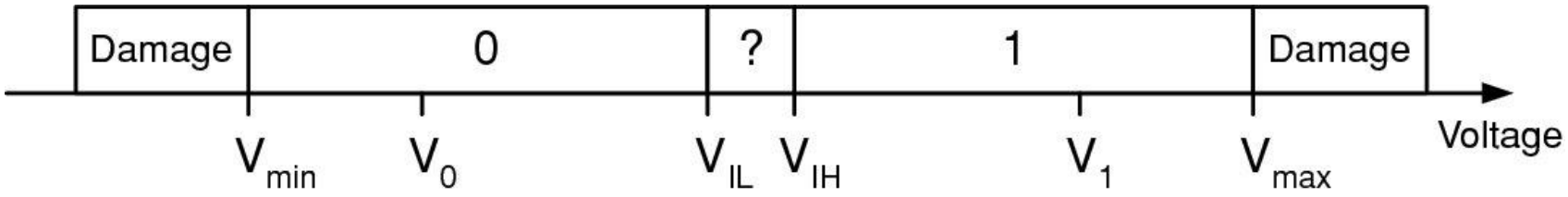
Digital Abstraction – Signal noise

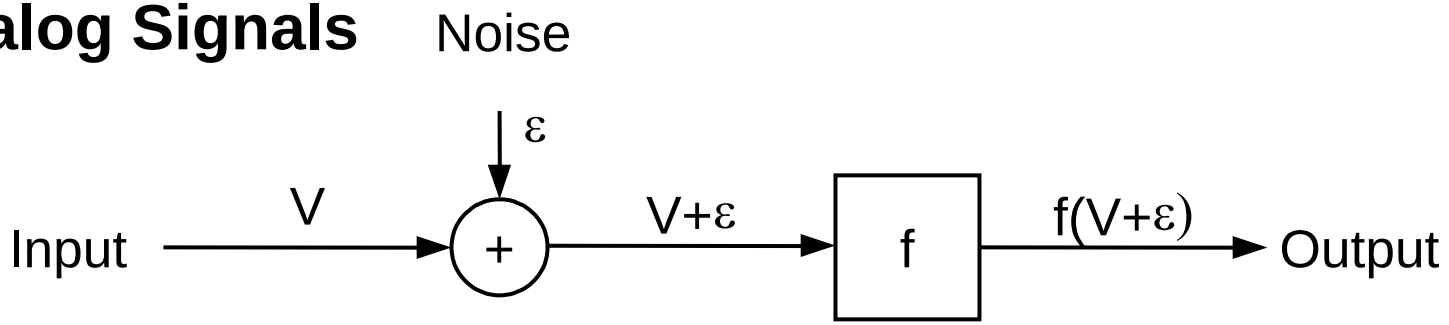
Voltage Range of Binary Signals



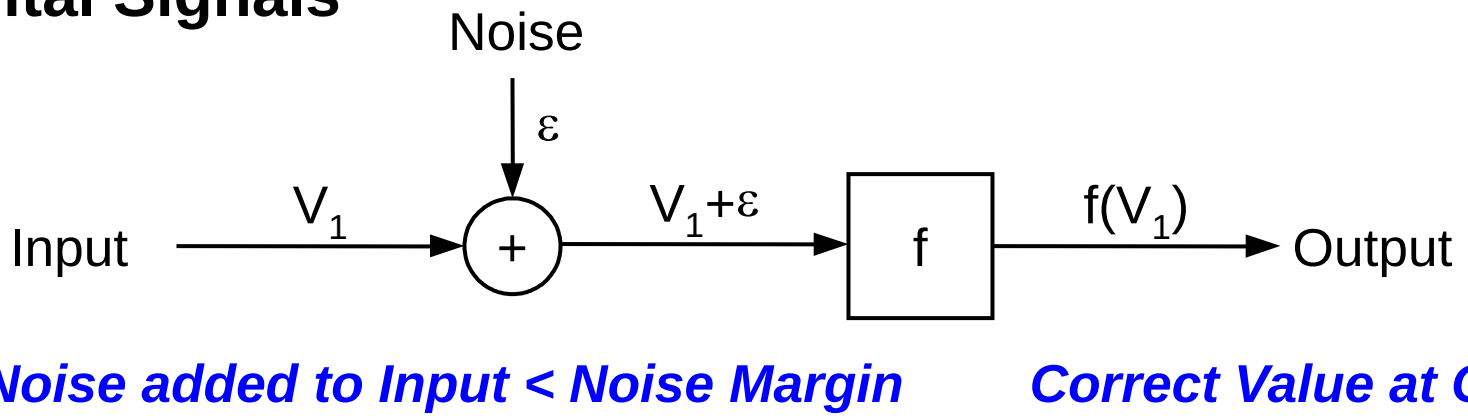
Parameter	Value	Description
V_{min}	-0.3V	Absolute minimum voltage below which damage occurs
V_0	0.0V	Nominal voltage representing logic "0"
V_{OL}	0.2V	Maximum output voltage representing logic "0"
V_{IL}	0.7V	Maximum voltage considered to be a logic "0" by a module input
V_{IH}	1.7V	Minimum voltage considered to be a logic "1" by a module input
V_{OH}	2.1V	Minimum output voltage representing logic "1"
V_1	2.5V	Nominal voltage representing logic "1"
V_{max}	2.8V	Absolute maximum voltage above which damage occurs

Effect of Noise on Analog & Digital Signals

Analog Signals

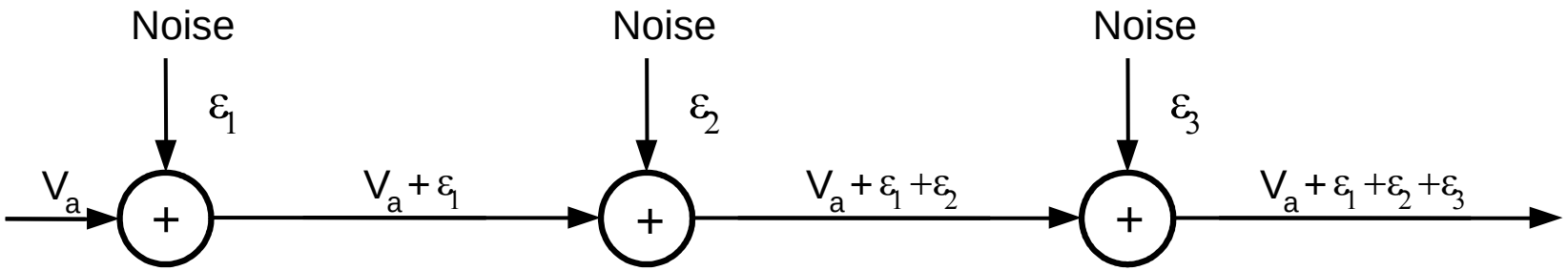


Digital Signals

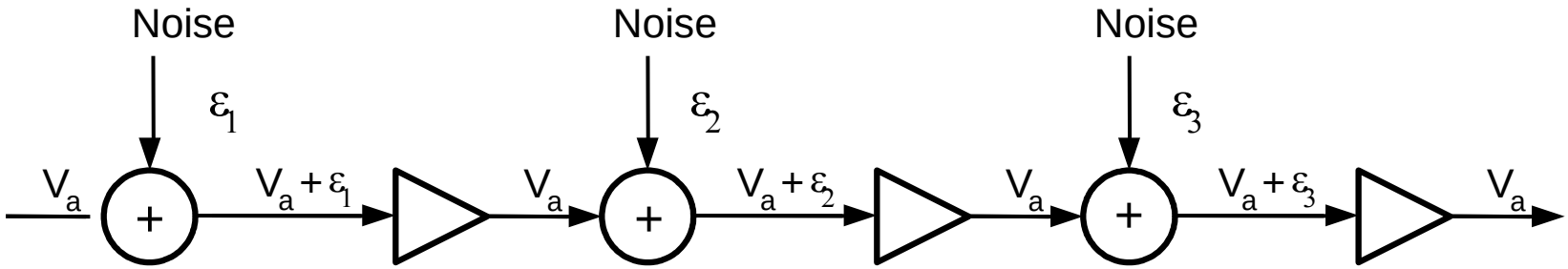


Restoration of Digital Signals

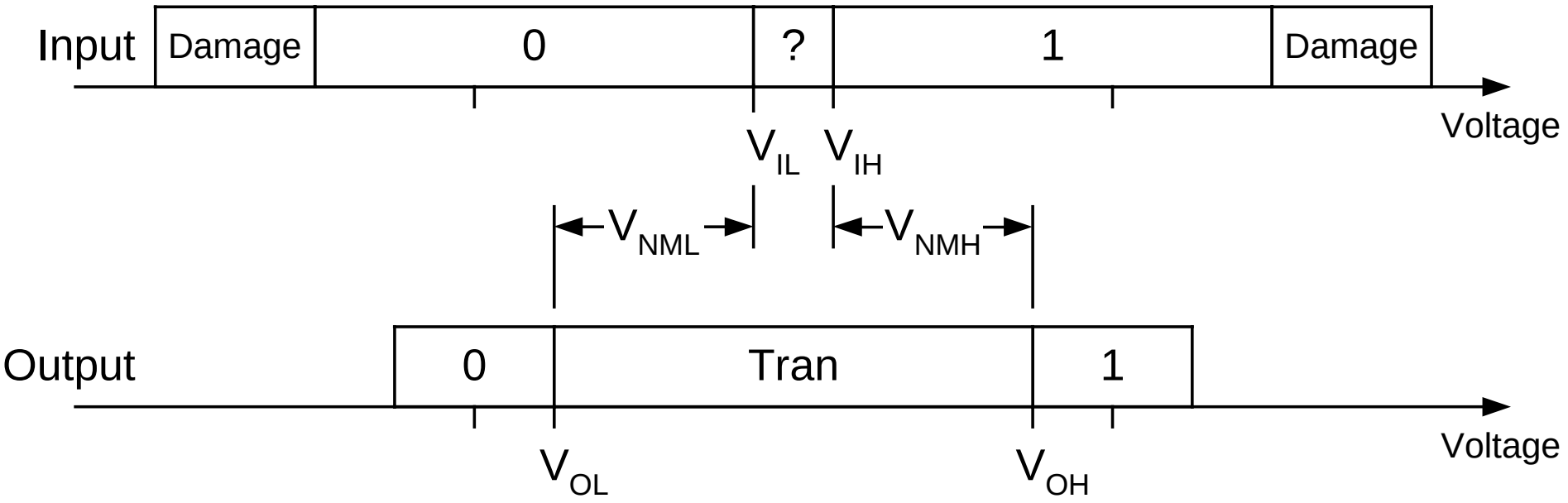
Noise Accumulation



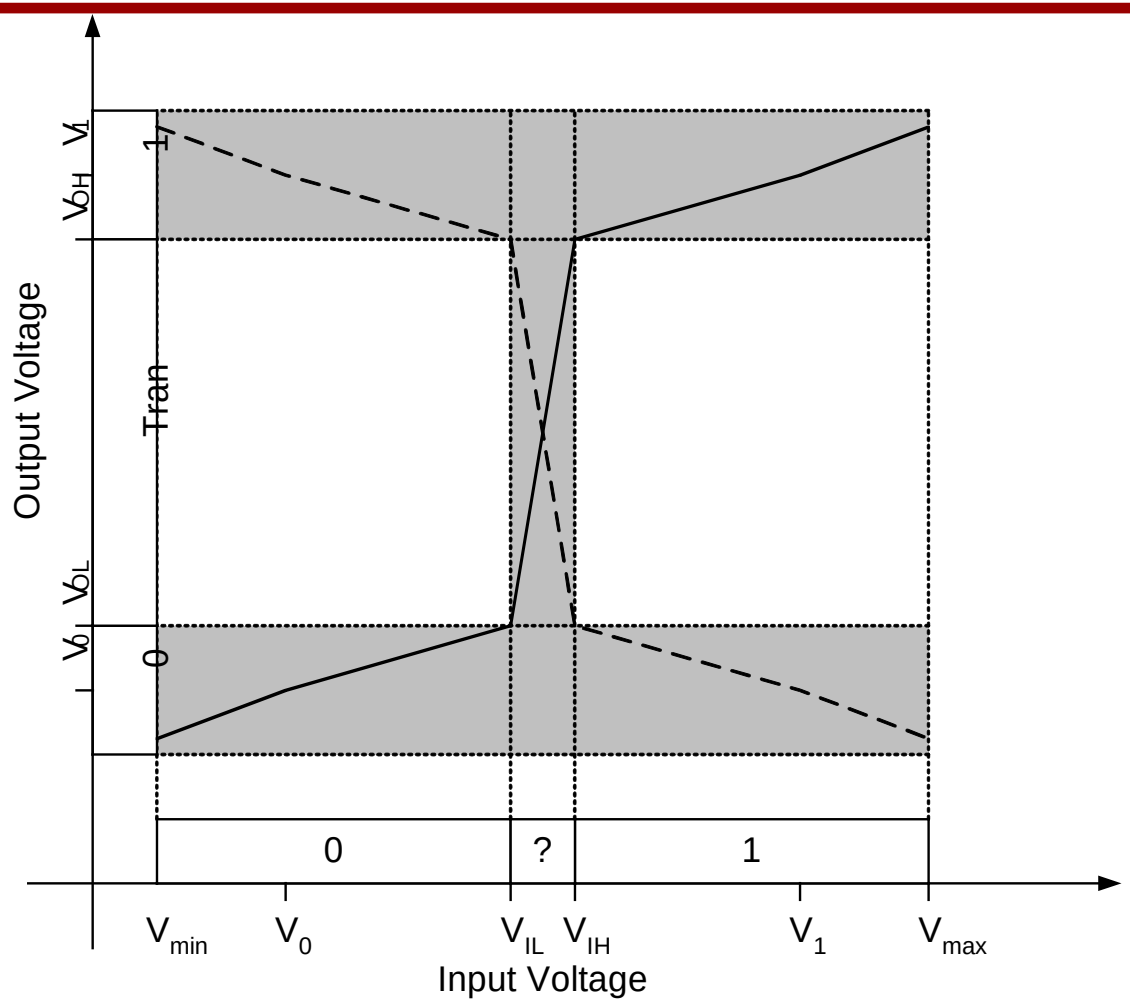
Signal Restoration



Input & Output Voltage Ranges



DC Transfer Curve for a Logic Module

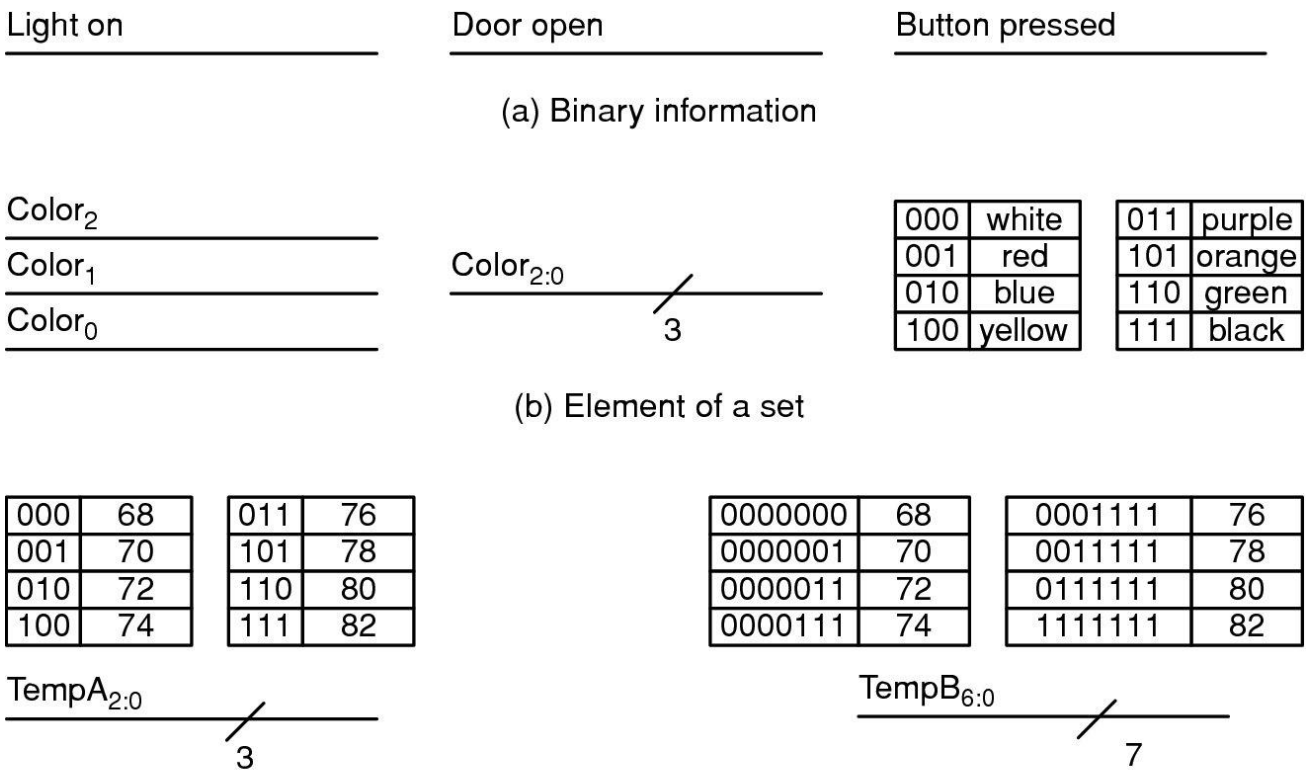


Summary

Unless noise margin is exceeded, a digital signal corrupted by noise can be restored to its original state.

Digital Abstraction – Data representation

Representing Information with Digital Signals



Representing the day of the year

- A Date ?
  - Days (9 bits)
  - Month, day (4 + 5 bits)
  - Month, day, day of week (4 + 5 + 3 bits)

  0111 00100 100 → July 4 Wednesday

- Pick a representation based on operations required

Representing subtractive colors

- Pick representation of colors to support the operation of subtractive color mixing (e.g., red + blue = purple)
  - No colors - white
  - Primary colors – red, blue, yellow
  - Derived colors – orange, purple, green, black

- How would you represent this?

000	White
001	Red
010	Blue
100	Yellow

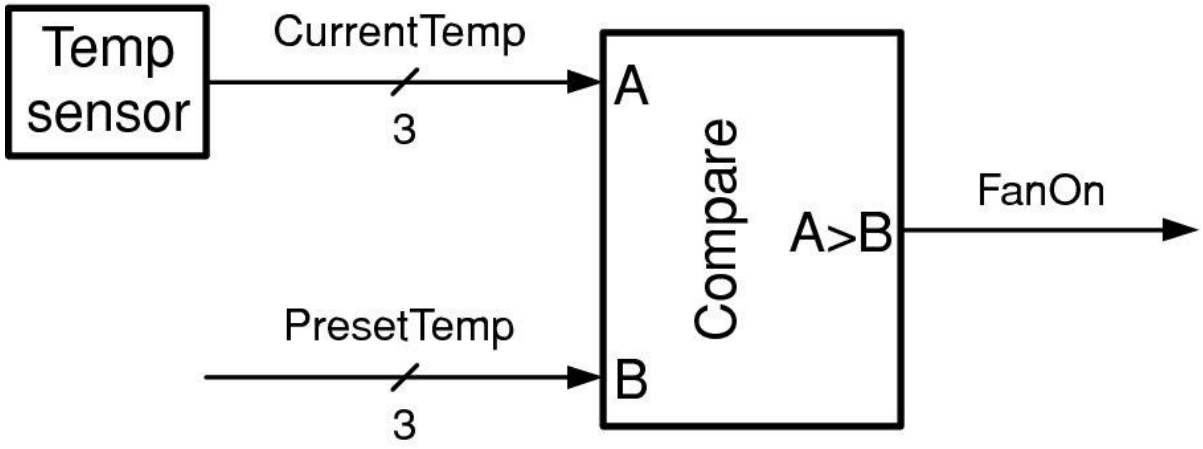
011	Purple
101	Orange
110	Green
111	Black

Summary

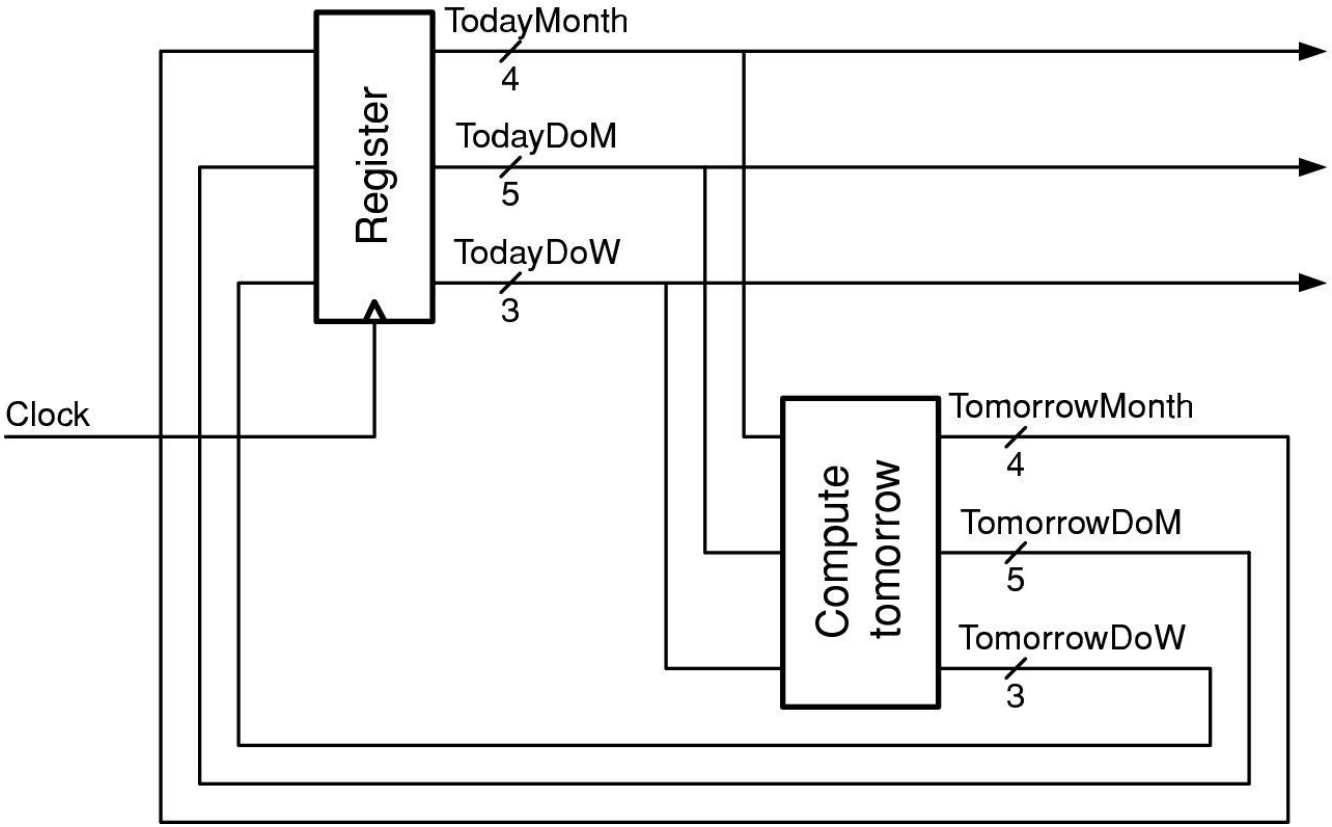
Digital signals can represent information via binary coded single-bit, multi-bit, after quantization if needed.

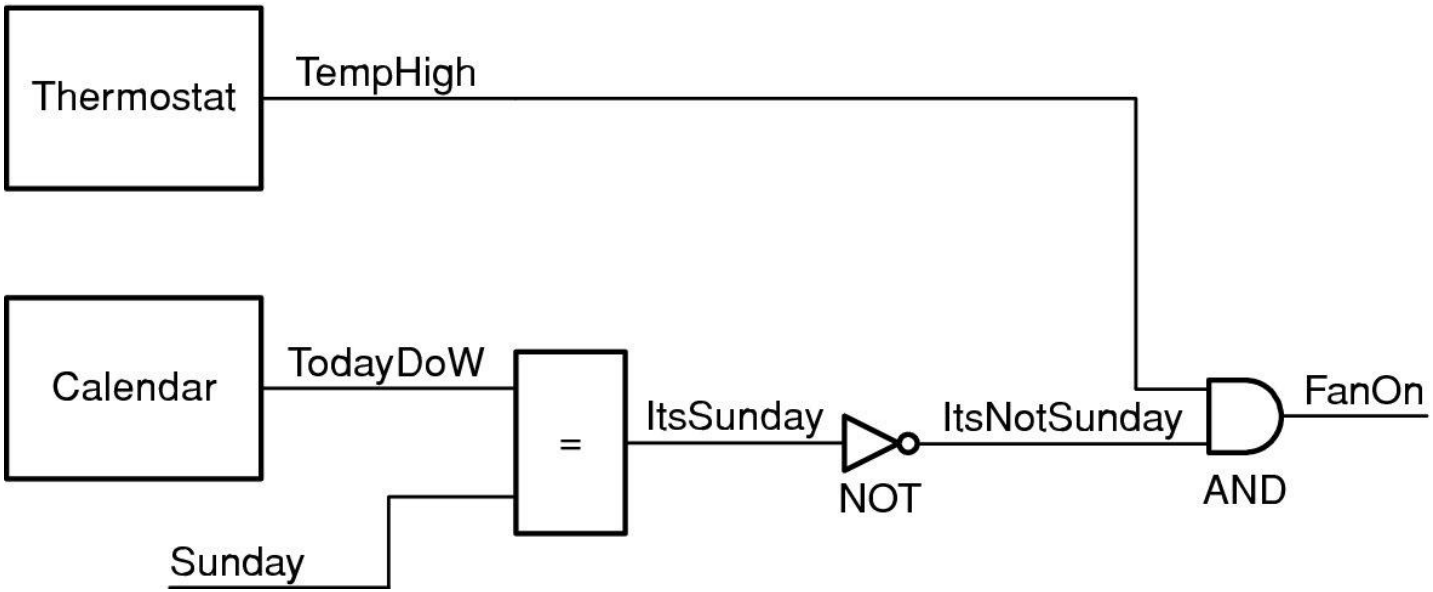
Digital Abstraction – Logic functions

Digital Logic functions



Example: Current day circuit




Thermostat
TempHigh
Calendar
TodayDoW
=
ItsSunday
NOT
ItsNotSunday
AND
FanOn
Sunday

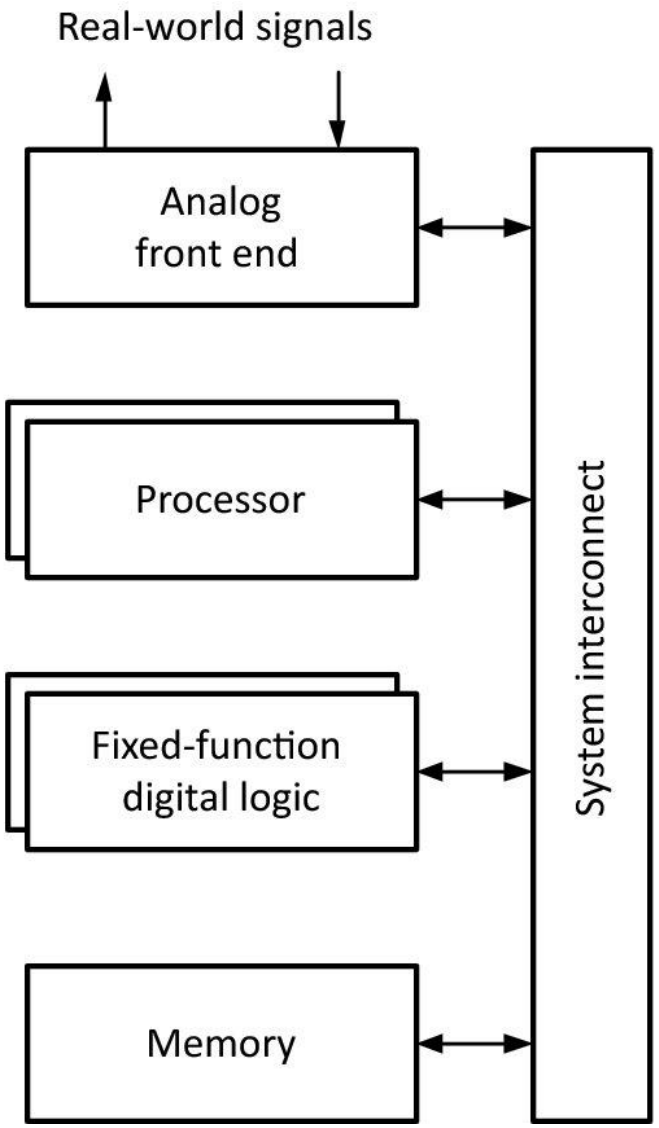
Verilog description

```
module Thermostat(presetTemp, currentTemp, fanOn) ;
  input [2:0] presetTemp, currentTemp ; // 3-bit inputs
  output fanOn ;                        // one bit output

  wire fanOn = (currentTemp > presetTemp) ; // compare temps
endmodule
```

```
# 011 000 -> 0
# 011 001 -> 0
# 011 010 -> 0
# 011 011 -> 0
# 011 100 -> 1
# 011 101 -> 1
# 011 110 -> 1
# 011 111 -> 1
```

Digital Logic in Systems



Summary

- Digital logic circuits perform logical functions – computing digital output signals whose values are functions of other digital signals.
  - Combinational logic circuit
  - Sequential logic circuit
- Can describe digital logic functions in Verilog.
  - Simulation
  - Synthesis