Lecture 1 – Introduction and Number systems

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Chapter 1 (first half)

About the course

- Name: Digital Systems and Microcontrollers (DSM)
- Textbook:
  - M. Morris Mano and Michael D. Ciletti, "*Digital Design*"
- Logistics:
  - Three 1-hour lectures per week
  - One 3-hour lab per week
  - One 1-hour tut per week

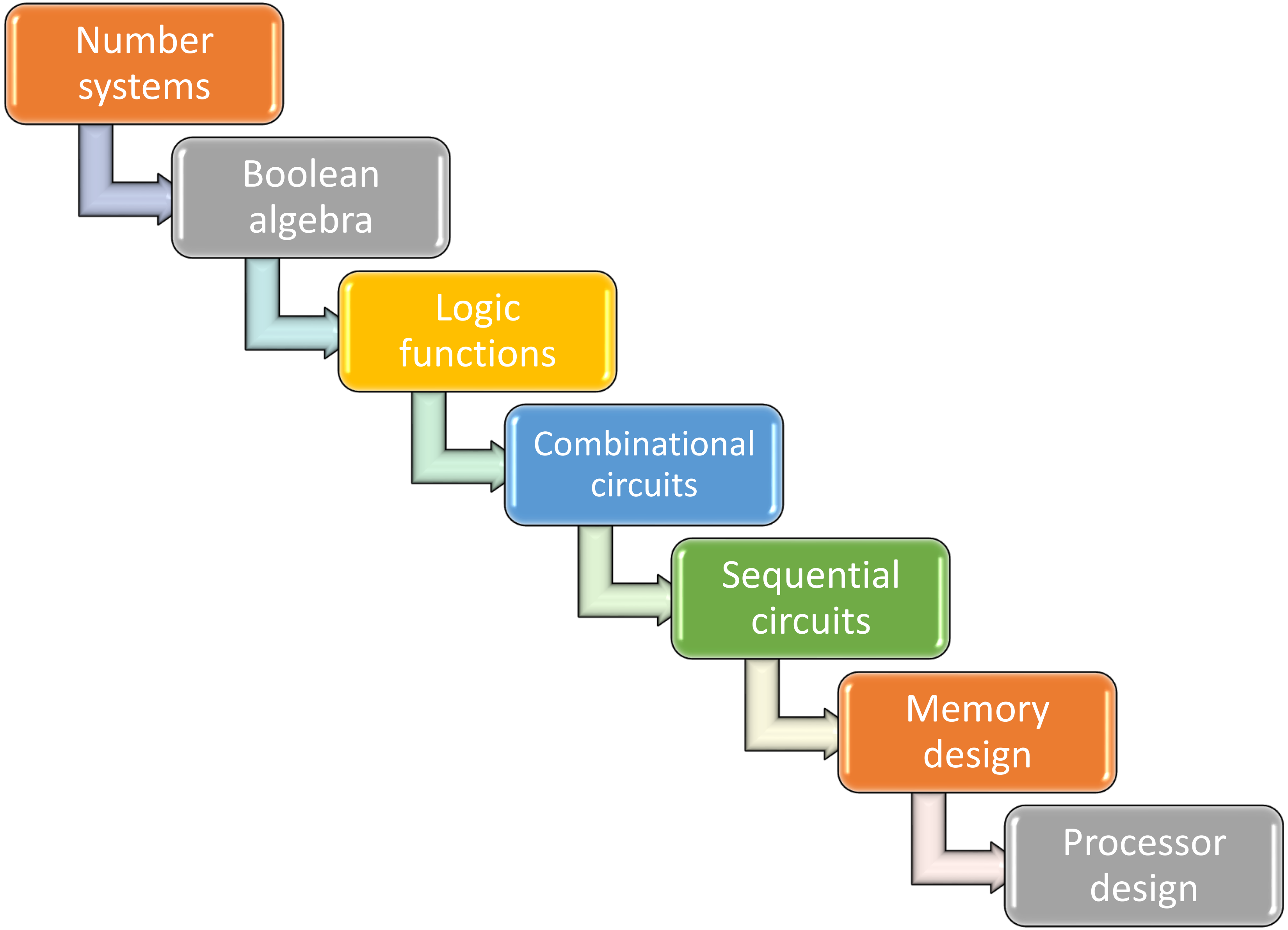
- Faculty: Dr. Ubaidulla (lectures)
  Dr. Harikumar Kandath (labs)

About the course

- Grading scheme:

Quizzes (x2)	10
Midsem	20
Lab reports (x9)	15
Lab exam	20
End semester	35
Total	100

About the course



Counting

- Lets take a relook at counting…

0 1 2 3 4 5 6 7 8 9 **10** **11 …**

- The number system:
  - Put symbols in specific places/positions to denote their "power"
  - The *base* or the *radix* of the decimal number system is 10

1	0	6	6
10^3	10^2	10^1	10^0
1000	100	10	1

1x1000+0x100+6x10+6x1 = 1066

1	9	4	0
10^3	10^2	10^1	10^0
1000	100	10	0

1x1000+9x100+4x10+0x1 = 1940

Various number systems

- Octal number system
  - The base or radix is 8
  - The symbols are: 0, 1, 2, 3, 4, 5, 6, 7
  - Counting in octal: 0, 1, 2, 3, 4, 5, 6, 7, **?**

    0, 1, 2, 3, 4, 5, 6, 7, **10, 11, …**

- Hexadecimal number system
  - The base or radix is 16
  - The symbols are: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F
  - Counting in Hex: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F, **10, 11, …**

Various number systems

- Hexadecimal number system
    - The base or radix is 16
    - The symbols are: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F
- Binary number system
    - The base or radix is 2
    - The symbols are: 0, 1 (bit)
    - Counting in binary : 0, 1, **10, 11**,…

- We denote the base of the number using a subscript: $(10395)_{10}$
- In general a number $(a_4a_3a_2a_1a_0)_r = a_4r^4 + a_3r^3 + a_2r^2 + a_1r^1 + a_0r^0$

Conversion to decimal

In general a number $(a_4a_3a_2a_1a_0)_r \;=\; a_4r^4 + a_3r^3 + a_2r^2 + a_1r^1 + a_0r^0$

- Octal to decimal:
  - $(110)_8 = 1*8^2 + 1*8^1 + 0*8^0 = (72)_{10}$
  - $(777)_8 =$
  - $(777)_8 = 7*8^2 + 7*8^1 + 7*8^0 =(511)_{10}$

- Hex to decimal:
  - $(110)_{16} = 1*16^2 + 1*16^1 + 0*16^0 = (272)_{10}$
  - $(BAD)_{16}$ = ?
  - $(BAD)_{16} = 11*16^2 + 10*16^1 +13*16^0 = (2989)_{10}$

Conversions to decimal

- Hex to decimal:
  - $(110)_{16} = 1*16^2 + 1*16^1 + 0*16^0 = (272)_{10}$
  - $(BAD)_{16} = 11*16^2 + 10*16^1 + 13*16^0 = (2989)_{10}$

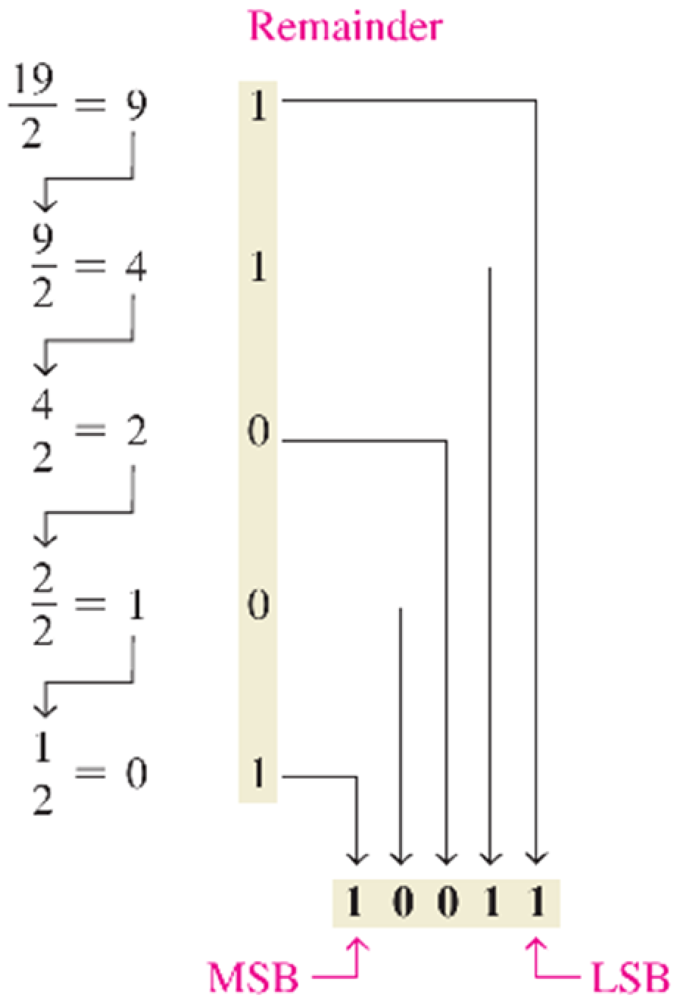
- Binary to decimal:
  - $(110)_2 = 1*2^2 + 1*2^1 + 0*2^0 = (6)_{10}$
  - $(101010)_2 =$
  - $(101010)_2 = 1*2^5 + 0*2^4 + 1*2^3 + 0*2^2 + 1*2^1 + 0*2^0 = (42)_{10}$

Conversions from decimal

- Algorithm:
  - Divide by radix
  - Save the remainder
  - Repeat till quotient ‘0’
  - Arrange remainders in reverse order

Eg: Convert $(19)_{10}$ to binary

$$(19)_{10} = (10011)_2$$



MSB – most significant bit
LSB – least significant bit

Conversions from Oct/Hex to Binary

- From Oct/Hex to binary, we can take a short cut because the bases are $8=2^3$ and $16=2^4$ respectively
- For octal: take each digit and convert it individually into *three* bits
- For hex: take each digit and convert it individually into *four* bits

- Octal number system
  - $(433)_8$ = 100011011
  - $(70)_8$ = 111000

- Hexadecimal number system
  - $(DEAD)_{16}$ = 1101111010101101
  - $(FEED)_{16}$ = 1111111011101101

Conversions from Binary to Oct/Hex

- The reverse course can be taken for converting binary to oct or hex
- For octal: take *three* bits and convert it individually into a symbol
- For hex: take *four* bits and convert it individually into a symbol

- Octal number system
  - $(110\ 101\ 011)_2 = (653)_8$
  - $(1\ 010\ 111\ 101)_2 = (1275)_8$
- Hexadecimal number system
  - $(11101011)_2 = (EB)_{16}$
  - $(110000110)_2 = (186)_{16}$