What is Transistor-Transistor Logic (TTL)?

The Transistor-Transistor Logic (TTL) is a logic family made up of BJTs (bipolar junction transistors). As the name suggests, the transistor performs two functions like logic as well as amplifying. The best examples of TTL are logic gates namely the 7402 NOR Gate & the 7400 NAND gate.

TTL logic includes several transistors that have several emitters as well as several inputs. The types of TTL or transistor-transistor logic mainly include Standard TTL, Fast TTL, Schottky TTL, High power TTL, Low power TTL & Advanced Schottky TTL.

The designing of TTL logic gates can be done with resistors and BJTs. There are several variants of TTL which are developed for different purposes such as the radiation-hardened TTL packages for space applications and Low power Schottky diodes that can provide an excellent combination of speed and lesser power consumption.

Characteristics of TTL

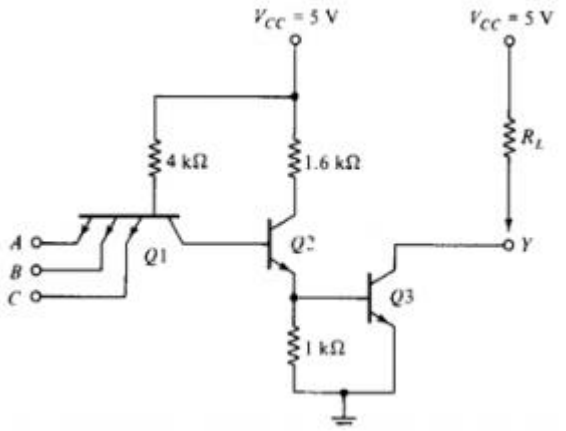
The characteristics of TTL include the following.

1. **Fan Out:** Number of loads the output of a GATE can drive without affecting its usual performance. By load we mean the amount of current required by the input of another Gate connected to the output of the given gate.
2. **Power Dissipation:** It represents the amount of power needed by the device. It is measured in mW. It is usually the product of supply voltage and the amount of average current drawn when the output is high or low.
3. **Propagation Delay:** It represents the transition time that elapses when the input level changes. The delay which occurs for the output to make its transition is the propagation delay.
4. **Noise Margin:** It represents the amount of noise voltage allowed at the input, which doesn't affect the standard output.

TTLs are classified based on the output.

Open Collector Output

The main feature is that its output is 0 when low and floating when high. Usually, an external Vcc may be applied.



Open Collector Output of Transistor-Transistor Logic

Transistor Q1 behaves as a cluster of diodes placed back to back. With any of the input at logic low, the corresponding emitter-base junction is forward biased and the voltage drop across the base of Q1 is around 0.9V, not enough for the transistors Q2 and Q3 to conduct. Thus the output is either floating or Vcc, i.e. High level.

Similarly, when all inputs are high, all base-emitter junctions of Q1 are reverse biased and transistor Q2 and Q3 get enough base current and are in saturation mode. The output is at logic low. (For a transistor to go to saturation, collector current should be greater than β times the base current).

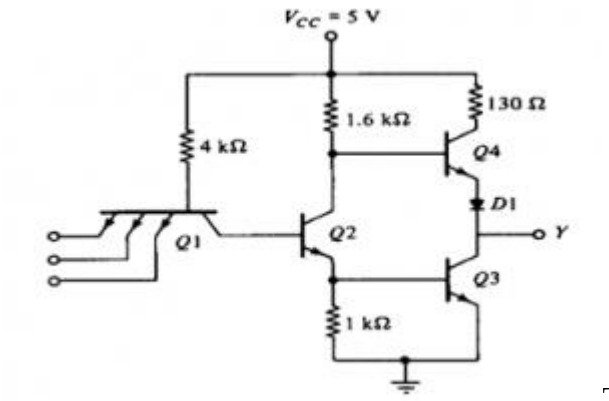
Applications

The applications of open collector output include the following.

- In driving lamps or relays
- In performing wired logic
- In the construction of a common bus system

Totem Pole Output

Totem Pole means the addition of an active pull up the circuit in the output of the Gate which results in a reduction of propagation delay.



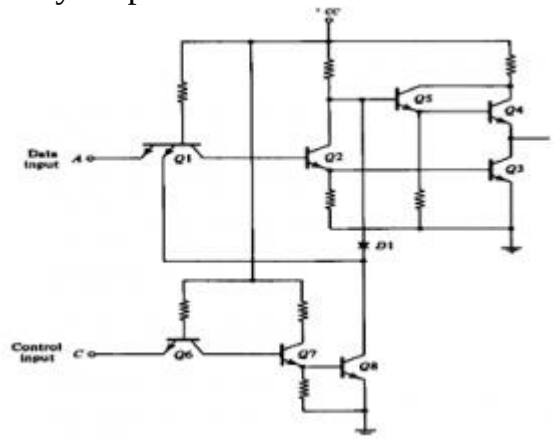
Totem Pole Output TTL

Logic operation is the same as the open collector output. The use of transistors Q4 and diode is to provide quick charging and discharging of parasitic capacitance across Q3. The resistor is used to keep the output current to a safe value.

Three State Gate

It provides 3 state output like the following

- Low-level state when a lower transistor is ON and an upper transistor is OFF.
- High-level state when the lower transistor is OFF and the upper transistor is ON.
- Third state when both transistors are OFF. It allows a direct wire connection of many outputs.



Three State Gate Transistor-Transistor Logic

TTL Family Features

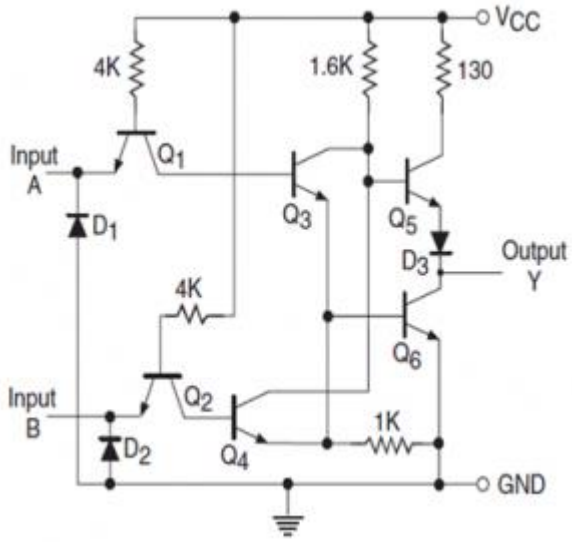
The features of the TTL family include the following.

- Logic low level is at 0 or 0.2V.
- Logic high level is at 5V.
- Typical fan out of 10. It means it can support at most 10 gates at its output.
- A basic TTL device draws a power of almost 10mW, which reduces with the use of Schottky devices.

- The average propagation delay is about 9ns.
- The noise margin is about 0.4V.
  - he 3 basic Logic gates implemented using TTL logic are given below:

NOR Gate

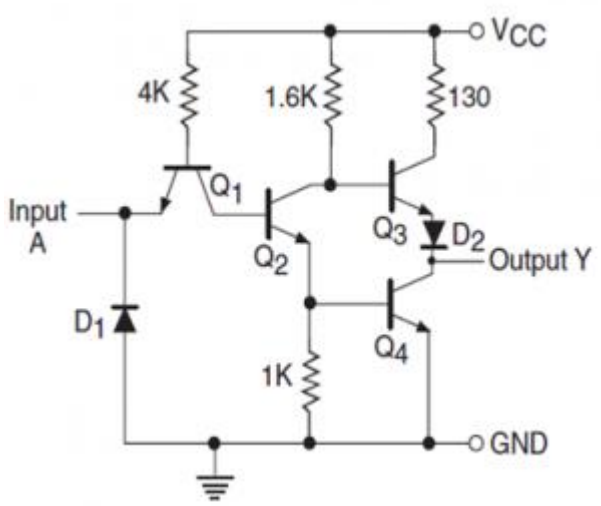
- Suppose input A is at logic high, the corresponding transistor's emitter-base junction is reverse biased, and base-collector junction is forward biased. Transistor Q3 gets base current from supply voltage Vcc and goes to saturation. As a result of the low collector voltage from Q3, transistor Q5 goes to cut off and on the other hand, if another input is low, Q4 is cut off and correspondingly Q5 is cut off and output is connected directly to the ground through transistor Q3. Similarly, when both inputs are logic low, the output will be at logic high.



NOR Gate TTL

NOT Gate

- When the input is low, the corresponding base-emitter junction is forward biased, and the base-collector junction is reverse biased. As a result transistor Q2 is cut off and also transistor Q4 is cut off. Transistor Q3 goes to saturation and diode D2 starts conducting and output is connected to Vcc and goes to logic high. Similarly, when input is at logic high, the output is at logic low.



Advantages and Disadvantages

The advantages of disadvantages of TTL include the following.

The main benefit of TTL is we can easily interface with other circuits & the ability to generate difficult logic functions because of certain voltage levels as well as good noise margins TTL has good features like fan-in which means the number of i/p signals that can be accepted through an input.

TTL is mainly immune to harm from stationary electricity discharges not like CMOS & as compared to CMOS these are economical. The main drawback of TTL is high current utilization. The TTL's high current demands can lead to offensive functioning because o/p states will be turned off. Even with different TTL versions that have low current consumption will be competitive to CMOS.

With the arrival of CMOS, TTL applications have been replaced through CMOS. But, TTL is still utilized in applications because they are quite robust & the logic gates are fairly cheap.

TTL Applications

The applications of TTL include the following.

- Used in controller application for providing 0 to 5Vs
- Used as a switching device in driving lamps and relays
- Used in processors of mini computers like DEC VAX
- Used in printers and video display terminals