

General Description

The SQ24335 is a sink and source double data rate (DDR) regulator designed for use in low input voltage, low-cost, low-noise systems where space is a key consideration. It maintains a fast transient response and requires a minimum output capacitance of only 20 μ F and all power requirements for DDR, DDR2, DDR3, DDR3L, Low-Power DDR3 and DDR4 VTT BUS termination. Additionally, it provides an open-drain PGOOD signal to monitor the output regulation and an EN signal that can be used to discharge VTT during S3(suspend to RAM) for DDR application

The SQ24335 is available in the DFN3 $\times$ 3-10 thermal pad package, and it's rated both Green and Pb-free. It's specified from -40 $^{\circ}$ C to 85 $^{\circ}$ C.

Ordering Information

SQ24335 □(□□□)
 Package Code
 Optional Spec Code

Ordering Number	Package type	Note
SQ24335DBD	DFN3 $\times$ 3-10	----

Features

- Input Voltage: Supports 2.5V Rail and 3.3V Rail
- VLDOIN Voltage Range: 1.1V to 3.5V
- Sink and Source Termination Regulator Includes Droop Compensation.
- Requires Minimum Output Capacitance of 20 μ F (Typically 3 $\times$ 10 μ F MLCCs) for Memory.
- PGOOD to Monitor Output Regulation
- Enable Function Option
- REFIN Input Allows for Flexible Input Tracking either Directly or Through Resistor Divider
- Remote Sensing(VOSNS)
- $\pm$ 10mA Buffered Reference(REFOUT)
- Built-in Soft-start, UVLO, and OCL
- Thermal Shutdown Protection
- Supports DDR, DDR2, DDR3, DDR3L, Low Power DDR3, DDR4 VTT Applications
- Compacted Package: DFN3 $\times$ 3-10 with Thermal Pad

Application

- Memory Termination Regulator for DDR, DDR2, DDR3, DDR3L, Low-Power DDR3 and DDR4
- Notebooks, Desktops, and Servers
- Base Stations

Typical Applications

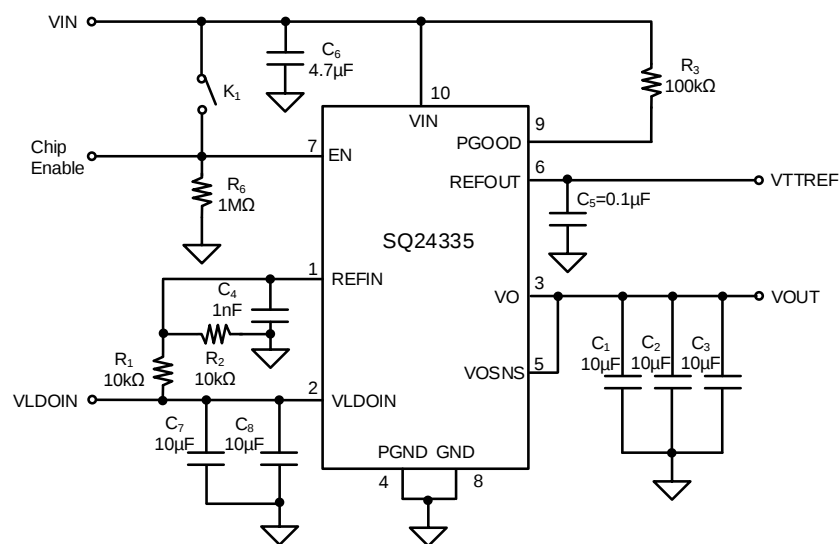
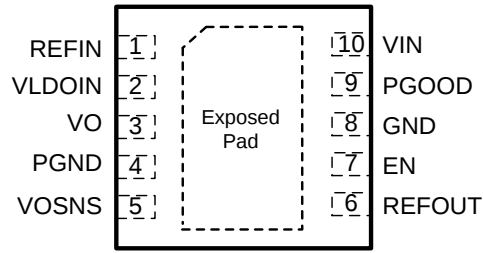


Figure 1. Schematic Diagram

Pinout (Top View)



(DFN3×3-10)

Top Mark: **DRFxyz** for SQ24335DBD (Device code: **DRF**; **x**=year code, **y**=week code, **z**= lot number code)

Pin Name	Pin Name	Pin Description
REFIN	1	Reference Input. Connect to GND through a 0.1μF ceramic capacitor.
VLDOIN	2	Supply voltage for the LDO. Use a 10μF (or greater) ceramic capacitor to supply this transient charge.
VO	3	Power output pin for the LDO. For stable operation, the total capacitance of the VO output pin must be greater than 20μF. Attach three, 10μF ceramic capacitors in parallel to minimize the effect of equivalent series resistance (ESR) and equivalent series inductance (ESL).
PGND	4	Power ground pin for the LDO.
VOSNS	5	Voltage sense input for the LDO. Connect to positive terminal of the output capacitor or load.
REFOUT	6	Reference output. Connect to GND Through a 0.1uF ceramic capacitor.
EN	7	Enable input. Driving this pin high turns on the regulator. Driving this pin low shuts off the regulator. For DDR VTT application, connect EN to SLP_S3. Do not leave it floating.
GND	8	Signal ground pin
PGOOD	9	Open drain power-good indicator, it's pulled high when VO output is within ±20% of REFOUT.
VIN	10	Input supply pin. A large bulk capacitance should be placed close to this pin to ensure that the input supply does not sag below the minimum VIN. A ceramic decoupling capacitor with a value between 1uF and 4.7uF is required.
Exposed Pad	/	The exposed pad should be connected to ground plane for the better thermal performance.

Block Diagram

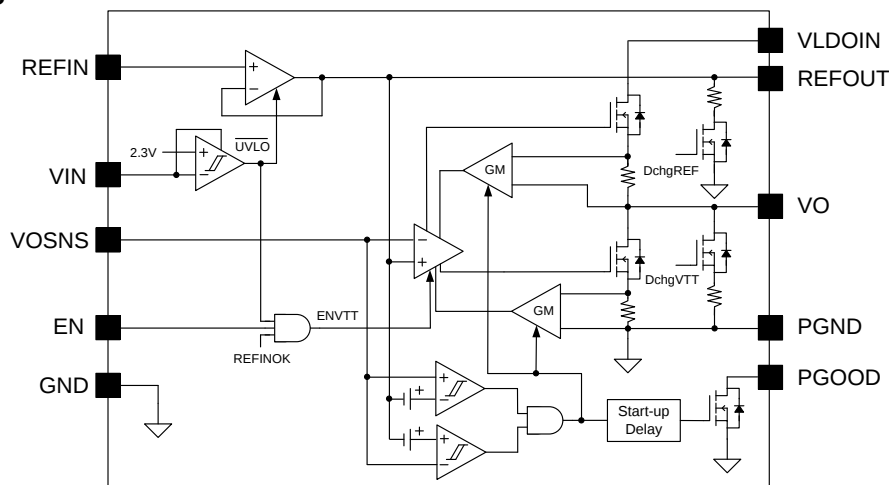


Figure 2. Block Diagram

Absolute Maximum Ratings (Note 1)

REFIN, REFOUT, VIN, VO, VLDOIN, VOSNS	-----	-0.3 to 3.6V
EN, PGOOD	-----	-0.3 to 6.5V
PGND	-----	-0.3 to 0.3V
Power Dissipation, P_D @ $T_A = 25^\circ\text{C}$	-----	1.8W
Package Thermal Resistance (Note 2)		
θ_{JA}	-----	54.7°C/W
θ_{JC}	-----	45.5°C/W
Junction Temperature Range	-----	-40°C to 150°C
Lead Temperature (Soldering, 10 sec.)	-----	260°C
Storage Temperature Range	-----	-65°C to 150°C

Recommended Operating Conditions (Note 3)

VIN	-----	2.375 to 3.5V
EN, VLDOIN, VOSNS	-----	-0.1 to 3.5V
REFIN	-----	0.5 to 1.8V
PGOOD, VO	-----	-0.1 to 3.5V
REFOUT	-----	-0.1 to 1.8V
PGND	-----	-0.1 to 0.1V
Junction Temperature Range	-----	-40°C to 125°C
Ambient Temperature Range	-----	-40°C to 85°C

Electrical Characteristics

($V_{VIN}=3.3V$, $V_{VLDOIN}=1.8V$, $V_{REFIN}=0.9V$, $V_{VOSNS}=0.9V$, $V_{EN}=V_{VIN}$, $C_{OUT}=3\times 10\mu F$, $T_A=-40^{\circ}C$ to $125^{\circ}C$, typical values are $T_A=25^{\circ}C$, unless otherwise specified. The values are guaranteed by test, design or statistical correlation)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Supply Current	I_{IN}	$V_{EN} = 3.3V$, No Load		0.7	1	mA
Shutdown Current	$I_{IN(SDN)}$	$V_{EN} = 0V$, $V_{REFIN} = 0V$, No Load		65	80	μA
		$V_{EN} = 0V$, $V_{REFIN} > 0.4V$, No Load		200	400	
Supply Current of VLDOIN	I_{LDOIN}	$V_{EN} = 3.3V$, No Load		1	50	μA
Shutdown Current of VLDOIN	$I_{LDOIN(SDN)}$	$V_{EN} = 0V$, No Load		0.1	50	μA
Input Current of REFIN	I_{REFIN}	$V_{EN} = 3.3V$			1	μA
Output DC Voltage of VO	V_{VOSNS}	$V_{REFOUT} = 1.25V(DDR1)$, $I_O = 0A$		1.25		V
			-15		15	mV
		$V_{REFOUT} = 0.9V(DDR2)$, $I_O = 0A$		0.9		V
			-15		15	mV
		$V_{REFOUT} = 0.75V(DDR3)$, $I_O = 0A$		0.75		V
			-15		15	mV
Output Voltage Tolerance to REFOUT	V_{VOTOL}	$V_{LDOIN}=1.50V$, $V_{OUT}=0.75V$, $-2A < I_{VO} < 2A$	-20		20	mV
		$V_{LDOIN}=1.35V$, $V_{OUT}=0.675V$, $-2A < I_{VO} < 2A$	-20		20	
		$V_{LDOIN}=1.20V$, $V_{OUT}=0.6V$, $-2A < I_{VO} < 2A$	-20		20	
VO Source Current Limit	I_{VOSRCL}	$V_{OSNS} = 0.9 \times V_{REFOUT}$, $T_A=25^{\circ}C$	3		4.5	A
VO Sink Current Limit	I_{VOSNCL}	$V_{OSNS} = 1.1 \times V_{REFOUT}$, $T_A=25^{\circ}C$	3.5		5.5	A
OUT Shutdown Discharge Resistance	R_{DSCHRG}	$V_{REFIN} = 0V$, $V_{VO} = 0.3V$, $V_{EN} = 0V$		18	25	Ω
VO PGOOD Threshold	$V_{TH(PG)}$	PGOOD window lower threshold with respect to REFOUT	-23.5%	-20%	-17.5%	
		PGOOD window upper threshold with respect to REFOUT	17.5%	20%	23.5%	
		PGOOD hysteresis		5%		
PGOOD Start-up Delay	$T_{PGSTUPDLY}$	Start-up rising edge, V_{OSNS} within 15% of REFOUT		2		ms
PGOOD Output Low Voltage	$V_{PGOODLOW}$	$I_{SINK} = 4mA$			0.4	V
PGOOD Bad Delay	$T_{PBADDLY}$	V_{OSNS} is outside of the $\pm 20\%$ PGOOD window		10		μs
Leakage Current	$I_{PGOODLK}$	$V_{OSNS} = V_{REFIN}$ (PGOOD high impedance), $V_{PGOOD} = V_{VIN} + 0.2V$			1	μA
REFIN Voltage Range	V_{REFIN}		0.5		1.8	V

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
REFIN Under Voltage Lockout	$V_{REFINUVLO}$	REFIN rising	360	390	420	mV
REFIN Under Voltage Lock Out Hysteresis	$V_{REFIN-UVHYS}$			20		mV
REFOUT Voltage	V_{REFOUT}			REFIN		V
REFOUT Voltage Tolerance to V_{REFIN}	$V_{REFOUTTOL}$	-10 mA < I_{REFOUT} < 10 mA, $V_{REFIN} = 1.25$ V	-15		15	mV
		-10 mA < I_{REFOUT} < 10 mA, $V_{REFIN} = 0.9$ V	-15		15	
		-10 mA < I_{REFOUT} < 10 mA, $V_{REFIN} = 0.75$ V	-15		15	
		-10 mA < I_{REFOUT} < 10 mA, $V_{REFIN} = 0.675$ V	-15		15	
		-10 mA < I_{REFOUT} < 10 mA, $V_{REFIN} = 0.6$ V	-15		15	
REFOUT Source Current Limit	$V_{REFOUT-SRCL}$	$V_{REFOUT} = 0$ V	10	40		mA
REFOUT Sink Current Limit	$I_{REFOUT-SNCL}$	$V_{REFOUT} = 0$ V	10	40		mA
UVLO Threshold	$V_{VINUVVIN}$	Wake up	2.2	2.3	2.375	V
		Hysteresis		50		mV
High-level Input Voltage	V_{ENIH}	Enable	1.2			V
Low-level Input Voltage	V_{ENIL}	Enable			0.3	
Hysteresis Voltage	V_{ENYST}	Enable		0.1		
Logic Input Leakage Current	I_{ENLEAK}	Enable	-1		1	μ A
Thermal Shutdown Threshold	T_{SD}			150		$^{\circ}$ C
Thermal Shutdown Hysteresis	T_{HYS}			20		$^{\circ}$ C

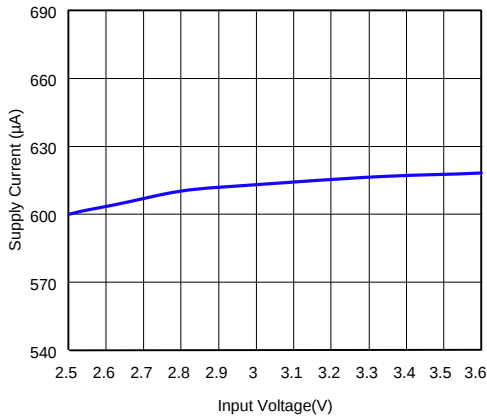
Note 1: Stresses beyond “Absolute Maximum Ratings” may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

Note 2: θ_{JA} is measured in the natural convection at $T_A = 25^{\circ}$ C on a Silergy EVB test board.

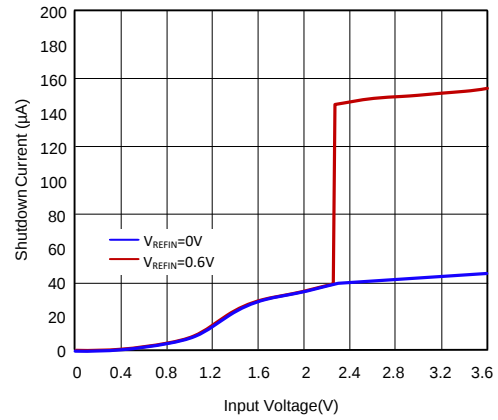
Note 3: The device is not guaranteed to function outside its operating conditions.

Typical Operating Characteristics

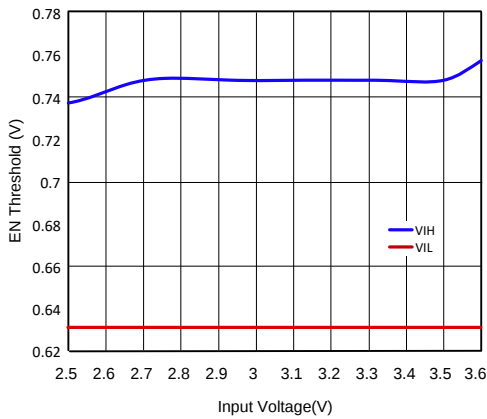
Supply Current vs. Input Voltage
($V_{LDIOIN}=1.2V$, $V_{REFIN}=0.6V$, EN ON, Null load)



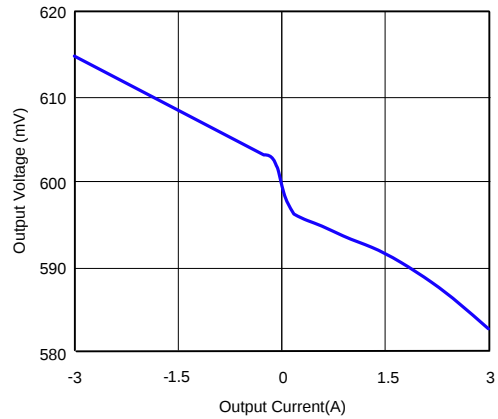
Shutdown Current vs. Input Voltage
($V_{EN}=0V$, Null load)



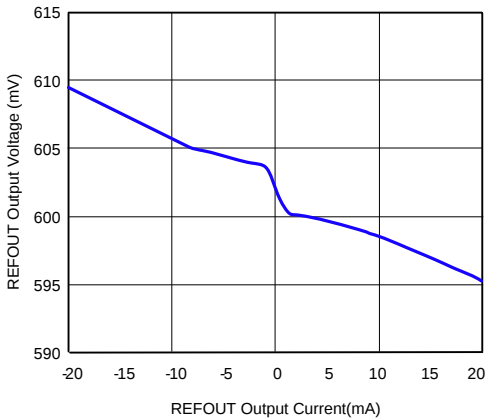
EN Threshold vs. Input Voltage
($V_{LDIOIN}=1.2V$, $V_{REFIN}=0.6V$, Null load)



OUT Load Regulation
($V_{IN}=3.3V$, $V_{LDIOIN}=1.2V$, $V_{REFIN}=0.6V$)

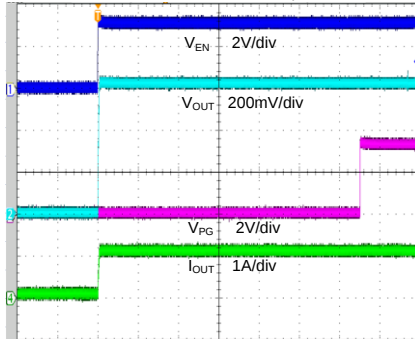


REFOUT Load Regulation
($V_{IN}=3.3V$, $V_{LDIOIN}=1.2V$, $V_{REFIN}=0.6V$)



Startup From Enable

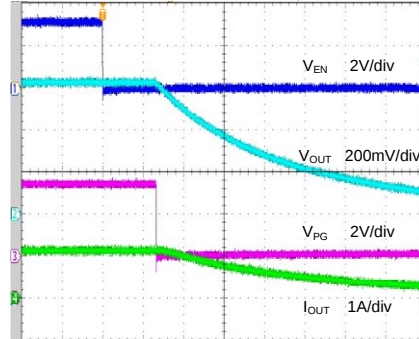
($V_{IN}=3.3V$, $V_{LDON}=1.2V$, $V_{REFIN}=0.6V$,
Source mode, 1A Load)



Time(400 μ s/div)

Shutdown From Enable

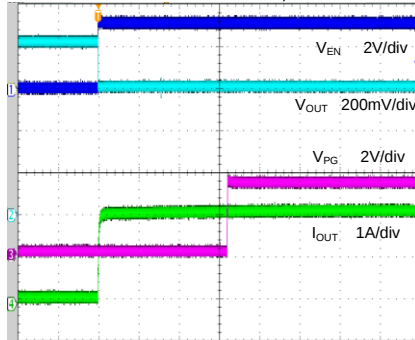
($V_{IN}=3.3V$, $V_{LDON}=1.2V$, $V_{REFIN}=0.6V$,
Source mode, 1A Load)



Time(4 μ s/div)

Startup From Enable

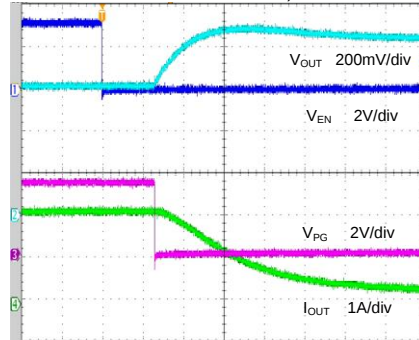
($V_{IN}=3.3V$, $V_{LDON}=1.2V$, $V_{REFIN}=0.6V$,
Sink mode, 2A Load)



Time(800 μ s/div)

Shutdown From Enable

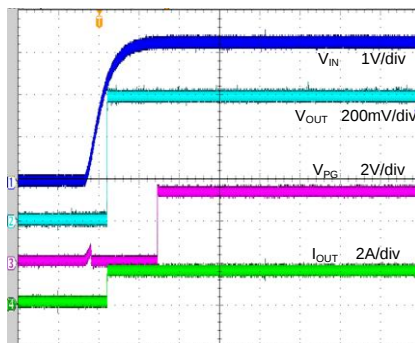
($V_{IN}=3.3V$, $V_{LDON}=1.2V$, $V_{REFIN}=0.6V$,
Sink mode, 2A Load)



Time(4 μ s/div)

Startup From VIN

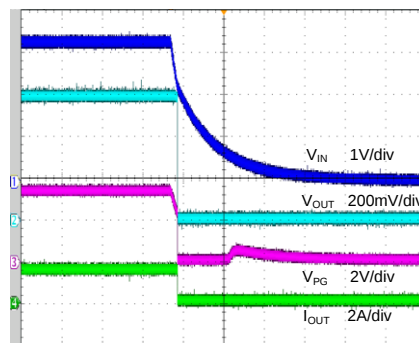
($V_{IN}=3.3V$, $V_{LDON}=1.2V$, $V_{REFIN}=0.6V$, 2A Load)



Time(2ms/div)

Shutdown From VIN

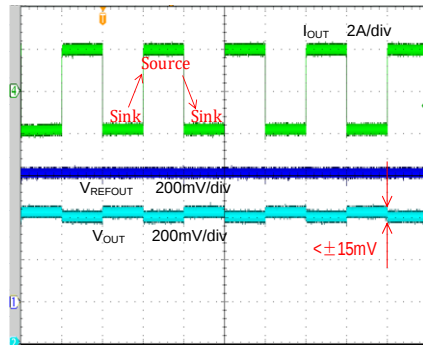
($V_{IN}=3.3V$, $V_{LDON}=1.2V$, $V_{REFIN}=0.6V$, 2A Load)



Time(4 μ s/div)

Load Transient

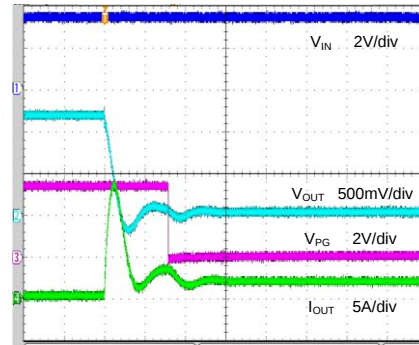
($V_{IN}=3.3V$, $V_{LDOIN}=1.2V$, $V_{REFIN}=0.6V$, $\pm 2A$ Load transient)



Time(10ms/div)

Short Circuit Response

($V_{IN}=3.3V$, $V_{LDOIN}=1.2V$, $V_{REFIN}=0.6V$)



Time(10 μ s/div)

Operation

The SQ24335DBD is a sink and source tracking termination regulator specifically designed for low input voltage, low-cost, and low external component count systems where space is a key application parameter. The device integrates a high-performance, low-dropout (LDO) linear regulator that is capable of both sourcing and sinking current. The LDO regulator employs a fast feedback loop so that small ceramic capacitors can be used to support the fast load transient response. To achieve tight regulation with minimum effect of trace resistance, connect a remote sensing terminal, VOSNS, to the positive terminal of each output capacitor as a separate trace from the high current path from VO.

Reference Output Function

When it is configured for DDR termination applications, REFOUT generates the DDR VTT reference voltage for the memory application. It is capable of supporting both a sourcing and sinking load of 10mA. REFOUT becomes active when REFIN voltage rises to 0.390 V and V_{IN} is above the UVLO threshold. When REFOUT is less than 0.375 V, it is disabled and subsequently discharges to GND through an internal 10-k Ω MOSFET. REFOUT is independent of the EN pin state.

En Control Function

When EN is driven high, the VO regulator begins normal operation. When the device drives EN low, VO discharges to GND through an internal 18- Ω MOSFET. REFOUT remains on when the device drives EN low. Ensure that the EN pin voltage remains lower than or equal to V_{VIN} at all times.

Power Good Function

The SQ24335DBD device provides an open-drain PGOOD output that goes high when the VO output is within $\pm 20\%$ of REFOUT. PGOOD de-asserts within 10 μ s after the output exceeds the size of the power good window. During initial VO start-up, PGOOD asserts high 2 ms (typ) after the VO enters power good window. Because PGOOD is an open-drain output, a pull-up resistor with a value between 1 k Ω and 100 k Ω , placed between PGOOD and a stable active supply voltage rail is required.

Current Limit Protection

The LDO has a constant over current limit (OCL). The OCL level reduces by one-half when the output voltage is not within the power good window. This reduction is a non-latch protection.

UVLO Protection

For V_{IN} under voltage lockout (UVLO) protection, the SQ24335DBD monitors V_{IN} voltage. When the V_{IN} voltage is lower than the UVLO threshold voltage, both the VO and REFOUT regulators are powered off. This shutdown is a non-latch protection.

Thermal Shutdown Protection

The SQ24335DBD monitors junction temperature. If the device junction temperature exceeds the threshold value, (typically 150°C), the VO and REFOUT regulators both shut off, discharged by the internal discharge MOSFETs. This shutdown is a non-latch protection.

Supply Filter Capacitor

Add a ceramic capacitor, with a value between 1 μ F and 4.7 μ F, placed close to the V_{IN} pin, to stabilize the bias supply (2.5-V rail or 3.3-V rail) from any parasitic impedance from the supply.

VLDOIN Input Capacitor

Depending on the trace impedance between the VLDOIN bulk power supply to the device, a transient increase of source current is supplied mostly by the charge from the VLDOIN input capacitor. Use a 10 μ F (or greater) ceramic capacitor to supply this transient charge. Provide more input capacitance as more output capacitance is used at the VO pin. In general, use one-half of the C_{OUT} value for input.

Output Filter Capacitor

For stable operation, the total capacitance of the VO output pin must be greater than 20 μ F. Attach three, 10- μ F ceramic capacitors in parallel to minimize the effect of equivalent series resistance (ESR) and equivalent series inductance (ESL). If the ESR is greater than 2 m Ω , insert an RC filter between the output and the VOSNS input to achieve loop stability. The RC filter time constant should be almost the same as or slightly lower than the time constant of the output capacitor and its ESR.

PCB Layout Guide

For best performance of the SQ24335DBD, the following guidelines must be strictly followed:

1. Place the input capacitors as close to VDLOIN pin as possible with short and wide connection
2. Place the output capacitor as close to VO pin as possible with short and wide connection. Place a ceramic capacitor with a value of at least 10- μ F as close to VO pin if the rest of output capacitors need to be placed on the load side.

3. Connect the VOSNS pin to the positive node of output capacitors as a separate trace. In DDR VTT application, connect the VO sense trace to DIMM side to ensure the VTT voltage at DIMM side is well regulated.
4. Consider adding low-pass filter at VOSNS if the VO sense trace is very long.
5. Connect the GND pin and PGND pin to the thermal pad directly.
6. SQ24335DBD uses its thermal pad to dissipate heat. In order to effectively remove heat from SQ24335DBD package, place numerous ground vias on the thermal pad. Use large ground copper plane, especially the copper plane on surface layer, to pour over those vias on thermal pad.

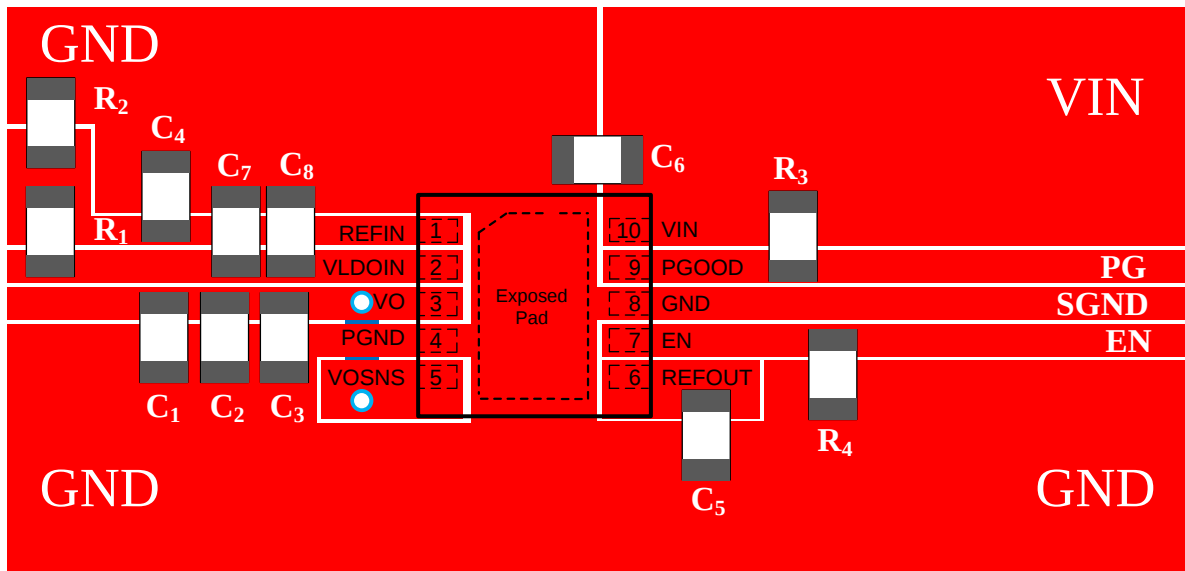
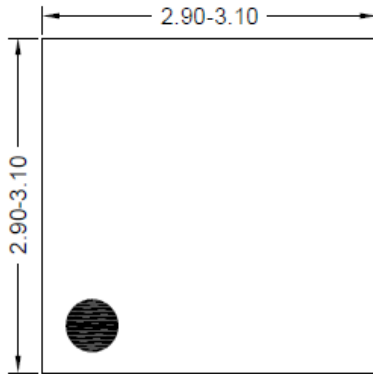
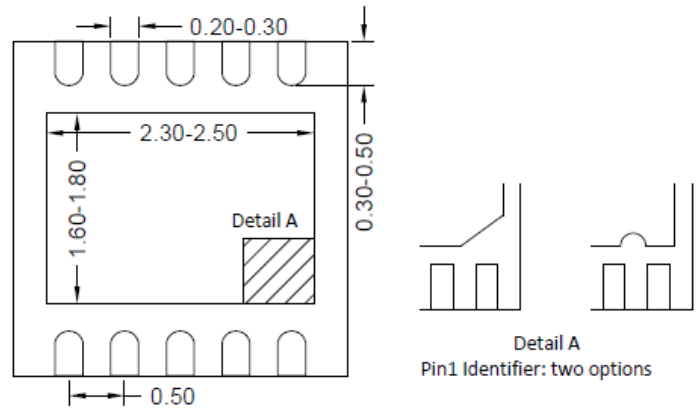


Figure 3. SQ24335DBD PCB Layout Suggestion

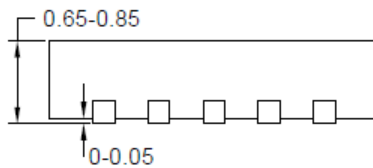
DFN3×3-10 Package Outline



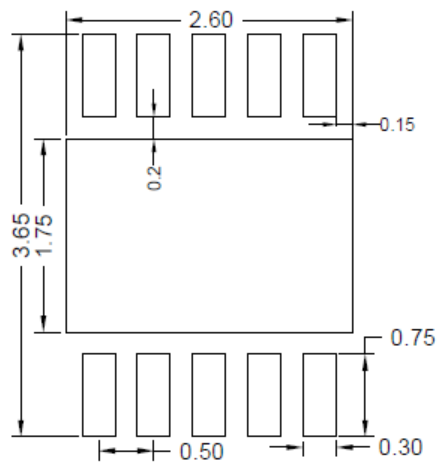
Top View



Bottom View



Side View



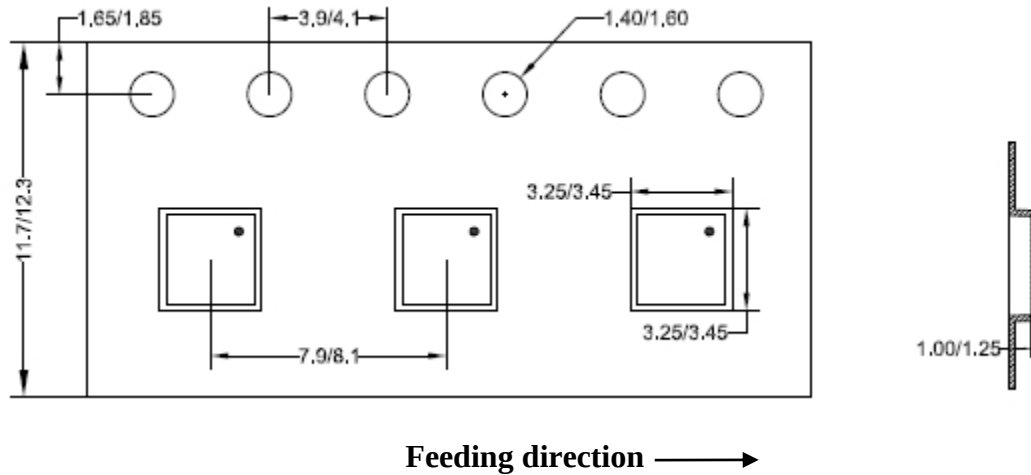
PCB layout (recommended)

Notes: All dimension in millimeter and exclude mold flash & metal burr.

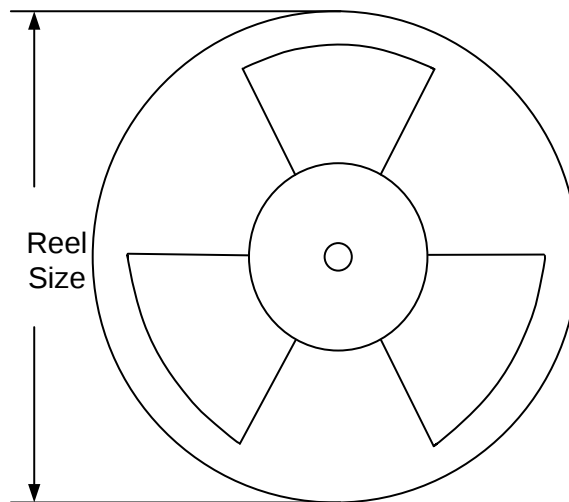
Taping & Reel Specification

1. Taping orientation

DFN3×3-10



2. Carrier Tape & Reel specification for packages



Package types	Tape width (mm)	Pocket pitch(mm)	Reel size (Inch)	Trailer length(mm)	Leader length (mm)	Qty per reel
DFN3×3	12	8	13"	400	400	5000

3. Others: NA

Revision History

The revision history provided is for informational purpose only and is believed to be accurate, however, not warranted. Please make sure that you have the latest revision.

Date	Revision	Change
Dec.09, 2020	Revision 0.9	Initial Release

IMPORTANT NOTICE

1. **Right to make changes.** Silergy and its subsidiaries (hereafter Silergy) reserve the right to change any information published in this document, including but not limited to circuitry, specification and/or product design, manufacturing or descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products are sold subject to Silergy's standard terms and conditions of sale.
2. **Applications.** Application examples that are described herein for any of these products are for illustrative purposes only. Silergy makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification. Buyers are responsible for the design and operation of their applications and products using Silergy products. Silergy or its subsidiaries assume no liability for any application assistance or designs of customer products. It is customer's sole responsibility to determine whether the Silergy product is suitable and fit for the customer's applications and products planned. To minimize the risks associated with customer's products and applications, customer should provide adequate design and operating safeguards. Customer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Silergy assumes no liability related to any default, damage, costs or problem in the customer's applications or products, or the application or use by customer's third-party buyers. Customer will fully indemnify Silergy, its subsidiaries, and their representatives against any damages arising out of the use of any Silergy components in safety-critical applications. It is also buyers' sole responsibility to warrant and guarantee that any intellectual property rights of a third party are not infringed upon when integrating Silergy products into any application. Silergy assumes no responsibility for any said applications or for any use of any circuitry other than circuitry entirely embodied in a Silergy product.
3. **Limited warranty and liability.** Information furnished by Silergy in this document is believed to be accurate and reliable. However, Silergy makes no representation or warranty, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information. In no event shall Silergy be liable for any indirect, incidental, punitive, special or consequential damages, including but not limited to lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges, whether or not such damages are based on tort or negligence, warranty, breach of contract or any other legal theory. Notwithstanding any damages that customer might incur for any reason whatsoever, Silergy's aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the Standard Terms and Conditions of Sale of Silergy.
4. **Suitability for use.** Customer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of Silergy components in its applications, notwithstanding any applications-related information or support that may be provided by Silergy. Silergy products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical systems or equipment, nor in applications where failure or malfunction of an Silergy product can reasonably be expected to result in personal injury, death or severe property or environmental damage. Silergy assumes no liability for inclusion and/or use of Silergy products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.
5. **Terms and conditions of commercial sale.** Silergy products are sold subject to the standard terms and conditions of commercial sale, as published at <http://www.silergy.com/stdterms>, unless otherwise agreed in a valid written individual agreement specifically agreed to in writing by an authorized officer of Silergy. In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. Silergy hereby expressly objects to and denies the application of any customer's general terms and conditions with regard to the purchase of Silergy products by the customer.
6. **No offer to sell or license.** Nothing in this document may be interpreted or construed as an offer to sell products that is open for acceptance or the grant, conveyance or implication of any license under any copyrights, patents or other industrial or intellectual property rights. Silergy makes no representation or warranty that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right. Information published by Silergy regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from Silergy under the patents or other intellectual property of Silergy.

For more information, please visit: www.silergy.com

©2020 Silergy Corp.

All Rights Reserved.