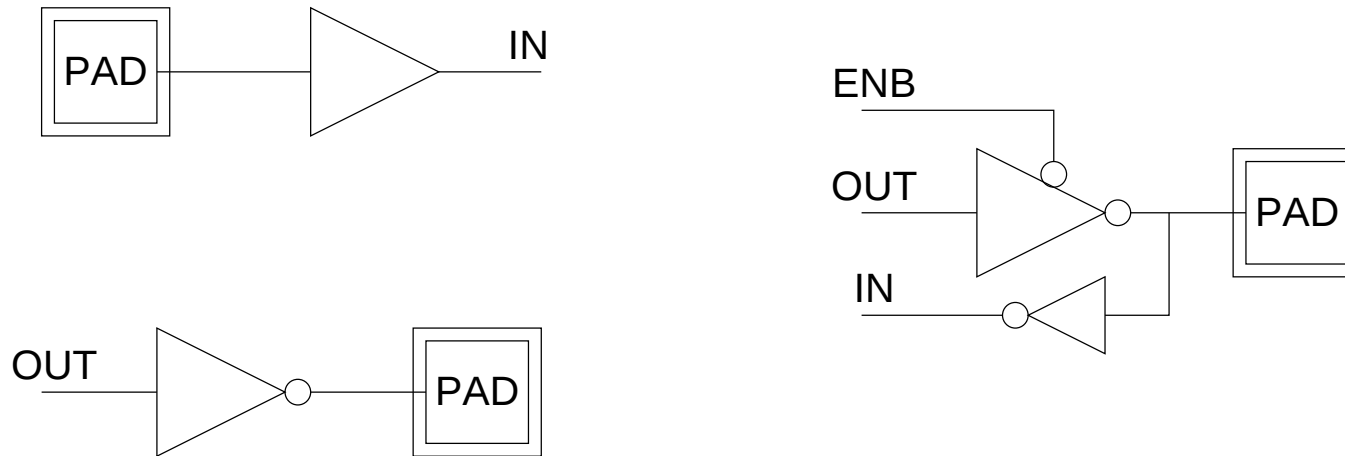


Input / Output

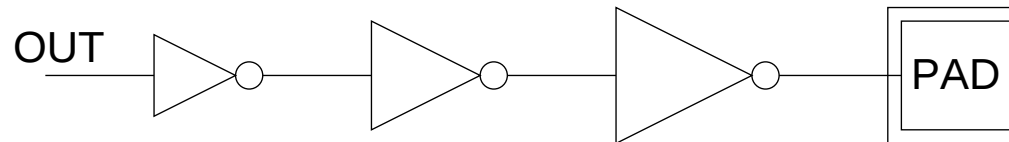
- I/O Pads



– A brief look at a selection of simple digital CMOS I/O pads

Output Pads

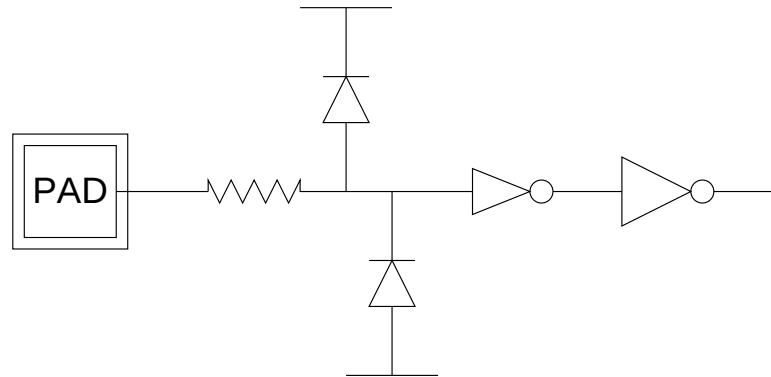
- Output pad driver



- ratioed inverters are used to provide appropriate drive capability
- final drive transistors are carefully designed to avoid latch-up
- pad rings are frequently powered separately (dirty power) to confine switching noise

Input Pads

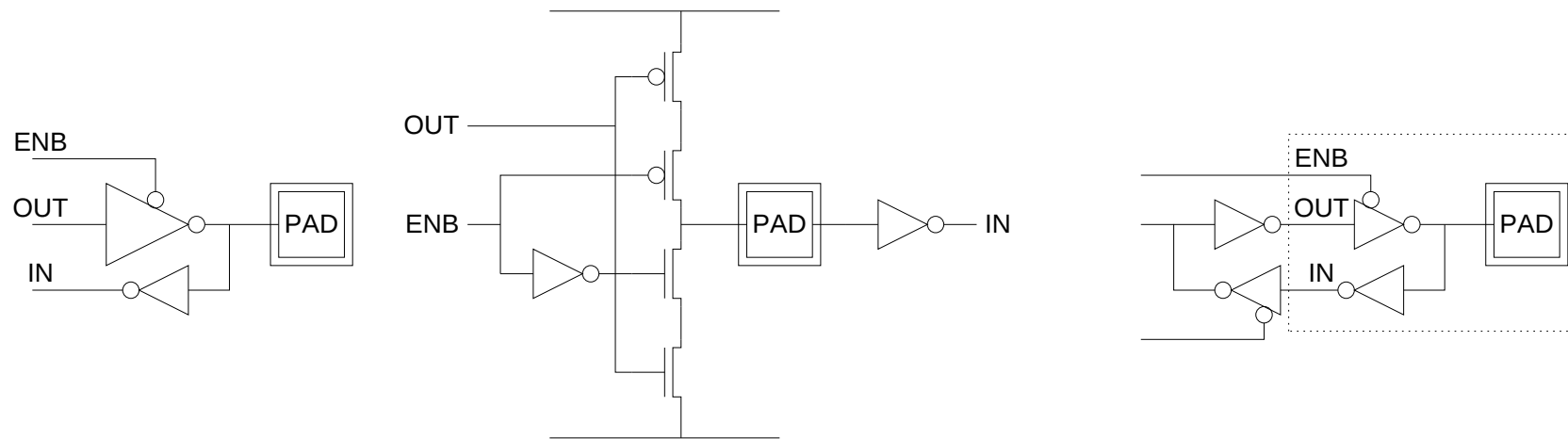
- Input protection



- must protect floating transistor gates from permanent damage via electrostatic discharge

Bidirectional Pads

- Simple bidirectional pad

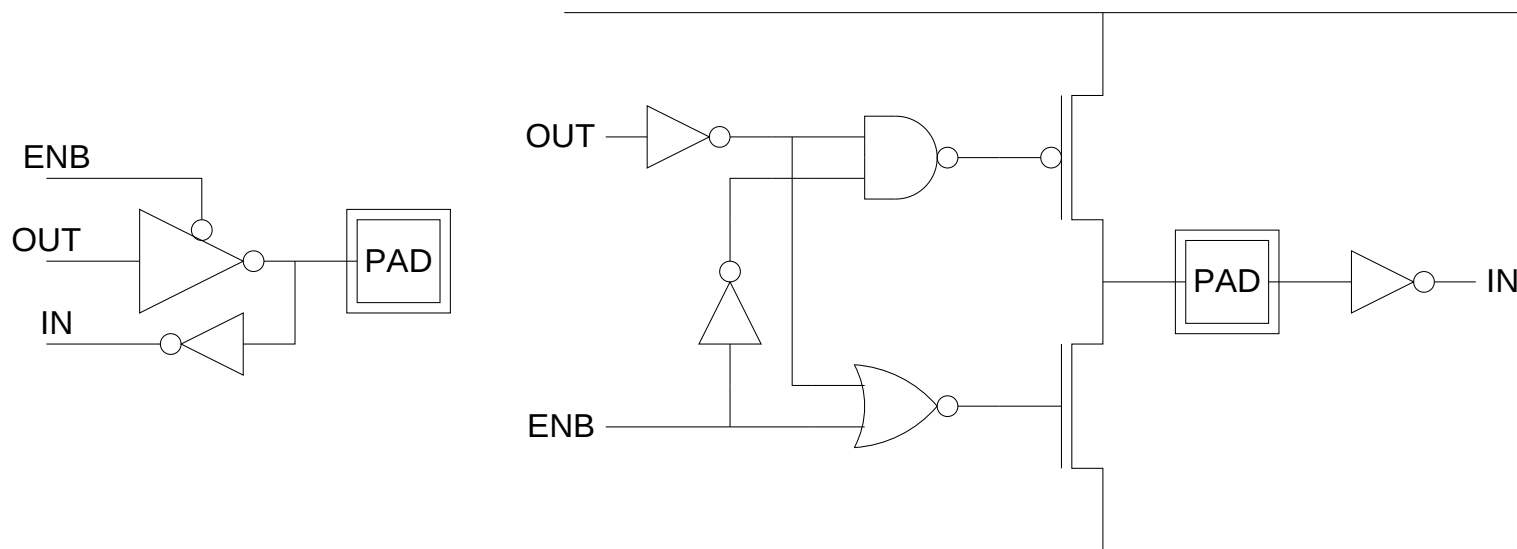


- bidirectional pad is a tristate inverter output driver combined with an input pad¹
- If IN and OUT are connected internally, we need buffering and an input enable control signal

¹note input protection is not shown here

Bidirectional Pads

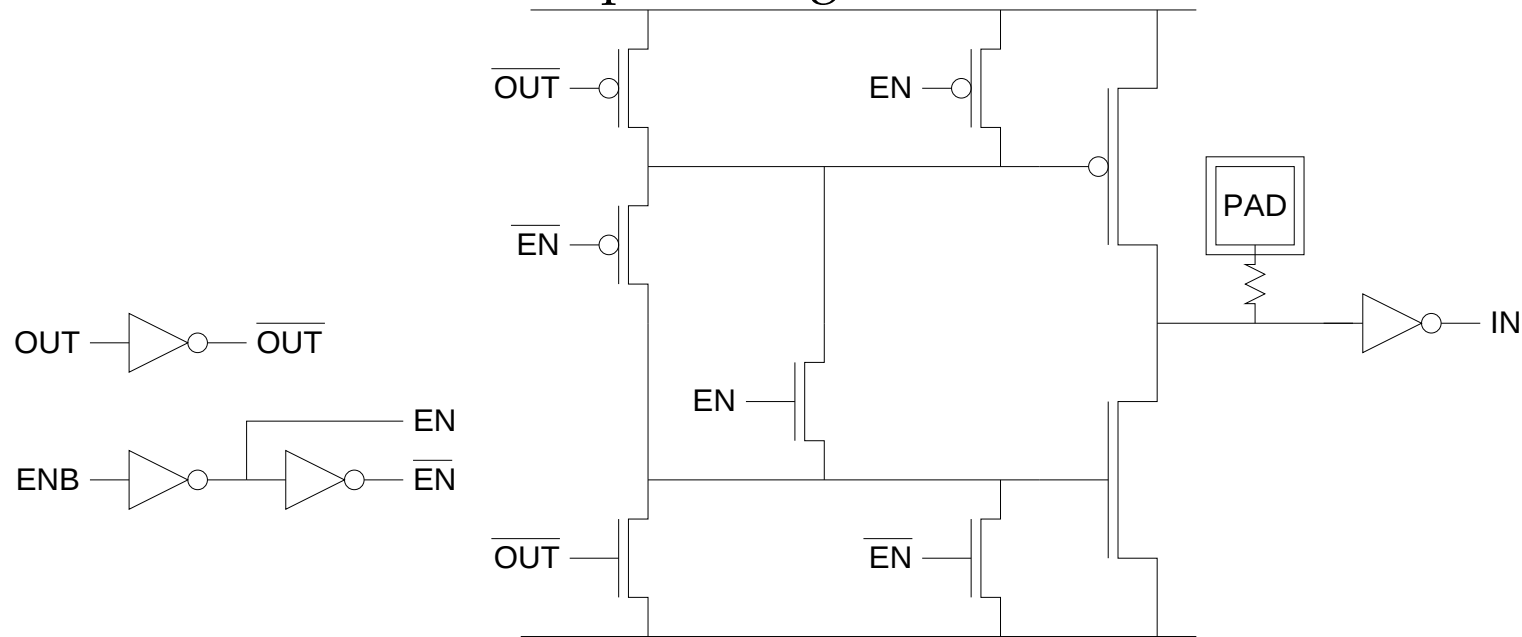
- Bidirectional pad with increased drive capability



- redesign to avoid series output transistors

Bidirectional Pads

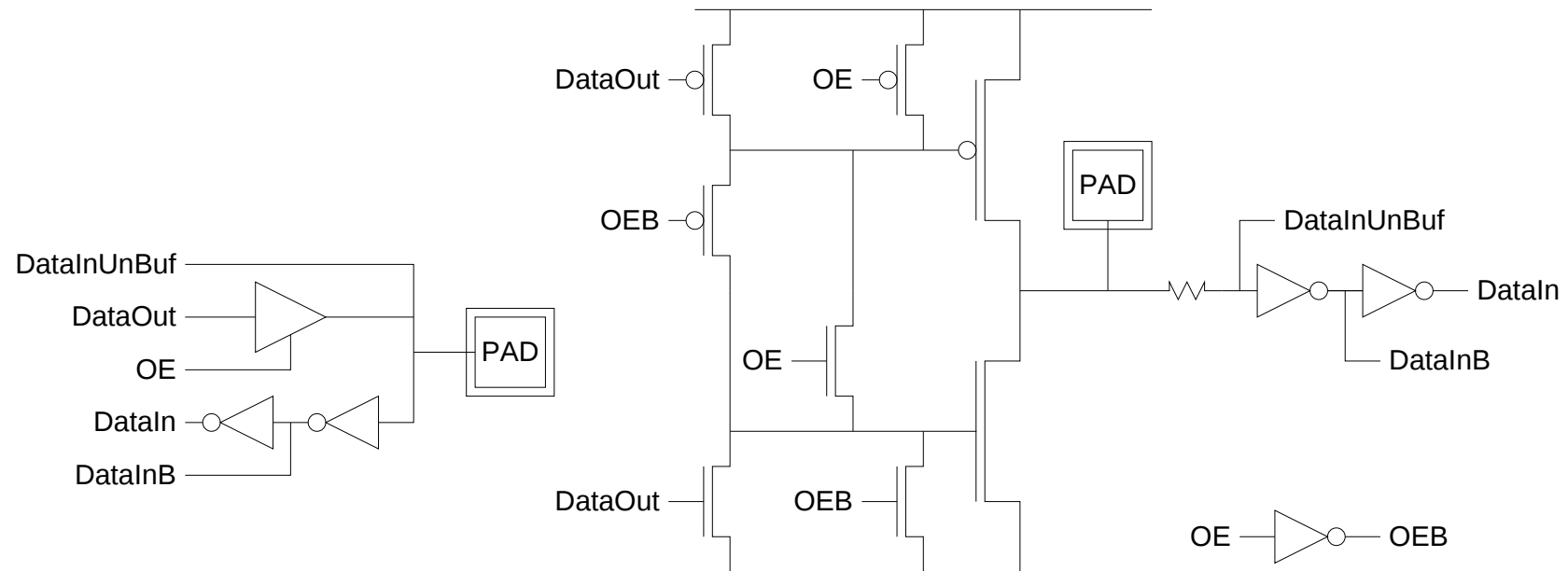
- Advanced bidirectional pad design



- logic gates are merged
- output transistors act as diodes when not enabled
- low value diffusion resistor completes input protection circuit

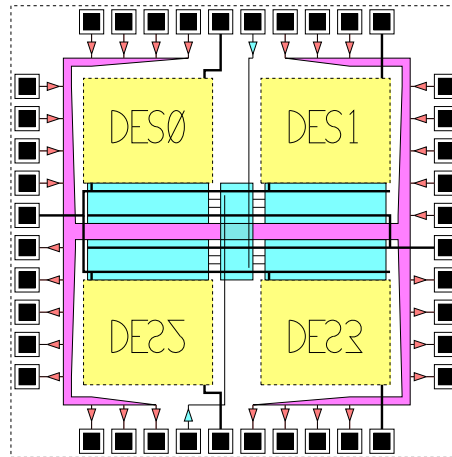
Bidirectional Pads

- MOSIS Bidirectional Pads

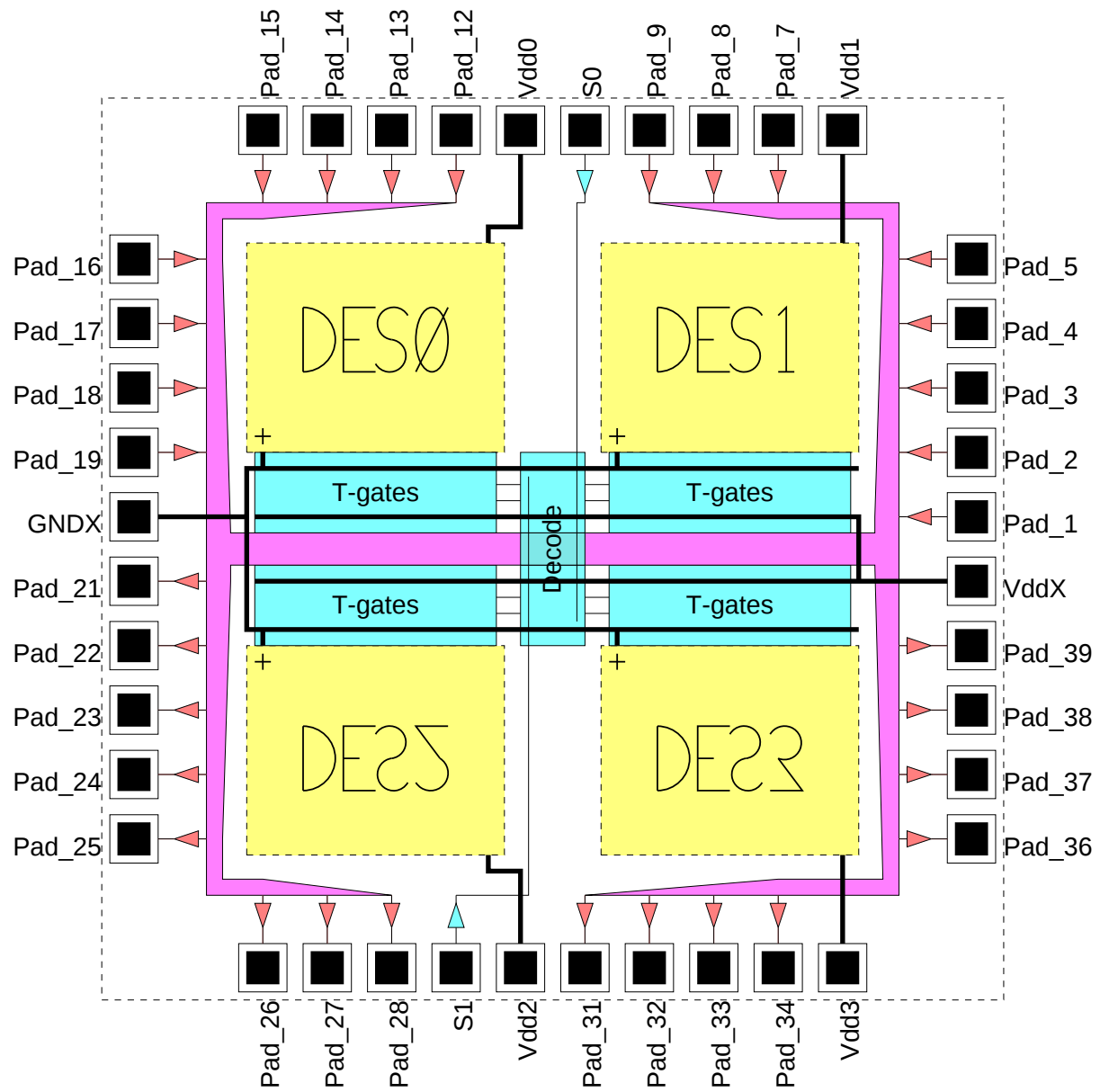


– less buffering on DataOut from core circuit

UoC Tiny Chip



- 40 Pad MOSIS AMI $0.5\mu m$ TinyChip Frame $1500\mu m \times 1500\mu m$
- 4 Designs $\approx 430\mu m \times \approx 380\mu m$
- 32 User I/O Pins (pre-selected as either input or output)
- Complete isolation of designs not under test



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