

# CSD95378BQ5MC Synchronous Buck NexFET™ Smart Power Stage

## 1 Features

- 60-A Continuous Operating Current Capability
- 93.4% System Efficiency at 30 A
- Low Power Loss of 2.8 W at 30 A
- High-Frequency Operation (up to 1.25 MHz)
- Diode Emulation Mode With FCCM
- Temperature Compensated Bidirectional Current Sense
- Analog Temperature Output (400 mV at 0°C)
- Fault Monitoring
  - High-Side Short, Overcurrent, and Overtemperature Protection
- 3.3-V and 5-V PWM Signal Compatible
- Tri-State PWM Input
- Integrated Bootstrap Diode
- Optimized Deadtime for Shoot-Through Protection
- High-Density SON 5 × 6 mm Footprint
- Ultra-Low Inductance Package
- System-Optimized PCB Footprint
- DualCool™ Packaging
- RoHS Compliant – Lead-Free Terminal Plating
- Halogen-Free

## 2 Applications

- Multiphase Synchronous Buck Converters
  - High-Frequency Applications
  - High-Current, Low Duty-Cycle Applications
- POL DC-DC Converters
- Memory and Graphic Cards
- Desktop and Server VR11.x / VR12.x V-core and Memory Synchronous Converters

## 3 Description

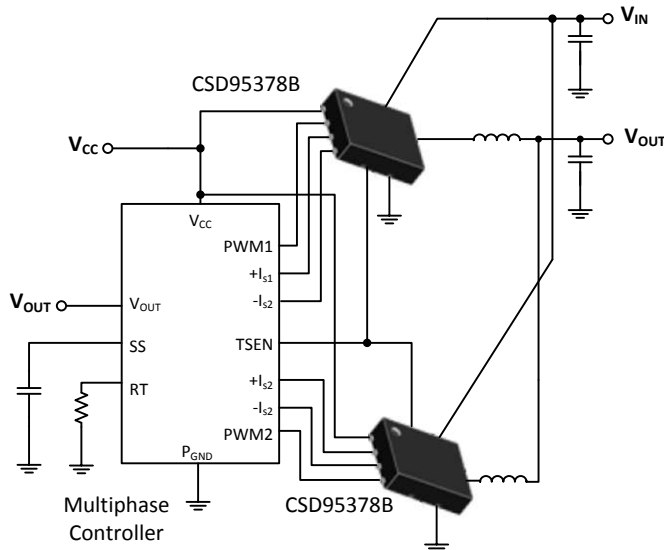
The CSD95378BQ5MC NexFET™ smart power stage is a highly-optimized design for use in a high-power, high-density synchronous buck converter. This product integrates the driver IC and power MOSFETs to complete the power stage switching function. This combination produces high-current, high-efficiency, and high-speed switching capability in a small 5 mm × 6 mm outline package. It also integrates the accurate current sensing system and temperature sensing functionality to simplify system design and improve accuracy. In addition, the PCB footprint is optimized to help reduce design time and simplify the completion of the overall system design.

### Device Information<sup>(1)</sup>

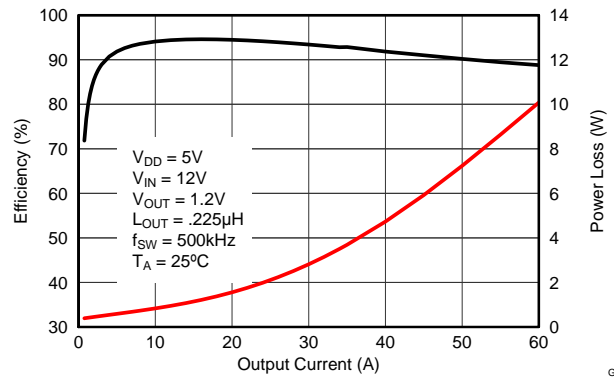
DEVICE	MEDIA	QTY	PACKAGE	SHIP
CSD95378BQ5MC	13-Inch Reel	2500	SON 5 mm × 6 mm DualCool Package	Tape and Reel
CSD95378BQ5MCT	7-Inch Reel	250		

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

### Application Diagram



### Typical Power Stage Efficiency and Power Loss



G001



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## 4 Revision History

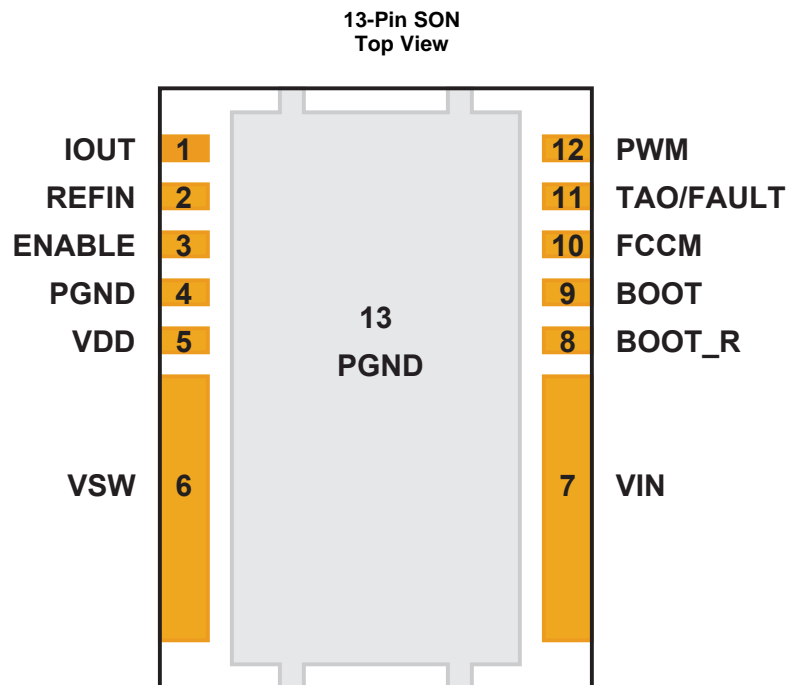
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

<b>Changes from Revision A (June 2014) to Revision B</b>	<b>Page</b>
• Corrected MAX A dimensions in <i>Mechanical Drawing</i> table to 1.050 mm (0.041 inch) .....	<b>8</b>

<b>Changes from Original (April 2014) to Revision A</b>	<b>Page</b>
• Updated the controller IC in the <i>Application Schematic</i> to the TPS40428 .....	<b>6</b>

## 5 Pin Configuration and Functions



### Pin Functions

PIN		DESCRIPTION
NAME	NUMBER	
BOOT	9	Bootstrap capacitor connection. Connect a minimum of 0.1 $\mu$ F 16 V X7R ceramic capacitor from BOOT to BOOT_R pins. The bootstrap capacitor provides the charge to turn on the control FET. The bootstrap diode is integrated.
BOOT_R	8	Return path for HS gate driver, connected to $V_{SW}$ internally.
ENABLE	3	Enables device operation. If ENABLE = logic HIGH, turns on device. If ENABLE = logic LOW, the device is turned off and both MOSFET gates are actively pulled low. An internal 100 k $\Omega$ pulldown resistor will pull the ENABLE pin LOW if left floating.
FCCM	10	This pin enables the diode emulation function. When this pin is held LOW, diode emulation mode is enabled for sync FET. When FCCM is HIGH, the device is operated in Forced Continuous Conduction Mode. An internal 5 $\mu$ A current source will pull the FCCM pin to 3.3 V if left floating.
IOUT	1	Output of current sensing amplifier. $V(IOUT) - V(REFIN)$ is proportional to the phase current.
$P_{GND}$	4	Power ground, connected directly to pin 13.
$P_{GND}$	13	Power ground.
PWM	12	Pulse width modulated tri-state input from external controller. Logic LOW sets control FET gate low and sync FET gate high. Logic HIGH sets control FET gate high and sync FET gate low. Open or High Z sets both MOSFET gates low if greater than the tri-state shutdown hold-off time ( $t_{3HT}$ ).
REFIN	2	External reference voltage input for current sensing amplifier.
TAO/ FAULT	11	Temperature analog output. Reports a voltage proportional to the die temperature. An ORing diode is integrated in the IC. When used in multiphase application, a single wire can be used to connect the TAO pins of all the ICs. Only the highest temperature will be reported. TAO will be pulled up to 3.3 V if thermal shutdown occurs. TAO should be bypassed to $P_{GND}$ with a 1 nF 16 V X7R ceramic capacitor.
$V_{DD}$	5	Supply voltage to gate driver and internal circuitry.
$V_{IN}$	7	Input voltage pin. Connect input capacitors close to this pin.
$V_{SW}$	6	Phase node connecting the HS MOSFET source and LS MOSFET drain - pin connection to the output inductor.

## 6 Specifications

### 6.1 Absolute Maximum Ratings

 $T_A = 25^\circ\text{C}$  (unless otherwise noted)<sup>(1)</sup>

	MIN	MAX	UNIT
$V_{IN}$ to $P_{GND}$	-0.3	25	V
$V_{IN}$ to $V_{SW}$	-0.3	25	V
$V_{IN}$ to $V_{SW}$ (10 ns)	-7	27	V
$V_{SW}$ to $P_{GND}$	-0.3	20	V
$V_{SW}$ to $P_{GND}$ (10 ns)	-7	23	V
$V_{DD}$ to $P_{GND}$	-0.3	7	V
ENABLE, PWM, FCCM, TAO, IOU, REFIN to $P_{GND}$	-0.3	$V_{DD} + 0.3\text{ V}$	V
BOOT to BOOT_R <sup>(2)</sup>	-0.3	$V_{DD} + 0.3\text{ V}$	V
$P_D$ Power dissipation		12	W
$T_J$ Operating junction	-55	150	$^\circ\text{C}$
$T_{stg}$ Storage temperature	-55	150	$^\circ\text{C}$

- (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) Should not exceed 7 V.

### 6.2 ESD Ratings

	VALUE	UNIT
$V_{(ESD)}$ Electrostatic discharge	Human body model (HBM)	$\pm 2000$
	Charged device model (CDM)	$\pm 500$
		V

### 6.3 Recommended Operating Conditions

 $T_A = 25^\circ$  (unless otherwise noted)

	MIN	MAX	UNIT
$V_{DD}$ Gate drive voltage	4.5	5.5	V
$V_{IN}$ Input supply voltage <sup>(1)</sup>		16	V
$V_{OUT}$ Output voltage		5.5	V
$I_{OUT}$ Continuous output current	$V_{IN} = 12\text{ V}, V_{DD} = 5\text{ V}, V_{OUT} = 1.2\text{ V},$ $f_{SW} = 500\text{ kHz}, L_{OUT} = 0.225\text{ }\mu\text{H}$ <sup>(2)</sup>	60	A
$I_{OUT-PK}$ Peak output current <sup>(3)</sup>		90	A
$f_{SW}$ Switching frequency	$C_{BST} = 0.1\text{ }\mu\text{F}$ (min)	1250	kHz
On time duty cycle	$f_{SW} = 1\text{ MHz}$	85%	
Minimum PWM on time	40		ns
Operating temperature	-40	125	$^\circ\text{C}$

- (1) Operating at high  $V_{IN}$  can create excessive AC voltage overshoots on the switch node ( $V_{SW}$ ) during MOSFET switching transients. For reliable operation, the switch node ( $V_{SW}$ ) to ground voltage must remain at or below the Absolute Maximum Ratings.
- (2) Measurement made with six 10  $\mu\text{F}$  (TDK C3216X5R1C106KT or equivalent) ceramic capacitors placed across  $V_{IN}$  to  $P_{GND}$  pins.
- (3) System conditions as defined in Note 1. Peak output current is applied for  $t_p = 50\text{ }\mu\text{s}$ .

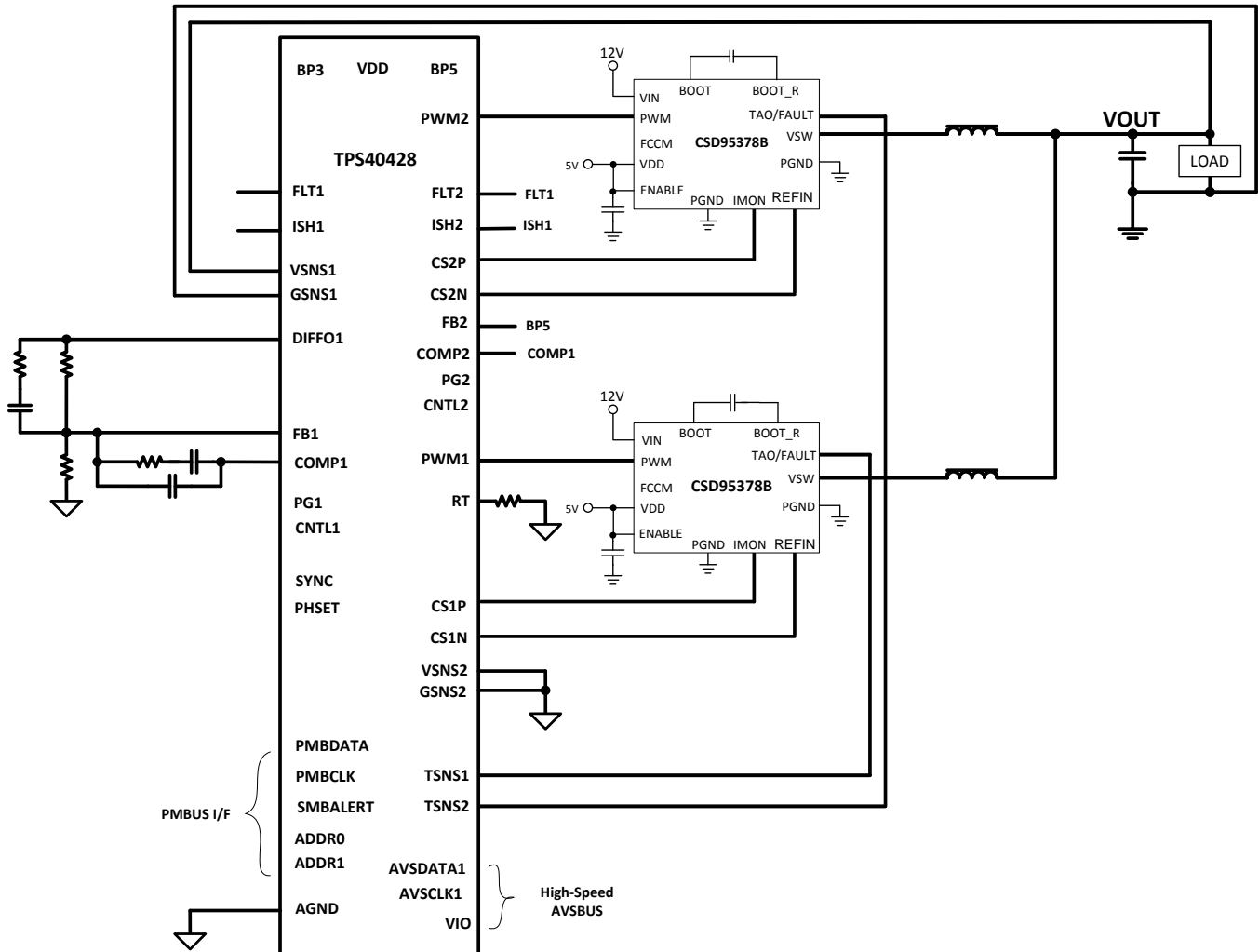
## 6.4 Thermal Information

$T_A = 25^\circ\text{C}$  (unless otherwise noted)

THERMAL METRIC		MIN	TYP	MAX	UNIT
$R_{\theta JC}$	Junction-to-case (top of package) thermal resistance <sup>(1)</sup>			5	$^\circ\text{C/W}$
$R_{\theta JB}$	Junction-to-board thermal resistance <sup>(2)</sup>			1.5	$^\circ\text{C/W}$

- (1)  $R_{\theta JC}$  is determined with the device mounted on a 1 inch<sup>2</sup> (6.45 cm<sup>2</sup>), 2 oz (0.071 mm thick) Cu pad on a 1.5 inch x 1.5 inch, 0.06 inch (1.52 mm) thick FR4 board.
- (2)  $R_{\theta JB}$  value based on hottest board temperature within 1 mm of the package.

## 7 Application Schematic



## 8 Device and Documentation Support

### 8.1 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](http://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.

### 8.2 Trademarks

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All other trademarks are the property of their respective owners.

### 8.3 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.

### 8.4 Glossary

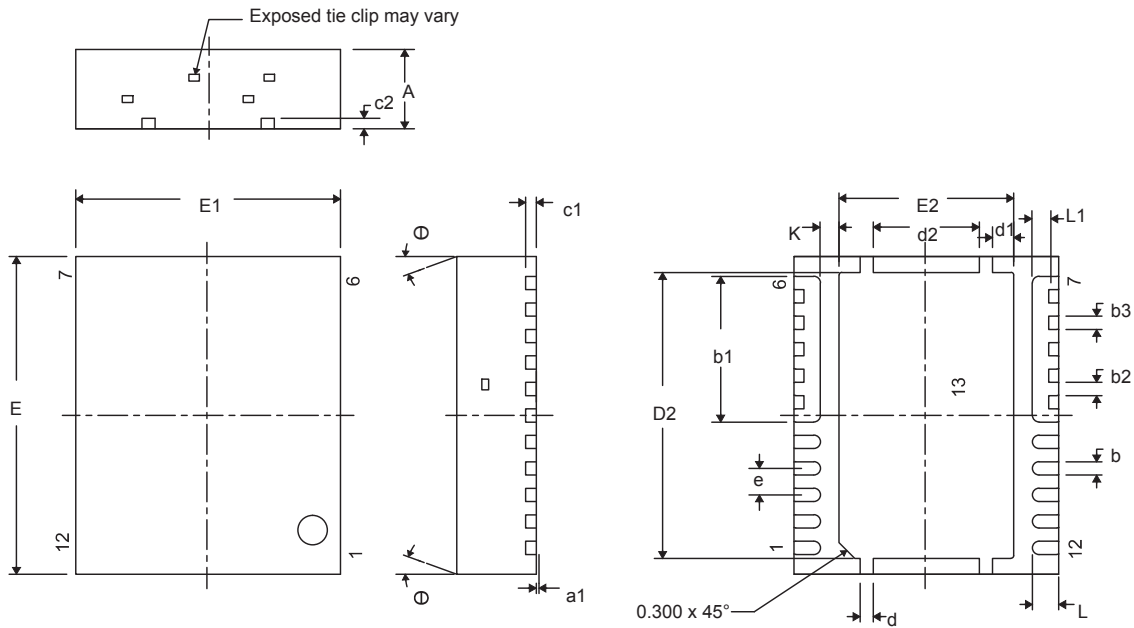
[SLYZ022](#) — *TI Glossary*.

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

## 9 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.

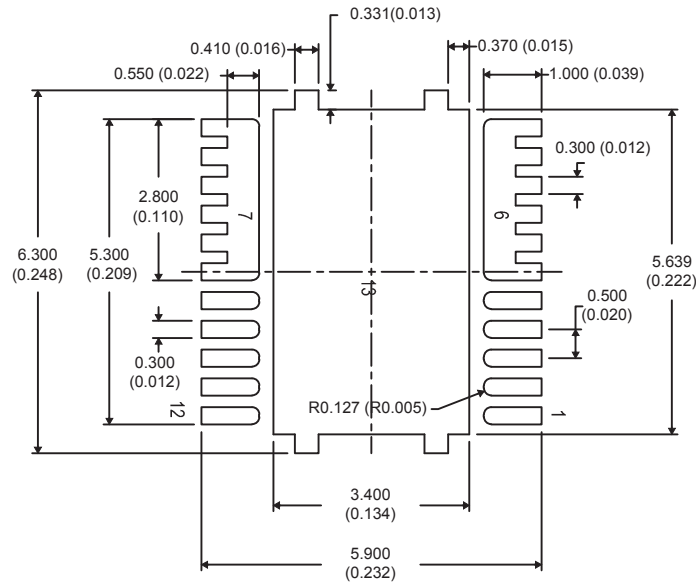
### 9.1 Mechanical Drawing



DIM	MILLIMETERS			INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	0.950	1.000	1.050	0.037	0.039	0.041
a1	0.000	0.000	0.050	0.000	0.000	0.002
b	0.200	0.250	0.320	0.008	0.010	0.013
b1	2.750 TYP			0.108 TYP		
b2	0.200	0.250	0.320	0.008	0.010	0.013
b3	0.250 TYP			0.010 TYP		
c1	0.150	0.200	0.250	0.006	0.008	0.010
c2	0.200	0.250	0.300	0.008	0.010	0.012
D2	5.300	5.400	5.500	0.209	0.213	0.217
d	0.200	0.250	0.300	0.008	0.010	0.012
d1	0.350	0.400	0.450	0.014	0.016	0.018
d2	1.900	2.000	2.100	0.075	0.079	0.083
E	5.900	6.000	6.100	0.232	0.236	0.240
E1	4.900	5.000	5.100	0.193	0.197	0.201
E2	3.200	3.300	3.400	0.126	0.130	0.134
e	0.500 TYP			0.020 TYP		
K	0.350 TYP			0.014 TYP		
L	0.400	0.500	0.600	0.016	0.020	0.024
L1	0.210	0.310	0.410	0.008	0.012	0.016
θ	0.00	—	—	0.00	—	—

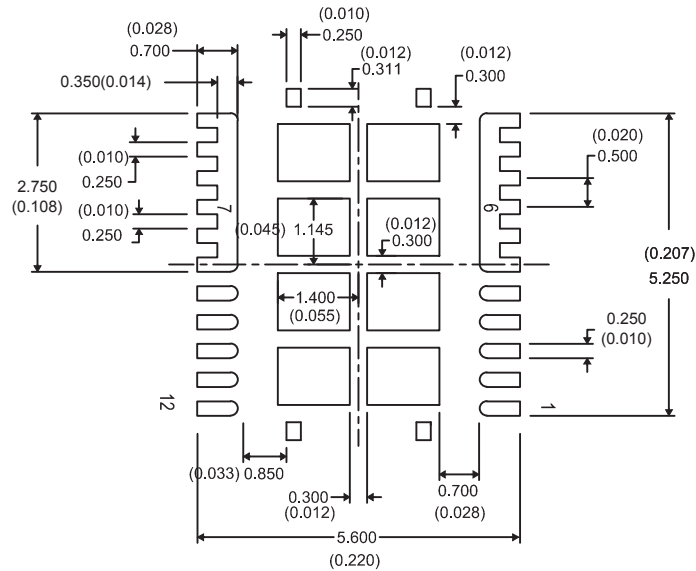


## 9.2 Recommended PCB Land Pattern



1. Dimensions are in mm (inches).

## 9.3 Recommended Stencil Opening



1. Dimensions are in mm (inches).
2. Stencil thickness is 100  $\mu\text{m}$ .

**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
CSD95378BQ5MC	ACTIVE	VSON-CLIP	DMC	12	2500	Pb-Free (RoHS Exempt)	CU SN	Level-2-260C-1 YEAR		95378BMC	<a href="#">Samples</a>
CSD95378BQ5MCT	ACTIVE	VSON-CLIP	DMC	12	250	Pb-Free (RoHS Exempt)	CU SN	Level-2-260C-1 YEAR		95378BMC	<a href="#">Samples</a>

(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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**TAPE AND REEL INFORMATION**

**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
CSD95378BQ5MC	VSON-CLIP	DMC	12	2500	330.0	15.4	5.3	6.3	1.2	8.0	12.0	Q1
CSD95378BQ5MC	VSON-CLIP	DMC	12	2500	330.0	12.4	5.3	6.3	1.2	8.0	12.0	Q1
CSD95378BQ5MCT	VSON-CLIP	DMC	12	250	180.0	12.4	5.3	6.3	1.2	8.0	12.0	Q1

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
CSD95378BQ5MC	VSON-CLIP	DMC	12	2500	336.6	336.6	41.3
CSD95378BQ5MC	VSON-CLIP	DMC	12	2500	367.0	367.0	35.0
CSD95378BQ5MCT	VSON-CLIP	DMC	12	250	210.0	185.0	35.0

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Logic	<a href="http://logic.ti.com">logic.ti.com</a>
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Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
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OMAP Applications Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>
Wireless Connectivity	<a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a>

### Applications

Automotive and Transportation	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>

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