



## CD4046BM/CD4046BC Micropower Phase-Locked Loop

### General Description

The CD4046B micropower phase-locked loop (PLL) consists of a low power, linear, voltage-controlled oscillator (VCO), a source follower, a zener diode, and two phase comparators. The two phase comparators have a common signal input and a common comparator input. The signal input can be directly coupled for a large voltage signal, or capacitively coupled to the self-biasing amplifier at the signal input for a small voltage signal.

Phase comparator I, an exclusive OR gate, provides a digital error signal (phase comp. I Out) and maintains 90° phase shifts at the VCO center frequency. Between signal input and comparator input (both at 50% duty cycle), it may lock onto the signal input frequencies that are close to harmonics of the VCO center frequency.

Phase comparator II is an edge-controlled digital memory network. It provides a digital error signal (phase comp. II Out) and lock-in signal (phase pulses) to indicate a locked condition and maintains a 0° phase shift between signal input and comparator input.

The linear voltage-controlled oscillator (VCO) produces an output signal (VCO Out) whose frequency is determined by the voltage at the VCO<sub>IN</sub> input, and the capacitor and resistors connected to pin C1<sub>A</sub>, C1<sub>B</sub>, R1 and R2.

The source follower output of the VCO<sub>IN</sub> (demodulator Out) is used with an external resistor of 10kΩ or more.

The INHIBIT input, when high, disables the VCO and source follower to minimize standby power consumption. The zener diode is provided for power supply regulation, if necessary.

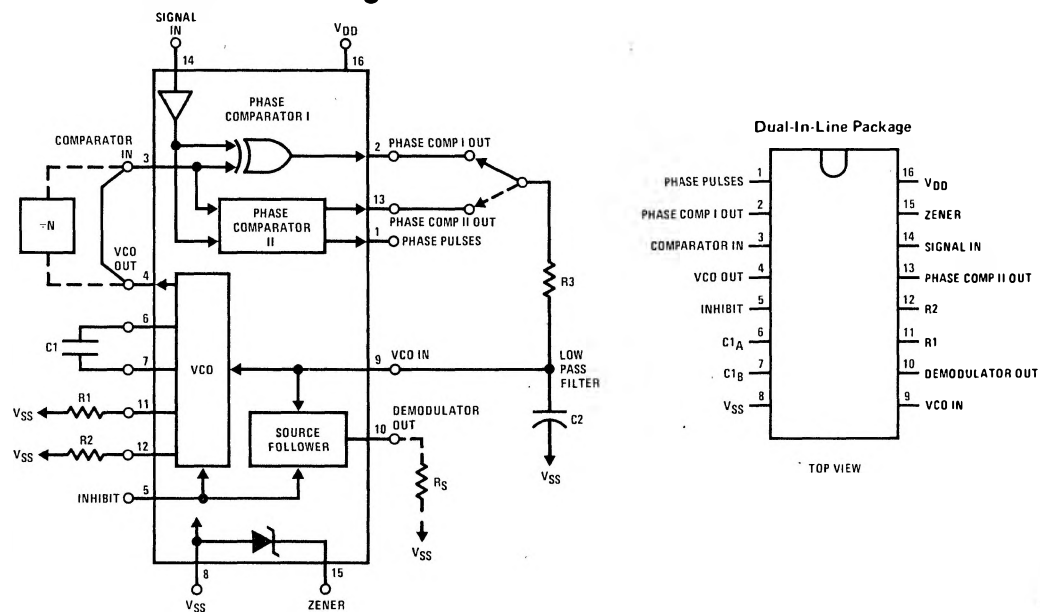
### Features

- Wide supply voltage range 3.0V to 18V
- Low dynamic power consumption 70μW (typ.) at  $f_0 = 10 \text{ kHz}$ ,  $V_{DD} = 5 \text{ V}$
- VCO frequency 1.3 MHz (typ.) at  $V_{DD} = 10 \text{ V}$
- Low frequency drift with temperature 0.06%/°C at  $V_{DD} = 10 \text{ V}$
- High VCO linearity 1% (typ.)

### Applications

- FM demodulator and modulator
- Frequency synthesis and multiplication
- Frequency discrimination
- Data synchronization and conditioning
- Voltage-to-frequency conversion
- Tone decoding
- FSK modulation
- Motor speed control

### Block and Connection Diagrams



**Absolute Maximum Ratings**

(Notes 1 and 2)

|                                                |                               |
|------------------------------------------------|-------------------------------|
| $V_{DD}$ DC Supply Voltage                     | -0.5 to +18 V <sub>DC</sub>   |
| $V_{IN}$ 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 <sub>DC</sub>       |
| $V_{IN}$ Input Voltage            | 0 to $V_{DD}$ V <sub>DC</sub> |
| $T_A$ Operating Temperature Range | -55°C to +125°C               |
| CD4046BM                          | -40°C to +85°C                |
| CD4046BC                          |                               |

**DC Electrical Characteristics** CD4046BM (Note 2)

| Parameter                                                     | Conditions                                                                                | -55°C |      | 25°C  |                   |      | 125°C |      | Units   |
|---------------------------------------------------------------|-------------------------------------------------------------------------------------------|-------|------|-------|-------------------|------|-------|------|---------|
|                                                               |                                                                                           | Min   | Max  | Min   | Typ               | Max  | Min   | Max  |         |
| $I_{DD}$ Quiescent Device Current                             | PIN 5 = $V_{DD}$ , PIN 14 = $V_{DD}$ ,<br>PIN 3, 9 = $V_{SS}$<br>$V_{DD} = 5V$            |       | 5    |       | 0.005             | 5    |       | 150  | $\mu A$ |
|                                                               | $V_{DD} = 10V$                                                                            |       | 10   |       | 0.01              | 10   |       | 300  | $\mu A$ |
|                                                               | $V_{DD} = 15V$                                                                            |       | 20   |       | 0.015             | 20   |       | 600  | $\mu A$ |
|                                                               | PIN 5 = $V_{DD}$ , PIN 14 = Open<br>PIN 3, 2 = $V_{SS}$<br>$V_{DD} = 5V$                  |       | 45   |       | 5                 | 35   |       | 185  | $\mu A$ |
|                                                               | $V_{DD} = 10V$                                                                            |       | 450  |       | 20                | 350  |       | 650  | $\mu A$ |
|                                                               | $V_{DD} = 15V$                                                                            |       | 1200 |       | 50                | 900  |       | 1500 | $\mu A$ |
| $V_{OL}$ Low Level Output Voltage                             | $V_{DD} = 5V$                                                                             |       | 0.05 |       | 0                 | 0.05 |       | 0.05 | V       |
|                                                               | $V_{DD} = 10V$                                                                            |       | 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                            | $V_{DD} = 5V$                                                                             | 4.95  |      | 4.95  | 5                 |      | 4.95  |      | V       |
|                                                               | $V_{DD} = 10V$                                                                            | 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<br>Comparator and Signal In  | $V_{DD} = 5V$ , $V_O = 0.5V$ or $4.5V$                                                    |       | 1.5  |       | 2.25              | 1.5  |       | 1.5  | V       |
|                                                               | $V_{DD} = 10V$ , $V_O = 1V$ or $9V$                                                       |       | 3.0  |       | 4.5               | 3.0  |       | 3.0  | V       |
|                                                               | $V_{DD} = 15V$ , $V_O = 1.5V$ or $13.5V$                                                  |       | 4.0  |       | 6.25              | 4.0  |       | 4.0  | V       |
| $V_{IH}$ High Level Input Voltage<br>Comparator and Signal In | $V_{DD} = 5V$ , $V_O = 0.5V$ or $4.5V$                                                    | 3.5   |      | 3.5   | 2.75              |      | 3.5   |      | V       |
|                                                               | $V_{DD} = 10V$ , $V_O = 1V$ or $9V$                                                       | 7.0   |      | 7.0   | 5.5               |      | 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                             | $V_{DD} = 5V$ , $V_O = 0.4V$                                                              | 0.64  |      | 0.51  | 0.88              |      | 0.36  |      | mA      |
|                                                               | $V_{DD} = 10V$ , $V_O = 0.5V$                                                             | 1.6   |      | 1.3   | 2.25              |      | 0.9   |      | mA      |
|                                                               | $V_{DD} = 15V$ , $V_O = 1.5V$                                                             | 4.2   |      | 3.4   | 8.8               |      | 2.4   |      | mA      |
| $I_{OH}$ High Level Output Current                            | $V_{DD} = 5V$ , $V_O = 4.6V$                                                              | -0.64 |      | -0.51 | -0.88             |      | -0.36 |      | mA      |
|                                                               | $V_{DD} = 10V$ , $V_O = 9.5V$                                                             | -1.6  |      | -1.3  | -2.25             |      | -0.9  |      | mA      |
|                                                               | $V_{DD} = 15V$ , $V_O = 13.5V$                                                            | -4.2  |      | -3.4  | -8.8              |      | -2.4  |      | mA      |
| $I_{IN}$ Input Current                                        | All Inputs Except Signal Input<br>$V_{DD} = 14V$ , $V_{IN} = 0V$                          | -0.1  |      |       | -10 <sup>-5</sup> | -0.1 | -1.0  |      | $\mu A$ |
|                                                               | $V_{DD} = 15V$ , $V_{IN} = 15V$                                                           | 0.1   |      |       | 10 <sup>-5</sup>  | 0.1  | 1.0   |      | $\mu A$ |
| $C_{IN}$ Input Capacitance                                    | Any Input, (Note 3)                                                                       |       |      |       |                   |      | 7.5   |      | pF      |
| $P_T$ Total Power Dissipation                                 | $f_o = 10kHz$ , $R1 = 1M\Omega$<br>$R2 = \infty$ , $V_{COIN} = V_{DD}/2$<br>$V_{DD} = 5V$ |       |      |       | 0.07              |      |       |      | mW      |
|                                                               | $V_{DD} = 10V$                                                                            |       |      |       | 0.6               |      |       |      | mW      |
|                                                               | $V_{DD} = 15V$                                                                            |       |      |       | 2.4               |      |       |      | mW      |
|                                                               |                                                                                           |       |      |       |                   |      |       |      |         |

# DC Electrical Characteristics CD4046BC (Note 2)

CD4046BM/CD4046BC

| Parameter                                                            | Conditions                                                                                                                           | -40°C |      | 25°C  |                   |      | 85°C  |      | Units |
|----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|-------|------|-------|-------------------|------|-------|------|-------|
|                                                                      |                                                                                                                                      | Min   | Max  | Min   | Typ               | Max  | Min   | Max  |       |
| I <sub>DD</sub> Quiescent Device Current                             | PIN 5 = V <sub>DD</sub> , PIN 14 = V <sub>DD</sub> ,<br>PIN 3,9 = V <sub>SS</sub><br>V <sub>DD</sub> = 5V                            |       | 20   |       | 0.005             | 20   |       | 150  | μA    |
|                                                                      | V <sub>DD</sub> = 10V                                                                                                                |       | 40   |       | 0.01              | 40   |       | 300  | μA    |
|                                                                      | V <sub>DD</sub> = 15V                                                                                                                |       | 80   |       | 0.015             | 80   |       | 600  | μA    |
|                                                                      | PIN 5 = V <sub>DD</sub> , PIN 14 = Open, *<br>PIN 3,9 = V <sub>SS</sub><br>V <sub>DD</sub> = 5V                                      |       | 70   |       | 5                 | 55   |       | 205  | μA    |
|                                                                      | V <sub>DD</sub> = 10V                                                                                                                |       | 530  |       | 20                | 410  |       | 710  | μA    |
|                                                                      | V <sub>DD</sub> = 15V                                                                                                                |       | 1500 |       | 50                | 1200 |       | 1800 | μA    |
|                                                                      | V <sub>DD</sub> = 5V                                                                                                                 |       |      |       |                   |      |       |      |       |
|                                                                      | V <sub>DD</sub> = 10V                                                                                                                |       |      |       |                   |      |       |      |       |
|                                                                      | V <sub>DD</sub> = 15V                                                                                                                |       |      |       |                   |      |       |      |       |
| V <sub>OL</sub> Low Level Output Voltage                             | V <sub>DD</sub> = 5V                                                                                                                 |       | 0.05 |       | 0                 | 0.05 |       | 0.05 | V     |
|                                                                      | V <sub>DD</sub> = 10V                                                                                                                |       | 0.05 |       | 0                 | 0.05 |       | 0.05 | V     |
|                                                                      | V <sub>DD</sub> = 15V                                                                                                                |       | 0.05 |       | 0                 | 0.05 |       | 0.05 | V     |
| V <sub>OH</sub> High Level Output Voltage                            | V <sub>DD</sub> = 5V                                                                                                                 | 4.95  |      | 4.95  | 5                 |      | 4.95  |      | V     |
|                                                                      | V <sub>DD</sub> = 10V                                                                                                                | 9.95  |      | 9.95  | 10                |      | 9.95  |      | V     |
|                                                                      | V <sub>DD</sub> = 15V                                                                                                                | 14.95 |      | 14.95 | 15                |      | 14.95 |      | V     |
| V <sub>IL</sub> Low Level Input Voltage<br>Comparator and Signal In  | V <sub>DD</sub> = 5V, V <sub>O</sub> = 0.5V or 4.5V                                                                                  |       | 1.5  |       | 2.25              | 1.5  |       | 1.5  | V     |
|                                                                      | V <sub>DD</sub> = 10V, V <sub>O</sub> = 1V or 9V                                                                                     |       | 3.0  |       | 4.5               | 3.0  |       | 3.0  | V     |
|                                                                      | V <sub>DD</sub> = 15V, V <sub>O</sub> = 1.5V or 13.5V                                                                                |       | 4.0  |       | 6.25              | 4.0  |       | 4.0  | V     |
| V <sub>IH</sub> High Level Input Voltage<br>Comparator and Signal In | V <sub>DD</sub> = 5V, V <sub>O</sub> = 0.5V or 4.5V                                                                                  | 3.5   |      | 3.5   | 2.75              |      | 3.5   |      | V     |
|                                                                      | V <sub>DD</sub> = 10V, V <sub>O</sub> = 1V or 9V                                                                                     | 7.0   |      | 7.0   | 5.5               |      | 7.0   |      | V     |
|                                                                      | V <sub>DD</sub> = 15V, V <sub>O</sub> = 1.5V or 13.5V                                                                                | 11.0  |      | 11.0  | 8.25              |      | 11.0  |      | V     |
| I <sub>OL</sub> Low Level Output Current                             | V <sub>DD</sub> = 5V, V <sub>O</sub> = 0.4V                                                                                          | 0.52  |      | 0.44  | 0.88              |      | 0.36  |      | mA    |
|                                                                      | V <sub>DD</sub> = 10V, V <sub>O</sub> = 0.5V                                                                                         | 1.3   |      | 1.1   | 2.25              |      | 0.9   |      | mA    |
|                                                                      | V <sub>DD</sub> = 15V, V <sub>O</sub> = 1.5V                                                                                         | 3.6   |      | 3.0   | 8.8               |      | 2.4   |      | mA    |
| I <sub>OH</sub> High Level Output Current                            | V <sub>DD</sub> = 5V, V <sub>O</sub> = 4.6V                                                                                          | -0.52 |      | -0.44 | -0.88             |      | -0.36 |      | mA    |
|                                                                      | V <sub>DD</sub> = 10V, V <sub>O</sub> = 9.5V                                                                                         | -1.3  |      | -1.1  | -2.25             |      | -0.9  |      | mA    |
|                                                                      | V <sub>DD</sub> = 15V, V <sub>O</sub> = 13.5V                                                                                        | -3.6  |      | -3.0  | -8.8              |      | -2.4  |      | mA    |
| I <sub>IN</sub> Input Current                                        | All Inputs Except Signal Input<br>V <sub>DD</sub> = 15V, V <sub>IN</sub> = 0V                                                        |       | -0.3 |       | -10 <sup>-5</sup> | -0.3 |       | -1.0 | μA    |
|                                                                      | V <sub>DD</sub> = 15V, V <sub>IN</sub> = 15V                                                                                         |       | 0.3  |       | 10 <sup>-5</sup>  | 0.3  |       | 1.0  | μA    |
| C <sub>IN</sub> Input Capacitance                                    | Any Input, (Note 3)                                                                                                                  |       |      |       |                   | 7.5  |       |      | pF    |
| P <sub>T</sub> Total Power Dissipation                               | f <sub>O</sub> = 10 kHz, R <sub>1</sub> = 1 MΩ<br>R <sub>2</sub> = ∞, V <sub>COIN</sub> = V <sub>DD</sub> /2<br>V <sub>DD</sub> = 5V |       |      |       | 0.07              |      |       |      | mW    |
|                                                                      | V <sub>DD</sub> = 10V                                                                                                                |       |      |       | 0.6               |      |       |      | mW    |
|                                                                      | V <sub>DD</sub> = 15V                                                                                                                |       |      |       | 2.4               |      |       |      | mW    |
|                                                                      |                                                                                                                                      |       |      |       |                   |      |       |      |       |

**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 table of "Recommended Operating Conditions" and "Electrical Characteristics" provides conditions for actual device operation.

**Note 2:** V<sub>SS</sub> = 0V unless otherwise specified.

**Note 3:** Capacitance is guaranteed by periodic testing.

# AC Electrical Characteristics CD4046BM/CD4046BC $T_A = 25^\circ\text{C}$ , $C_L = 50\text{ pF}$

| Parameter                                                             | Conditions                                                                                                                                                                                                                                                                                                      | Min               | Typ                                  | Max                | Units                                                                   |
|-----------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|--------------------------------------|--------------------|-------------------------------------------------------------------------|
| <b>VCO Section</b>                                                    |                                                                                                                                                                                                                                                                                                                 |                   |                                      |                    |                                                                         |
| Operating Current $I_{DD}$                                            | $f_o = 10\text{ kHz}$ , $R1 = 1\text{ M}\Omega$<br>$R2 = \infty$ , $V_{COIN} = V_{DD}/2$<br>$V_{DD} = 5\text{ V}$<br>$V_{DD} = 10\text{ V}$<br>$V_{DD} = 15\text{ V}$                                                                                                                                           |                   | 20<br>90<br>200                      |                    | $\mu\text{A}$<br>$\mu\text{A}$<br>$\mu\text{A}$                         |
| $f_{MAX}$ = Maximum Operating Frequency                               | $C1 = 50\text{ pF}$ , $41 = 10\text{ k}\Omega$ ,<br>$R2 = \infty$ , $V_{COIN} = V_{DD}$<br>$V_{DD} = 5\text{ V}$<br>$V_{DD} = 10\text{ V}$<br>$V_{DD} = 15\text{ V}$                                                                                                                                            | 0.4<br>0.6<br>1.0 | 0.8<br>1.2<br>1.6                    |                    | $\text{MHz}$<br>$\text{MHz}$<br>$\text{MHz}$                            |
| Linearity                                                             | $V_{COIN} = 2.5\text{ V} \pm 0.3\text{ V}$ ,<br>$R1 \geq 10\text{ k}\Omega$ , $V_{DD} = 5\text{ V}$<br>$V_{COIN} = 5\text{ V} \pm 2.5\text{ V}$ ,<br>$R1 \geq 400\text{ k}\Omega$ , $V_{DD} = 10\text{ V}$<br>$V_{COIN} = 7.5\text{ V} \pm 5\text{ V}$ ,<br>$R1 \geq 1\text{ M}\Omega$ , $V_{DD} = 15\text{ V}$ |                   | 1<br>1<br>1                          |                    | %<br>%<br>%                                                             |
| Temperature-Frequency Stability<br>No Frequency Offset, $f_{MIN} = 0$ | $\% / ^\circ\text{C} \propto 1/f$ , $V_{DD}$<br>$R2 = \infty$<br>$V_{DD} = 5\text{ V}$<br>$V_{DD} = 10\text{ V}$<br>$V_{DD} = 15\text{ V}$                                                                                                                                                                      |                   | 0.12–0.24<br>0.04–0.08<br>0.015–0.03 |                    | $\% / ^\circ\text{C}$<br>$\% / ^\circ\text{C}$<br>$\% / ^\circ\text{C}$ |
| Frequency Offset, $f_{MIN} \neq 0$                                    | $V_{DD} = 5\text{ V}$<br>$V_{DD} = 10\text{ V}$<br>$V_{DD} = 15\text{ V}$                                                                                                                                                                                                                                       |                   | 0.06–0.12<br>0.05–0.1<br>0.03–0.06   |                    | $\% / ^\circ\text{C}$<br>$\% / ^\circ\text{C}$<br>$\% / ^\circ\text{C}$ |
| $V_{COIN}$ Input Resistance ( $V_{COIN}$ )                            | $V_{DD} = 5\text{ V}$<br>$V_{DD} = 10\text{ V}$<br>$V_{DD} = 15\text{ V}$                                                                                                                                                                                                                                       |                   | $10^6$<br>$10^6$<br>$10^6$           |                    | $\text{M}\Omega$<br>$\text{M}\Omega$<br>$\text{M}\Omega$                |
| VCO Output Duty Cycle                                                 | $V_{DD} = 5\text{ V}$<br>$V_{DD} = 10\text{ V}$<br>$V_{DD} = 15\text{ V}$                                                                                                                                                                                                                                       |                   | 50<br>50<br>50                       |                    | %<br>%<br>%                                                             |
| $t_{THL}$ VCO Output Transition Time                                  | $V_{DD} = 5\text{ V}$                                                                                                                                                                                                                                                                                           |                   | 90                                   | 200                | ns                                                                      |
| $t_{THL}$                                                             | $V_{DD} = 10\text{ V}$<br>$V_{DD} = 15\text{ V}$                                                                                                                                                                                                                                                                |                   | 50<br>45                             | 100<br>80          | ns<br>ns                                                                |
| <b>Phase Comparators Section</b>                                      |                                                                                                                                                                                                                                                                                                                 |                   |                                      |                    |                                                                         |
| $R_{IN}$ Input Resistance<br>Signal Input                             | $V_{DD} = 5\text{ V}$<br>$V_{DD} = 10\text{ V}$<br>$V_{DD} = 15\text{ V}$                                                                                                                                                                                                                                       | 1<br>0.2<br>0.1   | 3<br>0.7<br>0.3                      |                    | $\text{M}\Omega$<br>$\text{M}\Omega$<br>$\text{M}\Omega$                |
| Comparator Input                                                      | $V_{DD} = 5\text{ V}$<br>$V_{DD} = 10\text{ V}$<br>$V_{DD} = 15\text{ V}$                                                                                                                                                                                                                                       |                   | $10^6$<br>$10^6$<br>$10^6$           |                    | $\text{M}\Omega$<br>$\text{M}\Omega$<br>$\text{M}\Omega$                |
| AC-Coupled Signal Input Voltage<br>Sensitivity                        | $C_{SERIES} = 1000\text{ pF}$<br>$f = 50\text{ kHz}$<br>$V_{DD} = 5\text{ V}$<br>$V_{DD} = 10\text{ V}$<br>$V_{DD} = 15\text{ V}$                                                                                                                                                                               |                   | 200<br>400<br>700                    | 400<br>800<br>1400 | mV<br>mV<br>mV                                                          |
| <b>Demodulator Output</b>                                             |                                                                                                                                                                                                                                                                                                                 |                   |                                      |                    |                                                                         |
| Offset Voltage ( $V_{COIN} - V_{DEM}$ )                               | $R_S \geq 10\text{ k}\Omega$ , $V_{DD} = 5\text{ V}$<br>$R_S \geq 10\text{ k}\Omega$ , $V_{DD} = 10\text{ V}$<br>$R_S \geq 50\text{ k}\Omega$ , $V_{DD} = 15\text{ V}$                                                                                                                                          |                   | 1.50<br>1.50<br>1.50                 | 2.2<br>2.2<br>2.2  | V<br>V<br>V                                                             |
| Linearity                                                             | $R_S \geq 50\text{ k}\Omega$<br>$V_{COIN} = 2.5 \pm 0.3\text{ V}$ , $V_{DD} = 5\text{ V}$<br>$V_{COIN} = 5 \pm 2.5\text{ V}$ , $V_{DD} = 10\text{ V}$<br>$V_{COIN} = 7.5 \pm 5\text{ V}$ , $V_{DD} = 15\text{ V}$                                                                                               |                   | 0.1<br>0.6<br>0.8                    |                    | %<br>%<br>%                                                             |
| <b>Zener Diode</b>                                                    |                                                                                                                                                                                                                                                                                                                 |                   |                                      |                    |                                                                         |
| $V_Z$ Zener Diode Voltage<br>CD4046BM<br>CD4046BC                     | $I_Z = 50\text{ }\mu\text{A}$                                                                                                                                                                                                                                                                                   | 6.7<br>6.3        | 7.0<br>7.0                           | 7.3<br>7.7         | V<br>V                                                                  |
| $R_Z$ Zener Dynamic Resistance                                        | $I_Z = 1\text{ mA}$                                                                                                                                                                                                                                                                                             |                   | 100                                  |                    | $\Omega$                                                                |

## Phase Comparator State Diagrams

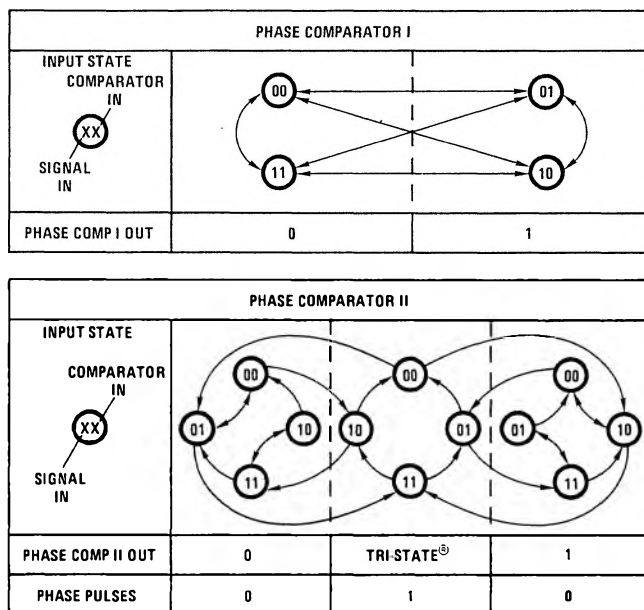


FIGURE 2

## Typical Waveforms

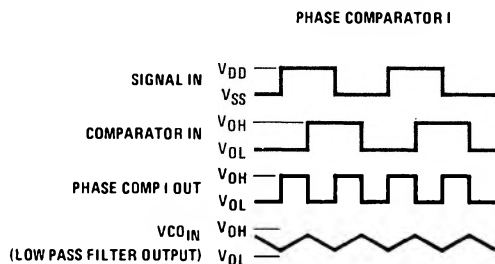


FIGURE 3. Typical Waveform Employing Phase Comparator I in Locked Condition

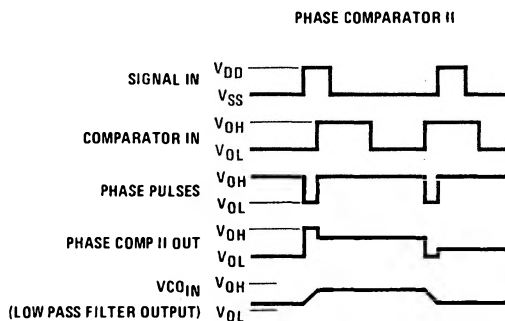


FIGURE 4. Typical Waveform Employing Phase Comparator II in Locked Condition

# Typical Performance Characteristics

Typical Center Frequency vs  
C1 for R1 = 10 k $\Omega$ , 100 k $\Omega$   
and 1 M $\Omega$

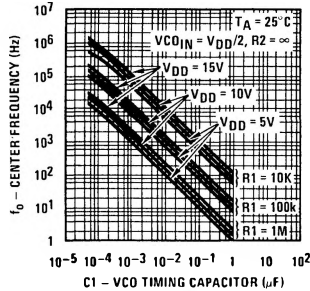


FIGURE 5a

Typical Frequency Offset vs  
C1 for R2 = 10 k $\Omega$ , 100 k $\Omega$   
and 1 M $\Omega$

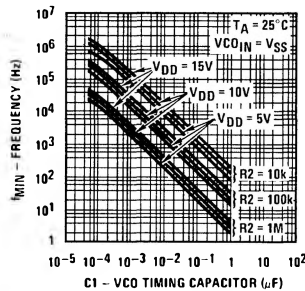


FIGURE 5b

Typical  $f_{MAX}/f_{MIN}$  vs  
R2/R1

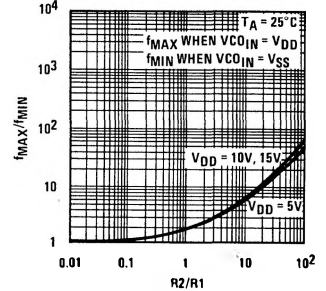


FIGURE 5c

Typical VCO Power Dissipation  
at Center Frequency vs R1

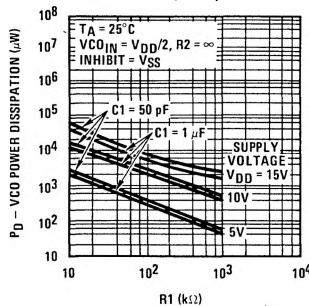


FIGURE 6a

Typical VCO Power Dissipation  
at  $f_{MIN}$  vs R2

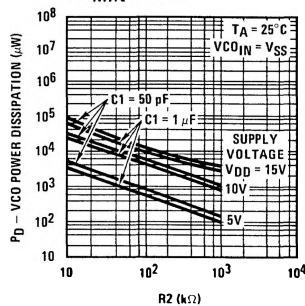


FIGURE 6b

Typical Source Follower  
Power Dissipation vs  $R_S$

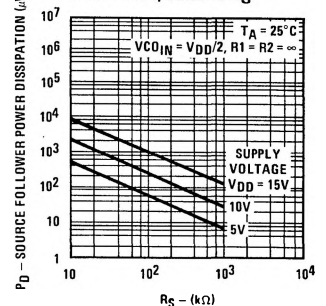


FIGURE 6c

Typical VCO Linearity vs  
R1 and C1

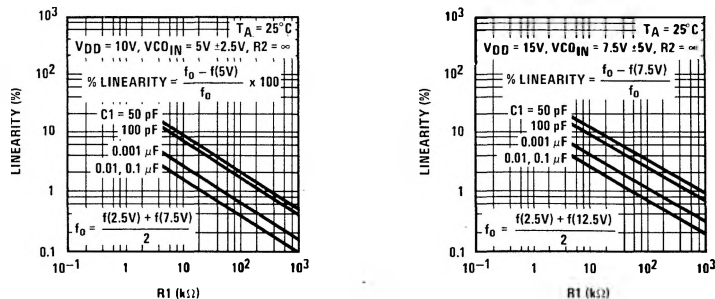


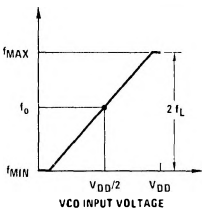
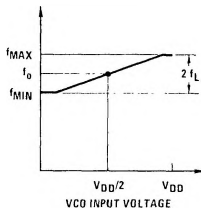
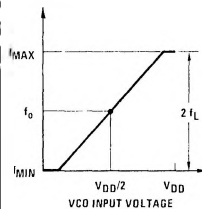
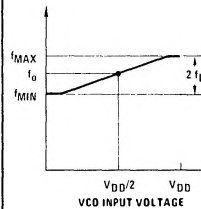
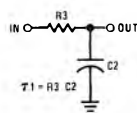
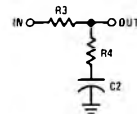
FIGURE 7

Note. To obtain approximate total power dissipation of PLL system for no-signal input: Phase Comparator I,  $P_D(\text{Total}) = P_D(f_0) + P_D(f_{MIN}) + P_D(R_S)$ ; Phase Comparator II,  $P_D(\text{Total}) = P_D(f_{MIN})$ .

## Design Information

This information is a guide for approximating the value of external components for the CD4046B in a phase-locked-loop system. The selected external components must be within the following ranges:  $R_1, R_2 \geq 10 \text{ k}\Omega$ ,  $R_S \geq 10 \text{ k}\Omega$ ,  $C_1 \geq 50 \text{ pF}$ .

In addition to the given design information, refer to *Figure 5* for  $R_1$ ,  $R_2$  and  $C_1$  component selections.

| CHARACTERISTICS                           | USING PHASE COMPARATOR I                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                  | USING PHASE COMPARATOR II                                                                                                                                                         |                                                                                                                                                                                                                                                                                                 |
|-------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                           | VCO WITHOUT OFFSET<br>R2 = ∞                                                                                                                  | VCO WITH OFFSET                                                                                                                                                                                                                                                                                                                                                                                                                                  | VCO WITHOUT OFFSET<br>R2 = ∞                                                                                                                                                      | VCO WITH OFFSET                                                                                                                                                                                                                                                                                 |
| VCO Frequency                             |                                                              |                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                  |                                                                                                                                                                                                               |
| For No Signal Input                       | VCO in PLL system will adjust to center frequency, f <sub>0</sub>                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                  | VCO in PLL system will adjust to lowest operating frequency, f <sub>min</sub>                                                                                                     |                                                                                                                                                                                                                                                                                                 |
| Frequency Lock Range, 2 f <sub>L</sub>    | 2 f <sub>L</sub> = full VCO frequency range<br>2 f <sub>L</sub> = f <sub>max</sub> - f <sub>min</sub>                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                 |
| Frequency Capture Range, 2f <sub>C</sub>  |  $2 f_C \approx \frac{1}{\pi} \sqrt{\frac{2 \pi f_L}{\tau}}$ |                                                                                                                                                                                                                                                                                                                                                                                                                                                  | f <sub>C</sub> = f <sub>L</sub>                                                                                                                                                   |                                                                                                                                                                                                                                                                                                 |
| Loop Filter Component Selection           |  <p>For 2 f<sub>C</sub>, see Ref.</p>                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                 |
| Phase Angle Between Signal and Comparator | 90° at center frequency (f <sub>0</sub> ), approximating 0° and 180° at ends of lock range (2 f <sub>L</sub> )                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Always 0° in lock                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                 |
| Locks on Harmonics of Center Frequency    | Yes                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                  | No                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                 |
| Signal Input Noise Rejection              | High                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Low                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                 |
| VCO Component Selection                   | <p>–Given: f<sub>0</sub></p> <p>–Use f<sub>0</sub> with <i>Figure 5a</i> to determine R1 and C1</p>                                           | <p>–Given: f<sub>0</sub> and f<sub>L</sub></p> <p>–Calculate f<sub>min</sub> from the equation</p> $f_{min} = f_0 - f_L$ <p>–Use f<sub>min</sub> with <i>Figure 5b</i> to determine R2 and C1</p> <p>–Calculate <math>\frac{f_{max}}{f_{min}}</math> from the equation</p> $\frac{f_{max}}{f_{min}} = \frac{f_0 + f_L}{f_0 - f_L}$ <p>–Use <math>\frac{f_{max}}{f_{min}}</math> with <i>Figure 5c</i> to determine ratio R2/ R1 to obtain R1</p> | <p>–Given: f<sub>max</sub></p> <p>–Calculate f<sub>0</sub> from the equation</p> $f_0 = \frac{f_{max}}{2}$ <p>–Use f<sub>0</sub> with <i>Figure 5a</i> to determine R1 and C1</p> | <p>–Given: f<sub>min</sub> and f<sub>max</sub></p> <p>–Use f<sub>min</sub> with <i>Figure 5b</i> to determine R2 and C1</p> <p>–Calculate <math>\frac{f_{max}}{f_{min}}</math></p> <p>–Use <math>\frac{f_{max}}{f_{min}}</math> with <i>Figure 5c</i> to determine ratio R2/R1 to obtain R1</p> |

REF. G.S. Moschytz, "Miniaturized RC Filters Using Phase-Locked Loop", BSTJ, May, 1965.  
 Floyd Gardner, "Phaselock Techniques," John Wiley & Sons, 1966.