National Semiconductor

# CD4538BM/CD4538BC Dual Precision Monostable Multivibrator

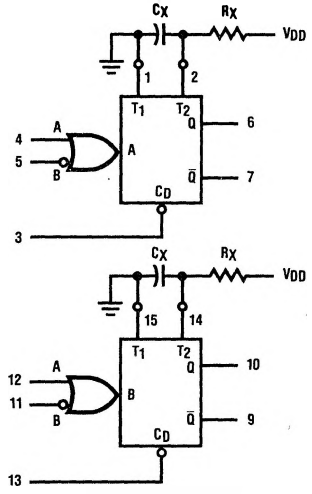
## General Description

The CD4538B is a dual, precision monostable multivibrator with independent trigger and reset controls. The device is retriggerable and resettable, and the control inputs are internally latched. Two trigger inputs are provided to allow either rising or falling edge triggering. The reset inputs are active low and prevent triggering while active. Precise control of output pulse-width has been achieved using linear CMOS techniques. The pulse duration and accuracy are determined by external components $R_X$ and $C_X$. The device does not allow the timing capacitor to discharge through the timing pin on power-down condition. For this reason, no external protection resistor is required in series with the timing pin. Input protection from static discharge is provided on all pins.

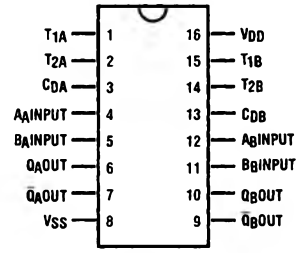
## Features

- Wide supply voltage range 3.0V to 15V
- High noise immunity 0.45 $V_{CC}$ (typ.)
- Low power fan out of 2 driving 74L
  TTL compatibility or 1 driving 74LS
- New Formula: $PW_{OUT} = RC$
  (PW in seconds, R in Ohms, C in Farads)
- ±1.0% pulse-width variation from part to part (typ.)
- Wide pulse-width range 1 μs to ∞
- Separate latched reset inputs
- Symmetrical output sink and source capability
- Low standby current 5 nA (typ.) @ 5 $V_{DC}$
- Pin Compatible to CD4528B

## Block & Connection Diagrams




RX AND CX ARE EXTERNAL COMPONENTS
$V_{DD}$ = Pin 16
$V_{SS}$ = Pin 8




CD4538BM
CD4538BC

## Truth Table

| Inputs | | | Outputs | |
|---|---|---|---|---|
| Clear | A | B | Q | $\overline{Q}$ |
| L | X | X | L | H |
| X | H | X | L | H |
| X | X | L | L | H |
| H | L | ↓ | ⎍ | ⎎ |
| H | ↑ | H | ⎍ | ⎎ |

H = High Level
L = Low Level
↑ = Transition from Low to High
↓ = Transition from High to Low
⎍ = One High Level Pulse
⎎ = One Low Level Pulse
X = Irrelevant

## Absolute Maximum Ratings (Notes 1 and 2)

| | |
|---|---|
| $V_{DD}$ DC Supply Voltage | $-0.5\,V$ to $+18\,V_{DC}$ |
| $V_{IN}$ Input Voltage | $-0.5$ to $V_{DD}+0.5\,V_{DC}$ |
| $T_S$ Storage Temperature Range | $-65°C$ to $+150°C$ |
| $P_D$ Package Dissipation | 500 mW |
| $T_L$ Lead Temperature (soldering, 10 seconds) | 300 °C |

## Recommended Operating Conditions (Note 2)

| | |
|---|---|
| $V_{DD}$ DC Supply Voltage | $+3$ to $+15\,V_{DC}$ |
| $V_{IN}$ Input Voltage | 0 to $V_{DD}\,V_{DC}$ |
| $T_A$ Operating Temperature Range | |
| CD4538BM, | $-55°C$ to $+125°C$ |
| CD4538BC | $-40°C$ to $+85°C$ |

## DC Electrical Characteristics (Note 2) — CD4538BM

| Parameter | | Conditions | −55°C | | 25°C | | | 125°C | | Units |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Min. | Typ. | Max. | Min. | Max. | |
| $I_{DD}$ | Quiescent Device Current | $V_{DD}=5\,V$ } $V_{IH}=V_{DD}$ | | 5 | | 0.005 | 5 | | 150 | μA |
| | | $V_{DD}=10\,V$ } $V_{IL}=V_{SS}$ | | 10 | | 0.010 | 10 | | 300 | μA |
| | | $V_{DD}=15\,V$ } All outputs open | | 20 | | 0.015 | 20 | | 600 | μA |
| $V_{OL}$ | Low Level Output Voltage | $V_{DD}=5\,V$ } $\lvert I_O\rvert < 1\mu A$ | | 0.05 | | 0 | 0.05 | | 0.05 | V |
| | | $V_{DD}=10\,V$ } $V_{IH}=V_{DD}$, $V_{IL}=V_{SS}$ | | 0.05 | | 0 | 0.05 | | 0.05 | V |
| | | $V_{DD}=15\,V$ | | 0.05 | | 0 | 0.05 | | 0.05 | V |
| $V_{OH}$ | High Level Output Voltage | $V_{DD}=5\,V$ } $\lvert I_O\rvert < 1\mu A$ | 4.95 | | 4.95 | 5 | | 4.95 | | V |
| | | $V_{DD}=10\,V$ } $V_{IH}=V_{DD}$, $V_{IL}=V_{SS}$ | 9.95 | | 9.95 | 10 | | 9.95 | | V |
| | | $V_{DD}=15\,V$ | 14.95 | | 14.95 | 15 | | 14.95 | | V |
| $V_{IL}$ | Low Level Input Voltage | $\lvert I_O\rvert < 1\mu A$ | | | | | | | | |
| | | $V_{DD}=5\,V$, $V_O=0.5\,V$ or $4.5\,V$ | | 1.5 | | 2.25 | 1.5 | | 1.5 | V |
| | | $V_{DD}=10\,V$, $V_O=1.0\,V$ or $9.0\,V$ | | 3.0 | | 4.50 | 3.0 | | 3.0 | V |
| | | $V_{DD}=15\,V$, $V_O=1.5\,V$ or $13.5\,V$ | | 4.0 | | 6.75 | 4.0 | | 4.0 | V |
| $V_{IH}$ | High Level Input Voltage | $\lvert I_O\rvert < 1\mu A$ | | | | | | | | |
| | | $V_{DD}=5\,V$, $V_O=0.5\,V$ or $4.5\,V$ | 3.5 | | 3.5 | 2.75 | | 3.5 | | V |
| | | $V_{DD}=10\,V$, $V_O=1.0\,V$ or $9.0\,V$ | 7.0 | | 7.0 | 5.50 | | 7.0 | | V |
| | | $V_{DD}=15\,V$, $V_O=1.5\,V$ or $13.5\,V$ | 11.0 | | 11.0 | 8.25 | | 11.0 | | V |
| $I_{OL}$ | Low Level Output Current | $V_{DD}=5\,V$, $V_O=0.4\,V$ } $V_{IH}=V_{DD}$ | 0.64 | | 0.51 | 0.88 | | 0.36 | | mA |
| | | $V_{DD}=10\,V$, $V_O=0.5\,V$ } $V_{IL}=V_{SS}$ | 1.6 | | 1.3 | 2.25 | | 0.9 | | mA |
| | | $V_{DD}=15\,V$, $V_O=1.5\,V$ | 4.2 | | 3.4 | 8.8 | | 2.4 | | mA |
| $I_{OH}$ | High Level Output Current | $V_{DD}=5\,V$, $V_O=4.6\,V$ } $V_{IH}=V_{DD}$ | −0.64 | | −0.51 | −0.88 | | −0.36 | | mA |
| | | $V_{DD}=10\,V$, $V_O=9.5V$ } $V_{IL}=V_{SS}$ | −1.6 | | −1.3 | −2.25 | | −0.9 | | mA |
| | | $V_{DD}=15\,V$, $V_O=13.5\,V$ | −4.2 | | −3.4 | −8.8 | | −2.4 | | mA |
| $I_{IN}$ | Input Current, pin 2 or 14 | $V_{DD}=15\,V$, $V_{IN}=0\,V$ or $15\,V$ | | ±0.02 | | $\pm 10^{-5}$ | ±0.05 | | ±0.5 | μA |
| $I_{IN}$ | Input Current, other inputs | $V_{DD}=15\,V$, $V_{IN}=0\,V$ or $15\,V$ | | ±0.1 | | $\pm 10^{-5}$ | ±0.1 | | ±1.0 | μA |

## DC Electrical Characteristics (Note 2) — CD4538BC

| Parameter | | Conditions | −40°C | | 25°C | | | 85°C | | Units |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Min. | Typ. | Max. | Min. | Max. | |
| $I_{DD}$ | Quiescent Device Current | $V_{DD}=5V$ } $V_{IH}=V_{DD}$ | | 20 | | 0.005 | 20 | | 150 | μA |
| | | $V_{DD}=10V$ } $V_{IL}=V_{SS}$ | | 40 | | 0.010 | 40 | | 300 | μA |
| | | $V_{DD}=15V$ } All outputs open | | 80 | | 0.015 | 80 | | 600 | μA |
| $V_{OL}$ | Low Level Output Voltage | $V_{DD}=5V$ } $\lvert I_O\rvert < 1\mu A$ | | 0.05 | | 0 | 0.05 | | 0.05 | V |
| | | $V_{DD}=10V$ } $V_{IH}=V_{DD}$, $V_{IL}=V_{SS}$ | | 0.05 | | 0 | 0.05 | | 0.05 | V |
| | | $V_{DD}=15V$ | | 0.05 | | 0 | 0.05 | | 0.05 | V |
| $V_{OH}$ | High Level Output Voltage | $V_{DD}=5V$ } $\lvert I_O\rvert < 1\mu A$ | 4.95 | | 4.95 | 5 | | 4.95 | | V |
| | | $V_{DD}=10V$ } $V_{IH}=V_{DD}$, $V_{IL}=V_{SS}$ | 9.95 | | 9.95 | 10 | | 9.95 | | V |
| | | $V_{DD}=15V$ | 14.95 | | 14.95 | 15 | | 14.95 | | V |
| $V_{IL}$ | Low Level Input Voltage | $\lvert I_O\rvert < 1\mu A$ | | | | | | | | |
| | | $V_{DD}=5V$, $V_O=0.5V$ or $4.5V$ | | 1.5 | | 2.25 | 1.5 | | 1.5 | V |
| | | $V_{DD}=10V$, $V_O=1.0V$ or $9.0V$ | | 3.0 | | 4.50 | 3.0 | | 3.0 | V |
| | | $V_{DD}=15V$, $V_O=1.5V$ or $13.5V$ | | 4.0 | | 6.75 | 4.0 | | 4.0 | V |
| $V_{IH}$ | High Level Input Voltage | $\lvert I_O\rvert < 1\mu A$ | | | | | | | | |
| | | $V_{DD}=5V$, $V_O=0.5V$ or $4.5V$ | 3.5 | | 3.5 | 2.75 | | 3.5 | | V |
| | | $V_{DD}=10V$, $V_O=1.0V$ or $9.0V$ | 7.0 | | 7.0 | 5.50 | | 7.0 | | V |
| | | $V_{DD}=15V$, $V_O=1.5V$ or $13.5V$ | 11.0 | | 11.0 | 8.25 | | 11.0 | | V |
| $I_{OL}$ | Low Level Output Current | $V_{DD}=5V$, $V_O=0.4V$ } $V_{IH}=V_{DD}$ | 0.52 | | 0.44 | 0.88 | | 0.36 | | mA |
| | | $V_{DD}=10V$, $V_O=0.5V$ } $V_{IL}=V_{SS}$ | 1.3 | | 1.1 | 2.25 | | 0.9 | | mA |
| | | $V_{DD}=15V$, $V_O=1.5V$ | 3.6 | | 3.0 | 8.8 | | 2.4 | | mA |
| $I_{OH}$ | High Level Output Current | $V_{DD}=5V$, $V_O=4.6V$ } $V_{IH}=V_{DD}$ | −0.52 | | −0.44 | −0.88 | | −0.36 | | mA |
| | | $V_{DD}=10V$, $V_O=9.5V$ } $V_{IL}=V_{SS}$ | −1.3 | | −1.1 | −2.25 | | −0.9 | | mA |
| | | $V_{DD}=15V$, $V_O=13.5V$ | −3.6 | | −3.0 | −8.8 | | −2.4 | | mA |
| $I_{IN}$ | Input Current, pin 2 or 14 | $V_{DD}=15V$, $V_{IN}=0V$ or $15V$ | | ±0.02 | | $\pm 10^{-5}$ | ±0.05 | | ±0.5 | μA |
| $I_{IN}$ | Input Current, other inputs | $V_{DD}=15V$, $V_{IN}=0V$ or $15V$ | | ±0.3 | | $\pm 10^{-5}$ | ±0.3 | | ±1.0 | μA |

**Note 1:** "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed, they are not meant to imply that the devices should be operated at these limits. The tables of "Recommended Operating Conditions" and "Electrical Characteristics" provide conditions for actual device operation.

**Note 2:** $V_{SS}=0V$ unless otherwise specified.

## AC Electrical Characteristics $T_A = 25°C$, $C_L = 50\,pF$, and $t_r = t_f = 20\,ns$ unless otherwise specified.

| Parameter | | Conditions | | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|---|
| $t_{TLH}$, $t_{THL}$ | Output Transition Time | $V_{DD} = 5\,V$ | | | 100 | 200 | ns |
| | | $V_{DD} = 10\,V$ | | | 50 | 100 | ns |
| | | $V_{DD} = 15\,V$ | | | 40 | 80 | ns |
| $t_{PLH}$, $t_{PHL}$ | Propagation Delay Time | Trigger Operation — A or B to Q or $\overline{Q}$ | | | | | |
| | | $V_{DD} = 5\,V$ | | | 300 | 600 | ns |
| | | $V_{DD} = 10\,V$ | | | 150 | 300 | ns |
| | | $V_{DD} = 15\,V$ | | | 100 | 220 | ns |
| | | Reset Operation — $C_D$ to Q or $\overline{Q}$ | | | | | |
| | | $V_{DD} = 5\,V$ | | | 250 | 500 | ns |
| | | $V_{DD} = 10\,V$ | | | 125 | 250 | ns |
| | | $V_{DD} = 15\,V$ | | | 95 | 190 | ns |
| $t_{WL}$, $t_{WH}$ | Minimum Input Pulse Width A, B, or $C_D$ | | | | | | |
| | | $V_{DD} = 5\,V$ | | | 35 | 70 | ns |
| | | $V_{DD} = 10\,V$ | | | 30 | 60 | ns |
| | | $V_{DD} = 15\,V$ | | | 25 | 50 | ns |
| $t_{RR}$ | Minimum Retrigger Time | $V_{DD} = 5\,V$ | | | | 0 | ns |
| | | $V_{DD} = 10\,V$ | | | 0 | 0 | ns |
| | | $V_{DD} = 15\,V$ | | | | 0 | ns |
| $C_{IN}$ | Input Capacitance | Pin 2 or 14 | | | 10 | | pF |
| | | other inputs | | | 5 | 7.5 | pF |
| $PW_{OUT}$ | Output Pulse Width (Q or $\overline{Q}$) (Note: For typical distribution, see Figure 9) | $R_X = 100\,k\Omega$, $C_X = 0.002\,\mu F$ | $V_{DD} = 5\,V$ | 208 | 226 | 244 | μs |
| | | | $V_{DD} = 10\,V$ | 211 | 230 | 248 | μs |
| | | | $V_{DD} = 15\,V$ | 216 | 235 | 254 | μs |
| | | $R_X = 100\,k\Omega$, $C_X = 0.1\,\mu F$ | $V_{DD} = 5\,V$ | 8.83 | 9.60 | 10.37 | ms |
| | | | $V_{DD} = 10\,V$ | 9.02 | 9.80 | 10.59 | ms |
| | | | $V_{DD} = 15\,V$ | 9.20 | 10.00 | 10.80 | ms |
| | | $R_X = 100\,k\Omega$, $C_X = 10.0\,\mu F$ | $V_{DD} = 5\,V$ | 0.87 | 0.95 | 1.03 | s |
| | | | $V_{DD} = 10\,V$ | 0.89 | 0.97 | 1.05 | s |
| | | | $V_{DD} = 15\,V$ | 0.91 | 0.99 | 1.07 | s |
| Pulse Width Match between circuits in the same package $C_X = 0.1\,\mu F$, $R_X = 100\,k\Omega$ | | $R_X = 100\,k\Omega$, $C_X = 0.1\,\mu F$ | $V_{DD} = 5\,V$ | | ±1 | | % |
| | | | $V_{DD} = 10\,V$ | | ±1 | | % |
| | | | $V_{DD} = 15\,V$ | | ±1 | | % |
| **Operating Conditions** | | | | | | | |
| $R_X$ | External Timing Resistance | | | 5.0 | | * | kΩ |
| $C_X$ | External Timing Capacitance | | | 0 | | No Limit | pF |

*The maximum usable resistance $R_X$ is a function of the leakage of the Capacitor $C_X$, leakage of the CD4538B, and leakage due to board layout, surface resistance, etc.

## Logic Diagram

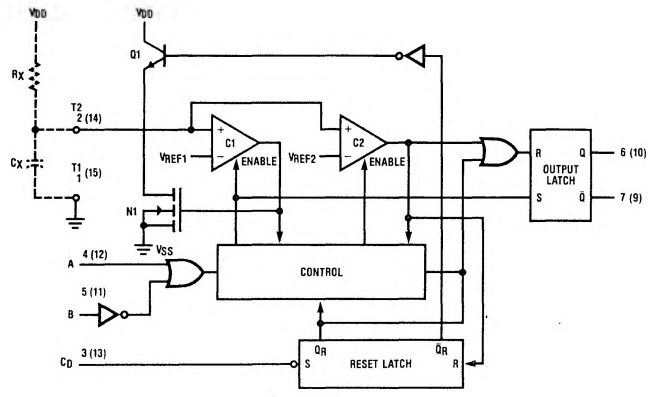



**Figure 1.**

## Theory of Operation

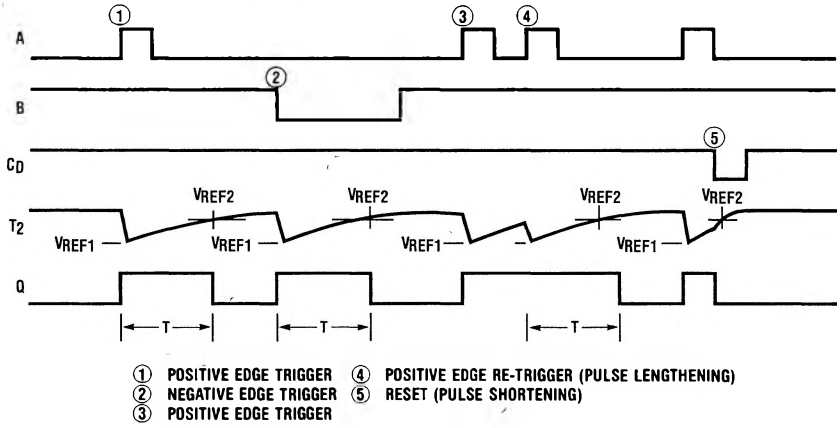



**Figure 2.**

### Trigger Operation

The block diagram of the CD4538B is shown in Figure 1, with circuit operation following.

As shown in Figures 1 and 2, before an input trigger occurs, the monostable is in the quiescent state with the Q output low, and the timing capacitor $C_X$ completely charged to $V_{DD}$. When the trigger input A goes from $V_{SS}$ to $V_{DD}$ (while inputs B and $C_D$ are held to $V_{DD}$) a valid trigger is recognized, which turns on comparator C1 and N-Channel transistor N1①. At the same time the output latch is set. With transistor N1 on, the capacitor $C_X$ rapidly discharges toward $V_{SS}$ until $V_{REF1}$ is reached. At this point the output of comparator C1 changes state and transistor N1 turns off. Comparator C1 then turns off while at the same time comparator C2 turns on. With transistor N1 off, the capacitor $C_X$ begins to charge through the timing resistor, $R_X$, toward $V_{DD}$. When the voltage across $C_X$ equals $V_{REF2}$, comparator C2 changes state causing the output latch to reset (Q goes low) while at the same time disabling comparator C2. This ends the timing cycle with the monostable in the quiescent state, waiting for the next trigger.

A valid trigger is also recognized when trigger input B goes from $V_{DD}$ to $V_{SS}$ (while input A is at $V_{SS}$ and input $C_D$ is at $V_{DD}$)②.

It should be noted that in the quiescent state $C_X$ is fully charged to $V_{DD}$ causing the current through resistor $R_X$ to be zero. Both comparators are "off" with the total device current due only to reverse junction leakages. An added feature of the CD4538B is that the output latch is set via the input trigger without regard to the capacitor voltage. Thus, propagation delay from trigger to Q is independent of the value of $C_X$, $R_X$, or the duty cycle of the input waveform.

### Retrigger Operation

The CD4538B is retriggered if a valid trigger occurs③ followed by another valid trigger④ before the Q output has returned to the quiescent (zero) state. Any retrigger, after the timing node voltage at pin 2 or 14 has begun to rise from $V_{REF1}$, but has not yet reached $V_{REF2}$, will cause an increase in output pulse width T. When a valid retrigger is initiated④, the voltage at T2 will again drop to $V_{REF1}$ before progressing along the RC charging curve toward $V_{DD}$. The Q output will remain high until time T, after the last valid retrigger.

### Reset Operation

The CD4538B may be reset during the generation of the output pulse. In the reset mode of operation, an input pulse on $C_D$ sets the reset latch and causes the capacitor to be fast charged to $V_{DD}$ by turning on transistor Q1 ⑤. When the voltage on the capacitor reaches $V_{REF2}$, the reset latch will clear and then be ready to accept another pulse. If the $C_D$ input is held low, any trigger inputs that occur will be inhibited and the Q and $\overline{Q}$ outputs of the output latch will not change. Since the Q output is reset when an input low level is detected on the $C_D$ input, the output pulse T can be made significantly shorter than the minimum pulse width specification.

## Typical Applications

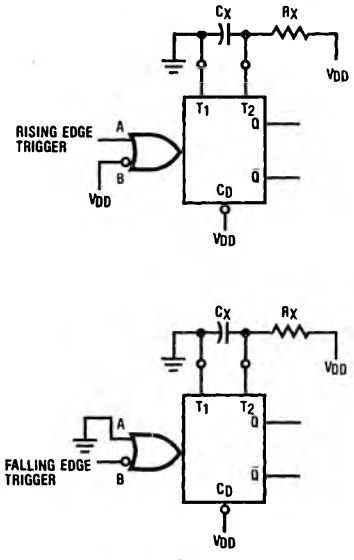



Figure 3. Retriggerable Monostables Circuitry

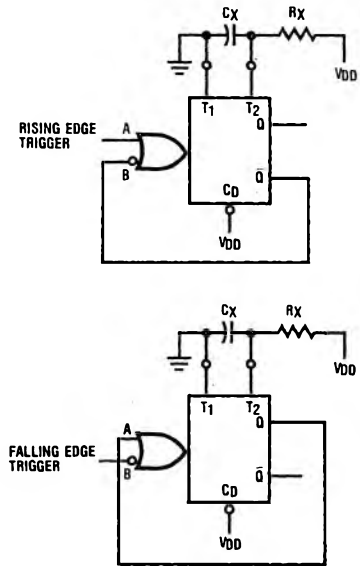



Figure 4. Non-retriggerable Monostables Circuitry

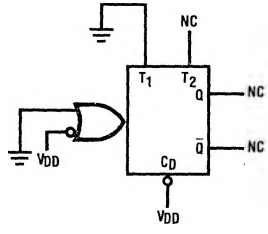



Figure 5. Connection of Unused Sections

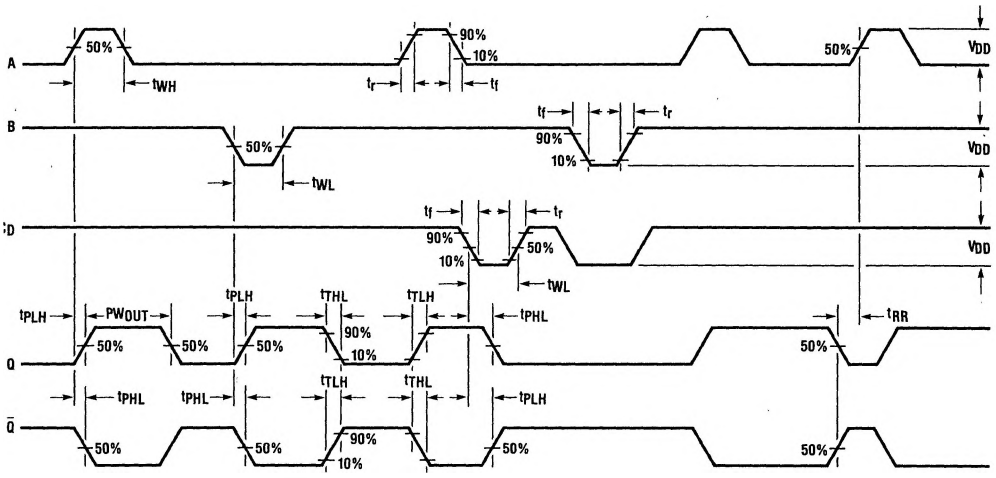
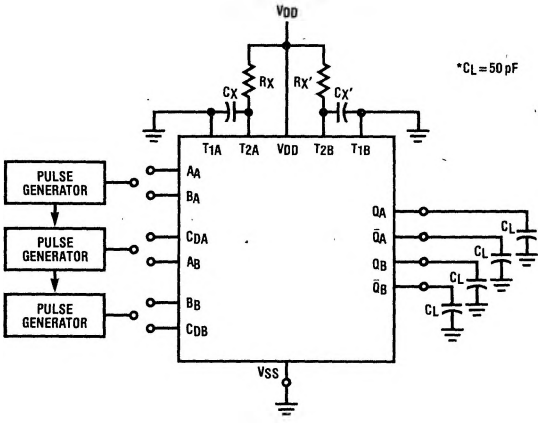
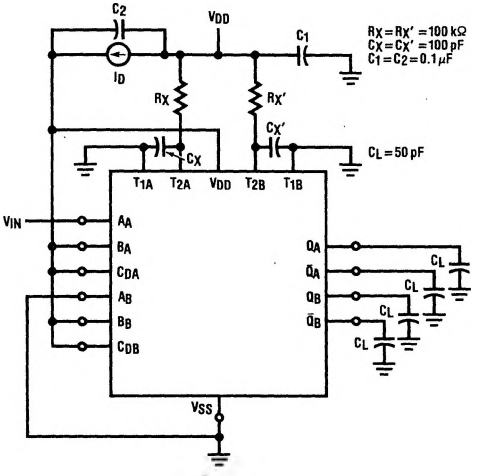



**Figure 6. Switching Test Waveforms**



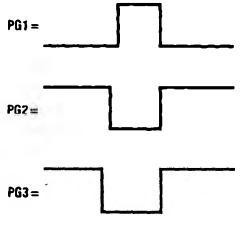



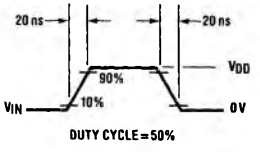

**INPUT CONNECTIONS**

| CHARACTERISTICS | CD | A | B |
|---|---|---|---|
| $t_{PLH}$, $t_{PHL}$, $t_{TLH}$, $t_{THL}$, $PW_{OUT}$, $t_{WH}$, $t_{WL}$ | $V_{DD}$ | PG1 | $V_{DD}$ |
| $t_{PLH}$, $t_{PHL}$, $t_{TLH}$, $t_{THL}$, $PW_{OUT}$, $t_{WH}$, $t_{WL}$ | $V_{DD}$ | $V_{SS}$ | PG2 |
| $t_{PLH(R)}$, $t_{PHL(R)}$, $t_{WH}$, $t_{WL}$ | PG3 | PG1 | PG2 |

*INCLUDES CAPACITANCE OF PROBES, WIRING, AND FIXTURE PARASITIC

NOTE: SWITCHING TEST WAVEFORMS FOR PG1, PG2, PG3 ARE SHOWN IN FIGURE 6.




DUTY CYCLE = 50%

**Figure 7. Switching Test Circuit**

**Figure 8. Power Dissipation Test Circuit and Waveforms**

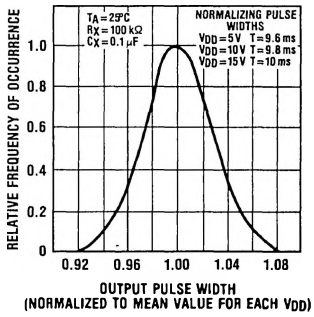



Figure 9. Typical Normalized Distribution of Units for Output Pulse Width

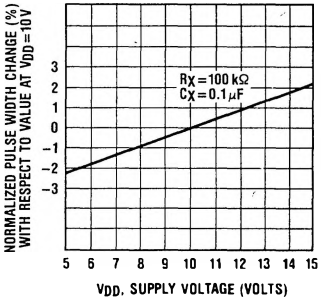



Figure 10. Typical Pulse Width Variation as a Function of Supply Voltage $V_{DD}$

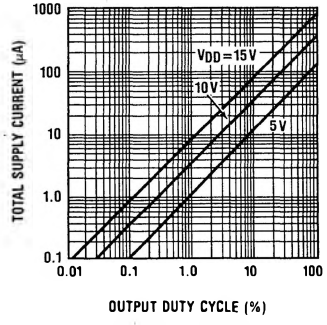



Figure 11. Typical Total Supply Current Versus Output Duty Cycle, $R_X = 100\,k\Omega$, $C_L = 50\,pF$, $C_X = 100\,pF$, One Monostable Switching Only

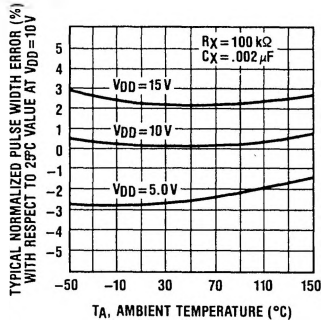



Figure 12. Typical Pulse Width Error Versus Temperature

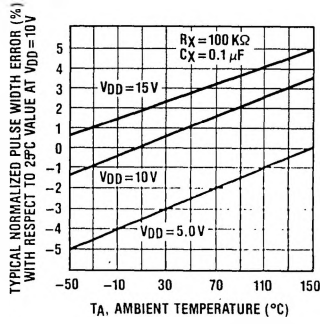



Figure 13. Typical Pulse Width Error Versus Temperature

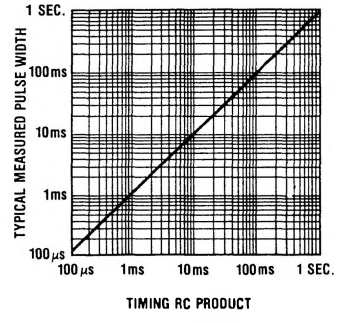



Figure 14. Typical Pulse Width Versus Timing RC Product