75MHz, Low Noise, Rail-to-Rail Output Variable Gain Amplifier

Features

- Variable Gain Control
- 30dB per volt Attenuation
- Pin-Programmable Gain Range:
  1dB to 28dB with 75MHz Bandwidth
  21dB to 48dB with 12MHz Bandwidth
- Any Intermediate Gain Range
- Bandwidth Independent of Variable Gain
- ± 1dB Typical Gain Accuracy
- Differential Gain Control Interface
  with High Input Impedance
- High Slew Rate：1500 V/μs
- Rail-to-Rail Output
- Single or Dual Supply Operation:
  - + 8 V to +12 V
  - ± 4 V to ± 6V
- Low Quiescent Current: 9mA
- Extended Temperature Ranges
  From -40°C to +125°C
- Green Packaging: SOP-8/MSOP-8

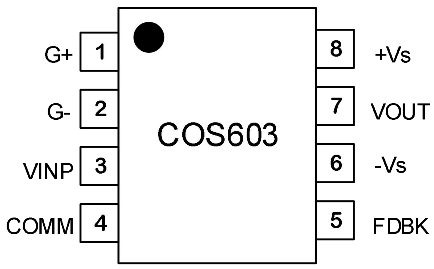
Applications

- RF/IF AGC Amplifier
- Video Gain Controls
- Signal Measurements
- A/D Range Extensions

General Description

The COS603 is a low noise, rail-to-rail output, voltage-controlled amplifier for use in RF and IF AGC systems. It provides accurate, pin selectable gains of 1dB to 28dB with a bandwidth of 75MHz or 21dB to 48dB with a bandwidth of 12MHz. Any intermediate gain range may be arranged using one external resistor. The power consumption is only 90 mW at the recommended ±5V Supplies.

The differential gain control interface allows the use of either differential or single-ended positive or negative control voltages. Several of these amplifiers can be cascaded and their voltage control gains offset to optimized the system SNR.



Pin Diagram

Rev1.1

1. Block Diagram and Pin Functions

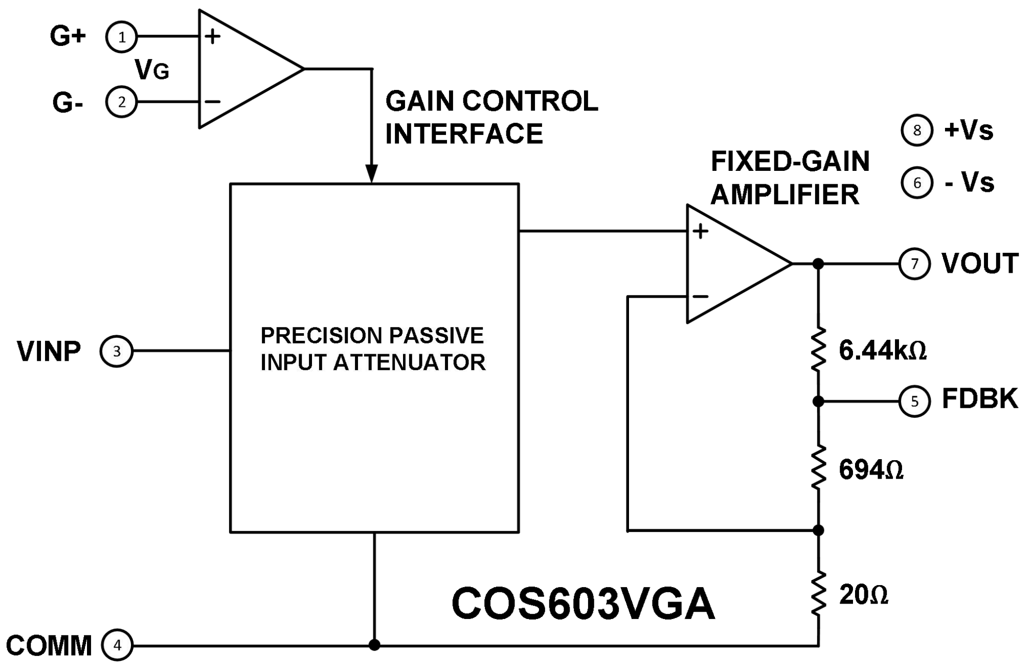


Figure 1.Block Diagram

Pin Description

Pin No.	Pin Name	Description
1	G+	Gain Control Input High (Positive Voltage Increases Gain)
2	G-	Gain Control Input Low (Negative Voltage Increases Gain)
3	VINP	Amplifier Input
4	COMM	Amplifier Ground
5	FDBK	Connection to Feedback Network
6	-Vs	Negative Power Supply or Ground
7	VOUT	Amplifier Output
8	+Vs	Positive Power Supply

2. Package and Ordering Information

Model	Package	Order Number	Package Option	Marking Information
COS603VGA	SOP-8	COS603VGA	Tape and Reel, 4000	COS603VGA
	MSOP-8	COS603VGAMR	Tape and Reel, 3000	COS603VGA

3. Product Specification

3.1 Absolute Maximum Ratings [1]

Parameter	Rating	Units
Power Supply: +Vs, -Vs	± 6.5	V
Input Voltage: VINP (Pin 3)	±2.5V Continuous	V
	±Vs for 10ms	V
G+, G- (Pin 1 and Pin 2)	±Vs	V
Input Current [2]	10	mA
Internal Power Dissipation	400	mW
Storage Temperature Range	-65 to 150	°C
Junction Temperature	150	°C
Operating Temperature Range	-40 to 125	°C
ESD Susceptibility, HBM	4000	V

(1) Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.
(2) Input terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5V beyond the supply rails should be current-limited to 10mA or less.

3.2 Thermal Data

Parameter	Rating	Unit
Package Thermal Resistance, $R_{\theta JA}$ (Juntion-to-ambient)	155 (SOP8) 206 (MSOP8)	°C/W

3.3 Recommended Operating Conditions

Parameter	Rating	Unit
DC Supply Voltage	± 4 to ± 6	V
G+, G- Voltage Range	-0.6 ~ +0.6	V
Operating Ambient Temperature	-40 to +85	°C

3.4 Electrical Characteristics

(T_A=+25°C, V_S = ±5V, －500mV ≤ V_G ≤ +500 mV, G- = 0 V, R_L=500Ω, C_L=5pF, unless otherwise noted)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input Characteristics						
Input Resistance	R_{IN}		95	100	105	Ω
Input Capacitance	C_{IN}			2		pF
1dB Compression Point		f=10MHz, Rs=10Ω, gain = maximum		-7.5		dBm
Peak Input Voltage				±1.5	±2.0	V
Output Characteristics						
Output Voltage Swing from Rail	V_{SWR}	R_L=500Ω		300		mV
Short-Circuit Current	I_{SR}	Sourcing		64		mA
	I_{SK}	Sinking		56		mA
Output Impedance	Z_{OUT}	f ≤ 10MHz		2		Ω
Total Harmonic Distortion	THD	f=10MHz, V_{OUT}=1Vrms		-60		dBc
Third-Order Intercept	IP3	f=40MHz, Rs=50Ω, gain = maximum		15		dBm
Accuracy						
Gain Accuracy		-400mV ≤ V_G ≤ +400mV, f= 100kHz,	-1	±0.5	+1	dB
		T_{MIN} to T_{MAX}	-1.5		+1.5	dB
Gain (Low Gain Mode, f=10.7MHz)	Gv	V_G=+0.6V	27.5	28.5	29.5	dB
		V_G=0 V	11.5	12.5	13.5	dB
		V_G=-0.6V	0.3	1.3	2.3	dB
Gain (High Gain Mode, f=2MHz)		V_G=+0.6V	46.5	47.5	48.5	dB
		V_G=0 V	31	32	33	dB
		V_G=-0.6V	20	21	22	dB
Output Offset Voltage	V_{OS}	V_G=0,			50	mV
		V_G=0, T_{MIN} to T_{MAX}			100	mV
Output Offset Variation vs V_G		-500mV ≤ V_G ≤ +500mV,			50	mV
		T_{MIN} to T_{MAX}			100	mV

Gain Control Interface						
Gain Scaling Factor		100kHz, -500mV ≤ V_G ≤ +500mV,	25	30	35	dB/V
		T_{MIN} to T_{MAX}	23		37	dB/V
G+, G- Voltage Range			-2		+2	V
Input Bias current	I_B				1	nA
Input Offset Current	I_{BOS}				1	nA
Differential Input Resistance		Pin 1 to Pin 2	1			GΩ
Response Rate		Full 30dB gain change		80		dB/μs
Power Supply						
Operating Voltage Range	V_S		8		12	V
			±4		±6	
Quiescent Current / Amplifier	I_Q			9		mA
		T_{MIN} to T_{MAX}			12	mA
Power Supply Rejection Ratio	PSRR	V_S = ±4V to ±6V	60	80		dB
Dynamic Performance						
-3 dB Small-Signal Bandwidth	f_{-3dB}	Low gain mode		75		MHz
		High gain mode, C_{FB}=12p		12		MHz
Slew Rate	SR	R_L ≥ 500Ω		1500		V/μs
Noise Performance						
Voltage Noise Density	e_n	f=10kHz		18		nV/√Hz

4.0 Application Notes

The COS603 is a low noise, rail-to-rail output, voltage-controlled amplifier for use in RF and IF AGC systems. It provides accurate, pin selectable gains of 1dB to 28dB with a bandwidth of 75MHz or 21dB to 48dB with a bandwidth of 12MHz. Any intermediate gain range may be arranged using one external resistor. The power consumption is only 90 mW at the recommended ±5V Supplies.

The differential gain control interface allows the use of either differential or single-ended positive or negative control voltages. Several of these amplifiers can be cascaded and their voltage control gains offset to optimized the system SNR.

Programming The Fixed-Gain Amplifier Using PIN Strapping

There are three modes the user can program the gain of the COS603 output amplifier using Pin 5 (FDBK), as shown in Figure 2, Figure 4, and Figure 6.

(A) In the high gain mode, FDBK is unconnected as shown in Figure 2. The gain range is from 21dB to 48dB and a bandwidth of 12MHz as shown in Figure 3. An optional C_{FB} capacitor can be used to extend the frequency response in this default mode.

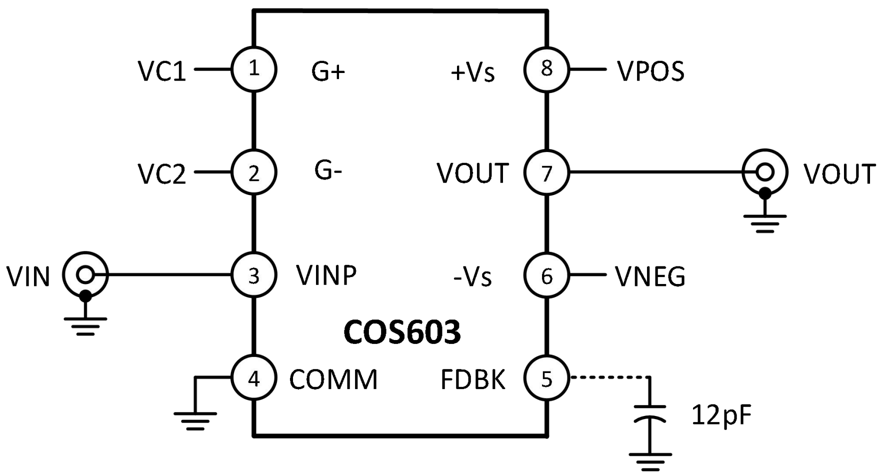


Figure 2. The High Gain Mode (default mode),
FDBK is unconnected or connect to a frequency compensation capacitor C_{FB}

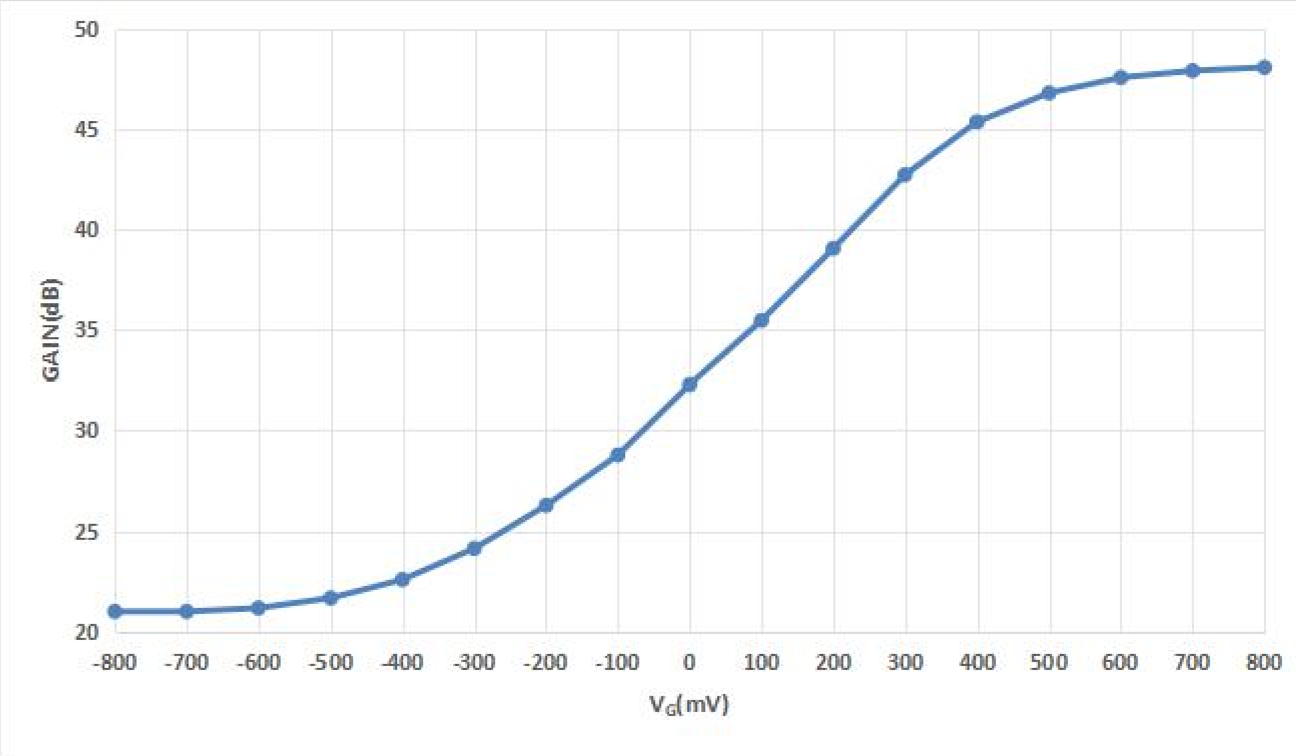


Figure 3. Gain vs. V_G for High Gain Configuration, 21dB to 48dB; 12MHz Bandwidth

(B) In the low gain mode, V_{OUT} and FDBK are shorted as shown in Figure 4, the gain range is lowered to 1dB to 28dB as shown in Figure 5.

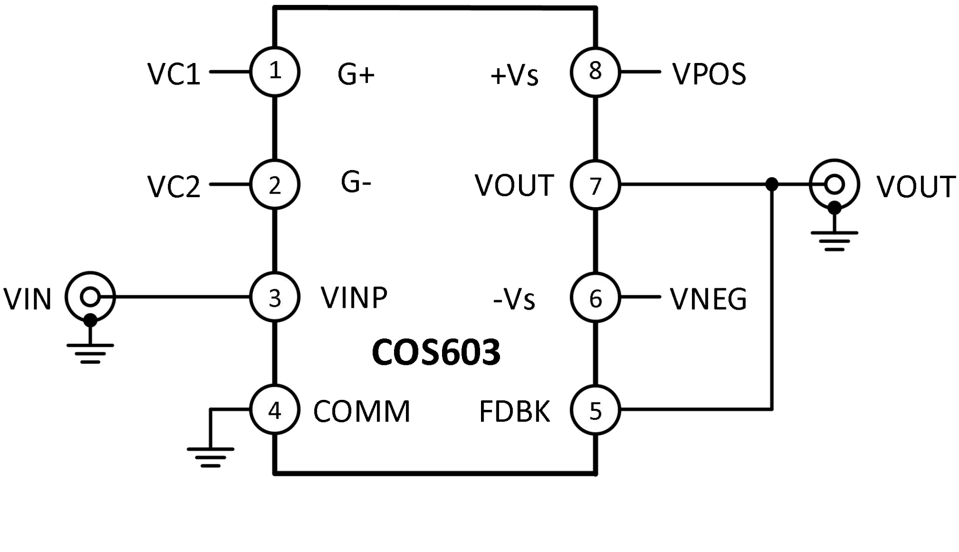


Figure 4. The Low Gain Mode, V_{OUT} and FDBK are shorted

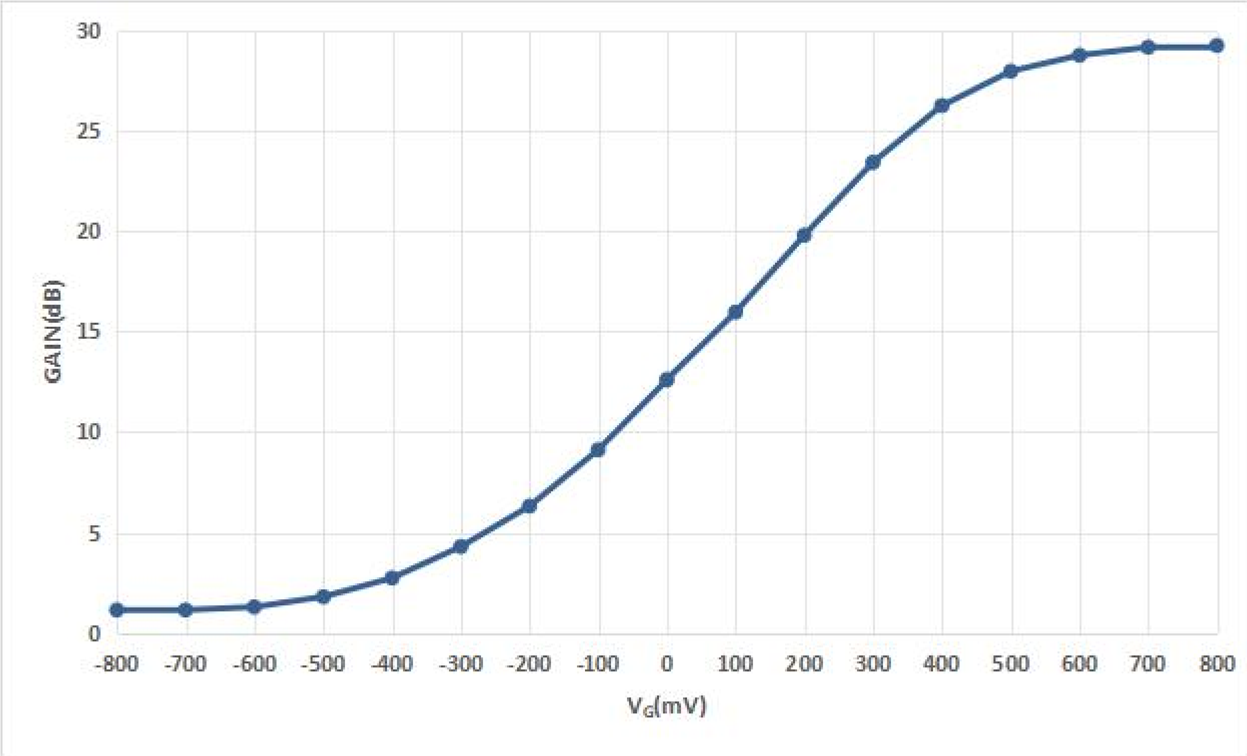


Figure 5. Gain vs. V_G for Low Gain Configuration, 1dB to 28dB; 75MHz Bandwidth

(C) When an external resistor is placed between V_{OUT} and FDBK as shown in Figure 6, any intermediate gain can be achieved.

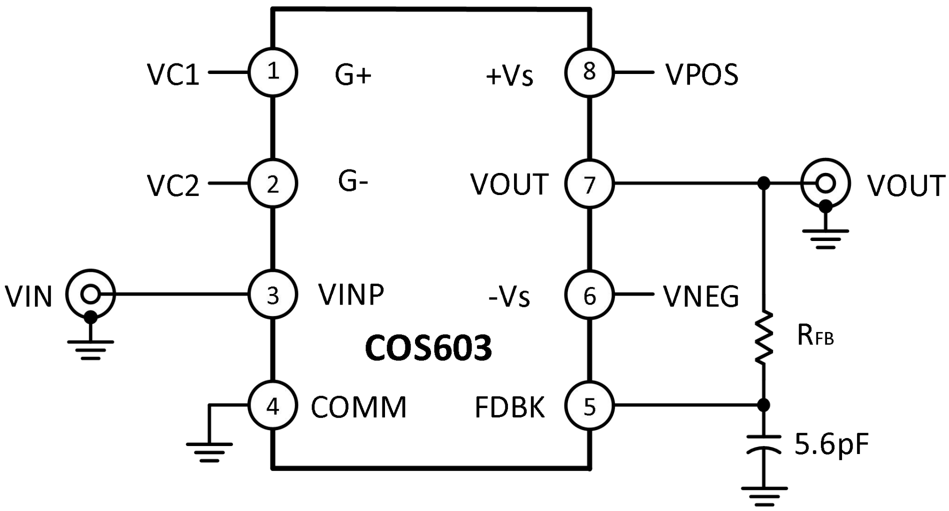


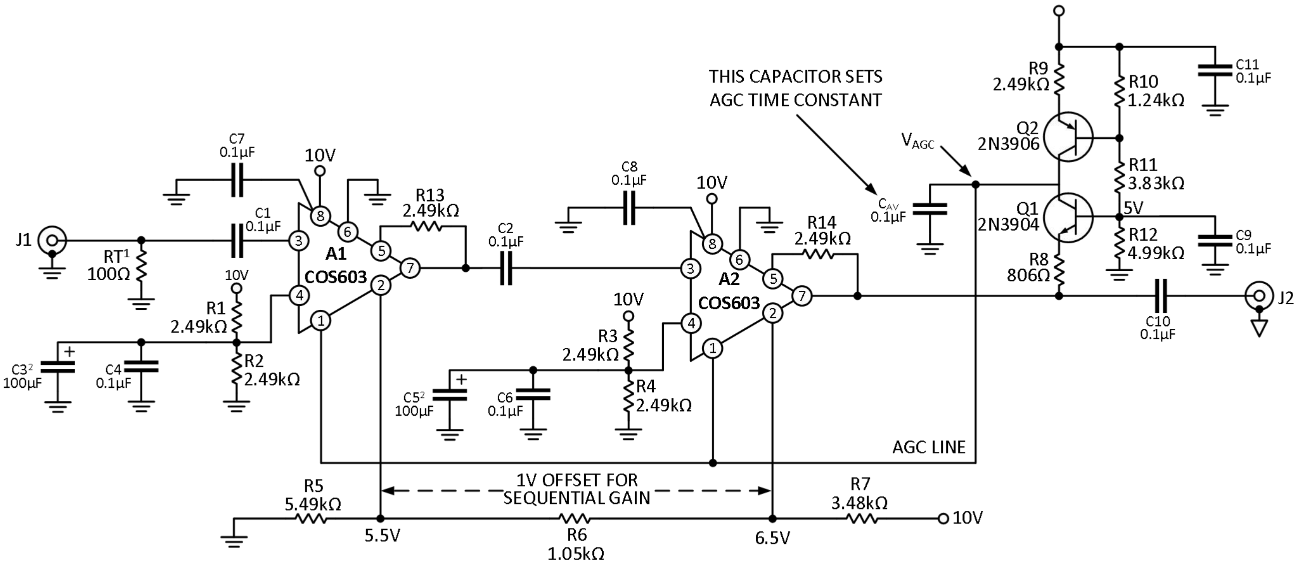
Figure 6. Configuration for Intermediate Gain Range

A Low Noise AGC Amplifier Example

The COS603 can be connected as an AGC amplifier as shown in Figure 7. The circuit operates from a single 10V supply with two cascaded amplifiers in sequential gain mode for maximum SNR. An external resistor programs each gain of the amplifier.

Resistors R1, R2, R3, and R4 bias the common pins of A1 and A2 at 5 V. The common pin is a low impedance point and must have a low impedance path to ground, provided here by the 100 μF tantalum capacitors and the 0.1 μF ceramic capacitors. The cascaded amplifiers operate in sequential gain. Here, the offset voltage between Pin 2 (G-) of A1 and A2 is 1.05 V, provided by a voltage divider consisting of Resistors R5, R6, and R7. Using standard values, the offset is not exact, but it is not critical for this application. The gain of both A1 and A2 is programmed by Resistors R13 and R14, respectively, to be about 42 dB; therefore, the maximum gain of the circuit is twice that, or 84 dB. The gain control range can be shifted up by as much as 20 dB by appropriate choices of R13 and R14.

C2 blocks the small dc offset voltage at the output of A1 (which might otherwise saturate A2 at its maximum gain) and introduces a high-pass corner at about 16 kHz, eliminating low frequency noise. A half-wave detector is used as an AGC signal generator, based on Q1 and R8. The current into capacitor, C_{AV}, is the difference between the collector current of Q2 (biased to be 300 μA at 300 K, 27°C) and the collector current of Q1, which increases with the amplitude of the output signal.



¹RT PROVIDES A 50Ω INPUT IMPEDANCE.
²C3 AND C5 ARE TANTALUM.

Figure 7. A Low Noise AGC Amplifier

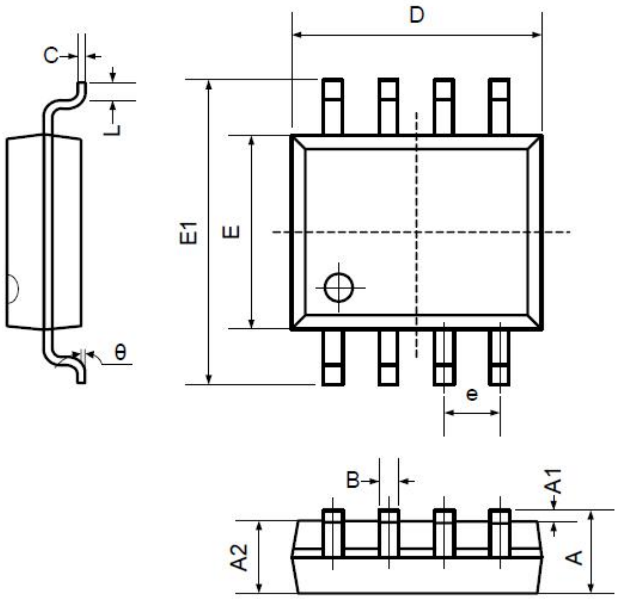
Power-Supply Bypassing and Layout

The COS603VGA operates from a single +8V to +12V supply or dual ±4V to ±6V supplies. For single-supply operation, bypass the power supply +Vs with a 0.1μF ceramic capacitor which should be placed close to the +Vs pin. For dual-supply operation, both the +Vs and the -Vs supplies should be bypassed to ground with separate 0.1μF ceramic capacitors. 2.2μF tantalum capacitor can be added for better performance.

The length of the current path is directly proportional to the magnitude of parasitic inductances and thus the high frequency impedance of the path. High speed currents in an inductive ground return create an unwanted voltage noise. Broad ground plane areas will reduce the parasitic inductance. Thus a ground plane layer is important for high speed circuit design.

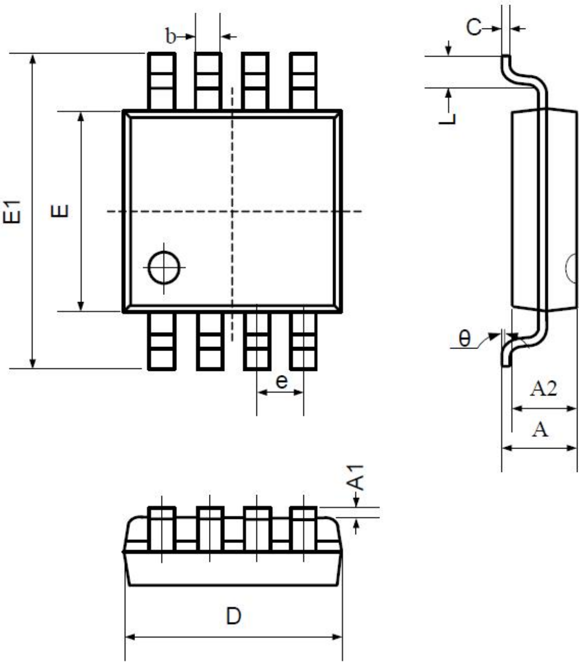
5. Package Information

5.1 SOP8 (Package Outline Dimensions)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
B	0.330	0.510	0.013	0.020
C	0.190	0.250	0.007	0.010
D	4.780	5.000	0.188	0.197
E	3.800	4.000	0.150	0.157
E1	5.800	6.300	0.228	0.248
e	1.270TYP		0.050TYP	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

5.2 MSOP8 (Package Outline Dimensions)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.800	1.200	0.031	0.047
A1	0.000	0.200	0.000	0.008
A2	0.760	0.970	0.030	0.038
b	0.30 TYP		0.012 TYP	
c	0.15 TYP		0.006 TYP	
D	2.900	3.100	0.114	0.122
e	0.65 TYP		0.026 TYP	
E	2.900	3.100	0.114	0.122
E1	4.700	5.100	0.185	0.201
L	0.410	0.650	0.016	0.026
θ	0°	6°	0°	6°

6. Related Parts

Part Number	Description
COS6042	24kHz, 0.5µA, Nano-Power Op Amps, 1.4V to 5.5V Supply
COS8042	170MHz, 6.1mA, High Speed Op Amps, 3.2V to 12V Supply
COS2172	10MHz, 1.2mA, RRIO Op Amps, 4.5 to 40V Supply
COS2333	350kHz, 18µA, Precision Op Amps, 1.8 to 5.5V Supply, Zero Drift, Vos<10µV
COS8552	1.5MHz, 55µA, Precision Op Amps, 1.8 to 5.5V Supply, Zero Drift, Vos<10µV
COS2388	9MHz, 570µA, Precision Op Amps, 1.8 to 5.5V Supply, Zero Drift, Vos<10µV
COS2227	10MHz, 1.3mA, Precision Op Amps, 4.5 to 36V Supply, Vos<50µV
COS2182	5MHz, 580µA, RRIO Precision Op Amps, 4.5 to 40V Supply, Vos<50µV
COS620	1.5MHz, 1.3mA, Instrumentation Amps, 4.5 to 36V Supply, Vos<50µV
COSINA333	150kHz, 65µA, Instrumentation Amps, 1.8 to 5.5V Supply, Vos<25µV