# CD54/74HC4016
# CD54/74HCT4016

## High-Speed CMOS Logic



Vcc = 14
GND = 7

92CS-3985I
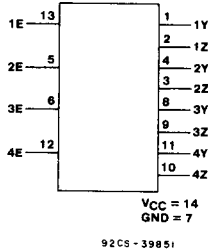
**FUNCTIONAL DIAGRAM**

## Quad Bilateral Switch

**Type Features:**
- Wide analog-input-voltage range: 0-10 V
- Low "ON" resistance: 45 Ω typ. @ $V_{CC}$=4.5 V
  35 Ω typ. @ $V_{CC}$=6 V
  30 Ω typ. @ $V_{CC}$=9 V
- Fast switching and propagation delay times
- Low "OFF" leakage current
- Built-in "Break-before-make" switching
- Suitable for Sample and Hold applications

The RCA CD54/74HC/HCT4016 contains 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.

Each switch has two input/output terminals (nY,nZ) and an active high enable input (nE). Current through the switch will not cause additional $V_{CC}$ current provided the analog voltage is maintained between $V_{CC}$ and Gnd.

The CD54HC4016 and CD54HCT4016 are supplied in 14-lead hermetic dual-in-line ceramic packages (F suffix). The CD74HC4016 and CD74HCT4016 are supplied in 14-lead dual-in-line plastic packages (E suffix) and in 14-lead dual-in-line surface-mount plastic packages (M suffix). Both types are also available in chip form (H suffix).

**Family Features:**
- Wide operating temperature range:
  CD74HC/HCT: –40 to +125° C
- CD54HC/CD74HC types:
  2 V to 10 V operation
  High noise immunity:
  $N_{IL}$ = 30%, $N_{IH}$ = 30% of $V_{CC}$; @ $V_{CC}$ = 5 V
- CD54HCT/CD74HCT types:
  Direct LSTTL input logic compatibility
  $V_{IL}$ = 0.8 V max., $V_{IH}$ = 2 V min.
  CMOS input compatibility
  $I_I \leq 1 \mu A$ @ $V_{OL}$, $V_{OH}$
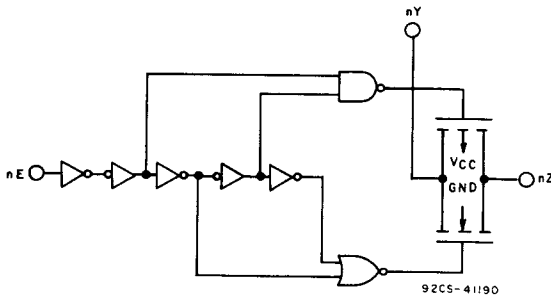- Alternate Source is Philips/Signetics



*Fig. 1 - Logic diagram.*

**TRUTH TABLE**

| INPUT nE | SWITCH |
|----------|--------|
| L | OFF |
| H | ON |

H = High Level Voltage
L = Low Level Voltage

# CD54/74HC4016
# CD54/74HCT4016

## MAXIMUM RATINGS, *Absolute-Maximum Values:*

DC SUPPLY-VOLTAGE ($V_{CC}$):
(Voltages referenced to ground)
HCT Types ........................................................................................................ –0.5 to +7 V
HC Types .......................................................................................................... –0.5 to +10.5 V
DC INPUT DIODE CURRENT, $I_{IK}$ (FOR $V_I < $ –0.5 V OR $V_I > V_{CC}$ +0.5 V) ............................................. ±20 mA
DC SWITCH DIODE CURRENT, $I_{OK}$ (FOR $V_O < $ –0.5 V OR $V_O > V_{CC}$ +0.5 V) ........................................... ±20 mA
DC SWITCH CURRENT, $I_O$ (FOR $V_I > $ –0.5 V OR $V_I < V_{CC}$ +0.5 V) .................................................. +25 mA
DC $V_{CC}$ OR GROUND CURRENT ($I_{CC}$) ............................................................................... ±50 mA
POWER DISSIPATION PER PACKAGE ($P_D$):
For $T_A$ = –40 to +100°C (PACKAGE TYPE E) ............................................................................. 500 mW
For $T_A$ = +100 to +125°C (PACKAGE TYPE E) ............................................... Derate Linearly at 8 mW/°C to 300 mW
For $T_A$ = –55 to +100°C (PACKAGE TYPE F, H) ........................................................................... 500 mW
For $T_A$ = +100 to +125°C (PACKAGE TYPE F, H) ............................................ Derate Linearly at 8 mW/°C to 300 mW
For $T_A$ = –40 to +70°C (PACKAGE TYPE M) .............................................................................. 400 mW
For $T_A$ = +70 to +125°C (PACKAGE TYPE M) ............................................... Derate Linearly at 6 mW/°C to 70 mW
OPERATING-TEMPERATURE RANGE ($T_A$):
PACKAGE TYPE F, H .......................................................................................... –55 to +125°C
PACKAGE TYPE E, M .......................................................................................... –40 to +125°C
STORAGE TEMPERATURE ($T_{stg}$) .......................................................................... –65 to +150°C
LEAD TEMPERATURE (DURING SOLDERING):
At distance 1/16 ± 1/32 in. (1.59 ± 0.79 mm) from case for 10 s max. ...................................................... +265°C
Unit inserted into a PC Board (min. thickness 1/16 in., 1.59 mm)
with solder contacting lead tips only ................................................................................... +300°C

```
        ┌───────∪───────┐
  1Y ─1 │               │ 14─ Vcc
  1Z ─2 │               │ 13─ 1E
  2Z ─3 │               │ 12─ 4E
  2Y ─4 │               │ 11─ 4Y
  2E ─5 │               │ 10─ 4Z
  3E ─6 │               │ 9 ─ 3Z
 GND ─7 │               │ 8 ─ 3Y
        └───────────────┘
          92CS-39852
```
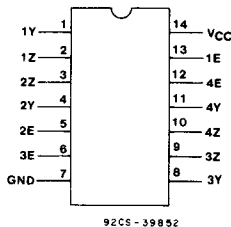
### TERMINAL ASSIGNMENT

## RECOMMENDED OPERATING CONDITIONS
**For maximum reliability, nominal operating conditions should be selected so that operation is always within the following ranges:**

| CHARACTERISTIC | LIMITS | | UNITS |
|---|---|---|---|
| | MIN. | MAX. | |
| Supply-Voltage Range (For $T_A$=Full Package-Temperature Range) $V_{CC}$:* | | | |
|     CD54/74HC Types | 2 | 10 | V |
|     CD54/74HCT Types | 4.5 | 5.5 | |
| DC Input Voltage, $V_C$, and Analog Switch Voltage, $V_{I/O}$ | 0 | $V_{CC}$ | V |
| Operating Temperature, $T_A$: | | | |
|     CD74 Types | –40 | +125 | °C |
|     CD54 Types | –55 | +125 | |
| Input Rise and Fall Times, $t_r, t_f$ (Control Inputs) | | | |
|     at 2 V | 0 | 1000 | |
|     at 4.5 V | 0 | 500 | |
|     at 6 V | 0 | 400 | ns |
|     at 9 V | 0 | 250 | |

*Unless otherwise specified, all voltages are referenced to Ground.

# CD54/74HC4016
# CD54/74HCT4016

## STATIC ELECTRICAL CHARACTERISTICS

| CHARAC-TERISTIC | TEST CONDITIONS LOGIC $V_I$ (V) | SWITCH $V_{IS}$ (V) | $V_{CC}$ (V) | 74HC/54HC +25°C Min | Typ | Max | 74HC -40/+85°C Min | Max | 54HC -55/+125°C / 74HC -40/+125°C Min | Max | TEST CONDITIONS LOGIC $V_I$ (V) | SWITCH $V_{IS}$ (V) | $V_{CC}$ (V) | 74HCT/54HCT +25°C Min | Typ | Max | 74HCT -40/+85°C Min | Max | 54HCT -55/+125°C / 74HCT -40/+125°C Min | Max | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| High-Level Input Voltage $V_{IH}$ | | | 2 | 1.5 | — | — | 1.5 | — | 1.5 | — | — | — | 4.5 to 5.5 | 2 | — | — | 2 | — | 2 | — | V |
| | | | 4.5 | 3.15 | — | — | 3.15 | — | 3.15 | — | | | | | | | | | | | |
| | | | 6 | 4.2 | — | — | 4.2 | — | 4.2 | — | | | | | | | | | | | |
| Low-Level Input Voltage $V_{IL}$ | | | 2 | — | — | 0.5 | — | 0.5 | — | 0.5 | — | — | 4.5 to 5.5 | — | — | 0.8 | — | 0.8 | — | 0.8 | V |
| | | | 4.5 | — | — | 1.35 | — | 1.35 | — | 1.35 | | | | | | | | | | | |
| | | | 6 | — | — | 1.8 | — | 1.8 | — | 1.8 | | | | | | | | | | | |
| "On" Resistance $R_{on}$ | $V_{IL}$ or $V_{IH}$ | $V_{CC}$ or Gnd | 4.5 | — | 45 | 180 | — | 225 | — | 270 | $V_{IL}$ or $V_{IH}$ | $V_{CC}$ or Gnd | 4.5 | — | 45 | 180 | — | 225 | — | 270 | Ω |
| | | | 6 | — | 35 | 160 | — | 200 | — | 240 | | | | — | — | — | — | — | — | — | |
| | | | 9 | — | 30 | 135 | — | 170 | — | 205 | | | | — | — | — | — | — | — | — | |
| $I_O = 1$ mA | $V_{IL}$ or $V_{IH}$ | $V_{CC}$ to Gnd | 4.5 | — | 85 | 320 | — | 400 | — | 480 | $V_{IL}$ or $V_{IH}$ | $V_{CC}$ to Gnd | 4.5 | — | 85 | 320 | — | 400 | — | 480 | Ω |
| | | | 6 | — | 55 | 240 | — | 300 | — | 360 | | | | — | — | — | — | — | — | — | |
| | | | 9 | — | 35 | 170 | — | 215 | — | 255 | | | | — | — | — | — | — | — | — | |
| Maximum "On" Resistance between any two switches $\Delta R_{on}$ | $V_{IL}$ or $V_{IH}$ | $V_{CC}$ to Gnd | 4.5 | — | 10 | — | — | — | — | — | $V_{IL}$ or $V_{IH}$ | $V_{CC}$ to Gnd | 4.5 | — | 10 | — | — | — | — | — | Ω |
| | | | 6 | — | 8.5 | — | — | — | — | — | | | | — | — | — | — | — | — | — | |
| Switch Off Leakage Current $I_{IZ}$ | En=Gnd | $V_{CC}$ or Gnd | 6 | — | — | ±0.1 | — | ±1 | — | ±1 | En=Gnd | $V_{CC}$ or Gnd | 5.5 | — | — | ±0.1 | — | ±1 | — | ±1 | |
| | | | 10 | — | — | ±0.1 | — | ±1 | — | ±1 | | | | — | — | — | — | — | — | — | |
| Logic Input Leakage Current $I_I$ | $V_{CC}$ or Gnd | — | 6 | — | — | ±0.1 | — | ±1 | — | ±1 | ** | — | 5.5 | — | — | ±0.1 | — | ±1 | — | ±1 | |
| Quiescent Device Current $I_{CC}$ $I_O = 0$ mA | $V_{CC}$ or Gnd | $V_{CC}$ or Gnd | 6 | — | — | 2 | — | 20 | — | 40 | $V_{CC}$ or Gnd | — | 5.5 | — | — | 2 | — | 20 | — | 40 | µA |
| | | | 10 | — | — | 16 | — | 160 | — | 320 | | | | — | — | — | — | — | — | — | |
| Additional Quiescent Device Current per input pin: 1 unit load $\Delta I_{CC}$* | — | — | | — | — | — | — | — | — | — | $V_{CC}-2.1$ | — | 4.5 to 5.5 | — | 100 | 360 | — | 450 | — | 490 | |

*For dual-supply systems theoretical worst case ($V_I$ = 2.4 V, $V_{CC}$ = 5.5 V) specification is 1.8 mA.
**Any voltage between $V_{CC}$ and Gnd.

### HCT Input Loading Table

| Input | Unit Loads* |
|---|---|
| E | 1 |

*Unit Load is $\Delta I_{CC}$ limit specified in Static Characteristics Chart, e.g., 360 µA max. @ 25°C.

**SWITCHING CHARACTERISTICS** ($V_{CC}$=5 V, $T_A$=25° C, Input $t_r, t_f$=6 ns)

| CHARACTERISTIC | | $C_L$ (pF) | TYPICAL VALUES | | UNITS |
|---|---|---|---|---|---|
| | | | HC | HCT | |
| Propagation Delay Time: | | | | | |
| Switch In to Switch Out | $t_{PLH}, t_{PHL}$ | | 4 | 4 | |
| Switch Turn Off | | | | | |
| E to Out | $t_{PLZ}, t_{PHZ}$ | 15 | 12 | 14 | ns |
| Switch Turn On | $t_{PZH}$ | | 16 | 14 | |
| $\overline{E}$ to Out | $t_{PZL}$ | | 16 | 22 | |
| Power Dissipation Capacitance* | $C_{PD}$ | — | 12 | 12 | pF |

*$C_{PD}$ is used to determine the dynamic power consumption, per package.

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

$f_i$ = input frequency

$f_o$ = output frequency

$C_L$ = output load capacitance

$C_S$ = switch capacitance

$V_{CC}$ = supply voltage.

**SWITCHING CHARACTERISTICS** ($C_L$=50 pF, Input $t_r, t_f$=6 ns)

| CHARACTERISTIC | | $V_{CC}$ | LIMITS | | | | | | | | | | | | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 25° C | | | | −40° C to +85° C | | | | −55° C to +125° C | | | | |
| | | | HC | | HCT | | 74HC | | 74HCT | | 54HC | | 54HCT | | |
| | | | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | |
| Propagation Delay Time | $t_{PLH}$ | 2 | — | 60 | — | — | — | 75 | — | — | — | 90 | — | — | |
| Switch In to Out | $t_{PHL}$ | 4.5 | — | 12 | — | 12 | — | 15 | — | 15 | — | 18 | — | 18 | |
| | | 6 | — | 10 | — | — | — | 13 | — | — | — | 15 | — | — | |
| | | 9 | — | 8 | — | — | — | 10 | — | — | — | 12 | — | — | |
| Switch Turn-On | | 2 | — | 190 | — | — | — | 240 | — | — | — | 285 | — | — | |
| En to Out | | 4.5 | — | 38 | — | 35 | — | 48 | — | 44 | — | 57 | — | 53 | |
| | $t_{PZH}$ | 6 | — | 32 | — | — | — | 41 | — | — | — | 48 | — | — | |
| | | 9 | — | 28 | — | — | — | 35 | — | — | — | 42 | — | — | ns |
| | | 2 | — | 190 | — | — | — | 240 | — | — | — | 285 | — | — | |
| | $t_{PZL}$ | 4.5 | — | 38 | — | 52 | — | 48 | — | 65 | — | 57 | — | 73 | |
| | | 6 | — | 32 | — | — | — | 41 | — | — | — | 48 | — | — | |
| | | 9 | — | 28 | — | — | — | 35 | — | — | — | 42 | — | — | |
| Switch Turn-Off | | 2 | — | 145 | — | — | — | 180 | — | — | — | 220 | — | — | |
| En to Out | $t_{PHZ}$ | 4.5 | — | 29 | — | 35 | — | 36 | — | 44 | — | 44 | — | 53 | |
| | $t_{PLZ}$ | 6 | — | 25 | — | — | — | 31 | — | — | — | 38 | — | — | |
| | | 9 | — | 22 | — | — | — | 28 | — | — | — | 33 | — | — | |
| Input (Control) | $C_I$ | — | — | 10 | — | 10 | — | 10 | — | 10 | — | 10 | — | 10 | pF |
| Capacitance | | | | | | | | | | | | | | | |

# CD54/74HC4016
# CD54/74HCT4016

## ANALOG CHANNEL CHARACTERISTICS - Typical Values at T$_A$ = 25° C

| CHARACTERISTIC | | TEST CONDITIONS | V$_{CC}$ V | HC | HCT | UNITS |
|---|---|---|---|---|---|---|
| Switch Frequency Response Bandwidth at –3 dB (Fig. 13) | | Fig. 4 Notes 1 and 2 | 4.5 | >200 | >200 | MHz |
| Crosstalk Between Any Two Switches (Fig. 14) | | Fig. 5 Notes 2 and 3 | 4.5 | TBE | TBE | dB |
| Total Harmonic Distortion | | 1 kHz, V$_{IS}$=4 V$_{P-P}$ Fig. 6 V$_{IS}$=8 V$_{P-P}$ | 4/5 9 | 0.078 0.018 | 0.078 0.018 | % |
| Control to Switch Feedthrough Noise | | Fig. 7 | 4.5 9 | TBE TBE | TBE TBE | mV |
| Switch "OFF" Signal Feedthrough (Fig. 14) | | Fig. 8 Notes 2 and 3 | 4.5 | –62 | –62 | dB |
| Switch Input Capacitance | C$_S$ | — | — | 5 | 5 | pF |

Notes:

1. Adjust input level for 0 dBm at output, f = 1 MHz.
2. V$_{IS}$ is centered at V$_{CC}$/2.
3. Adjust input for 0 dBm at V$_{IS}$.
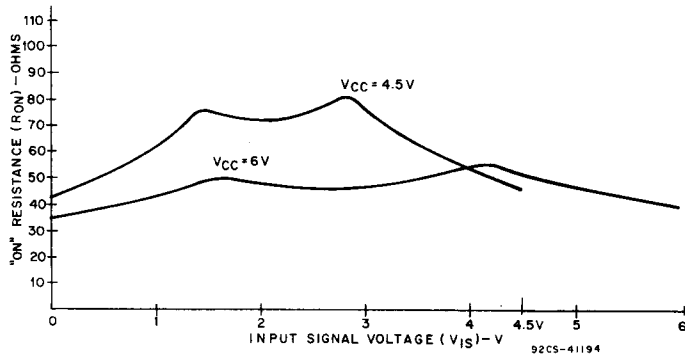
Fig. 2 - Typical "ON" resistance vs. input signal voltage.

Fig. 3 - Typical "ON" resistance vs. input signal voltage.

## ANALOG TEST CIRCUITS

Fig. 4 - Frequency response test circuit.
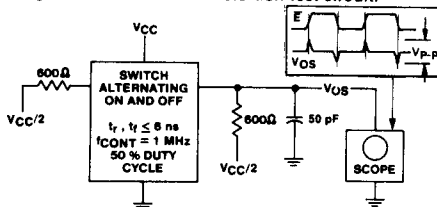
Fig. 6 - Total harmonic distortion test circuit.

Fig. 7 - Control-to-switch feedthrough noise test circuit.
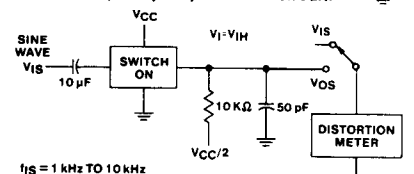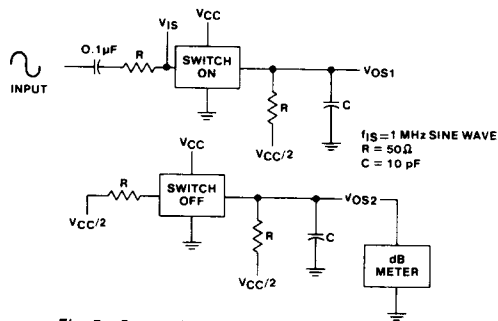
Fig. 5 - Crosstalk between two switches test circuit.
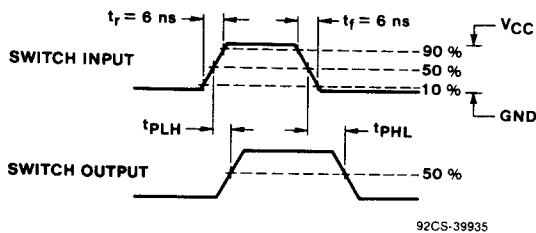
Fig. 8 - Switch off signal feedthrough.
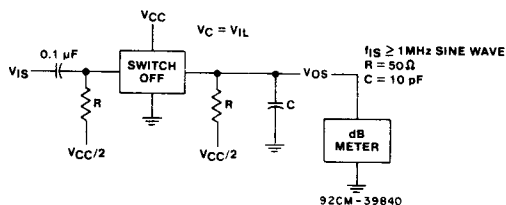
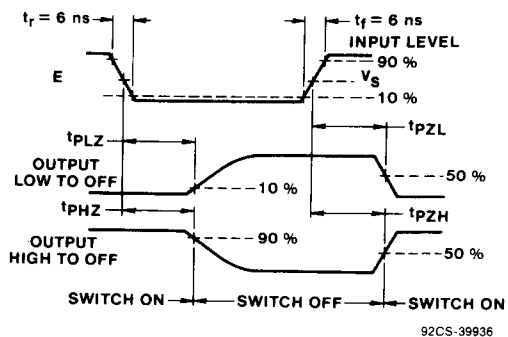Fig. 9 - Switch propagation - delay times waveforms.

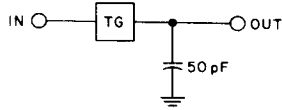Fig. 10 - Switch turn-on and turn-off propagation delay times waveforms.

|  | 54/74HC | 54/74HCT |
|---|---|---|
| Input Level | $V_{CC}$ | 3 V |
| Switching Voltage, $V_s$ | 50% $V_{CC}$ | 1.3 V |

# CD54/74HC4016
# CD54/74HCT4016

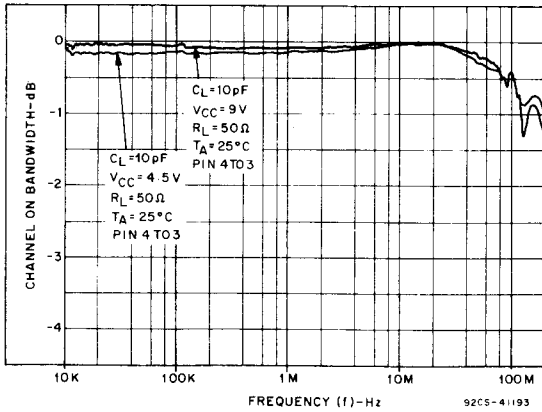GND FOR $t_{PLZ}$ AND $t_{PZL}$ } IN○─┤TG├─ $R_L = 1 k\Omega$ ─○OUT { $V_{CC}$ FOR $t_{PLZ}$ AND $t_{PZL}$
$V_{CC}$ FOR $t_{PHZ}$ AND $t_{PZH}$                            $C_L$ 50 pF            GND FOR $t_{PHZ}$ AND $t_{PZH}$
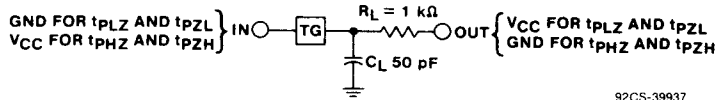
92CS-39937

Fig. 11 - Switch on/off propagation delay time test circuit.

IN ○─┤TG├─○ OUT
50 pF
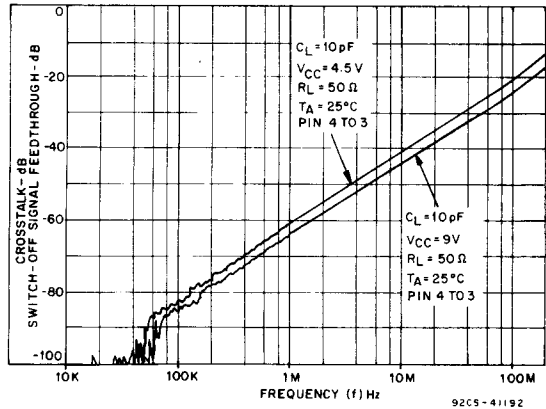
92CS-38835

Fig. 12 - Switch-in to switch-out propagation delay time test circuit.



Fig. 13 - Switch frequency response.

Fig. 14 - Switch-off signal feedthrough and crosstalk vs. frequency.