Microphone Preamplifier with Variable Compression and Noise Gating

SSM2166*

FEATURES
Complete Microphone Conditioner in a 14-Lead Package
Single +5 V Operation
Adjustable Noise Gate Threshold
Compression Ratio Set by External Resistor
Automatic Limiting Feature—Prevents ADC Overload
Adjustable Release Time
Low Noise and Distortion
Power-Down Feature
20 kHz Bandwidth (±1 dB)
Low Cost

APPLICATIONS
Microphone Preamplifier/Processor
Computer Sound Cards
Public Address/Paging Systems
Communication Headsets
Telephone Conferencing
Guitar Sustain Effects Generator
Computerized Voice Recognition
Surveillance Systems
Karaoke and DJ Mixers

GENERAL DESCRIPTION

The SSM2166 integrates a complete and flexible solution for conditioning microphone inputs in computer audio systems. It is also excellent for improving vocal clarity in communications and public address systems. A low noise voltage controlled amplifier (VCA) provides a gain that is dynamically adjusted by a control loop to maintain a set compression characteristic. The compression ratio is set by a single resistor and can be varied from 1:1 to over 15:1 relative to a user defined "rotation point;" signals above the rotation point are limited to prevent overload and eliminate "popping." In the 1:1 compression setting the SSM2166 can be programmed with a fixed gain of up to 20 dB; this gain is in addition to the variable gain in other compression settings. The input buffer can also be configured for front-end gains of 0 dB to 20 dB. A downward expander (noise gate) prevents amplification of noise or hum. This results in optimized signal levels prior to digitization, thereby eliminating the need for additional gain or attenuation in the digital domain that could add noise or impair accuracy of speech recognition algorithms. The compression ratio and time constants are set externally. A high degree of flexibility is provided by the VCA Gain, Rotation Point, and Noise Gate adjustment pins.

The SSM2166 is an ideal companion product for audio codecs used in computer systems, such as the AD1845 and AD1847. The device is available in 14-lead SOIC and P-DIP packages, and guaranteed for operation over the extended industrial temperature range of –40°C to +85°C. For similar features/performance in an 8-lead package, please refer to the SSM2165.

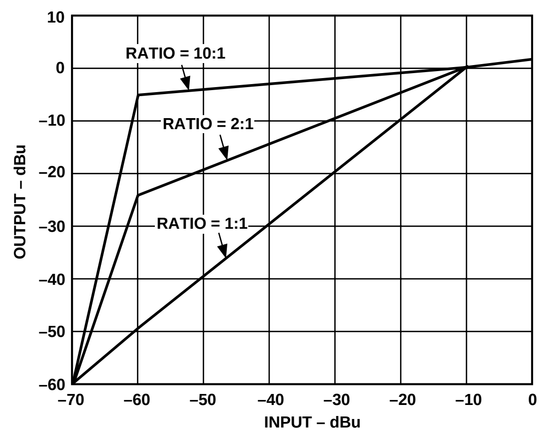


Figure 1. SSM2166 Compression and Gating Characteristics with 10 dB of Fixed Gain (The Gain Adjust Pin Can Be Used to Vary This Fixed Gain Amount)

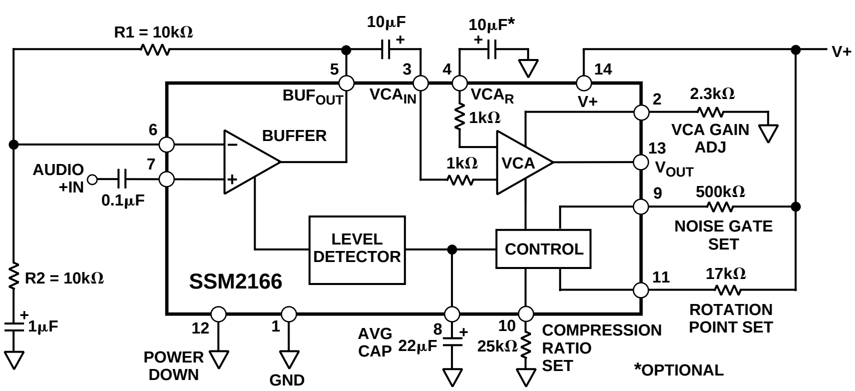


Figure 2. Functional Block Diagram and Typical Speech Application

*Patents pending.

REV. A

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 781/329-4700 World Wide Web Site: http://www.analog.com
Fax: 781/326-8703

SSM2166–SPECIFICATIONS

($V+ = +5$ V, $f = 1$ kHz, $R_L = 100$ kΩ, $R_{GATE} = 600$ kΩ, $R_{ROTATION} = 3$ kΩ, $R_{COMP} = 0$ Ω, $R1 = 0$ Ω, $R2 = \infty$Ω, $T_A = +25$°C, unless otherwise noted, $V_{IN} = 300$ mV rms.)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
AUDIO SIGNAL PATH						
Voltage Noise Density	e_n	15:1 Compression		17		nV/√Hz
Noise		20 kHz Bandwidth, V_{IN} = GND		–109		dBu[1]
Total Harmonic Distortion	THD+N	2nd and 3rd Harmonics, V_{IN} = –20 dBu 22 kHz Low-Pass Filter		0.25	0.5	%
Input Impedance	Z_{IN}			180		kΩ
Output Impedance	Z_{OUT}			75		Ω
Load Drive		Resistive	5			kΩ
		Capacitive			2	nF
Buffer						
Input Voltage Range		1% THD		1		V rms
Output Voltage Range		1% THD		1		V rms
VCA						
Input Voltage Range		1% THD		1		V rms
Output Voltage Range		1% THD		1.4		V rms
Gain Bandwidth Product		1:1 Compression, VCA G = 60 dB		30		MHz
CONTROL SECTION						
VCA Dynamic Gain Range				60		dB
VCA Fixed Gain Range				–60 to +19		dB
Compression Ratio, Min				1:1		
Compression Ratio, Max		See Figure 5 for R_{COMP}/R_{ROT}		15:1		
Control Feedthrough		15:1 Compression, Rotation Point = –10 dBu		±5		mV
POWER SUPPLY						
Supply Voltage Range	V_S		4.5		5.5	V
Supply Current	I_{SY}			7.5	10	mA
Quiescent Output Voltage Level				2.2		V
Power Supply Rejection Ratio	PSRR			50		dB
POWER DOWN						
Supply Current		Pin 12 = V+[2]		10	100	µA

NOTES
[1]0 dBu = 0.775 V rms.
[2]Normal operation: Pin 12 = 0 V.
Specifications subject to change without notice.

ABSOLUTE MAXIMUM RATINGS

Supply Voltage . . . .+10 V
Audio Input Voltage . . . . .Supply Voltage
Operating Temperature Range . . . . –40°C to +85°C
Storage Temperature Range . . . . –65°C to +150°C
Junction Temperature (T_J) . . . . +150°C
Lead Temperature (Soldering, 60 sec) . . . . +300°C

ESD RATINGS

883 (Human Body) Model . . . . 2.0 kV

THERMAL CHARACTERISTICS

Thermal Resistance
14-Lead Plastic DIP
θ_{JA} . . . . 83°C/W
θ_{JC} . . . . 39°C/W
14-Lead SOIC
θ_{JA} . . . . 120°C/W
θ_{JC} . . . . 36°C/W

ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option
SSM2166P	–40°C to +85°C	Plastic DIP	N-14
SSM2166S	–40°C to +85°C	Narrow SOIC	SO-14

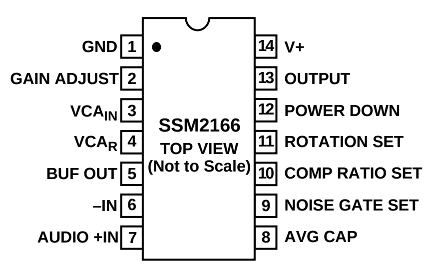
CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although the SSM2166 features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

PIN DESCRIPTION

Pin #	Mnemonic	Function
1	GND	Ground
2	GAIN ADJUST	VCA Gain Adjust Pin. A resistor from this pin to ground sets the fixed gain of the VCA. To check the setting of this pin the compression pin (Pin 10) should be grounded for no compression. The gain can be varied from 0 dB to 20 dB. For 20 dB leave the pin open. For 0 dB of fixed gain, a typical resistor value is approximately 1 kΩ. For 10 dB of fixed gain, the resistor value is approximately 2 kΩ–3 kΩ. For resistor values < 1 kΩ, the VCA can attenuate or mute. Refer to Figure 6.
3	VCA_{IN}	VCA Input Pin. A typical connection is a 10 µF capacitor from the buffer output pin (Pin 5) to this pin.
4	VCA_R	Inverting Input to the VCA. This input can be used as a nonground reference for the audio input signal (see application notes).
5	BUF OUT	Input Buffer Amplifier Output Pin. Must not be loaded by capacitance to ground.
6	–IN	Inverting Input to the Buffer. A 10 kΩ feedback resistor R1 from the buffer output Pin 5 to this input pin, and a resistor R2, from this pin through a 1 µF to ground gives gains of 6 dB to 20 dB for R2 = 10 kΩ to 1.1 kΩ.
7	AUDIO +IN	Input Audio Signal. The input signal should be ac-coupled (0.1 µF typical) into this pin.
8	AVG CAP	Detector Averaging Capacitor. A capacitor, 2.2 µF–22 µF, to ground from this pin is the averaging capacitor for the detector circuit.
9	NOISE GATE SET	Noise Gate Threshold Set Point. A resistor to V+ sets the level below which input signals are downward-expanded. For a 0.7 mV threshold, the resistor value is approximately 380 kΩ. Increasing the resistor value reduces the threshold. See Figure 4.
10	COMP RATIO SET	Compression Ratio Set Pin. A resistor to ground from this pin sets the compression ratio as shown in Figure 1. Figure 5 gives resistor values for various rotation points.
11	ROTATION SET	Rotation Point Set Pin. This is set by a resistor to the positive supply. This resistor together with the gain adjust pin determines the onset of limiting. A typical value for this resistor is 17K for a 100 mV "rotation point." Increasing the resistor value reduces the level at which limiting occurs. Refer to Figure 9.
12	POWER DOWN	Power-Down Pin. Connect to ground for normal operation. Connect to positive supply for power-down mode.
13	OUTPUT	Output Signal.
14	V+	Positive Supply, +5 V Nominal.

PIN CONFIGURATION



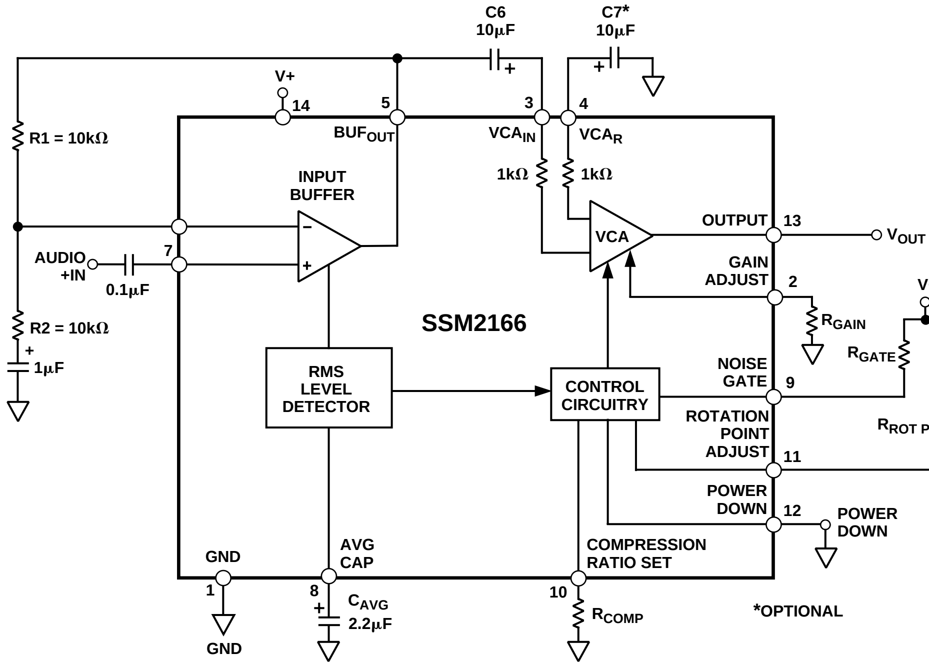


Figure 14. Functional Block Diagram and Typical Application

bandwidth is unaffected). The GBW plots are shown in Figure 10b. The lower 3 dB cutoff frequency of the SSM2166 is set by the input impedance of the VCA (1 kΩ) and C6. While the noise of the input buffer is fixed, the input referred noise of the VCA is a function of gain. The VCA input noise is designed to be a minimum when the gain is at a maximum, thereby optimizing the usable dynamic range of the part. A photograph of the SSM2166's wideband peak-to-peak output noise is illustrated in Figure 10b.

The Level Detector

The SSM2166 incorporates a full-wave rectifier and a patent-pending, true rms level detector circuit whose averaging time constant is set by an external capacitor connected to the AVG CAP pin (Pin 8). For optimal low frequency operation of the level detector down to 10 Hz, the value of the capacitor should be 2.2 µF. Some experimentation with larger values for the AVG CAP may be necessary to reduce the effects of excessive low frequency ambient background noise. The value of the averaging capacitor affects sound quality: too small a value for this capacitor may cause a "pumping effect" for some signals, while too large a value can result in slow response times to signal dynamics. Electrolytic capacitors are recommended here for lowest cost and should be in the range of 2 µF to 47 µF. Capacitor values from 18 µF to 22 µF have been found to be more appropriate in voiceband applications, where capacitors on the low end of the range seem more appropriate for music program material.

The rms detector filter time constant is approximately given by 10•C_{AVG} milliseconds where C_{AVG} is in µF. This time constant controls both the steady-state averaging in the rms detector as well as the release time for compression; that is, the time it takes for the system gain to react when a large input is followed by a small signal. The attack time, the time it takes for the gain to be reduced when a small signal is followed by a large signal, is controlled partly by the AVG CAP value, but is mainly controlled by internal circuitry that speeds up the attack for large level changes. This limits overload time to under 1 ms in most cases.

The performance of the rms level detector is illustrated in Figure 15 for a C_{AVG} of 2.2 µF (Figure 15a) and 22 µF (Figure 15b). In each of these photographs, the input signal to the SSM2166 (not shown) is a series of tone bursts in 6 successive 10 dB steps. The tone bursts range from –66 dBV (0.5 mV rms) to –6 dBV (0.5 V rms). As illustrated in the photographs, the attack time of the rms level detector is dependent only on C_{AVG}, but the release times are linear ramps whose decay times are dependent on both C_{AVG} and the input signal step size. The rate of release is approximately 240 dB/s for a C_{AVG} of 2.2 µF, and 12 dB/s for a C_{AVG} of 22 µF.

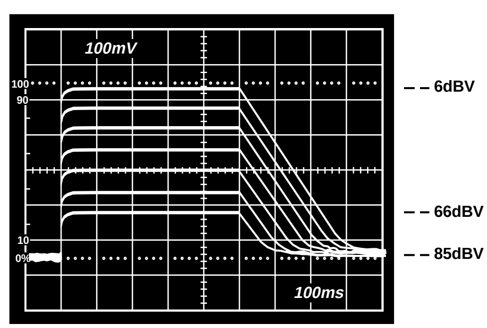


Figure 15a. RMS Level Detector Performance with C_{AVG} = 2.2 µF