Faculty of Artificial Intelligence
Ghulam Ishaq Khan Institute of Engineering Sciences and Technology

Smart Density-Based Traffic Simulator

Project Report for

CE-221: Digital Logic Design

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1 Project Overview

This project implements a smart, density-based traffic control system designed for a two-way junction. The project deliverables include:

1. **Density-Based Switching:** Junction lighting controlled by density comparison, utilizing binary adders and magnitude comparators.

2. **Emergency Override:** A priority mechanism that instantly sets all signals to 'Red' (Halt) status.

3. **Logic Implementation:** Application of push counters, reset counters, NAND logic, and ensuring system fail-safes.

The design was first verified using Karnaugh maps, simulated in Proteus, and finally implemented on a hardware breadboard.

2 Operational Logic

The traffic control logic is designed with a default bias towards **Lane A**, maintaining a *Green* signal for Lane A and *Red* for Lane B under normal conditions.

Automatic signal switching is governed by a dynamic density comparison. Lane B is granted passage only when its vehicle density (D_B) significantly exceeds that of Lane A (D_A), adhering to the threshold condition:

$$D_B > D_A + 2$$

The system also incorporates manual control:

- Dip switches allow for operator-controlled signal switching.

- A high-priority emergency interrupt that sets all signals to *Red*.

- In the event of conflicting inputs (e.g., both manual switches toggled ON), the logic defaults to a safety and makes both signals Red.

3 Hardware Used

The following components were utilized in the hardware implementation:

Component Name	Qty	Function
NE 555 (timer)	2	Increase counter
74LS90 (decade counter)	2	Maintain counter
74LS47 (BCD decoder)	2	Decode signal for 7-seg display
7-SEG Anode	2	Display density
74LS83 (Adder)	1	Density logic
74LS85 (comparator)	1	Density logic
7400 (NAND)	4	Density logic
8-bit DIP Switch	1	Manual control
LEDs	4	Visual indication of the traffic lights
Resistors (220Ω, $1k\Omega$, $10k\Omega$)	20	Current limiting, NE 555 use.
Capacitor ($1\mu F$)	4	Regulate volt supply, NE 555 use
Breadboard	4	Platform for circuit assembly.
9V Battery	1	Energy Supply

Table 1: List of Components

4 Block Diagram

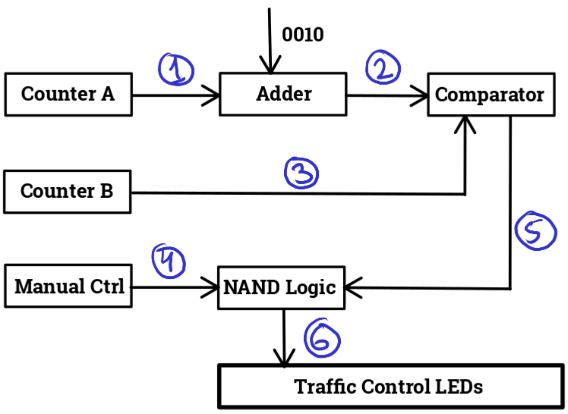
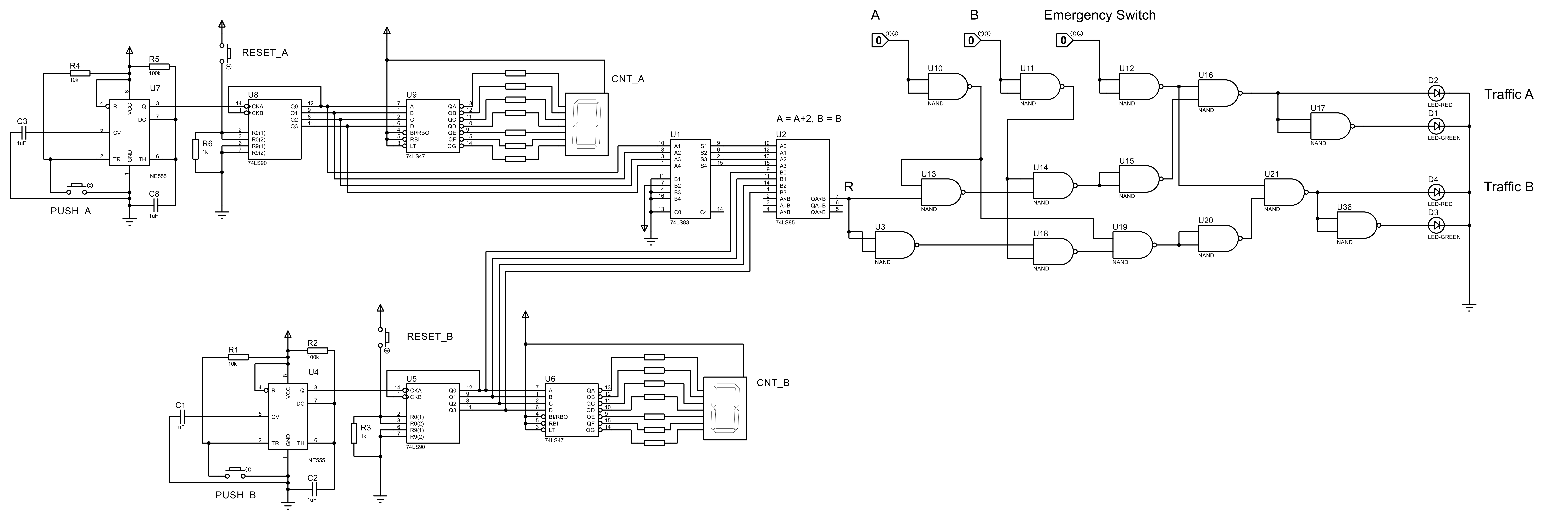


Figure 1: Design Block Diagram


PUSH_A
RESET_A
CNT_A
PUSH_B
RESET_B
CNT_B
A = A+2, B = B
R
A
B
Emergency Switch
Traffic A
Traffic B
U7
NE555
U8
74LS90
U9
74LS47
U1
74LS83
U2
74LS85
U4
U5
U6
R1
10k
R2
100k
R3
1k
R4
10k
R5
100k
R6
1k
C1
1uF
C2
1uF
C3
1uF
C8
1uF
D1
LED-GREEN
D2
LED-RED
D3
LED-GREEN
D4
LED-RED
NAND

5 Design Equations & K-Maps

The following Karnaugh maps represent the logic simplification for the state variables. Note: A and B are the manual switches for each junction, E is the emergency override, and $R =$ Density $A + 2 <$ Density B.

5.1 Green at Traffic A

$RE \backslash AB$	00	01	11	10
00	1	0	0	1
01	0	0	0	0
11	0	0	0	0
10	0	0	0	1

Figure 2: K-Map for Green Light at A

$$\mathbf{G_A = \overline{R}\,\overline{E}\,\overline{B} + A\overline{B}\,\overline{E}}$$

5.2 Red at Traffic A

Since $R_A = \overline{G_A}$,

$$R_A = \overline{(\overline{R}\,\overline{E}\,\overline{B}) + (A\overline{B}\,\overline{E})}$$

DeMorgan (Sum to Product):

$$R_A = (\overline{\overline{R}\,\overline{E}\,\overline{B}}) \cdot (\overline{A\overline{B}\,\overline{E}})$$

DeMorgan (Product to Sum):

$$R_A = (R + E + B) \cdot (\overline{A} + B + E)$$

Let $X = B + E$, and use absorption:

$$R_A = (X + R)(X + \overline{A})$$

$$\mathbf{R_A = B + E + R\overline{A}}$$

5.3 Green at Traffic B

$R\,E$ \ $A\,B$	00	01	11	10
00	0	1	0	0
01	0	0	0	0
11	0	0	0	0
10	1	1	0	0

Figure 3: K-Map for Green Light at B

$$\mathbf{G_B = R\,\overline{E}\,\overline{A} + \overline{A}\,B\,\overline{E}}$$

5.4 Red at Traffic B

Since $R_B = \overline{G_B}$,

$$R_B = \overline{R\,\overline{E}\,\overline{A} + \overline{A}\,B\,\overline{E}}$$

DeMorgan (Sum to Product):

$$R_B = (\overline{R\,\overline{E}\,\overline{A}}) \cdot (\overline{\overline{A}\,B\,\overline{E}})$$

DeMorgan (Product to Sum):

$$R_B = (\overline{R} + E + A) \cdot (A + \overline{B} + E)$$

Let $X = A + E$, and use absorption:

$$R_B = (X + \overline{R})(X + \overline{B})$$

$$\mathbf{R_B = A + E + \overline{R}\,\overline{B}}$$

6 Full Truth Table

A and B are the manual switches for each junction, E is the emergency override, and $R = \text{Density } A + 2 < \text{Density } B$.

Table 2: Full Truth Table

Inputs				Traffic A		Traffic B	
E	A	B	R	G_A	R_A	G_B	R_B
0	0	0	0	1	0	0	1
0	0	0	1	0	1	1	0
0	0	1	0	0	1	1	0
0	0	1	1	0	1	1	0
0	1	0	0	1	0	0	1
0	1	0	1	1	0	0	1
0	1	1	0	0	1	0	1
0	1	1	1	0	1	0	1
1	0	0	0	0	1	0	1
1	0	0	1	0	1	0	1
1	0	1	0	0	1	0	1
1	0	1	1	0	1	0	1
1	1	0	0	0	1	0	1
1	1	0	1	0	1	0	1
1	1	1	0	0	1	0	1
1	1	1	1	0	1	0	1

7 Hardware Implementation

The circuit was successfully assembled on a breadboard. Below is the snapshot of the working circuit.

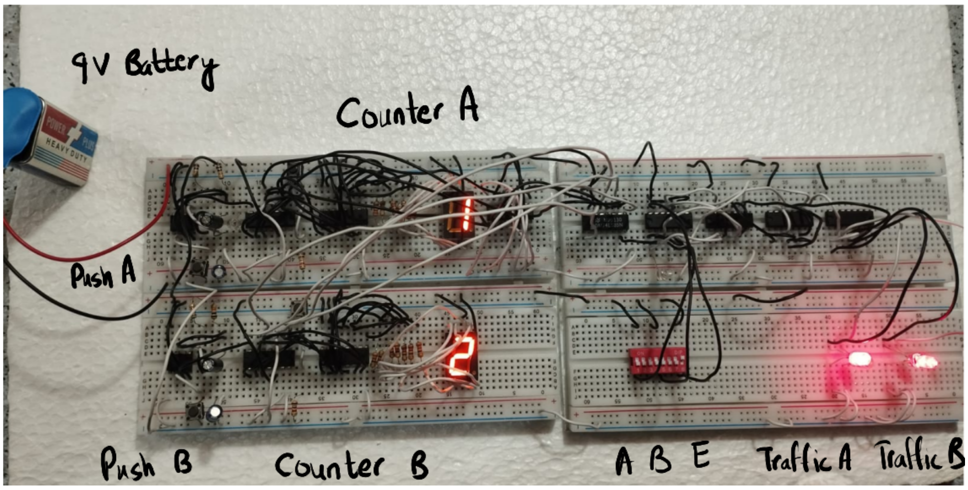


Figure 4: Final Breadboard Assembly (the Emergency Override is ON in the state shown).

8 Source

All available project files, including the Proteus simulation schematics, hardware implementation details, and design logs, are available at the following GitHub repository:

`https://github.com/Sel68/CE221_TrafficSimulator`

9 Acknowledgments

We acknowledge the course instructor for providing the foundational concepts, lectures, and direction that shaped both the design approach and theoretical basis of this project