Lab Experiment # 10

Building digital logic circuits using Decoders

Objectives

- **To learn how to build combinational logic circuits using decoders.**

Background

In a **Combinational Logic Circuit**, the output is dependant at all times on the combination of its inputs. Some examples of a combinational circuit include **Multiplexers**, **De-multiplexers**, **Encoders**, **Decoders**, **Full** and **Half Adders** etc.

A Decoder is a circuit with two or more inputs and one or more outputs. Its basic function is to accept a binary word (code) as an input and create a different binary word as an output.

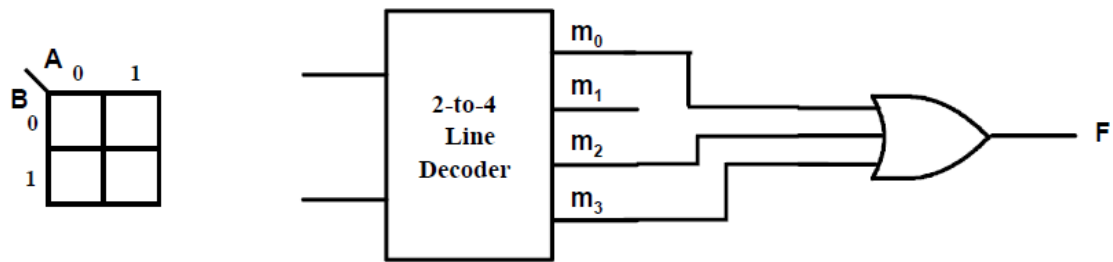| A	B	D1	D2	D3	D4
0	0	1	0	0	0
0	1	0	1	0	0
1	0	0	0	1	0
1	1	0	0	0	1
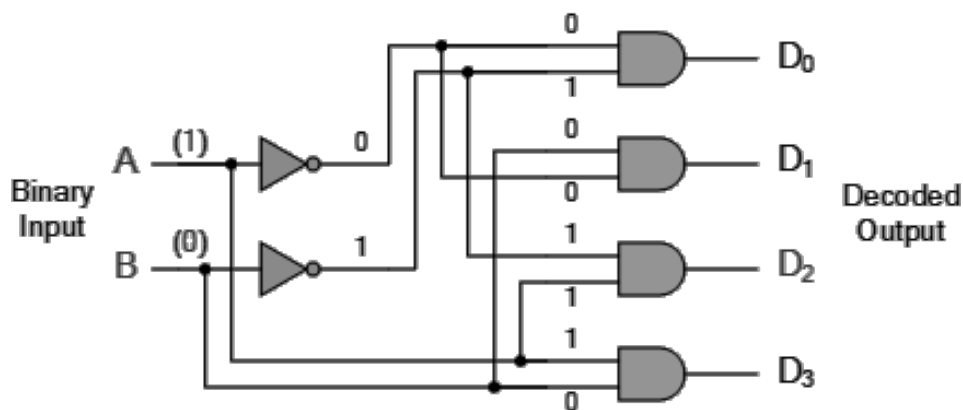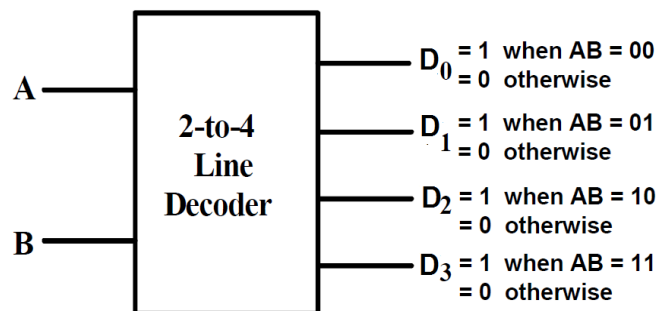
Logic Functions Realized with Decoders:
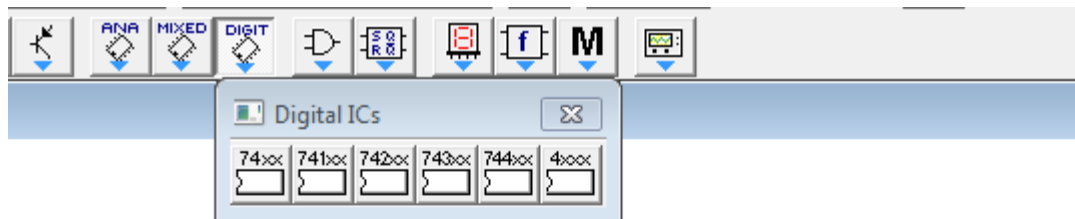
Example: $F = A + B'$

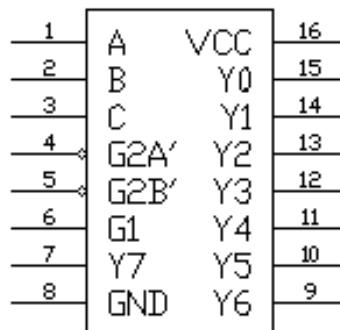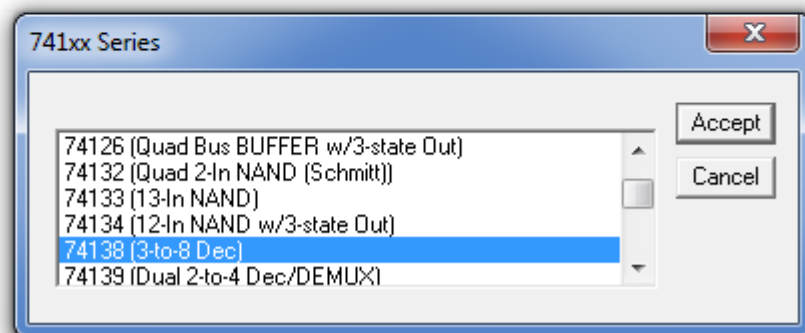$$= A (B + B') + B' (A + A')$$

$$= AB + AB' + A'B'$$

Drawing Decoders using EWB:

Click on the button on the toolbar, then drag a 741xx digital IC into your workspace. From the list, select either 74138 (3-8 decoder) or 74154 (4-16 decoder) as shown next.
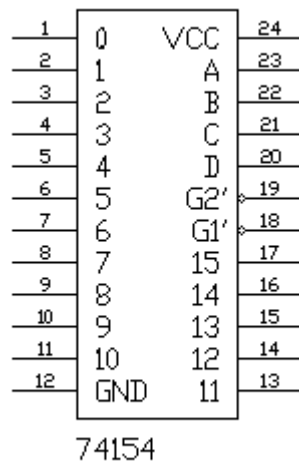

74138 (3-8 decoder)

The 3-to-8 decoder truth table is shown next:

| G2A'	G1	G2B'	C	B	A	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7
			Select										
x	x	1	x	x	x	1	1	1	1	1	1	1	1
x	0	X	x	x	x	1	1	1	1	1	1	1	1
0	1	0	0	0	0	0	1	1	1	1	1	1	1
0	1	0	0	0	1	1	0	1	1	1	1	1	1
0	1	0	0	1	1	1	1	0	1	1	1	1	1
0	1	0	0	1	1	1	1	1	0	1	1	1	1
0	1	0	1	0	0	1	1	1	1	0	1	1	1
0	1	0	1	0	1	1	1	1	1	1	0	1	1
0	1	0	1	1	0	1	1	1	1	1	1	0	1
0	1	0	1	1	1	1	1	1	1	1	1	1	0
1	1	0	x	x	x	Output corresponding to stored address 0; all others 1							

74154 (4-16 decoder)

Example: drawing a 4-input function using 74154 (Sum of minterms)

Next is the function $F(D, C, B, A) = \Sigma\ 0, 7, 8, 10, 13, 15$
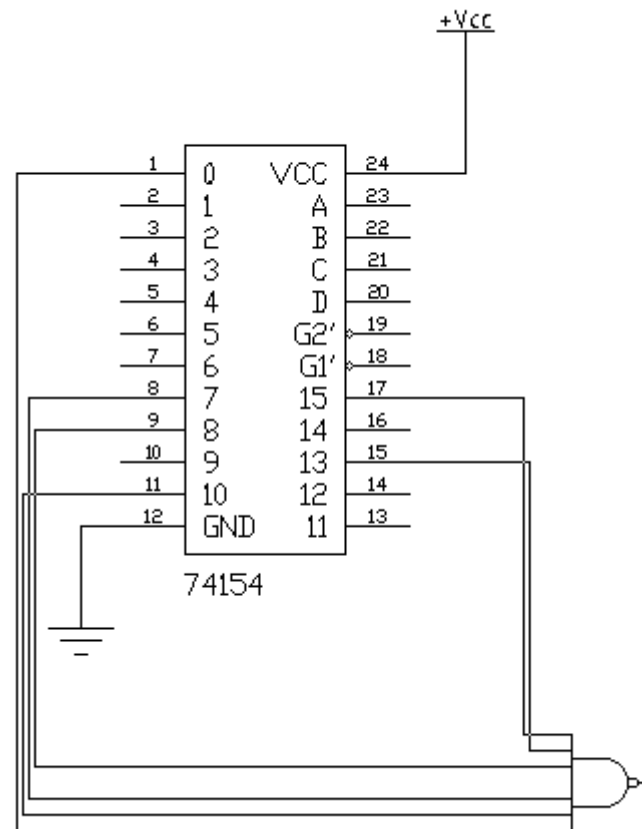
Example: drawing a 4-input function using 74154 (Product of maxterms)

Next is the function F(D, C, B, A)= Π 11 , 12, 13, 15
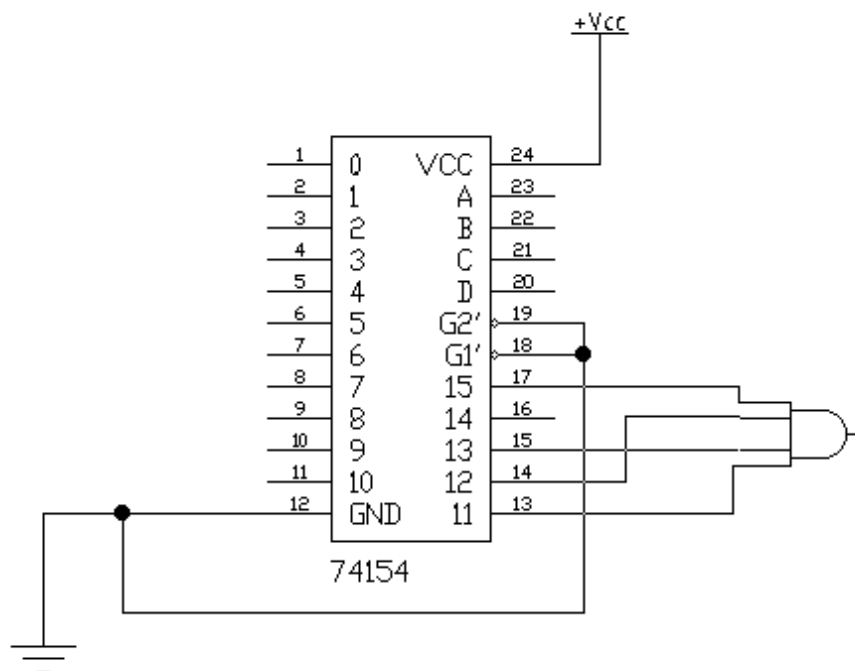
Lab Tasks

Task 1: Implementing 3-variable Boolean expressions using 3-8 decoder

Implement the following function using 3-8 decoders.

	A	B	C	F
0	0	0	0	1
1	0	0	1	1
2	0	1	0	0
3	0	1	1	1
4	1	0	0	1
5	1	0	1	0
6	1	1	0	0
7	1	1	1	0

The above function can be implemented as shown next. <u>Redraw this circuit using EWB</u>.
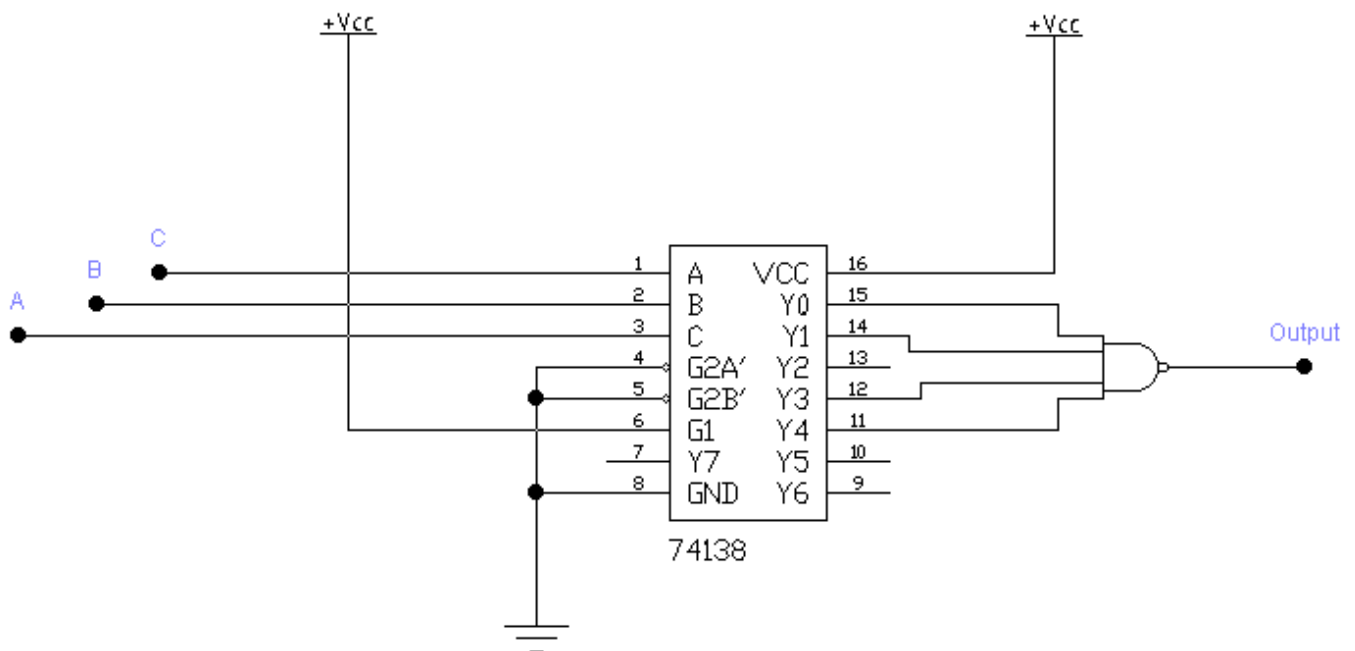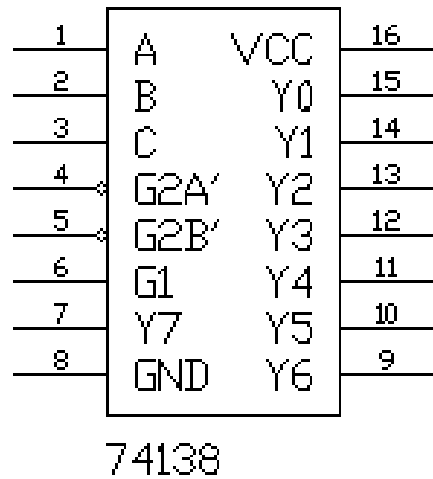

Task 2: Implementing multiple 3-variable Boolean expressions using 3-8 decoder

Implement the following three functions using 3-8 decoders.

	A	B	C	F1	F2	F3
0	0	0	0	0	1	1
1	0	0	1	1	1	0
2	0	1	0	0	0	1
3	0	1	1	1	1	0

4	1	0	0	0	1	1
5	1	0	1	1	0	0
6	1	1	0	1	0	0
7	1	1	1	0	0	1

```
      1                          16
   ──────  A        VCC  ──────
      2                          15
   ──────  B         Y0  ──────
      3                          14
   ──────  C         Y1  ──────
      4                          13
   ─────╲ G2A'       Y2  ──────
      5                          12
   ─────╲ G2B'       Y3  ──────
      6                          11
   ──────  G1        Y4  ──────
      7                          10
   ──────  Y7        Y5  ──────
      8                          9
   ──────  GND       Y6  ──────

              74138
```
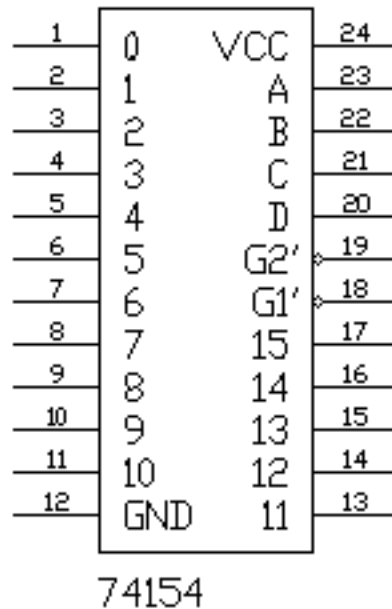
Task 3: Problems with verbal description

Design a combinational circuit (using **one 4-16 decoder**) with four inputs, and one output to implement the following function.

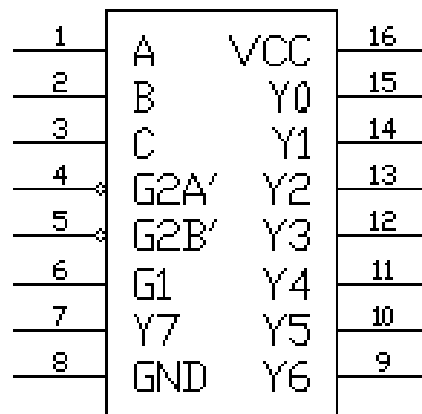|	A	B	C	D	F
0	0	0	0	0	0
1	0	0	0	1	1
2	0	0	1	0	0
3	0	0	1	1	1
4	0	1	0	0	0
5	0	1	0	1	0
6	0	1	1	0	1
7	0	1	1	1	1
8	1	0	0	0	1
9	1	0	0	1	0
10	1	0	1	0	1
11	1	0	1	1	0
12	1	1	0	0	1
13	1	1	0	1	0
14	1	1	1	0	0

15	1	1	1	1	1

```
  1 ──┤ 0      VCC ├── 24
  2 ──┤ 1        A ├── 23
  3 ──┤ 2        B ├── 22
  4 ──┤ 3        C ├── 21
  5 ──┤ 4        D ├── 20
  6 ──┤ 5      G2' ├── 19
  7 ──┤ 6      G1' ├── 18
  8 ──┤ 7       15 ├── 17
  9 ──┤ 8       14 ├── 16
 10 ──┤ 9       13 ├── 15
 11 ──┤ 10      12 ├── 14
 12 ──┤ GND     11 ├── 13

        74154
```
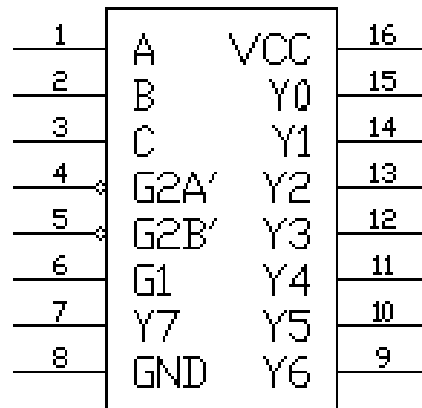
Task 4: Problems with verbal description

Design a combinational circuit (using **two 3-8 decoder**) with four inputs, and one output to implement the following function.

	A	B	C	D	F
0	0	0	0	0	0
1	0	0	0	1	1
2	0	0	1	0	0
3	0	0	1	1	1
4	0	1	0	0	0
5	0	1	0	1	0
6	0	1	1	0	1
7	0	1	1	1	1
8	1	0	0	0	1
9	1	0	0	1	0
10	1	0	1	0	1
11	1	0	1	1	0
12	1	1	0	0	1
13	1	1	0	1	0
14	1	1	1	0	0
15	1	1	1	1	1

```
 1 ──┤ A      VCC ├── 16
 2 ──┤ B       Y0 ├── 15
 3 ──┤ C       Y1 ├── 14
 4 ──┤ G2A'    Y2 ├── 13
 5 ──┤ G2B'    Y3 ├── 12
 6 ──┤ G1      Y4 ├── 11
 7 ──┤ Y7      Y5 ├── 10
 8 ──┤ GND     Y6 ├── 9
```

74138

```
 1 ──┤ A      VCC ├── 16
 2 ──┤ B       Y0 ├── 15
 3 ──┤ C       Y1 ├── 14
 4 ──┤ G2A'    Y2 ├── 13
 5 ──┤ G2B'    Y3 ├── 12
 6 ──┤ G1      Y4 ├── 11
 7 ──┤ Y7      Y5 ├── 10
 8 ──┤ GND     Y6 ├── 9
```

74138