CDCVF2509 3.3V Phase-Lock Loop Clock Driver

1 Features

- Designed to meet and exceed PC133 SDRAM registered DIMM specification Rev. 1.1
- Spread Spectrum Clock-compatible
- Operating frequency: 50MHz to 175MHz
- Static phase error distribution at 66MHz to 166MHz is ±125ps
- Jitter (cyc - cyc) at 66MHz to 166MHz is typical = 70ps
- Advanced deep submicron process results in more than 40% lower power consumption versus current generation PC133 devices
- Available in plastic 24-pin TSSOP
- Phase-lock loop clock distribution for synchronous DRAM applications
- Distributes one clock input to one bank of five and one bank of four outputs
- Separate output enable for each output bank
- External feedback (FBIN) terminal is used to synchronize the outputs to the clock input
- 25-Ω On-chip series damping resistors
- No external RC network required
- Operates at 3.3V

2 Applications

- DRAM applications
- PLL-based clock distributors
- Non-PLL clock buffers

3 Description

The CDCVF2509 is a high-performance, low-skew, low-jitter, phase-lock loop (PLL) clock driver. The device uses a PLL to precisely align, in both frequency and phase, the feedback (FBOUT) output to the clock (CLK) input signal. The device is specifically designed for use with synchronous DRAMs. The CDCVF2509 operates at a 3.3V $V_{CC}$and provides integrated series-damping resistors designed for driving point-to-point loads.

One bank of five outputs and one bank of four outputs provide nine low-skew, low-jitter copies of CLK. Output signal duty cycles are adjusted to 50%, independent of the duty cycle at CLK. Each bank of outputs is enabled or disabled separately through the control (1G and 2G) inputs. When the G inputs are high, the outputs switch in phase and frequency with CLK. When the G inputs are low, the outputs are disabled to the logic-low state.

Unlike many products containing PLLs, the CDCVF2509 does not require external RC networks. The loop filter for the PLL is included on-chip, minimizing component count, board space, and cost.

The device is based on PLL circuitry, therefore the CDCVF2509 requires a stabilization time to achieve phase lock of the feedback signal to the reference signal. This stabilization time is required following power up and application of a fixed-frequency, fixed-phase signal at CLK, and following any changes to the PLL reference or feedback signals. The PLL can be bypassed by strapping AV_{CC} to ground.

The CDCVF2509A is characterized for operation from 0°C to 85°C.

For application information, see the *High Speed Distribution Design Techniques for CDC509/516/2509/2510/2516* and *Using CDC2509A/2510A PLL with Spread Spectrum Clocking (SSC)* application notes.

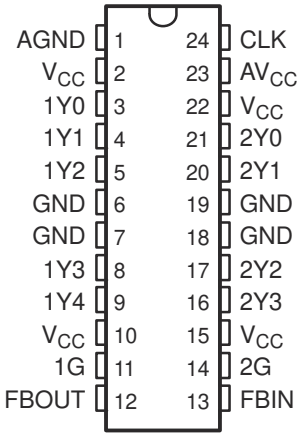
Function Table

INPUTS			OUTPUTS		
1G	2G	CLK	1Y (0:4)	2Y (0:3)	FBOUT
X	X	L	L	L	L
L	L	H	L	L	H
L	H	H	L	H	H
H	L	H	H	L	H
H	H	H	H	H	H

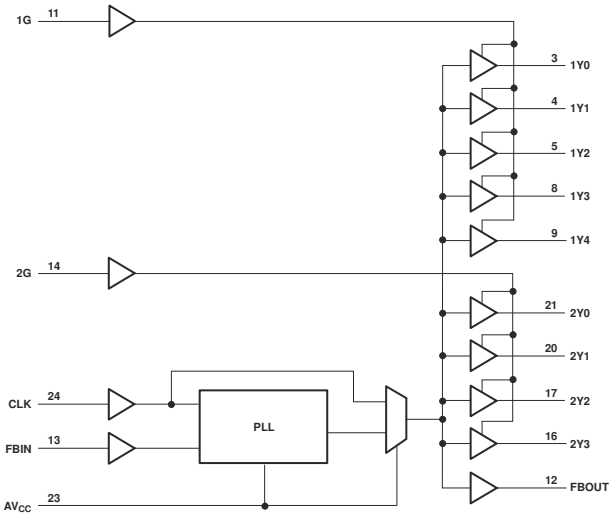
Available Options

T_A	PACKAGE
	SMALL OUTLINE (PW)
0°C to 85°C	CDCVF2509PWR
	CDCVF2509PW

PW PACKAGE
(TOP VIEW)



Pinout



Functional Block Diagram

Table of Contents

Pin Configuration and Functions

PW PACKAGE
(TOP VIEW)

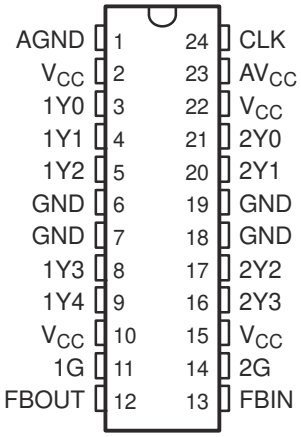


Table 4-1. Pin Functions

PIN		TYPE	DESCRIPTION
NAME	NO.		
CLK	24	I	Clock input. CLK provides the clock signal to be distributed by the CDCVF2509A clock driver. CLK is used to provide the reference signal to the integrated PLL that generates the clock output signals. CLK must have a fixed frequency and fixed phase for the PLL to obtain phase lock. Once the circuit is powered up and a valid CLK signal is applied, a stabilization time is required for the PLL to phase lock the feedback signal to its reference signal.
FBIN	13	I	Feedback input. FBIN provides the feedback signal to the internal PLL. FBIN must be hard-wired to FBOUT to complete the PLL. The integrated PLL synchronizes CLK and FBIN so that there is nominally zero phase error between CLK and FBIN.
1G	11	I	Output bank enable. 1G is the output enable for outputs 1Y(0:4). When 1G is low, outputs 1Y(0:4) are disabled to a logic-low state. When 1G is high, all outputs 1Y(0:4) are enabled and switch at the same frequency as CLK.
2G	14	I	Output bank enable. 2G is the output enable for outputs 2Y(0:3). When 2G is low, outputs 2Y(0:3) are disabled to a logic low state. When 2G is high, all outputs 2Y(0:3) are enabled and switch at the same frequency as CLK.
FBOUT	12	O	Feedback output. FBOUT is dedicated for external feedback. It switches at the same frequency as CLK. When externally wired to FBIN, FBOUT completes the feedback loop of the PLL. FBOUT has an integrated 25-Ω series-damping resistor.
1Y (0:4)	3, 4, 5, 8, 9	O	Clock outputs. These outputs provide low-skew copies of CLK. Output bank 1Y(0:4) is enabled via the 1G input. These outputs can be disabled to a logic-low state by deasserting the 1G control input. Each output has an integrated 25-Ω series-damping resistor.
2Y (0:3)	16, 17, 21, 20	O	Clock outputs. These outputs provide low-skew copies of CLK. Output bank 2Y(0:3) is enabled via the 2G input. These outputs can be disabled to a logic-low state by deasserting the 2G control input. Each output has an integrated 25-Ω series-damping resistor.
AV_{CC}	23	Power	Analog power supply. AV_{CC} provides the power reference for the analog circuitry. In addition, AV_{CC} can be used to bypass the PLL. When AV_{CC} is strapped to ground, PLL is bypassed and CLK is buffered directly to the device outputs.
AGND	1	Ground	Analog ground. AGND provides the ground reference for the analog circuitry.
V_{CC}	2, 10, 15, 22	Power	Power supply
GND	6, 7, 18, 19	Ground	Ground

4 Specifications

4.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

		UNIT
AV_{CC}	Supply voltage range (2)	$AV_{CC} < V_{CC}$ +0.7 V
V_{CC}	Supply voltage range	–0.5 V to 4.3 V
V_I	Input voltage range (3)	–0.5 V to 4.6 V
V_O	Voltage range applied to any output in the high or low state(3) (4)	–0.5 V to V_{CC} + 0.5 V
I_{IK}	Input clamp current (V_I< 0)	–50 mA
I_{OK}	Output clamp current (V_O< 0 or $V_O > V_{CC}$)	±50 mA
I_O	Continuous output current (V_O = 0 to V_{CC})	±50 mA
	Continuous current through each V_{CC} or GND	±100 mA
	Maximum power dissipation at T_A = 55°C (in still air)(5)	0.7 W
T_{stg}	Storage temperature range	–65°C to 150°C

(1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) AV_{CC} **must not** exceed V_{CC}+ 0.7 V
(3) The input and output negative-voltage ratings may be exceeded if the input and output clamp-current ratings are observed.
(4) This value is limited to 4.6 V maximum.
(5) The maximum package power dissipation is calculated using a junction temperature of 150°C and a board trace length of 750 mils. For more information, see the *Package Thermal Considerations* application note in the *ABT Advanced BiCMOS Technology Data Book* (SCBD002).

4.2 Dissipation Ratings

PACKAGE	BOARD TYPE	$R_{\theta JA}$	$T_A \le 25°C$ POWER RATING	DERATING FACTORS ABOVE $T_A \le 25°C$	$T_A = 70°C$ POWER RATING	$T_A = 85°C$ POWER RATING
PW	JEDEC low-K	114.5°C/W	920 mW	8.7 mW/°C	520 mW	390 mW
	JEDEC high-K	62.1°C/W	1690 mW	16.1 mW/°C	960 mW	720 mW

4.3 Recommended Operating Conditions

See (1)

		MIN	MAX	UNIT
V_{CC}, AV_{CC}	Supply voltage	3	3.6	V
V_{IH}	High-level input voltage	2		V
V_{IL}	Low-level input voltage		0.8	V
V_I	Input voltage	0	V_{CC}	V
I_{OH}	High-level output current		–12	mA
I_{OL}	Low-level output current		12	mA
T_A	Operating free-air temperature	0	85	°C

(1) Unused inputs must be held high or low to prevent them from floating.

4.4 Package Thermal Resistance

CDCVF2509APW 24-PIN TSSOP(1)			THERMAL AIRFLOW (CFM)				UNIT
			0	150	250	500	
$R_{\theta JA}$	High K		88	83	81	77	°C/W
$R_{\theta JC}$	High K	26.5					

(1) The package thermal impedance is calculated in accordance with JESD 51 and JEDEC2S2P (high-k board).

4.5 Electrical Characteristics

over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	V_{CC}, AV_{CC}	MIN	TYP[1]	MAX	UNIT
V_{IK}	Input clamp voltage	I_I = -18 mA	3 V			–1.2	V
V_{OH}	High-level output voltage	I_{OH} = -100 µA	MIN to MAX	V_{CC}–0.2			V
		I_{OH} = -12 mA	3 V	2.1			
		I_{OH} = -6 mA	3 V	2.4			
V_{OL}	Low-level output voltage	I_{OL} = 100 µA	MIN to MAX			0.2	V
		I_{OL} = 12 mA	3 V			0.8	
		I_{OL} = 6 mA	3 V			0.55	
I_{OH}	High-level output current	V_O= 1 V	3 V	–28			mA
		V_O = 1.65 V	3.3 V		–36		
		V_O = 3.135 V	3.6 V			-8	
I_{OL}	Low-level output current	V_O= 1.95 V	3 V	30			mA
		V_O = 1.65 V	3.3 V		40		
		V_O = 0.4 V	3.6 V			10	
I_I	Input current	V_I = V_{CC} or GND	3.6 V			±5	µA
I_{CC} [2]	Supply current (static, output not switching)	V_I = V_{CC} or GND, I_O = 0, Outputs: low or high	3.6 V, 0 V			40	µA
ΔI_{CC}	Change in supply current	One input at V_{CC} - 0.6 V, Other inputs at V_{CC} or GND	3.3 V to 3.6 V			500	µA
C_i	Input capacitance	V_I = V_{CC} or GND	3.3 V		2.5		pF
C_o	Output capacitance	V_O = V_{CC} or GND	3.3 V		2.8		pF

(1) For conditions shown as MIN or MAX, use the appropriate value specified under the *recommended operating conditions* section.
(2) For dynamic I_{CC} vs Frequency, see Figure 4-6 and Figure 4-7.

4.6 Timing Requirements

over recommended ranges of supply voltage and operating free-air temperature

		MIN	MAX	UNIT
f_{clk}	Clock frequency	50	175	MHz
	Input clock duty cycle	40%	60%	
	Stabilization time[1]		1	ms

(1) The time required for the integrated PLL circuit to obtain phase lock of its feedback signal to its reference signal. For phase lock to be obtained, a fixed-frequency, fixed-phase reference signal must be present at CLK. Until phase lock is obtained, the specifications for propagation delay, skew and jitter parameters given in the *switching characteristics* table are not applicable. This parameter does not apply for input modulation under SSC application.

4.7 Switching Characteristics

over recommended ranges of supply voltage and operating free-air temperature, C_L = 25 pF (see Figure 5-1 and Figure 5-2)[3] [1]

PARAMETER		FROM (INPUT)	TO (OUTPUT)	V_{CC}, AV_{CC} = 3.3 V ± 0.3 V			UNIT
				MIN	TYP	MAX	
$t_{(\varphi)}$	Phase error time- static (normalized) (see Figure 4-1 through Figure 4-4)	CLK↑ = 66 MHz to 166 MHz	FBIN↑	–125		125	ps
$t_{sk(o)}$	Output skew time[2]	Any Y	Any Y			100	ps
	Phase error time-jitter [4]	CLK = 66 MHz to 100 MHz	Any Y or FBOUT	–50		50	ps
	$Jitter_{(cycle-cycle)}$ (see Figure 4-5)	CLK = 66 MHz to 100 MHz	Any Y or FBOUT		-70		ps
		CLK = 100 MHz to 166 MHz			-65		
	Duty cycle	$f_{(CLK)}$ > 60 MHz	Any Y or FBOUT	45%		55%	

over recommended ranges of supply voltage and operating free-air temperature, C_L = 25 pF (see Figure 5-1 and Figure 5-2)(3) (1)

PARAMETER		FROM (INPUT)	TO (OUTPUT)	V_{CC}, AV_{CC} = 3.3 V ± 0.3 V			UNIT
				MIN	TYP	MAX	
t_r	Rise time	V_O = 0.4 V to 2 V	Any Y or FBOUT	0.3		1.1	ns/V
t_f	Fall time	V_O = 2 V to 0.4 V	Any Y or FBOUT	0.3		1.1	ns/V
t_{PLH}	Low-to-high propagation delay time, bypass mode	CLK	Any Y or FBOUT	1.8		3.9	ns
t_{PHL}	High-to-low propagation delay time, bypass mode	CLK	Any Y or FBOUT	1.8		3.9	ns

(1) These parameters are not production tested.
(2) The $t_{sk(o)}$ specification is only valid for equal loading of all outputs.
(3) The specifications for parameters in this table are applicable only after any appropriate stabilization time has elapsed.
(4) Calculated per PC DRAM SPEC ($t_{phase\ error}$, static-jitter$_{(cycle\text{-}to\text{-}cycle)}$).

4.8 Typical Characteristics

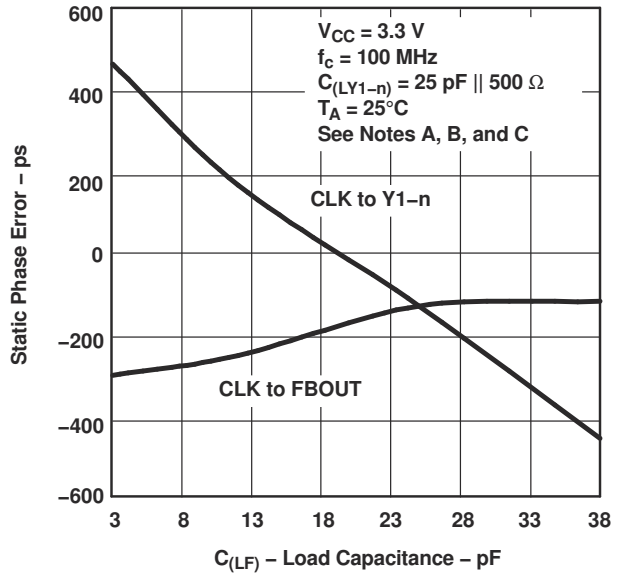


Figure 4-1. Static Phase Error vs Load Capacitance

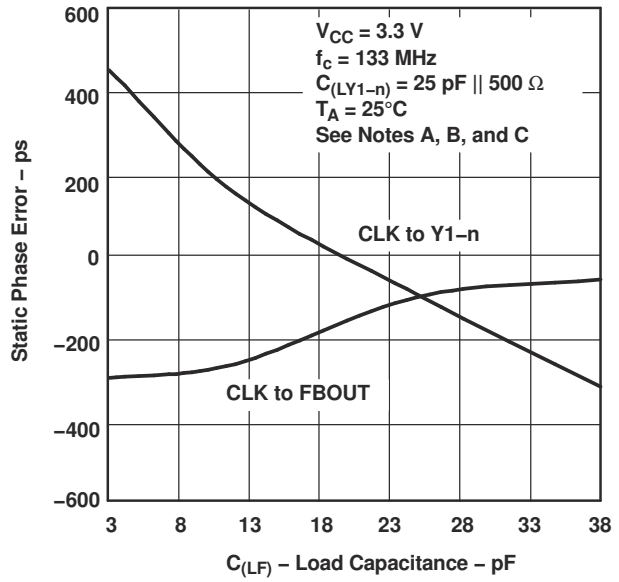


Figure 4-2. Static Phase Error vs Load Capacitance

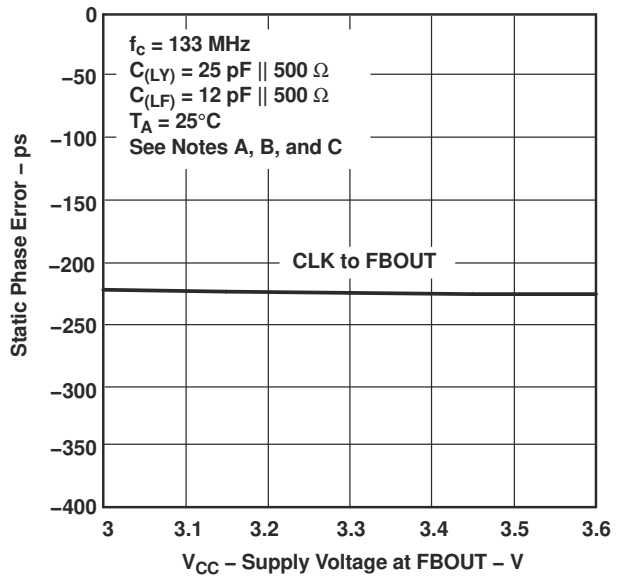


Figure 4-3. Static Phase Error vs Supply Voltage at FBOUT

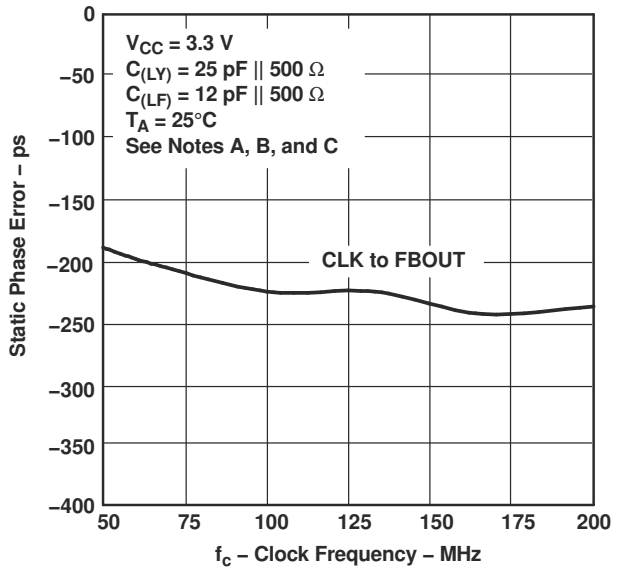


Figure 4-4. Static Phase Error vs Clock Frequency

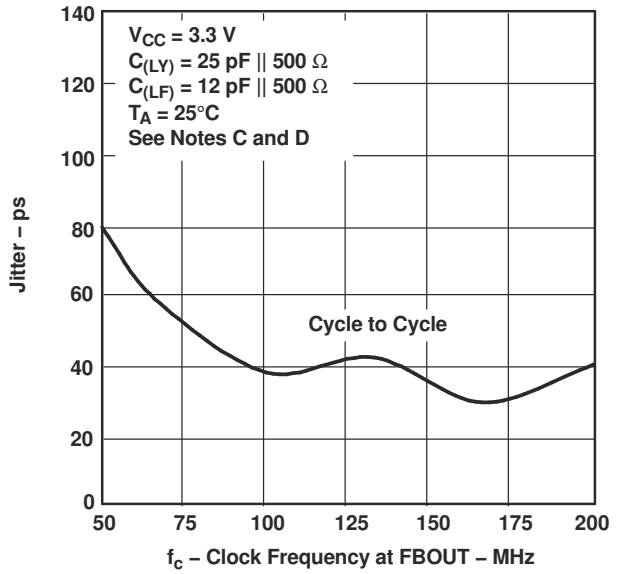


Figure 4-5. Jitter vs Clock Frequency at FBOUT

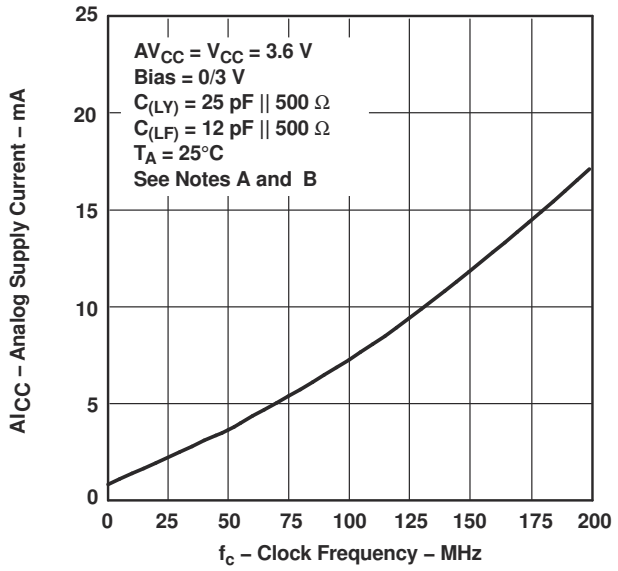


Figure 4-6. Analog Supply Current vs Clock Frequency

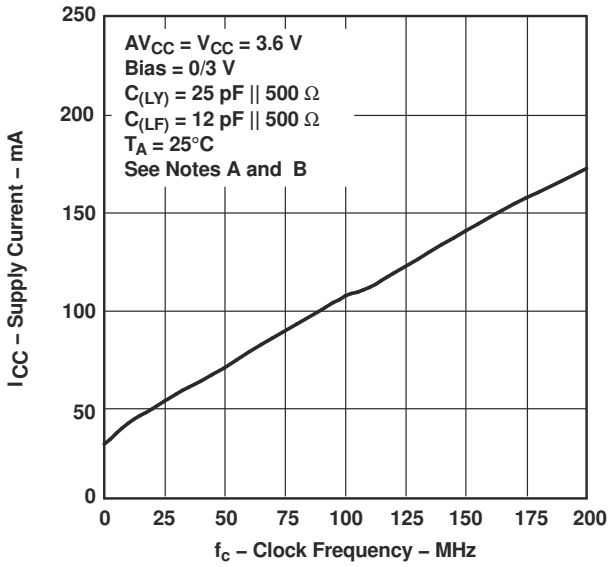
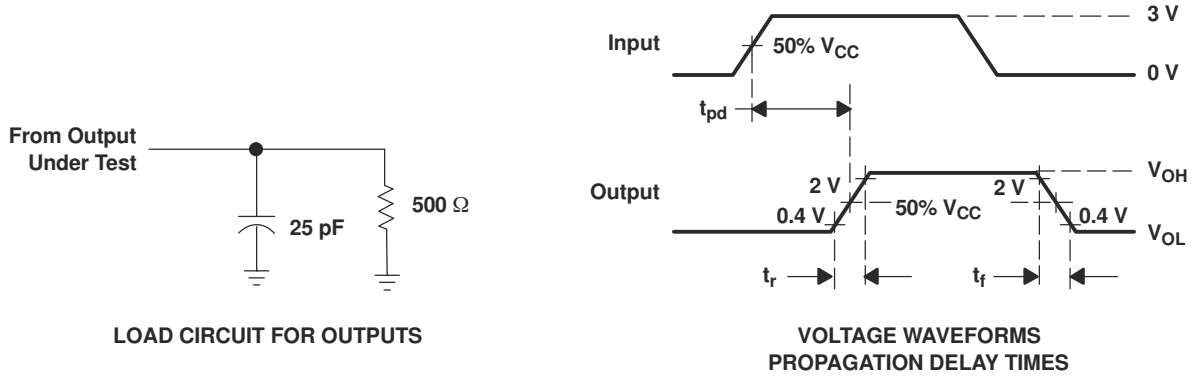


Figure 4-7. Supply Current vs Clock Frequency

1. Trace length FBOUT to FBIN = 5 mm, Z_O = 50 Ω
2. $C_{(LY)}$ = Lumped capacitive load Y_{1-n}
3. $C_{(LFx)}$ = Lumped feedback capacitance at FBOUT = FBIN
4. $C_{(LFx)}$ = Lumped feedback capacitance at FBOUT = FBIN.

5 Parameter Measurement Information



LOAD CIRCUIT FOR OUTPUTS

VOLTAGE WAVEFORMS
PROPAGATION DELAY TIMES

NOTES: A. C_L includes probe and jig capacitance.
B. All input pulses are supplied by generators having the following characteristics: PRR ≤ 133 MHz, Z_O = 50 Ω, t_r ≤ 1.2 ns, t_f ≤ 1.2 ns.
C. The outputs are measured one at a time with one transition per measurement.

Figure 5-1. Load Circuit and Voltage Waveforms

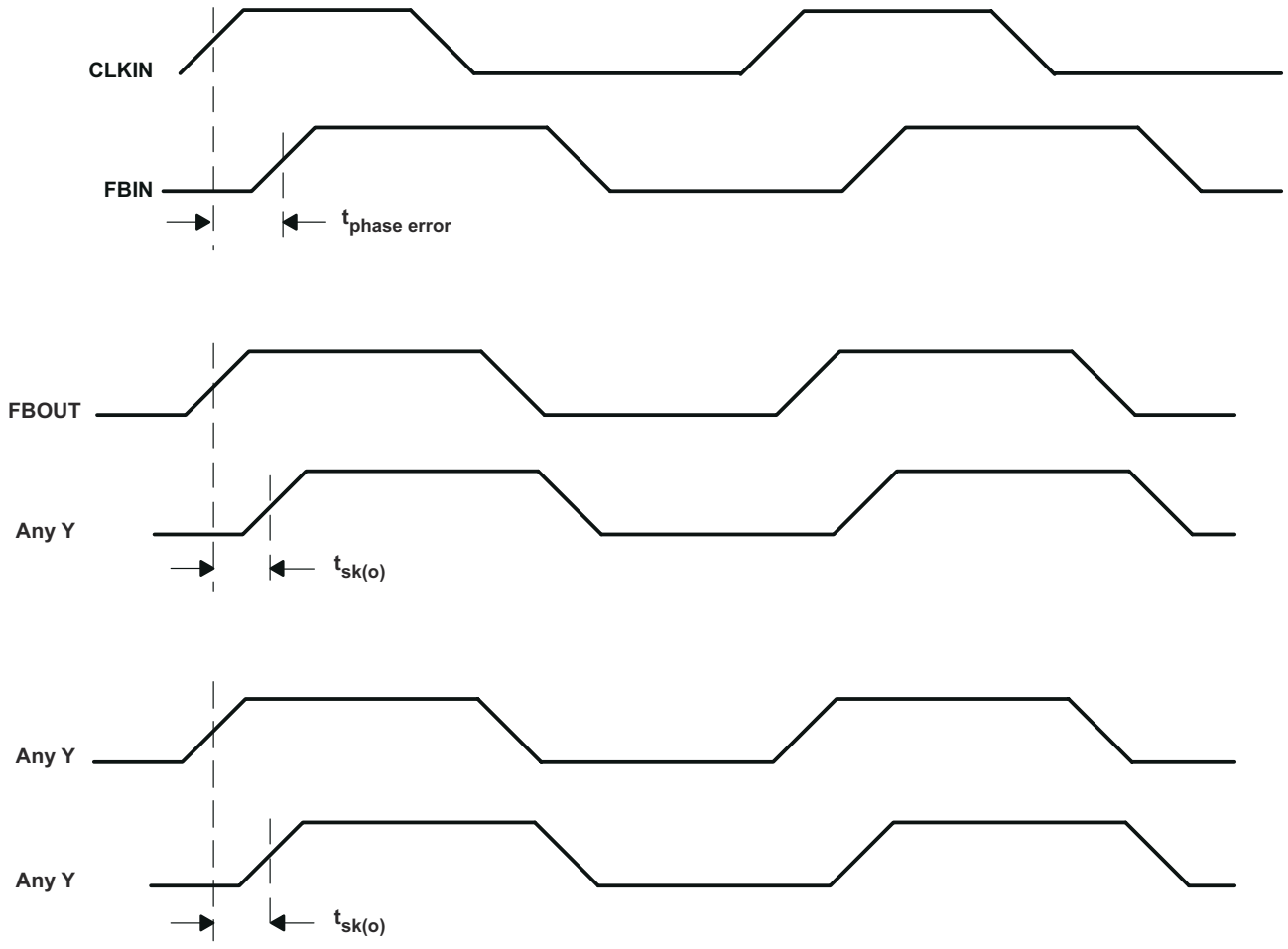


Figure 5-2. Skew Calculations

6 Device and Documentation Support

TI offers an extensive line of development tools. Tools and software to evaluate the performance of the device, generate code, and develop solutions are listed below.

6.1 Documentation Support

6.1.1 Related Documentation

For related documentation, see the following:

- Texas Instruments, *High Speed Distribution Design Techniques for CDC509/516/2509/2510/2516* application note
- Texas Instruments, *Using CDC2509A/2510A PLL with Spread Spectrum Clocking (SSC)* application note

6.2 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

6.3 Trademarks

TI E2E™ is a trademark of Texas Instruments.
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6.4 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

6.5 Glossary

TI Glossary	This glossary lists and explains terms, acronyms, and definitions.

7 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision D (February 2010) to Revision E (February 2024)	Page
• Updated the numbering format for tables, figures, and cross-references throughout the document	1
• Removed bullet from *Features*: Use CDCVF2509A (SCAS765) as a Replacement for This Device	1
• Added *Device and Documentation Support* section	12

Changes from Revision C (January 2009) to Revision D (February 2010)	Page
• Added the PACKAGE THERMAL RESISTANCE table	5

Changes from Revision B (June 2005) to Revision C (January 2009)	Page
• Added NOT RECOMMENDED FOR NEW DESIGNS	1

Changes from Revision A (July 2004) to Revision B (June 2005)	Page
• Changed Rise time values in the Switching Characteristics table From: Min =0.5 Max = 2.5 To: Min = 0.3 Max = 1.1	7
• Changed Fall time values in the Switching Characteristics table From: Min =0.5 Max = 2.5 To: Min = 0.3 Max = 1.1	7
• Changed Low-to-high propagation delay time values in the Switching Characteristics table From: Min =0.4 Max = 2.3 To: Min = 1.8 Max = 3.9	7
• Changed High-to-low propagation delay time values in the Switching Characteristics table From: Min =0.4 Max = 2.3 To: Min = 1.8 Max = 3.9	7

Changes from Revision * (April 2004) to Revision A (July 2004)	Page
• Added CDCVF2509PW package number to the AVAILABLE OPTIONS table	1

8 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

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)
CDCVF2509PW	Active	Production	TSSOP (PW) | 24	60 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 85	CKV2509
CDCVF2509PWR	Active	Production	TSSOP (PW) | 24	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 85	CKV2509
CDCVF2509PWRG4	Active	Production	TSSOP (PW) | 24	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 85	CKV2509

(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.

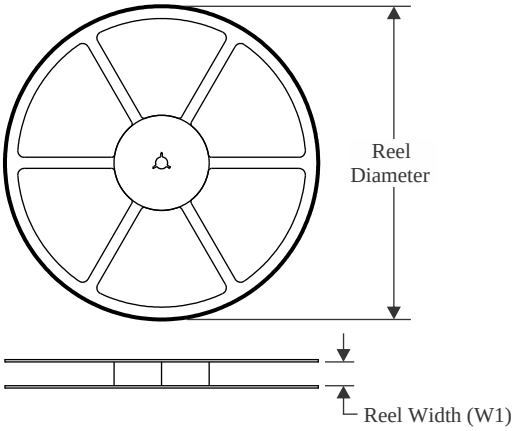
(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will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

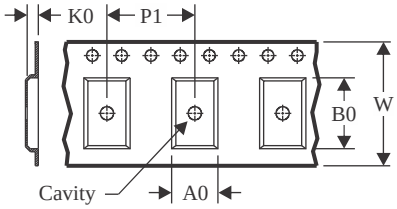
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

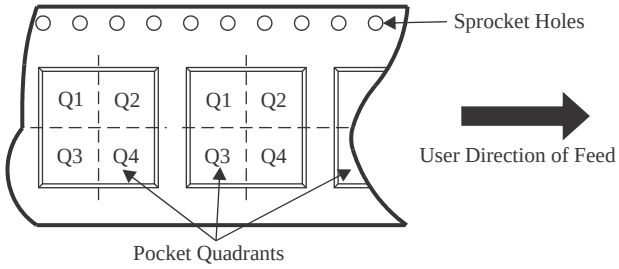


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

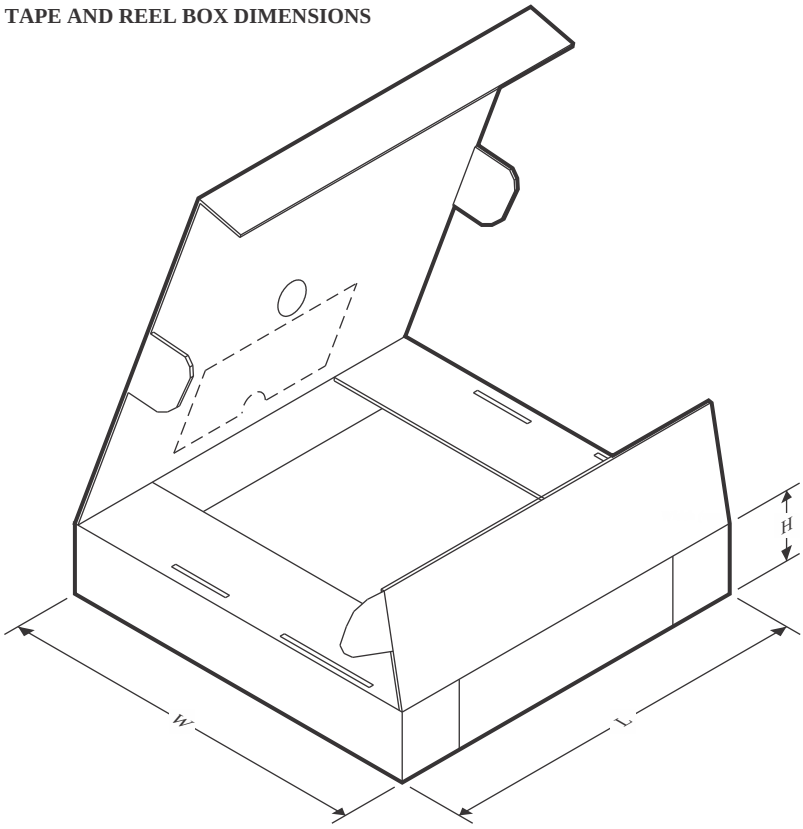
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
CDCVF2509PWR	TSSOP	PW	24	2000	330.0	16.4	6.95	8.3	1.6	8.0	16.0	Q1
CDCVF2509PWRG4	TSSOP	PW	24	2000	330.0	16.4	6.95	8.3	1.6	8.0	16.0	Q1

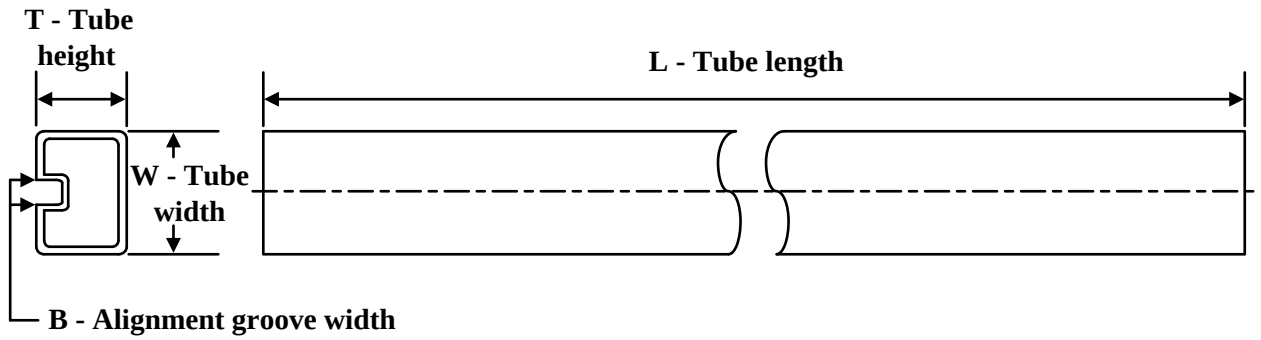
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
CDCVF2509PWR	TSSOP	PW	24	2000	353.0	353.0	32.0
CDCVF2509PWRG4	TSSOP	PW	24	2000	353.0	353.0	32.0

TUBE



*All dimensions are nominal

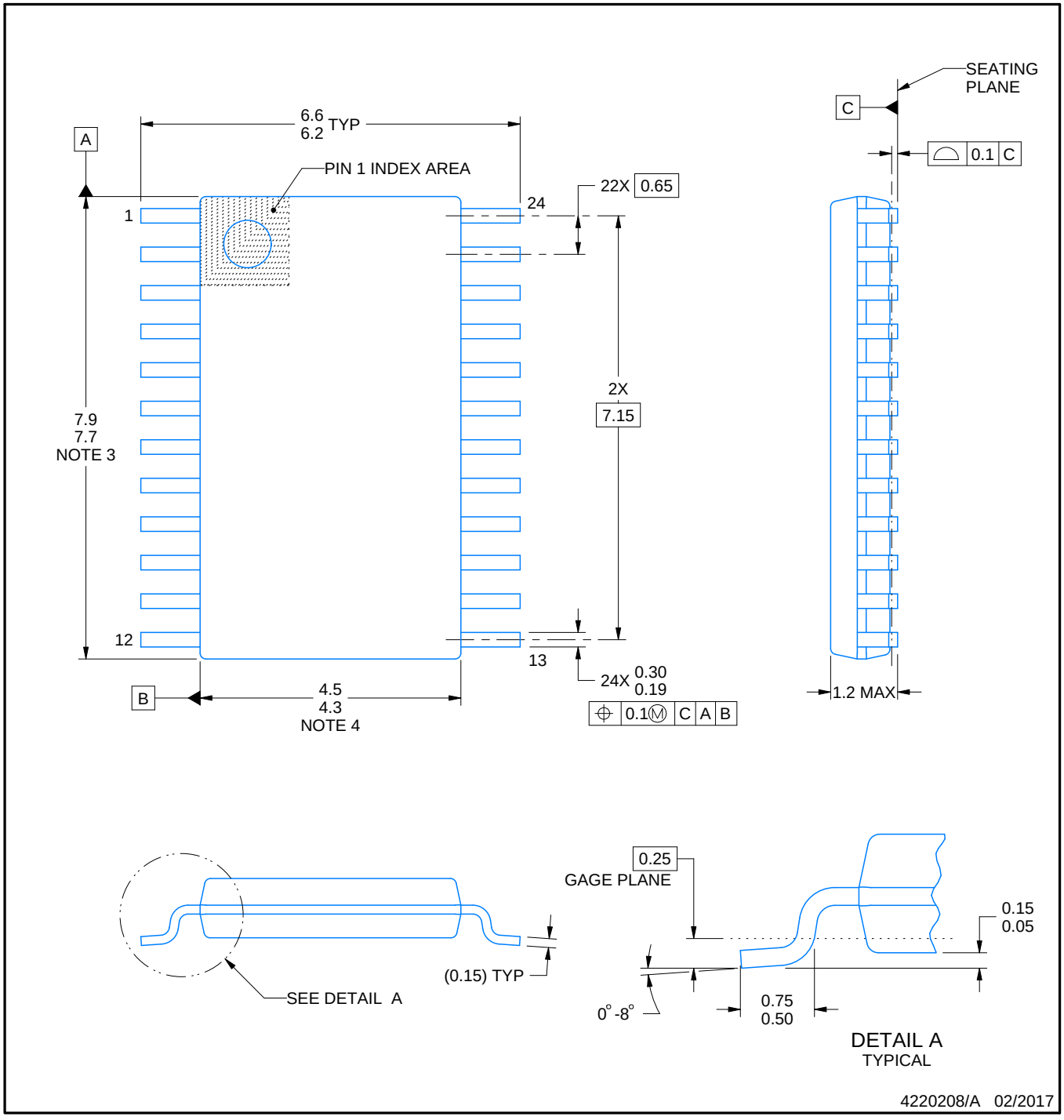
Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
CDCVF2509PW	PW	TSSOP	24	60	530	10.2	3600	3.5

PACKAGE OUTLINE

PW0024A

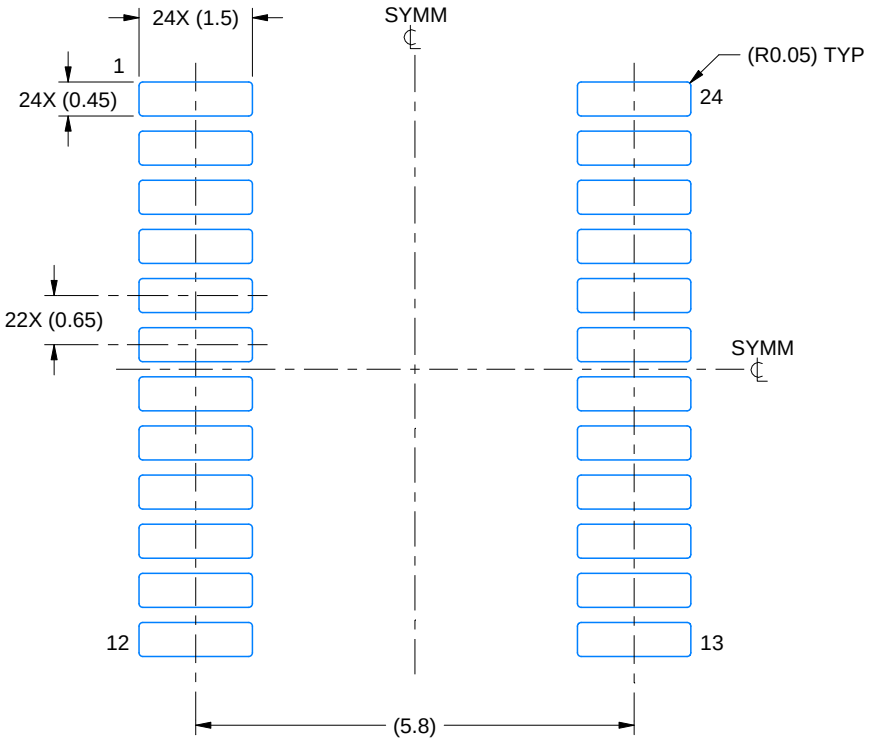
TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE

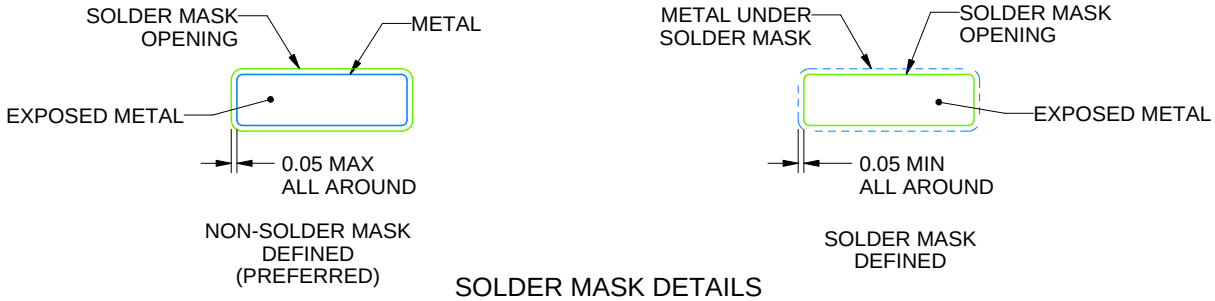


NOTES:

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.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



SOLDER MASK DETAILS

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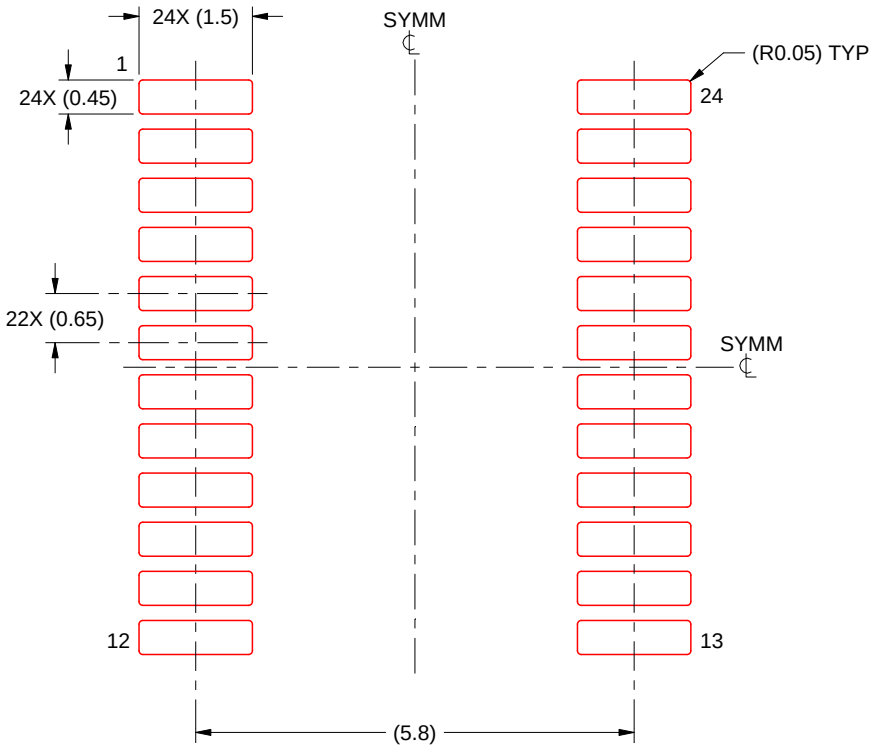
NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



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

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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.

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