

# CD4020B, CD4024B, CD4040B Types

## CMOS Ripple-Carry Binary Counter/Dividers

High-Voltage Types (20-Volt Rating)

CD4020B – 14 Stage

CD4024B – 7 Stage

CD4040B – 12 Stage

■ CD4020B, CD4024B, and CD4040B are ripple-carry binary counters. All counter stages are master-slave flip-flops. The state of a counter advances one count on the negative transition of each input pulse; a high level on the RESET line resets the counter to its all zeros state. Schmitt trigger action on the input-pulse line permits unlimited rise and fall times. All inputs and outputs are buffered.

The CD4020B and CD4040B types are supplied in 16-lead hermetic dual-in-line ceramic packages (D and F suffixes), 16-lead dual-in-line plastic packages (E suffix), 16-lead small-outline package (NSR suffix), 16-lead ceramic flat packages (K suffix), and in chip form (H suffix).

The CD4024B types are supplied in 14-lead hermetic dual-in-line ceramic packages (D and F suffixes), 14-lead dual-in-line plastic packages (E suffix), 14-lead small-outline package (NSR suffix), and in chip form (H suffix).

### MAXIMUM RATINGS, Absolute-Maximum Values:

#### DC SUPPLY-VOLTAGE RANGE, ( $V_{DD}$ )

Voltages referenced to  $V_{SS}$  Terminal) ..... -0.5V to +20V

INPUT VOLTAGE RANGE, ALL INPUTS ..... -0.5V to  $V_{DD}$  +0.5V

DC INPUT CURRENT, ANY ONE INPUT .....  $\pm 10$ mA

#### POWER DISSIPATION PER PACKAGE ( $P_D$ ):

For  $T_A = -55^\circ\text{C}$  to  $+100^\circ\text{C}$  ..... 500mW

For  $T_A = +100^\circ\text{C}$  to  $+125^\circ\text{C}$  ..... Derate Linearly at 12mW/ $^\circ\text{C}$  to 200mW

#### DEVICE DISSIPATION PER OUTPUT TRANSISTOR

FOR  $T_A = \text{FULL PACKAGE-TEMPERATURE RANGE (All Package Types)}$  ..... 100mW

OPERATING-TEMPERATURE RANGE ( $T_A$ ) .....  $-55^\circ\text{C}$  to  $+125^\circ\text{C}$

STORAGE TEMPERATURE RANGE ( $T_{stg}$ ) .....  $-65^\circ\text{C}$  to  $+150^\circ\text{C}$

#### LEAD TEMPERATURE (DURING SOLDERING):

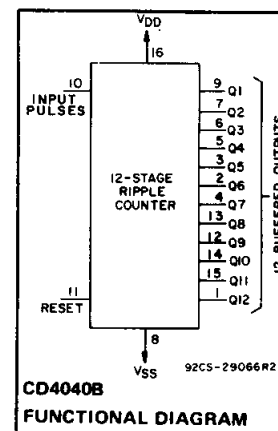
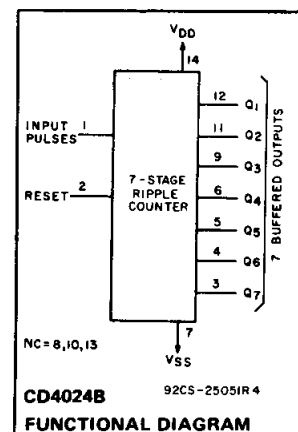
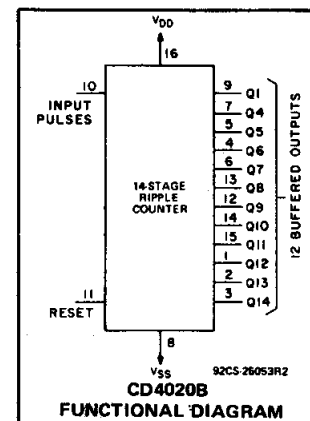
At distance  $1/16 \pm 1/32$  inch ( $1.59 \pm 0.79$ mm) from case for 10s max .....  $+265^\circ\text{C}$

### Features:

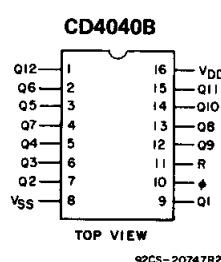
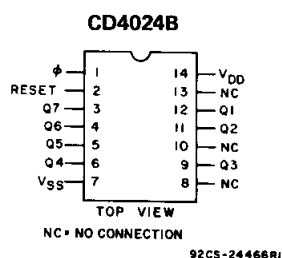
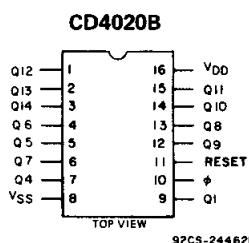
- Medium-speed operation
- Fully static operation
- Buffered inputs and outputs
- 100% tested for quiescent current at 20 V
- Standardized, symmetrical output characteristics
- Fully static operation
- Common reset
- 5-V, 10-V, and 15-V parametric ratings
- Maximum input current of  $1 \mu\text{A}$  at 18 V over full package-temperature range; 100 nA at 18 V and  $25^\circ\text{C}$
- Noise margin (over full package-temperature range):
  - 1 V at  $V_{DD} = 5 \text{ V}$
  - 2 V at  $V_{DD} = 10 \text{ V}$
  - 2.5 V at  $V_{DD} = 15 \text{ V}$
- Meets all requirements of JEDEC Tentative Standard No. 13B, "Standard Specifications for Description of 'B' Series CMOS Devices"

### Applications:

- Control counters
- Frequency dividers
- Timers
- Time-delay circuits



### TERMINAL ASSIGNMENTS



## CD4020B, CD4024B, CD4040B Types

**RECOMMENDED OPERATING CONDITIONS** at  $T_A = 25^\circ\text{C}$ , Unless Otherwise Specified  
For maximum reliability, nominal operating conditions should be selected so that operation is always within the following ranges:

| CHARACTERISTIC                                                           | $V_{DD}$      | Min.              | Max.           | UNITS         |
|--------------------------------------------------------------------------|---------------|-------------------|----------------|---------------|
| Supply Voltage Range (at $T_A = \text{Full Package-Temperature Range}$ ) |               | 3                 | 18             | V             |
| Input-Pulse Frequency, $f_\phi$                                          | 5<br>10<br>15 | —<br>—<br>—       | 3.5<br>8<br>12 | MHz           |
| Input-Pulse Width, $t_W$                                                 | 5<br>10<br>15 | 140<br>60<br>40   | —<br>—<br>—    | ns            |
| Input-Pulse Rise or Fall Time, $t_{r\phi}, t_{f\phi}$                    | 5<br>10<br>15 | Unlimited         | —              | $\mu\text{s}$ |
| Reset Pulse Width, $t_W$                                                 | 5<br>10<br>15 | 200<br>80<br>60   | —              | ns            |
| Reset Removal Time, $t_{REM}$                                            | 5<br>10<br>15 | 350<br>150<br>100 | —              | ns            |

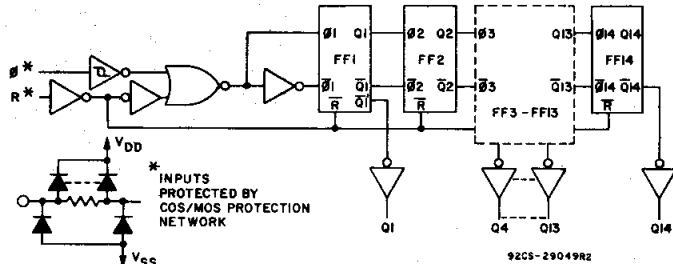


Fig. 1 — Logic diagram for CD4020B.

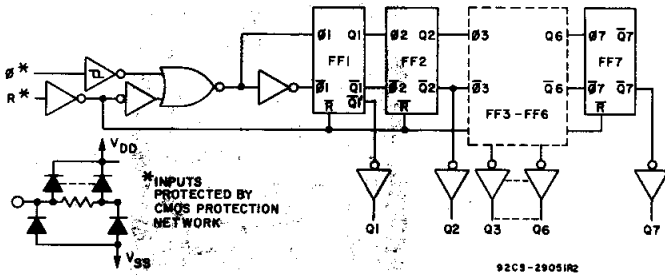


Fig. 2 — Logic diagram for CD4024B.

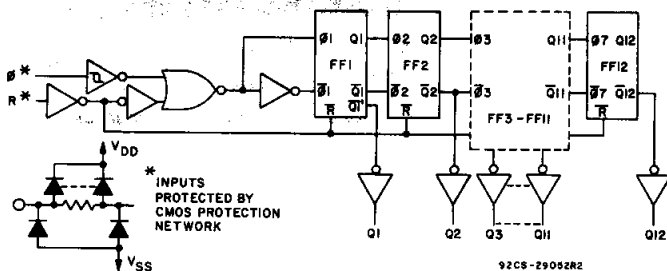


Fig. 3 — Logic diagram for CD4040B.

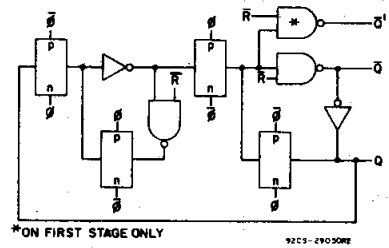


Fig. 4 — Detail of typical flip-flop stage.

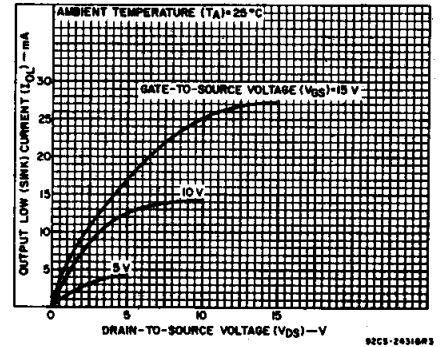


Fig. 5 — Typical output low (sink) current characteristics.

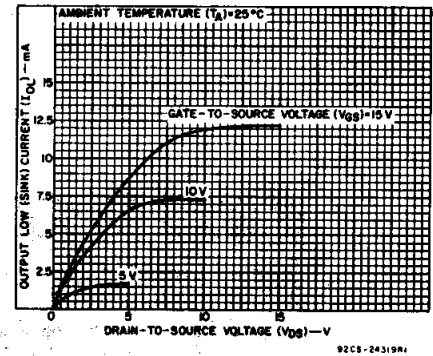


Fig. 6 — Minimum output low (sink) current characteristics.

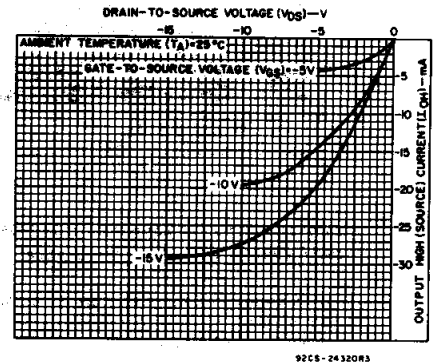


Fig. 7 — Typical output high (source) current characteristics.

# CD4020B, CD4024B, CD4040B Types

## STATIC ELECTRICAL CHARACTERISTICS

| CHARACTER-<br>ISTIC                                         | CONDITIONS            |                        |                        | LIMITS AT INDICATED TEMPERATURES (°C) |       |       |       |       |                   |      | UNITS |
|-------------------------------------------------------------|-----------------------|------------------------|------------------------|---------------------------------------|-------|-------|-------|-------|-------------------|------|-------|
|                                                             | V <sub>O</sub><br>(V) | V <sub>IN</sub><br>(V) | V <sub>DD</sub><br>(V) |                                       |       |       |       | +25   |                   |      |       |
|                                                             |                       |                        |                        | -55                                   | -40   | +85   | +125  | Min.  | Typ.              | Max. |       |
| Quiescent Device<br>Current,<br>I <sub>DD</sub> Max.        | —                     | 0,5                    | 5                      | 5                                     | 5     | 150   | 150   | —     | 0.04              | 5    | μA    |
|                                                             | —                     | 0,10                   | 10                     | 10                                    | 10    | 300   | 300   | —     | 0.04              | 10   |       |
|                                                             | —                     | 0,15                   | 15                     | 20                                    | 20    | 600   | 600   | —     | 0.04              | 20   |       |
|                                                             | —                     | 0,20                   | 20                     | 100                                   | 100   | 3000  | 3000  | —     | 0.08              | 100  |       |
| Output Low<br>(Sink) Current<br>I <sub>OL</sub> Min.        | 0.4                   | 0,5                    | 5                      | 0.64                                  | 0.61  | 0.42  | 0.36  | 0.51  | 1                 | —    | mA    |
|                                                             | 0.5                   | 0,10                   | 10                     | 1.6                                   | 1.5   | 1.1   | 0.9   | 1.3   | 2.6               | —    |       |
|                                                             | 1.5                   | 0,15                   | 15                     | 4.2                                   | 4     | 2.8   | 2.4   | 3.4   | 6.8               | —    |       |
| Output High<br>(Source)<br>Current,<br>I <sub>OH</sub> Min. | 4.6                   | 0,5                    | 5                      | -0.64                                 | -0.61 | -0.42 | -0.36 | -0.51 | -1                | —    | mA    |
|                                                             | 2.5                   | 0,5                    | 5                      | -2                                    | -1.8  | -1.3  | -1.15 | -1.6  | -3.2              | —    |       |
|                                                             | 9.5                   | 0,10                   | 10                     | -1.6                                  | -1.5  | -1.1  | -0.9  | -1.3  | -2.6              | —    |       |
|                                                             | 13.5                  | 0,15                   | 15                     | -4.2                                  | -4    | -2.8  | -2.4  | -3.4  | -6.8              | —    |       |
| Output Voltage:<br>Low-Level,<br>V <sub>OL</sub> Max.       | —                     | 0,5                    | 5                      | 0.05                                  |       |       |       | —     | 0                 | 0.05 | V     |
|                                                             | —                     | 0,10                   | 10                     | 0.05                                  |       |       |       | —     | 0                 | 0.05 |       |
|                                                             | —                     | 0,15                   | 15                     | 0.05                                  |       |       |       | —     | 0                 | 0.05 |       |
| Output Voltage:<br>High-Level,<br>V <sub>OH</sub> Min.      | —                     | 0,5                    | 5                      | 4.95                                  |       |       |       | 4.95  | 5                 | —    | V     |
|                                                             | —                     | 0,10                   | 10                     | 9.95                                  |       |       |       | 9.95  | 10                | —    |       |
|                                                             | —                     | 0,15                   | 15                     | 14.95                                 |       |       |       | 14.95 | 15                | —    |       |
| Input Low<br>Voltage,<br>V <sub>IL</sub> Max.               | 0.5, 4.5              | —                      | 5                      | 1.5                                   |       |       |       | —     | —                 | 1.5  | V     |
|                                                             | 1, 9                  | —                      | 10                     | 3                                     |       |       |       | —     | —                 | 3    |       |
|                                                             | 1.5,13.5              | —                      | 15                     | 4                                     |       |       |       | —     | —                 | 4    |       |
| Input High<br>Voltage,<br>V <sub>IH</sub> Min.              | 0.5, 4.5              | —                      | 5                      | 3.5                                   |       |       |       | 3.5   | —                 | —    | V     |
|                                                             | 1, 9                  | —                      | 10                     | 7                                     |       |       |       | 7     | —                 | —    |       |
|                                                             | 1.5,13.5              | —                      | 15                     | 11                                    |       |       |       | 11    | —                 | —    |       |
| Input Current<br>I <sub>IN</sub> Max.                       | —                     | 0,18                   | 18                     | ±0.1                                  | ±0.1  | ±1    | ±1    | —     | ±10 <sup>-5</sup> | ±0.1 | μA    |

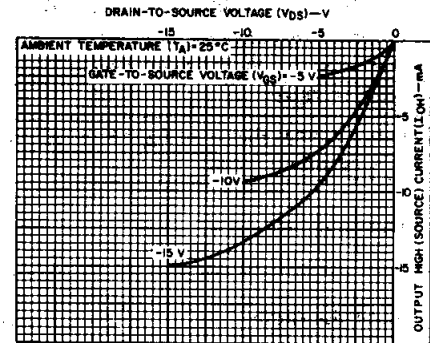


Fig. 8 — Minimum output high (source) current characteristics.

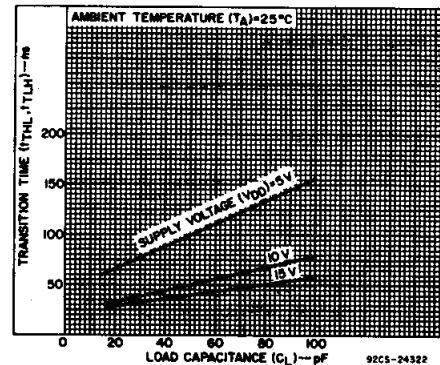
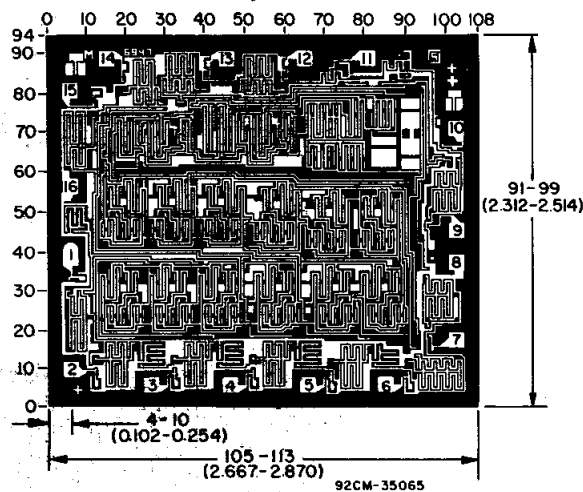
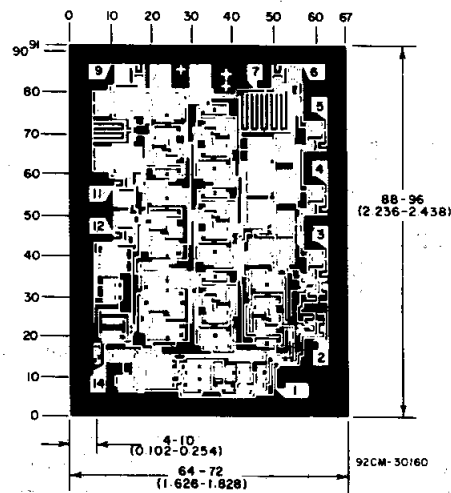


Fig. 9 — Typical transition time as a function of load capacitance.



Dimensions and Pad Layout for CD4020BH. Dimensions and pad layout for CD4040BH are identical.

Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated. Grid graduations are in mils (10<sup>-3</sup> inch).



Dimensions and Pad Layout for CD4024BH.

# CD4020B, CD4024B, CD4040B Types

DYNAMIC ELECTRICAL CHARACTERISTICS at  $T_A = 25^\circ\text{C}$ , Input  $t_r, t_f = 20\text{ ns}$ ,  
 $C_L = 50\text{ pF}$ ,  $R_L = 200\text{ k}\Omega$

| CHARACTERISTIC                                                                               | TEST<br>CONDITIONS | V <sub>DD</sub><br>(V) | LIMITS    |      |      | UNITS |
|----------------------------------------------------------------------------------------------|--------------------|------------------------|-----------|------|------|-------|
|                                                                                              |                    |                        | Min.      | Typ. | Max. |       |
| Input-Pulse Operation                                                                        |                    |                        |           |      |      |       |
| Propagation Delay Time, $\phi$ to<br>Q <sub>1</sub> Out; t <sub>PHL</sub> , t <sub>PLH</sub> |                    | 5                      | —         | 180  | 360  | ns    |
|                                                                                              |                    | 10                     | —         | 80   | 160  |       |
|                                                                                              |                    | 15                     | —         | 65   | 130  |       |
| Q <sub>n</sub> to Q <sub>n</sub> + 1;<br>t <sub>PHL</sub> , t <sub>PLH</sub>                 |                    | 5                      | —         | 100  | 330  | ns    |
|                                                                                              |                    | 10                     | —         | 40   | 80   |       |
|                                                                                              |                    | 15                     | —         | 30   | 60   |       |
| Transition Time,<br>t <sub>THL</sub> , t <sub>TLH</sub>                                      |                    | 5                      | —         | 100  | 200  | ns    |
|                                                                                              |                    | 10                     | —         | 50   | 100  |       |
|                                                                                              |                    | 15                     | —         | 40   | 80   |       |
| Minimum Input-Pulse<br>Width, t <sub>W</sub>                                                 |                    | 5                      | —         | 70   | 140  | ns    |
|                                                                                              |                    | 10                     | —         | 30   | 60   |       |
|                                                                                              |                    | 15                     | —         | 20   | 40   |       |
| Input-Pulse Rise or Fall<br>Time, t <sub>rφ</sub> , t <sub>fφ</sub>                          |                    | 5                      | Unlimited |      |      | μs    |
|                                                                                              |                    | 10                     |           |      |      |       |
|                                                                                              |                    | 15                     |           |      |      |       |
| Maximum Input-Pulse<br>Frequency, f <sub>φ</sub>                                             |                    | 5                      | 3.5       | 7    | —    | MHz   |
|                                                                                              |                    | 10                     | 8         | 16   | —    |       |
|                                                                                              |                    | 15                     | 12        | 24   | —    |       |
| Input Capacitance, C <sub>I</sub>                                                            | Any Input          |                        | —         | 5    | 7.5  | pF    |
| Reset Operation                                                                              |                    |                        |           |      |      |       |
| Propagation Delay<br>Time, t <sub>PHL</sub>                                                  |                    | 5                      | —         | 140  | 280  | ns    |
|                                                                                              |                    | 10                     | —         | 60   | 120  |       |
|                                                                                              |                    | 15                     | —         | 50   | 100  |       |
| Minimum Reset Pulse<br>Width, t <sub>W</sub>                                                 |                    | 5                      | —         | 100  | 200  | ns    |
|                                                                                              |                    | 10                     | —         | 40   | 80   |       |
|                                                                                              |                    | 15                     | —         | 30   | 60   |       |
| Reset Removal Time,<br>t <sub>REM</sub>                                                      |                    | 5                      | —         | 175  | 350  | ns    |
|                                                                                              |                    | 10                     | —         | 75   | 150  |       |
|                                                                                              |                    | 15                     | —         | 50   | 100  |       |

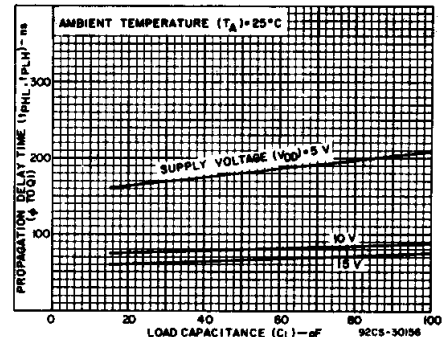


Fig. 10 — Typical propagation delay time as a function of load capacitance ( $\phi$  to  $Q_1$ ).

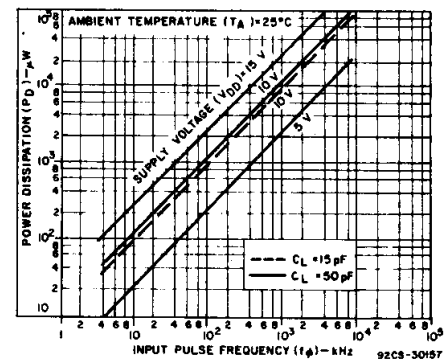


Fig. 11 — Typical dynamic power dissipation as a function of input pulse frequency for CD4020B.

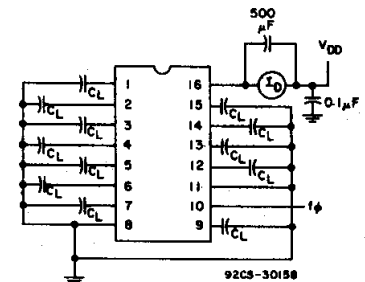


Fig. 12 — Dynamic power dissipation test circuit for CD4020B.

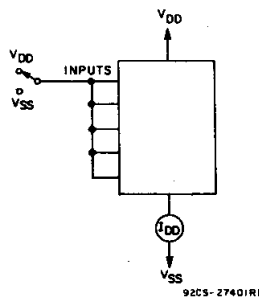


Fig. 13 — Quiescent device current test circuit.

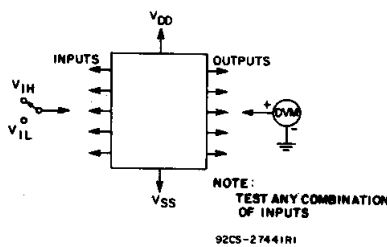


Fig. 14 — Input voltage test circuits.

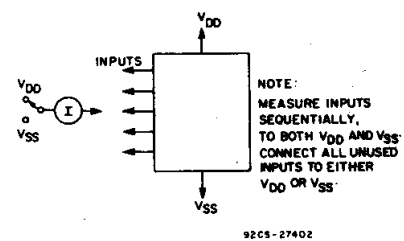


Fig. 15 — Input current test circuit.

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