

# DATA SHEET

For a complete data sheet, please also download:

- The IC06 74HC/HCT/HCU/HCMOS Logic Family Specifications
- The IC06 74HC/HCT/HCU/HCMOS Logic Package Information
- The IC06 74HC/HCT/HCU/HCMOS Logic Package Outlines

## **74HC/HCT4316** Quad bilateral switches

Product specification  
File under Integrated Circuits, IC06

September 1993

# Quad bilateral switches

# 74HC/HCT4316

## FEATURES

- Low “ON” resistance:  
 160 Ω (typ.) at  $V_{CC} - V_{EE} = 4.5\text{ V}$   
 120 Ω (typ.) at  $V_{CC} - V_{EE} = 6.0\text{ V}$   
 80 Ω (typ.) at  $V_{CC} - V_{EE} = 9.0\text{ V}$
- Logic level translation:  
 to enable 5 V logic to communicate  
 with ± 5 V analog signals
- Typical “break before make” built in
- Output capability: non-standard
- I<sub>CC</sub> category: MSI

## GENERAL DESCRIPTION

The 74HC/HCT4316 are high-speed Si-gate CMOS devices. They are specified in compliance with JEDEC standard no. 7A.

The 74HC/HCT4316 have four independent analog switches. Each switch has two input/output terminals (nY, nZ) and an active HIGH select input (nS). When the enable input ( $\bar{E}$ ) is HIGH, all four analog switches are turned off.

Current through a switch will not cause additional  $V_{CC}$  current provided the voltage at the terminals of the switch is maintained within the supply voltage range;  $V_{CC} \gg (V_Y, V_Z) \gg V_{EE}$ . Inputs nY and nZ are electrically equivalent terminals.

$V_{CC}$  and GND are the supply voltage pins for the digital control inputs ( $\bar{E}$  and nS). The  $V_{CC}$  to GND ranges are 2.0 to 10.0 V for HC and 4.5 to 5.5 V for HCT.

The analog inputs/outputs (nY and nZ) can swing between  $V_{CC}$  as a positive limit and  $V_{EE}$  as a negative limit.  $V_{CC} - V_{EE}$  may not exceed 10.0 V.

See the “4016” for the version without logic level translation.

## QUICK REFERENCE DATA

$V_{EE} = \text{GND} = 0\text{ V}$ ;  $T_{\text{amb}} = 25\text{ }^\circ\text{C}$ ;  $t_r = t_f = 6\text{ ns}$

SYMBOL	PARAMETER	CONDITIONS	TYPICAL		UNIT
			HC	HCT	
t <sub>PZH</sub>	turn “ON” time $\bar{E}$ to $V_{OS}$ nS to $V_{OS}$	$C_L = 15\text{ pF}$ ; $R_L = 1\text{ k}\Omega$ ; $V_{CC} = 5\text{ V}$	19	19	ns
			16	17	ns
t <sub>PZL</sub>	turn “ON” time $\bar{E}$ to $V_{OS}$ nS to $V_{OS}$		19	24	ns
			16	21	ns
t <sub>PHZ</sub> / t <sub>PLZ</sub>	turn “OFF” time $\bar{E}$ to $V_{OS}$ nS to $V_{OS}$		20	21	ns
			16	19	ns
C <sub>I</sub>	input capacitance		3.5	3.5	pF
C <sub>PD</sub>	power dissipation capacitance per switch	notes 1 and 2	13	14	pF
C <sub>S</sub>	max. switch capacitance		5	5	pF

## Notes

1. C<sub>PD</sub> is used to determine the dynamic power dissipation (P<sub>D</sub> in μW):  

$$P_D = C_{PD} \times V_{CC}^2 \times f_i + \sum \{ (C_L + C_S) \times V_{CC}^2 \times f_o \}$$
 where:  
 $f_i$  = input frequency in MHz  
 $f_o$  = output frequency in MHz  
 $\sum \{ (C_L + C_S) \times V_{CC}^2 \times f_o \}$  = sum of outputs

- $C_L$  = output load capacitance in pF
- $C_S$  = max. switch capacitance in pF
- $V_{CC}$  = supply voltage in V
- 2. For HC the condition is  $V_I = \text{GND to } V_{CC}$   
 For HCT the condition is  $V_I = \text{GND to } V_{CC} - 1.5\text{ V}$

Quad bilateral switches

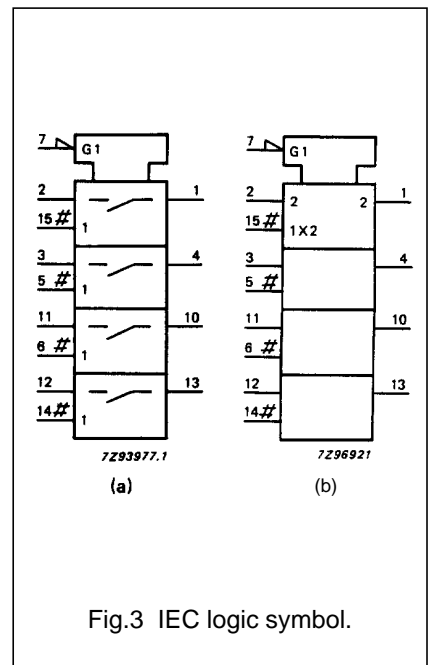
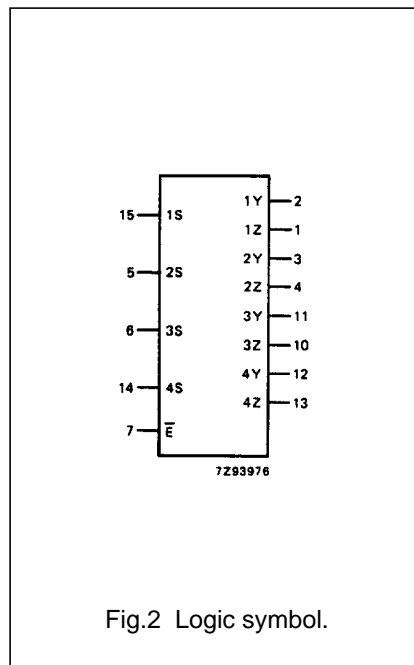
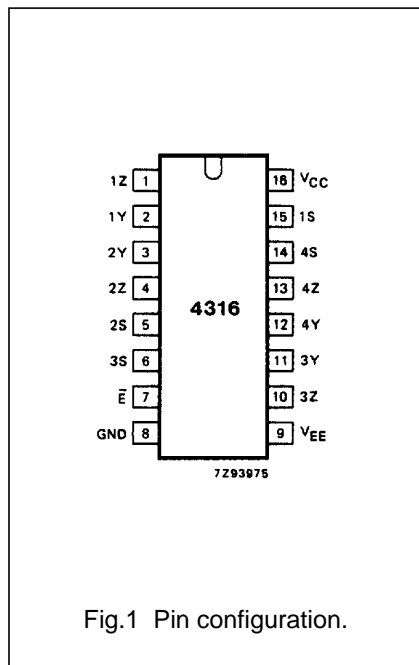
74HC/HCT4316

ORDERING INFORMATION

See "74HC/HCT/HCU/HCMOS Logic Package Information".

PIN DESCRIPTION

PIN NO.	SYMBOL	NAME AND FUNCTION
1, 4, 10, 13	1Z to 4Z	independent inputs/outputs
2, 3, 11, 12	1Y to 4Y	independent inputs/outputs
7	$\bar{E}$	enable input (active LOW)
8	GND	ground (0 V)
9	$V_{EE}$	negative supply voltage
15, 5, 6, 14	1S to 4S	select inputs (active HIGH)
16	$V_{CC}$	positive supply voltage



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FUNCTION TABLE

INPUTS		SWITCH
$\bar{E}$	nS	
L	L	off
L	H	on
H	X	off

Note

- H = HIGH voltage level  
L = LOW voltage level  
X = don't care

APPLICATIONS

- Signal gating
- Modulation
- Demodulation
- Chopper

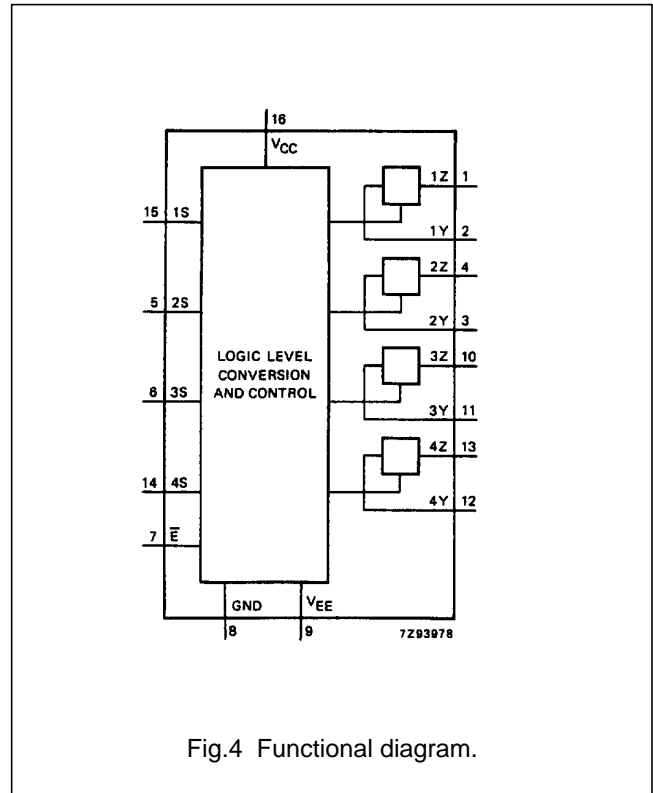


Fig.4 Functional diagram.

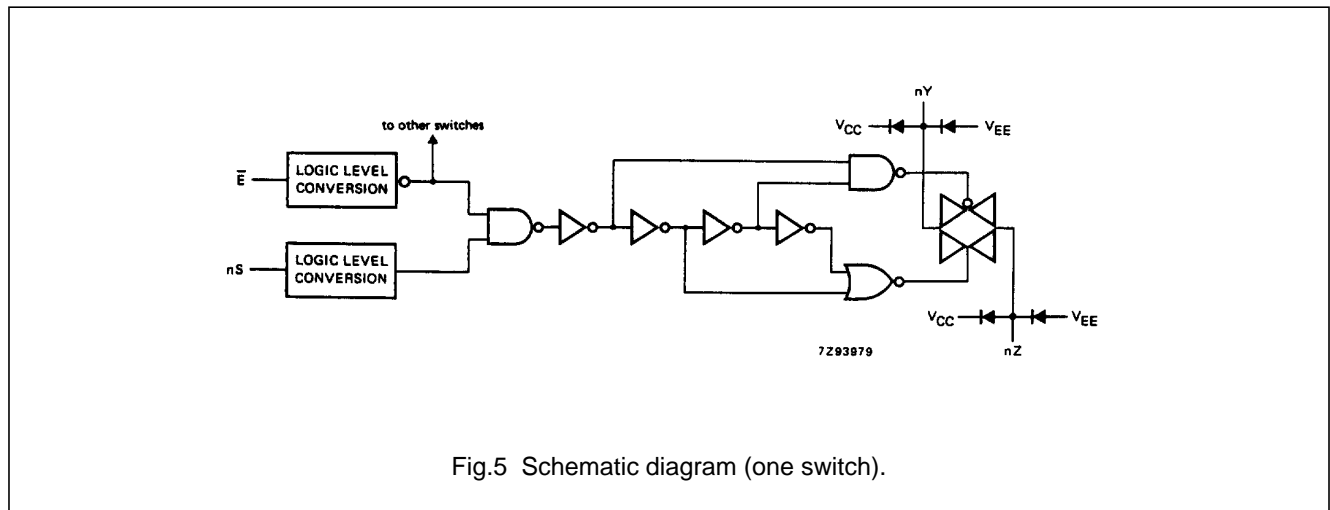


Fig.5 Schematic diagram (one switch).

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**RATINGS**

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages are referenced to  $V_{EE} = \text{GND}$  (ground = 0 V)

SYMBOL	PARAMETER	MIN.	MAX.	UNIT	CONDITIONS
$V_{CC}$	DC supply voltage	-0.5	+11.0	V	
$\pm I_{IK}$	DC digital input diode current		20	mA	for $V_I < -0.5 \text{ V}$ or $V_I > V_{CC} + 0.5 \text{ V}$
$\pm I_{SK}$	DC switch diode current		20	mA	for $V_S < -0.5 \text{ V}$ or $V_S > V_{CC} + 0.5 \text{ V}$
$\pm I_S$	DC switch current		25	mA	for $-0.5 \text{ V} < V_S < V_{CC} + 0.5 \text{ V}$
$\pm I_{EE}$	DC $V_{EE}$ current		20	mA	
$\pm I_{CC}$ ; $\pm I_{GND}$	DC $V_{CC}$ or GND current		50	mA	
$T_{stg}$	storage temperature range	-65	+150	°C	
$P_{tot}$	power dissipation per package				for temperature range: -40 to +125 °C 74HC/HCT
	plastic DIL		750	mW	above +70 °C: derate linearly with 12 mW/K
	plastic mini-pack (SO)		500	mW	above +70 °C: derate linearly with 8 mW/K
$P_S$	power dissipation per switch		100	mW	

**Note to ratings**

To avoid drawing  $V_{CC}$  current out of terminal Z, when switch current flows in terminals  $Y_n$ , the voltage drop across the bidirectional switch must not exceed 0.4 V. If the switch current flows into terminals Z, no  $V_{CC}$  current will flow out of terminal  $Y_n$ . In this case there is no limit for the voltage drop across the switch, but the voltages at  $Y_n$  and Z may not exceed  $V_{CC}$  or  $V_{EE}$ .

**RECOMMENDED OPERATING CONDITIONS**

SYMBOL	PARAMETER	74HC			74HCT			UNIT	CONDITIONS
		min.	typ.	max.	min.	typ.	max.		
$V_{CC}$	DC supply voltage $V_{CC}-\text{GND}$	2.0	5.0	10.0	4.5	5.0	5.5	V	see Figs 6 and 7
$V_{CC}$	DC supply voltage $V_{CC}-V_{EE}$	2.0	5.0	10.0	2.0	5.0	10.0	V	see Figs 6 and 7
$V_I$	DC input voltage range	GND		$V_{CC}$	GND		$V_{CC}$	V	
$V_S$	DC switch voltage range	$V_{EE}$		$V_{CC}$	$V_{EE}$		$V_{CC}$	V	
$T_{amb}$	operating ambient temperature range	-40		+85	-40		+85	°C	see DC and AC CHARACTERISTICS
$T_{amb}$	operating ambient temperature range	-40		+125	-40		+125	°C	
$t_r, t_f$	input rise and fall times		6.0	1000 500 400 250		6.0	500	ns	$V_{CC} = 2.0 \text{ V}$ $V_{CC} = 4.5 \text{ V}$ $V_{CC} = 6.0 \text{ V}$ $V_{CC} = 10.0 \text{ V}$

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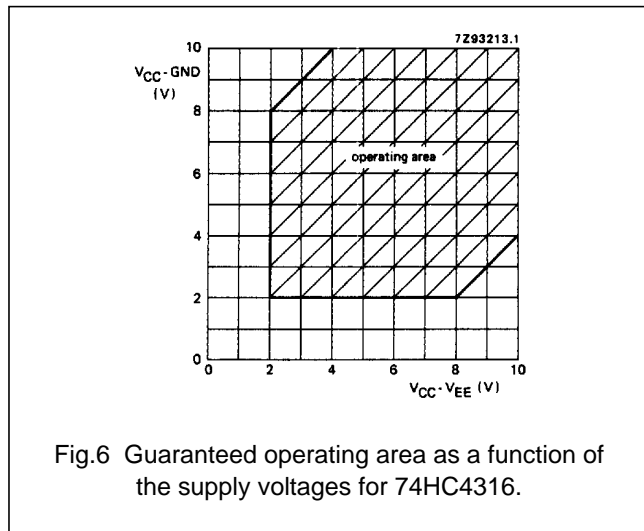


Fig.6 Guaranteed operating area as a function of the supply voltages for 74HC4316.

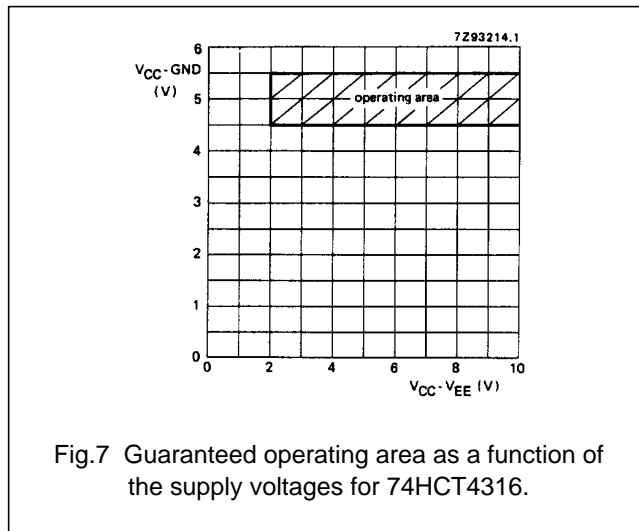


Fig.7 Guaranteed operating area as a function of the supply voltages for 74HCT4316.

DC CHARACTERISTICS FOR 74HC/HCT

For 74HC:  $V_{CC} - GND$  or  $V_{CC} - V_{EE} = 2.0, 4.5, 6.0$  and  $9.0$  V

For 74HCT:  $V_{CC} - GND = 4.5$  and  $5.5$  V;  $V_{CC} - V_{EE} = 2.0, 4.5, 6.0$  and  $9.0$  V

SYMBOL	PARAMETER	$T_{amb}$ (°C)						UNIT	TEST CONDITIONS					
		74HC/HCT							$V_{CC}$ (V)	$V_{EE}$ (V)	$I_S$ (µA)	$V_{is}$	$V_I$	
		+25			-40 to +85		-40 to +125							
		min.	typ.	max.	min.	max.	min.							max.
$R_{ON}$	ON resistance (peak)		-	-		-		-	Ω	2.0	0	100	$V_{CC}$ to $V_{EE}$	$V_{IH}$ or $V_{IL}$
			160	320		400		480	Ω	4.5	0	1000		
			120	240		300		360	Ω	6.0	0	1000		
			85	170		215		255	Ω	4.5	-4.5	1000		
$R_{ON}$	ON resistance (rail)		160	-		-		-	Ω	2.0	0	100	$V_{EE}$	$V_{IH}$ or $V_{IL}$
			80	160		200		240	Ω	4.5	0	1000		
			70	140		175		210	Ω	6.0	0	1000		
			60	120		150		180	Ω	4.5	-4.5	1000		
$R_{ON}$	ON resistance (rail)		170	-		-		-	Ω	2.0	0	100	$V_{CC}$	$V_{IH}$ or $V_{IL}$
			90	180		225		270	Ω	4.5	0	1000		
			80	160		200		240	Ω	6.0	0	1000		
			65	135		170		205	Ω	4.5	-4.5	1000		
$\Delta R_{ON}$	maximum $\Delta$ ON resistance between any two channels		-						Ω	2.0	0		$V_{CC}$ to $V_{EE}$	$V_H$ or $V_{IL}$
			16						Ω	4.5	0			
			9						Ω	6.0	0			
			6						Ω	4.5	-4.5			

Notes

- At supply voltages ( $V_{CC} - V_{EE}$ ) approaching 2.0 V the analog switch ON-resistance becomes extremely non-linear. Therefore it is recommended that these devices are used to transmit digital signals only, when using these supply voltages.
- For test circuit measuring  $R_{ON}$  see Fig.8.

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**DC CHARACTERISTICS FOR 74HC**

Voltages are referenced to GND (ground = 0 V)

SYMBOL	PARAMETER	$T_{amb}$ (°C)							UNIT	TEST CONDITIONS			
		74HC								$V_{CC}$ (V)	$V_{EE}$ (V)	$V_I$	OTHER
		+25			-40 to +85		-40 to +125						
		min.	typ.	max.	min.	max.	min.	max.					
$V_{IH}$	HIGH level input voltage	1.5 3.15 4.2 6.3	1.2 2.4 3.2 4.3		1.5 3.15 4.2 6.3		1.5 3.15 4.2 6.3		V	2.0 4.5 6.0 9.0			
$V_{IL}$	LOW level input voltage		0.8 2.1 2.8 4.3	0.5 1.35 1.8 2.7		0.5 1.35 1.8 2.7	0.5 1.35 1.8 2.7	V	2.0 4.5 6.0 9.0				
$\pm I_I$	input leakage current			0.1 0.2		1.0 2.0	1.0 2.0	$\mu A$	6.0 10.0	0 0	$V_{CC}$ or GND		
$\pm I_S$	analog switch OFF-state current			0.1		1.0	1.0	$\mu A$	10.0	0	$V_{IH}$ or $V_{IL}$	$ V_S  = V_{CC} - V_{EE}$ (see Fig.10)	
$\pm I_S$	analog switch ON-state current			0.1		1.0	1.0	$\mu A$	10.0	0	$V_{IH}$ or $V_{IL}$	$ V_S  = V_{CC} - V_{EE}$ (see Fig.11)	
$I_{CC}$	quiescent supply current			8.0 16.0		80.0 160.0	160.0 320.0	$\mu A$	6.0 10.0	0 0	$V_{CC}$ or GND	$V_{is} = V_{EE}$ or $V_{CC}$ ; $V_{OS} = V_{CC}$ or $V_{EE}$	

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## AC CHARACTERISTICS FOR 74HC

GND = 0 V;  $t_r = t_f = 6$  ns;  $C_L = 50$  pF

SYMBOL	PARAMETER	$T_{amb}$ (°C)						UNIT	TEST CONDITIONS			
		74HC							$V_{CC}$ (V)	$V_{EE}$ (V)	OTHER	
		+25			-40 to +85		-40 to +125					
		min.	typ.	max.	min.	max.	min.		max.			
$t_{PHL}/t_{PLH}$	propagation delay $V_{is}$ to $V_{os}$		17 6 5 4	60 12 10 8		75 15 13 10		90 18 15 12	ns	2.0 4.5 6.0 4.5	0 0 0 -4.5	$R_L = \infty$ ; $C_L = 50$ pF (see Fig.18)
$t_{PZH}/t_{PZL}$	turn "ON" time $\bar{E}$ to $V_{os}$		61 22 18 19	205 41 35 37		255 51 43 47		310 62 53 56	ns	2.0 4.5 6.0 4.5	0 0 0 -4.5	$R_L = 1$ k $\Omega$ ; $C_L = 50$ pF (see Figs 19, 20 and 21)
$t_{PZH}/t_{PZL}$	turn "ON" time nS to $V_{os}$		52 19 15 17	175 35 30 34		220 44 37 43		265 53 45 51	ns	2.0 4.5 6.0 4.5	0 0 0 -4.5	$R_L = 1$ k $\Omega$ ; $C_L = 50$ pF (see Figs 19, 20 and 21)
$t_{PHZ}/t_{PLZ}$	turn "OFF" time $\bar{E}$ to $V_{os}$		63 23 18 21	220 44 37 39		275 55 47 49		330 66 56 59	ns	2.0 4.5 6.0 4.5	0 0 0 -4.5	$R_L = 1$ k $\Omega$ ; $C_L = 50$ pF (see Figs 19, 20 and 21)
$t_{PHZ}/t_{PLZ}$	turn "OFF" time nS to $V_{os}$		55 20 16 18	175 35 30 36		220 44 37 45		265 53 45 54	ns	2.0 4.5 6.0 4.5	0 0 0 -4.5	$R_L = 1$ k $\Omega$ ; $C_L = 50$ pF (see Figs 19, 20 and 21)



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**DC CHARACTERISTICS FOR 74HCT**

Voltages are referenced to GND (ground = 0)

SYMBOL	PARAMETER	$T_{amb}$ (°C)							UNIT	TEST CONDITIONS			
		74HCT								$V_{CC}$ (V)	$V_{EE}$ (V)	$V_I$	OTHER
		+25			-40 to +85		-40 to +125						
		min.	typ.	max.	min.	max.	min.	max.					
$V_{IH}$	HIGH level input voltage	2.0	1.6		2.0		2.0		V	4.5 to 5.5			
$V_{IL}$	LOW level input voltage		1.2	0.8		0.8		0.8	V	4.5 to 5.5			
$\pm I_I$	input leakage current			0.1		1.0		1.0	$\mu A$	5.5	0	$V_{CC}$ or GND	
$\pm I_S$	analog switch OFF-state current			0.1		1.0		1.0	$\mu A$	10.0	0	$V_{IH}$ or $V_{IL}$	$ V_S  = V_{CC} - V_{EE}$ (see Fig.10)
$\pm I_S$	analog switch ON-state current			0.1		1.0		1.0	$\mu A$	10.0	0	$V_{IH}$ or $V_{IL}$	$ V_S  = V_{CC} - V_{EE}$ (see Fig.11)
$I_{CC}$	quiescent supply current			8.0 16.0		80.0 160.0		160.0 320.0	$\mu A$	5.5 5.0	0 -5.0	$V_{CC}$ or GND	$V_{is} = V_{EE}$ or $V_{CC}$ ; $V_{OS} = V_{CC}$ or $V_{EE}$
$\Delta I_{CC}$	additional quiescent supply current per input pin for unit load coefficient is 1 (note 1)		100	360		450		490	$\mu A$	4.5 to 5.5	0	$V_{CC} - 2.1 V$	other inputs at $V_{CC}$ or GND

**Note**

- The value of additional quiescent supply current ( $\Delta I_{CC}$ ) for a unit load of 1 is given here. To determine  $\Delta I_{CC}$  per input, multiply this value by the unit load coefficient shown in the table below.

INPUT	UNIT LOAD COEFFICIENT
nS	0.50
$\bar{E}$	0.50

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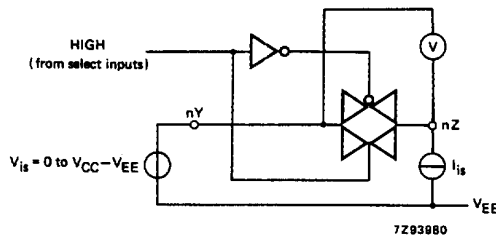


Fig.8 Test circuit for measuring  $R_{ON}$ .

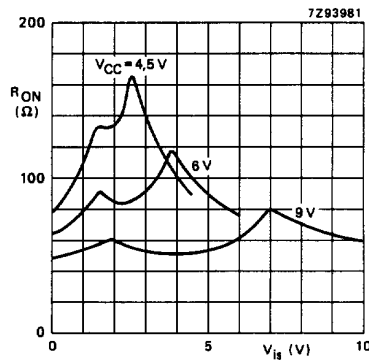


Fig.9 Typical  $R_{ON}$  as a function of input voltage  $V_{is}$  for  $V_{is} = 0$  to  $V_{CC} - V_{EE}$ .

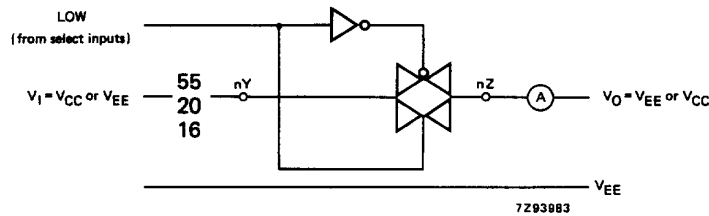


Fig.10 Test circuit for measuring OFF-state current.

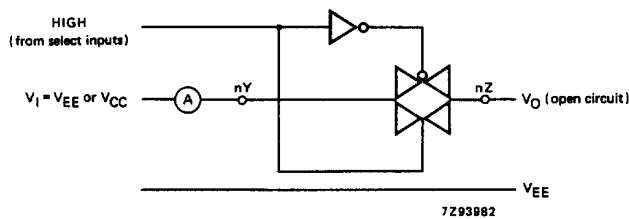


Fig.11 Test circuit for measuring ON-state current.

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**AC CHARACTERISTICS FOR 74HCT**GND = 0 V;  $t_r = t_f = 6$  ns;  $C_L = 50$  pF

SYMBOL	PARAMETER	$T_{amb}$ (°C)							UNIT	TEST CONDITIONS		
		74HCT								$V_{CC}$ (V)	$V_{EE}$ (V)	OTHER
		+25			-40 TO +85		-40 to +125					
		min.	typ.	max.	min.	max.	min.	max.				
$t_{PHL}/t_{PLH}$	propagation delay $V_{is}$ to $V_{os}$		6 4	12 8		15 10		18 12	ns	4.5 4.5	0 -4.5	$R_L = \infty$ ; $C_L = 50$ pF (see Fig.18)
$t_{PZH}$	turn "ON" time $\bar{E}$ to $V_{os}$		22 21	44 42		55 53		66 63	ns	4.5 4.5	0 -4.5	$R_L = 1$ k $\Omega$ ; $C_L = 50$ pF (see Figs 19, 20 and 21)
$t_{PZL}$	turn "ON" time $\bar{E}$ to $V_{os}$		28 21	56 42		70 53		84 63	ns	4.5 4.5	0 -4.5	(see Figs 19, 20 and 21)
$t_{PZH}$	turn "ON" time nS to $V_{os}$		20 17	40 34		53 43		60 51	ns	4.5 4.5	0 -4.5	$R_L = 1$ k $\Omega$ ; $C_L = 50$ pF (see Figs 19, 20 and 21)
$t_{PZL}$	turn "ON" time nS to $V_{os}$		25 17	50 34		63 43		75 51	ns	4.5 4.5	0 -4.5	(see Figs 19, 20 and 21)
$t_{PHZ}/t_{PLZ}$	turn "OFF" time $\bar{E}$ to $V_{os}$		25 23	50 46		63 58		75 69	ns	4.5 4.5	0 -4.5	$R_L = 1$ k $\Omega$ ; $C_L = 50$ pF (see Figs 19, 20 and 21)
$t_{PHZ}/t_{PLZ}$	turn "OFF" time nS to $V_{os}$		22 20	44 40		55 50		66 60	ns	4.5 4.5	0 -4.5	$R_L = 1$ k $\Omega$ ; $C_L = 50$ pF (see Figs 19, 20 and 21)

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ADDITIONAL AC CHARACTERISTICS FOR 74HC/HCT

Recommended conditions and typical values

GND = 0 V; T<sub>amb</sub> = 25 °C

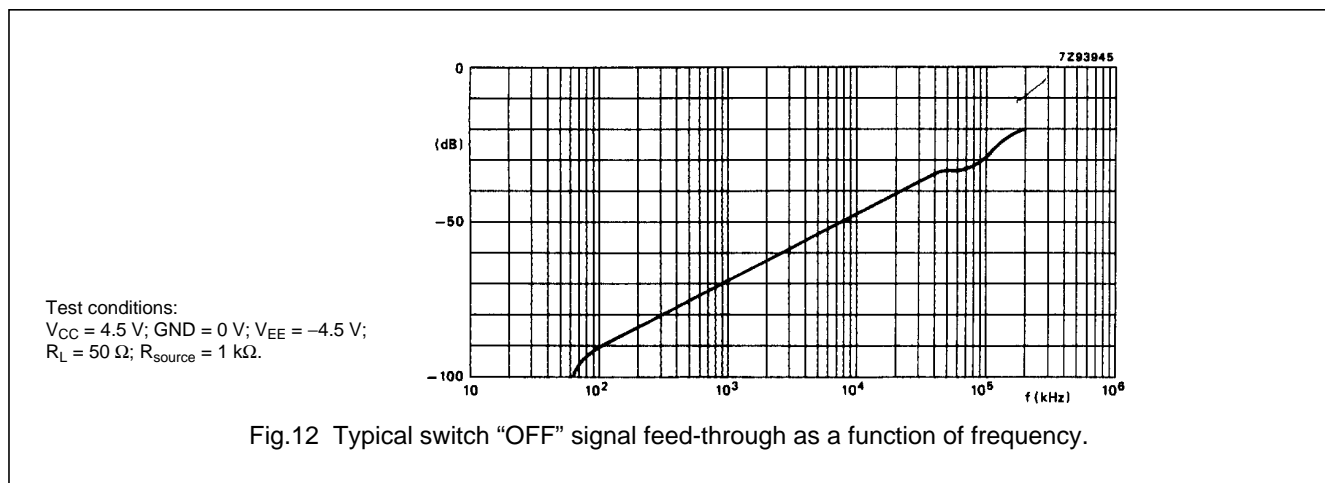
SYMBOL	PARAMETER	typ.	UNIT	V <sub>CC</sub> (V)	V <sub>EE</sub> (V)	V <sub>is(p-p)</sub> (V)	CONDITIONS
	sine-wave distortion f = 1 kHz	0.80 0.40	% %	2.25 4.5	-2.25 -4.5	4.0 8.0	R <sub>L</sub> = 10 kΩ; C <sub>L</sub> = 50 pF (see Fig.14)
	sine-wave distortion f = 10 kHz	2.40 1.20	% %	2.25 4.5	-2.25 -4.5	4.0 8.0	R <sub>L</sub> = 10 kΩ; C <sub>L</sub> = 50 pF (see Fig.14)
	switch "OFF" signal feed-through	-50 -50	dB dB	2.25 4.5	-2.25 -4.5	note 1	R <sub>L</sub> = 600 Ω; C <sub>L</sub> = 50 pF f = 1 MHz (see Figs 12 and 15)
	crosstalk between any two switches	-60 -60	dB dB	2.25 4.5	-2.25 -4.5	note 1	R <sub>L</sub> = 600 Ω; C <sub>L</sub> = 50 pF; f = 1 MHz; (see Fig.16)
V <sub>(p-p)</sub>	crosstalk voltage between control and any switch (peak-to-peak value)	110 220	mV mV	4.5 4.5	0 -4.5		R <sub>L</sub> = 600 kΩ; C <sub>L</sub> = 50 pF; f = 1 MHz ( $\bar{E}$ or nS, square-wave between V <sub>CC</sub> and GND, t <sub>r</sub> = t <sub>f</sub> = 6 ns) (see Fig.17)
f <sub>max</sub>	minimum frequency response (-3 dB)	150 160	MHz MHz	2.25 4.5	-2.25 -4.5	note 2	R <sub>L</sub> = 50 Ω; C <sub>L</sub> = 10 pF (see Figs 13 and 14)
C <sub>S</sub>	maximum switch capacitance	5	pF				

Notes

1. Adjust input voltage V<sub>is</sub> to 0 dBm level (0 dBm = 1 mW into 600 Ω).
2. Adjust input voltage V<sub>is</sub> to 0 dBm level at V<sub>OS</sub> for 1 MHz (0 dBm = 1 mW into 50 Ω).

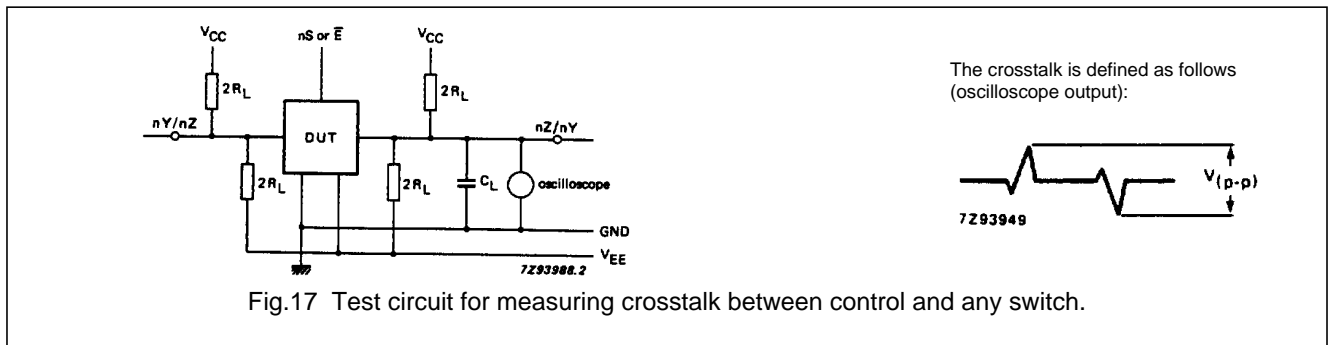
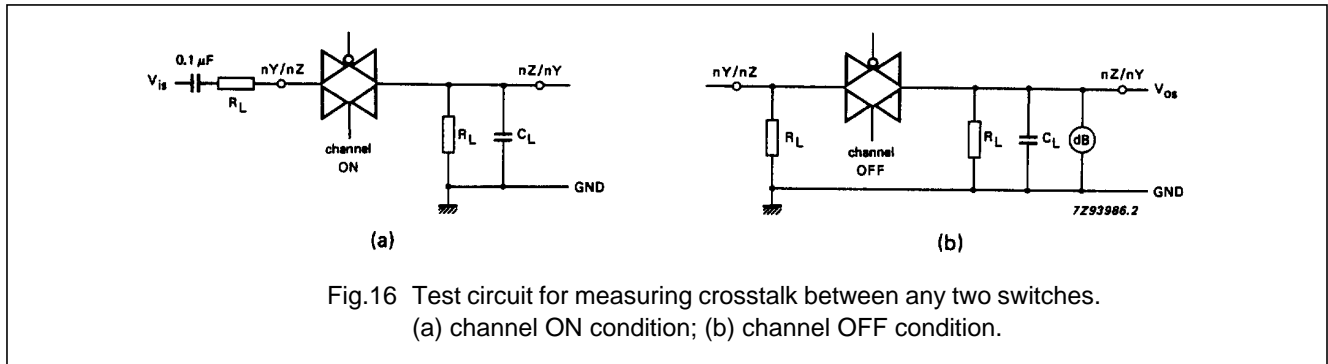
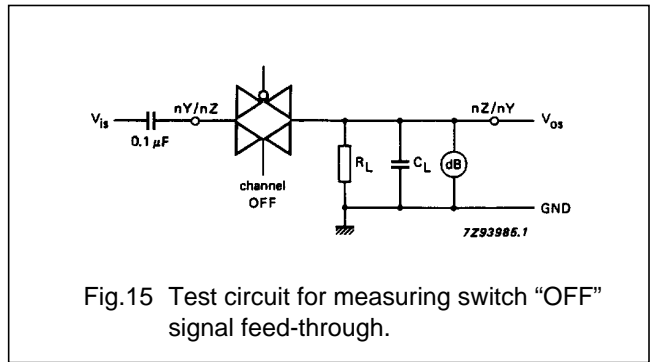
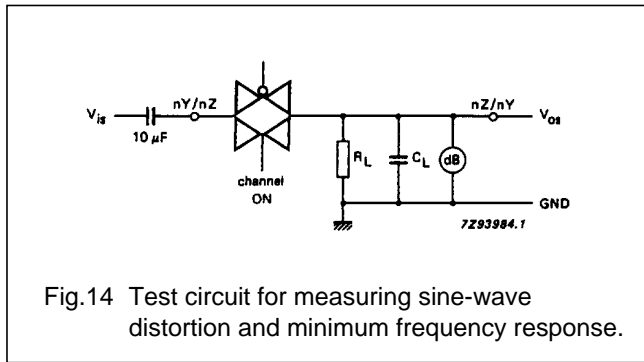
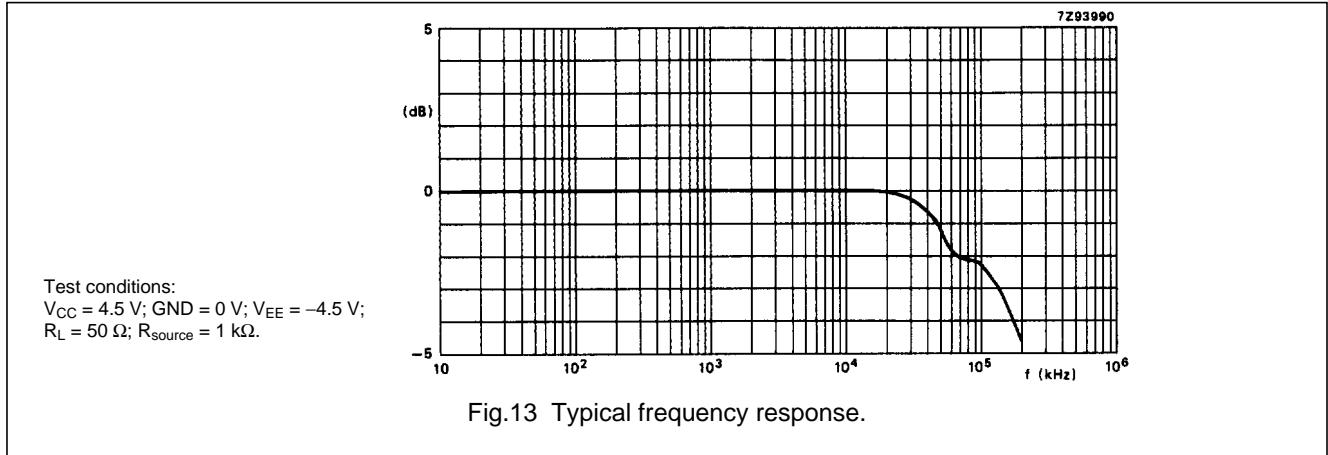
General note

V<sub>is</sub> is the input voltage at an nY or nZ terminal, whichever is assigned as an input.  
V<sub>OS</sub> is the output voltage at an nY or nZ terminal, whichever is assigned as an output.



Quad bilateral switches

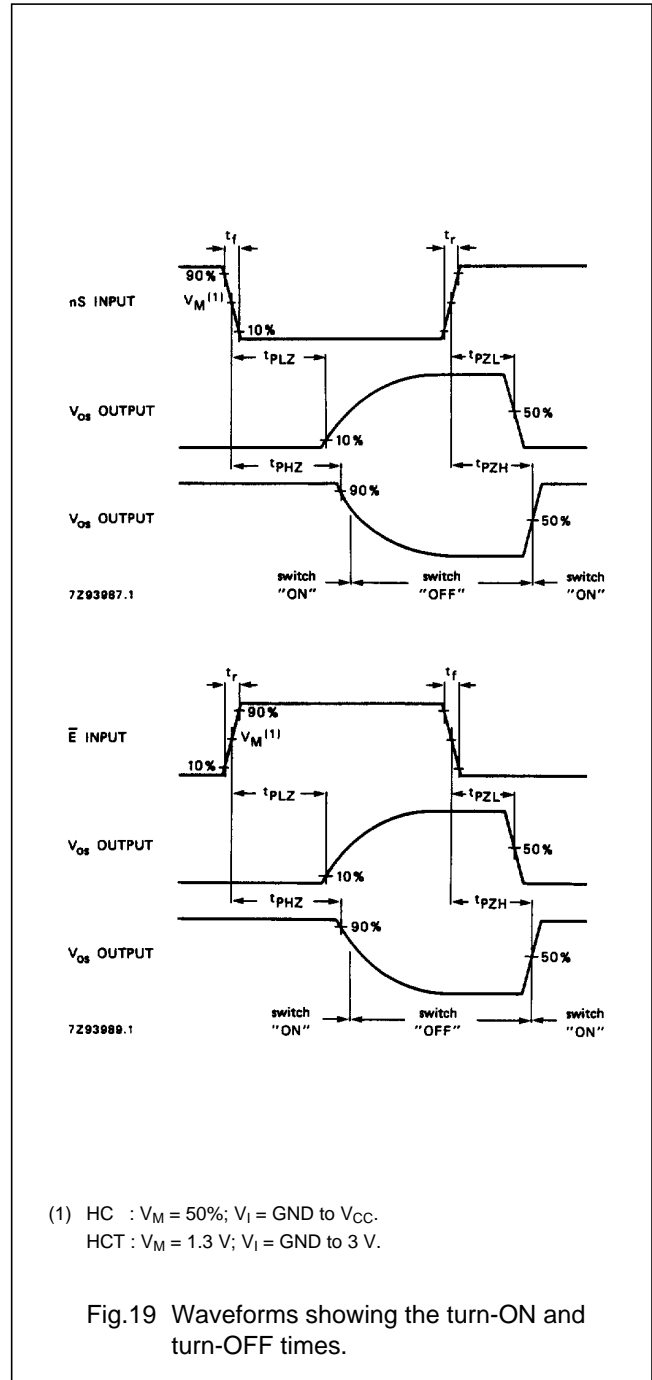
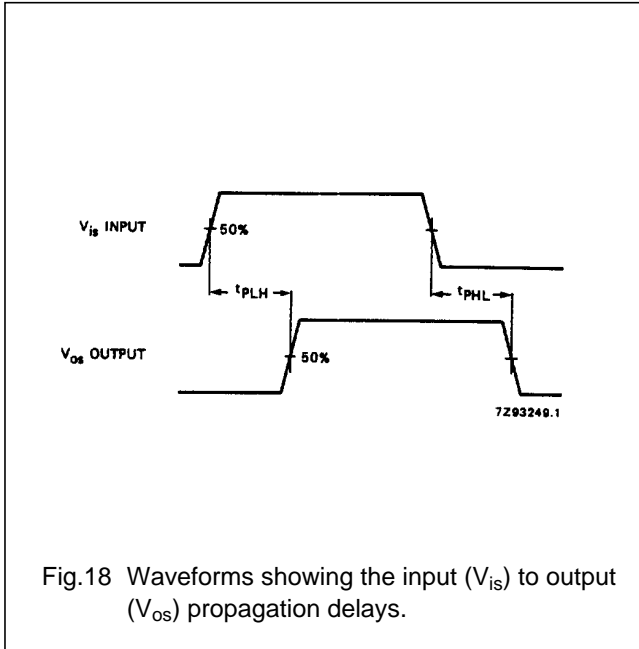
74HC/HCT4316



Quad bilateral switches

74HC/HCT4316

AC WAVEFORMS



Quad bilateral switches

74HC/HCT4316

TEST CIRCUIT AND WAVEFORMS

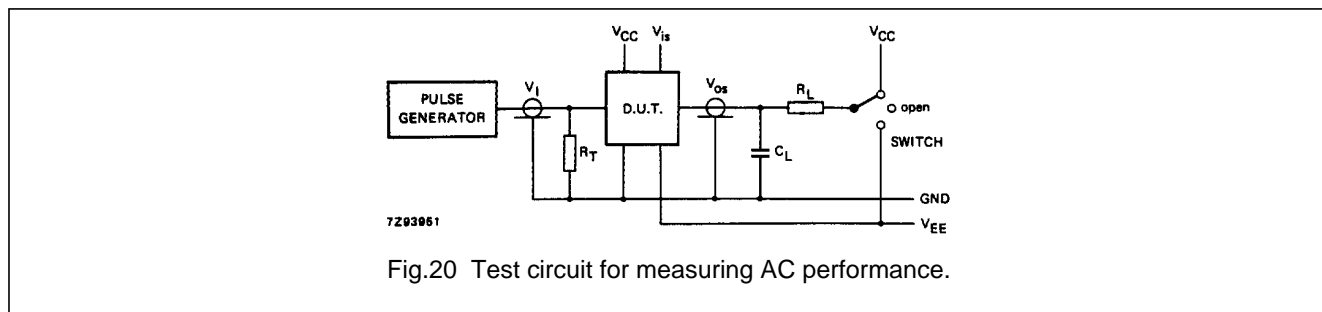


Fig.20 Test circuit for measuring AC performance.

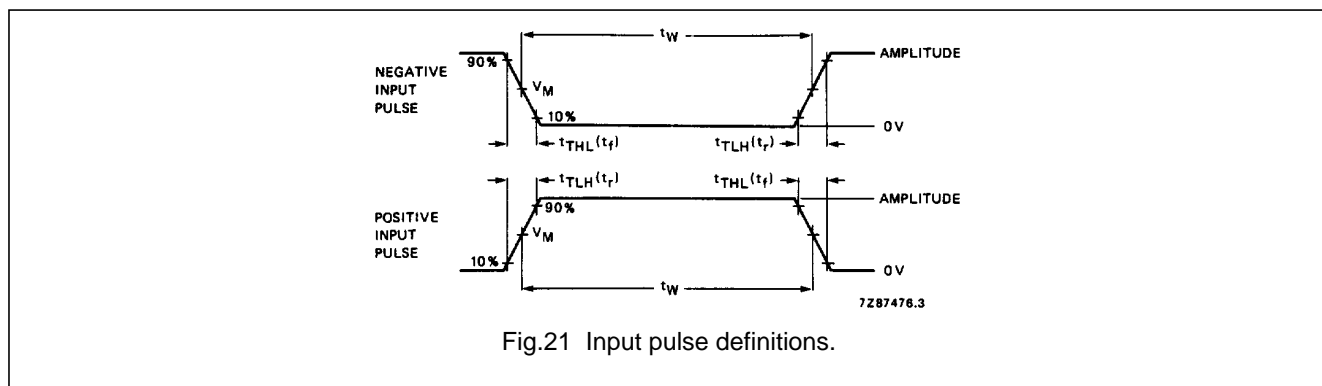


Fig.21 Input pulse definitions.

Conditions

TEST	SWITCH	V <sub>is</sub>
t <sub>PZH</sub>	V <sub>EE</sub>	V <sub>CC</sub>
t <sub>PZL</sub>	V <sub>CC</sub>	V <sub>EE</sub>
t <sub>PHZ</sub>	V <sub>EE</sub>	V <sub>CC</sub>
t <sub>PLZ</sub>	V <sub>CC</sub>	V <sub>EE</sub>
others	open	pulse

FAMILY	AMPLITUDE	V <sub>M</sub>	t <sub>r</sub> ; t <sub>f</sub>	
			f <sub>max</sub> ; PULSE WIDTH	OTHER
74HC	V <sub>CC</sub>	50%	< 2 ns	6 ns
74HCT	3.0 V	1.3 V	< 2 ns	6 ns

Definitions for Figs 20 and 21:

C<sub>L</sub> = load capacitance including jig and probe capacitance (see AC CHARACTERISTICS for values).

R<sub>T</sub> = termination resistance should be equal to the output impedance Z<sub>O</sub> of the pulse generator.

t<sub>r</sub> = t<sub>f</sub> = 6 ns; when measuring f<sub>max</sub>, there is no constraint to t<sub>r</sub>, t<sub>f</sub> with 50% duty factor.

PACKAGE OUTLINES

See "74HC/HCT/HCU/HCMOS Logic Package Outlines".