Basic Electronics Engineering (Spring 2024)

Resources of PPT:

- www.google.com

- Digital Design, 4th Edition
  M. Morris Mano and Michael D. Ciletti

Syllabus

Module-I: (Analog Electronics) 10 Hrs

Part-1: Introduction to electronic Systems Part-2: Diode circuit models and Applications: - Introduction to circuit models, Clippers and Clampers.Part-3: Transistors –BJT and MOSFET: - BJT construction and operation, BJT configurations, BJT current components BJT characteristics, Transistor as an amplifier and switch, MOSFET.

Module-II: (Digital Electronics Fundamentals) 10 Hrs

Part-1: Brief on Digital Electronics: - Review of logic gates, Number systems Part-2: Combinational Circuits: - Combinational logic (4 variables K-map), Flip flops (T, D, JK), Counters and Registers Part-3: Data Converters: - Digital-to-Analog Converter (DAC), Analog-to-Digital Converter (ADC).

Module-III (Special Topic in Electronics) 16 Hrs

Part-1: Operational Amplifier (Op-amp) and application: - Op-amp: Introduction, Internal Block diagram of Op-amp, Op-amp Characteristics Part-2: Linear operations using Op-amp:- Inverting amplifier, Non-inverting Amplifier, Voltage follower, Summing and Difference amplifier, Integrator and Differentiator, Comparator Part-3: Miscellaneous Electronic Devices:- SCR, LED, Photodiode, Laser, Solar Cells, Opto-Couplers. Part-4: Sensors:- Introduction and describing sensor performance, Temperature sensors, Light sensors, Force sensors, Displacement sensors, Motion sensors, Sound sensors, Sensor interfacing. Part-5: Introduction to basic Communication systems/principles: Fundamentals of Analog communication (AM, FM), Introduction to digital communication (Sampling, PAM, PCM, PPM, PWM, Modulation and demodulation techniques), Communication Networks, Introduction to Mobile Communication (Lecture notes to be provided)

Syllabus

Suggested Reading:

- **Mano and Ciletti, "Digital Design", Pearson**
- **Sedra and Smith, "Microelectronic Circuits", Oxford University Press**

1’s Complement Subtraction

Subtraction of Smaller Number from Larger Number:

Example-1: Subtract $(1010)_2$ from $(1111)_2$ using 1’s complement method.

Step-1: Find the 1’s complement of 1010. It will be found by replacing all 0 to 1 and all 1 to 0. In this way, the required 1’s complement will be 0101.

Step-2: In this step, we need to add the vale calculated in step-1 to 1111.

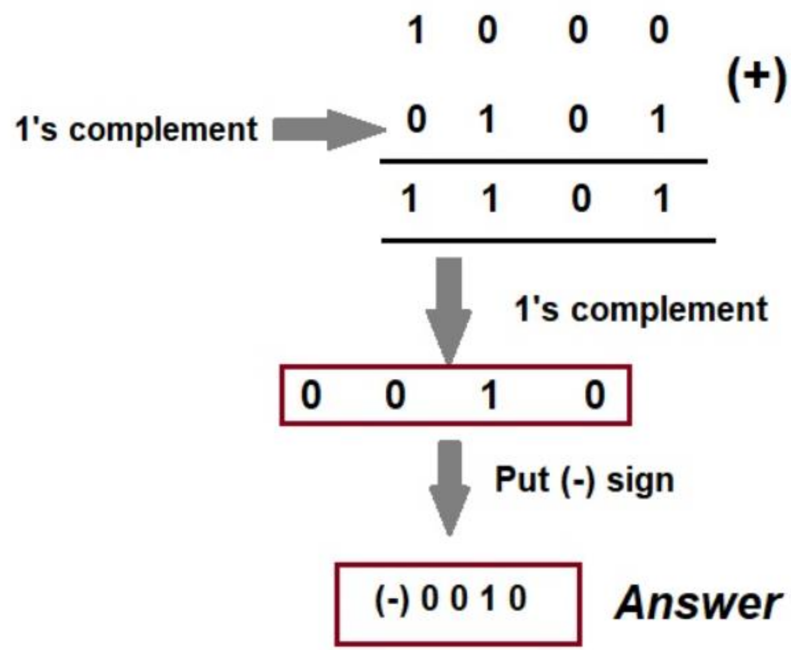
$$
\begin{array}{lccccc}
 & & 1 & 1 & 1 & 1 \\
+ & & & & & \\
 & & 0 & 1 & 0 & 1 \\
\hline
\text{Carry} & 1 & 0 & 1 & 0 & 0 \\
 & & + & & & 1 \\
\hline
 & & \boxed{0} & \boxed{1} & \boxed{0} & \boxed{1}
\end{array}
\quad \textit{Answer}
$$

1's Complement Subtraction

Subtraction of Larger Number from Smaller Number:

Example: Subtract $(1010)_2$ from $(1000)_2$ using 1's complement method.

The 1's complement of $(1010)_2$ is $(0101)_2$.



2’s Complement Subtraction

Subtraction of Smaller Number from Larger Number:

Exampe-1: Subtract $(1010)_2$ from $(1111)_2$ using 2’s complement method.

Step-1: 2’s complement of $(1010)_2$ is $(0110)_2$.

Step-2: Add $(0110)_2$ to $(1111)_2$.

$$
\begin{array}{rccccc}
 & & 1 & 1 & 1 & 1 \\
+ & & 0 & 1 & 1 & 0 \\
\hline
\text{Omit this carry} & 1 & 0 & 1 & 0 & 1
\end{array}
$$

$$\boxed{0\;\;1\;\;0\;\;1}\quad \textit{Answer}$$

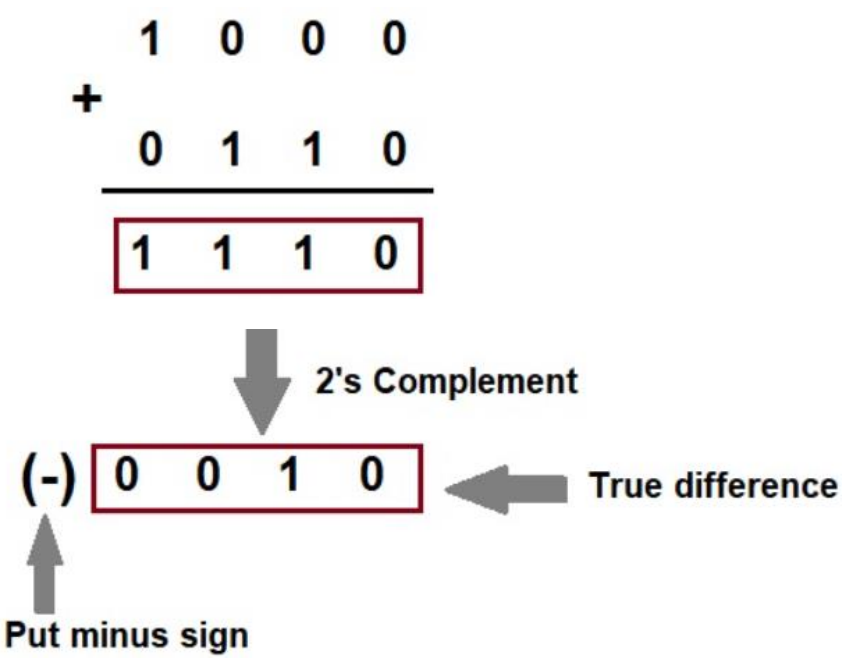
2’s Complement Subtraction

Subtraction of Larger Number from Smaller Number:

Example-2: Subtract $(1010)_2$ from $(1000)_2$ using 2’s complement.

Step-1: Find the 2’s complement of $(1010)_2$. It is $(0110)_2$.

Step-2: Add $(0110)_2$ to $(1000)_2$.



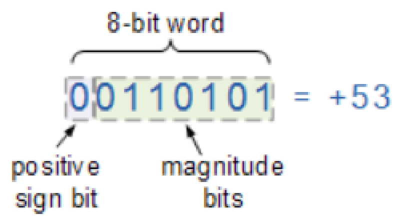
Comparative Observation

- Though both 1’s and 2’s complement method for subtracting binary numbers seems to be complicated when compared with direct method of subtraction of two binary numbers, both have some distinct advantage when applied using logic circuits, because they allow subtraction to be done using only addition.

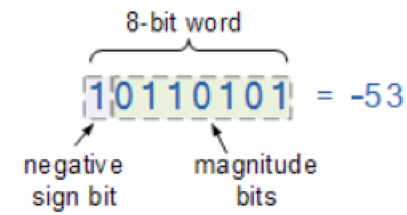
- The advantage in 2’s complement subtraction is that the end-around-carry operation present in 1’s complement method is not involved here.

Signed Binary Number

Positive Signed Binary Numbers



Negative Signed Binary Numbers



The disadvantage here is that whereas before we had a full range n-bit unsigned binary number, we now have an n-1 bit signed binary number giving a reduced range of digits from:

$$-2^{(n-1)} \text{ to } +2^{(n-1)}$$

So for example: if we have 4 bits to represent a signed binary number, (1-bit for the **Sign bit** and 3-bits for the **Magnitude bits**), then the actual range of numbers we can represent in sign-magnitude notation would be:

$$-2^{(4-1)} - 1 \quad \text{to} \quad +2^{(4-1)} - 1$$

$$-2^{(3)} - 1 \quad \text{to} \quad +2^{(3)} - 1$$

Signed Binary Number

signed-magnitude representation: 10001001

signed-1's-complement representation: 11110110

signed-2's-complement representation: 11110111

Decimal	Signed-2's Complement	Signed-1's Complement	Signed Magnitude
+7	0111	0111	0111
+6	0110	0110	0110
+5	0101	0101	0101
+4	0100	0100	0100
−4	1100	1011	1100
−5	1011	1010	1101
−6	1010	1001	1110
−7	1001	1000	1111

Addition of 1’s Complement Signed Binary Numbers

<u>Both the numbers are positive</u>

Example: 8 + 5 = ?

1’s complement representation of 8 = 00001000

1’s complement representation of 5 = 00000101

Since 8 and 5 are positive, so their 1’complement representation will be the same as its true (uncomplemented) form.

$$\begin{array}{r} 0\,0\,0\,0\,1\,0\,0\,0 \\ +\;\; 0\,0\,0\,0\,0\,1\,0\,1 \\ \hline 0\,0\,0\,0\,1\,1\,0\,1 \end{array}$$

Sum: 0 0 0 0 1 1 0 1

Sign bit is zero, so the result is a positive number

$$\begin{array}{r} 8 \\ +\;\; 5 \\ \hline 13 \end{array}$$

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13 => 00001101

Addition of 1's Complement Signed Binary Numbers

Negative number with smaller magnitude than the positive number

Example: 8 + (-5) = ?

This example can also be read as a subtraction problem, that is 8 – 5 = ?

1's complement representation of 8 = 00001000

1's complement representation of -5 = 11111010

```
                  0 0 0 0 1 0 0 0
              +   1 1 1 1 1 0 1 0
                 -----------------
Discard Carry   1 0 0 0 0 0 0 1 0
              +   Add 1 to the result 1
                 -----------------
                  0 0 0 0 0 0 1 1
```

Sum: 0 0 0 0 0 0 1 1

Sign bit is zero, so the result is a positive number

```
   8
+ -5
-----
   3
```

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3 => 00000011

Addition of 1’s Complement Signed Binary Numbers

<u>Negative number with larger magnitude than the positive number</u>

Example: -8 + 5 = ?

1’s complement representation of -8 = 11110111

1’s complement representation of 5 = 00000101

$$
\begin{array}{r}
1\,1\,1\,1\,0\,1\,1\,1 \\
+\quad 0\,0\,0\,0\,0\,1\,0\,1 \\
\hline
1\,1\,1\,1\,1\,1\,0\,0
\end{array}
$$

Sum: 1 1 1 1 1 1 0 0

Sign bit is one, so the result is a negative number

$$
\begin{array}{r}
-8 \\
+\quad 5 \\
\hline
-3
\end{array}
$$

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-3 => 11111100

Addition of 1's Complement Signed Binary Numbers

Both the numbers are negative

Example: -8 + (-5) = ?

1's complement representation of -8 = 11110111

1's complement representation of -5 = 11111010

```
                   1 1 1 1 0 1 1 1
               +   1 1 1 1 1 0 1 0
                  -----------------
Discard Carry  1   1 1 1 1 0 0 0 1
               +   Add 1 to the result 1
                  -----------------
                   1 1 1 1 0 0 1 0
```

Sum: 1 1 1 1 0 0 1 0

Sign bit is one, so the result is a negative number

```
   -8
+  -5
------
  -13
```

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-13 => 11110010

Addition of 2’s Complement Signed Binary Numbers

<u>Both the numbers are positive</u>

Example: 8 + 5 = ?

2’s complement representation of 8 = 00001000

2’s complement representation of 5 = 00000101

```
    0 0 0 0 1 0 0 0
+   0 0 0 0 0 1 0 1
-------------------
    0 0 0 0 1 1 0 1
```

Sum: 0 0 0 0 1 1 0 1

Sign bit is zero, so the result is a positive number

```
    8
+   5
-----
   1 3
```

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13 => 00001101

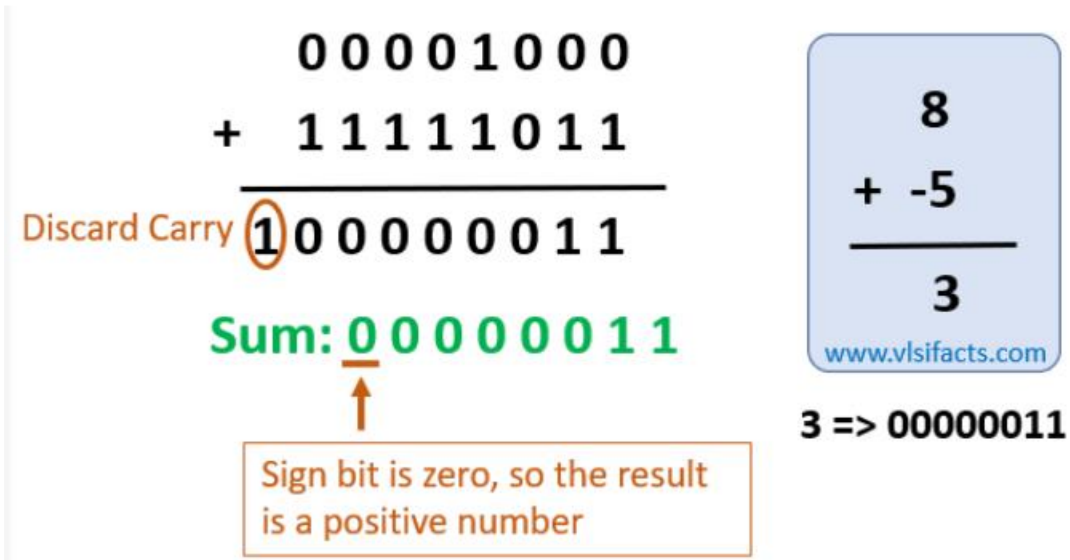
Addition of 2’s Complement Signed Binary Numbers

Negative number with smaller magnitude than the positive number

Example: 8 + (-5) = ?

2’s complement representation of 8 = 00001000

2’s complement representation of -5 = 11111011



Addition of 2’s Complement Signed Binary Numbers

Negative number with larger magnitude than the positive number

Example: -8 + 5 = ?

2’s complement representation of -8 = 11111000

2’s complement representation of 5 = 00000101

```
    1 1 1 1 1 0 0 0
+   0 0 0 0 0 1 0 1
-------------------
    1 1 1 1 1 1 0 1
```

Sum: 1 1 1 1 1 1 0 1

Sign bit is one, so the result is a negative number

```
   -8
+   5
-----
   -3
```

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-3 => 11111101

Addition of 2's Complement Signed Binary Numbers

Both the numbers are negative

Example: -8 + (-5) = ?

2's complement representation of -8 = 11111000

2's complement representation of -5 = 11111011

```
                 1 1 1 1 1 0 0 0
               + 1 1 1 1 1 0 1 1
               -----------------
Discard Carry  1 1 1 1 1 0 0 1 1
```

Sum: 1 1 1 1 0 0 1 1

Sign bit is one, so the result is a negative number

-8
+ -5
-13

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-13 => 11110011

Binary Coded Decimal (BCD) Code

Decimal Symbol	BCD Digit
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

$$(185)_{10} = (0001\ 1000\ 0101)_{BCD} = (10111001)_2$$

BCD Addition

- When the binary sum is equal to or less than 1001 (without a carry), the corresponding BCD digit is correct.

- When the binary sum is greater than or equal to 1010, the result is an invalid BCD digit. The addition of $6 = (0110)_2$ to thee binary sum converts it to the correct BCD digit and also produces a carry as required.

$$\begin{array}{rr} 4 & 0100 \\ +5 & +0101 \\ \hline 9 & 1001 \end{array}$$

$$\begin{array}{rr} 4 & 0100 \\ +8 & +1000 \\ \hline 12 & 1100 \\ & +0110 \\ \hline & 10010 \end{array}$$

$\longleftarrow 6 = (0110)_2$

0001 0010

1 2

Gray Code

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

Decimal Symbol	BCD Digit
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001