

600 nA, Rail-to-Rail Input/Output Op Amps

Features

- Low Quiescent Current: 600 nA/amplifier (typical)
- Rail-to-Rail Input/Output
- Gain Bandwidth Product: 14 kHz (typical)
- Wide Supply Voltage Range: 1.4V to 6.0V
- Unity Gain Stable
- Available in Single, Dual, and Quad
- Chip Select (\overline{CS}) with MCP6043
- Available in 5-lead and 6-lead SOT-23 Packages
- Temperature Ranges:
 - Industrial: -40°C to +85°C
 - Extended: -40°C to +125°C

Applications

- Toll Booth Tags
- Wearable Products
- Temperature Measurement
- Battery Powered

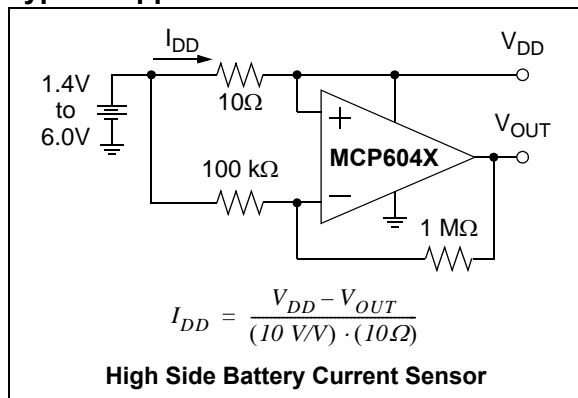
Design Aids

- SPICE Macro Models
- FilterLab[®] Software
- Mindi[™] Circuit Designer & Simulator
- MAPS (Microchip Advanced Part Selector)
- Analog Demonstration and Evaluation Boards
- Application Notes

Related Devices

- MCP6141/2/3/4: G = +10 Stable Op Amps

Typical Application



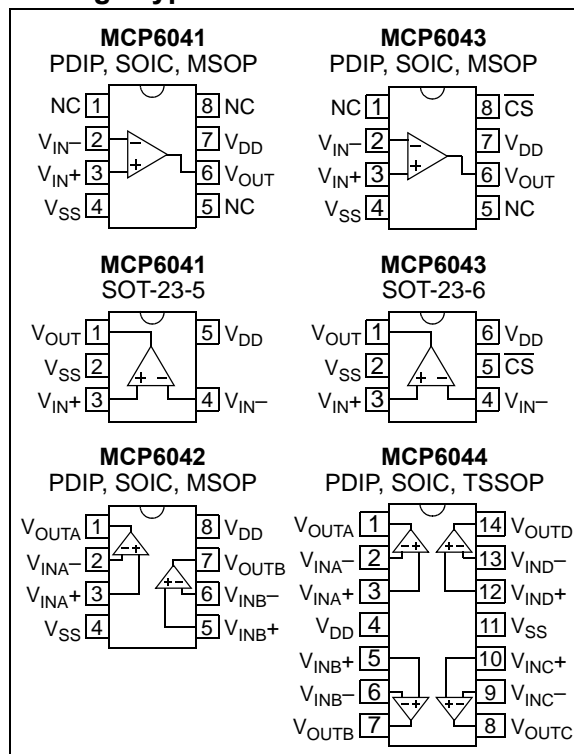
Description

The MCP6041/2/3/4 family of operational amplifiers (op amps) from Microchip Technology Inc. operate with a single supply voltage as low as 1.4V, while drawing less than 1 μA (maximum) of quiescent current per amplifier. These devices are also designed to support rail-to-rail input and output operation. This combination of features supports battery-powered and portable applications.

The MCP6041/2/3/4 amplifiers have a gain-bandwidth product of 14 kHz (typical) and are unity gain stable. These specifications make these op amps appropriate for low frequency applications, such as battery current monitoring and sensor conditioning.

The MCP6041/2/3/4 family operational amplifiers are offered in single (MCP6041), single with Chip Select (\overline{CS}) (MCP6043), dual (MCP6042), and quad (MCP6044) configurations. The MCP6041 device is available in the 5-lead SOT-23 package, and the MCP6043 device is available in the 6-lead SOT-23 package.

Package Types



MCP6041/2/3/4

1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

$V_{DD} - V_{SS}$	7.0V
Current at Input Pins	± 2 mA
Analog Inputs (V_{IN+} , V_{IN-})	$V_{SS} - 1.0V$ to $V_{DD} + 1.0V$
All Other Inputs and Outputs	$V_{SS} - 0.3V$ to $V_{DD} + 0.3V$
Difference Input voltage	$ V_{DD} - V_{SS} $
Output Short Circuit Current	continuous
Current at Output and Supply Pins	± 30 mA
Storage Temperature.....	$-65^{\circ}C$ to $+150^{\circ}C$
Junction Temperature.....	$+150^{\circ}C$
ESD protection on all pins (HBM; MM)	≥ 4 kV; 200V

† **Notice:** Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

†† See Section 4.1 “Rail-to-Rail Input”

DC ELECTRICAL CHARACTERISTICS

Electrical Characteristics: Unless otherwise indicated, $V_{DD} = +1.4V$ to $+5.5V$, $V_{SS} = GND$, $T_A = 25^{\circ}C$, $V_{CM} = V_{DD}/2$, $V_{OUT} \approx V_{DD}/2$, $V_L = V_{DD}/2$, and $R_L = 1$ M Ω to V_L (refer to Figure 1-2 and Figure 1-3).						
Parameters	Sym	Min	Typ	Max	Units	Conditions
Input Offset						
Input Offset Voltage	V_{OS}	-3	—	+3	mV	$V_{CM} = V_{SS}$
Drift with Temperature	$\Delta V_{OS}/\Delta T_A$	—	± 2	—	$\mu V/^{\circ}C$	$V_{CM} = V_{SS}$, $T_A = -40^{\circ}C$ to $+85^{\circ}C$
	$\Delta V_{OS}/\Delta T_A$	—	± 15	—	$\mu V/^{\circ}C$	$V_{CM} = V_{SS}$, $T_A = +85^{\circ}C$ to $+125^{\circ}C$
Power Supply Rejection	PSRR	70	85	—	dB	$V_{CM} = V_{SS}$
Input Bias Current and Impedance						
Input Bias Current	I_B	—	1	—	pA	
Industrial Temperature	I_B	—	20	100	pA	$T_A = +85^{\circ}$
Extended Temperature	I_B	—	1200	5000	pA	$T_A = +125^{\circ}$
Input Offset Current	I_{OS}	—	1	—	pA	
Common Mode Input Impedance	Z_{CM}	—	$10^{13} 6$	—	ΩpF	
Differential Input Impedance	Z_{DIFF}	—	$10^{13} 6$	—	ΩpF	
Common Mode						
Common-Mode Input Range	V_{CMR}	$V_{SS}-0.3$	—	$V_{DD}+0.3$	V	
Common-Mode Rejection Ratio	CMRR	62	80	—	dB	$V_{DD} = 5V$, $V_{CM} = -0.3V$ to $5.3V$
	CMRR	60	75	—	dB	$V_{DD} = 5V$, $V_{CM} = 2.5V$ to $5.3V$
	CMRR	60	80	—	dB	$V_{DD} = 5V$, $V_{CM} = -0.3V$ to $2.5V$
Open-Loop Gain						
DC Open-Loop Gain (large signal)	A_{OL}	95	115	—	dB	$R_L = 50$ k Ω to V_L , $V_{OUT} = 0.1V$ to $V_{DD}-0.1V$
Output						
Maximum Output Voltage Swing	V_{OL} , V_{OH}	$V_{SS} + 10$	—	$V_{DD} - 10$	mV	$R_L = 50$ k Ω to V_L , 0.5V input overdrive
Linear Region Output Voltage Swing	V_{OVR}	$V_{SS} + 100$	—	$V_{DD} - 100$	mV	$R_L = 50$ k Ω to V_L , $A_{OL} \geq 95$ dB
Output Short Circuit Current	I_{SC}	—	2	—	mA	$V_{DD} = 1.4V$
	I_{SC}	—	20	—	mA	$V_{DD} = 5.5V$
Power Supply						
Supply Voltage	V_{DD}	1.4	—	6.0	V	(Note 1)
Quiescent Current per Amplifier	I_Q	0.3	0.6	1.0	μA	$I_O = 0$

Note 1: All parts with date codes November 2007 and later have been screened to ensure operation at $V_{DD} = 6.0V$. However, the other minimum and maximum specifications are measured at 1.4V and/or 5.5V.

AC ELECTRICAL CHARACTERISTICS

Electrical Characteristics: Unless otherwise indicated, $V_{DD} = +1.4V$ to $+5.5V$, $V_{SS} = GND$, $T_A = 25^\circ C$, $V_{CM} = V_{DD}/2$, $V_{OUT} \approx V_{DD}/2$, $V_L = V_{DD}/2$, $R_L = 1\text{ M}\Omega$ to V_L , and $C_L = 60\text{ pF}$ (refer to [Figure 1-2](#) and [Figure 1-3](#)).

Parameters	Sym	Min	Typ	Max	Units	Conditions
AC Response						
Gain Bandwidth Product	GBWP	—	14	—	kHz	
Slew Rate	SR	—	3.0	—	V/ms	
Phase Margin	PM	—	65	—	°	$G = +1\text{ V/V}$
Noise						
Input Voltage Noise	E_{ni}	—	5.0	—	μV_{P-P}	$f = 0.1\text{ Hz to }10\text{ Hz}$
Input Voltage Noise Density	e_{ni}	—	170	—	nV/ $\sqrt{\text{Hz}}$	$f = 1\text{ kHz}$
Input Current Noise Density	i_{ni}	—	0.6	—	fA/ $\sqrt{\text{Hz}}$	$f = 1\text{ kHz}$

MCP6043 CHIP SELECT (\overline{CS}) ELECTRICAL CHARACTERISTICS

Electrical Characteristics: Unless otherwise indicated, $V_{DD} = +1.4V$ to $+5.5V$, $V_{SS} = GND$, $T_A = 25^\circ C$, $V_{CM} = V_{DD}/2$, $V_{OUT} \approx V_{DD}/2$, $V_L = V_{DD}/2$, $R_L = 1\text{ M}\Omega$ to V_L , and $C_L = 60\text{ pF}$ (refer to [Figure 1-2](#) and [Figure 1-3](#)).

Parameters	Sym	Min	Typ	Max	Units	Conditions
\overline{CS} Low Specifications						
\overline{CS} Logic Threshold, Low	V_{IL}	V_{SS}	—	$V_{SS}+0.3$	V	
\overline{CS} Input Current, Low	I_{CSL}	—	5	—	pA	$\overline{CS} = V_{SS}$
\overline{CS} High Specifications						
\overline{CS} Logic Threshold, High	V_{IH}	$V_{DD}-0.3$	—	V_{DD}	V	
\overline{CS} Input Current, High	I_{CSH}	—	5	—	pA	$\overline{CS} = V_{DD}$
\overline{CS} Input High, GND Current	I_{SS}	—	-20	—	pA	$\overline{CS} = V_{DD}$
Amplifier Output Leakage, \overline{CS} High	I_{OLEAK}	—	20	—	pA	$\overline{CS} = V_{DD}$
Dynamic Specifications						
\overline{CS} Low to Amplifier Output Turn-on Time	t_{ON}	—	2	50	ms	$G = +1V/V$, $\overline{CS} = 0.3V$ to $V_{OUT} = 0.9V_{DD}/2$
\overline{CS} High to Amplifier Output High-Z	t_{OFF}	—	10	—	μs	$G = +1V/V$, $\overline{CS} = V_{DD}-0.3V$ to $V_{OUT} = 0.1V_{DD}/2$
Hysteresis	V_{HYST}	—	0.6	—	V	$V_{DD} = 5.0V$

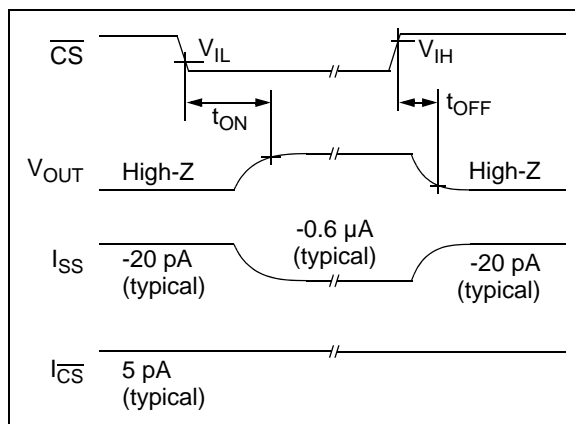


FIGURE 1-1: Chip Select (\overline{CS}) Timing Diagram (MCP6043 only).

MCP6041/2/3/4

TEMPERATURE CHARACTERISTICS

Electrical Characteristics: Unless otherwise indicated, $V_{DD} = +1.4V$ to $+5.5V$, $V_{SS} = GND$.						
Parameters	Sym	Min	Typ	Max	Units	Conditions
Temperature Ranges						
Specified Temperature Range	T_A	-40	—	+85	°C	Industrial Temperature parts
	T_A	-40	—	+125	°C	Extended Temperature parts
Operating Temperature Range	T_A	-40	—	+125	°C	(Note 1)
Storage Temperature Range	T_A	-65	—	+150	°C	
Thermal Package Resistances						
Thermal Resistance, 5L-SOT-23	θ_{JA}	—	256	—	°C/W	
Thermal Resistance, 6L-SOT-23	θ_{JA}	—	230	—	°C/W	
Thermal Resistance, 8L-PDIP	θ_{JA}	—	85	—	°C/W	
Thermal Resistance, 8L-SOIC	θ_{JA}	—	163	—	°C/W	
Thermal Resistance, 8L-MSOP	θ_{JA}	—	206	—	°C/W	
Thermal Resistance, 14L-PDIP	θ_{JA}	—	70	—	°C/W	
Thermal Resistance, 14L-SOIC	θ_{JA}	—	120	—	°C/W	
Thermal Resistance, 14L-TSSOP	θ_{JA}	—	100	—	°C/W	

Note 1: The MCP6041/2/3/4 family of Industrial Temperature op amps operates over this extended range, but with reduced performance. In any case, the internal Junction Temperature (T_J) must not exceed the Absolute Maximum specification of $+150^\circ\text{C}$.

1.1 Test Circuits

The test circuits used for the DC and AC tests are shown in [Figure 1-2](#) and [Figure 1-3](#). The bypass capacitors are laid out according to the rules discussed in [Section 4.6 “Supply Bypass”](#).

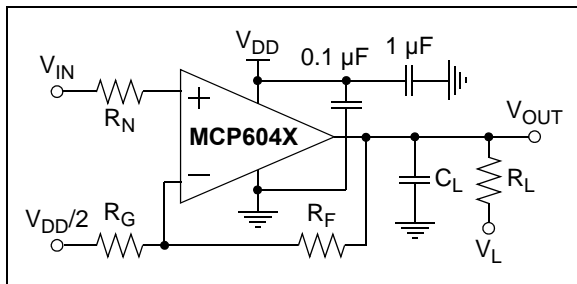


FIGURE 1-2: AC and DC Test Circuit for Most Non-Inverting Gain Conditions.

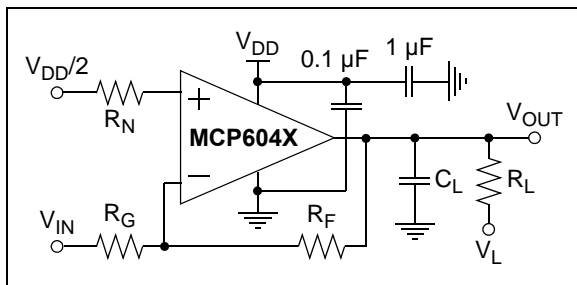
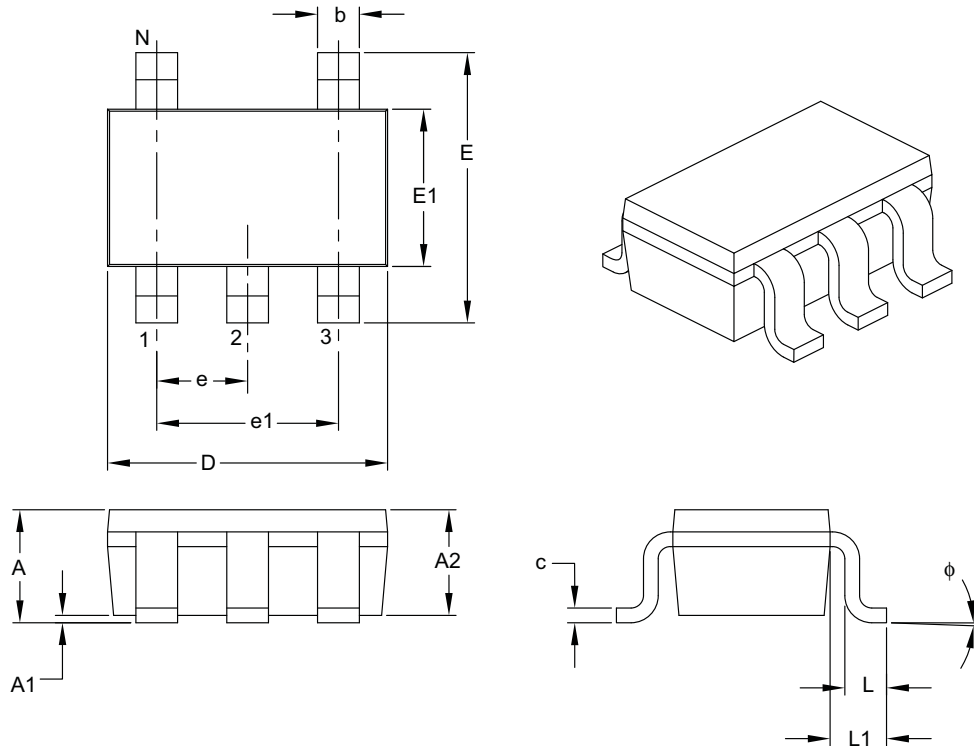


FIGURE 1-3: AC and DC Test Circuit for Most Inverting Gain Conditions.

5-Lead Plastic Small Outline Transistor (OT) [SOT-23]



Dimension Limits	Units	MILLIMETERS		
		MIN	NOM	MAX
Number of Pins	N	5		
Lead Pitch	e	0.95 BSC		
Outside Lead Pitch	e1	1.90 BSC		
Overall Height	A	0.90	–	1.45
Molded Package Thickness	A2	0.89	–	1.30
Standoff	A1	0.00	–	0.15
Overall Width	E	2.20	–	3.20
Molded Package Width	E1	1.30	–	1.80
Overall Length	D	2.70	–	3.10
Foot Length	L	0.10	–	0.60
Footprint	L1	0.35	–	0.80
Foot Angle	φ	0°	–	30°
Lead Thickness	c	0.08	–	0.26
Lead Width	b	0.20	–	0.51

Notes:

- Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.127 mm per side.
- Dimensioning and tolerancing per ASME Y14.5M.

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-091B

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

<u>PART NO.</u>	<u>X</u>	<u>/XX</u>	Examples:
Device	Temperature Range	Package	
MCP6041: Single Op Amp MCP6041T Single Op Amp (Tape and Reel for SOT-23, SOIC, MSOP)			a) MCP6041-I/P: Industrial Temp., 8LD PDIP package.
MCP6042 Dual Op Amp MCP6042T Dual Op Amp (Tape and Reel for SOIC and MSOP)			b) MCP6041T-E/OT: Tape and Reel, Extended Temp., 5LD SOT-23 package.
MCP6043 Single Op Amp w/ Chip Select MCP6043T Single Op Amp w/ Chip Select (Tape and Reel for SOT-23, SOIC, MSOP)			a) MCP6042-I/SN: Industrial Temp., 8LD SOIC package.
MCP6044 Quad Op Amp MCP6044T Quad Op Amp (Tape and Reel for SOIC and TSSOP)			b) MCP6042T-E/MS: Tape and Reel, Extended Temp., 5LD SOT-23 package.
Temperature Range	I = -40°C to +85°C E = -40°C to +125°C		a) MCP6043-I/P: Industrial Temp., 8LD PDIP package.
Package	CH = Plastic Small Outline Transistor (SOT-23), 6-lead (Tape and Reel - MCP6043 only) MS = Plastic Micro Small Outline (MSOP), 8-lead OT = Plastic Small Outline Transistor (SOT-23), 5-lead (Tape and Reel - MCP6041 only) P = Plastic DIP (300 mil Body), 8-lead, 14-lead SL = Plastic SOIC (150 mil Body), 14-lead SN = Plastic SOIC (150 mil Body), 8-lead ST = Plastic TSSOP (4.4 mm Body), 14-lead		b) MCP6043T-E/CH: Tape and Reel, Extended Temp., 6LD SOT-23 package.
			a) MCP6044-I/SL: Industrial Temp., 14LD PDIP package.
			b) MCP6044T-E/ST: Tape and Reel, Extended Temp., 14LD TSSOP package.