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Design of Automated Monitoring and Operating Light System

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*Abstract***.** In this paper monitoring and operating light system has been designed. The main idea is to detect the failure of each light within a street or area. It indicates the location of the failing lights and resets the display once the light is fixed and maintained. The system is designed to continuously monitor street lights during operation hours. To perform the proposed task first to design the circuit and then developing software which control, and manage operation of lights. Design of a friendly user window which represents a graphical model in order to monitor the operation of the system is another task. A laboratory size model which represents certain street or zone have been designed. Tests has been performed in order to show the effectiveness of the proposed design

1. Introduction

Street lights are designed to provide adequate levels of lighting to both pedestrians and vehicles. Street lighting in built up areas is designed to provide a safe and comfortable visual environment for pedestrian movement at night. Such lighting is provided at an adequate level both for convenience and safety[1-3].

With the advent of such lighting, regular maintenance and monitoring become essential, with payment on contract agreements usually being performed based on making residents feel secure, to enhance the appearance of the area after dark, and to perform some tasks during night time hours[4-7].

Operation and maintenance of infrastructure and facilities of power distribution (at the feeder level) have always been a major concern of power utility companies and local authority such as municipalities. Their main concern is usually the inefficient utilization of resource in order to give good customer service level. Managing the street lighting is an area of interest due to the vast distribution of lighting network implemented in cities and towns. The size of the distribution has grown tremendously and as such there is a need to have a monitoring and management system to help reduce the energy operating cost while improving and optimizing the utilization of workforce to handle maintenance activities [8].

The objective of this paper is to design an automatic monitoring and operating lights system. It is designed mainly to detect the failure of each light within a street or area. The system monitored is displayed on personal computer and monitors the zone or area for the failing lights and presents the display when the light is maintained and operates again. The designed system contains hardware circuits well as a software program.

It is proposed to build a small scale model to monitor a set of lights. This model can be used to test and verify the correct operation of the system.

The objective of this paper can be summarized as follows:

1. Design hardware circuit:
2. Develop software which control and manage operation of lights
3. Design friendly user interface window which represent graphical model
4. To build a small model which represent certain area or zone lights
5. To monitor the operation of the system.

A functional block diagram of the proposed system is shown in Fig. 1.

2. Hardware Design

Hard ware design consists of designating and integrating sevral parts, hard ware design consists of designing Controlling the Parallel Port, Voltage Regulator Circuit (SV),Light Sensing Circuit, Level Shifting Circuit, Lights ON/OFF Switching Circuit, Testing Circuit Power Control, and Power Consumption Reduction. Each circuit will be explained below.

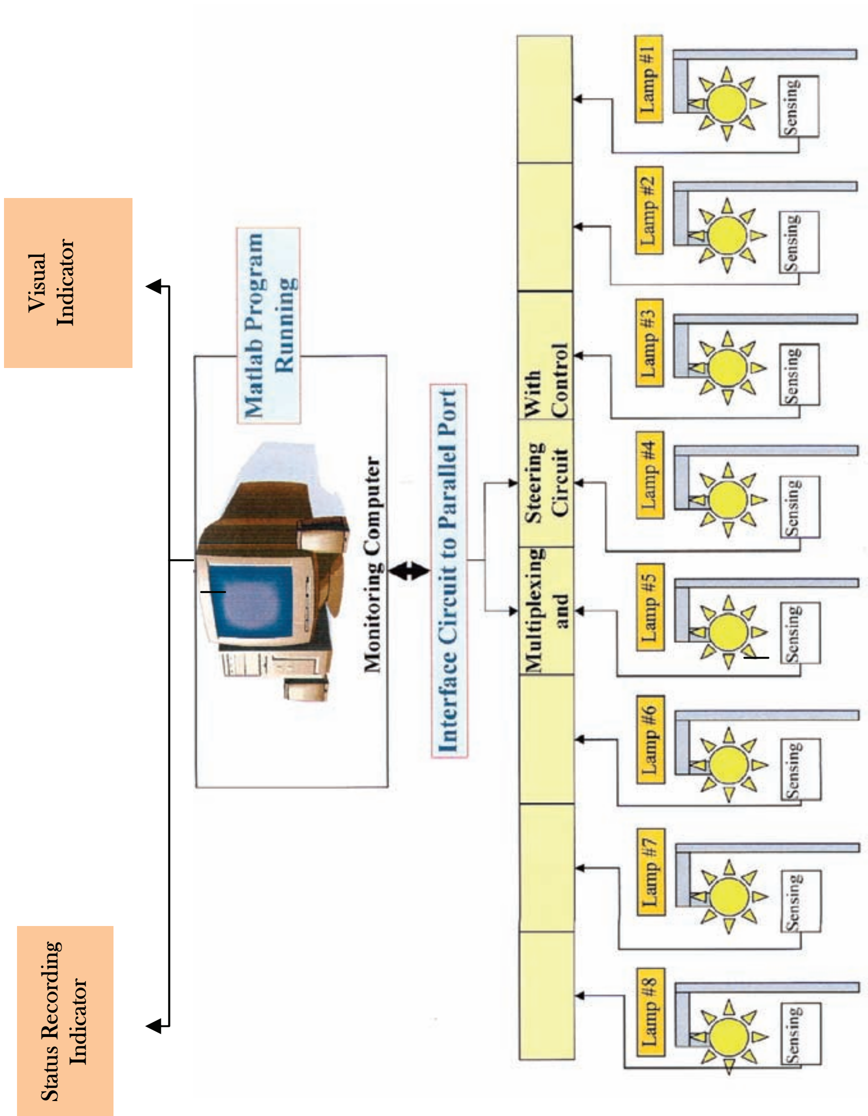

Fig. 1. A functional block diagram of the proposed system.

2.1 Voltage Regulator Circuit (VRC)

To generate the required regulated 5V DC voltage, an AC adaptor is used along with a voltage regulator. The regulated output will drive all ICs in the circuits. The regulator that is used for DC voltage regulation is the L7805CV that accepts a wide range of input voltages (5.5 and up to 30 V). It produces steady state 5 volts output. The L7805CV can provide enough power to drive all the circuits in monitoring system.

In addition, the regulator requires two 0.1 μF capacitors. One is placed at the input and one at the output. These capacitors suppress higher frequency noise to ground. The circuit diagram of the voltage regulation circuit is shown in Fig. 2.

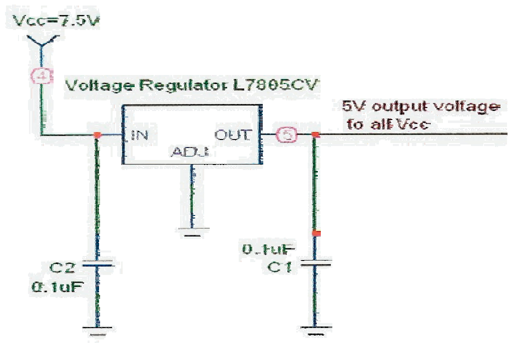

Fig. 2. Voltage regulation circuit.

2.2 Light Sensing Circuit

Operation of light system can be detected without breaking the AC lines. This can be achieved by using a photocell or phototransistor[9-10]. Photocells are light, affordable and run off DC supplies. They offer a better alternative to be used in this project.

A photocell is a type of resistor. When light strikes the cell, it allows current to flow more freely. When it darks, its resistance increases dramatically to become virtually open circuit. The circuit diagram for the photo sensing circuit is shown in Fig. 3.

2.3 Level Shifting Circuit

The voltage level produced by the photo sensing circuit varies depending on photocell sensitivity, light intensity, and supply voltage.

The output high voltage from the photo detection circuit never reaches 5V when light is exposed on the photocell. In addition the output level never reaches 0V when light is not exposed down on the photocell. Therefore it is necessary to design a level shifting circuit to make sure that the signal levels that represent the lamp status match with the TTL logic levels required by the computer input.

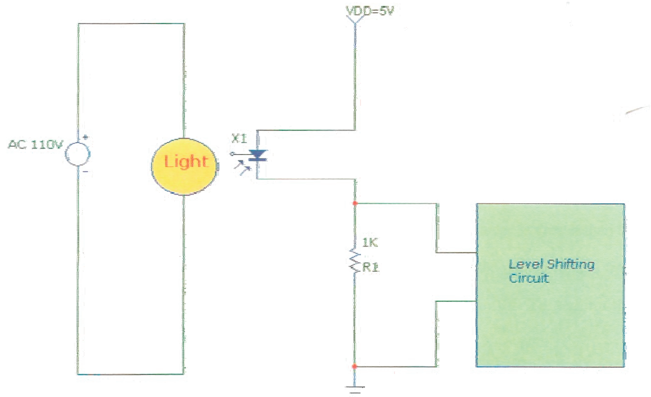

Fig. 3. Photo sensing circuit.

2.3.1 Level Comparator

Level outputs from the photo detection circuit can be measured. The midpoint between the lights OFF output voltage level and lights ON output voltage level is determined. A circuit (voltage divider circuit) can be used to generate the midpoint voltage level. This midpoint voltage can be used as a reference voltage. When the output from the photocell is greater than the midpoint value (reference voltage), the new output is set to 5V. When the output voltage from the photocell is less than the reference voltage, the output is set to 0V. The circuit diagram of level shifting circuit is shown in Fig. 4.

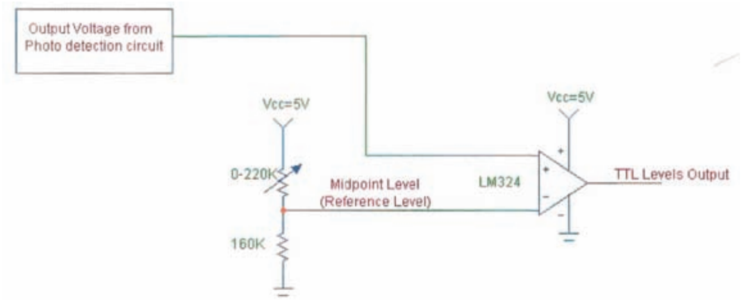

Fig. 4. Level shifting circuit using comparators.

2.3.2 Transistor Switching

In general transistors are used in one of two modes. The first mode involves amplification of small AC signals. The second mode involves switching the transistor ON and OFF. The second mode can be used to produce the required TTL levels at the output.

The output from the photo detection circuit is fed directly to the base of a transistor. When light is ON, the photo detection circuit output was found to be around 2.4V. This voltage is sufficient to drive the transistor into the saturation region, where the voltage VCE drops to below 0.2V (virtually 0V). When the light is OFF, the output from the photo detection circuit is 0. This drives the transistor into the OFF region. This causes the voltage VCE to be the same level as (5V). The Level shifting circuit using transistor is shown in Fig. 5.

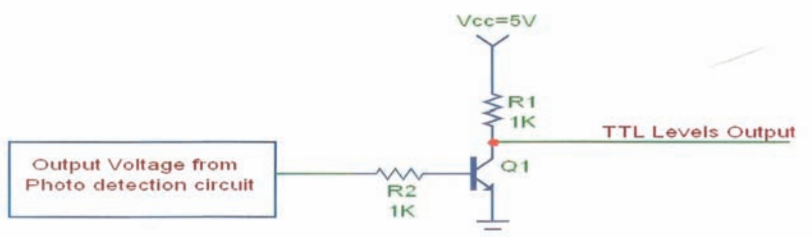

Fig. 5. Level shifting circuit using transistor switching.

2.4 Lights ON/OFF Switching Circuit

Normally street lights are supplied with AC power (110 or 220) volts. In this model by using AC powered, lights are better resemble the real life situation. These lights will be controlled by our system ON or OFF depending on the daytime or nighttime hours. To control the lights ON and OFF operation, we need to use a relay. This relay should be capable of delivering the required current to all light system when lights are to be turned ON.

The relay used in this project is the DS2Y. Its connection points are rated for 110V and can pass up to lamps. This is a little less than required. Thus two relays are used in parallel as shown in Fig. 6. These relays are switched ON by supplying them with 5V. This causes all the lamps to turn ON. When the data pins are set to produce 0V both relays are set open and thus lights are turned OFF.

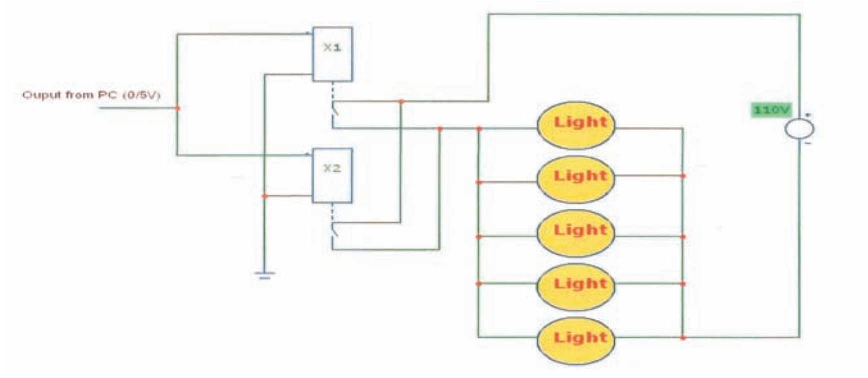

Fig. 6. Lights ON-OFF switching control circuit.

2.5 Testing Circuit Power Control

Lights are not expected to change (fail and be replaced) at a very fast rate. Rather when a light fails it might take up to a couple of days before it is actually replaced. Therefore continuous fast rate testing is not needed for this application. In order to save energy, the voltage regulator will be turned off during the time that there is no testing is done. The regulator will be turned on only during the test time [11].

Turning the regulator on and off is done by disconnecting its input power via using a relay. This relay is controlled (ON or OFF) using one of the computer parallel port output lines. In this manner no power is consumed by the voltage regulator or the rest of the monitoring system when no testing is being done. This saves energy and extends the life of the monitoring system. The controlling circuit is shown in Fig. 7.

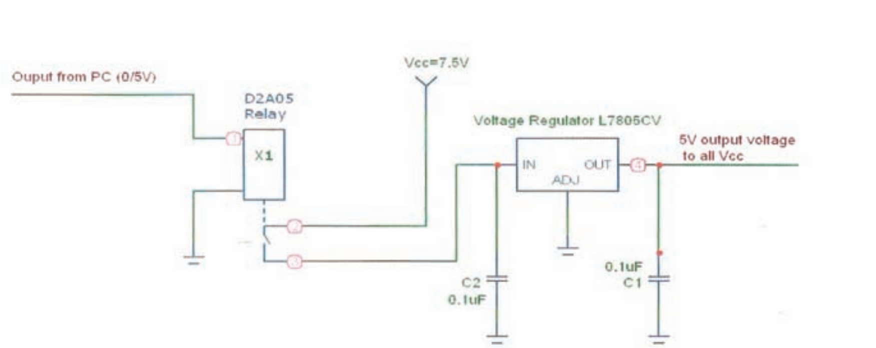

Fig. 7. Controlling circuit.

2.6 Power Consumption Reduction

While operating, the monitoring system consumes a certain amount of power (P). If operated continuously it will consume an amount of energy equal to P.t. Testing time in general takes less than one second. Thus, if the testing is performed once every 5 min, the percentage of energy that will be saved is over 99.67%. The more we increase the time period between consecutive tests the more energy the system will save.

The overall circuit design is shown in Fig. 8.

3. Software Design

The control program is developed using Matlab programming language [12-13].

According to the steps outlined below, a flowchart for the designed program is shown in Fig. 9. The following steps show the organization of the program:

Step 1: Initialize all variables

Step 2: Read reference time

Step 3: Calculate time difference

Step 4: Check stop button signal

Step 5: If stop button pressed (stop program running)

Step 6: If time difference is greater than specified time period between tests (run steps 7 through 9)

Step 7: Perform test

Step 8: Update lights status on display

Step 9: Write failures in Log file

Step l0: Otherwise Loop back to 3

Step l1: Stop

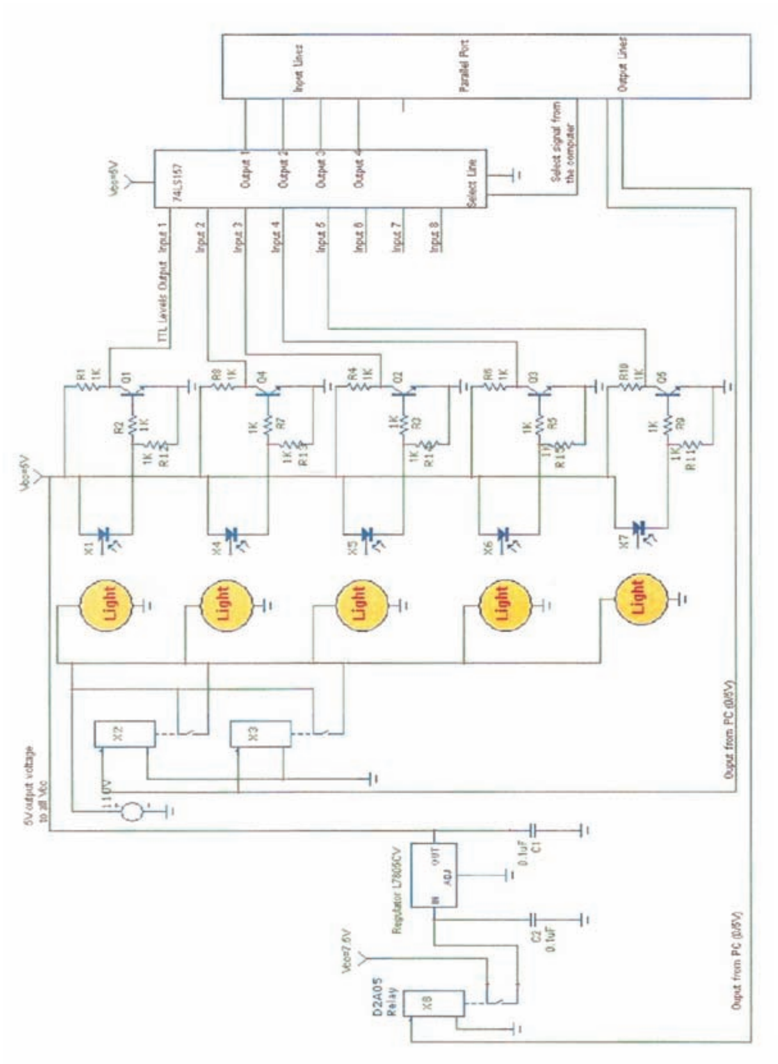

Fig. 8. The overall designed model.

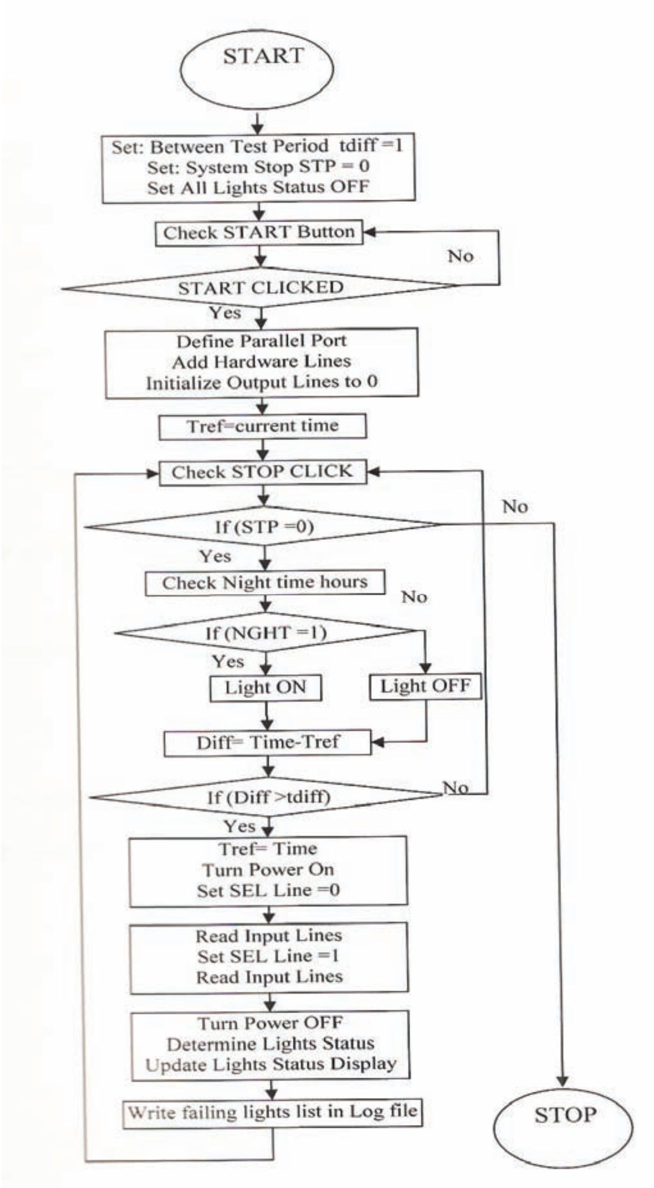

Fig. 9. Street lights monitoring system Flowchart.

The software is coded using Matlab package and utilizing different building functions from the Matlab package.

The interface program has a START and STOP buttons to start running the program and to stop running the program. It also has a field to specify the time period between tests. It allows the user to define the time period between the tests to make the refresh rate faster or slower. The upper side of the window contains the street lights status indicators. In the program, we also have a check box that if selected forces the lights to be ON all the time to serve cases like dark tunnels. The interface window is displayed in Fig. 10.

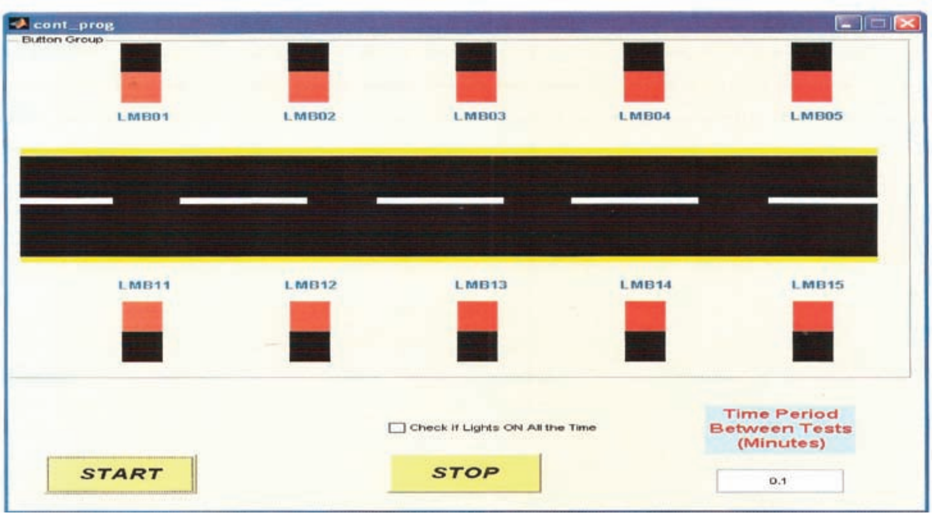

Fig. 10. Visual program for Street lights monitoring system interface.

4.2 Test and Results

A hardware model is built as shown in Fig. 10. The model is fully functional and undergoes numerous testing conditions [13].

Figures 11-12 show different testing for the system, Fig. 11 shows the two lights are on while the rest is off. on lights indicated by green light where off lights are indicated by red lights. During testing as shown in Fig. 12, Lights number 1, 3, 11, and 12 are on while lights number 4, 5, 13, 14 and 15 are off.

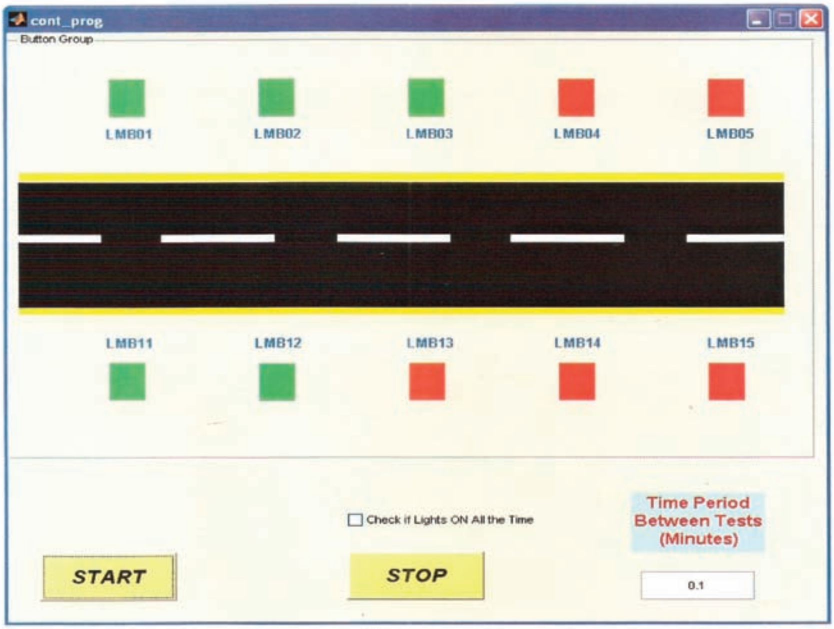

Fig. 11. Testing: Green light indicating operating lamps in the model.

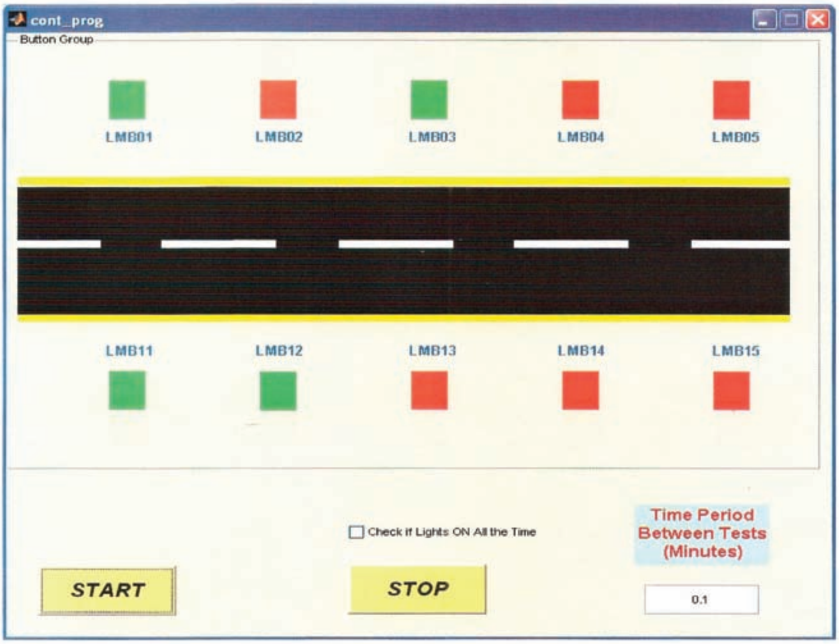

Fig. 12. Light 02 failing with correct status indication.

5. Conclusions

In this paper an automated monitoring and operation light systems has been designed. The monitoring system design includes hardware and software systems. The monitoring system is designed to detect the failure of each light within a street or zone area. It indicates the location of the failing lights and resets the display once the light is fixed and maintained. The system is designed to continuously monitor lights during operation hours. In addition power consumption is minimized. A laboratory size model has been implemented to verify the design method. The proposed model can be implemented to operate for certain ones and zeros and control light system.

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تصميم نظام للتشغيل والمراقبة الآلية لنظم إضاءة الشوارع

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جدة – المملكة العربية السعودية

المستخلص. إدارة إضاءة الطرق عن طريق شركات الكهرباء والسلطات المحلية عادة ما يواجه صعوبة نتيجة للتكاليف الباهظة للتشغيل، والكفاءة المتدنية، وتزايد شكوى المواطنين. والشكوى كثيرًا ما تتكرر نتيجة لعدم وجود متابعة وفقدان الإضاءة. وهناك جهود كبيرة تبذل لتخفيض تكلفة التشغيل وزيادة الكفاءة وتحسين صورة الخدمة.

إن نظام المراقبة صمم لمعرفة الأعطال في كل مصباح في نفس الشارع. ويحدد موقع الأعطال للمصابيح، ومن ثم يعمل على الإصلاح والتشغيل مرة ثانية. لقد صمم النظام ليراقب باستمرار إضاءة الشارع خلال ساعات العمل.

لقد تم تصميم نموذج معملي لدراسة إمكانية تطبيق النظام المقترح للتشغيل ولمراقبة إضاءة مصابيح الشوارع.