

CS271 First Principles

First Commercially Successful Computers

- PDP DEC machines
- Honeywell
- Burroughs
- Digital Equipment Corporation
- IBM

Pre-integrated circuit

Soldier

Can't mass produce

Analog Computers

Current & voltage

Unreliable

Temp

Hard to read

Required calibration

Tight specs for power supplies

Digital Computers

1's & 0's

Need more digits for same resolution

Forgiveness

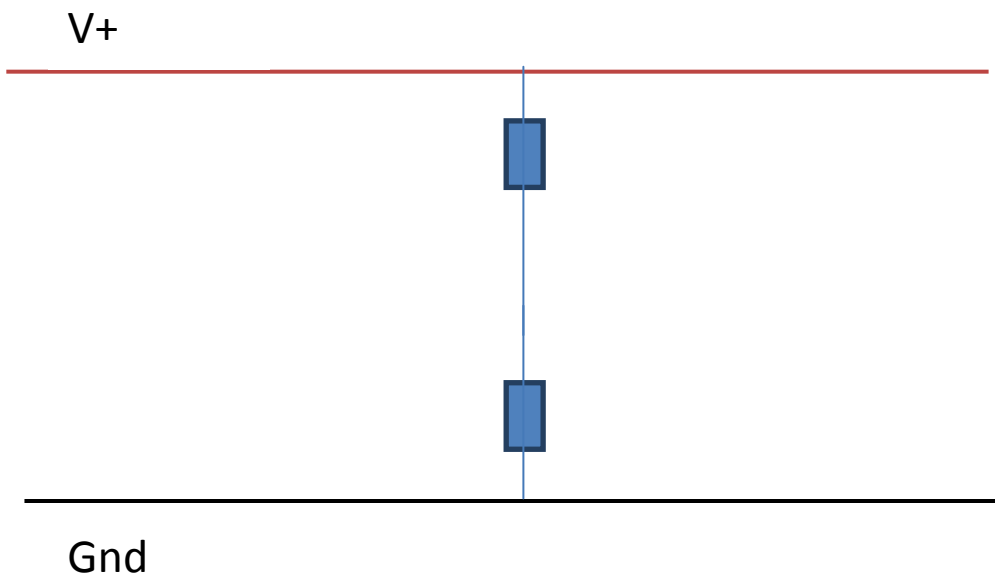
Absolute accuracy

No drift

Digital Logic

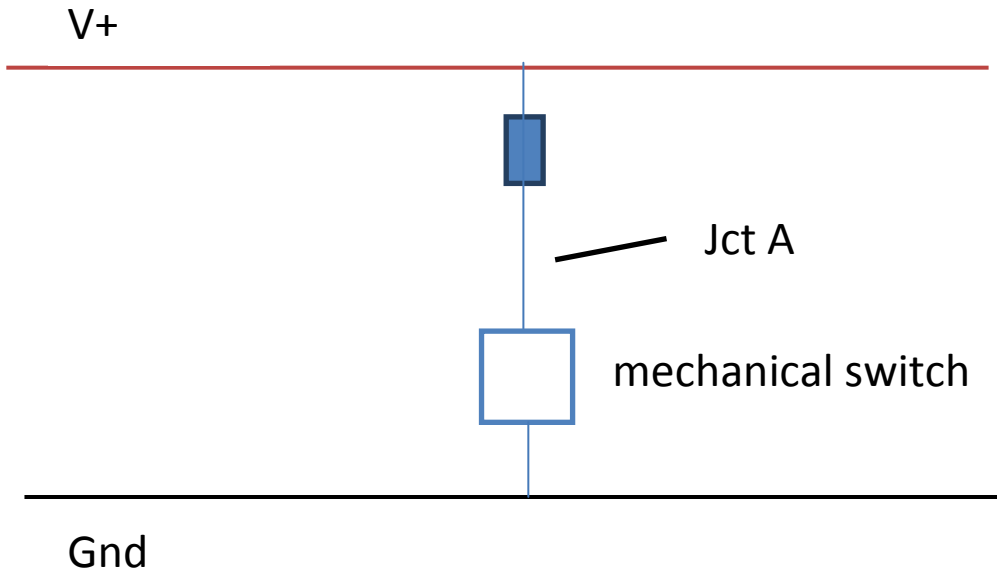
Resistor – voltage to heat

Voltage Divider



2 resistors in serial

Shared V drop

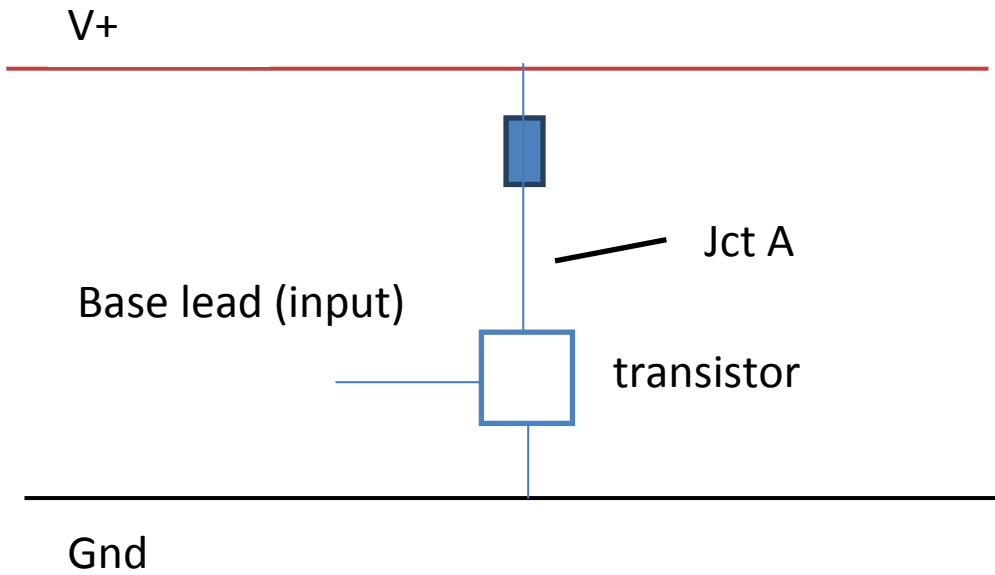


Closed: $A = 0$

Open $A = V$

No V drop

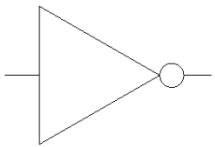
Inverter



Base lead on = A off

Base lead off = A on

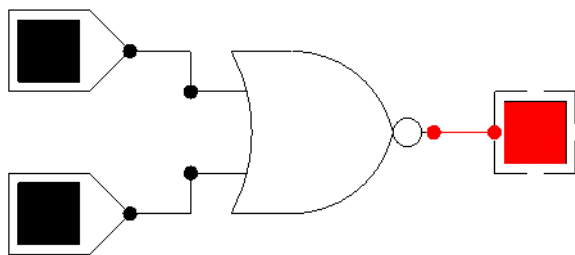
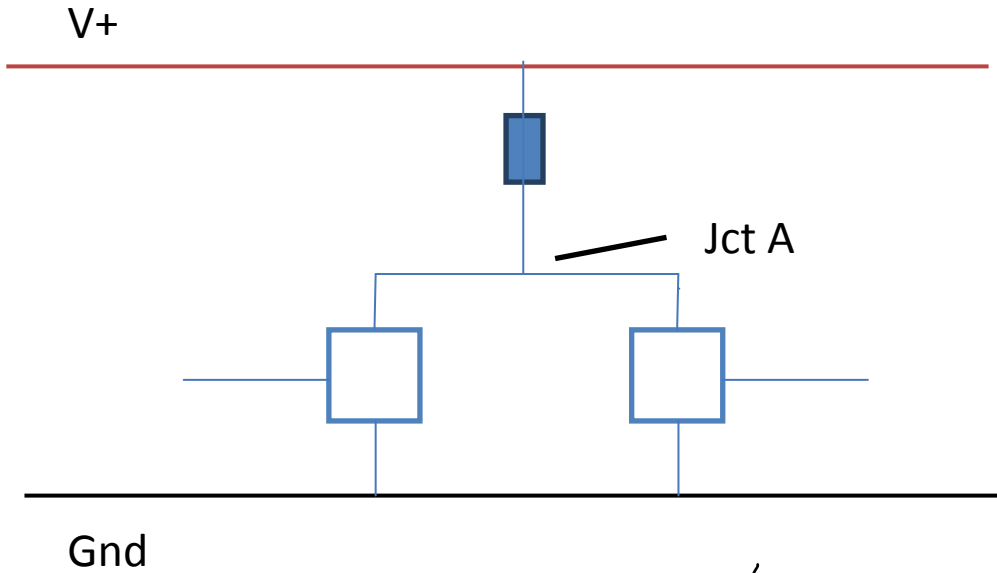
This creates an **inverter**



A	Out
1	0
0	1

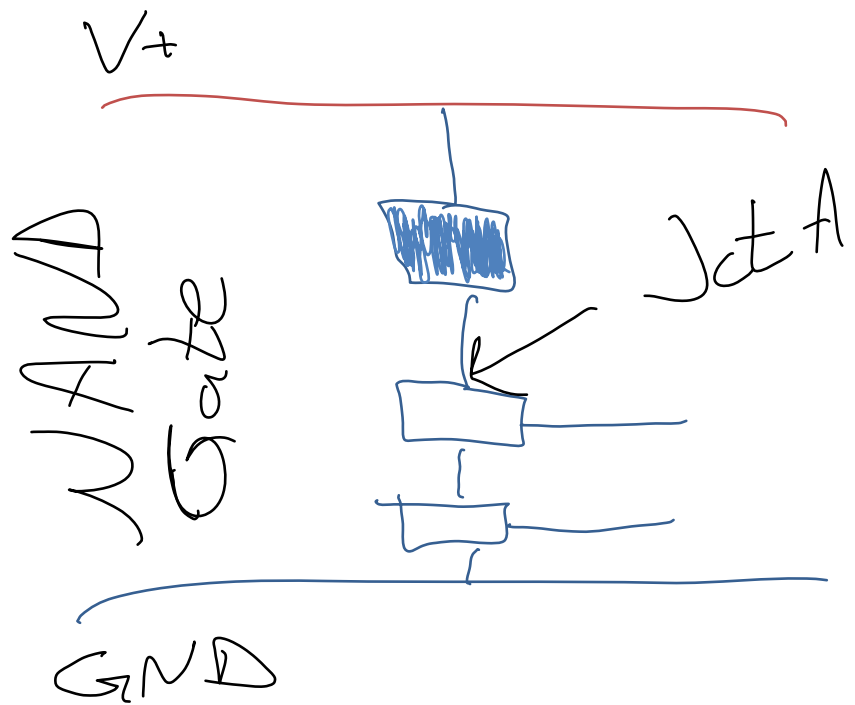
NOR

Additional transistor in parallel



A	B	Out
1	1	0
0	1	0
1	0	0
0	0	1

NOR



Beginning of Logic

NOR + Inverter = OR

A	B	Out	-Out
1	1	0	1
0	1	0	1
1	0	0	1
0	0	1	0

OR

NOR with inverted inputs

A	B	-A	-B	Out
1	1	0	0	0
0	1	1	0	0
1	0	0	1	0
0	0	1	1	0

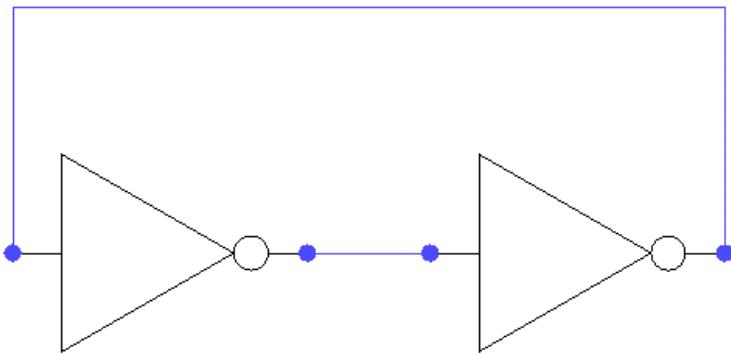
AND

Resistor Transistor Logic (RTL)

Registers

Storage

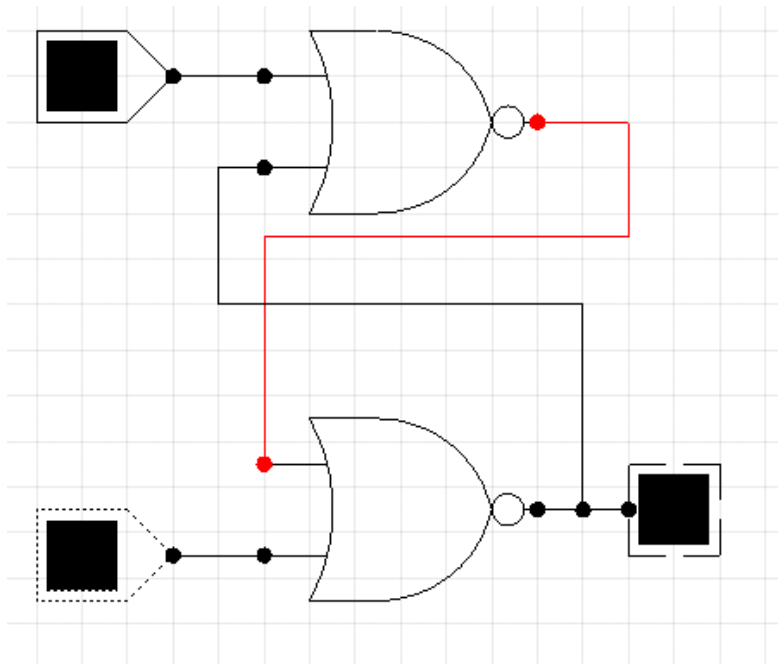
How do we go from AND and OR to here?



Stable feedback loop

Flip-flop

Usually done with NOR

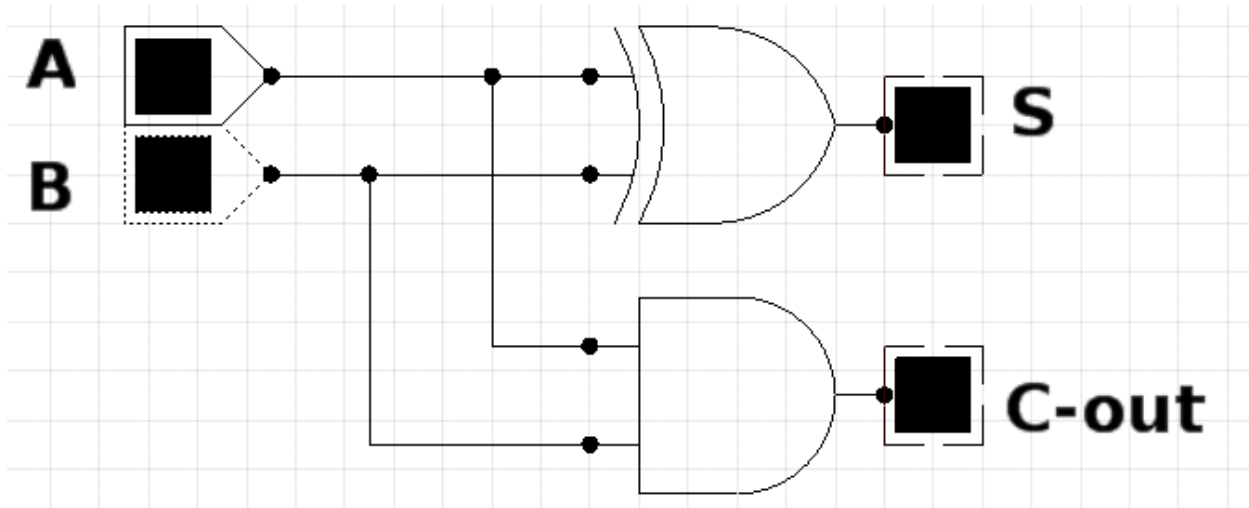


Adders

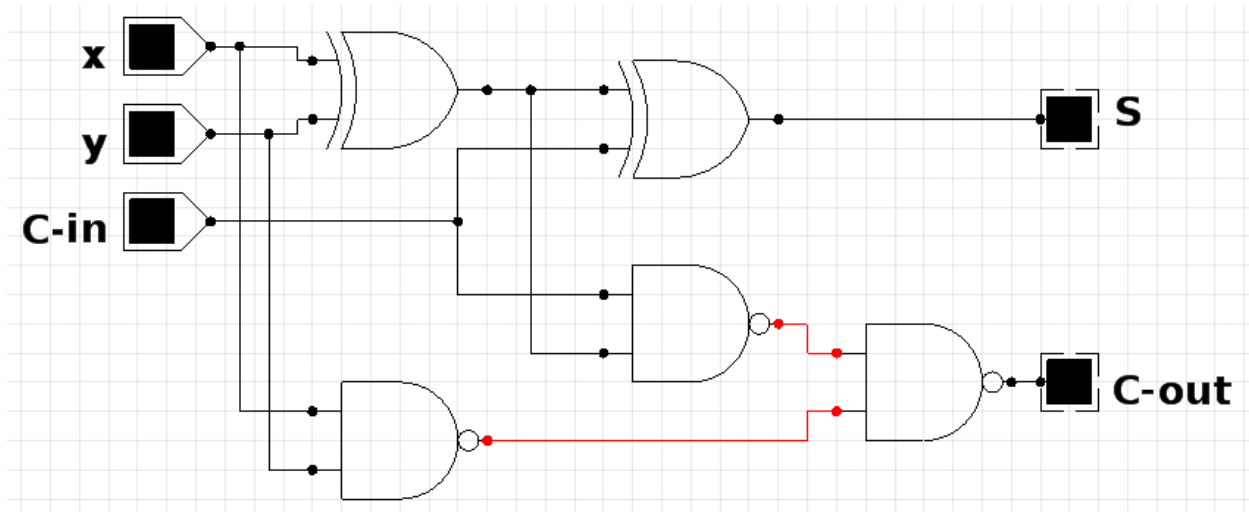
Addition of binary numbers is synthesizable from these fundamental logic blocks

Review binary add & sub

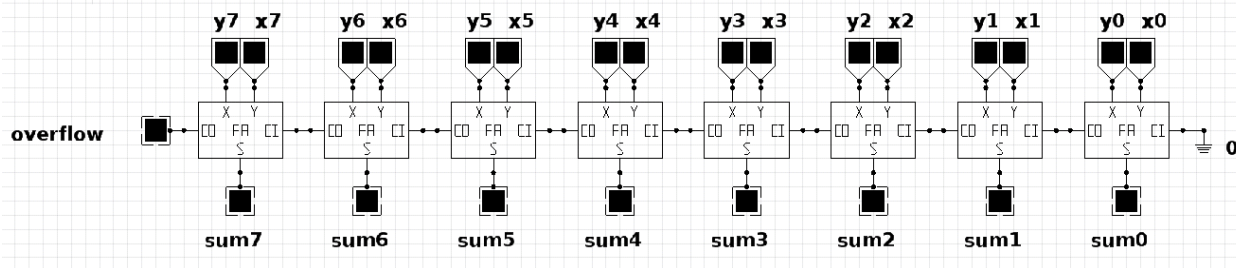
Half-Adder



Full-Adder



8-bit full adder



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To implement 1 NOR-gate register may take 20 transistors

In 1960 a transistor was a \$2 part

\$40 for NOR gates for 1 bit of register (parts only)

Solder this on a circuit board along with resistors, copper wire, etc.

\$50 for the register

A 16-bit register would cost \$800

Today, an nVidia card with 1.4 Billion registers can be had for \$100

The Interconnection Problem

Physical need to interconnect the pieces became limiting factor

Integrated circuit to the rescue