

# CDCR83 DIRECT RAMBUS™ CLOCK GENERATOR

SCAS632B – APRIL 2001 – REVISED OCTOBER 2005

- 400-MHz Differential Clock Source for Direct Rambus™ Memory Systems for an 800-MHz Data Transfer Rate
- Synchronizes the Clock Domains of the Rambus Channel With an External System or Processor Clock
- Three Power Operating Modes to Minimize Power for Mobile and Other Power-Sensitive Applications
- Operates From a Single 3.3-V Supply and 120 mW at 300 MHz (Typ)
- Packaged in a Shrink Small-Outline Package (DBQ)
- Supports Frequency Multipliers: 4, 6, 8, 16/3
- No External Components Required for PLL
- Supports Independent Channel Clocking
- Spread Spectrum Clocking Tracking Capability to Reduce EMI
- Designed for Use With TI's 133-MHz Clock Synthesizers CDC924 and CDC921
- Cycle-Cycle Jitter Is Less Than 50 ps at 400 MHz
- Certified by Gigatest Labs to Exceed the Rambus DRCG Validation Requirement
- Supports Industrial Temperature Range of –40°C to 85°C

DBQ PACKAGE  
(TOP VIEW)

VDDIR	1	24	S0
REFCLK	2	23	S1
VDDP	3	22	VDDO
GNDP	4	21	GNDO
GNDI	5	20	CLK
PCLKM	6	19	NC
SYNCLKN	7	18	CLKB
GND C	8	17	GNDO
VDDC	9	16	VDDO
VDDIPD	10	15	MULT0
STOPB	11	14	MULT1
PWRDNB	12	13	S2

NC – No internal connection

## description

The Direct Rambus clock generator (DRCG) provides the necessary clock signals to support a Direct Rambus memory subsystem. It includes signals to synchronize the Direct Rambus channel clock to an external system or processor clock. It is designed to support Direct Rambus memory on a desktop, workstation, server, and mobile PC motherboards. DRCG also provides an off-the-shelf solution for a broad range of Direct Rambus memory applications.

The DRCG provides clock multiplication and phase alignment for a Direct Rambus memory subsystem to enable synchronous communication between the Rambus channel and ASIC clock domains. In a Direct Rambus memory subsystem, a system clock source provides the REFCLK and PCLK clock references to the DRCG and memory controller, respectively. The DRCG multiplies REFCLK and drives a high-speed BUSCLK to RDRAMs and the memory controller. Gear ratio logic in the memory controller divides the PCLK and BUSCLK frequencies by ratios M and N such that  $PCLKM = SYNCLKN$ , where  $SYNCLK = BUSCLK/4$ . The DRCG detects the phase difference between PCLKM and SYNCLKN and adjusts the phase of BUSCLK such that the skew between PCLKM and SYNCLKN is minimized. This allows data to be transferred across the SYNCLK/PCLK boundary without incurring additional latency.

User control is provided by multiply and mode selection terminals. The multiply terminals provide selection of one of four clock frequency multiply ratios, generating BUSCLK frequencies ranging from 267 MHz to 400 MHz with clock references ranging from 33 MHz to 100 MHz. The mode select terminals can be used to select a bypass mode where the frequency multiplied reference clock is directly output to the Rambus channel for systems where synchronization between the Rambus clock and a system clock is not required. Test modes are provided to bypass the PLL and output REFCLK on the Rambus channel and to place the outputs in a high-impedance state for board testing.

The CDCR83 is characterized for operation over free-air temperatures of –40°C to 85°C.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

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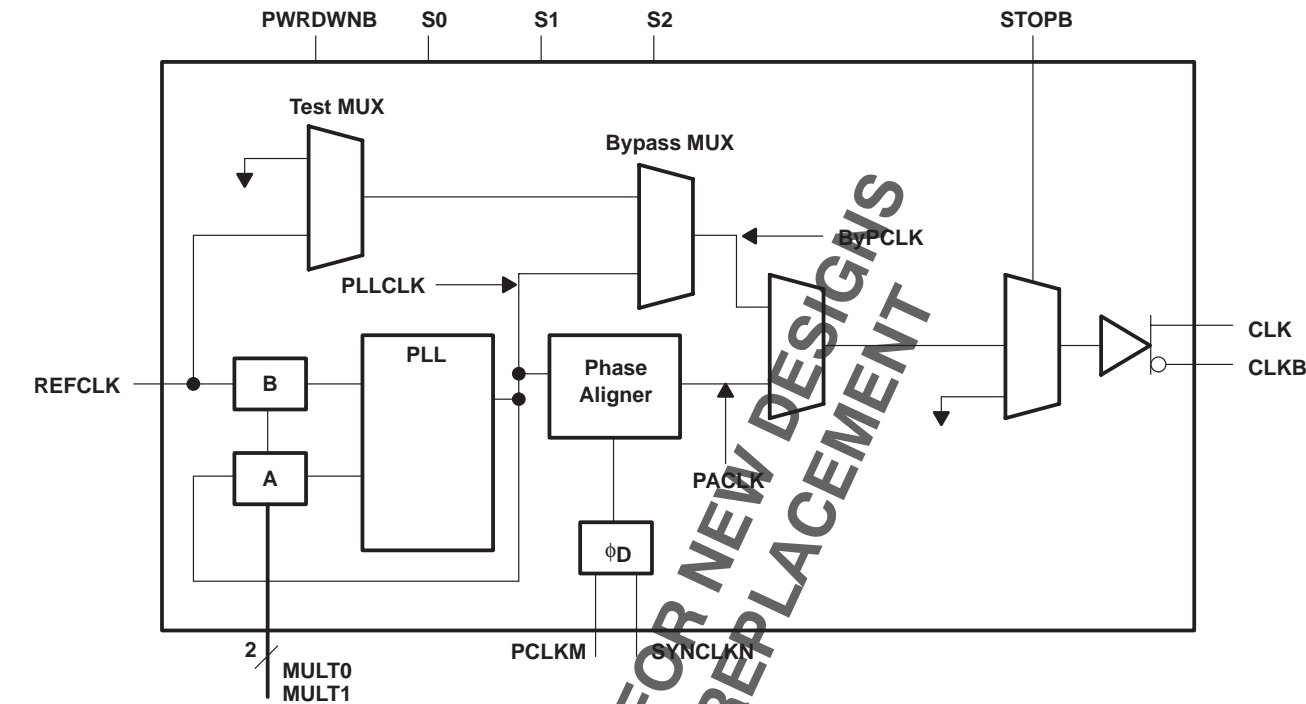
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functional block diagram



FUNCTION TABLE†

MODE	S0	S1	S2	CLK	CLKB
Normal	0	0	0	Phase aligned clock	Phase aligned clock B
Bypass	1	0	0	PLLCLK	PLLCLKB
Test	1	1	0	REFCLK	REFCLKB
Output test (OE)	0	1	X	Hi-Z	Hi-Z
Reserved	0	0	1	—	—
Reserved	1	0	1	—	—
Reserved	1	1	1	Hi-Z	Hi-Z

† X = don't care, Hi-Z = high impedance

### Terminal Functions

TERMINAL NAME	NO.	I/O	DESCRIPTION
CLK	20	O	Output clock
CLKB	18	O	Output clock (complement)
GNDC	8		GND for phase aligner
GNDI	5		GND for control inputs
GNDO	17, 21		GND for clock outputs
GNDP	4		GND for PLL
MULT0	15	I	PLL multiplier select
MULT1	14	I	PLL multiplier select
NC	19		Not used
PCLKM	6	I	Phase detector input
PWRDNB	12	I	Active low power down
REFCLK	2	I	Reference clock
S0	24	I	Mode control
S1	23	I	Mode control
S2	13	I	Mode control
STOPB	11	I	Active low output disable
SYNCLKN	7	I	Phase detector input
V <sub>DDC</sub>	9		V <sub>DD</sub> for phase aligner
V <sub>DDIPD</sub>	10		Reference voltage for phase detector inputs and STOPB
V <sub>DDIR</sub>	1		Reference voltage for REFCLK
V <sub>DDO</sub>	16, 22		V <sub>DD</sub> for clock outputs
V <sub>DDP</sub>	3		V <sub>DD</sub> for PLL

NOT RECOMMENDED FOR NEW DESIGNS  
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## PLL divider selection

Table 1 lists the supported REFCLK and BUSCLK frequencies. Other REFCLK frequencies are permitted, provided that (267 MHz < BUSCLK < 400 MHz) and (33 MHz < REFCLK < 100 MHz).

**Table 1. REFCLK and BUSCLK Frequencies**

MULT0	MULT1	REFCLK (MHz)	MULTIPLY RATIO	BUSCLK (MHz)
0	0	67	4	267
0	1	50	6	300
0	1	67	6	400
1	1	33	8	267
1	1	50	8	400
1	0	67	16/3	356

**Table 2. Clock Output Driver States**

STATE	PWRDNB	STOPB	CLK	CLKB
Powerdown	0	X	GND	GND
CLK stop	1	0	V <sub>X</sub> , STOP	V <sub>X</sub> , STOP
Normal	1	1	PACLK/PLLCLK/ REFCLK†	PACCLKB/PLLCLKB/ REFCLKB

† Depending on the state of S0, S1, and S2

## absolute maximum ratings over operating free-air temperature (unless otherwise noted)†

Supply voltage range, V <sub>DD</sub> (see Note 1)	–0.5 V to 4 V
Output voltage range, V <sub>O</sub> , at any output terminal	–0.5 V to V <sub>DD</sub> + 0.5 V
Input voltage range, V <sub>I</sub> , at any input terminal	–0.5 V to V <sub>DD</sub> + 0.5 V
Continuous total power dissipation	see Dissipation Rating Table
Operating free-air temperature range, T <sub>A</sub>	–40°C to 85°C
Storage temperature range, T <sub>stg</sub>	–65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°C

† 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.

NOTE 1: All voltage values are with respect to the GND terminals.

**DISSIPATION RATING TABLE**

PACKAGE	T <sub>A</sub> ≤ 25°C POWER RATING	DERATING FACTOR ABOVE T <sub>A</sub> = 25°C‡	T <sub>A</sub> = 70°C POWER RATING	T <sub>A</sub> = 85°C POWER RATING
DBQ	1400 mW	11 mW/°C	905 mW	740 mW

‡ This is the inverse of the junction-to-ambient thermal resistance when board-mounted and with no air flow.

### recommended operating conditions

	MIN	NOM	MAX	UNIT
Supply voltage, $V_{DD}$	3.135	3.3	3.465	V
High-level input voltage, $V_{IH}$ (CMOS)	$0.7 \times V_{DD}$			V
Low-level input voltage, $V_{IL}$ (CMOS)			$0.3 \times V_{DD}$	V
Initial phase error at phase detector inputs (required range for phase aligner)	$-0.5 \times t_c(PD)$		$0.5 \times t_c(PD)$	
REFCLK low-level input voltage, $V_{IL}$			$0.3 \times V_{DDIR}$	V
REFCLK high-level input voltage, $V_{IH}$	$0.7 \times V_{DDIR}$			V
Input signal low voltage, $V_{IL}$ (STOPB)			$0.3 \times V_{DDIPD}$	V
Input signal high voltage, $V_{IH}$ (STOPB)	$0.7 \times V_{DDIPD}$			V
Input reference voltage for (REFCLK) ( $V_{DDIR}$ )	1.235		3.465	V
Input reference voltage for (PCLKM and SYSCLKN) ( $V_{DDIPD}$ )	1.235		3.465	V
High-level output current, $I_{OH}$			-16	mA
Low-level output current, $I_{OL}$			16	mA
Operating free-air temperature, $T_A$	-40		85	°C

### timing requirements

	MIN	MAX	UNIT
Input cycle time, $t_{c(in)}$	10	40	ns
Input cycle-to-cycle jitter		250	ps
Input duty cycle over 10,000 cycles	40%	60%	
Input frequency modulation, $f_{mod}$	30	33	kHz
Modulation index, nonlinear maximum 0.5%		0.6%	
Phase detector input cycle time (PCLKM and SYNCLKN)	30	100	ns
Input slew rate, SR	1	4	V/ns
Input duty cycle (PCLKM and SYNCLKN)	25%	75%	

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

PARAMETER		TEST CONDITIONS†		MIN	TYP‡	MAX	UNIT	
V <sub>O(STOP)</sub>	Output voltage during CLK Stop (STOPB = 0)	See Figure 1		1.1		2		
V <sub>O(X)</sub>	Output crossing-point voltage	See Figure 1 and Figure 6		1.3		1.8	V	
V <sub>O</sub>	Output voltage swing	See Figure 1		0.4		0.6	V	
V <sub>IK</sub>	Input clamp voltage	V <sub>DD</sub> = 3.135 V, I <sub>I</sub> = −18 mA				−1.2	V	
V <sub>OH</sub>	High-level output voltage	See Figure 1				2	V	
		V <sub>DD</sub> = min to max, I <sub>OH</sub> = 1 mA		V <sub>DD</sub> − 0.1 V				
		V <sub>DD</sub> = 3.135 V, I <sub>OH</sub> = 16 mA		2.4				
V <sub>OL</sub>	Low-level output voltage	See Figure 1		1			V	
		V <sub>DD</sub> = min to max, I <sub>OL</sub> = 1 mA		0.1				
		V <sub>DD</sub> = 3.135 V, I <sub>OL</sub> = 16 mA		0.5				
I <sub>OH</sub>	High-level output current	V <sub>DD</sub> = 3.135 V, V <sub>O</sub> = 1.95 V		−32	−52		mA	
		V <sub>DD</sub> = 3.3 V, V <sub>O</sub> = 1.65 V		−51				
		V <sub>DD</sub> = 3.465 V, V <sub>O</sub> = 3.135 V		−14.5	−21			
I <sub>OL</sub>	Low-level output current	V <sub>DD</sub> = 3.135 V, V <sub>O</sub> = 1.95 V		43	61.5		mA	
		V <sub>DD</sub> = 3.3 V, V <sub>O</sub> = 1.65 V		65				
		V <sub>DD</sub> = 3.465 V, V <sub>O</sub> = 0.4 V		25.5 36				
I <sub>OZ</sub>	High-impedance-state output current	S0 = 0, S1 = 1				±10	μA	
I <sub>OZ(STOP)</sub>	High-impedance-state output current during CLK stop	Stop = 0, V <sub>O</sub> = GND or V <sub>DD</sub>				±100	μA	
I <sub>OZ(PD)</sub>	High-impedance-state output current in power-down state	PWRDNB = 0, V <sub>O</sub> = GND or V <sub>DD</sub>		−10		100	μA	
I <sub>IH</sub>	High-level input current	REFCLK, PCLKM, SYNCLKN, STOPB	V <sub>DD</sub> = 3.465 V, V <sub>I</sub> = V <sub>DD</sub>			10	μA	
		PWRDNB, S0, S1, S2, MULT0, MULT1	V <sub>DD</sub> = 3.465 V, V <sub>I</sub> = V <sub>DD</sub>			10		
I <sub>IL</sub>	Low-level input current	REFCLK, PCLKM, SYNCLKN, STOPB	V <sub>DD</sub> = 3.465 V, V <sub>I</sub> = 0			−10	μA	
		PWRDNB, S0, S1, S2, MULT0, MULT1	V <sub>DD</sub> = 3.465 V, V <sub>I</sub> = 0			−10		
Z <sub>O</sub>	Output impedance	High state	R <sub>I</sub> at I <sub>O</sub> −14.5 mA to −16.5 mA		15	35	50	Ω
		Low state	R <sub>I</sub> at I <sub>O</sub> 14.5 mA to 16.5 mA		11	17	35	
	Reference current	V <sub>DDIR</sub> , V <sub>DDIPD</sub>	V <sub>DD</sub> = 3.465 V	PWRDNB = 0		50		μA
				PWRDNB = 1		0.5		mA
C <sub>I</sub>	Input capacitance	V <sub>I</sub> = V <sub>DD</sub> or GND		2			pF	
C <sub>O</sub>	Output capacitance	V <sub>O</sub> = V <sub>DD</sub> or GND		3			pF	
I <sub>DD(PD)</sub>	Supply current in power-down state	REFCLK = 0 MHz to 100 MHz, PWDNB = 0, STOPB = 1				100	μA	
I <sub>DD(CLKSTOP)</sub>	Supply current in CLK stop state	BUSCLK configured for 400 MHz				30	mA	
I <sub>DD(NORMAL)</sub>	Supply current in normal state	BUSCLK = 400 MHz				70	mA	

†  $V_{DD}$  refers to any of the following:  $V_{DD}$ ,  $V_{DDIPD}$ ,  $V_{DDIR}$ ,  $V_{DDO}$ ,  $V_{DDC}$ , and  $V_{DDP}$

‡ All typical values are at  $V_{DD} = 3.3\text{ V}$ ,  $T_A = 25^\circ\text{C}$ .

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

PARAMETER				TEST CONDITIONS	MIN	TYP†	MAX	UNIT
t <sub>c(out)</sub>	Clock output cycle time				2.5		3.75	ns
t <sub>(jitter)</sub>	Total cycle jitter over 1, 2, 3, 4, 5, or 6 clock cycles	Infinite and stopped phase alignment	267 MHz	See Figure 3			80	ps
			300 MHz				70	
			356 MHz				60	
			400 MHz				50	
t <sub>(phase)</sub>	Phase detector phase error for distributed loop			Static phase error‡	−100		100	ps
t <sub>(phase, SSC)</sub>	PLL output phase error when tracking SSC			Dynamic phase error‡	−100		100	ps
t <sub>(DC)</sub>	Output duty cycle over 10,000 cycles			See Figure 4	45%		55%	
t <sub>(DC, err)</sub>	Output cycle-to-cycle duty cycle error	Infinite and stopped phase alignment	267 MHz	See Figure 5			80	ps
			300 MHz				70	
			356 MHz				60	
			400 MHz				50	
t <sub>r</sub> , t <sub>f</sub>	Output rise and fall times (measured at 20%–80% of output voltage)			See Figure 7	160		400	ps
Δt	Difference between rise and fall times on a single device (20%–80%)  t <sub>f</sub> – t <sub>r</sub>			See Figure 7			100	ps

† All typical values are at  $V_{DD} = 3.3$  V,  $T_A = 25^\circ\text{C}$ .

‡ Assured by design

### state transition latency specifications

PARAMETER		FROM	TO	TEST CONDITIONS	MIN	TYP†	MAX	UNIT
$t_{(powerup)}$	Delay time, PWRDNB↑ to CLK/CLKB output settled (excluding $t_{(DISTLOCK)}$ )	Powerdown	Normal	See Figure 8			3	ms
	Delay time, PWRDNB↑ to internal PLL and clock are on and settled						3	
$t_{(VDDpowerup)}$	Delay time, power up to CLK/CLKB output settled	$V_{DD}$	Normal	See Figure 8			3	ms
	Delay time, power up to internal PLL and clock are on and settled						3	
$t_{(MULT)}$	MULT0 and MULT1 change to CLK/CLKB output resettled (excluding $t_{(DISTLOCK)}$ )	Normal	Normal	See Figure 9			1	ms
$t_{(CLKON)}$	STOPB↑ to CLK/CLKB glitch-free clock edges	CLK Stop	Normal	See Figure 10			10	ns
$t_{(CLKSETL)}$	STOPB↑ to CLK/CLKB output settled to within 50 ps of the phase before STOPB was disabled	CLK Stop	Normal	See Figure 10			20	cycles
$t_{(CLKOFF)}$	STOPB↓ to CLK/CLKB output disabled	Normal	CLK Stop	See Figure 10			5	ns

† All typical values are at  $V_{DD} = 3.3$  V,  $T_A = 25^\circ\text{C}$ .

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### state transition latency specifications (continued)

PARAMETER	FROM	TO	TEST CONDITIONS	MIN	TYP†	MAX	UNIT
t(powerdown)	Delay time, PWRDNB↓ to the device in the power-down mode	Normal	Powerdown	See Figure 8		1	ms
t(STOP)	Maximum time in CLKSTOP (STOPB = 0) before reentering normal mode (STOPB = 1)	STOPB	Normal	See Figure 10		100	μs
t(ON)	Minimum time in normal mode (STOPB = 1) before reentering CLKSTOP (STOPB = 0)	Normal	CLK stop	See Figure 10	100		ms
t(DISTLOCK)	Time from when CLK/CLKB output is settled to when the phase error between SYNCLKN and PCLKM falls within t(phase)	Unlocked	Locked			5	ms

† All typical values are at V<sub>DD</sub> = 3.3 V, T<sub>A</sub> = 25°C.

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## PARAMETER MEASUREMENT INFORMATION

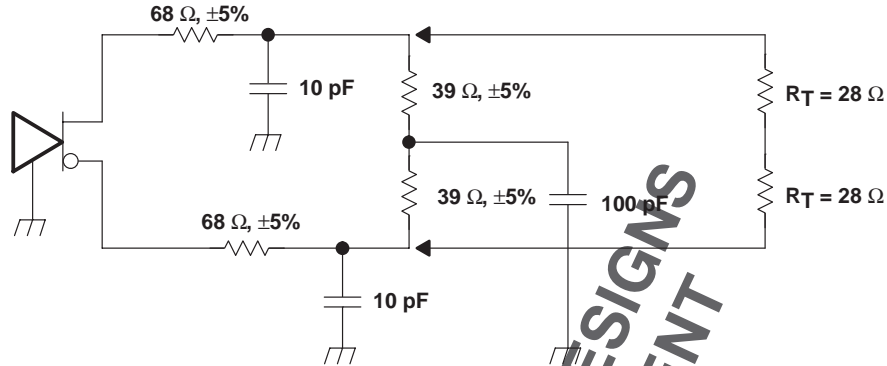


Figure 1. Test Load and Voltage Definitions ( $V_{O(STOP)}$ ,  $V_{O(X)}$ ,  $V_O$ ,  $V_{OH}$ ,  $V_{OL}$ )

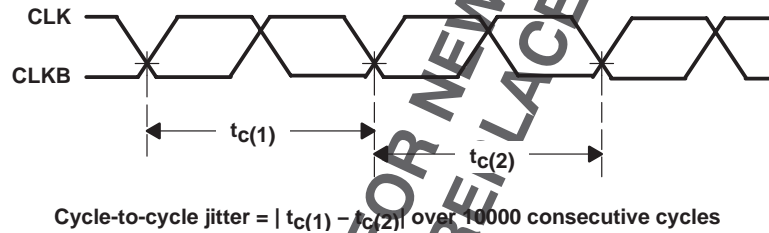


Figure 2. Cycle-to-Cycle Jitter

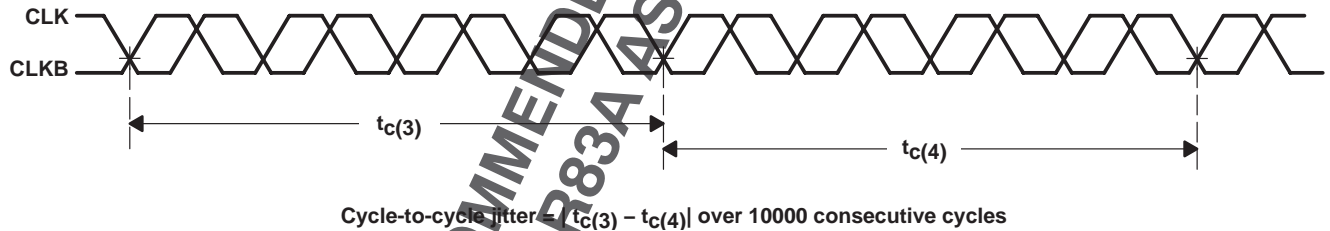
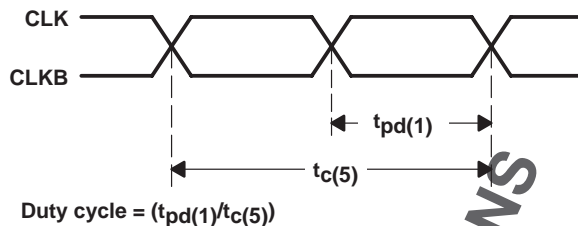
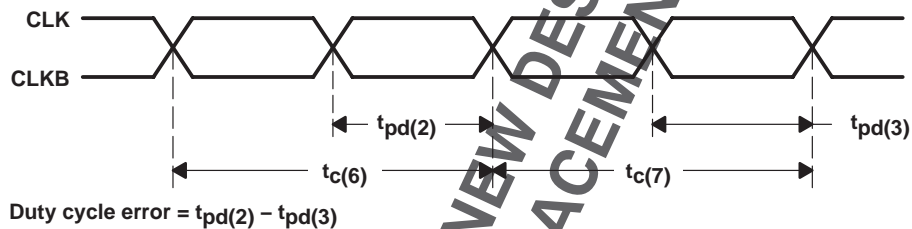


Figure 3. Short Term Cycle-to-Cycle Jitter Over Four Cycles

**PARAMETER MEASUREMENT INFORMATION**



**Figure 4. Output Duty Cycle**



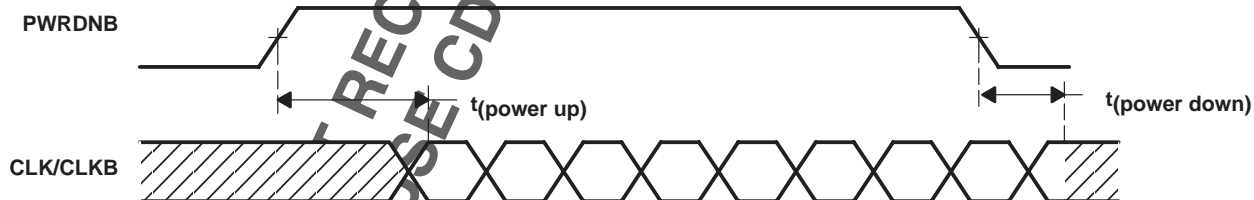
**Figure 5. Duty Cycle Error (Cycle-to-Cycle)**



**Figure 6. Crossing-Point Voltage**



**Figure 7. Voltage Waveforms**



**Figure 8. PWRDNB Transition Timings**

PARAMETER MEASUREMENT INFORMATION

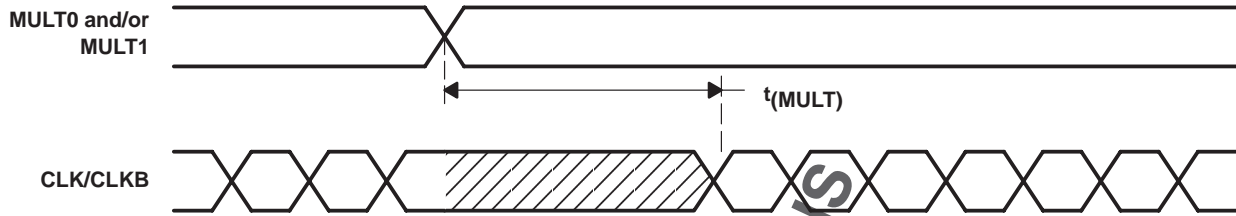
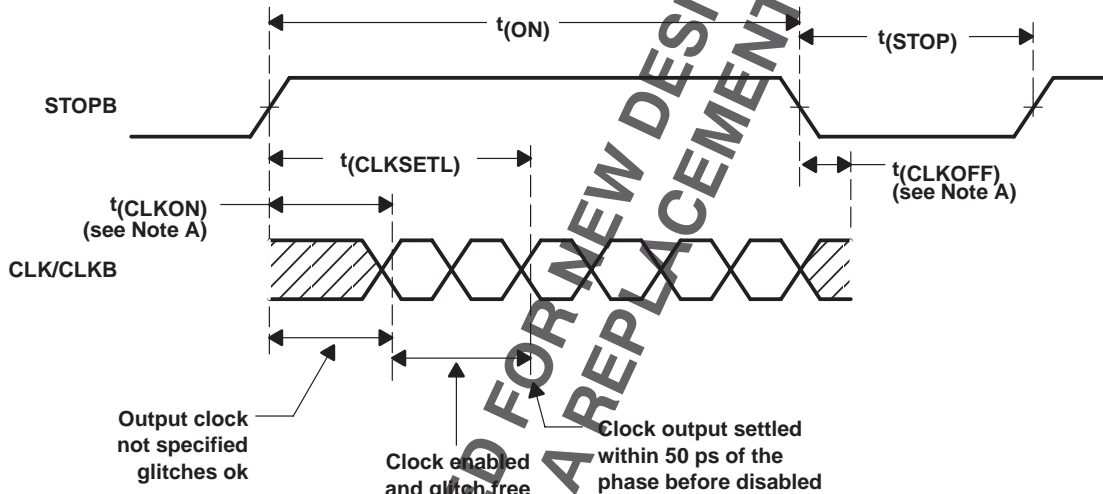


Figure 9. MULT Transition Timings



NOTE A:  $V_{ref} = V_O \pm 200 \text{ mV}$

Figure 10. STOPB Transition Timings

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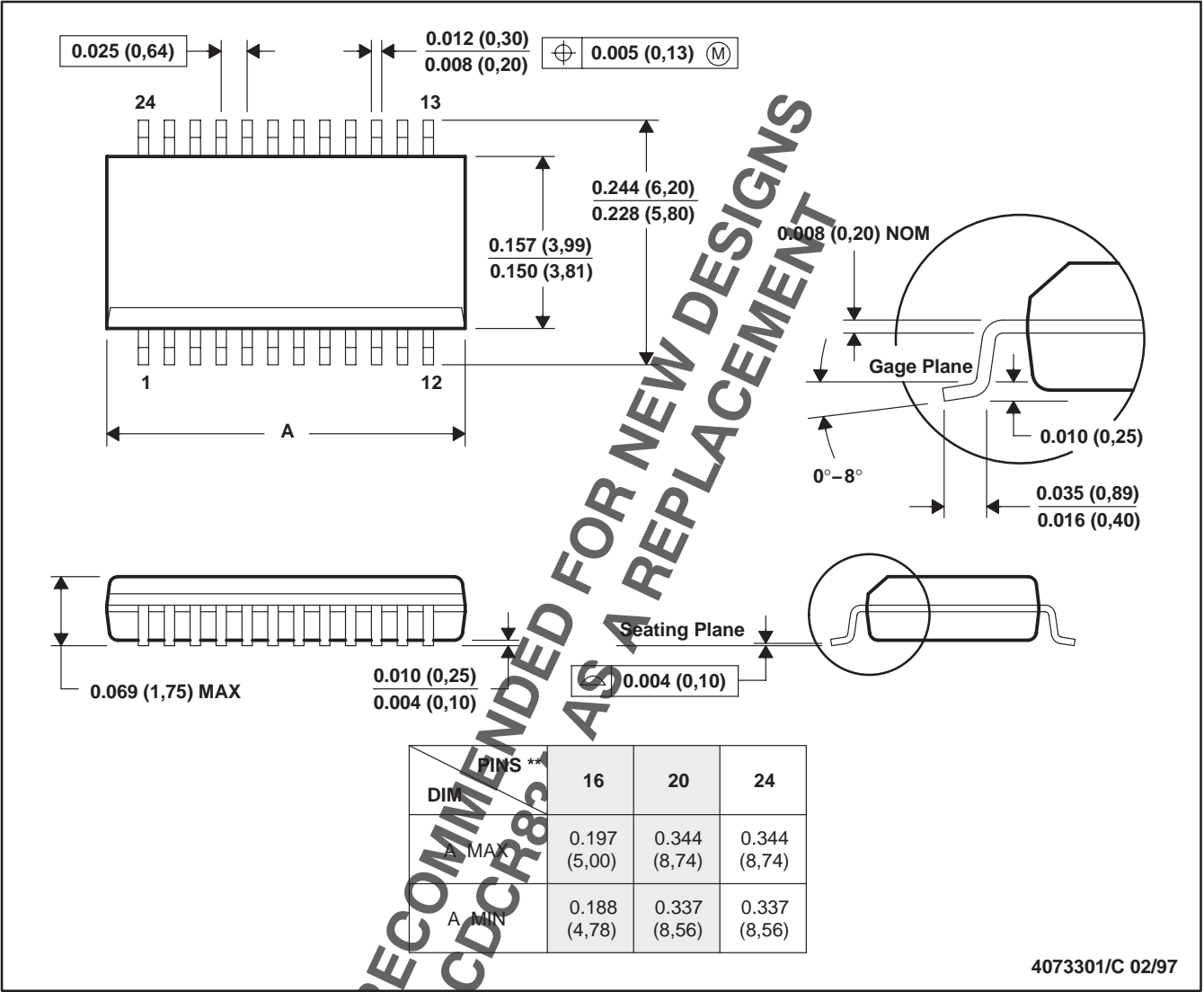
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MECHANICAL DATA

DBQ (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

24-PIN SHOWN



- NOTES: A. All linear dimensions are in inches (millimeters).  
B. This drawing is subject to change without notice.  
C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).  
D. Falls within JEDEC MO-13.

## PACKAGING INFORMATION

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
CDCR83DBQ	NRND	SSOP/ QSOP	DBQ	24	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
CDCR83DBQG4	NRND	SSOP/ QSOP	DBQ	24	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
CDCR83DBQQR	NRND	SSOP/ QSOP	DBQ	24	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
CDCR83DBQQRG4	NRND	SSOP/ QSOP	DBQ	24	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

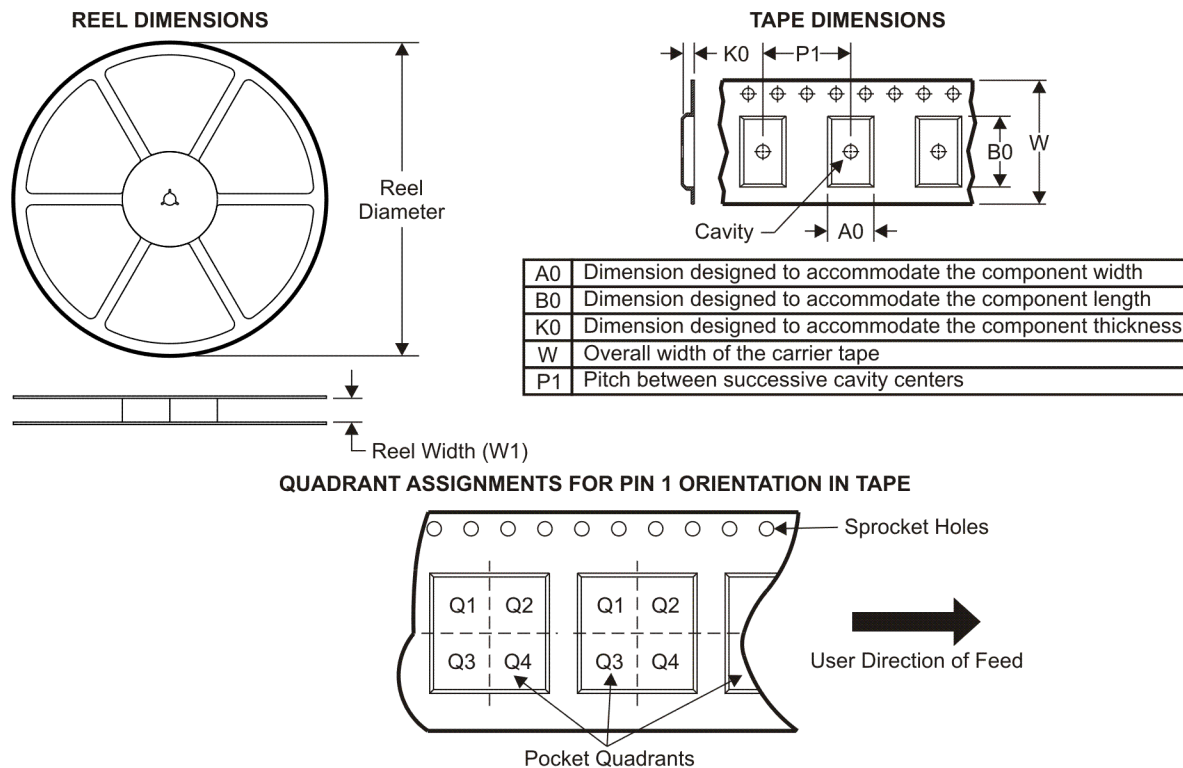
**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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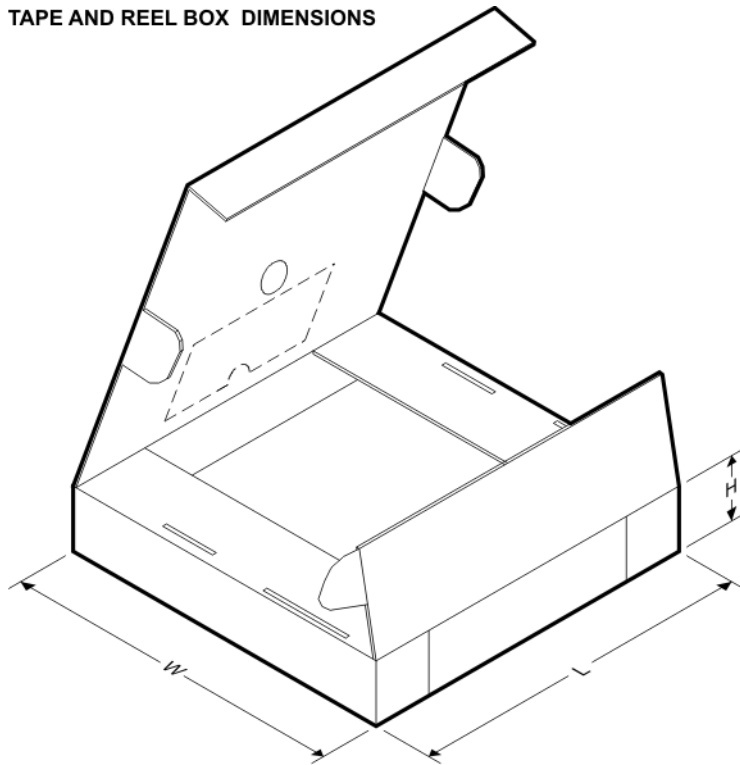
**TAPE AND REEL INFORMATION**



\*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
CDCR83DBQR	SSOP/QSOP	DBQ	24	2500	330.0	16.4	6.5	9.0	2.1	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)
CDCR83DBQR	SSOP/QSOP	DBQ	24	2500	346.0	346.0	33.0

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