

# **Relationship between Hardware and Software & Analog Electronics**

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# **Relationship between Hardware and Software**

**Question:** Can high level language program (Software) be run on computer processor (Hardware) directly?

**Ans:** Computer understands only program written in 0/1. It is called Machine Code/Program.

So, High level language program must be converted to Machine Language Program.

## Compiler

## Assembler

High Level Language Program → Assembly Language Program → Machine Language Program

int main()	call _____main	c7 44 24 0c 0a 00 00
{	mov DWORD PTR [esp+12], 10	83 44 24 0c 05
int a=10;	add DWORD PTR [esp+12], 5	b8 00 00 00 00
a=a+5;	mov eax, 0	
return 0;		
}		

**Question:** What kind of machine code does computer processor understand?

**Ans:** Every computer processor has something called **Instruction Set Architecture (ISA)** which defines machine code for specific instruction.

Compiler/Assembler must generate machine code based on ISA. ISA is the one that connects Hardware and Software together.

**Question:** How does computer processor itself run machine code?

**Ans:** Every modern processor is based on Von Neumann Model.

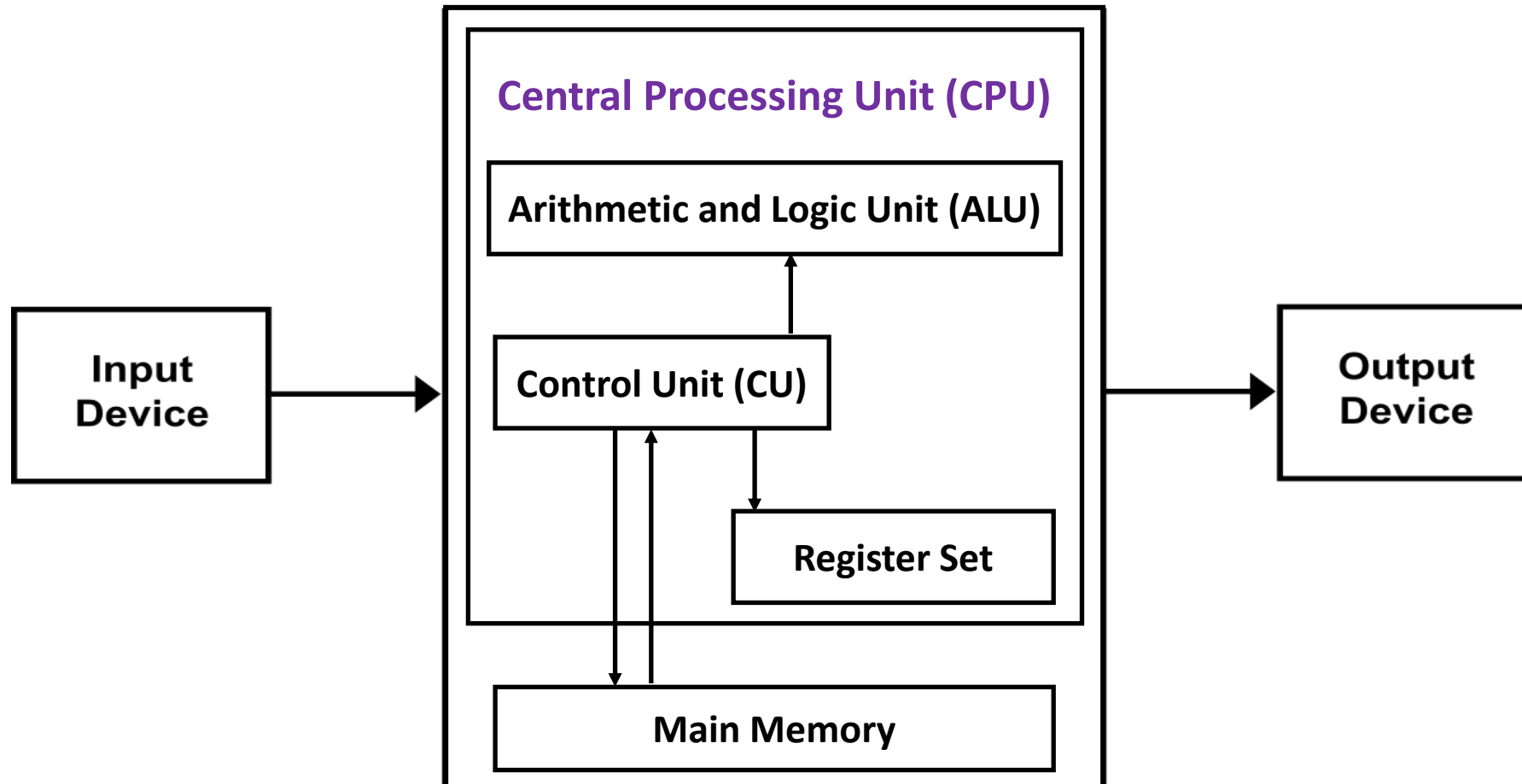


Figure: Von Neumann Model

1. Computer will fetch instruction from Main Memory (RAM).
2. Instruction will be decoded by control unit and will select registers and/or immediate values.
3. Data within registers and/or immediate values will be sent to Arithmetic and Logic Unit (ALU) to perform operations.
4. ALU will perform operation and result will be sent to the register to be written.
5. Control unit can send data from registers to Main memory.

**Question:** How are computer building blocks like ALU, CU, Register Set, Main Memory etc. made of?

**Ans:** They are made of digital electronics building block like AND/OR etc.

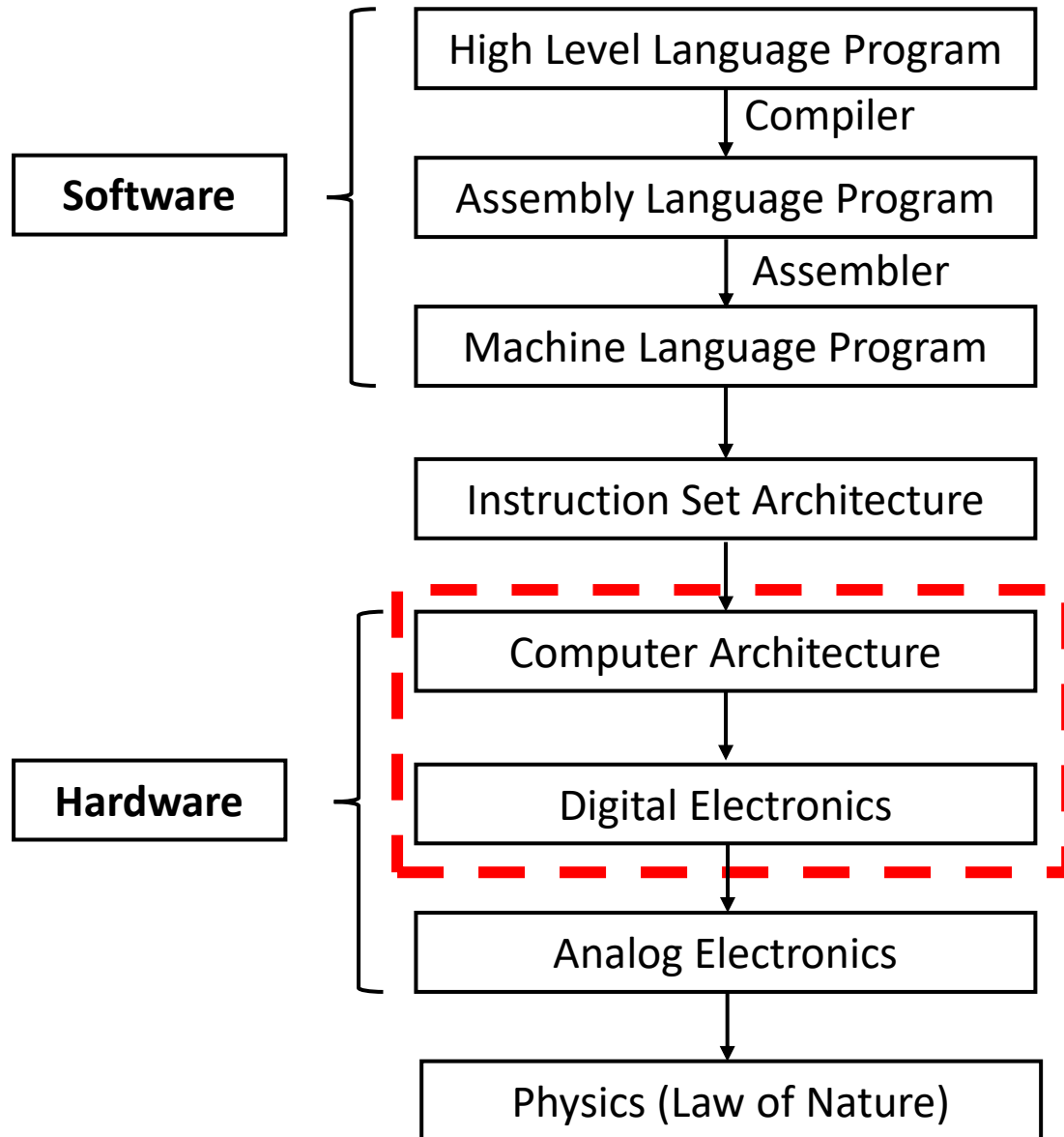


**Question:** How are digital electronics building block like AND/OR etc. made of?

**Ans:** They are made of analog electronics building block called transistor.

**Question:** How does a high level language program run on transistor inside of computer processor?

# Answer: Connection between High Level Language Program and Transistor



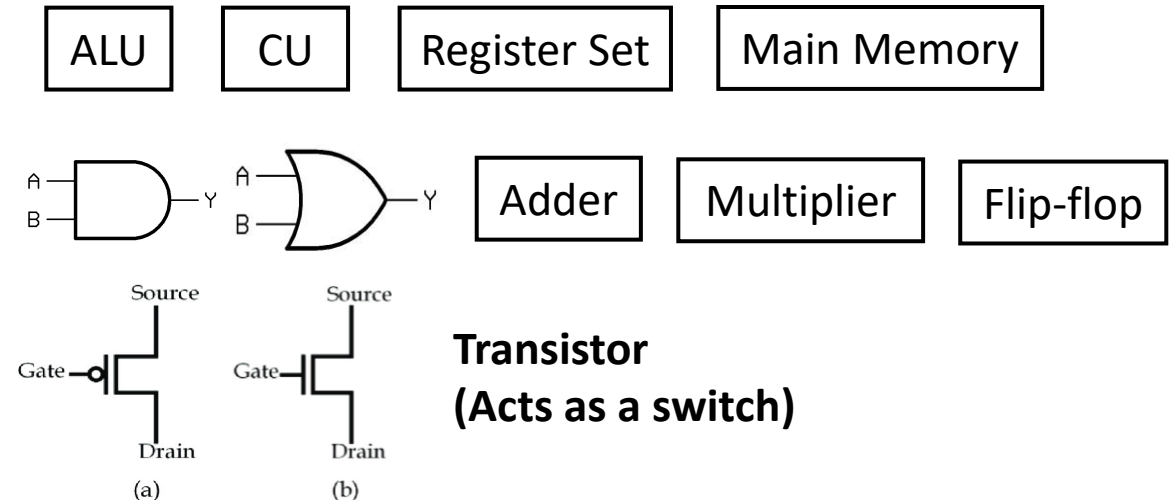
```
int main(){int a=10; a=a+5; return 0;}
```

```
mov DWORD PTR [rbp-4], 10
add DWORD PTR [rbp-4], 5
```

```
c7 45 fc 0a 00 00 00
83 45 fc 05
```

c7 is opcode for mov  
83 is opcode for add

**From Intel ISA**



# **Analog Electronics I**

**Question:** What is the role of transistor?

**Answer:** Transistor works as

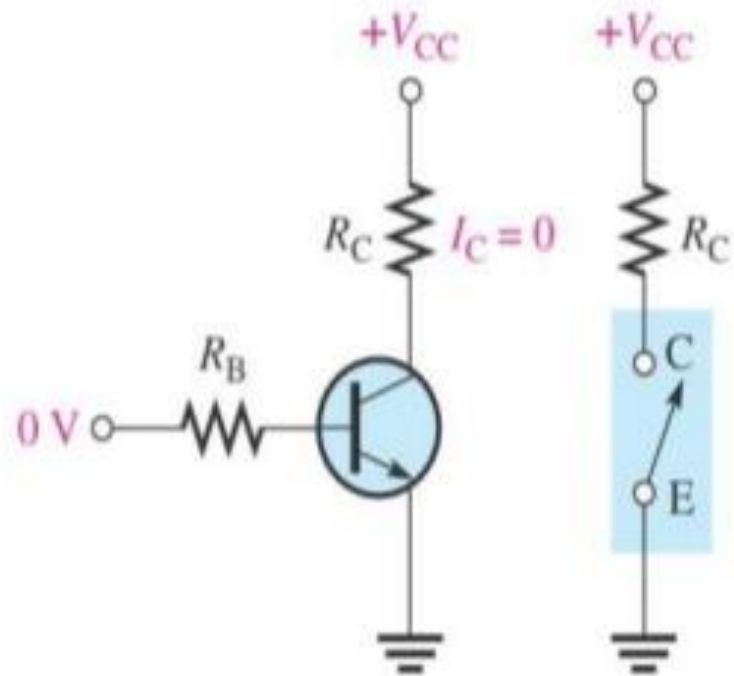
1. Switch and
2. Amplifier

**Question:** Explain the role of transistor in computer processor.

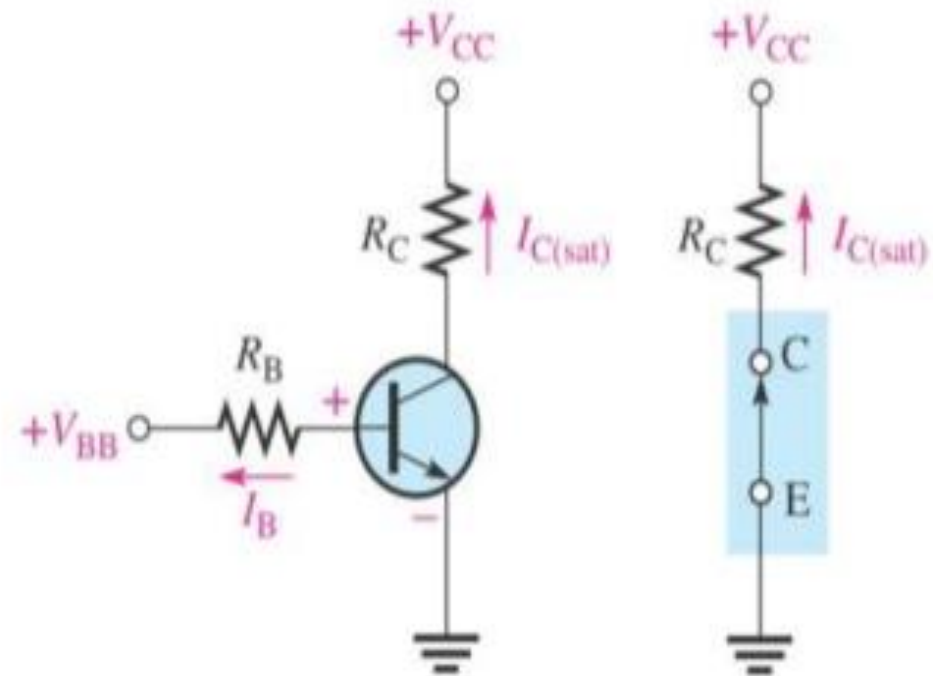
**Answer:** Transistor works as switch inside computer processor.

**Question:** How does BJT transistor work as switch?

**Answer:**

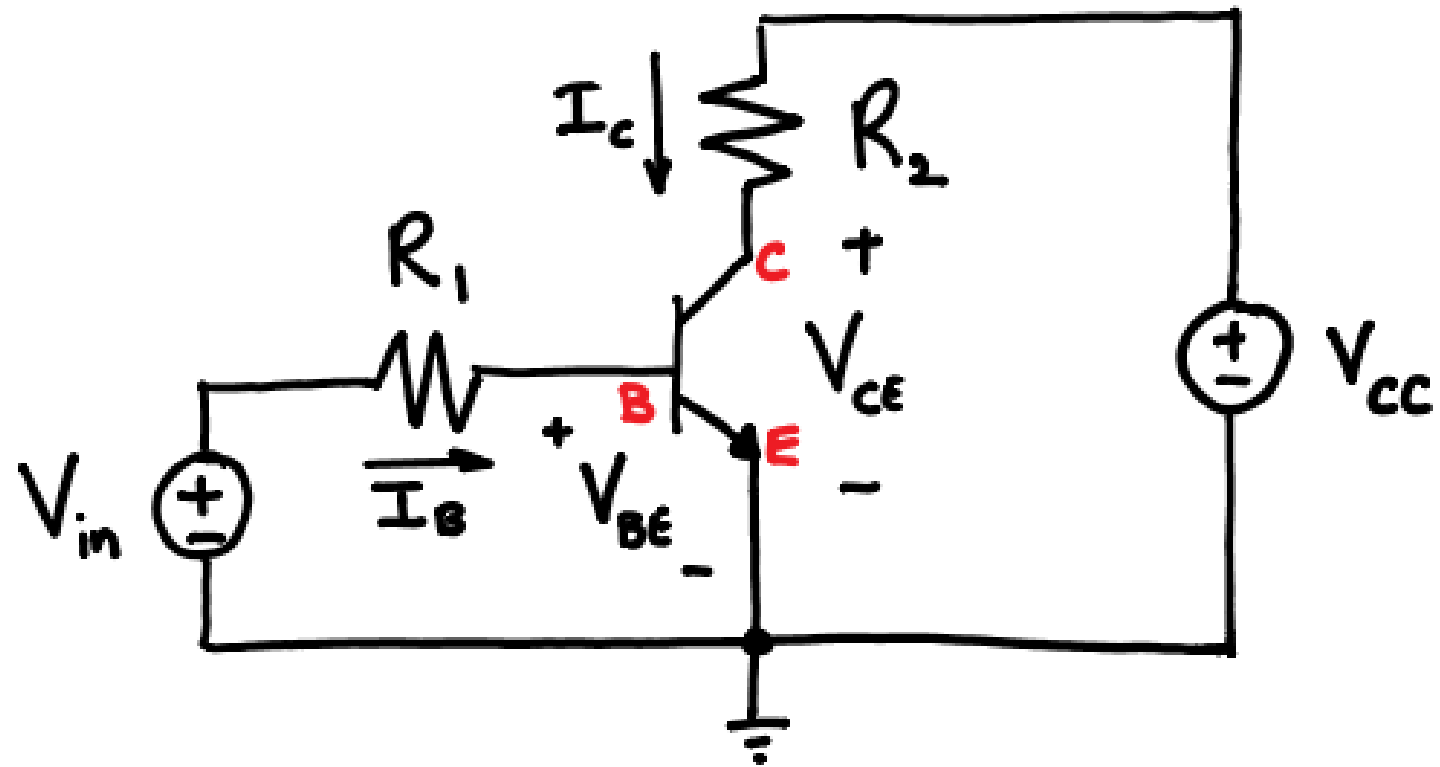


(a) Cutoff — open switch



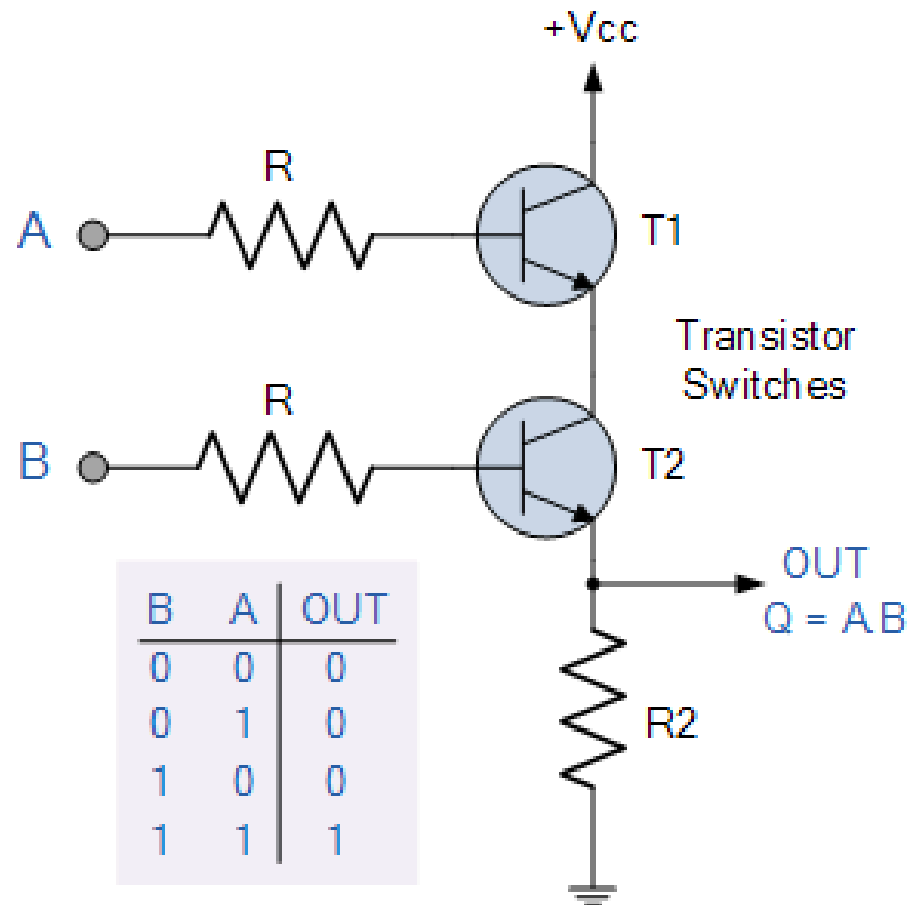
(b) Saturation — closed switch

## Transistor Circuit Diagram



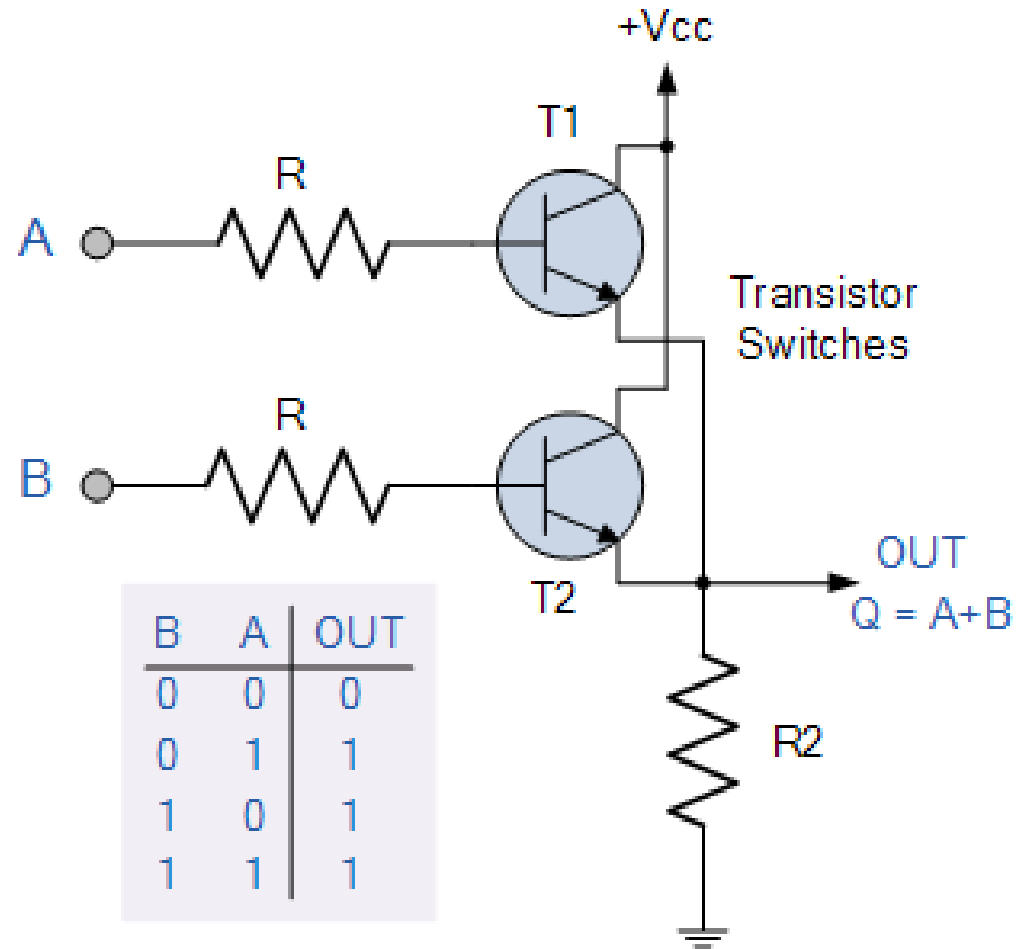


# 2-input Transistor AND Gate



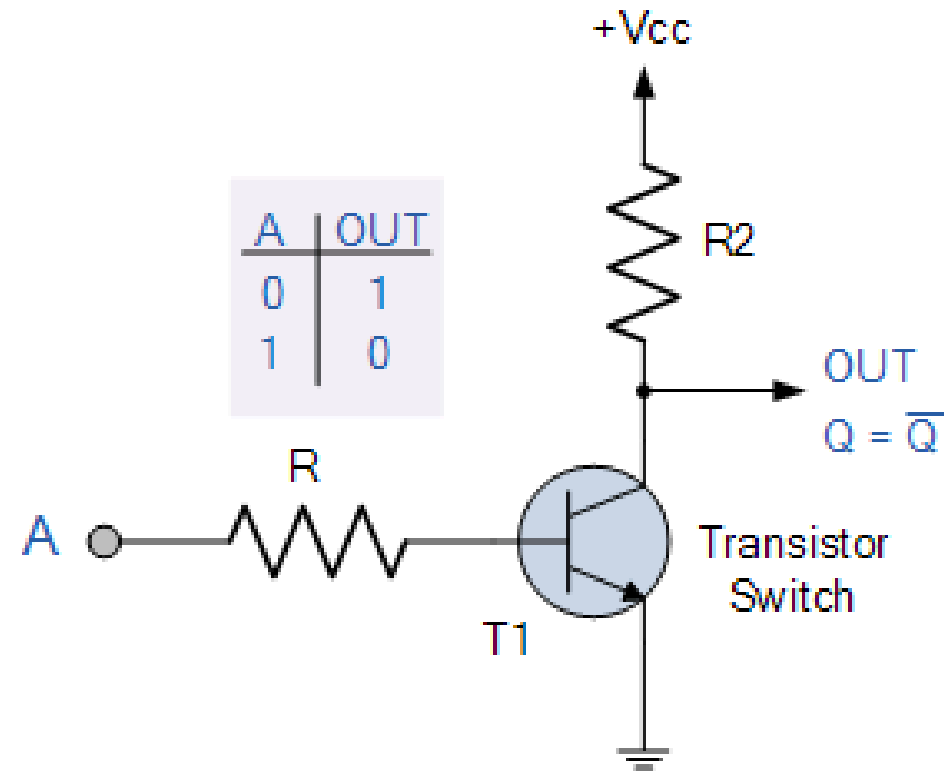
Link: [https://www.electronics-tutorials.ws/logic/logic\\_2.html](https://www.electronics-tutorials.ws/logic/logic_2.html)

# 2-input Transistor OR Gate



Link: [https://www.electronics-tutorials.ws/logic/logic\\_3.html](https://www.electronics-tutorials.ws/logic/logic_3.html)

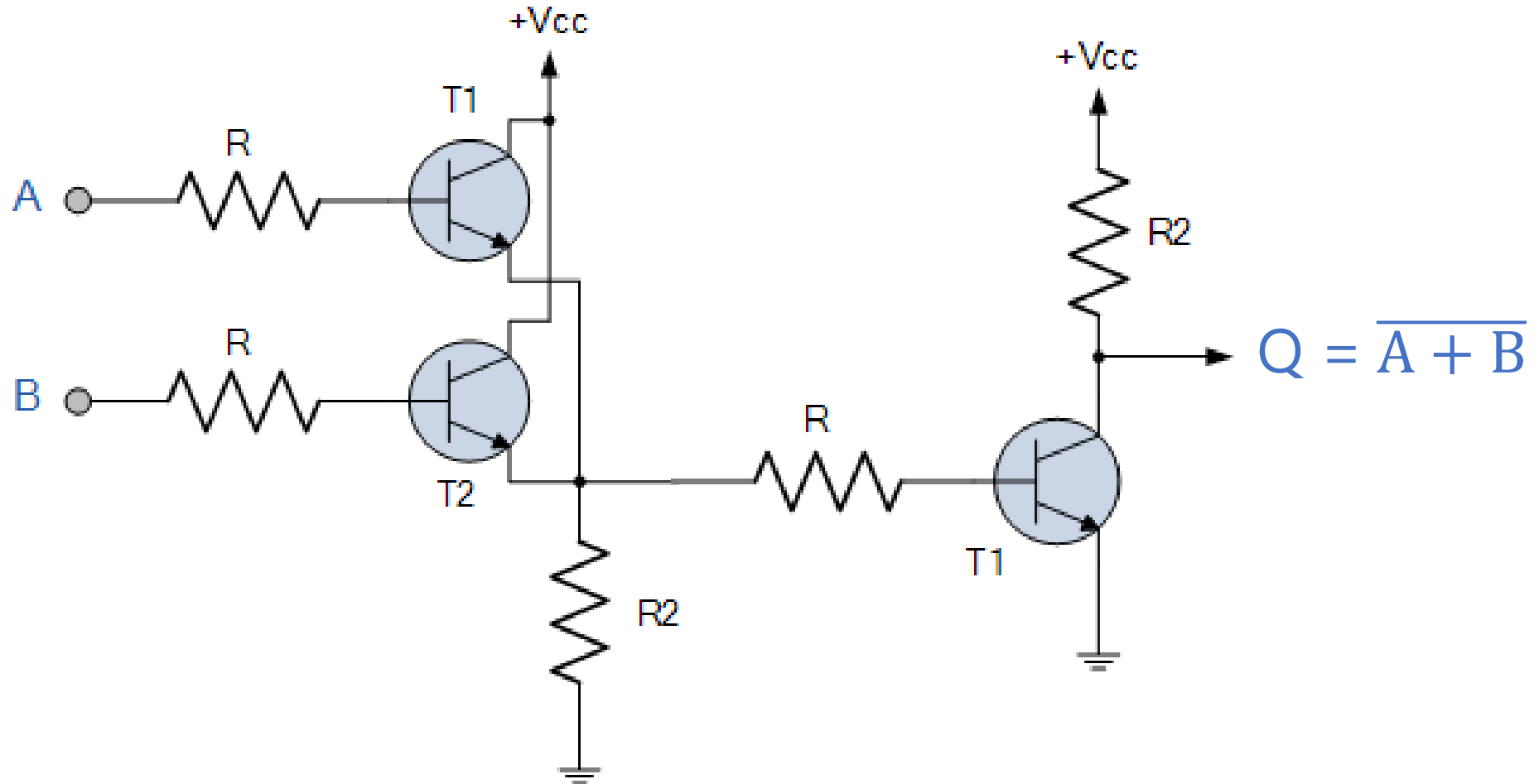
# 1-input Transistor NOT Gate (Inverter)



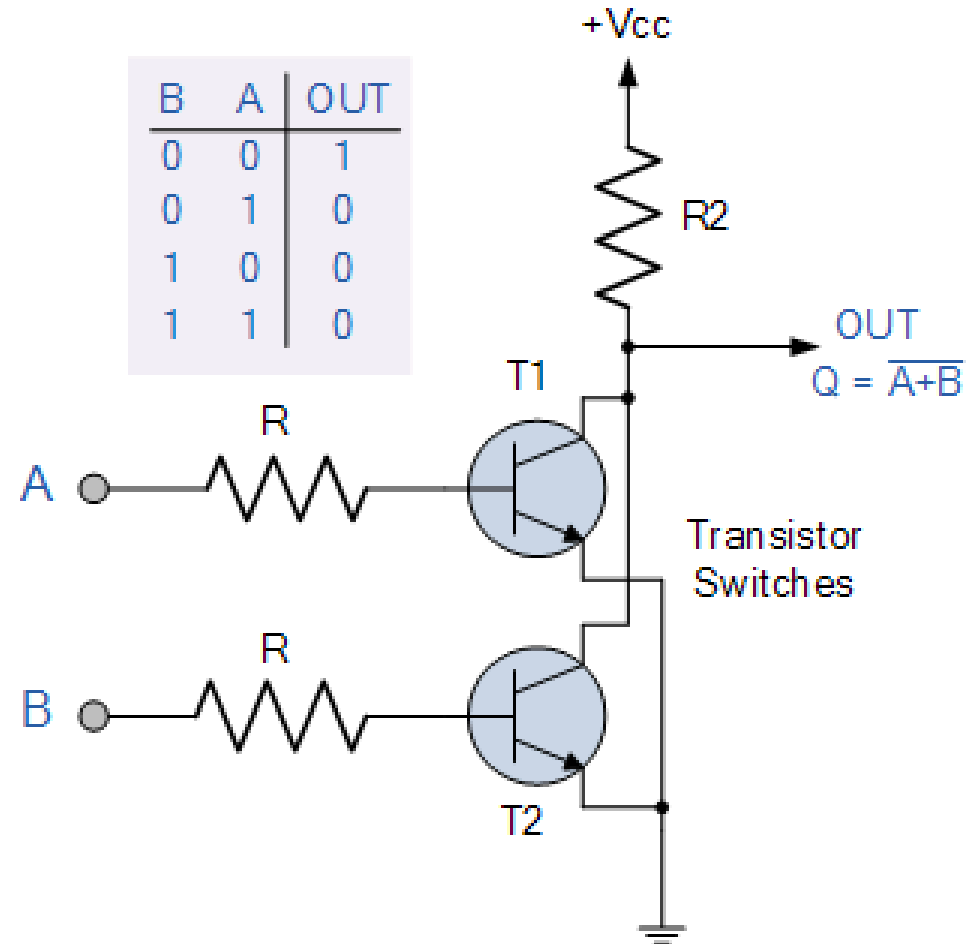
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**Question:** Implement NOR  $(\overline{A + B})$  logic gate by using BJT transistor.

**Ans:** 2-input NOR Gate



## Ans: Equivalent 2-input NOR Gate



Link: [https://www.electronics-tutorials.ws/logic/logic\\_6.html](https://www.electronics-tutorials.ws/logic/logic_6.html)

**Question:** What type of transistor is used in real life modern processor?

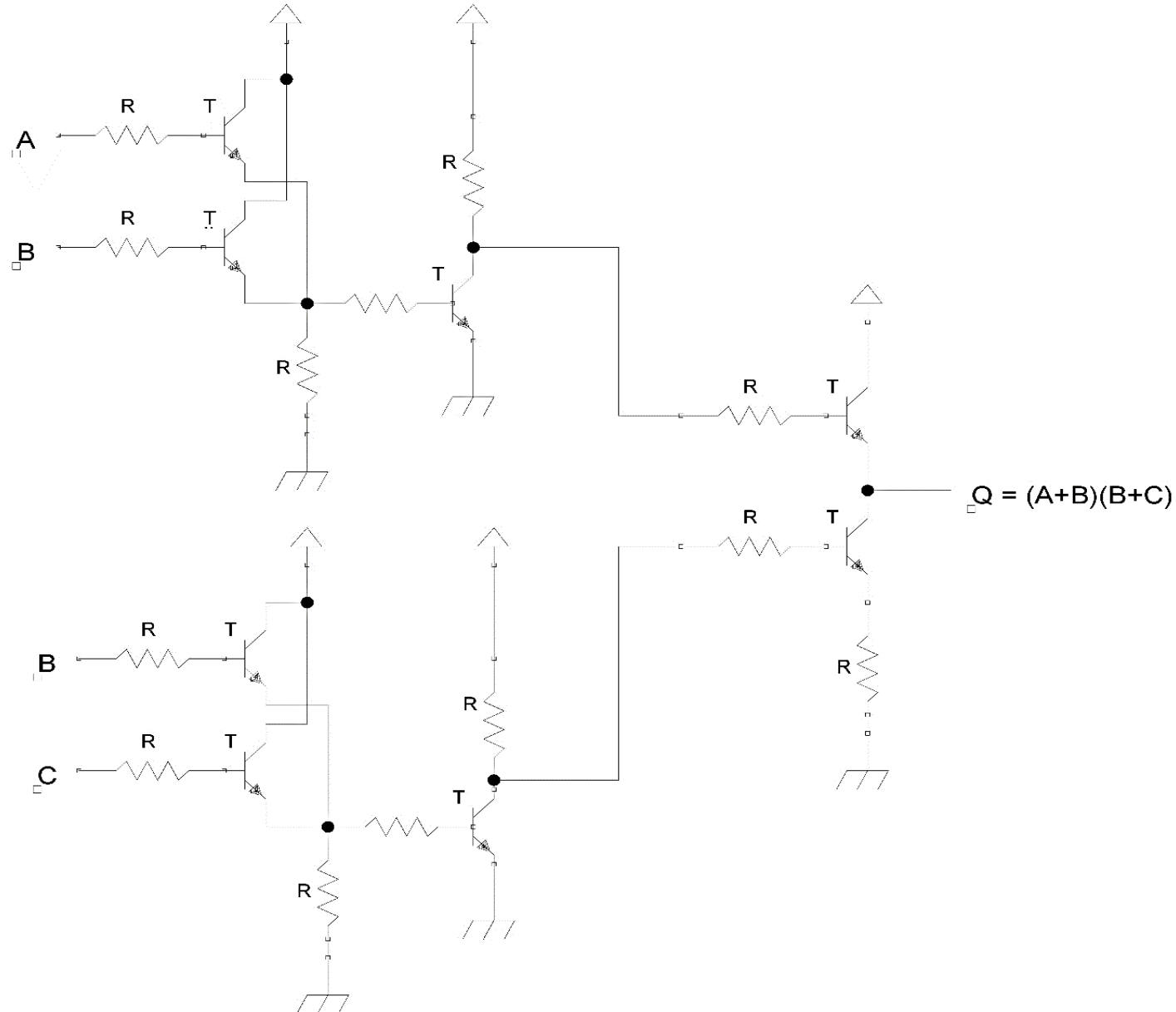
**Answer:**

CMOS = Complementary Metal–Oxide–  
Semiconductor Field Effect Transistor

# Example: BJT

**Question:** Implement  $\overline{(A + B)}(B + C)$  by using BJT transistor.

**Answer:**



# Exercises

1. Implement **NOR** ( $\overline{A + B}$ )/  $\overline{A + B + C}$ /( $\overline{A + B}$ )( $\overline{B + C}$ )/any Boolean expression by using BJT transistor.



Thank You 😊