

## Radiation Hardened BCD Decade Synchronous Counter

September 1995

### Features

- 3 Micron Radiation Hardened SOS CMOS
- 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 (Si)/s 20ns Pulse
- Latch-Up Free Under Any Conditions
- Fanout (Over Temperature Range)
  - Standard Outputs: 10 LSTTL Loads
  - Bus Driver Outputs: 15 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 = 30% of VCC Max
  - VIH = 70% of VCC Min
- Input Current Levels  $I_i \leq 5\mu\text{A}$  @ VOL, VOH

### Description

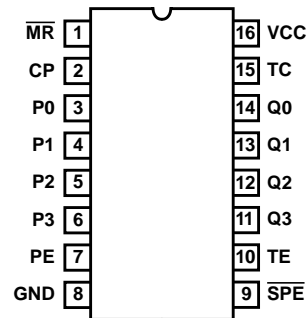
The Intersil HCS160MS is a Radiation Hardened high speed presettable BCD decade synchronous counter that features an asynchronous reset and look-ahead carry logic. Counting and parallel presetting are accomplished synchronously with the low-to-high transition of the clock. A low level on the synchronous parallel enable input,  $\overline{\text{SPE}}$ , disables counting and allows data at the preset inputs, P0 - P3, to be loaded into the counter. The counter is reset by a low on the master reset input,  $\overline{\text{MR}}$ . Two count enables, PE and TE are provided for n-bit cascading. TE also controls the terminal count output, TC. The terminal count output indicates a maximum count for one clock pulse and is used to enable the next cascaded stage to count.

The HCS160MS utilizes advanced CMOS/SOS technology to achieve high-speed operation. This device is a member of radiation hardened, high-speed, CMOS/SOS Logic Family.

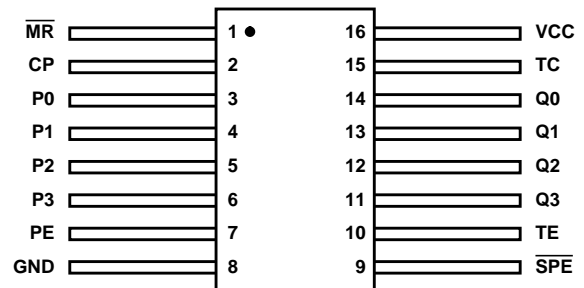
The HCS160MS is supplied in a 16 lead Ceramic flatpack (K suffix) or a SBDIP Package (D suffix.)

### Pinouts

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



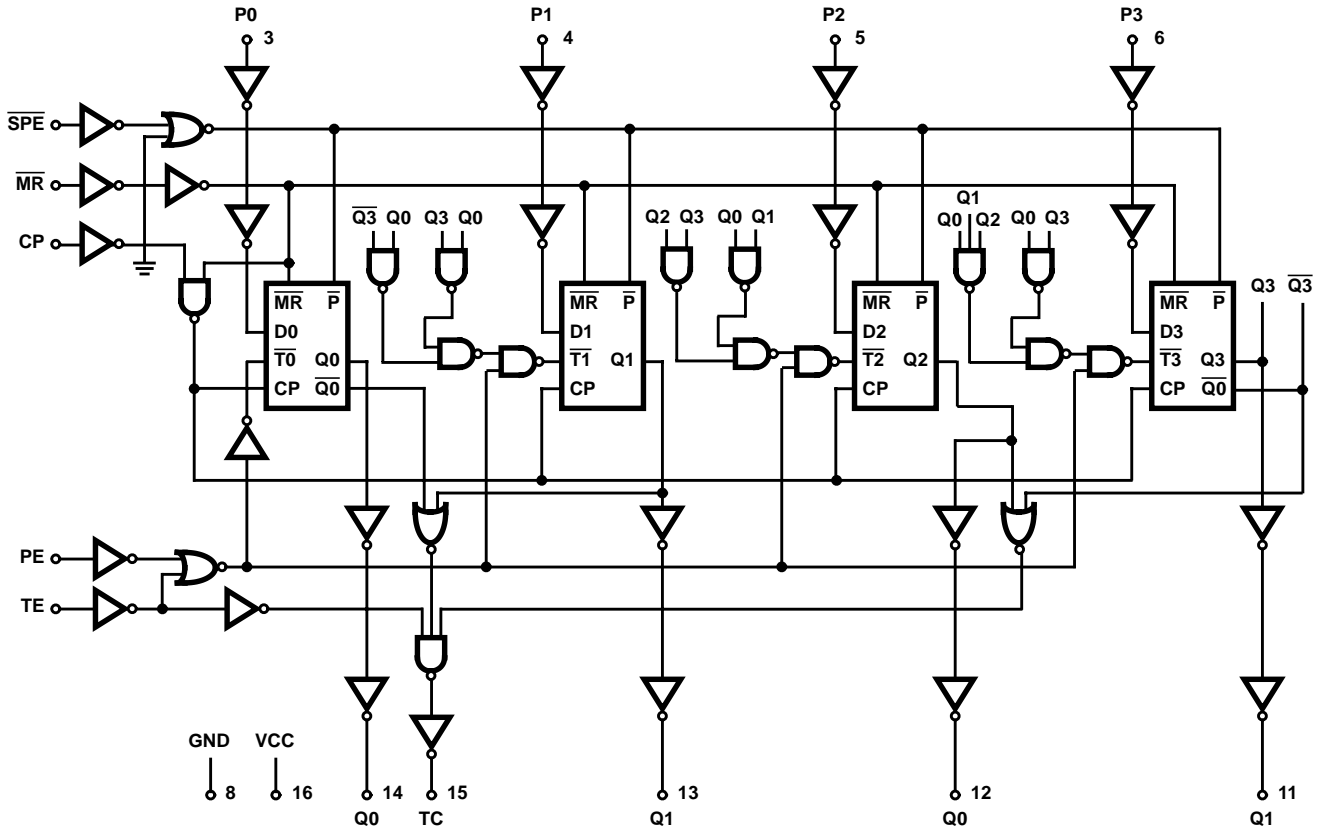
16 LEAD CERAMIC METAL SEAL  
FLATPACK PACKAGE (FLATPACK)  
MIL-STD-1835 CDFP4-F16, LEAD FINISH C  
TOP VIEW



### Ordering Information

PART NUMBER	TEMPERATURE RANGE	SCREENING LEVEL	PACKAGE
HCS160DMSR	-55°C to +125°C	Intersil Class S Equivalent	16 Lead SBDIP
HCS160KMSR	-55°C to +125°C	Intersil Class S Equivalent	16 Lead Ceramic Flatpack
HCS160D/Sample	+25°C	Sample	16 Lead SBDIP
HCS160K/Sample	+25°C	Sample	16 Lead Ceramic Flatpack
HCS160HMSR	+25°C	Die	Die

**Functional Block Diagram**



**TRUTH TABLE**

OPERATING MODE	INPUTS					OUTPUTS		
	$\overline{MR}$	CP	PE	TE	$\overline{SPE}$	Pn	Qn	TC
Reset (Clear)	L	X	X	X	X	X	L	L
Parallel Load	H		X	X	l	l	L	L
	H		X	X	l	h	H	(Note 1)
Count	H		h	h	h (Note 3)	X	Count	(Note 1)
Inhibit	H	X	l (Note 2)	X	h (Note 3)	X	qn	(Note 1)
	H	X	X	l (Note 2)	h (Note 3)	X	qn	L

H = HIGH Voltage Level

L = LOW Voltage Level

h = HIGH voltage level one setup time prior to the LOW-to-HIGH clock transition

l = LOW voltage level one setup time prior to the LOW-to-HIGH clock transition

X = Immaterial

q = Lower case letter indicate the state of the referenced output prior to the LOW-to-HIGH clock transition

= LOW-to-HIGH clock transition

**NOTES:**

1. The TC output is HIGH when TE is HIGH and the counter is at terminal count (HHHH for 161 and HLLH for 160)
2. The HIGH-to-LOW transition of PE or TE on the 54/74161 and 54/74160 should only occur while CP is high for conventional operation
3. The LOW-to-HIGH transition of  $\overline{SPE}$  on the 54/74161 and 54/74160 should only occur while CP is high for conventional operation

# Specifications HCS160MS

## 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	$\theta_{JA}$	$\theta_{JC}$
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 (VCC)	+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)	100ns 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 = 3.15V, VIL = 1.35V, (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".

## Specifications HCS160MS

**TABLE 2. AC ELECTRICAL PERFORMANCE CHARACTERISTICS**

PARAMETER	SYMBOL	(NOTES 1, 2) CONDITIONS	GROUP A SUB- GROUPS	TEMPERATURE	LIMITS		UNITS
					MIN	MAX	
CP to QN	T <sub>PHL</sub> , T <sub>PLH</sub>	VCC = 4.5V	9	+25°C	2	27	ns
			10, 11	+125°C, -55°C	2	33	ns
CP to TC	T <sub>PHL</sub> , T <sub>PLH</sub>	VCC = 4.5V	9	+25°C	2	24	ns
			10, 11	+125°C, -55°C	2	29	ns
TE to TC	T <sub>PHL</sub> , T <sub>PLH</sub>	VCC = 4.5V	9	+25°C	2	19	ns
			10, 11	+125°C, -55°C	2	23	ns
$\overline{MR}$ to QN, $\overline{MR}$ to TC	T <sub>PHL</sub>	VCC = 4.5V	9	+25°C	2	32	ns
			10, 11	+125°C, -55°C	2	39	ns

**NOTES:**

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

**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	-	38	pF
			1	+125°C, -55°C	-	63	pF
Input Capacitance	C <sub>IN</sub>	VCC = Open, f = 1MHz	1	+25°C	-	10	pF
			1	+125°C, -55°C	-	10	pF
Output Transition Time	T <sub>T<sub>HL</sub></sub> , T <sub>T<sub>LH</sub></sub>	VCC = 4.5V	1	+25°C	-	15	ns
			1	+125°C, -55°C	-	22	ns
Max Operating Frequency	F <sub>MAX</sub>	VCC = 4.5V	1	+25°C	30	-	MHz
			1	+125°C, -55°C	20	-	MHz

**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.

**TABLE 4. DC POST RADIATION ELECTRICAL PERFORMANCE CHARACTERISTICS**

PARAMETER	SYMBOL	(NOTES 1, 2) CONDITIONS	TEMPERATURE	200K 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

## Specifications HCS160MS

**TABLE 4. DC POST RADIATION ELECTRICAL PERFORMANCE CHARACTERISTICS (Continued)**

PARAMETER	SYMBOL	(NOTES 1, 2) CONDITIONS	TEMPERATURE	200K LIMITS		UNITS
				MIN	MAX	
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 = 3.15V, VIL = 1.35V, (Note 3)	+25°C	-	-	-
CP to QN	T <sub>PHL</sub> , T <sub>PLH</sub>	VCC = 4.5V	+25°C	2	29	ns
CP to TC	T <sub>PHL</sub> , T <sub>PLH</sub>	VCC = 4.5V	+25°C	2	33	ns
TE to TC	T <sub>PHL</sub> , T <sub>PLH</sub>	VCC = 4.5V	+25°C	2	23	ns
$\overline{\text{MR}}$ to QN, $\overline{\text{MR}}$ to TC	T <sub>PHL</sub>	VCC = 4.5V	+25°C	2	39	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 HCS160MS

**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	ICC, IOL/H, IOZL.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/6005	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, 7, 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					
11 - 15	1 - 10	-	16	-	-
STATIC II BURN-IN					
11 - 15	8	-	1 - 7, 9, 10, 16	-	-
DYNAMIC BURN-IN					
-	4, 6, 8	11 - 15	1, 3, 5, 7, 9, 10, 16	2	-

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
11 - 15	8	1 - 7, 9, 10, 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.

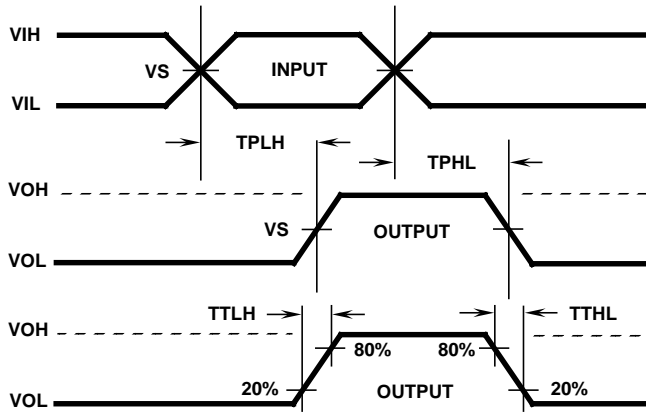
**Intersil Space Level Product Flow - 'MS'**

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.

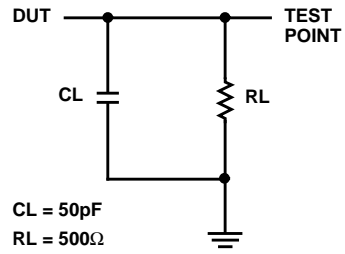
**AC Timing Diagrams**



**AC VOLTAGE LEVELS**

PARAMETER	HCS	UNITS
VCC	4.50	V
$V_{IH}$	4.50	V
$V_S$	2.25	V
$V_{IL}$	0	V
GND	0	V

**AC Load Circuit**





# HCS160MS

## 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:  $\text{SiO}_2$

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

### WORST CASE CURRENT DENSITY:

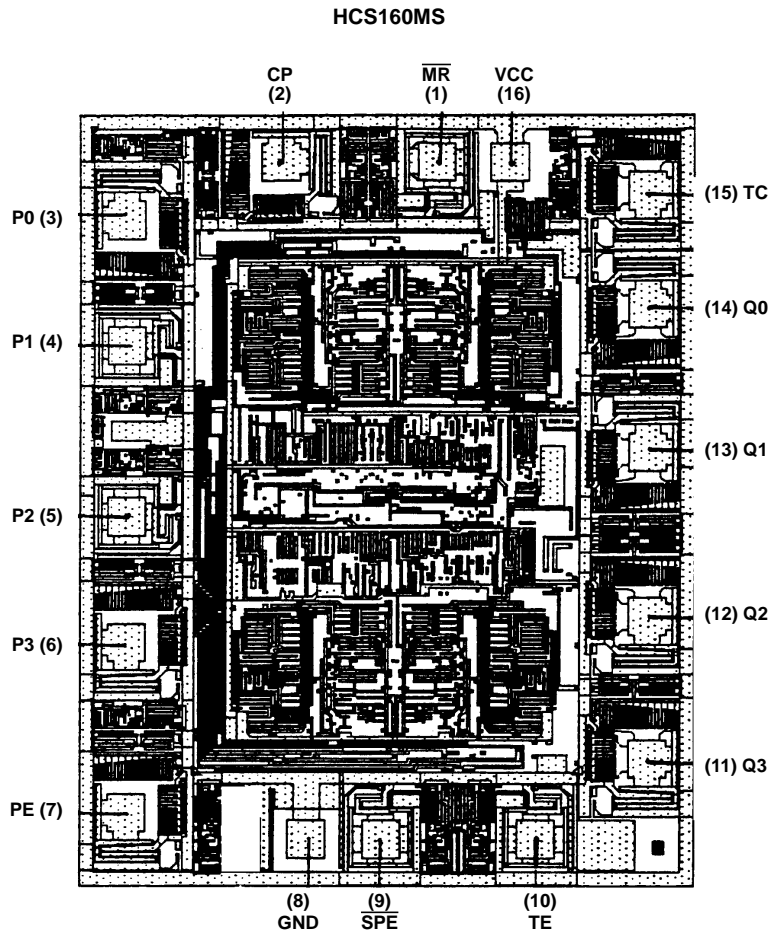
$<2.0 \times 10^5 \text{A/cm}^2$

### BOND PAD SIZE:

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

4 mils x 4 mils

## Metallization Mask Layout



All Intersil semiconductor products are manufactured, assembled and tested under **ISO9000** quality systems certification.

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