

SBOS254B - JULY 2002 - REVISED NOVEMBER 2003

Dual, VARIABLE GAIN AMPLIFIER with Input Buffer

FEATURES

- GAIN RANGE: up to 43dB
- 30MHz BANDWIDTH
- LOW CROSSTALK: 65dB at Max Gain, 5MHz
- HIGH-SPEED VARIABLE GAIN ADJUST
- POWER SHUTDOWN MODE
- HIGH IMPEDANCE INPUT BUFFER

APPLICATIONS

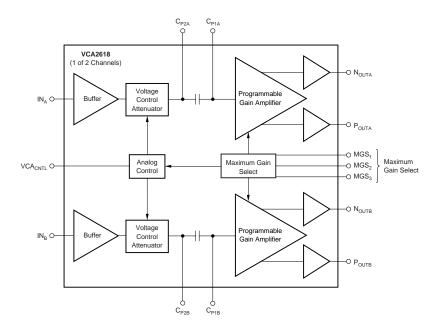
- ULTRASOUND SYSTEMS
- WIRELESS RECEIVERS
- **TEST EQUIPMENT**
- RADAR

DESCRIPTION

The VCA2618 is a highly integrated, dual receive channel, Variable Gain Amplifier (VGA) with analog gain control.

The VCA2618'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 (A/D) converters. A separate power-down pin reduces power consumption.

The VCA2618 also features low crosstalk and outstanding distortion performance. The combination of low noise and gain range programmability make the VCA2618 a versatile building block in a number of applications where noise performance is critical. The VCA2618 is available in a TQFP-32 package.





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ABSOLUTE MAXIMUM RATINGS(1)

Power Supply (+V _S)	+6V
Analog Input	
Logic Input	$-0.3V$ to $(+V_S + 0.3V)$
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 ⁽¹⁾	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER	TRANSPORT MEDIA, QUANTITY
VCA2618Y	TQFP-32 Surface-Mount	PBS "	-40°C to +85°C	VCA2618Y	VCA2618YT VCA2618YR	Tape and Reel, 250 Tape and Reel, 2000

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

ELECTRICAL CHARACTERISTICS

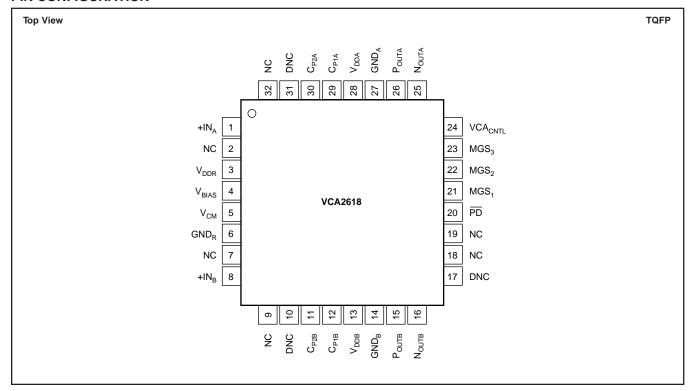
At $T_A = +25^{\circ}C$, $V_{DD} = 5V$, load resistance = 500Ω on each output to ground differential output $(2V_{PP})$, MGS = 111, and $f_{IN} = 5MHz$, unless otherwise noted.

		VCA2618Y			
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
BUFFER					
Input Resistance			600		kΩ
Input Capacitance			5		pF
Input Bias Current			1		nA
Maximum Input Voltage			1		V_{PP}
Input Voltage Noise	PGA Gain = 45dB, $R_S = 50\Omega$		5.4		nV/ Hz
Input Current Noise	Independent of Gain		350		fA/ Hz
Noise Figure	$R_F = 550\Omega$, PGA Gain = 45dB, $R_S = 75\Omega$		13		dB
Bandwidth			100		MHz
PROGRAMMABLE VARIABLE GAIN A	MPLIFIER				
Peak Input Voltage			1		V_{PP}
–3dB Bandwidth			30		MHz
Slew Rate			300		V/µs
Output Signal Range	$R_L \ge 500\Omega$ Each Side to Ground		2.5 ±1		V
Output Impedance			1		Ω
Output Short-Circuit Current			±40		mA
3rd-Harmonic Distortion	$V_{OUT} = 2V_{PP}, VCA_{CNTL} = 3.0V$	-45	-50		dBc
2nd-Harmonic Distortion	$V_{OUT} = 2V_{PP}, VCA_{CNTL} = 3.0V$	-42	-50		dBc
2nd-Harmonic Distortion	$V_{OUT} = 2V_{PP}, VCA_{CNTL} = 3.0V, MGS = 011$		-60		dBc
Overload Performance (2nd-Harmonic Distortion)	Input Signal = 1V _{PP} , VCA _{CNTL} = 2V		-40 to -45		dB
Time Delay			5		ns
IMD, 2-Tone	$V_{OUT} = 2V_{PP}, f = 9.95MHz$		-59		dBc
Crosstalk			65		dB
Group Delay Variation	1MHz < f < 10MHz, Full Gain Range		13		ns
ACCURACY					
Gain Slope	$VCA_{CNTL} = 0.2V \text{ to } 3.0V$		16		dB/V
Gain Error ⁽¹⁾	$VCA_{CNTL} = 0.2V \text{ to } 3.0V$		±2.0		dB
	$VCA_{CNTL} = 0.4V \text{ to } 2.9V$		±1.3	±2	dB
Output Offset Voltage			±50		mV
GAIN CONTROL INTERFACE					
Input Voltage (VCA _{CNTL}) Range		1	0.2 to 3.0		V
Input Resistance			1		MΩ
Response Time	45dB Gain Change		0.2		μs
POWER SUPPLY			F.0		.,
Specified Operating Range	Operating Feet Observed	4.75	5.0	5.25	V
Power Dissipation Power-Down	Operating, Each Channel		120 9.2	150	mW mW

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



PIN CONFIGURATION



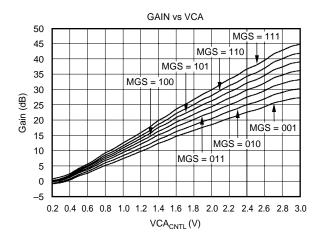
PIN DESCRIPTIONS

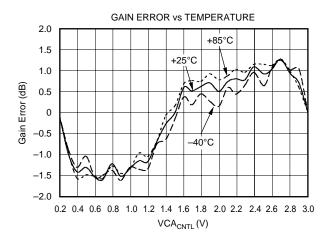
PIN	DESIGNATOR	DESCRIPTION	PIN	DESIGNATOR	DESCRIPTION
1	+IN _A	Noninverting Input Channel A	17	DNC	Do Not Connect
2	NC	No Internal Connection	18	NC	No Internal Connection
3	V_{DDR}	Internal Reference Supply	19	NC	No Internal Connection
4	V _{BIAS}	Bias Voltage	20	PD	Power-Down (Active LOW)
5	V _{CM}	Common-Mode Voltage	21	MGS_1	Maximum Gain Select 1 (MSB)
6	GND _R	Internal Reference Ground	22	MGS_2	Maximum Gain Select 2
7	NC	Not Connected	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	DNC	Do Not Connect	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	DNC	Do Not Connect
16	N _{OUTB}	Negative Output Channel B	32	NC	No Internal Connection

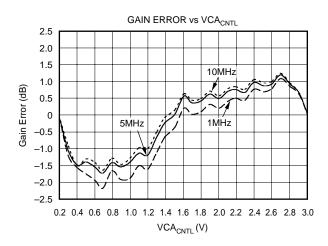


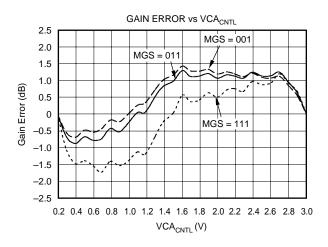
TYPICAL CHARACTERISTICS

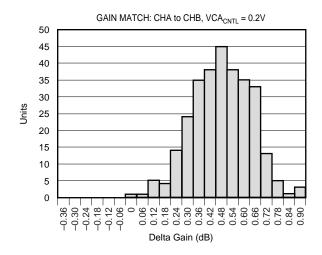
At T_A = +25°C, V_{DD} = 5V, load resistance = 500 Ω on each output to ground, differential output (2V_{PP}) MGS = 111, and f_{IN} = 5MHz, unless otherwise noted.

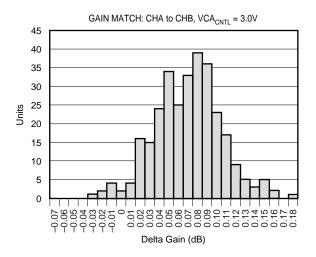






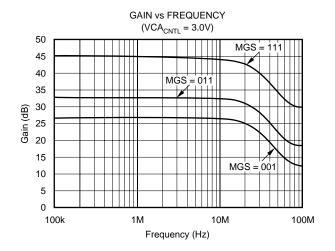


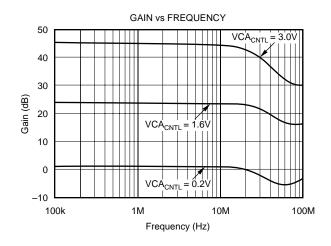


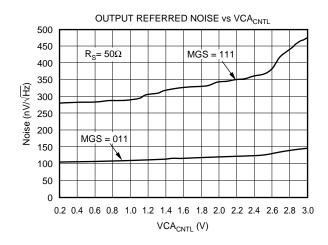


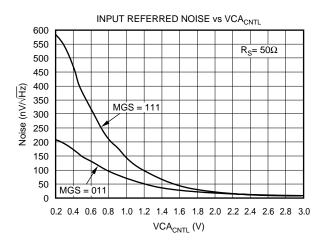


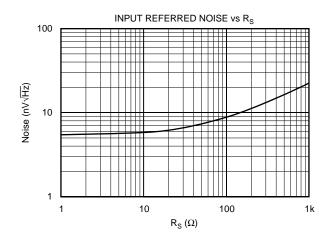
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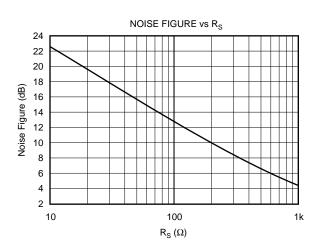




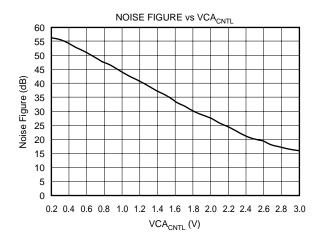


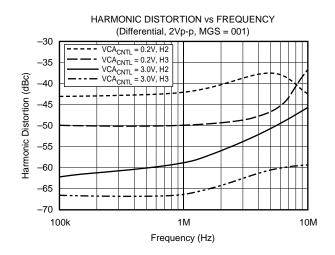


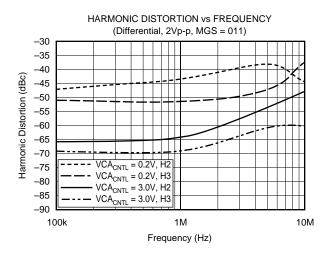


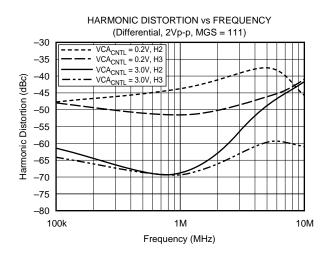


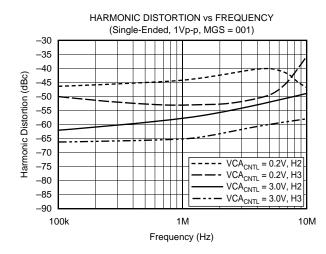
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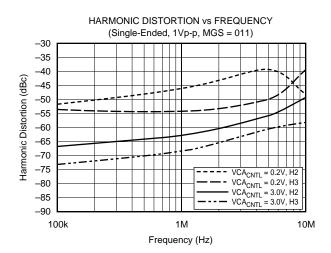






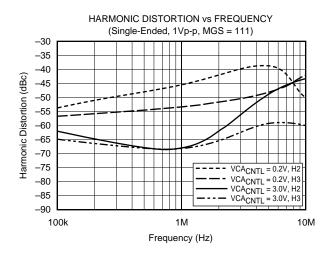


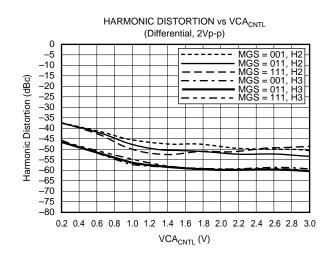


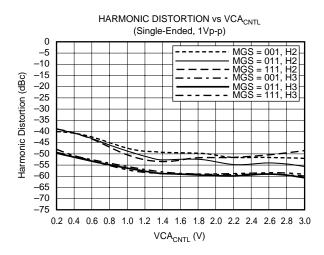


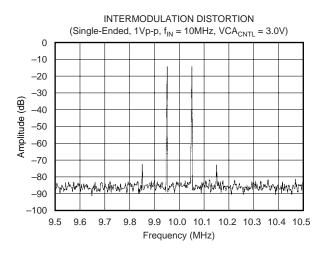


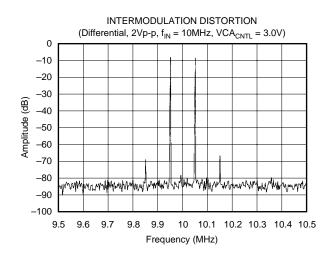
At $T_A = +25^{\circ}C$, $V_{DD} = 5V$, load resistance = 500Ω on each output to ground, differential output ($2V_{\text{pp}}$) MGS = 111, and $f_{\text{IN}} = 5\text{MHz}$, unless otherwise noted.

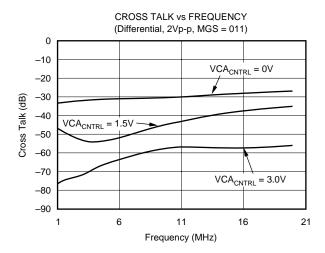




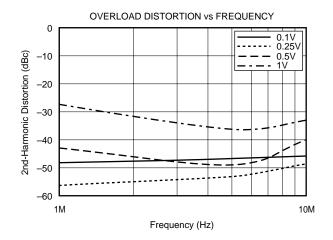


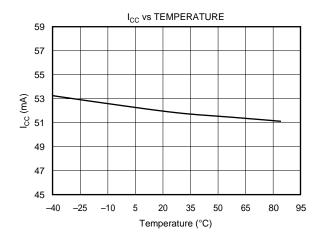


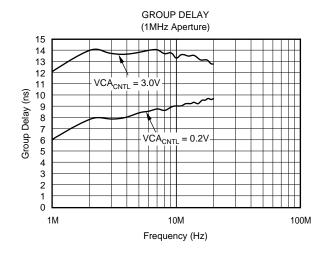




At $T_A = +25$ °C, $V_{DD} = 5V$, load resistance = 500Ω on each output to ground, differential output (2Vp-p) MGS = 111, and $f_{IN} = 5MHz$, unless otherwise noted.









OVERVIEW

The VCA2618 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 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 30MHz, making the usable bandwidth of the VCA2618 between 75kHz and 30MHz.

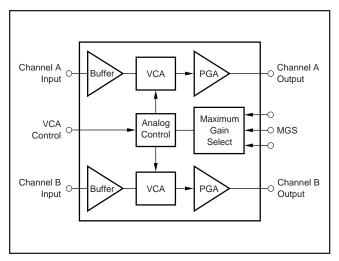


FIGURE 1. Simplified Block Diagram of the VCA2618.

INPUT BUFFER

The input buffer is a unity gain amplifier (gain of +1) with a bandwidth of 100 MHz with an input resistance of approximately $600 k\Omega$. The input buffer isolates the circuit driving the VCA2618 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 VCA2618 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 $_{\rm CNTL}$) 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.

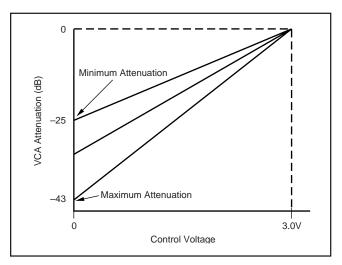


FIGURE 2. Swept Attenuator Characteristic.

The MGS bits adjust the overall range of attenuation and maximum gain while the VCA_{CNTL} voltage adjusts the actual attenuation factor. 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 VCA₂₆₁₈. 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.

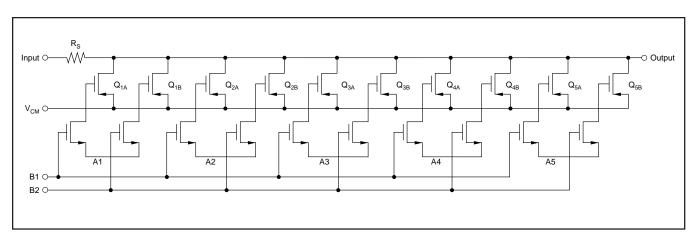


FIGURE 3. Programmable Attenuator Section.



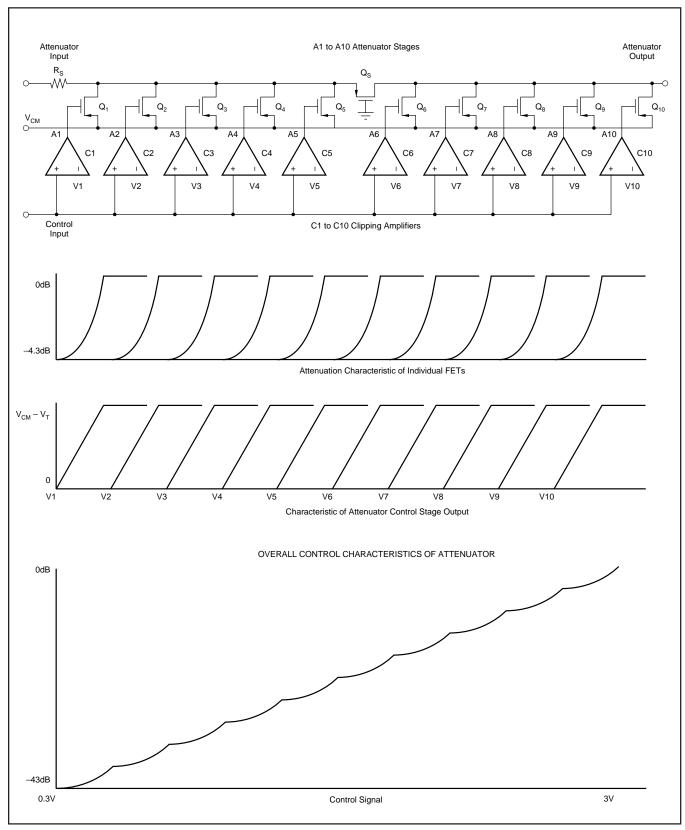


FIGURE 4. Piecewise Approximation to Logarithmic Control Characteristics.

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 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:

$$\frac{1}{\left(2 \bullet \pi \bullet 500 \text{k} \Omega \bullet \left(220 \text{pF} + C_{\text{EXTERNAL}}\right)\right)}$$

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.

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_{CNTL} input is set to 0V (the maximum attenuation for VCA). For VCA_{CNTL} = 3V (no attenuation), the VCA + PGA gain will be controlled by the programmed PGA gain (25dB to 43dB in 3dB steps). For clarity, the gain and attenuation factors are detailed in Table I.

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

MGS SETTING	ATTENUATOR GAIN VCA _{CNTL} = 0V to 3V	ATTENUATOR + DIFFERENTIAL PGA GAIN
000	Not Valid	Not Valid
001	-25dB to 0dB	0dB to 25dB
010	-28dB to 0dB	0dB to 28dB
011	-31dB to 0dB	0dB to 31dB
100	-34dB to 0dB	0dB to 34dB
101	-37dB to 0dB	0dB to 37dB
110	-40dB to 0dB	0dB to 40dB
111	-43dB to 0dB	0dB to 43dB

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.

LAYOUT CONSIDERATIONS

The VCA2618 is an analog amplifier capable of high gain. When working on a PCB layout for the VCA2618, it is recommended to utilize a solid ground plane that is connected to analog ground. This helps to maximize the noise performance of the VCA2618.

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.

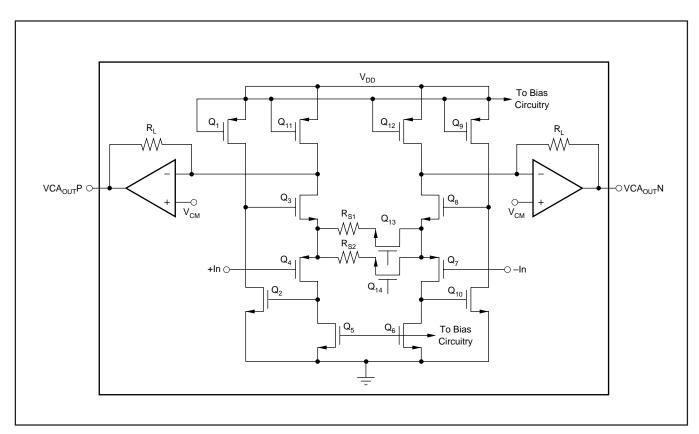


FIGURE 5. Simplified Block Diagram of the PGA Section with the VCA2618.



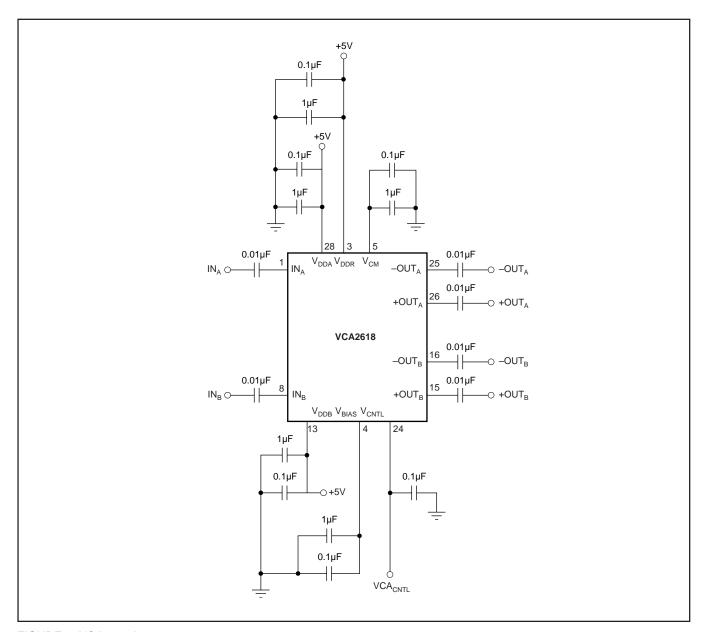


FIGURE 6. VCA2618 Layout.



PACKAGE OPTION ADDENDUM

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PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins P	ackage Qty	e Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
VCA2618YT	ACTIVE	TQFP	PBS	32	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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PACKAGE MATERIALS INFORMATION

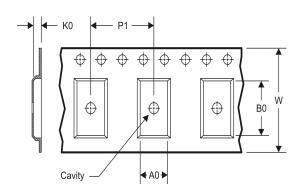
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TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
В0	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

TAPE AND REEL INFORMATION

*All dimensions are nominal

Device	Package Type	Package Drawing			Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
VCA2618YT	TQFP	PBS	32	250	177.8	16.4	7.2	7.2	1.5	12.0	16.0	Q2

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*All dimensions are nominal

ĺ	Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
I	VCA2618YT	TQFP	PBS	32	250	210.0	185.0	35.0

PBS (S-PQFP-G32)

PLASTIC QUAD FLATPACK



NOTES: A. All linear dimensions are in millimeters.

B. This drawing is subject to change without notice.



PBS (S-PQFP-G32)

PLASTIC QUAD FLATPACK



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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