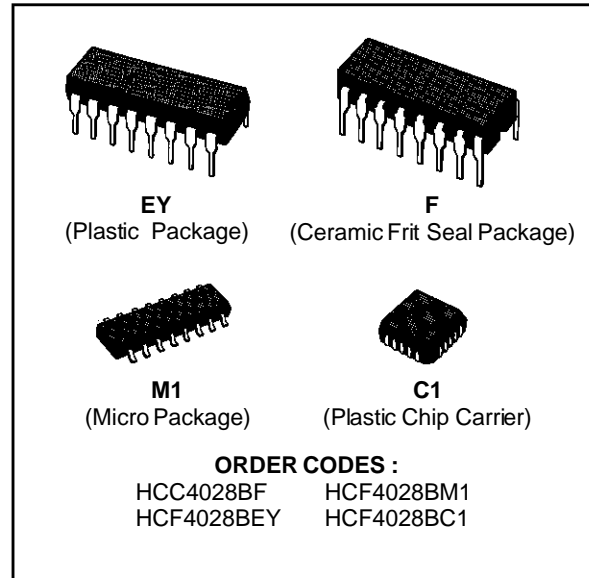


## BCD-TO-DECIMAL DECODER

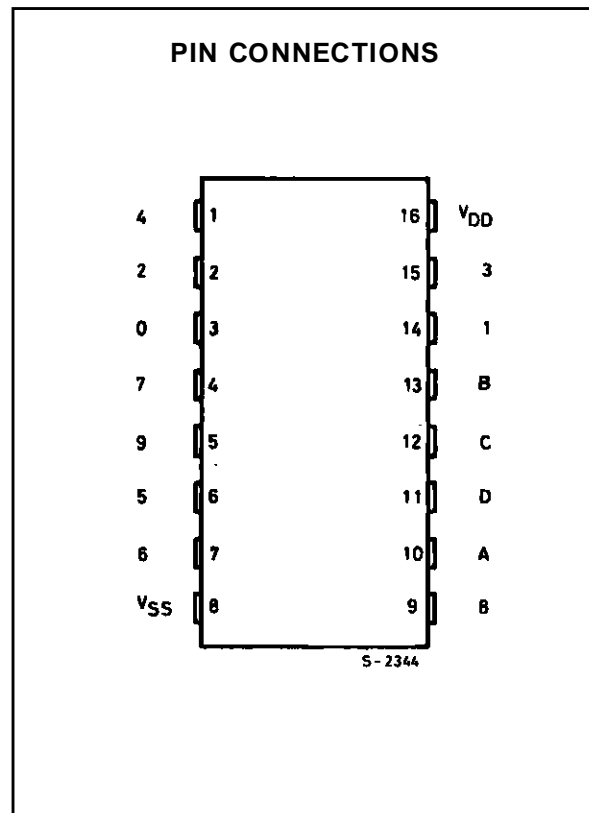
- BCD-TO-DECIMAL DECODING OR BINARY-TO-OCTAL DECODING
- HIGH DECODED OUTPUT DRIVE CAPABILITY
- "POSITIVE LOGIC" INPUTS AND OUTPUTS : DECODED OUTPUTS GO HIGH ON SELECTION
- MEDIUM-SPEED OPERATION :  $t_{PHL}$ ,  $t_{PLH}$  = 80ns (typ.) @  $V_{DD} = 10V$
- STANDARDIZED SYMMETRICAL OUTPUT CHARACTERISTICS
- QUIESCENT CURRENT SPECIFIED TO 20V FOR HCC DEVICE
- 5V, 10V, AND 15V PARAMETRIC RATINGS
- INPUT CURRENT OF 100nA AT 18V AND 25°C FOR HCC DEVICE
- 100% TESTED FOR QUIESCENT CURRENT
- MEETS ALL REQUIREMENTS OF JEDEC TENTATIVE STANDARD N° 13A, "STANDARD SPECIFICATIONS FOR DESCRIPTION OF "B" SERIES CMOS DEVICES"



### DESCRIPTION

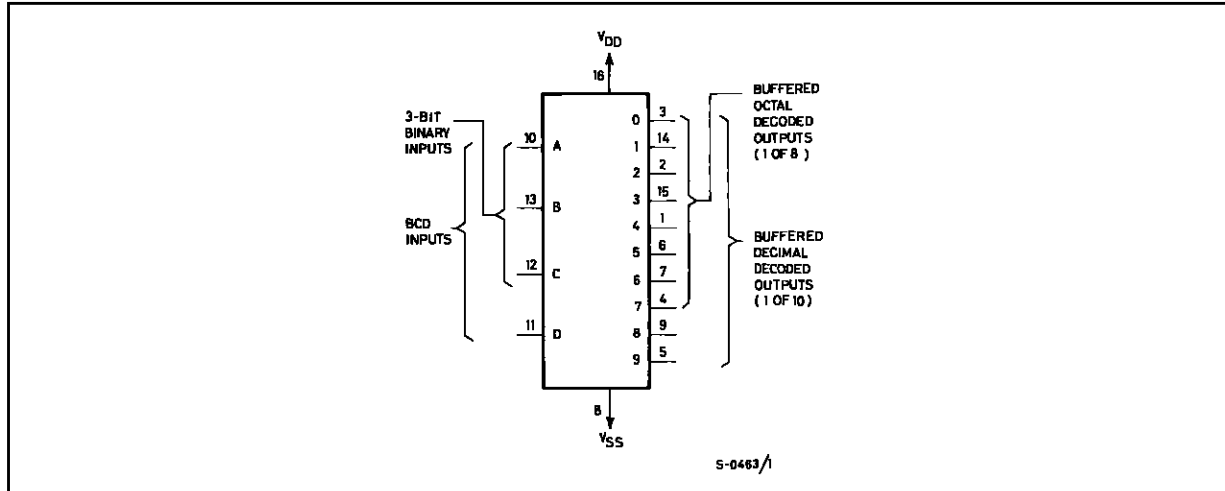
The **HCC4028B** (extended temperature range) and **HCF4028B** (intermediate temperature range) are monolithic integrated circuit, available in 16-lead dual in-line plastic or ceramic package and plastic micropackage.

The **HCC/HCF4028B** types are BCD-to-decimal or binary-to-octal decoders consisting of buffering on all 4 inputs, decoding-logic gates, and 10 output buffers. A BCD code applied to the four inputs, A to D, results in a high level at the selected one of 10 decimal decoded outputs. Similarly, a 3-bit binary code applied to inputs A through C is decoded in octal code at output 0 to 7 if D = "0". High drive capability is provided at all outputs to enhance dc and dynamic performance in high fan-out applications.



# HCC/HCF4028B

## FUNCTIONAL DIAGRAM



## ABSOLUTE MAXIMUM RATINGS

| Symbol     | Parameter   | Value                   | Unit        |
|------------|---|-------------------------|-------------|
| $V_{DD}^*$ | Supply Voltage : <b>HCC</b> Types<br><b>HCF</b> Types   | - 0.5 to + 20           | V           |
|            |   | - 0.5 to + 18           | V           |
| $V_i$      | Input Voltage   | - 0.5 to $V_{DD} + 0.5$ | V           |
| $I_i$      | DC Input Current (any one input)  | $\pm 10$                | mA          |
| $P_{tot}$  | Total Power Dissipation (per package)<br>Dissipation per Output Transistor<br>for $T_{op} =$ Full Package-temperature Range | 200                     | mW          |
|            |   | 100                     | mW          |
| $T_{op}$   | Operating Temperature : <b>HCC</b> Types<br><b>HCF</b> Types  | - 55 to + 125           | $^{\circ}C$ |
|            |   | - 40 to + 85            | $^{\circ}C$ |
| $T_{stg}$  | Storage Temperature   | - 65 to + 150           | $^{\circ}C$ |

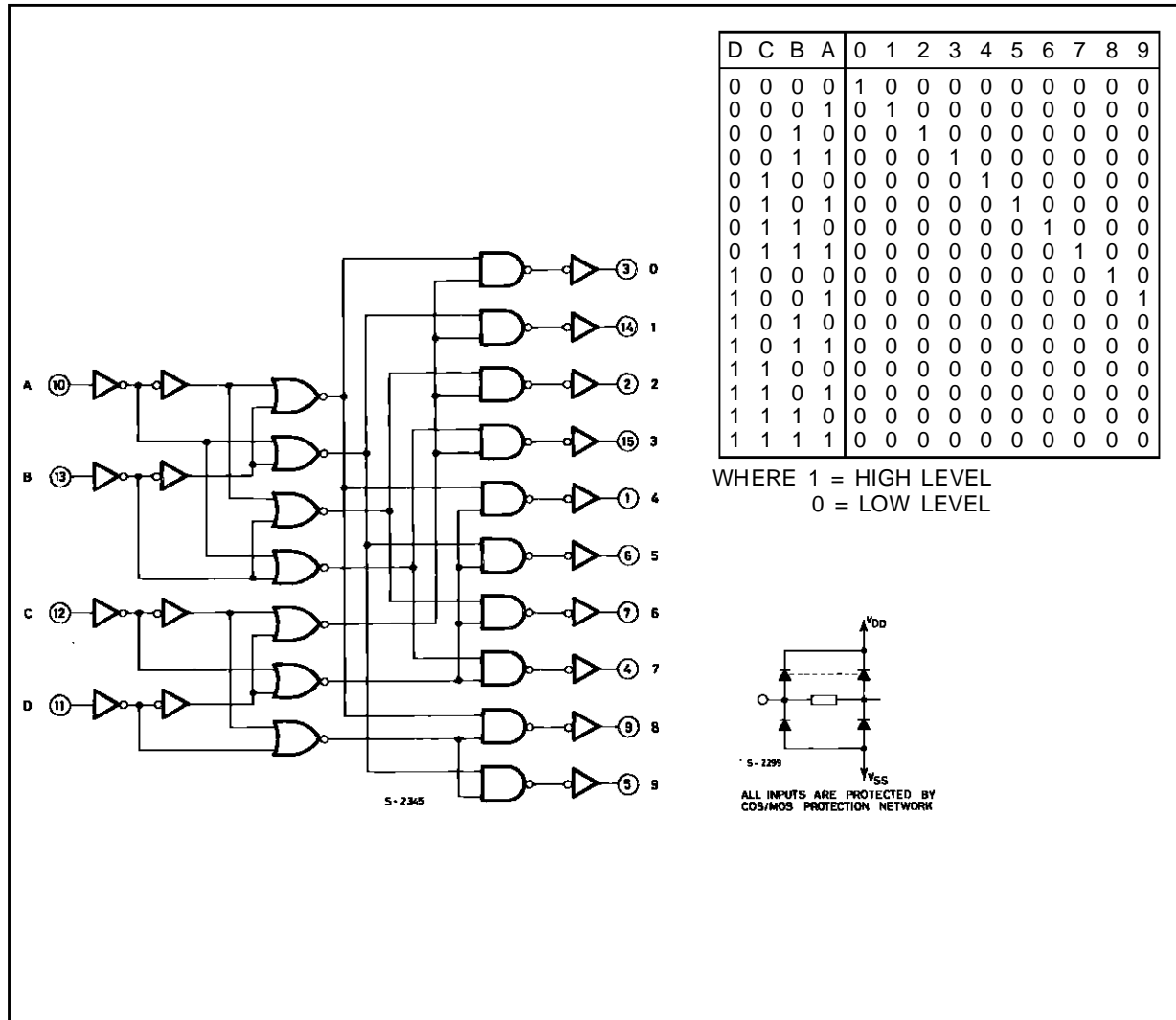
Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for external periods may affect device reliability.

\* All voltage values are referred to  $V_{SS}$  pin voltage.

## RECOMMENDED OPERATING CONDITIONS

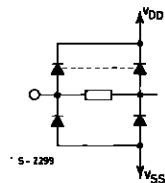
| Symbol   | Parameter  | Value         | Unit        |
|----------|--|---------------|-------------|
| $V_{DD}$ | Supply Voltage : <b>HCC</b> Types<br><b>HCF</b> Types        | 3 to 18       | V           |
|          |  | 3 to 15       | V           |
| $V_i$    | Input Voltage  | 0 to $V_{DD}$ | V           |
| $T_{op}$ | Operating Temperature : <b>HCC</b> Types<br><b>HCF</b> Types | - 55 to + 125 | $^{\circ}C$ |
|          |  | - 40 to + 85  | $^{\circ}C$ |

LOGIC DIAGRAM AND TRUTH TABLE



| D | C | B | A | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

WHERE 1 = HIGH LEVEL  
0 = LOW LEVEL



ALL INPUTS ARE PROTECTED BY CDS/MOS PROTECTION NETWORK

# HCC/HCF4028B

## STATIC ELECTRICAL CHARACTERISTICS (over recommended operating conditions)

| Symbol                            | Parameter             |           | Test Conditions       |                       |                                |                        | Value              |           |        |                        |           |                     | Unit    |         |
|-----------------------------------|-----------------------|-----------|-----------------------|-----------------------|--------------------------------|------------------------|--------------------|-----------|--------|------------------------|-----------|---------------------|---------|---------|
|                                   |                       |           | V <sub>I</sub><br>(V) | V <sub>O</sub><br>(V) | I <sub>O</sub>  <br>( $\mu$ A) | V <sub>DD</sub><br>(V) | T <sub>Low</sub> * |           | 25°C   |                        |           | T <sub>High</sub> * |         |         |
|                                   |                       |           |                       |                       |                                |                        | Min.               | Max.      | Min.   | Typ.                   | Max.      | Min.                |         | Max.    |
| I <sub>L</sub>                    | Quiescent Current     | HCC Types | 0/ 5                  |                       |                                | 5                      |                    | 5         |        | 0.04                   | 5         |                     | 150     | $\mu$ A |
|                                   |                       |           | 0/10                  |                       |                                | 10                     |                    | 10        |        | 0.04                   | 10        |                     | 300     |         |
|                                   |                       |           | 0/15                  |                       |                                | 15                     |                    | 20        |        | 0.04                   | 20        |                     | 600     |         |
|                                   |                       |           | 0/20                  |                       |                                | 20                     |                    | 100       |        | 0.08                   | 100       |                     | 3000    |         |
|                                   |                       | HCF Types | 0/ 5                  |                       |                                | 5                      |                    | 20        |        | 0.04                   | 20        |                     | 150     |         |
|                                   |                       |           | 0/10                  |                       |                                | 10                     |                    | 40        |        | 0.04                   | 40        |                     | 300     |         |
| V <sub>OH</sub>                   | Output High Voltage   |           | 0/ 5                  |                       | < 1                            | 5                      | 4.95               |           | 4.95   |                        |           | 4.95                | V       |         |
|                                   |                       |           | 0/10                  |                       | < 1                            | 10                     | 9.95               |           | 9.95   |                        |           | 9.95                |         |         |
|                                   |                       |           | 0/15                  |                       | < 1                            | 15                     | 14.95              |           | 14.95  |                        |           | 14.95               |         |         |
| V <sub>OL</sub>                   | Output Low Voltage    |           | 5/0                   |                       | < 1                            | 5                      |                    | 0.05      |        |                        | 0.05      | 0.05                | V       |         |
|                                   |                       |           | 10/0                  |                       | < 1                            | 10                     |                    | 0.05      |        |                        | 0.05      | 0.05                |         |         |
|                                   |                       |           | 15/0                  |                       | < 1                            | 15                     |                    | 0.05      |        |                        | 0.05      | 0.05                |         |         |
| V <sub>IH</sub>                   | Input High Voltage    |           |                       | 0.5/4.5               | < 1                            | 5                      | 3.5                |           | 3.5    |                        |           | 3.5                 | V       |         |
|                                   |                       |           |                       | 1/9                   | < 1                            | 10                     | 7                  |           | 7      |                        |           | 7                   |         |         |
|                                   |                       |           |                       | 1.5/13.5              | < 1                            | 15                     | 11                 |           | 11     |                        |           | 11                  |         |         |
| V <sub>IL</sub>                   | Input Low Voltage     |           |                       | 4.5/0.5               | < 1                            | 5                      |                    | 1.5       |        |                        | 1.5       | 1.5                 | V       |         |
|                                   |                       |           |                       | 9/1                   | < 1                            | 10                     |                    | 3         |        |                        | 3         | 3                   |         |         |
|                                   |                       |           |                       | 13.5/1.5              | < 1                            | 15                     |                    | 4         |        |                        | 4         | 4                   |         |         |
| I <sub>OH</sub>                   | Output Drive Current  | HCC Types | 0/5                   | 2.5                   |                                | 5                      | - 2                |           | - 1.6  | - 3.2                  |           | - 1.15              | mA      |         |
|                                   |                       |           | 0/5                   | 4.6                   |                                | 5                      | - 0.64             |           | - 0.51 | - 1                    |           | - 0.36              |         |         |
|                                   |                       |           | 0/10                  | 9.5                   |                                | 10                     | - 1.6              |           | - 1.3  | - 2.6                  |           | - 0.9               |         |         |
|                                   |                       |           | 0/15                  | 13.5                  |                                | 15                     | - 4.2              |           | - 3.4  | - 6.8                  |           | - 2.4               |         |         |
|                                   |                       | HCF Types | 0/5                   | 2.5                   |                                | 5                      | - 1.53             |           | - 1.36 | - 3.2                  |           | - 1.1               |         |         |
|                                   |                       |           | 0/5                   | 4.6                   |                                | 5                      | - 0.52             |           | - 0.44 | - 1                    |           | - 0.36              |         |         |
|                                   |                       |           | 0/10                  | 9.5                   |                                | 10                     | - 1.3              |           | - 1.1  | - 2.6                  |           | - 0.9               |         |         |
|                                   |                       |           | 0/15                  | 13.5                  |                                | 15                     | - 3.6              |           | - 3.0  | - 6.8                  |           | - 2.4               |         |         |
| I <sub>OL</sub>                   | Output Sink Current   | HCC Types | 0/5                   | 0.4                   |                                | 5                      | 0.64               |           | 0.51   | 1                      |           | 0.36                | mA      |         |
|                                   |                       |           | 0/10                  | 0.5                   |                                | 10                     | 1.6                |           | 1.3    | 2.6                    |           | 0.9                 |         |         |
|                                   |                       |           | 0/15                  | 1.5                   |                                | 15                     | 4.2                |           | 3.4    | 6.8                    |           | 2.4                 |         |         |
|                                   |                       | HCF Types | 0/5                   | 0.4                   |                                | 5                      | 0.52               |           | 0.44   | 1                      |           | 0.36                |         |         |
|                                   |                       |           | 0/10                  | 0.5                   |                                | 10                     | 1.3                |           | 1.1    | 2.6                    |           | 0.9                 |         |         |
|                                   |                       |           | 0/15                  | 1.5                   |                                | 15                     | 3.6                |           | 3.0    | 6.8                    |           | 2.4                 |         |         |
| I <sub>IH</sub> , I <sub>IL</sub> | Input Leakage Current | HCC Types | 0/18                  | Any Input             |                                | 18                     |                    | $\pm$ 0.1 |        | $\pm$ 10 <sup>-5</sup> | $\pm$ 0.1 |                     | $\pm$ 1 | $\mu$ A |
|                                   |                       | HCF Types | 0/15                  |                       |                                | 15                     |                    | $\pm$ 0.3 |        | $\pm$ 10 <sup>-5</sup> | $\pm$ 0.3 |                     | $\pm$ 1 |         |
| C <sub>I</sub>                    | Input Capacitance     |           | Any Input             |                       |                                |                        |                    |           | 5      | 7.5                    |           |                     | pF      |         |

\* T<sub>Low</sub> = - 55°C for HCC device : - 40°C for HCF device.

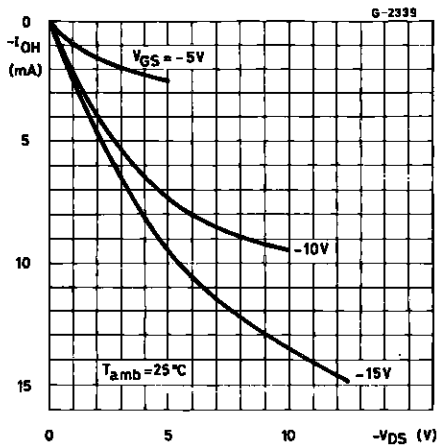
\* T<sub>High</sub> = + 125°C for HCC device : + 85°C for HCF device.

The Noise Margin for both "1" and "0" levels is : 1V min. with V<sub>DD</sub> = 5V, 2V min. with V<sub>DD</sub> = 10V, 2.5 V min. with V<sub>DD</sub> = 15V.

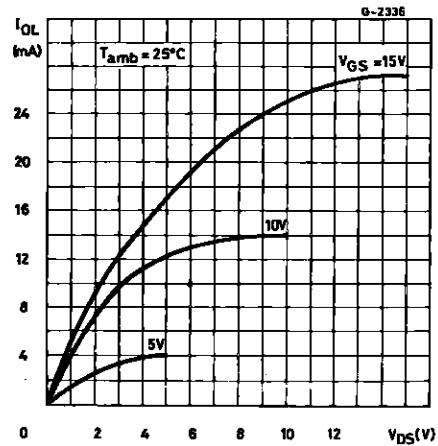
**DYNAMIC ELECTRICAL CHARACTERISTICS** ( $T_{amb} = 25^{\circ}\text{C}$ ,  $C_L = 50\text{pF}$ ,  $R_L = 200\text{k}\Omega$ , typical temperature coefficient for all  $V_{DD}$  values is  $0.3\%/^{\circ}\text{C}$ , all input rise and fall times =  $20\text{ns}$ )

| Symbol                | Parameter                               | Test Conditions |              | Value |      |      | Unit |
|-----------------------|---|-----------------|--------------|-------|------|------|------|
|                       |   |                 | $V_{DD}$ (V) | Min.  | Typ. | Max. |      |
| $t_{PHL}$ , $t_{PLH}$ | Propagation Delay Time (clock to "out") |                 | 5            |       | 175  | 350  | ns   |
|                       |   |                 | 10           |       | 80   | 160  |      |
|                       |   |                 | 15           |       | 60   | 120  |      |
| $t_{THL}$ , $t_{TLH}$ | Transition Time                         |                 | 5            |       | 100  | 200  | ns   |
|                       |   |                 | 10           |       | 50   | 100  |      |
|                       |   |                 | 15           |       | 40   | 80   |      |

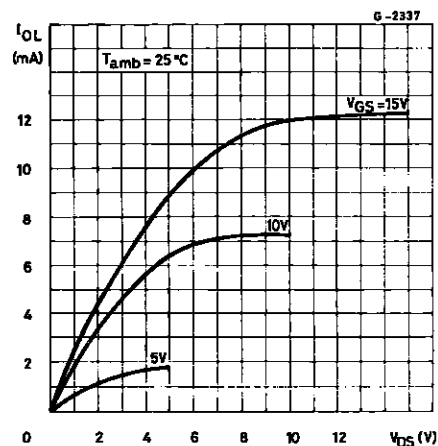
Minimum Output High (source) Current Characteristics.



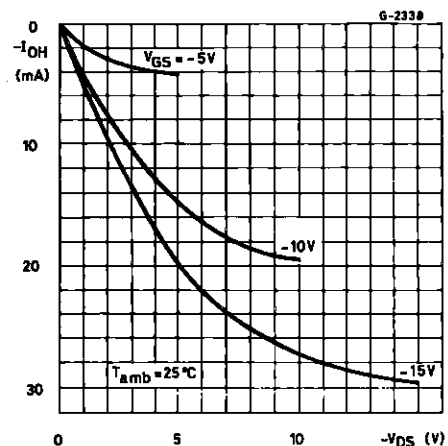
Typical Output Low (sink) Current.



Minimum Output Low (Sink) Current Characteristics.

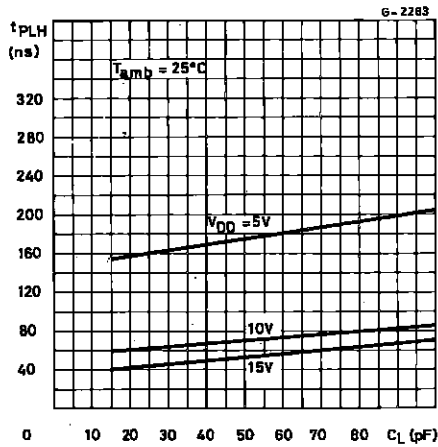


Typical Output High (source) Current Characteristics.

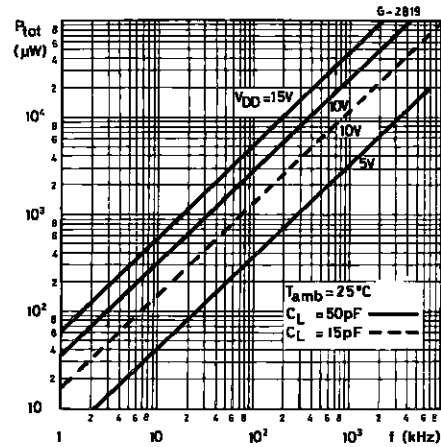


# HCC/HCF4028B

Typical Propagation Delay Time as a Function load Capacitance.



Typical Dynamic Power Dissipation as a Function of Input Frequency .

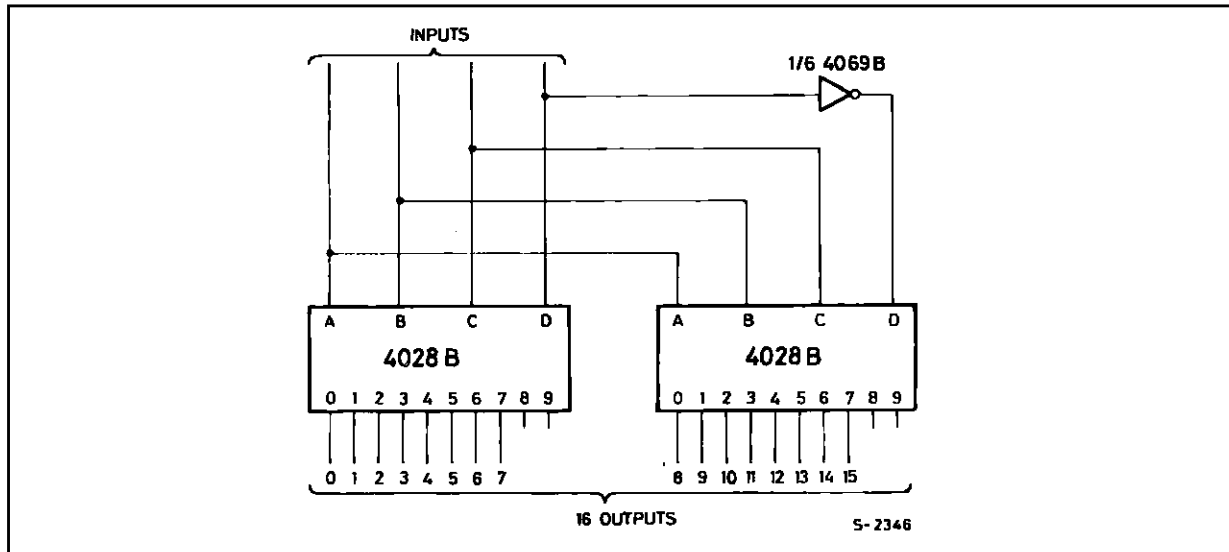


## TYPICAL APPLICATIONS

The circuit shown in fig. 1 converts any 4-bit code to a decimal or hexadecimal code Fig 2 shows a number of codes and the decimal or hexadecimal number in these codes which must be applied to the input pins of the HCC/HCF4028B to select a particular output.

For example : in order to get a "high" on output n8 the input must be either an 8 expressed in 4-bit binary code, a 15 expressed in 4-bit gray code, or a 5 expressed in excess-3code.

Figure 1 : Code Conversion Circuit.





# HCC/HCF4028B

## TYPICAL APPLICATIONS (continued)

Figure 3 : 6-bit binary to 1 of 64 Address Decoder.

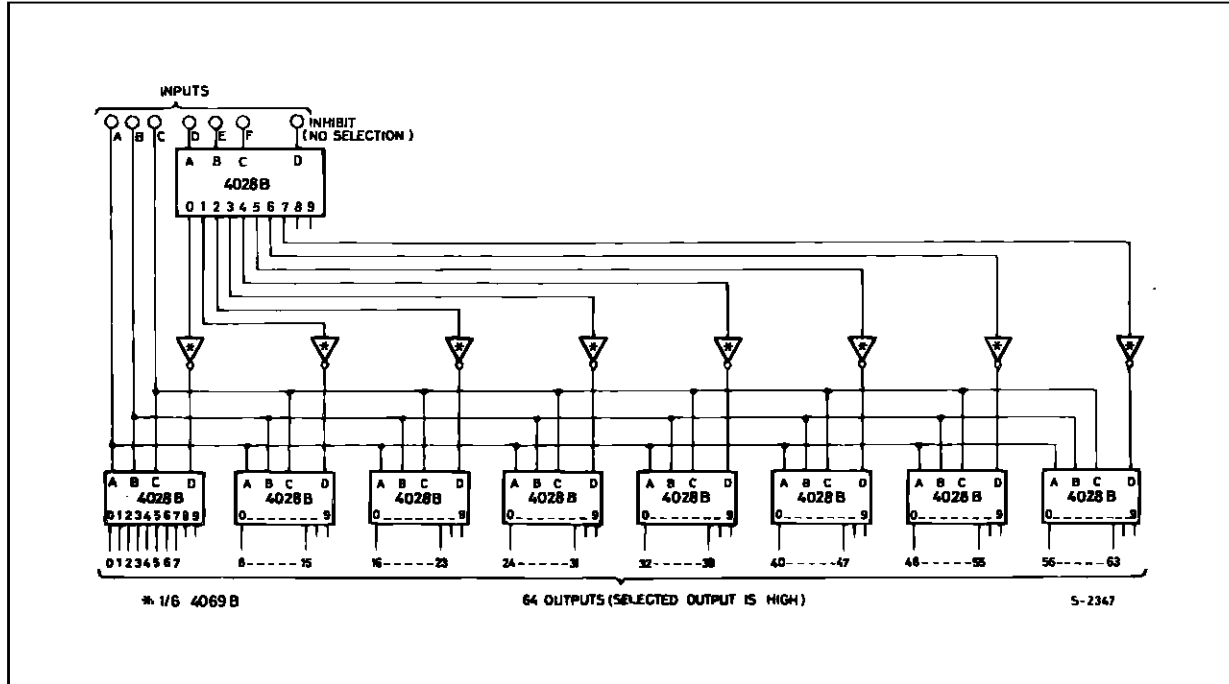
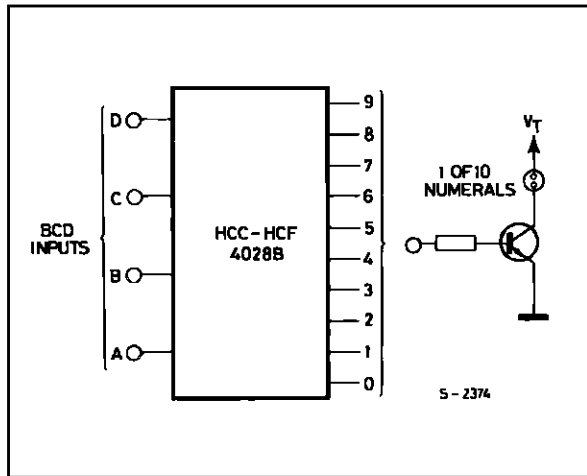


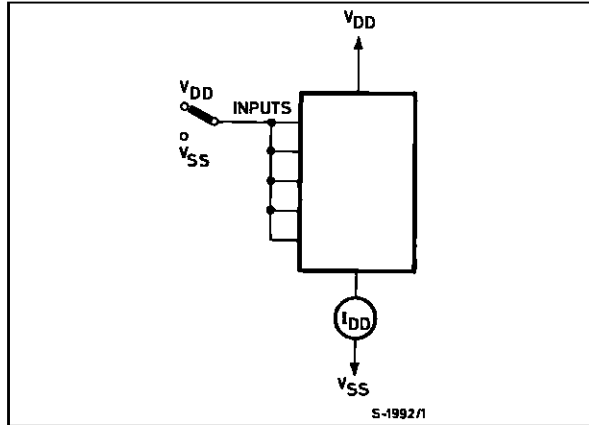
Figure 4 : Neon Readout (nixie tube) Display Application.



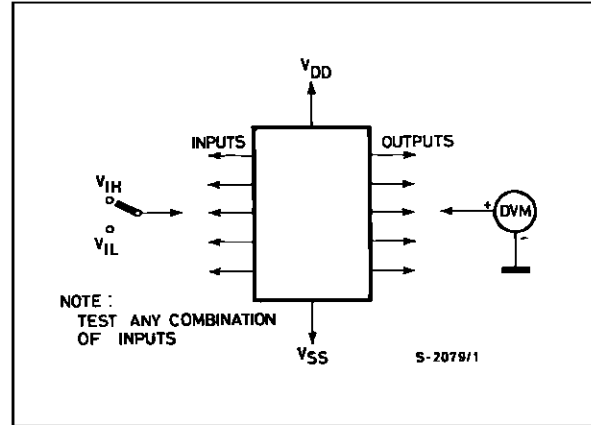


TEST CIRCUITS

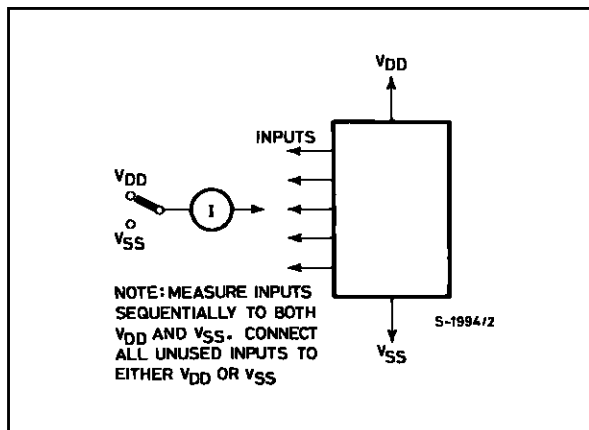
Quiescent Device Current.



Noise Immunity.

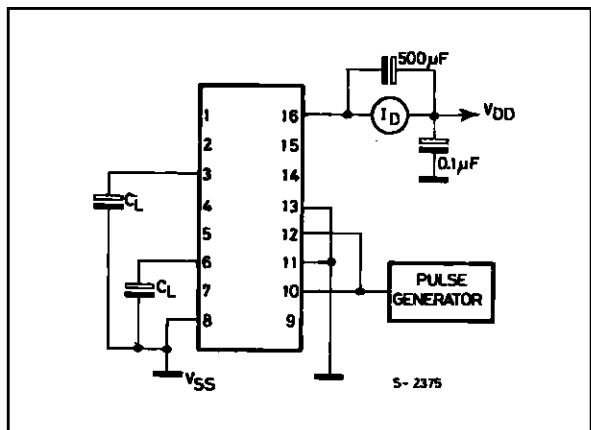


Input Leakage Current.

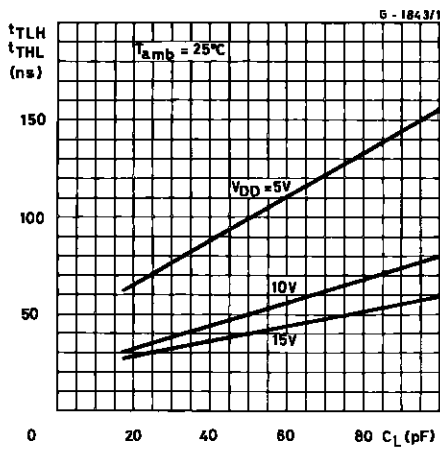


NOTE: MEASURE INPUTS SEQUENTIALLY TO BOTH V<sub>DD</sub> AND V<sub>SS</sub>. CONNECT ALL UNUSED INPUTS TO EITHER V<sub>DD</sub> OR V<sub>SS</sub>

Dynamic Power Dissipation.

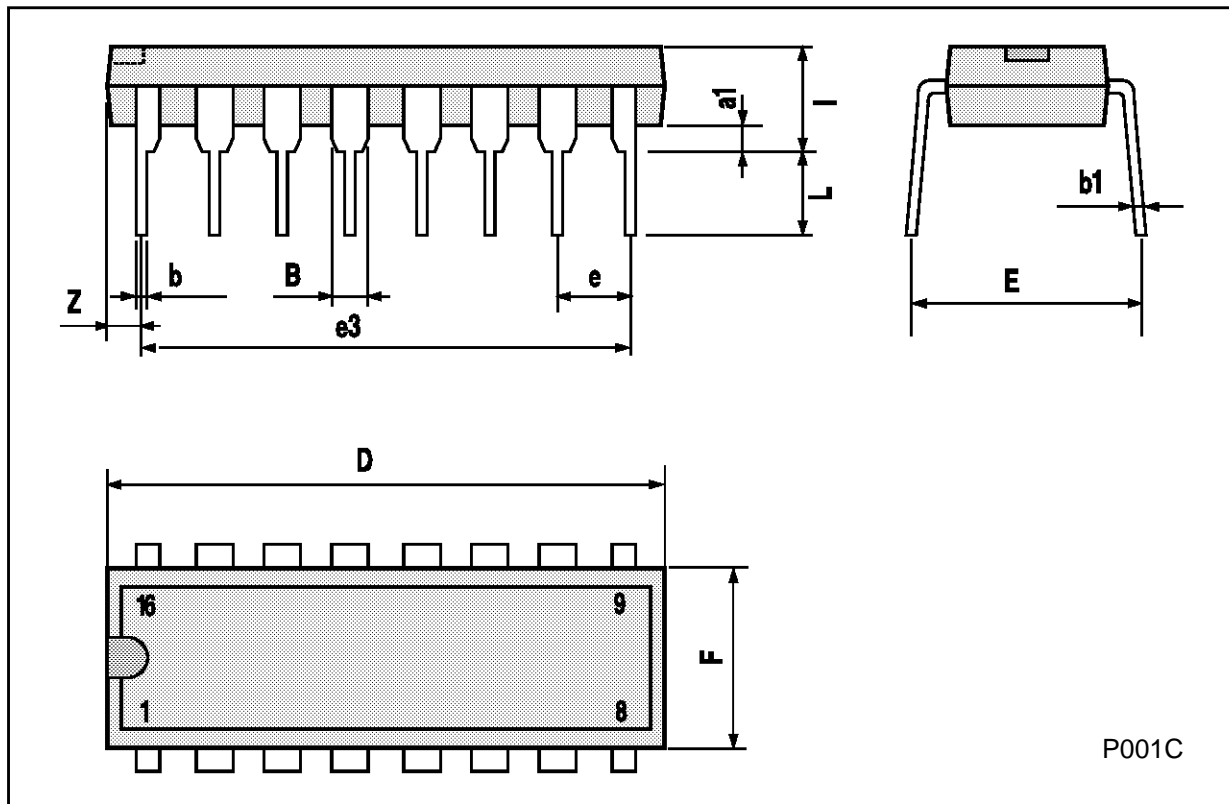


Typical Transition Time vs. Load Capacitance.



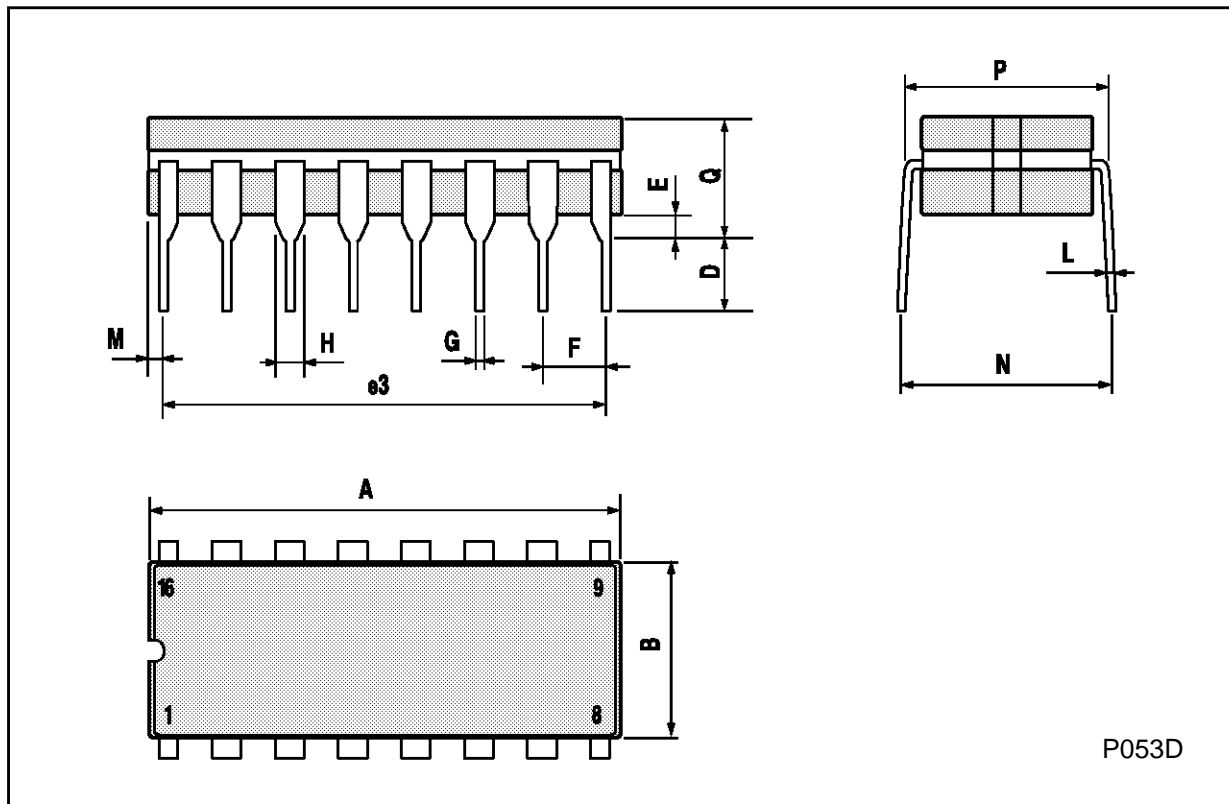
**Plastic DIP16 (0.25) MECHANICAL DATA**

| DIM. | mm   |       |      | inch  |       |       |
|------|------|-------|------|-------|-------|-------|
|      | MIN. | TYP.  | MAX. | MIN.  | TYP.  | MAX.  |
| a1   | 0.51 |       |      | 0.020 |       |       |
| B    | 0.77 |       | 1.65 | 0.030 |       | 0.065 |
| b    |      | 0.5   |      |       | 0.020 |       |
| b1   |      | 0.25  |      |       | 0.010 |       |
| D    |      |       | 20   |       |       | 0.787 |
| E    |      | 8.5   |      |       | 0.335 |       |
| e    |      | 2.54  |      |       | 0.100 |       |
| e3   |      | 17.78 |      |       | 0.700 |       |
| F    |      |       | 7.1  |       |       | 0.280 |
| I    |      |       | 5.1  |       |       | 0.201 |
| L    |      | 3.3   |      |       | 0.130 |       |
| Z    |      |       | 1.27 |       |       | 0.050 |



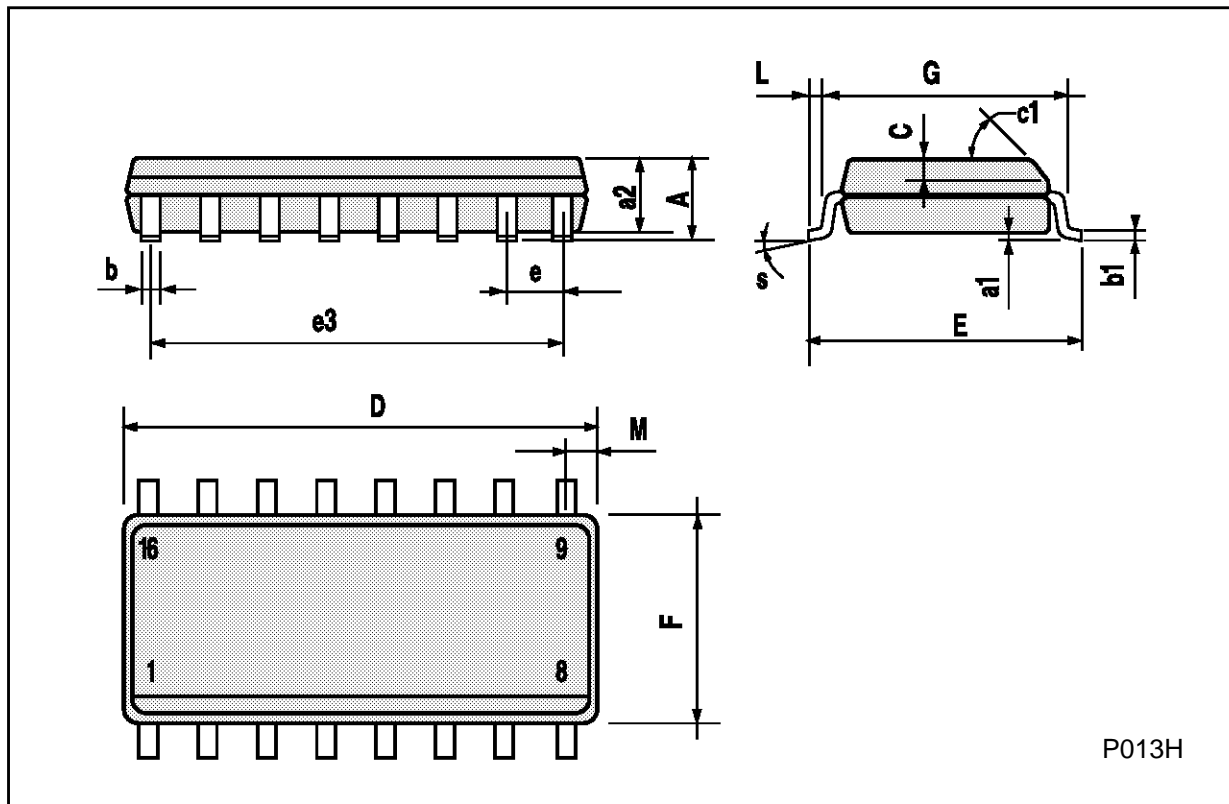
**Ceramic DIP16/1 MECHANICAL DATA**

| DIM. | mm   |       |      | inch  |       |       |
|------|------|-------|------|-------|-------|-------|
|      | MIN. | TYP.  | MAX. | MIN.  | TYP.  | MAX.  |
| A    |      |       | 20   |       |       | 0.787 |
| B    |      |       | 7    |       |       | 0.276 |
| D    |      | 3.3   |      |       | 0.130 |       |
| E    | 0.38 |       |      | 0.015 |       |       |
| e3   |      | 17.78 |      |       | 0.700 |       |
| F    | 2.29 |       | 2.79 | 0.090 |       | 0.110 |
| G    | 0.4  |       | 0.55 | 0.016 |       | 0.022 |
| H    | 1.17 |       | 1.52 | 0.046 |       | 0.060 |
| L    | 0.22 |       | 0.31 | 0.009 |       | 0.012 |
| M    | 0.51 |       | 1.27 | 0.020 |       | 0.050 |
| N    |      |       | 10.3 |       |       | 0.406 |
| P    | 7.8  |       | 8.05 | 0.307 |       | 0.317 |
| Q    |      |       | 5.08 |       |       | 0.200 |



**SO16 (Narrow) MECHANICAL DATA**

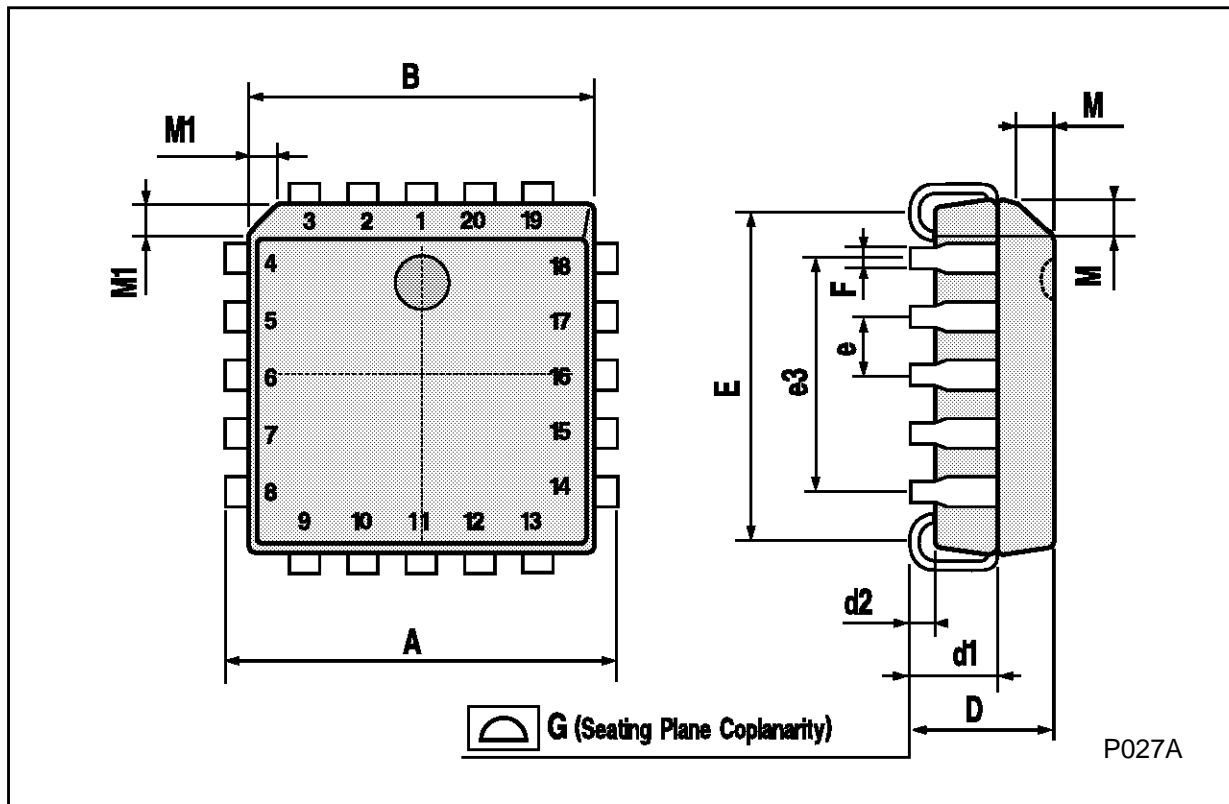
| DIM. | mm         |      |      | inch  |       |       |
|------|------------|------|------|-------|-------|-------|
|      | MIN.       | TYP. | MAX. | MIN.  | TYP.  | MAX.  |
| A    |            |      | 1.75 |       |       | 0.068 |
| a1   | 0.1        |      | 0.2  | 0.004 |       | 0.007 |
| a2   |            |      | 1.65 |       |       | 0.064 |
| b    | 0.35       |      | 0.46 | 0.013 |       | 0.018 |
| b1   | 0.19       |      | 0.25 | 0.007 |       | 0.010 |
| C    |            | 0.5  |      |       | 0.019 |       |
| c1   | 45° (typ.) |      |      |       |       |       |
| D    | 9.8        |      | 10   | 0.385 |       | 0.393 |
| E    | 5.8        |      | 6.2  | 0.228 |       | 0.244 |
| e    |            | 1.27 |      |       | 0.050 |       |
| e3   |            | 8.89 |      |       | 0.350 |       |
| F    | 3.8        |      | 4.0  | 0.149 |       | 0.157 |
| G    | 4.6        |      | 5.3  | 0.181 |       | 0.208 |
| L    | 0.5        |      | 1.27 | 0.019 |       | 0.050 |
| M    |            |      | 0.62 |       |       | 0.024 |
| S    | 8° (max.)  |      |      |       |       |       |



P013H

**PLCC20 MECHANICAL DATA**

| DIM. | mm   |      |       | inch  |       |       |
|------|------|------|-------|-------|-------|-------|
|      | MIN. | TYP. | MAX.  | MIN.  | TYP.  | MAX.  |
| A    | 9.78 |      | 10.03 | 0.385 |       | 0.395 |
| B    | 8.89 |      | 9.04  | 0.350 |       | 0.356 |
| D    | 4.2  |      | 4.57  | 0.165 |       | 0.180 |
| d1   |      | 2.54 |       |       | 0.100 |       |
| d2   |      | 0.56 |       |       | 0.022 |       |
| E    | 7.37 |      | 8.38  | 0.290 |       | 0.330 |
| e    |      | 1.27 |       |       | 0.050 |       |
| e3   |      | 5.08 |       |       | 0.200 |       |
| F    |      | 0.38 |       |       | 0.015 |       |
| G    |      |      | 0.101 |       |       | 0.004 |
| M    |      | 1.27 |       |       | 0.050 |       |
| M1   |      | 1.14 |       |       | 0.045 |       |



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