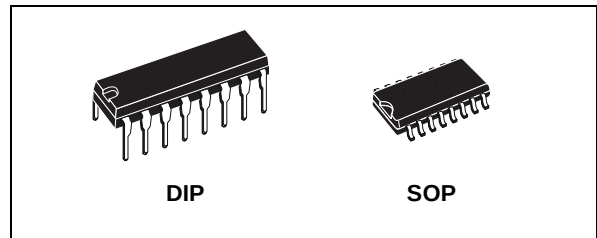


## BCD TO DECIMAL DECODER

- 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.) at  $V_{DD}$  = 10V
- QUIESCENT CURRENT SPECIF. UP TO 20V
- STANDARDIZED SYMMETRICAL OUTPUT CHARACTERISTICS
- INPUT LEAKAGE CURRENT  
 $I_I$  = 100nA (MAX) AT  $V_{DD}$  = 18V  $T_A$  = 25°C
- 100% TESTED FOR QUIESCENT CURRENT
- MEETS ALL REQUIREMENTS OF JEDEC JESD13B "STANDARD SPECIFICATIONS FOR DESCRIPTION OF B SERIES CMOS DEVICES"

### DESCRIPTION

HCF4028B is a monolithic integrated circuit fabricated in Metal Oxide Semiconductor technology available in DIP and SOP packages. HCF4028B is a BCD to DECIMAL or BINARY to OCTAL decoder consisting of buffering on all 4



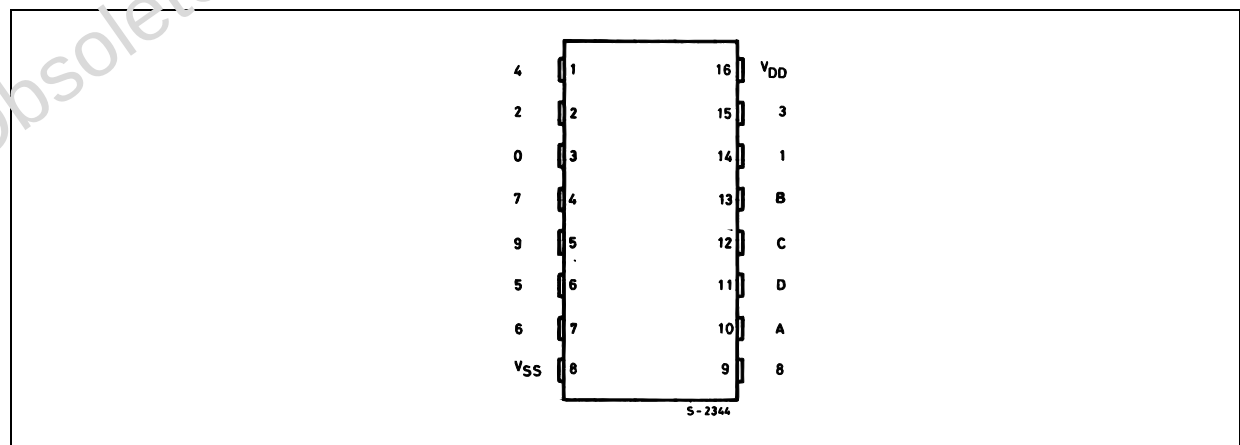
### ORDER CODES

| PACKAGE | TUBE       | 1 & R         |
|---------|------------|---------------|
| DIP     | HCF4028BEY |               |
| SOP     | HCF4028BM1 | HCF4028M013TR |

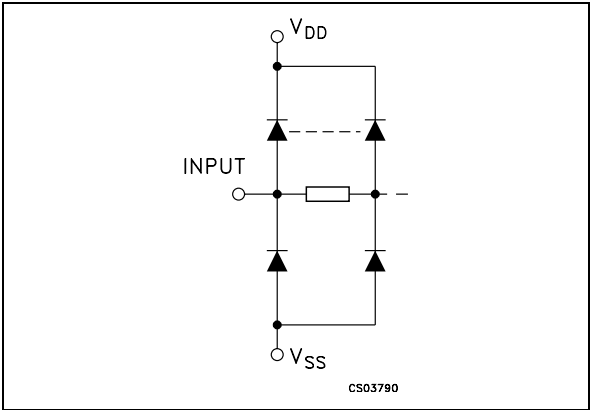
inputs, decoding logic gates, and 10 output buffers.

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.

### PIN CONNECTION



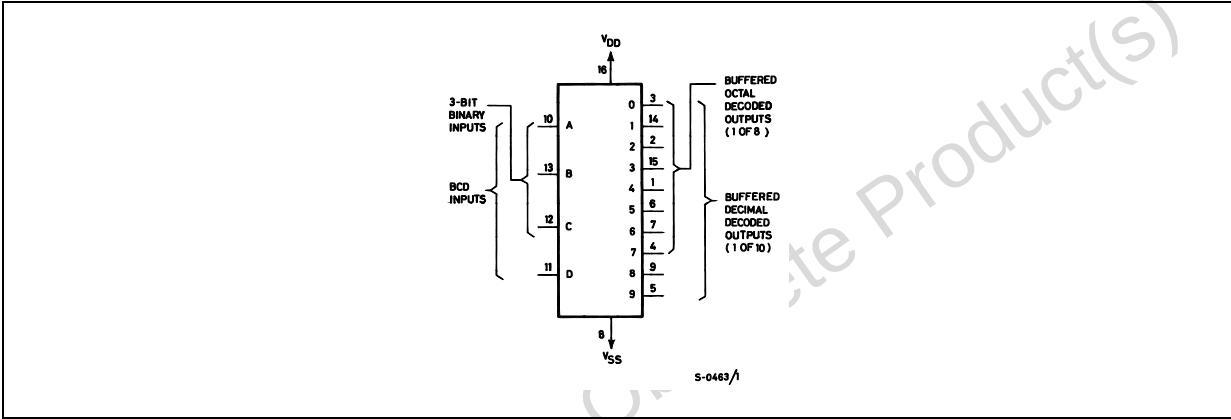
IINPUT EQUIVALENT CIRCUIT



PIN DESCRIPTION

| PIN No                         | SYMBOL          | NAME AND FUNCTION                |
|--------------------------------|-----------------|----------------------------------|
| 10, 13, 12, 11                 | A, B, C, D      | BCD Data Inputs                  |
| 10, 13, 12                     | A, B, C         | 3-Bit Binary Inputs              |
| 3, 14, 2, 15, 1, 6, 7, 4, 9, 5 | 0 to 9          | Buffered DECIMAL Decoded Outputs |
| 3, 14, 2, 15, 1, 6, 7, 4       | 0 to 7          | Buffered OCTAL Decoded Outputs   |
| 8                              | V <sub>SS</sub> | Negative Supply Voltage          |
| 16                             | V <sub>DD</sub> | Positive Supply Voltage          |

FUNCTIONAL DIAGRAM



TRUTH TABLE

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



## DC SPECIFICATIONS

| Symbol          | Parameter                 | Test Conditions       |                       |                          |                        | Value                 |                   |      |             |      |              |      | Unit |
|-----------------|---------------------------|-----------------------|-----------------------|--------------------------|------------------------|-----------------------|-------------------|------|-------------|------|--------------|------|------|
|                 |                           | V <sub>I</sub><br>(V) | V <sub>O</sub><br>(V) | I <sub>O</sub>  <br>(μA) | V <sub>DD</sub><br>(V) | T <sub>A</sub> = 25°C |                   |      | -40 to 85°C |      | -55 to 125°C |      |      |
|                 |                           |                       |                       |                          |                        | Min.                  | Typ.              | Max. | Min.        | Max. | Min.         | Max. |      |
| I <sub>L</sub>  | Quiescent Current         | 0/5                   |                       |                          | 5                      |                       | 0.04              | 5    |             | 150  |              | 150  | μA   |
|                 |                           | 0/10                  |                       |                          | 10                     |                       | 0.04              | 10   |             | 300  |              | 300  |      |
|                 |                           | 0/15                  |                       |                          | 15                     |                       | 0.04              | 20   |             | 600  |              | 600  |      |
|                 |                           | 0/20                  |                       |                          | 20                     |                       | 0.08              | 100  |             | 3000 |              | 3000 |      |
| V <sub>OH</sub> | High Level Output 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> | Low Level Output 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> | High Level Input Voltage  |                       | 0.5/4.5               | <1                       | 5                      | 3.5                   |                   |      | 3.5         |      | 3.5          |      | V    |
|                 |                           |                       | 1/9                   | <1                       | 10                     | 7                     |                   |      | 7           |      | 7            |      |      |
|                 |                           |                       | 1.5/18.5              | <1                       | 15                     | 11                    |                   |      | 11          |      | 11           |      |      |
| V <sub>IL</sub> | Low Level Input Voltage   |                       | 0.5/4.5               | <1                       | 5                      |                       |                   | 1.5  |             | 1.5  |              | 1.5  | V    |
|                 |                           |                       | 9/1                   | <1                       | 10                     |                       |                   | 3    |             | 3    |              | 3    |      |
|                 |                           |                       | 1.5/18.5              | <1                       | 15                     |                       |                   | 4    |             | 4    |              | 4    |      |
| I <sub>OH</sub> | Output Drive Current      | 0/5                   | 2.5                   |                          | 5                      | -1.36                 | -3.2              |      | -1.1        |      | -1.1         |      | mA   |
|                 |                           | 0/5                   | 4.6                   |                          | 5                      | -0.44                 | -1                |      | -0.36       |      | -0.36        |      |      |
|                 |                           | 0/10                  | 9.5                   |                          | 10                     | -1.1                  | -2.6              |      | -0.9        |      | -0.9         |      |      |
|                 |                           | 0/15                  | 13.5                  |                          | 15                     | -3.0                  | -6.8              |      | -2.4        |      | -2.4         |      |      |
| I <sub>OL</sub> | Output Sink Current       | 0/5                   | 0.4                   |                          | 5                      | 0.44                  | 1                 |      | 0.36        |      | 0.36         |      | mA   |
|                 |                           | 0/10                  | 0.5                   |                          | 10                     | 1.1                   | 2.6               |      | 0.9         |      | 0.9          |      |      |
|                 |                           | 0/15                  | 1.5                   |                          | 15                     | 3.0                   | 6.8               |      | 2.4         |      | 2.4          |      |      |
| I <sub>I</sub>  | Input Leakage Current     | 0/18                  | any input             |                          | 18                     |                       | ±10 <sup>-5</sup> | ±0.1 |             | ±1   |              | ±1   | μA   |
| C <sub>I</sub>  | Input Capacitance         |                       | any input             |                          |                        |                       | 5                 | 7.5  |             |      |              |      | pF   |

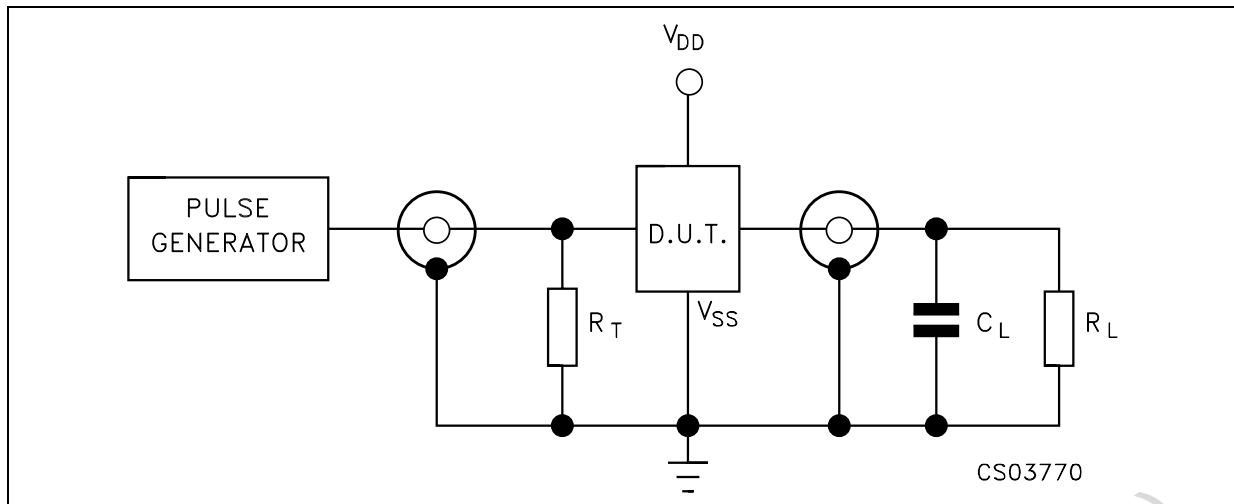
The Noise Margin for both "1" and "0" level is: 1V min. with V<sub>DD</sub>=5V, 2V min. with V<sub>DD</sub>=10V, 2.5V min. with V<sub>DD</sub>=15V

DYNAMIC ELECTRICAL CHARACTERISTICS (T<sub>amb</sub> = 25°C, C<sub>L</sub> = 50pF, R<sub>L</sub> = 200K $\Omega$ , t<sub>r</sub> = t<sub>f</sub> = 20 ns)

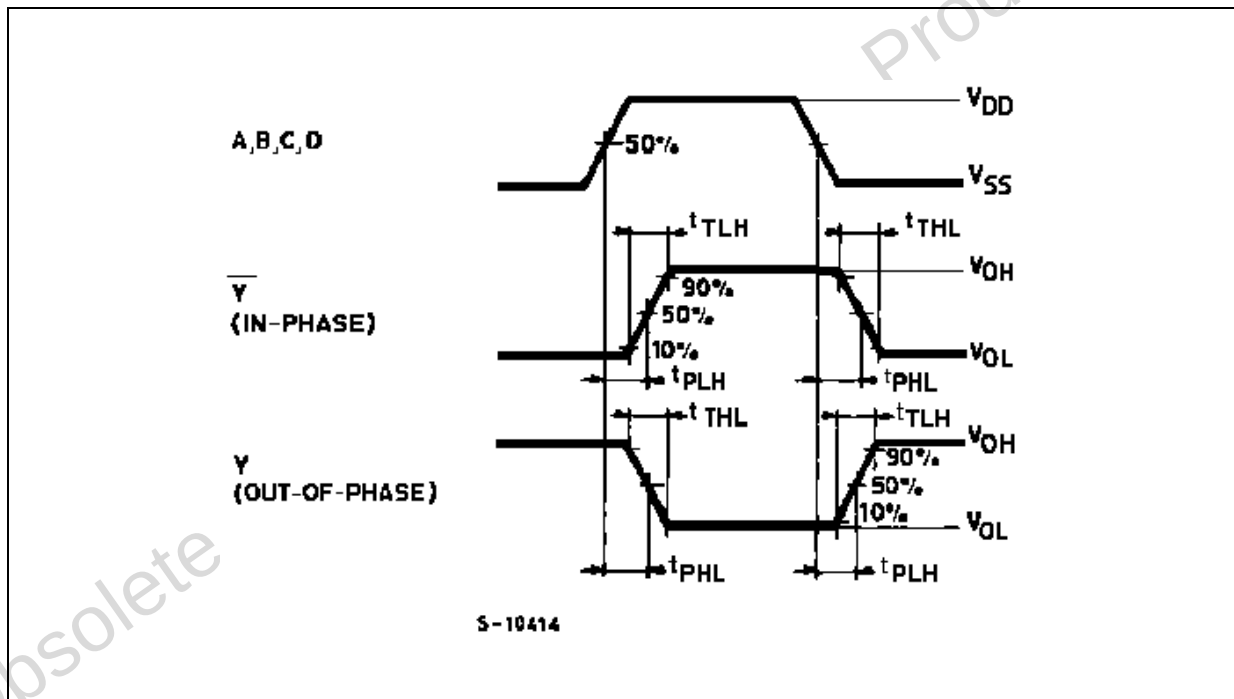
| Symbol                            | Parameter                                  | Test Condition      |  | Value (*) |      |      | Unit |
|-----------------------------------|--------------------------------------------|---------------------|--|-----------|------|------|------|
|                                   |                                            | V <sub>DD</sub> (V) |  | Min.      | Typ. | Max. |      |
| t <sub>PHL</sub> t <sub>PLH</sub> | Propagation Delay Time<br>(Clock to "Out") | 5                   |  |           | 175  | 350  | ns   |
|                                   |                                            | 10                  |  |           | 80   | 160  |      |
|                                   |                                            | 15                  |  |           | 60   | 120  |      |
| t <sub>THL</sub> t <sub>TLH</sub> | Transition Time<br>(Carry Out Line)        | 5                   |  |           | 100  | 200  | ns   |
|                                   |                                            | 10                  |  |           | 50   | 100  |      |
|                                   |                                            | 15                  |  |           | 25   | 50   |      |

(\*) Typical temperature coefficient for all V<sub>DD</sub> value is 0.3 %/°C.

## TEST CIRCUIT



$C_L = 50\text{pF}$  or equivalent (includes jig and probe capacitance)  
 $R_L = 200\text{k}\Omega$   
 $R_T = Z_{\text{OUT}}$  of pulse generator (typically  $50\Omega$ )

WAVEFORM : PROPAGATION DELAY TIMES ( $f=1\text{MHz}$ ; 50% duty cycle)

## TYPICAL APPLICATION

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 HCF4028B to select a particular output. For example: in order to get a "high" on output 8 the input must be either an 8 expressed in

4-bit binary code or a 15 expressed in excess-3code.

FIGURE 1 : CODE CONVERSION CIRCUIT

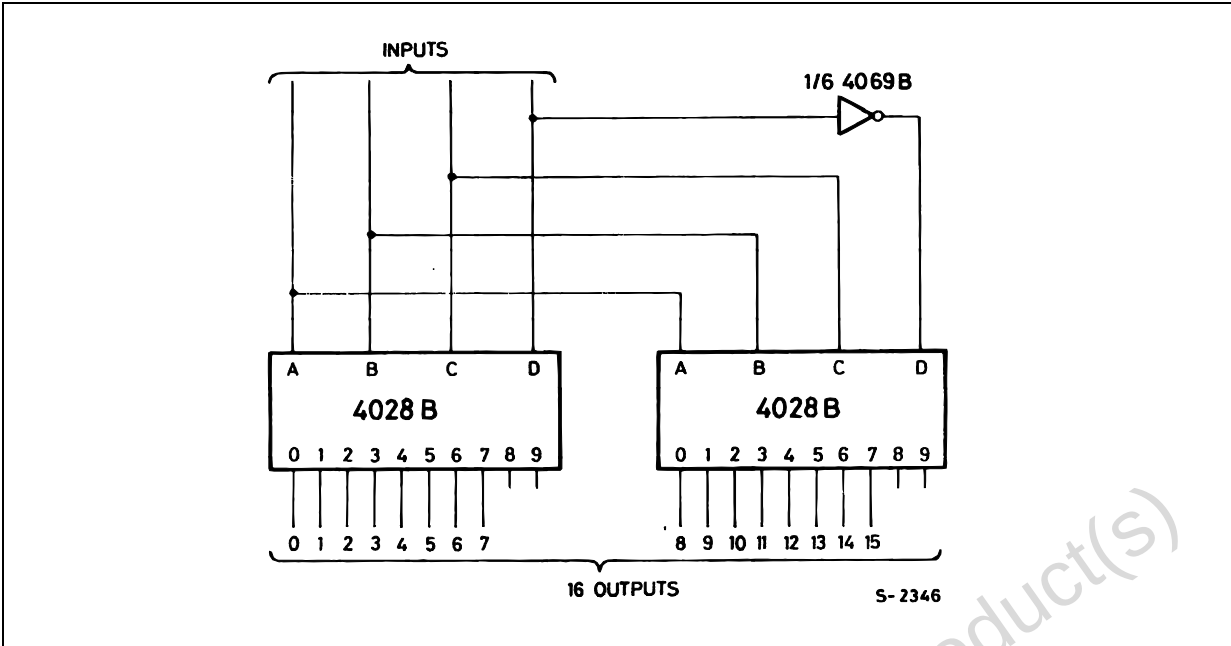


FIGURE 2 : CODE CONVERSION CHART

| INPUTS |   |   |   | INPUT CODES     |            |          |               |       |      | OUTPUT NUMBER |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
|--------|---|---|---|-----------------|------------|----------|---------------|-------|------|---------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|
|        |   |   |   | HEXA<br>DECIMAL | DECIMAL    |          |               |       |      |               |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| D      | C | B | A | 4 BIT BINARY    | 4 BIT GRAY | EXCESS 3 | EXCESS 3 GRAY | AIKEN | 4221 | 0             | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| L      | L | L | L | 0               | 0          |          |               | 0     | 0    | H             | L | L | L | L | L | L | L | L | L | L  | L  | L  | L  | L  | L  |
| L      | L | L | H | 1               | 1          |          |               | 1     | 1    | L             | H | L | L | L | L | L | L | L | L | L  | L  | L  | L  | L  | L  |
| L      | L | H | L | 2               | 3          |          | 0             | 2     | 2    | L             | L | H | L | L | L | L | L | L | L | L  | L  | L  | L  | L  | L  |
| L      | L | H | H | 3               | 2          | 0        | 3             | 3     |      | L             | L | L | H | L | L | L | L | L | L | L  | L  | L  | L  | L  | L  |
| L      | H | L | L | 4               | 7          | 1        | 4             | 4     |      | L             | L | L | L | H | L | L | L | L | L | L  | L  | L  | L  | L  | L  |
| L      | H | L | H | 5               | 6          | 2        |               |       | 3    | L             | L | L | L | L | H | L | L | L | L | L  | L  | L  | L  | L  | L  |
| L      | H | H | L | 6               | 4          | 3        | 1             |       | 4    | L             | L | L | L | L | L | H | L | L | L | L  | L  | L  | L  | L  | L  |
| L      | H | H | H | 7               | 5          | 4        | 2             |       |      | L             | L | L | L | L | L | L | H | L | L | L  | L  | L  | L  | L  | L  |
| H      | L | L | L | 8               | 15         | 5        |               |       |      | L             | L | L | L | L | L | L | L | H | L | L  | L  | L  | L  | L  | L  |
| H      | L | L | H | 9               | 14         | 6        |               |       | 5    | L             | L | L | L | L | L | L | L | L | H | L  | L  | L  | L  | L  | L  |
| H      | L | H | L | 10              | 12         | 7        | 9             |       | 6    | L             | L | L | L | L | L | L | L | L | L | H  | L  | L  | L  | L  | L  |
| H      | L | H | H | 11              | 13         | 8        |               | 5     |      | L             | L | L | L | L | L | L | L | L | L | L  | H  | L  | L  | L  | L  |
| H      | H | L | L | 12              | 8          | 9        | 5             | 6     |      | L             | L | L | L | L | L | L | L | L | L | L  | L  | H  | L  | L  | L  |
| H      | H | L | H | 13              | 9          |          | 6             | 7     | 7    | L             | L | L | L | L | L | L | L | L | L | L  | L  | L  | H  | L  | L  |
| H      | H | H | L | 14              | 11         |          | 8             | 8     | 8    | L             | L | L | L | L | L | L | L | L | L | L  | L  | L  | L  | H  | L  |
| H      | H | H | H | 15              | 10         |          | 7             | 9     | 9    | L             | L | L | L | L | L | L | L | L | L | L  | L  | L  | L  | L  | H  |

FIGURE 3 : 6 BIT BINARY TO 1 OF 64 ADDRESS DECODER

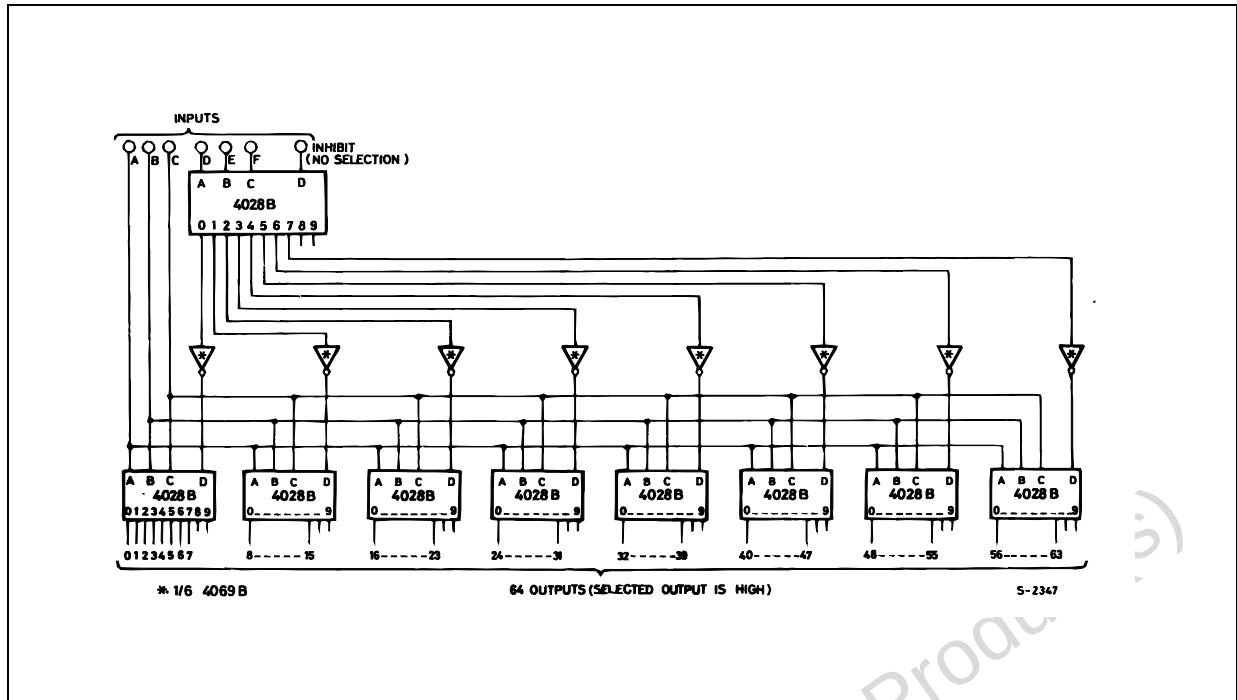
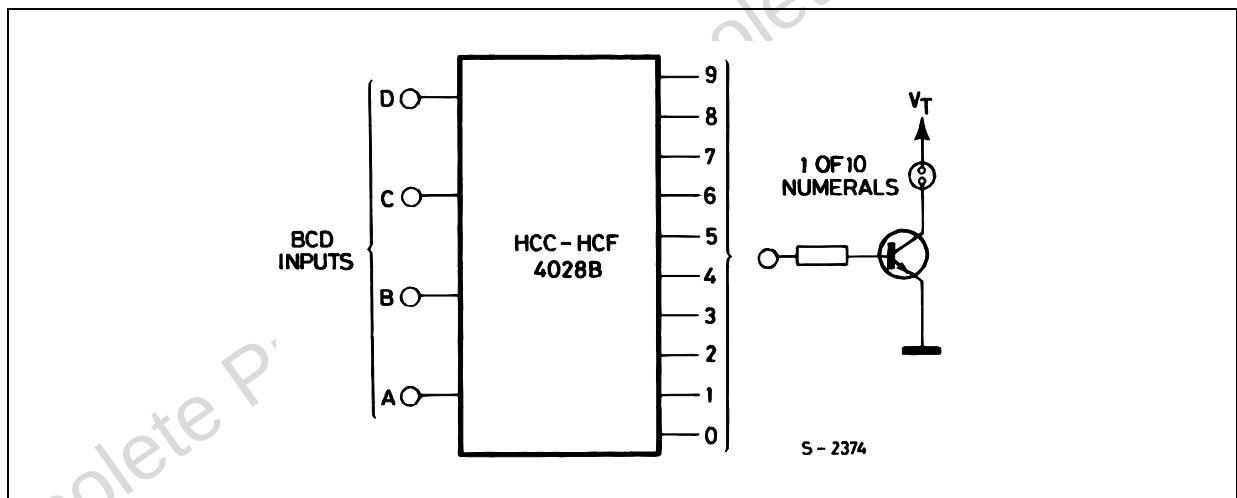
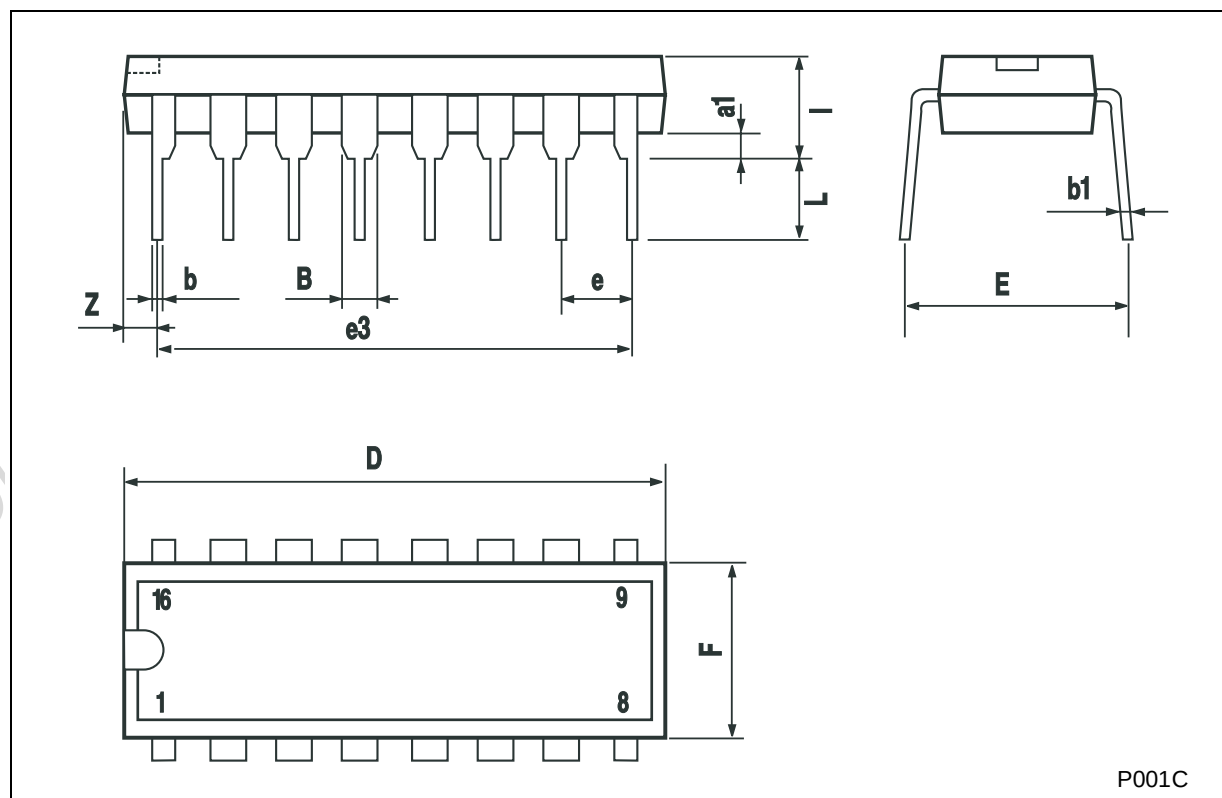


FIGURE 4 : NEON READOUT (NIXIE TUBE) DISPLAY APPLICATION



## Plastic DIP-16 (0.25) MECHANICAL DATA

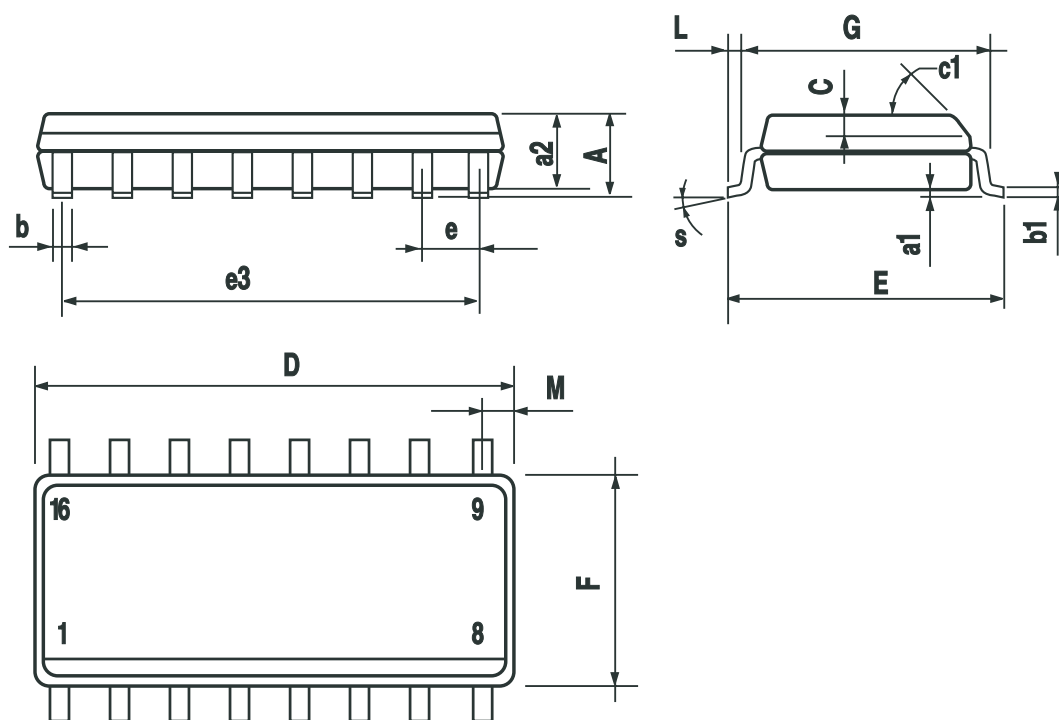
| DIM. | mm.  |       |      | inch  |       |       |
|------|------|-------|------|-------|-------|-------|
|      | MIN. | TYP   | MAX. | MIN.  | TYP.  | MAX.  |
| a1   | 0.51 |       |      | 0.020 |       |       |
| B    | 0.77 |       | 1.65 | 0.030 |       | 0.065 |
| b    |      | 0.5   |      |       | 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 |



P001C

## SO-16 MECHANICAL DATA

| DIM. | mm.        |      |      | inch  |       |       |
|------|------------|------|------|-------|-------|-------|
|      | MIN.       | TYP  | MAX. | MIN.  | TYP.  | MAX.  |
| A    |            |      | 1.75 |       |       | 0.068 |
| a1   | 0.1        |      | 0.2  | 0.003 |       | 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.)  |      |      |       |       |       |



PO13H

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