



## Dual, VARIABLE GAIN AMPLIFIER with Input Buffer

### FEATURES

- **GAIN RANGE:** 40dB
- **40MHz BANDWIDTH**
- **LOW CROSSTALK:** 70dB at Max Gain, 5MHz
- **HIGH-SPEED VARIABLE GAIN ADJUST**
- **POWER SHUTDOWN MODE**
- **HIGH IMPEDANCE INPUT BUFFER**

### APPLICATIONS

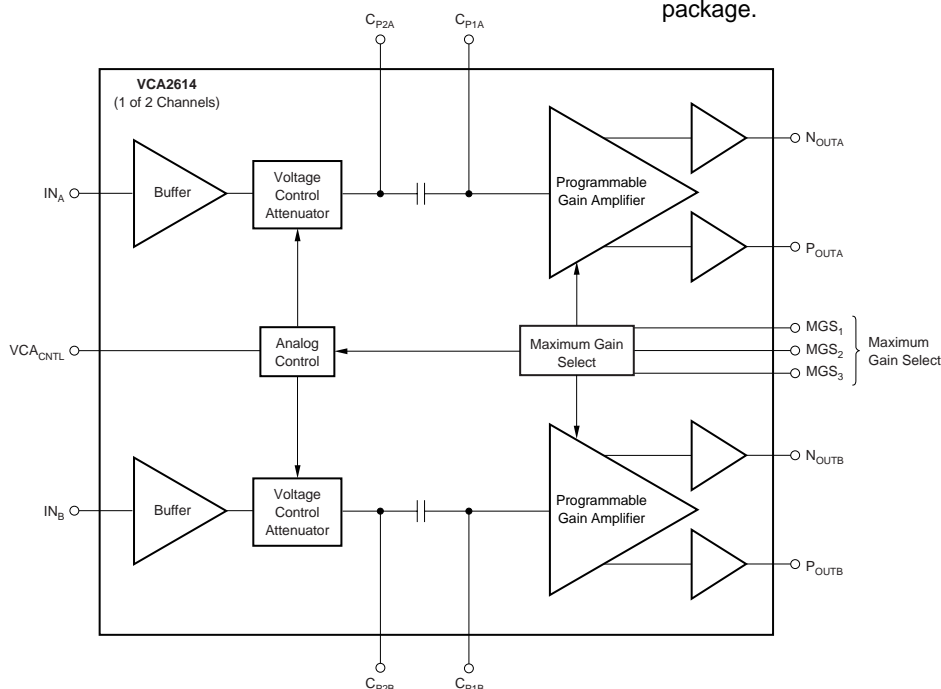
- **ULTRASOUND SYSTEMS**
- **GAMMA CAMERAS**
- **WIRELESS RECEIVERS**
- **TEST EQUIPMENT**

### DESCRIPTION

The VCA2614 is a highly integrated, dual receive channel, Variable Gain Amplifier (VGA) with analog gain control.

The VCA2614's VGA section consists of two parts: the Voltage Controlled Attenuator (VCA) and the Programmable Gain Amplifier (PGA). The gain and gain range of the PGA can be digitally programmed. The combination of these two programmable elements results in a variable gain ranging from 0dB up to a maximum gain as defined by the user through external connections. The single-ended unity gain input buffer provides predictable high input impedance. The output of the VGA can be used in either a single-ended or differential mode to drive high-performance Analog-to-Digital Converters (ADCs). A separate power-down pin reduces power consumption.

The VCA2614 also features low crosstalk and outstanding distortion performance. The combination of low noise and gain range programmability makes the VCA2614 a versatile building block in a number of applications where noise performance is critical. The VCA2614 is available in a TQFP-32 package.



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.

## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

|                                       |                                   |
|---------------------------------------|-----------------------------------|
| Power Supply (+V <sub>S</sub> ) ..... | +6V                               |
| Analog Input .....                    | –0.3V to (+V <sub>S</sub> + 0.3V) |
| Logic Input .....                     | –0.3V to (+V <sub>S</sub> + 0.3V) |
| Case Temperature .....                | +100°C                            |
| Junction Temperature .....            | +150°C                            |
| Storage Temperature .....             | –40°C to +150°C                   |

NOTE: (1) Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. Exposure to absolute maximum conditions for extended periods may affect device reliability.



## ELECTROSTATIC DISCHARGE SENSITIVITY

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.

## PACKAGE/ORDERING INFORMATION

| PRODUCT       | PACKAGE-LEAD               | PACKAGE DESIGNATOR <sup>(1)</sup> | SPECIFIED TEMPERATURE RANGE | PACKAGE MARKING | ORDERING NUMBER             | TRANSPORT MEDIA, QUANTITY                 |
|---------------|----------------------------|-----------------------------------|-----------------------------|-----------------|-----------------------------|---|
| VCA2614Y<br>" | TQFP-32 Surface-Mount<br>" | PBS<br>"                          | –40°C to +85°C<br>"         | VCA2614Y<br>"   | VCA2614Y/250<br>VCA2614Y/2K | Tape and Reel, 250<br>Tape and Reel, 2000 |

NOTE: (1) For the most current specifications and package information, refer to our web site at [www.ti.com](http://www.ti.com).

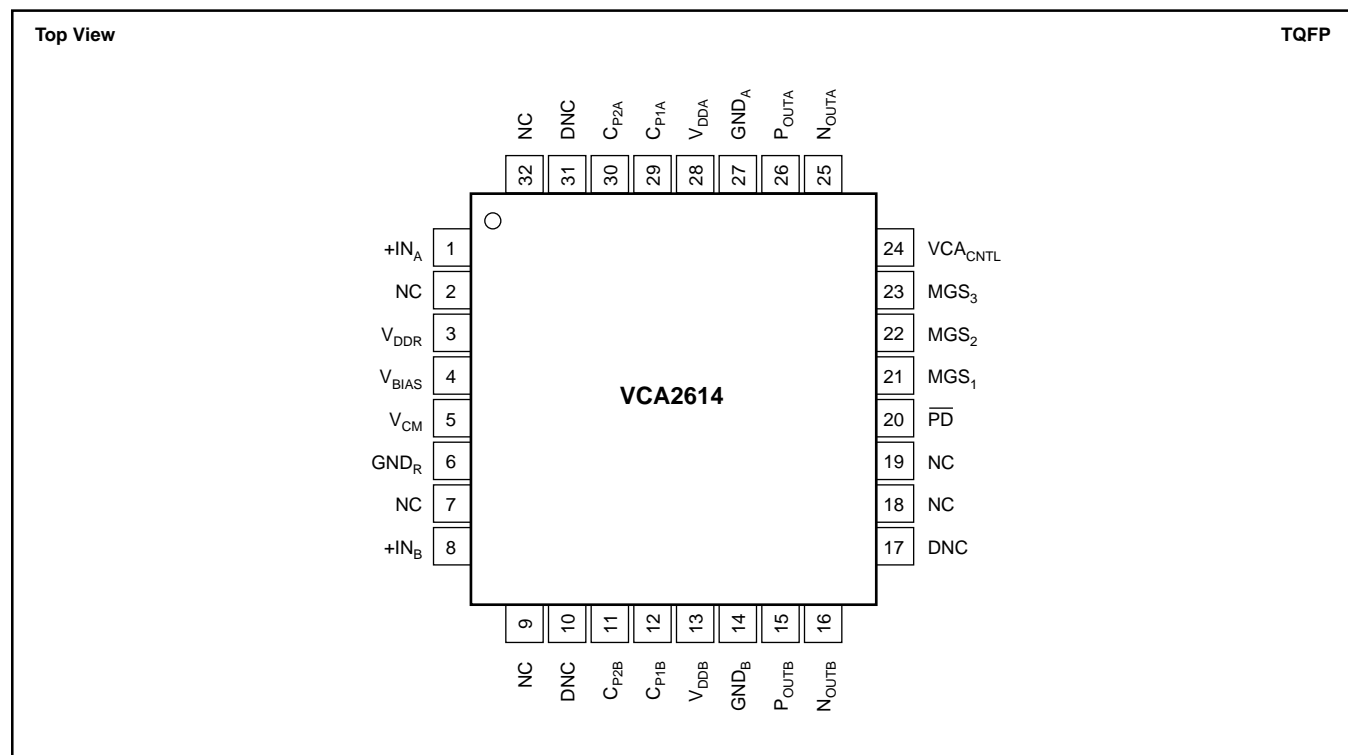
## ELECTRICAL CHARACTERISTICS

At T<sub>A</sub> = +25°C, V<sub>DD</sub> = 5V, load resistance = 500Ω on each output to ground differential output (2V<sub>p-p</sub>), MGS = 011, and f<sub>IN</sub> = 5MHz, unless otherwise noted.

| PARAMETER                                      | CONDITIONS  | VCA2614Y |            |                   | UNITS            |
|--|---|----------|------------|-------------------|------------------|
|  |   | MIN      | TYP        | MAX               |                  |
| <b>BUFFER</b>                                  |   |          |            |                   |                  |
| Input Resistance                               |   |          | 600        |                   | kΩ               |
| Input Capacitance                              |   |          | 5          |                   | pF               |
| Input Bias Current                             |   |          | 1          |                   | nA               |
| Maximum Input Voltage                          |   |          | 1          |                   | V <sub>p-p</sub> |
| Input Voltage Noise                            | MGS = 111, PGA Gain = 44.2dB, R <sub>S</sub> = 50Ω                          |          | 4.8        |                   | nV/√Hz           |
| Input Current Noise                            | Independent of Gain   |          | 350        |                   | fA/√Hz           |
| Noise Figure                                   | R <sub>F</sub> = 550Ω, PGA Gain = 44.2dB, R <sub>S</sub> = 75Ω              |          | 13         |                   | dB               |
| Bandwidth                                      |   |          | 100        |                   | MHz              |
| <b>PROGRAMMABLE VARIABLE GAIN AMPLIFIER</b>    |   |          |            |                   |                  |
| Peak Input Voltage                             |   |          | 1          |                   | V <sub>p-p</sub> |
| –3dB Bandwidth                                 |   |          | 40         |                   | MHz              |
| Slew Rate                                      |   |          | 300        |                   | V/μs             |
| Output Signal Range                            | R <sub>L</sub> ≥ 500Ω Each Side to Ground<br>f = 5MHz                       |          | 2.5 ±1     |                   | V                |
| Output Impedance                               |   |          | 1          |                   | Ω                |
| Output Short-Circuit Current                   |   |          | ±40        |                   | mA               |
| 3rd-Harmonic Distortion                        | f = 5MHz, V <sub>OUT</sub> = 2V <sub>p-p</sub> , VCA <sub>CNTL</sub> = 3.0V | –45      | –60        |                   | dBc              |
| 2nd-Harmonic Distortion                        | f = 5MHz, V <sub>OUT</sub> = 2V <sub>p-p</sub> , VCA <sub>CNTL</sub> = 3.0V | –45      | –50        |                   | dBc              |
| Overload Performance (2nd-Harmonic Distortion) | Input Signal = 1V <sub>p-p</sub> , MGS = 111, VCA <sub>CNTL</sub> = 2V      |          | –40 to –45 |                   | dB               |
| Time Delay                                     |   |          | 5          |                   | ns               |
| IMD, 2-Tone                                    | V <sub>OUT</sub> = 2V <sub>p-p</sub> , f = 9.95MHz                          |          | –59        |                   | dBc              |
| Crosstalk                                      |   |          | 70         |                   | dB               |
| Group Delay Variation                          | 1MHz < f < 10MHz, Full Gain Range   |          | 13         |                   | ns               |
| <b>ACCURACY</b>                                |   |          |            |                   |                  |
| Gain Slope                                     |   |          | 10.5       |                   | dB/V             |
| Gain Error                                     |   |          |            | ±2 <sup>(1)</sup> | dB               |
| Output Offset Voltage                          |   |          | ±50        |                   | mV               |
| <b>GAIN CONTROL INTERFACE</b>                  |   |          |            |                   |                  |
| Input Voltage (VCA <sub>CNTL</sub> ) Range     |   |          | 0.2 to 3.0 |                   | V                |
| Input Resistance                               |   |          | 1          |                   | MΩ               |
| Response Time                                  | 40dB Gain Change, MGS = 111   |          | 0.2        |                   | μs               |
| <b>POWER SUPPLY</b>                            |   |          |            |                   |                  |
| Specified Operating Range                      |   | 4.75     | 5.0        | 5.25              | V                |
| Power Dissipation                              | Operating, Each Channel   |          | 120        | 150               | mW               |
| Power-Down                                     |   |          | 9.2        |                   | mW               |

NOTE: (1) Referenced to best fit dB-linear curve.

## PIN CONFIGURATION

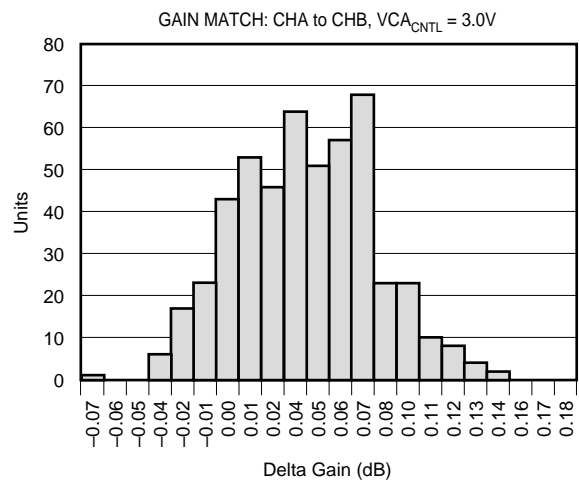
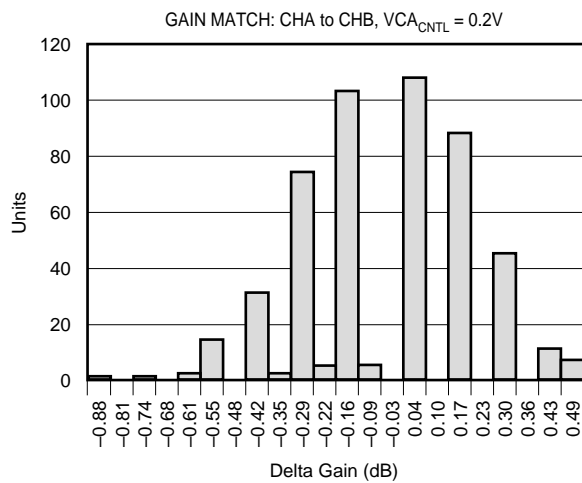
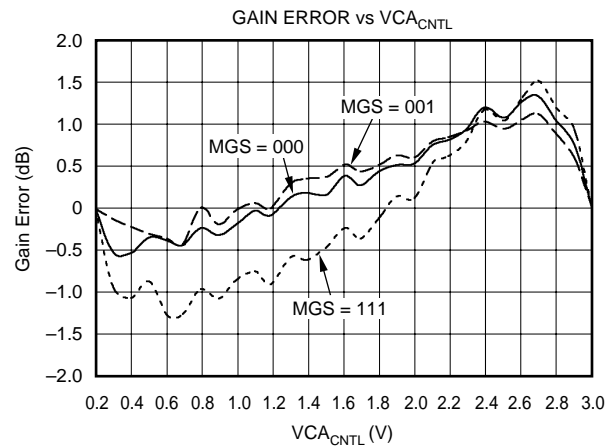
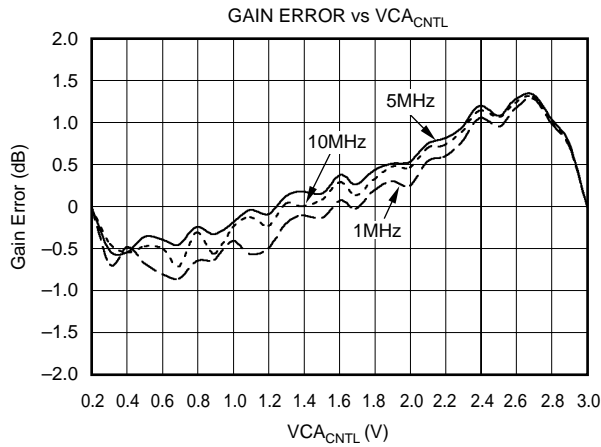
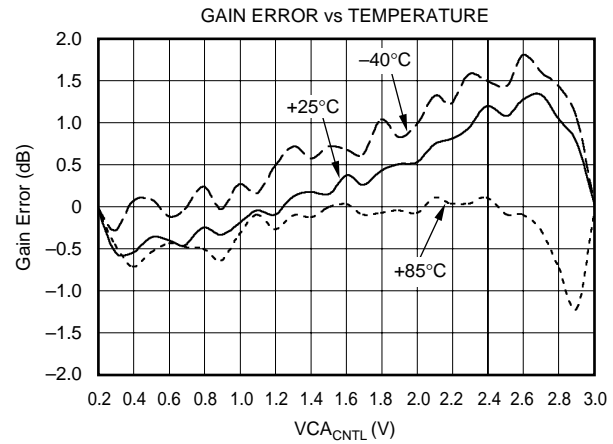
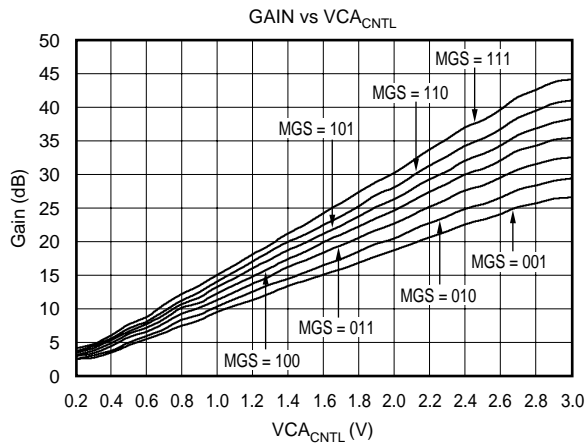


## PIN DESCRIPTIONS

| PIN | DESIGNATOR        | DESCRIPTION                  | PIN | DESIGNATOR          | DESCRIPTION                   |
|-----|-------------------|------------------------------|-----|---------------------|-------------------------------|
| 1   | +IN <sub>A</sub>  | Input Channel A              | 17  | DNC                 | Do Not Connect                |
| 2   | NC                | No Internal Connection       | 18  | NC                  | No Internal Connection        |
| 3   | V <sub>DDR</sub>  | Internal Reference Supply    | 19  | NC                  | No Internal Connection        |
| 4   | V <sub>BIAS</sub> | Bias Voltage                 | 20  | PD                  | Power Down (Active LOW)       |
| 5   | V <sub>CM</sub>   | Common-Mode Voltage          | 21  | MGS <sub>1</sub>    | Maximum Gain Select 1 (MSB)   |
| 6   | GND <sub>R</sub>  | Internal Reference Ground    | 22  | MGS <sub>2</sub>    | Maximum Gain Select 2         |
| 7   | NC                | No Internal Connection       | 23  | MGS <sub>3</sub>    | Maximum Gain Select 3 (LSB)   |
| 8   | +IN <sub>B</sub>  | Input Channel B              | 24  | VCA <sub>CNTL</sub> | VCA Analog Control            |
| 9   | NC                | No Internal Connection       | 25  | N <sub>OUTA</sub>   | Negative VCA Output Channel A |
| 10  | DNC               | Do Not Connect               | 26  | P <sub>OUTA</sub>   | Positive VCA Output Channel A |
| 11  | C <sub>P2B</sub>  | Coupling Capacitor Channel B | 27  | GND <sub>A</sub>    | Ground Channel A              |
| 12  | C <sub>P1B</sub>  | Coupling Capacitor Channel B | 28  | V <sub>DDA</sub>    | +5V Supply Channel A          |
| 13  | V <sub>DDB</sub>  | +5V Supply Channel B         | 29  | C <sub>P1A</sub>    | Coupling Capacitor Channel A  |
| 14  | GND <sub>B</sub>  | Ground Channel B             | 30  | C <sub>P2A</sub>    | Coupling Capacitor Channel A  |
| 15  | P <sub>OUTB</sub> | Positive Output Channel B    | 31  | DNC                 | Do Not Connect                |
| 16  | N <sub>OUTB</sub> | Negative Output Channel B    | 32  | NC                  | No Internal Connection        |

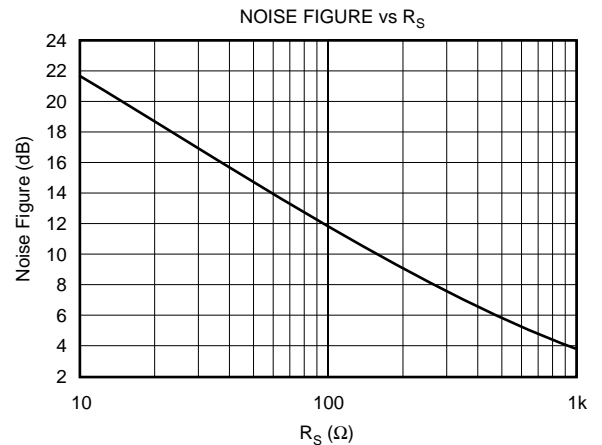
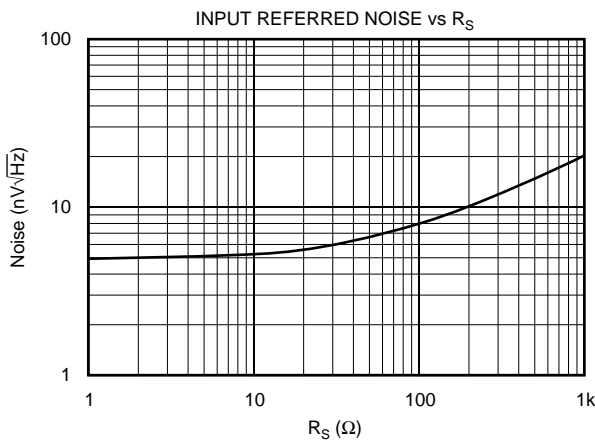
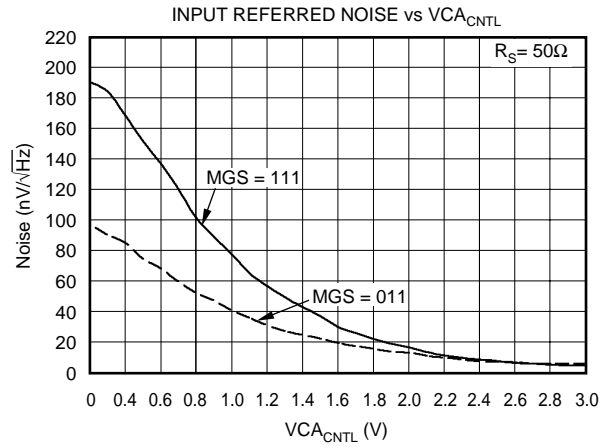
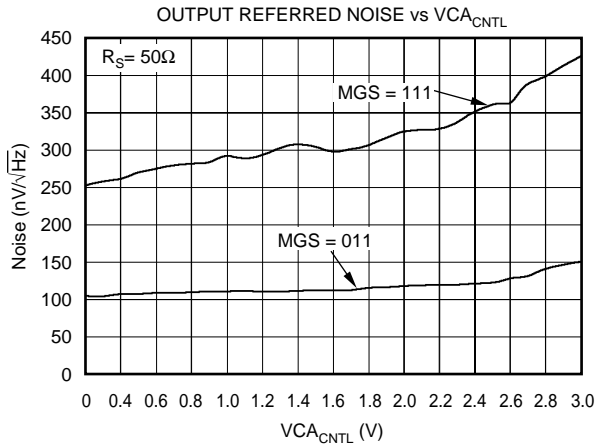
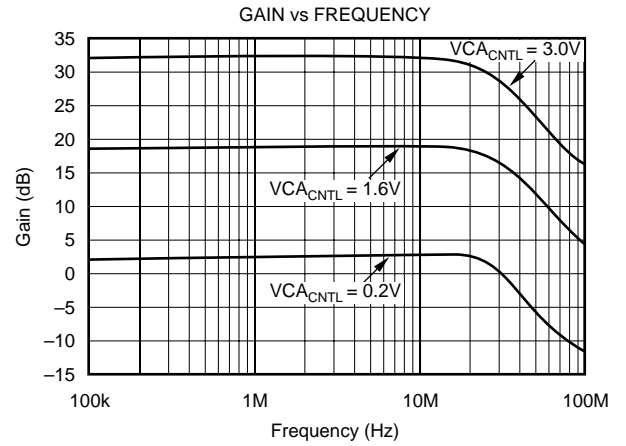
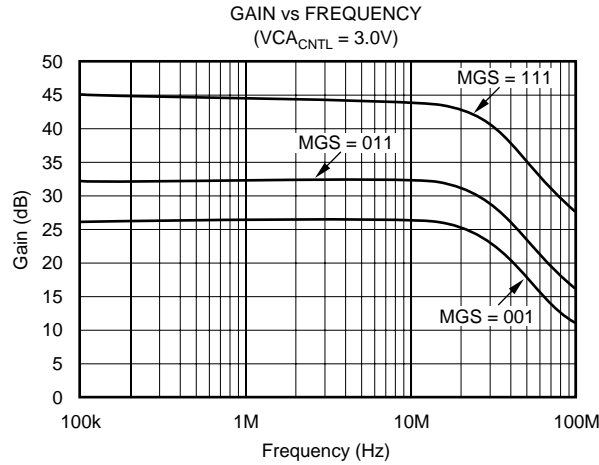
# TYPICAL CHARACTERISTICS

At  $T_A = +25^\circ\text{C}$ ,  $V_{DD} = 5\text{V}$ , load resistance =  $500\Omega$  on each output to ground, differential output (2Vp-p) MGS = 011, and  $f_{IN} = 5\text{MHz}$ , unless otherwise noted.



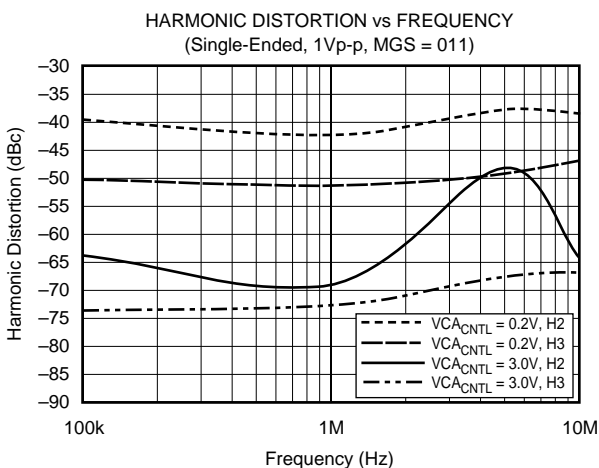
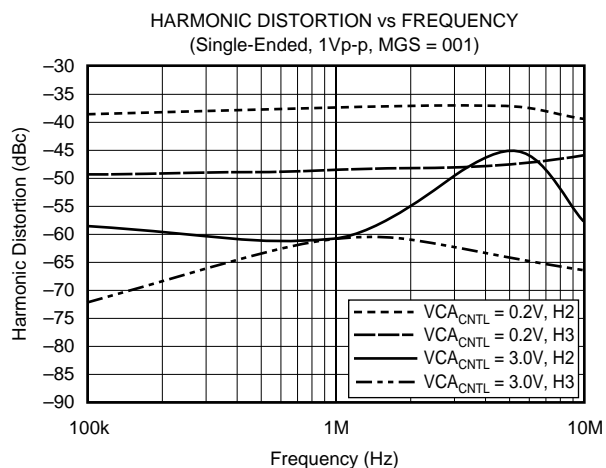
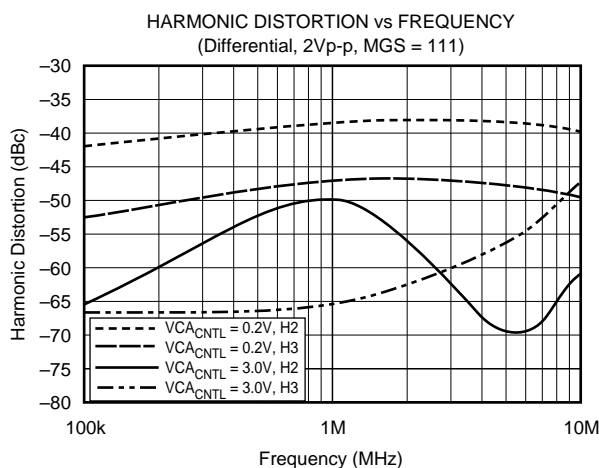
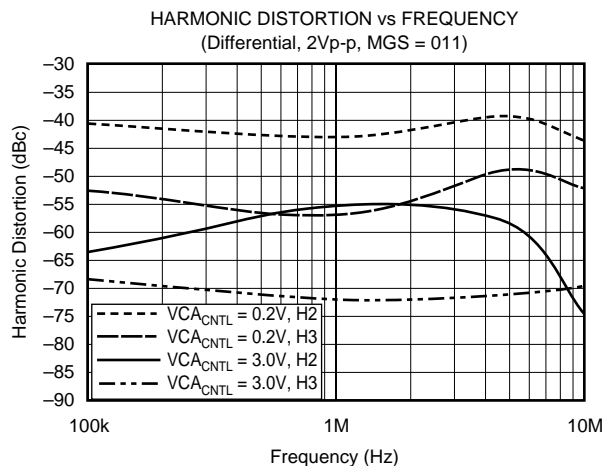
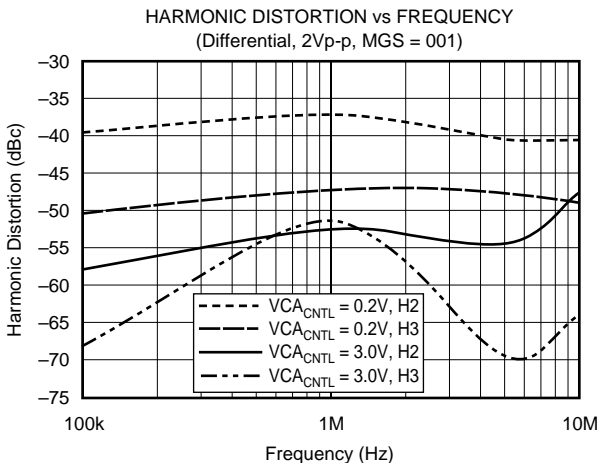
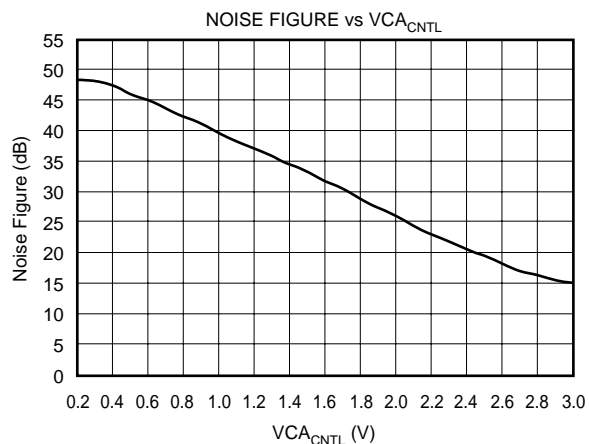
# TYPICAL CHARACTERISTICS (Cont.)

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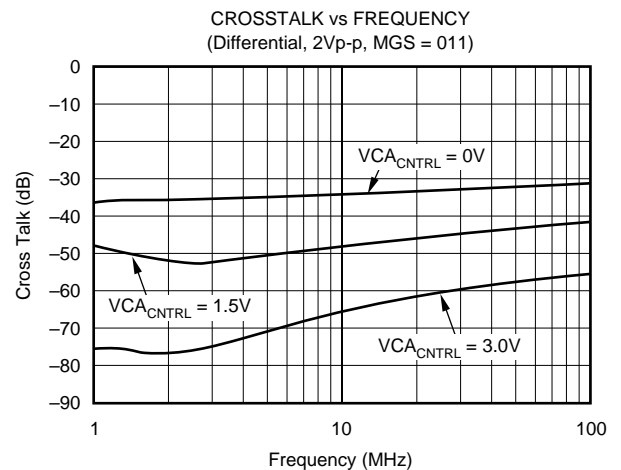
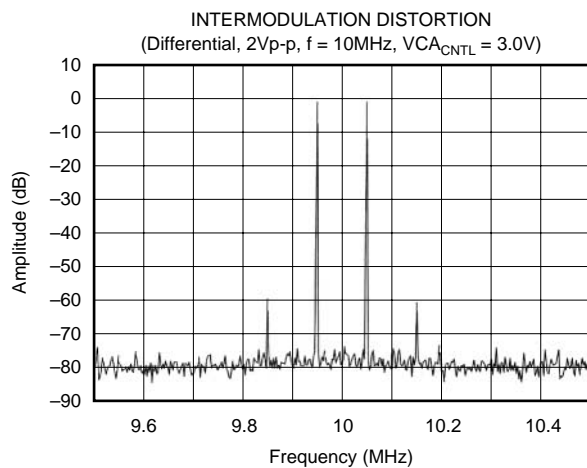
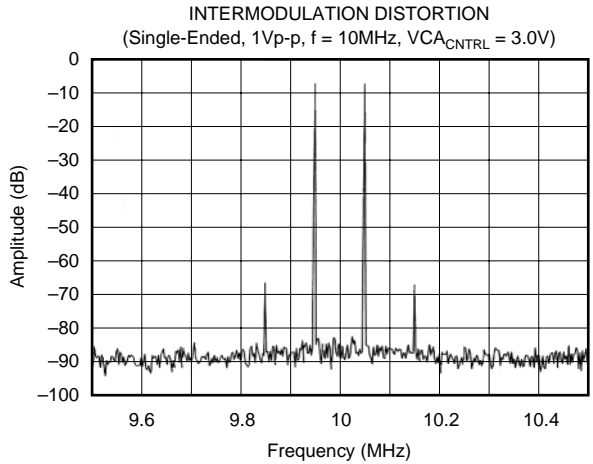
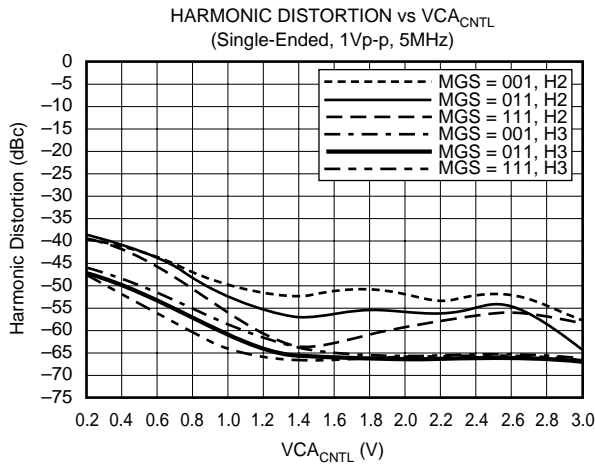
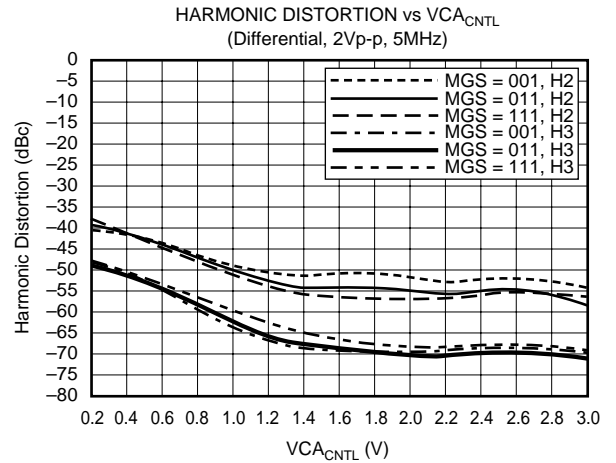
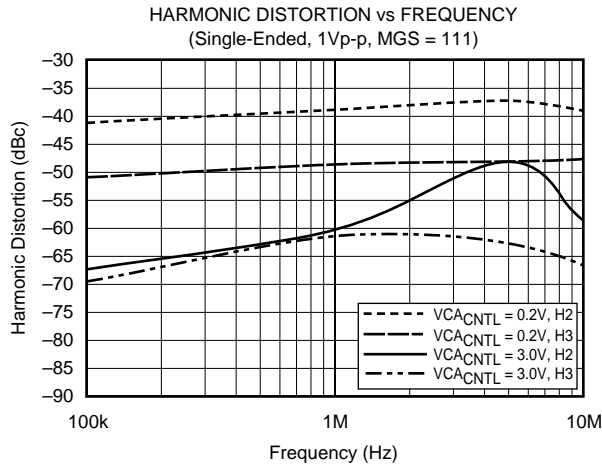
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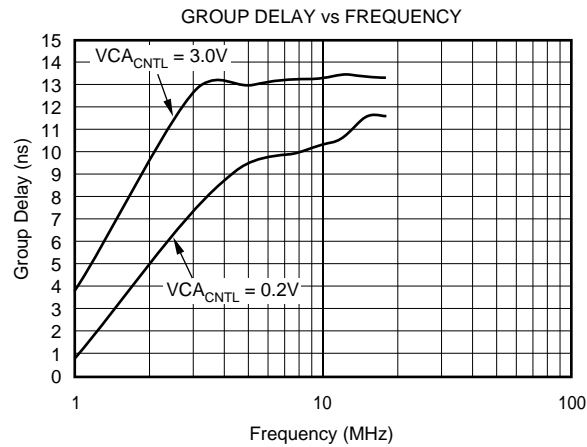
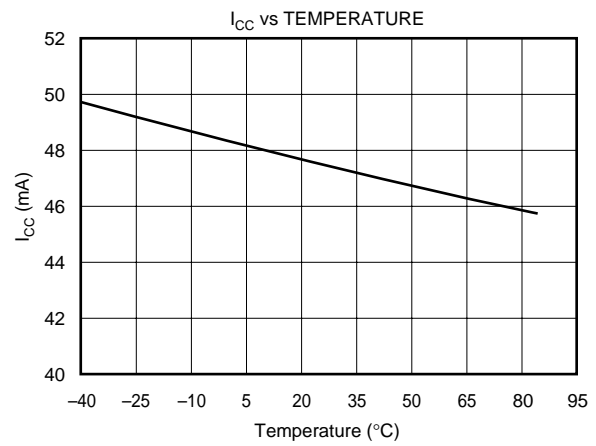
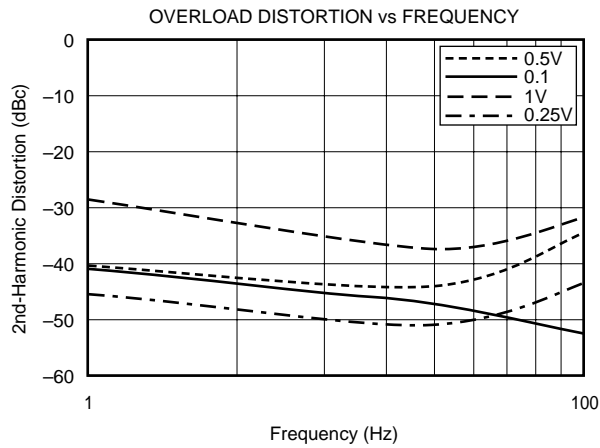
# TYPICAL CHARACTERISTICS (Cont.)

At  $T_A = +25^\circ\text{C}$ ,  $V_{DD} = 5\text{V}$ , load resistance =  $500\Omega$  on each output to ground, differential output (2Vp-p) MGS = 011, and  $f_{IN} = 5\text{MHz}$ , unless otherwise noted.



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# OVERVIEW

The VCA2614 is a dual-channel, VGA consisting of three primary blocks: an Input Buffer, a VCA, and a PGA (as shown in Figure 1). All stages are AC-coupled with the coupling into the PGA stage being made variable by placing an external capacitor between the  $C_{P1}$  and  $C_{P2}$  pins. This will be discussed further in the PGA section. By using the internal coupling into the PGA, the result is a high-pass filter characteristic with cutoff at approximately 75kHz. The output PGA naturally rolls off at around 40MHz, making the usable bandwidth of the VCA2614 between 75kHz and 40MHz.

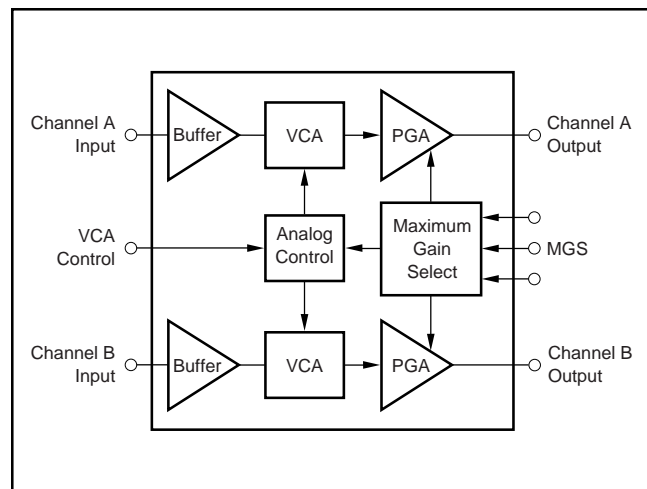


FIGURE 1. Simplified Block Diagram of the VCA2614.

## INPUT BUFFER

The input buffer is a unity gain amplifier (gain of +1) with a bandwidth of 100MHz with an input resistance of approximately 600k $\Omega$ . The input buffer isolates the circuit driving the VCA2614 inputs from the internal VCA block, which would present a varying impedance to the input circuitry. To allow symmetrical operation of the input buffer, the input to the buffer must be AC-coupled through an external capacitor. The recommended value of the capacitor is 0.01 $\mu$ F. It should be noted that if the capacitor value were increased, the

power-on time of the VCA2614 would be increased. If a decrease in the power-on time is needed, the value can be decreased to no less than 100pF.

## VOLTAGE-CONTROLLED ATTENUATOR

The magnitude of the VCA input signal from the input buffer is reduced by a programmable attenuation factor, set by the analog VCA Control Voltage ( $V_{CA_{CNTL}}$ ) at pin 24. The maximum attenuation is programmable by using the three MGS bits (pins 21, 22, and 23). Figure 2 illustrates this dual-adjust characteristic.

The MGS bits adjust the overall range of attenuation and maximum gain while the  $V_{CA_{CNTL}}$  voltage adjusts the actual attenuation factor. At any given maximum gain setting, the analog variable gain characteristic is linear in dB as a function of the control voltage, and is created as a piecewise approximation of an ideal dB-linear transfer function, see Figure 4. The VCA control circuitry is common to both channels of the VCA2614. The range for the  $V_{CA_{CNTL}}$  input spans from 0V to 3V. Although overdriving the  $V_{CA_{CNTL}}$  input above the recommended 3V maximum will not damage the part, this condition should be avoided.

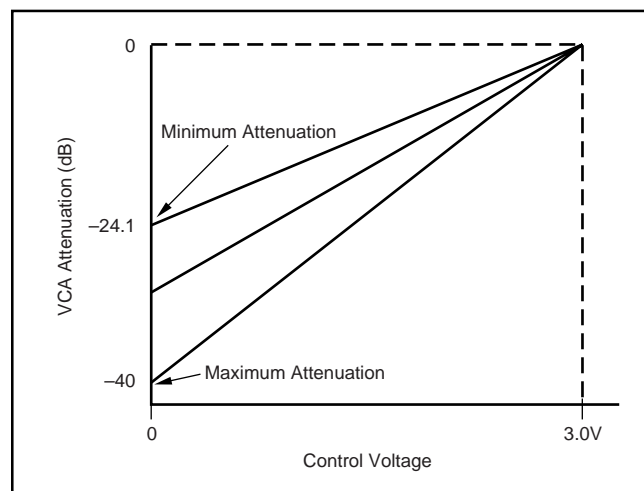


FIGURE 2. Swept Attenuator Characteristic.

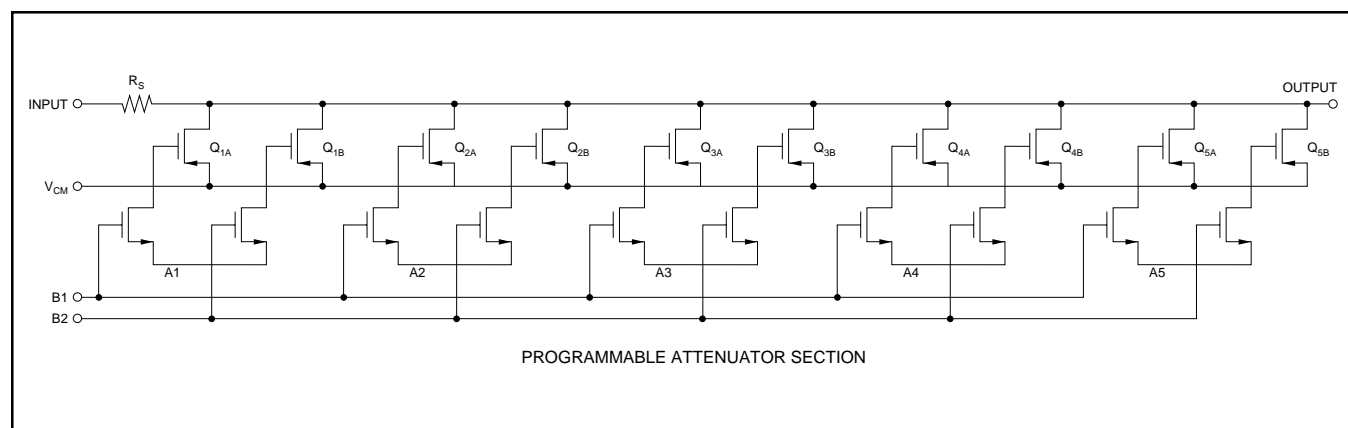


FIGURE 3. Programmable Attenuator Section.

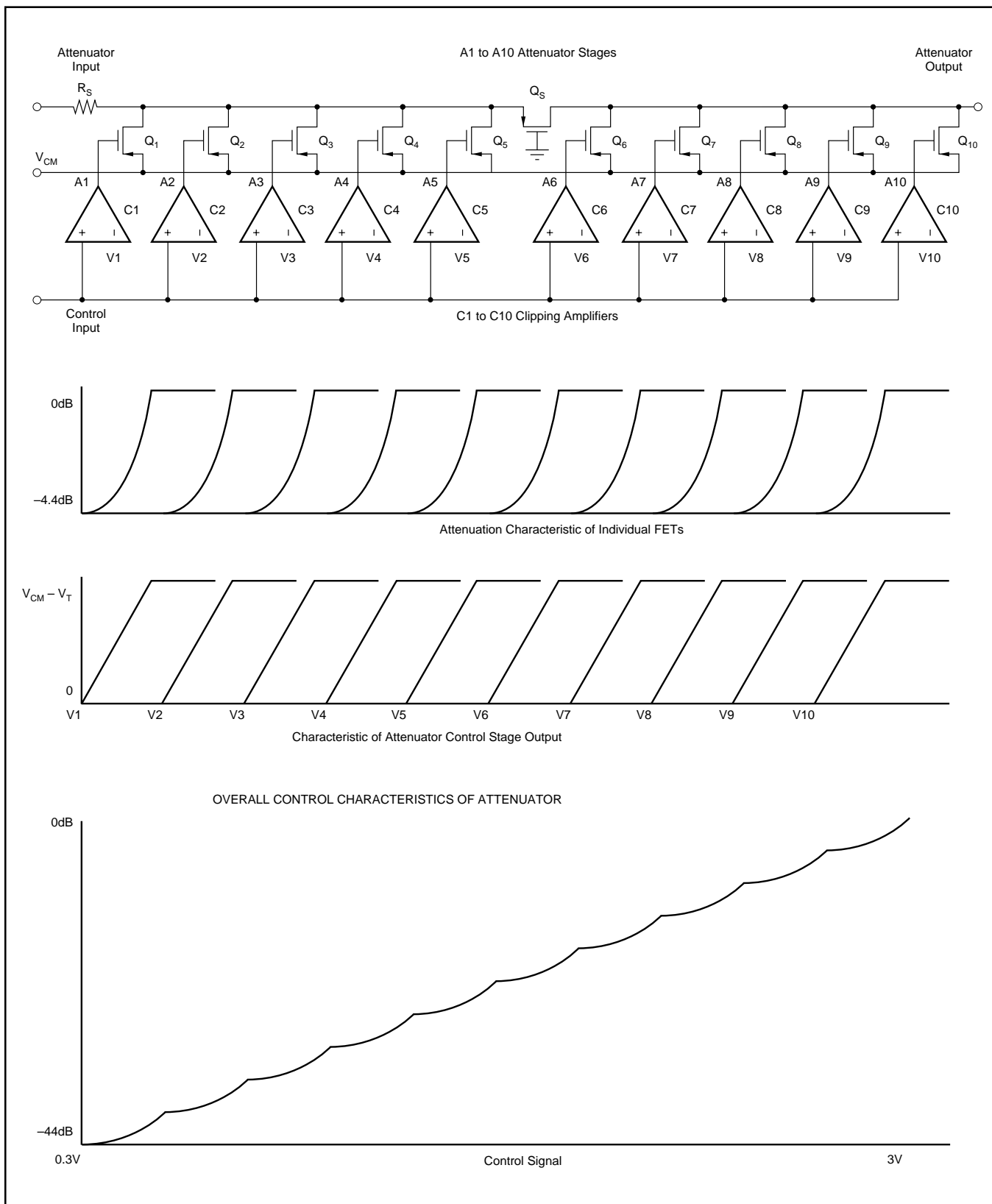


FIGURE 4. Piecewise Approximation to Logarithmic Control Characteristics.

Figure 5 shows a simplified circuit diagram of the PGA block. As stated before, the input to the PGA is AC-coupled by an internal capacitor. Provisions are made so that an external capacitor can be placed in parallel with the internal capacitor, thus lowering the usable low-frequency bandwidth. The low-frequency bandwidth is set by the following equation:

where  $C_{\text{EXTERNAL}}$  is the external capacitor value in picofarads. Care should be taken to avoid using too large a value of capacitor, as this can increase the power-on delay time.

As described previously, the PGA gain is programmed with the same MGS bits that control the VCA maximum attenuation factor. Specifically, the maximum PGA gain at each MGS setting is the inverse (reciprocal) of the maximum VCA attenuation at that setting. Therefore, the VCA + PGA overall gain will always be 0dB (unity) when the analog VCA<sub>CNTL</sub> input is set to 0V (the maximum attenuation for VCA). For VCA<sub>CNTL</sub> = 3V (no attenuation), the VCA + PGA gain will be controlled by the programmed PGA gain. For clarity, the gain and attenuation factors are detailed in Table I.

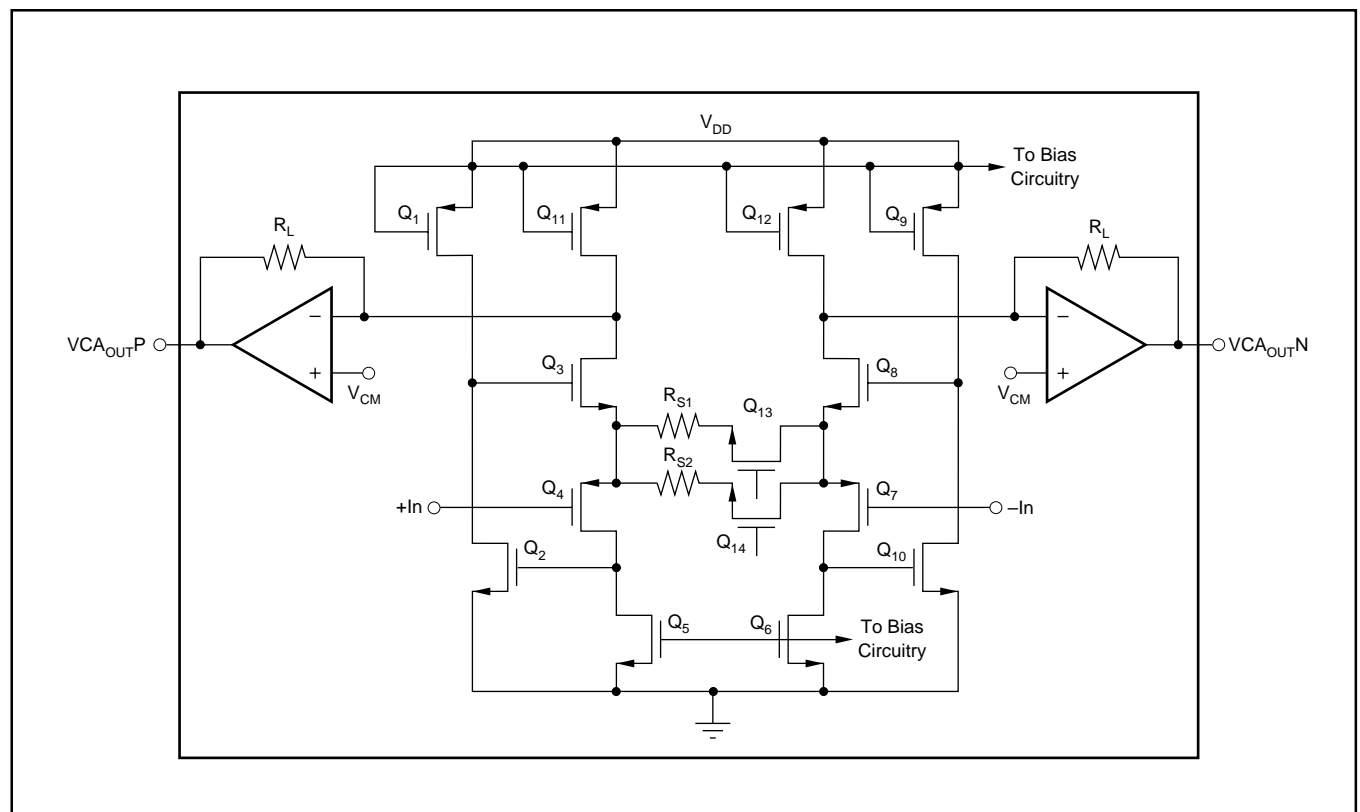
| MGS<br>SETTING | ATTENUATOR GAIN<br>VCA <sub>CNTL</sub> = 0.02V to 3V | ATTENUATOR +<br>DIFFERENTIAL PGA GAIN |
|----------------|--|---------------------------------------|
| 000            | Not Valid  | Not Valid                             |
| 001            | -24.1dB to 0dB                                       | 2.6dB to 26.7dB                       |
| 010            | -26.9dB to 0dB                                       | 2.6dB to 29.5dB                       |
| 011            | -29.5dB to 0dB                                       | 3.0dB to 35.6dB                       |
| 100            | -32.4dB to 0dB                                       | 3.1dB to 35.5dB                       |
| 101            | -34.8dB to 0dB                                       | 3.4dB to 38.3dB                       |
| 110            | -37.3dB to 0dB                                       | 3.7dB to 44.1dB                       |
| 111            | -40.0dB to 0dB                                       | 4.1dB to 44.2dB                       |

TABLE I. MGS Settings.

input buffer noise dominates; at maximum VCA attenuation (large input signals), the PGA noise dominates. Note that if the PGA output is used single-ended, the apparent gain will be 6dB lower.

The VCA2614 is an analog amplifier capable of high gain. When working on a PCB layout for the VCA2614, it is recommended to utilize a solid ground plane that is connected to analog ground. This helps to maximize the noise performance of the VCA2614.

Adequate power-supply decoupling must be used in order to achieve the best possible performance. Decoupling capacitors on the VCA<sub>CNTL</sub> voltage should also be used to help minimize noise. Recommended values can be obtained from the layout diagram of Figure 6.



**VCA2614**  
SBOS185D

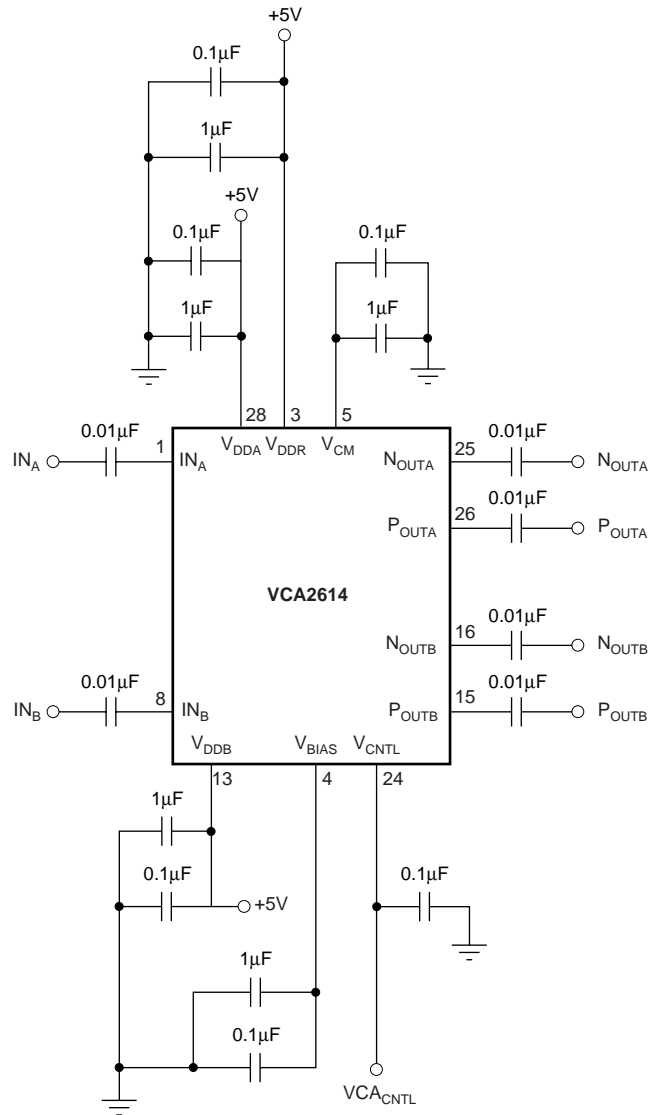


FIGURE 6. VCA2614 Layout.

**PACKAGING INFORMATION**

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package Qty | Eco Plan<br>(2)            | Lead/Ball Finish | MSL Peak Temp<br>(3) | Op Temp (°C) | Top-Side Markings<br>(4) | Samples                 |
|------------------|---------------|--------------|--------------------|------|-------------|----------------------------|------------------|----------------------|--------------|--------------------------|-------------------------|
| VCA2614Y/250     | ACTIVE        | TQFP         | PBS                | 32   | 250         | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-3-260C-168 HR  |              | 2614Y                    | <a href="#">Samples</a> |
| VCA2614Y/2K      | ACTIVE        | TQFP         | PBS                | 32   | 2000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-3-260C-168 HR  |              | 2614Y                    | <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) Only one of markings shown within the brackets will appear on the physical device.

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**TAPE AND REEL INFORMATION**


\*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 |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| VCA2614Y/250 | TQFP         | PBS             | 32   | 250  | 177.8              | 16.4               | 7.2     | 7.2     | 1.5     | 12.0    | 16.0   | Q2            |
| VCA2614Y/2K  | TQFP         | PBS             | 32   | 2000 | 330.0              | 16.8               | 7.2     | 7.2     | 1.5     | 12.0    | 16.0   | Q2            |

## TAPE AND REEL BOX DIMENSIONS

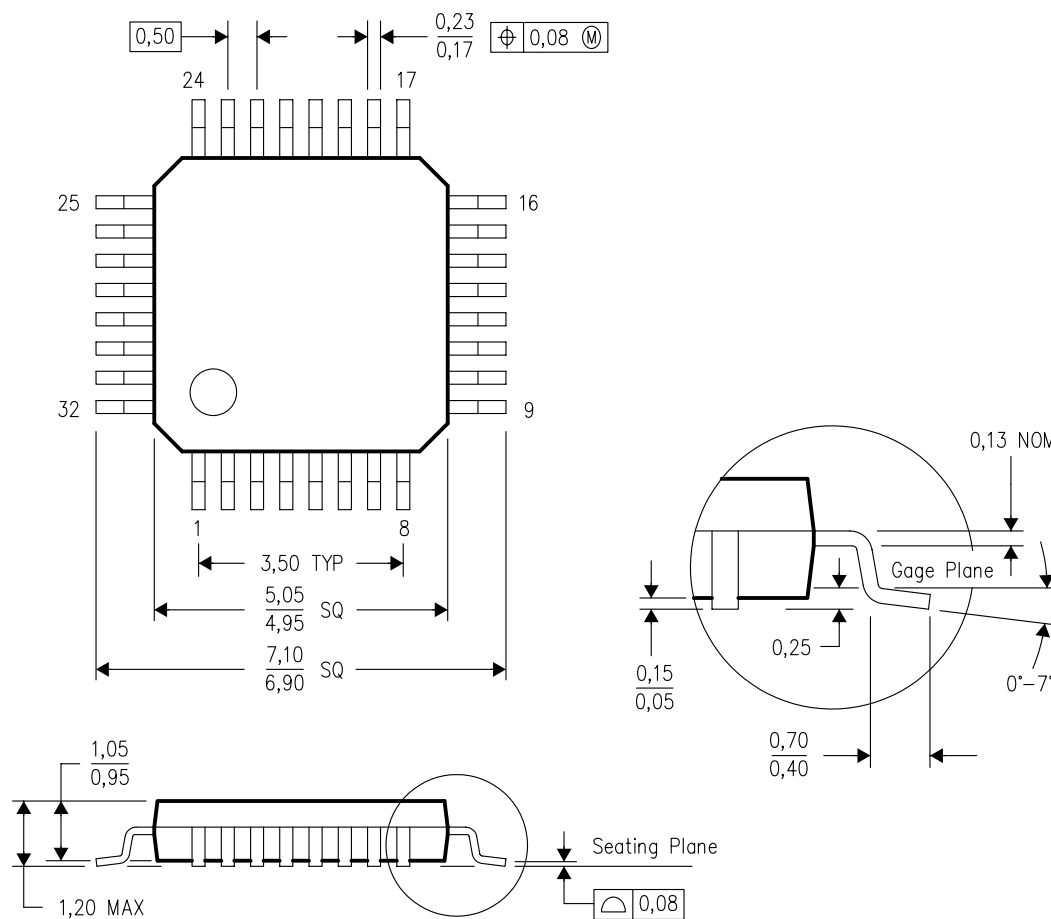


\*All dimensions are nominal

| Device       | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| VCA2614Y/250 | TQFP         | PBS             | 32   | 250  | 210.0       | 185.0      | 35.0        |
| VCA2614Y/2K  | TQFP         | PBS             | 32   | 2000 | 367.0       | 367.0      | 38.0        |

## PBS (S-PQFP-G32)

## PLASTIC QUAD FLATPACK



4087735/B 07/05

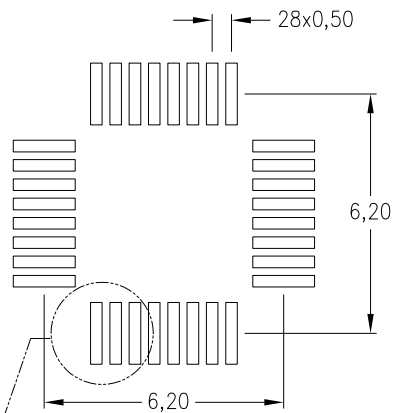
- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.



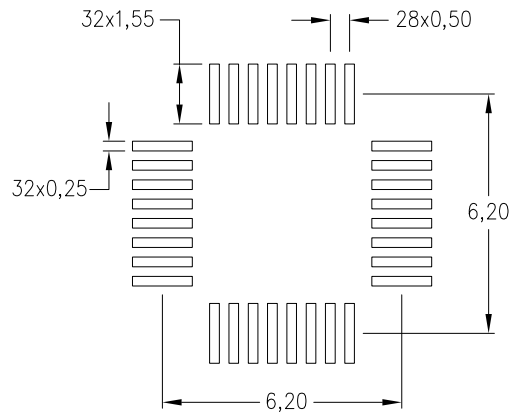
PBS (S-PQFP-G32)

PLASTIC QUAD FLATPACK

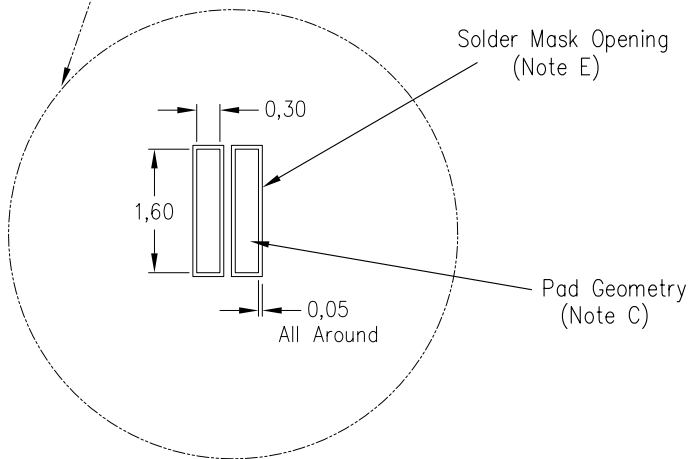
Example Board Layout  
(Note C)



0,127mm Thick Stencil Design Example  
(Note D)



Non Solder Mask  
Defined Pad



4212229/A 10/11

- 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. 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.
  - E. Customers should contact their board fabrication site for recommended solder mask tolerances between and around signal pads.

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