National Semiconductor

October 1995

74VHC04 • 74VHCT04
Hex Inverter

General Description

The 74VHC/VHCT04 is an advanced high speed CMOS INVERTER fabricated with silicon gate CMOS technology. It achieves the high speed operation similar to equivalent Bipolar Schottky TTL while maintaining the CMOS low power dissipation.

The internal circuit is composed of 3 stages including buffer output, which provide high noise immunity and stable output. An input protection circuit ensures that 0V–7V can be applied to the input pins without regard to the supply voltage. This device can be used to interface 5V to 3V systems and two supply systems such as battery back up. This circuit prevents device destruction due to mismatched supply and input voltages.

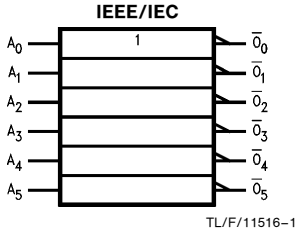
Features

- High noise immunity:
  VHC $V_{NIH} = V_{NIL} = 28\%\ V_{CC}$ (Min)
  VHCT $V_{IH} = 2.0V$, $V_{IL} = 0.8V$
- Power down protection:
  VHC inputs only
  VHCT inputs and outputs
- Low Noise:
  VHC $V_{OLP} = 0.4V$ (typ)
  VHCT $V_{OLP} = 0.8V$ (typ)
- Low power dissipation:
  $I_{CC} = 2\ \mu A$ (Max) @ $T_A = 25°C$
- Balanced propagation delays: $t_{pLH} \cong t_{pHL}$
- Pin and function compatible with 74HC/HCT04

Commercial	Package Number	Package Description
74VHC04M	M14A	14-Lead Molded JEDEC SOIC
74VHC04SJ	M14D	14-Lead Molded EIAJ SOIC
74VHC04MSC	MSC14	14-Lead Molded EIAJ Type 1 SSOP
74VHC04MTC	MTC14	14-Lead Molded JEDEC Type 1 TSSOP
74VHC04N	N14A	14-Lead Molded DIP
74VHCT04M	M14A	14-Lead Molded JEDEC SOIC
74VHCT04SJ	M14D	14-Lead Molded EIAJ SOIC
74VHCT04MTC	MTC14	14-Lead Molded JEDEC Type 1 TSSOP
74VHCT04N	N14A	14-Lead Molded DIP

Note: Surface mount packages are also available on Tape and Reel. Specify by appending the suffix letter "X" to the ordering code.
EIAJ Type I SSOP available on Tape and Reel only, order MSCX.

Logic Symbol



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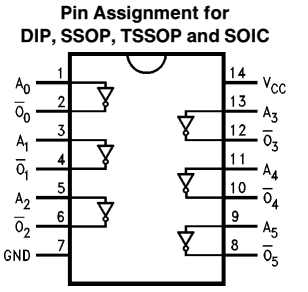
Connection Diagram



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Pin Names	Description
A_n	Inputs
$\overline{O}_n$	Outputs

Truth Table

A	O
L	H
H	L

Absolute Maximum Ratings (Note 1)

Supply Voltage (V_{CC})	−0.5V to +7.0V
DC Input Voltage (V_{IN})	−0.5V to +7.0V
DC Output Voltage (V_{OUT})	
VHC	−0.5V to V_{CC} + 0.5V
VHCT*	−0.5V to 7.0V
Input Diode Current (I_{IK})	−20 mA
Output Diode Current (I_{OK})	
VHC	±20 mA
VHCT	−20 mA
DC Output Current (I_{OUT})	±25 mA
DC V_{CC}/GND Current (I_{CC})	±50 mA
Storage Temperature (T_{STG})	−65°C to +150°C
Lead Temperature (T_L) (Soldering, 10 seconds)	260°C

*V_{OUT} > V_{CC} only if output is in H state.

Note 1: *Absolute Maximum Ratings are values beyond which the device may be damaged or have its useful life impaired. The databook specifications should be met, without exception, to ensure that the system design is reliable over its power supply, temperature, and output/input loading variables. National does not recommend operation outside databook specifications.*

Recommended Operating Conditions

Supply Voltage (V_{CC})	
VHC	2.0V to +5.5V
VHCT	4.5V to +5.5V
Input Voltage (V_{IN})	0V to +5.5V
Output Voltage (V_{OUT})	0V to V_{CC}
Operating Temperature (T_{OPR})	
74VHC/VHCT	−40°C to +85°C
Input Rise and Fall Time (t_r, t_f)	
V_{CC} = 3.3V ±0.3V (VHC only)	0 ~ 100 ns/V
V_{CC} = 5.0V ±0.5V	0 ~ 20 ns/V

DC Characteristics for 'VHC Family Devices

Symbol	Parameter	V_{CC} (V)	74VHC T_A = 25°C			74VHC T_A = −40°C to +85°C		Units	Conditions	
			Min	Typ	Max	Min	Max			
V_{IH}	High Level Input Voltage	2.0	1.50			1.50		V		
		3.0–5.5	0.7 V_{CC}			0.7 V_{CC}				
V_{IL}	Low Level Input Voltage	2.0			0.50		0.50	V		
		3.0–5.5			0.3 V_{CC}		0.3 V_{CC}			
V_{OH}	High Level Output Voltage	2.0	1.9	2.0		1.9		V	V_{IN} = V_{IH} or V_{IL}	I_{OH} = −50 μA
		3.0	2.9	3.0		2.9				
		4.5	4.4	4.5		4.4				
		3.0	2.58			2.48		V		I_{OH} = −4 mA
		4.5	3.94			3.80				I_{OH} = −8 mA
V_{OL}	Low Level Output Voltage	2.0		0.0	0.1		0.1	V	V_{IN} = V_{IH} or V_{IL}	I_{OL} = +50 μA
		3.0		0.0	0.1		0.1			
		4.5		0.0	0.1		0.1			
		3.0			0.36		0.44	V		I_{OL} = 4 mA
		4.5			0.36		0.44			I_{OL} = 8 mA
I_{IN}	Input Leakage Current	0–5.5			±0.1		±1.0	μA	V_{IN} = 5.5V or GND	
I_{CC}	Quiescent Supply Current	5.5			2.0		20.0	μA	V_{IN} = V_{CC} or GND	

DC Characteristics for 'VHC Family Devices

Symbol	Parameter	V_{CC} (V)	74VHC $T_A = 25°C$ Typ	74VHC $T_A = 25°C$ Limits	Units	Conditions
**V_{OLP}	Quiet Output Maximum Dynamic V_{OL}	5.0	0.4	0.8	V	$C_L = 50$ pF
**V_{OLV}	Quiet Output Minimum Dynamic V_{OL}	5.0	−0.4	−0.8	V	$C_L = 50$ pF
**V_{IHD}	Minimum High Level Dynamic Input Voltage	5.0		3.5	V	$C_L = 50$ pF
**V_{ILD}	Maximum Low Level Dynamic Input Voltage	5.0		1.5	V	$C_L = 50$ pF

**Parameter guaranteed by design.

DC Characteristics for 'VHCT Family Devices

Symbol	Parameter	V_{CC} (V)	74VHCT $T_A = 25°C$ Min	Typ	Max	74VHCT $T_A = -40°C$ to $+85°C$ Min	Max	Units	Conditions	
V_{IH}	High Level Input Voltage	4.5 5.5	2.0 2.0			2.0 2.0		V		
V_{IL}	Low Level Input Voltage	4.5 5.5			0.8 0.8		0.8 0.8	V		
V_{OH}	High Level Output Voltage	4.5	3.15	3.65		3.15		V	$V_{IN} = V_{IH}$ or V_{IL}	$I_{OH} = -50\ \mu A$
			2.5			2.4		V		$I_{OH} = -8$ mA
V_{OL}	Low Level Output Voltage	4.5		0.0	0.1		0.1	V	$V_{IN} = V_{IH}$ or V_{IL}	$I_{OL} = 50\ \mu A$
					0.36		0.44	V		$I_{OL} = 8$ mA
I_{IN}	Input Leakage Current	0–5.5			±0.1		±1.0	μA	$V_{IN} = 5.5V$ or GND	
I_{CC}	Quiescent Supply Current	5.5			2.0		20.0	μA	$V_{IN} = V_{CC}$ or GND	
I_{CCT}	Maximum I_{CC}/Input	5.5			1.35		1.50	mA	$V_{IN} = 3.4V$ Other Inputs = V_{CC} or GND	
I_{OPD}	Output Leakage Current (Power Down State)	0.0			+0.5		+5.0	μA	$V_{OUT} = 5.5V$	

DC Characteristics for 'VHCT Family Devices

Symbol	Parameter	V_{CC} (V)	74VHCT $T_A = 25°C$ Typ	74VHCT $T_A = 25°C$ Limits	Units	Conditions
**V_{OLP}	Quiet Output Maximum Dynamic V_{OL}	5.0	0.8	1.0	V	$C_L = 50$ pF
**V_{OLV}	Quiet Output Minimum Dynamic V_{OL}	5.0	−0.8	1.0	V	$C_L = 50$ pF
**V_{IHD}	Minimum High Level Dynamic Input Voltage	5.0		2.0	V	$C_L = 50$ pF
**V_{ILD}	Maximum Low Level Dynamic Input Voltage	5.0		0.8	V	$C_L = 50$ pF

**Parameter guaranteed by design.

AC Electrical Characteristics for 'VHC Family Devices:

Symbol	Parameter	V_{CC} (V)	74VHC			74VHC		Units	Conditions
			$T_A = 25°C$			$T_A = -40°C$ to $+85°C$			
			Min	Typ	Max	Min	Max		
t_{PHL}, t_{PLH}	Propagation Delay	3.3 ±0.3		5.0	7.1	1.0	8.5	ns	$C_L = 15$ pF
				7.5	10.6	1.0	12.0		$C_L = 50$ pF
		5.0 ±0.5		3.8	5.5	1.0	6.5	ns	$C_L = 15$ pF
				5.3	7.5	1.0	8.5		$C_L = 50$ pF
C_{IN}	Input Capacitance			4	10		10	pF	V_{CC} = OPEN
C_{PD}	Power Dissipation Capacitance			18				pF	(Note 1)

Note 1: C_{PD} is defined as the value of the internal equivalent capacitance which is calculated from the operating current consumption without load. Average operating current can be obtained by the equation: I_{CC} (opr.) = C_{PD} * V_{CC} * f_{IN} + I_{CC}/6 (per gate).

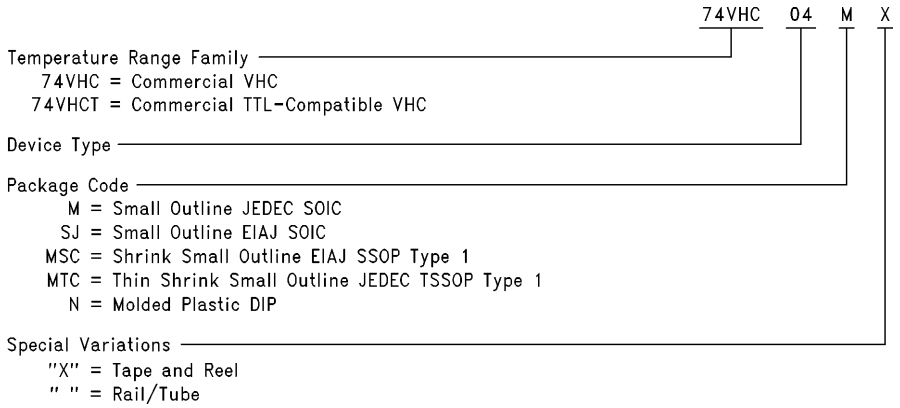
AC Electrical Characteristics for 'VHCT Family Devices:

Symbol	Parameter	V_{CC} (V)	74VHCT			74VHCT		Units	Conditions
			$T_A = 25°C$			$T_A = -40°C$ to $+85°C$			
			Min	Typ	Max	Min	Max		
t_{PHL}, t_{PLH}	Propagation Delay	5.0 ±0.5		4.7	6.7	1.0	7.5	ns	$C_L = 15$ pF
				5.5	7.7	1.0	8.5		$C_L = 50$ pF
C_{IN}	Input Capacitance			4	10		10	pF	V_{CC} = OPEN
C_{PD}	Power Dissipation Capacitance			14				pF	(Note 1)

Note 1: C_{PD} is defined as the value of the internal equivalent capacitance which is calculated from the operating current consumption without load. Average operating current can be obtained by the equation: I_{CC} (opr.) = C_{PD} * V_{CC} * f_{IN} + I_{CC}/6 (per gate).

Ordering Information

The device number is used to form part of a simplified purchasing code, where the package type and temperature range are defined as follows:



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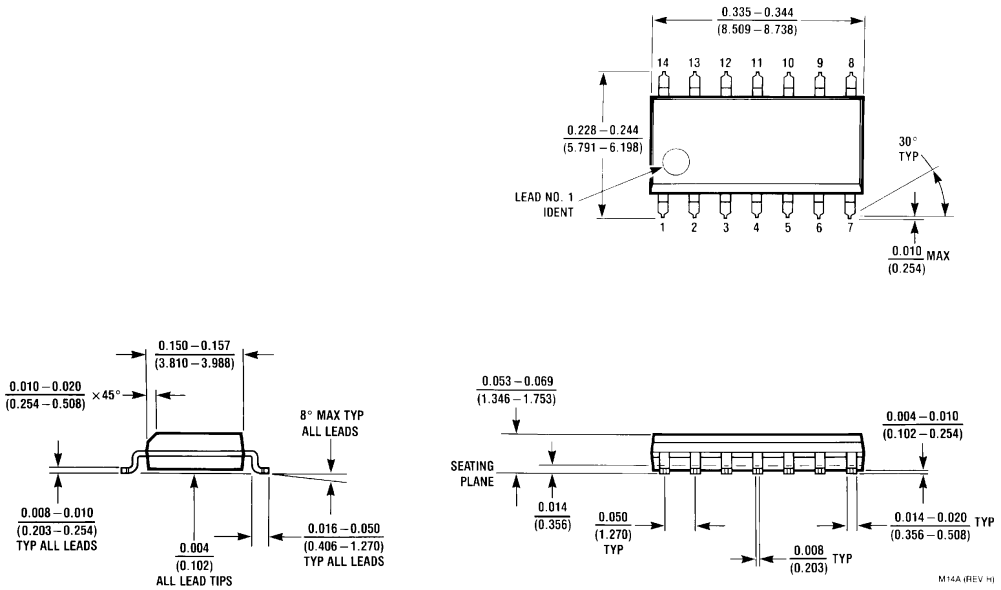
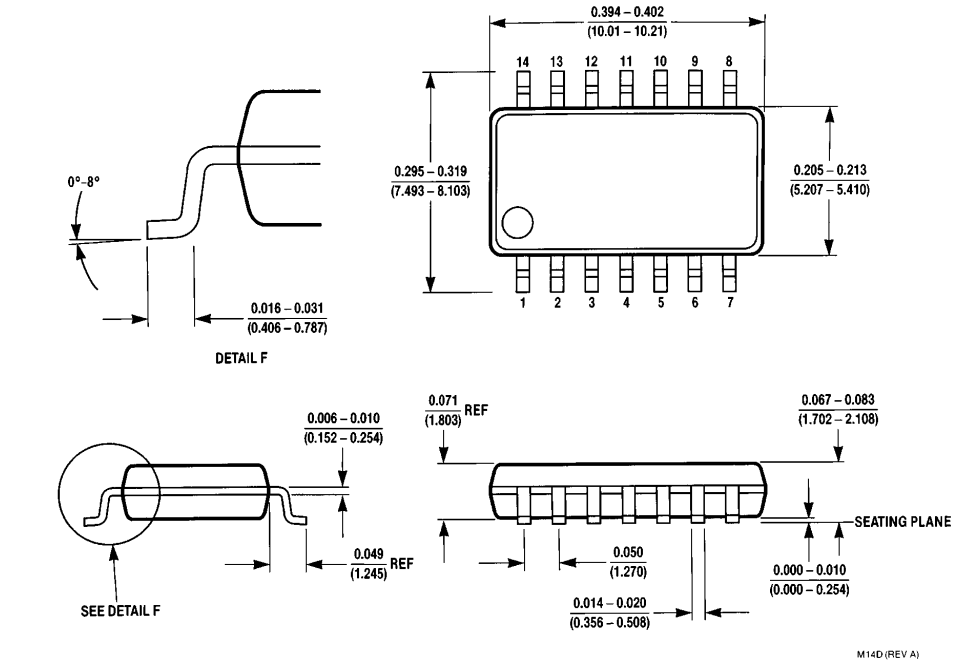
Physical Dimensions inches (millimeters) (Continued)

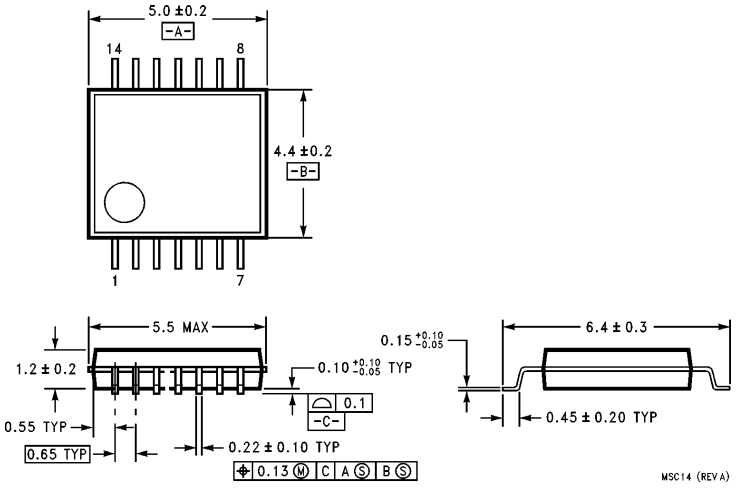


14-Lead Small Outline Integrated Circuit JEDEC SOIC (M)
Order Number 74VHC04M, 74VHC04MX, 74VHCT04M or 74VHCT04MX
NS Package Number M14A

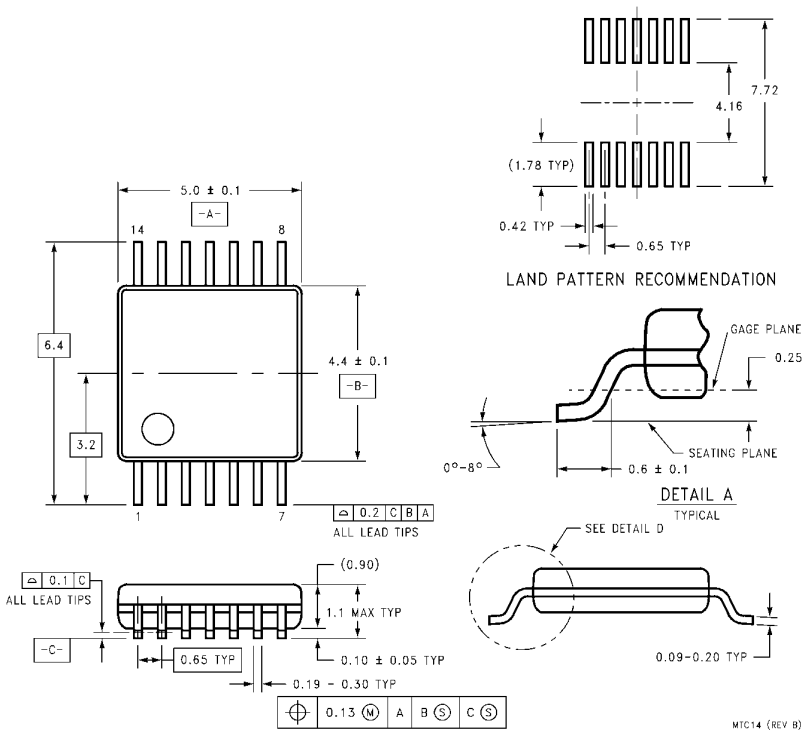


14-Lead Small Outline Package—EIAJ SOIC (SJ)
Order Number 74VHC04SJ, 74VHC04SJX, 74VHCT04SJ or 74VHCT04SJX
NS Package Number M14D

Physical Dimensions inches (millimeters) (Continued)

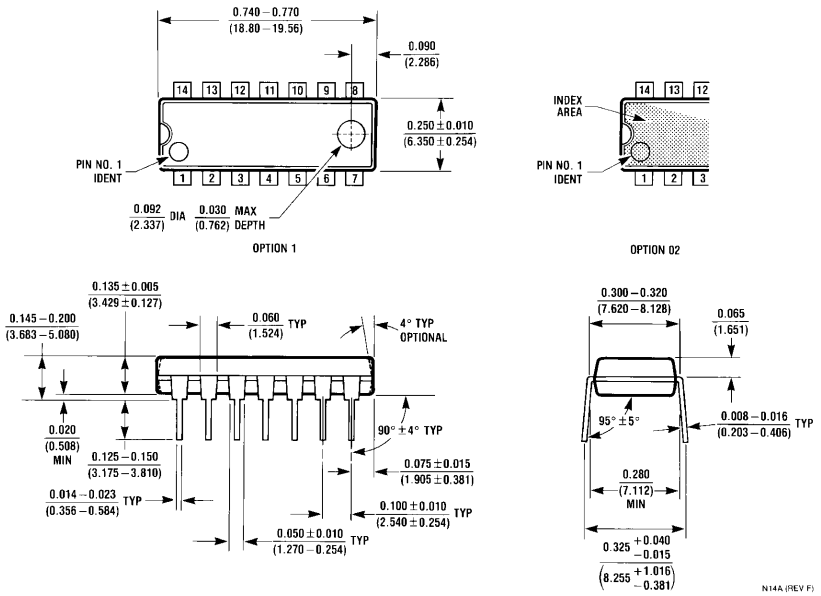


14-Lead Plastic EIAJ SSOP Type I (MSC)
Order Number 74VHC04MSCX
NS Package Number MSC14



14-Lead Plastic JEDEC TSSOP Type I (MTC)
Order Number 74VHC04MTC, 74VHC04MTCX, 74VHCT04MTC or 74VHCT04MTCX
NS Package Number MTC14

Physical Dimensions inches (millimeters) (Continued)



14-Lead Molded DIP
Order Number 74VHC04N or 74VHCT04N
NS Package Number N14A

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