

November 1994

## CMOS NAND Gates

### Features

- High-Voltage Types (20V Rating)
- Propagation Delay Time = 60ns (typ.) at CL = 50pF, VDD = 10V
- Buffered Inputs and Outputs
- Standardized Symmetrical Output Characteristics
- Maximum Input Current of 1μA at 18V Over Full Package-Temperature Range; 100nA at 18V and +25°C
- 100% Tested for Maximum Quiescent Current at 20V
- 5V, 10V and 15V Parametric Ratings
- Noise Margin (Over Full Package Temperature Range):
  - 1V at VDD = 5V
  - 2V at VDD = 10V
  - 2.5V at VDD = 15V
- Meets All Requirements of JEDEC Tentative Standards No. 13B, "Standard Specifications for Description of "B" Series CMOS Device's

### Description

CD4011BMS - Quad 2 Input

CD4012BMS - Dual 4 Input

CD4023BMS - Triple 3 Input

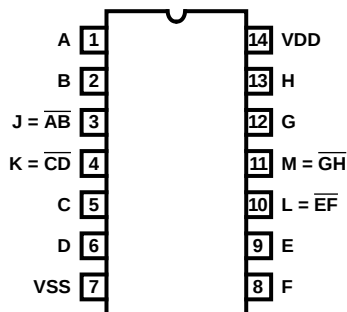
CD4011BMS, CD4012BMS, and CD4023BMS NAND gates provide the system designer with direct implementation of the NAND function and supplement the existing family of CMOS gates. All inputs and outputs are buffered.

The CD4011BMS, CD4012BMS and the CD4023BMS is supplied in these 14 lead outline packages:

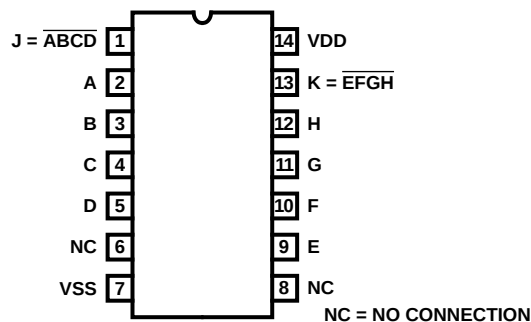
|                  | CD4011B | CD4012B | CD4023B |
|------------------|---------|---------|---------|
| Braze Seal DIP   | H4Q     | H4H     | H4Q     |
| Frit Seal DIP    | H1B     | H1B     | H1B     |
| Ceramic Flatpack | H3W     | H3W     | H3W     |

### Pinouts

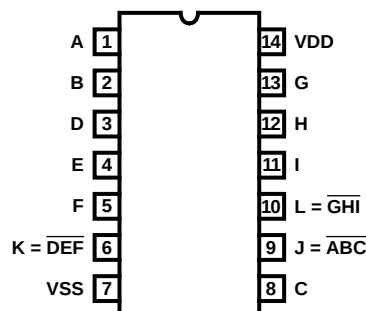
CD4011BMS  
TOP VIEW



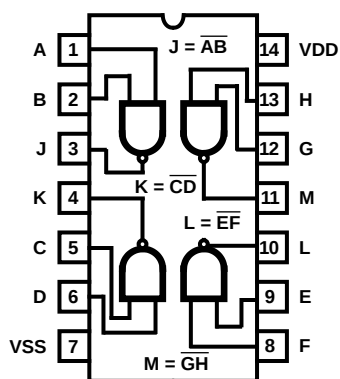
CD4012BMS  
TOP VIEW



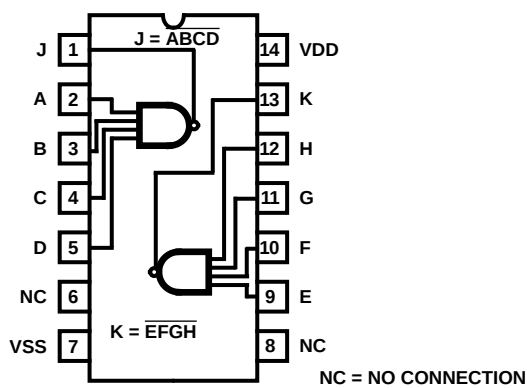
CD4023BMS  
TOP VIEW



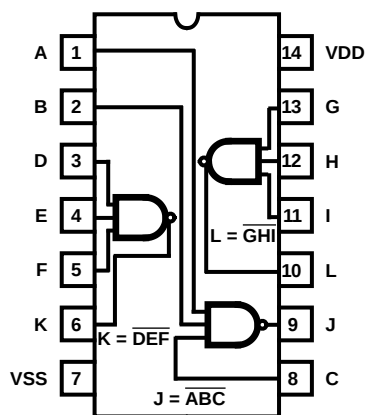
# Functional Diagrams



CD4011BMS



CD4012BMS



CD4023BMS

# Specifications CD4011BMS, CD4012BMS, CD4023BMS

## Absolute Maximum Ratings

DC Supply Voltage Range, (VDD) ..... -0.5V to +20V  
 (Voltage Referenced to VSS Terminals)  
 Input Voltage Range, All Inputs ..... -0.5V to VDD +0.5V  
 DC Input Current, Any One Input .....  $\pm 10\mu\text{A}$   
 Operating Temperature Range ..... -55°C to +125°C  
 Package Types D, F, K, H  
 Storage Temperature Range (TSTG) ..... -65°C to +150°C  
 Lead Temperature (During Soldering) ..... +265°C  
 At Distance 1/16  $\pm$  1/32 Inch (1.59mm  $\pm$  0.79mm) from case for  
 10s Maximum

## Reliability Information

Thermal Resistance .....  $\theta_{ja}$  .....  $\theta_{jc}$   
 Ceramic DIP and FRIT Package ..... 80°C/W ..... 20°C/W  
 Flatpack Package ..... 70°C/W ..... 20°C/W  
 Maximum Package Power Dissipation (PD) at +125°C  
 For TA = -55°C to +100°C (Package Type D, F, K) ..... 500mW  
 For TA = +100°C to +125°C (Package Type D, F, K) ..... Derate  
 Linearity at 12mW/°C to 200mW  
 Device Dissipation per Output Transistor ..... 100mW  
 For TA = Full Package Temperature Range (All Package Types)  
 Junction Temperature ..... +175°C

**TABLE 1. DC ELECTRICAL PERFORMANCE CHARACTERISTICS**

| PARAMETER                      | SYMBOL | CONDITIONS (NOTE 1)                   |           | GROUP A<br>SUBGROUPS | TEMPERATURE          | LIMITS         |                | UNITS         |
|--------------------------------|--------|---------------------------------------|-----------|----------------------|----------------------|----------------|----------------|---------------|
|                                |        |                                       |           |                      |                      | MIN            | MAX            |               |
| Supply Current                 | IDD    | VDD = 20V, VIN = VDD or GND           |           | 1                    | +25°C                | -              | 0.5            | $\mu\text{A}$ |
|                                |        |                                       |           | 2                    | +125°C               | -              | 50             | $\mu\text{A}$ |
|                                |        | VDD = 18V, VIN = VDD or GND           |           | 3                    | -55°C                | -              | 0.5            | $\mu\text{A}$ |
| Input Leakage Current          | IIL    | VIN = VDD or GND                      | VDD = 20  | 1                    | +25°C                | -100           | -              | nA            |
|                                |        |                                       |           | 2                    | +125°C               | -1000          | -              | nA            |
|                                |        |                                       | VDD = 18V | 3                    | -55°C                | -100           | -              | nA            |
| Input Leakage Current          | IIH    | VIN = VDD or GND                      | VDD = 20  | 1                    | +25°C                | -              | 100            | nA            |
|                                |        |                                       |           | 2                    | +125°C               | -              | 1000           | nA            |
|                                |        |                                       | VDD = 18V | 3                    | -55°C                | -              | 100            | nA            |
| Output Voltage                 | VOL15  | VDD = 15V, No Load                    |           | 1, 2, 3              | +25°C, +125°C, -55°C | -              | 50             | mV            |
| Output Voltage                 | VOH15  | VDD = 15V, No Load (Note 3)           |           | 1, 2, 3              | +25°C, +125°C, -55°C | 14.95          | -              | V             |
| Output Current (Sink)          | IOL5   | VDD = 5V, VOUT = 0.4V                 |           | 1                    | +25°C                | 0.53           | -              | mA            |
| Output Current (Sink)          | IOL10  | VDD = 10V, VOUT = 0.5V                |           | 1                    | +25°C                | 1.4            | -              | mA            |
| Output Current (Sink)          | IOL15  | VDD = 15V, VOUT = 1.5V                |           | 1                    | +25°C                | 3.5            | -              | mA            |
| Output Current (Source)        | IOH5A  | VDD = 5V, VOUT = 4.6V                 |           | 1                    | +25°C                | -              | -0.53          | mA            |
| Output Current (Source)        | IOH5B  | VDD = 5V, VOUT = 2.5V                 |           | 1                    | +25°C                | -              | -1.8           | mA            |
| Output Current (Source)        | IOH10  | VDD = 10V, VOUT = 9.5V                |           | 1                    | +25°C                | -              | -1.4           | mA            |
| Output Current (Source)        | IOH15  | VDD = 15V, VOUT = 13.5V               |           | 1                    | +25°C                | -              | -3.5           | mA            |
| N Threshold Voltage            | VNTH   | VDD = 10V, ISS = -10 $\mu\text{A}$    |           | 1                    | +25°C                | -2.8           | -0.7           | V             |
| P Threshold Voltage            | VPTH   | VSS = 0V, IDD = 10 $\mu\text{A}$      |           | 1                    | +25°C                | 0.7            | 2.8            | V             |
| Functional                     | F      | VDD = 2.8V, VIN = VDD or GND          |           | 7                    | +25°C                | VOH ><br>VDD/2 | VOL <<br>VDD/2 | V             |
|                                |        | VDD = 20V, VIN = VDD or GND           |           | 7                    | +25°C                |                |                |               |
|                                |        | VDD = 18V, VIN = VDD or GND           |           | 8A                   | +125°C               |                |                |               |
|                                |        | VDD = 3V, VIN = VDD or GND            |           | 8B                   | -55°C                |                |                |               |
| Input Voltage Low<br>(Note 2)  | VIL    | VDD = 5V, VOH > 4.5V, VOL < 0.5V      |           | 1, 2, 3              | +25°C, +125°C, -55°C | -              | 1.5            | V             |
| Input Voltage High<br>(Note 2) | VIH    | VDD = 5V, VOH > 4.5V, VOL < 0.5V      |           | 1, 2, 3              | +25°C, +125°C, -55°C | 3.5            | -              | V             |
| Input Voltage Low<br>(Note 2)  | VIL    | VDD = 15V, VOH > 13.5V,<br>VOL < 1.5V |           | 1, 2, 3              | +25°C, +125°C, -55°C | -              | 4              | V             |
| Input Voltage High<br>(Note 2) | VIH    | VDD = 15V, VOH > 13.5V,<br>VOL < 1.5V |           | 1, 2, 3              | +25°C, +125°C, -55°C | 11             | -              | V             |

NOTES: 1. All voltages referenced to device GND, 100% testing being implemented.  
 2. Go/No Go test with limits applied to inputs  
 3. For accuracy, voltage is measured differentially to VDD. Limit is 0.050V max.

## Specifications CD4011BMS, CD4012BMS, CD4023BMS

**TABLE 2. AC ELECTRICAL PERFORMANCE CHARACTERISTICS**

| PARAMETER         | SYMBOL | CONDITIONS (NOTE 1, 2)     | GROUP A<br>SUBGROUPS | TEMPERATURE   | LIMITS |     | UNITS |
|-------------------|--------|----------------------------|----------------------|---------------|--------|-----|-------|
|                   |        |                            |                      |               | MIN    | MAX |       |
| Propagation Delay | TPHL   | VDD = 5V, VIN = VDD or GND | 9                    | +25°C         | -      | 250 | ns    |
|                   | TPLH   |                            | 10, 11               | +125°C, -55°C | -      | 338 | ns    |
| Transition Time   | TTHL   | VDD = 5V, VIN = VDD or GND | 9                    | +25°C         | -      | 200 | ns    |
|                   | TTLH   |                            | 10, 11               | +125°C, -55°C | -      | 270 | ns    |

**NOTES:**

1. CL = 50pF, RL = 200K, Input TR, TF < 20ns.
2. -55°C and +125°C limits guaranteed, 100% testing being implemented.

**TABLE 3. ELECTRICAL PERFORMANCE CHARACTERISTICS**

| PARAMETER               | SYMBOL | CONDITIONS                    | NOTES   | TEMPERATURE          | LIMITS |       | UNITS |
|-------------------------|--------|-------------------------------|---------|----------------------|--------|-------|-------|
|                         |        |                               |         |                      | MIN    | MAX   |       |
| Supply Current          | IDD    | VDD = 5V, VIN = VDD or GND    | 1, 2    | -55°C, +25°C         | -      | 0.25  | μA    |
|                         |        |                               |         | +125°C               | -      | 7.5   | μA    |
|                         |        | VDD = 10V, VIN = VDD or GND   | 1, 2    | -55°C, +25°C         | -      | 0.5   | μA    |
|                         |        |                               |         | +125°C               | -      | 15    | μA    |
|                         |        | VDD = 15V, VIN = VDD or GND   | 1, 2    | -55°C, +25°C         | -      | 0.5   | μA    |
|                         |        |                               |         | +125°C               | -      | 30    | μA    |
| Output Voltage          | VOL    | VDD = 5V, No Load             | 1, 2    | +25°C, +125°C, -55°C | -      | 50    | mV    |
| Output Voltage          | VOL    | VDD = 10V, No Load            | 1, 2    | +25°C, +125°C, -55°C | -      | 50    | mV    |
| Output Voltage          | VOH    | VDD = 5V, No Load             | 1, 2    | +25°C, +125°C, -55°C | 4.95   | -     | V     |
| Output Voltage          | VOH    | VDD = 10V, No Load            | 1, 2    | +25°C, +125°C, -55°C | 9.95   | -     | V     |
| Output Current (Sink)   | IOL5   | VDD = 5V, VOUT = 0.4V         | 1, 2    | +125°C               | 0.36   | -     | mA    |
|                         |        |                               |         | -55°C                | 0.64   | -     | mA    |
| Output Current (Sink)   | IOL10  | VDD = 10V, VOUT = 0.5V        | 1, 2    | +125°C               | 0.9    | -     | mA    |
|                         |        |                               |         | -55°C                | 1.6    | -     | mA    |
| Output Current (Sink)   | IOL15  | VDD = 15V, VOUT = 1.5V        | 1, 2    | +125°C               | 2.4    | -     | mA    |
|                         |        |                               |         | -55°C                | 4.2    | -     | mA    |
| Output Current (Source) | IOH5A  | VDD = 5V, VOUT = 4.6V         | 1, 2    | +125°C               | -      | -0.36 | mA    |
|                         |        |                               |         | -55°C                | -      | -0.64 | mA    |
| Output Current (Source) | IOH5B  | VDD = 5V, VOUT = 2.5V         | 1, 2    | +125°C               | -      | -1.15 | mA    |
|                         |        |                               |         | -55°C                | -      | -2.0  | mA    |
| Output Current (Source) | IOH10  | VDD = 10V, VOUT = 9.5V        | 1, 2    | +125°C               | -      | -0.9  | mA    |
|                         |        |                               |         | -55°C                | -      | -1.6  | mA    |
| Output Current (Source) | IOH15  | VDD = 15V, VOUT = 13.5V       | 1, 2    | +125°C               | -      | -2.4  | mA    |
|                         |        |                               |         | -55°C                | -      | -4.2  | mA    |
| Input Voltage Low       | VIL    | VDD = 10V, VOH > 9V, VOL < 1V | 1, 2    | +25°C, +125°C, -55°C | -      | 3     | V     |
| Input Voltage High      | VIH    | VDD = 10V, VOH > 9V, VOL < 1V | 1, 2    | +25°C, +125°C, -55°C | 7      | -     | V     |
| Propagation Delay       | TPHL   | VDD = 10V                     | 1, 2, 3 | +25°C                | -      | 120   | ns    |
|                         | TPLH   | VDD = 15V                     | 1, 2, 3 | +25°C                | -      | 90    | ns    |

## Specifications CD4011BMS, CD4012BMS, CD4023BMS

**TABLE 3. ELECTRICAL PERFORMANCE CHARACTERISTICS (Continued)**

| PARAMETER         | SYMBOL       | CONDITIONS | NOTES   | TEMPERATURE | LIMITS |     | UNITS |
|-------------------|--------------|------------|---------|-------------|--------|-----|-------|
|                   |              |            |         |             | MIN    | MAX |       |
| Transition Time   | TTHL<br>TTLH | VDD = 10V  | 1, 2, 3 | +25°C       | -      | 100 | ns    |
|                   |              | VDD = 15V  | 1, 2, 3 | +25°C       | -      | 80  | ns    |
| Input Capacitance | CIN          | Any Input  | 1, 2    | +25°C       | -      | 7.5 | pF    |

NOTES:

1. All voltages referenced to device GND.
2. The parameters listed on Table 3 are controlled via design or process and are not directly tested. These parameters are characterized on initial design release and upon design changes which would affect these characteristics.
3. CL = 50pF, RL = 200K, Input TR, TF < 20ns.

**TABLE 4. POST IRRADIATION ELECTRICAL PERFORMANCE CHARACTERISTICS**

| PARAMETER                 | SYMBOL       | CONDITIONS                  | NOTES      | TEMPERATURE | LIMITS      |                    | UNITS |
|---------------------------|--------------|-----------------------------|------------|-------------|-------------|--------------------|-------|
|                           |              |                             |            |             | MIN         | MAX                |       |
| Supply Current            | IDD          | VDD = 20V, VIN = VDD or GND | 1, 4       | +25°C       | -           | 2.5                | μA    |
| N Threshold Voltage       | VNTH         | VDD = 10V, ISS = -10μA      | 1, 4       | +25°C       | -2.8        | -0.2               | V     |
| N Threshold Voltage Delta | ΔVNTH        | VDD = 10V, ISS = -10μA      | 1, 4       | +25°C       | -           | ±1                 | V     |
| P Threshold Voltage       | VPTH         | VSS = 0V, IDD = 10μA        | 1, 4       | +25°C       | 0.2         | 2.8                | V     |
| P Threshold Voltage Delta | ΔVPTH        | VSS = 0V, IDD = 10μA        | 1, 4       | +25°C       | -           | ±1                 | V     |
| Functional                | F            | VDD = 18V, VIN = VDD or GND | 1          | +25°C       | VOH > VDD/2 | VOL < VDD/2        | V     |
|                           |              | VDD = 3V, VIN = VDD or GND  |            |             |             |                    |       |
| Propagation Delay Time    | TPHL<br>TPLH | VDD = 5V                    | 1, 2, 3, 4 | +25°C       | -           | 1.35 x +25°C Limit | ns    |

- NOTES: 1. All voltages referenced to device GND. 3. See Table 2 for +25°C limit.  
2. CL = 50pF, RL = 200K, Input TR, TF < 20ns. 4. Read and Record

**TABLE 5. BURN-IN AND LIFE TEST DELTA PARAMETERS +25°C**

| PARAMETER               | SYMBOL | DELTA LIMIT              |
|-------------------------|--------|--------------------------|
| Supply Current - SSI    | IDD    | ± 0.1μA                  |
| Output Current (Sink)   | IOL5   | ± 20% x Pre-Test Reading |
| Output Current (Source) | IOH5A  | ± 20% x Pre-Test Reading |

**TABLE 6. APPLICABLE SUBGROUPS**

| CONFORMANCE GROUP             | MIL-STD-883 METHOD | GROUP A SUBGROUPS             | READ AND RECORD  |
|-------------------------------|--------------------|-------------------------------|------------------|
| Initial Test (Pre Burn-In)    | 100% 5004          | 1, 7, 9                       | IDD, IOL5, IOH5A |
| Interim Test 1 (Post Burn-In) | 100% 5004          | 1, 7, 9                       | IDD, IOL5, IOH5A |
| Interim Test 2 (Post Burn-In) | 100% 5004          | 1, 7, 9                       | IDD, IOL5, IOH5A |
| PDA (Note 1)                  | 100% 5004          | 1, 7, 9, Deltas               |                  |
| Interim Test 3 (Post Burn-In) | 100% 5004          | 1, 7, 9                       | IDD, IOL5, IOH5A |
| PDA (Note 1)                  | 100% 5004          | 1, 7, 9, Deltas               |                  |
| Final Test                    | 100% 5004          | 2, 3, 8A, 8B, 10, 11          |                  |
| Group A                       | Sample 5005        | 1, 2, 3, 7, 8A, 8B, 9, 10, 11 |                  |

## Specifications CD4011BMS, CD4012BMS, CD4023BMS

**TABLE 6. APPLICABLE SUBGROUPS (Continued)**

| CONFORMANCE GROUP |              | MIL-STD-883 METHOD | GROUP A SUBGROUPS                     | READ AND RECORD              |
|-------------------|--------------|--------------------|---------------------------------------|------------------------------|
| 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, 2, 3, 8A, 8B, 9                    | Subgroups 1, 2 3             |

NOTE: 1. 5% Parametric, 3% Functional; Cumulative for Static 1 and 2.

**TABLE 7. TOTAL DOSE IRRADIATION**

| CONFORMANCE GROUPS | MIL-STD-883 METHOD | TEST      |            | READ AND RECORD |            |
|--------------------|--------------------|-----------|------------|-----------------|------------|
|                    |                    | PRE-IRRAD | POST-IRRAD | PRE-IRRAD       | POST-IRRAD |
| Group E Subgroup 2 | 5005               | 1, 7, 9   | Table 4    | 1, 9            | Table 4    |

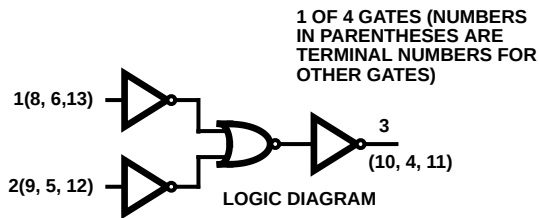
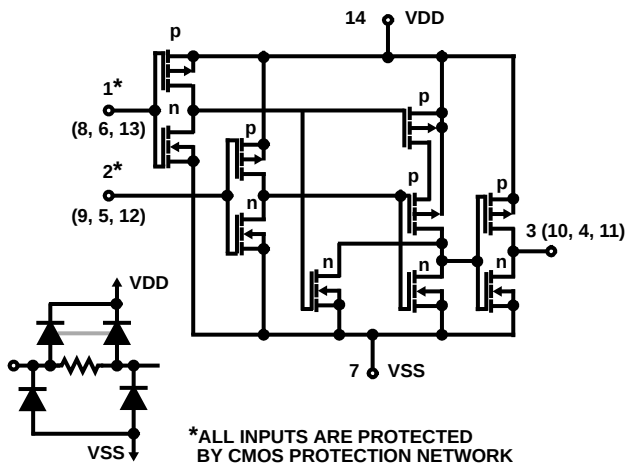
**TABLE 8. BURN-IN AND IRRADIATION TEST CONNECTIONS**

| FUNCTION                   | OPEN         | GROUND               | VDD                          | 9V ± -0.5V   | OSCILLATOR                  |       |
|----------------------------|--------------|----------------------|------------------------------|--------------|-----------------------------|-------|
|                            |              |                      |                              |              | 50kHz                       | 25kHz |
| PART NUMBER CD4011B        |              |                      |                              |              |                             |       |
| Static Burn-In 1<br>Note 1 | 3, 4, 10, 11 | 1, 2, 5 - 9, 12, 13  | 14                           |              |                             |       |
| Static Burn-In 2<br>Note 1 | 3, 4, 10, 11 | 7                    | 1, 2, 5, 6, 8, 9,<br>12 - 14 |              |                             |       |
| Dynamic Burn-In<br>Note 1  | -            | 7                    | 14                           | 3, 4, 10, 11 | 1, 2, 5, 6, 8, 9, 12,<br>13 |       |
| Irradiation<br>Note 2      | 3, 4, 10, 11 | 7                    | 1, 2, 5, 6, 8, 9,<br>12 - 14 |              |                             |       |
| PART NUMBER CD4012B        |              |                      |                              |              |                             |       |
| Static Burn-In 1<br>Note 1 | 1, 6, 8, 13  | 2 - 5, 7, 9 - 12     | 14                           |              |                             |       |
| Static Burn-In 2<br>Note 1 | 1, 6, 8, 13  | 7                    | 2 - 5, 9 - 12, 14            |              |                             |       |
| Dynamic Burn-In<br>Note 1  | 6, 8         | 7                    | 14                           | 1, 13        | 2 - 5, 9 - 12               |       |
| Irradiation<br>Note 2      | 1, 6, 8, 13  | 7                    | 2 - 5, 9 - 12, 14            |              |                             |       |
| PART NUMBER CD4023B        |              |                      |                              |              |                             |       |
| Static Burn-In 1<br>Note 1 | 6, 9, 10     | 1 - 5, 7, 8, 11 - 13 | 14                           |              |                             |       |
| Static Burn-In 2<br>Note 1 | 6, 9, 10     | 7                    | 1 - 5, 8, 11 - 14            |              |                             |       |
| Dynamic Burn-In<br>Note 1  | -            | 7                    | 14                           | 6, 9, 10     | 1 - 5, 8, 11 - 13           |       |
| Irradiation<br>Note 2      | 6, 9, 10     | 7                    | 1 - 5, 8, 11 - 14            |              |                             |       |

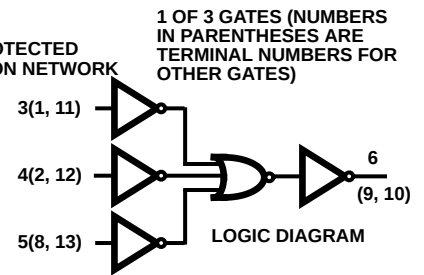
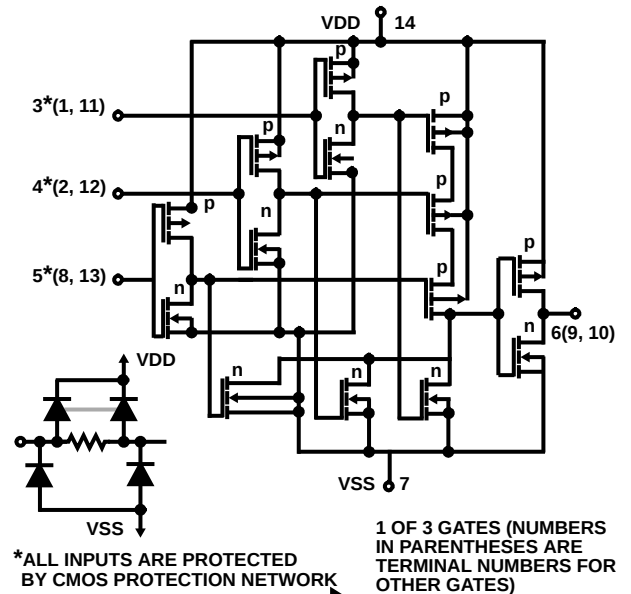
NOTE:

- Each pin except VDD and GND will have a series resistor of  $10K \pm 5\%$ ,  $VDD = 18V \pm 0.5V$
- Each pin except VDD and GND will have a series resistor of  $47K \pm 5\%$ ; Group E, Subgroup 2, sample size is 4 dice/wafer, 0 failures,  $VDD = 10V \pm 0.5V$

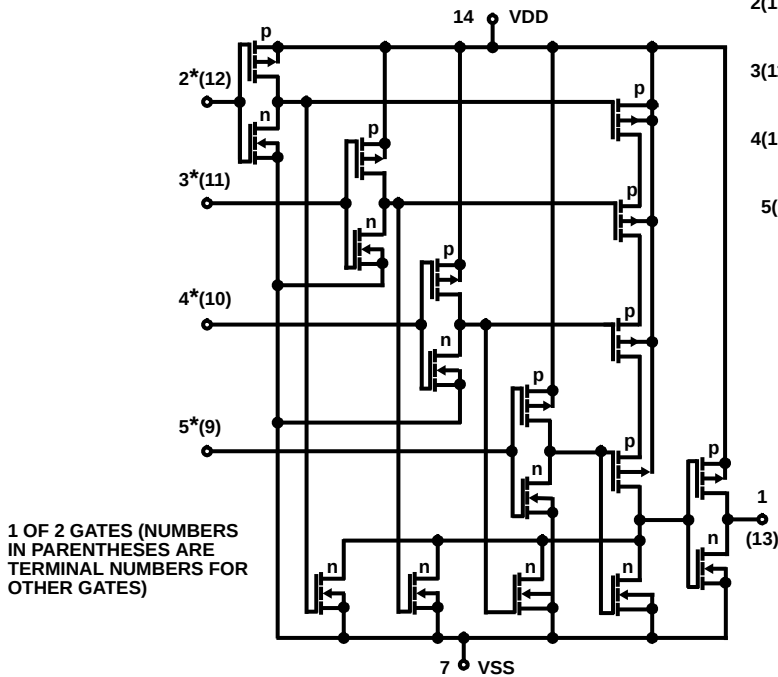
# Schematic and Logic Diagrams



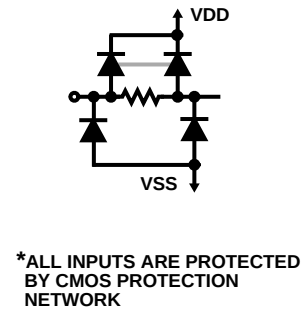
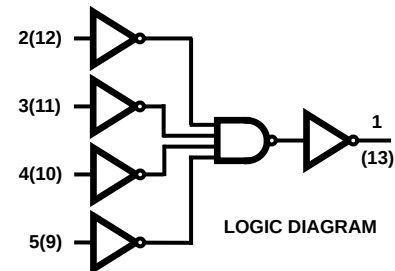
CD4011BMS



CD4023BMS



CD4012BMS



## Typical Performance Characteristics

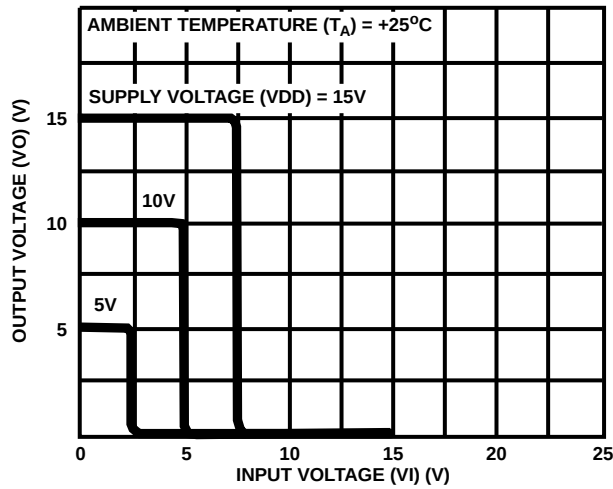


FIGURE 1. TYPICAL VOLTAGE TRANSFER CHARACTERISTICS

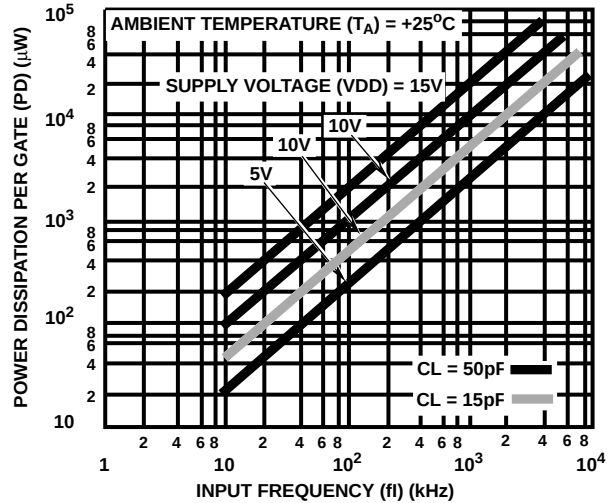


FIGURE 2. TYPICAL POWER DISSIPATION CHARACTERISTICS

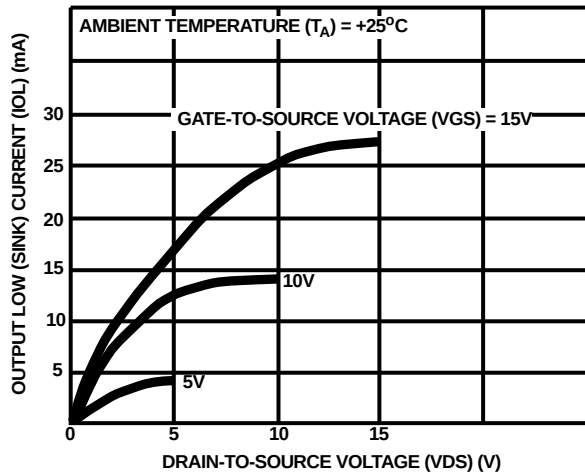


FIGURE 3. TYPICAL OUTPUT LOW (SINK) CURRENT CHARACTERISTICS

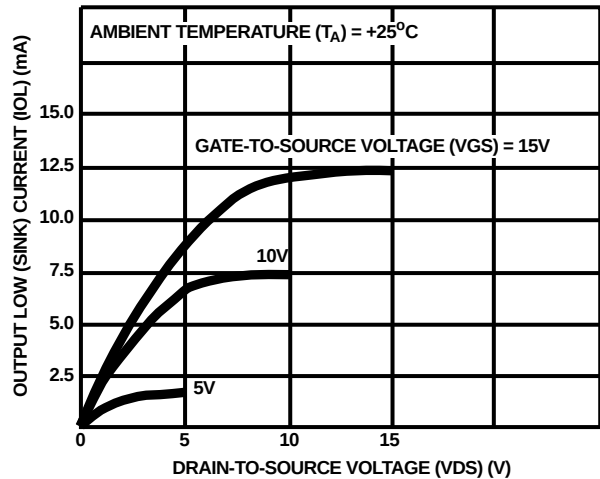


FIGURE 4. MINIMUM OUTPUT LOW (SINK) CURRENT CHARACTERISTICS

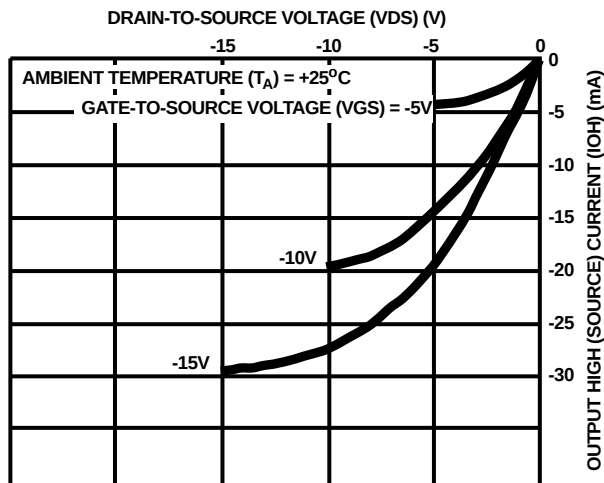


FIGURE 5. TYPICAL OUTPUT HIGH (SOURCE) CURRENT CHARACTERISTICS

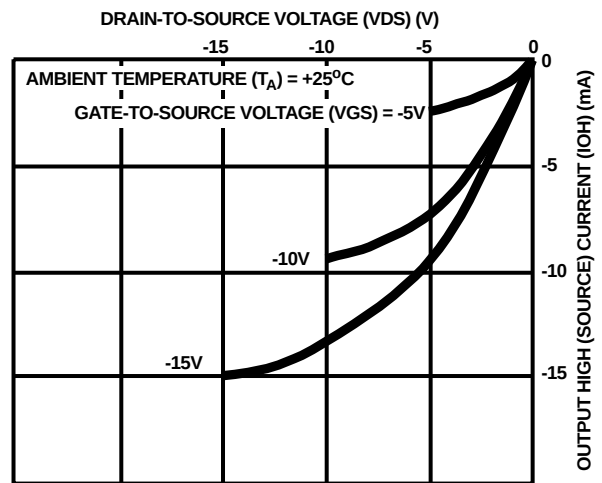


FIGURE 6. MINIMUM OUTPUT HIGH (SOURCE) CURRENT CHARACTERISTICS

# Typical Performance Characteristics (Continued)

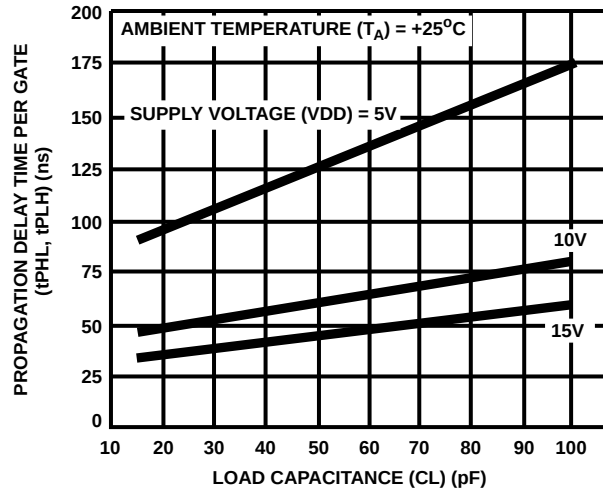


FIGURE 7. TYPICAL PROPAGATION DELAY TIME PER GATE AS A FUNCTION OF LOAD CAPACITANCE

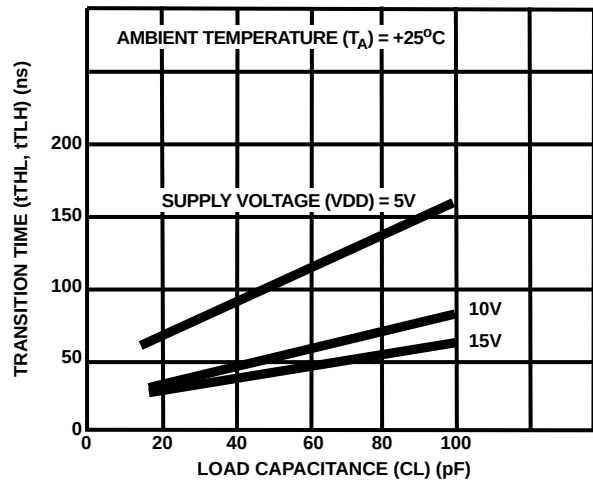
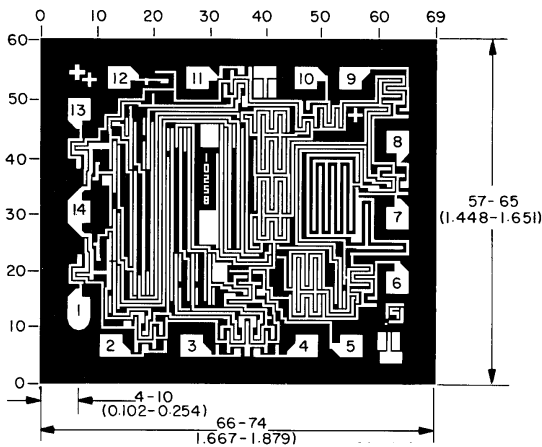
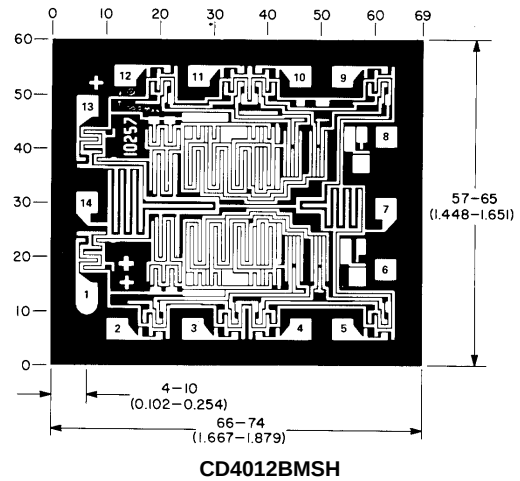
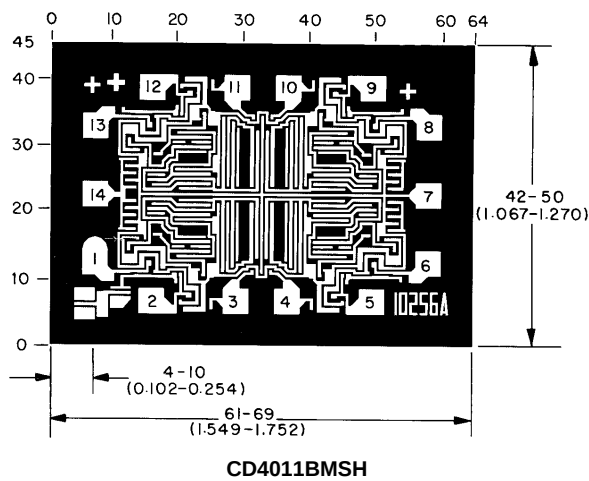


FIGURE 8. TYPICAL TRANSITION TIME AS A FUNCTION OF LOAD CAPACITANCE

## Chip Dimensions and Pad Layouts



Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated. Grid graduations are in mils ( $10^{-3}$  inch)

METALLIZATION: Thickness:  $11\text{k}\text{\AA}$  -  $14\text{k}\text{\AA}$ , AL.

PASSIVATION:  $10.4\text{k}\text{\AA}$  -  $15.6\text{k}\text{\AA}$ , Silane

BOND PADS: 0.004 inches X 0.004 inches MIN

DIE THICKNESS: 0.0198 inches - 0.0218 inches