	-	IOP	-	OFFLINE	Not exist	LT302AI1 CNF LI302 IOP	5.55	NR	-	NR	-	ONLINE	Exist	LT302AI1 NR LI302 NR	48.2	-
PT303	CNF	-	IOP	-	OFFLINE	Not exist	PT303AI1 CNF	16	LL	-	IOP	-	OFFLINE	Exist	-	39.3	Cannot be equalized
PDT304	LL	-	IOP	-	OFFLINE	Not exist	PDT304AI1 CNF	13.75	LL	-	IOP	-	OFFLINE	Exist	-	47.2	Cannot be equalized
AT305	CNF	-	IOP	-	OFFLINE	Not exist	AT305AI1 CNF AI305 IOP	6.85	NR	-	NR	-	ONLINE	Exist	AT305AI1 NR AI305 NR	66	-
FT306	LL	-	IOP	-	OFFLINE	Not exist	FT306AI1 CNF FI306 IOP	8.65	LL	-	NR	-	ONLINE	Exist	FI306 NR	44.6	-
FT307	-	-	-	-	-	Not exist	-	-	-	-	-	-	-	Exist	-	-	Not Powered
TT308	-	-	-	-	-	Not exist	-	-	-	-	-	-	-	Exist	-	-	Not in Database
TT401	-	-	-	-	-	Not exist	-	-	-	-	-	-	-	Exist	-	-	Not powered
PT402	CNF	-	IOP	-	OFFLINE	Not exist	PT-402 CNF PI402 IOP	11.3	NR	-	NR	-	ONLINE	Exist	PT-402 NR PI402 NR	22.8	-
PDT403	LL	-	IOP	-	OFFLINE	Not exist	PDT403AI1 CNF PDI403 IOP	3.8	LL	-	NR	-	ONLINE	Exist	PDI403 NR	26.5	-
FT101	CNF	-	IOP	-	OFFLINE	Not exist	FT101AI1 CNF FI101 IOP	6.6	LL	-	NR	-	ONLINE	Exist	FT101AI1 NR FI101 NR	32.3	-
FV102	-	CNF	OOP	-	OFFLINE	Not exist	FV102AO1 CNF FY102 OOP	11.7	-	NR	NR	-	ONLINE	Exist	FV102AO1 NR FY102 NR	29.7	-
MTLADM1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	MTL Diagnostics Tools

APPENDIX F: CALIBRATION FUNCTION CHECK

Segment 1

Segment	Device	EWS																Time Taken(s)	Faceplate		
		FF-AI												PVI							
		XD_SCALE				OUT_SCALE				PV_SCALE											
		Original		Change		Original		Change		Original		Change		Original		Change			AI Block Range	AO Block Range	PVI Block Range
		L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H				
1	TT201 (AI1)	-180	760	-120	701	-200	780	-104	702	-	-	-	-	-180	700	-160	703	60	-104 to -702	-	-160 to 703
	TT201 (AI3)	-180	760	-120	710	-180	760	-130	720	-	-	-	-	-180	760	-170	700	60	-130 to 720	-	-170 to 700
	PT202	0	100	20	75	-15	4000	-10	3000	-	-	-	-	-15	4000	-12	3500	60	-10 to 3000	-	-12 to 3500
	TT203	-200	850	-100	800	-200	200	-100	100	-	-	-	-	0	500	10	400	60	-100 to 100	-	10 to 400
	PDT204	-1000	1000	-900	900	-1500	1500	-1000	1000	-	-	-	-	-1500	1500	-1300	1300	60	-1000 to 1000	-	-1300 to 1300
	FV205	0	100	15	90	-	-	-	-	0	100	10	95	-	-	-	-	60	-	15 to 90	0 to 100
	AT208	0	20000	10	15000	0	20000	20	17000	-	-	-	-	0	20000	30	15000	60	20 to 17000	-	30 to 15000
	PDT501	-100	2000	-90	1000	-500	5000	-400	4000	-	-	-	-	-500	5000	-450	4500	60	-400 to 4000	-	-450 to 4500
	PT502	-100	100	-90	90	-1000	1000	-950	950	-	-	-	-	-100	100	-95	95	60	-950 to 950	-	-95 to 95
	TT503	-200	850	-100	800	-200	850	-150	830	-	-	-	-	-200	850	-50	700	60	-150 to 830	-	-50 to 700
	FT504	0	19	5	17	0	25	10	20	-	-	-	-	0	25	7	23	60	10 to 20	-	7 to 23
	AT207	0	14	3	13	0	14	5	10	-	-	-	-	0	30	10	20	60	5 to 10	-	10 to 20
	FT206	0	100	10	90	0	100	20	80	-	-	-	-	0	100	30	70	60	20 to 80	-	30 to 70
	TT901	0	100	10	90	-5	105	-3	100	-	-	-	-	0	100	20	80	60	-3 to 100	-	20 to 80

Segment 1, continue

375						PRM						FIELDBUS BUILDER						Remark
XD_SCALE		OUT_SCALE		PV_SCALE		XD_SCALE		OUT_SCALE		PV_SCALE		XD_SCALE		OUT_SCALE		PV_SCALE		
L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	
-120	701	-104	702	-	-	-120	701	-104	702	-	-	-120	701	-104	702	-	-	-
-120	710	-130	720	-	-	-120	710	-130	720	-	-	-120	710	-130	720	-	-	-
-15	4000	-10	3000	-	-	-15	4000	-10	3000	-	-	20	75	-10	3000	-	-	XD_scale in 375 and PRM does not change to the rescaled value in EWS
-100	800	-100	100	-	-	-100	800	-100	100	-	-	-100	800	-100	100	-	-	-
-1000	1000	-1000	1000	-	-	-1000	1000	-1000	1000	-	-	-900	900	-1000	1000	-	-	XD_scale in 375 and PRM does not change to the rescaled value in EWS
15	90	-	-	10	95	15	90	-	-	10	95	15	90	-	-	10	95	-
-	-	-	-	-	-	-	-	-	-	-	-	10	1500	20	17000	-	-	Not powered
-90	1000	-400	4000	-	-	-90	1000	-400	4000	-	-	-90	1000	-400	4000	-	-	-
-90	90	-950	950	-	-	CONNECTION FAIL				-	-	-90	90	-950	950	-	-	Connection Fail in PRM - ? Symbol in PRM. Therefore the XD and OUT scale does not update.
-100	800	-150	830	-	-	-100	800	-150	830	-	-	-100	800	-150	830	-	-	-
5	17	10	20	-	-	5	17	10	20	-	-	5	17	10	20	-	-	-
3	13	5	10	-	-	NO AI1 BLOCK				-	-	3	13	5	10	-	-	No AI1 block in PRM, but have AI1 block in 375
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Not powered
10	90	-3	100	-	-	10	90	-3	100	-	-	10	90	-3	100	-	-	-

Segment 2

Segment	Device	EWS																				Time Taken(s)	Faceplate		
		FF-AI																PVI							
		XD_SCALE				OUT_SCALE				PV_SCALE															
		Original		Change		Original		Change		Original		Change		Original		Change							AI Block Range	AO Block Range	PVI Block Range
		L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H								
2	LT301	0	100	10	90	0	100	15	80	-	-	-	-	0	100	20	70					1 min	15 to 80	-	20 to 70
	LT302	0	100	10	90	0	100	15	80	-	-	-	-	0	100	20	70					1 min	15 to 80	-	20 to 70
	PT303	0	2	0.5	1.5	0	2	1	1.5	-	-	-	-	0	3	0.9	2.9					1 min	1 to 1.5	-	0.9 to 2.9
	PDT304	0	3	1	2	0	3	0.5	2.5	-	-	-	-	0	3	0.9	2.9					1 min	0.5 to 2.5	-	0.9 to 2.9
	AT305	0	100	10	90	0	100	20	80	-	-	-	-	0	100	30	70					1 min	20 to 80	-	30 to 70
	FT306	0	100	10	90	0	100	20	80	-	-	-	-	0	100	30	70					1 min	20 to 80	-	30 to 70
	FT307	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-
	TT308	0	100	10	90	10	70	20	60	-	-	-	-	10	70	30	50					1 min	20 to 60	-	30 to 50
	TT401	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-
	PT402	0	125	10	120	0	125	20	120	-	-	-	-	0	125	30	100					1 min	20 to 120	-	30 to 100
	PDT403	0	10160	50	10000	0	10160	30	9000	-	-	-	-	0	10160	10	10100					1 min	30 to 9000	-	10 to 10100
	FT101	0	100	10	90	0	30	10	20	-	-	-	-	0	30	5	25					1 min	10 to 20	-	5 to 25
	FV102	0	100	10	90	-	-	-	-	20	50	25	40	20	50	25	40					1 min	10 to 90	-	0 to 100
	MTLADM1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-

Segment 2, continue

375						PRM						FIELDBUS BUILDER						Remark
XD_SCALE		OUT_SCALE		PV_SCALE		XD_SCALE		OUT_SCALE		PV_SCALE		XD_SCALE		OUT_SCALE		PV_SCALE		
L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	
Unable to load DD						10	90	15	80	-	-	10	90	15	80	-	-	On PRM the limit changes according to the limit change in EWS. The changing in the 375 cannot observed because the device is unable to load DD.
Unable to load DD						-	-	-	-	-	-	10	90	15	80	-	-	The changing on the limit in the 375 cannot observed because:- 1.375- Device unable to load DD 2.PRM- Unable to connect to device
375 cannot access to device						-	-	-	-	-	-	0.5	1.5	1	1.5	-	-	The changing on the limit in the 375 cannot observed because:- 1.375- Device Upload Aborted 2.PRM- Communication Error to device
376 cannot access to device						-	-	-	-	-	-	1	2	0.5	2.5	-	-	
Aborted						-	-	-	-	-	-	10	90	20	80	-	-	
Aborted						-	-	-	-	-	-	10	90	20	80	-	-	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	The device is not found in the live list
-200	850	-200	850	-	-	-	-	-	-	-	-	not in project database						Cannot observe at PRM because communication error to the device
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Not Powered
10	120	20	120	-	-	10	120	20	120	-	-	10	120	20	120	-	-	The limit change in EWS effects the limit change on that device and that is approve using the 375 and PRM
50	10000	30	9000	-	-	50	10000	30	9000	-	-	50	10000	30	9000	-	-	
0	30	0	30	-	-	0	30	0	30	-	-	10	90	10	20	-	-	The limit do not change according to EWS
10	90	-	-	24	40	10	90	-	-	25	40	10	90	-	-	25	40	The limit change in EWS effects the limit change on that device and that is approve using the 375 and PRM
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	The device is not found in the live list

APPENDIX G: PROJECT GANTT CHART

No.	Detail/ Month (2009-2010)	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
1	Selection of Project Topic						Mid Semester Break						
2	Preliminary Research Work												
3	Familiarizing with Yokogawa system												
5	Basic Interoperability Test (Basic Test) using Yokogawa system												
6	Familiarizing with SMAR system												
7	Basic Interoperability Test (Basic Test) using SMAR system												
8	Analysis and comparison												
9	Final Report												
10	Preparation for Final Oral Presentation												