

CMOS Micropower Phase-Locked Loop

■ CD4046B CMOS Micropower Phase-Locked Loop (PLL) consists of a low-power, linear voltage-controlled oscillator (VCO) and two different phase comparators having a common signal-input amplifier and a common comparator input. A 5.2-V zener diode is provided for supply regulation if necessary.

The CD4046B types are supplied in 16-lead hermetic dual-in-line ceramic packages (F3A suffix), 16-lead dual-in-line plastic packages (E suffix), 16-lead small-outline packages (NSR suffix), and 16-lead thin shrink small-outline packages (PW and PWR suffixes).

VCO Section

The VCO requires one external capacitor C1 and one or two external resistors (R1 or R1 and R2). Resistor R1 and capacitor C1 determine the frequency range of the VCO and resistor R2 enables the VCO to have a frequency offset if required. The high input impedance ($10^{12}\Omega$) of the VCO simplifies the design of low-pass filters by permitting the designer a wide choice of resistor-to-capacitor ratios. In order not to load the low-pass filter, a source-follower output of the VCO input voltage is provided at terminal 10 (DEMODULATOR OUTPUT). If this terminal is used, a load resistor (R_S) of 10 k Ω or more should be connected from this terminal to VSS. If unused this terminal should be left open. The VCO can be connected either directly or through frequency dividers to the comparator input of the phase comparators. A full CMOS logic swing is available at the output of the VCO and allows direct coupling to CMOS frequency dividers such as the RCA-CD4024, CD4018, CD4020, CD4022, CD4029, and CD4059. One or more CD4018 (Presettable Divide-by-N Counter) or CD4029 (Presettable Up/Down Counter), or CD4059A (Programmable Divide-by-"N" Counter), together with the CD4046B (Phase-Locked Loop) can be used to build a micropower low-frequency synthesizer. A logic 0 on the INHIBIT input "enables" the VCO and the source follower, while a logic 1 "turns off" both to minimize stand-by power consumption.

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 ± 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°C to $+125^\circ\text{C}$

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

LEAD TEMPERATURE (DURING SOLDERING):

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

Features:

- Very low power consumption:
70 μW (typ.) at VCO $f_o = 10$ kHz, $V_{DD} = 5$ V
- Operating frequency range up to 1.4 MHz (typ.) at $V_{DD} = 10$ V, $R_1 = 5$ k Ω
- Low frequency drift: 0.04%/ $^\circ\text{C}$ (typ.) at $V_{DD} = 10$ V
- Choice of two phase comparators:
Exclusive-OR network (I)
Edge-controlled memory network with phase-pulse output for lock indication (II)
- High VCO linearity: $<1\%$ (typ.) at $V_{DD} = 10$ V
- VCO inhibit control for ON-OFF keying and ultra-low standby power consumption
- Source-follower output of VCO control input (Demod. output)
- Zener diode to assist supply regulation
- Standardized, symmetrical output characteristics
- 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"

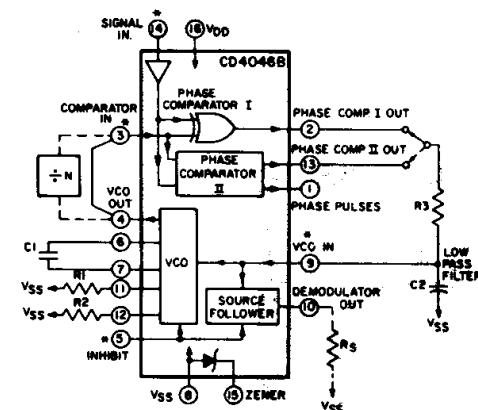
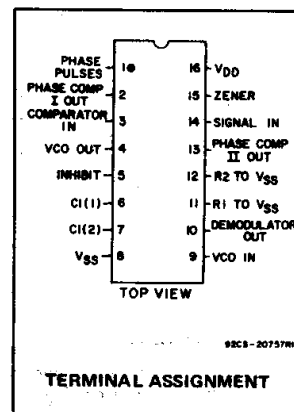
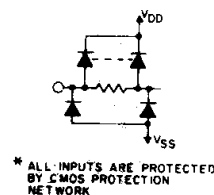


Fig. 1 - CMOS phase-locked loop block diagram.



Applications:

- FM demodulator and modulator
- Frequency synthesis and multiplication
- Frequency discriminator
- Data synchronization
- Voltage-to-frequency conversion
- Tone decoding
- FSK - Modems
- Signal conditioning
- (See ICAN-6101) "RCA COS/MOS Phase-Locked Loop - A Versatile Building Block for Micropower Digital and Analog Applications"



98CS-29172

Phase Comparators

The phase-comparator signal input (terminal 14) can be direct-coupled provided the signal swing is within CMOS logic levels [logic "0" $\leq 30\%$ ($V_{DD}-V_{SS}$), logic "1" $\geq 70\%$ ($V_{DD}-V_{SS}$)]. For smaller swings the signal must be capacitively coupled to the self-biasing amplifier at the signal input.

Phase comparator I is an exclusive-OR network; it operates analogously to an over-driven balanced mixer. To maximize the lock range, the signal- and comparator-input frequencies must have a 50% duty cycle. With no signal or noise on the signal input, this phase comparator has an average output voltage equal to $V_{DD}/2$. The low-pass filter connected to the output of phase comparator

CD4046B Types

RECOMMENDED OPERATING CONDITIONS at T_A = Full Package-Temperature Range
For maximum reliability, nominal operating conditions should be selected so that operation is always within the following ranges:

CHARACTERISTIC	LIMITS		UNITS
	Min.	Max.	
Supply-Voltage Range VCO Section: As Fixed Oscillator Phased-Lock-Loop Operation	3 5	18 18	V
Supply-Voltage Range Phase Comparator Section: Comparators VCO Operation	3 5	18 18	

DESIGN INFORMATION

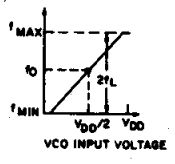
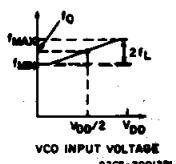
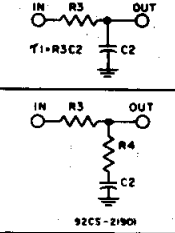
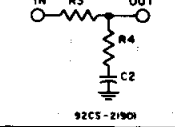
This information is a guide for approximating the values of external components for the CD4046B in a Phase-Locked-Loop system.

The selected external components must be within the following ranges:

$$5 \text{ k}\Omega \leq R_1, R_2, R_S \leq 1 \text{ M}\Omega$$

$$C_1 \geq 100 \text{ pF at } V_{DD} \geq 5 \text{ V;}$$

$$C_1 \geq 50 \text{ pF at } V_{DD} \geq 10 \text{ V}$$

Characteristics	Phase Comparator Used	Design Information
VCO Frequency		VCO WITHOUT OFFSET $R_2 = \infty$
		VCO WITH OFFSET
	1	
	2	
For No. Signal Input	1	Same as for No. 1
	2	VCO will adjust to lowest operating frequency, f_{min}
Frequency Lock Range, $2f_L$	1	$2f_L$ = full VCO frequency range $2f_L = f_{max} - f_{min}$
	2	Same as for No. 1
Frequency Capture Range, $2f_C$	1	
	2	$2f_C \approx \frac{1}{\pi\sqrt{\tau_1}}$ For $2f_C$, see Ref. (2)
Loop Filter Component Selection	1	
	2	$f_C = f_L$
Phase Angle Between Signal and Comparator	1	90° at center frequency (f_0) approximating 0° and 180° at ends of lock range ($2f_L$)
	2	Always 0° in lock
Locks On Harmonic of Center Frequency	1	Yes
	2	No
Signal Input Noise Rejection	1	High
	2	Low

For further information, see

- (1) F. Gardner, "Phase-Lock Techniques" John Wiley and Sons, New York, 1966
- (2) G. S. Moschytz, "Miniaturized RC Filters Using Phase-Locked Loop", BSTJ, May, 1965.

I supplies the averaged voltage to the VCO input, and causes the VCO to oscillate at the center frequency (f_0).

The frequency range of input signals on which the PLL will lock if it was initially out of lock is defined as the frequency capture range ($2f_C$).

The frequency range of input signals on which the loop will stay locked if it was initially in lock is defined as the frequency lock range ($2f_L$). The capture range is $\leq$ the lock range.

With phase comparator I the range of frequencies over which the PLL can acquire lock (capture range) is dependent on the low-pass-filter characteristics, and can be made as large as the lock range. Phase-comparator I enables a PLL system to remain in lock in spite of high amounts of noise in the input signal.

One characteristic of this type of phase comparator is that it may lock onto input frequencies that are close to harmonics of the VCO center-frequency. A second characteristic is that the phase angle between the signal and the comparator input varies between 0° and 180° , and is 90° at the center frequency. Fig. 2 shows the typical, triangular, phase-to-output response characteristic of phase-comparator I. Typical waveforms for a CMOS phase-locked-loop employing phase comparator I in locked condition of f_0 is shown in Fig. 3.

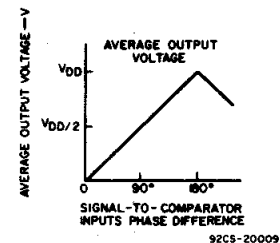


Fig. 2 - Phase-comparator I characteristics at low-pass filter output.

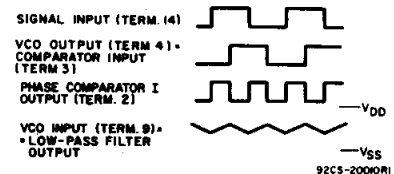


Fig. 3 - Typical waveforms for CMOS phase-locked loop employing phase comparator in locked condition of f_0 .

Phase-comparator II is an edge-controlled digital memory network. It consists of four flip-flop stages, control gating, and a three-state output circuit comprising p- and n-type drivers having a common output node. When the p-MOS or n-MOS drivers are ON they pull the output up to V_{DD} or down to V_{SS} , respectively. This type of phase-comparator acts only on the positive edges of the signal and comparator inputs. The duty cycles of the signal and comparator inputs are not important since positive transitions

CD4046B Types

STATIC ELECTRICAL CHARACTERISTICS

CHARACTERISTIC	CONDITIONS			LIMITS AT INDICATED TEMPERATURES (°C)							UNITS
	V _O (V)	V _{IN} (V)	V _{DD} (V)	-55	-40	+85	+125	+25			
								Min.	Typ.	Max.	
VCO Section											
Output Low (Sink) Current I _{OL} 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 (Source) Current, I _{OH} 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: Low-Level, V _{OL} Max.	Term. 4 driving CMOS	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: High-Level, V _{OH} Min.	e.g. Term.3	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 Current I _{IN} Max.	—	0.18	18	±0.1	±0.1	±1	±1	—	±10 ⁻⁵	±0.1	μA
Phase Comparator Section											
Total Device Current, I _{DD} Max. Term. 14 open, Term. 5 = V _{DD}	—	0.5	5	0.2				—	0.1	0.2	mA
	—	0.10	10	1				—	0.5	1	
	—	0.15	15	1.5				—	0.75	1.5	
	—	0.20	20	4				—	2	4	
Term. 14 = V _{SS} or V _{DD} , Term. 5 = V _{DD}	—	0.5	5	20				—	10	20	μA
	—	0.10	10	40				—	20	40	
	—	0.15	15	80				—	40	80	
	—	0.20	20	160				—	80	160	
Output Low (Sink) Current I _{OL} 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 (Source) Current I _{OH} 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	—	
DC-Coupled Signal Input and Comparator Input Voltage Sensitivity Low Level V _{IL} Max.	0.5,4.5	—	5	1.5				—	—	1.5	V
	1.9	—	10	3				—	—	3	
	1.5,13.5	—	15	4				—	—	4	
High Level V _{IH} Min.	0.5,4.5	—	5	3.5				3.5	—	—	V
	1.9	—	10	7				7	—	—	
	1.5,13.5	—	15	11				11	—	—	

control the PLL system utilizing this type of comparator. If the signal-input frequency is higher than the comparator-input frequency, the p-type output driver is maintained ON most of the time, and both the n and p drivers OFF (3 state) the remainder

of the time. If the signal-input frequency is lower than the comparator-input frequency, the n-type output driver is maintained ON most of the time, and both the n and p drivers OFF (3 state) the remainder of the time. If the signal- and comparator-

input frequencies are the same, but the signal input lags the comparator input in phase, the n-type output driver is maintained ON for a time corresponding to the phase difference. If the signal- and comparator-input frequencies are the same, but

CD4046B Types

STATIC ELECTRICAL CHARACTERISTICS

CHARACTERISTIC	CONDITIONS			LIMITS AT INDICATED TEMPERATURES (°C)							UNITS
	V _O (V)	V _{IN} (V)	V _{DD} (V)	-55	-40	+85	+125	+25			
								Min.	Typ.	Max.	
Phase Comparator Section (cont'd)											
Input Current I _{IN} Max. (except Term. 14)	—	0.18	18	±0.1	±0.1	±1	±1	—	±10 ⁻⁵	±0.1	μA
3-State Leakage Current, I _{OUT} Max.	0.18	0.18	18	±0.1	±0.1	±0.2	±0.2	—	±10 ⁻⁵	±0.1	μA

*Limit determined by minimum feasible leakage current measurement for automatic testing.

ELECTRICAL CHARACTERISTICS at T_A = 25°C

CHARACTERISTIC	TEST CONDITIONS		V _{DD} (V)	LIMITS			UNITS
				ALL TYPES			
				Min.	Typ.	Max.	
VCO Section							
Operating Power Dissipation, P _D	f _o = 10 kHz R ₂ = ∞ VCO _{IN} = $\frac{V_{DD}}{2}$	R ₁ = 1 MΩ	5	—	70	140	μW
			10	—	800	1600	
			15	—	3000	6000	
Maximum Operating Frequency f _{max}	C ₁ = 50 pF R ₂ = ∞ VCO _{IN} = V _{DD}	R ₁ = 10 kΩ	5	0.3	0.6	—	MHz
			10	0.6	1.2	—	
			15	0.8	1.6	—	
	C ₁ = 50 pF R ₂ = ∞ VCO _{IN} = V _{DD}	R ₁ = 5 kΩ	5	0.5	0.8	—	
			10	1	1.4	—	
			15	1.4	2.4	—	
Center Frequency (f _o) and Frequency Range (f _{max} —f _{min})	Programmable with external components R1, R2, and C1 See Design Information						
Linearity	VCO _{IN} = 2.5 V ± 0.3V, R ₁ = 10 kΩ		5	—	1.7	—	%
			10	—	0.5	—	
			10	—	4	—	
			15	—	0.5	—	
			15	—	7	—	
Temperature - Frequency Stability: No Frequency Offset f _{MIN} = 0			5	—	±0.12	—	% / °C
			10	—	±0.04	—	
			15	—	±0.015	—	
Frequency Offset f _{MIN} ≠ 0			5	—	±0.09	—	%
			10	—	±0.07	—	
			15	—	±0.03	—	
Output Duty Cycle			5, 10, 15	—	50	—	%
Output Transition Times, t _{THL} , t _{TLH}			5	—	100	200	ns
			10	—	50	100	
			15	—	40	80	

the comparator input lags the signal in phase, the p-type output driver is maintained ON for a time corresponding to the phase difference. Subsequently, the capacitor voltage of the low-pass filter connected to this phase comparator is adjusted until the signal and comparator inputs are equal in both phase and frequency. At this stable point both p- and n-type output drivers remain OFF and thus the phase comparator output becomes an open circuit and holds the voltage on the capacitor of the low-pass filter constant. Moreover the signal at the "phase pulses" output is a high level which can be used for indicating a locked condition. Thus, for phase comparator II, no phase difference exists between signal and comparator input over the full VCO frequency range. Moreover, the power dissipation due to the low-pass filter is reduced when this type of phase comparator is used because both the p- and n-type output drivers are OFF for most of the signal input cycle. It should be noted that the PLL lock range for this type of phase comparator is equal to the capture range, independent of the low-pass filter. With no signal present at the signal input, the VCO is adjusted to its lowest frequency for phase comparator II. Fig. 10 shows typical waveforms for a CMOS PLL employing phase comparator II in a locked condition.

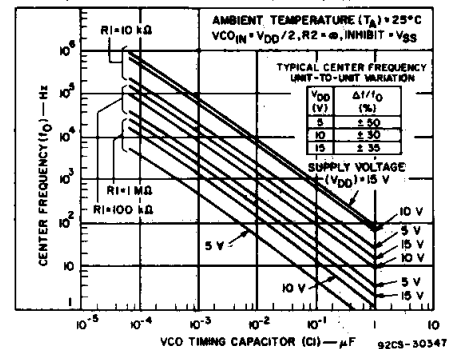


Fig. 4 - Typical center frequency as a function of C1 and R1 at V_{DD} = 5 V, 10 V, and 15 V.

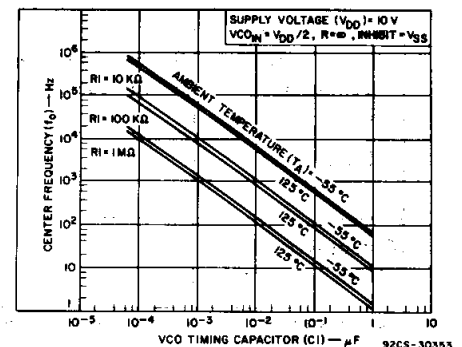


Fig. 5 - Center frequency as a function of C1 and R1 for ambient temperatures of -55°C to 125°C.

CD4046B Types

ELECTRICAL CHARACTERISTICS at $T_A = 25^\circ\text{C}$

CHARACTERISTIC	TEST CONDITIONS		V _{DD} (V)	LIMITS			UNITS
				ALL TYPES			
				Min.	Typ.	Max.	
VCO Section (cont'd)							
Source-Follower Output (Demodulated Output): Offset Voltage $ V_{COIN}-V_{DEM} $	$R_S > 10\text{ k}\Omega$		5 10 15	— — —	1.8 1.8 1.8	2.5 2.5 2.5	V
Linearity	$R_S=100\text{ k}\Omega$ $=300\text{ k}\Omega$ $=500\text{ k}\Omega$	$V_{COIN}=2.5\pm0.3\text{ V}$ $=5\pm2.5\text{ V}$ $=7.5\pm5\text{ V}$	5 10 15	— — —	0.3 0.7 0.9	— — —	%
Zener Diode Voltage (V_Z)	$I_Z = 50\text{ }\mu\text{A}$			4.45	5.5	6.15	V
Zener Dynamic Resistance, R_Z	$I_Z = 1\text{ mA}$			—	40	—	Ω
Phase Comparator Section							
Term. 14 (SIGNAL IN) Input Resistance R_{14}			5 10 15	1 0.2 0.1	2 0.4 0.2	— — —	M Ω
AC Coupled Signal Input Voltage Sensitivity* (peak-to-peak)	$f_{IN} = 100\text{ kHz}$, sine wave		5 10 15	— — —	180 330 900	360 660 1800	mV
Propagation Delay Times, Terms. 14 to 1: High to Low Level, t_{PHL}			5 10 15	— — —	225 100 65	450 200 130	ns
Low to High Level, t_{PLH}			5 10 15	— — —	350 150 100	700 300 200	ns
3-State Propagation Delay Times, Terms. 3 to 13: High Level to High Impedance, t_{PHZ}			5 10 15	— — —	225 100 95	450 200 190	ns
Terms. 14 to 13: Low Level to High Impedance, t_{PLZ}			5 10 15	— — —	285 130 95	570 260 190	ns
Input Rise or Fall Times, t_r , t_f Comparator Input, Term. 3	See Fig. 5 for Phase Comp. II output loading		5 10 15	— — —	— — —	50 1 0.3	μs
Signal Input, Term. 14			5 10 15	— — —	— — —	500 20 2.5	μs
Output Transition Times, t_{THL} , t_{TLH}			5 10 15	— — —	100 50 40	200 100 80	ns

* For sine wave, the frequency must be greater than 10 kHz for Phase Comparator II.

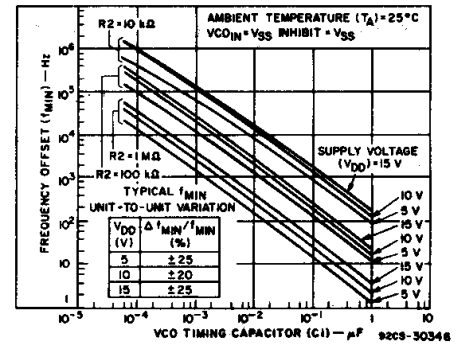


Fig. 6 - Typical frequency offset as a function of C_1 and R_2 for $V_{DD} = 5\text{ V}$, 10 V , and 15 V .

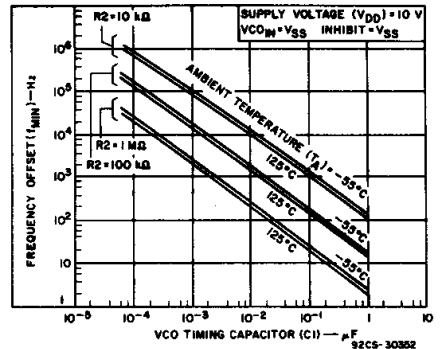


Fig. 7 - Frequency offset as a function of C_1 and R_2 for ambient temperatures of -55°C to 125°C .

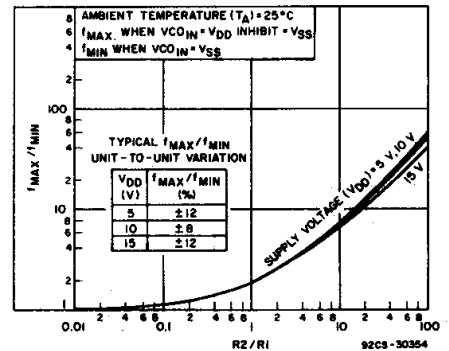


Fig. 8 - Typical f_{MAX}/f_{MIN} as a function of R_2/R_1 .

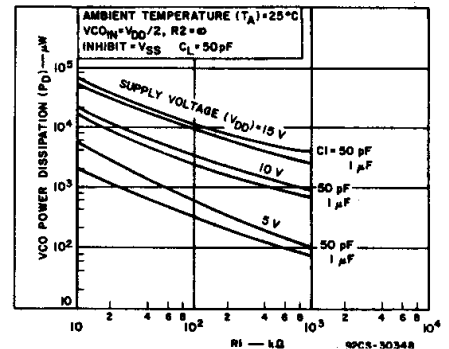


Fig. 9 - Typical VCO power dissipation at center frequency as a function of R_1 .

CD4046B Types

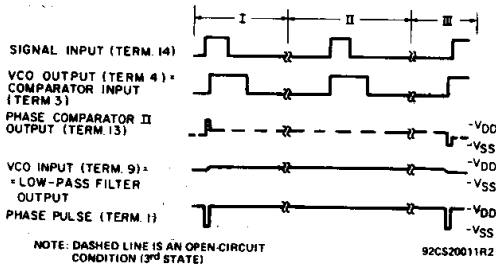


Fig. 10 - Typical waveforms for COS/MOS phase-locked loop employing phase comparator II in locked condition.

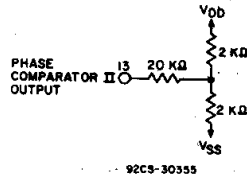


Fig. 11 - Phase comparator II output loading circuit.

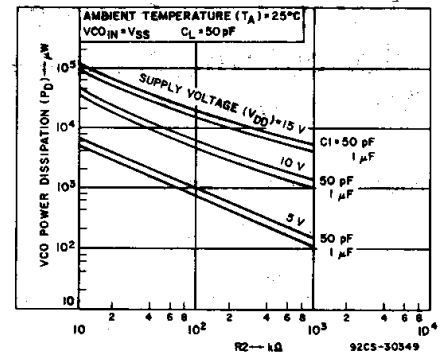


Fig. 12 - Typical VCO power dissipation at f_{MIN} as a function of $R2$.

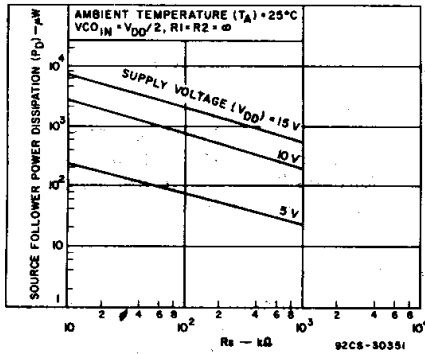


Fig. 13 - Typical source follower power dissipation as a function of R_s .

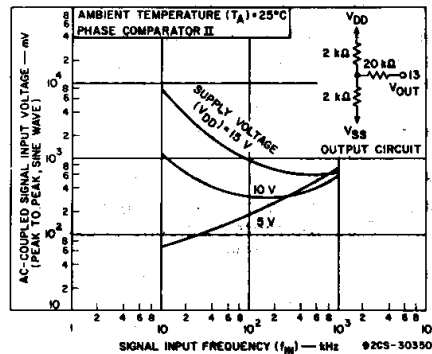


Fig. 14 - AC-coupled signal input voltage as a function of signal input frequency.

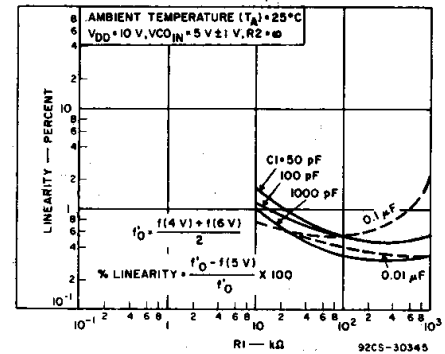


Fig. 15 - Typical VCO linearity as a function of $R1$ and $C1$ at $V_{DD} = 10$ V.

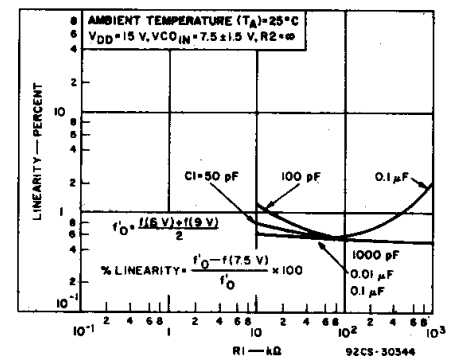
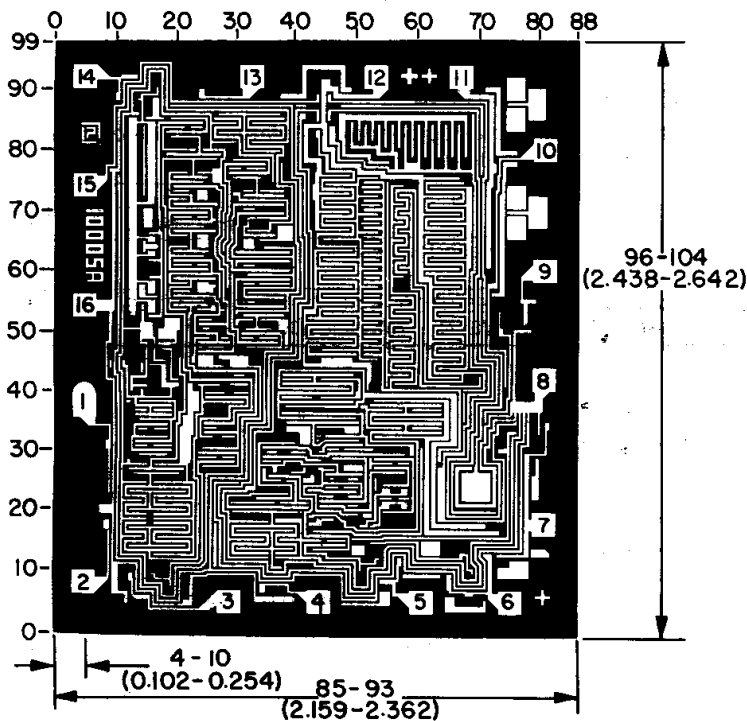


Fig. 16 - Typical VCO linearity as a function of $R1$ and $C1$ at $V_{DD} = 15$ V.



92CM-36467
Dimensions and pad layout for CD4046BH.

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

3

COMMERCIAL CMOS
HIGH VOLTAGE ICs

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
5962-9466401MEA	Active	Production	CDIP (J) 16	25 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	5962-9466401ME A CD4046BF3A
CD4046BE	Active	Production	PDIP (N) 16	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	-55 to 125	CD4046BE
CD4046BE.A	Active	Production	PDIP (N) 16	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	-55 to 125	CD4046BE
CD4046BEE4	Active	Production	PDIP (N) 16	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	-55 to 125	CD4046BE
CD4046BF	Active	Production	CDIP (J) 16	25 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	CD4046BF
CD4046BF.A	Active	Production	CDIP (J) 16	25 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	CD4046BF
CD4046BF3A	Active	Production	CDIP (J) 16	25 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	5962-9466401ME A CD4046BF3A
CD4046BF3A.A	Active	Production	CDIP (J) 16	25 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	5962-9466401ME A CD4046BF3A
CD4046BNSR	Active	Production	SOP (NS) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	CD4046B
CD4046BNSR.A	Active	Production	SOP (NS) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	CD4046B
CD4046BNSRE4	Active	Production	SOP (NS) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	CD4046B
CD4046BPW	Active	Production	TSSOP (PW) 16	90 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	CM046B
CD4046BPW.A	Active	Production	TSSOP (PW) 16	90 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	CM046B
CD4046BPWG4	Active	Production	TSSOP (PW) 16	90 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	CM046B
CD4046BPWR	Active	Production	TSSOP (PW) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	CM046B
CD4046BPWR.A	Active	Production	TSSOP (PW) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	CM046B

⁽¹⁾ **Status:** For more details on status, see our [product life cycle](#).

⁽²⁾ **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

⁽³⁾ **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

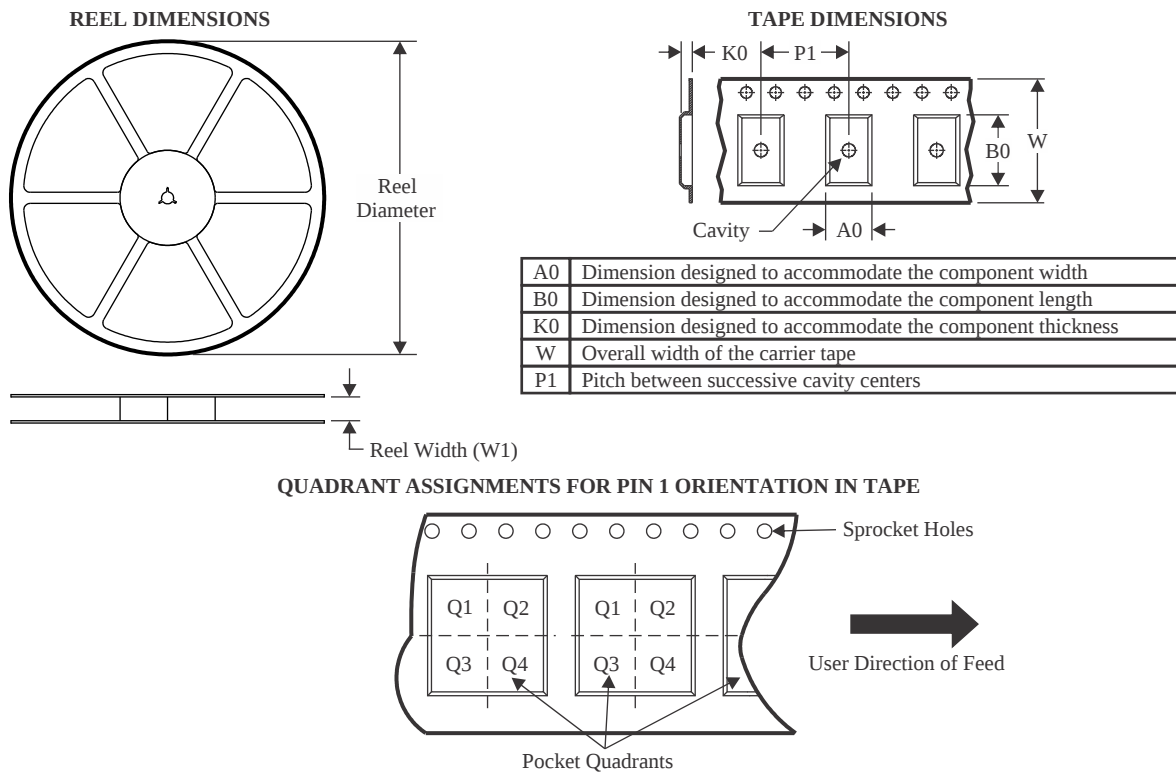
OTHER QUALIFIED VERSIONS OF CD4046B, CD4046B-MIL :

- Catalog : [CD4046B](#)
- Military : [CD4046B-MIL](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Military - QML certified for Military and Defense Applications

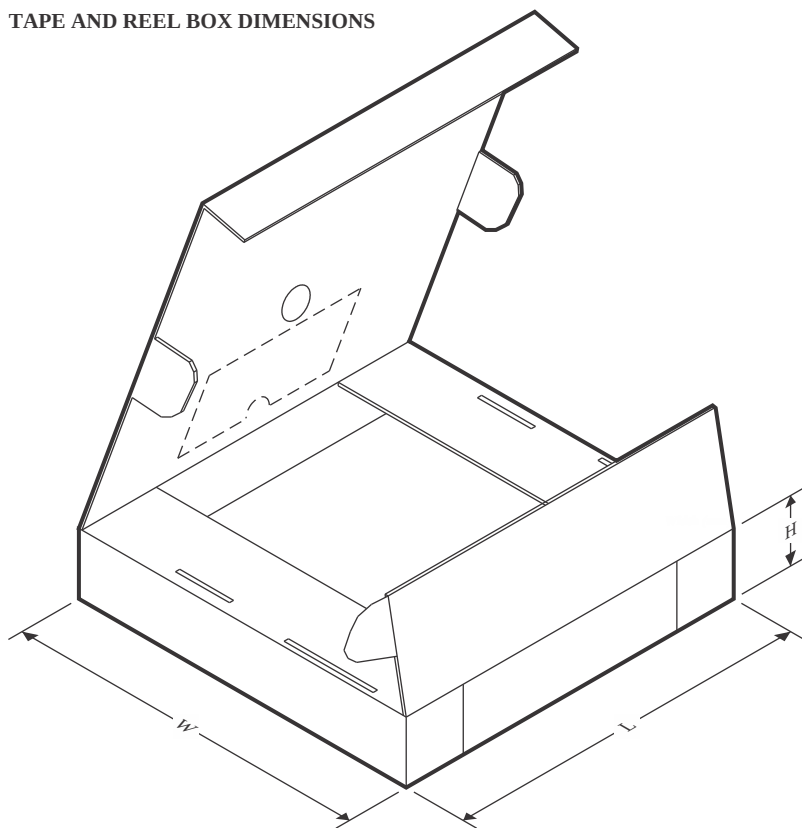
TAPE AND REEL INFORMATION



*All dimensions are nominal

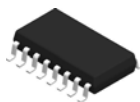
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
CD4046BNSR	SOP	NS	16	2000	330.0	16.4	8.45	10.55	2.5	12.0	16.2	Q1
CD4046BPWR	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
CD4046BNSR	SOP	NS	16	2000	353.0	353.0	32.0
CD4046BPWR	TSSOP	PW	16	2000	353.0	353.0	32.0

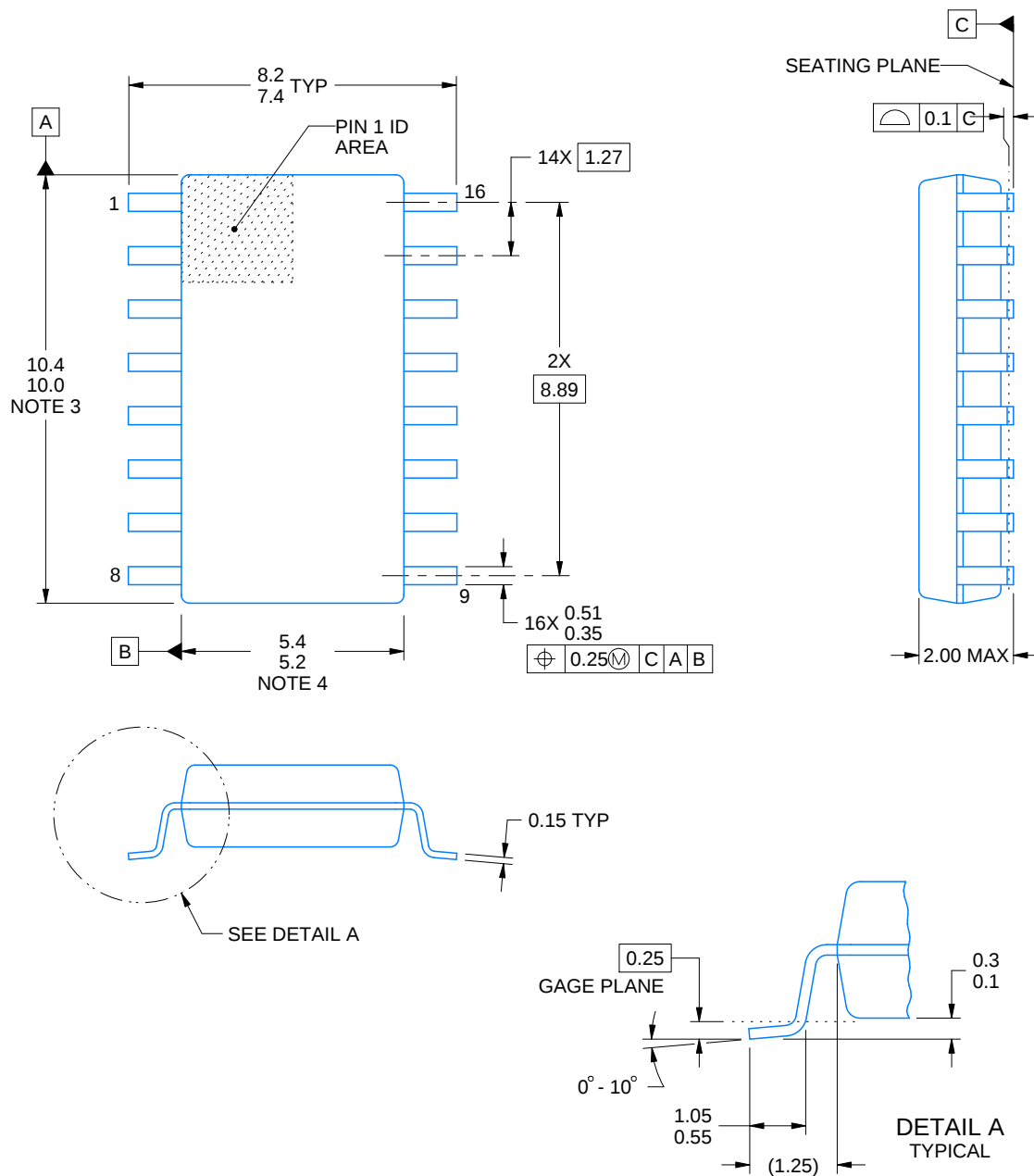


PACKAGE OUTLINE

NS0016A

SOP - 2.00 mm max height

SOP



4220735/A 12/2021

NOTES:

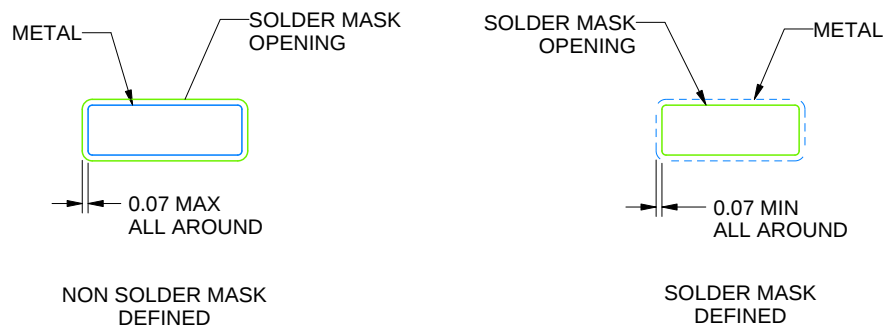
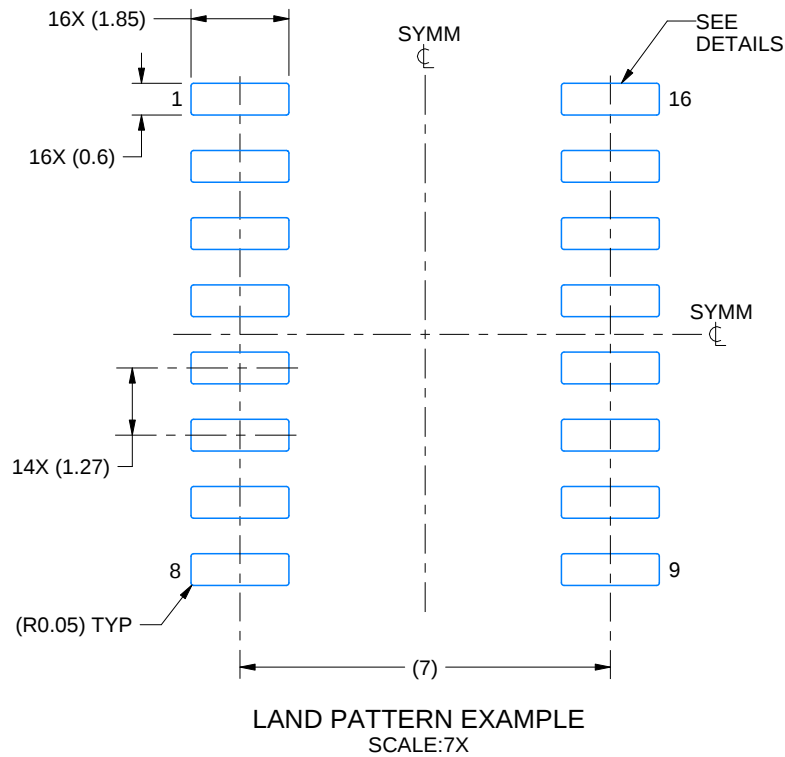
1. All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm, per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm, per side.

EXAMPLE BOARD LAYOUT

NS0016A

SOP - 2.00 mm max height

SOP



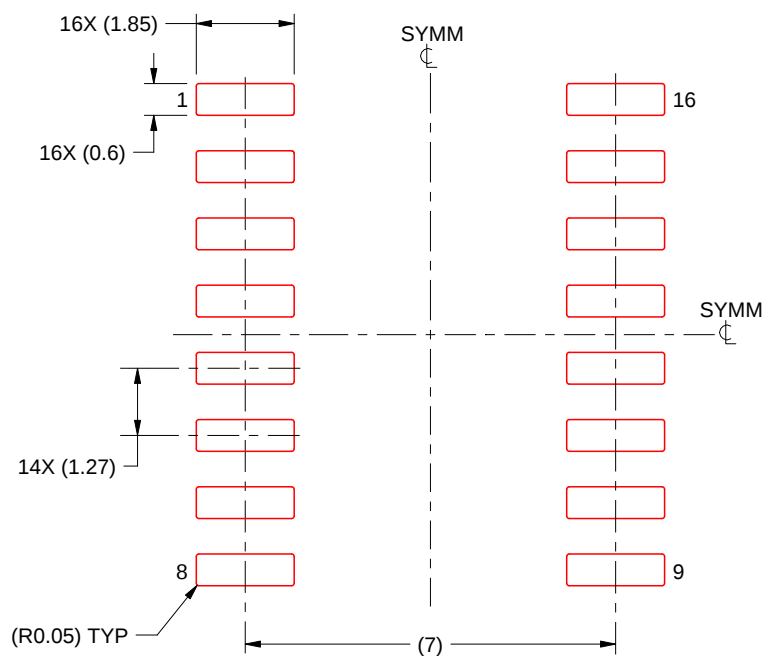
SOLDER MASK DETAILS

4220735/A 12/2021

NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.

6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE
 BASED ON 0.125 mm THICK STENCIL
 SCALE:7X

4220735/A 12/2021

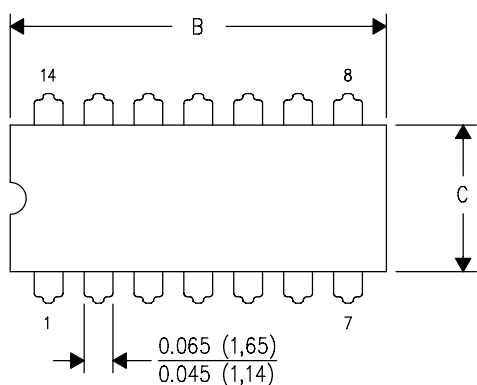
NOTES: (continued)

7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.

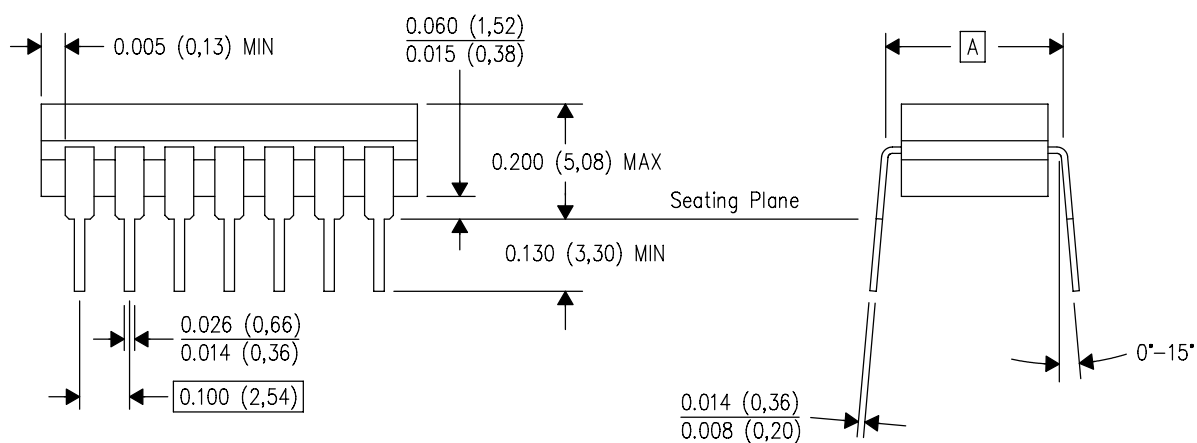
J (R-GDIP-T**)

14 LEADS SHOWN

CERAMIC DUAL IN-LINE PACKAGE



PINS ** DIM	14	16	18	20
A	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC
B MAX	0.785 (19,94)	.840 (21,34)	0.960 (24,38)	1.060 (26,92)
B MIN	—	—	—	—
C MAX	0.300 (7,62)	0.300 (7,62)	0.310 (7,87)	0.300 (7,62)
C MIN	0.245 (6,22)	0.245 (6,22)	0.220 (5,59)	0.245 (6,22)



4040083/F 03/03

- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. This package is hermetically sealed with a ceramic lid using glass frit.
 - D. Index point is provided on cap for terminal identification only on press ceramic glass frit seal only.
 - E. Falls within MIL STD 1835 GDIP1-T14, GDIP1-T16, GDIP1-T18 and GDIP1-T20.



TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



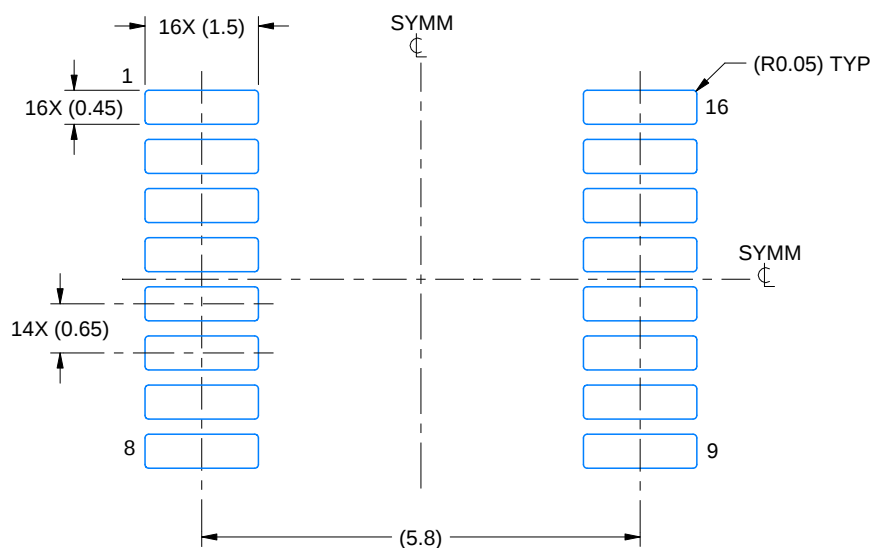
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.

EXAMPLE BOARD LAYOUT

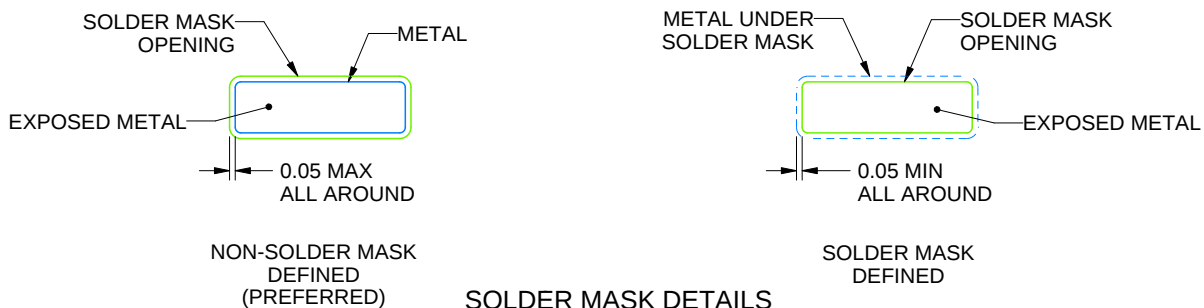
PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



4220204/B 12/2023

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

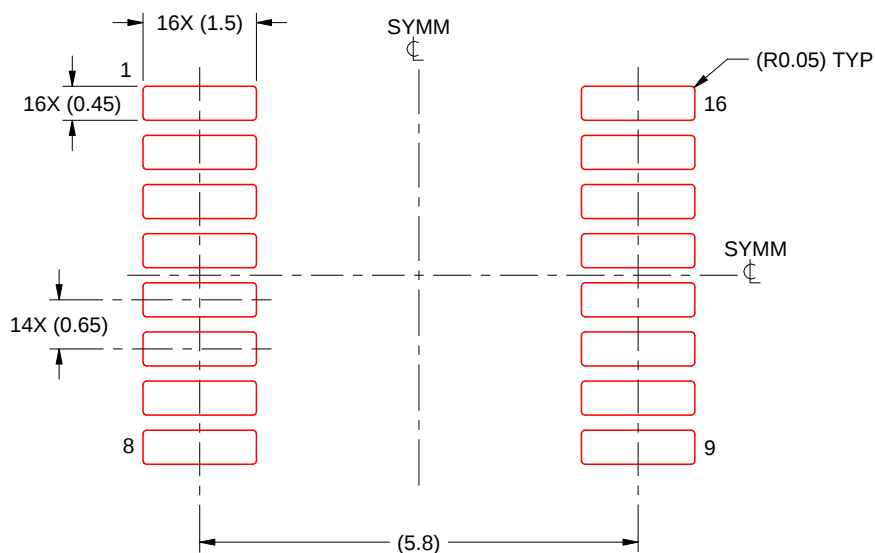
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 10X

4220204/B 12/2023

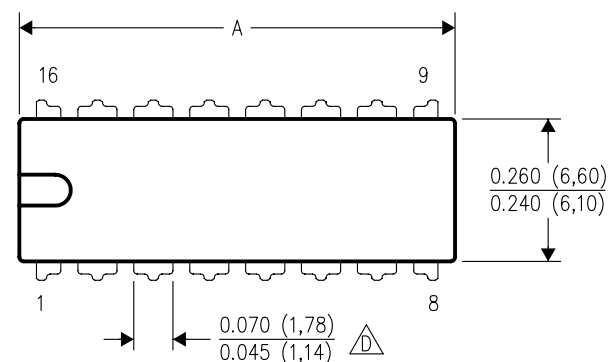
NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

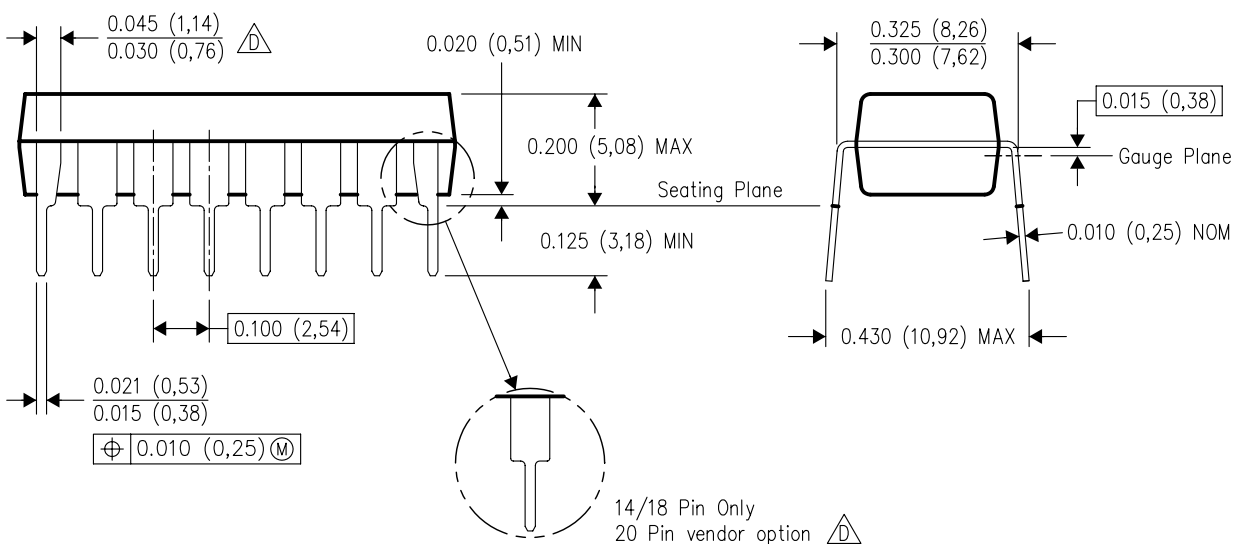
N (R-PDIP-T**)

16 PINS SHOWN

PLASTIC DUAL-IN-LINE PACKAGE



PINS ** DIM	14	16	18	20
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23,37)	1.060 (26,92)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21,59)	0.940 (23,88)
MS-001 VARIATION	AA	BB	AC	AD



4040049/E 12/2002

- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 -  Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).
 -  The 20 pin end lead shoulder width is a vendor option, either half or full width.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#), [TI's General Quality Guidelines](#), or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2026, Texas Instruments Incorporated

Last updated 10/2025