# Project Report On

# Automatic Illumination of Tunnel


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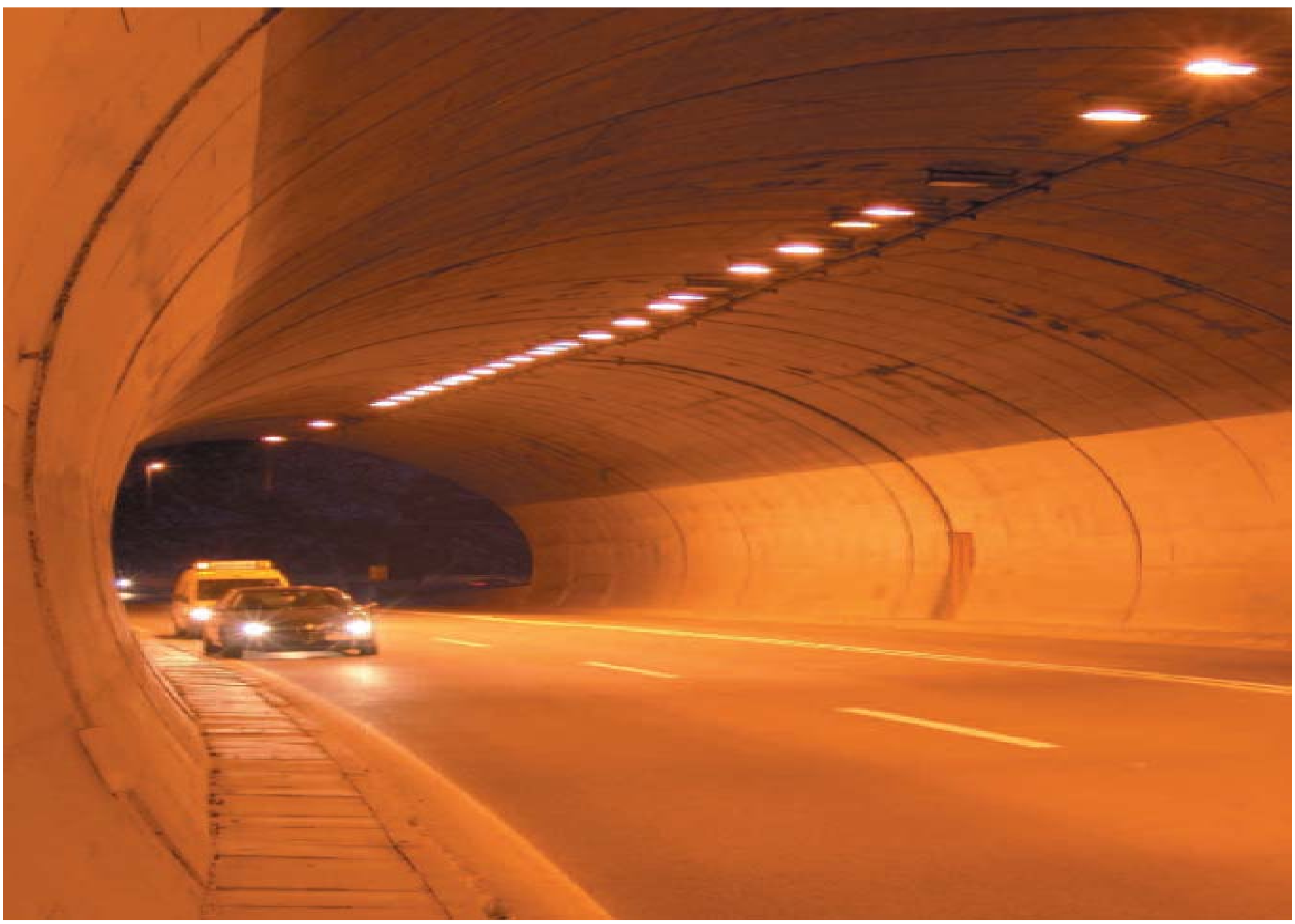

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## On

# Automatic Illumination of Tunnel

## At

**UVPCE, KHERVA**

GANPAT UNIVERSITY

**Submitted by**

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**May-2008**

**Internal Guide: Prof. J.P.Patel**

**DEPARTMENT OF MECHATRONICS**

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**GANPAT UNIVERSITY**

**KHERVA**

**May-2008**

# CERTIFICATE

This is to certify that the dissertation entitled

**AUTOMATIC ILLUMINATION OF TUNNEL**

Submitted by:

**Parekh Sulay K.**
**Patel Lav M. and**
**Patel Shaswat B.**

towards the partial fulfillment of the requirement for the award of the degree of Bachelor of Technology in the field of **Mechatronics Engineering** of Ganpat University is a record of a work submitted has in my opinion reached a level required for being accepted for examination.

The results embodied in this dissertation to best of my knowledge have not been submitted to any other university or institution for the award of the any degree or diploma.

**GUIDE**:

**EXTERNAL GUIDE:**

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# ABSTRACT

We have designed an electronic circuit for the automatic illumination of tunnel. Our main objective for the circuit is to reduce the idle time power consumption of lights in tunnel. According to the traffic density and light intensity outside the tunnel we have prepared a model which dims or turn the lights of during the idle time of the tunnel for saving the power consumption. In this project our main focus is on the power saving and illumination optimization.

# Introduction

## 1.1 Tunnel Basics

A tunnel is a horizontal passageway located underground. There are many different ways to excavate a tunnel, including manual labor, explosives, rapid heating and cooling, tunneling machinery or a combination of these methods. Some structures may require excavation similar to tunnel excavation, but are not actually tunnels. Shafts, for example, are often hand-dug or dug with boring equipment. But unlike tunnels, shafts are vertical and shorter.

The diagram below shows the relationship between these underground structures in a typical mountain tunnel. The opening of the tunnel is a portal. The "roof" of the tunnel, or the top half of the tube, is the crown. The bottom half is the invert. The basic geometry of the tunnel is a continuous arch. Because tunnels must withstand tremendous pressure from all sides, the arch is an ideal shape. In the case of a tunnel, the arch simply goes all the way around.

Fig 1.1: Tunnel

## 1.2 Tunnel lighting

As our road networks become more crowded, the use of tunnels and underpasses is expanding, to improve traffic flow, and also to protect local environments from increased traffic exposure. Within tunnels, where maintenance access can be limited, and where corrosive atmospheric conditions are common, reliable performance of the lighting system is critical, as is the need for absolute minimum maintenance operational requirements.

## 1.3 Objectives of tunnel lighting

The aims of tunnel lighting are:

- Firstly, to allow traffic to enter, pass through and exit the enclosed Section safely.
- Secondly, to do so without impeding the through-flow of traffic.

These aims are achieved by the adequate illumination of the tunnel interior, which allows drivers to quickly adjust to the light within, identify possible obstacles, and negotiate their passage without reducing speed. These requirements apply during the day when the contrast between outside and inside is significant and at night when it is less, but reversed.

## 1.4 Visual adjustment

The visual adjustment from high luminance to low luminance while driving is not instantaneous. This is because of two disability phenomena:

1**. Temporal adaptation:** Human eyes need more time to adapt from brightness to darkness than the reverse. During this period of adaptation, the distance travelled is a critical factor.

Fig 1.4.1: Temporal Adaptation

**2. Spatial adaptation:** the large difference in luminance between the outside and the inside of the tunnel will impede the vision of the driver when he is at the adaptation point (‘A’, opposite). The “Black Hole” phenomenon engenders a feeling of discomfort and insecurity.

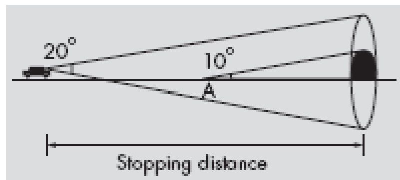



Fig 1.4.2: Spatial adaptation

## 1.5 Types of Tunnel Lighting

Tunnel Road Lighting must provide safety and comfort and maximize the visual performance of the users.

**Symmetrical and asymmetrical lighting**
Used generally for transition and interior zones for long tunnels, and in short tunnels, or low speed tunnels for all zones.

Asymmetrical lighting can also be a means of reinforcing the luminance level in one way tunnels.

**Asymmetric counter beam lighting**
To reinforce the luminance level and at the same time accentuate the negative contrast of potential obstacles. Counter beam lighting is achieved with asymmetrical light distribution facing into the traffic flow, both in the direction of the on coming driver and in the run of the road. The beam stops sharply at the vertical plane passing through the luminaire. No light is directed with the flow of traffic. This generates negative contrast and enhances visual adaptation.

**Other factors**
As well as the above, further factors must be taken into consideration when preparing tunnel lighting. These include the shape of the portal, type and density of traffic, traffic signage, contribution of wall luminance, orientation of tunnel, and many others. National, European and International legislation and guidance sets out minimum standards for tunnel lighting.

**Day time lighting of tunnels for different lengths**
(CIE-Guide for the lighting of tunnels and underpasses)

When lighting a tunnel, its length, geometry and immediate environment must be taken into account as well as traffic densities. Differing light levels are set for each project, according to the governing standards summarised below:

| Length of tunnel | 125m | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Is exit fully visible when viewed from stopping distance in front of tunnel? | - | yes | yes | no | no | no | yes | yes | no | no | no | no | - |
| Is daylight penetration good or poor? | - | - | - | good | good | poor | - | - | good | good | good | poor | |
| Is wall reflectance high (>0.4) or low (<0.2)? | - | - | - | high | low | - | - | - | high | high | low | - | - |
| Is traffic heavy (or does it include cyclists or pedestrians) or light? | - | light | heavy | light | - | - | light | heavy | light | heavy | - | - | - |
| **Lighting required** | ● | ● | ◐ | ● | ◐ | ◐ | ◐ | ○ | ◐ | ○ | ○ | ○ | ○ |

● No day time lighting ◐ 50% of normal threshold zone lighting level ○ normal threshold zone lighting level

Table 1.5: Lighting for different lengths of tunnels

# 2 Typical Tunnel Lighting Arrangements

The table below outlines some of the mounting options available and their respective advantages/disadvantages

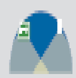
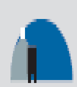
| | Mounting constraint | Arrangement type | Advantages | Disadvantages | Tunnel profile |
|---|---|---|---|---|---|
| **Ceiling mounting** | Enough spacing above legal and protection minimum height | Above road on several rows  | - best utilisation factor for luminaires<br>- glare limited | - luminaires concealed by signs <br>- heavy fixings | - Arched type with or without fan tubes<br>- Framed type with or without fan tubes |
| | | 1 row above road  | - less investment and maintenance | - closure of carriageway required | |
| **Wall mounting** | Not enough spacing above legal and protection minimum height | Twin opposite  | - easier access to luminaires<br>- 1 lane only need be closed | - utilisation factor downgraded<br>- high glare | - Arched type with fan tubes<br>- Framed type with or without fan tubes |
| | | Single sided  | - less investment and maintenance | - beware trucks blocking light  | |

Table 2.1: Advantages/ Disadvantages of Light mounting options

Here is the lighting arrangement shown in figure below.

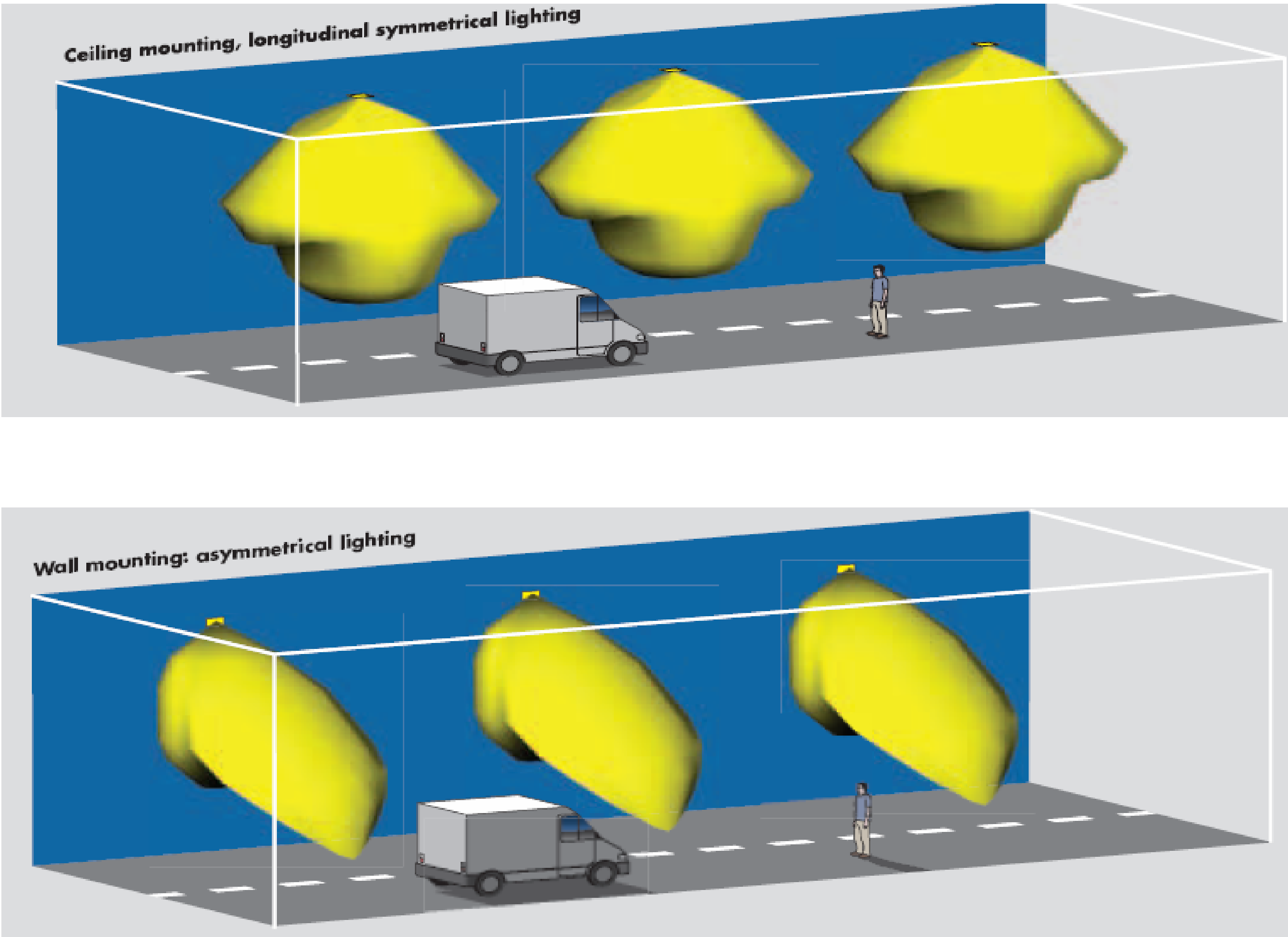



Fig 2.1(a) & (b): Mounting Arrangements

## 3. Controlling Tunnel lighting

For the critical approach areas and interiors of tunnels, close control of light levels is essential. Levels of light outside the tunnel, time of day, speed and density of traffic, all influence and lighting requirements within.

Lighting a tunnel is a complex and specialized task. We have developed dedicated lighting systems from concept to implementation, management and servicing. While luminance levels are used for accurate theoretical assessment, in practice, luminance is more often used.

Tunnel lighting generally has a control system which is adapted to tunnel applications like:

- Basic to highly technologically advanced innovative system.
- Fluorescent and HID lamp solutions.
- Easy to install and operate system.
- Cost efficient system.
- Optimization of safety conditions.

Generally, the tunnel has the switch on/ off system which doesn't have any control for the power consumption whilst the lighting is not required.

We have designed two ways for the above mentioned problem which are:

- PLC controlled Lighting System
- PLC controlled lighting system integrated power consumption control circuit.

The methods listed are both used for control lighting system where the former is for generally used in the tunnels presently while the latter is the circuit designed by us by integrating our power saving circuit with the PLC controlled lighting system.

• Ease of installation as integrated in operates systems control gear.
• Suitable for threshold and central zones
• Cost efficient systems
• Optimization of safety conditions

## 3.1Power line controls for HID lamps

• Automated but re-programmable controls
• Detailed feedback on supply, status logs

### 3.1.1 Benefits

• Individual control and monitoring
• Possible remote access option via central server
• Capacity to interface the system with database
• Low installation and operation costs
• Reduced maintenance schedules

### 3.2.1PLC controlled lighting system:

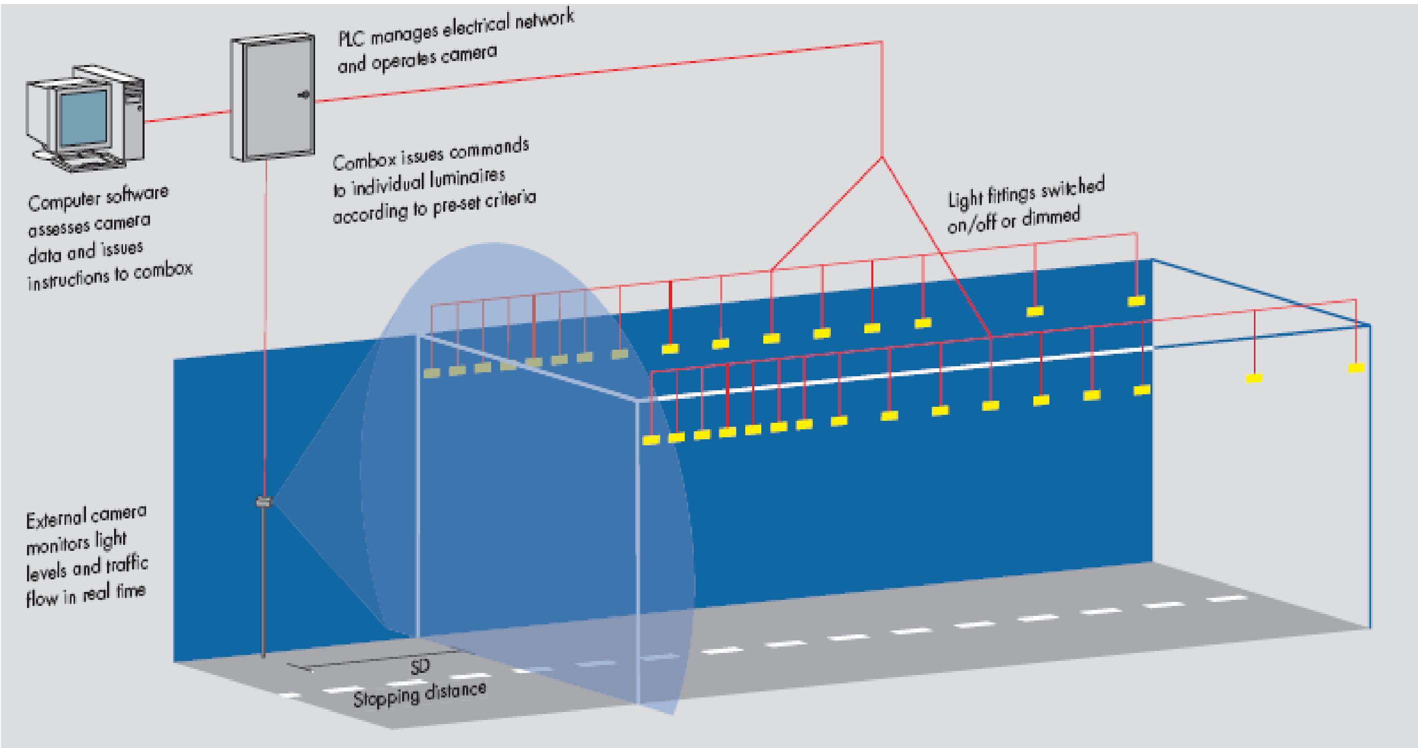



Fig 3.1: PLC controlled lighting system

Here, as shown in figure we can see the lighting arrangement in the tunnel are connected to the PLC system which in return is interfaced with the computer server. This arrangement, dims or on/off the lights according to the intensity of lights outside the tunnel or the density of vehicles inside the tunnel.

The working principle of the PLC controlled lighting system is:

A camera is fixed at entrance and exit of a tunnel if the tunnel is short or along with the entry and exit at regular interval of some distance if the tunnel is long. This camera acts as the light detecting sensor which is connected with the PLC as an input device. The lights, too, are attached to with PLC as the output device which can be controlled by the PLC. The computer has the software where all the details are been fed which is interfaced with the PLC as it's programming unit as well as it's operating system.

Once the light intensity is sensed by the camera, the signal is given back to the PLC which according to the computer program controls the light of the tunnel. If the light intensity is low the lighting is turned to full bright and if the light intensity is high the light inside tunnel is turned dim which is enough to illuminate the path inside the tunnel.

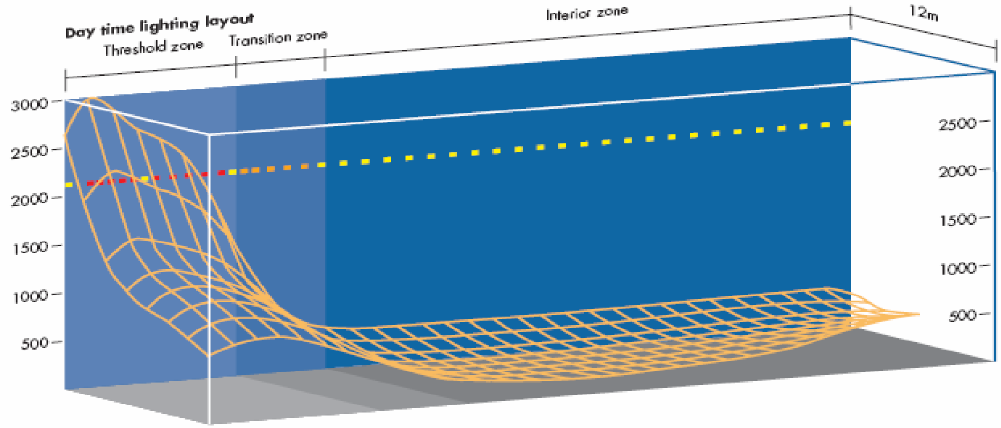
# Case study 1
# Chiptchak Mosquee Tunnel, Turkmenistan

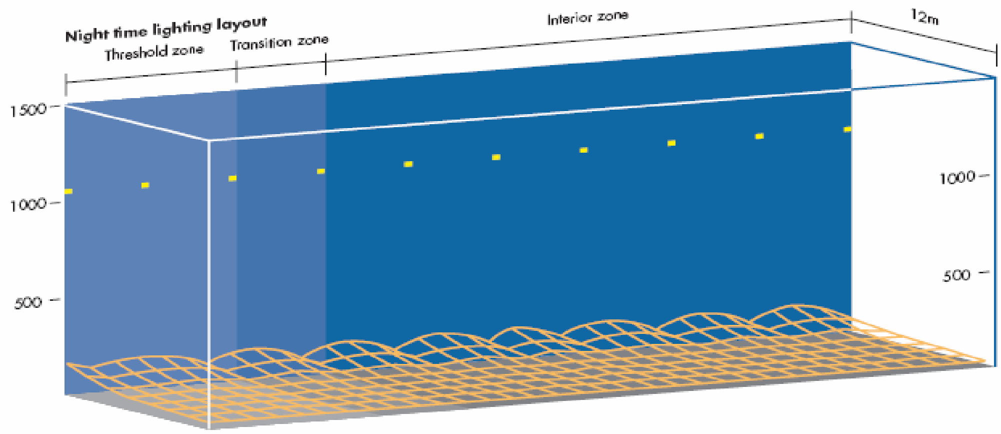
**Tunnel type**
Urban underpass
2 way traffic
One tube

**Technical data**
Length: 74m
Width: 24m
Speed limit 80km/h

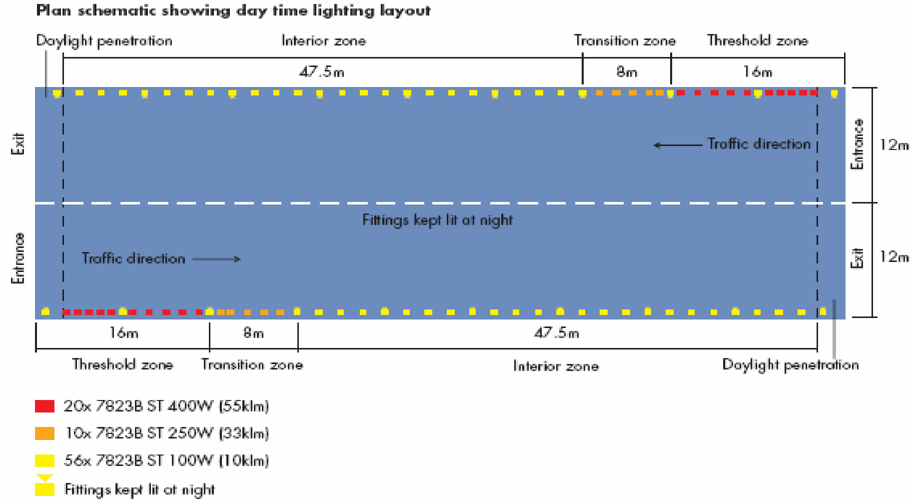
**Lighting system**
Aluminium asymmetric Gothard
Wall mounted, tilted 15º

20x 7823B ST 400W (55klm)
10x 7823B ST 250W (33klm)
56x 7823B ST 100W (10klm)



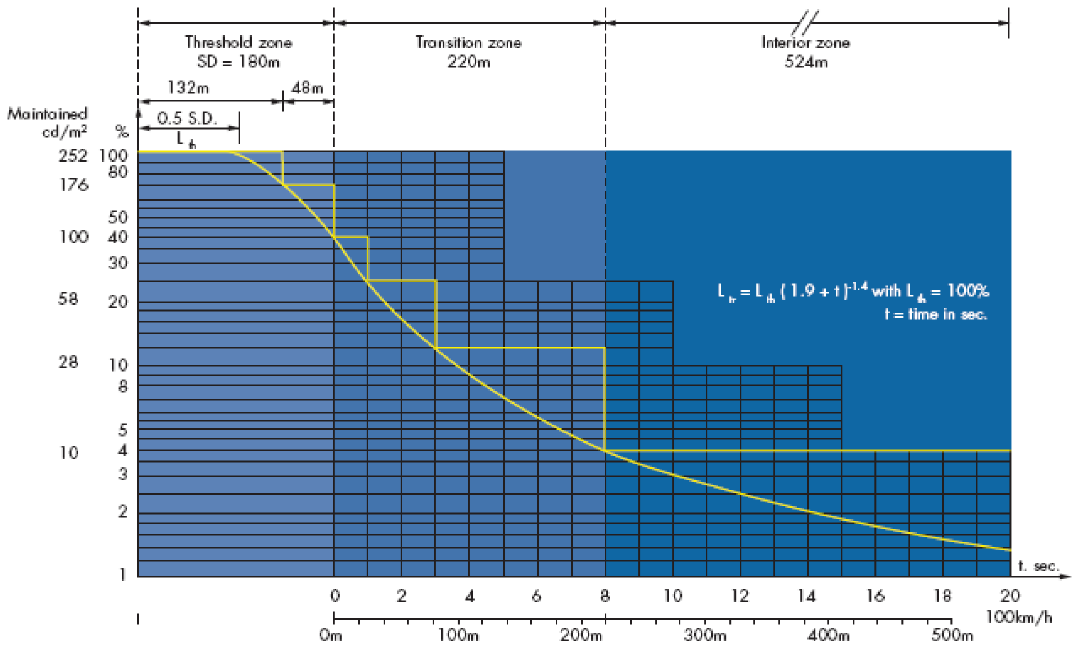

**Plan schematic showing day time lighting layout**



# Case study 2
# Katerini Tunnel, Greece

The national motorway, when completed, will run across Greece from Patras to Evzoni, via Athens and Thessaloniki. Three tunnels requiring a full tunnel lighting system are constructed in the Katerini area.

**Tunnel description**
Long motorway tunnel.
2 tubes - 3 lanes carriageway.




**Technical data**
Length: Right tube - 1100m
Left tube - 1100m

Speed limit: 100 km/h

Traffic flow: medium less than 1,000 vehicles per hour.

Stopping distance (SD):
180m on wet road.

Determination of $L_{th}$:
Right tube entrance:
$L_{20}$ = 3.500cd/m²
Left tube entrance:
$L_{20}$ = 5.000cd/m²

Lighting system: counterbeam and symmetric
Type of fitting: counterbeam and symmetric fittings

$k = L_{th}/L_{20} = 0.072$ for counter beam lighting system and for SD = 180m

Maintenance factor: 0.70

**Right tube details**
*Threshold zone*
$L_{th}$ to be maintained: $L_{20}$ x k = 252cd/m²
Length = 180m = SD
Threshold zone 1: 132m $L_{th}$ = 252cd/m² maintained
Threshold zone 2: 48m $L_{th}$ = 176 cd/m² maintained

*Transition zone*
The end of the transition zone is reached when the luminance is 3 times the interior luminance level

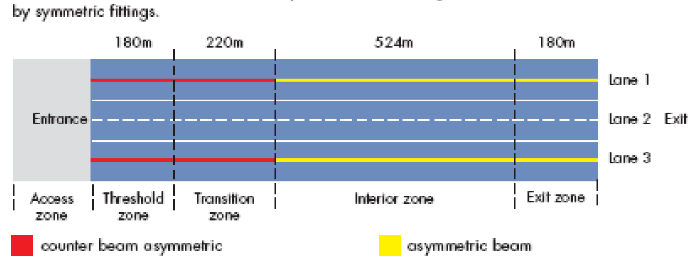
As the traffic flow is medium, the maintained level in the interior zone shall be 10cd/m² or 4% of the threshold zone level.
Length = 220m = given by CIE curve
Transition zone 1:
30m $L_{tr}$ = 100cd/m² maintained
Transition zone 2:
55m $L_{th}$ = 58cd/m² maintained
Transition zone 3:
135m $L_{th}$ = 28cd/m² maintained

*Interior zone*
Length = 524m
$L_{in}$ = 10cd/m² maintained

*Exit zone*
Luminance of the exit zone is equal to 5 times the interior zone luminance
Length = 180m
$L_{ex}$ = 50cd/m² maintained

**Lighting fitting arrangement**

**Day time**
Threshold and transition zones are lit by counter beam fittings. Interior and exit zones are lit by symmetric fittings.

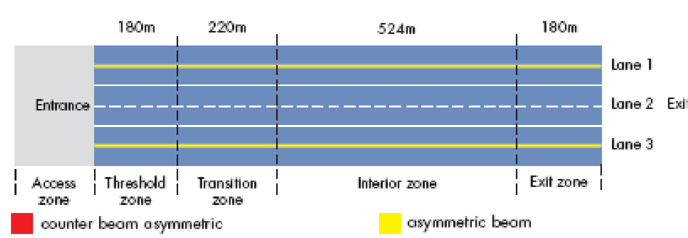



**Day time**

| Zones | Length (m) | No of fittings per tube | Counter beam 400W | Counter beam 250W | Symmetric 150W | Symmetric 250W |
|---|---|---|---|---|---|---|
| Threshold 1 | 180 | 276 | 276 | | | |
| Transition | 220 | 104 | 40 | 64 | | |
| Interior right | 524 | 256 | | | 196* | 60 |
| Exit | 180 | 86 | | | 30* | 56 |

*common to day time and night time

**Night time**
All zones are lit by symmetric fittings.



| Night time | | | | | | |
|---|---|---|---|---|---|---|
| Zones | Length (m) | No of fittings per tube | Counter beam | | Symmetric | |
| | | | 400W | 250W | 150W | 250W |
| Threshold 1 | 180 | 32 | | | 32 | |
| Transition | 220 | 36 | | | 36 | |
| Interior right | 524 | 88 | | | 88 | |
| Exit | 180 | 30 | | | 30 | |

### 3.2.2 PLC Integrated with Power saving lighting system:

In this method the only difference is the integration of the power saving unit with the PLC system for the control of the lighting in the tunnel. The construction and the working of this system are just more sophisticated than the above system.

Our project is based on this system which controls the light in tunnel based on the light intensity outside as well as the traffic density and the presence of traffic in the tunnel. The main objective behind our project is that the tunnel where the traffic is meager and very less can use this system for the power saving.

This power saving circuit acts as an input component to the PLC along with the camera for measuring the light intensity.

For the preparation of the circuit we need to have a IR transmitter and IR Receiver and a counter circuit which counts the presence of the vehicles in the tunnel.

Components used for the preparation of the circuit are:

- IR Transmitter
- IR Receiver
- X-OR(74LS86)
- NOT Gate (74LS04)
- OR Gate (74LS32)
- AND Gate(74LS08)
- 8-bit Up-Down Counter (74LS469)
- 555 Timer
- Relay Coil (5V)

# 4. Description of Components

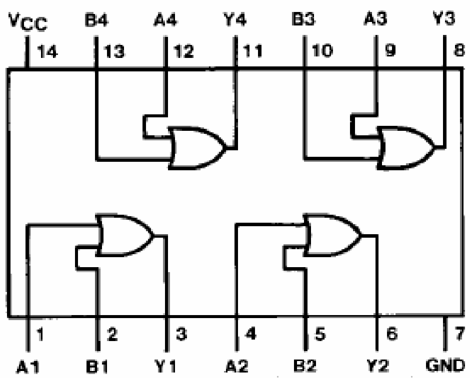
## 4.1 OR Gate

**DM74LS32**
**Quad 2-Input OR Gate**

**General Description**

This device contains four independent gates each of which performs the logic OR function.

**Connection Diagram**




**Function Table**

Y = A + B

| Inputs | | Output |
|---|---|---|
| A | B | Y |
| L | L | L |
| L | H | H |
| H | L | H |
| H | H | H |

H = HIGH Logic Level
L = LOW Logic Level

Fig & Table 4.1: Diagram and truth table of OR gate

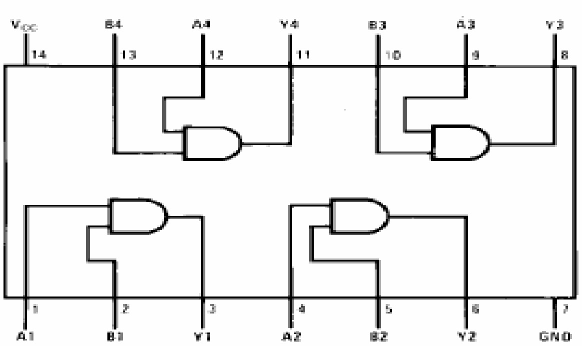
## 4.2 AND Gate

**DM74LS08**
**Quad 2-Input AND Gates**

**General Description**

This device contains four independent gates each of which performs the logic AND function.

**Connection Diagram**




**Function Table**

Y = AB

| Inputs | | Output |
|---|---|---|
| A | B | Y |
| L | L | L |
| L | H | L |
| H | L | L |
| H | H | H |

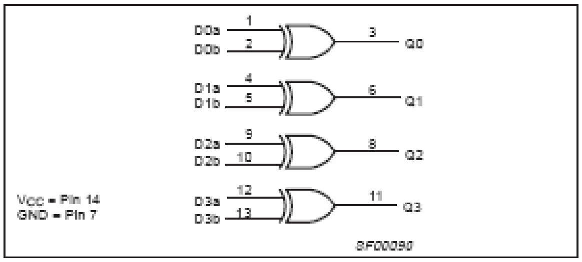
H = HIGH Logic Level
L = LOW Logic Level

Fig & Table 4.2: Diagram and truth table of AND gate

## 4.3 X-OR Gate:

**Quad 2-input Exclusive-OR gate** **74F86**

LOGIC DIAGRAM




FUNCTION TABLE

| INPUTS | | OUTPUT |
|---|---|---|
| Dna | Dnb | Qn |
| L | L | L |
| L | H | H |
| H | L | H |
| H | H | L |

NOTES:
H = High voltage level
L = Low voltage level

PIN CONFIGURATION

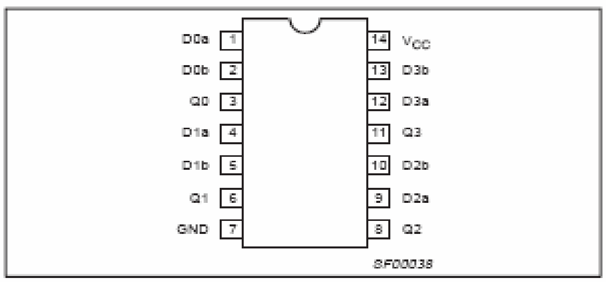
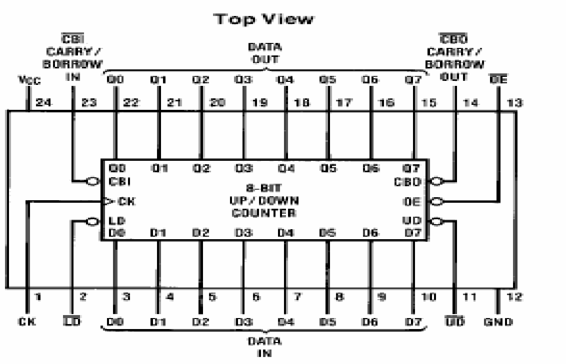



Fig & Table 4.3: Diagram and truth table of X-OR gate

## 4.4 8-bit Up/Down Counter:

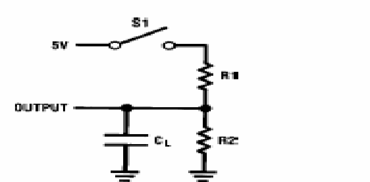
**DM54LS469/DM74LS469 8-Bit Up/Down Counter**

**Connection Diagram**




Order Number DM54LS469J,
DM74LS469J or DM74LS469N
See NS Package Number J24F or N24C

**Standard Test Load**




**Function Table**

| $\overline{OE}$ | CK | $\overline{LD}$ | $\overline{UD}$ | $\overline{CBI}$ | D7–D0 | Q7–Q0 | Operation |
|---|---|---|---|---|---|---|---|
| H | X | X | X | X | X | Z | HI-Z |
| L | ↑ | L | X | X | D | D | LOAD |
| L | ↑ | H | L | H | X | Q | HOLD |
| L | ↑ | H | L | L | X | Q plus 1 | INCREMENT |
| L | ↑ | H | H | H | X | Q | HOLD |
| L | ↑ | H | H | L | X | Q minus 1 | DECREMENT |

Fig & Table 4.4: Diagram and truth table of up/down counter

# 5. Logical Algorithm

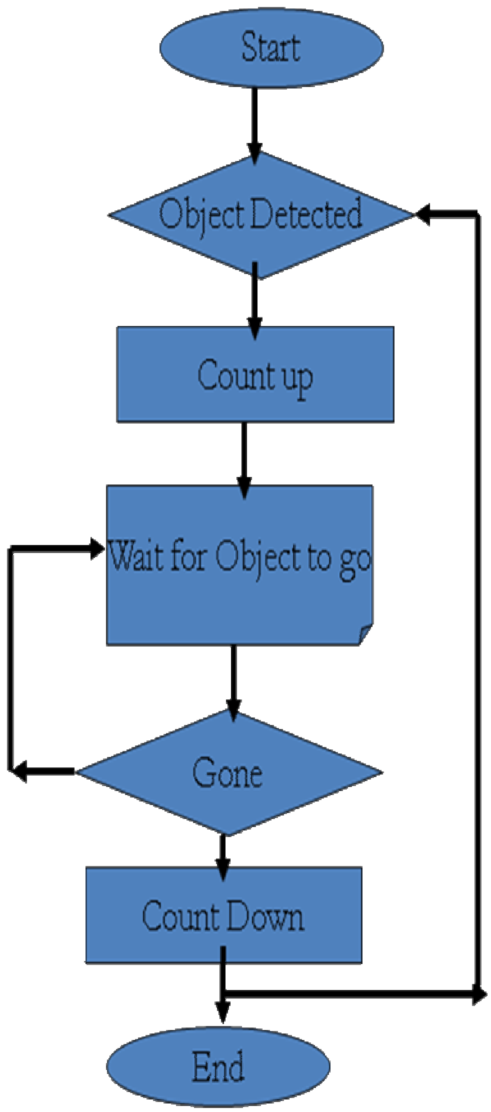



Fig 5.1: Flow chart for general logic

Here is the logical flow chart for the circuit where after the vehicle is detected the counter increases the count by 1 and the lights are switched on. The counter increases the count as the vehicles are entered. Once the vehicle exits the counter inverses and decreases the count by 1. When the counter counts to zero the lights are turned off.

The loop is constantly counts the entry and the exit of the car and turns the light on or off accordingly. As per requirement the lights can dimmed or can be turned off for the power saving.

# 6. Circuit Description

## 6.1 Counter Circuit:

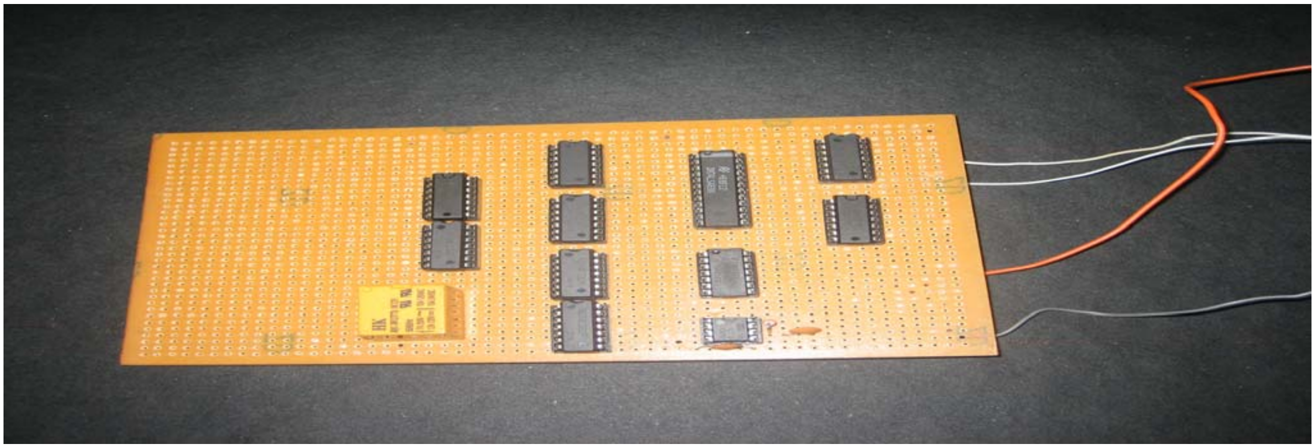


Fig 6.1: Counter Circuit

The counter circuit is shown in the figure above where 2 X-OR gates, 1 555 timer, 4 OR gates, 2 NOT gates and one 5 V Relay coil is used. The working of the circuit can be explained as when the car enters the IR receiver doesn't get the signal (i.e. Low signal) and similarly when the car exits. The X-ORed signal is given to the 8- bit counter inversed which increases the count. When the counter count>0 at that time the relay becomes NC (normally close) from NO (normally open) condition. When the Relay becomes NC the lights are turned on. Once the counter counts to count=0 the relay comes back to NO condition and the lights are turned off or dimmed.

## 6.2 IR Transmitter and IR Receiver:

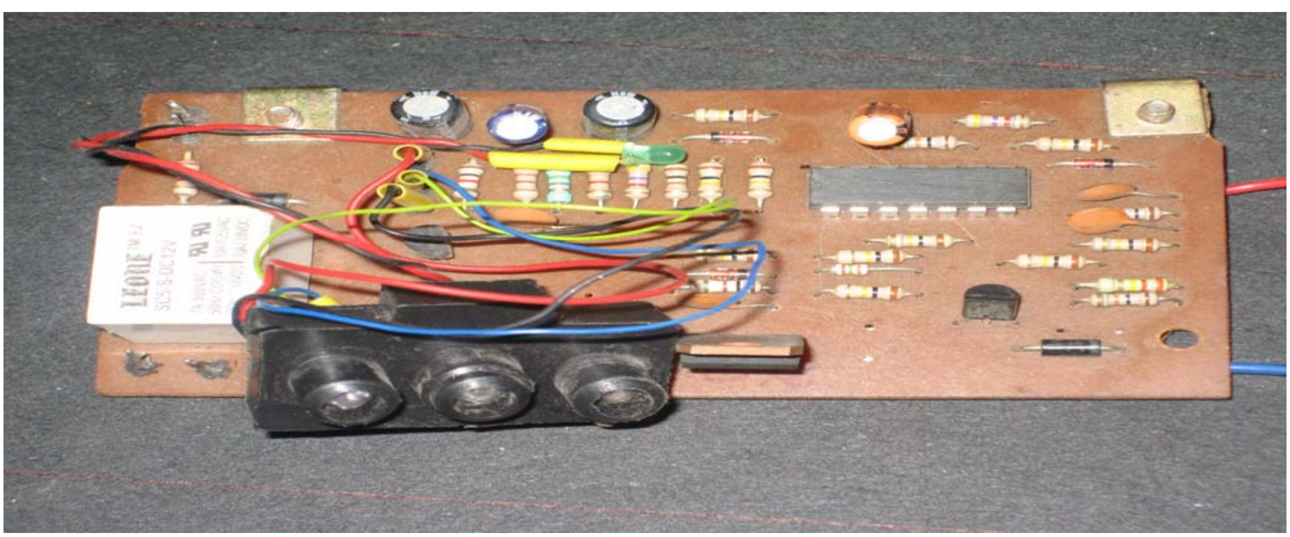


Fig 6.2.1: IR Transmitter/ IR Receiver

IR emitter and IR phototransistor. An infrared emitter is an LED made from gallium arsenide, which emits near-infrared energy at about 880nm. The infrared phototransistor acts as a transistor with the base voltage determined by the amount of light hitting the transistor. Hence it acts as a variable current source. Greater amount of IR light cause greater currents to flow through the collector-emitter leads. As shown in the diagram above, the phototransistor is wired in a similar configuration to the voltage divider. The variable current traveling through the resistor causes a voltage drop in the pull-up resistor. This voltage is measured as the output of the device.

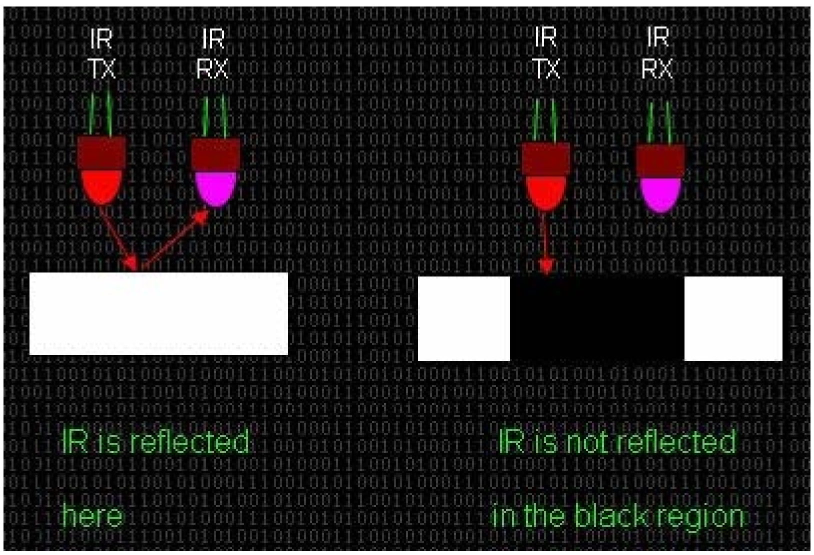



Fig 6.2.2: Working of IR transmitter/Receiver

## 6.3 General arrangement of power saving circuit:

Fig 6.3: Model of Power saving system

# 7. Power consumption

On the basis of these criteria and the previous experience of KACST, power consumption was calculated as follows:

- tunnels up to 200 metres long consume 22 watts per metre; and
- tunnels more than 200 metres long consume 35 watts per metre.

| Length (m) | Power needed (W) |
|---|---|
| 121 | 4,235 |
| 115 | 4,025 |
| 165 | 5,775 |
| 150 | 5,250 |
| 118 | 4,130 |
| 550 | 12,100 |
| 380 | 8,360 |
| 207 | 4,554 |
| **1,806** | **48,429** |

Table 7.1: Power consumption based on length of tunnel

The power calculated here are on hourly basis for the length of 2 km long tunnel which consumes approx. 50,000 watt per hour which tends to consumes (50,000*24)=1.2 MW and for a year it consumes approx. (1.2*365)=435 MW.

As per the calculated approximate value we can see the consumption of a tunnel is generally 1/8 of an annual thermal plant production of electricity per annum. It is observed that from 435MW consumption nearly 1/3 consumption is for the Idle time of the tunnel where the use for lights in tunnel is not required.

# 8. Conclusion

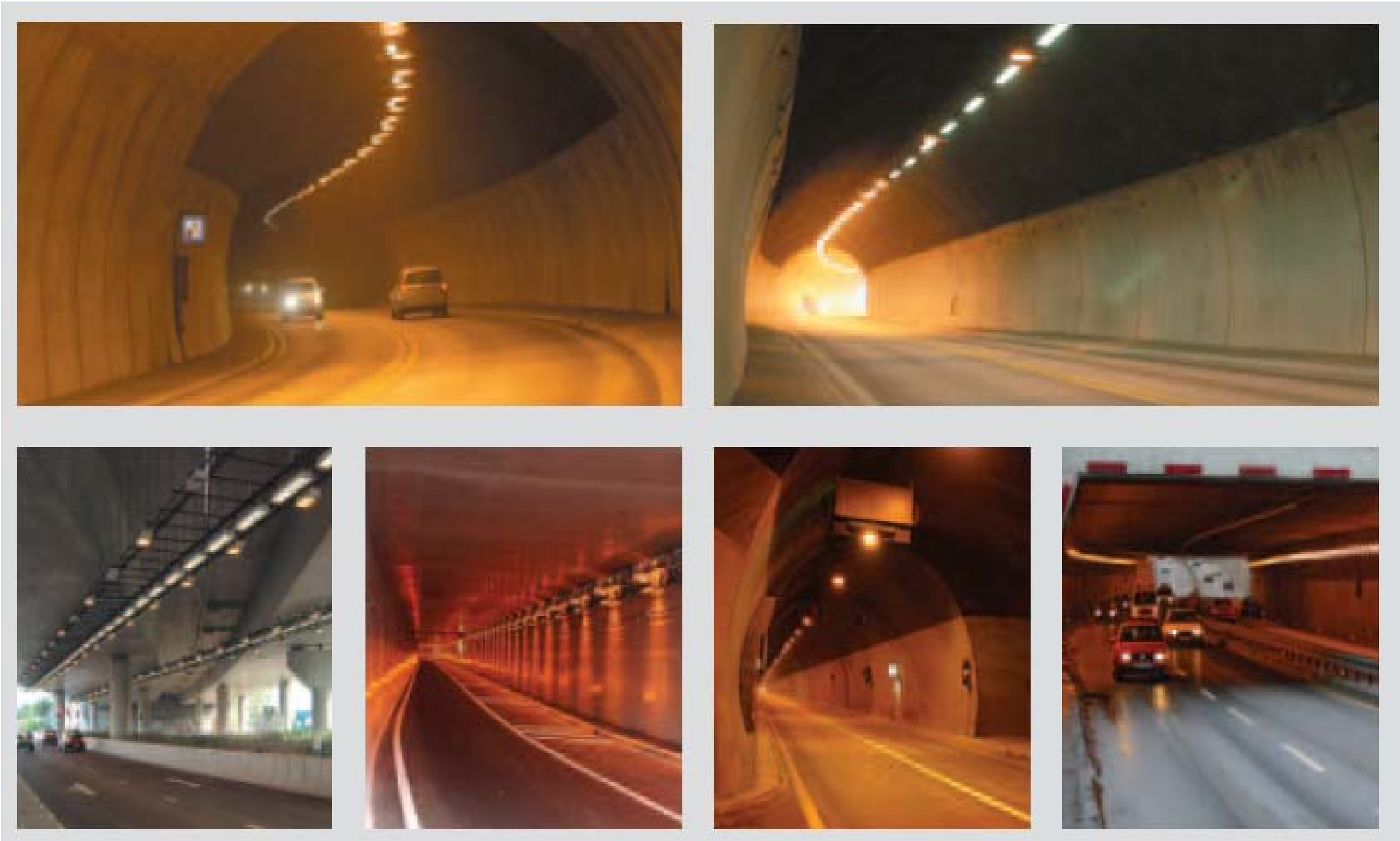


Fig 8: Applications for the circuit

## Bibliography:


- www.howstuffworks.com
- References from the “Digital Electronics” from Mano
- www.thornlighting.co.uk
- www.wikipedia.org
- Datasheet of gates from site of National Semi-Conductor