

## Radiation Hardened Inverting 3-to-8 Line Decoder/Demultiplexer

August 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
- 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 Ii ≤ 5μA at VOL, VOH

### Description

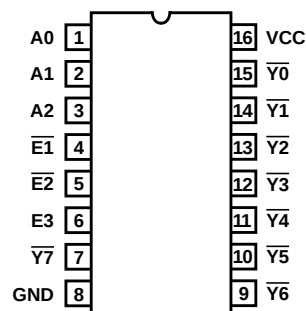
The Intersil HCS138MS is a Radiation Hardened 3-to-8 line Decoder/Demultiplexer. The outputs are active in the low state. Two active low and one active high enables ( $\overline{E1}$ ,  $\overline{E2}$ , E3) are provided. If the device is enabled, the binary inputs (A0, A1, A2) determine which one of the eight normally high outputs will go to a low logic level.

The HCS138MS utilizes advanced CMOS/SOS technology to achieve high-speed operation. This device is a member of radiation hardened, high-speed, CMOS/SOS Logic Family.

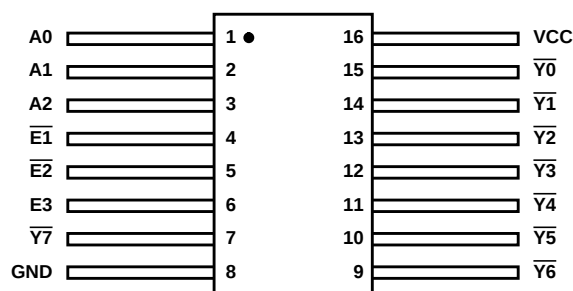
The HCS138MS is supplied in a 16 lead Ceramic flatpack (K suffix) or a SBDIP Package (D suffix).

### Pinouts

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

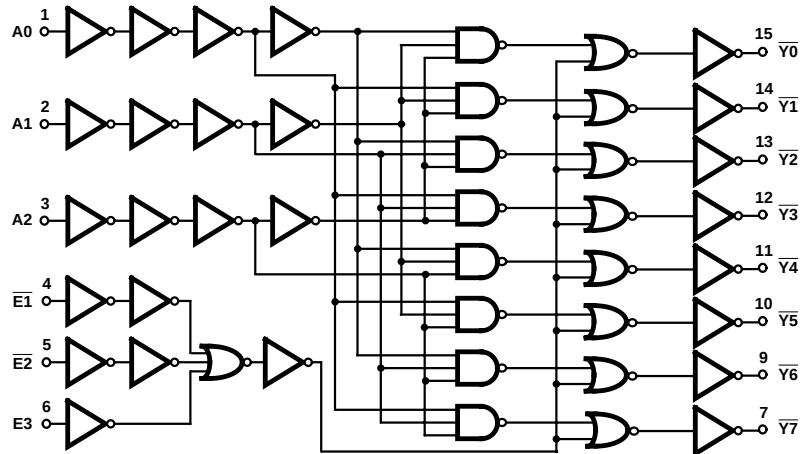


16 LEAD CERAMIC METAL SEAL  
FLATPACK PACKAGE (FLATPACK)  
MIL-STD-1835 CDFP4-F16  
TOP VIEW



### Ordering Information

| PART NUMBER    | TEMPERATURE RANGE | SCREENING LEVEL             | PACKAGE                  |
|----------------|-------------------|-----------------------------|--------------------------|
| HCS138DMSR     | -55°C to +125°C   | Intersil Class S Equivalent | 16 Lead SBDIP            |
| HCS138KMSR     | -55°C to +125°C   | Intersil Class S Equivalent | 16 Lead Ceramic Flatpack |
| HCS138D/Sample | +25°C             | Sample                      | 16 Lead SBDIP            |
| HCS138K/Sample | +25°C             | Sample                      | 16 Lead Ceramic Flatpack |
| HCS138HMSR     | +25°C             | Die                         | Die                      |

**Functional Diagram****TRUTH TABLE**

| INPUTS |    |    |    |    |    | OUTPUTS |    |    |    |    |    |    |    |
|--------|----|----|----|----|----|---------|----|----|----|----|----|----|----|
| ENABLE |    |    |    |    |    |         |    |    |    |    |    |    |    |
| E3     | E2 | E1 | A2 | A1 | A0 | Y0      | Y1 | Y2 | Y3 | Y4 | Y5 | Y6 | Y7 |
| X      | X  | H  | X  | X  | X  | H       | H  | H  | H  | H  | H  | H  | H  |
| L      | X  | X  | X  | X  | X  | H       | H  | H  | H  | H  | H  | H  | H  |
| X      | H  | X  | X  | X  | X  | H       | H  | H  | H  | H  | H  | H  | H  |
| H      | L  | L  | L  | L  | L  | L       | H  | H  | H  | H  | H  | H  | H  |
| H      | L  | L  | L  | L  | H  | H       | L  | H  | H  | H  | H  | H  | H  |
| H      | L  | L  | L  | H  | L  | H       | H  | L  | H  | H  | H  | H  | H  |
| H      | L  | L  | L  | H  | H  | H       | H  | H  | L  | H  | H  | H  | H  |
| H      | L  | L  | H  | L  | L  | H       | H  | H  | H  | L  | H  | H  | H  |
| H      | L  | L  | H  | H  | L  | H       | H  | H  | H  | H  | H  | L  | H  |
| H      | L  | L  | H  | H  | H  | H       | H  | H  | H  | H  | H  | H  | L  |

H = High Level, L = Low Level, X = Don't Care

## Specifications HCS138MS

### 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 . . . . . ±25mA  
 (All Voltage Reference to the VSS Terminal)  
 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 Rise and Fall Times at VCC = 4.5V (TR, TF) . . . . . 500ns Max  
 Operating Temperature Range (TA) . . . . . -55°C to +125°C  
 Input Low Voltage (VIL) . . . . . 0.0V to 30% of VCC  
 Input High Voltage (VIH) . . . . . 70% of VCC to VCC

**TABLE 1. DC ELECTRICAL PERFORMANCE CHARACTERISTICS**

| PARAMETER                         | SYMBOL | (NOTE 1)<br>CONDITIONS                                      | GROUP<br>A SUB-<br>GROUPS | TEMPERATURE          | LIMITS      |      | UNITS |
|-----------------------------------|--------|-------------------------------------------------------------|---------------------------|----------------------|-------------|------|-------|
|                                   |        |                                                             |                           |                      | MIN         | MAX  |       |
| Quiescent Current                 | ICC    | VCC = 5.5V,<br>VIN = VCC or GND                             | 1                         | +25°C                | -           | 40   | μA    |
|                                   |        |                                                             | 2, 3                      | +125°C, -55°C        | -           | 750  | μA    |
| Output Current<br>(Sink)          | IOL    | VCC = 4.5V, VIH = 4.5V,<br>VOUT = 0.4V, VIL = 0V            | 1                         | +25°C                | 7.2         | -    | mA    |
|                                   |        |                                                             | 2, 3                      | +125°C, -55°C        | 6.0         | -    | mA    |
| Output Current<br>(Source)        | IOH    | VCC = 4.5V, VIH = 4.5V,<br>VOUT = VCC -0.4V,<br>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 = 3.15V,<br>IOL = 50μA, VIL = 1.35V         | 1, 2, 3                   | +25°C, +125°C, -55°C | -           | 0.1  | V     |
|                                   |        | VCC = 5.5V, VIH = 3.85V,<br>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,<br>IOH = -50μA, VIL = 1.35V        | 1, 2, 3                   | +25°C, +125°C, -55°C | VCC<br>-0.1 | -    | V     |
|                                   |        | VCC = 5.5V, VIH = 3.85V,<br>IOH = -50μA, VIL = 1.65V        | 1, 2, 3                   | +25°C, +125°C, -55°C | VCC<br>-0.1 | -    | V     |
| Input Leakage<br>Current          | IIN    | VCC = 5.5V, VIN = VCC or<br>GND                             | 1                         | +25°C                | -           | ±0.5 | μA    |
|                                   |        |                                                             | 2, 3                      | +125°C, -55°C        | -           | ±5.0 | μA    |
| Noise Immunity<br>Functional Test | FN     | VCC = 4.5V,<br>VIH = 0.70(VCC),<br>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 HCS138MS

**TABLE 2. AC ELECTRICAL PERFORMANCE CHARACTERISTICS**

| PARAMETER         | SYMBOL | (NOTES 1, 2)<br>CONDITIONS | GROUP<br>A SUB-<br>GROUPS | TEMPERATURE   | LIMITS |     | UNITS |
|-------------------|--------|----------------------------|---------------------------|---------------|--------|-----|-------|
|                   |        |                            |                           |               | MIN    | MAX |       |
| Address to Output | TPLH   | VCC = 4.5V                 | 9                         | +25°C         | 2      | 28  | ns    |
|                   |        |                            | 10, 11                    | +125°C, -55°C | 2      | 34  | ns    |
|                   | TPHL   | VCC = 4.5V                 | 9                         | +25°C         | 2      | 28  | ns    |
|                   |        |                            | 10, 11                    | +125°C, -55°C | 2      | 34  | ns    |
| Enable to Output  | TPLH   | VCC = 4.5V                 | 9                         | +25°C         | 2      | 27  | ns    |
|                   |        |                            | 10, 11                    | +125°C, -55°C | 2      | 33  | ns    |
|                   | TPHL   | VCC = 4.5V                 | 9                         | +25°C         | 2      | 27  | ns    |
|                   |        |                            | 10, 11                    | +125°C, -55°C | 2      | 33  | ns    |

**NOTES:**

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

**TABLE 3. ELECTRICAL PERFORMANCE CHARACTERISTICS**

| PARAMETER                     | SYMBOL       | CONDITIONS                    | NOTES | TEMPERATURE | LIMITS |     | UNITS |
|-------------------------------|--------------|-------------------------------|-------|-------------|--------|-----|-------|
|                               |              |                               |       |             | MIN    | MAX |       |
| Capacitance Power Dissipation | CPD          | VCC = 5.0V, $f = 1\text{MHz}$ | 1     | +25°C       | -      | 78  | pF    |
|                               |              |                               | 1     | +125°C      | -      | 113 | pF    |
| Input Capacitance             | CIN          | VCC = 5.0V, $f = 1\text{MHz}$ | 1     | +25°C       | -      | 10  | pF    |
|                               |              |                               | 1     | +125°C      | -      | 10  | pF    |
| Output Transition Time        | TTHL<br>TTLH | VCC = 4.5V                    | 1     | +25°C       | -      | 15  | ns    |
|                               |              |                               | 1     | +125°C      | -      | 22  | 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.

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

| PARAMETER               | SYMBOL | (NOTES 1, 2)<br>CONDITIONS                         | TEMPERATURE | 200K RAD<br>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,<br>VOUT = 0.4V       | +25°C       | 6.0                | -    | mA    |
| Output Current (Source) | IOH    | VCC = 4.5V, VIN = VCC or GND,<br>VOUT = VCC - 0.4V | +25°C       | -6.0               | -    | mA    |

## Specifications HCS138MS

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

| PARAMETER                         | SYMBOL | (NOTES 1, 2)<br>CONDITIONS                                            | TEMPERATURE | 200K RAD<br>LIMITS |     | UNITS |
|-----------------------------------|--------|-----------------------------------------------------------------------|-------------|--------------------|-----|-------|
|                                   |        |                                                                       |             | MIN                | MAX |       |
| Output Voltage Low                | VOL    | VCC = 4.5V and 5.5V, VIH = 0.70(VCC),<br>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),<br>VIL = 0.30(VCC), IOH = -50μA | +25°C       | VCC<br>-0.1        | -   | V     |
| Input Leakage Current             | IIN    | VCC = 5.5V, VIN = VCC or GND                                          | +25°C       | -                  | ±5  | μA    |
| Noise Immunity<br>Functional Test | FN     | VCC = 4.5V, VIH = 0.70(VCC),<br>VIL = 0.30(VCC), (Note 3)             | +25°C       | -                  | -   | -     |
| Address to Output                 | TPLH   | VCC = 4.5V                                                            | +25°C       | 2                  | 34  | ns    |
|                                   | TPHL   | VCC = 4.5V                                                            | +25°C       | 2                  | 34  | ns    |
| Enable to Output                  | TPLH   | VCC = 4.5V                                                            | +25°C       | 2                  | 33  | ns    |
|                                   | TPHL   | VCC = 4.5V                                                            | +25°C       | 2                  | 33  | 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<br>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 inspection in accordance with method 5005 of MIL-STD-883 may be exercised.

## Specifications HCS138MS

**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 BURN-IN I TEST CONNECTIONS (Note 1)  |          |                     |                 |            |       |
| 7, 9 - 15                                   | 1 - 6, 8 |                     | 16              |            |       |
| STATIC BURN-IN II TEST CONNECTIONS (Note 1) |          |                     |                 |            |       |
| 7, 9 - 15                                   | 8        | -                   | 1 - 6, 16       | -          | -     |
| DYNAMIC BURN-IN TEST CONNECTIONS (Note 2)   |          |                     |                 |            |       |
| -                                           | 4, 5, 8  | 7, 9 - 15           | 3, 6, 16        | 2          | 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 680Ω ± 5% for dynamic burn-in

**TABLE 9. IRRADIATION TEST CONNECTIONS**

| OPEN      | GROUND | VCC = 5V ± 0.5V |
|-----------|--------|-----------------|
| 7, 9 - 15 | 8      | 1 - 6, 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.

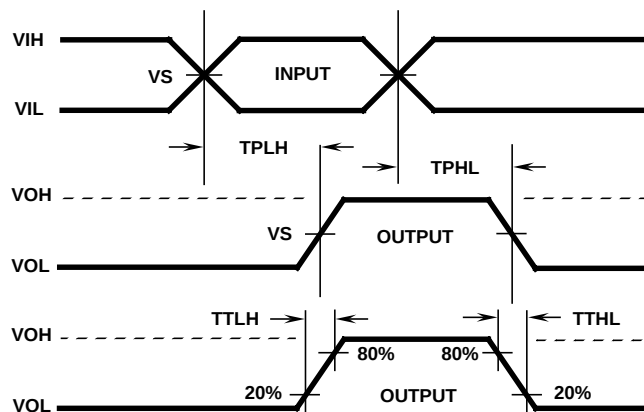
**Intersil Space Level Product Flow - 'MS'**

|                                                                                      |                                                                                    |
|--------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
| Wafer Lot Acceptance (All Lots) Method 5007<br>(Includes SEM)                        | 100% Interim Electrical Test 1 (T1)                                                |
| GAMMA Radiation Verification (Each Wafer) Method 1019,<br>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.,<br>+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,<br>10 Cycles                       | 100% Dynamic Burn-In, Condition D, 240 hrs., +125°C or<br>Equivalent, Method 1015  |
| 100% Constant Acceleration, Method 2001, Condition per<br>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.,<br>+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 (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.

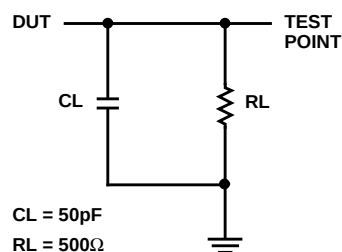
## AC Timing Diagrams



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



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

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## HCS138MS

### Die Characteristics

#### DIE DIMENSIONS:

85 x 101 mils

#### METALLIZATION:

Type: SiAl

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:

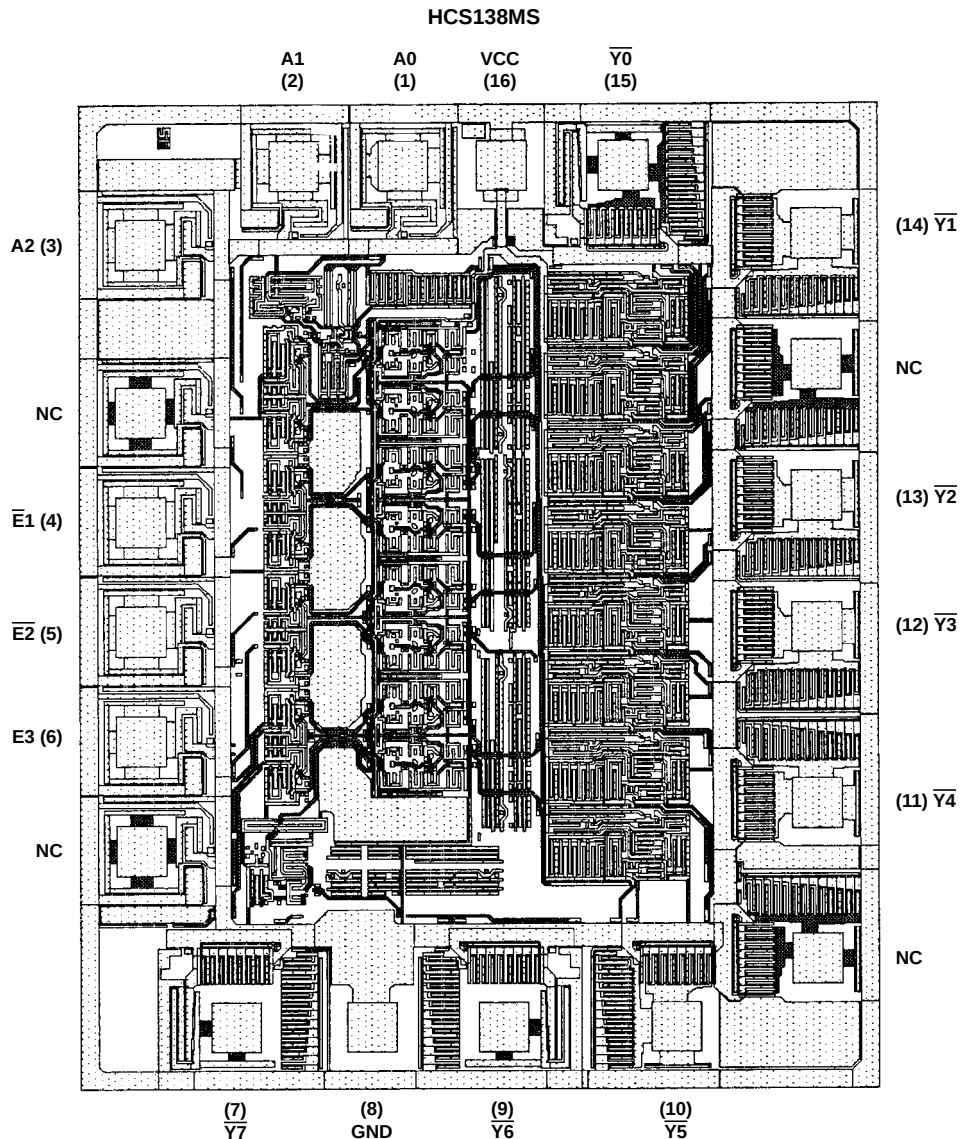
$<2.0 \times 10^5 \text{A/cm}^2$

#### BOND PAD SIZE:

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

4 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 HCS138 is TA14361A.