

## Radiation Hardened 8-Bit Parallel-Input/Serial Output Shift Register

September 1995

### Features

- 3 Micron Radiation Hardened CMOS SOS
- Total Dose 200K RAD (Si)
- SEP Effective LET No Upsets: >100 MEV-cm<sup>2</sup>/mg
- Single Event Upset (SEU) Immunity < 2 x 10<sup>-9</sup> Errors/Bit-Day (Typ)
- Dose Rate Survivability: >1 x 10<sup>12</sup> RAD (Si)/s
- Dose Rate Upset >10<sup>10</sup> RAD s(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°C
- Significant Power Reduction Compared to LSTTL ICs
- DC Operating Voltage Range: 4.5V to 5.5V
- Input Logic Levels
  - VIL = 0.3 VCC Max
  - VIH = 0.7 VCC Min
- Input Current Levels I<sub>i</sub> ≤ 5μA at VOL, VOH

### Description

The Intersil HCS166MS is an 8-bit shift register that has fully synchronous serial or parallel data entry selected by an active LOW Parallel Enable (PE) input. When the PE is LOW one setup time before the LOW-to-HIGH clock transition, parallel data is entered into the register. When PE is HIGH, data is entered into internal bit position Q0 from Serial Data Input (DS), and the remaining bits are shifted one place to the right (Q0 → Q1 → Q2m etc.) with each positive-going clock transition. For expansion of the register in parallel to serial converters, the Q7 output is connected to the DS input of the succeeding stage.

The clock input is a gated OR structure which allows one input to be used as an active LOW Clock Enable (CE) input. The pin assignment for the CP and CE inputs is arbitrary and can be reversed for layout convenience. The LOW-to-HIGH transition of CE input should only take place while the CP is HIGH for predictable operation.

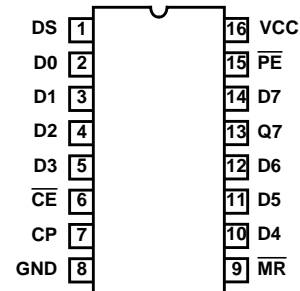
A LOW on the Master Reset (MR) input overrides all other inputs and clears the register asynchronously, forcing all bit positions to a LOW state.

The HCS166MS utilizes advanced CMOS/SOS technology to achieve high-speed operation. This device is a member of radiation hardened, high-speed, CMOS/SOS Logic Family.

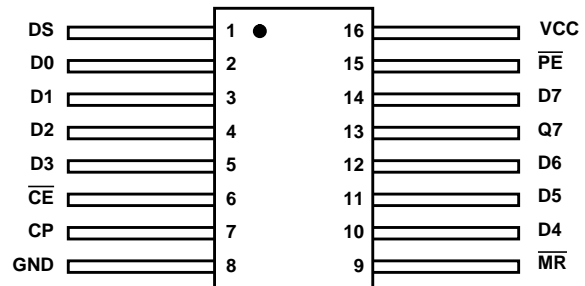
The HCS166MS is supplied in a 16 lead Ceramic flatpack (K suffix) or a SBDIP Package (D suffix).

### Pinouts

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



16 LEAD CERAMIC METAL SEAL FLATPACK PACKAGE (FLATPACK)  
MIL-STD-1835 CDFF4-F16, LEAD FINISH C  
TOP VIEW

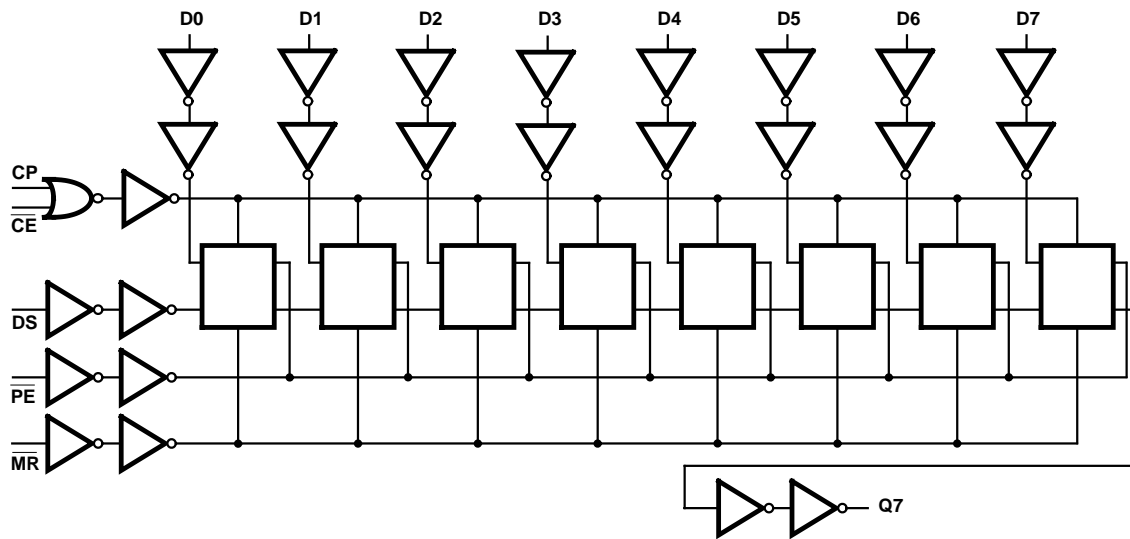


### Ordering Information

PART NUMBER	TEMPERATURE RANGE	SCREENING LEVEL	PACKAGE
HCS166DMSR	-55°C to +125°C	Intersil Class S Equivalent	16 Lead SBDIP
HCS166KMSR	-55°C to +125°C	Intersil Class S Equivalent	16 Lead Ceramic Flatpack
HCS166D/ Sample	+25°C	Sample	16 Lead SBDIP
HCS166K/ Sample	+25°C	Sample	16 Lead Ceramic Flatpack
HCS166HMSR	+25°C	Die	Die

# HCS166MS

## Functional Diagram



TRUTH TABLE

INPUTS						INTERNAL Q STATES		OUTPUT Q7
MASTER RESET	PARALLEL ENABLE	CLOCK ENABLE	CLOCK	SERIAL	PARALLEL	Q0 Q1		
					D0 - D7	Q0	Q1	
L	X	X	X	X	X	L	L	L
H	X	L	L	X	X	Q00	Q10	Q0
H	L	L		X	a . . . h	a	b	h
H	H	L		H	X	H	Q0n	Q6n
H	H	L		L	X	L	Q0n	Q6n
H	X	H		X	X	Q00	Q10	Q70

H = High Level

L = Low Level

X = Immaterial

= Transition from low to high level

a . . . h = The level of steady state input at inputs D0 thru D7, respectively.

Q00, Q10, Q70 = The level of Q0, Q1, or Q7, respectively, before the indicated steady state input conditions were established.

Q0n, Q6n = the level of Q0 or Q6, respectively, before the most recent transition of the clock.

# Specifications HCS166MS

## Absolute Maximum Ratings

Supply Voltage	-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	$\theta_{JA}$	$\theta_{JC}$
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	+4.5V to +5.5V	Input Low Voltage (VIL)	0.0V to 30% of VCC
Input Rise and Fall Times at 4.5V VCC (TR, TF)	.500ns Max	Input High Voltage (VIH)	70% of VCC 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 = 3.15V, IOL = 50µA, VIL = 1.35V	1, 2, 3	+25°C, +125°C, -55°C	-	0.1	V
		VCC = 5.5V, VIH = 3.85V, IOL = 50µA, VIL = 1.65V	1, 2, 3	+25°C, +125°C, -55°C	-	0.1	V
Output Voltage High	VOH	VCC = 4.5V, VIH = 3.15V, IOH = -50µA, VIL = 1.35V	1, 2, 3	+25°C, +125°C, -55°C	VCC -0.1	-	V
		VCC = 5.5V, VIH = 3.85V, IOH = -50µA, VIL = 1.65V	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 = 0.70(VCC), VIL = 0.30(VCC), (Note 2)	7, 8A, 8B	+25°C, +125°C, -55°C	-	-	-

**NOTES:**

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

# Specifications HCS166MS

**TABLE 2. AC ELECTRICAL PERFORMANCE CHARACTERISTICS**

PARAMETER	SYMBOL	(NOTES 1, 2) CONDITIONS	GROUP A SUB- GROUPS	TEMPERATURE	LIMITS		UNITS
					MIN	MAX	
CP or $\overline{CE}$ to Q7	TPHL TPLH	VCC = 4.5V	9	+25°C	2	32	ns
			10, 11	+125°C, -55°C	2	37	ns
$\overline{MR}$ to Q7	TPHL	VCC = 4.5V	9	+25°C	2	31	ns
			10, 11	+125°C, -55°C	2	36	ns

**NOTES:**

1. All voltages referenced to device GND.
2. AC measurements assume RL = 500Ω, CL = 50pF, Input TR = TF = 3ns, VIL = GND, VIH = VCC.

**TABLE 3. ELECTRICAL PERFORMANCE CHARACTERISTICS**

PARAMETER	SYMBOL	(NOTE 1) CONDITIONS	TEMPERATURE	LIMITS		UNITS
				MIN	MAX	
Capacitance Power Dissipation	CPD	VCC = 5.0V, f = 1MHz	+25°C	-	65	pF
			+125°C, -55°C	-	81	pF
Input Capacitance	CIN	VCC = 5.0V, f = 1MHz	+25°C	-	10	pF
			+125°C	-	10	pF
Output Transition Time (Figure 1)	TTHL TTLH	VCC = 4.5V	+25°C	-	15	ns
			+125°C, -55°C	-	22	ns
Clock Frequency (Figure 1)	fmax	VCC = 4.5V	+25°C	30	-	MHz
			-55°C to +125°C	20	-	MHz
$\overline{MR}$ Pulse Width (Figure 2)	tw	VCC = 4.5V	+25°C	20	-	ns
			-55°C to +125°C	30	-	ns
Clock Pulse Width (Figure 1)	tw	VCC = 4.5V	+25°C	16	-	ns
			-55°C to +125°C	24	-	ns
Set-up Time Data and $\overline{CE}$ to Clock, (Figure 3, 4)	tSU	VCC = 4.5V	+25°C	16	-	ns
			-55°C to +125°C	24	-	ns
Hold Time Data to Clock (Figure 4)	tH	VCC = 4.5V	+25°C	1	-	ns
			-55°C to +125°C	1	-	ns
Removal Time $\overline{MR}$ to Clock (Figure 3)	tREM	VCC = 4.5V	+25°C	0	-	ns
			-55°C to +125°C	0	-	ns
Set-up Time $\overline{PE}$ to CP (Figure 4)	tSU	VCC = 4.5V	+25°C	29	-	ns
			-55°C to +125°C	44	-	ns
Hold Time $\overline{PE}$ to $\overline{CP}$ or CE (Figure 4)	tH	VCC = 4.5V	+25°C	0	-	ns
			-55°C to +125°C	0	-	ns

**NOTE:**

1. 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.

## Specifications HCS166MS

**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 and 5.5V, VIH = 0.70(VCC), VIL = 0.30(VCC), IOL = 50μA	+25°C	-	0.1	V
Output Voltage High	VOH	VCC = 4.5V and 5.5V, VIH = 0.70(VCC), VIL = 0.30(VCC), IOH = -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 = 0.70(VCC), VIL = 0.30(VCC), (Note 3)	+25°C	-	-	-
CP or $\overline{CE}$ to Q7	TPHL	VCC = 4.5V	+25°C	2	37	ns
	TPLH	VCC = 4.5V	+25°C	2	37	ns
$\overline{MR}$ to Q7	TPHL	VCC = 4.5V	+25°C	2	36	ns

**NOTES:**

1. All voltages referenced to device GND.
2. AC measurements assume RL = 500Ω, CL = 50pF, Input TR = TF = 3ns, VIL = GND, VIH = VCC.
3. For functional tests, VO ≥ 4.0V is recognized as a logic "1", and VO ≤ 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	12μA
IOL/IOH	5	-15% of 0 Hour

## Specifications HCS166MS

**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, (Note 2)
	Subgroup B-6	Sample/5005	1, 7, 9	
Group D		Sample/5005	1, 7, 9	

**NOTES:**

1. Alternate Group A testing in accordance with Method 5005 of Mil-Std-883 may be exercised.
2. Table 5 parameters only.

**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 AND DYNAMIC BURN-IN TEST CONNECTIONS**

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

**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 1KΩ ± 5% for dynamic burn-in

**TABLE 9. IRRADIATION TEST CONNECTIONS**

OPEN	GROUND	VCC = 5V ± 0.5V
13	8	1 - 7, 9 - 12, 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.

## HCS166MS

### **Intersil 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:

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 (Intersil Name and/or Logo, P.O. Number, Customer Part Number, Lot Date Code, Intersil 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 Intersil.
  - 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 AC Load Circuit

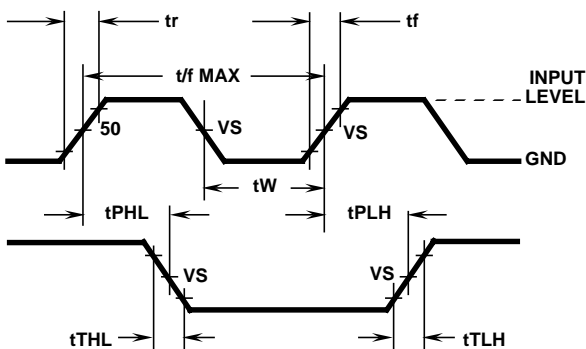


FIGURE 1. CLOCK PRE-REQUISITE TIMES AND PROPAGATION AND OUTPUT TRANSITION TIMES

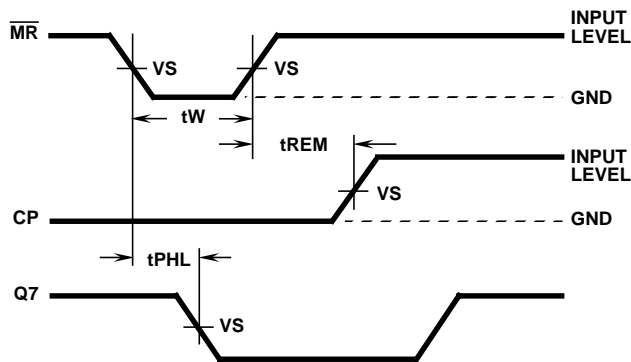


FIGURE 2. MASTER RESET PRE-REQUISITE TIMES AND PROPAGATION DELAYS.

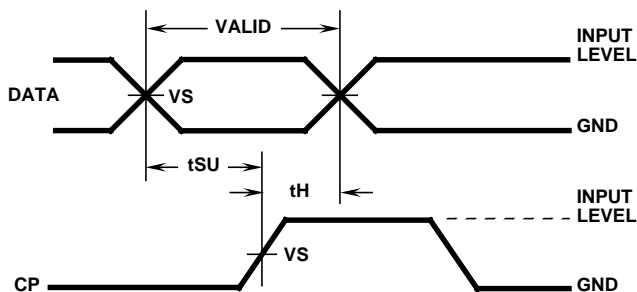


FIGURE 3. DATA PRE-REQUISITE TIMES

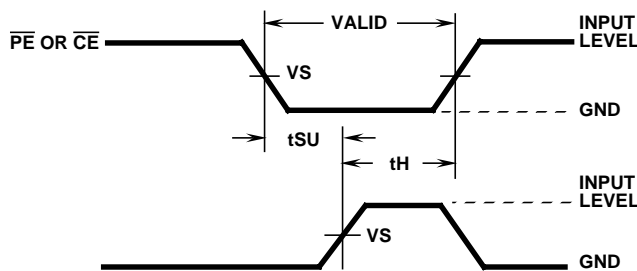


FIGURE 4. PARALLEL ENABLE OR CLOCK ENABLE PRE-REQUISITE TIMES

AC VOLTAGE LEVELS

PARAMETER	HCS	UNITS
VCC	4.50	V
VIH	4.50	V
VS	2.25	V
VIL	0	V
GND	0	V

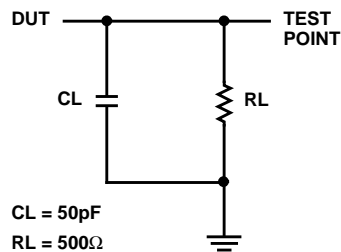


FIGURE 5. AC LOAD CIRCUIT

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# HCS166MS

## Die Characteristics

### DIE DIMENSIONS:

94 x 94 mils

### METALLIZATION:

Type: AlSi

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

### GLASSIVATION:

Type:  $\text{SiO}_2$

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

### WORST CASE CURRENT DENSITY:

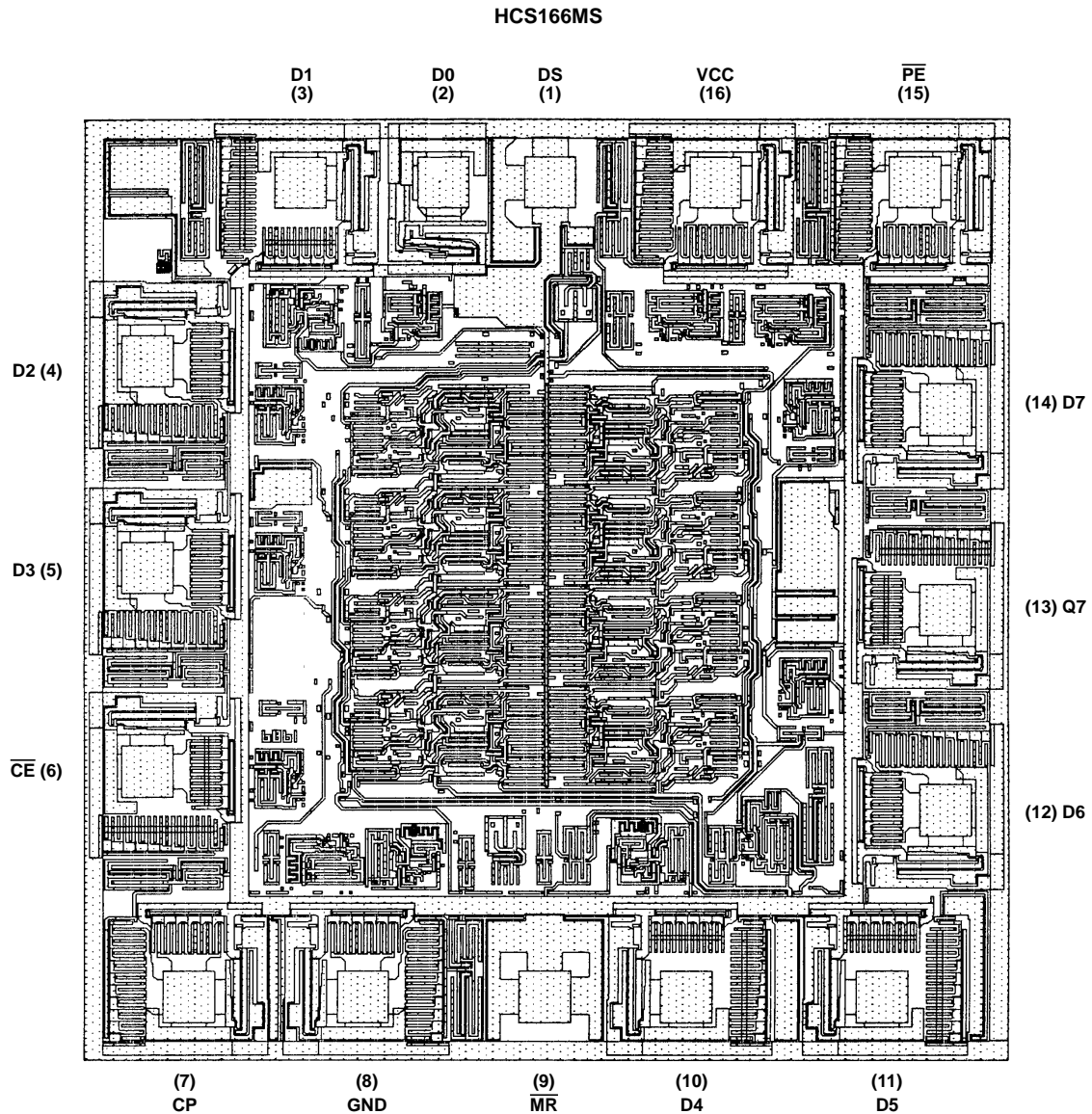
$< 2.0 \times 10^5 \text{A/cm}^2$

### 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 HCS166 is TA14386A.