IOP Conf. Series: Materials Science and Engineering **144** (2016) 012017 doi:10.1088/1757-899X/144/1/012017

Intelligent traffic control system using PLC

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Abstract. The paper presents the traffic control system controlled through a PLC which takes the signals from different sensors on roads. The global system developed ensures the coordination of four intersections, setting a path that respects coordination type green light, the integration of additional sensors, the implementation of probes radar to inform traffic participants about recommended speed for accessing the green state located in the intersection that will follow to cross.

1. Introduction

These days it is necessary to introduce a system of traffic control to be implemented in the city with high traffic. In order to implement such a system, it has to be implementable globally, at the level of an entire city, with knowledge of the geographical factors, of the infrastructure of the public roads, daily/weekly routes etc.

In an intersection the problem is local in nature. Ignoring the influence that the road infrastructure has in an intersection, one needs to establish the priority road, the traffic flow and the pedestrian flow. A regularly signalized intersection is programmed in a pre-established manner, the green time and the red time are periodically adapted, or not at all, at long time intervals, depending on the traffic flow [1].

At the same time, times are changed depending on the traffic flow at certain rush hours which are unchanged. There are certain settings, such as green light for pedestrians or green light for a certain lane, which are operational even if it is not necessary. This paper approaches the development of an adaptive system which "knows" the traffic flow in real time based on receiving certain signals from various sensors, and then, depending on theses, changes the times of statuses and eliminates certain statuses between red light and green light which are not necessary under certain circumstances.

Other signalizing systems are present in New York where 7,660 signalized intersections out of a total of 12,400 are controlled by a central computer. In Toronto, 83% of the signals are controlled by the MTSS (Main Traffic Signal System), and 15% use an adaptive system for controlling the signals. In Sidney 3,400 traffic signals are coordinated by the SCATS (Sidney Co-ordinate Adaptive Traffic System). By October 2010 SCATS had been licensed for 33,200 intersections in 144 cities throughout 24 countries. In Melbourne, 3,200 streetlights use SCATS, and 500 intersections have a priority system for public transportation [2].

The advantages of a streetlight installation which is designed and installed correctly are the following:

- it ensures a disciplined movement of the traffic participants;
- the green light, under the conditions of adequate spacing and proper coordination of the operation of several streetlight installations along a certain route or a network of streets;
- interrupting of a main traffic flow in order to allow the passing or infiltration of a secondary traffic flow;

A streetlight installation must contain the following ensemble: automated devices for managing traffic, streetlights, traffic probes, linking cables [3-5].

The types of automated devices for managing traffic may include:

- automated devices for managing traffic with preset operation;
- automated devices for managing traffic activated by vehicles or with operation adapted to the requirements of the traffic at specific moments;
- automated devices for managing traffic activated by pedestrians

Choosing a certain type of automated device with preset operation or one that is activated or semi-activated by vehicles is done depending on the situation, certain conditions which the intersections must meet.

A coordinated streetlight installation is implemented depending on the major requirements of traffic along a linear route (green light coordination type) or within an urban area (surface coordination type).

Green light coordination type can be applied when two or more intersections are adjacent on the same main road, with the purpose of reducing delays and preventing repeated stops. The purpose of these coordinated systems is to ensure maximum traffic flow along a certain route, without forced stops, while at the same time satisfying the requirements of crossing traffic [6].

2. Components of the installation

2.1. Programmable Logic Controllers

A Programmable Logic Controller PLC is a device used for the control and automation of complex systems and various equipments. Such programmable controllers are fairly recent, are meant to replace sequential circuits and relays, and are designed to function in an industrial environment.

They use programmable memories for storing instructions provided by the user who can implement logic functions, as well as sequential, time, counting and arithmetic functions. PLCs function by inspecting their inputs and, depending on their status and the functions created by the user, they switch outputs.

In other words, a programmable controller is an industrial computer specialized in real time applications. PLCs are systems which usually contain a processor, a power source, in-out modules, output modules and special, dedicated modules [7].

2.2. HMI Wentek and EasyBuilder 8000

The Weintek MT8070ih tablet allows the display of the graphical interface created with the programme Easy Builder 8000. The tablet has a touch screen with a 800x480 resolution, 3 serial ports (USB, micro USB and serial). It has a slot for an SD card, a mouse, a keyboard, a printer and other peripheral devices can be connected to it. The audio tablet has a speaker for issuing specific sound signals. It can render animations and can operate in strong electromagnetic fields [8].

It is a free programme from Weintek Company and it is used for the integration of certain PLCs, amongst which Siemens CPU 313c, with the aim of supplying a graphical interface for the application created by the user in the Siemens controller. The programme allows the association of each graphical element with an input, an output, a marker or any other element from the scheme introduced in the PLC by addressing certain TAGs [9].

2.3. Sensors
From the point of view of the positioning, the sensors which serve for the control of an intersection are:

Subterranean sensors: In this category the most frequently used type of sensor is the inductive one. It is made up of an inductive loop which is mounted under the roadbed (Figure 1). The loop is an insulated conductor which is connected to a main panel which generates frequencies between 10 KHz and 200 KHz by means of an electromagnet. As a vehicles drives over it, the inductivity of the loop decreases. These sensors can be used in order to identify the presence of vehicles, count the vehicles and calculate their weight.

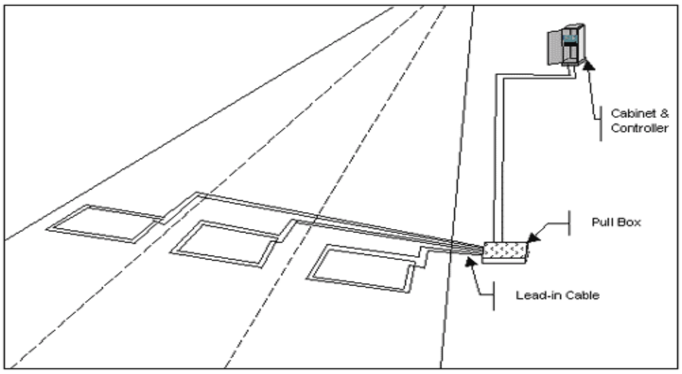

Figure 1. Location of the inductive sensors

Aerial sensors: In this category the following are included: the sensors mounted above the road, which can be optical sensors (Figure 2), video cameras (Figure 3), sensors with electromagnetic waves, acoustic sensors (Figure 4).

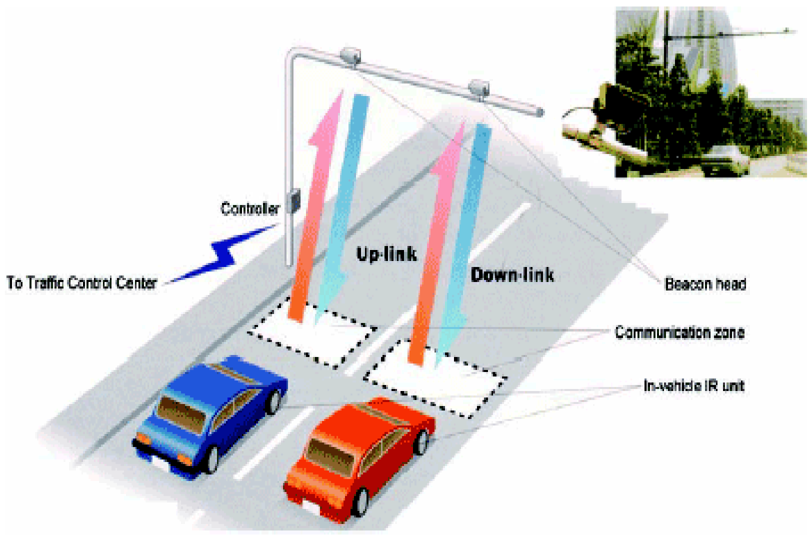

Figure 2. Location of infrared sensors

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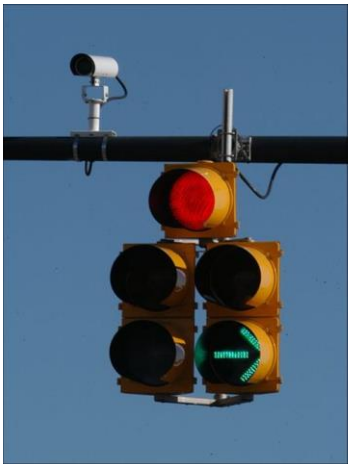

Figure 3. Video camera for reading traffic flow

Figure 4. Acoustic sensors for traffic

2.4. The LADDER scheme of the application

The scheme of the application is created in the LADDER language in the Step7 development programme and run on the Siemens CPU 313c PLC.

Line 1 represents the input I124.0 of the controller, which once activated switches on to the coil of the marker M0.0 (Figure 5) represents the meter of Status 1 (Table 1). We observe in Figure 5 the marker M3.7 which has its contact normally switched off and represents the repetition marker for the signalizing cycle. Marker M4.4 has its contact normally switched off.

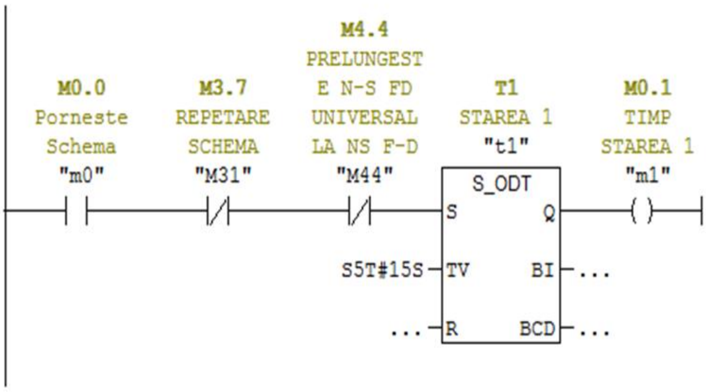

Figure 5. Conditions for first stage

Delays block

This block is represented by the inputs associated to every level of delay and by the time relays which actuates the statuses with the aim of prolonging them.

Table 1. Association of inputs with the levels of entry

Input	Level	Status
I 124.1	Level 1	Status 1
I 124.2	Level 2	
I 124.3	Level 3	
I 124.4	Level 1	Status 3
I 124.5	Level 2	
I 124.6	Level 3	
I 125.0	Level 1	Status 5
I 125.1	Level 2	
I 125.2	Level 3	
I 125.3	Level 1	Status 7
I 125.4	Level 2	
I 125.5	Level 3	

In Figure 6 we observe the normally switched on contact of input I124.1 specific for level 1 of delay. One can observe self-holding. The coil of marker M6.0 is held in its contact, and the normally switched off contact of marker M0.4 will switch off this self-holding. Because this input actuates status 1, marker M0.4 corresponding to status 2 will switch off this self-holding so that during the next cycle this delay should be applied only if the contact in input I124.1 is switched on.

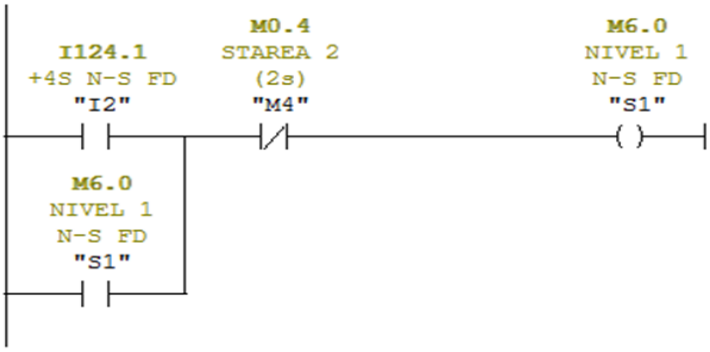

Figure 6. Settings for Level 1

The Line 9 (Figure 7) includes the normally switched on contact of marker M6.0 (Figure 6) which will power the time relay T100 when the normally switched on contact of marker M0.2 which represents status 1 will be switched on.

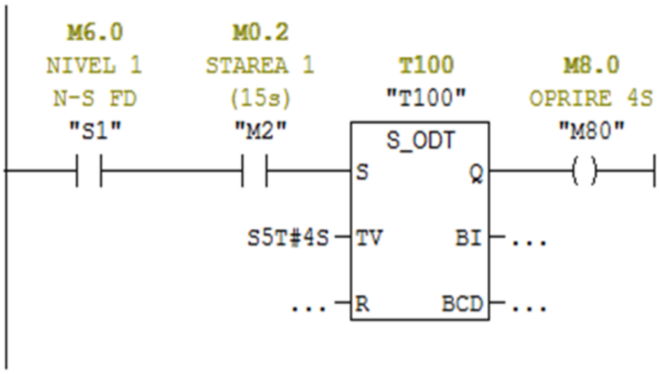

Figure 7. Line 9 in Ladder diagram

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Line 10 (Figure 8) includes the normally switched on contact of marker M6.0 which powers coil M4.4 (Figure 5) which switches off the power to the time relay of status 1 over a certain period and which is set by time relay T100 (Figure 7) which actuates the normally switched off contact of marker M8.0 (4 seconds).

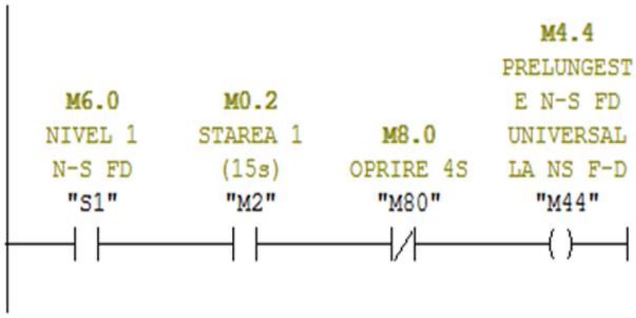

Figure 8. Conditions for insert supplement time

3. Graphical interface

The interface is created with the programme EasyBuilder. In order to create it one needs to know all the right labels for the ladder scheme, inputs and outputs used (Figure 9).

The Step 7 programme allows the export of a source of the programme with the extension .awl, and from this source one can export the symbols of the ladder scheme in a file with the extension .dif.

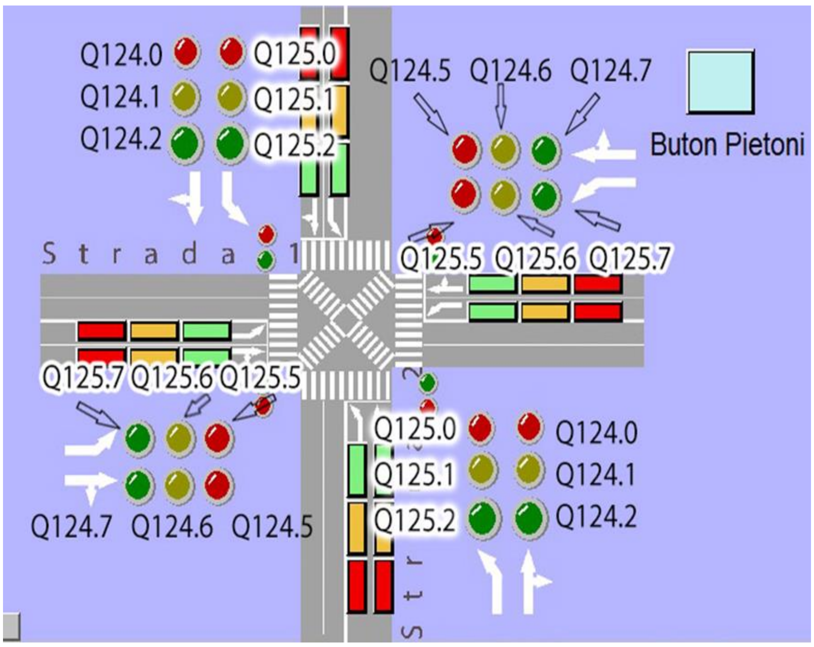

Figure 9. Association of the streetlight lamps with outputs Q of the PLC

In Figure 10, one can observe the association of the buttons for the delay levels with inputs I of the PLC.

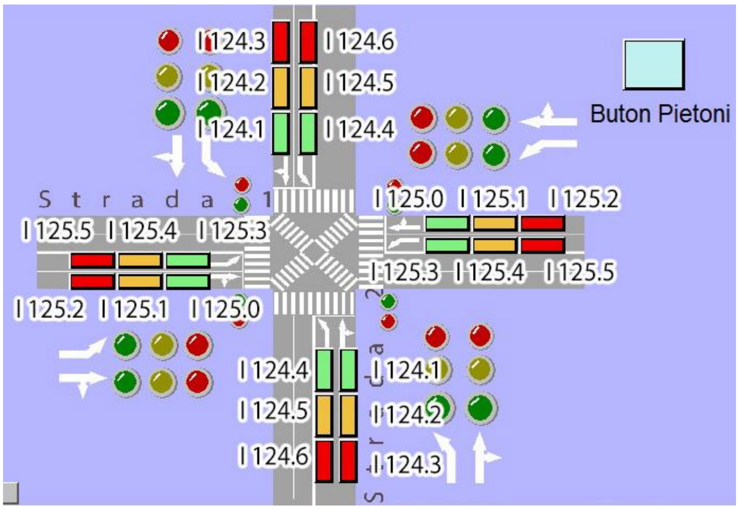

Figure 10. Association of the buttons for the delay levels of the inputs I of the PLC.

4. Conclusion

In the context of present-day urban traffic one needs to implement signalizing systems which would ensure the best traffic conditions. My project represents a local signalizing system, adaptive in real time, developed by means of the controller Siemens CPU 313C. The signalizing system can be implemented at the level of an intersection with four roads and two lanes per direction. At the entry points with delays one can apply signals, impulses (which come from sensors or are actuated manually) which will have effect in the prolongation of the green late for the selected road. The graphical interface clearly renders the functioning of the signalizing system, as well as the applied delays. The green light for pedestrians is activated only when a specific input is actuated; in our case, a button marked and located close to the pedestrian crossing so that those who wish to cross the intersection should be able to make this request.

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