Gates and Inverters：A Basic Functional Module in Digital Circuits

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SHENZHEN, GUANGDONG, CHINA, October 31, 2022 /EINPresswire.com/ -- Inverters are logic gates that implement logical non-switching in digital logic and their function represents the assumption of ideal switching performance in digital circuits, but in actual inverter design, the components have electrical characteristics that require special attention. In fact, the non-ideal transition zone behavior of CMOS inverters allows them to be used as Class A power amplifiers in analog circuits.

The output voltage of the inverter circuit represents the opposite logic level to the input. Inverters can be constructed using only NMOS transistors or a PMOS connected to a resistor. Because this "resistive drain" approach requires the use of only one type of transistor, the manufacturing costs are very small. However, since the current flows through the resistor in one of two states, this resistive drain configuration has problems with power consumption and the processing rate of state changes. Alternatively, the inverter can be configured as a CMOS inverter with two complementary transistors. This configuration can significantly reduce power consumption because one of the two transistors is always cut off in one of the two logic states. The processing speed can also be increased because the resistance of CMOS inverters is relatively low compared to NMOS-type and PMOS-type inverters. Inverters can also be constructed in resistor-transistor logic (RTL) or transistor-transistor logic (TTL) using a triode (BJT).

Digital Function Module for Gates and Inverters

Inverters are basic functional modules in digital circuits. A latch is formed by using the outputs of two serial inverters as inputs to a one-bit register. Sophisticated digital components such as latches, data selectors, decoders, and state machines all require the use of a basic inverter.

A six-inverter is an integrated circuit containing six inverters. For example, the 7404 TTL chip has 14 pins and the 4049 CMOS chip has 16 pins. Both chips have 2 pins each for the power supply/reference voltage and 12 pins for the inputs and outputs of the 6 inverters (the 4049 has 2 pins dangling).

Applications of Gates and Inverters

CMOS inverters are one of the most widely used devices in digital circuit design due to their complementary structure, which consists of an n-MOSFET and a p-MOSFET in a complementary push-pull configuration, with the n-MOSFET acting as the driver (pull-down tube) and the p-MOSFET as the load (pull-up tube). Schematic diagram of the basic CMOS structure containing a p-n-p-n parasitic structure, with the gates of the two transistors connected together as signal inputs; the substrates of the two transistors are each connected to their sources, the source of the n-MOSFET is connected to ground GND and the source of the p-MOSFET is connected to the supply voltage Vdd; the drains of the n-MOSFET and p-MOSFET are connected together as the output of the inverter.

In order to fabricate n-MOSFETs and p-MOSFETs in an integrated circuit, an insulated p-substrate region and an n-substrate region must be formed, therefore, CMOS integrated circuits have three processes: n-well, p-well, and double-well. The n-well is then formed, followed by a field oxide and gate oxide layer, impurity injection to form the source-drain region and the highly doped diffusion region, and finally deposition and etching of the metalized electrodes and a degree of passivation protection on the device surface. In this case parasitic n-p-n bipolar transistors Q1 and p-n-p bipolar transistors Q2 are formed inside the CMOS structure, with Rub and Rowell representing the p-substrate and n-trap resistors. In practice, CMOS inverter circuits may also contain other ancillary circuits such as electrostatic discharge (ESD) protection circuits, latch-up protection circuits, and input Schmitt shaping circuits.

There are currently two main methods for experiments on HPM effects: the irradiation method and the injection method. The irradiation method refers to the HPM irradiation of the target electronic system in the form of space electromagnetic waves, and the HPM effect threshold of the electronic system is obtained. The irradiation method is mainly for electronic systems and can more realistically simulate the HPM electromagnetic radiation environment of electronic systems in the actual application environment, which is the most effective means to obtain the HPM effect threshold of the whole electronic system; however, this method also has disadvantages, in order to more realistically simulate the actual situation, the experimental requirements are high: the microwave beam needs to cover the whole target electronic system and irradiate the intensity uniformly, which requires The distance between the microwave source radiation antenna and the effector must not be too small, but usually, the experiment needs to be carried out in a specific microwave darkroom, the experimental space is limited, it is difficult to meet the requirements of uniform irradiation. In addition, irradiation experiments from the HPM source to the internal components of the electronic system must go through a complex process of electromagnetic transmission and coupling, which is not conducive to the analysis of the HPM effect mechanism of the electronic system.

The injection method involves the injection of HPM by conduction into the sensitive ports of the target effector to observe its transient response. The injection method is mainly targeted at unit circuits or devices and is more suitable for studying HPM effect laws, effect mechanisms, and sensitive links. The injection method is easier to implement compared to the irradiation method, and the requirements for the experimental environment are relatively low and can be completed in a general laboratory. Two main issues need to be addressed: firstly, to reduce the microwave standing wave coefficient of the injection channel and improve the microwave injection efficiency, so that more microwave power enters the target circuit or device; secondly, the isolation between the microwave source and the effector target should be done well to avoid mutual influence and damage. There are attenuation, high-pass/low-pass filtering, isolation, etc.

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