

Radiation Hardened 8-Bit Universal Shift Register; Three-State

August 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)
-Bus Driver Outputs: 15 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

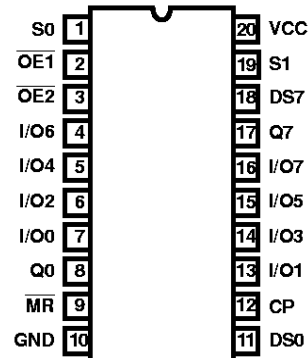
Description

The Harris HCTS299MS is a Radiation Hardened 8-bit shift/storage register with three-state bus interface capability. The register has four synchronous operating modes controlled by the two select inputs (S0, S1). The mode select, the serial data (DS0, DS7) and the parallel data (IO0 - IO7) respond only to the low to high transition of the clock (CP) pulse. S0, S1 and the data inputs must be one set up time period prior to the clocks positive transition. The master reset (MR) is an asynchronous active low input.

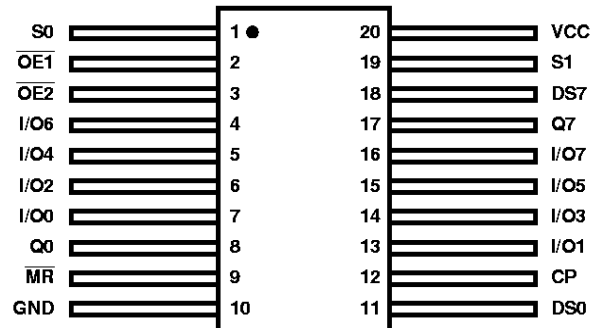
The HCTS299MS utilizes advanced CMOS/SOS technology to achieve high-speed operation. This device is a member of radiation hardened, high-speed, CMOS/SOS Logic Family with TTL input compatibility.

Pinouts

20 LEAD CERAMIC DUAL-IN-LINE
METAL SEAL PACKAGE (SBDIP)
MIL-STD-1835 CDIP2-T20
TOP VIEW



20 LEAD CERAMIC METAL SEAL
FLATPACK PACKAGE (FLATPACK)
MIL-STD-1835 CDFP4-F20
TOP VIEW

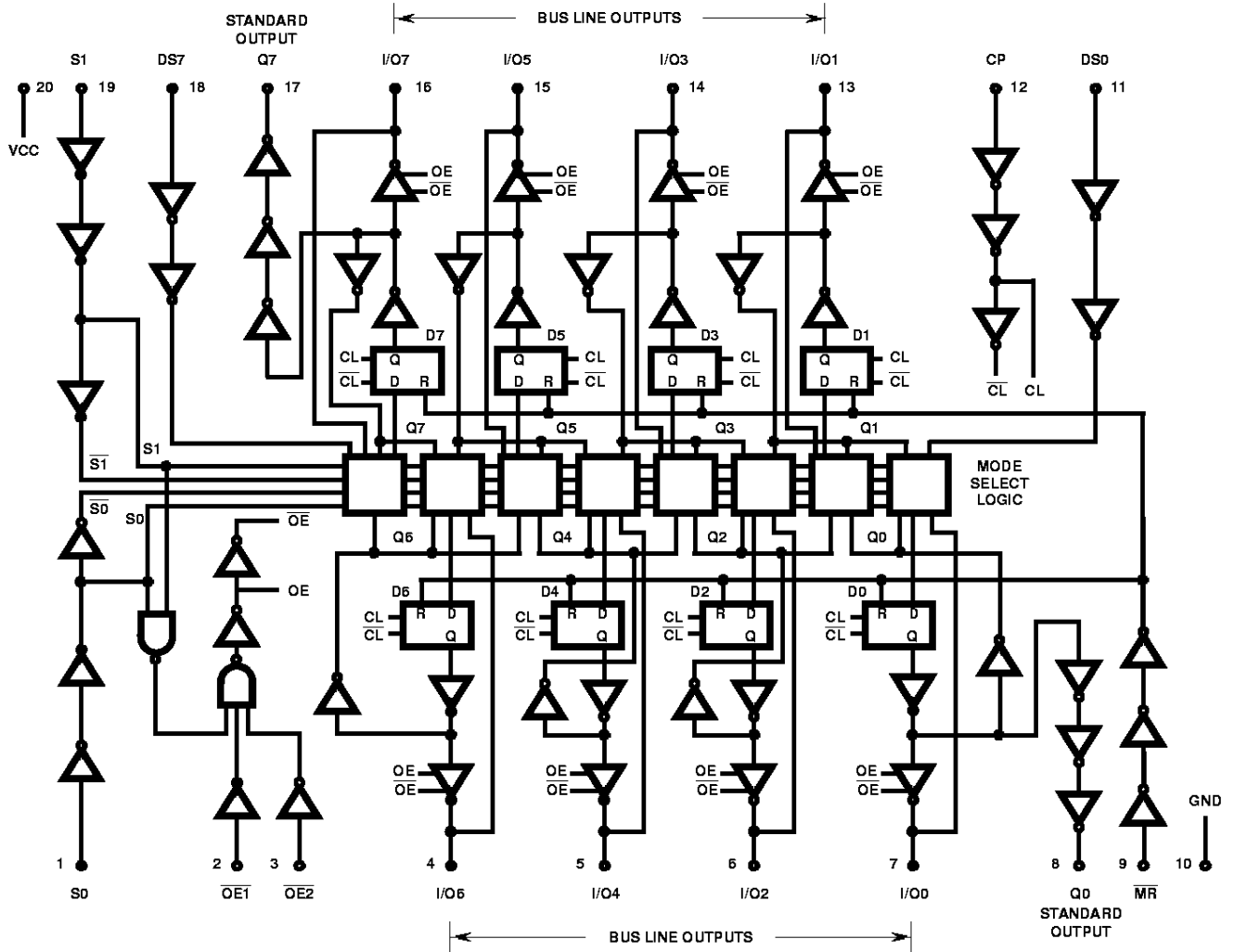


Ordering Information

PART NUMBER	TEMPERATURE RANGE	SCREENING LEVEL	PACKAGE
HCTS299DMSR	-55°C to $+125^\circ\text{C}$	Harris Class S Equivalent	20 Lead SBDIP
HCTS299KMSR	-55°C to $+125^\circ\text{C}$	Harris Class S Equivalent	20 Lead Ceramic Flatpack
HCTS299D/Sample	$+25^\circ\text{C}$	Sample	20 Lead SBDIP
HCTS299K/Sample	$+25^\circ\text{C}$	Sample	20 Lead Ceramic Flatpack
HCTS299HMSR	$+25^\circ\text{C}$	Die	Die








HCTS299MS

Functional Block Diagram



HCTS299MS

TRUTH TABLE
Register Operating Modes

FUNCTION	INPUTS							REGISTER OUTPUTS				
	\overline{MR}	CP	S0	S1	DS0	DS7	I/On	Q0	Q1	...	Q6	Q7
Reset (Clear)	L	X	X	X	X	X	X	L	L	...	L	L
Shift Right	H		h	l	l	X	X	L	q0	...	q5	q6
	H		h	l	h	X	X	H	q0	...	q5	Q6
Shift Left	H		l	h	X	l	X	q1	q2	...	q7	L
	H		l	h	X	h	X	q1	q2	...	q7	H
Hold (Do Nothing)	H		l	l	X	X	X	q0	q1	...	q6	q7
Parallel Load	H		h	h	X	X	l	L	L	...	L	L
	H		h	h	X	X	h	H	H	...	H	H

TRUTH TABLE
Three-State I/O Port Operating Mode

FUNCTION	INPUTS					INPUTS/OUTPUTS
	$\overline{OE1}$	$\overline{OE2}$	S0	S1	Qn (REGISTER)	I/O0 ... I/O7
Read Register	L	L	L	X	L	L
	L	L	L	X	H	H
	L	L	X	L	L	L
	L	L	X	L	H	H
Load Register	X	X	H	H	Qn = I/On	I/On = Inputs
Disable I/O	H	X	X	X	X	Z
	X	H	X	X	X	Z

H = High Voltage Level


L = Low Voltage Level

X = Immaterial

Z = Output in High Impedance State

h = Input Voltage High One Setup Time Prior Clock Transition

l = Input voltage Low One Setup Time Prior Clock Transition

 = Low-to-High Clock Transition

qn = Lower Case Letter Indicates the State of the Referenced Output One Setup Time Prior Clock Transition

Specifications HCTS299MS

Absolute Maximum Ratings

Supply Voltage (VCC)	-0.5 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	72°C/W	24°C/W
Ceramic Flatpack Package	107°C/W	28°C/W
Maximum Package Power Dissipation at +125°C Ambient		
SBDIP Package		0.69W
Ceramic Flatpack Package		0.47W
If device power exceeds package dissipation capability, provide heat sinking or derate linearly at the following rate:		
SBDIP Package		13.9mW/°C
Ceramic Flatpack Package		9.3mW/°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
Operating Temperature Range (TA)	-55°C to +125°C	Input High Voltage (VIH)	VCC/2 to VCC
Input Rise and Fall Times at 4.5V VCC (TR, TF)	500ns Max		

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	7.2	-	mA
			2, 3	+125°C, -55°C	6.0	-	mA
Output Current (Source)	IOH	VCC = 4.5V, VIH = 4.5V, VOUT = VCC - 0.4V, VIL = 0V	1	+25°C	-7.2	-	mA
			2, 3	+125°C, -55°C	-6.0	-	mA
Output Voltage Low	VOL	VCC = 4.5V, VIH = 2.25V, IOL = 50μA, VIL = 0.8V	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, IOH = -50μA, VIL = 0.8V	1, 2, 3	+25°C, +125°C, -55°C	VCC -0.1	-	V
		VCC = 5.5V, VIH = 2.75V, IOH = -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
Three-State Output Leakage Current	IOZ	Applied Voltage = 0V or VCC, VCC = 5.5V	1	+25°C	-	±1	μA
			2, 3	+125°C, -55°C	-	±50	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 referenced 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	
CLK to I/On	TPHL, TPLH	VCC = 4.5V	9	+25°C	2	28	ns
			10, 11	+125°C, -55°C	2	32	ns
CLK to Q0, Q7	TPHL, TPLH	VCC = 4.5V	9	+25°C	2	30	ns
			10, 11	+125°C, -55°C	2	34	ns
\overline{MR} to Output	TPHL	VCC = 4.5V	9	+25°C	2	32	ns
			10, 11	+125°C, -55°C	2	36	ns
\overline{OEn} to Output	TPZH	VCC = 4.5V	9	+25°C	2	23	ns
			10, 11	+125°C, -55°C	2	25	ns
	TPHZ		9	+25°C	2	25	ns
			10, 11	+125°C, -55°C	2	27	ns
	TPZL		9	+25°C	2	30	ns
			10, 11	+125°C, -55°C	2	34	ns
	TPLZ		9	+25°C	2	30	ns
			10, 11	+125°C, -55°C	2	34	ns

NOTES:

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

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	-	147	pF
			1	+125°C, -55°C	-	171	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
Max Operating Frequency	FMAX	VCC = 4.5V	1	+25°C	-	25	MHz
			1	+125°C, -55°C	-	16	MHz
Setup Time DS0, DS7, I/On to CLK	TSU	VCC = 4.5V	1	+25°C	20	-	ns
			1	+125°C, -55°C	30	-	ns

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TABLE 3. ELECTRICAL PERFORMANCE CHARACTERISTICS (Continued)

PARAMETER	SYMBOL	CONDITIONS	NOTES	TEMPERATURE	LIMITS		UNITS
					MIN	MAX	
Setup Time S1, S0 to CLK	TSU	VCC = 4.5V	1	+25°C	27	-	ns
				+125°C, -55°C	41	-	ns
Hold Time DS0, DS7, I/On, S0, S1 to CLK	TH	VCC = 4.5V	1	+25°C	0	-	ns
				+125°C, -55°C	0	-	ns
Recovery Time \overline{MR} to CLK	TREC	VCC = 4.5V	1	+25°C	5	-	ns
				+125°C, -55°C	5	-	ns
Pulse Width \overline{MR}	TW (\overline{MR})	VCC = 4.5V	1	+25°C	15	-	ns
				+125°C, -55°C	22	-	ns
Pulse Width CLK	TW (CLK)	VCC = 4.5V	1	+25°C	20	-	ns
				+125°C, -55°C	30	-	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	6.0	-	mA
Output Current (Source)	IOH	VCC = 4.5V, VIN = VCC or GND, VOUT = VCC - 0.4V	+25°C	-6.0	-	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, IOH = -50μA	+25°C	VCC - 0.1	-	V
Input Leakage Current	IIN	VCC = 5.5V, VIN = VCC or GND	+25°C	-	±5	μA
Three-State Output Leakage Current	IOZ	Applied Voltage = 0V or VCC, VCC = 5.5V	+25°C	-	±50	μA
Noise Immunity Functional Test	FN	VCC = 4.5V, VIH = 2.25V, VIL = 0.8V, (Note 3)	+25°C	-	-	-
CLK to I/On	TPHL, TPLH	VCC = 4.5V	+25°C	2	32	ns
CLK to Q0, Q7	TPHL, TPLH	VCC = 4.5V	+25°C	2	34	ns

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TABLE 4. DC POST RADIATION ELECTRICAL PERFORMANCE CHARACTERISTICS

PARAMETER	SYMBOL	(NOTES 1, 2) CONDITIONS	TEMPERATURE	200K RAD LIMITS		UNITS
				MIN	MAX	
\overline{MR} to Output	TPHL	VCC = 4.5V	+25°C	2	36	ns
\overline{OEn} to Output	TPZH	VCC = 4.5V	+25°C	2	25	ns
	TPHZ			2	27	ns
	TPZL	VCC = 4.5V	+25°C	2	34	ns
	TPLZ			2	34	ns

NOTES:

1. All voltages referenced to device GND.
2. AC measurements assume $R_L = 500\Omega$, $C_L = 50pF$, Input $T_R = T_F = 3ns$, $V_{IL} = GND$, $V_{IH} = 3V$.
3. For functional tests $V_O \geq 4.0V$ is recognized as a logic "1", and $V_O \leq 0.5V$ is recognized as a logic "0".

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

PARAMETER	GROUP B SUBGROUP	DELTA LIMIT
ICC	5	12 μ A
IOL/IOH	5	-15% of 0 Hour
IOZL/IOZH	5	$\pm 200nA$

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, IOZL/H
Interim Test I (Postburn-In)		100%/5004	1, 7, 9	ICC, IOL/H, IOZL/H
Interim Test II (Postburn-In)		100%/5004	1, 7, 9	ICC, IOL/H, IOZL/H
PDA		100%/5004	1, 7, 9, Deltas	
Interim Test III (Postburn-In)		100%/5004	1, 7, 9	
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 Inspection in accordance with Method 5005 of MIL-STD-883 may be exercised.

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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. STATIC BURN-IN AND DYNAMIC

OPEN	GROUND	1/2 VCC = 3V ± 0.5V	VCC = 6V ± 0.5V	OSCILLATOR	
				50kHz	25kHz
STATIC BURN-IN I TEST CONNECTIONS (Note 1)					
8, 17	1 - 7, 9 - 16, 18, 19	-	20	-	-
STATIC BURN-IN II TEST CONNECTIONS (Note 1)					
8, 17	10	-	1 - 7, 9, 11 - 16, 18 - 20	-	-
DYNAMIC BURN-IN TEST CONNECTIONS (Note 2)					
-	2, 3, 10, 18, 19	4 - 8, 13 - 17	1, 9, 20	12	11

NOTES:

1. Each pin except VCC and GND will have a resistor of 10kΩ ± 5% for static burn-in
2. Each pin except VCC and GND will have a resistor of 680Ω ± 5% for dynamic burn-in

TABLE 9. IRRADIATION TEST CONNECTIONS

OPEN	GROUND	VCC = 5V ± 0.5V
8, 17	10	1 - 7, 9, 11 - 16, 18 - 20

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.

HCTS299MS

Harris Space Level Product Flow - 'MS'

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

NOTES:

1. Failures from Interim electrical test 1 and 2 are combined for determining PDA 1.
2. 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.
3. Radiographic (X-Ray) inspection may be performed at any point after serialization as allowed by Method 5004.
4. Alternate Group A testing may be performed as allowed by MIL-STD-883, Method 5005.
5. 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 and Load Circuit

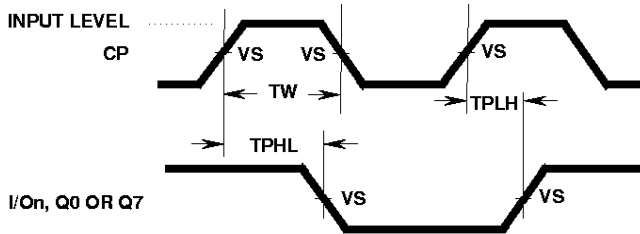


FIGURE 1. CLOCK PRE-REQUISITE AND PROPAGATION DELAYS

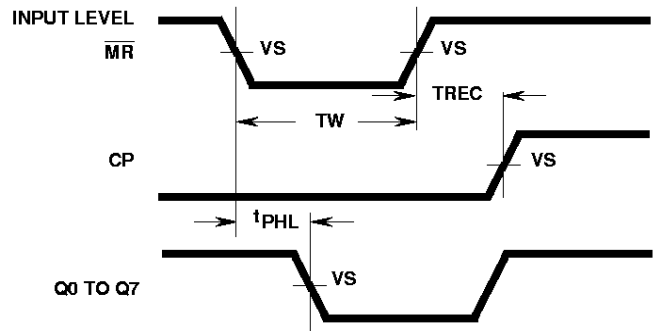


FIGURE 2. MASTER RESET PRE-REQUISITE AND PROPAGATION DELAYS

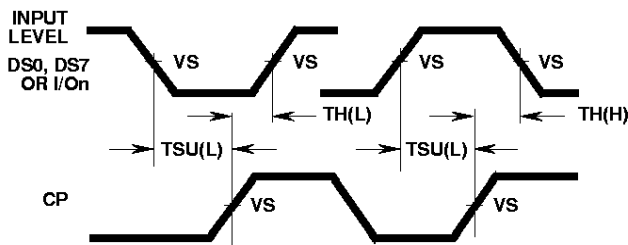


FIGURE 3. DATA PRE-REQUISITE TIMES

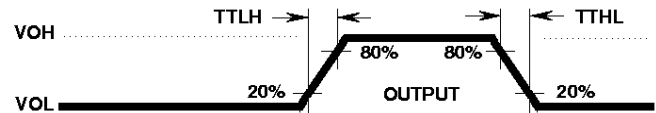


FIGURE 4. OUTPUT TRANSITION TIME

AC VOLTAGE LEVELS

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

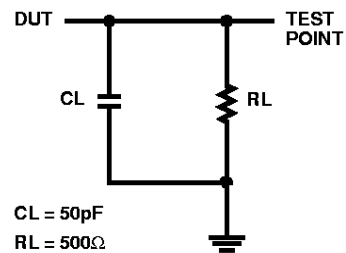
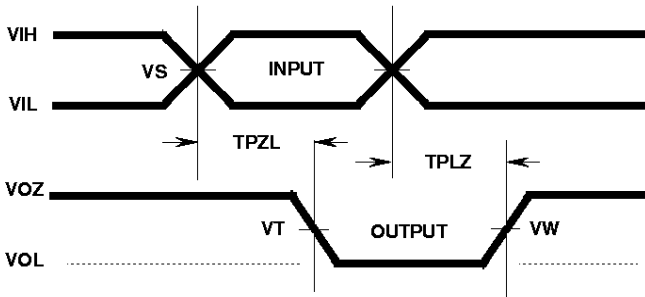


FIGURE 5. AC LOAD CIRCUIT

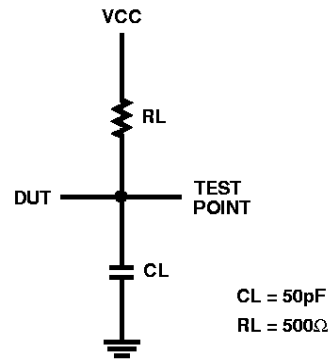
Three-State Low Timing Diagrams



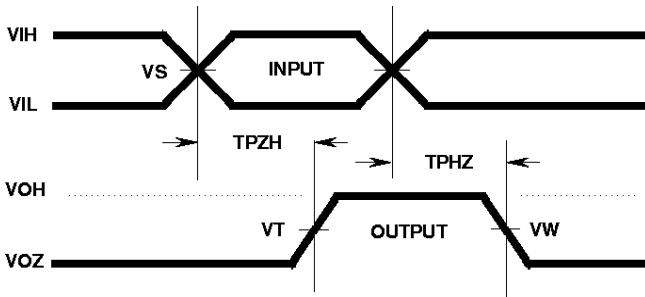
Three-State LOW VOLTAGE LEVELS

PARAMETER	HCTS	UNITS
VCC	4.50	V
VIH	3.00	V
VS	1.30	V
VT	1.30	V
VW	0.90	V
VIL	0	V
GND	0	V

Three-State Low Load Circuit



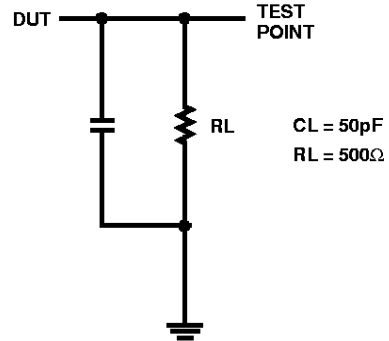
Three-State High Timing Diagrams



Three-State HIGH VOLTAGE LEVELS

PARAMETER	HCTS	UNITS
VCC	4.50	V
VIH	3.00	V
VS	1.30	V
VT	1.30	V
VW	3.60	V
VIL	0	V
GND	0	V

Three-State High Load Circuit



HCTS299MS

Die Characteristics

DIE DIMENSIONS:

123 x 94 mils

METALLIZATION:

Type: SiAl

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:

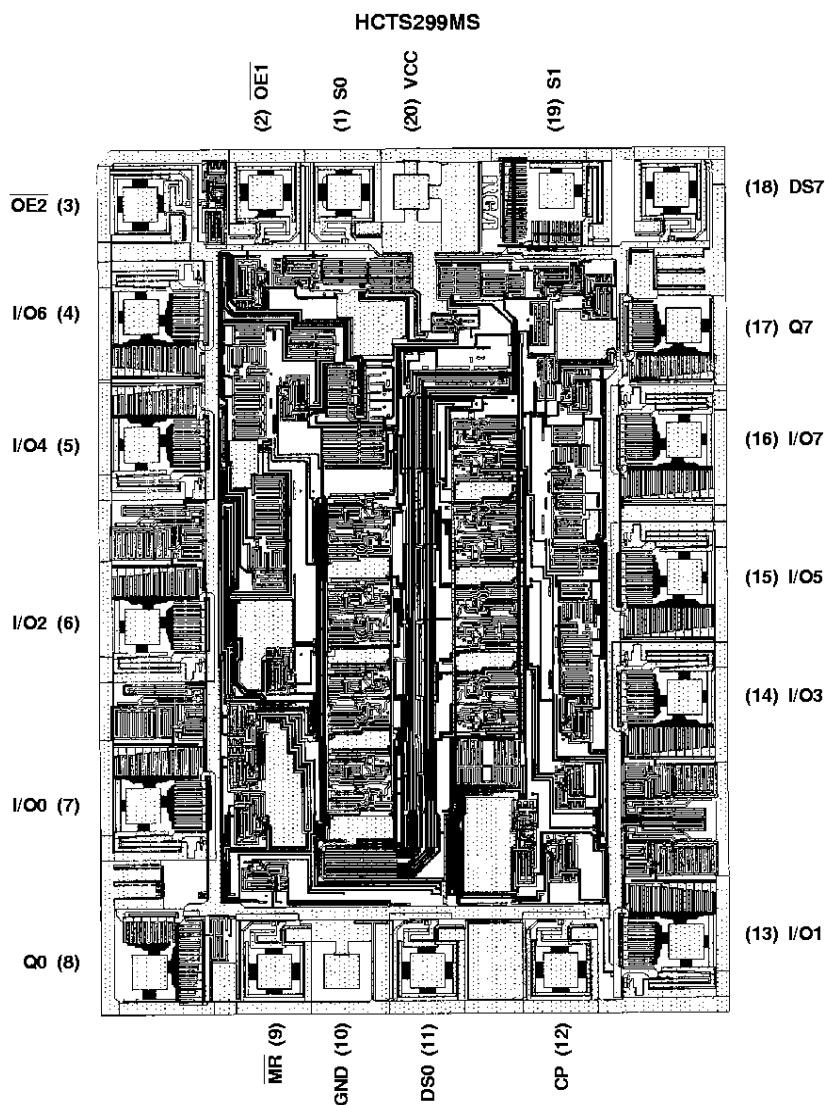
$<2.0 \times 10^5 \text{A/cm}^2$

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 HCTS299 is TA14480A.