Digital Logic Design

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- Digital Logic is concerned with the interconnection among digital components and modules and is a term used to denote the design and analysis of digital systems.

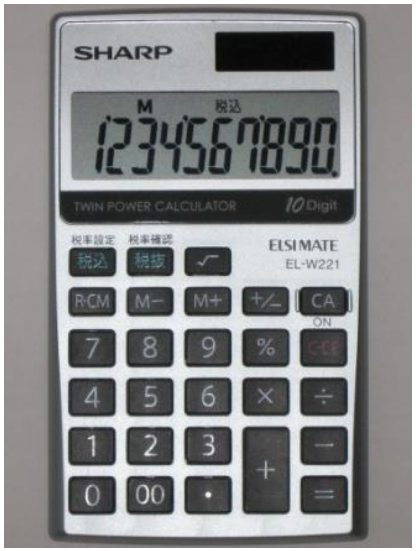
- Digital system: digital computer

- For many years application of digital electronics were confined to computer systems.

- Today digital technology is applied in a wide range of areas in addition to computers.

- Such applications as television, communications systems, radar, navigation and guidance systems, military systems, medical instrumentation, calculator, industrial process control, consumer electronics uses digital techniques

Digital Electronic Devices



Analog *versus* Digital

Digital circuits/systems also process time-varying signals!

- **Digital design** (*aka* logic design) is concerned with designing digital circuits, devices or systems such as computers.
  - The theory of operation of these devices forms a basis for other courses in your curriculum.
- **Analog devices** process time-varying signals that can have any value across a continuous range *and* produce results that are also in continuous form.
  - **Examples** of continuous signals: voltage, current, force.
- **Digital devices** process signals that take on only two discrete values (such as *0* and *1*) *and* produce output that can be represented by *0* and *1*.
  - **Examples** of digital devices: CDs, DVDs.

Digital Data: Advantages

- **Analog** has ambiguity; **Digital** has only one interpretation.

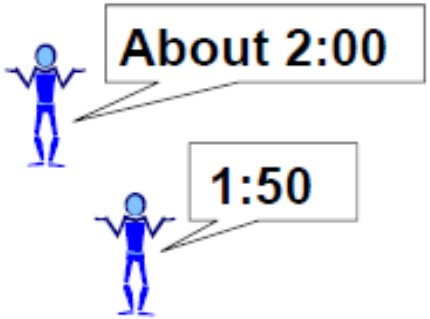
Analog Voltage meter

About 100

Digital Voltage meter

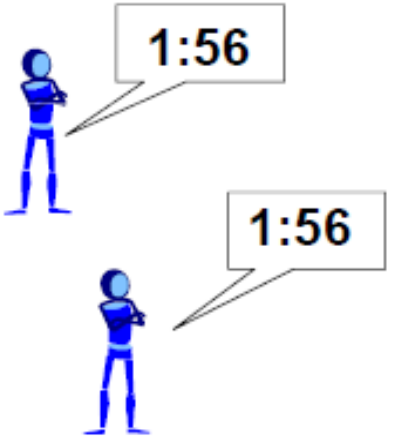
103.5

Analog Clock



Digital Clock

1:56 pm



No ambiguous information on the digital clock and digital voltage meter!

Digital (instead of Analog) Circuits: Why?

- Reproducing Results: analog circuit outputs vary with temperature, power-supply voltage, …
- Flexibility and Functionality: problem in digital form can be solved using a set of logical steps.
- Programmability: use of HDL and software tools.
- Speed: digital devices can produce results very quickly.
- Economy: mass-production made possible; this means putting a lot of functionality in a small place (the IC).

Much of today's digital design is done by writing programs in HDLs.

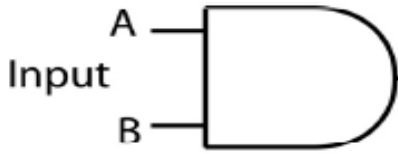
Binary Representation

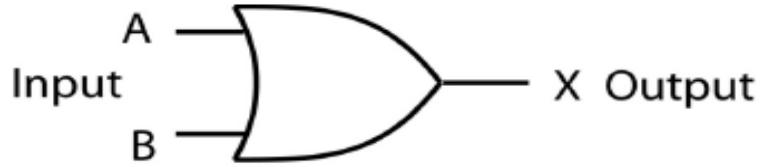
- Basis of all digital data is binary representation.
- Binary → means 'two'

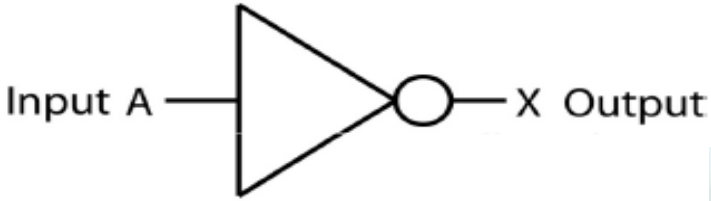
  1, 0 // True, False // Hot, Cold // On, Off
- Computers (digital systems) represent data in the binary system using:
  - Electrical voltages (e.g., in processors, memory);
  - Magnetism (e.g., in hard disks, floppy disks);
  - Light (e.g., in CD, DVD).

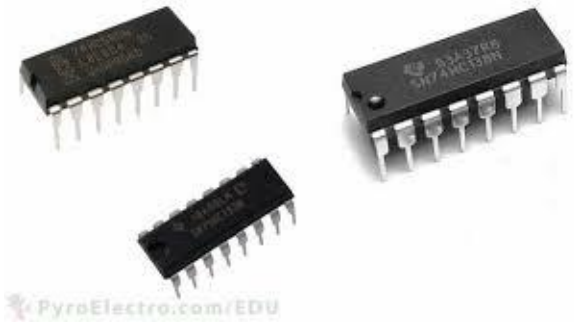
Gates

- **Gate**: most fundamental building block of a digital device or system.
  - A digital system (a chip) consists of many, many gates. They have *one or more digital inputs* and *one digital output*.
  - Gates are digital devices that perform various basic logic operations.
- **Basic gate types** are:
  - AND gate
  - OR gate
  - NOT gate

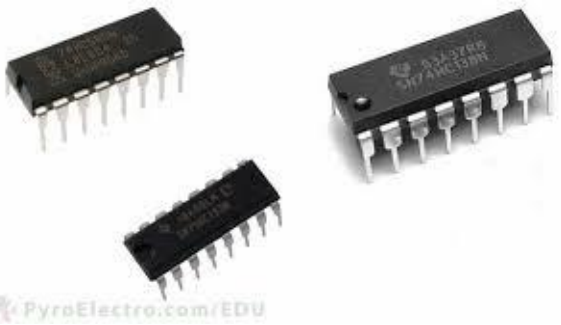


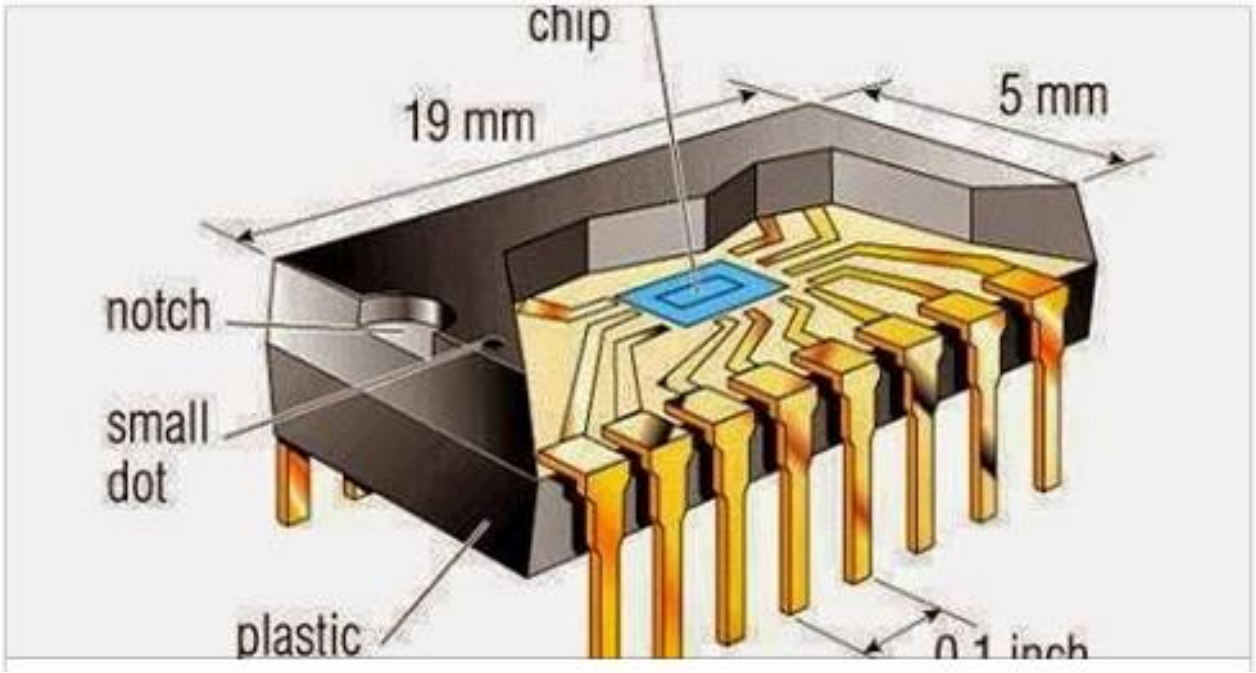






IC





Internal Structure of an IC

Digital Abstraction

- Digital circuits are built with analog components *and* deal with analog voltages and currents.
- **Digital abstraction** allows analog behaviour to be ignored by associating a *range* of voltages with each logic value:
  - **Examples**:
    - signals in a digital system may be restricted to two levels -5 and + 5 volts, corresponding to two discrete values of *0* and *1*.
    - *high* and *low* are often used to represent *1* and *0* when discussing electronic logic.

voltage	binary number	logic
+ 5 volts	1	true
– 5 volts	0	false

Integrated Circuits

- **Integrated Circuit** (**IC**): A collection of one or more gates fabricated on a single silicon chip to achieve a specific function.
  - ICs usually consist of "legs", referred to as *pins* or *DIPs*.
  - Pins are input/output connectors; their functionality can be obtained from the pin diagram or data sheet.
  - In educational labs, DIPs are usually packaged with *14 pins*.

Dual-In-line-Pin

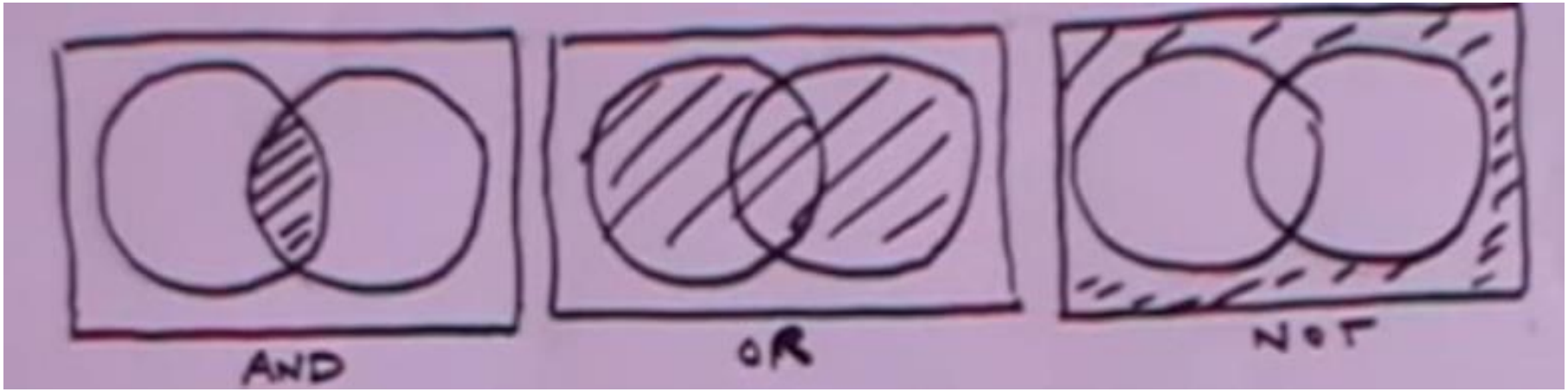
Classification of ICs based on size (i.e., number of gates)

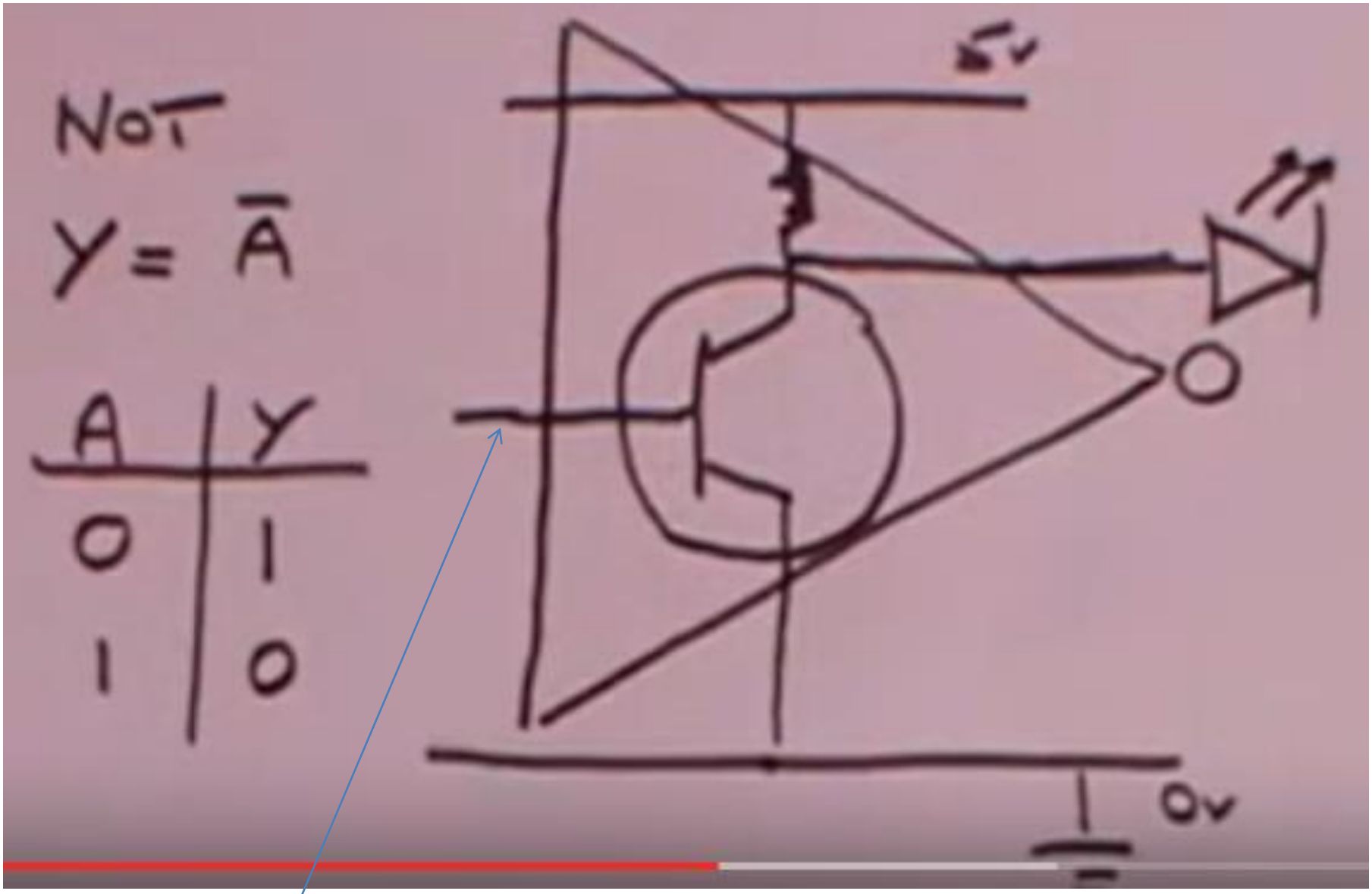
Name	Number of Gates
Small-Scale Integration (**SSI**)	< 20
Medium-Scale Integration (**MSI**)	20 – 200
Large-Scale Integration (**LSI**)	200 – 200000
Very Large-Scale Integration (**VLSI**)	≈ 1 million **transistors**

measure used for VLSIs

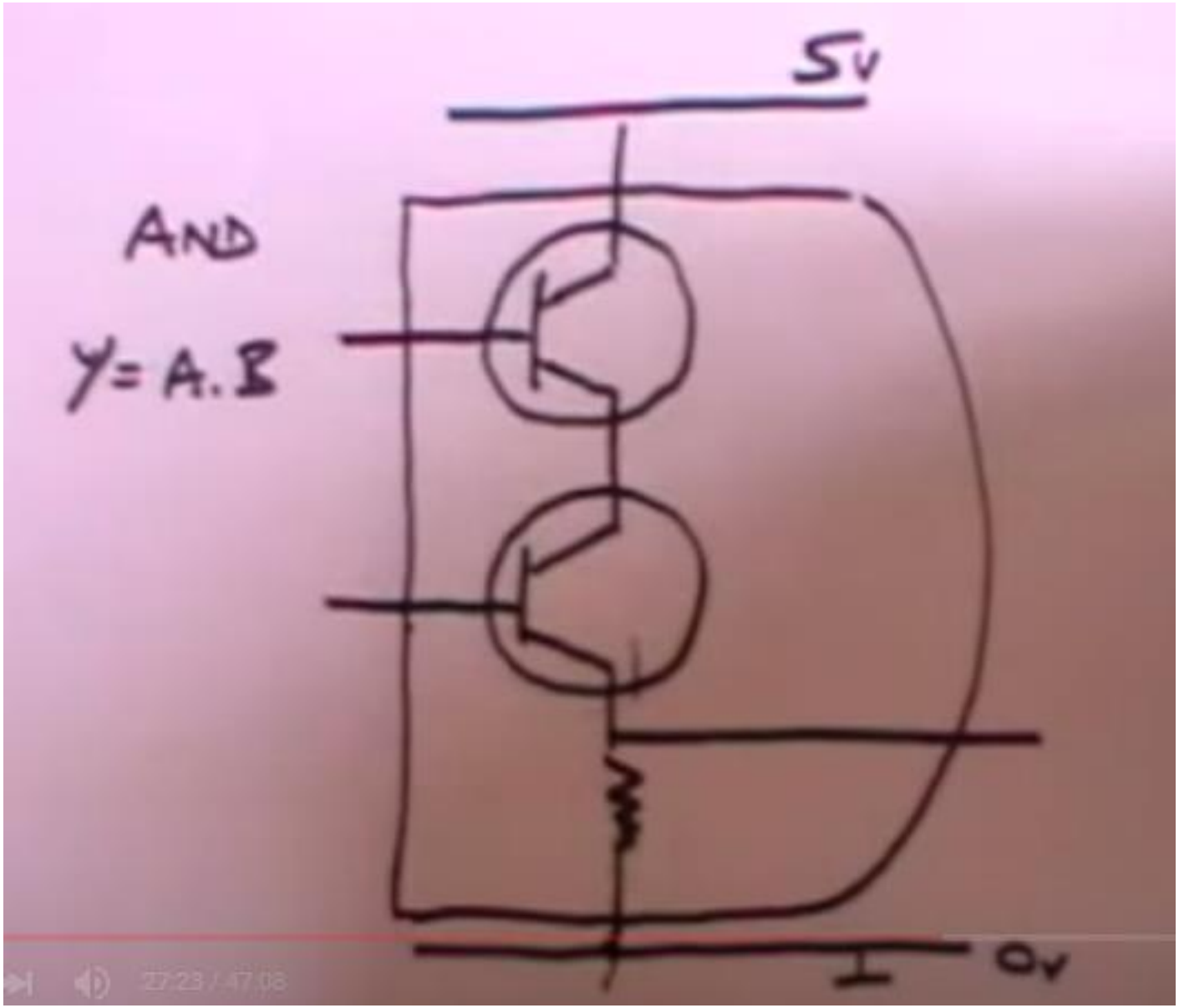
Software for Digital Design

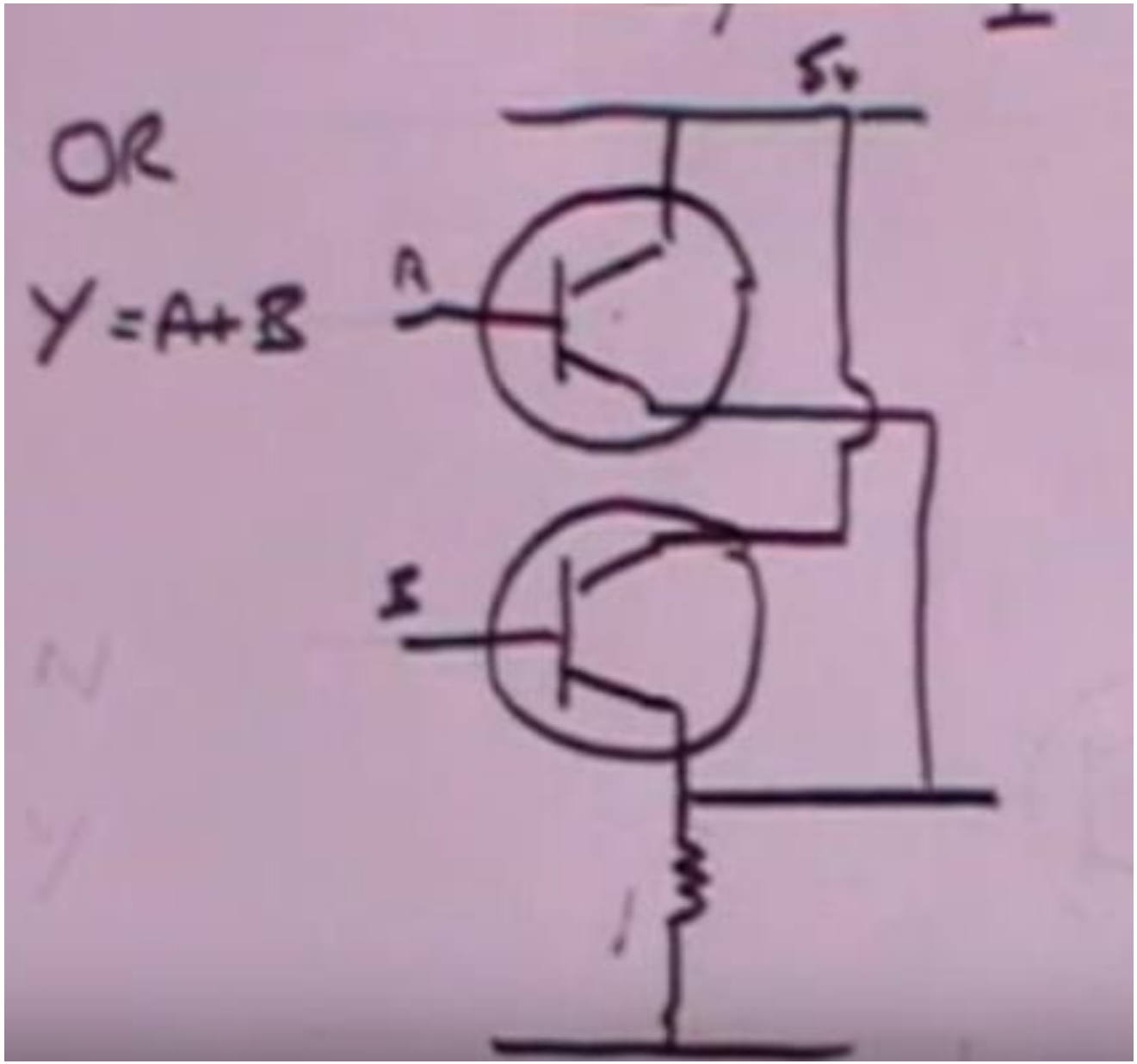
- Software is widely used in digital design. It can reduce design time, design cost, and improve design quality.
- It has been mainly used for:
  - drawing schematic diagrams;
  - circuit simulation and modelling;
  - testing and debugging;
  - timing analysis.
- **Example**:
  - VHDL software package (Xilinx ISE Project Navigator, with ModelSim XEIII Starter); it will be used for a lab experiment.

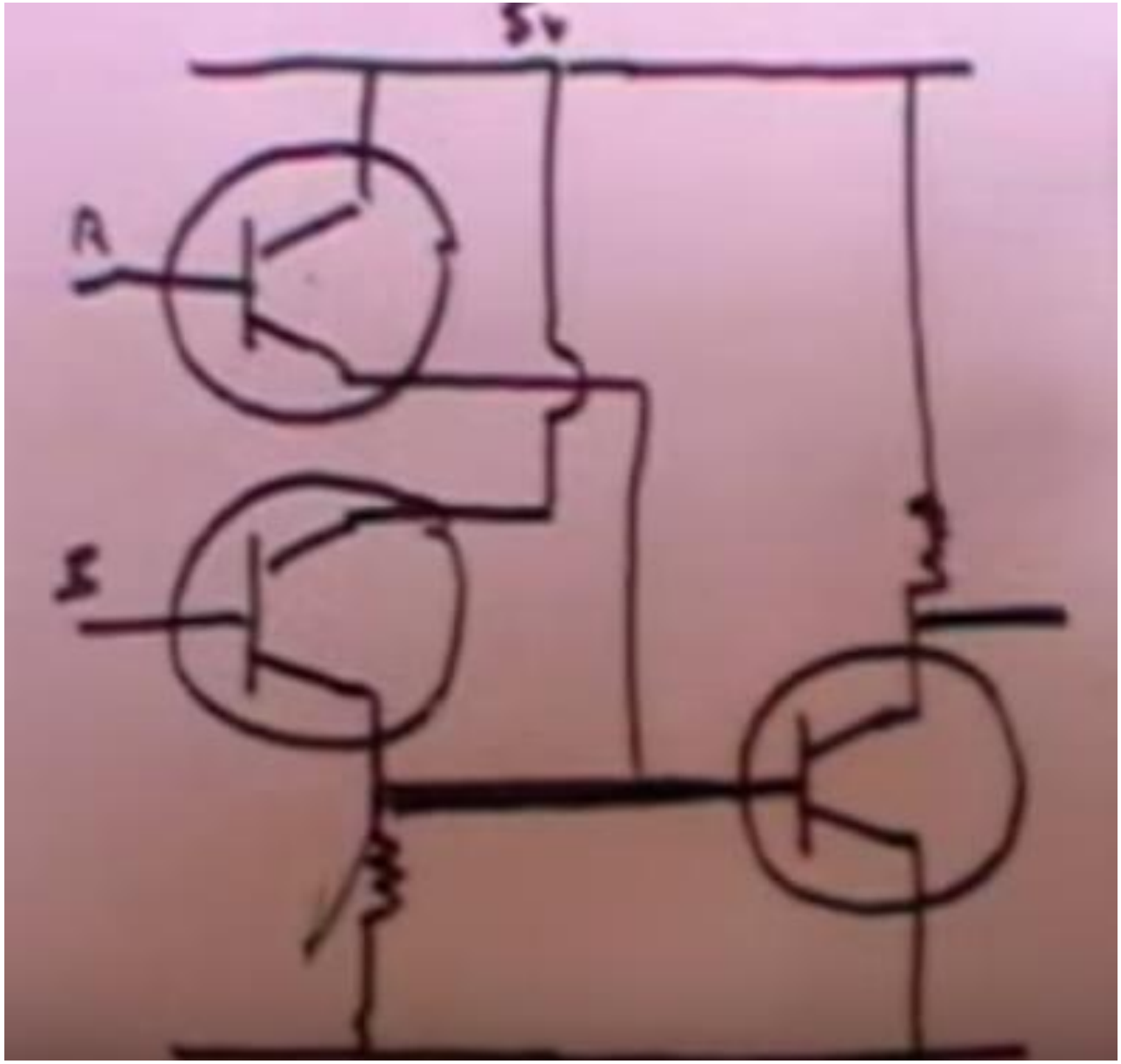

AND
OR
NOT



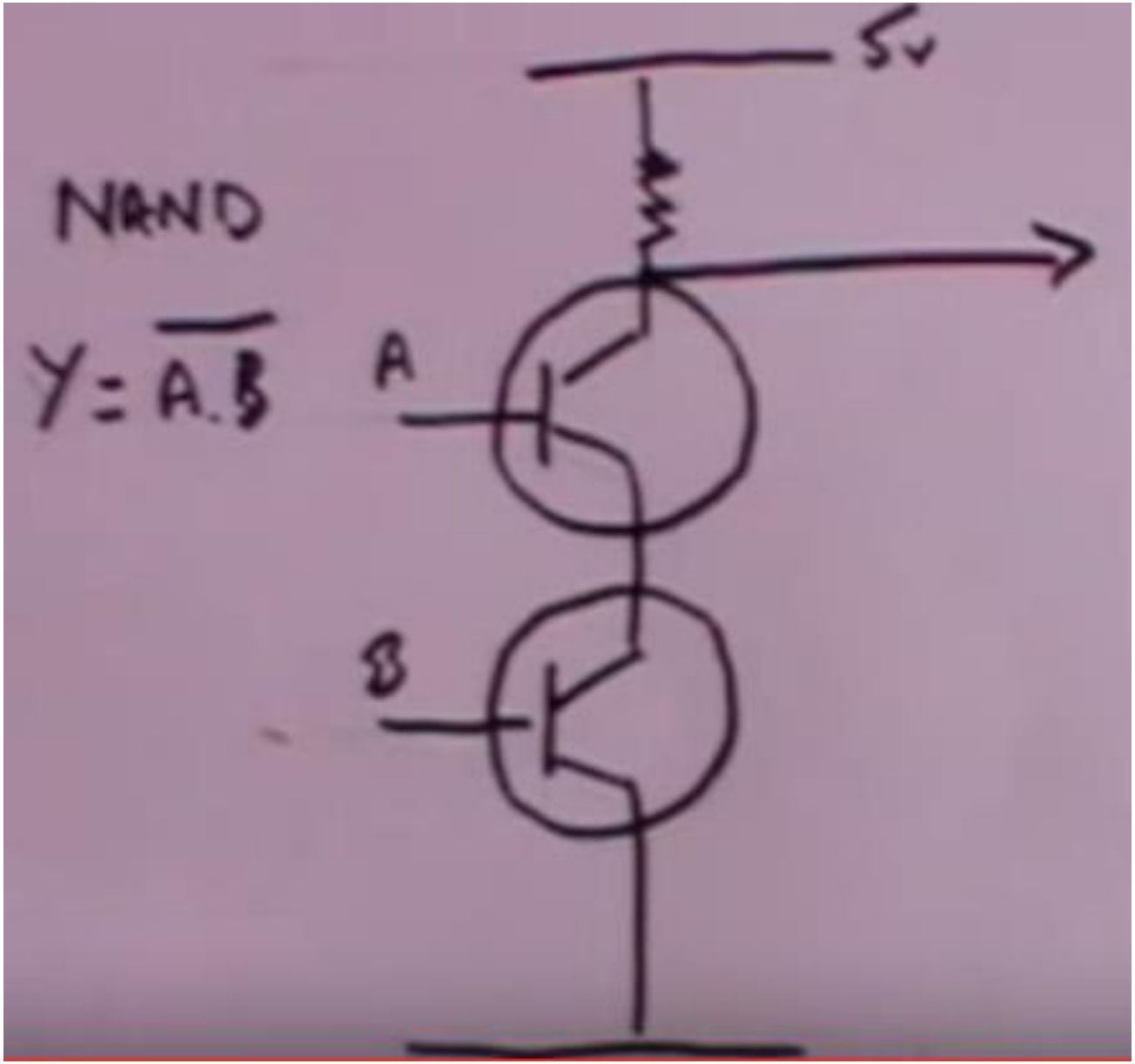
Zero and Positive voltage


5V
AND
Y= A.B
0V


OR
Y = A + B
A
B



NOR


5v
NAND
$Y = \overline{A.B}$
A
B

Textbook:

- Thomas L. Floyd, “Digital Fundamentals” 8 th edition, Prentice Hall.
- Digital Design By M. Morris Mano, 4th Edition, ISBN 01-30621218
- M. Morris Mano, “Digital Logic & Computer Design” Prentice Hall.

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