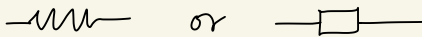



Digital Circuits

integrated digital circuits

- resistors, diodes and transistors
- on a single piece of semiconductor material called **substrate / die / chip**

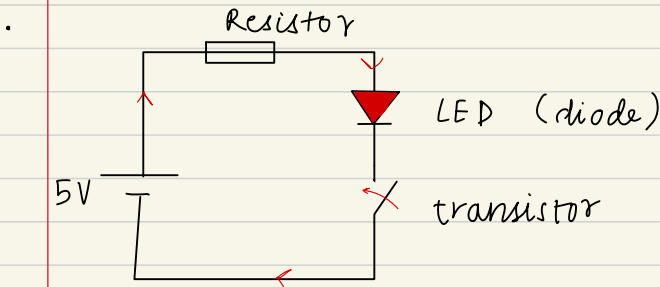
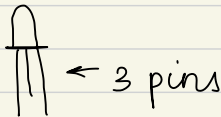
- resistor



- diodes (current flows only in 2 way)



- transistors (act as a switch) (most imp)



Scale of Integration (SI)

complexity of a circuit \propto no of gates

small-scale

< 12

medium-scale

12-99

large

100-9999

VLSI

10000-99999

ultra LSI

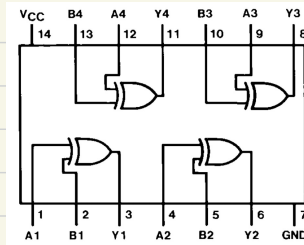
100000-999999

Giga LSI

> 1000000

eg of SSI

↓
simple scale
of integration



74LS283

open circuit causes at least a part of the circuit to not work due to no current flow through it

short circuit causes a large amount of current to gush through a part of the circuit

transistors

- used to make logic switch between High and Low

transistor-transistor logic

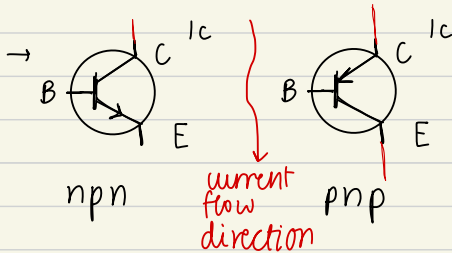
TTL circuits

→ bipolar junction transistors

BJT

→ base, emitter, collector

→ w/ correct voltage at B,
current will flow between
C and E



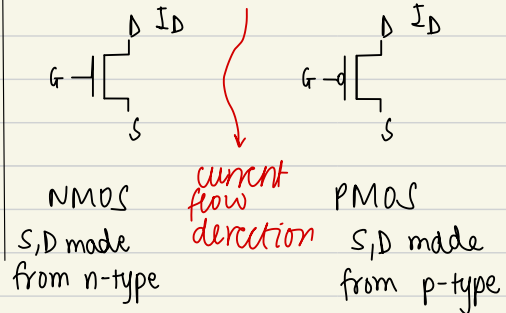
complementary metal-oxide semiconductor
CMOS circuits

→ unipolar field-effect

MOSFET (MOS field-effect trans)

→ gate, drain, source

→ w/ correct voltage at G,
current will flow between
S and D



TTL Family

- different prefixes
- differ in electrical characteristics such as power dissipation, delay time, switching speed
- same pin layout and logic function

TTL series	Prefix	E.g.
Standard	74	7404
High-speed	74H	74H04
Low-power	74L	74L04
Advanced low-power Schottky	74ALS	74ALS04

CMOS Family

- old series not compatible with TTL
- HC series pin-compatible with TTL (they share the same pin layout)
- HCT series is electrically-compatible with TTL (have similar voltage and current requirements and can be connected together)
 - ↳ CMOS o/p \rightarrow TTL I/P or vice-versa is cool

CMOS series	Prefix	E.g.
old	40/140 ✓	4001 14001
metal gate	74C ✓	74C02
high speed	74HC	74HC02
elec. comp with TTL ✚	74HCT ✓	74HCT02

CMOS > TTL

- Transistors as the only circuit element
- greater packing density
- simpler fabrication process
- lower power dissipation
- greater fan-out

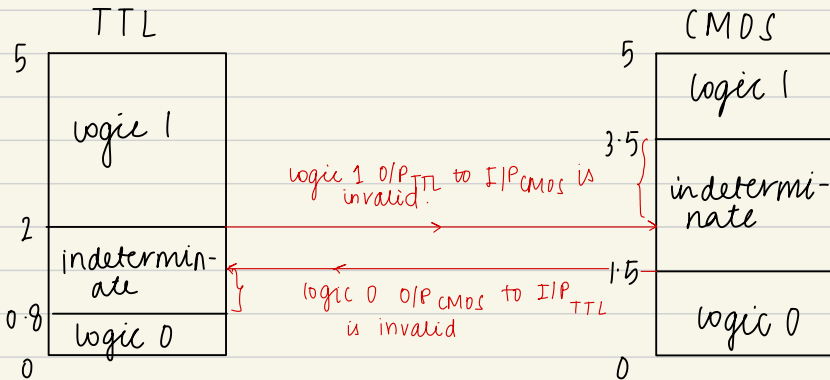
Logic-level voltage ranges

- TTL : V_{CC} nominally +5V
↑
common collector voltage

- CMOS :
→ V_{DD} ranges from +3 to +18V
↑
voltage drain drain

when CMOS and TTL ICs are used together, 5V is used.

Incompatible voltage ranges



aka floating inputs

what if pins are left unconnected in circuit

TTL

- acts as logic 1 ✓ indet. range
- measures DC level b/w 1.4 to 1.8 volts
- can be affected by other signals in the circuit = noise pick up.
- connect unused inputs to Vcc or gnd

CMOS

- picks up noise and may allow a huge amount of current to flow through IC
- ↑ damages IC
- all unused pins MUST be connected to Vcc or gnd.

active levels

a signal is called **active high** when it gives named result when it is logic 1

active low gives named result when its logic 0

active low : $\langle \text{NAME} \rangle^*$ [if a $\langle \text{NAME} \rangle^*$ signal exists, do not
high : $\langle \text{NAME} \rangle$ assume existence of $\langle \text{NAME} \rangle$]

- when a signal gives the result, its said to be **asserted**
else its **negated**

L9 practice problems

1. The following English expression describes the way a logic circuit needs to operate in order to drive a seatbelt warning indicator in a car.

$\begin{matrix} T & & F & & N \end{matrix}$
If the driver is present and the driver is not buckled up and the ignition switch is on, then turn on the warning light.

Using active high inputs driver_present, buckled_up and ignition_on, design a circuit to produce the active high output warning_light. = (driver_present)

AND
connector

(buckled_up)'
(ignition_on)

- (a) Construct the truth table.
- (b) Write the Boolean expression for warning_light.

TT row 6

(Question from Tocci, Widmer and Moss, 10th ed. Example 3-24)

2. Repeat Question 1. But this time with active low inputs driver_present*,
buckled_up*, ignition_on* and active low output warning_light*.

OR
connector

TT row 3

Note the meaning of active low. E.g. driver_present*=0 when the driver is present.

3. Repeat Question 1. But this time with active low inputs driver_present*,
buckled_up*, active high input ignition_on and active high output warning_light.

4. A logic circuit has four inputs A, B, C*, D* and one output F.
* denotes active low signals.

The output F is only asserted when either A or C* is asserted (but not both), and either B or D* is negated (but not both).

Construct the truth table for F and obtain its canonical sum-of-minterm expression.

$$F = (\quad) (\quad)$$

A	B	C*	
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

