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Circuit Simulation Project

https://esim.fossee.in/circuit-simulation-project

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Project Guide - Dr. Maheswari.R

Title of the Project - Design of a 4-bit BCD to Gray code Converter Ciruit using eSim

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Theory

- ***BCD*** - BCD or Binary Coded Decimal is a number system which assigns a four-bit binary code to each digit from 0 through 9 in a decimal (base-10) numeral. The decimal numbers 1-9 are represented in their normal 4-bit binary form, but from the decimal number 10, we represent each number as it's 4-bit binary equivalent.

  For example, the two-digit decimal number = 10 is divided into individual digits: 1 and 0.
  The binary representation of individual digits (4-bit)
  1 = 0001
  0 = 0000
  Hence, 10 = 0001 0000

The following is a comparison of Decimal, Binary and BCD:

Decimal	Binary	BCD
0	0000 0000	0000 0000
1	0000 0001	0000 0001
2	0000 0010	0000 0010
3	0000 0011	0000 0011
4	0000 0100	0000 0100
5	0000 0101	0000 0101
6	0000 0110	0000 0110
7	0000 0111	0000 0111
8	0000 1000	0000 1000
9	0000 1001	0000 1001
10	0000 1010	0001 0000
11	0000 1011	0001 0001
12	0000 1100	0001 0010
13	0000 1101	0001 0011
14	0000 1110	0001 0100
15	0000 1111	0001 0101

Image source : https://electricalengineering123.com/wp-content/uploads/2016/09/Binary-Coded-Decimal-Addition.jpg

- ***Gray code*** - Gray code is an ordering of the binary numeral system such that two successive values differ in only one bit. For example,

Decimal	Gray Code	Binary
0	0000	0000
1	0001	0001
2	0011	0010
3	0010	0011
4	0110	0100
5	0111	0101
6	0101	0110
7	0100	0111
8	1100	1000
9	1101	1001
10	1111	1010
11	1110	1011
12	1010	1100
13	1011	1101
14	1001	1110
15	1000	1111

Image source : https://www.dynapar.com/hs-fs/hubfs/uploadedImages/_Site_Root/Gray-Code-Encoder-Output.jpg?width=219&height=319&name=Gray-Code-Encoder-Output.jpg

- ***BCD to Gray code conversion:***

The truth table of BCD to Gray code conversion is:

BCD number is the input and the corresponding Gray code is the Output. Decimal number is taken for reference (in the table)

Decimal Number rep.	INPUT				OUTPUT			
	B3	B2	B1	B0	D3	D2	D1	D0
0	0	0	0	0	0	0	0	0
1	0	0	0	1	0	0	0	1
2	0	0	1	0	0	0	1	1
3	0	0	1	1	0	0	1	0
4	0	1	0	0	0	1	1	0
5	0	1	0	1	0	1	1	1
6	0	1	1	0	0	1	0	1
7	0	1	1	1	0	1	0	0
8	1	0	0	0	1	1	0	0
9	1	0	0	1	1	1	0	1

Truth Table reduction using K-Map:

1) D3

B3 B2 \ B1 B0	00	01	11	10
00	0	0	0	0
01	0	0	0	0
11	**x**	**x**	**x**	**x**
10	**1**	**1**	**x**	**x**

`D3 = B3`

2) D2

B3 B2 \ B1 B0	00	01	11	10
00	0	0	0	0
01	1	1	1	1
11	x	x	x	x
10	1	1	x	x

`D2 = B2 + B3`

3) D1

B3 B2 \ B1 B0	00	01	11	10
00	0	0	1	1
01	1	1	0	0
11	x	x	x	x
10	0	0	x	x

D1 = (B2'.B1) + (B2.B1')

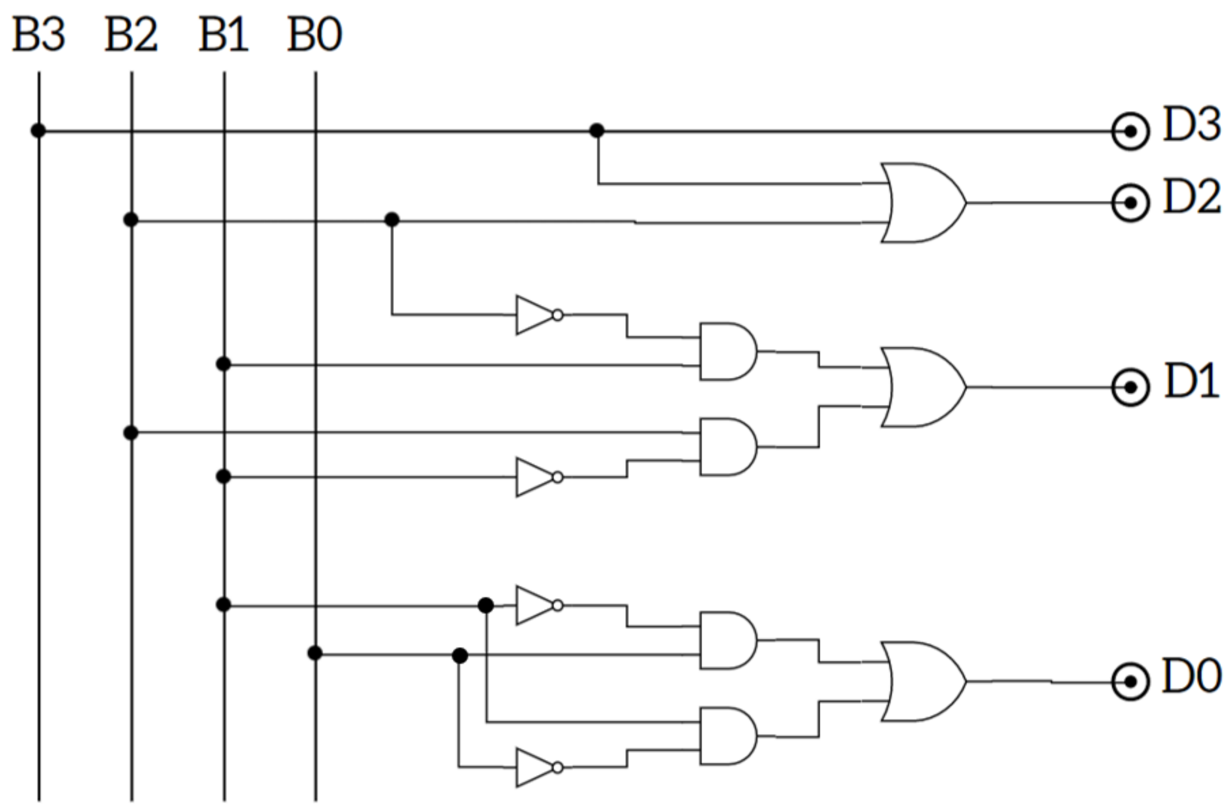
4) D0

B3 B2 \ B1 B0	00	01	11	10
00	0	1	0	1
01	0	1	0	1
11	x	x	x	x
10	0	1	x	x

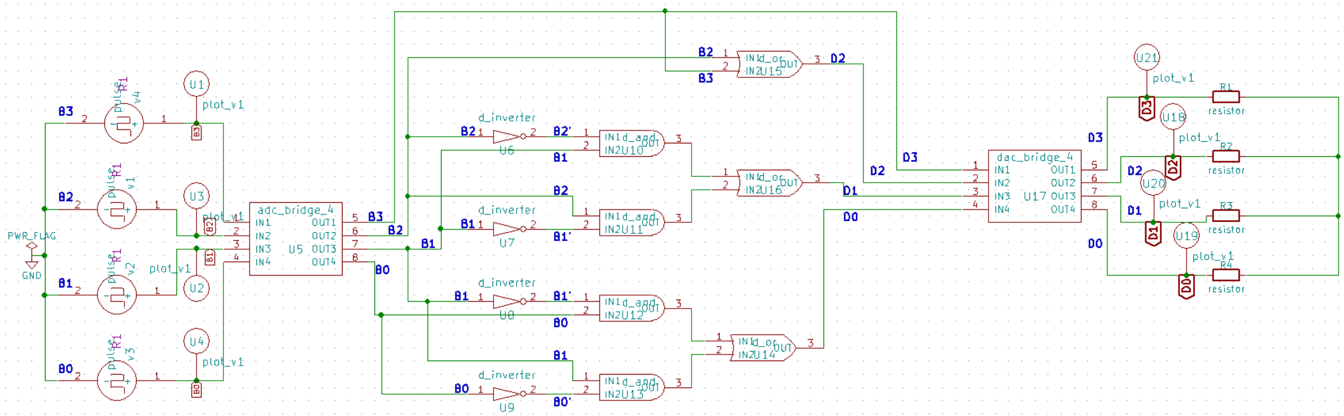
D1 = (B1'.B0) + (B1.B0')

- ***Circuit Diagram:***

The circuit can be implemented using basic gates - and, nor, not



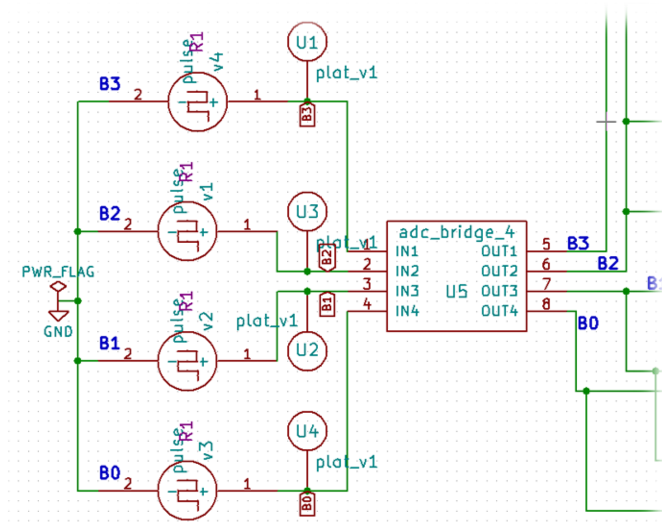
eSim Implementation



The main circuit has three parts:

1. **Input**

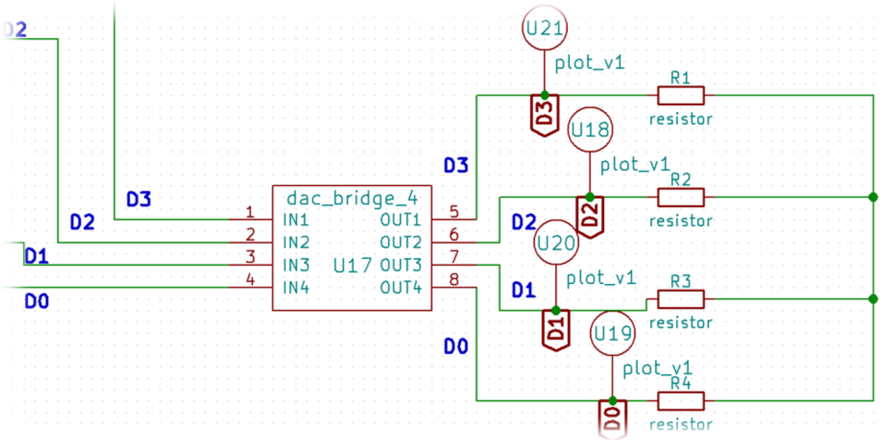
The 4-bit BCD input is of the form :- **B3 B2 B1 B0**



We make use of the analog to digital converter to convert the input analog pulses into digital as we make use of logic gates (that work only on digital signals)

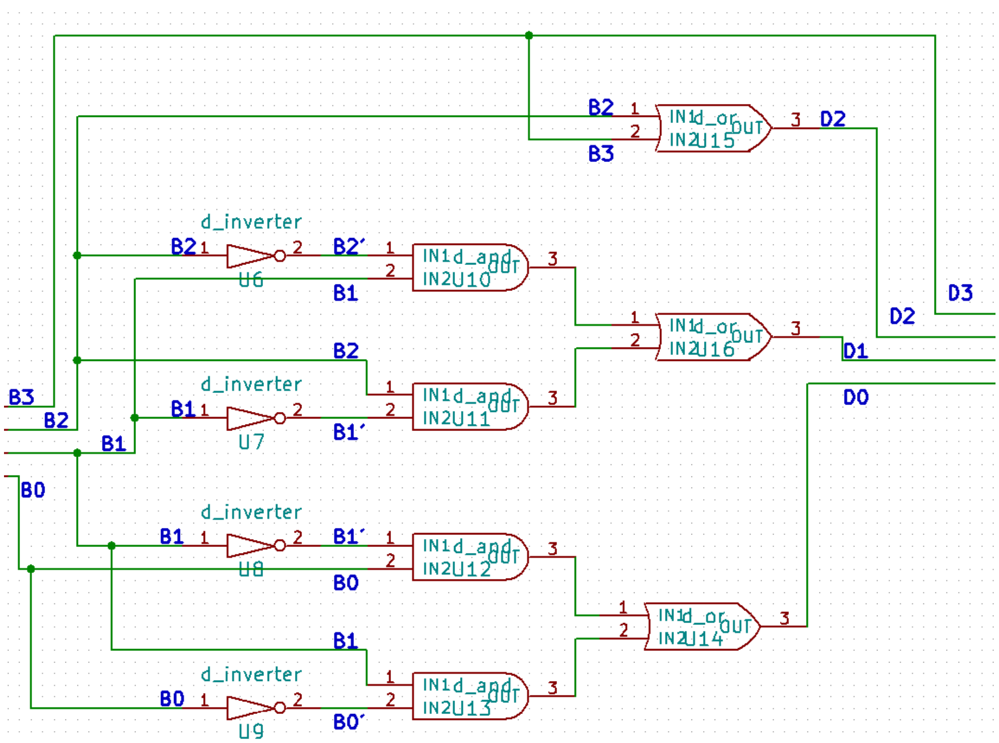
2. Output

The 4-bit Gray code output is of the form :- **D3 D2 D1 D0**



We make use of the digital to analog converter to convert the signals back into analog and compute the output

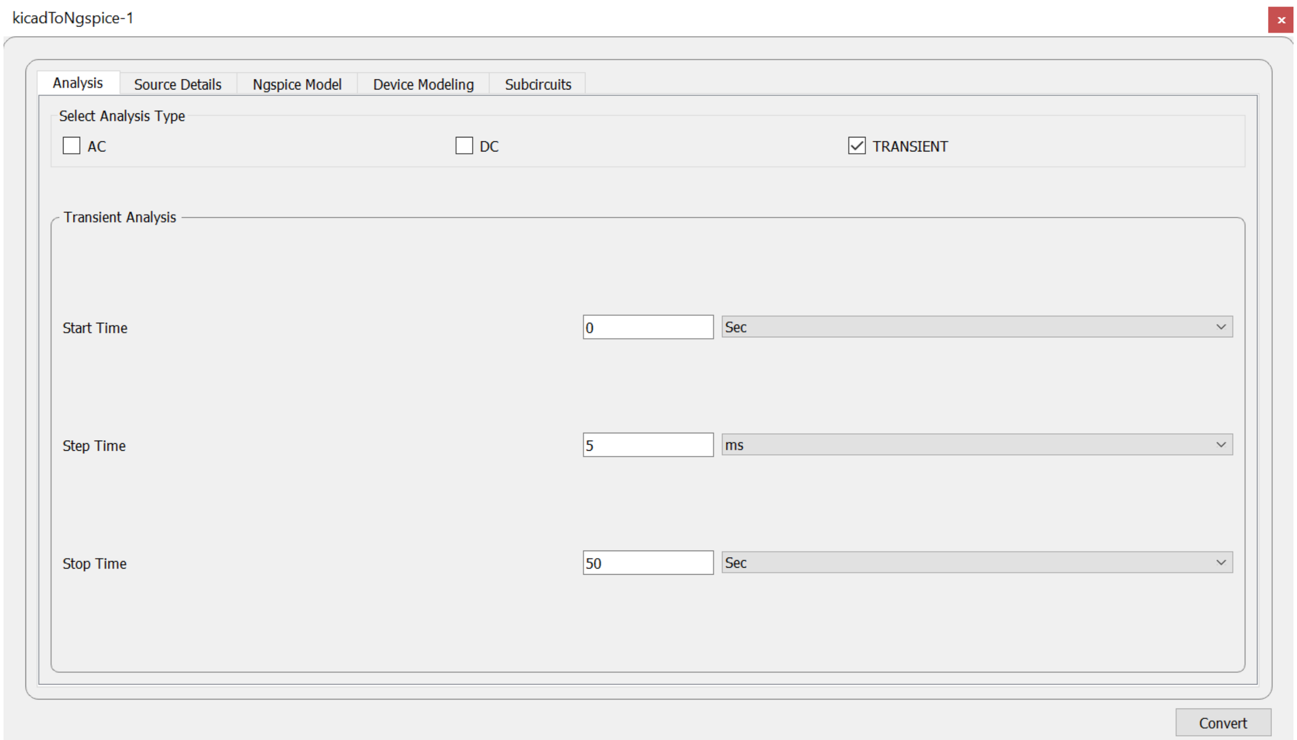
3. Logic Circuit



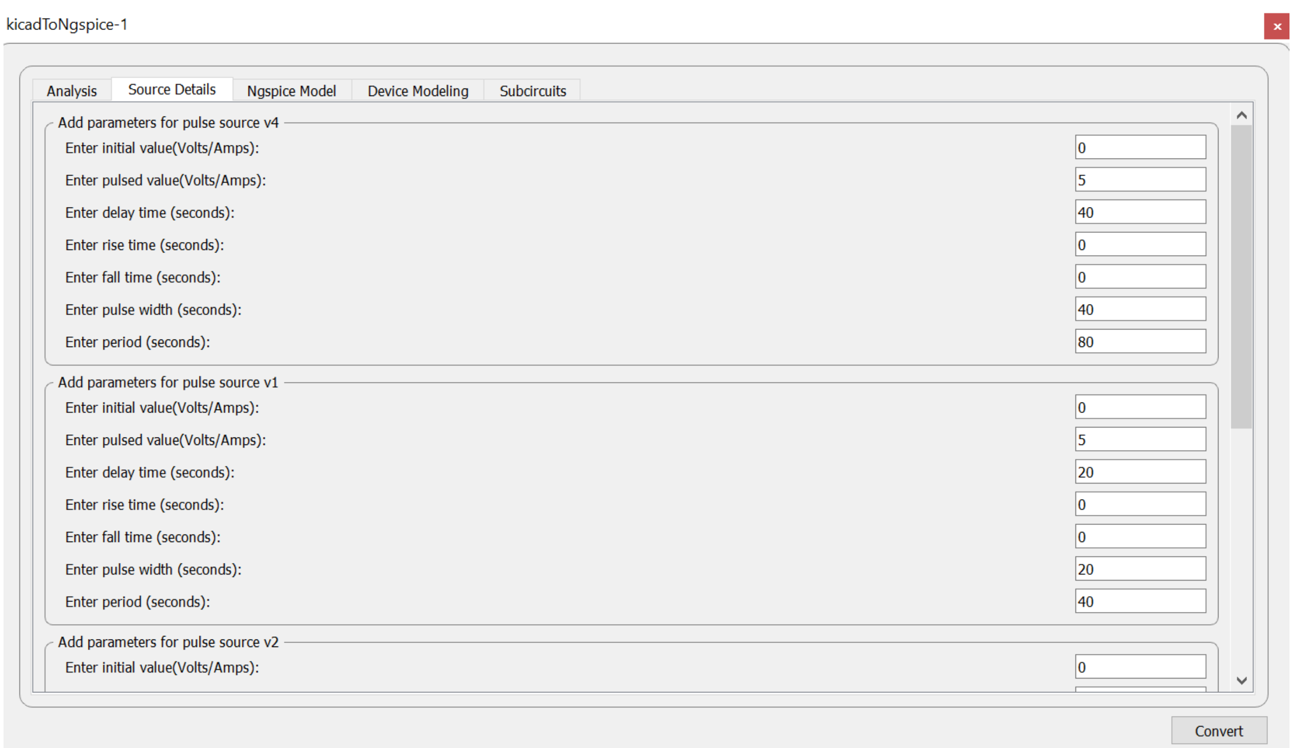
The circuit has been implemented from the previously derived logic circuit diagram.

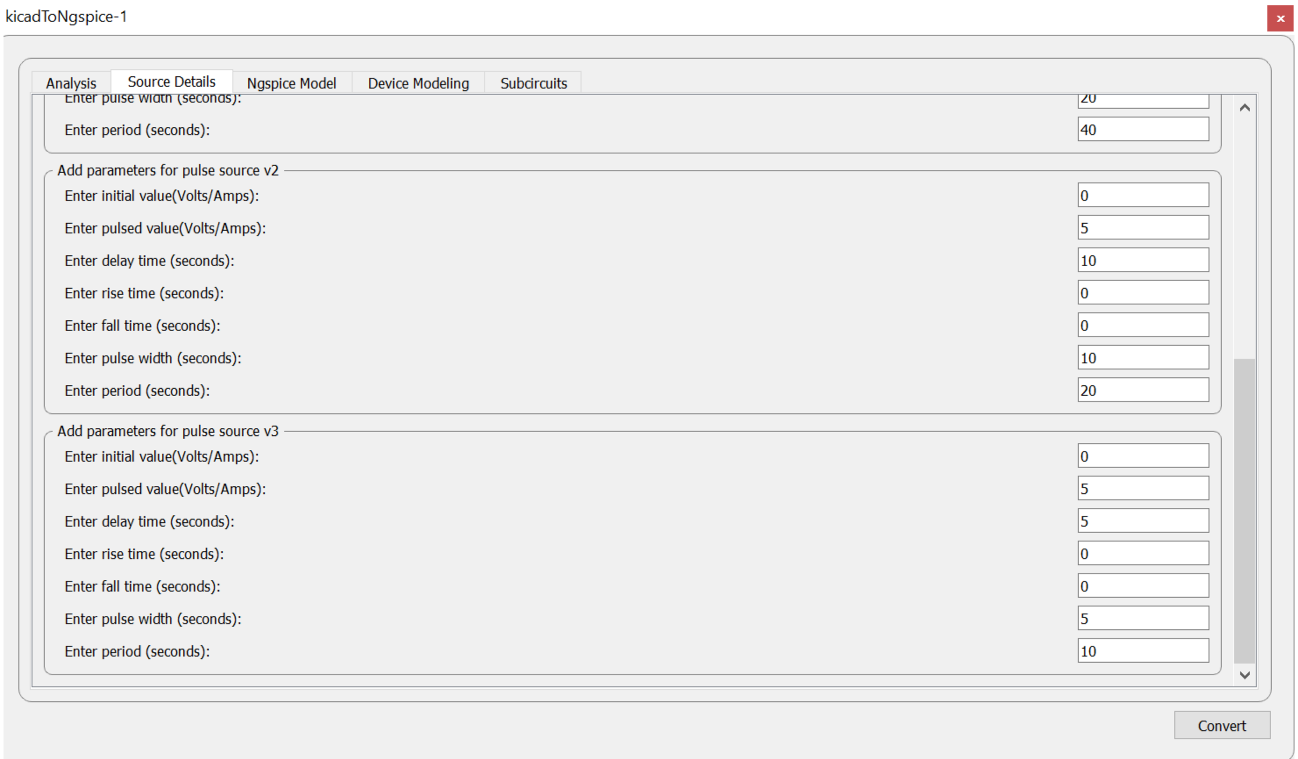
Kicad to Ngspice Conversion

Here we make use of transient analysis:



Source Details:



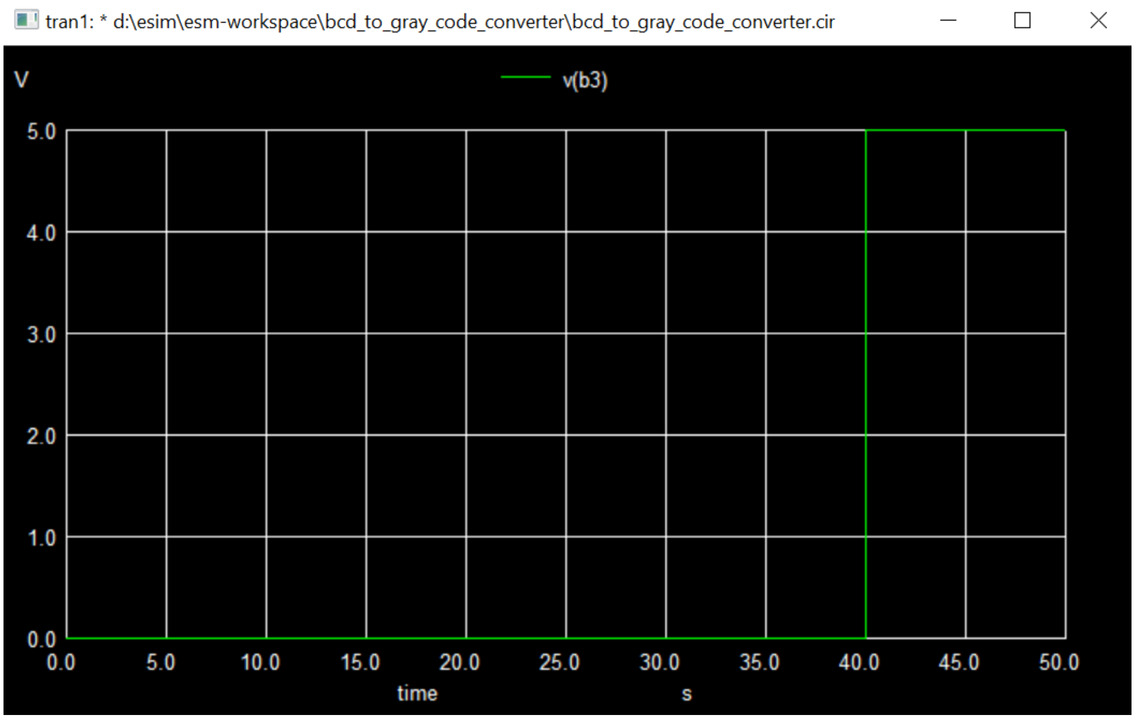


Other fields are left as default.

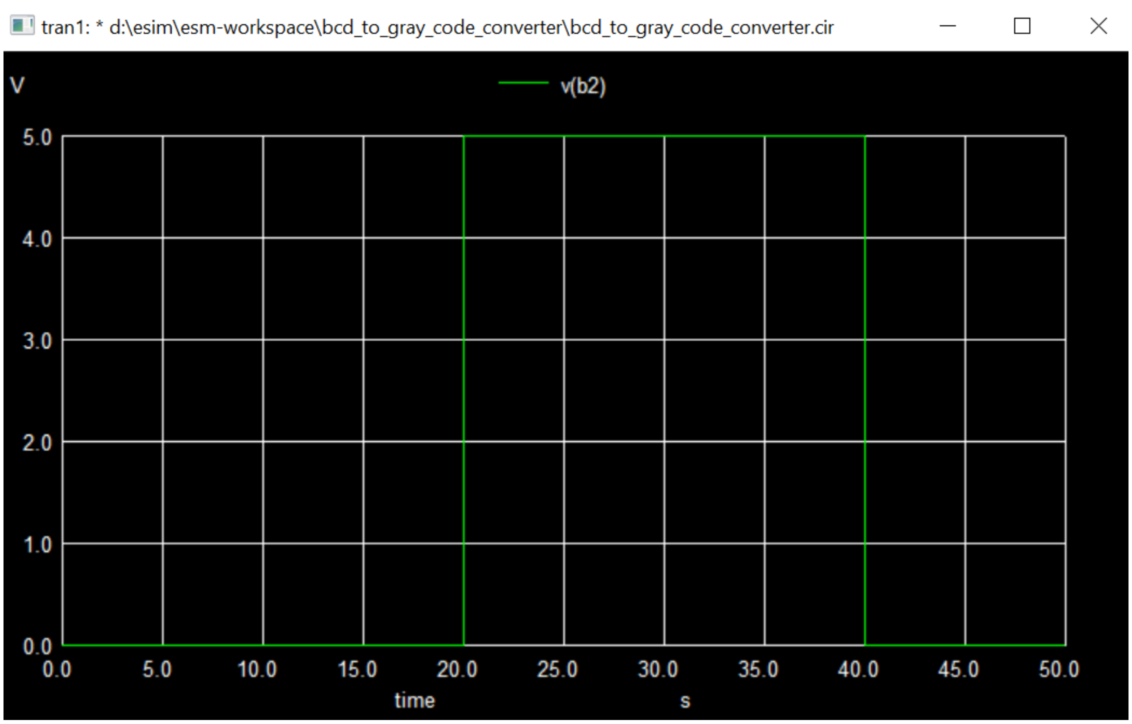
Circuit simulation Output

I. NGSPICE PLOTS:

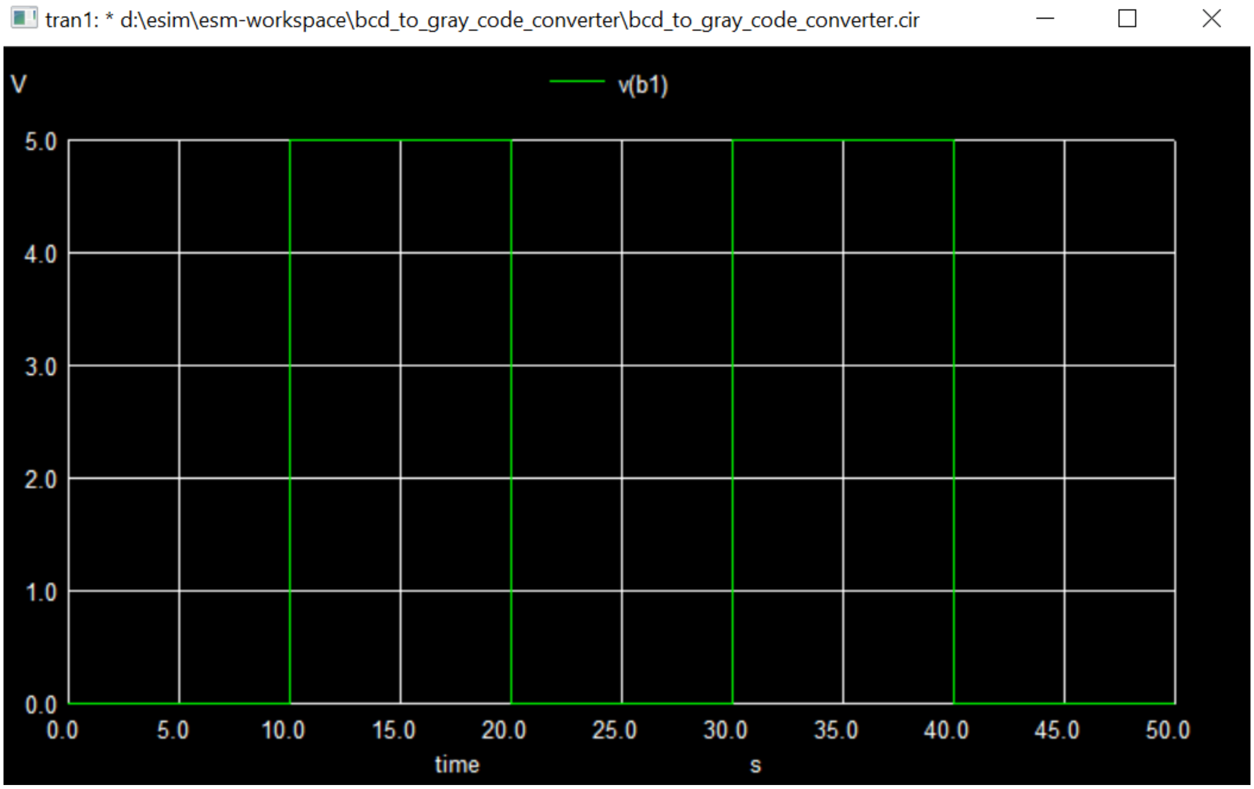
- Inputs:



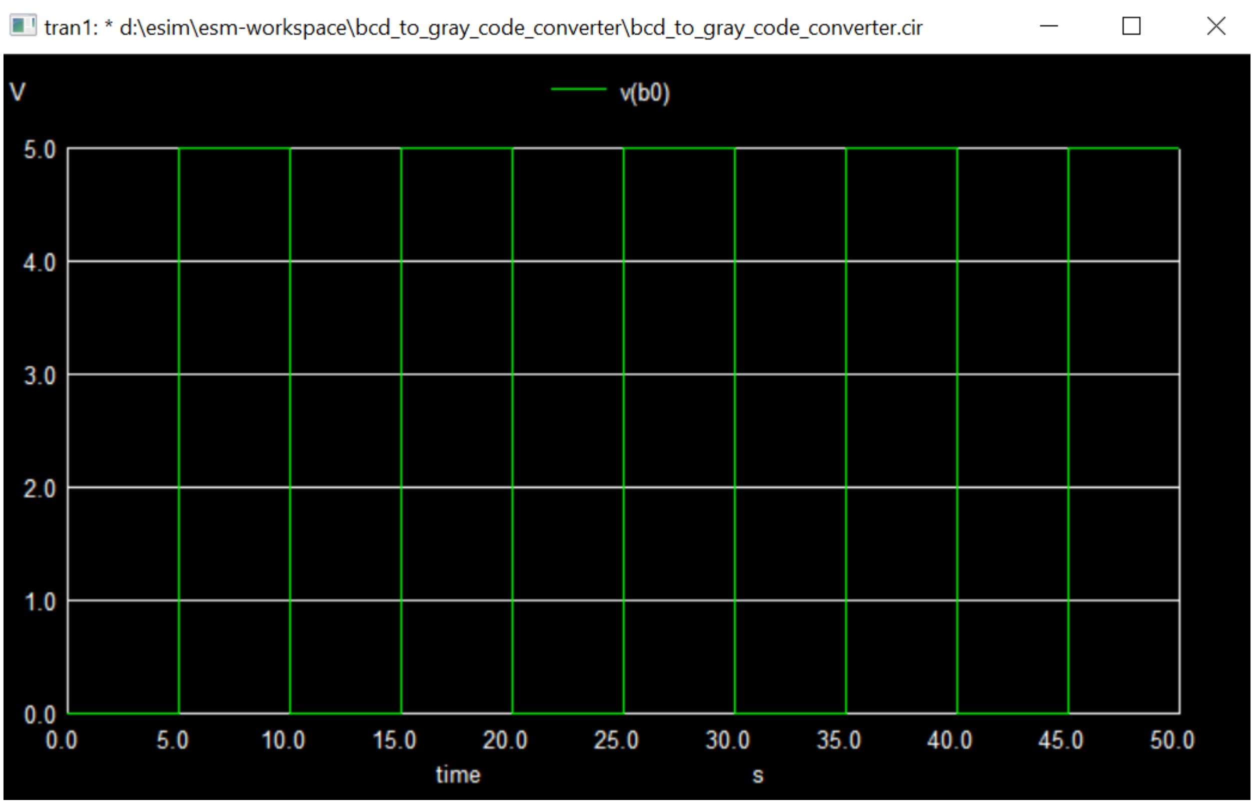
Ngspice plot of B3



Ngspice plot of B2

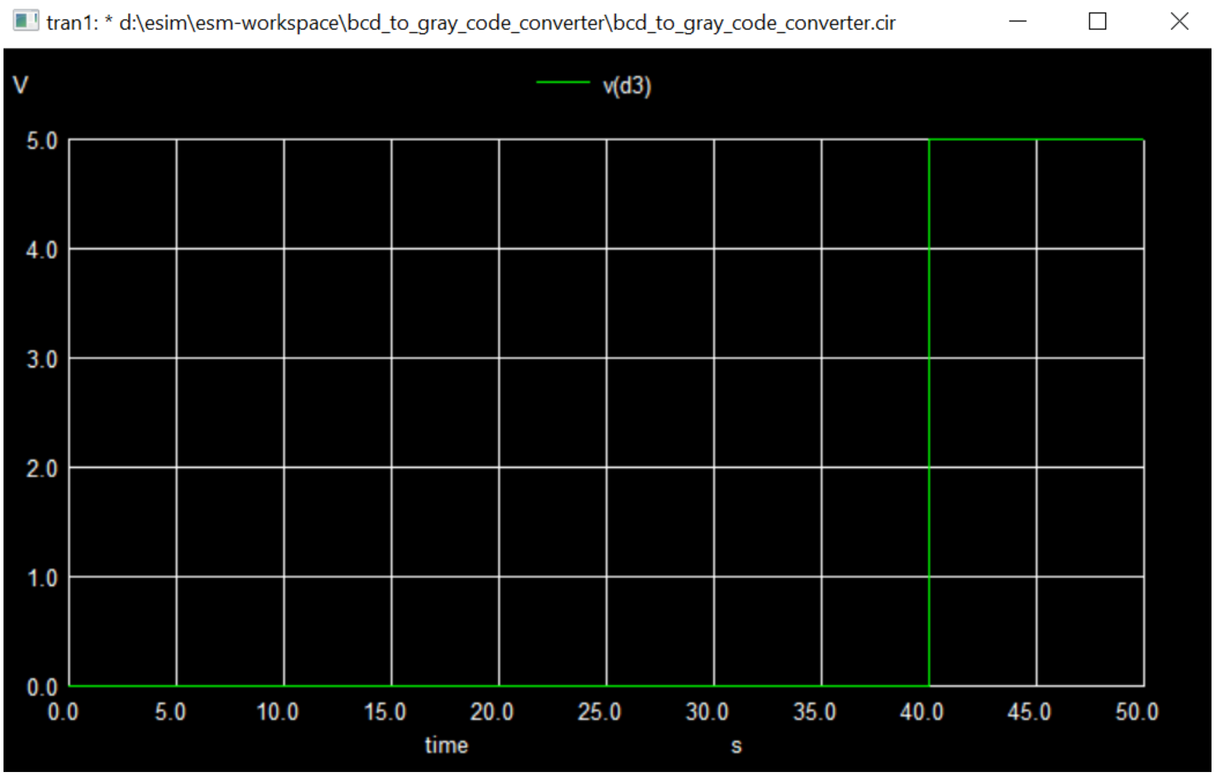


Ngspice plot of B1

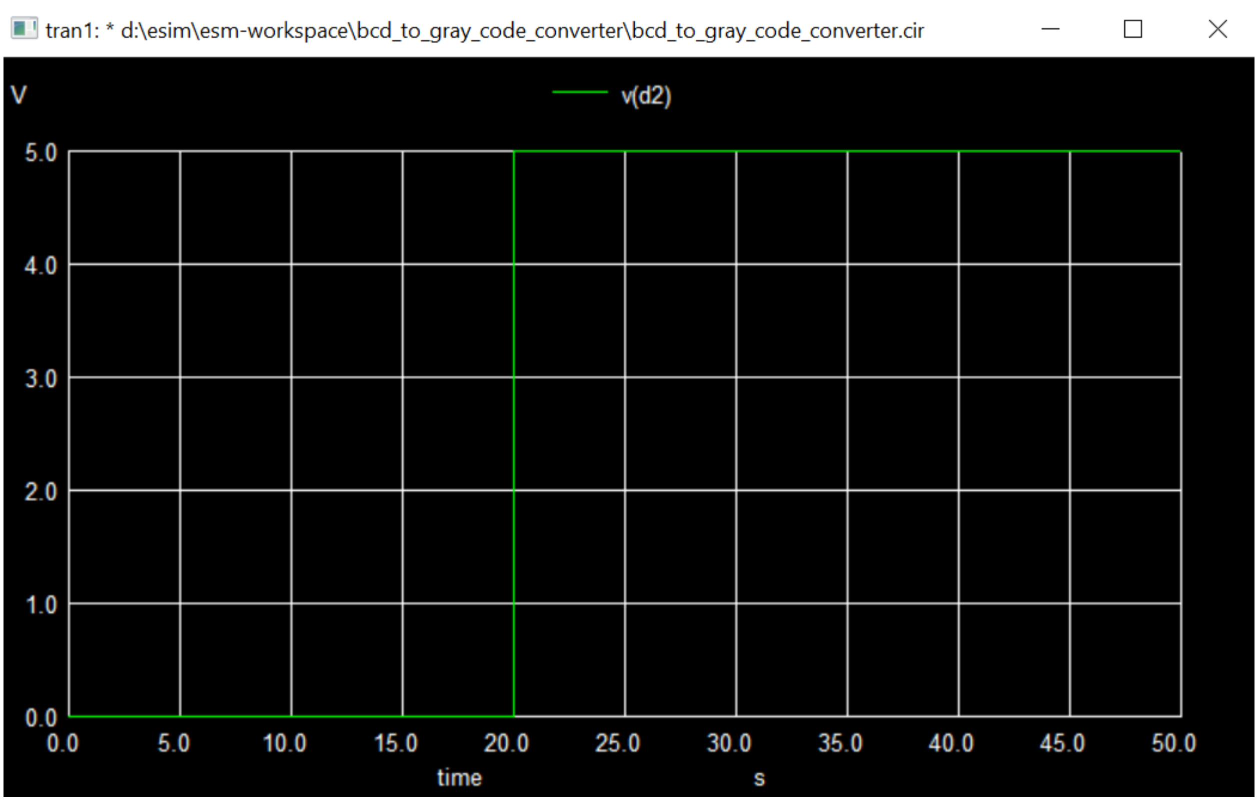


Ngspice plot of B0

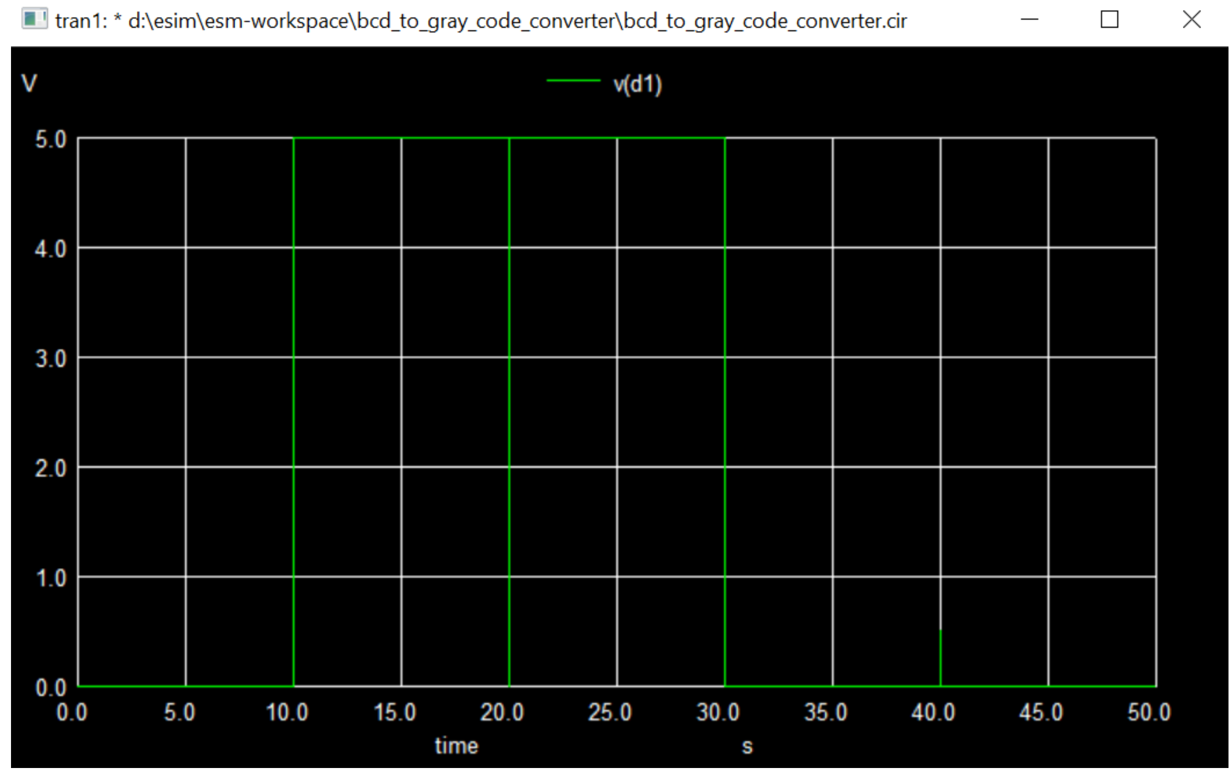
- Outputs:



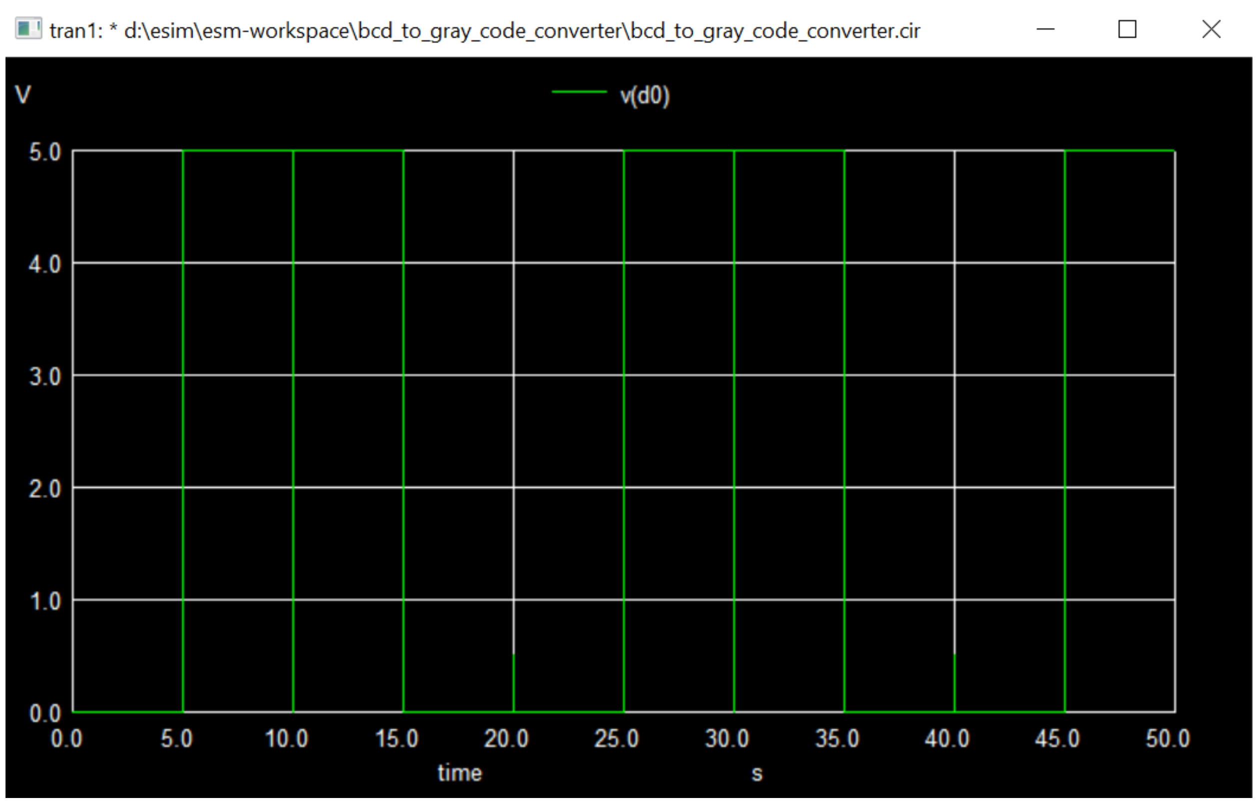
Ngspice plot of D3



Ngspice plot of D2

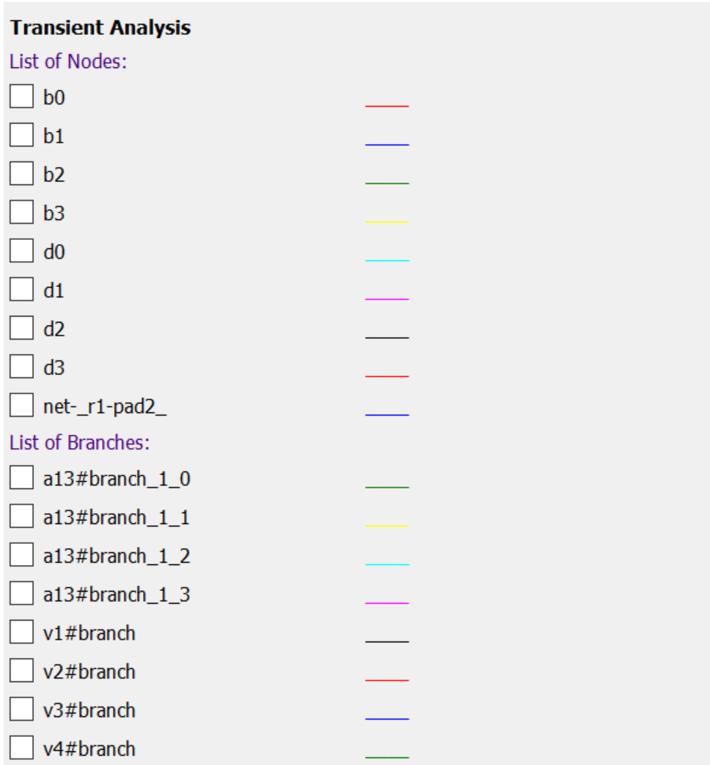


Ngspice plot of D1

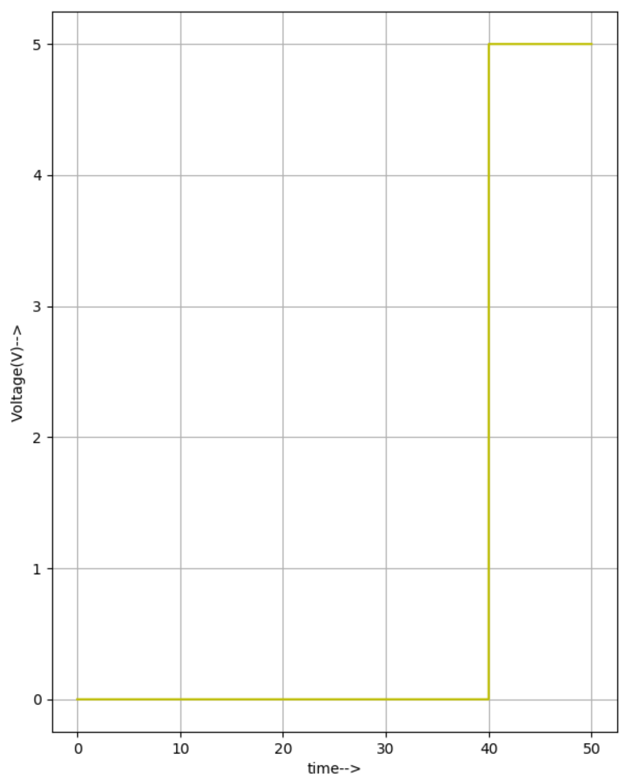


Ngspice plot of D0

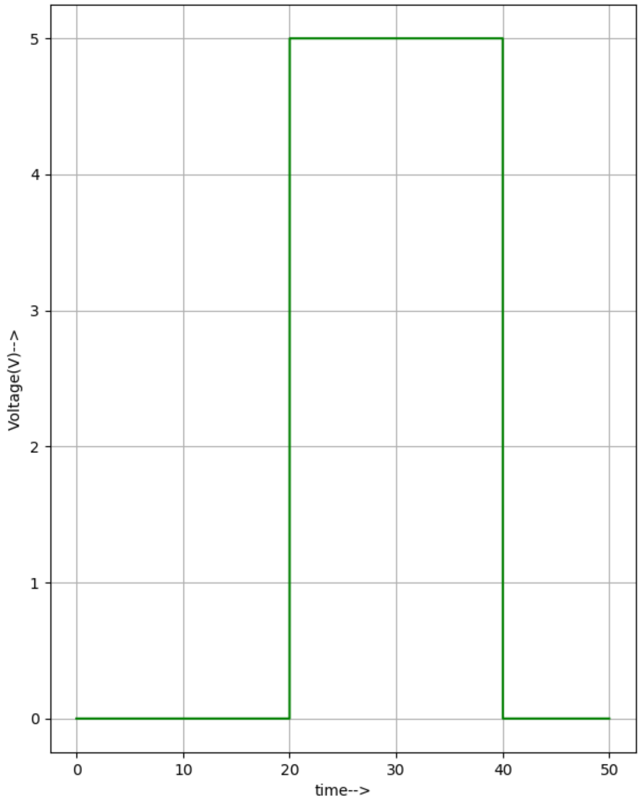
II. PYTHON PLOTS:



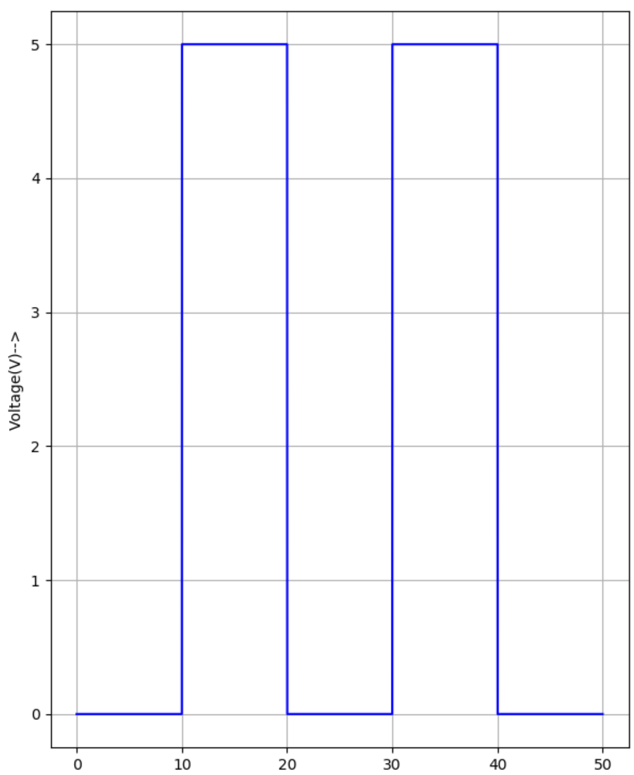
- Inputs:



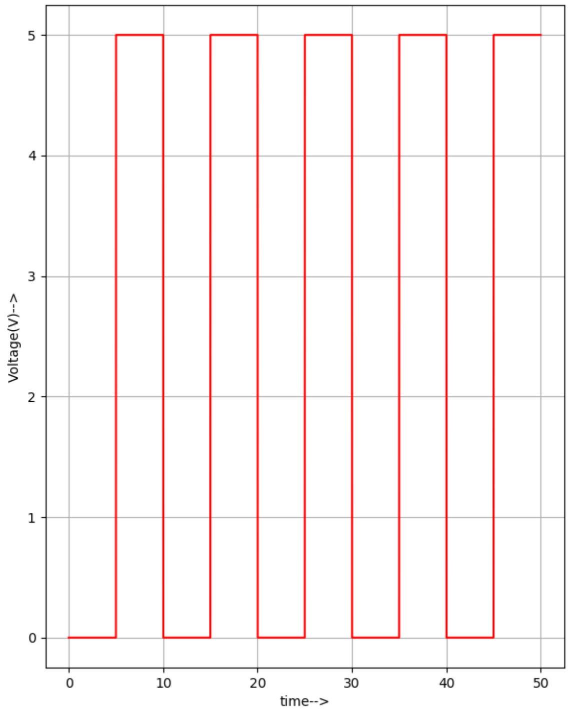
Python plot of B3



Python plot of B2

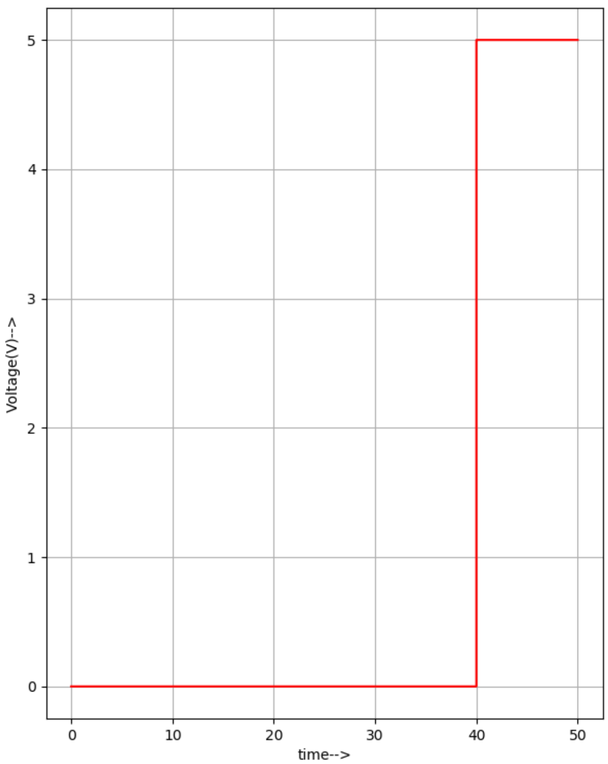


Python plot of B1

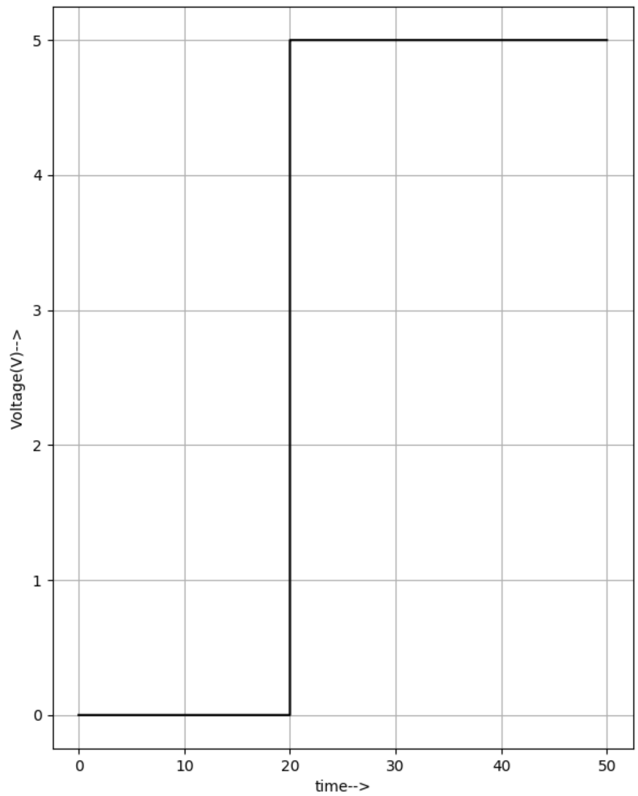


Python plot of B0

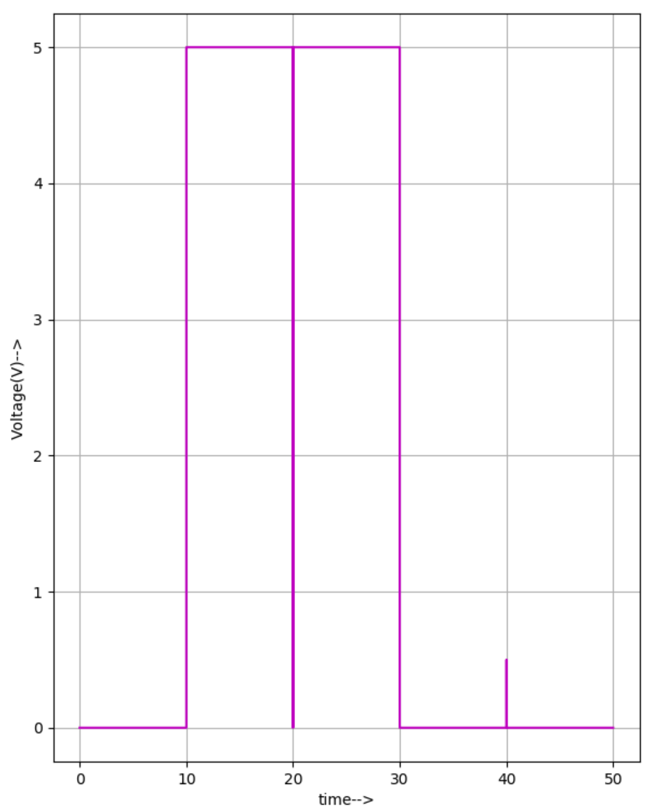
- Outputs:



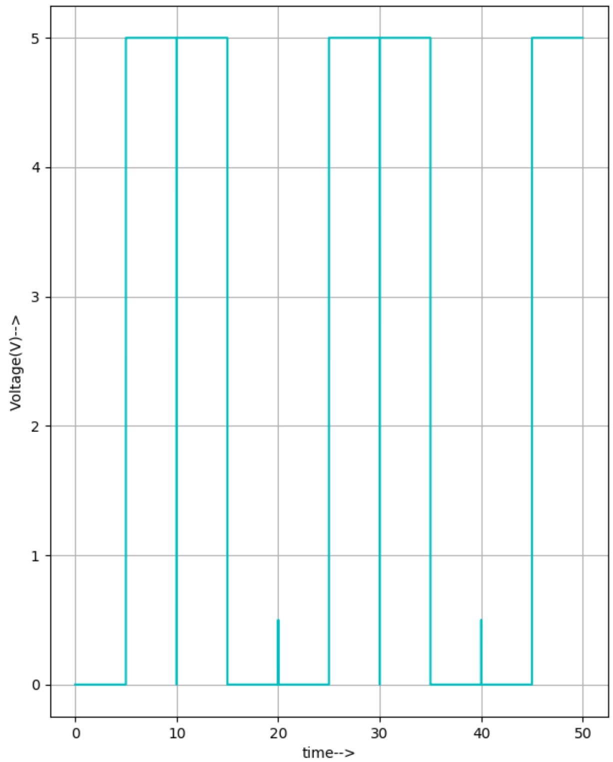
Python plot of D3



Python plot of D2



Python plot of D1



Python plot of D0

References:

https://whatis.techtarget.com/definition/binary-coded-decimal

https://www.sanfoundry.com/plc-program-implement-bcd-gray-code-converter/