FOUNDATION FIELDBUS INTEROPERABILITY TEST (FFIT)

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ELECTRICAL & ELECTRONICS ENGINEERING
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By

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
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Approved by,

(Ir Dr Idris bin Ismail)

UNIVERSITI TEKNOLOGI PETRONAS
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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.

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MOHD HISSAMMUDIN BIN MUSA

ABSTRACT

Fieldbus is a digital 2-way, multi-drop communication link among intelligent measurement and control devices such as sensors, actuators, controllers and etc. It serves as Local Area Network (LAN) for advanced process control, remote I/O and high speed factory automation applications. In analog control system, instrument devices such as sensor produce 4 – 20 mA signal output than travel from field devices to the control process at control room and again travelling from control room to the instrument devices with dedicated cable. In order to reduces the number of cable, fieldbus technology replace the 4 – 20 mA wiring in the field and enables bidirectional data transmission.

Nowadays, fieldbus gradually replacing 4 – 20 mA standard instrumentation signals used to transfer data between field devices and control process. For Foundation Fieldbus Interoperability Test, the main objective of this project is to carry out and recommend test procedure for Fieldbus Interoperability test by approach of designing, configuring and implementing a fieldbus test rig from the various loose field device, controllers and actuators plus the software development tool.

Basically Foundation Fieldbus Interoperability testing is focused on "interoperability" means the ability of the host to operate multiple devices without losses of functionality. This project aims to provide a brief familiarization to the fieldbus system for scientific researchers and engineers, as foundation for further development for either laboratory or industrial applications and testing. During this project, there are 2 laboratory tests that covered which are Basic Interoperability Test and Stress Test. The result will be reference for PETRONAS Technical Standard (PTS) FOUNDATION Fieldbus system.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Theoretically, Fieldbus is a digital 2-way, multi-drop communication link among intelligent measurement and control devices such as sensors, actuators, controllers and etc. It serves as a Local Area Network (LAN) for advanced process control, remote I/O and high-speed factory automation applications. In analog control system, instrument devices produce 4 – 20 mA signal output that travel from field devices to the control process at control room and again travelling from control room to the instrument device such as sensor with dedicated cable. Besides, 4-20 mA required an individual cable to transfer the signal but fieldbus allow multiple instruments to share a single cable to convey output signal. In order to reduces the number of cable, Fieldbus technology replace the conventional 4 - 20mA wiring in the field and enables bidirectional data transmission. The entire communication between devices, automation system as well as the process control system takes place over the bus system (Fieldbus).

1.2 Problem Statement

Fieldbus is the new technology that had been used in Malaysia nowadays but the study on its reliability is still questioning. This technology developed for the last 20 years but the major problem is the difficulty in finding trained personal in Fieldbus technology. One of the tests which can determine the reliability of this system is Interoperability test.

Interoperability test is the capability for the device from one manufacturer to interact with that of another manufacturer on a fieldbus network without loss of functionality for example FOXBORO's system can communicate with Yokogawa's system without loss any of functionality. The existing technology such as 4-20mA or Hart allows certain devices to work with particular manufacturer only. This is the main problem when different manufacturer try to communicate and run the standard configurations on a single Foundation Fieldbus (FF) segment. Thus, it limits the freedom to choose interoperable control products from their suppliers of choice and unable to integrate control systems, devices across the industry. The problems encountered are:

a) To explore and study the Foundation Fieldbus (FF) Basic Interoperability Test between host and devices.
b) To gain the basic knowledge for engineer and trainee in term of fieldbus technology, design and functionality.

1.2.2 Significance of Project

This project is the continuation of the previous project. However, for this project the author needs to complete the test as per Skill Group 14 (SKG14) requirement and develop a new graphic page for new valve that will be installing later. Upon completion of the research and testing, the final results might be implemented in PETRONAS Group-wide. The testing and calculation will determine the performance of the Foundation Fieldbus system. A comprehensive technical report on the FFIT will be the outcome of this project.

1.3 Objectives

The main objectives of the Foundation Fieldbus Interoperability Testing are project are:

a. To perform interoperability testing of Foundation Fieldbus (FF) namely basic test, stress test and diagnostic test.
b. To produce detail report and data analysis based on the test results.
c. To provide familiarization on the Fieldbus system for scientific researchers and engineers for further development.

1.4 Scope of Study

Another objective of this Foundation Fieldbus Interoperability test is to come-up with strong knowledge in designing, configuring and implementing a fieldbus technology system for future development. Beside, this project aims to give some familiarization to the engineer and student of FF Interoperability Test in order to implement this technology to the real industry.

The entire test involving Foundation Fieldbus Interoperability should be done only for Foundation Fieldbus application as the system will implement in PETRONAS group wide according to PETRONAS Technical Standards (PTS).

CHAPTER 2

LITERATURE REVIEW/THEORY

2.1 Literature Review

2.1.1 Fieldbus

The signal standard have advanced over a year starting with 3 -15 psi (Pneumatic Signal) standard then change to analog 4 - 20 mA (Analog Signal) and to the digital HART (Highway Addressable Remote Transducer) with 4 – 20 mA. Fieldbus is generic-term which describes a new digital communications network which will be used in industry to replace the existing 4 - 20 mA analogue signal. Fieldbus is a digital, bi-directional, multidrop, serial-bus, communication network used to link isolated field devices such as controllers, transducers, actuators and sensors. It serves as a Local Area Network (LAN) for advanced process control, remote input/output and high speed factory automation application.

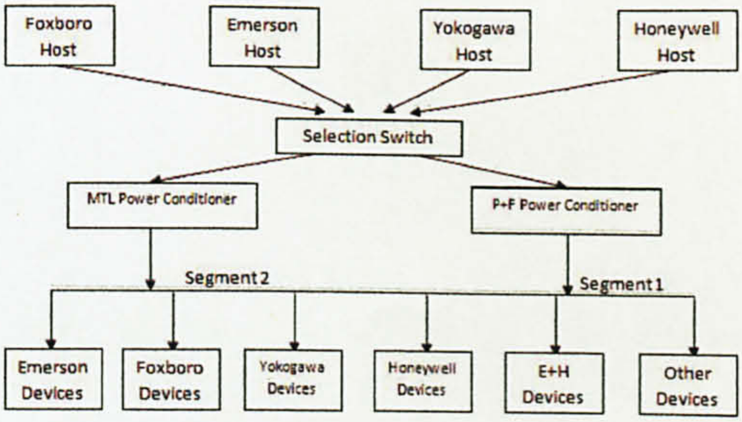

Figure 1: UTP's Foundation Fieldbus Architecture.

Foundation Fieldbus retains many of the desirable features of the 4 – 20 mA analog signals system such as a standardized physical interface to the wire, bus powered devices on a single wire and intrinsic safety option, it offers a host additional benefit to the users [2]:

Device Interoperability

Device interoperability means one fieldbus device can be replaced by a similar device with added functionality from a different manufacturer on the same fieldbus network while maintaining specified operations. This permits users to "mix and match" field devices and host systems from various manufacturers [2].

Enhanced Process Data

Foundation fieldbus allows multiple variables from each device can be brought into the plant control system for archival, trend analysis, process optimization studies and report generation. This access to accurate, high resolution data enables processes to be fine-tuned for better manufacturing throughput and reduced plant downtime [2]. This technology result the higher plant performance and profitability.

Improved Plant Safety

Fieldbus technology will help manufacturing plants keep up with increasingly stringent safety requirements by providing operators or engineers with earlier notification and warning of pending and current hazardous conditions. Fieldbus also allows for corrective action before an accidental shutdown of the plant or system.

Reduced Wiring and Maintenance Costs

Foundation fieldbus use of existing wiring and multi-drop connections provides significant savings in network installation costs (Figure 2). This includes reductions in intrinsic safety barrier termination and cable costs, particularly in areas where wiring is already in place [2]. Additional cost savings can be achieved through the decreased time required for construction and start-up, as well as simplified programming of control and logic functions using software control blocks built into fieldbus devices [2].

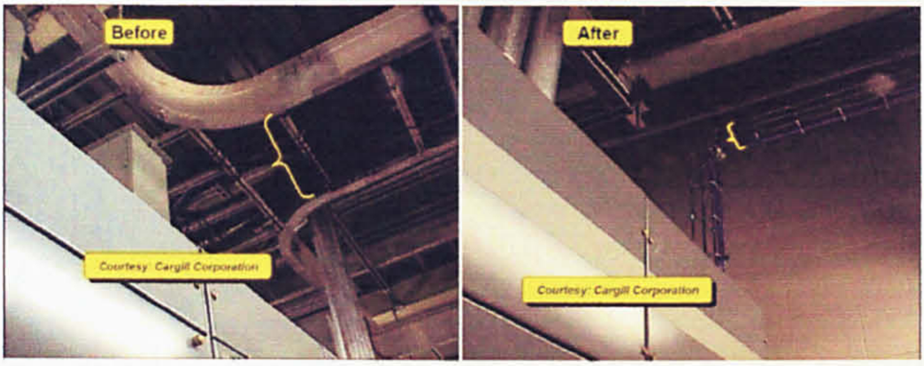

Figure 2: Wiring arrangement of Fieldbus [11].

2.1.2 Fieldbus Interoperability Test

The Fieldbus is an open bus standard which enables devices of different manufacturers to be integrated in one system and interchanged (interoperability) the data. Fieldbus interoperability is the ability of the digital instruments to be connected onto a Fieldbus network and have them communicate all available functionality to each other and with the networked hosts. In order to ensure interoperability between the systems from different hosts, device supplier such as Foxboro, Emerson, Yokogawa or Honeywell are required to test and register devices with the Foundation and make registered files available to the user. This is only feasible when all the devices exactly meet the specification. Devices approved by the Fieldbus FOUNDATION are a guarantee for the user and the manufacturer that they comply with the specification.

Figure 3: Logo of Fieldbus FOUNDATION members [6].

The Fieldbus Foundation's rigorous Interoperability Test and Registration Procedures thoroughly examine and verify all aspects of the intelligent field device [6]. In order to fulfill the registration process, manufacturers must submit their devices to independent lab verification performed by the Fieldbus Foundation or a qualified third party testing agency [5]. The interoperability test cannot begin until the manufacturer has completed both the communication stack and the physical layer conformance certifications. The physical layer conformance test verifies the electrical characteristics of the device, while the stack conformance test validates the messaging component of the device software [5].

2.1.2.1 Physical layer Testing.

The Physical Layer refers to the electrical characteristics of the field device [5]. Manufacturers or manufacturer chosen third party testing facilities perform physical layer testing. The Physical Layer Conformance Test Specification details cookbook style procedures that must be executed to verify that the field device conforms electrically to the FOUNDATION™ Fieldbus (FF) specifications [5]. The Physical Layer Conformance Test Specification covers all aspects of specified physical layer requirements such as:

a) Transmission Levels & Timing
b) Receiver Noise Rejection
c) Ripple Sensitivity
d) Operating Voltage
e) Input Impedance
f) Withstand Voltage

2.1.2.2 Conformance Testing

In addition to physical layer testing, the registered field device must contain a registered communication stack. The fieldbus communication stack is the messaging component of the field device that composed of the data link layer, the fieldbus access sub-layer, the fieldbus message specification, system management and network management agents [5].

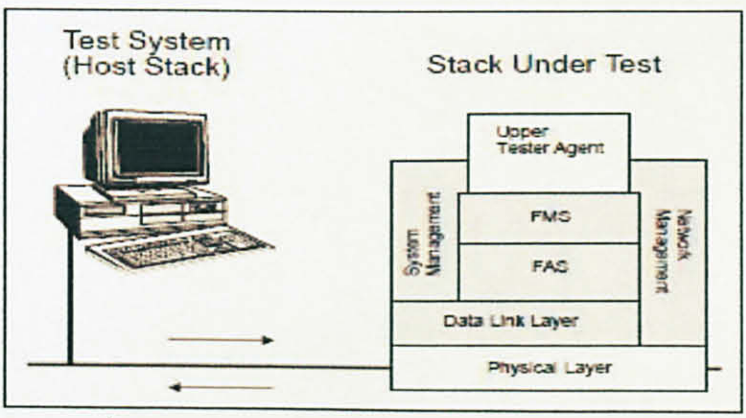

Figure 4: The Conformance Test System (CTS) communicates with the Upper Tester Agent [5].

The stack conformance test consists of a suite of both automated and manual test procedures [5]. Before the developer submits the stack software for registration, the developer ports an application, the Upper Test Agent (UTA), to the stack under test (SUT). The test system, utilizing a tested or "golden" stack, can communicate to the remote stack via the UTA. The UTA is responsible for collecting the remote indications from the SUT, which can later be verified by the test system after execution of a specific test procedure [5]. In addition, the test system can remotely instruct the UTA to trigger responses from the SUT which are recorded and evaluated by the test system. Hence, the test system can confirm all communication paths between the UTA and the SUT [5]. The Conformance testing system consists of:

a) Fieldbus Message Specification Messaging.
b) System Management Messaging.
c) Object Dictionary Conformance.
d) Data Link Timing.
e) Link Active Scheduler.

Additional test procedures examine the distribution and synchronization of the application time clock. All FF field devices are synchronized to a known sense of time that is specifically used to timestamp critical events such as alarm detection [5]. The specifications dictate that one device on the segment is assigned the role of primary time publisher, and all other devices capable of publishing the application time become backup time publishers [5].

2.1.2.3 Interoperability Testing

Once manufacturers have completed both physical layer and stack conformance testing, the device will qualify for interoperability testing. The primary goal of interoperability testing is to validate the user layer, or the function block application of the FF field device. Interoperability Testing consists of two separate test systems: the Interoperability Test System (ITS) and Device Description Verification [5].

2.1.3 Interoperability Test System

The interoperability test system is designed to verify the manufacture implementation is consistent with the Function block specifications [5]. The current version of the ITS contains over 280 individual test cases to validate all aspects of the user layer specifications. A special certification schedule, which executes all test cases for the device class, is used during the actual interoperability testing [5]. Devices must pass all applicable test cases in order to qualify for device registration.

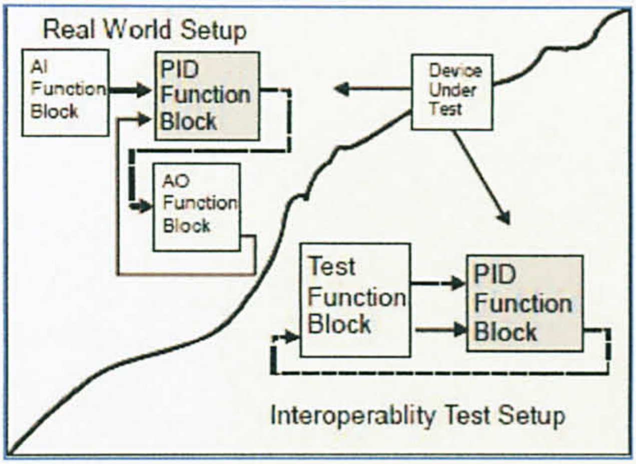

Figure 5: The Test Function Block (TFB) simulates real world devices [5].

The ITS is designed to simulate real world situations as just described. In order to properly synchronize field devices and simulate real world behavior, the ITS utilizes a separate device call a Test Function Block (TFB) [5]. The TFB can be thought of as a function block simulator. The TFB contains a custom function block with a set of input and output parameters tied to internal parameter value queues [5]. During the execution of a test case, the ITS will link the manufacturer's device under test (DUT) to the TFB's input and output parameters. Next, the test system will download specific information to the TFB's output parameter queues that would stimulate expected behavior in the DUT.

After execution, the ITS will upload the input parameter queues from the TFB and compare those against expected values. The ITS uses the above procedures to validate advanced behaviors including specific mode and status handling, cascade initialization handshaking and mode shedding operations [5].

2.1.4 Device Description Verification

The second key process during interoperability testing is the device description verification. A device description (DD) file is a binary file that contains descriptive information about the field device [5]. If manufacturers implement additional functionality above and beyond that specified in the Function Block Specifications, a manufacturer must supply a Device Description file. The Device Description Verification validates that a host using the Device Description Services (DDS) can access all descriptions for all the parameter in the device, including both standard and manufacturer specific [5]. Although the ITS cannot verify the functionality of custom function blocks, the Device Description Verification validates that all blocks, including those classified as custom, contain a complete device description reference.

Additional verification is made on the standard parameters to validate that the standard set of FF function block parameters conform to the specifications. The completion of the device description verification assures the user that a tool utilizing the FF Device Description Services will be able to access all parameters in the device [6]. This enables tools to configure both the standard, enhanced and custom set of parameters found in today's field devices.

CHAPTER 3

METHODOLOGY/PROJECT WORK

3.1 Procedure Identification

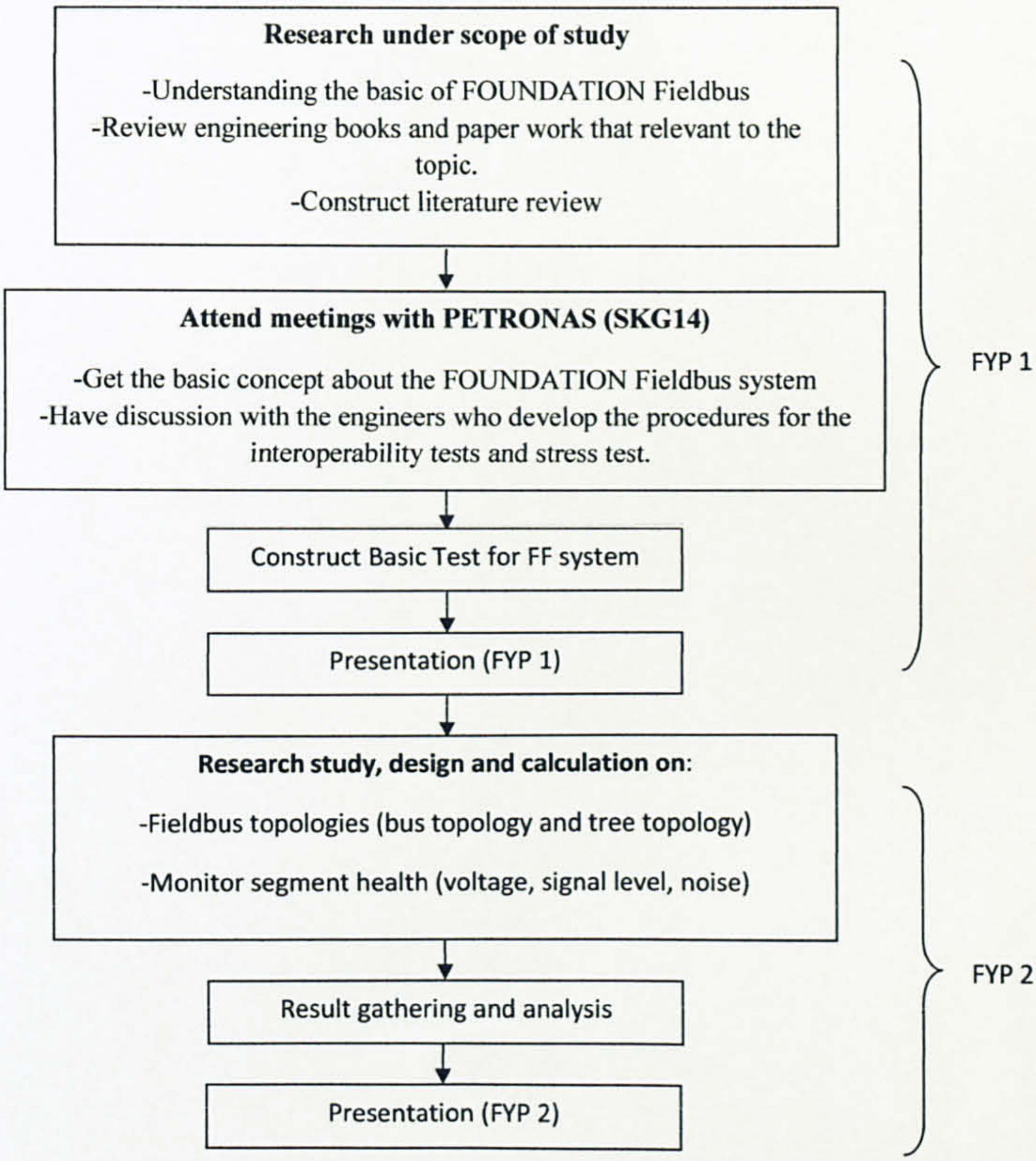

Figure 6: Flowchart for Procedure Identification

3.2 Lab Description

University Teknologi Petronas (UTP) Fieldbus Training Facility consists of four different Hosts – Foxboro, Emerson, Yokogawa and Honeywell. The field instrument device consists of 28 devices and using High Power Trunk / Field barrier Concept. Besides, there are three (3) cabinets are used to install all the Hosts and monitoring the systems. Devices in the test bench can separate into two (2) groups – Segment 1 and Segment 2.

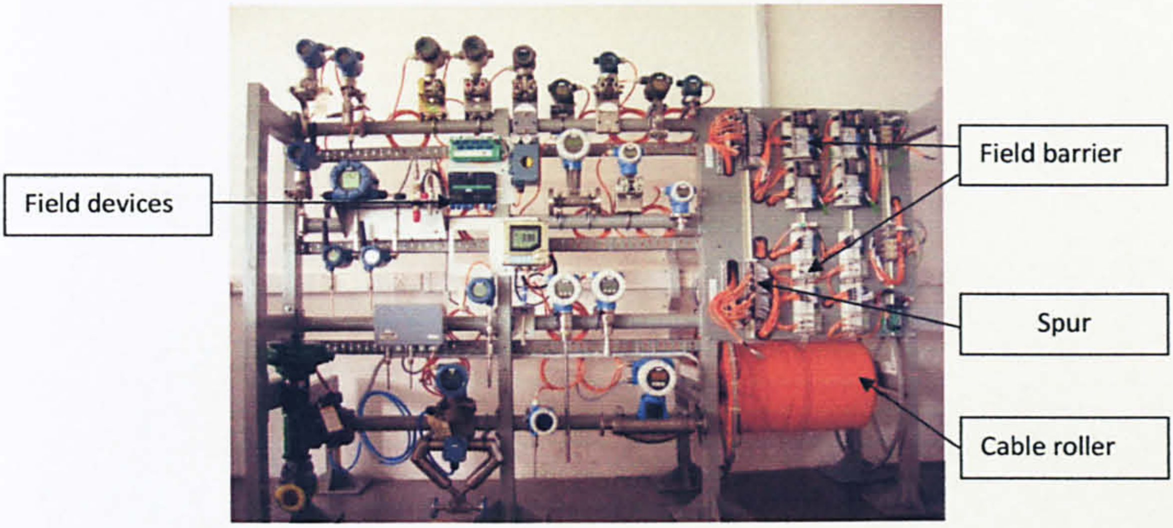

Figure 7: The field devices

Foundation Fieldbus is highly reliable when correctly installed and maintained. The key is in knowing what must be done to start with and to maintain a reliable fieldbus network.

In this project, the following equipment and software are being used to accomplish the testing and to record the necessary data:

I. IACC (Foxboro Host System)

II. Delta V (Emerson Host System)

III. FBT-6 Fieldbus Monitor

IV. Digital Multimeter

3.3 Test Description

In order to complete the Foundation Fieldbus Interoperability Test, the following experiments will be conducted throughout this project.

i. Basic Interoperability Test
ii. Stress Test

For Basic Interoperability Test, this entire test will covers [4]:

i. Initial download
ii. Device commissioning
iii. Device decommissioning
iv. Physical layer diagnostic / drop out test
v. Calibration function check.

For this project, the author only focuses on Foundation Fieldbus Basic Interoperability Test and Stress Test. All these tests had been conducted at Universiti Teknologi Petronas (UTP) FOUNDATION Fieldbus Training Facility at Building 23. The purposes of this test are:

- To test the basic functionality of the fieldbus devices and fieldbus Host from different manufacturer.
- To test foundation Fieldbus equipment of different type and manufacturer in a single interconnected system.

3.3.1 Summary of Method (Basic Interoperability Test)

The FOUNDATION Fieldbus Basic Interoperability Test can be represented as follows [4]:

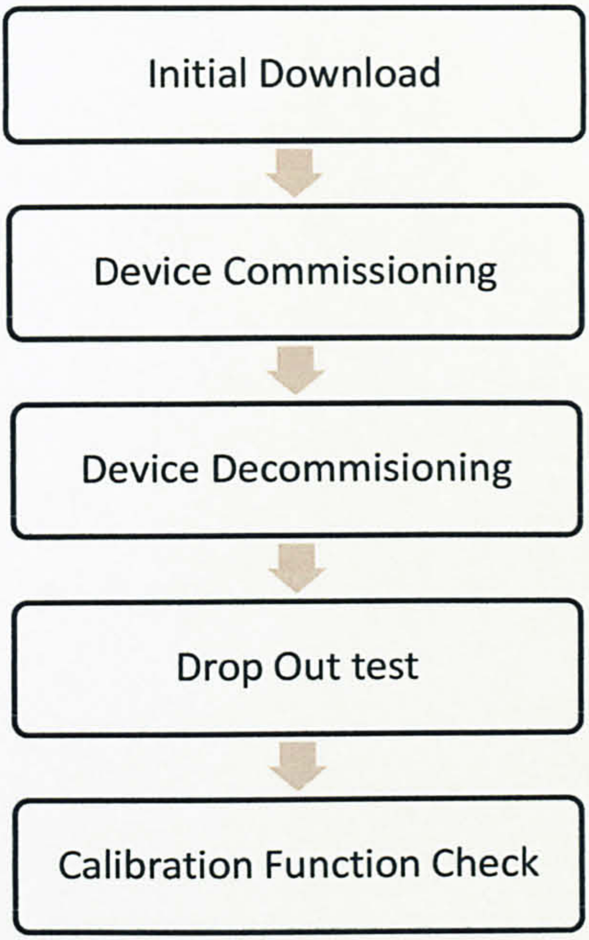

Figure 8: Scope of testing

Initial Download

Initial download need to be performed every time host switching is done. This is to ensure that all devices are properly recognized by the 'new' host and loaded with the identified host configuration and updated with current data [4].

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 pre-registered devices. Commissioning of a new device will be covered in the Extended Test [4].

Device Decommissioning

This test is to ensure a proper method of putting device in offline mode. The process must make sure that host does not scan the detached device as error [4].

Drop Out Test

To record the response or self-recovery of the devices if they are disconnected from the fieldbus system.

Calibration Function Check

This test is to test how online parameter download is performed on the device.

3.3.2 Summary of Method (Stress Test)

The Stress Test of Fieldbus Interoperability Testing covers stress operation of Fieldbus bus system and can be represented as follows:

i. **Test under fully loaded segments**

   To verify the maximum numbers of devices that **Host** and **Spur** can support.

ii. **Failure recovery / Communication lost**

   This test is to verify the host susceptibility to chattering, noise injection and total power failure.

iii. **Back-up of LAS**

   To control on wire and configure back up LAS on devices from different manufacturers [13].

iv. **Cable constraint**

   To observe the effect of using twisted single pair instrument cable instead of using Type A cable for trunk and spur and to identify the limits of using twisted single pair instrument cable for spur [13].

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Fieldbus Interoperability Testing

For this project, the author only focuses on FOUNDATION Fieldbus Basic Interoperability Test. There were 6 tests had been conducted for Foundation Fieldbus Basic Interoperability Testing using **Emerson** host, i.e:

I. Initial Download
II. Device Commissioning
III. Device Decommissioning
IV. Online Device Replacement
V. Calibration Function Check / Online Parameter Download
VI. Device Drop-Out

During this project, only Segment 2 of the instrument skid test bench was tested. The details of the device of Segment 2 are listed below as in Table 1 and Figure 7 shows the overall training facility of Emerson host.

The following background colors are made in parameter value fields in the Field Device Manager to indicate various states.

Table 2: Color in Field Device Manager Display

Color	Description
	Devices not connected
	Communication Fail
	Communication Ok
	No communication between devices and host

Table 1: Devices in Segment 2

NO.	DEVICE NAME	LOGIC NAME	ADD	VENDOR	MODEL
1	LT301	LT301	22	E+H	LEVELFLIX M
2	LT302	LT302	23	E+H	MICROPILOT M
3	PI303	PI303	24	E+H	CEREBAR
4	PDT304	PDI304	25	E+H	DELTABAR S
5	AT305	AI305	26	E+H	LIQUILINE
6	FT306	FI306	27	E+H	PROWILL 73
7	FT307	FI307	28	E+H	PROMASS 83
8	TT308	TI308	29	E+H	TMT162
9	TT401	TI401	30	HONEYWELL	N/A
10	PT402	PI402	31	HONEYWELL	ST3000FF
11	PDT403	PDI403	32	HONEYWELL	ST3000FF
12	FT101	FI101	33	FOXBORO	IASVT
13	FY102	FY102	34	FOXBORO	SRD POSITIONER
14	MTLADMI		35	MTL	MTL

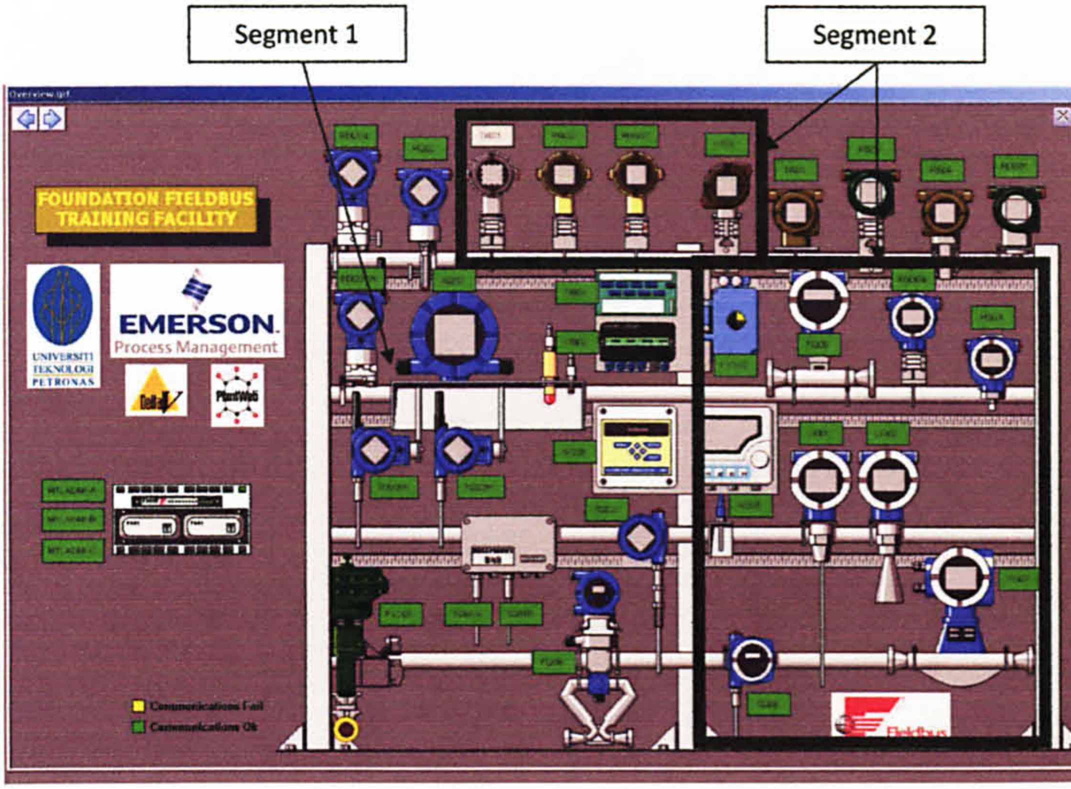

Figure 9: Emerson's Foundation Fieldbus Training Facility

4.1.1 Initial Download and Device Commissioning

At the beginning, before switching the status of the Selector Switch to Emerson, all the device in Segment 2 are in yellow as shown in Figure 7 and after the Initial Download, all the device in Segment 2 (except AT305, FT307 and FT101) turn into green as shown in Figure 8.

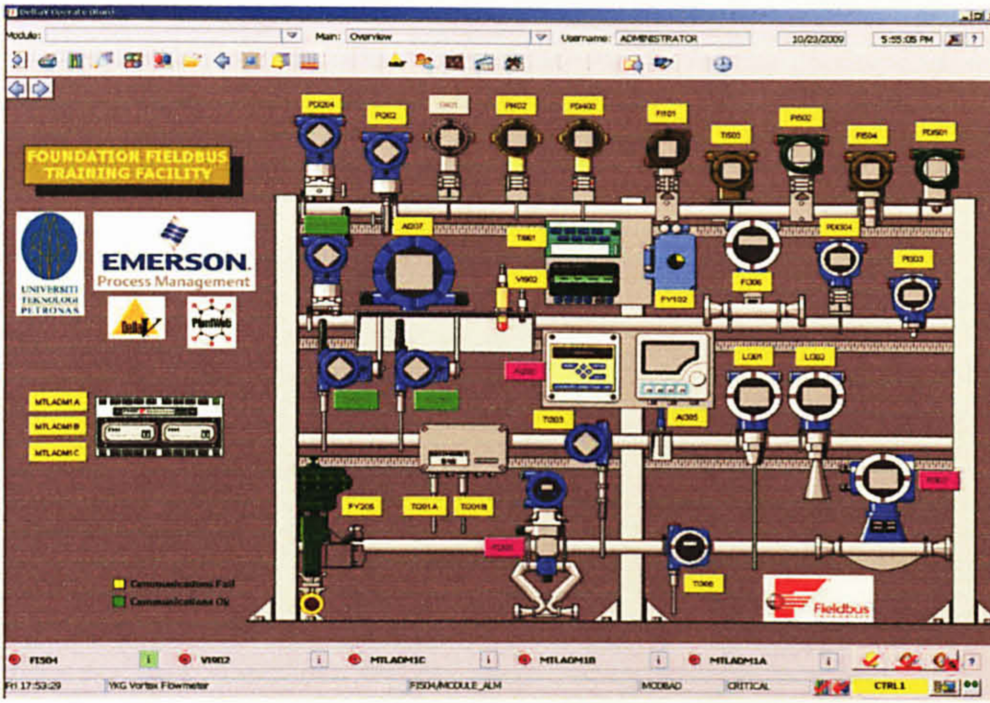

Figure 10: Device status before Initial Download

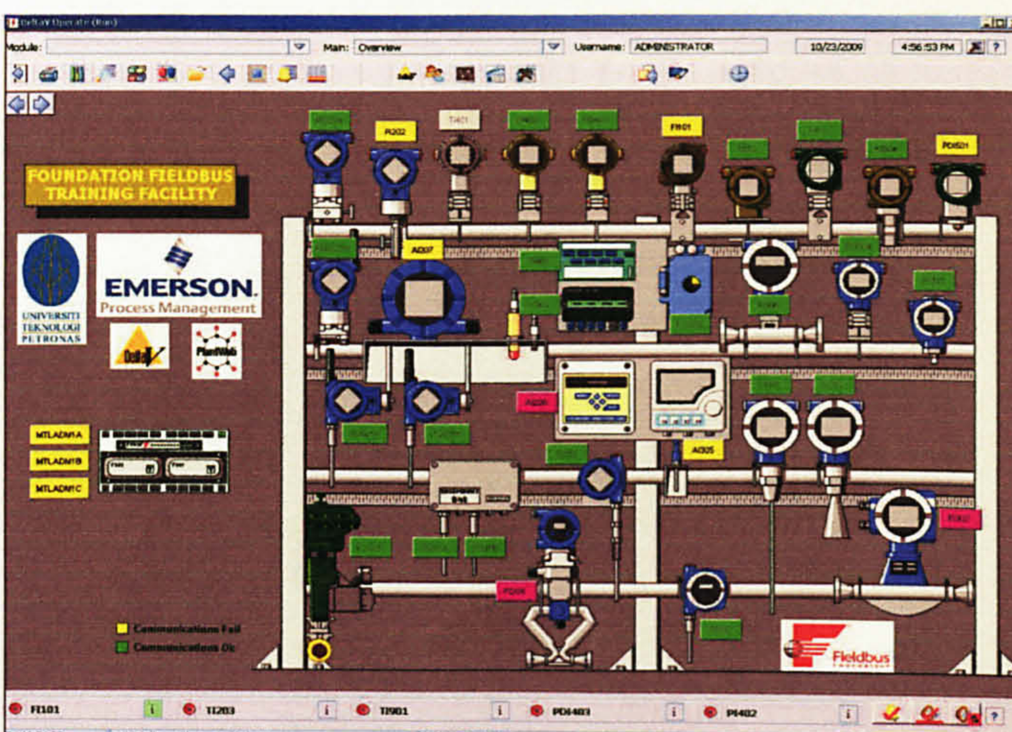

Figure 11: Device status after Initial Download

4.1.2 Device Decommissioning

For device decommissioning, the author only decommissioned 3 devices which are PT306, TT308 and PT303. All these devices took less than 1 minute to successfully being decommissioned. Figure 9 show the status of the device after the decommissioned where the color turn from green to yellow.

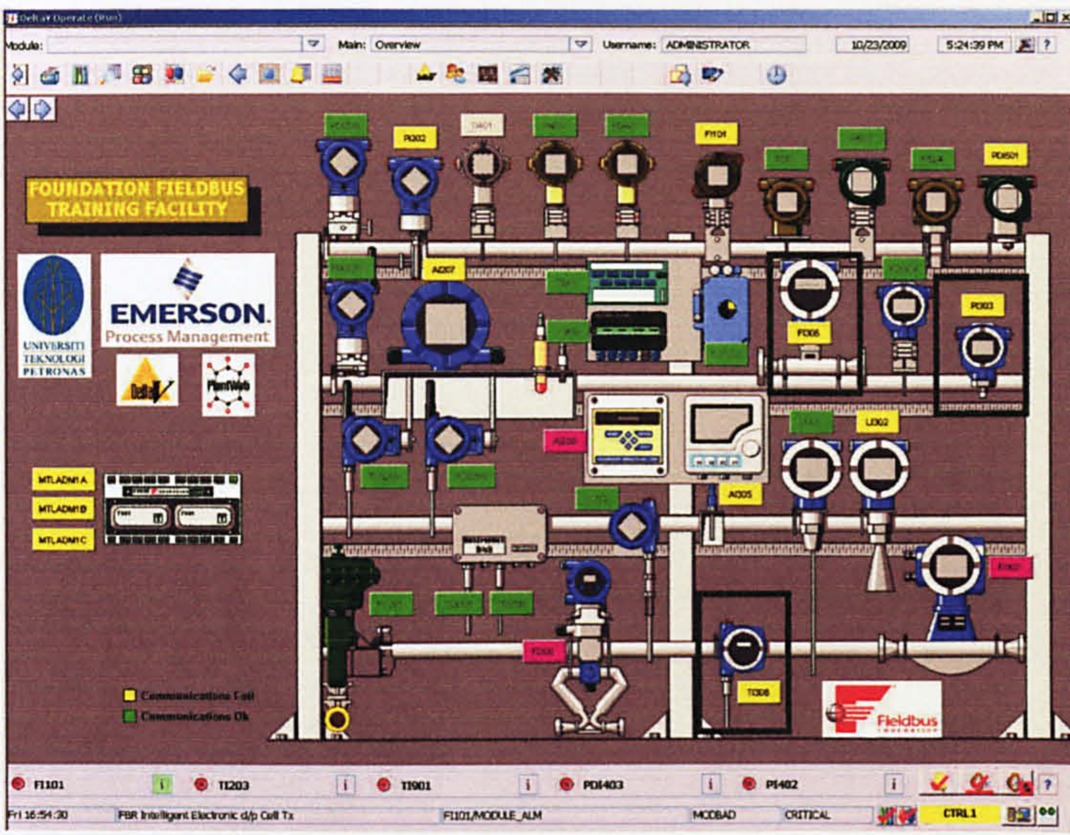

Figure 12: Device status (PT306, TT308 and PT303) after Commissioning.

4.2 Problem Encountered

During Initial Download, there are some communication fail of the devices (AT305, FT307 and FT101). At the beginning, these devices turn into green but after a few second these devices turn into yellow (Communication Fail) mean there are no communication between devices and host. The problems not the effect of interoperability but there are another factor that causes these problems. There are several factors that caused this problem:

- Cable not property tight.
- Leakage of signal during the communication.

4.3 Health Check Testing

The physical layer is what connects all the devices on a fieldbus segment together. It provides DC power to the devices and allows them to communicate with each other. The physical layer consists of four parts which are cable, wiring blocks, terminators and power supply. The most commons problems include [14]:

- Missing or extra terminators
- Improper grounding of the cable shield
- Water/condensation in cables, junction boxes, devices, splices,etc.
- Un-isolated fieldbus segments.
- Connectors not securely plugged in.
- Loose wires
- Damaged cable or wires
- Stray wire strands at wire terminations.
- Screw terminals and hold-down screws inadequately tightened down.

In order to solve these problems, portable fieldbus diagnostic test equipment (FBT-6) had been used to monitor segment health of the physical layer equipment at the University Teknologi Petronas (UTP) Fieldbus Training Facility.

The following data are made in parameter value fields in the FBT-6 (Figure 9) to identify several of problems:

- Voltage
- Signal level
- Noise
- Retransmits
- Shield shorts

Figure 13: Fieldbus Monitor FBT-6

4.4 Result

All these experiment had been done using FBT-6 that connected to the 'trunk' of the segment (Segment 1 with 500m twisted pair wire)

Experiment 1

Segment Measurements	Data	Acceptable Values	OK/BAD
Voltage	29,0V	9,0V Minimum	OK
Lowest Device Signal	549mV	150mV Minimum	OK
Lowest Device Signal Address	35 (23H)		
Lowest Device Signal Date/Time	Not Available		
Avg Fieldbus Frequency Noise (9KHz-40KHz)	5mV	75mV Maximum	OK
Peak Fieldbus Frequency Noise (9KHz-40KHz)	5mV	75mV Maximum	OK
Peak Fieldbus Frequency Noise Date/Time	Not Available		
Avg Low Frequency Noise (50Hz-4KHz)	13mV	150mV Maximum	OK
Peak Low Frequency Noise (50Hz-4KHz)	30mV	150mV Maximum	OK
Peak Low Frequency Noise Date/Time	Not Available		
Avg High Frequency Noise (90KHz-350KHz)	9mV	150mV Maximum	OK
Peak High Frequency Noise (90KHz-350KHz)	12mV	150mV Maximum	OK
Peak High Frequency Noise Date/Time	Not Available		
Shield Short	No Shorts	No Shorts	OK
LAS Address	16 (10H)		
Most Recent Add/Drop Address	33 (21H)		
Device Add or Drop	Add	None Added/Dropped	WARN
Date/Time of Device Add/Drop	Not Available		
Number of Active Devices	13		

* Three (3) terminator located at Power Conditioner, Field Barrier and Segment Protector

Table 3: Experiment 1

Experiment 2

Segment Measurements	Data	Acceptable Values	OK/BAD
Voltage	29,0V	9,0V Minimum	OK
Lowest Device Signal	837mV	150mV Minimum	OK
Lowest Device Signal Address	24 (18H)		
Lowest Device Signal Date/Time	Not Available		
Avg Fieldbus Frequency Noise (9KHz-40KHz)	5mV	75mV Maximum	OK
Peak Fieldbus Frequency Noise (9KHz-40KHz)	61mV	75mV Maximum	OK
Peak Fieldbus Frequency Noise Date/Time	Not Available		
Avg Low Frequency Noise (50Hz-4KHz)	12mV	150mV Maximum	OK
Peak Low Frequency Noise (50Hz-4KHz)	30mV	150mV Maximum	OK
Peak Low Frequency Noise Date/Time	Not Available		
Avg High Frequency Noise (90KHz-350KHz)	10mV	150mV Maximum	OK
Peak High Frequency Noise (90KHz-350KHz)	20mV	150mV Maximum	OK
Peak High Frequency Noise Date/Time	Not Available		
Shield Short	No Shorts	No Shorts	OK
LAS Address	16 (10H)		
Most Recent Add/Drop Address	35 (23H)		
Device Add or Drop	Add	None Added/Dropped	WARN
Date/Time of Device Add/Drop	Not Available		
Number of Active Devices	13		

* Terminator removed from Power Conditioner

Table 4: Experiment 2

Experiment 3

Segment Measurements	Data	Acceptable Values	OK/BAD
Voltage	29,0V	9,0V Minimum	OK
Lowest Device Signal	566mV	150mV Minimum	OK
Lowest Device Signal Address	24 (18H)		
Lowest Device Signal Date/Time	Not Available		
Avg Fieldbus Frequency Noise (9KHz-40KHz)	5mV	75mV Maximum	OK
Peak Fieldbus Frequency Noise (9KHz-40KHz)	61mV	75mV Maximum	OK
Peak Fieldbus Frequency Noise Date/Time	Not Available		
Avg Low Frequency Noise (50Hz-4KHz)	13mV	150mV Maximum	OK
Peak Low Frequency Noise (50Hz-4KHz)	30mV	150mV Maximum	OK
Peak Low Frequency Noise Date/Time	Not Available		
Avg High Frequency Noise (90KHz-350KHz)	12mV	150mV Maximum	OK
Peak High Frequency Noise (90KHz-350KHz)	40mV	150mV Maximum	OK
Peak High Frequency Noise Date/Time	Not Available		
Shield Short	No Shorts	No Shorts	OK
LAS Address	16 (10H)		
Most Recent Add/Drop Address	23 (17H)		
Device Add or Drop	Add	None Added/Dropped	WARN
Date/Time of Device Add/Drop	Not Available		
Number of Active Devices	13		

* Terminator removed from Field Barrier (FB)

Table 5: Experiment 3

Experiment 4

Segment Measurements	Data	Acceptable Values	OK/BAD
Voltage	29,0V	9,0V Minimum	OK
Lowest Device Signal	566mV	150mV Minimum	OK
Lowest Device Signal Address	24 (18H)		
Lowest Device Signal Date/Time	Not Available		
Avg Fieldbus Frequency Noise (9KHz-40KHz)	5mV	75mV Maximum	OK
Peak Fieldbus Frequency Noise (9KHz-40KHz)	61mV	75mV Maximum	OK
Peak Fieldbus Frequency Noise Date/Time	Not Available		
Avg Low Frequency Noise (50Hz-4KHz)	12mV	150mV Maximum	OK
Peak Low Frequency Noise (50Hz-4KHz)	30mV	150mV Maximum	OK
Peak Low Frequency Noise Date/Time	Not Available		
Avg High Frequency Noise (90KHz-350KHz)	11mV	150mV Maximum	OK
Peak High Frequency Noise (90KHz-350KHz)	40mV	150mV Maximum	OK
Peak High Frequency Noise Date/Time	Not Available		
Shield Short	No Shorts	No Shorts	OK
LAS Address	16 (10H)		
Most Recent Add/Drop Address	30 (1EH)		
Device Add or Drop	Drop	None Added/Dropped	BAD
Date/Time of Device Add/Drop	Not Available		
Number of Active Devices	12		

*** Terminator removed from Power Conditioner (PC) and Field Barrier (FB)**

Table 6: Experiment 4

Experiment 5

Segment Measurements	Data	Acceptable Values	OK/BAD
Voltage	29,0V	9,0V Minimum	OK
Lowest Device Signal	566mV	150mV Minimum	OK
Lowest Device Signal Address	24 (18H)		
Lowest Device Signal Date/Time	Not Available		
Avg Fieldbus Frequency Noise (9KHz-40KHz)	3mV	75mV Maximum	OK
Peak Fieldbus Frequency Noise (9KHz-40KHz)	61mV	75mV Maximum	OK
Peak Fieldbus Frequency Noise Date/Time	Not Available		
Avg Low Frequency Noise (50Hz-4KHz)	5mV	150mV Maximum	OK
Peak Low Frequency Noise (50Hz-4KHz)	30mV	150mV Maximum	OK
Peak Low Frequency Noise Date/Time	Not Available		
Avg High Frequency Noise (90KHz-350KHz)	7mV	150mV Maximum	OK
Peak High Frequency Noise (90KHz-350KHz)	92mV	150mV Maximum	OK
Peak High Frequency Noise Date/Time	Not Available		
Shield Short	No Shorts	No Shorts	OK
LAS Address	16 (10H)		
Most Recent Add/Drop Address	24 (18H)		
Device Add or Drop	Add	None Added/Dropped	WARN
Date/Time of Device Add/Drop	Not Available		
Number of Active Devices	13		

*** Terminators removed from Power Conditioner (PC), Field Barrier (FB) and Segment Protector**

Table 7: Experiment 5

4.5 Discussion

4.5.1 Voltage

A device with inadequate power (voltage) can exhibit a verity of behavior. Retransmissions, devices repeatedly dropping from and adding to the network, or not being seen on the network are all possible symptoms [14]. Resistance in cable, wire terminations and wiring blocks causes the voltage to drop; voltage is highest at the fieldbus power supply and lower at the field devices.

Based on the above experiment, voltage drop can calculate manually by using Ohms Law equation.

- The power supply and power conditioner output is 32 volts
- The cable used is has a resistance of 22 ohms/km for each conductor
- Each device at the chicken foot draws 0.02A

$$V_{loss} = I * R \qquad (1)$$

Where I is the current in the trunk cable and R is the resistance of the trunk cable.

$$V_{loss} = (13\ devices * 0.02) * \left(\frac{22\Omega}{1000m}\right) * 500m \qquad (2)$$

$$V_{loss} = 2.86\ \text{V} \qquad (3)$$

$$V_{field} = V_{supply} - V_{loss} = 32v - 2.86v = 29.14v \approx 29v \qquad (4)$$

4.5.2 Signal Level

The signal level of a device indicates how loudly it is talking to other devices. If a device talks too quietly or the bus is too noisy the other devices cannot hear it [14].

For exp 1: **Lowest Device Signal = 549mV (Condition OK)**

For exp 2: **Lowest Device Signal = 837mV (Condition OK)**

For exp 3: **Lowest Device Signal = 566mV (Condition OK)**

For exp 4: **Lowest Device Signal = 566mV (Condition OK)**

For exp 5: **Lowest Device Signal = 566mV (Condition OK)**

Each fieldbus segment should have 2 terminators installed. An extra terminator typically results in a signal level reduction of 30% and a missing terminator typically results in a signal level increase of 70%.

4.5.3 Noise

Noise can interfere with fieldbus signal causing communications to be corrupted or missed. Improperly grounded shield wires and routing fieldbus cables near other cables are typically sources of fieldbus noise [14].

For exp 1:

Avg Fieldbus Frequency Noise (9KHz-40KHz)	5mV (Condition GOOD)
Peak Fieldbus Frequency Noise (9KHz-40KHz)	5mV (Condition GOOD)
Avg Low Frequency Noise (50Hz-4KHz)	13mV (Condition GOOD)
Peak Low Frequency Noise (50Hz-4KHz)	30mV (Condition GOOD)
Avg High Frequency Noise (90KHz-350KHz)	9mV (Condition GOOD)
Peak High Frequency Noise (90KHz-350KHz)	12mV (Condition GOOD)

High average noise indicates the noise source is constantly present. Common causes of high average noise include a poorly grounded shield and routing of fieldbus cables near and parallel with other signal carrying cables or AC power cables [14]. Peak noise indicates the highest noise level detected by the tester. High peak noise with low average noise indicates the network is experiencing noise spikes [14].

Once the likely problem is identified take one or more of the actions recommended such as:

- Inspect the network cable and the connections
- Check the voltage at the devices.
- Verify that only 2 terminators are installed on the segment.

All these action usually consist of inspecting the cabling and connections associated with the problem devices such as:

- Connections not securely plugged in
- Loose wire
- Damaged cable or wires
- Stray wire strands at wire terminations
- Tie wraps too tight

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Fieldbus is the new technology that being used in Malaysia nowadays but the study on its reliability still in questing. It takes many advantages in control system compare with 4-20 mA standards. Fieldbus interoperability focuses on the capability for the device from different manufacturer to interact with another manufacturer on the fieldbus network without loss its functionality.

Foundation Fieldbus Interoperability Test aims to encounter and improve the critical problem that involve in this new technology such as:

- Fieldbus Interoperability between different manufacturer hosts system and devices.
- Lack of basic reference for user in term of fieldbus technology, design and functionality.

For the conclusion, this project achieving the main objectives which are to produce detail report and data analysis based on the interoperability testing of Foundation Fieldbus (FF) namely basic test, stress test and diagnostic test. By referring the report and data, it will provide familiarization on the Fieldbus system for scientific researchers and engineers for further development.

The result that obtained from Basic Interoperability Test and Stress Test will contribute as a reference for the Petronas engineer that can be used to start the new technology in this arena.

5.2 Recommendation.

For the semester of this project, the author wishes to complete the Stress Test that provide by SKG14 and install/configure a new valve that available at the UTP Fieldbus Training Facility.

5.2.1 Stress test

This test should involve the fully loaded segment which confirm the maximum number of devices that could be used, the power failure recovery, communication integrity soak test, back up of LAS (Link Active Scheduler), the control in field and the test of maximum cable length and different cable type.

5.2.2 Installation of ValvGuard

The installation of the new valve will cover:

- Installation of the instrument air
- Wiring
- Valve configuration and installation in FF host

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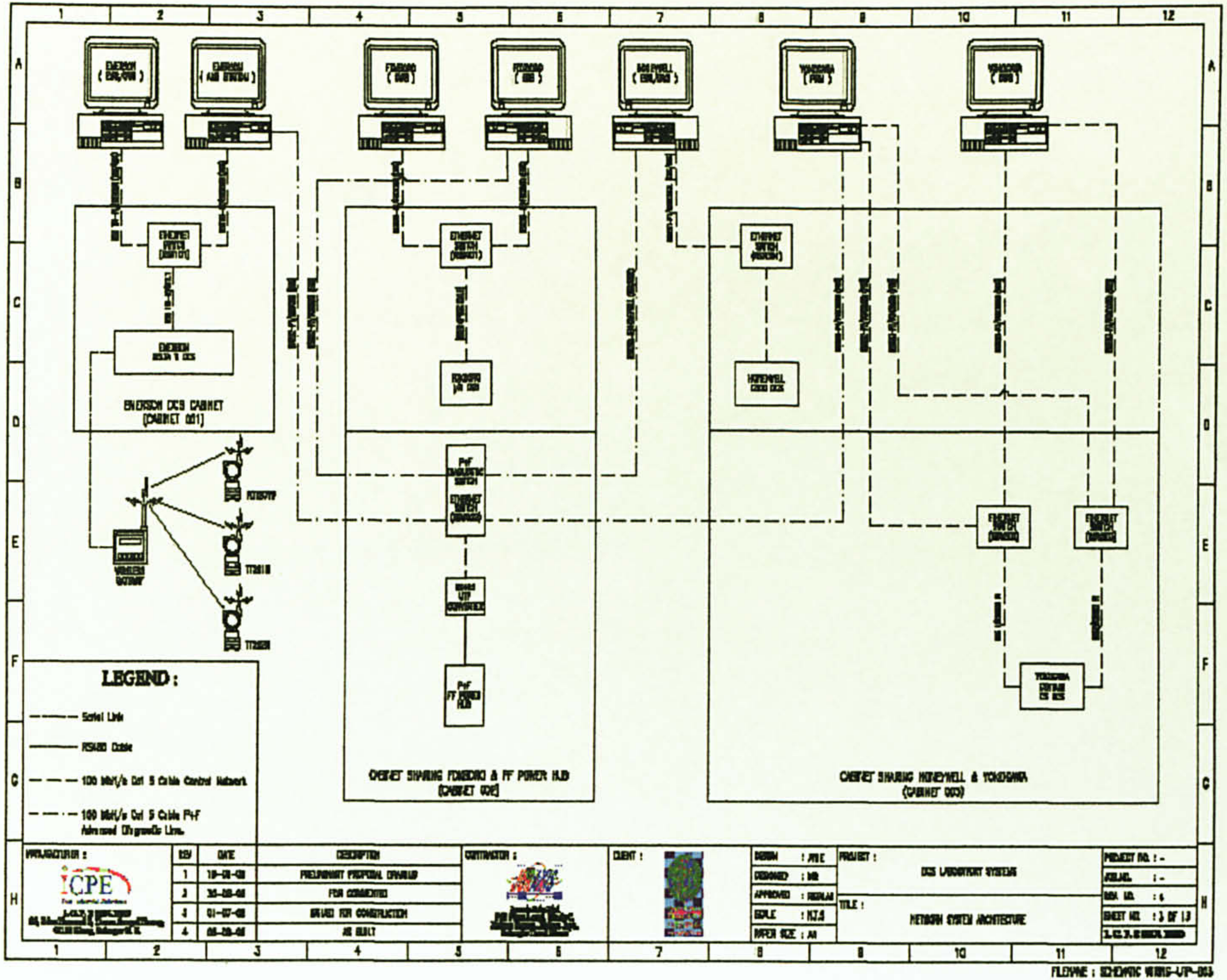
APPENDIX A

SCHEMATIC DIAGRAM


LEGEND :
Serial Link
RS485 Cable
100 Mbit/s Cat 5 Cable Control Network
100 Mbit/s Cat 5 Cable P+F Advanced Diagnostic Line.
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CABINET SHARING FOXBORO & FF POWER HUB (CABINET 002)
CABINET SHARING HONEYWELL & YOKOGAWA (CABINET 003)
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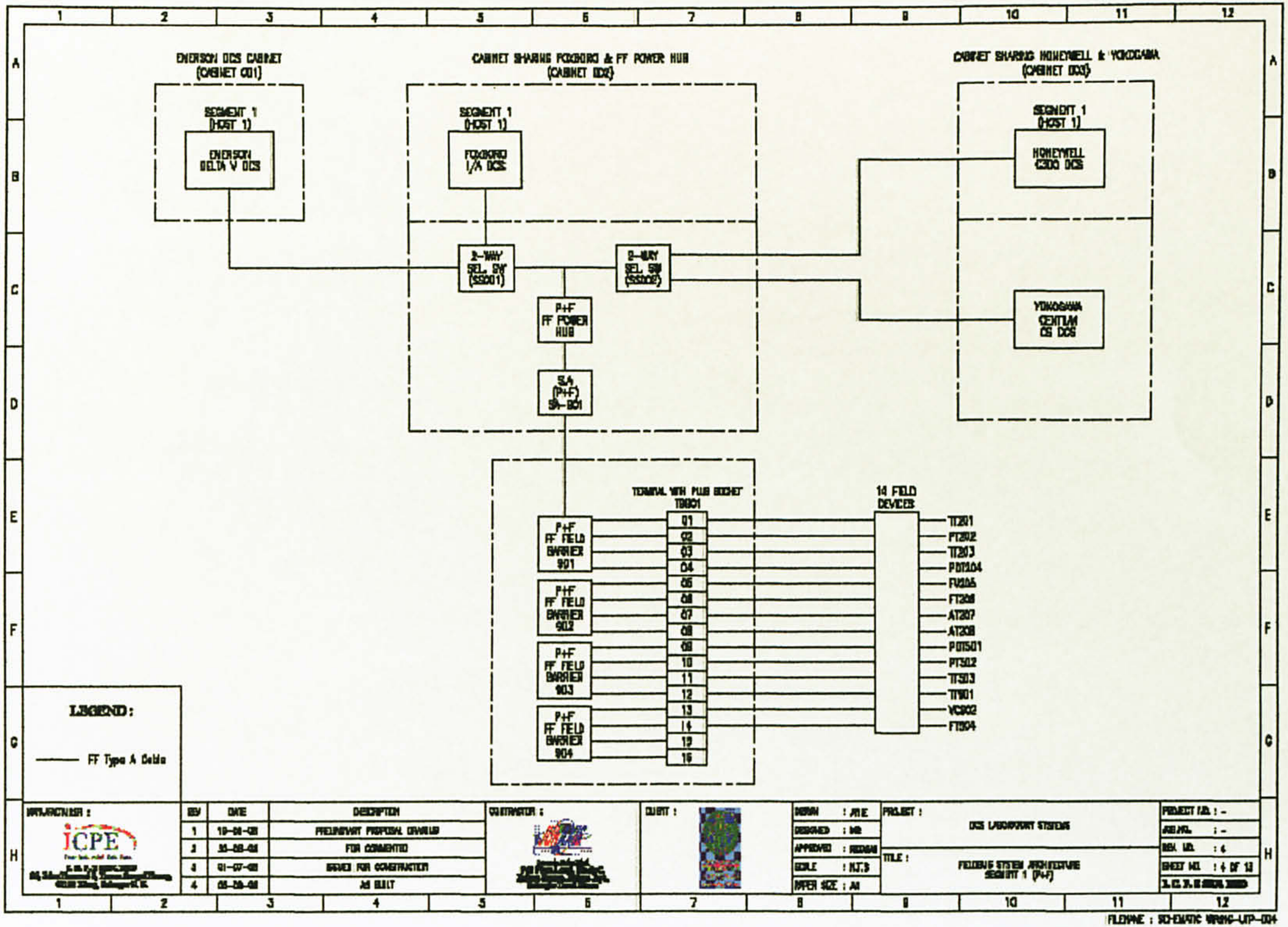
DCS LABORATORY SYSTEMS
TITLE :
NETWORK SYSTEM ARCHITECTURE



EMERSON DCS CABINET
(CABINET C01)
SEGMENT 1
(HOST 1)
EMERSON
DELTA V DCS
CABINET SHARING FOXBORO & FF POWER HUB
(CABINET C02)
SEGMENT 1
(HOST 1)
FOXBORO
I/A DCS
2-WAY
SEL. SW
(SS001)
2-WAY
SEL. SW
(SS002)
P+F
FF POWER
HUB
S.A
(P+F)
SA-801
CABINET SHARING HONEYWELL & YOKOGAWA
(CABINET C03)
SEGMENT 1
(HOST 1)
HONEYWELL
C300 DCS
YOKOGAWA
CENTUM
CS DCS
TERMINAL WITH PLUG SOCKET
TB001
P+F
FF FIELD
BARRIER
901
P+F
FF FIELD
BARRIER
902
P+F
FF FIELD
BARRIER
903
P+F
FF FIELD
BARRIER
904
01
02
03
04
05
06
07
08
09
10
11
12
13
14
15
16
14 FIELD
DEVICES
TT201
PT202
TT203
PDT104
FV105
FT206
AT207
AT208
PDT501
PT502
TT503
TT601
VC902
FT504
LEGEND :
FF Type A Cable
MANUFACTURER :
REV
DATE
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FOR COMMENTED
ISSUED FOR CONSTRUCTION
AS BUILT
CONTRACTOR :
CLIENT :
DRAWN
DESIGNED
APPROVED
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DCS LABORATORY SYSTEMS
TITLE :
FIELDBUS SYSTEM ARCHITECTURE
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REV. NO. : 4
SHEET NO. : 4 OF 12
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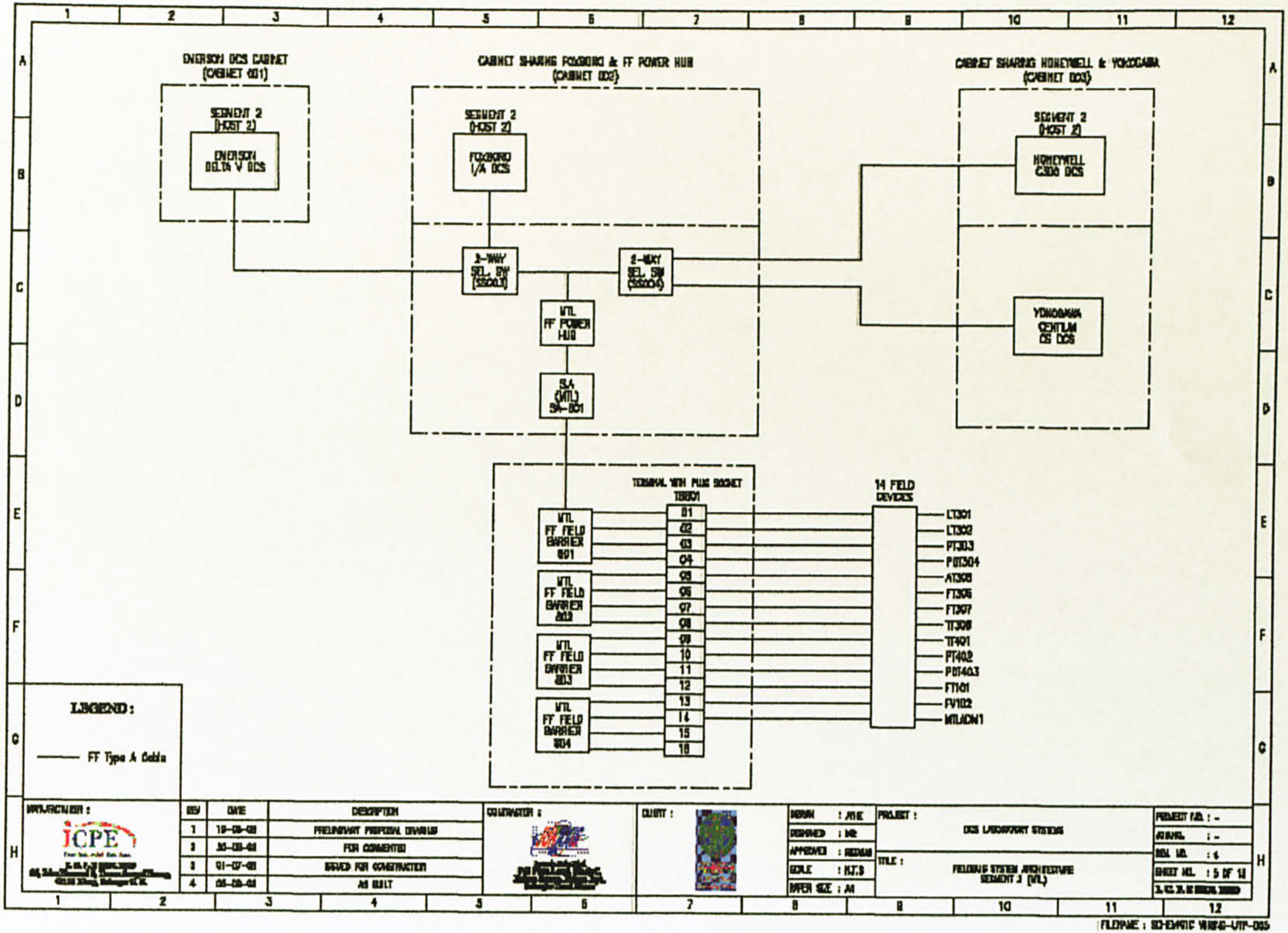
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SEGMENT 2 (HOST 2)
EMERSON DELTA V DCS
CABINET SHARING FOXBORO & FF POWER HUB (CABINET 002)
SEGMENT 2 (HOST 2)
FOXBORO I/A DCS
3-WAY SEL. SW (SS003)
2-WAY SEL. SW (SS004)
MTL FF POWER HUB
SA (MTL) SA-001
CABINET SHARING HONEYWELL & YOKOGAWA (CABINET 003)
SEGMENT 2 (HOST 2)
HONEYWELL C300 DCS
YOKOGAWA CENTUM CS DCS
TERMINAL WITH PLUG SOCKET TB001
MTL FF FIELD BARRIER 001
MTL FF FIELD BARRIER 002
MTL FF FIELD BARRIER 003
MTL FF FIELD BARRIER 004
14 FIELD DEVICES
LT301
LT302
PT303
PDT304
AT305
FT306
FT307
TT308
TT401
PT402
PDT403
FT101
FV102
MTLADM1
LEGEND :
FF Type A Cable
MANUFACTURER :
REV
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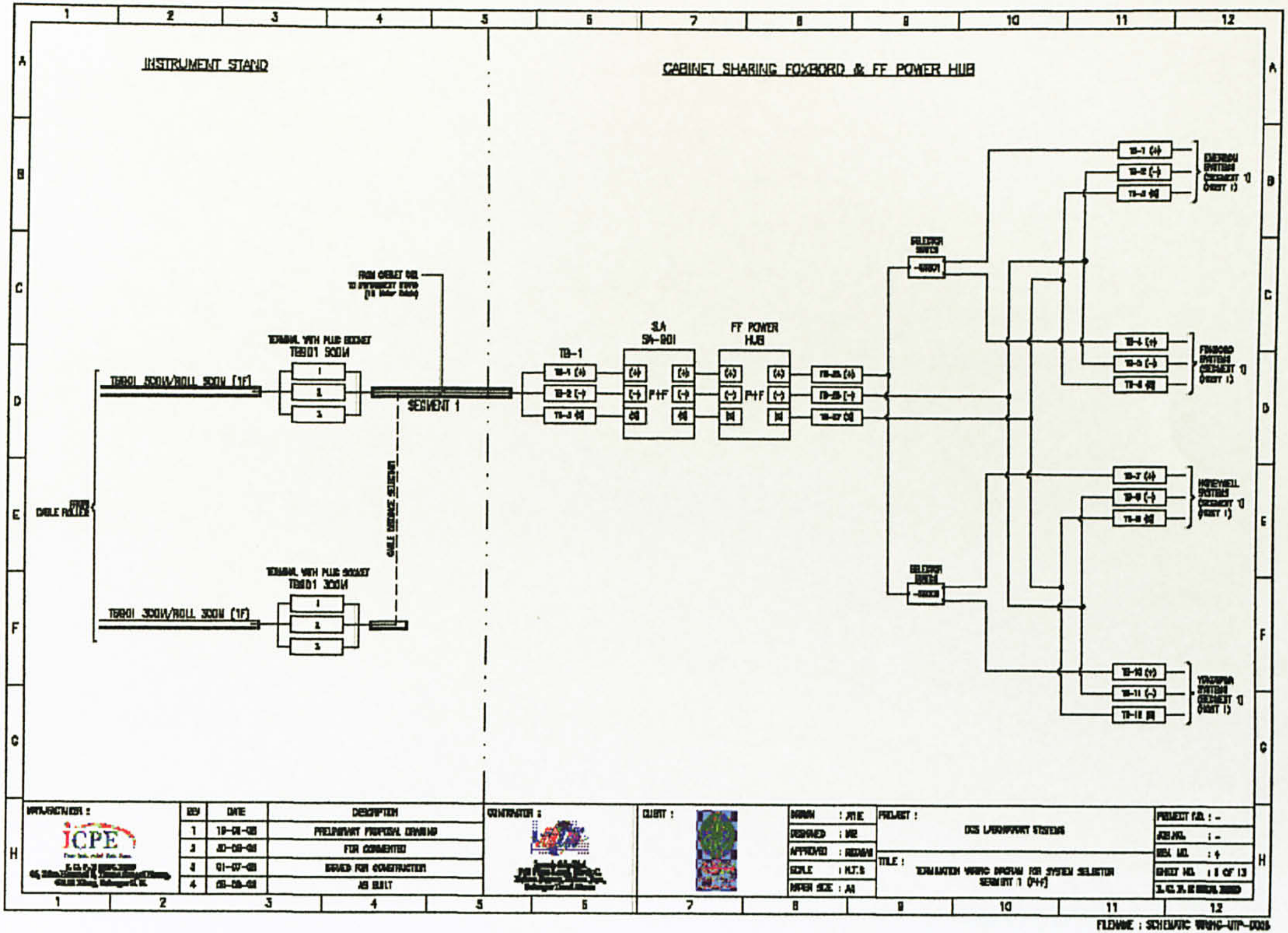
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TERMINAL WITH PLUG SOCKET
TB901 300M
SEGMENT 1
TB-1
FF POWER
HUB
SA-901
DCS LABORATORY SYSTEMS
DESCRIPTION
PRELIMINARY PROPOSAL DRAWING
FOR COMMENTED
ISSUED FOR CONSTRUCTION
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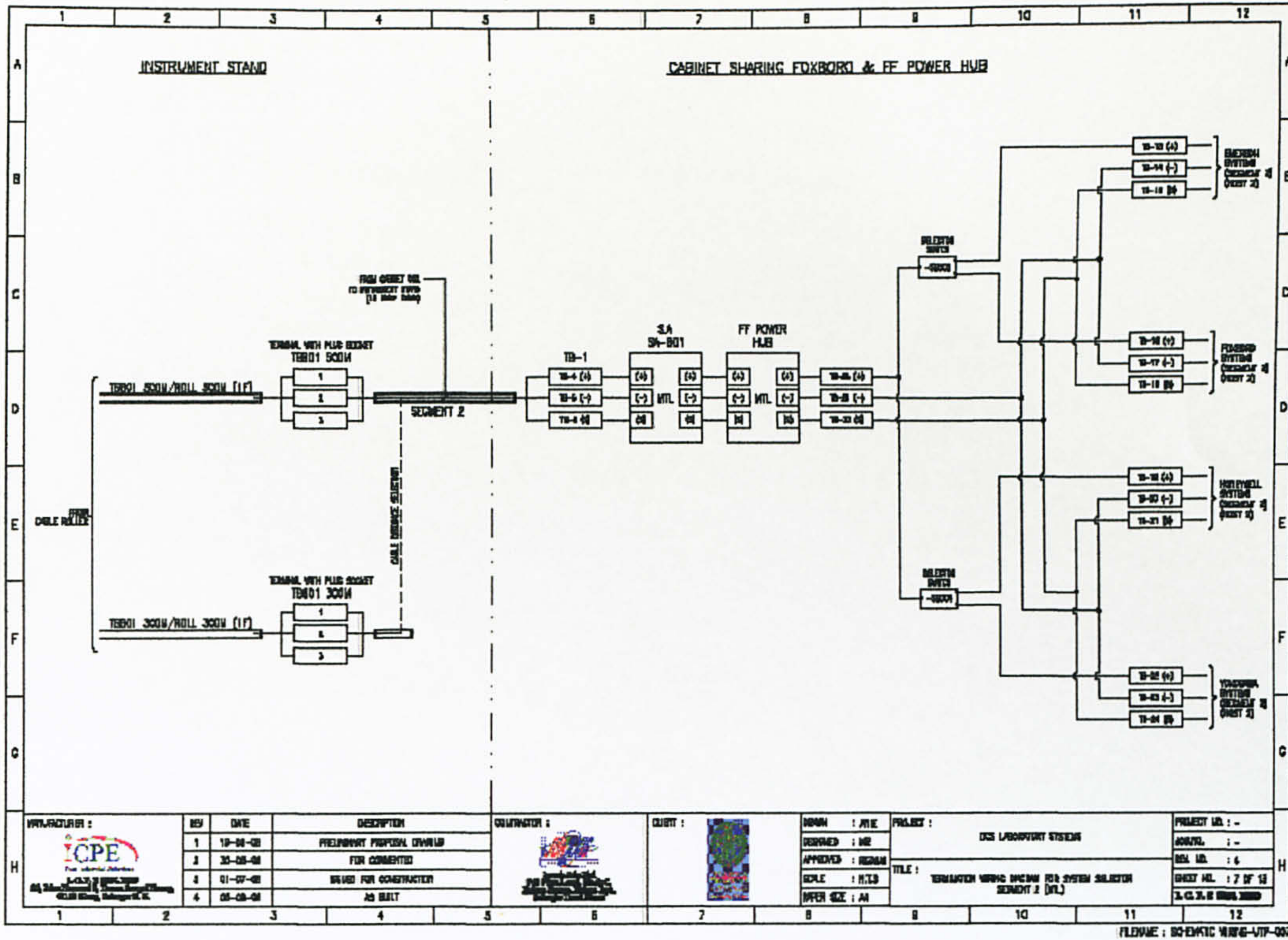
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TB801 300M/ROLL 300M (1F)
TERMINAL WITH PLUG SOCKET
TB801 500M
TERMINAL WITH PLUG SOCKET
TB801 300M
SEGMENT 2
CABLE DISTANCE SELECTION
TB-1
SLA
SA-B01
MTL
FF POWER
HUB
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REV
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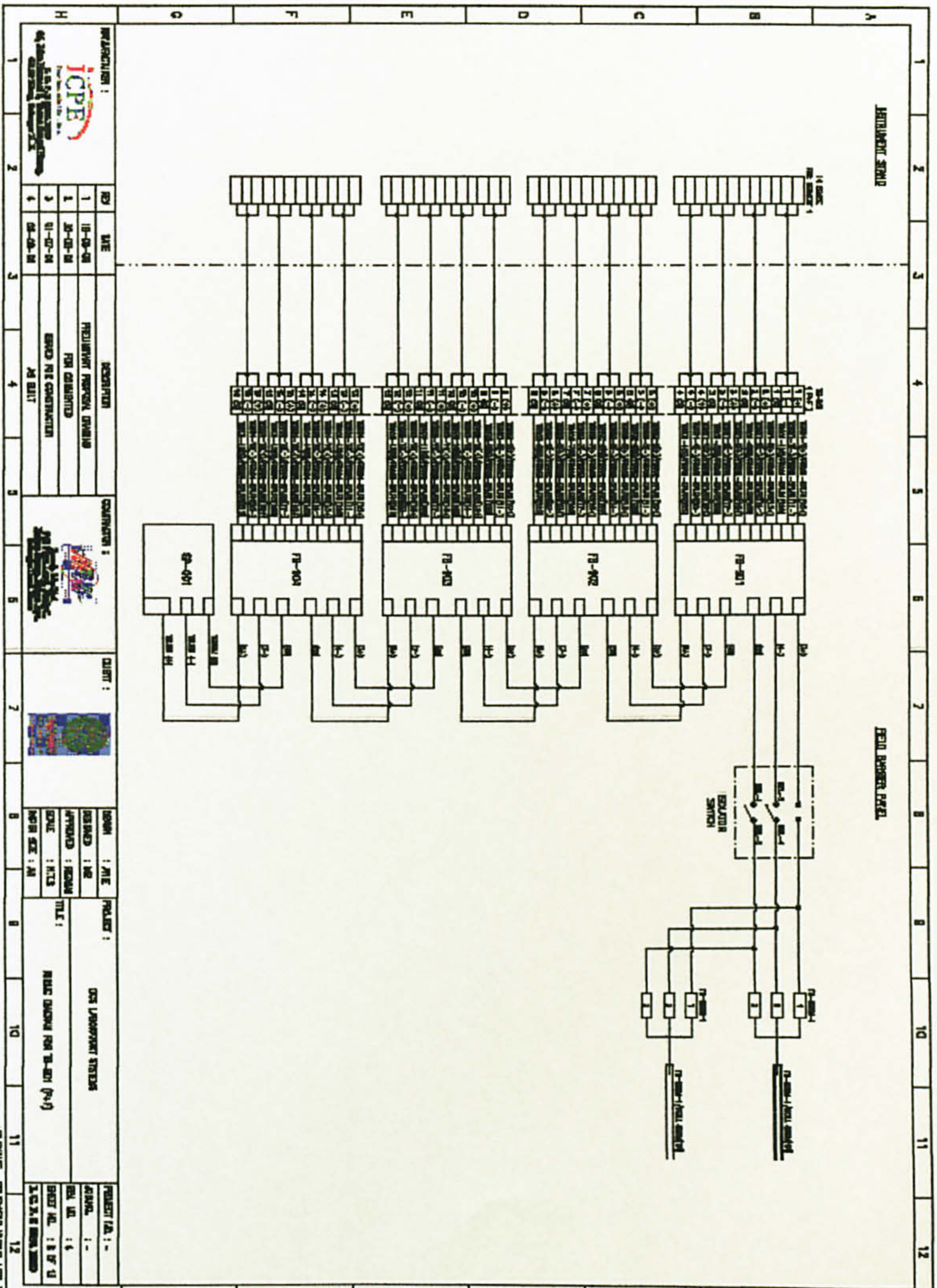

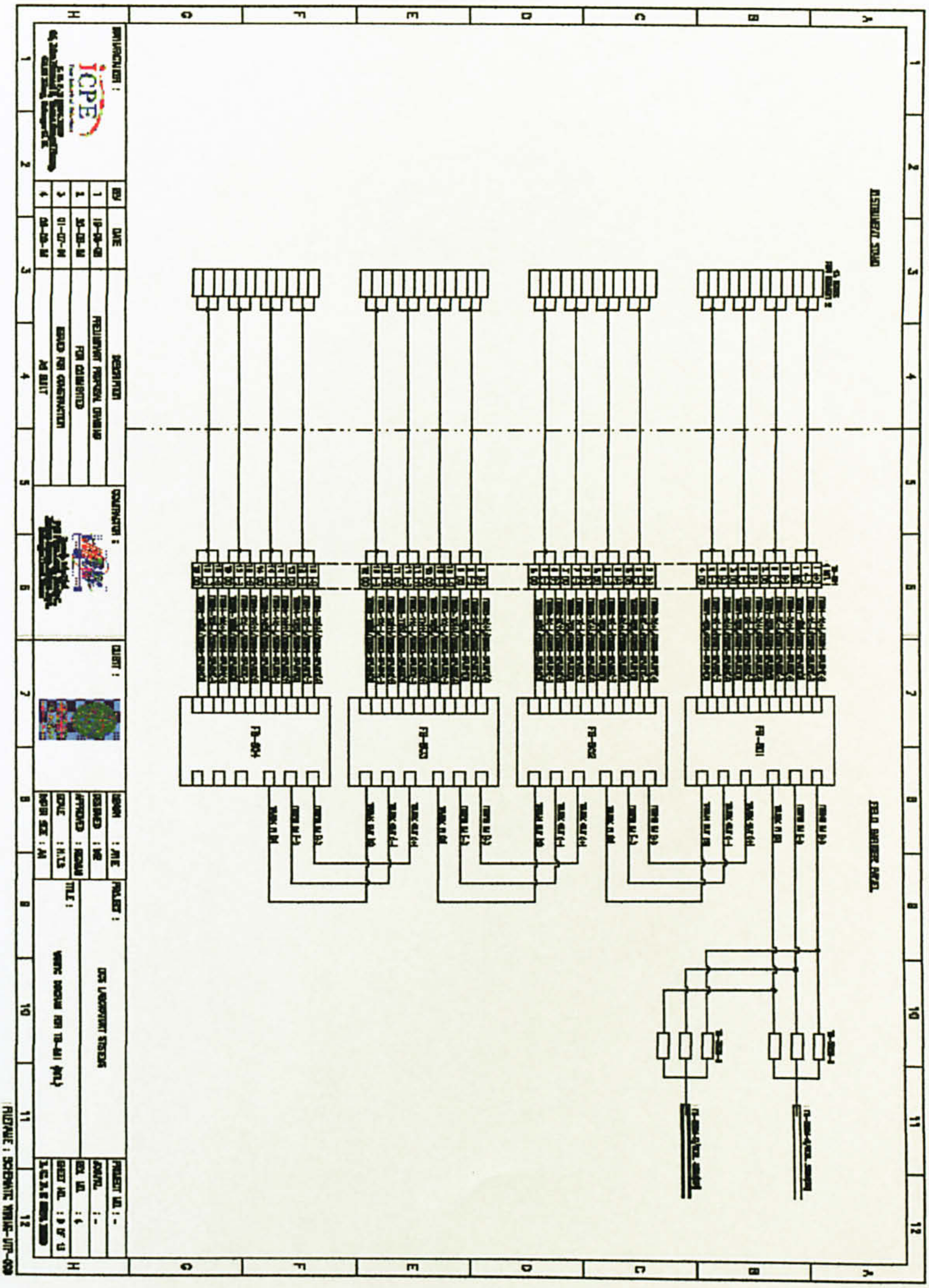

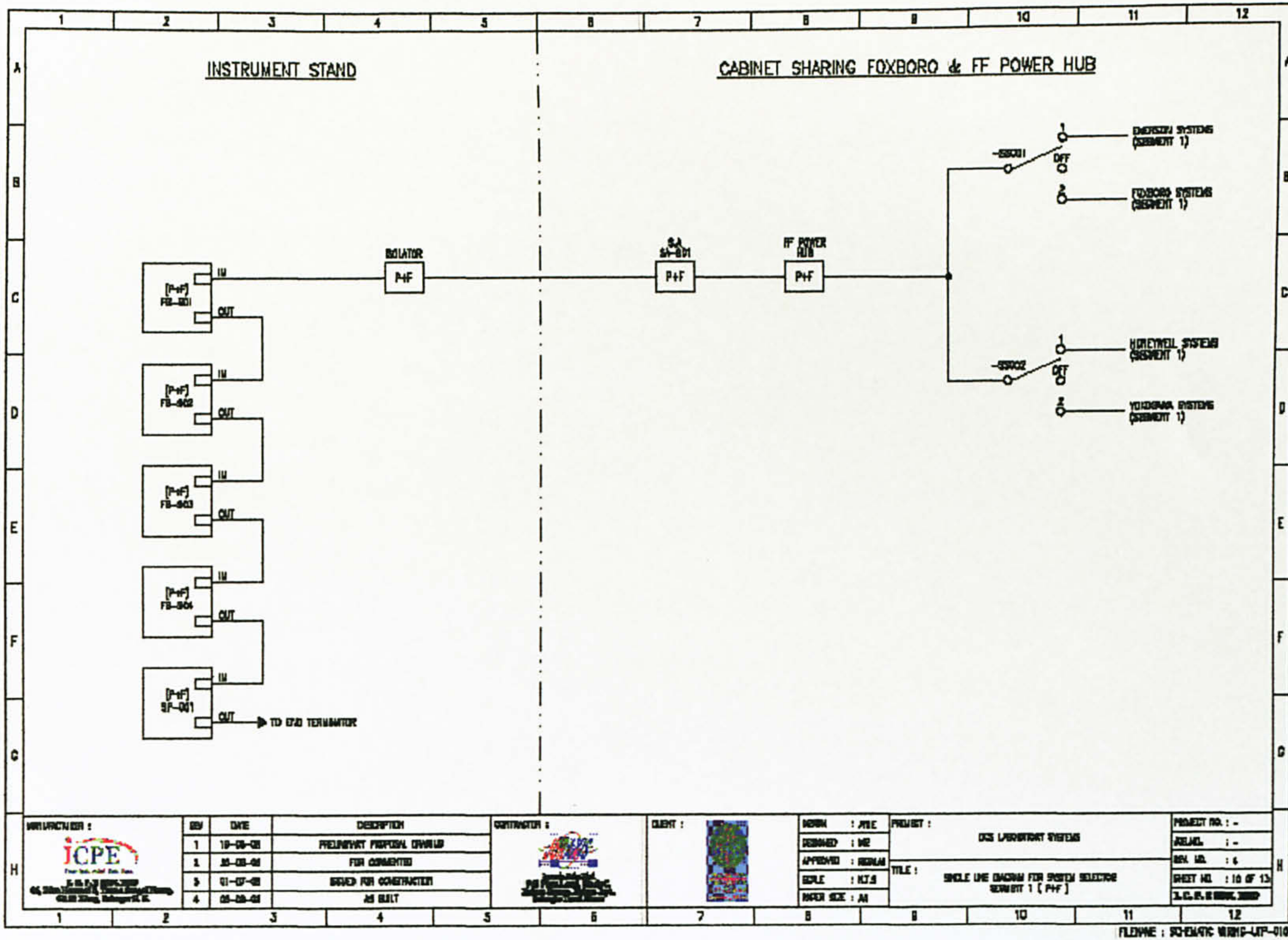
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ISOLATOR
P+F
FF POWER HUB
IN
OUT
TO END TERMINATOR
OFF
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FOXBORO SYSTEMS (SEGMENT 1)
HONEYWELL SYSTEMS (SEGMENT 1)
YOKOGAWA SYSTEMS (SEGMENT 1)
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ICPE
REV
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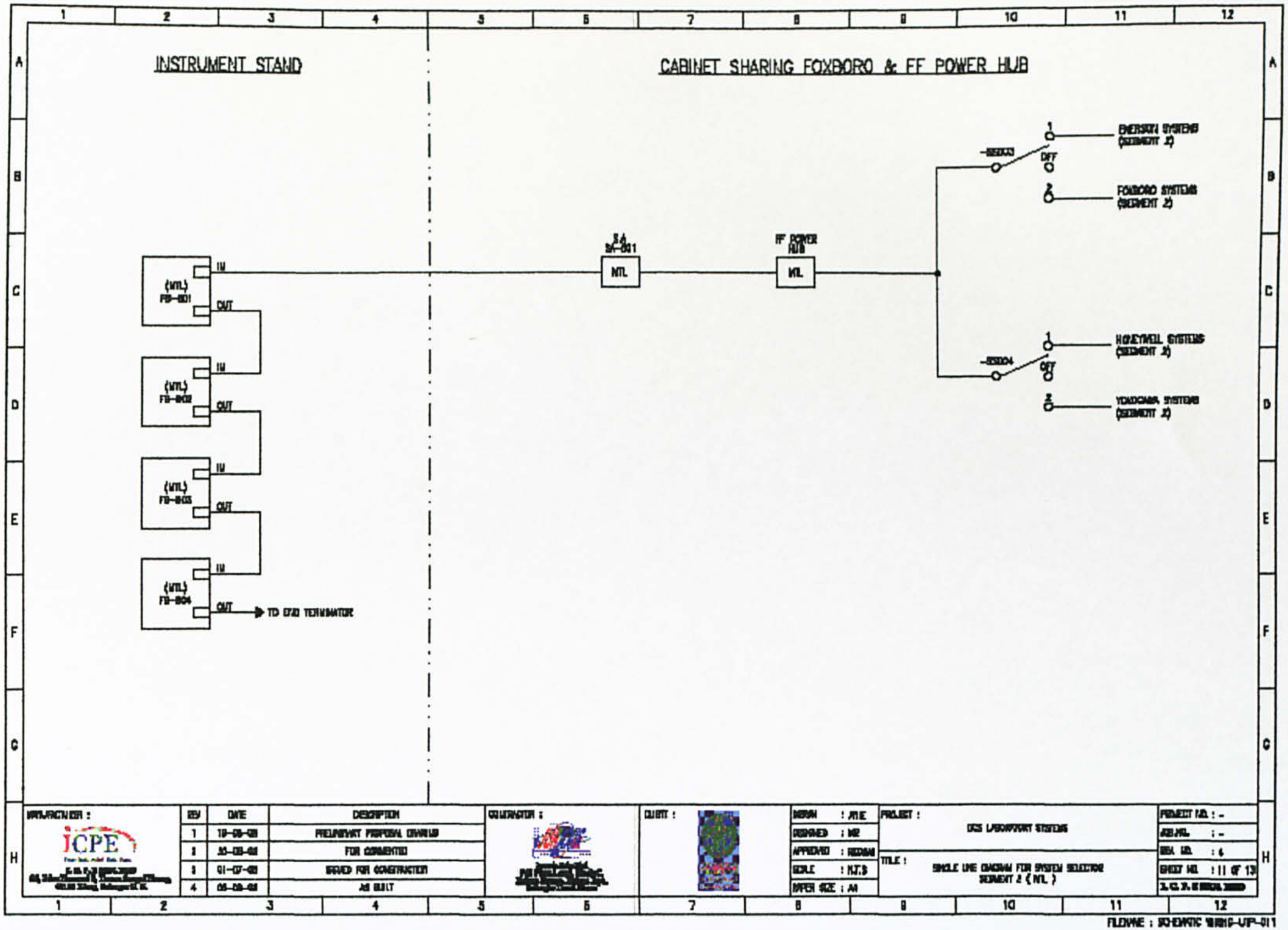

INSTRUMENT STAND
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(MTL)
IN
OUT
TO EXD TERMINATOR
MTL
FF POWER HUB
OFF
EMERSON SYSTEMS (SEGMENT 2)
FOXBORO SYSTEMS (SEGMENT 2)
HONEYWELL SYSTEMS (SEGMENT 2)
YOKOGAWA SYSTEMS (SEGMENT 2)
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ICPE
REV
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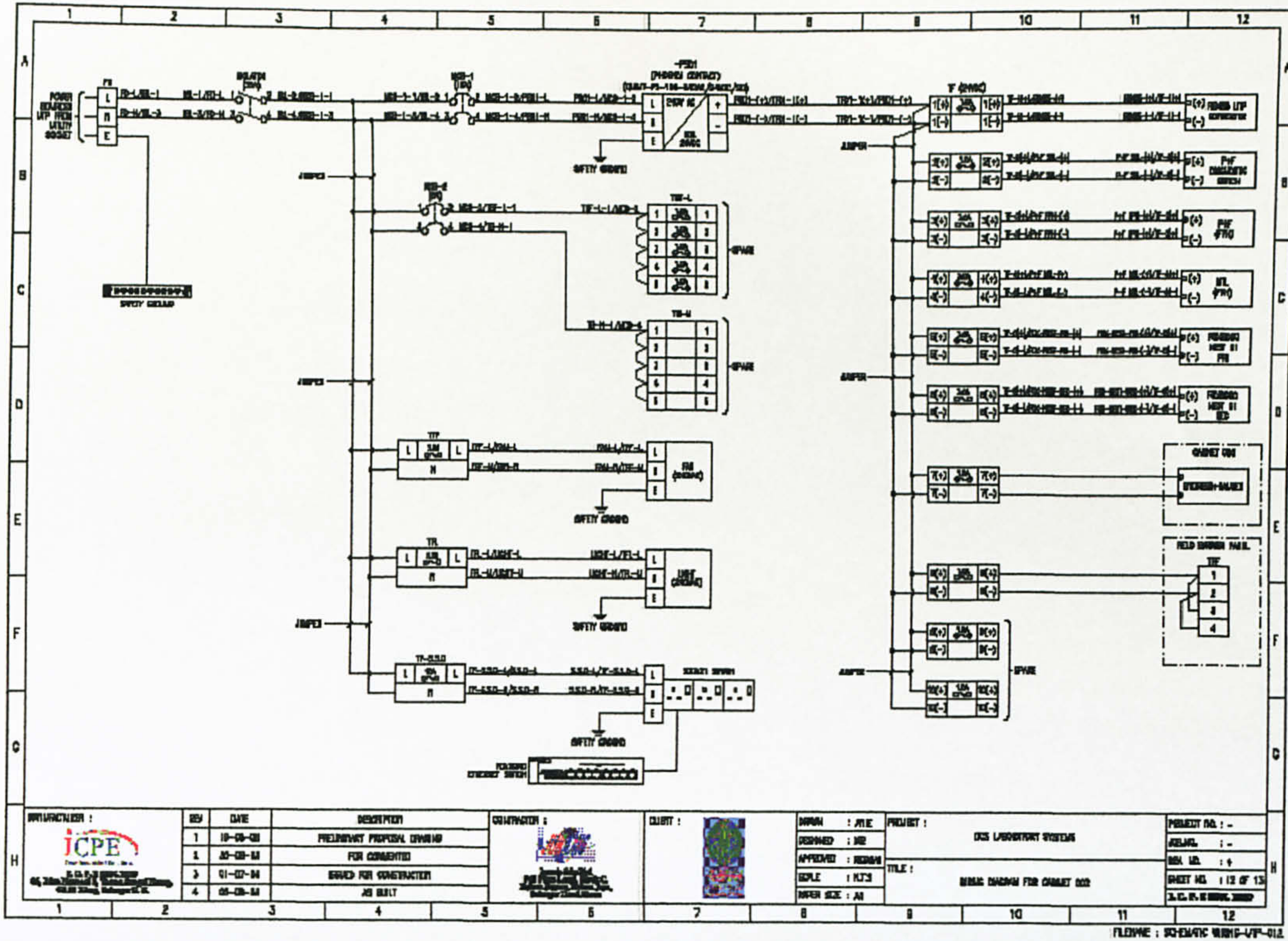
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JUMPER
SPARE
LIGHT
MANUFACTURER :
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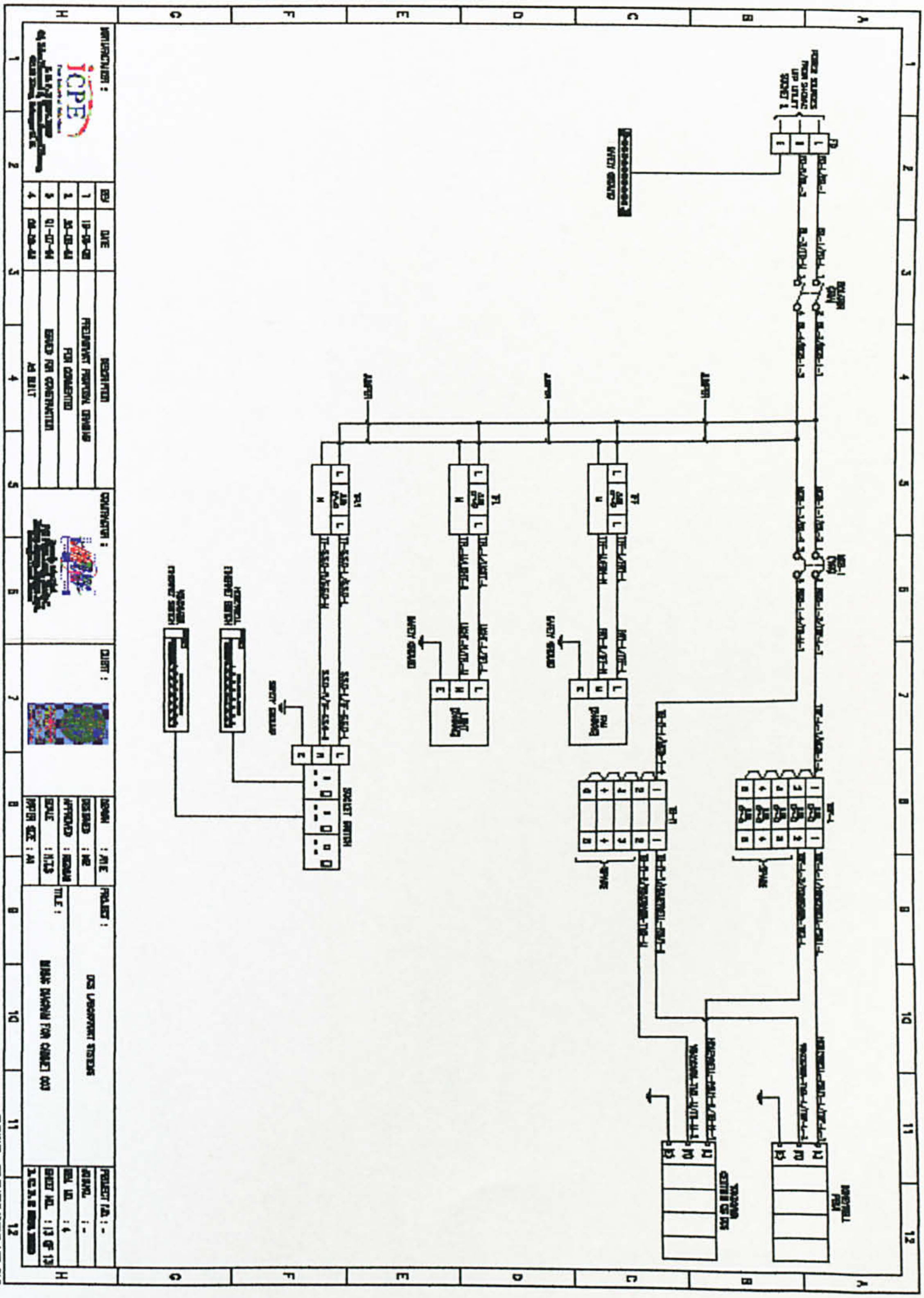

APPENDEX B: Gantt Chart

No.	Detail/ Week	1	2	3	4	5	6	7		8	9	10	11	12	13	14
1	Project Work Continue	■	■	■					Mid-Semester Break							
2	Submission of Progress Report 1				●											
3	Project Work Continue				■	■	■	■								
4	Submission of Progress Report 2									●						
5	Seminar (compulsory)										■	■	■			
5	Project work continue									■	■	■	■			
6	Poster Exhibition											●				
7	Submission of Dissertation (soft bound)													●		
8	Oral Presentation														●	
9	Submission of Project Dissertation (Hard Bound)															●

● Suggested milestone

■ Process