



CDC3RL02 Low Phase-Noise Two-Channel Clock Fan-Out Buffer

1 Features

- Low Additive Noise:
 - -149 dBc/Hz at 10-kHz Offset Phase Noise
 - 0.37 ps (RMS) Output Jitter
- Limited Output Slew Rate for EMI Reduction (1- to 5-ns Rise/Fall Time for 10-pF to 50-pF Loads)
- Adaptive Output Stage Controls Reflection
- Regulated 1.8-V Externally Available I/O Supply
- Ultra-Small 8-bump YFP 0.4-mm Pitch WCSP (0.8 mm × 1.6 mm)
- ESD Performance Exceeds JESD 22
 - 2000-V Human-Body Model (A114-A)
 - 1000-V Charged-Device Model (JESD22-C101-A Level III)

2 Applications

- Cellular Phones
- Global Positioning Systems (GPS)
- Wireless LAN
- FM Radio
- WiMAX
- W-BT

3 Description

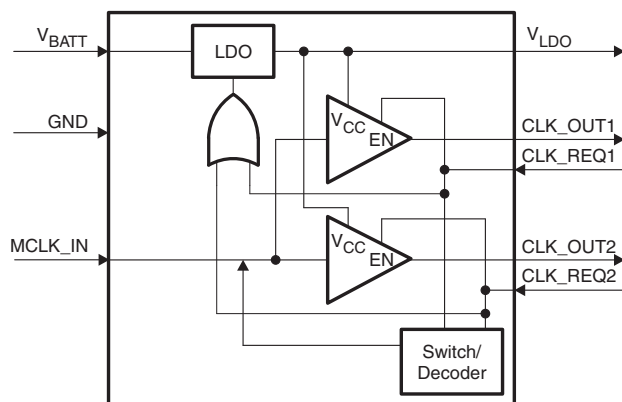
The CDC3RL02 is a two-channel clock fan-out buffer and is ideal for use in portable end-equipment, such as mobile phones, that require clock buffering with minimal additive phase noise and fan-out capabilities. It buffers a single master clock, such as a temperature compensated crystal oscillator (TCXO) to multiple peripherals. The device has two clock request inputs (CLK_REQ1 and CLK_REQ2), each of which enable a single clock output.

The CDC3RL02 accepts square or sine waves at the master clock input (MCLK_IN), eliminating the need for an AC coupling capacitor. The smallest acceptable sine wave is a 0.3-V signal (peak-to-peak). CDC3RL02 has been designed to offer minimal channel-to-channel skew, additive output jitter, and additive phase noise. The adaptive clock output buffers offer controlled slew-rate over a wide capacitive loading range which minimizes EMI emissions, maintains signal integrity, and minimizes ringing caused by signal reflections on the clock distribution lines.

The CDC3RL02 has an integrated Low-Drop-Out (LDO) voltage regulator which accepts input voltages from 2.3 V to 5.5 V and outputs 1.8 V, 50 mA. This 1.8-V supply is externally available to provide regulated power to peripheral devices such as a TCXO.

The CDC3RL02 is offered in a 0.4-mm pitch wafer-level chip-scale (WCSP) package (0.8 mm × 1.6 mm) and is optimized for very low standby current consumption.

Simplified Block Diagram



Device Information⁽¹⁾

PART NUMBER	PACKAGE	BODY SIZE (NOM)
CDC3RL02	DSBGA (8)	0.80 mm × 1.60 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.



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4 Revision History

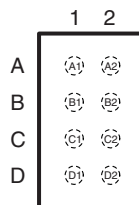
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision A (September 2015) to Revision B	Page
• Added <i>Thermal Information</i> table, <i>Overview</i> , <i>Feature Description</i> section, <i>Power Supply Recommendations</i> section, and <i>Layout</i> section	1

Changes from Original (November 2009) to Revision A	Page
• Formatted document to new standards.	1

5 Pin Configuration and Functions

**YFP Package
8-Pin DSBGA
Top View**



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
V _{BATT}	A1	I	Input to internal LDO
CLK_OUT1	A2	O	Clock output 1
V _{LDO}	B1	O	1.8 V I/O supply for CDC3RL02 and external TCXO
CLK_REQ1	B2	I	Clock request from peripheral 2
MCLK_IN	C1	I	Master clock input
CLK_REQ2	C2	I	Clock request from peripheral 1
GND	D1	–	Ground
CLK_OUT2	D2	O	Clock output 2

YFP Package Pin Assignments

	1	2
A	V _{BATT}	CLK_OUT1
B	V _{LDO}	CLK_REQ1
C	MCLK_IN	CLK_REQ2
D	GND	CLK_OUT2

6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
V _{BATT}	Voltage range ⁽²⁾	–0.3	7	V
	Voltage range ⁽³⁾	–0.3	V _{BATT} + 0.3	V
		–0.3	V _{BATT} + 0.3	
I _{IK}	Input clamp current at V _{BATT} , CLK_REQ_1/2, and MCLK_IN	V _I < 0	–50	mA
I _O	Continuous output current		±20	mA
	Continuous current through GND, V _{BATT} , V _{LDO}		±50	mA
T _J	Operating virtual junction temperature	–40	150	°C
T _A	Operating ambient temperature range	–40	85	°C
T _{stg}	Storage temperature range	–55	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) The input negative-voltage and output voltage ratings may be exceeded if the input and output current ratings are observed.

(3) All voltage values are with respect to network ground pin.

6.2 ESD Ratings

		VALUE	UNIT
V _(ESD)	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾	±2000
		Charged-device model (CDM), per JEDEC specification JESD22-C101 ⁽²⁾	±1000
		Machine Model	200

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process. Manufacturing with less than 500-V HBM is possible with the necessary precautions.
- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process. Manufacturing with less than 250-V CDM is possible with the necessary precautions.

6.3 Recommended Operating Conditions

See ⁽¹⁾

			MIN	MAX	UNIT
V _{BATT}	Input voltage to internal LDO		2.3	5.5	V
V _I	Input voltage	MCLK_IN, CLK_REQ1/2	0	1.89	V
V _O	Output voltage	CLK_OUT1/2	0	1.8	V
V _{IH}	High-level input voltage	CLK_REQ1/2	1.3	1.89	V
V _{IL}	Low-level input voltage	CLK_REQ1/2	0	0.5	V
I _{OH}	High-level output current, DC current		–8		mA
I _{OL}	Low-level output current, DC current			8	mA

- (1) All unused inputs of the device must be held at V_{CC} or GND to ensure proper device operation. See the TI application report, *Implications of Slow or Floating CMOS Inputs*, [SCBA004](#).

6.4 Thermal Information

THERMAL METRIC ⁽¹⁾		CDC3RL02	UNIT
		YFP (TSSOP)	
		8 PINS	
R _{θJA}	Junction-to-ambient thermal resistance	107.8	°C/W
R _{θJC(top)}	Junction-to-case (top) thermal resistance	1.3	°C/W
R _{θJB}	Junction-to-board thermal resistance	18.1	°C/W
ψ _{JT}	Junction-to-top characterization parameter	4.5	°C/W
ψ _{JB}	Junction-to-board characterization parameter	18.1	°C/W

- (1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, [SPRA953](#).

6.5 Electrical Characteristics

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

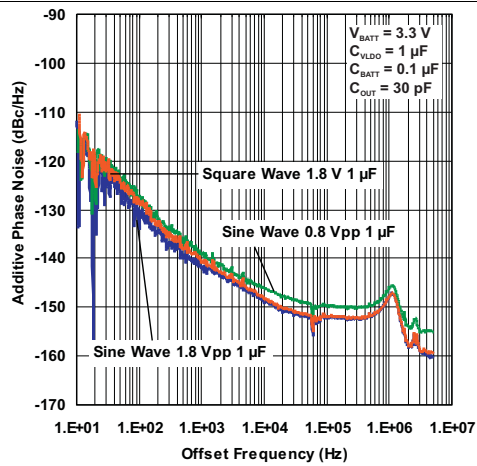
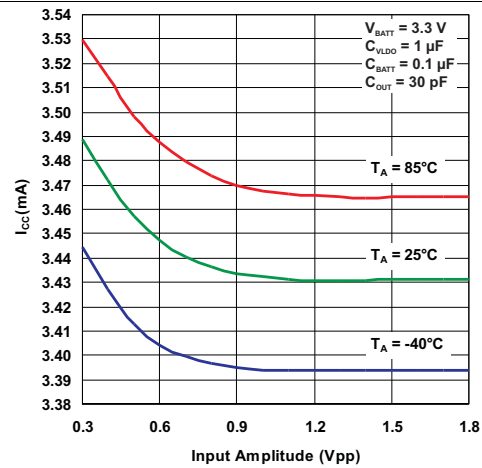
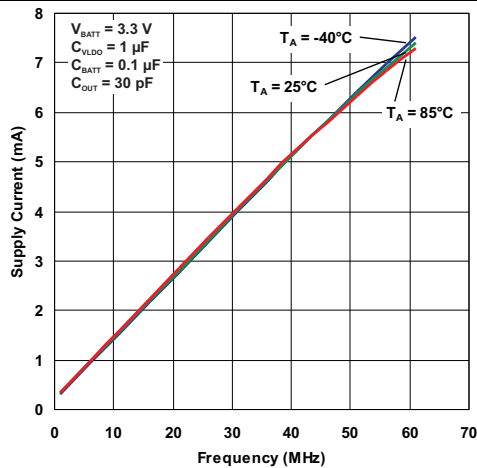
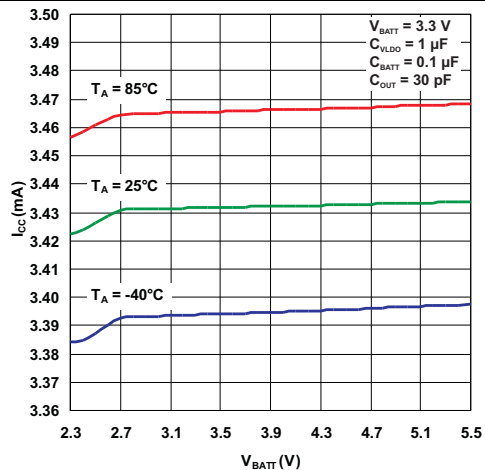
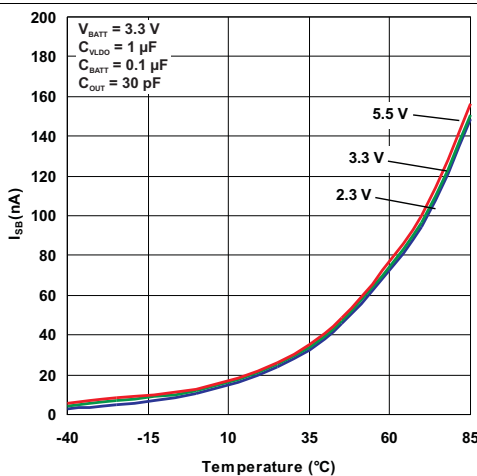
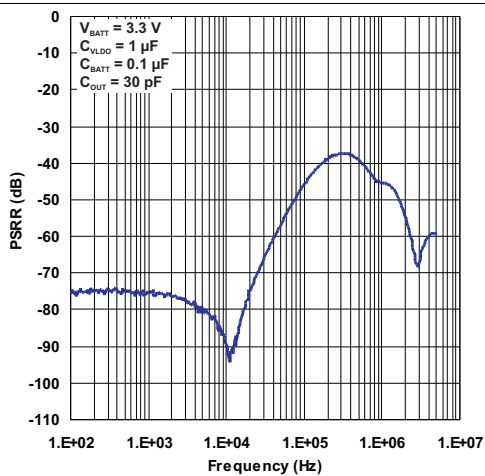
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
LDO						
V _{OUT}	LDO output voltage	I _{OUT} = 50 mA	1.71	1.8	1.89	V
C _{LDO}	External load capacitance		1		10	μF
I _{OUT(SC)}	Short circuit output current	R _L = 0 Ω		100		mA
I _{OUT(PK)}	Peak output current	V _{BATT} = 2.3 V, V _{LDO} = V _{OUT} – 5%			100	mA
PSR	Power supply rejection	V _{BATT} = 2.3 V, I _{OUT} = 2 mA,	f _{IN} = 217 Hz and 1 kHz	60		dB
			f _{IN} = 3.25 MHz	40		
t _{SU}	LDO startup time	V _{BATT} = 2.3 V, C _{LDO} = 1 μF, CLK_REQ_n to V _{LDO} = 1.71 V		0.2		ms
		V _{BATT} = 5.5 V, C _{LDO} = 10 μF, CLK_REQ_n to V _{LDO} = 1.71 V			1	

Electrical Characteristics (continued)

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
POWER CONSUMPTION						
I_{SB}	Standby current	Device in standby (all $V_{CLK_REQ_n} = 0$ V)		0.2	1	μ A
I_{CCS}	Static current consumption	Device active but not switching		0.4	1	mA
I_{OB}	Output buffer average current	$f_{IN} = 26$ MHz, $C_{LOAD} = 50$ pF		4.2		mA
C_{PD}	Output power dissipation capacitance	$f_{IN} = 26$ MHz			44	pF
MCLK_IN INPUT						
I_I	MCLK_IN, CLK_REQ_1/2 leakage current	$V_I = V_{LDO}$ or GND			1	μ A
C_I	MCLK_IN capacitance	$f_{IN} = 26$ MHz		4.75		pF
R_I	MCLK_IN impedance	$f_{IN} = 26$ MHz		6		k Ω
f_{IN}	MCLK_IN frequency range		10	26	52	MHz
MCLK_IN LVCMOS SOURCE						
Additive phase noise	$f_{IN} = 26$ MHz, $t_r/t_f \leq 1$ ns	1-kHz offset		–140		dBc/Hz
		10-kHz offset		–149		
		100-kHz offset		–153		
		1-MHz offset		–148		
Additive jitter	$f_{IN} = 26$ MHz, $V_{PP} = 0.8$ V, BW = 10–5 MHz			0.37		ps (rms)
t_{DL}	MCLK_IN to CLK_OUT_n propagation delay			11		ns
DC_L	Output duty cycle	$f_{IN} = 26$ MHz, $DC_{IN} = 50\%$	45%	50%	55%	
MCLK_IN SINUSOIDAL SOURCE						
V_{MA}	Input amplitude		0.3		1.8	V
Additive phase noise	$f_{IN} = 26$ MHz, $V_{MA} = 1.8$ V _{PP}	1-kHz offset		–141		dBc/Hz
		10-kHz offset		–149		
		100-kHz offset		–152		
		1-MHz offset		–148		
	$f_{IN} = 26$ MHz, $V_{MA} = 0.8$ V _{PP}	1-kHz offset		–139		
		10-kHz offset		–146		
		100-kHz offset		–150		
		1-MHz offset		–146		
Additive jitter	$f_{IN} = 26$ MHz, $V_{MA} = 1.8$ V _{PP} , BW = 10–5 MHz			0.41		ps (RMS)
t_{DS}	MCLK_IN to CLK_OUT_1/2 propagation delay			12		ns
DC_S	Output duty cycle	$f_{IN} = 26$ MHz, $V_{MA} > 1.8$ V _{PP}	45%	50%	55%	
CLK_OUT_N OUTPUTS						
t_r	20% to 80% rise time	$C_L = 10$ pF to 50 pF		1	5.2	ns
t_f	20% to 80% fall time	$C_L = 10$ pF to 50 pF		1	5.2	ns
t_{sk}	Channel-to-channel skew	$C_L = 10$ pF to 50 pF ($C_{L1} = C_{L2}$)		–0.5	0.5	ns
V_{OH}	High-level output voltage	$I_{OH} = -100$ μ A, reference to V_{LDO}		–0.1		V
		$I_{OH} = -8$ mA		1.2		
V_{OL}	Low-level output voltage	$I_{OL} = 20$ μ A			0.2	V
		$I_{OL} = 8$ mA			0.55	

6.6 Typical Characteristics


Figure 1. Additive Phase Noise vs Offset Frequency

Figure 2. Supply Current vs Input Amplitude

Figure 3. Supply Current vs Input Frequency

Figure 4. Supply Current vs Supply Voltage

Figure 5. Standby Current vs Temperature

Figure 6. Power Supply Rejection vs Input Frequency

Typical Characteristics (continued)

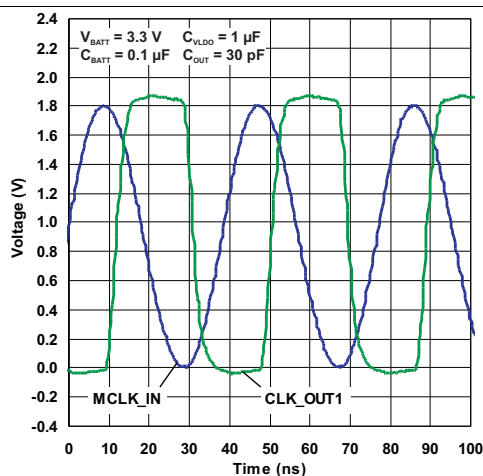


Figure 7. Sine-Wave Input vs Square-Wave Output

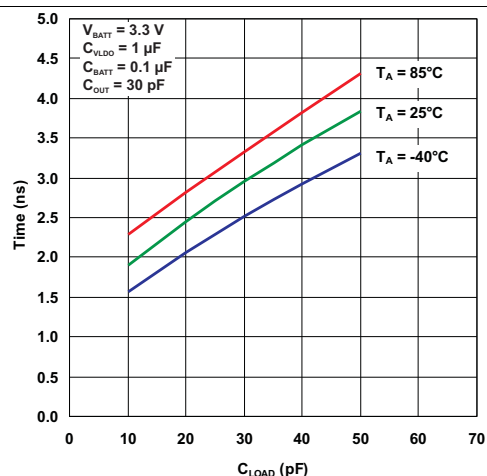


Figure 8. Rise Time vs Load

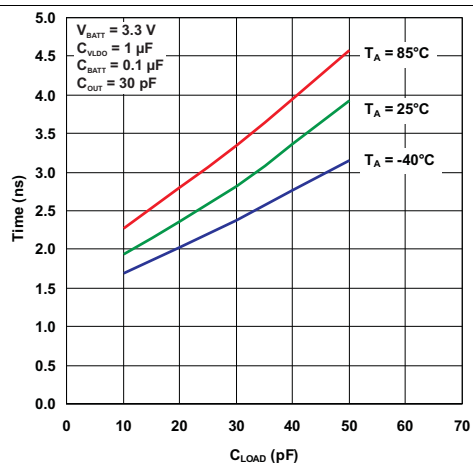


Figure 9. Fall Time vs Load

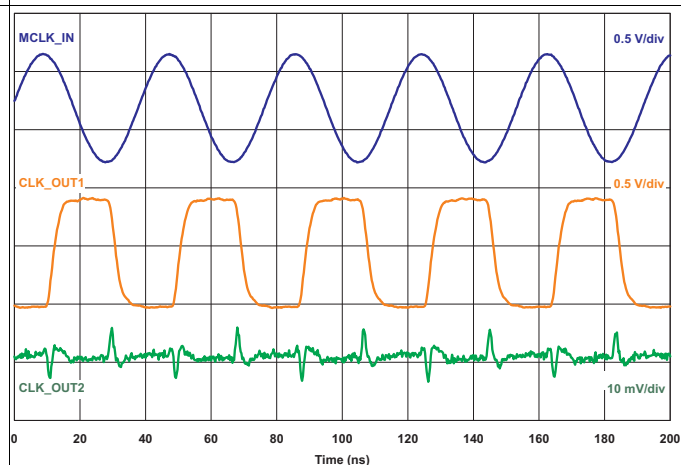


Figure 10. Digital Cross-Talk Scope Shot

7 Detailed Description

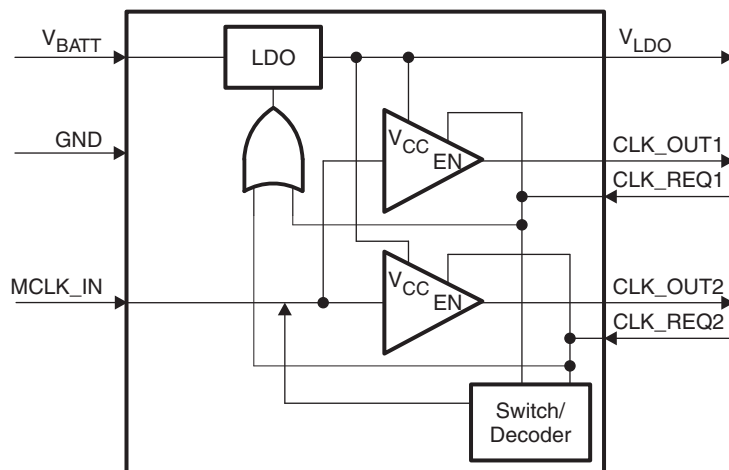
7.1 Overview

The CDC3RL02 is a two-channel clock fan-out buffer and is ideal for use in portable end-equipment, such as mobile phones, that require clock buffering with minimal additive phase noise and fan-out capabilities. It buffers a single master clock, such as a temperature compensated crystal oscillator (TCXO) to multiple peripherals. The device has two clock request inputs (CLK_REQ1 and CLK_REQ2), each of which enable a single clock output.

The CDC3RL02 accepts square or sine waves at the master clock input (MCLK_IN), eliminating the need for an AC coupling capacitor. The smallest acceptable sine wave is a 0.3-V signal (peak-to-peak). CDC3RL02 has been designed to offer minimal channel-to-channel skew, additive output jitter, and additive phase noise. The adaptive clock output buffers offer controlled slew-rate over a wide capacitive loading range which minimizes EMI emissions, maintains signal integrity, and minimizes ringing caused by signal reflections on the clock distribution lines.

The CDC3RL02 has an integrated Low-Drop-Out (LDO) voltage regulator which accepts input voltages from 2.3 V to 5.5 V and outputs 1.8 V, 50 mA. This 1.8-V supply is externally available to provide regulated power to peripheral devices such as a TCXO.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 Low Additive Noise

The CDC3RL02 features –149 dBc/Hz at 10 kHz offset phase noise and 0.37 ps (RMS) of output jitter, to make sure that the buffered signals are clean.

7.3.2 Regulated 1.8-V Externally Available I/O Supply

The CDC3RL02 allows users to connect to the output of the internal LDO, for providing power to other ICs. For more information, refer to [LDO](#).

7.3.3 Ultra-Small 8-bump YFP 0.4-mm Pitch WCSP Package

Using the ultra-small YFP package, the CDC3RL02 is very small and allows it to be placed on a board with minimum work.

7.4 Device Functional Modes

[Table 1](#) is the function table for CDC3RL02.

Table 1. Function Table

INPUTS			OUTPUTS	
CLK_REQ1	CLK_REQ2	MCLK_IN	CLK_OUT1	CLK_OUT2
L	L	X	L	L
L	H	CLK	L	CLK
H	L	CLK	CLK	L
H	H	CLK	CLK	CLK

8 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

8.1.1 Input Clock Squarer

Figure 11 shows the input stage of the CDC3RL02. The input signal at MCLK_IN can be a square wave or sine wave. C_{MCLK} is an internal AC coupling capacitor that allows a direct connection from the TCXO to the CDC3RL02 without an external capacitor.

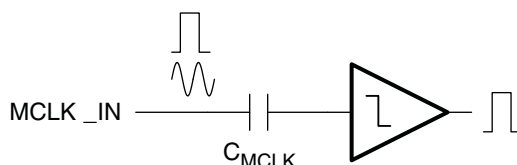


Figure 11. Input Stage with Internal AC Coupling Capacitor

Any external component added in the series path of the clock signal will potentially add phase noise and jitter. The error source associated with the internal decoupling capacitor is included in the specification of the CDC3RL02. The recommended clock frequency band of the CDC3RL02 is 10 MHz to 52 MHz for specified functionality. All performance metrics are specified at 26 MHz. The lowest acceptable sinusoidal signal amplitude is 0.8 V_{PP} for specified performance. Amplitudes as low as 0.3 V_{PP} are acceptable but with reduced phase-noise and jitter performance.

8.1.2 Output Stage

Each output drives 1.8-V LVCMOS levels. Adaptive output buffers limit the rise/fall time of the output to within 1 ns to 5 ns with load capacitance between 10 pF and 50 pF. Fast slew rates introduce EMI into the system. Each output buffer limits EMI by keeping the rise/fall time above 1 ns. Slow rise/fall times can induce additive phase noise and duty cycle errors in the load device. The output buffer limits these errors by keeping the rise/fall time below 5 ns. In addition, the output stage dynamically alters impedance based on the instantaneous voltage level of the output. This dynamic change limits reflections keeping the output signal monotonic during transitions. Each output is active low when not requested to avoid false clocking of the load device.

8.1.3 LDO

A low noise 1.8-V LDO is integrated to provide the I/O supply for the output buffers. The LDO output is externally available to power a clock source such as a TCXO. A clean supply is provided to the clock buffers and the clock source for optimum phase noise performance. The input range of the LDO allows the device to be powered directly from a single cell Li battery. The LDO is enabled by either of the CLK_REQ_N signals. When disabled, the device enters a low power shutdown mode consuming less than 1 µA from the battery. The LDO requires an output decoupling capacitor in the range of 1 µF to 10 µF for compensation and high frequency PSR. This capacitor must stay within the specified range over the entire operating temperature range. An input bypass capacitor of 1 µF or larger is recommended.

8.2 Typical Application

The CDC3RL02 is ideal for use in mobile applications as shown in Figure 12. In this example, a single low noise TCXO system clock source is buffered to drive a mobile GPS receiver and WLAN transceiver. Each peripheral independently requests an active clock by asserting a single clock request line (CLK_REQ_1 or CLK_REQ_2). When both clock request lines are inactive, the CDC3RL02 enters a low current shutdown mode. In this mode, the LDO output, CLK_OUT_1, and CLK_OUT_2 are pulled to GND and the TCXO will be unpowered.

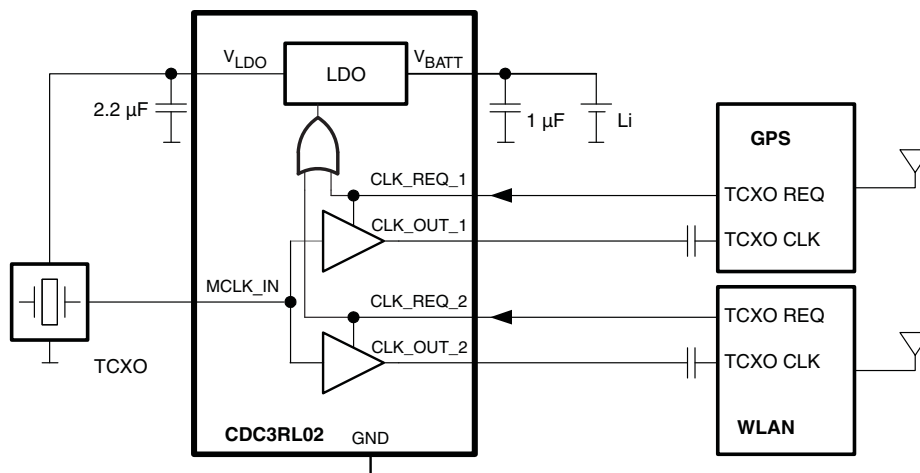


Figure 12. Mobile Application

When either peripheral requests the clock, the CDC3RL02 will enable the LDO and power the TCXO. The TCXO output (square wave, sine wave, or clipped sine wave) is converted to a square wave and buffered to the requested output.

8.2.1 Design Requirements

For the typical application, the user must know the following parameters.

Table 2. Design Parameters

PARAMETER	DESCRIPTION	EXAMPLE VALUE
V_{BATT}	Input voltage from battery or power supply	3.7 V
MCLK_IN	Input frequency from a TCXO	26 MHz

8.2.2 Detailed Design Procedure

The designer must make sure that all parameters are within the ranges specified in [Recommended Operating Conditions](#).

Each device which receives a clock output from the CDC3RL02 should have the CLK request pin connected to the appropriate CLK_REQ pin on the CDC3RL02. This will enable the output buffer when a device requests the clock signal.

It is possible to have a control the outputs of the clock by using a GPIO from a controller to control the CLK_REQ pins.

If one of the outputs is unused, then tie the CLK_REQ and CLK_OUT pins to ground. If the clock will always be required, and the user wishes, it is acceptable to tie the CLK_REQ pin to a 1.8 V source (such as V_{LDO}).

8.2.3 Application Curves

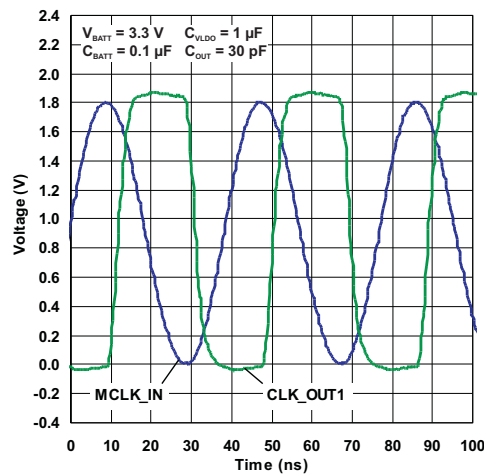


Figure 13. Sine Wave Input vs Output

9 Power Supply Recommendations

General power supply recommendations are to be considered for the CDC3RL02. These include:

- Decoupling capacitors placed close to the V_{BATT} pin of typical values (1 μ F)
- V_{BATT} be within the recommended voltage range

10 Layout

10.1 Layout Guidelines

To ensure reliability of the device, following common printed-circuit board layout guidelines is recommended.

- Bypass capacitors should be used on power supplies and should be placed as close as possible to the V_{BATT} pin
- Short trace-lengths should be used to avoid excessive loading
- For improved performance on the clock output lines, use a ground trace on the sides of the clock trace to minimize crosstalk and EMI

10.2 Layout Example

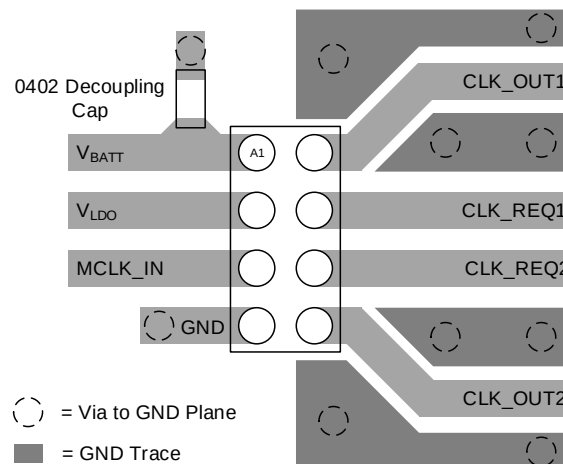


Figure 14. Example Layout for YFP Package

11 Device and Documentation Support

11.1 Community Resources

The following links connect to TI community resources. Linked contents are 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](#).

TI E2E™ Online Community *TI's Engineer-to-Engineer (E2E) Community*. Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

11.2 Trademarks

E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

11.3 Electrostatic Discharge Caution



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

11.4 Glossary

[SLYZ022](#) — *TI Glossary*.

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

12 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 Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
CDC3RL02BYFPR	ACTIVE	DSBGA	YFP	8	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-40 to 85	4LN	Samples
CDC3RL02YFPR	ACTIVE	DSBGA	YFP	8	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-40 to 85	(4L2 ~ 4LN)	Samples

(1) 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.

(2) 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)

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

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

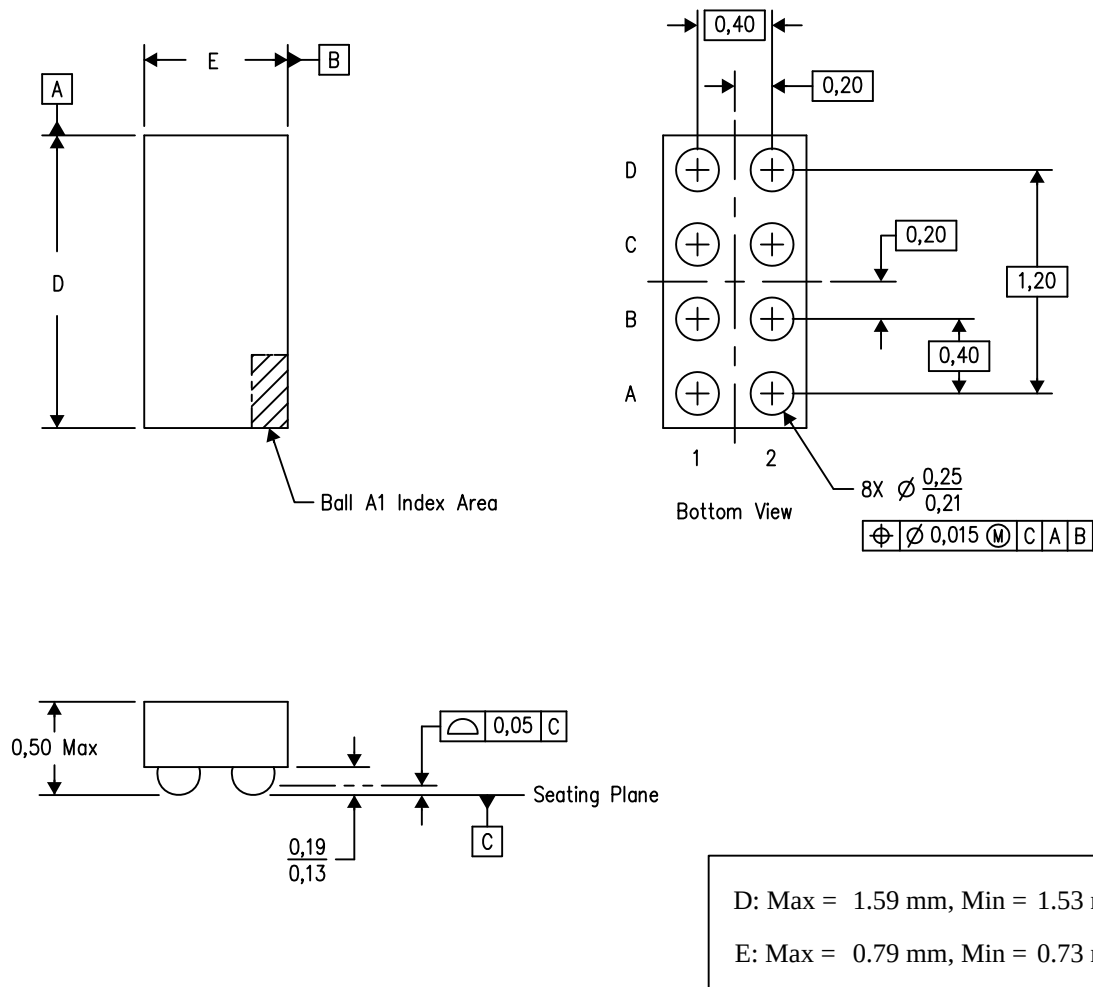
(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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YFP (R-XBGA-N8)

DIE-SIZE BALL GRID ARRAY



4206986-4/T 05/13

- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - B. This drawing is subject to change without notice.
 - C. NanoFree™ package configuration.

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