Modelling and Simulation of Traffic Lights on Road Intersections

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Abstract –This paper aims to achieve a program that operates the traffic light of intersections with TwidoSoft programming language. The order of priority between traffic rules is implemented in machine specific language TwidoSoft. At the end of this paper is a simulated traffic congestion situation.

Key-Words: - Modeling and Simulation, PLC Twido, Programming, Ladder.

1 Introduction

Road signalling is done by light signals, signs and markings and other means provided in the road rules [4], [5]. People who use public roads must comply with the meaning of light signals, indicators, markings and signals that drive the movement of agents and drivers of vehicles.

The order of priority between the rules of movement, the various means of road signs and signals that drive traffic agent is as follows [2]: special warning light and/or audible signals, policeman's signals, temporary signs that changes the normal operation of traffic, light signals, signs, markings, traffic regulations. The traffic sign and road safety equipment are designed to be installed and/or applied for public road manager in agreement with police. The meaning, and the traffic sign size, shape, symbol, colour and conditions of performance, location, installation and implementation are set by state standards [14], [15].

2 Light Signals

Signals are bright white lights or coloured differently, issued successively, continuously or intermittently for one or more lighting fixtures that make up a traffic light. Depending on the lighting fixtures, traffic lights are [17]: with a luminaire, flashing warning light, with two luminaires for pedestrians and cyclists, with three lighting devices for vehicles, with four or more lighting devices, for trams.

Lights are mounted on the vertical axis of the post or on the console, the portal or suspended on cables, the lens colour sequence, from top to bottom, being as follows [9]: the order of signal lights with three colours is red, yellow, green, for the one with two lights the signal sequence is with two colours: red, green. Red-light emitting light signals for routing traffic in the intersection before the intersection shall be compulsorily installed in order to be visible from a distance of at least 50 m. This can be repeated in the middle, above or across the intersection. The meaning of the light signals for guiding the movement of vehicles is valid for the entire width of carriageway open to traffic managers to whom they are addressed.

On roads with two or more lanes on the way, for different directions, removed by longitudinal markings, traffic lights can be installed over one or some of the bands, where the meaning of light signals is limited to the band or bands as indicated. Red, yellow and green signals can be under the form of arrows of the same colour on a black background [6], [7], [8]. In this case the prohibition or permission required by the signal crossing light is limited to the direction or directions indicated by the arrows.

And arrows have the same meaning if applied to an additional panel accompanying the traffic lights at the bottom. Arrow for going forward is pointing up. It is not allowed to enter an intersection even if the signal light or an indicator of priority allows to, if the driver of the vehicle is likely to remain restrained because traffic congestion, hindering or

impeding traffic. When the traffic lights is accompanied by one or more lamps emitting light as one flashing green or arrows on a black background to the right, they only allow the passage towards the indicated direction, irrespective of the time of traffic light signals in operation. Vehicle drivers are obliged to prioritize the passage of road users they intersect with and move according to traffic light colour meaning that they address to [13].

Red signal forbids crossing. The vehicle must be stopped before the red signal to stop marking or, where appropriate, pedestrian crossing, and in its absence, the right light. If the traffic lights are installed above or across the intersection, in the absence of the stop marking or pedestrians passage marking, the vehicle must be stopped before the edge of carriageway of the road to be crossed. When the red signal works together with the yellow, it announces the emergence of green signal. When the yellow signal appears after the green signal, the vehicle driver who approaches the intersection must not pass the provided places, unless the occurrences of signal is so close to those places that the vehicle could not be stooped safely. Flashing yellow signal enables passing in compliance with road signs and traffic rules applicable in that place.

The same meaning applies to the flashing yellow signal lamps installed in a dangerous place. When above the bands, separated by longitudinal markings are installed devices that emit red and green signals, they are meant for signalling bands with reverse circulation. Red signal, having the form of two angled and cross-over bars forbid vehicles access on the lane and the green signal, under the form of an arrow pointing down, allows the entry of vehicles and traffic on that lane. Intermediate light signal announcing green signal when changing bands is under the form of yellow or white arrows with the tip pointing towards downright diagonal. This signal notifies that the lane is about to be closed for the drivers it addresses to and that they are obliged to go to the lane or lanes indicated by arrows. Driver entering an intersection when the traffic light is green has to comply with the meaning of the signs installed inside it.

Vehicles moving in actions that require intervention or emergency missions can move through intersections, even if traffic light signals prohibit passage or the existing signs require or prohibit access. Drivers of such vehicles are obliged to use early warning sound and light facilities.

Light signals for pedestrians are green and red. These work related to the signals for directing movement of vehicles. Green signal may have in its field the image of a pedestrian walking and the red one the image of a stopped pedestrian.

Light signals for pedestrians may be accompanied by acoustic signals to ensure crossing for blind people. On the areas of road where traffic levels permit, the public road manager may place special traffic lights or manual command panels to be made directly by pedestrians with the approval of the police. Green signal allows the passage. When the green signal begins to operate intermittently it means that time allocated for crossing the road is being exhausted and the red signal follows. Red signal forbids pedestrians to engage on the carriageway. If case of correlated lights along a route, colour timing devices as well as lighting devices that display related times and moving speed for vehicle drivers can be installed.

Warning lights are installed out of the intersection and consists of a luminaire with flashing yellow light. Its field can include the image of a moving, yellow pedestrian on black background. For signalling and routing traffic on the sectors of roads, except highways, where works are carried out on the carriageway, temporary mobile traffic lights can be installed, in order to be visible from a distance of at least 150 m [1].

2 PLC Twido

2.1 Presentation of Twido PLC

Twido PLC is dedicated to small and medium automatic control systems, with a number of inputs /outputs between 10 and 250. Automatic Twido range is available in two versions: compact and modular (Fig. 1). Both versions use the same plug-ins I/O options and programming software [12]. Twido Compact is used in automated independent and simple applications (automatic doors, automatic machines, pump stations, etc.).

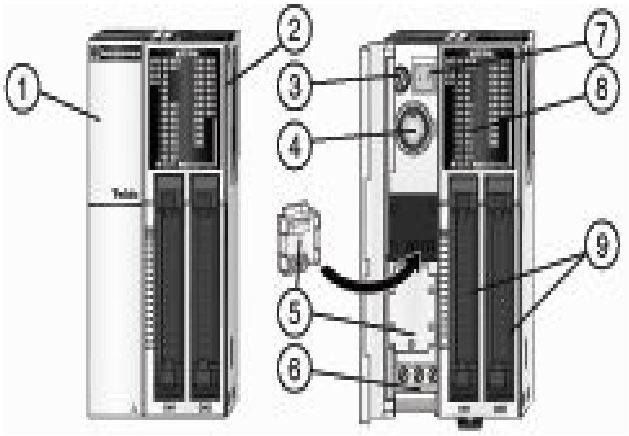

Fig. 1: Automatic TWDLMA 20DRT.

The assembly and use of this type of automated device are very simple. The second variant, Twido Modular is used primarily in repetitive applications (industrial washing machines, washing machine facilities, elevators, woodworking machinery, compressors, etc.). This type of automated device, based on the "just enough" concept provides the ultimate solution for a machine automation [11]. Basic module can include a number of 20 or 40 inputs/outputs. For larger configurations basic module can be extended with plug-ins I/O depending on the application being used.

The controller has a modular TWDLMDA 20DRT analogous channel, 12 digital inputs and 8 outputs (6 outputs with relay and 2 transistors), an analogous potentiometer, an integrated serial port, and a terminal block which accepts 7 input/output as extensions. Input voltage is 24 V.

2.2 TwidoSoft Programming Language

TwidoSoft is a graphical development environment aimed at the creation, configuration and maintenance of applications for Twido controller. TwidoSoft gives the opportunity to create different types of software applications and then to transfer a controller for these applications in order to be put into execution [10].

TwidoSoft can run under Windows 98, 2000 or XP and integrate additional functionality and configuration editing and online help [3]. To download the programs made with TwidoSoft the Twido machine can use special cables (TSXPCX3030 or TSXPXC1031) or you can use Bluetooth wireless technology (Fig. 2). To create a control program for controller Twido means to write a series of instructions in one of the Twido programming languages: instructions (a set of logical expressions written as a sequence of Boolean instructions); ladder diagram (is a graph that describes a logical expression, like a relay logic diagram representing the control circuits of a relay - output, contacts, blocks representing instruction), Grafcet language (consists of a series of steps and transitions).

Management process covers both the acquisition and processing of process data and commands to perform the process. Command can be made by humans based on data obtained from monitoring. If orders are made automatically print an algorithm that takes into account the data obtained from monitoring, without consulting the human operator, we deal with automated process management. Management process involves the computer running a program (usually written in language

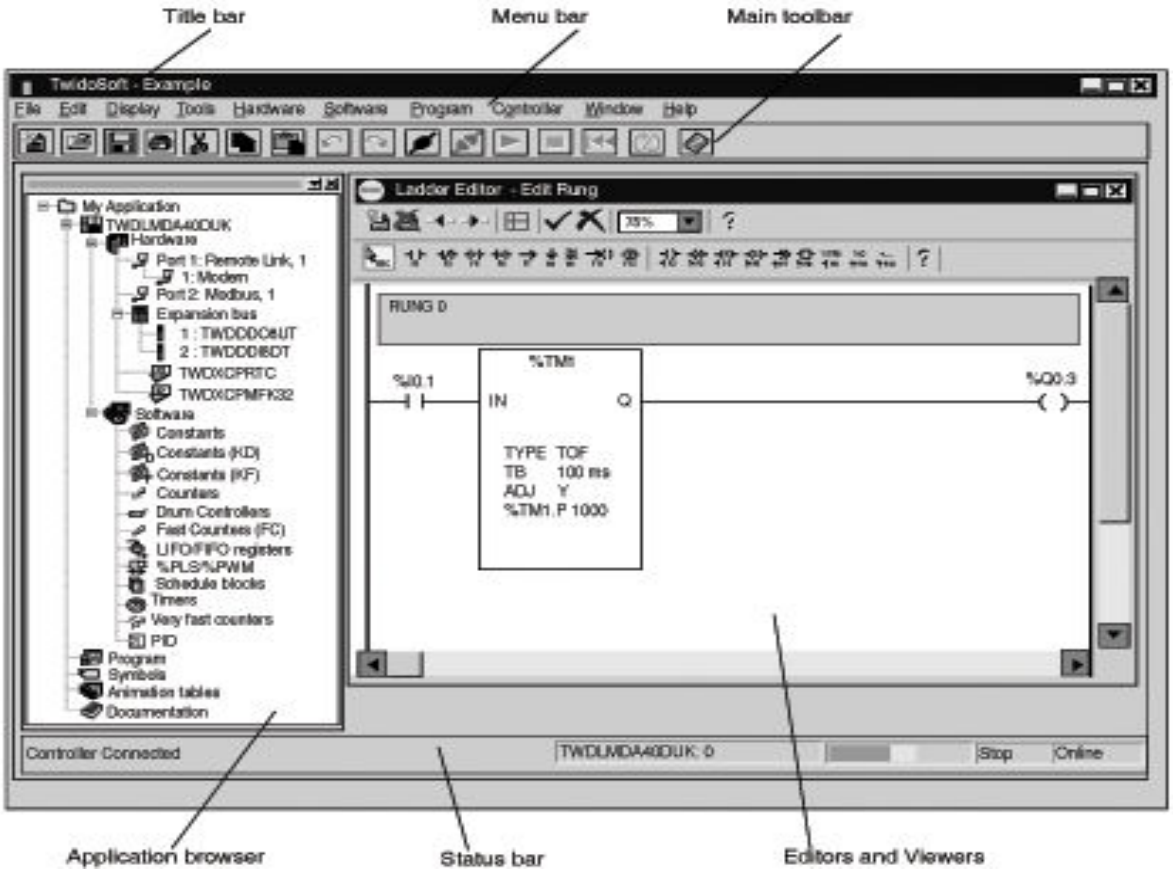

Fig. 2: Window work TwidoSoft.

microprocessor) to solve an application process. Computer programs running on a trial run unlinked to achieve results, without a condition that is related to a given time. But if management processes should be satisfied: a prerequisite, namely problem solving within a maximum feature called real time.

3 Command of a Traffic Light Controlled Intersection

3.1 Wiring Diagram of the Machine at Intersection

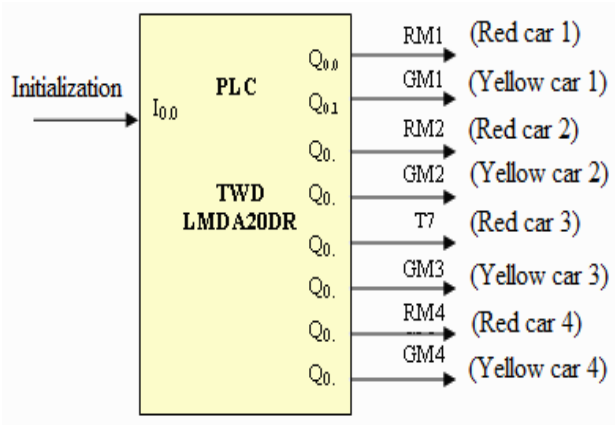

Fig. 3: Wiring diagram of automatics.

PLC TWD LMDA 20DRT has 8 digital outputs, to which controls for lights intersection are attached according to Fig. 3. A single digital input is attached to the automated device, used to initialize the program. Semaphored intersection symbolized in Fig. 4 is divided into four groups of LEDs. We chose a semaphored intersection operating according to the four-stroke flow chart shown in Fig. 5: in time 1 group 1 indicates green for cars and at the same time the green colour and pedestrians travelling between group 1 and 2 (red indicates other groups) in 2, 3 and 4 times during the 1 they repeat for group 2, 3 and 4, then resume with 1. Given the choice of this type of operation of the intersection and that the machine has only 8 outputs: RM and GM (red cars and yellow cars). The other commands are derived from them [5], [6]:

$$VM = \overline{RM + GM}\ ,\quad RP = RM + GM\ ,\quad VP = VM\ .$$

Resistors are chosen so that through each LED a current between 10 and 20 mA flows. Power sources for LEDs, relays and PLC are shown in Fig. 6. For proper operation (safety) of intersection lights, LED lighting (especially those which command cars) has to be monitored so that the

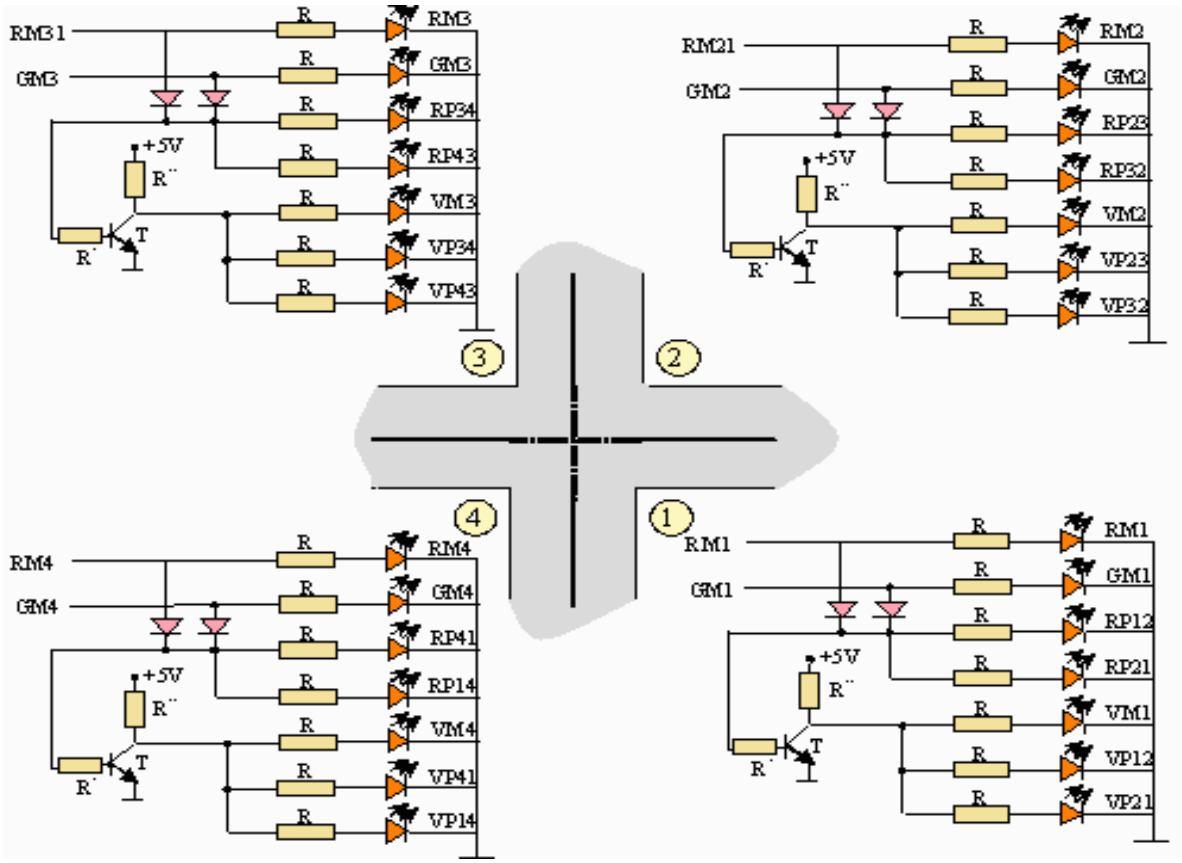

Fig. 4: Wiring diagram for power LEDs.

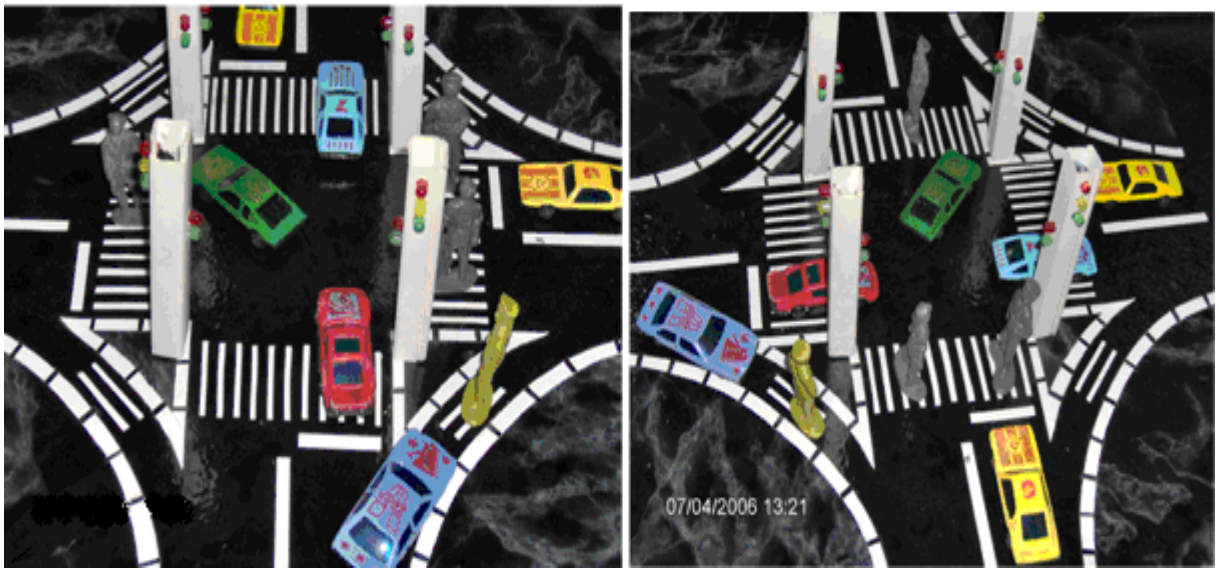

Fig. 5: Explanatory lights on an intersection.

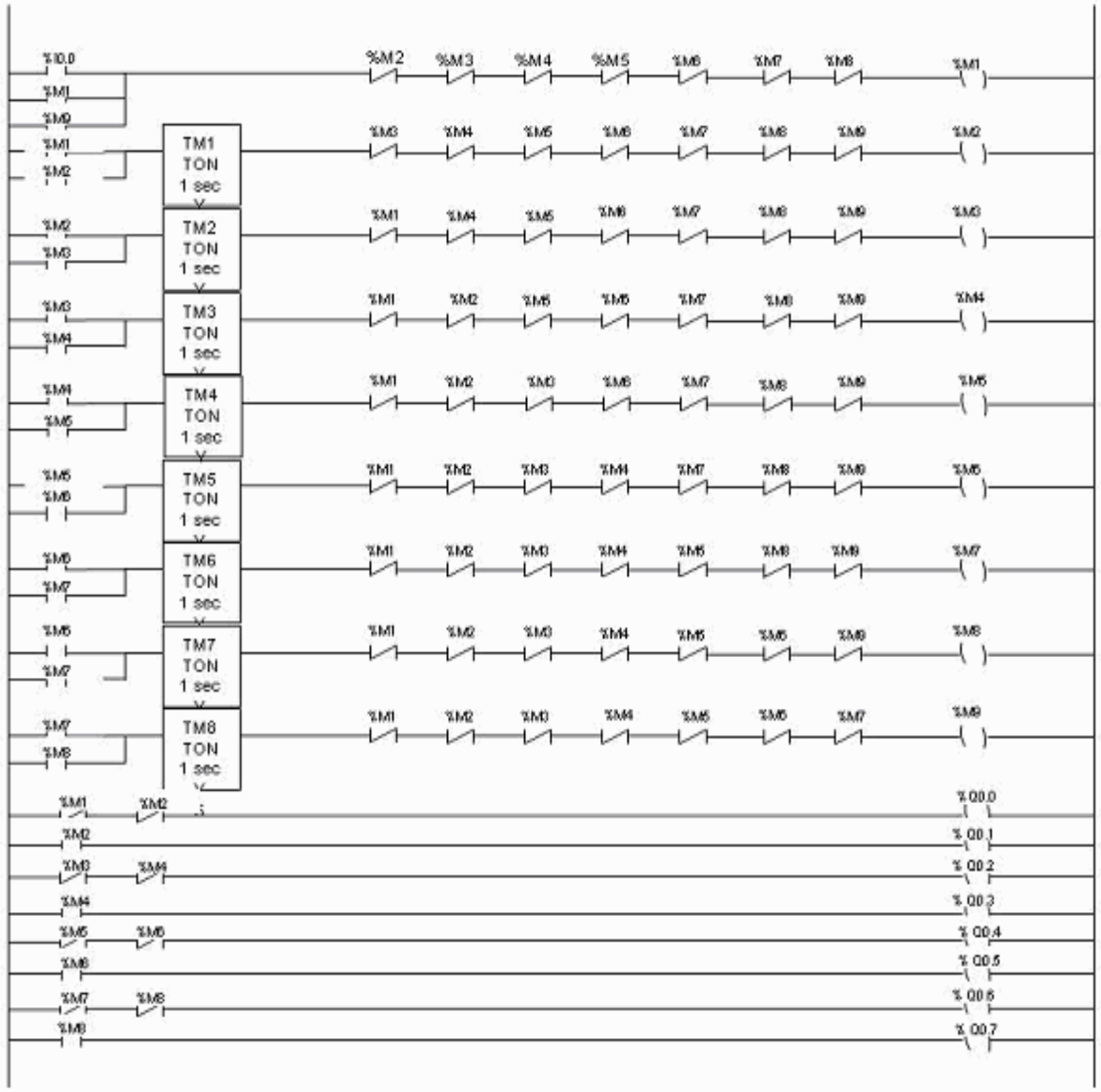

Fig. 6: Program of the intersection in order TwidoSoft (Ladder language type).

intersection operates normally. Monitoring can be d one with optical transducers (photodiodes and photoresistors, phototransistors, etc.) Serial or current transducers with LEDs that [7]. For a malfunction, the machine has to command in flashing yellow.

3.2 The Management of the Intersection

To this end one will use TWDLMDA 20DRT machine that has 12 inputs and 8 outputs. Using only one input and all 8 outputs of the application, we can achieve the logic diagram of the application (Fig. 7). An impulse to output 10.0 applies that transmits the output instruction and the output will be interpreted by the following input rule. This input is the first moment of signalling, namely the occurrence of the red colour for the first traffic light lights. To calculate the time for this colour type one shall use a TON timer (T*imer* O*n*-D*elay*). After the 15 seconds allocated to the red colour, an output impulse will be issued and the program will develop the next sequence, ie a new input followed by a new timer that calculates the 5-second time allotted to the yellow colour for the machines stooped at the first traffic light, red for pedestrians P12 and P21 and for the states of the other traffic lights (Fig. 5). This output is actually an entry in the following sequence, the green colour allocation made both for the machines at the S1 and the pedestrians P12 and P21. After the passage of time, lights will resume the same instructions, but this time for S2. S4 shows green lights for both cars and pedestrians as P3. A delay of 10 seconds for the green traffic light was set, 5 seconds to 15 seconds for yellow and red [16].

All other lights show red for both pedestrians and for cars. Microcontroller tests whether 10 seconds have passed. If so, then S1 will be yellow and red lights for pedestrians P12 and P21 and the other lights. Microcontroller test if the last 5 seconds during the corresponding traffic light yellow colour. If passed this time, then S2 will show green lights for cars and pedestrians P23 and P32.

One shall test again whether the 5 seconds passed. If passed, then S2 will show yellow lights for cars and pedestrians red for P23 and P32. The other traffic lights will show the red light for both cars and for pedestrians as well.

The microcontroller tests whether the 5-second time corresponding to the yellow traffic light passed. If this time passed, then S3 will show green lights for cars and pedestrians P34 and P43. One shall test again whether the 10 seconds passed. If passed, then the S3 will show yellow lights for cars and pedestrians red for P34 and P43.

The other lights will indicate red both for cars and pedestrians. The microcontroller tests whether the 5 seconds corresponding to the yellow traffic light passed. If this time passed, then S4 will show green lights for cars and pedestrians P14 and P41. One shall test again whether the 10 seconds passed. If passed, then S4 will show yellow lights for cars and pedestrians and red for P14 and P41. The other lights will indicate red both for cars and pedestrians.

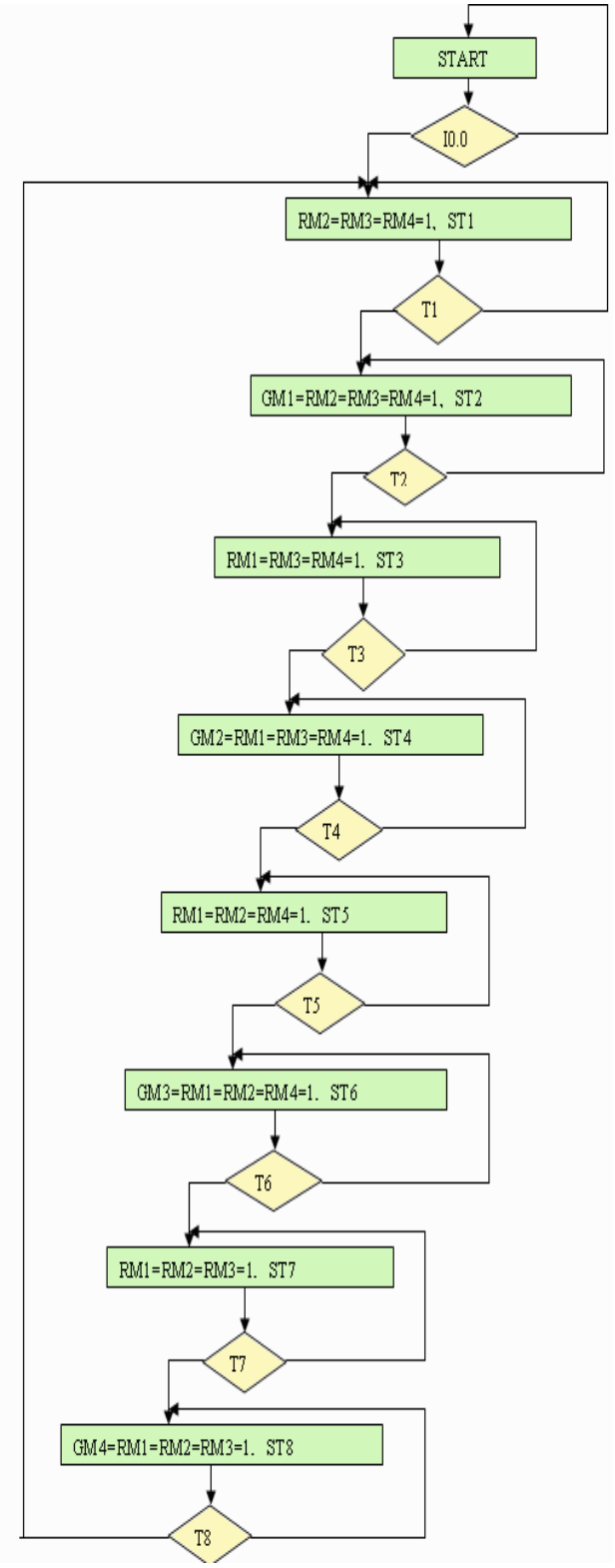

Fig. 7: Scheme logic control program for the intersection.

Microcontroller tests whether the appropriate time for a second yellow traffic light passed. If this time passed the cycle resumes. In implementing the program simple inputs and denied inputs, simple outputs and TON timers were used. An input is the instruction to take back an impulse to its use in carrying out an instruction. Depending on the type of the input (simple or denied) the result will be sent to the corresponding output.

The result of the input pulse can be transmitted to the output with some delay, it is possible that timers calculated using the time elapsed from receipt until the momentum which it is transmitted to the output in order to obtain a positive realization of the program. The following were used: I0.0 simple main input which takes the impulse, 9 simple inputs and 9 denied inputs coming from the 9 simple outputs from each sequence of the program performance, 8 timers that calculate the time between making sequences and all 8 outputs of the controller, depending on their condition and realizing the LED lighting.

A TwidoSoft application contains a program, a configuration, the symbols and documentation. These components can be used in any order when an application is made. Slot is Twido programming software using TwidoSoft, using a type language Ladder (IEC standard) [3], [4], [5].

The basic elements used to write the program in language LAD, we used only contacts and coils. It works as follows:

Coil Set (Latch) - (S) -: set the bit to 1 when the line is evaluated to 1 logical and nothing when the line is evaluated to 0 logical.

Reset coil (*Unlatch*) - (R*)* -: set the bit to 0 when the line is evaluated to logical 1 and nothing when the line is evaluated to logical 0.

Normally open contact - | | -: validate program line to right when the line is validated to left and the corresponding bit is the logical 1.

Normally closed contact -|/|-: validate program line to right when the line is validated to left and the corresponding bit is the logical 1.

Active contacts on ascending front - |P| -: Validate the right part of the program line for a cycle when the left part is validated.

Active contacts on descending front - |N| -: Validate the right part of the program line for a cycle when the left part is not validated.

As a linear program, it was written in block OB1 and is called cyclically by the operating system machine.

Run is done as follows:

- Program lines are evaluated from left to right and from top to bottom.
- Branches within a line are evaluated from top left to bottom right.

In Fig. 8 is presented the moment when the safety sensors are activated following the breakthrough of the barrier, as a result is turned out "presence lamp car", which corresponds to switching on the red bulb light.

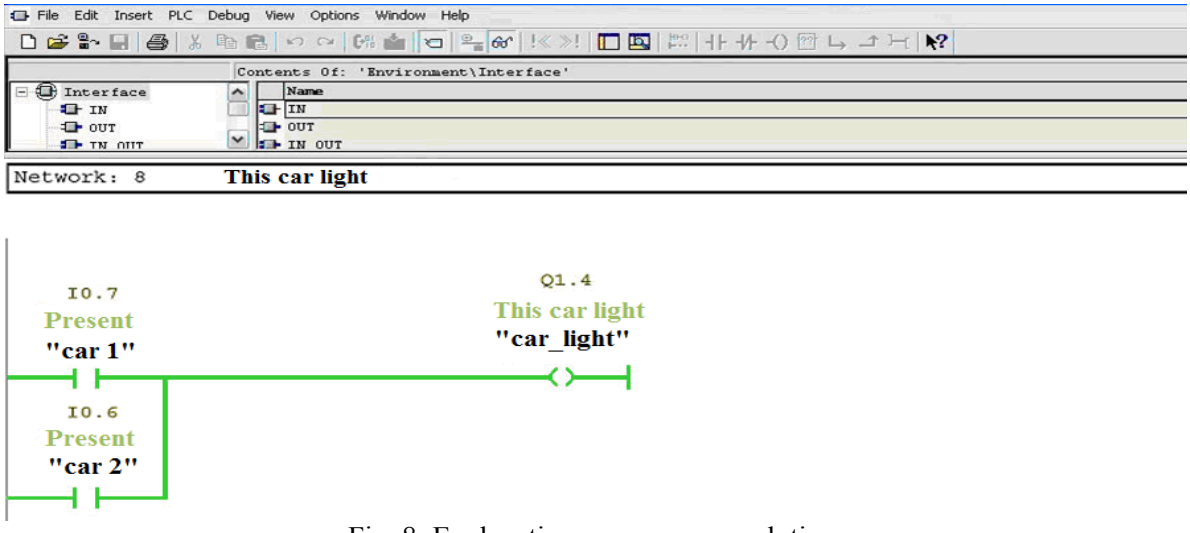

Fig. 8: Explanation on program evolution.

Coil -( )-: set the bit to 1 when the line is evaluated to logical 1 and to 0 when the line is evaluated to logic al 0.

Coil denied -(/) -: set the bit to 0 when the line is evaluated to logical 1 and to 1 when the line is evaluated to logical 0; generally not used because it can bring confusion.

6 Signalling Traffic Simulation

For a management application are not usually sufficient only variables that can be stored in internal system needs an external data memory.

Special instructions allow the CPU (Central Processor Unit) to a specific location in external memory is selected by an address bus and its contents are moved to one of the internal registers through an 8-bit data bus. An additional bus control points where an external memory read operation from external memory or external memory write (RW-Read Write signal). One of the most common applications of computer use is creating a system of traffic lights and traffic. This is a management process to ensure that both traffic monitoring function and decision function by ordering the traffic light colors, when requested by pedestrians. When you refer a motion sensor, the central computer unit process starts a timer, if no traffic light is off.

It simulates the operation of two port lights adapted to 8-bit parallel communications. Each light comes with 3 lights: red, green and yellow. Each of the three bulbs are connected to one pin assigned port used - in this case port 01h.

To turn one or more of the six bulbs will be sent to port 01h a binary value corresponding assignments bulbs, the port pins. Specifically, only to turn red light bulb 2 will be sent to port 01h 100000xx binary value; can have any value from the set (00, 01, 10, 11), these values have no influence functioning light. To send the binary value on the port it should be converted into hexadecimal code. Thus, binary code is 10000000 80h in hexadecimal. Thus, for the light bulb just 1 red light (left) will be sent to port 80h code.

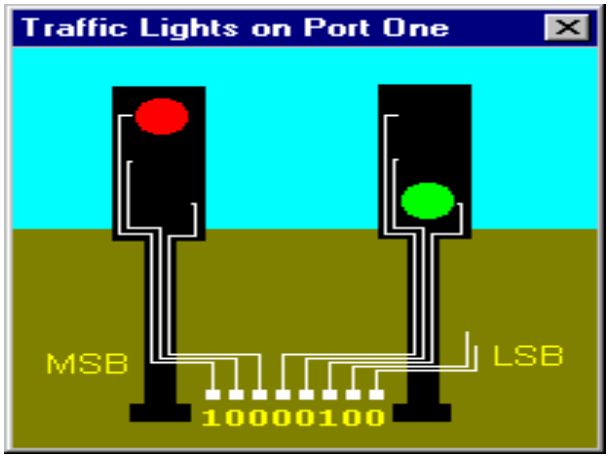

Fig. 9: View order traffic lights.

Pine:	Traffic Light:	Bulb:
0,1	-	Unused
2	2	Green,
3	2	Yellow
4	2	Red
5	1	Green
6	1	Yellow
7	1	Red

Transfer between registers using the instruction:

```
MOV AL, BL; loading OF registry registry
           value BL
```

To load a register with immediate value is used for instruction:

```
MOV DL, 05; initialize register 05 value
```

The syntax is:

```
MOV reg, Val
```

where reg is any registry general AL BL CL or DL and Val is an immediate value represented in base 16.

To transfer data to/from memory using the instruction:

```
MOV AL,[C0];loaded into the AL register
           value at the address C0
MOV DL,[BL];loaded into the register at the
           address value to the value of BL
MOV [C8],CL;CL register transfer into
           memory at address C8
MOV [DL],AL;transfer value to the value of
           DL in the AL register.
```

The syntax is:

```
MOV dest, source
```

Other possible commands:

```
MOV reg,[Val]
MOV reg1,[reg2]
MOV [Val], MOV reg [reg1],
```

where reg1 and reg2 general registers may be any of the AL, BL, CL or DL.

In case of a program is recommended to use for lighting bulbs, to retain constant hex code for each sequence of ignition in hand. Thus, to obtain result in Fig. 9 was used sequence of commands:

```
MOV AL,84
OUT 01
```

If the lights intermittently, eg yellow bulbs, use the following sequence:

```
     MOV  AL,48
I:   OUT  01
     XOR  AL,48
     JMP  I
```

Example: Traffic control lights

```
CLO          ; all intermediate-unused closing
Jmp Start:   ; Jump to tag home
db 84 db 88 db 30 db 50;
      area data: constant lights order
Start: MOV BL,03;
      BL load start address of data area
Next: MOV AL,[BL];
      loaded into the AL command code content
OUT BL 01; Send content on port 01, write
```

```
                command all the traffic lights flash
INC BL,
BL PMC,7 ; test whether flared
JNZ NEXT; If you have not lit go to Next
Jmp Start   ; Otherwise, go back to the START
              label.
END         ; End program
```

7 Conclusions

Responding to some questions:
- such as what does traffic mean for each of us?
- which are the problems encountered in the life of drivers and pedestrians?
- which is/should be role of actors in proper circulation?
- which are the steps to follow for a better involvement of men in observing traffic rules?
- solving a problem with implementing a new solution?
you can create the premises for an appropriate movement.

The progress of electronic technology over the last decades has been an emergence microcontroller turning point both in terms of beach virtually unlimited field of application of these revolutionary components of technically and technologically and in terms of design and implementation of design techniques, synthesis and testing. Microcontrollers meet the qualities of applications that are used, such as flexibility, simplicity and small size.

The advantages of speed, computing power and, especially, a considerable reduction of costs are quantified. This work meant for developing a programming language through a program through which TwidoSoft could perform the traffic lights of an intersection illustrates the advantages of use of such material. Also, the price of these components, becomes more and more trivial every day, for which the they are gaining ground in front of traditional components used in intersections traffic lights.

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