ALARM DESIGN FOR SCADA SYSTEM OF ASSEMBLY CELL - 200 TRAINER

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ALARM DESIGN FOR SCADA SYSTEM OF ASSEMBLY CELL-200 TRAINER

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A project report submitted
In fulfillment of the requirements for the award of the
Degree of Master of Electrical Engineering

Faculty of Electrical and Electronic Engineering
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APRIL 2008

I declare that this report on "Alarm Design for SCADA System of Assembly Cell-200 Trainer" is the result of my own project except for works which have been cited in the references. The report has not been accepted any degree and not concurrently submitted in candidature of any other degree.

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Date : APRIL 2008

For my dearest soul mate Fazrina,

My beautiful angel Iman 'Irdina,

&

My entire family for their encouragement and blessings

ACKNOWLEDGMENT

In the name of Allah S.W.T., the Most Beneficent, the Most Merciful. First and foremost, all praise to Allah for the entire incredible gift endowed upon me and for giving me the health and strength to complete this final project.

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Nevertheless, I wish that this report will be beneficial and does contribute in Electrical Engineering field, as a reference and encouragement for further exploration and researches.

ABSTRACT

Alarm systems play a vital role in maintaining the safe operation in process plant. Moreover, the safety and efficiency of a plant's operation is assured by the usage of a reliable and user friendly alarm system. In this project, the main objective is to introduce an alarm feature inside the SCADA system. Identification of suitable guidelines in designing a good alarm system display is also part of the project's objective. Introduction of alarm feature inside the SCADA system is done by putting the Supervisory Control and Data Acquisition (SCADA) system to Assembly Cell-200 Trainer. Here, the SCADA system is equipped with an alarm system as the mean to monitor and control the trainer. The alarm design adopts the available alarm system guidelines as to figure out and judge the most suitable guidelines to be applied in this project. This exercise proves that general guidelines (e.g., use of an alarm philosophy) are essential in developing this projects. However, detailed guidelines (e.g., colour coding and symbol features) should be used more carefully and consistent to ensure the creation of understandable and recognizable display. From this project, a properly designed alarm system is developed, which provides the operators with enough information to prevent any abnormalities, fault conditions or undesired errors in the plant. This project also summarizes the principal guidelines to consider when designing and developing alarms in SCADA environment.

ABSTRAK

Sistem penggera memainkan peranan yang penting di dalam keselamatan operasi di sesebuah loji pemproses. Selain itu, keselamatan dan kecekapan operasi sebuah loji terjamin dengan penggunaan sistem penggera yang boleh diharap dan mesra pengguna. Di dalam projek ini, objektif utama adalah untuk memperkenalkan ciri-ciri penggera di dalam sistem SCADA. Mengenalpasti panduan yang sesuai dalam mereka sistem penggera yang baik juga merupakan sebahagian daripada objektif projek. Pengenalan ciri-ciri penggera di dalam sistem SCADA dilakukan dengan melengkapkan Alat Latihan Assembly Cell-200 dengan sistem SCADA. Di dalam projek ini, sistem SCADA dilengkapi dengan sistem penggera sebagai kaedah untuk memantau dan mengawal alat latihan tersebut. Rekaan penggera diadaptasi daripada panduan sistem penggera yang sedia ada dengan cara mengenal pasti dan menilai panduan-panduan yang bersesuaian untuk diaplikasikan di dalam projek ini. Menerusi kaedah ini, panduan umum (sbg.cth. penggunaan falsafah penggera) yang diperlukan dalam membangunkan projek ini dapat diketahui. Walau bagaimanapun, panduan yang lebih terperinci (sbg. cth. kod warna dan cirri-ciri simbol) perlu digunakan dengan lebih berhati-hati dan konsisten bagi memastikan terbinanya paparan yang mudah difahami dan dikenalpasti. Daripada projek yang sudah dibangunkan, sistem penggera yang direka dengan baik akan menyediakan maklumat yang cukup kepada pengguna untuk mengelakkan apa jua ketidaknormalan, keadaan ralat atau ralat yang berlaku di dalam loji. Kesimpulannya, projek ini merumuskan bahawa terdapat panduan-panduan asas yang perlu diambil kira semasa mereka cipta dan membangunkan penggera di dalam persekitaran SCADA.

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LIST OF ABBREVIATIONS

SCADA	-	Supervisory Control And Data Aqusition
PLC	-	Programmable Logic Controller
RTU	-	Remote Terminal Unit
GUI	-	Graphical User Interface
2D	-	Two Dimensional
I/O	-	Input and Output

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CHAPTER I

INTRODUCTION

1.1 Introduction

An alarm system is a fundamental element of most current day operator interfaces to industrial manufacturing plants. The alarms are generally initiated by a process variable, or measurement, passing a pre-defined limit, which signifies that the variable is approaching an undesirable or unsafe value.

Usually, the alarm systems in a manufacturing plant are built on a platform that can be monitored and controllable by the operators. It is also important for the alarm system to be easily viewed by the operators. With those features, alarm becomes an ideal system to provide the information to the operators which then allow them to evaluate what is occurring and take appropriate actions to remedy the situation.

In most manufacturing plants, we would expect to see much of the alarm systems embedded in the basic control system, typically a Supervisory Control and Data Acquisition (SCADA) system. This brings the benefits of integration with main control for the process and makes it simple to provide alarms related to the process condition. Software tools in the SCADA package allow the alarms to be configured easily and offer the facilities to group and prioritize the alarms. One of the long standing attractions of SCADA system has been their ability to record the occurrence of each and every alarm in the system with high degree of time resolution, thus supporting problem analysis and the reconstruction of the sequence of events during a plant outage.

Throughout this project, the alarm system will be implemented using a SCADA software called an IGSS supplied by 7 Technologies. This true object-oriented program software will be integrated with a test platform, which is a small-scale assembly line named Assembly Cell-200 Trainer. This trainer adopts features from real industrial processes but in a smaller-scale, which enables a real application and execution of SCADA system. The assembly line consists of feeding station, pick and place station, part assembly station, storage and retrieve station and rejection station. The integration between trainer and SCADA software will be linked by Programmable Logic Controllers (PLC) as the remote terminal unit (RTU).

Nowadays, alarms are designed in various forms purposely for attracting attention and appropriate response from the operators. The signal forms and qualities presented to the operators may include an audible warning, visual indication such as a flashing light or text background and a message of some description.

As the focus of this project, a few elements of alarm system design are to be stressed, mainly on graphical interface aspect. The first and foremost are the objectives of the alarm system: what are the conditions on the application and what are the events the alarm is trying to prevent. The alarm system priorities with their exact meaning must be clarified. Other elements are the presentation and retrieval method such as the coding definition which varies through colours, shapes, tones. Methods for the acknowledgment/silencing are also one of the important elements to be focused.

In terms of the controlling criteria, it is necessary for the alarm system to trigger a prompt action from the operator and there should be no redundant alarms for same alarm conditions. The design should also capable to cater no alarms "in" during normal operations and able to manage any changes in the alarm system.

Based on the above mentioned elements, the characteristics of an effective alarm system can be outlined as follows:

i. It is contextually relevant i.e. correct, not spurious or of low operational value.
ii. It is unique and not duplicating another alarm.
iii. It provides adequate time for response.
iv. It is prioritized, thus indicating the importance to the operator dealing with the problem.
v. It is understandable i.e. the alarm message is clear and easily recognized.

Hence, if the design stage of the alarm system is not meticulously executed, the alarm information presented to the operator will be misleading and potentially of no operational value.

1.2 Problem Statement

In the event of emergency cases in industry, alarms act as the most critical features in a SCADA system due to their functions to trigger the necessary actions from the operators. Ironically, there is no such specific guideline to design it. However, the considerations in designing the alarm system differ from one company to others. For a company which adopts a more complex alarm system, the disadvantages are more on the operators, where more comprehensive and longer hours of training are required. But, if a simpler and effective system is chosen, the time and cost for training purposes can be saved.

As each of SCADA software is unique by its own capability and features, the design stage of alarm system has been very complicated. Due to this reason, the preparation of a common set of guidelines for alarm system design will be stressed out in this project. Hence, a common and basic set of guidelines should be prepared for SCADA users as the aid in lining out the utmost requirements and considerations during the alarm design stage and everything related to it.

1.3 Objectives

The aims of this project are:

i. To design an understandable and an easy-to-recognize graphical user interface for an alarm system in SCADA software

ii. To identify characteristics of a good and well designed alarm system

iii. To develop a SCADA system for Assembly Cell-200 Trainer for monitoring and controlling purpose.

1.4 Project Scope

Figure 1.1 is a view of the relationship between Assembly Cell-200 Trainer, SCADA software, alarm system, and the user. Users identify and manipulate alarms through SCADA software display, and take necessary actions through alarm system display to deal with the abnormal conditions. The area with dotted border represents the scope of this project, that is, the interaction between alarm system, SCADA software and the Assembly Cell-200 Trainer. Specifically, this project focuses on the specific requirement for the presentation, layout and functionality of alarm systems.

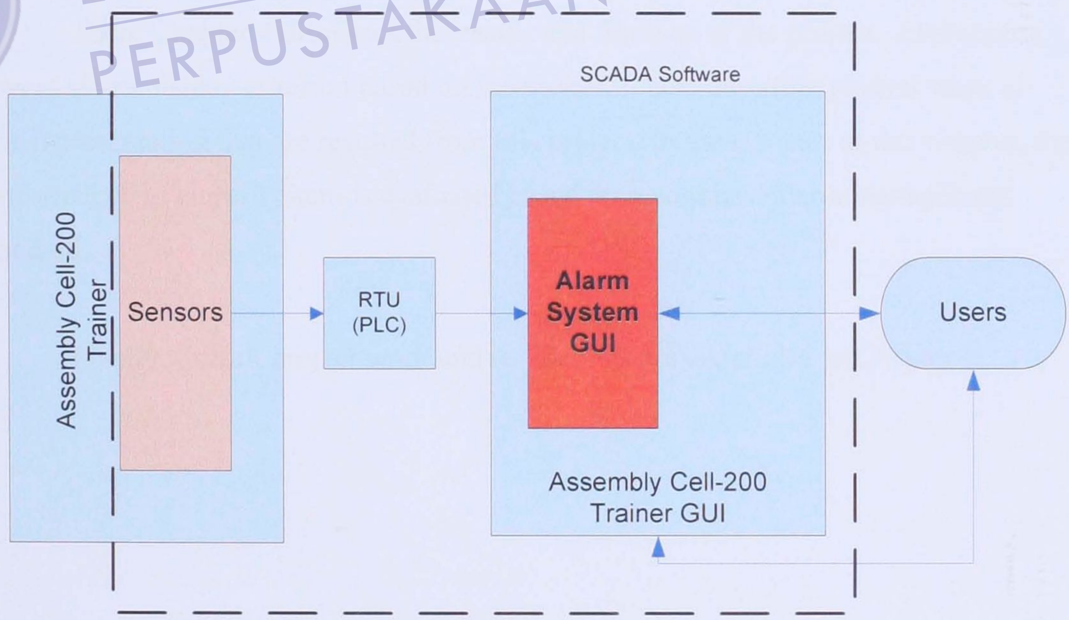

Figure 1.1: Scope of the project.

1.8 Report Outline

This report consolidates the research work in alarm system design, through the implementation of SCADA system in Assembly Cell-200 Trainer. Chapter 1 outlines the objectives, methods and problem statements in regards to this project. This chapter also provides the rough idea of what alarm system is.

Chapter 2 is mainly on the details of alarm system and the literature review. It explains about alarm types, alarm features considered during the design stage and highlights a few recent studies in this field.

In Chapter 3, the methodology applied in this project is described in detail. The method begins with designing human machine interface and alarm interface using SCADA Software. In parallel, the Assembly Cell 200 Trainer task is programmed using PLC. The next step is to integrate the trainer controller with SCADA Software in order for the system to operate. Finally, the functionality of the alarm system is validated based on the guidelines identified in Chapter 2.

Then, Chapter 4 discusses the results and findings of the project. Elaboration covers alarm display criterion based on the trainer. It also describes several ways of alarm presentation that are resulted from this project. In the last part of this chapter, the performance of alarm system is evaluated based on recognized alarm management standard.

Finally, overall project work and its findings are concluded in Chapter 5.

CHAPTER II

LITERATURE REVIEW

This chapter covers the review of the past literature and discusses in detail about alarm system that is used in this study. Moreover, the international standard about alarm system will be discussed, together with the explanation about alarm types and features that must be considered in alarm system design. At the end of this chapter, examples of alarm system application in several areas are discussed.

2.0 Introduction

Before discussing in depth about an alarm system design, the difference between alarm and alarm system need to be clarified. Alarm is some signal designed to "alert, inform, guide or confirm", and an alarm system is a system for "generating and processing alarms and presenting them to users" [1]. From that we can summarize, the alarm system is a basic support system for operator in managing the abnormal situation.

In industrial field, the alarm system plays a very important role. The primary function of the alarm system is to warn the operator about a situation that is not normal, where a warning function helps the operator to control the future behaviour of a plant by attracting attention to undesired process conditions [1]. The system should inform the operator about plant conditions that require timely assessment and possibly corrective action in order to maintain plant goals in terms of safety, productivity, environment and efficiency.

The secondary function of the alarm system is to serve as an alarm and event log [1]. The operator or higher user can use the alarm log for analysis of incidents or optimising plant operation. The alarm log information also can be utilized for monitoring and improving the alarm system performance in plant. Thus, the alarm log should be flexible and contain the events, suppressed alarms and other pieces of information that were not presented in main alarm list, but could be useful for offline investigation of incidents.

In alarm system design, several guidelines both for the design process and the presentation and functionality of alarm systems are provided by international organizations. Among the available guidelines in the area of alarm management and rationalization, the best known is the British Engineering Equipment and Materials Users Assn. (EEMUA), which has a guideline, "Alarm Systems, a Guide to Design, Management and Procurement, EEMUA Publication No. 191." This guideline has some metrics for good performance of an alarm system. Other than this, The British Health & Safety Executive (HSE) also comes out with a couple of guidelines entitled "Better Alarm Handling" and the Technical Measure Document, "Control Systems."

More documents are offered by ISA with ISA TR91.00.02, "Criticality Classification Guideline". The document provides guidance in defining types of systems, as well as ANSI/ISA S18.1 1992, "Annunciator Sequences and Specifications".

IEC has IEC 61508, "Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems," and IEC 61511, "Functional Safety: Safety Instrumented Systems for the Process Industry Sector," which address safety-related and safety instrumented systems that may have some application where credit is taken for alarms during risk assessment.

Well-known and often used guidelines for ergonomic design of control centers, human system interfaces and alarm systems are IEC-62241, ISO-11064, NUREG-0700 and NUREG-0711 [2]. Based on the study that has been done, the existing alarm design guidelines can be divided into two main categories; guidelines for the design process and guidelines for the presentation and functionality of the alarm system

From a study conducted by Engineering Equipment and Materials Users Association (EEMUA), a number of important characteristics for an individual alarm have been identified, as follows:

(i) Timely – presented at the right time.
(ii) Relevant – for the operators, not a false alarm.
(iii) Unique – not a duplicate of another alarm.
(iv) Prioritized – helps the operators to focus their attention.
(v) Understandable – speaks the operator's language.
(vi) Diagnostic and advisory – indicates what has happened what actions are needed.
(vii) Manageable – not too many alarms

These recommendations are important to consider in this project. However, general recommendations do not provide the alarm system designers with concrete help. Instead, the basic theory should be considered as a foundation and/or vision for the designers. Design guidelines provide better, clearer and more detailed support in the design projects.

2.1 Alarms Types

From the outset of any alarm system study, it is important to recognise the characteristic of each alarm type. From the designers or plants users' point of view it is very important to make a clear distinction between alarms that provide production support and those that are used as safeguards against hazards. There are five types of alarms that normally can be found in industries [3], as below:

2.1.1 Process Alarms

These alarms may be to do with efficiency of the process. Process alarms normally incorporated into the plant control system (typically PLC SCADA system) and often share the same sensors as the control system.

2.1.2 Machinery/Equipment Alarms

These alarms assist in detection of problems with equipment and indirectly affect the operation of the process/production. It may simply be an important status relevant to the operation of the process (e.g. 'Conveyor stopped') or it may be critical to the equipment (e.g. 'bearing temperature high').

2.1.3 Safety Related Alarms

These alarms are used to alert operators to a condition that may be potentially dangerous or damaging for the operation. They will always demand a defined and prompt response form the operator.

2.1.4 Shutdown Alarms

These alarms tell the operator that the Safety Instrumented System (SIS) has initiated an automatic shutdown event. It contributes as a layer of protection because it informs and status of an emergency shutdown, supporting corrective and subsequent actions by the operator.

2.1.5 Fire and Gas Alarms

These alarms belong to the safety-related types but are usually built within dedicated and entirely independent fire and gas detection systems. This approach is essential for protection of personnel since it must be assumed that all other control systems may be shut down or damaged due to fire or gas conditions.

2.2 Alarms System Design

Alarm system are found on many user interfaces for instance in control rooms of power stations, chemical plants or in production plants, in control centers for railway, road or air traffic, in aircraft cockpits, on bridges control system, etc. Practically, a well-designed alarm system is an important tool to maintain the high efficiency in plant's operations. Poorly designed alarm systems will cause unnecessary disturbances, waste of resources, and decreased plant operability [4]. Based on that, alarm functionality aspect must be given a high priority during the design stage.

2.2.1 Alarm Generation

The main purpose of alarm system is to provide information to operators about system malfunction in plant. Hence, the alarm system shall be able to generate basic alarms (refer to alarm types) which provides the functionality needed to detect simple disturbances in the process. The alarm limit settings should be systematically determined and documented during plant design, commissioning and operation. Proper alarm limits settings are important to ensure that alarms are triggered early enough for effective response to be performed by operators, while on the other hand attempting to minimise the number of false alarms caused by too tight alarm limits.

When alarm is generated, it is necessary for the alarm to require an operator response. A response could be a physical action to manipulate the process state, contact field operator, instrument technicians etc. It may also be a purely cognitive response, where the operator only does some mental processing.

2.2.2 Alarm Structuring

In alarm structuring, selection, sorting and grouping facilities should be provided to make the system more flexible and usable by letting operators configure online what information they would like to be presented and adapted to their special needs. There are some possible criteria for grouping and sorting alarms such as time, system area, operator responsibility and priority.

In other side, alarm suppression is one of the functions in alarm structuring that must be included in the alarm system. The objective of alarm suppression is to ensure that the presented alarms at any time are relevant to the operator's work under the current process conditions, and to avoid alarm flooding during process disturbances.

2.2.3 Alarm Prioritisation

The purpose of prioritisation is to help the operator to decide which alarms to deal with when several occur at the same time in a disturbance, and to show especially urgent alarms to the operator during normal operation. The alarms should be prioritised based on severity of consequences that could be prevented by taking corrective actions. There are only four alarm priorities that should be implemented [5] as follows:

(i) High Priority

Alarms that warn on dangerous condition, which could cause the shutdown of major activities.

(ii) Medium Priority

Alarms that should be acted on as quickly as possible; but will not cause a shutdown.

(iii) Low Priority

Alarms that should be dealt with when time permits.

(iv) Event only.

Statistical or technical information. No enunciator sounds for these.

When doing the alarm prioritisation, every site of alarms should have written rules on how priorities should be assigned. This is to ensure that the operators are familiar and comfortable with the prioritisation rules employed by the system designers, so that priority information can be effectively utilised by operators when handling alarms.

2.2.4 Alarm Presentation

An alarm system can be presented in many ways such as through visual display units in form of graphical user interface. The alarm system display can be a combination of lists and tiles displays as well as separate displays covering different systems or areas. Furthermore, the alarm system display should support the task of monitoring and controlling the future behaviour of the plant by attracting the operators' attention towards process conditions that require assessment or action. It should show only alarms that are relevant in the current process conditions. One of the examples that alarm system can be displayed is to have an associated enunciator panel (situated next to operator display) with illuminated pushbutton. Each pushbutton would indicate the area form which the alarms originate and also depressed would cause the appropriate schematic to appear on the operator display.

A good alarm system must contain a historical log of alarms and events (or alarms list). The log is used for analysing incidents which happen during operation. The alarm list should be in chronologically ordered or designed such that repeating alarms do not cause them to become unusable (i.e. same alarm filling up several lines in the list)

Improvement on alarm system design and colour-coding would drastically reduce operator errors and thus improve usability [6]. When alarm system is presented in term of priority events, it must be perfectly able to be differentiated by operators. That kind of alarm should be coded using colours and possibly other means. This is to ensure that different priorities are visually separated in a way that makes it very quick and easy to spot the most important alarms among the less important ones. For colours that used in prioritisation, it should be used exclusively for alarms, reflect alarm importance and make alarm easily distinguishable form the less important information in the alarm and process control system. The suggested colours for alarms where red for high priority alarms, magenta for medium priority and yellow for low priority. Symbols, location of information, font type, blink frequency, etc. are among the available means for additional information coding [5].

Warning signals are colour-coded depending on the severity level, and a simple click of the warning signal provides more detailed information [6]. The colours representing the alarms are coded depending upon the severity of warnings, and the most severe alarms are designed to draw the operator attention by flashing the signals on the screen. A relevant screen to an alarm can be directly accessed by clicking the alarm list. Moreover, if an alarm is related to a serious accident, the relevant screen will be automatically shown on the screen.

From a survey conducted on the operators, the result shows that the four-step colour severity coding scheme is the most preferred for alarms [6]. In the colour coding scheme, red is for the severest alarms, yellow for warning information, green for informing a normal condition of important information, and, finally, white for a normal condition of unimportant data on the screen. Improvement on alarm system design and colour-coding would drastically reduce operators' errors and thus improve the usability.

2.2.5 Alarm Handling

During the alarm system design, alarm handling or alarm processing must be taken into account. Better alarm handling brings a good result in operation. One of its criteria is every alarm that is triggered should require acceptance. In other words, the operators are obliged to accept each alarm as to confirm that the alarm message has been read and understood.

Another criteria is the alarm system should be possible to shelve individual alarms. The objective of alarm shelving is to allow operators to remove standing or nuisance alarms that the alarm generation and structuring mechanisms have failed to prevent. Shelving an alarm means removing it from the main alarm list and placing it on a shelve list. The alarm is then prevented from re-occurring on the main list until it is removed from the shelf. Shelving will normally be controlled by the operator. He/she shall be able to easily observe what alarms are shelved in the dedicated shelve list, as well as through symbols in the process pictures. The operator also should be required to document the reason for shelving the alarm in an administrative system.

To make alarm handling more effective, the navigation in alarm display should be quick and easy. This is to support effective operator response to alarms by allowing quick navigation to additional information. It shall be possible to navigate from the alarm lists to the process display where the alarm is shown or it should be possible to click at an alarm in any display to get more information about it, such as alarm response procedures.

Based on experience of TNB Malaysia in Substation Alarm Monitoring System [7], they are face a displaying large volume of rapidly changing information in National Load Despatch Center (NLDC) which is undesirable due to difficulty of operators understanding the alarm data and filtering through needed information. The scope of SCADA is broad such that the data requirements overlap between planning, operations and maintenance. They proposed the system called SAMS (Substation Alarm Monitoring System) to be share centralized SCADA data for operation and maintenance. Supervisory Control and Data Acquisition (SCADA) system is the primary source of data for many activities in an electric utility. SAMS system was interfaced with the SCADA system using the logger serial ports. The logger provides necessary input data in readable ASCII format. Capturing logger alarms electronically enables engineers in MTU to use the information for maintenance purposes which be handled by SAMS system.

2.3 Example of alarm system implementation

In CERN [8], the concept of alarm system is based on limit and status checking. Multiple alarm priority levels are supported and alarms are handled centrally where information can only exist in one place. An email can be generated in response to alarm condition. This function is supported by Man-Machine Interface (MMI) element which consists of combination of synoptic diagrams and text. The MMI also capable to support multiple screens, offers a library of standard graphical symbol and standard windows editing facilities.

In contrast, different focus of alarm handling is practiced by City of Houston's Wastewater Operation [9]. All alarm information at treatment plants can be easily viewed with the extra features of extended graphic design, where information about alarm from each sections/plants are displayed in one screen. They used SCADA software that consists of three major subsystems that helped in alarm handling. Those subsystems are CMX (a real time database and programming package for real time data processing), XIS (a relational database for historical data processing) and XOS (human machine interface package for graphics display). CMX offers the real time trending for data analysis, transfer data into the XIS server for historical data archiving, initiates and logs alarm messages into the alarm and event summaries.

From both cases, their applied SCADA offer relatively same features, where both have different level of users and different level of access into the system. For example, the operators can acknowledge the alarm from the field but cannot modify the graphics or the database program.

CHAPTER III

METHODOLOGY

This chapter discusses the procedure and methodology applied in this project. The explanation begins with the designing stage of alarm system in SCADA software for the trainer and followed by the methodology of PLC programming that used in this project. Then, the integration and validation between PLC programming, SCADA software and the trainer are shown in the last part of this chapter.

3.1 Project Flow

This section describes the whole procedures involve in this project. In this project, an alarm system development consists of several phases as illustrated in Figure 3.1.

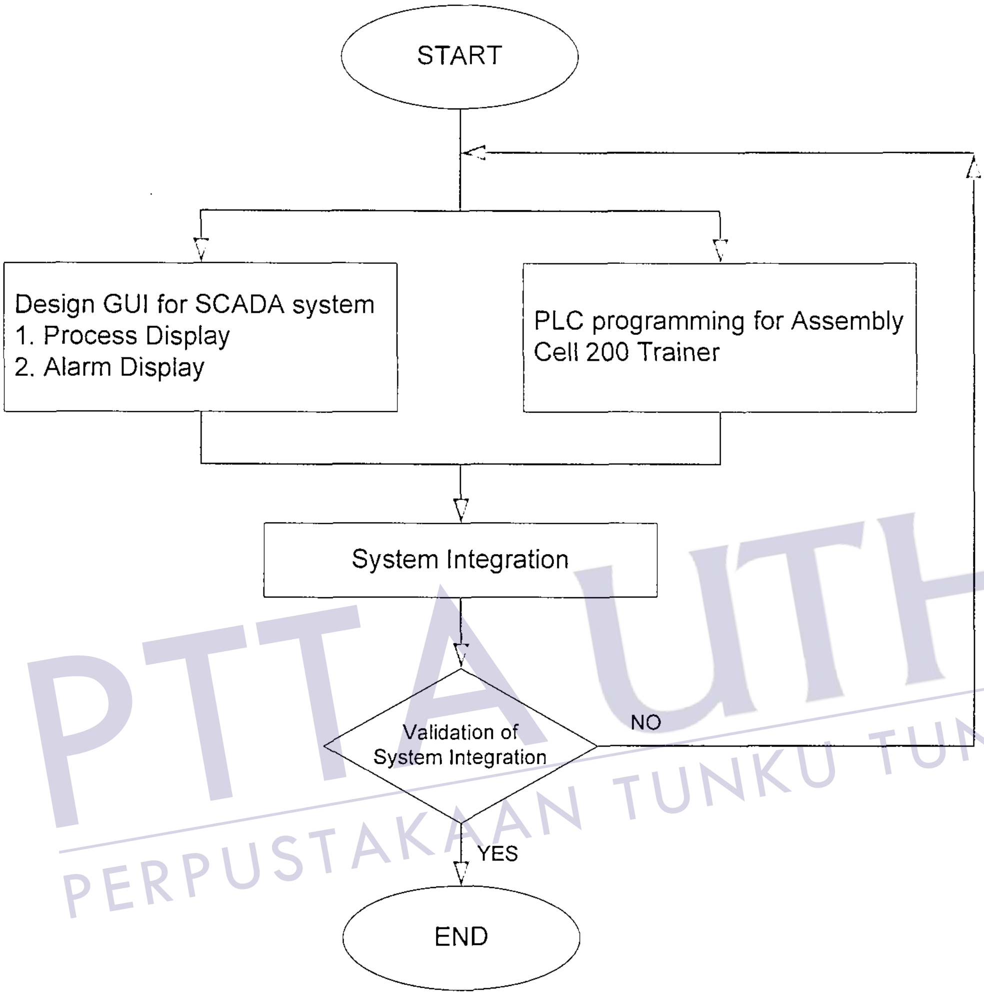

Figure 3.1: Flowchart of research work

3.2 Assembly Cell 200 Trainer

In this project, Assembly Cell-200 Trainer is used as a test platform. Assembly Cell-200 Trainer adopts features from real industrial processes but in a smaller-scale and enables a real application and execution of SCADA system. The assembly line consists of feeding station, pick and place station, part assembly station, storage and retrieve station and rejection station. The trainer picture and layout can be viewed in Figure 3.2 and Figure 3.3 below.

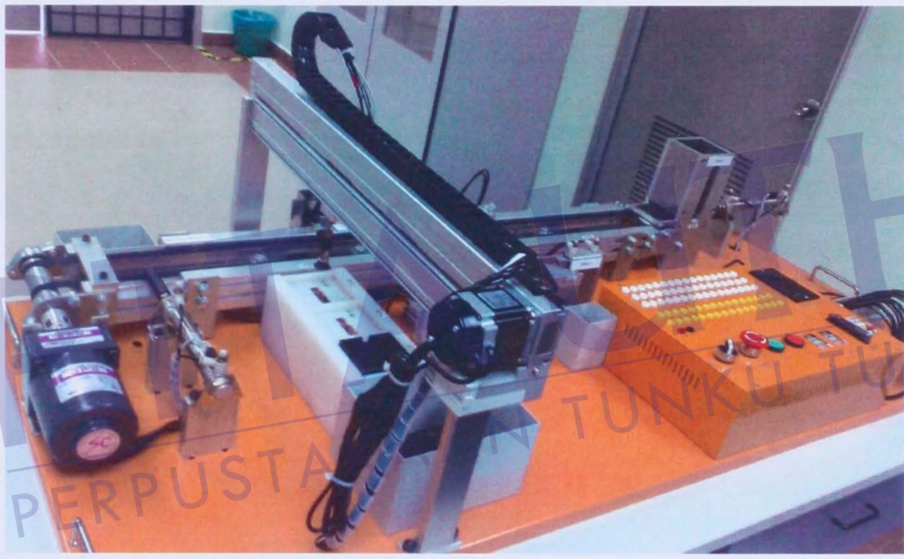

Figure 3.2: Assembly Cell 200 Trainer

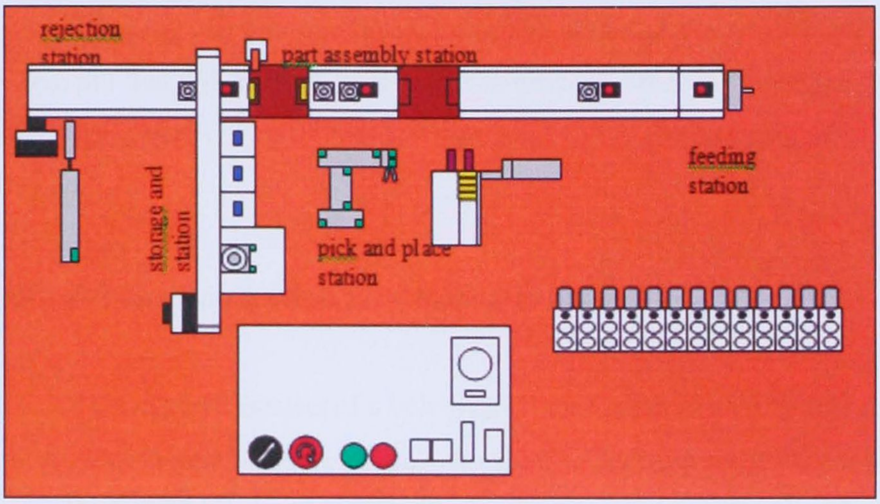

Figure 3.3: Layout of Assembly Cell 200 Trainer

3.2.1 Feeding Station

Feeding station consists of a tower type feeder which houses the pallets. Pallets are stacked up in the feeder. When Start button in the control panel is pushed, a single rod pneumatic cylinder will push the pallet onto running conveyor. The running conveyor will then transfer the pallet from feeding station to assembly station.

3.2.2 Pick and Place Station and Part Assembly Station

These stations are equipped with a pick and place 3-axis robot, a pin feeder, pins (in a pin feeder) and stopper. When the pallet arrives at assembly station, it will be stopped by the stopper before a pick and place process takes place. Then, the pin feeder will supply the pin to the 3-axis robot. Then robot will pick the pin and place it into the first pitch of pallet in the assembly section. This process will be repeated for second pitch of the pallet.

The pick and place station is equipped with an inductive sensor to detect a reject pin that will be separated from the process. Once both pitches at the pallet is filled up, the pallet will be transferred to the storage section.

3.2.3 Pick and Place Station and Part Assembly Station

This station consists of a belt type electric actuator that is driven by high performance stepper motor with encoder feedback, a stopper, a photoelectric sensor, four containers (Storage 1, Storage 2, Storage 3 and Retrieve box), a pneumatic cylinder with vacuum pad and an ejector.

Before pallet is picked up and placed onto storage containers, it will pass through a photoelectric sensor. Photoelectric sensor is used to check the quality of finished products and separate the reject product from the process. The proper assembled pallets will be transferred to storage containers (Storage 1 until Storage 3). When the storage container is full, the first good finish product that entered the storage container will be transferred to retrieve box and this process will be repeated for second pallet and so on. The process applied first in first out (FIFO) concept.

3.2.4 Rejection Station

When reject product is detected, it will bypass the storage process, but it will go to the rejection section. A mechanical stopper will stop the reject product and pneumatic cylinder will push the reject product into a reject bin.

3.3 Designing a SCADA Graphical User Interface (GUI)

During the design and development of GUI for SCADA system, a number of criteria must be considered based on guidelines that has been discussed in earlier chapter of this report.

The display of the process must provide clear and concise communication between the user and the system application. For the ease of user operation, there are several principles that guide the GUI design standardization [11]. Some of the common guidelines are listed below.

(i) Consistency.

A consistent format must be used in the menu structure, display elements, graphics and interaction with the function of the system mode and provide different ways of doing it at different places in the system

(ii) Feedback.

To ensure proper communication, provide feedback

(iii) Verification

Any critical entries to the system should be verified. To prevent any accidental entries, request should be confirmed by two keystrokes. For example – emergency stop or change of mode from auto to manual to vice versa.

(iv) Organization

Organization of elements on the interface is important and applies to screen layout and functions. The screen layout should be such that the users can easily learn where to look for information. The function should be organized in an intuitive manner.

(v) Choice of Elements

The selection of the elements should be carefully done. If a combination of touch screen, and point and click device are used, the touch screen needs to have verification for data entry.

(vi) Ease of use

Increase the use of mouse functionality and minimize typing by the user

Throughout the experience, feedback and more complex demand from SCADA users; mainly industrial players, the trend of process has moved away from black screens to very light backgrounds and gray schemes for the processing equipment. Now, more colours are reserved for critical changing information and alarms. The innovation resulted to the use of primary colours, yoked navigation, embedded alarm indications and tabs to navigate among windows. This concept is adapted in this project. Refer Table 3.1 for colour and other features assignment that has been used in process diagrams.

REFERENCES

[1] M L Bransby, J Jekinson. "The management of alarm system." Bransby Automation Ltd & Tekton Engineering Technical Documentation for Health and Safety Executive (HSE), Norway, 1998.

[2] Anna Thunberg, Anna-Lisa Osvalder. "What Constitutes a Well-Designed Alarm System?" Human Factors and Power Plants and HPRCT 13th Annual Meeting, 2007 IEEE 8th, pp. 85 -91.

[3] Dave Macdonald. "Practical Hazops, Trips and Alarms" Newness 2004.

[4] Yoshitaka Yuki. "Alarm system optimization for increasing operations productivity." ISA Transactions 41, 2002, pp. 383–387

[5] David Bailey, Edwin Wright "Practical SCADA for Industry" Newness 2003.

[6] Sung H. Han, Huichul Yang, Dong-Gwan Im, "Designing a human–computer interface for a process control room: A case study of a steel manufacturing company" International Journal of Industrial Ergonomics 37. 2007, pp. 383–393

[7] Wan Azlan Wan Kamarulzaman, Azlan Muhamad Sufian, Rosdi Embong, Mohd. Shafik Mohd. Taha, "Substation Alarm Monitoring System" TENCON Proceedings, 2000, pp. 603 – 608, Volume 2.

[8] A.Daneels, W.Salter. "What is SCADA?" International Conference on Accelerator and Large Experimental Physics Control System. 1999, pp. 339-343

[9] B.Dieu. "Application of the SCADA system in wastewater treatment plants." ISA Transactions 40, 2001, pp. 267–281

[10] Jeff Gould. "Implementing effective alarm systems for startups" Alarm Management Insider, Matrikon Inc. 2007.

[11] Mike Barker, Jawahar Rawtani "Practical Batch Process Management" Newness 2005.

[12] EEMUA Publication 191 "Alarm Systems: A Guide to Design, Management, and Procurement". 1999