Hardware Security
-- Digital Logic Design

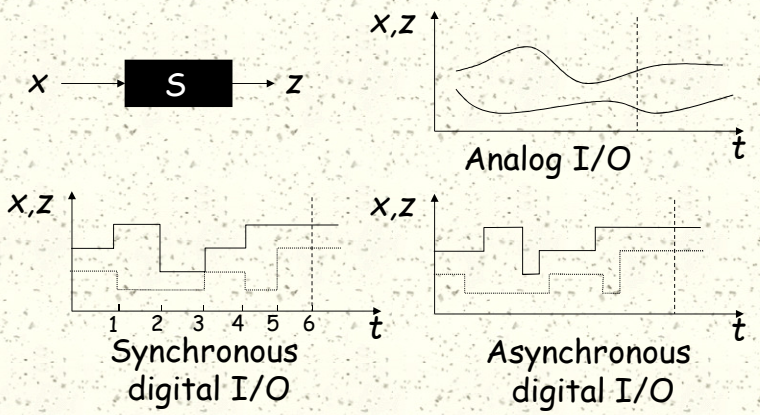
Cybersecurity Specialization

Outline: Digital Logic Design 101

- Digital system design/synthesis
  - System specification
  - System implementation
  - Function simplification/optimization
- Design examples
  - Combinational circuits
  - Sequential system
- Don't care conditions

Digital Systems

- Digital vs. analog
- Synchronous vs. asynchronous



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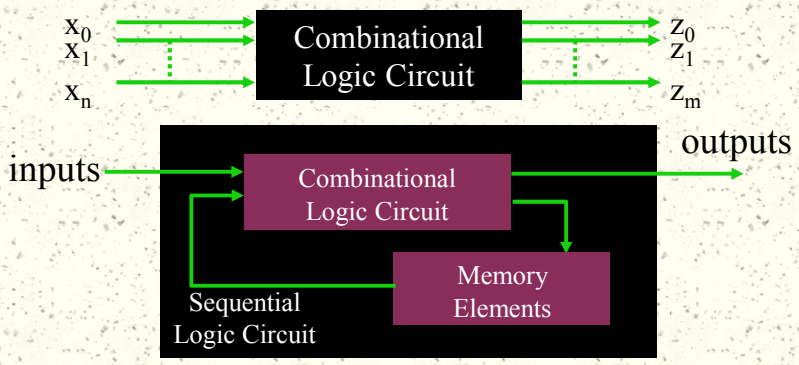

Digital System Specification

- The **specification** of a system is a description of its functionality and other characteristics required for its use.
- Developing system specification
  - From high-level to binary-level
    - Input (input signals and current state) encoding
    - Output (output signals and next state) encoding
    - Express output as Boolean functions of input
  - Truth table
  - State transition graph/table

Example: System Specification

- A system that tells whether a given month has 31 days.
- High-level system spec:
  - Input: $x \in \{1,2,3,4,5,6,7,8,9,10,11,12\}$
  - Output: $z \in \{0,1\}$
  - Function:

$$z = F(x) = \begin{cases} 0 & x=2,4,6,9.11 \\ 1 & x=1,3,5,7,8,10,12 \end{cases}$$

x	1	2	3	4	5	6	7	8	9	10	11	12
z	1	0	1	0	1	0	1	1	0	1	0	1

Example: System Spec

- A system that tells whether a given month has 31 days.
- Binary-level system spec:
  - Input variables/bits: x_3, x_2, x_1, x_0
  - Output variable/bit: z
  - Function:

    $z(x_3,x_2,x_1,x_0) = x'_3x_0 + x_3x'_0$

x	$x_3x_2x_1x_0$	z
1	0 0 0 1	1
2	0 0 1 0	0
3	0 0 1 1	1
4	0 1 0 0	0
5	0 1 0 1	1
6	0 1 1 0	0
7	0 1 1 1	1
8	1 0 0 0	1
9	1 0 0 1	0
10	1 0 1 0	1
11	1 0 1 1	0
12	1 1 0 0	1