

February 1998 - Revised March 2002

High-Speed CMOS Logic Quad Analog Switch with Level Translation

Features

- **Wide Analog-Input-Voltage Range**
 $V_{CC} - V_{EE}$ 0V to 10V
- **Low "ON" Resistance**
 - 45Ω (Typ) $V_{CC} = 4.5V$
 - 35Ω (Typ) $V_{CC} = 6V$
 - 30Ω (Typ) $V_{CC} - V_{EE} = 9V$
- **Fast Switching and Propagation Delay Times**
- **Low "OFF" Leakage Current**
- **Built-In "Break-Before-Make" Switching**
- **Logic-Level Translation to Enable 5V Logic to Accommodate ±5V Analog Signals**
- **Wide Operating Temperature Range . . . -55°C to 125°C**
- **HC Types**
 - 2V to 10V Operation
 - High Noise Immunity: $N_{IL} = 30\%$, $N_{IH} = 30\%$ of V_{CC} at $V_{CC} = 5V$
- **HCT Types**
 - Direct LSTTL Input Logic Compatibility, $V_{IL} = 0.8V$ (Max), $V_{IH} = 2V$ (Min)
 - CMOS Input Compatibility, $I_I \leq 1\mu A$ at V_{OL} , V_{OH}

Description

The 'HC4316 and CD74HCT4316 contain four independent digitally controlled analog switches that use silicon-gate CMOS technology to achieve operating speeds similar to LSTTL with the low power consumption of standard CMOS integrated circuits.

In addition these devices contain logic-level translation circuits that provide for analog signal switching of voltages between $\pm 5V$ via 5V logic. Each switch is turned on by a high-level voltage on its select input (S) when the common Enable (E) is Low. A High E disables all switches. The digital inputs can swing between V_{CC} and GND; the analog inputs/outputs can swing between V_{CC} as a positive limit and V_{EE} as a negative limit. Voltage ranges are shown in Figures 2 and 3.

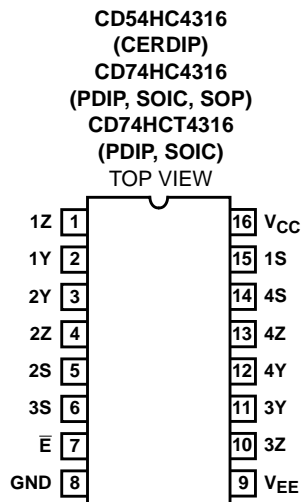
Ordering Information

PART NUMBER	TEMP. RANGE (°C)	PACKAGE
CD54HC4316F3A	-55 to 125	16 Ld CERDIP
CD74HC4316E	-55 to 125	16 Ld PDIP
CD74HC4316M	-55 to 125	16 Ld SOIC
CD74HC4316NSR	-55 to 125	16 Ld SOP
CD74HCT4316E	-55 to 125	16 Ld PDIP
CD74HCT4316M	-55 to 125	16 Ld SOIC

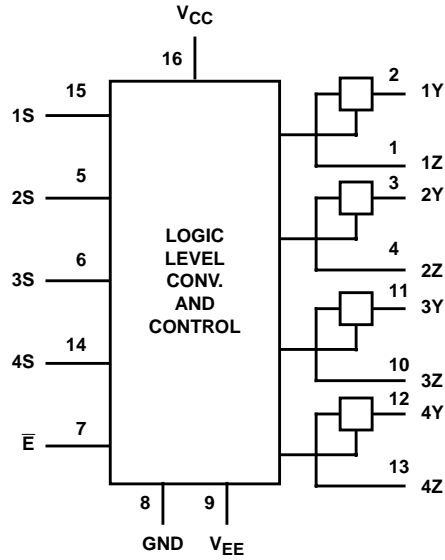
NOTES:

1. When ordering, use the entire part number. Add the suffix 96 to obtain the variant in the tape and reel.
2. Wafer and die is available which meets all electrical specifications. Please contact your local TI sales office or customer service for ordering information.

Pinout



Functional Diagram



TRUTH TABLE

INPUTS		SWITCH
\bar{E}	S	
L	L	OFF
L	H	ON
H	X	OFF

NOTE:
 H = High Level Voltage
 L = Low Level Voltage
 X = Don't Care

Logic Diagram

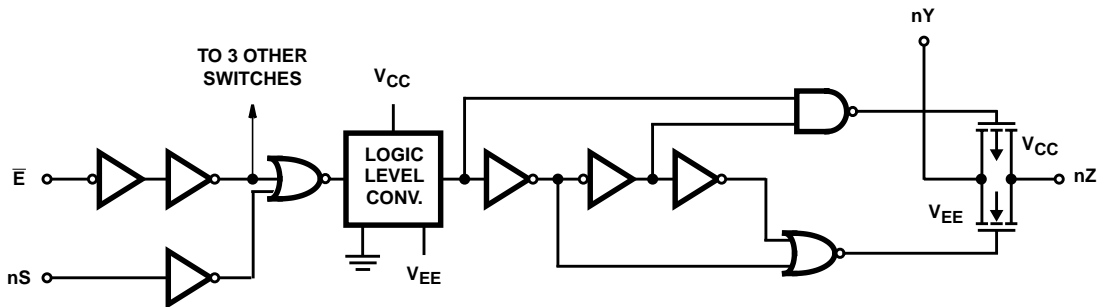


FIGURE 1. ONE SWITCH

CD54/74HC4316, CD74HCT4316

Absolute Maximum Ratings

DC Supply Voltage, V_{CC}	-0.5V to 7V
DC Supply Voltage, $V_{CC} - V_{EE}$	-0.5V to 10.5V
DC Supply Voltage, V_{EE}	0.5V to -7V
DC Input Diode Current, I_{IK}	
For $V_I < -0.5V$ or $V_I > V_{CC} + 0.5V$	$\pm 20mA$
DC Switch Diode Current, I_{OK}	
For $V_I < V_{EE} - 0.5V$ or $V_I < V_{CC} + 0.5V$	$\pm 25mA$
DC Switch Diode Current	
For $V_I > V_{EE} - 0.5V$ or $V_I < V_{CC} + 0.5V$	$\pm 25mA$
DC Output Diode Current, I_{OK}	
For $V_O < -0.5V$ or $V_O > V_{CC} + 0.5V$	$\pm 20mA$
DC Output Source or Sink Current per Output Pin, I_O	
For $V_O > -0.5V$ or $V_O < V_{CC} + 0.5V$	$\pm 25mA$
DC V_{CC} or Ground Current, I_{CC}	$\pm 50mA$

Operating Conditions

Temperature Range, T_A	-55°C to 125°C
Supply Voltage Range, V_{CC}	
HC Types2V to 6V
HCT Types4.5V to 5.5V
Supply Voltage Range, $V_{CC} - V_{EE}$	
HC, HCT Types (Figure 2)2V to 10V
Supply Voltage Range, V_{EE}	
HC, HCT Types (Figure 3)	0V to -6V
DC Input or Output Voltage, V_I	GND to V_{CC}
Analog Switch I/O Voltage, V_{IS}	V_{EE} (Min)
.....	V_{CC} (Max)
Input Rise and Fall Time, t_r, t_f	
2V	1000ns (Max)
4.5V	500ns (Max)
6V	400ns (Max)

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

NOTE:

- The package thermal impedance is calculated in accordance with JESD 51-7.

Thermal Information

Package Thermal Impedance, θ_{JA} (see Note 3):	
PDIP Package	67°C/W
SOIC Package	73°C/W
SOP Package	64°C/W
Maximum Junction Temperature (Plastic Package)	150°
Maximum Storage Temperature Range	-65°C to 150°
Maximum Lead Temperature (Soldering 10s)	300°
SOIC - Lead Tips Only	

Recommended Operating Area as a Function of Supply Voltage

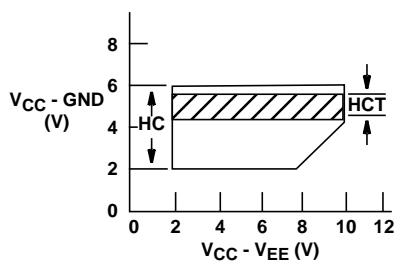


FIGURE 2.

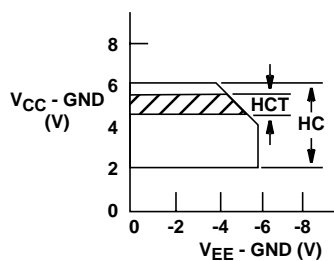


FIGURE 3.

CD54/74HC4316, CD74HCT4316

DC Electrical Specifications

PARAMETER	SYMBOL	TEST CONDITIONS				25°C			-40°C TO 85°C		-55°C TO 125°C		UNITS
		V _I (V)	V _{IS} (V)	V _{EE} (V)	V _{CC} (V)	MIN	TYP	MAX	MIN	MAX	MIN	MAX	
HC TYPES													
High Level Input Voltage	V _{IH}	-	-	-	2	1.5	-	-	1.5	-	1.5	-	V
					4.5	3.15	-	-	3.15	-	3.15	-	V
					6	4.2	-	-	4.2	-	4.2	-	V
Low Level Input Voltage	V _{IL}	-	-	-	2	-	-	0.5	-	0.5	-	0.5	V
					4.5	-	-	1.35	-	1.35	-	1.35	V
					6	-	-	1.8	-	1.8	-	1.8	V
“ON” Resistance I _O = 1mA Figure 4, 5	R _{ON}	V _{IH} or V _{IL}	V _{CC} or V _{EE}	0	4.5	-	45	180	-	225	-	270	Ω
				0	6	-	35	160	-	200	-	240	Ω
				-4.5	4.5	-	30	135	-	170	-	205	Ω
			V _{CC} to V _{EE}	0	4.5	-	85	320	-	400	-	480	Ω
				0	6	-	55	240	-	300	-	360	Ω
				-4.5	4.5	-	35	170	-	215	-	255	Ω
Maximum “ON” Resistance Between Any Two Channels	ΔR _{ON}	-	-	0	4.5	-	10	-	-	-	-	-	Ω
				0	6	-	8.5	-	-	-	-	-	Ω
				-4.5	4.5	-	5	-	-	-	-	-	Ω
Switch Off Leakage Current	I _{IZ}	V _{IH} or V _{IL}	V _{CC} - V _{EE}	0	6	-	-	±0.1	-	±1	-	±1	μA
				-5	5	-	-	±0.1	-	±1	-	±1	μA
Control Input Leakage Current	I _{IL}	V _{CC} or GND	-	0	6	-	-	±0.1	-	±1	-	±1	μA
Quiescent Device Current I _O = 0	I _{CC}	V _{CC} or GND	When V _{IS} = V _{EE} , V _{OS} = V _{CC}	0	6	-	-	8	-	80	-	160	μA
				-5	5	-	-	16	-	160	-	320	μA
When V _{IS} = V _{CC} , V _{OS} = V _{EE}				0	6	-	-	8	-	80	-	160	μA
				-5	5	-	-	16	-	160	-	320	μA
HCT TYPES													
High Level Input Voltage	V _{IH}	-	-	-	4.5 to 5.5	2	-	-	2	-	2	-	V
Low Level Input Voltage	V _{IL}	-	-	-	4.5 to 5.5	-	-	0.8	-	0.8	-	0.8	V
“ON” Resistance I _O = 1mA Figure 4, 5	R _{ON}	V _{IH} or V _{IL}	V _{CC} or V _{EE}	0	4.5	-	45	180	-	225	-	270	Ω
				-4.5	4.5	-	30	135	-	170	-	205	Ω
			V _{CC} to V _{EE}	0	4.5	-	85	320	-	400	-	480	Ω
				-4.5	4.5	-	35	170	-	215	-	255	Ω
Maximum “ON” Resistance Between Any Two Channels	ΔR _{ON}	-	-	0	4.5	-	10	-	-	-	-	-	Ω
				-4.5	4.5	-	5	-	-	-	-	-	Ω
Switch Off Leakage Current	I _{IZ}	V _{IH} or V _{IL}	V _{CC} - V _{EE}	0	6	-	-	±0.1	-	±1	-	±1	μA
				-5	5	-	-	±0.1	-	±1	-	±1	μA

CD54/74HC4316, CD74HCT4316

DC Electrical Specifications (Continued)

PARAMETER	SYMBOL	TEST CONDITIONS				25°C			-40°C TO 85°C		-55°C TO 125°C		UNITS
		V _I (V)	V _{IS} (V)	V _{EE} (V)	V _{CC} (V)	MIN	TYP	MAX	MIN	MAX	MIN	MAX	
Control Input Leakage Current	I _I	V _{CC} or GND	-	0	5.5	-	-	±0.1	-	±1	-	±1	μA
Quiescent Device Current I _O = 0	I _{CC}	Any Voltage Between V _{CC} and GND	When V _{IS} = V _{EE} , V _{OS} = V _{CC}	0	5.5	-	-	8	-	80	-	160	μA
			When V _{IS} = V _{CC} , V _{OS} = V _{EE}	-4.5	5.5	-	-	16	-	160	-	320	μA
Additional Quiescent Device Current Per Input Pin: 1 Unit Load	ΔI _{CC}	V _{CC} -2.1	-	-	4.5 to 5.5	-	100	360	-	450	-	490	μA

NOTE: For dual-supply systems theoretical worst case (V_I = 2.4V, V_{CC} = 5.5V) specification is 1.8mA.

HCT Input Loading Table

INPUT	UNIT LOADS
All	0.5

NOTE: Unit Load is ΔI_{CC} limit specified in DC Electrical Table, e.g., 360μA max at 25°C.

Switching Specifications Input t_r, t_f = 6ns

PARAMETER	SYMBOL	TEST CONDITIONS	V _{EE} (V)	V _{CC} (V)	25°C			-40°C TO 85°C		-55°C TO 125°C		UNITS
					MIN	TYP	MAX	MIN	MAX	MIN	MAX	
HC TYPES												
Propagation Delay, Switch In to Out	t _{PLH} , t _{PHL}	C _L = 50pF	0	2	-	-	60	-	75	-	90	ns
			0	4.5	-	-	12	-	15	-	18	ns
			0	6	-	-	10	-	13	-	15	ns
			-4.5	4.5	-	-	8	-	10	-	12	ns
Turn "ON" Time \bar{E} to Out	t _{pZH} , t _{pZL}	C _L = 50pF	0	2	-	-	205	-	255	-	310	ns
			0	4.5	-	-	41	-	51	-	62	ns
			0	6	-	-	35	-	43	-	53	ns
			-4.5	4.5	-	-	37	-	47	-	56	ns
		C _L = 15pF	-	5	-	17	-	-	-	-	-	ns
Turn "ON" Time nS to Out	t _{pZH} , t _{pZL}	C _L = 50pF	0	2	-	-	175	-	220	-	265	ns
			0	4.5	-	-	35	-	44	-	53	ns
			0	6	-	-	30	-	37	-	45	ns
			-4.5	4.5	-	-	34	-	43	-	51	ns
		C _L = 15pF	-	5	-	14	-	-	-	-	-	ns
Turn "OFF" Time \bar{E} to Out	t _{pLZ} , t _{pHZ}	C _L = 50pF	0	2	-	-	205	-	255	-	310	ns
			0	4.5	-	-	41	-	51	-	62	ns
			0	6	-	-	35	-	43	-	53	ns
			-4.5	4.5	-	-	37	-	47	-	56	ns
		C _L = 15pF	-	5	-	17	-	-	-	-	-	ns

CD54/74HC4316, CD74HCT4316

Switching Specifications Input t_r , $t_f = 6\text{ns}$ (Continued)

PARAMETER	SYMBOL	TEST CONDITIONS	V_{EE} (V)	V_{CC} (V)	25°C			-40°C TO 85°C		-55°C TO 125°C		UNITS
					MIN	TYP	MAX	MIN	MAX	MIN	MAX	
Turn "OFF" Time nS to Out	t_{PLZ} , t_{PHZ}	$C_L = 50\text{pF}$	0	2	-	-	175	-	220	-	265	ns
			0	4.5	-	-	35	-	44	-	53	ns
			0	6	-	-	30	-	37	-	45	ns
			-4.5	4.5	-	-	34	-	43	-	51	ns
		$C_L = 15\text{pF}$	-	5	-	14	-	-	-	-	-	ns
Input (Control) Capacitance	C_I	-	-	-	-	10	-	10	-	10	pF	
Power Dissipation Capacitance (Notes 4, 5)	C_{PD}	-	-	5	-	42	-	-	-	-	pF	
HCT TYPES												
Propagation Delay, Switch In to Switch Out	t_{PLH} , t_{PHL}	$C_L = 50\text{pF}$	0	4.5	-	-	12	-	15	-	18	ns
			-4.5	4.5	-	-	8	-	10	-	12	ns
Turn "ON" Time \bar{E} to Out	t_{PZH}	$C_L = 50\text{pF}$	0	4.5	-	-	44	-	55	-	66	ns
			-4.5	4.5	-	-	42	-	53	-	63	ns
		$C_L = 15\text{pF}$	-	5	-	18	-	-	-	-	-	ns
	t_{PZL}	$C_L = 50\text{pF}$	0	4.5	-	-	56	-	70	-	85	ns
			-4.5	4.5	-	-	42	-	53	-	63	ns
		$C_L = 15\text{pF}$	-	5	-	24	-	-	-	-	-	ns
Turn "ON" Time nS to Out	t_{PZH}	$C_L = 50\text{pF}$	0	4.5	-	-	40	-	53	-	60	ns
			-4.5	4.5	-	-	34	-	43	-	51	ns
		$C_L = 15\text{pF}$	-	5	-	17	-	-	-	-	-	ns
	t_{PZL}	$C_L = 50\text{pF}$	0	4.5	-	-	50	-	63	-	75	ns
			-4.5	4.5	-	-	34	-	43	-	51	ns
		$C_L = 15\text{pF}$	-	5	-	18	-	-	-	-	-	ns
Turn "OFF" Time \bar{E} to Out	t_{PLZ}	$C_L = 50\text{pF}$	0	4.5	-	-	50	-	63	-	75	ns
			-4.5	4.5	-	-	46	-	58	-	69	ns
	t_{PLZ} , t_{PHZ}	$C_L = 15\text{pF}$	-	5	-	21	-	-	-	-	-	ns
			-	5	-	21	-	-	-	-	-	ns
Turn "OFF" Time nS to Out	t_{PHZ}	$C_L = 50\text{pF}$	0	4.5	-	-	44	-	55	-	66	ns
			-4.5	4.5	-	-	40	-	50	-	60	ns
	t_{PLZ} , t_{PHZ}	$C_L = 15\text{pF}$	-	5	-	18	-	-	-	-	-	ns
			-	5	-	18	-	-	-	-	-	ns
Input (Control) Capacitance	C_I	-	-	-	-	10	-	10	-	10	pF	
Power Dissipation Capacitance (Notes 4, 5)	C_{PD}	-	-	5	-	47	-	-	-	-	pF	

NOTES:

4. C_{PD} is used to determine the dynamic power consumption, per package.
5. $P_D = C_{PD} V_{CC}^2 f_i + \sum (C_L + C_S) V_{CC}^2 f_o$ where f_i = input frequency, f_o = output frequency, C_L = output load capacitance, C_S = switch capacitance, V_{CC} = supply voltage.

Analog Channel Specifications $T_A = 25^\circ\text{C}$

PARAMETER	TEST CONDITIONS	V_{CC} (V)	HC4316	CD74HCT4316	UNITS
Switch Frequency Response Bandwidth at -3dB Figure 6	Figure 9, Notes 6, 7	4.5	>200	>200	MHz
Crosstalk Between Any Two Switches Figure 7	Figure 8, Notes 7, 8	4.5	TBE	TBE	dB

CD54/74HC4316, CD74HCT4316

Analog Channel Specifications $T_A = 25^\circ\text{C}$ (Continued)

PARAMETER	TEST CONDITIONS	V_{CC} (V)	HC4316	CD74HCT4316	UNITS
Total Harmonic Distortion	1kHz, $V_{IS} = 4V_{P-P}$ Figure 10	4.5	0.078	0.078	%
	1kHz, $V_{IS} = 8V_{P-P}$ Figure 10	9	0.018	0.018	%
Control to Switch Feedthrough Noise	Figure 11	4.5	TBE	TBE	mV
		9	TBE	TBE	mV
Switch "OFF" Signal Feedthrough Figure 7	Figure 12, Notes 7, 8	4.5	-62	-62	dB
Switch Input Capacitance, C_S	-	-	5	5	pF

NOTES:

6. Adjust input level for 0dBm at output, $f = 1\text{MHz}$.
7. V_{IS} is centered at $V_{CC}/2$.
8. Adjust input for 0dBm at V_{IS} .

Typical Performance Curves

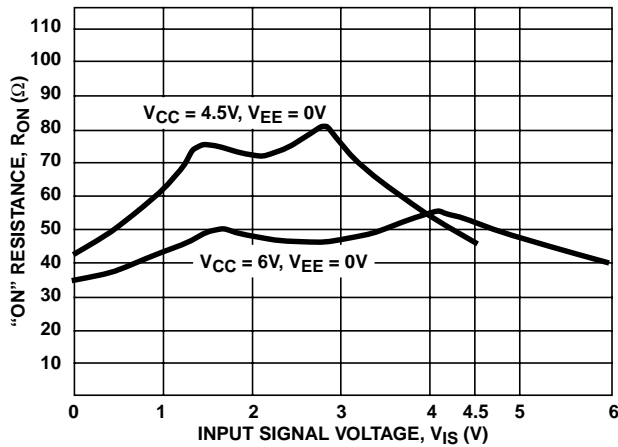


FIGURE 4. TYPICAL "ON" RESISTANCE vs INPUT SIGNAL VOLTAGE

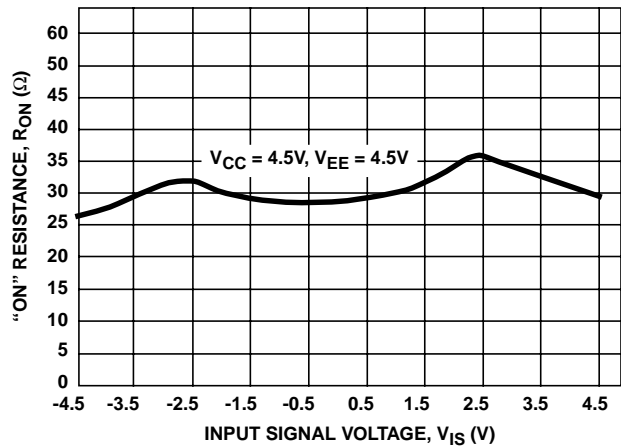


FIGURE 5. TYPICAL "ON" RESISTANCE vs INPUT SIGNAL VOLTAGE

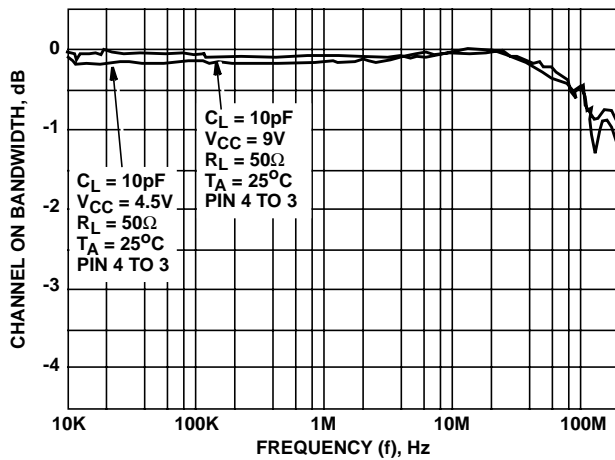


FIGURE 6. SWITCH FREQUENCY RESPONSE

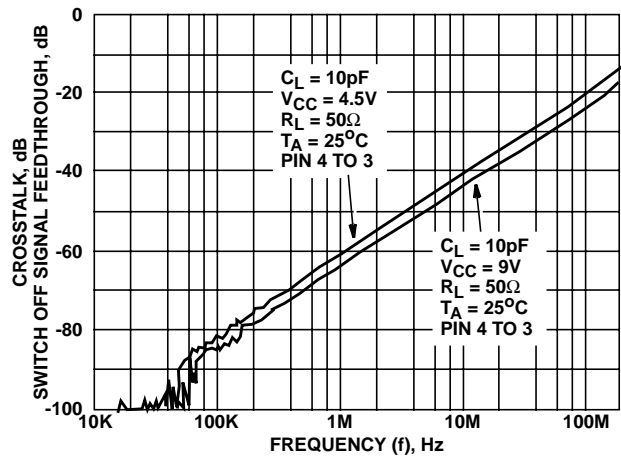


FIGURE 7. SWITCH-OFF SIGNAL FEEDTHROUGH AND CROSSTALK vs FREQUENCY

Analog Test Circuits

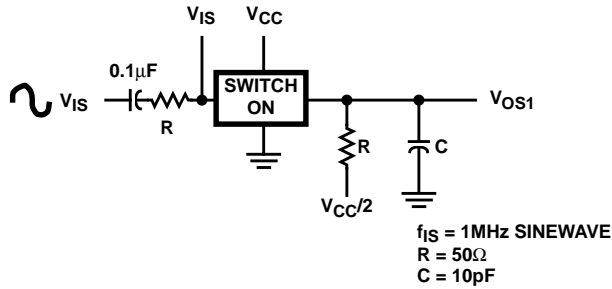


FIGURE 8. CROSTALK BETWEEN TWO SWITCHES TEST CIRCUIT

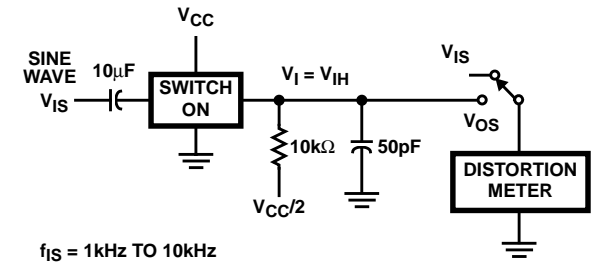
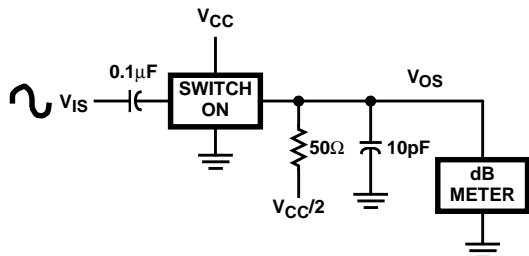
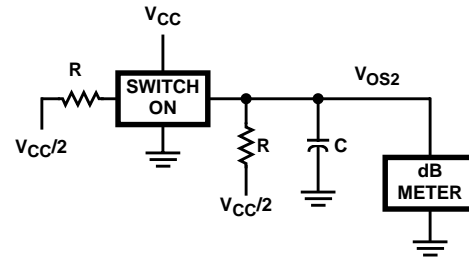


FIGURE 9. FREQUENCY RESPONSE TEST CIRCUIT

FIGURE 10. TOTAL HARMONIC DISTORTION TEST CIRCUIT

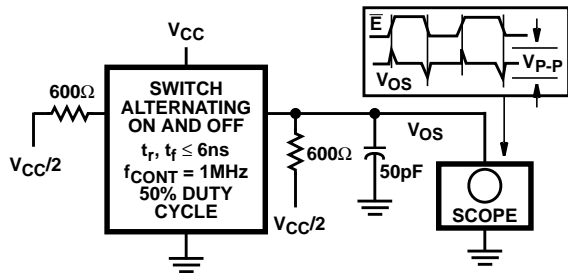


FIGURE 11. CONTROL-TO-SWITCH FEEDTHROUGH NOISE TEST CIRCUIT

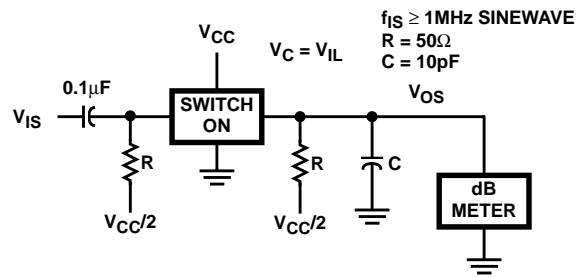


FIGURE 12. SWITCH OFF SIGNAL FEEDTHROUGH

Test Circuits and Waveforms

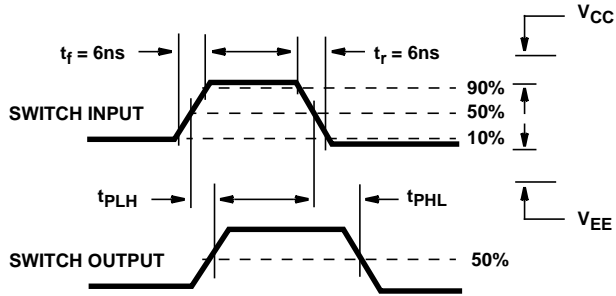


FIGURE 13. SWITCH PROPAGATION DELAY TIMES

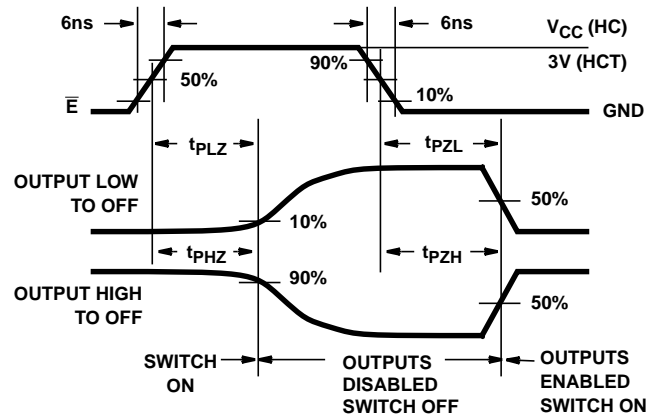


FIGURE 14. SWITCH TURN-ON AND TURN-OFF PROPAGATION DELAY TIMES WAVEFORMS

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