
CC2592 2.4-GHz Range Extender

1 Introduction

1.1 Features

- Seamless Interface to 2.4-GHz Low-Power RF Devices from Texas Instruments
- +22-dBm Output Power
- 3-dB Typical Improved Sensitivity on CC2520, CC253X, and CC85XX
- Very Few External Components
 - Integrated Switches
 - Integrated Matching Network
 - Integrated Balun
 - Integrated Inductors
 - Integrated PA
 - Integrated LNA
- Digital Control of LNA Gain by HGM Terminal
- 100 nA in Power Down (LNA_EN = PA_EN = 0)
- Low-Transmit Current Consumption
 - 155 mA at 3 V for +22 dBm, PAE = 34%
- Low-Receive Current Consumption
 - 4.0-mA for High-Gain Mode
 - 1.9-mA for Low-Gain Mode
- 4.7-dB LNA Noise Figure, Including T/R Switch and External Antenna Match
- RoHS Compliant 4-mm × 4-mm QFN-16 Package
- 2.0-V to 3.7-V Operation
- –40°C to +125°C Operation

1.2 Applications

- All 2.4-GHz ISM Band Systems
- Wireless Sensor Networks
- Wireless Industrial Systems
- IEEE 802.15.4 and ZigBee® Metering Systems
- IEEE 802.15.4 and ZigBee Gateways
- Wireless Consumer Systems
- Wireless Audio Systems

1.3 Description

The CC2592 device is a cost-effective and high-performance RF front end for low-power and low-voltage 2.4-GHz wireless applications.

The CC2592 device is a range extender for all CC25XX 2.4-GHz low-power RF transceivers, transmitters, and system-on-chip products from Texas Instruments.

To increase the link budget, the CC2592 device provides a power amplifier for increased output power and an LNA with a low-noise figure for improved receiver sensitivity.

The CC2592 device provides a very small size, high-output power RF design with its 4-mm × 4-mm QFN-16 package.

The CC2592 device contains PA, LNA, switches, RF-matching, and balun for simple design of high-performance wireless applications.



1.4 Functional Block Diagram

Figure 1-1 shows a simplified block diagram of the CC2592 device.

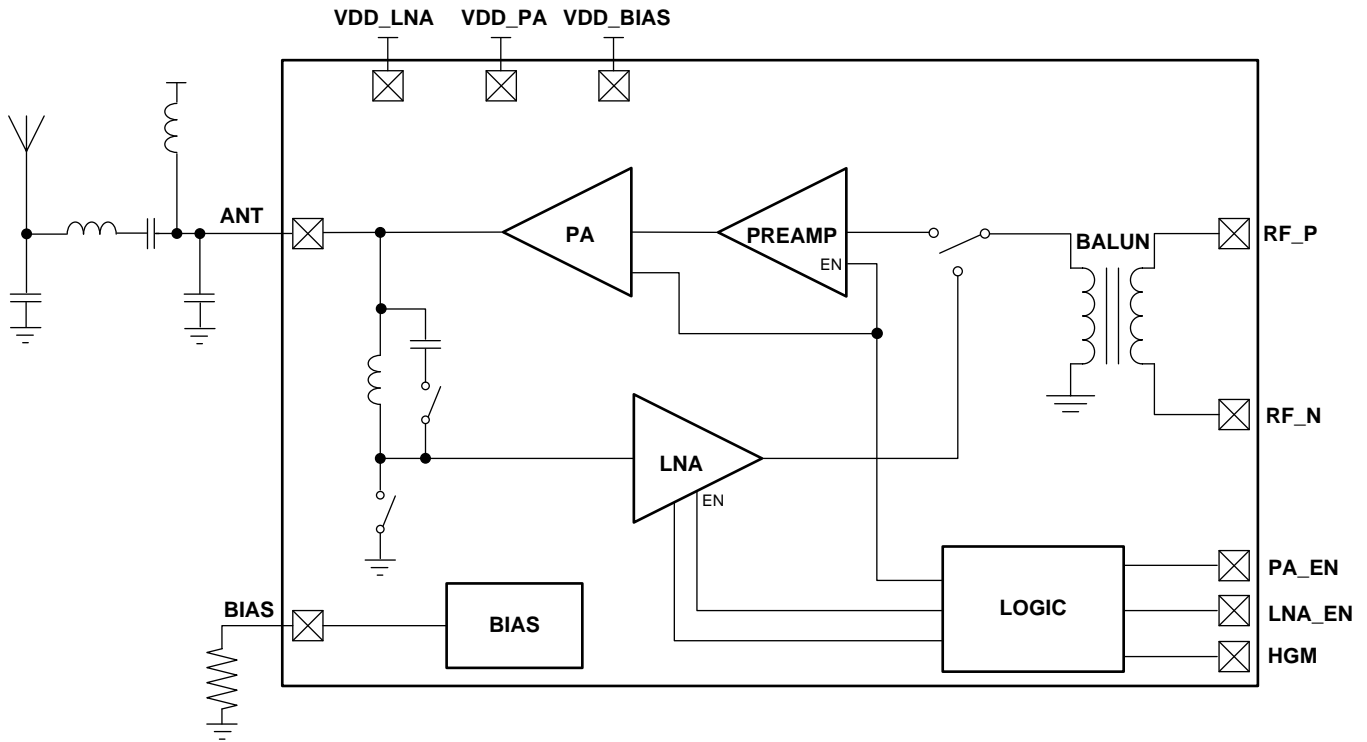


Figure 1-1. CC2592 Simplified Block Diagram

Revision History

| Date | Literature Number | Changes |
|---------------|--------------------------|-----------------|
| February 2014 | SWRS159 | Initial release |

2 Device Characteristics

2.1 Absolute Maximum Ratings

Under no circumstances must the absolute maximum ratings be violated. Stress exceeding one or more of the limiting values may cause permanent damage to the device.

| Parameter | Conditions | Value | Unit |
|---------------------------------|---|--------------------------|------|
| Supply voltage | All supply terminals must have the same voltage | -0.3 to 3.8 | V |
| Voltage on any digital terminal | | -0.3 to VDD+0.3, max 3.8 | V |
| Input RF level | | +10 | dBm |

2.2 Handling Ratings

Under no circumstances must the handling ratings be violated. Stress exceeding one or more of the limiting values may cause permanent damage to the device.

| Parameter | Conditions | Value | Unit |
|---------------------------|---------------------|------------|------|
| Storage temperature range | | -50 to 150 | °C |
| ESD | Human Body Model | 2000 | V |
| | Charge Device Model | 1000 | V |

2.3 Recommended Operating Conditions

The operating conditions for the CC2592 device are listed below.

| Parameter | Conditions | Min | Max | Unit |
|---------------------------|------------|------|--------|------|
| Ambient temperature range | | -40 | 125 | °C |
| Operating supply voltage | | 2.0 | 3.7 | V |
| Operating frequency range | | 2400 | 2483.5 | MHz |

2.4 Electrical Characteristics

$T_c = 25^\circ\text{C}$, $V_{DD} = 3.0\text{ V}$, $f_{RF} = 2440\text{ MHz}$ (unless otherwise noted). Measured on CC2592EM reference design including external matching components.

| Parameter | Test Conditions | Min | Typ | Max | Unit |
|---|--|-------|------|-------|---------------|
| Receive current, high-gain mode | HGM = 1 | | 4 | | mA |
| Receive current, low-gain mode | HGM = 0 | | 1.9 | | mA |
| Transmit current | $P_{OUT} = 20\text{ dBm}$ | | 123 | | mA |
| | $P_{OUT} = 22\text{ dBm}$ | | 155 | | |
| Transmit current | No input signal | | 50 | | mA |
| Power down current | EN = 0 | | 0.1 | 0.3 | μA |
| High-input level (control terminals) | PA_EN, LNA_EN, HGM | 1.3 | | Vdd | V |
| Low-input level (control terminals) | PA_EN, LNA_EN, HGM | | | 0.3 | V |
| Power down - Receive mode switching time | | | 1 | | μs |
| Power down - Transmit mode switching time | | | 1 | | μs |
| RF Receive | | | | | |
| Gain, high-gain mode | HGM = 1 | | 11 | | dB |
| Gain, low-gain mode | HGM = 0 | | 6 | | dB |
| Gain variation over frequency | 2400 to 2483.5 MHz, HGM = 1 | | 2 | | dB |
| Gain variation over power supply | 2.0 V to 3.7 V, HGM = 1 | | 1.5 | | dB |
| Gain variation over temperature | -40°C to 85°C , HGM = 1 | | 1.7 | | dB |
| Gain variation over temperature | 85°C to 125°C , HGM = 1 | | 1 | | dB |
| Noise figure, high-gain mode | HGM = 1, including internal T/R switch and external antenna match | | 4.7 | | dB |
| Input 1-dB compression, high-gain mode | HGM = 1 | | -18 | | dBm |
| Input IP3, high-gain mode | HGM = 1 | | -9 | | dBm |
| Input reflection coefficient, S11 | HGM = 1, measured at antenna port | | -15 | | dB |
| RF Transmit | | | | | |
| Gain | | | 24 | | dB |
| Output power, P_{OUT} | $P_{IN} = 0.0\text{ dBm}$ | | 20.3 | | dBm |
| | $P_{IN} = 4.0\text{ dBm}$ | | 21.9 | | |
| Power added efficiency, PAE | $P_{OUT} = 22\text{ dBm}$ | | 34 | | % |
| Output 1-dB compression | | | 15 | | dBm |
| Output power variation over frequency | 2400 to 2483.5 MHz, $P_{IN} = 4\text{ dBm}$ | | 0.5 | | dB |
| Output power variation over power supply | 2.0 V to 3.7 V, $P_{IN} = 4\text{ dBm}$ | | 3.8 | | dB |
| Output power variation over temperature | -40°C to 125°C , $P_{IN} = 4\text{ dBm}$ | | 1.7 | | dB |
| Second harmonic power | FCC requirement | | | -41.2 | dBm |
| Third harmonic power | FCC requirement | | | -41.2 | dBm |
| VSWR | No damage | 20:1 | | | |
| | Stability | 7.5:1 | | | |

3 Device Information

3.1 Terminal and I/O Configuration

Figure 3-1 and Table 3-1, provide the terminal layout and description for the CC2592 device.

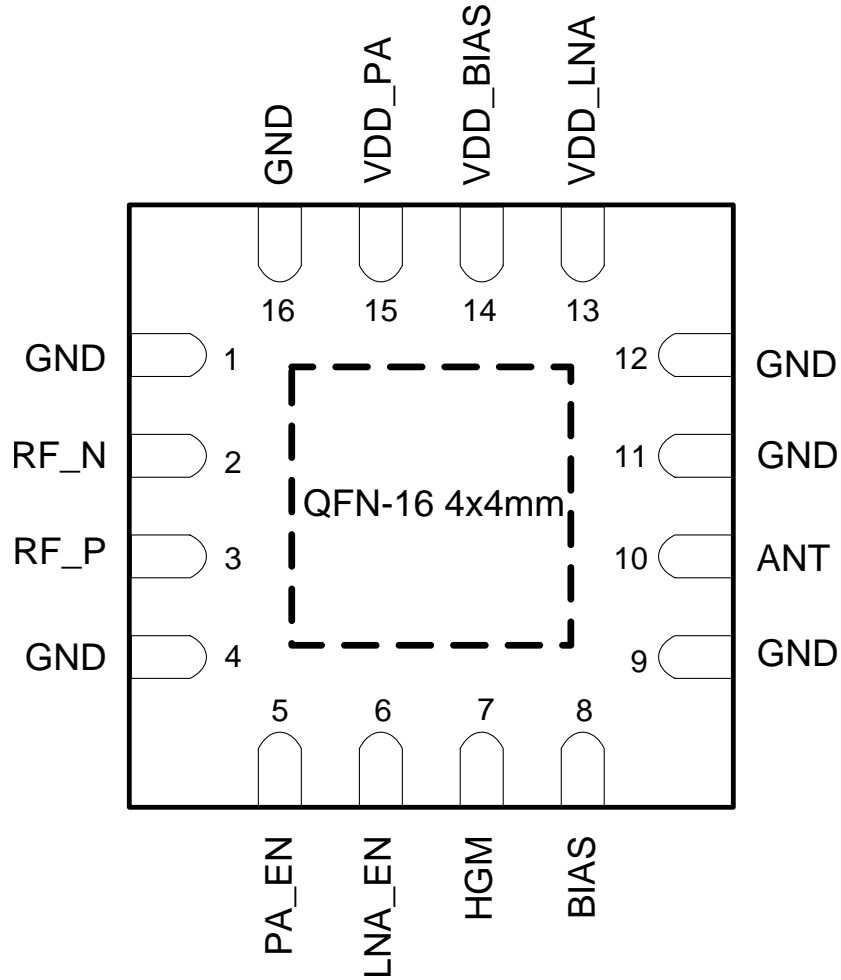


Figure 3-1. Terminal Top View

Table 3-1. Terminal Functions

| Terminal | | Type | Description |
|---------------------|----------|---------------|---|
| No. | Name | | |
| – | GND | Ground | The exposed die attach pad must be connected to a solid ground plane. See CC2592EM reference design for the recommended layout. |
| 1, 4, 9, 11, 12, 16 | GND | Ground | Ground connections. Only terminals 9, 11, and 12 should be shorted to the die attach pad on the top PCB layer. |
| 2 | RF_N | RF | RF interface toward CC25xx device |
| 3 | RF_P | RF | RF interface toward CC25xx device |
| 5 | PA_EN | Digital input | Digital control terminal. See Table 9-1 for details. |
| 6 | LNA_EN | Digital input | Digital control terminal. See Table 9-1 or details. |
| 7 | HGM | Digital input | Digital control terminal HGM = 1 → Device in High Gain Mode HGM = 0 → Device in Low Gain Mode |
| 8 | BIAS | Analog | Biasing input. Resistor between this node and ground sets bias current for PA and LNA. |
| 10 | ANT | RF | Antenna interface |
| 13 | VDD_LNA | Power | 2.0- to 3.7-V power |
| 14 | VDD_BIAS | Power | 2.0- to 3.7-V power |
| 15 | VDD_PA | Power | 2.0- to 3.7-V power |

4 Sensitivity Improvement Example

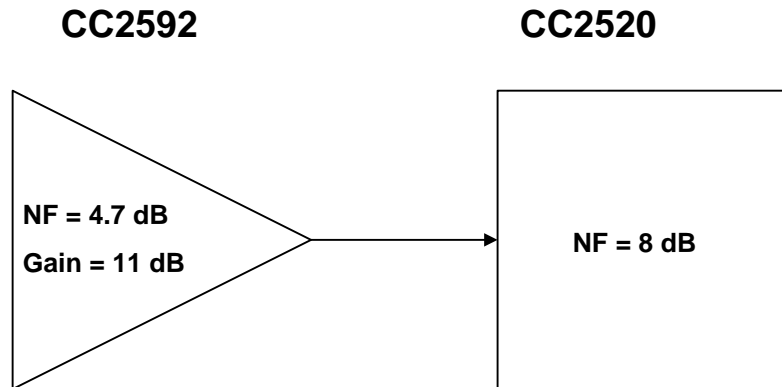


Figure 4-1.

The noise factor of a system consisting of the CC2592 device and a CC2520 device, as seen in [Figure 4-1](#) is given by:

$$F = F_1 + \frac{F_2 - 1}{G_1} = 10^{\frac{4.7}{10}} + \frac{10^{\frac{8}{10}} - 1}{10^{\frac{11}{10}}} = 3.37 \quad (1)$$

The noise figure is:

$$NF = 10 \log(F) = 10 \log(3.37) = 5.28 \text{ dB} \quad (2)$$

The noise figure is reduced from 8 dB for the CC2520 standalone to 5.28 dB for the CC2592 and CC2520 device combination, leading to a 2.72-dB theoretical improvement in sensitivity.

In practice, tests on the CC2592 and CC25XX devices show around 3-dB improvement in sensitivity. For the CC2538 and CC2592 devices, the improvement is almost 4 dB (approximately –97 dBm to –101 dBm)

5 CC2592EM Evaluation Module

Figure 5-1 shows an evaluation module circuit of the CC2592 device.

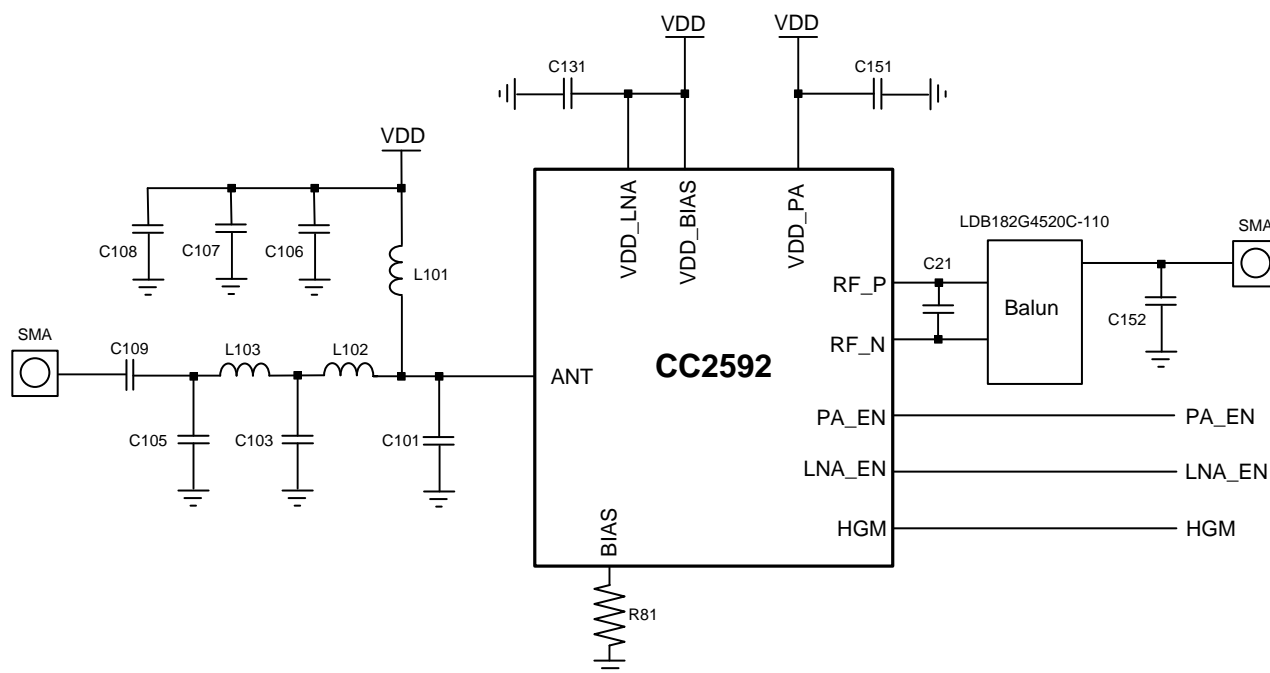


Figure 5-1. CC2592 Evaluation Module

Table 5-1 lists the materials in the CC2592 evaluation module circuit.

Table 5-1. List of Materials

| Device | Function | Value |
|--------|--------------------------|----------------------------------|
| L101 | PA bias inductor | 4.7 nH, Multilayer chip inductor |
| L102 | Part of antenna match | 1 nH, Multilayer chip inductor |
| L103 | Part of antenna match | 1.8 nH, Multilayer chip inductor |
| C101 | Part of antenna match | 2.2-pF 0402 Chip capacitor |
| C103 | Part of antenna match | 2.2-pF 0402 Chip capacitor |
| C105 | Part of antenna match | 0.1-pF 0402 Chip capacitor |
| C106 | Decoupling | 12-pF 0402 Chip capacitor |
| C107 | Decoupling | 1-nF 0402 Chip capacitor |
| C108 | Decoupling | 1- μ F 0402 Chip capacitor |
| C109 | DC block | 18-pF 0402 Chip capacitor |
| C21 | Balun matching capacitor | 0.2-pF 0402 Chip capacitor |
| C152 | Balun matching capacitor | 0.3-pF 0402 Chip capacitor |
| C131 | Decoupling | 1-nF 0402 Chip capacitor |
| C151 | Decoupling | 12-pF 0402 Chip capacitor |
| R81 | Bias resistor | 3.9 k Ω , 0402 resistor |

6 Typical Characteristics

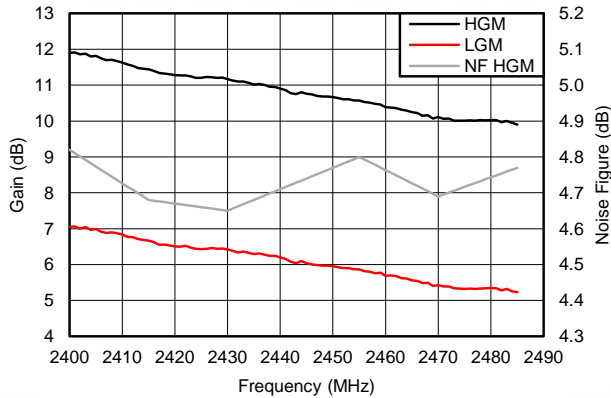


Figure 1. LNA Gain and Noise Figure Versus Frequency

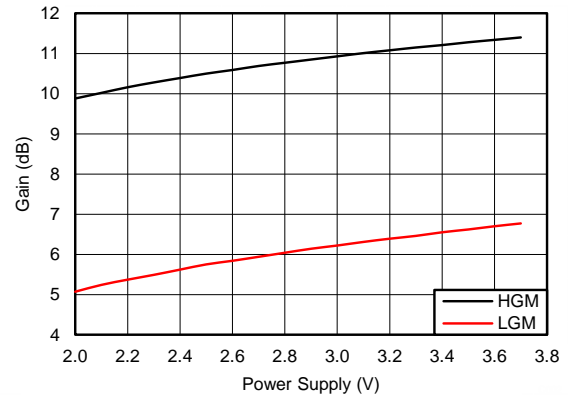


Figure 2. LNA Gain Versus Power Supply

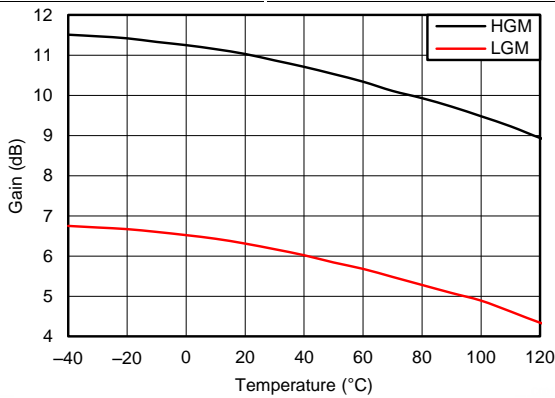


Figure 3. LNA Gain Versus Temperature

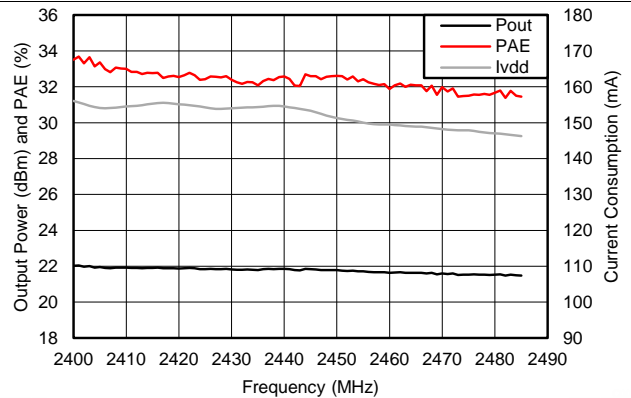


Figure 4. Output Power, PAE, and Current Consumption Versus Frequency
Input Power Level = +4 dBm

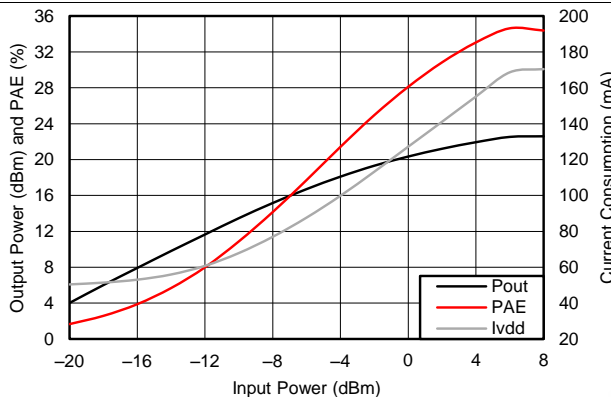


Figure 5. Output Power, PAE, and Current Consumption Versus Input Power

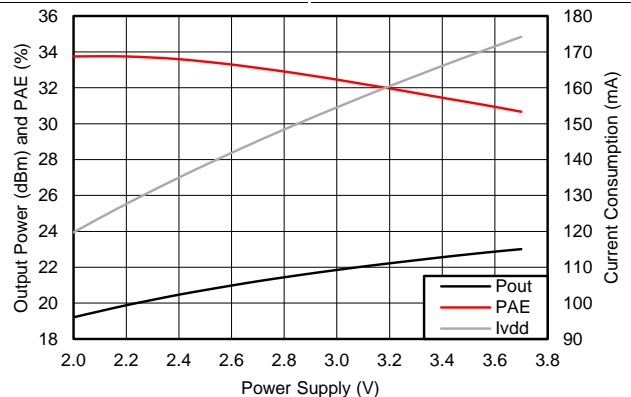


Figure 6. Output Power, PAE, and Current Consumption Versus Power Supply
Input Power Level = +4 dBm

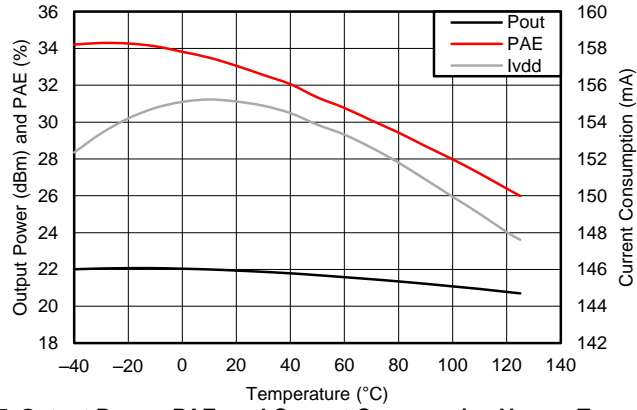


Figure 7. Output Power, PAE, and Current Consumption Versus Temperature
Input Power Level = +4 dBm

7 Controlling the Output Power from CC2592

The output power of the CC2592 device is controlled by controlling the input power. The CC2592 PA is designed to work in compression (class AB).

Driving the CC2592 device too far into saturation might result in spurious emissions and harmonics above regulatory limits. This caution should especially be considered for systems targeting a wide operating temperature range, where a combination of low temperature, low supply voltage, and a transceiver that increases output power (drive level) at low temperature, can result in high spurious emissions.

Figure 7-1 shows the maximum recommended drive level versus temperature and supply voltage.

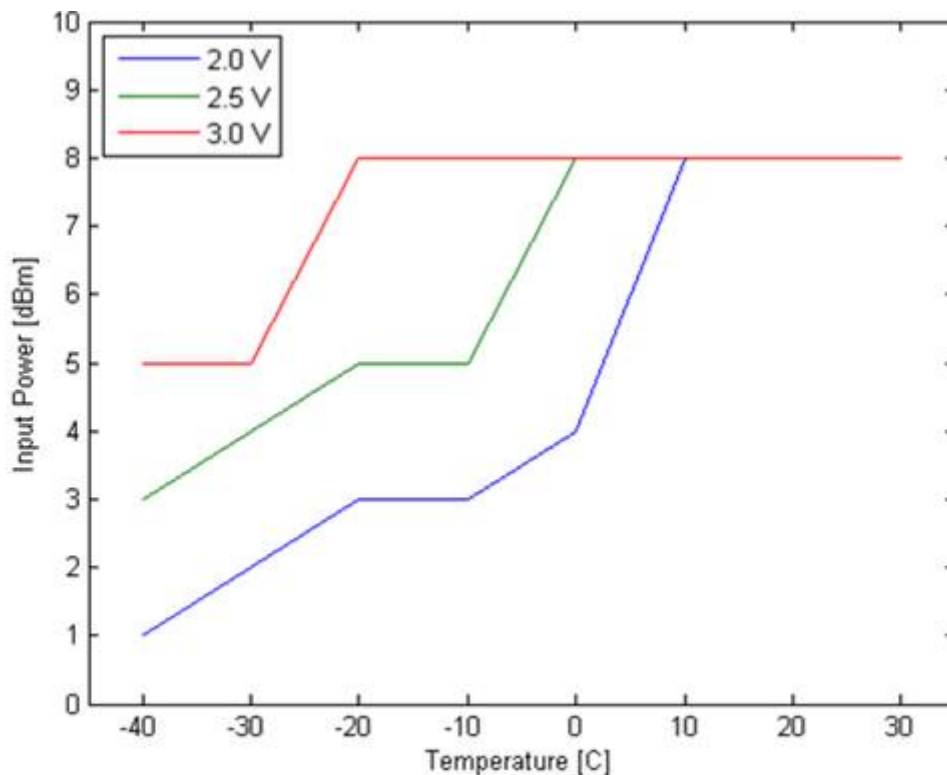


Figure 7-1. Maximum Recommended Drive Level

8 Input Levels on Control Terminals

The three digital control terminals (PA_EN, LNA_EN, and HGM) have built-in level-shifting functionality, meaning that if the CC2592 device operates off a 3.7-V supply voltage, the control terminals still sense 1.6- to 1.8-V signals as a logical 1. However, the input voltages should not have a logical 1 level that is higher than the supply.

9 Connecting the CC2592 Device to a CC25xx Device

Table 9-1 shows the control logic for connecting CC2592 to a CC25xx device.

Table 9-1. Control Logic for Connecting CC2592 to a CC25xx Device

| PA_EN | LNA_EN | HGM | Mode of Operation |
|-------|--------|-----|-------------------|
| 0 | 0 | X | Power Down |
| X | 1 | 0 | RX Low-Gain Mode |
| X | 1 | 1 | RX High-Gain Mode |
| 1 | 0 | X | TX |

Figure 9-1 shows the application circuit for the CC2592 and CC253X devices.

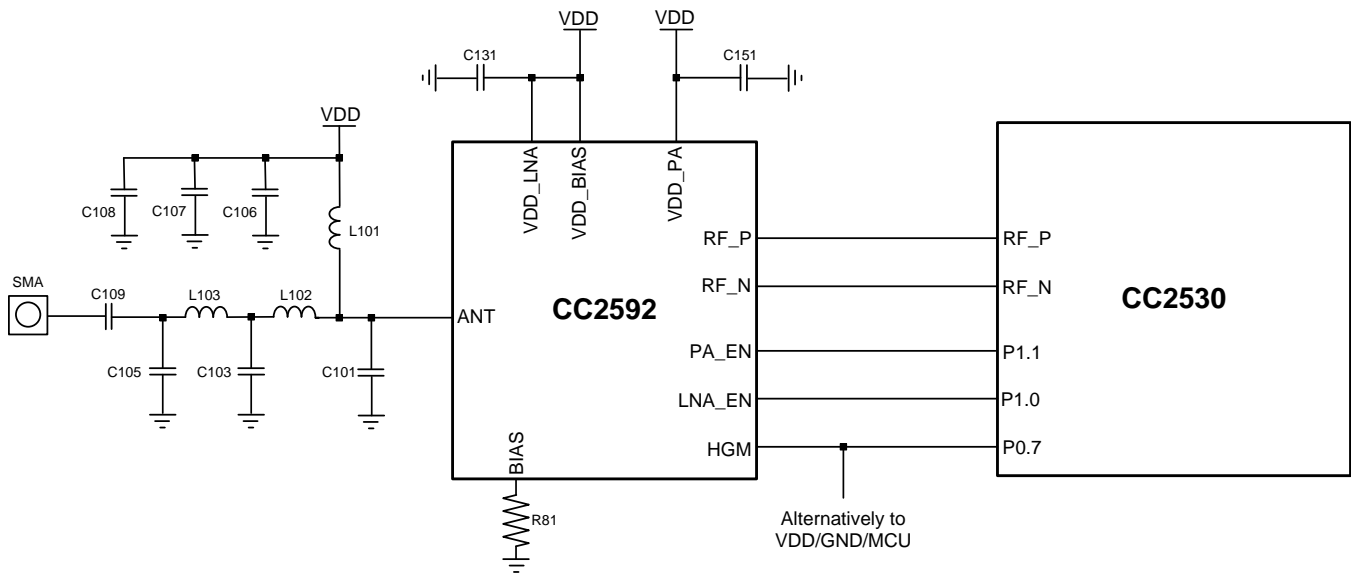


Figure 9-1. Application Circuit Example for CC2530 + CC2592

10 Device and Documentation Support

10.1 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

Table 10-1. Related Links

| PARTS | PRODUCT FOLDER | SAMPLE & BUY | TECHNICAL DOCUMENTS | TOOLS & SOFTWARE | SUPPORT & COMMUNITY |
|--------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| CC2592 | Click here | Click here | Click here | Click here | Click here |

10.2 Trademarks

ZigBee is a registered trademark of ZigBee Alliance.

10.3 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.

10.4 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms and definitions.

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 |
|------------------|---------------|--------------|-----------------|------|-------------|-------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| CC2592RGVR | ACTIVE | VQFN | RGV | 16 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | CC2592 | Samples |
| CC2592RGVT | ACTIVE | VQFN | RGV | 16 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU Call TI | Level-2-260C-1 YEAR | -40 to 125 | CC2592 | 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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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 |
|------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| CC2592RGVR | VQFN | RGV | 16 | 2500 | 330.0 | 12.4 | 4.3 | 4.3 | 1.5 | 8.0 | 12.0 | Q2 |
| CC2592RGVT | VQFN | RGV | 16 | 250 | 180.0 | 12.4 | 4.3 | 4.3 | 1.5 | 8.0 | 12.0 | Q2 |

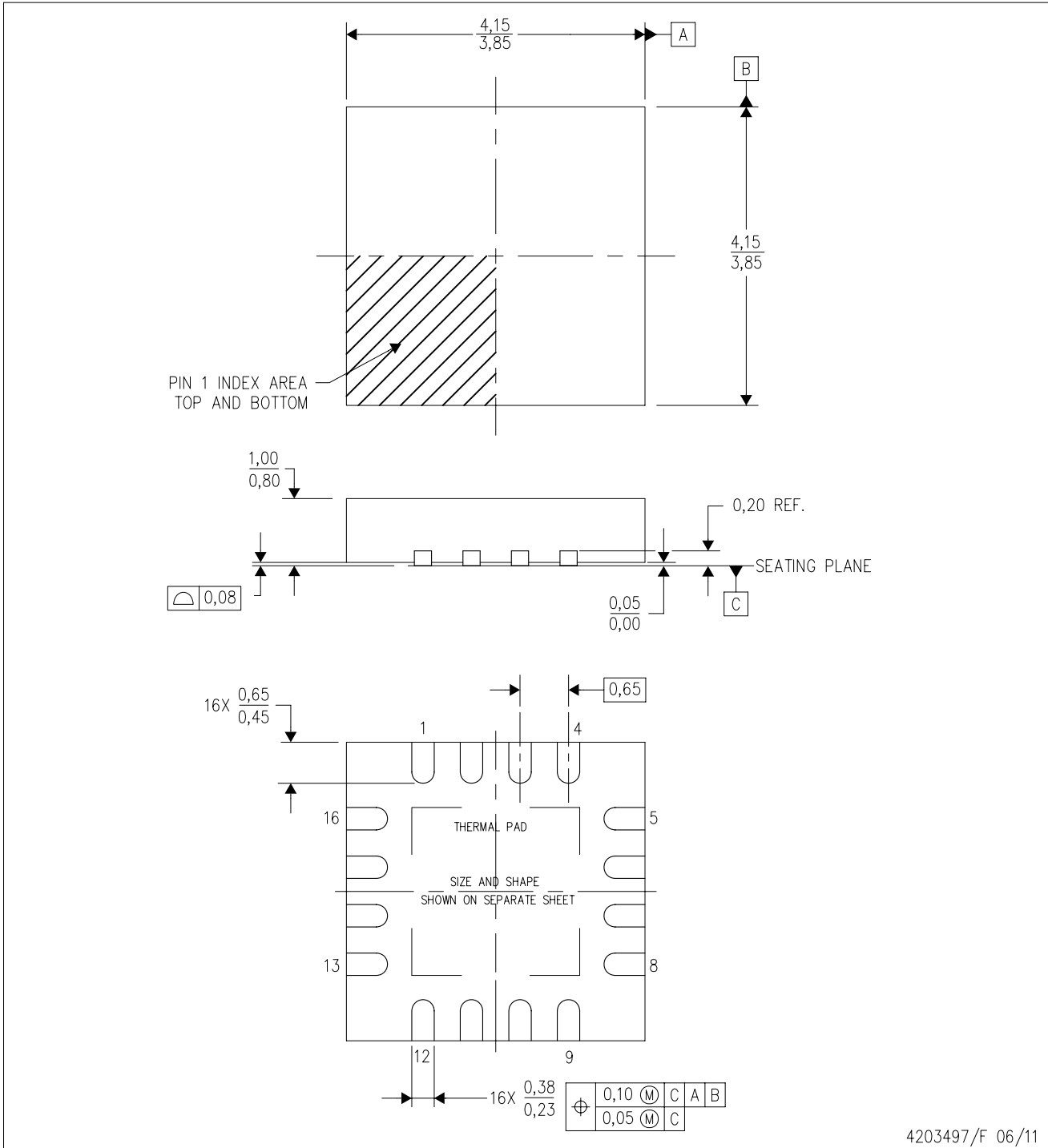
TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|------------|--------------|-----------------|------|------|-------------|------------|-------------|
| CC2592RGVR | VQFN | RGV | 16 | 2500 | 338.1 | 338.1 | 20.6 |
| CC2592RGVT | VQFN | RGV | 16 | 250 | 210.0 | 185.0 | 35.0 |

RGV (S-PVQFN-N16)

PLASTIC QUAD FLATPACK NO-LEAD



4203497/F 06/11

- NOTES:
- All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - This drawing is subject to change without notice.
 - Quad Flatpack, No-leads (QFN) package configuration.
 - The package thermal pad must be soldered to the board for thermal and mechanical performance.
 - See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
 - Falls within JEDEC MO-220.

THERMAL PAD MECHANICAL DATA

RGV (S-PVQFN-N16)

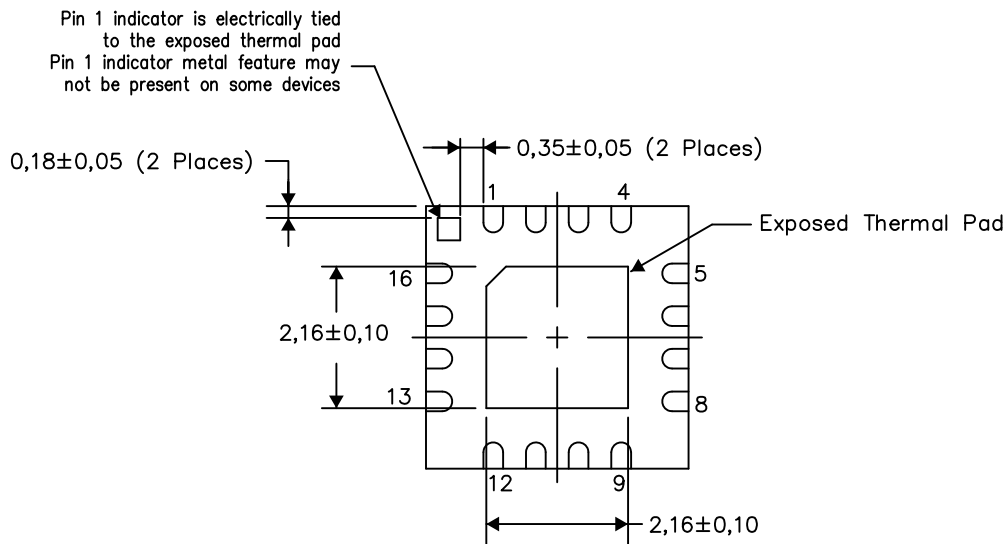
PLASTIC QUAD FLATPACK NO-LEAD

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.



Bottom View

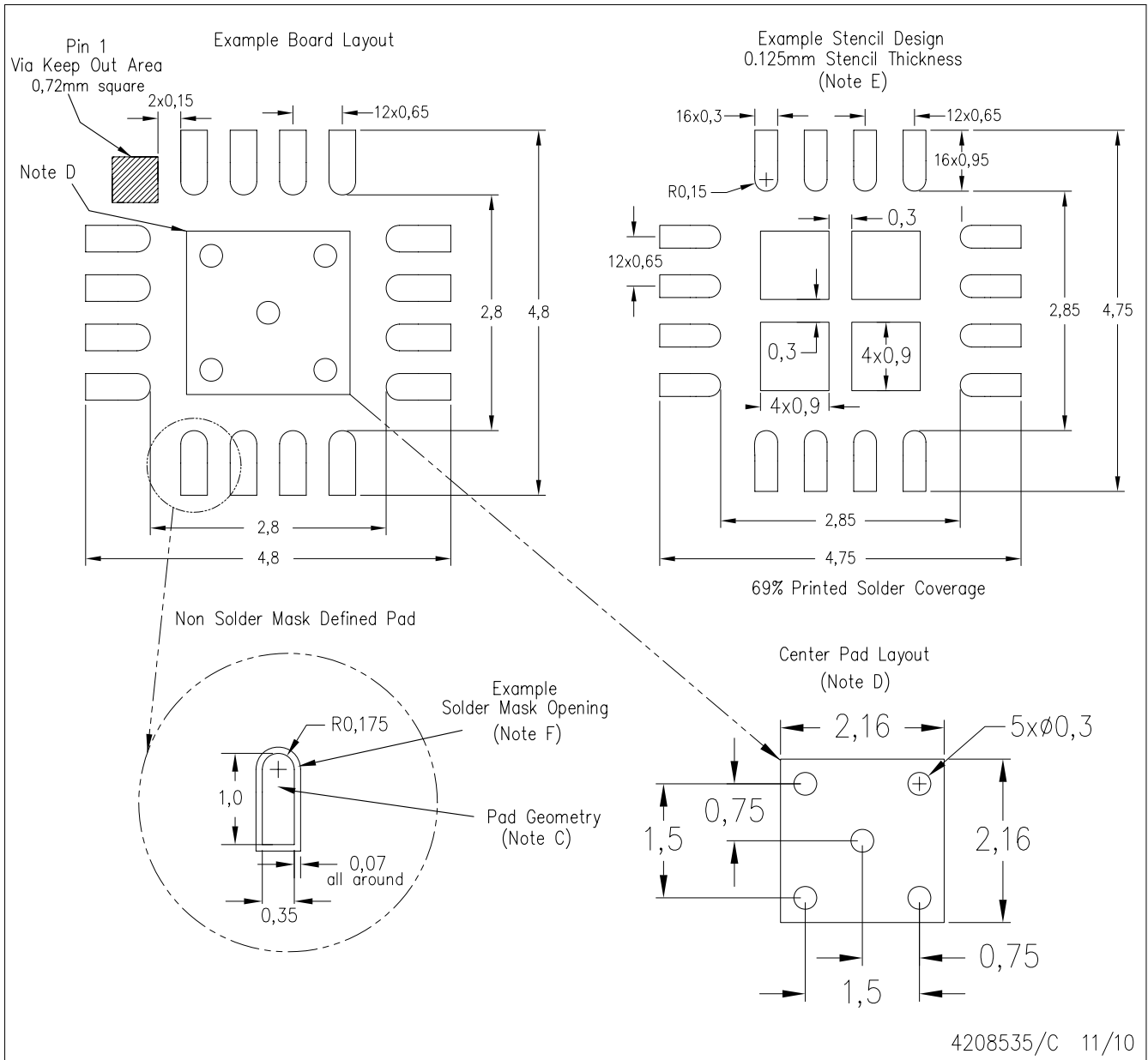
Exposed Thermal Pad Dimensions

4206351-2/L 05/13

NOTE: All linear dimensions are in millimeters

RGV (S-PVQFN-N16)

PLASTIC QUAD FLATPACK NO-LEAD



- NOTES: A. All linear dimensions are in millimeters.
 B. This drawing is subject to change without notice.
 C. Publication IPC-7351 is recommended for alternate designs.
 D. This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, QFN 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>>.
 E. 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.
 F. Customers should contact their board fabrication site for solder mask tolerances.

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TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products

| | |
|------------------------------|--|
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| Data Converters | dataconverter.ti.com |
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