ECEN 3100 Digital Logic
Fall 2008

Laboratory #5 – T-bird Taillight Controller

Name #1 (Primary Author)
Name #2 (Secondary Author)

Date and Time

Abstract: The objective of this laboratory is to learn how to program and use Programmable Logic Devices (PLDs). The ABEL programming language, ispLever (Lattice Semiconductor's software development environment, and Lattice Semiconductor's GAL16V8 or GAL22V10 were used to implement a controller for the taillights for a Ford Thunderbird.

Introduction (NOTE: information in the introduction was gathered from the description given in the laboratory assignment)**:** The T-bird tail lights refer to the tail lights on the old Ford Thunderbird automobile. The tail lights consist of a set of 3 lights on the right and left side on the rear of the car. Lighting the lights in various sequences indicated right and left turns, brakes (stop), and emergency flashers. Figure 1 describes the tail light functionality

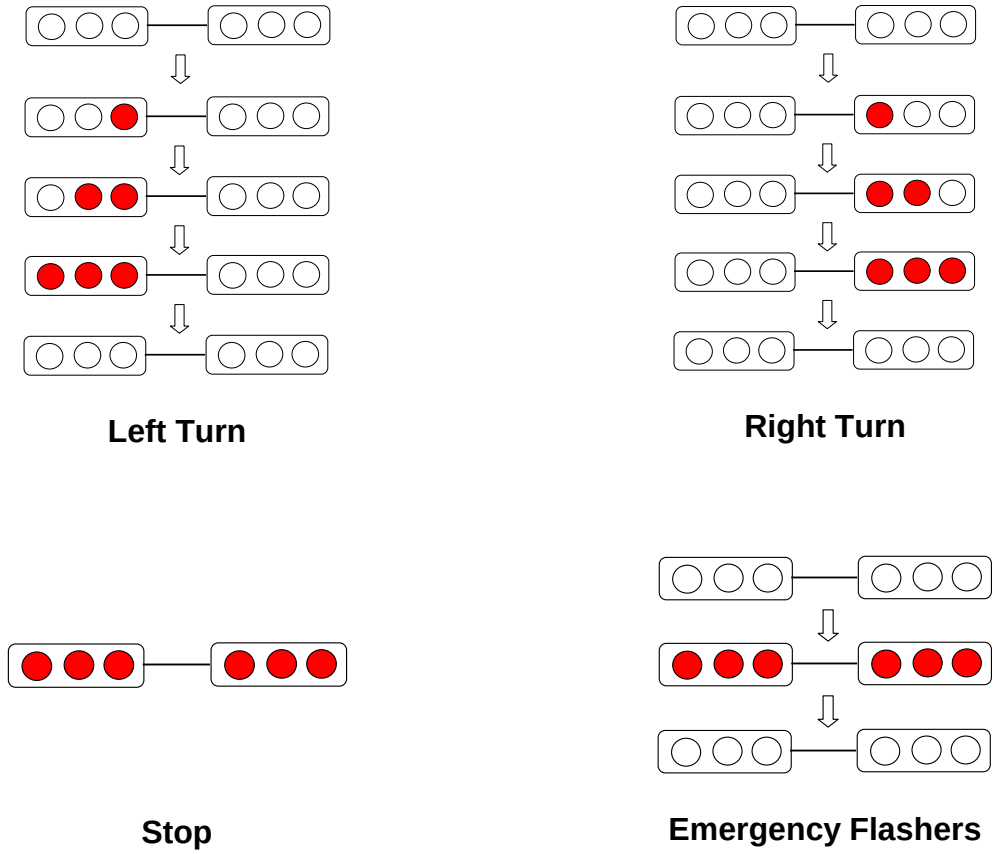

Figure 1 – T-bird Tail Light Functions.

ABEL is one of several hardware description languages used to describe the implementation of a logic circuit in a programmable device. ABEL is an acronym for Advanced Boolean Expression Language. The ABEL language programming manual can be found on Lattice Semiconductor's website [1].

The development environment we used is Lattice Semiconductor's ispLever. The programmable devices we used in the design are the GAL16V8 or the GAL22V10. The application, the documentation, and the specification for the GAL devices can be downloaded from the "download" page on Lattice Semiconductor's website [2].

Main Body:

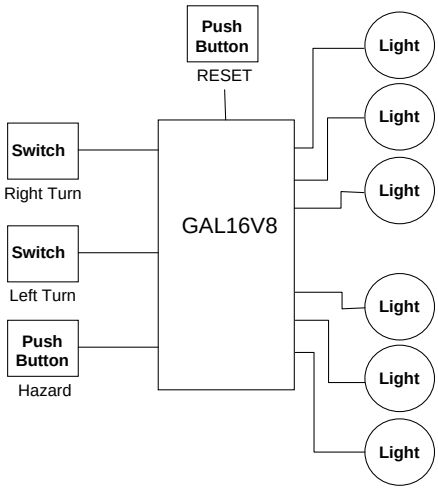

Figure 2. Block diagram of the circuit.

Figure 2 show a block diagram of the circuit. The T-Bird tail light controller uses only 1 GAL16V8 device, two switches to emulate the right and left turn signals, and two push buttons. One push button for the emergency flashers (hazard lights); and another for the system reset. The brakes are activated when both the left and right turn switches are activated. The brakes override the other light functions except system reset. Table 1 shows these functions.

RESET	Haz	Right	Left	Function
0	0	0	0	Nothing – all lights are off
0	0	0	1	Left turn.
0	0	1	0	Right turn
0	0	1	1	Brake
0	1	0	0	Emergency flashers
0	1	0	1	Emergency flashers
0	1	1	0	Emergency flashers
0	1	1	1	Brake
1	0	0	0	Reset – all lights are off
1	0	0	1	Reset – all lights are off
1	0	1	0	Reset – all lights are off
1	0	1	1	Reset – all lights are off
1	1	0	0	Reset – all lights are off
1	1	0	1	Reset – all lights are off
1	1	1	0	Reset – all lights are off
1	1	1	1	Reset – all lights are off

Table 1. System functions

The program for the controller is as follows

```
MODULE tbirdsd

TITLE 'State Machine for T-Bird Tail Lights'

" Input and Output Pins
CLOCK, LEFT, RIGHT, HAZ, RESET     pin 1, 2, 3, 4, 5;
L3Z, L2Z, L1Z, R1Z, R2Z, R3Z     pin 18..13 istype 'reg';

" Definitions
QSTATE       = [L3Z,L2Z,L1Z,R1Z,R2Z,R3Z];    "State variables
IDLE   = [  0,  0,  0,  0,  0,  0];       "State definitions
L1       = [  0,  0,  1,  0,  0,  0];
L2       = [  0,  1,  1,  0,  0,  0];
L3       = [  1,  1,  1,  0,  0,  0];
R1       = [  0,  0,  0,  1,  0,  0];
R2       = [  0,  0,  0,  1,  1,  0];
R3       = [  0,  0,  0,  1,  1,  1];
LR3    = [  1,  1,  1,  1,  1,  1];

equations
QSTATE.CLK = CLOCK;

state_diagram QSTATE
state IDLE:  if RESET then IDLE
                  else if (HAZ # LEFT & RIGHT) then LR3
                  else if LEFT then L1 else if RIGHT then R1
                  else IDLE;
state L1:  if RESET then IDLE else if HAZ then LR3 else L2;
state L2:  if RESET then IDLE else if HAZ then LR3 else L3;
state L3:  goto IDLE;
state R1:  if RESET then IDLE else if HAZ then LR3 else R2;
state R2:  if RESET then IDLE else if HAZ then LR3 else R3;
state R3:  goto IDLE;
state LR3:  goto IDLE;


END
```

Attached is the “chip report” for the system showing the logic equations generated by the compiler, chip usage, and pin diagram for connecting the GAL chip to the switches, push button, and LEDs.

CHIP REPORT

ispLEVER 6.0.00.34.28.06 - Device Utilization Chart Tue Oct 16 19:05:46 2007

State Machine for T-Bird Tail Lights

Module : 'tbirdsd'

Input files:

ABEL PLA file : tbird_taillights.tt3
Device library : P16V8R.dev

Output files:

Report file : tbird_taillights.rpt
Programmer load file : tbird_taillights.jed

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State Machine for T-Bird Tail Lights

P16V8R Programmed Logic:

```
L3Z.D   = (  L3Z.Q & !L2Z.Q & !L1Z.Q & R1Z.Q & R2Z.Q & R3Z.Q & !RESET
           #   L3Z.Q & L2Z.Q & L1Z.Q & !R1Z.Q & R3Z.Q & !RESET & HAZ
```

```
           #   L3Z.Q & L2Z.Q & R1Z.Q & R2Z.Q & R3Z.Q & !RESET & HAZ
           #   L3Z.Q & L2Z.Q & L1Z.Q & R1Z.Q & R2Z.Q & R3Z.Q & !RESET & LEFT
             & RIGHT ); " ISTYPE 'INVERT'
L3Z.C   = (  CLOCK );

L2Z.D   = (  L3Z.Q & !L1Z.Q & R1Z.Q & R2Z.Q & R3Z.Q & !RESET
           #   L3Z.Q & L2Z.Q & L1Z.Q & !R1Z.Q & R3Z.Q & !RESET & HAZ
           #   L3Z.Q & L2Z.Q & L1Z.Q & R2Z.Q & R3Z.Q & !RESET & HAZ
           #   L3Z.Q & L2Z.Q & R1Z.Q & R2Z.Q & R3Z.Q & !RESET & LEFT & RIGHT );
         " ISTYPE 'INVERT'
L2Z.C   = (  CLOCK );

L1Z.D   = (  L3Z.Q & !L1Z.Q & R1Z.Q & R2Z.Q & R3Z.Q & !RESET
           #   L3Z.Q & L2Z.Q & L1Z.Q & !R1Z.Q & R3Z.Q & !RESET & HAZ
           #   L3Z.Q & L2Z.Q & L1Z.Q & R2Z.Q & R3Z.Q & !RESET & HAZ
           #   L3Z.Q & L2Z.Q & R1Z.Q & R2Z.Q & R3Z.Q & !RESET & LEFT );
         " ISTYPE 'INVERT'
L1Z.C   = (  CLOCK );

R1Z.D   = (  L3Z.Q & L2Z.Q & L1Z.Q & !R1Z.Q & R3Z.Q & !RESET
           #   L3Z.Q & L2Z.Q & L1Z.Q & R2Z.Q & R3Z.Q & !RESET & HAZ
           #   L3Z.Q & !L1Z.Q & R1Z.Q & R2Z.Q & R3Z.Q & !RESET & HAZ
           #   L3Z.Q & L2Z.Q & L1Z.Q & R2Z.Q & R3Z.Q & !RESET & RIGHT );
         " ISTYPE 'INVERT'
R1Z.C   = (  CLOCK );

R2Z.D   = (  L3Z.Q & L2Z.Q & L1Z.Q & !R1Z.Q & R3Z.Q & !RESET
           #   L3Z.Q & L2Z.Q & R1Z.Q & R2Z.Q & R3Z.Q & !RESET & HAZ
           #   L3Z.Q & !L1Z.Q & R1Z.Q & R2Z.Q & R3Z.Q & !RESET & HAZ
           #   L3Z.Q & L2Z.Q & L1Z.Q & R2Z.Q & R3Z.Q & !RESET & LEFT & RIGHT );
         " ISTYPE 'INVERT'
R2Z.C   = (  CLOCK );

R3Z.D   = (  L3Z.Q & L2Z.Q & L1Z.Q & !R1Z.Q & !R2Z.Q & R3Z.Q & !RESET
           #   L3Z.Q & L2Z.Q & L1Z.Q & R2Z.Q & R3Z.Q & !RESET & HAZ
           #   L3Z.Q & !L1Z.Q & R1Z.Q & R2Z.Q & R3Z.Q & !RESET & HAZ
           #   L3Z.Q & L2Z.Q & L1Z.Q & R1Z.Q & R2Z.Q & R3Z.Q & !RESET & LEFT
             & RIGHT ); " ISTYPE 'INVERT'
R3Z.C   = (  CLOCK );
```

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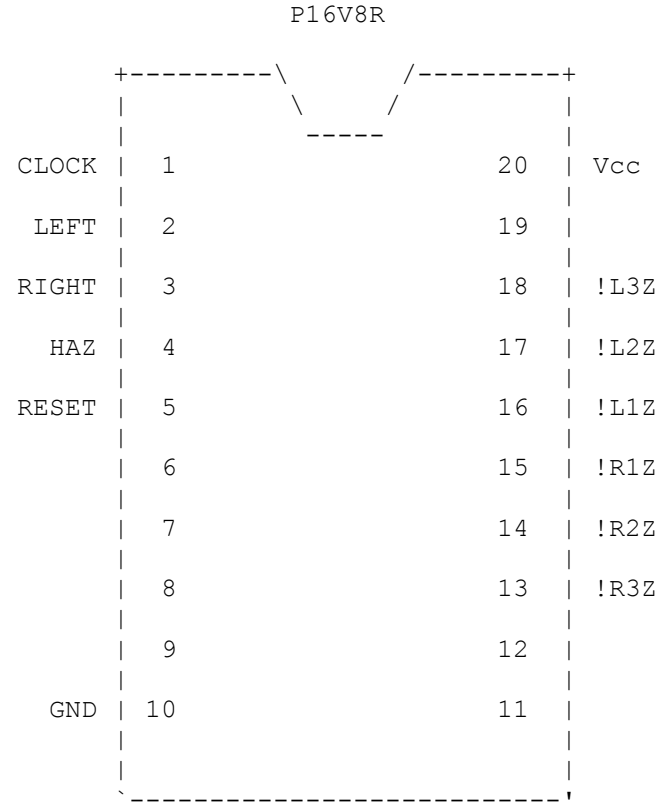
State Machine for T-Bird Tail Lights

P16V8R Chip Diagram:



SIGNATURE: N/A

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State Machine for T-Bird Tail Lights

P16V8R Resource Allocations:

Device Resources	Resource Available	Design Requirement	Unused
Input Pins:			
Input:	10	5	5 (50 %)
Output Pins:			
In/Out:	8	6	2 (25 %)
Output:	-	-	-
Buried Nodes:			
Input Reg:	-	-	-
Pin Reg:	8	6	2 (25 %)
Buried Reg:	-	-	-

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State Machine for T-Bird Tail Lights

P16V8R Product Terms Distribution:

Signal Name	Pin Assigned	Terms Used	Terms Max	Terms Unused
L3Z.D	18	4	8	4
L2Z.D	17	4	8	4
L1Z.D	16	4	8	4
R1Z.D	15	4	8	4
R2Z.D	14	4	8	4
R3Z.D	13	4	8	4

==== List of Inputs/Feedbacks ====

Signal Name	Pin	Pin Type
CLOCK	1	CLK
RESET	5	INPUT
HAZ	4	INPUT
LEFT	2	INPUT
RIGHT	3	INPUT

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State Machine for T-Bird Tail Lights

P16V8R Unused Resources:

Pin Number	Pin Type	Product Terms	Flip-flop Type
6	INPUT	-	-
7	INPUT	-	-
8	INPUT	-	-
9	INPUT	-	-
12	BIDIR	NORMAL 7	D
19	BIDIR	NORMAL 7	D

Summary: The laboratory was completed successfully. When tested the lights generated the correct patterns for the control inputs.

References:

[1] http://www.latticesemi.com/lit/docs/manuals/abel_ref.pdf
[2] http://www.latticesemi.com/

ENCE-3100 Laboratory #3a Sign-off

Please attach this sheet to your lab report.

Name _____

Name _____

☐ T-Bird Tail Lights verified

Comments

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T.A./Instructor Signature Date