Progressive Brake Light

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Faculty of the Electrical Engineering Technology Program
of the University of Cincinnati
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Bachelor of Science
in Electrical Engineering Technology
at the College of Engineering & Applied Science
by

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Bachelor of Science University of Cincinnati

May 2011

Faculty Advisor: Professor Xuefu Zhou
June 7, 2011

Professor Xuefu Zhou
University of Cincinnati
College of Engineering & Applied Science
2220 Victory Parkway
Cincinnati, OH 45206

Dear Professor Xuefu Zhou:

Attached is my final report on the “Progressive Brake Light” which was requested by the ECET faculty.

This final report covers the details that led to the completion of our project. In this report you will see the problem, solution, credibility, and methodology. These sections will be followed by project conception, design objectives, methodology (design requirements, procedure, and testing), budget, timeline, problems encountered, analysis of problems solved, and future recommendations. The collection of these sections will illustrate the process of how the device was conceived as an idea, through its implementation.

Throughout the duration of this project, I was advised not only by you, but also all of the advisors for Senior Design. These faculty members were instrumental in the design, implementation, and documentation of our project. I appreciate your time and effort reviewing this report. If any questions or comments arise, feel free to contact me.

Sincerely,

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Progressive Brake Light

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Submitted in partial fulfillment of the degree of
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Electrical Engineering Technology

Student Signature ______________________________

Advisor Signature ______________________________
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ABSTRACT

When a vehicle is moving at a moderate pace during traffic, it can be quite difficult to tell if the driver ahead is simply tapping their brakes or slamming them. This causes most drivers to react no matter what the situation because of this unknown factor. A progressive brake light uses an analog distance sensor to measure the amount of compression on a brake pedal. Based on that level of compression, the brake light would output different patterns to indicate tapping the brakes, normal braking or slamming the brakes. The input and output is controlled through an 8051 microcontroller. By keeping drivers more alert to the situation they are approaching the drivers following would be able to react accordingly. This would cause traffic to move at a faster pace while also creating a safer situation for other drivers.
INTRODUCTION

Driving is a normal part of most individual’s daily routines. This would include a personal motor vehicle or public transportation. During most weekdays a normal occurrence of the phenomenon “Traffic Jams” happens during the peak driving hours. Most individuals dislike the highly congested traffic for many reasons. Safety is typically one of those reasons.

When a vehicle is moving at a moderate pace during traffic, it can be quite difficult to tell if the driver ahead is simply tapping their brakes or slamming them. This causes most drivers to react no matter what the situation because of this unknown factor. If a progressive brake light was installed on a vehicle the driver would be able to tell if the person ahead was trying to stop or just tapping their brakes. The progressive brake light system has three phases to indicate if a driver is tapping the brakes, normally braking, or slamming them. By indicating to other people what a driver is trying to do when pressing the brake, a person could react properly. This would cause traffic to move at a faster pace while also creating a safer situation for other drivers.

DISCUSSION

Problem

The standard break light on most vehicles today has two simple functions, on or off. This is applied when the driver presses the brake pedal with any amount of pressure. The difference between a tap of the breaks and a complete compression doesn’t matter for the output of the light. This would be comparable to having a stop light with only the green and red lights functioning. During a high congestion of traffic this can cause drivers to become overly cautious of vehicles ahead. When a driver does not know if the vehicle in front of them is trying to stop or just lightly pressing the brake, the driver has no choice but to also press their brake as a precautionary measure. A study from smartmotorist.com states, “Over 95% of motor vehicle accidents (MVAs, in the USA, or Road Traffic Accidents, RTAs, in Europe) involve some degree of driver behavior.” This includes poor braking habits. When a driver is tapping their brakes frequently other drivers have no choice but to apply the brakes. This can cause a chain reaction and slow the rate of traffic. Quick stops and frequent braking can cause a driver to become overly cautious which could lead to accidents.

Solution

A Progressive Brake Light is a modified version of the standard brake light used on nearly all vehicles today. A study in Europe from 2003 tested 30 drivers using a brake light that would flash when decelerating at a rate of 6m/s² or more. This rate of deceleration is considered a fast stop or slamming the brakes. Their results showed that 60% agreed that a blinking brake light caused the driver to be more alert and stop at a faster rate. When the vehicle was stopped at 7m/s² or more 80% agreed that the flashing light was helpful. By using a brake light that would emit patterns or flashing signal, a driver would be able to control a situation better.

The Progressive Brake Light would display a variable pattern on the brake light based on the compression level of the brake pedal. The brake light would emit a small amount of light that would flash slowly to indicate the brake pedal has only been tapped or lightly pressed. This light would be orange or yellow and appear similar to a hazard light on automobiles. If the pedal was pressed at a medium level to produce a normal braking pattern, the light would emit a reasonable amount of light to indicate a normal stopping brake light. Finally, when the pedal is compressed strongly to stop the car at the fastest rate possible, the brake light would emit a very bright light with a flashing pattern. This flashing pattern would indicate to drivers nearby that the vehicle is trying to stop abruptly.
Methodology

The Progressive Brake Light will use a microcontroller to control the operations of the lights. A timer function for stage one and two could also be controlled using the microcontroller. The program will be written in embedded programming language. The brake pedal will be replicated using a homemade model of an actual brake. This will be a compressible device similar to how a brake pedal operates.

The brake light will be constructed of a group of LED’s placed on a platform to replicate a real brake light. An analog distance sensor will be used to detect the level of compression. The sensor outputs a voltage level based on the distance acquired. This voltage level will be converted from analog signal to a digital input. The input will be read from the microcontroller and output to the correct lighting stage based on the distance. The demonstration will show the brake compressed at each level with the proper output displayed on the brake light. The block diagram in Figure 1 shows the process and arrangement of the Progressive Brake Light system.

Figure 1: Progressive Brake Light Block Diagram
Progressive Brake Light

Hardware

The hardware used in this project will consist of a few components. An 8051 microcontroller will be used for the main programming function and output for the project. The microcontroller will output logic high signals to a relay switch which will enable a group of LEDs on the brake light to emit. The relay switch will enable a 12 Volt battery to power the LEDs and display the proper lighting output. Each lighting stage of the project will be controlled using an analog distance sensor. The GP2Y0A21 Sharp distance sensor can detect a range of 4cm to 30cm. Based on the distance recorded the sensor will output a voltage level. This level will be converted using a voltage divider circuit and NOT gates tied to each output pin of the op amps. This converts a high signal input to low which would be monitored on the 8051 port pins. As each pins logic level is dropped low the microcontroller will run the program according to the input. The output from the 8051 will be fed into relay switches to control the LEDs.

Software

There is very little software used in this project but it is important. The 8051 microcontroller is used to program the lighting outputs. This will be programmed in embedded systems language. The program will read the input from the analog distance sensor and will send an output signal to a relay switch based on the distance measured. Three levels of input are possible for the microcontroller to read. A tap would have only one port pin low. A normal braking level would have two port pins tied low and finally slamming the brakes would place three port pins low. For each level the microcontroller will run a loop which will operate the LED output based on the input provided.

Implementation

This project took around four months to complete with some technical issues delaying the original time line. The original estimation was around 3 months. The timeline for this project has been created and can be seen below in Figure 2.
Figure 2: Project Gantt Chart Timeline

The Gantt chart in Figure 2 shows the timeline that was followed during the design, building, and testing process. The timeline runs about four months of work broken down by each process.

Budget

<table>
<thead>
<tr>
<th>Component</th>
<th>Manufacture (If Available)</th>
<th>Part Number</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog Distance Sensor</td>
<td>Sharp</td>
<td>GP2Y0A21</td>
<td>$20</td>
</tr>
<tr>
<td>LED Strips</td>
<td>n/a</td>
<td>n/a</td>
<td>$35</td>
</tr>
<tr>
<td>Brake Replica</td>
<td>n/a</td>
<td>n/a</td>
<td>$15</td>
</tr>
<tr>
<td>8051 Microcontroller Kit</td>
<td>n/a</td>
<td>n/a</td>
<td>Free</td>
</tr>
<tr>
<td>Project Case (For 8051)</td>
<td>n/a</td>
<td>n/a</td>
<td>$15</td>
</tr>
</tbody>
</table>

Figure 3: Parts List with Estimated Cost

The parts list shown in Figure 3 is the list of necessary components to complete the project. This list is the final version based on all components used in the building process. The final total cost based on the estimations listed in Figure 3 would be around $85 dollars.

The goal for this project was to create a fully functioning Progressive Brake Light. The final budget shows that this system is very cheap and could easily be adapted on to a new car system. The Progressive Brake Light system offers a cheap solution to an everyday driving problem.

Credentials

Through my studies at the University of Cincinnati, I have developed many skill sets which will benefit this project. My work in embedded systems and circuit analysis will help the production of the microcontroller and wiring scheme. Additionally my work from electronics, digital systems, and circuit analysis helped to provide knowledge to complete the project.

Qualification

I have been involved with my families used car business since I was born. Automobiles are second nature to me and I found a strong interest in electronic systems built into vehicles. I will apply my passion into my project which will be a great learning experience. I have done minor work on automobile electrical systems but I would like to learn more. This project helped me expand my knowledge of automobile electrical systems as well as project management.
Progressive Brake Light

Problems Encountered

The original design for this project had some design flaws when put into production. This caused some major delay in the building process. The original design called for the use of four relay switches. Two of the relays were placed as inputs to the microcontroller to drop the port pins to ground when activated. The problem occurred due to a low amount of current driving from the 741 op amps to the relays. The original circuit can be seen below.

Figure 4: Original Circuit design

A solution to the problem was to remove the input relays and use NOT gates to invert the signal and drop the port pins. This allows the microcontroller to start the program operations and output the proper light sequence. Another adjustment made was adding a third 741 op amp into the voltage divider to increase the output accuracy levels. This allowed each 741 to turn on when the analog distance sensor was located at each level of compression (taping, normal braking, and slamming brakes). The first op amp would output when analog sensor was in the taping level. During normal braking both the first and second 741’s would output and finally when the sensor was almost fully compressed all three 741’s would be outputting logic high. Figure 5 below shows an updated version on the circuit diagram.

Figure 5: Updated Circuit design
Future Recommendations

Full Scale reproduction

The project was designed to be for demo purposes only but the project could be adapted into a real model. A full size vehicle could be used to input the system and display the output on the brake lights. This would truly show the operation of the system on a realistic scale. This adaptation would require knowledge of the automobiles on board computer system and how to properly write code into that system. Also the analog distance sensor would need to be attached to the brake pedal to get full scale function from the system.

Time Function

The original system does not take into account that the driver would be pressing the brake pedal for an extended amount of time. If a driver was approaching a stop light or stop sign the driver would eventually fully press the pedal to ensure a complete stop. On the current system this would cause the output to read a slamming function and cause the brake light to flash constantly until the pedal was released. A simple time function could be placed into the system to monitor the amount of time a pedal is pressed and revert to a normal brake light output. If the brakes were slammed the output would stay in “slammed brake” mode for a few seconds then output a solid brake light to indicate the car has continued to stop or is fully stopped.

CONCLUSION

The Progressive Brake Light system can be a useful system for future cars. This system can alert drivers to the specific type of situation they are approaching. If a person could tell when a driver is slamming there brakes versus tapping them, other drivers could react faster to the appropriate situation. The Progressive Brake Light system would also help the flow of traffic jams by allowing drivers to maintain higher speeds without worrying whether the vehicle ahead is trying to fully stop or just tapping their brakes. The project required skills learned from the classroom and personal experience. This is a fairly cheap solution to a problem that can cause serious injury or even worse, death. This project could be a stepping stone to a new series of safety measure taken by car companies to make driving a better experience.
REFERENCES

APPENDIX A

Program Code

: Jakob Bayman Sr Design 2011
: Progressive Brake Light system

: Start of program

.EQU COUNT, 30H

MOV TMOD, #01H ; INITIALIZE TIMER MODE

MAIN:

: Start of timer function (used for future development) and for Delay function

XX1:

MOV tl0, #0afh ; clr timer lo bit
MOV th0, #3ch ; clr timer hi bit
Setb tr0 ; start timer

Loop:

jnb tf0, Loop ; overflow check if not stay at loop
clr tf0 ; reset overflow
clr tr0 ; stop timer

: Begin checking ports on microcontroller for system operation

Lght:

clr p2.3 ; clears out the output ports 2.3, 2.2
clr p2.2

: The following sequences check the status of input ports 3.5, 3.6, 3.7
: based on the status of those ports the program will output the proper sequence

XX2:

setb p3.5 ; test switch for open or closed
jnb p3.5, XX3 ; jump to next stage check if closed
sjmp Lght ; if not closed jump to Lght to start checking sequence over

XX3:

setb p3.6 ; test switch for open or closed
jnb p3.6, XX4 ; jump to stage one if closed
sjmp SG1 ; if p3.5 is only closed start stage 1 output
XX4:

```
setb p3.7 ; test switch for open or closed
jnb p3.7, SG3 ; if closed jump to stage 3 output
sjmp SG2 ; if p3.6 and p3.5 are only closed start stage 2 output

; Stage 1 is used when port 3.5 is closed this stage is used for tapping the brakes
```

SG1:

```
setb p2.3 ; output to LED for stage 1
LCALL DELY ; used for short delay
LCALL DELY
LCALL DELY
LCALL DELY
LCALL DELY
clr p2.3 ; turns off p2.3 to make LED flash as its toggles
LCALL DELY
LCALL DELY
LCALL DELY
LCALL DELY
setb p2.3 ; turns off p2.3 to make LED flash as its toggles
LCALL DELY
LCALL DELY
LCALL DELY
LCALL DELY
LCALL DELY
clr p2.3 ; turns off p2.3 to make LED flash as its toggles
jnb p3.5, Chk ; check for change to input ports if not check next port
Chk:

jnb p3.6, Lght ; check for change to input ports if so restart program
jnb p3.7, Lght ; check for change to input ports if so restart program
sjmp SG1 ; if no change to input ports loop stage 1 output
```

; Stage 2 is the standard output of a brake light which is fully lit up LEDs with no flash
; Stage 2 occurs when a normal amount of compression is applied to brake, aka average stop

SG2:

```
setb p2.3 ; output to LED for stage 2
```
Progressive Brake Light

```
setb p2.2 ;turns on p2.2, p2.3

LCALL DELY ;delay

LCALL DELY ;delay

LCALL DELY

LCALL DELY

jnb p3.5, C1 ;check for change to input ports if not check next port

C1:  jnb p3.6, C2 ;check for change to input ports if not check next port

C2:  jnb p3.7, Lght ;check for change to input ports if so restart program

sjmp SG2 ;Loop Stage 2 output if no changes to ports

:Stage 3 is used when the brake has been slammed or fully compressed

:The output has all lights on and flashes at a fast rate

SG3:  setb p2.3 ;output to LED for stage 3

setb p2.2 ;turns on p2.2, p2.3

LCALL DELY

LCALL DELY

LCALL DELY

clr p2.3 ;turn off p2.3, 2.2

clr p2.2

LCALL DELY

LCALL DELY ;delay

LCALL DELY

setb p2.2 ;turn on p2.2, p2.3

setb p2.3

LCALL DELY

LCALL DELY

LCALL DELY

clr p2.3

clr p2.2

jnb p3.5, B1 ;check for change to input ports if not check next port
```
Progressive Brake Light

B1:  jnb  p3.6, B2  ;check for change to input ports if not check next port

B2:  jnb  p3.7, SG3  ;check for change to input ports if no change, loop Stage 3 output
      sjmp  Lght  ;if port p3.7 is not close jump to beginning to restart program

;SUBROUTINE
;Used for delay function during the program

DELY:  MOV  TH0, #0D8H  ;LOAD UPPER BYTE
      MOV  TL0, #0EFH  ;LOAD LOWER BYTE
      SETB  TR0  ;Start Delay timer
      RET  ;Return from subroutine

.END
Progressive Brake Light

Analog Distance Sensor Output

NOTES:
- White paper (90% Reflectance)
- Gray paper (18% Reflectance)
Progressive Brake Light

Circuit Diagram

<table>
<thead>
<tr>
<th>Components</th>
<th>Value/Manufacture</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1-R4</td>
<td>1K ohm /5%</td>
</tr>
<tr>
<td>U1 - Analog Distance Sensor</td>
<td>Sharp GP2D120</td>
</tr>
<tr>
<td>U2-U4</td>
<td>LM741 Op Amp/ Texas Instruments</td>
</tr>
<tr>
<td>D1 - D2</td>
<td>Diode/ National Semiconductor</td>
</tr>
<tr>
<td>U5-U7</td>
<td>NOT Gate/ Assorted Manufacture</td>
</tr>
<tr>
<td>U8</td>
<td>89C51RB2-UM/ ATMEl</td>
</tr>
<tr>
<td>K1 - K2</td>
<td>QUAZ-SS-105D/ Radio Shack</td>
</tr>
<tr>
<td>LED1 &amp; LED2</td>
<td>Flexible LED Strips/ Oznium.com</td>
</tr>
</tbody>
</table>
**LM741 Operational Amplifier**

**General Description**

The LM741 series are general purpose operational amplifiers which feature improved performance over industry standards like the LM709. They are direct, plug-in replacements for the 709C, LM201, MC1499 and 748 in most applications. The amplifiers offer many features which make their application nearly foolproof: overload protection on the input and output, no latch-up when the common mode range is exceeded, as well as freedom from oscillations.

The LM741C is identical to the LM741/LM741A except that the LM741C has its performance guaranteed over a 0°C to +70°C temperature range, instead of −55°C to +125°C.

**Features**

**Connection Diagrams**

**Metal Can Package**

**Dual-in-Line or S.O. Package**

**Ceramic Flatpack**

Order Number LM741C

Soo NS Package Number J06A, M08A or N08E

**Typical Application**

Offset Nulling Circuit

**Progressive Brake Light**

**SHARP**

**GP2D120**
Optoelectronic Device

**FEATURES**
- Analog output
- Effective range: 4 to 30 cm
- Typical response time: 39 ms
- Typical start up delay: 44 ms
- Average Current Consumption: 33 mA

**DESCRIPTION**
The GP2D120 is a distance measuring sensor with integrated signal processing and analog voltage output.

**Figure 1. Pinout**

**Figure 2. Block Diagram**