

# Zero-Drift, Single-Supply, Rail-to-Rail Input/Output Operational Amplifiers

## General Description

This family of amplifiers has ultra low offset, drift, and bias current. The ET8550X are high-precision amplifiers featuring rail-to-rail input and output swings respectively. Either single or dual supplies can be used in the range from 2.7V to 5V with a single supply.

The ET8550X provides the benefits previously found only in expensive auto-zeroing or chopper-stabilized amplifiers. These new zero-drift amplifiers combine low cost with high accuracy. No external capacitors are required.

The ET8550X are perfectly suited for applications where error sources cannot be tolerated, since the offset voltage is only  $1\mu\text{V}$  and the drift is  $0.005\mu\text{V}/^\circ\text{C}$ . With nearly zero drift over operating temperature range, medical equipment, temperature, position and pressure sensors, and strain gauge amplifiers all benefit greatly. The rail-to-rail input and output swings provided by the ET8550X make both high-side and low-side sensing easy.

The ET8550X are specified for the extended industrial/automotive temperature range ( $-40^\circ\text{C}$  to  $+125^\circ\text{C}$ ).

The ET85501 single amplifier is available in MSOP8, SOP8 and SOT23-5 packages.

The ET85502 dual amplifier is available in MSOP8 and SOP8 packages.

## Features

- Low offset voltage :  $1\mu\text{V}$  (Typ)
- Input offset drift :  $0.005\mu\text{V}/^\circ\text{C}$  (Typ)
- Overload recovery time :  $50\mu\text{s}$  (Typ)
- Low supply current :  $770\mu\text{A}/\text{OpAmp}$  (Typ)
- High gain, CMRR, PSRR : 130dB (Typ)
- Ultra low input bias current :  $20\text{pA}$  (Typ)
- No external capacitors required
- 2.7V to 5.0V single-supply operation

## Applications

- Temperature sensors
- Pressure sensors
- Precision current sensing
- Strain gauge amplifiers
- Medical instrumentation
- Thermocouple amplifiers

# ET8550X

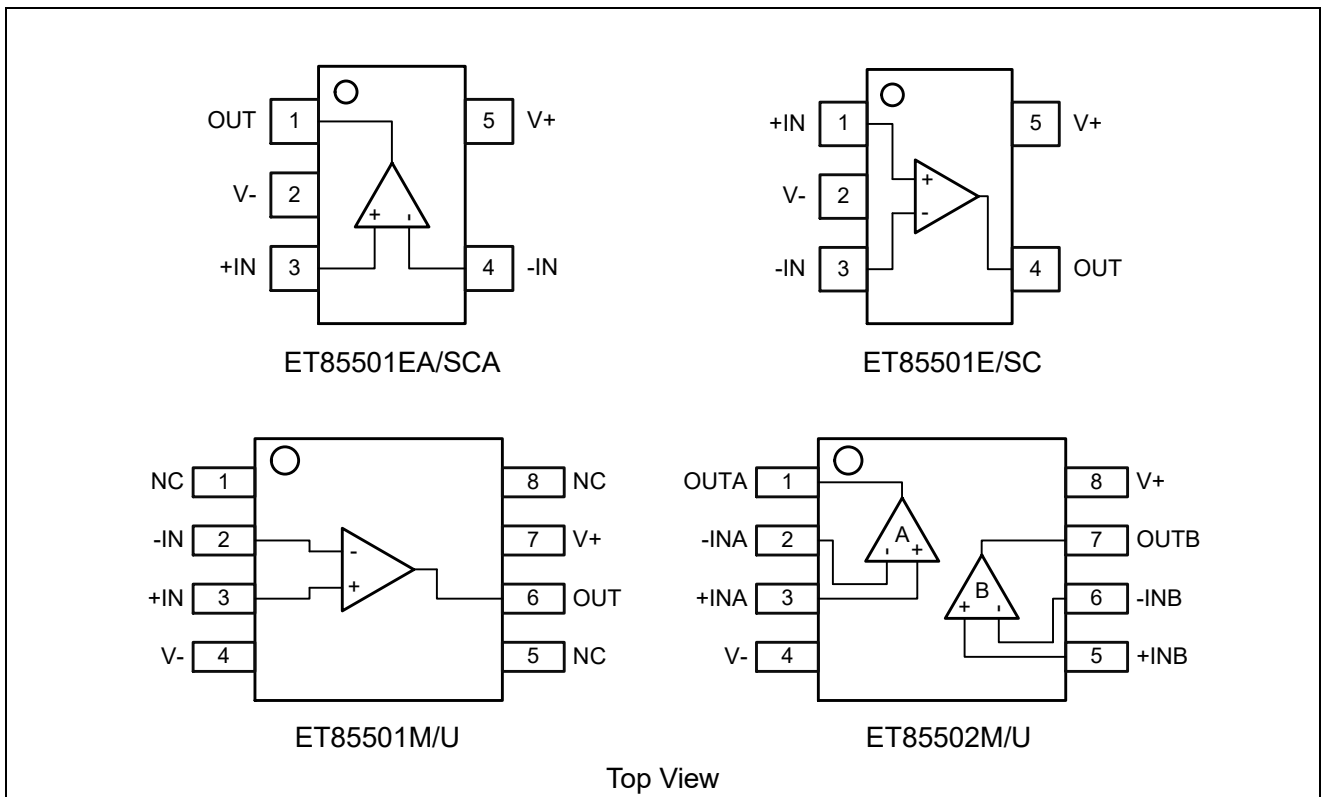
## Device information

ET 8550 X<sub>①</sub> X<sub>②</sub>

<u>X</u> <sub>①</sub> Channel number	
1	Single channel
2	Dual channel

<u>X</u> <sub>②</sub> Package		
M		SOP8
U		MSOP8
E	EA	SOT23-5
SC	SCA	SC70-5

## Pin Configuration



## Pin Function

ET85501M ET85501U	Pin Number	Symbol	Descriptions
	1	NC	/
	2	-IN	Inverting input
	3	+IN	Non-inverting input
	4	V-	Negative supply
	5	NC	/
	6	OUT	Output
	7	V+	Positive supply
	8	NC	/

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ET85501EA ET85501SCA	Pin Number	Symbol	Descriptions
	1	OUT	Output
	2	V-	Negative supply
	3	+IN	Non-inverting input
	4	-IN	Inverting input
	5	V+	Positive supply

ET85501E ET85501SC	Pin Number	Symbol	Descriptions
	1	+IN	Non-inverting input
	2	V-	Negative supply
	3	-IN	Inverting input
	4	OUT	Output
	5	V+	Positive supply

ET85502M ET85502U	Pin Number	Symbol	Descriptions
	1	OUTA	Output
	2	-INA	Inverting input
	3	+INA	Non-inverting input
	4	V-	Negative supply
	5	+INB	Non-inverting input
	6	-INB	Inverting input
	7	OUTB	Output
	8	V+	Positive supply

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## Absolute Maximum Ratings

Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are only stress ratings, and functional operation of the device at these or any other conditions beyond those indicated under recommended operating conditions are not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

Parameter	Rating	Unit
Supply Voltage <sup>(1)</sup>	6.0	V
Input Voltage	GND-0.3V to Vs+0.3	V
Differential Input Voltage	±5.0	V
ESD (Human Body Model)	±2000	V
Storage Temperature Range	-65 to +150	°C
Max Junction Temperature Range	+150	°C
Lead Temperature Range (Soldering, 60 sec)	300	°C

**Note(1):** All voltage values, except differential voltage are with respect to network terminal.

## Thermal Characteristics

Symbol	Package	Ratings	Value	Unit
R <sub>θJA</sub>	SOP8	Thermal Characteristics, Thermal Resistance, Junction-to-Air	150	°C/W
	MSOP8		210	°C/W
	SOT23-5		190	°C/W
	SC70-5		230	°C/W

## Recommended Operating Conditions

Parameter	MIN	MAX	Unit
Supply Voltage (V <sub>S</sub> )	2.7	5.0	V
Operating Temperature (T <sub>A</sub> )	-40	125	°C

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## Electrical Characteristics

$V_S = 5\text{ V}$ ,  $V_{CM} = 2.5\text{ V}$ ,  $V_O = 2.5\text{ V}$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise noted.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
INPUT CHARACTERISTICS						
Offset Voltage	V <sub>OS</sub>			1	5	μV
		−40°C ≤ T <sub>A</sub> ≤ +125°C			10	μV
Input Bias Current	I <sub>B</sub>			10	50	pA
		−40°C ≤ T <sub>A</sub> ≤ +85°C		160	300	pA
		−40°C ≤ T <sub>A</sub> ≤ +125°C		2.5	4	nA
Input Offset Current	I <sub>OS</sub>			20	70	pA
		−40°C ≤ T <sub>A</sub> ≤ +85°C		30	150	pA
		−40°C ≤ T <sub>A</sub> ≤ +125°C		150	400	pA
Input Voltage Range	V <sub>IN</sub>		0		5	V
Common-Mode Rejection Ratio	CMRR	V <sub>CM</sub> = 0 V to +5 V	120	140		dB
		−40°C ≤ T <sub>A</sub> ≤ +125°C	115	130		dB
Large Signal Voltage Gain <sup>(2)</sup>	A <sub>VO</sub>	R <sub>L</sub> = 10 kΩ, V <sub>O</sub> = 0.3 V to 4.7 V	125	145		dB
		−40°C ≤ T <sub>A</sub> ≤ +125°C	120	135		dB
Offset Voltage Drift	ΔV <sub>OS</sub> /ΔT	−40°C ≤ T <sub>A</sub> ≤ +125°C		0.005	0.04	μV/°C
OUTPUT CHARACTERISTICS						
Output Voltage High	V <sub>OH</sub>	R <sub>L</sub> = 100 kΩ to GND	4.99	4.998		V
		R <sub>L</sub> = 100 kΩ to GND @−40°C to +125°C	4.99	4.997		V
		R <sub>L</sub> = 10 kΩ to GND	4.95	4.98		V
		R <sub>L</sub> = 10 kΩ to GND @−40°C to +125°C	4.95	4.975		V
Output Voltage Low	V <sub>OL</sub>	R <sub>L</sub> = 100 kΩ to V+		1	10	mV
		R <sub>L</sub> = 100 kΩ to V+ @−40°C to +125°C		2	10	mV
		R <sub>L</sub> = 10 kΩ to V+		10	30	mV
		R <sub>L</sub> = 10 kΩ to V+ @−40°C to +125°C		15	30	mV
Output Short-Circuit Limit Current	I <sub>SC</sub>		±25	±50		mA
		−40°C to +125°C		±40		mA
Output Current	I <sub>O</sub>			±30		mA
		−40°C to +125°C		±15		mA
POWER SUPPLY						
Power Supply Rejection Ratio	PSRR	V <sub>S</sub> = 2.7 V to 5.5 V	120	130		dB
		−40°C ≤ T <sub>A</sub> ≤ +125°C	115	130		dB
Supply Current/Amplifier	I <sub>SY</sub>	V <sub>O</sub> = 0 V		770	975	μA
		−40°C ≤ T <sub>A</sub> ≤ +125°C		1067	1264	μA

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DYNAMIC PERFORMANCE						
Slew Rate	SR	$R_L = 10\text{ k}\Omega$		0.4		V/ $\mu$ s
Overload Recovery Time				0.05	0.3	ms
Gain Bandwidth Product	GBP			1.5		MHz
NOISE PERFORMANCE						
Voltage Noise	$e_n$ p-p	0 Hz to 10 Hz		1.0		$\mu$ V p-p
	$e_n$ p-p	0 Hz to 1 Hz		0.32		$\mu$ V p-p
Voltage Noise Density	$e_n$	$f = 1\text{ kHz}$		42		nV/ $\sqrt{\text{Hz}}$
Current Noise Density	$i_n$	$f = 10\text{ Hz}$		2		fA/ $\sqrt{\text{Hz}}$

**Note(2):** Gain testing is dependent upon test bandwidth.

$V_S = 2.7\text{ V}$ ,  $V_{CM} = 1.35\text{ V}$ ,  $V_O = 1.35\text{ V}$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise noted.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
INPUT CHARACTERISTICS						
Offset Voltage	$V_{OS}$			1	5	$\mu$ V
		$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$			10	$\mu$ V
Input Bias Current	$I_B$			10	50	pA
		$-40^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$		160	300	pA
		$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		2.5	4	nA
Input Offset Current	$I_{OS}$			10	50	pA
		$-40^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$		30	150	
		$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		150	400	pA
Input Voltage Range	$V_{IN}$		0		2.7	V
Common-Mode Rejection Ratio	CMRR	$V_{CM} = 0\text{ V to }+2.7\text{ V}$	115	130		dB
		$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	110	130		dB
Large Signal Voltage Gain <sup>(2)</sup>	$A_{VO}$	$R_L = 10\text{ k}\Omega$ , $V_O = 0.3\text{ V to }4.7\text{ V}$	110	140		dB
		$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	105	130		dB
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		0.005	0.04	$\mu$ V/ $^\circ\text{C}$
OUTPUT CHARACTERISTICS						
Output Voltage High	$V_{OH}$	$R_L = 100\text{ k}\Omega$ to GND	2.685	2.697		V
		$R_L = 100\text{ k}\Omega$ to GND @ $-40^\circ\text{C}$ to $+125^\circ\text{C}$	2.685	2.696		V
		$R_L = 10\text{ k}\Omega$ to GND	2.67	2.68		V
		$R_L = 10\text{ k}\Omega$ to GND @ $-40^\circ\text{C}$ to $+125^\circ\text{C}$	2.67	2.675		V
Output Voltage Low	$V_{OL}$	$R_L = 100\text{ k}\Omega$ to V+		1	10	mV
		$R_L = 100\text{ k}\Omega$ to V+ @ $-40^\circ\text{C}$ to $+125^\circ\text{C}$		2	10	mV
		$R_L = 10\text{ k}\Omega$ to V+		10	20	mV
		$R_L = 10\text{ k}\Omega$ to V+ @ $-40^\circ\text{C}$ to $+125^\circ\text{C}$		15	20	mV

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Output Short-Circuit Limit Current	I <sub>sc</sub>		±10	±15		mA
		−40°C to +125°C		±10		mA
Output Current	I <sub>o</sub>			±10		mA
		−40°C to +125°C		±5		mA
POWER SUPPLY						
Power Supply Rejection Ratio	PSRR	V <sub>S</sub> = 2.7 V to 5.5 V	120	130		dB
		−40°C ≤ T <sub>A</sub> ≤ +125°C	115	130		dB
Supply Current/Amplifier	I <sub>SY</sub>	V <sub>O</sub> = 0 V		764	900	μA
		−40°C ≤ T <sub>A</sub> ≤ +125°C		1115	1279	μA
DYNAMIC PERFORMANCE						
Slew Rate	SR	R <sub>L</sub> = 10 kΩ		0.5		V/μs
Overload Recovery Time				0.05		ms
Gain Bandwidth Product	GBP			1		MHz
NOISE PERFORMANCE						
Voltage Noise	e <sub>n</sub> p-p	0 Hz to 10 Hz		1.6		μV p-p
Voltage Noise Density	e <sub>n</sub>	f = 1 kHz		75		nV/√Hz
Current Noise Density	i <sub>n</sub>	f = 10 Hz		2		fA/√Hz

**Note(2):** Gain testing is dependent upon test bandwidth.

## Application Notes

### Layout Guidelines

For best operational performance of the device, use good printed circuit board (PCB) layout practices, including:

Place the external components as close to the device as possible. This configuration prevents parasitic errors (such as the Seebeck effect) from occurring.

To reduce parasitic coupling, run the input traces as far away from the supply lines and digital signal as possible.

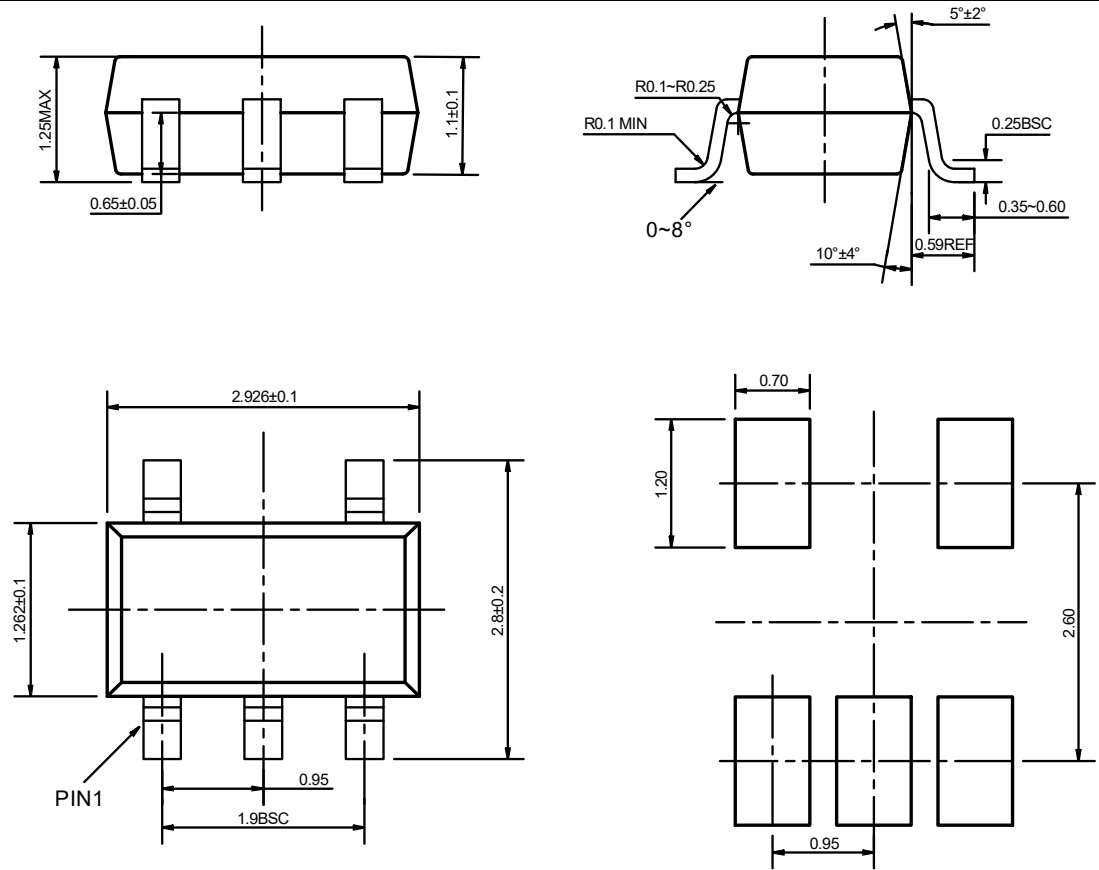
Low-ESR, 0.1 $\mu\text{F}$  ceramic bypass capacitors must be connected between each supply pin and ground, placed as close to the device as possible. A single bypass capacitor from V+ to ground is applicable to single supply applications.

Consider a driven, low-impedance guard ring around the critical traces. A guard ring can significantly reduce leakage currents from nearby traces that are at different potentials.

# ET8550X

## Package Dimension

SOT23-5



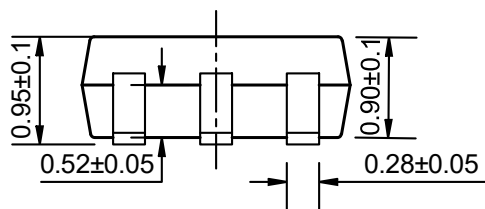
**Recommended Land Pattern**

Unit: mm

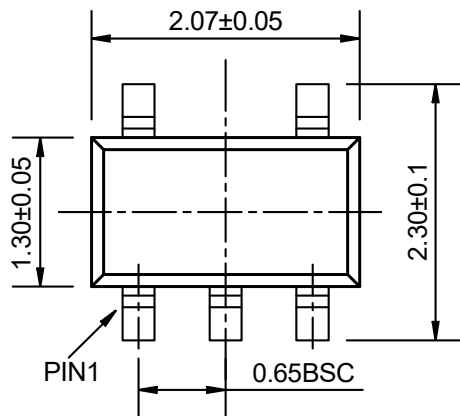
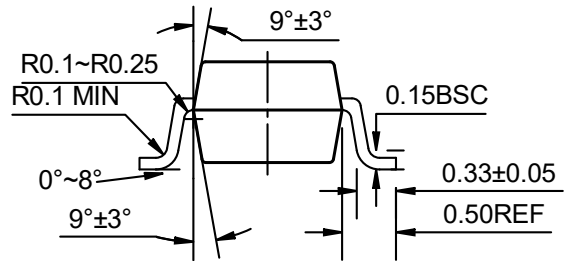


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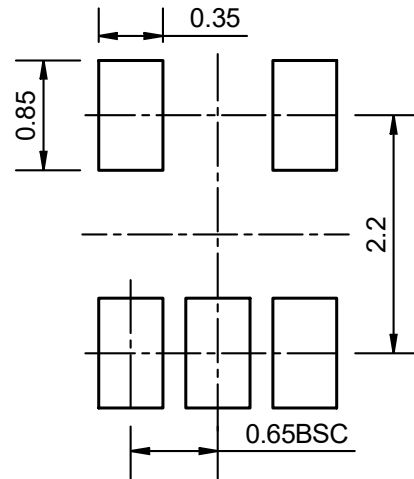
SC70-5



SIDE VIEW



TOP VIEW

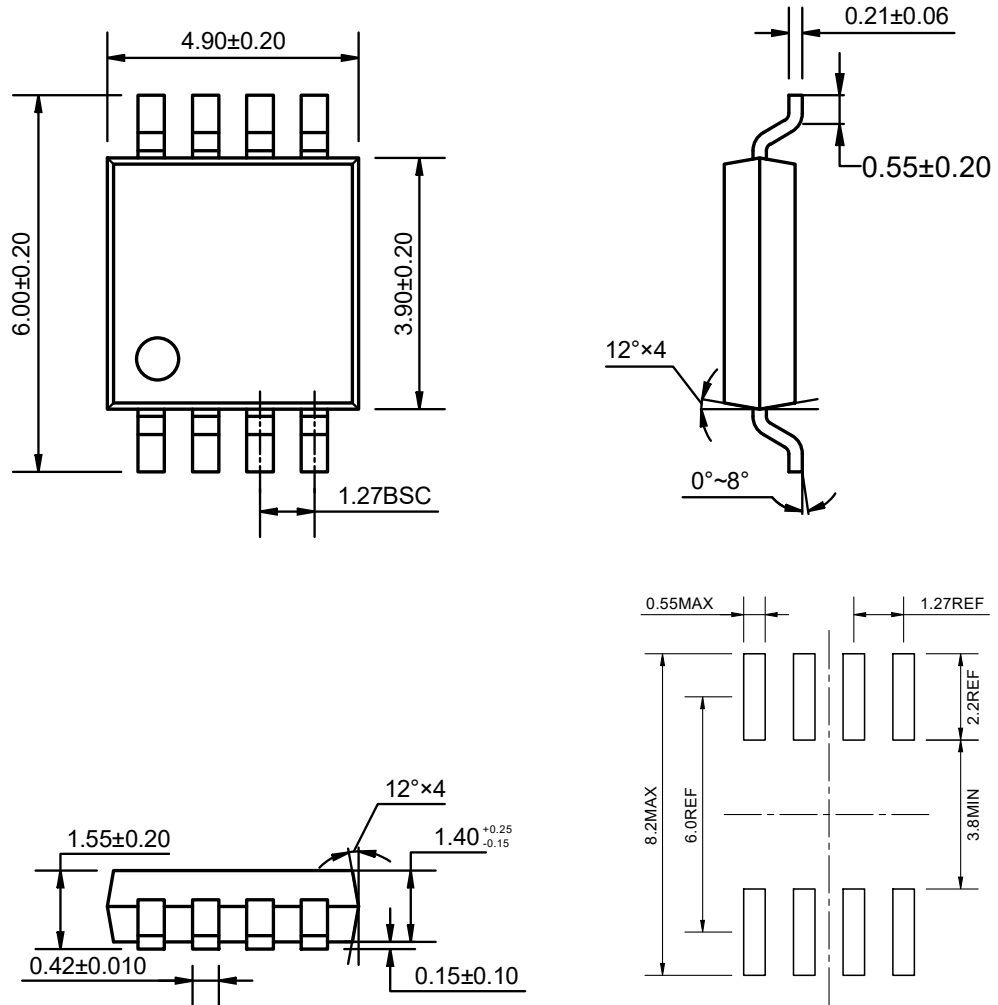


Recommended Land Pattern

Unit: mm

# ET8550X

SOP8

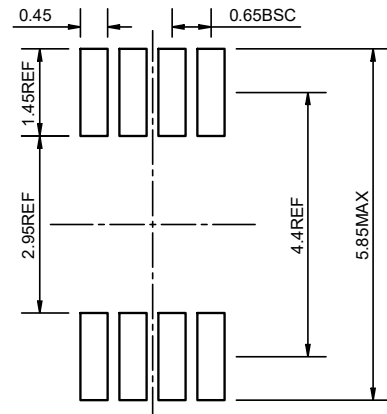
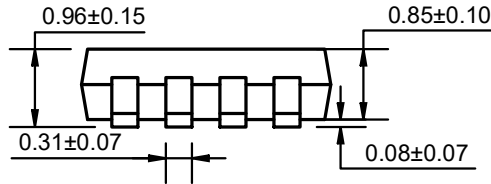
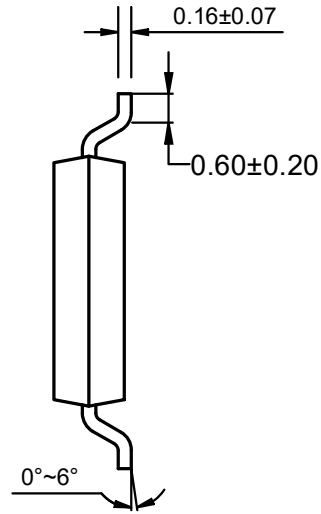
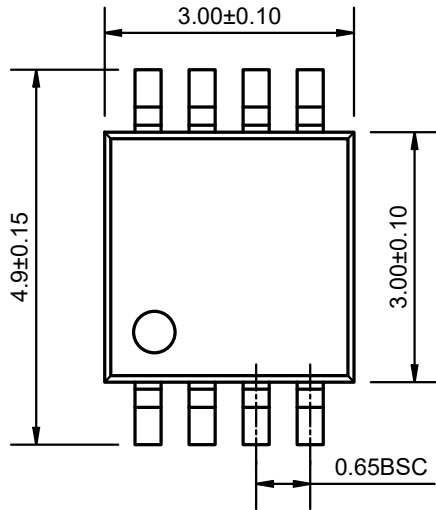


**Recommended Land Pattern**

Unit: mm

# ET8550X

MSOP8



**Recommended Land Pattern**

Unit: mm

## Revision History and Checking Table

Version	Date	Revision Item	Modifier	Function & Spec Checking	Package & Tape Checking
0	2021-4-11	Preliminary Version	Liuxm	Liuxm	Liujiy
1.0	2023-2-27	Official version	Shibo	Wanggp	Liujiy
1.1	2023-9-27	Naming updates	Shibo	Wanggp	Liujiy