

Manufacturing of Full Automatic Carwash Using with Intelligent Control Algorithms

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Abstract—In this paper the intelligent control of full automatic car wash using a programmable logic controller (PLC) has been investigated and designed to do all steps of carwashing. The Intelligent control of full automatic carwash has the ability to identify and profile the geometrical dimensions of the vehicle chassis. Vehicle dimension identification is an important point in this control system to adjust the washing brushes position and time duration. The study also tries to design a control set for simulating and building the automatic carwash. The main purpose of the simulation is to develop criteria for designing and building this type of carwash in actual size to overcome challenges of automation. The results of this research indicate that the proposed method in process control not only increases productivity, speed, accuracy and safety but also reduce the time and cost of washing based on dynamic model of the vehicle. A laboratory prototype based on an advanced intelligent control has been built to study the validity of the design and simulation which its appropriate performance confirms the validity of this study.

Keywords—Automatic Carwash, Dimension, PLC.

I. INTRODUCTION

IN modern industries, industrial automation was inevitable, which means if it doesn't move quickly enough in competition with others it will lose. Many factories use programmable logic controls (PLCs) in automation processes to diminish production cost and to increase quality and reliability [1], [2].

Nowadays in competitive world, high rate of production, the possibility of rapid changes in the production line, dealing with marketing needs with high quality is essential for success and survival of any industry which is not achievable except by advanced automation. Hence, this research tries to design and build a laboratory prototype with advanced algorithms, so automatic carwash is a smart move.

Research reports show that, till now, no complete research activity was done on full automatic carwash to be able to take samples of car dimensions and do all steps of washing automatically, but some parts of that was optimized by Camilo in 1999 in which water recycling system in automatic carwash have been pointed out [3].

In the case of PLC and its application in industry due to

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advances of science and technology done extensive researches can be done as yang and his colleagues noted in 2003 in the field of PLC automation [4].

PLC is a specialized computer used for the control and operation of manufacturing process and machinery. It uses a programmable memory to store instructions and execute functions including on/off control, timing, counting, sequencing, arithmetic, and data handling [5].

in a conventional automatic carwash, a limited number of washing steps, such as the moisture and drying is done automatically, and even in most set of existing carwash extensive restrictions on the optimization of these categories exists which is not compatible with all types of cars. In order to save time, energy, cost and create competitive automatic carwash system, this study is trying to use PLC, and the project is designed so that it can perform all the steps needed to wash all types of cars. This feature is intended for the following:

- a) The duration of washing for each vehicle will be different to the five cycles vary provided to implement a specific cycle depending on the host or client to be repeated or it's possible to put different washing cycle in the menu choice that individuals order their own preferable washing process, which is the unique feature of this type of carwash.
- b) Ability to wash at least 3 cars simultaneously [6].
- c) Manual control facilitates can also be added.
- d) Possibility to increase additional cycle on the system in the future.

Conditions of the existing carwash systems and urgent need to increase systems performance, attracts researches to work on this project [7].

II. INTELLIGENT CONTROL OF THE CARWASH PROCESS

In this study, washing process with a variety of simultaneous functions and control sequence that requires more than one step of the program is dealing. After car enter and establish on a conveyor belt, various digital and analog sensors measure geometric aspects of car and sends data into the process controller to control and implement the program depending on the type of car.

This stage is the stage as the criterion for entry of process. In the next step car moves on the conveyor and is washed, then it is completely dried.

Process control application was conducted with SIMATIC MANAGER software and was run by PLC. PLC not only because of its high reliability feature in comparison with

relays, but also its ability to control all system functions, including starting point, biopsy, stop, monitor, etc. are used. In this process, we used PLCs, which in addition to the basic logic control, has the possibility of using continuous control, analog processing and it provides communication between them. These specific tasks, depending on model of PLC, are done by internal main central processing unit (CPU) or functional modules which can be installed on PLC. In this process for sampling the geometrical dimensions of the vehicle, speed is required for and because the main CPU processing module is responsible for operations and functions of the modules, equipped modules with a smart independent CPU is used. These modules are intelligent and have ability to plan and act on the signal processing without need for main CPU so it helps to increase speed.

III. START UP STATE

Before CPU execute the user's program, PLC must be set to launch operations, which is applicable in many ways. Considering the functional program of system, no data should be cleaned in the case of power failure and program must run from the point it was stopped before, so that the rest part of program which is not implemented yet, should be followed. For this reason the launch of system must be hot restart.

IV. PRECISION ANALOG TO DIGITAL CONVERSION

The control system is dealing with continuous signals. Sampled analog dates are considered as a continuous signal. Converters should use A/D, allowing PLC to give the information in the signal as a continuous process. In the PLC converter A/D inputs on the analog modules are embedded. The analog values received from the sensor input modules in the specified time are sampled and converted to the binary data to be readable by a digital controller.

V. CONSTRUCTION OF CARWASH CONTROL

In this study, design of automatic control of carwash using PLC, has been built in a laboratory prototype. This sample has been examined in 4 steps:

A. Stepper Motor Control

In this process, moving conveyor belt was controlled by stepper motor in which the number of pulses and pulse frequency determines the acceleration of motor rotation and movement of conveyor belt (See Fig. 1).

The function of motor can be controlled by PLC according to the number and frequency of pulses and these factors changes. Of course this requires the implementation of specific programs, but for better performance, a special module for stepper motor control in three Forward, Backward and off is designed which is programmable on the base of motor type and can be changed and adjusted easily.



Fig. 1 Stepper motor control

B. Sampling of Vehicle Dimensions

The geometry sampling of vehicle by metering sensors is carried out and data is sent to I/O function unit with two decimal places (Fig. 2). PLC uses these dates to adjust functional program of the device.



Fig. 2 Sampling of vehicle dimensions

C. Washing

Then vehicle moving on conveyor belt enters the washing part (Fig. 3) that in this part the time to wash will vary according to the size of cars. Cycles of washing includes washing with water, and then with detergent and brushes horizontally and vertically and with pneumatic Jack which is attached, and washing is done by warm water with pressure.



Fig. 3 Washing

D. Drying

Considering ability to wash three more vehicles increases the complexity of system and PLC is in charge of making discipline and coordination among all parts, as can be seen in Fig. 4 after the wash cycle car enters the tunnel dryer with dryer that is blowing warm air into the chassis in a closed container and is dried thoroughly.

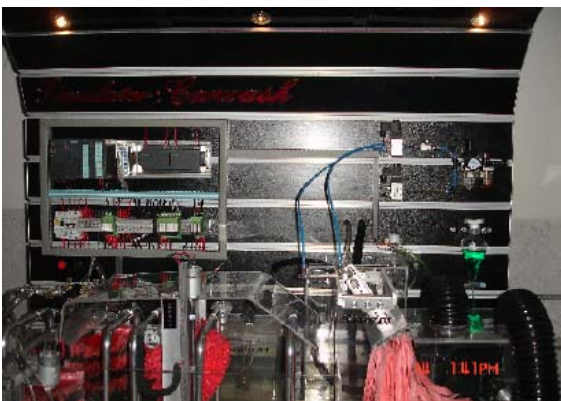


Fig. 4 Drying

Performance of laboratory samples indicates the fact that the control set above is capable in practice. What is calculated in the design is also expected in practice.

VI. HARDWARE ERROR DETECTION AND INTERRUPTION OF ANALOG MODULES

Considering that the input data of process that enters PLC should be in high accuracy modules with ability to pause and feature special diagnostics interrupt and hardware interrupt have been used to in the states of wire break and high limit and low limit in Fig. 5 shows how to create interrupt for analog signals.

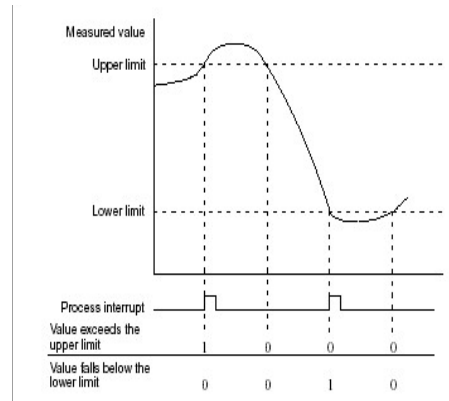


Fig. 5 Conditions interrupting for analog signal

TABLE I
RESOLUTION

Resolution	Interference Frequency (HZ)	Integration time (ms)
9+Signbit	400	2.5
12+Signbit	60	16.6
12+Signbit	50	20
14+Signbit	10	100

Other important factors in choosing an analog module are the resolution and the analog input to digital value converting time (Integration time). This parameter sets the resolution in accordance with Table I.

VII. INVESTIGATION OF ERRORS IN FUNCTION MODULE

The smart CPU used in Carwash process planning is one kind of FMs called SFB30, which provides counting pulses up to 10 KHz frequency. In fact, this function receives rapid pulses from various kinds of sensors and sends them to stepper motor in order to count, compare and finally produces independent outputs. This function works on the base of positive edge of pulse in one of the following ways:

- Method 1: with sampling times of 10, 1, 0.1 sec
- Method 2: with a sampling time of 4, 2, 1msec

The pulse frequency is obtained by division of the number of positive edges to sampling time. For example if the time is selected to be 1 second, and at this time duration 6500 samples are received so, the frequency of pulses will be 6500 Hz. first method is used for high frequencies and is high accurate and at the same time it has the lowest loading cycle time. Second method is used for low frequencies; the accuracy is satisfying and can support hardware interruption. This method has more loading on scanning cycle. Keeping in mind, that this function has ability to measure frequencies up to 10 KHz, if the input's frequency exceeds this amount, the output will not be trustable and in some cases the CPU will stop working.

We know that the resolution of measured frequency increases with respect to sampling time increment, so, in order to get more accuracy, if high accuracy is required we need much more sampling time, which in this case measurement of

frequency needs more time that, is not appropriate for control system.

In the first method of measurement error is reduced with increasing sampling time. Table II shows the error rate. Calculation of maximum measurement error of the measured frequency is indicated in (1);

$$\text{Max. Measurement Error in \% of Measured Value} = \frac{0.001 + 1/\text{frequency}}{\text{sample time}} \times 100 (\%) \quad (1)$$

TABLE II
ERROR RATE FOR METHOD 1

Frequency (kHz)	Sample Time (sec)	Max. Measurement Error in % of Measured Value
10	0.1	1.1
10	1	0.11
10	10	0.011

Due to the measuring principle, the measurement error increases as the measured frequency decreases.

In the second method, the error rate has inverse relation with sampling time, but as can be seen in Table III is more than one method.

Maximum measurement error of the measurement frequency in this method is indicated in (2);

$$\text{Max. Measurement Error in \% of Measured Value} = \pm \text{frequency} \times \text{factor}(\%) \pm 0.001 \quad (2)$$

The factor used to calculate the measurement error in the above equation depends on the CPU.

The factor cannot exceed a maximum value. In other words, if the equation in Table IV yields a factor for application which is larger than the maximum factor, we must use the maximum factor in (2) in order to calculate the measurement error.

TABLE III
ERROR RATE FOR METHOD 2

Frequency	Sample Time	Max. Measurement Error in % of Measured Value
10 KHZ	1ms	5%
10KHZ	2ms	2%
10KHZ	4ms	1%

VIII. TROUBLESHOOTING

In this process a set of features to detect system's errors are expected, with use of these features, maintenance of the project can easily take place and where the error is, can be found easily and quickly. This minimizes the process of stopping times that are caused by errors.

IX. RESULTS

Putting all discussions together, one can conclude that the proposed method for controlling automatic carwash removes restrictions that exist on common systems and introduces a

unique way to create error-free and highly efficient project. Considering that wide ranges of parameters are given to the PLCs, which can be changed according to our needs makes the project flexible and ensures easy and trouble free washing. The final result of project is automatic carwash lines that can implement its task flawlessly even in a bad condition of environment.

TABLE IV
FACTOR FOR CALCULATING THE MAX. MEASUREMENT ERROR IN FUNCTION MODULE

CPU (IFM)	Factor Calculation (%)	Max. Factor for Sample of:		
		1ms	2ms	4ms
CPU 312	$(0.01 + 0.0018 \times \text{frequency in Hz})$	5	2	1
CPU 314	$(0.01 + 0.0012 \times \text{frequency in Hz})$	3.5	1.5	0.75

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