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**

Number Systems and Conversions

- Most observables are analog
- But the most convenient way to represent and transmit information electronically is digital
- Analog/digital and digital/analog conversion is essential

What is Signal?

$$y = f(x)$$

Output / Range

Input / Domain

$$y = \sin x$$

$$y = 5e^{x} + 4x^{2} + \frac{3}{5 + x^{4}}$$

Number Systems and Conversions

$$y = f(x)$$

Output / Range

Input / Domain

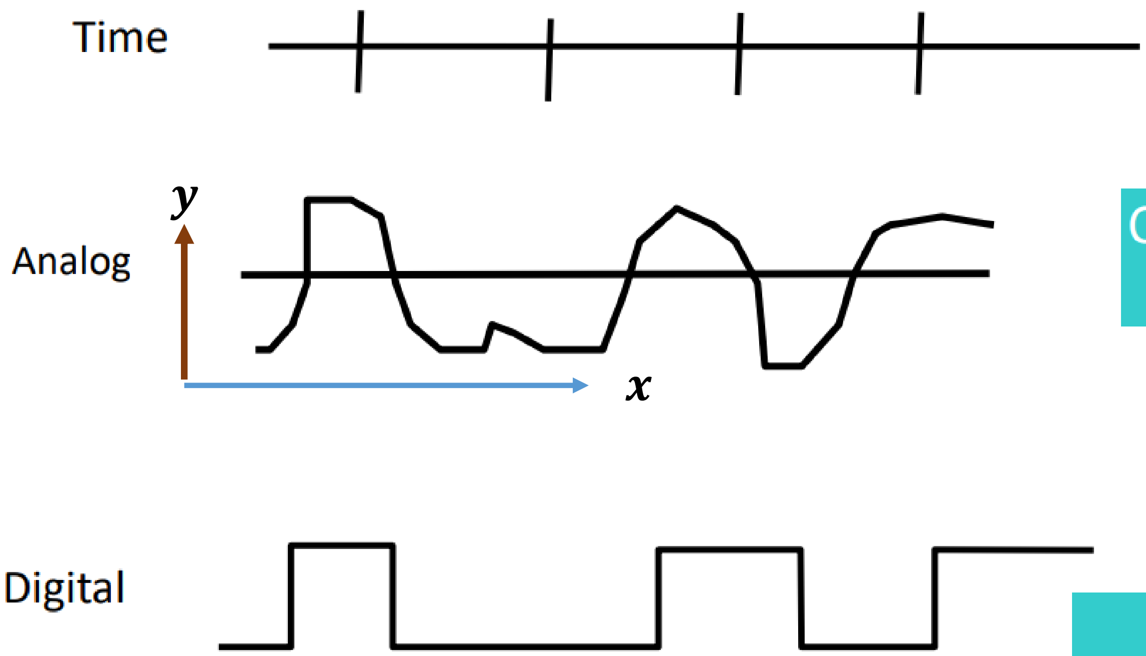
Analog Signals: x **can be of any value** y **can be of any value as per** f

Digital Signals: x **can be of any value** y **can be of discrete value as per** f

Number Systems and Conversions

Analog Signals: x **can be of any value** y **can be of any value as per** f

Digital Signals: x **can be of any value** y **can be of discrete value as per** f



Continuous in value & time

Discrete in value

Difference Between Analog And Digital Signal

Analog Signals	Digital Signals
Continuous signals	Discrete signals
Represented by sine waves	Represented by square waves
Human voice, natural sound, analog electronic devices are few examples	Computers, optical drives, and other electronic devices
Continuous range of values	Discontinuous values
Records sound waves as they are	Converts into a binary waveform.
Only be used in analog devices.	Suited for digital electronics like computers, mobiles and more.

Number Systems and Conversions

Discrete ?

Decimal	Binary	Hexadecimal	Octal
0	0	0	0
1	1	1	1
2		2	2
3		3	3
4		4	4
5		5	5
6		6	6
7		7	7
8		8	
9		9	
		A (10)	
		B (11)	
		C (12)	
		D (13)	
		E (14)	
		F (15)	

Number Systems and Conversions

For any number systems: $\boldsymbol{a_4 a_3 a_2 a_1 a_0}$

- Discrete Values (a_n)
- Basis/ Radix
- Powers

Basis/ Radix:

Decimal	10
Binary	2
Hexadecimal	16

Powers:

Decimal	Any integer no. including 0
Binary	Any integer no. including 0
Hexadecimal	Any integer no. including 0

A number N in base or radix b can be written as:

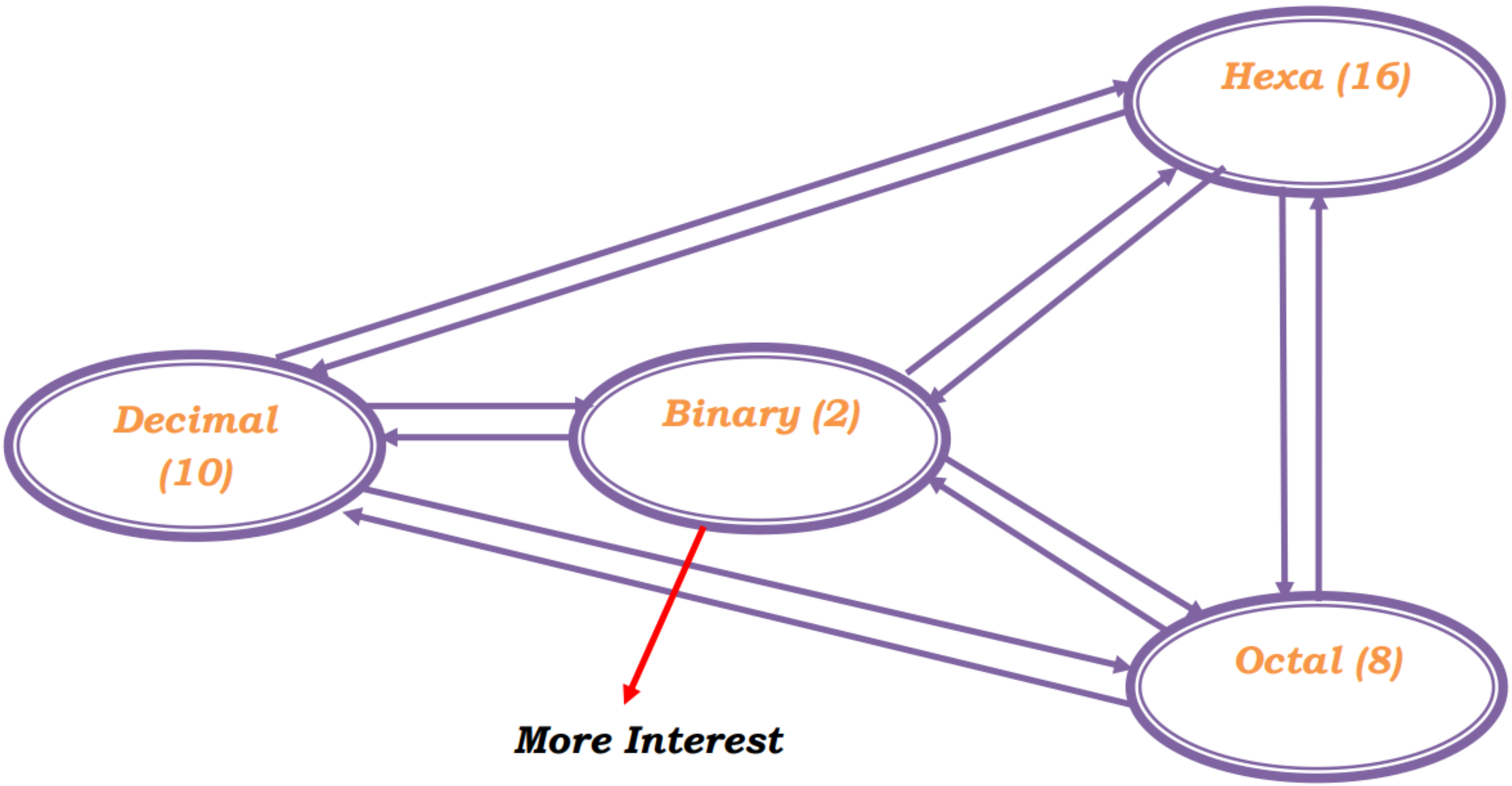
$$(N)_b = d_{n-1}\ d_{n-2}\ \text{-- -- -- --}\ d_1\ d_0\ .\ d_{-1}\ d_{-2}\ \text{-- -- -- --}\ d_{-m}$$

In the above, d_{n-1} to d_0 is the integer part, then follows a radix point, and then d_{-1} to d_{-m} is the fractional part.

Most Significant Digit (MSD): d_{n-1}

Least Significant Digit (LSD): d_{-m}

Number Systems and Conversions



Decimal to Other Base System

- **Step 1** – Divide the decimal number to be converted by the value of the new base.
- **Step 2** – Get the remainder from Step 1 as the rightmost digit (least significant digit) of new base number.
- **Step 3** – Divide the quotient of the previous divide by the new base.
- **Step 4** – Record the remainder from Step 3 as the next digit (to the left) of the new base number.

- Repeat Steps 3 and 4, getting remainders from right to left, until the quotient becomes zero in Step 3.
- The last remainder thus obtained will be the Most Significant Digit (MSD) of the new base number.

Decimal to Other Base System

General Rule 1: Conversion from decimal to other base

1. Divide decimal number by the base (2, 8, 16,…).
2. The remainder is the lowest-order digit.
3. Repeat first two steps unit no divisor remains.

General Rule 2: Decimal fraction conversion to anther base

1. Multiply decimal number by the base (2, 8,…).
2. The integer is the highest-order digit.
3. Repeat first two steps until fraction becomes zero.

Decimal to Other Base System

Decimal to Binary:

Decimal Number: 29_{10}

Step	Operation	Result	Remainder
Step 1	29 / 2	14	1
Step 2	14 / 2	7	0
Step 3	7 / 2	3	1
Step 4	3 / 2	1	1
Step 5	1 / 2	0	1

As mentioned in Steps 2 and 4, the remainders have to be arranged in the reverse order so that the first remainder becomes the Least Significant Digit (LSD) and the last remainder becomes the Most Significant Digit (MSD).

Decimal to Other Base System

Decimal to Binary:

Example 2 Convert 13_{10} to binary number

Division by 2		Quotient integer	remainder
$\frac{13}{2}$	=	6	1 (a_0)
$\frac{6}{2}$		3	0 (a_1)
$\frac{3}{2}$		1	1 (a_2)
$\frac{1}{2}$		0	1 (a_3)
Answer		$(13)_{10} = (a_3\ a_2\ a_1\ a_0) = (1101)_2$	

Decimal to Other Base System

Decimal to Binary:

Example 3: Convert 0.625_{10} to binary number

Multiply by 2	Integer		Fraction	coefficient
0.625*2 =	1	+	0.25	$a_1 = 1$
0.250*2 =	0	+	0.50	$a_2 = 0$
0.500*2 =	1	+	0(stop)	$a_3 = 1$

Answer $(0.625)_{10} = (0.a_1\ a_2\ a_3)_2 = (0.101)_2$

Correct order

Decimal to Other Base System

Decimal to Octal:

Example 1: Convert 266_{10} to octal number.

$$\frac{266}{8} = 33 + \text{remainder of } 2 \text{ (LSD)}$$

$$\frac{33}{8} = 4 + \text{remainder of } 1$$

$$\frac{4}{8} = 0 + \text{remainder of } 4$$

$$266_{10} = 4\ 1\ 2_{(8)}$$

Decimal to Other Base System

Decimal to Octal:

Example 2: Convert 0.35_{10} to octal number.

Multiply by 8	Integer		Fraction	coefficient
0.35*8=	2	+	0.80	$a_1 = 2$
0.8*8 =	6	+	0.40	$a_2 = 6$
0.4*8 =	3	+	0.20	$a_3 = 3$
0.2*8 =	1	+	0.60	$a_4 = 1$
0.6*8 =	4	+	0.80	$a_5 = 4$
Answer	$(0.35)_{10} = (0.a_1\ a_2\ a_3\ a_4\ a_5)_2 = (0.26314)_8$			

Repeated
"stop"

Correct
order

Decimal to Other Base System

Decimal to Octal:

Convert $(0.513)_{10}$ to octal.

$$0.513 \times 8 = 4.104$$

$$0.104 \times 8 = 0.832$$

$$0.832 \times 8 = 6.656$$

$$0.656 \times 8 = 5.248$$

$$0.248 \times 8 = 1.984$$

$$0.984 \times 8 = 7.872$$

The answer, to seven significant figures, is obtained from the integer part of the products:

$$(0.513)_{10} = (0.406517\ldots)_8$$

Decimal to Other Base System

Decimal to Hexadecimal:

Example 1: Convert 423_{10} to hex number.

$$\frac{423}{16} = 26 + \text{remainder of } 7 \text{ (LSD)}$$

$$\frac{26}{16} = 1 + \text{remainder of } 10$$

$$\frac{1}{16} = 0 + \text{remainder of } 1$$

$$423_{10} = 1\ A\ 7_{(16)}$$

Decimal to Other Base System

Decimal to Hexadecimal:

Example 1: Convert 423_{10} to hex number.

$\frac{423}{16}$ = 26 + remainder of 7 (LSD)

$\frac{26}{16}$ = 1 + remainder of 10

$\frac{1}{16}$ = 0 + remainder of 1

423_{10} = 1 A $7_{(16)}$

Other Base System to Decimal

Binary to Decimal:

$$(110101)_2 = 2^5 \times 1 + 2^4 \times 1 + 2^3 \times 0 + 2^2 \times 1 + 2^1 \times 0 + 2^0 \times 1$$
$$= 32 + 16 + 4 + 1 = (53)_{10}$$

$(1010.01)_2$

$1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 0 \times 2^0 + 0 \times 2^{-1} + 1 \times 2^{-2} = 8+0+2+0+0+0.25 = 10.25$

$(1010.01)_2 = (10.25)_{10}$

Other Base System to Decimal

Octal to Decimal:

$(12.2)_8$

$1 \times 8^1 + 2 \times 8^0 + 2 \times 8^{-1} = 8+2+0.25 = 10.25$

$(12.2)_8 = (10.25)_{10}$

$$(127.4)_8 = 1 \times 8^2 + 2 \times 8^1 + 7 \times 8^0 + 4 \times 8^{-1} = (87.5)_{10}$$

$$24.6_8 = (2*8^1) + (4*8^0) + (6*8^{-1}) = 20.75_{10}$$

Other Base System to Decimal

Hexadecimal to Decimal:

Hexadecimal: $a_4a_3a_2a_1a_0 = (21AF3)_{16}$

Decimal: $= 16^4 \times a_4 + 16^3 \times a_3 + 16^2 \times a_2 + 16^1 \times a_1 + 16^0 \times a_0$

$$= 16^4 \times 2 + 16^3 \times 1 + 16^2 \times 10 + 16^1 \times 15 + 16^0 \times 3$$

$$= (137971)_{10}$$

$$= 10^5 \times 1 + 10^4 \times 3 + 10^3 \times 7 + 10^2 \times 9 + 10^1 \times 7 + 10^0 \times 1$$

$$= b_5b_4b_3b_2b_1b_0$$

$$(B65F)_{16} = 11 \times 16^3 + 6 \times 16^2 + 5 \times 16^1 + 15 \times 16^0 = (46{,}687)_{10}$$

Base 5 to Base 10 (Decimal) Conversion:

$$(4021.2)_5 = 4 \times 5^3 + 0 \times 5^2 + 2 \times 5^1 + 1 \times 5^0 + 2 \times 5^{-1} = (511.4)_{10}$$

Other Base System to Non-Decimal System

- **Step 1** – Convert the original number to a decimal number (base 10).
- **Step 2** – Convert the decimal number so obtained to the new base number.

Octal to Binary: Octal Number – 25_8

Step 1 – Convert to Decimal

Step	Octal Number	Decimal Number
Step 1	25_8	$((2 \times 8^1) + (5 \times 8^0))_{10}$
Step 2	25_8	$(16 + 5)_{10}$
Step 3	25_8	21_{10}

Octal Number – 25_8 = Decimal Number – 21_{10}

Step 2 – Convert Decimal to Binary

Step	Operation	Result	Remainder
Step 1	21 / 2	10	1
Step 2	10 / 2	5	0
Step 3	5 / 2	2	1
Step 4	2 / 2	1	0
Step 5	1 / 2	0	1

Decimal Number – 21_{10} = Binary Number – 10101_2

Octal Number – 25_8 = Binary Number – 10101_2

Other Base System to Non-Decimal System

Octal to Binary (Short Cut Method):

- **Step 1** – Convert each octal digit to a 3 digit binary number (the octal digits may be treated as decimal for this conversion).
- **Step 2** – Combine all the resulting binary groups (of 3 digits each) into a single binary number.

Octal Number – 25_8

Step	Octal Number	Binary Number
Step 1	25_8	2_{10} 5_{10}
Step 2	25_8	010_2 101_2
Step 3	25_8	010101_2

Octal Number – 25_8 = Binary Number – 10101_2

Other Base System to Non-Decimal System

Binary to Octal: Binary Number – 10101_2

- **Step 1** – Divide the binary digits into groups of three (starting from the right).
- **Step 2** – Convert each group of three binary digits to one octal digit.

Step	Binary Number	Octal Number
Step 1	10101_2	010 101
Step 2	10101_2	2_8 5_8
Step 3	10101_2	25_8

Binary Number – 10101_2 = Octal Number – 25_8

Other Base System to Non-Decimal System

Binary to Hexadecimal: Binary Number – 10101_2

- **Step 1** – Divide the binary digits into groups of four (starting from the right).
- **Step 2** – Convert each group of four binary digits to one hexadecimal symbol.

Step	Binary Number	Hexadecimal Number
Step 1	10101_2	0001 0101
Step 2	10101_2	1_{10} 5_{10}
Step 3	10101_2	15_{16}

Binary Number – 10101_2 = Hexadecimal Number – 15_{16}

Other Base System to Non-Decimal System

Hexadecimal to Binary:

- **Step 1** – Convert each hexadecimal digit to a 4 digit binary number (the hexadecimal digits may be treated as decimal for this conversion).
- **Step 2** – Combine all the resulting binary groups (of 4 digits each) into a single binary number.

Step	Hexadecimal Number	Binary Number
Step 1	15_{16}	$1_{10}\ 5_{10}$
Step 2	15_{16}	$0001_2\ 0101_2$
Step 3	15_{16}	00010101_2

Hexadecimal Number – 15_{16} = Binary Number – 10101_2

Number Systems and Conversions

For each r-base number system, there exists two types of complement systems:

- **(r-1)'s complement**
- **r's complement**

Given a number N,

- **(r-1)'s complement:** $(r^n - 1) - N$
- **r's complement:** $r^n - N$

The 9's complement of 546700 is 999999 − 546700 = 453299.

The 9's complement of 012398 is 999999 − 012398 = 987601.

The 1's complement of 1011000 is 0100111.

The 1's complement of 0101101 is 1010010.

the 10's complement of 012398 is 987602

the 2's complement of 0110111 is 1001001