

Logic Families – Significance and Types

There are a variety of circuit configurations or more appropriately various approaches used to produce different types of digital integrated circuit. Each such fundamental approach is called a *logic family*. The idea is that different logic functions, when fabricated in the form of an IC with the same approach, or in other words belonging to the same logic family, will have identical electrical characteristics. These characteristics include supply voltage range, speed of response, power dissipation, input and output logic levels, current sourcing and sinking capability, fan-out, noise margin, etc. In other words, the set of digital ICs belonging to the same logic family are electrically compatible with each other.

Significance

A digital system in general comprises digital ICs performing different logic functions, and choosing these ICs from the same logic family guarantees that different ICs are compatible with respect to each

other and that the system as a whole performs the intended logic function. In the case where the output of an IC belonging to a certain family feeds the inputs of another IC belonging to a different family, we must use established interface techniques to ensure compatibility. Understanding the features and capabilities of different logic families is very important for a logic designer who is out to make an optimum choice for his new digital design from the available logic family alternatives. A not so well thought out choice can easily underkill or overkill the design with either inadequate or excessive capabilities.

Types of Logic Family

The entire range of digital ICs is fabricated using either bipolar devices or MOS devices or a combination of the two. Different logic families falling in the first category are called bipolar families, and these include diode logic (DL), resistor transistor logic (RTL), diode transistor logic (DTL), transistor transistor logic (TTL), emitter coupled logic (ECL), also known as current mode logic (CML), and integrated injection logic (I²L). The logic families that use MOS devices as their basis are known as MOS families, and the prominent members belonging to this category are the PMOS family (using P-channel MOSFETs), the NMOS family (using N-channel MOSFETs) and the CMOS family (using both N- and P-channel devices). The Bi-MOS logic family uses both bipolar and MOS devices.

Of all the logic families listed above, the first three, that is, diode logic (DL), resistor transistor logic (RTL) and diode transistor logic (DTL), are of historical importance only. Diode logic used diodes and resistors and in fact was never implemented in integrated circuits. The RTL family used resistors and bipolar transistors, while the DTL family used resistors, diodes and bipolar transistors. Both RTL and DTL suffered from large propagation delay owing to the need for the transistor base charge to leak out if the transistor were to switch from conducting to nonconducting state. Figure 1 shows the simplified schematics of a two-input AND gate using DL [Fig. 1(a)], a two-input NOR gate using RTL [Fig. 1(b)] and a two-input NAND gate using DTL [Fig. 1(c)]. The DL, RTL and DTL families, however, were rendered obsolete very shortly after their introduction in the early 1960s owing to the arrival on the scene of transistor transistor logic (TTL).

Logic families that are still in widespread use include TTL, CMOS, ECL, NMOS and Bi-CMOS. The PMOS and I²L logic families, which were mainly intended for use in custom large-scale integrated (LSI) circuit devices, have also been rendered more or less obsolete, with the NMOS logic family replacing them for LSI and VLSI applications.

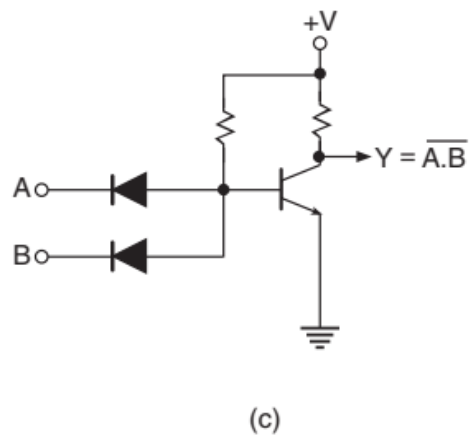
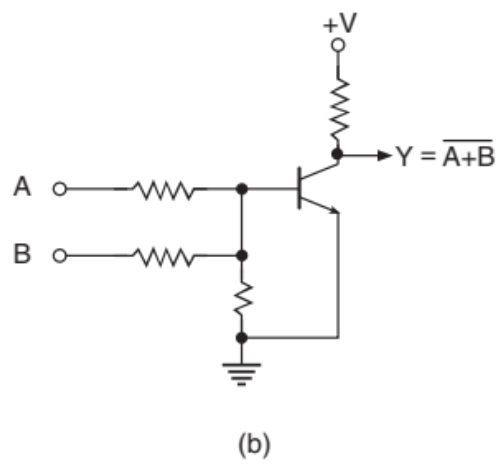
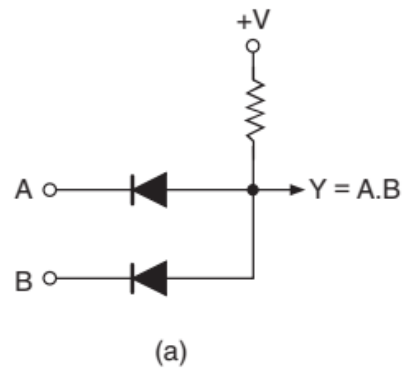


Fig 1