

Radiation Hardened Synchronous 4-Bit Up/Down Counter

September 1995

Features

- 3 Micron Radiation Hardened CMOS SOS
- Total Dose 200K RAD (Si)
- SEP Effective LET No Upsets: $>100 \text{ MEV-cm}^2/\text{mg}$
- Single Event Upset (SEU) Immunity $< 2 \times 10^{-9}$ Errors/Bit-Day (Typ)
- Dose Rate Survivability: $>1 \times 10^{12}$ RAD (Si)/s
- Dose Rate Upset $>10^{10}$ RAD (Si)/s 20ns Pulse
- Latch-Up Free Under Any Conditions
- Fanout (Over Temperature Range)
 - Standard Outputs - 10 LSTTL Loads
- Military Temperature Range: -55°C to $+125^\circ\text{C}$
- Significant Power Reduction Compared to LSTTL ICs
- DC Operating Voltage Range: 4.5V to 5.5V
- LSTTL Input Compatibility
 - VIL = 0.8V Max
 - VIH = VCC/2 Min
- Input Current Levels $I_i \leq 5\mu\text{A}$ at VOL, VOH

Description

The Harris HCTS193MS is a Radiation Hardened 4-bit binary UP/DOWN synchronous counter.

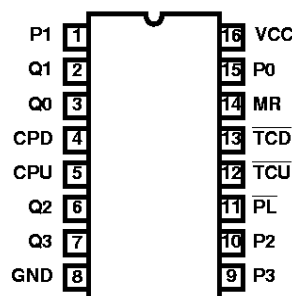
Presetting the counter to the number on the preset data inputs (P0 - P3) is accomplished by a low on the asynchronous parallel load input (PL). The counter is incremented on the low to high transition of the clock-up input (high on the clock-down), decremented on the low to high transition of the clock-down input (high on the clock-up). A high level on the MR input overrides any other input to clear the counter to zero. The Terminal Count Up goes low half a clock period before the zero count is reached and returns high at the maximum count. The Terminal Count Down mode goes low half a clock period before the maximum count and returns high at the maximum count.

The HCTS193MS utilizes advanced CMOS/SOS technology to achieve high-speed operation. This device is a member of radiation hardened, high-speed, CMOS/SOS Logic Family.

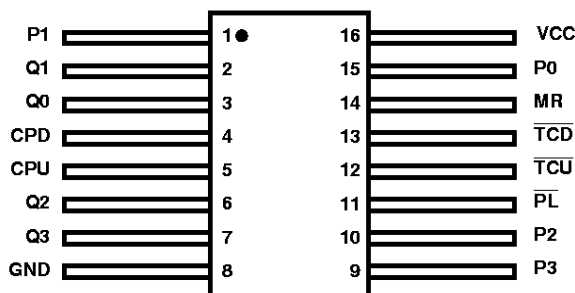
The HCTS193MS is supplied in a 16 lead Ceramic flatpack (K suffix) or a SBDIP Package (D suffix).

Pinouts

16 LEAD CERAMIC DUAL-IN-LINE
METAL SEAL PACKAGE (SBDIP)
MIL-STD-1835 CDIP2-T16
TOP VIEW



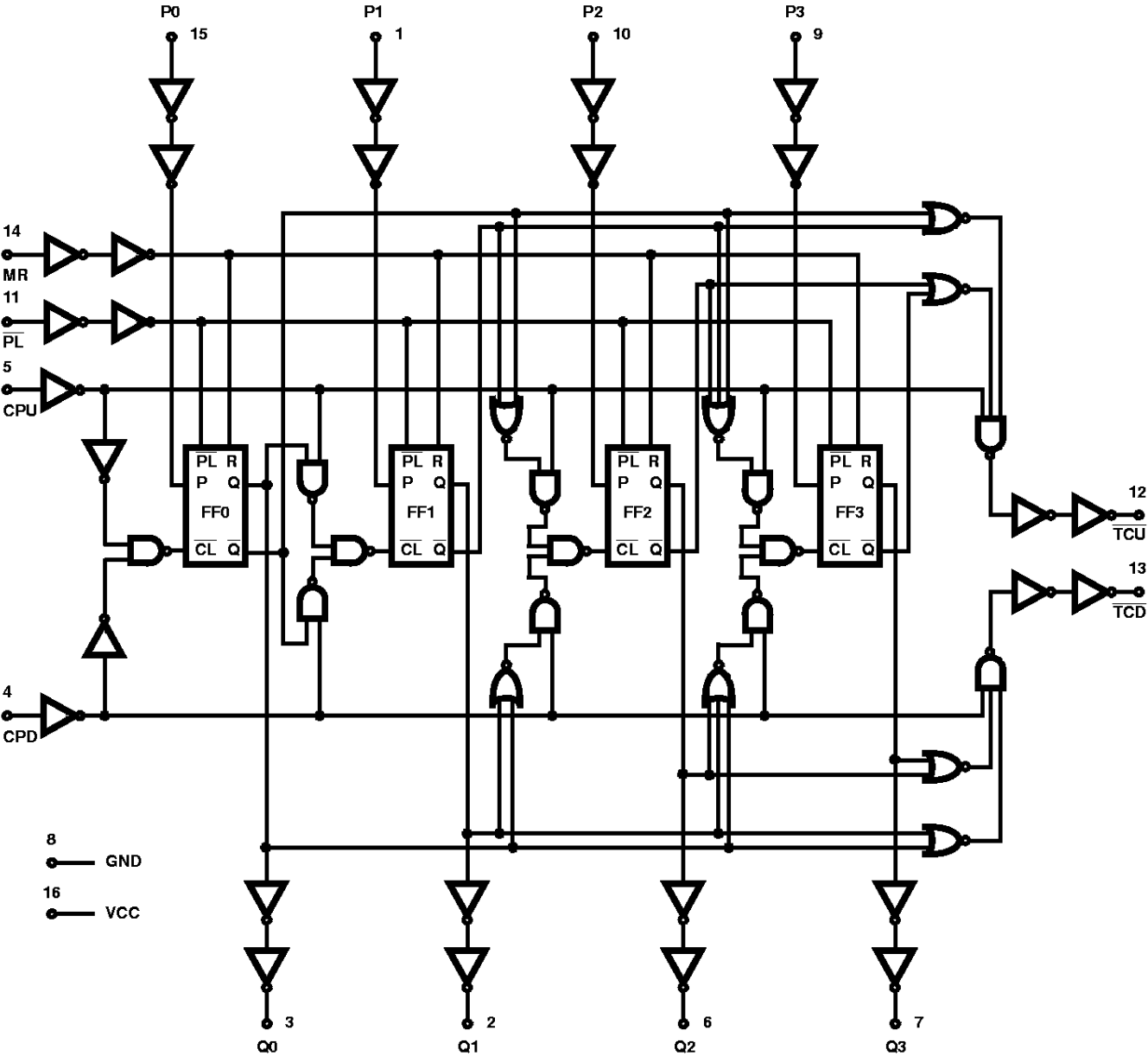
16 LEAD CERAMIC METAL SEAL
FLATPACK PACKAGE (FLATPACK)
MIL-STD-1835 CDFP4-F16
TOP VIEW



Ordering Information

PART NUMBER	TEMPERATURE RANGE	SCREENING LEVEL	PACKAGE
HCTS193DMSR	-55°C to $+125^\circ\text{C}$	Harris Class S Equivalent	16 Lead SBDIP
HCTS193KMSR	-55°C to $+125^\circ\text{C}$	Harris Class S Equivalent	16 Lead Ceramic Flatpack
HCTS193D/Sample	$+25^\circ\text{C}$	Sample	16 Lead SBDIP
HCTS193K/Sample	$+25^\circ\text{C}$	Sample	16 Lead Ceramic Flatpack
HCTS193HMSR	$+25^\circ\text{C}$	Die	Die

Functional Diagram



TRUTH TABLE

FUNCTION	CLOCK UP	CLOCK DOWN	RESET	PARALLEL LOAD
Count Up		H	L	H
Count Down	H		L	H
Reset	X	X	H	X
Load Preset Inputs	X	X	L	L

H = High Level, L = Low Level, X = Immaterial, = Transition from low to high

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Absolute Maximum Ratings

Supply Voltage (VCC)	-0.5V to +7.0V
Input Voltage Range, All Inputs	-0.5V to VCC +0.5V
DC Input Current, Any One Input	±10mA
DC Drain Current, Any One Output (All Voltage Reference to the VSS Terminal)	±25mA
Storage Temperature Range (TSTG)	-65°C to +150°C
Lead Temperature (Soldering 10sec)	+265°C
Junction Temperature (TJ)	+175°C
ESD Classification	Class 1

Reliability Information

Thermal Resistance	θ_{JA}	θ_{JC}
SBDIP Package	73°C/W	24°C/W
Ceramic Flatpack Package	114°C/W	29°C/W
Maximum Package Power Dissipation at +125°C Ambient		
SBDIP Package		0.68W
Ceramic Flatpack Package		0.44W
If device power exceeds package dissipation capability, provide heat sinking or derate linearly at the following rate:		
SBDIP Package		13.7mW/°C
Ceramic Flatpack Package		8.8mW/°C

CAUTION: As with all semiconductors, stress listed under "Absolute Maximum Ratings" may be applied to devices (one at a time) without resulting in permanent damage. This is a stress rating only. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. The conditions listed under "Electrical Performance Characteristics" are the only conditions recommended for satisfactory device operation..

Operating Conditions

Supply Voltage (VCC)	+4.5V to +5.5V	Input Low Voltage (VIL)	0.0V to 0.8V
Input Rise and Fall Times at 4.5V VCC (TR, TF)	500ns Max.	Input High Voltage (VIH)	VCC/2 to VCC
Operating Temperature Range (TA)	-55°C to +125°C		

TABLE 1. DC ELECTRICAL PERFORMANCE CHARACTERISTICS

PARAMETER	SYMBOL	(NOTE 1) CONDITIONS	GROUP A SUB- GROUPS	TEMPERATURE	LIMITS		UNITS
					MIN	MAX	
Quiescent Current	ICC	VCC = 5.5V, VIN = VCC or GND	1	+25°C	-	40	μA
			2, 3	+125°C, -55°C	-	750	μA
Output Current (Sink)	IOL	VCC = 4.5V, VIH = 4.5V, VOUT = 0.4V, VIL = 0V	1	+25°C	4.8	-	mA
			2, 3	+125°C, -55°C	4.0	-	mA
Output Current (Source)	IOH	VCC = 4.5V, VIH = 4.5V, VOUT = VCC -0.4V, VIL = 0V	1	+25°C	-4.8	-	mA
			2, 3	+125°C, -55°C	-4.0	-	mA
Output Voltage Low	VOL	VCC = 4.5V, VIH = 2.25V, IOL = 50μA, VIL = 0.80V	1, 2, 3	+25°C, +125°C, -55°C	-	0.1	V
		VCC = 5.5V, VIH = 2.75V, IOL = 50μA, VIL = 0.8V	1, 2, 3	+25°C, +125°C, -55°C	-	0.1	V
Output Voltage High	VOH	VCC = 4.5V, VIH = 2.25V, IOL = -50μA, VIL = 0.80V	1, 2, 3	+25°C, +125°C, -55°C	VCC -0.1	-	V
		VCC = 5.5V, VIH = 2.75V, IOL = -50μA, VIL = 0.8V	1, 2, 3	+25°C, +125°C, -55°C	VCC -0.1	-	V
Input Leakage Current	IIN	VCC = 5.5V, VIN = VCC or GND	1	+25°C	-	±0.5	μA
			2, 3	+125°C, -55°C	-	±5.0	μA
Noise Immunity Functional Test	FN	VCC = 4.5V, VIH = 2.25V, VIL = 0.8V (Note 2)	7, 8A, 8B	+25°C, +125°C, -55°C	-	-	-

NOTES:

1. All voltages reference to device GND.
2. For functional tests $VO \geq 4.0V$ is recognized as a logic "1", and $VO \leq 0.5V$ is recognized as a logic "0".

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TABLE 2. AC ELECTRICAL PERFORMANCE CHARACTERISTICS

PARAMETER	SYMBOL	(NOTES 1, 2) CONDITIONS	GROUP A SUB- GROUPS	TEMPERATURE	LIMITS		UNITS
					MIN	MAX	
CPU to Qn	TPLH	VCC = 4.5V	9	+25°C	2	29	ns
			10, 11	+125°C, -55°C	2	34	ns
	TPHL	VCC = 4.5V	9	+25°C	2	35	ns
			10, 11	+125°C, -55°C	2	41	ns
CPD to Qn	TPLH	VCC = 4.5V	9	+25°C	2	31	ns
			10, 11	+125°C, -55°C	2	36	ns
	TPHL	VCC = 4.5V	9	+25°C	2	36	ns
			10, 11	+125°C, -55°C	2	42	ns
PL to Qn	TPLH	VCC = 4.5V	9	+25°C	2	32	ns
			10, 11	+125°C, -55°C	2	36	ns
	TPHL	VCC = 4.5V	9	+25°C	2	45	ns
			10, 11	+125°C, -55°C	2	53	ns
MR to Qn	TPHL	VCC = 4.5V	9	+25°C	2	37	ns
			10, 11	+125°C, -55°C	2	44	ns

NOTES:

1. All voltages referenced to device GND.
2. AC measurements assume $R_L = 500\Omega$, $C_L = 50\text{pF}$, Input $T_R = T_F = 3\text{ns}$, $V_{IL} = \text{GND}$, $V_{IH} = 3\text{V}$.

TABLE 3. ELECTRICAL PERFORMANCE CHARACTERISTICS

PARAMETER	SYMBOL	CONDITIONS	NOTES	TEMPERATURE	LIMITS		UNITS
					MIN	MAX	
Capacitance Power Dissipation	CPD	VCC = 5.0V, f = 1MHz	1	+25°C	-	53	pF
			1	+125°C, -55°C	-	75	pF
Input Capacitance	CIN	VCC = 5.0V, f = 1MHz	1	+25°C	-	10	pF
			1	+125°C	-	10	pF
Output Transition Time	TTHL TTLH	VCC = 4.5V	1	+25°C	-	15	ns
			1	+125°C, -55°C	-	22	ns
Maximum Operating Frequency (CPU, CPD)	FMAX	VCC = 4.5V	1	+25°C	-	25	MHz
			1	+125°C, -55°C	-	15	MHz
Setup Time Pn to PL	TSU	VCC = 4.5V	1	+25°C	15	-	ns
			1	+125°C, -55°C	22	-	ns
Hold Time Pn to PL	TH	VCC = 4.5V	1	+25°C	0	-	ns
			1	+125°C, -55°C	0	-	ns
Hold Time CPD to CPU or CPU to CPD	TH	VCC = 4.5V	1	+25°C	16	-	ns
			1	+125°C, -55°C	24	-	ns
Pulse Width CPU to CPD	TW	VCC = 4.5V	1	+25°C	23	-	ns
			1	+125°C, -55°C	35	-	ns
Pulse Width PL	TW	VCC = 4.5V	1	+25°C	16	-	ns
			1	+125°C, -55°C	24	-	ns

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TABLE 3. ELECTRICAL PERFORMANCE CHARACTERISTICS (Continued)

PARAMETER	SYMBOL	CONDITIONS	NOTES	TEMPERATURE	LIMITS		UNITS
					MIN	MAX	
Pulse Width MR	TW	VCC = 4.5V	1	+25°C	20	-	ns
			1	+125°C, 55°C	30	-	ns
Recovery Time PL to CPU, CPD	TREC	VCC = 4.5V	1	+25°C	15	-	ns
			1	+125°C, 55°C	22	-	ns
Recovery Time MR to CPU, CPD	TREC	VCC = 4.5V	1	+25°C	5	-	ns
			1	+125°C, 55°C	5	-	ns

NOTE:

- The parameters listed in Table 3 are controlled via design or process parameters. Min and Max Limits are guaranteed but not directly tested. These parameters are characterized upon initial design release and upon design changes which affect these characteristics.

TABLE 4. DC POST RADIATION ELECTRICAL PERFORMANCE CHARACTERISTICS

PARAMETER	SYMBOL	(NOTES 1, 2) CONDITIONS	TEMPERATURE	200K RAD LIMITS		UNITS
				MIN	MAX	
Quiescent Current	ICC	VCC = 5.5V, VIN = VCC or GND	+25°C	-	0.75	mA
Output Current (Sink)	IOL	VCC = 4.5V, VIN = VCC or GND, VOUT = 0.4V	+25°C	4.0	-	mA
Output Current (Source)	IOH	VCC = 4.5V, VIN = VCC or GND, VOUT = VCC - 0.4V	+25°C	-4.0	-	mA
Output Voltage Low	VOL	VCC = 4.5V or 5.5V, VIH = VCC/2, VIL = 0.8V, IOL = 50μA	+25°C	-	0.1	V
Output Voltage High	VOH	VCC = 4.5V or 5.5V, VIH = VCC/2, VIL = 0.8V, IOL = -50μA	+25°C	VCC -0.1	-	V
Input Leakage Current	IIN	VCC = 5.5V, VIN = VCC or GND	+25°C	-	±5	μA
Noise Immunity Functional Test	FN	VCC = 4.5V, VIH = 2.25V, VIL = 0.8V, (Note 3)	+25°C	-	-	-
CPU to Qn	TPLH	VCC = 4.5V	+25°C	2	34	ns
	TPHL	VCC = 4.5V	+25°C	2	41	ns
CPD to Qn	TPLH	VCC = 4.5V	+25°C	2	36	ns
	TPHL	VCC = 4.5V	+25°C	2	42	ns
PL to Qn	TPLH	VCC = 4.5V	+25°C	2	36	ns
	TPHL	VCC = 4.5V	+25°C	2	53	ns
MR to Qn	TPHL	VCC = 4.5V	+25°C	2	44	ns

NOTES:

- All voltages referenced to device GND.
- AC measurements assume RL = 500Ω, CL = 50pF, Input TR = TF = 3ns, VIL = GND, VIH = 3V.
- For functional tests VO ≥ 4.0V is recognized as a logic "1", and VO ≤ 0.5V is recognized as a logic "0".

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TABLE 5. BURN-IN AND OPERATING LIFE TEST, DELTA PARAMETERS (+25°C)

PARAMETER	GROUP B SUBGROUP	DELTA LIMIT
ICC	5	12μA
IOL/IOH	5	-15% of 0 Hour

TABLE 6. APPLICABLE SUBGROUPS

CONFORMANCE GROUPS		METHOD	GROUP A SUBGROUPS	READ AND RECORD
Initial Test (Preburn-In)		100%/5004	1, 7, 9	ICC, IOL/H
Interim Test I (Postburn-In)		100%/5004	1, 7, 9	ICC, IOL/H
Interim Test II (Postburn-In)		100%/5004	1, 7, 9	ICC, IOL/H
PDA		100%/5004	1, 7, 9, Deltas	
Interim Test III (Postburn-In)		100%/5004	1, 7, 9	ICC, IOL/H
PDA		100%/5004	1, 7, 9, Deltas	
Final Test		100%/5004	2, 3, 8A, 8B, 10, 11	
Group A (Note 1)		Sample/5005	1, 2, 3, 7, 8A, 8B, 9, 10, 11	
Group B	Subgroup B-5	Sample/5005	1, 2, 3, 7, 8A, 8B, 9, 10, 11, Deltas	Subgroups 1, 2, 3, 9, 10, 11
	Subgroup B-6	Sample/5005	1, 7, 9	
Group D		Sample/5005	1, 7, 9	

NOTE: 1. Alternate Group A testing in accordance with method 5005 of MIL-STD-883 may be exercised.

TABLE 7. TOTAL DOSE IRRADIATION

CONFORMANCE GROUPS	METHOD	TEST		READ AND RECORD	
		PRE RAD	POST RAD	PRE RAD	POST RAD
Group E Subgroup 2	5005	1, 7, 9	Table 4	1, 9	Table 4 (Note 1)

NOTE: 1. Except FN test which will be performed 100% Go/No-Go.

TABLE 8. DYNAMIC BURN-IN TEST CONNECTIONS

OPEN	GROUND	1/2 VCC = 3V ± 0.5V	VCC = 6V ± 0.5V	OSCILLATOR	
				50kHz	25kHz
STATIC BURN-IN I TEST CONNECTIONS (Note 1)					
2, 3, 6, 7, 12, 13	1, 4, 5, 8 - 11, 14, 15	-	16	-	-
STATIC BURN-IN II TEST CONNECTIONS (Note 1)					
2, 3, 6, 7, 12, 13	8	-	1, 4, 5, 9 - 11, 14 - 16	-	-
DYNAMIC BURN-IN TEST CONNECTIONS (Note 2)					
-	1, 8 - 10, 14, 15	2, 3, 6, 7, 12, 13	4, 11, 16	5	-

NOTES:

- Each pin except VCC and GND will have a resistor of 10KΩ ± 5% for static burn-in.
- Each pin except VCC and GND will have a resistor of 1KΩ ± 5% for dynamic burn-in.

TABLE 9. IRRADIATION TEST CONNECTIONS

OPEN	GROUND	VCC = 5V ± 0.5V
2, 3, 6, 7, 12, 13	8	1, 4, 5, 9 - 11, 14 - 16

NOTE: Each pin except VCC and GND will have a resistor of 47KΩ ± 5% for irradiation testing. Group E, Subgroup 2, sample size is 4 dice/wafer 0 failures.

Harris Space Level Product Flow - 'MS'

Wafer Lot Acceptance (All Lots) Method 5007 (Includes SEM)	100% Interim Electrical Test 1 (T1)
GAMMA Radiation Verification (Each Wafer) Method 1019, 4 Samples/Wafer, 0 Rejects	100% Delta Calculation (T0-T1)
100% Nondestructive Bond Pull, Method 2023	100% Static Burn-In 2, Condition A or B, 24 hrs. min., +125°C min., Method 1015
Sample - Wire Bond Pull Monitor, Method 2011	100% Interim Electrical Test 2 (T2)
Sample - Die Shear Monitor, Method 2019 or 2027	100% Delta Calculation (T0-T2)
100% Internal Visual Inspection, Method 2010, Condition A	100% PDA 1, Method 5004 (Notes 1 and 2)
100% Temperature Cycle, Method 1010, Condition C, 10 Cycles	100% Dynamic Burn-In, Condition D, 240 hrs., +125°C or Equivalent, Method 1015
100% Constant Acceleration, Method 2001, Condition per Method 5004	100% Interim Electrical Test 3 (T3)
100% PIND, Method 2020, Condition A	100% Delta Calculation (T0-T3)
100% External Visual	100% PDA 2, Method 5004 (Note 2)
100% Serialization	100% Final Electrical Test
100% Initial Electrical Test (T0)	100% Fine/Gross Leak, Method 1014
100% Static Burn-In 1, Condition A or B, 24 hrs. min., +125°C min., Method 1015	100% Radiographic, Method 2012 (Note 3)
	100% External Visual, Method 2009
	Sample - Group A, Method 5005 (Note 4)
	100% Data Package Generation (Note 5)

NOTES:

- Failures from Interim electrical test 1 and 2 are combined for determining PDA 1.
- Failures from subgroup 1, 7, 9 and deltas are used for calculating PDA. The maximum allowable PDA = 5% with no more than 3% of the failures from subgroup 7.
- Radiographic (X-Ray) inspection may be performed at any point after serialization as allowed by Method 5004.
- Alternate Group A testing may be performed as allowed by MIL-STD-883, Method 5005.
- Data Package Contents:
 - Cover Sheet (Harris Name and/or Logo, P.O. Number, Customer Part Number, Lot Date Code, Harris Part Number, Lot Number, Quantity).
 - Wafer Lot Acceptance Report (Method 5007). Includes reproductions of SEM photos with percent of step coverage.
 - GAMMA Radiation Report. Contains Cover page, disposition, Rad Dose, Lot Number, Test Package used, Specification Numbers, Test equipment, etc. Radiation Read and Record data on file at Harris.
 - X-Ray report and film. Includes penetrometer measurements.
 - Screening, Electrical, and Group A attributes (Screening attributes begin after package seal).
 - Lot Serial Number Sheet (Good units serial number and lot number).
 - Variables Data (All Delta operations). Data is identified by serial number. Data header includes lot number and date of test.
 - The Certificate of Conformance is a part of the shipping invoice and is not part of the Data Book. The Certificate of Conformance is signed by an authorized Quality Representative.

AC Timing Diagrams

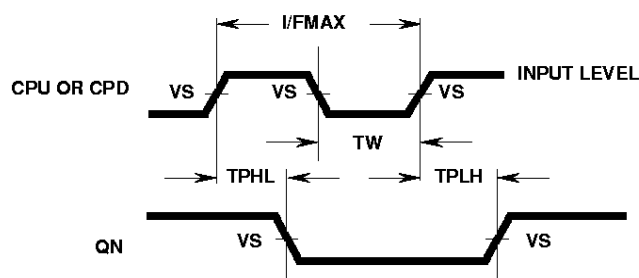


FIGURE 1. CLOCK TO OUTPUT DELAYS AND CLOCK PULSE WIDTH

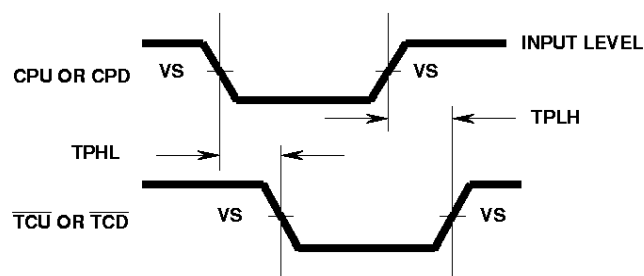


FIGURE 2. CLOCK TO TERMINAL COUNT DELAYS

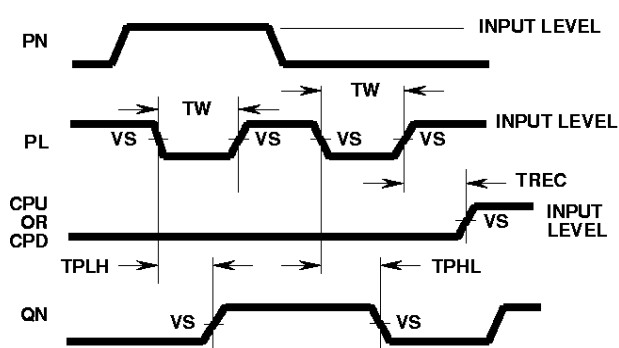


FIGURE 3. PARALLEL LOAD PULSE WIDTH, PARALLEL LOAD TO OUTPUT DELAYS, AND PARALLEL LOAD TO CLOCK RECOVERY TIME

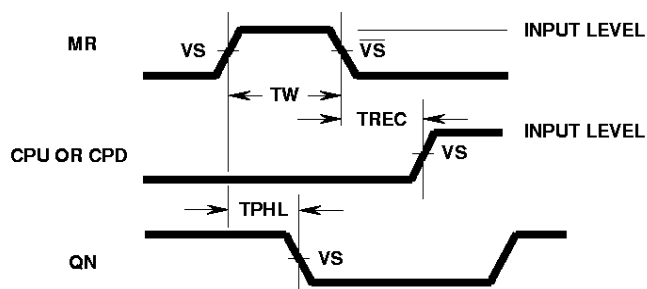


FIGURE 4. MASTER RESET PULSE WIDTH, MASTER RESET TO OUTPUT DELAY AND MASTER RESET TO CLOCK RECOVERY TIME

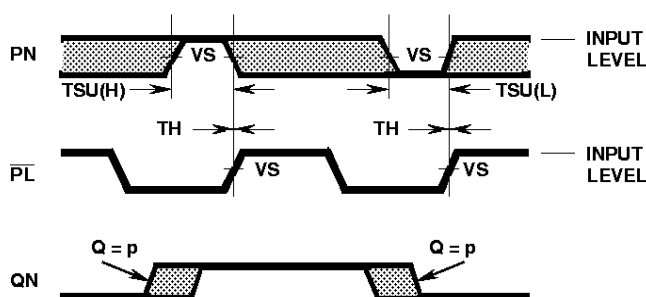


FIGURE 5. SETUP AND HOLD TIMES DATA TO PARALLEL LOAD (PL)

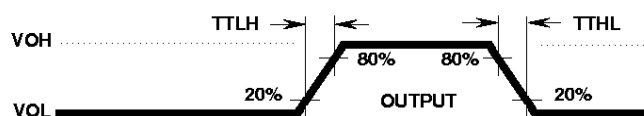


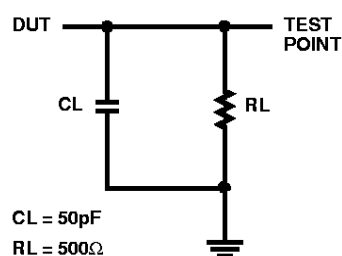
FIGURE 6. OUTPUT TRANSITION TIME

AC Timing Diagrams

AC VOLTAGE LEVELS

PARAMETER	HCTS	UNITS
VCC	4.50	V
VIH	3.00	V
VS	1.30	V
VIL	0	V
GND	0	V

AC Load Circuit



HCTS193MS

Die Characteristics

DIE DIMENSIONS:

104 x 86 mils

METALLIZATION:

Type: AlSi

Metal Thickness: $11\text{k}\text{\AA} \pm 1\text{k}\text{\AA}$

GLASSIVATION:

Type: SiO_2

Thickness: $13\text{k}\text{\AA} \pm 2.6\text{k}\text{\AA}$

WORST CASE CURRENT DENSITY:

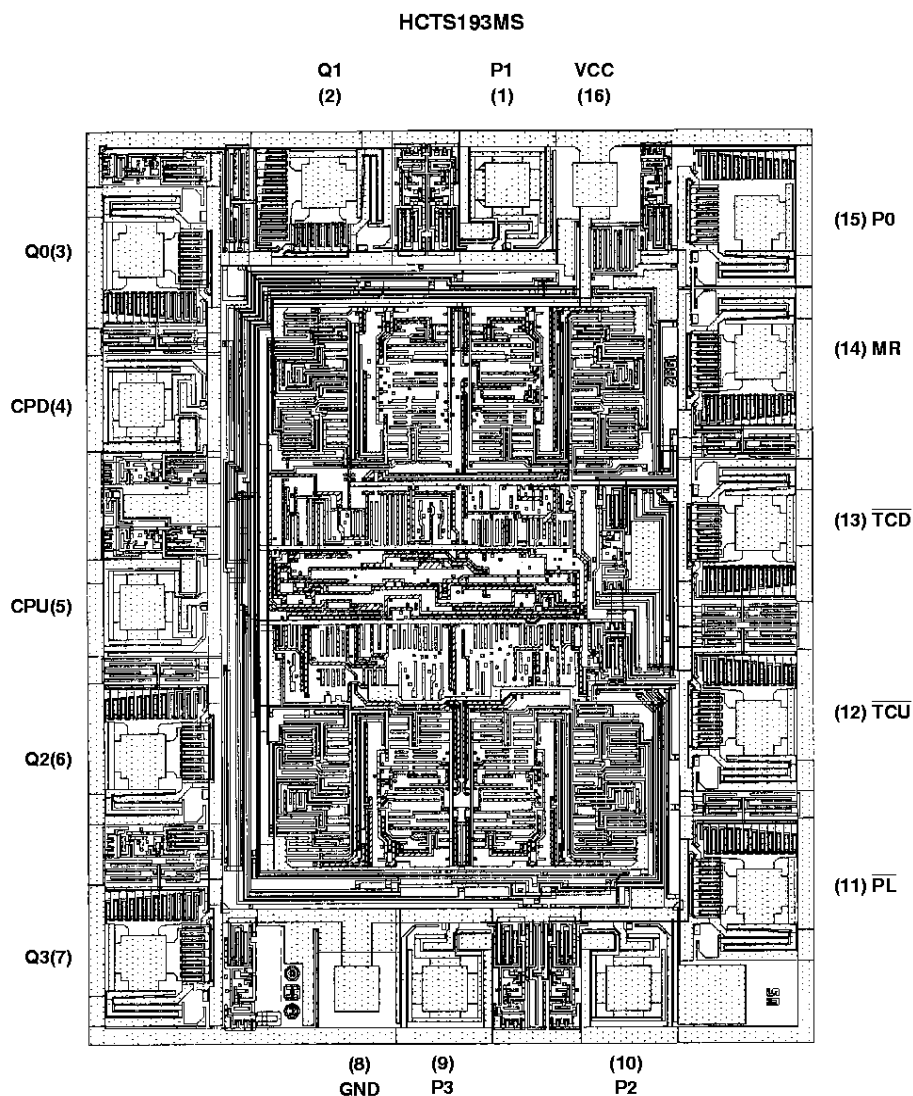
$< 2.0 \times 10^5 \text{A/cm}^2$

BOND PAD SIZE:

$100\mu\text{m} \times 100\mu\text{m}$

4 mils x 4 mils

Metallization Mask Layout



NOTE: The die diagram is a generic plot from a similar HCS device. It is intended to indicate approximate die size and bond pad location.
The mask series for the HCTS193 is TA14451A.