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/HCT4051
8-channel analog multiplexer/demultiplexer

Product specification
File under Integrated Circuits, IC06

December 1990

Philips
Semiconductors

PHILIPS

FEATURES

- Wide analog input voltage range: ± 5 V.
- Low "ON" resistance:
  80 Ω (typ.) at $V_{CC} - V_{EE} = 4.5$ V
  70 Ω (typ.) at $V_{CC} - V_{EE} = 6.0$ V
  60 Ω (typ.) at $V_{CC} - V_{EE} = 9.0$ 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_{CC} category: MSI

GENERAL DESCRIPTION

The 74HC/HCT4051 are high-speed Si-gate CMOS devices and are pin compatible with the "4051" of the "4000B" series. They are specified in compliance with JEDEC standard no. 7A.

The 74HC/HCT4051 are 8-channel analog multiplexers/demultiplexers with three digital select inputs (S_0 to S_2), an active LOW enable input ($\overline{E}$), eight independent inputs/outputs (Y_0 to Y_7) and a common input/output (Z).

With $\overline{E}$ LOW, one of the eight switches is selected (low impedance ON-state) by S_0 to S_2. With $\overline{E}$ HIGH, all switches are in the high impedance OFF-state, independent of S_0 to S_2.

V_{CC} and GND are the supply voltage pins for the digital control inputs (S_0 to S_2, and $\overline{E}$). 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 (Y_0 to Y_7, and Z) 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.

For operation as a digital multiplexer/demultiplexer, V_{EE} is connected to GND (typically ground).

QUICK REFERENCE DATA

V_{EE} = GND = 0 V; T_{amb} = 25 °C; $t_r = t_f$ = 6 ns

SYMBOL	PARAMETER	CONDITIONS	TYPICAL		UNIT
			HC	HCT	
t_{PZH}/ t_{PZL}	turn "ON" time	C_L = 15 pF; R_L = 1 kΩ; V_{CC} = 5 V			
	$\overline{E}$ to V_{os}		22	22	ns
	S_n to V_{os}		20	24	ns
t_{PHZ}/ t_{PLZ}	turn "OFF" time				
	$\overline{E}$ to V_{os}		18	16	ns
	S_n to V_{os}		19	20	ns
C_I	input capacitance		3.5	3.5	pF
C_{PD}	power dissipation capacitance per switch	notes 1 and 2	25	25	pF
C_S	max. switch capacitance				
	independent (Y)		5	5	pF
	common (Z)		25	25	pF

Notes

1. C_{PD} is used to determine the dynamic power dissipation (P_D 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 = GND to V_{CC}
   For HCT the condition is V_I = GND to V_{CC} – 1.5 V

ORDERING INFORMATION

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

PIN DESCRIPTION

PIN NO.	SYMBOL	NAME AND FUNCTION
3	Z	common input/output
6	$\overline{E}$	enable input (active LOW)
7	V_{EE}	negative supply voltage
8	GND	ground (0 V)
11, 10, 9	S_0 to S_2	select inputs
13, 14, 15, 12, 1, 5, 2, 4	Y_0 to Y_7	independent inputs/outputs
16	V_{CC}	positive supply voltage

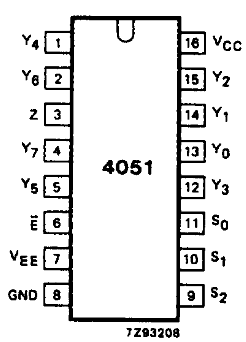


Fig.1 Pin configuration.

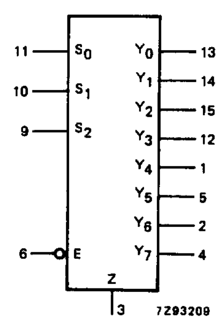


Fig.2 Logic symbol.

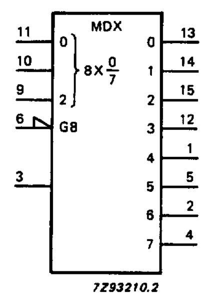


Fig.3 IEC logic symbol.

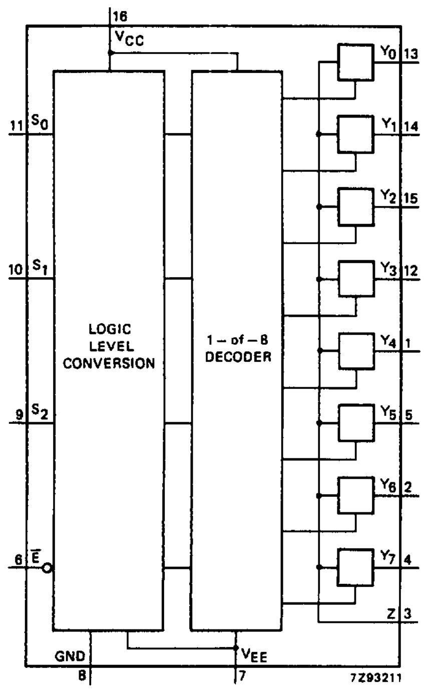


Fig.4 Functional diagram.

APPLICATIONS

- Analog multiplexing and demultiplexing
- Digital multiplexing and demultiplexing
- Signal gating

FUNCTION TABLE

INPUTS				channel ON
$\overline{E}$	S_2	S_1	S_0	
L	L	L	L	Y_0 – Z
L	L	L	H	Y_1 – Z
L	L	H	L	Y_2 – Z
L	L	H	H	Y_3 – Z
L	H	L	L	Y_4 – Z
L	H	L	H	Y_5 – Z
L	H	H	L	Y_6 – Z
L	H	H	H	Y_7 – Z
H	X	X	X	none

Notes

1. H = HIGH voltage level
   L = LOW voltage level
   X = don’t care

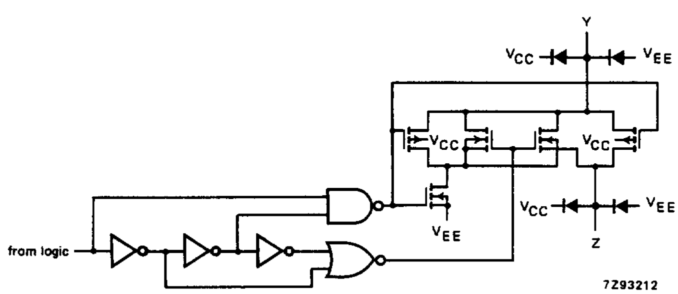


Fig.5 Schematic diagram (one switch).

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)
Voltages are referenced to V_{EE} = 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 $V_I < -0.5$ V or $V_I > V_{CC} + 0.5$ V
$\pm I_{SK}$	DC switch diode current		20	mA	for $V_S < -0.5$ V or $V_S > V_{CC} + 0.5$ V
$\pm I_S$	DC switch current		25	mA	for -0.5 V $< V_S < V_{CC} + 0.5$ 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

1. 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 terminal Z, no V_{CC} current will flow out of terminals 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} – 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 V V_{CC} = 4.5 V V_{CC} = 6.0 V V_{CC} = 10.0 V

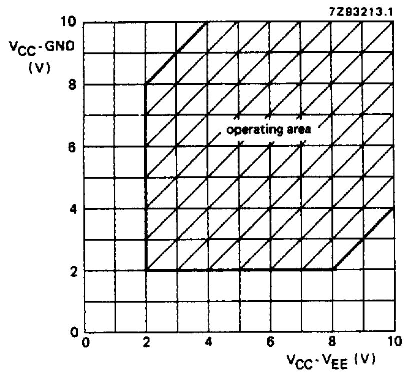


Fig.6 Guaranteed operating area as a function of the supply voltages for 74HC4051.

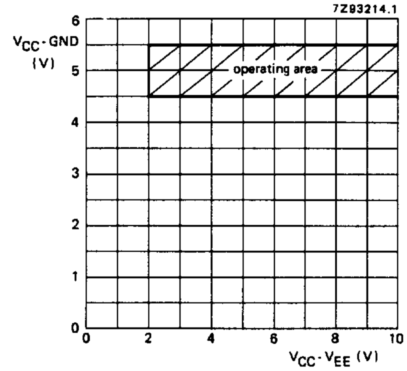


Fig.7 Guaranteed operating area as a function of the supply voltages for 74HCT4051.

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) 74HC/HCT +25 min.	typ.	max.	–40 to +85 min.	max.	–40 to +125 min.	max.	UNIT	TEST CONDITIONS V_{CC} (V)	V_{EE} (V)	I_S (μA)	V_{is}	V_I
R_{ON}	ON resistance (peak)		– 100 90 70	– 180 160 130		– 225 200 165		– 270 240 195	Ω Ω Ω Ω	2.0 4.5 6.0 4.5	0 0 0 –4.5	100 1000 1000 1000	V_{CC} to V_{EE}	V_{IH} or V_{IL}
R_{ON}	ON resistance (rail)		150 80 70 60	– 140 120 105		– 175 150 130		– 210 180 160	Ω Ω Ω Ω	2.0 4.5 6.0 4.5	0 0 0 –4.5	100 1000 1000 1000	V_{EE}	V_{IH} or V_{IL}
R_{ON}	ON resistance (rail)		150 90 80 65	– 160 140 120		– 200 175 150		– 240 210 180	Ω Ω Ω Ω	2.0 4.5 6.0 4.5	0 0 0 –4.5	100 1000 1000 1000	V_{CC}	V_{IH} or V_{IL}
ΔR_{ON}	maximum ΔON resistance between any two channels		– 9 8 6						Ω Ω Ω Ω	2.0 4.5 6.0 4.5	0 0 0 –4.5		V_{CC} to V_{EE}	V_{IH} or V_{IL}

Notes to DC characteristics

1. 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 be used to transmit digital signals only, when using these supply voltages.
2. For test circuit measuring R_{ON} see Fig.8.

DC CHARACTERISTICS FOR 74HC

Voltages are referenced to GND (ground = 0 V)

SYMBOL	PARAMETER	T_{amb} (°C) 74HC +25 min.	typ.	max.	−40 to +85 min.	max.	−40 to +125 min.	max.	UNIT	TEST CONDITIONS V_{CC} (V)	V_{EE} (V)	V_i	OTHER
V_{IH}	HIGH level input voltage	1.5 3.15 4.2 6.3	1.2 2.4 3.2 4.7		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	μA	6.0 10.0	0 0	V_{CC} or GND	
$\pm I_S$	analog switch OFF-state current per channel			0.1		1.0		1.0	μA	10.0	0	V_{IH} or V_{IL}	$\|V_S\| = V_{CC} - V_{EE}$ Fig.10
$\pm I_S$	analog switch OFF-state current all channels			0.4		4.0		4.0	μA	10.0	0	V_{IH} or V_{IL}	$\|V_S\| = V_{CC} - V_{EE}$ Fig.10
$\pm I_S$	analog switch ON-state current			0.4		4.0		4.0	μA	10.0	0	V_{IH} or V_{IL}	$\|V_S\| = V_{CC} - V_{EE}$ Fig.11
I_{CC}	quiescent supply current			8.0 16.0		80.0 160.0		160.0 320.0	μA	6.0 10.0	0 0	V_{CC} or GND	$V_{is} = V_{EE}$ or V_{CC}; $V_{os} = V_{CC}$ or V_{EE}

AC CHARACTERISTICS FOR 74HC

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

SYMBOL	PARAMETER	T_{amb} (°C) 74HC +25 min.	+25 typ.	+25 max.	−40 to +85 min.	−40 to +85 max.	−40 to +125 min.	−40 to +125 max.	UNIT	TEST CONDITIONS V_{CC} (V)	V_{EE} (V)	OTHER
t_{PHL}/ t_{PLH}	propagation delay V_{is} to V_{os}		14 5 4 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.17)
t_{PZH}/ t_{PZL}	turn “ON” time $\overline{E}$ to V_{os}		72 29 21 18	345 69 59 51		430 86 73 64		520 104 88 77	ns	2.0 4.5 6.0 4.5	0 0 0 −4.5	$R_L = 1$ kΩ; $C_L = 50$ pF (see Fig.18, 19 and 20)
t_{PZH}/ t_{PZL}	turn “ON” time S_n to V_{os}		66 28 19 16	345 69 59 51		430 86 73 64		520 104 88 77	ns	2.0 4.5 6.0 4.5	0 0 0 −4.5	$R_L = 1$ kΩ; $C_L = 50$ pF (see Fig.18, 19 and 20)
t_{PHZ}/ t_{PLZ}	turn “OFF” time $\overline{E}$ to V_{os}		58 31 17 18	290 58 49 42		365 73 62 53		435 87 74 72	ns	2.0 4.5 6.0 4.5	0 0 0 −4.5	$R_L = 1$ kΩ; $C_L = 50$ pF (see Fig.18, 19 and 20)
t_{PHZ}/ t_{PLZ}	turn “OFF” time S_n to V_{os}		61 25 18 18	290 58 49 42		365 73 62 53		435 87 74 72	ns	2.0 4.5 6.0 4.5	0 0 0 −4.5	$R_L = 1$ kΩ; $C_L = 50$ pF (see Fig.18, 19 and 20)

DC CHARACTERISTICS FOR 74HCT

Voltages are referenced to GND (ground = 0)

SYMBOL	PARAMETER	T_{amb} (°C) 74HCT +25 min.	typ.	max.	−40 to +85 min.	max.	−40 to +125 min.	max.	UNIT	TEST CONDITIONS V_{CC} (V)	V_{EE} (V)	V_i	OTHER
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	μA	5.5	0	V_{CC} or GND	
$\pm I_S$	analog switch OFF-state current per channel			0.1		1.0		1.0	μA	10.0	0	V_{IH} or V_{IL}	$\|V_S\| = V_{CC} - V_{EE}$ (see Fig.10)
$\pm I_S$	analog switch OFF-state current all channels			0.4		4.0		4.0	μA	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			0.4		4.0		4.0	μA	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	μA	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}
ΔI_{CC}	additional quiescent supply current per input pin for unit load coefficient is 1 (note 1)		100	360		450		490	μA	4.5 to 5.5	0	V_{CC} − 2.1 V	other inputs at V_{CC} or GND

Note to HCT types

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

INPUT	UNIT LOAD COEFFICIENT
S_n	0.50
$\overline{E}$	0.50

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}		5 4	12 8		15 10		18 12	ns	4.5 4.5	0 −4.5	$R_L = \infty$; $C_L = 50$ pF (see Fig.17)
t_{PZH}/ t_{PZL}	turn "ON" time $\overline{E}$ to V_{os}		26 16	55 39		69 49		83 59	ns	4.5 4.5	0 −4.5	$R_L = 1$ kΩ; $C_L = 50$ pF (see Fig.18, 19 and 20)
t_{PZH}/ t_{PZL}	turn "ON" time S_n to V_{os}		28 16	55 39		69 49		83 59	ns	4.5 4.5	0 −4.5	$R_L = 1$ kΩ; $C_L = 50$ pF (see Fig.18, 19 and 20)
t_{PHZ}/ t_{PLZ}	turn "OFF" time $\overline{E}$ to V_{os}		19 16	45 32		56 40		68 48	ns	4.5 4.5	0 −4.5	$R_L = 1$ kΩ; $C_L = 50$ pF (see Fig.18, 19 and 20)
t_{PHZ}/ t_{PLZ}	turn "OFF" time S_n to V_{os}		23 16	45 32		56 40		68 48	ns	4.5 4.5	0 −4.5	$R_L = 1$ kΩ; $C_L = 50$ pF (see Fig.18, 19 and 20)

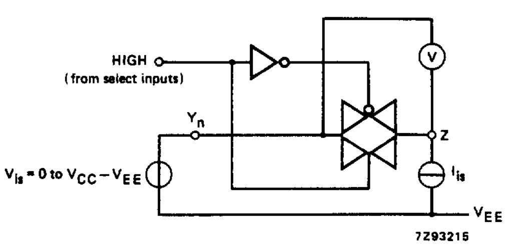


Fig.8 Test circuit for measuring R_{ON}.

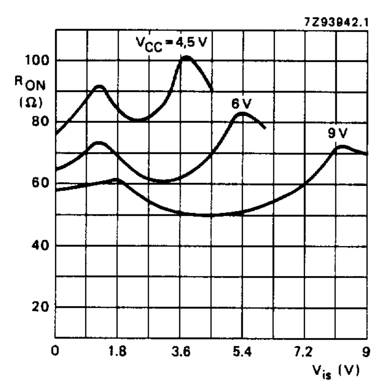


Fig.9 Typical R_{ON} as a function of input voltage V_{is} for V_{is} = 0 to $V_{CC} - V_{EE}$.

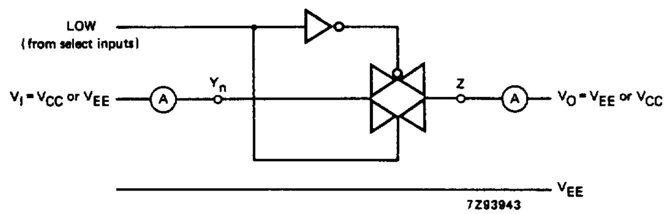


Fig.10 Test circuit for measuring OFF-state current.

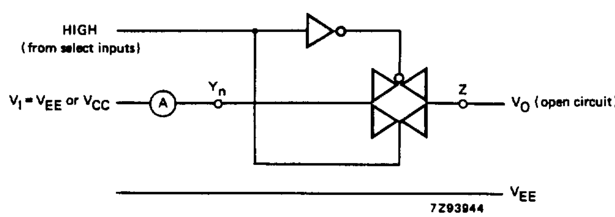


Fig.11 Test circuit for measuring ON-state current.

ADDITIONAL AC CHARACTERISTICS FOR 74HC/HCT

Recommended conditions and typical values

GND = 0 V; T_{amb} = 25 °C

SYMBOL	PARAMETER	typ.	UNIT	V_{CC} (V)	V_{EE} (V)	$V_{is(p-p)}$ (V)	CONDITIONS
	sine-wave distortion f = 1 kHz	0.04 0.02	% %	2.25 4.5	–2.25 –4.5	4.0 8.0	R_L = 10 kΩ; C_L = 50 pF (see Fig.14)
	sine-wave distortion f = 10 kHz	0.12 0.06	% %	2.25 4.5	–2.25 –4.5	4.0 8.0	R_L = 10 kΩ; C_L = 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_L = 600 Ω; C_L = 50 pF (see Figs 12 and 15)
$V_{(p-p)}$	crosstalk voltage between control and any switch (peak-to-peak value)	110 220	mV mV	4.5 4.5	0 –4.5		R_L = 600 Ω; C_L = 50 pF; f = 1 MHz ($\overline{E}$ or S_n, square-wave between V_{CC} and GND, t_r = t_f = 6 ns) (see Fig.16)
f_{max}	minimum frequency response (–3dB)	170 180	MHz MHz	2.25 4.5	–2.25 –4.5	note 2	R_L = 50 Ω; C_L = 10 pF (see Fig.13 and 14)
C_S	maximum switch capacitance independent (Y) common (Z)	 5 25	 pF pF				

Notes to AC characteristics

1. Adjust input voltage V_{is} to 0 dBm level (0 dBm = 1 mW into 600 Ω).
2. Adjust input voltage V_{is} to 0 dBm level at V_{os} for 1 MHz (0 dBm = 1 mW into 50 Ω).

General note

V_{is} is the input voltage at a Y_n or Z terminal, whichever is assigned as an input.
V_{os} is the output voltage at a Y_n or Z terminal, whichever is assigned as an output.

Test conditions:
V_{CC} = 4.5 V; GND = 0 V; V_{EE} = –4.5 V;
R_L = 50 Ω; R_{source} = 1 kΩ

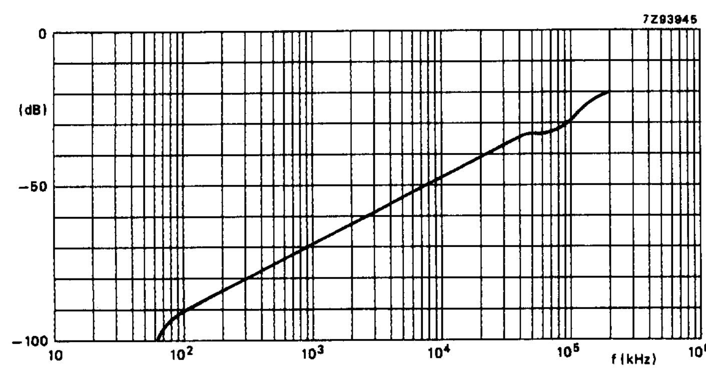


Fig.12 Typical switch “OFF” signal feed-through as a function of frequency.

Test conditions:
V_{CC} = 4.5 V; GND = 0 V; V_{EE} = –4.5 V;
R_L = 50 Ω; R_{source} = 1 kΩ

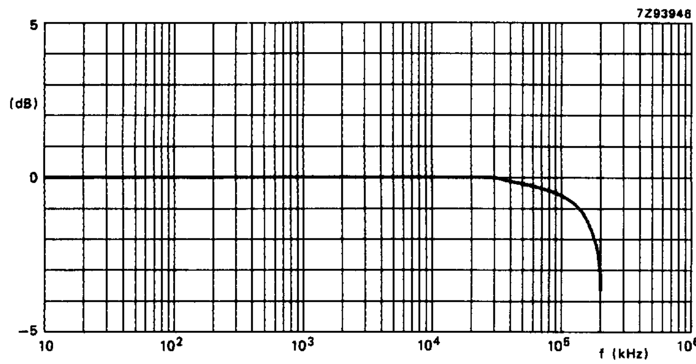


Fig.13 Typical frequency response.

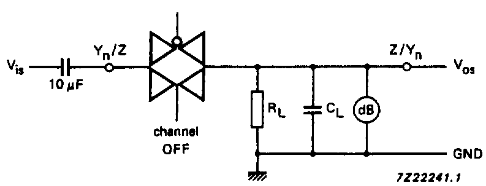


Fig.14 Test circuit for measuring sine-wave distortion and minimum frequency response.

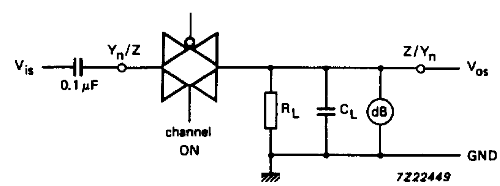
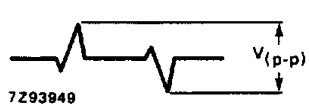


Fig.15 Test circuit for measuring switch “OFF” signal feed-through.

The crosstalk is defined as follows (oscilloscope output):



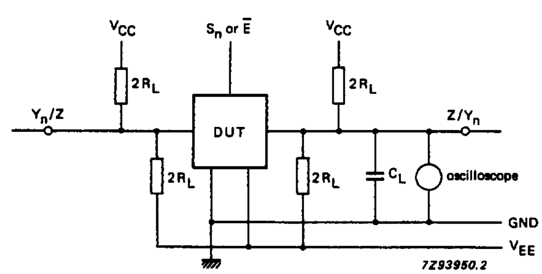


Fig.16 Test circuit for measuring crosstalk between control and any switch.

AC WAVEFORMS

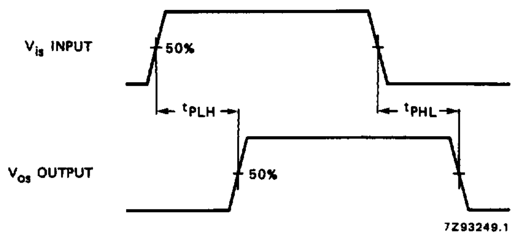
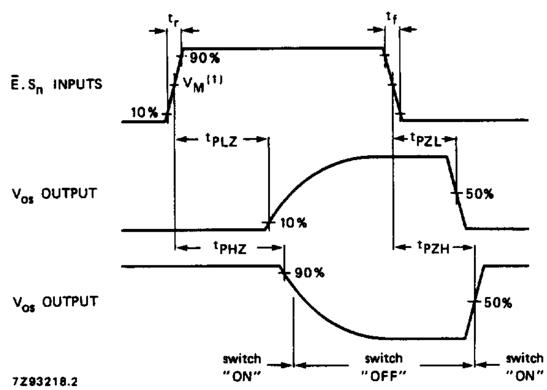


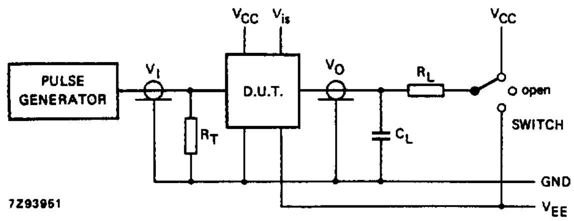
Fig.17 Waveforms showing the input (V_{is}) to output (V_{os}) propagation delays.



(1) HC : V_M = 50%; V_I = GND to V_{CC}.
HCT: V_M = 1.3 V; V_I = GND to 3 V.

Fig.18 Waveforms showing the turn-ON and turn-OFF times.

TEST CIRCUIT AND WAVEFORMS



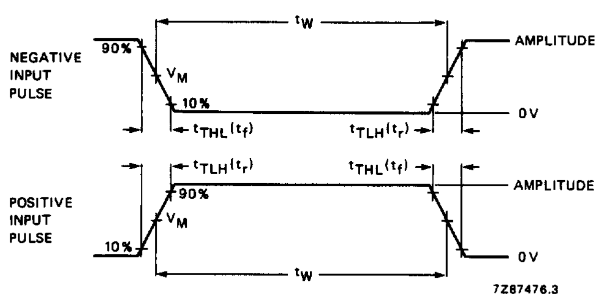
Conditions

TEST	SWITCH	V_{is}
t_{PZH}	V_{EE}	V_{CC}
t_{PZL}	V_{CC}	V_{EE}
t_{PHZ}	V_{EE}	V_{CC}
t_{PLZ}	V_{CC}	V_{EE}
others	open	pulse

FAMILY	AMPLITUDE	V_M	t_r; t_f	
			f_{max}; PULSE WIDTH	OTHER
74HC	V_{CC}	50%	< 2 ns	6 ns
74HCT	3.0 V	1.3 V	< 2 ns	6 ns

C_L = load capacitance including jig and probe capacitance (see AC CHARACTERISTICS for values).
R_T = termination resistance should be equal to the output impedance Z_O of the pulse generator.
t_r = t_f = 6 ns; when measuring f_{max}, there is no constraint to t_r, t_f with 50% duty factor.

Fig.19 Test circuit for measuring AC performance.



Conditions

TEST	SWITCH	V_{is}
t_{PZH}	V_{EE}	V_{CC}
t_{PZL}	V_{CC}	V_{EE}
t_{PHZ}	V_{EE}	V_{CC}
t_{PLZ}	V_{CC}	V_{EE}
others	open	pulse

FAMILY	AMPLITUDE	V_M	t_r; t_f	
			f_{max}; PULSE WIDTH	OTHER
74HC	V_{CC}	50%	< 2 ns	6 ns
74HCT	3.0 V	1.3 V	< 2 ns	6 ns

C_L = load capacitance including jig and probe capacitance (see AC CHARACTERISTICS for values).
R_T = termination resistance should be equal to the output impedance Z_O of the pulse generator.
t_r = t_f = 6 ns; when measuring f_{max}, there is no constraint to t_r, t_f with 50% duty factor.

Fig.20 Input pulse definitions.

PACKAGE OUTLINES

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