MIC7201

GainBlock™ Difference Amplifier

Preliminary Information

General Description

The MIC7201 difference amplifier is an analog gain block designed to convert a differential signal to a signal-ended signal. It features an extended common-mode range that includes rail-to-rail input/output capabilities. The part is packaged in the SOT-23-5 IttyBitty™ package.

The MIC7201 is designed using the MIC7101 operational amplifier plus well-matched monolithic resistors to provide a unity-gain stable differential input to signal-ended output amplifier that requires a minimum of external components. Performance is guaranteed from 2.2V through 10V.

Features

- Operates from 2.2V to 10V
- ±1% typical gain error
- 0.6mA typical supply current at 2.2V
- 400kHz bandwidth
- Small SOT-23-5 package
- Suitable for driving capacitive loads

Applications

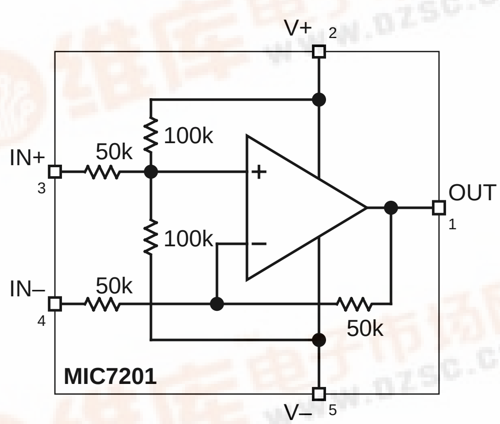
- Cellular telephones
- Digital audio systems
- Mobile communications
- Portable computers and PDAs

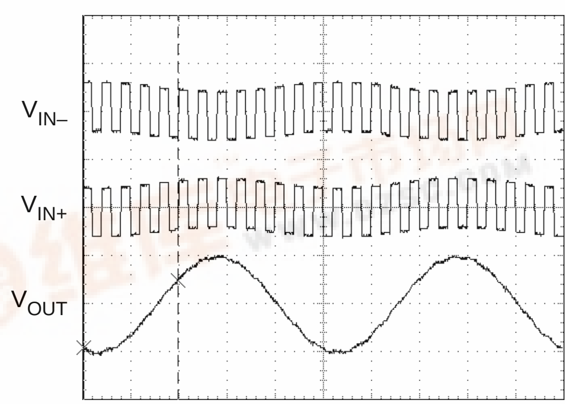
Ordering Information

Part Number	Temperature Range	Package
MIC7201BM5	–40°C to +85°C	SOT-23-5

Other voltages available. Contact Micrel for details.

Block Diagram





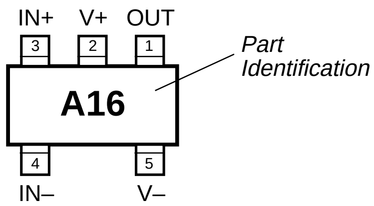
Difference Amplifier Behavior

The desired 100mV, 400Hz differential sinusoidal signal is shown applied to inputs V_{IN-} and V_{IN+}. A 500mV, 5kHz square-wave "noise" signal is superimposed on both V_{IN-} and V_{IN+}.

These signals demonstrate the noise cancellation ability of the MIC7201. The output (V_{OUT}) shows the recovered single-ended 200mV peak-to-peak, 400Hz sine wave.

GainBlock is a trademark of Micrel, Inc.

Pin Configuration



SOT-23-5

Pin Description

Pin Number	Pin Name	Pin Function
1	OUT	Amplifier Output: Single-ended output.
2	V+	Positive Supply: Positive power supply input.
3	IN+	Noniverting Input: In-phase differential input.
4	IN–	Inverting Input: Out-of-phase differential input.
5	V–	Ground: Power supply ground return.

Absolute Maximum Ratings (Note 1)

Supply Voltage (V_{V+}–$V_{V–}$) 12V
Differential Input Voltage (V_{V+}–$V_{V–}$) .... ±(V_{V+}–$V_{V–}$)
I/O Pin Voltage (V_{IN}, V_{OUT}), **Note 2**
.... $V_{V–}$–0.3V to V_{V+}+0.3V
Junction Temperature (T_J) .... +150°C
Storage Temperature (T_S) .... –65°C to +150°C
Lead Temperature (soldering, 10 sec.) .... 260°C
ESD, **Note 5** 2kV

Operating Ratings (Note 1)

Supply Voltage (V_{V+}–$V_{V–}$) .... +2.2V to +10V
Input Voltage (V_{IN+}, $V_{IN–}$) .... $V_{V–}$ to V_{V+}
Continuous Output Current .... ±15mA
Junction Temperature (T_J) .... –40°C to +85°C
Max. Junction Temperature ($T_{J(max)}$), **Note 3** .... +85°C
Package Thermal Resistance (θ_{JA}), **Note 4** .... 325°C/W
Max. Power Dissipation .... **Note 3**

Electrical Characteristics (2.2V)

V_{V+} = 2.2V, $V_{V–}$ = 0V, V_{CM} = V_{OUT} = V+/2; R_L = 1MΩ; T_J = 25°C, **bold** values indicate –40°C ≤ T_J ≤ +85°C; unless noted

Symbol	Parameter	Condition	Min	Typ	Max	Units
E_Z	Zero Error	$E_Z = \lvert V_{OUT} - V_{V+}/2 \rvert$		9	44	mV
TCV_{OS}	Input Offset Voltage Temp. Drift			14		µV/°C
R_{IN}	Input Resistance		35	50	65	kΩ
CMRR	Common-mode Rejection Ratio	V_{CM} = 0V to V_{V+}		65		dB
±PSRR	Split-Supply Rejection Ratio	$V_{V+} = \lvert V_{V-} \rvert$ = 1.1V to 2.5V, V_{CM} = 0V		50		dB
+PSRR	Single-Supply Rejection Ratio, **Note 8**	V_{V+} = 2.2V to 5V, $V_{V–}$ = 0V, V_{CM} = 1.1V		6		dB
E_G	Gain Error, **Note 9**	0.2V ≤ V_{OUT} ≤ 2.0V		±1		%
V_{OUT}	Output Voltage Swing **Note 10**	output high, R_L = 2k, specified as $V_{V+} - V_{OUT}$		10	33 **50**	mV mV
		output low, R_L = 2k		10	33 **50**	mV mV
		output high, R_L = 600Ω, specified as $V_{V+} - V_{OUT}$		33		mV mV
		output low, R_L = 600Ω		33		mV mV
I_{SC}	Output Short-Circuit Current	sinking or sourcing, **Note 6**, **Note 7**	20	60		mA
BW	Bandwidth	–3dB point		400		kHz
SR	Slew Rate			0.5		V/µs
THD	Total Harmonic Distortion	f = 1kHz f = 10kHz		0.02 0.02		% %
e_n	Input Referred Voltage Noise	f = 1kHz		30		$nV/\sqrt{Hz}$
I_S	Supply Current	no load		0.6	2.0	mA

Electrical Characteristics (5V)

V_{V+} = +5V, V_{V-} = 0V, V_{CM} = V_{OUT} = V+/2; R_L = 1MΩ; T_J = 25°C, **bold** values indicate –40°C ≤ T_J ≤ +85°C; unless noted

Symbol	Parameter	Condition	Min	Typ	Max	Units
E_Z	Zero Error	$E_Z = \lvert V_{OUT} - V_{V+}/2 \rvert$		26	100	mV
TCV_{OS}	Input Offset Voltage Temp. Drift			14		µV/°C
R_{IN}	Input Resistance		35	50	65	kΩ
CMRR	Common-Mode Rejection Ratio	V_{CM} = 0V to V_{V+}		65		dB
±PSRR	Split-Supply Rejection Ratio	$V_{V+} = \lvert V_{V-} \rvert$ = 2.5V to 5V, V_{CM} = 0V		50		dB
+PSRR	Single-Supply Rejection Ratio, **Note 8**	V_{V+} = 5V to 10V, V_{V-} = 0V, V_{CM} = 2.5V		6		dB
E_G	Gain Error, **Note 9**	0.5V ≤ V_{OUT} ≤ 4.5V		±1		%
V_{OUT}	Output Voltage Swing **Note 10**	output high, R_L = 2k, specified as $V_{V+} - V_{OUT}$		15	50 **75**	mV mV
		output low, R_L = 2k		15	50 **75**	mV mV
		output high, R_L = 600Ω, specified as $V_{V+} - V_{OUT}$		50		mV mV
		output low, R_L = 600Ω		50		mV mV
I_{SC}	Output Short-Circuit Current	sinking or sourcing, **Note 6**, **Note 7**	40	110		mA
BW	Bandwidth	–3dB point		250		kHz
SR	Slew Rate			0.5		V/µs
THD	Total Harmonic Distortion	f = 1kHz f = 10kHz		0.02 0.02		% %
e_n	Input Referred Voltage Noise	f = 1kHz		30		$nV/\sqrt{Hz}$
I_S	Supply Current	no load		0.8	2.8	mA

Electrical Characteristics (10V)

V_{V+} = 10V, V_{V-} = 0V, V_{CM} = V_{OUT} = V+/2; R_L = 1MΩ; T_J = 25°C, **bold** values indicate –40°C ≤ T_J ≤ +85°C; unless noted

Symbol	Parameter	Condition	Min	Typ	Max	Units
E_Z	Zero Error	$E_Z = \lvert V_{OUT} - V_{V+}/2 \rvert$		60	200	mV
TCV_{OS}	Input Offset Voltage Temp. Drift			14		µV/°C
R_{IN}	Input Resistance		35	50	65	kΩ
CMRR	Common-Mode Rejection Ratio	V_{CM} = 0V to V_{V+}		65		dB
±PSRR	Split-Supply Rejection Ratio	$V_{V+} = \lvert V_{V-} \rvert$ = 2.5V to 5V, V_{CM} = 0V		50		dB
+PSRR	Single-Supply Rejection Ratio, **Note 8**	V_{V+} = 5V to 10V, V_{V-} = 0V, V_{CM} = 2.5V		6		dB
E_G	Gain Error, **Note 9**	0.5V ≤ V_{OUT} ≤ 9.5V		±1		%

Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{OUT}	Output Voltage Swing **Note 10**	output high, R_L = 2k, specified as $V_{V+} – V_{OUT}$		24	80 **120**	mV mV
		output low, R_L = 2k		24	80 **120**	mV mV
		output high, R_L = 600Ω, specified as $V_{V+} – V_{OUT}$		80		mV mV
		output low, R_L = 600Ω		80		mV mV
I_{SC}	Output Short-Circuit Current	sinking or sourcing, **Note 6**, **Note 7**	40	200		mA
BW	Bandwidth	–3dB point		250		kHz
SR	Slew Rate			0.5		V/µs
THD	Total Harmonic Distortion	f = 1kHz f = 10kHz		0.02 0.02		% %
e_n	Input Referred Voltage Noise	f = 1kHz		30		$nV/\sqrt{Hz}$
I_S	Supply Current	no load		1.2	4.0	mA

Internal Op Amp Typical Characteristics

+2.2V ≤ V_{V+} ≤ 10V, $V_{V–}$ = 0V, $V_{CM} = V_{OUT}$ = V+/2; R_L = 1MΩ; T_J = 25°C, **bold** values indicate –40°C ≤ T_J ≤ +85°C; unless noted

Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{OS}	Input Offset Voltage			0.11		mV
TCV_{OS}	Input Offset Voltage Drift			1.0		µV/°C
I_B	Input Bias Current			1.0		pA
I_{OS}	Input Offset Current			0.5		pA
R_{IN}	Input Resistance			>1		TΩ
CMRR	Common-Mode Rejection Ratio	0V ≤ V_{CM} ≤ V_{V+}		80		dB
V_{CM}	Input Common-Mode Voltage	input low		–0.3		V
		input high		V_{V+}+0.3		V
PSRR	Power Supply Rejection Ratio	$V_{V+} = \lvert V_{V–} \rvert$ = 1.1V to 1.65V, V_{CM} = 0V		60		dB

General Note: Devices are ESD protected; however, handling precautions are recommended. All limits guaranteed by testing or statistical analysis.

Note 1: Absolute maximum ratings indicate limits beyond which damage to the component may occur. Electrical specifications do not apply when operating the device outside its recommended operating ratings.

Note 2: I/O pin voltage is any external voltage to which an input or output is referenced.

Note 3: The maximum allowable power dissipation is a function of the maximum junction temperature, $T_{J(max)}$; the junction-to-ambient thermal resistance, θ_{JA}; and the ambient temperature, T_A. The maximum allowable power dissipation at any ambient temperature is calculated using: $P_D = (T_{J(max)} – T_A) / \theta_{JA}$. Exceeding the maximum allowable power dissipation will result in excessive die temperature.

Note 4: Thermal resistance, θ_{JA}, applies to a part soldered on a printed-circuit board.

Note 5: Human body model, 1.5k in series with 100pF.

Note 6: Short circuit may cause the device to exceed maximum allowable power dissipation. See **Note 3**.

Note 7: Shorting V_{OUT} to V+ when V+ > 10V may damage the device.

Note 8: Limited by internal bias-network resistors. Power supply must be "clean." Power supply should be bypassed as shown in typical application circuit.

Note 9: The gain error specification applies to differential, inverting, and noninverting gains.

Note 10: Since the part is specified in a single-supply configuration, the output load (R_L) is a Thevenin equivalent value. The actual load consists of 2 × R_L to ground and 2 × R_L to the supply (V+).

Applications Information

Input Common Mode Voltage

The MIC7201 tolerates overdriving the inputs by at least 300mV beyond either rail without producing phase inversion. If the absolute maximum input voltage is exceeded, the input current should be limited to ±5mA to prevent reducing reliability. A 10kΩ series input resistor, used as a current limiter will protect the input structure from voltages as large as 50V above the supply or below ground.

Output Voltage Swing

Output resistance of the MIC7201 is symmetric; sink and source output resistances are equal. Output voltage swing is determined by the load and, given the approximate output resistance, which may be readily calculated with the following formula:

$$R_{OUT} \approx \frac{V_{DROP}}{I_{LOAD}}$$

V_{DROP} is the voltage dropped within the amplifier output stage. V_{DROP} and I_{LOAD} can be determined from the V_{OUT} (output swing) portion of the appropriate Electrical Characteristics table. I_{LOAD} is equal to the typical output high voltage minus V+/2 and divided by R_{LOAD}. For example, using the Electrical Characteristics DC (5V) table, the typical output voltage drop using a 2kΩ load (connected to V+/2) is 0.015V, which produces an I_{LOAD} of (2.5V – 0.015V) / 2kΩ ≈ 1.243mA.

Then:

$$R_{OUT} = \frac{15mV}{1.243mA} = 12.1 \approx 12\Omega$$

Driving Capacitive Loads

Driving a capacitive load introduces phase-lag into the output signal, and this in turn reduces system phase margin. The application that is least forgiving of reduced phase margin is a unity gain amplifier. The MIC7201 typically can drive a 500pF capacitive load connected directly to its output.

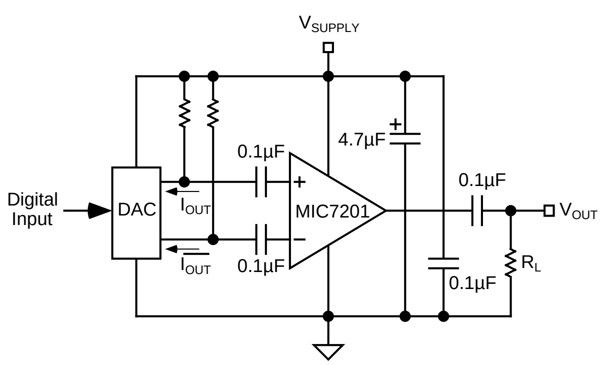


Figure 1. Audio DAC

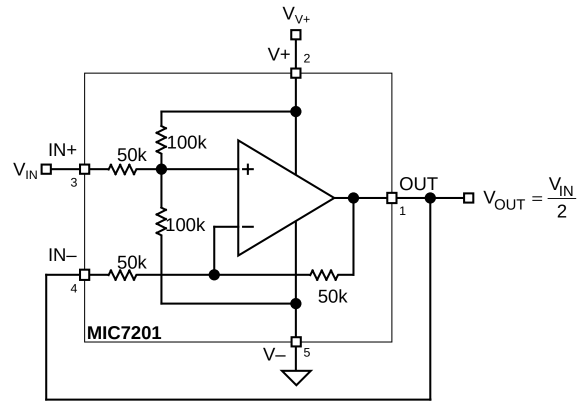


Figure 2. Gain of One-Half

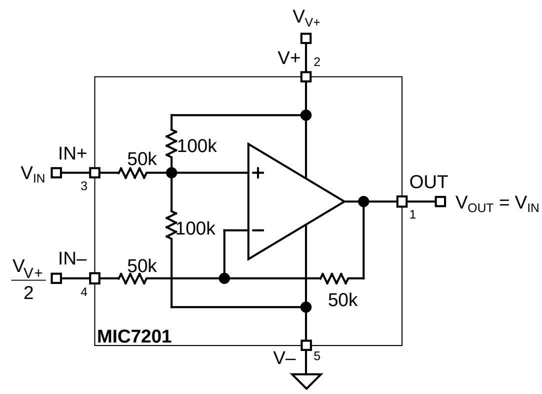


Figure 3. Voltage Follower

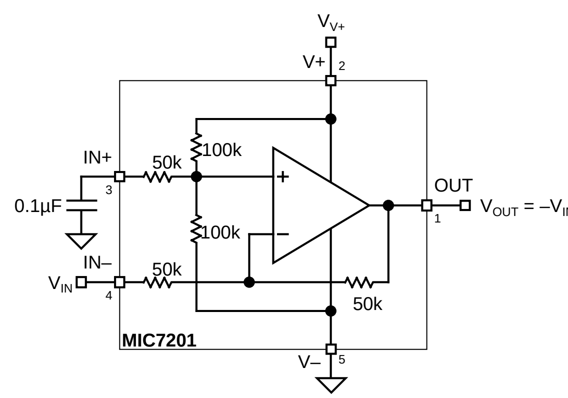


Figure 4. Inverting Unity Gain

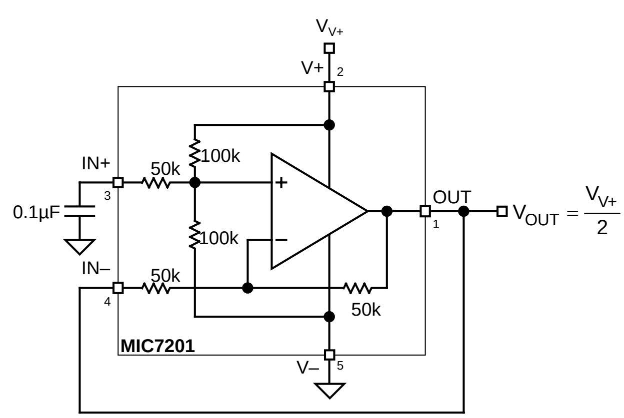
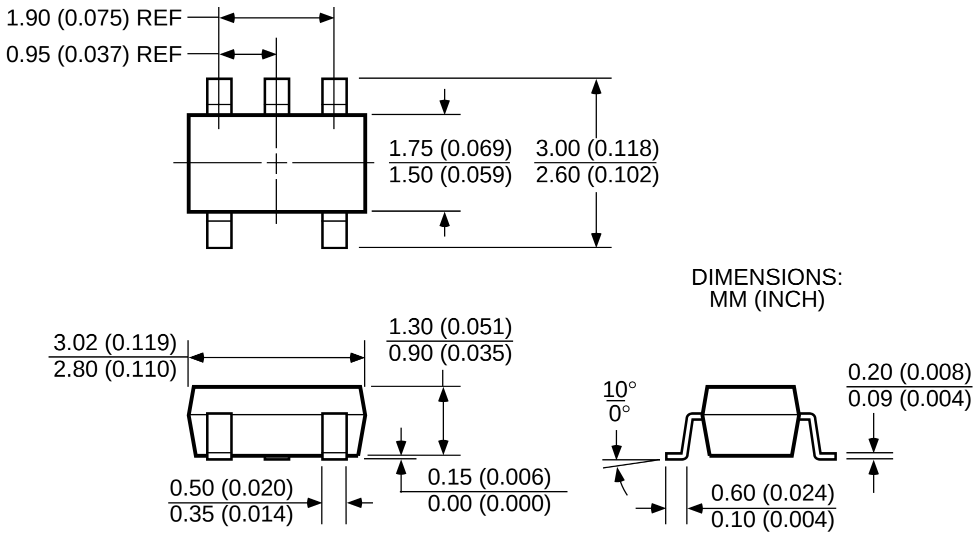


Figure 5. Virtual Ground Generator

Package Information



SOT-23-5 (M5)

MICREL INC. 1849 FORTUNE DRIVE SAN JOSE, CA 95131 USA
TEL + 1 (408) 944-0800 FAX + 1 (408) 944-0970 WEB http://www.micrel.com