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Honeywell Experion System For Teaching Purposes

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Abstract

Honeywell Experion Process Knowledge System (PKS) is an advanced Distributed Control system with integrated advanced process automation platform. The platform integrates both DCS and SCADA topologies which makes the software more versatile. Experion is extensively used for several applications across the process industry. The platform was purchased by Murdoch University and served as a valuable asset to the University. It is a great teaching tool for students pursuing a career in engineering as it introduces an industrial prospective to the course. The main objective of the thesis project involves development of Honeyell Experion software to be integrated into the industrial computer systems facility for students to gain an understanding of the operation of the system.

The entire scope of the thesis project mediated around the Honeywell Experion Process Knowledge System software. The ultimate goal of the project was integration of the Honeywell Experion teaching system into the Industrial Computer Systems facility. Before conquering the mammoth goal of the thesis, it is proprietary to understand the basic driving concepts of the Experion system. The previous works undertaken on the project included some basic setup of a test server, and basic simulation and configuration aspects. This thesis would be a continuation of the work undertaken during previous years.

However to proceed to further stages of the thesis the first step would be to surpass the initial configuration of the project elements. Therefore initial weeks of the thesis project were spent on understanding the structure of the Experion software and configuring basic elements. Following these initial steps the primary focus of the project was brought towards understanding the operation of some of the Regulatory Control Blocks present in the Experion environment.

The functionality of regulatory control blocks was explored by undertaking research on the PID control block. Many features offered by the PID control block were explored and understood. Following this step some systems were simulated in Microsoft Office Excel

and controlled by the PID control block configured in the Experion system. The data exchange between both the mediums was done by Microsoft Office data Exchange add-in provided by Honeywell. These simulations were designed to demonstrate the use of options provided by the PID block.

Similar research was performed on other regulatory control blocks present in the Experion environment such as PIDFF, PIER and PID-PL blocks. The functionalities researched and simulations created were documented.

The report provides a brief overview of the tasks accomplished. Firstly describing the operation of Experion software and functionalities offered, it moves on to describing the primary attention area of the project.

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1 Introduction

Honeywell Experion Process Knowledge System (PKS) is an advanced Distributed Control system with an integrated advanced process automation platform (Honeywell Process Solutions). The platform integrates both DCS and SCADA topologies which makes the software more versatile. Experion is extensively used for several applications across the process industry. The platform was purchased by Murdoch University and served as a valuable asset to the University. It is a great teaching tool for students pursuing career in engineering as it introduces an industrial prospective to the course. The main objective of the thesis project involves development of Honeyell Experion software to be integrated into the industrial computer systems facility for students to gain understanding of the operation of the system.

To be able to fulfil the final objective of the project, it is essential to study all the functionalities provided by the Experion software. On commencement of the project it was essential to be familiar with the Experion software environment itself. Consequently initial weeks of the thesis project were spent on technical research related to the Experion software. Following this step base elements for the project were setup.

Fundamental functionality of Experion software is to provide process control solutions. In saying that, it is therefore essential to explore process control algorithms and solutions provided by the software. Experion provides a selection of process control blocks under Regulatory Control Blocks section. PID controllers form the basis of process control and are extensively used around process industry. It is one of the regulatory control blocks present in the Experion environment. Consequently it was one of the first blocks to be explored. Following this few other regulatory control blocks were also studied. There were also process simulations created to demonstrate the functionality offered by these control blocks.

The report provides a brief overview of the tasks accomplished. Firstly describing the operation of Experion software and functionalities offered, it moves on to describing the primary attention area of the project. It is also essential to mention that some of the work done during the thesis overlaps with a postgraduate student Nurazlina Nain who has also been involved in the development of the project as a whole.

2 Background Information

2.1 Honeywell Experion Process Knowledge System

Honeywell Experion PKS system provides an economic control system equipped with the safety features. The system widens the role of Distributed Control System(DCS) by addressing manufacturing objectives of facilitating productivity management and exchange of process data. It provides a plant wide infrastructure by optimizing work performances and accelerating process innovation and improvement. The system integrates DCS and SCADA functionalities where DCS functionality incorporates continuous, logic and object oriented control and also operates on redundant servers which facilitate online system backup, load balancing and in the event of a temporary halt in the primary server. (Honeywell Process Solutions)

2.1.1 Basic Control System Topology

Experion control system topology incorporates a primary server and controllers sharing a global database. This facilitates a onetime configuration with the need of controller data entered only once into the database. This form of topology provides the advantage of reduction in the configuration time and instant access to point detail, trend and alarm data. The system can be subdivided into hardware components described in the following sub-sections.

2.1.2 Supervisory Platform

This platform includes non-proprietary computing platforms running windows operating systems and serving as both Experion Servers and Experion Stations. Experion Stations are able to serve as both engineering and operating interfaces, depending on software loaded on each node.

2.1.3 C200/ C200E, C300

Using a small hardware form factor supporting a scaleable and modular architecture. Commonality and flexibility of hardware components, and their placement within the system, reduce initial cost-to-purchase, and minimize cost-of-ownership while plant safety is guaranteed.

2.1.4 Safety Manager Controller

The SIL3 safety controller executes safety strategies independently from the process control layer. It communicates with dedicated Input/Output (I/O) modules that are directly connected to the Safety Manager Controller. Safety Manager is a fully redundant controller that seamlessly integrates in the Experion topology. Safety Manager Controllers can connect to each other through a dedicated network or through the FTE network. The “SafeNet” connection is a SIL $ certified safety protocol.

2.1.5 Process Machinery and Drives (PMD) Controller

PMD is a controller unit that contains an integrated application execution environment, two independent fieldbus interfaces, an Up-line interfaces, an FTE system interface.

2.1.6 Integrated Controllers

The server integrates a number of Honeywell loop controllers and recorders. The integration effectively reduces engineering time by integrating the device configuration tools and/or diagnostic features with the Experion platform.

3 Technical Review

3.1 SCADA support

Experion can also host other SCADA devices along with the generic C200/C200E, C300 and ACE Controllers. The SCADA devices can be incorporated into the system using Serial (RS232 or RS485), Control Net or Ethernet interfaces such as MODBUS TCP. Within the Experion system the Quick Builder tool provides assistance in incorporating a SCADA interface.

3.2 On process Migration

Experion provides on process migration which makes the system more versatile by providing the capability of upgrading the system to a newer licensed option. The system can be operated on redundant servers and process controllers to perform the system upgrade. This is however not feasible with the SCADA connected controllers.

3.3 Off process Migration

As On process migration does not allow migration of SCADA components of the system, the off process migration can be used to upgrade this component. The off process migration can be performed without license on the redundant or the non-redundant components of the system.

3.4 Redundancy

Experion is equipped with a redundancy protection system intact where by redundancy is associated with servers, networks, controllers and selected I/O. Redundancy accommodates critical components of the software and is useful in transfer of the system from primary to secondary should a problem arise in primary. It also assists while performing the on-process migration of the system.

3.5 Configuration Studio

Configuration Studio provides a central platform for the configuration of Experion system. Solitary tools can be launched through the Configuration Studio to build parts of the system. Specific tools can be chosen and launched from the customised list to perform a task. A screen capture of the Configuration Studio window is provided in Figure 1.

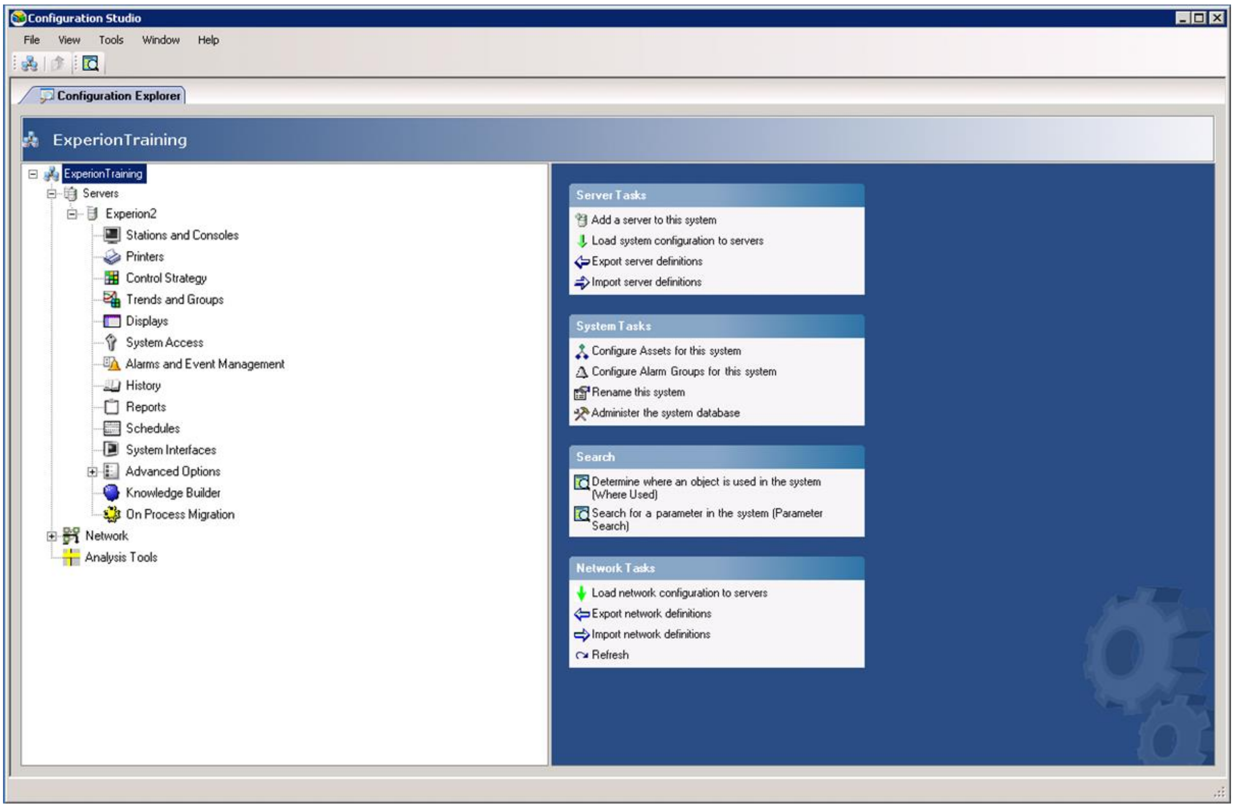

Figure 1: Overview Screen of Configuration Studio

A variety of tools can be accessed by choosing the appropriate section within the Configuration Studio. Server settings and asset configuration can be accessed by clicking on the first item in the hierarchy on the left hand side, in this case “ExperionTrainig”. Within the servers category dropdown menu of Exeprion2 can be accessed. Appropriate category can be chosen to launch the tools if example Stations and Consoles option can be chosen create or change station and console settings, and Control strategy can be used to launch Control Builder which provides a programming environment for the configuration of control systems.

The tools that can be launched through the configuration studio are listed below:

- Enterprise Model Builder
- Quick Builder
- System Displays
- Control Builder
- HMIWeb Display Builder

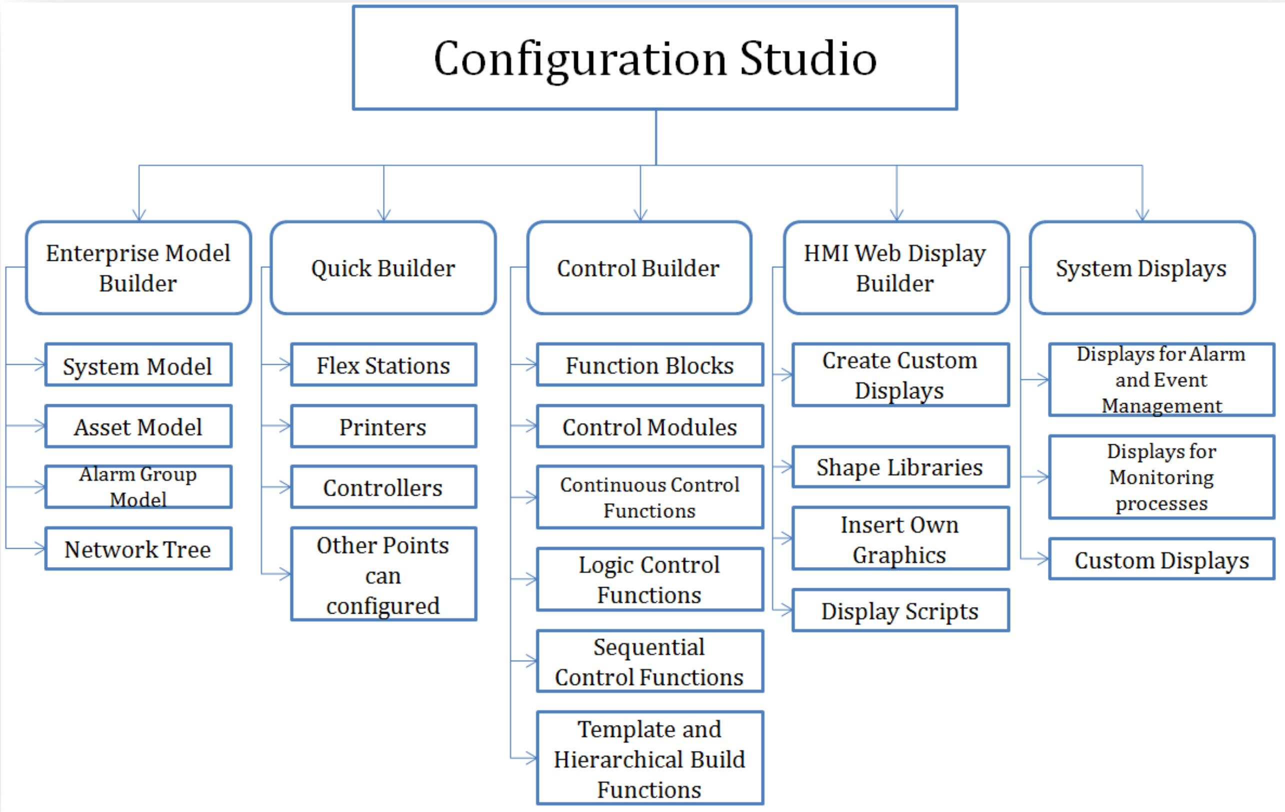

Figure 2: Hierarchical Structure of Elements in Configuration Studio

3.6 Enterprise Model Builder

Enterprise model builder is one of the initial tools used in the configuration of the system. The asset model for the system is built using this tool.

Enterprise model builder in Experion facilitates building the model or frame of the process or a plant. The configuration studio provides the tools for the variety of components used to define the Enterprise Model Builder and comprise of the:

- System Model
- Asset Model
- Alarm Group Model
- Network Tree

3.6.1 System Model

Building the system model involves defining servers involved in the system. Other servers that do not essentially form a part of the system can also be configured. Configuration of the system model defines the outline of the system.

3.6.2 Asset Model

Defining the asset model is the essential part of Enterprise Model Builder. Defining of assets assists in:

- Navigation through the Experion System
- Defines the responsibility of users and operators
- Resolving data references
- Management of Alarms
- Organization of points, displays and reports

3.6.2.1 About Assets in an asset model

The experion Asset model hosts a hierarchical asset structure using data bases. Each asset of the Experion system is a database unit which can be utilized to represent a physical item in a process plant, for Example: A facility, a section of the plant, equipment or a building. This form of asset structure proposes several advantages; some of which are listed below:

- Allocation or restriction of access which can be termed as Scope of Responsibility (SOR) can be easily granted to parts of the plants.
- The assets can also be categorised according to the operators or stations. This provides the flexibility of nominating selected points of the plant to be controlled

by certain operator or station. Any alarm or custom displays associated with the asset can also be accessed.

- This form of system provides the ease of logical representation of the system similar to the physical assets present in the plant.
- Navigation through the system is also made simple as the naming convention can be designed to be user-friendly avoiding the addressing of the equipment with tag names.
- The alarms of the system are automatically categorized according to the asset allocation.

3.6.3 Alarm Group Model

Alarm groups and their respective aggregated alarms can be defined in the Alarm Group Model.

3.6.4 Network Tree

Network tree represents a graphical view of the network. This provides the user with the ease of viewing the status of entire system on one screen. The Network tree of experion system works alongside with the System Event server and System Performance Server displaying the system errors, which would assist with troubleshooting the faults that occur in the system.

3.7 Quick Builder

Hardware components of the system such as Flex Stations, Printers, Controllers and standard (non-C200/C200E) points can be configured. The objects from the configuration studio can be downloaded to the server database after the configuration of these hardware points.

3.8 Control Builder

Control Builder is one of the essential components of the Experion system. Programming and configuration of the control strategies into the system is performed through the Control Builder. It provides a graphical tool for building the control strategies for process control application. The graphical feature of the application minimises the effort of design, implementation and documentation of the program.

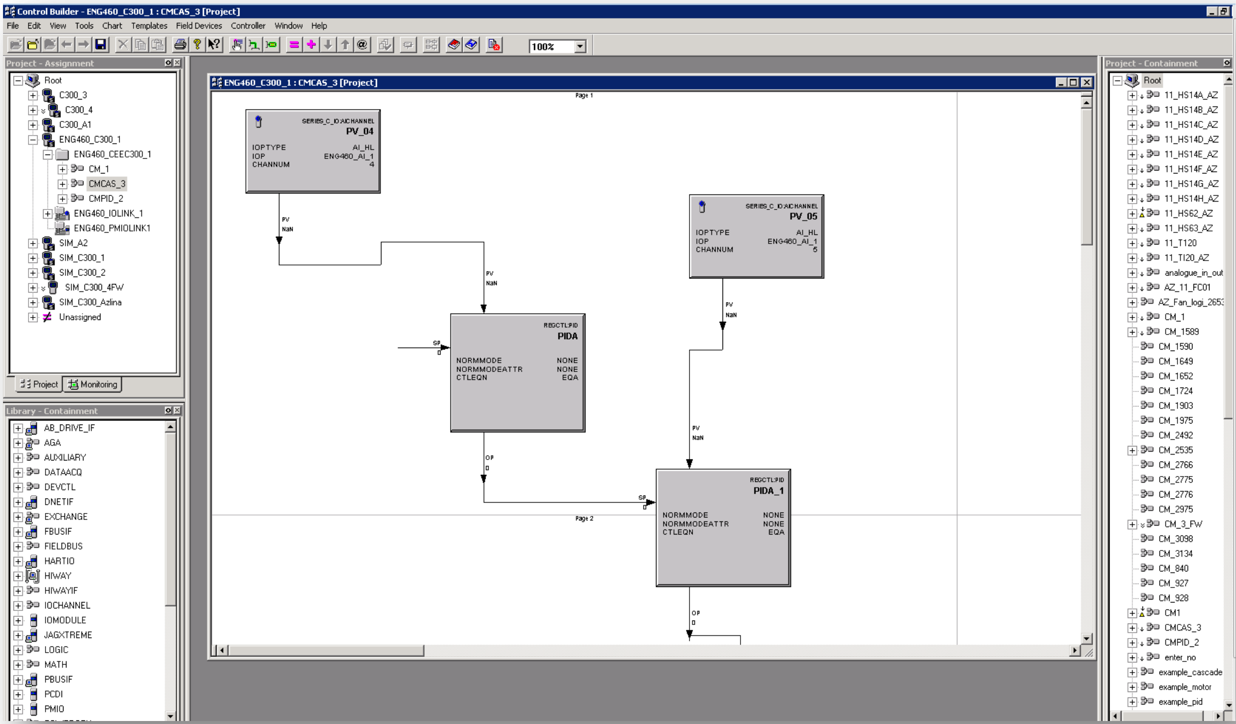

Figure 3: Overview Screen of Control Builder

The application hosts a variety of function blocks, control modules and various other features which assist in several process applications. Some of the many functionalities offered by the application are detailed in the subsections below.

3.8.1 Function Blocks

The function blocks host several control functionalities that assists in performing a variety of tasks to solve control problems in hand. The function blocks present in the control builder are categorised into Regulatory Control Blocks, Device Control Blocks, Logic Blocks, Sequential Blocks and Auxiliary Blocks. These function blocks can be incorporated into a program in the control module by choosing from the “Function block library” and dragging into the control module window. Inputs and outputs of this block can then be wired to other function blocks to execute the preferred control strategy.

3.8.2 Control Modules

Two primary types of the control modules are provided by Experion; Normal Control Modules (CM's) which are used to perform the continuous process control applications and Sequential Control Modules (SCM's) which are used to perform sequential and batch control applications. Different types of the function blocks are used in these control modules to perform the respective tasks.

3.8.3 Continuous Control Functions

Experion incorporates the built-in control functionality which minimises the engineering costs and facilitates an instantaneous communication with the process. The system provides various configuration options that assist in enhancing the performance of the system. This also equips the system with the ability of managing failures sustained due to the control strategy.

3.8.4 Logic Control Functions

The logic functions in Experion are provided to enhance the design efficiency. The logic functions contain a wide collection of algorithms that can assist in configuration and better operation of the system. The capabilities provided by the system include; "intuitive interlock tracking and Direct access to device maintenance statistics such as motor runtime". (Honeywell)

3.8.5 Sequential Control Functions

Sequential control functions are very import in the event of abnormal situation management. The Sequential control functionality is built-in with the capability to overcome uncharacteristic process behaviours. Using the functionalities provided the device states can be altered depending on the process situation. A sequence of steps can be programmed into the control module which would provide the ability to safely handle abnormal situations. The system also possesses the ability to enable the system to rapidly rebound.

3.8.6 Template and Hierarchical Build Functions

Experion provides users the ability to create customized function block templates. The system also provides hierarchical build functions which also assist users to arrange control modules reflecting the process hierarchy.

3.9 System Display

Displays that are used to configure items such as reports, group, display, trends, Station settings and Console Stations. Experion provides an extensive list of system displays that assist in monitoring and configuration.

3.9.1 System Displays for Managing Alarms and Events

Experion's System displays for alarm and event management provides a flexible operating environment. The displays provide users with the option of sorting the alarms and events according to priority, asset assignment and many others.

The Alarm Summary Window in the station provides online information about the alarms occurring in the system. The displays can also be configured to display most recent or high priority unacknowledged alarms.

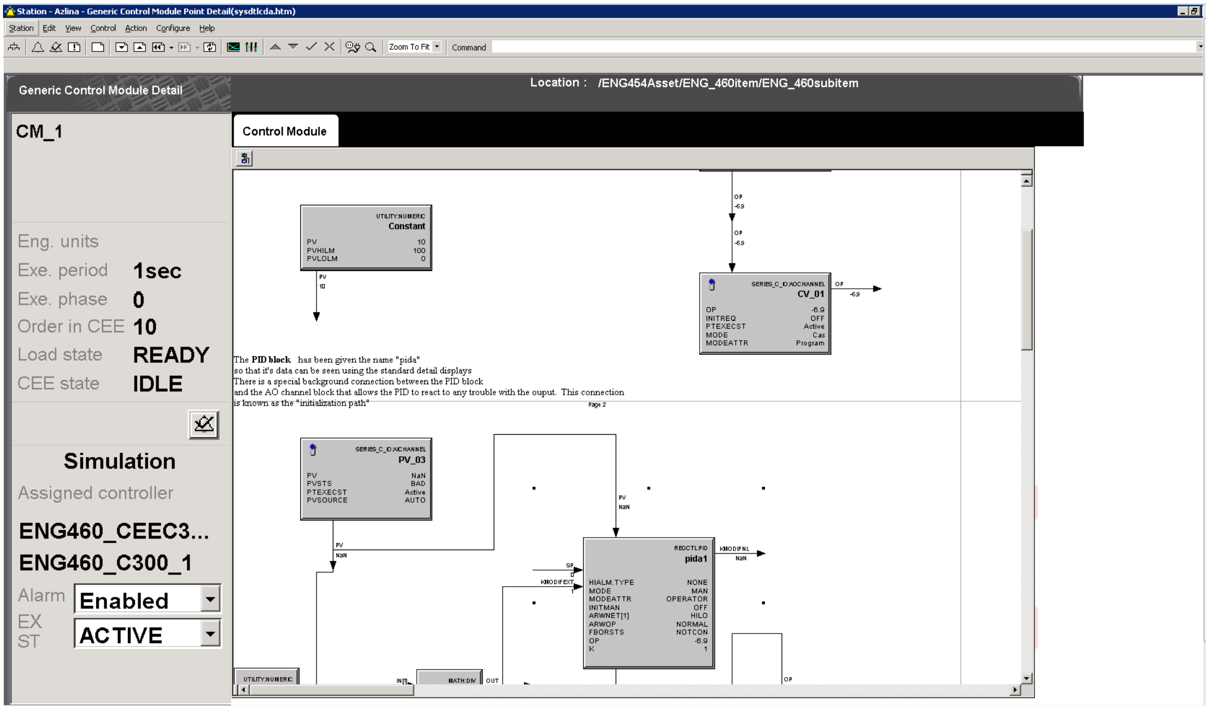

Figure 4: Point Detail Display of a Control Module

3.9.2 System Displays for Monitoring the Process

Experion also provides variety of displays and faceplates that are useful for process monitoring. Detailed information of a configured point can be accessed by double clicking on a particular point in the station display. These displays are known as point detail displays. The displays show current values of the points and also enable editing a few configuration parameters. Popup windows that are similar to the left hand side of the point detail displays are also available and provide essential information corresponding to the point.

Trends and group displays can also be configured to ease system monitoring. Trends can be configured to display process value changes over time. On the other hand group displays can be configured to display values of up to eight process points.

Specialized system displays can also be built to display desired process conditions. These displays can be built through HMI display builder. Experion provides several built in graphics which assist the users in building customized displays.

3.10 HMI Display Builder

Display Builder is a graphical tool for creating the user (custom) displays using Web-Based features. Displays are saved in HTML format. A number of built in graphics are available in the shape library for users to include in the displays. Custom graphics such as photos and layout diagrams can also be included.

The system also provides an advanced scripting functionality to design complex animations. However abundant functions are also available which perform advanced graphics which minimises the use of scripting.

3.11 Stations

Honeywell Experion runs on a supervisory infrastructure constituting single or multiple servers and a number of work station computers running the user interface called Station. Station software is Experion's user interface that provides control and monitoring of process points. All the alarm and event information can also be monitored and managed through the station interface. The software also provides trending functionality where process trends can be configured and read online. The data in the trend can also be copied onto other applications such as Microsoft Office Excel by simply using the copy data option. There are different types of stations that are customized for specific applications. These types are explained in the following sub-sections.

3.11.1 Flex Stations

Flex stations are the stations that run on a standard computer. There are two formats of flex station configurations.

3.11.1.1 Static

Static Flex stations are dedicated to a particular PC and are permanent connections. These stations are mostly opted by operators.

3.11.1.2 Rotary

The rotary station is described as “as required” connection. Using rotary stations provides an ease to the allocation of license specifications. This connection is useful if full time access to the server is not necessary.

3.11.2 Console Stations

Console stations are connected strictly to the process controller. These type of stations are advisable for processes which need continuous monitoring of information. All the critical data can be viewed without any loss.

3.12 Simulation Environment

Honeywell is incorporated with outstanding simulation environment that provides the opportunity to simulate CEE based controllers. The environment is present on the server computer. The simulation environment along with the CEE controllers can simulate PMIO, SIMIOLIM and Foundation Field bus interface modules.

These simulated controllers can be integrated with actual plant controllers to facilitate process applications. Most of the configuration strategies of simulation environment are similar to the actual control processors. The simulation environment is very useful as it is economical and reduces the cost. The environment is also idle for process training of the system configuration.

Seeing the training capabilities provided by the simulation environment, the environment was taken advantage of and controllers used in the thesis were all simulated. As the primary objective of the thesis is to use the system for teaching purposes the simulated controllers were adequate for the functioning of the project.

3.13 Data Exchange

Experion accommodates a range of data exchange capabilities that make the system extremely versatile. The data exchange capabilities of the system are listed below.

3.13.1 Open Data base Connectivity (ODBC) Driver

Experion's ODBC driver provides an option for ODBC-compliant client applications to retrieve data from the experion server database. An example of ODBC-compliant applications include Microsoft Access.

3.13.2 OLE for Process Control (OPC)

Experion provides standard OPC interfaces customized to a specific purpose. Both reading and writing of the data is possible through the OPC interface.

4 Statement of the problem or project proposal or objectives

Honeywell Experion Process Knowledge System (PKS) is an advanced Distributed Control system with integrated advanced process automation platform. The platform integrates both DCS and SCADA topologies which makes the software more versatile. Experion is extensively used for several applications across process industry. The platform was purchased by Murdoch University and served as a valuable asset to the University. It is a great teaching tool for students pursuing career in engineering as it introduces an industrial prospective to the course.

The software was acquired by Murdoch University and was beneficial in providing assistance with various aspects of the course. The software was integrated with Murdoch University's pilot plant to provide students with an opportunity to implement and experiment with complex control algorithms. Seeing the learning capabilities provided by the software, it was decided to utilize the software as a teaching tool for students studying industrial computer systems engineering. Following this thought the particular thesis was proposed.

The final goal of the thesis was proposed as development and integration of a new Honeywell Experion System in the industrial computer systems facility. To be able to use the system as a teaching tool firstly individual components of the system are to be explored and understood. Therefore before integrating the system into the ICSE facility, a test system was setup to enable exploring the functions of the system. This project was initially undertaken by Edwin Lum an industrial computer systems student as a part of his thesis in 2011, followed by ENG 454 students in the consecutive years. As Edwin Lum was first to undertake the Experion teaching system project initial steps of addressing security issues, installation of the system and initial configuration steps were undertaken. Additional progress was made by subsequent ENG454 students, exploring the exchange of data of the system with other software platforms such as Microsoft office Excel and also OPC communication. The project this year is shared with the postgraduate student Nurazlina Nain. The two projects cover different areas of the Experion system, with some overlap in the initial phases.

This section of the report outlines the initial objectives set to of the thesis. However it is essential to mention that most of the software was unfamiliar and the depth of the concepts was only roughly estimated to plan the initial objectives. As the thesis progressed some parts of the thesis occupied more time and considering the time limitation of the thesis certain objectives could not be completely explored.

The software itself is sophisticated and complex as it was primarily designed for use in an industrial framework. The software has the capability to be virtually integrated with any form of process aiming to be controlled. Hence there are a multitude of obstacles to overcome before the final objective of the project can be fulfilled.

The Experion software was mostly unfamiliar and therefore documentation providedby Honeywell was the primary information source available. Primarily training manuals from Honeywell were searched and tutorials provided on the relating topics were followed. The manuals served as a great starting point as the information was broken down into basic steps. Other research on the software and its operation was also done in Knowledge Builder. Knowledge Builder is a tool provided by Honeywell which hosts a wide range of information on the Experion system. After an appropriate research on the operation of the software basic framework of objectives to be accomplished were outlined.

Framework of the entire thesis can be broken down into five main categories detailed below:

- Development of a simulation environment to be used for teaching purposes.
- Configuration and testing of a C300 simulation system on all the client machines.

- Design of HMI screens.
- Integration of the system with Seimens PLC's and other devices in the facility and possible integration with other SCADA systems such as WinCC etc.
- Implicit is the development of appropriate software in both the simulated and physical controllers/PLCs and HMI screens plus appropriate tutorials/laboratory work for use in an educational setting to teach others students about the Experion System.

Further detail of these tasks is presented in the in following sub-sections

4.1 Development of the Simulation Environment

As mentioned earlier in the report Experion has the ability of providing users the opportunity to simulate a controller. Previous work undertaken on the thesis project covers a majority of the configuration steps. However, setting up a simulation of process controller was the initial step. Therefore a simulated controller was to be created for the purposes of the thesis. Creating a new controller also provides a good opportunity to revise and re-asses previous documentation

The Experion software also provides a host of control blocks to assist with the control problem in hand. Following the initial step, the subsequent focus would be towards knowing and understanding the functionality of these Function blocks. One of the main function blocks to be focused on would be Regulatory control blocks which contain blocks important for the process control applications (Example: PID, PIDFF etc). Addressing the functionality of these blocks provides several tasks. As the thesis is mainly concerned with providing a teaching environment, functionality of these blocks can be demonstrated by simulating variety of processes in a client application.

Configuration and setup of Station would be one of the main aspects of building a complete system. Honeywell integrates several innovative and effective features into Experion's station software. A very basic configuration was covered during the previous work undertaken on the project and hence more advanced capabilities were to be examined.

Experion also provides the ability to backup and recovery in the event of node failures due to possible viruses, failed applications, disk corruption, accidental deletion, natural calamities and other hardware or software shutdowns. This backup and restore function is an essential area of research in the later stages of the thesis. As the thesis is being designed for educational purposes the software could be operated by students who might not completely be familiar with all the aspects. Therefore the backup and restore could be very essential to bring the system back to a desired default state after being used by students.

4.2 Configuration and Testing of C300 Simulation System On All the Client Machines

Honeywell provides an option for data exchange with Microsoft Office Excel. This option facilitates implementation of various types of control strategies for better plant performance.

Previous works undertaken on the project covered basic establishment of Excel communication. This work might be sufficient for current purposes, basic information provided could be utilized in simulation and integration of advanced processes with the Experion system. Also some of the documentation relating to the excel communication needs to be revised and a final detailed version is required to be created.

Also other elements of client configuration that could be researched involve:

- Configuration and Set up of Station software on the client machines
- Application Control Environment (ACE)
- Setup of OPC server and communication

4.3 Design of HMI screens

HMI web display builder provided by Honeywell provides the capability of building custom displays incorporating several complex features. Honeywell also provides several built in displays that make designing of the displays quicker and more effective. The software also has the functionality to design animations, which could be useful to represent different plant operating conditions or state of equipment. Several complex animations can also be created using scripting functionality. Visual basic scripts can be written for the objects in the displays to enable more advanced and user-friendly operation.

Some of the files created by Honeywell during the development of the tutorials for their training program were used in this report. Filtering these files and extraction of useful information could also aid with the design of the teaching system.

4.4 Integration of the system with PLC's and other devices in the facility and possible integration with other SCADA systems such as WinCC

"OPC is dedicated to ensuring interoperability in automation by creating and maintaining open specifications that standardize the communication of acquired process data, alarm and event records, historical data, and batch data to multi-vendor enterprise systems and between production devices." (Honeywell Process Solutions)

The work that can be done regarding the OPC communication is listed below:

- Establishing OPC Communications with Labview, Semens PLC's and Allen Bradley PLC's
- Communication with other SCADA systems such as WinCC

4.5 Designing appropriate tutorials

Creating tutorials on every step of work done is very essential component of the thesis as the main purpose of the project is to adapt the work done for teaching purposes. It is essential for a considerable amount of time to be spent on documentation of tutorials. The tutorials documented need to be clearly detailed with a step by step illustration.

5 Accomplishments or Performed tasks

As stated above the project requires several sequential steps to be undertaken. After the tasks of the thesis were outlined, the project was started by performing research on the system and understanding the system as a whole. After some initial research of the system was done, building and configuring the simulated controller was initiated. Following this initial step more advanced development was achieved.

This section provides additional information on the accomplishments and the activities performed during the thesis. The difficulties faced during the thesis and the techniques used to overcome these difficulties are also described.

5.1 Building and Configuration of C300 Controller and Building of Asset Structure and Update of Previous Documentation

As described earlier the Experion is an extensive piece of software created for the control of vast variety of plant applications. Therefore understanding the scope of the software is essential. Consequently, the project commenced by undertaking research on the fundamental concepts of the system. Most of the information was primarily obtained from the Honeywell's online resource and Training manuals provided by Honeywell. (Murdoch Research Repository)

Following on from the research, eminent parts of the system were started to be built and configured. One of the immediate things was to setup an asset structure for the system and configuration of simulated C300 controller. A new C300 controller and Assets was configured following the prompts provided by the previous documentation, which allowed verifying the previous documentation. (Murdoch Research Repository). This newly created controller and assets was customised to the thesis project in hand as shown in the Figure 5. Some errors were encountered during the controller configuration and these errors were eliminated and documented for future reference.

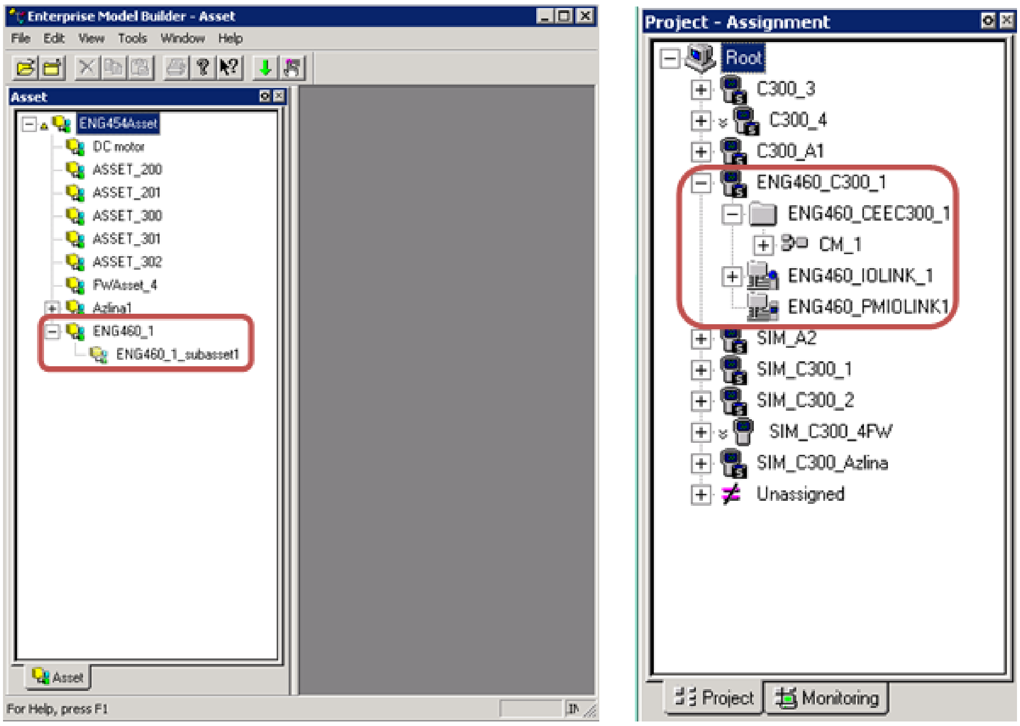

Figure 5: Customized Assets and Controllers Created

An example of the errors that occurred while programming the control module is that, active locks were being created on the control modules even when the modules were not currently being used. These errors would prohibit the user from using the control module or downloading it. Therefore the error was addressed and solution was found. A screen shot of the error generated is presented in the Figure 6. The tutorial for clearing out active locks was created so it could guide other users if the error was to be encountered in the future. (Honeywell)

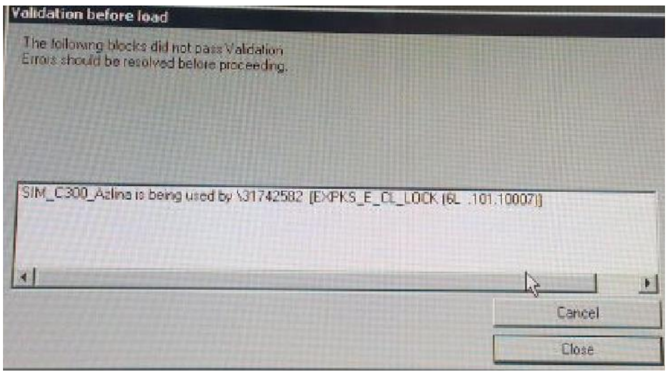

Figure 6: Screen Capture of the Active Lock Error

5.2 Main Focus Of the Project

Subsequent to the establishment of the foundation of the system, the Control module could now incorporate a control algorithm for process control applications. Experion's Control Execution Environment (CEE) accommodates a magnitude of function blocks that can be used for variety of process control applications. After consultation with the project supervisor, primary objective was chosen as; exploring the functionality of Regulatory Control Blocks. Honeywell Experion system was majorly designed for process control applications; investigating the operation of function blocks designed for process control would be initial step.

Regulatory Control blocks of Experion system offer a veritable "toolkit" of process control functions. Each block is configured to perform a single control function, and multiple blocks may be connected to form complex control strategies. The Regulatory Control blocks also incorporate additional control flexibility and customization features. Some of the examples of regulatory control blocks present in Honeywell's Control Execution Environment (CEE) include:

- PID
- PIDFF
- PIDER
- PID-PL
- RTIOCTL etc.

Each regulatory function block offers distinct functionality suitable for a variety of process control problems. The functionality of each control block was explored sequentially starting from the basic PID Block and proceeding to blocks with advanced functionality such as PID-PL (PID Profit Loop) Block. An overview of the functionalities of some these blocks is presented in the subsections below.

5.2.1 PID Block Description

Since the emergence of process control in 1940's PID Controllers have become a customary tool in process control. It is the most conventional form of feedback process controller used. In the modern day process control, PID control loops are most dominant. There are different variations of the PID controllers. The controllers can be simulated digitally on a computer system or physical PID controllers are also manufactured with one or more built in loop options. They can also be embedded with other controllers to form special purpose complex control systems.

PID control is a significant component of a Distributed Control System. The Control block is generally integrated with other function blocks (logic, sequential etc.) to operate variety of sophisticated industrial systems. It can also be used as a lower level control system while implementing the complex control strategies; where the set points from the multivariable controller are given to lower level controllers. Therefore PID controllers are an important asset for a process control engineer and can be addressed as "bread and butter of control engineering". (Error Squated PID)

The implementation of the PID controllers has sustained several changes throughout the years. Initially operated by mechanics and pneumatics, most of the modern day operation is performed through microprocessors. Operation with microprocessors have provided the prospect of developing advanced features of automatic tuning, gain scheduling and continuous adaptation.

Considering the importance of the PID controller in process control, operation and features provided by the PID controller block was the primary task to master. In the Honeywell Experion Environment PID Controller function block was one of the Regulatory Control Block's. The block provides several variations of the PID control strategy that can be useful in the control of different industrial processes. The Block can be used by itself or can be combined with other PID controller function blocks to implement cascade control strategy.

The types of equations present in the block and the additional advanced options provided by the block are discussed in this section.

As mentioned earlier the block is one of the regulatory control blocks provided in the library of Control Builder. To include the block as part of the control system, it can be dragged and dropped into the respective control module. The inputs and outputs can then be connected to other function blocks to implement required procedure. Figure 7 shows the location of Experion's PID block in the Control Builder Library.

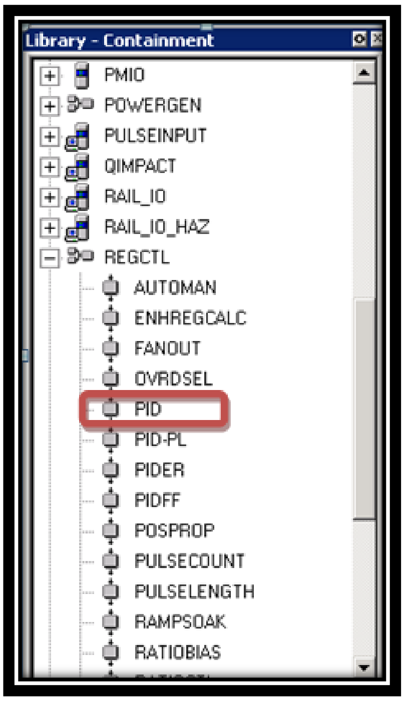

Figure 7: Location of PID controller Block in Library

PID controller configuration window can be launched by double clicking the PID controller function block. The configuration window hots various tabs in which the PID controller settings can be configured. The Algorithm tab of this configuration window provides the choice of strategies that can be configured into the block.

5.2.2 Algorithm Tab of PID Control Block

The following Figure 8 depicts the algorithm tab of the PID block.

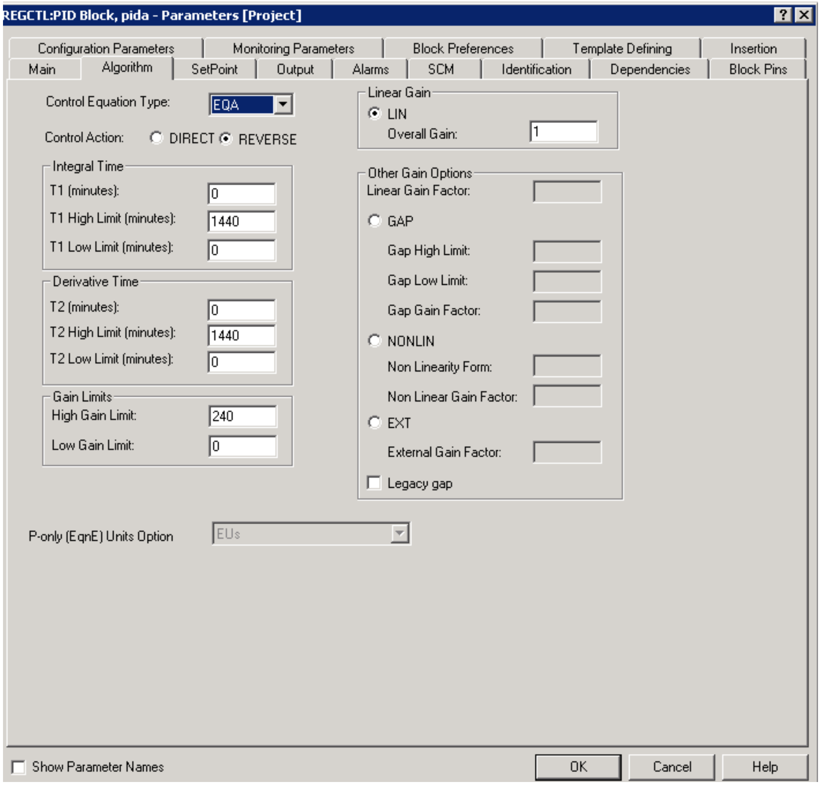

Figure 8: Algorithm Tab of the PID Block

The tab provides various options associated with; specifying the values of tuning parameters, type of equation to be used and different gain options. “Control Equation Type” option is where desired type of equation to be used by the block is chosen. Description of these equations and their practical usage is discussed in the following sub-sections.

5.2.2.1 Equation A

Equation A presents a standard PID equation with all the three proportional Integral and derivative terms acting on the error. If only PI or PD terms were chosen to be used then the T1s and T2s can be given value of ‘0’.

The equation used by Honeywell is presented below:

$$CV = K * L^{-1}\left[\left(1 + \frac{1}{T1_s} + \frac{T2_s}{1 + a * T2_s}\right) * (PVP_s - SPP_s)\right]$$

K	=	Gain of the PID Controller
$T1_s$	=	Integral Time of the PID Controller
$T2_s$	=	Derivative Time of the PID Controller
PVP_s	=	Process Variable
SPP_s	=	Set Point

This equation can be used similar to the standard PID algorithm with processes that are not challenging to control.

5.2.2.2 Equation B

With Equation B the proportional and integral terms acts on the error whereas the derivative term follows the PV of the process. The equation used by Honeywell is presented below.

$$CV = K * L^{-1}\left[\left(1 + \frac{1}{T1_s} + \frac{T2_s}{1 + a * T2_s}\right) * PVP_s - \left(1 + \frac{1}{T1_s}\right) * SPP_s\right]$$

The PI-D type in some controller manuals is referred to as derivative on PV. In the PI-D implementation, derivative term follows the PV and not the error. Thus eliminating undesirable kick in the output of the controller, that occurs with a step change in the setpoint. This implementation is preferred anytime the derivative action is used.

5.2.2.3 Equation C

Equation C provided by Experion is similar to an I-PD controller. With an I-PD controller, only the integral term acts on the error, and the proportional and derivative terms follow the PV of the process. This form of implementation eliminates the proportional and derivative kick reflecting on the controller output. The I-PD controller is useful for eliminating the Set Point overshoot with self-regulating processes displaying measurement lags. The form of equation used by Honeywell is presented below.

$$CV = K * L^{-1}\left[\left(1 + \frac{1}{T1_s} + \frac{T2_s}{1 + a * T2_s}\right) * PVP_s - \left(\frac{1}{T1_s}\right) * SPP_s\right]$$

Several self-regulating control loops of level or temperature display a measurement lag. In both the cases the actual reading of the input is not observed by the control system due to the measurement lag.

Using a generic PID controller and implementing a step change would show acceptable control, whereas the real process would overshoot the desired set point. The implementation of the I-PD controller would eliminate these unmeasured overshoots in the process variable. With a level control system a large controller gain is usually applied, which results in an excessive change of valve position even with a minute change in the set point. For a process which cannot handle these sudden hikes in the valve, the I-PD controller would be the most appropriate controller to be used.

The I-PD controller type is recommended for all kinds of process applications unless there is a need for the control variable to attain the set point quicker and the unmeasured process overshoot is acceptable. As the I-PD controller eliminates large spikes in the valve position, this would also minimize downstream disturbances that might be caused by the valve.

5.2.2.4 Equation D

Equation D in the Honeywell Experion system is programmed to implement I-only control. One of the primary reasons to use the I-only control is that it eliminates any deviation in the process. Thus implementation of an I-only controller would bring the process to its usual operating condition and steady state.

One of the draw backs of the I only controller is that the controller exhibits slower response time when compared to P-only controllers. P-only controllers depend on fewer parameters compares resulting in a faster response time. The I-only controller would be employed on a process where offset is truly undesirable. Practical applications of the I-only controllers would also be included for the systems in which the process variables are operated over a very narrow region and entail fine-tuned control. The primary purpose of incorporating the I-only controllers to a control system is to remove the offset in the process variable. Following is the equation used by Honeywell to employ the I-only control.

$$CV = L^{-1}[\frac{1}{T1_s} * (PVP_s - SPP_s)]$$

5.2.2.5 Equation E

Equation E present in the Experion system is similar to a gain only controller equation. It can be used in the situations of a capacity system where there is no need for an integral term to be present in the controller. Simulation of a capacity system was done to demonstrate the use of the controller. The equation used by Experion for is used in shown below.

$$CV = K * (PV - SP) + OPBIAS.FIX + OPBIAS.FLOAT$$

5.2.2.6 Other Gain Options

The PID controller block also provides different options for the calculation of a process gain. These gain options are designed to assist with the control of the processes with special characteristics. These gain options provided by the controller are described in the following sections.

5.2.2.7 GAP Gain

The Gap gain is one of the advanced options provided by Experion to assist with complex process control problems. This option provides the capability to reduce the sensitivity of the control system when the PV is within the user specified band width of the set point. A gain factor can be entered which is used to calculate the scaled down version of the overall process gain. The value can only range between 0 to 1 and is multiplied with the linear gain to calculate the overall process gain.

This option would be help reduce any overshoot that might occur due to the excess process gain by slowing down the process around the set point.

5.2.2.8 NON-Linearity Form (Error Squared)

The non-linearity form provides the control action which is proportional to the square of the error rather than the error itself. The equation used to calculate this gain is presented in the following Equation.

$$K = KLIN * \left[NLFORM + NLGAIN * \frac{|PV - SP|}{(PVEUHI - PVEULO)} \right]$$

Where:

KLIN = Linear gain specified by the user

NLFORM = nonlinear gain form (user-configured; may be 0 or 1)

NLGAIN = nonlinear gain specified by the user

This equation is used to calculate the gain of the controller and is applied to the control equation chosen in the Control Equation Type option. The absolute value of the error is used in the gain equation to maintain the direction.

In the implementation of this non-linear equation, the effective controller gain becomes smaller as the error approaches zero. The error squared controllers are mainly used in the control of surge or averaging level systems. It is recommended that the error squared on gain form of controller is implemented as a P-only controller as any I tuning could result in unstable control.

A surge tank is used as storage or a reservoir for a process in the downstream of the tank. The purpose of the tank is to absorb any sudden rises in pressure or flow caused in the inlet of the tank. The tank also acts as a reservoir and supplies additional water for the downstream process.

An example of such a system would be a tank with various input flows that are blended inside the tank. The control objective of with this tank would be to minimize flow disturbance to the downstream process and also maintain the level of the tank at desired set point. Minimizing flow disturbances to the downstream process would essentially mean reduction in the control valve movement. The error squared control algorithms are best suited for this type of control systems.

For this kind of control it is essential to incorporate the range of the process variable in the control equation and hence the presence of (PVEUHI-PVEULO) term in the equation deriving gain of the control system.

5.2.2.9 External Gain

External gain factor allows the user to modify the gain of the controller by a user specified input value. This value could be sourced from the process directly or the user program. The formula used by Honeywell is presented in equation below.

K = KLIN * KMODIFEXT

Where:

KLIN = linear gain

KMODIFEXT = External gain modifier

The primary use of this option is to compensate for non-linear process gain. The PID controller gain can be tuned depending upon the changing gain of the process. An example being; a tank with a varying cross sectional area. The gain of the controller could be modified to compensate for non-linear level change caused by varying tank shape.

5.2.3 Simulation and Control of a Non-linear System

As mentioned in the previous section the PID controller provides an external gain option. Using this option gain of the system can be modified with changing process characteristics. It was also mentioned that this kind of control system is most beneficial for process with changing model example being a tank with varying cross sectional area.

Therefore to demonstrate this functionality a non-linear conical tank process was simulated in Microsoft offices excel. The communication between excel and Experion was achieved through Microsoft Excel Data Exchange functionality provided by Experion. A Spread sheet used for the simulation of the system and configuration done in the control module is explained in the following sub-sections.

5.2.3.1 Non-Linear system Excel Simulation:

For the simulation of the Non-linear system firstly an equation of a non-linear tank was formulated. An example provided in Process Dynamics modelling and control Page 323 provided a reference equation for simulation of the system. (ebook.net)

This equation was inserted as cell formulas into excel. Suitable model constants such as height and radius of the tank were chosen. Figure 10 shows the spread sheet used for simulation of the system.

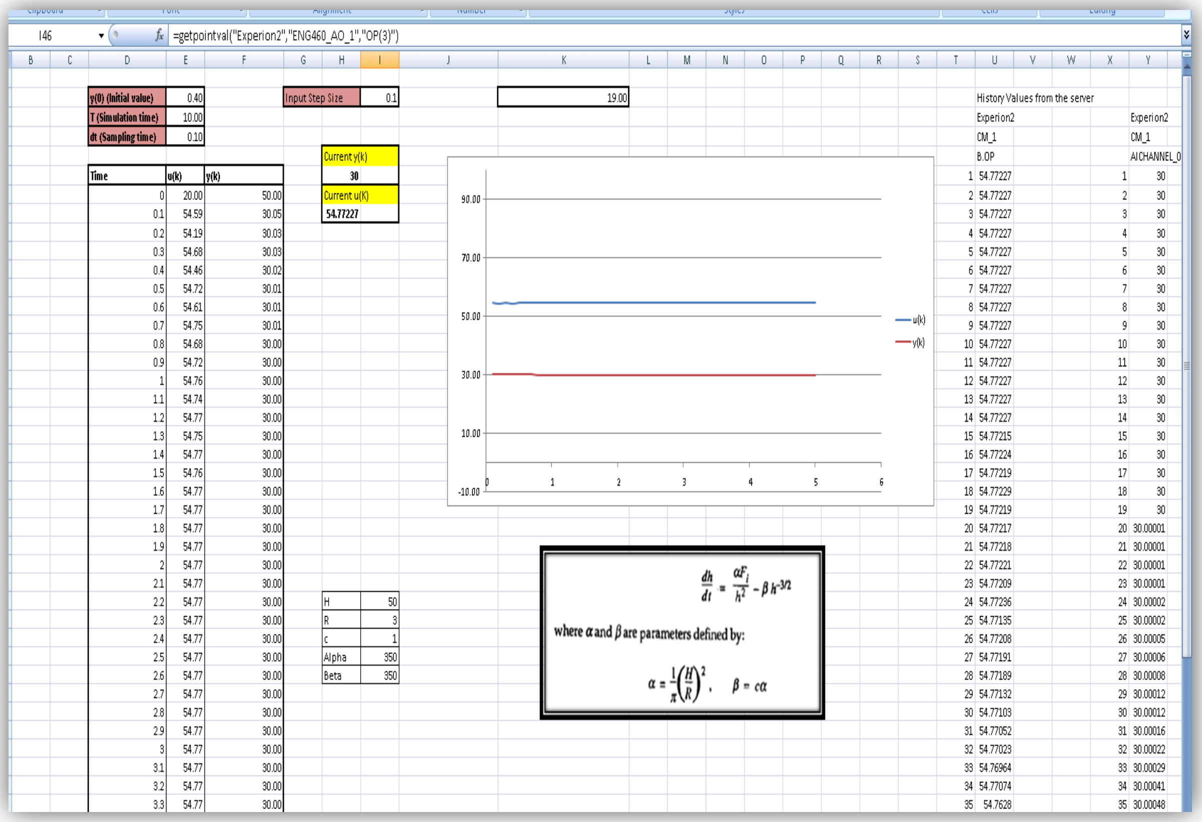

Figure 9: Non-linear Simulation Spread Sheet

On the left hand side of the spread sheet process variable values are calculated from input and time values according to the system equation. On the right hand side of the spread sheet history values of process inputs and outputs were gathered. These history values are used to plot the process on an excel chart and also assist in the calculation of process variable values.

5.2.3.2 Programming of non-linear system in the Control Module

After proper simulation of a non-linear system in Microsoft excel spread sheet, PID controller configuration was commenced. Initially Analogue input and output blocks were placed in the control module to be used as PV and OP of the process. The OP value was being read by the spread sheet to be used as input to the non-linear system and the output of the system equation was written to as PV value.

To enable modification of the External gain factor, the parameter was added as one of the block inputs. Figure 10 shows the function block programming of External Gain

feature.

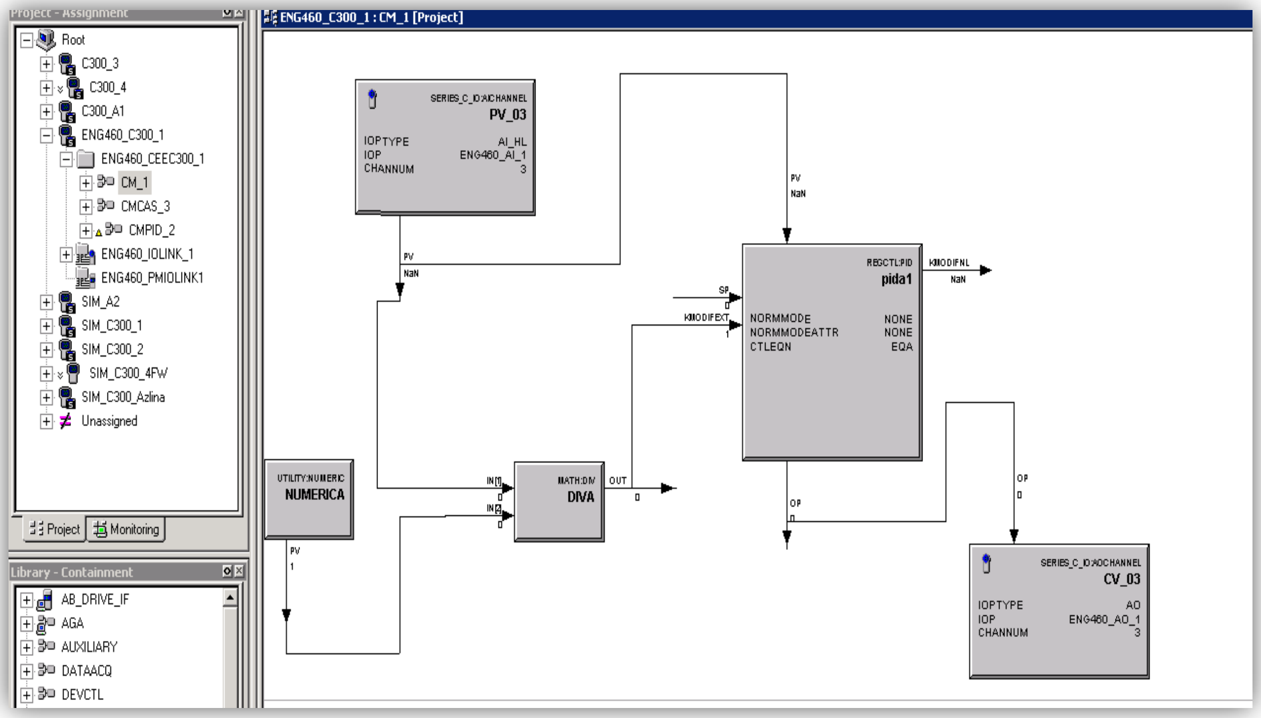

Figure 10: Function Block Programming of External Gain Feature

To enable the external gain option the “EXT” option in the algorithm tab was chosen as shown in Figure 11 PV value was divided by a constant to generate the value of external gain factor as shown in Figure 11. This value was wired to the external gain factor input created earlier.

The Linear gain and integral time of the PID controller were tuned to be 2 and 0.3. These factors behave similar to the regular PID Block and can be tuned as usual.

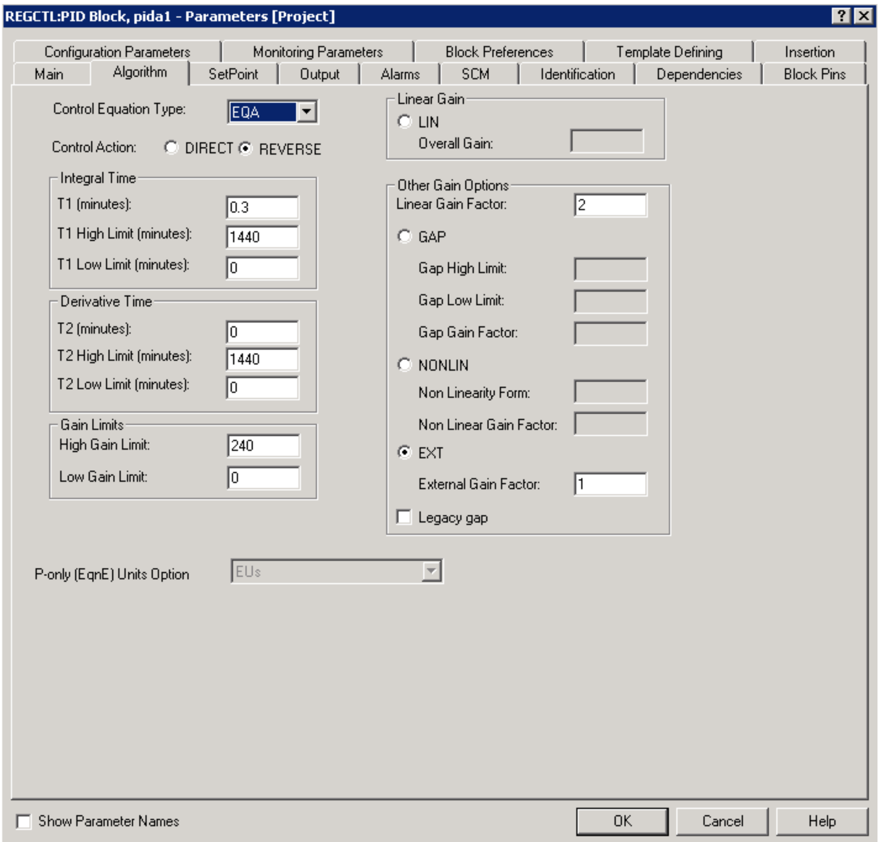

Figure 11: External Gain option Enabled in the Algorithm Tab

5.2.3.3 Setup of Station Display

A rotary station called ENG460 was setup for the purposes of this thesis project. All the display pages were accessed through this station. Flex stations configured in the system are shown in Figure 12.

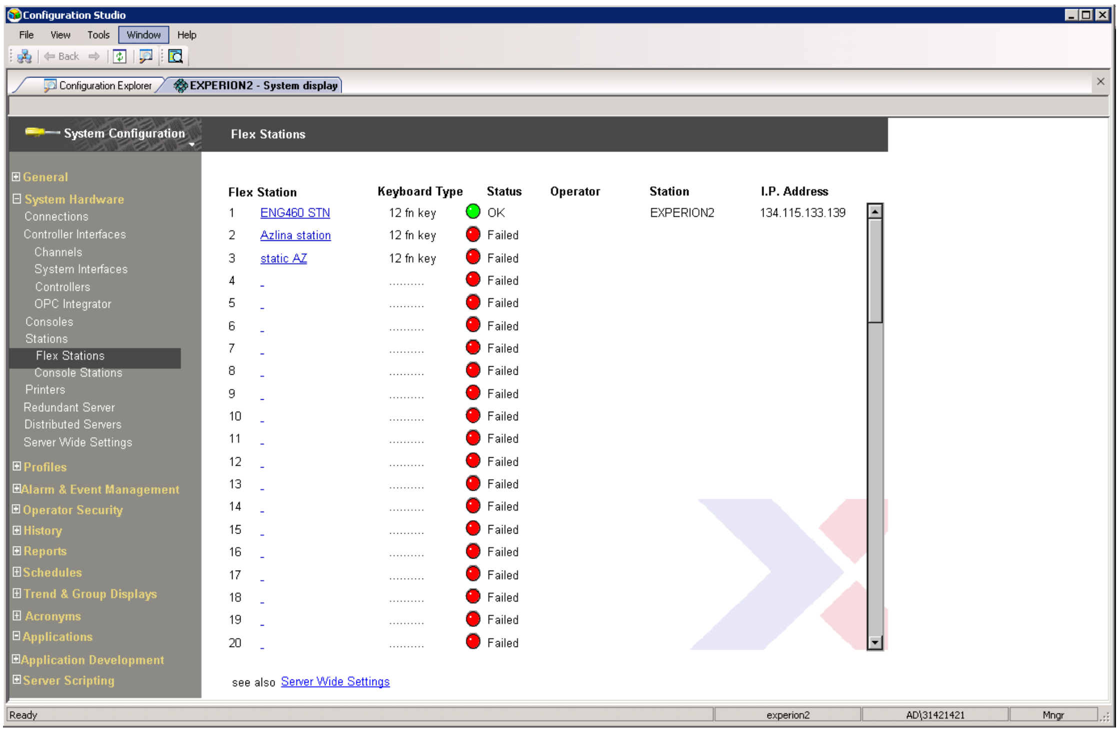

Figure 12: Flex Stations Created in the Experion Environment

Using HMI display builder a customized display page as shown in Figure 13 was created for the non-linear system simulation.

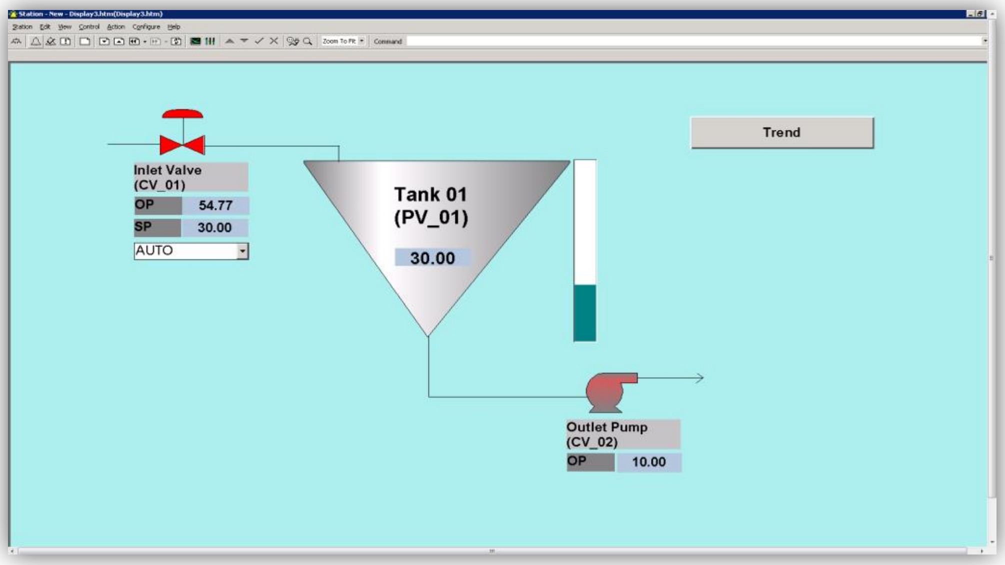

Figure 13: Station Display of Non-linear System

Colour change Animations were programmed into the inlet valve and the pump. At the extreme operating conditions, the colour of the equipment is programmed as red. This is done to ease the identification of extreme equipment operating conditions for the operators.

A trend page displaying set point OP and PV values of the system was also created and can be navigated into by using “Trend” button on the screen. Figure 14 depicts the trend page of the system.

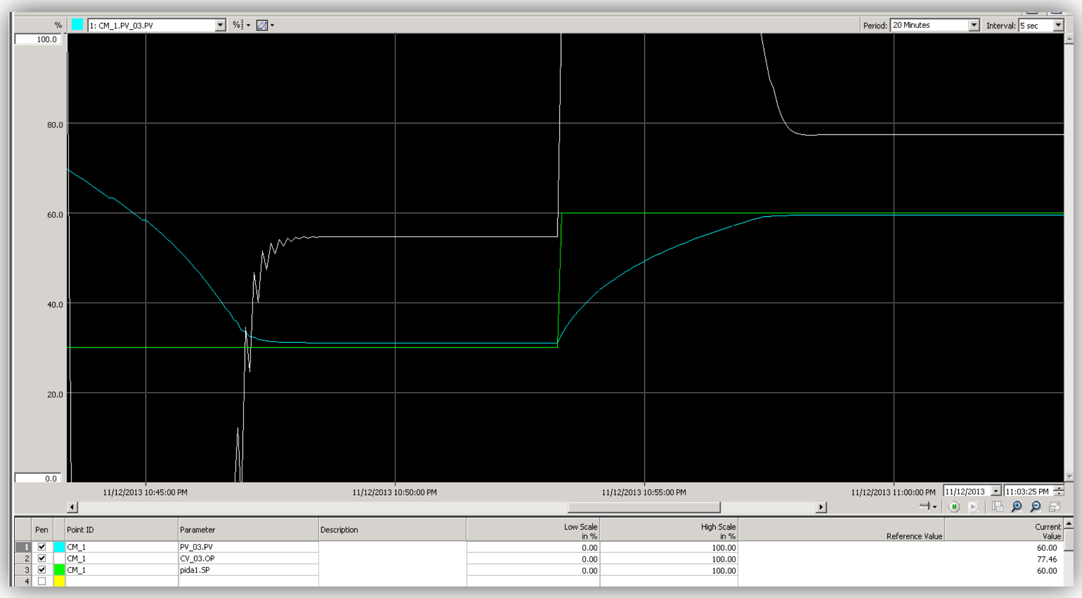

Figure 14: Trend Page Configured for Monitoring Non-Linear System

5.2.3.4 Testing of the Non-Linear Functionality Against Generic PID controller

After integrating all the components created for the exercise, the external gain functionality was tested against functionality of a generic PID controller. Figure 16 and Figure 16 are the results obtained by testing the controllers.

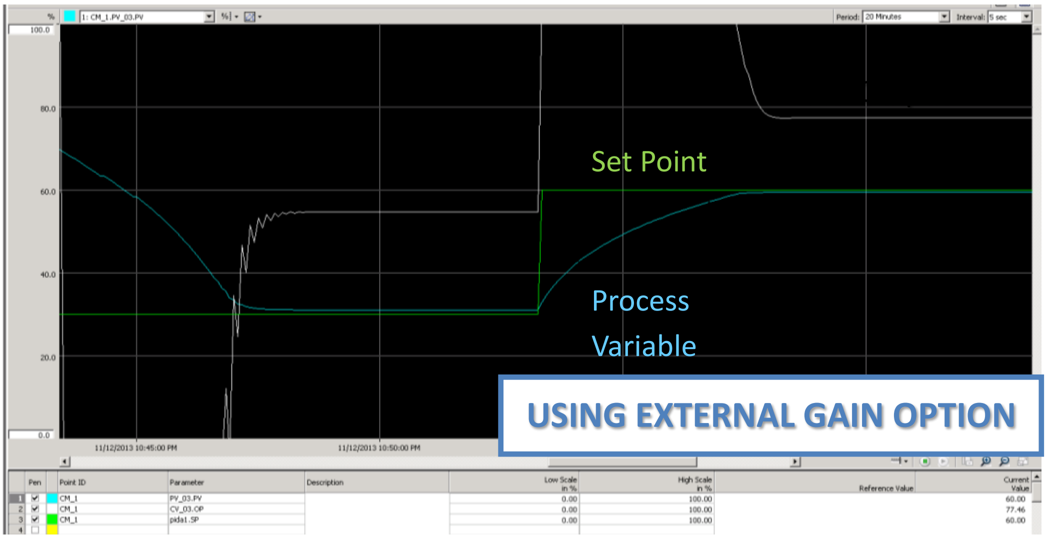

Figure 15: Results Produced by using the External Gain Option

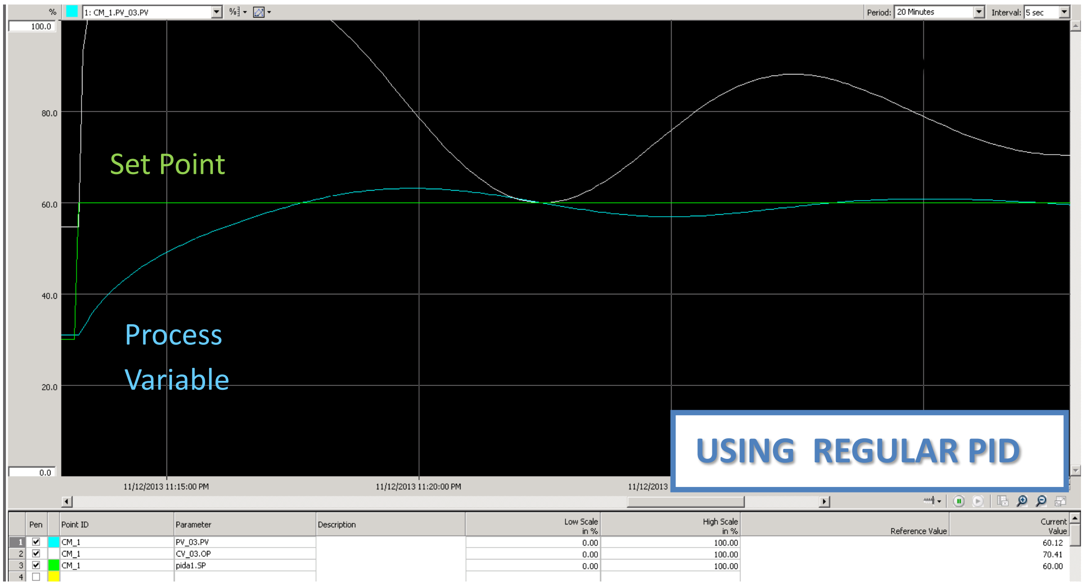

Figure 16: Results Produced by using Regular PID

As observed above using the external gain provided a more desirable system response. Using a generic PID even with the best possible tuning it would always result in the process variable oscillating about the set point as seen in Figure 16. The external gain option eliminates this oscillations and provides a smooth response. Hence the advanced option provided by Experion's PID controller block is in fact very beneficial and would be significantly useful in an industrial setting.

5.2.4 PID-PL Function Block

Profit Loop PKS is a model predictive controller present in the Honeywell Experion environment. The controller challenges the fundamental technology of a PID controller and introduces field proven model based control and optimization at a regulatory control level. In most cases profit loop can be used to replace standard PID controllers. A Profit loop controller provides better control with difficult to control systems effected by excessive noise, systems where a lot of valve ware is observed and also systems which exhibit frequent change.

Model based control comprises of different features compared to PID control, where a mathematical equation is used to depict the process behaviour. By depicting the behaviour of the process the controller calculates the output operating value. This kind of implementation is different to generic PID where the desired controller output is obtained by changing a few tuning parameters. The Profit Loop controller is the only form of model based control that runs in embedded controller. The generic PID controller is extremely popular across the process industry but can sometimes be expensive to tune as it has no knowledge of the process characteristics. Profit loop provides superior control and in some studies it has been proven that the stability can be increased by 30% compared to traditional PID. As Profit loop is a predictive controller it can account for differences in the behaviours of difficult to control loops. The controller also provides the option of filtering its output which is useful to reduce valve travel by up to 50% which would in turn reduce the maintenance costs. The profit loop filters the valve movement thereby minimizing the damage of the valve. (Honeywell Process Solutions)

The controller is also easy to tune compared to a generic PID controller as it only uses one tuning parameter (Performance ratio) instead of three used in a regular PID block. This parameter determines the speed of the response i.e., the user can choose aggressiveness and robustness of the control loop.

The Profit Loop controller has all of the generic PID controller functionalities along with the advanced model predictive control features. The Profit loop option can be chosen from the Algorithm tab of the Profit loop function block, which can be launched by double clicking on the block. The following Figure 17 depicts the Algorithm tab of the Profit loop controller.

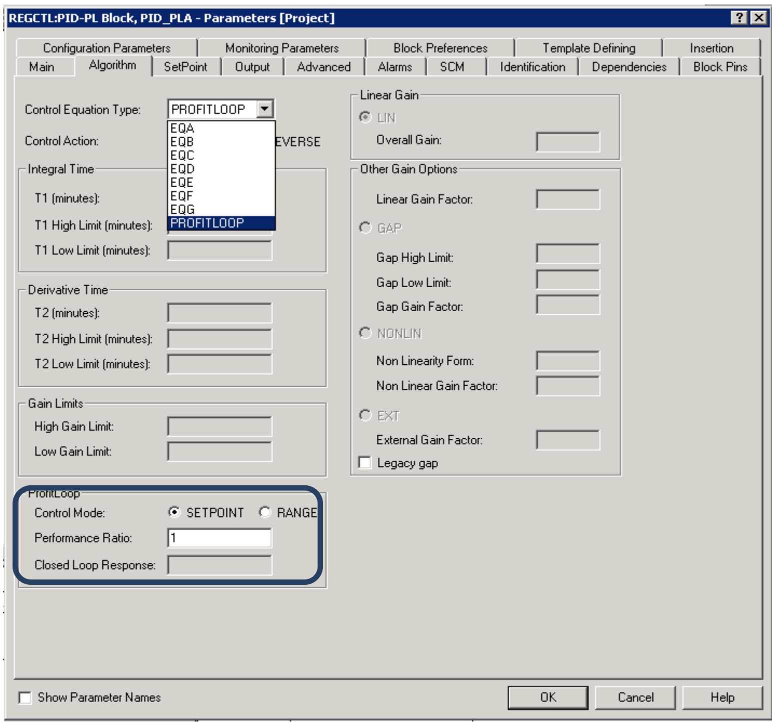

Figure 17: Algorithm Tab of Profit Loop

5.2.5 Algorithm Tab of PID-PL

The Profit Loop column highlighted in the figure above contains the Profit Loop specific configuration elements. A short description of the functionalities of these parameters is provided below.

5.2.5.1 Control Mode

The control mode option contains two options that can be selected. By selecting the setpoint option, the function block calculates its OP such that the process variable tracks the setpoint. Whereas choosing the range option enables the process variable to stay within the high and low set point limits.

5.2.5.2 Performance Ratio

The Performance ratio option defines how hard the function block will push to the set point or a range limit. In other words it defines the speed of the response. The parameter is the ratio of closed loop control response time to open loop control response time and can range from 0.1 to 10. The Performance ratio parameter is only available to be set for non-integrating processes.

The default performance ratio of 1.0 represents steady-state control and reaches the control objective at the natural process response time. Decreasing this ratio (PRFRATIO < 1) leads to faster, more aggressive control. The process will be driven to its set point more quickly than its natural open loop response. Increasing the ratio (PRFRATIO > 1) leads to slower, but more robust, control. The process will be driven to its Set Point more slowly than its natural open loop response. For integrating processes, use Closed Loop Response to specify the integrator performance. In this case, Performance Ratio is set to 1.

5.2.5.3 Closed Loop Response Time

Closed loop response time option is available for systems with integrating element. A value greater than 0.1 can be entered.

5.2.6 Advanced Tab of PID-PL

The advanced tab is an additional tab present in the Profit Loop controller compared to other PID controllers. All of the process model specifications can be configured in this tab. The tab provides the options of manual entry of a process model in Laplace transform terms, PV and OP settings, optimization and in addition allows to launch Profit Loop Assistant (A tool to assist with model prediction).

Entries or changes in the area are treated differently, whether working in project view or in Monitoring view. While in the project mode, if entries or changes are made in the model area, the parameter values are updated in the Engineering Repository Database (ERDB) immediately. Whereas in the monitoring mode; if the entries or changes are made in the model area, they are displayed, but the function block is not updated until the Update Model command is selected. A picture of the advanced tab is presented below in Figure 17.

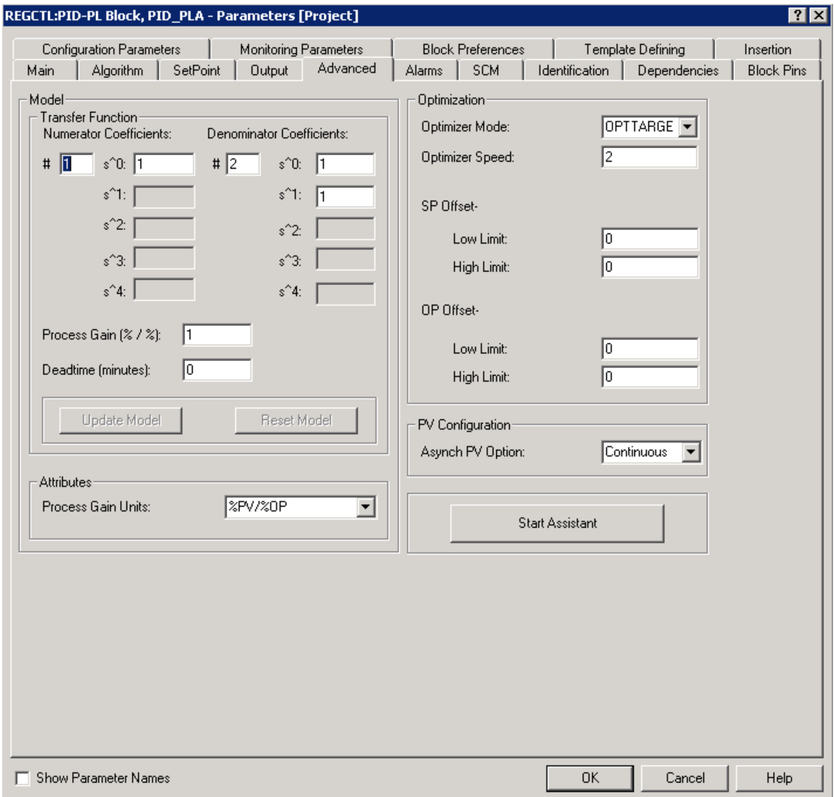

Figure 18: Advanced Tab of PID-PL

The block also provides the optimization functionalities, which can be imposed on the PV. When the control module is set to Range (on the Algorithm form), it can allow the process to completely float within the range, or may impose a secondary optimization objective to drive the process to an optimal state.

The desired optimization modes are provided as

- NONE: No Optimization
- MINIMIZE: Optimize toward the lower limit of the range (minimize the PV)
- MAXIMIZE: Optimize towards the upper limit of the range (minimize the PV)
- OPTTARGET: Optimize towards a specific optimization value.
- DUALRANGE: Strive to keep the optimal solution between optimization limits, SPLOLMOPT and SPHILMOPT

The Optimizer speed option dictates how fast the optimizer drives the process towards the optimal target. A value of 0.1 to 10.0 can be entered and the value is dimensionless.

The Start Assistant option launches Honeywell's profit loop assistant. The Profit loop Assitant is a companion intended to simplify Profit Loop PKS configuration activities. The assistant provides various tools to help with the model identification process. An overview of the functionalities provided by the block is itemized in the following sub-section.

5.2.7 Profit Loop Assistant

Profit Loop Assistant is a companion intended to simplify Profit Loop PKS configuration activities. The configuration of Profit Loop PKS regulatory control point (PID-PL) does not require a good understanding of math and concepts involved in model predictive control as the profit loop assistant tool assists the users with model development of the process. The Profit Loop also helps the user in guiding through model definition if the user intends to enter own algorithm into the Profit Loop configuration.

As the Profit Loop PKS is a model predictive controller it must be supplied with a process model. The Profit Loop Assistant provides the following options to assist with model definition.

Model by Loop Type: Parameters for a certain loop type can be specified for various loops. Individual loop can be modified accordingly.

Model from PID Tuning: Model of the process is extracted from existing PID tuning constants.

Model by Step Testing: Automatic step generator and model identifier calculated the model from step responses of the process.

Mode by Direct Entry: If an existing Laplace model is available for the process, this model can be entered directly and used.

5.2.8 Model by Step Testing

Profit Loop Assistant provides a convenient solution for modelling of the process problem in hand. It provides various methods to generate the appropriate process model. One of the options provided by the assistant is to model by Step Testing. In this method Profit Loop Assistant steps the input of the process between its upper and lower bound to formulate the model. To employ this option the system needs to be online for the assistant to change the input's operating point.

After launching the profit loop assistant successfully, to attain the model using the option of Model by step testing a four step process is followed. The Figure 19 shows the screen capture of the Profit Loop Assistant window.

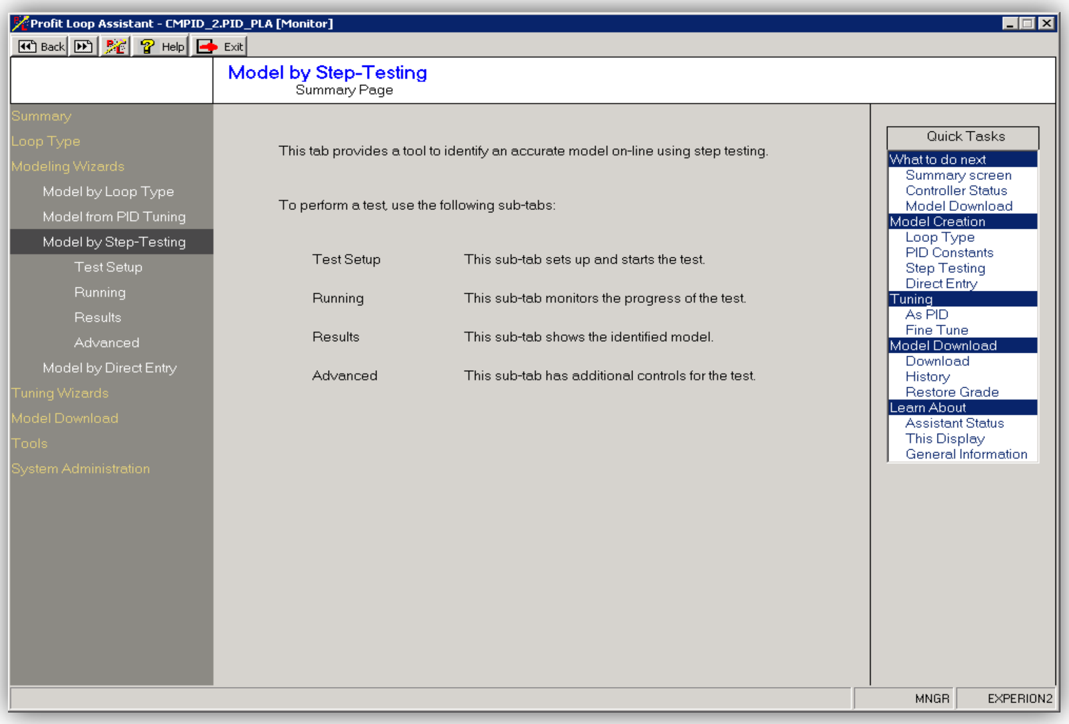

Figure 19: Profit Loop Assistant Window

The first step includes setting up of the status parameter for the test to run. Some of these parameters include estimated response time, Upper Bound and Lower Bounds of the system. Figure 20 provides an overview of the test setup tab.

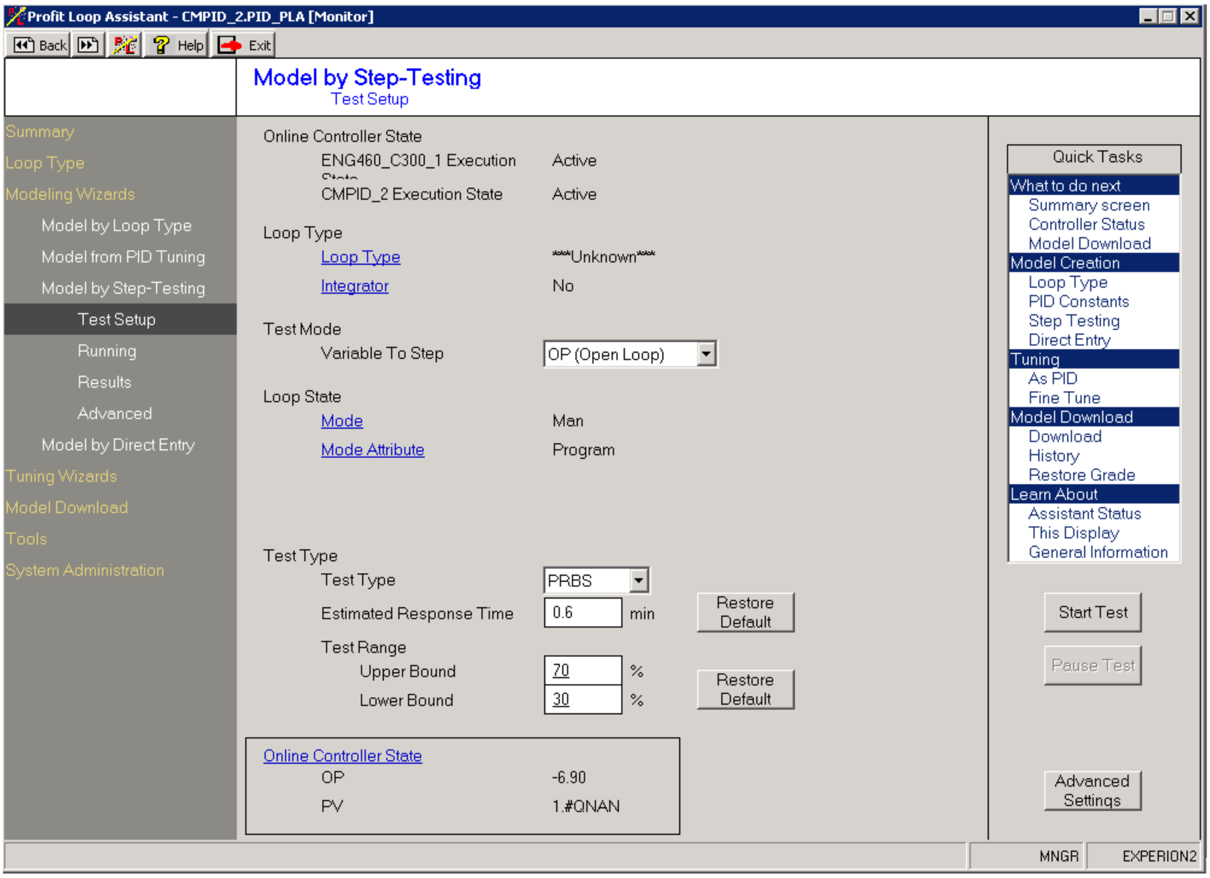

Figure 20: Test Setup Sub-tab of Profit Loop Assistant

The advanced sub-tab also provides some of the additional parameters that can also be configured before starting the test. The maximum time of the test is one of the preliminary options that could be configured through the advanced sub-tab.

After setting up all the essential parameters are setup, the test can be started by clicking on the “Start Test” button. After this step the profit loop assistant opens the running tab in which the future input moves are plotted and shown. Figure 21 shows the running sub-tab of profit loop assistant.

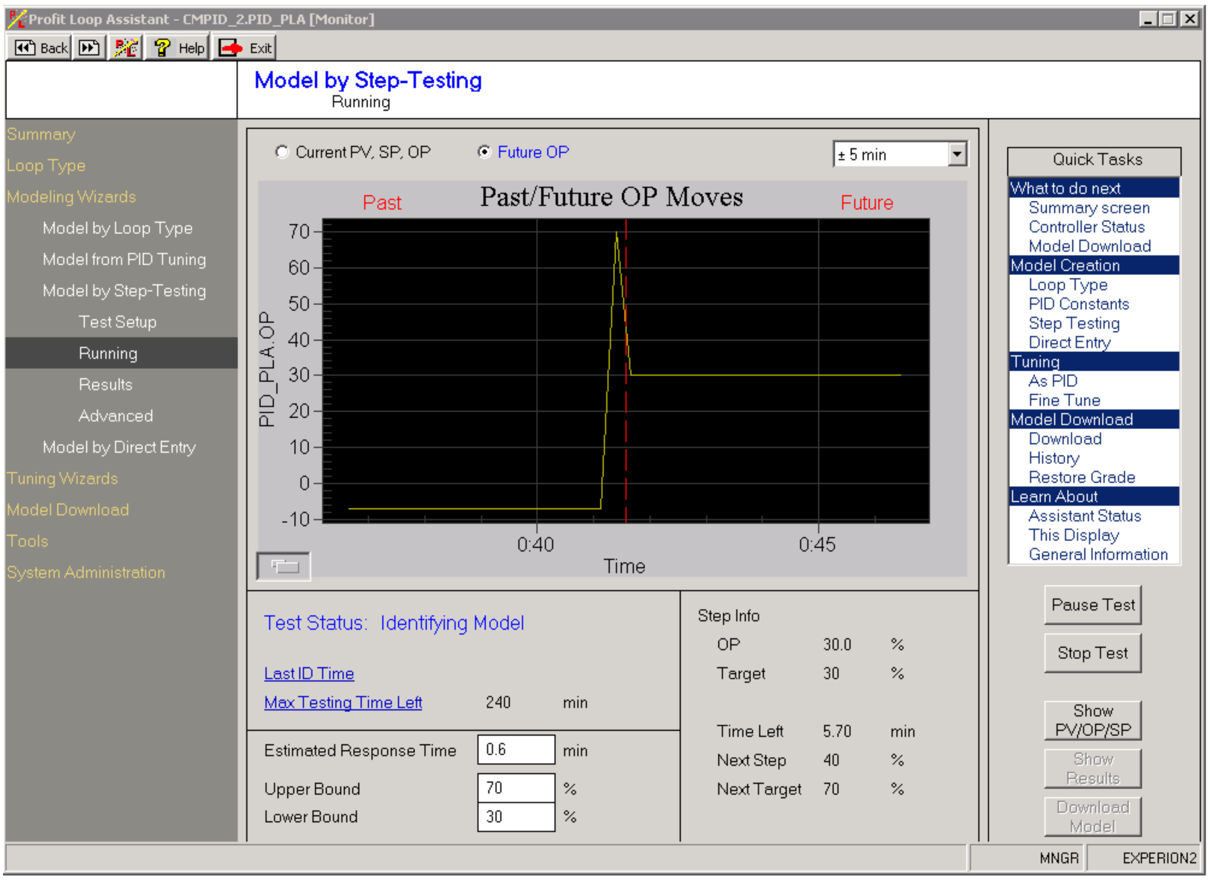

Figure 21: Running Sub-Tab of Profit Loop Assistant

After performing the tests the profit loop assistant generates an adequate model which can be accessed by clicking the Show results options. If the transfer function model as shown in Figure 22 is satisfactory this model can be downloaded to the controller and used for the control of the system.

For ease of comparison this method was applied to a first order system simulated in an excel spread sheet. The gain and time constant of the system were set as 2 and 0.3. The Figure 22 shows the results obtained from the step testing. It can be seen that the gain of the system was estimated by the profit loop assistant as 1.97 and integral time as 0.327 are very close to the actual process parameters. Therefore it can be said that the PID-PL controller provides a substantial estimate of the process. It was also observed that the output of the controller was smooth with minimal oscillations.

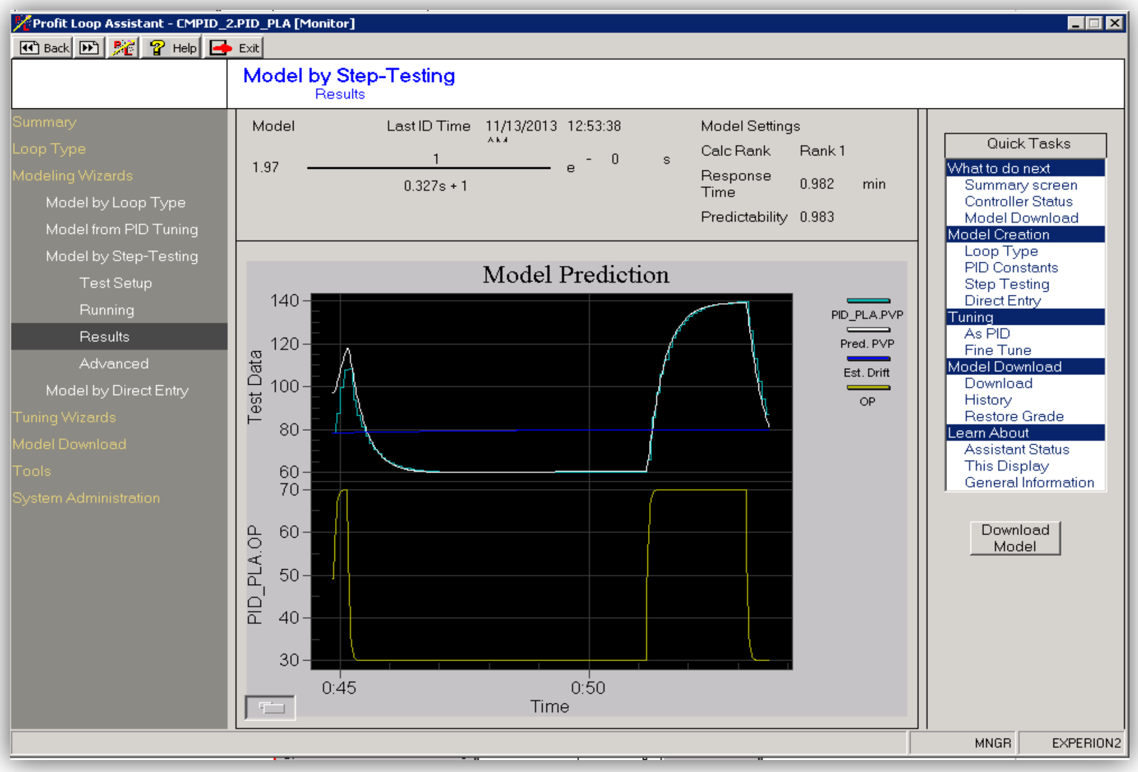

Figure 22: Results Sub-Tab of Profit Loop Assistant

6 Proposed Future Improvements

The Experion environment has a vast capability and there are a multitude of features that can be explored. This thesis only addresses some of the many directions of the project goal. There are a number of future directions that the project could progress towards. This section lists some of these future works and addresses the immediate future objectives that can be initiated.

6.1 System Backup and Restore for Control Builder

The Experion provides Backup and restore functionality which provides a safety mechanism to recover the system. The functionality is provided by Honeywell to prevent the loss of process configuration information. This functionality protects the system from viruses, failed applications, disk corruption, accidental deletion and other forms of hardware and software shutdowns.

The backup and restore function is an essential area of research in the later stages of the thesis. As the thesis is being designed for educational purposes the software could be operated by students who might not completely be familiar with all the aspects. Therefore the backup and restore could be very essential to put the system back to a desired default state after being used by students.

6.2 Explore Sequential Control Modules (SCM's)

Sequential control modules in Experion serve a similar functionality as state machine design programming. The plant can be configured to perform tasks in a sequential fashion. This functionality can be useful for programming start-up or shutdown sequences of a plant. Safety procedures can also be programmed using sequential control modules. The safety procedures can be programmed in the event of equipment failures etc.

6.3 Integration of the system with PLC's and other devices in the facility and possible integration with other SCADA systems such as WinCC etc

"OPC is dedicated to ensuring interoperability in automation by creating and maintaining open specifications that standardize the communication of acquired process data, alarm and event records, historical data, and batch data to multi-vendor enterprise systems and between production devices." (Honeywell)

The work that can be done on the OPC communication is listed below:

- OPC Communications
  - Labview
  - Seimens PLC
  - Allen Bradley PLC
- Setup of OPC server
- Communication with other SCADA systems such as WinCC
- Application Control Environment (ACE) knowledge
- Other forms of communication (apart from OPC)

6.4 Simulation of Different Processes in LabView

After establishing the OPC communication with other softwares such as LabVIEW similar and more complex process simulations performed in Microsoft office excel can more easily be performed using LabVIEW.

6.5 Simulation of Process in Experion and Controller in Excel

In this thesis all the controller simulations were done in Experion and process simulations were performed in Microsoft office excel. Differing to this approach, it can be attempted to simulate a process in Experion programming environment and control the system using control strategy programmed in excel.

Exploring the functionality of Auxiliary control blocks present in the Experion programming environment could be a possible starting point to accomplish this objective.

7 Conclusion

The entire scope of the thesis project was around the Honeywell Experion Process Knowledge System software. The ultimate goal of the project was to integrate Honeywell Experion teaching system into the Industrial Computer Systems facility. Before conquering the major goal of the thesis, it was required to understand the basic driving concepts of the Experion system. The previous works undertaken on the project included some basic setup of a test server, and basic simulation and configuration aspects. This thesis was a continuation of the work undertaken during previous years.

However to proceed to further stages of the thesis, initial step was to surpass the initial configuration of the project elements. Therefore primary weeks of the thesis project were spent on understanding the structure of the Experion software and configuring basic elements. Following these initial steps the primary focus of the project was brought towards understanding the operation of some of the Regulatory Control Blocks present in the Experion environment.

The functionality of regulatory control blocks was explored by undertaking research on PID control block. Many features offered by the PID control block were researched and understood. Following this step some systems were simulated in Microsoft office Excel and controlled by the PID control block configured in the Experion system. The data exchange between both mediums was done by the Microsoft office data Exchange add-in provided by Honeywell. These simulations were designed to demonstrate the use of options provided by the PID block.

Similar research was performed on other regulatory control blocks present in the Experion environment such as PIDFF, PIER and PID-PL blocks. The functionalities researched and simulations created were documented.

While the initial objectives set were not utterly completed as the scope of the objectives was underestimated, adequate work has been performed with regards to the primary objective of the project. And although many challenges were encountered while undertaking the thesis, the knowledge obtained by studying the Experion system was invaluable. Exploring the operation of an industrial scale SCADA system was a great opportunity.

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Appendices elaborate the overall procedure and functionality. Extensive documentation was generated to help future students use and explore the Experion Process Knowledge System.

These Appendices are available electronically in the Eng Shared Area.

Appendix A – PID Block Parameter Description

The Appendix describes the describes the parameters of the PID Block and functionalities that can be accomplished using this Block

Appendix B – PID-PL Block Parameter Description

The Appendix describes the describes the parameters of the PID-PL Block and functionalities that can be accomplished using this Block

Appendix C – Simulation of a First Order System

The Appendix provides the steps undertaken for simulation and integration of a First order system with Experion System. Control of this system was achieved by configuring a PID Block in the Experion environment.

Appendix D – Simulation of a Non-Linear system

The Appendix provides the steps undertaken for simulation and integration of a capacity system with Experion System. Control of this system was achieved by configuring a PID Block in the Experion environment.

Appendix E – Simulation of a Non-Linear system

The Appendix provides the steps undertaken for simulation and integration of a Non-linear System demonstrating the error squared PID functionality. Control of this system was achieved by configuring a PID Block in the Experion environment.

Appendix F – Cascade Control System Setup

The Appendix provides the steps undertaken for simulation and integration of a System demonstrating the Cascade Configuration using PID Control Blocks.

Appendix G – Feed Forward Control System Setup

The Appendix provides the steps undertaken for simulation and integration of a System demonstrating the Feed Forward Configuration using PIDFF Control Block.

Appendix H – Profit Loop Assistant Description

The Appendix describes the functionalities provided by the Profit loop Assistant, used in PID-PL Block.

Appendix I– PID-PL Model by step test for First order system

The Appendix provides a demonstration of step testing and obtaining the model using Profit Loop Assistant.

Appendix J– Clearing Active locks formed on the Control Modules

The Appendix provides a tutorial of clearing the active locks that are formed on the control modules which result in causing of errors.