



SNS COLLEGE OF ENGINEERING

Coimbatore-35
An Autonomous Institution



Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A+' Grade
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

19EC505-VLSI DESIGN

III YEAR/ V SEMESTER

UNIT 2 –COMBINATIONAL LOGIC CIRCUITS



OUTLINE



- A Brief History
- CMOS Gate Design
- Pass Transistors
- Transmission Gate logic
- Activity
- Assessment
- Summary



A Brief History



1958: First integrated circuit

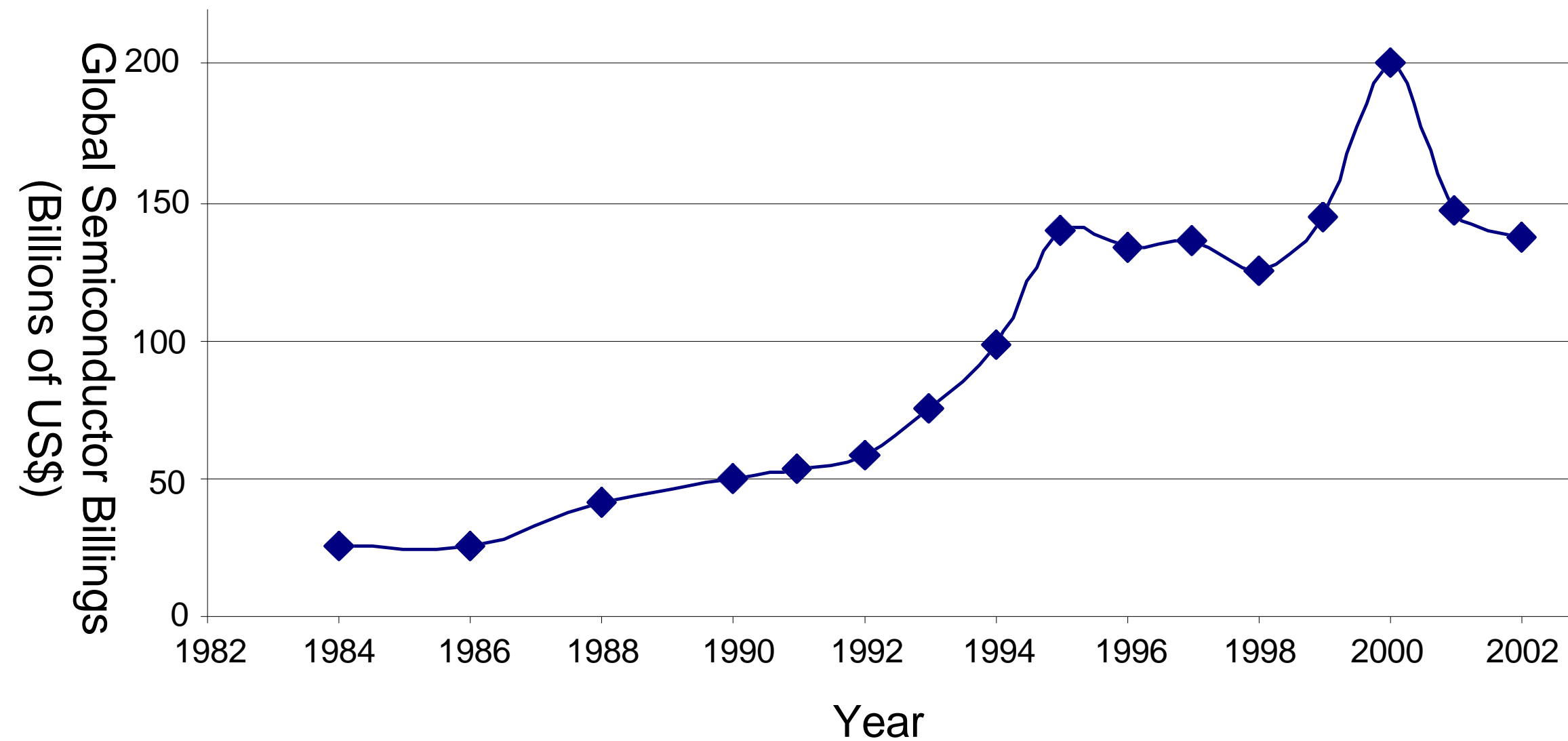
- Flip-flop using two transistors
- Built by Jack Kilby at Texas Instruments

2003-Intel Pentium 4 mprocessor (55 million transistors)

512 Mbit DRAM (> 0.5 billion transistors) miniaturization of transistors Smaller is cheaper, faster, lower in power! Revolutionary effects on society



Annual Sales





Transistor Types

➤ **Bipolar transistors**

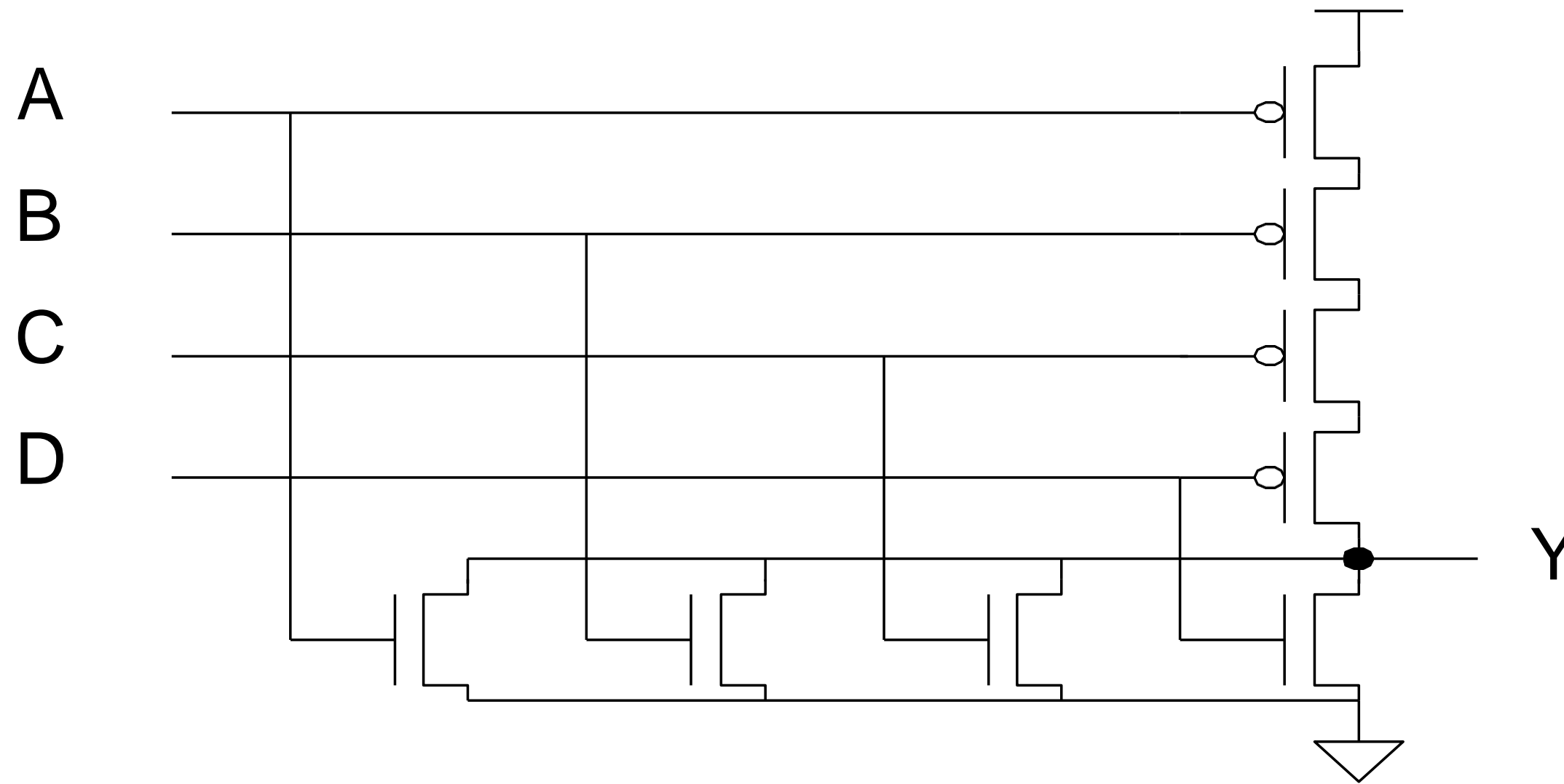
- npn or pnp silicon structure
- Small current into very thin base layer controls large currents between emitter and collector
- Base currents limit integration density

➤ **Metal Oxide Semiconductor Field Effect Transistors**

- nMOS and pMOS MOSFETS
- Voltage applied to insulated gate controls current between source and drain
- Low power allows very high integration



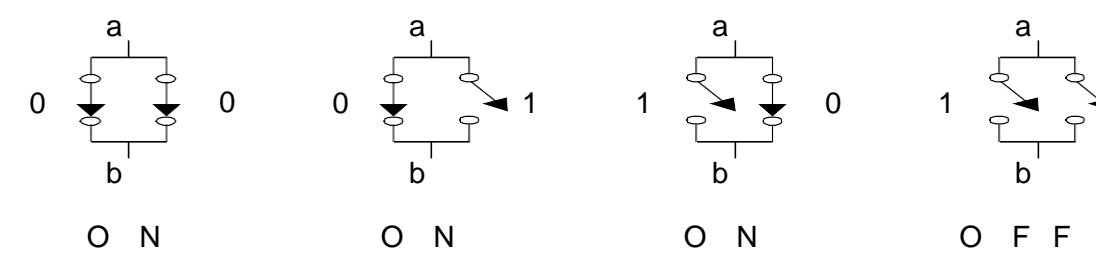
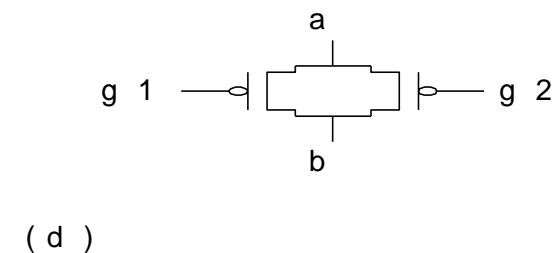
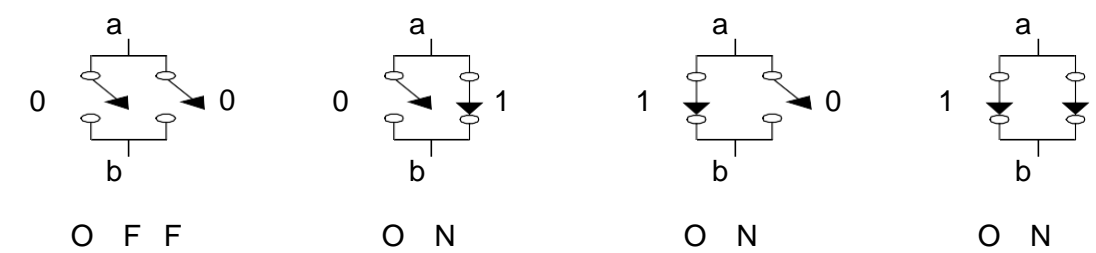
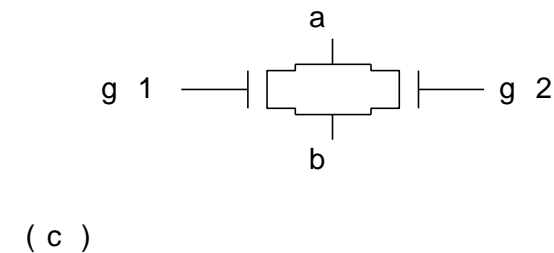
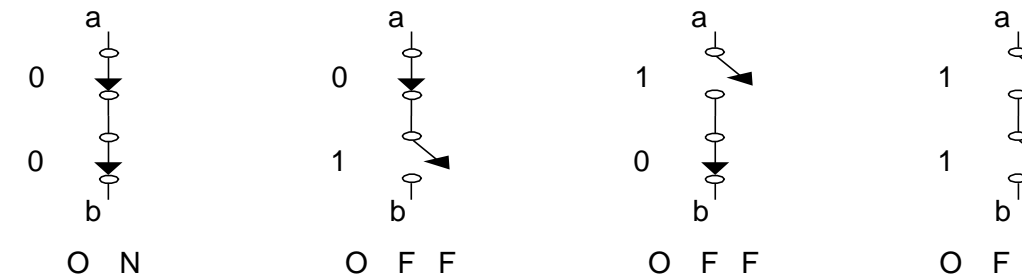
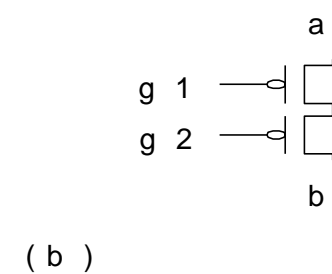
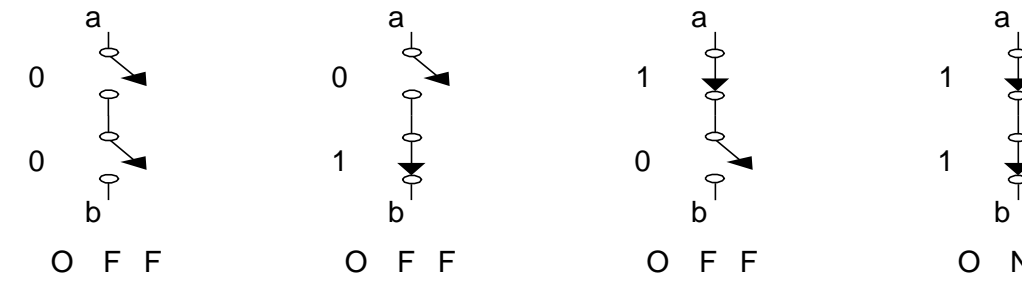
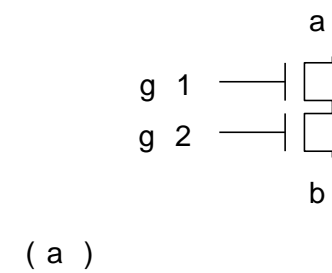
CMOS Gate Design-4 input NOR





Series and Parallel Connections

- nMOS: 1 = ON
- pMOS: 0 = ON
- *Series*: both must be ON
- *Parallel*: either can be ON





Conduction Complement

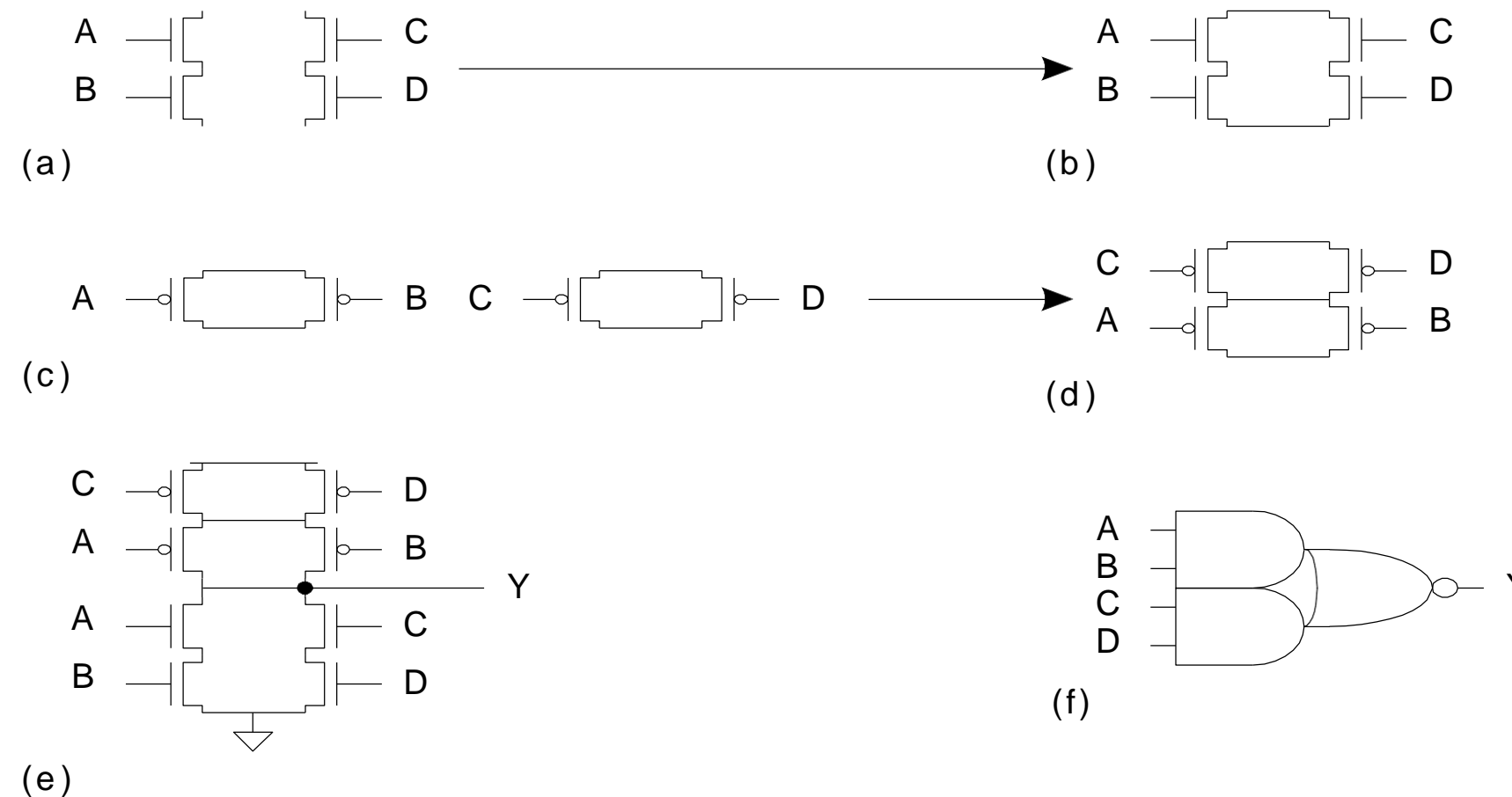
- Complementary CMOS gates always produce 0 or 1
- Ex: NAND gate- **.ns—n-MOS Series—pMOS parallel**
 - Series nMOS: $Y=0$ when both inputs are 1
 - Thus $Y=1$ when either input is 0
 - Requires parallel pMOS
- Rule of Conduction Complements
 - Pull-up network is complement of pull-down
 - Parallel \rightarrow series, series \rightarrow parallel



Compound Gates

- Compound gates can do any inverting function

- Ex: $Y = \overline{A B + C D}$ (AND-AND-OR-INVERT, AOI22)

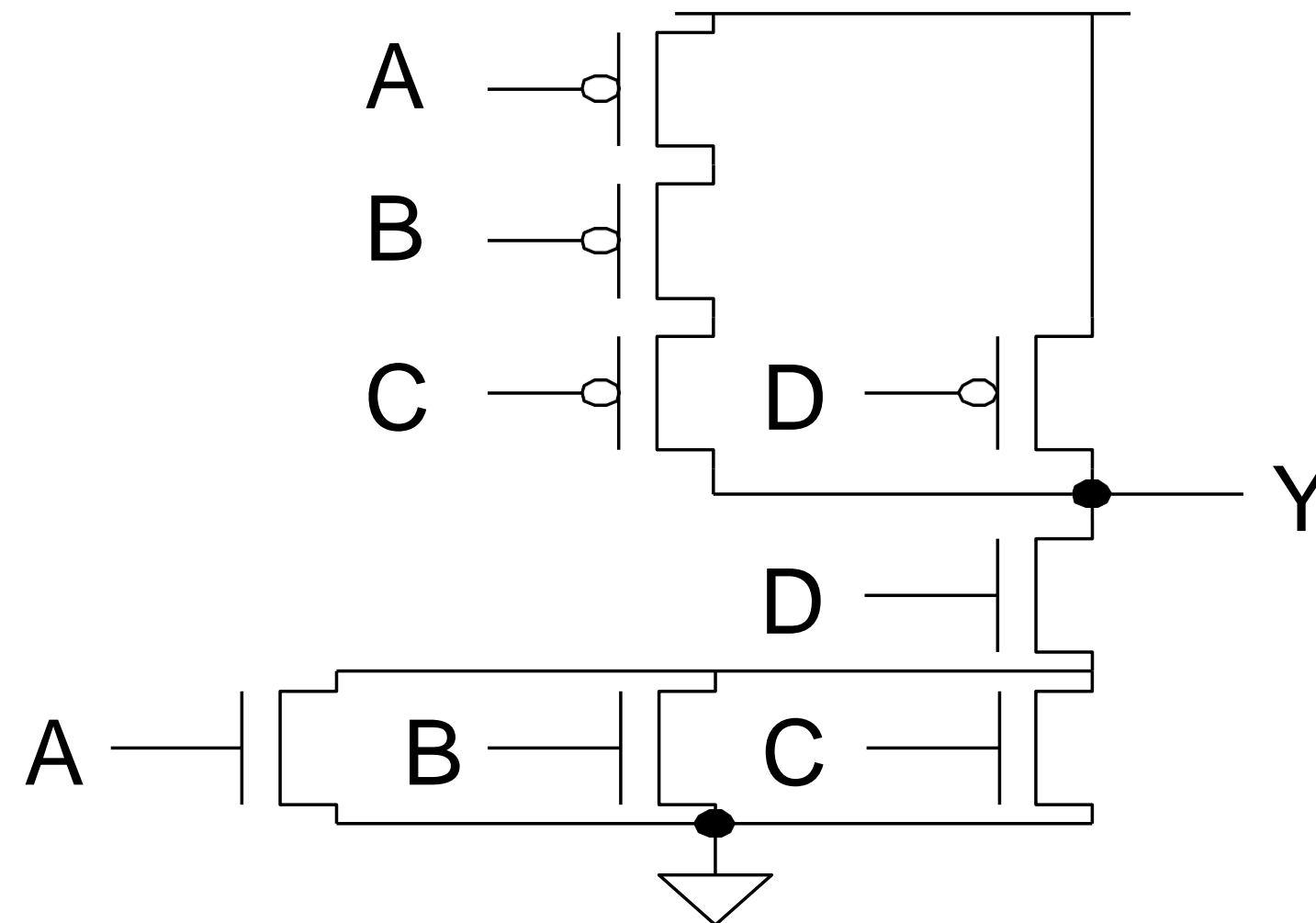




Example: O3AI



$$Y = \overline{(A+B+C)D}$$





Strength of Signal



How close it approximates ideal voltage source

V_{DD} and GND rails are strongest 1 and 0

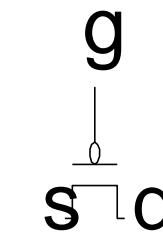
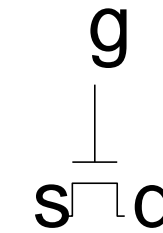
- nMOS pass strong 0

But degraded or weak 1

- pMOS pass strong 1

But degraded or weak 0

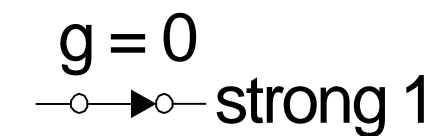
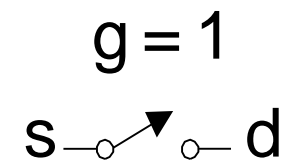
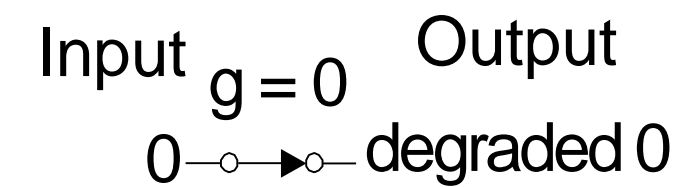
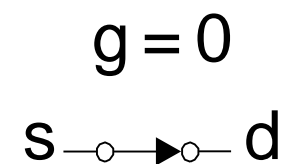
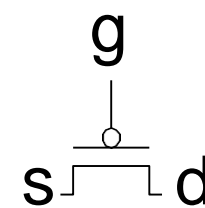
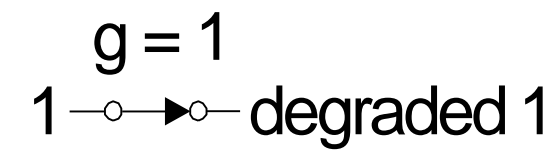
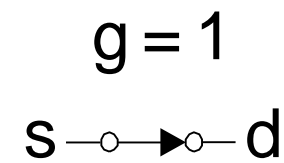
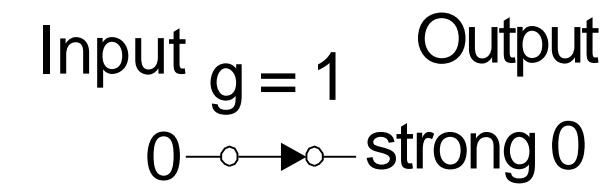
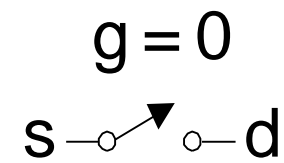
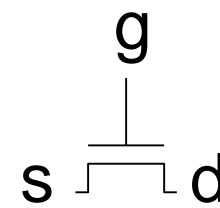
Thus nMOS are best for pull-down network





Transistors can be used as switches

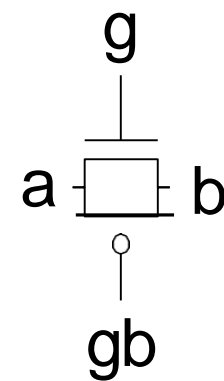
Pass Transistors



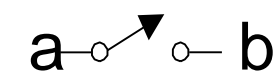


Transmission Gates

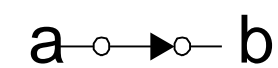
- Pass transistors produce degraded outputs
- *Transmission gates* pass both 0 and 1 well



$g = 0, gb = 1$



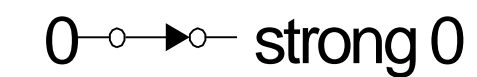
$g = 1, gb = 0$



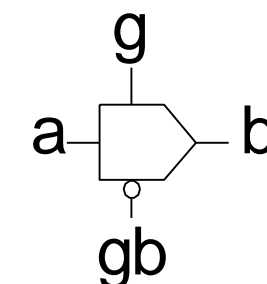
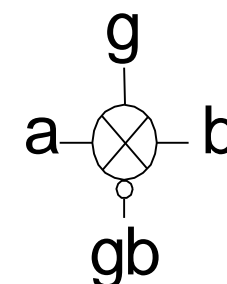
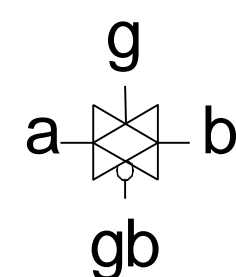
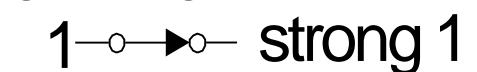
Input

Output

$g = 1, gb = 0$



$g = 1, gb = 0$





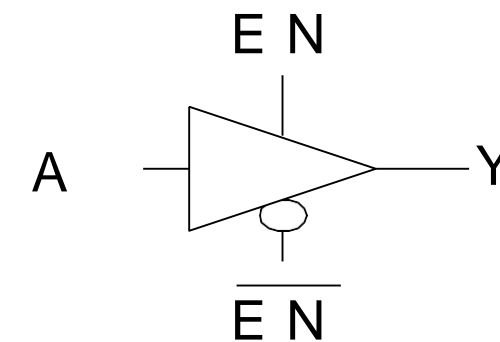
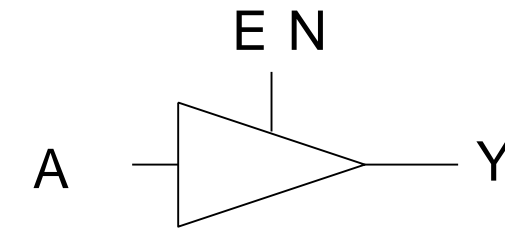
Tristates



- Tristate buffer produces Z when not enabled

EN	A	Y
0	0	Z
0	1	Z
1	0	0
1	1	1

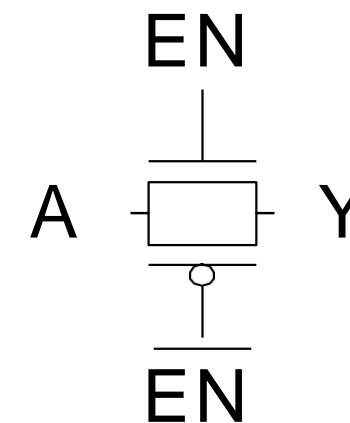
EXAMPLES OF COMBINATIONAL LOGIC/19EC505-VLSI DESIGN/T.G.Ramabharathi/Assistant Professor/ECE/SNSCE





Non restoring Tristate

- Transmission gate acts as tristate buffer
 - Only two transistors
 - But non restoring
 - Noise on A is passed on to Y





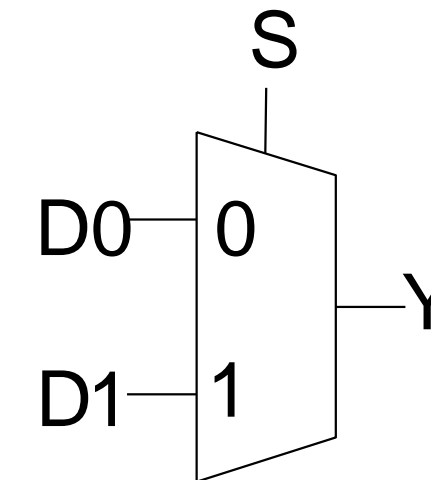
Multiplexers

- 2:1 multiplexer chooses between two inputs



S	D1	D0	Y
0	X	0	0
0	X	1	1
1	0	X	0
1	1	X	1

DESIGN/T.G.Ramabharathi/ant
AssisProfessor/ECE/SNSCE



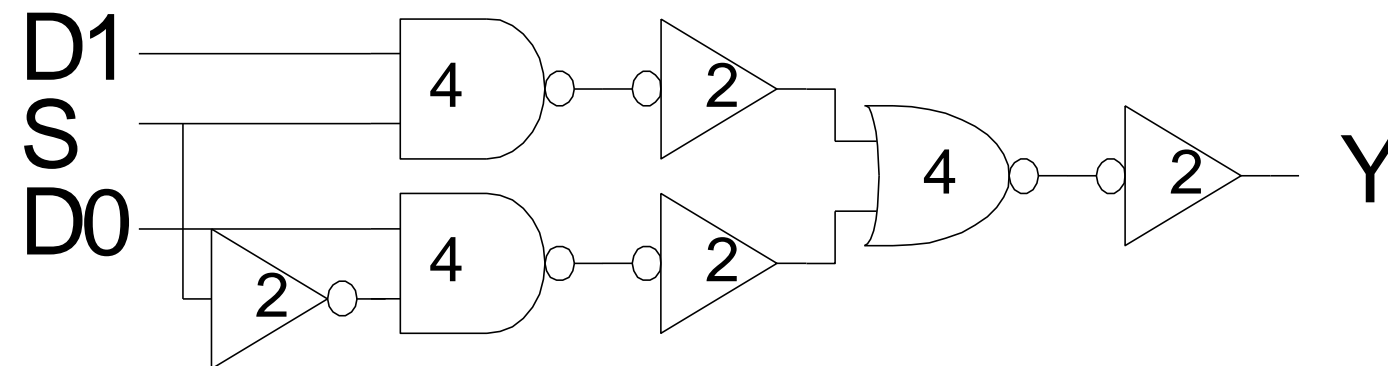
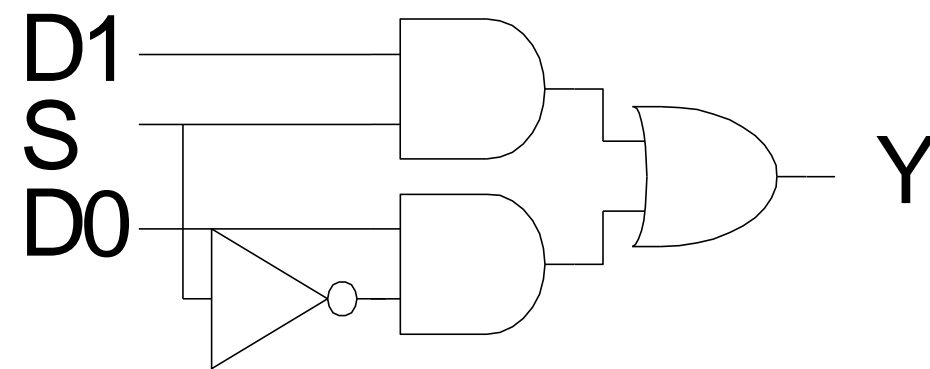


Gate-Level Mux Design



$$Y = SD_1 + \bar{S}D_0 \text{ (too many transistors)}$$

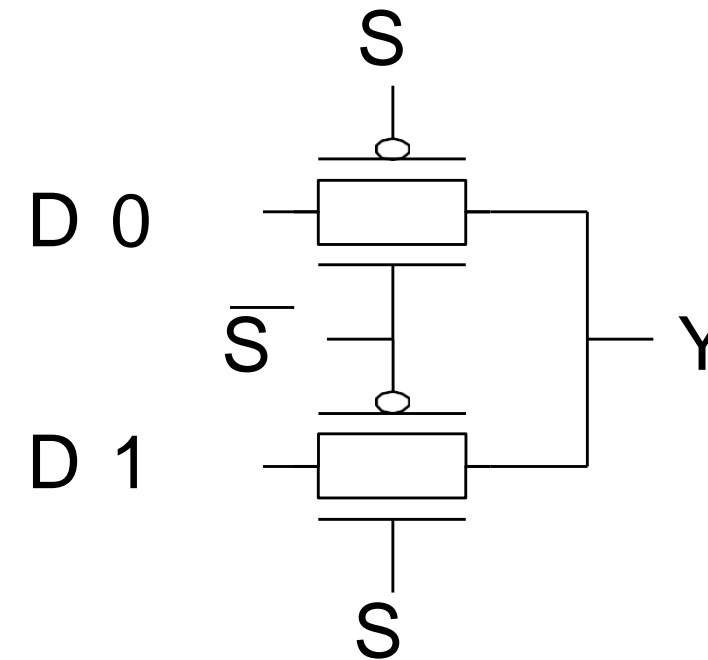
How many transistors are needed? 20





Transmission Gate Mux

- Nonrestoring mux uses two transmission gates
 - Only 4 transistors





Assessment



How many transistors are needed to
make 2:1 Mux? ---

Draw 2:1 mux using TG

Draw 4:1 mux using TG

nMOS pass strong -----

But degraded or weak -----

pMOS pass strong -----

But degraded or weak -----

Thus nMOS are best for pull-down network



THANK YOU