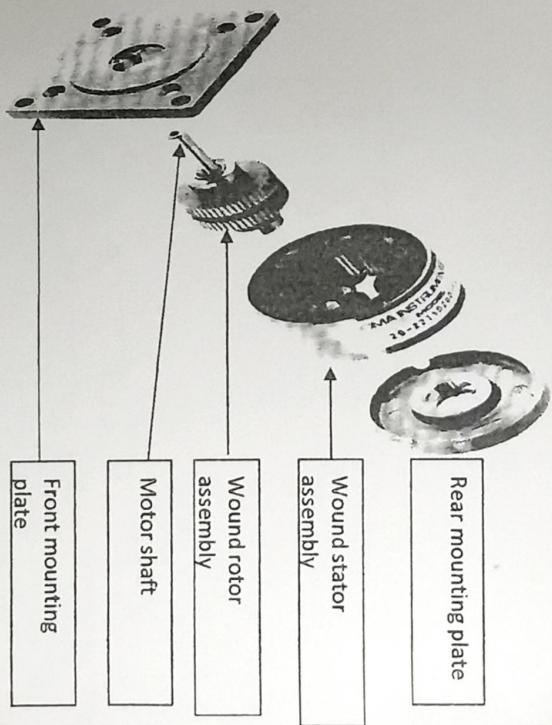


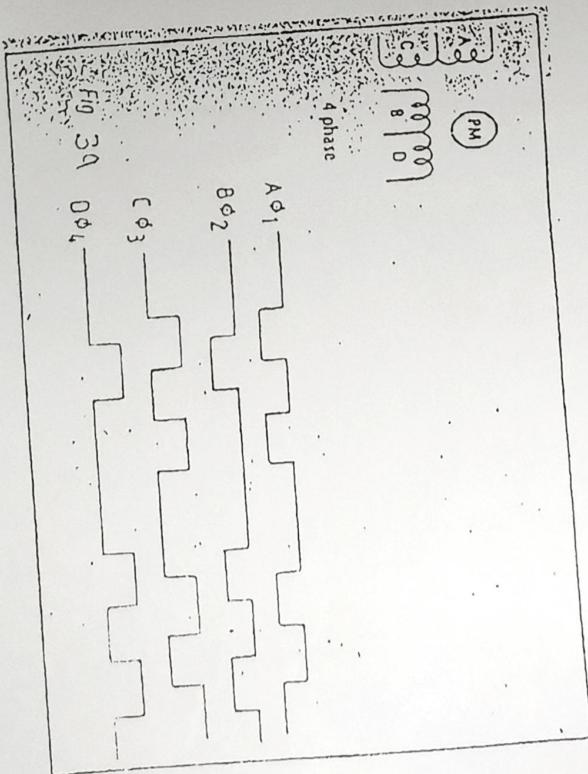
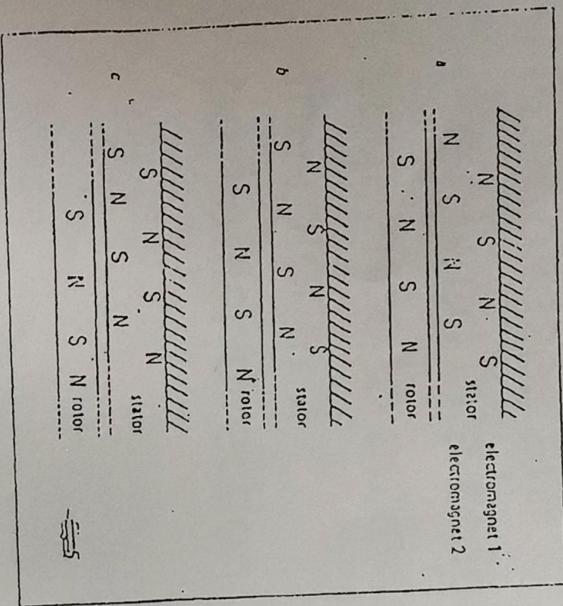
## Manual Stepper Motor Motion Control

- Study the stepper motor design and structure
- Study the control scheme
- Study the control and drive circuit diagram
- Vary the frequency of clock and measure the frequency on the oscilloscope and corresponding rotational speed
- Tabulate the results

- Unipolar winding
- 8 poles on stator
- PM Rotor
- 50 poles on rotor
- 200 (50x4) pulses to Make one rotation
- 1.8 degree rotation per pulse



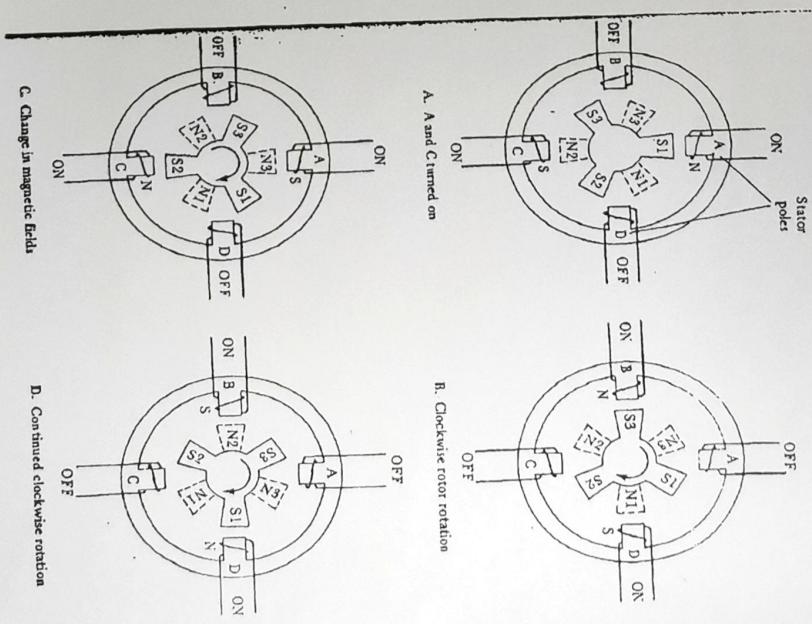
# 'unwound' motor



No. of poles decide the step angle.  
200 poles gives 1.8 deg /pulse  
48 poles give 7.5 deg /pulse

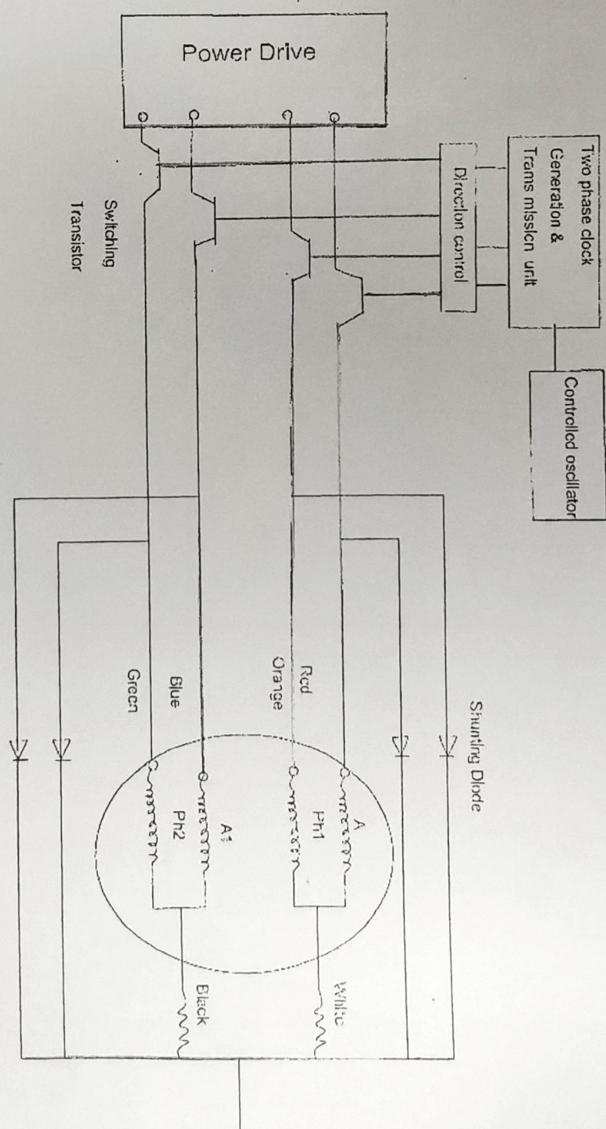
# Operational steps of PM stepper

- Four phases are energised in a proper sequence to advance the rotor in a particular direction



# Stepper motor control

- Clock
- Frequency
- Sequence generator
- Amplifier



(Block Diagram)

Direction

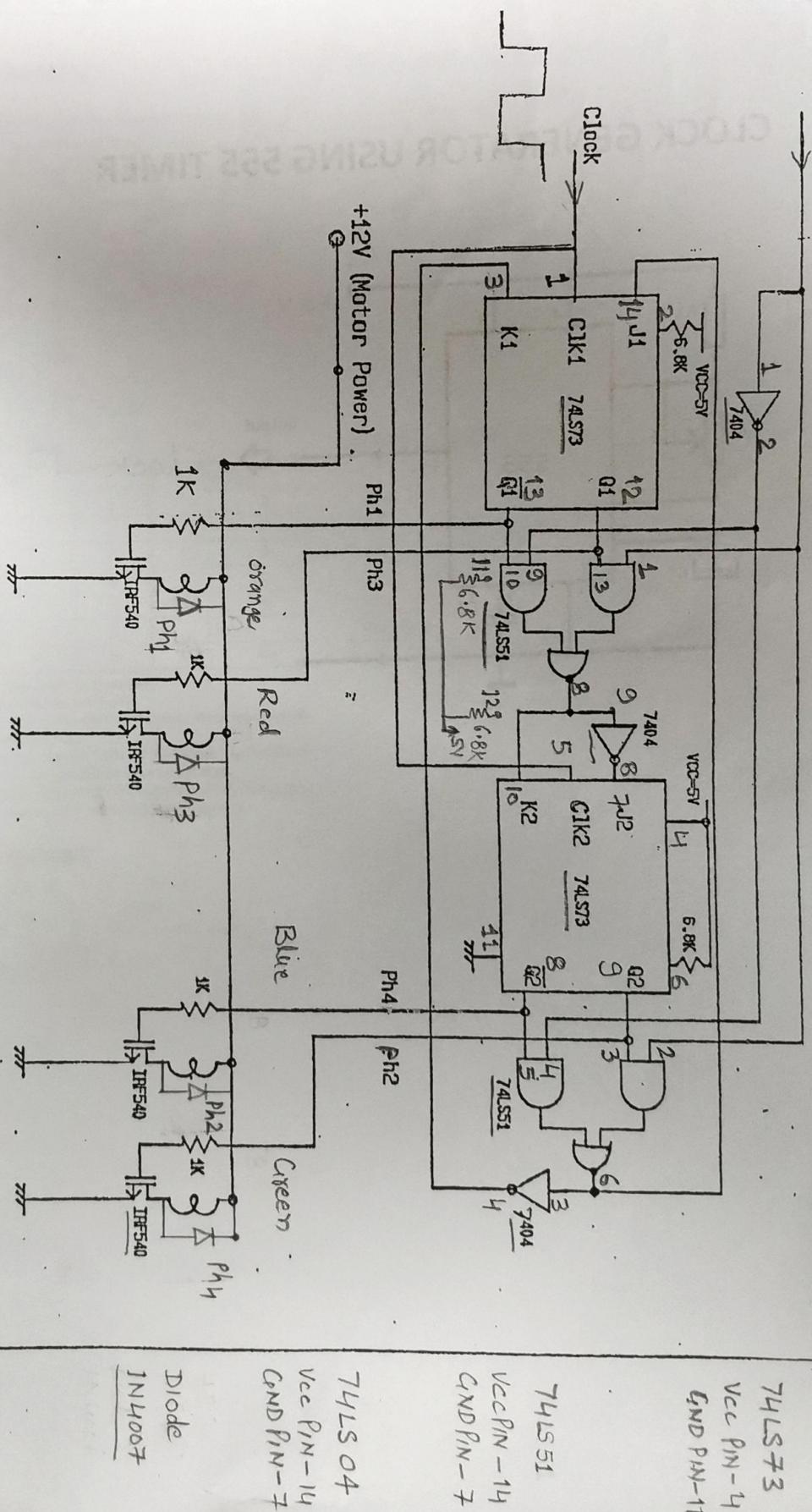
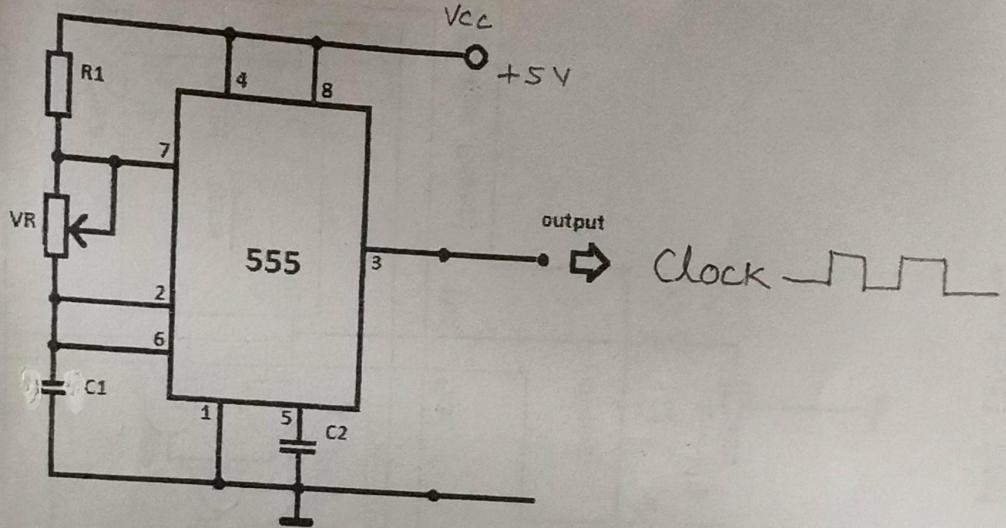


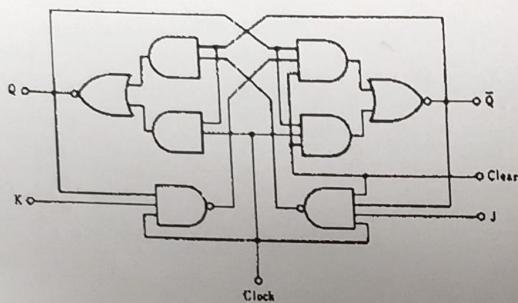
Figure Control and Drive Circuit for Stepper Motor

# CLOCK GENERATOR USING 555 TIMER

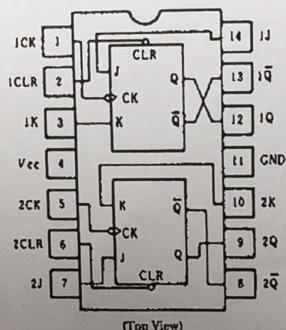


# HD74LS73A • Dual J-K Flip-Flops (with Clear)

## ■ BLOCK DIAGRAM (1/2)



## ■ PIN ARRANGEMENT



## ■ FUNCTION TABLE

Inputs				Outputs	
Clear	Clock	J	K	Q	$\bar{Q}$
L	X	X	X	L	H
H	↓	L	L	$Q_0$	$\bar{Q}_0$
H	↓	H	L	H	L
H	↓	L	H	L	H
H	↓	H	H	Toggle	
H	H	X	X	$Q_0$	$\bar{Q}_0$

Notes) H; high level, L; low level, X; irrelevant

↓; transition from high to low level

$Q_0$ ; level of Q before the indicated steady-state input conditions were established.

$\bar{Q}_0$ ; complement of  $Q_0$  or level of Q before the indicated steady-state input conditions were established.

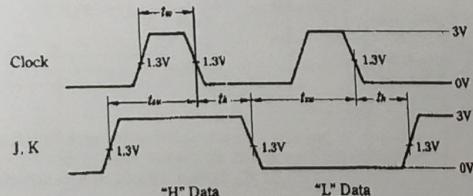
Toggle; each output changes to the complement of its previous level on each active transition indicated by ↓.

## ■ RECOMMENDED OPERATING CONDITION

Item		Symbol	min	typ	max	Unit
Clock frequency		$f_{clock}$	0	—	30	MHz
Pulse width	Clock High	$t_{\text{w}}$	20	—	—	ns
	Clear Low		25	—	—	
Setup time	"H" Data	$t_{\text{su}}$	20↓	—	—	ns
	"L" Data		20↓	—	—	
Hold time		$t_h$	0↓	—	—	ns

Note) ↓; The arrow indicates the falling edge.

## ■ TIMING DEFINITION



# HD74LS73A

## ELECTRICAL CHARACTERISTICS ( $T_a = -20 \sim +75^\circ\text{C}$ )

Item	Symbol	Test Conditions	min	typ*	max	Unit
Input voltage	$V_{IH}$		2.0	—	0.8	V
	$V_{IL}$		—	—	—	V
Output voltage	$V_{OH}$	$V_{CC} = 4.75V, V_{IH} = 2V, V_{IL} = 0.8V, I_{OH} = -400\mu\text{A}$	2.7	—	0.5	V
	$V_{OL}$	$V_{CC} = 4.75V, V_{IH} = 2V, V_{IL} = 0.8V$	—	—	0.4	V
Input current	J, K		—	—	20	
	Clear	$I_{IH}$	—	—	60	$\mu\text{A}$
	Clock		—	—	80	
	J, K		—	—	0.4	
	Clear	$I_{IL}$	$V_{CC} = 5.25V, V_I = 0.4V$	—	0.8	mA
	Clock		—	—	0.8	
	J, K		—	—	0.1	
	Clear	$I_I$	$V_{CC} = 5.25V, V_I = 7V$	—	0.3	mA
	Clock		—	—	0.4	
Short-circuit output current	$I_{OS}$	$V_{CC} = 5.25V$	—	20	—	mA
Supply current **	$I_{CC}$	$V_{CC} = 5.25V$	—	4	6	mA
Input clamp voltage	$V_{IK}$	$V_{CC} = 4.75V, I_{IN} = -18\text{mA}$	—	—	-1.5	V

\*  $V_{CC} = 5V, T_a = 25^\circ\text{C}$

\*\* With all outputs open,  $I_{CC}$  is measured with the Q and  $\bar{Q}$  outputs high in turn. At the time of measurement, the clock input is grounded.

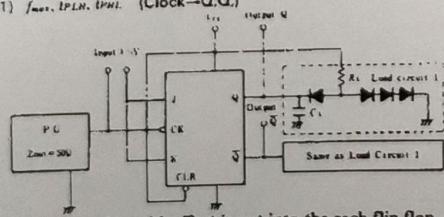
## SWITCHING CHARACTERISTICS ( $V_{CC} = 5V, T_a = 25^\circ\text{C}$ )

Item	Symbol	Inputs	Outputs	Test Conditions	min	typ	max	Unit
Maximum clock frequency	$f_{max}$				30	45	—	MHz
Propagation delay time	$t_{PLH}$ $t_{PHL}$	Clear Clock	Q, $\bar{Q}$	$C_L = 15\text{pF}, R_L = 2\text{k}\Omega$	—	15	20	ns
		Clock			—	15	20	ns

## TESTING METHOD

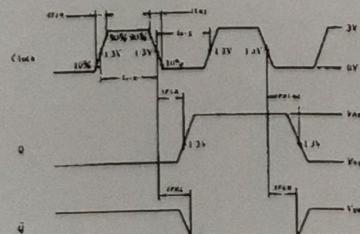
### 1) Test Circuit

1.1)  $f_{max}$ ,  $t_{PLH}$ ,  $t_{PHL}$  (Clock  $\rightarrow$  Q,  $\bar{Q}$ )



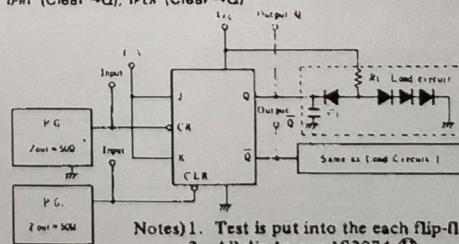
- Notes) 1. Test is put into the each flip flop
- 2. All diodes are 1S2074 (D)
- 3.  $C_L$  includes probe and jig capacitance.

### Waveform



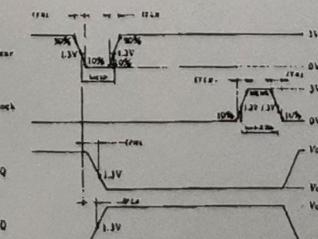
Note) Clock input pulse;  $t_{TLH} \leq 15\text{ns}$ ,  
 $t_{THL} \leq 6\text{ns}$ ,  $PRR = 1\text{MHz}$ , duty cycle = 50% and; for  $f_{max}$ .  
 $t_{TLH} = t_{THL} \leq 2.5\text{ns}$ .

1.2)  $t_{PLH}$  (Clear  $\rightarrow$  Q),  $t_{PHL}$  (Clear  $\rightarrow$   $\bar{Q}$ )



- Notes) 1. Test is put into the each flip flop
- 2. All diodes are 1S2074 (D).
- 3.  $C_L$  includes probe and jig capacitance.

### Waveform



Note) Clear and clock input pulse;  
 $t_{TLH} \leq 15\text{ns}$ ,  $t_{THL} \leq 6\text{ns}$ ,  
 $PRR = 1\text{MHz}$



August 1986  
Revised March 2000

## DM74LS51

### Dual 2-Wide 2-Input, 2-Wide 3-Input AND-OR-INVERT Gate

#### General Description

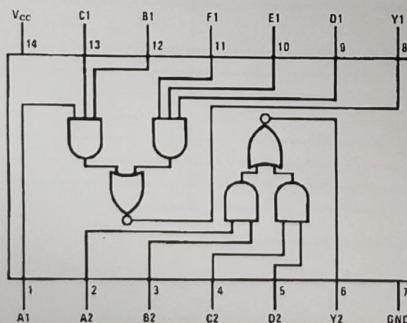
This device contains two independent combinations of gates each of which performs the logic AND-OR-INVERT function. Each package contains one 2-wide 2-input and one 2-wide 3-input AND-OR-INVERT gates.

#### Ordering Code:

Order Number	Package Number	Package Description
DM74LS51M	M14A	14-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-120, 0.150 Narrow
DM74LS51N	N14A	14-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300 Wide

Devices also available in Tape and Reel. Specify by appending the suffix letter "X" to the ordering code.

#### Connection Diagram



#### Function Table

$Y_1 = \overline{(A_1)(B_1)(C_1) + (D_1)(E_1)(F_1)}$						
Inputs						Output
A1	B1	C1	D1	E1	F1	$Y_1$
H	H	H	X	X	X	L
X	X	X	H	H	H	L
Other Combinations						H

$Y_2 = \overline{(A_2)(B_2) + (C_2)(D_2)}$					
Inputs					Output
A2	B2	C2	D2	$Y_2$	
H	H	X	X	L	
X	X	H	H	L	
Other Combinations					H

H = HIGH Logic Level  
L = LOW Logic Level  
X = Either LOW or HIGH Logic Level

**Absolute Maximum Ratings**(Note 1)

Supply Voltage	7V
Input Voltage	7V
Operating Free Air Temperature Range	0°C to +70°C
Storage Temperature Range	-65°C to +150°C

Note 1: The "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. The device should not be operated at these limits. The parametric values defined in the Electrical Characteristics tables are not guaranteed at the absolute maximum ratings. The "Recommended Operating Conditions" table will define the conditions for actual device operation.

**Recommended Operating Conditions**

Symbol	Parameter	Min	Nom	Max	Units
V <sub>CC</sub>	Supply Voltage	4.75	5	5.25	V
V <sub>IH</sub>	HIGH Level Input Voltage	2			V
V <sub>IL</sub>	LOW Level Input Voltage			0.8	V
I <sub>OH</sub>	HIGH Level Output Current			-0.4	mA
I <sub>OL</sub>	LOW Level Output Current			8	mA
T <sub>A</sub>	Free Air Operating Temperature	0		70	°C

**Electrical Characteristics**

over recommended operating free air temperature range (unless otherwise noted)

Symbol	Parameter	Conditions	Min	Typ (Note 2)	Max	Units	
V <sub>I</sub>	Input Clamp Voltage	V <sub>CC</sub> = Min, I <sub>I</sub> = -18 mA			-1.5	V	
V <sub>OH</sub>	HIGH Level Output Voltage	V <sub>CC</sub> = Min, I <sub>OH</sub> = Max, V <sub>IL</sub> = Max	2.7	3.4		V	
V <sub>OL</sub>	LOW Level Output Voltage	V <sub>CC</sub> = Min, I <sub>OL</sub> = Max, V <sub>IH</sub> = Min I <sub>OL</sub> = 4 mA, V <sub>CC</sub> = Min		0.35 0.25	0.5 0.4	V	
I <sub>I</sub>	Input Current @ Max Input Voltage	V <sub>CC</sub> = Max, V <sub>I</sub> = 7V			0.1	mA	
I <sub>IH</sub>	HIGH Level Input Current	V <sub>CC</sub> = Max, V <sub>I</sub> = 2.7V			20	µA	
I <sub>IL</sub>	LOW Level Input Current	V <sub>CC</sub> = Max, V <sub>I</sub> = 0.4V			-0.36	mA	
I <sub>OS</sub>	Short Circuit Output Current	V <sub>CC</sub> = Max (Note 3)	-20		-100	mA	
I <sub>CCH</sub>	Supply Current with Outputs HIGH	V <sub>CC</sub> = Max			0.8	mA	
I <sub>CCL</sub>	Supply Current with Outputs LOW	V <sub>CC</sub> = Max			1.4	2.8	mA

Note 2: All typicals are at V<sub>CC</sub> = 5V, T<sub>A</sub> = 25°C.

Note 3: Not more than one output should be shorted at a time, and the duration should not exceed one second.

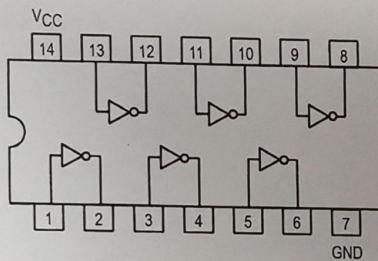
**Switching Characteristics**

at V<sub>CC</sub> = 5V and T<sub>A</sub> = 25°C

Symbol	Parameter	C <sub>L</sub> = 50 pF, R <sub>L</sub> = 2 kΩ		Units
		Min	Max	
t <sub>PLH</sub>	Propagation Delay Time LOW-to-HIGH Level Output	4	18	ns
t <sub>PHL</sub>	Propagation Delay Time HIGH-to-LOW Level Output	3	15	ns

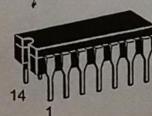


## HEX INVERTER

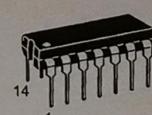


**SN54/74LS04**

**HEX INVERTER**  
**LOW POWER SCHOTTKY**



J SUFFIX  
CERAMIC  
CASE 632-08



N SUFFIX  
PLASTIC  
CASE 646-06



D SUFFIX  
SOIC  
CASE 751A-02

### ORDERING INFORMATION

SN54LSXXJ	Ceramic
SN74LSXXN	Plastic
SN74LSXXXD	SOIC

### GUARANTEED OPERATING RANGES

Symbol	Parameter	54	Min	Typ	Max	Unit
V <sub>CC</sub>	Supply Voltage	54 74	4.5 4.75	5.0 5.0	5.5 5.25	V
T <sub>A</sub>	Operating Ambient Temperature Range	54 74	-55 0	25 25	125 70	°C
I <sub>OH</sub>	Output Current — High	54, 74			-0.4	mA
I <sub>OL</sub>	Output Current — Low	54 74			4.0 8.0	mA

# SN54/74LS04

## DC CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE (unless otherwise specified)

Symbol	Parameter	Limits			Unit	Test Conditions
		Min	Typ	Max		
V <sub>IH</sub>	Input HIGH Voltage	2.0			V	Guaranteed Input HIGH Voltage for All Inputs
V <sub>IL</sub>	Input LOW Voltage	54		0.7	V	Guaranteed Input LOW Voltage for All Inputs
		74		0.8		
V <sub>IK</sub>	Input Clamp Diode Voltage		-0.65	-1.5	V	V <sub>CC</sub> = MIN, I <sub>IN</sub> = -18 mA
V <sub>OH</sub>	Output HIGH Voltage	54	2.5	3.5	V	V <sub>CC</sub> = MIN, I <sub>OH</sub> = MAX, V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> per Truth Table
		74	2.7	3.5	V	
V <sub>OL</sub>	Output LOW Voltage	54, 74	0.25	0.4	V	I <sub>OL</sub> = 4.0 mA
		74	0.35	0.5	V <sup>+</sup>	I <sub>OL</sub> = 8.0 mA
I <sub>IH</sub>	Input HIGH Current		20	μA	V <sub>CC</sub> = MAX, V <sub>IN</sub> = 2.7 V	
			0.1	mA	V <sub>CC</sub> = MAX, V <sub>IN</sub> = 7.0 V	
I <sub>IL</sub>	Input LOW Current			-0.4	mA	V <sub>CC</sub> = MAX, V <sub>IN</sub> = 0.4 V
I <sub>OS</sub>	Short Circuit Current (Note 1)	-20		-100	mA	V <sub>CC</sub> = MAX
I <sub>CC</sub>	Power Supply Current Total, Output HIGH Total, Output LOW			2.4	mA	V <sub>CC</sub> = MAX
				6.6		

Note 1: Not more than one output should be shorted at a time, nor for more than 1 second.

## AC CHARACTERISTICS (T<sub>A</sub> = 25°C)

Symbol	Parameter	Limits			Unit	Test Conditions
		Min	Typ	Max		
t <sub>PLH</sub>	Turn-Off Delay, Input to Output		9.0	15	ns	V <sub>CC</sub> = 5.0 V C <sub>L</sub> = 15 pF
t <sub>PHL</sub>	Turn-On Delay, Input to Output		10	15	ns	