

10MHz, 低噪声, 轨至轨, CMOS 运算放大器

概述 General Description

SL721/722/724是CMOS型、轨至轨输出/输出的电压反馈型运算放大器。可以支持1.7~5.5V的供电范围, 每个通道仅消耗530 μ A的电流, 拥有较低的失调电压和温漂。

该系列产品拥有10MHz的增益带宽积, 外接500pF电容负载时也能保证单位增益下稳定工作, 并且内置了EMI滤波器, 可以抑制外部干扰。同时低至1pA的输入偏置电流让该系列产品在传感器应用场景更具优势。

该系列产品支持在-40℃至125℃的温度范围内长期稳定工作, 并且拥有较高的ESD防护等级(8kV HBM)。

SL721/722/724系列产品提供多种封装形式, 适配于各种应用。尤其是四通道的QFN2*2-16L, 封装尺寸为2.00mm*2.00mm, 最大限度节省了PCB板的空间。

特性 Features

- 超低功耗: 530 μ A/通道
- 宽输入的供电范围: 1.7V to 5.5V
- 工作温度范围: -40℃至 125℃
- 轨至轨的输入和输出
- 低失调电压: 2mV (最大)
- 失调电压的温度漂移: 0.7 μ V/℃
- 超低的输入偏置电流: 1pA
- 增益带宽积: 10MHz
- 高 ESD 防护等级: 8kV (HBM)
- 单位增益稳定
- 内置 EMI 滤波器
- 提供多种封装形式:
 - 单通道: SOT-353、SOT23-5、SOT23-6
 - 双通道: DFN2x2-8L、SOP8、MSOP8、TSSOP8
 - MSOP10
 - 四通道: SOP14、TSSOP14、QFN2x2-16L

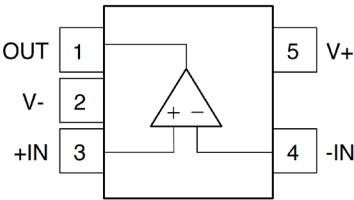
应用产品 Applications

- 传感器信号处理电路
- 家用电器
- 医疗仪器
- 个人电子产品
- 便携式设备
- 电池管理系统

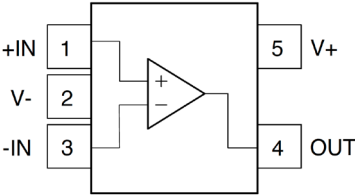
产品信息 Product Information

产品名称	封装	尺寸
SL721-A05A	SOT353(SC70-5)	1.25mm*1.00mm
SL721-T05A	SOT23-5	2.92mm*1.60mm
SL721-T06A	SOT23-6	2.92mm*1.60mm
SL722-D08	DFN2x2-8L	2.00mm*2.00mm
SL722-M08	MSOP8	3.00mm*3.00mm
SL722-S08	SOP8	4.90mm*3.90mm
SL722-C08	TSSOP8	3.00mm*4.40mm
SL722-M10	MSOP10	3.00mm*3.00mm
SL724-Q14	QFN2x2-16L	2.00mm*2.00mm
SL724-C14	TSSOP14	4.40mm*5.00mm
SL724-S14	SOP14	8.65mm*3.90mm

引脚定义 Pin Configurations



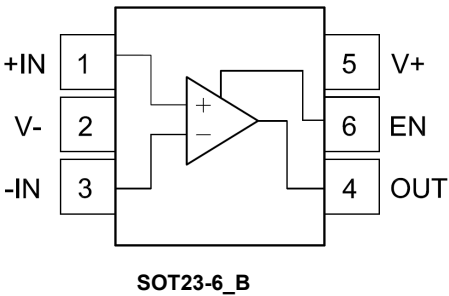
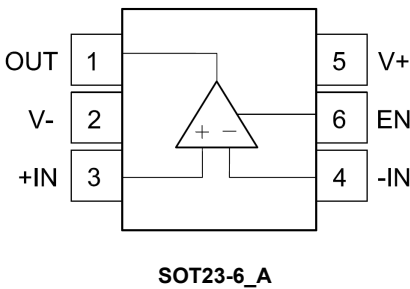
SOT23-5_A/SOT353_A



SOT23-5_B/SOT353_B

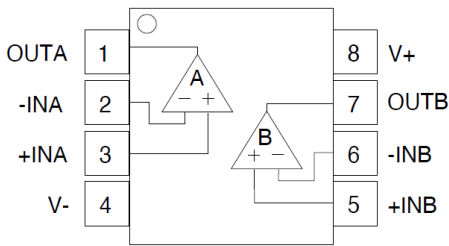
引脚 Pin			I/O	描述 Description
名称 Name	SOT23-5_A SOT353_A	SOT23-5_B SOT353_B		
-IN	4	3	I	反相输入端
+IN	3	1	I	同相输入端
OUT	1	4	O	输出端
V-	2	2	-	负电源
V+	5	5	-	正电源

引脚定义 Pin Configurations

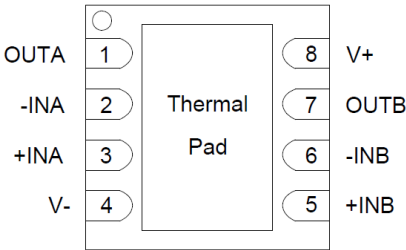


引脚 Pin			I/O	描述 Description
名称 Name	SOT23-5_A	SOT23-5_B		
-IN	4	3	I	反相输入端
+IN	3	1	I	同相输入端
OUT	1	4	O	输出端
V-	2	2	-	负电源
EN	5	5	I	关断（低电平有效）
V+	6	6	-	正电源

引脚定义 Pin Configurations



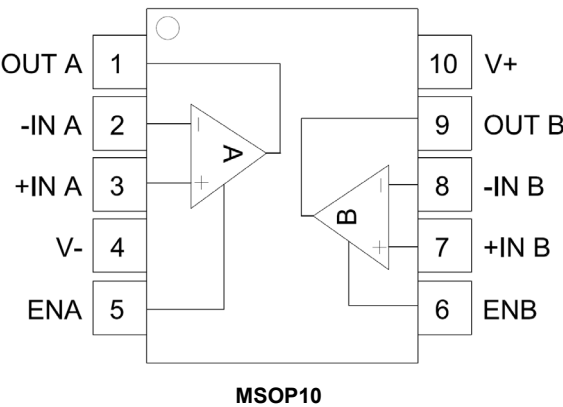
SOP8/MSOP8



DFN2x2-8L

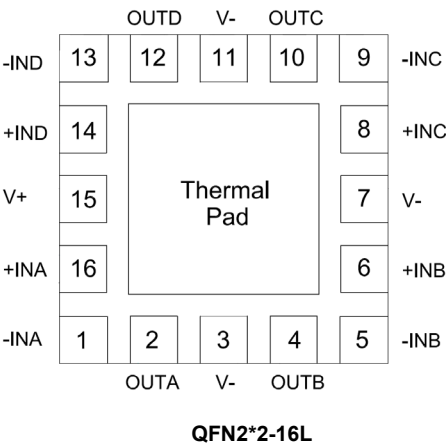
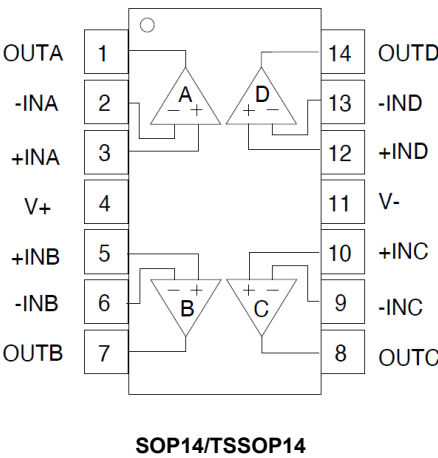
引脚 Pin			I/O	描述 Description
名称 Name	SOP8、MSOP8	DFN2x2-8L		
-INA	2	2	I	反相输入端，通道 A
+INA	3	3	I	同相输入端，通道 A
-INB	6	6	I	反相输入端，通道 B
+INB	5	5	I	同相输入端，通道 B
OUTA	1	1	O	输出端，通道 A
OUTB	7	7	O	输出端，通道 B
V-	4	4	-	负电源
V+	8	8	-	正电源

引脚定义 Pin Configurations



引脚 Pin		I/O	描述 Description
名称 Name	MSOP10		
-INA	2	I	反相输入端，通道 A
+INA	3	I	同相输入端，通道 A
-INB	8	I	反相输入端，通道 B
+INB	7	I	同相输入端，通道 B
OUTA	1	O	输出端，通道 A
OUTB	9	O	输出端，通道 B
V-	4	-	负电源
V+	10	-	正电源
ENA	5	I	关断（低电平有效）
ENB	6	I	关断（低电平有效）

引脚定义 Pin Configurations



引脚 Pin			I/O	描述 Description
名称 Name	SOP14、TSSOP14	QFN2*2-16L		
-INA	2	1	I	反相输入端，通道 A
+INA	3	16	I	同相输入端，通道 A
-INB	6	5	I	反相输入端，通道 B
+INB	5	6	I	同相输入端，通道 B
-INC	9	9	I	反相输入端，通道 C
+INC	10	8	I	同相输入端，通道 C
-IND	13	13	I	反相输入端，通道 D
+IND	12	14	I	同相输入端，通道 D
OUTA	1	2	O	输出端，通道 A
OUTB	7	4	O	输出端，通道 B
OUTC	8	10	O	输出端，通道 C
OUTD	14	12	O	输出端，通道 D
V-	11	3,7,11	-	负电源
V+	4	15	-	正电源

1 规格参数 Specifications

1.1 极限参数 Absolute Maximum Ratings ^①

	最小值	最大值	单位
供电电压 Supply Voltage, $V_S = (V+) - (V-)$		6	V
共模输入电压 Common Mode Input Voltage ^②	$(V-) - 0.3$	$(V+) + 0.3$	V
差模输入电压 Differential Input Voltage		$ (V+) - (V-) $	V
输入电流 Input Current ^②	-10	10	mA
输出短路电流 Output Short-Circuit Current ^③	See DC Table		
存储温度 Storage Temperature, T_{STG}	-65	150	°C
结温 Junction Temperature		150	°C

- 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 above those indicated in the operational section of this specification is not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.
- ② The input pins are protected by ESD diode clamps which are connected to the power-supply rails. The input current should be limited to 10mA or less if the input voltages extend 0.3V beyond the power-supply rails.
- ③ Short-Circuit to either power-supply rail.

1.2 静电防护能力 ESD Ratings

			值	单位
$V_{(ESD)}$	静电放电	人体模式 Human-Body Model (HBM)	±8000	V
	Electrostatic Discharge	充电模式 Charged-Device Model (CDM)	±2000	V

1.3 推荐工作条件 Recommended Operating Conditions

		最小值	典型值	最大值	单位
供电电压 Supply Voltage ($V+ - V-$)		1.7		5.5	V
额定温度 Specified Temperature	$V_S = 1.7 \sim 5.5V$	-40		125	°C

1.4 直流电气特性 DC Electrical Characteristics

T _A = 25°C, V _S = 1.7V to 5.5V, V _{CM} = V _{OUT} = V _S /2, 且 R _L = 10kΩ 连接至 V _S /2, 其他情况另做说明。								
参数 Parameter		条件 Test Conditions		温度 Temp	最小值	典型值	最大值	单位
失调电压 Offset Voltage								
V _{OS}	输入失调电压	V _S = 5V			-2.00	±0.50	2.00	mV
ΔV _{OS} /ΔT	温漂	V _S = 5V		-40°C to 125°C		±0.70		μV/°C
输入偏置电流 Input Bias Current								
I _B	输入偏置电流					1		pA
I _{OS}	输入失调电流					1		pA
输入阻抗 Input Impedance								
Z _{Diff}	差模					10 ¹³ 2		Ω pF
Z _{CM}	共模					10 ¹³ 5		Ω pF
输入电压范围 Input Voltage Range								
V _{CM}	共模输入电压范围				-0.1		V _S +0.1	V
CMRR	共模抑制比	V _S = 5V			74	88		dB
		-0.1V < V _{CM} < 3.6V	-40°C to 125°C	72				
		V _S = 5V			61	74		dB
		-0.1V < V _{CM} < 5.1V	-40°C to 125°C	60				
输出范围 Output Voltage and Current Range								
V _{OH}	输出电压距离正电源轨	V _S = 5V, R _L = 10kΩ to V _S /2				9	15	mV
V _{OL}	输出电压距离负电源轨	V _S = 5V, R _L = 10kΩ to V _S /2				5	10	mV
I _{SC}	短路电流	V _S = 5V				±44		mA
开环增益 Open-Loop Gain								
A _{OL}	开环增益	V _S = 5V, R _L = 10kΩ,			106	122		dB
		0.05V < V _{OUT} < 4.95V	-40°C to 125°C	103				
		V _S = 5V, R _L = 2kΩ,			94	106		dB
		0.15V < V _{OUT} < 4.85V	-40°C to 125°C	90				
供电范围 Power Supply Range								
I _Q	静态电流	V _S = 5V,				530	600	μA
		V _{CM} = 0V	-40°C to 125°C				650	
		V _S = 1.7V,				510	580	μA
		V _{CM} = 0V	-40°C to 125°C				630	
PSRR	电源抑制比	V _S = 1.7V to 5.5V			73	87		dB
			-40°C to 125°C	71				

1.5 交流电气特性 AC Electrical Characteristics

T _A = 25°C, V _S = 1.7V to 5.5V, V _{CM} = V _{OUT} = V _S /2, 且 R _L = 10kΩ 连接至 V _S /2, 其他情况另做说明。						
参数 Parameter		条件 Test Conditions	最小值	典型值	最大值	单位
GBP	增益带宽积	V _S = 5V, R _L = 10kΩ, C _L = 20pF		10		MHz
噪声 Noise						
E _n	输入电压噪声	V _S = 5V, f = 0.1Hz to 10Hz		8.6		μV _{P-P}
e _n	输入电压噪声密度	V _S = 5V, f = 1kHz		25		nV/√Hz
		V _S = 5V, f = 10kHz		12		

1.6 动态电气特性 Dynamic Electrical Characteristics

T _A = 25°C, V _S = 1.7V to 5.5V, V _{CM} = V _{OUT} = V _S /2, 且 R _L = 10kΩ 连接至 V _S /2, 其他情况另做说明。						
参数 Parameter		条件 Test Conditions	最小值	典型值	最大值	单位
SR	压摆率 (10% to 90%)	V _S = 5V, G = 1, C _L = 20pF, 4V step, Rising		16		V/μs
		V _S = 5V, G = 1, C _L = 20pF, 4V step, Falling		14		V/μs
t _S	建立时间	V _S = 5V, G = 1, C _L = 100pF, 2V step, 0.1%		1		μs
t _{OLRT}	过载恢复时间	V _S = 5V, V _{IN} × gain > V _S		200		ns

1.7 直流特征曲线 Typical DC Characteristics

$T_A = 25^\circ\text{C}$, $V_S = 5\text{V}$, $V_{CM} = V_{OUT} = V_S/2$, 且 $R_L = 10\text{k}\Omega$ 连接至 $V_S/2$, 其他情况另做说明。

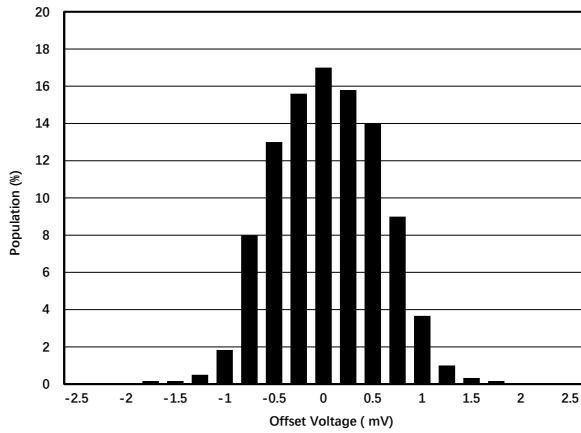


图 1.7.1. 输入失调电压分布图

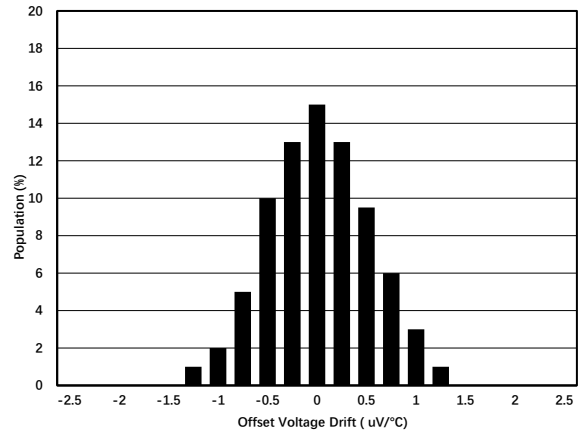


图 1.7.2. 温漂分布图

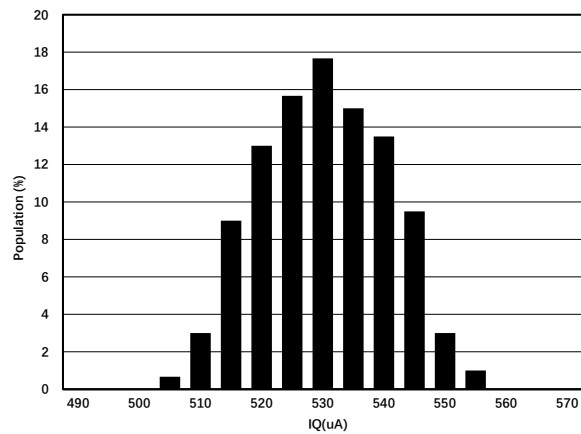


图 1.7.3. 静态电流分布图

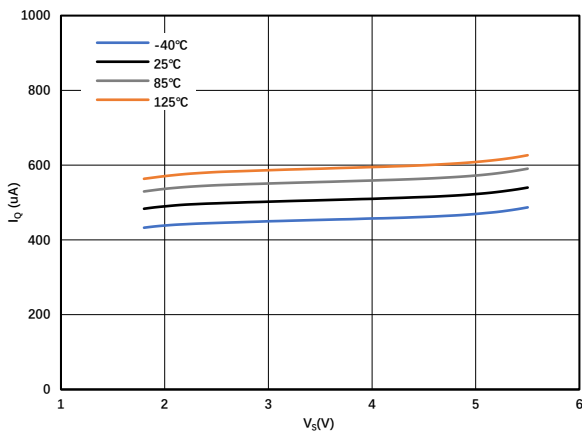


图 1.7.4. 静态电流 vs 供电电压 @ $V_{CM} = 0\text{V}$

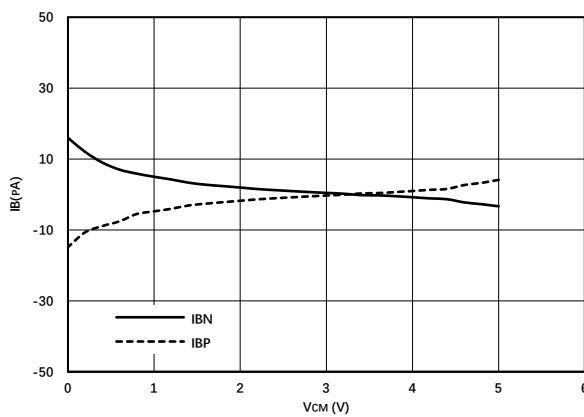


图 1.7.5. 输入偏置电流 vs 共模电压 @ $V_S = 5\text{V}$

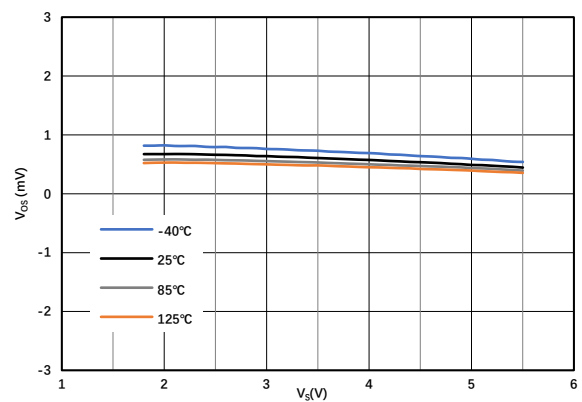


图 1.7.6. 输入失调电压 vs 供电电压 @ $V_{CM} = 0\text{V}$

1.7 直流特征曲线 Typical DC Characteristics (continued)

$T_A = 25^\circ\text{C}$, $V_S = 5\text{V}$, $V_{CM} = V_{OUT} = V_S/2$, 且 $R_L = 10\text{k}\Omega$ 连接至 $V_S/2$, 其他情况另做说明。

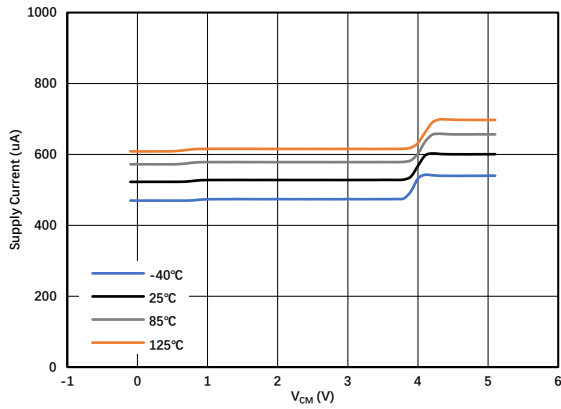


图 1.7.6. 静态电流 vs 共模电压 @ $V_S = 5\text{V}$

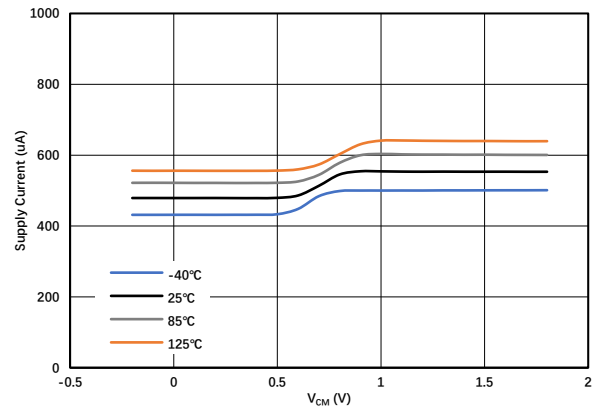


图 1.7.7. 静态电流 vs 共模电压 @ $V_S = 1.7\text{V}$

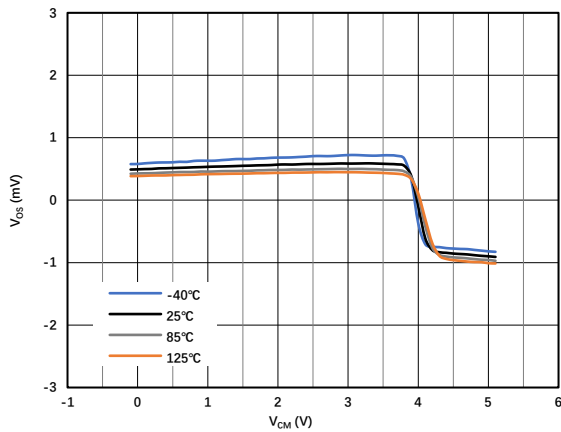


图 1.7.8. 输入失调电压 vs 共模电压 @ $V_S = 5\text{V}$

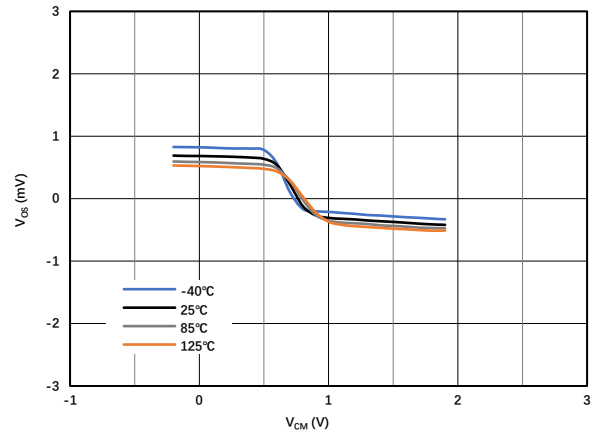


图 1.7.9. 输入失调电压 vs 共模电压 @ $V_S = 1.7\text{V}$

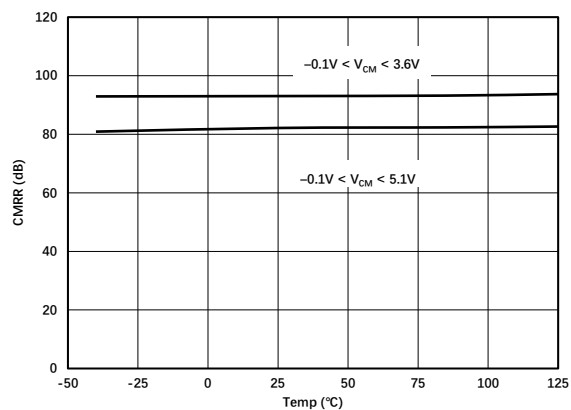


图 1.7.10. 直流 CMRR 与温度的关系 @ $V_S = 5\text{V}$

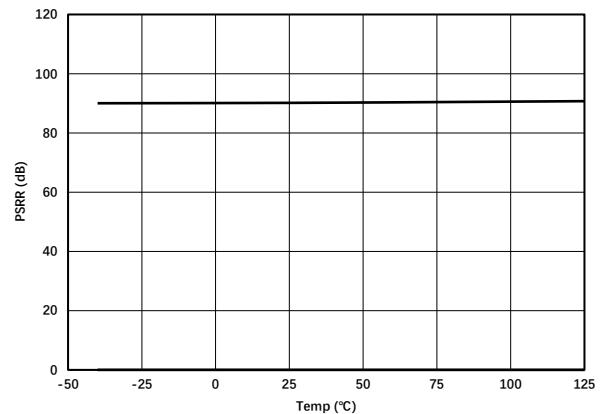


图 1.7.11. 直流 PSRR 与温度的关系 @ $V_S = 1.7\text{V}$ 到 5.5V

1.7 直流特征曲线 Typical DC Characteristics (continued)

$T_A = 25^\circ\text{C}$, $V_S = 5\text{V}$, $V_{CM} = V_{OUT} = V_S/2$, 且 $R_L = 10\text{k}\Omega$ 连接至 $V_S/2$, 其他情况另做说明。

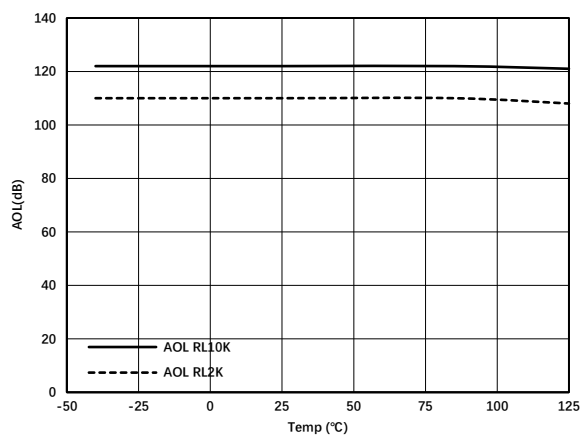


图 1.7.12. 开环增益与温度的关系 @ $V_S = 5.0\text{V}$

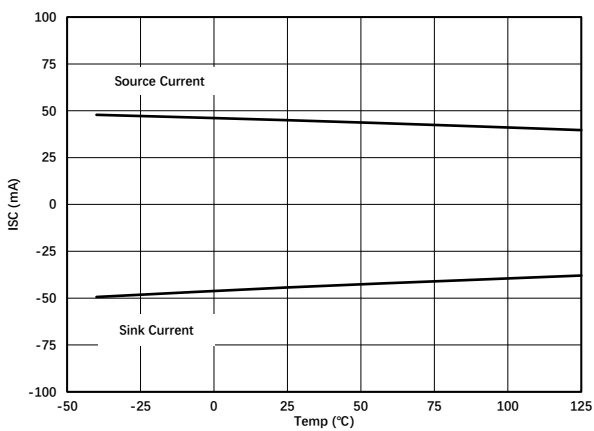


图 1.7.13. 输出短路电流与温度的关系 @ $V_S = 5\text{V}$

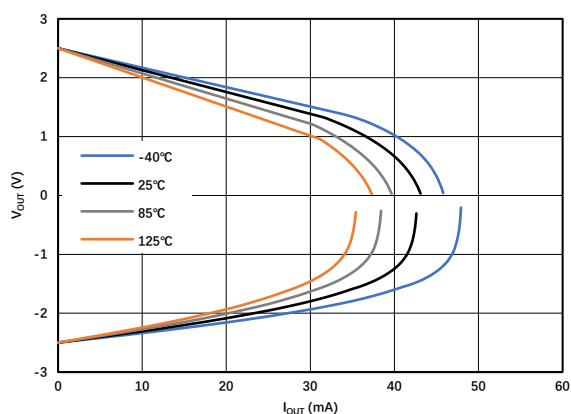


图 1.7.14. 输出电压 vs 输出电流 @ $V_S = 5\text{V}$

1.8 交流特征曲线 Typical AC Characteristics

$T_A = 25^\circ\text{C}$, $V_S = 5\text{V}$, $V_{CM} = V_{OUT} = V_S/2$, 且 $R_L = 10\text{k}\Omega$ 连接至 $V_S/2$, 其他情况另做说明。

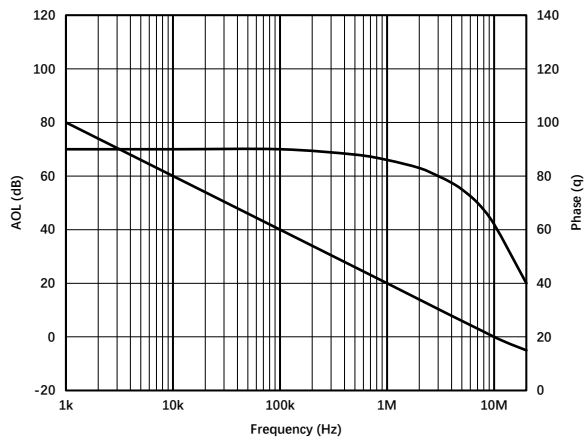


图 1.8.1. 开环增益与相位

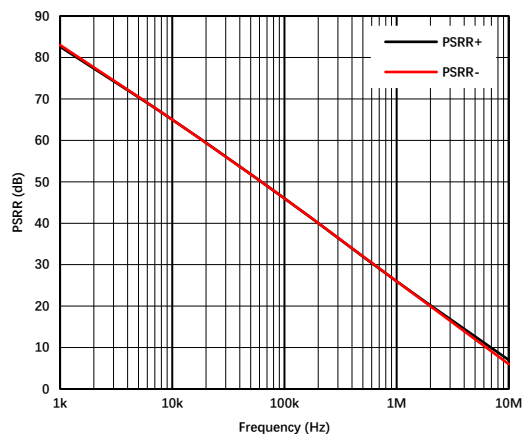


图 1.8.2. PSRR vs 频率

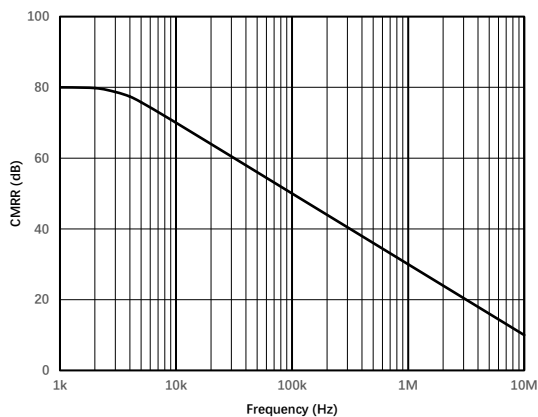


图 1.8.3. CMRR vs 频率

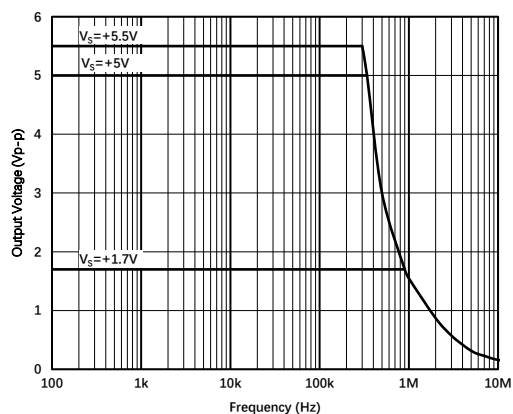


图 1.8.4. 最大输出电压 vs 频率

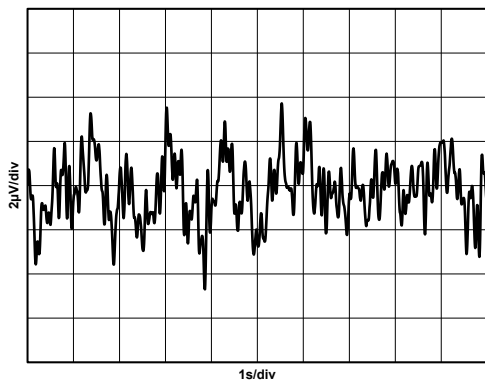


图 1.8.5. 0.1Hz 到 10Hz 噪声

1.9 动态特征曲线 Typical Dynamic Characteristics

$T_A = 25^\circ\text{C}$, $V_S = 5\text{V}$, $V_{CM} = V_{OUT} = V_S/2$, 且 $R_L = 10\text{k}\Omega$ 连接至 $V_S/2$, 其他情况另做说明。

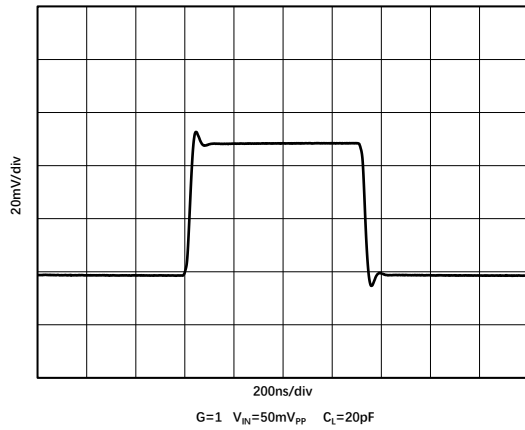


图 1.9.1. 小信号阶跃响应 @ $V_S = 5\text{V}$

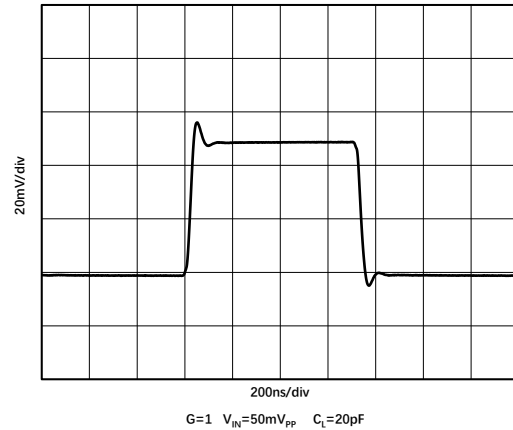


图 1.9.2. 小信号阶跃响应 @ $V_S = 1.7\text{V}$

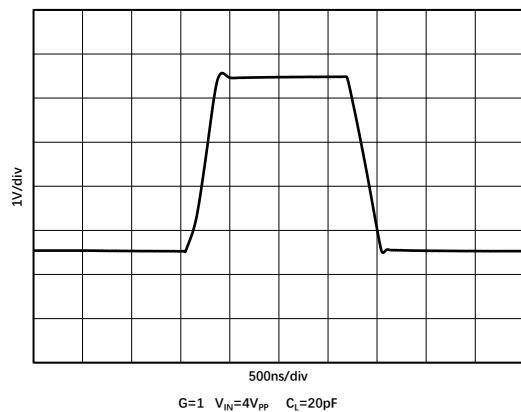


图 1.9.3. 大信号阶跃响应 @ $V_S = 5\text{V}$

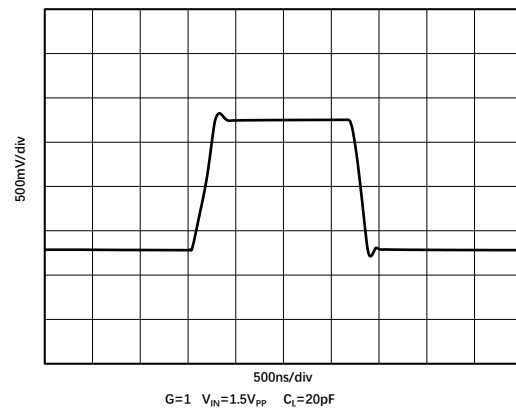


图 1.9.4. 大信号阶跃响应 @ $V_S = 1.7\text{V}$

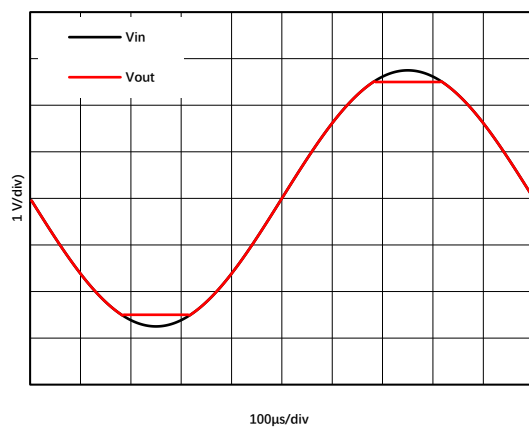


图 1.9.5. 无相位翻转

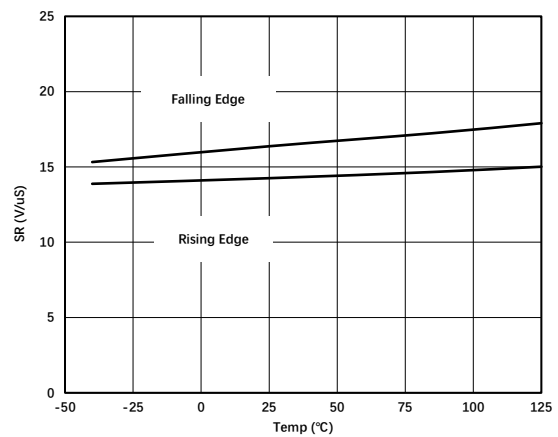


图 1.9.6. 压摆率 vs 温度

1.9 动态特征曲线 Typical Dynamic Characteristics (continue)

$T_A = 25^\circ\text{C}$, $V_S = 5\text{V}$, $V_{CM} = V_{OUT} = V_S/2$, 且 $R_L = 10\text{k}\Omega$ 连接至 $V_S/2$, 其他情况另做说明。

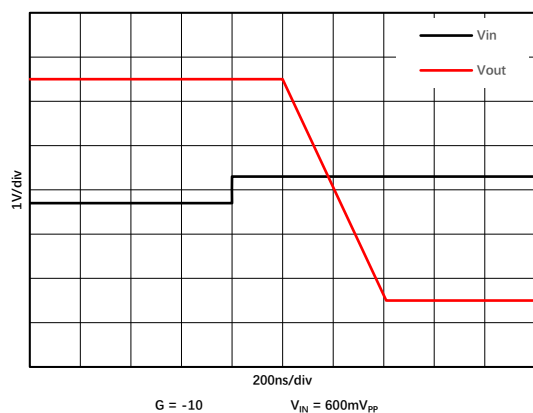


图 1.9.7. 正过载恢复

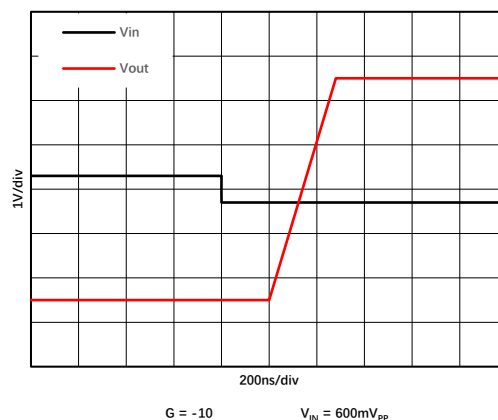


图 1.9.8. 负过载恢复

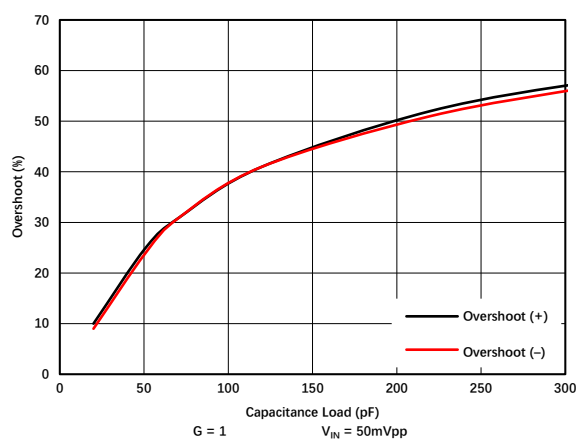


图 1.9.9. 小信号过冲与容性负载

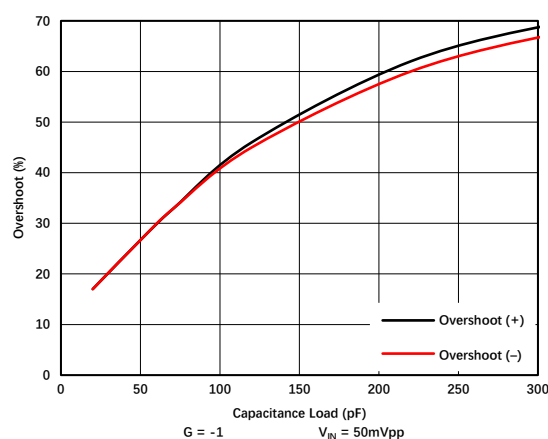
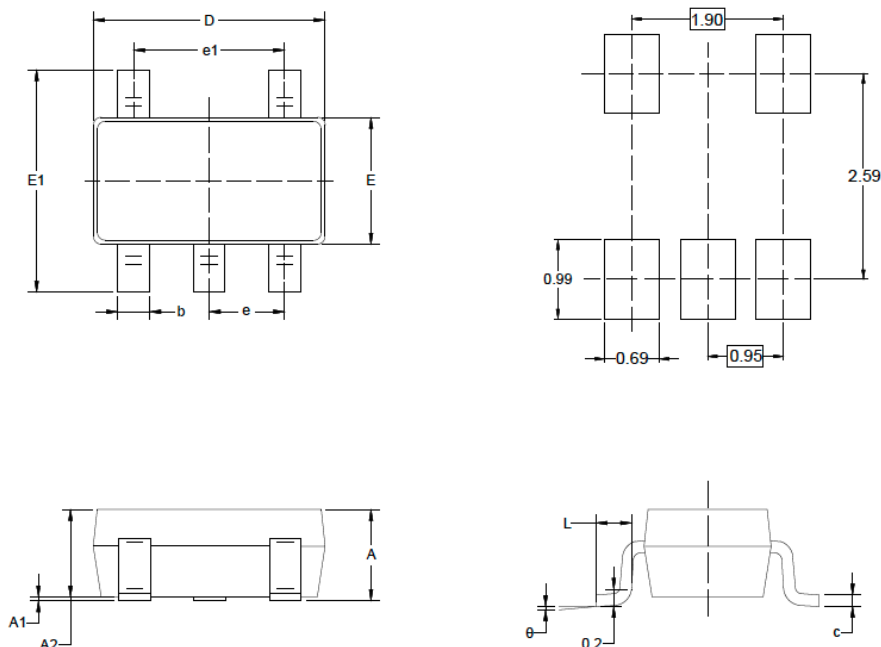


图 1.9.10. 小信号过冲与容性负载

2 封装外形尺寸 Package Outline Dimensions

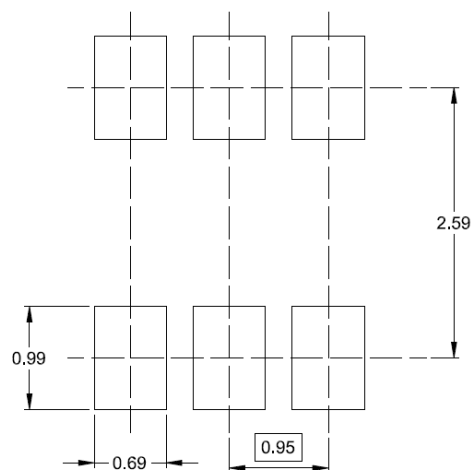
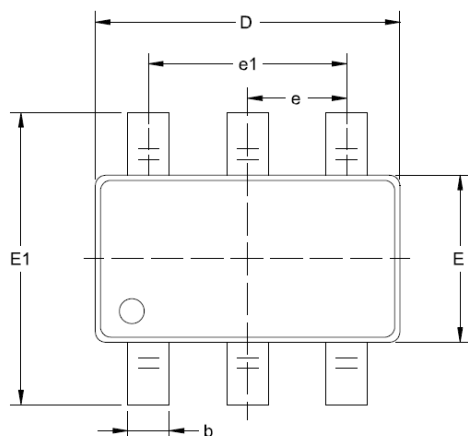
SOT23-5



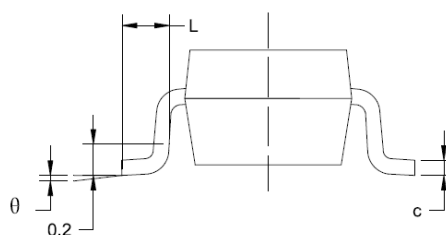
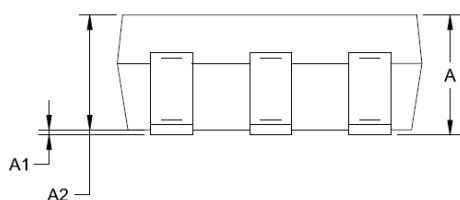
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037 BSC	
e1	1.900 BSC		0.075 BSC	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

2 封装外形尺寸 Package Outline Dimensions (continued)

SOT23-6



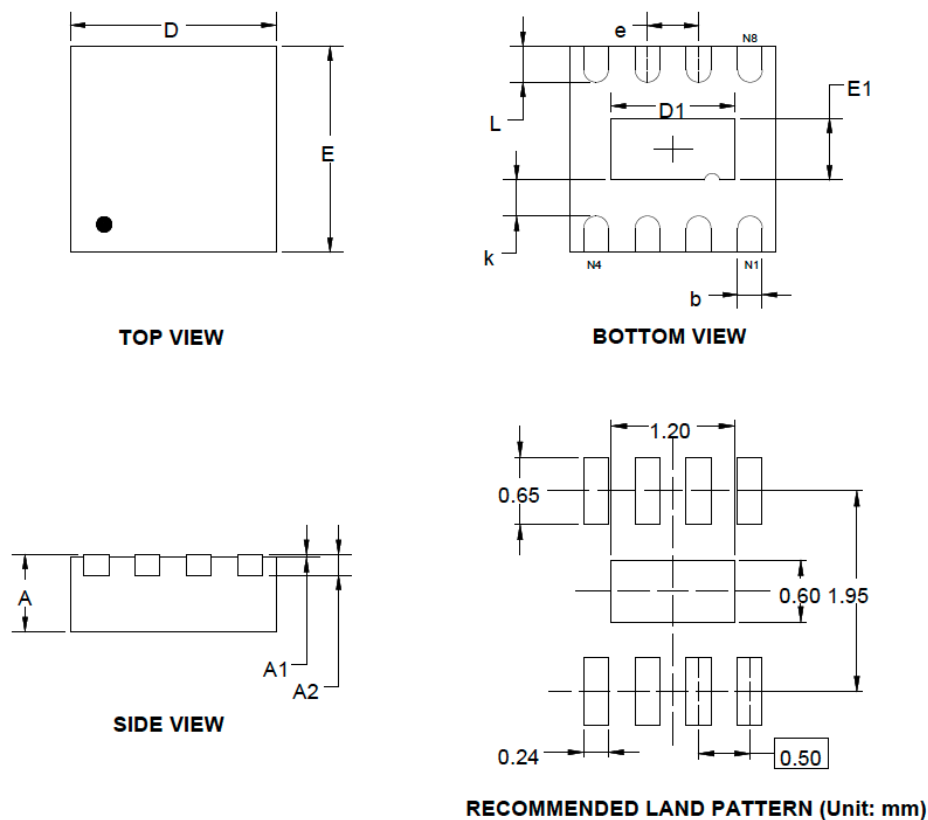
RECOMMENDED LAND PATTERN (Unit: mm)



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
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037 BSC	
e1	1.900 BSC		0.075 BSC	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

2 封装外形尺寸 Package Outline Dimensions (continued)

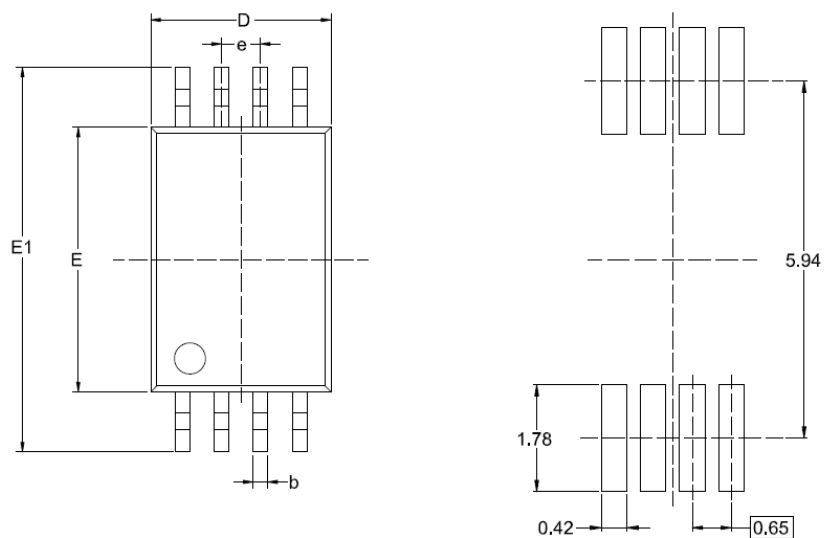
DFN-2×2-8L



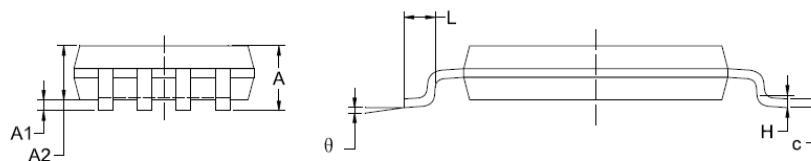
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	1.900	2.100	0.075	0.083
D1	1.100	1.300	0.043	0.051
E	1.900	2.100	0.075	0.083
E1	0.500	0.700	0.020	0.028
k	0.200 MIN		0.008 MIN	
b	0.180	0.300	0.007	0.012
e	0.500 TYP		0.020 TYP	
L	0.250	0.450	0.010	0.018

2 封装外形尺寸 Package Outline Dimensions (continued)

TSSOP8



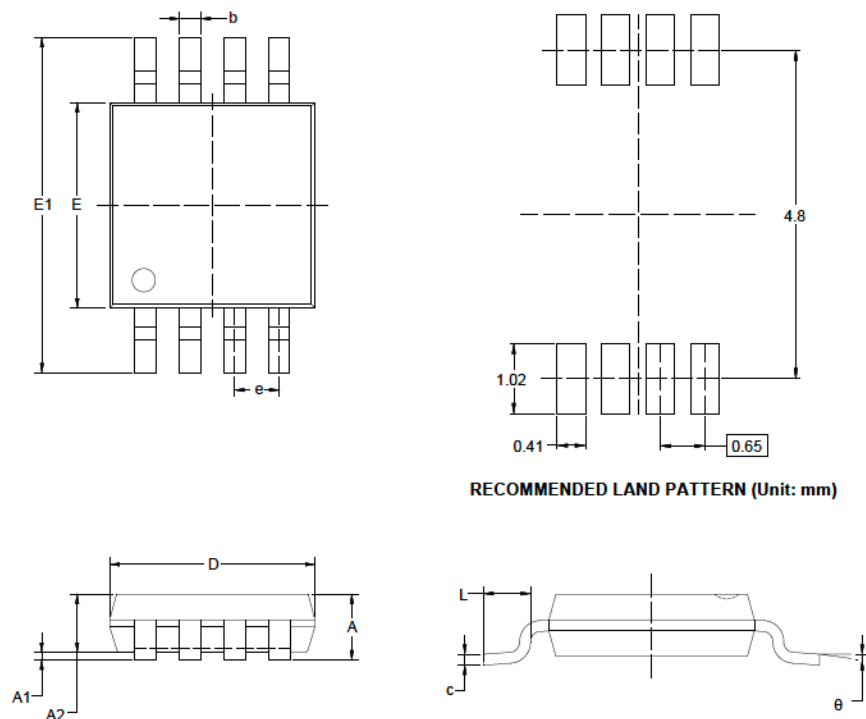
RECOMMENDED LAND PATTERN (Unit: mm)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A		1.100		0.043
A1	0.050	0.150	0.002	0.006
A2	0.800	1.000	0.031	0.039
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	2.900	3.100	0.114	0.122
E	4.300	4.500	0.169	0.177
E1	6.300	6.500	0.248	0.256
e	0.650 BSC		0.026 BSC	
L	0.500	0.700	0.02	0.028
H	0.25 TYP		0.01 TYP	
θ	1°	7°	1°	7°

2 封装外形尺寸 Package Outline Dimensions (continued)

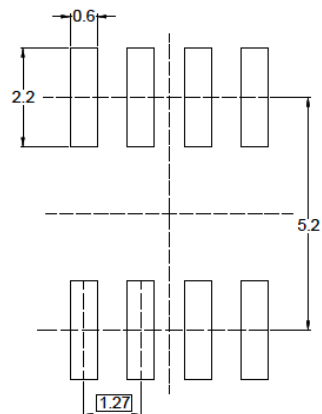
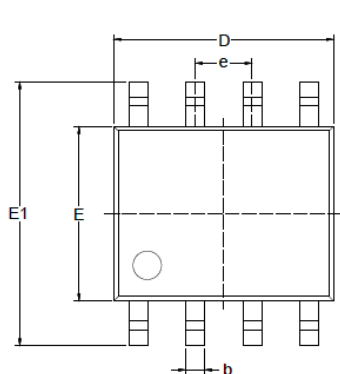
MSOP8



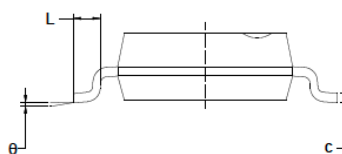
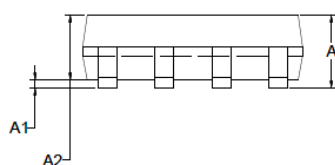
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026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

3 封装外形尺寸 Package Outline Dimensions (continued)

SOP8



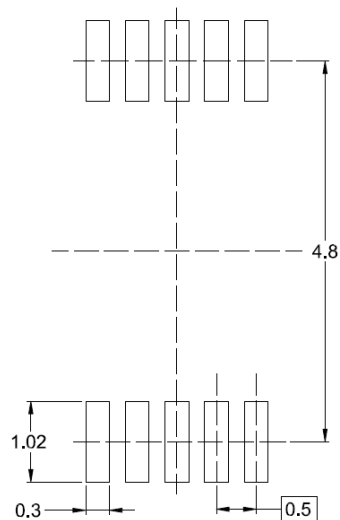
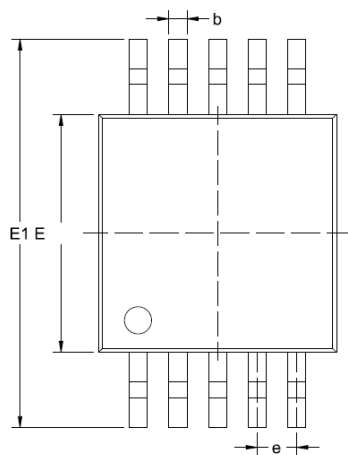
RECOMMENDED LAND PATTERN (Unit: mm)



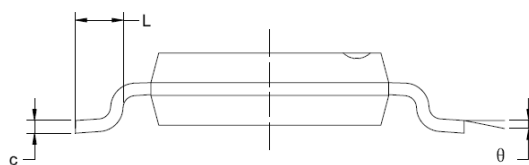
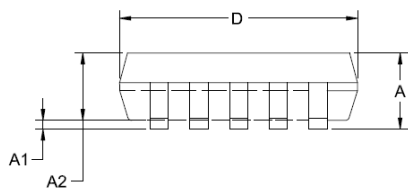
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

2 封装外形尺寸 Package Outline Dimensions (continued)

MSOP10



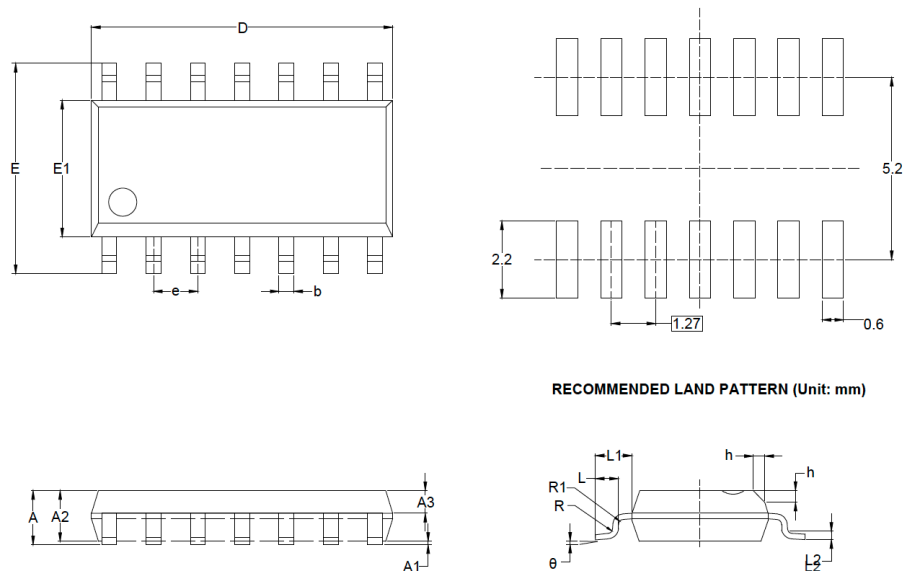
RECOMMENDED LAND PATTERN (Unit: mm)



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	0.180	0.280	0.007	0.011
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.500 BSC		0.020 BSC	
L	0.400	0.800	0.016	0.031
θ	0°	6°	0°	6°

2 封装外形尺寸 Package Outline Dimensions (continued)

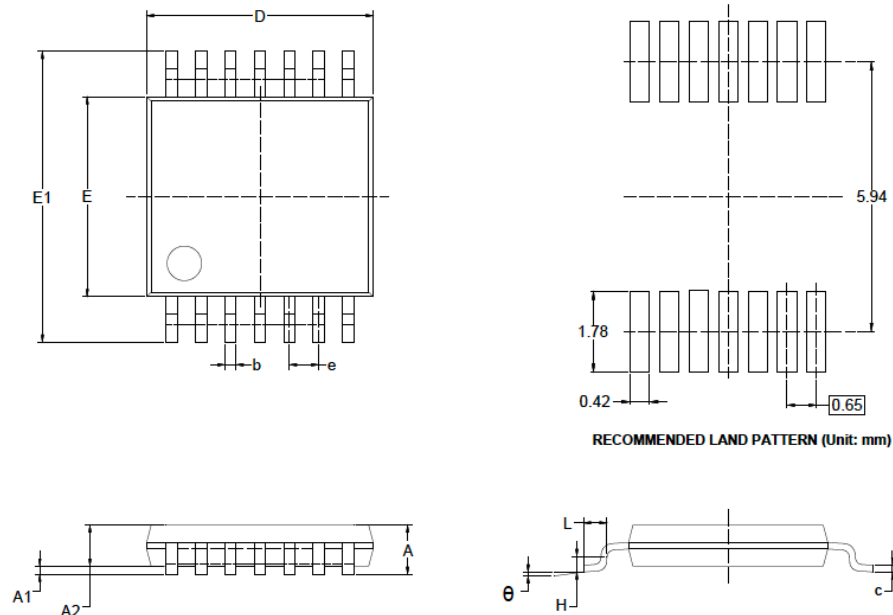
SOP14



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
A2	1.25	1.65	0.049	0.065
A3	0.55	0.75	0.022	0.030
b	0.36	0.49	0.014	0.019
D	8.53	8.73	0.336	0.344
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
L	0.45	0.80	0.018	0.032
L1	1.04 REF		0.040 REF	
L2	0.25 BSC		0.01 BSC	
R	0.07		0.003	
R1	0.07		0.003	
h	0.30	0.50	0.012	0.020
θ	0°	8°	0°	8°

2 封装外形尺寸 Package Outline Dimensions (continued)

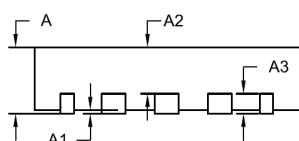
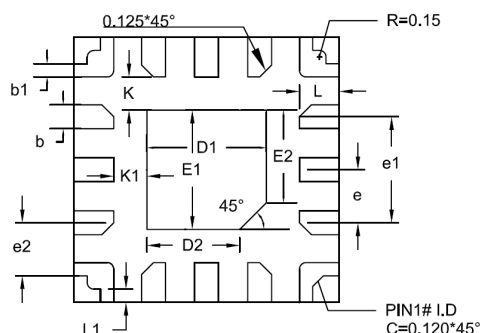
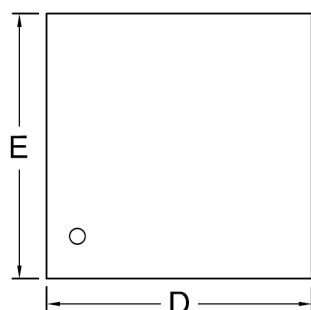
TSSOP14



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	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.860	5.100	0.191	0.310
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650 BSC		0.026 BSC	
L	0.500	0.700	0.02	0.028
H	0.25 TYP		0.01 TYP	
θ	1°	7°	1°	7°

2 封装外形尺寸 Package Outline Dimensions (continued)

QFN2x2-16L



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.50	0.60	0.020	0.024
A1	0.000	0.05	0.000	0.002
A2	0.4TYP		0.016 TYP	
A3	0.152TYP		0.006 TYP	
D	1.95	2.05	0.077	0.081
D1	0.85	0.95	0.033	0.037
D2	0.70TYP		0.028 TYP	
E	1.95	2.05	0.077	0.081
E1	0.85	0.95	0.033	0.037
E2	0.70TYP		0.028 TYP	
e	0.40BSC		0.016 BSC	
e1	0.80BSC		0.031 BSC	
e2	0.40BSC		0.016 BSC	
L	0.25	0.35	0.010	0.014
L1	0.10TYP		0.004 TYP	
b	0.13	0.23	0.005	0.009
b1	0.10TYP		0.004 TYP	
k	0.25BSC		0.010 BSC	
k1	0.25BSC		0.010 BSC	