CHAPTER 1

INTRODUCTION

1.1 Background of Study

Fieldbus technology has been developed and designed for the field devices to reside on a powered bus and communicate with the host system. In contrast to conventional remote I/O system, fieldbus is used together with smart field devices where more reliable amount of data can be transmitted from the field to the main system. The function block is internally built into the field device. It also reduces the signal conversion compared to conventional analogue signal communication system as has been applied by the 4-20mA standards. It is believed that with fieldbus adopted in the mainstream process control, a reduced maintenance and operational costs, increased plant efficiency and performance, reliability optimization and easier asset management. All fieldbus field devices and host system that are made from different vendors supposed to be interoperable with each other.

1.2 Problem Statement

Interoperability and reliability including stress level of fieldbus devices are some of the major issues for the industry to fully implement this technology into process system. Therefore, a series of comprehensive test needs to be done to clarify all of the outstanding issues. The fieldbus system and smart field device also need to be properly configured to ensure a better utilization of the diagnostic alarm management system. An interoperability test needs to be done to detect any possible device conflict since different systems and devices are made by different manufacturers. Commissioning and decommissioning errors are also expected for each of the fieldbus segments and a thorough study of the unexpected problems is important as a method of trouble shooting. Where the host vendor or device come from should not be an issue. The other issue of fieldbus is the effect of noise and overvoltage that caused device drop off, controller robustness and fieldbus barrier interoperability. If the results obtained are convincing, it is safe to conclude that fieldbus is interoperable within multiple range of systems and devices. If not, steps need to be taken to solve the error and correct procedures should be worked out. Stress test is needed to be done to validate and record host and device durability. Among of the test elements include maximum noise level and overvoltage test, fieldbus controller robustness and fieldbus barrier interoperability.

1.3 Objective and Scope of Study

1) Interoperability Test

The objective is to test the interoperability of field devices from different vendors. The scope of interoperability includes Device Description (DD) files that allows host system to acknowledge field device and its parameters that can be tested through device commissioning and decommissioning.

2) Reliability Test

The objective is to verify the reliability of current fieldbus segment. The scope of reliability test includes segment design validation that requires a design to be simulated. The test data is compared against measured data and conform to the implemented High Power Trunk (HPT) concept.

3) Stress Test

The objective is to verify the maximum noise of a wire before device drop out occurred. The scope of stress test includes a maximum noise level check that a device can withstand with regard to the wire condition before device drop out will occur.

1.4 The Relevancy of Project

Interoperability and reliability tests including stress test have been done by following a specific methodological test approach. Regardless of which vendors the host system and field devices came from it should be able to communicate with each other and be able to reside on the powered bus. The ability of a host to recognize a device and knows all about the parameters made possible by a DD files. The devices and associated files that has passed testing done by Foundation Fieldbus (FF) might work properly with one system yet will have problems with the other system. It is important to note that each vendor have to follow FF standards and devices must passed a comprehensive verification test. Also, different vendors might have different optimization and enhancement of fieldbus system. Therefore, all of the tests done are important and relevant to the project.

CHAPTER 2

LITERATURE REVIEW/THEORY

2.1 Theory

Process control system as well as critical control system has adopted a new technology based on fieldbus infrastructure. Fieldbus is known as a digital two way communication technology linked with smart measurement and control devices, operating on 31.25 kb/s using the H1 technology that used a Shielded Twisted Pair (STP) cable where decoding is unnecessary [1]. The reason is all of the signal are coded in the same form and had been standardized for the use of all fieldbus devices. Processing time of measurement data and signals henceforth is faster since the elimination of encryption/decryption process that takes more time to process, depending on the complexity [2].

Interoperability of fieldbus field devices and systems made by different manufacturers although theoritically is not an issue [3], tests still need to be done to rectify and record a possible technical errors as what has happened at a few Foundation Fieldbus installations in PETRONAS so that a proper study can be conducted and a troubleshooting or maintenance can be done accordingly [4].

Reliability test is also important and needs to be conducted comprehensively to ensure an uninterrupted communication or device failure, which normally termed as device drop out [5]. Diagnostic parameter should match standards set by Foundation Fieldbus. An unreliable system would render the process control system to fails accordingly and lead to a possibly catastrophic event [6] [7].

The theoretical claims of H1 cable length is 1900 meters [8]. However the practical length when installed with devices remains to be experimented in this project. Each of the fieldbus segments could be installed with up to 32 devices. The case is different when maximum current requirement is taken into account.

The common problem when transmitting a signal over a long distance using a cable is that there will be a voltage drop. Having taken this fact into account, an empirical approach is set to test the voltage magnitude that can be delivered to the farthest of the segment's end [9].

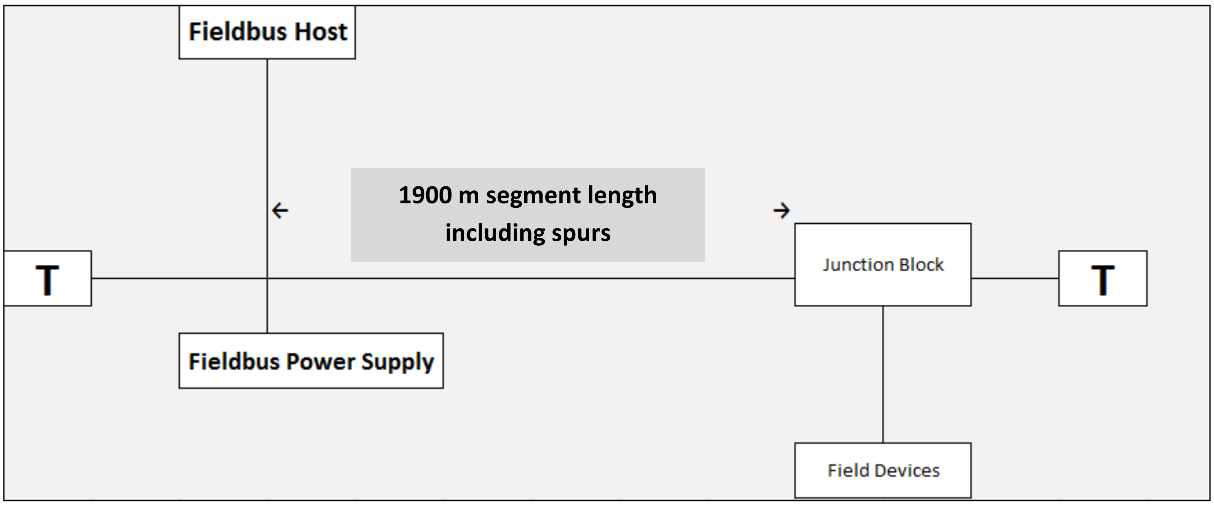

Figure 1: Fieldbus connection and segment length

Figure 1 shows a fieldbus connection with terminator at both end. Fieldbus used in process systems, if proved to be interoperable and reliable will be used widely in the industry and changed the dynamics of process control system. The technology itself offers numerous advantages and that is why most industry players want to implement the technology in their process systems and developers to keep improving and setting new standards for the establishment of fieldbus communication.

CHAPTER 3

METHODOLOGY/PROJECT WORK

3.1 Procedure Identification

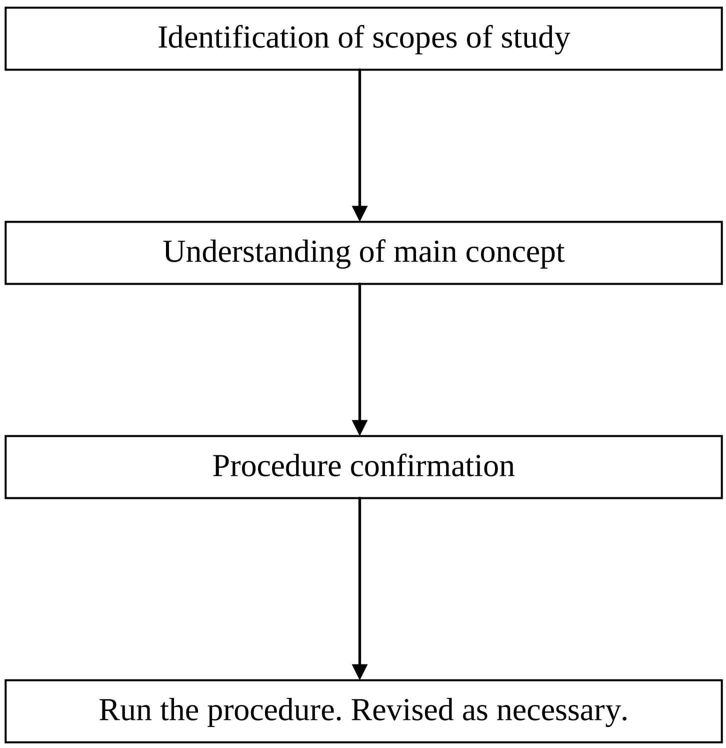

Figure 2: Procedure Identification Sequence

Figure 2 shows the steps for procedure identification sequence. The first step in procedure identification is to identify the scope of study with regard to the wide fieldbus area. Next, when the scopes are identified, the main concept of each scope needs to be understood before the procedure can be confirmed. Lastly, the procedure is tested for practicality by running it and revised as necessary according to the different host systems. This is important because different host system might have different software and hardware design. For instance, a procedure that works for Emerson host system might not be working with Foxboro host system due to the Live List function that it has.

3.2 Interoperability

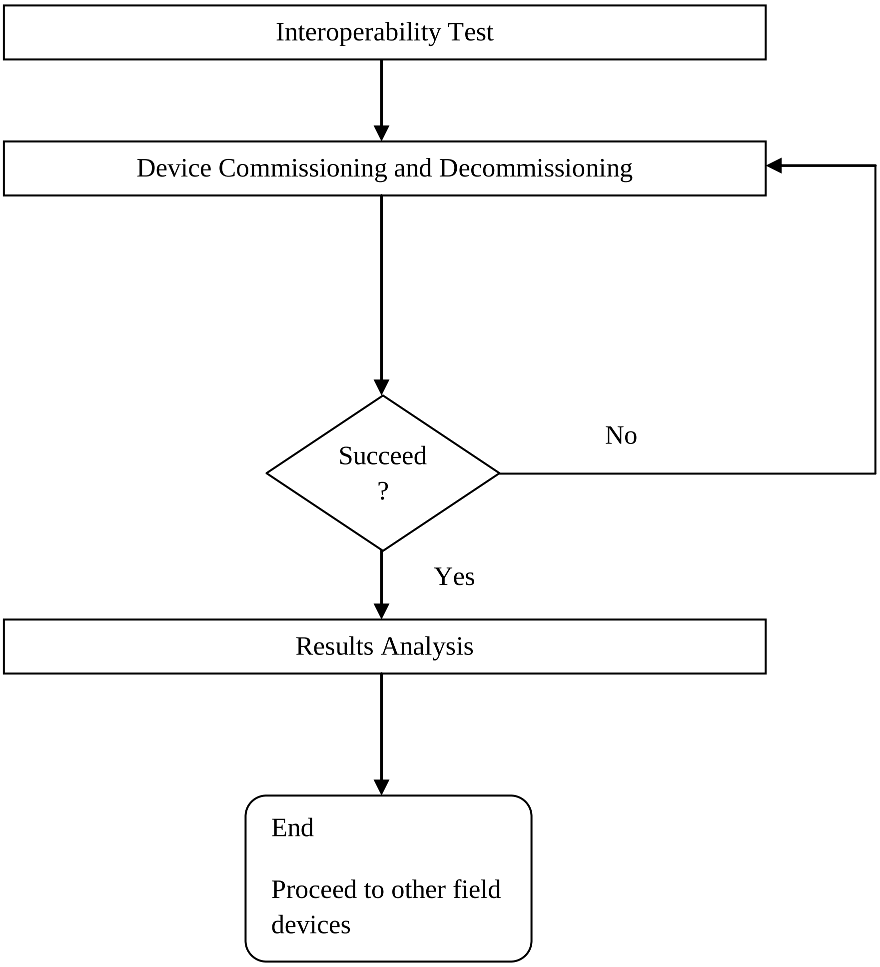

Figure 3: Interoperability Test Methodology

Testing of fieldbus devices interoperability made by different manufacturers is done by commissioning and decommissioning the element installed to the fieldbus segment. In this project, there are two segments used. Each segment consists of 12 field devices including temperature, flow, level, pressure transmitters and one valve. Fieldbus field device integration into the system's performance is measured through observation from host system control system. Fox Computer Aided Engineering software (IACC) is used to configure and integrate field devices to host system (Foxboro). Device commissioning and decommissioning time is observed through the system configuration download results and recorded so that system acknowledgement time of field device commissioned can be estimated. Detailed report on the result is generated using function from Fox CAE and used as an analysis and troubleshooting reference. Test procedures are included in Appendix IV.

3.3 Reliability Test

Reliability test scopes of work are subdivided into two which are hardware and software reliability. For hardware, reliability can affect interoperability. The fieldbus field devices use a stack of Link Active Scheduler (LAS) that separates time critical process data (refer to Appendix I). Its most important function is to control the traffic on the bus. Field devices of different types and manufacturers are installed per segment of the fieldbus and by doing so digital communication signals on a link can be verified of any interference, signal crossover and data synchronization by LAS. Should LAS fail to function properly signal from field devices will not be able to communicate with main system in an acceptable manner thus jeopardizing its reliability (refer to Appendix I). For software reliability, sequence of events are observed to ensure consistency with previous or current work. Software data accumulation of measurement signal from field devices should work for the specified scan time. For process systems the acceptable scan time is 3 seconds. Figure 3 shows the interoperability test methodology.

Fieldbus segment design check is used for design validation of fieldbus segments. P+F Segment Design Checker is the design software tool in the validation process. Validation result is then used to compare with actual readings measured using Digital Multi-Meter (DMM) from lab.

The system used a tree topology with High Power Trunk concept as shown in Figure 4. In contrast to the FISCO/FNICO concepts, the High Power Trunk concept does not limit the energy on the Fieldbus segment cable to intrinsically

(FISCO) safe or non incendive levels (FNICO). The concept allows the energy on the spur connections to be limited to the instruments. This permits the maximum number of devices on a segment while also being able to achieve maximum cable lengths. The energy limitation for protection is done in the field, inside the junction box.

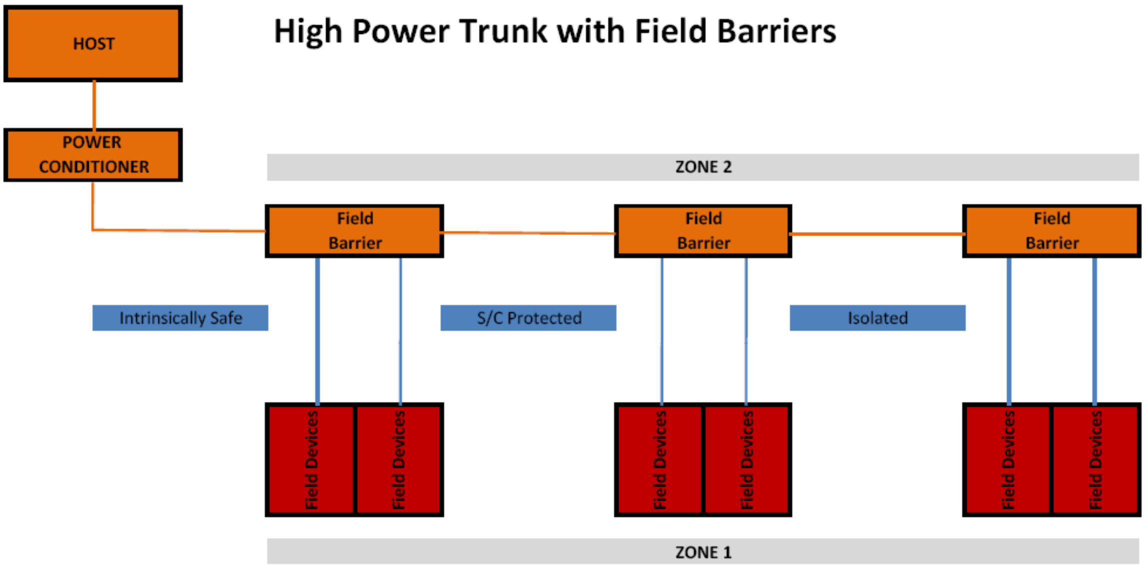

Figure 4: High Power Trunk Concept diagram for Reliability Test

Figure 4 shows the High Power Trunk (HPT) concept with the usage of power conditioner instead of normal power supply and Field Barrier instead of a typical junction box. Figure 5 shows the segment design validation methodology that involves segment design where simulation of host system and field device is done based on current configuration. The design is validated before being run to simulate the result and finally the data obtained from the simulation is observed.

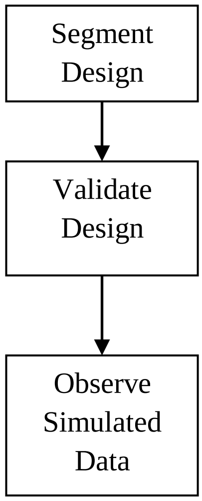

Figure 5: Segment Design Validation Methodology for Reliability Test

3.4 Stress Test

Stress test is done as part of the interoperability test and mainly consists of three parts which are the effect of noise, field barrier interoperability and controller robustness. It is mainly aimed to study the effect of unexpected interference in forms of noise or high voltage on the wire and response of the system.

The test is conducted to check the maximum noise or voltage level that the device can withstand before drop out will occur. The equipments used for this test are signal generator, oscilloscope, and field transmitter. The hook up diagram is shown in Figure 6.

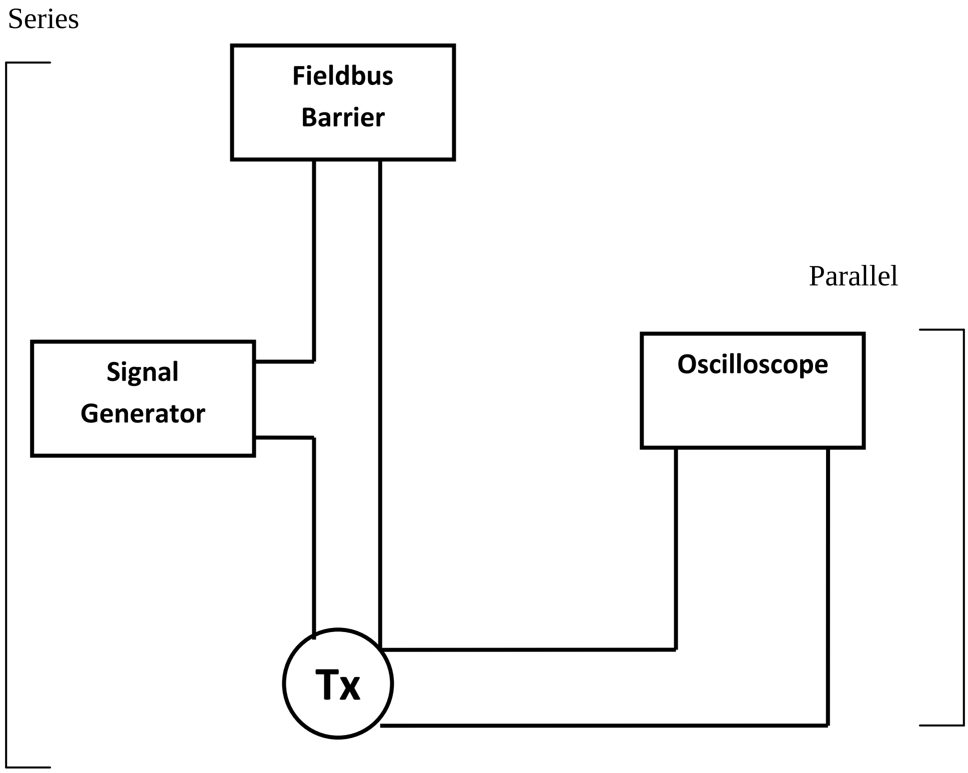

Figure 6: Maximum Noise Level Test Diagram

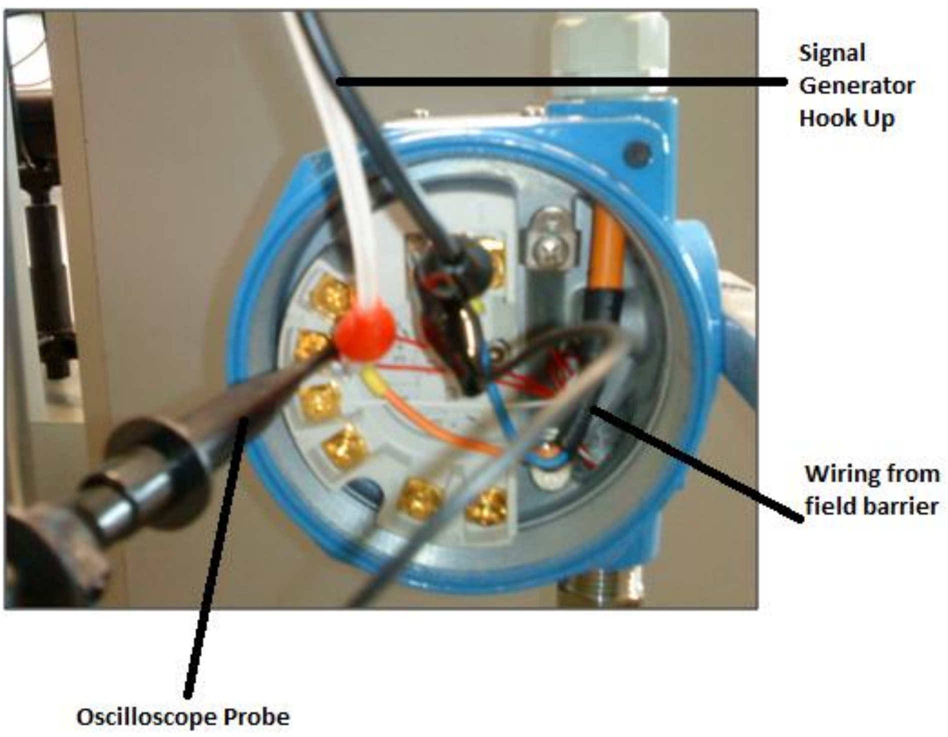

Figure 7: Maximum Noise Level Actual Hook Up and Termination

Figure 7 shows the actual hook up of signal generator, oscilloscope and wiring from field barrier for maximum noise level test. Figure 8 shows the initial oscilloscope setting and calibration before the signal from generator is injected to the field device.

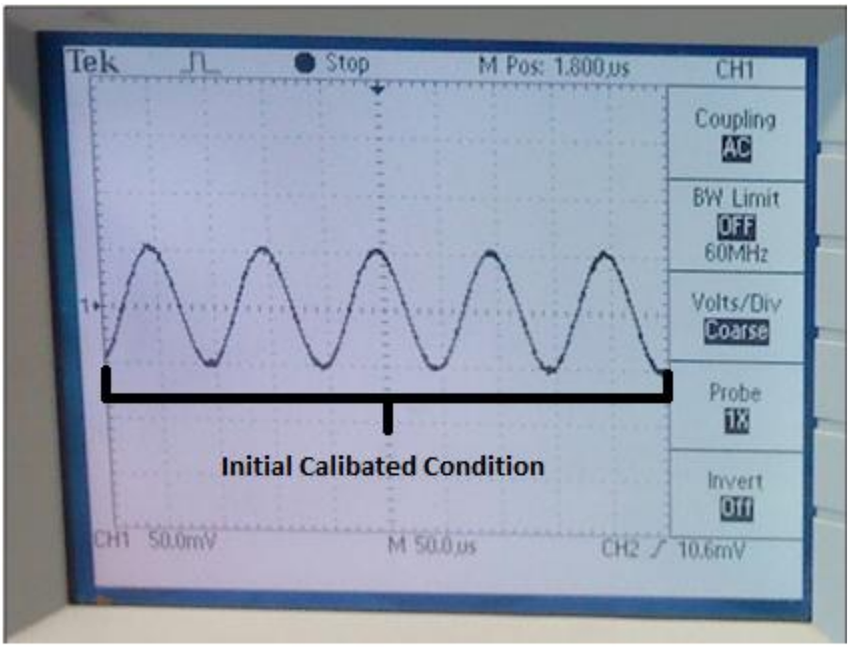

Figure 8: Initial Oscilloscope Setting

The transmitter is connected in series with the signal generator and field barrier while in parallel with oscilloscope. The frequency of the signal generator is set to 10 KHz. The amplitude of the signal is varied in order to obtain a different noise level which is injected to the transmitter. Signal measurement is plotted and observed through the oscilloscope.

3.5 Tools and Equipments Used

The following are the tools and equipment used :

- Hardware
  - Foxboro Host System – Consisting of main controllers, central processor processors and fieldbus module.

- 375 Fieldbus Communicator – Used for field device monitoring and calibration.
- Oscilloscope – Used in stress test for signal output reading and monitoring.
- Signal Generator – Used in stress test for signal injection to the field.
- Engineering Workstation (EWS) – Main workstation for fieldbus system configuration.

- Software
  - Foxboro IACC Computer Aided Engineering Software – Software for system configuration and monitoring.
  - Pepperl + Fuchs Segment Checker – Software for segment design and validation.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Results

The following are the results of the tests that have been done. This test includes fieldbus device commissioning, decommissioning and stress test which covers the scope of interoperability and reliability. Segment validation check is conducted to simulate the current configuration of fieldbus network that uses HPT concept instead of FISCO and FNICO. Among of the tests that have been completed to date are device commissioning, decommissioning, segment design validation and stress test to determine the maximum noise level before device drop put will occur.

4.1.1 Device Commissioning

The result of device commissioning is shown in Table 1. Only 8 devices on segment 1 are tested because the other 4 devices on this particular segment currently need to be offlined due to configuration issues and only transmitters are selected for testing.

Table 1: Device Commissioning Status

Tag	Description	Manufacturer	Status	Remark
LT301	Level Tx	Endress &Hauser	Ok	Commissioned
LT302	Level Tx	Endress &Hauser	Ok	Commissioned
PT202	Pressure Tx	Rosemount	Ok	Commissioned
TT203	Temperature Tx	Rosemount	Ok	Commissioned
TT503	Temperature Tx	Yokogawa	Ok	Commissioned
FT101	Flow Tx	Honeywell	Ok	Commissioned
FT504	Flow Tx	Yokogawa	Ok	Commissioned
TT307	Temperature Tx	Honeywell	Ok	Failed

Field devices consisting of valves will be tested once the configuration procedure is completed. All of the field devices except for Honeywell Temperature Transmitter TT307 successfully commissioned. It failed due to Device Description (DD) files incompatibility with Foxboro Host system. However it is noted that the same DD file works well with other Host System despite having the same version of file being installed for the particular field device. The problem has been forwarded to vendor for further investigation.

4.1.2 Device Decommissioning

Table 2 shows the device commissioning status. All of the field devices except for Honeywell Temperature Transmitter TT307 successfully decommissioned. The same transmitter is not able to be decommissioned.

Table 2: Device Decommissioning Status

Tag	Description	Manufacturer	Status	Remark
LT301	Level Tx	Endress &Hauser	Ok	Decommissioned
LT302	Level Tx	Endress &Hauser	Ok	Decommissioned
PT202	Pressure Tx	Rosemount	Ok	Decommissioned
TT203	Temperature Tx	Rosemount	Ok	Decommissioned
TT503	Temperature Tx	Yokogawa	Ok	Decommissioned
FT101	Flow Tx	Honeywell	Ok	Decommissioned
FT504	Flow Tx	Yokogawa	Ok	Decommissioned
TT307	Temperature Tx	Honeywell	Ok	Failed

Commissioning and decommissioning data of several devices on segment 1 and 2 as shown in Table 1 and Table 2 are obtained through the empirical method. Only devices with online status are chosen for the purpose of this test because of known problems with other off lined devices, which can be trouble-shooted in later times. Tools used are the IACC workbench for Foxboro system and Emerson 375 Field Communicator for fieldbus devices. The total time taken for each devices is three minutes.

4.1.3 Segment Design Validation

The complete test result can be referred to the Appendix II attached to this report. Shown below are brief details of the obtained test data. Shown in Table 3 is the project parameters and description. The parameters are set to simulate the actual configuration. Table 4 shows the segment checker summary with simulated High Power Trunk design concept with $0.8mm^2$ (AWG18) cable.

Table 3: Project Parameters and Description

Parameters	Description
Segment type	Fieldbus Foundation: FieldBarrier
Cable type	A $0.8mm^2$ (AWG 18)
Environment type	46°C (ambient temperature added)
Default Field Device Current	10mA
Default Spur Length	0.5m
Short Circuit Checking	On

Table 4: Segment Checker Results

Checker Summary	
Topology Check	success
Power Distribution Check	success
Short Circuit Check	success

The simulated field devices operating voltage and other specific data of the fieldbus system that is designed based on fieldbus High Power Trunk concept are shown in Appendix II of this report. The measured field devices operating voltage are listed in Table 5 for segment 1. Measured devices operating voltage are compared with actual parameter set by Foundation Fieldbus which is 9V. Voltage tolerance is +/- 0.05% or from 11.4V to 12.6 V from parameter value. This is also conform to voltage level not exceeding 12.8V for HPT stated by Pepperl + Fuchs while still in a safety margin which means the voltage is above 9V minimum.

Table 5: Measured field devices operating voltage

Devices	Measured voltage (V)	Remarks (Tolerance)
FT 206	12.14	+/- 5 %
AT 207	11.54	+/- 5 %
TT 201	11.51	+/- 5 %
TT 203	12.21	+/- 5 %
PT 202	11.89	+/- 5%
PT 501	12.07	+/- 5 %
PT 502	12.04	+/- 5 %
TT 503	11.92	+/- 5 %
PDT 204	12.27	+/- 5 %
TT 902	11.88	+/- 5 %
TT 901	11.84	+/- 5 %
AT 208	11.54	+/- 5 %
FT 504	11.51	+/- 5 %

4.1.4 Stress Test Result

The field device is randomly selected. The purpose is to compare the maximum noise level a device can withstand. It is perceived that different field device can withstand a different maximum noise level before device drop out or communication failure.

Field device : Temperature Transmitter TT 308
Field barrier : MTL Field Barrier
Segment : 2
Frequency : 10 khz

Figure 6 shows the noise level variation and device condition with respect to noise level. The noise level and device condition parameters as shown in the Table 6 are set by Fieldbus Foundation through FBT documentation as a reference for the stress level test.

Table 6: Noise level variation and device status condition

Noise Level	Device Condition
50 mV or Less	Normal
50-100 mV	Normal
100-150 mV	Normal
150 mV or More	Device dropout

Table 6 shows the noise level variation and device condition with respect to noise level. The noise level and device condition parameters as shown in the Table 6 are set by Fieldbus Foundation through FBT documentation as a reference for the stress level test.

4.2 Discussions

The discussions are carried on based on the obtained tests result which has been done and stated in section 4.1. Findings and troubleshooting measures are included in this section where necessary. Result justification is important to show the relevancy and reliability of the obtained empirical data. As an additional note for interoperability and reliability, based on discussions done with PETRONAS Group Technical Support engineer there are practical issues regarding fieldbus technology as being experienced by PETRONAS Penapisan Melaka plant. It appears that an interoperability problem caused by the Link Active Scheduler that allows one signal to be transmitted at a time did not work in a desired manner. It can be inferred that the signals come from multiple devices interfered with each other which resulted in uncontrolled traffic. This fact justifies further the importance of tests conducted in this project to if not solve, rectify the problem. If the problem persists, the test should be conducted in a different point of view which involves digital signal processing scope of work

4.2.1 Commissioning

Commissioning of field devices can be determined to be successful via a configuration download that is performed with no error and its status in the CP003 configuration and Fox CAE Live List. All of the four devices on each of segments 1 and 2 based on the results are installed and working properly. H1 card will detect new devices attached to the card through the Link Active Scheduler is seen in the commissioned directory, Fieldbus Block module in the Instrumented Automation (IA) series software. A successful commissioning will enable the resource, transducer and function blocks be accessed from system Engineering Work Station (EWS). Device commissioning map the virtual field device in the system to the link of H1 card and physical devices through the aid of Device Description (DD) files that acts like a driver hardware for the computer to be able to acknowledge the device. It is noted that device download, that is performed before commissioning did not affect the system or other devices in the segment. Refer to Appendix III for more details on findings.

4.2.2 Decommissioning

Decommissioning of field devices can be determined to be successful via its status in the CP003 configuration and Fox CAE Live List. All of the four devices on each of segments 1 and 2 based on the results are installed and working properly. Obviously from the result in Table 4, LT 301 and FT 101 which is installed on segment 2 of the fieldbus network still exist in the Fox CAE (IACC) live list in contrast to the CP 003 configuration which reported to be normal (disappeared) after device decommissioning are performed. This error however does not occurred to the device installed in segment 1 which are LT 302 and FT 102. The Live List will enable the function to explore Device Description (DD). In this case, it shows that Live List still acknowledged two of the devices in segment 2 even after being decommissioned and deleted from configuration. This is because Live List function actually depends on DD files. Decommissioning also serves the purpose of setting the field device to be in offline mode for maintenance or device replacement. It also functions to detach field device from the system by disconnecting the link from H1 card to the physical layer of fieldbus system. The device must be removed from the segment once it has been put in an offline state. Refer to Appendix III for more details on findings.

4.2.3 Segment Design Validation

The current installation of fieldbus system is utilising the High Power Trunk concept which permits power restriction free of fieldbus segment. The minimum operating voltage for field devices is 9V as specified by Fieldbus Foundation to ensure that at least 9V of potential difference can be delivered into the farthest end of the segment and maximum is 32 V. From Table 5 which shows the measured devices operating voltage of an average 12V with 13 devices installed for segment 1, it can be well concluded that the current segment is well fitted and maximum current requirement of each device and the length of segments have well taken into account.

4.2.4 Stress Test

Standard noise average for fieldbus device should not more than 50 mV which is in accord to the Fieldbus FBT-3 documentation. This is because different noise level will have a varied effect on wire condition as shown below:

Table 7: Noise level and wire condition

Noise Level	Wire Condition
25 mV or Less	Excellent
25-50 mV	Okay
50-100 mV	Marginal
100 mV or More	Poor

Table 7 Shows the FBT-03 Fieldbus documentation of wire condition parameters. From the test, it is found that TT 307 is dropped out from the host system which indicates a communication failure when noise voltage exceeds 150mV. The device still operates normally if the voltage is around 100 mV and

less than 150 mV. This test data conform to the current standard documented by FBT-3 fieldbus checker that indicates a poor wire condition when noise level exceeds 100 mV. However, it is clearly shown that TT307 temperature transmitter can withstand a noise level up to 120 mV before a possible device drop out occurred.

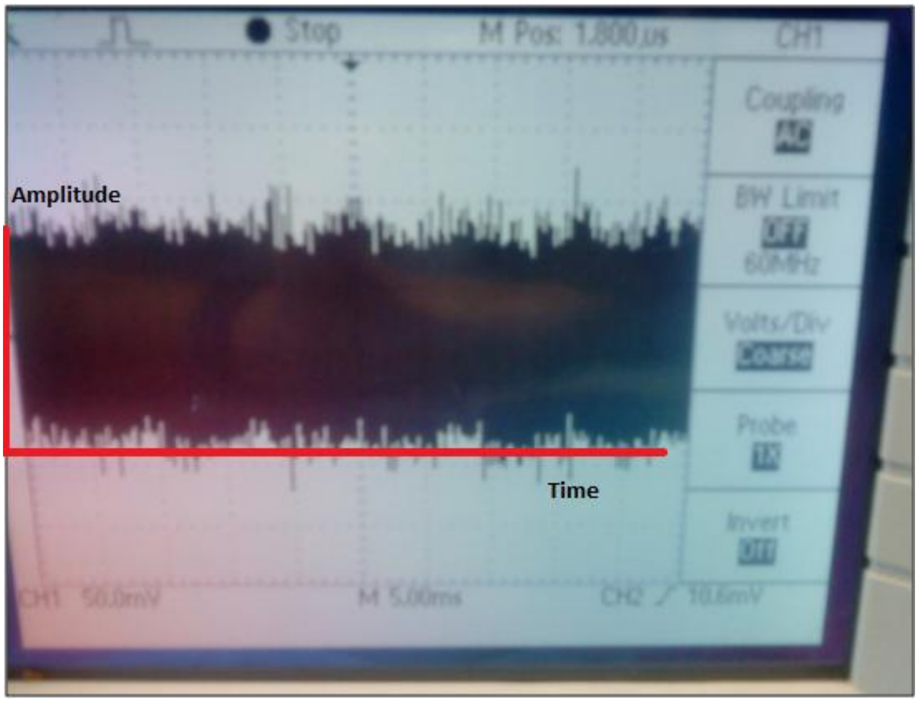

Figure 9: Output Signal of Noise Level When Exceeding 120 mV

The frequency used is 10kHz. As seen from Figure 9, the noise level is high when voltage exceeding 150mV and different field devices can withstand different level of noise, which also depends on the wire condition. The voltage is represented by the Y-axis (amplitude) and calculated by voltage per division on the oscilloscope while the X-axis represents time.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Interoperability of fieldbus devices has shown a promising result with most of the device have passed the test and met the parameters set by Fieldbus Foundation. However, it is noted that problems such as Device Description (DD) file acknowledgement still happens as shown by the failure of field deice TT307 to be commissioned and decommissioned in to the Foxboro host system.

The reliability of the current fieldbus configuration including topology and design concept are demonstrated by simulation and comparison with measured value. The system and field devices can be inferred as reliable when no unexpected communication loss occurred during a specific tasks are performed or in normal online condition.

The maximum noise level of a device can withstand that also reflects the wire condition is successfully tested from the stress test. It is concluded that while maximum noise level conformed to the parameter set by Fieldbus Foundation, however different type of devices may have a different maximum noise capability before device drop out occurred, depending on the specific cable connected and the initial level of noise in the cable.

5.2 Recommendation

For the interoperability test, it is recommended that the field devices and host system to be connected to the actual plant and the whole test is done again. This is because unexpected problems and errors could be evident when real simulation is done and a more practical data can be obtained.

For the reliability test, it is recommended that software reliability is also included in the test. This is because a software error could occur and will result in alarm management failure. A proper software handling is also suggested for it not to be malfunction, as what is happened to the IACC software that works together with Foxboro host. It is perceived that the software required a specific step of shut down. It is also recommended that the switching of different hosts not to be done as it can affect the overall system integrity.

For the stress test, it is recommended that a more comprehensive method of testing to be developed apart from the maximum noise level test. This is important because device integrity can be verified from many other technical point of view and it can be a major contributing factor to the fieldbus interoperability and reliability.

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