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THE GRAPHICAL MODELING, SIMULATION AND REALIZATION OF AN EQUIPMENT WITH OPTO - REFLECTIVE SENSORS FOR THE MANAGEMENT OF URBAN PUBLIC TRANSPORT PASSENGERS

Abstract: The development of an equipment capable to carry out a real-time evaluation above loading of urban buses, allows the optimization of the urban transport vehicles distribution on a network segment, reducing waiting times, the passenger crowds in buses and at the same time decreasing the need of buses maintenance, issues with direct effects on the growth of the carriers economic profit.

A solution based on optical detection is one that can generate results with high accuracy in relatively low cost conditions. This advantage can be obtained only if the constructive version of the equipment is properly designed, taking into account the geometric parameters of the light slots emitted and received by the sensors. Therefore, using three-dimensional CAD modelling, it was realized an optimal constructive variant. This graphical method also allows it the viewing, variation and synchronization of sensors geometrical parameters, so in this way, the equipment can produce the desired effect. Further, it has been carried out a graphical simulation of the designed equipment function, in order to validate the obtained results. Later, the designed equipment was achieved and tested under laboratory conditions, in order to be implemented and used under real conditions, on the buses of an urban public transport operator.

Key words: urban buses, optical detection, geometric parameters, CAD Modelling, graphical simulation.

1. INTRODUCTION

In urban, suburban and regional road route transport, planning and optimization of economic decisions must be based on knowledge of the precise flow of travellers. In such cases, the mere counting tickets sold, is not enough because of the different systems of subscriptions and the uncertainty regarding the connection between the distance and the ticket price. For this reason it is proposed to automate the passenger counting.

A very efficient solution in this field requires ultra precise counting and linking with satellite global positioning system (GPS) [1, 2].

The functions performed by counting system are:
• detecting passengers crossing and their sense of movement through threshold-type;
• counting inputs and outputs and counting passengers inside the bus;
• determination of the position of the bus on the entire length of the route with GPS system;
• processing data by the computer installed on the bus;
• storing information on semiconductor memory cards interchangeable and development of statistical databases in order to improve management decisions.

2. THEORETICAL RESEARCH OF TRAFFIC MONITORING PASSENGERS FROM THE BUS, TROUGH THE OPTICAL DETECTION

Optical detection is a method just intrusive, but that presents a series of limitations on the applicability in vehicles or travellers detection [3]. Major restrictions with regard to the optical detection technique, makes this method not very prevalent. The detection method based on optical sensors also has advantages such as:

• signal response capacity very good, less than one millisecond;
• high detection pattern;
• electric power supply in 10 - 30 V DC field and it doesn't require specialized electronic mounting elements;

For applying this method of detection it can be used two types of sensors. The first is the optical sensor, which contains two transmitter and receiver elements in separately casing and the other type of sensor is opto-reflective, which contains a reflective plate located to a distance from the emitter, but the transmitter and receiver elements are in the same casing, and it does not require separate power supply [4, 5].

For development the experimental stand, it was used the second option, because this type of sensor is capable to detect objects on a greater distance and also can identify different entities.

The 3D model of this sensor is shown in Figure 1.
3. DESIGNING THE EXPERIMENTAL STAND AND OPTIMIZATION GEOMETRICAL PARAMETERS OF THE USED SENSORS

For carrying out the laboratory conditions tests with regard to the detection of the passengers from an urban bus, it was developed an experimental stand that simulates the access through the front side of the Turkkar ED bus salon. The stand has been designed in order to be able to monitor a high precision number of travellers who ascend and descend from the city bus. The stand frame is made of square tube 20 x 20 mm, aluminium sheet flooring over is applied underlayment paint. Stanchions are executed from 15 x 15 mm jib and they are fixed to the metallic support in two points. On the stanchions from the ascending and descending floor, are placed the opto-reflective sensors by four adjustable mounts. The sensors are powered by a 12V DC power from a constant voltage source. The CAD model achieved for the designed stand is represented in Figure 2 [6].

![Fig. 2 Experimental stand 3D CAD model](image)

Legend:
1. Metallic frame; 2. Aluminum floor;
3. Stanchions; 4. Optical beam;
5. Opto-reflective sensor; 6. Reflective plate.

Opto-reflective sensor (also known as retro-reflective sensor) allows detection of objects on a long distance, making easy the detection of people who ascend and descend from the bus, regardless of their height, running speed or the number of people who pass simultaneously.

From the point of view of the operation principle, an optical beam is emitted between emitter and reflective plate. An object is detected when the effective radius of light is cut off. Reflective plate is an optical device which reflect light back in the direction of the light source. In order to ensure the proper functioning for the elements of detection and for achieving appropriate results of measurements, identification of geometrical parameters for sensors mounting and adjustment operations is a very important issue. In the case of opto-reflective sensors, the detection position is less accurate than of the optical sensor with transmitter-receiver, because the effective light beam is wider and taper.

![Fig. 3 The situation with sensor placed offset by the reflective plate](image)

At very small distances, reflective plate returns the entire light to the optical transmitter and not to the receiver. This fact can cause an effect called “blind spot” (the lack of light to the receiver, which leads to incorrect functioning of the sensor).

Maximum detection distance is defined as the distance between the sensor and the reflective plate. Minimum and maximum distance is the position where the obtained excess light has the unitaire value. This excess will depend on the reflection capacity of the reflective plate and its surface.

Another factor of influence is the angle under which the slot light meets reflective plate. At an angle of 90° with an error of ± 10°, this effect can be neglected. In the case of angular values exceeding this limit, can be possible a random detection or only a part of the light beam to be reflected, with consequences leading to major changes in the value of the received voltage. Thus, the possibility of programming the maximum detection distance, as well as directing the incident cone spot, are common features of this type of sensors. Possibility of connecting the sensor to a serial type data acquisition system (for example RS 232), is also an included configuring option.

Realization of 3D CAD model allows the determination of the optimum mounting position for the detection elements and the identification of optimum geometrical parameters of the slot light emission so as to fit into the above mentioned values [7]. In Figure 2 is shown the situation in which the sensor is in optimal functioning position, the axis of the light cone being inclined at 90° to the reflective plate, while in figure 3 is shown the situation in which the sensor is placed offset by the reflective plate, and the emitted light cone axis disposed at an 70° angle.

In this situation, the slot light reflected by the plate is sent to the emitter and not to the receiver, so producing the effect of blind spot.

After positioning and adjustment of the detection elements to the stand, it is made a simulation of how the projected installation works.
In Figure 4 is shown how it works the sensor located on the front side position, used for detecting the persons who are ascending on the bus.

![Fig. 4 Simulation of detection at the ascending moment](image)

In Figure 5 is shown how it works the sensor located on the back side position, used for detecting the persons who are descending from the bus.

![Fig. 5 Simulation of detection at the descending moment](image)

When the emitted cone of light is interrupted by one or more persons that pass right through them, the sensor signal register variations between the actual voltage and zero voltage, indicating the absence of the incident wave reflection. Depending on the filling degree of the light spot and the speed of passengers passing, it is possible to identify the number of persons who are transiting the monitored area.

Even during simultaneously ascending or descending, the sensors work independently, recording the number of passengers accurately. When the ascending sensor registers a person, the descending sensor doesn’t record it again, and vice versa.

In Figure 6 is shown the voltage variation recorded from the emitted sensor signal, when is activity in the ascending or descending area [8].

![Fig. 6 The sensor voltage variation](image)

4. CONSTRUCTION OF THE DESIGNED STAND AND PERFORMING TEST IN THE LABORATORY CONDITIONS

Obtaining the optimum functional and constructive parameters, determined as a result of graphical modelling and simulation of the designed detection system, it can proceed to the real construction stage.

In Figure 7 is shown the final stand built variant obtained, ready for testing.

![Fig. 7 The real stand constructed and equipped for testing](image)

1. DC power supply 2. Multimeter

In order to be able to perform measurements on the built stand, it was equipped with a DC power source which supply the detection elements, and with two devices for measuring the voltage from the ascending and descending sensors detection area. It was carried out different measurements in terms of varying the height of placing the sensors and the travel speeds.
The results of measurements carried out

<table>
<thead>
<tr>
<th>Sensor position</th>
<th>Sensor height [mm]</th>
<th>Ascending sensor voltage variation [V]</th>
<th>Descending sensor voltage variation [V]</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>12.1</td>
<td>12.0</td>
<td>Slow motion</td>
</tr>
<tr>
<td>500</td>
<td></td>
<td>11.6 ÷ 12</td>
<td>11.6 ÷ 12</td>
<td>Quick motion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.7 ÷ 8.1</td>
<td>7.2 ÷ 9.3</td>
<td>Quick motion</td>
</tr>
<tr>
<td>700</td>
<td></td>
<td>11.6 ÷ 12</td>
<td>11.8 ÷ 12</td>
<td>Quick motion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11.8 ÷ 12</td>
<td>10.3 ÷ 12.1</td>
<td>Quick motion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.3 ÷ 9.8</td>
<td>4.5 ÷ 8.6</td>
<td>Quick motion</td>
</tr>
<tr>
<td>900</td>
<td></td>
<td>10.5 ÷ 11.8</td>
<td>11.5 ÷ 12</td>
<td>Quick motion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.7 ÷ 12.0</td>
<td>7.3 ÷ 11.9</td>
<td>Quick motion</td>
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<tr>
<td></td>
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<td>7.5</td>
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<td>1100</td>
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<td>7.8 ÷ 11</td>
<td>8.1 ÷ 11.9</td>
<td>Quick motion</td>
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</tbody>
</table>

The results of the performed tests, written in Table 1, indicate that the most accurate detection area is in the interval between 500 ÷ 700 mm. The 700 ÷ 1100 mm interval is also a pretty accurate area, without measurement errors, but measured voltage values are lower than in the first case. So, it results that the height positioning of the sensors around 700 mm value, determined by the CAD model is the optimal functioning position.

5. DEVELOPMENT DIRECTIONS OF THE RESEARCH CARRIED OUT

With the purpose of completion and implementation of the designed urban transport passengers management equipment, the development directions for the research carried out, are based on:

- Equipping the system with a RS unit of data acquisition;
- Testing in laboratory conditions of the measuring and data acquisition system;
- Testing in real conditions and implementation on the urban buses, of the system designed and simulated in laboratory conditions.

6. CONCLUSIONS

In the context of positive effects brought by the management systems of urban bus passengers monitoring, regard to the quality improvement decisions, the main desideratum watched is the completion and implementation of a reliable, precise and accessible solutions, in terms of cost conditions, on the urban public transportation vehicles.

The quality of a trip depends on the comfort, safety, regularity and rhythmicity of urban buses circulation. Ensuring sufficient capacity, easy accessibility, minimal time for the home-destination displacement, ensuring a reasonable transport of any weather conditions, comfort, features, and minimum negative effects for the residents and the environment, all at low cost conditions, may be possible by the passenger management projected system.

Using three-dimensional modelling by SolidWorks program, it was achieved the experimental stand model that simulates actual operating conditions of a passenger management system and also it was possible identification the optimum geometrical parameters for positioning and functioning of the used detection elements. Realization of 3D CAD model has facilitated the construction and testing in laboratory conditions of the passenger activity detection system. The results of the performed tests, confirm the accuracy of the data used in the graphical modelling and allow taking the decision according to which the stand being completed with the measured data acquisition elements and proceeding to using the designed system on the urban public transport vehicles.

REFERENCES


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