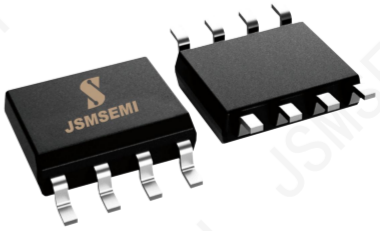
Product Description

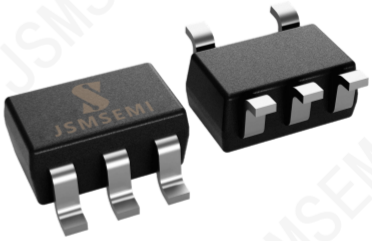
The MCP6L91 (single) and MCP6L92 (dual)are low noise. low voltage.and micro power operational amplifiers. With an excellent bandwidth of 10MHz, a slew rate of 9V/μs, and a quiescent current of 1000μA per amplifier at 5V. the MCP6L9x family can be designedinto a wi de range of applicati ons.

The MCP6L9x op-ampsare designedto provide optimal performancein low voltsgesnd low noise systems. The input common-mode voltage range indludes ground, and the maximum input fffset voltage are 3.5mV.

These parts provide rail-to-rail output swing into heavy laads The MCP6L9x family is specifiedfor single or dual power supplies of +2.4V to+5.5V. All models are specified over the extended industrial temperaturerange of -40℃ to +125℃.



SOP-8



SOT-23-5L

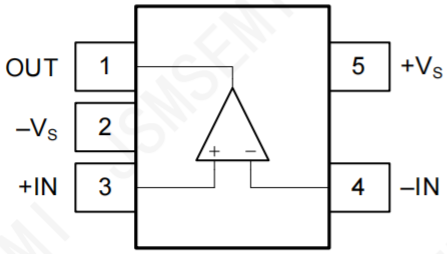
Features

- General Purpose 10 MHz Amplifiers, Low Cost
- High Slew Rate: 9 V/μs
- Low Offset Voltage:3.5 mV Maximum
- Low Power:1000 μA per Amplifier Supply Current
- Unit Gain Stable
- Railto-Rail input and Output
- Operating Power Supply: +2.4 V to +5.5 V
- Operating Temperature Range:-40°C to +125°C
- Low Noise: 20 nV/ Hz@10kHz

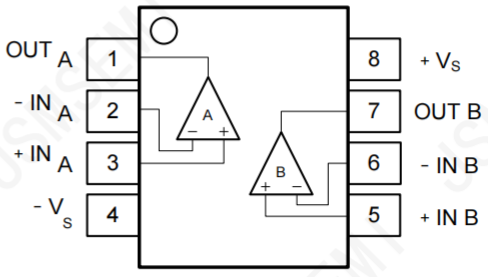
Applications

- Photodiode Amplification
- Sensor Interfaces
- Audio Outputs
- Active Filters
- Driving A/D Converters
- Portable Equipment &
- Battery-Powered Instrumentation

Pin Configuration



SOT-23-5L



SOP-8

Absolute Maximum Ratings

Supply Voltage, $+V_S$ to $-V_S$ 7V
Input Common Mode Voltage Range..... $(-V_S)$ - 0.5V to $(+V_S)$ + 0.5V
Storage Temperature Range ..... -65℃ to +150℃
Junction Temperature ..... +160℃
Lead Temperature (Soldering 10sec)..... +260℃
ESD Susceptibility
HBM..... 4000V
CDM 1000V
Recommended operating conditions
Operating Temperature Range ..... -40℃ to +125℃

Note: Stress greater than 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 these or any other conditions outside those indicated in the operational sections of this specification are not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

Ordering Information

Order number	Package	Marking	Operation Temperature Range	MSL Grade	Ship, Quantity	Green
MCP6L91T-E/OT-JSM	UUJS	SOT-23-5L	-40 to 125°C	3	T&R,3000	Rohs
MCP6L92T-E/SN-JSM	MCP6L92E	SOP-8	-40 to 125°C	3	T&R,2500	Rohs

Electrical Characteristics

VS=5.0V,TA=+25℃,VCM=VS/2,VO=VS /2,and RL=10kΩ connected to VS/2,unless otherwise noted.
Boldface limits apply over the specified temperature range,TA=-40 to+125℃.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
INPUT CHARACTERISTICS						
Vos	Input offset voltage		-3.0	±0.8	+3.0	mV
		B Version	-0.9	± 0.4	+0.9	mV
		C Version	-0.35	±0.1	+0.35	mV
VosTC	Offset voltage drift			3		μV /°C
IB	Input bias current			1		pA
	Over temperature			800		
Ios	Input offset current			1		pA
VcM	Common-mode voltage range		Vs--0.1		Vs++0.1	V
CMRR	Common-mode rejection ratio	Vcm=0.05Vto 3.5V	70	84		dB
	Over temperature			80		
		Vcm=Vs--0.1 to Vs++0.1V	60	76		
AvoL	Open-loop voltage gain	RL=10kΩ,Vo=0.1 to 4.9V	90	102		
	Over temperature			90		
		RL=600Ω,Vo=0.2 to 4.8V	80	89		
	Over temperature			80		
RIn	Input resistance			100		GΩ
CIn	Input capacitance	Differential		2.0		pF
		Common mode		3.5		
OUTPUT CHARACTERISTICS						
VoH	High output voltage swing	RL=600Ω		Vs+-100		mV
		RL=10kΩ		Vs+-8		
VoL	Low output voltage swing	RL=600Ω		100		mV
		RL=10kΩ		8		
ZoUT	Closed-loop output impedance	f=200kHz,G=+1		0.8		Ω
	Open-loop output impedance	f=1MHz,Io=0		3		
Isc	Short-circuit current	Source current through 10Ω		40		mA
		Sink current through 10Ω		40		

Electrical Characteristics

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DYNAMIC PERFORMANCE						
GBW	Gain bandwidth product	f=1kHz		10		MHz
ΦM	Phase margin	CL=100pF		60		o
SR	Slew rate	G=+1,CL=100pF, Vo=1.5V to 3.5V		9		V/μs
BWp	Full power bandwidth	<1%distortion		400		kHz
ts	Settling time	To 0.1%,G=+1,2V step		0.25		μs
		To 0.01%,G=+1,2V step		0.28		
toR	Overload recovery time	VIn*Gain>Vs		0.5		μs
NOISE PERFORMANCE						
Vn	Input voltage noise	f=0.1 to 10 Hz		12		μV P-P
en	Input voltage noise density	f=10kHz		20		nV/ Hz
In	Input current noise density	f=10kHz		5		fA/ Hz
POWER SUPPLY						
Vs	Operating supply voltage		2.5		5.5	V
PSRR	Power supply rejectionratio	Vs=2.5V to 5.5V, Vcm<Vs++0.5V	70	95		dB
	Over temperature			80		
IQ	Quiescent current(per amplifier)			900	1200	μA
	Over temperature			1200	1600	
THERMAL	CHARACTERISTICS					
TA	Operating temperaturerange		-40		+125	°C
θJA	Package thermal resistance	SOT23-5		190		°C/W
		SOP-8		125		

Typical Performance characteristics

At TA= +25℃, VCM = VS/2, and RL= 10kΩconnected to VS/2, unless otherwise noted.

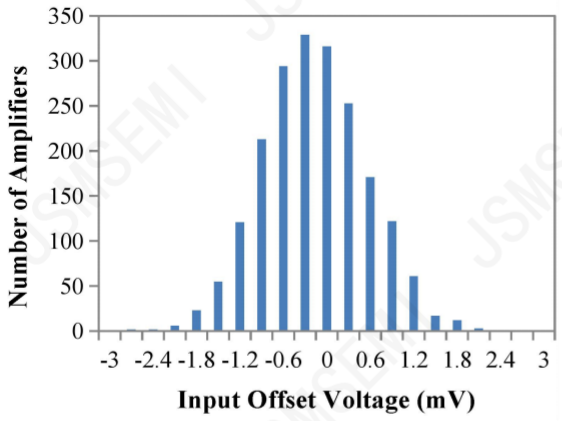


Fig.2 Input Offset Voltage Production Temperature

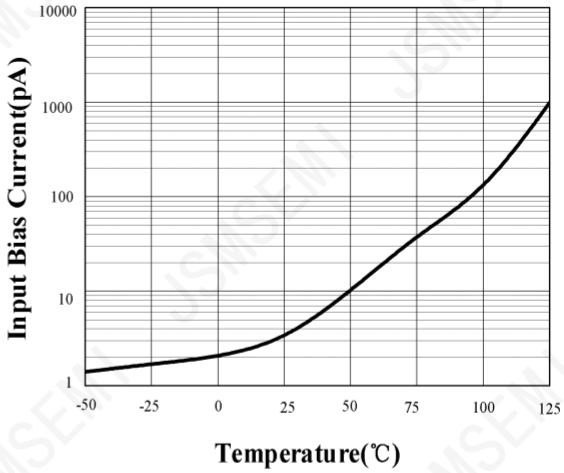


Fig.3 Input Bias Current as a Function of

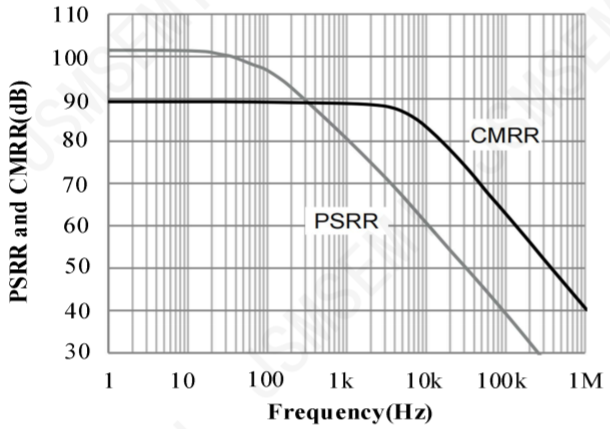


Fig.4 Power Supply and Common-mode Rejection Ratio as a Function of Frequency

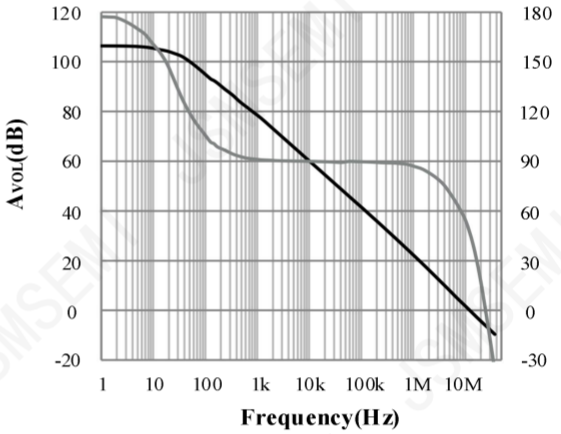


Fig.5 Open-loop Gain and Phase as a function of Frequency

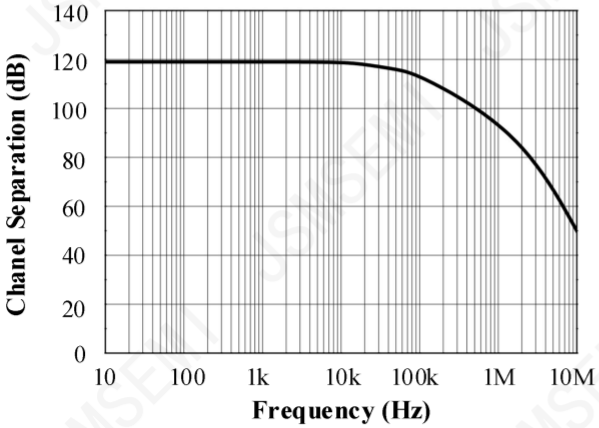


Fig.6 Channel Separation as a function of Frequency

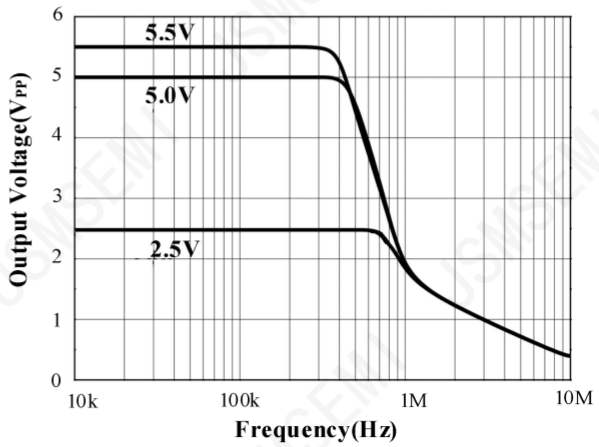


Fig.7 Maximum Output Voltage as a function of Frequency

Typical Performance characteristics

(T_A=+25℃,V_{CM}=V_S/2,and R_L=10kΩ connected to V_S/2,unless other wise noted.)

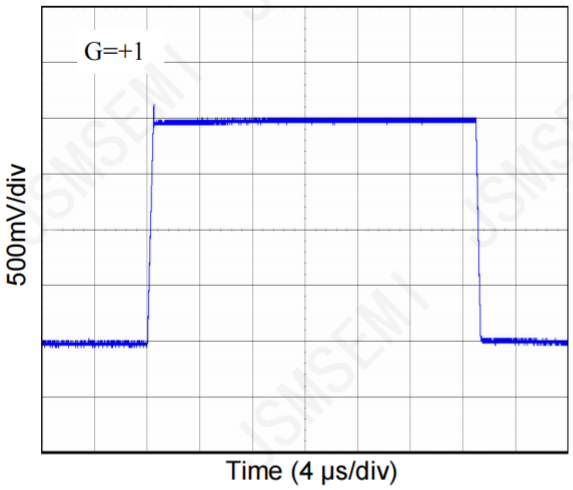


Fig.8 Large-Signal Step Response at 2.7V

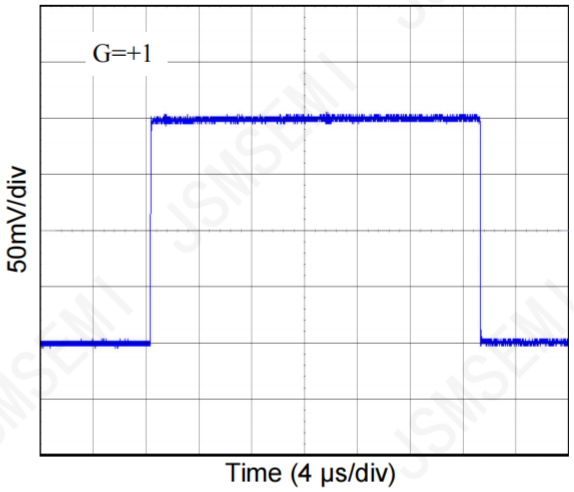


Fig.9 Small-Signal Step Response at 2.7V

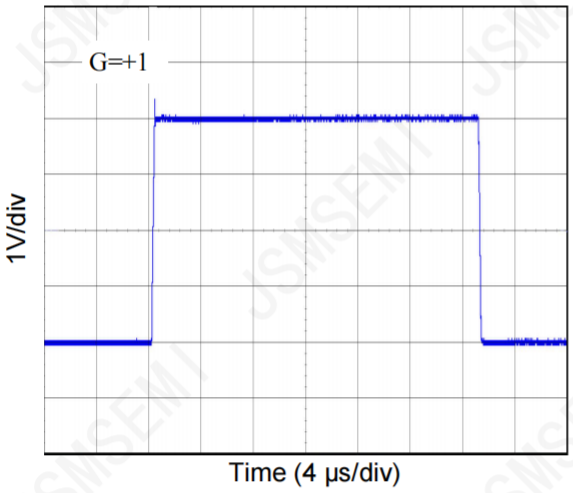


Fig.10 Large-Signal Step Response at 5V

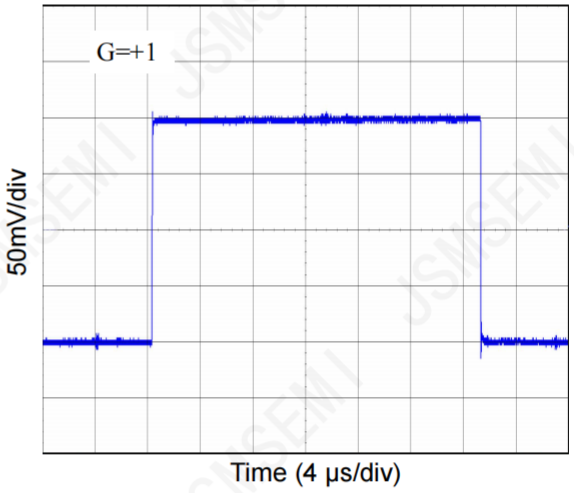


Fig.11 Small-Signal Step Response at 5V

Application Note

1.LowInput Bias Current

The MCP6L9x family is a CMOS op-amp family and features very low input bias current in pA range. The low input bias current allows the amplifiers to be used in applications with high resistance sources. Care must be taken to minimize PCB Surface Leakage.
See below section on “PCB Surface Leakage” for more details.

2.PCB Surface Leakage

In applications where low input bias curent is critical, Printed Circuit Board (PCB)surface leakage effects need to be considered. Surface leakage is caused by humidity, dust or other contamination on the board. Under low humidity conditions, a typical resistance between nearby traces is $10^{12}\Omega$. A 5V difference would cause 5pA of current to flow, which is greater than the MCP6L9x's input bias current at +25 (±1pA, typical). It is recommended to use multi-layer PCB layout and route the op-amp's -IN and +IN signal under the PCB surface

The effective way to reduce surface leakage is to use a guard ring around sensitive pins (or traces). The guard ring is biased at the same voltage as the sensitive pin. An example of this type of layout is shown in Figure 12 for Inverting Gain application.

1. For Non-Inverting Gain and Unity-Gain Buffer:
a) Connect the non-inverting pin (+IN) to the input with a wire that does not touch the PCB surface.
b) Connect the guard ring to the inverting input pin (-IN). This biases the guard ring to the Common Mode input voltage.
2. For Inverting Gain and Trans-impedance Gain Amplifiers (convert current to voltage,such as photo detectors):
a) Connect the guard ring to the non-inverting input pin (+IN). This biases the guard ring to the same reference voltage as the op-amp (e.g., Vs/2 or ground).
b) Connect the inverting pin (-IN) to the input with a wire that does not touch the PCB surface.

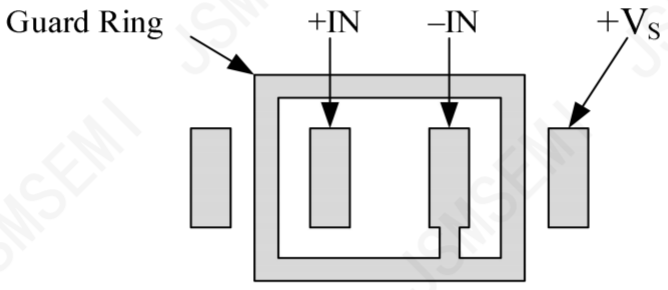


Fig. 12 Use a Guard Ring around Sensitive Pins

3.Ground Sensing And Rail To Rail

The input common-mode voltage range of the MCP6L9x series extends 300mV beyond the supply rails. This is achieved with a complementary input stage—a N-channel input differential pair in parallel with a P-channel differential pair. For normal operation, inputs should be limited to this range. The absolute maximum input voltage is 500mV beyond the
supplies. Inputs greater than the input common-mode range but less than the maximum input voltage, while not valid, will not cause any damage to the op-amp. Unlike some other op amps, if input current is limited, the inputs may go beyond the supplies without phase inversion, as shown in Figure 13. Since the input common-mode range extends from (Vs_- –0.1V) to (Vs_+ + 0.1V), the MCP6L9x op-amps can easily perform 'true ground' sensing

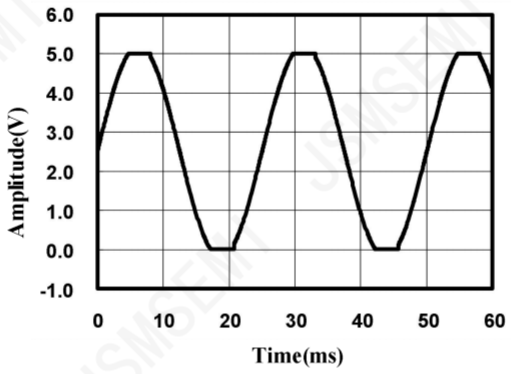


Fig. 13 No Phase Inversion with Inputs Greater Than the Power-Supply Voltage

A topology of class AB output stage with common-source transistors is used to achieve rail-to-rail output. For light resistive loads (e.g. 100kΩ), the output voltage can typically swing to within 5mV from the supply rails. With moderate resistive loads (e.g. 10kΩ), the output can typically swing to within 10mV from the supply rails and maintain high open-loop gain.

The maximum output current is a function of total supply voltage. As the supply voltage to the amplifier increases, the output current capability also increases. Attention must be paid to keep the junction temperature of the IC below 150 when the output is in continuous short-circuit. The output of the amplifier has reverse-biased ESD diodes connected to each supply. The output should not be forced more than 0.5V beyond either supply, otherwise current will flow through these diodes.

4.Capacitive Load And Stability

The MCP6L9x can directly drive lnF in unity-gain without oscillation. The unity-gain follower (buffer) is the most sensitive configuration to capacitive loading.Direct capacitive loading reduces the phase margin of amplifiers and this results in ringing or even oscillation. Applications that require greater capacitive drive capability should use an isolation resistor between the output and the capacitive load like the circuit in Figure 14. The isolation resistor RISO and the load capacitor CL form a zero to increase stability. The bigger the RISO resistor value, the more stable VOUT will be. Note that this method results in a loss of gain accuracy because RISO forms a voltage divider with the RL.

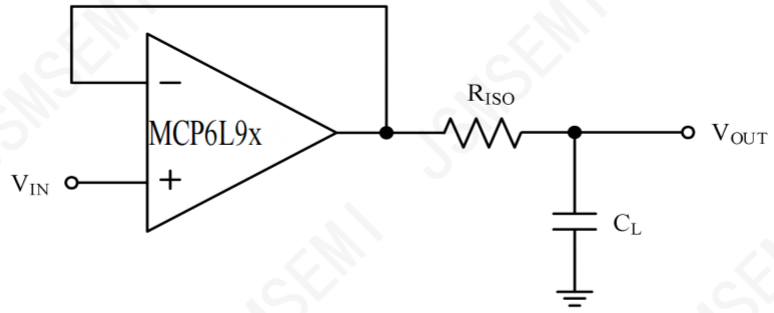


Fig. 14 Indirectly Driving Heavy Capacitive Load

An improvement circuit is shown in Figure 15. It provides DC accuracy as well as AC stability. The RF provides the DC accuracy by connecting the inverting signal with the output.The CF and RISO serve to counteract the loss of phase margin by feeding the high frequency component of the output signal back to the amplifier’s inverting input, thereby preserving phase margin in the overall feedback loop.

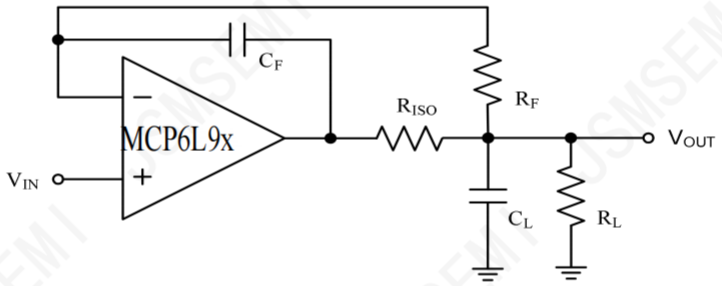


Fig. 15 Indirectly Driving Heavy Capacitive Load with DC Accuracy

For no-buffer configuration, there are two other ways to increase the phase margin: (a)by increasing the amplifier’s gain, or (b) by placing a capacitor in parallel with the feedback resistor to counteract the parasitic capacitance associated with inverting node.

5.Power Supply Layout And Bypass

The MCP6L9x family operates from either a single +2.4V to +5.5V supply or dual±1.2V to ±2.25V supplies . For single-supply operation, bypass the power supply VS with a ceramic capacitor (i.e. 0.01μF to 0.1μF) which should be placed close (within 2mm for good high frequency performance) to the Vs pin. For dual-supply operation both the Vs+ and theVS－ supplies should be bypassed to ground with separate 0.1μF ceramic capacitors. A bulk capacitor (i.e. 2.2 μF or larger tantalum capacitor) within 100mm to provide large, slow currents and better performance. This bulk capacitor can be shared with other analog parts.
Good PC board layout techniques optimize performance by decreasing the amount of stray capacitance at the op-amp’s inputs and output. To decrease stray capacitance, minimize trace lengths and widths by placing external components as close to the device as possible. Use surface-mount components whenever possible. For the op-amp, soldering the part to the board directly is strongly recommended. Try to keep the high frequency big current loop area small to minimize the EMI (electromagnetic interfacing).

6. Grounding

A ground plane layer is important for the MCP6L9x circuit design. The length of the current path speed currents in an inductive ground return will create an unwanted voltage noise. Broad ground plane areas will reduce the parasitic inductance.

7.Input To Output Coupling

To minimize capacitive coupling, the input and output signal traces should not be parallel This helps reduce unwanted positive feedback.

Typical Application Circuits

1.Differential Amplifier

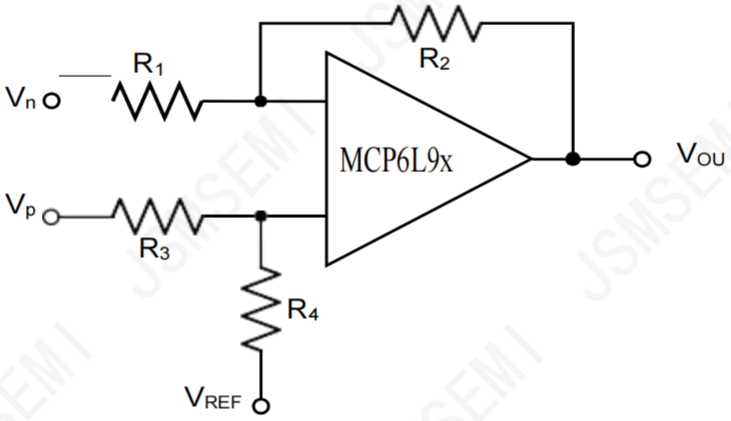


Fig.16Differential Amplifier

The circuit shown in Figure 16 performs the difference function. If the resistors ratios are equal R4/R3 = R2/R1, then:

$$V_{OUT}=(V_p-V_n)\times R_2/R_1+V_{REF}$$

2.Instrumentation Amplifier

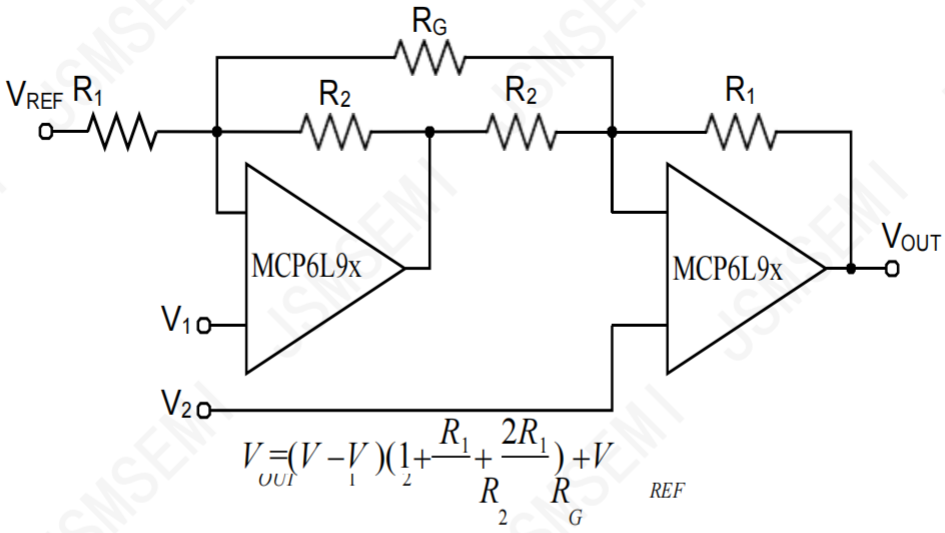


Fig.17Instrumentation Amplifier

The MCP6L9x family is well suited for conditioning sensor signals in battery-powered applications. Figure 17 shows a two op-amp instrumentation amplifier, using the MCP6L9x op-amps. The circuit works well for applications requiring rejection of common-mode noise at higher gains. The reference voltage (VREF) is supplied by a low-impedance source. In single voltage supply applications, the VREF is typically VS/2.

3.Buffered Chemical Sensors

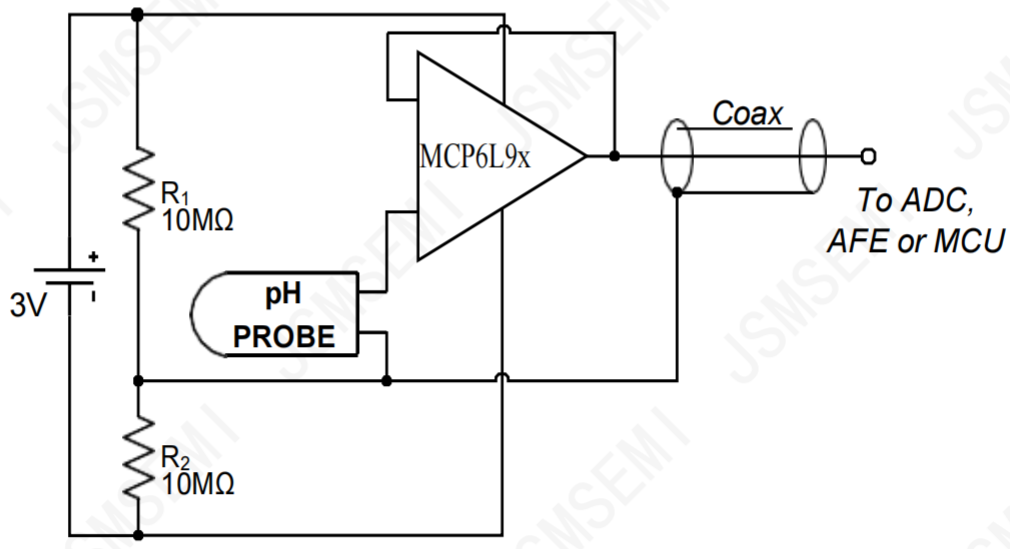


Fig.18 Buffered pH Probe

The MCP6L9x family has input bias current in the pA range. This is ideal in buffering high impedance chemical sensors, such as pH probes. As an example, the circuit in Figure 7 eliminates expansive low-leakage cables that is required to connect a pH probe (general purpose combination pH probes, e.g Corning 476540)to metering ICs such as ADC, AFE
and/or MCU. An MCP6L9x op-amp and a lithium battery are housed in the probe assembly. A conventional low-cost coaxial cable can be used to carry the op-amp's output signal to subsequent ICs for pH reading.

4. Shunt-Based Current Sensing Amplifier

The current sensing amplification shown in Figure 8 has a slew rate of 2πfVpp for the output of sine wave signal, and has a slew rate of 2fVpp for the output of triangular wave signal. In most of motor control systems, the PWM frequency is at 10kHz to 20kHz, and one cycle time is 100us for a 10kHz of PWM frequency . In current shunt monitoring for a motorphase, the phase current is converted to a phase voltage signal for ADC sampling. This sampling voltage signal must be settled before entering the ADC. As the Figure 8 shown, the total settling time of a current shunt monitor circuit includes: the rising edge delay time (tsk)due to the op-amp's slew rate, and the measurement settling time (tser). If the minimum duty cycle of the PWM is defined at 5%, and the tse is required at 20% of a total time window for a phase current monitoring, in case of a 33V motor control system (3.3V MCU with 12-bit ADC), the op-amp's slew rate should be more than:

$$3.3V/(100\mu s \times 5\% \times 20\%)=3.3\ V/\mu s$$

At the same time, the op-amp's bandwidth should be much greater than the PWM fequency. like 10 time at least.

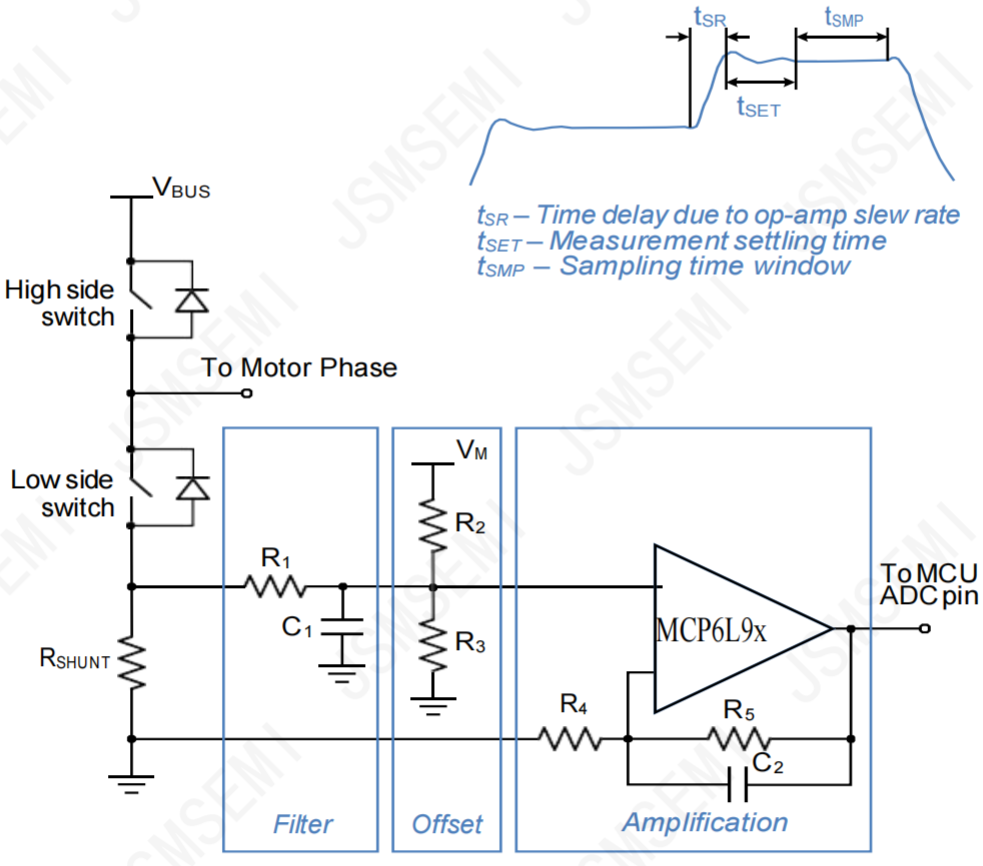
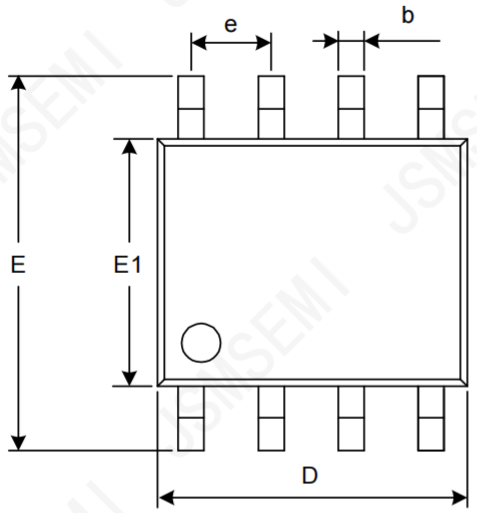
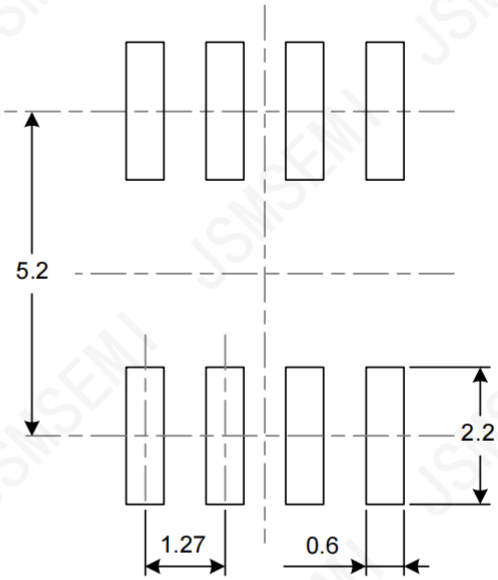


Fig.19 Current Shunt Monitor Circuit

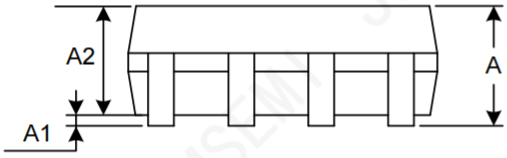
Package Information

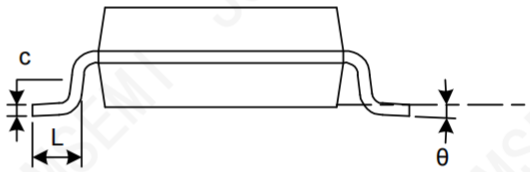
SOP-8





RECOMMENDED LAND PATTERN (Unit: mm)

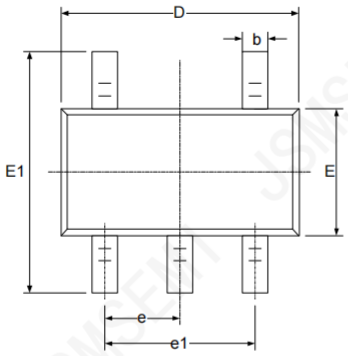


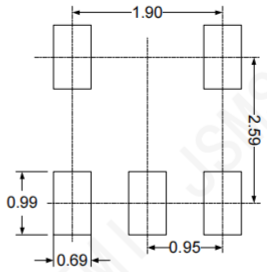


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.800	5.000	0.189	0.197
e	1.270 (BSC)		0.050 (BSC)	
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

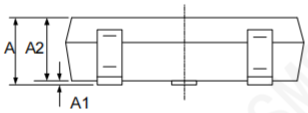
Package Information

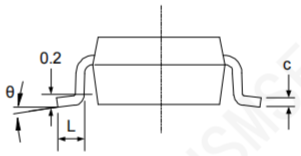
SOT-23-5L





RECOMMENDED LAND PATTERN (Unit: mm)





Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

Revision History

Rev.	Change	Date
V1.0	Initial version	6/20/2023

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