Precision, 11MHz, Low-Noise, RRIO, CMOS Amplifiers

CJOA845x Series Operational Amplifiers

1 Introduction

The CJOA845x family of single-, dual-, and quad- channel operational amplifiers represents a new generation of general-purpose, low-power op-amps. Featuring rail-to-rail input and output (RRIO) swings, low quiescent current (typical 750μA) combined with a wide bandwidth (11MHz) and very low noise (8nV/√Hz at 10kHz) makes this family very attractive for a variety of battery-powered applications that require a good balance between cost and performance, such as audio outputs, motor phase current sensing, photodiode amplification, barcode scanners and white goods. The low input bias current supports these amplifiers to be used in applications with mega-ohm source impedances.

The robust design of the CJOA845x amplifiers provides ease-of-use to the circuit designer: unity-gain stability with capacitive loads of up to 300pF, integrated RF/EMI rejection filter, no phase reversal in overdrive conditions, and high electro-static discharge (ESD) protection (4-kV HBM). The CJOA845x amplifiers are optimized for operation at voltages as low as +1.8V (±0.9V) and up to +5.5V (±2.75V) at the temperature range of 0°C to 70°C, and operation at voltages from +2.0V (±1.0V) to +5.5V (±2.75V) over the extended temperature range of -40°C to +125°C.

The CJOA8451 (single) is available in both SOT-23-5L and SOT-353 packages. The CJOA8452 (dual) is offered in DFNWB2X2-8L, SOP8, TSSOP8, and MSOP8 packages. The quad-channel CJOA8454 is offered in SOP14, and TSSOP14 packages.

2 Features

- Wide Unity-Gain Bandwidth: 11MHz
- High Slew Rate: 11V/μs
- Fast Settling: 0.26us to 0.1%
- Low Noise: 8nV/√Hz at 10kHz
- Low Input Offset Voltage: ±0.35mV Maximum
- Single 1.8V to 5.5V Supply Voltage
- Rail-to-Rail Input and Output
- Internal RF/EMI Filter
- Low Supply Current: 750uA at 5V Supply Per Amplifier
- Extended Temperature Range: -40°C to +125°C

3 Applications

- Battery-Powered Instruments
- Motor Phase Current Sense
- Sensor Signal Conditioning

4 Available Packages

PART NUMBER	PACKAGE
CJOA8451-M5N	SOT-23-5L
CJOA8451-R5N	SOT-353
CJOA8452-PAN	SOP8
CJOA8452-PDN	MSOP8
CJOA8452-BAN	TSSOP8
CJOA8452-DCN	DFNWB2X2-8L
CJOA8454-PHN	SOP14
CJOA8454-PIN	TSSOP14

5 Pin Configuration and Marking Information

5.1 Pin Configuration and Function

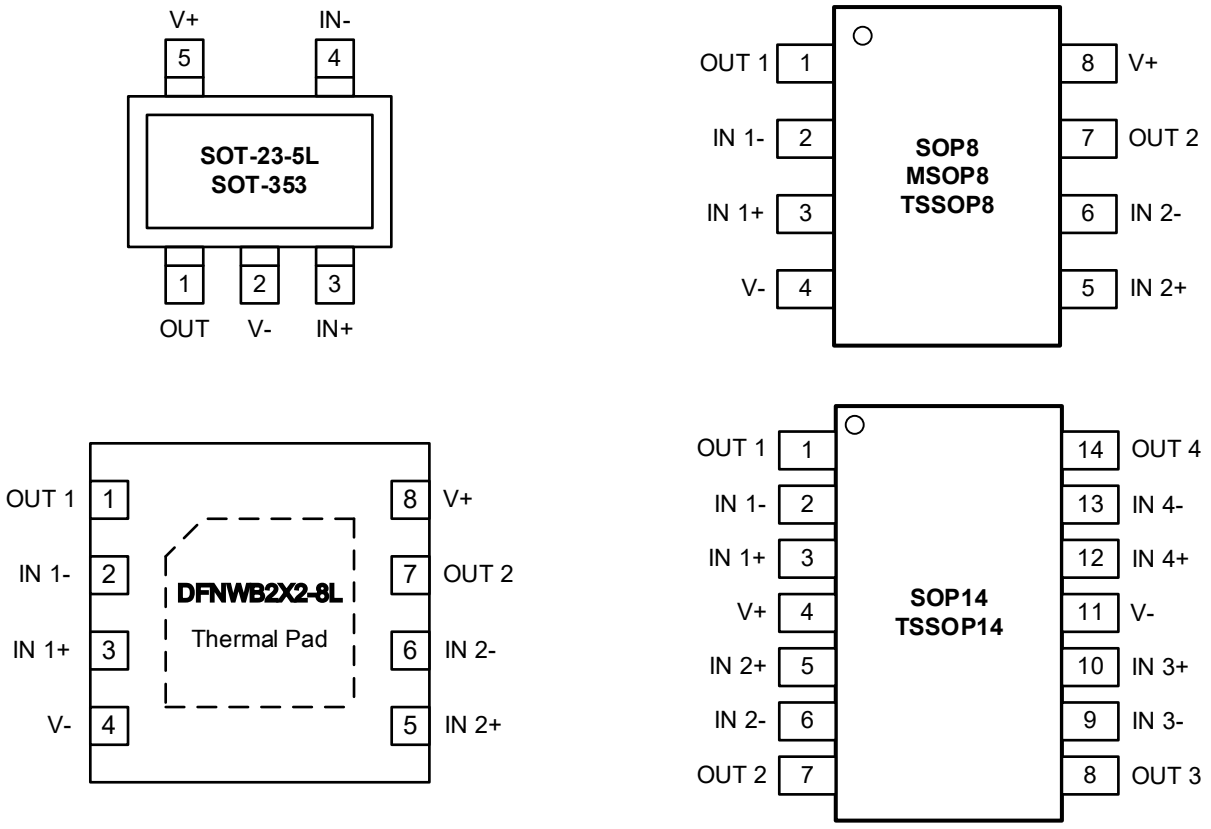
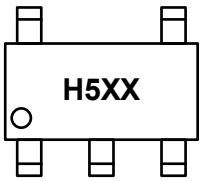


Figure 5-1. CJOA845x Pin Map

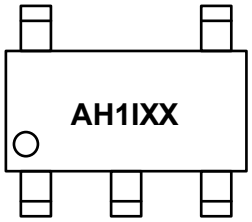
PIN NAME	CJOA8451	CJOA8452	CJOA8454	I / O	DESCRIPTION
	SOT-23-5L / SOT-353	SOP8/MSOP8/ TSSOP8/ DFNWB2X2-8L	SOP14 / TSSOP14		
OUT1	1	1	1	O	Output of the operational amplifier 1
IN1-	4	2	2	I	Negative input of the operational amplifier 1
IN1+	3	3	3	I	Positive input of the operational amplifier 1
V+	5	8	4	-	Positive (highest) supply
IN2+	-	5	5	I	Positive input of the operational amplifier 2
IN2-	-	6	6	I	Negative input of the operational amplifier 2
OUT2	-	7	7	O	Output of the operational amplifier 2
OUT3	-	-	8	O	Output of the operational amplifier 3
IN3-	-	-	9	I	Negative input of the operational amplifier 3
IN3+	-	-	10	I	Positive input of the operational amplifier 3
V-	2	4	11	-	Negative (lowest) supply or ground for single supply
IN4+	-	-	12	I	Positive input of the operational amplifier 4
IN4-	-	-	13	I	Negative input of the operational amplifier 4
OUT4	-	-	14	O	Output of the operational amplifier 4

5 Pin Configuration and Marking Information

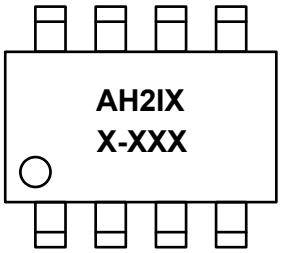
5.2 Marking Information



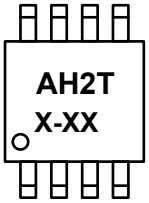
SOT-353



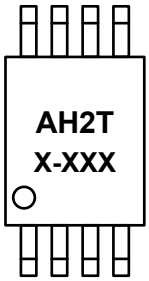
SOT-23-5L



SOP8



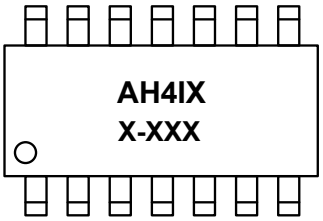
MSOP8



TSSOP8



DFNWB2×2-8L



SOP14



TSSOP14

"XX", "X-XX", X-XXX: Code, indicates weekly record information.

6 Specifications

6.1 Absolute Maximum Ratings

over operating ambient temperature range, unless otherwise specified(1).

CHARACTERISTIC		SYMBOL	VALUE	UNIT
Supply voltage (V_{S+} - V_{S-})		V_S	10	V
Signal input pins	Voltage(2)		V_{S-} - 0.5V ~ V_{S+} + 0.5V	V
	Current(2)		±10	mA
Output short-circuit			Continuous(3)	mA
Maximum junction temperature		$T_{J\ MAX}$	150	°C
Storage temperature		T_{stg}	-65 ~ +150	°C
Soldering temperature & time		T_{solder}	260°C, 10s	-

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions. Exposure to absolute-maximum rated conditions for extended periods may affect device reliability.

(2) Input pins are diode-clamped to the power-supply rails. Current limit input signals that can swing more than 0.5V beyond the supply rails to 10mA or less.

(3) Short circuits from outputs to V_S can cause excessive heating and eventual destruction. 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.

6.2 Recommend Operating Conditions

over operating ambient temperature range, unless otherwise specified.

PARAMETER		SYMBOL	MIN.	NOM.	MAX.	UNIT
Power supply range	T_A = 0°C ~ +70°C	V_S	1.8		5.5	V
	T_A = -40°C ~ +125°C		2.0		5.5	
Operating ambient temperature		T_A	-40		+125	°C

6 Specifications

6.3 ESD Ratings

ESD RATINGS		VALUE	UNIT
Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(4)	5000	V
	Charged-device model (CDM), per JEDEC specification JESD22-C101(5)	2000	V
	Machine model (MM), per JESD22-A115C	250	V

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

6.4 Thermal Information

THERMAL METRIC(6)	SYMBOL	CJOA845X Series				UNIT
Junction-to-ambient thermal resistance	$R_{\Theta JA}$	**SOT-353**	**SOT-23-5L**	**SOP8**	**MSOP8**	°C/W
		333.0	192.3	125.0	201.6	
		TSSOP8	**DFNWB2×2-8L**	**SOP14**	**TSSOP14**	
		160.0	94.0	115.7	112.0	
Reference maximum power dissipation for continuous operation	$P_{D\ Ref}$	**SOT-353**	**SOT-23-5L**	**SOP8**	**MSOP8**	W
		0.37	0.65	1.00	0.62	
		TSSOP8	**DFNWB2×2-8L**	**SOP14**	**TSSOP14**	
		0.78	1.32	1.08	1.11	

(6) T_A = 25°C, measured on evaluation board with 1oz. copper traces of minimum pad size, all device outputs were active.

6 Specifications

6.5 Electrical Characteristics

$V_S = V_{S+} - V_{S-} = 5.0V$, $T_A = 25°C$, $V_{CM} = V_S / 2$, $V_O = V_S / 2$, and $R_L = 10k\Omega$ connected to $V_S / 2$, unless otherwise noted. Boldface limits apply over the specified temperature range, $T_A = -40°C$ to $+125°C$.

CHARACTERISTIC	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
OFFSET VOLTAGE						
Input offset voltage	V_{OS}	CJOA8451, CJOA8452	-	±0.1	±0.35	mV
		CJOA8454	-	±0.12	±0.50	
Offset voltage drift	V_{OS} TC	T_A = -40°C to +125°C	-	±1	±2.3	µV/°C
Power supply rejection ratio	PSRR	V_S = 2.0 to 5.5V, $V_{CM} < V_{S+}$ - 2V	95	110	-	dB
		T_A = -40°C to +125°C	82	-	-	
INPUT BIAS CURRENT						
Input bias current	I_B	-	-	1	-	pA
		T_A = +85°C	-	150	-	pA
		T_A = +125°C	-	500	-	pA
Input offset current	I_{OS}	-	-	1	-	pA
NOISE						
Input voltage noise	V_n	f = 0.1 to 10Hz	-	3	-	μV_{PP}
Input voltage noise density	e_n	f = 100Hz	-	19	-	nV/√Hz
		f = 10kHz	-	8	-	
Input current noise density	I_n	f = 1kHz	-	3	-	fA/√Hz
INPUT VOLTAGE						
Common-mode voltage range	V_{CM}	-	V_{S-} - 0.1	-	V_{S+} + 0.1	V
Common-mode rejection ratio	CMRR	V_S = 5.5V, V_{CM} = -0.1 to 5.6V	80	96	-	dB
		V_{CM} = 0 to 5.3V, T_A = -40°C to +125°C	75	-	-	
		V_S = 2.0V, V_{CM} = -0.1 to 2.1V	76	90	-	
		V_{CM} = 0 to 1.8V, T_A = -40°C to +125°C	70	-	-	
INPUT IMPEDANCE						
Input capacitance	C_{IN}	Differential	-	2.0	-	pF
		Common mode	-	3.5	-	
OPEN-LOOP GAIN						
Open-loop voltage gain	A_{VOL}	R_L = 10kΩ, V_O = 0.05 to 3.5V	97	105	-	dB
		T_A = -40°C to +125°C	87	-	-	
		R_L = 600Ω, V_O = 0.15 to 3.5V	85	90	-	
		T_A = -40°C to +125°C	75	-	-	

6 Specifications

6.5 Electrical Characteristics(continue)

V_S = V_{S+} - V_{S-} = 5.0V, T_A = 25°C, V_{CM} = V_S / 2, V_O = V_S / 2, and R_L = 10kΩ connected to V_S / 2, unless otherwise noted. Boldface limits apply over the specified temperature range, T_A = -40°C to +125°C.

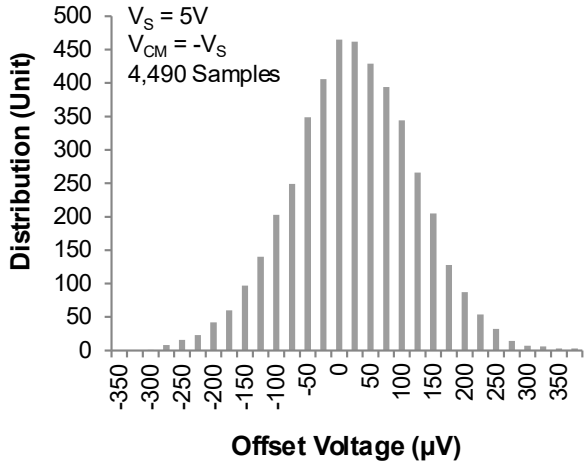
CHARACTERISTIC	SYMBOL	TEST CONDITIONS(7)	MIN.	TYP.	MAX.	UNIT
FREQUENCY RESPONSE						
Gain bandwidth product	GBW	-	-	11	-	MHz
Slew rate	SR	G = +1, C_L = 100pF, V_O = 1.5V to 3.5V	-	11	-	V/μs
Total harmonic distortion + noise	THD + N	G = +1, f = 1kHz, V_O = 0.5V_{RMS}	-	0.0005	-	%
Settling time	t_S	To 0.1%, G = +1, 1V step	-	0.26	-	μs
		To 0.01%, G = +1, 1V step	-	0.34	-	
Overload recovery time	t_{OR}	V_{IN} * Gain > V_S	-	0.3	-	μs
OUTPUT						
High output voltage swing	V_{OH}	R_L = 10kΩ	V_{S+} - 12	V_{S+} - 8	-	mV
		R_L = 600Ω	V_{S+} - 180	V_{S+} - 125	-	
Low output voltage swing	V_{OL}	R_L = 10kΩ	-	V_{S-} + 6	V_{S-} + 9	mV
		R_L = 600Ω	-	V_{S-} + 90	V_{S-} + 130	
Short-circuit current	I_{SC}	-	-	±75	-	mA
POWER SUPPLY						
Quiescent current (per amplifier)	I_Q	V_S = 2.0V	-	625	760	μA
		V_S = 5.0V	-	750	930	

6 Specifications

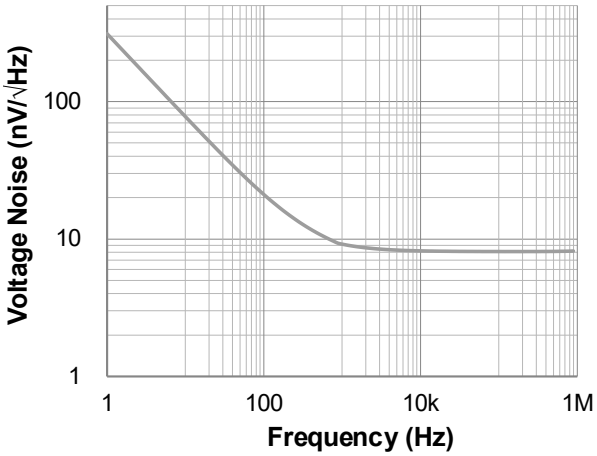
6.6 Typical Characteristics

At T_A = 25°C, V_{CM} = V_S / 2 and R_L = 10kΩ connected to V_S / 2, unless otherwise specified.

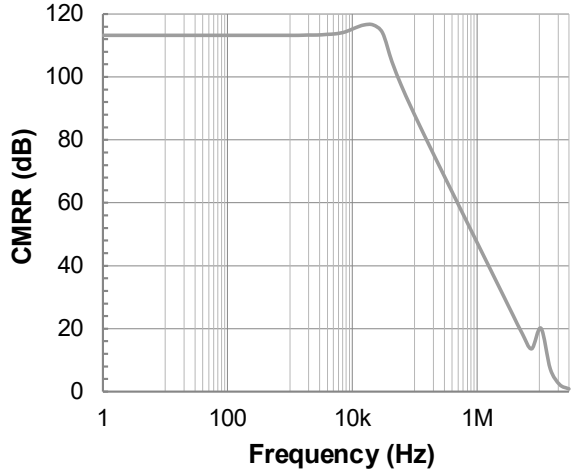
Offset Voltage Production Distribution



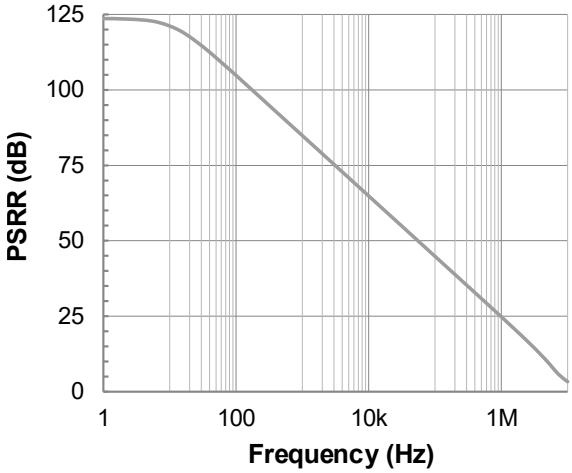
Input Voltage Noise Spectral Density as a function of Frequency



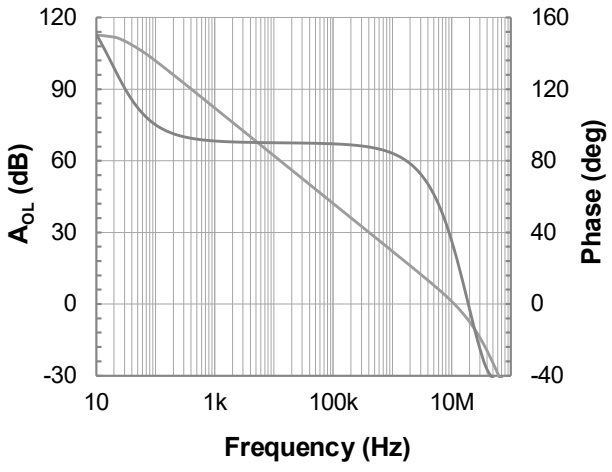
Common-mode Rejection Ratio as a function of Frequency



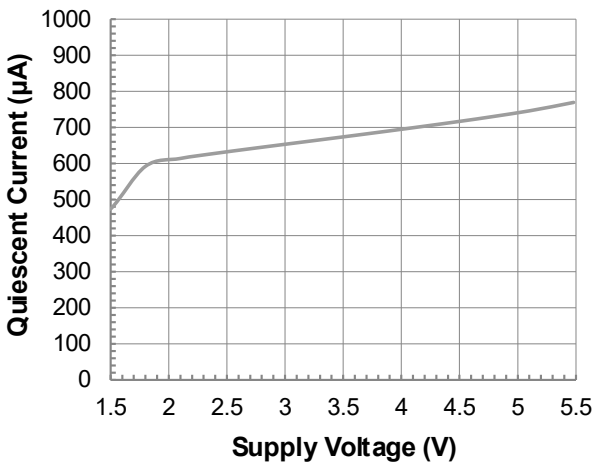
Power Supply Rejection Ratio as a function of Frequency



Open-loop Gain and Phase as a function of Frequency



Quiescent Current as a function of Supply Voltage

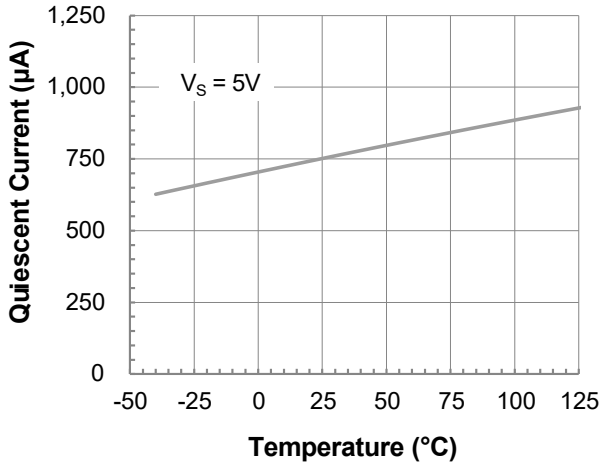


6 Specifications

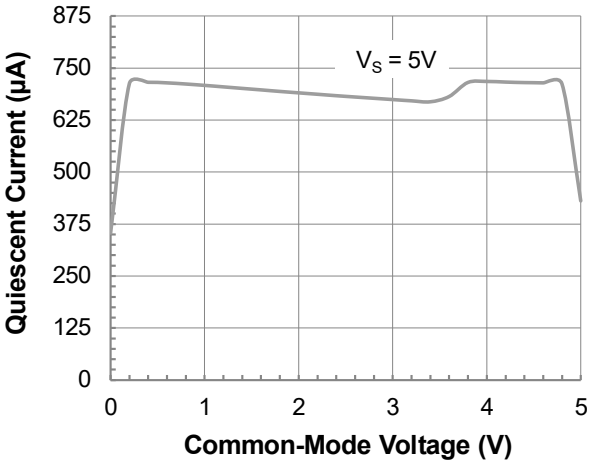
6.6 Typical Characteristics(continue)

At T_A = 25°C, V_{CM} = V_S / 2 and R_L = 10kΩ connected to V_S / 2, unless otherwise specified.

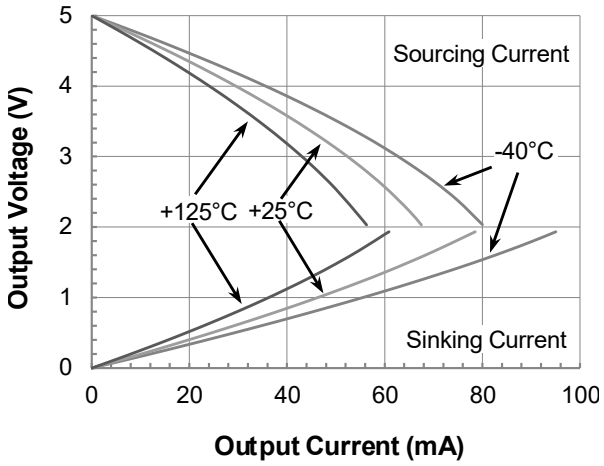
Quiescent Current as a function of Temperature



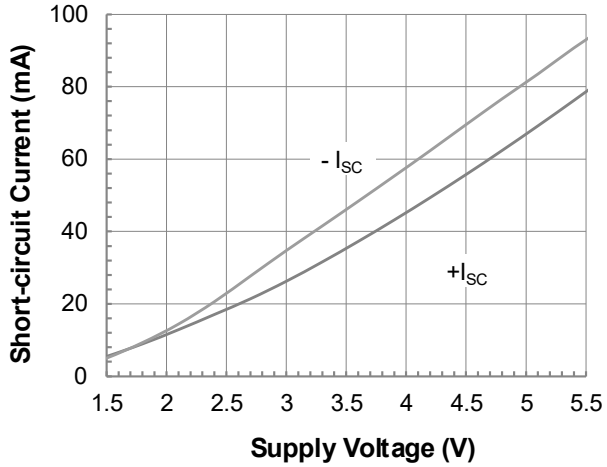
Quiescent Current as a function of Input Common-mode Voltage



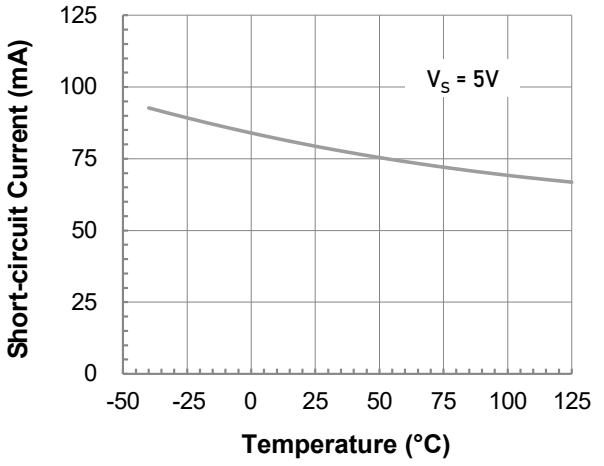
Output Voltage Swing as a function of Output Current



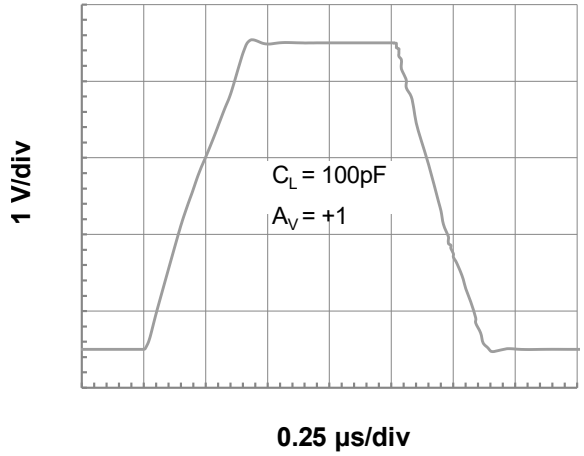
Short-circuit Current as a function of Supply Voltage



Short-circuit Current as a function of Temperature



Large Signal Step Response

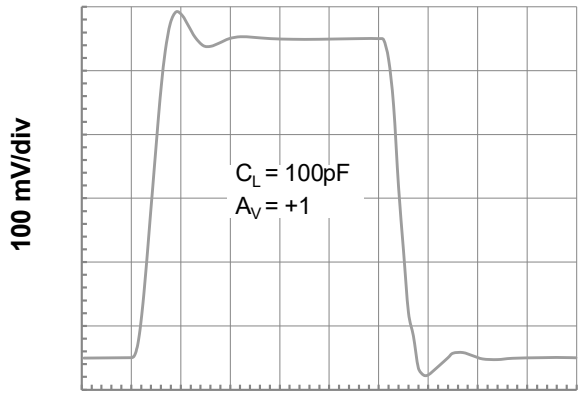


6 Specifications

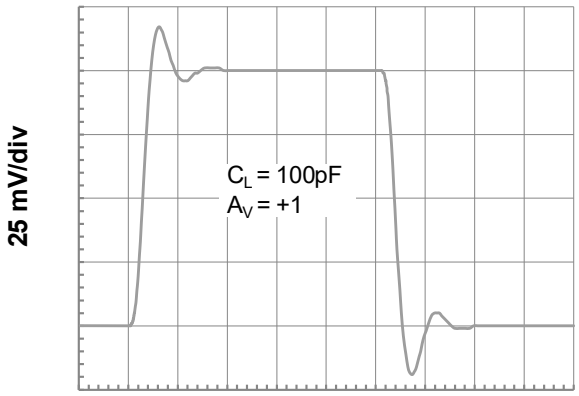
6.6 Typical Characteristics(continue)

At T_A = 25°C, V_{CM} = V_S / 2 and R_L = 10kΩ connected to V_S / 2, unless otherwise specified.

Small Signal Step Response (500 mV)



Small Signal Step Response (500 mV)



7 Detail Description

7.1 Description

The CJOA845x is a family of low-power, rail-to-rail input and output operational amplifiers specifically designed for portable applications. These devices operate from 1.8V to 5.5V at the temperature range of 0°C to 70°C, are unity-gain stable, and suitable for a wide range of general-purpose applications. The class AB output stage is capable of driving ≤10kΩ loads connected to any point between V_{S+} and ground. The input common-mode voltage range includes both rails, and allows the CJOA845x family to be used in virtually any single-supply application. Rail-to-rail input and output swing significantly increases dynamic range, especially in low-supply applications, and makes them ideal for driving sampling analog-to-digital converters (ADCs).

7.2 Feature Description

Rail-to-Rail Input

The input common-mode voltage range of the CJOA845x series extends 100mV beyond the negative and positive supply rails. This performance is achieved with a complementary input stage: an N-channel input differential pair in parallel with a P-channel differential pair. The N-channel pair is active for input voltages close to the positive rail, typically V_{S+} - 1.4V to the positive supply, whereas the P-channel pair is active for inputs from 100mV below the negative supply to approximately V_{S+} - 1.4V. There is a small transition region, typically V_{S+} - 1.2V to V_{S+} - 1V, in which both pairs are on. This 200mV transition region can vary up to 200mV with process variation. Thus, the transition region (both stages on) can range from V_{S+} - 1.4V to V_{S+} - 1.2V on the low end, up to V_{S+} - 1V to V_{S+} - 0.8V on the high end. Within this transition region, PSRR, CMRR, offset voltage, offset drift, and THD can be degraded compared to device operation outside this region.

The typical input bias current of the CJOA845x during normal operation is approximately 1pA. In overdriven conditions, the bias current can increase significantly. The most common cause of an overdriven condition occurs when the operational amplifier is outside of the linear range of operation. When the output of the operational amplifier is driven to one of the supply rails, the feedback loop requirements cannot be satisfied and a differential input voltage develops across the input pins. This differential input voltage results in activation of parasitic diodes inside the front-end input chopping switches that combine with electromagnetic interference (EMI) filter resistors to create the equivalent circuit. Notice that the input bias current remains within specification in the linear region.

Rail-to-Rail Output

Designed as a micro-power, low-noise operational amplifier, the CJOA845x delivers a robust output drive capability. A class AB output stage with common-source transistors is used to achieve full rail-to-rail output swing capability. For resistive loads up to 100kΩ, the output swings typically to within 5mV of either supply rail regardless of the power-supply voltage applied. Different load conditions change the ability of the amplifier to swing close to the rails. For resistive loads up to 600Ω, the output swings typically to within 125mV of the positive supply rail and within 90mV of the negative supply rail.

Overload Recovery

Overload recovery is defined as the time required for the operational amplifier output to recover from a saturated state to a linear state. The output devices of the operational amplifier enter a saturation region when the output voltage exceeds the rated operating voltage, either because of the high input voltage or the high gain. After the device enters the saturation region, the charge carriers in the output devices require time to return back to the linear state. After the charge carriers return back to the linear state, the device begins to slew at the specified slew rate. Thus, the propagation delay in case of an overload condition is the sum of the overload recovery time and the slew time. The overload recovery time for the CJOA845x family is approximately 0.3μs.

7 Detail Description

7.2 Feature Description(continue)

EMI Rejection

Circuit performance is often adversely affected by high frequency EMI. When the signal strength is low and transmission lines are long, an op-amp must accurately amplify the input signals. However, all op-amp pins — the non-inverting input, inverting input, positive supply, negative supply, and output pins —are susceptible to EMI signals. These high frequency signals are coupled into an op-amp by various means, such as conduction, near field radiation, or far field radiation. For example, wires and printed circuit board (PCB) traces can act as antennas and pick up high frequency EMI signals. Amplifiers do not amplify EMI or RF signals due to their relatively low bandwidth. However, due to the nonlinearities of the input devices, op-amps can rectify these out of band signals. When these high frequency signals are rectified, they appear as a dc offset at the output.

The CJOA845x op-amps have integrated EMI filters at their input stage. A mathematical method of measuring EMIRR is defined as follows:

$$EMIRR = 20 \log (V_{IN_PEAK} / \Delta_{VOS})$$

8 Application and Implementation

8.1 Application Information

The CJOA845x features 11MHz bandwidth and 11V/μs slew rate with only 750μA supply current per amplifier, providing good ac performance at very low power consumption. DC applications are also well served with a low input noise voltage of 8nV/√Hz at 1kHz, low input bias current, and an input offset voltage of 0.35mV typically. The typical offset voltage drift is 1μV/°C, over the full temperature range the input offset voltage changes only 100μV (0.35mV to 0.45mV).

8.2 Typical Application Circuits

Input EMI Filter and Clamp Circuit

Figure 9-1 shows the input EMI filter and clamp circuit. The CJOA845x op-amps have internal ESD protection diodes (D1, D2, D3, and D4) that are connected between the inputs and each supply rail. These diodes protect the input transistors in the event of electrostatic discharge and are reverse biased during normal operation. This protection scheme allows voltages as high as approximately 500mV beyond the rails to be applied at the input of either terminal without causing permanent damage. These ESD protection current-steering diodes also provide in-circuit, input overdrive protection, as long as the current is limited to 20mA as stated in the Absolute Maximum Ratings.

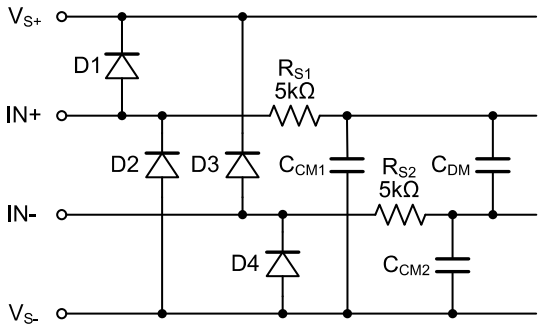


Figure 9-1. Input EMI Filter and Clamp Circuit

Operational amplifiers vary in susceptibility to EMI. If conducted EMI enters the operational amplifier, the dc offset at the amplifier output can shift from its nominal value when EMI is present. This shift is a result of signal rectification associated with the internal semiconductor junctions. Although all operational amplifier pin functions can be affected by EMI, the input pins are likely to be the most susceptible. The EMI filter of the CJOA845x family is composed of two 5kΩ input series resistors (R_{S1} and R_{S2}), two common-mode capacitors (C_{CM1} and C_{CM2}), and a differential capacitor (C_{DM}). These RC networks set the -3dB low-pass cutoff frequencies at 35MHz for common-mode signals, and at 22MHz for differential signals.

CAPACITIVE LOAD AND STABILITY

The CJOA845x family can safely drive capacitive loads of up to 300pF in any configuration. As with most amplifiers, driving larger capacitive loads than specified may cause excessive overshoot and ringing, or even oscillation. A heavy capacitive load reduces the phase margin and causes the amplifier frequency response to peak. Peaking corresponds to over-shooting or ringing in the time domain. Therefore, it is recommended that external compensation be used if the CJOA845x op-amps must drive a load exceeding 300pF. This compensation is particularly important in the unity-gain configuration, which is the worst case for stability.

A quick and easy way to stabilize the op-amp for capacitive load drive is by adding a series resistor, R_{ISO}, between the amplifier output terminal and the load capacitance, as shown in Figure 9-2. R_{ISO} isolates the amplifier output and feedback network from the capacitive load. The bigger the R_{ISO} resistor value, the more stable V_{OUT} will be. Note that this method results in a loss of gain accuracy because R_{ISO} forms a voltage divider with the R_L.

8 Application and Implementation

8.2 Typical Application Circuits (continued)

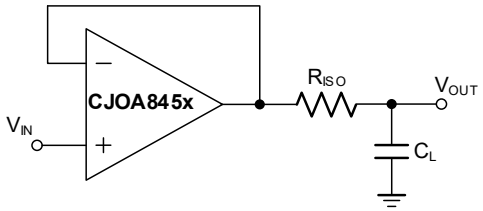


Figure 9-2. Indirectly Driving Heavy Capacitive Load

An improvement circuit is shown in Figure 9-3. 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. For no-buffer configuration, there are two others 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.

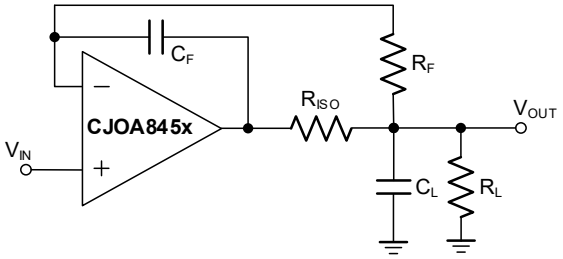


Figure 9-3. Indirectly Driving Heavy Capacitive Load with DC Accuracy

Input-to-Output Coupling

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

Active Filter

The CJOA845x family is well-suited for active filter applications that require a wide bandwidth, fast slew rate, low-noise, single supply operational amplifier. Figure 9-4 shows a 500kHz, second-order, low-pass filter using the multiple-feedback (MFB) topology. The components have been selected to provide a maximally-flat Butterworth response. Beyond the cut-off frequency, roll-off is -40dB/dec. The Butterworth response is ideal for applications that require predictable gain characteristics, such as the anti-aliasing filter used in front of an ADC.

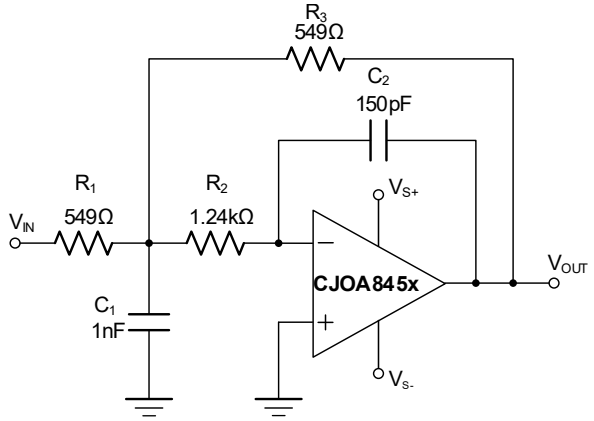


Figure 9-4. Second-Order, Butterworth, 500kHz Low-Pass Filter

8 Application and Implementation

8.2 Typical Application Circuits (continued)

One point to observe when considering the MFB filter is that the output is inverted, relative to the input. If this inversion is not required, or not desired, a non-inverting output can be achieved through one of these options:

1. adding an inverting amplifier.
2. adding an additional second-order MFB stage.
3. using a non-inverting filter topology, such as the Sallen-Key (shown in Figure 9-5).

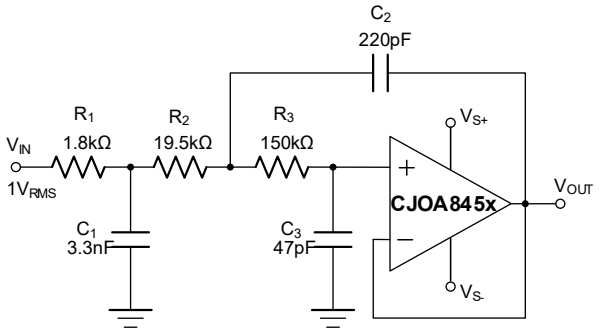


Figure 9-5. Configured as a Three-Pole, 20kHz, Sallen-Key Filter

Motor Phase Current Sensing

The current sensing amplification shown in Figure 9-6 has a slew rate of $2\pi V_{PP}$ for the output of sine wave signal, and has a slew rate of $2fV_{PP}$ 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 100μs for a 10kHz of PWM frequency. In current shunt monitoring for a motor phase, 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 9-6 shown, the total settling time of a current shunt monitor circuit includes: the rising edge delay time (t_{SR}) due to the op-amp's slew rate, and the measurement settling time (t_{SET}). For a 2-shunt solution of motor phase current sensing, if the minimum duty cycle of the PWM is defined at 5%, and the t_{SR} is required at 20% of a total time window for a phase current monitoring, in case of a 3.3V motor control system (3.3V MCU with 12-bit ADC), the op-amp's slew rate should be more than:

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

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

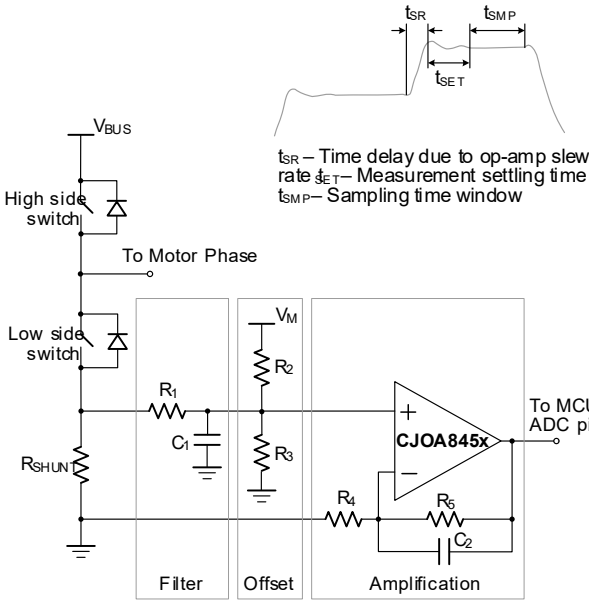


Figure 9-6. Current Shunt Monitor Circuit

8 Application and Implementation

8.2 Typical Application Circuits (continued)

Differential Amplifer

The circuit shown in Figure 9-7 performs the difference function. If the resistors ratios are equal $R_4 / R_3 = R_2 / R_1$, then:

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

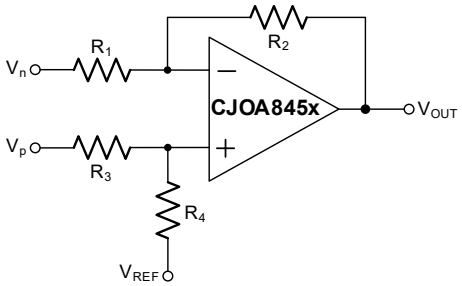


Figure 9-7. Differential Amplifier

Instrumentation Amplifier

The CJOA845x family is well suited for conditioning sensor signals in battery-powered applications. Figure 9-8 shows a two op-amp instrumentation amplifier, using the CJOA845x op-amps. The circuit works well for applications requiring rejection of common-mode noise at higher gains. The reference voltage (V_{REF}) is supplied by a low-impedance source. In single voltage supply applications, the V_{REF} is typically $V_S / 2$.

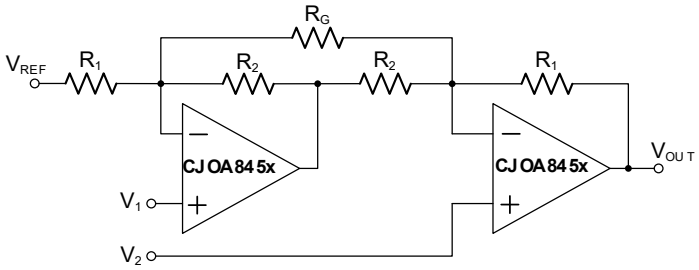
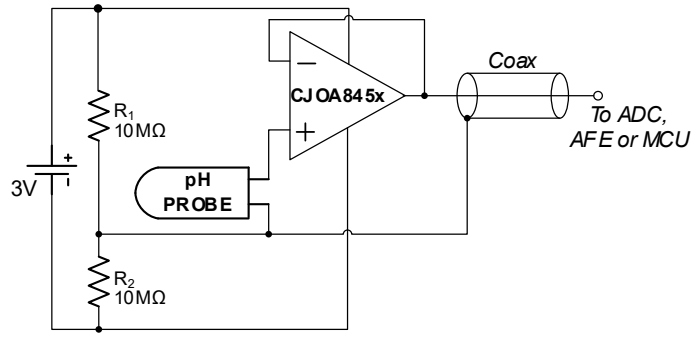


Figure 9-8. Instrumentation Amplifier

Buffered Chemical Sensors

The CJOA845x 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 9-9 eliminates expansive low-leakage cables that 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. A CJOA845x 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.



All components contained within the pH probe

Figure 9-9. Buffered pH Probe

8 Application and Implementation

8.3 Power Supply Recommendations

The CJOA845x family is optimized for operation at voltages as low as +1.8V (±0.9V) and up to +5.5V (±2.75V) at the temperature range of 0°C to 70°C, and fully specified and ensured for operation from 2.0V to 5.5V (±1.0V to ±2.75V). In addition, many specifications apply from -40°C to +125°C. Parameters that vary significantly with operating voltages or temperature are illustrated in the Typical Characteristics graphs.

NOTE: Supply voltages (V_{S+} to V_{S-}) higher than +10V can permanently damage the device.

8.4 Layout Guidelines

To achieve the maximum performance of the extremely high input impedance and low offset voltage of the CJOA845x op-amps, care is needed in laying out the circuit board. The PCB surface must remain clean and free of moisture to avoid leakage currents between adjacent traces. Surface coating of the circuit board reduces surface moisture and provides a humidity barrier, reducing parasitic resistance on the board. The use of guard rings around the amplifier inputs further reduces leakage currents. Figure 9-10 shows proper guard ring configuration and the top view of a surface-mount layout. The guard ring does not need to be a specific width, but it should form a continuous loop around both inputs. By setting the guard ring voltage equal to the voltage at the non-inverting input, parasitic capacitance is minimized as well. For further reduction of leakage currents, components can be mounted to the PCB using Teflon standoff insulators.

Other potential sources of offset error are thermoelectric voltages on the circuit board. This voltage, also called Seebeck voltage, occurs at the junction of two dissimilar metals and is proportional to the temperature of the junction. The most common metallic junctions on a circuit board are solder-to-board trace and solder-to-component lead. If the temperature of the PCB at one end of the component is different from the temperature at the other end, the resulting Seebeck voltages are not equal, resulting in a thermal voltage error.

This thermocouple error can be reduced by using dummy components to match the thermoelectric error source. Placing the dummy component as close as possible to its partner ensures both Seebeck voltages are equal, thus canceling the thermocouple error. Maintaining a constant ambient temperature on the circuit board further reduces this error. The use of a ground plane helps distribute heat throughout the board and reduces EMI noise pickup.

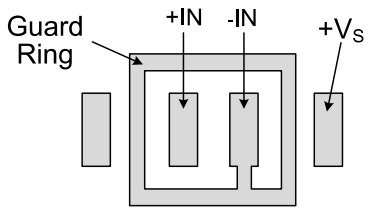


Figure 9-10. Guard Ring

9 Notes and Revision History

9.1 Associated Product Family and Others

To view other products of the same type or IC products of other types, click the official website of SZCJ -- ***http://www.szcjsemi.com*** for more details.

9.2 Notes

Electrostatic Discharge Caution



This IC may be damaged by ESD. Relevant personnel shall comply with correct installation and use specifications to avoid ESD damage to the IC. If appropriate measures are not taken to prevent ESD damage, the hazards caused by ESD include but are not limited to degradation of integrated circuit performance or complete damage of integrated circuit. For some precision integrated circuits, a very small parameter change may cause the whole device to be inconsistent with its published specifications.

9.3 Revision History

December 2025: released CJOA845x rev - 1.0.

10 Orderable, Mechanical, and Packaging Information

The following pages include mechanical packaging and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser based versions of this data sheet, refer to the left hand navigation.

Orderable Information

MODEL	DEVICE	PACKAGE	OP TEMP	ECO PLAN	MSL	PACKING OPTION	SORT
CJOA8451	CJOA8451-M5N	SOT-23-5L	-40 ~ 125°C	RoHS & Green	Level 3 168 HR	Tape and Reel 3000 Units / Reel	Active
CJOA8451	CJOA8451-R5N	SOT-353	-40 ~ 125°C	RoHS & Green	Level 3 168 HR	Tape and Reel 3000 Units / Reel	Active
CJOA8452	CJOA8452-PAN	SOP8	-40 ~ 125°C	RoHS & Green	Level 3 168 HR	Tape and Reel 4000 Units / Reel	Active
CJOA8452	CJOA8452-PDN	MSOP8	-40 ~ 125°C	RoHS & Green	Level 3 168 HR	Tape and Reel 4000 Units / Reel	Active
CJOA8452	CJOA8452-BAN	TSSOP8	-40 ~ 125°C	RoHS & Green	Level 3 168 HR	Tape and Reel 3000 Units / Reel	Active
CJOA8452	CJOA8452-DCN	DFNW2X2-8L	-40 ~ 125°C	RoHS & Green	Level 3 168 HR	Tape and Reel 3000 Units / Reel	Active
CJOA8454	CJOA8454-PHN	SOP14	-40 ~ 125°C	RoHS & Green	Level 3 168 HR	Tape and Reel 2500 Units / Reel	Active
CJOA8454	CJOA8454-PIN	TSSOP14	-40 ~ 125°C	RoHS & Green	Level 3 168 HR	Tape and Reel 3000 Units / Reel	Active
Others	-	-	-	-	-	-	Customized

Note:

ECO PLAN: For the RoHS and Green certification standards of this product, please refer to the official report provided by SZCJ

MSL: Moisture Sensitivity Level. Determined according to JEDEC industry standard classification.

SORT: Specifically defined as follows:

Active: Recommended for new products;

Customized: Products manufactured to meet the specific needs of customers;

Preview: The device has been released and has not been fully mass produced. The sample may or may not be available;

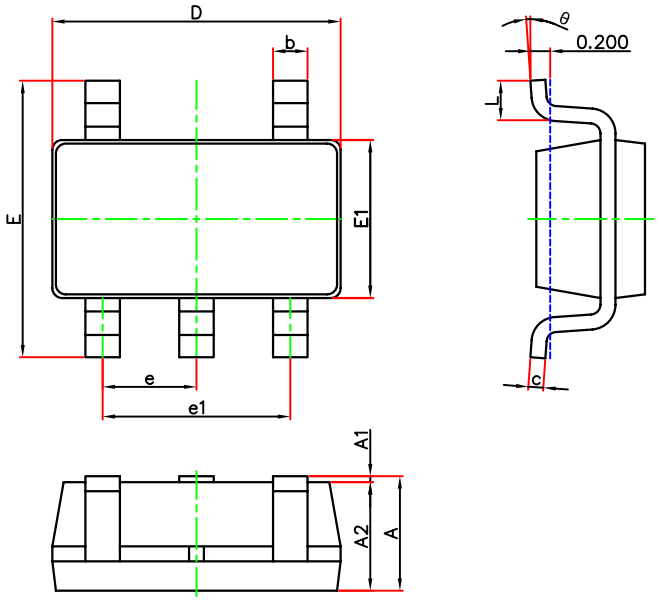
NoRD: It is not recommended to use the device for new design. The device is only produced for the needs of existing customers;

Obsolete: The device has been discontinued.

Mechanical Information

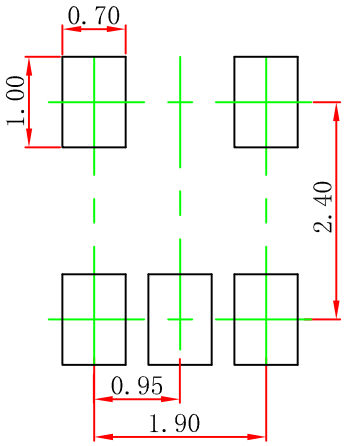
SOT-23-5L Mechanical Information

SOT-23-5L Outline Dimensions



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	1.000	1.200	0.039	0.047
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	2.600	3.000	0.102	0.118
E1	1.500	1.700	0.059	0.067
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°

SOT-23-5L Suggested Pad Layout

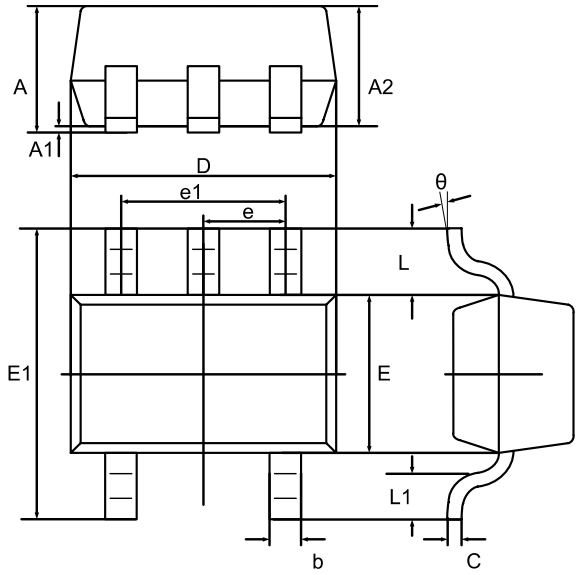


Note:
1. Controlling dimension: in millimeters.
2. General tolerance: ±0.05mm.
3. The pad layout is for reference purpose only.

Mechanical Information

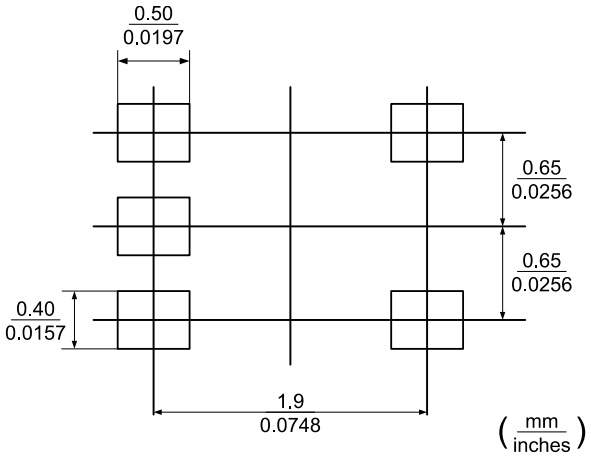
SOT-353 Mechanical Information

SOT-353 Outline Dimensions



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.90	1.10	0.035	0.043
A1	0.00	0.10	0.000	0.004
A2	0.90	1.00	0.035	0.039
b	0.15	0.35	0.006	0.014
C	0.08	0.15	0.003	0.006
D	2.00	2.20	0.079	0.087
E	1.15	1.35	0.045	0.053
E1	2.15	2.45	0.085	0.096
e	0.65 typ.		0.026 typ.	
e1	1.20	1.40	0.047	0.055
L	0.525 ref.		0.026 ref.	
	0.26	0.46	0.010	0.018
θ	0°	8°	0°	8°

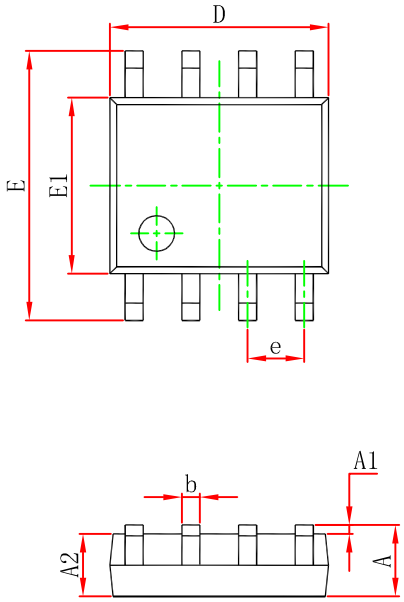
SOT-353 Suggested Pad Layout



Mechanical Information

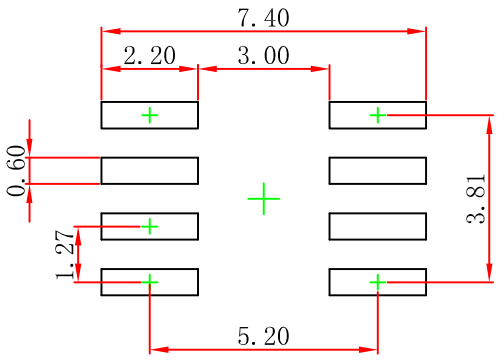
SOP8 Mechanical Information

SOP8 Outline Dimensions



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.370	1.670	0.054	0.066
A1	0.070	0.250	0.003	0.010
A2	1.350	1.550	0.053	0.061
b	0.300	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	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°

SOP8 Suggested Pad Layout

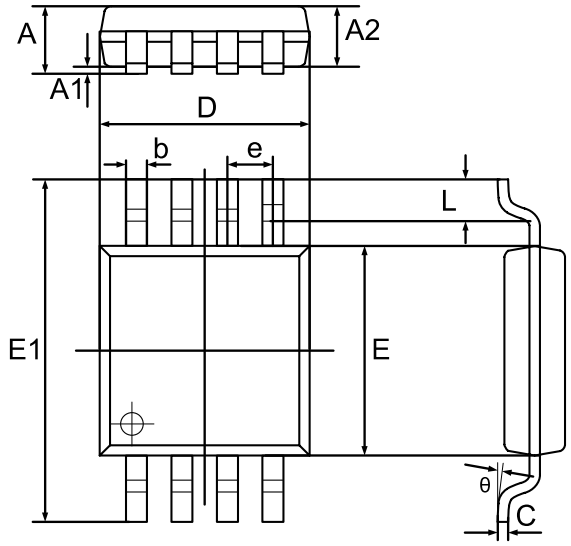


Note:
1. Controlling dimension: in millimeters.
2. General tolerance: ±0.05mm.
3. The pad layout is for reference purpose only.

Mechanical Information

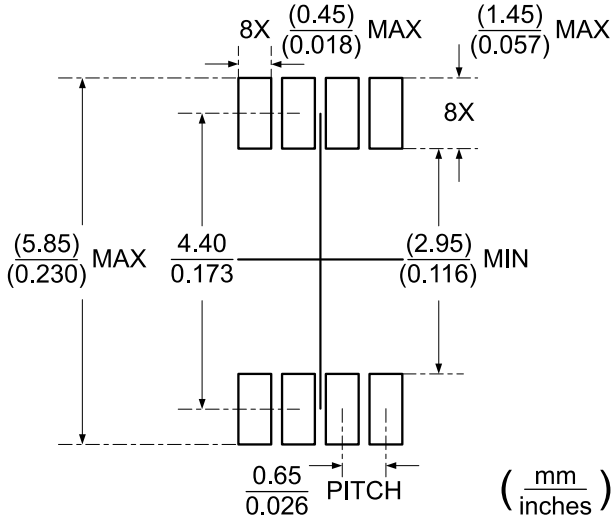
MSOP8 Mechanical Information

MSOP8 Outline Dimensions



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.800	1.100	0.031	0.043
A1	0.050	0.150	0.002	0.006
A2	0.750	0.950	0.030	0.037
b	0.290	0.380	0.011	0.015
C	0.150	0.200	0.006	0.008
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.700	5.100	0.185	0.201
e	0.650 TYP.		0.026 TYP.	
L	0.400	0.700	0.016	0.028
θ	0°	8°	0°	8°

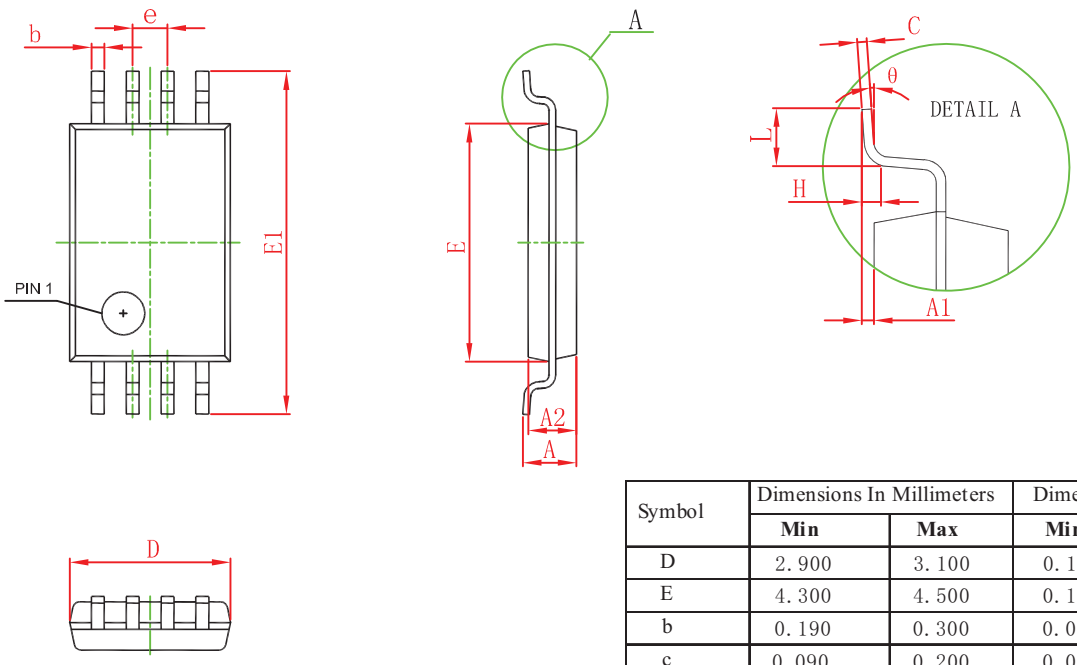
MSOP8 Suggested Pad Layout



Mechanical Information

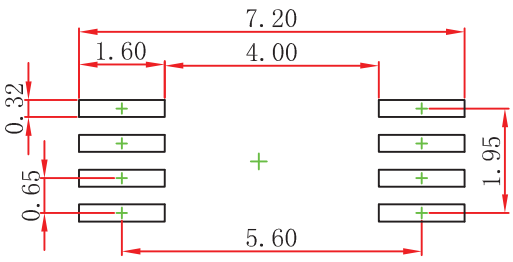
TSSOP8 Mechanical Information

Outline Dimensions



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	**Max**	**Min**	**Max**
D	2.900	3.100	0.114	0.122
E	4.300	4.500	0.169	0.177
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
E1	6.250	6.550	0.246	0.258
A		1.200		0.047
A2	0.800	1.000	0.031	0.039
A1	0.050	0.150	0.002	0.006
e	0.65 (BSC)		0.026(BSC)	
L	0.500	0.700	0.020	0.028
H	0.25(TYP		0.01(TYP	
θ	1°	7°	1°	7°

TSSOP8 Suggest Pad Layout

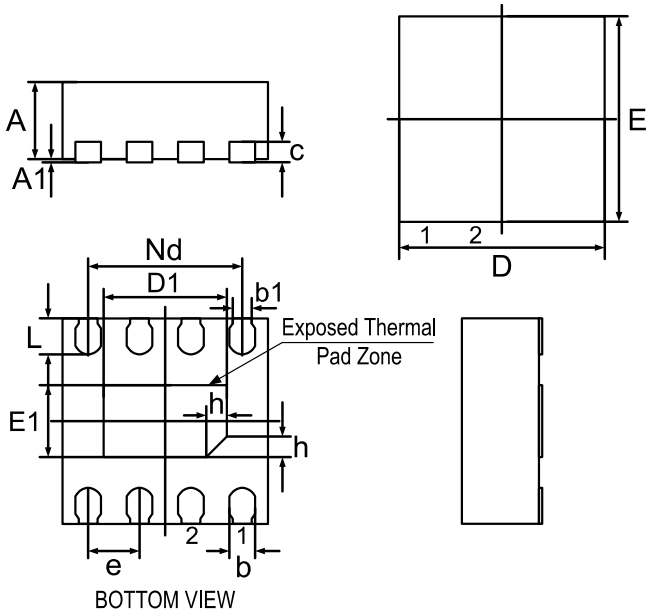


Note:
1.Controlling dimension:in millimeters.
2.General tolerance:± 0.05mm.
3.The pad layout is for reference purposes only.

Mechanical Information

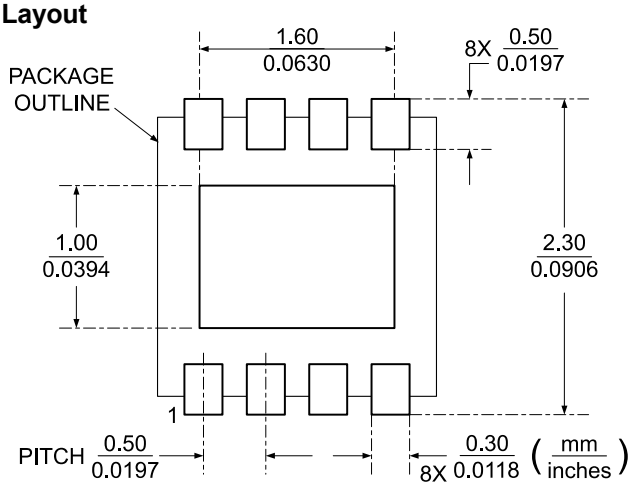
DFNWB2X2-8L Mechanical Information

DFNWB2X2-8L Outline Dimensions



Symbol	Dimensions In Millimeters		
	Min.	Nom.	Max.
A	0.70	0.75	0.80
A1	-	0.02	0.05
b	0.20	0.25	0.30
b1		0.18 REF	
c	0.18	0.20	0.25
D	1.90	2.00	2.10
D1	1.10	1.20	1.30
Nd		1.50 BSC	
E	1.90	2.00	2.10
E1	0.60	0.70	0.80
e		0.50 BSC	
L	0.30	0.35	0.40
h	0.15	0.20	0.25

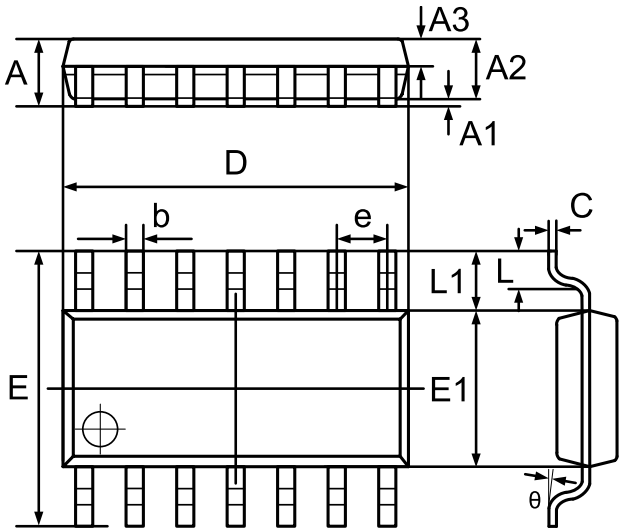
DFNW2X2-8L Suggested Pad Layout



Mechanical Information

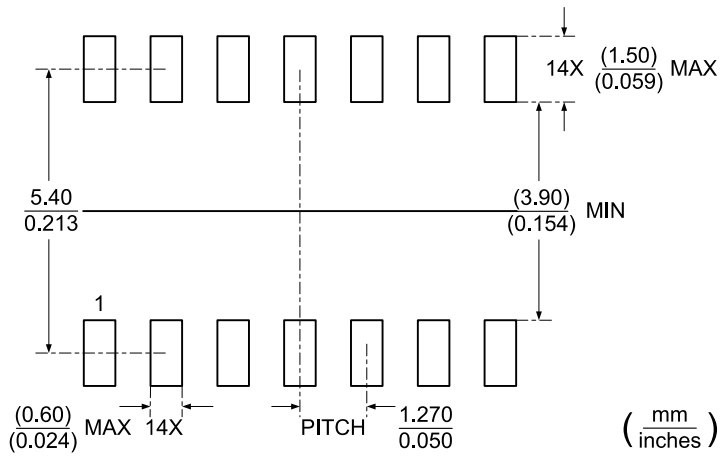
SOP14 Mechanical Information

SOP14 Outline Dimensions



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.450	1.850	0.057	0.073
A1	0.100	0.300	0.004	0.012
A2	1.350	1.550	0.053	0.061
A3	0.550	0.750	0.022	0.030
b	0.406 TYP.		0.016 TYP.	
C	0.203 TYP.		0.008 TYP.	
D	8.630	8.830	0.340	0.348
E	5.840	6.240	0.230	0.246
E1	3.850	4.050	0.152	0.159
e	1.270 TYP.		0.050 TYP.	
L1	1.040 REF.		0.041 REF.	
L	0.350	0.750	0.014	0.030
θ	2°	8°	2°	8°

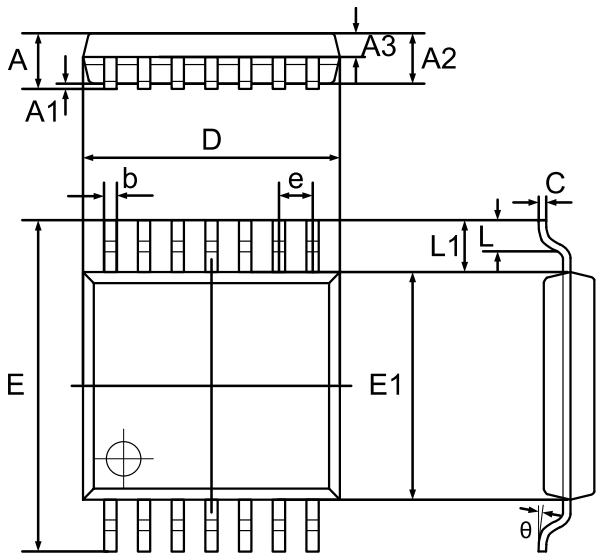
SOP14 Suggested Pad Layout



Mechanical Information

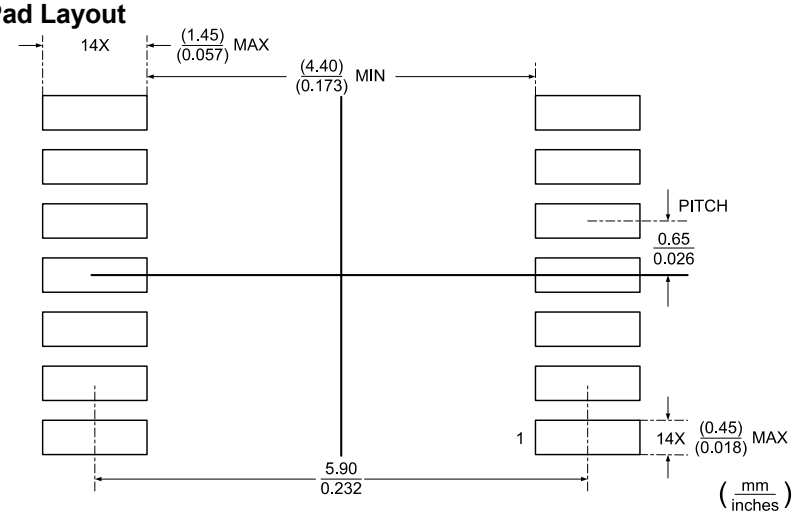
TSSOP14 Mechanical Information

TSSOP14 Outline Dimensions



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	-	1.200	-	0.047
A1	0.050	0.150	0.002	0.006
A2	0.900	1.050	0.035	0.041
A3	0.390	0.490	0.015	0.019
b	0.200	0.290	0.008	0.011
C	0.130	0.180	0.005	0.007
D	4.860	5.060	0.191	0.199
E	6.200	6.600	0.244	0.260
E1	4.300	4.500	0.169	0.177
e	0.650 TYP.		0.026 TYP.	
L1	1.000 REF		0.039 REF	
L	0.450	0.750	0.018	0.030
θ	0°	8°	0°	8°

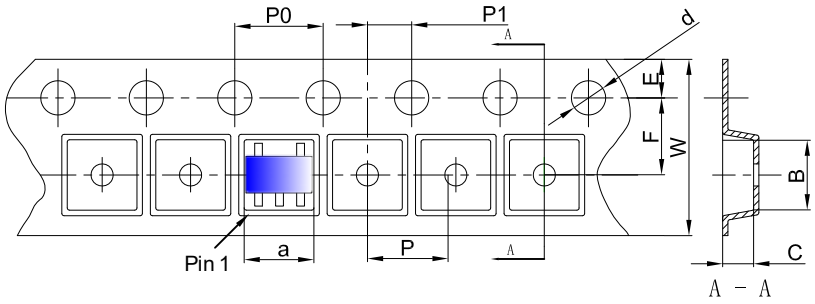
TSSOP14 Suggested Pad Layout



Packaging Information

SOT-23-5L Tape and Reel Information

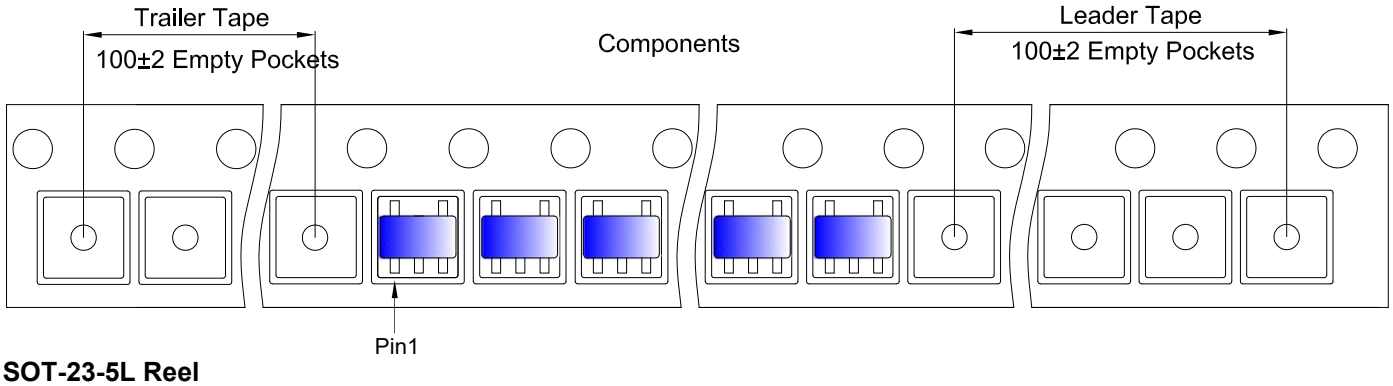
SOT-23-5L Embossed Carrier Tape



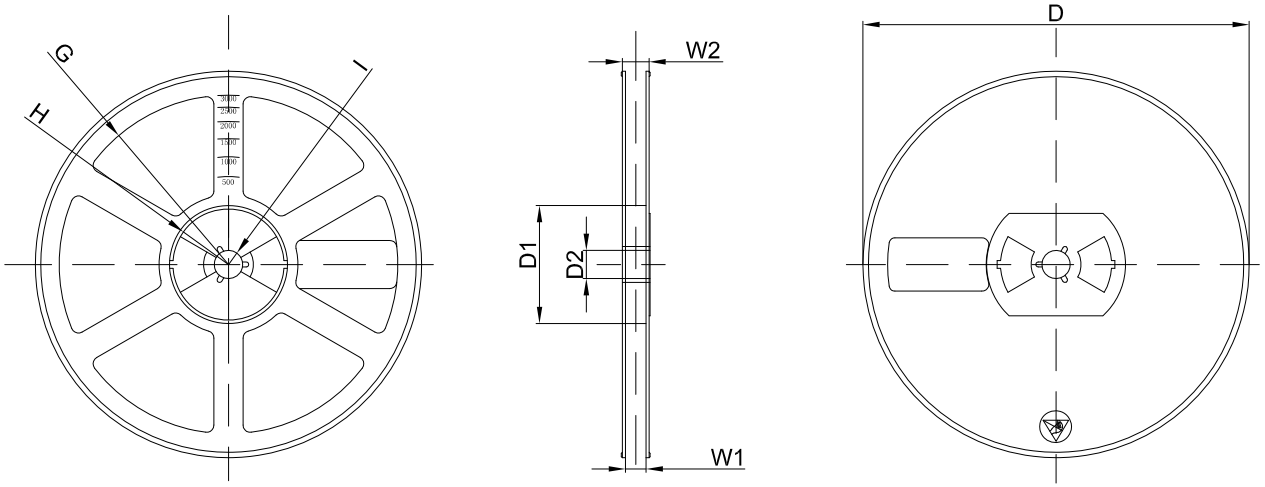
Packaging Description:
SOT-23-5L parts are shipped in tape. The carrier tape is made from a dissipative (carbon filled) polycarbonate resin. The cover tape is a multilayer film (Heat Activated Adhesive in nature) primarily composed of polyester film, adhesive layer, sealant, and anti-static sprayed agent. These reeled parts in standard option are shipped with 3,000 units per 7″ or 18.0cm diameter reel. These reels are clear in color and is made of polystyrene plastic (anti-static coated).

Dimensions are in millimeter										
Pkg type	a	B	C	d	E	F	P0	P	P1	W
SOT-23-5L	3.17	3.23	1.37	Φ1.55	1.75	3.50	4.00	4.00	2.00	8.00

SOT-23-5L Tape Leader and Trailer



SOT-23-5L Reel



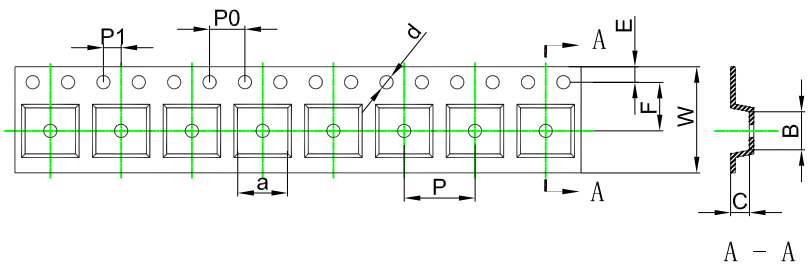
Dimensions are in millimeter								
Reel Option	D	D1	D2	G	H	I	W1	W2
7″Dia	Φ180.00	60.00	13.00	R78.00	R25.60	R6.50	9.50	13.10

REEL	Reel Size	Box	Box size (mm)	Carton	Carton size (mm)	G.W.(kg)
3,000 pcs	7 inch	30,000 pcs	203×203×195	120,000 pcs	438×438×220	

Packaging Information

SOP8 Tape and Reel Information

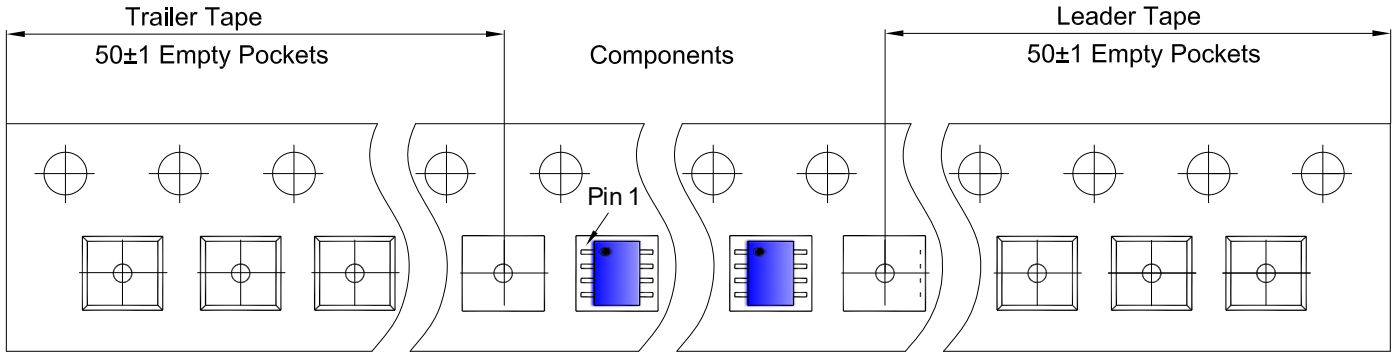
SOP8 Embossed Carrier Tape



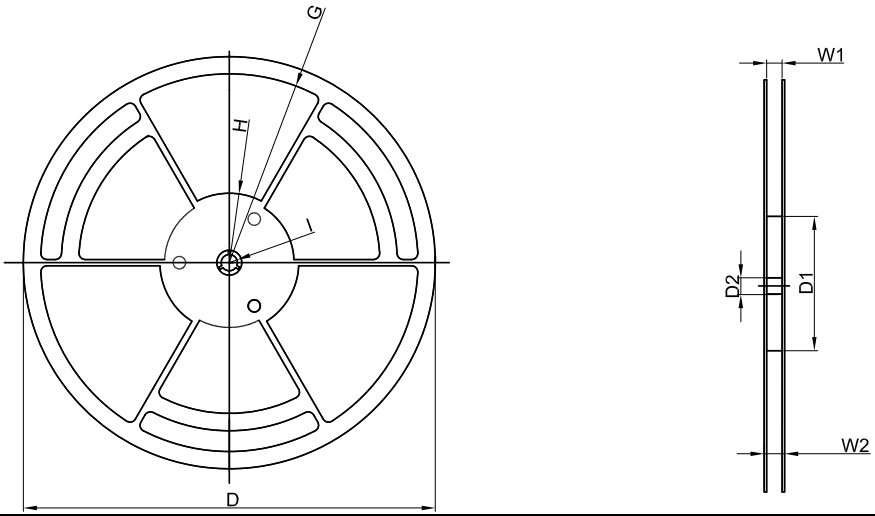
Packaging Description:
SOP8 parts are shipped in tape. The carrier tape is made from a dissipative (carbon filled) polycarbonate resin. The cover tape is a multilayer film (Heat Activated Adhesive in nature) primarily composed of polyester film, adhesive layer, sealant, and anti-static sprayed agent. These reeled parts in standard option are shipped with 2,500 units per 13″ or 33cm diameter reel. These reels are clear in color and is made of polystyrene plastic (anti-static coated).

Dimensions are in millimeter										
Pkg type	a	B	C	d	E	F	P0	P	P1	W
SOP8	6.40	5.40	2.10	Φ1.50	1.75	5.50	4.00	8.00	2.00	12.00

SOP8 Tape Leader and Trailer



SOP8 Reel



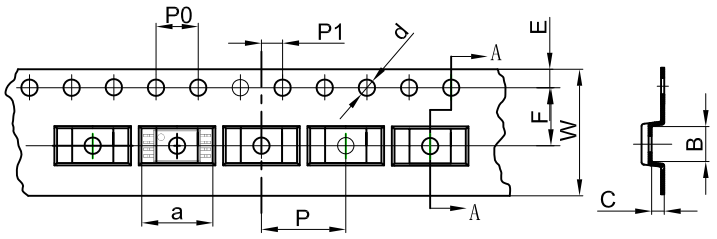
Dimensions are in millimeter								
Reel Option	D	D1	D2	G	H	I	W1	W2
13″Dia	Φ330.00	100.00	13.00	R151.00	R56.00	R6.50	12.40	17.60

REEL	Reel Size	Box	Box size (mm)	Carton	Carton size (mm)	G.W.(kg)
4,000 pcs	13 inch	8,000 pcs	360×360×65	64,000 pcs	565×380×390	

Packaging Information

TSSOP8 Tape and Reel Information

Embossed Carrier Tape



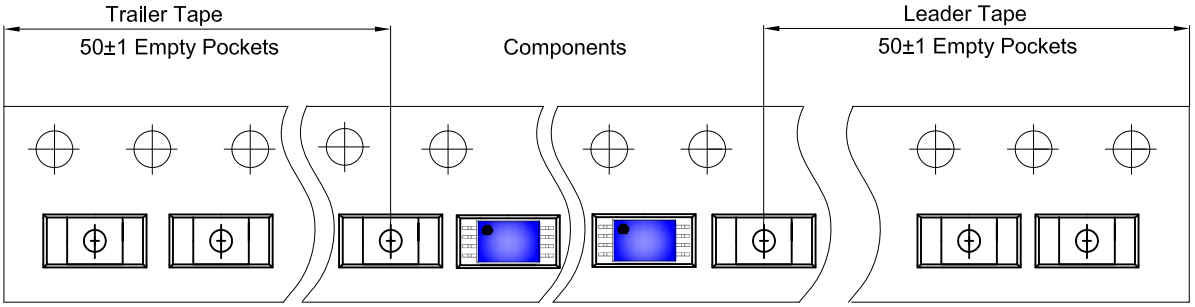
Packaging Description:

TSSOP8 parts are shipped in tape. The carrier tape is made from a dissipative (carbon filled) polycarbonate resin. The cover tape is a multilayer film (Heat Activated Adhesive in nature) primarily composed of polyester film, adhesive layer, sealant, and anti-static sprayed agent. These reeled parts in standard option are shipped with 3,000 units per 13" or 33cm diameter reel. The reels are clear in color and is made of polystyrene plastic (anti-static coated).

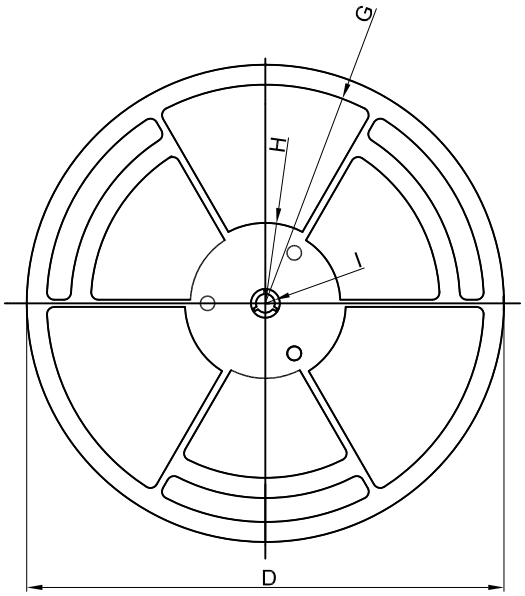
ALL DIM IN mm

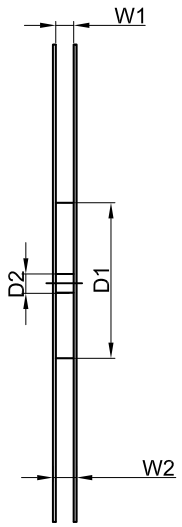
Dimensions are in millimeter										
Pkg type	a	B	C	d	E	F	P0	P	P1	W
TSSOP8	6.76	3.30	1.20	Ø1.50	1.75	5.50	4.00	8.00	2.00	12.00

Tape Leader and Trailer



Reel





Dimensions are in millimeter								
Reel Option	D	D1	D2	G	H	I	W1	W2
13"Dia	Ø330.00	100.00	13.00	R151.00	R56.00	R6.50	12.40	17.60

REEL	Reel Size	Box	Box Size(mm)	Carton	Carton Size(mm)	G.W.(kg)
3,000 pcs	13 inch	3,000 pcs	336×336×48	24,000 pcs	445×355×365	

DISCLAIMER

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