1. DESCRIPTION

The XL4558 device is a dual general-purpose operational amplifier. The combination of the wide supply voltage range (10V to 30V), low noise (6.5nV/ √Hz), and distortion performance (0.0001% THD+N) of the device allow the XL4558 to be used in various audio applications.

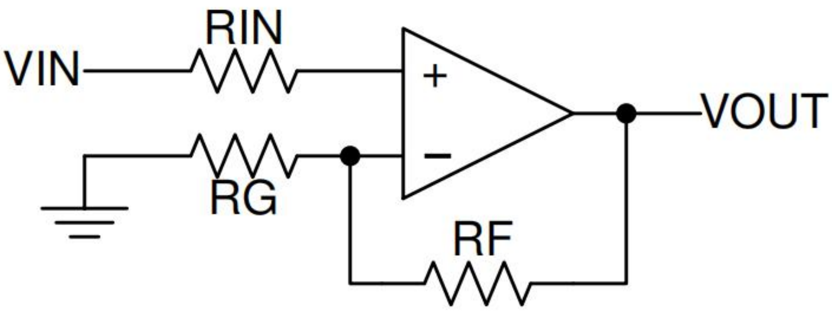
The high common-mode input voltage range and the absence of latch-up of the device are designed for voltage-follower applications. The internal frequency compensation of the device allows for stability without external components.

2. FEATURES

- Wide common-mode and differential voltage
- ranges
- No frequency compensation required
- Low power consumption
- No latch-up
- Gain bandwidth product: 4MHz typical
- Gain and phase match between amplifiers
- Low noise: 6.5nV/√Hz typical at 10kHz
- Low distortion and noise: 0.0001% at 1kHz

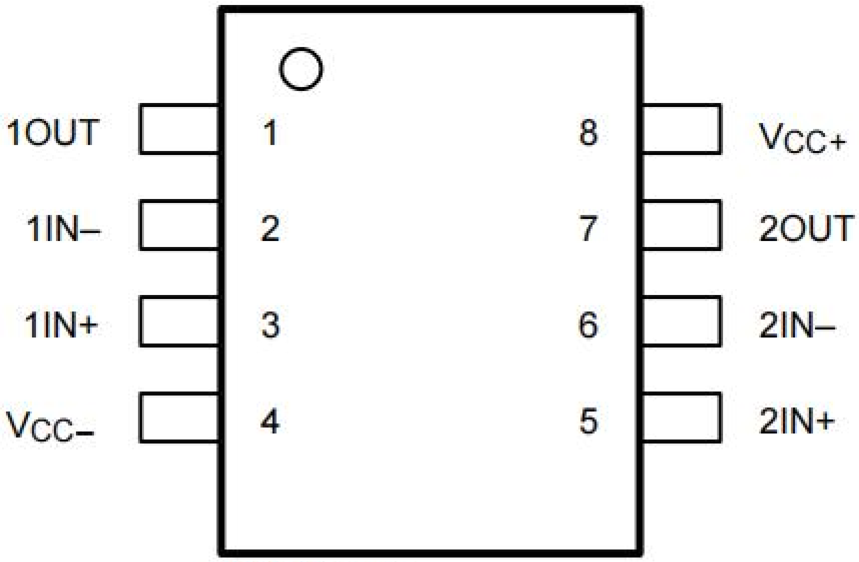
3. APPLICATIONS

- AV receivers
- Professional audio mixers
- Soundbars
- Wireless speakers



Noninverting Amplifier Schematic

4. PIN CONFIGURATION AND FUNCTIONS



Not to scale

PIN		TYPE	DESCRIPTION
NAME	NO.		
1IN+	3	I	Noninverting input
1IN-	2	I	Inverting Input
1OUT	1	O	Output
2IN+	5	I	Noninverting input
2IN-	6	I	Inverting Input
2OUT	7	O	Output
V_{CC+}	8	–	Positive Supply
V_{CC-}	4	–	Negative Supply

5. SPECIFICATIONS

5.1. Absolute Maximum Ratings

over operating ambient temperature range (unless otherwise noted)(1)

		MIN	MAX	UNIT
V_{CC+}	Supply voltage(2)		18	V
V_{CC-}			-18	
V_{ID}	Differential input voltage(3)		±30	V
V_I	Input voltage (any input)(2) (4)		±15	V
I_O	Output Current(5)		±125	mA
T_J	Operating virtual junction temperature		150	°C
T_{STG}	Storage temperature	-65	150	°C

(1) Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If used outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully

(2) All voltage values, unless otherwise noted, are with respect to the midpoint between VCC+ and VCC–.

(3) Differential voltages are at IN+ with respect to IN–.

(4) The magnitude of the input voltage must never exceed the magnitude of the supply voltage or 15V, whichever is less

(5) Temperature and supply voltages must be limited to ensure that the dissipation rating is not exceeded.

5.2. ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	±2500	V
		Charged-device model (CDM), per ANSI/ESDA/JEDEC JS-002(2)	±1500	

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

(2) JEDEC document JEP157 states that 250V CDM allows safe manufacturing with a standard ESD control process

5.3. Recommended Operating Conditions

			MIN	MAX	UNIT
V_{CC+}	Supply voltage		5	15	V
V_{CC-}			-5	-15	
T_A	Operating free-air temperature	XL4558	-40	85	°C

5.4. Thermal Information

THERMAL METRIC		XL4558 PS(SOP) 8 PINS	Unit
$R_{\theta JA}$	Junction-to-ambient thermal resistance	122.9	°CW
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	60.1	°CW
$R_{\theta JB}$	Junction-to-board thermal resistance	77.5	°CW
ψ_{JT}	Junction-to-top characterization parameter	15.7	°CW
ψ_{JB}	Junction-to-board characterization parameter	76.0	°CW
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	°CW

5.5. Electrical Characteristics

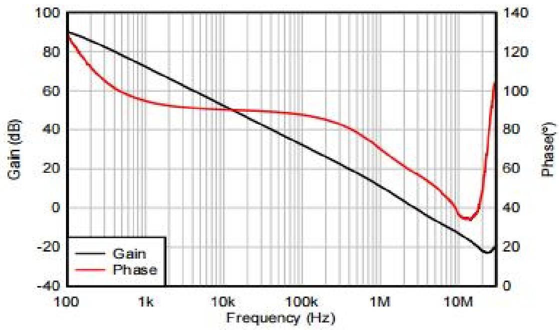
For V_{CC+} = 15 V, V_{CC-} = -15 V at T_A ≅ 25°C, R_L = 2 kΩ unless otherwise noted.

PARAMETER		TEST CONDITIONS[1]	TA	MIN	TYP	MAX	UNIT
V_{OS}	Input offset voltage	VO=0V			0.3	6	mV
			Full range[2]			7.5	
I_{IO}	Input offset current	VO=0V			5	200	nA
			Full range[2]			300	
I_{IB}	Input bias current	VO=0V			80	500	nA
			Full range[2]			800	
V_{ICR}	Common-mode input voltage range			±12	±14		V
V_{OUT}	Maximum output voltage swing	R_L = 10kΩ		±12	±14.1		V
		R_L = 2kΩ		±10	±13.8		
			Full range[2]	±10			
A_{VD}	Large-signal differential voltage amplification	R_L ≥ 2kΩ, V_O = ±10V		20	830		V/mV
				86	118		dB
			Full range[2]	15			V/mV
				83			dB
GBW	Gain-bandwidth product	f = 10kHz			4		MHz
SSBW	Small-signal bandwidth	V_O = 200mV_{PP}, <1dB peaking			3		MHz
CMRR	Common-mode rejection ratio	(V–) + 3V < V_{ICR} < (V+) – 3V		70	94		dB
	Input impedance	Common-mode			550 || 5.6		MΩ || pF
		Differential			450 || 0.8		kΩ || pF
K_{SVS}	Supply-voltage sensitivity ($\Delta V_{IO}/\Delta V_{CC}$)	VCC = ±5V to ±15V			25	150	µV/V
				76	92		dB
e_N	Input voltage noise	f = 0.1Hz to 10Hz			0.38		µVPP
					0.063		µVRMS
	Input voltage noise density	f = 1kHz			7		nV/√Hz
		f = 10kHz			6.5		
I_N	Input current noise density	f = 1kHz			0.15		pA/√Hz
THD+N	Total harmonic distortion + noise	V_{CC} = 30V, AVD = 1V/V, f = 1kHz, V_O = 3V_{RMS}, R_L = 2kΩ			0.0001		%
					120		dB
I_{CC}	Supply current (both amplifiers)	V_O = 0V, No load			2.5	5.6	mA
			Full range[2]		2.65	6.5	
V_{O1}/V_{O2}	Crosstalk attenuation	R_S = 1kΩ, f = 10kHz, A_{VD} = 1V/V			120		dB
tr	Rise time	V_I = 20mV, C_L = 100pF			67		ns
	Overshoot	V_I = 20mV, C_L = 100pF			16.8		%
SR	Slew rate	V_{STEP} = 10V, C_L = 100pF		1.1	2.2		V/µs

(1) All characteristics are measured under open-loop conditions with zero common-mode input voltage, unless otherwise specified.
(2) Full range is –40°C to 85°C for XL4558.

5.6. TYPICAL CHARACTERISTICS

at T_A ≅ 25°C, V_{CC} = 30V (±15V), V_{CM} = V_{CC} / 2, R_L = 2kΩ connected to V_{CC} / 2 (unless otherwise noted)



C_L= 22pF

Figure 5-1. Open-Loop Gain and Phase vs Frequency

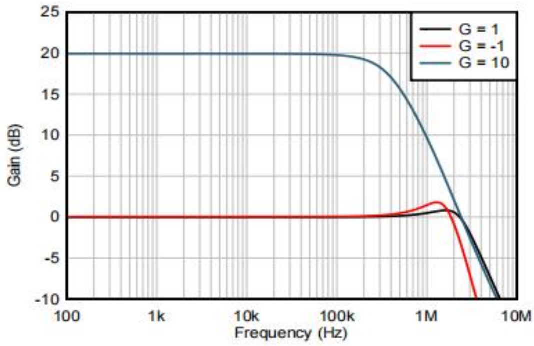


Figure 5-2.Closed-Loop Gain vs Frequency

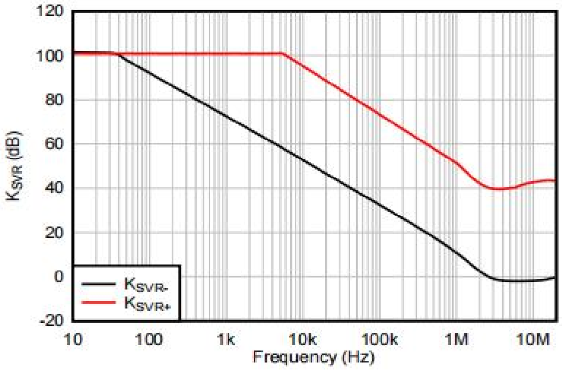


Figure 5-3. Supply Voltage Sensitivity vs Frequency

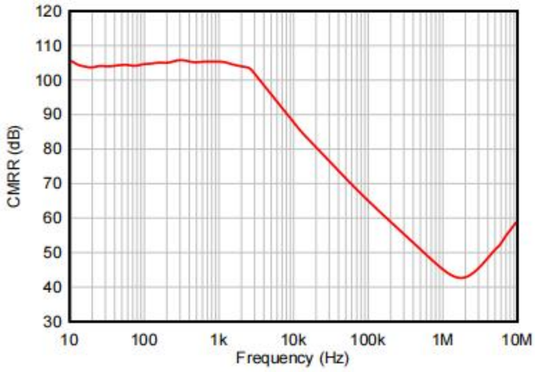


Figure 5-4. Common-Mode Rejection Ratio vs Frequency

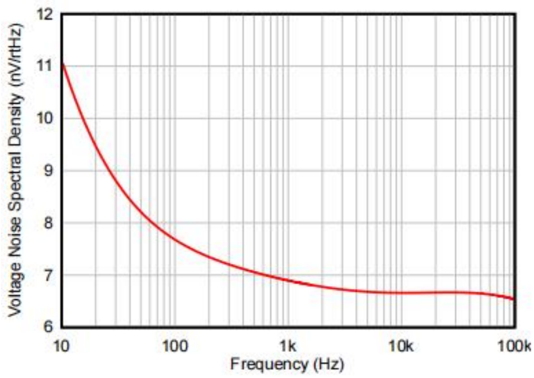


Figure 5-5. Input Noise Voltage vs Frequency

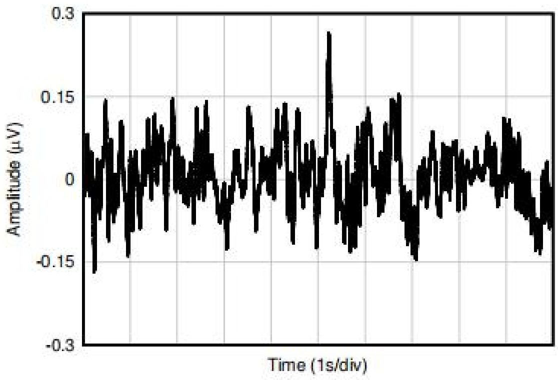
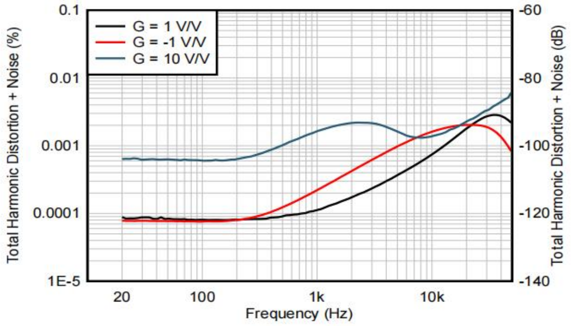
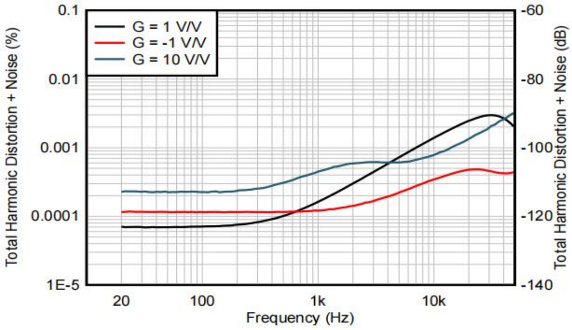


Figure 5-6. 0.1Hz to 10Hz Noise



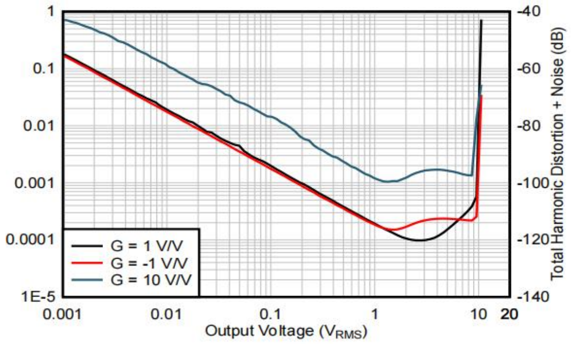
R_l = 2 kΩ

Figure 5-7.THD+N vs Frequency



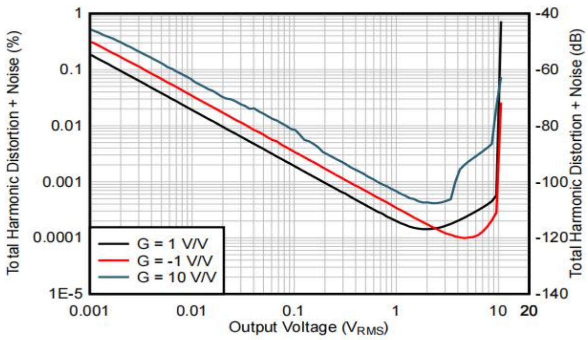
R_L = 10 kΩ

Figure 5-8.THD+N vs Frequency



R_L = 2 kΩ

Figure 5-9.THD+N vs Amplitude



R_L = 10 kΩ

Figure 5-10.THD+N vs Amplitude

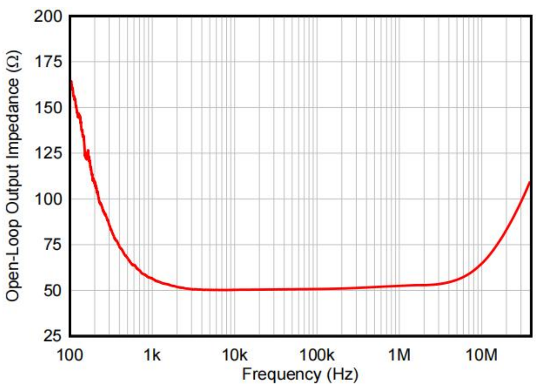


Figure 5-11. Open-Loop Output Impedance vs Frequency

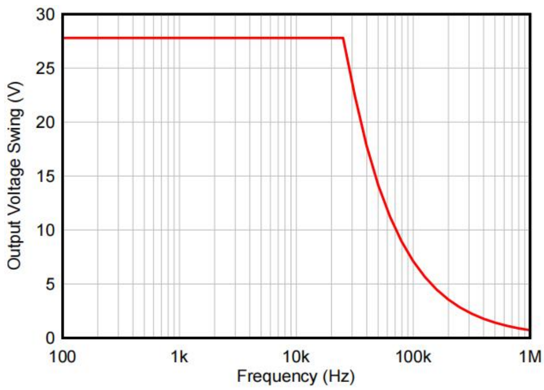


Figure 5-12. Output Voltage Swing vs Frequency

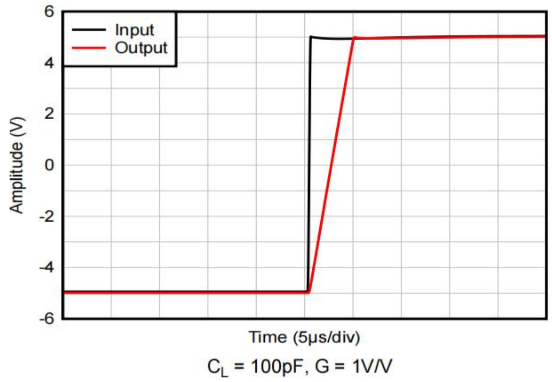


Figure 5-13. Large Signal Step Response

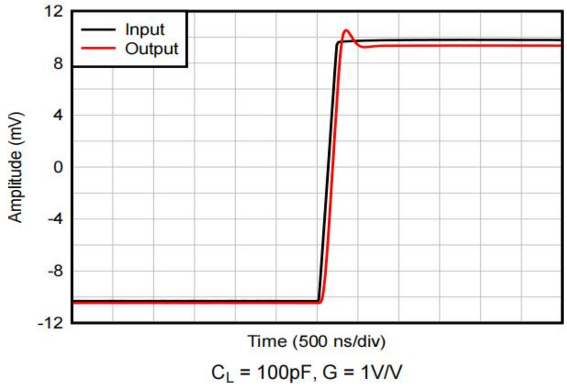


Figure 5-14.Small Signal Step Response

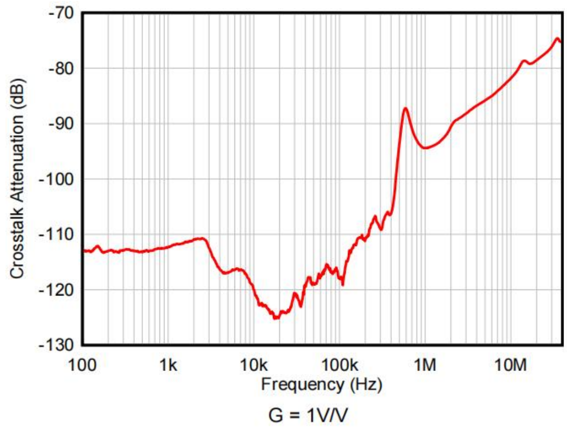


Figure 5-15. Crosstalk Attenuation vs Frequency

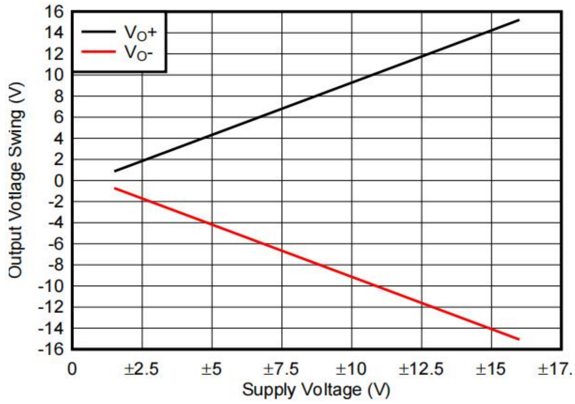


Figure 5-16.Maximum Output Voltage Swing vs Operating Voltage

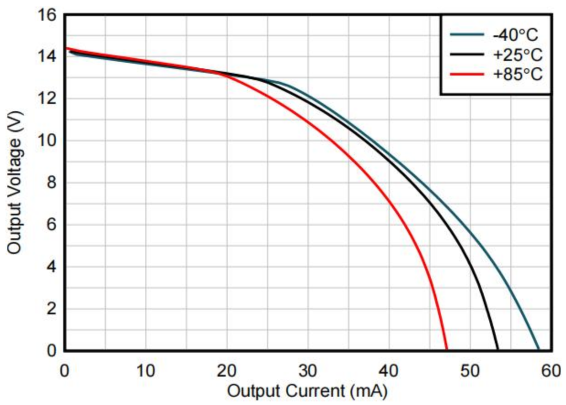


Figure 5-17. Output Voltage Swing vs Output Current (Sourcing)

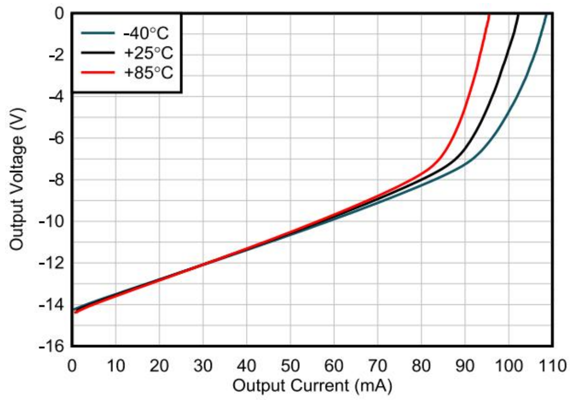


Figure 5-18. Output Voltage Swing vs Output Current (Sinking)

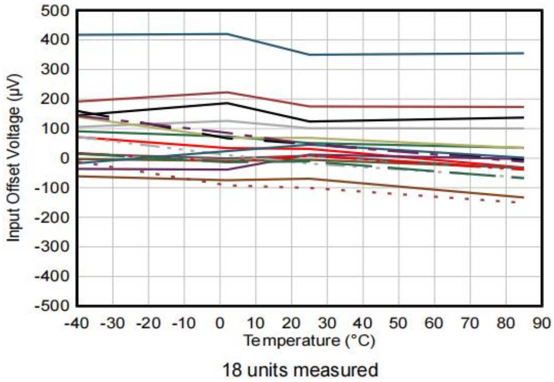


Figure 5-19. Offset Voltage vs Temperature

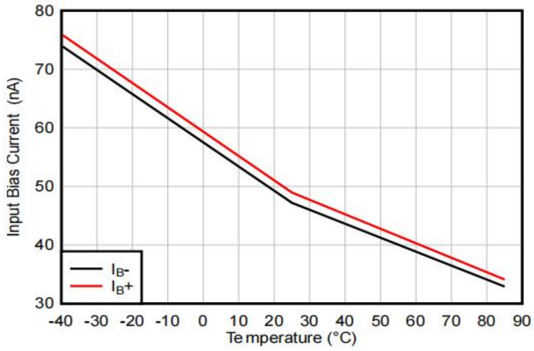


Figure 5-20.Bias Current vs Temperature

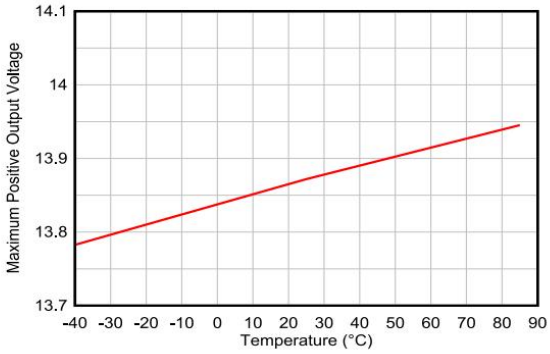


Figure 5-21. Positive Output Voltage Swing vs Temperature

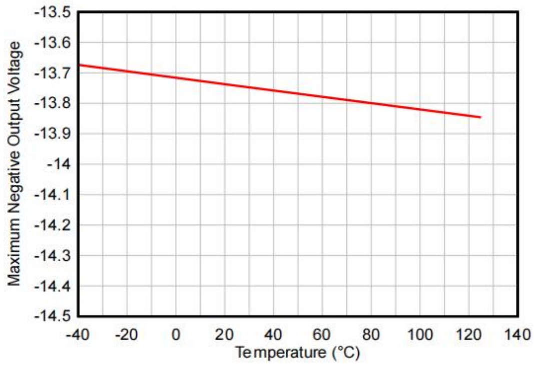


Figure 5-22. Negative Output Voltage Swing vs Temperature

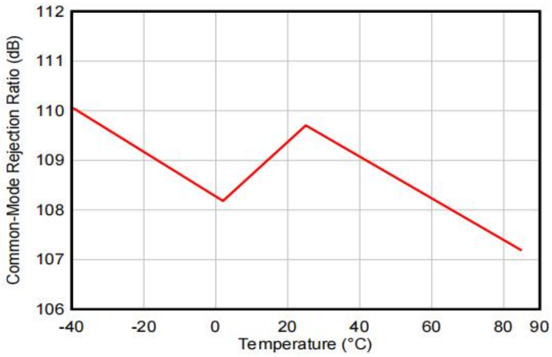


Figure 5-23.Common-Mode Rejection Ratio vs Temperature

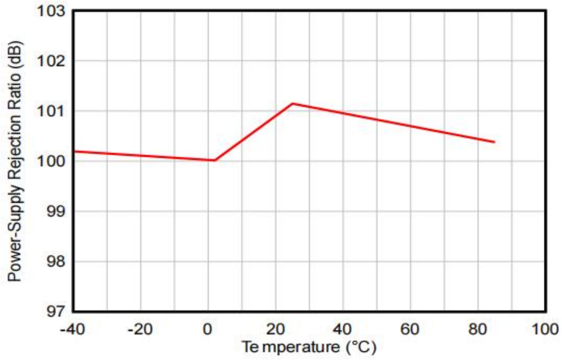


Figure 5-24. Power Supply Rejection Ratio vs Temperature

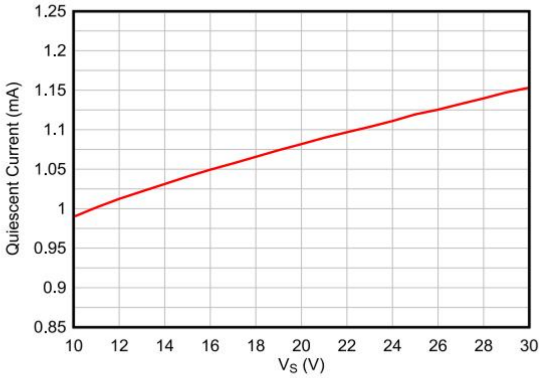


Figure 5-25.Supply Current vs Supply Voltage

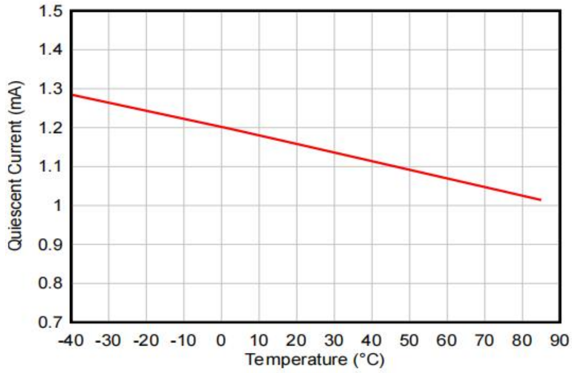


Figure 5-26. Supply Current vs Temperature

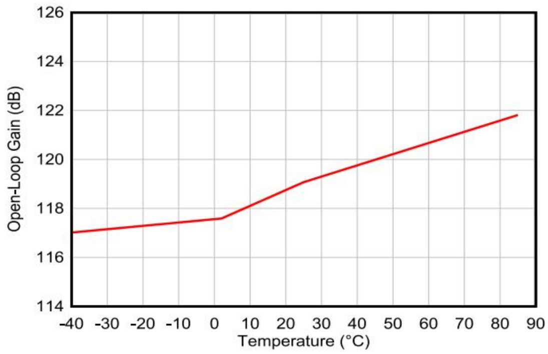


Figure 5-27. Open-Loop Gain vs Temperature

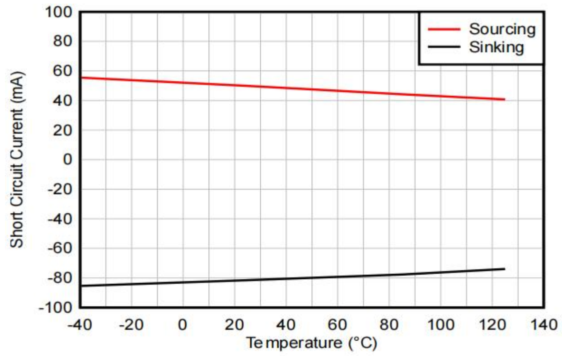


Figure 5-28.Short-Circuit Current vs Temperature

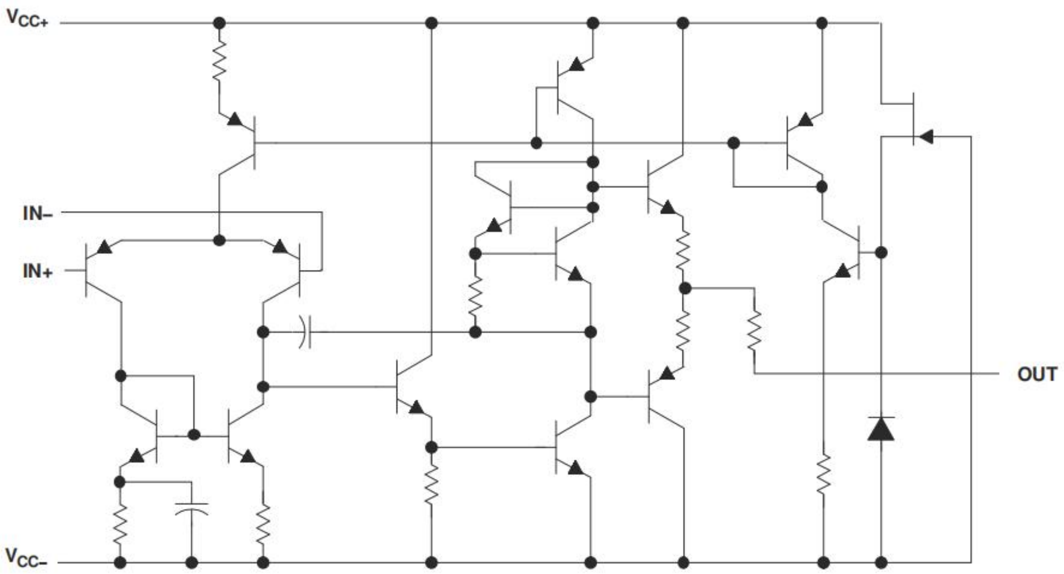
6. DETAILED DESCRIPTON

6.1. Overview

The XL4558 device is a dual general-purpose operational amplifier. The combination of the wide supply voltage range (10V to 30V), low noise (6.5nV/NHz),and distortion performance(0.0001%THD+N) of the device allow the XL4558 to be used in various audio applications.

The high common-mode input voltage range and the absence of latch-up of this device are designed for voltage-follower applications. The internal frequency compensation of the device allows for stability without external components.

6.2. Functional Block Diagram



6.3. Feature Description

6.3.1. Unity-Gain Bandwidth

The unity-gain bandwidth is the frequency up to which an amplifier with a unity gain can be operated without greatly distorting the signal. The XL4558 device has a 4MHz gain-bandwidth product.

6.3.2. Common-Mode Rejection Ratio

The common-mode rejection ratio (CMRR) of an amplifier is a measure of how well the device rejects unwanted input signals common to both input leads.The CMRR is found by taking the ratio of the change in input offset voltage to the change in the input voltage, then converting the ratio to decibels. Ideally theCMRR is infinite, but in practice, amplifiers are designed to have the CMRR as high as possible. The CMRR of the XL4558 device is 94dB.

6.3.3. Slew Rate

The slew rate is the rate at which an operational amplifier can change the output when there is a change on the input. The XL4558 device has a 2.2V/µs slew rate.

6.4. Device Functional Modes

The XL4558 device is powered on when the supply is connected. Each of these devices can be operated as a single-supply operational amplifier or dual-supply amplifer depending on the application.

7. APPLICATION AND LMPLEMENTATION

7.1. Application Information

The XL4558 is a dual general-purpose device that offers a wide supply range and excellent AC performance.This device operates up to 30V supply rails and offers low noise(6.5nVNHZ) and distortion performance (0.0001% THD+N).These XL4558 features are designed for both audio and industrial applications.

7.2. Typical Application

Some applications require differentialsignals.Figure 7-1 shows a simple circuit to convert a single-ended input of 2V to 10V into differential output of ±8V on a single 15V supply. The output range is intentionally limited to maximize linearity.The circuit is composed of two amplifiers. One amplifier acts as a buffer and creates a voltage, VouT+.The second amplifier inverts the input and adds a reference voltage to generate V_{OUT-}.Both V_{OUT+} and V_{OUT-}range from 2V to 10V. The difference,V_{DIFF},is the difference between V_{OUT+} and V_{OUT-}-.

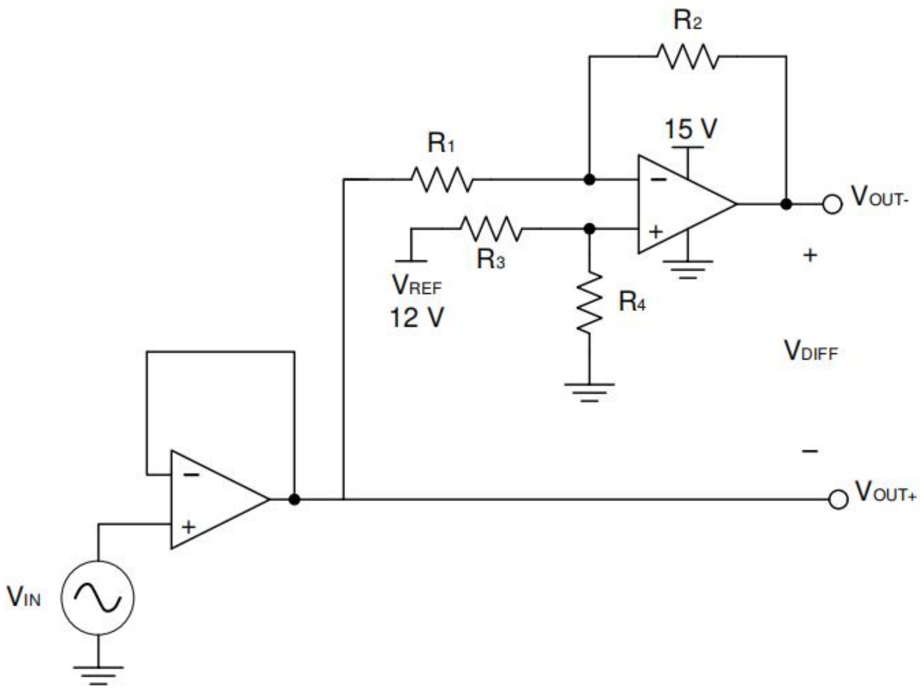


Figure 7-1. Schematic for Single-Ended Input to Differential Output Conversion

7.2.1. Design Requirements

- The design requirements are as follows:
- Supply voltage: 15V
- Reference voltage:12V
- Input: 2V to 10V
- Output differential: ±8V

7.2.2. Detailed Design Procedure

The circuit in Figure 7-1 takes a single-ended input signal,V_{IN},and generates two output signals,V_{OUt+} and V_{OUT-}, using two amplifiers and a reference voltage,V_{REF}. V_{OUT+} is the output of the first amplifier and is a buffered version of the input signal,V_{IN} (see Equation 1). V_{OUT-} is the output of the second amplifier which uses VREF to add an offset voltage to V_{IN} and feedback to add inverting gain. The transfer function for V_{OUT-} is Equation 2.

$$V_{OUT+} = V_{IN} \tag{1}$$

$$V_{OUT-} = V_{REF} \times \left(\frac{R_4}{R_3 + R_4}\right) \times \left(1 + \frac{R_2}{R_1}\right) - V_{IN} \times \frac{R_2}{R_1} \tag{2}$$

The differential output signal, V_{DIFF},is the difference between the two single-ended output signals, V_{OUT+} and V_{OUT-}. Equation 3 shows the transfer function for V_{DIFF}.By applying the conditions that R_1=R_2 and R_3=R_4,the transfer function is simplified into Equation 6. Using this configuration, the maximum input signal is equal to the reference voltage and the maximum output of each amplifier is equal to the V_{REF}.The differential output range is 2 x V_{REF}.Furthermore, the common-mode voltage is one half of V_{REF}(see Equation 7).

$$V_{DIFF} = V_{OUT+} - V_{OUT-} = V_{IN} \times \left(1 + \frac{R_2}{R_1}\right) - V_{REF} \times \left(\frac{R_4}{R_3 + R_4}\right)\left(1 + \frac{R_2}{R_1}\right) \tag{3}$$

$$V_{OUT+} = V_{IN} \tag{4}$$

$$V_{OUT-} = V_{REF} - V_{IN} \tag{5}$$

$$V_{DIFF} = 2 \times V_{IN} - V_{REF} \tag{6}$$

$$V_{CM} = \left(\frac{V_{OUT+} + V_{OUT-}}{2}\right) = \frac{1}{2}V_{REF} \tag{7}$$

7.2.2.1. Amplifier Selection

Linearity over the input range is key for good DC accuracy. The common-mode input range and the output swing limitations determine the linearity. In general, an amplifier with rail-to-rail input and output swing is required.Bandwidth is a key concern for this design.The XL4558 device has a bandwidth of 4MHz, therefore this circuit can only process signals with frequencies of less than 4MHz.

7.2.2.2. Passive Component Selection

The transfer function of V_{OUT-} is heavily reliant on resistors (R_1,R_2,R_3,and R_4), therefore recommends to use resistors with low tolerances to maximize performance and minimize error. This design uses resistors with resistance values of 36kΩ with tolerances measured to be within 2% of these resistor values. If the noise of the system is a key parameter, the user can select smaller resistance values (6kΩ or lower) to keep the overall system noise low and the noise from the resistors lower than the amplifier noise.

7.2.3. Application Curves

The measured transfer functions in Figure 7-2, Figure 7-3, and Figure 7-4 were generated by sweeping the input voltage from 0V to 12V. However, this design must only be used between 2V and 10V for optimum linearity.

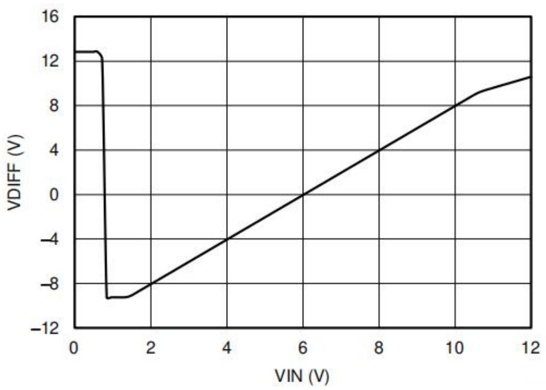


Figure 7-2. Differential Output Voltage Node vs Input Voltage

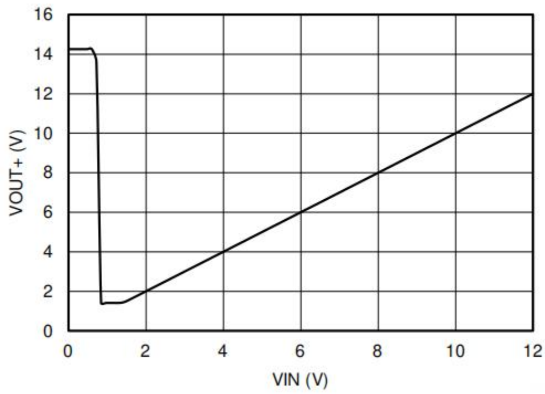


Figure 7-3. Positive Output Voltage Node vs Input

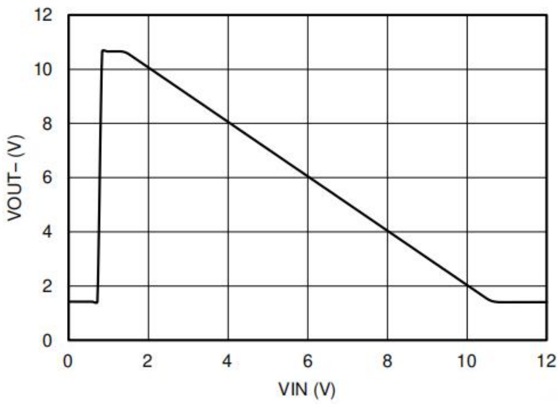


Figure 7-4. Positive Output Voltage Node vs Input Voltage

7.3. Power Supply Recommendations

The XL4558 device is specified for ±5V to ±15V operation; many specifications apply for -0°C to 70C. TheTypical Characteristics section presents parameters that can exhibit significant variance with regard to operating voltage or temperature.

Place 0.1pF bypass capacitors dose to the power-supply pins to reduce errors coupling in from noisy or high impedance power supplies. For more detailed information on bypass capacitor placement, refer to the 7.4.1Layout Guidelines.

7.4. Layout

7.4.1. Layout Guidelines

For best operational performance of the device, use good printed circuit board (PCB) layout practices, indluding:

- Noise can propagate into analog circuitry through the operational amplifier and the power pins of the circuit as a whole. Bypass capacitors are used to reduce the coupled noise by providing low impedance power sources local to the analog circuitry.
  - Connect low-ESR,0.1pF ceramic bypass capacitors between each supply pin and ground, placed as close to the device as possible. A single bypass capacitor from V+ to ground is applicable for single-supply applications.
- Separating grounding for analog and digital portions of circuitry is one of the simplest and most effective methods of noise suppression. One or more layers on multilayer PCBs are usually devoted to ground planes. and analog grounds, paying attention to the flow of the ground current. A ground plane helps distribute heat and reduces EMI noise pickup. Make sure to physically separate digital
- To reduce parasitic coupling, run the input traces as far away from the supply or output traces as possible.lf it is not possible to keep the traces separate, it is much better to cross the sensitive trace perpendicular as opposed to in parallel with the noisy trace.
- Place the external components as close to the device as possible. Keeping RFand RG cose to the inverting input minimizes parasitic capacitance. as shown in 7.4.2Layout Example.
- Keep the length of input traces as short as possible. Always remember that the input traces are the most sensitive part of the circuit.
- Consider a driven, low-impedance guard ring around the critical traces. Aguard ring can significantly reduce leakage currents from nearby traces that are at different potentials.

7.4.2. Layout Example

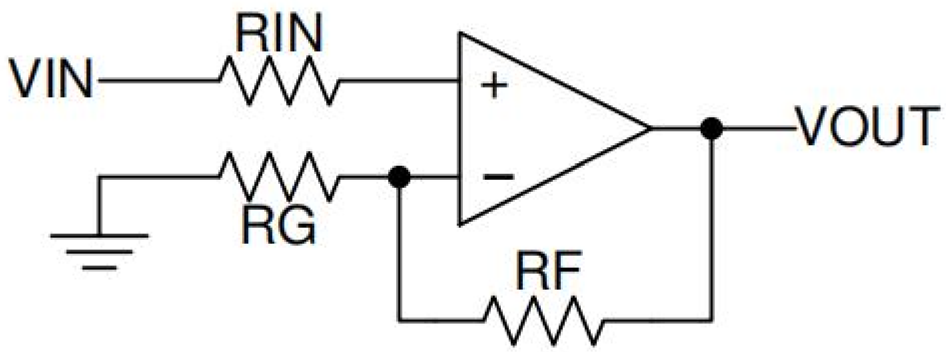


Figure 7-5. Operational Amplifier Schematic for Noninverting Configuration

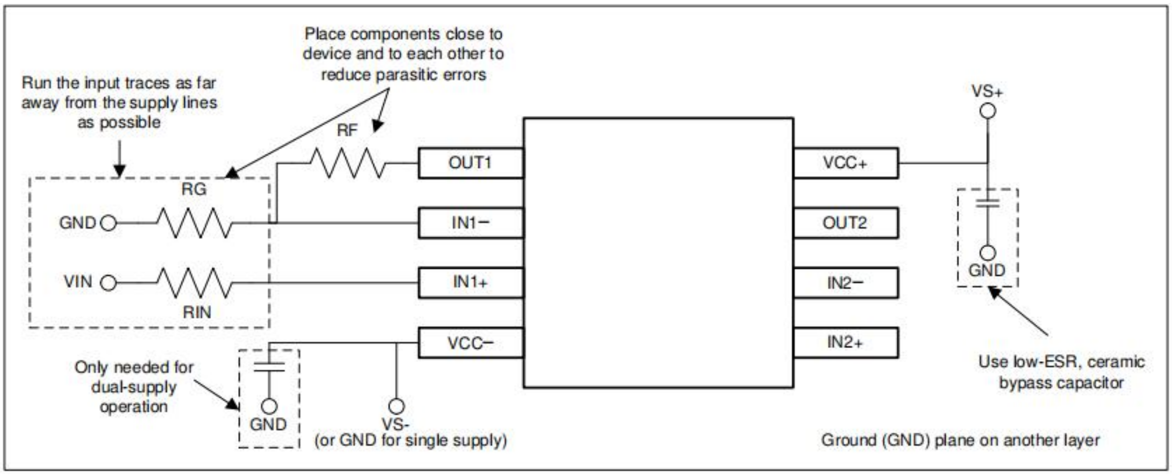


Figure 7-6. Operational Amplifier Board Layout for Noninverting Configuration

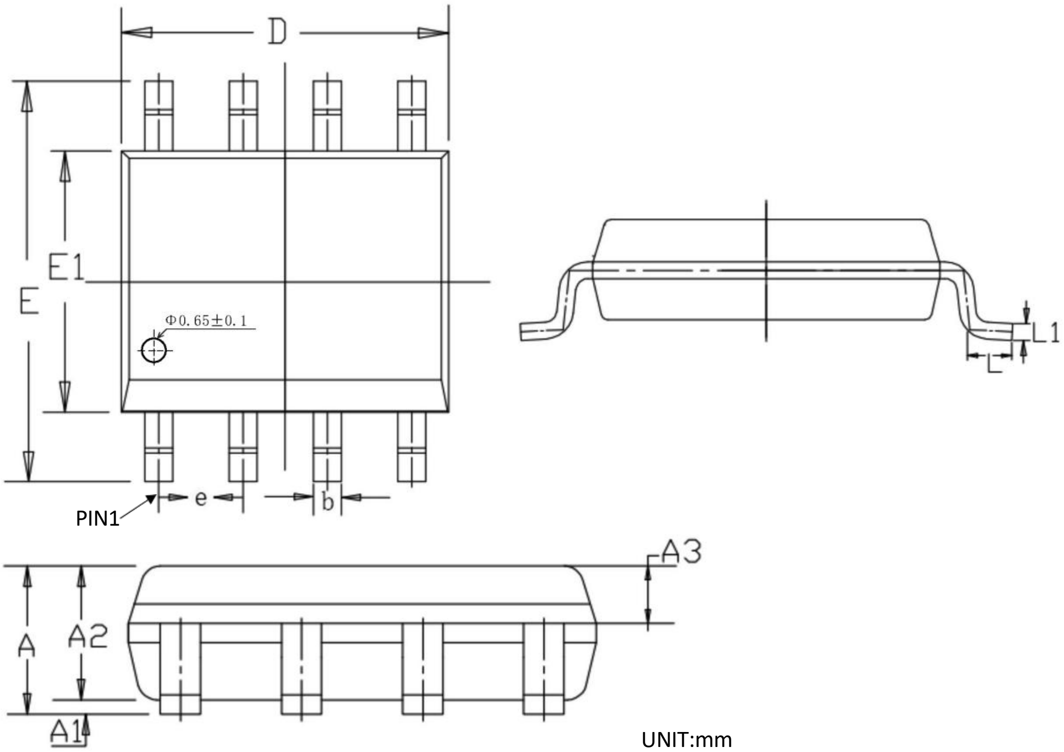
8. ORDERING INFORMATION

Ordering Information

Part Number	Device Marking	Package Type	Body size (mm)	Temperature (℃)	MSL	Transport Media	Package Quantity
XL4558	XL4558	SOP8	4.90 * 3.90	- 40 to 85	MSL3	T&R	2500

9. DIMENSIONAL DRAWINGS

SOP8



UNIT:mm

	MIN	NOM	MAX
A	1.450	1.550	1.650
A1	0.100	0.150	0.200
A2	1.300	1.400	1.500
A3	0.600	0.650	0.700
b	0.380	–	0.510
e	1.240	1.270	1.300
D	4.800	4.900	5.000
E	5.800	6.000	6.200
E1	3.800	3.900	4.000
L	0.450	0.600	0.750
L1	—	0.25BSC	—