MAX40108 — 1V, Low-Power, Precision Operational Amplifier

General Description

The MAX40108 is a low-power, high-precision operational amplifier (op amp) that operates with a power supply voltage as low as 0.9V.

Available in a space-saving, 1.22mmx 0.92mm, 6-bump wafer-level package (WLP) with a 0.4mm bump pitch, it is designed for use in portable, consumer, medical, and industrial applications.

The MAX40108 features rail-to-rail CMOS inputs and outputs, a 168kHz GBW consuming only 25.5μA (typ) supply current and 1μV (typ) zero-drift input offset voltage over time and temperature. The zero-drift feature reduces the high 1/f noise typically found in CMOS input operational amplifiers, making it useful for a wide variety of low-frequency measurement applications.

The MAX40108 operates from a 0.9V to 3.6V power supply voltage and is specified over the -40°C to +125°C extended operating temperature range.

Applications

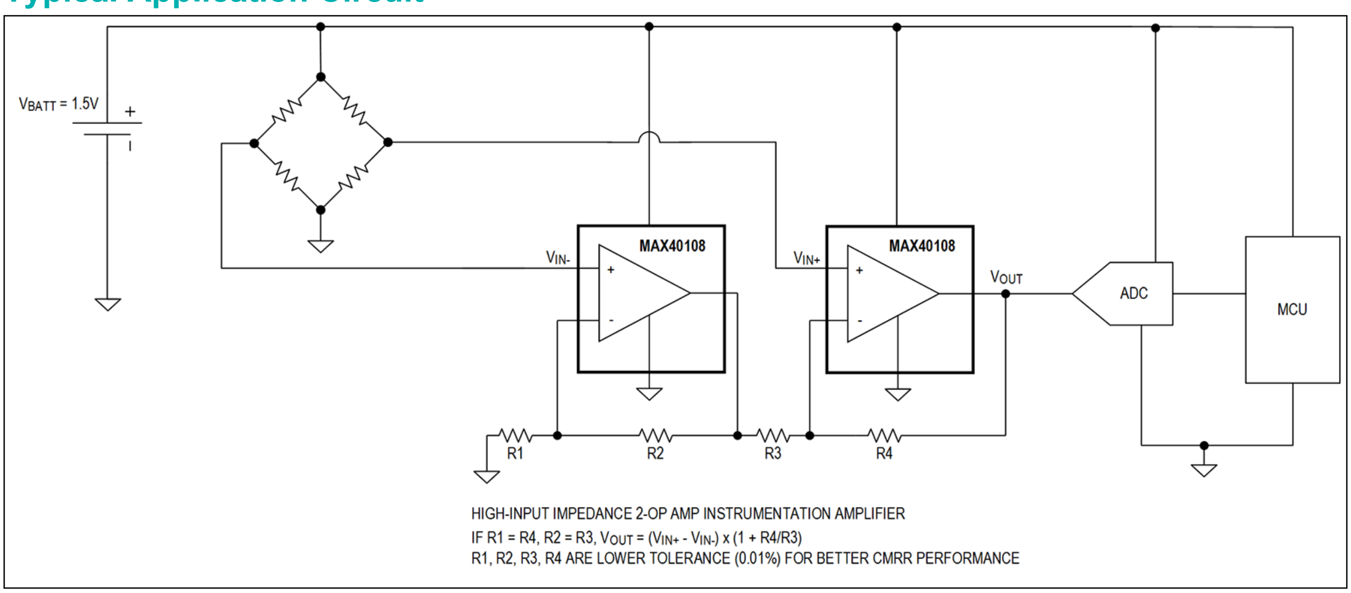
- Wearable Devices
- Home Medical (Blood Glucose,Weight Scale, Blood Pressure, EKG)
- Fitness and Health (Smart Watch, Heart-Rate Monitor)
- Industrial IOT (Pressure, Flow, Level, Temperature, Proximity)

Benefits and Features

- Supply Voltage Range: 0.9V to 3.6V
- Low 25.5μA Quiescent Current
- Very Low 1μV (typ) Input Offset Voltage
- Rail-to-Rail Inputs and Outputs
- Internal EMI Rejection
- 168kHz GBW
- Low Input Bias Current
- Power-Saving Shutdown Mode
- Available in Tiny, 1.22mm x 0.92mm, 6-bump WLP and 8-pin TDFN

***Ordering Information** appears at end of data sheet.*

Typical Application Circuit



19-100763; Rev 0; 7/20

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Absolute Maximum Ratings

V_{DD} to GND .... -0.3V to +4V
IN+ to IN- .... -0.3V to V_{DD} + 0.3V
OUT to GND .... -0.3V to V_{DD} + 0.3V
IN+, IN- to GND .... -0.3V to V_{DD} + 0.3V
Continuous Current into Any Input/Output Pin 10mA
Output Short-Circuit Duration to Either V_{DD} or GND .. Continuous
Continuous Power Dissipation (Derate 10.51mW/°C above +70°C) 840.78mW
Operating Temperature Range .... -40°C to +125°C
Junction Temperature .... +150°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Package Information

WLP

Package Code	N60M1+1
Outline Number	21-100427
Land Pattern Number	Refer to Application Note 1891
Thermal Resistance, Four-Layer Board:	
Junction to Ambient (θ_{JA})	95.15°C/W
Junction to Case (θ_{JC})	56°C/W

TDFN

Package Code	T822+3C
Outline Number	21-0168
Land Pattern Number	90-0065
Thermal Resistance, Four-Layer Board:	
Junction to Ambient (θ_{JA})	85.3°C/W
Junction to Case (θ_{JC})	8.9°C/W

For the latest package outline information and land patterns (footprints), go to *www.maximintegrated.com/packages*. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to *www.maximintegrated.com/thermal-tutorial*.

Electrical Characteristics

(V_{DD} = +1.5V, GND = 0, V_{CM} = V_{DD}/2, R_{LOAD} = 10kΩ to V_{DD}/2, $V_{\overline{SHDN}}$ = V_{DD}, T_A = -40°C ≤ T_A ≤ +125°C unless otherwise noted. Typical values are at +25°C.(*Note 1*))

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
DC SPECIFICATIONS						
Input Offset Voltage	V_{OS}	0°C ≤ T_A ≤ +85°C		1	10	µV
		-40°C ≤ T_A ≤ +125°C			25	
Input Offset Voltage Drift	ΔV_{OS}			25		nV/°C
Input Bias Current	I_B (Note 2)	-40°C ≤ T_A ≤ +85°C		55	200	pA
		-40°C ≤ T_A ≤ +125°C			400	
Input Offset Current	I_{OS}			110		pA
Input Common-Mode Range	V_{CM}	Guaranteed by CMRR test	-0.1		V_{DD} + 0.1	V

Electrical Characteristics (continued)

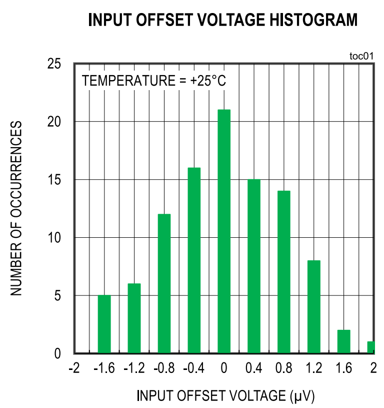
(V_{DD} = +1.5V, GND = 0, V_{CM} = V_{DD}/2, R_{LOAD} = 10kΩ to V_{DD}/2, $V_{\overline{SHDN}}$ = V_{DD}, T_A = -40°C ≤ T_A ≤ +125°C unless otherwise noted. Typical values are at +25°C.(Note 1))

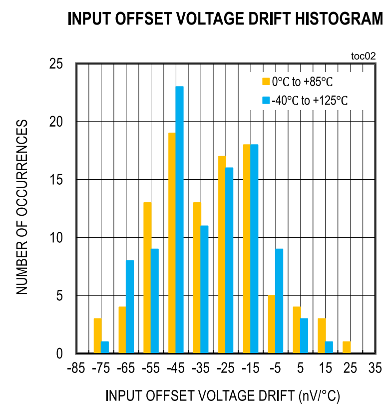
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Common-Mode Rejection Ratio	CMRR	−0.1V ≤ V_{CM} ≤ V_{DD} + 0.1V		107	135		dB
Power-Supply Rejection Ratio	PSRR			116	140		dB
Open-Loop Gain	A_{OL}	(150mV - GND) ≤ V_{OUT} ≤ (V_{DD} - 150mV), R_{LOAD} = 10kΩ to V_{DD}/2		106	130		dB
Output Voltage Swing High	V_{OH}	V_{DD} - V_{OUT}	R_{LOAD} = 10kΩ to V_{DD}/2			25	mV
			No load			15	
Output Voltage Swing Low	V_{OL}	V_{OUT}	R_{LOAD} = 10kΩ to V_{DD}/2			25	mV
			No load			5	
Short Circuit Current	I_{SC}				25		mA
AC SPECIFICATIONS							
Gain Bandwidth Product	GBW				168		kHz
Slew Rate	SR				0.08		V/µs
Input Voltage Noise Density	V_N	f = 1kHz, unity gain			117		nV/√Hz
Input Voltage Noise Density	V_N	f = 1kHz, gain = 10			90		nV/√Hz
Input Voltage Noise		0.1Hz to 10Hz			2.5		μV_{P-P}
Input Current Noise Density	I_N	f = 1kHz			100		fA/√Hz
Phase Margin	PM	C_{LOAD} = 10pF			60		°
Capacitive Loading Stability					50		pF
POWER SUPPLY							
Supply Voltage	V_{DD}	Guaranteed by PSRR, -40°C < T_A < +125°C		0.9		3.6	V
Supply Current	I_{DD}				25.5	42	µA
Power-Up Time	t_{ON}	V_{DD} = 0V to 3V step, AV = 1V/V			250		µs
Shutdown Supply Current	$I_{\overline{SHDN}}$	-40ºC ≤ T_A ≤ +85ºC			320	1600	nA
		-40°C ≤ T_A ≤ +125°C			320	3000	
Turn-On Time	t_{ONSD}	V_{DD} = 3.3V, $V_{\overline{SHDN}}$ = 0V to 3.3V step in <1µs			600		µs
LOGIC INPUT DC CHARACTERISTICS							
Input Low Level	V_{IL}	Active level				0.37 x V_{DD}	V
Input High Level	V_{IH}			0.8*V_{DD}			V
Input Leakage Current	I_L				60	250	nA

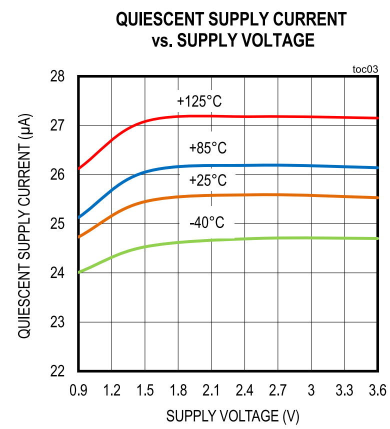
Note 1: Specifications are 100% tested at T_A = +25°C (exceptions noted). All temperature limits are guaranteed by design.
Note 2: Not production tested, guaranteed by design and bench characterization.

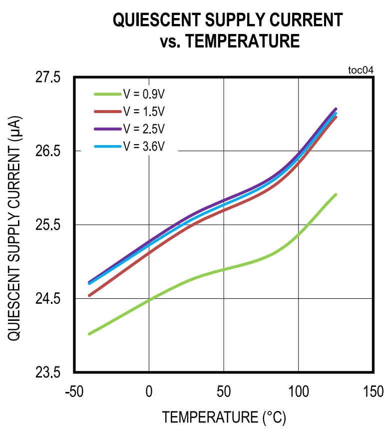
Typical Operating Characteristics

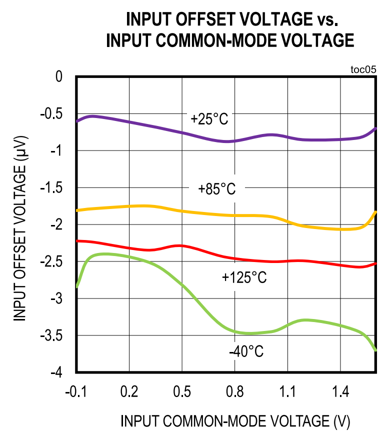
(V_{DD} = +1.5V, GND = 0, V_{CM} = V_{DD}/2, R_{LOAD} = 10kΩ to V_{DD}/2, $V_{\overline{SHDN}}$ = V_{DD}, T_A = -40°C to +125°C unless otherwise noted. Typical values are at +25°C.)

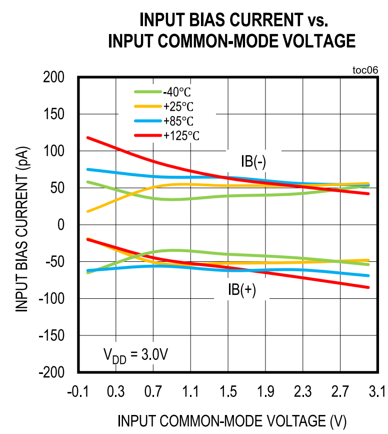


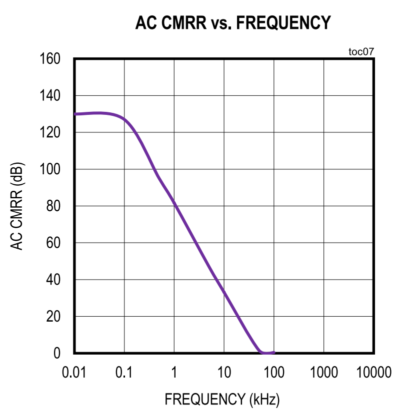


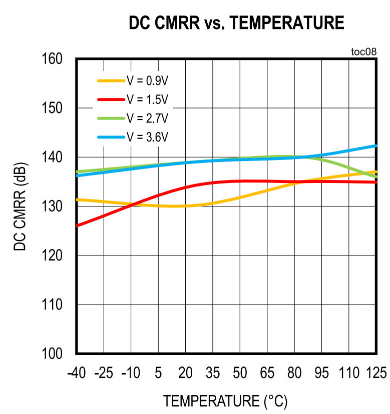


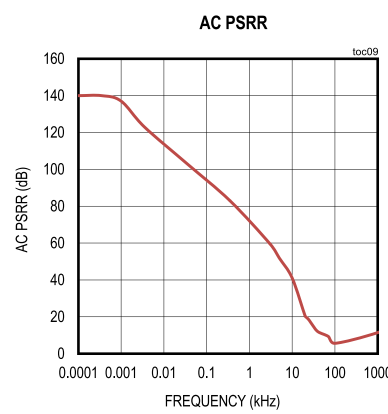








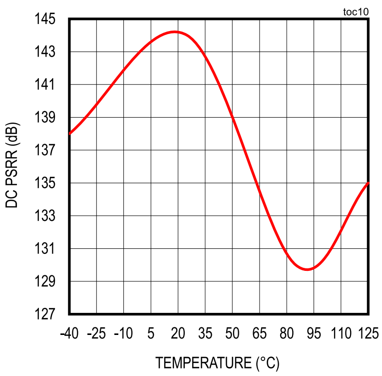




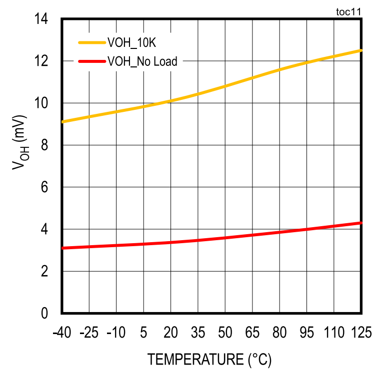
Typical Operating Characteristics (continued)

(V_{DD} = +1.5V, GND = 0, V_{CM} = V_{DD}/2, R_{LOAD} = 10kΩ to V_{DD}/2, $V_{\overline{SHDN}}$ = V_{DD}, T_A = -40°C to +125°C unless otherwise noted. Typical values are at +25°C.)

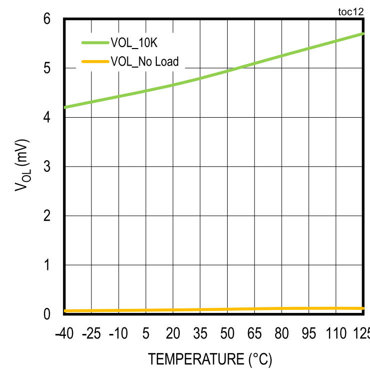
DC PSRR vs. TEMPERATURE



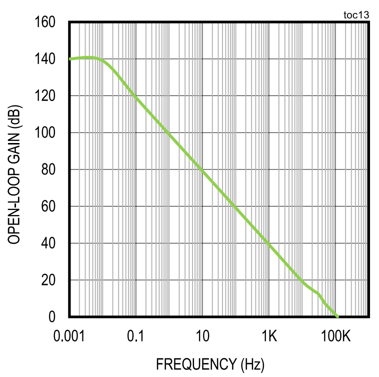
OUTPUT VOLTAGE SWING HIGH vs. TEMPERATURE



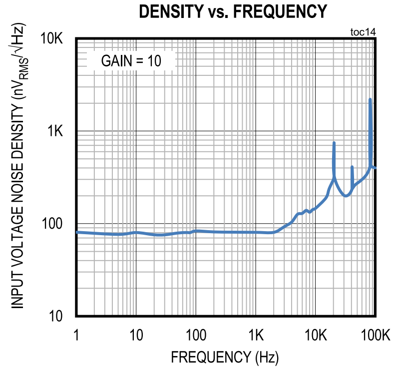
OUTPUT VOLTAGE SWING LOW vs. TEMPERATURE



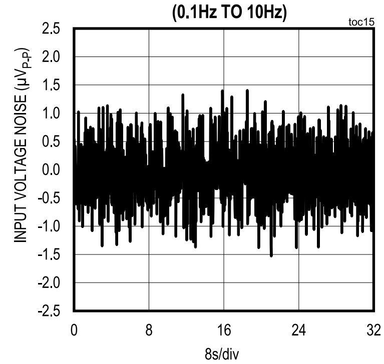
OPEN-LOOP GAIN vs. FREQUENCY



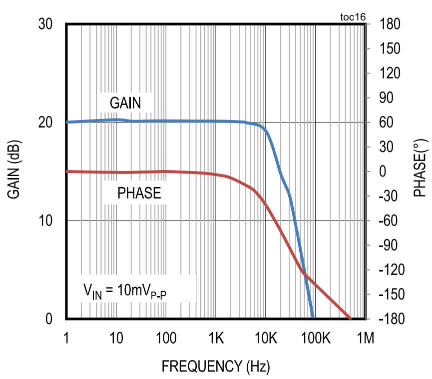
INPUT VOLTAGE NOISE DENSITY vs. FREQUENCY



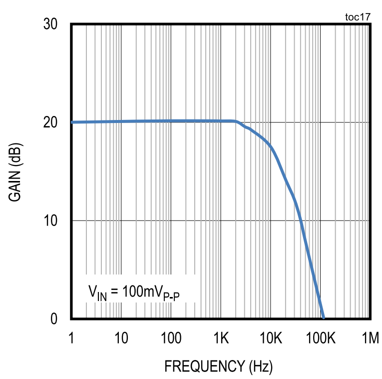
INTEGRATED NOISE (0.1Hz TO 10Hz)



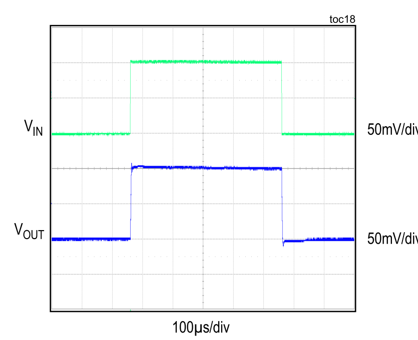
SMALL SIGNAL GAIN AND PHASE vs. FREQUENCY



LARGE SIGNAL GAIN vs. FREQUENCY



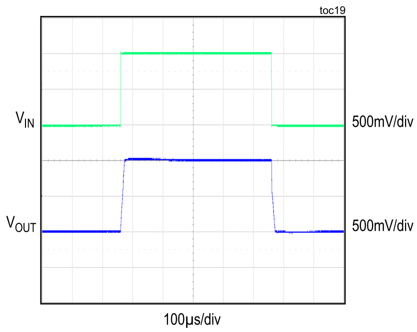
SMALL SIGNAL STEP RESPONSE vs. TIME



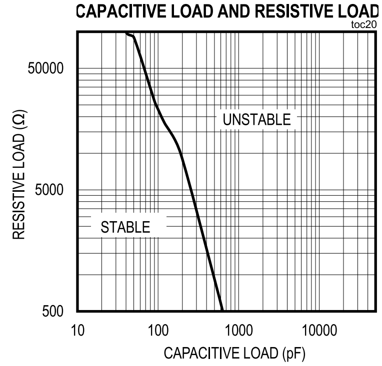
Typical Operating Characteristics (continued)

(V_{DD} = +1.5V, GND = 0, V_{CM} = V_{DD}/2, R_{LOAD} = 10kΩ to V_{DD}/2, $V_{\overline{SHDN}}$ = V_{DD}, T_A = -40°C to +125°C unless otherwise noted. Typical values are at +25°C.)

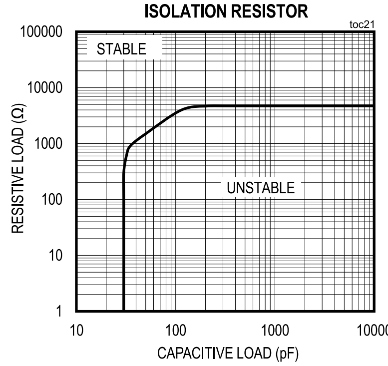
LARGE SIGNAL STEP RESPONSE vs. TIME



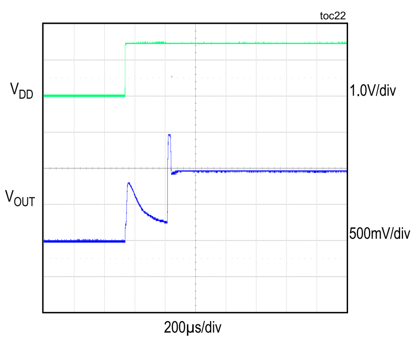
STABILITY vs. CAPACITIVE LOAD AND RESISTIVE LOAD



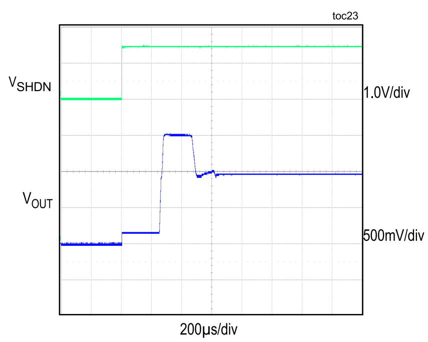
STABILITY vs. CAPACITIVE LOAD AND ISOLATION RESISTOR



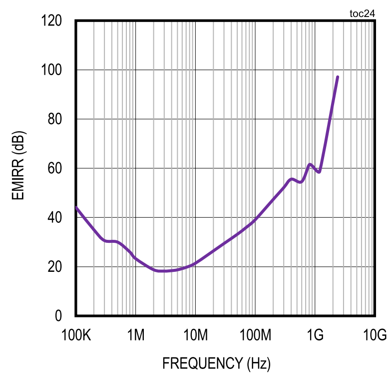
POWER-UP TIME



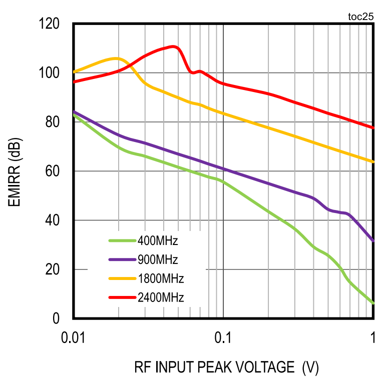
SHUTDOWN ENABLE RESPONSE



EMIRR vs. FREQUENCY



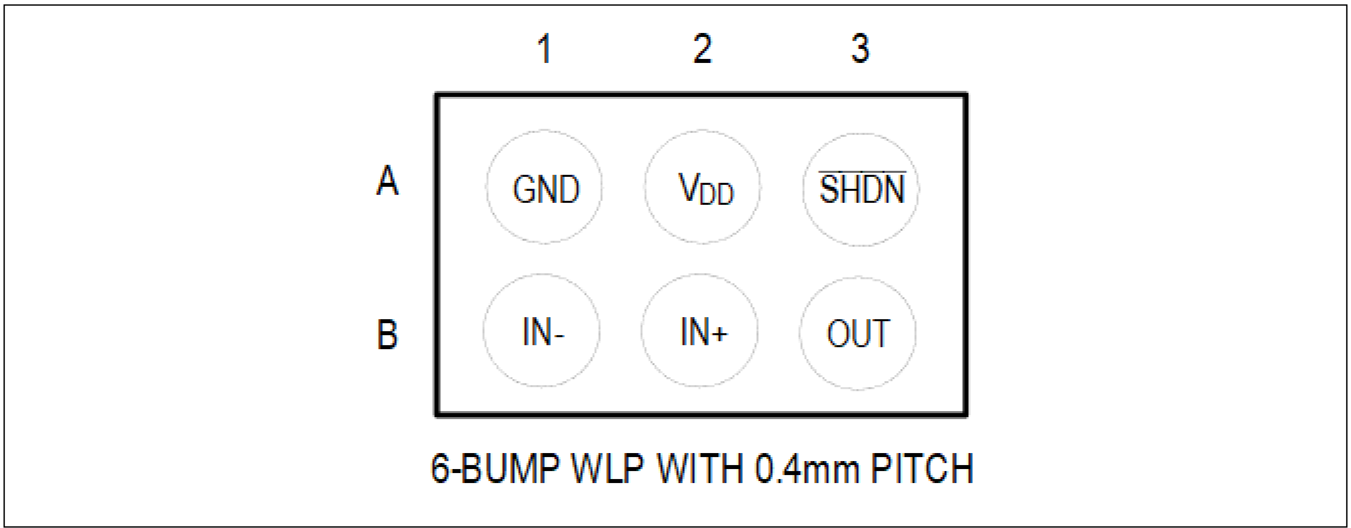
EMIRR vs. RF INPUT VOLTAGE



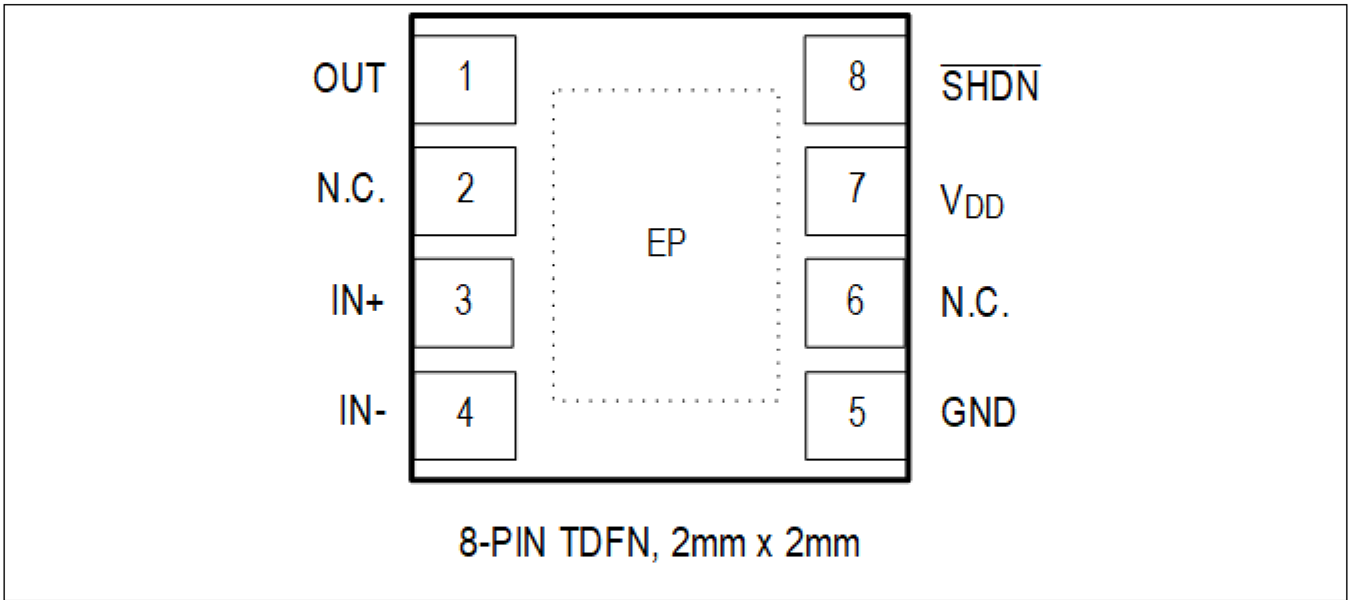
Pin Configurations

WLP

TOP VIEW (BUMP SIDE DOWN)



TDFN



Pin Description

PIN		NAME	FUNCTION
WLP	TDFN		
B2	3	IN+	Noninverting Input

Pin Description (continued)

PIN		NAME	FUNCTION
WLP	TDFN		
A1	5	GND	Ground
B1	4	IN-	Inverting Input
A2	7	VDD	Positive Supply
B3	1	OUT	Output
A3	8	SHDN_	Shutdown (Active Low)
—	2, 6	NC	Do Not Connect

Detailed Description

The MAX40108 is a precision, low-power op amp with a power supply as low as 0.9V that is ideal for portable consumer, medical, and industrial applications. The device uses an auto-zero technique that allows precision and low-noise with a minimum amount of power. The MAX40108 features rail-to rail CMOS inputs and outputs at just 25.5μA supply current and 1μV (typ) input-referred offset voltage. The low input offset voltage, CMOS inputs, and the absence of 1/f noise allows for optimization of sensor interfaces, in particular for sensors that operate with low voltage and at low frequency.

The MAX40108 achieves rail-to-rail performance at the input through the use of a low-noise charge pump. The rail-to-rail input maximizes the amplifier input dynamic range when it is operating at its minimum supply voltage of 0.9V. This also ensures a glitch-free, common-mode input-voltage range extending from the negative supply rail up to the positive supply rail, eliminating crossover distortion common to traditional n-channel/p-channel CMOS pair inputs. The charge pump requires no external components, and in most applications is entirely transparent to the user. The operating frequency is well beyond the unity-gain frequency of the amplifier, avoiding aliasing or other signal integrity issues in sensitive applications.

The device features a shutdown mode that greatly reduces quiescent current while the device is not operational.

Auto-Zero

The MAX40108 features Maxim's patented autochop circuit, which reduces input offset voltage and 1/f noise, while reducing the output ripple typically associated with chopping circuits.

Shutdown Operation

The device features an active-low shutdown mode that lowers the quiescent current to a typical value of 320nA. In shutdown mode, the inputs and output are high impedance. This allows multiple devices to be multiplexed onto a single line without the use of external buffers. Pull $\overline{SHDN}$ high for normal operation.

The shutdown high (V_{IH}) and low (V_{IL}) threshold voltages are designed for ease of integration with digital controls like microcontroller outputs. These thresholds are independent of supply, eliminating the need for external pulldown circuitry. See the *Typical Operating Characteristics* for output voltage response to a shutdown disable signal.

Applications Information

Overview

The MAX40108 low-power, low-noise, and precision op amp is designed for applications that interface with sensors like the ones found in portable medical, such as ECG and blood glucose meter, as well as industrial equipment. Because the MAX40108 supply voltage can operate as low as 0.9V, the amplifier can be used in applications with single-cell battery (1.5V, nom) by connecting the device directly to the battery voltage.

Power-Up Settling Time

The MAX40108 typically requires 250μs to power up. During this startup time, the output is indeterminate. The application circuit should allow for this initial delay. See the *Typical Operating Characteristics* for the Power-Up Time curve.

Capacitive-Load Stability

Driving large capacitive loads can cause instability in many op amps. The MAX40108 is stable with capacitive loads up to 50pF. Stability with higher capacitive loads can be improved by adding an isolation resistor in series with the op-amp output. This resistor improves the circuit's phase margin by isolating the load capacitor from the amplifier's output. Note that this solution reduces the gain and output voltage swing because R_{ISO} forms a voltage-divider with the load resistor. The graph in the *Typical Operating Characteristics* gives the stable operation region for capacitive load versus isolation resistors.

Power Supplies and Layout

The MAX40108 operates either with a single supply from +0.9V to +3.6V with respect to ground or with dual supplies from ±0.45V to ±1.8V. Bypass both supplies with bypass capacitor to ground when used with dual supplies; bypass V_{DD} with bypass capacitor to ground when used with single supply.

Careful layout technique helps optimize performance by decreasing the amount of stray capacitance at the op amp's inputs and outputs. To decrease stray capacitance, minimize trace lengths by placing external components close to the op amp's pins.

Ordering Information

PART NUMBER	TEMP RANGE	PIN-PACKAGE	TOP MARK
MAX40108ANT+	-40°C to +125°C	6 WLP	+BE
MAX40108ANT+T	-40°C to +125°C	6 WLP	+BE
MAX40108ATA*	-40°C to +125°C	8 TDFN	BTR
MAX40108ATA+T*	-40°C to +125°C	8 TDFN	BTR

+ Denotes a lead(Pb)-free/RoHS-compliant package.

T Denotes tape-and-reel.

**Future product—contact factory for availability.*

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	7/20	Release for intro	—