

CD74HC40105, CD74HCT40105

High Speed CMOS Logic 4-Bit x 16-Word FIFO Register

Features

- Independent Asynchronous Inputs and Outputs
- Expandable in Either Direction
- Reset Capability
- Status Indicators on Inputs and Outputs
- Three-State Outputs
- Shift-Out Independent of Three-State Control
- Fanout (Over Temperature Range)
 - Standard Outputs 10 LSTTL Loads
 - Bus Driver Outputs 15 LSTTL Loads
- Wide Operating Temperature Range . . . -55°C to 125°C
- Balanced Propagation Delay and Transition Times
- Significant Power Reduction Compared to LSTTL Logic ICs
- HC Types
 - 2V to 6V Operation
 - High Noise Immunity: $N_{IL} = 30\%$, $N_{IH} = 30\%$ of V_{CC} at $V_{CC} = 5V$
- HCT Types
 - 4.5V to 5.5V Operation
 - 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}

Applications

- Bit-Rate Smoothing
- CPU/Terminal Buffering
- Data Communications
- Peripheral Buffering
- Line Printer Input Buffers
- Auto-Dialers
- CRT Buffer Memories
- Radar Data Acquisition

Description

The Harris CD74HC40105 and CD74HCT40105 are high-speed silicon-gate CMOS devices that are compatible, except for "shift-out" circuitry, with the Harris CD40105B. They are low-power first-in-out (FIFO) "elastic" storage registers that can store 16 four-bit words. The 40105 is capable of handling input and output data at different shifting rates. This feature makes particularly useful as a buffer between asynchronous systems.

Each work position in the register is clocked by a control flip-flop, which stores a marker bit. A "1" signifies that the position's data is filled and a "0" denotes a vacancy in that position. The control flip-flop detects the state of the preceding flip-flop and communicates its own status to the succeeding flip-flop. When a control flip-flop is in the "0" state and sees a "1" in the preceding flip-flop, it generates a clock pulse that transfers data from the preceding four data latches into its own four data latches and resets the preceding flip-flop to "0". The first and last control flip-flops have buffered outputs. Since all empty locations "bubble" automatically to the input end, and all valid data ripple through to the output end, the status of the first control flip-flop (DATA-IN READY) indicates if the FIFO is full, and the status of the last flip-flop (DATA-OUT READY) indicates if the FIFO contains data. As the earliest data are removed from the bottom of the data stack (the output end), all data entered later will automatically propagate (ripple) toward the output.

Ordering Information

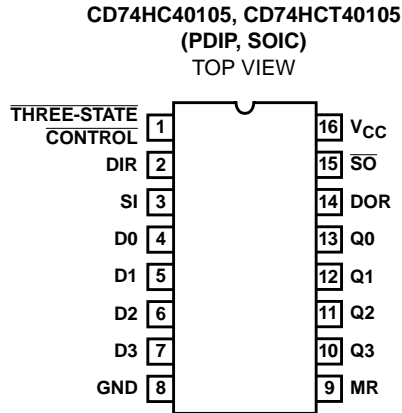
PART NUMBER	TEMP. RANGE (°C)	PACKAGE	PKG. NO.
CD74HC40105E	-55 to 125	16 Ld PDIP	E16.3
CD74HCT40105E	-55 to 125	16 Ld PDIP	E16.3
CD74HC40105M	-55 to 125	16 Ld SOIC	M16.15
CD74HCT40105M	-55 to 125	16 Ld SOIC	M16.15

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 for this part number is available which meets all electrical specifications. Please contact your local sales office or Harris customer service for ordering information.

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Pinout



Loading Data

Data can be entered whenever the DATA-IN READY (DIR) flag is high, by a low to high transition on the SHIFT-IN (SI) input. This input must go low momentarily before the next word is accepted by the FIFO. The DIR flag will go low momentarily, until the data have been transferred to the second location. The flag will remain low when all 16-word locations are filled with valid data, and further pulses on the SI input will be ignored until DIR goes high.

Unloading Data

As soon as the first word has rippled to the output, the data-out ready output (DOR) goes HIGH and data of the first word is available on the outputs. Data of other words can be removed by a negative-going transition on the shift-out input (\overline{SO}). This negative-going transition causes the DOR signal to go LOW while the next word moves to the output. As long as valid data is available in the FIFO, the DOR signal will go high again, signifying that the next word is ready at the output. When the FIFO is empty, DOR will remain LOW, and any further commands will be ignored until a "1" marker ripples down to the last control register and DOR goes HIGH. If during unloading SI is HIGH, (FIFO is full) data on the data input of the FIFO is entered in the first location.

Master Reset

A high on the MASTER RESET (MR) sets all the control logic marker bits to "0". DOR goes low and DIR goes high. The contents of the data register are not changed, only declared invalid, and will be superseded when the first word is loaded. Thus, MR does not clear data within the register but only the control logic. If the shift-in flag (SI) is HIGH during the master reset pulse, data present at the input (D0 to D3) are immediately moved into the first location upon completion of the reset process.

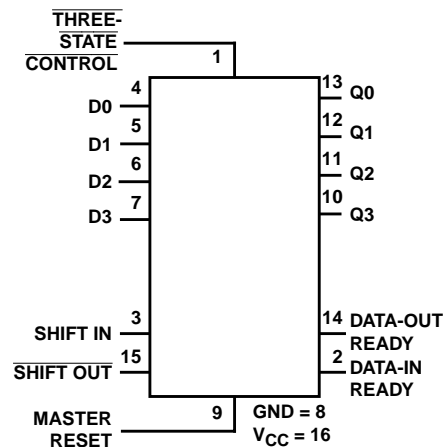
Three-State Outputs

In order to facilitate data busing, three-state outputs (Q0 to Q3) are provided on the data output lines, while the load condition of the register can be detected by the state of the DOR output. A HIGH on the three-state control flag (output enable input OE) forces the outputs into the high-impedance OFF-state mode. Note that the shift-out signal, unlike that in the Harris CD40105B, is independent of the three-state output control. In the CD40105B, the three-state control must not be shifted from High to Low when the shift-out signal is Low (data loss would occur). In the high-speed CMOS version this restriction has been eliminated.

Cascading

The 40105 can be cascaded to form longer registers simply by connecting the DIR to SO and DOR to SI. In the cascaded mode, a MASTER RESET pulse must be applied after the supply voltage is turned on. For words wider than four bits, the DIR and the DOR outputs must be gated together with AND gates. Their outputs drive the SI and SO inputs in parallel, if expanding is done in both directions (see Figures 12 and 13).

Functional Diagram



CD74HC40105, CD74HCT40105

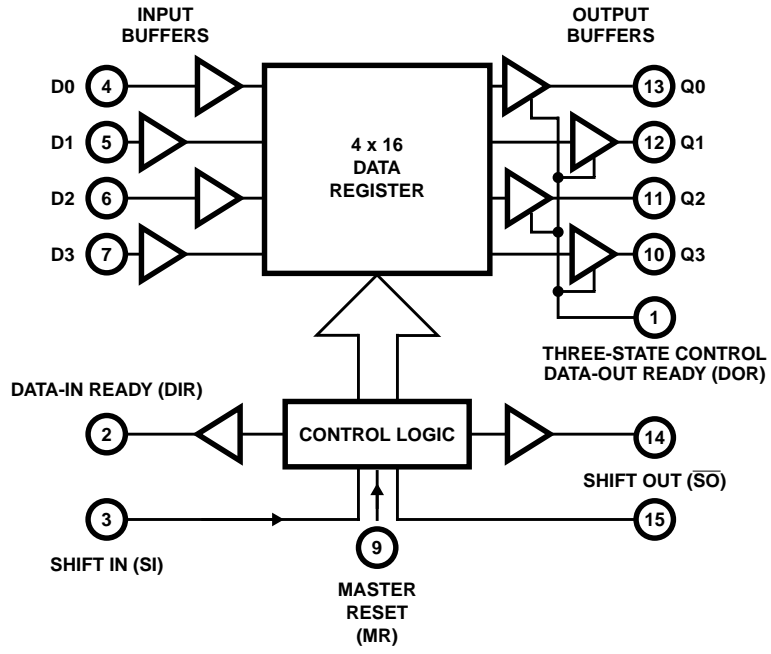
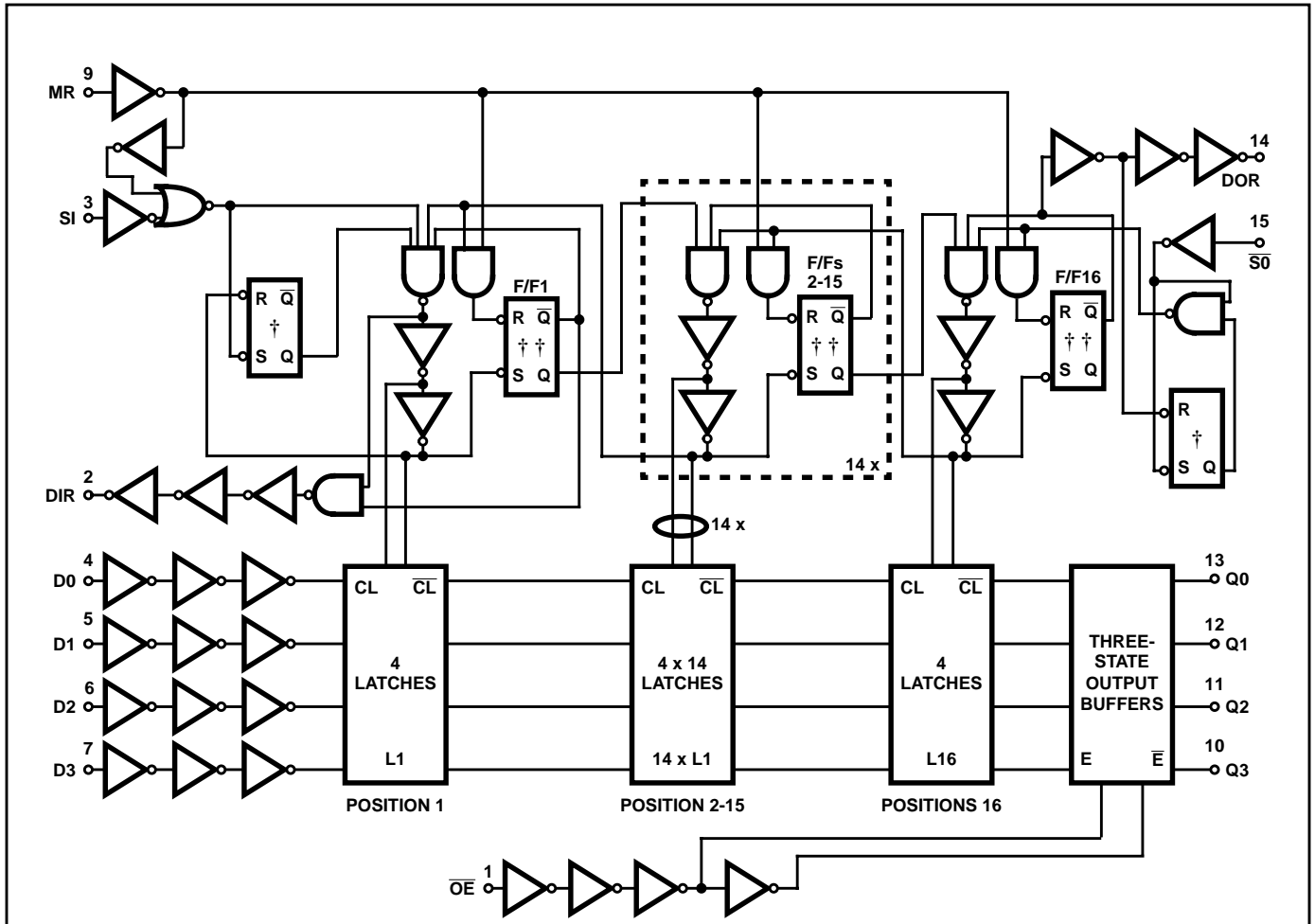


FIGURE 1. FUNCTIONAL BLOCK DIAGRAM

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† "S" overrides "R".
 †† "R" overrides "S".

FIGURE 2. LOGIC DIAGRAM

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Absolute Maximum Ratings

DC Supply Voltage, V_{CC}	-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 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}	$\pm 50mA$

Thermal Information

Thermal Resistance (Typical, Note 3)	θ_{JA} (°C/W)
PDIP Package	90
SOIC Package	160
Maximum Junction Temperature	150°C
Maximum Storage Temperature Range	-65°C to 150°C
Maximum Lead Temperature (Soldering 10s)	300°C (SOIC - Lead Tips Only)

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
DC Input or Output Voltage, V_I, V_O	0V to V_{CC}
Input Rise and Fall Time	
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:

- θ_{JA} is measured with the component mounted on an evaluation PC board in free air.

DC Electrical Specifications

PARAMETER	SYMBOL	TEST CONDITIONS		V_{CC} (V)	25°C			-40°C TO 85°C		-55°C TO 125°C		UNITS
		V_I (V)	I_O (mA)		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
High Level Output Voltage CMOS Loads	V_{OH}	V_{IH} or V_{IL}	-0.02	2	1.9	-	-	1.9	-	1.9	-	V
			-0.02	4.5	4.4	-	-	4.4	-	4.4	-	V
			-0.02	6	5.9	-	-	5.9	-	5.9	-	V
High Level Output Voltage TTL Loads	V_{OH}	V_{IH} or V_{IL}	-	-	-	-	-	-	-	-	-	V
			-4	4.5	3.98	-	-	3.84	-	3.7	-	V
			-5.2	6	5.48	-	-	5.34	-	5.2	-	V
Low Level Output Voltage CMOS Loads	V_{OL}	V_{IH} or V_{IL}	0.02	2	-	-	0.1	-	0.1	-	0.1	V
			0.02	4.5	-	-	0.1	-	0.1	-	0.1	V
			0.02	6	-	-	0.1	-	0.1	-	0.1	V
Low Level Output Voltage TTL Loads	V_{OL}	V_{IH} or V_{IL}	-	-	-	-	-	-	-	-	-	V
			4	4.5	-	-	0.26	-	0.33	-	0.4	V
			5.2	6	-	-	0.26	-	0.33	-	0.4	V
Input Leakage Current	I_I	V_{CC} or GND	-	6	-	-	± 0.1	-	± 1	-	± 1	μA
Quiescent Device Current	I_{CC}	V_{CC} or GND	0	6	-	-	8	-	80	-	160	μA

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DC Electrical Specifications (Continued)

PARAMETER	SYMBOL	TEST CONDITIONS		V _{CC} (V)	25°C			-40°C TO 85°C		-55°C TO 125°C		UNITS
		V _I (V)	I _O (mA)		MIN	TYP	MAX	MIN	MAX	MIN	MAX	
Three-State Leakage Current	I _{OZ}	V _{IL} or V _{IH}	V _O = V _{CC} or GND	6	-	-	±0.5	-	±5	-	±10	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
High Level Output Voltage CMOS Loads	V _{OH}	V _{IH} or V _{IL}	-0.02	4.5	4.4	-	-	4.4	-	4.4	-	V
High Level Output Voltage TTL Loads			-4	4.5	3.98	-	-	3.84	-	3.7	-	V
Low Level Output Voltage CMOS Loads	V _{OL}	V _{IH} or V _{IL}	0.02	4.5	-	-	0.1	-	0.1	-	0.1	V
Low Level Output Voltage TTL Loads			4	4.5	-	-	0.26	-	0.33	-	0.4	V
Input Leakage Current	I _I	V _{CC} and GND	0	5.5	-	-	±0.1	-	±1	-	±1	µA
Quiescent Device Current	I _{CC}	V _{CC} or GND	0	5.5	-	-	8	-	80	-	160	µA
Three-State Leakage Current	I _{OZ}	V _{IL} or V _{IH}	V _O = V _{CC} or GND	5.5	-	-	±0.5	-	±5	-	±10	µA
Additional Quiescent Device Current Per Input Pin: 1 Unit Load	ΔI _{CC} (Note)	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
OE	0.75
SI, SO	0.4
Dn	0.3
MR	1.5

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

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Prerequisite for Switching Specifications

PARAMETER	SYMBOL	V _{CC} (V)	25°C		-40°C TO 85°C		-55°C TO 125°C		UNITS
			MIN	MAX	MIN	MAX	MIN	MAX	
HC TYPES									
SI Pulse Width HIGH or LOW	t _W	2	80	-	100	-	120	-	ns
		4.5	16	-	20	-	24	-	ns
		6	14	-	17	-	20	-	ns
S _O Pulse Width HIGH or LOW	t _W	2	120	-	150	-	180	-	ns
		4.5	24	-	30	-	36	-	ns
		6	20	-	26	-	31	-	ns
DIR Pulse Width HIGH or LOW	t _W	2	200	-	250	-	300	-	ns
		4.5	40	-	50	-	60	-	ns
		6	34	-	43	-	51	-	ns
DOR Pulse Width HIGH or LOW	t _W	2	200	-	250	-	300	-	ns
		4.5	40	-	50	-	60	-	ns
		6	34	-	43	-	51	-	ns
MR Pulse Width HIGH	t _W	2	120	-	150	-	180	-	ns
		4.5	24	-	30	-	36	-	ns
		6	20	-	26	-	31	-	ns
Removal Time MR to SI	t _{REM}	2	50	-	65	-	75	-	ns
		4.5	10	-	13	-	15	-	ns
		6	9	-	11	-	13	-	ns
Set-Up Time Dn to SI	t _{SU}	2	5	-	5	-	5	-	ns
		4.5	5	-	5	-	5	-	ns
		6	5	-	5	-	5	-	ns
Hold Time Dn to SI	t _H	2	125	-	155	-	190	-	ns
		4.5	25	-	31	-	38	-	ns
		6	21	-	26	-	32	-	ns
Maximum Pulse Frequency SI, S _O	f _{MAX}	2	3	-	2	-	2	-	MHz
		4.5	15	-	12	-	10	-	MHz
		6	18	-	14	-	12	-	MHz
HCT TYPES									
SI Pulse Width HIGH or LOW	t _W	4.5	16	-	20	-	24	-	ns
S _O Pulse Width HIGH or LOW	t _W	4.5	16	-	20	-	24	-	ns
DIR Pulse Width HIGH or LOW	t _W	4.5	40	-	50	-	60	-	ns
DOR Pulse Width HIGH or LOW	t _W	4.5	40	-	50	-	60	-	ns
MR Pulse Width HIGH	t _W	4.5	24	-	30	-	36	-	ns
Removal Time MR to SI	t _{REM}	4.5	15	-	19	-	22	-	ns
Set-Up Time Dn to SI	t _{SU}	4.5	0	-	0	-	0	-	ns
Hold Time Dn to SI	t _H	4.5	25	-	31	-	38	-	ns
Maximum Pulse Frequency SI, S _O	f _{MAX}	4.5	15	-	12	-	10	-	MHz

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

PARAMETER	SYMBOL	TEST CONDITIONS	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 MR to DIR, DOR	t_{PHL}, t_{PLH}	$C_L = 50\text{pF}$	2	-	-	175	-	220	-	265	ns
		$C_L = 50\text{pF}$	4.5	-	-	35	-	44	-	53	ns
		$C_L = 15\text{pF}$	5	-	15	-	-	-	-	-	ns
		$C_L = 50\text{pF}$	6	-	-	30	-	37	-	45	ns
SI to DIR	t_{PHL}, t_{PLH}	$C_L = 50\text{pF}$	2	-	-	210	-	265	-	315	ns
		$C_L = 50\text{pF}$	4.5	-	-	42	-	53	-	63	ns
		$C_L = 15\text{pF}$	5	-	18	-	-	-	-	-	ns
		$C_L = 50\text{pF}$	6	-	-	36	-	45	-	54	ns
$\overline{S}\overline{O}$ to DOR	t_{PHL}, t_{PLH}	$C_L = 50\text{pF}$	2	-	-	210	-	265	-	315	ns
		$C_L = 50\text{pF}$	4.5	-	-	42	-	53	-	63	ns
		$C_L = 15\text{pF}$	5	-	18	-	-	-	-	-	ns
		$C_L = 50\text{pF}$	6	-	-	36	-	45	-	54	ns
$\overline{S}\overline{O}$ to Q _n	t_{PHL}, t_{PLH}	$C_L = 50\text{pF}$	2	-	-	400	-	500	-	600	ns
		$C_L = 50\text{pF}$	4.5	-	-	80	-	100	-	120	ns
		$C_L = 15\text{pF}$	5	-	35	-	-	-	-	-	ns
		$C_L = 50\text{pF}$	6	-	-	68	-	85	-	102	ns
Propagation Delay/Ripple thru Delay SI to DOR	t_{PLH}	$C_L = 50\text{pF}$	2	-	-	2000	-	2500	-	3000	ns
			4.5	-	-	400	-	500	-	600	ns
			6	-	-	340	-	425	-	510	ns
Propagation Delay/Ripple thru Delay $\overline{S}\overline{O}$ to DIR	t_{PLH}	$C_L = 50\text{pF}$	2	-	-	2500	-	3125	-	3750	ns
			4.5	-	-	500	-	625	-	750	ns
			6	-	-	425	-	532	-	638	ns
Propagation Delay/Ripple thru Delay SI to Q _n	t_{PLH}	$C_L = 50\text{pF}$	2	-	-	1500	-	1900	-	2250	ns
			4.5	-	-	300	-	380	-	450	ns
			6	-	-	260	-	330	-	380	ns
Three-State Output Enable OE to Q _n	t_{PZH}, t_{PZL}	$C_L = 50\text{pF}$	2	-	-	150	-	190	-	225	ns
			4.5	-	-	30	-	38	-	45	ns
			6	-	-	26	-	33	-	38	ns
Three-State Output Disabe OE to Q _n	t_{PHZ}, t_{PLZ}	$C_L = 50\text{pF}$	2	-	-	140	-	175	-	210	ns
			4.5	-	-	28	-	35	-	42	ns
			6	-	-	24	-	30	-	36	ns
Output Transition Time	t_{TLH}, t_{THL}	$C_L = 50\text{pF}$	2	-	-	75	-	95	-	110	ns
			4.5	-	-	15	-	19	-	22	ns
			6	-	-	13	-	16	-	19	ns
Maximum SI, $\overline{S}\overline{O}$ Frequency	f_{MAX}	$C_L = 15\text{pF}$	5	-	32	-	-	-	-	MHz	
Input Capacitance	C_{IN}	$C_L = 50\text{pF}$	-	-	-	10	-	10	-	10	pF
Power Dissipation Capacitance (Notes 4, 5)	C_{PD}	$C_L = 15\text{pF}$	5	-	83	-	-	-	-	-	pF

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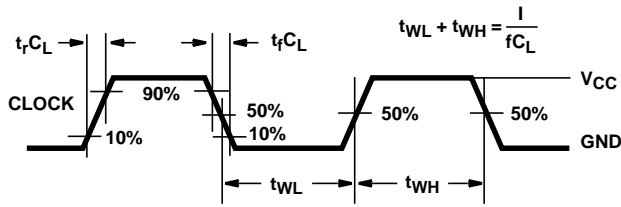
Switching Specifications Input $t_r, t_f = 6\text{ns}$ (Continued)

PARAMETER	SYMBOL	TEST CONDITIONS	V_{CC} (V)	25°C			-40°C TO 85°C		-55°C TO 125°C		UNITS
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
Three-State Output Capacitance	C_O	$C_L = 50\text{pF}$	-	-	-	15	-	15	-	15	pF
HCT TYPES											
Propagation Delay Time MR to DIR, DOR	t_{PLH}, t_{PHL}	$C_L = 50\text{pF}$	4.5	-	-	36	-	45	-	54	ns
		$C_L = 15\text{pF}$	5	-	15	-	-	-	-	-	ns
SI to DIR	t_{PLH}, t_{PHL}	$C_L = 50\text{pF}$	4.5	-	-	42	-	53	-	63	ns
		$C_L = 15\text{pF}$	5	-	18	-	-	-	-	-	ns
$\overline{S}O$ to DOR	t_{PLH}, t_{PHL}	$C_L = 50\text{pF}$	4.5	-	-	42	-	53	-	63	ns
		$C_L = 15\text{pF}$	5	-	18	-	-	-	-	-	ns
$\overline{S}O$ to Qn	t_{PLH}, t_{PHL}	$C_L = 50\text{pF}$	4.5	-	-	80	-	100	-	120	ns
		$C_L = 15\text{pF}$	5	-	35	-	-	-	-	-	ns
Propagation Delay/Ripple thru Delay SI to DOR	t_{PLH}	$C_L = 50\text{pF}$	4.5	-	-	400	-	500	-	600	ns
Propagation Delay/Ripple thru Delay $\overline{S}O$ to DIR	t_{PLH}	$C_L = 50\text{pF}$	4.5	-	-	500	-	625	-	750	ns
Propagation Delay/Ripple thru Delay SI to Qn	t_{PLH}	$C_L = 50\text{pF}$	4.5	-	-	300	-	380	-	450	ns
Three-State Output Enable $\overline{O}E$ to Qn	t_{PZH}, t_{PZL}	$C_L = 50\text{pF}$	4.5	-	-	35	-	44	-	53	ns
Three-State Output Disabe $\overline{O}E$ to Qn	t_{PHZ}, t_{PLZ}	$C_L = 50\text{pF}$	4.5	-	-	30	-	38	-	45	ns
Output Transition Time	t_{TLH}, t_{THL}	$C_L = 50\text{pF}$	4.5	-	-	15	-	19	-	22	ns
Maximum CP Frequency	f_{MAX}	$C_L = 15\text{pF}$	5	-	32	-	-	-	-	-	MHz
Input Capacitance	C_{IN}	$C_L = 50\text{pF}$	-	-	-	10	-	10	-	10	pF
Power Dissipation Capacitance (Notes 4, 5)	C_{PD}	$C_L = 15\text{pF}$	5	-	83	-	-	-	-	-	pF
Three-State Output Capacitance	C_O	$C_L = 50\text{pF}$	-	-	-	15	-	15	-	15	pF

NOTES:

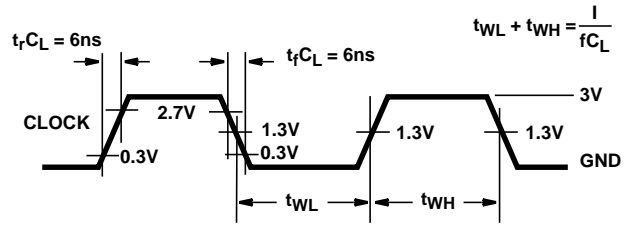
- C_{PD} is used to determine the dynamic power consumption, per package.
- $P_D = C_{PD} V_{CC}^2 f_i + \sum (C_L V_{CC}^2 f_o)$ where f_i = Input Frequency, f_o = Output Frequency, C_L = Output Load Capacitance, V_{CC} = Supply Voltage.

Test Circuits and Waveforms



NOTE: Outputs should be switching from 10% V_{CC} to 90% V_{CC} in accordance with device truth table. For f_{MAX} , input duty cycle = 50%.

FIGURE 3. HC CLOCK PULSE RISE AND FALL TIMES AND PULSE WIDTH



NOTE: Outputs should be switching from 10% V_{CC} to 90% V_{CC} in accordance with device truth table. For f_{MAX} , input duty cycle = 50%.

FIGURE 4. HCT CLOCK PULSE RISE AND FALL TIMES AND PULSE WIDTH

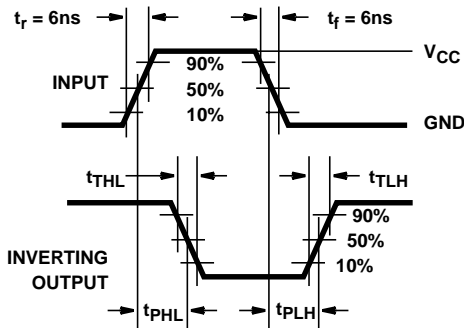


FIGURE 5. HC TRANSITION TIMES AND PROPAGATION DELAY TIMES, COMBINATION LOGIC

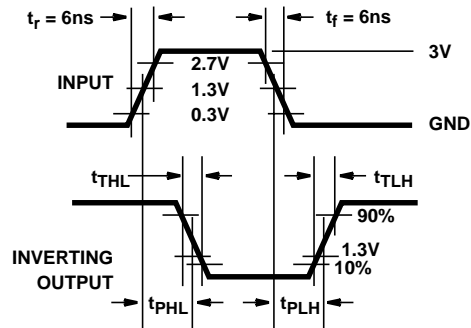


FIGURE 6. HCT TRANSITION TIMES AND PROPAGATION DELAY TIMES, COMBINATION LOGIC

Test Circuits and Waveforms (Continued)

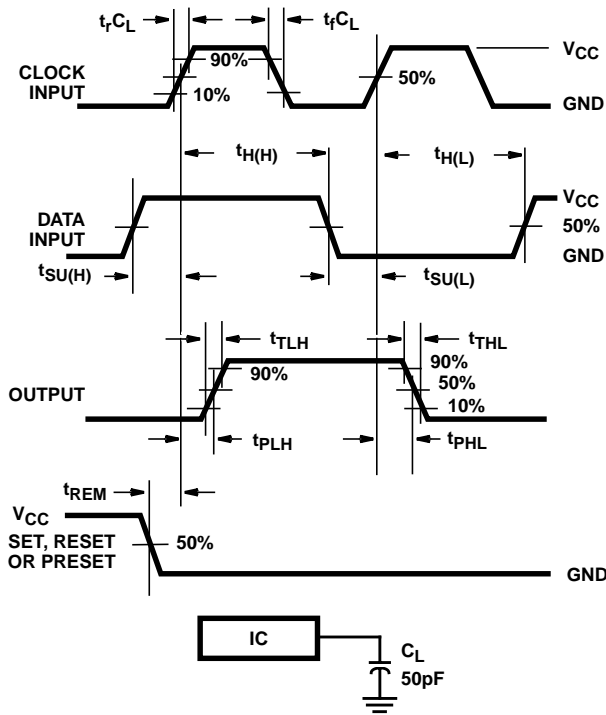


FIGURE 7. HC SETUP TIMES, HOLD TIMES, REMOVAL TIME, AND PROPAGATION DELAY TIMES FOR EDGE TRIGGERED SEQUENTIAL LOGIC CIRCUITS

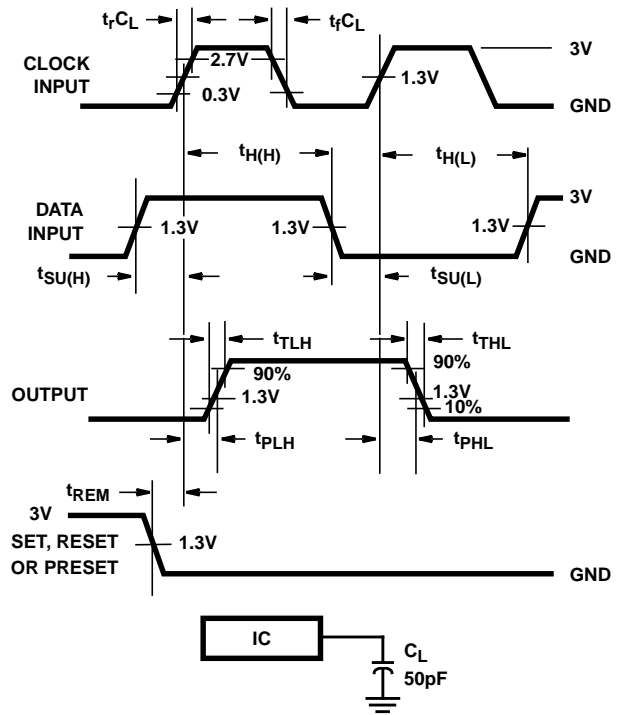


FIGURE 8. HCT SETUP TIMES, HOLD TIMES, REMOVAL TIME, AND PROPAGATION DELAY TIMES FOR EDGE TRIGGERED SEQUENTIAL LOGIC CIRCUITS

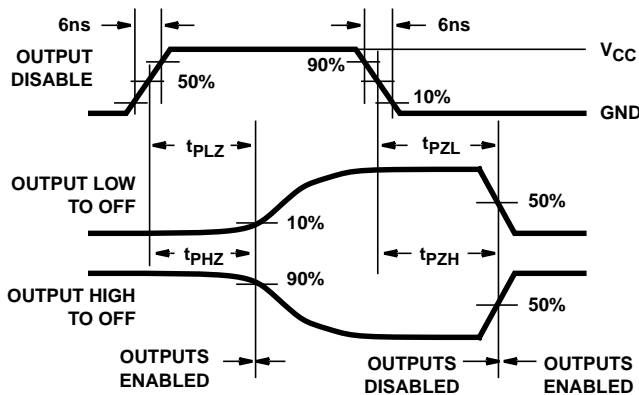


FIGURE 9. HC THREE-STATE PROPAGATION DELAY WAVEFORM

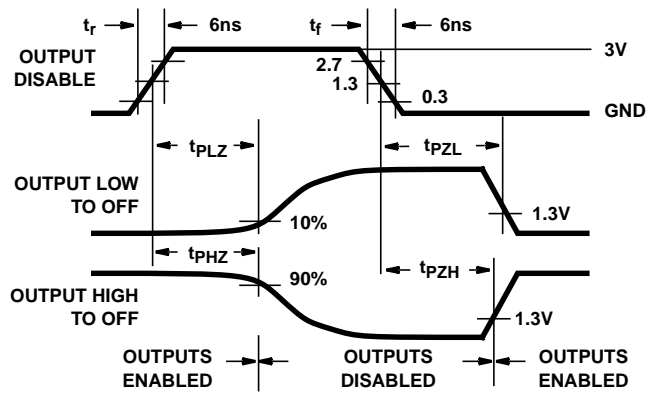
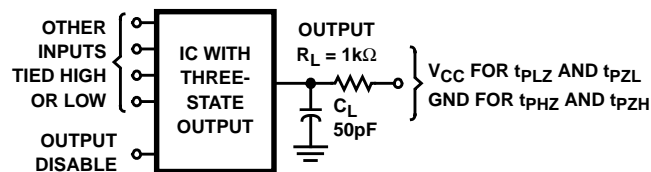
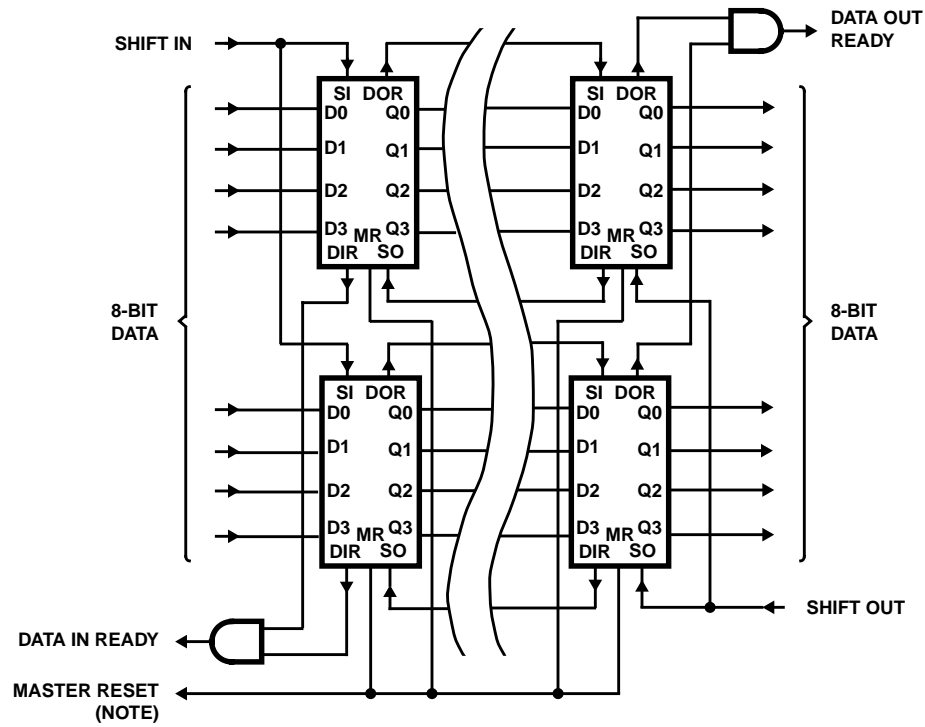


FIGURE 10. HCT THREE-STATE PROPAGATION DELAY WAVEFORM



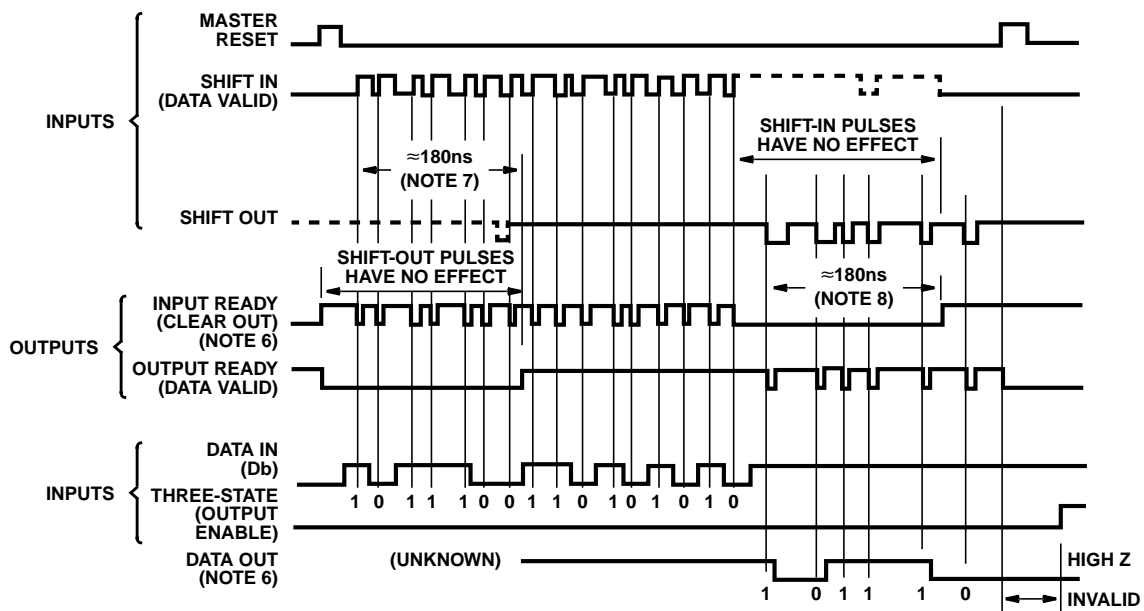
NOTE: Open drain waveforms t_{PZ_L} and t_{PZ_H} are the same as those for three-state shown on the left. The test circuit is Output $R_L = 1k\Omega$ V_{CC} , $C_L = 50pF$.

FIGURE 11. HC AND HCT THREE-STATE PROPAGATION DELAY TEST CIRCUIT



NOTE: Pulse must be applied for cascading by 16 N bits.

FIGURE 13. EXPANSION, 8-BITS WIDE BY 16 N-BITS LONG USING HC/HCT40105



NOTES:

6. Data valid goes to high level in advance of the data out by a maximum of 38ns at $V_{CC} = 4.5V$ for $C_L = 50pF$ and $T_A = 25^{\circ}C$.
7. At $V_{CC} = 4.5V$, ripple time from position 1 to position 16.
8. At $V_{CC} = 4.5V$, ripple time from position 16 to position 1.

FIGURE 14. TIMING DIAGRAM FOR THE CD74HC/HCT40105

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