

QUAD BILATERAL SWITCHES

FEATURES

- Low "ON" resistance:
90 Ω (typ.) at V_{CC} = 4.5 V
80 Ω (typ.) at V_{CC} = 6.0 V
65 Ω (typ.) at V_{CC} = 9.0 V
- Individual switch controls
- Typical "break before make" built in
- Output capability: non-standard
- I_{CC} category: SSI

GENERAL DESCRIPTION

The 74HC/HCT4016 are high-speed Si-gate CMOS devices and are pin compatible with the "4016" of the "4000B" series. They are specified in compliance with JEDEC standard no. 7A.

The 74HC/HCT4016 have four independent analog switches (transmission gates).

Each switch has two input/output terminals (Y_n, Z_n) and an active HIGH enable input (E_n). When E_n is connected to V_{CC}, a low bidirectional path between Y_n and Z_n is established (ON condition). When E_n is connected to ground (GND), the switch is disabled and a high impedance between Y_n and Z_n is established (OFF condition).

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} > (V_Y, V_Z) > GND. Inputs Y_n and Z_n are electrically equivalent terminals.

SYMBOL	PARAMETER	CONDITIONS	TYPICAL		UNIT
			HC	HCT	
t _{PZH} / t _{PZL}	turn "ON" time E _n to V _{OS}	C _L = 15 pF R _L = 1 kΩ V _{CC} = 5 V	16	17	ns
t _{PHZ} / t _{PLZ}	turn "OFF" time E _n to V _{OS}		14	20	ns
C _I	input capacitance		3.5	3.5	pF
C _{PD}	power dissipation capacitance per switch	notes 1 and 2	12	12	pF
C _S	max. switch capacitance		5	5	pF

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

Notes

1. C_{PD} is used to determine the dynamic power dissipation (P_D in μW):

$$P_D = C_{PD} \times V_{CC}^2 \times f_i + \sum \{ (C_L + C_S) \times V_{CC}^2 \times f_o \}$$

f_i = input frequency in MHz
f_o = output frequency in MHz
Σ{(C_L + C_S) × V_{CC}² × 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/PACKAGE OUTLINES

PC74HC/HCT4016P: 14-lead DIL; plastic (SOT-27).
PC74HC/HCT4016T: 14-lead mini-pack; plastic (SO-14; SOT-108A).

PIN DESCRIPTION

PIN NO.	SYMBOL	NAME AND FUNCTION
1, 4, 8, 11	Y ₀ to Y ₃	independent inputs/outputs
7	GND	ground (0 V)
2, 3, 9, 10	Z ₀ to Z ₃	independent inputs/outputs
13, 5, 6, 12	E ₀ to E ₃	enable inputs (active HIGH)
14	V _{CC}	positive supply voltage

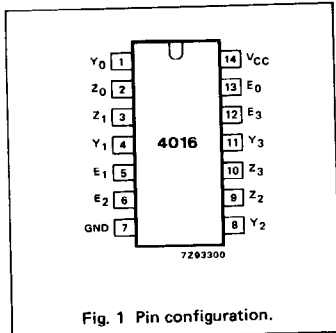


Fig. 1 Pin configuration.

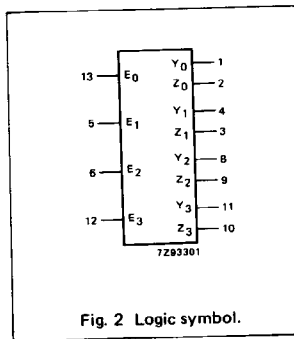


Fig. 2 Logic symbol.

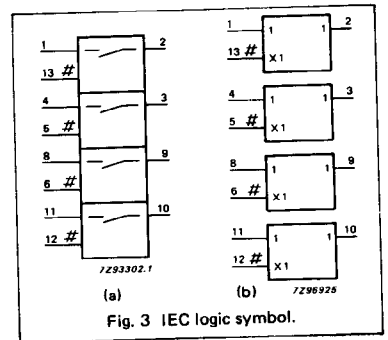
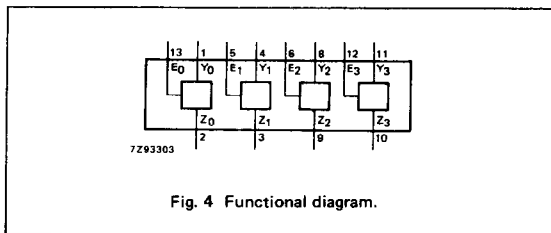


Fig. 3 IEC logic symbol.



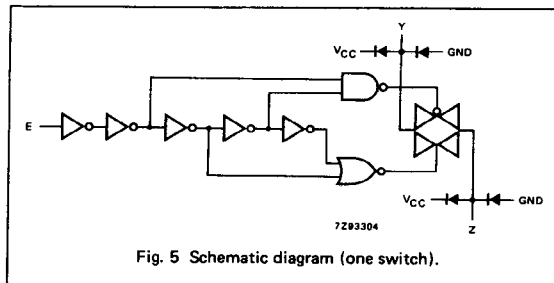
APPLICATIONS

- Signal gating
- Modulation
- Demodulation
- Chopper

FUNCTION TABLE

INPUT E_n	CHANNEL IMPEDANCE
L	high
H	low

H = HIGH voltage level
L = LOW voltage level



RATINGS

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

Voltages are referenced to GND (ground = 0 V)

SYMBOL	PARAMETER	MIN.	MAX.	UNIT	CONDITIONS
V _{CC}	DC supply voltage	-0.5	+11.0	V	
±I _{IJK}	DC digital input diode current		20	mA	for V _I < -0.5 V or V _I > V _{CC} + 0.5 V
±I _{SK}	DC switch diode current		20	mA	for V _S < -0.5 V or V _S > V _{CC} + 0.5 V
±I _S	DC switch current		25	mA	for -0.5 V < V _S < V _{CC} + 0.5 V
±I _{CC} , ±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	

RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	74HC			74HCT			UNIT	CONDITIONS
		min.	typ.	max.	min.	typ.	max.		
V _{CC}	DC supply voltage	2.0	5.0	10.0	4.5	5.0	5.5	V	
V _I	DC input voltage range	GND		V _{CC}	GND		V _{CC}	V	
V _S	DC switch voltage range	GND		V _{CC}	GND		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

DC CHARACTERISTICS FOR 74HC/HCT

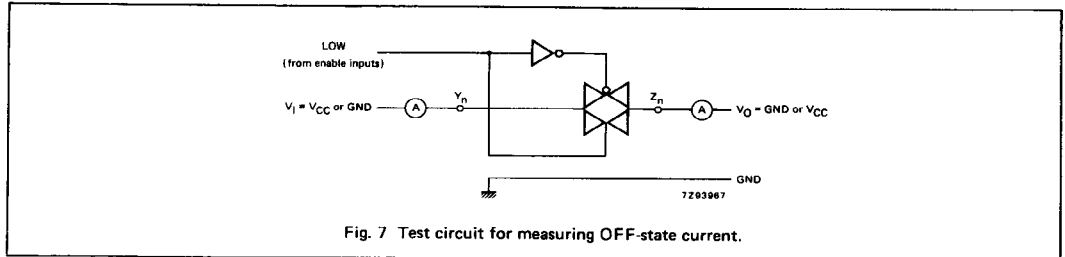
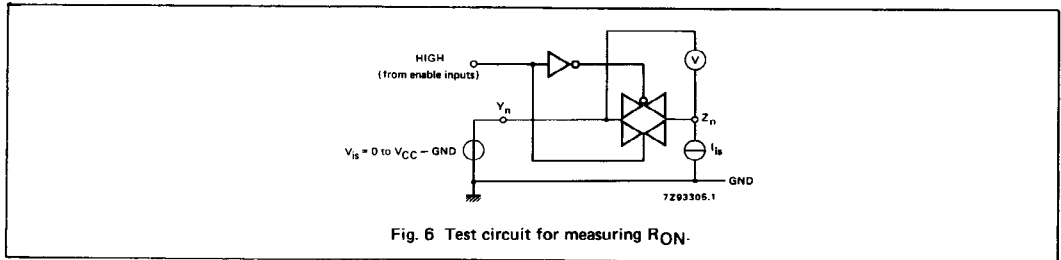
For 74HC: $V_{CC} = 2.0, 4.5, 6.0$ and 9.0 V

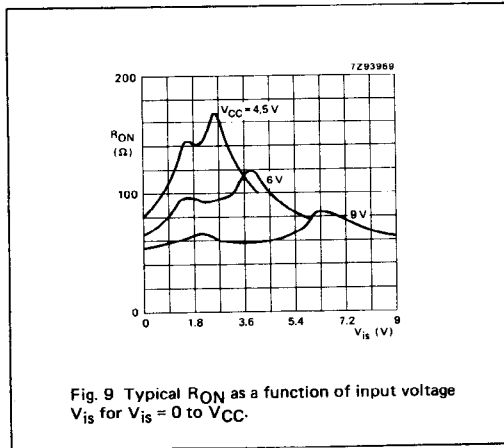
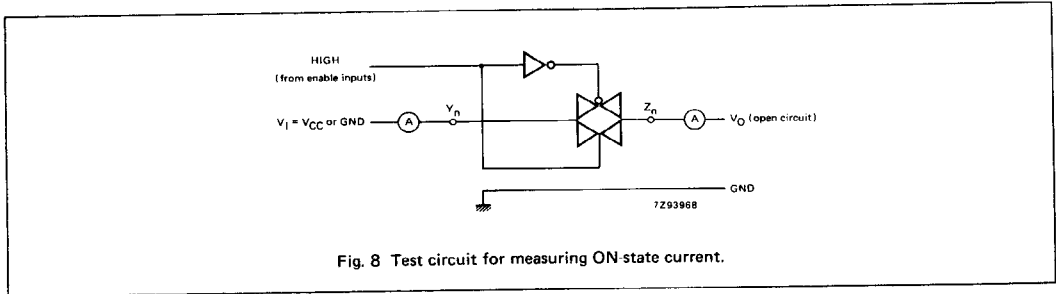
For 74HCT: $V_{CC} = 4.5$ V

SYMBOL	PARAMETER	T_{amb} (°C)						UNIT	TEST CONDITIONS				
		74HC/HCT							V_{CC} 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)	—	—	320	—	—	—	Ω	2.0	100	V_{CC} to GND	V_{IH} or V_{IL}	
		120	240	—	400	—	Ω	4.5	1000				
		85	170	—	300	—	Ω	6.0	1000				
				—	213	—	Ω	9.0	1000				
R_{ON}	ON resistance (rail)	160	—	—	—	—	—	Ω	2.0	100	GND	V_{IH} or V_{IL}	
		80	160	—	200	—	Ω	4.5	1000				
		70	140	—	175	—	Ω	6.0	1000				
		60	120	—	150	—	Ω	9.0	1000				
R_{ON}	ON resistance (rail)	170	—	—	—	—	—	Ω	2.0	100	V_{CC}	V_{IH} or V_{IL}	
		90	180	—	225	—	Ω	4.5	1000				
		80	160	—	200	—	Ω	6.0	1000				
		65	135	—	170	—	Ω	9.0	1000				
ΔR_{ON}	maximum ΔR_{ON} resistance between any two channels	—	—	—	—	—	—	Ω	2.0	—	V_{CC} to GND	V_{IH} or V_{IL}	
		16	—	—	—	—	—	Ω	4.5	—			
		12	—	—	—	—	—	Ω	6.0	—			
		9	—	—	—	—	—	Ω	9.0	—			

Notes to DC characteristics

- At supply voltages 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.
- For test circuit measuring R_{ON} see Fig. 6.





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 _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	0.50 1.35 1.80 2.70		0.50 1.35 1.80 2.70		0.50 1.35 1.80 2.70	V	2.0 4.5 6.0 9.0		
±I _I	input leakage current			0.1 0.2		1.0 2.0		1.0 2.0	μA	6.0 10.0	V _{CC} or GND	
±I _S	analog switch OFF-state current per channel			0.1		1.0		1.0	μA	10.0	V _{IH} or V _{IL}	V _S = V _{CC} - GND (see Fig. 7)
±I _S	analog switch ON-state current			0.1		1.0		1.0	μA	10.0	V _{IH} or V _{IL}	V _S = V _{CC} - GND (see Fig. 8)
I _{CC}	quiescent supply current			2.0 4.0		20.0 40.0		40.0 80.0	μA	6.0 10.0	V _{CC} or GND	V _{is} = GND or V _{CC} ; V _{os} = V _{CC} or GND

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	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 9.0	R _L = ∞; C _L = 50 pF (see Fig. 16)
t _{PZH} / t _{PZL}	turn "ON" time E _n to V _{os}		52 19 15 11	190 38 32 28		240 48 41 35		235 57 48 42	ns	2.0 4.5 6.0 9.0	R _L = 1 kΩ; C _L = 50 pF (see Figs 17 and 18)
t _{PHZ} / t _{PLZ}	turn "OFF" time E _n to V _{os}		47 17 14 13	145 29 25 22		180 36 31 28		220 44 38 33	ns	2.0 4.5 6.0 9.0	R _L = 1 kΩ; C _L = 50 pF (see Figs 17 and 18)

DC CHARACTERISTICS FOR 74HCT

Voltages are referenced to GND (ground = 0 V)

SYMBOL	PARAMETER	T _{amb} (°C)						UNIT	TEST CONDITIONS			
		74HCT							V _{CC} 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		
±I _I	input leakage current			0.1		1.0		1.0	μA	5.5	V _{CC} or GND	
±I _S	analog switch OFF-state current per channel			0.1		1.0		1.0	μA	5.5	V _{IH} or V _{IL}	V _S = V _{CC} - GND (see Fig. 7)
±I _S	analog switch ON-state current			0.1		1.0		1.0	μA	5.5	V _{IH} or V _{IL}	V _S = V _{CC} - GND (see Fig. 8)
I _{CC}	quiescent supply current			2.0		20.0		40.0	μA	4.5 to 5.5	V _{CC} or GND	V _{IS} = GND or V _{CC} ; V _{OS} = V _{CC} or GND
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	V _{CC} -2.1V	other inputs at V _{CC} or GND

Note

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
E _n	1.00

AC CHARACTERISTICS FOR 74HCT

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

SYMBOL	PARAMETER	T _{amb} (°C)						UNIT	V _{CC} V	TEST CONDITIONS	
		74HCT								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	12		15		18	ns	4.5	R _L = ∞; C _L = 50 pF (see Fig. 16)
t _{PZH}	turn "ON" time E _n to V _{Os}		19	35		44		53	ns	4.5	R _L = 1 kΩ; C _L = 50 pF (see Figs 17 and 18)
t _{PZL}	turn "ON" time E _n to V _{Os}		20	35		44		53	ns	4.5	R _L = 1 kΩ; C _L = 50 pF (see Figs 17 and 18)
t _{PHZ} / t _{PLZ}	turn "OFF" time E _n to V _{Os}		23	35		44		53	ns	4.5	R _L = 1 kΩ; C _L = 50 pF (see Figs 17 and 18)

ADDITIONAL AC CHARACTERISTICS FOR 74HC/HCT

Recommended conditions and typical values

GND = 0 V; $t_r = t_f = 6$ ns

SYMBOL	PARAMETER	typ.	UNIT	V _{CC} V	V _{is(p-p)} V	CONDITIONS
	sine-wave distortion f = 1 kHz	0.80 0.40	% %	4.5 9.0	4.0 8.0	R _L = 10 kΩ; C _L = 50 pF (see Fig. 14)
	sine-wave distortion f = 10 kHz	2.40 1.20	% %	4.5 9.0	4.0 8.0	R _L = 10 kΩ; C _L = 50 pF (see Fig. 14)
	switch "OFF" signal feed-through	-50 -50	dB dB	4.5 9.0	note 1	R _L = 600 Ω; C _L = 50 pF; f = 1 MHz (see Figs 10 and 15)
	crosstalk between any two switches	-60 -60	dB dB	4.5 9.0	note 1	R _L = 600 Ω; C _L = 50 pF; f = 1 MHz (see Fig. 12)
V _(p-p)	crosstalk voltage between enable or address input to any switch (peak-to-peak value)	110 220	mV mV	4.5 9.0		R _L = 600 Ω; C _L = 50 pF; f = 1 MHz (E _n , square wave between V _{CC} and GND, t _r = t _f = 6 ns) (see Fig. 13)
f _{max}	minimum frequency response (-3dB)	150 160	MHz MHz	4.5 9.0	note 2	R _L = 50 Ω; C _L = 10 pF (see Figs 11 and 14)
C _S	maximum switch capacitance	5	pF			

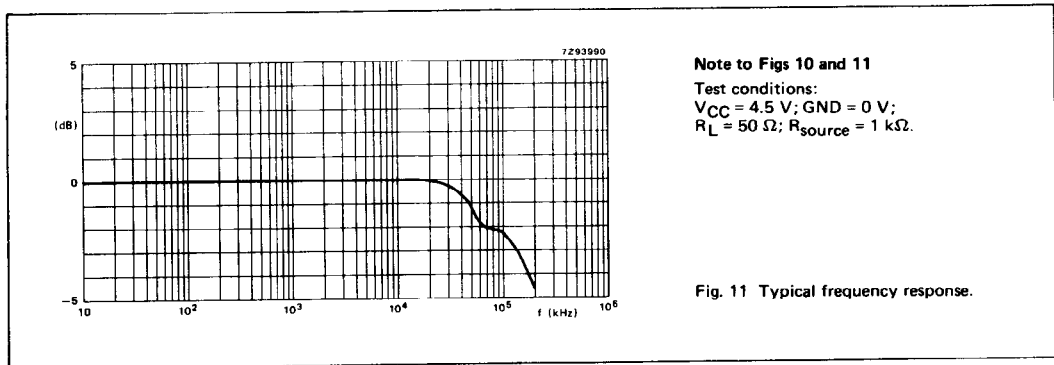
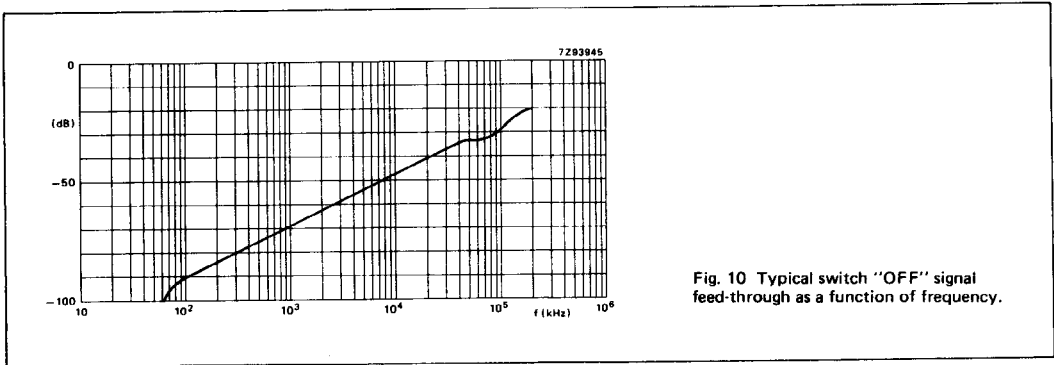
Notes to AC characteristics

General note

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

Notes

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).



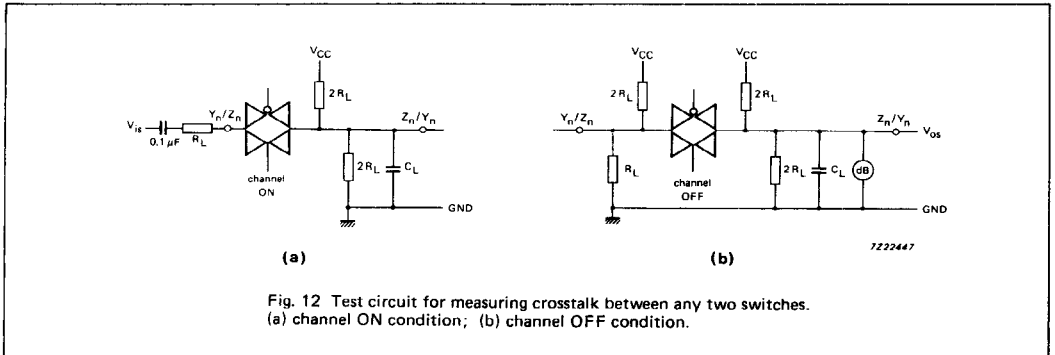


Fig. 12 Test circuit for measuring crosstalk between any two switches.
(a) channel ON condition; (b) channel OFF condition.

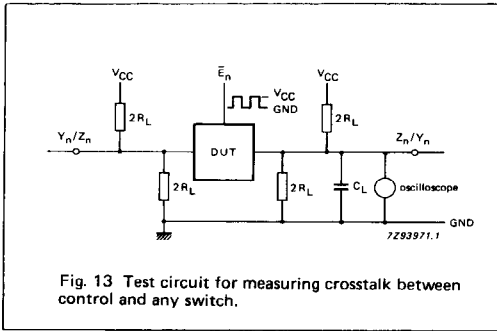


Fig. 13 Test circuit for measuring crosstalk between control and any switch.

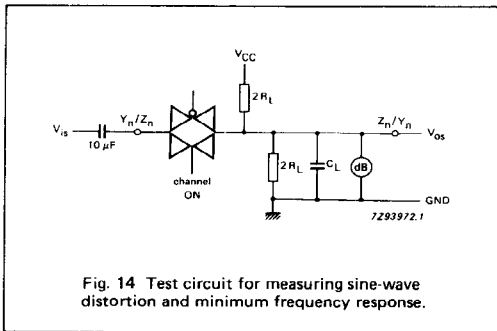
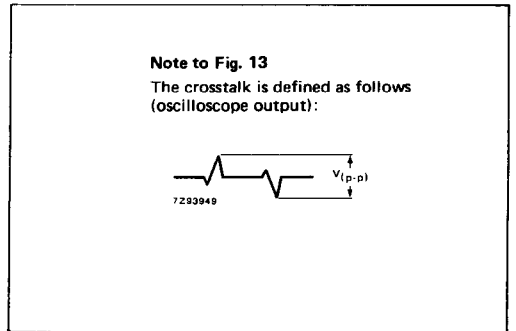


Fig. 14 Test circuit for measuring sine-wave distortion and minimum frequency response.

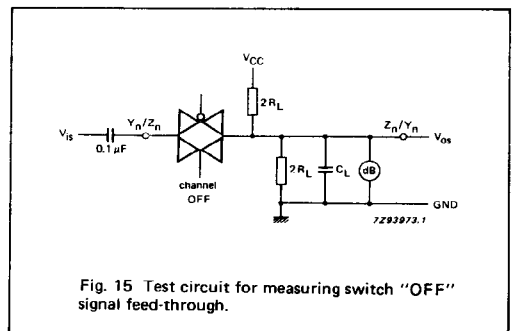
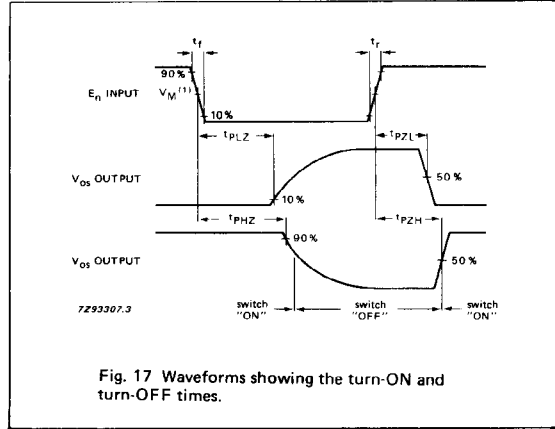
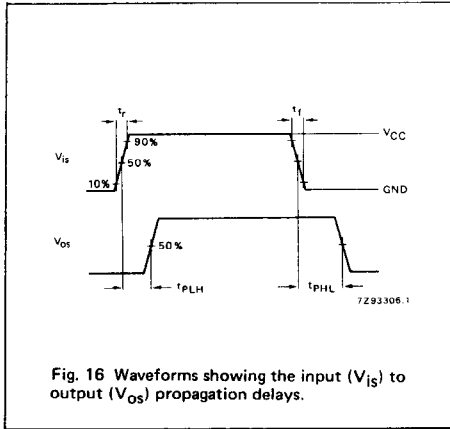


Fig. 15 Test circuit for measuring switch "OFF" signal feed-through.

AC WAVEFORMS



Note to AC waveforms

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

TEST CIRCUIT AND WAVEFORMS

