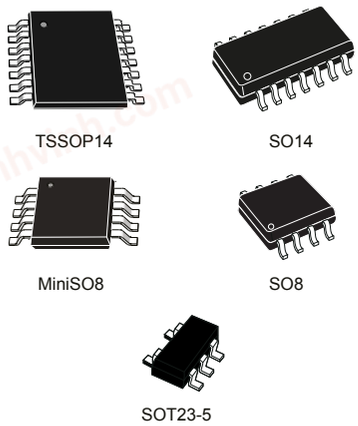
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TSB511, TSB512, TSB514

Datasheet

Rail-to-rail inputs and outputs, 36 V, 6 MHz op amps



Maturity status link
TSB511, TSB512, TSB514

Related products	
TSB711	For higher precision
TSB712	
TSB714	

Features

- Rail-to-rail input and output
- Low offset voltage: 1.5 mV maximum
- Wide supply voltage range: 2.7 V to 36 V
- Gain bandwidth product: 6 MHz
- Slew rate of 3 V/µs
- Low noise: 12 nV/√Hz
- Integrated EMI filter
- 2 kV HBM ESD tolerance
- Extended temperature range: - 40 °C to + 125 °C
- Automotive-grade available

Applications

- High-side and low-side current sensing
- Hall effect sensors
- Test and measurement equipment
- Motor control
- Industrial process control
- Stain gauge

Description

The TSB511, TSB512, TSB514 is a series of 6 MHz bandwidth amplifiers featuring rail-to-rail input and output, which are guaranteed to operate from 2.7 to 36 V single supply as well as from ± 1.35 V to ± 18 V dual supplies.

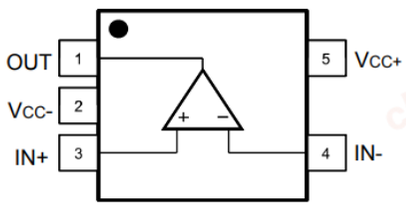
These amplifiers have the advantage of offering a large span of supply voltage and a wide bandwidth.

The combination of wide bandwidth, slew rate, low noise, rail-to-rail capability makes the TSB511, TSB512, TSB514 useful in a wide variety of applications such as: filters, power supply and motor control, actuator driving and resistive transducers.

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1 Pin connection

Figure 1. **TSB511 pin connections (top view)**

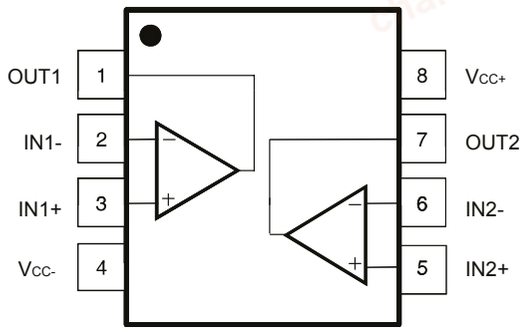


SOT23-5

Table 1. **TSB511 pin description**

Pin	Pin name	Description
1	OUT1	Output
2	VCC -	Negative supply voltage
3	IN+	Positive input voltage
4	IN-	Negative input voltage
5	VCC +	Positive supply voltage

Figure 2. **TSB512 pin connections (top view)**



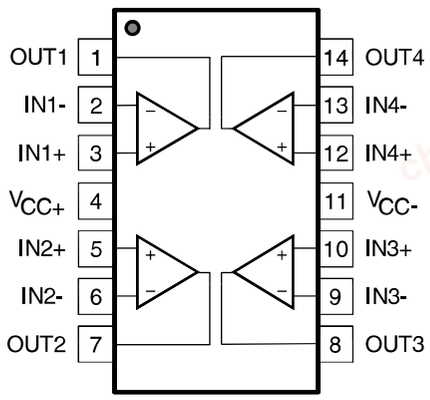
SO8 - MiniSO8

Table 2. **TSB512 pin description**

Pin	Pin name	Description
1	OUT1	Output
2	IN1-	Negative input voltage
3	IN1+	Positive input voltage
4	VCC-	Negative supply voltage
5	IN2+	Positive input voltage
6	IN2-	Negative input voltage
7	OUT2	Output
8	VCC+	Positive supply voltage

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Figure 3. **TSB514 pin connections (top view)**



SO14 - TSSOP14

Table 3. **TSB514 pin description**

Pin	Pin name	Description
1	OUT1	Output
2	IN1-	Negative input voltage
3	IN1+	Positive input voltage
4	VCC+	Positive supply voltage
5	IN2+	Positive input voltage
6	IN2-	Negative input voltage
7	OUT2	Output
8	OUT3	Output
9	IN3-	Negative input voltage
10	IN3+	Positive input voltage
11	VCC-	Negative supply voltage
12	IN4+	Positive input voltage
13	IN4-	Negative input voltage
14	OUT4	Output

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2 Maximum ratings

Table 4. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage (1)	+ 40 or ± 20	V
V_{ID}	Differential input voltage (2)	± 2	V
V_{IN}	Input voltage (3)	(V_{CC-}) - 0.2 to (V_{CC+}) + 0.2	V
I_{IN}	Input current (3)	± 10	mA
Tstg	Storage temperature	- 65 to 150	°C
Tj	Junction temperature	150	°C
Rth-ja	Thermal resistance junction to ambient (4) (5)		°C/W
	SOT23-5	250	
	MiniSO8	190	
	SO8	125	
	SO14	105	
	TSSOP14	100	
ESD	Human Body Model (HBM) (6)	2	kV
	Charged Device Model (CDM) (7)	1	

1. *All voltage values, except differential voltage, are with respect to network ground terminal.*
2. *The differential voltage is the non-inverting input terminal with respect to the inverting input terminal.*
3. *Input voltage may be extended to the condition that the input current is limited to +/-10 mA. Input current must be limited by a resistor in series with the inputs when the input voltage is beyond the rails or the differential input voltage is above +/-2 V.*
4. *Rth are typical values.*
5. *Short-circuits can cause excessive heating and destructive dissipation.*
6. *According to JEDEC standard JESD22-A114F.*
7. *According to ANSI/ESD STM5.3.1.*

Table 5. Operating conditions

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage	2.7 to 36	V
V_{ICM}	Common mode voltage on input pins	(V_{CC-}) to (V_{CC+}) + 0.1	V
T	Operating free-air temperature range	-40 to 125	°C

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3 Electrical characteristics

Table 6. Electrical characteristics at V_{CC+} = 5 V, V_{CC-} = 0 V, V_{ICM} = V_{OUT} = V_{CC}/2, T = 25 °C and R_L connected to V_{CC}/2 (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
V_{IO}	Input offset voltage	$V_{CC-} \le V_{ICM} \le V_{CC+}$				mV
		T = 25 °C			±1.5	
		Tmin < T < Tmax			±2	
$\lvert\Delta V_{IO}/\Delta T\rvert$	Input offset voltage drift	Tmin < T < Tmax		2		µV/°C
I_{IB}	Input bias current (1)	$V_{ICM} = V_{CC}/2$				nA
		T = 25 °C	-100		0	
		Tmin < T < Tmax	-200		0	
I_{IO}	Input offset current (2)	$V_{ICM} = V_{CC}/2$		10		
A_{VD}	Open loop gain	(V_{CC-}) + 0.5 V ≤ V_{OUT} ≤ (V_{CC+}) - 0.5 V, R_L ≥ 10 kΩ				dB
		T = 25 °C	105	120		
		Tmin < T < Tmax	100			
CMR	Common mode rejection ratio: 20 log ($\Delta V_{icm}/\Delta V_{io}$)	$V_{CC-} \le V_{ICM} \le V_{CC+}$				dB
		T = 25 °C	75	105		
		Tmin < T < Tmax	70			
V_{OH}	High level output voltage (drop voltage from V_{CC+})	No load, Tmin < T < Tmax			90	mV
		I_{source} = 2 mA, Tmin < T < Tmax			200	
V_{OL}	Low-level output voltage	No load, Tmin < T < Tmax			90	
		I_{sink} = 2 mA, Tmin < T < Tmax			200	
I_{OUT}	I_{sink}	$V_{OUT} = V_{CC}$				mA
		T = 25 °C	20	50		
		Tmin < T < Tmax	15			
	I_{source}	V_{OUT} = 0 V				
		T = 25 °C	20	50		
		Tmin < T < Tmax	15			
I_{CC}	Supply current (per channel)	No load, T = 25 °C		1.4		mA
		Tmin < T < Tmax			2.3	
AC performance						
GBP	Gain bandwidth product	R_L = 10 kΩ, C_L = 100 pF	4.5	6		MHz
SR	Slew rate	3 V step, R_L = 10 kΩ, C_L = 100 pF, A_V = 1 V/V, 10% to 90%	2	2.7		V/µs
THD+N	Total harmonic distortion + noise	V_{IN} = 1 V_{rms}, A_V = +1, f = 1 kHz, BW = 22 kHz				%
		R_L = 10 kΩ		0.0003		
		R_L = 1 kΩ		0.0004		
Φm	Phase margin	R_L = 10 kΩ, C_L = 100 pF, Unity gain		34		°

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Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
C_{Load}	Capacitive load drive			100		pF
en	Input voltage noise density	f = 10 kHz		12		nV/√Hz
en p-p	Input noise voltage	0.1 Hz ≤ f ≤ 10 Hz		0.8		µVpp

1. *Current is positive when it is sinked into the op amp.*
2. *I_{io} is defined as $|I_{ibp} – I_{ibn}|$.*

Table 7. Electrical characteristics at V_{CC+} = 36 V, V_{CC-} = 0 V, $V_{ICM} = V_{OUT} = V_{CC}/2$, T = 25 °C and R_L connected to $V_{CC}/2$ (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
V_{IO}	Input offset voltage	$V_{CC-} ≤ V_{ICM} ≤ V_{CC+}$				mV
		T = 25 °C			±1.5	
		Tmin < T < Tmax			±2	
$\|\Delta V_{IO}/\Delta T\|$	Input offset voltage drift	Tmin < T < Tmax		2		µV/°C
I_{IB}	Input bias current (1)	$V_{ICM} = V_{CC}/2$				nA
		T = 25 °C	-100		0	
		Tmin < T < Tmax	-200		0	
I_{IO}	Input offset current (2)	$V_{ICM} = V_{CC}/2$		10		
A_{VD}	Open loop gain	$(V_{CC-}) + 0.5\ V ≤ V_{OUT} ≤ (V_{CC+}) - 0.5\ V$, $R_L ≥ 10\ kΩ$				dB
		T = 25 °C	110	125		
		Tmin < T < Tmax	105			
CMR	Common mode rejection ratio: 20 log ($\Delta V_{icm}/\Delta V_{io}$)	$V_{CC-} ≤ V_{ICM} ≤ V_{CC+}$				dB
		T = 25 °C	90	120		
		Tmin < T < Tmax	85			
SVR	Power supply rejection ratio: 20 log ($\Delta V_{cc}/\Delta V_{io}$)	5 V < $(V_{CC+}) - (V_{CC-})$ < 36 V, $V_{ICM} = V_{CC}/2$, Tmin < T < Tmax	100	125		dB
V_{OH}	High level output voltage (drop voltage from V_{CC+})	No load, Tmin < T < Tmax			120	mV
		I_{source} = 2 mA, Tmin < T < Tmax			200	
		I_{source} = 15 mA, Tmin < T < Tmax			1000	
V_{OL}	Low-level output voltage	No load, Tmin < T < Tmax			120	
		I_{sink} = 2 mA, Tmin < T < Tmax			200	
		I_{sink} = 15 mA, Tmin < T < Tmax			1000	
I_{OUT}	I_{sink}	$V_{OUT} = V_{CC}$				mA
		T = 25 °C	25	50		
		Tmin < T < Tmax	20			
	I_{source}	V_{OUT} = 0 V				
		T = 25 °C	25	50		
		Tmin < T < Tmax	20			
I_{CC}	Supply current (per channel)	No load, T = 25 °C		1.8		mA
		Tmin < T < Tmax			3	

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Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
AC performance						
GBP	Gain bandwidth product	R_L = 10 kΩ, C_L = 100 pF	4.5	6		MHz
SR	Slew rate	9 V step, R_L = 10 kΩ, C_L = 100 pF, A_V = 1 V/V, 10% to 90%	2.2	3		V/µs
THD+N	Total harmonic distortion + noise	V_{IN} = 1 V_{rms}, A_V = +1, f = 1 kHz, BW = 22 kHz				%
		R_L = 10 kΩ		0.0003		
		R_L = 1 kΩ		0.0003		
Φm	Phase margin	R_L = 10 kΩ, C_L = 100 pF, Unity gain		45		°
C_{Load}	Capacitive load drive			100		pF
e_n	Input voltage noise density	f = 10 kHz		12		nV/√Hz
e_n p-p	Input noise voltage	0.1 Hz ≤ f ≤ 10 Hz		0.5		µVpp
CR	Cross talk	V_{OUT} = 5 Vpp, A_V = +11, R_L = 10 kΩ				dB
		f = 1 kHz		125		
		f = 10 kHz		100		

1. *Current is positive when it is sinked into the op amp.*
2. *I_{io} is defined as $|I_{ibp} - I_{ibn}|$.*

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4 Typical performance characteristics

Figure 4. Supply current vs. supply voltage

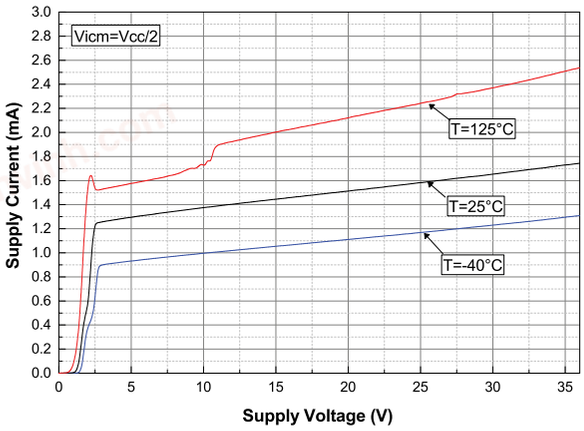


Figure 5. Input offset voltage vs. supply voltage

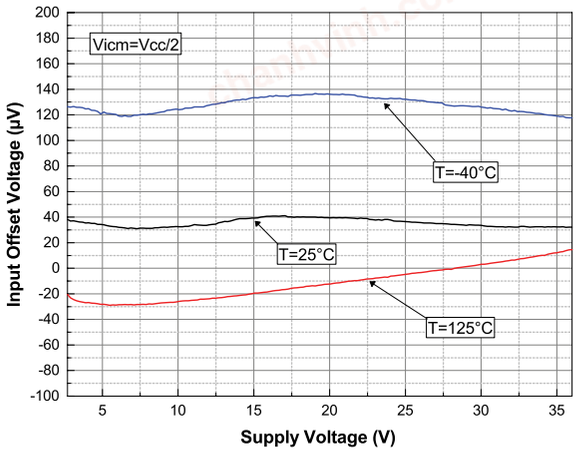


Figure 6. Input offset voltage vs. common mode voltage at V_{CC} = 5 V

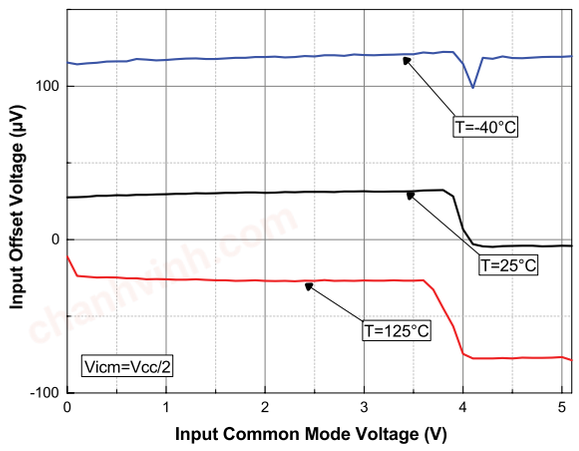
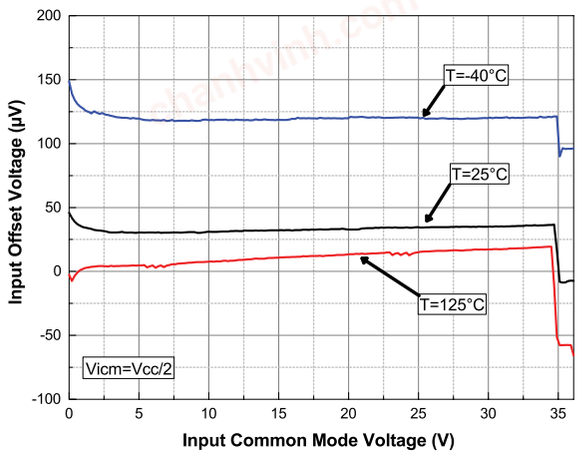


Figure 7. Input offset voltage vs. common mode voltage at V_{CC} = 36 V



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Figure 8. Input bias current vs. temperature at $V_{ICM} = V_{CC}/2$

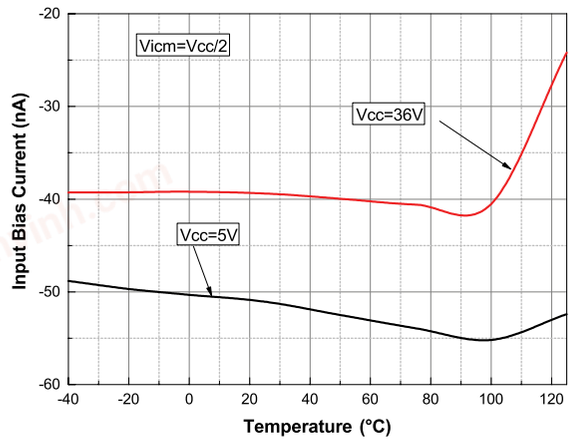


Figure 9. Input bias current vs. common mode voltage at V_{CC} = 5 V

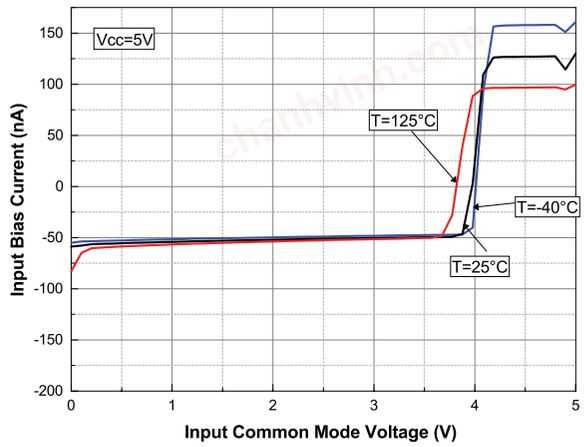


Figure 10. Input bias current vs. common mode voltage at V_{CC} = 36 V

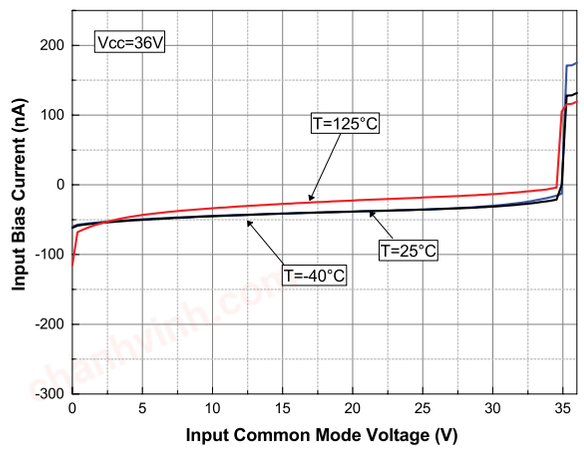


Figure 11. Output current vs. output voltage at V_{CC} = 5 V

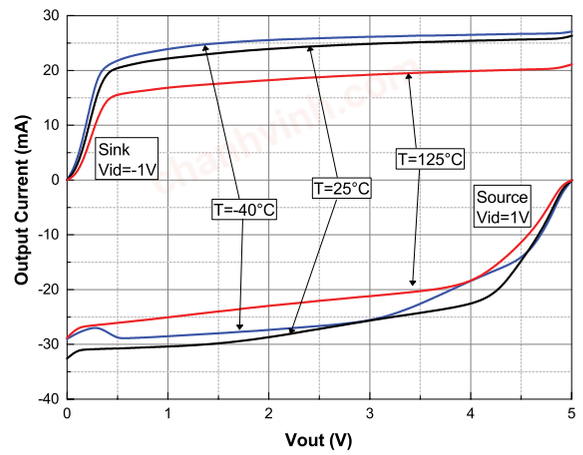


Figure 12. Output current vs. output voltage at V_{CC} = 36 V

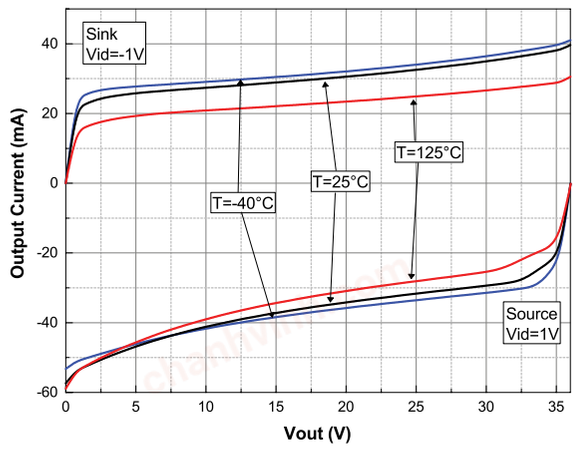
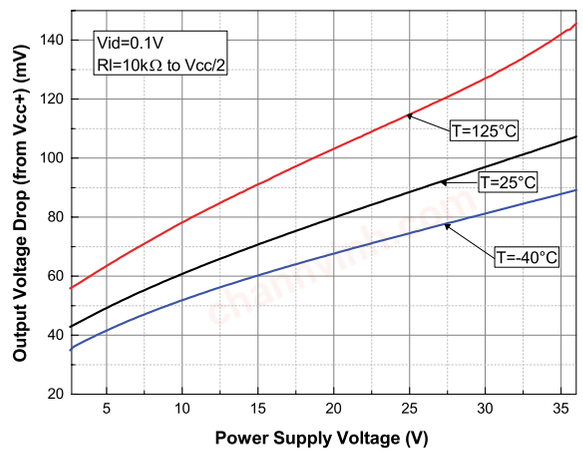


Figure 13. Output voltage (V_{OH}) vs. supply voltage



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Figure 14. Output voltage (V_{OL}) vs. supply voltage

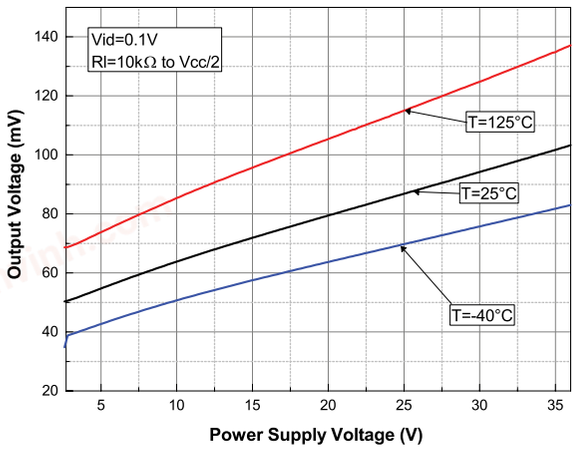


Figure 15. Channel separation vs. frequency at V_{CC} = 36 V

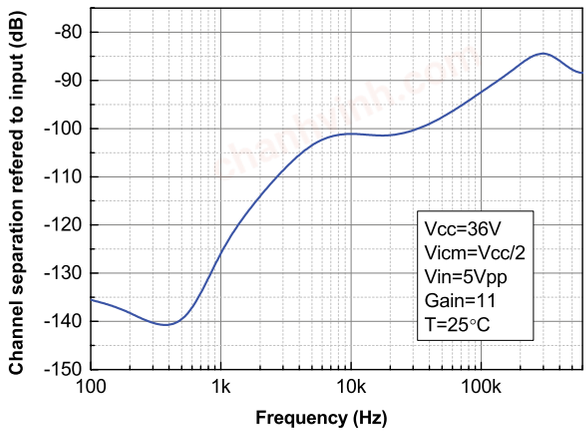


Figure 16. Positive slew rate at V_{CC} = 36 V

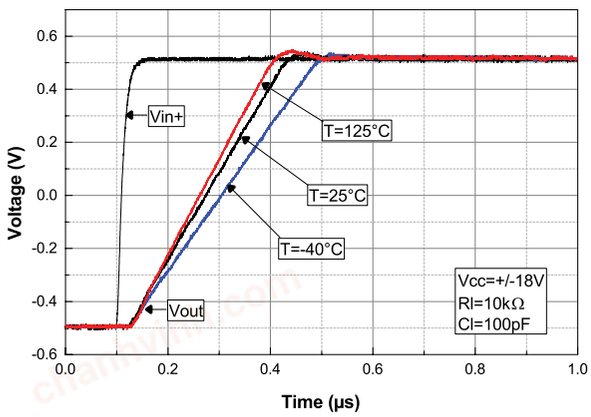


Figure 17. Negative slew rate at V_{CC} = 36 V

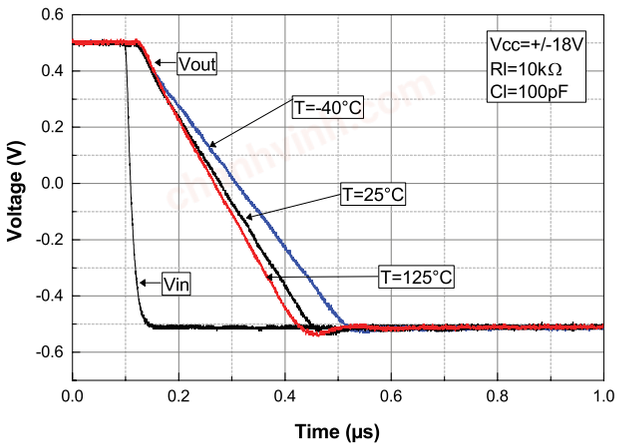


Figure 18. Bode diagram at V_{CC} = 5 V

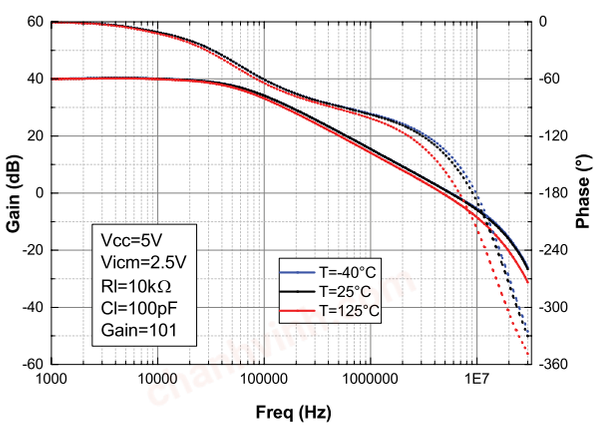
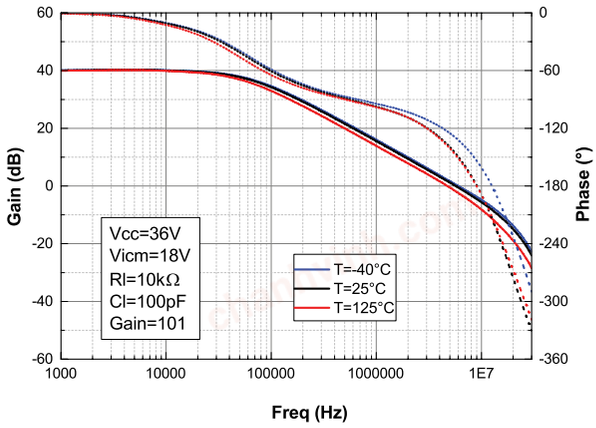


Figure 19. Bode diagram at V_{CC} = 36 V



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Figure 20. Phase margin vs. output current at V_{CC} = 5 V

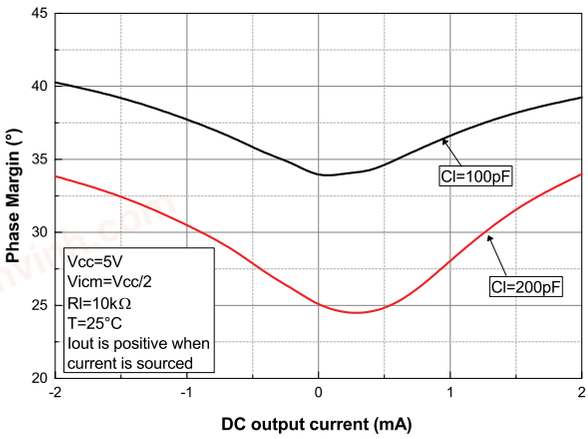


Figure 21. Phase margin vs. output current at V_{CC} = 36 V

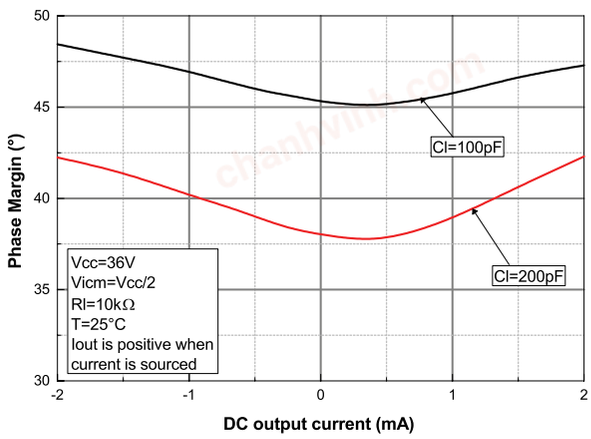


Figure 22. Phase margin vs. capacitive load

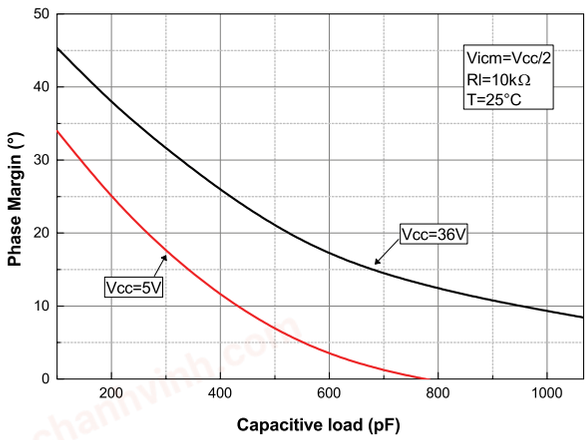


Figure 23. Overshoot vs. capacitive load at V_{CC} = 36 V

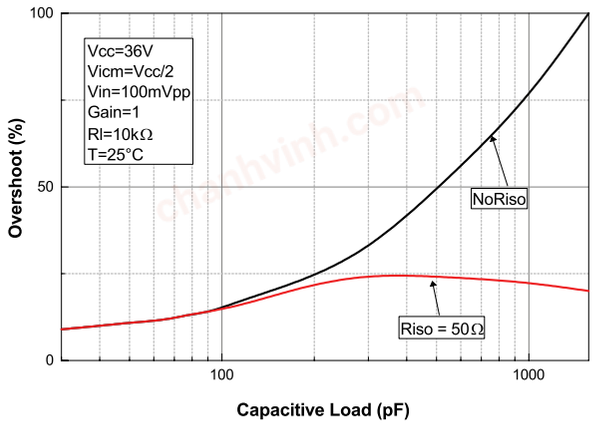


Figure 24. Small step response at V_{CC} = 5 V

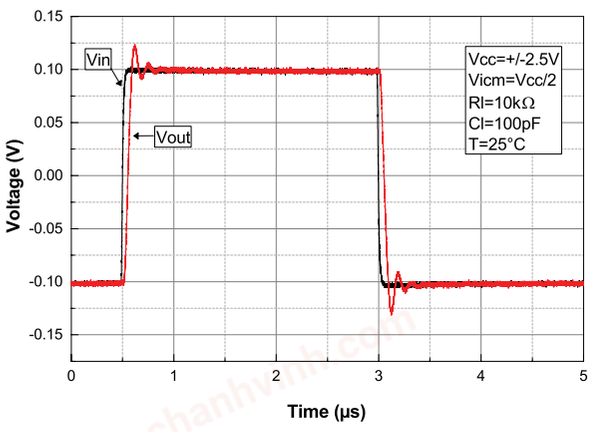
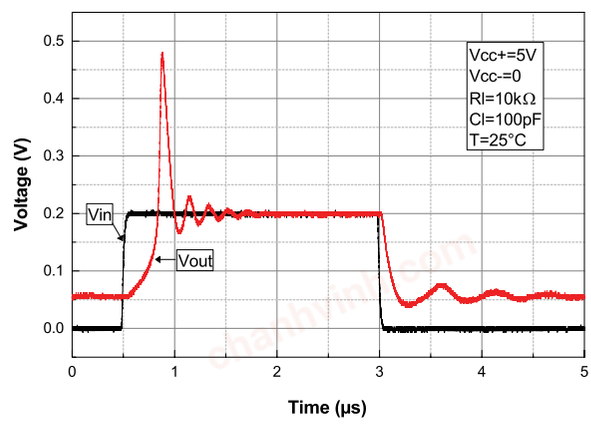


Figure 25. Desaturation time at low rail at V_{CC} = 5 V



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Figure 26. Desaturation time at high rail at V_{CC} = 5 V

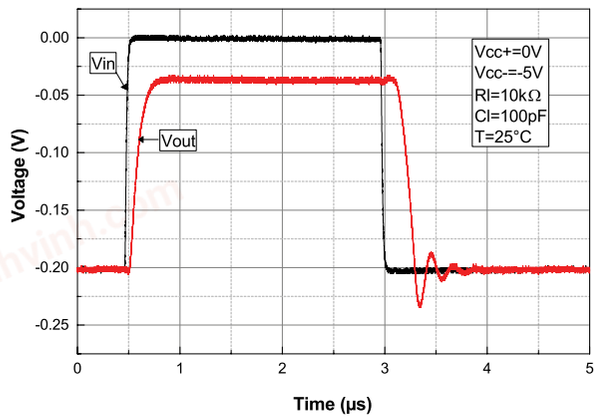


Figure 27. Small step response at V_{CC} = 36 V

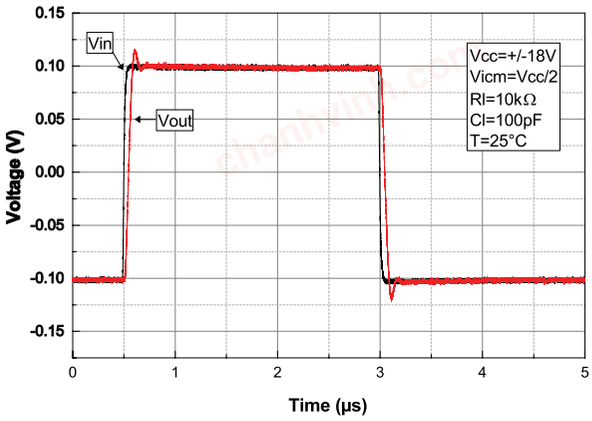


Figure 28. Amplifier behavior close to low rail at V_{CC} = 36 V

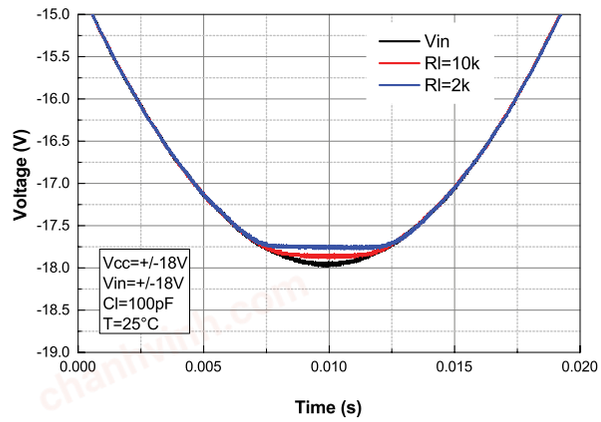


Figure 29. Amplifier behavior close to high rail at V_{CC} = 36 V

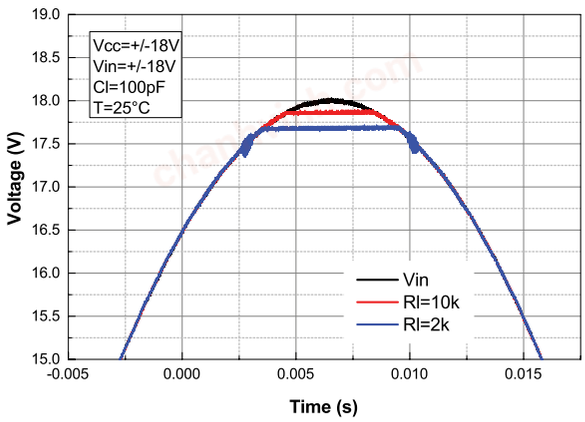


Figure 30. Noise vs. frequency at V_{CC} = 5 V

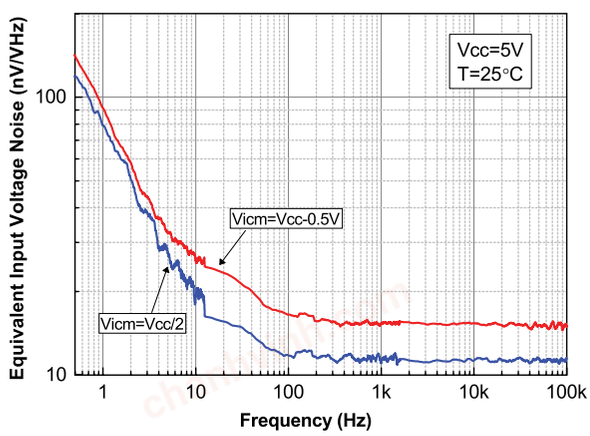
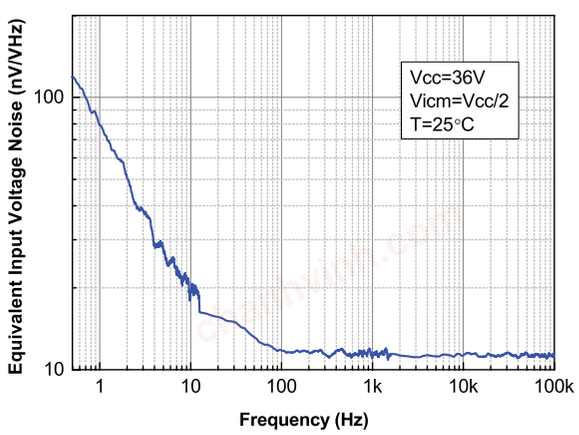


Figure 31. Noise vs. frequency at V_{CC} = 36 V



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Figure 32. Noise vs. time at V_{CC} = 36 V

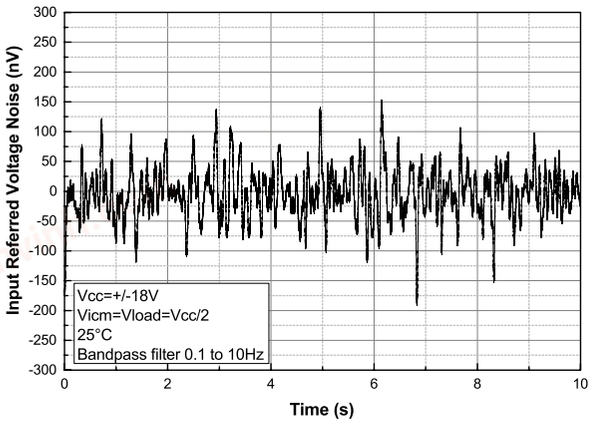


Figure 33. THD+N vs. frequency

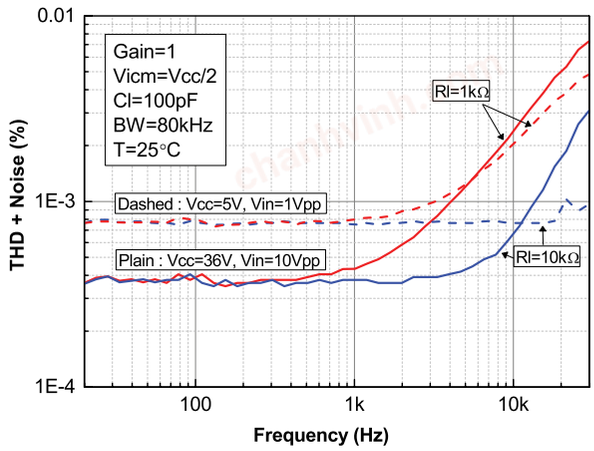


Figure 34. THD+N vs. frequency

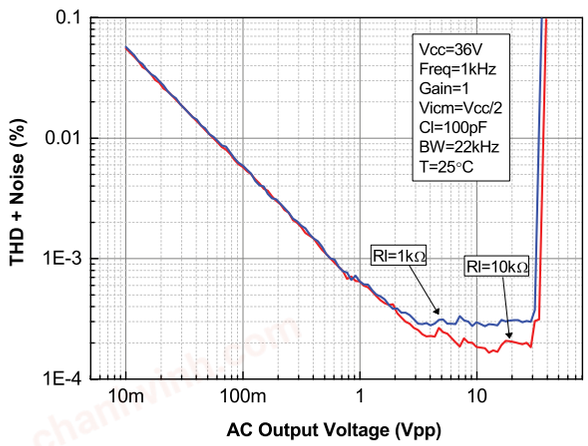


Figure 35. PSRR vs. frequency at V_{CC} = 10 V

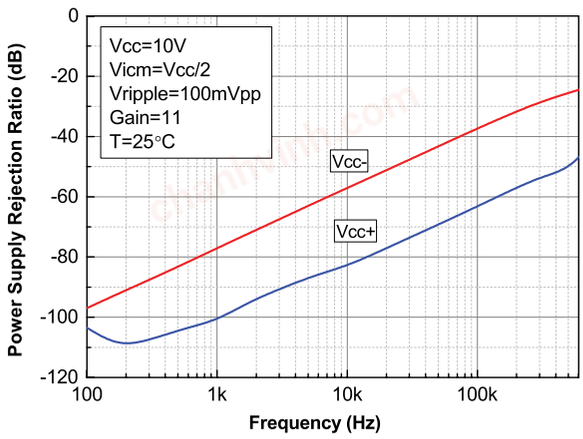
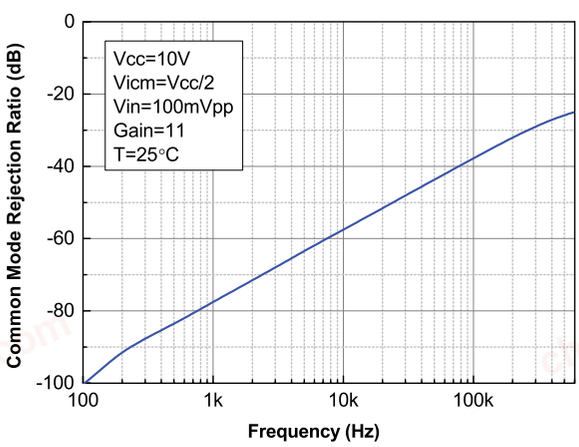


Figure 36. CMRR vs. frequency at V_{CC} = 10 V



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5 Ordering information

Table 8. **Order codes**

Order code	Package	Packaging	Marking
TSB511ILT	SOT23-5	Tape & Reel	K232
TSB511IYLT (1)			K233
TSB512IDT	SO8		TSB512I
TSB512IYDT (1)			TSB512IY
TSB512IST	MiniSO8		K232
TSB512IYST (1)			K233
TSB514IDT	SO14		TSB514I
TSB514IYDT (1)			TSB514IY
TSB514IPT	TSSOP14		B514I
TSB514IYPT (1)			B514IY

1. *Qualified and characterized according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q002 or equivalent.*

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6 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions and product status are available at: www.st.com. ECOPACK is an ST trademark.

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6.1 SOT23-5 package information

Figure 37. **SOT23-5 package outline**

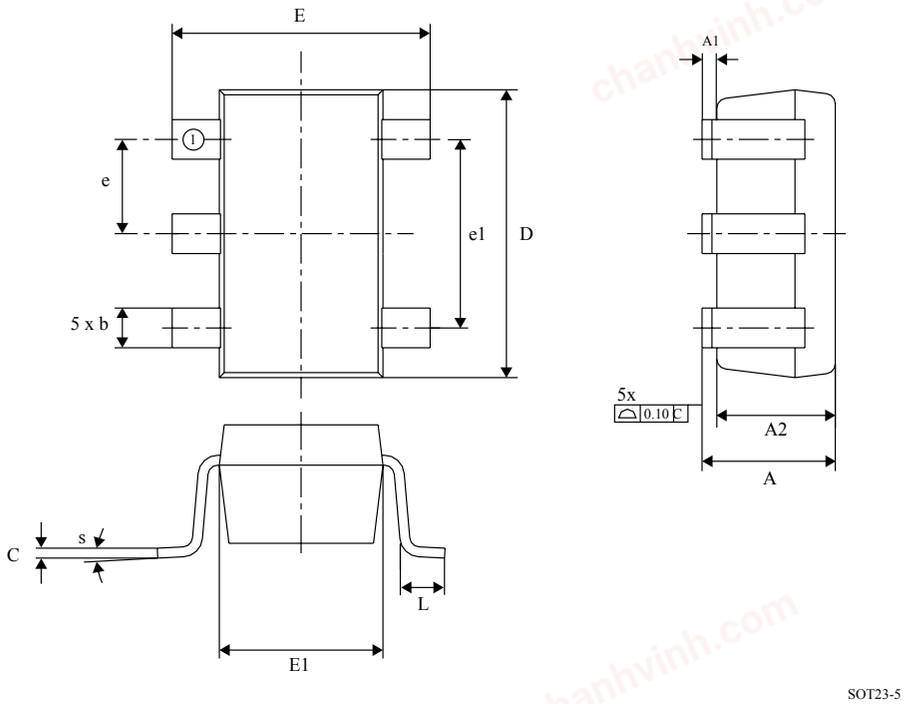


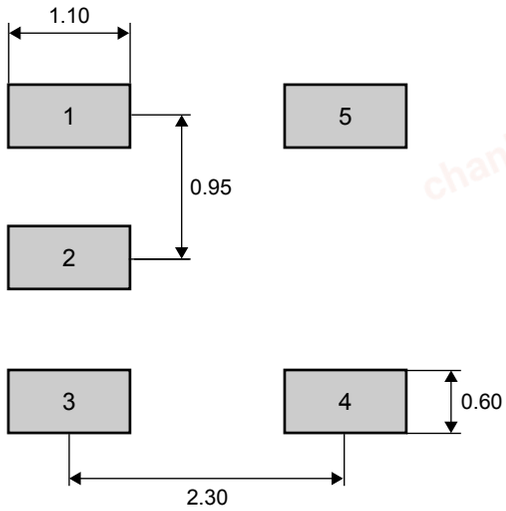
Table 9. **SOT23-5 mechanical data**

Symbol	Milimeters			Inches[1]		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.45			0.057
A1	0.00		0.15	0.000		0.006
A2	0.90	1.15	1.30	0.035	0.045	0.051
b	0.30		0.50	0.012		0.020
c	0.08		0.22	0.003		0.009
D		2.90			0.114	
E		2.80			0.110	
E1		1.60			0.063	
e		0.95			0.037	
e1		1.90			0.075	
L	0.30	0.45	0.60	0.012	0.018	0.024
θ	0	4	8	0	4	8

1. *Values in inches are converted from mm and rounded to 4 decimal digits.*

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Figure 38. **SOT23-5 recommended footprint**



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6.2 MiniSO8 package information

Figure 39. **MiniSO8 package outline**

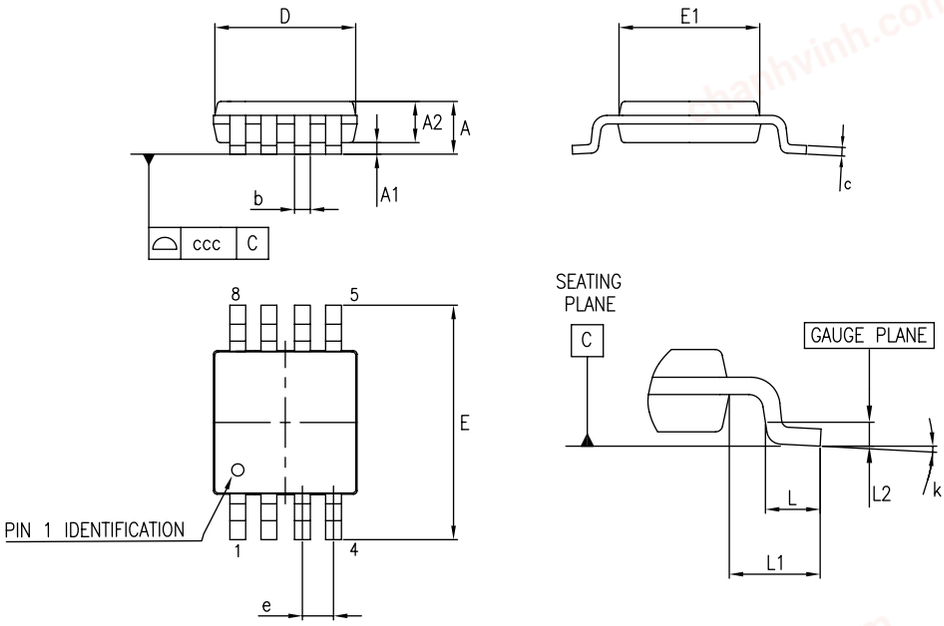


Table 10. **MiniSO8 mechanical data**

Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.1			0.043
A1	0		0.15	0		0.006
A2	0.75	0.85	0.95	0.03	0.033	0.037
b	0.22		0.4	0.009		0.016
c	0.08		0.23	0.003		0.009
D	2.8	3	3.2	0.11	0.118	0.126
E	4.65	4.9	5.15	0.183	0.193	0.203
E1	2.8	3	3.1	0.11	0.118	0.122
e		0.65			0.026	
L	0.4	0.6	0.8	0.016	0.024	0.031
L1		0.95			0.037	
L2		0.25			0.01	
k	0°		8°	0°		8°
ccc			0.1			0.004

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6.3 SO8 package information

Figure 40. **SO8 package outline**

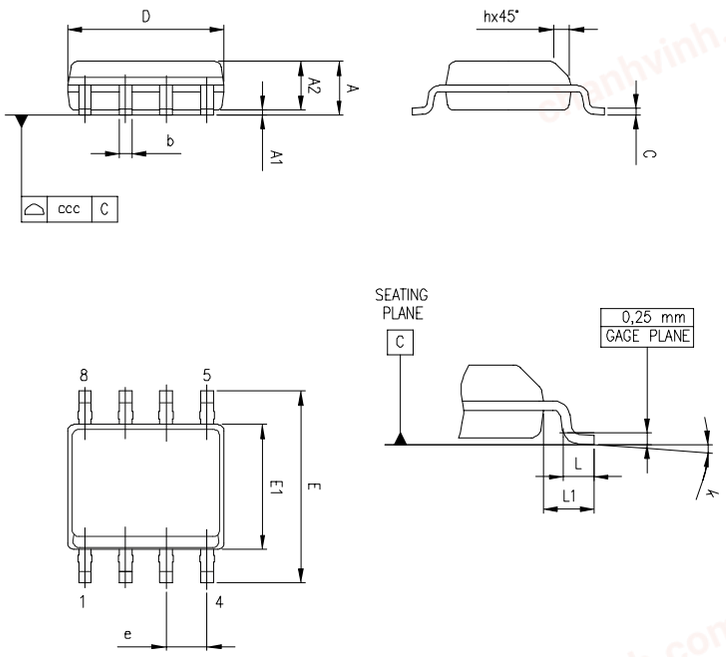


Table 11. **SO8 mechanical data**

Dim.	mm			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
A1	0.1		0.25	0.004		0.01
A2	1.25			0.049		
b	0.28		0.48	0.011		0.019
c	0.17		0.23	0.007		0.01
D	4.8	4.9	5	0.189	0.193	0.197
E	5.8	6	6.2	0.228	0.236	0.244
E1	3.8	3.9	4	0.15	0.154	0.157
e		1.27			0.05	
h	0.25		0.5	0.01		0.02
L	0.4		1.27	0.016		0.05
L1		1.04			0.04	
k	0		8 °	1 °		8 °
ccc			0.1			0.004

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6.4 SO14 package information

Figure 41. **SO14 package outline**

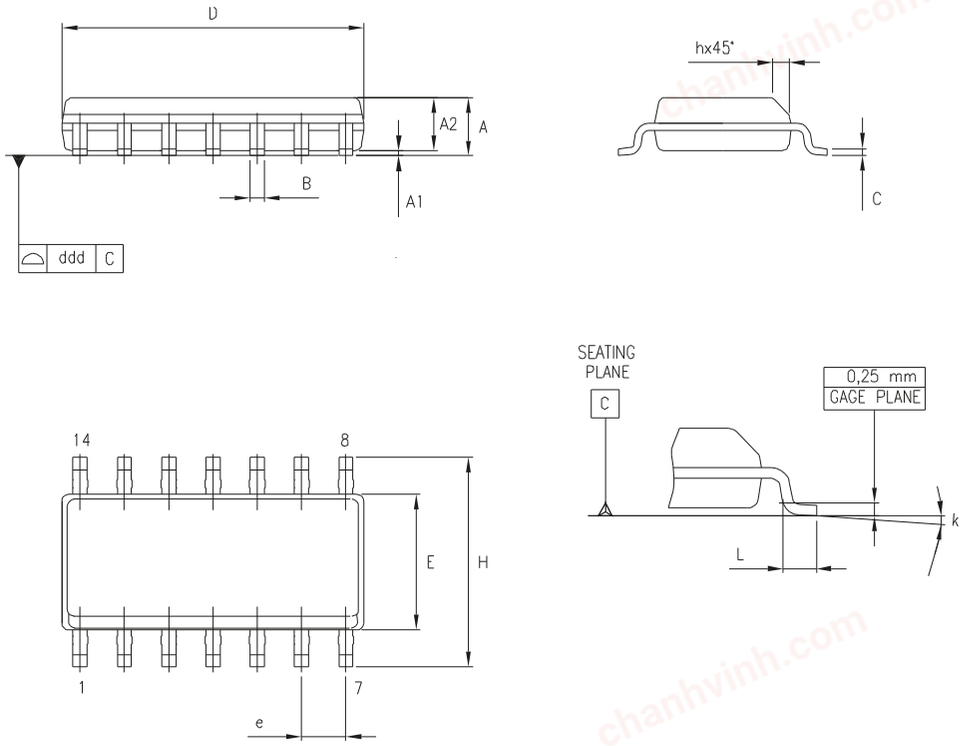


Table 12. **SO14 mechanical data**

Dimensions [1]						
Symbol	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	1.35		1.75	0.05		0.068
A1	0.10		0.25	0.004		0.009
A2	1.10		1.65	0.04		0.06
B	0.33		0.51	0.01		0.02
C	0.19		0.25	0.007		0.009
D [2]	8.55		8.75	0.33		0.34
E	3.80		4.0	0.15		0.15
e		1.27			0.05	
H	5.80		6.20	0.22		0.24
L	0.40		1.27	0.015		0.05
k	0°		8°	0°		8°
ddd			0.10			0.004

1. *Drawing dimensions include “Single” and “Matrix” versions.*
2. *Dimension “D” does not include mold flash, protrusions or gate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.15 mm per side.*

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6.5 TSSOP14 package information

Figure 42. **TSSOP14 package outline**

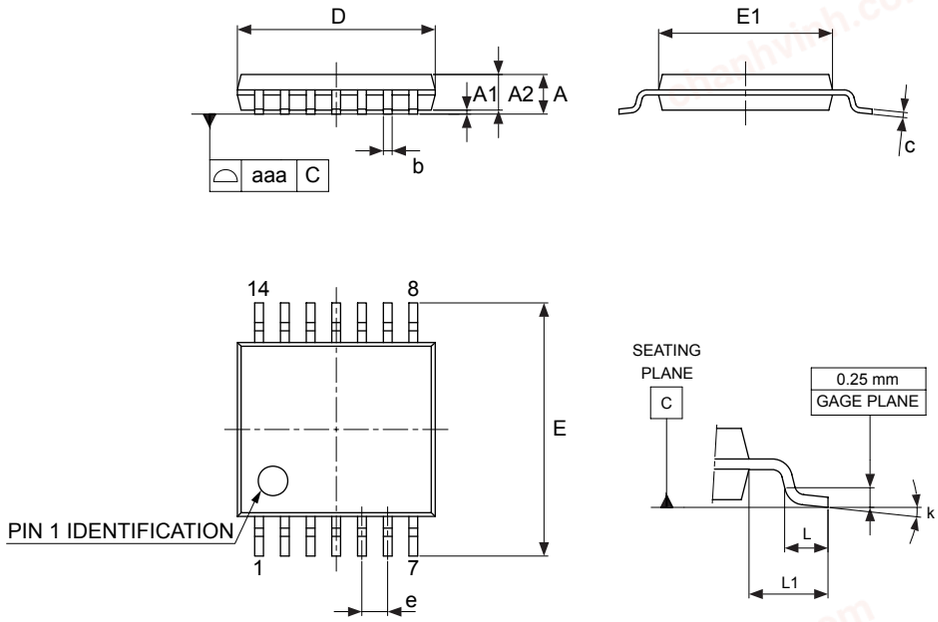


Table 13. **TSSOP14 mechanical data**

Symbol	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.047
A1	0.05		0.15	0.002	0.004	0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.012
c	0.09		0.20	0.004		0.0089
D	4.90	5.00	5.10	0.193	0.197	0.201
E	6.20	6.40	6.60	0.244	0.252	0.260
E1	4.30	4.40	4.50	0.169	0.173	0.176
e		0.65			0.0256	
L	0.45	0.60	0.75	0.018	0.024	0.030
L1		1.00			0.039	
k	0°		8°	0°		8°
aaa			0.10			0.004

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Revision history

Table 14. **Document revision history**

Date	Revision	Changes
26-Jan-2022	1	Initial release.

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