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This could be the solution, but…

- Basic problem with solution 1:
  - To much Hardware
  - Therefore an expensive design
  - The proposed design requires an AND gate for every input

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Solution 2 – Multipurpose Pins

- Single pin with many functions
  - Electrical Implementation:
    - Tri-state
    - Bi-directional
    - Push and Pull
      - Open collector
      - Open drain
      - Wired-or
      - Wired-and

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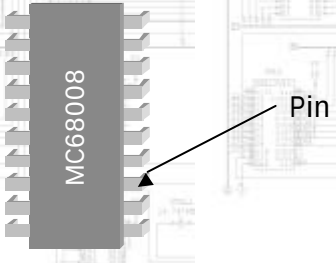
Ordinary Pins

- Pins, Pads and Wires.



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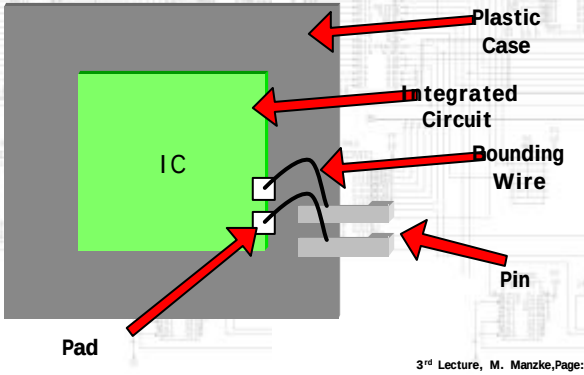
Integrated Circuit (IC) Package



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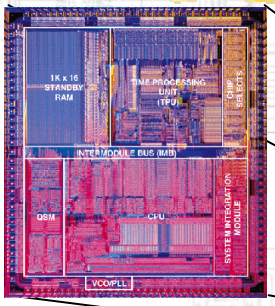
Integrated Circuit (IC) Package



IC

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Input Pin

Pad

Protecting Circuitry

IC Circuitry

Pin

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Output Pin

V_{CC}

(1)

Signal from IC Circuitry

Switch

Pad

Switch

Pin

(0)

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Fully Driven Output Pin

- Fully Driven:
  - Always outputting (0) or (1).
  - Only one output per wire connection.
  - At any time, exactly one switch is open.

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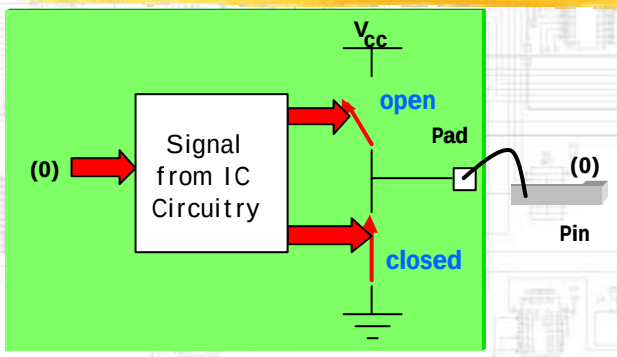
Output (0)



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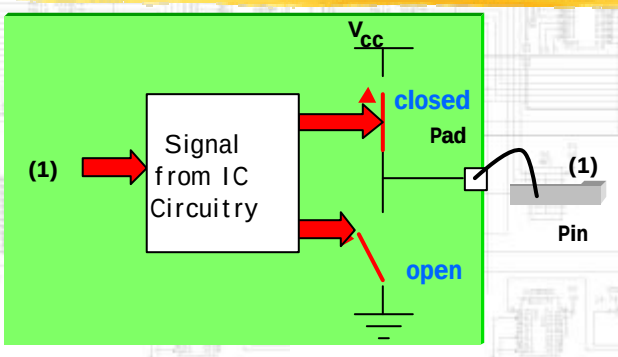
Output (1)



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Tri-state Output

- Pin effectively has 3 states:
  - Low
  - High
  - High-Impedance (Hi-Z) [disconnected]
- Third state:
  - Can disconnect from wire.

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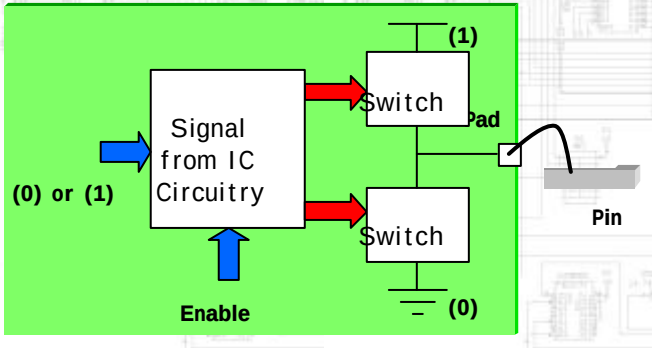
Output (0),(1) or (Hi-Z)



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Disconnect (Hi-Z)

- To disconnect:
  - -> Open both switch
- At any time, at most one switch is closed.
- Both switches may be open.

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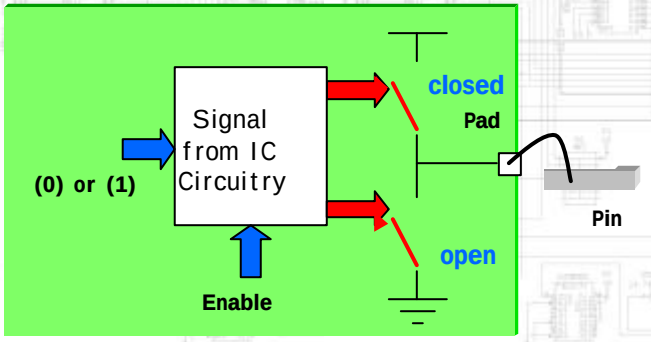
High-Impedance (Hi-Z)



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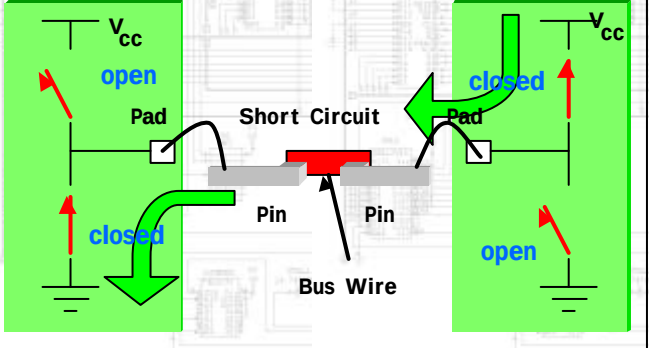
Tri-state - Pin Driving Conflict



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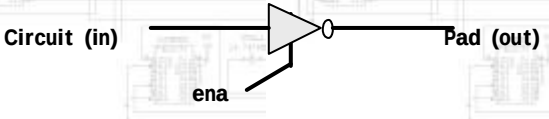
Need a Circuit Enable

ena = 0 -> out = Hi-Z
ena = 1 -> out = in

Variation:



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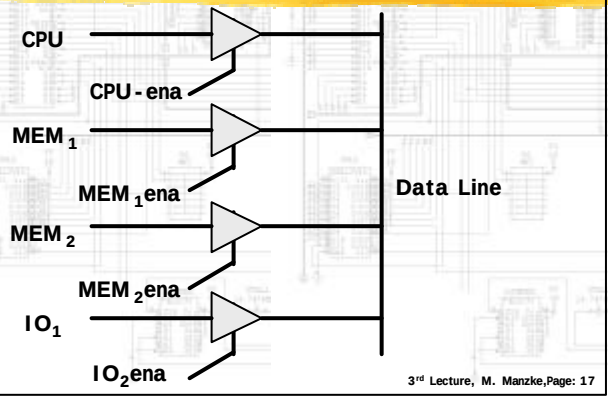
Data Bus



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Tri-state

- Cheap Hardware
- Need for Control Lines
- Design must ensure that only 1 control is active at a time.

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Address, Data and Control Bus

- Address Bus
  - CPU → All Devices
- Data Bus
  - CPU ↔ All Devices
  - -> We need multiplexers
    - -> Tri-state

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Data Bus