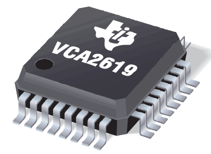
Burr-Brown Products from Texas Instruments



VCA2619

SBOS276A − AUGUST 2003 − REVISED AUGUST 2003

Dual, Variable Gain Amplifier with Input Buffer

FEATURES

- **GAIN RANGE: 50dB**
- **LOW CROSSTALK: −60dB at Max Gain, f_{IN} = 5MHz**
- **HIGH−SPEED VARIABLE GAIN ADJUST**
- **POWER SHUTDOWN MODE**
- **HIGH IMPEDANCE INPUT BUFFER**

APPLICATIONS

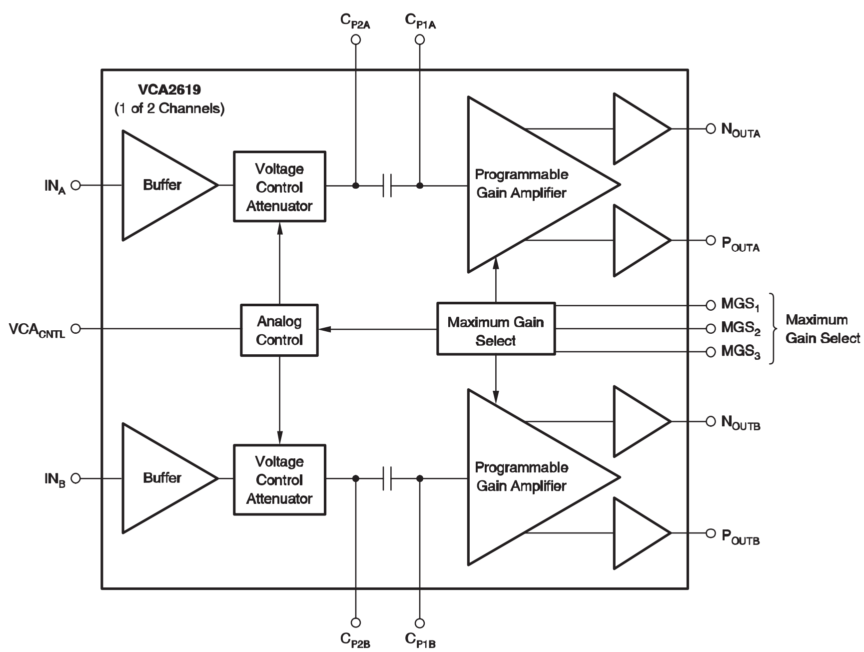
- **ULTRASOUND SYSTEMS**
- **WIRELESS RECEIVERS**
- **TEST EQUIPMENT**
- **RADAR**

DESCRIPTION

The VCA2619 is a highly integrated, dual receive channel, Variable Gain Amplifier (VGA) with analog gain control.

The VCA2619s 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 (A/D) converters. A separate power−down pin reduces power consumption.

The VCA2619 also features low crosstalk and outstanding distortion performance. The combination of low noise and gain range programmability make the VCA2619 a versatile building block in a number of applications where noise performance is critical. The VCA2619 is available in a TQFP−32 package.



ABSOLUTE MAXIMUM RATINGS(1)

Power Supply (+V_S)	+6V
Analog Input	−0.3V to (+V_S + 0.3V)
Logic Input	−0.3V to (+V_S + 0.3V)
Case Temperature	+100°C
Junction Temperature	+150°C
Storage Temperature	−40°C to +150°C

(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.

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(1)	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER	TRANSPORT MEDIA, QUANTITY
VCA2619Y	TQFP−32	PBS	−40°C to +85°C	VCA2619Y	VCA2619YT	Tape and Reel, 250
					VCA2619YR	Tape and Reel, 2000

(1) For the most current specification and package information, refer to our web site at www.ti.com.

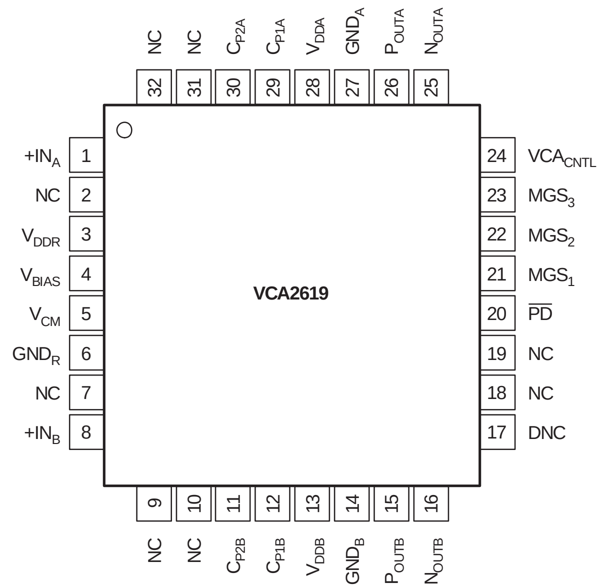
ELECTRICAL CHARACTERISTICS

At T_A = +25°C, V_{DD} = 5V, load resistance = 500Ω on each output to ground single−ended output (1Vpp), MGS = 111, VCA_{CNTL} = 2.9V and f_{IN} = 5MHz, unless otherwise noted.

PARAMETER	CONDITIONS	VCA2619 MIN	TYP	MAX	UNIT
BUFFER					
Input Resistance			600		kΩ
Input Capacitance			5		pF
Input Bias Current			1		nA
Maximum Input Voltage			1		Vpp
Input Voltage Noise	PGA Gain = 45dB, R_S = 50Ω		5.9		nV/√Hz
Input Current Noise	Independent of Gain		350		fA/√Hz
Noise Figure	R_F = 550Ω, PGA Gain = 45dB, R_S = 75Ω		13		dB
Bandwidth			100		MHz
PROGRAMMABLE VARIABLE GAIN AMPLIFIER					
Peak Input Voltage			1		Vpp
–3dB Bandwidth			20		MHz
Slew Rate			300		V/µs
Output Signal Range	R_L ≥ 500Ω Each Side to Ground		2.5 ±1		V
Output Impedance			1		Ω
Output Short−Circuit Current			±40		mA
3rd-Harmonic Distortion	V_{OUT} = 1Vpp, VCA_{CNTL} = 2.9V	−45	−60		dBc
2nd-Harmonic Distortion	V_{OUT} = 1Vpp, VCA_{CNTL} = 2.9V	−42	−50		dBc
2nd-Harmonic Distortion	Differential, V_{OUT} = 2Vpp, VCA_{CNTL} = 3.0V, MGS = 011		−50		dBc
Overload Performance (2nd-Harmonic Distortion)	Input Signal = 0.5Vpp, VCA_{CNTL} = 2V		–40 to –45		dB
Time Delay			5		ns
IMD, 2−Tone	V_{OUT} = 2Vpp, f = 9.95MHz		−59		dBc
Crosstalk	2Vpp Differential		−60		dB
ACCURACY					
Gain Slope	VCA_{CNTL} = 0.4V to 2.9V		20		dB/V
Gain Error(1)	VCA_{CNTL} = 0.2V to 3.0V		±2.75		dB
	VCA_{CNTL} = 0.4V to 2.9V		±1.50	±2.0	dB
Output Offset Voltage			±50		mV
Gain Range	VCA_{CNTL} = 0.2V to 3.0V		52		dB
	VCA_{CNTL} = 0.4V to 2.9V	48	50		dB
GAIN CONTROL INTERFACE					
Input Voltage (VCA_{CNTL}) Range			0 to 3.0		V
Input Resistance			1		MΩ
Response Time	45dB Gain Change		0.2		µs
POWER SUPPLY					
Specified Operating Range		4.75	5.0	5.25	V
Power Dissipation			240	300	mW
Power−Down			9.2		mW

(1) Referenced to best fit dB−linear curve.

PIN CONFIGURATION



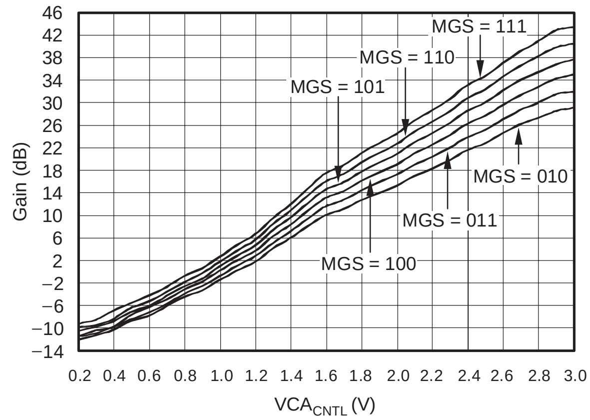
PIN CONFIGURATION

PIN	DESIGNATOR	DESCRIPTION	PIN	DESIGNATOR	DESCRIPTION
1	$+IN_A$	Noninverting Input Channel A	17	DNC	Do Not Connect
2	NC	No Internal Connection	18	NC	No Internal Connection
3	V_{DDR}	Internal Reference Supply	19	NC	No Internal Connection
4	V_{BIAS}	Bias Voltage	20	$\overline{PD}$	Power-Down (Active LOW)
5	V_{CM}	Common−Mode Voltage	23	MGS_1	Maximum Gain Select 1 (MSB)
6	GND_R	Internal Reference Ground	22	MGS_2	Maximum Gain Select 2
7	NC	No Internal Connection	23	MGS_3	Maximum Gain Select 3 (LSB)
8	$+IN_B$	Noninverting Input Channel B	24	VCA_{CNTL}	VCA Analog Control
9	NC	No Internal Connection	25	N_{OUTA}	Negative VCA Output Channel A
10	NC	No Internal Connection	26	P_{OUTA}	Positive VCA Output Channel A
11	C_{P2B}	Coupling Capacitor Channel B	27	GND_A	Ground Channel A
12	C_{P1B}	Coupling Capacitor Channel B	28	V_{DDA}	+5V Supply Channel A
13	V_{DDB}	+5V Supply Channel B	29	C_{P1A}	Coupling Capacitor Channel A
14	GND_B	Ground Channel B	30	C_{P2A}	Coupling Capacitor Channel A
15	P_{OUTB}	Positive Output Channel B	31	NC	No Internal Connection
16	N_{OUTB}	Negative Output Channel B	32	NC	No Internal Connection

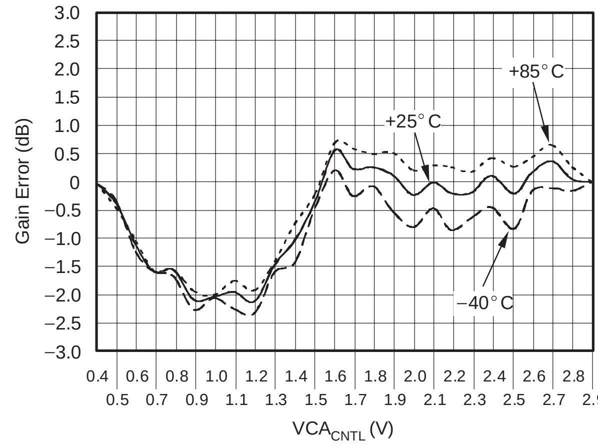
TYPICAL CHARACTERISTICS

At T_A = 25°C and V_{DD} = 5V, load resistance = 500Ω on each output to ground, differential output ($2V_{PP}$) MGS = 111, and f_{IN} = 5MHz, unless otherwise noted.

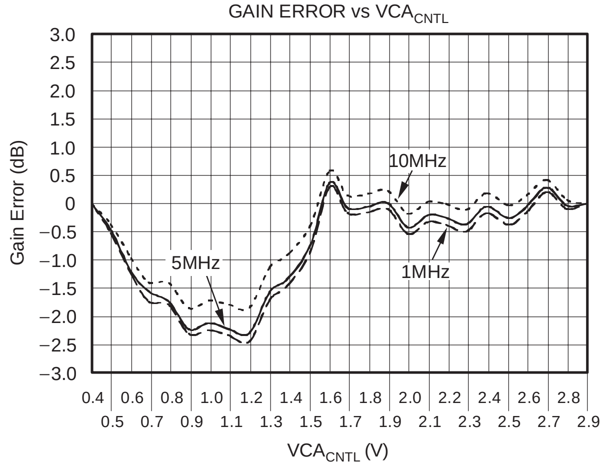
GAIN vs VCA



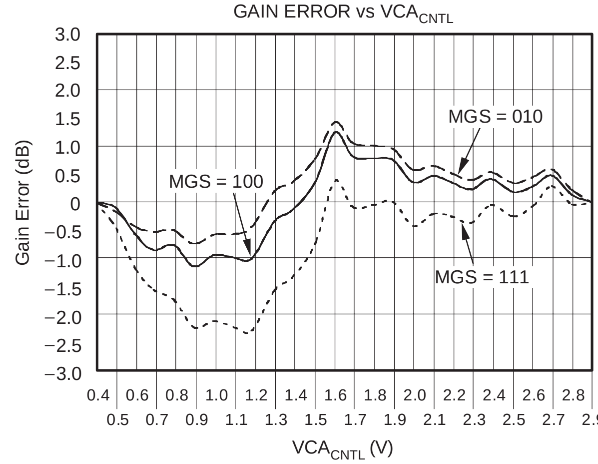
GAIN ERROR vs TEMPERATURE



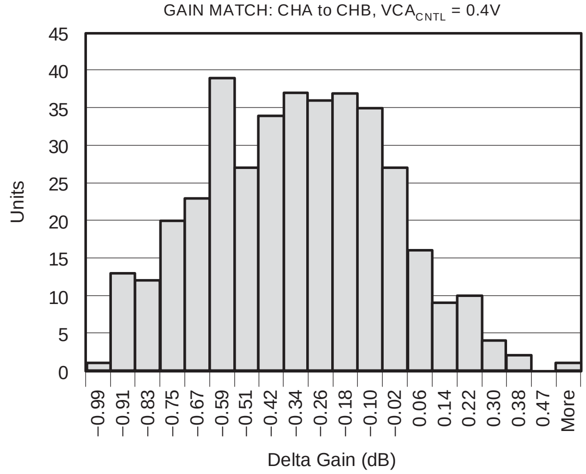
GAIN ERROR vs VCA$_{CNTL}$



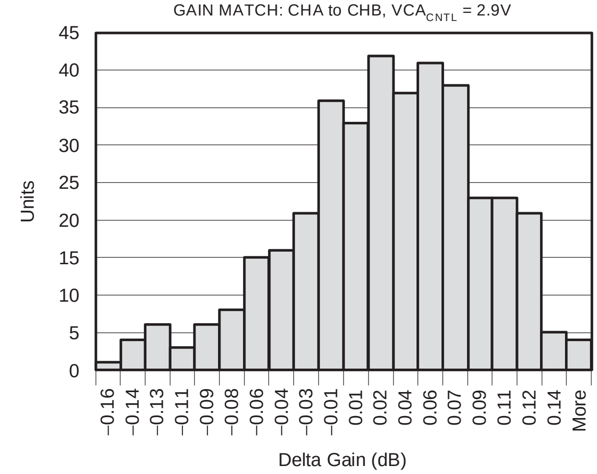
GAIN ERROR vs VCA$_{CNTL}$



GAIN MATCH: CHA to CHB, VCA$_{CNTL}$ = 0.4V



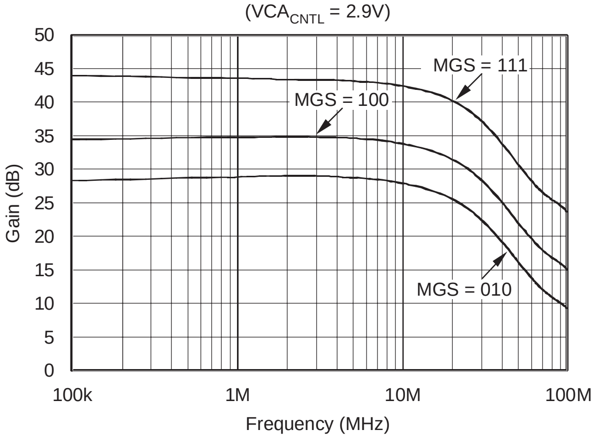
GAIN MATCH: CHA to CHB, VCA$_{CNTL}$ = 2.9V



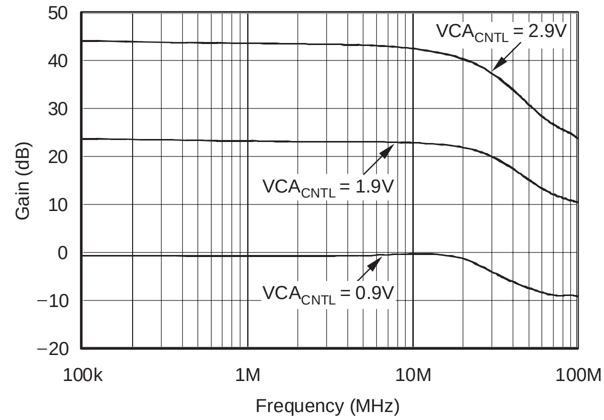
TYPICAL CHARACTERISTICS (continued)

At T_A = 25°C and V_{DD} = 5V, load resistance = 500Ω on each output to ground, differential output ($2V_{PP}$) MGS = 111, and f_{IN} = 5MHz, unless otherwise noted.

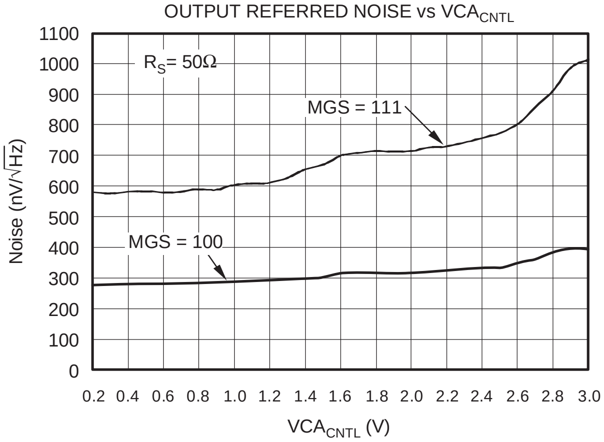
GAIN vs FREQUENCY
(VCA_{CNTL} = 2.9V)



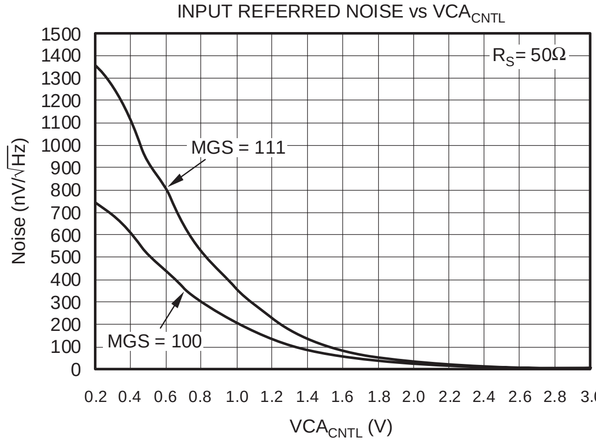
GAIN vs FREQUENCY
(MGS = 111)



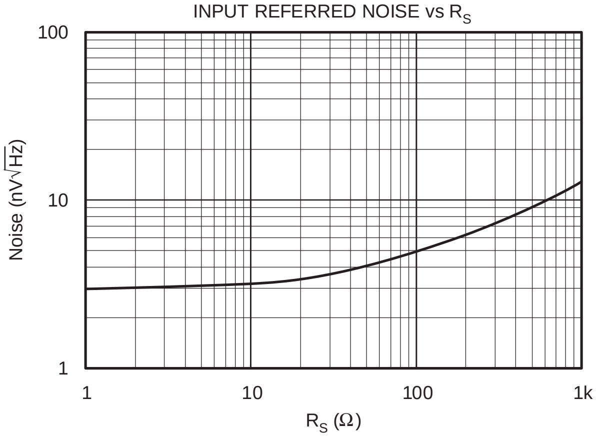
OUTPUT REFERRED NOISE vs VCA_{CNTL}



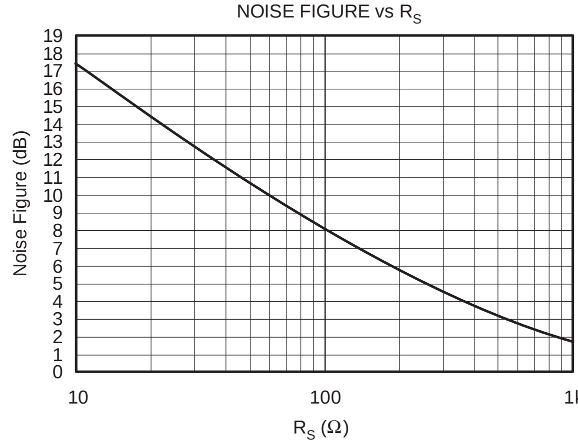
INPUT REFERRED NOISE vs VCA_{CNTL}



INPUT REFERRED NOISE vs R_S



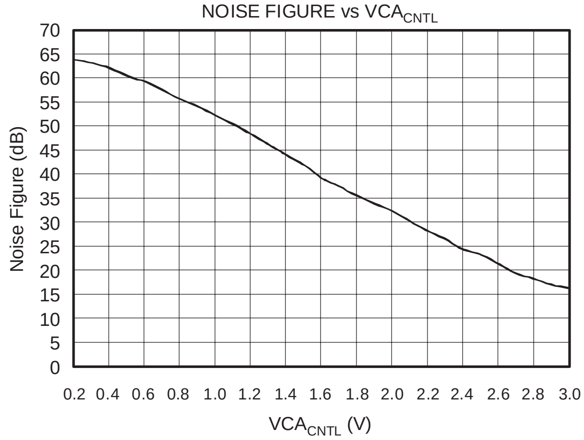
NOISE FIGURE vs R_S



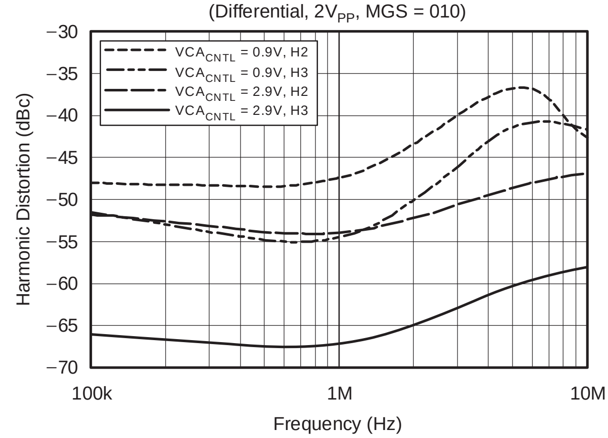
TYPICAL CHARACTERISTICS (continued)

At T_A = 25°C and V_{DD} = 5V, load resistance = 500Ω on each output to ground, differential output ($2V_{PP}$) MGS = 111, and f_{IN} = 5MHz, unless otherwise noted.

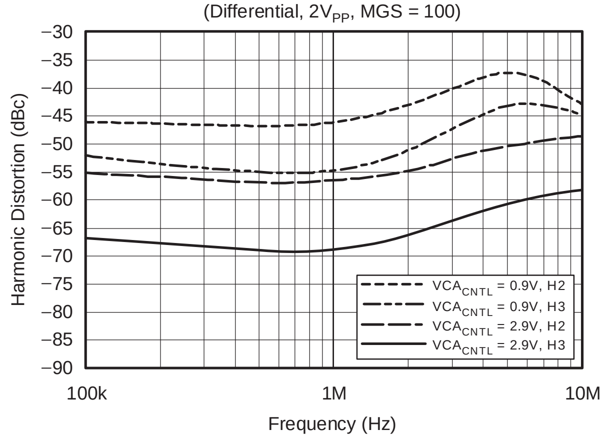
NOISE FIGURE vs VCA_{CNTL}



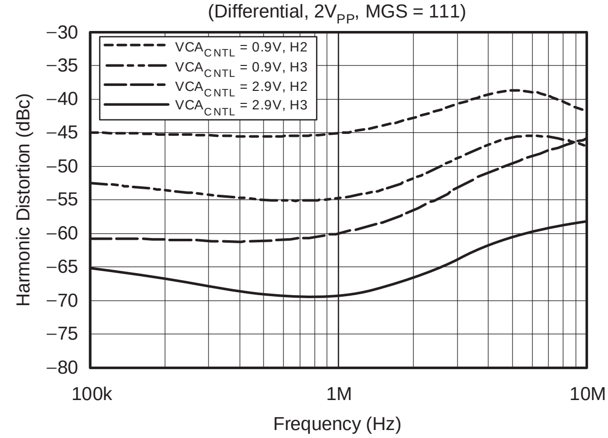
HARMONIC DISTORTION vs FREQUENCY
(Differential, $2V_{PP}$, MGS = 010)



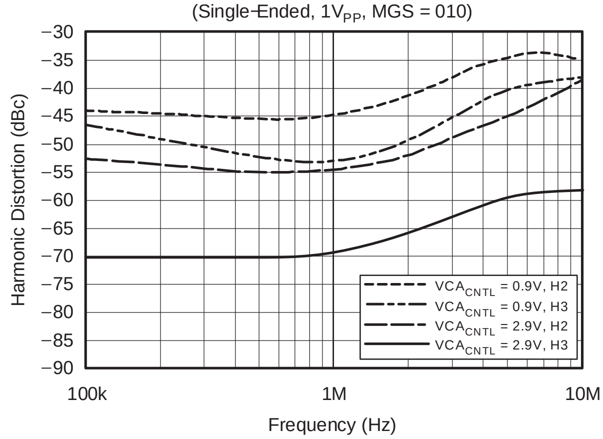
HARMONIC DISTORTION vs FREQUENCY
(Differential, $2V_{PP}$, MGS = 100)



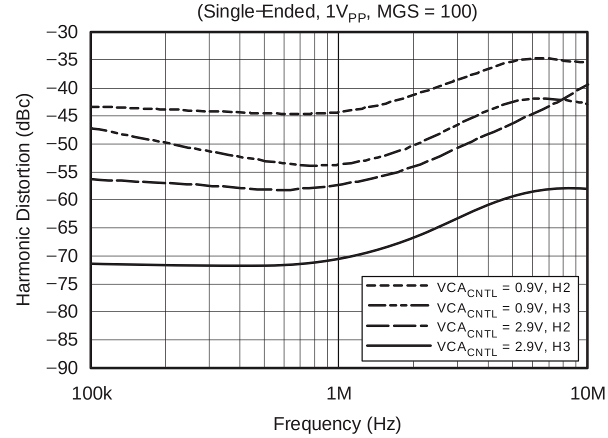
HARMONIC DISTORTION vs FREQUENCY
(Differential, $2V_{PP}$, MGS = 111)



HARMONIC DISTORTION vs FREQUENCY
(Single−Ended, $1V_{PP}$, MGS = 010)



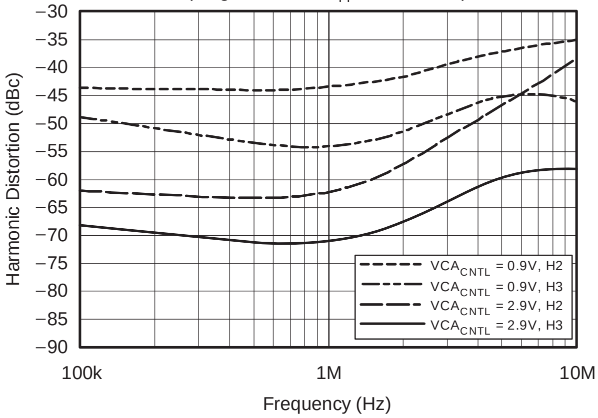
HARMONIC DISTORTION vs FREQUENCY
(Single−Ended, $1V_{PP}$, MGS = 100)



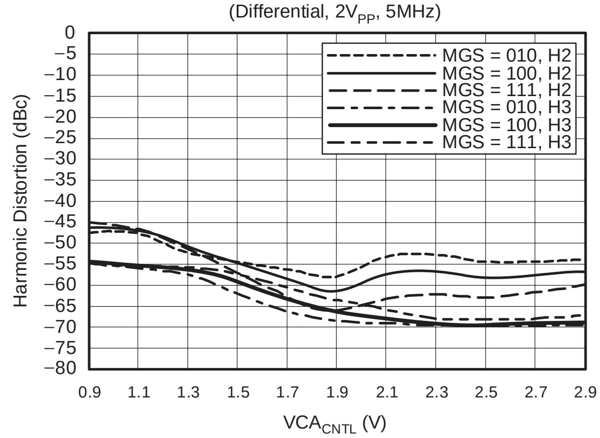
TYPICAL CHARACTERISTICS (continued)

At T_A = 25°C and V_{DD} = 5V, load resistance = 500Ω on each output to ground, differential output ($2V_{PP}$) MGS = 111, and f_{IN} = 5MHz, unless otherwise noted.

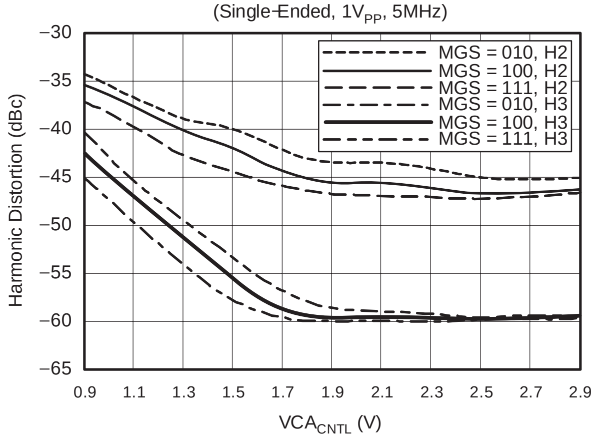
HARMONIC DISTORTION vs FREQUENCY
(Single-Ended, $1V_{PP}$, MGS = 111)



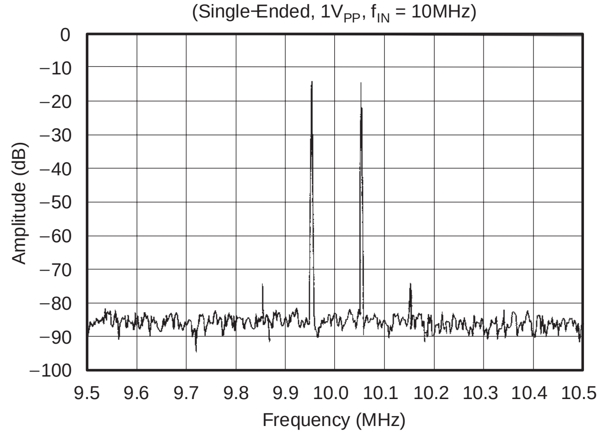
HARMONIC DISTORTION vs VCA_{CNTL}
(Differential, $2V_{PP}$, 5MHz)



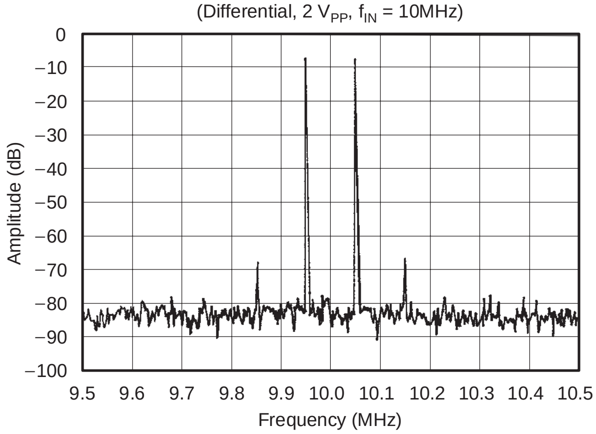
HARMONIC DISTORTION vs VCA_{CNTL}
(Single-Ended, $1V_{PP}$, 5MHz)



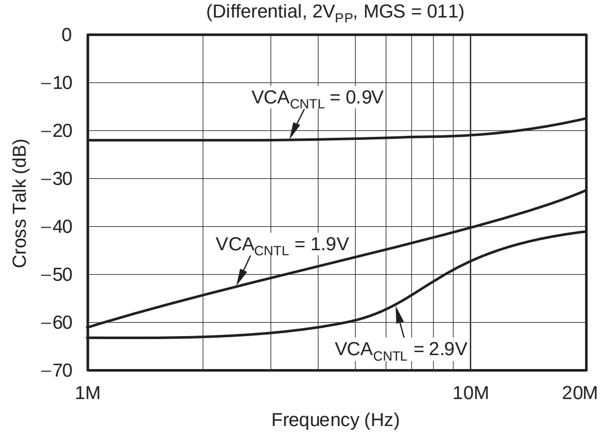
INTERMODULATION DISTORTION
(Single-Ended, $1V_{PP}$, f_{IN} = 10MHz)



INTERMODULATION DISTORTION
(Differential, 2 V_{PP}, f_{IN} = 10MHz)

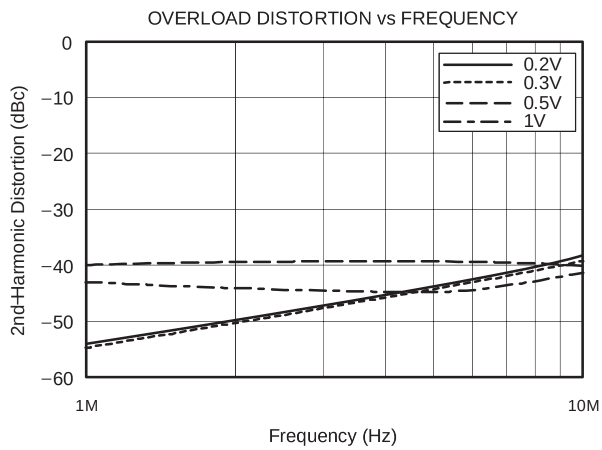


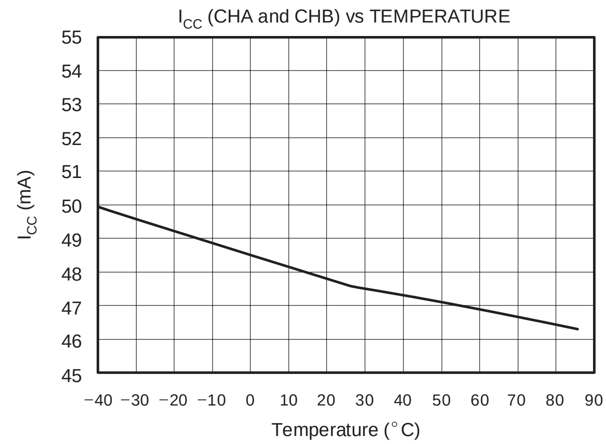
CROSS TALK vs FREQUENCY
(Differential, $2V_{PP}$, MGS = 011)



TYPICAL CHARACTERISTICS (continued)

At T_A = 25°C and V_{DD} = 5V, load resistance = 500Ω on each output to ground, differential output ($2V_{PP}$) MGS = 111, and f_{IN} = 5MHz, unless otherwise noted.





OVERVIEW

The VCA2619 is a dual-channel, VGA consisting of three primary blocks: an Input Buffer, a VCA, and a PGA. All stages are ac coupled, with the coupling into the PGA stage being made variable by placing an external capacitor between the CP1 and CP2 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 30MHz, making the usable bandwidth of the VCA2619 between 75kHz and 30MHz.

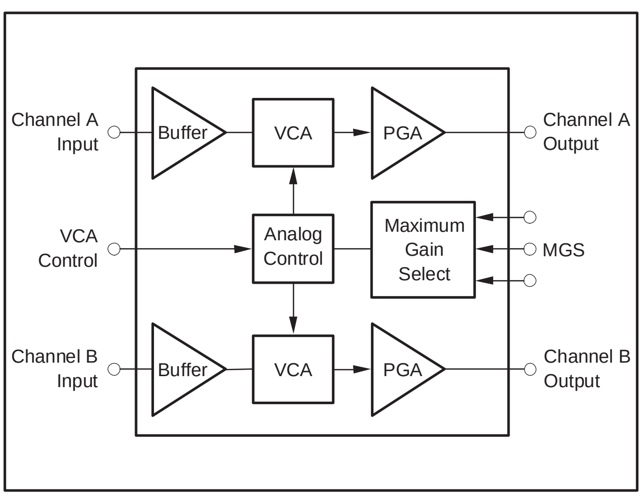


Figure 1. Simplified Block Diagram of the VCA2619.

INPUT BUFFER

The input buffer is a unity gain amplifier (gain of +1) with a bandwidth of 100MHz with an input resistance of approximately 600kΩ. The input buffer isolates the circuit driving the VCA2619 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 0.01µF. It should be noted that if the capacitor value were increased, the power-on time of the VCA2619 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 (VCA_{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.

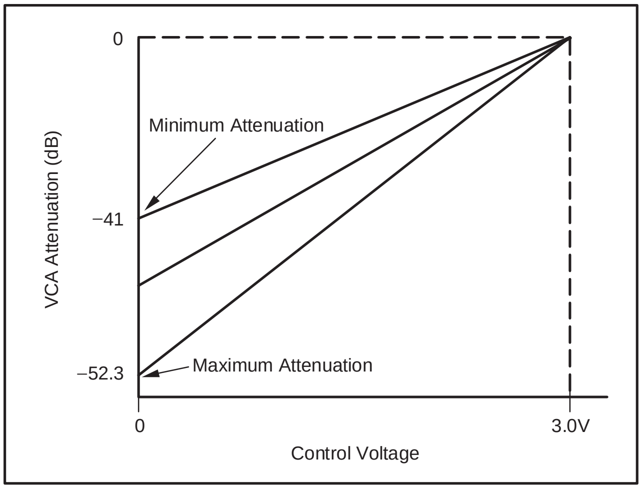


Figure 2. Swept Attenuator Characteristic.

The MGS bits adjust the overall range of attenuation and maximum gain while the VCA_{CNTL} voltage adjusts the actual attenuation factor. Figure 3 is a simplified version of the voltage control attenuator. Figure 4 illustrates the piecewise approximation to the logarithmic control characteristics. 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. The VCA control circuitry is common to both channels of the VCA2619. The range for the VCA_{CNTL} input spans from 0V to 3V. Although overdriving the VCA_{CNTL} input above the recommended 3V maximum will not damage the part, this condition should be avoided.

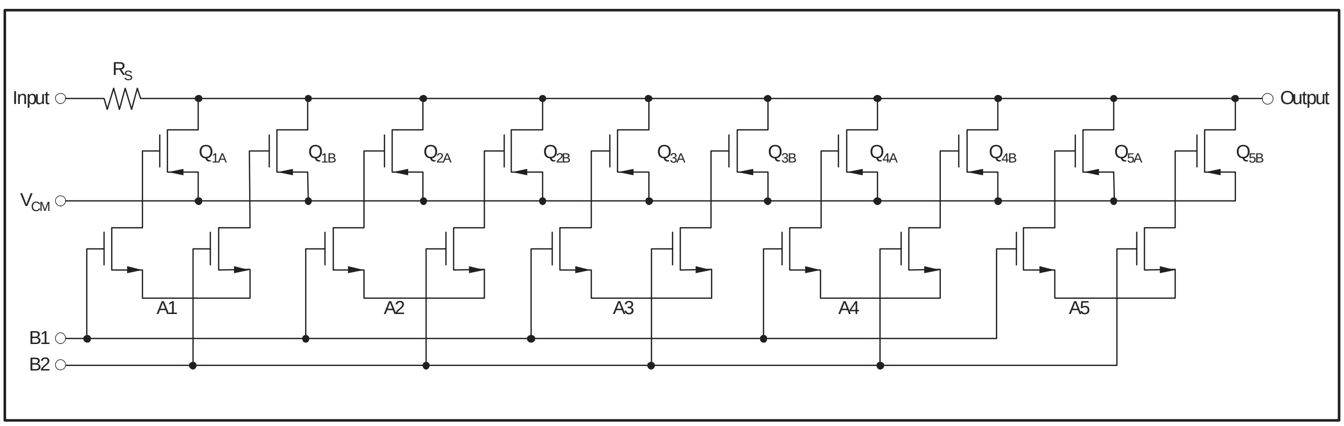


Figure 3. Simplified Attenuator Diagram.

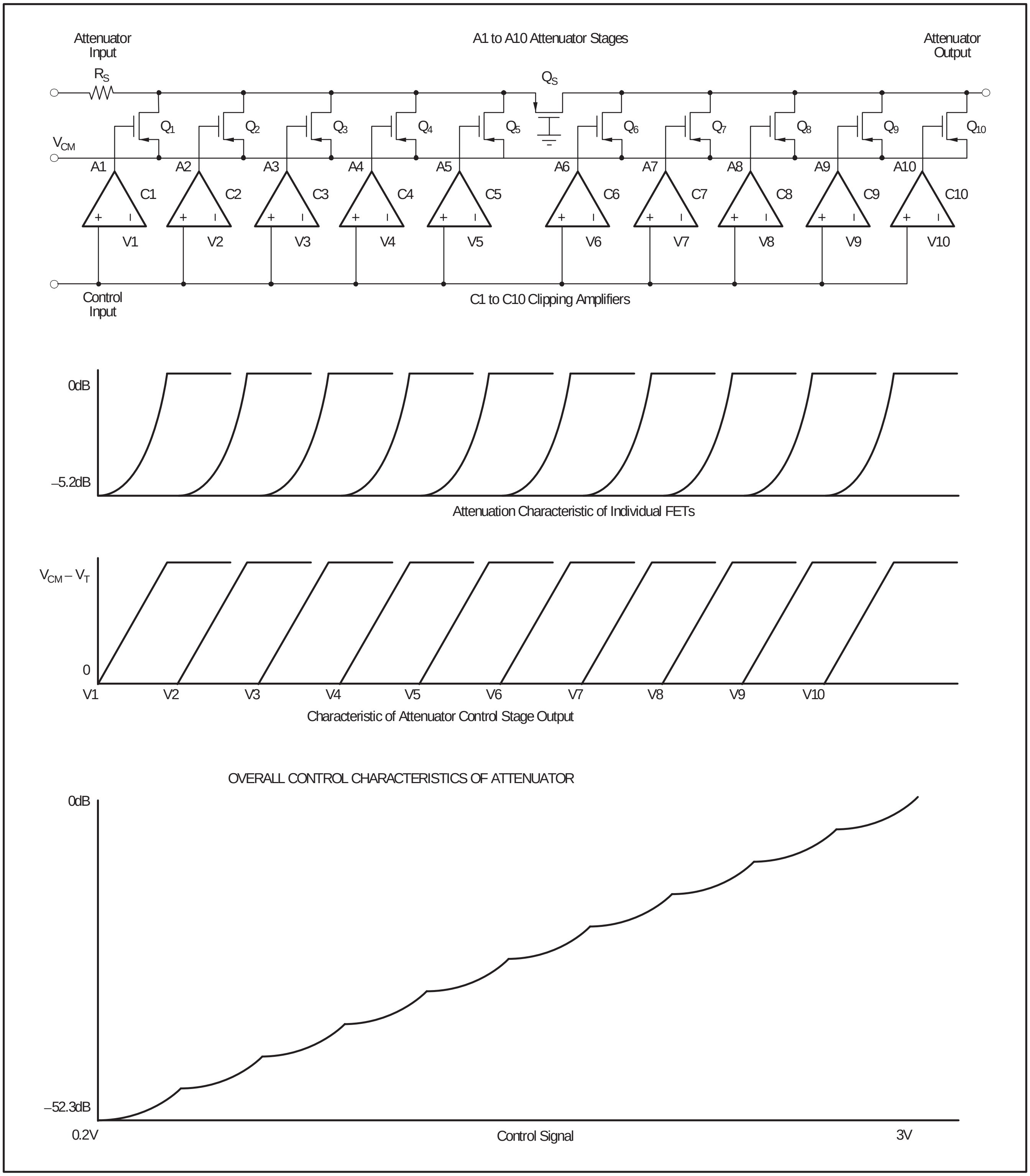


Figure 4. Piecewise Approximation to Logarithmic Control Characteristics.

PGA POST-AMPLIFIER

Figure 5 shows a simplified circuit diagram of the PGA block. As stated before, the input to the PGA is ac coupled with 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:

$$\frac{1}{(2 \cdot \pi \cdot 500k\Omega \cdot (220pF + C_{EXTERNAL}))} \quad (1)$$

where $C_{EXTERNAL}$ is the external capacitor value in farads.

Care should be taken to avoid using too large a value of capacitor, as this can increase the power-on delay time.

The PGA gain is programmed with the same MGS bits that control the VCA maximum attenuation factor. For VCA_{CNTL} = 3V (no attenuation), the VCA + PGA gain will be controlled by the programmed PGA gain (29dB to 43dB in approximately 3dB steps). For clarity, the gain and attenuation factors are detailed in Table I.

Table 1. MGS Settings.

MGS SETTING	ATTENUATOR GAIN VCA_{CNTL} = 0.2V TO 3V	ATTENUATOR + DIFFERENTIAL PGA GAIN
000	Not Valid	Not Valid
001	Not Valid	Not Valid
010	–41.0dB to 0dB	–12dB to 29dB
011	–43.3dB to 0dB	–11.5dB to 31.8dB
100	–46.4dB to 0dB	–11.5dB to 34.9dB
101	–48.2dB to 0dB	–10.6dB to 37.6dB
110	–50.2dB to 0dB	–9.8dB to 40.4dB
111	–52.3dB to 0dB	–9.3dB to 43.3dB

The PGA architecture converts the single−ended signal from the VCA into a differential signal. Low input noise was also a requirement of the PGA design due to the large amount of signal attenuation that can be asserted before the PGA. At minimum VCA attenuation (used for small input signals), the input buffer noise dominates; at maximum VCA attenuation (large input signals), the PGA noise dominates. Note that if the PGA output is single−ended, the apparent gain will be 6dB lower.

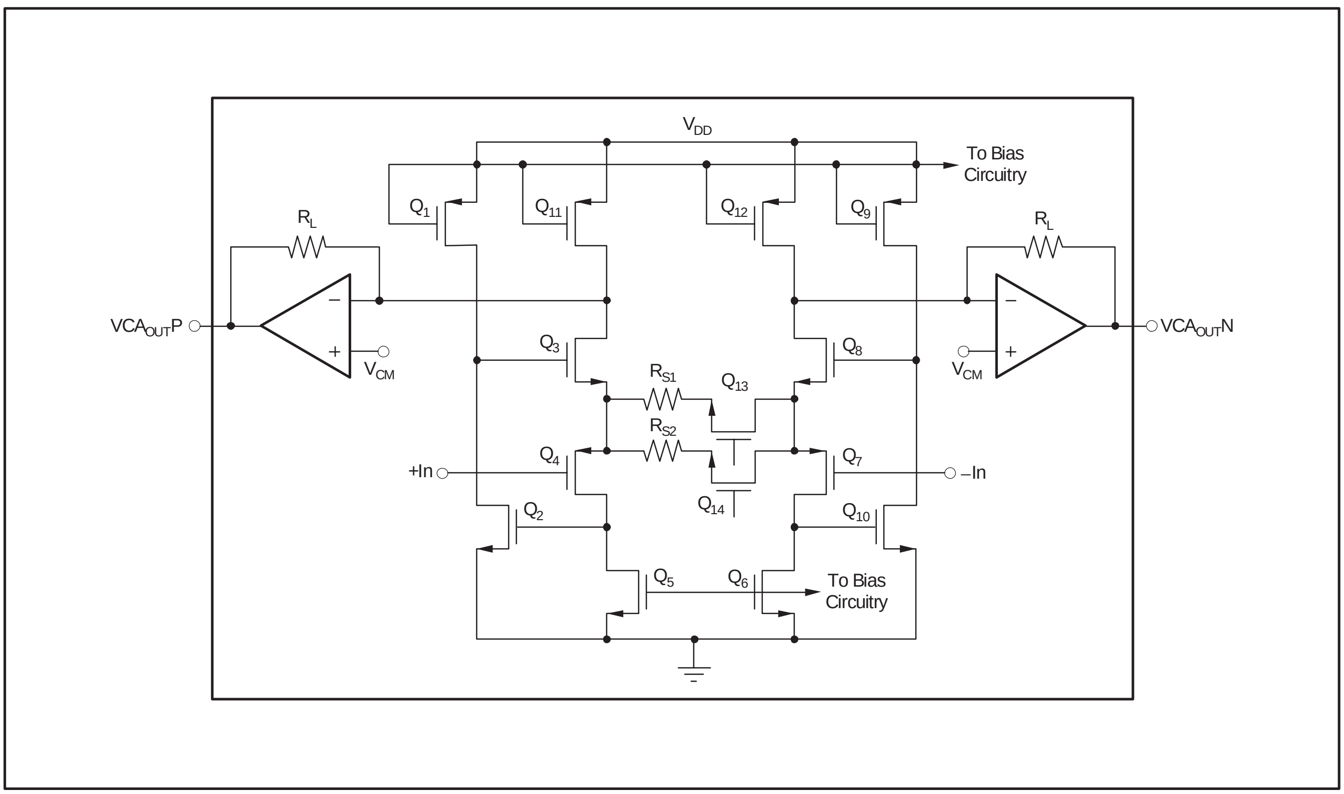


Figure 5. Simplified Block Diagram of PGA.

LAYOUT CONSIDERATIONS

The VCA2619 is an analog amplifier capable of high gain. When working on a PCB layout for the VCA2619, it is recommended to utilize a solid ground plane that is connected to analog ground. This helps to maximize the noise performance of the VCA2619.

Adequate power−supply decoupling must be used in order to achieve the best possible performance. Decoupling capacitors on the VCA_{CNTL} voltage should also be used to help minimize noise. Recommended values can be obtained from the layout diagram of Figure 6.

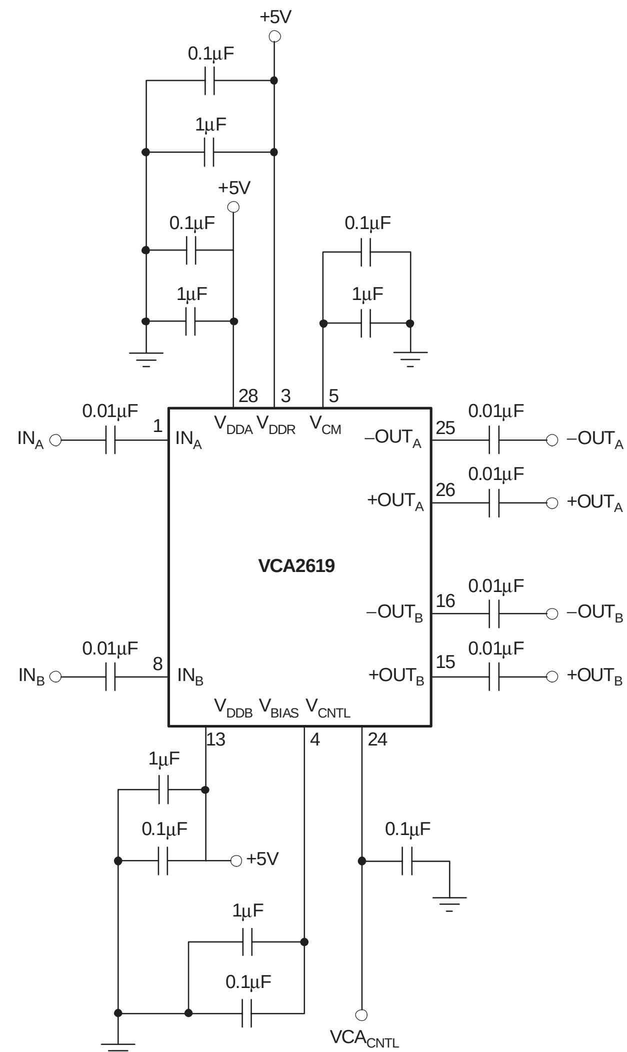


Figure 6. VCA2619 Layout.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
VCA2619YR	ACTIVE	TQFP	PBS	32	2000	TBD	CU SNPB	Level-3-235C-168 HR
VCA2619YRG4	ACTIVE	TQFP	PBS	32		TBD	Call TI	Call TI
VCA2619YT	ACTIVE	TQFP	PBS	32	250	TBD	CU SNPB	Level-3-235C-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.

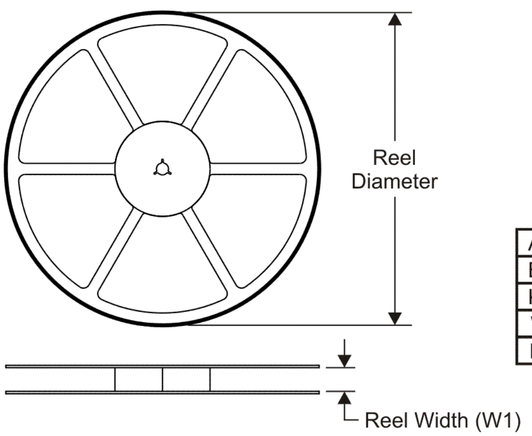
(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been 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)

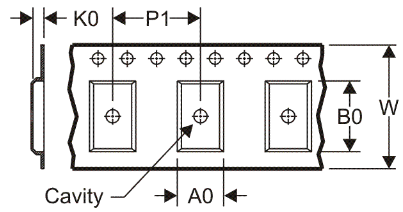
(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

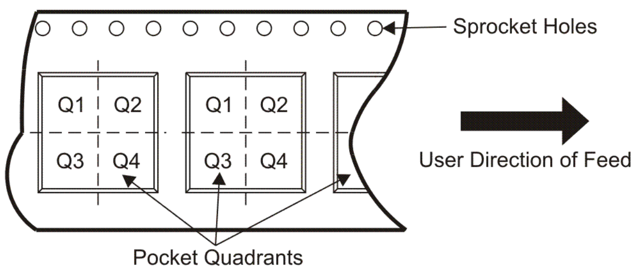
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION





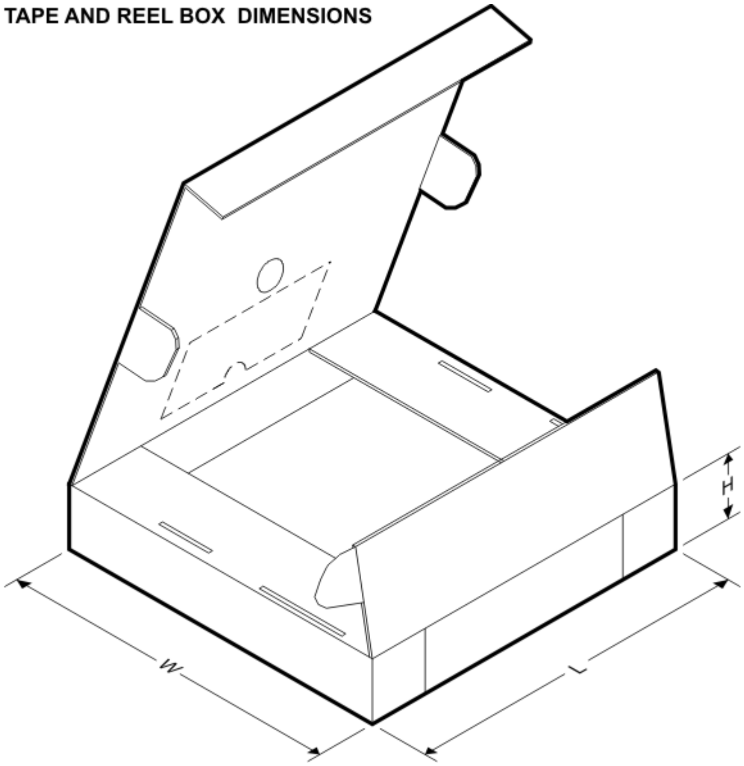
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers



*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
VCA2619YR	TQFP	PBS	32	2000	330.0	16.8	7.2	7.2	1.5	12.0	16.0	Q2
VCA2619YT	TQFP	PBS	32	250	177.8	16.4	7.2	7.2	1.5	12.0	16.0	Q2

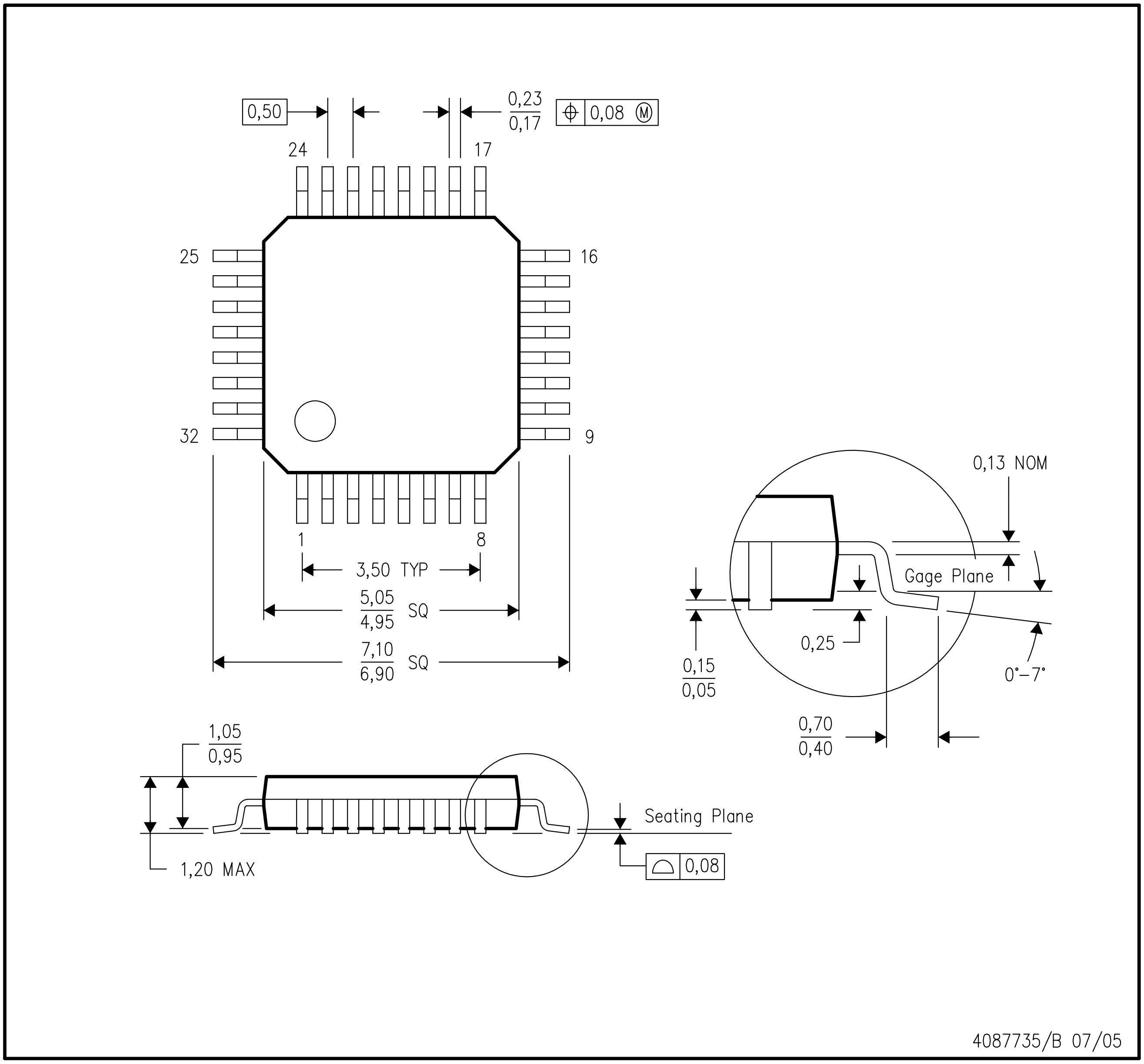
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
VCA2619YR	TQFP	PBS	32	2000	346.0	346.0	33.0
VCA2619YT	TQFP	PBS	32	250	190.5	212.7	31.8

PBS (S-PQFP-G32) PLASTIC QUAD FLATPACK



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

IMPORTANT NOTICE

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

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Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
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Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
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