

CS220 – Logic Design TTL and CMOS

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 - Introduction
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 - CMOS ICs
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TTL and CMOS Introduction

- TTL and CMOS are families of digital ICs. Gates within a family are _____, i.e. they are easily connected together.
- The bipolar families (those which use a bipolar junction transistor or BJT as their base element) are: RTL, DTL, TTL, ECL, HTL, and IIL. TTL and ECL are the most commonly used.

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TTL and CMOS Introduction

- There are several types of TTL (transistor-transistor logic): standard, low-power, high-speed, Schottky, advanced Schottky, and advanced low-power Schottky.
- The unipolar or FET or MOS families include: PMOS, NMOS, and CMOS. The MOS families typically use much less _____ than the bipolar families. Most modern microprocessors are based upon CMOS.

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TTL and CMOS Introduction

- Integrated circuits (ICs) may be grouped according to complexity:
 - SSI: less than 12 gates on an IC (basic gates)
 - MSI: 12 to 99 gates (adder, counters, etc)
 - LSI: 100 to 9999 gates (clocks, calculators)
 - _____: 10,000 to 99,999 (microcontrollers)
 - ULSI: over 100,000 (microprocessors)

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TTL and CMOS Digital IC Terminology

- Acceptable input and typical output voltage levels for TTL and CMOS inverters are shown on page 105.
- For TTL any input between 2 V and 5 V is acceptable as a logic 1, while an output logic 1 level is guaranteed to be between 2.4 V and 5 V (typically 3.5 V). There is a 0.4 V high _____.

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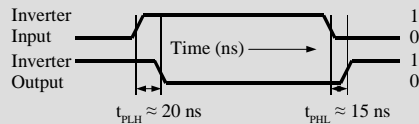
TTL and CMOS Digital IC Terminology

- Any input between 0 V and 0.8 V is acceptable as a logic 0, while an output logic 0 level is guaranteed to be between 0 V and 0.4 V (typically 0.1 V). There is also a 0.4 V low noise margin.
- Note that the noise margins for the CMOS inverter (operated from a 10 V supply) are much higher, approximately 3 V (2.95 V).

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TTL and CMOS Digital IC Terminology

- We have assumed that the output of a gate can change instantaneously. In fact, it takes time for the output to change due to a change in input.



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TTL and CMOS Digital IC Terminology

- If an input signal and output signal are separated by N gates, we can estimate the worst-case total propagation delay as N times the worst-case delay of a single gate.
- On a clocked or _____ system, the total propagation delay will limit the clock rate. (A 1 GHz clock has a period of 1 ns.)

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TTL and CMOS Digital IC Terminology

- In order to be compatible not only must the input and output voltage levels agree, but the input and output current directions and levels must match.
- As shown in Fig. 6-3 (pg 107), when a TTL output is low, current must flow from the input of the succeeding gate into the output. The output is said to _____ current.

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TTL and CMOS Digital IC Terminology

- When a TTL output is high current flows from the output to the input of the succeeding gate. The output is said to source current.
- Each family has a specified limit to the number of inputs that can be connected to a single output. This limit is known as the _____ of the logic family. TTL _____ is typically 10 gates while that for CMOS is 50.

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TTL and CMOS Digital IC Terminology

- Noise margins, propagation time, power dissipation, voltage levels, current levels and fanout are all used to characterize logic families.
- The application may dictate the choice of logic family – speed, power requirements, noise levels – must be considered.

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TTL and CMOS TTL ICs

- The six TTL _____ can be identified by markings on the IC. Here are the markings found on a hex inverter from each subfamily:
 - Standard TTL: 7404
 - Low Power TTL: 74L04
 - Low Power Schottky: 74LS04
 - Schottky TTL: 74S04
 - Advanced Low Power Schottky: 74ALS04
 - Advanced Schottky: 74AS04

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TTL and CMOS TTL ICs

- The subfamilies can be ranked by speed:

Speed	TTL Subfamily
Fastest	Advanced Schottky
↓	Schottky
	Advanced Low Power Schottky
	Low Power Schottky
	Standard TTL
Slowest	Low Power

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TTL and CMOS TTL ICs

- Or by power dissipation:

Power	TTL Subfamily
Low	Low Power
↓	Advanced Low Power Schottky
	Low Power Schottky
	Advanced Schottky
	Standard TTL
High	Schottky

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TTL and CMOS TTL ICs

- The 7400 TTL series is called the commercial series. The 5400 series is known as the military (mil spec) series.
- Unless the TTL IC is a _____ device or has open-collector outputs, the outputs of TTL gates cannot be connected together.
- Unconnected inputs will "float HIGH", that is, act like they are connected to a logical 1. (It is good practice to connect unused inputs.)

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TTL and CMOS CMOS ICs

- CMOS is noted for low _____.
- There are three popular series: 4000, 74C00, and 74HC00.
- The 4000 and 74C00 series are compatible. They can run from supply voltages of 3 to 15 V. The 74C00 series features functions and pin outs that are the same as the 7400 TTL series. (The 4011, 74C00 and 7400 are all quad two-input NAND ICs.)

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TTL and CMOS CMOS ICs

- The 74HC00 series is a high speed series with propagation delays on the order of 8 to 12 ns. They also have a greater fan out than the 4000 or 74C00 series.
- Special care must be used when working with CMOS ICs to prevent damage due to _____. (See pg 117) It is recommended that all unused inputs be connected to either ground or the power supply.)

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TTL and CMOS Interfacing

- Incompatible logic families can be connected with additional _____ circuitry. The _____ circuitry supplies the required voltage levels and current.
- Interfacing TTL and CMOS is relatively straightforward when both are using a 5 V supply. Refer to Fig. 6-15 (pg 119). Figs. (a) and (b) use pull-up resistors to ensure sufficient current to the TTL gate when the output is LOW.

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TTL and CMOS Interfacing

- A CMOS gate can directly drive a single low power TTL device. For driving multiple TTL gates use a CMOS _____ as shown in Fig. 6-15 (d).
- Interfacing TTL and CMOS circuits that use different supply voltages is a bit trickier. Some interface circuits that can be used in this situation are shown in Fig. 6-16.

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TTL and CMOS Interfacing

- CMOS gates can drive LED indicators using the circuits shown in Fig. 6-17. At voltages greater than 5 V _____ resistors are required (Fig. 6-17 (c) – (f)).
- A _____ resistor is always needed when driving an LED from a TTL gate. (Refer to Fig. 6-18).

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