TOSHIBA

e-Learning

Basics of CMOS Logic ICs

Chapter1 Overview of CMOS Logic ICs

Toshiba Electronic Devices & Storage Corporation

01

Overview of CMOS Logic ICs

1.1 What is a **Logic** IC?

Logic = Boolean or binary

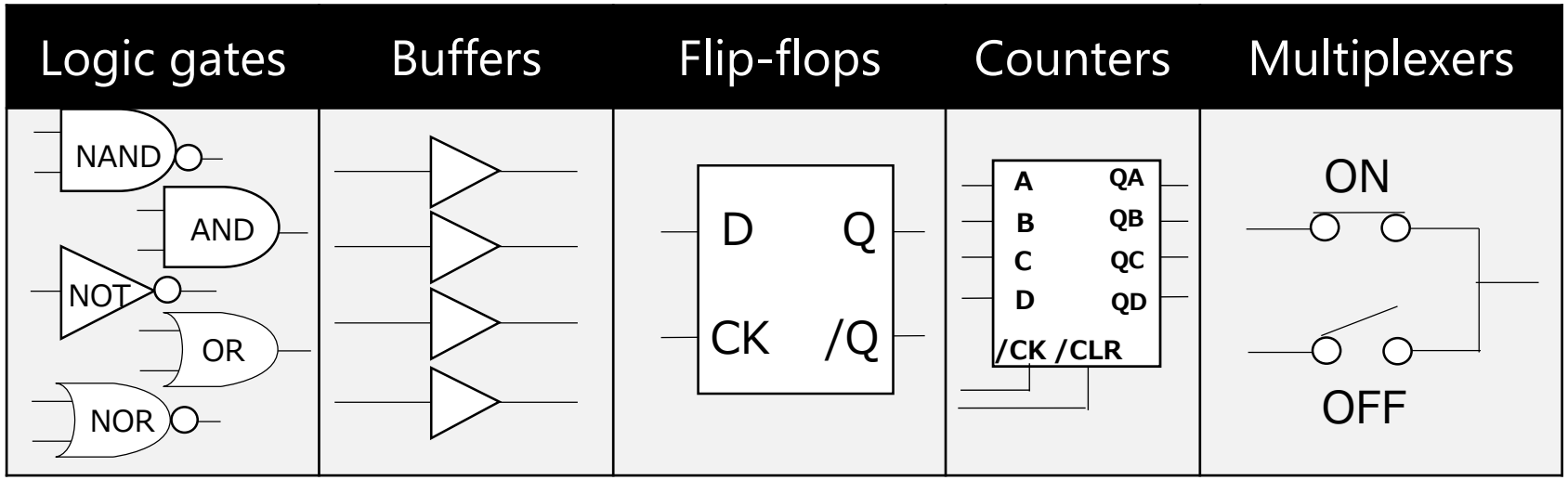
A logic IC is a semiconductor device that implements a basic logical operation that is performed on one or more digital input signals (represented by 1 and 0 or H and L) to produce a digital output signal.

Example: Truth table of a NAND gate

Input			Output
A	B	Logical operation	
L	L	→	H
L	H	→	H
H	L	→	H
H	H	→	L

1.1 What is a Logic IC?

Typical functions of logic ICs



Analog switches that connect or disconnect the conducting path of an analog signal are also classified as logic ICs.

1.2 What is a Standard Logic IC?

Basic logic gates are available from multiple manufacturers as industry-standard ICs, which are functionally and pin-compatible. These ICs are called standard logic ICs.
Standard logic ICs from different manufacturers are housed in pin-compatible packages, except some small packages.
Standard logic ICs with the same function number provide the same function and pin assignment.

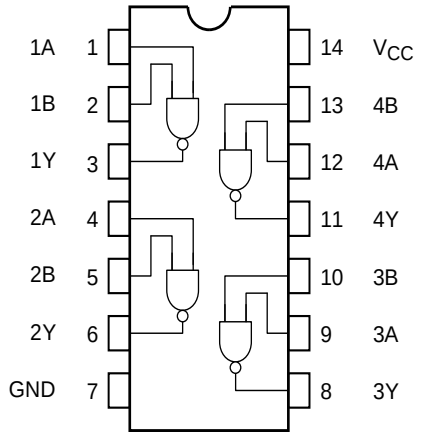
【Part number】

74VHC00FT

NAND

Parts with the same number provide the same function and pin assignment.

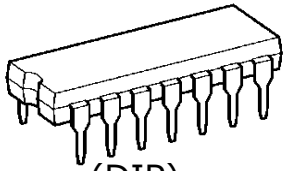
【 Pin assignment 】



(top view)

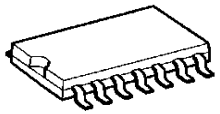
Packages

TC74HC00AP
(Lead pitch: 2.54 mm)



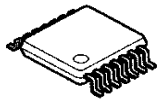
(DIP)
DIP14-P-300-2.54

TC74VHC00F
(Lead pitch: 1.27 mm)



(SOP)
SOP14-P-300-1.27A

74VHC00FT
(Lead pitch: 0.65 mm)



(TSSOP)
TSSOP14-P-0044-0.65A

1.2 What is a Standard Logic IC?

【Reference: Function numbers of typical standard logic ICs】

The function numbers of standard logic ICs are predefined according to the function, number of circuits, input logic, and output logic.

Function number	Function name
00	Quad 2-Input NAND
02	Quad 2-input NOR
04	Hex Inverter
05	Hex Inverter (Open-Drain)
07	Hex Buffer (Open-Drain)
08	Quad 2-Input AND
14	Hex Schmitt Inverter
17	Hex Schmitt Buffer
21	Dual 4-Input AND
32	Quad 2-Input OR
74	Dual D-Type Flip-Flop with Preset and Clear
86	Quad Exclusive OR

Function number	Function name
123	Dual Monostable Multivibrator
125	Quad Bus Buffer (3-State)
138	3-to-8 Line Decoder
157	Quad 2-Channel Multiplexer
164	8-Bit Serial-In/Parallel-Out Shift Register
244	Octal Bus Buffer (3-State)
245	Octal Bus Transceiver (3-State)
273	Octal D-Type Flip-Flop with Clear
373	Octal D-Type Latch (3-State)
541	Octal Bus Buffer (3-State)
574	Octal D-Type Flip-Flop (3-State)
595	8-Bit Shift Register/Latch (3-State)

1.3 Types of Standard Logic

Standard logic ICs are classified into the following types according to their structure (i.e., manufacturing process used), which differ in electrical characteristics. At present, CMOS logic ICs that combine low power consumption and low cost are most commonly used.

■ TTL (transistor-transistor logic)

- Bipolar logic that was initially widely used as standard logic ICs
- Provides a higher current drive capability and operating speed but dissipates more power than CMOS logic ICs

■ CMOS logic (CMOS: Complementary MOSFET)

- Combines p-channel and n-channel MOSFETs to achieve lower power dissipation than TTL
- Was initially slower than TTL, but now provides higher operating speed than TTL because of fine wafer fabrication processes

■ BiCMOS logic (bipolar CMOS)

- Uses a CMOS process for the input stage and logic circuit to reduce power dissipation and bipolar transistors for the output stage to provide a high current drive capability
- High cost incurred by complicated manufacturing processes because of MOS-bipolar combination

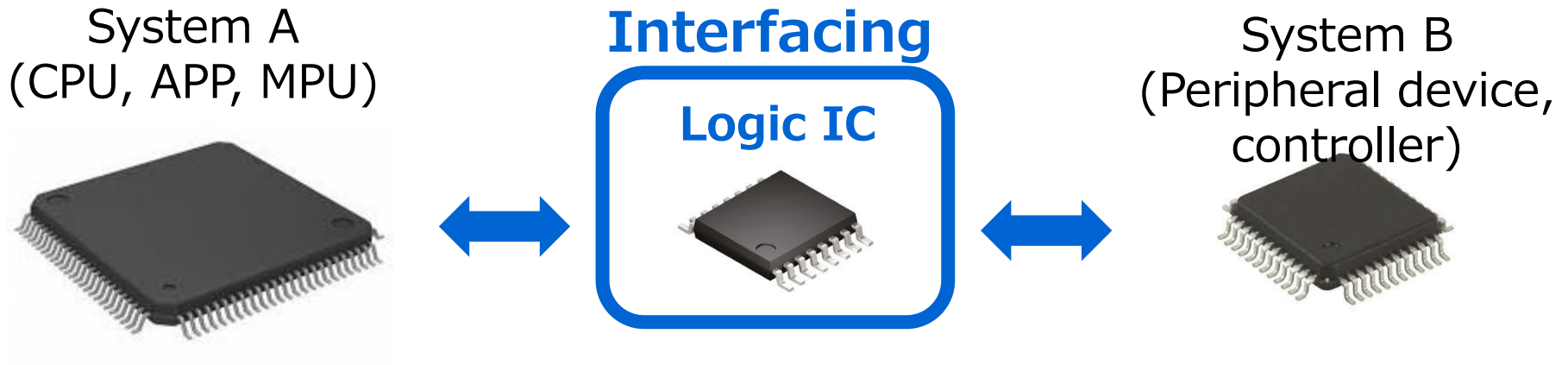
1.4 Equipment in which CMOS Logic ICs are used

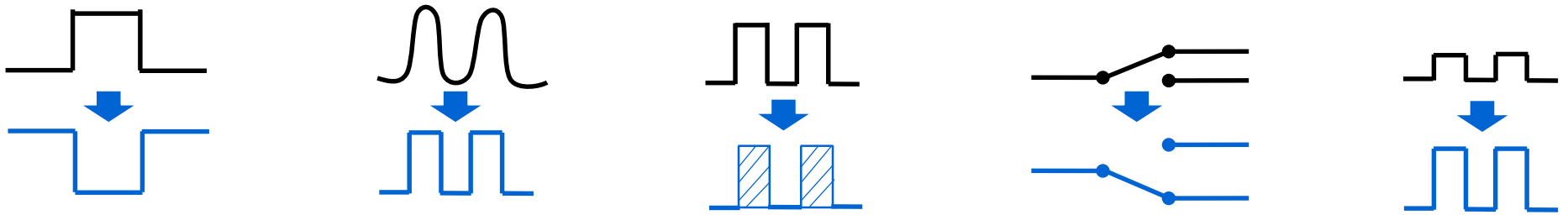
In the past, CMOS logic ICs played an important role in implementing main system functions. However, peripheral components are being integrated into LSI chips to improve the functionality and reduce the size of electric and electronic applications. Even so, CMOS logic ICs are used in various applications as they are indispensable for glue logic that interfaces different LSI chips and boards.

Logic ICs are used in various devices and appliances.

1.5 Reasons why CMOS Logic ICs are used

Logic ICs are required to interface different LSI chips and boards. They are also used to make minor modifications and adjustments to logic circuits such as increasing signal drive capabilities (i.e., buffering signals), shaping signal waveforms, adjusting signal output timing, and making minor changes to a system.

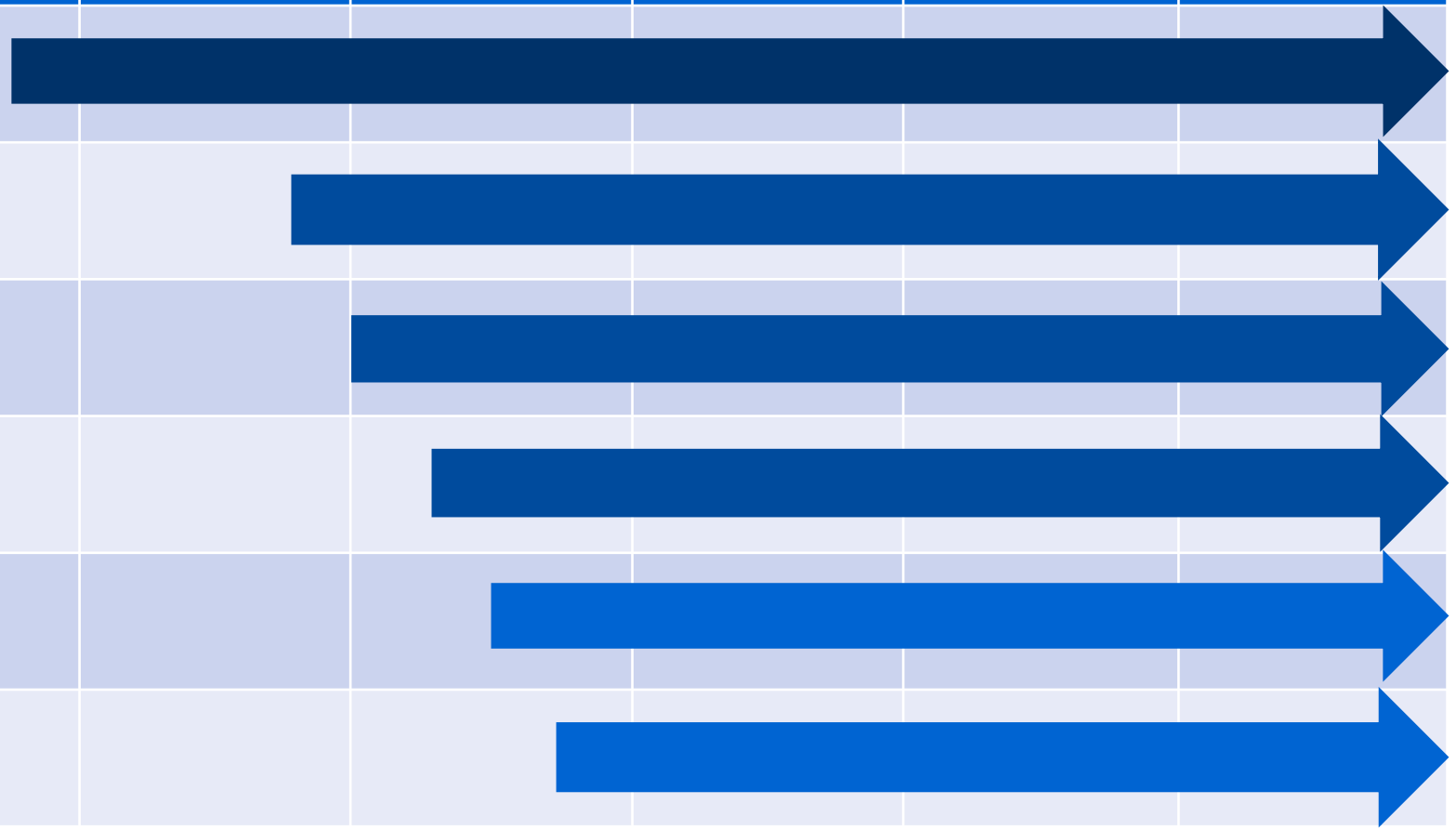




1.6 Classification of CMOS Logic ICs and overview of each series

Since the launch of the first Standard CMOS series (4000 series),
Toshiba has released successive generations of high-speed and low-voltage CMOS logic ICs.

Series Name	Start of production					
	1970s	1980s	1990s	2000s	2010s	2020s
4000 Series Standard CMOS						
74HC Series High-Speed CMOS						
74AC Series Advanced CMOS						
74VHC Series Very-High-Speed CMOS						
74LCX Series Low-Voltage CMOS						
74VCX Series Very-Low-Voltage CMOS						



1.6 Classification of **Toshiba's** CMOS logic ICs and overview of each series

Toshiba continues to supply CMOS logic ICs with a wide operating range (1.2 V to 18 V) suitable for various applications.

https://toshiba.semicon-storage.com/jp/semiconductor/knowledge/faq/logic_common/logic_common_01.html

Type	Series	Part number	Operating voltage range (V)	Propagation delay time (ns)*1	Output current (mA)*2	Input-tolerant function*3	Output power-down protection*3
For 5-V Systems	Standard CMOS	TC4000B TC4500B	3 to 18	200 (at 5.0 V)	±0.51 (at 5.0 V)	- *4	-
	High-Speed CMOS	TC74HC	2 to 6	23 (at 4.5 V)	±4.0 or ±6.0 (at 4.5 V)	- *4	-
		TC74HCT	4.5 to 5.5				
	Advanced CMOS	TC74AC	2 to 5.5	8.5 (at 4.5 V)	±24 (at 4.5 V)	-	-
		TC74ACT	4.5 to 5.5				
	Very-High-Speed CMOS	TC74VHC 74VHC TC74VHC9 74VHC9	2 to 5.5	8.5 (at 4.5 V)	±8.0 (at 4.5 V)	✓	-
		TC74VHCT 74VHCT	4.5 to 5.5			✓	✓
		TC74VHCV 74VHCV	1.8 to 5.5		±16 (at 4.5 V)	✓	✓
For low-voltage systems	Low-Voltage CMOS	TC74LCX 74LCX	1.65 to 3.6	6.5 (at 3.0 V)	±24 (at 3.0 V)	✓	✓
	Very-Low-Voltage CMOS	TC74VCX	1.2 to 3.6	4.2 (at 2.3 V)	±24 (at 3.0 V)	✓	✓

*1: Maximum propagation delay time of typical ICs (TC4001, 74HC244, TC74AC244, 74VHC244, 74LCX244, and TC74VCX244) at 85°C, except for the TC4001 for which the maximum propagation delay time at 25°C is shown

*2: Those output current values are from DC characteristics table of the datasheet. Absolute maximum rated output current is specified separately.

*3: The terms "tolerant function" and "power-down protection" are sometimes used interchangeably. The input- and output-tolerant functions may be referred to as input and output power-down protection, respectively.

*4: TC4049BF/BP, TC4050BF/BP, TC74HC4049BP/BF/BFT, 74HC4049D, TC74HC4050BP/BF/BFT and 74HC4050D have the input-tolerant function that allows level shifting from a higher voltage to a lower voltage.

TOSHIBA