

Highly Integrated Digital Controller for Isolated Power

Check for Samples: [UCD3138](#)

1 Introduction

1.1 Features

- Digital Control of up to 3 Independent Feedback Loops
 - Dedicated PID based hardware
 - 2-pole/2-zero configurable
 - Programmable
 - Non-Linear Control
- Up to 16MHz Error Analog to Digital Converter (EADC)
 - Configurable Resolution as Small as 1mV/LSB
 - Automatic Resolution Selection
 - Up to 8x Oversampling
 - Hardware Based Averaging (up to 8x)
 - 14 bit Effective DAC
- Up to 8 High Resolution Digital Pulse Width Modulated (DPWM) Outputs
 - 250ps Pulse Width Resolution
 - 4ns Frequency Resolution
 - 4ns Phase Resolution
 - Adjustable Phase Shift Between Outputs
 - Adjustable Dead-band Between Pairs
 - Up to 2MHz Switching Frequency
- Configurable PWM Edge Movement
 - Trailing Modulation
 - Leading Modulation
 - Dual Edge Modulation
- Configurable Feedback Control
 - Voltage Mode
 - Average Current Mode
 - Peak Current Mode Control
 - Constant Current
 - Constant Power
- Configurable Modulation Methods
 - Frequency Modulation
 - Phase Shift Modulation
 - Pulse Width Modulation
- Fast, Automatic and Smooth Mode Switching
 - Frequency Modulation and PWM
 - Phase Shift Modulation and PWM
- High Efficiency and Light Load Management
 - Burst Mode
 - Ideal Diode Emulation
- Synchronous Rectifier Soft On/Off
- Low IC Standby Power
- Soft Start / Stop with and without Pre-bias
- Fast Input Voltage Feed Forward Hardware
- Primary Side Voltage Sensing
- Copper Trace Current Sensing
- Flux and Phase Current Balancing for Non-Peak Current Mode Control Applications
- Current Share Bus Support
 - Analog Average
 - Master/Slave
- Feature Rich Fault Protection Options
 - 7 High Speed Analog Comparators
 - Cycle-by-Cycle Current Limiting
 - Programmable Fault Counting
 - External Fault Inputs
 - 4–10 Digital Comparators
 - Programmable blanking time
- Synchronization of DPWM waveforms between multiple UCD313x devices
- 14 channel, 12 bit, 265 ksps General Purpose ADC with integrated
 - Programmable averaging filters
 - Dual sample and hold
- Internal Temperature Sensor
- Fully Programmable High-Performance 31.25MHz, 32-bit ARM7TDMI-S Processor
 - 32 kByte (kB) Program Flash
 - 2 kB Data Flash with ECC
 - 4 kB Data RAM
 - 4 kB Boot ROM Enables Firmware Boot-Load in the Field via I²C or UART
- Communication Peripherals
 - I²C/PMBus
 - 2 UARTs
- JTAG Debug Port
- Timer capture with selectable input pins
- Up to 5 Additional General Purpose Timers
- Built In Watchdog: BOD and POR
- 64-pin QFN and 40-pin QFN packages
- Operating Temperature: –40°C to 125°C
- Fusion Digital Power GUI Support

PRODUCT PREVIEW


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.

1.2 Applications

- Power Supplies and Telecom Rectifiers
- Power Factor Correction
- Isolated dc-dc Modules

2 Overview

2.1 Description

The UCD3138 is a digital power supply controller from Texas Instruments offering superior levels of integration and performance in a single chip solution. The flexible nature of the UCD3138 makes it suitable for a wide variety of power conversion applications. In addition, multiple peripherals inside the device have been specifically optimized to enhance the performance of ac/dc and isolated dc/dc applications and reduce the solution component count in the IT and network infrastructure space.

The UCD3138 is a fully programmable solution offering customers complete control of their application, along with ample ability to differentiate their solution. At the same time, TI is committed to simplifying our customer's development effort through offering best in class development tools, including application firmware, Code Composer Studio™ software development environment, and TI's Fusion Power Development GUI which enables customers to configure and monitor key system parameters.

At the core of the UCD3138 controller are the digital control loop peripherals, also known as Fusion Digital Power Peripherals (FDPP). Each FDPP implements a high speed digital control loop consisting of a dedicated Error Analog to Digital Converter (EADC), a PID based 2 pole–2 zero digital compensator and DPWM outputs with 250 ps pulse width resolution. The device also contains a 12-bit, 265ksps general purpose ADC with up to 14 channels, timers, interrupt control, JTAG debug and PMBus and UART communications ports. The device is based on a 32-bit ARM7TDMI-S RISC microcontroller that performs real-time monitoring, configures peripherals and manages communications. The ARM microcontroller executes its program out of programmable flash memory as well as on-chip RAM and ROM.

In addition to the FDPP, specific power management peripherals have been added to enable high efficiency across the entire operating range, high integration for increased power density, reliability, and lowest overall system cost and high flexibility with support for the widest number of control schemes and topologies. Such peripherals include: light load burst mode, synchronous rectification, LLC and phase shifted full bridge mode switching, input voltage feed forward, copper trace current sense, ideal diode emulation, constant current constant power control, synchronous rectification soft on and off, peak current mode control, flux balancing, secondary side input voltage sensing, high resolution current sharing, hardware configurable soft start with pre bias, as well as several other features. Topology support has been optimized for voltage mode and peak current mode controlled phase shifted full bridge, single and dual phase PFC, bridgeless PFC, hard switched full bridge and half bridge, and LLC half bridge and full bridge.

2.2 Ordering Information

PART NUMBER	PIN COUNT	PACKAGE	SUPPLY	TOP SIDE MARKING	OPERATING TEMPERATURE RANGE, T _A
UCD3138RGCT	64	QFN	250 (Small Reel)	UCD3138	–40°C to 125°C
UCD3138RGCR	64	QFN	2000 (Large Reel)	UCD3138	–40°C to 125°C
UCD3138RHAT	40	QFN	250 (Small Reel)	UCD3138	–40°C to 125°C
UCD3138RHAR	40	QFN	2500 (large Reel)	UCD3138	–40°C to 125°C

2.3 Product Selection Matrix

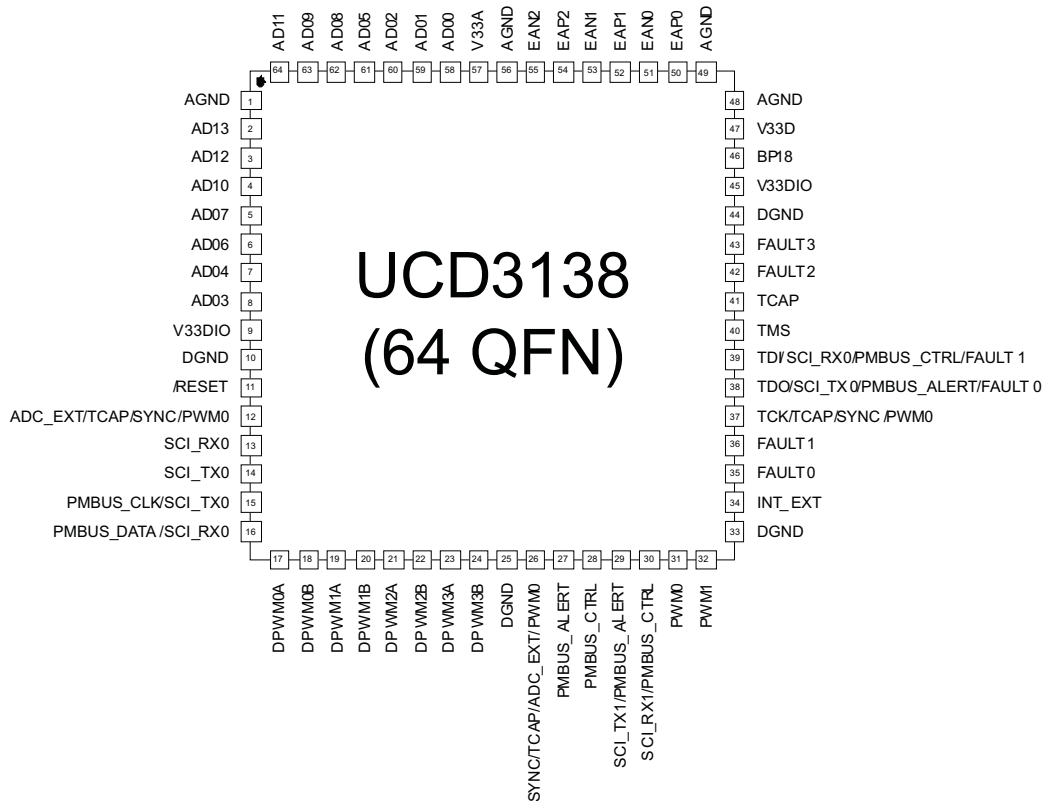
FEATURE	UCD3138 64 PIN	UCD3138 40 PIN
ARM7TDMI-S Core Processor	31.25 MHz	31.25 MHz
High Resolution DPWM Outputs (250ps Resolution)	8	8
Number of High Speed Independent Feedback Loops (# Regulated Output Voltages)	3	3
12-bit, 265ksps, General Purpose ADC Channels	14	7
Digital Comparators at ADC Outputs	4	4
Flash Memory (Program)	32 KB	32 KB
Flash Memory (Data)	2 KB	2 KB
Flash Security	√	√
RAM	4KB	4 KB
DPWM Switching Frequency	up to 2 MHz	up to 2 MHz
Programmable Fault Inputs	4	1 + 2 ⁽¹⁾
High Speed Analog Comparators with Cycle-by-Cycle Current Limiting	7 ⁽²⁾	6 ⁽²⁾
UART (SCI)	2	1 + 1 ⁽¹⁾
PMBus	√	√
Timers	4 (16 bit) and 1 (24 bit)	4 (16 bit) and 1 (24 bit)
Timer PWM Outputs	2	1
Timer Capture Inputs	1	1 ⁽¹⁾
Watchdog	√	√
On Chip Oscillator	√	√
Power-On Reset and Brown-Out Reset	√	√
JTAG	√	√
Package Offering	64 Pin QFN (9mm x 9mm)	40 Pin QFN (6mm x 6mm)
Internal Reference (Tolerance)	±1%	±1%
Sync IN and Sync OUT Functions	√	√
Total GPIO (includes all pins with multiplexed functions such as, DPWM, Fault Inputs, SCI, etc.)	30	17
External Interrupts	1	0

(1) This number represents an alternate pin out that is programmable via firmware. See the Peripherals Programming manual for details.

(2) To facilitate simple OVP and UVP connections both comparators B and C are connected to the AD03 pin.

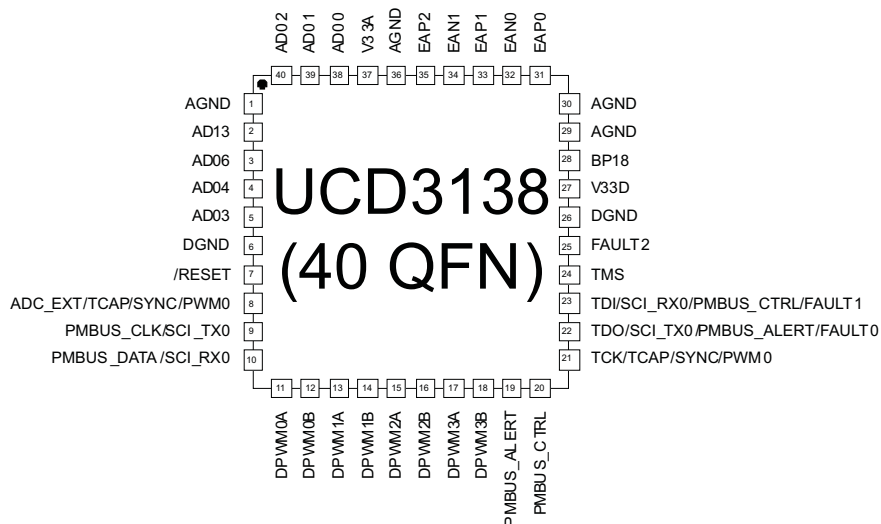
PRODUCT PREVIEW

2.4 UCD3138 64 QFN – Pin Assignments



PRODUCT PREVIEW

2.5 UCD3138 40 QFN – Pin Assignments



PRODUCT PREVIEW

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/ Ball Finish	MSL Peak Temp ⁽³⁾	Samples (Requires Login)
UCD3138RGCR	PREVIEW	VQFN	RGC	64	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	
UCD3138RGCT	PREVIEW	VQFN	RGC	64	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	
UCD3138RHAR	PREVIEW	VQFN	RHA	40	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	
UCD3138RHAT	PREVIEW	VQFN	RHA	40	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	

⁽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.

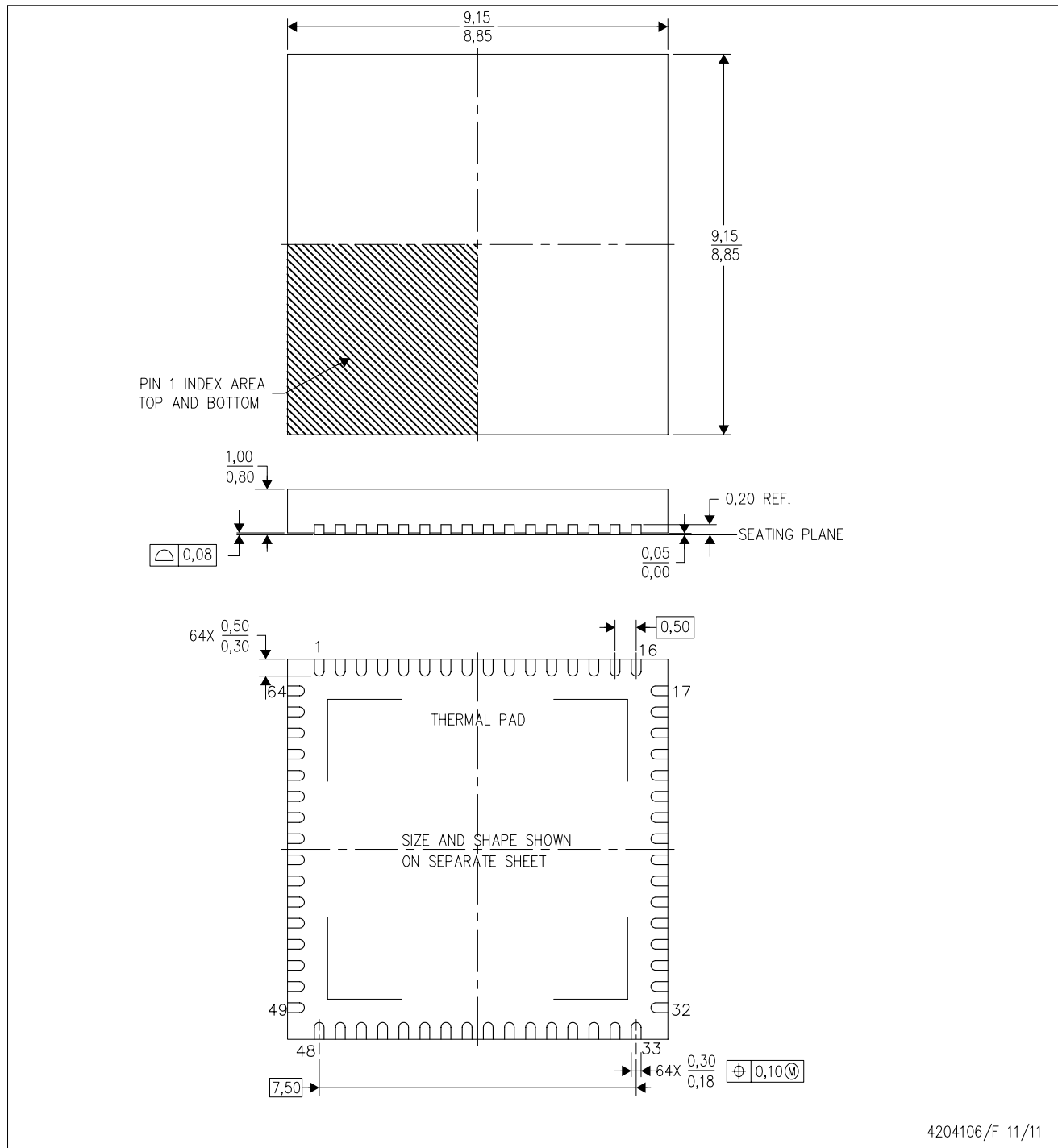
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

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RGC(S-PVQFN-N64) CUSTOM DEVICE PLASTIC QUAD FLATPACK NO-LEAD



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- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5-1994.
 - B. This drawing is subject to change without notice.
 - C. Quad Flatpack, No-leads (QFN) package configuration.
 - D. The package thermal pad must be soldered to the board for thermal and mechanical performance.
 - E. See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.

THERMAL PAD MECHANICAL DATA

RGC (S-PVQFN-N64)

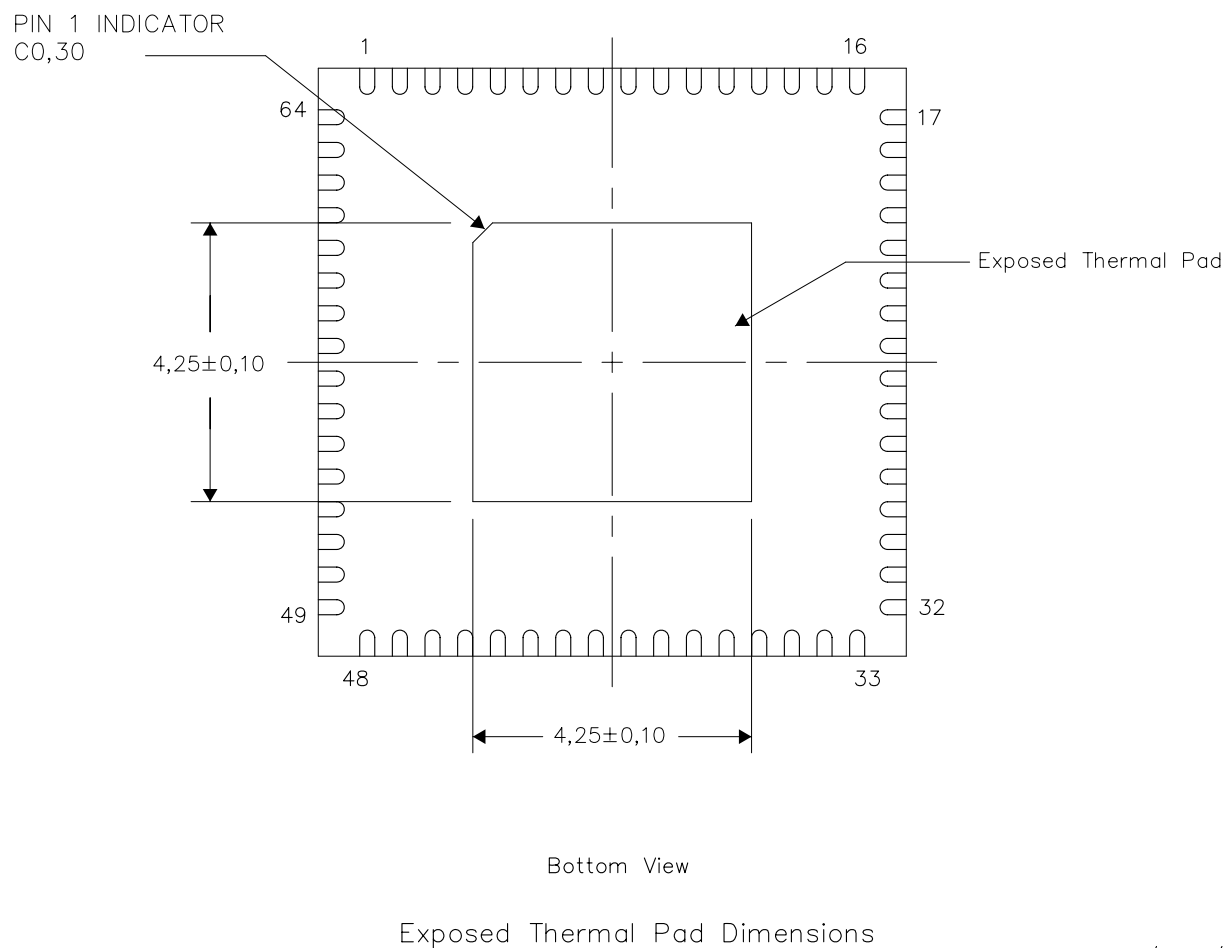
PLASTIC QUAD FLATPACK NO-LEAD

THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No-Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.

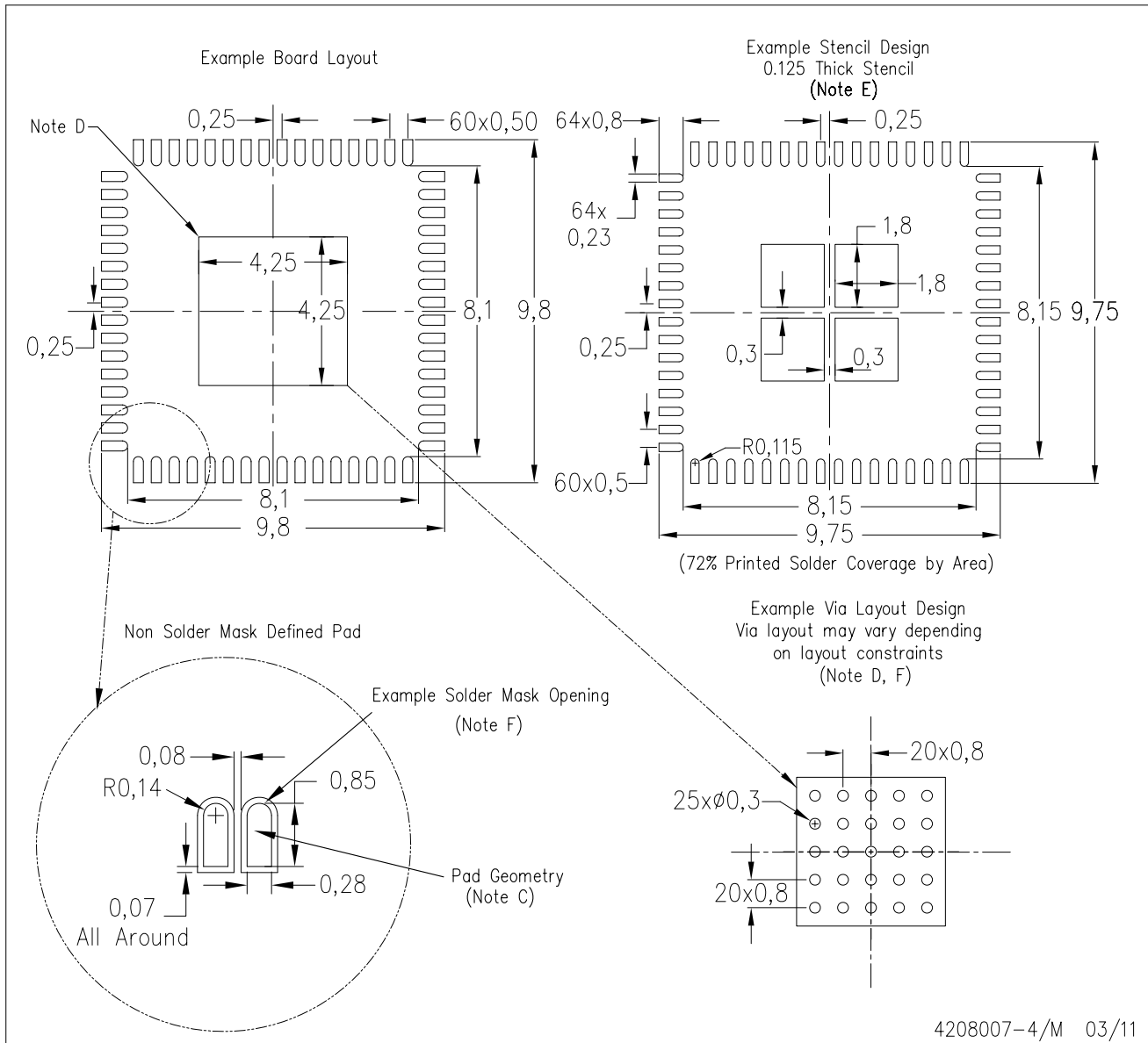


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NOTE: A. All linear dimensions are in millimeters

RGC (S-PVQFN-N64)

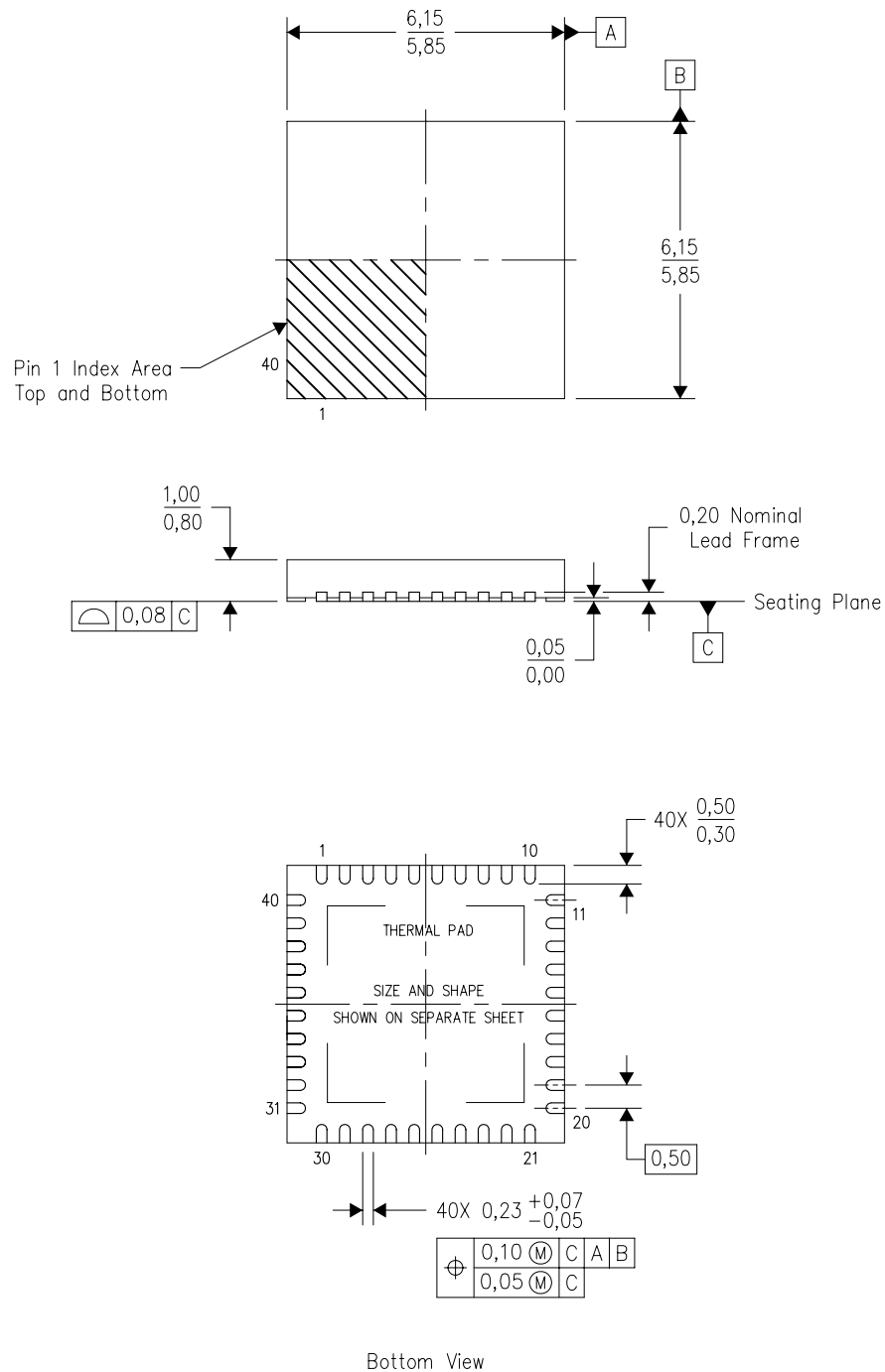
PLASTIC QUAD FLATPACK NO-LEAD



- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Publication IPC-7351 is recommended for alternate designs.
 - This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, Quad Flat-Pack Packages, Texas Instruments Literature No. SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <<http://www.ti.com>>.
 - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
 - Customers should contact their board fabrication site for recommended solder mask tolerances and via tenting recommendations for vias placed in thermal pad.

RHA (S-PVQFN-N40)

PLASTIC QUAD FLATPACK NO-LEAD



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- 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. QFN (Quad Flatpack No-Lead) Package configuration.
 - D. The package thermal pad must be soldered to the board for thermal and mechanical performance.
 - E. See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
 - F. Package complies to JEDEC MO-220 variation VJJD-2.

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