PATRIoT lab

Lecture 1 – Introduction and Number systems

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Chapter 1 (first half)

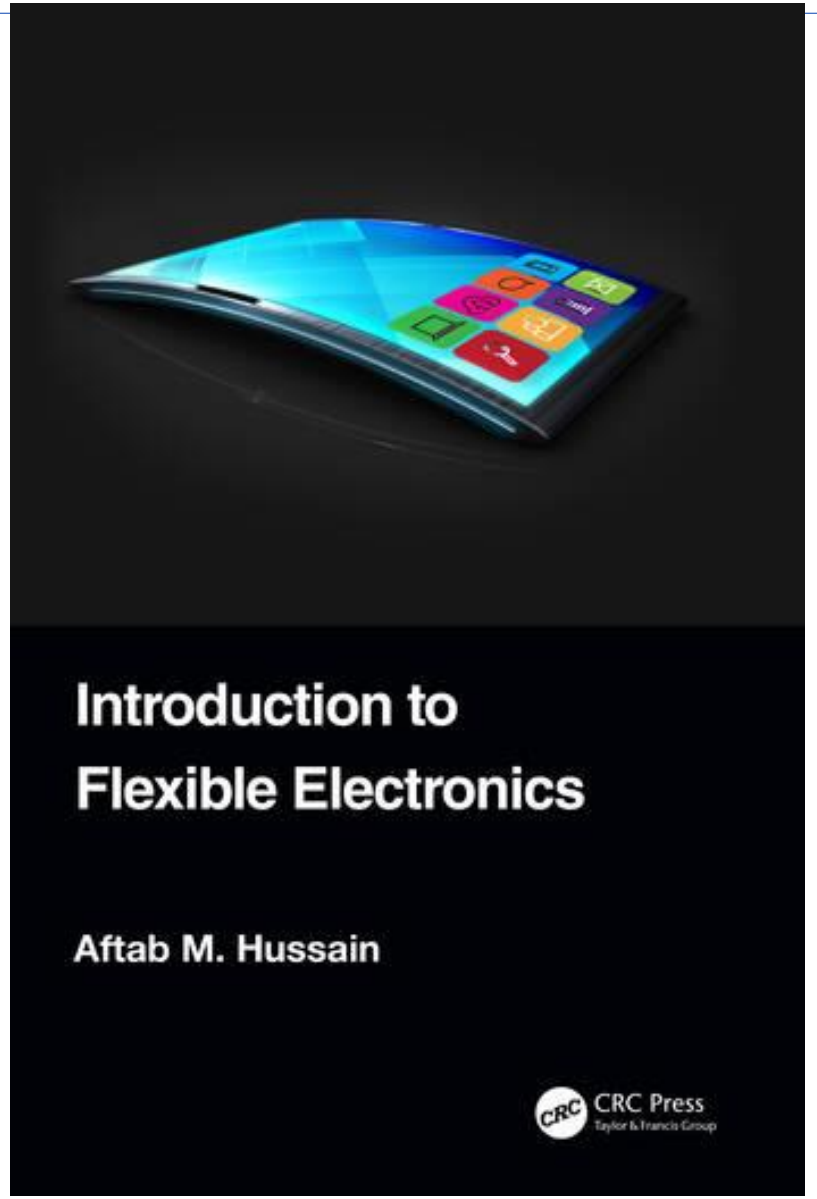
Introductions

- B. Tech in IIT Roorkee (2009):
- After B. Tech.:
  - Design Engineer, Analog Devices India (2011)
- Joined KAUST as M.S. in 2011
- Continued as Ph.D. from Jan 2013
- Postdoc in Harvard University up to Jan 2018
- Asst. Prof., CVEST, IIITH

- Total of 90+ research papers and 11 patents in the last 10 years

Courses

- Digital Systems and Microcontrollers (DSM) [UG1 core]
  - Digital logic
  - Basic digital circuits
  - Basics of microcontrollers
- Embedded Systems Workshop [CS UG2 core]
- Communications and Controls in IoT [ECE UG2 elective]
- Flexible Electronics [Open Elective]
  - Materials for flexible electronics
  - Processes and applications



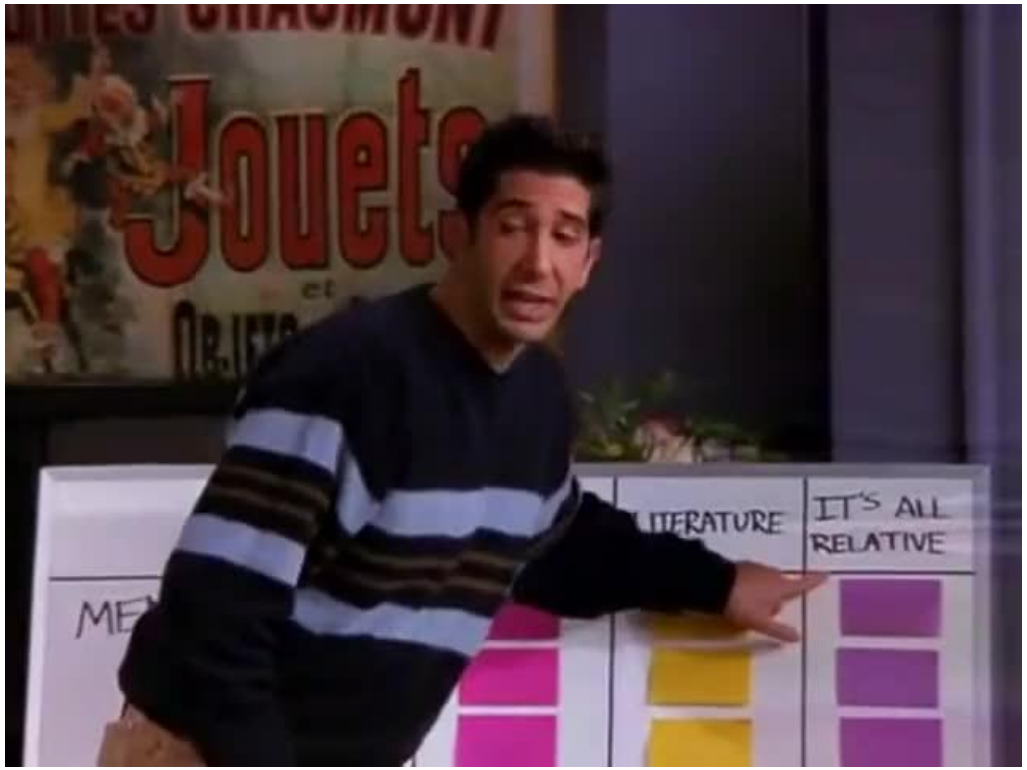
About the course

- 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

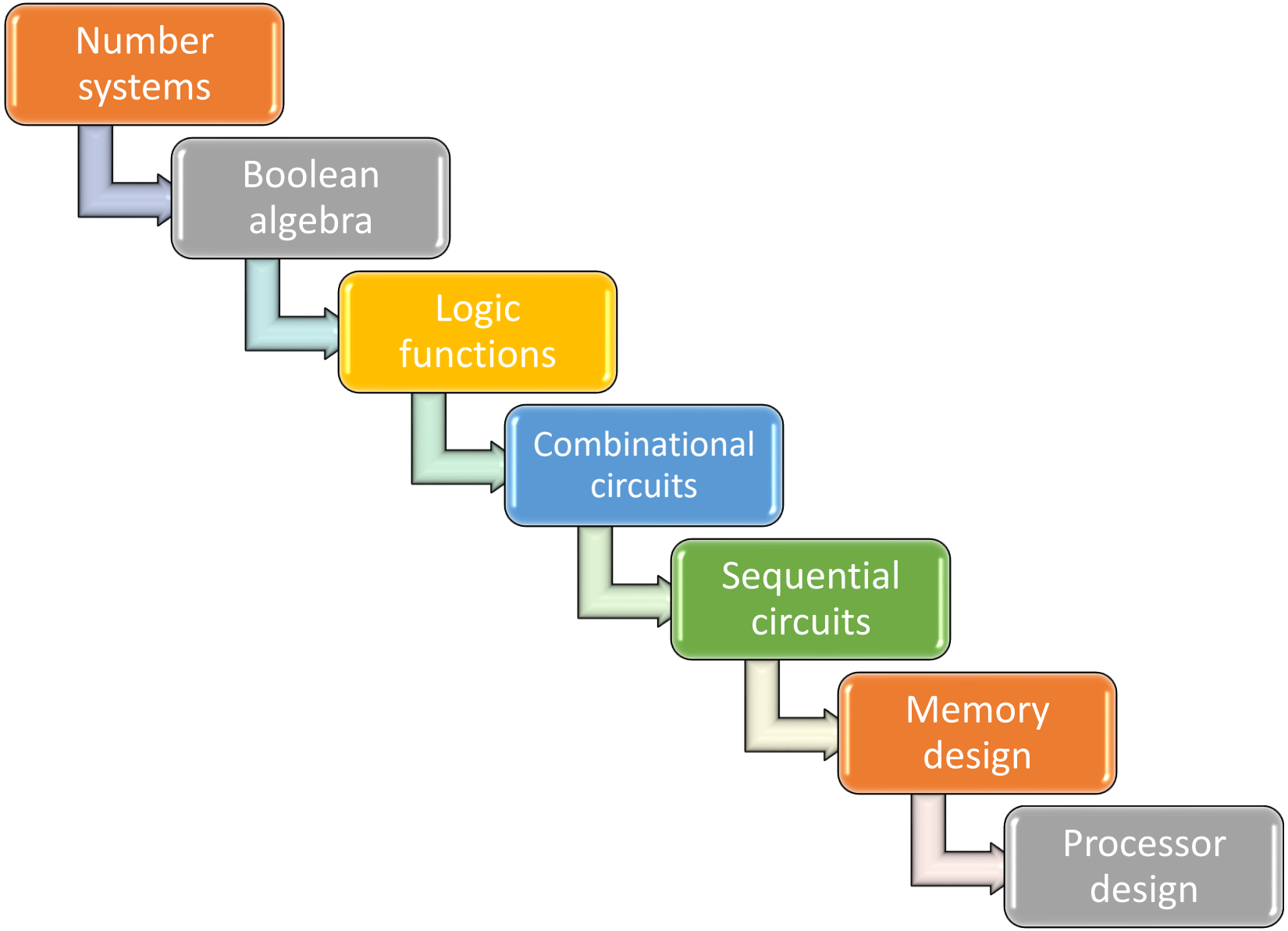
- Faculty: Dr. Aftab M. Hussain (lectures B)
  Dr. Ubaidulla P (lectures A)
  Dr. Harikumar Kandath (labs)

About the course

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



About the course

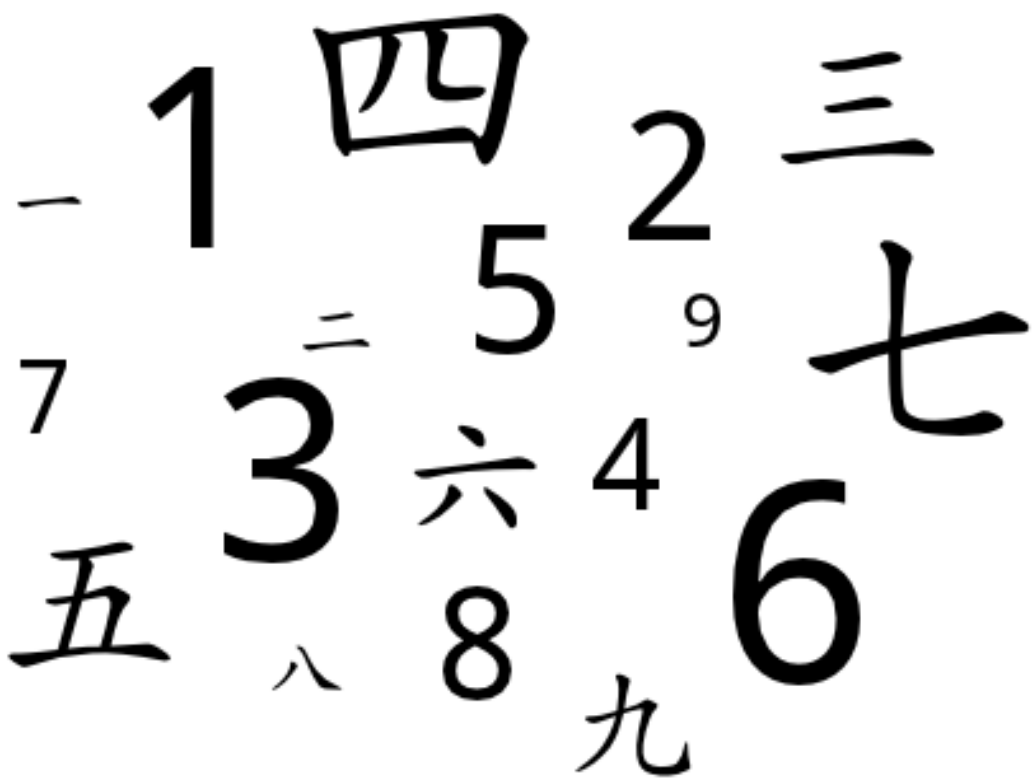


Here… We… Go…

Counting

- Lets learn counting…

0 1 2 3 4 5 6 7 8 9 **10**



Counting

- Lets learn counting…

0 1 2 3 4 5 6 7 8 9 **10**

- The place-value 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

The “power” of the radix

- Many everyday things are because of the radices of the ancient past:
  - 24 hours in a day
  - 60 minutes in an hour
  - 60 seconds in a minute
  - 360° in a circle

- Things not dependent on the radix:
  - Days in a year
  - The value of pi (or other constants)

Various number systems

- Octal number system
  - The base or radix is 8
  - The symbols are: 0, 1, 2, 3, 4, 5, 6, 7
- 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
- We denote the base of the number using a suffix subscript: $(10395)_{10}$
- In general a number $(a_4a_3a_2a_1a_0)_r = a_4r^4 + a_3r^3 + a_2r^2 + a_1r^1 + a_0r^0$

Conversions to decimal

- Octal number system
  - $(110)_8 = 1*8^2 + 1*8^1 + 0*8^0 = (72)_{10}$
  - $(777)_8 =$
- Hexadecimal number system
  - $(110)_{16} = 1*16^2 + 1*16^1 + 0*16^0 = (272)_{10}$
  - $(BAD)_{16} =$
- Binary number system
  - $(110)_2 = 1*2^2 + 1*2^1 + 0*2^0 = (6)_{10}$
  - $(101010)_2 =$

Conversions from decimal

- Algorithm:
  - Divide by radix
  - Save the remainder
  - Repeat
  - Arrange remainders in reverse order
- Octal number system
  - 912
  - 75
- Hexadecimal number system
  - 1729
  - 133
- Binary number system
  - 21
  - 10

Conversions from Oct/Hex to Binary

- From Oct/Hex to binary, we can take a short cut because the bases are $(2)^3$ and $(2)^4$ 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
  - $(433)_8$
  - $(70)_8$
- Hexadecimal number system
  - $(DEAD)_{16}$
  - $(FEED)_{16}$

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
  - $(110101011)_2$
  - $(1010111101)_2$
- Hexadecimal number system
  - $(11101011)_2$
  - $(110000110)_2$
  - $(101011111)_2$