STUDY OF PLC AND ITS APPLICATION IN A SMART TRAFFIC CONTROL SYSTEM

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology in

Electronics & Instrumentation Engineering

By

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Department of Electronics & Communication Engineering

National Institute of Technology

Rourkela-2012-2013

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CERTIFICATE

This is to certify that the project work titled "**STUDY OF PLC AND ITS APPLICATION IN A SMART TRAFFIC CONTROL SYSTEM**" submitted by Rohan Dutta(109EI0138) & Rupak Das(109EI0319) for the award of Bachelor of Technology Degree in Electronics and Instrumentation Engineering for the session 2009-2013 at National Institute of Technology, Rourkela is an authentic work carried out by them under my supervision and guidance.

Date

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ABSTRACT

PLC or Programmable logic controller was used to control a mechantronics system using specific functions.Basic PLC functions such as timing,sequencing,controlling and relaying were implemented.The basic programming logic and ladder programming was studied and implemented.The intelligent or “Smart Traffic Control” is one which would be able to calculate the vehicle density in a lane at a 4-way crossing and then decide the priority automatically using a program burned in microcontroller.

In practical situations sensors are used to detect presence of vehicles in a lane and calculate the density and sends an interrupt signal to the control unit .In PLC the status of the sensors are checked and certain logical operations are performed to decide which lane is to be serviced first.Under low density condition it would operate sequentially.Ladder diagram was developed for the implementation of the same in PLC.

1. PLC

1.1 INTRODUCTION

Over time control system engineering has evolved greatly.In the past manual control was the only the form of control.More recently electrical control based on relays were used.These relays allow switching of power without a mechanical switch.PLC or a programmable logic controller is used to check and control a system using digital inputs which can be programmed for automation.The growth of PLC started in 1970s.The PLCs have become a major component of factory mainly because of the advantages they offer like

- Cost effective control for complete system
- Flexible and reusable
- Compuatational abilities
- Analytical power and decision making

PLCs are available in different designs or formats which vary in the type of their inputs and outputs and the software used for programming.

1.2 OPERATION OF PLC

CHECKING THE INPUT STATUS- PLC takes a look at each input todetermine whether it is on or off condition.

EXECUTING THE PROGRAM-PLC executes a program by oneinstruction at a time. If the first input is on then it should turn on the first output.Since it is already known, it should be able to decide whether the first output shouldbe turned on based on the state of the first input. It will store the execution resultsfor use later during the next step.

UPDATING OUTPUT STATUS-In the end PLC updates the status of the outputs based on which inputs are on during the first step andthe results of executing your program during the second step.

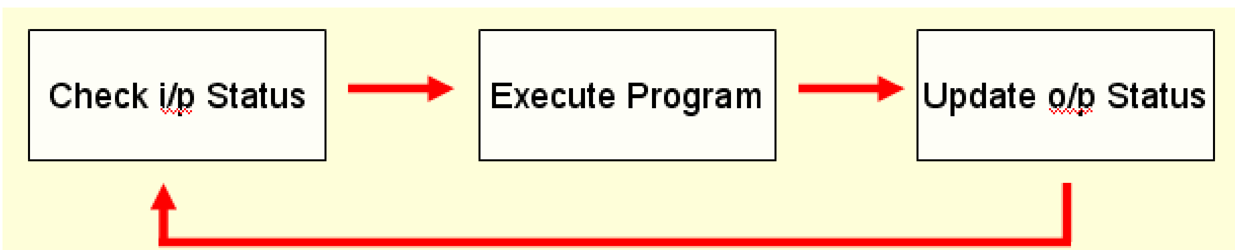


Fig1.1 Operation of PLC

1.3 BASIC PLC schema

The basic PLC schema includes memory,CPU, power supply, input block, output block, communication and expansion connections. Figure 1.2 shows the PLC system overview.

CPU modules - The Central Processing Unit (CPU) Module is the brain of the PLC and is used to read inputs, execute the control programs and update the outputs. The CPU consists of a arithmetic logic unit (ALU), timing and control circuitry, accumulator,address stacks,program counter and instructionregisters. A PLC works by continuously scanning a program.

Memory - The memory includes pre-programmed ROM containingPLC's operating system, driver program, application programs and RAM . PLC manufacturers offer different types of retentive memory to saveuser programs and data while power is cut-off, so that the PLC can resume execution of the control program as soon as power is restored.

I/O Modules –The input and output (I/O) modules connect the PLC to the sensors and actuators and provide isolation for the low-voltage, low-current signals thatthe PLC uses internally from electrical circuits required bymost sensors and actuators. A wide range of I/O modules are available including:digital (logical) I/O modules and analog(continuous) I/O modules.

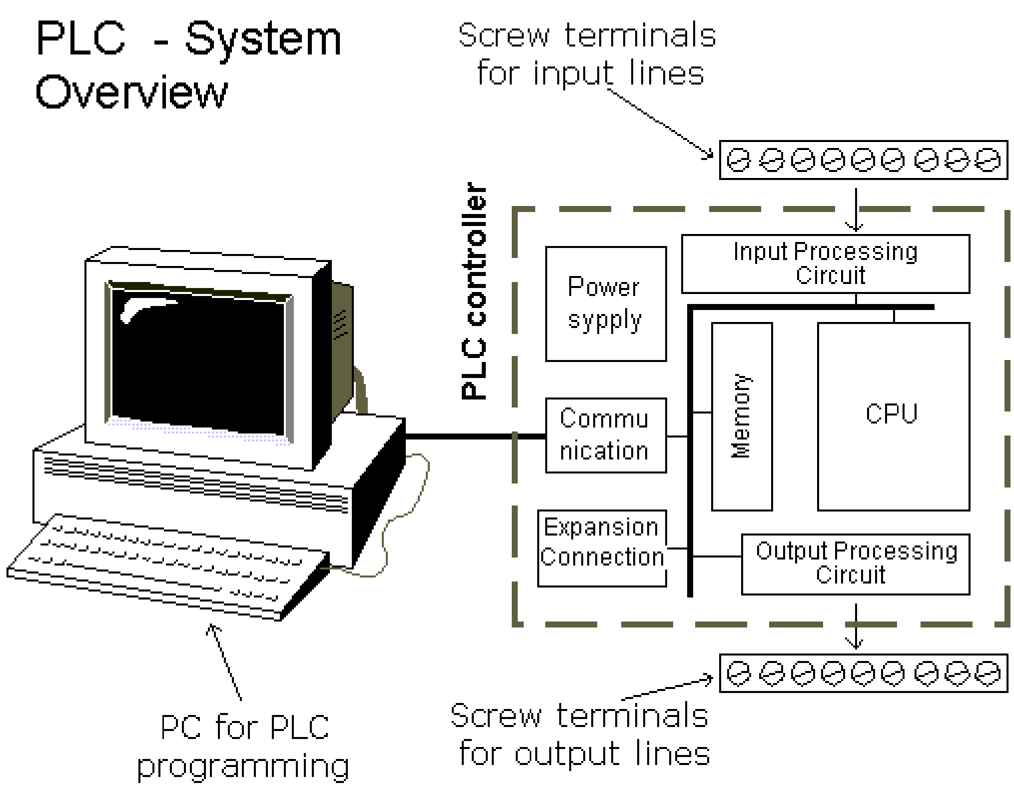


Fig1.2 Overview of PLC

1.4 LSM CONTROLLER

LSM or linear synchronous motion controller is a mechatronics system having different components such as X-Y table,rotary table,conveyor belt,motors,sensors,actuators,single and double acting cylinders which are controlled by programming in Control X software.

The specifications of the LSM controller used by us are:

- Operating Voltage: 24 VDC
- Inputs: sixteen Opto-Isolated digital inputs
- Windows software ControlX
- Outputs: 8 Relayed digital inputs
- Programming: Statement/Instruction
- Operator interface: Display - Windows based high resolution interface
- Plug & Play operation

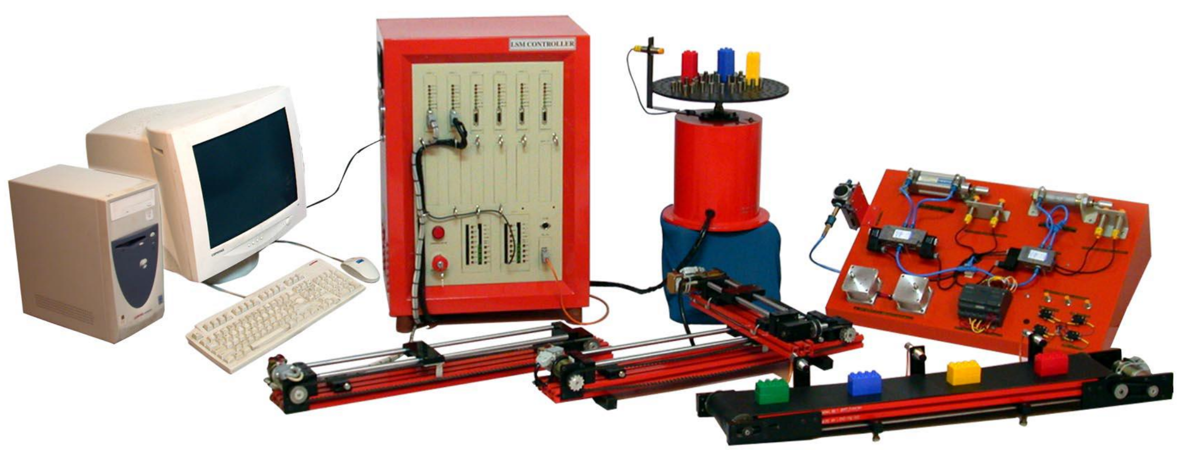


Fig1.3 LSM Controller

Fig1.4 Conveyor Belt

Fig1.5 AC Synchronous Motor

Fig1.6 Single Acting Cylinder

Fig1.7 Capacitive Sensors

Some commonly used commands in Control X Software

OUTPUT COMMAND:

To turn “ON” or “OFF” the Output of LSM Controller Package PLC command is:

set_output (Output Address, Status of the Output)

TO DELAY THE OPERATIONS:

Delay(TIME PERIOD)

TO SET THE POSITION OF AXIS

set_pos output adress,no of pulses or interval

TO SET THE VELOCITY AND ACCELERATION

set_vel (output adress,velocity)

set_acc (output adress,acceleration)

2. APPLICATIONS OF PLC

Problem Statements solved using Control X on LSM Controller

(a) An AC synchronous motor was controlled by operating it in clockwise and anti-clockwise direction in manual mode. In programming time delay and loop operation were performed.

- For i=1 to 10
- Set_output 4,1
- Delay(3000)
- Set_output 4,0
- Delay(3000)
- Set_output 5,1
- Delay(3000)
- Set_output 5,**0**
- Next

(b)It was required to control single acting spring return cylinder and double acting cylinder in manual mode. Speeds of pistons of both cylinders were adjustable. In Programming time delay and loop operations were performed.

- For 1=1 to 10
- Set_output 3,1 #single acting cylinder
- Set_output 4,1 #double acting cylinder
- Delay(3000)
- Set_output 3,0
- Set_output 4,0
- Set_output 5,1
- Delay(3000)
- Set_output 5,0
- Next

2.1 A PLC design for operation in an automated packaging plant

- For i=1 to 5
- Set_open 2,200
- Dowhile get_input(15)=0
- Loop
- Stop_axis 2
- Set_output 6,1
- Delay 3000
- Set_output 6,0
- Delay 1000
- Set_output 7,1
- Delay 3000
- Set_output 7,0
- Set_open 2,200
- Dowhile get_input(14)=0
- Loop
- Stop_axis 2
- Set_output 5,1
- Delay 3000
- Set_output 5,0
- Delay 1000
- Set_output 4,1
- Delay 3000
- Set_output 4,0
- Set_open 2,200
- Next

Here we have used AC synchronous motors and conveyor beltfor operation.In a bottle packaging industry the bottles are arranged in a given order at regular intervals.The conveyor belt moves and hence the bottle moves forward.Whenever it reaches a designated point a photo-electric sensor detects its presence and sends an interrupt signal.Whenever filling up or packaging is required there is a delay operation which stops the conveyor belt for a brief period and activates the motors in clockwise or anticlockwise direction as desired using different commands in Control X software.The program was run and results were observed on the PLC hardware.

2.2 A PLC design for controlling the pressure of a pump

- Set_output 3,1
- Dowhile get_input(4)=0
- Loop
- Set_output 6,1
- Delay 3000
- Set_output 6,0
- Delay 1000
- Set_output 7,1
- Delay 3000
- Set_output 7,0
- Next

Here we used specified Control X commands for operating the the operation of a single-acting cylinder.It is used mainly for the purpose of venting out excess pressure in a process plant.The main principle is that whenever a pressure above the threshold value is detected the synchronous motors open up the venting chamber and hence release the excess pressure.Once pressure gets back to normal level the motor once again closes the venting chamber.

3. TRAFFIC CONTROL SYSTEM

3.1 Overview

Traffic Control Systems are used at a point where there are more than two paths for passage of vehicles or wherever passage is to be given to pedestrians to cross a road.It is also used wherever two paths cross each other thus creating a four-way lane.These systems are also put in place at points where there are by-lanes attached to the main road.The main aim of a traffic control system is to control the flow of vehicles through a lane and prevent accidents or road blockage.These systems are also used at points wherever a vehicle needs to be stopped for any purpose.

In our country the traffic control system is mostly based on sequential logic.There are three lights red for stop,yellow for get ready and green for go.Each light operates for a given period one after the other.The programming is so done that two lanes won't have the green light at the same time.

The traffic control system at a certain places are even controlled manually by traffic personnel but human error calls for automation to prevent undesirable incidents on road.

The traffic signals control the vehicle movements.they are connected to electronics system which control the signals.They mainly work on logics which can be classified as

a. signal phase and cycle length which is dependent on the traffic flow on the desired tracks.
b. system responds to interrupts or timing based system and open the desired signal as required

3.2 Brief History

- J. P. Knight created the first traffic signal which was developed in London, England in 1868.
- The modern traffic light was invented in America. New York had installed a three color system in 1918 which was operated manually from a tower in the middle of the street.
- In 1923 Garrett Morgan patented an electric traffic light system using a pole with a cross section on which the words STOP and GO were illuminated.
- In 1926 , first automatic signals were installed in London; they depended on a timer to activate them.
- A better idea was the inductive-loop device: a loop of wire was embedded in the road and connected to a box controlling lights; a current of electricity passes through the loop, and when the steel body of cars passed over, it produced a light activating signal .
- In the current scenario in some countries, traffic is automatically routed onto limited access highway by the help of computer activated guidance systems that calculate traffic volume on thehighway. Global positioning satellite system (GPS) is installed in many cars.These systems link with a satellite and inform drivers what are the possible routes to their destination. Such systems eventually enable the drivers to determine the best route to a destination under prevailing traffic conditions thus optimizing time.

3.3 Advantages of a good Traffic Control System

A properly ordered traffic control system can

1. Provide for orderly movement of traffic
2. Increase capacity at intersection
3. Reduce frequency and severity of certain kind of clashes
4. Provide continuous movement of traffic at a desired speed
5. Interrupt heavy traffic to allow pedestrians to pass
6. Effectively perform traffic management

But using a generalized traffic control system fails to detect high priority situations or emergency conditions.Hence the need for a Smart Traffic Control System arises which would work on certain conditions and be able to take decisions automatically.

4. SMART TRAFFIC CONTROL SYSTEM

4.1 Introduction

A Smart Traffic Control System automizes the traffic control activity and uses certain logical and mathematical operations and derives priority order of the lanes based on certain factors and hence controls the traffic in an optimized manner.It uses inputs from sensors and sends interrupt signals to the controlling unit which in turn handles the operation of traffic signals automatically.

4.2 Need for Smart Traffic Control

- Increasing number of vehicles and lower phase of highways developments have led to traffic congestion problem.
- Time of travel, environment quality, quality of life and road safety are all adversely affected as a result of traffic congestions.
- Delays caused due to traffic congestions indirectly affect productivity, efficiency, and energy losses.
- Human error can cause mismanagement.
- Emergency situations like medical emergencies,costruction work,accidents,etc

4.3 Modes of operation

Traffic load is dependent on factors such as time,day,season ,weather and unpredictable situations like accidents or construction activity or any special event.

Traffic control system can be broadly classified as

- Saturated-:Aim to serve as many drivers as possible
- Unsaturated-:Reduces mean delay for drivers

An adaptive control system must be able to diagnose the saturation condition and be able to change the objective function .The main aim of this project is to minimize waiting time for each lane as well as serving the busy lanes as much as possible

The system can be divided into four main parts-:

- Hardware Model
- Programming
- Sensors
- PLC

The objective is to build a prototype that has the ability to collect information of the busy tracks by sensors and using a control unit to shift service to a given lane as per priority.

An intelligent traffic system works in four different modes

1. Normal flow
2. Peak flow
3. Off time
4. Manual operation

Normal flow occurs when the traffic in a lane is less than a certain fixed threshold value.In this time the traffic signals operate sequentially.

Peak time is the period in which the traffic density crosses the threshold value in a given lane and that lane gets service irrespective of its sequence.

Manual operation involves closing of lanes and opening of lanes manually in case of an emergency or for allowing pedestrians to pass through.

The design operation should be such that every lane gets service after certain amount of time.

In a practical design inductive loops are used as sensors to detect the presence of vehicles at intersections.Its basic function is to provide interrupts to control units.It has two parts – a coil and a detector unit.Coil is main part of the sensor and consists of more loops of wire embedded in the pavement.Inductive coil is connected to the detector unit which is an electronic circuit.When vehicles pass over or rest on the loop then due to induction more current flows through the loop and this causeschange in frequency.Detector unit detects these signals and then send an interrupt signal to the control unit.

In the prototype hardware that we have used we have implemented potentiometers to vary the density and outputs are connected to a microcontroller which sends it to its control unit to operate the LEDs.

4.4 Practical Design

In a practical design inductive loops are used as sensors to detect the presence of vehicles at intersections.Its basic function is to provide interrupts to control units.It has two parts,coil and a detector unit.Coil is main part of sensor and consists of more loops of wire embedded in the pavement.Inductive coil is connected to the detector unit which is an electronic circuit.When vehicles pass over or rest on the loop then due to induction more current flows through the loop and this causes change in frequency.Detector unit can detect these signals and then sends an interrupt signal to the control unit for further operation.

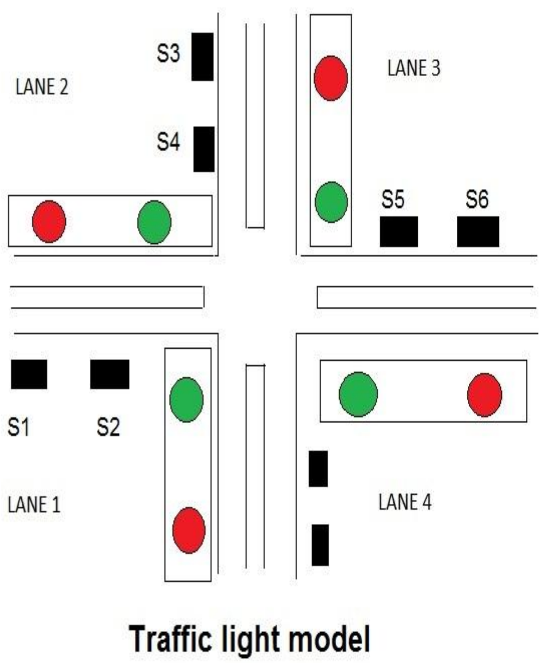


Fig4.1 Smart Traffic Light Model

5. PROTOTYPE HARDWARE

5.1 Hardware components used

For our prototype we designed a circuit and implemented it in hardware and program was burned in order to make it operational.

The basic hardware components that have been used are

- ATMEGA16(Microcontroller)
- IC7805(Voltage Regulator)
- LEDs
- Potentiometer
- Resistors(330KΩ)
- Capacitor

5.2 ATMEGA16

It is a 8-bit AVR microcontroller with 16Kb in system programmable flash.It has 32×8 general purpose registers,512bytes of EEPROM,1KB of internal SRAM and JTAG cable.It has peripheral features like two 8-bit timers/counters,one16-bit timer and a comparator/prescaler. It has 32 programmable I/O lines divided into four ports,PORT A,PORT B,PORT C and PORT D.It has pins for V_{CC},Gnd voltage,RESET and clock.It has a speed grade of 0-8 MHz.

The programming was done using a programmer and Sinaprog.exe and a code was burned into the microcontroller.

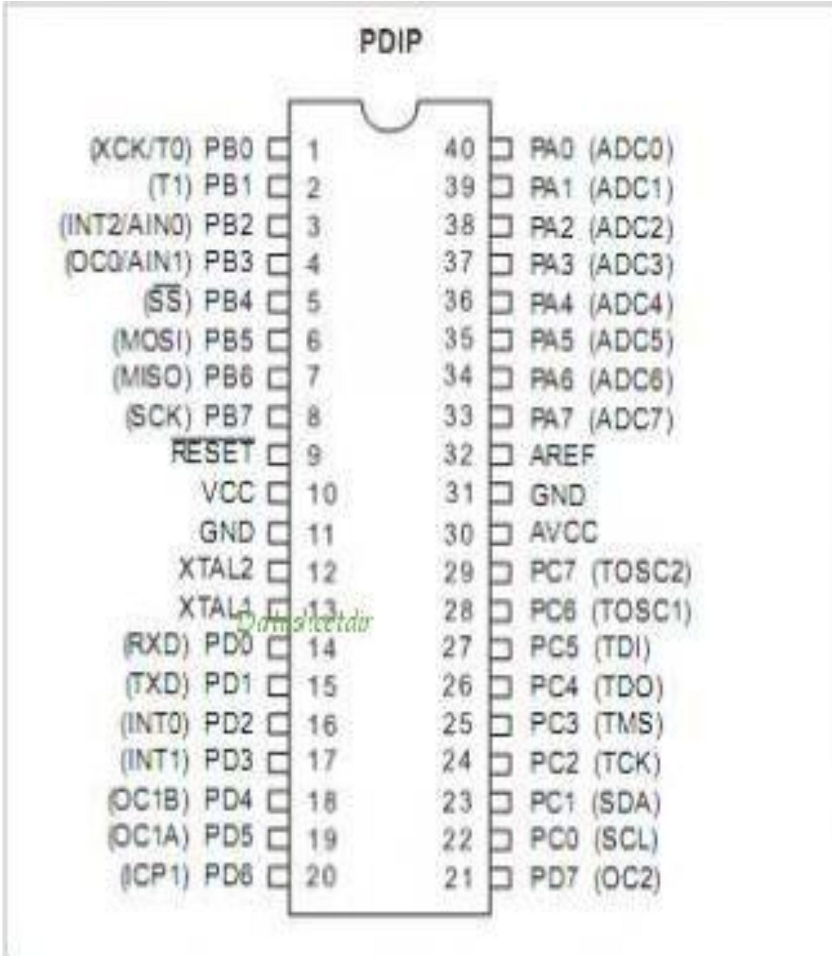


Fig5.1 Pin Diagram of ATMEGA16

5.3 IC7805

It is a voltage regulator.It converts a 12V input from adapter to a regulated voltage of 5V.

It has 3 pins

1. Input Voltage(5-18V)
2. Gnd(0V)
3. Output Voltage(5V)

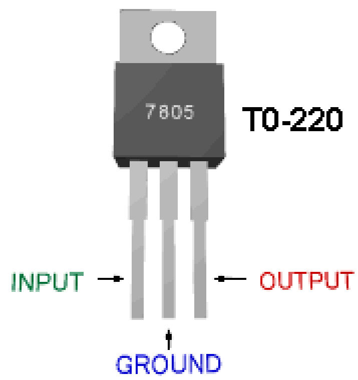


Fig5.2 IC7805 Pin Configuration

5.4 POTENTIOMETER

It is a three terminal resistor with a sliding contact that forms an adjustable voltage divider.Here it has been used in place of sensors for density detection in the lanes.The three terminals are

1. V_{CC}
2. Gnd
3. Connected to ADC pin of ATMEGA16

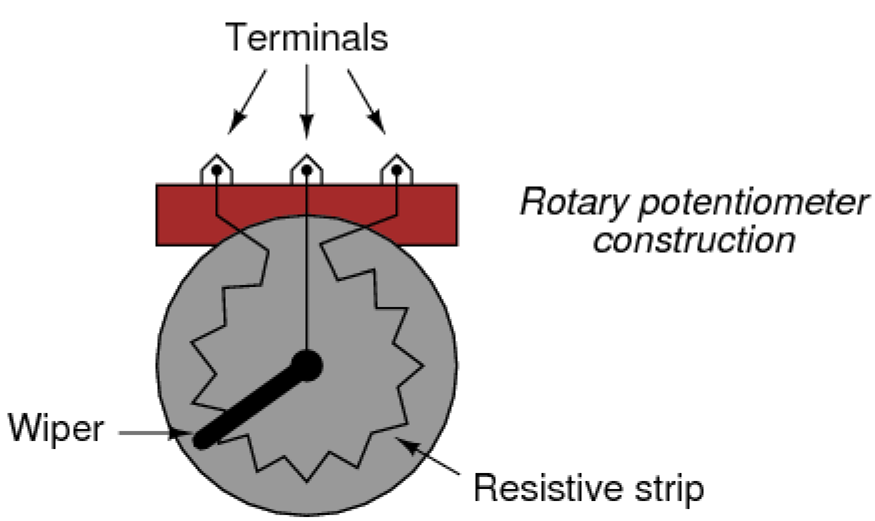
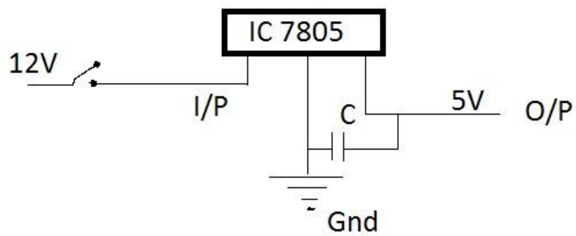


Fig5.3 Potentiometer

5.5 CIRCUIT



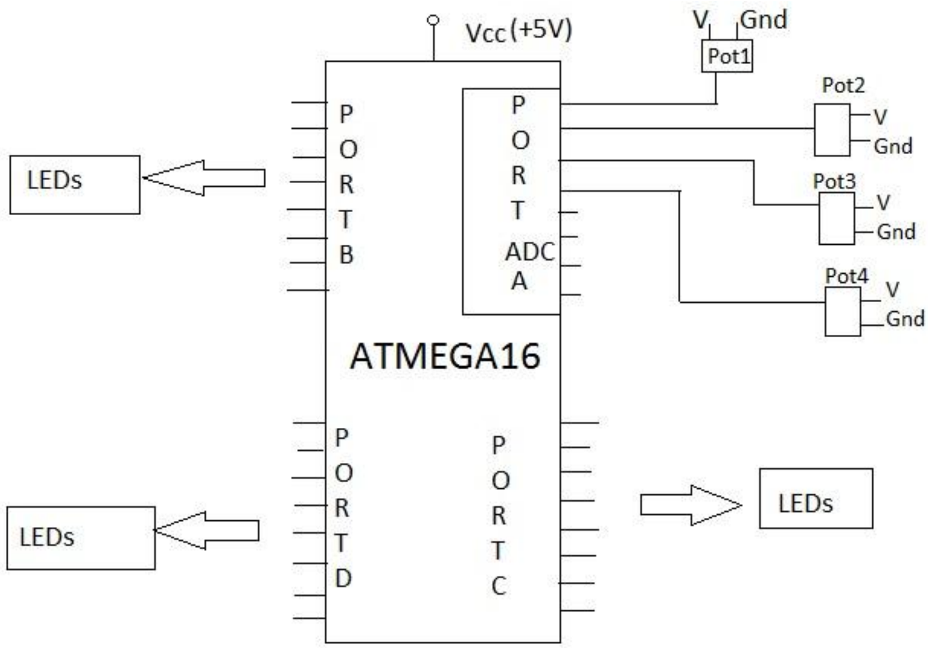


Fig5.4 Overall circuit Diagram of Smart Traffic Control

6.SOFTWARE IMPLEMENTATION

6.1 AVR STUDIO 4.0

AVR Studio 4.0 is an integrated development platform (IDP) for developing and debugging Atmel AVR microcontroller applications.It gave us seamless and easy-to-use environment to write, build and debug our applications written in C/C++ or assembly code. Atmel Studio 4.0 supports all 8 & 32 bit AVR, SoC wireless family, SAM3 and SAM4 microcontrollers, and connects easily to Atmel debuggers and development kits.

6.2 CODE

```
#include<avr/io.h>
#include<util/delay.h>
#include<avr/adc.h>

#define L1          500
#define L2          500
#define L3          500
#define L4          500

#define LG1         PC0
#define LR1         PC1
#define LG2         PC2
#define LR2         PC3
#define LG3         PC4
#define LR3         PC5
#define LG4         PC6
#define LR4         PC7

void main(void)
{
DDRB=0xff;
DDRC=0xff;
DDRD=0xff;

adc_init();

int ln1,ln2,ln3,ln4;
```

```
while(1)
{

ln1=read_adc_channel(0);
ln2=read_adc_channel(1);
ln3=read_adc_channel(2);
ln4=read_adc_channel(3);

if(ln1<255)
{
	PORTB&=0xf0;
	PORTB|=0x01;
}
else if(ln1<510)
{
	PORTB&=0xf0;
	PORTB|=0x03;
}
else if(ln1<765)
{
	PORTB&=0xf0;
	PORTB|=0x07;
}
else
{
	PORTB&=0xf0;
	PORTB|=0x0f;
}

if(ln2<255)
{
	PORTB&=0x0f;
	PORTB|=0x10;
}
else if(ln2<510)
{
	PORTB&=0x0f;
	PORTB|=0x30;
}
else if(ln2<765)
{
	PORTB&=0x0f;
	PORTB|=0x70;
}
else
{
	PORTB&=0x0f;
```

```
        PORTB|=0xf0;
    }

    if(ln3<255)
    {
        PORTD&=0xf0;
        PORTD|=0x01;
    }
    else if(ln3<510)
    {
        PORTD&=0xf0;
        PORTD|=0x03;
    }
    else if(ln3<765)
    {
        PORTD&=0xf0;
        PORTD|=0x07;
    }
    else
    {
        PORTD&=0xf0;
        PORTD|=0x0f;
    }

    if(ln4<255)
    {
        PORTD&=0x0f;
        PORTD|=0x10;
    }
    else if(ln4<510)
    {
        PORTD&=0x0f;
        PORTD|=0x30;
    }
    else if(ln4<765)
    {
        PORTD&=0x0f;
        PORTD|=0x70;
    }
    else
    {
        PORTD&=0x0f;
        PORTD|=0xf0;
    }


    if(ln1>L1)
```

```
{
      PORTC=_BV(LR1)|_BV(LR2)|_BV(LG3)|_BV(LR4);
      _delay_ms(500);
      _delay_ms(500);
      _delay_ms(500);
      _delay_ms(500);
}
else if(ln2>L2)
{
      PORTC=_BV(LR2)|_BV(LR1)|_BV(LR3)|_BV(LG4);
      _delay_ms(500);
      _delay_ms(500);
      _delay_ms(500);
      _delay_ms(500);
}
else if(ln3>L3)
{
      PORTC=_BV(LR3)|_BV(LG1)|_BV(LR2)|_BV(LR4);
      _delay_ms(500);
      _delay_ms(500);
      _delay_ms(500);
      _delay_ms(500);
}
else if(ln4>L4)
{
      PORTC=_BV(LR4)|_BV(LR1)|_BV(LG2)|_BV(LR3);
      _delay_ms(500);
      _delay_ms(500);
      _delay_ms(500);
      _delay_ms(500);
}
else
      ;
      PORTC=_BV(LR1)|_BV(LR2)|_BV(LG3)|_BV(LR4);
      _delay_ms(500);
      _delay_ms(500);
      _delay_ms(500);
      _delay_ms(500);

ln1=read_adc_channel(0);
ln2=read_adc_channel(1);
ln3=read_adc_channel(2);
ln4=read_adc_channel(3);

if(ln1>L1)
{
      PORTC=_BV(LR1)|_BV(LR2)|_BV(LG3)|_BV(LR4);
```

```
        _delay_ms(500);
        _delay_ms(500);
        _delay_ms(500);
        _delay_ms(500);
    }
    else if(ln2>L2)
    {
        PORTC=_BV(LR2)|_BV(LR1)|_BV(LR3)|_BV(LG4);
        _delay_ms(500);
        _delay_ms(500);
        _delay_ms(500);
        _delay_ms(500);
    }
    else if(ln3>L3)
    {
        PORTC=_BV(LR3)|_BV(LG1)|_BV(LR2)|_BV(LR4);
        _delay_ms(500);
        _delay_ms(500);
        _delay_ms(500);
        _delay_ms(500);
    }
    else if(ln4>L4)
    {
        PORTC=_BV(LR4)|_BV(LR1)|_BV(LG2)|_BV(LR3);
        _delay_ms(500);
        _delay_ms(500);
        _delay_ms(500);
        _delay_ms(500);
    }
    else
        ;

        PORTC=_BV(LR2)|_BV(LR1)|_BV(LR3)|_BV(LG4);
        _delay_ms(500);
        _delay_ms(500);
        _delay_ms(500);
        _delay_ms(500);

    ln1=read_adc_channel(0);
    ln2=read_adc_channel(1);
    ln3=read_adc_channel(2);
    ln4=read_adc_channel(3);

    if(ln1>L1)
    {
        PORTC=_BV(LR1)|_BV(LR2)|_BV(LG3)|_BV(LR4);
        _delay_ms(500);
```

```
            _delay_ms(500);
            _delay_ms(500);
            _delay_ms(500);
      }
      else if(ln2>L2)
      {
            PORTC=_BV(LR2)|_BV(LR1)|_BV(LR3)|_BV(LG4);
            _delay_ms(500);
            _delay_ms(500);
            _delay_ms(500);
            _delay_ms(500);
      }
      else if(ln3>L3)
      {
            PORTC=_BV(LR3)|_BV(LG1)|_BV(LR2)|_BV(LR4);
            _delay_ms(500);
            _delay_ms(500);
            _delay_ms(500);
            _delay_ms(500);
      }
      else if(ln4>L4)
      {
            PORTC=_BV(LR4)|_BV(LR1)|_BV(LG2)|_BV(LR3);
            _delay_ms(500);
            _delay_ms(500);
            _delay_ms(500);
            _delay_ms(500);
      }
      else
            ;

            PORTC=_BV(LR3)|_BV(LG1)|_BV(LR2)|_BV(LR4);
            _delay_ms(500);
            _delay_ms(500);
            _delay_ms(500);
            _delay_ms(500);

      ln1=read_adc_channel(0);
      ln2=read_adc_channel(1);
      ln3=read_adc_channel(2);
      ln4=read_adc_channel(3);

      if(ln1>L1)
      {
            PORTC=_BV(LR1)|_BV(LR2)|_BV(LG3)|_BV(LR4);
            _delay_ms(500);
            _delay_ms(500);
```

```
		_delay_ms(500);
		_delay_ms(500);
	}
	else if(ln2>L2)
	{
		PORTC=_BV(LR2)|_BV(LR1)|_BV(LR3)|_BV(LG4);
		_delay_ms(500);
		_delay_ms(500);
		_delay_ms(500);
		_delay_ms(500);
	}
	else if(ln3>L3)
	{
		PORTC=_BV(LR3)|_BV(LG1)|_BV(LR2)|_BV(LR4);
		_delay_ms(500);
		_delay_ms(500);
		_delay_ms(500);
		_delay_ms(500);
	}
	else if(ln4>L4)
	{
		PORTC=_BV(LR4)|_BV(LR1)|_BV(LG2)|_BV(LR3);
		_delay_ms(500);
		_delay_ms(500);
		_delay_ms(500);
		_delay_ms(500);
	}
	else
		;

		PORTC=_BV(LR4)|_BV(LR1)|_BV(LG2)|_BV(LR3);
		_delay_ms(500);
		_delay_ms(500);
		_delay_ms(500);
		_delay_ms(500);


	}
	}
```

6.3 Ladder Logic concept

It is a PLC based concept used for programming.It is developed to create relay logic by selecting ladder programming method the amount of training needed is very less.Relays are normally drawn in a schematic to represent the input coil.It is a simple device using magnetic field to control a switch.The contact which closed when input coil is energized is called normally open and those which close when not energized are called normally closed.In this logic we often use an output status as an input to another.The ladders are arranged in rungs.All rungs in a ladder receive same voltage supply.

6.4 LADDER LOGIC DIAGRAM

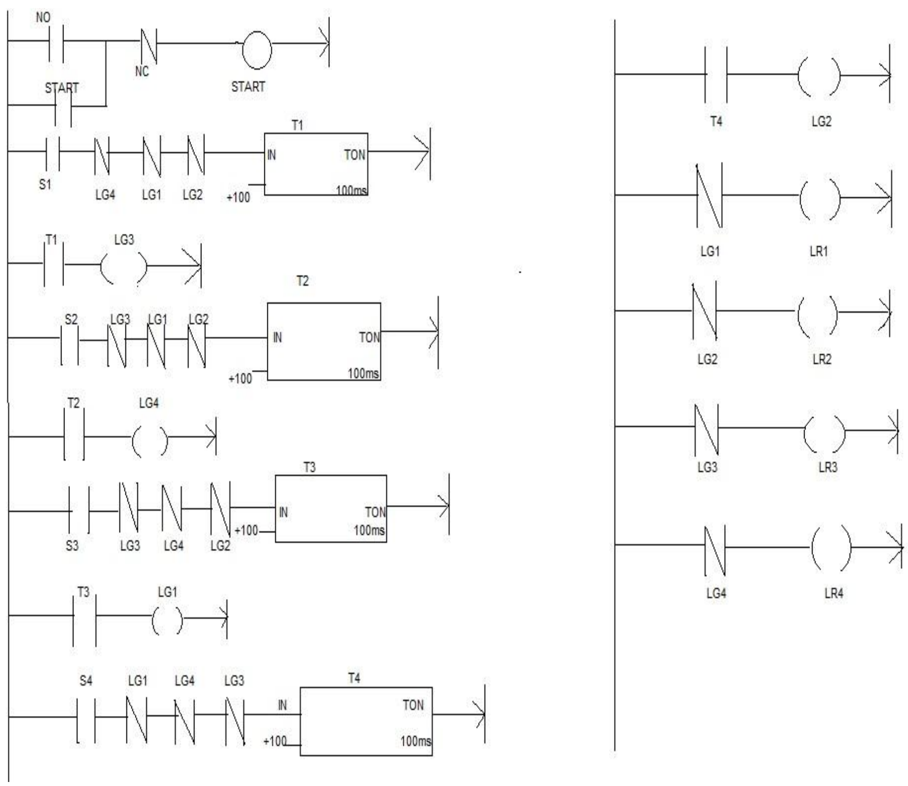


Fig6.1 Ladder Logic diagram of Smart Traffic System

Mnemonics

LG(1,2,3,4)-Green light of respective lanes

LR(1,2,3,4)-Red light of respective lanes

T(1,2,3,4)-On timers for respective lanes to allow traffic flow

S(1,2,3,4)- switches representing whether density of a lane is high or not

RESULTS AND DISCUSSION

The program was burned and then the model was given power supply. By tuning the potentiometer initially density of all lanes were kept low. As a result the traffic system operates in a sequential order servicing one lane after the other. The status of the LEDS give the status of any given lane.

Next when we increased the density of lane 3 via potentiometer LG1 or the green light in lane 1 gets on and that lane gets service irrespective of its sequence. After a fixed time interval however the control shifts to the next lane in sequence.As a result all lanes get service but the lane with higher density gets higher preference.

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