Design and Implementation of a Sensor-Based Traffic Control System

Adejumobi O.K., Sadiq M.O., Adedibu O.A., Ayeni M.O., Fakunle A.O.

Abstract— The problem of traffic congestion due to the rapid increase in the number of vehicles passing through Sango - Polytechnic Ibadan Junction has led to this design, 'Sensor-Based Traffic Light Control System'.This system is designed to coordinate the smoothness of traffic during the peak hours (between 7:00-8:30am & 3:00-5:00pm) during the working days (Mondays-Fridays). The traffic light system is designed using Programmable Integrated Circuit (PIC) F1508/9 Microcontroller as the major component, Phototransistors and Infrared LEDs as Sensors for effective traffic control. The PIC is implemented via an IC programmer using a micro-C language. The developed traffic light control system worked according to specificationsusing a prototype that resembles the real application. The System gives priority to congested traffic rather than the usual fixed-time operations. It is however recommended that the design be solar powered and more sensitive sensors such as the RFID be used to improve upon this design.In conclusion, the functionality of the prototype shows that the developed system can be used for a real life traffic control at road intersections. Besides it can be used as a teaching aid in schools and road safety agenciesfor various road users.

Index Terms— Traffic, Sensors, Vehicles, Microcontrollers, Control System.

I. INTRODUCTION

Many traffic light systems operate on a timing mechanism that changes the lights after a given time interval. The older system used weight/time as a trigger mechanism. A sensor-based traffic light system senses the presence or absence of vehicles and reacts accordingly. The idea behind this intelligent traffic system is that drivers will not need to waitunnecessarily. The traffic system reacts to motion to control light changes. Once the infrared object detector picks up the presence of a car, a switch causes the traffic lights to change. In order to accomplish this, algorithms are used to govern the actions of the traffic control system. The problem of traffic rules violation and congestion at the T-junction at the main gate of the Polytechnic, Ibadan along Sango-Eleyele road led to the design of the Sensor-Based Traffic Control System (see Figure 1). The junction consists of 3-control lighting Poles controlled by a microcontroller, infrared LED, and the Phototransistor chosen to control the trafficlights; The Phototransistorswill sense the presence of vehicles

Adejumobi, O.K., Computer Engineering Department, The Polytechnic, Ibadan, P.M.B 22, U.I, Post Office, Ibadan, Oyo State.

Sadiq, M.O., Electrical Engineering Department, The Polytechnic, Ibadan, P.M.B 22, U.I, Post Office, Ibadan, Oyo State.

Adedibu, O.A., Electrical Engineering Department, The Polytechnic, Ibadan, P.M.B 22, U.I, Post Office, Ibadan, Oyo State.

Ayeni, M.O., Electrical Engineering Department, The Polytechnic, Ibadan, P.M.B 22, U.I, Post Office, Ibadan, Oyo State.

Fakunle, A.O. Electrical Engineering Department, The Polytechnic, Ibadan, P.M.B 22, U.I, Post Office, Ibadan, Oyo State.

through the signals they receive from the infrared LEDs and send the appropriate signals to the microcontroller to take decisions.The aim of this Paper therefore is to design a Sensor-Based Traffic Controlling System that will implement a program that will monitor and control traffic thereby minimizing the waiting time of vehicles and reducing traffic congestion at the institution's main gate (see Figure 1)
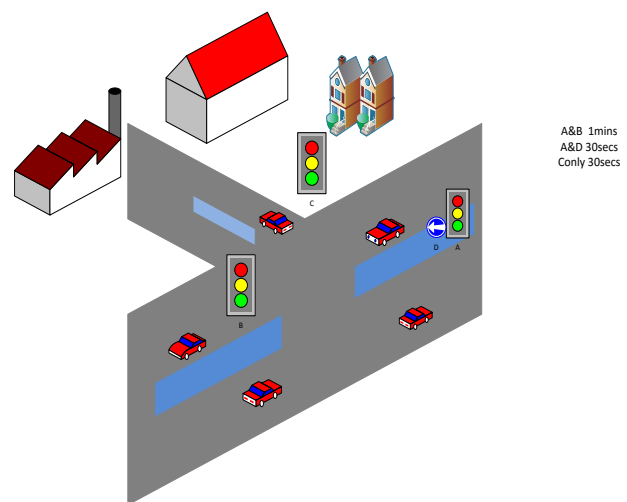

Figure 1: The Traffic Flow at the Polytechnic, IbadanMain Gate

A. Keys:

E-S Eleyele to Sango
E-P Eleyele to Polytechnic
P-E Polytechnic to Eleyele
P-S Polytechnic to Sango
S-P Sango to Polytechnic
S-E Sango to Eleyele

The first automatic experimental traffic lights in England were deployed in wolver Hampton in 1927. However, the drawback of having some vehicles stopped when there were no cars going in the other direction annoyed people[1].
Lane-control lights are specific type of trafficlight used to manage traffic on a multi-way road, highway or toll way. Typically, these lights allow or forbid traffic to use one or more of the available lanes by the use of green lights or arrows (to permit) or by red lights or crosses (to prohibit). In the US, lane-control lights are often used to control and/or direct the flow of traffic through toll plazas and highway tunnels, such as during unusually-heavy traffic flow when more lanes may be required in one direction than in the other direction, or during a hurricane evacuation, when the lane signals for all lanes will show green for one direction to assist in more rapid traffic flow from the evacuation site. Lane (Webster and Cobbe,1966) The Federal Highway Administration created "The Manual on Uniform Traffic Control Devices." This

document set uniform standards for all traffic signals and road signs [4]. Another type of traffic control system is the PC traffic Light controlled system which has a pressure plate placed at intersections. Once a car was on the plate, the computers would know that a car was waiting at the red light.Some of the detection included knowing the number of waiting cars against the red light and the length of time waited by the first vehicle at the red[6]. The Computers could detect and change the length of the green light based on the volume of the waiting cars[3].

Conventional traffic signal lighting, still common in some areas, utilizes a standard light bulb. Typically, a 67watt, 69watts or 115watt medium base (household lamp in the US) light bulb provides the illumination. Light the bounces off a mirrored glass or polished aluminum reflector bowl and out through a polycarbonate plastic or glass signal lens. In some signals these lenses were cut to include specific refracting patterns [5].

II. METHODOLOGY AND DESIGN CONSIDERATIONS

The design is divided into the Hardware and Software Procedures.

(A) Hardware Design Consideration

The hardware considerations for the implementation of this design is divided into four (4) Sections namely; the IR LED, Phototransistor, Microcontroller and the traffic Lights Poles (see Figures 2& 5).

(B) Software Design Consideration

This is divided into two (2) parts namely;the State diagram and Main Program Code.

(1) State Diagram(see Figures 3 & 4)

STATE B

If no vehicle in sensor B

Jump to state C

Else if no (vehicle in sensor A and B) & vehicle in C

Jump to state D

Else continue normal flow

STATE C

If vehicle in sensor C & no vehicle in sensor A

Jump to state D

Else If no vehicle in sensor C& vehicle in sensor B

Jump to state B

Else continue normal mode
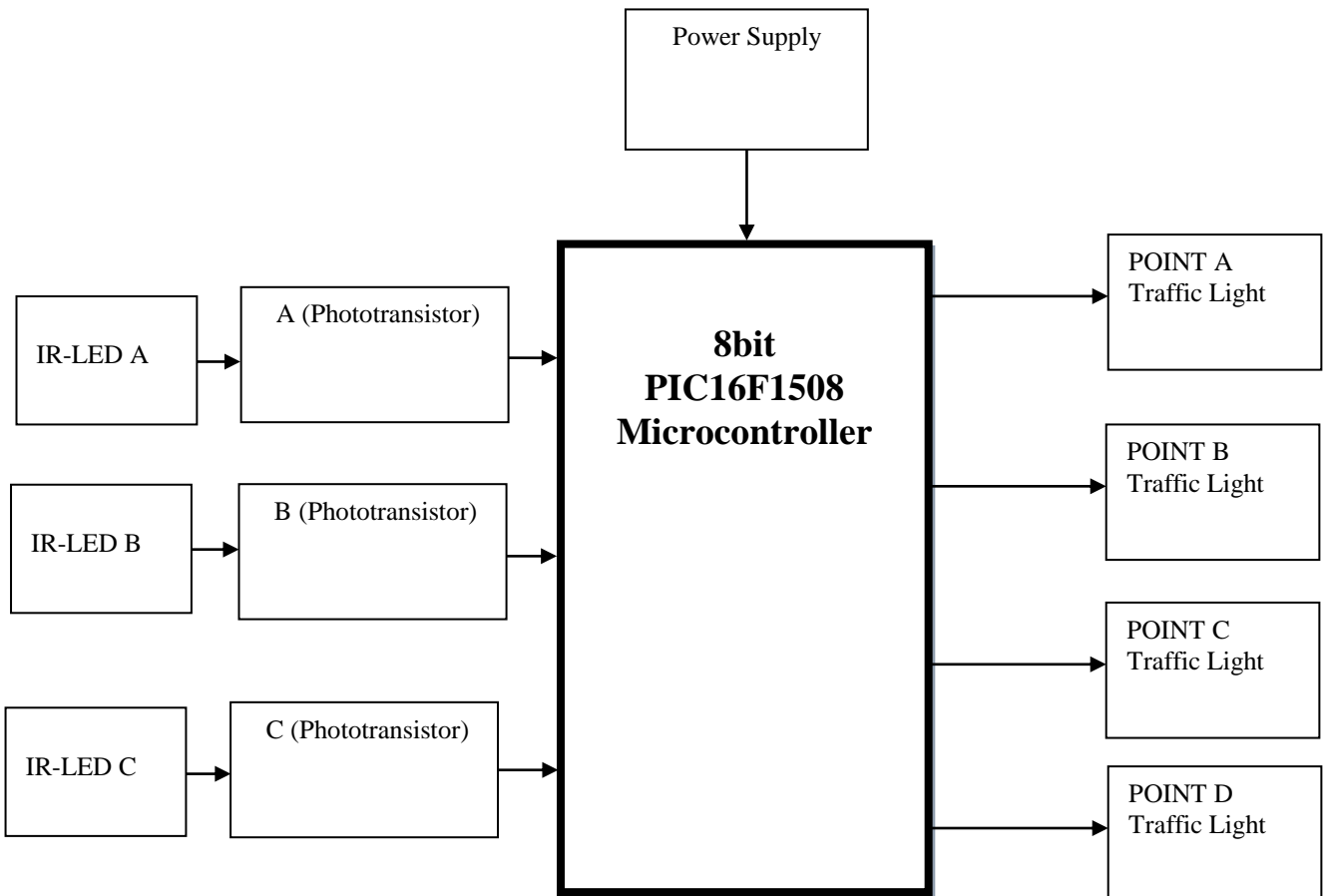
STATE D

If no vehicle in C,

Jump to state E

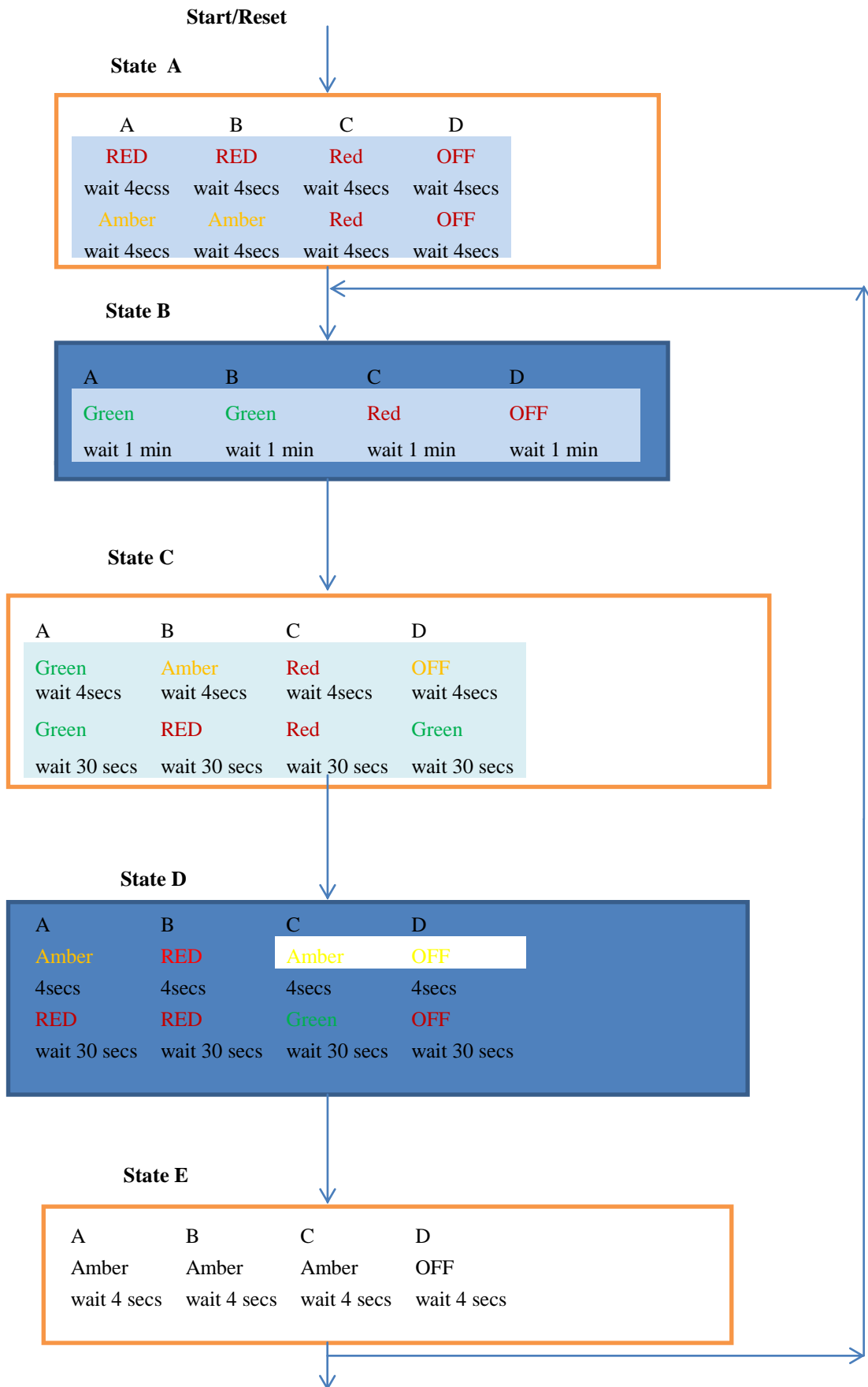**Figure 2: Block Diagram of Sensor-Based Traffic Light Controlling System**

Start/Reset

State A

A	B	C	D
RED	RED	Red	OFF
wait 4ecss	wait 4secs	wait 4secs	wait 4secs
Amber	Amber	Red	OFF
wait 4secs	wait 4secs	wait 4secs	wait 4secs

State B

A	B	C	D
Green	Green	Red	OFF
wait 1 min	wait 1 min	wait 1 min	wait 1 min

State C

A	B	C	D
Green	Amber	Red	OFF
wait 4secs	wait 4secs	wait 4secs	wait 4secs
Green	RED	Red	Green
wait 30 secs	wait 30 secs	wait 30 secs	wait 30 secs

State D

A	B	C	D
Amber	RED	Amber	OFF
4secs	4secs	4secs	4secs
RED	RED	Green	OFF
wait 30 secs	wait 30 secs	wait 30 secs	wait 30 secs

State E

A	B	C	D
Amber	Amber	Amber	OFF
wait 4 secs	wait 4 secs	wait 4 secs	wait 4 secs

Figure 3:State Diagram

STATE B

STATE C

STATE D

Figure 4: Sensor Active Mode State Diagram

III. DESIGN DETAILS

The design was done in modules so as to allow for easy modification, correction and adjustability. It was then implemented with precautions taken based on Figure 5.

Three different LEDs are placed on each of the three lanes for displaying purposes. The controller was designed in such a way that it samples all the lanes in turn to detect whether there is a vehicle on any lane and this is delayed for a time period of 1min. Once the input status is high, the PIC coordinates the action by given the lane with high input a passage immediately and indicates Red on the LED output of the two other lanes. If there is no high input on the other lane, the controller will pass the next turn on the same lane.

The System Operation

The microcontroller-based traffic light system for road intersection control was developed to direct the movement of vehicles meeting at a road junction without any collision. To achieve this, the microcontroller allocates time for each path when the vehicles along that path will move and the other vehicles from the other path will stop. When the time allocated for a specific path has been exhausted, the red light will be ON meaning stop and the next line will be ON (green light) which means the vehicle in that path should start moving. When the time is about to be exhausted, the Amber light will be ON in the third path informing the vehicles in that path to be ready to move, and after some seconds the green light will be ON.

IV. TESTING, RESULTS AND DISCUSSIONS

Results of Test Carried Out:

The result of the final system functional test carried out on the system consists of five different states as shown in Figure 4, each representing a process state.

Discussion

The following keys are used to discuss the results of the test carried out as shown in Figure 1:

A – Eleyele to Sango traffic

B – Sango to Eleyele traffic

C – Polytechnic to either Sango or Eleyele traffic

D – Eleyele to Polytechnic traffic

State A (start up):

At start up, the output of the system shows that all traffic at the junction are on Red (with the exception of traffic D which is OFF) indicating that vehicles are to stop. A 4seconds delay is applied to all lights then traffic A and B switches to Amber while traffic C and D maintain their states after which another four seconds delay is applied to all lights which takes the operation of the traffic control system to State B.

State B:

After the final delay in State A, traffic A and B switches to Green while traffic C and D still maintains their state at Red and OFF respectively. Then a one minute delay is applied to the system which then moves the operation of the traffic control system to State C.

State C:

After the final delay in State B, traffic A maintains its state at Green, traffic B switches to Amber while traffics C and D maintain their states at Red and OFF respectively.
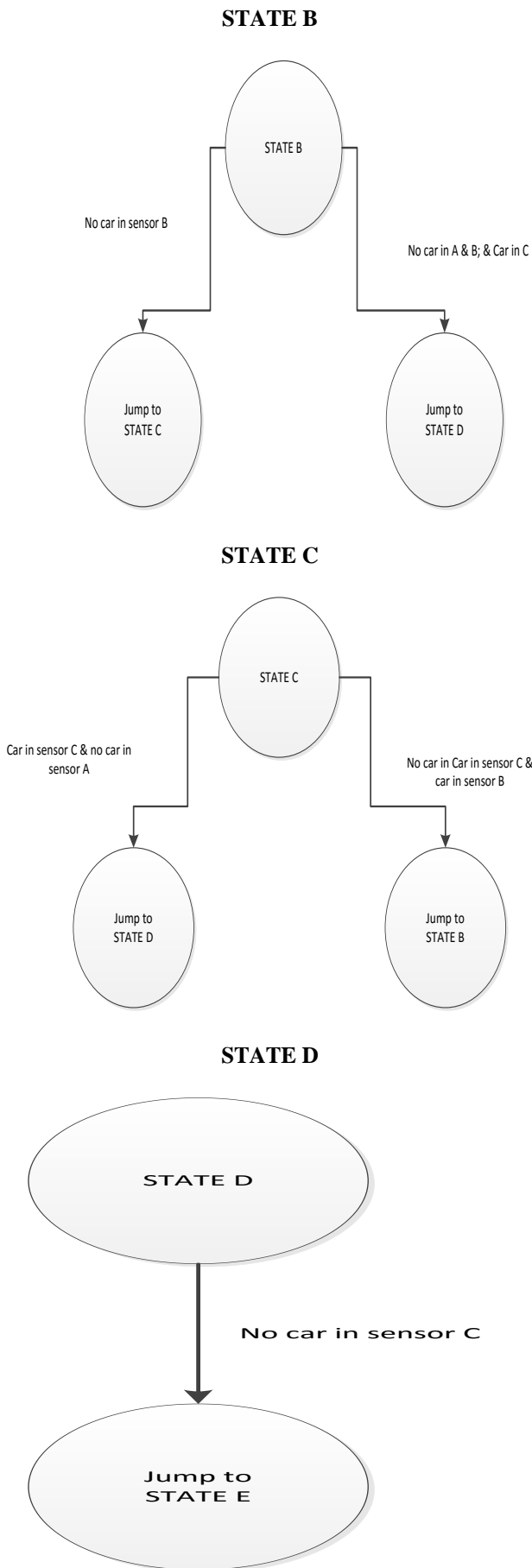
Then a four seconds delay is applied to the system, which keeps traffic A at Green, traffic B and C at Red, and traffic D at Green preceded by a thirty seconds delay which takes the operation of the traffic control system to State D.

State D:

This state precedes the final delay at state C. In this state, traffic switches to Amber, B maintains the state at Red, C switches to Amber and D at off. A four seconds delay is applied to the system which switches traffic A and B to Red, traffic C to Green and D remains OFF preceded by a thirty seconds delay which takes the operation of the traffic control system to its final state.

State E:

At state E, the traffic A,B and C are on Amber while traffic D goes OFF and a four seconds delay is applied which causes the traffic control system to return to state B and repeat the operations continuously.

V. CONCLUSION AND RECOMMENDATIONS

This Paper has successfully presented a functional but low cost Sensor-based traffic light system at the main entrance gate of the Polytechnic, Ibadan. The traffic light system is designed using PIC F1508/9 microcontroller, Power section, Phototransistor and Infrared LEDs. Then, for effective traffic control, the PIC is implemented via an IC programmer using a microC program. The developed traffic light control system worked according to specifications and can be used for a real life traffic control system at road intersection. However, the developed system could be improved upon by incorporating more sensitive sensors and Solar Panels into the system.
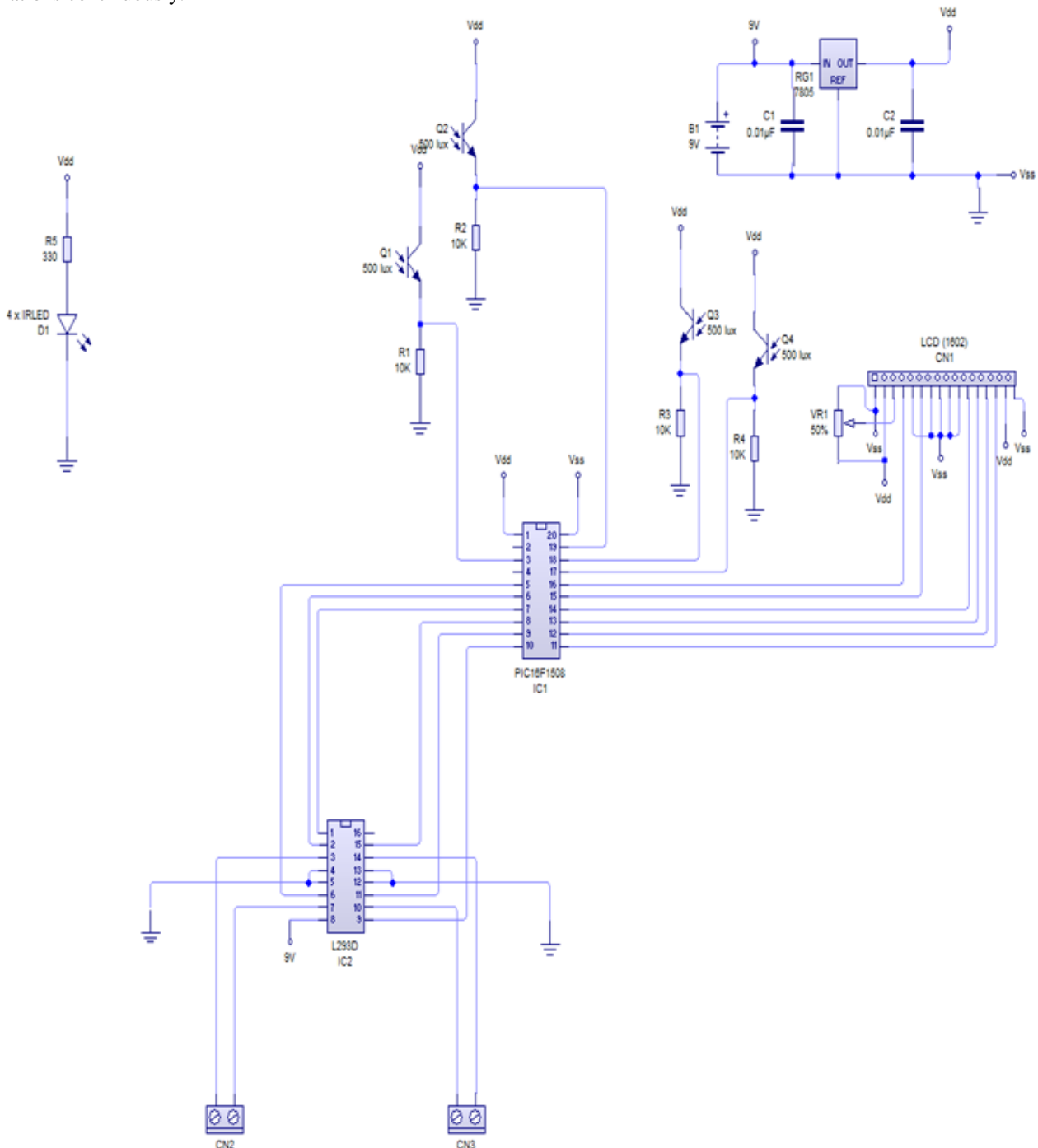

Figure 5: The Circuit diagram of the Traffic Control System.

Main Program Written In High Level Language
The compiler that will be used for this project is MikroC and the codes are written below:

Program Code

```
#define Max 60
#define Min 30

sbit Tosango_Red at RC3_bit;
sbit ToSango_Amber at RC6_bit;
sbit ToSango_Green at RC7_bit;

sbit Toeleyele_Red  at RA0_bit;
sbit Toeleyele_Amber at RA1_bit;
sbit Toeleyele_Green at RA2_bit;

sbit FromPoly_Red  at RC0_bit;
sbit FromPoly_Amber at RC1_bit;
sbit FromPoly_Green at RC2_bit;

sbit ToPoly_Green at RB7_bit;
chari;

//Sensor connection
#define FromPoly   3     //RA4 AN3
#define Tosango    10    //RB4 AN10
#define Toeleyele 11     //RB5 AN11
//parameters
//#define is_not>
//#define is <
#define is_not<
#define is >

#define present 1000
#define vehicle ADC_Read

voidstateA();
voidstateB();
voidstateC();
voidstateD();
voidstateE();
charnextstate,B,C_,D,E;

void main() {
TRISA = 0x18;
TRISB = 0x30;
TRISC = 0x00;
ANSELA = 0x10;    //RA$ analog input AN3
ANSELB = 0x30;      //RB4 & RB5 analog input AN10 &
AN11 respectively
ANSELC = 0;   // all portc bits are digital inputs
OSCCON = 0x7B;

PORTC = PORTB = PORTC = 255;
delay_ms(8000);
PORTC = PORTB = PORTC = 0;

stateA();
nextState = B;
while(1)
 {

if(nextState == B)
```

```
stateB() ;
if(nextState == C)
stateC();
if(nextState == D)
stateD()  ;
if(nextState == E)
stateE() ;

}


}

voidstateA()
{
 Tosango_Red = 1;
 Toeleyele_Red = 1;
 FromPoly_red = 1;
 ToPoly_Green = 0;
delay_ms(4000);
 Tosango_Amber = 1;
 Toeleyele_Amber = 1;
 FromPoly_red = 1;
 ToPoly_Green = 0;
delay_ms(4000);
}

voidstateB ()
{
 PORTA=PORTB=PORTC=0;
for(i = 0; i<Max;i++)    //1min
 {
 Tosango_Green = 1;
 Toeleyele_Green = 1;
 FromPoly_Red = 1;
 ToPoly_Green = 0;
delay_ms(1000);
if(vehicle(Tosango) is_not present  &&  vehicle(Toeleyele)
is_not present
&&vehicle(FromPoly) is present)
  {  nextstate = D; //stateD();
break;
  }
else if(vehicle(Toeleyele) is_not present)
 {
nextstate = C; // stateC();
break;
 }

 }
nextstate = C;
}

voidstateC ()
{
 PORTA=PORTB=PORTC=0;
 Tosango_Green = 1;
 Toeleyele_Amber = 1;
 FromPoly_Red = 1;
 ToPoly_Green = 0;
delay_ms(4000);
for(i = 0;i< Min; i++)    //30secs
 {
 Tosango_Green = 1;
```

```
 Toeleyele_Red = 1;
 FromPoly_Red = 1;
 ToPoly_Green = 1;
delay_ms(1000);

if(vehicle(FromPoly) is present && vehicle(Tosango) is_not
present)
   {
nextstate = D; //StateD();
break;
   }
else    if(vehicle(FromPoly)    is_not    present    &&
vehicle(Toeleyele) is present)
   {
nextstate = B;// stateB();
break;
   }
  }
nextstate =  D;
}

voidstateD()
{ PORTA=PORTB=PORTC=0;

 Tosang
o_Amber = 1;
 Toeleyele_Red = 1;
 FromPoly_Amber = 1;
 ToPoly_Green = 0;
delay_ms(4000);
for(i = 0;i<Min; i++)
 {
 Tosango_Red = 1;
 Toeleyele_Red = 1;
 FromPoly_Amber = 1;
 ToPoly_Green = 0;
delay_ms(100);
if( vehicle(FromPoly)is_not present)
   {
nextstate =  E; break;
   }
  }
nextstate = E;
}

voidstateE ()
{
 Tosango_Amber = 1;
 Toeleyele_Amber = 1;
 FromPoly_Amber = 1;
 ToPoly_Green = 0;
delay_ms(4000);
nextstate = B;
}
```

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