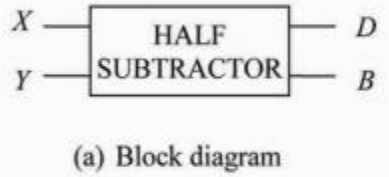
2.2.1.3 Half Subtractor

A half subtractor is an arithmetic circuit which performs subtraction operation on two input bits and produces result as difference and borrow in the output. It has two input and two output lines. It is usually used to subtract the first column of two binary numbers. The block diagram and truth table of the half subtractor circuit is shown in Figure 2.16. Treat X as minuend and Y as subtrahend and the subtraction operation is designated by X - Y. During subtraction, if a borrow is taken, the output signal, B becomes '1'.



(a) Block diagram

X	Y	D	B
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

(b) Truth table

Figure 2.16 Block diagram and truth table of half subtractor

From the truth table, the Boolean expression for D and B can be written as

$$D = X \oplus Y \; ; \; B = \overline{X}Y$$

The implementation of the expressions for D and B using gates gives the circuit of half subtractor.

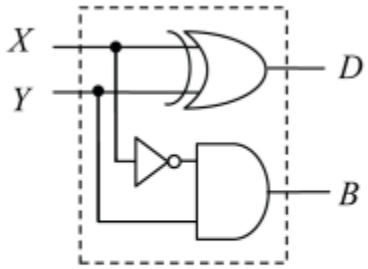
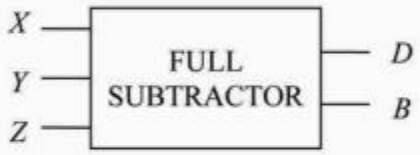


Figure 2.17 Logic diagram of half subtractor

2.2.1.4 Full Subtractor

A full subtractor is an arithmetic circuit which performs subtraction operation between two input bits with consideration that a borrow has been taken by a column lower to it and produces result as difference and borrow. It has three input and two output lines. Unlike, half subtractor, it can be used for subtraction of any column of two binary numbers. The block diagram and truth table of the full subtractor circuit is shown in Figure 2.18. Treat X as minuend, Y as subtrahend and Z as previous borrow. The subtraction operation is designated by X - Y - Z.



(a)Block diagram

X	Y	Z	D	B
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	0	1
1	0	0	1	0
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

(b) Truth table

Figure 2.18 Block diagram and truth table of full subtractor

From the truth table, the Boolean expression for D and B can be written as

$$D = \bar{X}\bar{Y}Z + \bar{X}Y\bar{Z} + X\bar{Y}\bar{Z} + XYZ$$
$$= (XY + \bar{X}\bar{Y})Z + (\bar{X}Y + X\bar{Y})\bar{Z}$$
$$= (\overline{X \oplus Y})Z + (X \oplus Y)\bar{Z}$$
$$= (X \oplus Y) \oplus Z$$
$$= X \oplus Y \oplus Z$$

and

$$B = \bar{X}\bar{Y}Z + \bar{X}Y\bar{Z} + \bar{X}YZ + XYZ$$
$$= \bar{X}YZ + \bar{X}\bar{Y}Z + \bar{X}YZ + \bar{X}Y\bar{Z} + \bar{X}YZ + \bar{X}YZ \quad (\therefore A + A + A = A)$$
$$= \bar{X}Z(Y + \bar{Y}) + \bar{X}Y(Z + \bar{Z}) + XY(X + \bar{X})$$
$$= \bar{X}Y + YZ + \bar{X}Z$$

The Implementation of expressions for D and B completes the design of full subtractor.

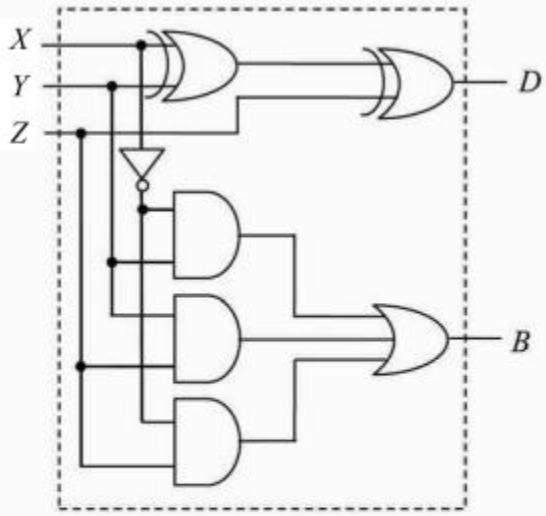


Figure 2.19 Logic diagram of full subtractor

Student Activity: Construct a full subtractor using two half subtractors. Use gates if required.