5-V, Rail-to-Rail Input/Output, 1.5-MHz Op Amp

Features

- Supply Voltage: 2.5 V to 5.5 V
- Offset Voltage: 5 mV Maximum
- Bandwidth: 1.5 MHz, Slew Rate: 0.7 V/μs
- Low Power: 100 μA per channel
- Rail-to-Rail Input and Output
- Low 1/f Noise: 22 nV/√Hz at 1 kHz
- –40°C to 125°C Operation Temperature Range

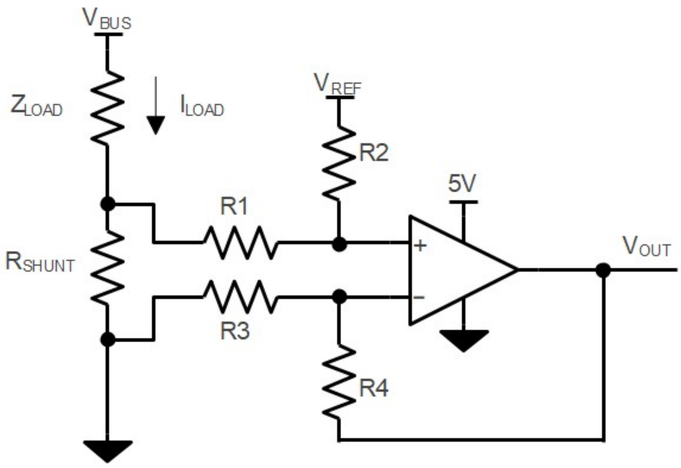
Applications

- Instrumentation
- Motor Control
- Industrial Control

Description

The LMV358X series of products are CMOS dual RRIO op-amps with low offset, low power, and stable high frequency response. They incorporate 3PEAK's proprietary and patented design techniques to achieve very good AC performance with 1.5-MHz bandwidth, 0.7-V/μs slew rate and low distortion while drawing only 100 μA of quiescent current per amplifier. The input common-mode voltage range extends 100-mV beyond V– and V+, and the outputs swing rail-to-rail. The LMV358X family can be used as plug-in replacements for many commercially available op-amps to reduce power and improve input/output range and performance.

Typical Application Circuit



$V_{OUT} = (I_{LOAD} \times R_{SHUNT}) \times (R2 / R1) + V_{REF}$

When $R3 = R1$, $R2 = R4$, $R_{SHUNT} << R1$

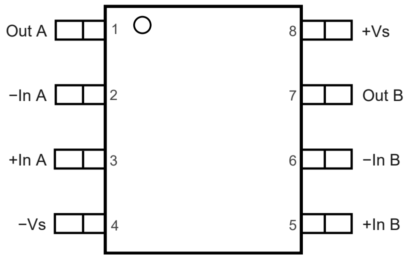
Table of Contents

Revision History

Date	Revision	Notes
2023-09-04	Rev.A.0	Initial release.

Pin Configuration and Functions

LMV358X
SOP8 Package
Top View



LMV358X
MSOP8 Package
Top View

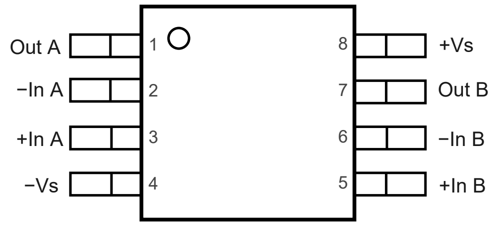


Table 1. Pin Functions: LMV358X

Pin No.	Name	I/O	Description
1	Out A	O	Output
2	−In A	I	Inverting input
3	+In A	I	Noninverting input
4	$-V_S$	-	Negative power supply
5	+In B	I	Noninverting input
6	−In B	I	Inverting input
7	Out B	O	Output
8	$+V_S$		Positive power supply

Specifications

Absolute Maximum Ratings

Over operating ambient temperature (unless otherwise noted) (1)

Parameter		Min	Max	Unit
	Supply Voltage, $(+V_S) – (–V_S)$		6.5	V
	Input Voltage	$(−V_S) – 0.3$	$(+V_S) + 0.5$	V
	Differential Input Voltage	$(−V_S) − (+V_S)$	$(+V_S) − (−V_S)$	V
	Input Current: +IN, –IN (2)	−10	10	mA
	Output Voltage	$(−V_S) − 0.3$	$(+V_S) + 0.3$	V
	Output Short-Circuit Duration (3)		Infinite	
T_J	Maximum Junction Temperature		150	°C
T_A	Operating Temperature Range	−40	125	°C
T_{STG}	Storage Temperature Range	–65	150	°C
T_L	Lead Temperature (Soldering 10 sec)		260	°C

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.
(2) The inputs are protected by ESD protection diodes to each power supply. If the input extends more than 300 mV beyond the power supply, the input current should be limited to less than 10 mA.
(3) A heat sink may be required to keep the junction temperature below the absolute maximum. This depends on the power supply voltage and how many amplifiers are shorted. Thermal resistance varies with the amount of PC board metal connected to the package. The specified values are for short traces connected to the leads.

ESD, Electrostatic Discharge Protection

Parameter		Condition	Minimum Level	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001 (1)	6	kV
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002 (2)	1.5	kV

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

Recommended Operating Conditions

Parameter		Min	Typ	Max	Unit
V_S	Supply Voltage, (+VS) – (−VS)	2.5		5.5	V
T_A	Operating Temperature Range	–40		125	°C

Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
SOP8	158	43	°C/W

Package Type	θ_{JA}	θ_{JC}	Unit
MSOP8	210	45	°C/W

Electrical Characteristics

All test condition: V_S = 5 V, T_A = 25°C, R_L = 10 kΩ, unless otherwise noted.

Parameter		Conditions	Min	Typ	Max	Unit
Power Supply						
V_S	Supply Voltage Range		2.5		5.5	V
I_Q	Quiescent Current per Amplifier			100	160	µA
		T_A = −40°C to 125°C			190	µA
PSRR	Power Supply Rejection Ratio	V_S = 2.5 V to 5.5 V	80	110		dB
		V_S = 2.5 V to 5.5 V, T_A = −40°C to 125°C	75			dB
Input Characteristics						
V_{OS}	Input Offset Voltage	V_{CM} = 0 V to 3 V	1	1.2	5	mV
		V_{CM} = 0 V to 3 V, T_A = −40°C to 125°C	0.15		5.6	mV
		V_{CM} = 3 V to 5 V	-5	1.2	7.4	mV
		V_{CM} = 3 V to 5 V, T_A = −40°C to 125°C	−5.6		11	mV
V_{OS} TC	Input Offset Voltage Drift (1)			1		µV/°C
I_B	Input Bias Current (1)	V_{CM} = 2.5 V	-300	10	300	pA
		V_{CM} = 2.5 V, T_A = −40°C to 125°C	-5		5	nA
I_{OS}	Input Offset Current (1)	V_{CM} = 2.5 V	-300	10	300	pA
		V_{CM} = 2.5 V, T_A = −40°C to 125°C	-5		5	nA
C_{IN}	Input Capacitance (2)	Differential Mode		6		pF
		Common Mode		8		pF
Av	Open−loop Voltage Gain	V_O = 0.1 V to 4.9 V	80	100		dB
		V_O = 0.1 V to 4.9 V, T_A = −40°C to 125°C	75			dB
V_{CMR}	Common−mode Input Voltage Range	T_A = −40°C to 125°C	(−V_S)−0.1		(+V_S)+0.1	V
CMRR	Common Mode Rejection Ratio	V_{CM} = 0 V to 5 V	60	80		dB
		V_{CM} = 0 V to 5 V, T_A = −40°C to 125°C	55			dB
		V_{CM} = 0 V to 3 V	85	110		dB
		V_{CM} = 0 V to 3 V, T_A = −40°C to 125°C	80			dB
Output Characteristics						
	Output Voltage Swing from Positive Rail	R_L = 10 kΩ to V_S/2		10	15	mV
		R_L = 10 kΩ to V_S/2, T_A = −40°C to 125°C			20	mV
	Output Voltage Swing from Negative Rail	R_L = 10 kΩ to V_S/2		10	15	mV
		R_L = 10 kΩ to V_S/2, T_A = −40°C to 125°C			20	mV

Electrical Characteristics (Continued)

All test condition: V_S = 5 V, T_A = 25°C, R_L = 10 kΩ, unless otherwise noted.

Parameter		Conditions	Min	Typ	Max	Unit
I_{SC}	Output Short−Circuit Current	Sink or Source	70	90		mA
		Sink or Source, TA = −40°C to 125°C	60			mA
AC Specifications						
GBW	Gain−Bandwidth Product (1)			1.5		MHz
SR	Slew Rate (1)	G = 1, 2 V step, T_A = −40°C to 125°C		0.7		V/μs
t_S	Settling Time, 0.1% (1)	G = 1, 2 V step		4.3		ns
	Settling Time, 0.01% (2)	G = 1, 2 V step		5.4		ns
PM	Phase Margin (1)	R_L= 10 kΩ, C_L= 100 pF		80		°
GM	Gain Margin (1)	R_L= 10 kΩ, C_L= 100 pF		15		dB
	Channel Separation (1)	f = 100 kHz				dB
Noise Performance						
E_N	Input Voltage Noise (1)	f = 0.1 Hz to 10 Hz,		2.1		$μV_{RMS}$
e_N	Input Voltage Noise Density (1)	f = 1 kHz		22		nV/√Hz
i_N	Input Current Noise (1)	f = 1 kHz		2		fA/√Hz
THD+N	Total Harmonic Distortion and Noise (2)	f = 1 kHz, G = 1, R_L = 10 kΩ, V_{OUT} = 1 V_{RMS}		0.002		%

(1) Provided by bench test and design simulation.
(2) Provided by design simulation.

Typical Performance Characteristics

All test condition: V_S = 5 V, V_{CM} = 2.5 V, unless otherwise noted.

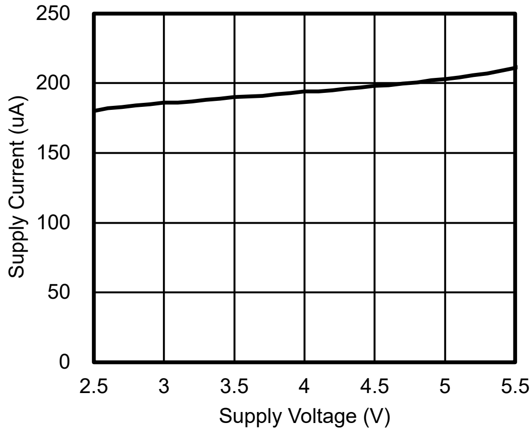


Figure 1. Supply Current vs Supply Voltage

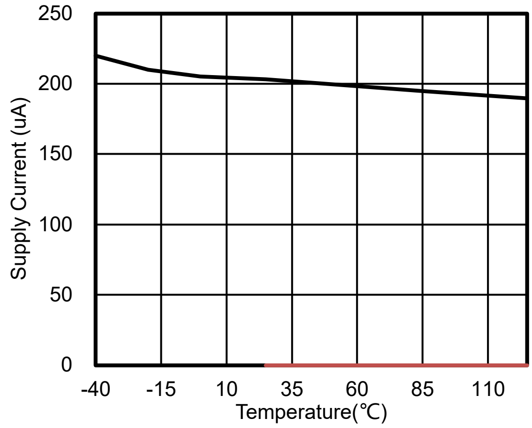


Figure 2. Supply Current vs Temperature

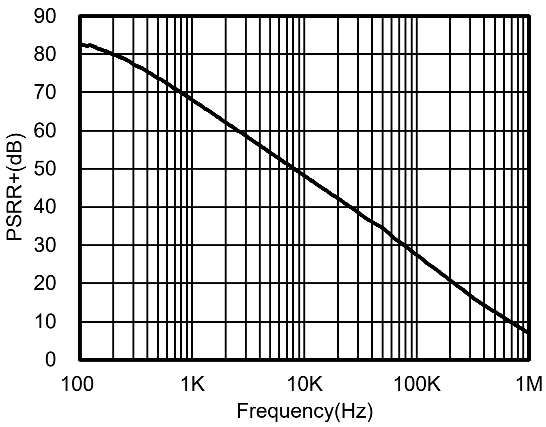


Figure 3. PSRR+ vs Frequency

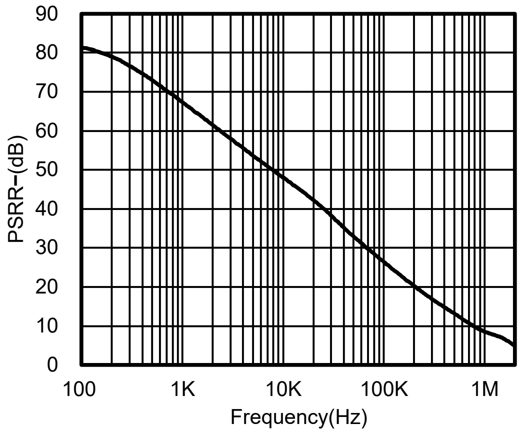


Figure 4. PSRR− vs Frequency

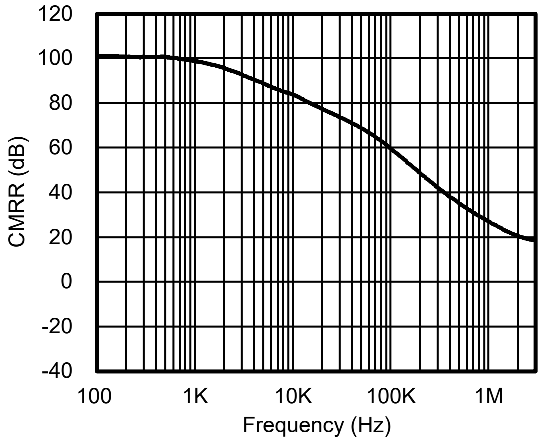


Figure 5. CMRR vs Frequency

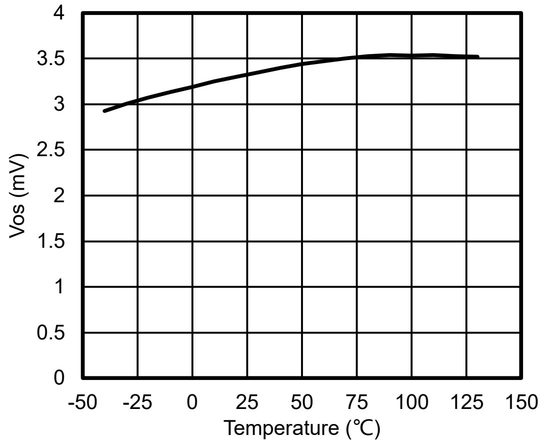


Figure 6. Open Loop Gain and Phase Margin vs Frequency, RL = 10 kΩ

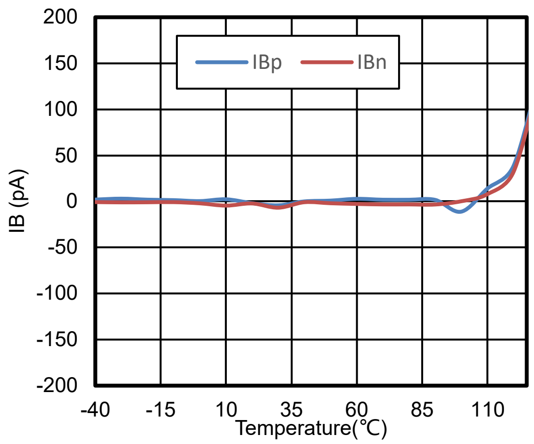


Figure 7. I_B vs Temperature

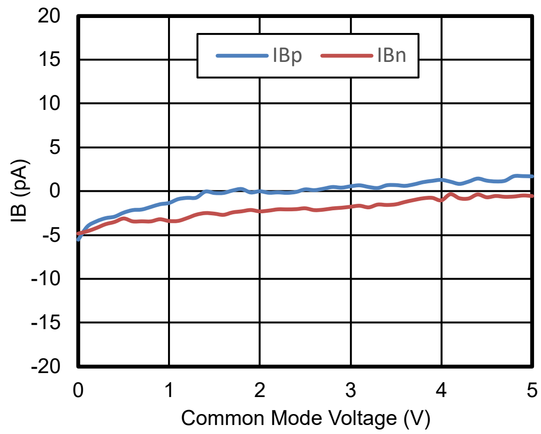


Figure 8. I_B vs V_{CM}, V_S = 5 V

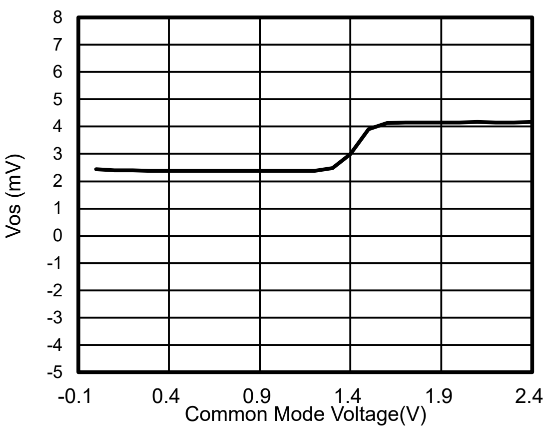


Figure 9. V_{OS} vs V_{CM}, V_S = 2.5 V

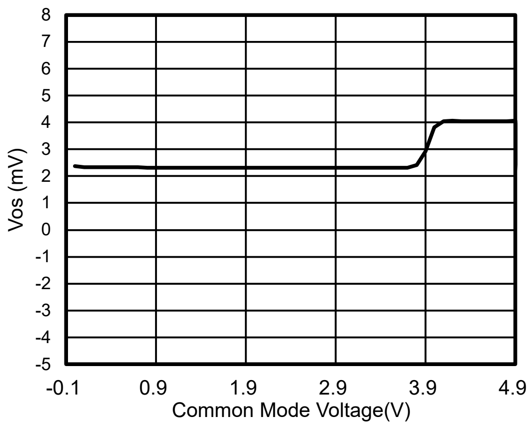


Figure 10. V_{OS} vs V_{CM}, V_S = 5 V

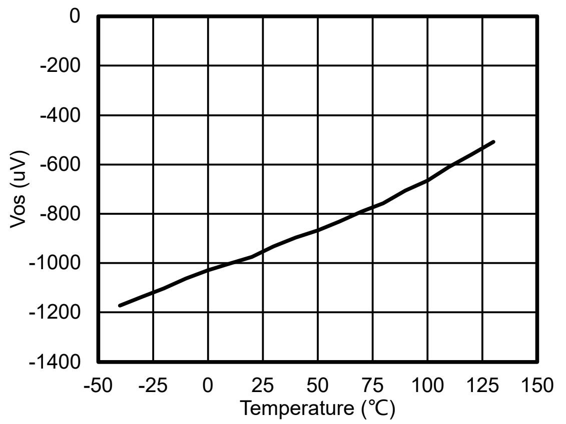


Figure 11. V_{OS} vs Temperature

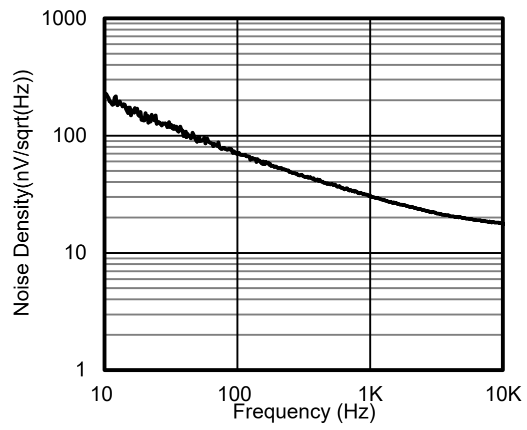


Figure 12. Voltage Noise Spectral Density vs Frequency, V_{CM} = 2.5 V

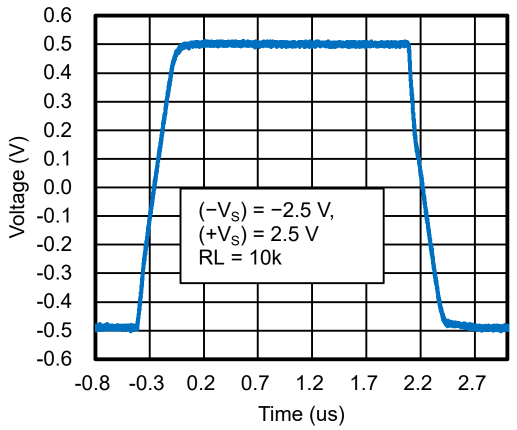


Figure 13. Large Signal Step Response

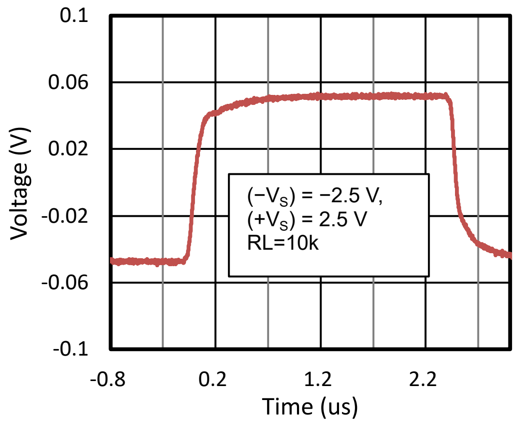


Figure 14. Small Signal Step Response

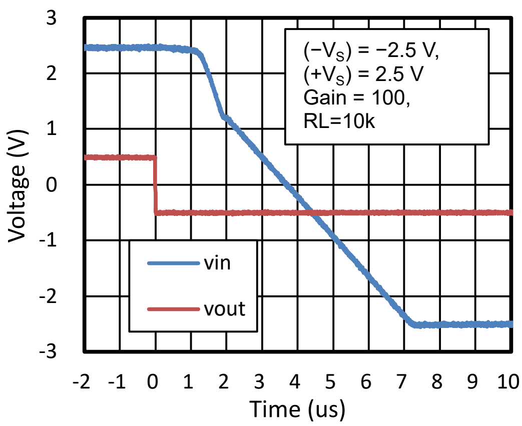


Figure 15. Overload Recovery at Negative Rail

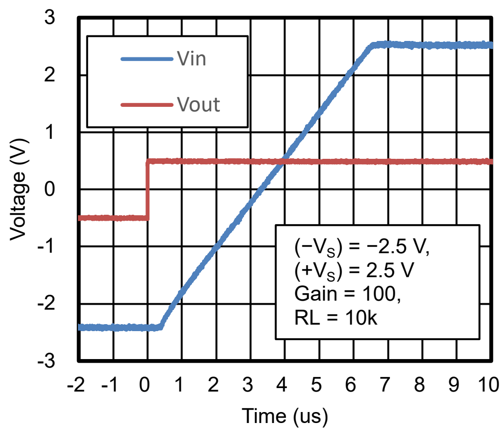


Figure 16. Overload Recovery at Positive Rail

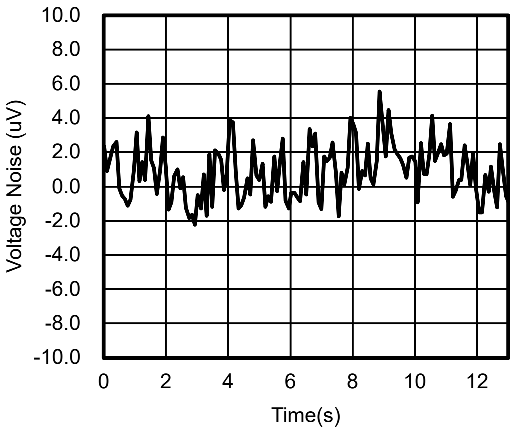


Figure 17. 0.1 to 10 Hz Voltage Noise, V_{CM} = 2.5 V

Detailed Description

Functional Block Diagram

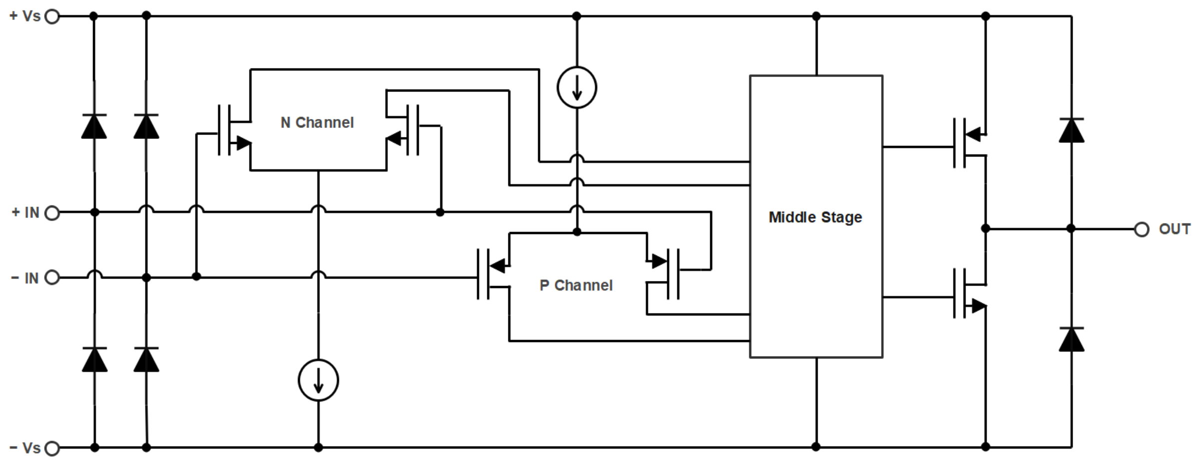


Figure 18. Functional Block Diagram

Application and Implementation

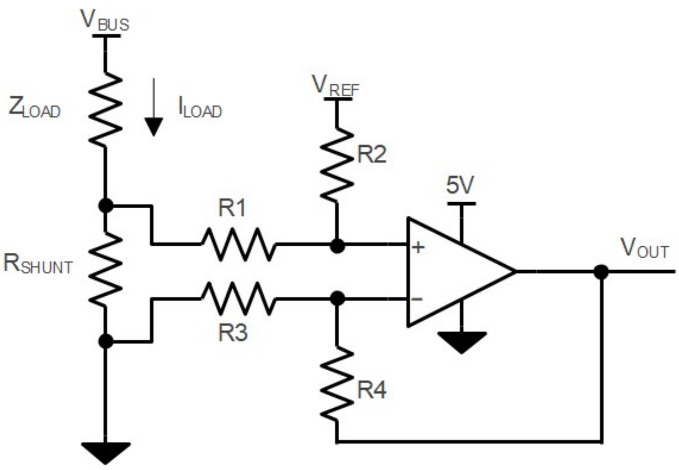
Note

Information in the following application sections is not part of the 3PEAK's component specification and 3PEAK does not warrant its accuracy or completeness. 3PEAK's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

Application Information

Low-Side Current Sensing Application

The following figure shows the device configured in a low-side current sensing application. The low-side current sensing method consists of placing a sense resistor between the load and the circuit ground. The voltage dropping across the resistor is amplified by different amplifier circuits with the device. The V_{REF} can be used to add bias voltage to output voltage. Particular attention must be paid to the matching and precision of R1, R2, R3, and R4, to maximize the accuracy of the measurement.



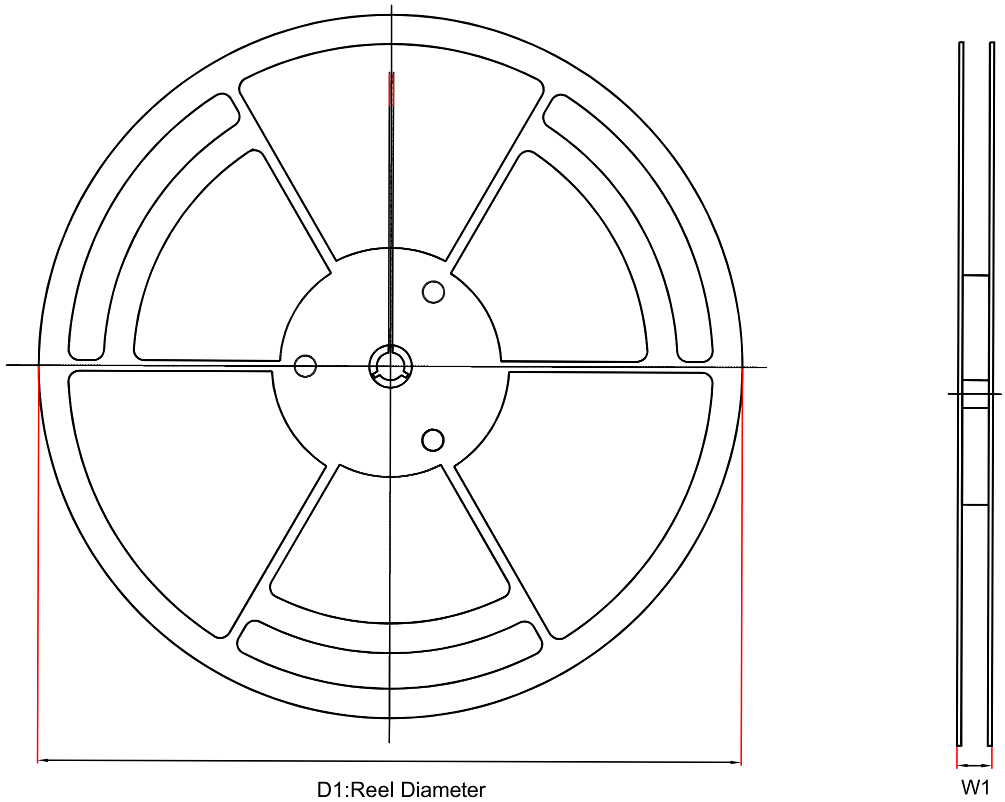
$$V_{OUT} = (I_{LOAD} \times R_{SHUNT}) \times (R2 / R1) + V_{REF}$$

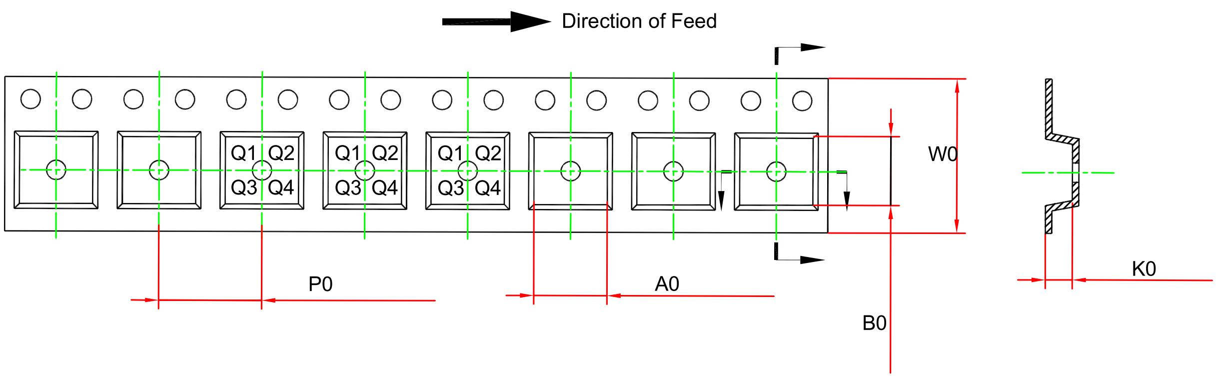
When $R3 = R1$, $R2 = R4$, $R_{SHUNT} \ll R1$

Power Supply Recommendations

Place 0.1-μF bypass capacitors close to the power-supply pins for reducing coupling errors from the noisy or high impedance power supplies.

Tape and Reel Information



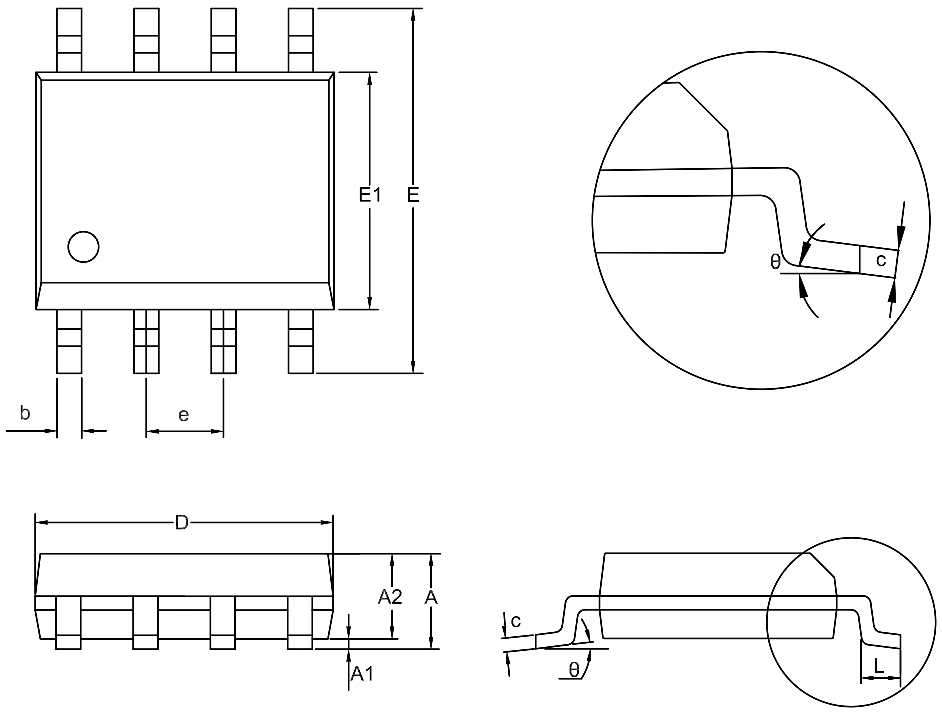


Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
LMV358X-SO1R	SOP8	330	17.6	6.5	5.4	2	8	12	Q1
LMV358X-VS1R	MSOP8	330	17.6	5.1	3.3	1.3	8	12	Q1

Package Outline Dimensions

SOP8

Package Outline Dimensions SO1(SOP-8-A)



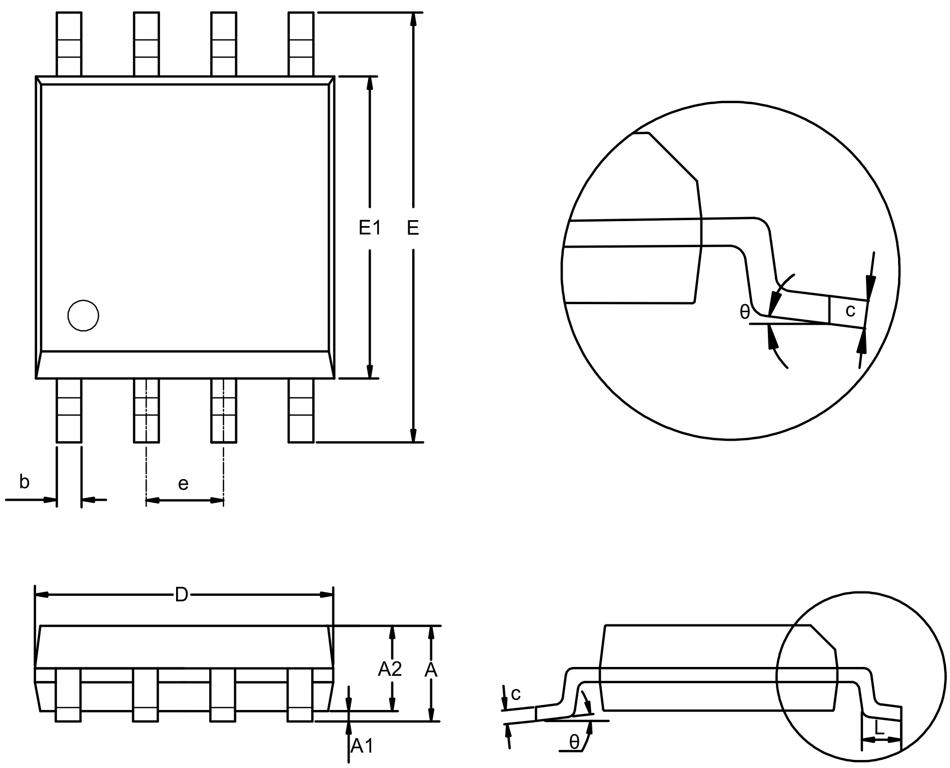
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.550	0.049	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050 BSC	
L	0.400	1.000	0.016	0.039
θ	0	8°	0	8°

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

MSOP8

Package Outline Dimensions VS1(MSOP-8-A)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	1.100	0.031	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	4.700	5.100	0.185	0.201
E1	2.900	3.100	0.114	0.122
e	0.650 BSC		0.026 BSC	
L	0.400	0.800	0.016	0.031
θ	0	8°	0	8°

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
LMV358X-SO1R	−40 to 125°C	SOP8	V358X	MSL3	Tape and Reel,4000	Green
LMV358X-VS1R	−40 to 125°C	MSOP8	V358X	MSL3	Tape and Reel,3000	Green

Green: 3PEAK defines "Green" to mean RoHS compatible and free of halogen substances.

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