

### Features

- Supply Voltage: 3V to 36V
- Low Supply Current: 100µA per channel
- Input Common-Mode Voltage Range Includes Ground
- Can Work as Comparator
- Rail to Rail Output
- Bandwidth: 0.9 MHz
- Slew Rate: 0.5V/µs
- Excellent EMI Suppress Performance: 71dB at 1GHz
- Offset Voltage: ±3mV Maximum
- Offset Voltage Temperature Drift: 7 µV/°C
- -40°C to 125°C Operation Temperature Range

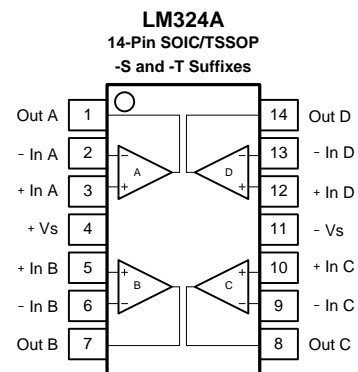
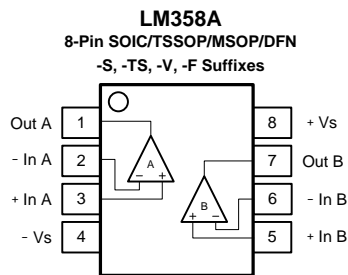
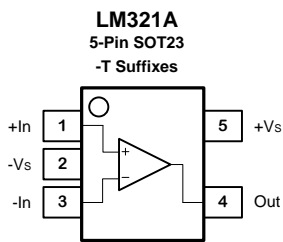
### Applications

- Power Module
- Sensor Interface
- Motor Control
- Audio

### Description

The LM321A/358A/324A series amplifiers are newest high supply voltage amplifiers with low offset, low power and stable frequency response. They incorporate 3PEAK’s proprietary and patented design techniques to achieve very good AC performance with 0.9MHz bandwidth, 0.5V/µs slew rate and maximum 3mV offset while drawing only 100µA of quiescent current per amplifier. The input common-mode voltage range extends to V<sub>-</sub>, and the outputs swing rail-to-rail. The LM321A/358A/324A family can be used as plug-in replacements for many commercially available op-amps to reduce power and improve input/output range and performance. The combination of features makes the LM321A/358A/324A ideal choices for power module, industrial control, motor control and audio application.

### Pin Configuration



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## Revision History

Date	Revision	Notes
2018/3/21	Rev.Pre	Pre-Release Version
2018/11/1	Rev.0	Initial Version
2018/12/25	Rev.0.01	Update date code information of LM358A-F1R: "AAYW" -> "YW"
2019/1/14	Rev.0.02	Update Mark Information of LM358A-SR, LM358A-CSR:"LM358A"->"358A"; Update Package Information: Remove "SC70", Update Package Dimensions of SOIC-8
2019/6/26	Rev.0.03	Add temperature limit of VOL, VOH, Isc Update Package Dimension
2019/8/16	Rev.0.04	Update the description of VOL, VOH in Electrical Characteristics: Remove VOL, VOH, Maximum Output Swing -> Output Voltage Swing from Positive and Negative Rail; Output Voltage Swing Low-> Output Voltage Swing from Negative Rail
2019/12/25	Rev.0.05	Update the mark of LM358A-F1R: "58A"->"58"
2020/9/24	Rev.A	Update the description of Absolute Maximum Ratings: "Maximum Junction Temperature" -> "Maximum Operating Junction Temperature"
2020/12/11	Rev.A.1	Add Maximum Value of I <sub>B</sub> , I <sub>IN</sub> in Electrical Characteristics
2021/5/10	Rev.A.2	Update Spec: I <sub>q</sub> of LM321A
2022/4/29	Rev.A.3	Update EC table: Add max of I <sub>os</sub> , Add common voltage range in 25 degree.

## Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity
LM321A-TR	-40 to 125°C	5-Pin SOT23	21AXX <sup>Note 1</sup>	3	Tape and Reel, 3000
LM358A-SR	-40 to 125°C	8-Pin SOIC	358A XXXX <sup>Note 1</sup>	3	Tape and Reel, 4000
LM358A-CSR	-40 to 85°C	8-Pin SOIC	358A XXXX <sup>Note 1</sup>	3	Tape and Reel, 4000
LM358A-F1R	-40 to 125°C	8-Pin DFN 1.5*1.5	58 YW <sup>Note 1</sup>	1	Tape and Reel, 3000
LM358A-TSR	-40 to 125°C	8-Pin TSSOP	LM358A XXXX <sup>Note 1</sup>	3	Tape and Reel, 3000
LM358A-VR	-40 to 125°C	8-Pin MSOP	LM358A XXXX <sup>Note 1</sup>	3	Tape and Reel, 3000
LM324A-SR	-40 to 125°C	14-Pin SOIC	LM324A XXXX <sup>Note 1</sup>	3	Tape and Reel, 2500
LM324A-CSR	-40 to 85°C	14-Pin SOIC	LM324A XXXX <sup>Note 1</sup>	3	Tape and Reel, 2500
LM324A-TR	-40 to 125°C	14-Pin TSSOP	LM324A XXXX <sup>Note 1</sup>	3	Tape and Reel, 3000

Note 1: "XX" or "XXXX" identify the manufacture information.

## Absolute Maximum Ratings <sup>Note 1</sup>

Parameters	Rating
Supply Voltage, (+V <sub>S</sub> )– (-V <sub>S</sub> )	40 V
Input Voltage	(-V <sub>S</sub> ) – 0.3 to (+V <sub>S</sub> ) + 0.3
Differential Input Voltage	(+V <sub>S</sub> ) - (-V <sub>S</sub> )
Input Current: +I <sub>N</sub> , –I <sub>N</sub> <sup>Note 2</sup>	±10mA
Output Short-Circuit Duration <sup>Note 3</sup>	Infinite
Maximum Operating Junction Temperature	150°C
Operating Temperature Range	–40 to 125°C
Storage Temperature Range	–65 to 150°C
Lead Temperature (Soldering, 10 sec)	260°C

Note 1: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

Note 2: The inputs are protected by ESD protection diodes to each power supply. If the input extends more than 300mV beyond the power supply, the input current should be limited to less than 10mA.

Note 3: A heat sink may be required to keep the junction temperature below the absolute maximum. This depends on the power supply voltage and how many amplifiers are shorted. Thermal resistance varies with the amount of PC board metal connected to the package. The specified values are for short traces connected to the leads.

## ESD Rating

Symbol	Parameter	Condition	Minimum Level	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001	3	kV
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002	2	kV

## Thermal Information

Package Type	θ <sub>JA</sub>	θ <sub>JC</sub>	Unit
5-Pin SOT23	250	81	°C/W
8-Pin SOIC	158	43	°C/W
8-Pin TSSOP	191	44	°C/W
8-Pin MSOP	210	45	°C/W
8-Pin DFN 1.5*1.5	200		°C/W
14-Pin SOIC	120	36	°C/W
14-Pin TSSOP	180	35	°C/W

## Electrical Characteristics

All test condition is  $V_S = 30V$ ,  $T_A = 25^\circ C$ ,  $R_L = 10k\Omega$ ,  $C_L = 100pF$ , unless otherwise noted.

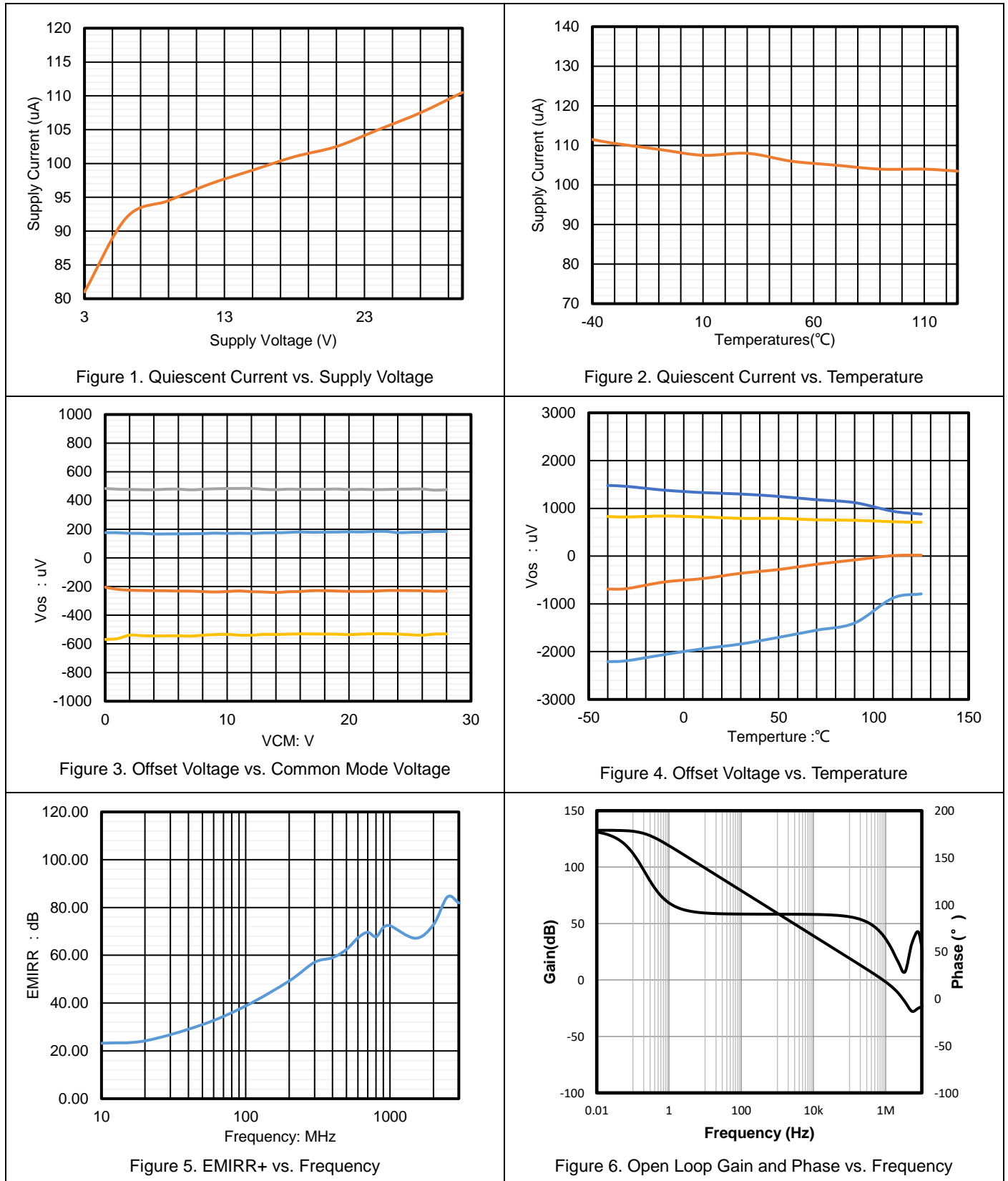
Symbol	Parameter	Conditions	$T_A$	Min	Typ	Max	Unit
<b>Power Supply</b>							
$V_S$	Supply Voltage Range			3		36	V
$I_Q$	Quiescent Current per Amplifier, LM321A	$V_S = 30V$			150	250	$\mu A$
			Operating Range			350	$\mu A$
$I_Q$	Quiescent Current per Amplifier, LM358A, LM324A	$V_S = 5V$			150	200	$\mu A$
			Operating Range			300	$\mu A$
$I_Q$	Quiescent Current per Amplifier, LM358A, LM324A	$V_S = 30V$			110	200	$\mu A$
			Operating Range			250	$\mu A$
PSRR	Power Supply Rejection Ratio	$V_S = 5V$ to $36V$		85	120		dB
			Operating Range	80			dB
<b>Input Characteristics</b>							
$V_{OS}$	Input Offset Voltage	$V_S = 30V$ , $V_{CM} = 0V$ to $28V$		-3	0.1	3	mV
			Operating Range	-7		7	mV
$V_{OS}$	Input Offset Voltage	$V_S = 5V$ , $V_{CM} = 0V$ to $3V$		-3	0.1	3	mV
			Operating Range	-7		7	mV
$V_{OS}$ TC	Input Offset Voltage Drift		Operating Range		7		$\mu V/^\circ C$
$I_B$	Input Bias Current				60	500	$\mu A$
			Operating Range			600	1000
$I_{OS}$	Input Offset Current <sup>Note 1</sup>				60	500	$\mu A$
			Operating Range			600	1000
$I_{IN}$	Different Input Current	$V_S = 36V$ , $V_{ID} = 36V$			5	150	nA
		$V_S = 36V$ , $V_{ID} = 36V$	Operating Range			20	1000
$C_{IN}$	Input Capacitance	Differential Mode			5		pF
		Common Mode			5		pF
$A_V$	Open-loop Voltage Gain			95	110		dB
			Operating Range	90			dB
$V_{CMR}$	Common-mode Input Voltage Range			(V-)		(V+) - 1.5	V
			Operating Range	(V-)		(V+) - 2	V
CMRR	Common Mode Rejection Ratio	$V_{CM} = 0V$ to $28V$		75	120		dB
			Operating Range	70	90		dB
<b>Output Characteristics</b>							
	Output Voltage Swing from Positive and Negative Rail	$R_{LOAD} = 10k\Omega$ to $V_S/2$			200	300	mV
			Operating Range			700	mV
		$R_{LOAD} = 2k\Omega$ to $V_S/2$			1.1	1.3	V

			Operating Range			2	V
	Output Voltage Swing from Negative Rail	$V_S = 5V, R_{LOAD} = 10k\Omega$ to 0V			5	10	mV
$I_{SC}$	Output Short-Circuit Current			25	30		mA
			Operating Range	15			mA
<b>AC Specifications</b>							
GBW	Gain-Bandwidth Product				0.9		MHz
SR	Slew Rate	$G = 1, 2V$ step			0.5		V/ $\mu s$
$t_s$	Settling Time, 0.1%	$G = 1, 2V$ step			4		$\mu s$
	Settling Time, 0.01%				5		$\mu s$
PM	Phase Margin	$V_S = 30V, R_L = 1K, C_L = 100pF$			60		°
GM	Gain Margin	$V_S = 30V, R_L = 1K, C_L = 100pF$			15		dB
	Channel Separation	$f = 1$ kHz to 20 kHz			120		dB
<b>Noise Performance</b>							
$E_N$	Input Voltage Noise	$f = 0.1Hz$ to 10Hz			3		$\mu V_{RMS}$
$e_N$	Input Voltage Noise Density	$f = 1kHz$			70		nV/ $\sqrt{Hz}$
$i_N$	Input Current Noise	$f = 1kHz$			3		fA/ $\sqrt{Hz}$
THD+N	Total Harmonic Distortion and Noise	$f = 1kHz, G = 1, R_L = 10k\Omega, V_{OUT} = 6V_{RMS}$			0.001		%

Note 1: Provided by bench test and design simulation

## Typical Performance Characteristics

$V_S = \pm 15V$ ,  $V_{CM} = 0V$ ,  $R_L = 10k\Omega$ , unless otherwise specified.



$V_s = \pm 15V$ ,  $V_{CM} = 0V$ ,  $R_L = 10k\Omega$ , unless otherwise specified.

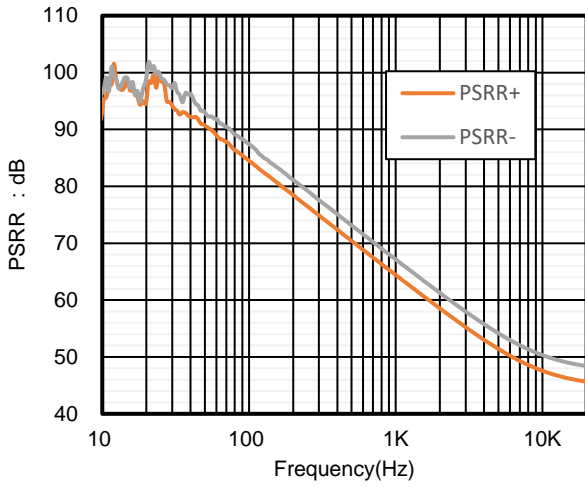


Figure 7. PSRR vs. Frequency

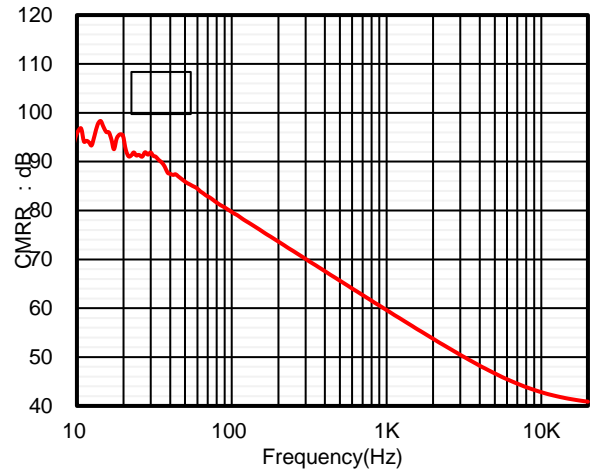


Figure 8. CMRR vs. Frequency

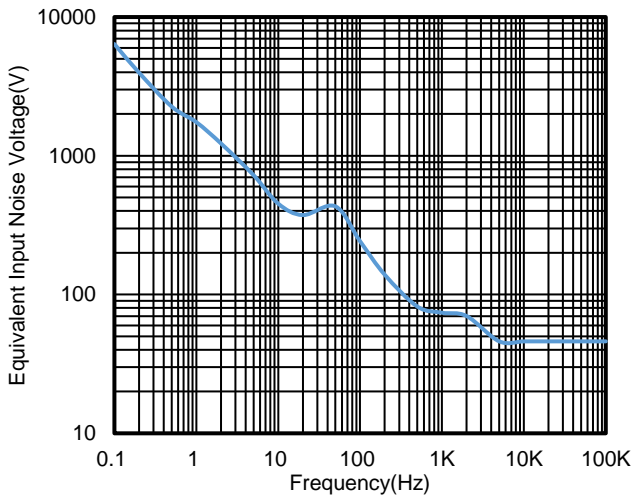


Figure 9. Voltage Noise Spectral Density vs. Frequency

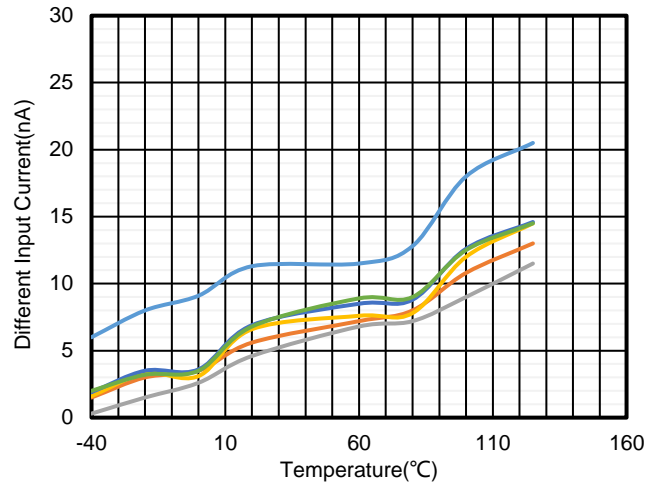
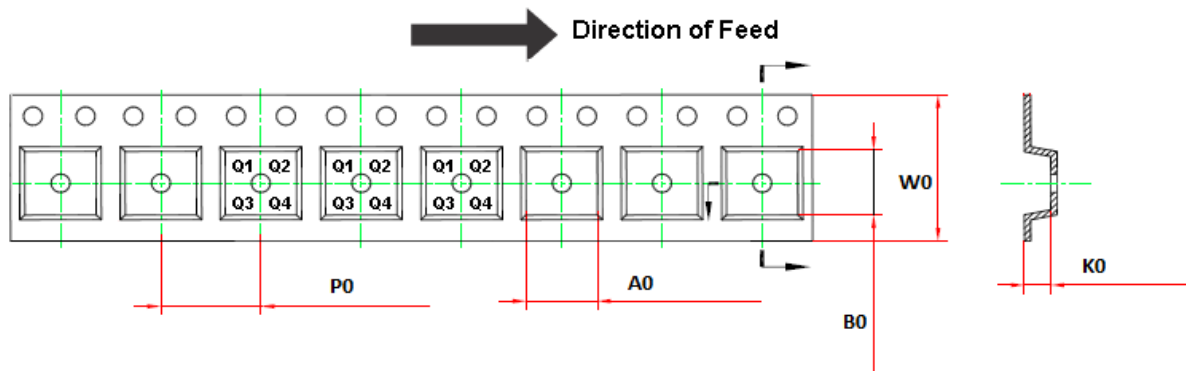
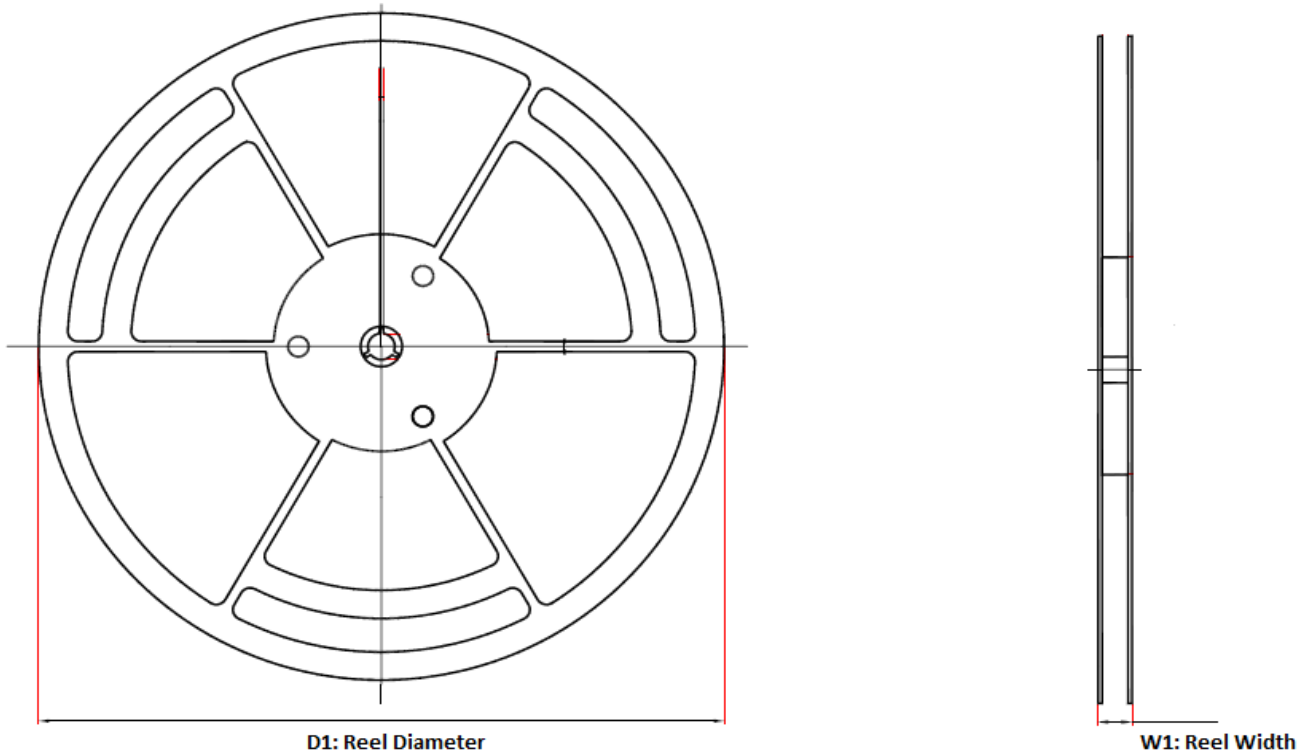


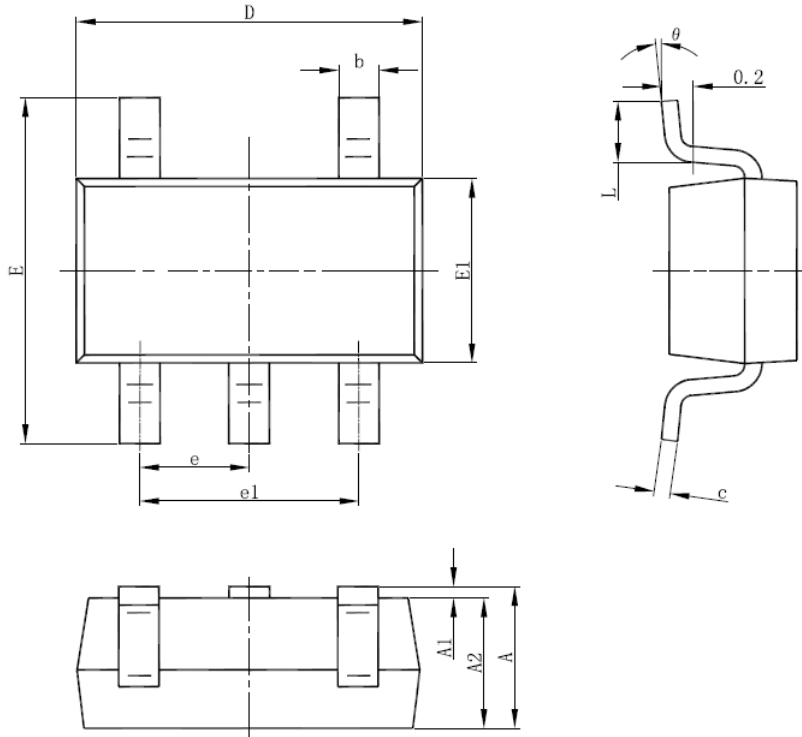
Figure 10. Different Input Current vs. Temperature



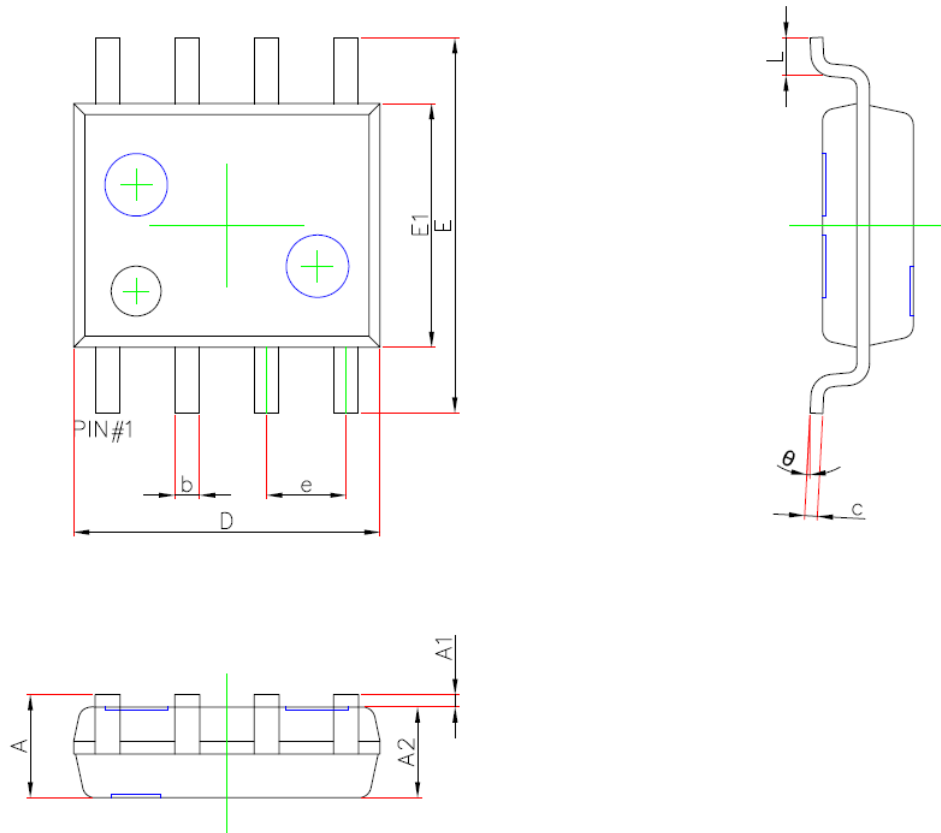
### Tape and Reel Information



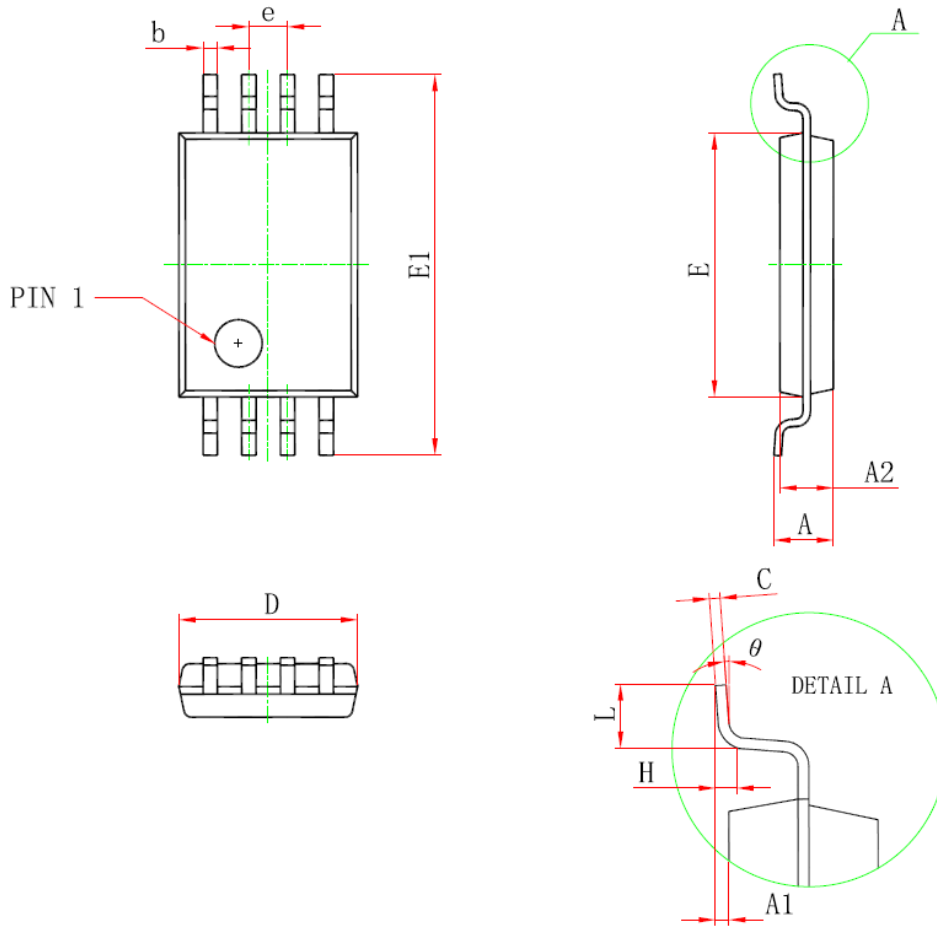
Order Number	Package	D1	W1	A0	B0	K0	P0	W0	Pin1 Quadrant
LM321A-TR	5-Pin SOT23	180.0	13.1	3.2	3.2	1.4	4.0	8.0	Q3
LM358A-SR	8-Pin SOIC	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
LM358A-CSR	8-Pin SOIC	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
LM358A-VR	8-Pin MSOP	330.0	17.6	5.2	3.3	1.5	8.0	12.0	Q1
LM358A-TSR	8-Pin TSSOP	330.0	17.6	6.8	3.3	1.2	8.0	12.0	Q1
LM358A-F1R	8-Pin DFN 1.5*1.5	178.0	12.3	1.7	1.7	0.75	4.0	8.0	Q1
LM324A-SR	14-Pin SOIC	330.0	21.6	6.5	9.0	2.1	8.0	16.0	Q1
LM324A-CSR	14-Pin SOIC	330.0	21.6	6.5	9.0	2.1	8.0	16.0	Q1
LM324A-TR	14-Pin TSSOP	330.0	17.6	6.8	5.4	1.2	8.0	12.0	Q1

**Package Outline Dimensions**
**SOT23-5**


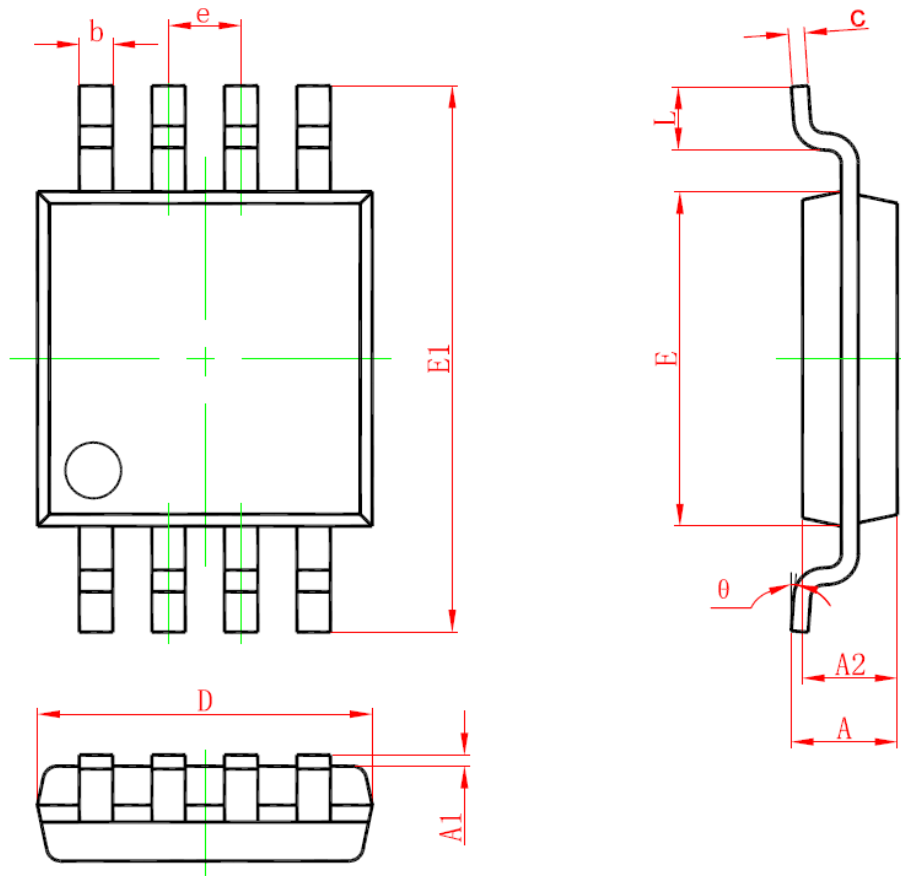
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E1	1.500	1.700	0.059	0.067
E	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
theta	0°	8°	0°	8°

**SOIC-8**


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270(BSC)		0.050(BSC)	
L	0.400	0.800	0.016	0.031
$\theta$	0°	8°	0°	8°

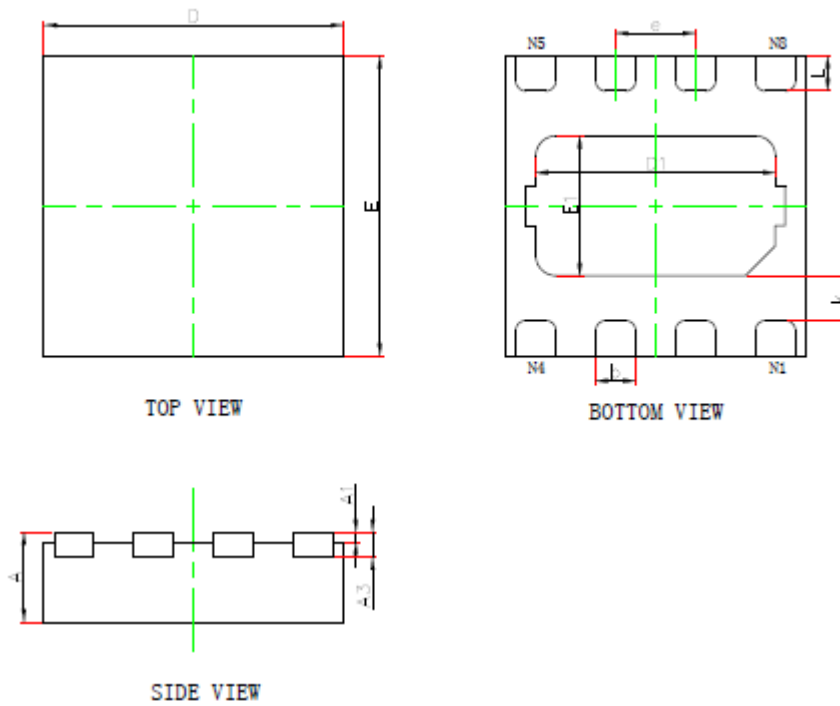
**TSSOP-8**


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°

**MSOP-8**


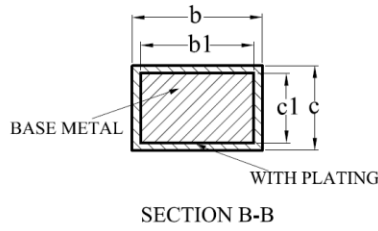
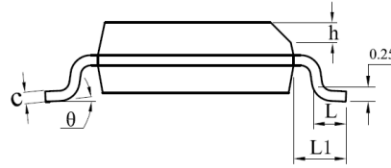
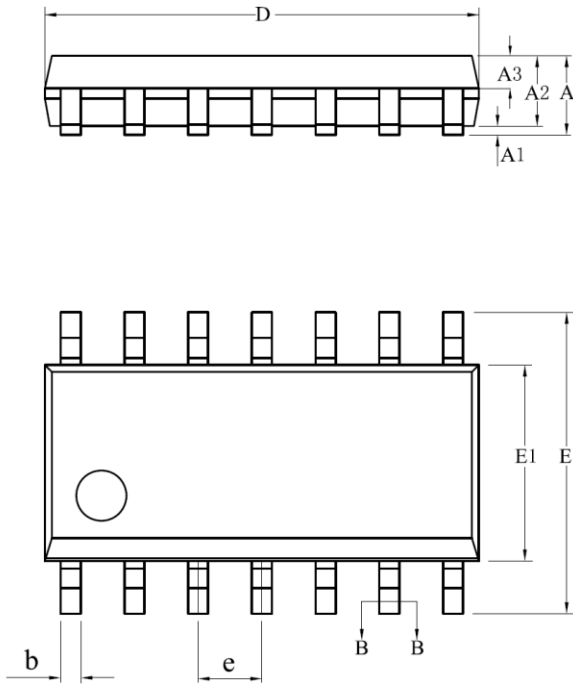
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
e	0.650(BSC)		0.026(BSC)	
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
L	0.400	0.800	0.016	0.031
$\theta$	0°	6°	0°	6°

DFN-8 1.5\*1.5



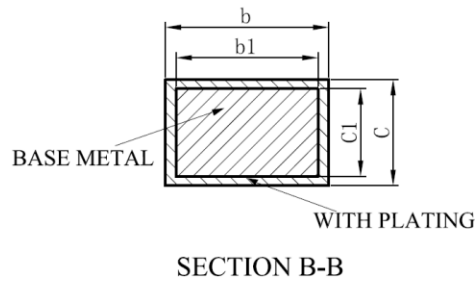
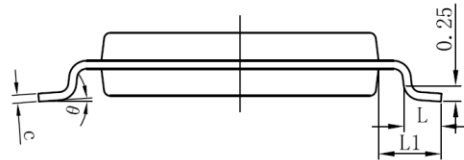
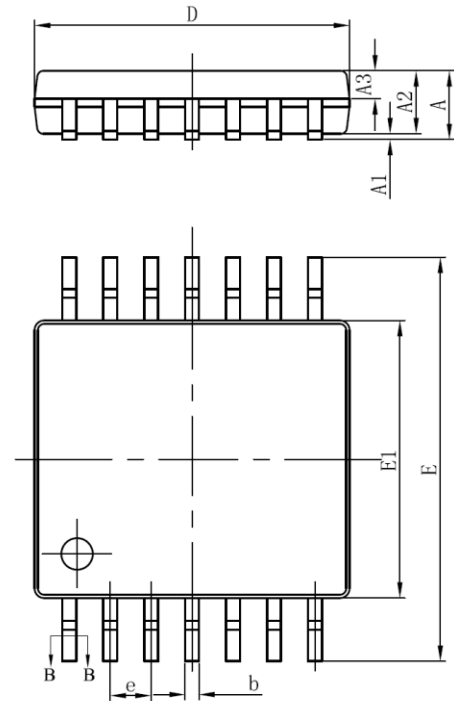
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.400	0.500	0.016	0.020
A1	0.000	0.050	0.000	0.002
A3	0.700	0.800		
A3	0.127REF.		0.005REF.	
D	1.450	1.550	0.057	0.061
E	1.450	1.550	0.057	0.061
D1	1.100	1.300	0.043	0.051
E1	0.600	0.800	0.024	0.031
k	0.200MIN.		0.008REF.	
b	0.150	0.250	0.006	0.010
e	0.400TYP.		0.016TYP.	
L	0.099	0.251	0.004	0.010

### SOIC-14



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.75
A1	0.05	—	0.225
A2	1.30	1.40	1.50
A3	0.60	0.65	0.70
b	0.39	—	0.47
b1	0.38	0.41	0.44
c	0.20	—	0.24
c1	0.19	0.20	0.21
D	8.55	8.65	8.75
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e	1.27BSC		
h	0.25	—	0.50
L	0.50	—	0.80
L1	1.05REF		
$\theta$	0	—	8°

### TSSOP-14



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.20
A1	0.05	—	0.15
A2	0.90	1.00	1.05
A3	0.39	0.44	0.49
b	0.20	—	0.28
b1	0.19	0.22	0.25
c	0.13	—	0.17
c1	0.12	0.13	0.14
D	4.90	5.00	5.10
E1	4.30	4.40	4.50
E	6.20	6.40	6.60
e	0.65BSC		
L	0.45	0.60	0.75
L1	1.00BSC		
$\theta$	0	—	8°

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