Very high accuracy (5 µV) zero drift micropower 5 V operational amplifiers

Description

The TSZ121/122 of high precision operational amplifiers offer very low input offset voltages with virtually zero drift.TSZ121 is the single version, TSZ122 the dual version, with pinouts compatible with industry standards.The TSZ121/122 offers rail-to-rail input and output, excellent speed/ power consumption ratio, and 400 kHz gain bandwidth product, while consuming less than 40 µA at 5 V. The devices also feature an ultra-low input bias current.These features make theTSZ121/122 family ideal for sensor interfaces, battery-powered applications and portable applications.

Applications

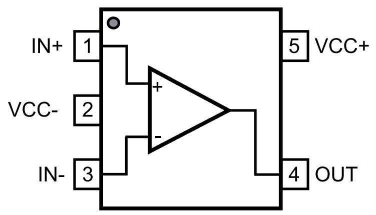
- Battery-powered applications
- Portable devices
- Signal conditioning
- Medical instrumentation

Features

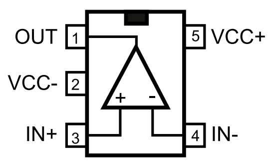
- Very high accuracy and stability: offset voltage 5 µV max at 25 °C, 8 µV over full temperature range (-40 °C to 125 °C)
- Rail-to-rail input and output
- Low supply voltage: 1.8 - 5.5 V
- Low power consumption: 40 µA max. at 5 V
- Gain bandwidth product: 400 kHz
- High tolerance to ESD: 4 kV HBM
- Extended temperature range: -40 to 125 °C

Package pin connections

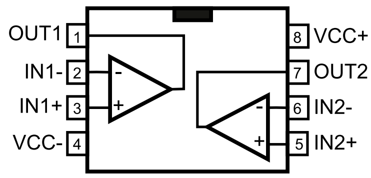
Figure 1. Pin connections for each package (top view)



SC70-5



SOT23-5



SOP-8

Absolute maximum ratings and operating conditions

Table 1. Absolute maximum ratings (AMR)

Symbol	Parameter		Value	Unit
V_{CC}	Supply voltage (1)		6	V
V_{id}	Differential input voltage (2)		$\pm V_{CC}$	V
V_{in}	Input voltage (3)		(V_{CC-}) - 0.2 to (V_{CC+}) + 0.2	V
I_{in}	Input current (4)		10	mA
T_{stg}	Storage temperature		-65 to 150	°C
T_j	Maximum junction temperature		150	°C
R_{thja}	Thermal resistance junction to ambient (5) (6)	SC70-5	205	°C/W
		SOT23-5	250	
		SOP-8	125	
ESD	HBM: human body model (7)		4	kV
	MM: machine model (8)		300	V
	CDM: charged device model (9)		1.5	kV
	Latch-up immunity		200	mA

1. All voltage values, except the differential voltage are with respect to the network ground terminal.
2. The differential voltage is the non-inverting input terminal with respect to the inverting input terminal.
3. V_{cc} - V_{in} must not exceed 6 V, Vin must not exceed 6 V
4. Input current must be limited by a resistor in series with the inputs.
5. R_{th} are typical values.
6. Short-circuits can cause excessive heating and destructive dissipation.
7. Human body model: 100 pF discharged through a 1.5 kΩ resistor between two pins of the device, done for all couples of pin combinations with other pins floating.
8. Machine model: a 200 pF cap is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5 Ω), done for all couples of pin combinations with other pins floating.
9. Charged device model: all pins plus package are charged together to the specified voltage and then discharged directly to ground.

Table 2. Operating conditions

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage	1.8 to 5.5	V
V_{icm}	Common mode input voltage range	(V_{CC-}) - 0.1 to (V_{CC+}) + 0.1	V
T_{oper}	Operating free air temperature range	-40 to 125	°C

Electrical characteristics

Table 3. Electrical characteristics at V_{CC+} = 1.8 V with V_{CC-} = 0 V, V_{icm} = V_{CC}/2, T = 25 ° C, and R_L = 10 kΩ connected to V_{CC}/2 (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V_{io}	Input offset voltage	T = 25 °C		1	5	µV
		-40 °C < T < 125 °C			8	
$\Delta V_{io}/\Delta T$	Input offset voltage drift (1)	-40 °C < T < 125 °C		10	30	nV/°C
I_{ib}	Input bias current (V_{out} = V_{CC}/2)	T = 25 °C		50	200 (2)	pA
		-40 °C < T < 125 °C			300 (2)	
I_{io}	Input offset current (V_{out} = V_{CC}/2)	T = 25 °C		100	400 (2)	
		-40 °C < T < 125 °C			600 (2)	
CMR	Common mode rejection ratio, 20 log ($\Delta V_{icm}/\Delta V_{io}$), V_{ic} = 0 V to V_{CC}, V_{out} = V_{CC}/2, R_L > 1 MΩ	T = 25 °C	110	122		dB
		-40 °C < T < 125 °C	110			
A_{vd}	Large signal voltage gain, V_{out} = 0.5 V to (V_{CC} - 0.5 V)	T = 25 °C	118	135		
		-40 °C < T < 125 °C	110			
V_{OH}	High-level output voltage	T = 25 °C			30	mV
		-40 °C < T < 125 °C			70	
V_{OL}	Low-level output voltage	T = 25 °C			30	
		-40 °C < T < 125 °C			70	
I_{out}	I_{sink} (V_{out} = V_{CC})	T = 25 °C	7	8		mA
		-40 °C < T < 125 °C	6			
	I_{source} (V_{out} = 0 V)	T = 25 °C	5	7		
		-40 °C < T < 125 °C	4			
I_{CC}	Supply current (per amplifier, V_{out} = V_{CC}/2, R_L > 1 MΩ)	T = 25 °C		28	40	µA
		-40 °C < T < 125 °C			40	
GBP	Gain bandwidth product	R_L = 10 kΩ, C_L = 100 pF		400		kHz
F_u	Unity gain frequency			300		
ϕm	Phase margin			55		Degrees
G_m	Gain margin			17		dB
SR	Slew rate (3)			0.17		V/µs
t_s	Setting time	To 0.1 %, V_{in} = 1 Vp-p, R_L = 10 kΩ, C_L = 100 pF		50		µs
e_n	Equivalent input noise voltage	f = 1 kHz		60		nV/√Hz
		f = 10 kHz		60		
$\int e_n$	Low-frequency peak-to-peak input noise	Bandwidth, f = 0.1 to 10 Hz		1.1		µVpp
C_s	Channel separation	f = 100 Hz		120		dB
t_{init}	Initialization time	T = 25 °C		50		µs
		-40 °C < T < 125 °C		100		

Table 4. Electrical characteristics at V_{CC+} = 3.3 V with V_{CC-} = 0 V, V_{icm} = V_{CC}/2, T = 25 ° C, and R_L = 10 kΩ connected to V_{CC}/2 (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V_{io}	Input offset voltage	T = 25 °C		1	5	μV
		-40 °C < T < 125 °C			8	
$\Delta V_{io}/\Delta T$	Input offset voltage drift [1]	-40 °C < T < 125 °C		10	30	nV/°C
I_{ib}	Input bias current (V_{out} = V_{CC}/2)	T = 25 °C		60	200 [2]	pA
		-40 °C < T < 125 °C			300 [2]	
I_{io}	Input offset current (V_{out} = V_{CC}/2)	T = 25 °C		120	400 [2]	
		-40 °C < T < 125 °C			600 [2]	
CMR	Common mode rejection ratio, 20 log ($\Delta V_{icm}/\Delta V_{io}$), V_{ic} = 0 V to V_{CC}, V_{out} = V_{CC}/2, R_L > 1 MΩ	T = 25 °C	115	128		dB
		-40 °C < T < 125 °C	115			
A_{vd}	Large signal voltage gain, V_{out} = 0.5 V to (V_{CC} - 0.5 V)	T = 25 °C	118	135		
		-40 °C < T < 125 °C	110			
V_{OH}	High-level output voltage	T = 25 °C			30	mV
		-40 °C < T < 125 °C			70	
V_{OL}	Low-level output voltage	T = 25 °C			30	
		-40 °C < T < 125 °C			70	
I_{out}	I_{sink} (V_{out} = V_{CC})	T = 25 °C	15	18		mA
		-40 °C < T < 125 °C	12			
	I_{source} (V_{out} = 0 V)	T = 25 °C	14	16		
		-40 °C < T < 125 °C	10			
I_{CC}	Supply current (per amplifier, V_{out} = V_{CC}/2, R_L > 1 MΩ)	T = 25 °C		29	40	μA
		-40 °C < T < 125 °C			40	
GBP	Gain bandwidth product			400		kHz
F_u	Unity gain frequency	R_L = 10 kΩ, C_L = 100 pF		300		
ϕm	Phase margin			56		Degrees
G_m	Gain margin			19		dB
SR	Slew rate [3]			0.19		V/μs
t_s	Setting time	To 0.1 %, V_{in} = 1 Vp-p, R_L = 10 kΩ, C_L = 100 pF		50		μs
e_n	Equivalent input noise voltage	f = 1 kHz		40		nV/√Hz
		f = 10 kHz		40		
$\int e_n$	Low-frequency peak-to-peak input noise	Bandwidth, f = 0.1 to 10 Hz		0.8		μVpp
C_s	Channel separation	f = 100 Hz		120		dB
t_{init}	Initialization time	T = 25 °C		50		μs
		-40 °C < T < 125 °C		100		

Table 5. Electrical characteristics at V_{CC+} = 5 V with V_{CC-} = 0 V, V_{icm} = $V_{CC}/2$, T = 25 ° C, and R_L = 10 kΩ connected to $V_{CC}/2$ (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V_{io}	Input offset voltage	T = 25 °C		1	5	µV
		-40 °C < T < 125 °C			8	
$\Delta V_{io}/\Delta T$	Input offset voltage drift (1)	-40 °C < T < 125 °C		10	30	nV/°C
I_{ib}	Input bias current (V_{out} = $V_{CC}/2$)	T = 25 °C		70	200 (2)	pA
		-40 °C < T < 125 °C			300 (2)	
I_{io}	Input offset current (V_{out} = $V_{CC}/2$)	T = 25 °C		140	400 (2)	
		-40 °C < T < 125 °C			600 (2)	
CMR	Common mode rejection ratio, 20 log ($\Delta V_{icm}/\Delta V_{io}$), V_{ic} = 0 V to V_{CC}, V_{out} = $V_{CC}/2$, R_L > 1 MΩ	T = 25 °C	115	136		dB
		-40 °C < T < 125 °C	115			
SVR	Supply voltage rejection ratio, 20 log ($\Delta V_{CC}/\Delta V_{io}$), V_{CC} = 1.8 V to 5.5 V, V_{out} = $V_{CC}/2$, R_L > 1 MΩ	T = 25 °C	120	140		
		-40 °C < T < 125 °C	120			
A_{vd}	Large signal voltage gain, V_{out} = 0.5 V to (V_{CC} - 0.5 V)	T = 25 °C	120	135		
		-40 °C < T < 125 °C	110			
EMIRR (3)	EMI rejection rate = -20 log ($V_{RFpeak}/\Delta V_{io}$)	V_{RF} = 100 mV_p, f = 400 MHz		84		
		V_{RF} = 100 mV_p, f = 900 MHz		87		
		V_{RF} = 100 mV_p, f = 1800 MHz		90		
		V_{RF} = 100 mV_p, f = 2400 MHz		91		
V_{OH}	High-level output voltage	T = 25 °C			30	mV
		-40 °C < T < 125 °C			70	
V_{OL}	Low-level output voltage	T = 25 °C			30	
		-40 °C < T < 125 °C			70	
I_{out}	I_{sink} (V_{out} = V_{CC})	T = 25 °C	15	18		mA
		-40 °C < T < 125 °C	14			
	I_{source} (V_{out} = 0 V)	T = 25 °C	14	17		
		-40 °C < T < 125 °C	12			
I_{CC}	Supply current (per amplifier, V_{out} = $V_{CC}/2$, R_L > 1 MΩ)	T = 25 °C		31	40	µA
		-40 °C < T < 125 °C			40	
GBP	Gain bandwidth product	R_L = 10 kΩ, C_L = 100 pF		400		kHz
F_u	Unity gain frequency			300		

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
ϕm	Phase margin			53		Degrees
G_m	Gain margin	R_L = 10 kΩ, C_L = 100 pF		19		dB
SR	Slew rate (4)			0.19		V/μs
t_s	Setting time	To 0.1 %, V_{in} = 100 mVp-p, R_L = 10 kΩ, C_L = 100 pF		10		μs
e_n	Equivalent input noise voltage	f = 1 kHz		37		nV/√Hz
		f = 10 kHz		37		
$\int e_n$	Low-frequency peak-to-peak input noise	Bandwidth, f = 0.1 to 10 Hz		0.75		μVpp
C_s	Channel separation	f = 100 Hz		120		dB
t_{init}	Initialization time	T = 25 °C		50		μs
		-40 °C < T < 125 °C		100		

Electrical characteristic curves

Figure 2. Supply current vs. supply voltage

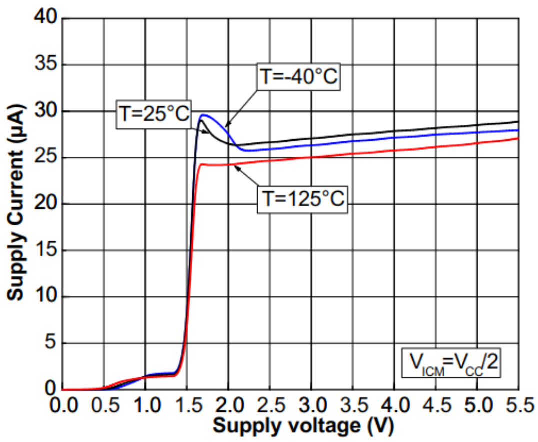


Figure 3. Input offset voltage distribution at V_{CC} = 5 V

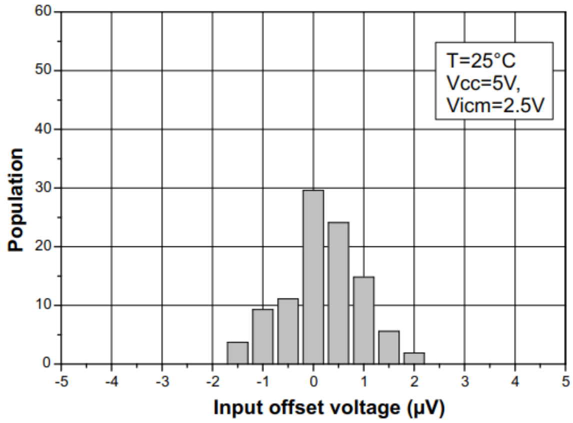


Figure 4. Input offset voltage distribution at V_{CC} = 3.3 V

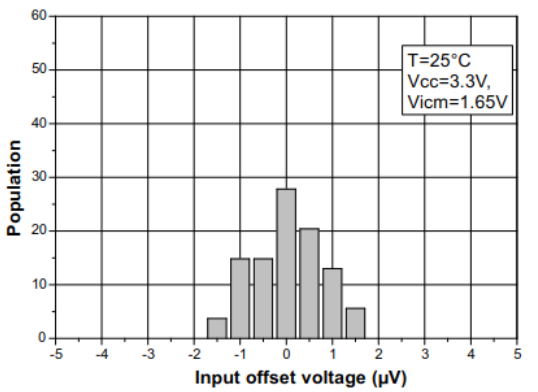


Figure 5. Input offset voltage distribution at V_{CC} = 1.8 V

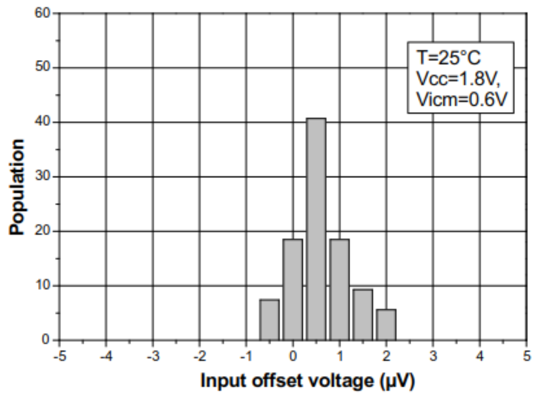


Figure 6. Vio temperature co-efficient distribution (-40 °C to 25 °C)

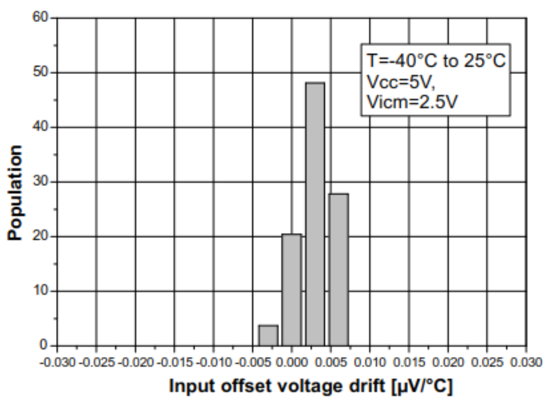


Figure 7. Vio temperature co-efficient distribution (25 °C to 125 °C)

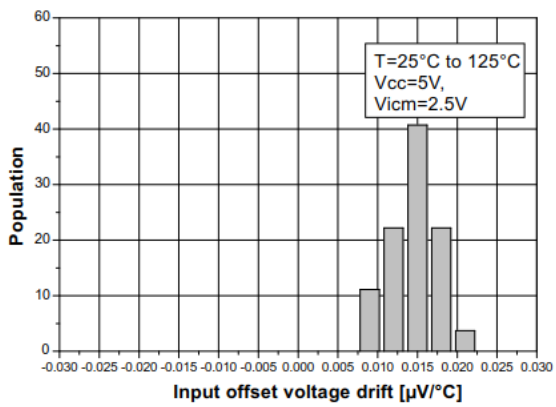


Figure 8. Input offset voltage vs. supply voltage

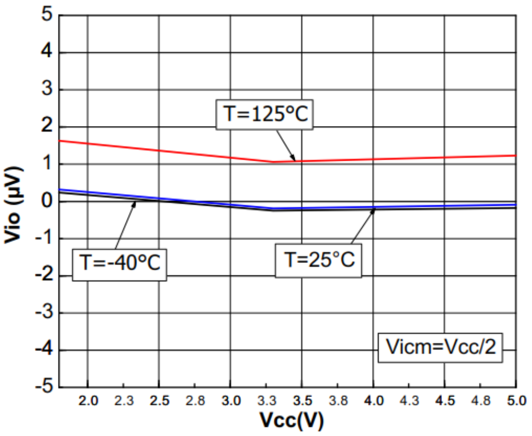


Figure 9. Input offset voltage vs. input common-mode at V_{CC} = 1.8 V

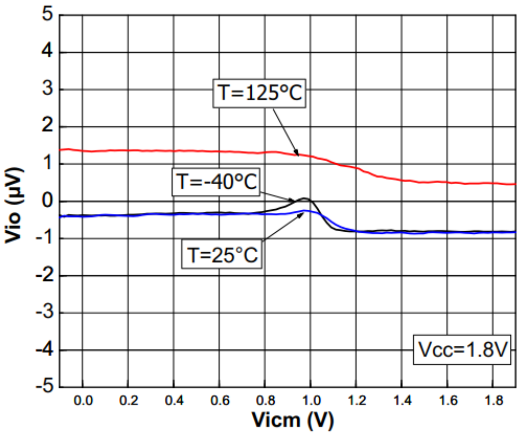


Figure 10. Input offset voltage vs. input common-mode at V_{CC} = 2.7 V

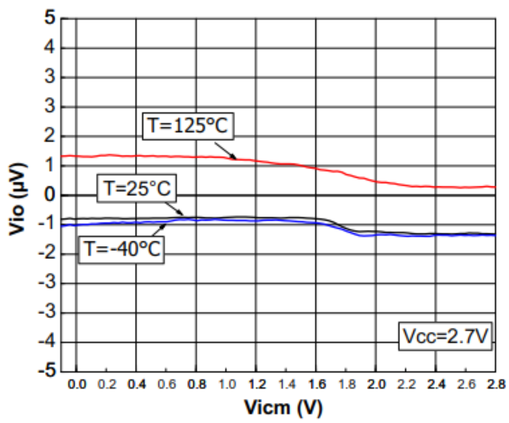


Figure 11. Input offset voltage vs. input common-mode at V_{CC} = 5.5 V

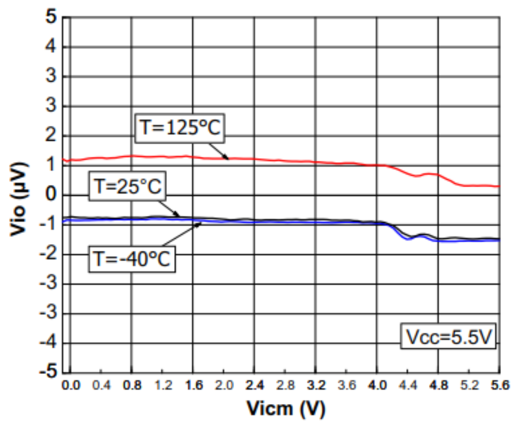


Figure 12. Input offset voltage vs. temperature

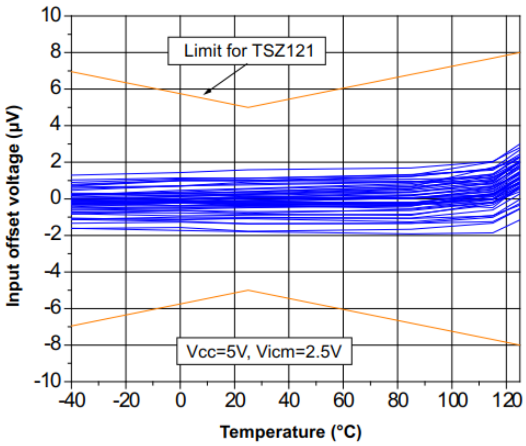


Figure 13. V_{OH} vs. supply voltage

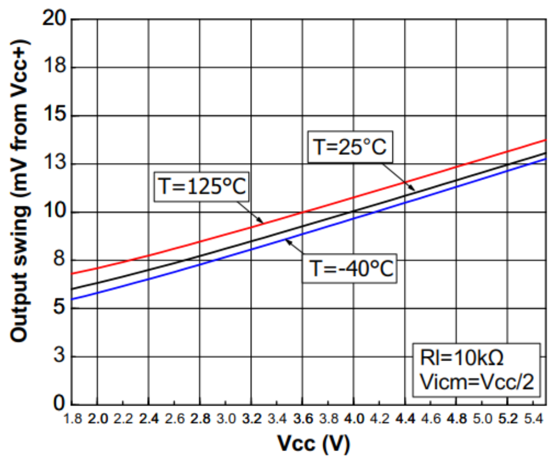


Figure 14. V_{OL} vs. supply voltage

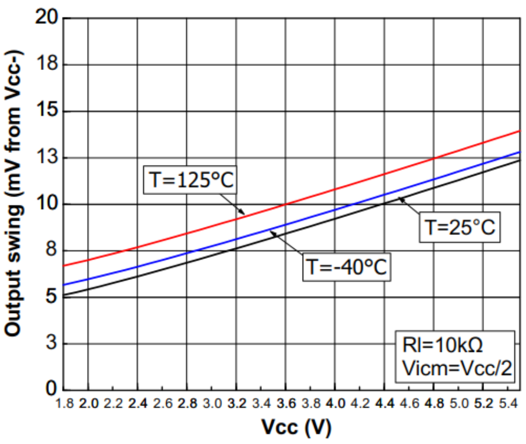


Figure 15. Output current vs. output voltage at V_{CC} = 1.8 V

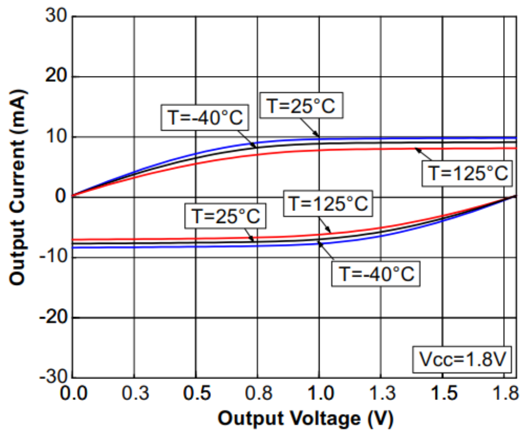


Figure 16. Output current vs. output voltage at V_{CC} = 5.5 V

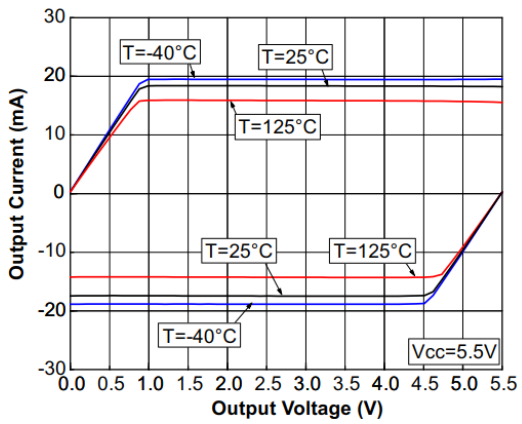


Figure 17. Input bias current vs. common mode at V_{CC} = 5 V

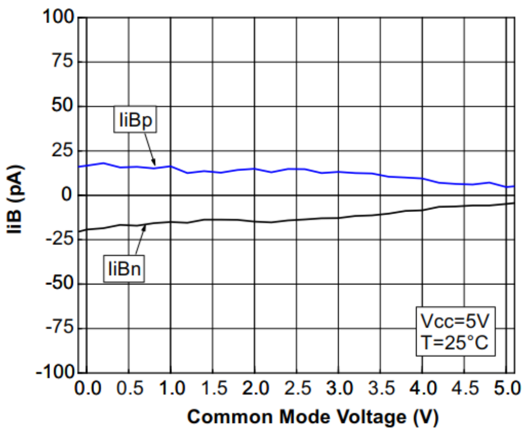


Figure 18. Input bias current vs. common mode at V_{CC} = 1.8 V

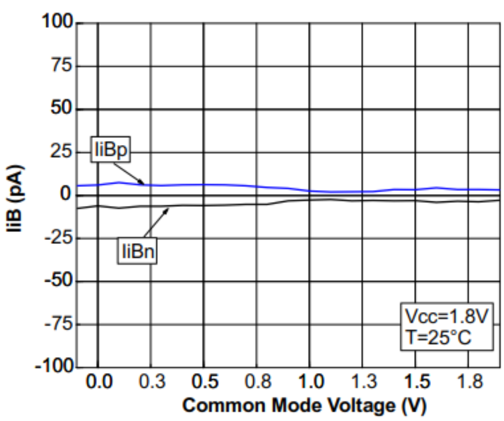
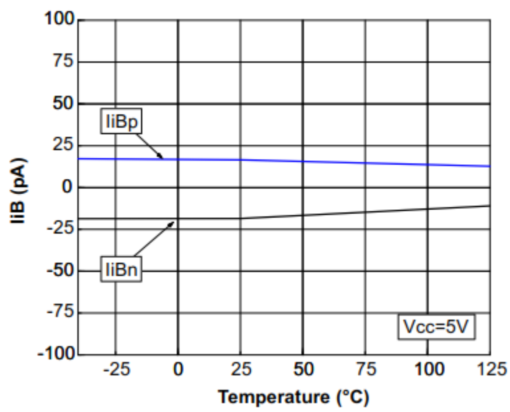


Figure 19. Input bias current vs. temperature at V_{CC} = 5 V



Very high accuracy (5 µV) zero drift micropower 5 V operational amplifiers

Figure 20. Bode diagram at V_{CC} = 1.8 V

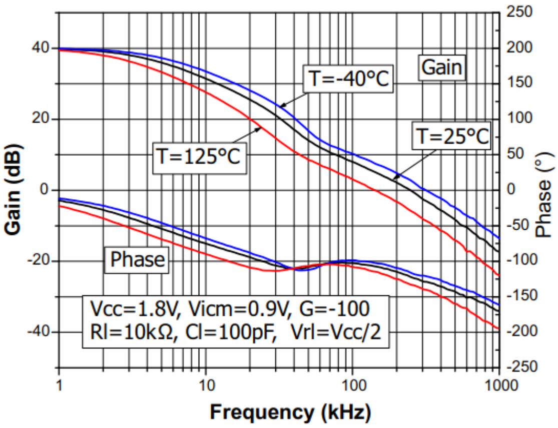


Figure 21. Bode diagram at V_{CC} = 2.7 V

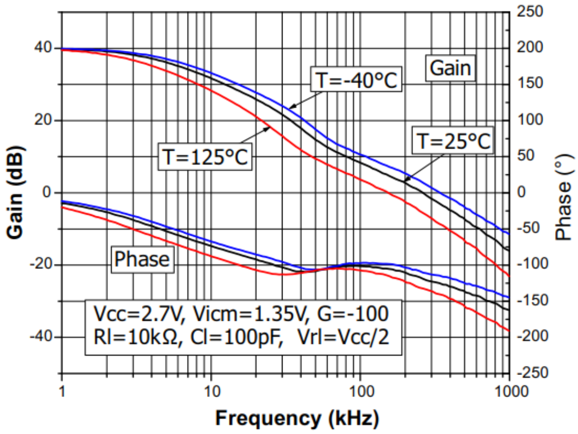


Figure 22. Bode diagram at V_{CC} = 5.5 V

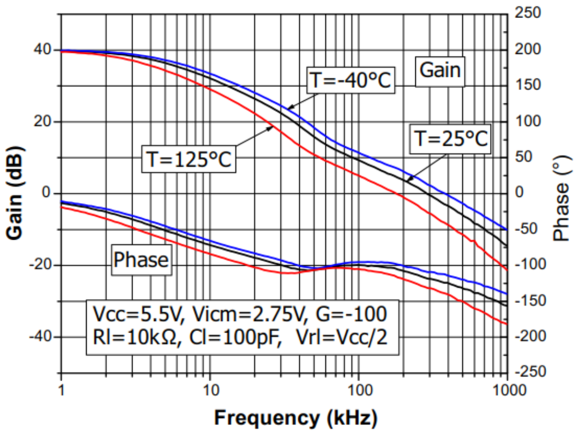


Figure 23. Open loop gain vs. frequency

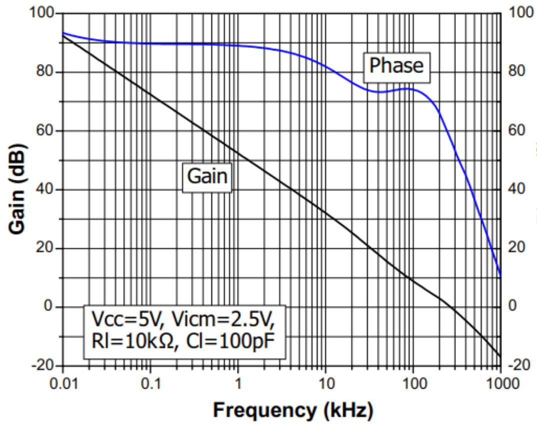


Figure 24. Positive slew rate vs. supply voltage

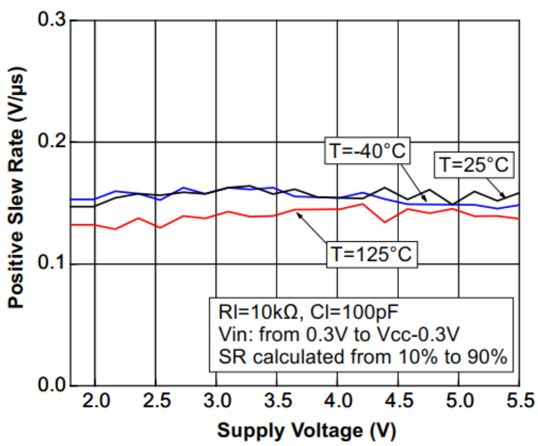


Figure 25. Negative slew rate vs. supply voltage

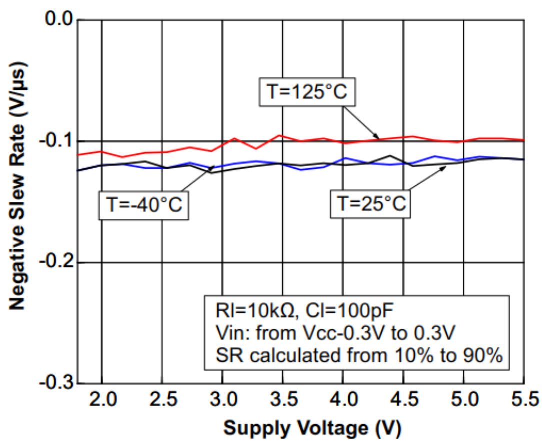


Figure 26. 0.1 Hz to 10 Hz noise

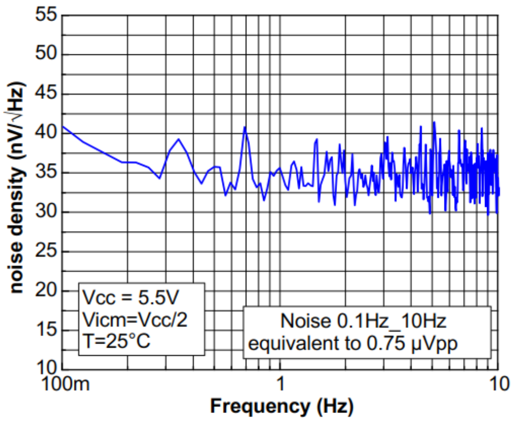


Figure 27. Noise vs. frequency

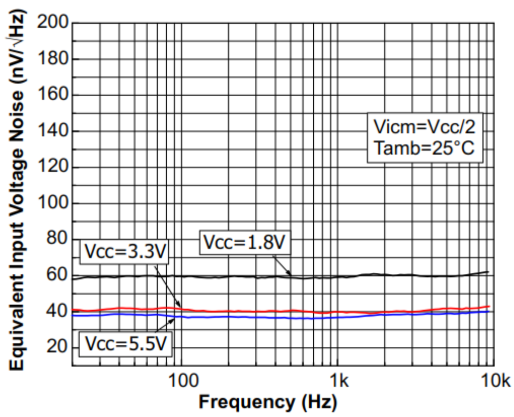


Figure 28. Noise vs. frequency and temperature

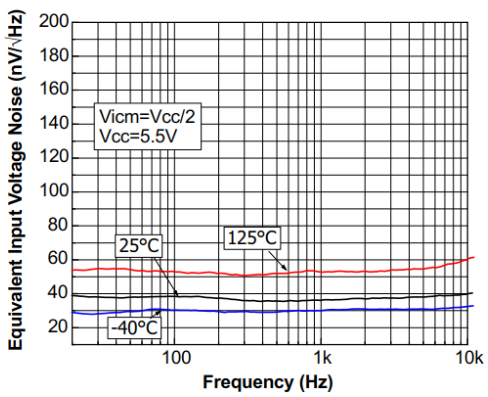


Figure 29. Output overshoot vs. load capacitance

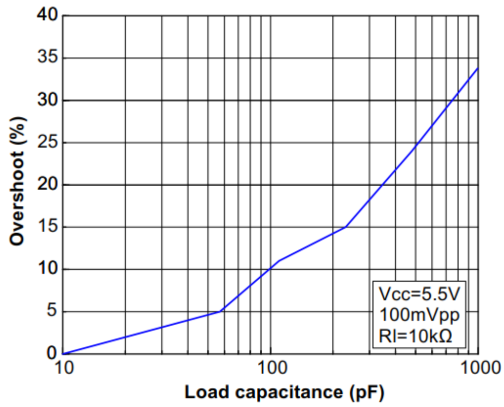


Figure 30. Small signal

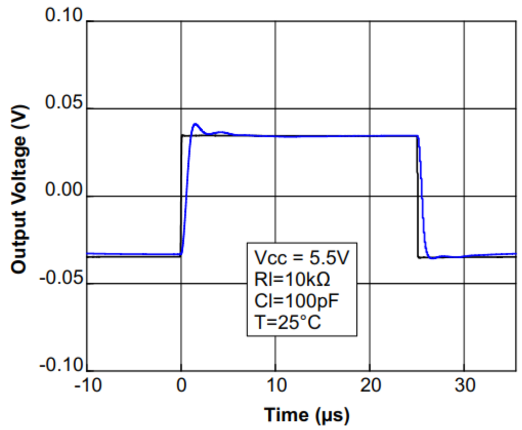


Figure 31. Large signal

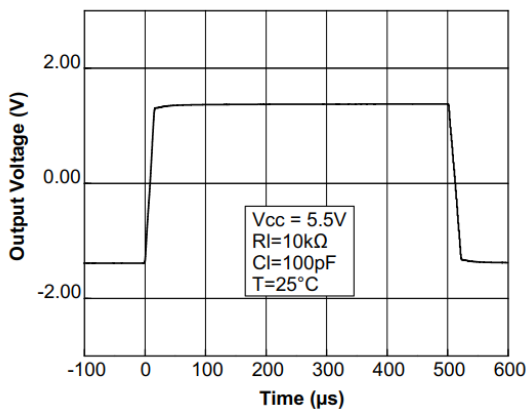


Figure 32. Positive overvoltage recovery at V_{CC} = 1.8 V

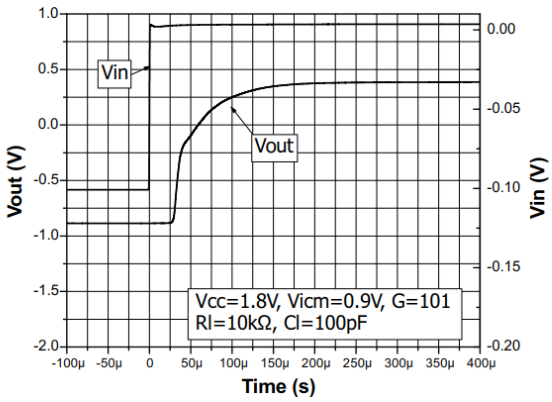


Figure 33. Positive overvoltage recovery at V_{CC} = 5 V

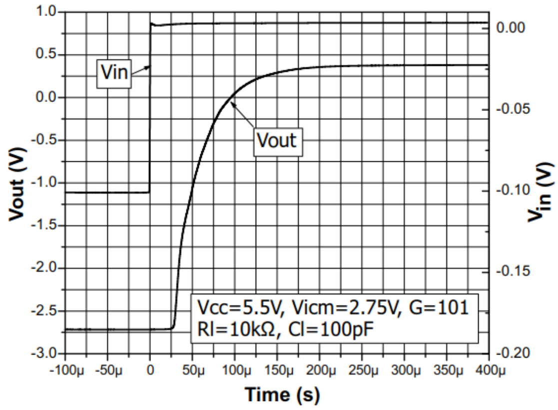


Figure 34. Negative overvoltage recovery at V_{CC} = 1.8 V

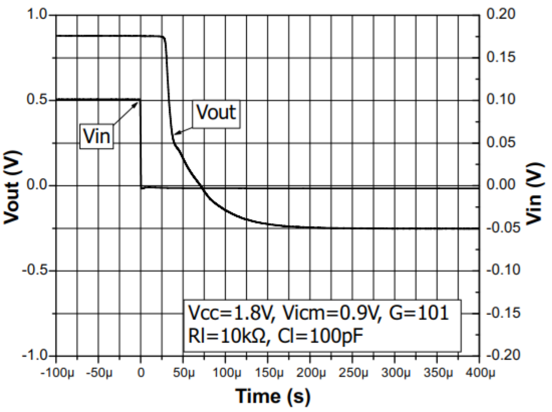


Figure 35. Negative overvoltage recovery at V_{CC} = 5 V

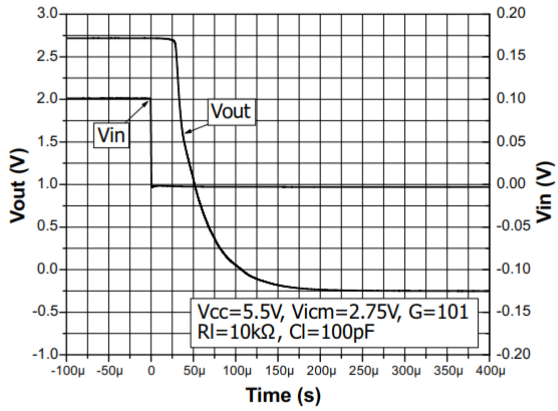


Figure 36. PSRR vs. frequency

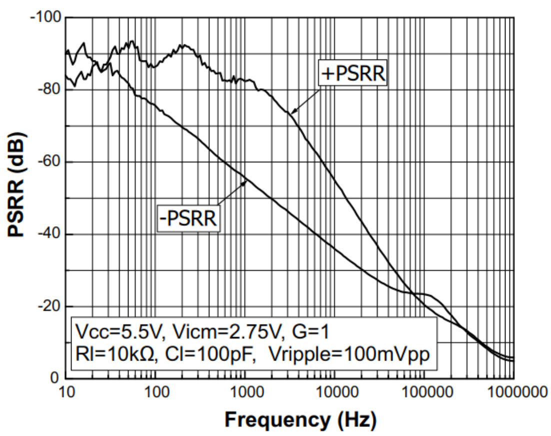
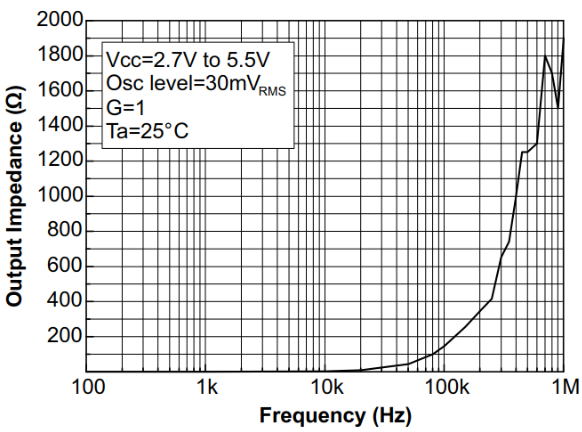
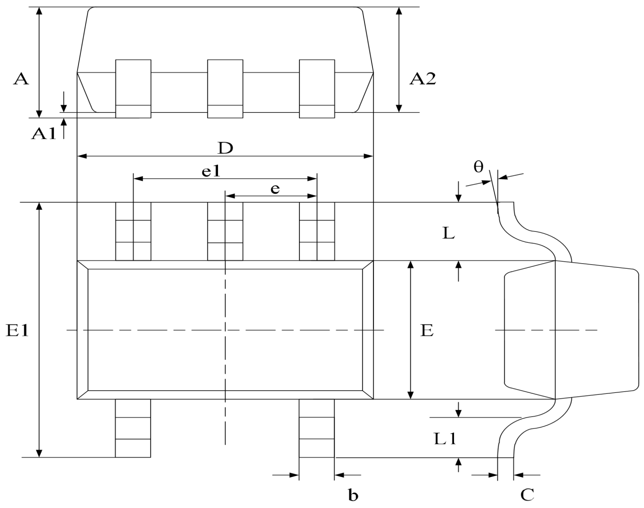


Figure 37. Output impedance vs. frequency



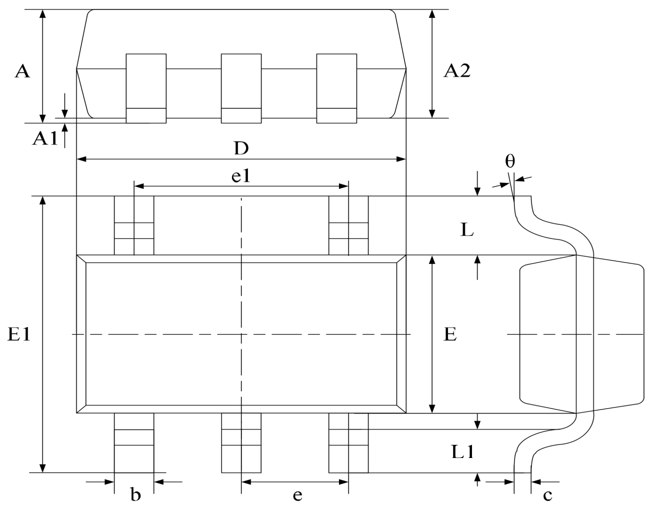
Package Dimension

SC70-5（SOT353）



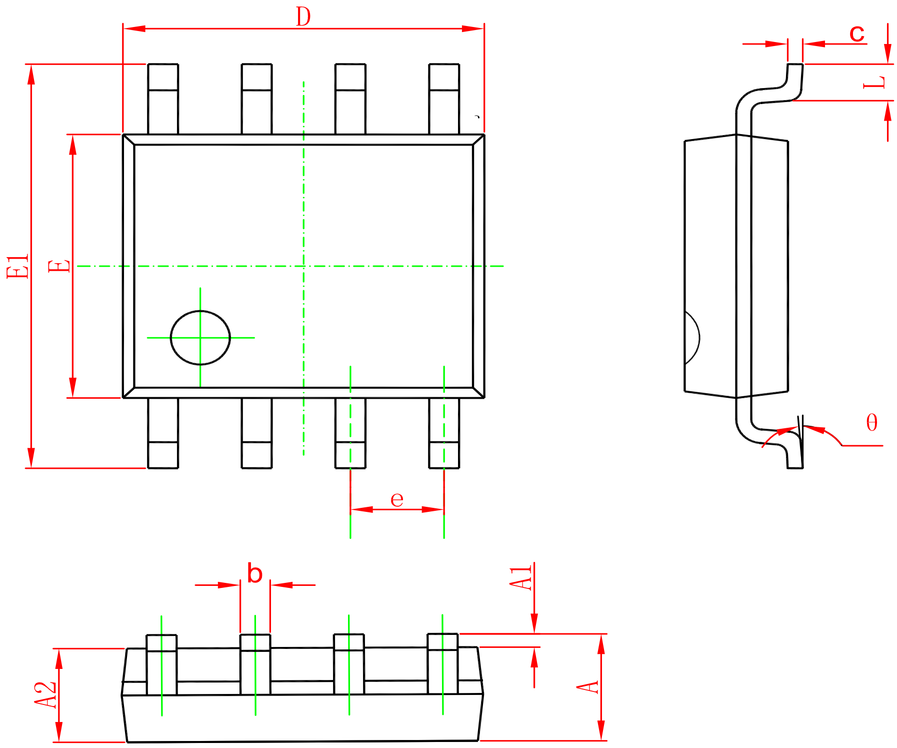
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.800	1.100	0.035	0.043
A1	0.000	0.100	0.000	0.004
A2	0.800	0.900	0.035	0.039
b	0.150	0.350	0.006	0.014
C	0.080	0.150	0.003	0.006
D	1.8500	2.150	0.079	0.087
E	1.100	1.400	0.045	0.053
E1	1.950	2.200	0.085	0.096
e	0.850 typ.		0.026 typ.	
e1	1.200	1.400	0.047	0.055
L	0.42 ref.		0.021 ref.	
L1	0.260	0.460	0.010	0.018
θ	0°	8°	0°	8°

SOT23-5



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.040	1.350	0.042	0.055
A1	0.040	0.150	0.002	0.006
A2	1.000	1.200	0.041	0.049
b	0.380	0.480	0.015	0.020
c	0.110	0.210	0.004	0.009
D	2.720	3.120	0.111	0.127
E	1.400	1.800	0.057	0.073
E1	2.600	3.000	0.106	0.122
e	0.950 typ.		0.037 typ.	
e1	1.900 typ.		0.078 typ.	
L	0.700 ref.		0.028 ref.	
L1	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

SOP-8



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	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	1.270(BSC)		0.050(BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

Ordering information

Order code	Package	Baseqty	Deliverymode	Maring
UMW TSZ121IYLT	SOT23-5	3000	Tape and reel	K192 U
UMW TSZ122IYDT	SOP-8	2500	Tape and reel	TSZ122
UMW TSZ122IDT	SOP-8	2500	Tape and reel	TSZ122
UMW TSZ121ICT	SC70-5	3000	Tape and reel	K44 U