

## CMOS Dual 4-Stage Static Shift Register With Serial Input/Parallel Output

December 1992

### Features

- High-Voltage Type (20V Rating)
- Medium Speed Operation 12MHz (typ.) Clock Rate at VDD - VSS = 10V
- Fully Static Operation
- 8 Master-Slave Flip-Flops Plus Input and Output Buffering
- 100% Tested For Quiescent Current at 20V
- 5V, 10V and 15V Parametric Ratings
- Standardized Symmetrical Output Characteristics
- Maximum Input Current of 1 $\mu$ A at 18V Over Full Package-Temperature Range; 100nA at 18V and 25 $^{\circ}$ C
- Noise Margin (Full Package-Temperature Range) =
  - 1V at VDD = 5V
  - 2V at VDD = 10V
  - 2.5V at VDD = 15V
- Meets All Requirements of JEDEC Tentative Standard No. 13B, "Standard Specifications for Description of 'B' Series CMOS Devices"

### Applications

- Serial-Input/Parallel-Output Data Queueing
- Serial to Parallel Data Conversion
- General-Purpose Register

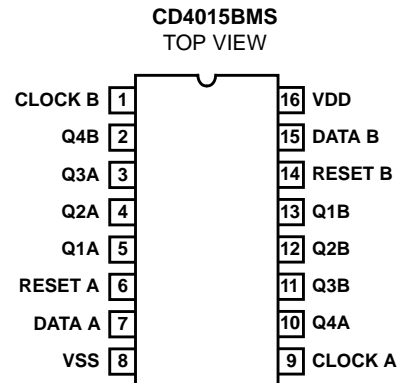
### Description

CD4015BMS consists of two identical, independent, 4-stage serial-input/parallel output registers. Each register has independent CLOCK and RESET inputs as well as a single serial DATA input. "Q" outputs are available from each of the four stages on both registers. All register stages are D type, master-slave flip-flops. The logic level present at the DATA input is transferred into the first register stage and shifted over one stage at each positive-going clock transition. Resetting of all stages is accomplished by a high level on the reset line. Register expansion to 8 stages using one CD4015BMS package, or to more than 8 stages using additional CD4015BMS's is possible.

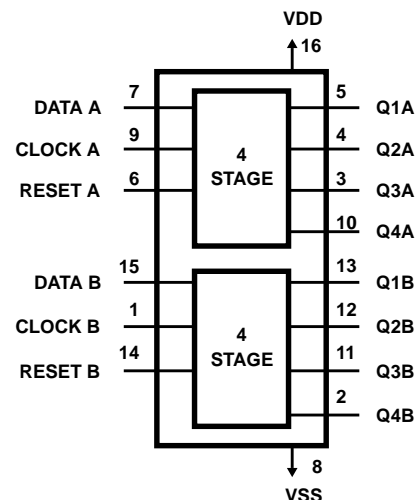
The CD4015BMS is supplied in these 16 lead outline packages:

|                  |     |
|------------------|-----|
| Braze Seal DIP   | H4X |
| Frit Seal DIP    | H1F |
| Ceramic Flatpack | H6W |

### Pinout



### Functional Diagram



# Specifications CD4015BMS

## 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 ..... ±10mA  
 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 ± 1/32 Inch (1.59mm ± 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                | -              | 10             | μA    |
|                                |        |                                       |           | 2                    | +125°C               | -              | 1000           | μA    |
|                                |        | VDD = 18V, VIN = VDD or GND           |           | 3                    | -55°C                | -              | 10             | μA    |
| Input Leakage Current          | IIL    | VIN = VDD or GND                      | VDD = 20  | 1                    | +25°C                | -100           | -              | nA    |
|                                |        |                                       | VDD = 18V | 2                    | +125°C               | -1000          | -              | nA    |
|                                |        |                                       |           | 3                    | -55°C                | -100           | -              | nA    |
| Input Leakage Current          | IIH    | VIN = VDD or GND                      | VDD = 20  | 1                    | +25°C                | -              | 100            | nA    |
|                                |        |                                       | VDD = 18V | 2                    | +125°C               | -              | 1000           | nA    |
|                                |        |                                       |           | 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 = -10μA                |           | 1                    | +25°C                | -2.8           | -0.7           | V     |
| P Threshold Voltage            | VPTH   | VSS = 0V, IDD = 10μA                  |           | 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 CD4015BMS

**TABLE 2. AC ELECTRICAL PERFORMANCE CHARACTERISTICS**

| PARAMETER                        | SYMBOL         | CONDITIONS (NOTE 1, 2)     | GROUP A<br>SUBGROUPS | TEMPERATURE   | LIMITS |     | UNITS |
|----------------------------------|----------------|----------------------------|----------------------|---------------|--------|-----|-------|
|                                  |                |                            |                      |               | MIN    | MAX |       |
| Propagation Delay<br>Clock To Q  | TPHL1<br>TPLH1 | VDD = 5V, VIN = VDD or GND | 9                    | +25°C         | -      | 320 | ns    |
|                                  |                |                            | 10, 11               | +125°C, -55°C | -      | 432 | ns    |
| Propagation Delay<br>Reset To Q  | TPHL2          | VDD = 5V, VIN = VDD or GND | 9                    | +25°C         | -      | 400 | ns    |
|                                  |                |                            | 10, 11               | +125°C, -55°C | -      | 540 | ns    |
| Transition Time                  | TTHL<br>TTLH   | VDD = 5V, VIN = VDD or GND | 9                    | +25°C         | -      | 200 | ns    |
|                                  |                |                            | 10, 11               | +125°C, -55°C | -      | 270 | ns    |
| Maximum Clock Input<br>Frequency | FCL            | VDD = 5V, VIN = VDD or GND | 9                    | +25°C         | 3      | -   | MHz   |
|                                  |                |                            | 10, 11               | +125°C, -55°C | 3/1.35 | -   | MHz   |

**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            | -      | 5     | μA    |
|                         |        |                               |       | +125°C                  | -      | 150   | μA    |
|                         |        | VDD = 10V, VIN = VDD or GND   | 1, 2  | -55°C, +25°C            | -      | 10    | μA    |
|                         |        |                               |       | +125°C                  | -      | 300   | μA    |
|                         |        | VDD = 15V, VIN = VDD or GND   | 1, 2  | -55°C, +25°C            | -      | 10    | μA    |
|                         |        |                               |       | +125°C                  | -      | 600   | μA    |
| Output Voltage          | VOL    | VDD = 5V, No Load             | 1, 2  | +25°C, +125°C,<br>-55°C | -      | 50    | mV    |
| Output Voltage          | VOL    | VDD = 10V, No Load            | 1, 2  | +25°C, +125°C,<br>-55°C | -      | 50    | mV    |
| Output Voltage          | VOH    | VDD = 5V, No Load             | 1, 2  | +25°C, +125°C,<br>-55°C | 4.95   | -     | V     |
| Output Voltage          | VOH    | VDD = 10V, No Load            | 1, 2  | +25°C, +125°C,<br>-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,<br>-55°C | -      | 3     | V     |

## Specifications CD4015BMS

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

| PARAMETER                     | SYMBOL         | CONDITIONS                    | NOTES   | TEMPERATURE          | LIMITS |     | UNITS |
|-------------------------------|----------------|-------------------------------|---------|----------------------|--------|-----|-------|
|                               |                |                               |         |                      | MIN    | MAX |       |
| Input Voltage High            | VIH            | VDD = 10V, VOH > 9V, VOL < 1V | 1, 2    | +25°C, +125°C, -55°C | +7     | -   | V     |
| Propagation Delay Clock To Q  | TPHL1<br>TPLH1 | VDD = 10V                     | 1, 2, 3 | +25°C                | -      | 160 | ns    |
|                               |                | VDD = 15V                     | 1, 2, 3 | +25°C                | -      | 120 | ns    |
| Propagation Delay Reset To Q  | TPHL2          | VDD = 10V                     | 1, 2, 3 | +25°C                | -      | 200 | ns    |
|                               |                | VDD = 15V                     | 1, 2, 3 | +25°C                | -      | 160 | ns    |
| Transition Time               | TTHL<br>TTLH   | VDD = 10V                     | 1, 2, 3 | +25°C                | -      | 100 | ns    |
|                               |                | VDD = 15V                     | 1, 2, 3 | +25°C                | -      | 80  | ns    |
| Maximum Clock Input Frequency | FCL            | VDD = 10V                     | 1, 2, 3 | +25°C                | 6      | -   | MHz   |
|                               |                | VDD = 15V                     | 1, 2, 3 | +25°C                | 8.5    | -   | MHz   |
| Minimum Data Setup Time       | TS             | VDD = 5V                      | 1, 2, 3 | +25°C                | -      | 70  | ns    |
|                               |                | VDD = 10V                     | 1, 2, 3 | +25°C                | -      | 40  | ns    |
|                               |                | VDD = 15V                     | 1, 2, 3 | +25°C                | -      | 30  | ns    |
| Clock Rise and Fall Time      | TRCL<br>TFCL   | VDD = 5V                      | 1, 2, 3 | +25°C                | -      | 15  | μs    |
|                               |                | VDD = 10V                     | 1, 2, 3 | +25°C                | -      | 15  | μs    |
|                               |                | VDD = 15V                     | 1, 2, 3 | +25°C                | -      | 15  | μs    |
| Minimum Clock Pulse Width     | TWCL           | VDD = 5V                      | 1, 2, 3 | +25°C                | -      | 180 | ns    |
|                               |                | VDD = 10V                     | 1, 2, 3 | +25°C                | -      | 80  | ns    |
|                               |                | VDD = 15V                     | 1, 2, 3 | +25°C                | -      | 50  | ns    |
| Minimum Reset Pulse Width     | TWR            | VDD = 5V                      | 2, 3    | +25°C                | -      | 200 | ns    |
|                               |                | VDD = 10V                     | 2, 3    | +25°C                | -      | 80  | ns    |
|                               |                | VDD = 15V                     | 2, 3    | +25°C                | -      | 60  | 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       | -           | 25                 | 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. 2. CL = 50pF, RL = 200K, Input TR, TF < 20ns. 3. See Table 2 for +25°C limit. 4. Read and Record

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

| PARAMETER               | SYMBOL | DELTA LIMIT              |
|-------------------------|--------|--------------------------|
| Supply Current - MSI-2  | IDD    | ± 1.0µA                  |
| 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 |                                       |
| Group B                       | Subgroup B-5       | Sample 5005                   | 1, 2, 3, 7, 8A, 8B, 9, 10, 11, Deltas |
|                               | 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 |
| Static Burn-In 1<br>Note 1 | 2 - 5, 10 - 13 | 1, 6 - 9, 14, 15 | 16                  |                |            |       |
| Static Burn-In 2<br>Note 1 | 2 - 5, 10 - 13 | 8                | 1, 6, 7, 9, 14 - 16 |                |            |       |
| Dynamic Burn-In<br>Note 1  | -              | 6, 8, 14         | 16                  | 2 - 5, 10 - 13 | 1, 9       | 7, 15 |
| Irradiation<br>Note 2      | 2 - 5, 10 - 13 | 8                | 1, 6, 7, 9, 14 - 16 |                |            |       |

NOTE:

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

# Specifications CD4015BMS

## Logic Diagram

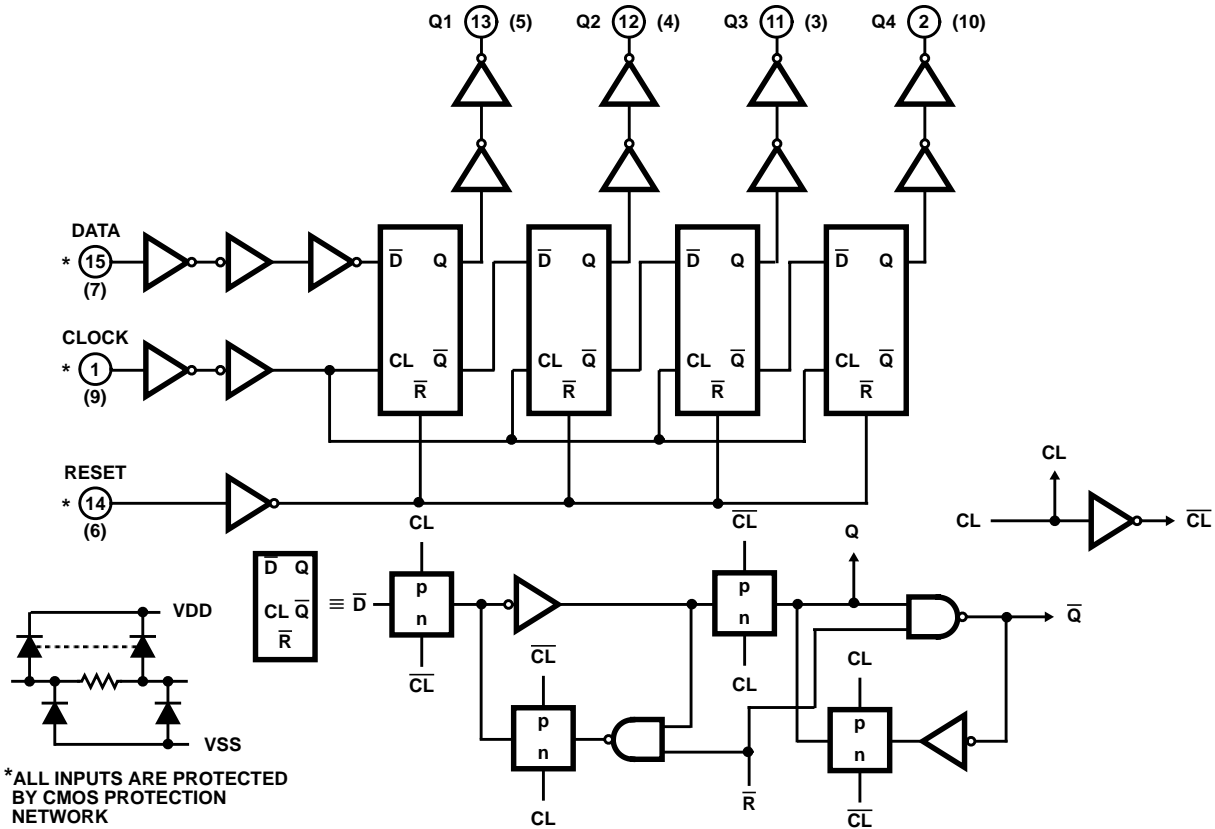


FIGURE 1. CD4015BMS LOGIC DIAGRAM

### TRUTH TABLE

| CL | D | R | Q1 | Qn   |
|----|---|---|----|------|
|    | 0 | 0 | 0  | Qn-1 |
|    | 1 | 0 | 1  | Qn-1 |
|    | X | 0 | Q1 | Qn   |
| X  | X | 1 | 0  | 0    |

(No Change)

X = Don't care Case

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Typical Performance Characteristics

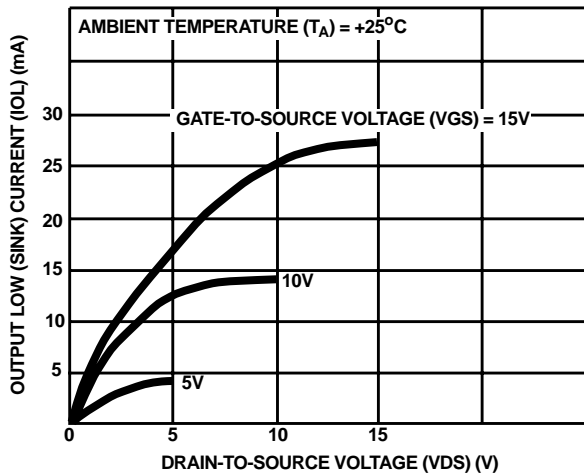


FIGURE 2. TYPICAL OUTPUT LOW (SINK) CURRENT CHARACTERISTICS

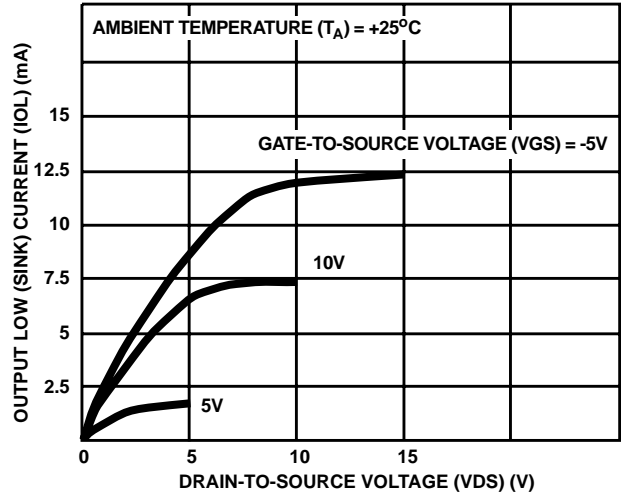


FIGURE 3. MINIMUM OUTPUT LOW (SINK) CURRENT CHARACTERISTICS

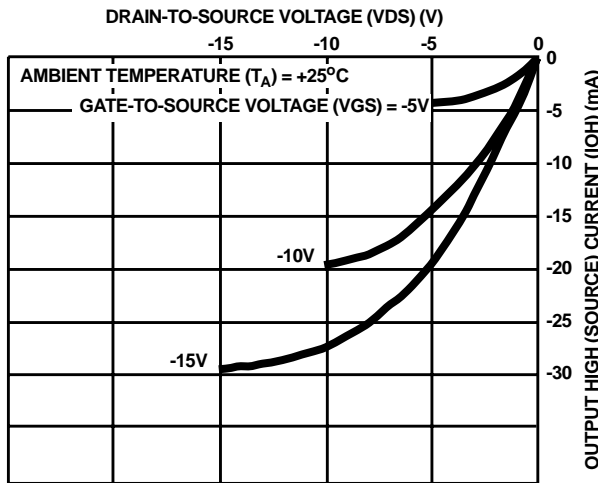


FIGURE 4. TYPICAL OUTPUT HIGH (SOURCE) CURRENT CHARACTERISTICS

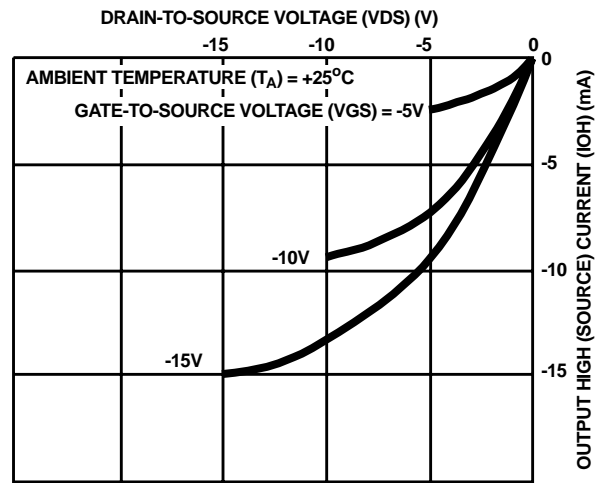


FIGURE 5. MINIMUM OUTPUT HIGH (SOURCE) CURRENT CHARACTERISTICS

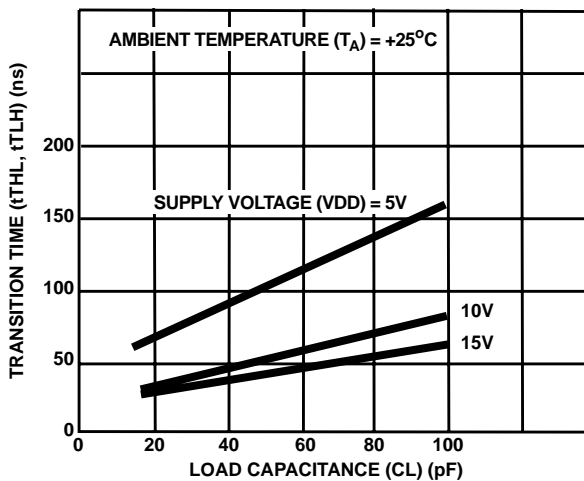


FIGURE 6. TYPICAL TRANSITION TIME AS A FUNCTION OF LOAD CAPACITANCE

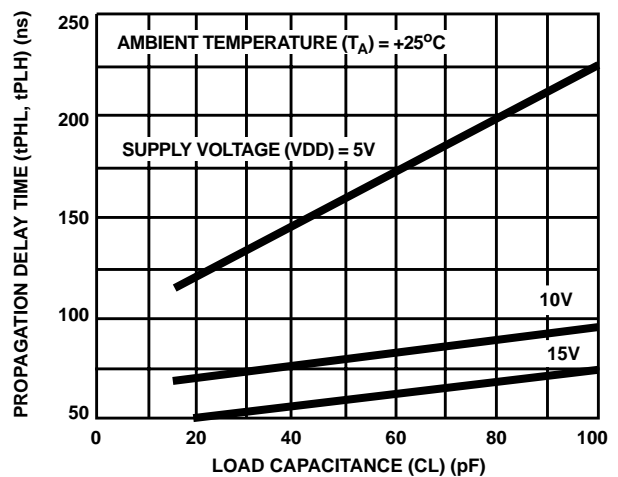


FIGURE 7. TYPICAL PROPAGATION DELAY TIME AS A FUNCTION OF LOAD CAPACITANCE

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## Typical Performance Characteristics (Continued)

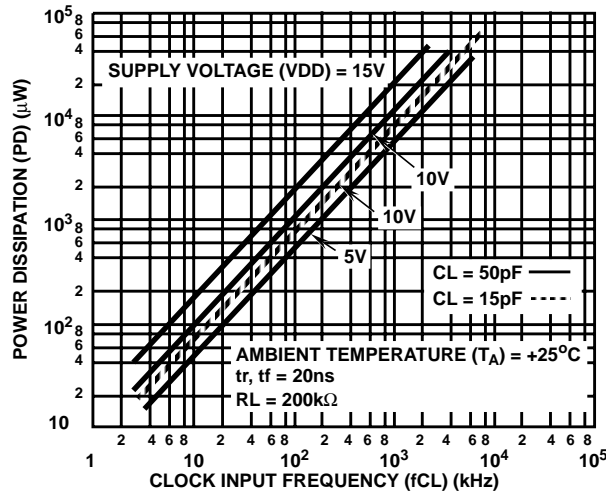
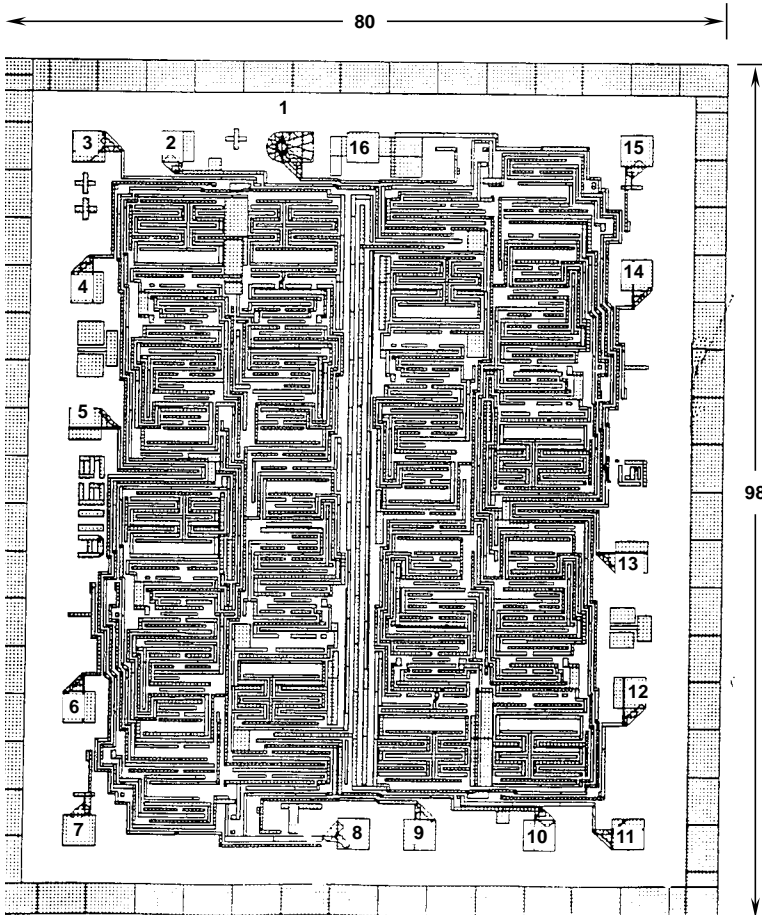


FIGURE 8. TYPICAL POWER DISSIPATION AS A FUNCTION OF FREQUENCY

## Chip Dimensions and Pad Layout



**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

**DIE SIZE:** X = 80 (77 - 85) = (1.956 - 2.159)

Y = 98 (95 - 103) = (2.413 - 2.616)

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