

## PROCESS CONTROL SYSTEM USING COMPLEX MODULES

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*Process control system (PCS) can be realized in several levels. Each level plays exactly fix role from data acquisition, load and store data, and data processing to the management process. One of process control systems is realized in practice in cement factory – Holcim Serbia. In this paper we describe how PCS is realized with complex modules.*

**Keywords:** Modules, Process Control System

### 1. INTRODUCTION

A Process Control System performs the control of the entire equipment in a cement factory. Standard software which follows process control consists of software modules for all the necessary items like forward and reverse motor valves, actuators, analogue values, PID – loops etc, and their corresponding face plates. Modular standard software guarantees a uniform programming method and this technique is less prone to errors and simplifies changes.

Following system is named WinCC&Step7 templates. It consists of a set of standard modules and methods for building of industrial control systems based on PLC Siemens S7 – 400 or S7 – 300 and operator stations under WinCC Version 5.x and Windows NT/2000/XP.

The WinCC&Step7 Templates are specially designed to meet the complete standard for automatic control systems and visualization system, also handles the PID – Proportional Integrative Derivative – control loop and display of alarms and process measurement. The standard modules consist of two parts: PLC part and OS part [1].

### 2. MODULE DESCRIPTION

WinCC&Step7 includes several standard modules. Motor module controls all types of motor devices, valves, positioning devices, and all other devices controlled by start/stop commands, variable speed motor module extension to the motor module for Siemens family frequency inverters/converters, group module serves all devices that form a group. It gives the group start/stop signals and the emergency stop signal for the group. This module scans all motor devices in the group and forms all group status bits, path module connects and controls the motor devices in sequences that form the material flow path. It supports multiple paths in one group and it supports dynamic path transition, analog module transforms and filters analog value, controls the result value and also diagnoses the condition of the hardware analog input, special

modules and all other modules are build into project just once and only if necessary. There are LVD, KWh, archives, shift reports, trends and other modules.

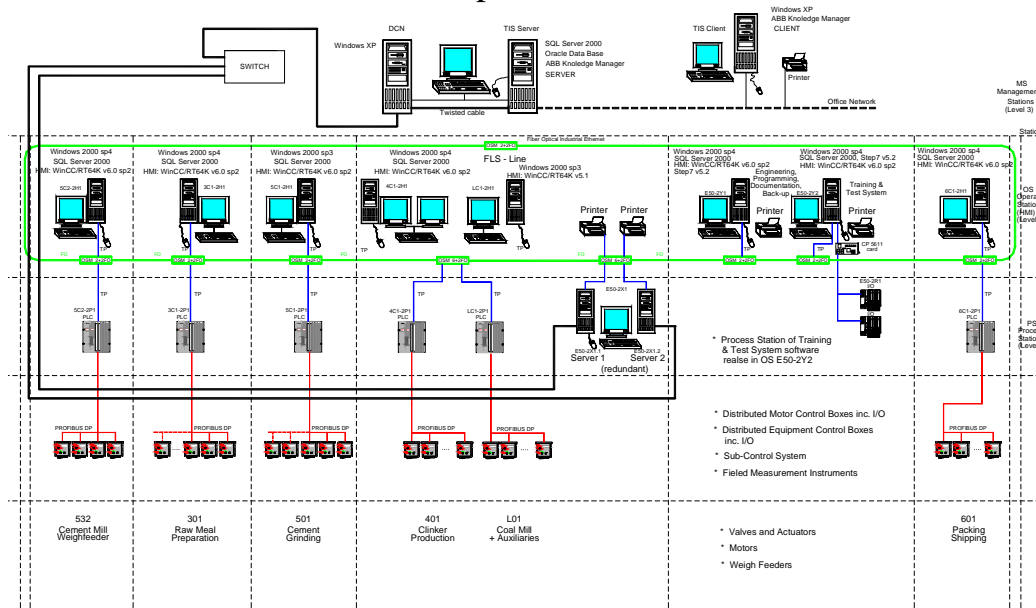


Fig. 1. Layout of Process Control System

### 3. ANALOG MODULE

The analog module transforms and filters analog value, controls the result value and diagnoses the condition of the hardware analog input. The basic features of the PLC analog module are connection to real hardware input or to M memory address, ready value input bypass scaling and over range/under range check, two points linear scaling of the analog value, analog value first order filtering, adjustable filter time, four limits: min limit (alarm), low limit (warning), high limit (warning), max limit (alarm) – each can be independently enabled/disabled. Over range and under range limits of the hardware analog input, standby value, setting for automatic switch to the standby value on hardware input failure, discovery of communication “Profibus DP” errors without alarm, sensor failure alarm and automatic connection to the total standard module providing the following functions integrating of the measured value to infinite total counter, indication of the integration absolute start time, password protected reset command, measuring of maximums and minimums, indications of the last maximum and last minimum absolute time and reset commands.

For OS analog module, the features are indication of scaled and filtered value.

Coloring of the indication with different colors according to the value condition

- White – normal condition, no alarm or warnings
- Margenta – value under min limit
- Blue – value under low limit
- Yellow – value above high limit
- Red – value above max limit
- Red – over range or under range

- Yellow green – standby values enabled ready value and over range/under range check

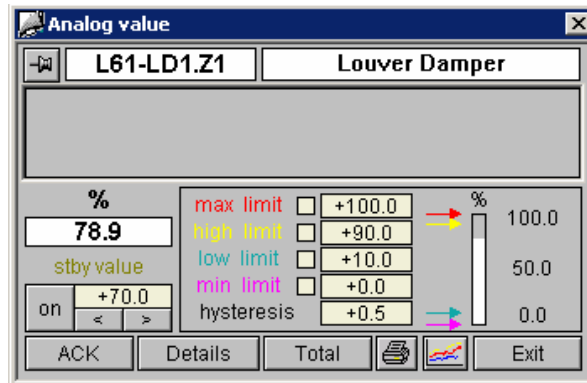


Fig. 2. Analog Values of Module

#### 4. MODULE THE BASIC PRINCIPLES OF OPERATION OF ANALOG MODULE

The analog module is called each PLC scan cycle. It reads the raw integer value from the hardware analog input or the M memory address. The raw value is scaled with the expression

$$V_U = S_L + \frac{(AI_V - AI_L) \cdot (S_H - S_L)}{AI_H - AI_L} \quad (1)$$

where are:  $V_U$  - Value unfiltered,  $S_L$  - Scale low,  $AI_V$  - AI value,  $AI_L$  - AI low,  $AI_H$  - AI high,  $S_H$  - scale high and  $S_L$  - scale low. The result is passed through a first order filter, according to the expression

$$A = \frac{1}{F_T - OB_{ST}} \quad (2)$$

where are  $F_T$  - filter time and  $OB_{ST}$  - scan time

#### 5. MODULE MOTOR MODULE

Motor module controls all types of motor devices, valves, positioning devices, and all other devices controlled by start/stop commands. The module supports automatic, single and local mode. This module is universal, covering wide range of devices.

The basic features of the PLC motor module are:

- three modes of operation; automatic, single and local,
- each device can control up to 4 sound and light status warnings,
- each device is connected to its neighbour devices in the material flow path,
- different times and timers for the following functions are contactor time, siren time, rest time, period work time, period pause time, post running time, non fatal time and fatal enable time,
- usage of custom software timers, thus freeing all built-in PLC timers for user logic,
- the module has the following groups of bits: command bits, setting bits, bypass settings, ready values

- support of reversible and non reversible devices
- open/close valves control
- control of valves with analog feedback
- connection to variable speed standard

For OS motor module each device has a popup window with the following controls/indications: HAC code and text description, alarm window, device color photo, device schematic view, work hours, start count, single stop, single start X button, single start Y button, ACK button, Single mode toggle button, local mode toggle button, check button, close button and show motor module monitor button.

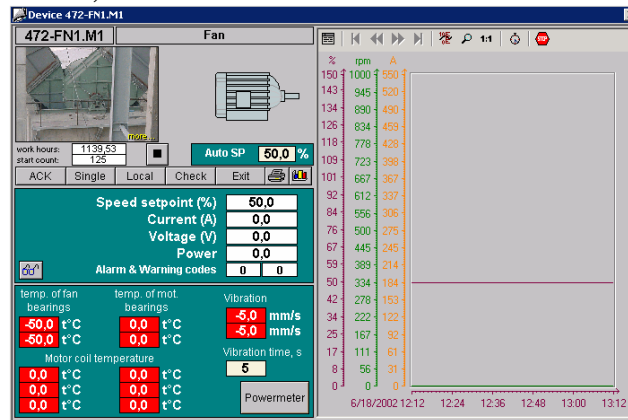


Figure 3. Full View of Motor Module

## 6. THE BASIC PRINCIPLES OF OPERATION OF MOTOR MODULE

The motor module is called in each PLC scan cycle. The first thing that the motor module function does is to read all digital inputs related to the motor module. Addresses of these inputs are the value in the HWIA elements in the motor module UDT, each address is represented in BCD format. Value 0 means the input is not connected. Value 0001 means I 0.1, and value 9997 means 999.7. The motor module read all configured inputs and puts their values in the HWI elements. The HWI elements are inverted according to the HWIN settings. Some inputs are bypassed according to the HWIB settings. The result is stored in the HWIR bits. The HWIR bits are used later in all motor logic. The “Settings” bits contain static settings that determine the behaviour of the motor. The “Commands” bits contain dynamic settings that determine the behaviour of the motor. The “Feedback” bits reflect the current condition of the device. The “Status” bits and the “Alarm” bits have almost the same bits are active only on run time, on start or check button pressed. The motor module supports user warnings and alarms by the “Force\_Warning” and “Force\_Failure” bits. The ACK command resets all alarms and status bits. The local mode of operation accepts start/stop commands from local push buttons that must be connected to the module. The local stop button works in all modes, but in auto or single mode a “Local stop button pressed” alarm is issued. In local mode there are no interlocks and all alarms are self acknowledged on rising edge of the local start button. The single mode of operation accepts start/stop commands from the device popup, the single stop button works in all modes. In single mode are no interlocks.

## 7. GROUP MODULE

The group module serves all devices that form a group. It gives the group start/stop signals and the emergency stop signal for the group. This module scans all motor devices in the group and forms all group status bits.

- features of the PLC group module
- initiates automatic start/stop sequences for the group;
- group standby mode;
- group device check;
- OS emergency stop;
- local push panic emergency stop;
- group local mode;
- group single mode;
- toggle interlock release;
- arrange group status bits;
- support of standard group alarms;
- group status bits for the OS;
- group work time;
- group start count;
- group successful start count;
- group demo mode
- features of the group module

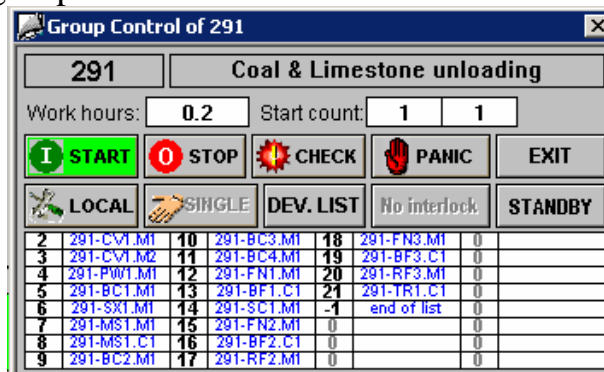


Fig. 4. Features of the PLC Group Module

The OS group module has the following features:

- HAC-code and text description; group work time indicator; group start count and successful start count indicator; group start button; group stop button; group check button; group emergency stop button; group local mode toggle button; group single mode toggle button; show device list button; release interlock toggle button; group standby toggle button; show group module monitor popup button; show path module monitor popup button;
- support of 8 built-in group alarm and warning messages;
- group screen with the following controls and indications: group title; show group popup button; group start button; group stop button; group alarm window;


- show group button and dot group indication in MainButtons.PDL

## 8. PATH MODULE

The Path select module connects and controls the motor devices in sequences that form the material flow path. It supports multiple paths within one group and dynamic path transition.

Features of the PLC path module:

- simultaneous support of max 8 paths;
- independent individual devices settings for each path: direction X or Y; in sequence; non-fatal device; start/stop sequences for devices in sequence; start/stop sequences for devices not in sequence;
- dynamic path transition;
- automatic path transition refuse (on device fault or unsuccessful reverse);
- map of allowed dynamic path transitions;
- external subgroup support for each path: connection to external subgroup; start/stop of external subgroup; support of non-fatal external subgroup; OK and fault feedback from external subgroup; adjustable timer for external group starting;



Path module monitor 291

Current/Next Path				external				Transition Permission								CancelStartTimeLeft		Succ_Rev_TimeLeft	
PathIndex	Ext	Start	Time	req	start	OK	fault	1	2	3	4	5	6	7	8	Hex			
1	70	60	53					1								FF	<input type="checkbox"/>	Path_Transition_Refused	
2	0	60	60					2								FF	<input type="checkbox"/>	Ext_Group_Not_Starting	
3	0	60	60					3								FF	<input type="checkbox"/>	Hold_Next_Path_Start	
4	0	60	60					4								FF	<input type="checkbox"/>	Hold_Next_Transition	
5	0	60	60					5								FF	<input type="checkbox"/>	Prev_Auto_Start	
6	0	60	60					6								FF	<input checked="" type="checkbox"/>	Auto_Start	
7	0	60	60					7								FF	<input type="checkbox"/>	Auto_Stop	
8	0	60	60					8								FF	<input type="checkbox"/>	Hold_Start	

COMMANDS & ALARMS

Fig. 5. Features of The OS Path Module

Features of the OS path module:

- the path select module has only a monitor popup that shows the current condition of the module. This includes indications and controls for current/next path; path index; external start time; external start time left; external required bits; external non fatal bits; external start/stop bits; external OK bits; external fault bits; transition permission map; command & alarm bits,

The basic principle of operation are:

- the path select module uses the principle of cascade connection of motor devices. This connection ensures the start/stop sequences in automatic mode and the device interlocks
- the operator can choose any path only when the group is completely stopped. During automatic start or stop sequence and work path transition is allowed only if it is permitted in the path transition map

- start of the external subgroup (Ext\_Start\_Stop) signal is issued upon the following conditions: the group is starting or running (for the current path) and during a transition to a new path.
- all raised Ext\_Start\_Stop signals are kept until all devices that are interlocked by external subgroups are running in auto mode. These are all devices that have In\_Seq=1 and Next=0 in their path description.
- the Next\_Path value is assigned to the Current\_Path value on one of the following circumstances: all devices in the current and the next path are running and all common devices are successfully reversed according to the next path and the group is completely stopped
- the OS structure tag includes all parameters from addresses (db 0 – db 579)
- in the PLC the Path DB is constructed using two standard UDTs. The 'Path\_Def' UDT contains all basic path module parameters. The 'Path\_Device\_Def' is a small structure that defines the behaviour of one device in a sequence. The 'Path\_Def' UDT is always placed in the start of the DB and is named P. Placing 'Path\_Device\_Def' UDTs for every device in each path makes the path description. At the end of each path description must be placed an EndPathMarker int with initial and actual value 0.

## 9. CONCLUSION

In this paper, we describe the Process Control System can be realized in several levels. Each level plays role from data acquisition, load and store data, and data processing to the management process and shows realisation very complex modules. Modular standard software guarantees a uniform programming method and this technique is less prone to errors and simplifies changes.

This system is realized in practice in cement factory – Holcim Serbia, Serbia&Montenegro.

The paper proposes a new method for investigation influence voltage dependence on the output of distant current's transformer symmetrical components in the control conductor with primary current.

The influence of different short contacts are examined and the values of the currents through distant relay and input voltage of relay are determined as well as the values of primary functions for all modes of short contacts.

## 10. REFERENCES

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