



**TS1851**  
**TS1852**  
**TS1854**

# 1.8V INPUT/OUTPUT RAIL TO RAIL LOW POWER OPERATIONAL AMPLIFIERS

- OPERATING AT  $V_{CC} = 1.8V$  to  $6V$
- RAIL TO RAIL INPUT & OUTPUT
- EXTENDED  $V_{icm}$  ( $V_{ee} - 0.2V$  to  $V_{CC} + 0.2V$ )
- LOW SUPPLY CURRENT ( $120\mu A$ )
- GAIN BANDWIDTH PRODUCT ( $480kHz$ )
- HIGH STABILITY (able to drive  $500pF$ )
- ESD TOLERANCE ( $2kV$ )
- LATCH-UP IMMUNITY
- AVAILABLE IN SOT23-5 MICROPACKAGE

## DESCRIPTION

The TS185x (Single, Dual & Quad) is operational amplifier able to operate with voltages as low as 1.8V and features both Input and Output Rail to Rail ( $1.71 @ V_{CC} = 1.8V, R_L = 2k\Omega$ ),  $120\mu A$  consumption current and  $480kHz$  Gain Bandwidth Product.

With a such low consumption and a sufficient GBP for many applications, this Op-Amp is very well-suited for any kind of battery-supplied and portable equipment applications.

The TS1851 is housed in the space-saving 5 pin SOT23-5 package which simplifies the board design (outside dimensions are  $2.8mm \times 2.9mm$ ).

## APPLICATION

- Two-cell battery-powered systems
- Portable/Battery-powered electronic equipment
- Cordless phones
- Cellular phones
- Laptops
- PDAs

## ORDER CODE

Part Number	Temperature Range	Package					SOT23 Marking
		N	D	P	L	S	
TS1851/AI	-40, +125°C		•		•		K161/K162
TS1852/AI		•	•	•		•	
TS1854/AI		•	•	•			

S = Small Outline Package (miniSO) - only available in Tape & Reel (ST)

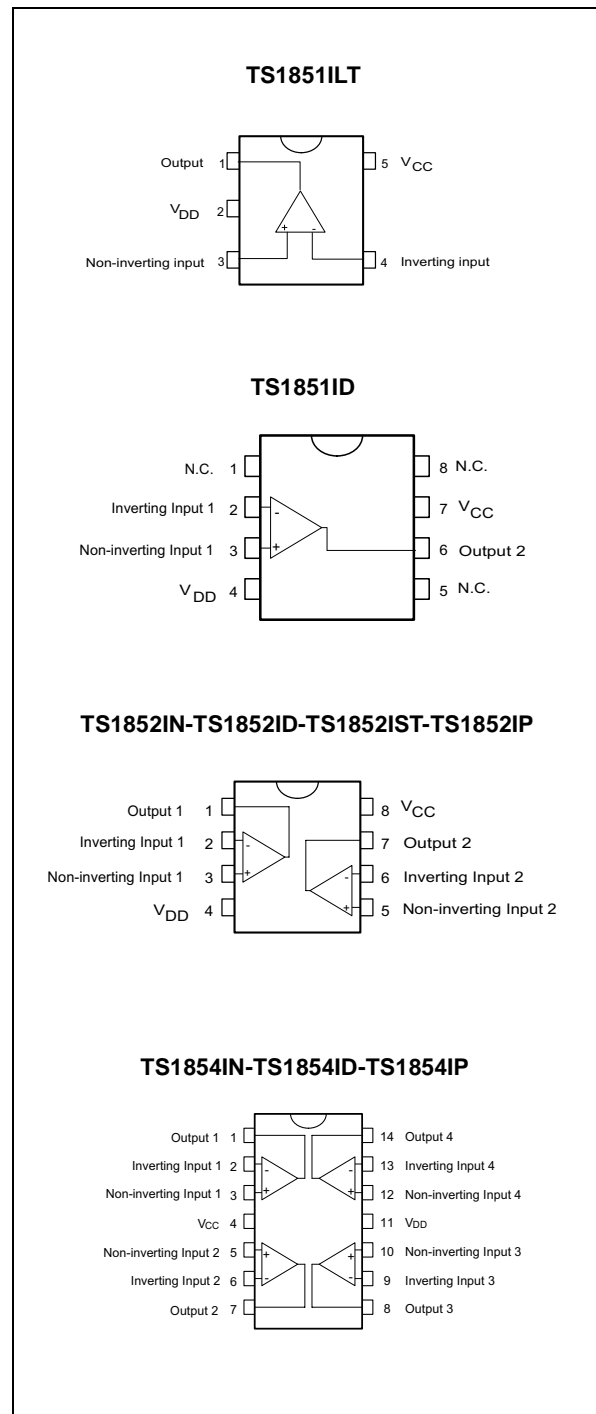
N = Dual in Line Package (DIP)

D = Small Outline Package (SO) - also available in Tape & Reel (DT)

P = Thin Shrink Small Outline Package (TSSOP) - only available in Tape & Reel (PT)

L = Tiny Package (SOT23-5) - only available in Tape & Reel (LT)

## PIN CONNECTIONS (top view)



**ABSOLUTE MAXIMUM RATINGS**

Symbol	Parameter	Value	Unit
$V_{CC}$	Supply voltage <sup>1)</sup>	7	V
$V_{id}$	Differential Input Voltage <sup>2)</sup>	$\pm 1$	V
$V_i$	Input Voltage <sup>3)</sup>	-0.3 to $V_{CC} + 0.3$	V
$T_{oper}$	Operating Free Air Temperature Range	-40 to + 125	°C
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_j$	Maximum Junction Temperature	150	°C
$R_{thjc}$	Thermal Resistance Junction to Case <sup>4)</sup>		°C/W
	SOT23-5	81	
	DIP8	41	
	DIP14	33	
	miniSO8	39	
	SO8	40	
	SO14	31	
$R_{thja}$	TSSOP8	37	
	TSSOP14	32	
$R_{thja}$	Thermal Resistance Junction to Ambient - SOT23-5	256	°C/W
ESD	Human Body Model	2	kV
	Lead Temperature (soldering, 10sec)	250	°C

1. All voltages values, except differential voltage are with respect to network terminal.
2. Differential voltages are non-inverting input terminal with respect to the inverting input terminal.
3. The magnitude of input and output voltages must never exceed  $V_{CC} + 0.3V$ .
4. Short-circuits can cause excessive heating. Destructive dissipation can result from simultaneous short-circuit on all amplifiers

**OPERATING CONDITIONS**

Symbol	Parameter	Value	Unit
$V_{CC}$	Supply Voltage	1.8 to 6	V
$V_{icm}$	Common Mode Input Voltage Range <sup>1)</sup>	$V_{ee} - 0.2$ to $V_{CC} + 0.2$	V
$V_{icm}$	Common Mode Input Voltage Range <sup>2)</sup>	$V_{ee}$ to $V_{CC}$	V

1. At 25°C, for  $1.8 \leq V_{CC} \leq 6V$ ,  $V_{icm}$  is extended to  $V_{ee} - 0.2V$ ,  $V_{CC} + 0.2V$ .
2. In full temperature range, both Rails can be reached when  $V_{CC}$  does not exceed 5.5V.

**ELECTRICAL CHARACTERISTICS** $V_{CC} = +1.8V$ ,  $V_{ee} = 0V$ ,  $T_{amb} = 25^{\circ}C$  (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{io}$	Input Offset Voltage TS1851/2/4 TS1851A/2A/4A		0.1	3 1	mV
$\Delta V_{io}$	Input Offset Voltage Drift		2		$\mu V/^{\circ}C$
$I_{io}$	Input Offset Current <sup>1)</sup>		1	9	nA
$I_{ib}$	Input Bias Current <sup>1)</sup>		10	50	nA
CMR	Common Mode Rejection Ratio $0 \leq V_{icm} \leq V_{CC}$	55	85		dB
SVR	Supply Voltage Rejection Ratio $V_{icm} = 0.5V$	70	80		dB
$A_{vd}$	Large Signal Voltage Gain $R_L = 10k\Omega$ $R_L = 2k\Omega$	80 70	100 88		dB
$V_{OH}$	High Level Output Voltage $R_L = 10k\Omega$ $R_L = 2k\Omega$	1.7 1.65	1.77 1.7		V
$V_{OL}$	Low Level Output Voltage $R_L = 10k\Omega$ $R_L = 2k\Omega$		40 62	70 90	mV
$I_o$	Output Source Current $V_{ID} = 100mV$ , $V_O = V_{DD}$	2	29		mA
	Output Sink Current $V_{ID} = -100mV$ , $V_O = V_{CC}$	2	46		
$I_{CC}$	Supply Current (per amplifier) $A_{VCL} = 1$ , no load		120	170	$\mu A$
GBP	Gain Bandwidth Product $R_L = 10k\Omega$ , $C_L = 100pF$ , $f = 100kHz$	300	480		kHz
SR	Slew Rate $R_L = 10k\Omega$ , $C_L = 100pF$ , $AV = 1$	0.1	0.18		$V/\mu s$
$\phi_m$	Phase Margin $C_L = 100pF$		60		Degrees
en	Input Voltage Noise		40		$nV/\sqrt{Hz}$
THD	Total Harmonic Distortion		0.01		%

1. Maximum values including unavoidable inaccuracies of the industrial test.

**ELECTRICAL CHARACTERISTICS**
 $V_{CC} = +3V$ ,  $V_{ee} = 0V$ ,  $T_{amb} = 25^{\circ}C$  (unless otherwise specified)

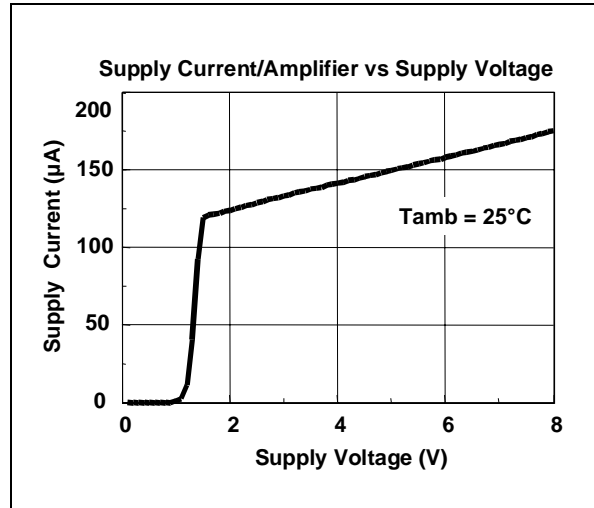
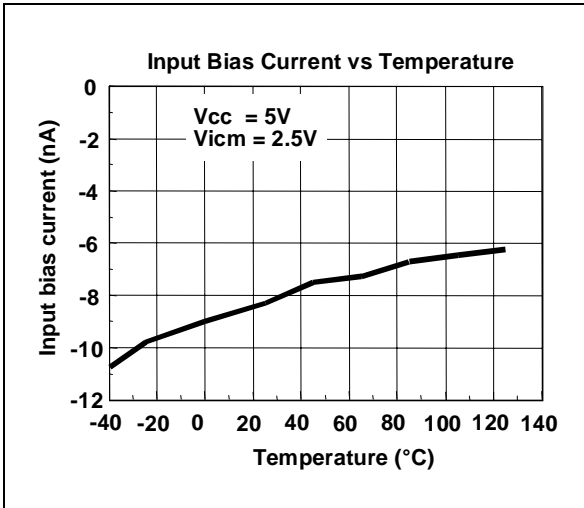
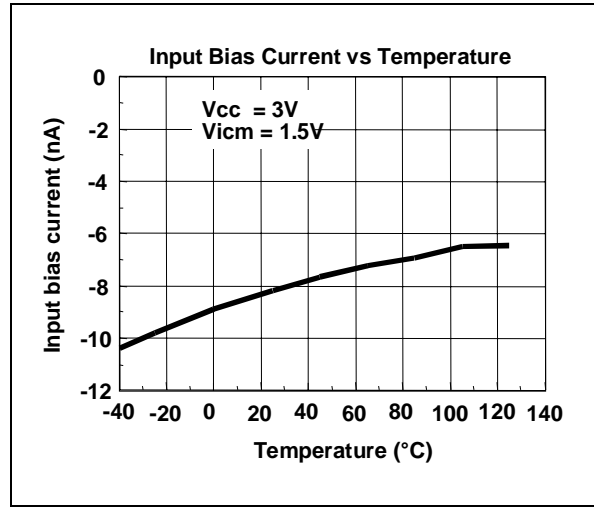
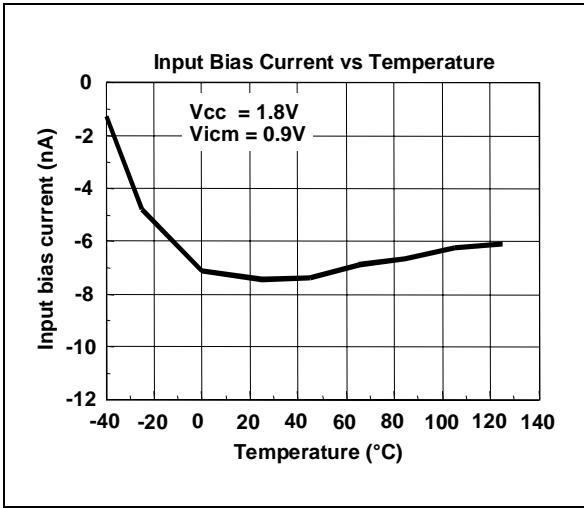
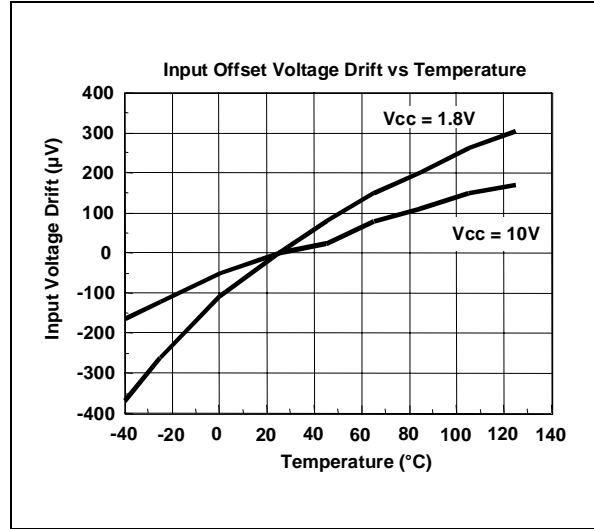
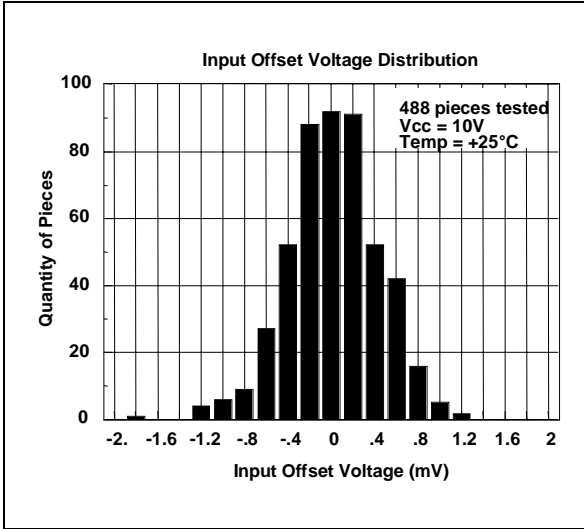
Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{io}$	Input Offset Voltage TS1851/2/4 TS1851A/2A/4A		0.1	3 1	mV
$\Delta V_{io}$	Input Offset Voltage Drift		2		$\mu V/^{\circ}C$
$I_{io}$	Input Offset Current <sup>1)</sup>		1	9	nA
$I_{ib}$	Input Bias Current <sup>1)</sup>		10	55	nA
CMR	Common Mode Rejection Ratio $0 \leq V_{icm} \leq V_{CC}$	60	90		dB
SVR	Supply Voltage Rejection Ratio $V_{icm} = V_{CC}/2$	70	85		dB
$A_{vd}$	Large Signal Voltage Gain $R_L = 10k\Omega$ $R_L = 2k\Omega$	83 74	99 90		dB
$V_{OH}$	High Level Output Voltage $R_L = 10k\Omega$ $R_L = 2k\Omega$	2.9 2.85	2.96 2.94		V
$V_{OL}$	Low Level Output Voltage $R_L = 10k\Omega$ $R_L = 2k\Omega$		10 46	90 100	mV
$I_o$	Output Source Current $V_{ID} = 100mV$ , $V_O = V_{DD}$	2	47		mA
	Output Sink Current $V_{ID} = -100mV$ , $V_O = V_{CC}$	2	47		
$I_{CC}$	Supply Current (per amplifier) $A_{VCL} = 1$ , no load		150	200	$\mu A$
GBP	Gain Bandwidth Product $R_L = 10k\Omega$ , $C_L = 100pF$ , $f = 100kHz$	370	600		kHz
SR	Slew Rate $R_L = 10k\Omega$ , $C_L = 100pF$ , $AV = 1$	0.12	0.2		V/ $\mu s$
$\phi_m$	Phase Margin $C_L = 100pF$		60		Degrees
en	Input Voltage Noise		40		nV/ $\sqrt{Hz}$
THD	Total Harmonic Distortion		0.01		%

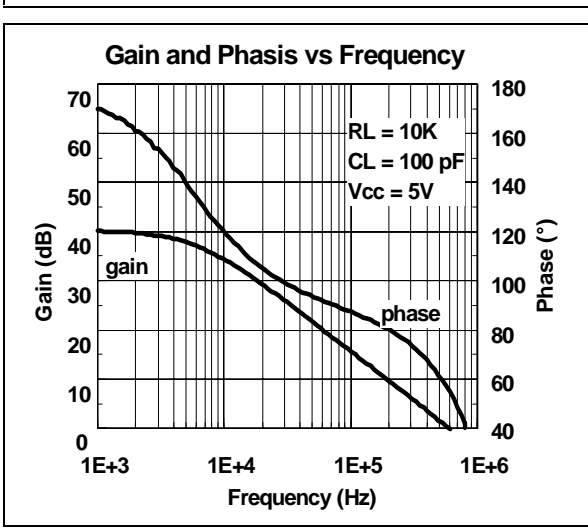
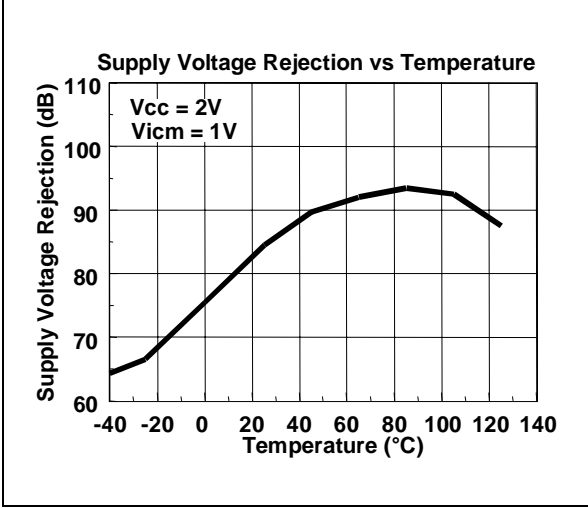
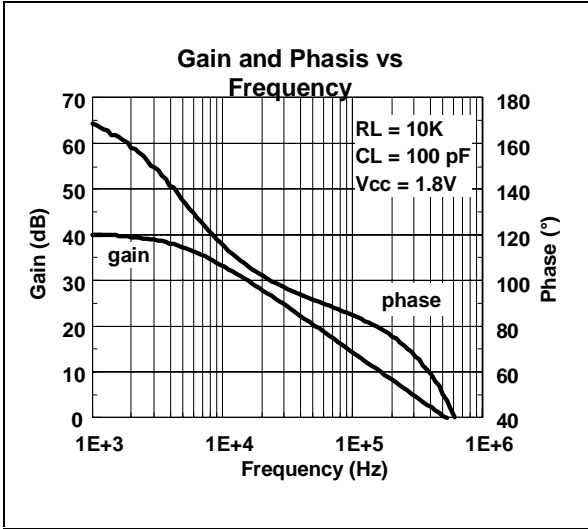
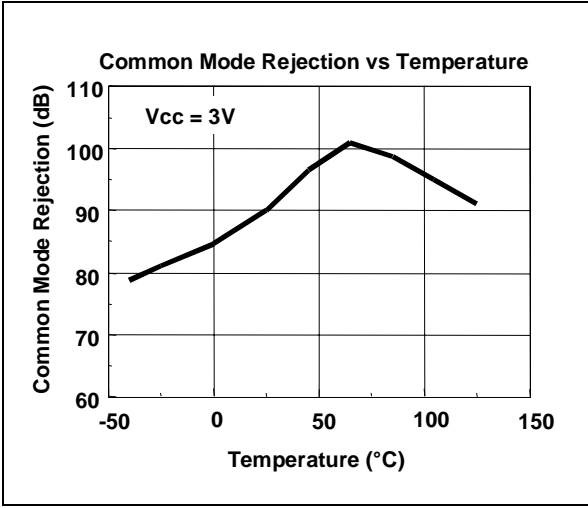
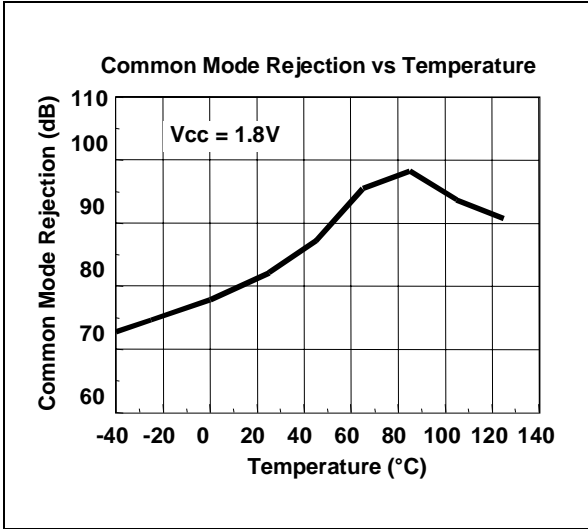
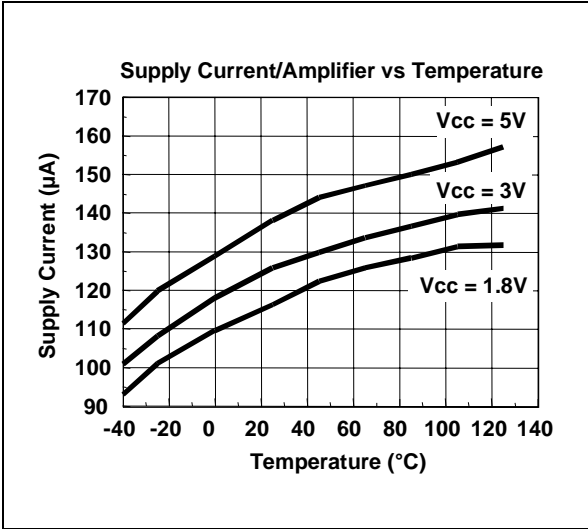
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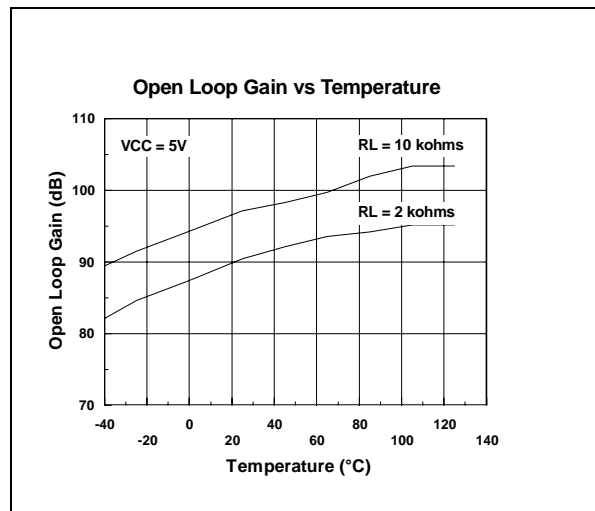
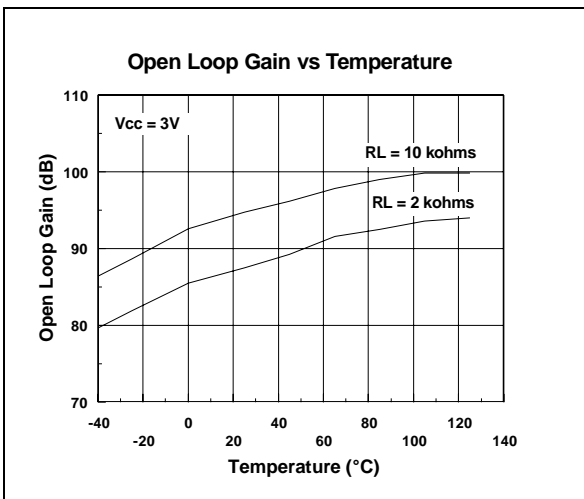
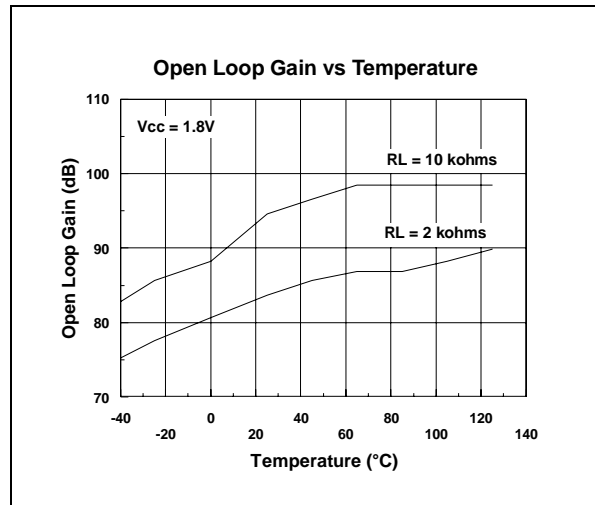
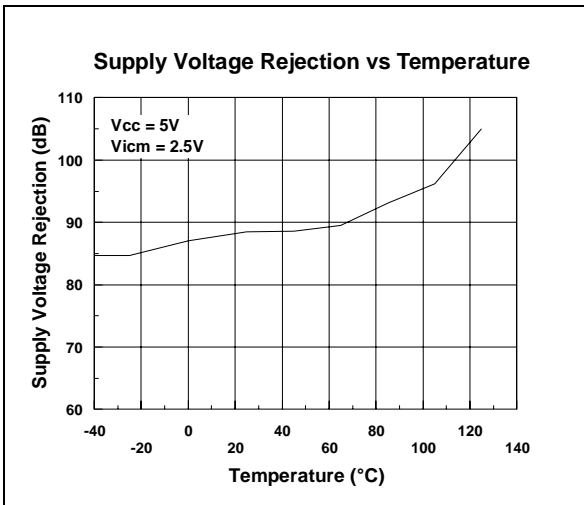
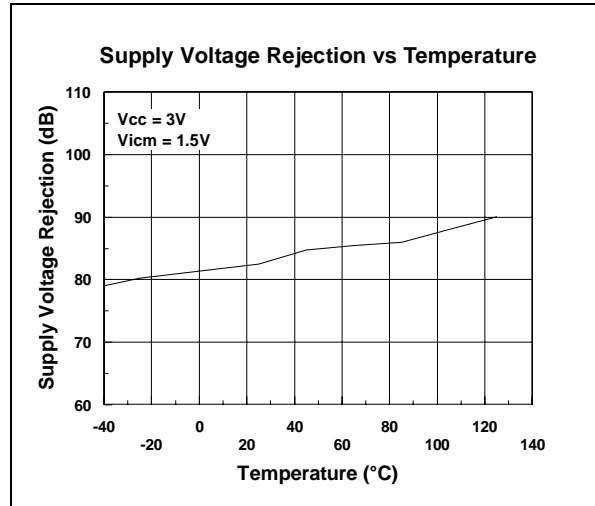
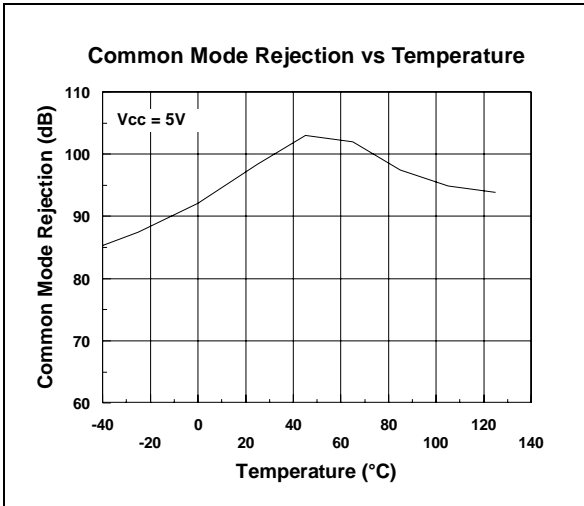
**ELECTRICAL CHARACTERISTICS** $V_{CC} = +5V$ ,  $V_{ee} = 0V$ ,  $T_{amb} = 25^{\circ}C$  (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{io}$	Input Offset Voltage TS1851/2/4 TS1851A/2A/4A		0.1	3 1	mV
$\Delta V_{io}$	Input Offset Voltage Drift		2		$\mu V/^{\circ}C$
$I_{io}$	Input Offset Current <sup>1)</sup>		1	9	nA
$I_{ib}$	Input Bias Current <sup>1)</sup>		16	63	nA
CMR	Common Mode Rejection Ratio $0 \leq V_{icm} \leq V_{CC}$	65	95		dB
SVR	Supply Voltage Rejection Ratio $V_{icm} = V_{CC}/2$	70	90		dB
$A_{vd}$	Large Signal Voltage Gain $R_L = 10k\Omega$ $R_L = 2k\Omega$	85 77	97 93		dB
$V_{OH}$	High Level Output Voltage $R_L = 10k\Omega$ $R_L = 2k\Omega$	4.85 4.8	4.95 4.91		V
$V_{OL}$	Low Level Output Voltage $R_L = 10k\Omega$ $R_L = 2k\Omega$		40 80	180 200	mV
$I_o$	Output Source Current $V_{ID} = 100mV$ , $V_O = V_{DD}$	2	48		mA
	Output Sink Current $V_{ID} = -100mV$ , $V_O = V_{CC}$	2	48		
$I_{CC}$	Supply Current (per amplifier) $A_{VCL} = 1$ , no load		162	220	$\mu A$
GBP	Gain Bandwidth Product $R_L = 10k\Omega$ , $C_L = 100pF$ , $f = 100kHz$	380	630		kHz
SR	Slew Rate $R_L = 10k\Omega$ , $C_L = 100pF$ , $AV = 1$	0.13	0.25		$V/\mu s$
$\phi_m$	Phase Margin $C_L = 100pF$		60		Degrees
en	Input Voltage Noise		40		$nV/\sqrt{Hz}$
THD	Total Harmonic Distortion		0.01		%

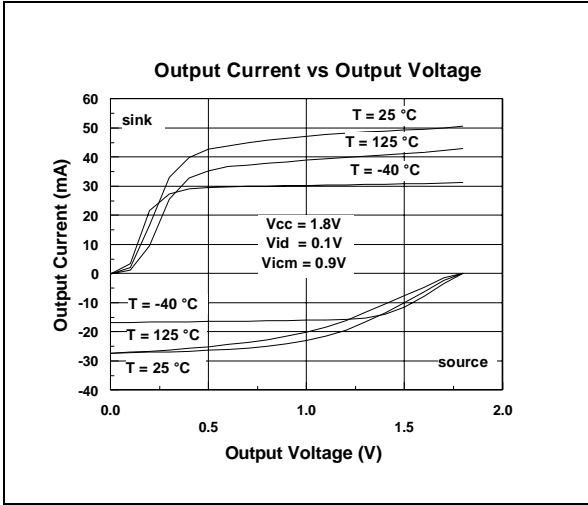
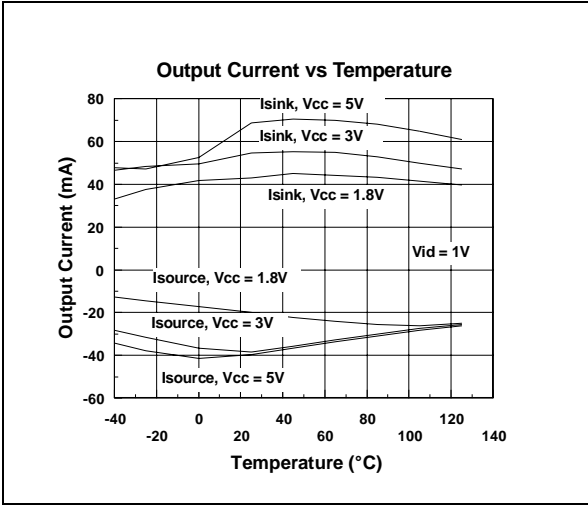
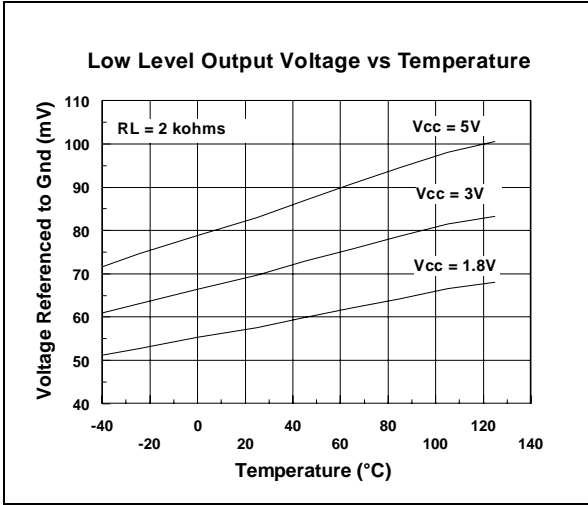
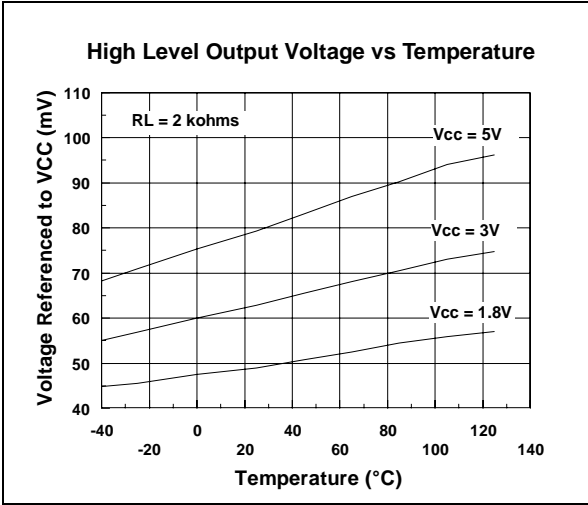
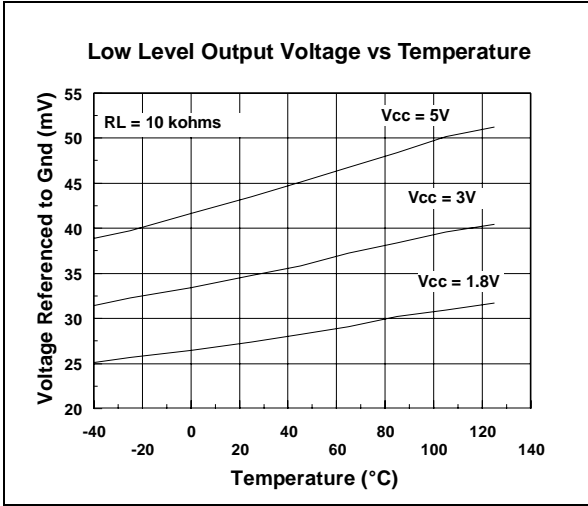
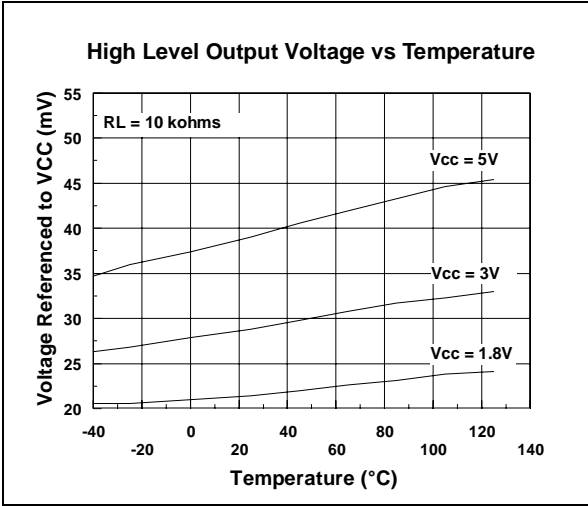
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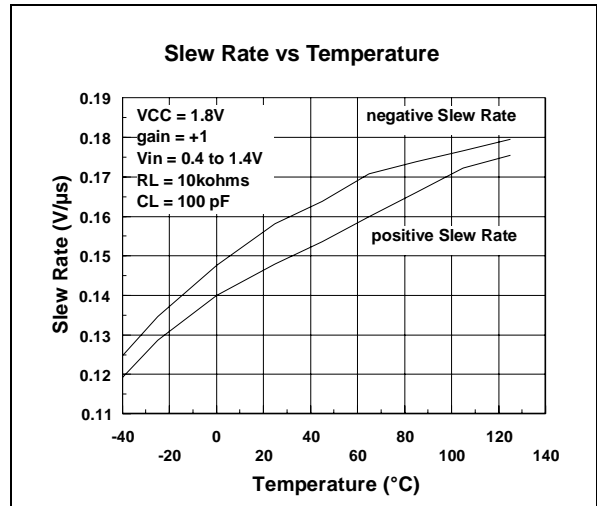
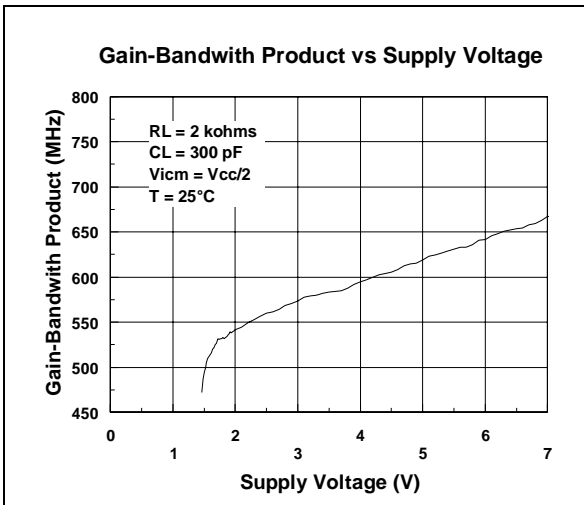
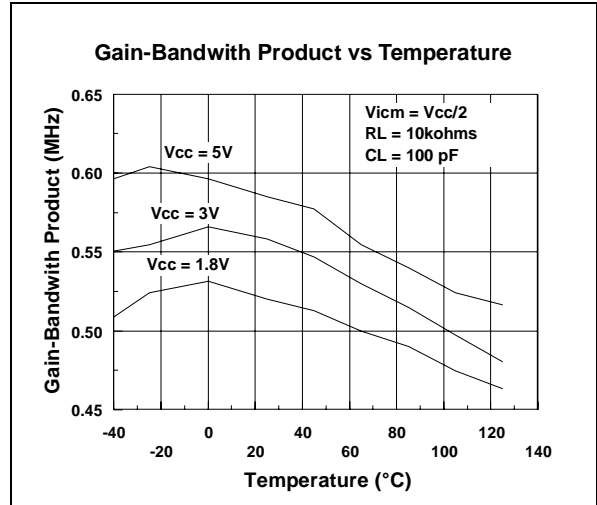
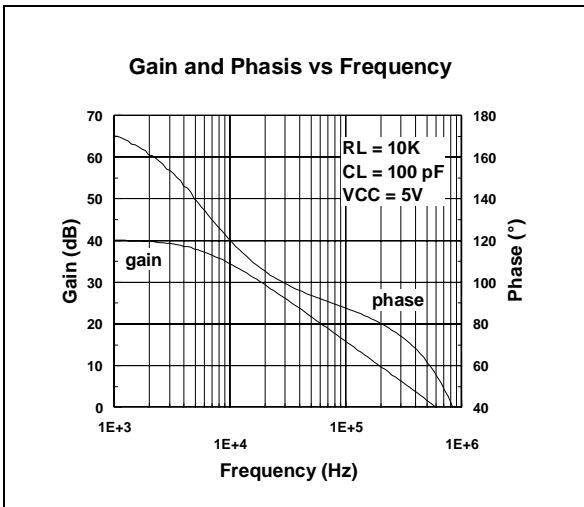
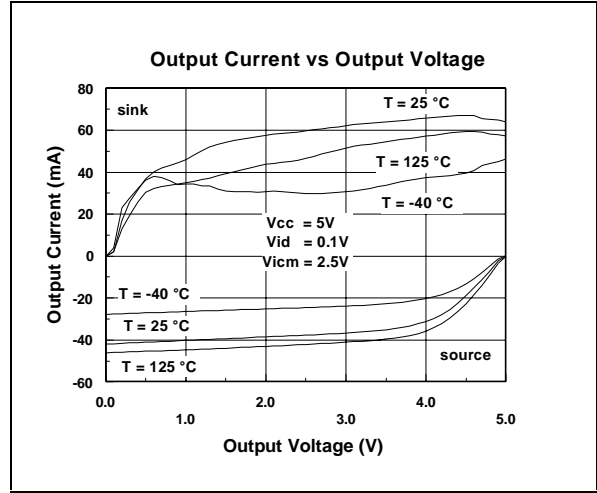
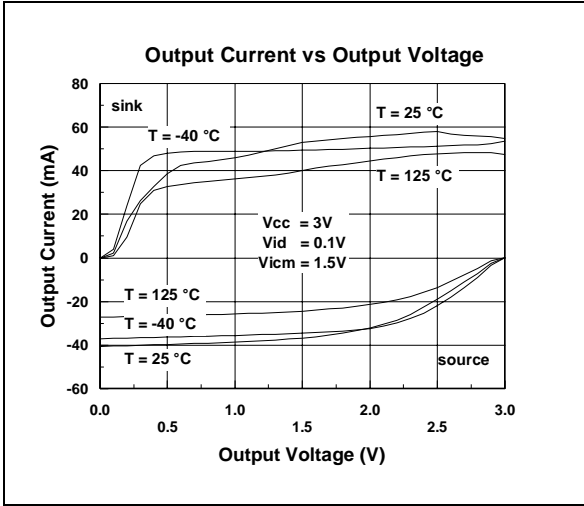


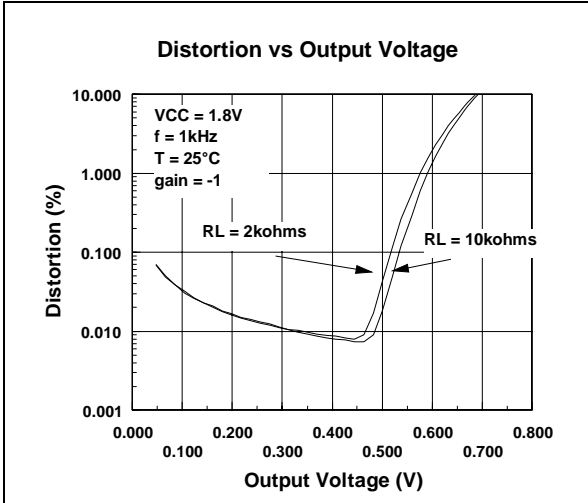
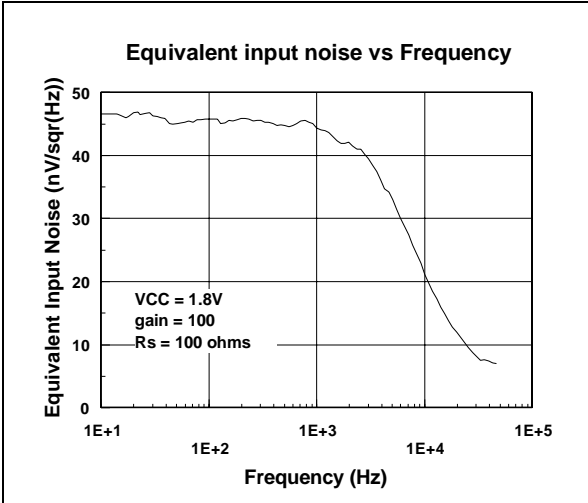
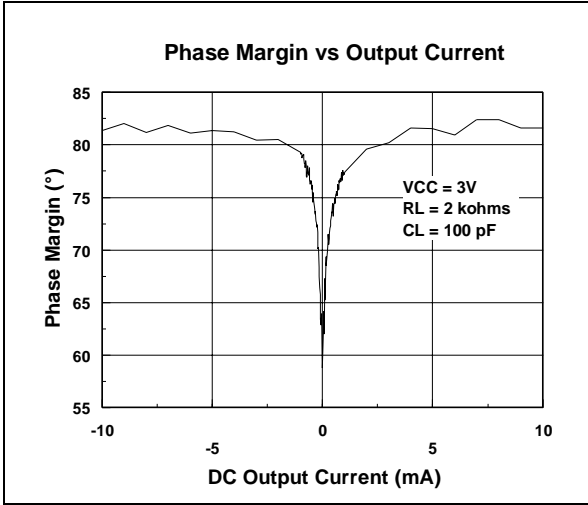
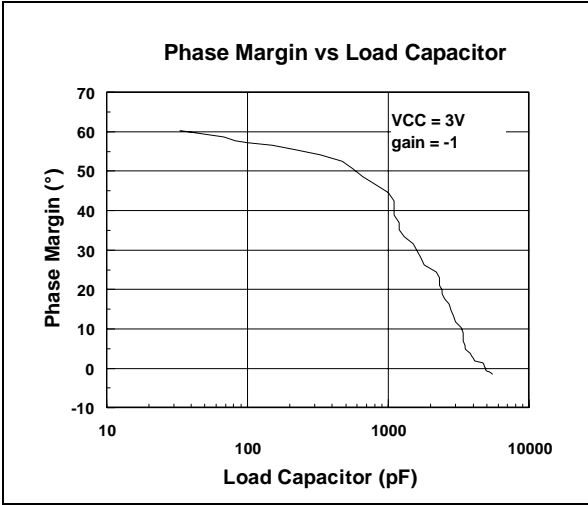
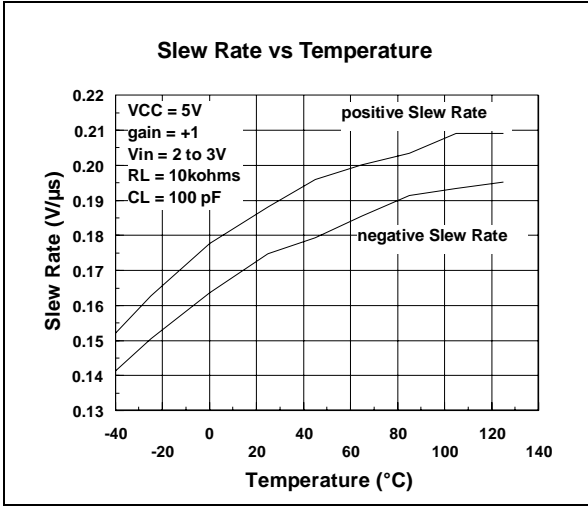
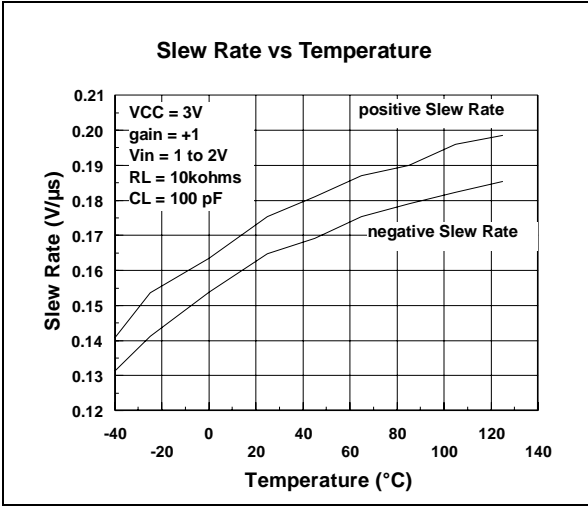


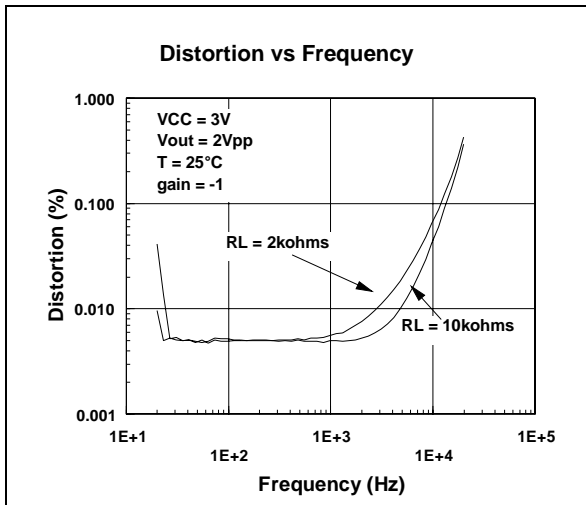
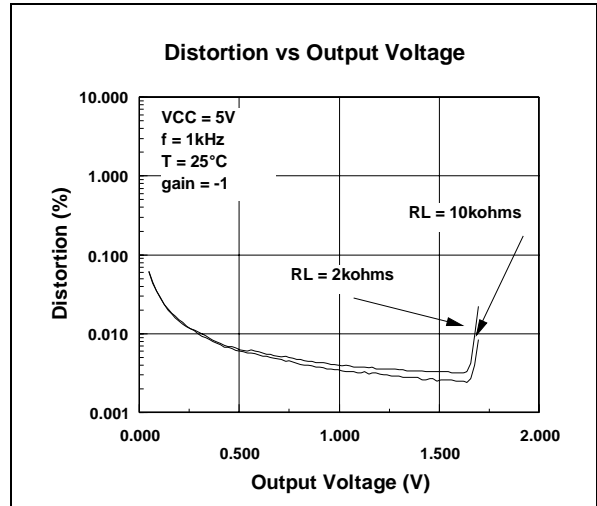
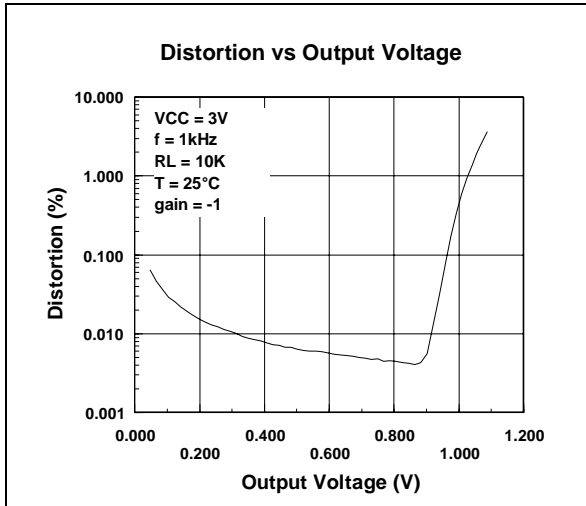




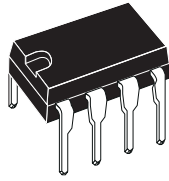




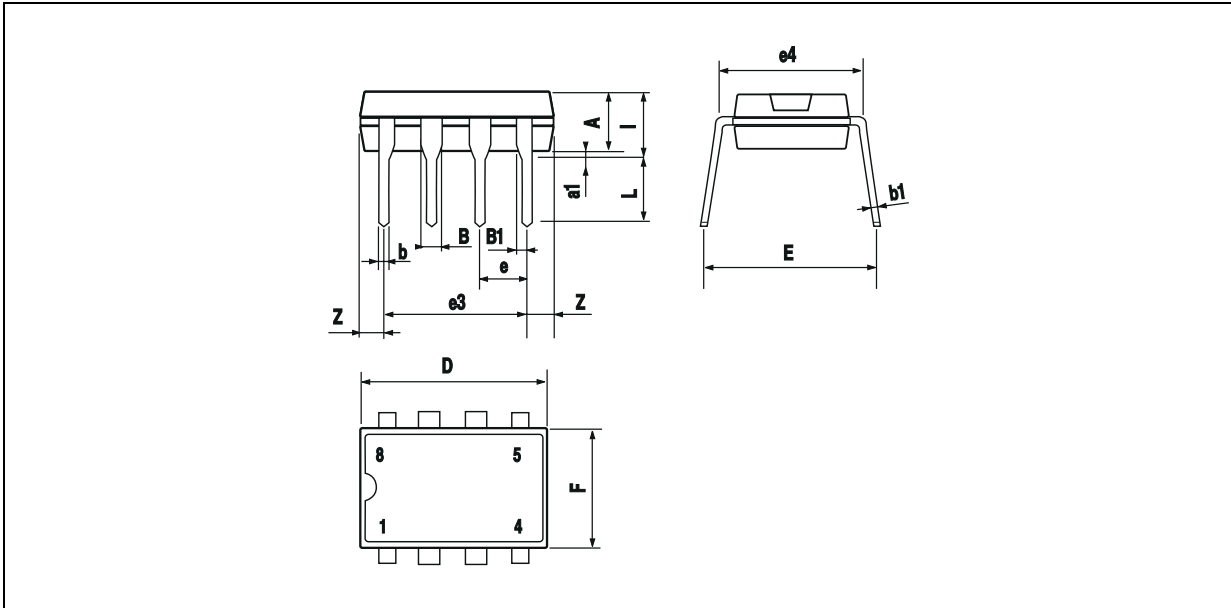




TS1852IN



**PACKAGE MECHANICAL DATA**  
8 PINS - PLASTIC DIP



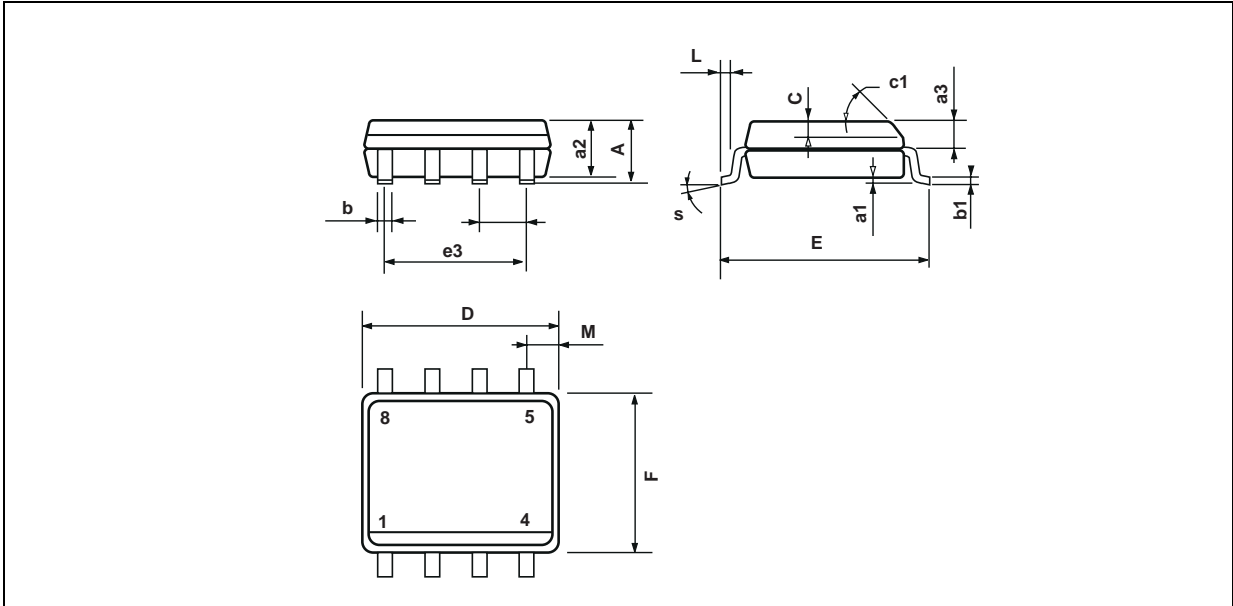
Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A		3.32			0.131	
a1	0.51			0.020		
B	1.15		1.65	0.045		0.065
b	0.356		0.55	0.014		0.022
b1	0.204		0.304	0.008		0.012
D			10.92			0.430
E	7.95		9.75	0.313		0.384
e		2.54			0.100	
e3		7.62			0.300	
e4		7.62			0.300	
F			6.6			0.260
i			5.08			0.200
L	3.18		3.81	0.125		0.150
Z			1.52			0.060

**TS1851-TS1852-TS1854**

**TS1851ID - TS1851AID - TS1852ID - TS1852AID**  
**TS1851IDT - TS1851AIDT - TS1852IDT TS1852AIDT**



**PACKAGE MECHANICAL DATA**  
**8 PINS - PLASTIC MICROPACKAGE (SO)**

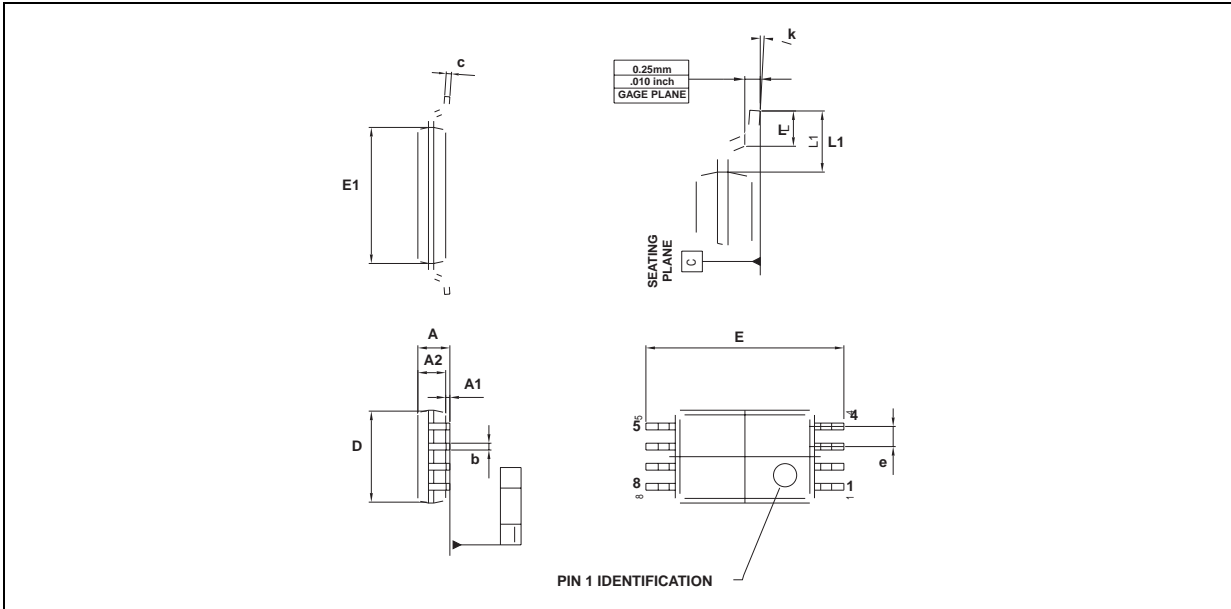


Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A		3.32			0.131	
a1	0.51			0.020		
B	1.15		1.65	0.045		0.065
b	0.356		0.55	0.014		0.022
b1	0.204		0.304	0.008		0.012
D			10.92			0.430
E	7.95		9.75	0.313		0.384
e		2.54			0.100	
e3		7.62			0.300	
e4		7.62			0.300	
F			6.6			0.260
i			5.08			0.200
L	3.18		3.81	0.125		0.150
Z			1.52			0.060

TS1851IP-TS1851AIP-TS1852IP-TS1852AIP -  
 TS1851IPT - TS1851AIPT - TS1852IPT - TS1852AIPT

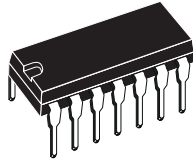


**PACKAGE MECHANICAL DATA**  
 8 PINS - THIN SHRINK SMALL OUTLINE PACKAGE



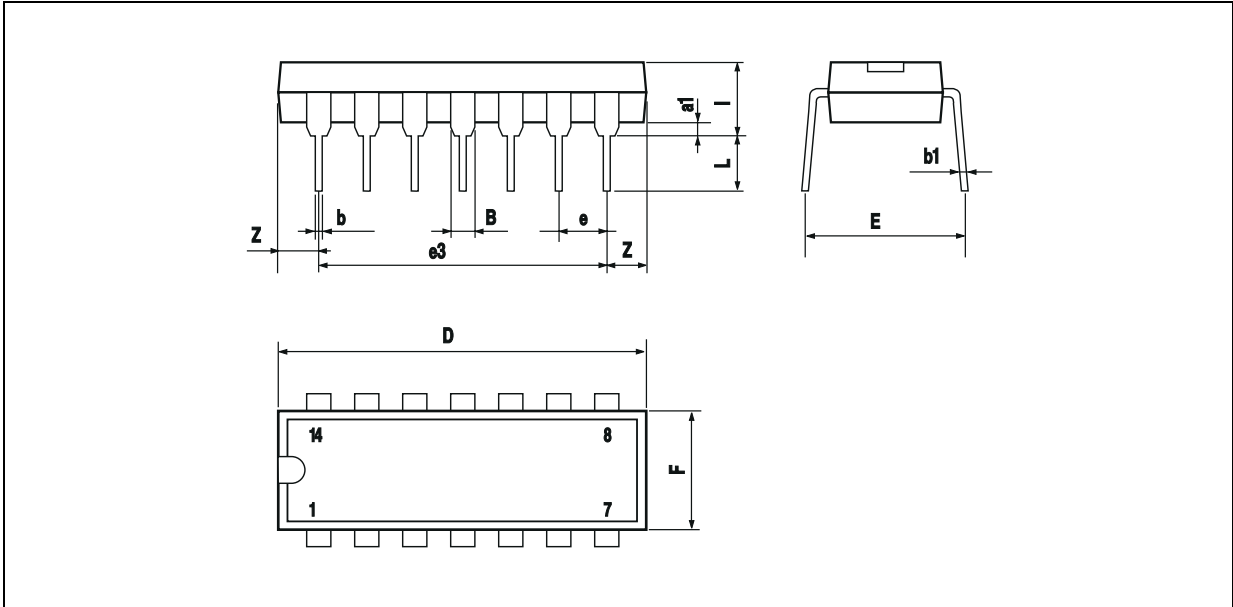
Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.05
A1	0.05		0.15	0.01		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.15
c	0.09		0.20	0.003		0.012
D	2.90	3.00	3.10	0.114	0.118	0.122
E		6.40			0.252	
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.025	
k	0°		8°	0°		8°
l	0.50	0.60	0.75	0.09	0.0236	0.030
L	0.45	0.600	0.75	0.018	0.024	0.030
L1		1.000			0.039	

TS1854IN



PACKAGE MECHANICAL DATA

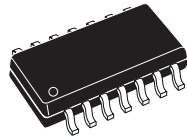
14 PINS - PLASTIC DIP



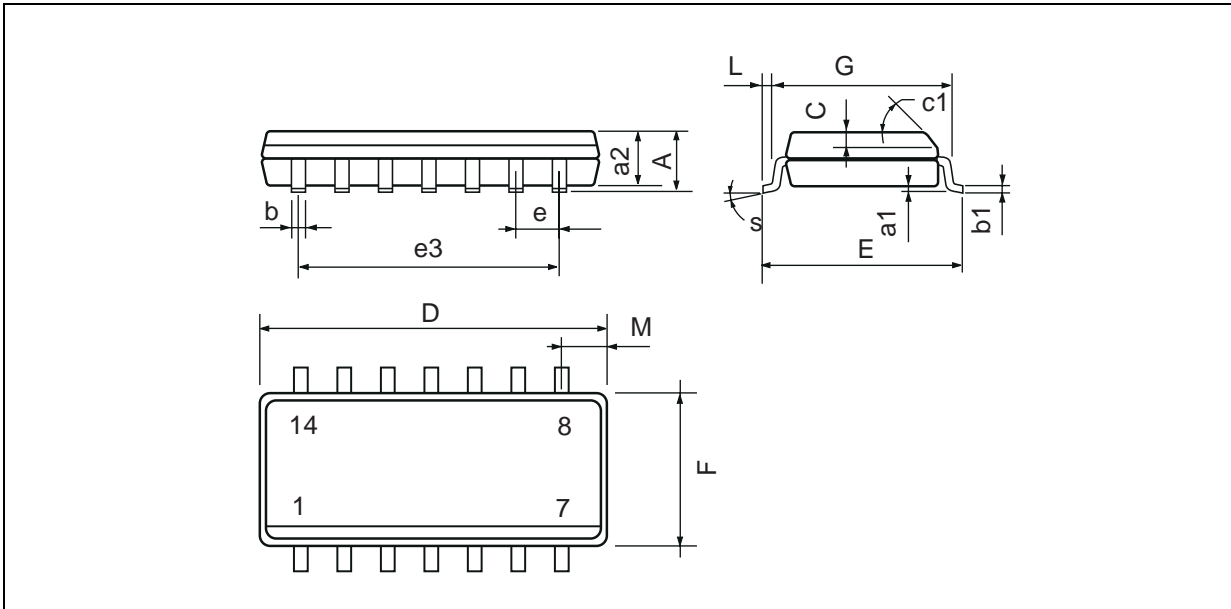
Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
a1	0.51			0.020		
B	1.39		1.65	0.055		0.065
b		0.5			0.020	
b1		0.25			0.010	
D			20			0.787
E		8.5			0.335	
e		2.54			0.100	
e3		15.24			0.600	
F			7.1			0.280
i			5.1			0.201
L		3.3			0.130	
Z	1.27		2.54	0.050		0.100



TS1854ID-TS1854AID-TS1854IDT-TS1854AIDT



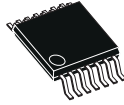
**PACKAGE MECHANICAL DATA**  
14 PINS - PLASTIC MICROPACKAGE (SO)



Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.2	0.004		0.008
a2			1.6			0.063
b	0.35		0.46	0.014		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.020	
c1	45° (typ.)					
D (1)	8.55		8.75	0.336		0.344
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		7.62			0.300	
F (1)	3.8		4.0	0.150		0.157
G	4.6		5.3	0.181		0.208
L	0.5		1.27	0.020		0.050
M			0.68			0.027
S	8° (max.)					

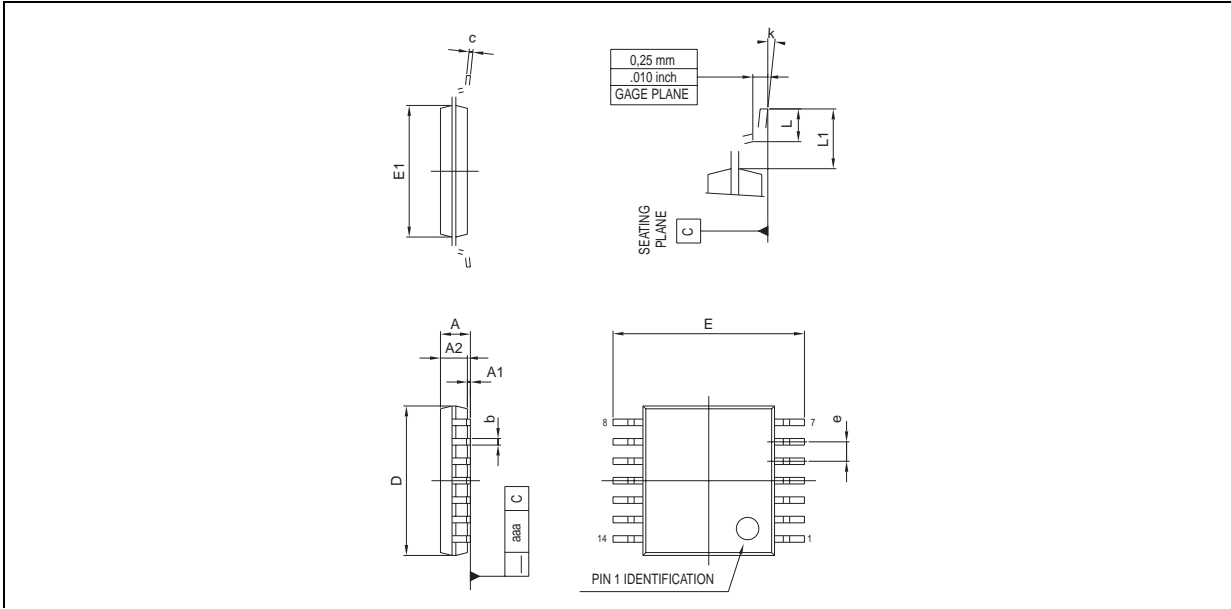
Note : (1) D and F do not include mold flash or protrusions - Mold flash or protrusions shall not exceed 0.15mm (.066 inc) ONLY FOR DATA BOOK.

TS1854IP- TS1854AIP- TS185AIP- TS1854IPT



**PACKAGE MECHANICAL DATA**

14 PINS - THIN SHRINK SMALL OUTLINE PACKAGE

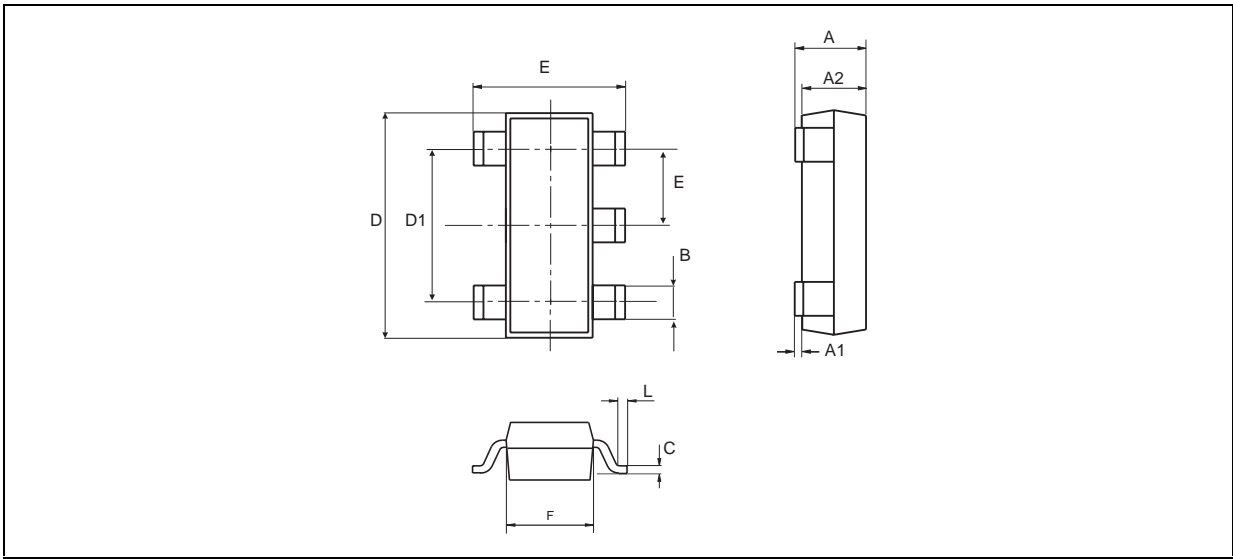


Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.05
A1	0.05		0.15	0.01		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.15
c	0.09		0.20	0.003		0.012
D	4.90	5.00	5.10	0.192	0.196	0.20
E		6.40			0.252	
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.025	
k	0°		8°	0°		8°
L	0.450	0.600	0.750	0.018	0.024	0.030
L1		1.00			0.039	
aaa			0.100			0.004

TS1851ILT - TS1851AILT



**PACKAGE MECHANICAL DATA**  
5 PINS - TINY PACKAGE (SOT23)

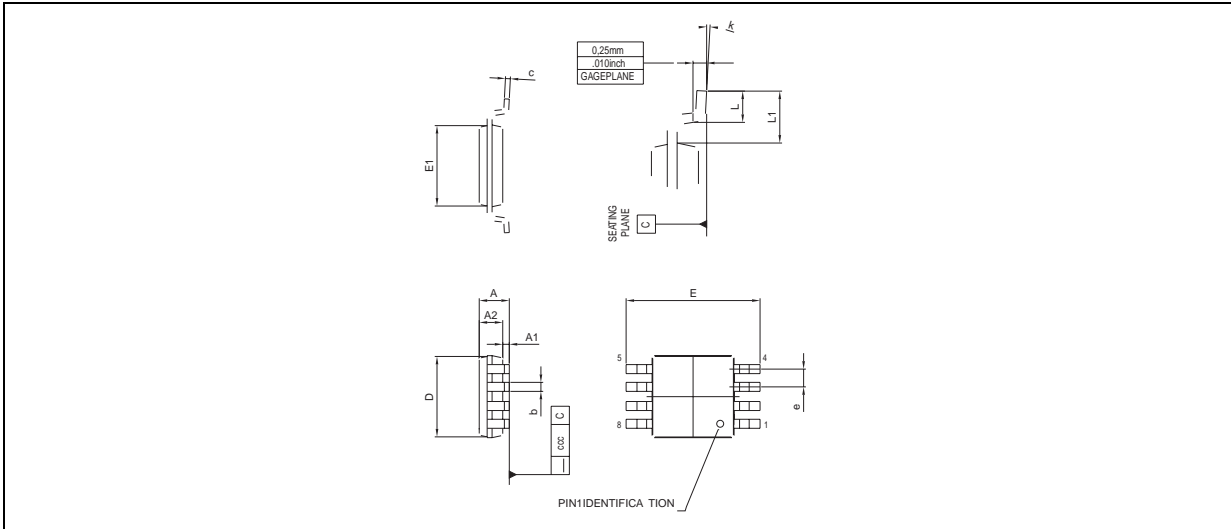


Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.90	1.20	1.45	0.035	0.047	0.057
A1	0		0.15			0.006
A2	0.90	1.05	1.30	0.035	0.041	0.051
B	0.35	0.40	0.50	0.014	0.016	0.020
C	0.09	0.15	0.20	0.004	0.006	0.008
D	2.80	2.90	3.00	0.110	0.114	0.118
D1		1.90			0.075	
e		0.95			0.037	
E	2.60	2.80	3.00	0.102	0.110	0.118
F	1.50	1.60	1.75	0.059	0.063	0.069
L	0.3	0.5	0.60	0.012	0.014	0.024
K	0d		10d	0d		10d

TS1852IST



**PACKAGE MECHANICAL DATA**  
8 PINS - PLASTIC MICROPACKAGE (miniSO)



Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.100			0.043
A1	0.050	0.100	0.150	0.002	0.004	0.006
A2	0.780	0.860	0.940	0.031	0.034	0.037
b	0.250	0.330	0.400	0.010	0.013	0.016
c	0.130	0.180	0.230	0.005	0.007	0.009
D	2.900	3.000	3.100	0.114	0.118	0.122
E	4.750	4.900	5.050	0.187	0.193	0.199
E1	2.900	3.000	3.100	0.114	0.118	0.122
e		0.650			0.026	
L	0.400	0.550	0.700	0.016	0.022	0.028
L1		0.950			0.037	
k	0d	3d	6d	0d	3d	6d
aaa			0.100			0.004

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