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

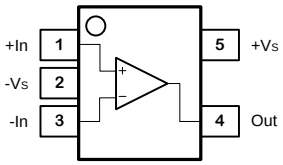
Description

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–, 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.

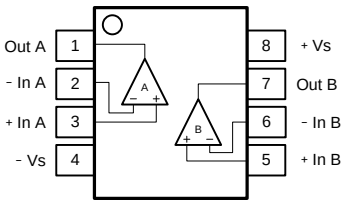
The combination of features makes the LM321A/358A/324A ideal choices for power module, industrial control, motor control and audio application.

Pin Configuration

LM321A
5-Pin SOT23
-T Suffixes



LM358A
8-Pin SOIC/TSSOP/MSOP/DFN
-S, -TS, -V, -F Suffixes



LM324A
14-Pin SOIC/TSSOP
-S and -T Suffixes

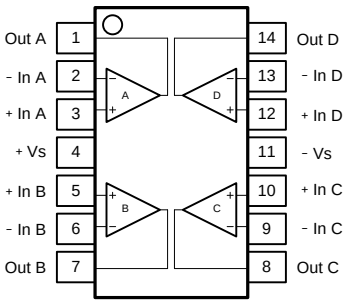


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Revision History

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_B, I_{IN} in Electrical Characteristics
2021/5/10	Rev.A.2	Update Spec: Iq of LM321A
2022/4/29	Rev.A.3	Update EC table: Add max of Ios, 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 Note 1	3	Tape and Reel, 3000
LM358A-SR	-40 to 125°C	8-Pin SOIC	358A XXXX Note 1	3	Tape and Reel, 4000
LM358A-CSR	-40 to 85°C	8-Pin SOIC	358A XXXX Note 1	3	Tape and Reel, 4000
LM358A-F1R	-40 to 125°C	8-Pin DFN 1.5*1.5	58 YW Note 1	1	Tape and Reel, 3000
LM358A-TSR	-40 to 125°C	8-Pin TSSOP	LM358A XXXX Note 1	3	Tape and Reel, 3000
LM358A-VR	-40 to 125°C	8-Pin MSOP	LM358A XXXX Note 1	3	Tape and Reel, 3000
LM324A-SR	-40 to 125°C	14-Pin SOIC	LM324A XXXX Note 1	3	Tape and Reel, 2500
LM324A-CSR	-40 to 85°C	14-Pin SOIC	LM324A XXXX Note 1	3	Tape and Reel, 2500
LM324A-TR	-40 to 125°C	14-Pin TSSOP	LM324A XXXX Note 1	3	Tape and Reel, 3000

Note 1: “XX” or “XXXX” identify the manufacture information.

Absolute Maximum Ratings Note 1

Parameters	Rating
Supply Voltage, $(+V_S)$– $(-V_S)$	40 V
Input Voltage	$(-V_S)$ – 0.3 to $(+V_S)$ + 0.3
Differential Input Voltage	$(+V_S)$ - $(-V_S)$
Input Current: +IN, –IN Note 2	±10mA
Output Short-Circuit Duration Note 3	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_{JA}	θ_{JC}	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°C, R_L = 10kΩ, C_L =100pF, unless otherwise noted.

Symbol	Parameter	Conditions	T_A	Min	Typ	Max	Unit
Power Supply							
V_S	Supply Voltage Range			3		36	V
I_Q	Quiescent Current per Amplifier, LM321A	V_S = 30V			150	250	μA
			Operating Range			350	μA
		V_S = 5V			150	200	μA
			Operating Range			300	μA
I_Q	Quiescent Current per Amplifier, LM358A, LM324A	V_S = 30V			110	200	μA
			Operating Range			250	μA
		V_S = 5V			100	150	μA
			Operating Range			200	μA
PSRR	Power Supply Rejection Ratio	V_S = 5V to 36V		85	120		dB
			Operating Range	80			dB
Input Characteristics							
V_{OS}	Input Offset Voltage	V_S = 30V, V_{CM} = 0V to 28V		-3	0.1	3	mV
			Operating Range	-7		7	mV
		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		μV/°C
I_B	Input Bias Current				60	500	pA
			Operating Range		600	1000	pA
I_{OS}	Input Offset Current[Note 1]				60	500	pA
			Operating Range		600	1000	pA
I_{IN}	Different Input Current	V_S = 36V, V_{ID} = 36V			5	150	nA
		V_S = 36V, V_{ID} = 36V	Operating Range		20	1000	nA
C_{IN}	Input Capacitance	Differential Mode			5		pF
		Common Mode			5		pF
Av	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
Output Characteristics							
	Output Voltage Swing from Positive and Negative Rail	R_{LOAD} = 10kΩ to V_S/2			200	300	mV
			Operating Range			700	mV
		R_{LOAD} = 2kΩ to V_S/2			1.1	1.3	V

			Operating Range			2	V
	Output Voltage Swing from Negative Rail	V_S = 5V, R_{LOAD} = 10kΩ to 0V			5	10	mV
I_{SC}	Output Short-Circuit Current			25	30		mA
			Operating Range	15			mA
AC Specifications							
GBW	Gain-Bandwidth Product				0.9		MHz
SR	Slew Rate	G = 1, 2V step			0.5		V/μs
t_S	Settling Time, 0.1%	G = 1, 2V step			4		μs
	Settling Time, 0.01%				5		μs
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
Noise Performance							
E_N	Input Voltage Noise	f = 0.1Hz to 10Hz			3		μV_{RMS}
e_N	Input Voltage Noise Density	f = 1kHz			70		nV/√Hz
i_N	Input Current Noise	f = 1kHz			3		fA/√Hz
THD+N	Total Harmonic Distortion and Noise	f = 1kHz, G =1, R_L = 10kΩ, V_{OUT} = $6V_{RMS}$			0.001		%

Note 1: Provided by bench test and design simulation

Typical Performance Characteristics

V_S = ±15V, V_{CM} = 0V, R_L = 10kΩ, unless otherwise specified.

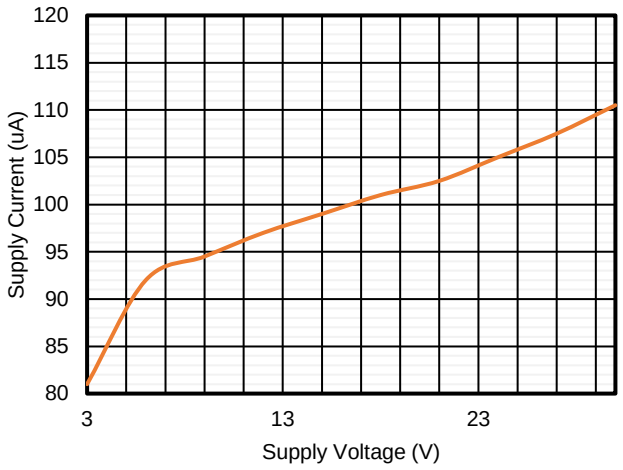


Figure 1. Quiescent Current vs. Supply Voltage

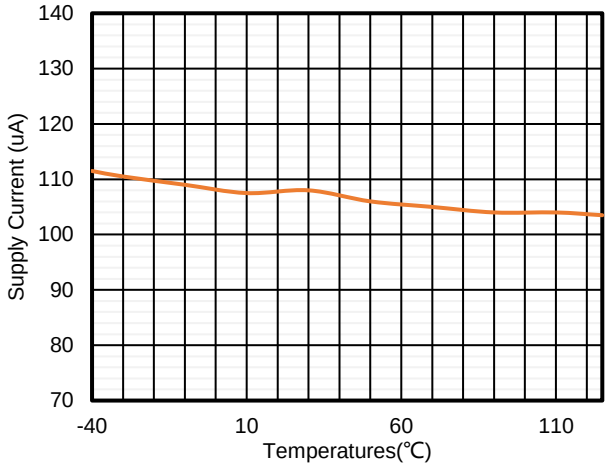


Figure 2. Quiescent Current vs. Temperature

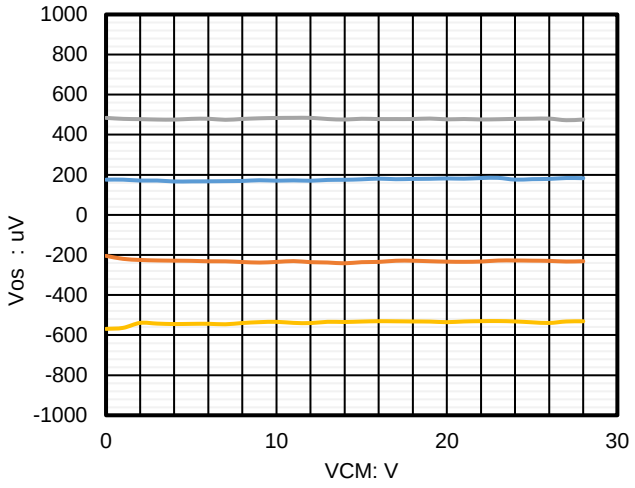


Figure 3. Offset Voltage vs. Common Mode Voltage

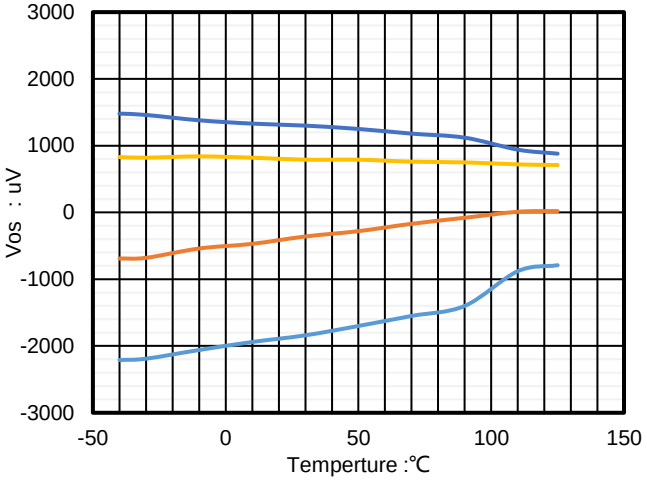


Figure 4. Offset Voltage vs. Temperature

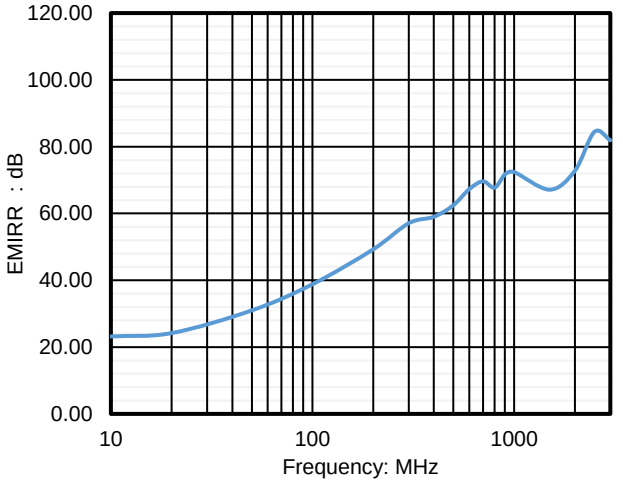


Figure 5. EMIRR+ vs. Frequency

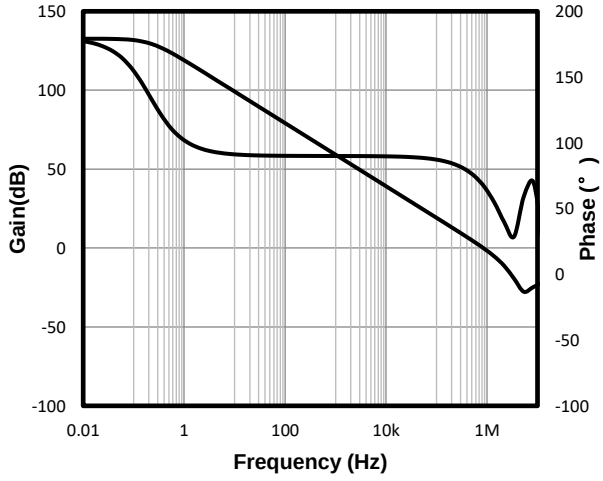


Figure 6. Open Loop Gain and Phase vs. Frequency

V_S = ±15V, V_{CM} = 0V, R_L = 10kΩ, unless otherwise specified.

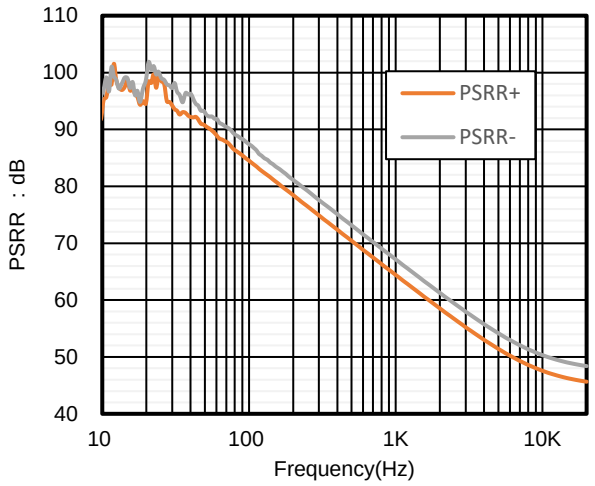


Figure 7. PSRR vs. Frequency

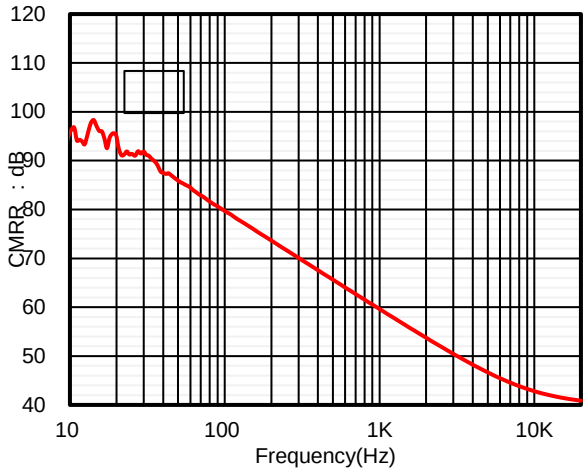


Figure 8. CMRR vs. Frequency

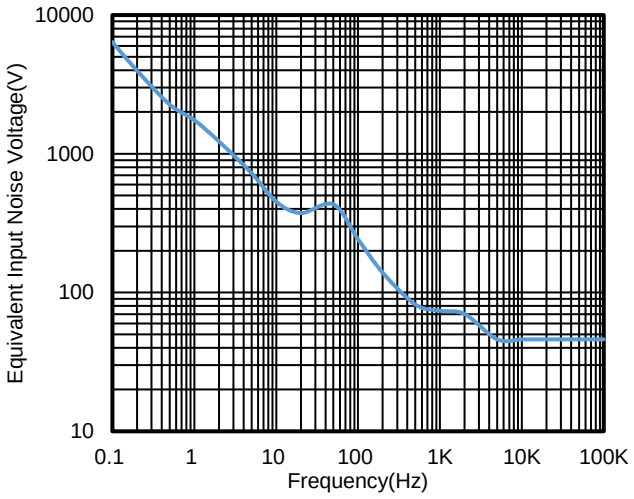


Figure 9. Voltage Noise Spectral Density vs. Frequency

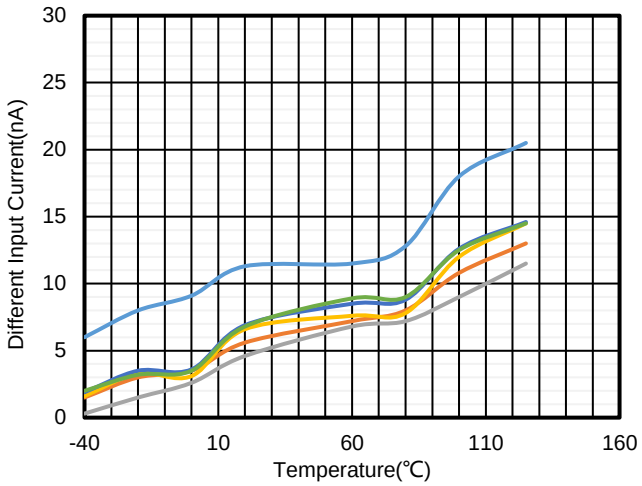
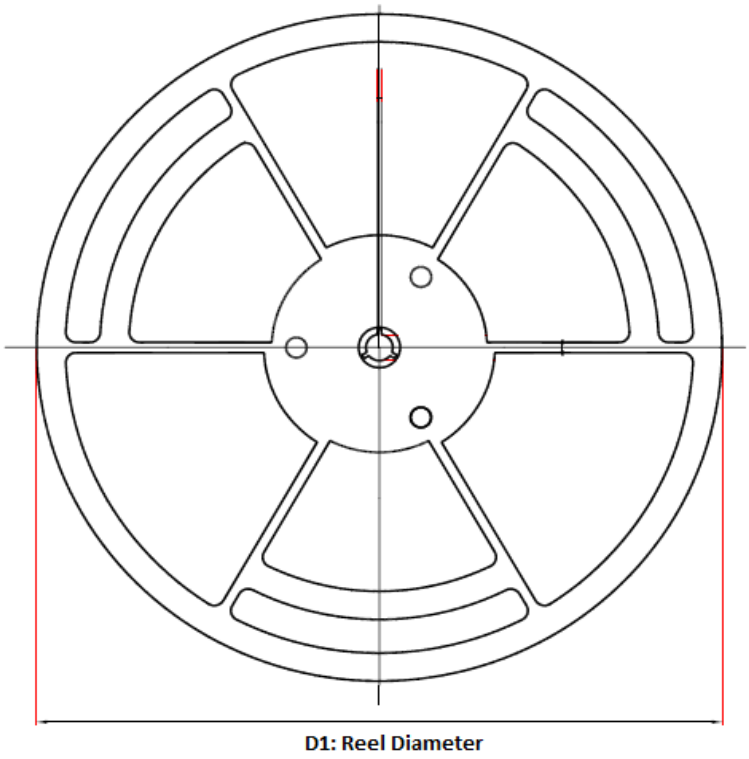


Figure 10. Different Input Current vs. Temperature

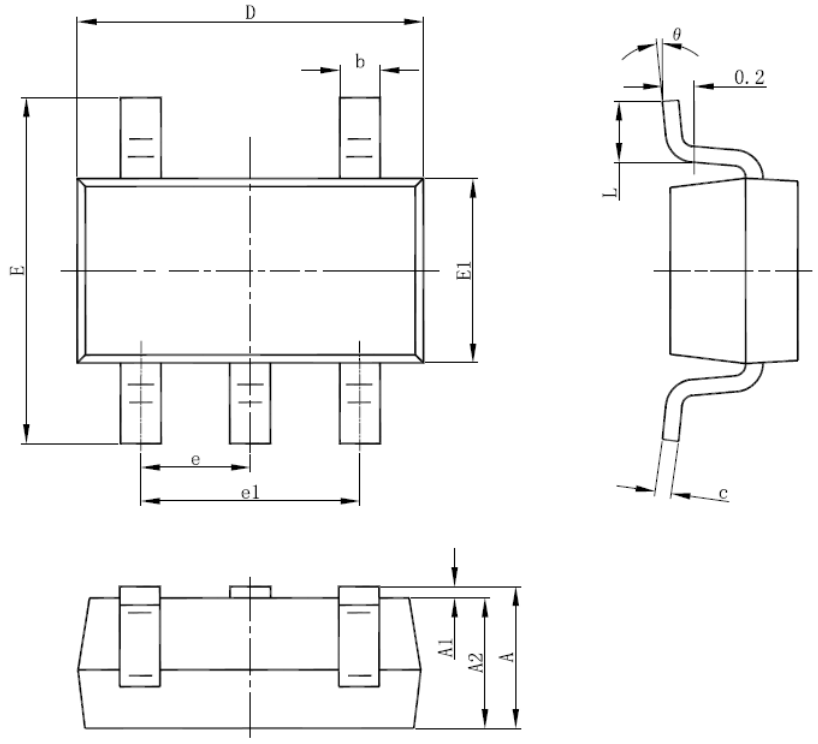
Tape and Reel Information



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

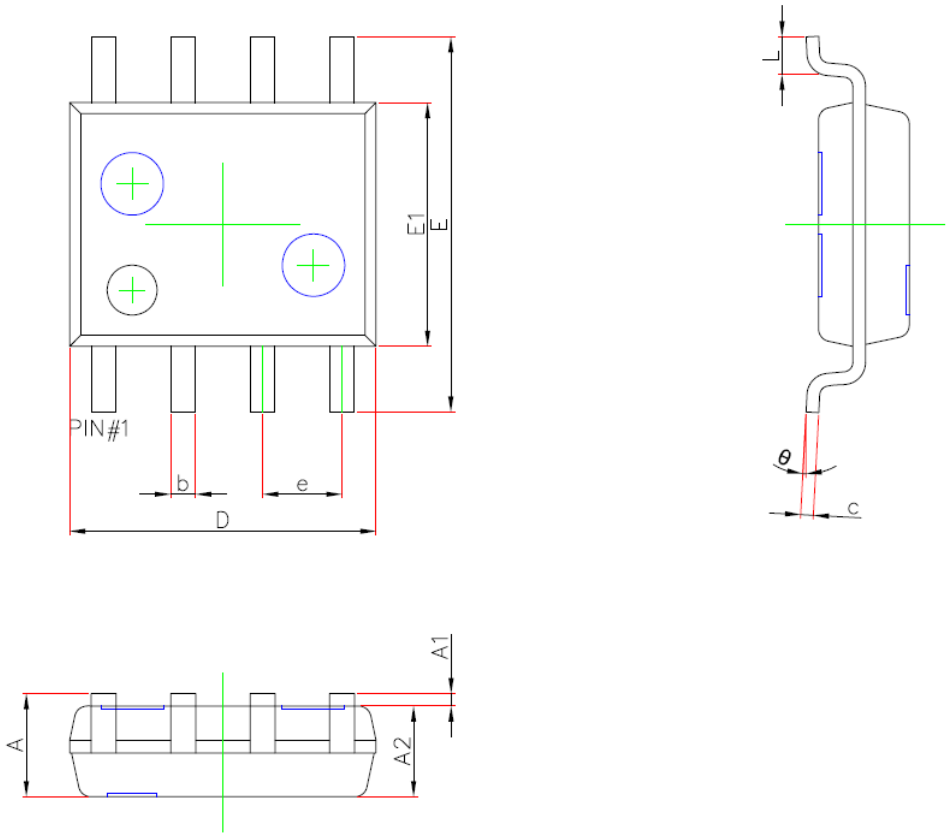
Package Outline Dimensions

SOT23-5



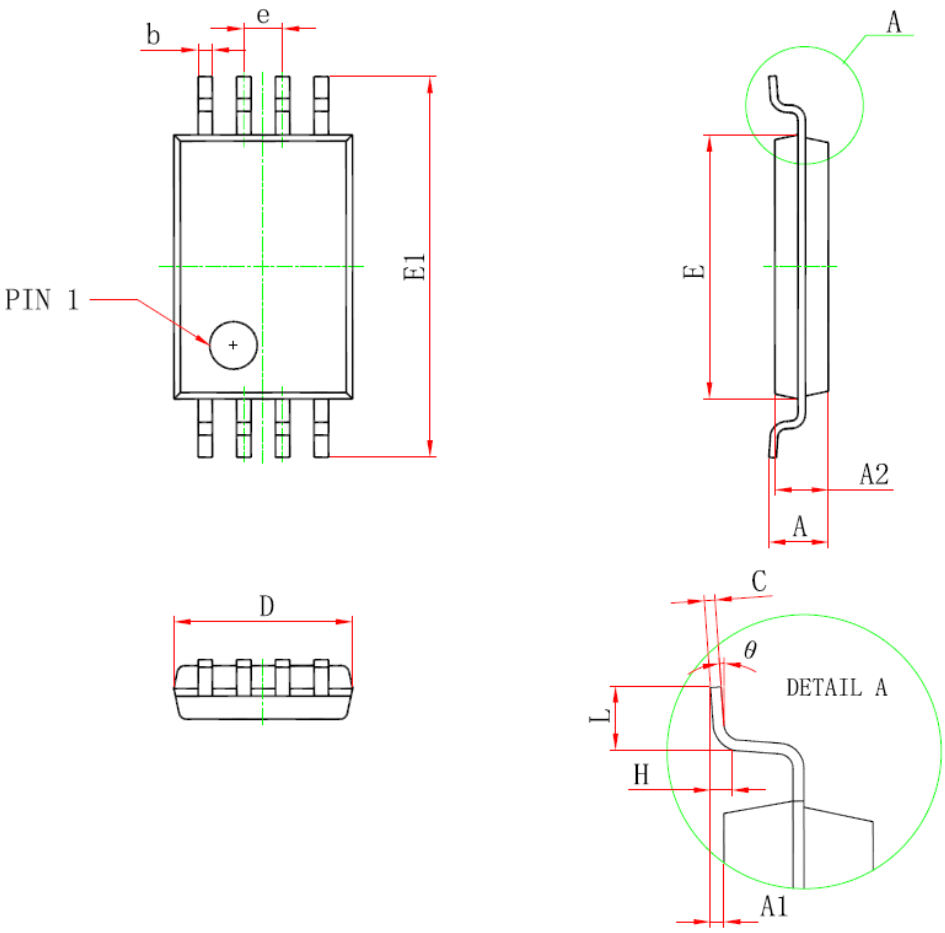
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E1	1.500	1.700	0.059	0.067
E	2.650	2.950	0.104	0.116
e	0.950(BSC)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

SOIC-8



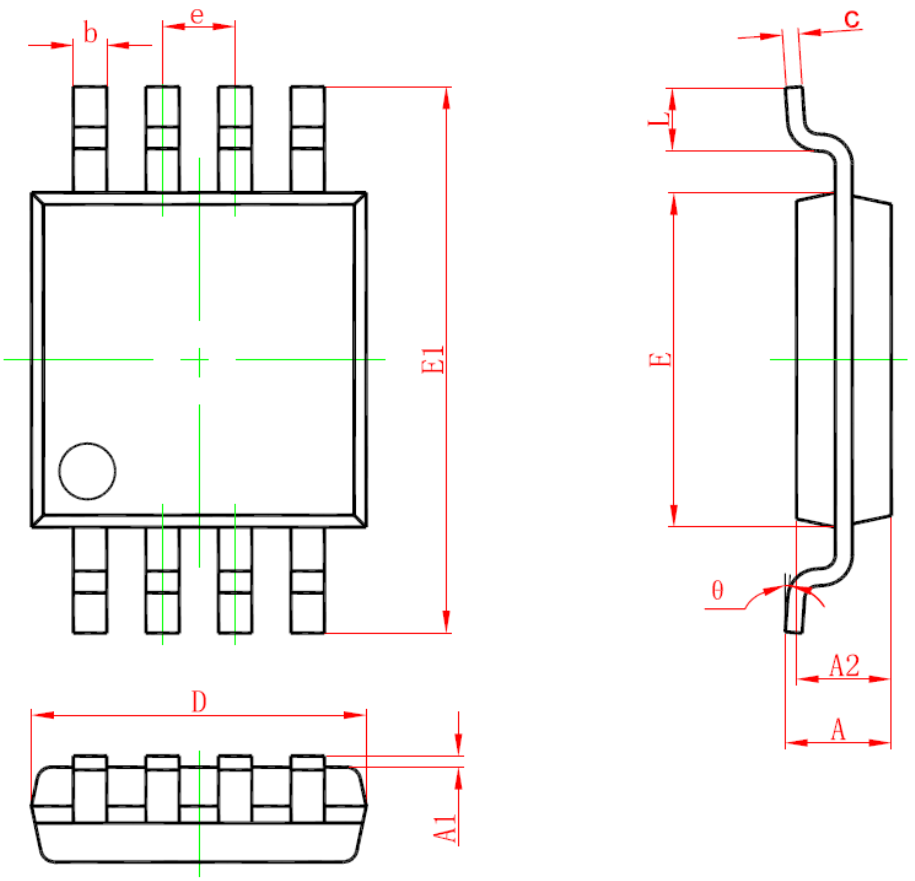
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270(BSC)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

TSSOP-8



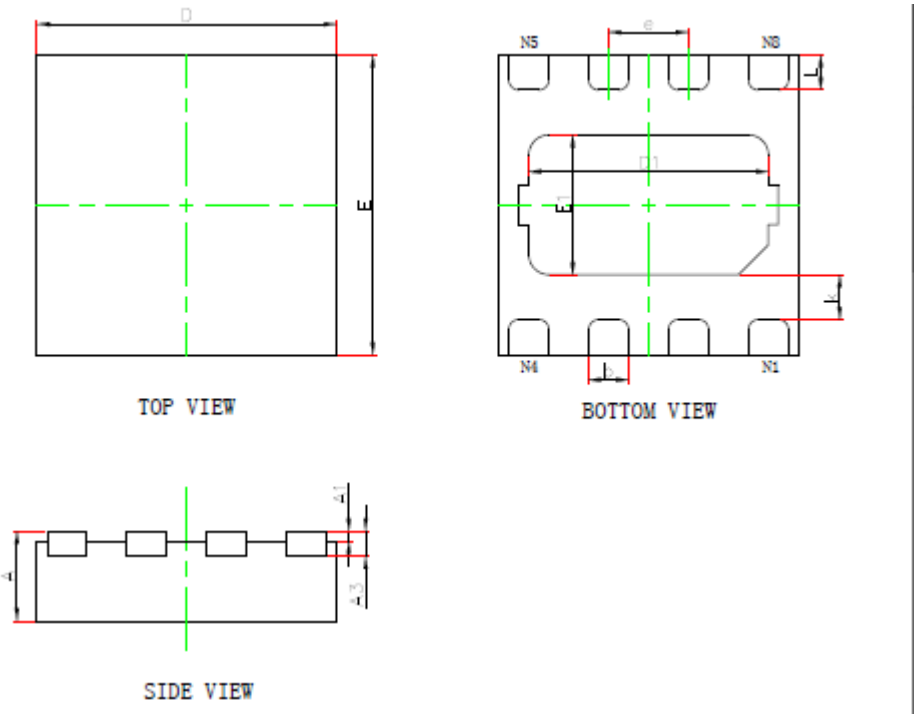
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	**Max**	**Min**	**Max**
D	2.900	3.100	0.114	0.122
E	4.300	4.500	0.169	0.177
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
E1	6.250	6.550	0.246	0.258
A		1.200		0.047
A2	0.800	1.000	0.031	0.039
A1	0.050	0.150	0.002	0.006
e	0.65 (BSC)		0.026(BSC)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

MSOP-8



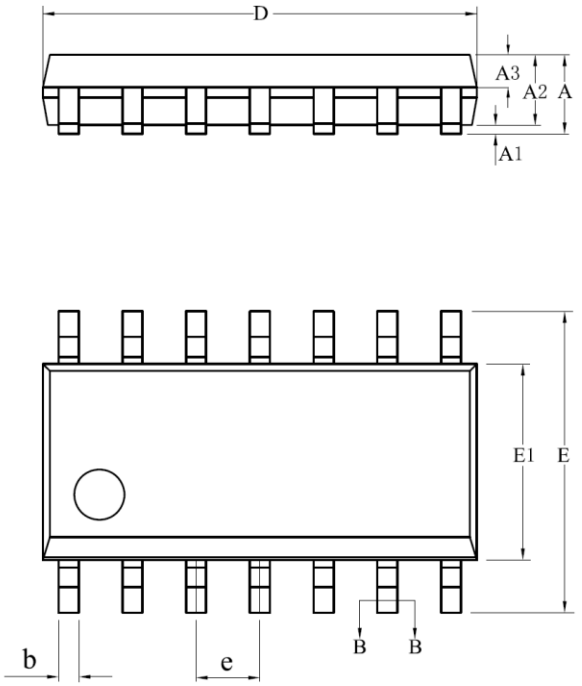
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
e	0.650(BSC)		0.026(BSC)	
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187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

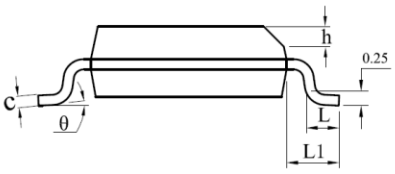
DFN-8 1.5*1.5

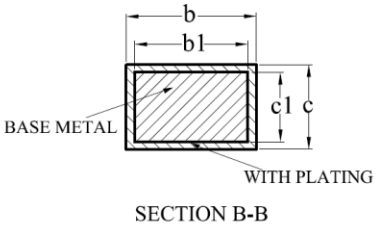


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.400	0.500	0.016	0.020
A1	0.000	0.050	0.000	0.002
A3	0.700	0.800		
A3	0.127REF.		0.005REF.	
D	1.450	1.550	0.057	0.061
E	1.450	1.550	0.057	0.061
D1	1.100	1.300	0.043	0.051
E1	0.600	0.800	0.024	0.031
k	0.200MIN.		0.008REF.	
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

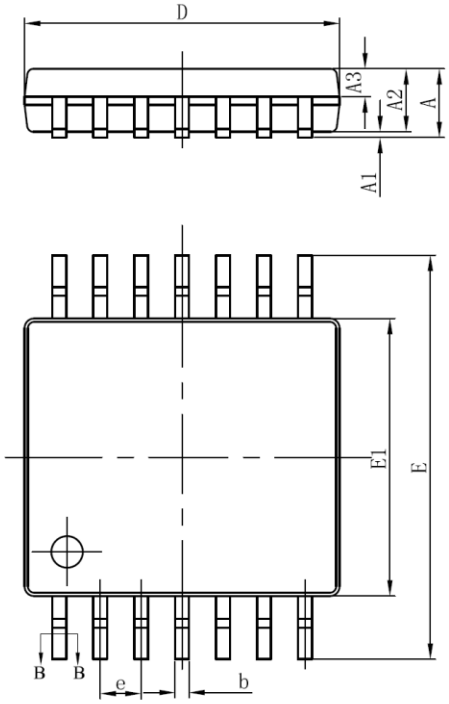


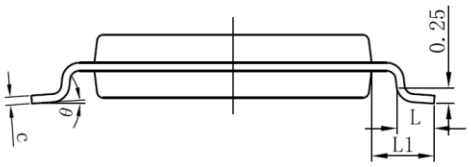


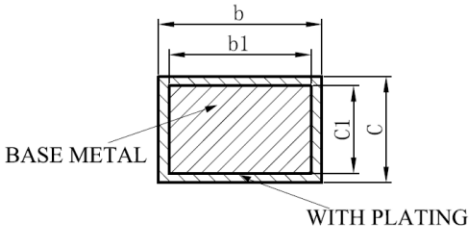


SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.75
A1	0.05	—	0.225
A2	1.30	1.40	1.50
A3	0.60	0.65	0.70
b	0.39	—	0.47
b1	0.38	0.41	0.44
c	0.20	—	0.24
c1	0.19	0.20	0.21
D	8.55	8.65	8.75
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e	1.27BSC		
h	0.25	—	0.50
L	0.50	—	0.80
L1	1.05REF		
θ	0	—	8°

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		
θ	0	—	8°

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