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An Embedded Platform for Intelligent Traffic Control

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***Abstract*—Safety and comfort of road users is fast becoming a matter of grave concern. The number of accidents on roads has shot up greatly with the increase in vehicle traffic, so has the race to build a safer and much more reliable system for traffic control and management. Traffic management rides on an extremely balanced equation. A change in timing of Traffic lights has adverse effects on traffic. A change applied too early may lead to congestion on other roads and a change too late may wreak havoc; long traffic jams, instance of road rage, accidents etc. The ideal automated traffic signal is yet to be built. This report presents an adaptive traffic control system where the traffic load is continuously measured by sensors connected to a microcontroller-based system. The traffic lights of an area are interconnected with a communication network through which traffic load and synchronization information is exchanged. As a result, the duration of each traffic light cycle changes dynamically. This means that the timing of the traffic light changes according to the load, the side with the greatest load is given time wise priority.**

Keywords-component; Sensors; Microcontroller; Embedded Algorithm;Iintelligent control

I. INTRODUCTION

In most parts of the world, traffic lights have a meager setup using a microcontroller with fixed signal timings. This has been the norm for quite a long time now. However, in the present times of ever increasing vehicular traffic these systems appear to be quite cumbersome. Fixed signal timings mean no heed is paid to the traffic density. This leads to long queues at traffic lights causing congestion on roads and extreme discomfort to road users, which in turn leads to excessive disobedience of traffic signals and accidents.

Interest in Traffic Sensing comes from the problems caused by traffic congestion and a synergy of new technologies for simulations, real-time control, and communications networks. Traffic congestion has been increasing worldwide due to ballooning motorization, urbanization, population growth, and changes in population density. Congestion reduces efficiency of transportation infrastructure and increases travel time, air pollution, and fuel consumption. Many researchers have attempted to upgrade the current traffic system with fixed time delays to the intelligent traffic system with time delay as a function of traffic frequency. Intelligent traffic control system proposed in [1] is based on the spacing between the vehicles but this system is not 100% accurate. Design of intelligent traffic control system based on DSP and Nios II. Using Dual-CPU, Intelligent Traffic Control System combined with logic control in FPGA has been discussed in [2]. But this system is not cost effective. For an intelligent traffic control system before implementing any control algorithm, it is necessary to monitor the traffic frequency first. There are various ways to monitor the traffic like, video image processing [3], vehicles counting through intersecting proximity/ touch sensors array. Different countries have their own traffic control systems. A novel traffic control system framework, the Mobile Intelligent Traffic Control System (MITCS), designed for Taiwan is proposed in [4]. Similarly, an intelligent traffic control system is operational in Beijing by the name SCOOT [5].

The authors aim to make an Intelligent Traffic Sensing and Traffic Signaling System which senses traffic using a set of proximity sensors and touch sensors planted in the road, calculates the density using the code embedded on a microcontroller and apply the change On-The-Go. This system is highly accurate; i.e changes to the timing are applied in the presently running cycle without delay for maximum comfort of road users. Visualization is via high intensity LEDs. The main plus points of our system are that it is Low Cost (hardware costs around $ 400) and is highly accurate. The present systems cost anywhere upwards of $ 30,000.

The organization of the paper is as follows: In section 2, we discuss the proposed design that also presents the block diagram for our proposed system. Detailed circuit description is provided for each block used in this section. In section 3, we present the software implementation along with algorithm and flow diagram. In section 4, PCB designing, actual circuit implementation on PCB and simulated schematic are shown. Finally, some conclusions are offered in section 5.

II. PROPOSED WORK

The work is divided into three modules. In the first module, the traffic frequency is sensed by the proximity sensors or magnetic pick up based touch sensors. The sensors output is first amplified and then converted

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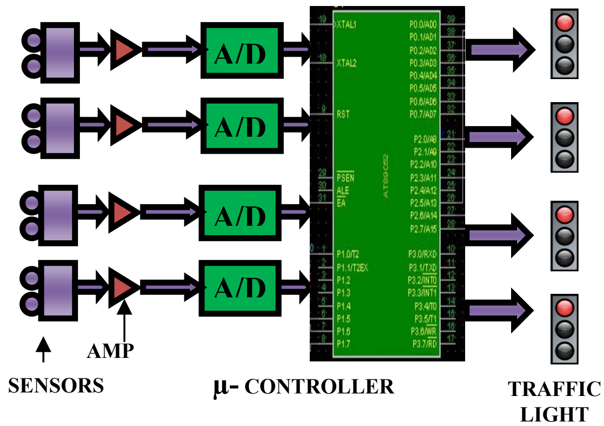

Figure. 1 Block Diagram of Intelligent Traffic Control System

in to digital form in order to interface with the programmed microcontroller. In the second module, a programmed embedded processor is used to decide the delay for traffic signal according to the frequency of the traffic. In the third module, the output from the different ports of the microcontroller goes to different traffic lights as shown in Figure 1.

A. Sensors Unit

The sensor module consists of a horde of components. The sensors can be Proximity sensors(Laser based or IR based). For very heavy traffic where there are multiple lanes Proximity sensors can only proximate the vehicles running across the side lanes, the middle lanes cannot be approximated by these sensors. In such cases, Magnetic Pick Up based touch sensors are used. These touch sensors can be buried inside the road, whenever the vehicle cross the magnetic plunger of the sensor will generate a current in spring loaded coil. The proposed work is a prototype of intelligent traffic control system where authors have proposed Proximity sensors as shown in Figure 2. In these sensor units, the IR-LED as emitter , IR Photodiode as detector , Amplifiers and Analog to Digital Convertors to amplify and convert the minuscule outputs from the sensors to a value recognizable by the microcontroller. The sensor module in the proposed model is consisting of:

1) 5 sets of IR LEDs and Photodiodes
2) ST358 Op-amp
3) Analog to Digital Convertor
4) Signals sent via FRC Connectors
5) Output tailored for Microcontroller use

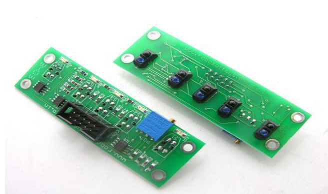

Figure. 2 TCRT Sensor Module [6]

B. Embedded Processor

The selection of embedded processor depends on the condition of traffic light. In the proposed work, four traffic light terminals are interfaced through the four ports of standard microcontroller AT89C52. The AT89C52 is a low power, high performance CMOS 8-bit microcomputer with 8K bytes of Flash programmable and erasable read only memory (PEROM). The device is manufactured using Atmel's high density nonvolatile memory technology and is compatible with the industry-standard 80C51 and 80C52 instruction set and pin-out. The processor Flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, and Atmel AT89C52 is a powerful microcomputer which provides a highly-flexible and low cost solution to many embedded control applications. The AT89C52 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, three 16-bit timer/counter, a six-vector two-level interrupt architecture, full-duplex serial port, on-chip oscillator and clock circuitry[7]. The extension of ports can be done by using 8255 standard PPI. This low cost intelligent traffic control system shown in Figure 3 works in the following steps:

1) Proximity Sensors send a pulse every time a vehicle comes near it
2) The pulse is amplified and converted into a digital pulse
3) The output is fed to the Microcontroller
4) According to the number of activated sensors the Stop and Go Timing is decided.
5) The change in timing is applied in the same cycle.

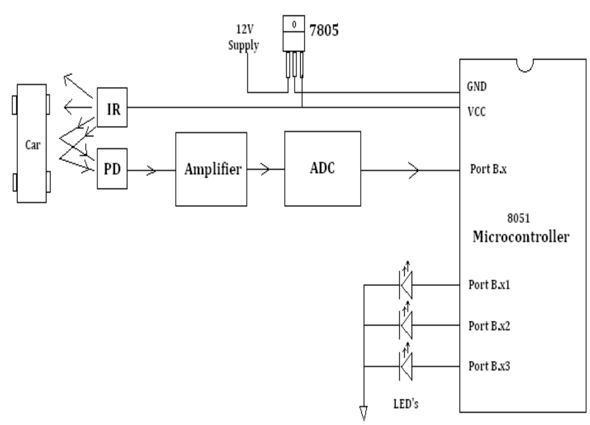

Figure. 3 Sensor Interface with Microcontroller.

C. Traffic Light Terminals

In this low cost based prototype, author has used the small range proximity sensors and LEDs for traffic light terminals. But in actual implementation the proposed model, the microcontroller port cannot drive the high power rated traffic light lamps. These traffic light lamps can be driven

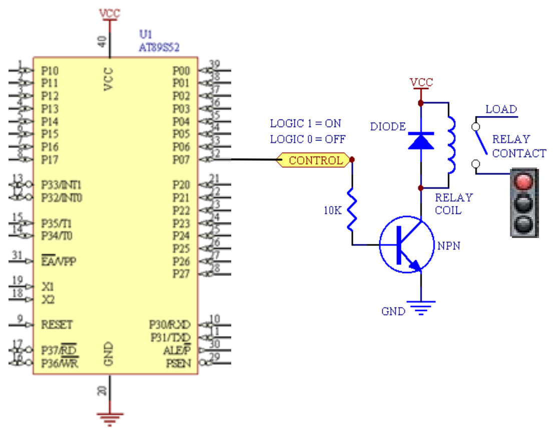

Figure. 4 Traffic Light Driving Relay Interface with Microcontroller.

by a relay which is switched through a transistor. The base terminal of transistor is connected with the microcontroller output as shown in Figure 4.

III. Software Implementation

In this work the traffic is sensed by the TCRT-LFSM–digital sensor. The moment a vehicle cross the sensor the IR signal from IR LED is reflected back to the phototransistor. When the phototransistor conducts, the voltage goes to the comparator input and comparator output goes to zero as both inputs become equal as shown in Figure 5.

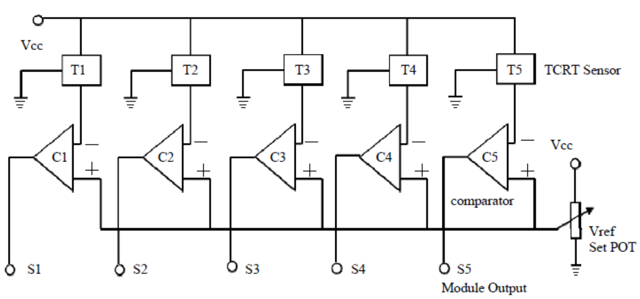

Figure. 5 Schematic Diagram of TCRT-LFSM–digital sensor [6]

A. Flow Chart

The microcontroller IC AT89C52 was programmed using the assembly language. The instruction set used and the flow of program control is shown in Figure 6. Apart from the main function, other functions are defined for:

Default Go Time = 6 secs. Per Side (No Sensors Activated)

Go Time for side when 1 sensor activated = 10 sec.
Go Time for side when 2 sensor activated = 15 sec.
Go Time for side when 3 sensor activated = 20 sec.
Go Time for side when 4 sensor activated = 25 sec.
Go Time for side when 5 sensor activated = 30 sec.

The stop time of the other sides increase correspondingly to the number of sensors activated of the previous side.

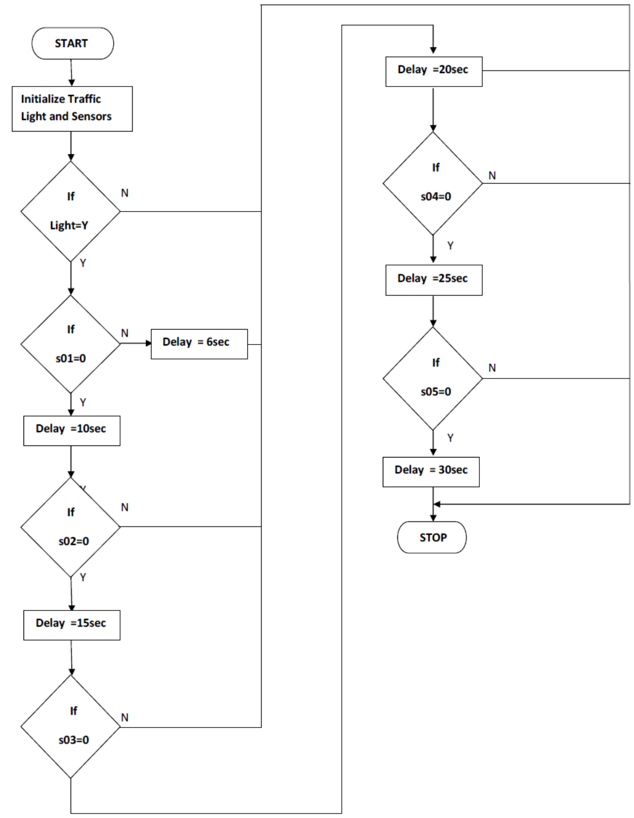

Figure. 6 Flow Chart

The ports are checked turn wise for the number of activated sensors and the Go time is set according to the function above.

When the Green light of the signal is about to end, the yellow light of the next signal turns on indicating the road users that the signal is about to turn green.

B. Algorithm of Microcontroller Operation

The Before programming the AT89C52, the address, data, and control signals should be set up according to the “Flash Programming Modes [8].” To program the AT89C52,take the following steps:

1) Input the desired memory location on the address lines.
2) Input the appropriate data byte on the data lines.
3) Activate the correct combination of control signals.
4) Raise EA/VPP to 12V.
5) Pulse ALE/PROG once to program a byte in the Flash array or the lock bits. The byte write cycle is self-timed and typically takes no more than 50 µs. Repeat steps 1 through 5, changing the address and data for the entire array or until the end of the object file is reached.

Programming is done on Keil software. Various steps to program 8051:

1. Write the code in a notepad file.
2. *.hex file is generated using Keil software.
3. *.hex file is burnt into the micro-controller using burner.

Algorithm:-

```
#include<reg51.h>      //Header file for 8051
#include<delay.h>      //Header file for Delay
#define s22 P20
#define s21 P21
#define s23 P22
#define s25 P23
#define s24 P24
#define r2 P27
#define y2 P26
#define g2 P25

#define s12 P10
#define s11 P11
#define s13 P12
#define s15 P13
#define s14 P14
#define g1 P17
#define y1 P16
#define r1 P15

#define s02 P00
#define s01 P01
#define s03 P02
#define s05 P03
#define s04 P04
#define g0 P07
#define y0 P06
#define r0 P05

#define s32 P30
#define s31 P31
#define s33 P32
#define s35 P33
#define s34 P34
#define g3 P37
#define y3 P36
#define r3 P35

unsigned char delay1,delay2,delay3,delay4;
void check1()
{
If(s01==1||s02==1||s03==1||s04==1||s05==
1)
{
If(s01==1)
delay1=10;
If(s02==1)
delay1=15;
If(s03==1)
delay1=20;
If(s04==1)
delay1=25;
If(s05==1)
delay1=30;
}
else
delay1=6;
}
```

```
void check2()
{
if(s11==1||s12==1||s13==1||s14==1||s15==1)
{
if(s11==1)
delay2=10;
if(s12==1)
delay2=15;
if(s13==1)
delay2=20;
if(s14==1)
delay2=25;
if(s15==1)
delay2=30;
}
else
delay2=6;
}

void check3()
{
if(s21==1||s22==1||s23==1||s24==1||s25==1)
{
if(s21==1)
delay3=10;
if(s22==1)
delay3=15;
if(s23==1)
delay3=20;
if(s24==1)
delay3=25;
if(s25==1)
delay3=30;
}
else
delay3=6;
}

void check4()
{
if(s31==1||s32==1||s33==1||s34==1||s35==1)
{
if(s31==1)
delay4=10;
if(s32==1)
delay4=15;
if(s33==1)
delay4=20;
if(s34==1)
delay4=25;
if(s35==1)
delay4=30;
}
else
delay4=6;
}
```

```
void main()
{
r1=r2=r3=r0=y1=y2=y3=y0=g1=g2=g3=g0=1;
//off all leds
s01=s02=s03=s04=s05=1;
//make input sensor pins
s11=s12=s13=s14=s15=1;
//make input sensor pins
s21=s22=s23=s24=s25=1;
//make input sensor pins
s31=s32=s33=s34=s35=1;
//make input sensor pins
while(1)
{
check2();
r1=1;r2=r3=r0=0;
y1=y2=y3=y0=g2=g3=g0=1;
g1=0;
//0 means ON 1means OFF
secdelay(delay2);
y1=y2=y0=1;y3=0;r3=1;
secdelay(3);
check4();
r3=1;r2=r0=r1=0;
y1=y2=y3=y0=g2=g1=g0=1;
g3=0;
secdelay(delay4);
y1=y3=y0=1;y2=0;r2=1;
secdelay(3);
check3();
r2=1;r3=r1=r0=0;
y1=y2=y3=y0=g3=g1=g0=1;
g2=0;
secdelay(delay3);
y1=y3=y2=1;y0=0;r0=1;
secdelay(3);
check1();
r0=1;r2=r3=r1=0;
y1=y2=y3=y0=g2=g3=g1=1;
g0=0;
secdelay(delay1);
y2=y3=y0=1;y1=0;r1=1;
secdelay(3);
}
}
```

IV. Hardware Implementation and Schematic Description

With reference to Figure.8 the sensors consists of IR emitter and photo detector pairs. In this prototype authors has used four ports of microcontroller where the sensors are interfaced with the five pins as input to the port and traffic light LEDs has interfaced with the remaining three pins of same port as output. For the traffic system shown in Figure7, four sets of traffic lights and sensor units are interfaced with the four ports of AT89C52.

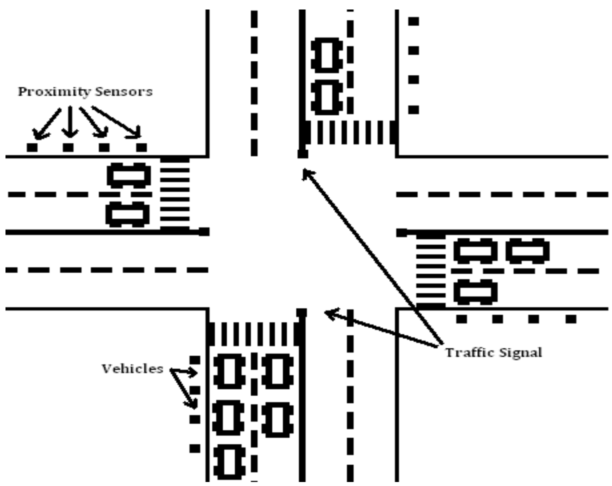

Figure. 7 Traffic System for Proposed Prototype

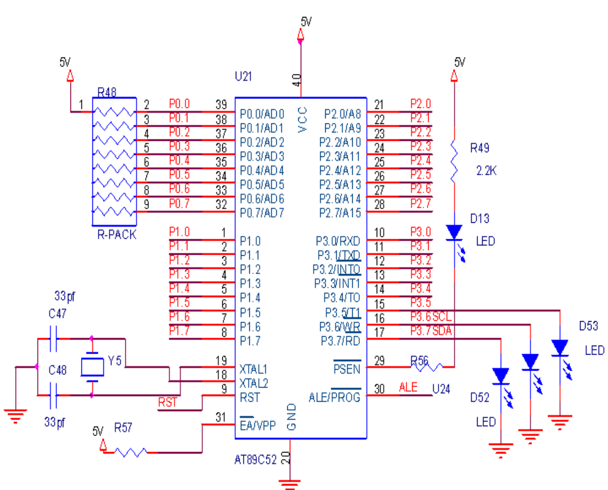

Figure. 8 Schematic of Port wise Hardware Implementation

Figure 8 shows the port wise hardware implementation. This schematic has been drawn in ORCAD. Where all the four ports are used for all traffic sensor units and traffic lights. After the simulation and successful code execution the work is actually implemented as shown in Figure 9.

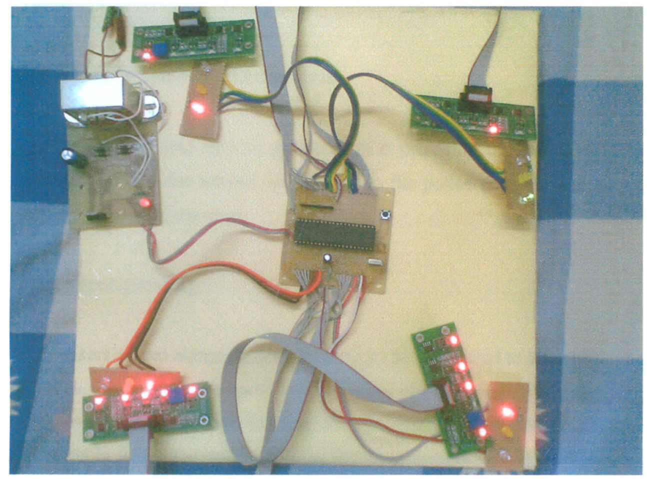

Figure. 9. Actual Hardware Implementation

V. Conclusion and Future Scopes

In this work of intelligent traffic control, the traffic frequency is measured as a function of number of vehicles which comes under the contact of sensing unit. The number of traffic sensing units with traffic lights can be extended by using 8255 PPI interfacing chip with microcontroller port. Apart from this the following things can be added in this project:

1) Providing the all green signals for ambulance, fire brigade and other emergency services.
2) To detect and locate the vehicle violating the traffic signals.
3) Remote monitoring of traffic by implementing the IP /wireless protocols in embedded core [8].
4) Auto shutdown with alarms when there is sensor failure occurs.

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