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 Vicm (V_{ee} - 0.2V to V_{CC} + 0.2V)
- LOW SUPPLY CURRENT (120µA)
- 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 = 2kΩ), 120µA 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 x 2.9mm).

APPLICATION

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

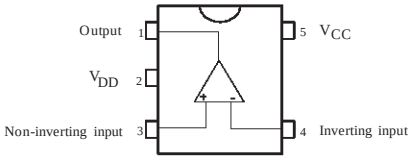
ORDER CODE

Part Number	Temperature Range	Package				SOT23 Marking
		N	D	P	L	
TS1851I/AI	-40, +125°C		•		•	K161/K162
TS1852I/AI		•	•	•		
TS1854I/AI		•	•	•		

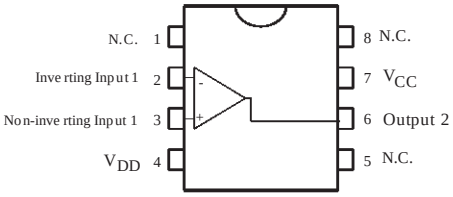
N = Dual in Line Package (DIP)
D = Small Outline Package (SO) - also available in Tape & Reel (DT)
P = Thin Shrink Small Outline Package (TSSOP) - only available in Tape & Reel (PT)
L = Tiny Package (SOT23-5) - only available in Tape & Reel (LT)

PIN CONNECTIONS (top view)

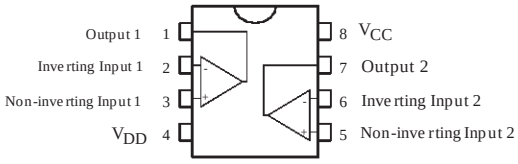
TS1851ILT



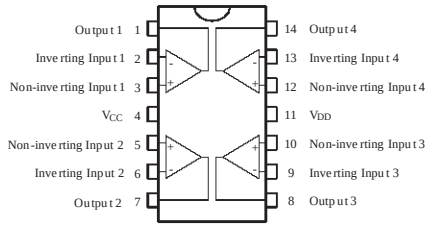
TS1851ID-TS1851IDT



TS1852IN-TS1852ID-TS1852IDT-TS1852IPT



TS1854IN-TS1854ID-TS1854IDT-TS1854IPT



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage [1]	7	V
V_{id}	Differential Input Voltage [2]	±1	V
V_i	Input Voltage [3]	-0.3 to V_{CC} +0.3	V
T_{oper}	Operating Free Air Temperature Range	-40 to + 125	°C
T_{std}	Storage Temperature	-65 to +150	°C
T_j	Maximum Junction Temperature	150	°C
R_{thjc}	Thermal Resistance Junction to Case [4] SOT23-5 DIP8 DIP14 SO8 SO14 TSSOP8 TSSOP14	 81 42 32 28 22 26 21	°C/W
R_{thja}	Thermal Resistance Junction to Ambient - SOT23-5	256	°C/W
ESD	Human Body Model	2	kV
	Lead Temperature (soldering, 10sec)	260	°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 [1]	V_{ee} -0.2 to V_{CC} + 0.2	V
V_{icm}	Common Mode Input Voltage Range [2]	V_{ee} to V_{CC}	V

1. At 25°C, for $1.8 \le V_{CC} \le 6V$, 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°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
ΔV_{io}	Input Offset Voltage Drift		2		µV/°C
I_{io}	Input Offset Current [1]		1	9	nA
I_{ib}	Input Bias Current [1]		10	50	nA
CMR	Common Mode Rejection Ratio $0 \le V_{icm} \le V_{CC}$	55	85		dB
SVR	Supply Voltage Rejection Ratio V_{icm} = 0.5V	70	80		dB
A_{vd}	Large Signal Voltage Gain R_L = 1Okω R_L = 2kω	80 70	100 88		dB
V_{OH}	High Level Output Voltage R_L = 10kω R_L = 2kω	1.7 1.65	1.77 1.7		V
V_{OL}	Low Level Output Voltage R_L = 10kω R_L = 2kω		40 62	70 90	mV
I_o	Output Source Current V_{ID} = 100mV, V_O = V_{DD} Output Sink Current V_{ID} = -100mV, V_O = V_{CC}	2 2	29 46		mA
I_{CC}	Supply Current (per amplifier) A_{VCL} = 1, no load		120	170	µA
GBP	Gain Bandwith Product R_L = 10kω, C_L = 100pF, f = 100kHz	300	480		kHz
SR	Slew Rate R_L = 10kω, C_L = 100pF, AV = 1	0.1	0.18		V/µs
ϕm	Phase Margin C_L = 100pF		60		Degrees
en	Input Voltage Noise		40		nV/√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°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
ΔV_{io}	Input Offset Voltage Drift		2		µV/°C
I_{io}	Input Offset Current [1]		1	9	nA
I_{ib}	Input Bias Current [1]		10	55	nA
CMR	Common Mode Rejection Ratio $0 \le V_{icm} \le V_{CC}$	60	90		dB
SVR	Supply Voltage Rejection Ratio $V_{icm} = V_{CC/2}$	70	85		dB
A_{vd}	Large Signal Voltage Gain R_L = 1Okω R_L = 2kω	83 74	99 90		dB
V_{OH}	High Level Output Voltage R_L = 10kω R_L = 2kω	2.9 2.85	2.96 2.94		V
V_{OL}	Low Level Output Voltage R_L = 10kω R_L = 2kω		10 46	90 100	mV
I_o	Output Source Current V_{ID} = 100mV, $V_O = V_{DD}$ Output Sink Current V_{ID} = -100mV, $V_O = V_{CC}$	2 2	47 47		mA
I_{CC}	Supply Current (per amplifier) A_{VCL} = 1, no load		150	200	µA
GBP	Gain Bandwith Product R_L = 10kω, C_L = 100pF, f = 100kHz	370	600		kHz
SR	Slew Rate R_L = 10kω, C_L = 100pF, AV = 1	0.12	0.2		V/µs
ϕm	Phase Margin C_L = 100pF		60		Degrees
en	Input Voltage Noise		40		nV/√Hz
THD	Total Harmonic Distortion		0.01		%

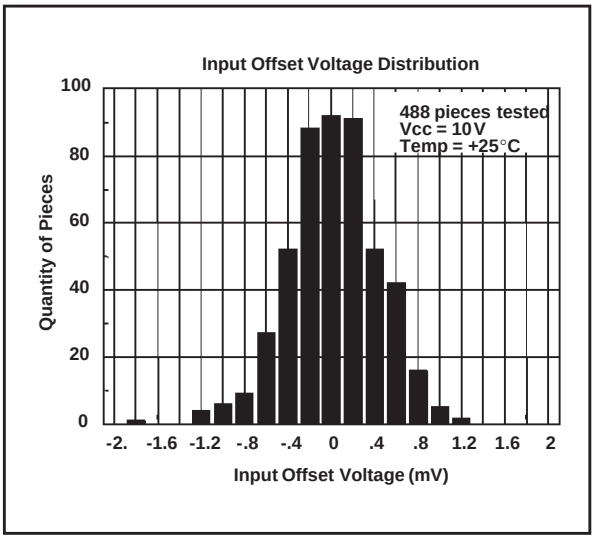
1. Maximum values including unavoidable inaccuracies of the industrial test.

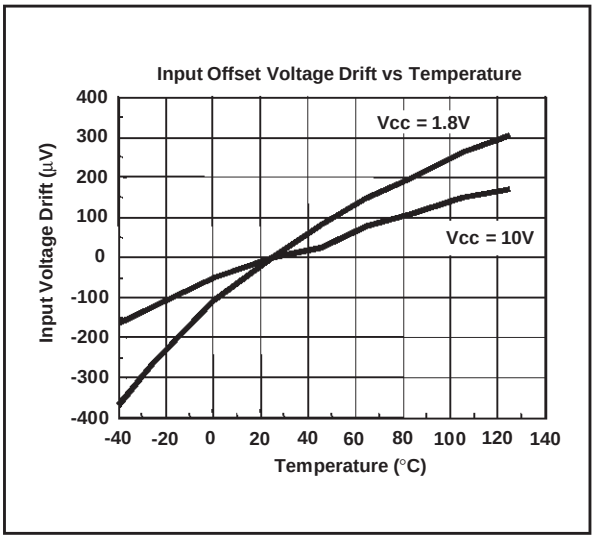
ELECTRICAL CHARACTERISTICS

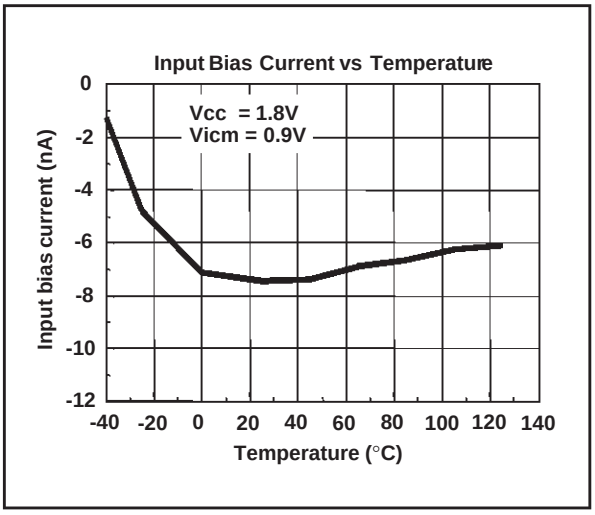
V_{CC} = **+5V**, V_{ee} = **0V**,
T_{amb} = 25°C (unless otherwise specified)

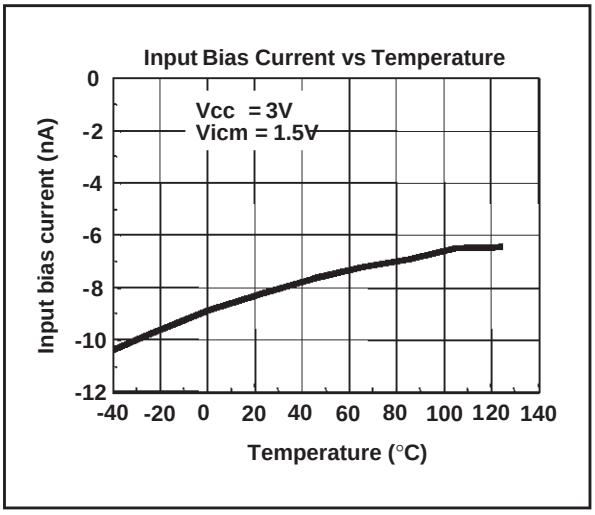
Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{io}	Input Offset Voltage TS1851/2/4 TS1851A/2A/4A		0.1	3 1	mV
ΔV_{io}	Input Offset Voltage Drift		2		µV/°C
I_{io}	Input Offset Current [1]		1	9	nA
I_{ib}	Input Bias Current [1]		16	63	nA
CMR	Common Mode Rejection Ratio $0 \le V_{icm} \le V_{CC}$	65	95		dB
SVR	Supply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

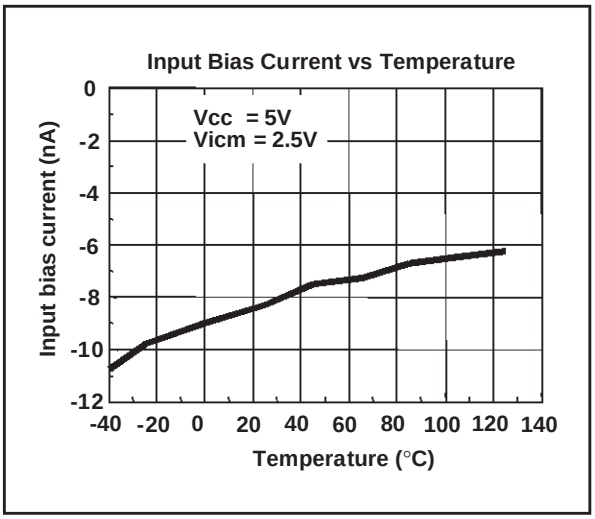
1. Maximum values including unavoidable inaccuracies of the industrial test.

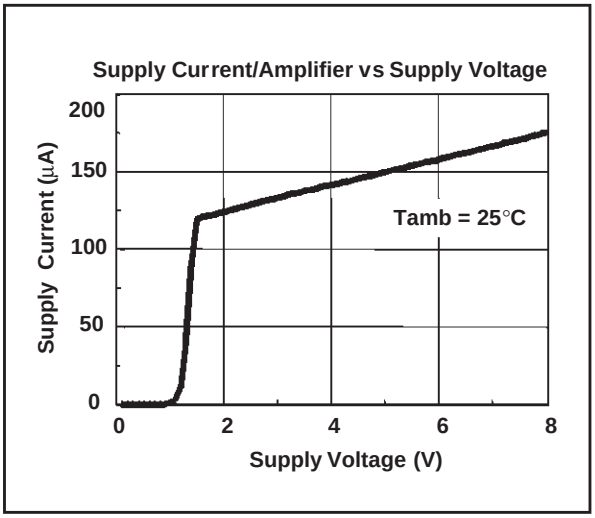

Input Offset Voltage Distribution
488 pieces tested
Vcc = 10V
Temp = +25°C
Quantity of Pieces
100
80
60
40
20
0
-2.
-1.6
-1.2
-.8
-.4
0
.4
.8
1.2
1.6
2
Input Offset Voltage (mV)

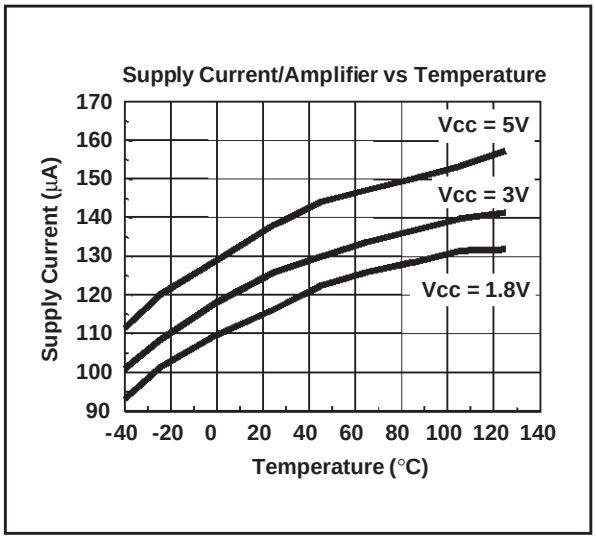

Input Offset Voltage Drift vs Temperature
Vcc = 1.8V
Vcc = 10V
Input Voltage Drift (µV)
400
300
200
100
0
-100
-200
-300
-400
-40
-20
0
20
40
60
80
100
120
140
Temperature (°C)

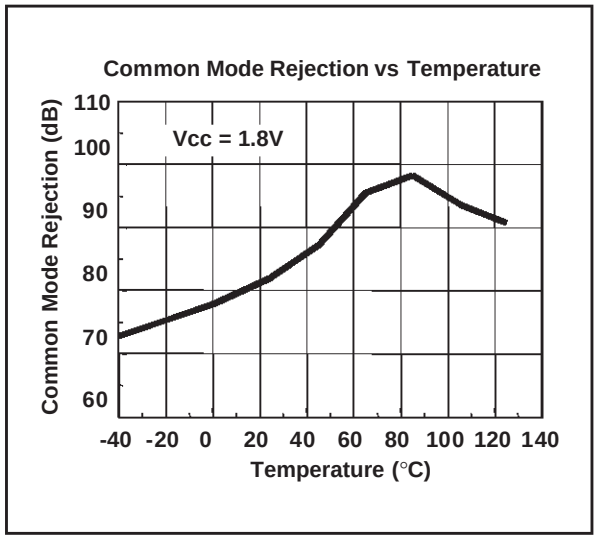

Input Bias Current vs Temperature
Vcc = 1.8V
Vicm = 0.9V
Input bias current (nA)
0
-2
-4
-6
-8
-10
-12
-40
-20
0
20
40
60
80
100
120
140
Temperature (°C)

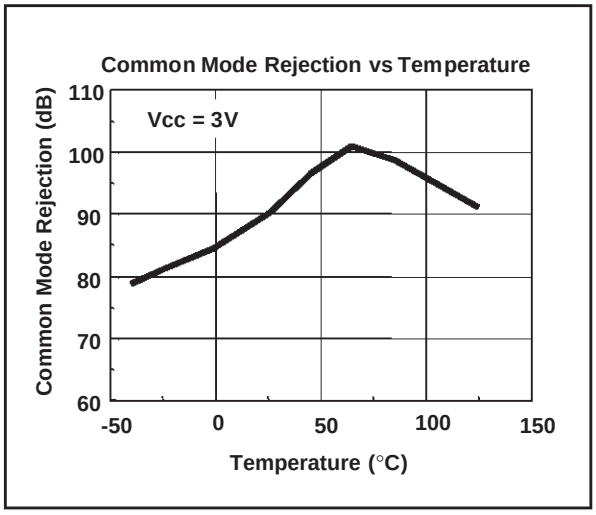

Input Bias Current vs Temperature
Vcc = 3V
Vicm = 1.5V
Input bias current (nA)
0
-2
-4
-6
-8
-10
-12
-40
-20
0
20
40
60
80
100
120
140
Temperature (°C)

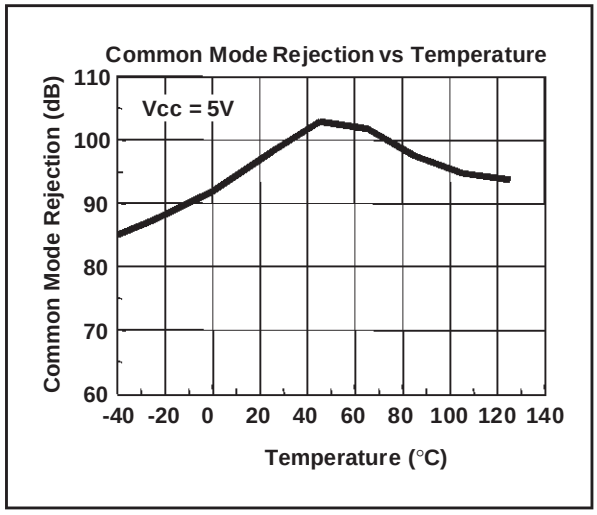

Input Bias Current vs Temperature
Vcc = 5V
Vicm = 2.5V
Input bias current (nA)
0
-2
-4
-6
-8
-10
-12
-40
-20
0
20
40
60
80
100
120
140
Temperature (°C)

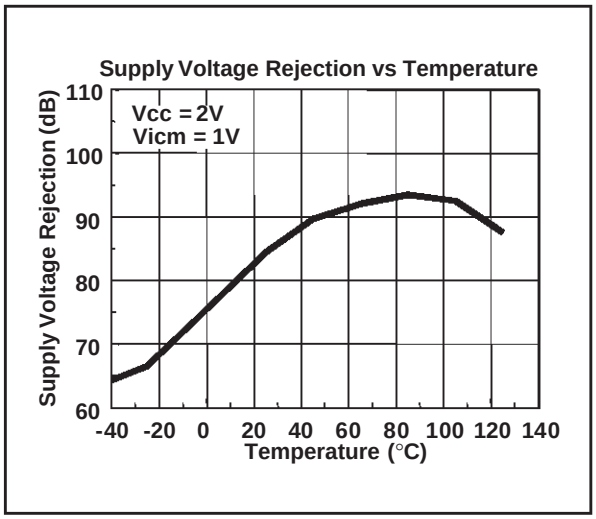

Supply Current/Amplifier vs Supply Voltage
Tamb = 25°C
Supply Current (µA)
200
150
100
50
0
0
2
4
6
8
Supply Voltage (V)

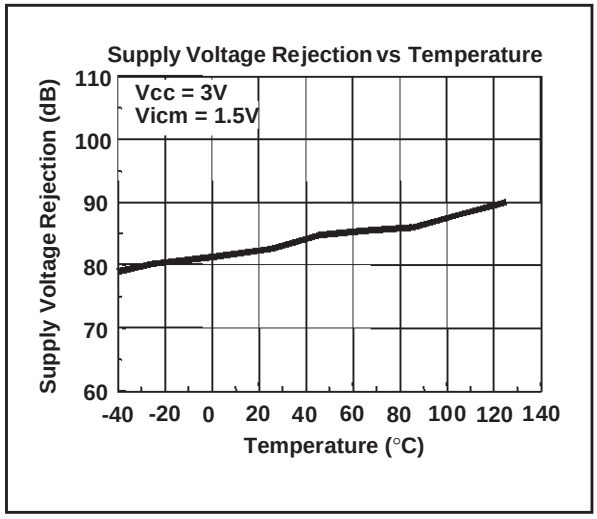

Supply Current/Amplifier vs Temperature
Supply Current (µA)
170
160
150
140
130
120
110
100
90
Vcc = 5V
Vcc = 3V
Vcc = 1.8V
-40 -20 0 20 40 60 80 100 120 140
Temperature (°C)

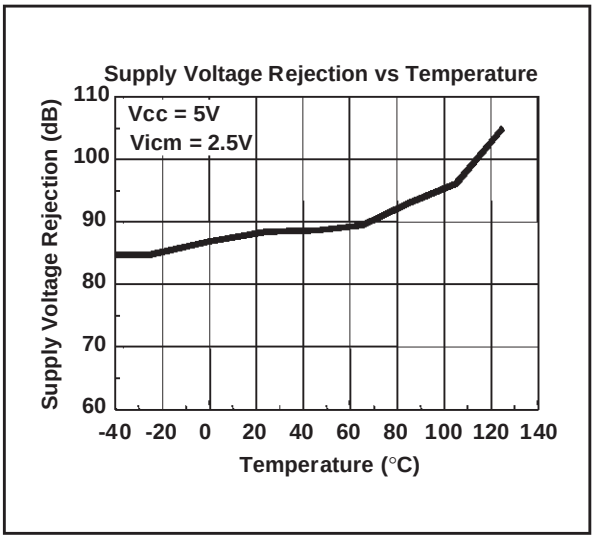

Common Mode Rejection vs Temperature
Common Mode Rejection (dB)
110
100
90
80
70
60
Vcc = 1.8V
-40 -20 0 20 40 60 80 100 120 140
Temperature (°C)

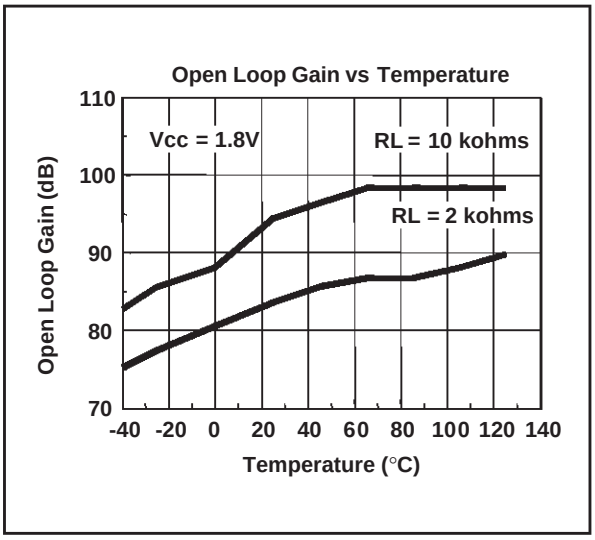

Common Mode Rejection vs Temperature
Common Mode Rejection (dB)
110
100
90
80
70
60
Vcc = 3V
-50 0 50 100 150
Temperature (°C)

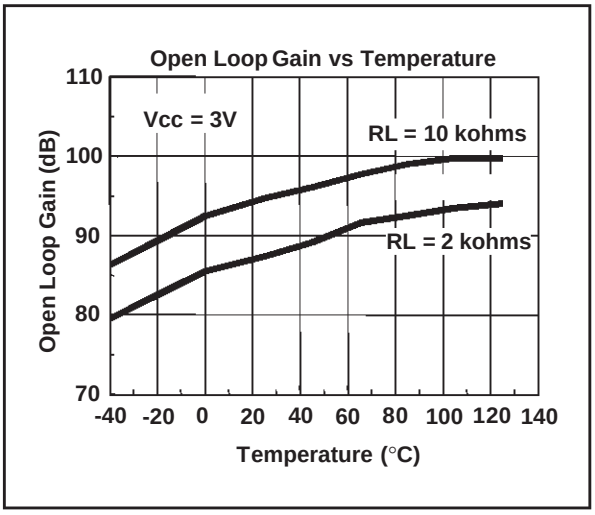

Common Mode Rejection vs Temperature
Common Mode Rejection (dB)
110
100
90
80
70
60
Vcc = 5V
-40 -20 0 20 40 60 80 100 120 140
Temperature (°C)

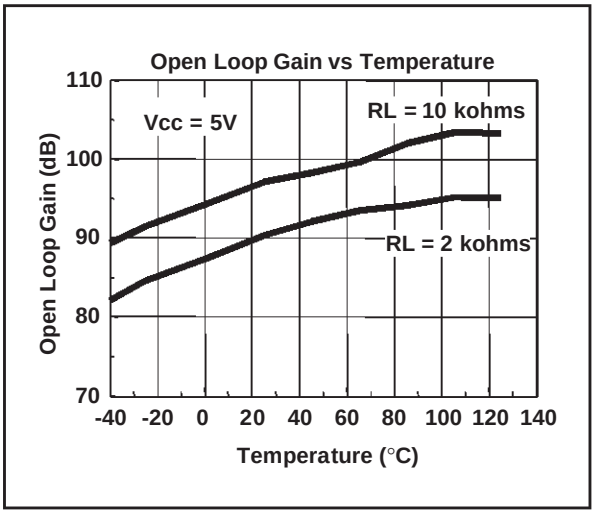

Supply Voltage Rejection vs Temperature
Supply Voltage Rejection (dB)
110
100
90
80
70
60
Vcc = 2V
Vicm = 1V
-40 -20 0 20 40 60 80 100 120 140
Temperature (°C)

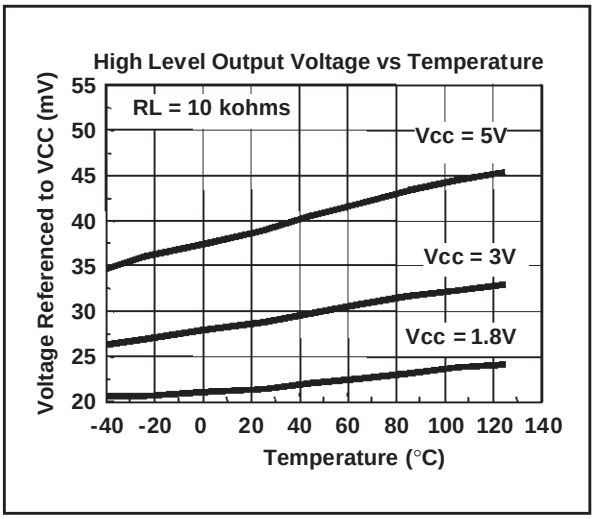

Supply Voltage Rejection vs Temperature
Supply Voltage Rejection (dB)
110
100
90
80
70
60
Vcc = 3V
Vicm = 1.5V
-40 -20 0 20 40 60 80 100 120 140
Temperature (°C)

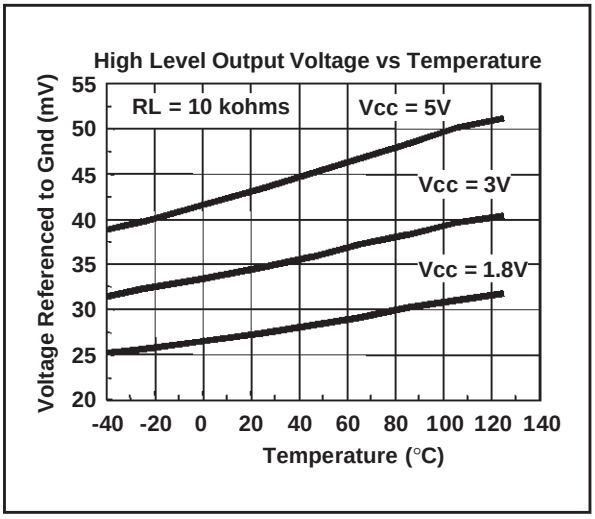

Supply Voltage Rejection vs Temperature
Vcc = 5V
Vicm = 2.5V
Supply Voltage Rejection (dB)
110
100
90
80
70
60
-40 -20 0 20 40 60 80 100 120 140
Temperature (°C)

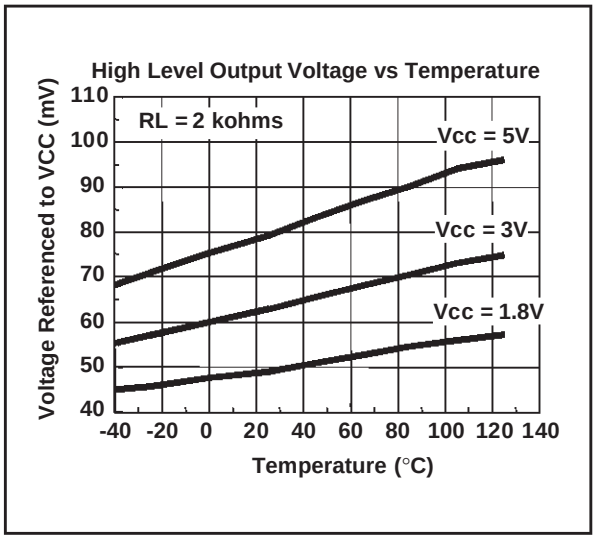

Open Loop Gain vs Temperature
Vcc = 1.8V
RL = 10 kohms
RL = 2 kohms
Open Loop Gain (dB)
110
100
90
80
70
-40 -20 0 20 40 60 80 100 120 140
Temperature (°C)

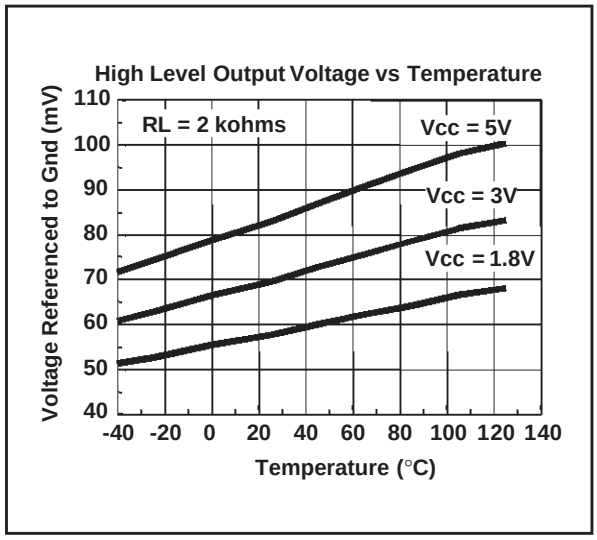

Open Loop Gain vs Temperature
Vcc = 3V
RL = 10 kohms
RL = 2 kohms
Open Loop Gain (dB)
110
100
90
80
70
-40 -20 0 20 40 60 80 100 120 140
Temperature (°C)

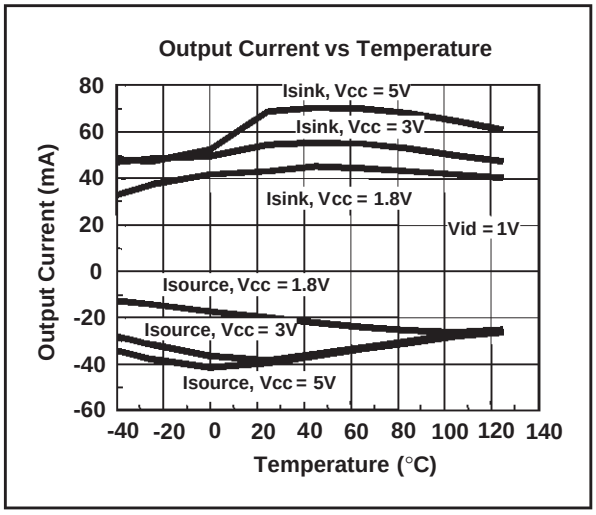

Open Loop Gain vs Temperature
Vcc = 5V
RL = 10 kohms
RL = 2 kohms
Open Loop Gain (dB)
110
100
90
80
70
-40 -20 0 20 40 60 80 100 120 140
Temperature (°C)

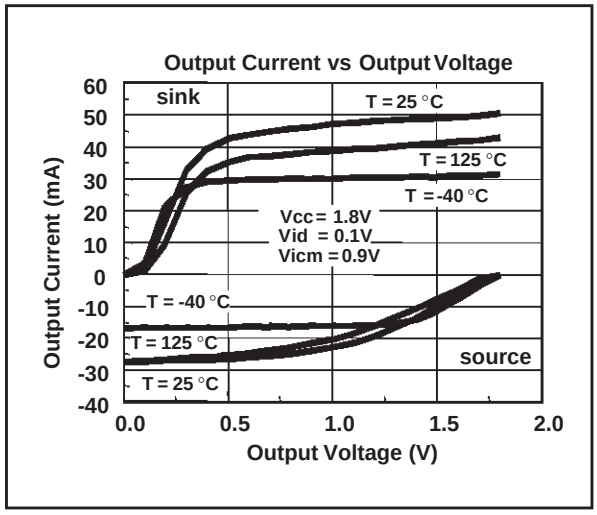

High Level Output Voltage vs Temperature
RL = 10 kohms
Vcc = 5V
Vcc = 3V
Vcc = 1.8V
Voltage Referenced to VCC (mV)
55
50
45
40
35
30
25
20
-40 -20 0 20 40 60 80 100 120 140
Temperature (°C)

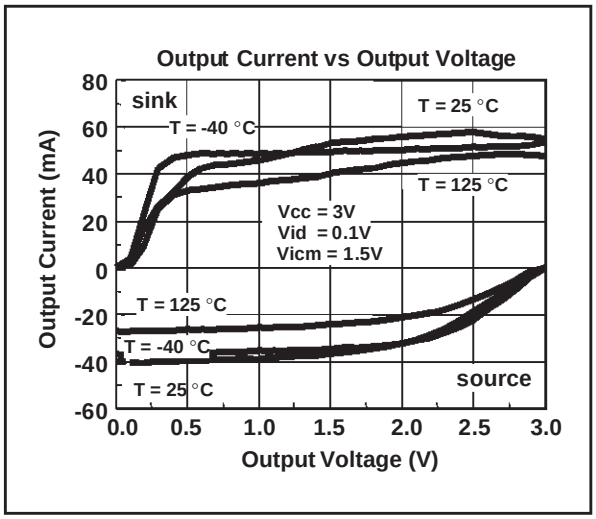

High Level Output Voltage vs Temperature
RL = 10 kohms
Vcc = 5V
Vcc = 3V
Vcc = 1.8V
Voltage Referenced to Gnd (mV)
55
50
45
40
35
30
25
20
-40 -20 0 20 40 60 80 100 120 140
Temperature (°C)

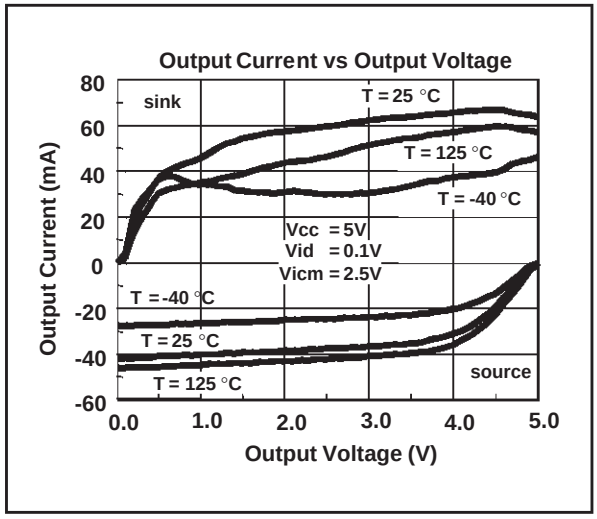

High Level Output Voltage vs Temperature
RL = 2 kohms
Vcc = 5V
Vcc = 3V
Vcc = 1.8V
Voltage Referenced to VCC (mV)
Temperature (°C)

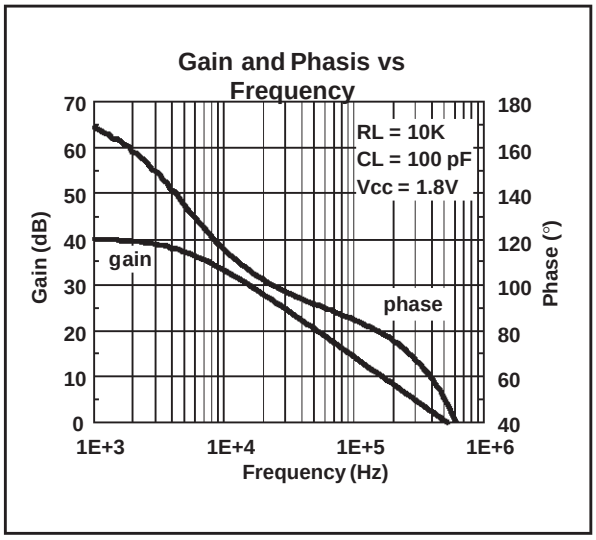

High Level Output Voltage vs Temperature
RL = 2 kohms
Vcc = 5V
Vcc = 3V
Vcc = 1.8V
Voltage Referenced to Gnd (mV)
Temperature (°C)

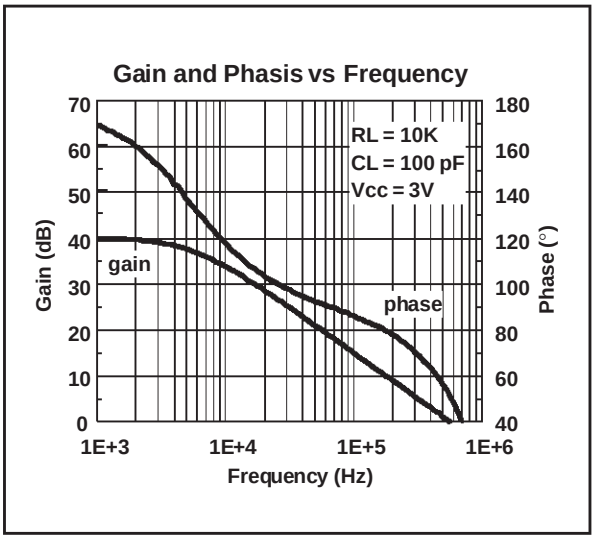

Output Current vs Temperature
Isink, Vcc = 5V
Isink, Vcc = 3V
Isink, Vcc = 1.8V
Vid = 1V
Isource, Vcc = 1.8V
Isource, Vcc = 3V
Isource, Vcc = 5V
Output Current (mA)
Temperature (°C)

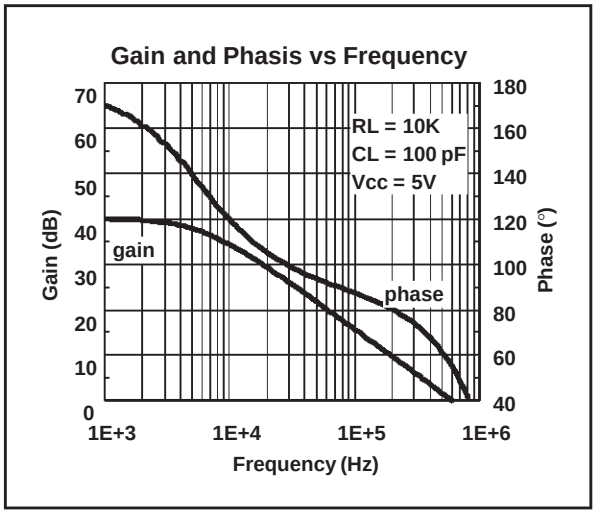

Output Current vs Output Voltage
sink
T = 25 °C
T = 125 °C
T = -40 °C
Vcc = 1.8V
Vid = 0.1V
Vicm = 0.9V
T = -40 °C
T = 125 °C
T = 25 °C
source
Output Current (mA)
Output Voltage (V)

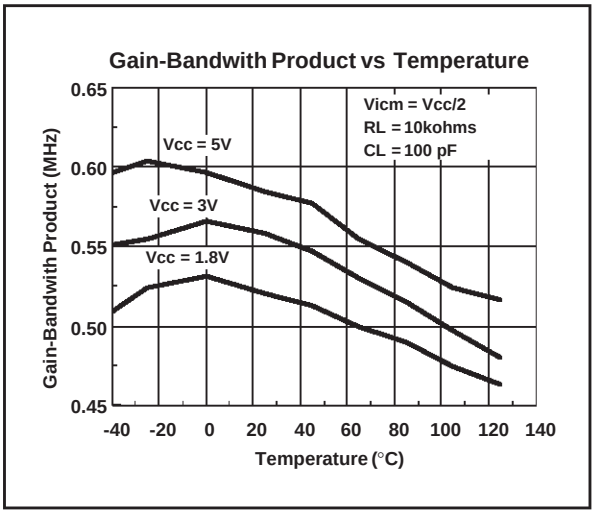

Output Current vs Output Voltage
sink
T = 25 °C
T = -40 °C
T = 125 °C
Vcc = 3V
Vid = 0.1V
Vicm = 1.5V
T = 125 °C
T = -40 °C
T = 25 °C
source
Output Current (mA)
Output Voltage (V)

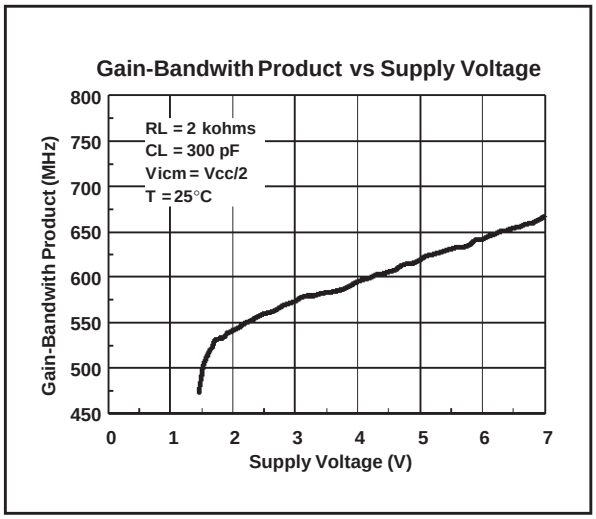

Output Current vs Output Voltage
sink
T = 25 °C
T = 125 °C
T = -40 °C
Vcc = 5V
Vid = 0.1V
Vicm = 2.5V
T = -40 °C
T = 25 °C
T = 125 °C
source
Output Current (mA)
Output Voltage (V)

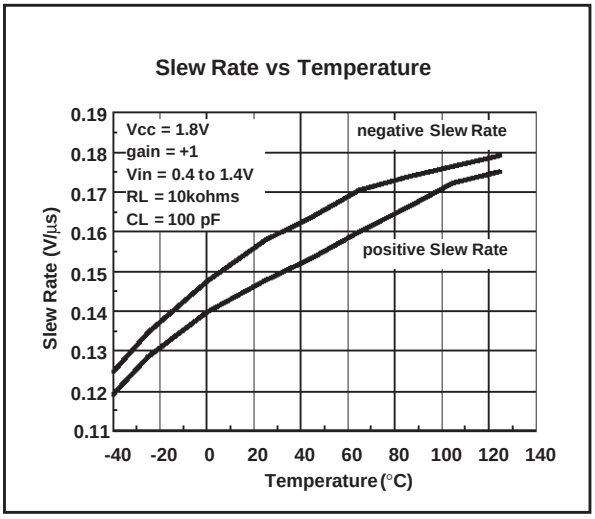

Gain and Phasis vs Frequency
RL = 10K
CL = 100 pF
Vcc = 1.8V
gain
phase
Gain (dB)
Phase (°)
Frequency (Hz)
70
60
50
40
30
20
10
0
180
160
140
120
100
80
60
40
1E+3
1E+4
1E+5
1E+6

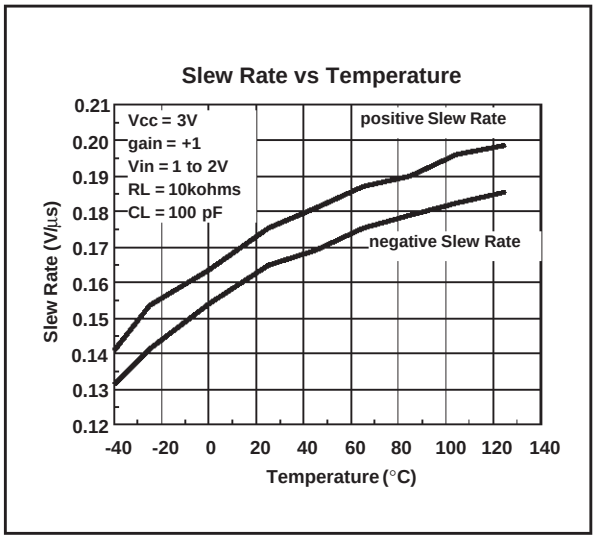

Gain and Phasis vs Frequency
RL = 10K
CL = 100 pF
Vcc = 3V
gain
phase
Gain (dB)
Phase (°)
Frequency (Hz)
70
60
50
40
30
20
10
0
180
160
140
120
100
80
60
40
1E+3
1E+4
1E+5
1E+6

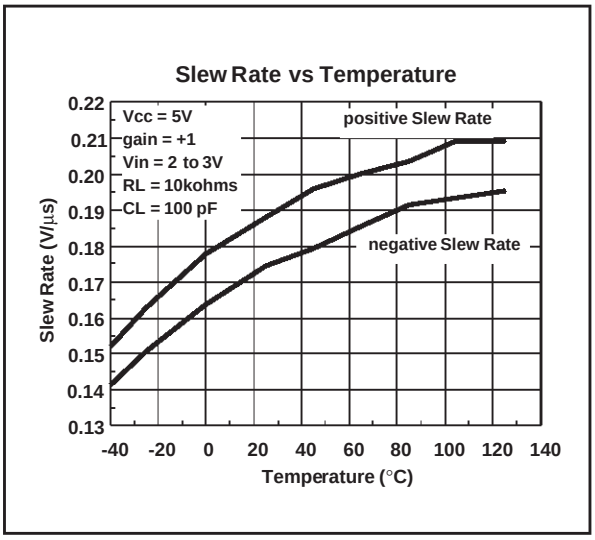

Gain and Phasis vs Frequency
RL = 10K
CL = 100 pF
Vcc = 5V
gain
phase
Gain (dB)
Phase (°)
Frequency (Hz)
70
60
50
40
30
20
10
0
180
160
140
120
100
80
60
40
1E+3
1E+4
1E+5
1E+6

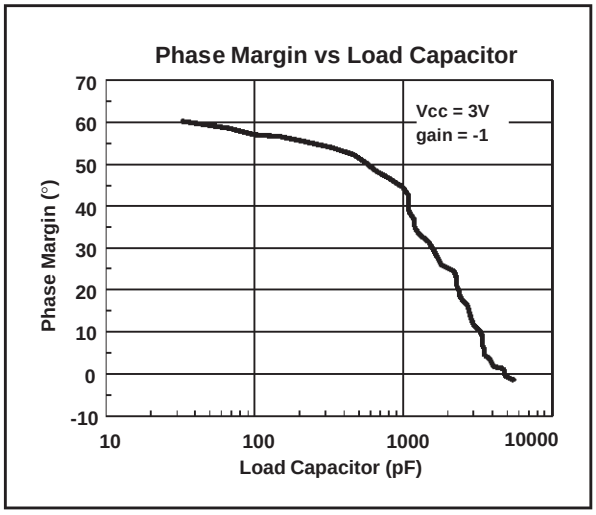

Gain-Bandwith Product vs Temperature
Vicm = Vcc/2
RL = 10kohms
CL = 100 pF
Vcc = 5V
Vcc = 3V
Vcc = 1.8V
Gain-Bandwith Product (MHz)
Temperature (°C)
0.65
0.60
0.55
0.50
0.45
-40
-20
0
20
40
60
80
100
120
140

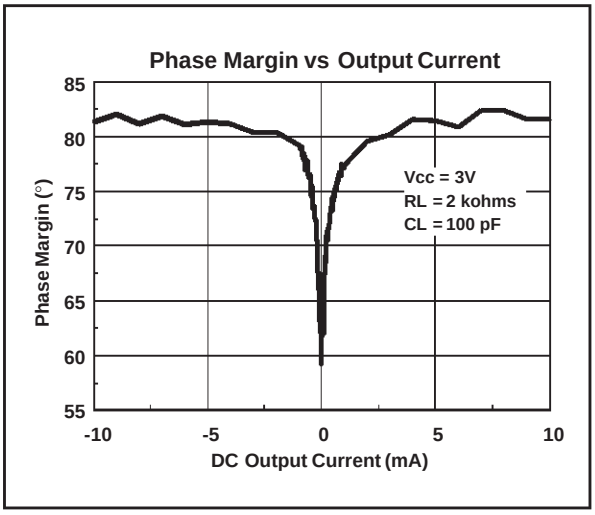

Gain-Bandwith Product vs Supply Voltage
RL = 2 kohms
CL = 300 pF
Vicm = Vcc/2
T = 25°C
Gain-Bandwith Product (MHz)
Supply Voltage (V)
800
750
700
650
600
550
500
450
0
1
2
3
4
5
6
7

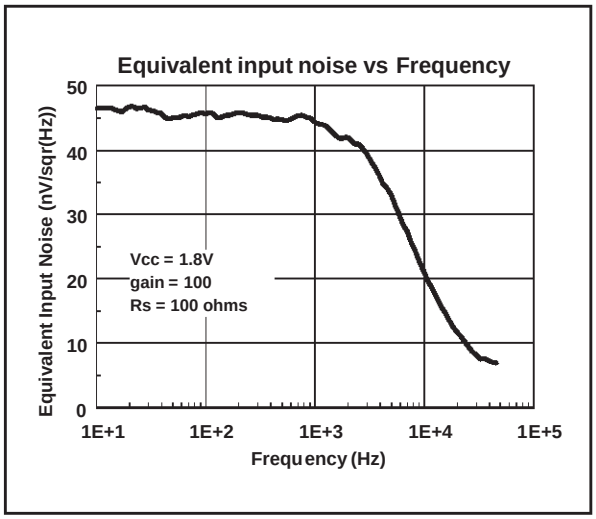

Slew Rate vs Temperature
Vcc = 1.8V
gain = +1
Vin = 0.4 to 1.4V
RL = 10kohms
CL = 100 pF
negative Slew Rate
positive Slew Rate
Slew Rate (V/µs)
Temperature (°C)
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
-40
-20
0
20
40
60
80
100
120
140

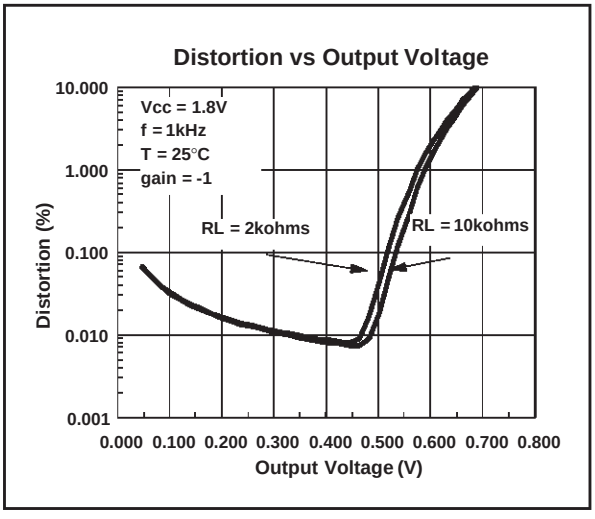

Slew Rate vs Temperature
Vcc = 3V
gain = +1
Vin = 1 to 2V
RL = 10kohms
CL = 100 pF
positive Slew Rate
negative Slew Rate
Slew Rate (V/µs)
Temperature (°C)

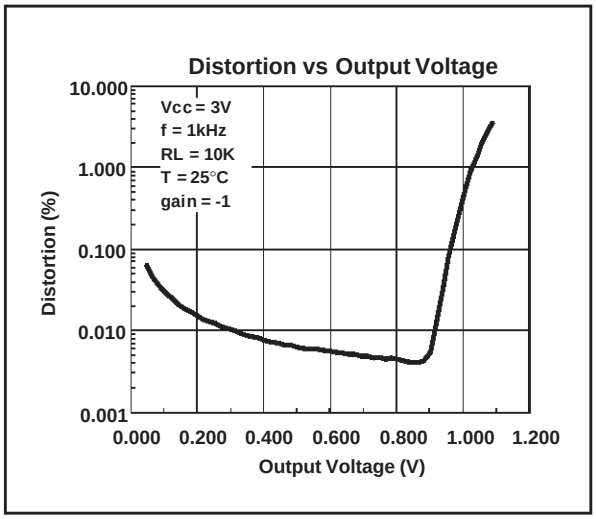

Slew Rate vs Temperature
Vcc = 5V
gain = +1
Vin = 2 to 3V
RL = 10kohms
CL = 100 pF
positive Slew Rate
negative Slew Rate
Slew Rate (V/µs)
Temperature (°C)

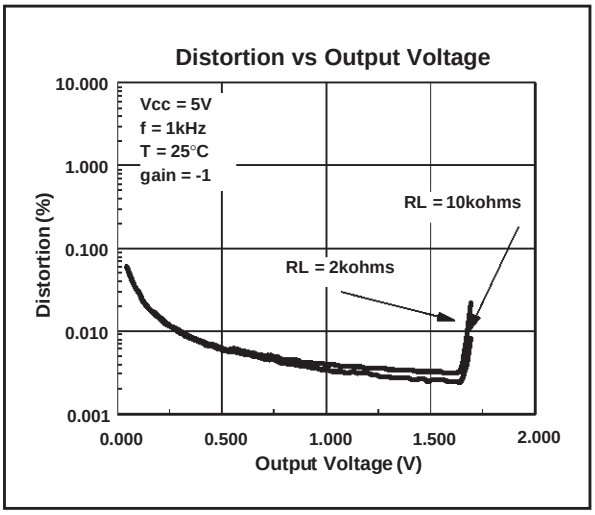

Phase Margin vs Load Capacitor
Vcc = 3V
gain = -1
Phase Margin (°)
Load Capacitor (pF)

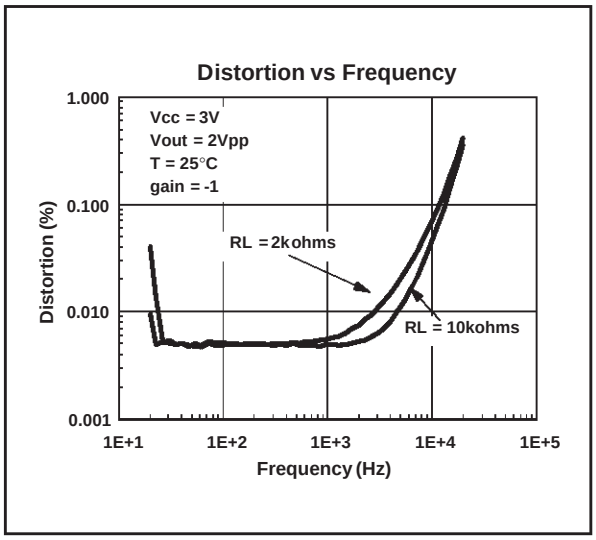

Phase Margin vs Output Current
Vcc = 3V
RL = 2 kohms
CL = 100 pF
Phase Margin (°)
DC Output Current (mA)


Equivalent input noise vs Frequency
Vcc = 1.8V
gain = 100
Rs = 100 ohms
Equivalent Input Noise (nV/sqr(Hz))
Frequency (Hz)

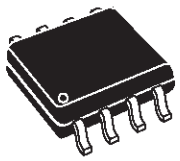

Distortion vs Output Voltage
Vcc = 1.8V
f = 1kHz
T = 25°C
gain = -1
RL = 2kohms
RL = 10kohms
Distortion (%)
Output Voltage (V)


Distortion vs Output Voltage
Vcc = 3V
f = 1kHz
RL = 10K
T = 25°C
gain = -1
Distortion (%)
10.000
1.000
0.100
0.010
0.001
0.000 0.200 0.400 0.600 0.800 1.000 1.200
Output Voltage (V)


Distortion vs Output Voltage
Vcc = 5V
f = 1kHz
T = 25°C
gain = -1
RL = 10kohms
RL = 2kohms
Distortion (%)
10.000
1.000
0.100
0.010
0.001
0.000 0.500 1.000 1.500 2.000
Output Voltage (V)

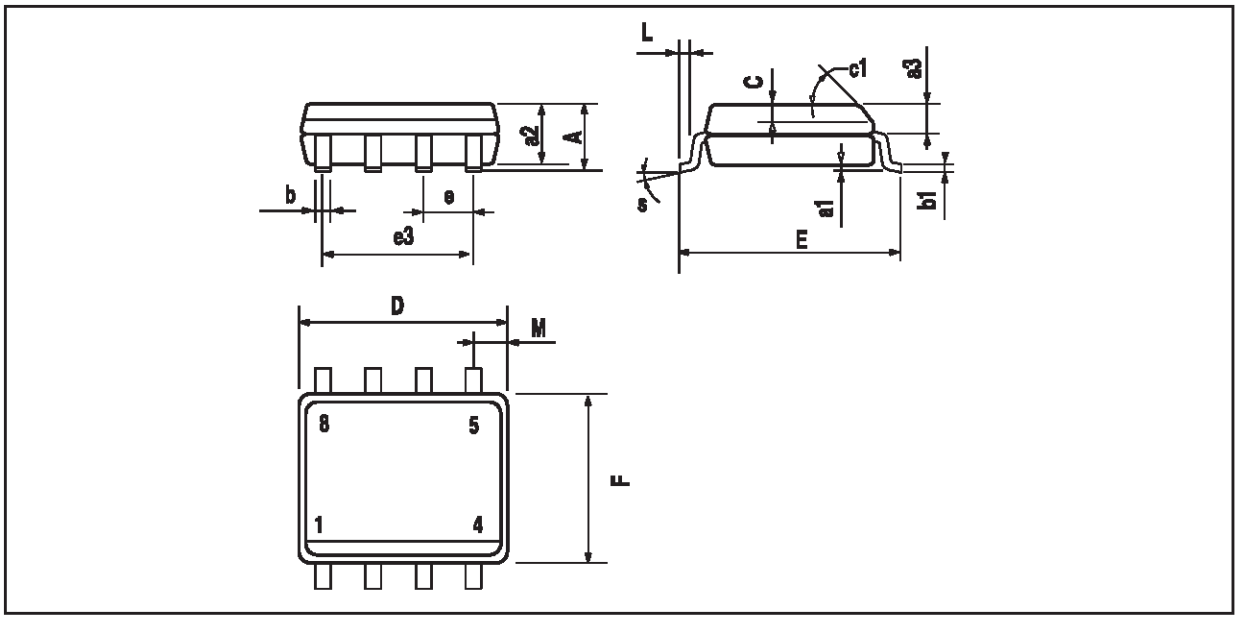

Distortion vs Frequency
Vcc = 3V
Vout = 2Vpp
T = 25°C
gain = -1
RL = 2kohms
RL = 10kohms
Distortion (%)
1.000
0.100
0.010
0.001
1E+1 1E+2 1E+3 1E+4 1E+5
Frequency (Hz)

TS1851ID - TS1852ID



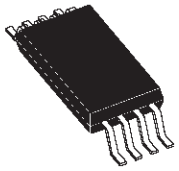
PACKAGE MECHANICAL DATA

8 PINS - PLASTIC MICROPACKAGE (SO)



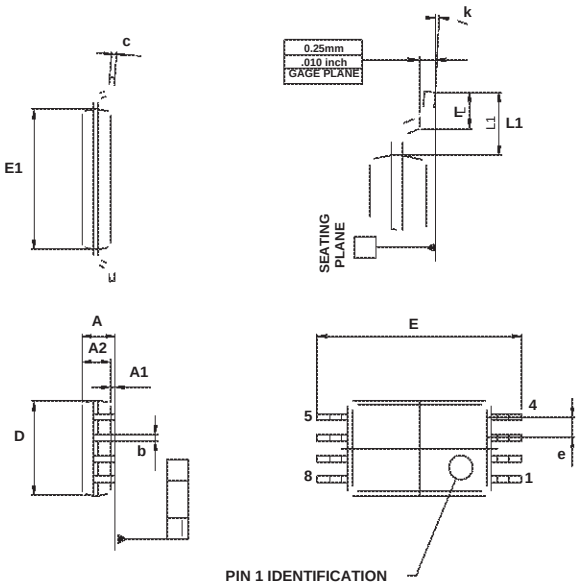
Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.25	0.004		0.010
a2			1.65			0.065
a3	0.65		0.85	0.026		0.033
b	0.35		0.48	0.014		0.019
b1	0.19		0.25	0.007		0.010
C	0.25		0.5	0.010		0.020
c1	45° (typ.)					
D	4.8		5.0	0.189		0.197
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		3.81			0.150	
F	3.8		4.0	0.150		0.157
L	0.4		1.27	0.016		0.050
M			0.6			0.024
S	8° (max.)					

TS1852IPT



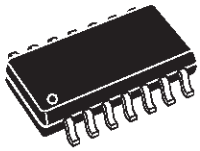
PACKAGE MECHANICAL DATA

8 PINS - THIN SHRINK SMALL OUTLINE PACKAGE



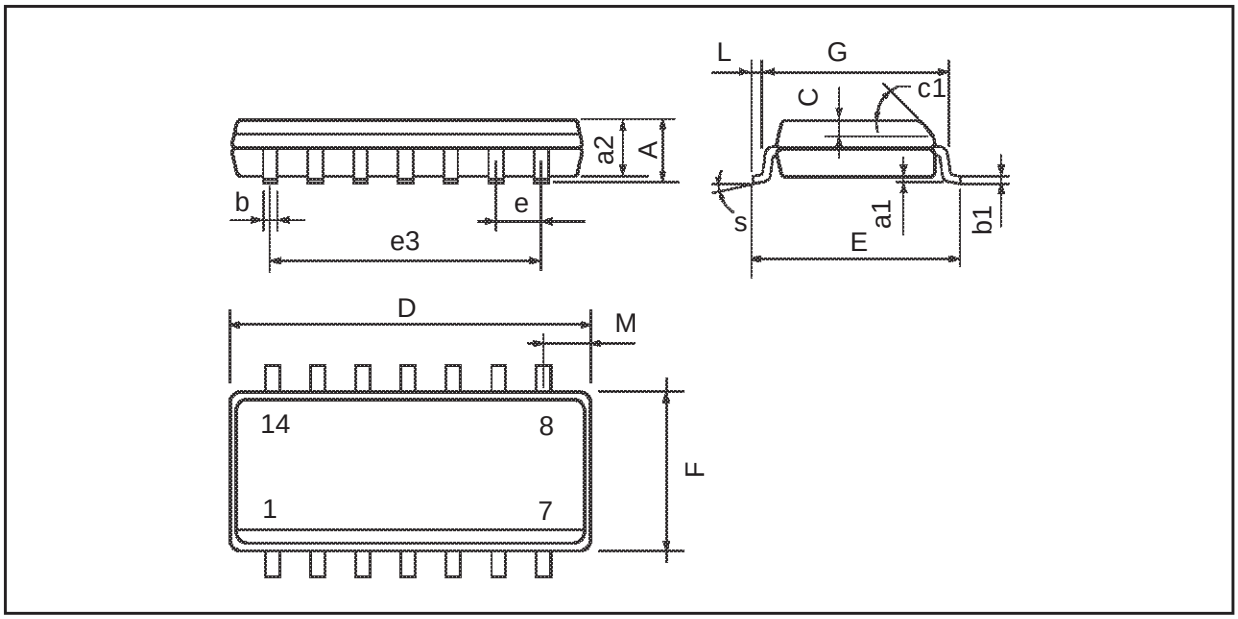
Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.05
A1	0.05		0.15	0.01		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.15
c	0.09		0.20	0.003		0.012
D	2.90	3.00	3.10	0.114	0.118	0.122
E		6.40			0.252	
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.025	
k	0°		8°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

TS1854ID



PACKAGE MECHANICAL DATA

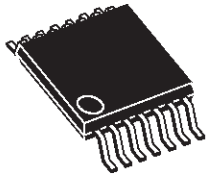
14 PINS - PLASTIC MICROPACKAGE (SO)



Dim.	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.)					

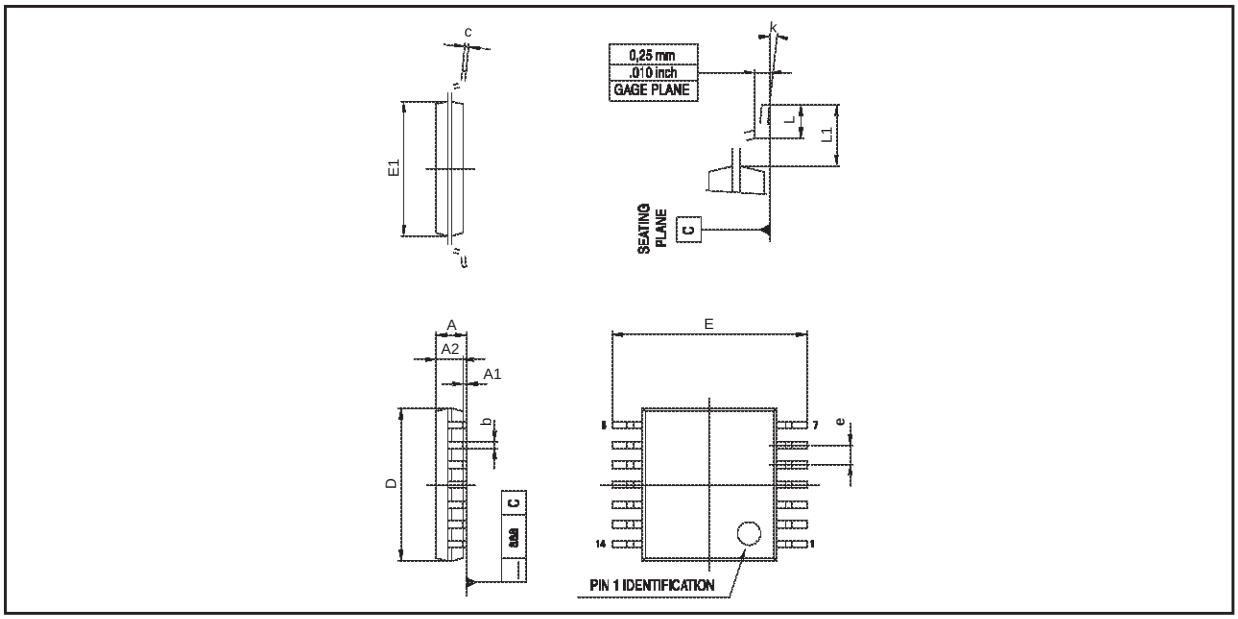
Note : (1) D and F do not include mold flash or protrusions - Mold flash or protrusions shall not exceed 0.15mm (.066 inc) ONLY FOR DATA BOOK.

TS1854IPT



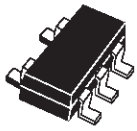
PACKAGE MECHANICAL DATA

14 PINS - THIN SHRINK SMALL OUTLINE PACKAGE



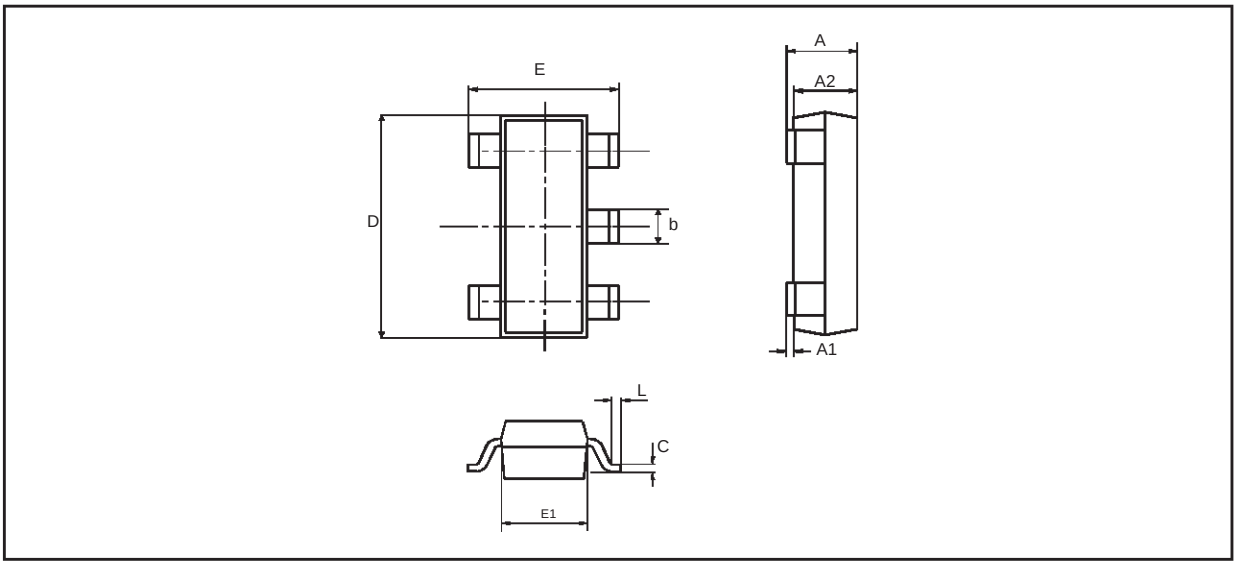
Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.05
A1	0.05		0.15	0.01		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.15
c	0.09		0.20	0.003		0.012
D	4.90	5.00	5.10	0.192	0.196	0.20
E		6.40			0.252	
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.025	
k	0°		8°	0°		8°
l	0.50	0.60	0.75	0.09	0.0236	0.030

TS1851ILT



PACKAGE MECHANICAL DATA

5 PINS - TINY PACKAGE (SOT23)



Dim.	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	0.0118
F	1.50	1.60	1.75	0.059	0.063	0.069
L	0.10	0.5	0.60	0.004	0.014	0.024
K	0d		10d	0d		10d