

1MHz, Rail-to-Rail I/O CMOS Operational Amplifiers

FEATURES

- Rail-to-Rail Input/Output
- High Slew Rate: 1V/μs
- Low Input Bias Current: 1pA at 25°C(TYP)
- Gain Bandwidth Product: 1MHz
- Low Offset Voltage Drift: 3μV/°C (TYP)
- Low Power Consumption: 90μA at 5V (Per Amplifier)
- Low Supply Voltage: 2.5V to 5.5V
- Extended Temperature: -40°C to +125°C

APPLICATIONS

- Battery-Powered Applications
- Portable Devices
- Signal Conditioning
- Active Filtering
- Current Sensor Amplifier
- Weight Scale Sensor
- Medical/Industrial Instrumentation
- Instrumentation

PRODUCT DESCRIPTION

TSV321/TSV358/TSV324 are the most cost-effective amplifiers for low voltage, low power consumption and low-cost applications. The rail-to-rail output and rail-to-rail inputs that exceed power supply range make the TSV321 series easy to use for very low voltage supply applications.

Low I_B feature of these amplifiers allows the parts to be ideal for many sensor applications. 1MHz GBW and 1V/μs slew rate under low power supply voltage can meet almost all sensor requirement.

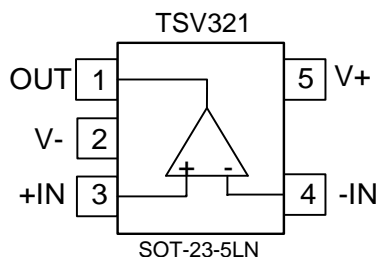
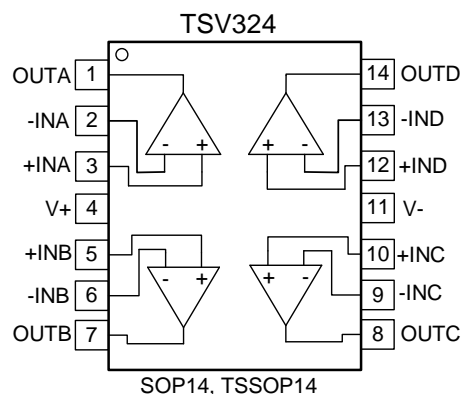
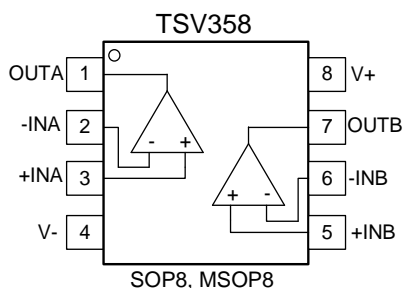
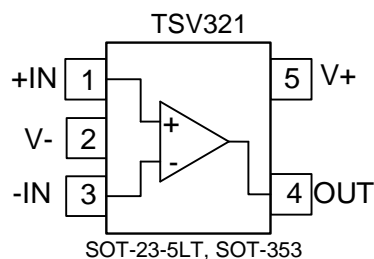
Small Packages:

TSV321 in a SOT-23-5L and SOT-353

TSV358 in a SOP8 and MSOP8

TSV324 in a SOP14 and TSSOP14

PIN ASSIGNMENTS



ORDERING INFORMATION

Model	Part Number	Eco Plan	Package	AMP	Container, Pack Qty
TSV321	TSV321SOT235LTR	RoHS	SOT-23-5LT	1	Reel, 3000
TSV321	TSV321SOT353R	RoHS	SOT-353 ⁽¹⁾	1	Reel, 3000
TSV321	TSV321SOT235LNR	RoHS	SOT-23-5LN	1	Reel, 3000
TSV358	TSV358SOP8R	RoHS	SOP8	2	Reel, 2500
TSV358	TSV358MSOP8R	RoHS	MSOP8	2	Reel, 3000
TSV324	TSV324SOP14R	RoHS	SOP14	4	Reel, 2500
TSV324	TSV324TSSOP14R	RoHS	TSSOP14	4	Reel, 3000

(1) SC70-5 renamed to SOT-353.

ABSOLUTE MAXIMUM RATINGS

Over operating free-air temperature range (unless otherwise noted) ⁽¹⁾

Parameter	Min	Max	Unit
Supply Voltage		7.0	V
Signal Input Terminal Voltage	(V-) - 0.5	(V+) + 0.5	V
Operating Temperature	-40	150	°C
Junction Temperature		150	°C
Storage Temperature	-65	150	°C
Lead Temperature (Soldering, 10s)		260	°C
ESD HBM		±3000	V
ESD MM		±400	V
ESC CDM		±1000	V

(1) Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ESD CAUTION



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

ELECTRICAL CHARACTERISTICS

Boldface limits apply over the specified temperature range, $V_S = +2.5V$ to $+5.5V$, $T_A = -40^\circ C$ to $+125^\circ C$.

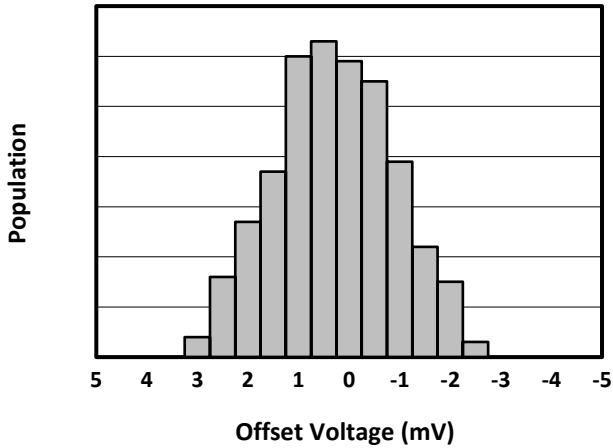
At $T_A = +25^\circ C$, $R_L = 100k\Omega$ connected to $V_S / 2$, and $V_{OUT} = V_S / 2$ (unless otherwise noted)

Parameter	Operating Conditions		Min	Typ	Max	Unit
V_S Specified Voltage Range			2.5		5.5	V
I_S Supply Current	$I_o = 0, V_S = 5V$			90	132	μA
PSRR Power Supply Rejection Ratio	$V_S = 2.5V$ to $5.5V, V_{CM} < (V+) - 2V$ $T_A = -40^\circ C$ to $+125^\circ C$		75 68	90		dB dB
Input Characteristics						
V_{OS} Input Offset Voltage	$V_S = 5V$			1	3.5	mV
dV_{OS}/dT Drift				3		$\mu V/^\circ C$
I_B Input Bias Current				1		pA
I_{OS} Input Offset Current				1		pA
CMRR Common Mode Rejection Ratio	$V_S = 5.5V$	$(V-) - 0.2V < V_{CM} < (V+) - 2V$ $T_A = -40^\circ C$ to $+125^\circ C$	73 65	87		dB dB
		$(V-) - 0.2V < V_{CM} < (V+) + 0.2V$ $T_A = -40^\circ C$ to $+125^\circ C$	60 56	72		dB dB
A_{OL} Open-Loop Gain	$V_S = 5V$	$R_L = 5k\Omega, 0.125V < V_O < 4.875V$ $T_A = -40^\circ C$ to $+125^\circ C$	96 70	102		dB dB
		$R_L = 100k\Omega, 0.025V < V_O < 4.975V$ $T_A = -40^\circ C$ to $+125^\circ C$	101 76	110		dB dB
Output Characteristics						
V_{OUT} Output Voltage Swing from Rail	$R_L = 100k\Omega$			10		mV
R_{OUT} Open-Loop Output Impedance	$f = 1MHz, I_o = 0$			280		Ω
Dynamic Performance						
GBW Gain Bandwidth Product				1		MHz
SR Slew Rate	$G = +1$			1		V/ μs
t_s Settling Time to 0.1% Overload Recovery Time	$V_{OUT} = 2V$ step, $G = +1$ $V_{in} * Gain > V_S$			3		μs
				1		μs
THD+N Total Harmonic Distortion+ Noise	$V_S = 5V, V_o = 3V_{pp}, G = +1, f = 1kHz$			TBD		%
Noise Performance						
e_n Input Voltage Noise Density	$f = 10kHz$			40		nV/ \sqrt{Hz}
V_{NOISE} Input Voltage Noise	$f = 0.1Hz$ to $10Hz$			6.5		μV_{pp}
Temperature Range						
θ_{JA}	Specified Range		-40		125	$^\circ C$
	Thermal Resistance SOP8, SOT-353			150		$^\circ C/W$
	SOT-23-5L, MSOP8			200		$^\circ C/W$
	TSSOP14, SOP14			100		$^\circ C/W$

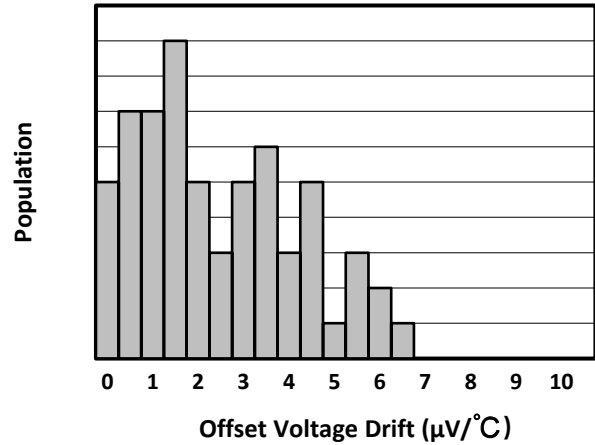
TYPICAL CHARACTERISTICS

At $T_A = +25^\circ\text{C}$, $R_L = 10\text{k}\Omega$ connected to $V_S / 2$, and $V_{OUT} = V_S / 2$ (unless otherwise noted)

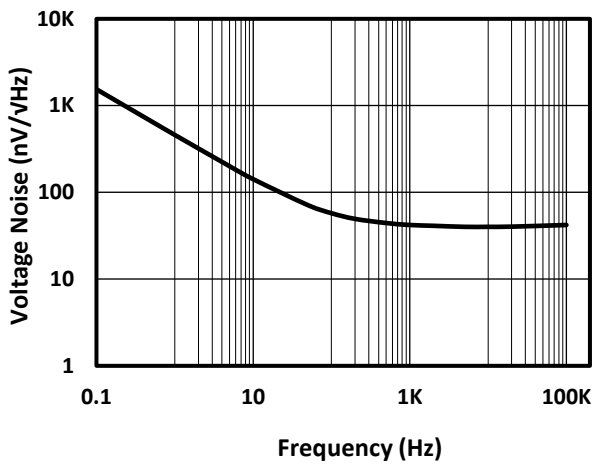
Offset Voltage Production Distribution



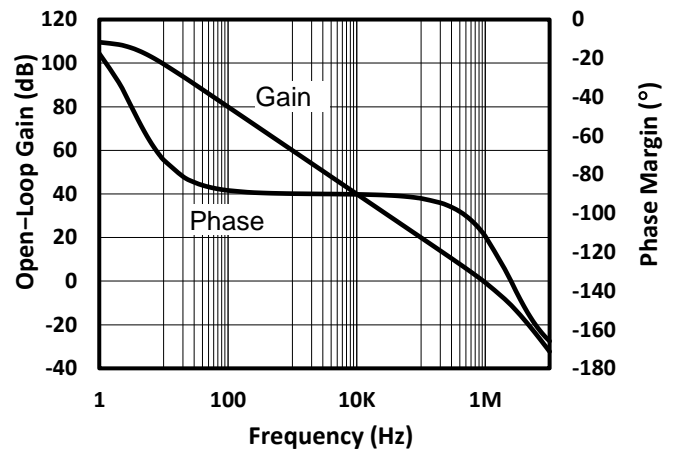
Offset Voltage Drift Magnitude Production Distribution



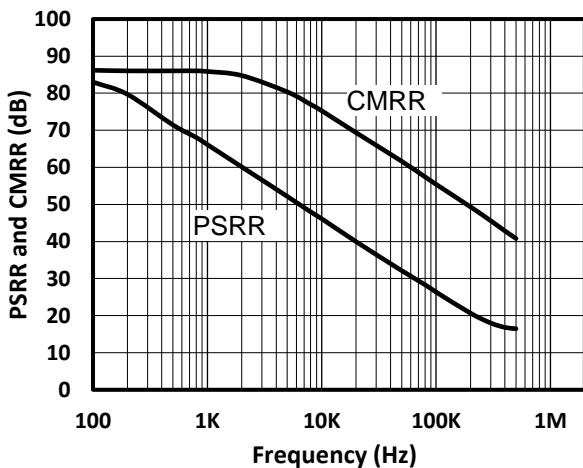
Input Voltage Noise Spectral Density vs Frequency



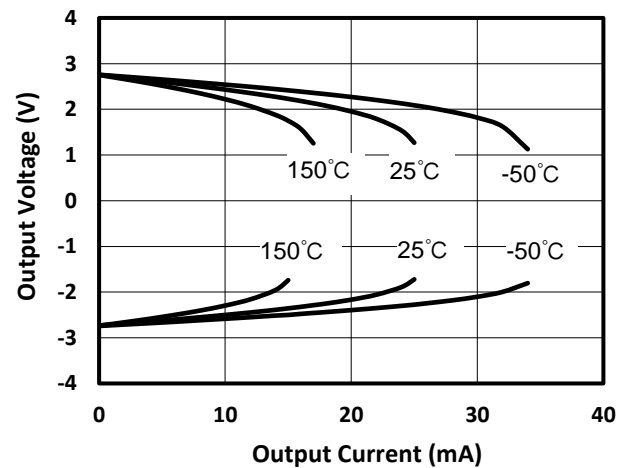
Open-Loop Gain and Phase vs Frequency



Power-Supply and Common-Mode Rejection Ratio vs Frequency



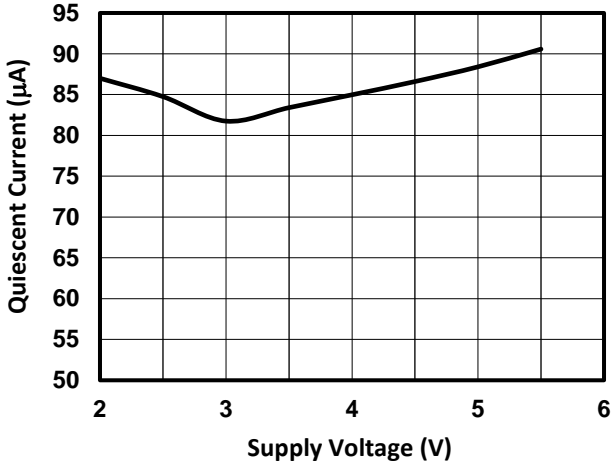
Output Voltage Swing vs Output Current



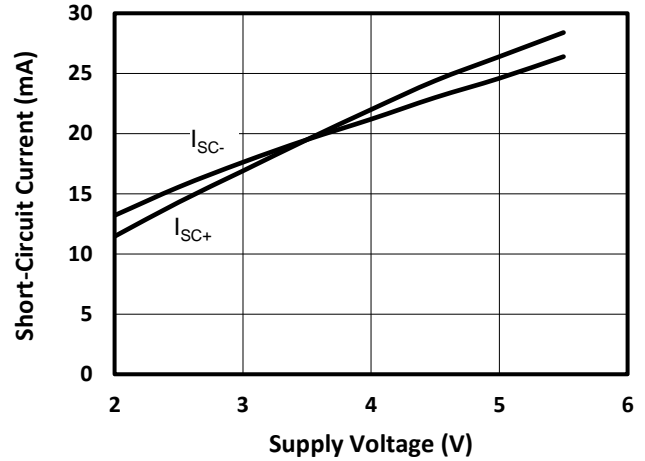
TYPICAL CHARACTERISTICS

At $T_A = +25^\circ\text{C}$, $R_L = 10\text{k}\Omega$ connected to $V_S / 2$, and $V_{OUT} = V_S / 2$ (unless otherwise noted)

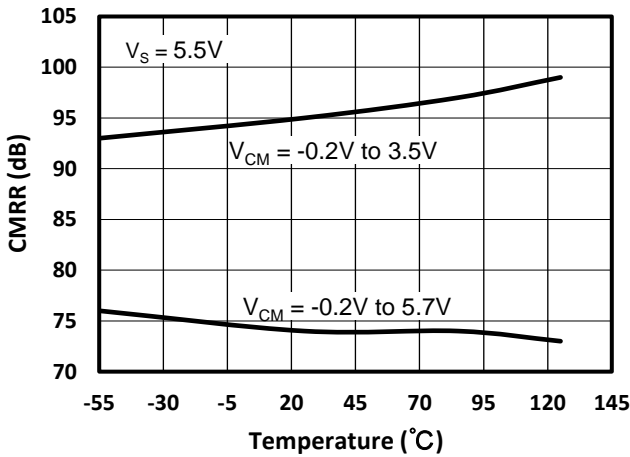
Quiescent Current vs Supply Voltage



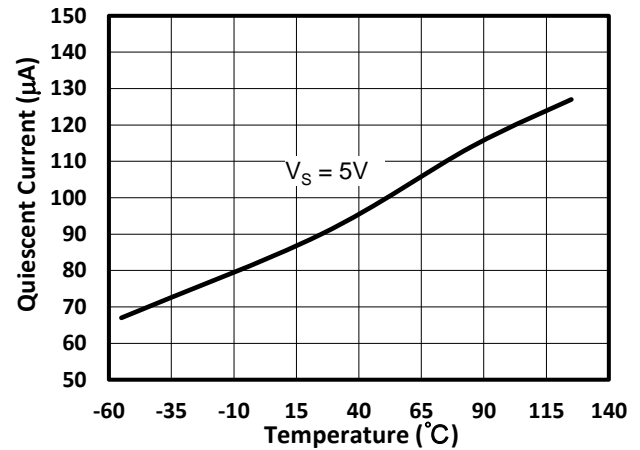
Continuous Short-Circuit Current vs Power-Supply Voltage



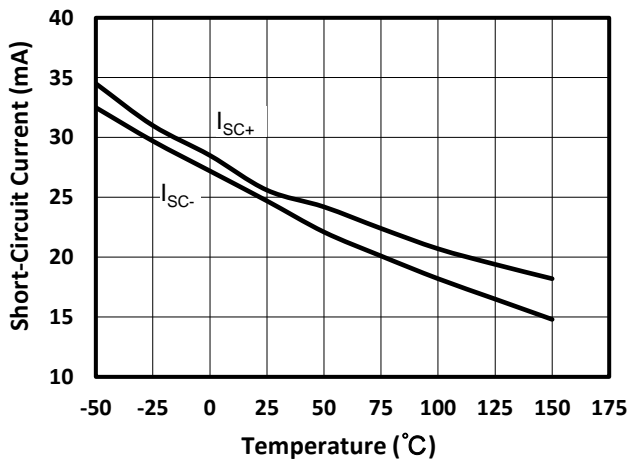
Common-Mode Rejection Ratio vs Temperature



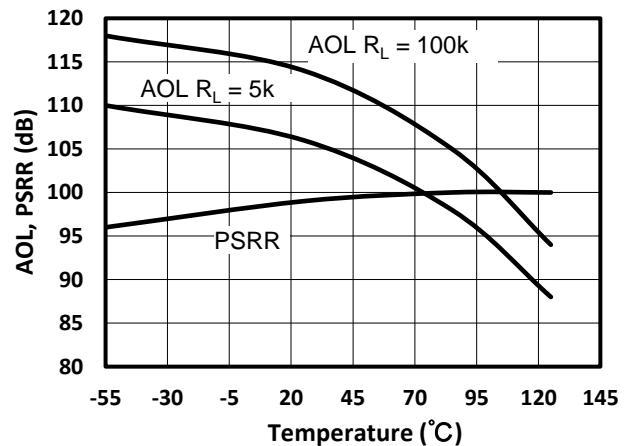
Quiescent Current vs Temperature



Short-Circuit Current vs Temperature



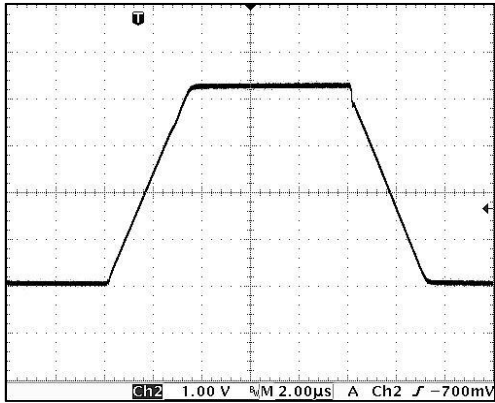
Open-Loop Gain and Power-Supply Rejection Ratio vs Temperature



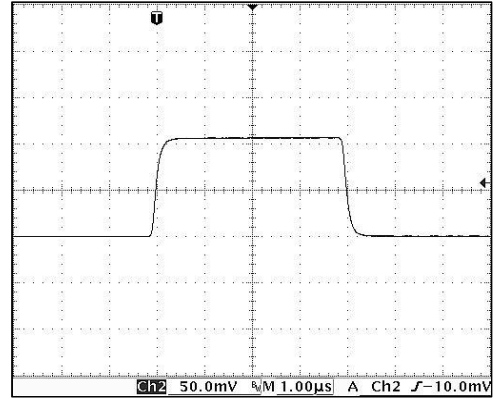
TYPICAL CHARACTERISTICS

At $T_A = +25^\circ\text{C}$, $R_L = 10\text{k}\Omega$ connected to $V_S / 2$, and $V_{OUT} = V_S / 2$ (unless otherwise noted)

Large-Signal Step Response

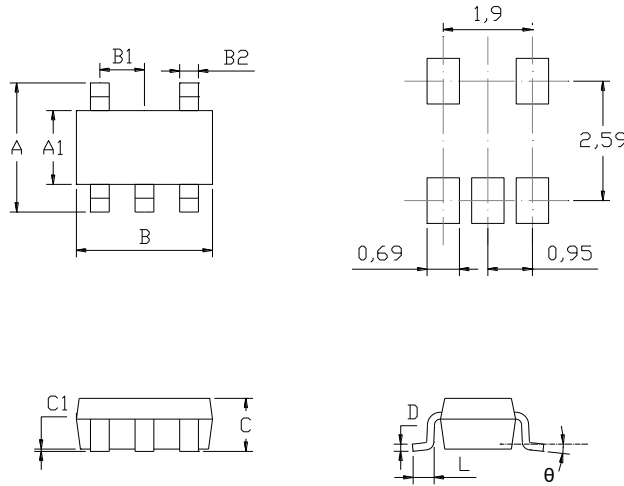


Small-Signal Step Response



MECHANICAL DIMENSIONS

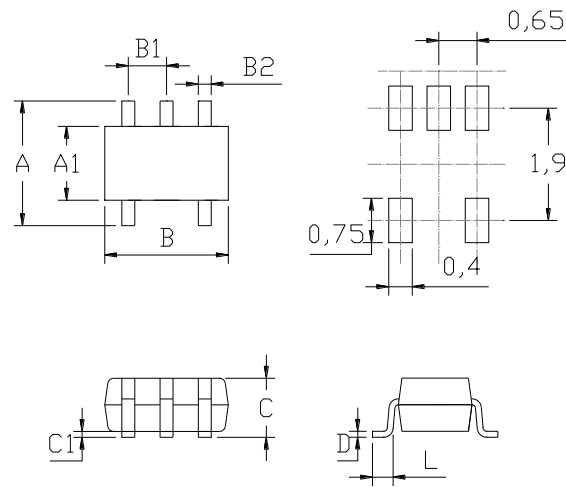
SOT-23-5LT(N) PACKAGE MECHANICAL DRAWING



SOT-23-5LT(N) PACKAGE MECHANICAL SPECIFICATIONS

symbol	dimensions			
	millimeters		inches	
	min	max	min	max
A	2.650	2.950	0.104	0.116
A1	1.500	1.700	0.059	0.067
B	2.820	3.020	0.111	0.119
B1	0.95		0.037	
B2	0.300	0.500	0.012	0.020
C		1.250		0.049
C1	0	0.100	0	0.004
L	0.300	0.600	0.012	0.024
D	0.100	0.200	0.004	0.008
θ	0°	8°	0°	8°

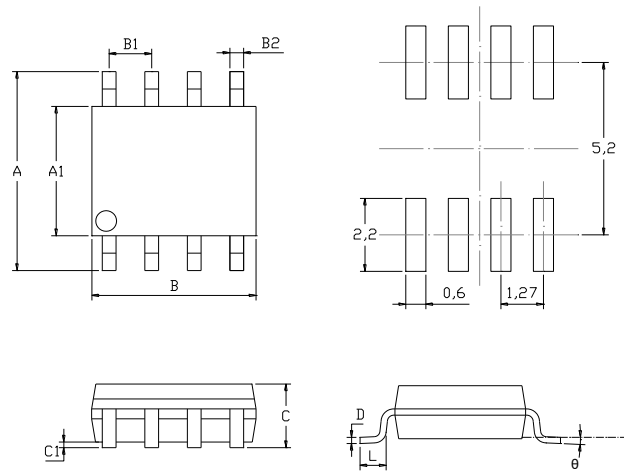
SOT-353 PACKAGE MECHANICAL DRAWING



SOT-353 PACKAGE MECHANICAL SPECIFICATIONS

symbol	dimensions			
	millimeters		inches	
	min	max	min	max
A	2.150	2.450	0.085	0.096
A1	1.150	1.350	0.045	0.053
B	2.000	2.200	0.079	0.087
B1	0.650		0.026	
B2	0.150	0.350	0.006	0.014
C	0.900	1.000	0.035	0.039
C1	0	0.100	0	0.004
L	0.260	0.460	0.010	0.018
D	0.080	0.150	0.003	0.006
θ	0°	8°	0°	8°

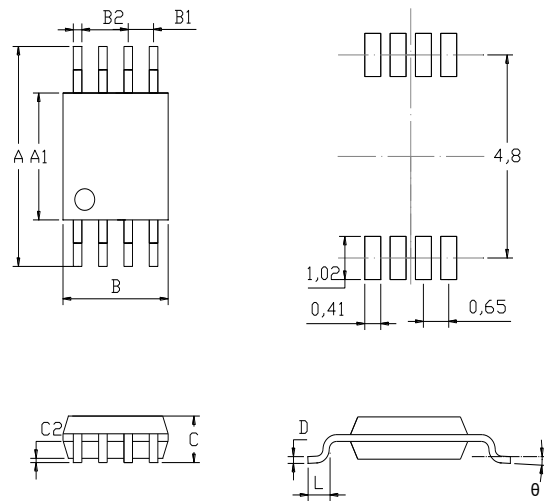
SOP8 PACKAGE MECHANICAL DRAWING



SOP8 PACKAGE MECHANICAL SPECIFICATIONS

symbol	dimensions			
	millimeters		inches	
	min	max	min	max
A	5.800	6.200	0.228	0.244
A1	3.800	4.000	0.150	0.157
B	4.700	5.100	0.185	0.201
B1	1.270		0.050	
B2	0.330	0.510	0.013	0.020
C		1.750		0.069
C1	0.100	0.250	0.004	0.010
L	0.400	1.270	0.016	0.050
D	0.170	0.250	0.007	0.010
θ	0°	8°	0°	8°

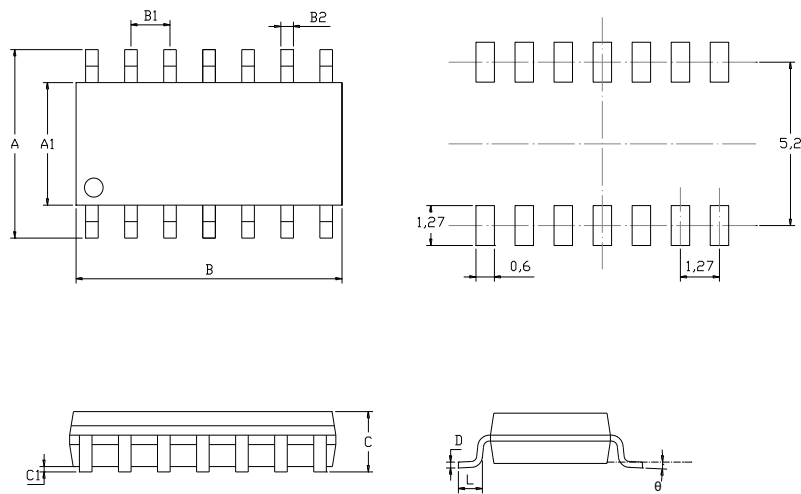
MSOP8 PACKAGE MECHANICAL DRAWING



MSOP8 PACKAGE MECHANICAL SPECIFICATIONS

symbol	dimensions			
	millimeters		inches	
	min	max	min	max
A	4.750	5.050	0.187	0.199
A1	2.900	3.100	0.114	0.122
B	2.900	3.100	0.114	0.122
B1	0.650		0.026	
B2	0.250	0.380	0.010	0.015
C	0.820	1.100	0.032	0.043
C2	0.020	0.150	0.001	0.006
L	0.400	0.800	0.016	0.031
D	0.090	0.230	0.004	0.009
θ	0°	6°	0°	6°

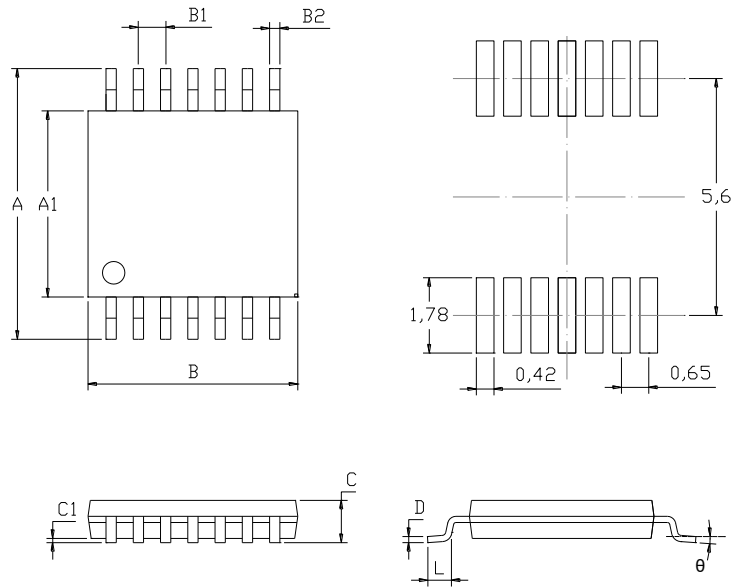
SOP14 PACKAGE MECHANICAL DRAWING



SOP14 PACKAGE MECHANICAL SPECIFICATIONS

symbol	dimensions			
	millimeters		inches	
	min	max	min	max
A	5.800	6.200	0.228	0.244
A1	3.800	4.000	0.150	0.157
B	8.450	8.850	0.333	0.348
B1	1.270		0.050	
B2	0.310	0.510	0.012	0.020
C		1.750		0.069
C1	0.100	0.250	0.004	0.010
L	0.400	1.270	0.016	0.050
D	0.100	0.250	0.004	0.010
theta	0°	8°	0°	8°

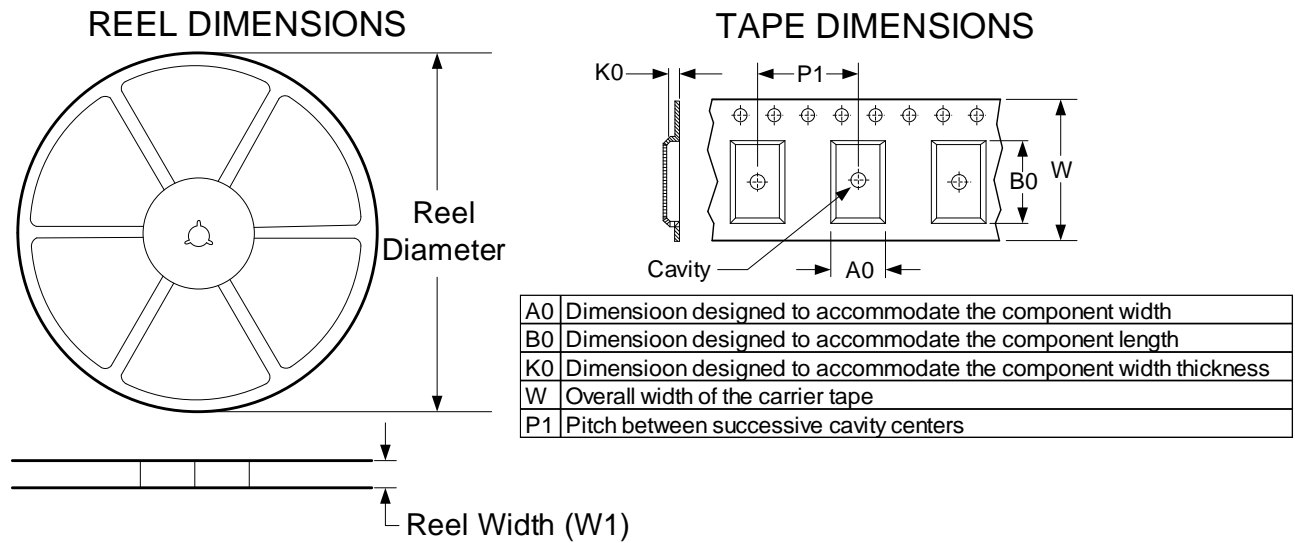
TSSOP14 PACKAGE MECHANICAL DRAWING



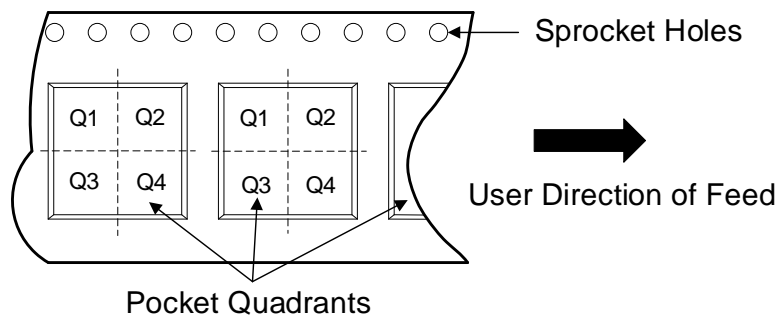
TSSOP14 PACKAGE MECHANICAL SPECIFICATIONS

symbol	dimensions			
	millimeters		inches	
	min	max	min	max
A	6.250	6.550	0.246	0.258
A1	4.300	4.500	0.169	0.177
B	4.900	5.100	0.193	0.201
B1	0.650		0.026	
B2	0.190	0.300	0.007	0.012
C		1.200		0.047
C1	0.050	0.150	0.002	0.006
L	0.500	0.700	0.020	0.028
D	0.090	0.200	0.004	0.008
θ	1°	7°	1°	7°

TAPE AND REEL INFORMATION



QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



Device	Package Type	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TSV321SOT235LTR	SOT-23-5LT	5	3000	180.0	9.0	3.2	3.3	1.4	4.0	8.0	Q3
TSV321SOT353R	SOT-353	5	3000	180.0	9.0	3.2	3.3	1.4	4.0	8.0	Q3
TSV321SOT235LNR	SOT-23-5LN	5	3000	180.0	9.0	3.2	3.3	1.4	4.0	8.0	Q3
TSV358SOP8R	SOP8	8	2500	330.0	12.4	6.4	5.4	2.1	8.0	12.0	Q1
TSV358MSOP8R	MSOP8	8	3000	330.0	12.4	5.2	3.3	1.5	8.0	12.0	Q1
TSV324SOP14R	SOP14	14	2500	330.0	12.4	6.5	9.0	2.1	8.0	16.0	Q1
TSV324TSSOP14R	TSSOP14	14	3000	330.0	12.4	6.8	5.4	1.2	8.0	12.0	Q1

REVISION HISTORY

NOTE: Page numbers for previous revisions may be different from that of the current version.

2020/7/16 — REV KY1.0.2B to REV KY1.0.3B

Added notice to ABSOLUTE MAXIMUM RATINGS.....	2
Updated the format of ELECTRICAL CHARACTERISTICS	3
Updated MECHANICAL DIMENSIONS	7

2020/8/24 — REV KY1.0.3B to REV KY1.0.4B

Updated the package of TSV321.....	1
Changed SC70-5 to SOT-353	2

2020/12/2 — REV KY1.0.4B to REV KY1.1.4B

Updated TYPICAL CHARACTERISTICS.....	4
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2021/07/21 — REV KY1.1.4B to REV KY1.2.4B

Updated TSSOP14 SPQ.....	2,13
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CONTACT INFORMATION

Trusignal Microelectronics

Phone: +86 512-65923982

Fax: +86 512-65923995

Email: support@kunyuanic.com; support@kunyuanic.com;