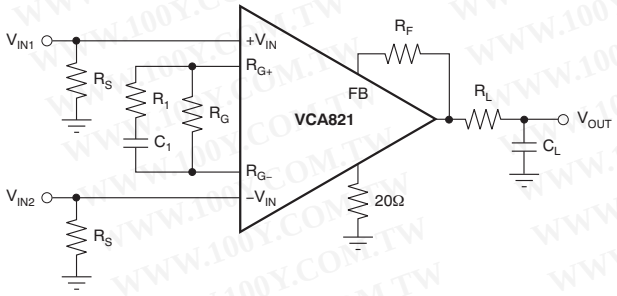
Ultra-Wideband, > 40dB Gain Adjust Range, Linear in dB VARIABLE GAIN AMPLIFIER

FEATURES

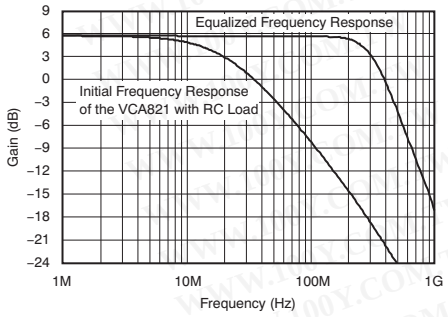
- 710MHz SMALL-SIGNAL BANDWIDTH (G = +2V/V)
- 320MHz, 4V_{PP} BANDWIDTH (G = +10V/V)
- 0.1dB GAIN FLATNESS to 135MHz
- 2500V/µs SLEW RATE
- > 40dB GAIN ADJUST RANGE
- HIGH GAIN ACCURACY: 20dB ±0.3dB
- HIGH OUTPUT CURRENT: ±90mA

APPLICATIONS

- AGC RECEIVERS with RSSI
- DIFFERENTIAL LINE RECEIVERS
- PULSE AMPLITUDE COMPENSATION
- VARIABLE ATTENUATORS
- VOLTAGE-TUNABLE ACTIVE FILTERS



Differential Equalizer



Differential Equalization of an RC Load

DESCRIPTION

The VCA821 is a dc-coupled, wideband, linear in dB, continuously variable, voltage-controlled gain amplifier. It provides a differential input to single-ended conversion with a high-impedance gain control input used to vary the gain down 40dB from the nominal maximum gain set by the gain resistor (R_G) and feedback resistor (R_F).

The VCA821 internal architecture consists of two input buffers and an output current feedback amplifier stage integrated with a multiplier core to provide a complete variable gain amplifier (VGA) system that does not require external buffering. The maximum gain is set externally with two resistors, providing flexibility in designs. The maximum gain is intended to be set between 6dB and 32dB. Operating from ±5V supplies, the gain control voltage for the VCA821 adjusts the gain linearly in dB as the control voltage varies from 0V to +2V. For example, set at a maximum gain of 20dB, the VCA821 provides 20dB, at V_G = +2V, to less than –20dB at V_G = 0V. The VCA821 offers excellent gain linearity. For a 20dB maximum gain, and a gain-control input voltage varying between +1V and +2V, the gain does not deviate by more than ±0.3dB (maximum at +25°C).

VCA821 RELATED PRODUCTS

SINGLES	DUALS	GAIN ADJUST RANGE (dB)	INPUT NOISE (nV/√Hz)	SIGNAL BANDWIDTH (MHz)
VCA810	—	80	2.4	35
—	VCA2612	45	1.25	80
—	VCA2613	45	1	80
—	VCA2615	52	0.8	50
—	VCA2617	48	4.1	50
VCA820	—	40	8.2	150
VCA821	—	40	6.0	420
VCA822	—	40	8.2	150
VCA824	—	40	6.0	420

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.

ORDERING INFORMATION(1)

PRODUCT	PACKAGE-LEAD	PACKAGE DESIGNATOR	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER	TRANSPORT MEDIA, QUANTITY
VCA821	SO-14	D	–40°C to +85°C	VCA821ID	VCA821ID	Rail, 50
					VCA821IDR	Tape and Reel, 2500
VCA821	MSOP-10	DGS	–40°C to +85°C	BOR	VCA821IDGST	Tape and Reel, 250
					VCA821IDGSR	Tape and Reel, 2500

(1) For the most current package and ordering information see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.

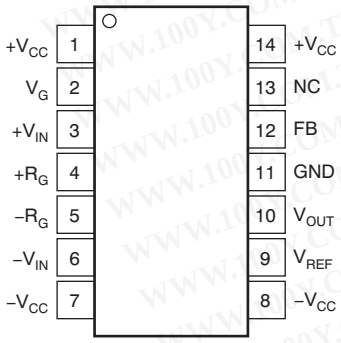
ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range (unless otherwise noted)

		VCA821	UNIT
Power Supply		±6.5	V
Internal Power Dissipation		See Thermal Characteristics	
Input Voltage Range		$\pm V_S$	V
Storage Temperature Range		–65 to +125	°C
Lead Temperature (soldering, 10s)		+260	°C
Junction Temperature (T_J)		+150	°C
Junction Temperature (T_J), Maximum Continuous Operation		+140	C
ESD Rating:	Human Body Model (HBM)	2000	V
	Charge Device Model (CDM)	1000	V
	Machine Model	200	V

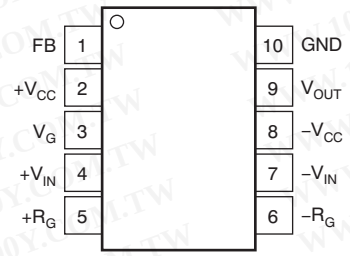
PIN CONFIGURATIONS

D PACKAGE
SO-14
(TOP VIEW)



NC = No Connection

DGS PACKAGE
MSOP-10
(TOP VIEW)



ELECTRICAL CHARACTERISTICS: V_S = ±5V

At A_{VMAX} = 20dB, R_F = 402Ω, R_G = 80Ω, R_L = 100Ω, unless otherwise noted.

PARAMETER	CONDITIONS	VCA821 TYP +25°C	VCA821 MIN/MAX OVER TEMPERATURE +25°C(2)	0°C to 70°C(3)	–40°C to +85°C(3)	UNITS	MIN/MAX	TEST LEVEL(1)
AC PERFORMANCE								
Small-Signal Bandwidth	G = 6dB, V_O = 500mV$_{PP}$	710				MHz	typ	C
	G = 20dB, V_O = 500mV$_{PP}$	420				MHz	typ	C
	G = 40dB, V_O = 500mV$_{PP}$	170				MHz	typ	C
Large-Signal Bandwidth	G = 20dB, V_O = 4V$_{PP}$	320				MHz	typ	C
Gain Control Bandwidth	V_O = 200mV$_{PP}$	330	240	235	235	MHz	min	B
Bandwidth for 0.1dB Flatness	G = 20dB, V_O = 200mV$_{PP}$	135				MHz	typ	C
Slew Rate	G = 20dB, V_O = 5V Step	2500	1800	1700	1700	V/µs	min	B
Rise-and-Fall Time	G = 20dB, V_O = 5V Step	1.5	1.8	1.9	1.9	ns	max	B
Settling Time to 0.01%	G = 20dB, V_O = 5V Step	11				ns	typ	C
Harmonic Distortion								
2nd Harmonic	V_O = 2V$_{PP}$, f = 20MHz	–66	–64	–64	–64	dBc	min	B
3rd Harmonic	V_O = 2V$_{PP}$, f = 20MHz	–63	–61	–61	–61	dBc	min	B
Input Voltage Noise	f > 100kHz	6.0				nV/√Hz	typ	C
Input Current Noise	f > 100kHz	2.6				pA/√Hz	typ	C
GAIN CONTROL								
Absolute Gain Error	G_{MAX} = 20dB, V_G = 2V	±0.1	**±0.4**	±0.5	±0.6	dB	max	A
V_{ctrl0}		0.85				V	typ	C
V_{Slope}		0.09				V	typ	C
Absolute Gain Error	G_{MAX} = 20dB, V_G = 1V, (G = 18.06 dB)	±0.3	**±0.4**	±0.5	±0.6	dB	max	A
Gain at V_G = 0.2V	relative to max gain	–26	**–24**	–24	–23	dB	max	A
Gain Control Bias Current		10	**16**	16.6	16.7	µA	max	A
Average Gain Control Bias Current Drift				±12	±12	nA/°C	max	B
Gain Control Input Impedance		1.5 || 0.6				MΩ || pF	typ	C
DC PERFORMANCE								
Input Offset Voltage	G = 20dB, V_{CM} = 0V, V_G = 1V	±4	**±17**	±17.8	±19	mV	max	A
Average Input Offset Voltage Drift	G = 20dB, V_{CM} = 0V, V_G = 1V			30	30	µV/°C	max	B
Input Bias Current	G = 20dB, V_{CM} = 0V, V_G = 1V	19	**25**	29	31	µA	max	A
Average Input Bias Current Drift	G = 20dB, V_{CM} = 0V, V_G = 1V			90	90	nA/°C	max	B
Input Offset Current	G = 20dB, V_{CM} = 0V, V_G = 1V	±0.5	**±2.5**	±3.2	±3.5	µA	max	A
Average Input Offset Current Drift	G = 20dB, V_{CM} = 0V, V_G = 1V			±16	±16	nA/°C	max	B
Max Current Through Gain Resistance		±2.6	±2.55	±2.55	±2.5	mA	max	B
INPUT								
Most Positive Common Mode Input Voltage	R_L = 100Ω	+1.6	**+1.6**	+1.6	+1.6	V	min	A
Most Negative Common Mode Input Voltage	R_L = 100Ω	–2.1	**-2.1**	–2.1	–2.1	V	max	A
Common-Mode Rejection Ratio	V_{CM} = ±0.5V	80	**65**	60	60	dB	min	A
Input Impedance								
Differential		0.9 || 0.6				MΩ || pF	typ	C
Common-Mode		1 || 2				MΩ || pF	typ	C

(1) Test levels: (A) 100% tested at +25°C. Over temperature limits set by characterization and simulation. (B) Limits set by characterization and simulation. (C) Typical value only for information.
(2) Junction temperature = ambient for +25°C tested specifications.
(3) Junction temperature = ambient at low temperature limit; junction temperature = ambient +23°C at high temperature limit for over temperature specifications.

ELECTRICAL CHARACTERISTICS: V_S = ±5V (continued)

At A_{VMAX} = 20dB, R_F = 402Ω, R_G = 80Ω, R_L = 100Ω, unless otherwise noted.

		VCA821						
		TYP	MIN/MAX OVER TEMPERATURE					
PARAMETER	CONDITIONS	+25°C	+25°C[2]	0°C to 70°C[3]	–40°C to +85°C[3]	UNITS	MIN/ MAX	TEST LEVEL[1]
OUTPUT								
Output Voltage Swing	R_L = 1kΩ	±3.9	**±3.6**	±3.4	±3.3	V	min	A
	R_L = 100Ω	±3.6	**±3.5**	±3.3	±3.2	V	min	A
Output Current	V_O = 0V, R_L = 10Ω	±90	**±60**	±50	±45	mA	min	A
Output Impedance	G = +10V/V, f > 100kHz	0.01				Ω	typ	C
POWER SUPPLY								
Specified Operating Voltage		±5				V	typ	C
Minimum Operating Voltage		±3.5				V	typ	C
Maximum Operating Voltage			**±6**	±6	±6	V	max	A
Maximum Quiescent Current	V_G = 1V	34	**35**	35.5	36	mA	max	A
Minimum Quiescent Current	V_G = 1V	34	**32.5**	32	31.5	mA	max	A
Power-Supply Rejection Ratio (–PSRR)		–68	**–61**	–59	–58	dB	min	A
THERMAL CHARACTERISTICS								
Specified Operating Range D Package		–40 to +85				°C	typ	C
Thermal Resistance θ_{JA}	Junction-to-Ambient							
DGS MSOP-10		130				°C/W	typ	C
D SO-14		80				°C/W	typ	C

TYPICAL CHARACTERISTICS: V_S = ±5V, DC Parameters

At T_A = +25°C, R_L = 100Ω, V_G = +2V, and V_{IN} = single-ended input on $+V_{IN}$ with $-V_{IN}$ at ground, unless otherwise noted.

MAXIMUM DIFFERENTIAL INPUT VOLTAGE vs R_G

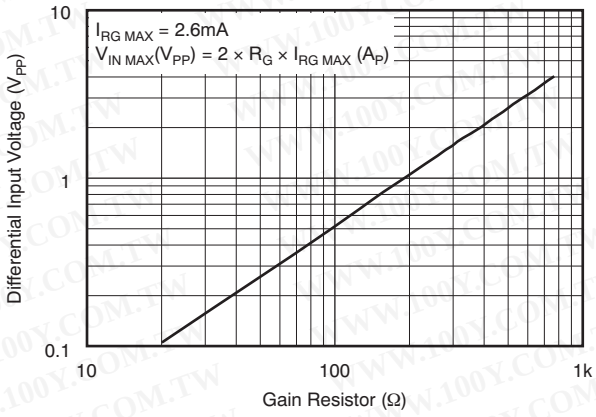


Figure 1.

MAXIMUM GAIN ADJUST RANGE vs R_F

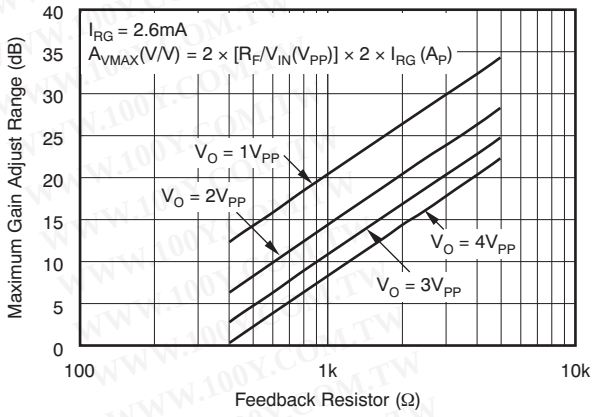


Figure 2.

MAXIMUM GAIN ADJUST RANGE vs PEAK-TO-PEAK OUTPUT VOLTAGE

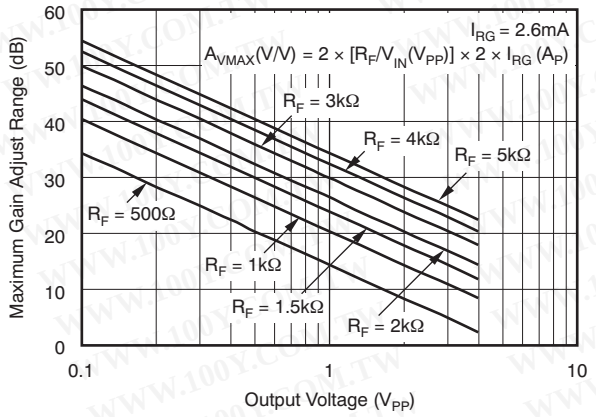


Figure 3.

GAIN ERROR BAND vs GAIN CONTROL VOLTAGE

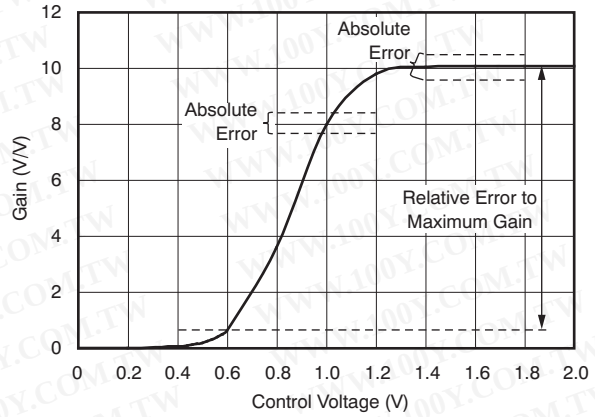


Figure 4.

GAIN ERROR BAND vs GAIN CONTROL VOLTAGE

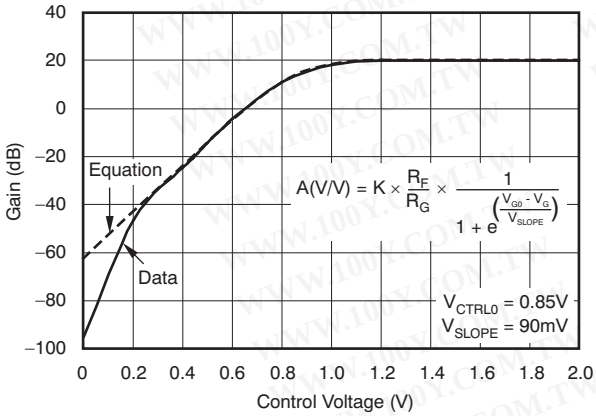


Figure 5.

RECOMMENDED R_F vs A_{VMAX}

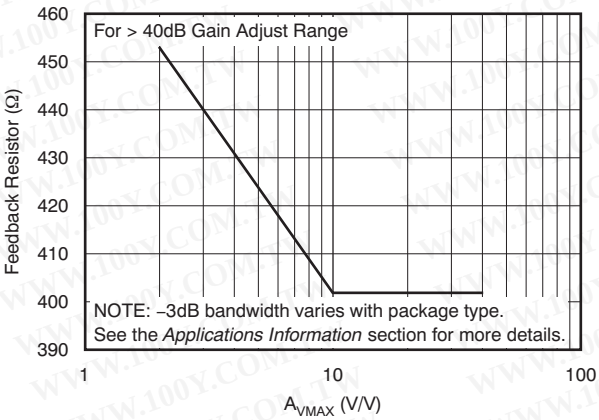


Figure 6.

TYPICAL CHARACTERISTICS: V_S = ±5V, DC and Power-Supply Parameters

At T_A = +25°C, R_L = 100Ω, V_G = +2V, and V_{IN} = single-ended input on $+V_{IN}$ with $-V_{IN}$ at ground, unless otherwise noted.

SUPPLY CURRENT vs CONTROL VOLTAGE (A_{VMAX} = 6dB)

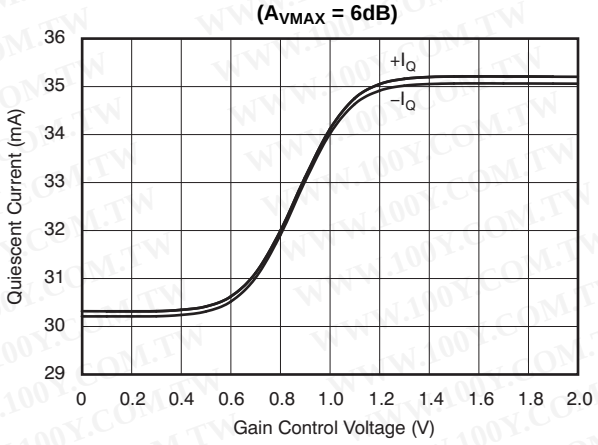


Figure 7.

SUPPLY CURRENT vs CONTROL VOLTAGE (A_{VMAX} = 20dB)

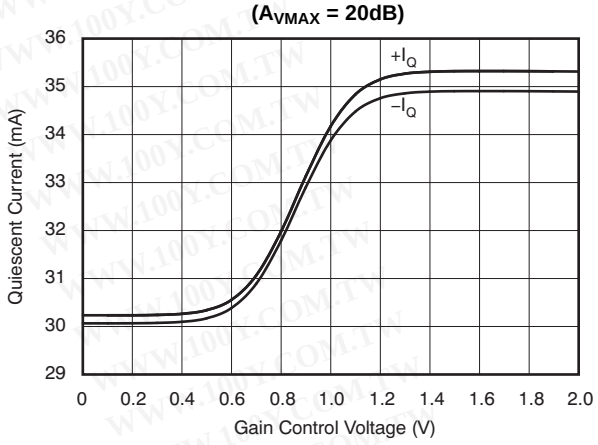


Figure 8.

SUPPLY CURRENT vs CONTROL VOLTAGE (A_{VMAX} = 32dB)

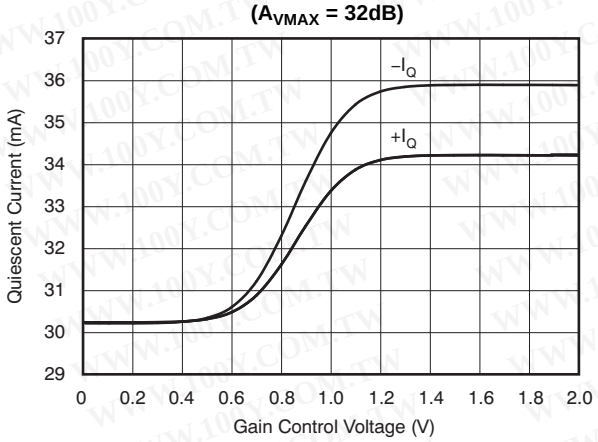


Figure 9.

TYPICAL DC DRIFT vs TEMPERATURE

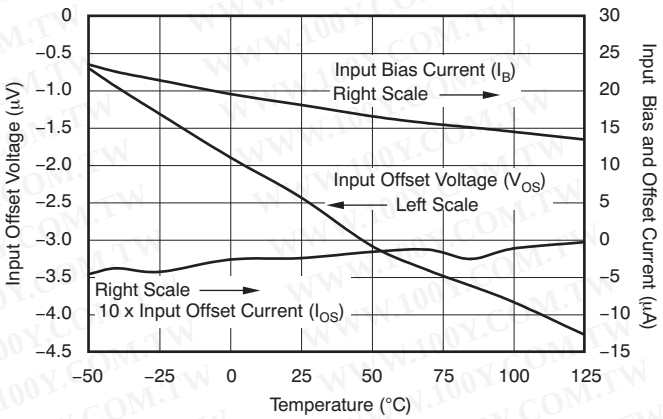


Figure 10.

TYPICAL CHARACTERISTICS: V_S = ±5V, A_{VMAX} = 6dB

At T_A = +25°C, R_L = 100Ω, R_F = 453Ω, R_G = 453Ω, V_G = +2V, V_{IN} = single-ended input on $+V_{IN}$ with $-V_{IN}$ at ground, and SO-14 package, unless otherwise noted.

SMALL-SIGNAL FREQUENCY RESPONSE

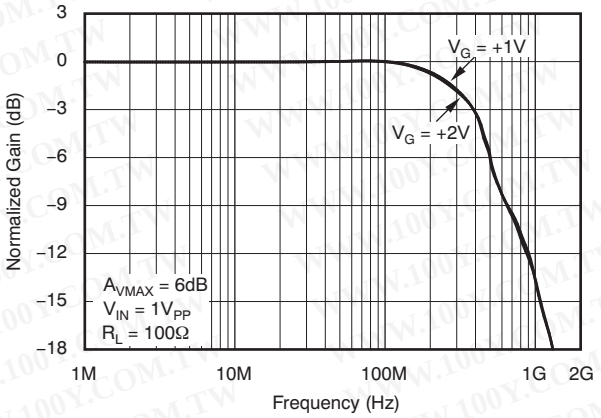


Figure 11.

LARGE-SIGNAL FREQUENCY RESPONSE

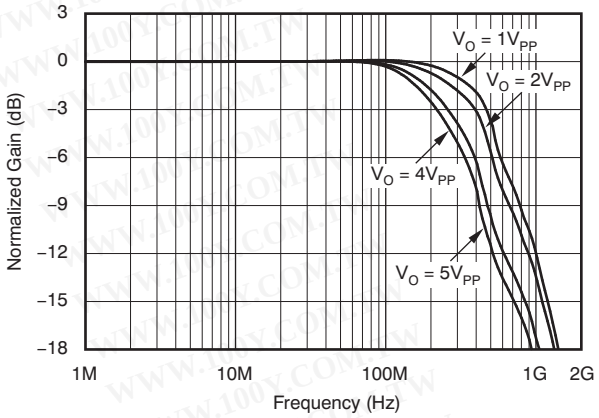


Figure 12.

SMALL-SIGNAL PULSE RESPONSE

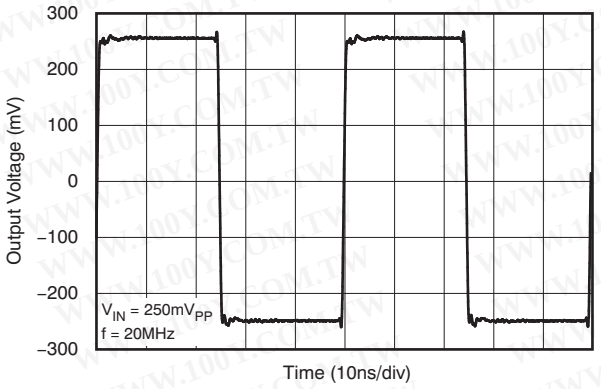


Figure 13.

LARGE-SIGNAL PULSE RESPONSE

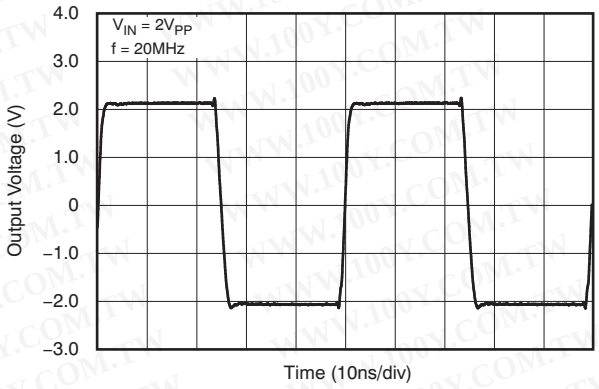


Figure 14.

COMPOSITE VIDEO dG/dP

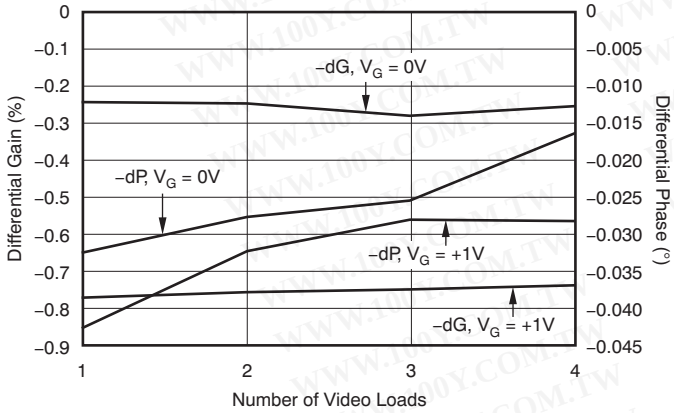


Figure 15.

GAIN FLATNESS, DEVIATION FROM LINEAR PHASE

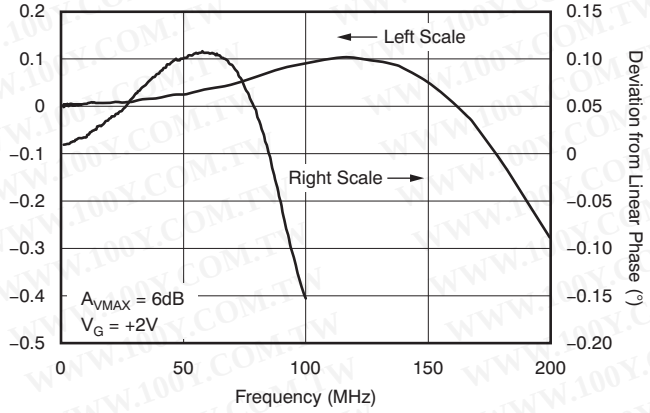


Figure 16.

TYPICAL CHARACTERISTICS: V_S = ±5V, A_{VMAX} = 6dB (continued)

At T_A = +25°C, R_L = 100Ω, R_F = 453Ω, R_G = 453Ω, V_G = +2V, V_{IN} = single-ended input on $+V_{IN}$ with $-V_{IN}$ at ground, and SO-14 package, unless otherwise noted.

HARMONIC DISTORTION vs FREQUENCY

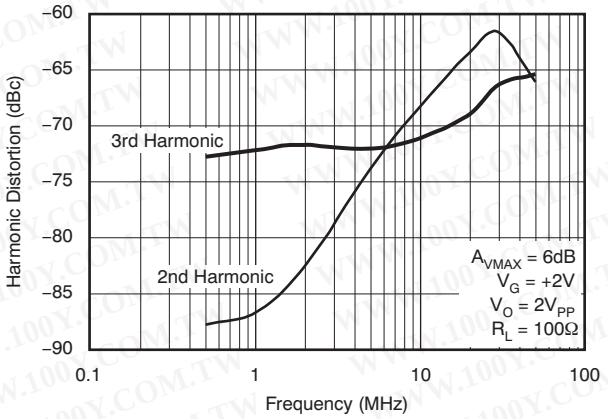


Figure 17.

HARMONIC DISTORTION vs LOAD RESISTANCE

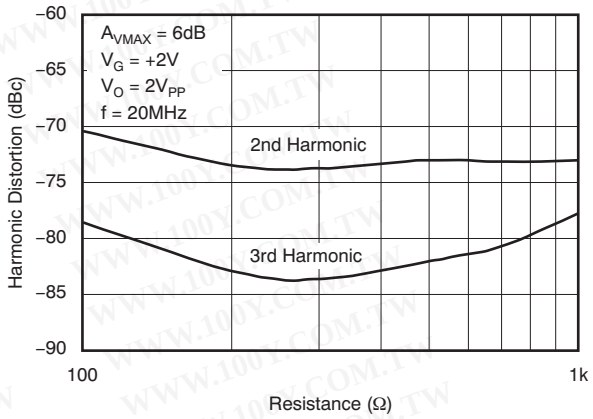


Figure 18.

HARMONIC DISTORTION vs OUTPUT VOLTAGE

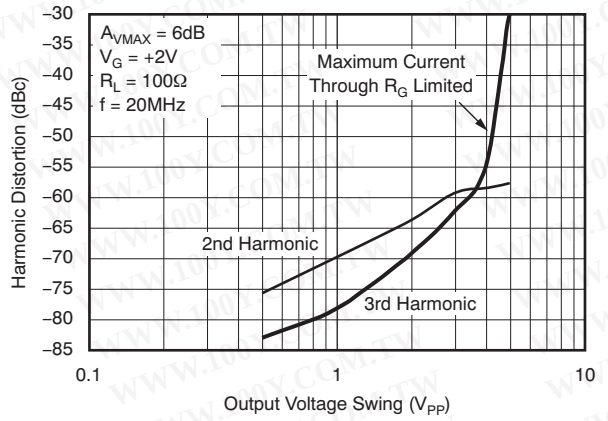


Figure 19.

HARMONIC DISTORTION vs GAIN CONTROL VOLTAGE

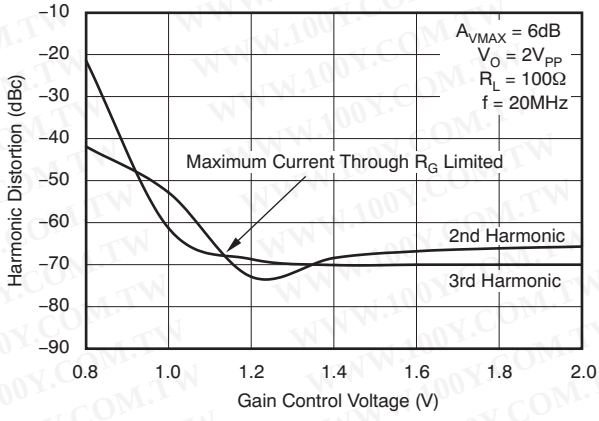


Figure 20.

TWO-TONE, 3RD-ORDER INTERMODULATION INTERCEPT

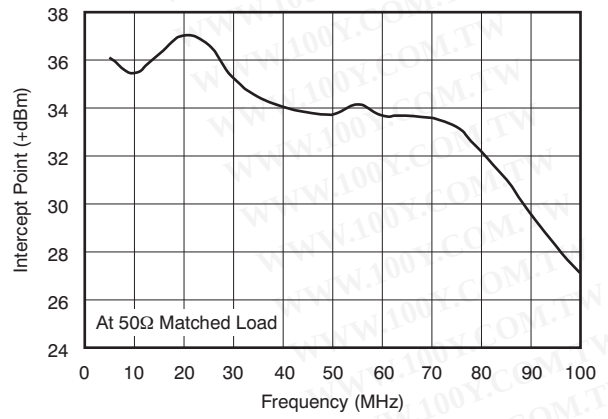


Figure 21.

TWO-TONE, 3RD-ORDER INTERMODULATION INTERCEPT vs GAIN CONTROL VOLTAGE

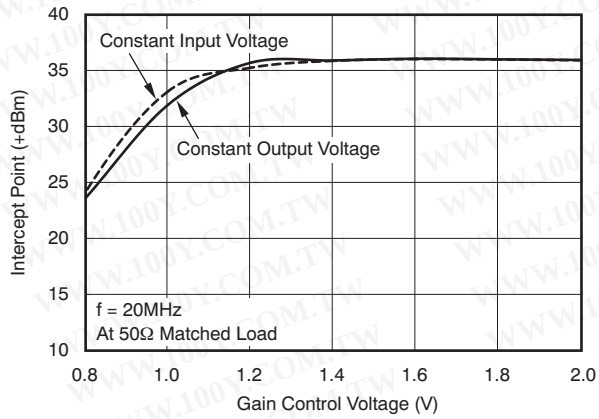


Figure 22.

TYPICAL CHARACTERISTICS: V_S = ±5V, A_{VMAX} = 6dB (continued)

At T_A = +25°C, R_L = 100Ω, R_F = 453Ω, R_G = 453Ω, V_G = +2V, V_{IN} = single-ended input on $+V_{IN}$ with $-V_{IN}$ at ground, and SO-14 package, unless otherwise noted.

GAIN vs GAIN CONTROL VOLTAGE

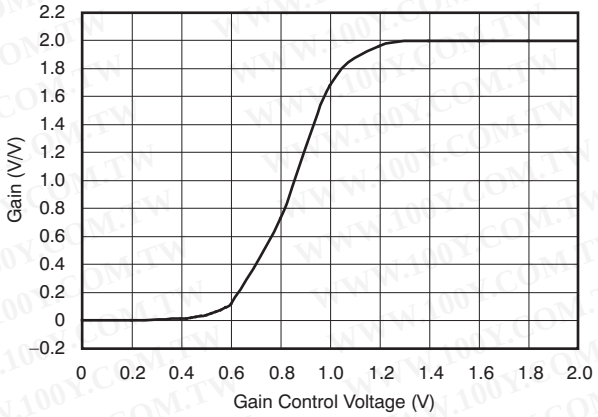


Figure 23.

GAIN CONTROL FREQUENCY RESPONSE

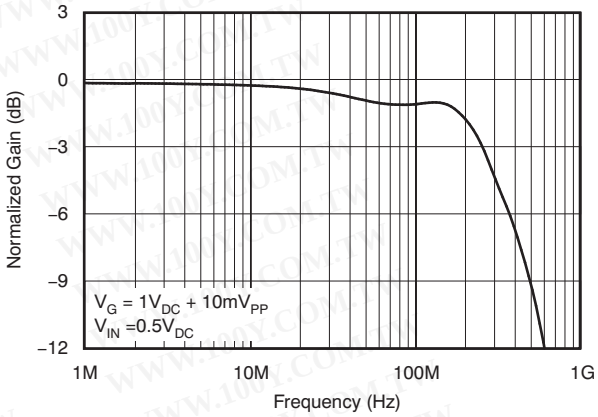


Figure 24.

GAIN CONTROL PULSE RESPONSE

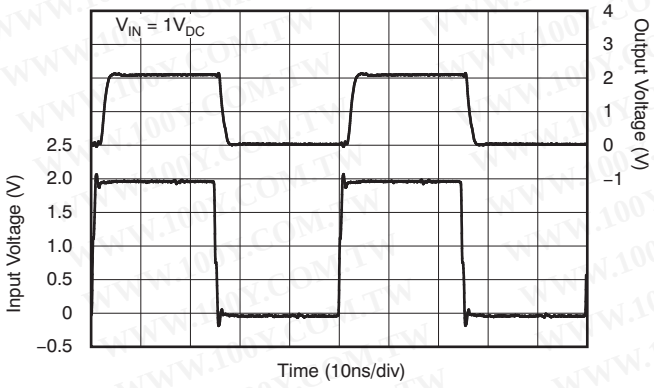


Figure 25.

FULLY-ATTENUATED RESPONSE

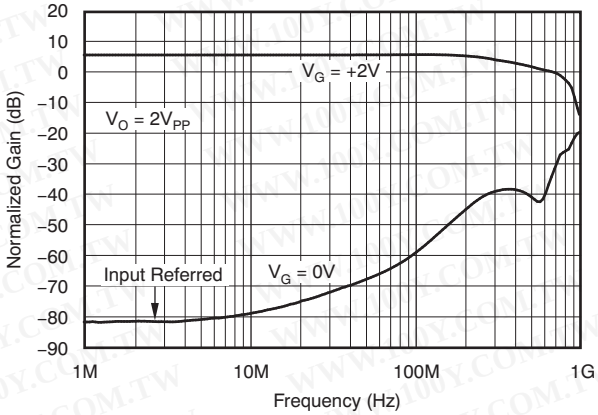


Figure 26.

GROUP DELAY vs GAIN CONTROL VOLTAGE

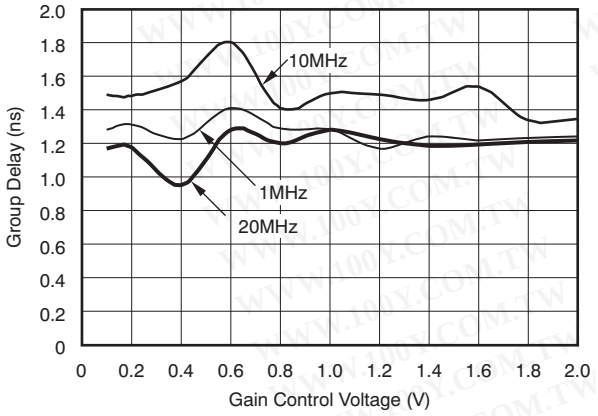


Figure 27.

GROUP DELAY vs FREQUENCY

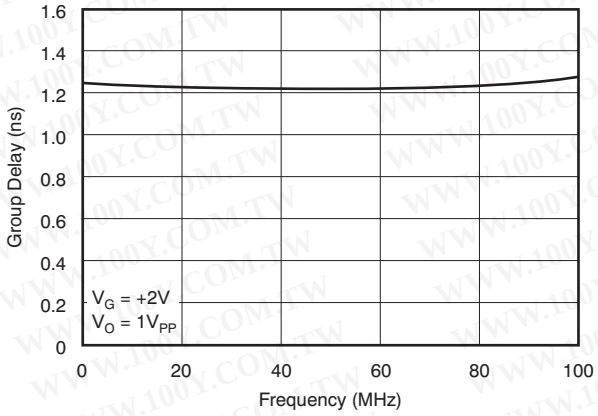


Figure 28.

TYPICAL CHARACTERISTICS: V_S = ±5V, A_{VMAX} = 6dB (continued)

At T_A = +25°C, R_L = 100Ω, R_F = 453Ω, R_G = 453Ω, V_G = +2V, V_{IN} = single-ended input on $+V_{IN}$ with $-V_{IN}$ at ground, and SO-14 package, unless otherwise noted.

RECOMMENDED R_S vs CAPACITIVE LOAD

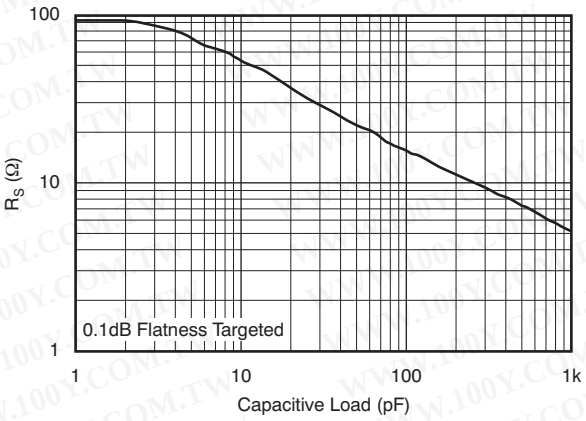


Figure 29.

FREQUENCY RESPONSE vs CAPACITIVE LOAD

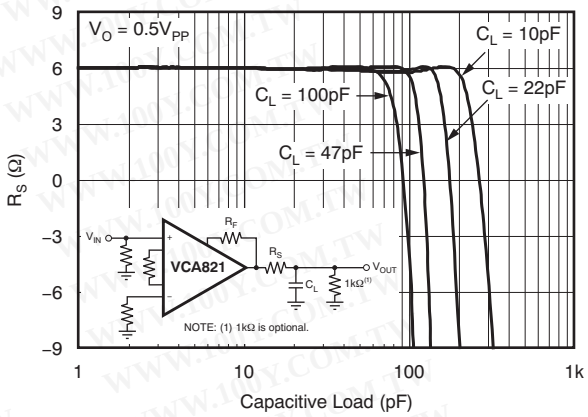


Figure 30.

OUTPUT VOLTAGE NOISE DENSITY

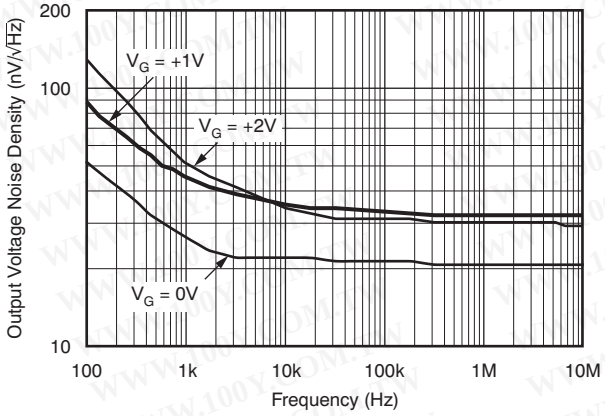


Figure 31.

INPUT CURRENT NOISE DENSITY

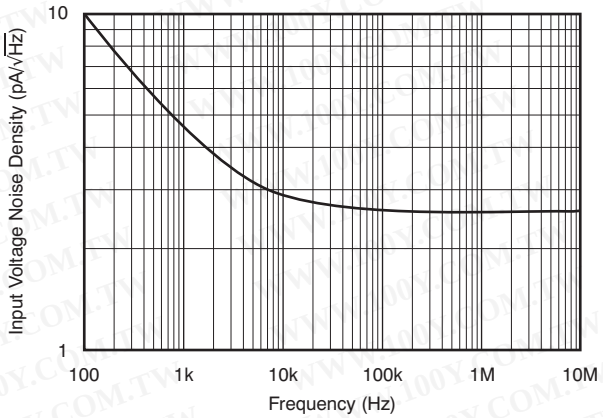


Figure 32.

TYPICAL CHARACTERISTICS: V_S = ±5V, A_{VMAX} = 20dB

At T_A = +25°C, R_L = 100Ω, R_F = 402Ω, R_G = 80Ω, V_G = +2V, and V_{IN} = single-ended input on $+V_{IN}$ with $-V_{IN}$ at ground, unless otherwise noted.

SMALL-SIGNAL FREQUENCY RESPONSE

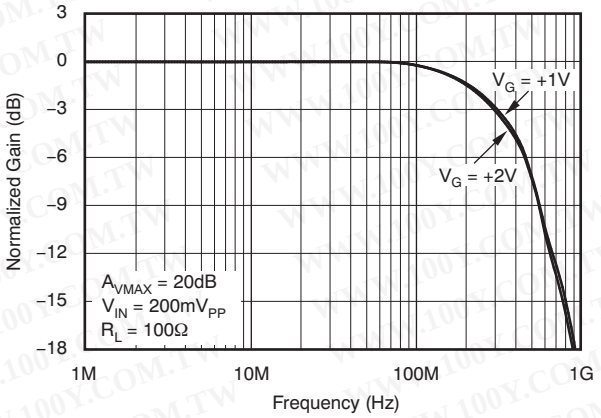


Figure 33.

LARGE-SIGNAL FREQUENCY RESPONSE

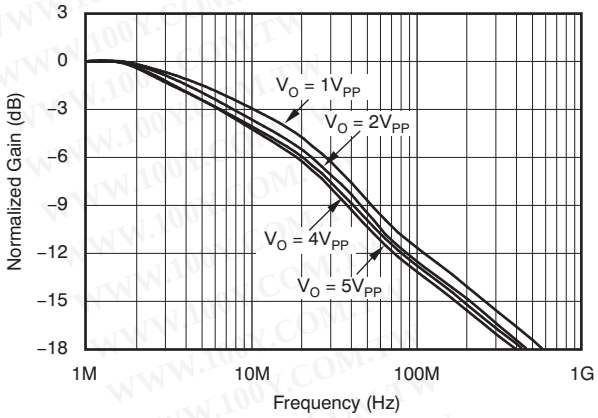


Figure 34.

SMALL-SIGNAL PULSE RESPONSE

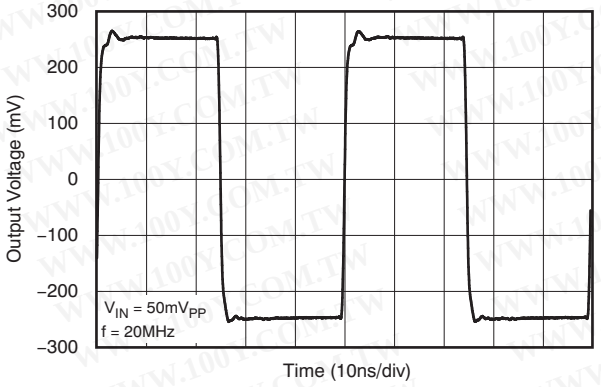


Figure 35.

LARGE-SIGNAL PULSE RESPONSE

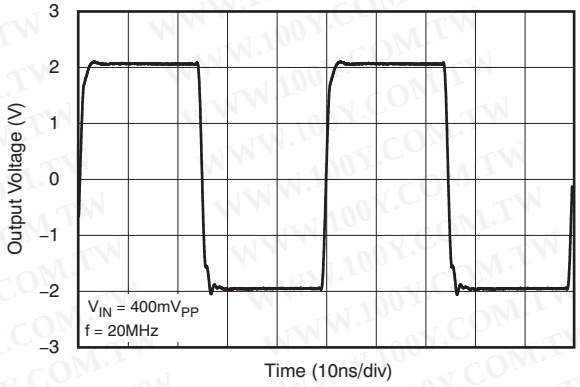


Figure 36.

GAIN FLATNESS, DEVIATION FROM LINEAR PHASE

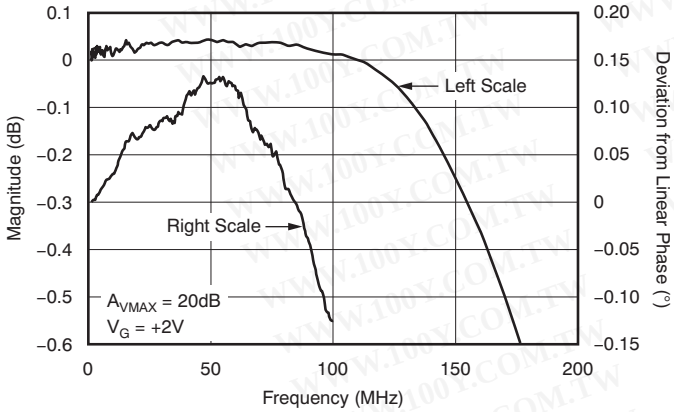


Figure 37.

OUTPUT VOLTAGE NOISE DENSITY

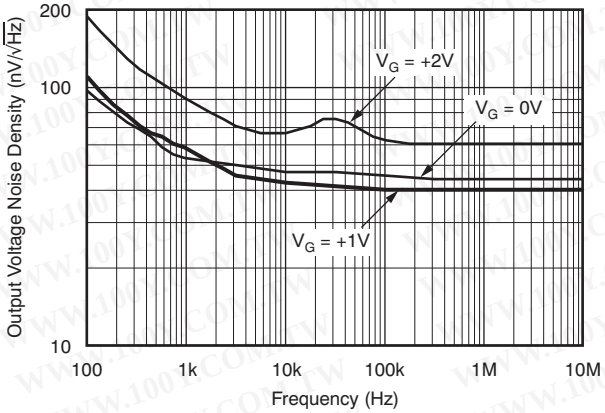


Figure 38.

TYPICAL CHARACTERISTICS: V_S = ±5V, A_{VMAX} = 20dB (continued)

At T_A = +25°C, R_L = 100Ω, R_F = 402Ω, R_G = 80Ω, V_G = +2V, and V_{IN} = single-ended input on $+V_{IN}$ with $-V_{IN}$ at ground, unless otherwise noted.

HARMONIC DISTORTION vs FREQUENCY

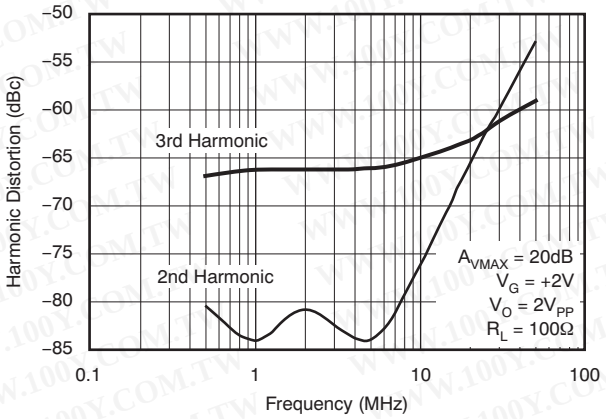


Figure 39.

HARMONIC DISTORTION vs LOAD RESISTANCE

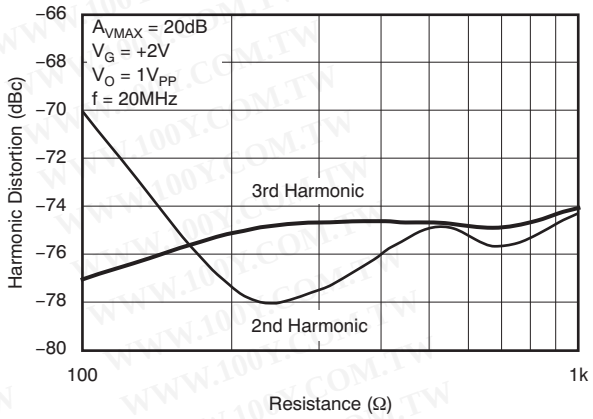


Figure 40.

HARMONIC DISTORTION vs OUTPUT VOLTAGE

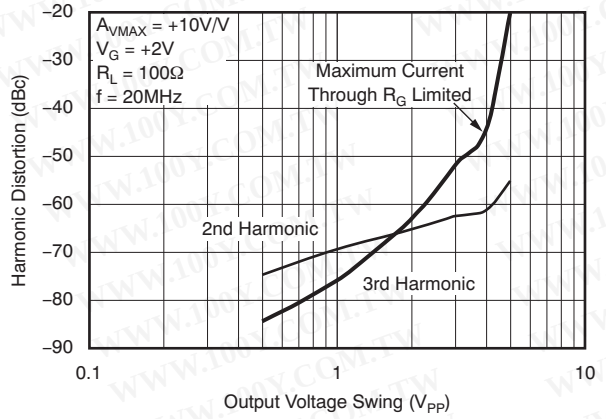


Figure 41.

HARMONIC DISTORTION vs GAIN CONTROL VOLTAGE

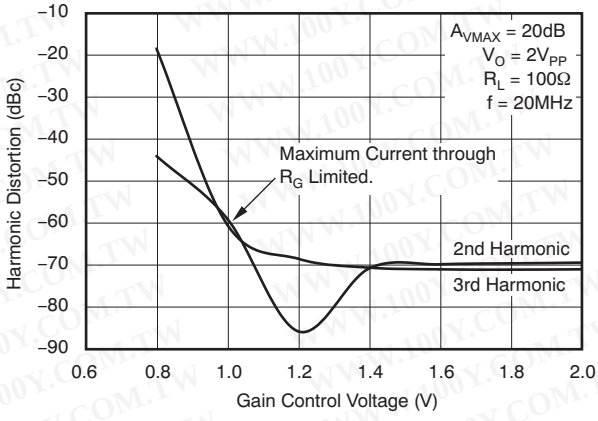


Figure 42.

TWO-TONE, 3RD-ORDER INTERMODULATION INTERCEPT

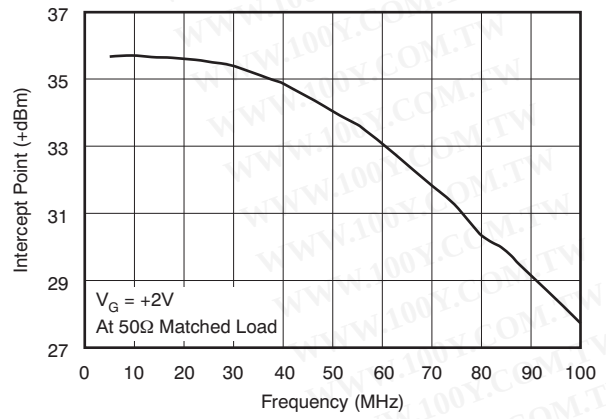


Figure 43.

TWO-TONE, 3RD-ORDER INTERMODULATION INTERCEPT vs GAIN CONTROL VOLTAGE

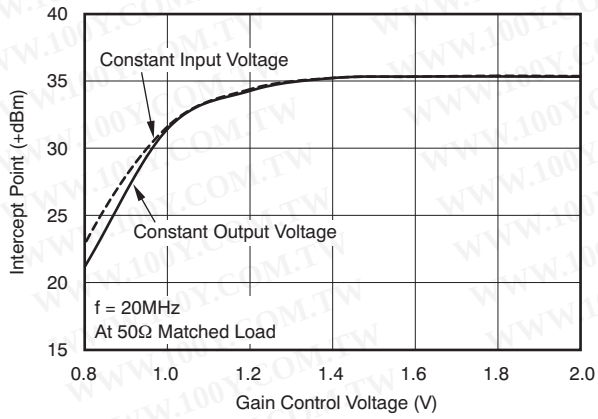


Figure 44.

TYPICAL CHARACTERISTICS: V_S = ±5V, A_{VMAX} = 20dB (continued)

At T_A = +25°C, R_L = 100Ω, R_F = 402Ω, R_G = 80Ω, V_G = +2V, and V_{IN} = single-ended input on $+V_{IN}$ with $-V_{IN}$ at ground, unless otherwise noted.

GAIN vs GAIN CONTROL VOLTAGE

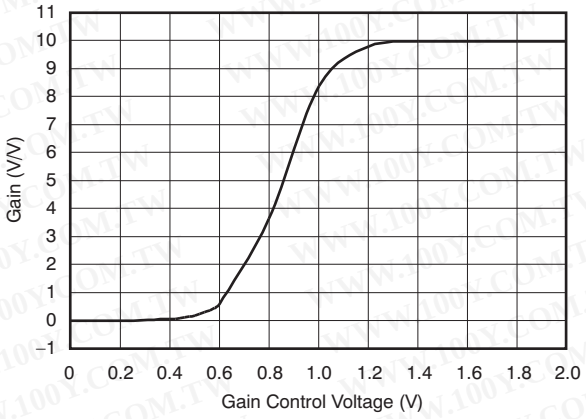


Figure 45.

GAIN CONTROL FREQUENCY RESPONSE

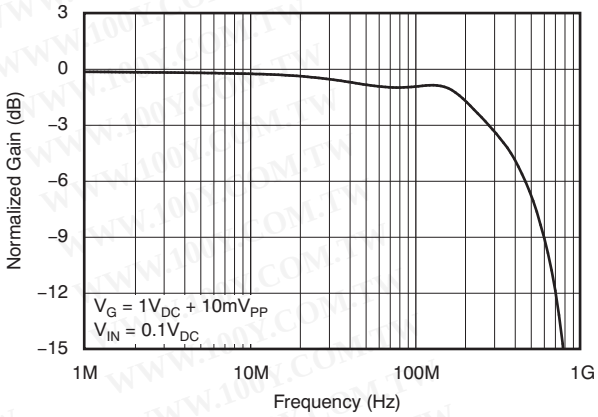


Figure 46.

GAIN CONTROL PULSE RESPONSE

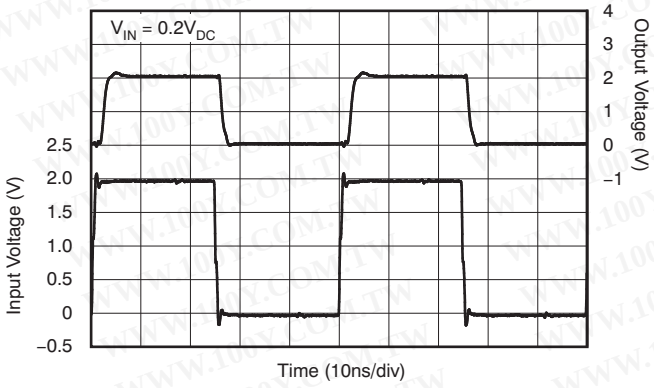


Figure 47.

OUTPUT VOLTAGE AND CURRENT LIMITATIONS

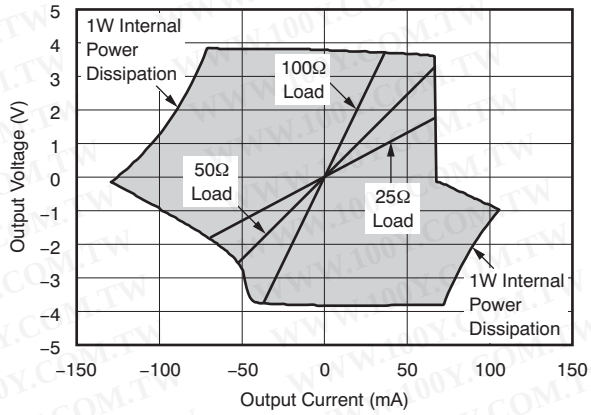


Figure 48.

FULLY-ATTENUATED RESPONSE

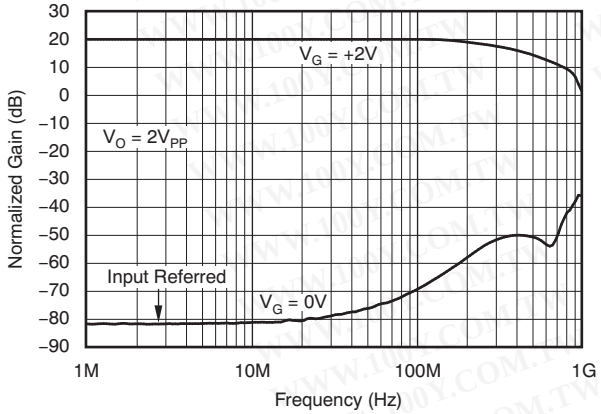


Figure 49.

I_{RG} LIMITED OVERDRIVE RECOVERY

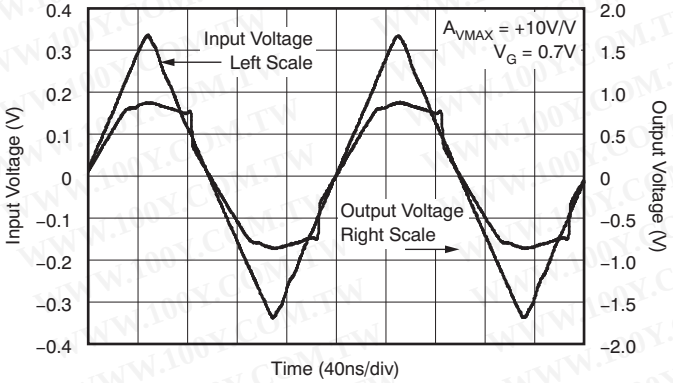


Figure 50.

TYPICAL CHARACTERISTICS: V_S = ±5V, A_{VMAX} = 20dB (continued)

At T_A = +25°C, R_L = 100Ω, R_F = 402Ω, R_G = 80Ω, V_G = +2V, and V_{IN} = single-ended input on $+V_{IN}$ with $-V_{IN}$ at ground, unless otherwise noted.

OUTPUT LIMITED OVERDRIVE RECOVERY

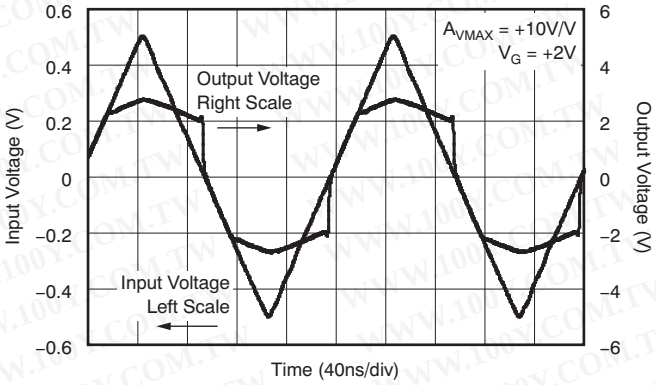


Figure 51.

GROUP DELAY vs GAIN CONTROL VOLTAGE

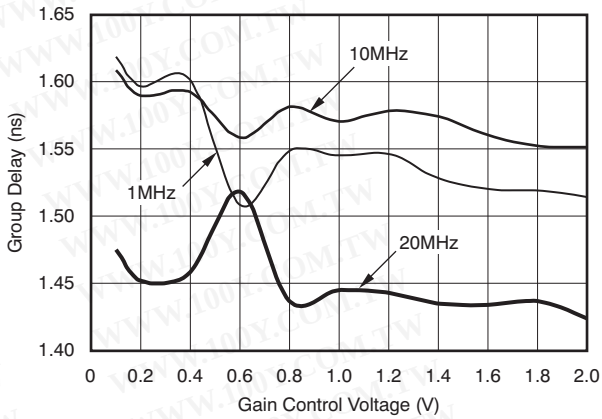


Figure 52.

GROUP DELAY vs FREQUENCY

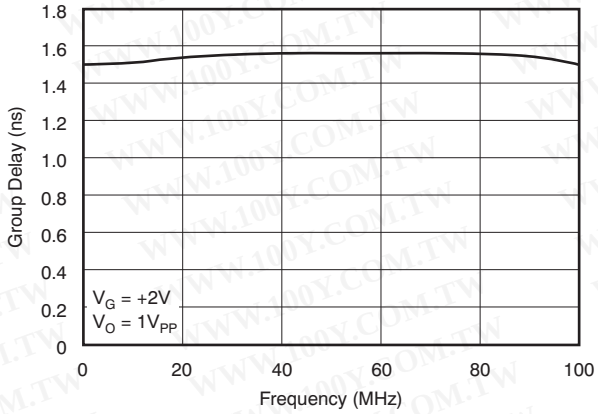


Figure 53.

TYPICAL CHARACTERISTICS: V_S = ±5V, A_{VMAX} = 32dB

At T_A = +25°C, R_L = 100Ω, R_F = 402Ω, R_G = 18Ω, V_G = +2V, V_{IN} = single-ended input on $+V_{IN}$ with $-V_{IN}$ at ground, and SO-14 package, unless otherwise noted.

SMALL-SIGNAL FREQUENCY RESPONSE

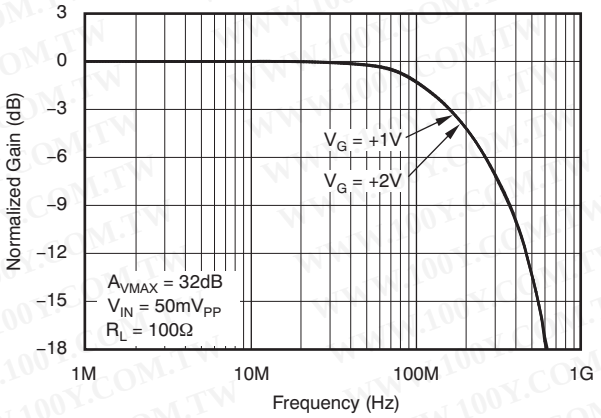


Figure 54.

LARGE-SIGNAL FREQUENCY RESPONSE

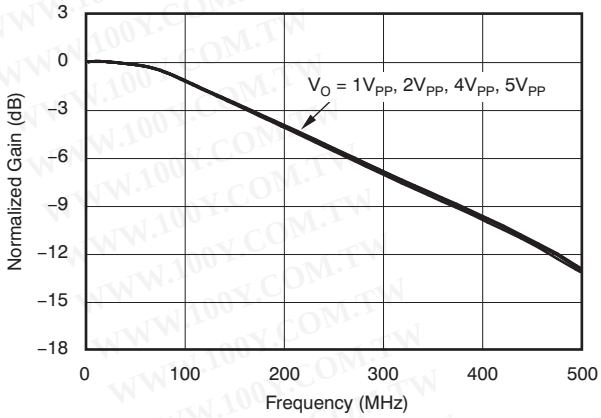


Figure 55.

SMALL-SIGNAL PULSE RESPONSE

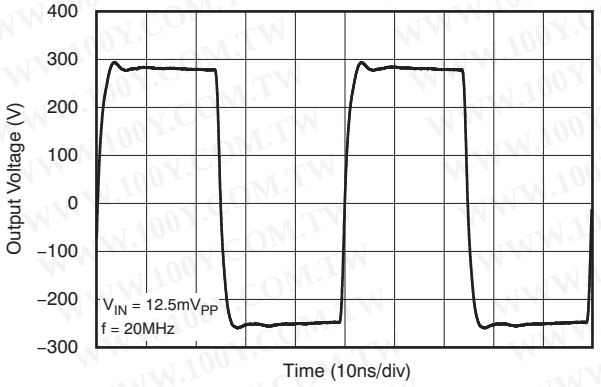


Figure 56.

LARGE-SIGNAL PULSE RESPONSE

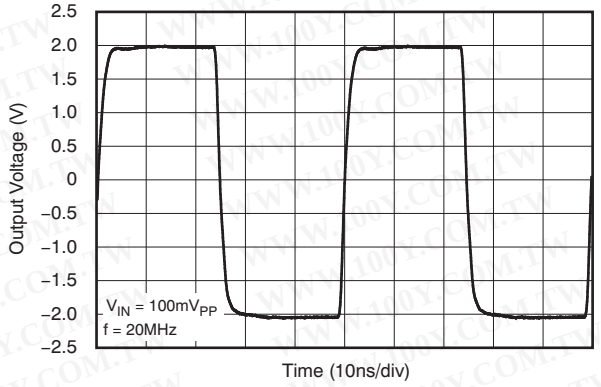


Figure 57.

GAIN FLATNESS, DEVIATION FROM LINEAR PHASE

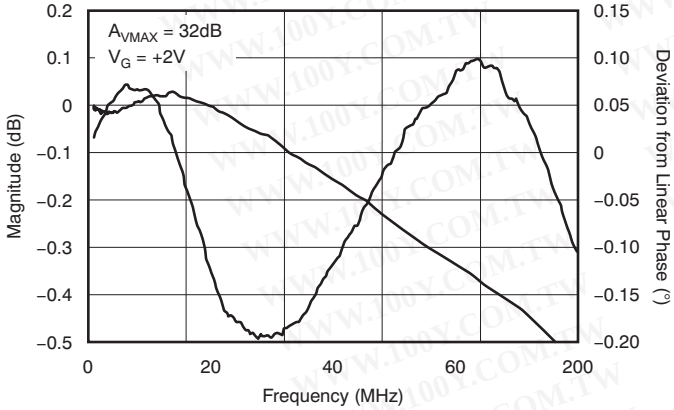


Figure 58.

OUTPUT VOLTAGE NOISE DENSITY

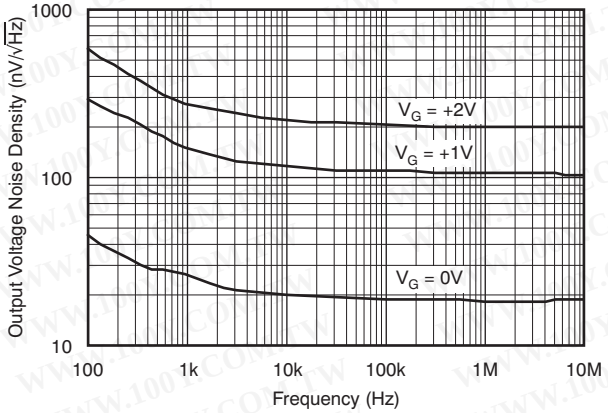


Figure 59.

TYPICAL CHARACTERISTICS: V_S = ±5V, A_{VMAX} = 32dB (continued)

At T_A = +25°C, R_L = 100Ω, R_F = 402Ω, R_G = 18Ω, V_G = +2V, V_{IN} = single-ended input on $+V_{IN}$ with $-V_{IN}$ at ground, and SO-14 package, unless otherwise noted.

HARMONIC DISTORTION vs FREQUENCY

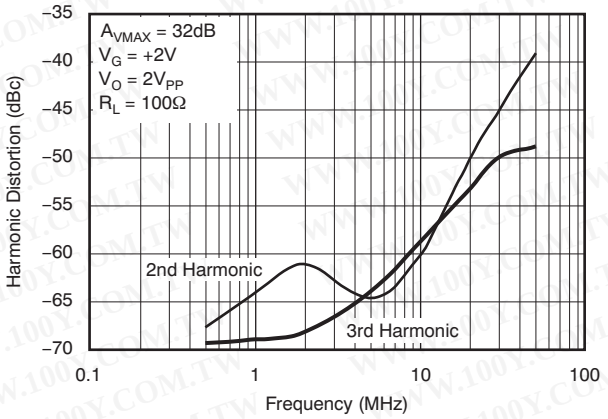


Figure 60.

HARMONIC DISTORTION vs LOAD RESISTANCE

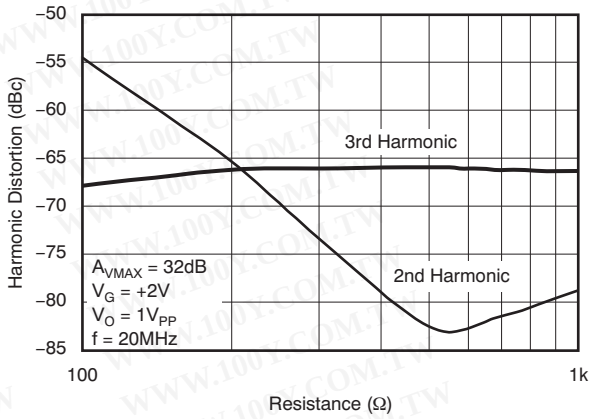


Figure 61.

HARMONIC DISTORTION vs OUTPUT VOLTAGE

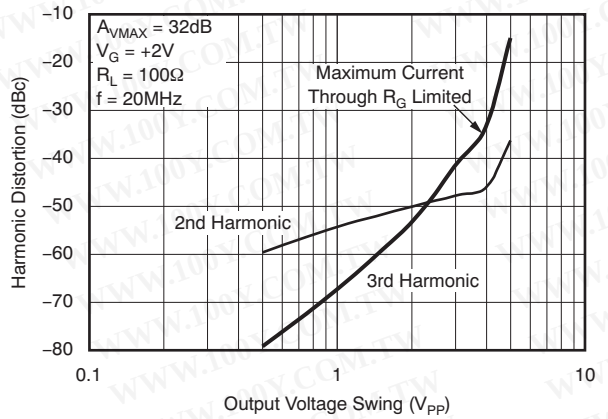


Figure 62.

HARMONIC DISTORTION vs GAIN CONTROL VOLTAGE

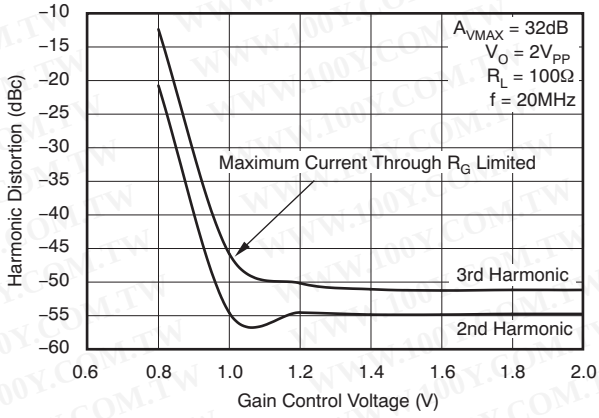


Figure 63.

TWO-TONE, 3RD-ORDER INTERMODULATION INTERCEPT

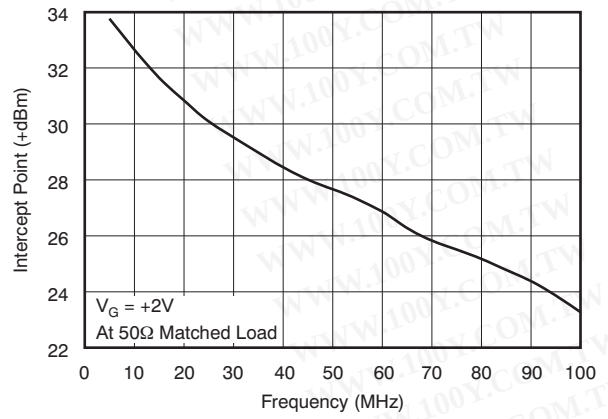


Figure 64.

TWO-TONE, 3RD-ORDER INTERMODULATION INTERCEPT vs GAIN CONTROL VOLTAGE

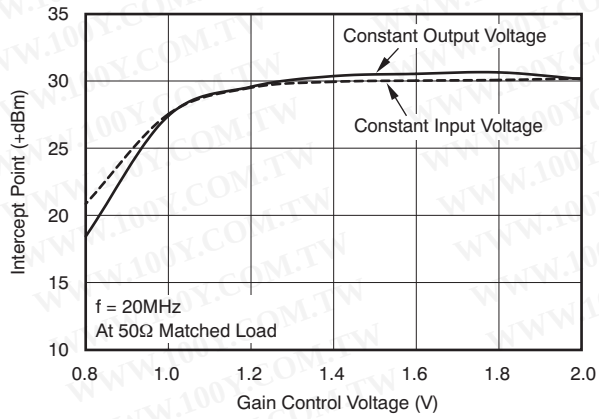


Figure 65.

TYPICAL CHARACTERISTICS: V_S = ±5V, A_{VMAX} = 32dB (continued)

At T_A = +25°C, R_L = 100Ω, R_F = 402Ω, R_G = 18Ω, V_G = +2V, V_{IN} = single-ended input on $+V_{IN}$ with $-V_{IN}$ at ground, and SO-14 package, unless otherwise noted.

GAIN vs GAIN CONTROL VOLTAGE

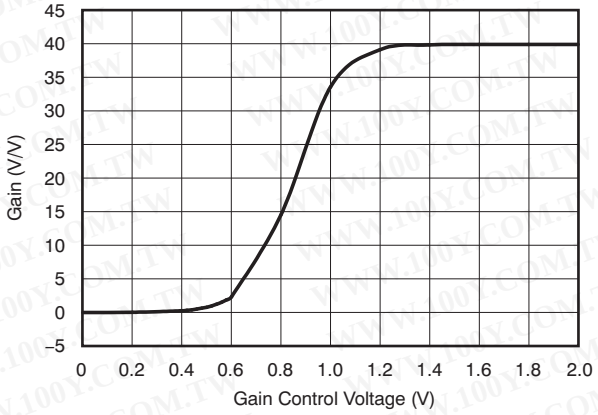


Figure 66.

GAIN CONTROL FREQUENCY RESPONSE

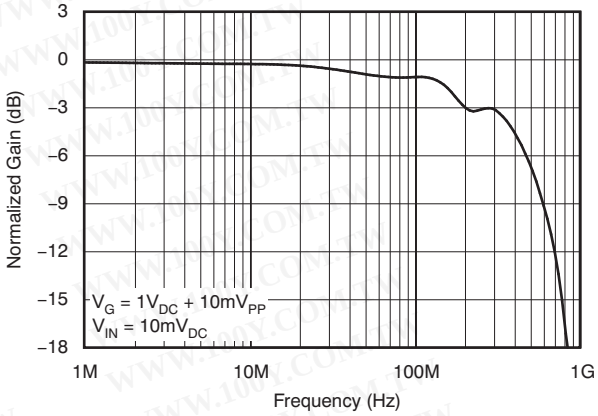


Figure 67.

GAIN CONTROL PULSE RESPONSE

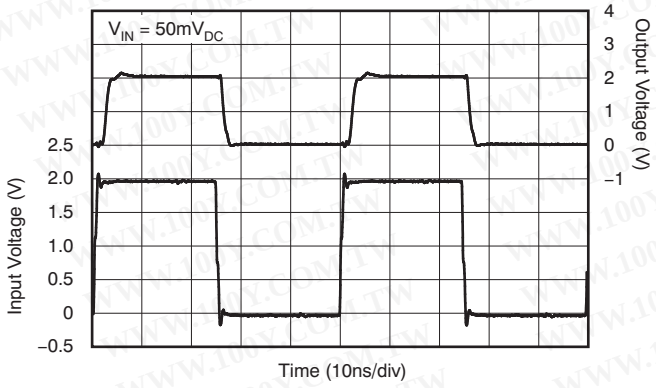


Figure 68.

FULLY ATTENUATED RESPONSE

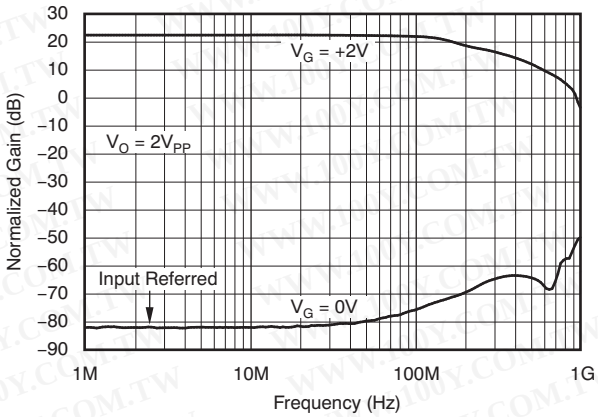


Figure 69.

I_{RG} LIMITED OVERDRIVE RECOVERY

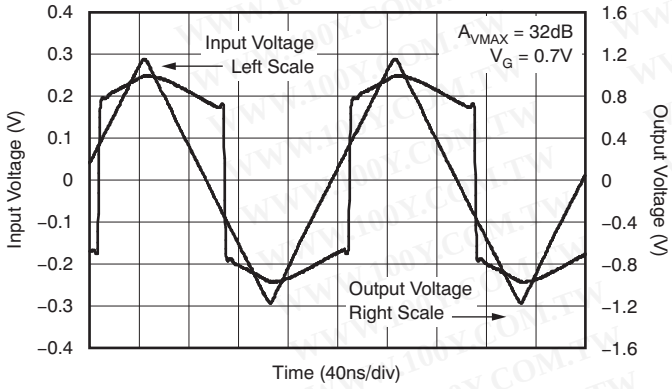


Figure 70.

OUTPUT LIMITED OVERDRIVE RECOVERY

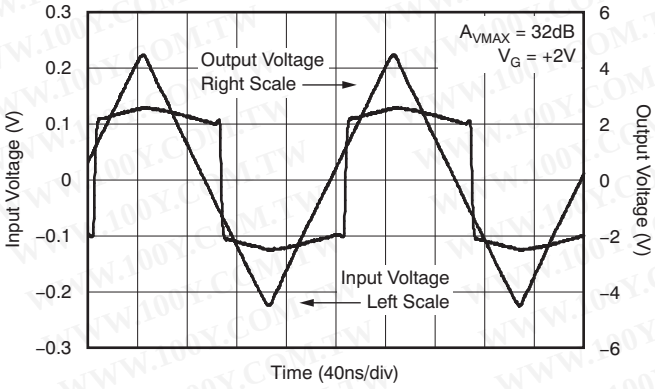


Figure 71.

TYPICAL CHARACTERISTICS: V_S = ±5V, A_{VMAX} = 32dB (continued)

At T_A = +25°C, R_L = 100Ω, R_F = 402Ω, R_G = 18Ω, V_G = +2V, V_{IN} = single-ended input on $+V_{IN}$ with $-V_{IN}$ at ground, and SO-14 package, unless otherwise noted.

GROUP DELAY vs GAIN CONTROL VOLTAGE

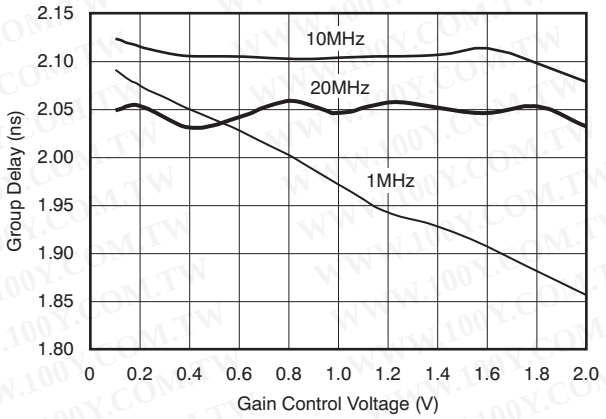


Figure 72.

GROUP DELAY vs FREQUENCY

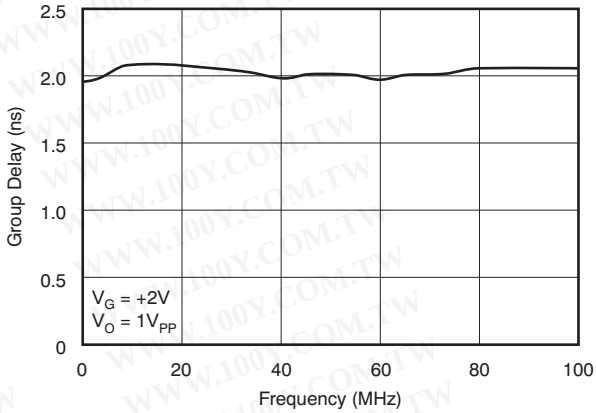


Figure 73.

APPLICATION INFORMATION

WIDEBAND VARIABLE GAIN AMPLIFIER OPERATION

The VCA821 provides an exceptional combination of high output power capability with a wideband, greater than 40dB gain adjust range, linear in dB variable gain amplifier. The VCA821 input stage places the transconductance element between two input buffers, using the output currents as the forward signal. As the differential input voltage rises, a signal current is generated through the gain element. This current is then mirrored and gained by a factor of two before reaching the multiplier. The other input of the multiplier is the voltage gain control pin, V_G. Depending on the voltage present on V_G, up to two times the gain current is provided to the transimpedance output stage. The transimpedance output stage is a current-feedback amplifier providing high output current capability and high slew rate, 2500V/µs. This exceptional full-power performance comes at the price of relatively high quiescent current (34mA), but low input voltage noise for this type of architecture (6nV/√Hz).

Figure 74 shows the dc-coupled, gain of +10V/V, dual power-supply circuit used as the basis of the ±5V Electrical Characteristics and Typical Characteristics.

For test purposes, the input impedance is set to 50Ω with a resistor to ground and the output impedance is set to 50Ω with a series output resistor. Voltage swings reported in the Electrical Characteristics table are taken directly at the input and output pins, while output power (dBm) is at the matched 50Ω load. For the circuit in Figure 74, the total effective load is 100Ω ‖ 1kΩ. Note that for the SO-14 package, there is a voltage reference pin, V_{REF} (pin 9). For the SO-14 package, this pin must be connected to ground through a 20Ω resistor in order to avoid possible oscillations of the output stage. In the MSOP-10 package, this pin is internally connected and does not require such precaution. An X2Y™ capacitor has been used for power-supply bypassing. The combination of low inductance, high resonance frequency, and integration of three capacitors in one package (two capacitors to ground and one across the supplies) enables the VCA821 to achieve the low second-harmonic distortion reported in the Electrical Characteristics table. More information on how the VCA821 operates can be found in the *Operating Suggestions* section.

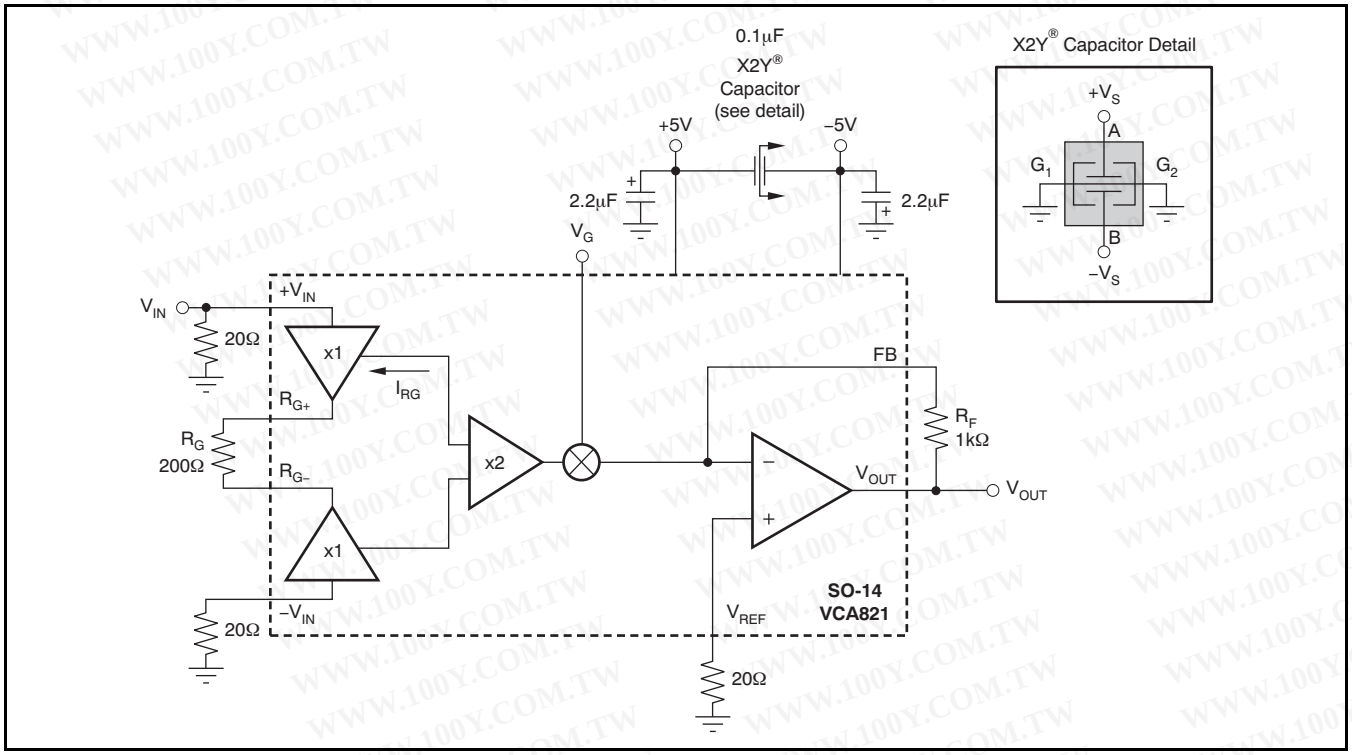


Figure 74. DC-Coupled, A_{VMAX} = 20dB, Bipolar Supply Specification and Test Circuit

DIFFERENCE AMPLIFIER

Because both inputs of the VCA821 are high-impedance, a difference amplifier can be implemented without any major problem. Figure 75 shows this implementation. This circuit provides excellent common-mode rejection ratio (CMRR) as long as the input is within the CMRR range of –2.1V to +1.6V. Note that this circuit does not make use of the gain control pin, V_G. Also, it is recommended to choose R_S such that the pole formed by R_S and the parasitic input capacitance does not limit the bandwidth of the circuit. Figure 76 shows the common-mode rejection ratio for this circuit implemented in a gain of 20dB for V_G = +2V. Note that because the gain control voltage is fixed and is normally set to +2V, the feedback element can be reduced in order to increase the bandwidth. When reducing the feedback element, make sure that the VCA821 is not limited by common-mode input voltage, the current flowing through R_G, or any other limitation described in this data sheet.

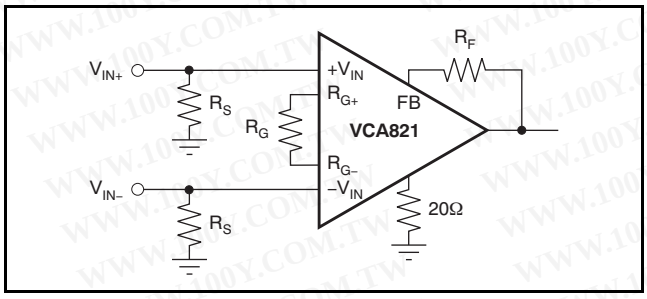


Figure 75. Difference Amplifier

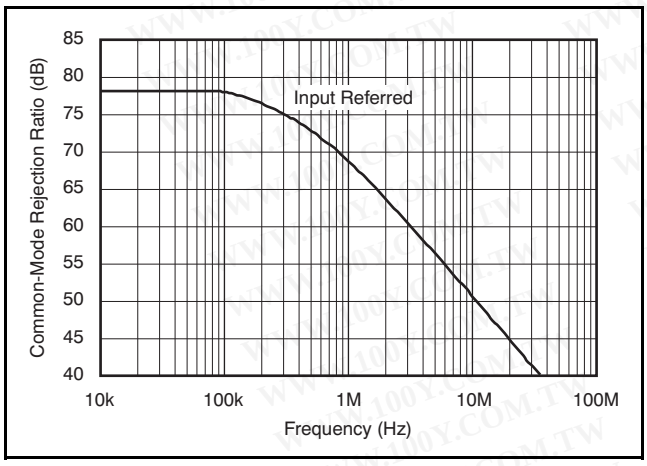


Figure 76. Common-Mode Rejection Ratio

DIFFERENTIAL EQUALIZER

If the application requires frequency shaping (the transition from one gain to another), the VCA821 can be used advantageously because its architecture allows the application to isolate the input from the gain setting elements. Figure 77 shows an implementation of such a configuration. The transfer function is shown in Equation 1.

$$G = 2 \times \frac{R_F}{R_G} \times \frac{1 + sR_GC_1}{1 + sR_1C_1} \quad (1)$$

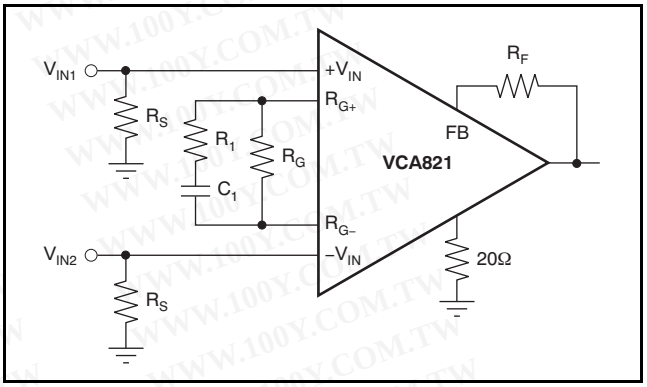


Figure 77. Differential Equalizer

This transfer function has one pole, P_1 (located at R_GC_1), and one zero, Z_1 (located at R_1C_1). When equalizing an RC load, R_L and C_L, compensate the pole added by the load located at R_LC_L with the zero Z_1. Knowing R_L, C_L, and R_G allows the user to select C_1 as a first step and then calculate R_1. Using R_L = 75Ω, C_L = 100pF and wanting the VCA821 to operate at a gain of +2V/V, which gives $R_F = R_G$ = 453Ω, allows the user to select C_1 = 15.5pF to ensure a positive value for the resistor R_1. With all these values known, to achieve greater than 300MHz bandwidth, R_1 can be calculated to be 20Ω. Figure 78 shows the frequency response for both the initial, unequalized frequency response and the resulting equalized frequency response.

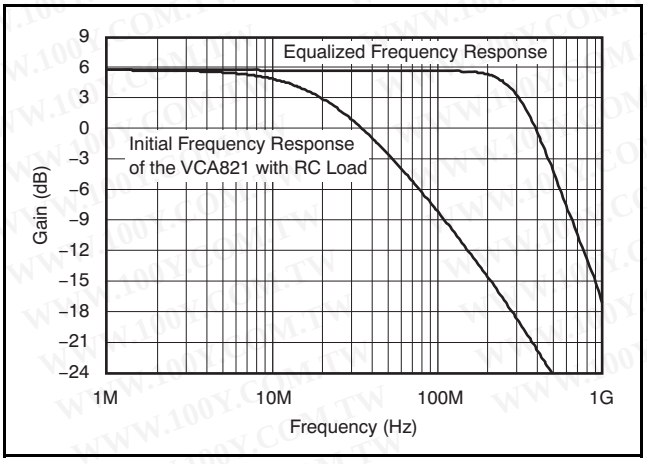


Figure 78. Differential Equalization of an RC Load

DIFFERENTIAL CABLE EQUALIZER

A differential cable equalizer can easily be implemented using the VCA821. An example of a cable equalization for 100 feet of Belden cable 1694F is illustrated in Figure 78, with Figure 79 showing the result for this implementation. This implementation has a maximum error of 0.2dB from dc to 70MHz.

Note that this implementation shows the cable attenuation side-by-side with the equalization in the same plot. For a given frequency, the equalization function realized with the VCA821 matches the cable attenuation. The circuit in Figure 80 is a driver circuit. To implement a receiver circuit, the signal is received differentially between the $+V_{IN}$ and $-V_{IN}$ inputs.

AGC LOOP

In the typical AGC loop shown in Figure 81, the OPA695 follows the VCA821 to provide 40dB of overall gain. The output of the OPA695 is rectified and integrated by an OPA820 to control the gain of the VCA821. when the output level exceeds the reference voltage (V_{REF}), the integrator ramps down reducing the gain of the AGC loop. Conversely, if the output is too small, the integrator ramps up increasing the net gain and the output voltage.

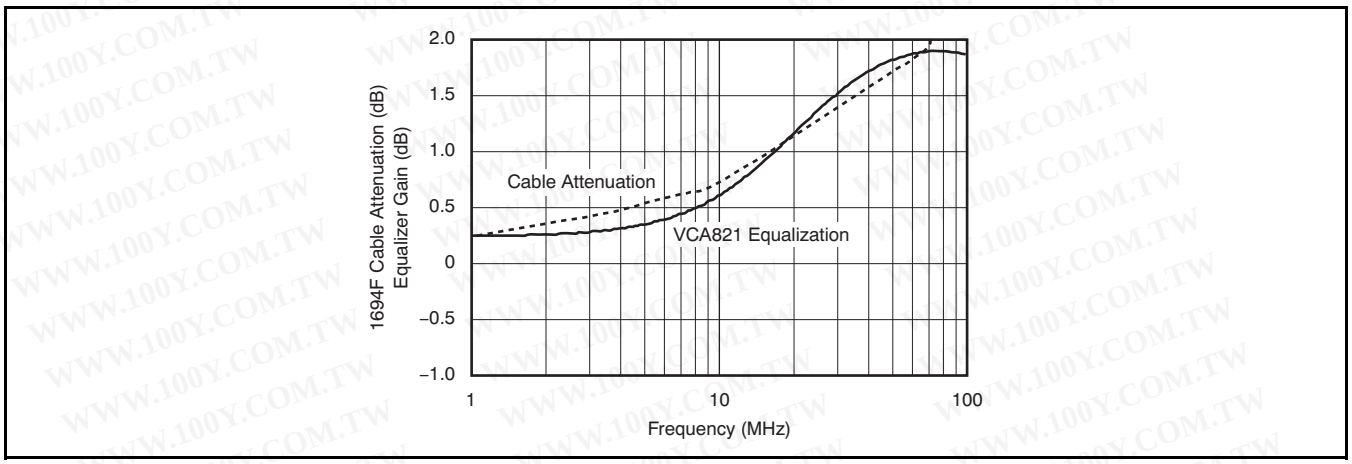


Figure 79. Cable Attenuation versus Equalizer Gain

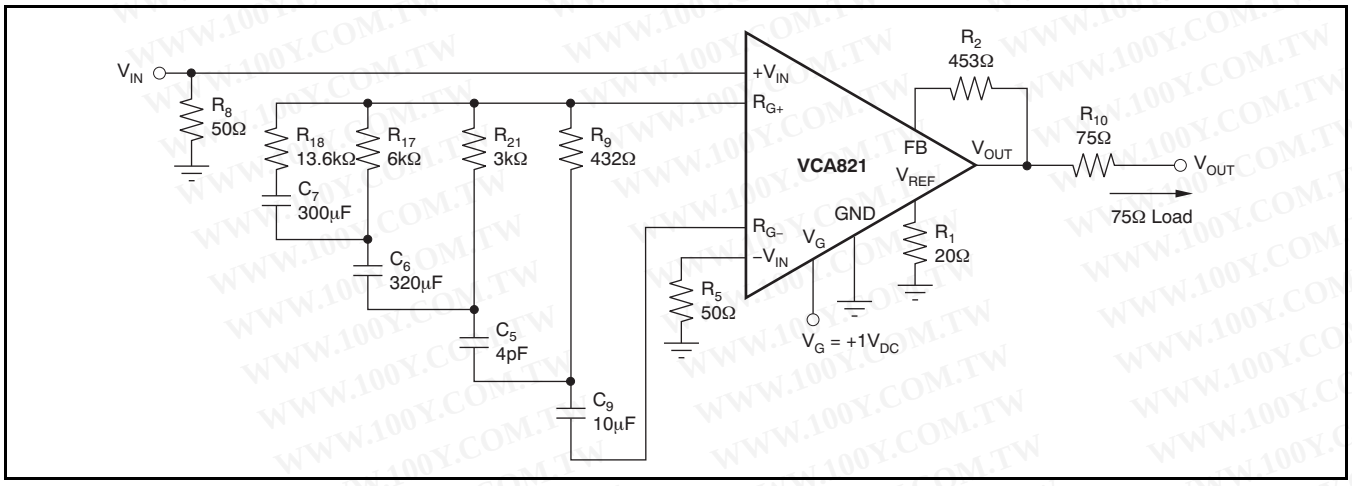


Figure 80. Differential Cable Equalizer

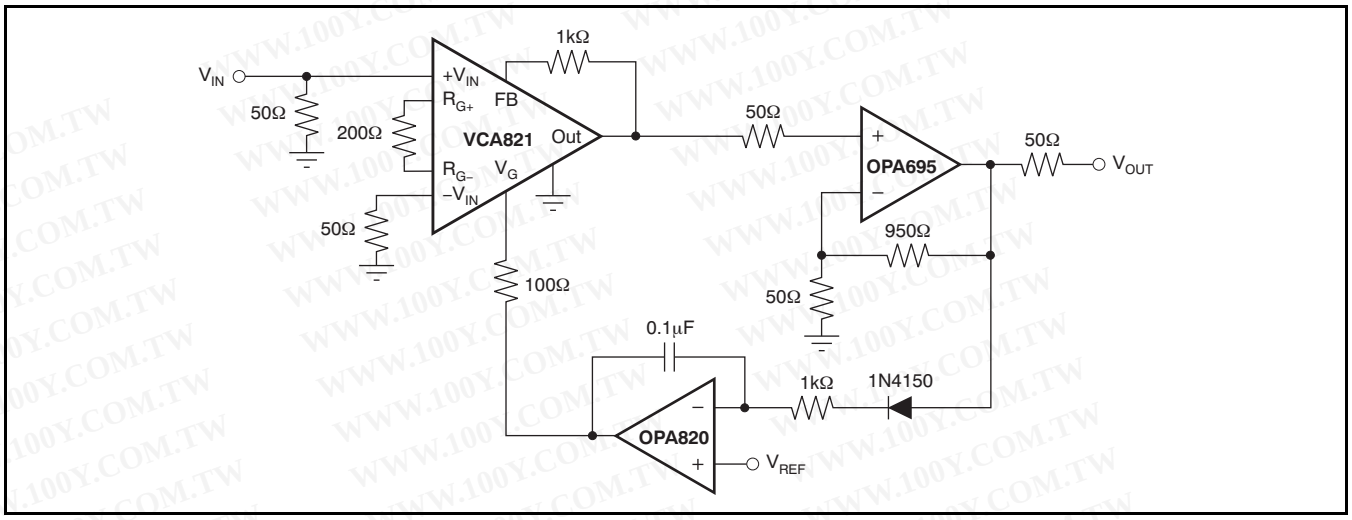


Figure 81. AGC Loop

DESIGN-IN TOOLS

DEMONSTRATION BOARDS

Two printed circuit boards (PCBs) are available to assist in the initial evaluation of circuit performance using the VCA821 in its two package options. Both of these are offered free of charge as unpopulated PCBs, delivered with a user's guide. The summary information for these fixtures is shown in Table 1.

Table 1. EVM Ordering Information

PRODUCT	PACKAGE	BOARD PART NUMBER	LITERATURE REQUEST NUMBER
VCA821ID	SO-14	DEM-VCA-SO-1B	SBOU050
VCA821IDGS	MSOP-10	DEM-VCA-MSOP-1A	SBOU051

The demonstration fixtures can be requested at the Texas Instruments web site (www.ti.com) through the VCA821 product folder.

MACROMODELS AND APPLICATIONS SUPPORT

Computer simulation of circuit performance using SPICE is often useful when analyzing the performance of analog circuits and systems. This principle is particularly true for video and RF amplifier circuits where parasitic capacitance and inductance can play a major role in circuit performance. A SPICE model for the VCA821 is available through the TI web page. The applications group is also available for design assistance. The models available from TI predict typical small-signal ac performance, transient steps, dc performance, and noise under a wide variety of operating conditions. The models include the noise terms found in the electrical specifications of the relevant product data sheet.

OPERATING SUGGESTIONS

Operating the VCA821 optimally for a specific application requires trade-offs between bandwidth, input dynamic range and the maximum input voltage, the maximum gain of operation and gain, output dynamic range and the maximum input voltage, the package used, loading, and layout and bypass recommendations. The Typical Characteristics have been defined to cover as much ground as possible to describe the VCA821 operation. There are four sections in the Typical Characteristics:

- V_S = ±5V DC Parameters and V_S = ±5V DC and Power-Supply Parameters, which include dc operation and the intrinsic limitation of a VCA821 design
- V_S = ±5V, A_{VMAX} = 6dB Gain of 6dB Operation
- V_S = ±5V, A_{VMAX} = 20dB Gain of 20dB Operation
- V_S = ±5V, A_{VMAX} = 32dB Gain of 32dB Operation

Where the Typical Characteristics describe the actual performance that can be achieved by using the amplifier properly, the following sections describe in detail the trade-offs needed to achieve this level of performance.

PACKAGE CONSIDERATIONS

The VCA821 is available in both SO-14 and MSOP-10 packages. Each package has, for the different gains used in the typical characteristics, different values of R_F and R_G in order to achieve the same performance detailed in the Electrical Characteristics table.

Figure 82 shows a test gain circuit for the VCA821. Table 2 lists the recommended configuration for the SO-14 and MSOP-10 packages.

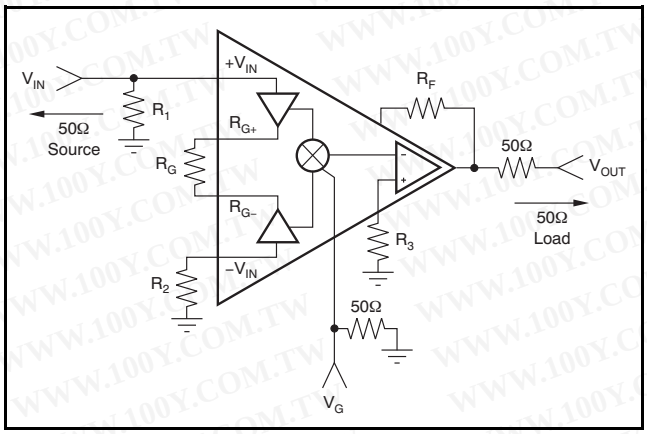


Figure 82. Test Circuit

Table 2. SO-14 and MSOP-10 R_F and R_G Configurations

	G = 2	G = 10	G = 40
R_F	453Ω	402Ω	402Ω
R_G	453Ω	80Ω	18Ω

There are no differences between the packages in the recommended values for the gain and feedback resistors. However, the bandwidth for the VCA821IDGS (MSOP-10 package) is lower than the bandwidth for the VCA821ID (SO-14 package). This difference is true for all gains, but especially true for gains greater than 5V/V, as can be seen in Figure 83 and Figure 84. Note that the scale must be changed to a linear scale to view the details.

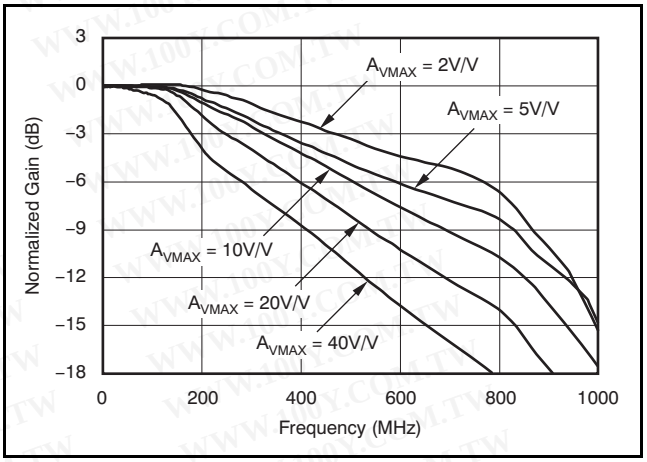


Figure 83. SO-14 Recommended R_F and R_G versus A_{VMAX}

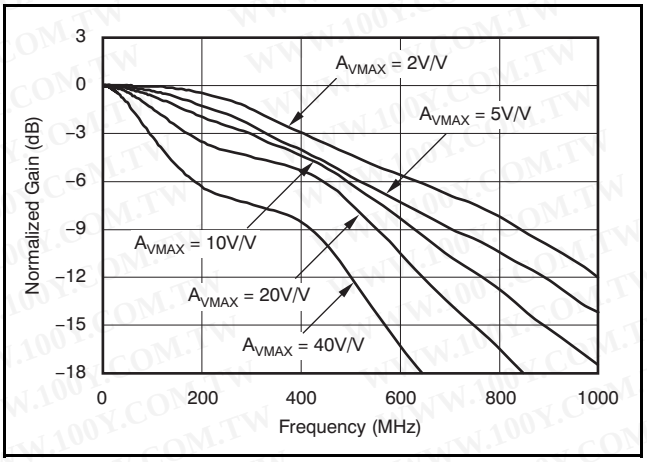


Figure 84. MSOP-10 Recommended R_F and R_G versus A_{VMAX}

MAXIMUM GAIN OF OPERATION

This section describes the use of the VCA821 in a fixed-gain application in which the V_G control pin is set at V_G = +1V. The tradeoffs described here are with bandwidth, gain, and output voltage range.

In the case of an application that does not make use of the V_{GAIN}, but requires some other characteristic of the VCA821, the R_G resistor must be set such that the maximum current flowing through the resistance I_{RG} is less than ±2.6mA typical, or 5.2mA$_{PP}$ as defined in the Electrical Characteristics table, and must follow Equation 2.

$$I_{RG} = \frac{V_{OUT}}{A_{VMAX} \times R_G} \quad (2)$$

As Equation 2 illustrates, once the output dynamic range and maximum gain are defined, the gain resistor is set. This gain setting in turn affects the bandwidth, because in order to achieve the gain (and with a set gain element), the feedback element of the output stage amplifier is set as well. Keeping in mind that the output amplifier of the VCA821 is a current-feedback amplifier, the larger the feedback element, the lower the bandwidth because the feedback resistor is the compensation element.

Limiting the discussion to the input voltage only and ignoring the output voltage and gain, Figure 1 illustrates the tradeoff between the input voltage and the current flowing through the gain resistor.

OUTPUT CURRENT AND VOLTAGE

The VCA821 provides output voltage and current capabilities that are unsurpassed in a low-cost monolithic VCA. Under no-load conditions at +25°C, the output voltage typically swings closer than 1V to either supply rails; the +25°C swing limit is within 1.2V of either rails. Into a 15Ω load (the minimum tested load), it is tested to deliver more than ±90mA.

The specifications described above, though familiar in the industry, consider voltage and current limits separately. In many applications, it is the voltage × current, or *V-I product*, that is more relevant to circuit operation. Refer to the *Output Voltage and Current Limitations* plot (Figure 48) in the Typical Characteristics. The X- and Y-axes of this graph show the zero-voltage output current limit and the zero-current output voltage limit, respectively. The four quadrants give a more detailed view of the VCA821 output drive capabilities, noting that the graph is bounded by a *Safe Operating Area* of 1W maximum internal power dissipation. Superimposing resistor load lines onto the plot shows that the VCA821 can drive ±2.5V into 25Ω or ±3.5V into 50Ω without exceeding the output capabilities or the 1W dissipation limit. A 100Ω load line (the standard test circuit load) shows the full ±3.9V output swing capability, as shown in the Typical Characteristics.

The minimum specified output voltage and current over-temperature are set by worst-case simulations at the cold temperature extreme. Only at cold startup do the output current and voltage decrease to the numbers shown in the Electrical Characteristics tables. As the output transistors deliver power, the respective junction temperatures increase, thereby increasing the available output voltage swing and output current.

In steady-state operation, the available output voltage and current are always greater than the temperature shown in the over-temperature specifications because the output stage junction temperatures are higher than the specified operating ambient.

INPUT VOLTAGE DYNAMIC RANGE

The VCA821 has a input dynamic range limited to +1.6V and –2.1V. Increasing the input voltage dynamic range can be done by using an attenuator network on the input. If the VCA821 is trying to regulate the amplitude at the output, such as in an AGC application, the input voltage dynamic range is directly proportional to Equation 3.

$$V_{IN(PP)} = R_G \times I_{RG(PP)} \quad (3)$$

As such, for unity-gain or under-attenuated conditions, the input voltage must be limited to the CMIR of ±1.6V (3.2V$_{PP}$) and the current (I_{RQ}) must flow through the gain resistor, ±2.6mA (5.2mA$_{PP}$). This configuration sets a minimum value for R_E such that the gain resistor must be greater than Equation 4.

$$R_{GMIN} = \frac{3.2V_{PP}}{5.2mA_{PP}} = 615.4\Omega \quad (4)$$

Values lower than 615.4Ω are gain elements that result in reduced input range, as the dynamic input range is limited by the current flowing through the gain resistor R_G (I_{RG}). If the I_{RG} current limits the performance of the circuit, the input stage of the VCA821 goes into overdrive, resulting in limited output voltage range. Such I_{RG}-limited overdrive conditions are shown in Figure 50 for the gain of 20dB and Figure 70 for the 32dB gain.

OUTPUT VOLTAGE DYNAMIC RANGE

With its large output current capability and its wide output voltage swing of ±3.9V typical on 100Ω load, it is easy to forget other types of limitations that the VCA821 can encounter. For these limitations, careful analysis must be done to avoid input stage limitation: either voltage or I_{RG} current. Note that if control pin V_G varies, the gain limitation may affect other aspects of the circuit.

BANDWIDTH

The output stage of the VCA821 is a wideband current-feedback amplifier. As such, the feedback resistance is the compensation of the last stage. Reducing the feedback element and maintaining the gain constant limits the useful range of I_{RG}, and therefore, reduces the gain adjust range. For a given gain, reducing the gain element limits the maximum achievable output voltage swing.

OFFSET ADJUSTMENT

As a result of the internal architecture used on the VCA821, the output offset voltage originates from the output stage and from the input stage and multiplier core. Figure 85 shows how to compensate both sources of the output offset voltage. Use this procedure to compensate the output offset voltage: starting with the output stage compensation, set V_G = –1V to eliminate all offset contribution of the input stage and multiplier core. Adjust the output stage offset compensation potentiometer. Finally, set V_G = +1V to the maximum gain and adjust the input stage and multiplier core potentiometer. This procedure effectively eliminates all offset contribution at the maximum gain. Because adjusting the gain modifies the contribution of the input stage and the multiplier core, some residual output offset voltage remains.

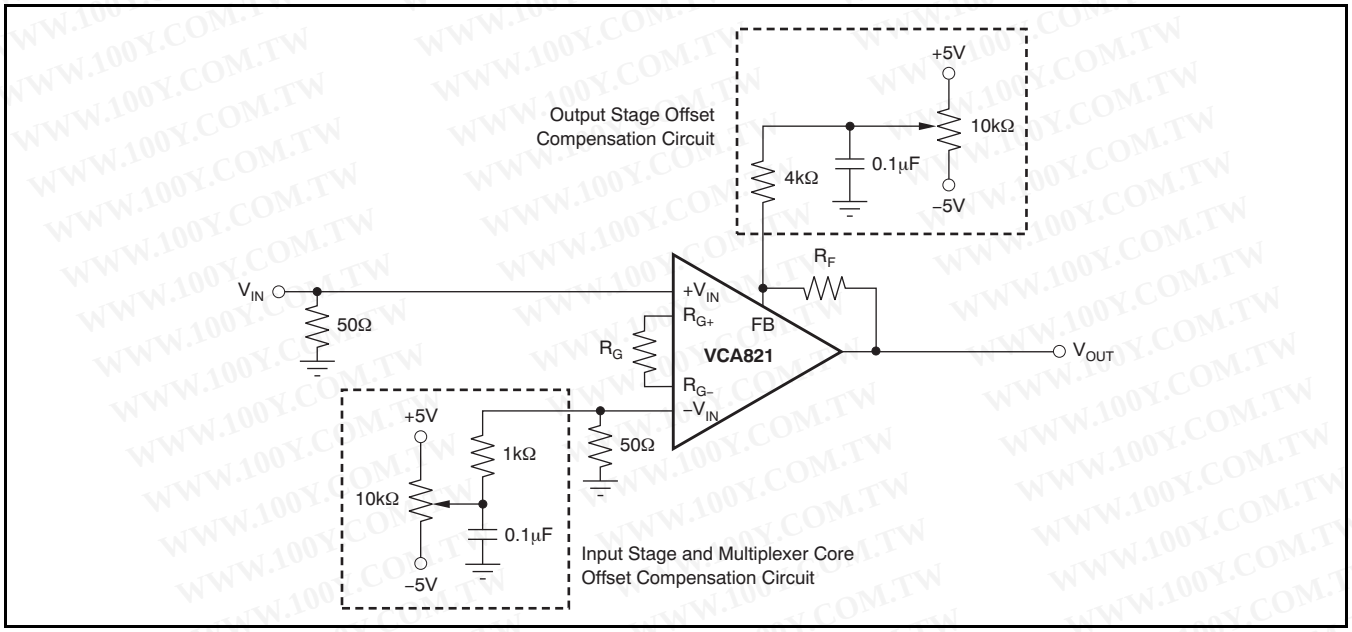


Figure 85. Adjusting the Input and Output Voltage Sources

NOISE

The VCA821 offers 6nV/√Hz input-referred voltage noise density at a gain of 20dB and 2.6pA/√Hz input-referred current noise density. The input-referred voltage noise density considers that all noise terms (except the input current noise but including the thermal noise of both the feedback resistor and the gain resistor) are expressed as one term.

This model is formulated in Equation 5 and Figure 86.

$$e_O = A_{VMAX} \times \sqrt{2 \times (R_S \times i_n)^2 + e_n^2 + 2 \times 4kTR_S} \quad (5)$$

A more complete model is shown in Figure 87. For additional information on this model and the actual modeled noise terms, please contact the High-Speed Product Application Support team at www.ti.com.

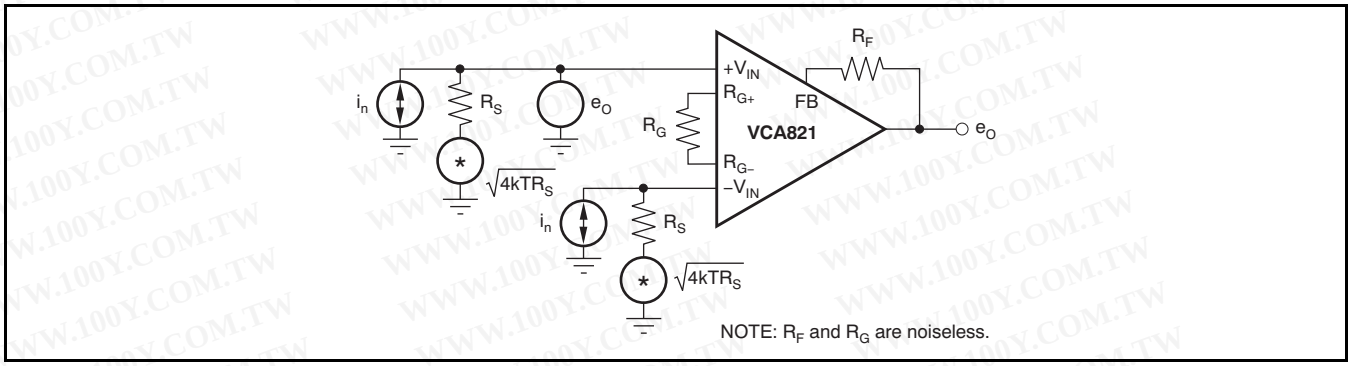


Figure 86. Simple Noise Model

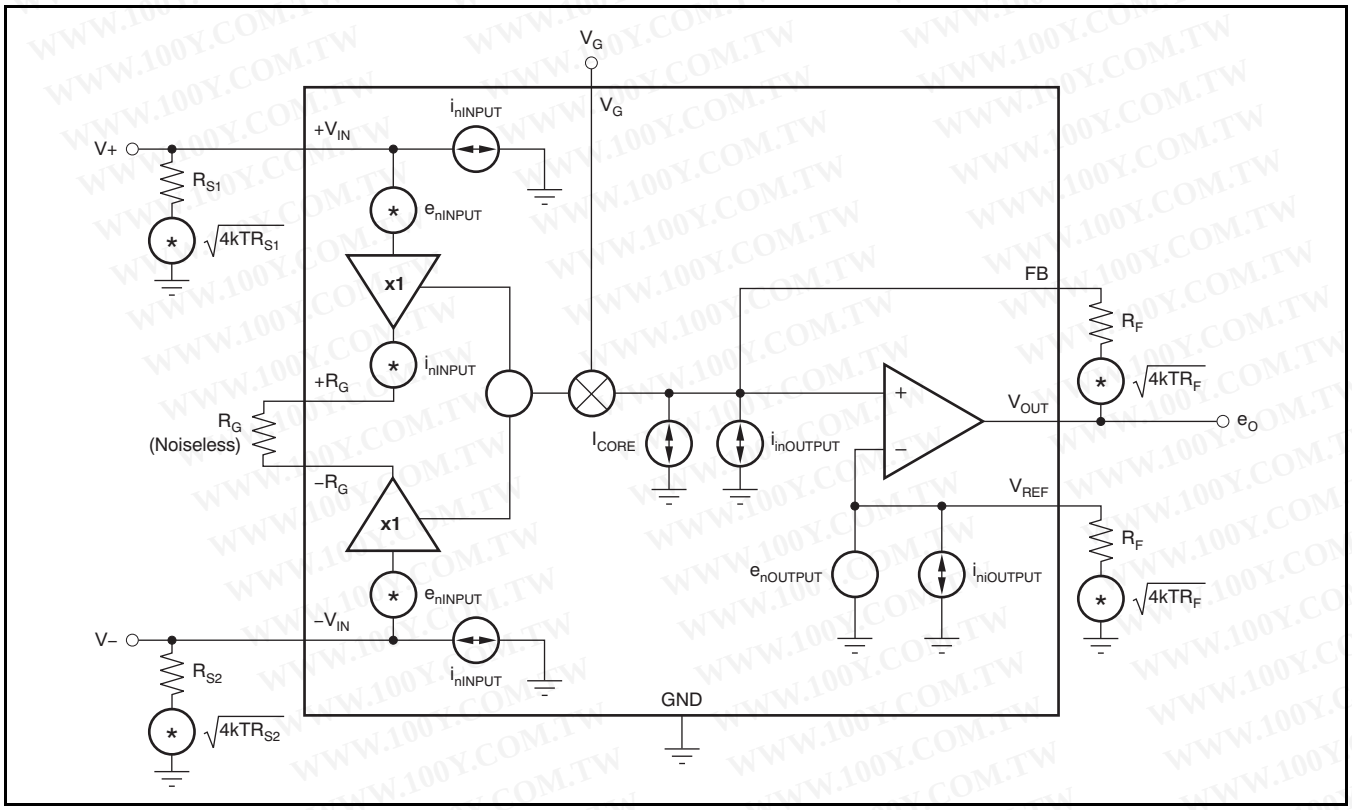


Figure 87. Full Noise Model

THERMAL ANALYSIS

The VCA821 does not require heatsinking or airflow in most applications. The maximum desired junction temperature sets the maximum allowed internal power dissipation as described in this section. In no case should the maximum junction temperature be allowed to exceed +150°C.

Operating junction temperature (T_J) is given by Equation 6:

$$T_J = T_A + P_D \times \theta_{JA} \quad (6)$$

The total internal power dissipation (P_D) is the sum of quiescent power (P_{DQ}) and additional power dissipated in the output stage (P_{DL}) to deliver load power. Quiescent power is simply the specified no-load supply current times the total supply voltage across the part. P_{DL} depends on the required output signal and load; for a grounded resistive load, however, it is at a maximum when the output is fixed at a voltage equal to one-half of either supply voltage (for equal bipolar supplies). Under this worst-case condition, $P_{DL} = V_S^2/(4 \times R_L)$, where R_L is the resistive load.

Note that it is the power in the output stage and not in the load that determines internal power dissipation. As a worst-case example, compute the maximum T_J using a VCA821ID (SO-14 package) in the circuit of Figure 74 operating at maximum gain and at the maximum specified ambient temperature of +85°C.

$$P_D = 10V(36mA) + 5^2/(4 \times 100\Omega) = 422.5mW \quad (7)$$

$$\text{Maximum } T_J = +85°C + (0.443W \times 80°C/W) = 120.5°C \quad (8)$$

This maximum operating junction temperature is well below most system level targets. Most applications should be lower because an absolute worst-case output stage power was assumed in this calculation of $V_{CC}/2$, which is beyond the output voltage range for the VCA821.

BOARD LAYOUT

Achieving optimum performance with a high-frequency amplifier such as the VCA821 requires careful attention to printed circuit board (PCB) layout parasitics and external component types. Recommendations to optimize performance include:

a) Minimize parasitic capacitance to any ac ground for all of the signal I/O pins. This recommendation includes the ground pin (pin 2). Parasitic capacitance on the output can cause instability: on both the inverting input and the noninverting input, it can react with the source impedance to cause unintentional band limiting. To reduce unwanted capacitance, a window around the signal I/O pins should be opened in all of the ground and power planes around those pins. Otherwise, ground and power planes should be unbroken elsewhere on the board. Place a small series resistance (greater than 25Ω) with the input pin connected to ground to help decouple package parasitics.

b) Minimize the distance (less than 0.25 inches, or 6.3mm) from the power-supply pins to high-frequency 0.1µF decoupling capacitors. At the device pins, the ground and power plane layout should not be in close proximity to the signal I/O pins. Avoid narrow power and ground traces to minimize inductance between the pins and the decoupling capacitors. The power-supply connections should always be decoupled with these capacitors. Larger (2.2µF to 6.8µF) decoupling capacitors, effective at lower frequencies, should also be used on the main supply pins. These capacitors may be placed somewhat farther from the device and may be shared among several devices in the same area of the PCB.

c) Careful selection and placement of external components preserve the high-frequency performance of the VCA821. Resistors should be a very low reactance type. Surface-mount resistors work best and allow a tighter overall layout. Metal-film and carbon composition, axially-leaded resistors can also provide good high-frequency performance. Again, keep the leads and PCB trace length as short as possible. Never use wire-wound type resistors in a high-frequency application. Because the output pin is the most sensitive to parasitic capacitance, always position the series output resistor, if any, as close as possible to the output pin. Other network components, such as inverting or non-inverting input termination resistors, should also be placed close to the package.

d) Connections to other wideband devices on the board may be made with short direct traces or through onboard transmission lines. For short connections, consider the trace and the input to the next device as a lumped capacitive load. Relatively wide traces (50mils to 100mils, or 1.27mm to 2.54mm) should be used, preferably with ground and power planes opened up around them.

e) Socketing a high-speed part like the VCA821 is not recommended. The additional lead length and pin-to-pin capacitance introduced by the socket can create an extremely troublesome parasitic network, which can make it almost impossible to achieve a smooth, stable frequency response. Best results are obtained by soldering the VCA821 onto the board.

INPUT AND ESD PROTECTION

The VCA821 is built using a very high-speed complementary bipolar process. The internal junction breakdown voltages are relatively low for these very small geometry devices. These breakdowns are reflected in the Section 2 table.

All pins on the VCA821 are internally protected from ESD by means of a pair of back-to-back reverse-biased diodes to either power supply, as shown in Figure 88. These diodes begin to conduct when the pin voltage exceeds either power supply by about 0.7V. This situation can occur with loss of the amplifier power supplies while a signal source is still present. The diodes can typically withstand a continuous current of 30mA without destruction. To ensure long-term reliability, however, diode current should be externally limited to 10mA whenever possible.

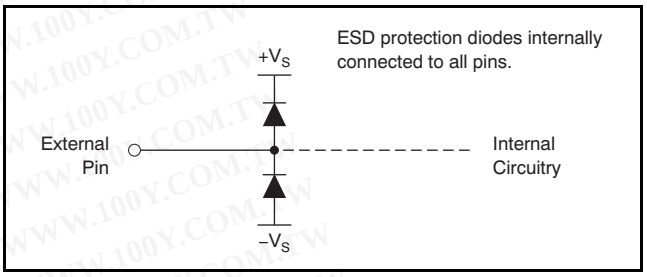


Figure 88. Internal ESD Protection

Revision History

Changes from Revision A (August 2008) to Revision B	Page
• Revised second paragraph in *Wideband Variable Gain Amplifier Operation* section describing pin 9	19

Changes from Original (December 2007) to Revision A	Page
• Changed storage temperature range rating in *Absolute Maximum Ratings* table from –40°C to +125°C to –65°C to +125°C	2

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
VCA821ID	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	VCA821ID	Samples
VCA821IDG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	VCA821ID	Samples
VCA821IDGSR	ACTIVE	VSSOP	DGS	10	2500	Green (RoHS & no Sb/Br)	CU NIPDAU | CU NIPDAUAG	Level-2-260C-1 YEAR	-40 to 85	BOR	Samples
VCA821IDGSRG4	ACTIVE	VSSOP	DGS	10	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	BOR	Samples
VCA821IDGST	ACTIVE	VSSOP	DGS	10	250	Green (RoHS & no Sb/Br)	CU NIPDAU | CU NIPDAUAG	Level-2-260C-1 YEAR	-40 to 85	BOR	Samples
VCA821IDGSTG4	ACTIVE	VSSOP	DGS	10	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	BOR	Samples
VCA821IDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	VCA821ID	Samples
VCA821IDRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	VCA821ID	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.

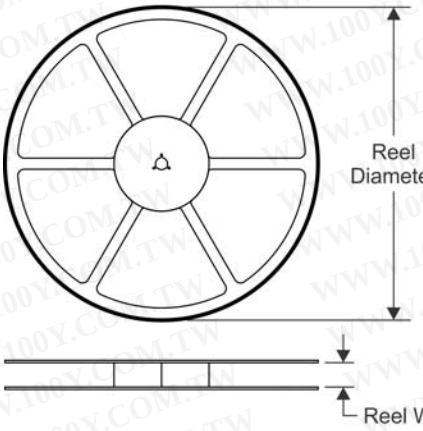
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(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.

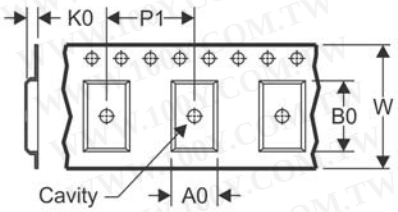
(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

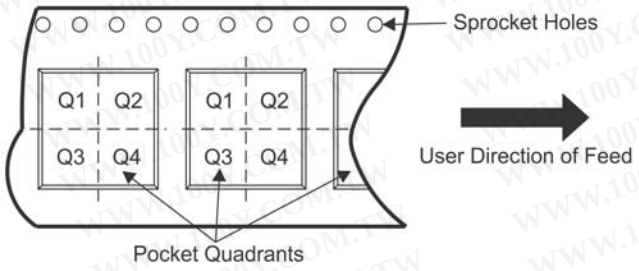


TAPE DIMENSIONS



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

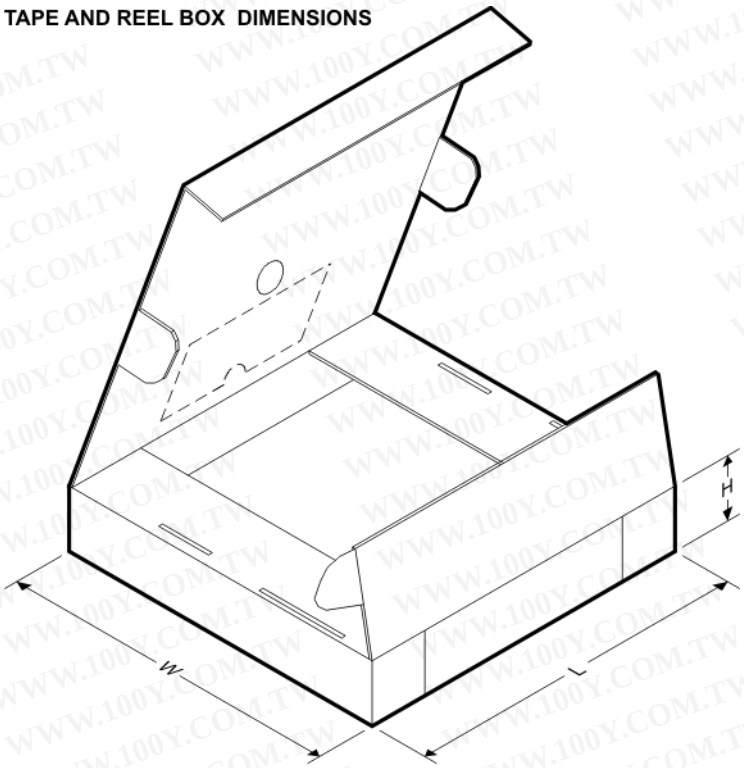
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
VCA821IDGSR	VSSOP	DGS	10	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
VCA821IDGST	VSSOP	DGS	10	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
VCA821IDR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1

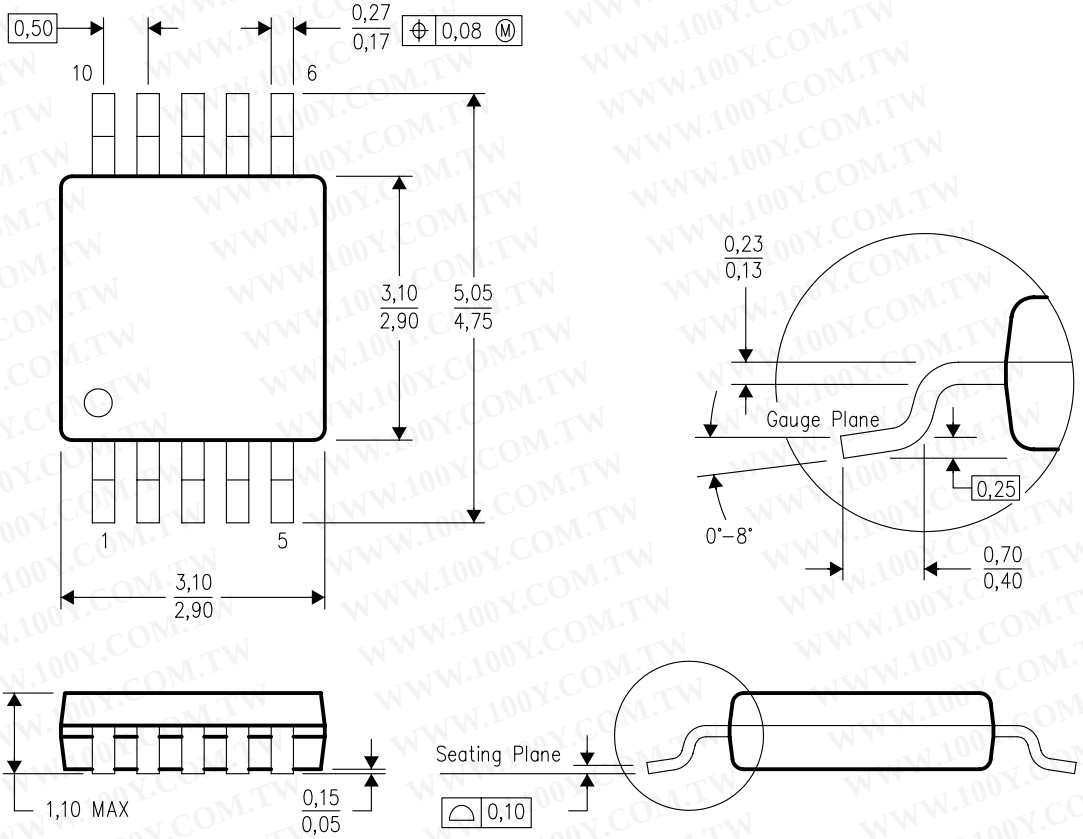
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
VCA821IDGSR	VSSOP	DGS	10	2500	367.0	367.0	35.0
VCA821IDGST	VSSOP	DGS	10	250	210.0	185.0	35.0
VCA821IDR	SOIC	D	14	2500	367.0	367.0	38.0

DGS (S–PDSO–G10) PLASTIC SMALL–OUTLINE PACKAGE



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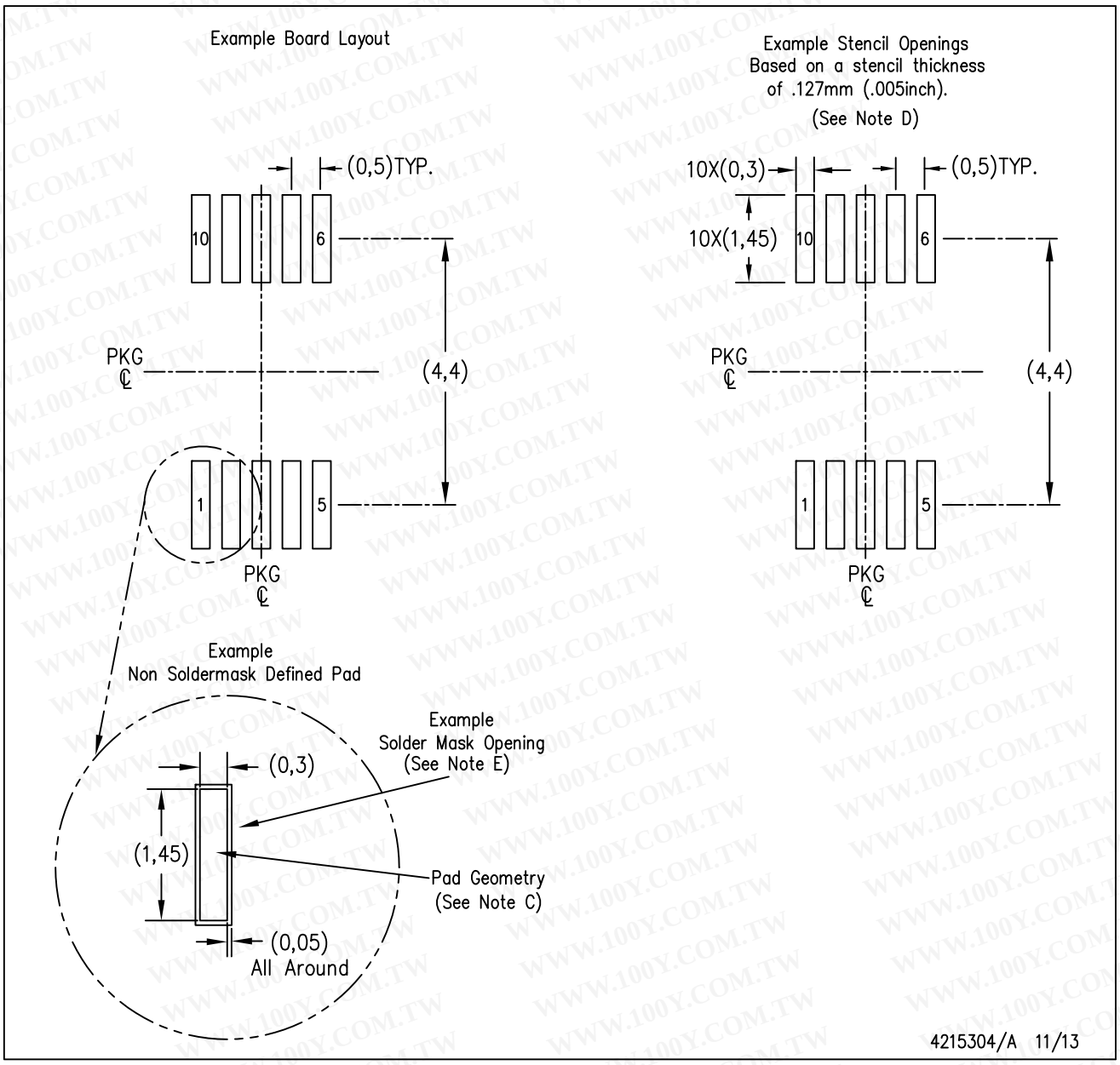
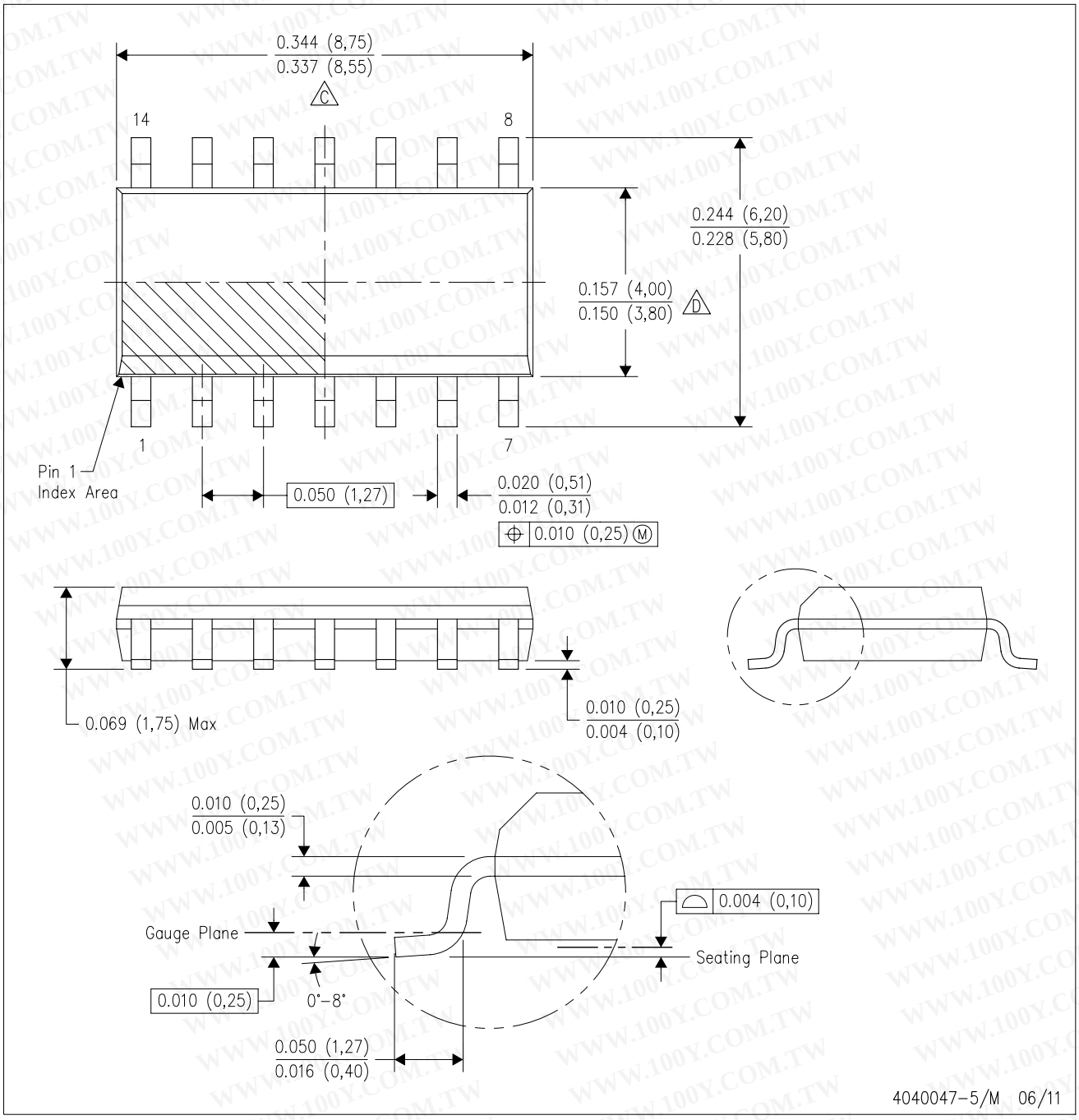
NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion.
D. Falls within JEDEC MO–187 variation BA.

DGS (S–PDSO–G10) PLASTIC SMALL OUTLINE PACKAGE



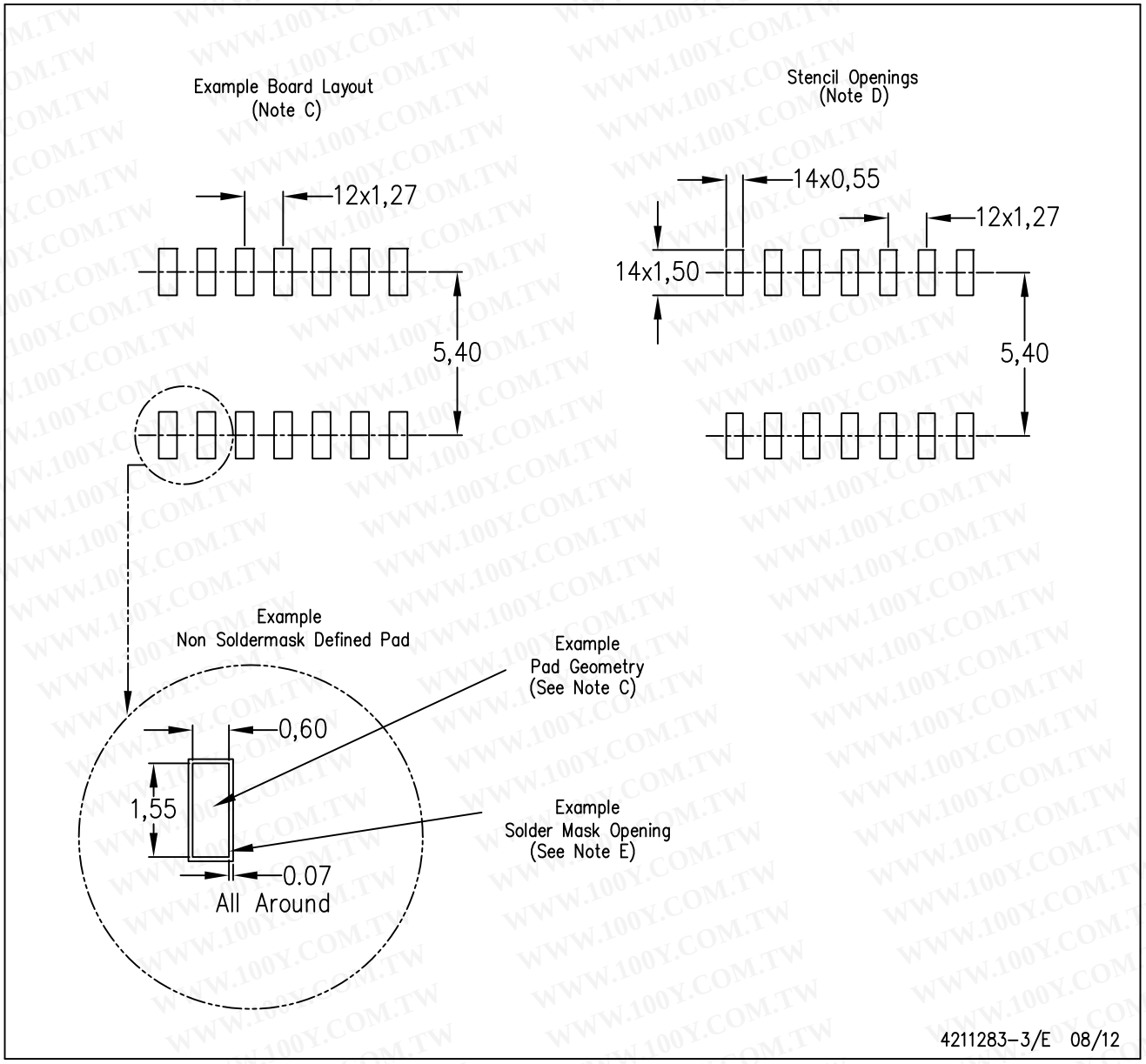
NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC–7525 for other stencil recommendations.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

D (R–PDSO–G14) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
E. Reference JEDEC MS–012 variation AB.

D (R–PDSO–G14) PLASTIC SMALL OUTLINE



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 other stencil recommendations.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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