ECE111 - Digital Circuits
Final Project Submission

User Manual

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Introduction

Hello there, and congratulations on the purchase of your latest product!
Unlike the big players such as Texas Instruments, this product was designed in a dorm room in New Delhi under the guidance of an exceptionally talented electronics professor.

Motivation: I've always wanted to learn the inner workings of electronic devices around me, and this course presented me with an opportunity to do exactly that.
I read about the ASCII system for representing information and was curious about making a system that could display english characters on a seven-segment display using binary inputs.
However, I concluded that making my own conversion scheme would be a lot more efficient as I wouldn't have to deal with the unnecessary characters in the beginning of an ASCII table and using only 5-bits (instead of the 7 needed for ASCII.)
The conversion takes place according to the scheme given below:

0	A	00000
1	B	00001
2	C	00010
3	D	00011
4	E	00100

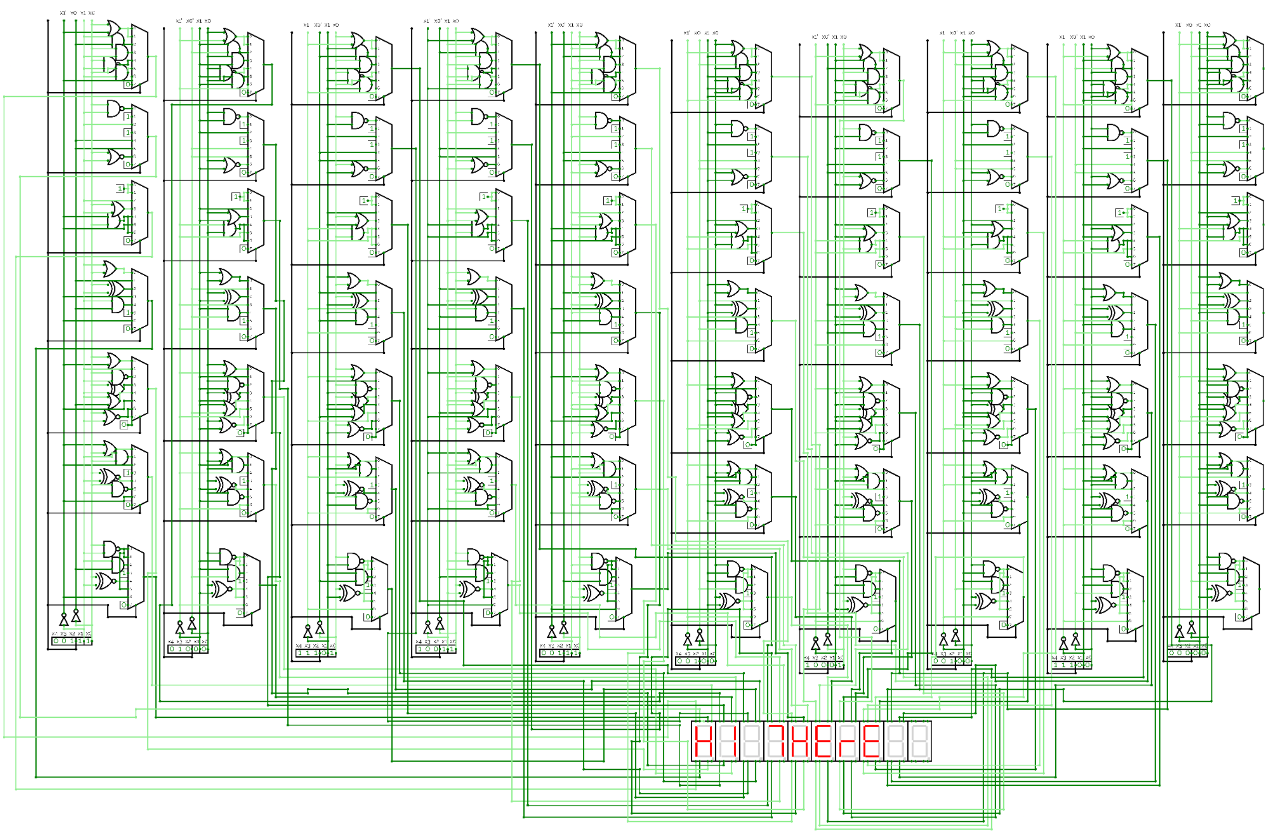
And so on…

I also wrote a python program where you can find the binary representation for English sentences instead of manually looking up the ASCII table for each character.

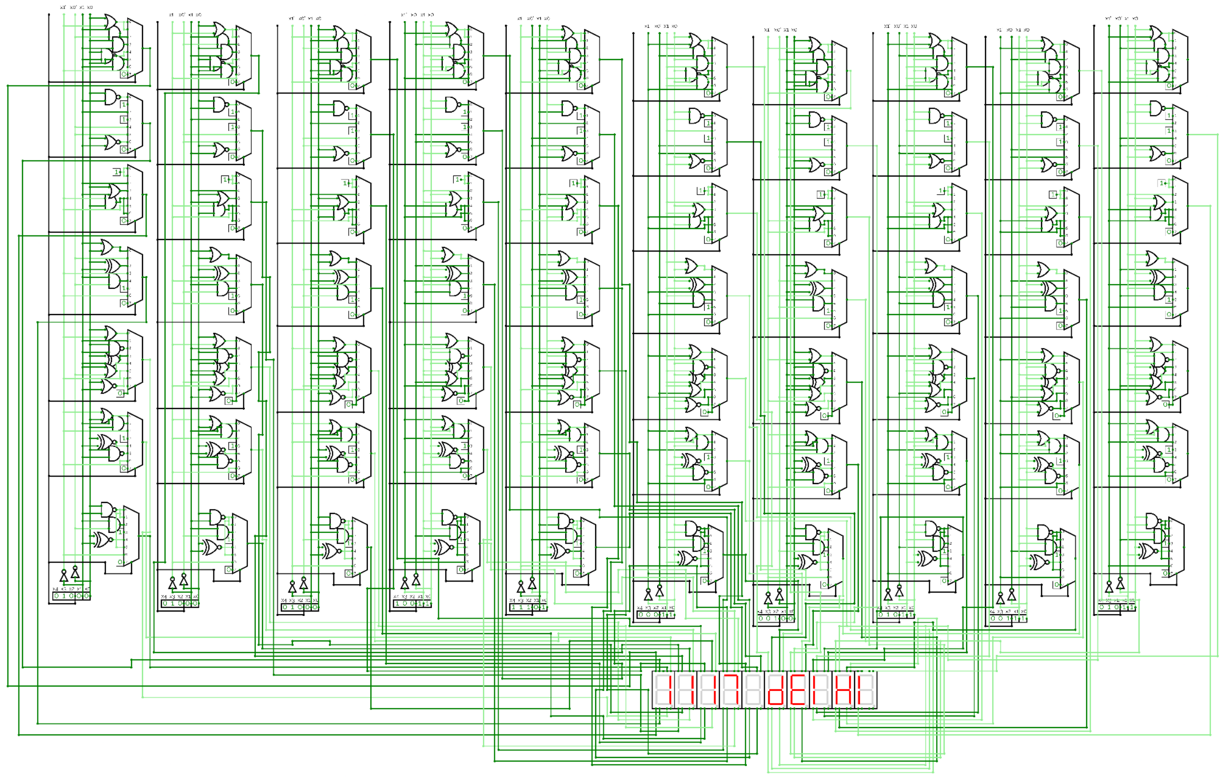
```
================= RESTART: C:\Users\adigi\Desktop\dcProject.py =================

Enter the string (<=9 characters long): aditya

Binary Equivalent: 00000 00011 01000 10011 11000 00000
```

Here are a few examples:

```
Enter the string (<=9 characters long): hi there

Binary Equivalent: 00111 01000 11010 10011 00111 00100 10001 00100
```



```
Enter the string (<=9 characters long): iiit delhi

Binary Equivalent: 01000 01000 01000 10011 11010 00011 00100 01011 00111 01000
```



These are just samples, the circuit can universally represent any English sentence just by changing the input bits.

I'll be elaborating on my design process now.

Truth Table

Given below is the truth table for the 7-segment display

	A_4	A_3	A_2	A_1	A_0	a	b	c	d	e	f	g
A	0	0	0	0	0	1	1	1	0	1	1	1
B	0	0	0	0	1	1	1	1	1	1	1	1
C	0	0	0	1	0	1	0	0	1	1	1	0

D	0	0	0	1	1	0	1	1	1	1	0	1
E	0	0	1	0	0	1	0	0	1	1	1	1
F	0	0	1	0	1	1	0	0	0	1	1	1
G	0	0	1	1	0	1	0	1	1	1	1	0
H	0	0	1	1	1	0	1	1	0	1	1	1
I	0	1	0	0	0	0	1	1	0	0	0	0
J	0	1	0	0	1	0	1	1	1	0	0	0
K	0	1	0	1	0	1	0	1	0	1	1	1
L	0	1	0	1	1	0	0	0	1	1	1	0
M	0	1	1	0	0	1	1	0	1	0	1	0
N	0	1	1	0	1	1	1	1	0	1	1	0
O	0	1	1	1	0	1	1	1	1	1	1	0
P	0	1	1	1	1	1	1	0	0	1	1	1
Q	1	0	0	0	0	1	1	1	0	0	1	1
R	1	0	0	0	1	0	0	0	0	1	0	1
S	1	0	0	1	0	1	0	1	1	0	1	1
T	1	0	0	1	1	1	1	1	0	0	0	0
U	1	0	1	0	0	0	1	1	1	1	1	0
V	1	0	1	0	1	0	1	1	1	1	0	0
W	1	0	1	1	0	0	1	0	1	0	1	0
X	1	0	1	1	1	1	0	0	1	0	0	1
Y	1	1	0	0	0	0	1	1	1	0	1	1
Z	1	1	0	0	1	1	1	0	1	1	0	1

K-maps and Equations

The K-maps seemed daunting at the beginning. I had to make 5-variable k-maps, something I didn’t have a lot of experience with.

However, persistence prevails!

For a

$x_4 = 0$

	00	01	11	10
00	1	1	0	1
01	1	1	0	1
11	1	1	1	1
10	0	0	0	1

$x_4 = 1$

	00	01	11	10
00	1	1	0	1
01	1	1	0	1
11	1	1	1	1
10	0	0	0	1

For b

$x_4 = 0$

	00	01	11	10
00	1	1	1	0
01	0	0	1	0
11	1	1	1	1

10	1	1	0	0

$x_4 = 1$

	00	01	11	10
00	1	0	1	0
01	1	1	0	1
11	1	1	1	1
10	1	1	0	0

For c

$x_4 = 0$

	00	01	11	10
00	1	1	1	0
01	0	0	1	1
11	0	1	0	1
10	1	1	0	1

$x_4 = 1$

	00	01	11	10
00	1	0	1	1
01	1	1	0	0
11	0	0	0	0
10	1	0	0	0

For d

$x_4 = 0$

	00	01	11	10
00	0	1	1	1
01	1	0	0	1
11	1	0	0	1
10	0	1	0	1

$x_4 = 1$

	00	01	11	10
00	0	0	0	1
01	1	1	1	1
11	0	0	0	0
10	1	1	0	0

For e

$x_4 = 0$

	00	01	11	10
00	1	1	1	1
01	1	1	1	1
11	0	1	1	1
10	0	0	1	1

$x_4 = 1$

	00	01	11	10
00	0	1	0	0
01	1	1	0	0
11	0	0	0	0
10	0	1	0	0

For f

$x_4 = 0$

	00	01	11	10
00	1	1	0	1
01	1	1	1	1
11	1	1	1	1
10	0	0	1	1

$x_4 = 1$

	00	01	11	10
00	1	0	0	1
01	1	0	0	1
11	0	0	0	0
10	1	0	0	0

For g

$x_4 = 0$

	00	01	11	10

00	1	1	1	0
01	1	1	1	0
11	0	0	1	0
10	0	0	0	1

$x_4 = 1$

	00	01	11	10
00	1	1	0	1
01	0	0	1	0
11	0	0	0	0
10	1	1	0	0

Equations

$$a = x_4 \left[\overline{x_3}\,\overline{x_2}\left(\overline{x_1}\,\overline{x_0} + x_1 x_0\right) + \overline{x_3}\,x_2\left(\overline{x_1} + \overline{x_0}\right) + x_3\overline{x_2}\left(\overline{x_1}\right) + x_3 x_2 (0) \right]$$

$$+ \overline{x_4}\left[\overline{x_3}\,\overline{x_2}\left(\overline{x_1} + \overline{x_0}\right) + \overline{x_3}\,x_2\left(\overline{x_1} + \overline{x_0}\right) + x_3\overline{x_2}\left(x_1\overline{x_0}\right) + x_3 x_2 (1) \right]$$

$$b = x_4 \left[\overline{x_3}\,\overline{x_2}\left(\overline{x_1}\,\overline{x_0} + x_1 x_0\right) + \overline{x_3}\,x_2\left(\overline{x_1} + \overline{x_0}\right) + x_3\overline{x_2}\left(\overline{x_1}\right) + x_3 x_2 (0) \right]$$

$$+ \overline{x_4}\left[\overline{x_3}\,\overline{x_2}\left(\overline{x_1} + x_0\right) + \overline{x_3}\,x_2\left(x_1 x_0\right) + x_3\overline{x_2}\left(\overline{x_1}\right) + x_3 x_2 (1) \right]$$

$$c = x_4 \left[\overline{x_3}\,\overline{x_2}\left(\overline{x_0} + x_1\right) + \overline{x_3}\,x_2\left(\overline{x_1}\right) + x_3\overline{x_2}\left(\overline{x_1}\,\overline{x_0}\right) + x_3 x_2 (0) \right]$$

$$+ \overline{x_4}\left[\overline{x_3}\,\overline{x_2}\left(\overline{x_1} + x_0\right) + \overline{x_3}\,x_2\left(x_1\right) + x_3\overline{x_2}\left(\overline{x_1} + \overline{x_0}\right) + x_3 x_2\left(\overline{x_1}\,x_0 + x_1\overline{x_0}\right) \right]$$

$$d = \overline{x_4}\left[\overline{x_3}\,\overline{x_2}(x_1+x_0) + \overline{x_3}x_2(\overline{x_0}) + x_3\overline{x_2}(x_1 \oplus x_0) + x_3x_2(\overline{x_0})\right]$$
$$+ x_4\left[\overline{x_3}\,\overline{x_2}(x_1\overline{x_0}) + \overline{x_3}x_2(1) + x_3\overline{x_2}(\overline{x_1}) + x_3x_2(0)\right]$$

$$e = \overline{x_4}\left[\overline{x_3}\,\overline{x_2}(1) + \overline{x_3}x_2(1) + x_3\overline{x_2}(x_1) + x_3x_2(x_1+x_0)\right]$$
$$+ x_4\left[\overline{x_3}\,\overline{x_2}(\overline{x_1}x_0) + \overline{x_3}x_2(\overline{x_1}) + x_3\overline{x_2}(\overline{x_1}\,\overline{x_0}) + x_3x_2(0)\right]$$

$$f = \overline{x_4}\left[\overline{x_3}\,\overline{x_2}(\overline{x_1}+\overline{x_0}) + \overline{x_3}x_2(1) + x_3\overline{x_2}(x_1) + x_3x_2(1)\right]$$
$$+ x_4\left[\overline{x_3}\,\overline{x_2}(\overline{x_0}) + \overline{x_3}x_2(\overline{x_0}) + x_3\overline{x_2}(\overline{x_1}\,\overline{x_0}) + x_3x_2(0)\right]$$

$$g = \overline{x_4}\left[\overline{x_3}\,\overline{x_2}(\overline{x_1}+x_0) + \overline{x_3}x_2(\overline{x_1}+x_0) + x_3\overline{x_2}(x_1\overline{x_0}) + x_3x_2(x_1x_0)\right]$$
$$+ x_4\left[\overline{x_3}\,\overline{x_2}(\overline{x_1}+\overline{x_0}) + \overline{x_3}x_2(x_1x_0) + x_3\overline{x_2}(\overline{x_1}) + x_3x_2(0)\right]$$

This project took lots of sleepless nights and dedication, but most importantly it helped me wrap my mind around the intricacies of designing a digital system.

Here’s the link to my circuitverse workspace:
https://circuitverse.org/users/116787/projects/dcfinalproject

Thank you for the review sir, have a great day!

Python Code (for reference)

```
def decToBase(n, base):
    h = list(l)[:base]
    char = dict([(key, l[key]) for key in h])
    valid = True
    no = ''
    if valid:
        a,b = int(n),0
        while a != 0:
            no += list(char.keys())[list(char.values()).index(a%base)]
            a = a//base
    no = no[::-1]
    return no
print()
s = input('Enter the string: ')
s = s.lower()
out = []
for i in s:
    if i.upper() in l:
        out.append(ord(i)-65)
    elif i == ' ':
        out.append(' ')
    # print(out)
for i in range(len(out)):
    if str(out[i]).isdigit():
        out[i] = decToBase(int(out[i]), 2)
        out[i] = str(out[i])[1:]
    elif out[i] == ' ':
        out[i] = '11010'
    # print(out)
print()
print('Binary Equivalent:', *out, sep=' ')
print()
```