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Implementation of automatic PLC code from MATLAB simulation model using B&R automation target for simulink

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Abstract

In this research work, auto generation of PLC code is explained. This work is carried out in real time. Mathematical Model created in MATLAB/Simulink gets automatically translated in C code using Real-Time workshop and later PLC Control implementation is done by using B&R Automation Target for Simulink software that can generate PLC code and HMI screens. The algorithm developed to connect simulation model and PLC-Automation Studio is elaborated. To show applicability of methodology, color mixing process model is described. Seamless integration into an Automation Studio project work makes the development process perfect guaranteeing maximum performance of the generated source code.

Keywords: Mixing process, Coloration control, B&R Automation Studio, HMI.

1. Introduction

In the modern industrial manufacturing, PLC device is well-adopted to a range of almost all types of automation tasks. The level of automation is determined by a PLC program. The processes can be modeled and controlled through the set of instructions to PLC. Thus PLC-program becomes underlying component for modern manufacturing. Inefficiency in generating the controlling code in the manufacturing plant may cause huge down time and ramp-up times [1]. Hence, auto generation of PLC program using rapid modeling and compiling tools to generate IEC standard PLC program is an efficient method to reduce the PLC development time.

Automatic generation of PLC code has been done several times before as for example in [5], [8], who generated ladder code or PLC code generation for industrial robot cells [6].

Software Engineers at NASA Kennedy Space developed a process and prototype software tool that automatically translates a high level specification of safety critical application software into ladder logic that executes on a PLC [7].

1.1. Model-Based Automation

In the field of industrial automation Model-Based development methods are becoming increasingly more significant. In case of numerical and complex control-oriented applications, the concept of the Model-Based design is used to realistically capture the numerical behaviour and interactively improves model parameters until the needed behaviour is reached.

1.2. MATLAB In Control Technology

MATLAB/Simulink provides many advantages especially for developers work with the classical control technology [3]. The simulation of models already during model creation is an outstanding advantage which saves a lot of time and thus helps to save costs. Hence, all models can be validated already during creation. Complex control-oriented tasks, which can normally be performed in the control technology by using cost-intensive expansions, can

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be created, tested and used by applying mathematical models.

1.3. B&R Automation Target for Simulink

The realization of MATLAB/Simulink models starts with the automatic code generation. With this product "B&R Automation Target for Simulink" B&R Industrial Automation provides a tool with highest level of integration with model based design software Math works**.** This tool allows testing and implementing MATLAB/Simulink models on the PLC hardware. Thus, the manual programming efforts are reduced to a minimum and in many cases actually not required.

MATLAB Simulink includes B&R Toolbox in simulation environment provides interface blocks, which handles communication between the automatically generated program unit and the rest of the components of the Automation Studio project.

In this paper the Section II explains Methodology, Section III deals with detailed algorithm for integrating simulink model and B&R target PLC Section IV gives verification & validation of results. Section V is conclusion and finally future work with an acknowledgement.

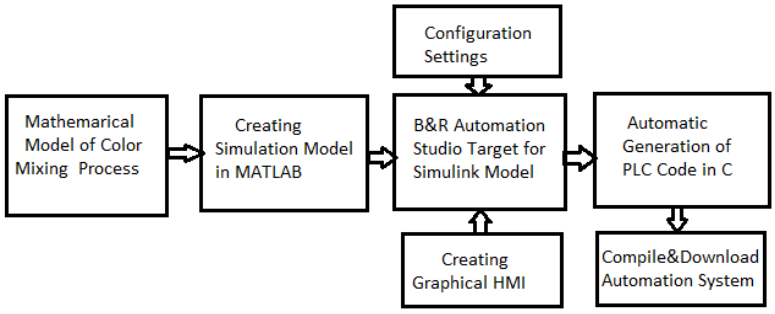

Fig.1. Block Diagram for Automatic Generation of PLC Code

2. Methodology

The module created in Simulink is automatically translated using Real-Time Workshop and Real-Time Workshop Embedded Coder (optional) into the optimal language for the B&R target system

The block diagram described in this paper employs, designing of mathematical model using formulas. Later, implementation of mathematical model of Color Mixing process using MATLAB Simulink is build with the help of simulink library blocks. The next step is to be carried out in an Automation Studio environment. In this we have to build model with the help of B&R blocks which are available in B&R toolbox in a simulink library. After doing configuration settings we are able to translate simulink models into a PLC code on a click of button. Above in the Fig1, the sequence of code generation is given for Color Mixing Process. The execution of extended parameter is based on the algorithm defined in the subsequent sections.

3. Algorithm for Integrating Simulink Model with B&R Automation Studio

The Color Mixing Process is on-line implemented using PLC and has been written in a specific language Automation Studio of B&R PLC [4]. For understanding the control process written in AS C language the corresponding sequence control for a tank is described.

The algorithm written in this paper for generating automatic PLC code is elaborated in steps to follow.

3.1. Step I-Developing Process Model in MATLAB Simulink

The Color Mixing Process studied here was also studied extensively by [1], [2] and [3].The Mathematical model of mixing process is developed in MATLAB Simulink environment. COLOR mixing plant consists of a mixing tank in which colors are mixed from the two auxiliaries In order to find an adequate control for the mixing process; the corresponding mathematical model is developed. The mathematical model for one tank is considered, knowing that the all three tanks have the same one. The model developed for color mixing process is as shown in Fig2.

These equations were modeled using MATLAB/ Simulink as illustrated in Fig2. The control system for the fluid mixer is designed in order to maintain the coloration of the output at the desired set-point and the level in the mixer in the neighboring of its set-point, not allowing it to be empty or to overflow. The output flow is considered as a disturbance.

3.2. Step II- Using B&R Automation Studio Toolbox; Creating Simulink Model which Translates Automatically into C-Code

The model shown in Fig.3 is Color Mixing Process Model

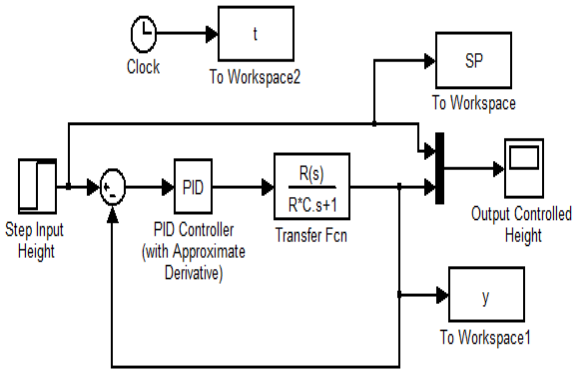

Fig. 2 Color Mixing Process Model developed in MATLAB/Simulink

created with the help of B&R blocks which is main part of the project. These all block variables will get reflected in automation studio in local/global variables files. In this model we have observed the Set Point given through environment Control block and the output which is controlled height can be seen at scope directly. This output can also be seen in watch window in AS. Also we can have trace of this parameter.

3.3. Step III-Applying configuration Settings to Color Mixing Model MATLAB Simulink

The Model created in MATLAB Simulink should have following project settings to allow automatic integration of the system for the configuration of the interface between Simulink and Automation Studio.

1. Fundamental sample time: The fundamental sample time of the Simulink model must be equal to the selected task class cycle of the PLC i.e. B&R.

The sample time is always entered in seconds. The error will get generated if the fundamental sample time specified in Simulink does not match the duration of the cyclic task class for the automaticallygenerated task in Automation Studio, the task will be suspended.

2. Automation Studio Project Path: The path of project created in Automation Studion.Base directory of the Automation Studio project containing the automatically generated task.
3. Automation Studio Task Name: Specify Name of the automatically generated task which will get generated automatically.
4. Checkbox Settings: Tick a checkbox to add task to hardware configuration: Automatically add the generated task to the current hardware configuration of the Automation Studio project.
5. Automation Studio configuration name: Check name of the current Automation Studio configuration in AS and specify same here.
6. Automation Studio PLC name: Name of the current Automation Studio PLC in AS.

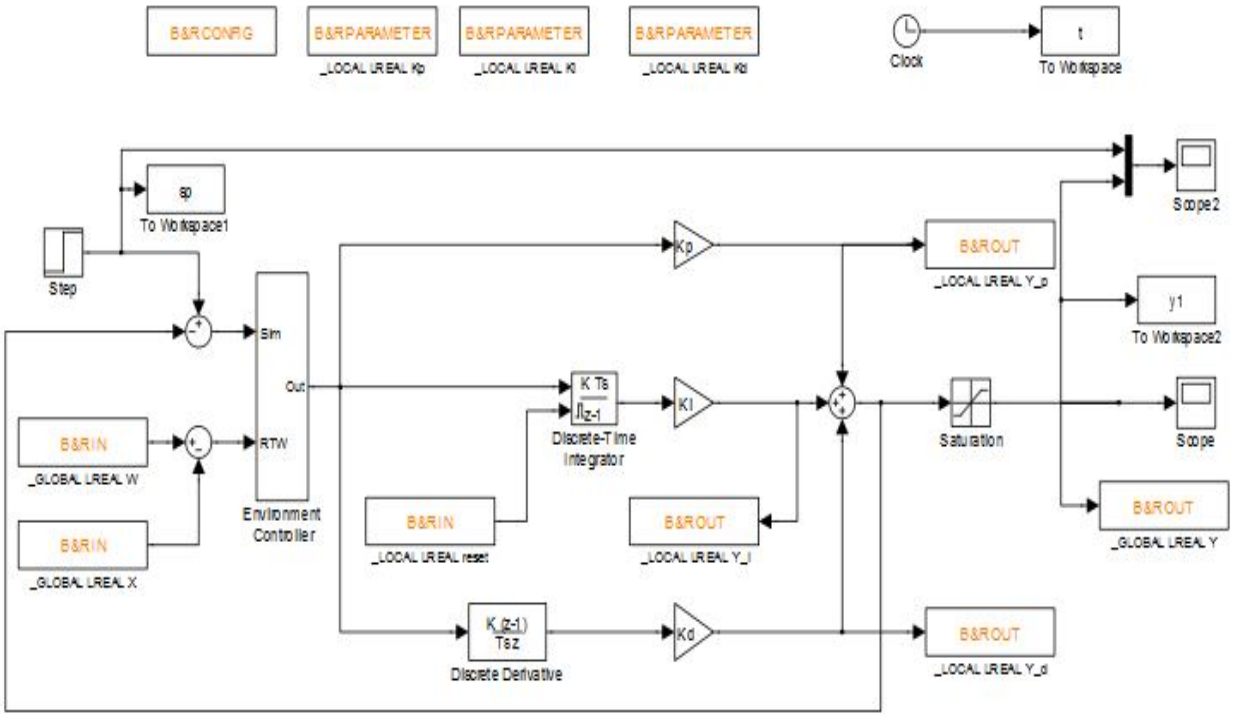

Fig. 3 Color Mixing Process Implemented in B&R Automatic Studio.

3.4. Step IV: Adding B&R Automation Studio Libraries

In order to be able to run the automatically generated source code on the B&R target two B&R Automation Studio libraries are required in the project: Add 'brsystem'& 'sys_lib' from exiting libraries.

3.5. Step V: Integration of Project: Automatic Code Generation & Project Download

After completing all above settings start the Automatic Code Generation by using the menu item Tools Real-Time Workshop. Build Model using (Ctrl+B) or using the corresponding button on the toolbar in MATLAB Simulink. Within fraction of second's message will appear in the MATLAB command window indicating that the code generation has been done successfully. Then the automatically generated source code is compiled in Automation Studio and transferred to the target system.

The simulink model from Matlab has been successfully transferred into C language source code in Automation Studio as shown in fig 4. With the 'automatic transfer' option being enabled the generated program is included into the Automation Studio project, the entire project is compiled and then transferred to the target system automatically.

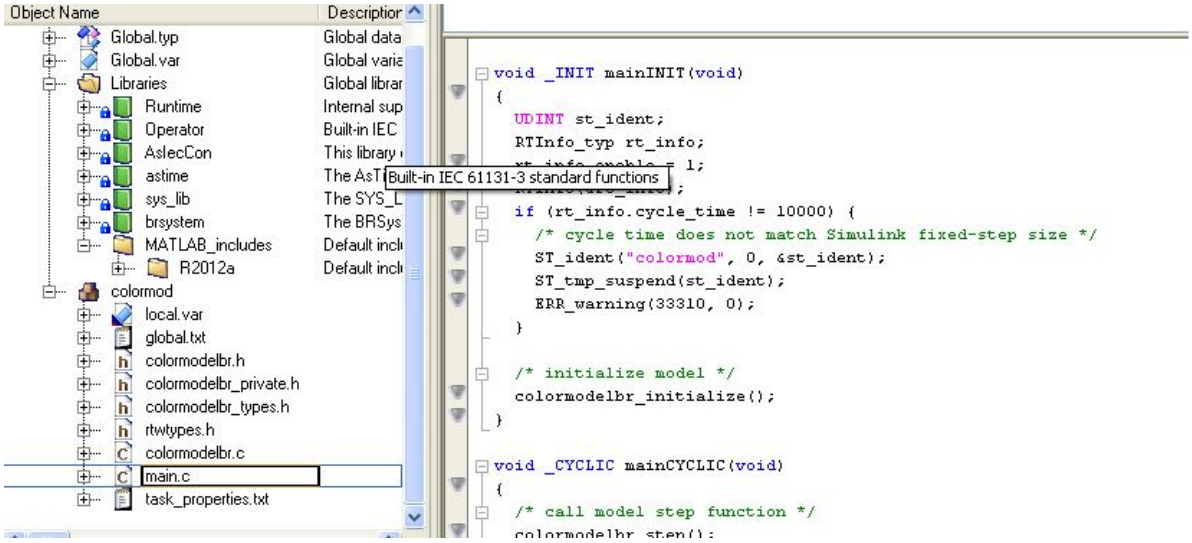

Fig. 4 Screen shot of Automatically Generated PLC code in C language.

3.6. Physical view: Hardware Assignment

To run the simulink model in real time connect hardware to it through AS. The assignment of the generated task to your hardware configuration can be done automatically by selecting the option 'Add task to hardware configuration'.

Name	Type	Scope	Force	Value
Input	LREAL	global		100.0
Output	LREAL	local		84.469795194715 5

Fig. 5 Screen shot of Watch Window

3.7. Debugging: B&R Automation Studio Watch

The result of the Automatic Code Generation can be easily verified by opening the B&R Automation Studio Watch window after the download to the target. The result can be seen in Fig.5 in Watch window function. Through the Automation Studio diagnostic tools like 'Watch' and 'Trace' the correct operation of the controller can are verified.

3.8. Trends (Real Time / Historical)

Trends are very useful with PID Controller. You can view the curve used to reach a certain set point. Study of certain values will result in optimizing your process, and it will certainly make if much more efficient.

3.9. Creating HMI in Automation Studio

Based on the designed PLC sequential control an adequate HMI (human machine interface) has been designed and implemented in Automation Studio for real time control purposes.

HMI gives the ability to the operator, and the user to view the plant in real time. Add to that the ability to have alarm management that can warn the operator of a problem. It can even log and print all the alarms in real time, which can help the developer to improve the production and efficiency. .

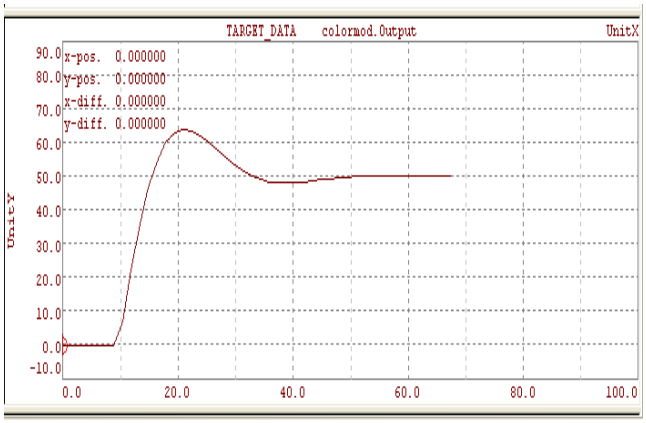

Fig. 6 Output Traced in B&R Automation Studio

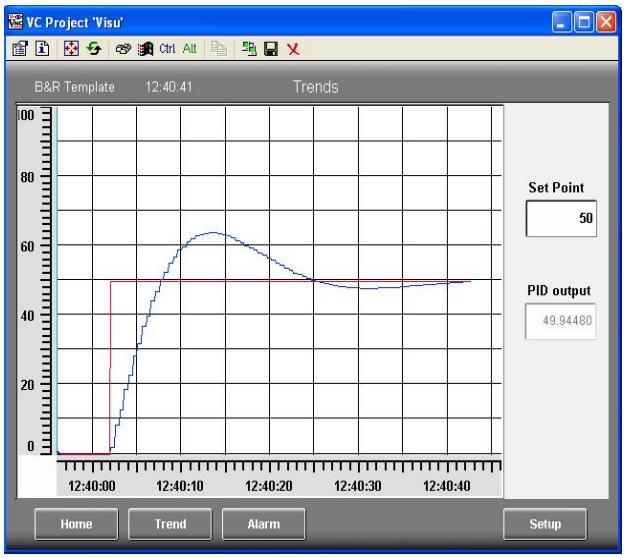

Fig. 7 Visualization- HMI Created in AS: Real Time Output

The entire color mixing plant operates with the designed HMI.The auxiliary tank levels are monitored, the level of the tanks are displayed and the fixed references are on-line displayed as numerical value. The operator can set a level; by using this product quality has been increasing through the use of correct amounts of liquid that occur during the process.

It can display texts, pictures, bar graphs, bitmap and animated pictures. More importantly it can also display System messages, reports, alarms, trends. Using HMI the main variables of the mixing process can be on-line monitored and controlled as shown in Fig 7, the Set Point can be entered using HMI set point input and simultaneously output can be viewed.

4. Verification & Validation of the Results

The PLC code has been generated according to the standards. The generated project does not contain any function blocks or data blocks other than the ones needed and used for the Color Mixing Process project. The PID controller gets tuned with the same parameters which are used in MATLAB simulink.

These PID settings which were entered in Matlab Simulink remain exactly same in Automaton Studio.
The generated HMI shows the real time output values and traces for easy analysis & understanding of the process.

5. Conclusion

This paper demonstrated a method for automatically generating PLC code and controlling the process through simulation model. The methodology combines the high level simulation and lower level PLC controlled devices thus improves the fidelity between high level system model and lower level. It reducing PLC code generation time, as a result, can reduce the designing and implementation time for PLC controlled manufacturing industries. The strength of the scheme is that this mechanism develops the HMI which the operators find very easy to operate. Model-Based Design, together with automatic code generation creates shorter and more cost efficient design workflows. Also adds many advantages to mixing process: high quality control, adequate set points can be on-line numerically fixed.

Acknowledgement

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