16-CHANNEL ANALOG MULTIPLEXER/DEMULTIPLEXER

FEATURES

- **Low "ON" resistance:**
  80 Ω (typ.) at V_{CC} = 4.5 V
  70 Ω (typ.) at V_{CC} = 6.0 V
  60 Ω (typ.) at V_{CC} = 9.0 V
  typical "break before make" built-in
- **Output capability: non-standard**
- **I_{CC} category: MSI**

GENERAL DESCRIPTION

The 74HC/HCT4067 are high-speed Si-gate CMOS devices and are pin compatible with the "4067" of the "4000B" series. They are specified in compliance with JEDEC standard no. 7A.

The 74HC/HCT4067 are 16-channel analog multiplexers/demultiplexers with four address inputs (S_0 to S_3), an active LOW enable input ($\overline{E}$), sixteen independent inputs/outputs (Y_0 to Y_{15}) and a common input/output (Z).

The "4067" contains sixteen bidirectional analog switches, each with one side connected to an independent input/output (Y_0 to Y_{15}) and the other side connected to a common input/output (Z).

With $\overline{E}$ LOW, one of the sixteen switches is selected (low impedance ON-state) by S_0 to S_3. All unselected switches are in the high impedance OFF-state. With $\overline{E}$ HIGH, all switches are in the high impedance OFF-state, independent of S_0 to S_3.

The analog inputs/outputs (Y_0 to Y_{15}, and Z) can swing between V_{CC} as a positive limit and GND as a negative limit. V_{CC} to GND may not exceed 10 V.

SYMBOL	PARAMETER	CONDITIONS	TYPICAL		UNIT
			HC	HCT	
t_{PZL}/ t_{PZH}	turn-on time $\overline{E}$ to V_{os} S_n to V_{os}	C_L = 15 pF R_L = 1 kΩ V_{CC} = 5 V	 26 29	 32 33	 ns ns
t_{PLZ}/ t_{PHZ}	turn-off time $\overline{E}$ to V_{os} S_n to V_{os}		 27 29	 26 30	 ns ns
C_I	input capacitance		3.5	3.5	pF
C_{PD}	power dissipation capacitance per switch	notes 1 and 2	29	29	pF
C_S	max. switch capacitance independent (Y) common (Z)		 5 45	 5 45	 pF 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):

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

   f_i = input frequency in MHz
   f_o = output frequency in MHz
   $\Sigma \{ (C_L + C_S) \times V_{CC}^2 \times f_o \}$ = 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

PACKAGE OUTLINES

24-lead DIL; plastic (SOT101A).
24-lead mini-pack; plastic (SO24; SOT137A).

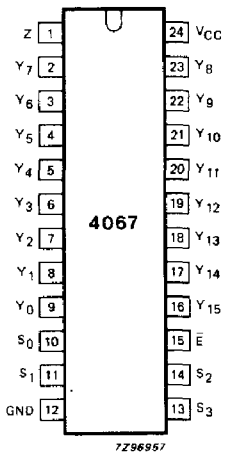


Fig. 1 Pin configuration.

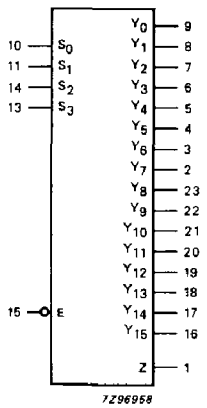


Fig. 2 Logic symbol.

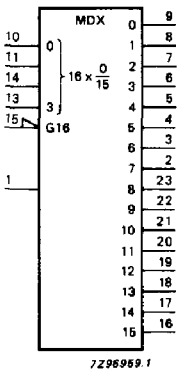


Fig. 3 IEC logic symbol.

PIN DESCRIPTION

PIN NO.	SYMBOL	NAME AND FUNCTION
1	Z	common input/output
9, 8, 7, 6, 5, 4, 3, 2, 23, 22, 21, 20, 19, 18, 17, 16	Y_0 to Y_{15}	independent inputs/outputs
10, 11, 14, 13	S_0 to S_3	address inputs
12	GND	ground (0 V)
15	$\overline{E}$	enable input (active LOW)
24	V_{CC}	positive supply voltage

APPLICATIONS

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

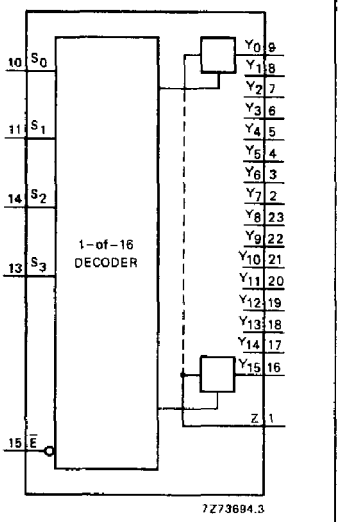


Fig. 4 Functional diagram.

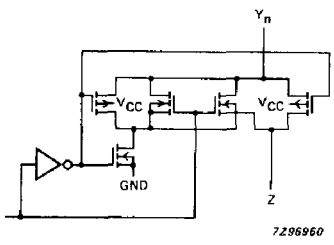


Fig. 5 Schematic diagram (one switch).

FUNCTION TABLE

INPUTS					CHANNEL ON
$\overline{E}$	S_3	S_2	S_1	S_0	
L	L	L	L	L	Y_0 – Z
L	L	L	L	H	Y_1 – Z
L	L	L	H	L	Y_2 – Z
L	L	L	H	H	Y_3 – Z
L	L	H	L	L	Y_4 – Z
L	L	H	L	H	Y_5 – Z
L	L	H	H	L	Y_6 – Z
L	L	H	H	H	Y_7 – Z
L	H	L	L	L	Y_8 – Z
L	H	L	L	H	Y_9 – Z
L	H	L	H	L	Y_{10} – Z
L	H	L	H	H	Y_{11} – Z
L	H	H	L	L	Y_{12} – Z
L	H	H	L	H	Y_{13} – Z
L	H	H	H	L	Y_{14} – Z
L	H	H	H	H	Y_{15} – Z
H	X	X	X	X	none

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

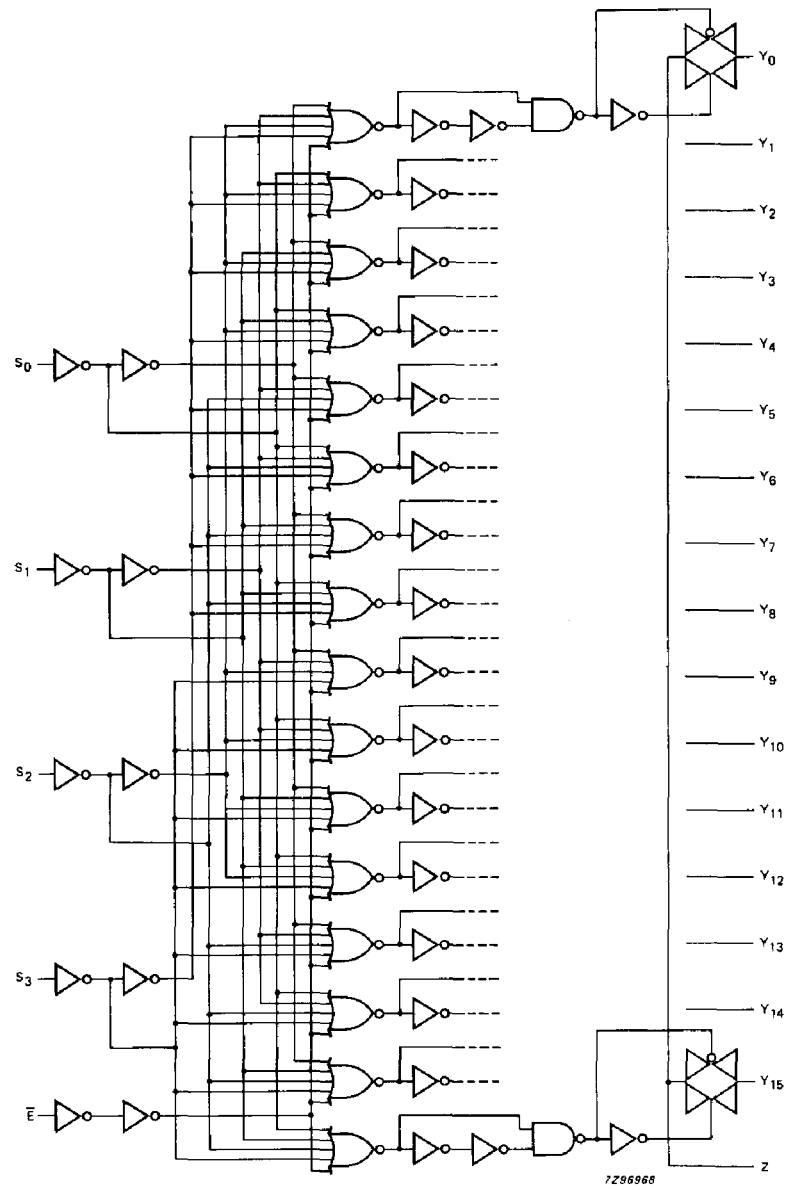


Fig. 6 Logic diagram.

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	
$\pm I_{IK}$	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
$\pm I_{CC}$; $\pm I_{GND}$	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 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 GND.

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} – GND = 2.0, 4.5, 6.0 and 9.0 V
For 74HCT: V_{CC} – GND = 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)		– 110 95 75	– 180 160 130		– 225 200 165		– 270 240 195	Ω Ω Ω Ω	2.0 4.5 6.0 9.0	100 1000 1000 1000	V_{CC} to GND	V_{IH} or V_{IL}
R_{ON}	ON-resistance (rail)		150 90 80 70	– 160 140 120		– 200 175 150		– 240 210 180	Ω Ω Ω Ω	2.0 4.5 6.0 9.0	100 1000 1000 1000	GND or V_{CC}	V_{IH} or V_{IL}
ΔR_{ON}	maximum variation of ON-resistance between any two channels		– 9 8 6						Ω Ω Ω Ω	2.0 4.5 6.0 9.0		V_{CC} to GND	V_{IH} or V_{IL}

Notes to DC characteristics

1. At supply voltages (V_{CC} – GND) approaching 2 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. 7.

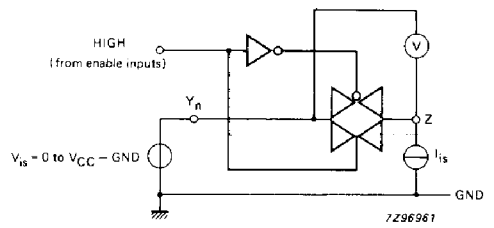


Fig. 7 Test circuit for measuring ON-resistance (R_{ON}).

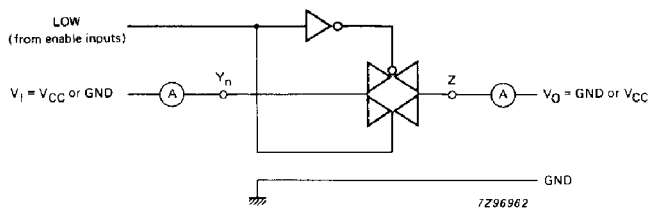


Fig. 8 Test circuit for measuring OFF-state current.

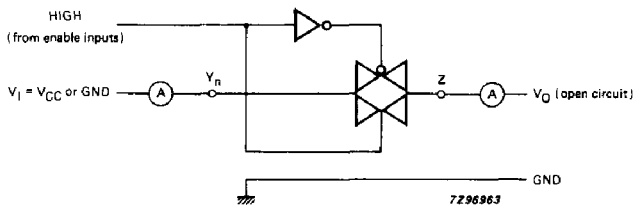


Fig. 9 Test circuit for measuring ON-state current.

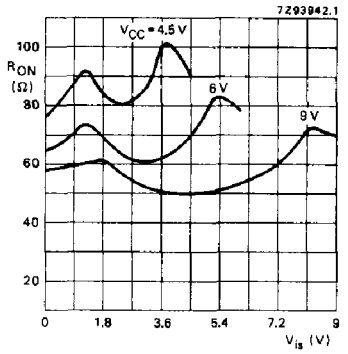


Fig. 10 Typical ON-resistance (R_{ON}) as a function of input voltage (V_{is}) for V_{is} = 0 to V_{CC} – GND.

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 4.7		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	0.50 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		
$\pm I_I$	input leakage current			0.1 0.2		1.0 2.0		1.0 2.0	μA	6.0 10.0	V_{CC} or GND	
$\pm I_S$	analog switch OFF-state current per channel			0.1		1.0		1.0	μA	10.0	V_{IH} or V_{IL}	$\lvert V_S \rvert = V_{CC} - GND$ (see Fig. 8)
$\pm I_S$	analog switch OFF-state current all channels			0.8		8.0		8.0	μA	10.0	V_{IH} or V_{IL}	$\lvert V_S \rvert = V_{CC} - GND$ (see Fig. 9)
$\pm I_S$	analog switch ON-state current			0.8		8.0		8.0	μA	10.0	V_{IH} or V_{IL}	$\lvert V_S \rvert = V_{CC} - GND$ (see Fig. 9)
I_{CC}	quiescent supply current			8.0 16.0		80.0 160		160 320	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									
		+25			−40 to +85		−40 to +125			V_{CC} V	OTHER
		min.	typ.	max.	min.	max.	min.	max.			
t_{PHL}/ t_{PLH}	propagation delay V_{is} to V_{os}; Y_n to Z		25 9 7 5	75 15 13 9		95 19 16 11		110 22 19 14	ns	2.0 4.5 6.0 9.0	$R_L = \infty$; C_L = 50 pF (see Fig. 16)
t_{PHL}/ t_{PLH}	propagation delay V_{is} to V_{os}; Z to Y_n		18 6 5 4	60 12 10 8		75 15 13 10		90 18 15 12	ns	2.0 4.5 6.0 9.0	
t_{PHZ}/ t_{PLZ}	turn-off time $\overline{E}$ to Y_n		74 27 22 20	250 50 43 38		315 63 54 48		375 75 64 57	ns	2.0 4.5 6.0 9.0	R_L = 1 kΩ; C_L = 50 pF (see Fig. 17)
t_{PHZ}/ t_{PLZ}	turn-off time S_n to Y_n		83 30 24 21	250 50 43 38		315 63 54 48		375 75 64 57	ns	2.0 4.5 6.0 9.0	
t_{PHZ}/ t_{PLZ}	turn-off time $\overline{E}$ to Z		85 31 25 24	275 55 47 42		345 69 59 53		415 83 71 63	ns	2.0 4.5 6.0 9.0	
t_{PHZ}/ t_{PLZ}	turn-off time S_n to Z		94 34 27 25	290 58 47 45		365 73 62 56		435 87 74 68	ns	2.0 4.5 6.0 9.0	
t_{PZH}/ t_{PZL}	turn-on time $\overline{E}$ to Y_n		80 29 23 17	275 55 47 42		345 69 59 53		415 83 71 63	ns	2.0 4.5 6.0 9.0	
t_{PZH}/ t_{PZL}	turn-on time S_n to Y_n		88 32 26 18	300 60 51 45		375 75 64 56		450 90 77 68	ns	2.0 4.5 6.0 9.0	
t_{PZH}/ t_{PZL}	turn-on time $\overline{E}$ to Z		85 31 25 18	275 55 47 42		345 69 59 53		415 83 71 63	ns	2.0 4.5 6.0 9.0	
t_{PZH}/ t_{PZL}	turn-on time S_n to Z		94 34 27 19	300 60 51 45		375 75 64 56		450 90 77 68	ns	2.0 4.5 6.0 9.0	

Note to AC characteristics for 74HC

Due to higher Z terminal capacitance (16 switches versus 1) the delay figures to the Z terminal are higher than those to the Y terminal.

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		
$\pm I_I$	input leakage current			0.1		1.0		1.0	μA	5.5	V_{CC} or GND	
$\pm I_S$	analog switch OFF-state current per channel			0.1		1.0		1.0	μA	5.5	V_{IH} or V_{IL}	$\lvert V_S \rvert = V_{CC} - GND$ (see Fig. 8)
$\pm I_S$	analog switch OFF-state current all channels			0.8		8.0		8.0	μA	5.5	V_{IH} or V_{IL}	$\lvert V_S \rvert = V_{CC} - GND$ (see Fig. 9)
$\pm I_S$	analog switch ON-state current			0.8		8.0		8.0	μA	5.5	V_{IH} or V_{IL}	$\lvert V_S \rvert = V_{CC} - GND$ (see Fig. 9)
I_{CC}	quiescent supply current			8.0		80.0		160	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} −2.1 V	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
$\overline{E}$	0.6
S_n	0.5

AC CHARACTERISTICS FOR 74HCT

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

SYMBOL	PARAMETER	T_{amb} (°C)							UNIT	TEST CONDITIONS	
		74HCT								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}; Y_n to Z		9	15		19		22	ns	4.5	$R_L = \infty$; C_L = 50 pF (see Fig. 16)
t_{PHL}/t_{PLH}	propagation delay V_{is} to V_{os}; Z to Y_n		6	12		15		18	ns	4.5	
t_{PHZ}/t_{PLZ}	turn-off time $\overline{E}$ to Y_n		26	55		69		83	ns	4.5	R_L = 1 kΩ; C_L = 50 pF (see Fig. 17)
t_{PHZ}/t_{PLZ}	turn-off time S_n to Y_n		31	55		69		83	ns	4.5	
t_{PHZ}/t_{PLZ}	turn-off time $\overline{E}$ to Z		30	60		75		90	ns	4.5	
t_{PHZ}/t_{PLZ}	turn-off time S_n to Z		35	60		75		90	ns	4.5	
t_{PZH}/t_{PZL}	turn-on time $\overline{E}$ to Y_n		32	60		75		90	ns	4.5	
t_{PZH}/t_{PZL}	turn-on time S_n to Y_n		35	60		75		90	ns	4.5	
t_{PZH}/t_{PZL}	turn-on time $\overline{E}$ to Z		38	65		81		98	ns	4.5	
t_{PZH}/t_{PZL}	turn-on time S_n to Z		38	65		81		98	ns	4.5	

Note to the AC characteristics

Due to higher Z terminal capacitance (16 switches versus 1) the delay figures to the Z terminal are higher than those to the Y terminal.

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	0.04 0.02	% %	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	0.12 0.06	% %	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 11 and 15)
f_{max}	minimum frequency response (−3 dB)	90 100	MHz MHz	4.5 9.0	note 2	R_L = 50 Ω; C_L = 10 pF (see Figs 12 and 13)
C_S	maximum switch capacitance independent (Y) common (Z)	 5 45	 pF pF			

Notes to the AC characteristics

General note

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

Notes

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

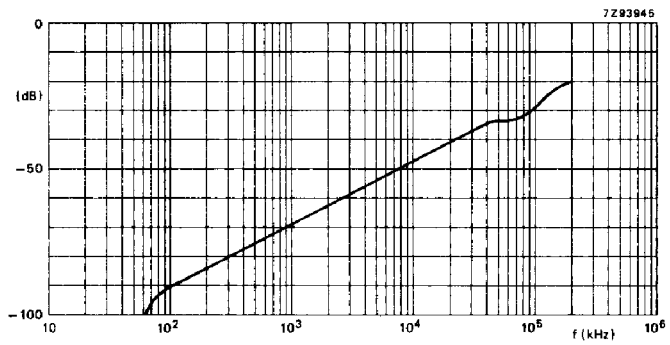


Fig. 11 Typical switch "OFF" signal feed-through as a function of frequency.

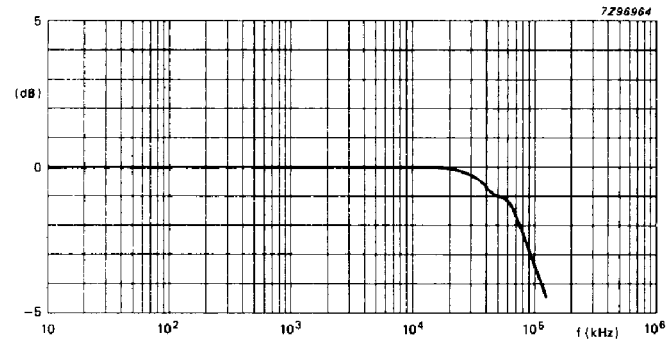


Fig. 12 Typical frequency response.

Note to Figs 11 and 12

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

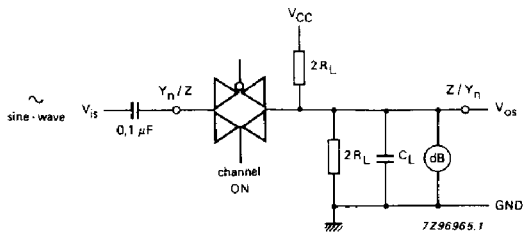


Fig. 13 Test circuit for measuring minimum frequency response.

Note to Fig. 13

Adjust input voltage to obtain 0 dBm at V_{os} when f_{in} = 1 MHz. After set-up frequency of f_{in} is increased to obtain a reading of −3 dB at V_{os}.

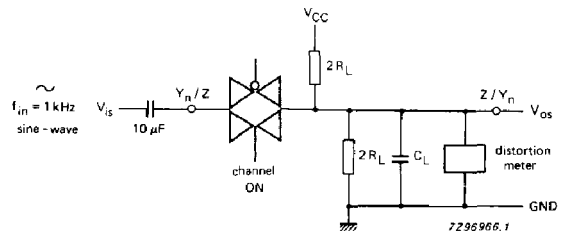


Fig. 14 Test circuit for measuring sine-wave distortion.

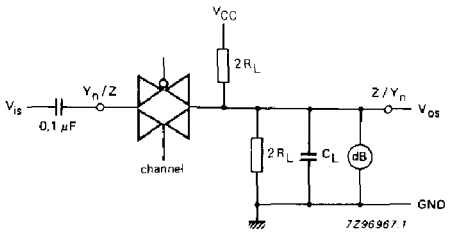


Fig. 15 Test circuit for measuring switch "OFF" signal feed-through.

AC WAVEFORMS

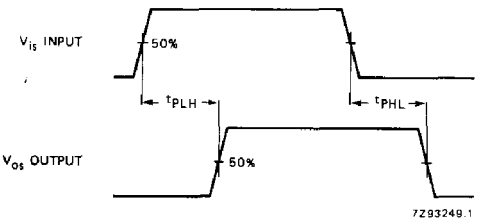


Fig. 16 Waveforms showing the input (V_{is}) to output (V_{os}) propagation delays.

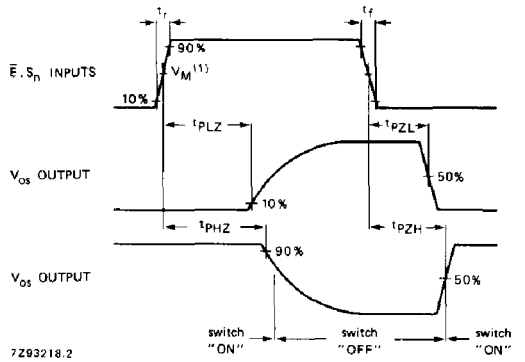
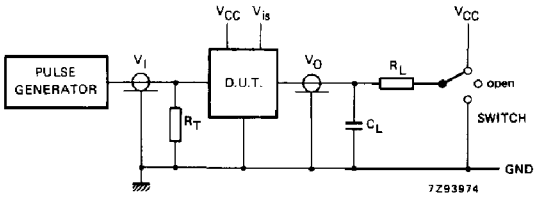


Fig. 17 Waveforms showing the turn-on and turn-off times.

Note to Fig. 17

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

TEST CIRCUIT AND WAVEFORMS



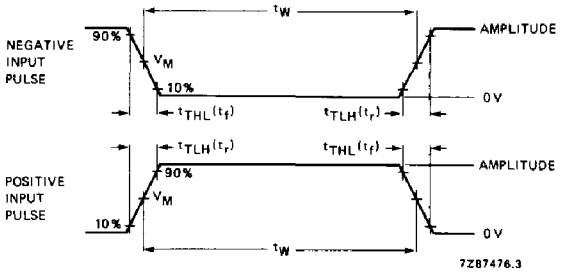


Fig. 19 Input pulse definitions.

Conditions

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

Fig. 18 Test circuit for measuring AC performance.

Definitions for Figs 18 and 19:

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 on t_r, t_f with 50% duty factor.

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