

CSD95472Q5MC Synchronous Buck NexFET™ Smart Power Stage

1 Features

- 60-A Continuous Operating Current Capability
- 94.4% System Efficiency at 1.2 V / 30 A
- Low Power Loss of 2.3 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 (600 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
- Ultralow 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

3 Description

The CSD95472Q5MC 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 and temperature sensing functionality to simplify system design and improve accuracy. In addition, the PCB footprint has been optimized to help reduce design time and simplify the completion of the overall system design.

Device Information⁽¹⁾

| DEVICE | MEDIA | QTY | PACKAGE | SHIP |
|---------------|--------------|------|----------------------------------|---------------------|
| CSD95472Q5MC | 13-Inch Reel | 2500 | SON 5 × 6 mm DualCool Package | Tape and Reel |
| CSD95472Q5MCT | 7-Inch Reel | 250 | | |

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

Application Diagram

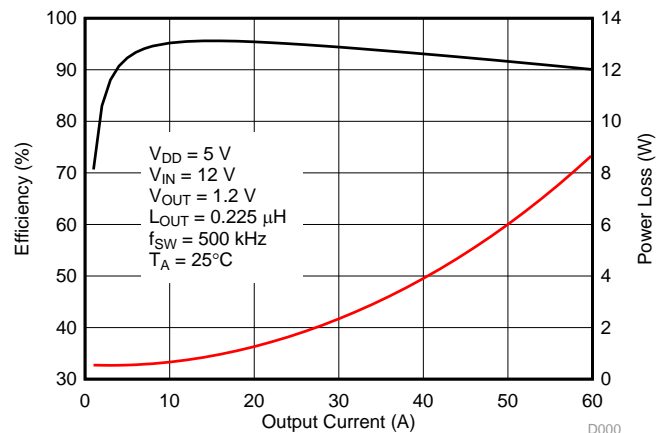
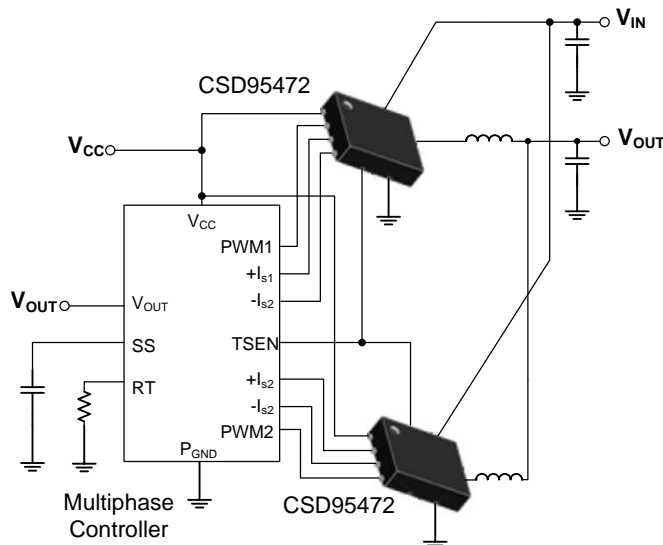


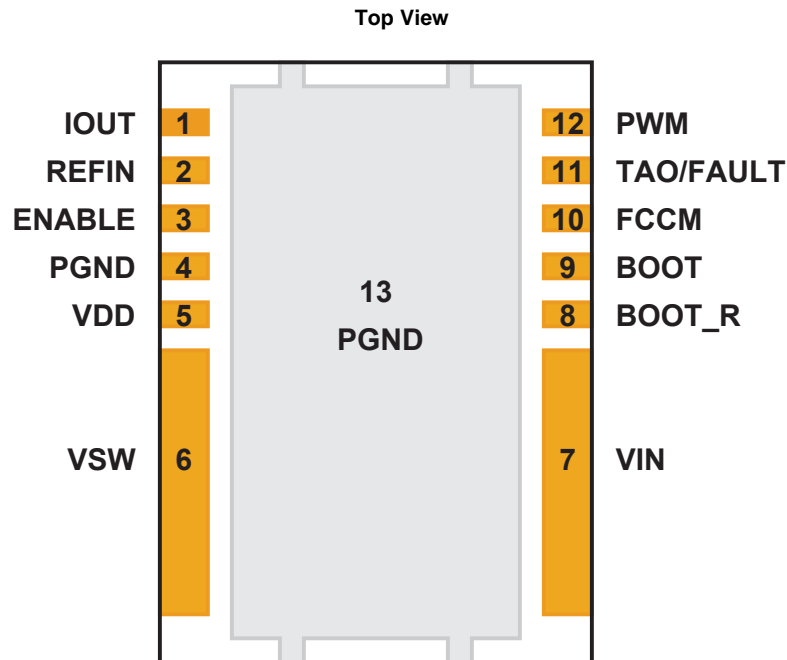
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4 Revision History

| DATE | REVISION | NOTES |
|---------------|----------|------------------|
| February 2016 | * | Initial release. |

5 Pin Configuration and Functions



Pin Functions

| PIN | | DESCRIPTION |
|--------|------------------|---|
| NUMBER | NAME | |
| 1 | IOUT | Output of current sensing amplifier. $V(\text{IOUT}) - V(\text{REFIN})$ is proportional to the phase current. |
| 2 | REFIN | External reference voltage input for current sensing amplifier. |
| 3 | ENABLE | 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 Ω pull-down resistor will pull the ENABLE pin LOW if left floating. |
| 4 | P _{GND} | Power ground, connected directly to pin 13. |
| 5 | V _{DD} | Supply voltage to gate driver and internal circuitry. |
| 6 | V _{SW} | Phase node connecting the HS MOSFET source and LS MOSFET drain – pin connection to the output inductor. |
| 7 | V _{IN} | Input voltage pin. Connect input capacitors close to this pin. |
| 8 | BOOT_R | Return path for HS gate driver, connected to V _{SW} internally. |
| 9 | BOOT | Bootstrap capacitor connection. Connect a minimum of 0.1 μF 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. |
| 10 | FCCM | 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 μA current source will pull the FCCM pin to 3.3 V if left floating. |
| 11 | TAO/ FAULT | 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. |
| 12 | PWM | 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}). |
| 13 | P _{GND} | Power ground. |

6 Specifications

6.1 Absolute Maximum Ratings

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

| | MIN | MAX | UNIT |
|--|------|-------------------------|------------------|
| V_{IN} to P_{GND} | -0.3 | 20 | V |
| V_{IN} to V_{SW} | -0.3 | 20 | V |
| V_{IN} to V_{SW} (10 ns) | | 23 | 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} ⁽²⁾ | -0.3 | $V_{DD} + 0.3\text{ V}$ | V |
| BOOT to BOOT_R ⁽²⁾ | -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) | ± 2000 |
| | Charged device model (CDM) | ± 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 ⁽¹⁾ | | 16 | V |
| V_{OUT} Output voltage | | 5.5 | V |
| I_{OUT} Continuous output current | $V_{IN} = 12\text{ V}$, $V_{DD} = 5\text{ V}$, $V_{OUT} = 1.2\text{ V}$, $f_{SW} = 500\text{ kHz}$, $L_{OUT} = 0.225\text{ }\mu\text{H}$ ⁽²⁾ | 60 | A |
| I_{OUT-PK} Peak output current ⁽³⁾ | | 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 μF (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 $t_p = 50\text{ }\mu\text{s}$.

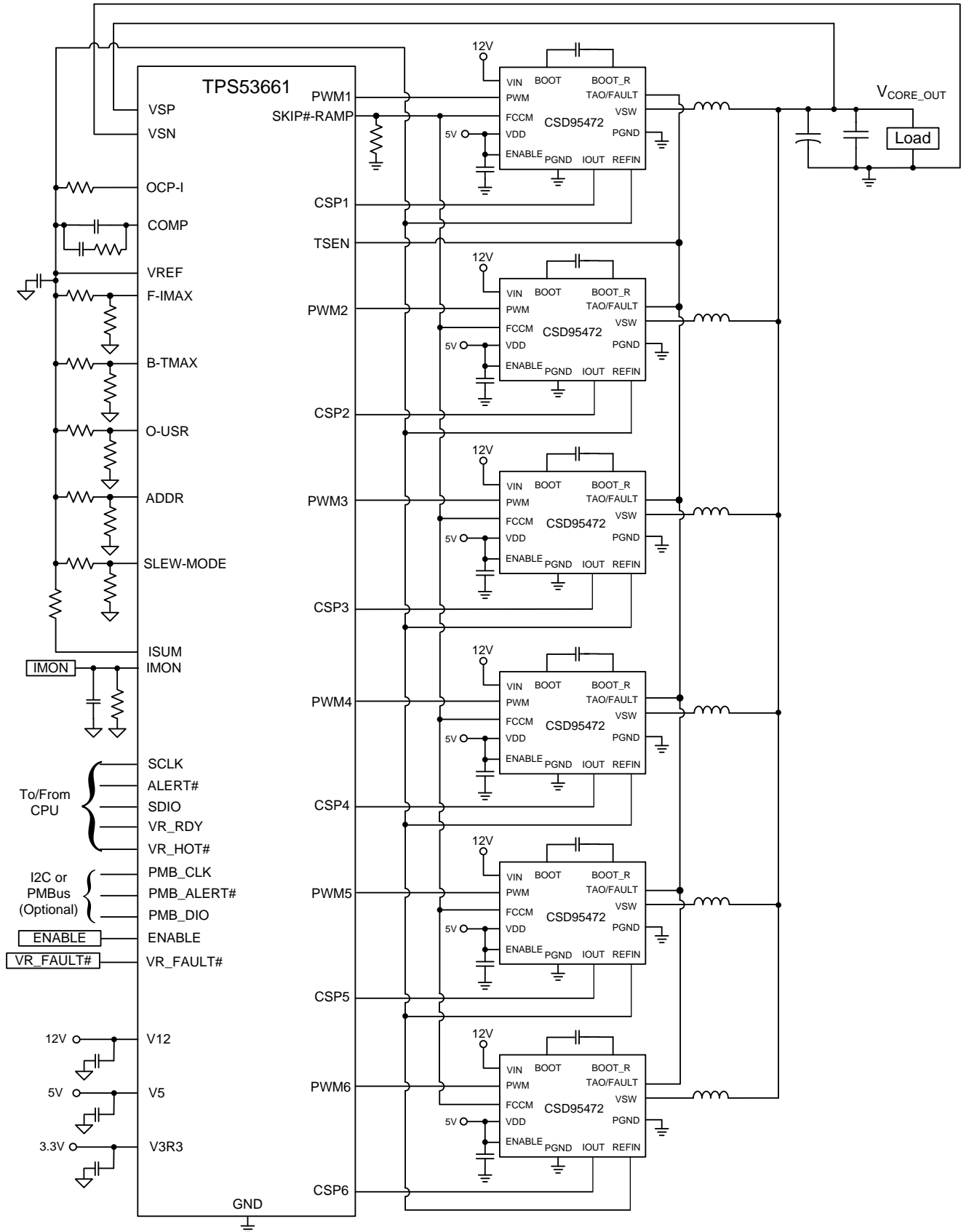
6.4 Thermal Information

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

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

- (1) $R_{\theta JC(top)}$ is determined with the device mounted on a 1 inch² (6.45 cm²), 2-oz (0.071 mm thick) Cu pad on a 1.5 inches x 1.5 inches, 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, 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

NexFET, DualCool, E2E are trademarks of Texas Instruments.
All other trademarks are the property of their respective owners.

8.3 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.

8.4 Glossary

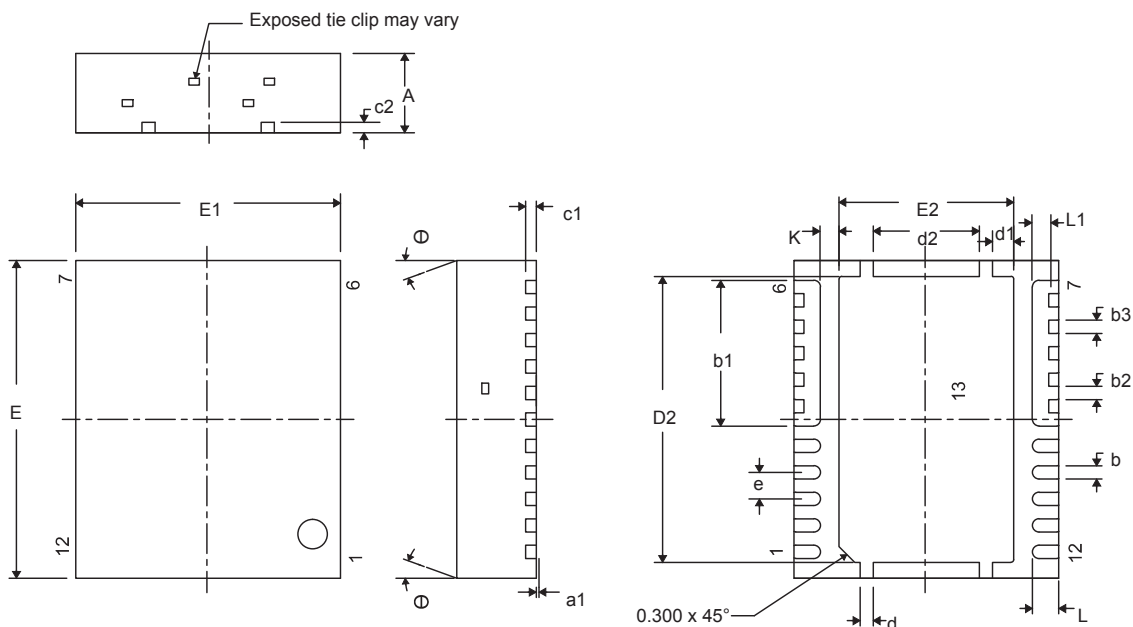
[SLYZ022](#) — *TI Glossary*.

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 | — | — |

PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|---------------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| CSD95472Q5MC | ACTIVE | VSON-CLIP | DMC | 12 | 2500 | RoHS-Exempt & Green | SN | Level-2-260C-1 YEAR | -55 to 150 | 95472MC | Samples |
| CSD95472Q5MCT | ACTIVE | VSON-CLIP | DMC | 12 | 250 | RoHS-Exempt & Green | SN | Level-2-260C-1 YEAR | -55 to 150 | 95472MC | 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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(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 finish/Ball material - Orderable Devices 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.

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