MCP616/7/8/9

2.3V to 5.5V Micropower Bi-CMOS Op Amps

Features

- Low Input Offset Voltage: ±150 µV (maximum)
- Low Noise: 2.2 μV_{P-P} (typical, 0.1 Hz to 10 Hz)
- Rail-to-Rail Output
- Low Input Offset Current: 0.3 nA (typical)
- Low Quiescent Current: 25 µA (maximum)
- Power Supply Voltage: 2.3V to 5.5V
- Unity Gain Stable
- Chip Select ($\overline{CS}$) Capability: MCP618
- Industrial Temperature Range: -40°C to +85°C
- No Phase Reversal
- Available in Single, Dual and Quad Packages

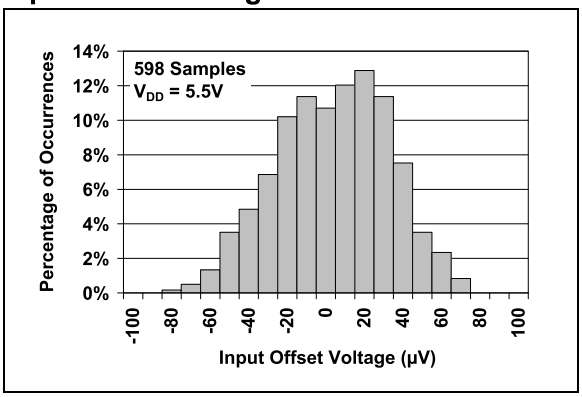
Typical Applications

- Battery Power Instruments
- Weight Scales
- Strain Gauges
- Medical Instruments
- Test Equipment

Design Aids

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

Input Offset Voltage

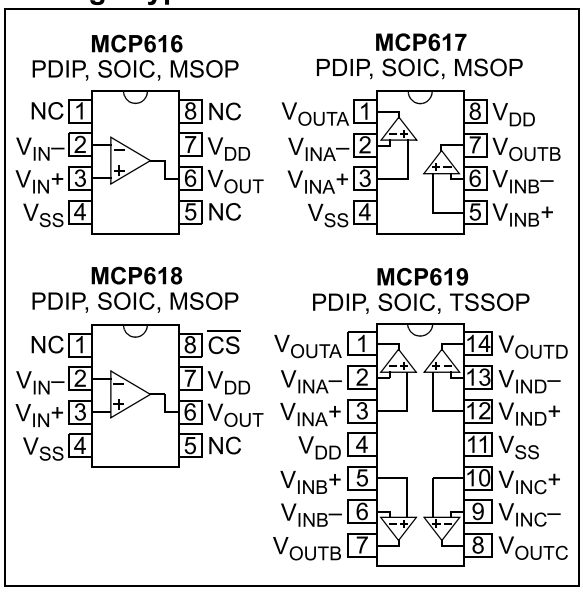


Description

The MCP616/7/8/9 family of operational amplifiers (op amps) from Microchip Technology Inc. are capable of precision, low-power, single-supply operation. These op amps are unity-gain stable, have low input offset voltage (±150 µV, maximum), rail-to-rail output swing and low input offset current (0.3 nA, typical). These features make this family of op amps well suited for battery-powered applications.

The single MCP616, the single MCP618 with Chip Select ($\overline{CS}$) and the dual MCP617 are all available in standard 8-lead PDIP, SOIC and MSOP packages. The quad MCP619 is offered in standard 14-lead PDIP, SOIC and TSSOP packages. All devices are fully specified from -40°C to +85°C, with power supplies from 2.3V to 5.5V.

Package Types



NOTES:

1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

$V_{DD} - V_{SS}$ 7.0V
Current at Analog Input Pins (V_{IN+} and V_{IN-}).....±2 mA
Analog Inputs (V_{IN}+ and V_{IN}–) †† .. V_{SS} – 0.3V to V_{DD} + 0.3V
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°C to +150°C
Maximum Junction Temperature (T_J).....+150°C
ESD Protection On All Pins (HBM; MM) ..... ≥ 4 kV; 400V

† 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 4.1.2 "Input Voltage and Current Limits"**.

DC ELECTRICAL CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, V_{DD} = +2.3V to +5.5V, V_{SS} = GND, T_A = +25°C, V_{CM} = V_{DD}/2, $V_{OUT} \approx V_{DD}/2$ and R_L = 100 kΩ to $V_{DD}/2$.

Parameters	Sym	Min	Typ	Max	Units	Conditions
Input Offset						
Input Offset Voltage	V_{OS}	–150	—	+150	µV	
Input Offset Drift with Temperature	$\Delta V_{OS}/\Delta T_A$	—	±2.5	—	µV/°C	T_A = -40°C to +85°C
Power Supply Rejection	PSRR	86	105	—	dB	
Input Bias Current and Impedance						
Input Bias Current	I_B	-35	-15	-5	nA	
At Temperature	I_B	-70	-21	—	nA	T_A = -40°C
At Temperature	I_B	—	-12	—	nA	T_A = +85°C
Input Offset Current	I_{OS}	—	±0.15	—	nA	
Common Mode Input Impedance	Z_{CM}	—	600||4	—	MΩ||pF	
Differential Input Impedance	Z_{DIFF}	—	3||2	—	MΩ||pF	
Common Mode						
Common Mode Input Voltage Range	V_{CMR}	V_{SS}		V_{DD} – 0.9	V	
Common Mode Rejection Ratio	CMRR	80	100	—	dB	V_{DD} = 5.0V, V_{CM} = 0.0V to 4.1V
Open-Loop Gain						
DC Open-Loop Gain (large signal)	A_{OL}	100	120	—	dB	R_L = 25 kΩ to $V_{DD}/2$, V_{OUT} = 0.05V to V_{DD} – 0.05V
DC Open-Loop Gain (large signal)	A_{OL}	95	115	—	dB	R_L = 5 kΩ to $V_{DD}/2$, V_{OUT} = 0.1V to V_{DD} – 0.1V
Output						
Maximum Output Voltage Swing	V_{OL}, V_{OH}	V_{SS} + 15	—	V_{DD} – 20	mV	R_L = 25 kΩ to $V_{DD}/2$, 0.5V input overdrive
	V_{OL}, V_{OH}	V_{SS} + 45	—	V_{DD} – 60	mV	R_L = 5 kΩ to $V_{DD}/2$, 0.5V input overdrive
Linear Output Voltage Range	V_{OUT}	V_{SS} + 50	—	V_{DD} – 50	mV	R_L = 25 kΩ to $V_{DD}/2$, A_{OL} ≥ 100 dB
	V_{OUT}	V_{SS} + 100	—	V_{DD} – 100	mV	R_L = 5 kΩ to $V_{DD}/2$, A_{OL} ≥ 95 dB
Output Short Circuit Current	I_{SC}	—	±7	—	mA	V_{DD} = 2.3V
	I_{SC}	—	±17	—	mA	V_{DD} = 5.5V
Power Supply						
Supply Voltage	V_{DD}	2.3	—	5.5	V	
Quiescent Current per Amplifier	I_Q	12	19	25	µA	I_O = 0

AC ELECTRICAL CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, V_{DD} = +2.3V to +5.5V, V_{SS} = GND, T_A = 25°C, V_{CM} = V_{DD}/2, V_{OUT} ≈ V_{DD}/2, R_L = 100 kΩ to V_{DD}/2 and C_L = 60 pF.

Parameters	Sym	Min	Typ	Max	Units	Conditions
AC Response						
Gain Bandwidth Product	GBWP	—	190	—	kHz	
Phase Margin	PM	—	57	—	°	G = +1V/V
Slew Rate	SR	—	0.08	—	V/µs	
Noise						
Input Noise Voltage	E_{ni}	—	2.2	—	μV_{P-P}	f = 0.1 Hz to 10 Hz
Input Noise Voltage Density	e_{ni}	—	32	—	nV/√Hz	f = 1 kHz
Input Noise Current Density	i_{ni}	—	70	—	fA/√Hz	f = 1 kHz

MCP618 CHIP SELECT ($\overline{CS}$) ELECTRICAL CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, V_{DD} = +2.3V to +5.5V, V_{SS} = GND, T_A = 25°C, V_{CM} = V_{DD}/2, V_{OUT} ≈ V_{DD}/2, R_L = 100 kΩ to V_{DD}/2 and C_L = 60 pF.

Parameters	Sym	Min	Typ	Max	Units	Conditions
$\overline{CS}$ Low Specifications						
$\overline{CS}$ Logic Threshold, Low	V_{IL}	V_{SS}	—	0.2 V_{DD}	V	
$\overline{CS}$ Input Current, Low	I_{CSL}	–1.0	0.01	—	µA	$\overline{CS}$ = V_{SS}
$\overline{CS}$ High Specifications						
$\overline{CS}$ Logic Threshold, High	V_{IH}	0.8 V_{DD}	—	V_{DD}	V	
$\overline{CS}$ Input Current, High	I_{CSH}	—	0.01	2	µA	$\overline{CS}$ = V_{DD}
GND Current	I_{SS}	-2	-0.05	—	µA	$\overline{CS}$ = V_{DD}
Amplifier Output Leakage	$I_{O(LEAK)}$	—	10	—	nA	$\overline{CS}$ = V_{DD}
$\overline{CS}$ Dynamic Specifications						
$\overline{CS}$ Low to Amplifier Output Turn-on Time	t_{ON}	—	9	100	µs	$\overline{CS}$ = 0.2V_{DD} to V_{OUT} = 0.9V_{DD}/2, G = +1 V/V, R_L = 1 kΩ to V_{SS}
$\overline{CS}$ High to Amplifier Output High-Z	t_{OFF}	—	0.1	—	µs	$\overline{CS}$ = 0.8V_{DD} to V_{OUT} = 0.1V_{DD}/2, G = +1 V/V, R_L = 1 kΩ to V_{SS}
$\overline{CS}$ Hysteresis	V_{HYST}	—	0.6	—	V	V_{DD} = 5.0V

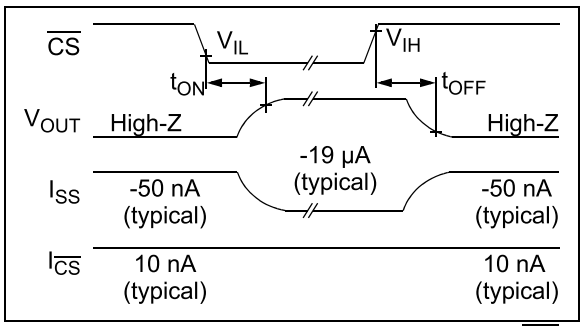


FIGURE 1-1: *Timing Diagram for the $\overline{CS}$ Pin on the MCP618.*

TEMPERATURE CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, V_{DD} = +2.3V to +5.5V and V_{SS} = GND.						
Parameters	**Sym**	**Min**	**Typ**	**Max**	**Units**	**Conditions**
Temperature Ranges						
Specified Temperature Range	T_A	-40	—	+85	°C	
Operating Temperature Range	T_A	-40	—	+125	°C	**Note 1**
Storage Temperature Range	T_A	-65	—	+150	°C	
Thermal Package Resistances						
Thermal Resistance, 8L-MSOP	θ_{JA}	—	211	—	°C/W	
Thermal Resistance, 8L-PDIP	θ_{JA}	—	89.3	—	°C/W	
Thermal Resistance, 8L-SOIC	θ_{JA}	—	149.5	—	°C/W	
Thermal Resistance, 14L-PDIP	θ_{JA}	—	70	—	°C/W	
Thermal Resistance, 14L-SOIC	θ_{JA}	—	95.3	—	°C/W	
Thermal Resistance, 14L-TSSOP	θ_{JA}	—	100	—	°C/W	

Note 1: The MCP616/7/8/9 operate over this extended temperature range, but with reduced performance. In any case, the Junction Temperature (T_J) must not exceed the Absolute Maximum specification of +150°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"**.

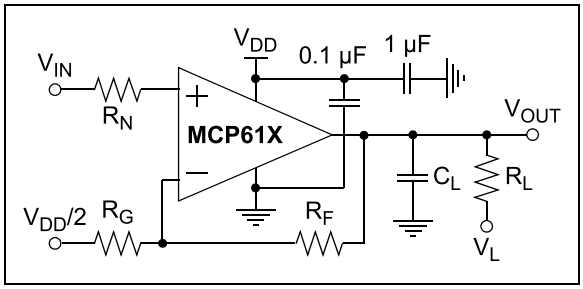


FIGURE 1-2: *AC and DC Test Circuit for Most Non-Inverting Gain Conditions.*

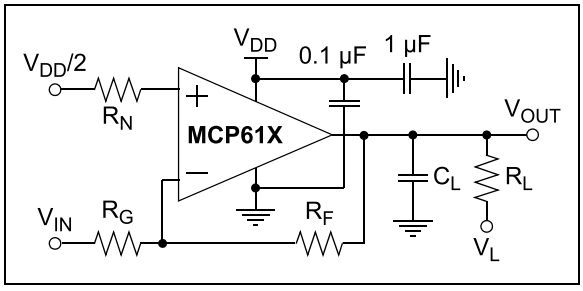


FIGURE 1-3: *AC and DC Test Circuit for Most Inverting Gain Conditions.*