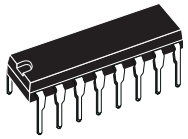
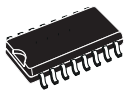
# HCF4089B

## BINARY RATE MULTIPLIER

- CASCADABLE IN MULTIPLES OF 4-BITS
- SET TO "15" INPUT AND "15" DETECT OUTPUT
- QUIESCENT CURRENT SPECIFIED UP TO 20V
- STANDARDIZED SYMMETRICAL OUTPUT CHARACTERISTICS
- 5V, 10V AND 15V PARAMETRIC RATINGS
- 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"



DIP



SOP

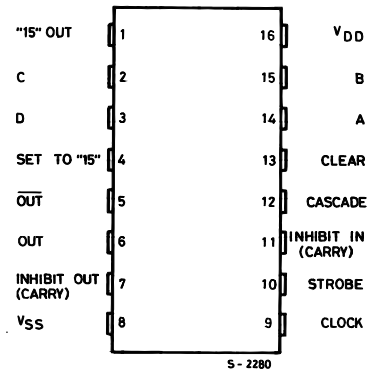
**ORDER CODES**

| PACKAGE | TUBE | T & R |
|---|---|---|
| DIP | HCF4089BEY | |
| SOP | HCF4089BM1 | HCF4089M013TR |

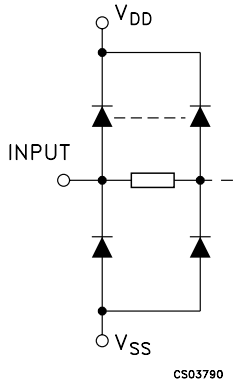
### DESCRIPTION

HCF4089B is a monolithic integrated circuit fabricated in Metal Oxide Semiconductor technology available in DIP and SOP packages.
HCF4089B is a low power 4-bit digital rate multiplier that provides an output pulse rate that is the clock input pulse rate multiplied by 1/16 times the binary input. For example, when the binary input number is 13, ther will be 13 output pulses for every 16 input pulses.
HCF4089B has an internal synchronous 4-bit counter, which, together with one of the four binary inputs bits, produces pulse trains as shown in the timing diagram.
If more than one binary input bit is high, the resulting pulse train is a combination of the above separate pulse trains. This device may be used to perform arithmetic operations (add, subtract, divide, raise to a power), solve algebrical and differential equations, generate natural logarithms and trigonometric functions, A/D and D/A conversions, and frequency division.

### PIN CONNECTION



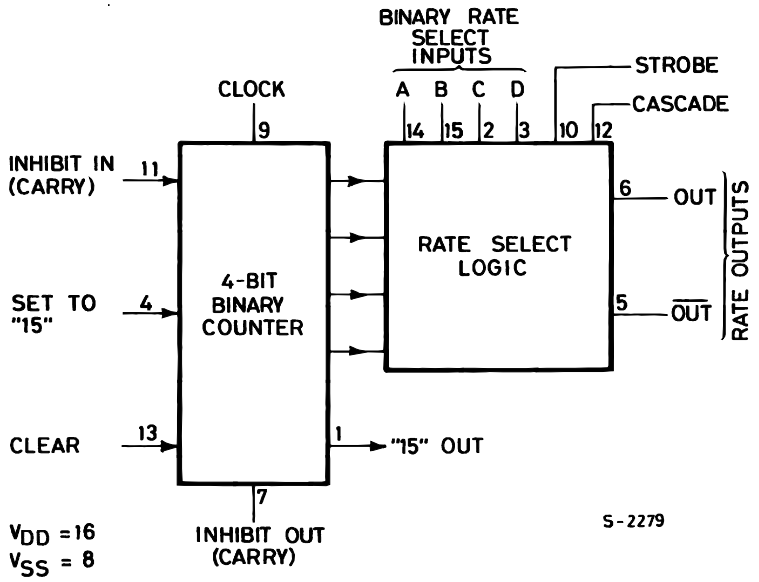
## IINPUT EQUIVALENT CIRCUIT




## PIN DESCRIPTION

| PIN No | SYMBOL | NAME AND FUNCTION |
|---|---|---|
| 14, 15, 2, 3 | A, B, C, D | Binary Rate Select Inputs |
| 5 | $\overline{OUT}$ | Rate Output |
| 6 | OUT | Rate Output |
| 4 | SET TO "15" | Set Input |
| 1 | "15" OUT | Output |
| 7 | INHIBIT OUT (CARRY) | Inhibit Out (Carry) |
| 13 | CLEAR | Clear Input |
| 12 | CASCADE | Cascade |
| 11 | INHIBIT IN (CARRY) | Inhibit Input (Carry) |
| 10 | STROBE | Strobe |
| 9 | CLOCK | Clock Input |
| 8 | $V_{SS}$ | Negative Supply Voltage |
| 16 | $V_{DD}$ | Positive Supply Voltage |

## FUNCTIONAL DIAGRAM



## TRUTH TABLE

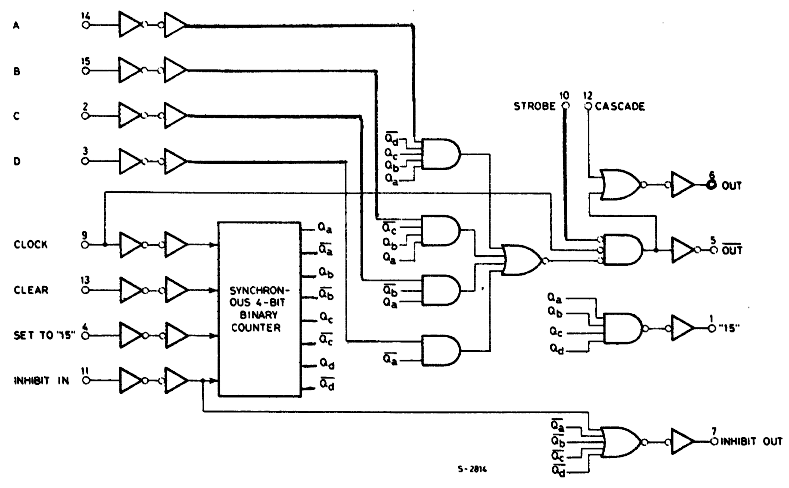
| INPUTS | | | | | | | | | | OUTPUTS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of Pulses or Input Logic Level | | | | | | | | | | Number of Pulses or Output Logic Level | | | |
| D | C | B | A | CLOCK | INH IN | STR. | CAS. | CLEAR | SET | OUT | $\overline{OUT}$ | INH OUT | "15" OUT |
| L | L | L | L | 16 | L | L | L | L | L | L | H | 1 | 1 |
| L | L | L | H | 16 | L | L | L | L | L | 1 | 1 | 1 | 1 |
| L | L | H | L | 16 | L | L | L | L | L | 2 | 2 | 1 | 1 |
| L | L | H | H | 16 | L | L | L | L | L | 3 | 3 | 1 | 1 |
| L | H | L | L | 16 | L | L | L | L | L | 4 | 4 | 1 | 1 |
| L | H | L | H | 16 | L | L | L | L | L | 5 | 5 | 1 | 1 |
| L | H | H | L | 16 | L | L | L | L | L | 6 | 6 | 1 | 1 |
| L | H | H | H | 16 | L | L | L | L | L | 7 | 7 | 1 | 1 |
| H | L | L | L | 16 | L | L | L | L | L | 8 | 8 | 1 | 1 |
| H | L | L | H | 16 | L | L | L | L | L | 9 | 9 | 1 | 1 |
| H | L | H | L | 16 | L | L | L | L | L | 10 | 10 | 1 | 1 |
| H | L | H | H | 16 | L | L | L | L | L | 11 | 11 | 1 | 1 |
| H | H | L | L | 16 | L | L | L | L | L | 12 | 12 | 1 | 1 |
| H | H | L | H | 16 | L | L | L | L | L | 13 | 13 | 1 | 1 |
| H | H | H | L | 16 | L | L | L | L | L | 14 | 14 | 1 | 1 |
| H | H | H | H | 16 | L | L | L | L | L | 15 | 15 | 1 | 1 |
| X | X | X | X | 16 | H | L | L | L | L | • | • | H | • |
| X | X | X | X | 16 | L | H | L | L | L | L | H | 1 | 1 |
| X | X | X | X | 16 | L | L | H | L | L | H | * | 1 | 1 |
| H | X | X | X | 16 | L | L | L | H | L | 16 | 16 | H | L |
| L | X | X | X | 16 | L | L | L | H | L | L | H | H | L |
| X | X | X | X | 16 | L | L | L | L | H | L | H | L | H |

X : Don't Care

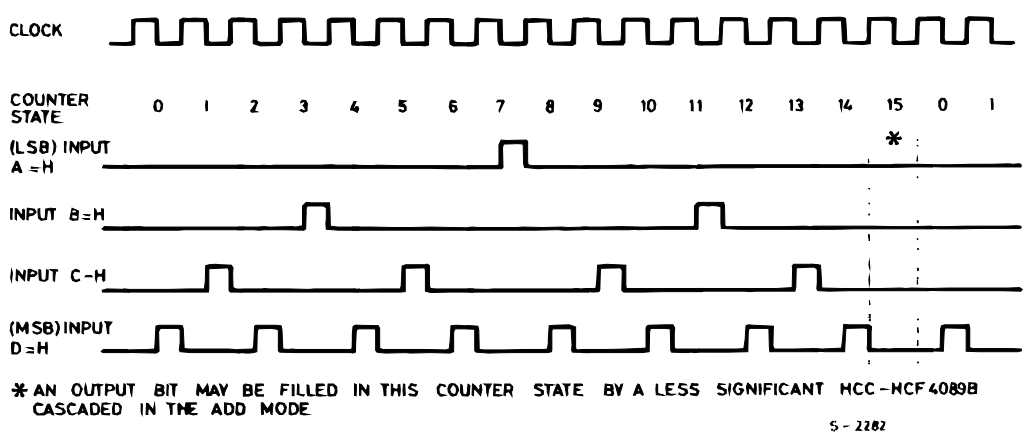
• : Depends on internal state of counter

*: Output same as the first 16 lines of this truth table (depending on values of A, B, C, D)

## LOGIC DIAGRAM



## TIMING CHART




## ABSOLUTE MAXIMUM RATINGS

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{DD}$ | Supply Voltage | -0.5 to +22 | V |
| $V_I$ | DC Input Voltage | -0.5 to $V_{DD}$ + 0.5 | V |
| $I_I$ | DC Input Current | ± 10 | mA |
| $P_D$ | Power Dissipation per Package | 200 | mW |
| | Power Dissipation per Output Transistor | 100 | mW |
| $T_{op}$ | Operating Temperature | -55 to +125 | °C |
| $T_{stg}$ | Storage Temperature | -65 to +150 | °C |

Absolute Maximum Ratings are those values beyond which damage to the device may occur. Functional operation under these conditions is not implied.

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

## RECOMMENDED OPERATING CONDITIONS

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{DD}$ | Supply Voltage | 3 to 20 | V |
| $V_I$ | Input Voltage | 0 to $V_{DD}$ | V |
| $T_{op}$ | Operating Temperature | -55 to 125 | °C |

## DC SPECIFICATIONS

| Symbol | Parameter | Test Condition | | | | Value | | | | | | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $V_I$ (V) | $V_O$ (V) | $\|I_O\|$ (μA) | $V_{DD}$ (V) | $T_A$ = 25°C | | | -40 to 85°C | | -55 to 125°C | | |
| | | | | | | Min. | Typ. | Max. | Min. | Max. | Min. | Max. | |
| $I_L$ | 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 | |
| $V_{OH}$ | 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 | | |
| $V_{OL}$ | 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 | |
| $V_{IH}$ | High Level Input Voltage | | 0.5/4.5 | <1 | 5 | 3.5 | | | 3.5 | | 3.5 | | V |
| | | | 1/9 | <1 | 10 | 7 | | | 7 | | 7 | | |
| | | | 1.5/13.5 | <1 | 15 | 11 | | | 11 | | 11 | | |
| $V_{IL}$ | Low Level Input 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 | |
| $I_{OH}$ | Output Drive Current | 0/5 | 2.5 | <1 | 5 | -1.36 | -3.2 | | -1.1 | | -1.1 | | mA |
| | | 0/5 | 4.6 | <1 | 5 | -0.44 | -1 | | -0.36 | | -0.36 | | |
| | | 0/10 | 9.5 | <1 | 10 | -1.1 | -2.6 | | -0.9 | | -0.9 | | |
| | | 0/15 | 13.5 | <1 | 15 | -3.0 | -6.8 | | -2.4 | | -2.4 | | |
| $I_{OL}$ | Output Sink Current | 0/5 | 0.4 | <1 | 5 | 0.44 | 1 | | 0.36 | | 0.36 | | mA |
| | | 0/10 | 0.5 | <1 | 10 | 1.1 | 2.6 | | 0.9 | | 0.9 | | |
| | | 0/15 | 1.5 | <1 | 15 | 3.0 | 6.8 | | 2.4 | | 2.4 | | |
| $I_I$ | Input Leakage Current | 0/18 | Any Input | | 18 | | $\pm 10^{-5}$ | ±0.1 | | ±1 | | ±1 | μA |
| $C_I$ | Input Capacitance | | Any Input | | | | 5 | 7.5 | | | | | pF |

The Noise Margin for both "1" and "0" level is: 1V min. with $V_{DD}$=5V, 2V min. with $V_{DD}$=10V, 2.5V min. with $V_{DD}$=15V

## DYNAMIC ELECTRICAL CHARACTERISTICS ($T_{amb}$ = 25°C, $C_L$ = 50pF, $R_L$ = 200KΩ, $t_r = t_f$ = 20 ns)

| Symbol | Parameter | Test Condition | | Value (*) | | | Unit |
|---|---|---|---|---|---|---|---|
| | | $V_{DD}$ (V) | | Min. | Typ. | Max. | |
| $t_{PHL}$ $t_{PLH}$ | Propagation Delay Time CLOCK to OUT | 5 | | | 110 | 220 | ns |
| | | 10 | | | 55 | 110 | |
| | | 15 | | | 45 | 90 | |
| $t_{PHL}$ $t_{PLH}$ | Propagation Delay Time CLOCK or STROBE to OUT | 5 | | | 150 | 300 | ns |
| | | 10 | | | 75 | 150 | |
| | | 15 | | | 60 | 120 | |
| $t_{PHL}$ $t_{PLH}$ | Propagation Delay Time CLOCK to INHIBIT High Level to Low Level | 5 | | | 360 | 720 | ns |
| | | 10 | | | 160 | 320 | |
| | | 15 | | | 110 | 220 | |
| $t_{PHL}$ $t_{PLH}$ | Propagation Delay Time LOW Level to HIGH Level | 5 | | | 250 | 500 | ns |
| | | 10 | | | 100 | 200 | |
| | | 15 | | | 75 | 150 | |

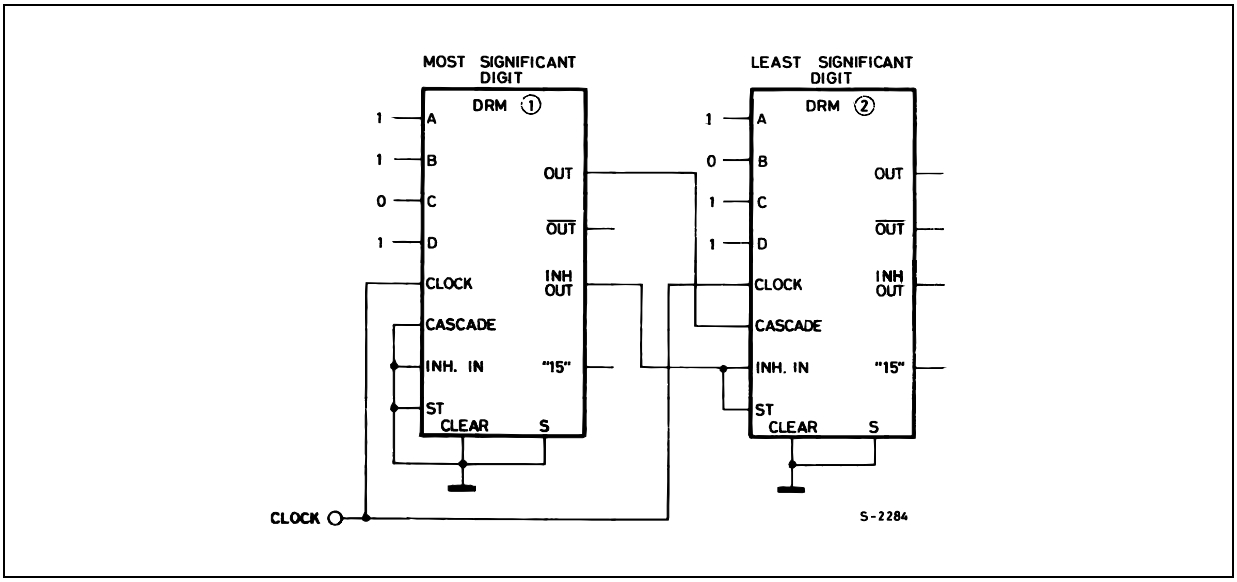
| Symbol | Parameter | Test Condition | | Value (*) | | | Unit |
|---|---|---|---|---|---|---|---|
| | | $V_{DD}$ (V) | | Min. | Typ. | Max. | |
| $t_{PHL}$ $t_{PLH}$ | Propagation Delay Time CLEAR to OUT | 5 | | | 380 | 760 | ns |
| | | 10 | | | 175 | 350 | |
| | | 15 | | | 130 | 260 | |
| $t_{PHL}$ $t_{PLH}$ | Propagation Delay Time CLOCK to "9" or "15" OUT | 5 | | | 300 | 600 | ns |
| | | 10 | | | 125 | 250 | |
| | | 15 | | | 90 | 180 | |
| $t_{PHL}$ $t_{PLH}$ | Propagation Delay Time CASCADE to OUT | 5 | | | 90 | 180 | ns |
| | | 10 | | | 45 | 90 | |
| | | 15 | | | 35 | 70 | |
| $t_{PHL}$ $t_{PLH}$ | Propagation Delay Time INHIBIT IN to INHIBIT OUT | 5 | | | 160 | 320 | ns |
| | | 10 | | | 75 | 150 | |
| | | 15 | | | 55 | 110 | |
| $t_{PHL}$ $t_{PLH}$ | Propagation Delay Time SET to OUT | 5 | | | 330 | 660 | ns |
| | | 10 | | | 150 | 300 | |
| | | 15 | | | 110 | 220 | |
| $t_{THL}$ $t_{TLH}$ | Transition Time | 5 | | | 100 | 200 | ns |
| | | 10 | | | 50 | 100 | |
| | | 15 | | | 40 | 80 | |
| $f_{CL}$ | Maximum Clock Frequency | 5 | | 1.2 | 2.4 | | MHz |
| | | 10 | | 2.5 | 5 | | |
| | | 15 | | 3.5 | 7 | | |
| $t_W$ | Clock Pulse Width | 5 | | 330 | 165 | | ns |
| | | 10 | | 170 | 85 | | |
| | | 15 | | 100 | 50 | | |
| $t_r$, $t_f$ | Clock Rise or Fall Time | 5 | | | | 15 | µs |
| | | 10 | | | | 15 | |
| | | 15 | | | | 15 | |
| $t_W$ | SET or CLEAR pulse Width | 5 | | 160 | 80 | | ns |
| | | 10 | | 90 | 45 | | |
| | | 15 | | 60 | 30 | | |
| $t_{setup}$ | INHIBIT Input Set-Up Time, High Level to Low Level | 5 | | 100 | 50 | | ns |
| | | 10 | | 40 | 20 | | |
| | | 15 | | 20 | 10 | | |
| $t_R$ | INHIBIT Input Removal Time | 5 | | 240 | 120 | | ns |
| | | 10 | | 130 | 65 | | |
| | | 15 | | 110 | 55 | | |
| $t_R$ | Minimum SET Removal Time | 5 | | 150 | 75 | | ns |
| | | 10 | | 80 | 40 | | |
| | | 15 | | 50 | 25 | | |
| $t_R$ | CLEAR Removal Time | 5 | | 60 | 30 | | ns |
| | | 10 | | 40 | 20 | | |
| | | 15 | | 30 | 15 | | |

(*) Typical temperature coefficient for all $V_{DD}$ value is 0.3 %/°C.

## APPLICATION NOTES

For words of more than 4 bits, HCF4089B device may be cascaded in two different modes : an ADD mode and a MULTIPLY mode.

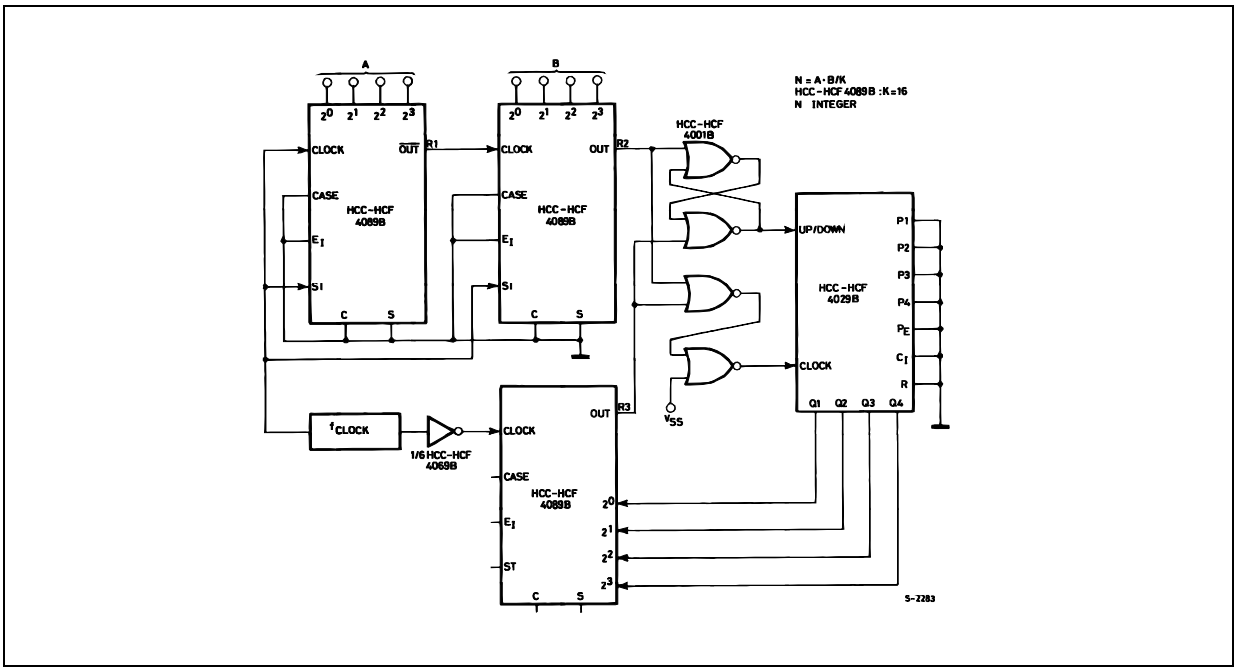
### TWO HCF4089B'S CASCADED IN THE "ADD" MODE WITH A PRESET NUMBER OF 189




In the ADD mode some of the gaps left by the more significant unit at the count of 15 are filled in by the less significant units. For example, when two units are cascaded in the ADD mode and programmed to 11 and 13, respectively, the more significant unit will have 11 output pulses and the other unit will have 13 output pulses for every 256 input pulses for a total of :

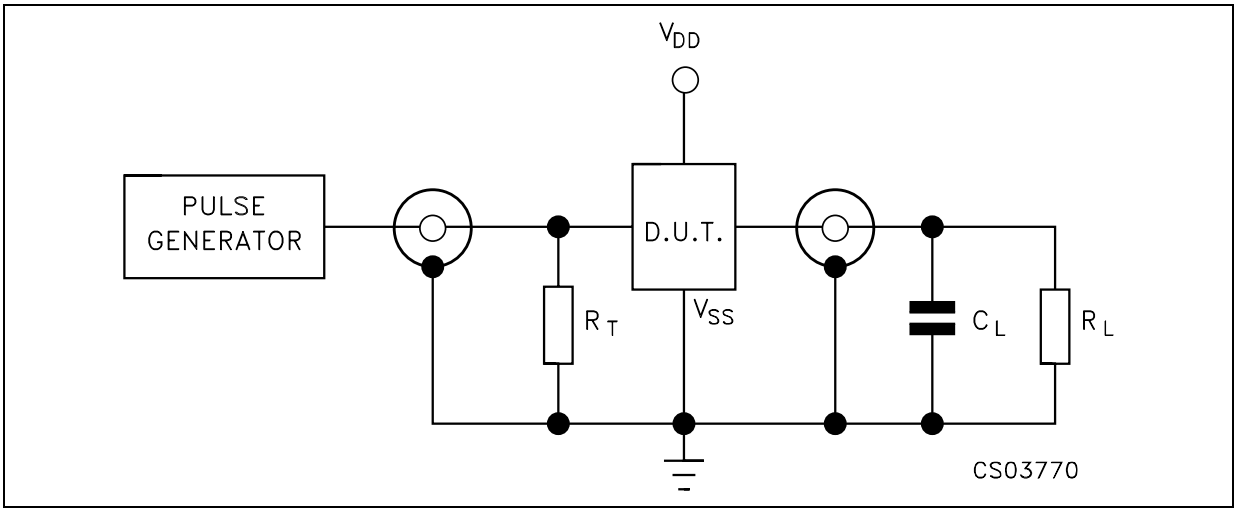
$$\frac{11}{16} + \frac{13}{256} = \frac{189}{256}$$

### TWO HCF4089B'S CASCADED IN THE "MULTIPLY" MODE FOR MULTIPLICATION OF TWO VARIABLES A AND B WITH LOOP CIRCUIT CONTROL




When the loop stabilities rate R2 = rate R3, thus $f_{clock}(\frac{A}{16} \bullet \frac{B}{16}) = f_{clock}(\frac{1}{16} \bullet \frac{N}{16})$ therefore N = AB

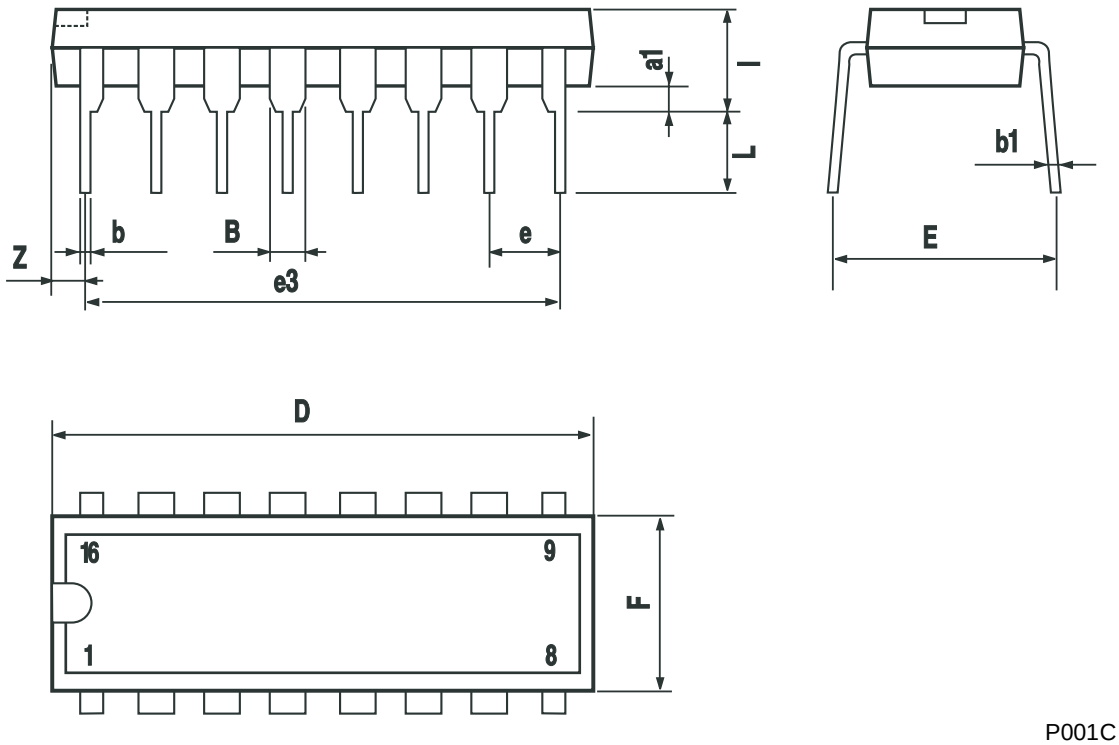
## TEST CIRCUIT




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

## Plastic DIP-16 (0.25) MECHANICAL DATA

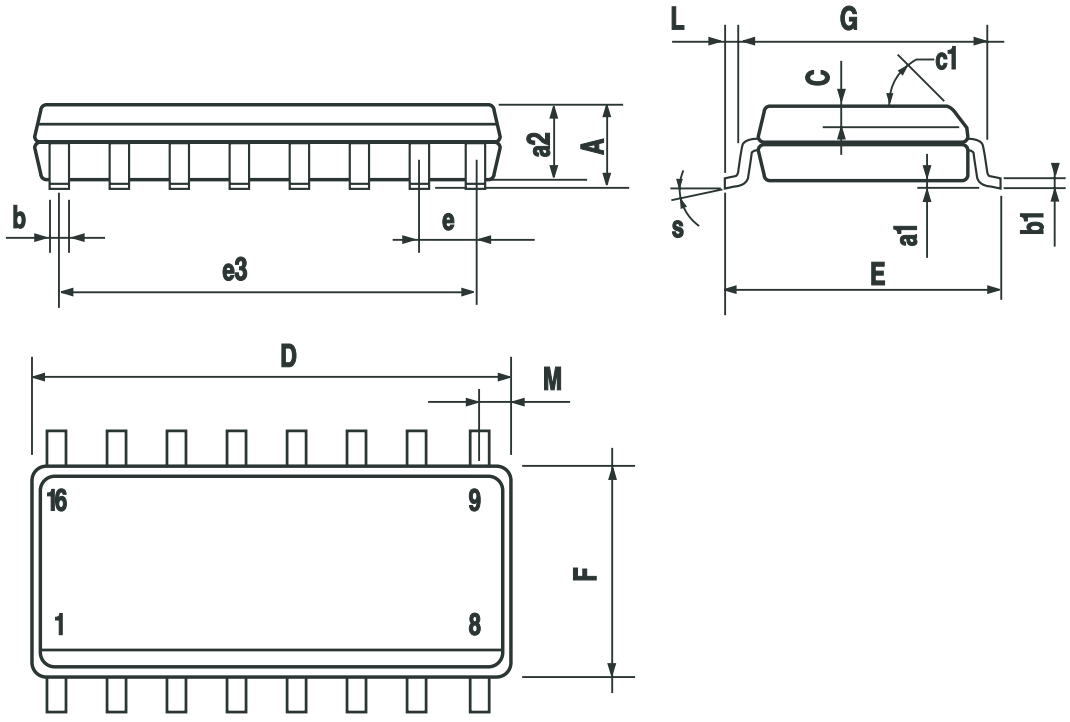
| DIM. | mm. | | | inch | | |
|---|---|---|---|---|---|---|
| | MIN. | TYP | MAX. | MIN. | TYP. | MAX. |
| a1 | 0.51 | | | 0.020 | | |
| B | 0.77 | | 1.65 | 0.030 | | 0.065 |
| b | | 0.5 | | | 0.020 | |
| b1 | | 0.25 | | | 0.010 | |
| D | | | 20 | | | 0.787 |
| E | | 8.5 | | | 0.335 | |
| e | | 2.54 | | | 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.) | | | | | |

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