

# CMOS 21-Stage Counter

High-Voltage Types (20-Volt Rating)

■ CD4045B is a timing circuit consisting of 21 counter stages, two output-shaping flip-flops, two inverter output drivers, and input inverters for use in a crystal oscillator. The CD4045B configuration provides 21 flip-flop counting stages, and two flip-flops for shaping the output waveform for a 3.125% duty cycle. Push-pull operation is provided by the inverter output drivers.

The first inverter is intended for use as a crystal oscillator/amplifier. However, it may be used as a normal logic inverter if desired. A crystal oscillator circuit can be made less sensitive to voltage-supply variations by the use of source resistors. In this device, the sources of the p and n transistors have been brought out to package terminals. If external resistors are not required, the sources must be shorted to their respective substrates ( $S_p$  to  $V_{DD}$ ,  $S_n$  to  $V_{SS}$ ). See Fig. 1. The first inverter in conjunction with an outboard inverter, such as 1/6 CD4069, and  $R_X$ ,  $C_X$ , and  $R_S$  can also be used to construct an RC oscillator. The following data is supplied as a guide in the selection of values for  $R_X$ ,  $R_S$ , and  $C_X$  used in Fig. 11:

1.  $R_X$  max = 10 M $\Omega$  with  $R_S$  = 10 M $\Omega$  and  $C_X$  = 50 pF
2.  $C_X$  max = 25  $\mu$ F with  $R_S$  = 560 k $\Omega$  and  $R_X$  = 50 k $\Omega$

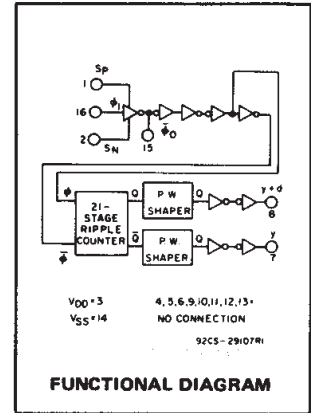
The CD4045B types are supplied in 16-lead dual-in-line ceramic packages (D and F suffixes), 16-lead dual-in-line plastic packages (E suffix), and in chip form (H suffix).

### Applications:

- Digital equipment in which ultra-low dissipation and/or operation using a battery source is required.
- Accurate timing from a crystal oscillator for timing applications such as wall clocks, table clocks, automobile clocks, and digital timing references in any circuit requiring accurately timed outputs at various intervals in the counting sequence.
- Driving miniature synchronous motors, stepping motors, or external bipolar transistors in push-pull fashion.

### Features:

- Very low operating dissipation . . . . . <1 mW (typ.) @  $V_{DD}$  = 5 V,  $f\phi$  = 1 MHz
- Output drivers with sink or source capability . . . . . 7 mA (typ.) @  $V_{DD}$  = 5 V
- Medium speed (typ.) . . . . .  $f\phi$  = 25 MHz @  $V_{DD}$  = 10 V
- 100% tested for quiescent current at 20 V
- 5-V, 10-V, and 15-V parametric ratings
- Meets all requirements of JEDEC Tentative Standard No. 13B, Standard Specifications for Description of 'B' Series CMOS Devices"



### MAXIMUM RATINGS, Absolute-Maximum Values:

|  |                                     |
|--|-------------------------------------|
| DC SUPPLY-VOLTAGE RANGE, ( $V_{DD}$ )                                      | -0.5V to +20V                       |
| Voltages referenced to $V_{SS}$ Terminal                                   |                                     |
| INPUT VOLTAGE RANGE, ALL INPUTS  | -0.5V to $V_{DD}$ + 0.5V            |
| DC INPUT CURRENT, ANY ONE INPUT  | $\pm$ 10mA                          |
| POWER DISSIPATION PER PACKAGE ( $P_D$ ):                                   |                                     |
| For $T_A$ = -55°C to +100°C  | 500mW                               |
| For $T_A$ = +100°C to +125°C   | Derate Linearly at 12mW/°C to 200mW |
| DEVICE DISSIPATION PER OUTPUT TRANSISTOR                                   |                                     |
| FOR $T_A$ = FULL PACKAGE-TEMPERATURE RANGE (All Package Types)             | 100mW                               |
| OPERATING-TEMPERATURE RANGE ( $T_A$ )                                      | -55°C to +125°C                     |
| STORAGE TEMPERATURE RANGE ( $T_{stg}$ )                                    | -85°C to +150°C                     |
| LEAD TEMPERATURE (DURING SOLDERING):                                       |                                     |
| At distance 1/16 $\pm$ 1/32 inch (1.59 $\pm$ 0.79mm) from case for 10s max | +265°C                              |

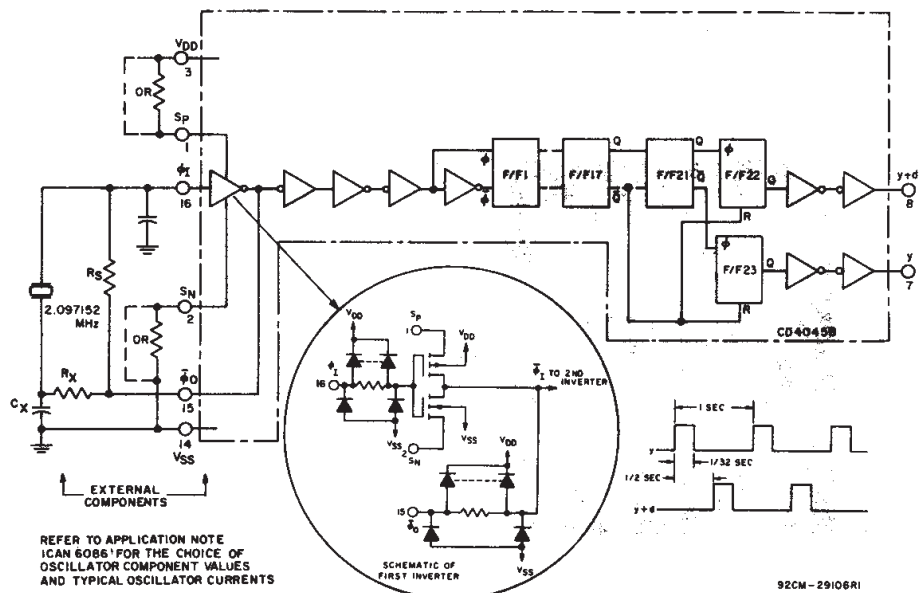


Fig. 1 - CD4045B and outboard components in a typical 21-stage counter application.

## CD4045B Types

### STATIC ELECTRICAL CHARACTERISTICS

| CHARACTERISTIC  | 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) | -55                                   | -40   | +85   | +125  | +25   |                   |      |       |
|   |                       |                        |                        |                                       |       |       |       | Min.  | Typ.              | Max. |       |
| Quiescent Device Current, 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 (Sink) Current I <sub>OL</sub> Min.                        | 0.4                   | 0,5                    | 5                      | 4.5                                   | 4.3   | 2.9   | 2.5   | 3.6   | 7                 | —    | mA    |
|   | 0.5                   | 0,10                   | 10                     | 11.2                                  | 10.5  | 7.7   | 6.3   | 9.1   | 18                | —    |       |
|   | 1.5                   | 0,15                   | 15                     | 29.4                                  | 28    | 19.6  | 16.8  | 23.8  | 47                | —    |       |
| Output High (Source) Current, I <sub>OH</sub> Min.                    | 4.6                   | 0,5                    | 5                      | -4.5                                  | -4.3  | -2.9  | -2.5  | -3.6  | -7                | —    | mA    |
|   | 9.5                   | 0,10                   | 10                     | -11.2                                 | -10.5 | -7.7  | -6.3  | -9.1  | -18               | —    |       |
|   | 13.5                  | 0,15                   | 15                     | -29.4                                 | -28   | -19.6 | -16.8 | -23.8 | -47               | —    |       |
| Pin 15 Output Low and High Current, I <sub>OL</sub> , I <sub>OH</sub> | 0.4,4.6               | 0,5                    | 5                      | —                                     |       |       |       | ±0.1  | ±0.18             | —    | mA    |
|   | 0.5,9.5               | 0,10                   | 10                     | —                                     |       |       |       | ±0.2  | ±0.3              | —    |       |
|   | 1.5,13.5              | 0,15                   | 15                     | —                                     |       |       |       | ±0.5  | ±1                | —    |       |
| Output Voltage: Low-Level, V <sub>OL</sub> Max.                       | —                     | 0,5                    | 5                      | 0.05                                  |       |       |       | —     | —                 | 0.05 | V     |
|   | —                     | 0,10                   | 10                     | 0.05                                  |       |       |       | —     | —                 | 0.05 |       |
|   | —                     | 0,15                   | 15                     | 0.05                                  |       |       |       | —     | —                 | 0.05 |       |
| Output Voltage: High-Level, 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 Voltage 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 Voltage, 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 I <sub>IN</sub> Max.                                    | —                     | 0,18                   | 18                     | ±0.1                                  | ±0.1  | ±1    | ±1    | —     | ±10 <sup>-5</sup> | ±0.1 | μA    |

### RECOMMENDED OPERATING CONDITIONS

For maximum reliability, nominal operating conditions should be selected so that operation is always within the following ranges

| CHARACTERISTIC   | V <sub>DD</sub><br>(V) | LIMITS |      | UNITS |
|--|------------------------|--------|------|-------|
|  |                        | Min.   | Max. |       |
| Supply-Voltage Range (For T <sub>A</sub> = Full Package-Temperature Range) | —                      | 3      | 18   | V     |
| Minimum Input-Pulse Width, t <sub>w</sub>                                  | 5                      | —      | 100  | ns    |
|  | 10                     | —      | 50   |       |
|  | 15                     | —      | 40   |       |
| Maximum Input-Pulse Frequency, f <sub>φ</sub><br>(External Pulse Source)   | 5                      | 5      | —    | MHz   |
|  | 10                     | 12     | —    |       |
|  | 15                     | 15     | —    |       |

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**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 CONDITIONS   | $V_{DD}$<br>V | LIMITS |      |      | UNITS         |
|---|---|---------------|--------|------|------|---------------|
|   |   |               | Min.   | Typ. | Max. |               |
| Propagation Delay Time:<br>$\phi_1$ to y or y+d out<br>$t_{PHL}, t_{PLH}$ |   | 5             | —      | 2.2  | 5.5  | $\mu\text{s}$ |
|   |   | 10            | —      | 0.9  | 2.7  |               |
|   |   | 15            | —      | 0.65 | 2    |               |
| Transition Time:<br>$t_{THL}, t_{TLH}$                                    |   | 5             | —      | 25   | 50   | ns            |
|   |   | 10            | —      | 13   | 25   |               |
|   |   | 15            | —      | 10   | 20   |               |
| Minimum Input-Pulse Width<br>$t_W$  |   | 5             | —      | 50   | 100  | ns            |
|   |   | 10            | —      | 25   | 50   |               |
|   |   | 15            | —      | 20   | 40   |               |
| Input-Pulse Rise or Fall Time:<br>$t_r\phi, t_f\phi$                      |   | 5             | —      | —    | 500  | $\mu\text{s}$ |
|   |   | 10            | —      | —    | 500  |               |
|   |   | 15            | —      | —    | 500  |               |
| Maximum Input-Pulse Frequency:<br>(External Pulse Source) $f_\phi$        |   | 5             | 5      | 10   | —    | MHz           |
|   |   | 10            | 12     | 25   | —    |               |
|   |   | 15            | 15     | 30   | —    |               |
| Input Capacitance, $C_{IN}$   | Any Input   |               | —      | 5    | 7.5  | pF            |
| Variation of Output Frequency<br>(Unit-to-Unit)                           | $f = 5\text{ MHz}$  | 5             | —      | 0.05 | —    | %             |
|   |   | 10            | —      | 0.03 | —    |               |
|   |   | 15            | —      | 0.1  | —    |               |
| <b>RC Oscillator Operation</b>  |   |               |        |      |      |               |
| Maximum Oscillator Frequency<br>(See Fig. 11)<br>$f_{osc}$                | $R_X = 50\text{ k}\Omega$ ,<br>$R_S = 560\text{ k}\Omega$ ,<br>$C_X = 50\text{ pF}$ | 5             | 45     | 60   | 75   | kHz           |
|   |   | 10            | 45     | 60   | 75   |               |
|   |   | 15            | 45     | 60   | 75   |               |

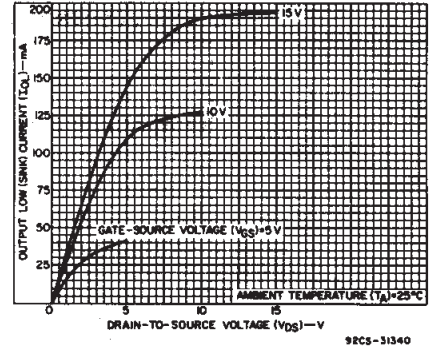


Fig. 2 — Typical output low (sink) current characteristics.

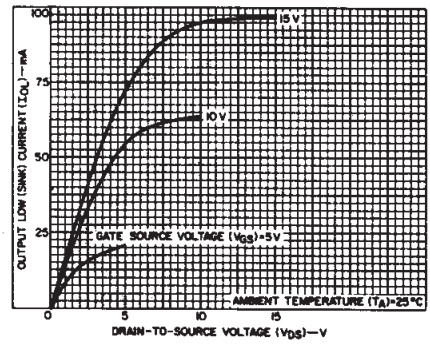


Fig. 3 — Minimum output low (sink) current characteristics.

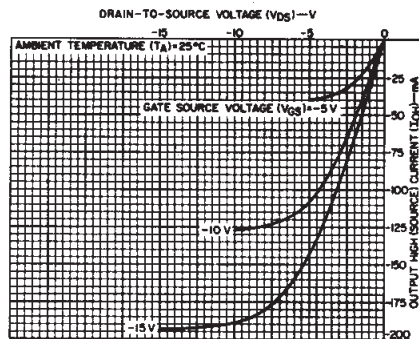


Fig. 4 — Typical output high (source) current characteristics.

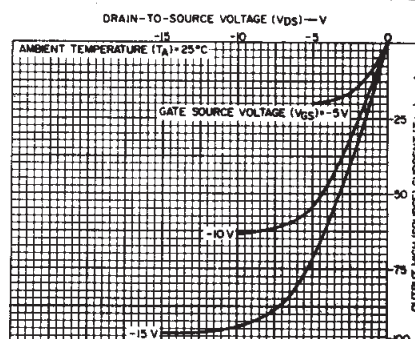


Fig. 5 — Minimum output high (source) current characteristics.

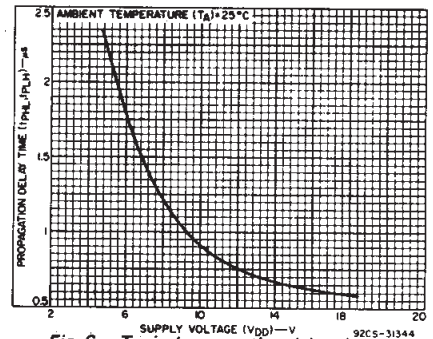


Fig. 6 — Typical propagation delay time as a function of supply voltage ( $\phi_1$  to y or y + d out vs.  $V_{DD}$ ).

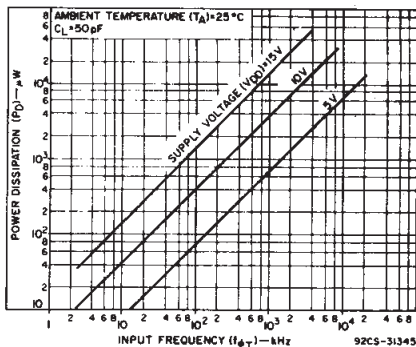


Fig. 7 — Typical power dissipation as a function of input frequency (21 counting stages).

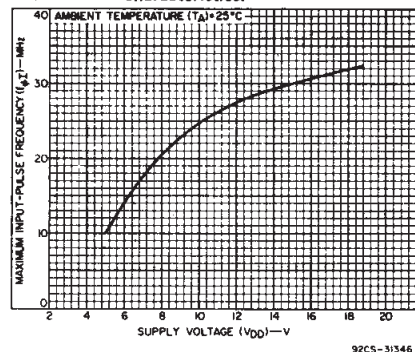


Fig. 8 — Typical maximum input-pulse frequency as a function of supply voltage.

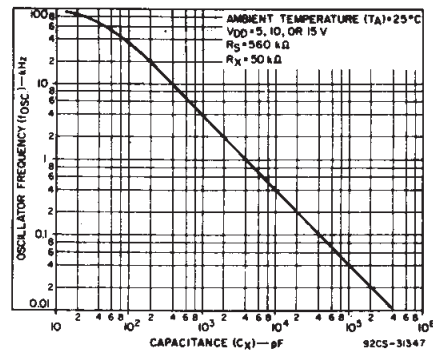


Fig. 9 — Typical RC oscillator frequency as a function of capacitance ( $C_X$ ). See Fig. 11.

# CD4045B Types

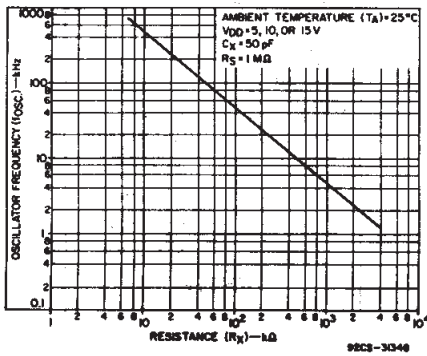


Fig. 10 - Typical RC oscillator frequency as a function of resistance ( $R_X$ ). See Fig. 11.

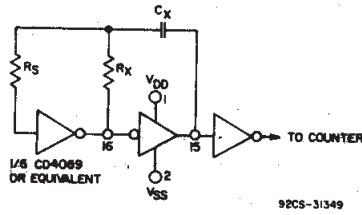


Fig. 11 - Typical RC circuit.

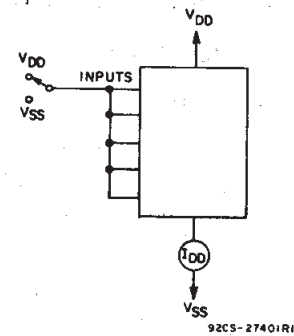


Fig. 12 - Quiescent-device-current test circuit.

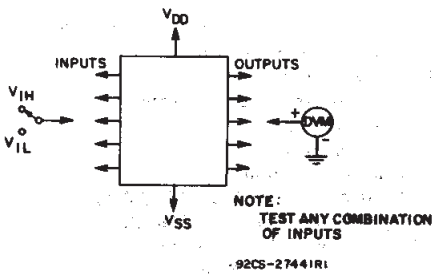


Fig. 13 - Noise-immunity test circuit.

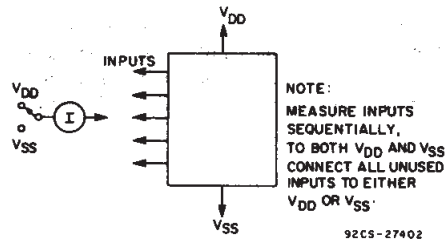


Fig. 14 - Input-leakage-current test circuit.

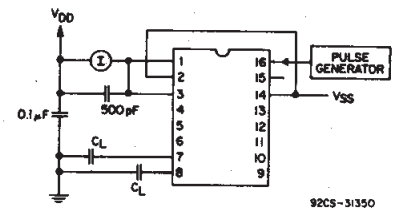
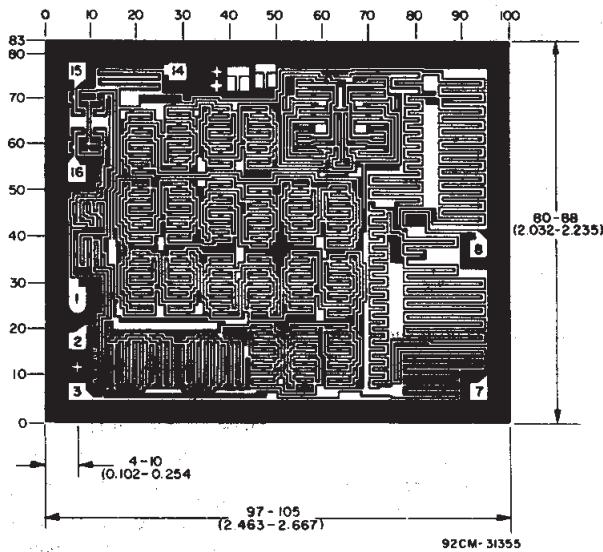


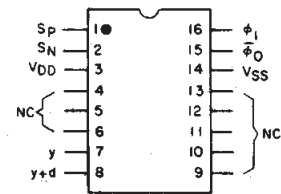
Fig. 15 - Dynamic power dissipation test circuit.



Chip dimensions and pad layout for CD4045B

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

## TERMINAL DIAGRAM Top View



NC = NO CONNECTION

**NOTE** Observe power-supply terminal connections,  $V_{DD}$  is terminal No. 3 and  $V_{SS}$  is terminal No. 14 (not 16 and 8 respectively, as in other CD4000B Series 16-lead devices).

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