

Low Power, Wide Input Range, Difference Amplifiers, $G = 0.5, 2$

Features

- High Reliability:
Input Protection to ± 65 V (power on & off)
Over Temperature Protection
- CMRR: 98 dB min ($G = 0.5$)
- CMRR Temperature Drift: 0.5 ppm/ $^{\circ}\text{C}$ max ($G = 0.5$)
- High Precision:
Input Offset Voltage: 75 μV max ($G = 0.5$, Grade B)
Input Offset Drift:
1 $\mu\text{V}/^{\circ}\text{C}$ max (-40°C to 85°C , $G = 0.5$, Grade B)
Gain Error: 60 ppm max ($G = 0.5$)
Gain Error Temperature Drift: 1.2 ppm/ $^{\circ}\text{C}$ max ($G = 0.5$)
- Wide Input Rang: 3 times of Supplies ($G = 0.5$)
- Bandwidth: 800 kHz ($G = 0.5$)
- Supply Current: 330 μA per channel
- Wide Power Supply Range: 2.7 V to 36 V; ± 1.35 V to ± 18 V
- Specified Temperature Range: -40°C to $+125^{\circ}\text{C}$

Applications

- Li-Ion Battery Formation & Grading
- Precision Data Acquisition
- Communication Systems
- Sensor Signal Conditioning
- Industrial Control

Applications Examples

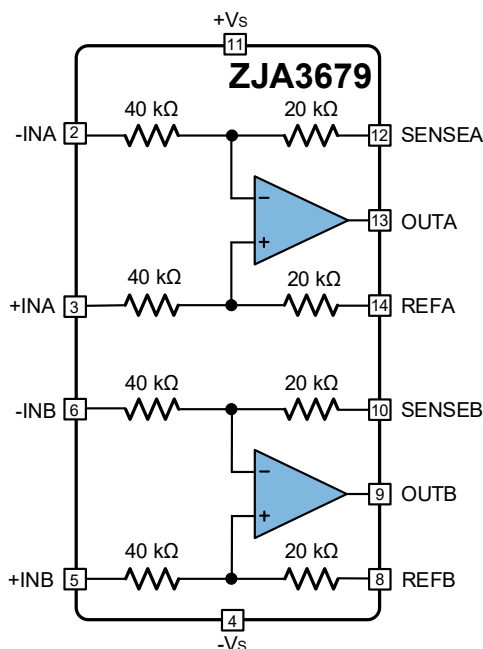


Figure 1. ZJA3679

General Description

The ZJA3678 and ZJA3679 are general-purpose difference amplifiers with the gain of 0.5 or 2 intended for precision signal conditioning in power critical applications that require both high performance and low power. They provide exceptional common-mode rejection ratio (98 dB min.) and 800 kHz bandwidth. The common-mode range of the amplifier extends to almost triple the supply voltage (for $G = 0.5$), making the amplifiers ideal for single-supply applications that require a high common-mode voltage range. The internal resistors and ESD circuitry at the inputs also provide overvoltage protection to the op amp.

Their unique design enables the ZJA3678 and ZJA3679 to with stand ± 65 V during power-up and power-down, protecting the entire system. Additionally, on-chip over-temperature protection (OTP) ensures reliable operation under harsh environments.

The ZJA3678/9 operate on single supplies (2.7 V to 36 V) or dual supplies (± 1.35 V to ± 18 V). The quiescent supply current is 330 μA per channel, which is ideal for battery-operated and portable systems.

The ZJA3678 is available in 8-lead MSOP and SOIC packages, and the ZJA3679 is offered in a 14-lead SOIC package. Both are specified for performance over the temperature range of -40°C to $+125^{\circ}\text{C}$ and are fully RoHS and MSL-1 compliant.

ZJA3676 Product Family

Product	Gain	Number of Channels	Package
ZJA3676	1	1	SOIC-8, MSOP-8
ZJA3677	1	2	SOIC-14
ZJA3678	0.5, 2	1	SOIC-8, MSOP-8
ZJA3679	0.5, 2	2	SOIC-14

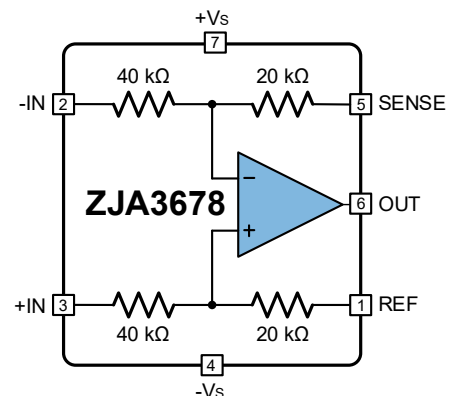


Figure 2. ZJA3678

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Version (Release B) ¹**Revision History****Sep. 2026 — Release B**

Changes Input Operating Voltage Range in Specifications

Update Ordering Guide, Product Order Model, Related Parts

Dec. 2024 — Release A

English version

Updated Figure 55/56/57, Current Source, Ordering Guide, Product Order Model , Related Parts

Dec. 2023**Sep. 2023—Initial**

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Pin Configurations and Function Descriptions

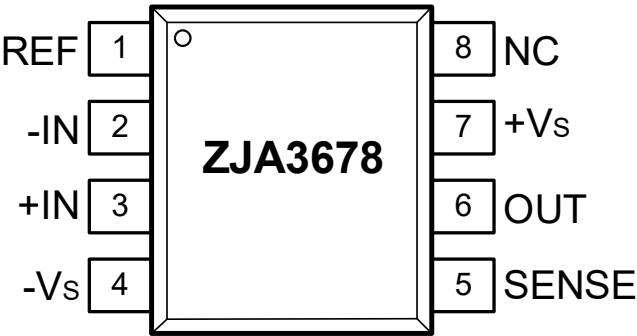


Figure 3. ZJA3678 Pin Configuration (8-lead SOIC)

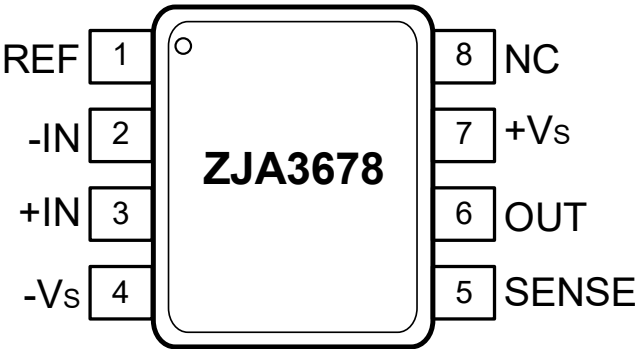


Figure 4. ZJA3678 Pin Configuration (8-lead MSOP)

Mnemonic	Pin No.	I/O ¹	Description
REF	1	AI	Reference input
-IN	2	AI	Inverting input
+IN	3	AI	Non-inverting input
-Vs	4	P	Negative power supply
SENSE	5	AI	Sense terminal
OUT	6	AO	Output
+Vs	7	P	Positive power supply
NC	8	--	No Connect. This pin is not internally connected

¹ AI: Analog Input; P: Power; AO: Analog Output.

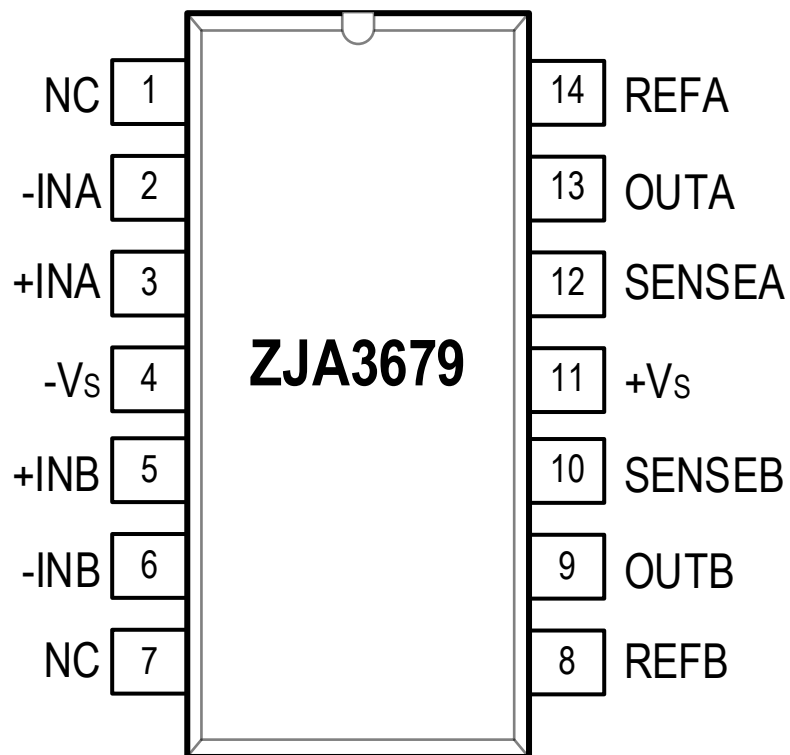


Figure 5. ZJA3679 Pin Configuration (14-lead SOIC)

Mnemonic	Pin No.	I/O ¹	Description
NC	1	--	No Connect. This pin is not internally connected
-INA	2	AI	Channel A inverting input
+INA	3	AI	Channel A non-inverting input
-Vs	4	P	Negative power supply
+INB	5	AI	Channel B non-inverting input
-INB	6	AI	Channel B inverting input
NC	7	--	No Connect. This pin is not internally connected
REFB	8	AI	Channel B reference voltage input
OUTB	9	AO	Channel B output
SENSEB	10	AI	Channel B sense terminal
+Vs	11	P	Positive power supply
SENSEA	12	AI	Channel A sense terminal
OUTA	13	AO	Channel A output
REFA	14	AI	Channel A reference input

¹ AI: Analog Input; P: Power; AO: Analog Output.

Absolute Maximum Ratings ¹

Parameter	Rating
Supply Voltage	40 V
Maximum Voltage at Any Input Pin	$(-V_S) + 65 \text{ V}$
Minimum Voltage at Any Input Pin	$(-V_S) - 65 \text{ V}$
Output Short-Circuit Duration to GND ²	Continuous
Operating Temperature Range	-40 °C to 125 °C
Storage Temperature Range	-65 °C to 150 °C
Junction Temperature Range	-65 °C to 150 °C
Maximum Reflow Temperature ³	260 °C
Lead Temperature, Soldering (10 sec)	300 °C
Electrostatic Discharge (ESD) ⁴	
Human Body Model (HBM) ⁵	3.5 kV
Charged Device Model (CDM) ⁶	2 kV

Thermal Resistance ⁷

Package Type	θ_{JA}	θ_{JC}	Unit
SOIC-8	158	43	°C/W
MSOP-8	190	44	°C/W
SOIC-14	120	36	°C/W

¹ These ratings apply at 25 °C, unless otherwise noted. Note that stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

² Limited by Over Temperature Protection (OTP).

³ IPC/JEDEC J-STD-020 Compliant

⁴ Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

⁵ ANSI/ESDA/JEDEC JS-001 Compliant

⁶ ANSI/ESDA/JEDEC JS-002 Compliant

⁷ θ_{JA} addresses the conditions for soldering devices onto circuit boards to achieve surface mount packaging.

Specifications

The ● denotes the specification which apply over the specified temperature range, otherwise specifications are at $T_A = 25\text{ }^{\circ}\text{C}$, $V_S = \pm 15\text{ V}$, $V_{REF} = 0\text{ V}$, $R_L = 10\text{ k}\Omega$, $G = 0.5$, unless otherwise noted.

Parameter	Symbol	Conditions		Min	Typ.	Max	Unit
Input characteristics							
System Offset ¹	V _{OS}	B Grade			10	75	μV
		B Grade, -40 °C to 85 °C				150	μV
		B Grade	●			225	μV
		A Grade			20	150	μV
		A Grade, -40 °C to 85 °C				250	μV
		A Grade	●			400	μV
System Offset Drift	TCV _{OS}	B Grade, -40 °C to 85 °C			0.3	1	μV/°C
		B Grade	●			1.5	μV/°C
		A Grade, -40 °C to 85 °C			0.5	2	μV/°C
		A Grade	●			2.5	μV/°C
Power Supply	PSRR	V _S = ±2.25 V to ±18 V			0.2	1.2	μV/V
		V _S = ±2.25 V to ±18 V	●			2.2	μV/V
Common Mode Rejection Ratio	CMRR	V _S = ±15 V, V _{CM} = ±10 V, R _S = 0 Ω		98	116		dB
			●	88			dB
Common Mode Rejection Ratio Drift			●		0.1	0.5	ppm/°C
Input Operating Voltage Range ²	IVR			3 (-V _S + 0.1)		+3 (V _S - 1.5)	V
Input Impedance ³							
Differential Mode	R _{IN}				120		kΩ
Common Mode					30		kΩ
Dynamic Performance							
Bandwidth					800		kHz
Slew Rate					1.1		V/μs
Settling Time	t _s	C _L = 100 pF, 0 to 10 V step, to 0.01%			14		μs
		C _L = 100 pF, 0 to 10 V step, to 0.001%			16		μs
Channel Separation		f = 1 kHz			140		dB
Gain							
Gain Error					0.001	0.006	%
			●			0.012	%
Gain Drift			●		0.2	1.2	ppm/°C
Gain Nonlinearity		V _{OUT} = 20 V _{P-P}				5	ppm
Output characteristics							
Output Voltage Swing ⁴		R _L = 10 kΩ	●	(-V _S) + 0.2		(+V _S) - 0.2	V
Short-Circuit Current	I _{SC}	Source			28		mA
		Sink			-15		mA
Capacitive Load Drive					200		pF
Noise ⁵							
Voltage Noise	e _{n,p-p}	f = 0.1 Hz to 10 Hz			2		μV _{P-P}
Voltage Noise Density	e _n	f = 1 kHz			45		nV/√Hz
Power Supply							
Supply Current ⁶					330	360	μA
			●			370	μA
Operating Voltage Range ⁷				±1.35		±18	V
Temperature Range							
		Specified Temperature Range		-40		+125	°C

¹ Includes input bias and offset current errors, referred to output (RTO).

² The input voltage range can also be limited by the absolute maximum input voltage or by the output swing. See the Input Voltage Range section in the Theory of Operation section for details.

³ Internal resistors are trimmed to be ratio matched and have $\pm 10\%$ absolute accuracy.

⁴ Output voltage swing varies with supply voltage and temperature.

⁵ Includes amplifier voltage and current noise, as well as noise from internal resistors.

⁶ Supply current varies with supply voltage and temperature.

⁷ Unbalanced dual supplies can be used, such as $-V_S = -1\text{ V}$ and $+V_S = +2\text{ V}$. The positive supply rail must be at least 2.7 V above the negative supply and reference voltage.

The ● denotes the specification which apply over the specified temperature range, otherwise specifications are at $T_A = 25\text{ }^{\circ}\text{C}$, $V_S = \pm 15\text{ V}$, $V_{REF} = 0\text{ V}$, $R_L = 10\text{ k}\Omega$, $G = 2$, unless otherwise noted.

Parameter	Symbol	Conditions		Min	Typ	Max	Unit
Input characteristics							
System Offset ¹	V _{OS}	B Grade			20	150	μV
		B Grade, -40 °C to 85 °C				300	μV
		B Grade	●			450	μV
		A Grade			40	300	μV
		A Grade, -40 °C to 85 °C				500	μV
		A Grade	●			800	μV
System Offset Drift	TCV _{OS}	B Grade, -40 °C to 85 °C			0.6	2	μV/°C
		B Grade	●			3	μV/°C
		A Grade, -40 °C to 85 °C			1.0	4	μV/°C
		A Grade	●			5	μV/°C
Power Supply	PSRR	V _S = ±2.25 V to ±18 V			0.1	0.6	μV/V
		V _S = ±2.25 V to ±18 V	●			1.1	μV/V
Common Mode Rejection Ratio	CMRR	V _S = ±15 V, V _{CM} = ±10 V, R _S = 0 Ω		104	122		dB
			●	94			dB
Common Mode Rejection Ratio Drift			●		0.05	0.25	ppm/°C
Input Operating Voltage Range ²	IVR			1.5 (-V _S + 0.1)		+1.5 (V _S - 1.5)	V
Input Impedance ³							
Differential Mode	R _{IN}				30		kΩ
Common Mode					30		kΩ
Dynamic Performance							
Bandwidth					400		kHz
Slew Rate					1.1		V/μs
Settling Time	t _s	C _L = 100 pF, 0 to 10 V step, to 0.01%			14		μs
		C _L = 100 pF, 0 to 10 V step, to 0.001%			17.5		μs
Channel Separation		f = 1 kHz			140		dB
Gain							
Gain Error					0.0005	0.003	%
			●			0.006	%
Gain Drift			●		0.1	0.6	ppm/°C
Gain Nonlinearity		V _{OUT} = 20 V _{P-P}				5	ppm
Output characteristics							
Output Voltage Swing ⁴		R _L = 10 kΩ	●	(-V _S) + 0.2		(+V _S) - 0.2	V
Short-Circuit Current	I _{SC}	Source			28		mA
		Sink			-15		mA
Capacitive Load Drive					200		pF
Noise ⁵							
Voltage Noise	e _{n,p-p}	f = 0.1 Hz to 10 Hz			4		μV _{P-P}
Voltage Noise Density	e _n	f = 1 kHz			90		nV/√Hz
Power Supply							
Supply Current ⁶					330	360	μA
			●			370	μA
Operating Voltage Range ⁷				±1.35		±18	V
Temperature Range							
		Specified Temperature Range		-40		+125	°C

¹ Includes input bias and offset current errors, referred to output (RTO).

² The input voltage range can also be limited by the absolute maximum input voltage or by the output swing. See the Input Voltage Range section in the Theory of Operation section for details.

³ Internal resistors are trimmed to be ratio matched and have $\pm 10\%$ absolute accuracy.

⁴ Output voltage swing varies with supply voltage and temperature.

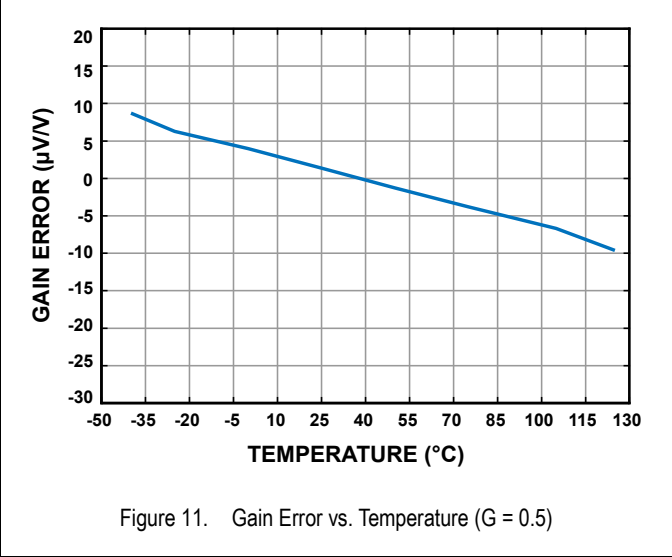
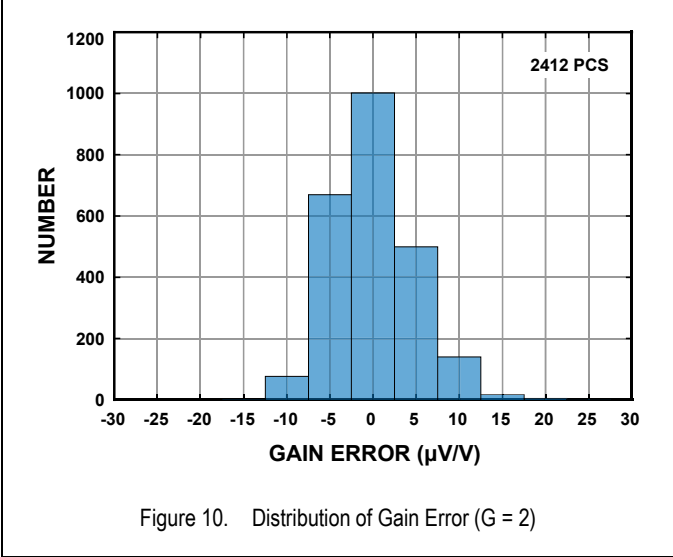
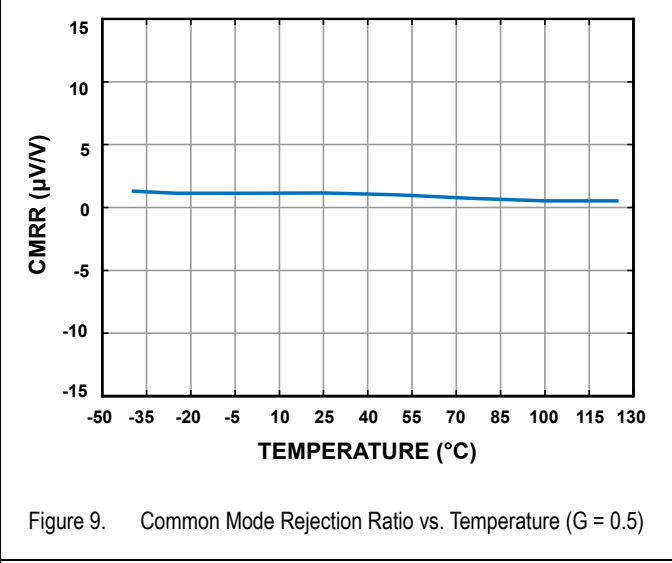
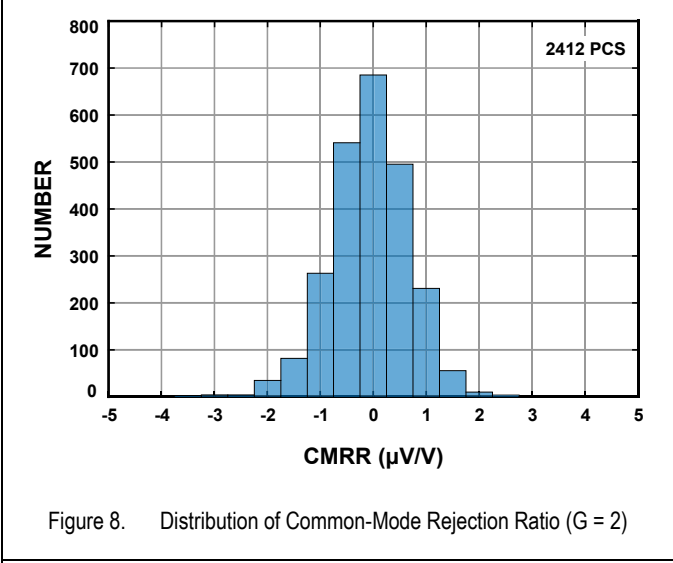
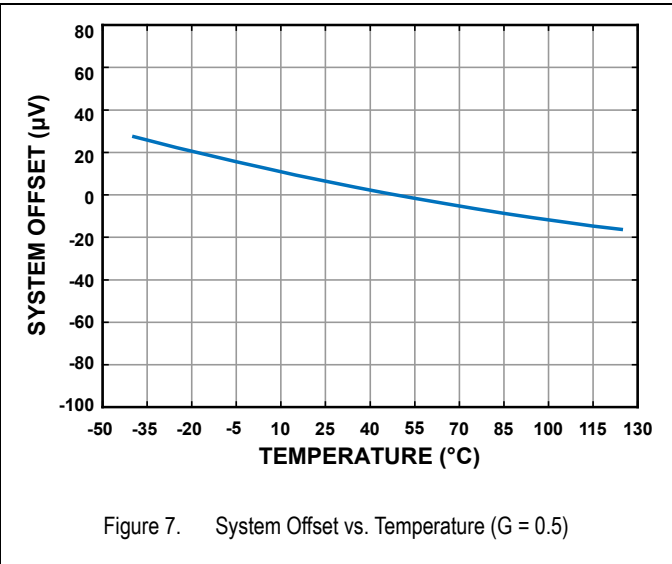
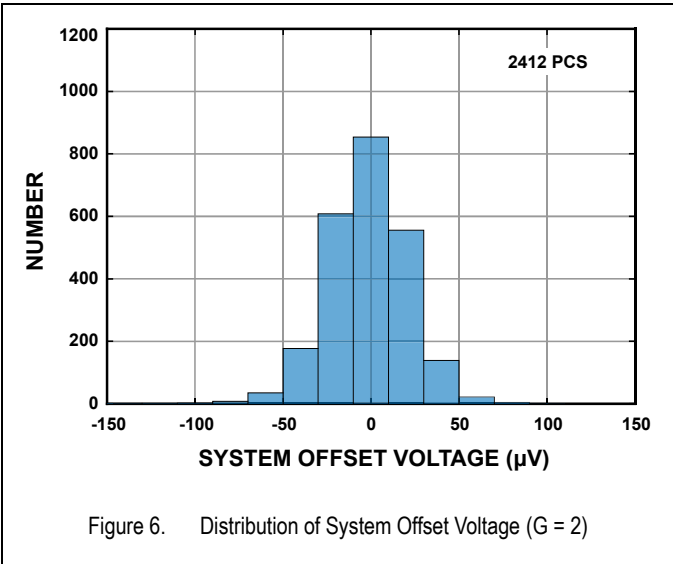
⁵ Includes amplifier voltage and current noise, as well as noise from internal resistors.

⁶ Supply current varies with supply voltage and temperature.

⁷ Unbalanced dual supplies can be used, such as $-V_S = -1\text{ V}$ and $+V_S = +2\text{ V}$. The positive supply rail must be at least 2.7 V above the negative supply and reference voltage.

Typical Performance Characteristics

Unless otherwise stated, $T_A = 25\text{ }^{\circ}\text{C}$, $V_S = \pm 15\text{ V}$, $R_L = 10\text{ k}\Omega$, $G = 0.5$ & 2 .



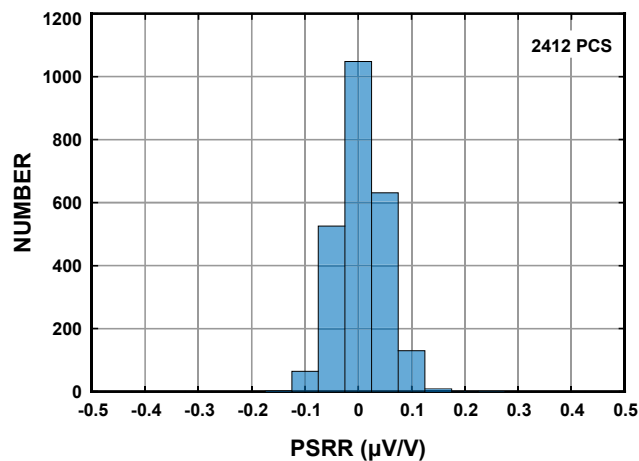


Figure 12. Distribution of PSRR (G = 2)

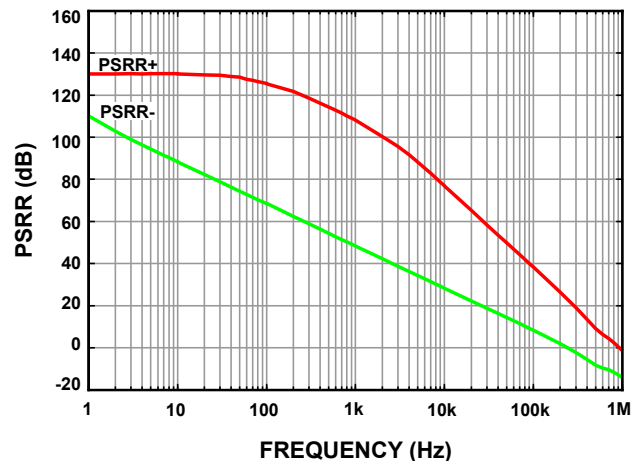


Figure 13. Power Supply Rejection Ratio (PSRR) vs. Frequency

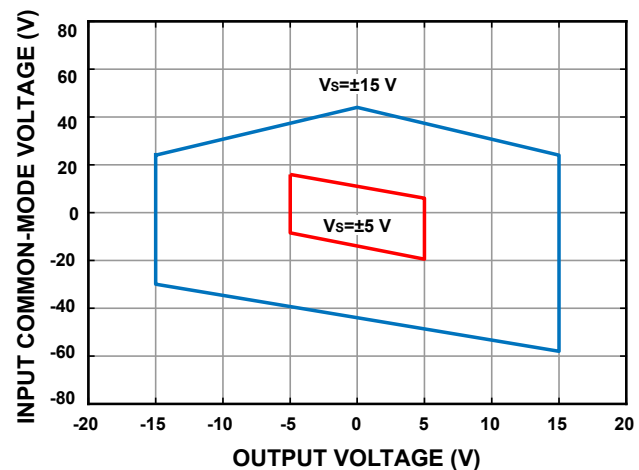


Figure 14. Input Common-Mode Voltage vs. Output Voltage (G = 0.5)

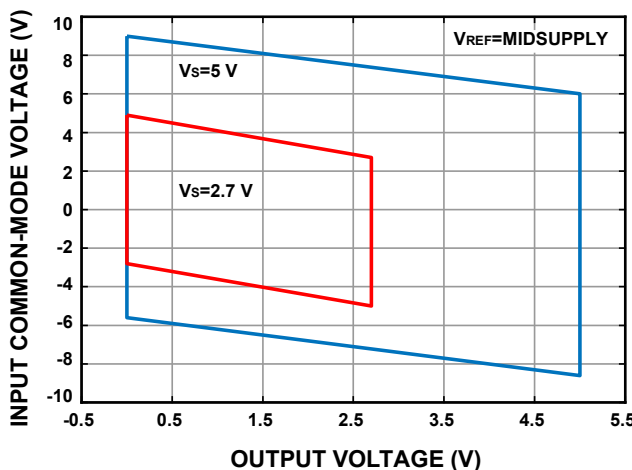


Figure 15. Input Common-Mode Voltage vs. Output Voltage ($V_{\text{REF}} = \text{MIDSUPPLY}$, G = 0.5)

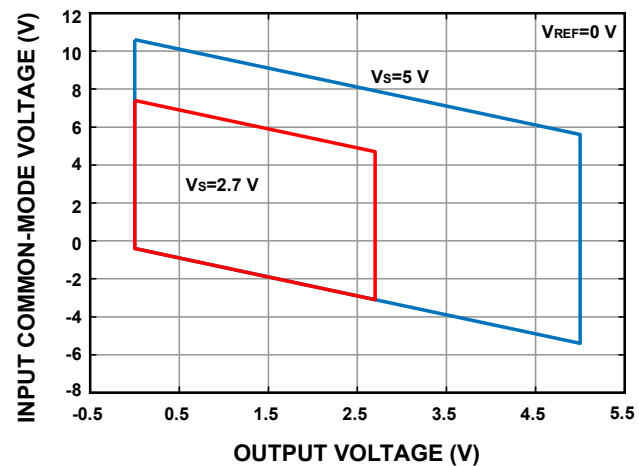


Figure 16. Input Common-Mode Voltage vs. Output Voltage ($V_{\text{REF}} = 0\text{ V}$, G = 0.5)

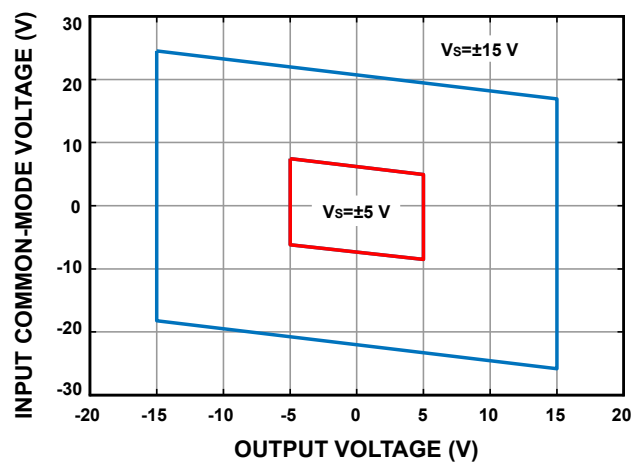


Figure 17. Input Common-Mode Voltage vs. Output Voltage (G = 2)

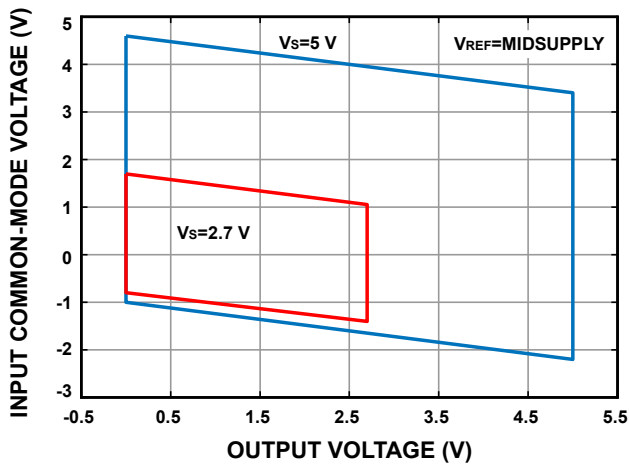


Figure 18. Input Common-Mode Voltage vs. Output Voltage ($V_{REF} = \text{MIDSUPPLY}$, $G = 2$)

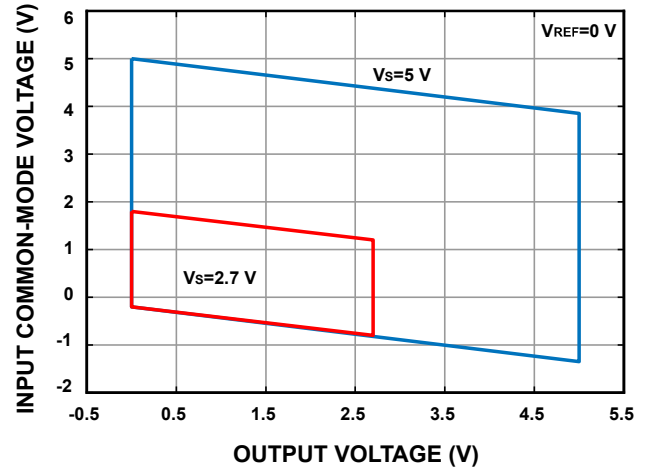


Figure 19. Input Common-Mode Voltage vs. Output Voltage ($V_{REF} = 0\text{ V}$, $G = 2$)

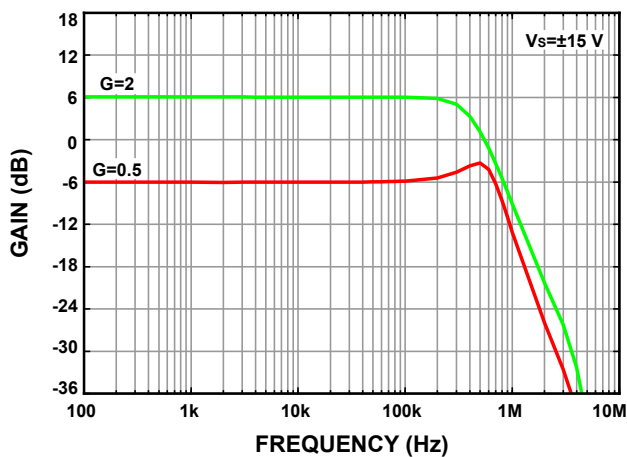


Figure 20. Gain vs. Frequency ($V_S = \pm 15\text{ V}$)

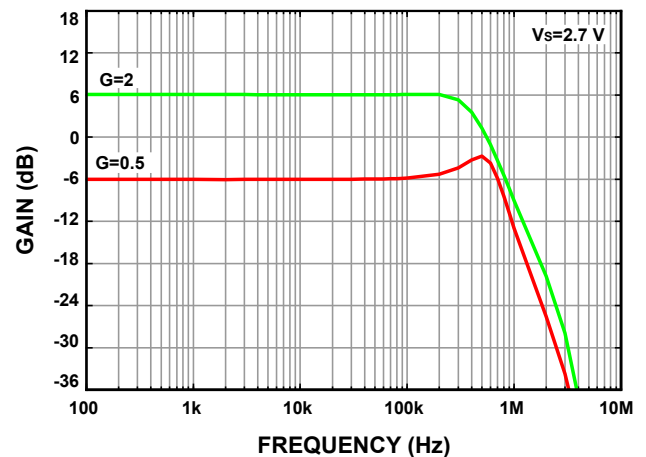


Figure 21. Gain vs. Frequency ($V_S = 2.7\text{ V}$)

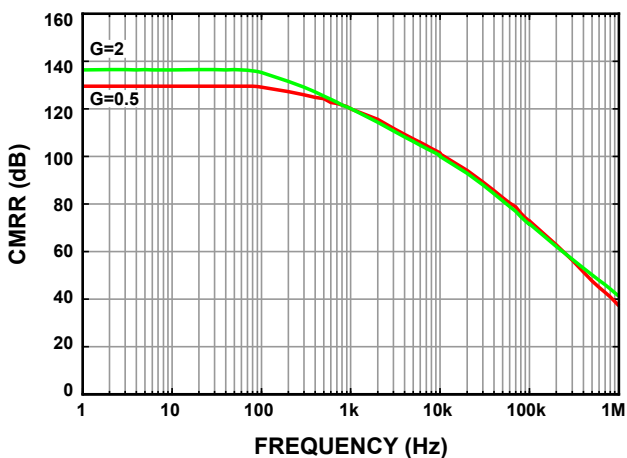


Figure 22. Common Mode Rejection Ratio vs. Frequency

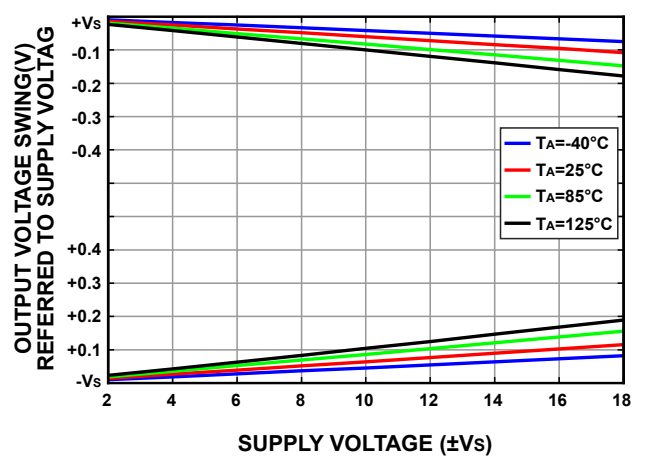


Figure 23. Output Voltage Swing vs. Supply Voltage ($R_L = 10\text{ k}\Omega$)

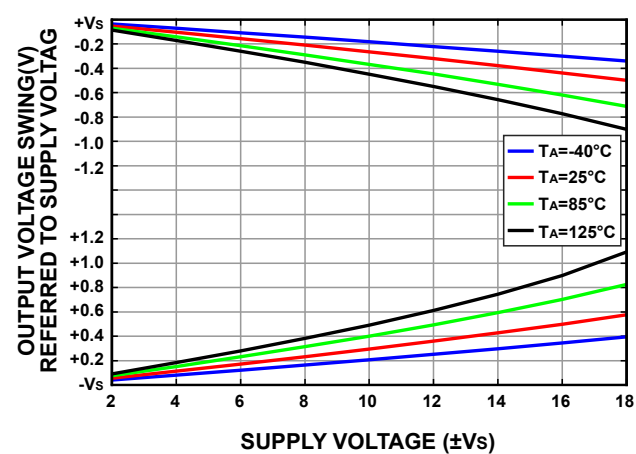


Figure 24. Output Voltage Swing vs. Supply Voltage ($R_L = 2\text{ k}\Omega$)

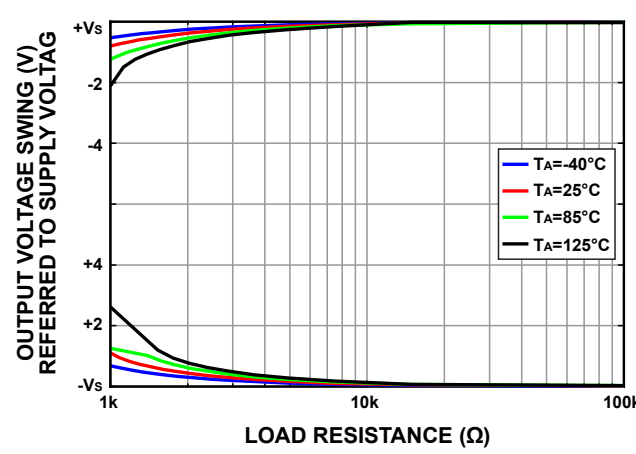


Figure 25. Output Voltage Swing vs. Load Resistance ($V_S = \pm 15\text{ V}$)

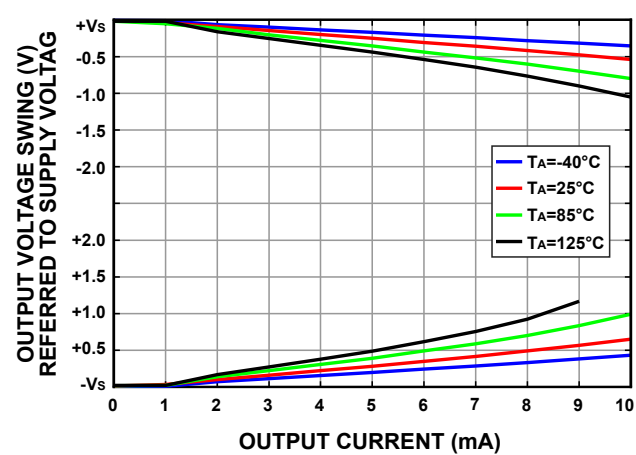


Figure 26. Output Voltage Swing vs. Output Current ($V_S = \pm 15\text{ V}$)

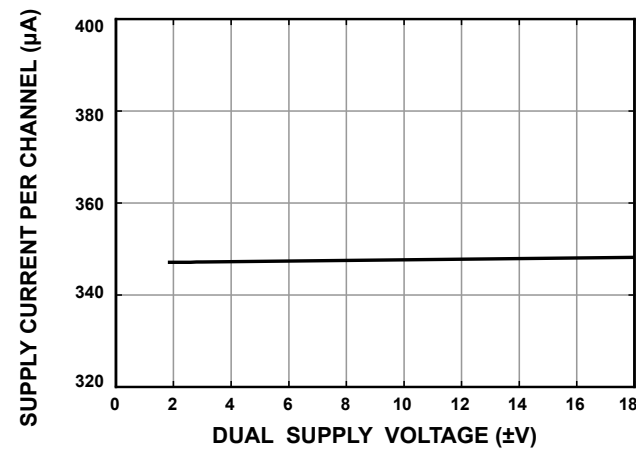


Figure 27. Supply Current Per Channel vs. Dual Supply Voltage ($V_{IN} = 0\text{ V}$)

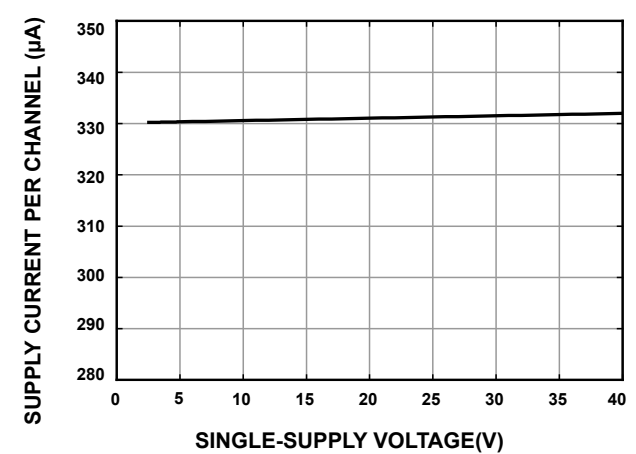


Figure 28. Supply Current Per Channel vs. Single-Supply Voltage ($V_{IN} = 0\text{ V}$, $V_{REF} = 0\text{ V}$)

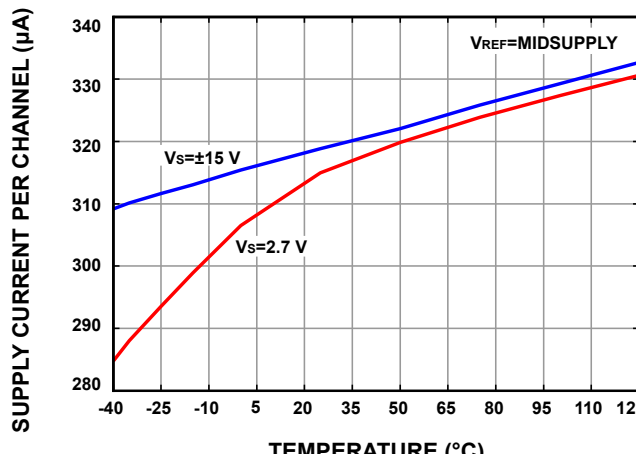
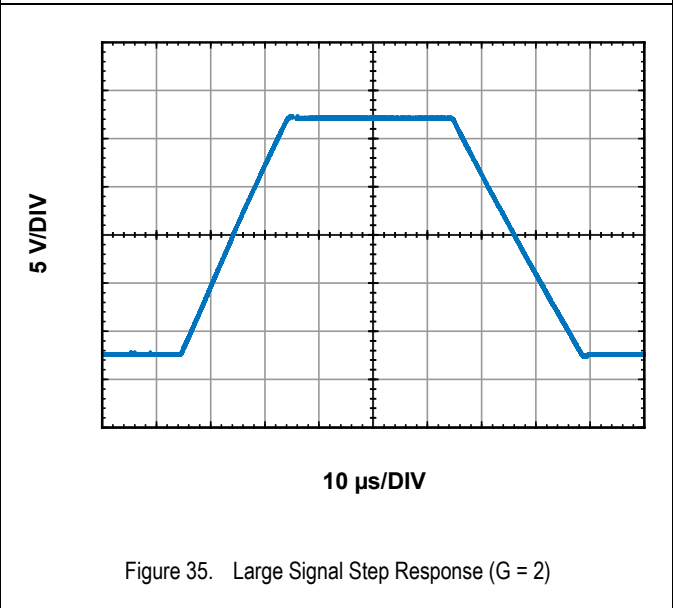
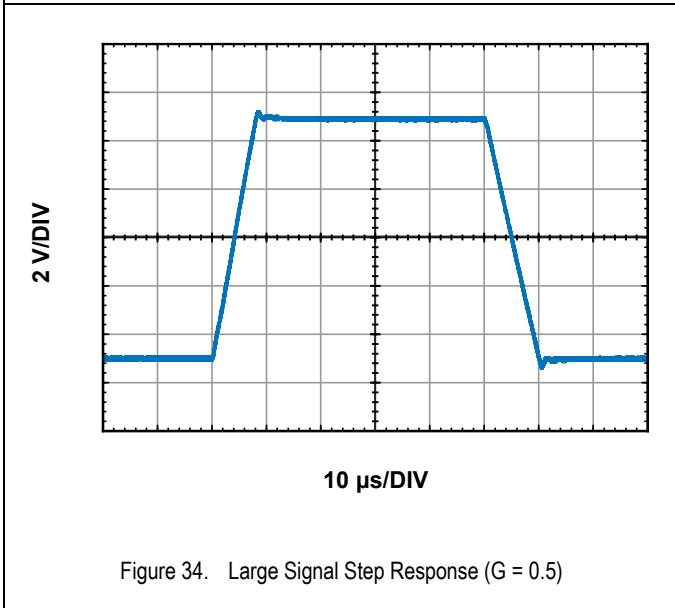
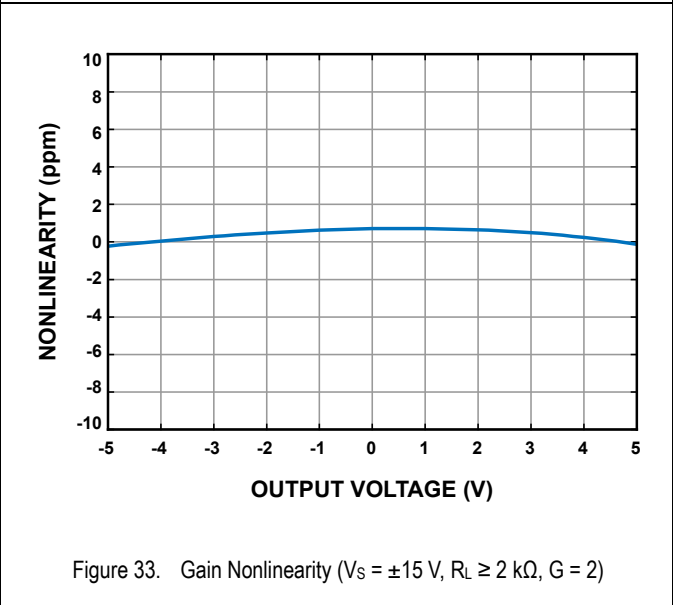
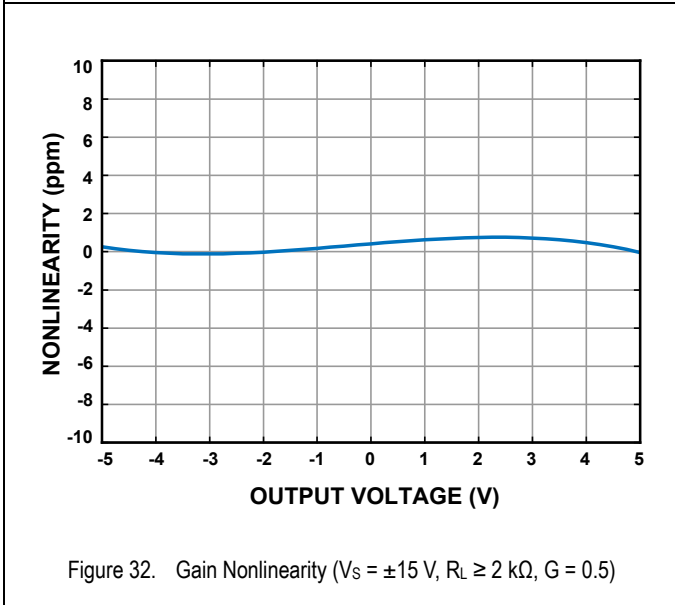
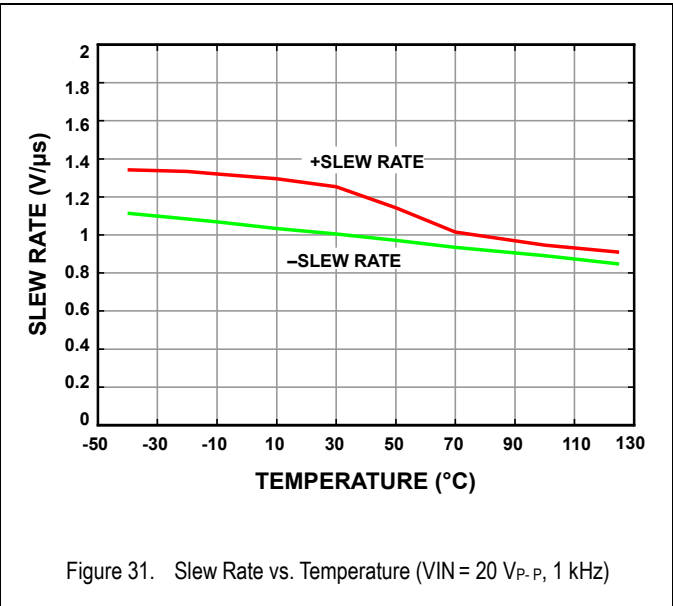
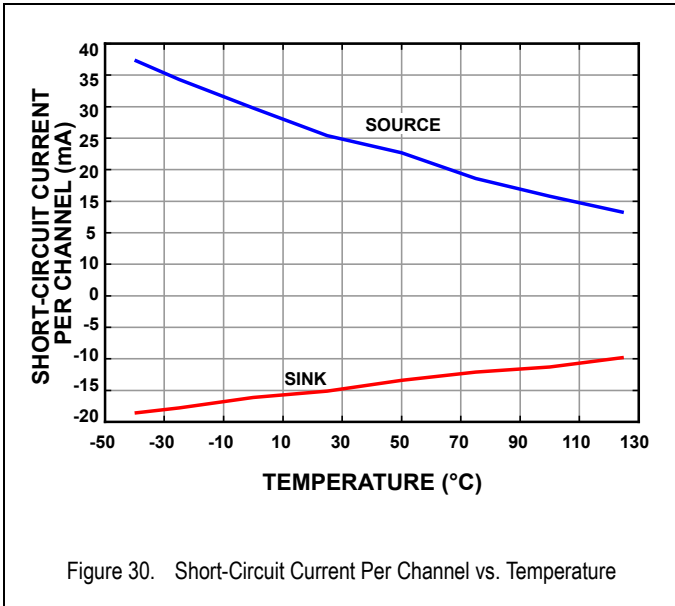


Figure 29. Supply Current Per Channel vs. Temperature



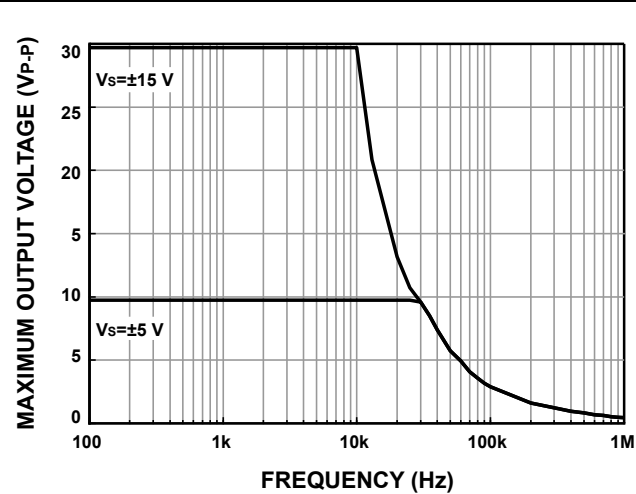


Figure 36. Maximum Output Voltage vs. Frequency (V_s = ±15 V, ±5 V)

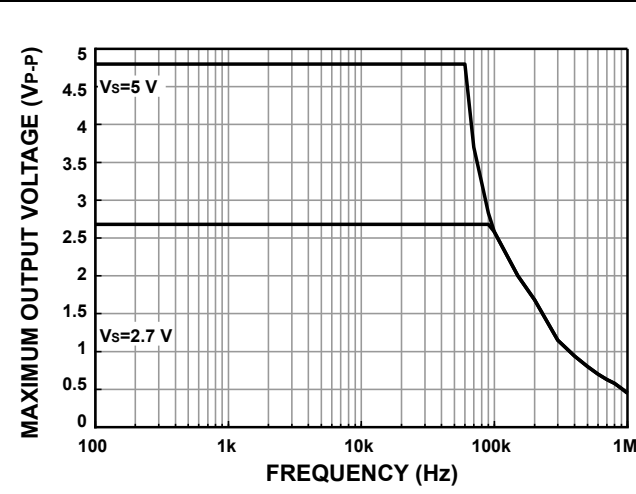


Figure 37. Maximum Output Voltage vs. Frequency (V_s = 5 V, 2.7 V)

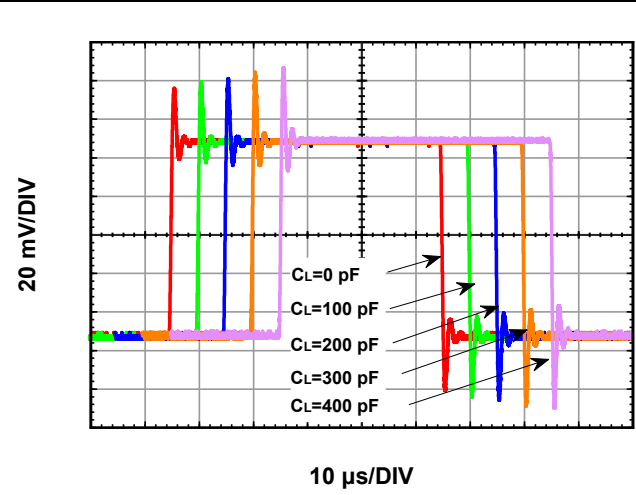


Figure 38. Small Signal Step Response for Various Capacitive Loads (G = 0.5)

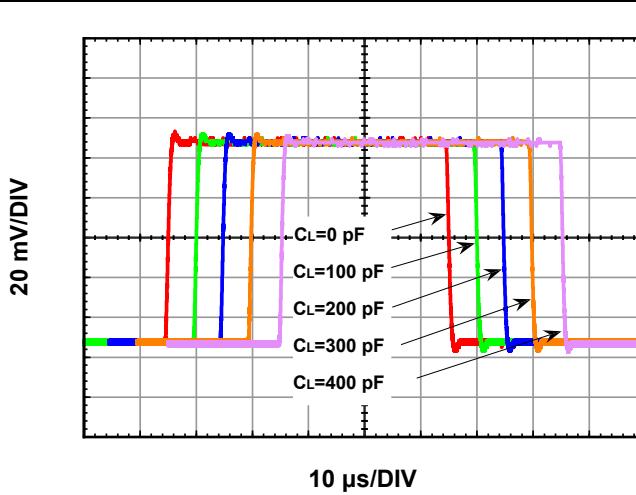


Figure 39. Small Signal Step Response for Various Capacitive Loads (G = 2)

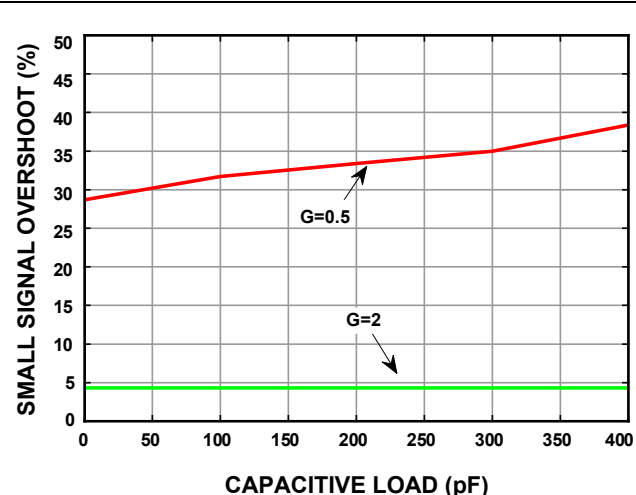


Figure 40. Small Signal Overshoot vs. Capacitive Load (R_L ≥ 2 kΩ, G = 0.5 & 2)

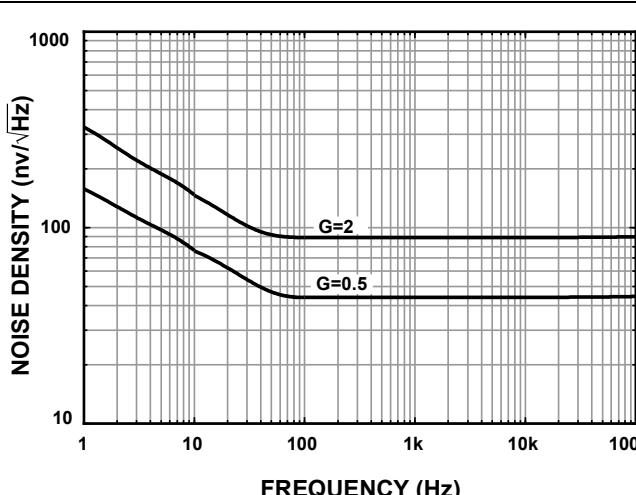
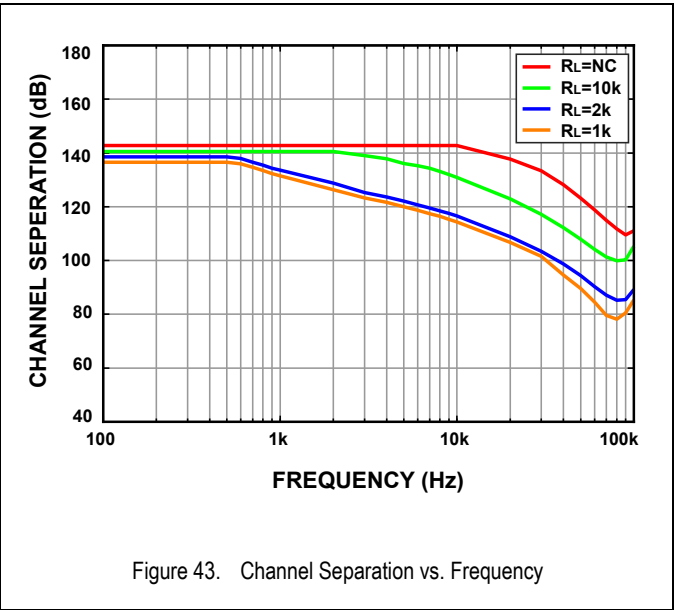
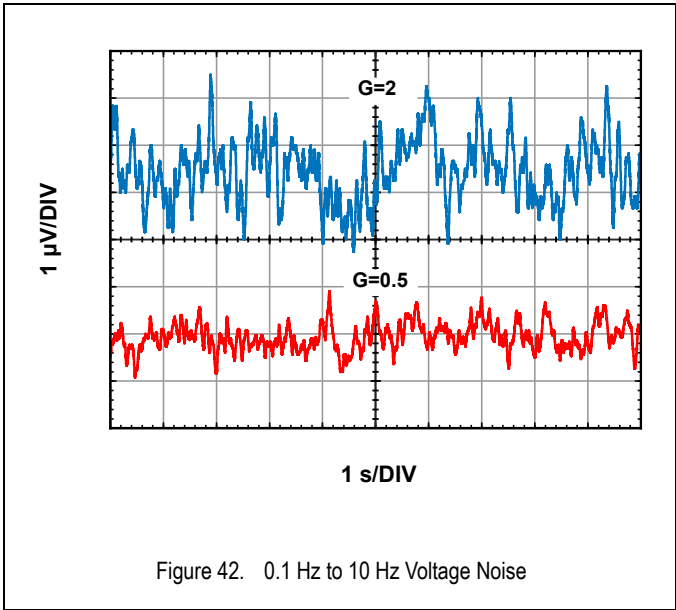


Figure 41. Voltage Noise Density vs. Frequency



Theory of Operation

Circuit Information

Each channel of the ZJA3678 and ZJA3679 consists of a low power, low noise op amp and four trimmed (ZHIJINGTRIM®) on-chip resistors. These resistors can be externally connected to make a variety of amplifier configurations, including difference, noninverting, and inverting configurations. Taking advantage of the integrated resistors of the ZJA3678/ZJA3679 provides the designer with several benefits over a discrete design, including smaller size, lower cost, and improved ac and dc performance. The ZJA3678 and ZJA3679 offer temperature characteristics that are difficult to achieve using discrete components. Even if achievable, the cost of using discrete components would likely be significantly higher.

DC Performance

Much of the dc performance of op amp circuits depends on the accuracy of the surrounding resistors. As is shown in Figure 44, the output voltage is found to be

$$\begin{aligned}
 V_{OUT} &= V_{+IN} \left(\frac{R_2}{R_1 + R_2} \right) \left(1 + \frac{R_4}{R_3} \right) - V_{-IN} \left(\frac{R_4}{R_3} \right) \\
 &= (V_{+IN} - V_{-IN}) \left(\frac{R_4}{R_3} \right) \left[1 + \frac{\frac{R_3}{R_4} - \frac{R_1}{R_2}}{2 \left(1 + \frac{R_1}{R_2} \right)} \right] + \left(\frac{V_{+IN} + V_{-IN}}{2} \right) \left(\frac{R_4}{R_3} \right) \left(\frac{\frac{R_3}{R_4} - \frac{R_1}{R_2}}{1 + \frac{R_1}{R_2}} \right) \\
 &= V_D \cdot G \cdot \left[1 + \frac{\frac{R_3}{R_4} - \frac{R_1}{R_2}}{2(1 + G^{-1})} \right] + V_{CM} \cdot G \cdot \left(\frac{\frac{R_3}{R_4} - \frac{R_1}{R_2}}{1 + G^{-1}} \right), G = \frac{R_4}{R_3}, V_D = V_{+IN} - V_{-IN}, V_{CM} = \frac{V_{+IN} + V_{-IN}}{2} \\
 &= V_D \cdot 0.5 \cdot \left(1 + \frac{\frac{R_3}{R_4} - \frac{R_1}{R_2}}{6} \right) + V_{CM} \cdot 0.5 \cdot \left(\frac{\frac{R_3}{R_4} - \frac{R_1}{R_2}}{3} \right), G = 0.5 \text{ for ZJA3678/ZJA3679}
 \end{aligned}$$

This equation demonstrates that the gain accuracy and CMRR of the ZJA3678/ZJA3679 is determined primarily by the matching of resistor ratios ($R_3 / R_4 - R_1 / R_2$). Even a 0.1 % mismatch in one resistor degrades the CMRR to $1 / (0.1\% / 3)$, which is 70 dB, for a $G = 0.5$ difference amplifier.

As long as the following ratio of the resistors is tightly matched:

$$\frac{R_2}{R_1} = \frac{R_4}{R_3}$$

the difference amplifier output voltage equation can be reduced to

$$V_{OUT} = \frac{R_4}{R_3} \cdot (V_{+IN} - V_{-IN})$$

The resistors on the ZJA3678/ZJA3679 are trimmed (ZHIJINGTRIM®) to match accurately. As a result, the ZJA3678/ZJA3679 provide superior performance over a discrete solution, enabling higher CMRR (88 dB min over specified temperature range), higher gain accuracy (better than 60 ppm at room temperature), and lower gain drift (1.2 ppm/°C max), over specified temperature range of -40 °C to 125 °C.

AC Performance

Component sizes and trace lengths are much smaller in an IC than on a PCB, therefore, the corresponding parasitic elements are also smaller, which results in improved ac performance of the ZJA3678/ZJA3679. For example, the positive and negative input terminals of the ZJA3678/ZJA3679 op amps are intentionally not pinned out, meaning that there is no direct connection to the inputs of the amplifier. The op amps are connected internally through the resistors, and there is no direct access to the pins. By not connecting these nodes to the traces on the PCB, the capacitance remains low, resulting in improved loop stability and excellent CMRR over frequency of 98 dB at $G = 0.5$.

Driving ZJA3678/ZJA3679

Care must be taken to drive the ZJA3678/ZJA3679 with a low impedance source in order to avoid significantly degrading the gain accuracy and CMRR. Because all configurations present several $k\Omega$ of input resistance, the ZJA3678/ZJA3679 do not require a high current drive from the source and therefore are easy to drive.

Input Voltage Range

The ZJA3678/ZJA3679 are able to measure input voltages beyond the supply rails. The internal resistors divide down the voltage before it reaches the internal op amp and provide protection to the op amp inputs. Figure 44 shows an example of how the voltage division works in a difference amplifier configuration. For the ZJA3678/ZJA3679 to measure correctly, the input voltages at the input nodes of the internal op amp must stay below 1.5 V of the positive supply rail, which is $(+V_S) - 1.5\text{ V}$, and can go close to the negative supply rail by 0.1 V, which is $(-V_S) + 0.1\text{ V}$. Refer to the Power Supplies section for more details.

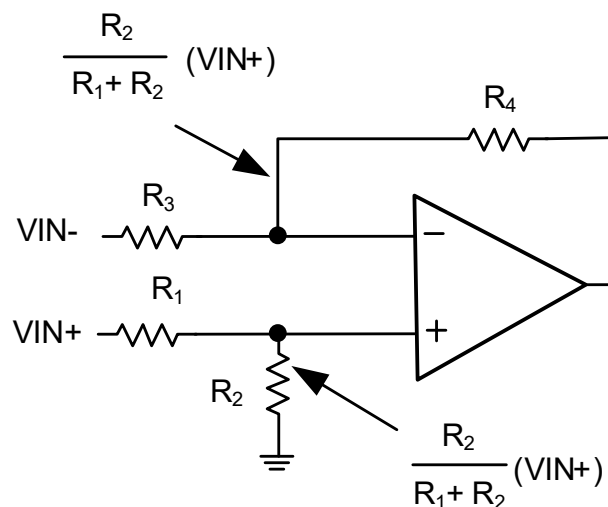


Figure 44. Voltage Division in the Difference Amplifier Configuration

The ZJA3678/ZJA3679 have integrated ESD diodes at the inputs that provide overvoltage protection. This feature simplifies system design by eliminating the need for additional external protection circuitry and enables a more robust precision system. The voltages at any of the inputs of the devices can safely range from $(-V_S) - 65\text{ V}$ to $(-V_S) + 65\text{ V}$. For example, on $\pm 10\text{ V}$ supplies, input voltages can go as high as -75 V to $+55\text{ V}$. Care must be taken to not exceed the $(-V_S) - 65\text{ V}$ to $(-V_S) + 65\text{ V}$ input limits to avoid risking damage to the devices.

Power Supplies

The ZJA3678/ZJA3679 operate over a wide range of supply voltages. They can operate on a single supply as low as 2.7 V and as high as 36 V, under appropriate setup conditions. For optimal performance, the user must ensure that the internal op amp is biased correctly through proper setup conditions. The internal input terminals of the op amp must have sufficient voltage headroom to operate properly. Proper operation of the device requires at least 1.5 V between the positive supply rail and the op amp input terminals. As shown in Figure 45, this relationship is expressed in the following equation:

$$\frac{R_1}{R_1 + R_2} \cdot V_{REF} < +V_S - 1.5 \text{ V}$$

For example, when operating on $\pm V_S = \pm 2 \text{ V}$ dual supplies and $V_{REF} = 0 \text{ V}$, it can be seen from Figure 45 that the input terminals of the op amp are biased at 0 V, allowing more than the required 1.5 V headroom. However, if $V_{REF} = 1 \text{ V}$ under the same conditions, the input terminals of the op amp are biased at 0.66 V ($G = 0.5$). Now the op amp does not have the required 1.5 V headroom and cannot function. Therefore, the user must increase the supply voltage or decrease V_{REF} to restore proper operation.

The ZJA3678/ZJA3679 are typically specified at single and dual supplies, but they can be used with unbalanced supplies, as well, for example, $-V_S = -5 \text{ V}$, $+V_S = 20 \text{ V}$. The difference between the two supplies must be kept below 36 V and at least 2.7 V.

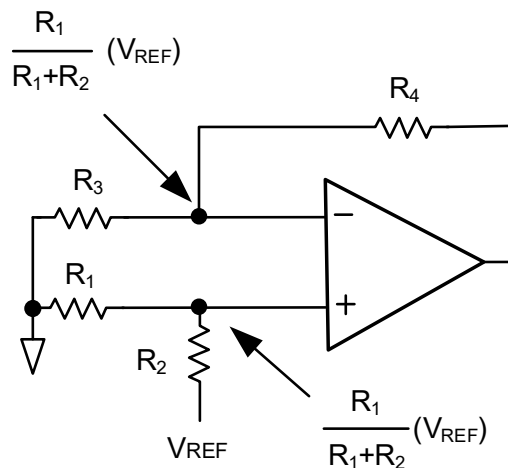


Figure 45. Ensure Sufficient Voltage Headroom on the Internal Op Amp Inputs

Use a stable dc voltage to power the ZJA3678 and ZJA3679. Noise on the supply pins can adversely affect performance. Place a bypass capacitor of 0.1 μF between each supply pin and ground, as close as possible to each supply pin. Use a tantalum capacitor of 10 μF between each supply and ground. It can be farther away from the supply pins and, typically, it can be shared by other precision integrated circuits. Refer to Layout Example for details.

Applications and Implementation

Configurations

The ZJA3678/ZJA3679 can be configured in several ways (see Figure 46 to Figure 52). Note that Figure 47 shows the ZJA3678/ZJA3679 as difference amplifiers with a midsupply reference voltage at the noninverting input, allowing the ZJA3678/ZJA3679 to be used as a level shifter, which is appropriate in single-supply applications that are referenced to midsupply.

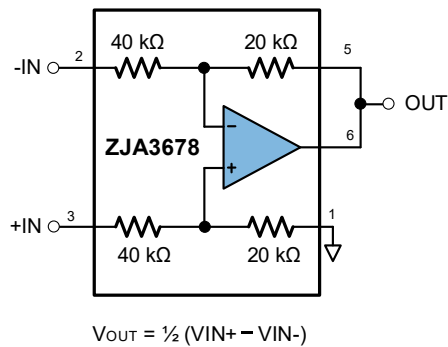


Figure 46. Difference Amplifier, Gain = 0.5

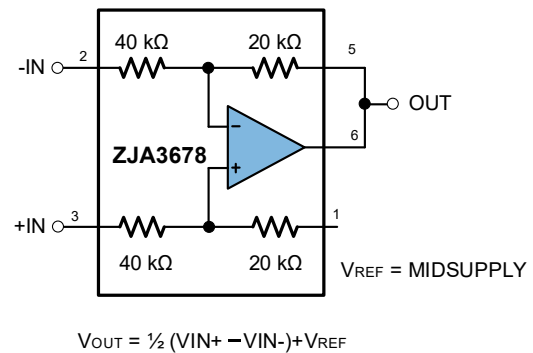


Figure 47. Difference Amplifier, Gain = 0.5, Referenced to Midsupply

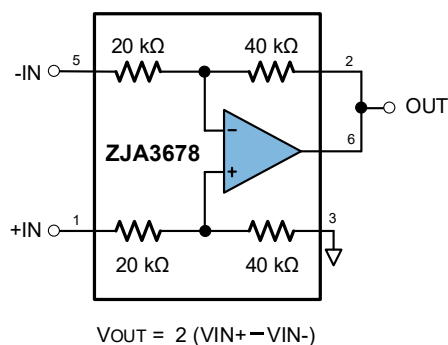


Figure 48. Difference Amplifier Gain = 2

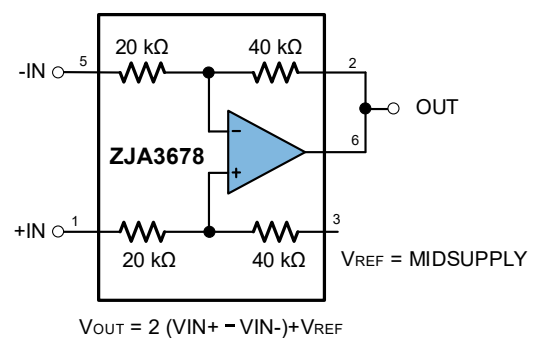


Figure 49. Difference Amplifier Gain = 2, Referenced to Midsupply

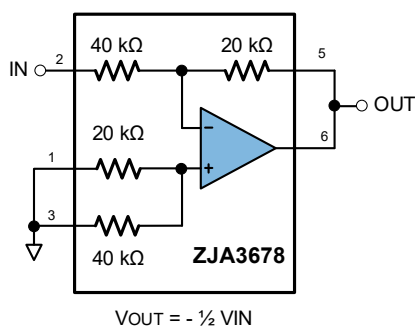


Figure 50. Inverting Amplifier, G = -0.5

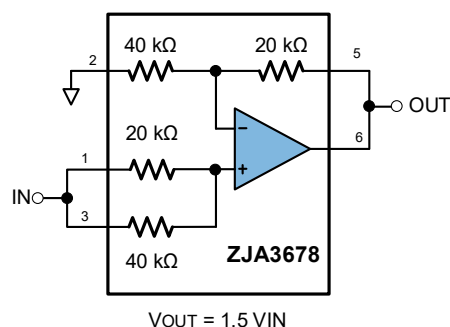


Figure 51. Noninverting Amplifier, G = 1.5

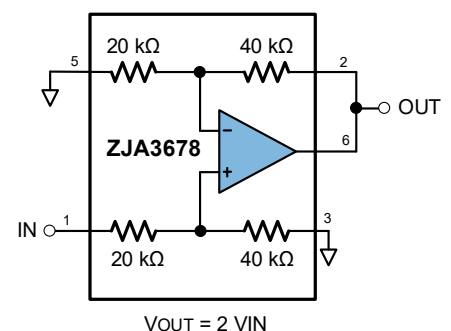


Figure 52. Noninverting Amplifier, G = 2

The reference must be driven with a low impedance source to maintain the internal resistor ratio. An example using the low power, low noise ZJA3008-1 as a reference is shown in Figure 53.

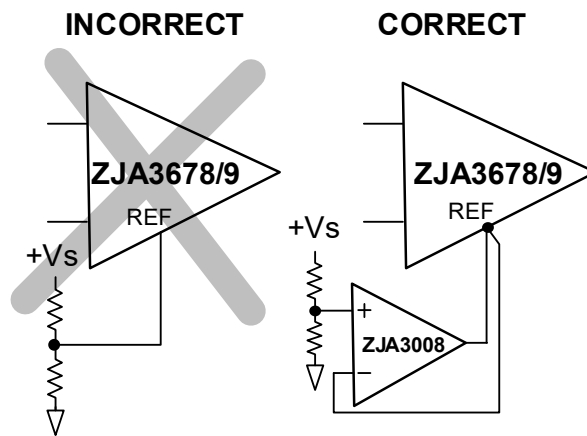


Figure 53. Driving the REF Pin

Differential Output

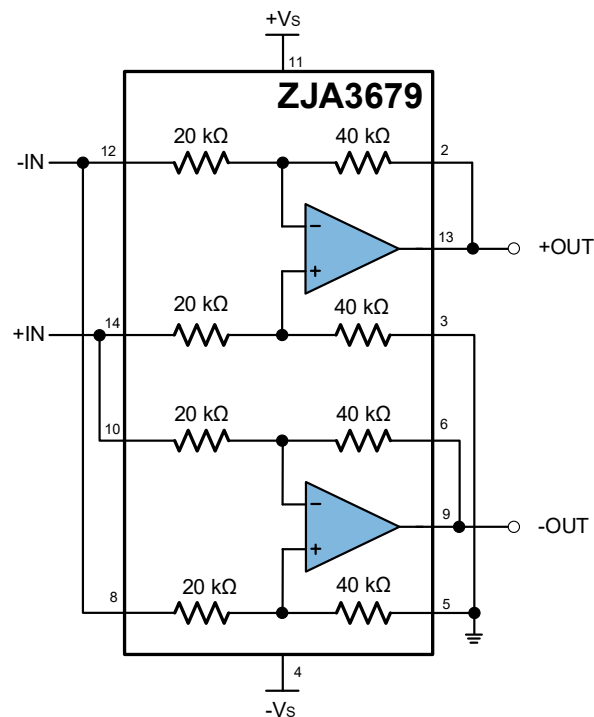


Figure 54. ZJA3679 Differential Output Configuration

The two difference amplifiers of the ZJA3679 can be configured to provide a differential output, as shown in Figure 54. This differential output configuration is suitable for various applications. The differential output voltage has a gain of 4 as shown in the following equation:

$$\begin{aligned}
 V_{DIFF_OUT} &= V_{+OUT} - V_{-OUT} \\
 &= 2 \cdot (V_{+IN} - V_{-IN}) - 2 \cdot (V_{-IN} - V_{+IN}) \\
 &= 4 \cdot (V_{+IN} - V_{-IN})
 \end{aligned}$$

Current Source

The ZJA3678 difference amplifier can be implemented as part of a voltage to current converter or a precision constant current source, as shown in Figure 55. Using an integrated precision solution such as the ZJA3678/ZJA3679 provides several advantages over a discrete solution, including space-saving, improved gain accuracy, and temperature drift. The internal resistors are tightly matched to minimize error and temperature drift. If the external resistors, R_1 and R_2 , are not well matched, they become a significant source of error in the system. Therefore, precision resistors or ZJM5491-1 are recommended to maintain performance. The ZJR1004-9 provides a precision voltage reference that also reduces error in the signal chain.

The ZJA3678 has rail-to-rail output capability that allows higher current outputs.

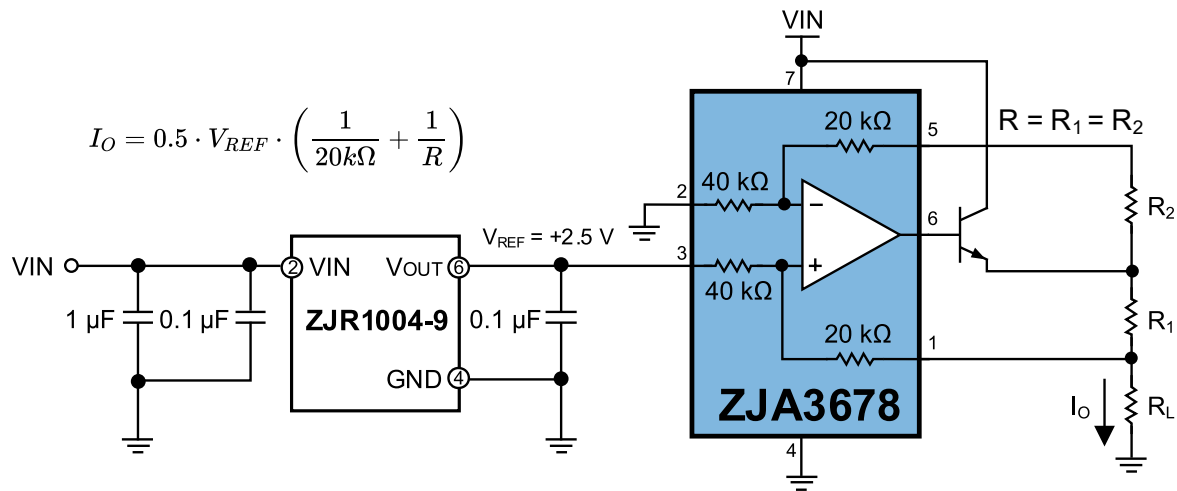


Figure 55. Building Constant Current Source by ZJR1004 and ZJA3678

Voltage and Current Monitoring

Voltage and current monitoring are critical in the following applications: power line protection, motor control applications, and battery monitoring. The ZJA3678/ZJA3679 can be used to monitor voltages and currents in a system, especially the sensor interface is differential and following signal conditioning is in single-ended, as shown in Figure 56.

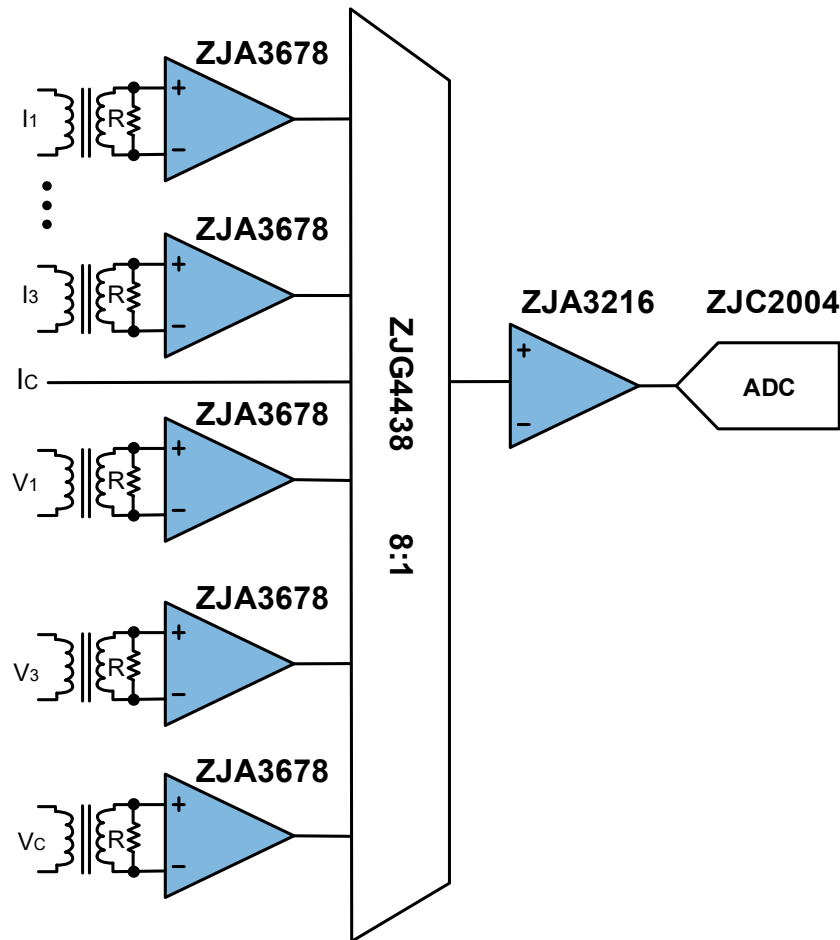
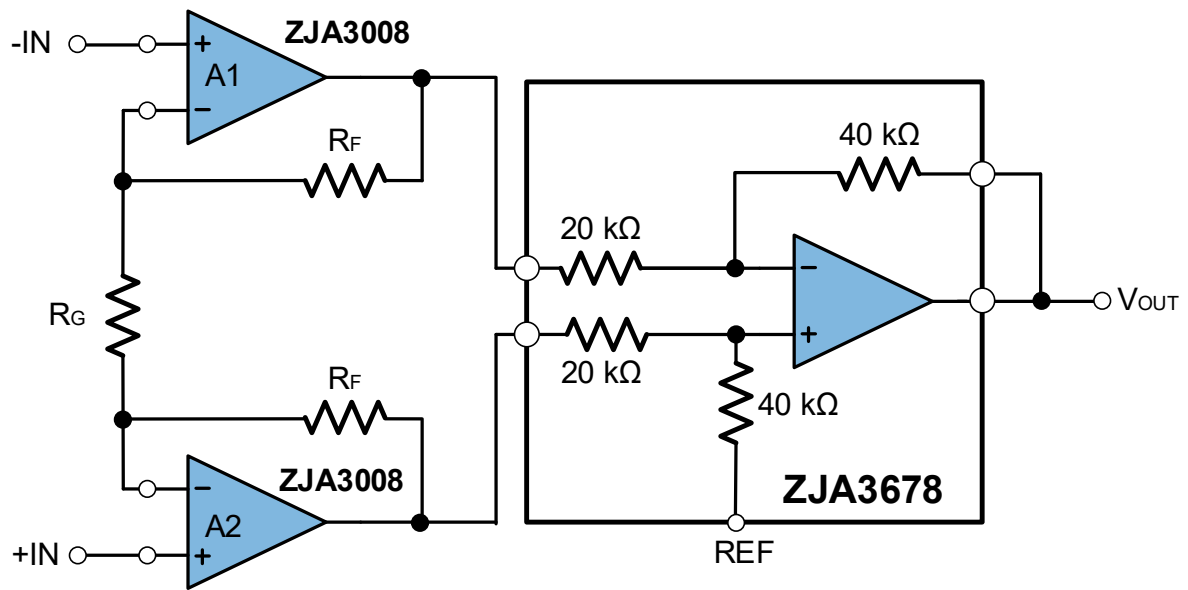


Figure 56. Voltage and Current Monitoring in 3-Phase Power Line Protection Using the ZJA3678

Figure 56 shows an example of how the ZJA3678 can be used to monitor voltage and current on a 3-phase power supply. I_1 through I_3 are the currents to be monitored, and V_1 through V_3 are the voltages to be monitored on each phase. I_c and V_c are the common or zero lines. Couplers or transformers interface the power lines to the front-end circuitry and provide attenuation, isolation, and protection. On the current monitoring side, current transformers (CTs) step down the power line current and isolate the front-end circuitry from the high voltage and high current lines. Across the inputs of each difference amplifier is a shunt resistor that converts the coupled current into a voltage. The value of the resistor is determined by the characteristics of the coupler or transformer and desired input voltage ranges to the ZJA3678. On the voltage monitoring side, potential transformers (PTs) are used to provide coupling and galvanic isolation. The ZJA3678 helps to build a robust system because it allows input voltages that are almost double its supply voltage, while providing additional input protection in the form of the integrated ESD diodes.

Building Instrumentation Amplifier

The ZJA3678 can be used as building blocks for a low power, low cost instrumentation amplifier. An instrumentation amplifier provides high impedance inputs and delivers high CMRR. For power supply up to 40 V design, ZJA3008-2 can be used. In 5 V supply system, ZJA3202-2 will be suitable.



$$V_{OUT} = 2 * \left(1 + 2 \frac{R_F}{R_G} \right) (V_{+IN} - V_{-IN})$$

Figure 57. Building Low Power Precision Instrumentation Amplifier by ZJA3008 and ZJA3678

Layout Guidelines

For best operational performance of the device, use good PCB layout practices, including:

- Noise can propagate into analog circuitry through the power pins of the circuit as a whole and op amp itself. Bypass capacitors are used to reduce the coupled noise by providing low-impedance power sources local to the analog circuitry.
 - Connect low-ESR, 0.1- μ F 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.
- Separate 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. A ground plane helps distribute heat and reduces EMI noise pickup. Make sure to physically separate digital and analog grounds paying attention to the flow of the ground current.
- In order to reduce parasitic coupling, run the input traces as far away from the supply or output traces as possible. If these traces cannot be kept separate, crossing the sensitive trace perpendicular is much better as opposed to in parallel with the noisy trace.
- Place the external components as close to the device as possible in order to minimize parasitic capacitance.
- 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. A guard ring can significantly reduce leakage currents from nearby traces that are at different potentials.
- Cleaning the PCB following board assembly is recommended for best performance.
- Any precision integrated circuit may experience performance shifts due to moisture ingress into the plastic package. Following any aqueous PCB cleaning process, baking the PCB assembly is recommended to remove moisture introduced into the device packaging during the cleaning process. A low temperature, post cleaning bake at 85 °C for 30 minutes is sufficient for most circumstances.

Layout Example

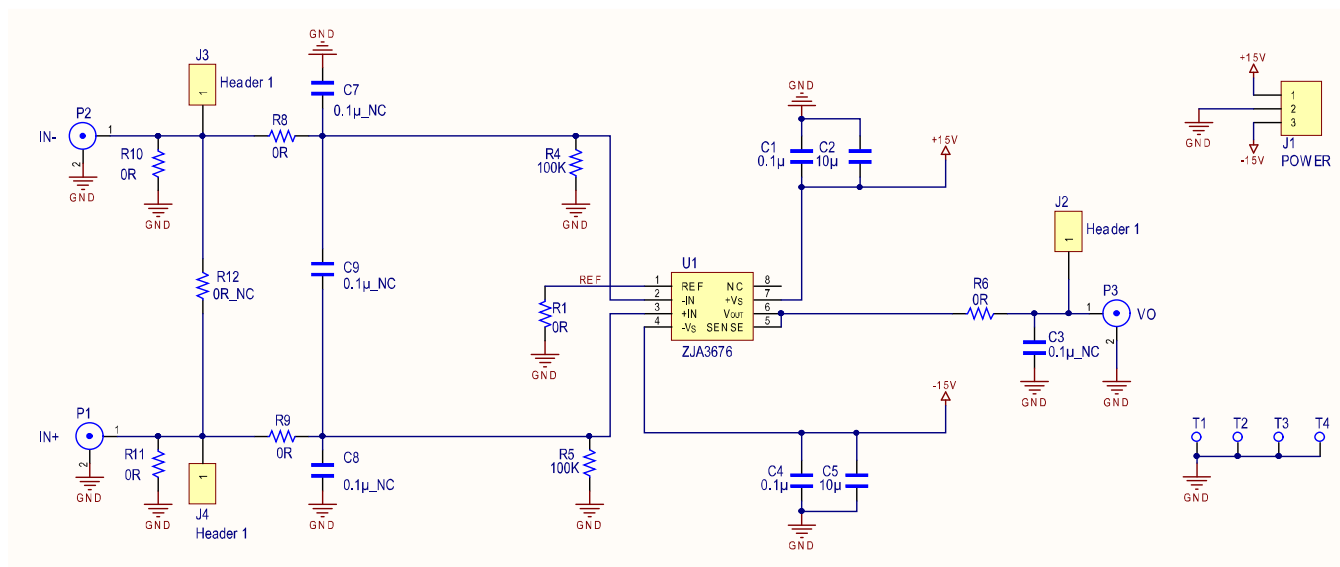


Figure 58. ZJA3676/8 Evaluation Board Schematic

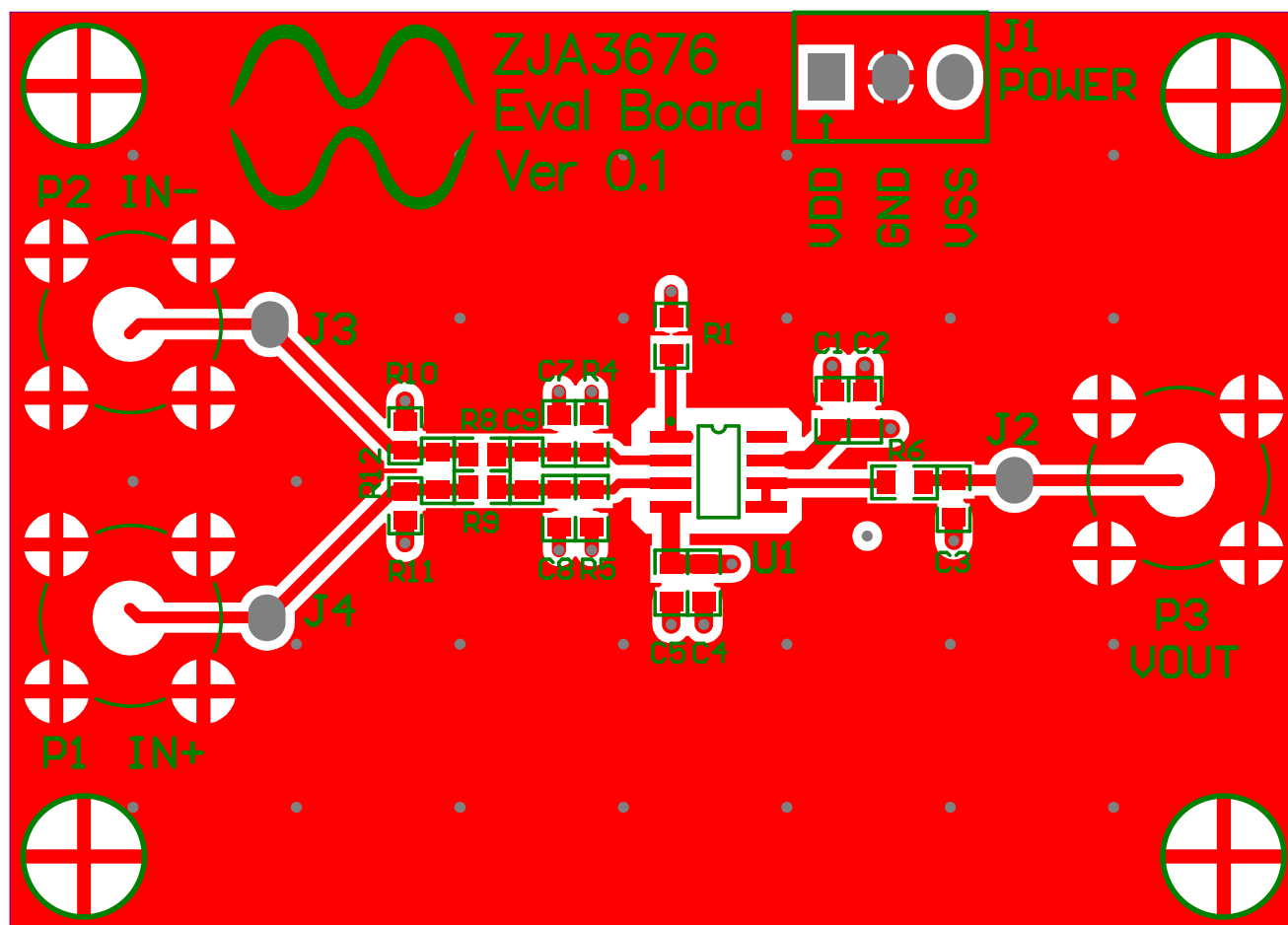


Figure 59. Layout of ZJA3676/8 Evaluation Board (Top Layer)

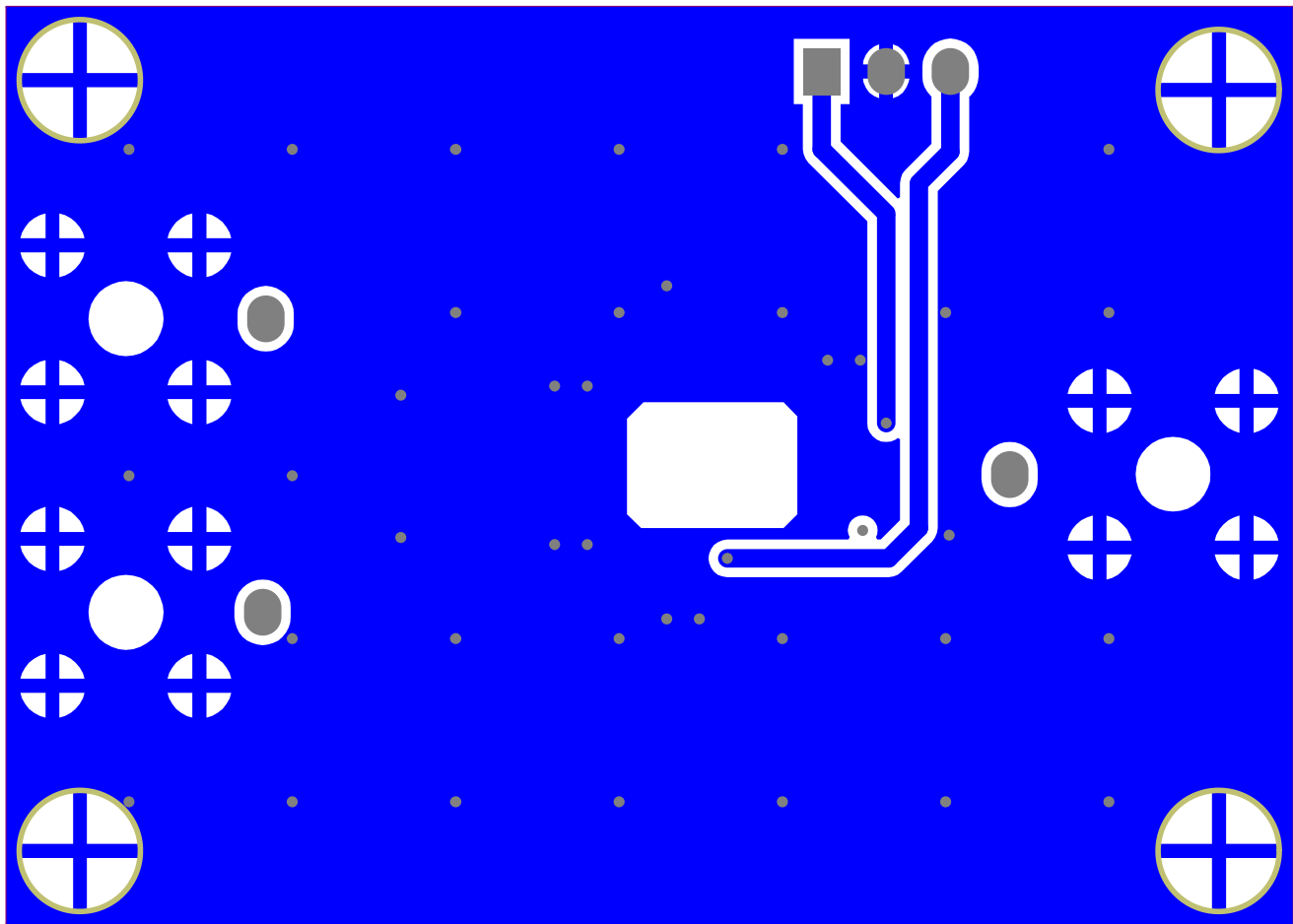


Figure 60. Layout of ZJA3676/8 Evaluation Board (Bottom Layer)

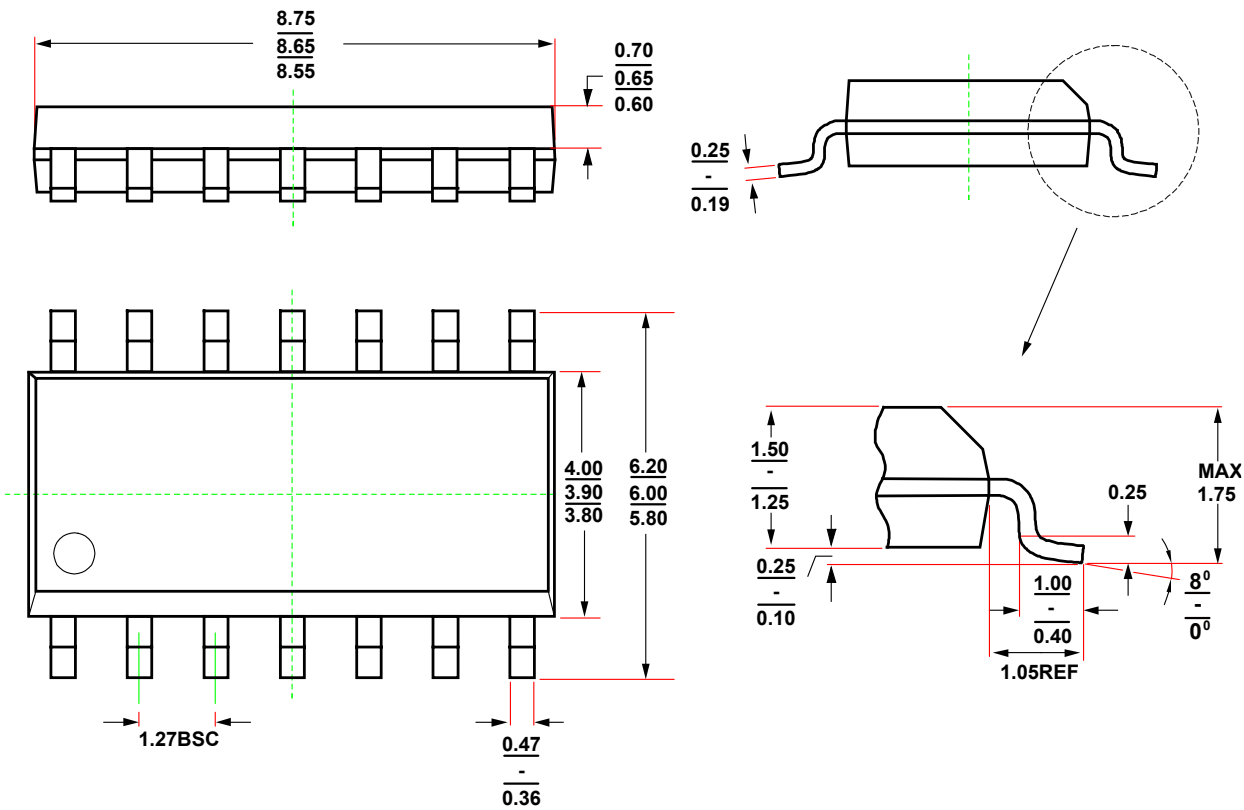


Figure 63. 14-Lead SOIC Package Dimensions shown in millimeters

Ordering Guide

Model	Orderable Device	Vos max. (G = 0.5, μV)	Package	External Package
ZJA3678	ZJA3678BSABT	75	SOIC-8	Tube
	ZJA3678BSABR			13" reel
	ZJA3678ASABT	150	SOIC-8	Tube
	ZJA3678ASABR			13" reel
	ZJA3678BUABT	75	MSOP-8	Tube
	ZJA3678BUABR			13" reel
	ZJA3678AUABT	150	MSOP-8	Tube
	ZJA3678AUABR			13" reel
ZJA3679	ZJA3679BSDBT	75	SOIC-14	Tube
	ZJA3679BSDBR			13" reel
	ZJA3679ASDBT	150	SOIC-14	Tube
	ZJA3679ASDBR			13" reel

Product Order Model

ZJXXXXX X X X X X Q1

Q1: Automotive Grade

External Package: T = Tube; R = Reel

Temperature Range: A = -40 °C to 125 °C Automotive Grade 1, B = -40 °C to 125 °C; E = -40 °C to 85 °C

Number of Pins: R = 3; K = 5; T = 6; A = 8; B = 10; D = 14; E = 16; P = 20

Package Type: S = SOIC; U = MSOP, TSSOP, SOT; T = DFN, QFN; X = SC70; W = WLCSP; Z = TSOT23; L = LS

Grade: B grade is better than A grade

Base: R = Voltage reference; A = Amplifier; C = Data Converter; G = Switches and Multiplexers; M = Others

Related Parts

Part Number	Description	Comments
ADC		
ZJC2020	20-bit 350 kSPS SAR ADC	Fully differential input, SINAD 101.4 dB, THD -118 dB
ZJC2000/2010	18-bit 400 kSPS/200 kSPS SAR ADC	Fully differential input, SINAD 99.3 dB, THD -113 dB
ZJC2001/2011	16-bit 500 kSPS/250 kSPS SAR ADC	Fully differential input, SINAD 95.3 dB, THD -113 dB
ZJC2002/2012	16-bit 500 kSPS/250 kSPS SAR ADC	Pseudo-differential unipolar input, SINAD 91.7 dB, THD -105 dB
ZJC2003/2013		Pseudo-differential bipolar input, SINAD 91.7 dB, THD -105 dB
ZJC2004/2014	18-bit 400 kSPS/200 kSPS SAR ADC	Pseudo-differential unipolar input, SINAD 94.2 dB, THD -105 dB
ZJC2005/2015		Pseudo-differential bipolar input, SINAD 94.2 dB, THD -105 dB
ZJC2007/2017	14-bit 600 kSPS/300 kSPS SAR ADC	Pseudo-differential unipolar input, SINAD 85 dB, THD -105 dB
ZJC2008/2018		Pseudo-differential bipolar input, SINAD 85 dB, THD -105 dB
ZJC2100/1-18	18-bit 400 kSPS/200 kSPS 4-ch differential SAR ADC, SINAD 99.3 dB, THD -113 dB	
ZJC2100/1-16	16-bit 500 kSPS/250 kSPS 4-ch differential SAR ADC, SINAD 95.3 dB, THD -113 dB	
ZJC2102/3-18	18-bit 400 kSPS/200 kSPS 8-ch pseudo-differential SAR ADC, SINAD 94.2 dB, THD -105 dB	
ZJC2102/3-16	16-bit 500 kSPS/250 kSPS 8-ch pseudo-differential SAR ADC, SINAD 91.7 dB, THD -105 dB	
ZJC2102/3-14	14-bit 600 kSPS/300 kSPS 8-ch pseudo-differential SAR ADC, SINAD 85 dB, THD -105 dB	
ZJC2104/5-18	18-bit 400 kSPS/200 kSPS 4-ch pseudo-differential SAR ADC, SINAD 94.2 dB, THD -105 dB	
ZJC2104/5-16	16-bit 500 kSPS/250 kSPS 4-ch pseudo-differential SAR ADC, SINAD 91.7 dB, THD -105 dB	
DAC		
ZJC2541-18/16/14	18/16/14-bit 1 MSPS single channel DAC with unipolar output	Power on reset to 0 V (ZJC2541) or $V_{REF}/2$ (ZJC2543), 1 nV-S glitch, SOIC-8, MSOP-10/8, DFN-10 packages
ZJC2543-18/16/14		
ZJC2542-18/16/14	18/16/14-bit 1 MSPS single channel DAC with bipolar output	Power on reset to 0 V (ZJC2542) or $V_{REF}/2$ (ZJC2544), 1 nV-S glitch, SOIC-14, TSSOP-16, QFN-16 packages
ZJC2544-18/16/14		
Amplifier		
ZJA3000-1/2/4	Single/Dual/Quad 36 V low bias current precision Op Amps	3 MHz, 35 μ V max Vos, 0.5 μ V/°C max TCvos, 25 pA max Ibias, 1 mA/ch, input to V- (ZJA3000 only), RRO, 4.5 V to 36 V
ZJA3001-1/2/4		
ZJA3018-2	OVP $\pm$ 75 V, 36 V, Low Power, High Precision Op Amp	1.3 MHz, 10 μ V max Vos, 0.5 μ V/°C max TCvos, 25 pA max Ibias, 0.5 mA/ch, OVP $\pm$ 75 V (ZJA3018 only), RRO, 4.5 V to 36 V
ZJA3008-2		
ZJA3512-2	Dual 36 V 7 MHz precision JFET Op Amps	7 MHz, 35 V/ μ S, 50 μ V max Vos, 1 μ V/°C max TCvos, 2 mA/ch, RRO, 9 V to 36 V
ZJA3216/06/02-1/2	Precision 20/10/5 MHz CMOS RRIO Op Amps	20/10/5 MHz, RRIO, 30 μ V max Vos, 1 μ V/°C max TCvos, 0.6 pA Ib, 2.7 V to 5.5 V
ZJA3600/1	36 V ultra-high precision in-amp	CMRR 105 dB min (G = 1), 25 pA max Ib, 25 μ V max Vosi, $\pm$ 2.4 V to $\pm$ 18 V, -40 °C to 125 °C
ZJA3611, ZJA3609	36 V precision wider bandwidth precision in-amp (G $\geq$ 10)	CMRR 120 dB min (G = 10), 25 pA max Ibias, 25 μ V max Vosi, 1.2 MHz BW (G = 10)
ZJA3676/7	Low power, G = 1 Single/Dual 36 V difference amplifier Low power, G = 0.5/2 Single/Dual 36 V difference amplifier	Input protection to $\pm$ 65 V, CMRR 104 dB min (G = 1), Vos 100 μ V max, gain error 15 ppm max, 500 kHz BW (G = 1), 330 μ A/channel, 2.7 V to 36 V
ZJA3678/9		
ZJA3669	High Common-Mode Voltage Difference Amplifier	$\pm$ 270 V CMV, 2.5 kV ESD, 96 dB min CMRR, 450 kHz BW, 4 V to 36 V, SOIC-8
ZJA3100	15 V precision fully differential amplifier	145 MHz, 447 V/ μ S, 50 nS to 16-bit, 50 μ V max Vos, 4.6 mA Iq, SOIC/MSOP-8, QFN-16
ZJA3236/26/22-2	Low-cost 20/10/5 MHz CMOS RRIO Op Amps	20/10/5 MHz, RRIO, 2 mV max Vos, 6 μ V/°C max TCvos, 0.6 pA Ib, 2.7 V to 5.5 V
ZJA3622/8	36 V low-cost precision in-amp	0.5 nA max Ibias, 125 μ V max Vosi, 625 kHz BW (G = 10), 3.3 mA Iq, $\pm$ 2.4 V to $\pm$ 18 V
Voltage Reference		
ZJR1004	40 V supply precision voltage reference	V_{OUT} = 2.048/2.5/3.3/3.4.096/5/10 V, 5 ppm/°C max drift -40 °C to 125 °C
ZJR1001/2	5.5 V low power voltage reference (ZJR1001 with noise filter option)	V_{OUT} = 2.048/2.5/3.3/3.4.096/5 V, 5 ppm/°C max drift -40 °C to 125 °C, $\pm$ 0.05% initial error, 130 μ A, ZJR1001/2 in SOT23-6, ZJR1003 in SOIC/MSOP-8
ZJR1003		
ZJR1302	5.5 V low power compact precision voltage reference	V_{OUT} = 2.048/2.5/3.3/3.4.096 V, 30 ppm/°C max drift -40 °C to 125 °C, 130 μ A, SOT23-3
Switches and Multiplexers		
ZJG4438/4439	36 V fault protection 8:1/dual 4:1 multiplexer	Protection to $\pm$ 50 V power on & off, latch-up immune, Ron 270 Ω , 14.8 pC, t_{ON} 166 nS
ZJG4428/4429	36 V 8:1/dual 4:1 multiplexer	Latch-up immune, Ron 270 Ω , 14.8 pC charge injection, t_{ON} 166 nS
Quad Matching Resistor		
ZJM5400	$\pm$ 75 V precision match resistors	Mismatch < 100 ppm, 10k:10k:10k:10k, 100k:100k:100k:100k, 100k:10k:10k:100k, 1k:1k:1k:1k, 1M:1M:1M:1M, 5k:1k:1k:5k, 5k:1.25k:1.25k:5k, 9k:1k:1k:9k, ESD: 3.5 kV