Microcontroller-based High-way Tunnel Electrical Controlling System

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ABSTRACT

High-way tunnels play an important role in our life. It's used to solve a lot of problems such as reducing the crowds in the traffic and shortening the way from place to another. High-way tunnels have many forms like long tunnels, short tunnels and mountain tunnels. In Yemen, there are several high-way tunnels. These high-way tunnels have many problems such as repeated electricity cut off and collected water from the tunnels which result to stop vehicles to enter this tunnel. This paper suggests and implements a solution using Arduino Microcontroller to control all the electrical equipment of a high-way tunnel to overcome all previous problems.

1. INTRODUCTION

The idea of using microcontroller to control the electrical parts of tunnels is not new. With the rapid development in microcontrollers, it makes the controlling of tunnels more simple. The related studies suggest and use different types of microcontroller. In such a system which uses Programmable Logic Controller (PLC) microcontroller to control all the electrical equipment of the tunnels[1]. In other projects, there are a control unit to control the tunnel equipment and control traffic in the tunnel [2]. Some projects are limited to control the lights of the tunnel using detectors and analyze the data by computer unit [3][4]. In other projects, drainage water has special paths underground using different method which is using Hidrogeologic controls [5][6]. In this paper, we suggest an electronic system to controller all electrical equipment of the high-way tunnel. The suggested controller system is based on Arduino microcontroller because this type of microcontroller is not expensive. The system has been designed, implemented and tested.

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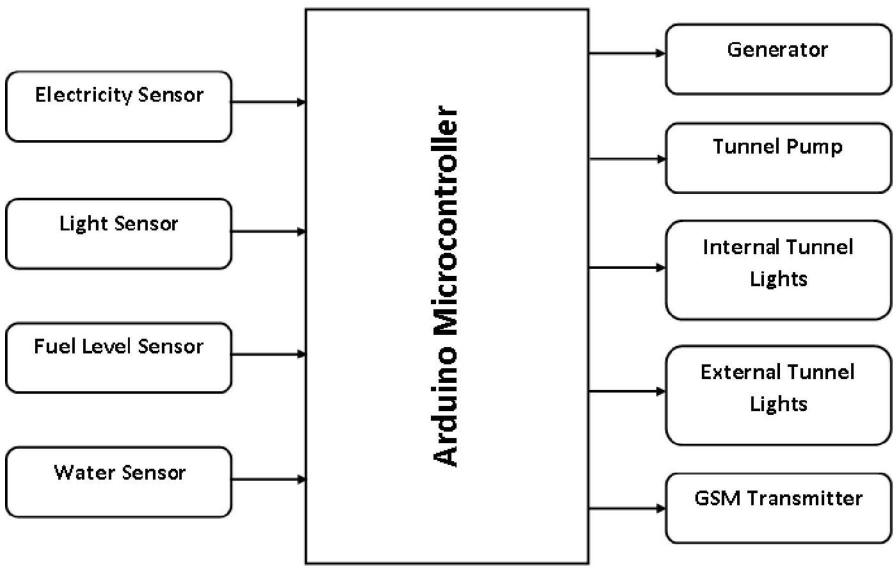
The electrical equipment which may exist in the tunnel are generator, pumps and lighting devices. When the public grid is off, the generator immediately turns on to feed all the other equipment of the tunnel by electricity. There is a tank under the tunnel to save the water which is collected from the tunnel when it rains. If the tank is filled by water, the pumps of the tunnel start ejecting the water outside the tunnel. The generator fuel level considered as an important parameter. If the fuel level of the generator under 50% of the overall fuel tank level, the system starts to reduce the consumption of the electricity by turning off some of the tunnel lights (internal and external lights) and sends a message to the supervisor of the tunnel to confirm him to fill the generator by fuel. This paper is structured as follows. In Section 2, the hardware implementations are discussed. In Section 3, the system software development is described. Finally, Section 4 draws some conclusions of this paper.

2. Hardware implementations

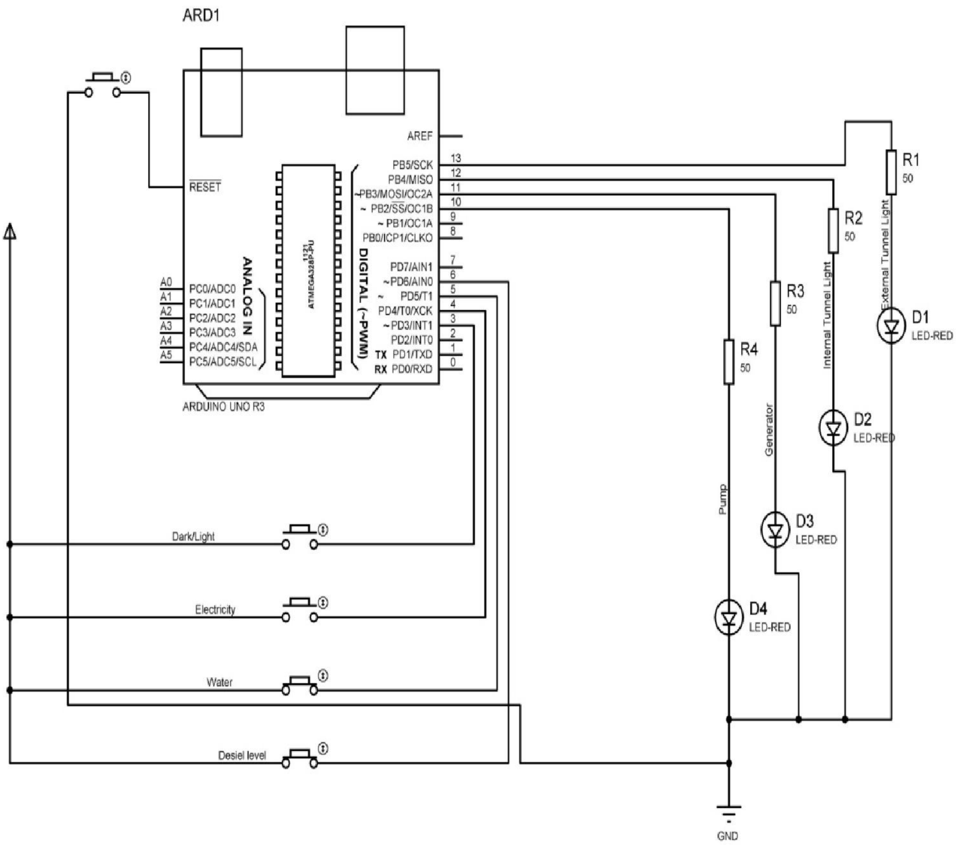
Figure[1] shows the block diagram of the suggested controlling system. The system has four inputs and five outputs. It should be noted that the inputs of the system are connected with digital sensors with two-level of values (zero/ one) because the digital sensors are more accurate than the analog one. All the components of the block diagram will be discussed separately as follows.



Figure(1): Block diagram of the system

2.1Arduino microcontroller and GSM shield

The used type of Arduino is AT mega Arduino microcontroller with 5V and frequency 1.3MHz. This chip gets its power from battery (9V) and has 13 digital pins for connecting digital inputs and outputs. In this system, Pins (3-6) are connected to the inputs of the system. Pin 3 is connected to light sensor, pin 4 is connected to electricity sensor, Pin 5 is connected to water sensor and pin 6 is connected to the fuel level sensor. The outputs are connected to pins (10-13). Pump sensor is connected to pin 10 and generator sensor is connected to pin 11. Pin 12 and 13 are connected to internal and external lights sensors respectively. GSM shield is used to inform the tunnel supervisor about the fuel level by SMS message. When the fuel level goes under 50% of the total fuel tank, it sends an SMS message directly to the supervisor to inform him that it is necessary to refill the generator by fuel. This operation is necessary to avoid generator stopping. Figure[2] shows the simulation of the circuit using Proteus program.



Figure(2): Simulation of the system using Proteus Program

2.2 Generator state

The generator starts to work when the electricity is cut off to feed all the electrical equipment of the tunnel by the electricity to ensure that the tunnel works properly. This operation is done when the electricity sensor returns zero. When the fuel level of the generator tank goes under 50% of the overall fuel tank level, the fuel level sensor returns zero.

2.3 Internal and External Tunnel Lights

The high-way Tunnel has its internal and external lights to provide the tunnel with enough illumination. The external lights should be turned off, in the daylight, to reduce electricity consumption especially when the generator is working. At night, the system turns all internal and external lights on.

2.4 Pumping state

Each tunnel has its pumps to ensure that the tunnel stay empty from water and any vehicle can pass from the tunnel without any obstacle. There is a sensor for this case that senses the water level. If the sensor returns one that means the system must start operating the pumps to eject the water outside the tunnel.

3. Software development

In this section the software requirements for this system are explained in details.

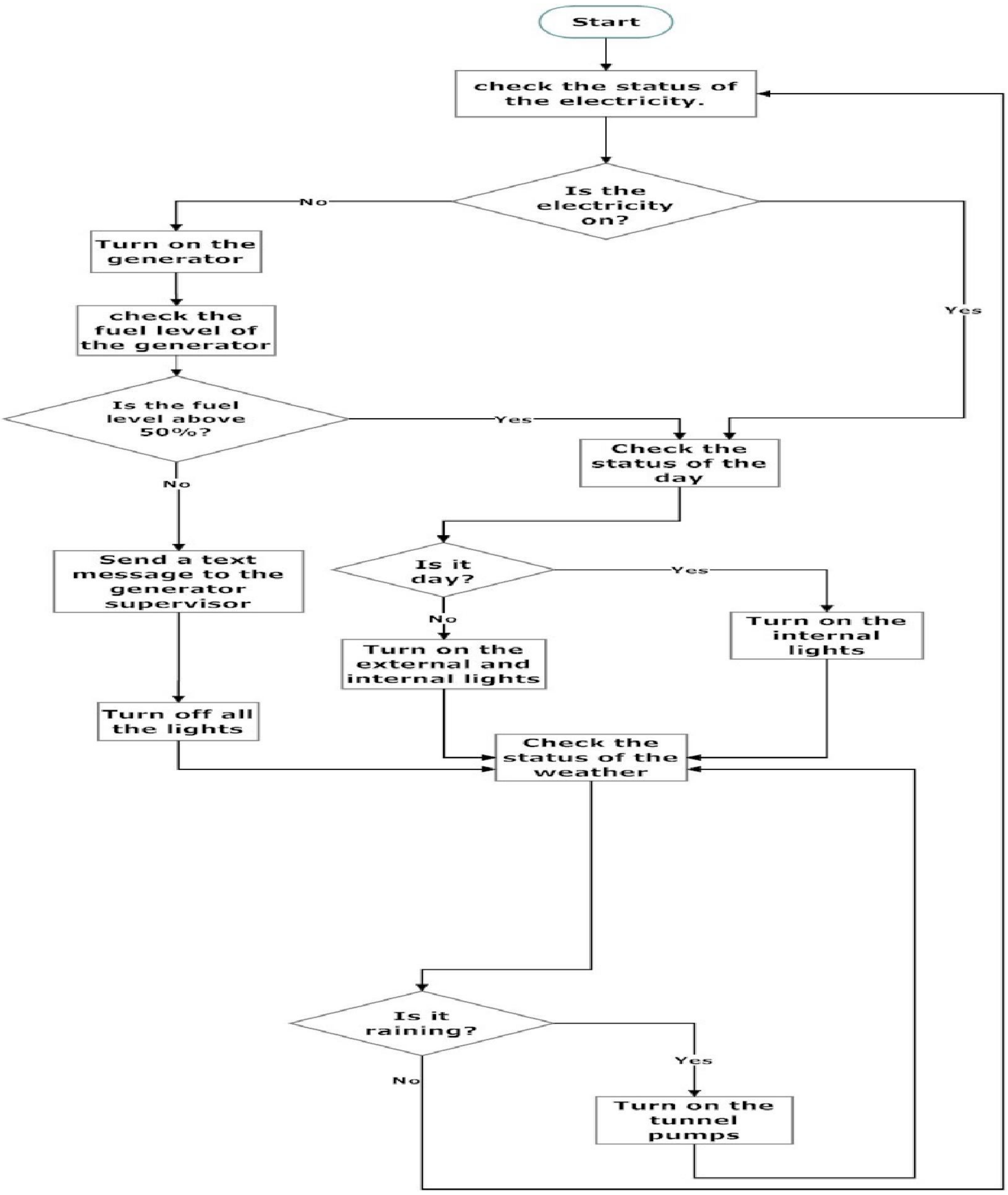
3.1 Truth table and flow chart

All the proposed system's components have been set to optimum states to balance between them and to let the electrical equipment of the tunnel work properly without any obstacles. Table[1] shows all possible states of the electrical equipment.

Table(1): Truth table of the system

Inputs					Outputs		
Day state	Electricity state	Water state	Fuel level (>=50%)	Pumps (on/off)	Generator (on/off)	Internal Tunnel	External Tunnel
0	0	0	0	0	1	1	0
0	0	0	1	0	1	1	1
0	0	1	0	1	1	1	0
0	0	1	1	1	1	1	1
0	1	0	0	0	0	1	1
0	1	0	1	0	0	1	1
0	1	1	0	1	0	1	1
0	1	1	1	1	0	1	1
1	0	0	0	0	0	0	0
1	0	0	1	0	0	1	0
1	0	1	0	1	0	0	0
1	0	1	1	1	0	1	0
1	1	0	0	0	0	1	0
1	1	0	1	0	0	1	0
1	1	1	0	1	0	1	0
1	1	1	1	1	0	1	0

As shown in figure 3, the flow chart of the software program explains the way how the system works. System starts to check the state of the electricity. After checking the electricity state, the system has two options depending on the state of the electricity: First, the system can use the generator when the public grid is off. The generator starts to work, and the system



Figure(3): Flow chart of the system

immediately checks the generator fuel level. If the fuel level under 50% of the total fuel level, the system sends an SMS message to the tunnel supervisor to inform him that he must refill the tank by fuel to avoid generator stopping. After sending an SMS message, the system turns all the lights off to decrease fuel consumption. If the fuel level is above 50% of the total fuel level, the system goes directly to check the day time. At the daylight, the system turns on internal lights. At night, the system turns on the internal and external lights. When the system finishes checking the day time, the system goes to measure the weather state. If the weather is raining, the system turns on the pumps of the tunnel to ensure that all the rainfalls are not collected in the tunnel. The system repeats this operation till the weather changes its state. Second option, the system uses the public gird. The system goes directly to check the day state and doing the rest of operation that illustrated previously.

3.2 System code

The main function of the interpreted codes of the truth table and flow chart as follows:

```
val1 = digitalRead (dark);  \\ read from light sensor connected to pin No. 3
val2 = digitalRead (elec);   \\ read from electricity sensor connected to pin No. 4
val3 = digitalRead (wtr);     \\ read from water sensor connected to pin No. 5
val4 = digitalRead (liq);      \\ read from fuel level sensor connected to pin No. 6
```

The above code reads the state of the sensors. Depending on the output sensors states (0/1) , the output of the Arduino is going to be as follows:

```
digitalWrite(pmp,LOW);  \\ turning off the pumps
digitalWrite(gen,HIGH);   \\ turning on the generator
digitalWrite(tun,HIGH);    \\ turning on the internal lights
digitalWrite(brg,LOW);    \\ turning off the external lights
```

The output states change depending on the sensors' states. This code is an example for one state and the other states can be gotten from the truth table and they are similar to the previous code.

4. Conclusion

The proposed system in this paper solves a big problem that faced by thousands of people in Yemen. This system is easy to get, easy to fabricate and has a low cost to build. This project is a contribution to serve Yemeni community and can be generalized to other countries. Collected water in the tunnel and repeated electricity cut off has been solved by this project. In the future there are two things can be included in this project. One of them is adding a motion sensor to detect the motion of the vehicles especially at the mid night to decrease the consumption of the electricity. The other thing is to add a solar board to supply the Arduino with power.

5. References

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