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DUAL PHASED FOUR WAY INTERSECTION REGULATED BY TRAFFIC LIGHTS WITH FIXED AND ADAPTIVE MOD OF OPERATION

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Abstract

Road traffic in many populated areas is mainly regulated using a traffic light, which in many cases is not sufficiently effectively configured. This can lead to unnecessary long waiting times and increase total time losses when passing through the intersection. This paper presents the results of the application program of the adaptive semaphore system of the four way two phase intersection, made using the LabVIEW software package, as well as the data and results of the analysis of the functioning of the intersection with adaptive and fixed traffic mode.

***Keywords**: adaptive traffic mode, fixed traffic mode, traffic regulation, traffic lights, virtual instrument.*

1. INTRODUCTION

From the functional point of view, surface intersection is the most complex element of the traffic network. Namely, the paths of traffic flows of different directions are crossed, the flows may change directions, the vehicle and pedestrian flows are crossed, different maneuvers take place. This indicates that surface intersections are areas with increased concentration of conflicts and increased risk of traffic accidents. That is precisely why it is necessary to have in mind that, while designing and constructing intersections, their main role is to ensure safe traffic and quickly and economically distribute traffic flows, in order to ensure that the conflicts among the participants in traffic are less frequent and that the congestion delay is as little as possible. These conditions have to be met by using minimal financial investments.

The main role of the traffic lights, ie light signals for traffic regulation at surface intersections, is the separation of conflicts between vehicles and pedestrians at characteristic points. Light signals regulate traffic flows in such a way as to allow vehicles of one group of flows (non-conflict or conflict-compatible) to pass in a given time period (phase), whereby the vehicles of the second group of flows will be collected at the same time. Then, the second group of vehicles is accommodated, during the same, or different time interval, then the third, possibly the fourth and so on, after which the cycle is repeated periodically. Vehicle accommodation is carried out on the basis of a signaling plan, which, in a unified way, accommodates all the flows grouped within the phases. The main problem that needs to be solved, when it comes to signalized intersection, is calculating and optimization of the signal plan, which implies determining the cycle duration, the number of phases, as well as calculating the distribution of green time intervals to each phase. The maximum recommended duration of the cycle is 120sec. Light signals can operate in a fixed mode when signal plans are determined based on previously collected traffic data, and also as adaptive systems, when light signals operate depending on changes in traffic parameters such as flow, speed, density, and more.

2. THE CYCLE, CAPACITY AND DEGREE OF SATURATION OF THE SURFACE INTERSECTION

The Webster method is used in order to determine the duration of the cycle (C) and the green times of the corresponding phases (gi) of the traffic lights

$$C = \frac{1.5 \cdot L + 5}{1 - Y}, \quad g_i = \frac{Y_i}{Y} \cdot (C - L), \quad L = n \cdot d + \sum_{i=1}^{n} \Delta t_i \quad \text{i} \quad Y = \sum_{i=1}^{n} Y_i \qquad (1)$$

here: L - represents the total lost or unused time at the intersection during the cycle, Yi = maxj {yj (i)} = maxj (Qi / Si) and yi = Qi / Si - the coefficient of utilization capacity of the i-traffic lane, number of phase of the signal plan, d - average time losses-congestion delays, per vehicle during the "green phase" and Δti – clearance interval between the phase "i" and the next phase. The Qi, Si and Y represent the traffic flow intensity of the i-th access lane, the saturated traffic flow of the i-th lane and the coefficient of utilization of the intersection capacity. Saturated traffic flows are determined on the basis of special tables and, as a rule, for this intersection, are constant. On the other hand, the intensity of traffic flows Qi can change over time (daily, weekly, monthly, etc) and are most often determined by counting or by using special detectors installed at the intersections. Intersections with constant cycle values are constant, calculated on the basis of pre-collected data on traffic flow intensity values, constitute a group of intersections with a fixed mode of traffic light system operation.

The intersections where the optimum cycle value is calculated and the distribution of green time to each phase is carried out in such a way that the values are adapted to the changes in traffic flows, belong to the group of intersections with the adaptive system of traffic lights mode of operation.

Adaptive traffic management systems are very complex systems. The functioning of such systems, as a rule, is based on the use of computer systems and corresponding software solutions. The basic components of the adaptive system are the data parameters, the traffic parameters, the corresponding computer system, the light source controller and the traffic lights (Figure 1a.).

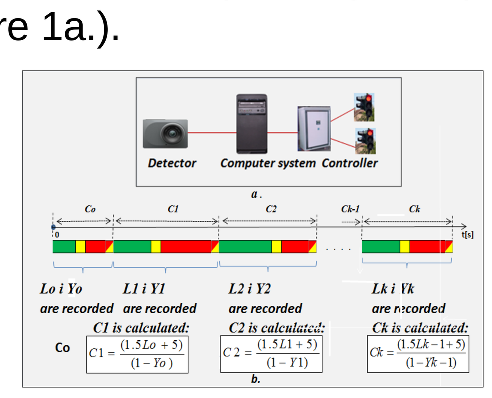

Fig. 1. System elements and cycle calculation

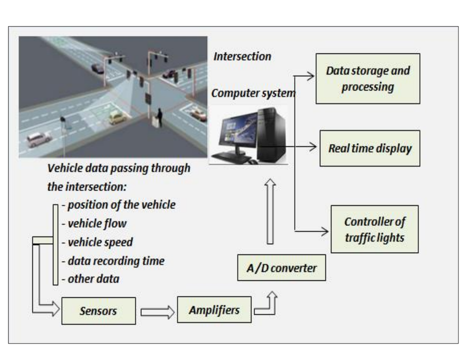

Fig. 2. Functional structure of the adaptive system

Figure 2 shows the functional structure of the adaptive traffic management system at intersections regulated by traffic lights.

The aim of this paper is to offer one of the possible solutions for an adaptive traffic management systems, based on the use of LabView software package. The basis of the solution lies in the fact that is necessary is to the measure of the intensity of traffic flows in the intersection lanes, during the current cycle (with the help of appropriate detectors), and use the values to calculate the duration of the next cycle (Figure 1b.):

$$C_{k+1} = (1.5L_k + 5)/(1 - Y_k) \qquad (2)$$

where k represents the current cycle and, in accordance with the relation (1) and the length of the green light for each phase, the capacity (ci), the saturation level (Xi) for each traffic lane:

$$g_{i,k+1} = (Y_{i,k}/Y_k)(C_{k+1} - L_k), \quad c_{i,k+1} = S_i(g_{i,k+1}/C_{k+1}) \quad \text{i} \quad X_{i,k+1} = Q_{i,k}/c_{i,k+1} \qquad (3)$$

When the saturation values for all traffic lanes are equal or less than one, then, the traffic takes place under conditions of unsaturated traffic flows, which means that vehicles stop only once in front of the stop line, and that all vehicles that "requested" pass through the crossroads are accommodated during the cycle. If the saturation level is larger than one, on one or more lanes, then the traffic takes place under conditions of oversaturated flows, which means that not all vehicles are accommodated during the cycle and that a certain number of vehicles stop several times before they pass through the intersection. This further leads to a significant increase in congestion delays, as well as an increase in the concentration of exhaust gases, increased anxiety and other undesirable occurrences.

3. RESULTS OF TESTING THE ADAPTIVE SYSTEM PROGRAM SOLUTION

The program solution for the adaptive traffic management system is calculated for a four-way, two phased isolated intersection regulated by traffic lights. The solution is based on the software platform called LabVIEW software package - a standard in the field of virtual instrumentation.

The graphic user interface package has two panels: a control panel for process control and tracking and a panel for making an application solution, or a block diagram. The testing of the software solution and comparing the obtained results was performed on two identical two-phase intersections, one of which works with the adaptive, and the other with a fixed traffic light mode of operation (with a cycle duration of 52 seconds). The testing was carried out by computer simulation, where the simulation program was also done in LabVIEW. This program is, in its essence, identical to that used by an adaptive mode of operation of traffic lights in real-life conditions. The only difference is that a special simulator (instead of the appropriate detectors) is used as the basis for the traffic flow in the simulation program, and that the elements of the signal timing plan are sent directly to the traffic lights. Figures 3 and 4 show the results of the test, ie the average value of traffic flows at the end of the current cycle (used to calculate the duration of the next one) and saturation levels within the respective cycles.

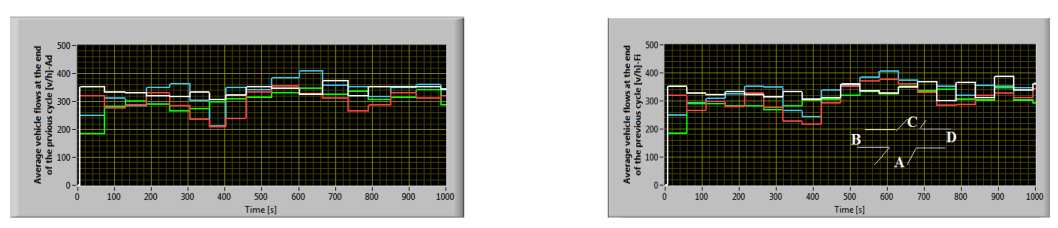

Fig. 3. Average values of traffic flows during testing times at intersections crossings with adaptive and fixed mode

The test results show (Figure 4) the advantages of adaptive mode of operation in relation to the intersections with the fixed mode of traffic lights operation. In the first one the traffic takes place in unsaturated traffic flows and with significantly smaller changes in the degree of saturation. However, the intersection with a fixed mode of operation, after the fourth cycle, undergoes the state of oversaturated flows, and under such circumstances, with minor changes, the traffic takes place until the end of the test period.

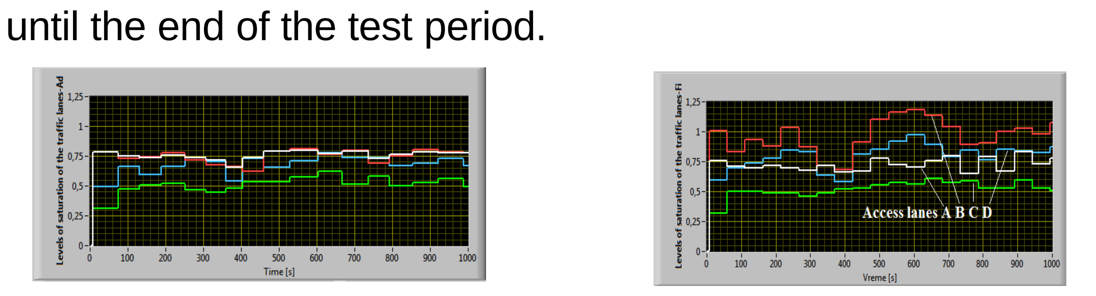

Fig. 4. Levels of saturation of intersection with adaptive and fixed mode of traffic light

4. CONCLUSION

The testing process was carried out for different cycle lengths of the system with a fixed mode of operation and different values of average traffic flows, and results are similar to those shown in the following tables. The software solution shows the benefits of the adaptive system when vehicles are in the dilemma zone, and when emergency vehicles are passing through the intersection. The development of computers, the rapid development of new technologies, and different types of sensors for detecting conditions and traffic parameters data, have enabled the creation of adaptive systems designed to control the light signals operation, not only on isolated and intersections regulated by traffic lights but also on the at-grade intersection. Nowadays, there is a large number of adaptive systems around the world installed in different locations, use different equipment, work under different conditions and achieve different results. What is common to most systems is the lack of information on essential modes of operation, used algorithms, and other elements of management control.

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