MIC864

Dual 350kHz Rail-to-Rail Operational Amplifier

General Description

The MIC864 is a dual operational amplifier offering small-size, low-power consumption (33µA/channel typical), 'greater-than-the-rails' input capability, and output range to within 15mV of the supply rails. The MIC864 can be operated with a single supply of +2.5V to +5.5V or a dual-supply of ±1.25V to ±2.75V, and features an excellent speed/power ratio with a gain bandwidth product of 350kHz.

The MIC864 was designed with input stage transconductance normalization, making it immune to common-mode rejection ratio (CMRR) and power supply rejection ratio (PSRR) degradation across the input voltage range. This feature makes the MIC864 superior to some earlier operational amplifiers, in which a region of the input voltage range was subject to degraded performance.

The MIC864 is available with an industry standard pin configuration in an 8-pin SOIC package, as well as a low profile extra-thin (XTDFN) package and is specified to operate from –40°C to +125°C junction temperature.

Data sheets and support documentation can be found on Micrel's web site at: www.micrel.com.

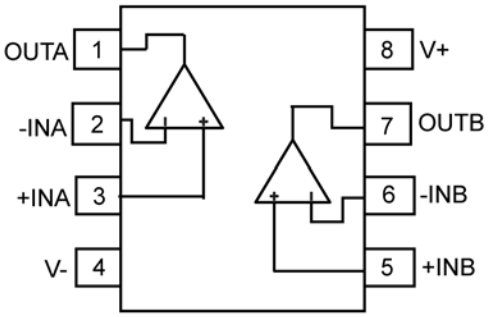
Features

- 2.5V to 5.5V single or ±1.25V to ±2.75V dual supply voltage
- 33µA per channel quiescent current
- 350kHz gain bandwidth product
- 0.2V/µs slew rate
- 18mA output drive capability (sink or source)
- 200mV greater-than-the-rails input capability
- Rail-to-rail output (within 15mV)
- 80dB common mode rejection ratio (CMRR)
- 80dB power supply rejection ratio (PSRR)
- 8-pin SOIC package
- 10-pin 2.5mm x 2.5mm x 0.4mm XTDFN package

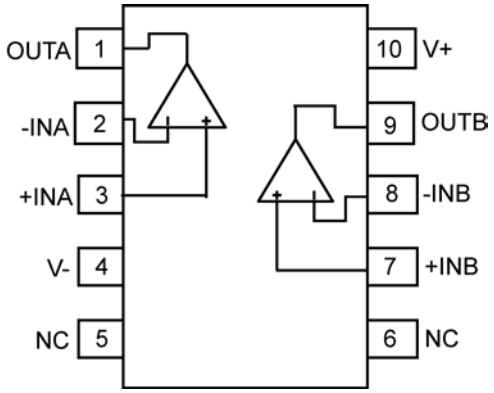
Applications

- Battery-powered equipment
- Cellular phone PA biasing circuits
- Carbon monoxide detectors
- Smoke detectors

Pin Configuration



MIC864 8-Pin SOIC (M)
(Top View)



MIC864 10-Pin 2.5mm x 2.5mm XTDFN (MX)
(Top View)

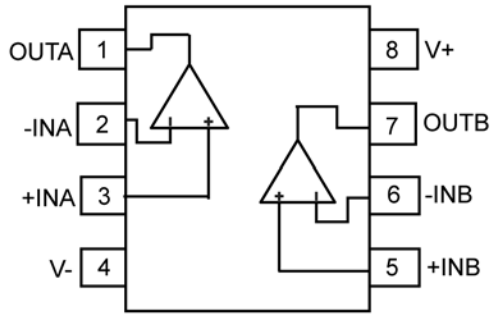
Ordering Information

Part Number	Marking	Junction Temperature Range	Package
MIC864YM	864YM	–40°C to +125°C	8-Pin SOIC
MIC864YMX	864	–40°C to +125°C	10-Pin Extra Thin DFN (2.5mm x 2.5mm x 0.4mm)[1]

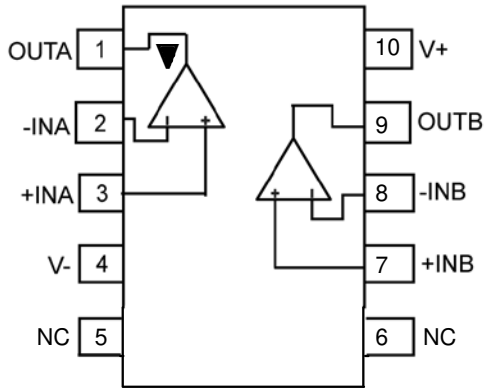
Note:

1. Extra Thin DFN package pin 1 identifier = ▼.

Pin Configuration



8-Pin SOIC (M)
(Top View)



10-Pin 2.5mm x 2.5mm XTDFN (MX)
(Top View)

Pin Description

Pin Number SOIC	Pin Number XTDFN	Pin Name	Pin Function
1	1	OUTA	Output of operational amplifier A.
2	2	–INA	Inverting input of operational amplifier A.
3	3	+INA	Non-inverting input of operational amplifier A.
4	4	V–	Negative Power Supply Connection. Connect to GND for single supply operation.
5	7	+INB	Non-inverting input of operational amplifier B.
6	8	–INB	Inverting input of operational amplifier B.
7	9	OUTB	Output of operational amplifier B.
8	10	V+	Positive Power Supply Input. Connect a 0.1µF ceramic bypass capacitor from V+ to V–, placed within 0.2in (5mm) of the MIC864.
-	5, 6	NC	Not internally connected, leave unconnected.
-	EP	ePad	Heatsink pad, connect to GND for best thermal performance.

Absolute Maximum Ratings[2]

Supply Voltage (V+ to V–) ..... +6.0V
Differential Input Voltage ($|V_{+IN} - V_{-IN}|$) ..... +6.0V
Input Voltage (V_{+IN}, $V_{–IN}$) ..... (V+) + 0.2V, (V–) – 0.2V
Output Short-Circuit Duration ..... Continuous
Lead Temperature (soldering, 10s) ..... 260°C
Storage Temperature (T_S) ..... –65°C to +150°C
Junction Temperature (T_J) ..... –40°C to +150°C
ESD Rating[4] ..... ESD Sensitive

Operating Ratings[3]

Supply Voltage (V+ to V–) ..... +2.5V to +5.5V
Differential Input Voltage ($|V_{+IN} - V_{-IN_}|$) ..... +2.5V to +5.5V
Input Voltage (V_{+IN}, $V_{–IN)}$ ..... (V+) + 0.2V, (V–) – 0.2V
Ambient Temperature (T_A) ..... –40°C to +125°C
Package Thermal Resistance
SOIC-8 (θ_{JA}) ..... 99°C/W
2.5mm x 2.5mm XTDF-10 (θ_{JA}) ..... 73°C/W

Electrical Characteristics[5]

V+ = +2.5V, V– = –2.5V, V_{CM} = ((V+) – (V-))/2; R_L = 100kΩ connected to ((V+) – (V–))/2; T_J = +25°C, unless otherwise noted.
Bold values indicate –40°C ≤ T_J ≤ +125°C.

Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
V_{OS}	Input Offset Voltage			2	**8**	mV
	Input Offset Voltage Temperature Coefficient			4		µV/°C
I_B	Input Bias Current			±2.5	±20	pA
I_{OS}	Input Offset Current			±0.5	±15	pA
V_{CM}	Input Voltage Range		(V–) – 0.2		(V+) + 0.2	V
CMRR	Common-Mode Rejection Ratio	(V–) – 0.2V < V_{CM} < (V+) + 0.2V	54	80		dB
PSRR	Power Supply Rejection Ratio	2.5 < V_S < 5.25V		80		dB
A_{VOL}	Large-Signal Voltage Gain	C_L = 100pF, R_L = 100kΩ		80		dB
V_{OUT}	Maximum Output Voltage Swing	R_L = 100kΩ	**(V–) + 0.015**		**(V+) – 0.015**	V
		R_L = 5kΩ	**(V–) + 0.125**		**(V+) – 0.125**	
GBW	Gain-Bandwidth Product	C_L = 100pF, R_L = 100kΩ		350		kHz
SR	Slew Rate	A_V = 1, C_L = 100pF, R_L = 100kΩ		0.2		V/µs
I_{SC}	Short-Circuit Output Current	Source, RL connected to V–		23		mA
		Sink, R_L connected to V+		15		
I_S	Supply Current per Amplifier	No Load		33	**50**	µA

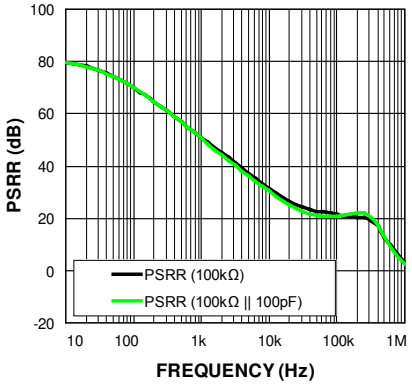
Notes:

2. Exceeding the absolute maximum rating may damage the device.
3. The device is not guaranteed to function outside its operating rating.
4. Devices are ESD Sensitive. Handling precautions recommended. Human body model, 1.5kΩ in series with 100pF.
5. Specification for packaged product only.

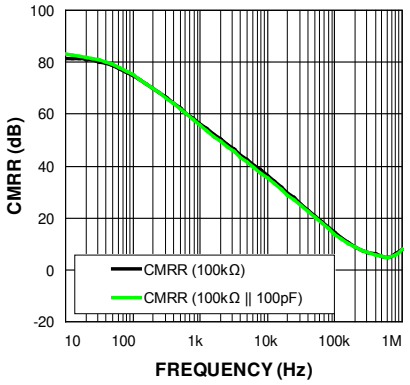
Typical Characteristics

V+ = V_S/2 = 2.5V, V– = –V_S/2 = –2.5V, R_L = 100kΩ , R_L and C_L connected in parallel to GND; T_A = +25°C, unless otherwise noted.

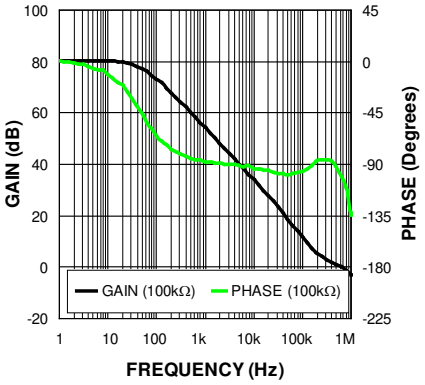
PSRR vs. Frequency



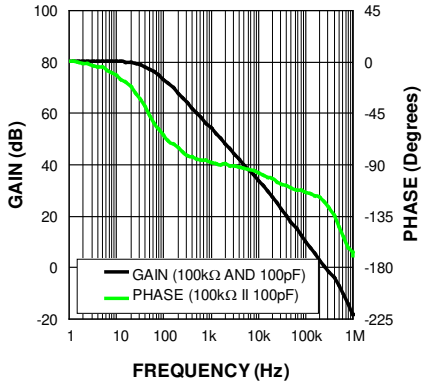
CMRR vs. Frequency



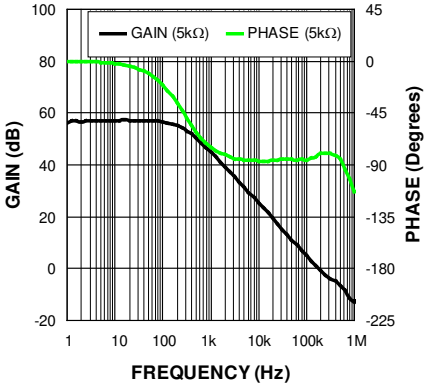
Open-Loop Gain and Phase vs. Frequency



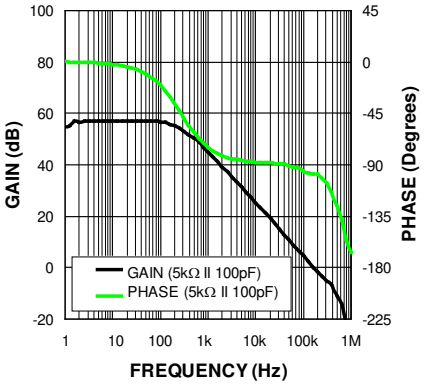
Open-Loop Gain and Phase vs. Frequency



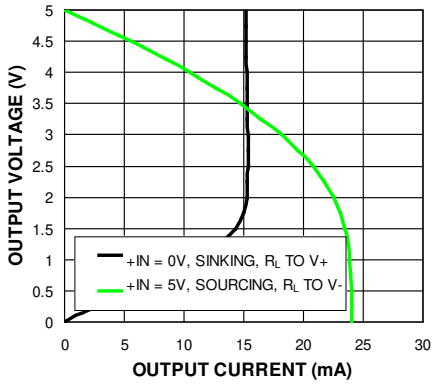
Open-Loop Gain and Phase vs. Frequency



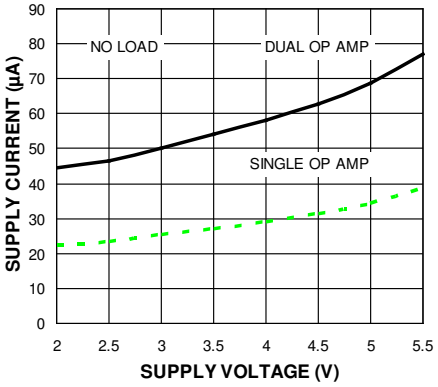
Open-Loop Gain and Phase vs. Frequency



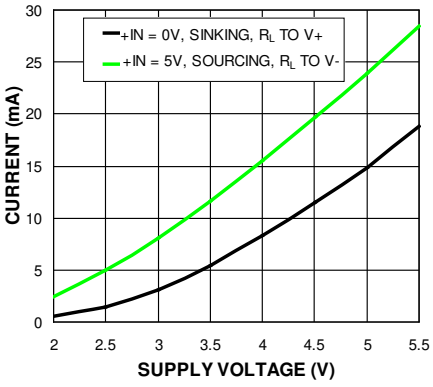
Output Voltage Swing vs. Output Current



Supply Current vs. Supply Voltage



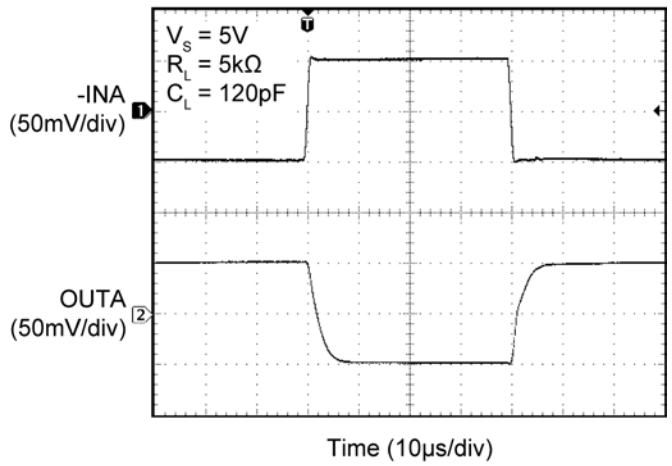
Short Circuit Current vs. Supply Voltage



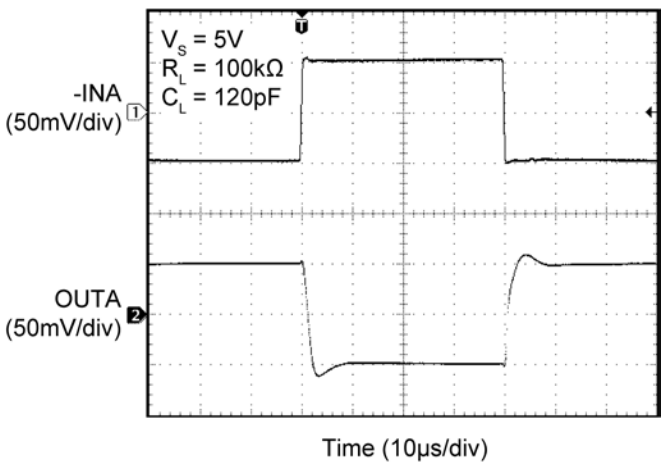
Functional Characteristics

V+ = V_S/2 = 2.5V, V– = -V_S/2 = 2.5V, R_L = 100kΩ , R_L and C_L connected in parallel to GND; T_A = +25°C, unless otherwise noted.

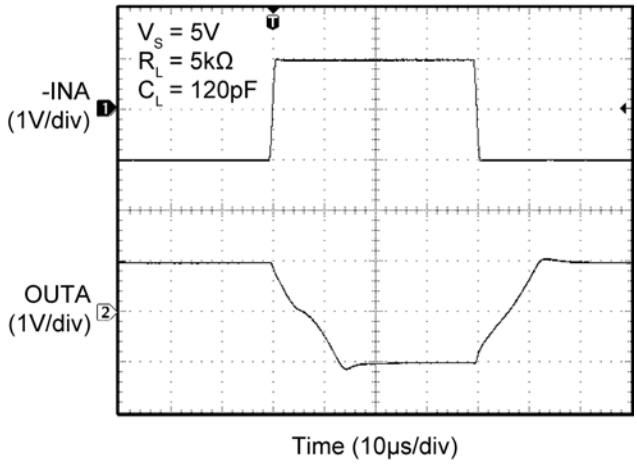
Small Signal Step Response (Inverting)



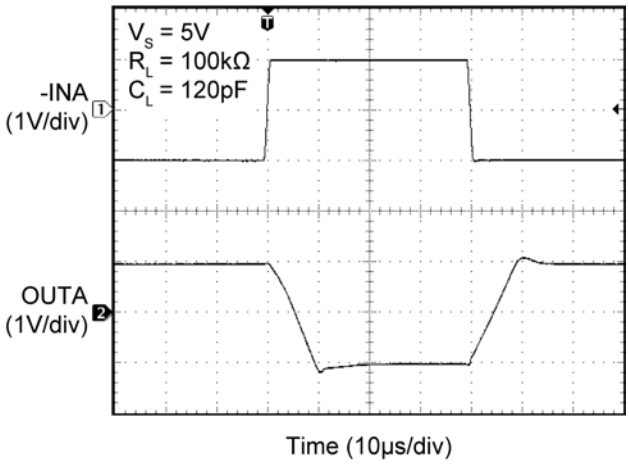
Small Signal Step Response (Inverting)



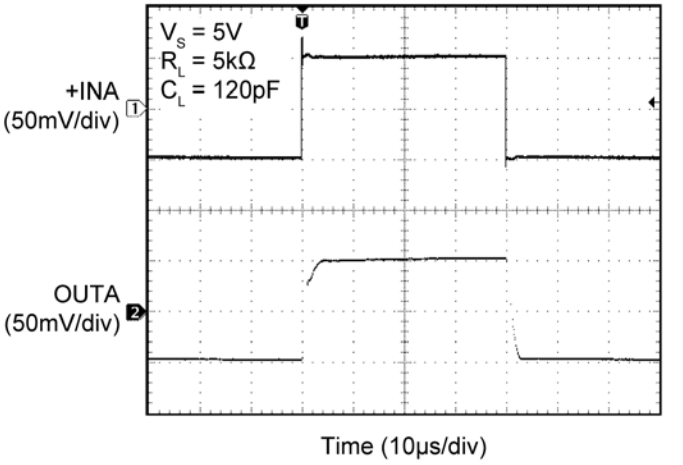
Large Signal Step Response (Inverting)



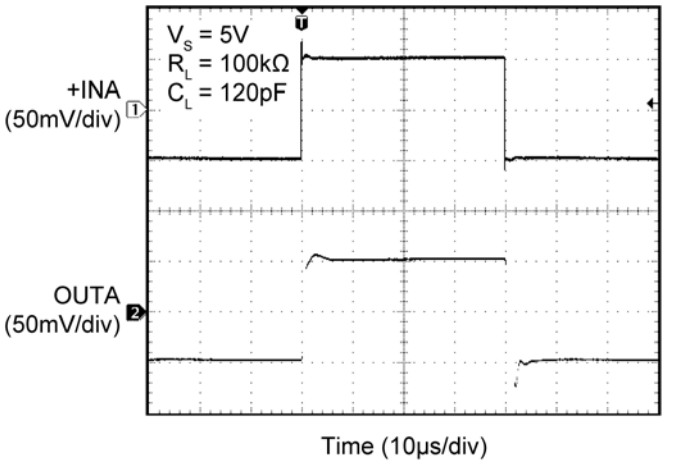
Large Signal Step Response (Inverting)



Small Signal Step Response (Non-Inverting)



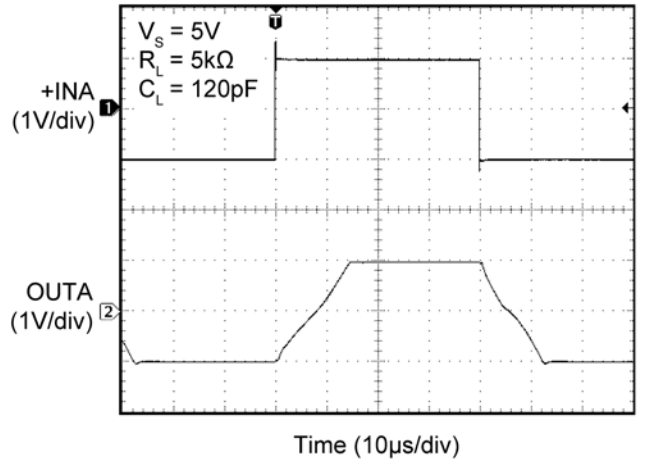
Small Signal Step Response (Non-Inverting)



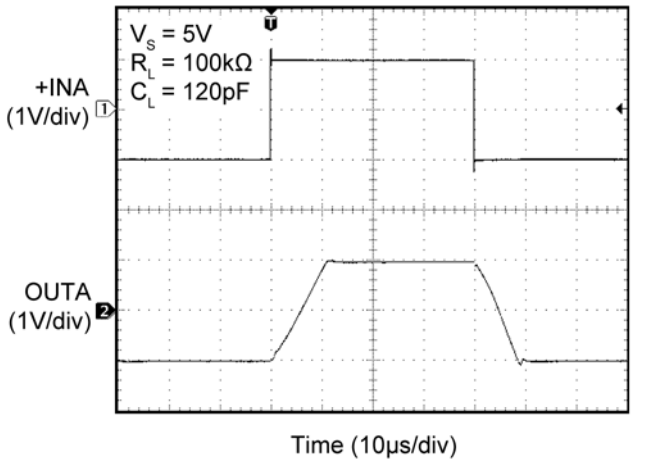
Functional Characteristics (Continued)

V+ = 5V, V– = -V_S/2 = 2.5V, R_L = 100kΩ , R_L and C_L connected in parallel to GND; T_A = +25°C, unless otherwise noted.

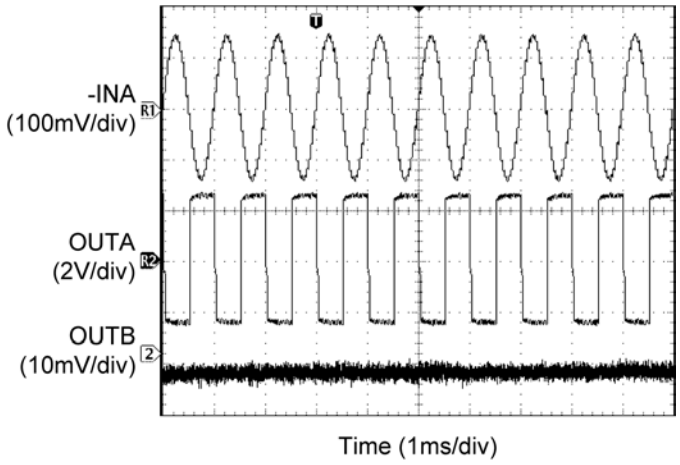
Large Signal Step Response (Non-Inverting)



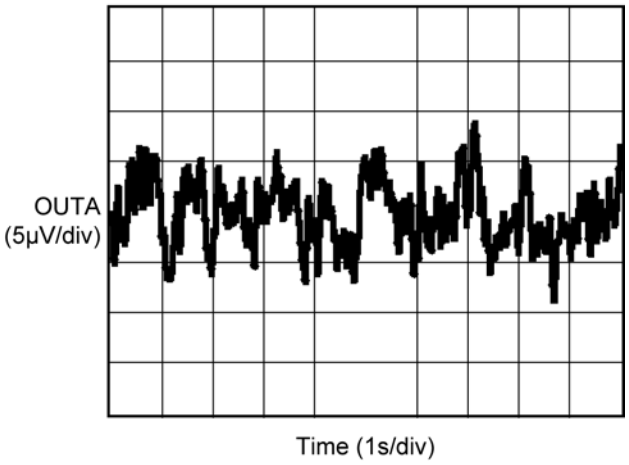
Large Signal Step Response (Non-Inverting)



Channel A – B Separation



0.1Hz to 10Hz Input Referred Voltage Noise



Functional Description

The MIC864 is a dual-operational amplifier with an input range 0.2V greater than the supply rails and an output range to within 15mV of the supply rails (100kΩ load). The MIC864 can be operated from a single from 2.5V to 5.25V supply or a dual ±1.25V to ±2.625V supply. It features a low 33µA quiescent current per channel with a gain bandwidth product of 350kHz.

Compared with other operational amplifiers in its class, the MIC864 offers dependable CMRR and PSRR. This is achieved through transconductance normalization, which ensures consistent performance across the entire input voltage range. This feature eliminates a region of the input voltage range where some earlier operational amplifiers were subject to degraded CMRR and PSRR.

Input Stage

The MIC864 uses parallel NFET and PFET differential input transistor pairs for a common-mode input voltage range beyond the supply rails. When input voltages are high, the NFET differential input pair operates. When input voltages are low, the PFET differential input pair operates.

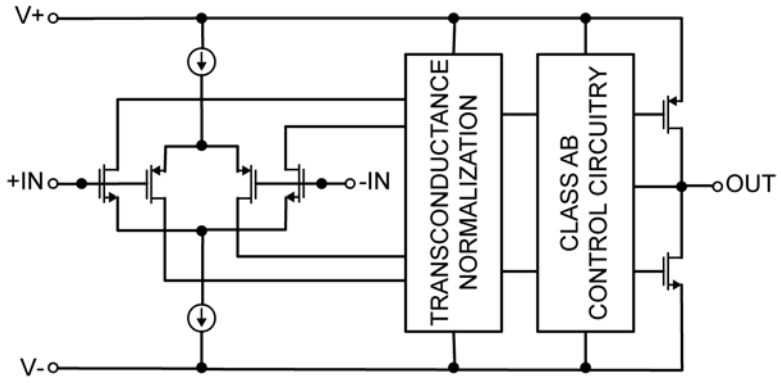
Transconductance Normalization

Hand-off between the NFET and PFET differential pairs is managed by the transconductance normalization circuit block. As the common-mode input voltage transitions between high and low voltages, this circuit block ensures smooth, consistent, and continuous operation.

Class AB Output Stage

Low output impedance is achieved by driving the common-emitter output stage with a class AB control circuit. In contrast with the common collector output stages of earlier operational amplifiers, this allows an output range very close to the supply rails.

Functional Diagram



MIC864 Block Diagram

Application Information

The MIC864 operational amplifier is optimized for portable applications such as cell phones, computer pads, media players, mobile chemical sensors, carbon monoxide detectors, and smoke detectors. A 2.5V to 5.25V supply voltage range allows operation from the regulated output of a lithium-ion battery. No-load supply current is 33µA per channel for long battery life. An input range 0.2V beyond the supply rails and an output range to within 15mV of the supply rails (100kΩ load) maximize dynamic range for improved signal to noise ratios in the application. High, consistent CMRR and PSRR minimize power supply noise coupling from adjacent circuitry.

Input protection

The IN- and IN+ inputs of the MIC864 are clamped to the V+ and V– pins using ESD protection diodes. Operation of IN+ or IN– beyond (V+) + 0.3V and (V–) – 0.3V is not recommended as this would turn on the ESD protection diodes and violates the Absolute Maximum Ratings.

Feedback

Feedback resistors in the 5kΩ and 100kΩ range are recommended. Load resistance and capacitance requirements must be considered when designing the feedback network, especially in unity-gain and low-gain circuits (see “Capacitive and Resistive Loads” section for further information).

When using high-value feedback resistors, place a low-value capacitor in parallel with the resistor connected between IN- and OUT. This capacitor counteracts the effects of the parasitic capacitance at the IN- pin which forms a pole that may otherwise degrade stability. However, a 68pF minimum load capacitance must be included to ensure stability.

When AC-coupling signals to the MIC864 through a capacitor, provide a DC-bias current path using a resistor. Otherwise, there will be no source for supplying the input bias current and the circuit will stop working.

Power Supply Bypassing

For single supply operation, connect a 0.1µF ceramic capacitor between the V+ and V– power supply pins. For dual supply operation, connect 0.1µF capacitors from V+ to GND and from GND to V–. Place these capacitors within 0.2in (5mm) of the MIC864. If no large-value capacitors are nearby then also include 10uF capacitors connected in similar fashion.

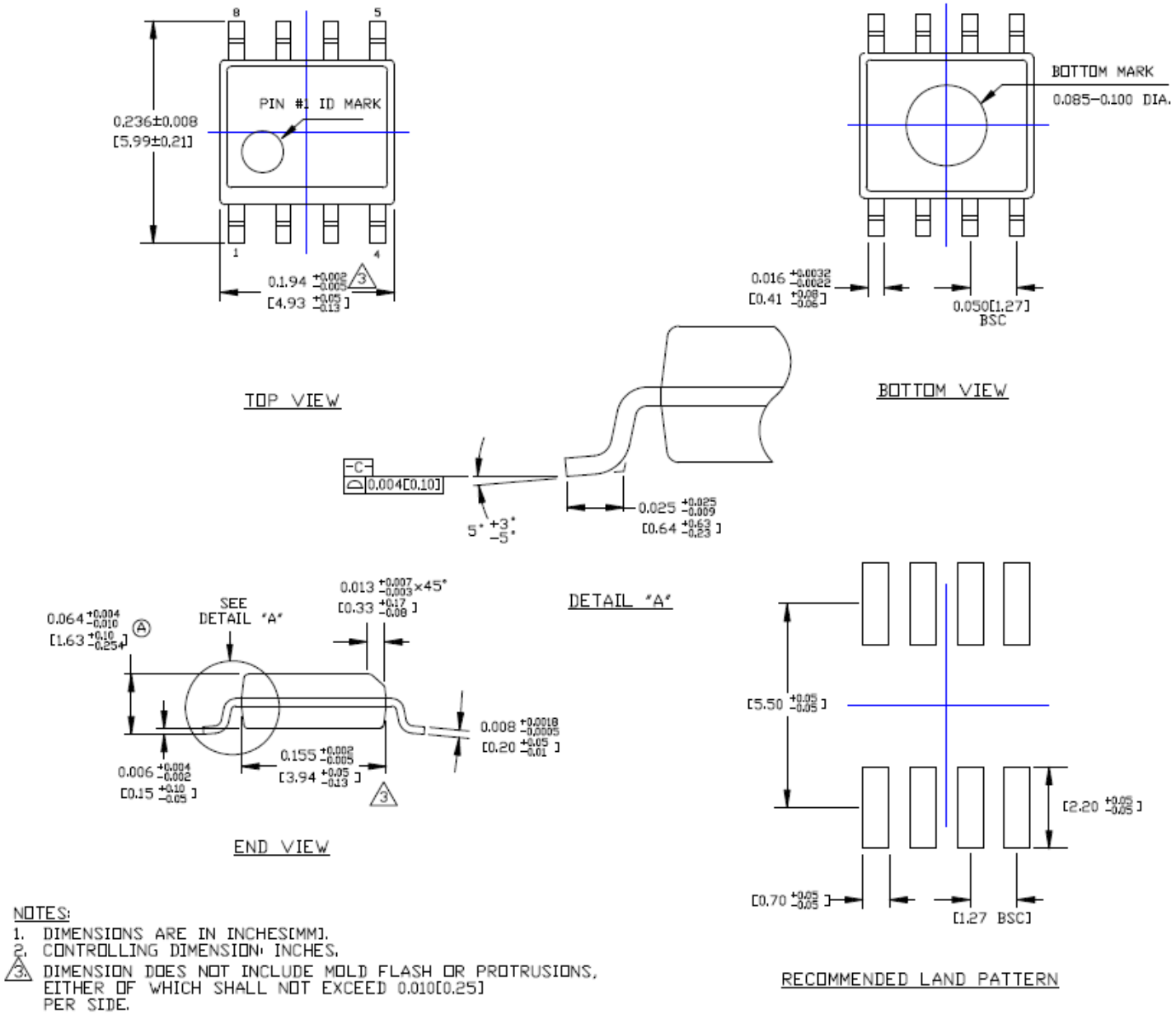
Capacitive and Resistive Loads

The MIC864 is internally compensated for unity-gain stability with load resistances between 5kΩ and 100kΩ, and a 100pF load capacitance. A 68pF minimum load capacitance is required to ensure unity-gain stability across production and temperature variations. Care should be taken to observe the minimum load capacitance requirement in circuits with a gain less than 2, and in circuits with a capacitor connected between the IN- and OUT pins.

Driving ADCs

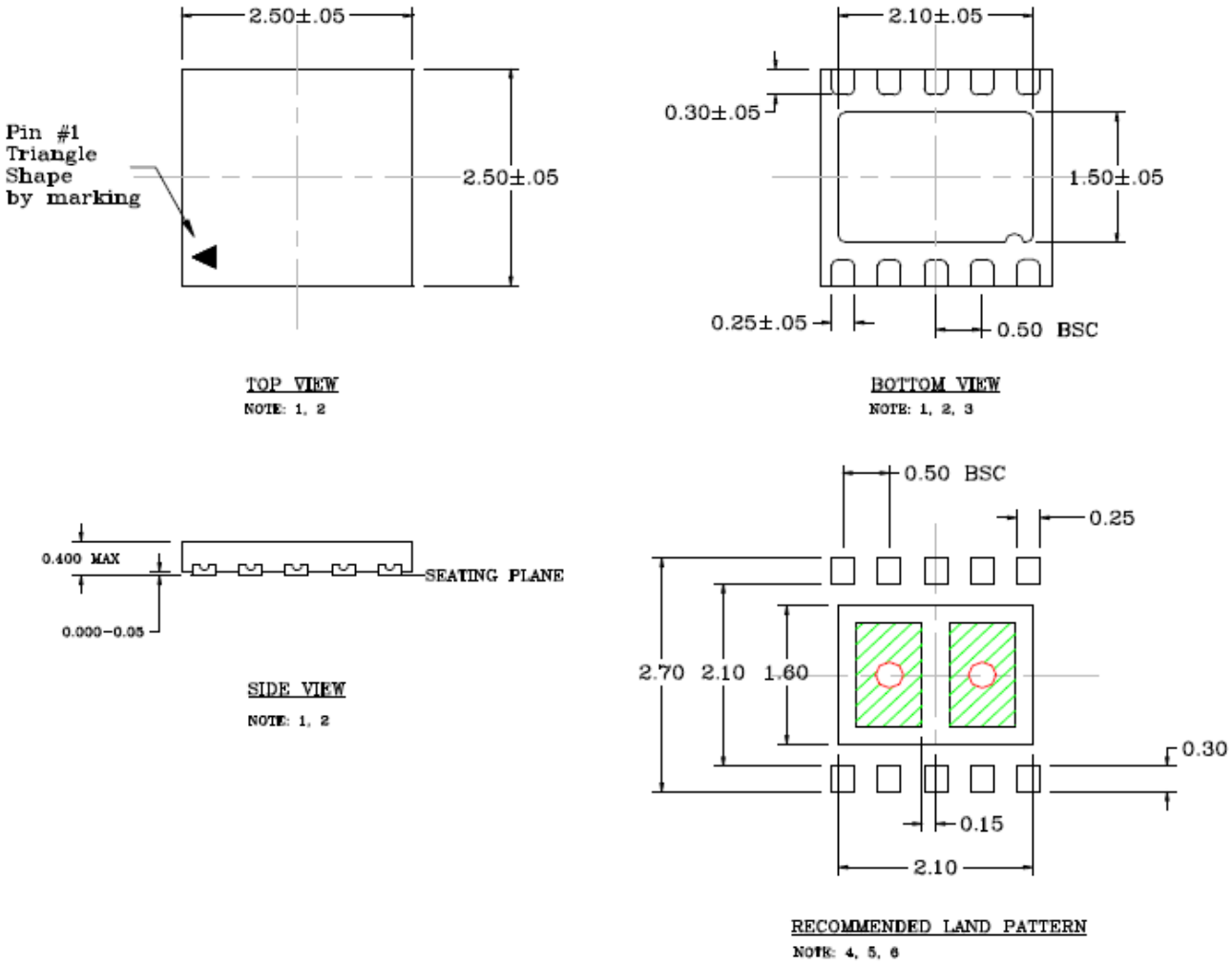
ADCs (analog-to-digital converters) typically include either a capacitive sample-and-hold or a capacitive DAC at their inputs. During operation, they periodically connect those capacitors to their inputs while sampling the input signal. General practice is to place a RC low-pass filter between the operational amplifier supplying the input signal and the ADC. The series resistor between the operational amplifier output and ADC input limits capacitive loading on the operational amplifier to prevent instability. The capacitor between the ADC input and GND minimizes glitches by supplying charge to the internal ADC capacitors.

Package Information



8-Pin SOIC (M)

Package Information



NOTE:

1. MAX PACKAGE WARPAGE IS 0.05mm
2. MAX ALLOWABLE BURR IS 0.076mm IN ALL DIRECTIONS.
3. LEAD AND EPAD CORNER MAXIMUM RADIUS 0.075mm.
4. GREEN RECTANGLES IN RECOMMENDED LAND PATERN IS SOLDER STENCIL OPENING ON EXPOSED PAD AREA. SIZE IS 0.60mm X 0.90mm. SPACING is 0.30mm.
5. RED CIRCLES IN LAND PATTERN ARE VIAS AND SHOULD BE CONNECTED TO GROUND FOR MAXIMUM PERFORMANCE. DIAMETER IS 0.30-0.35mm, PITCH IS 1.0mm.
6. RECOMMENDED LAND PATTERN TOLERANCE IS ±0.020mm UNLESS SPECIFIED.

10-Pin 2.5mm x 2.5mm XTDFN (MX)

MICREL, INC. 2180 FORTUNE DRIVE SAN JOSE, CA 95131 USA
TEL +1 (408) 944-0800 FAX +1 (408) 474-1000 WEB http://www.micrel.com

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