# 10MHz, RRIO, CMOS Operational Amplifier for Cost-Sensitive Systems

## General Description

The ET8560X series are low voltage (1.8V to 5.5V) operational amplifiers included single-channel (ET85601) and dual-channel (ET85602) and quad-channel (ET85604) with rail-to-rail input and output swing capabilities.These devices are highly cost-effective solutions for applications where low-voltage operation, a small footprint, and high capacitive load drive are required. Although the capacitive load drive of the ET8560X is 100 pF, the resistive open-loop output impedance makes stabilizing with higher capacitive loads simpler.

The ET8560X are specified for the extended industrial/automotive temperature range (-40°C to +125°C).

The ET85601 single amplifier is available in SOT23-5 and SC70-5 packages.

The ET85602 dual amplifier is available in MSOP8, SOP8 and TSOT23-8 packages.

The ET85604 quad amplifier is available in SOP14 and TSSOP14 packages.

## Features

- Low offset voltage: ±0.3 mV (Typ)
- Unity-gain bandwidth: 10 MHz (Typ)
- Low broadband noise: 10 nV/$\sqrt{Hz}$ (Typ)
- Low input bias current: ±1 pA (Typ)
- Low quiescent current: 550 μA (Typ)
- Rail-to-rail input and output
- Unity-gain stable
- Internal RFI and EMI filter
- Operational supply voltage range 1.8 V to 5.5V
- Easier to stabilize with higher capacitive load due to resistive open-loop output impedance
- Extended temperature range: -40°C to 125°C

## Applications

- Temperature sensors
- Smoke detectors
- Wearable devices
- Laptop computers
- Sensor signal conditioning
- Power modules
- Active filters
- Low-side current sensing

## Device information

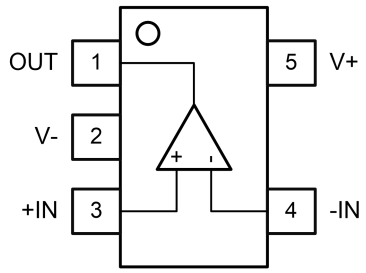
**ET 8560 X① X②**

| X① Channel number | |
|---|---|
| 1 | Single channel |
| 2 | Dual channel |
| 4 | Quad channel |

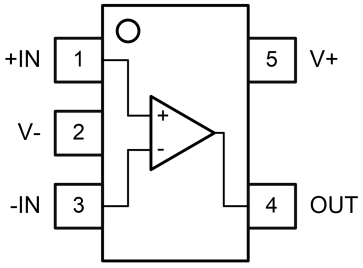
| X② Package | | |
|---|---|---|
| M | | SOP8/SOP14 |
| U | | MSOP8 |
| V | | TSSOP14 |
| E | EA | SOT23-5 |
| SC | SCA | SC70-5 |

| Part No. | Package | MSL |
|---|---|---|
| ET85601E / ET85601EA | SOT23-5 | 3 |
| ET85601SC / ET85601SCA | SC70-5 | 1 |
| ET85601M / ET85602M | SOP8 | 3 |
| ET85601U / ET85602U | MSOP8 | 3 |
| ET85602E | TSOT23-8 | 3 |
| ET85604M | SOP14 | 3 |
| ET85604V | TSSOP14 | 3 |

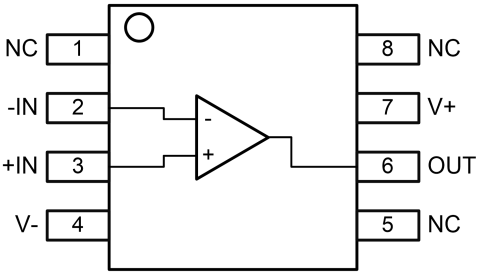
## Pin Configuration



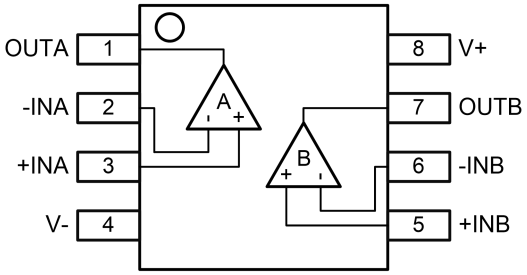

ET85601EA/SCA



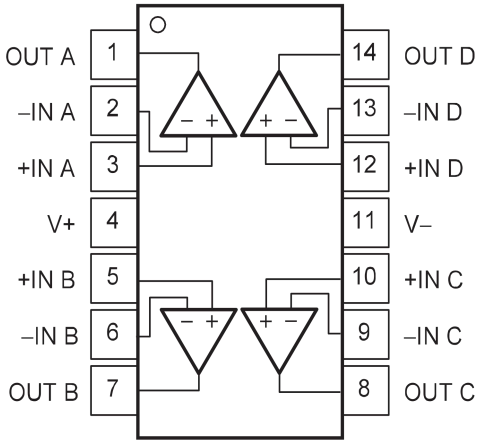

ET85601E/SC




ET85601M/U




ET85602M/U/E




ET85604M/V
Top View

## Pin Function

| | Pin Number | Symbol | Descriptions |
|---|---|---|---|
| ET85601M<br>ET85601U | 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 | / |

| | Pin Number | Symbol | Descriptions |
|---|---|---|---|
| ET85601EA<br>ET85601SCA | 1 | OUT | Output |
| | 2 | V- | Negative supply |
| | 3 | +IN | Non-inverting input |
| | 4 | -IN | Inverting input |
| | 5 | V+ | Positive supply |

| | Pin Number | Symbol | Descriptions |
|---|---|---|---|
| ET85601E<br>ET85601SC | 1 | +IN | Non-inverting input |
| | 2 | V- | Negative supply |
| | 3 | -IN | Inverting input |
| | 4 | OUT | Output |
| | 5 | V+ | Positive supply |

| | Pin Number | Symbol | Descriptions |
|---|---|---|---|
| ET85602M<br>ET85602U<br>ET85602E | 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 |

| | Pin Number | Symbol | Descriptions |
|---|---|---|---|
| ET85604M<br>ET85604V | 1 | OUTA | Output |
| | 2 | -INA | Inverting input |
| | 3 | +INA | Non-inverting input |
| | 4 | V+ | Positive supply |
| | 5 | +INB | Non-inverting input |
| | 6 | -INB | Inverting input |
| | 7 | OUTB | Output |
| | 8 | OUTC | Output |
| | 9 | -INC | Inverting input |
| | 10 | +INC | Non-inverting input |
| | 11 | V- | Negative supply |
| | 12 | +IND | Non-inverting input |
| | 13 | -IND | Inverting input |
| | 14 | OUTD | Output |

## 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:(V+) - (V-) | 0~6 | V |
| Common-mode Input Voltage(1) | (V-)-0.5V to (V+)+0.5 | V |
| Differential Input Voltage(1) | (V+) - (V-)+0.2 | V |
| Signal input pins Current(1) | -10~10 | mA |
| Output short-circuit(2) | Continuous | mA |
| ESD (Human Body Model) | ±2500 | V |
| ESD (Component Discharge Model) | ±1000 | V |
| Storage Temperature Range | -65 to +150 | °C |
| Max Junction Temperature Range | +150 | °C |

***Note1***:Input pins are diode-clamped to the power-supply rails. Current limit input signals that can swing more than 0.5 V beyond the supply rails to 10 mA or less.

***Note2***:Short-circuit to ground, one amplifier per package.

## Thermal Characteristics

| Symbol | Package | Ratings | Value | Unit |
|---|---|---|---|---|
| $R_{\theta JA}$ | SOP8 | Thermal Characteristics, Thermal Resistance, Junction-to-Air | 160 | °C/W |
| | MSOP8 | | 200 | °C/W |
| | SOT23-5 | | 215 | °C/W |
| | TSOT23-8 | | 185 | °C/W |
| | SC70-5 | | 230 | °C/W |
| | SOP14 | | 107 | °C/W |
| | TSSOP14 | | 136 | °C/W |

## Recommended Operating Conditions

| Parameter | MIN | MAX | Unit |
|---|---|---|---|
| Supply Voltage ($V_S$) | 1.8 | 5.0 | V |
| Operating Temperature ($T_A$) | -40 | 125 | °C |

## Electrical Characteristics

$V_S$ = (V+) – (V-) = 1.8 V to 5.5 V (±0.9 V to ±2.75 V), $T_A$ = 25°C, $R_L$ = 10 kΩ connected to $V_S$/2, and $V_{CM}$ = $V_{OUT}$ = $V_S$/2 (unless otherwise noted).

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **OFFSET VOLTAGE** | | | | | | |
| $V_{OS}$ | Input offset voltage | $V_S$ = 5 V | | ±0.3 | ±2 | mV |
| | | $V_S$ = 5 V, $T_A$ = -40°C to 125°C | | | ±2.5 | |
| $dV_{OS}/dT$ | $V_{OS}$ vs temperature | $V_S$ = 5 V, $T_A$ = -40°C to 125°C | | ±0.53 | | µV/°C |
| PSRR | Power-supply rejection ratio | $V_S$ = 1.8 to 5.5 V, $V_{CM}$ = (V-) | | ±7 | ±80 | µV/V |
| **INPUT VOLTAGE RANGE** | | | | | | |
| $V_{CM}$ | Common-mode voltage range | VS = 1.8 V to 5.5 V | (V-)-0.1 | | (V+)+0.1 | V |
| CMRR | Common-mode rejection ratio | $V_S$ = 5.5 V, (V-) - 0.1 V < $V_{CM}$< (V+) - 1.4 V, $T_A$ = –40°C to 125°C | 70 | 103 | | dB |
| | | $V_S$ = 5.5 V, VCM = –0.1 V to 5.6 V, $T_A$ = -40°C to 125°C | 57 | 87 | | |
| | | $V_S$ = 1.8 V, (V–) – 0.1 V < VCM < (V+) – 1.4 V, $T_A$ = -40°C to 125°C | | 88 | | |
| | | $V_S$ = 1.8 V, VCM = –0.1 V to 1.9 V, $T_A$ = -40°C to 125°C | | 81 | | |
| **INPUT BIAS CURRENT** | | | | | | |
| $I_B$ | Input bias current | $V_S$ = 5 V | | ±1 | | pA |
| $I_{OS}$ | Input offset current | | | ±1 | | pA |
| **NOISE** | | | | | | |
| $E_n$ | Input voltage noise (peak to peak) | $f$ = 0.1 Hz to 10 Hz, $V_S$ = 5 V | | 4.77 | | $\mu V_{PP}$ |
| $e_n$ | Input voltage noise density | $f$ = 1 kHz, $V_S$ = 5 V | | 16 | | nV/√Hz |
| | | $f$ = 10 kHz, $V_S$ = 5 V | | 10 | | |
| $i_n$ | Input current noise density[3] | $f$ = 1 kHz, $V_S$ = 5 V | | 23 | | fA/√Hz |
| **INPUT CAPACITANCE** | | | | | | |
| $C_{ID}$ | Differential[3] | | | 2 | | pF |
| $C_{IC}$ | Common-mode[3] | | | 4 | | pF |

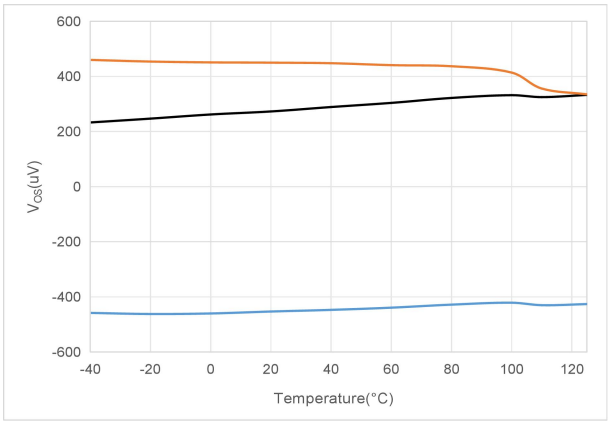
## Electrical Characteristics (Continued)

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **OPEN-LOOP GAIN** | | | | | | |
| $A_{OL}$ | Open-loop voltage gain | $V_S$ = 1.8 V, $R_L$ = 10 kΩ (V-) + 0.04 V < $V_O$< (V+) - 0.04 V | | 100 | | dB |
| | | $V_S$ = 5.5 V, $R_L$ = 10 kΩ (V-) + 0.1 V < $V_O$< (V+) - 0.1 V | 104 | 130 | | |
| | | $V_S$ = 1.8 V, $R_L$ = 2 kΩ (V-) + 0.06 V < $V_O$< (V+) - 0.06 V | | 100 | | |
| | | $V_S$ = 5.5 V, $R_L$ = 2 kΩ (V-) + 0.15 V < $V_O$< (V+) – 0.15 V | | 130 | | |
| **FREQUENCY RESPONSE** | | | | | | |
| GBW | Gain-bandwidth product | $V_S$ = 5 V, G =+1 | | 10 | | MHz |
| $\varphi_m$ | Phase margin | $V_S$ = 5 V, G =+1 | | 55 | | ° |
| SR | Slew rate | $V_S$ = 5 V, G =+1 | | 6 | | V/μs |
| $t_S$ | Settling time(3) | To 0.1%, $V_S$ = 5 V, 2V step, G = +1, $C_L$ = 100 pF | | 0.5 | | μs |
| | | To 0.01%, $V_S$ = 5 V, 2V step, G = +1, $C_L$ = 100 pF | | 1 | | |
| $t_{OR}$ | Overload recovery time | $V_S$ = 5 V, $V_{IN}$ × gain > $V_S$ | | 0.2 | | μs |
| THD+N | Total harmonic distortion + noise | $V_S$ = 5.5 V, $V_{CM}$ = 2.5 V, $V_O$ = 1 $V_{RMS}$, G = +1, $f$ = 1 kHz, | | 0.0008 | | % |
| **OUTPUT** | | | | | | |
| $V_O$ | Voltage output swing from supply rails | $V_S$ = 5.5 V, $R_L$ = 10 kΩ | | | 20 | mV |
| | | $V_S$ = 5.5 V, $R_L$ = 2 kΩ | | | 60 | |
| $I_{SC}$ | Short-circuit current | $V_S$ = 5 V | | ±50 | | mA |
| $Z_O$ | Open-loop output impedance(3) | $V_S$ = 5 V, $f$ = 10MHz | | 100 | | Ω |
| **POWER SUPPLY** | | | | | | |
| $V_S$ | Specified voltage range | | 1.8 (±0.9) | | 5.5 (±2.75) | V |
| $I_Q$ | Quiescent current per amplifier | $I_O$ = 0 mA, $V_S$ = 5.5 V | | 550 | 750 | μA |
| | | $I_O$ = 0 mA, $V_S$ = 5.5 V, $T_A$ = -40°C to 125°C | | | 800 | |

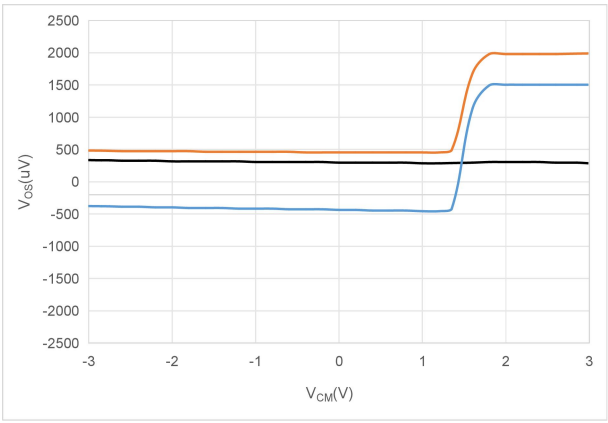
***Note3***:Guaranteed by design.

## Typical Characteristics

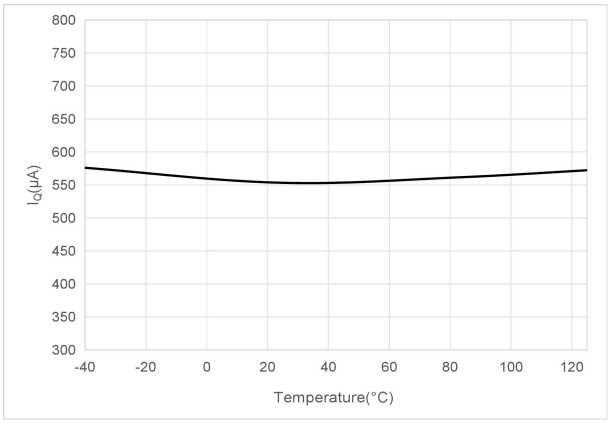
$V_S$ = 5.5 V(±2.75V), $V_{CM}$ = $V_{OUT}$ = $V_S$/2, and $R_L$ = 10kΩ connected to $V_S$/2,$T_A$ = 25°C (unless otherwise noted)



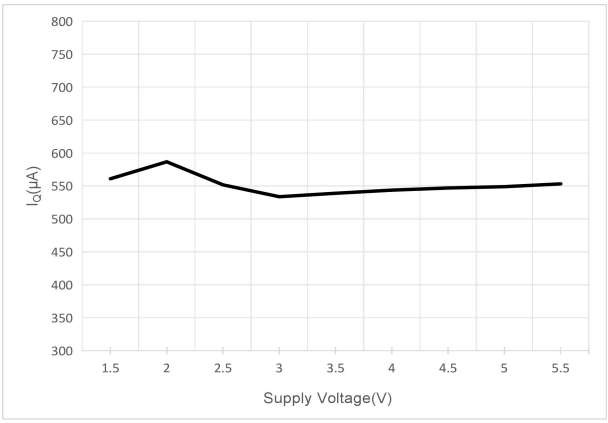

Offset Voltage vs Temperature



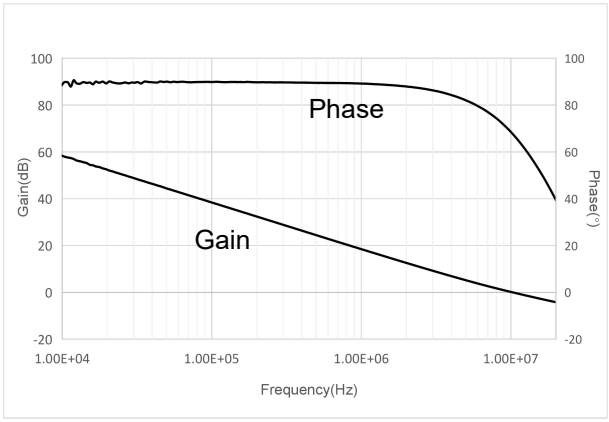

Offset Voltage vs Common-Mode Voltage



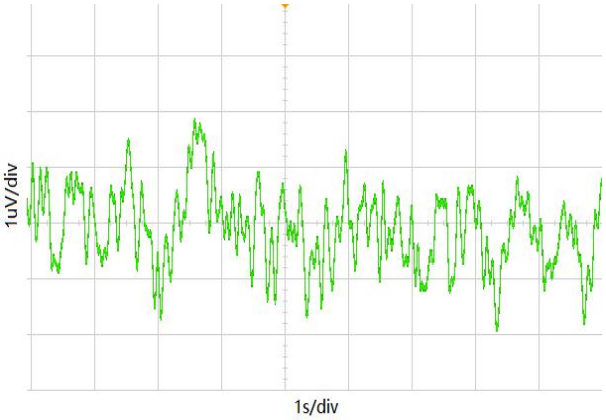

Quiescent Current vs Temperature




Quiescent Current vs Supply Voltage

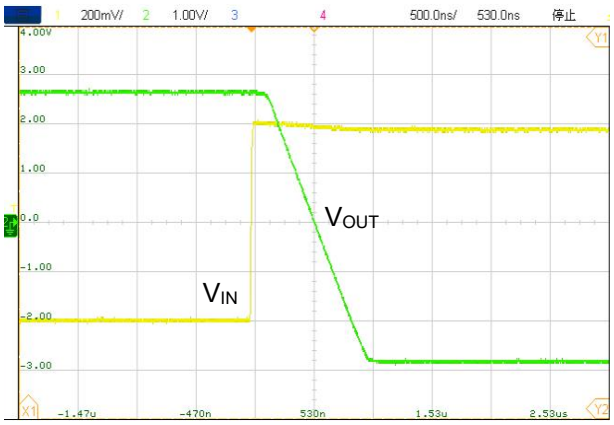



Open-Loop Gain vs Frequency



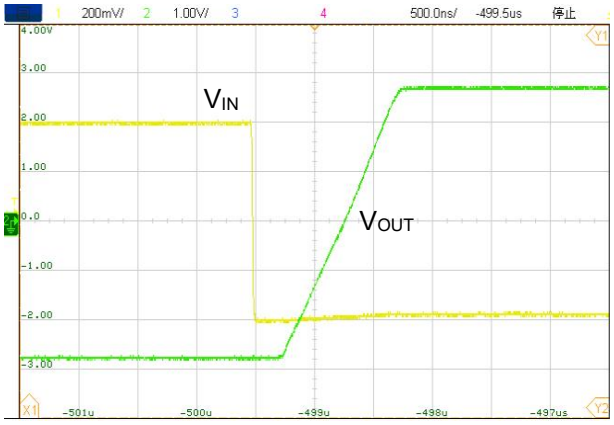

0.1 Hz to 10 Hz Noise

## Typical Characteristics (Continued)



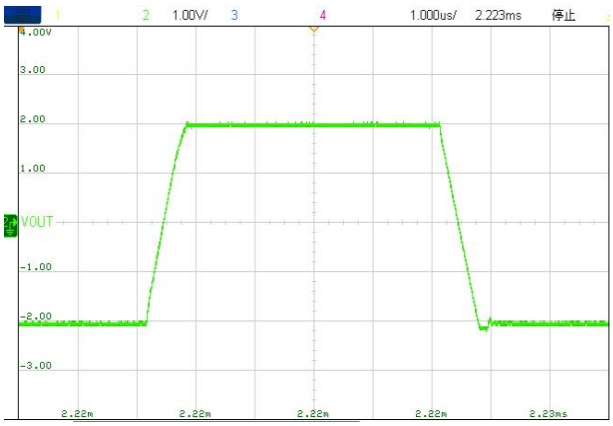

Positive Overload Recovery

(G = -10)



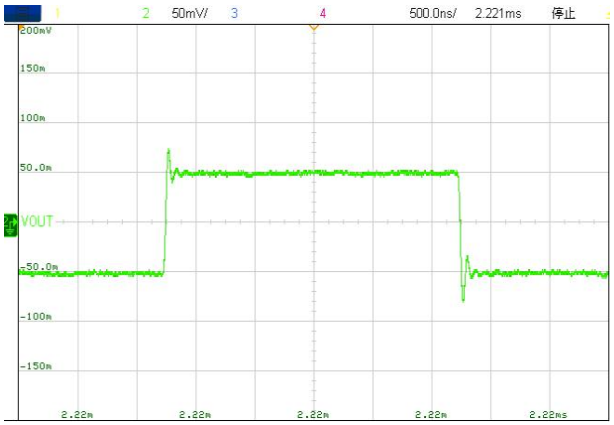

Negative Overload Recovery

(G = -10)




Large-Signal Step Response

(G = +1)




Small-Signal Step Response(100 mV)

(G = +1,$R_L$ = 10 kΩ,$C_L$ = 100 pF)

## Application Notes

### Layout Guidelines

For best operational performance of the device, use good PCB layout practices, including:

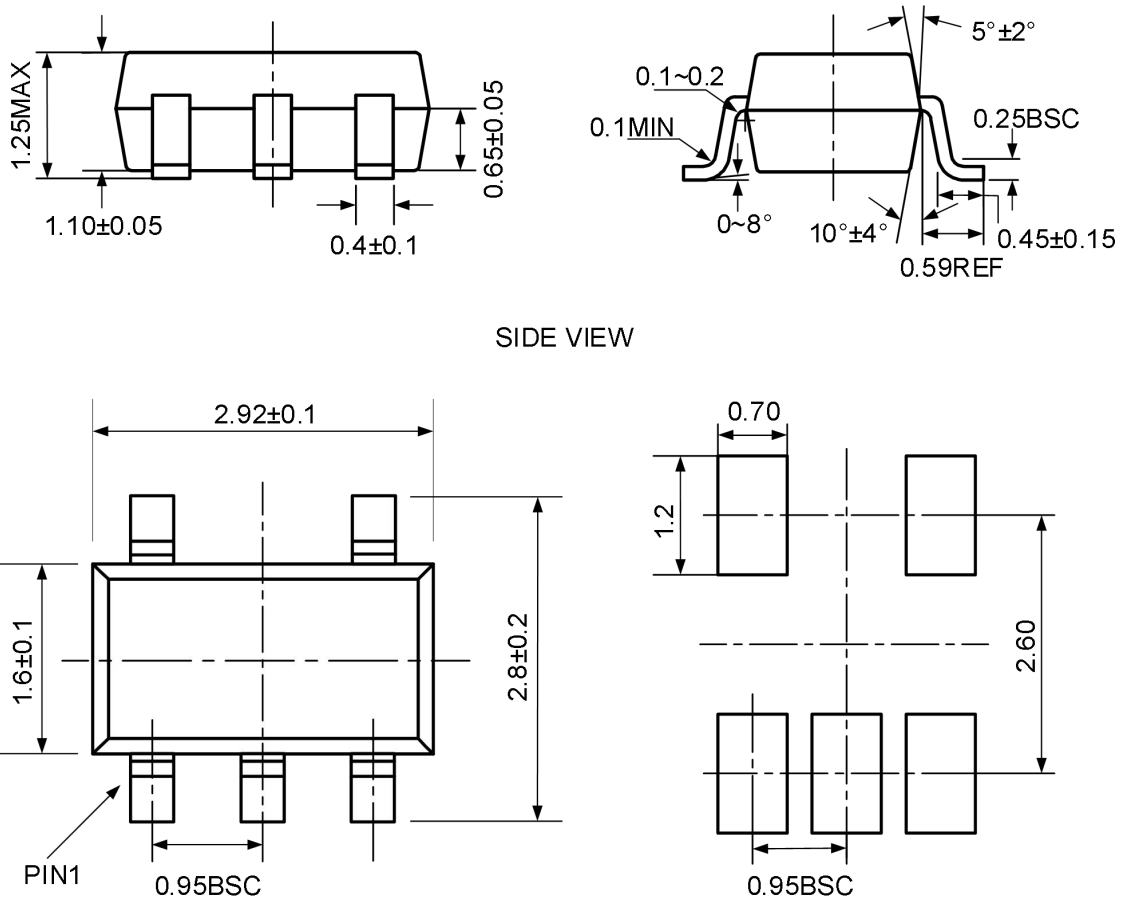
Place the external components as close to the device as possible. This configuration prevents parasitic errors (such as the Seebeck effect) from occurring.

To reduce parasitic coupling, run the input traces as far away from the supply lines and digital signal as possible.Low-ESR, 0.1 μF 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.

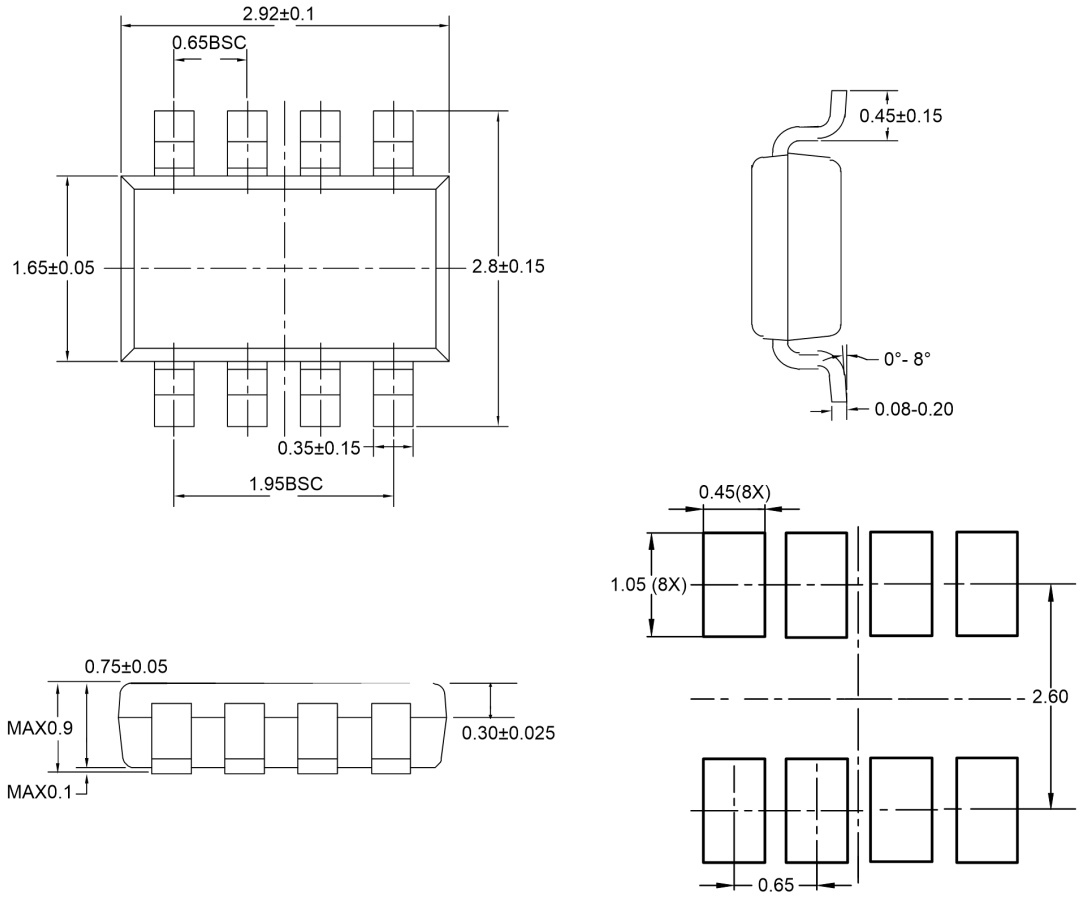
## Package Dimension

SOT23-5



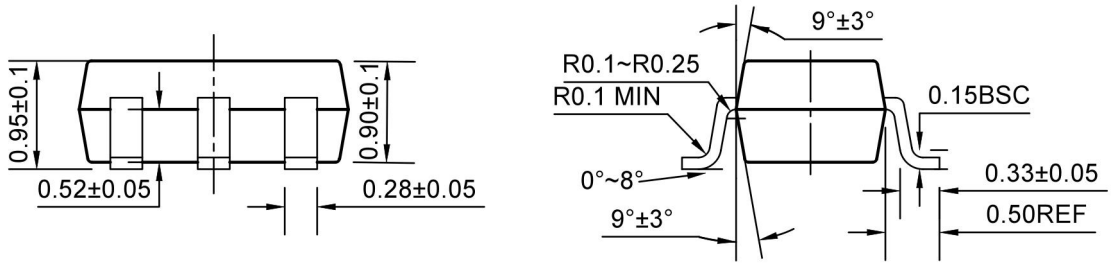

Unit: mm

TSOT23-8

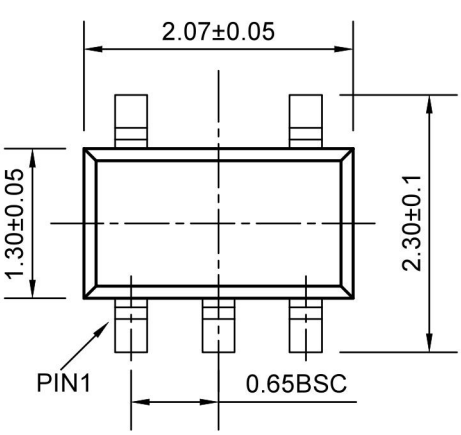



**Recommended Land Pattern**

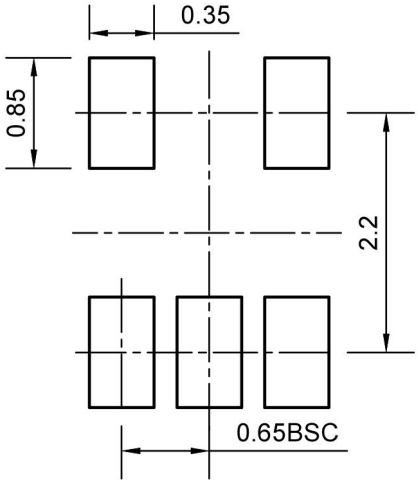
SC70-5




SIDE VIEW



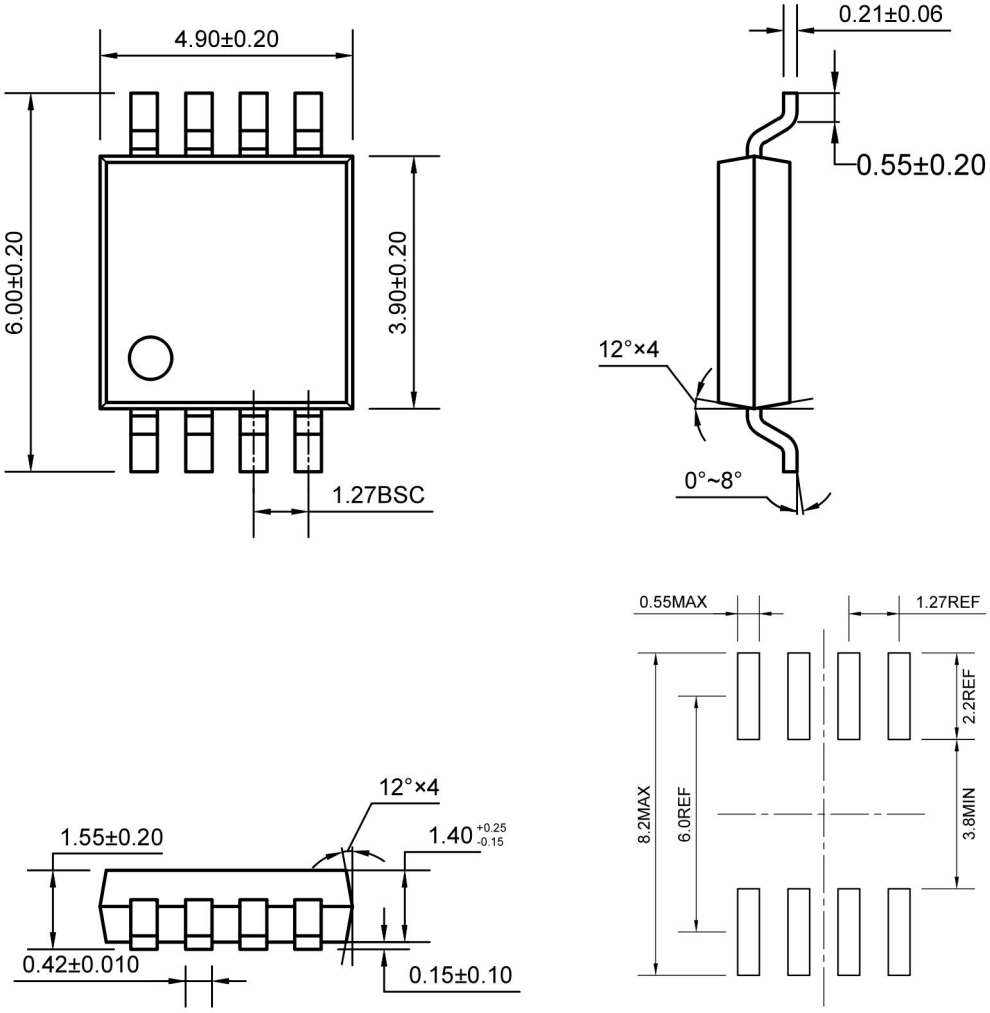

TOP VIEW




**Recommended Land Pattern**

Unit: mm

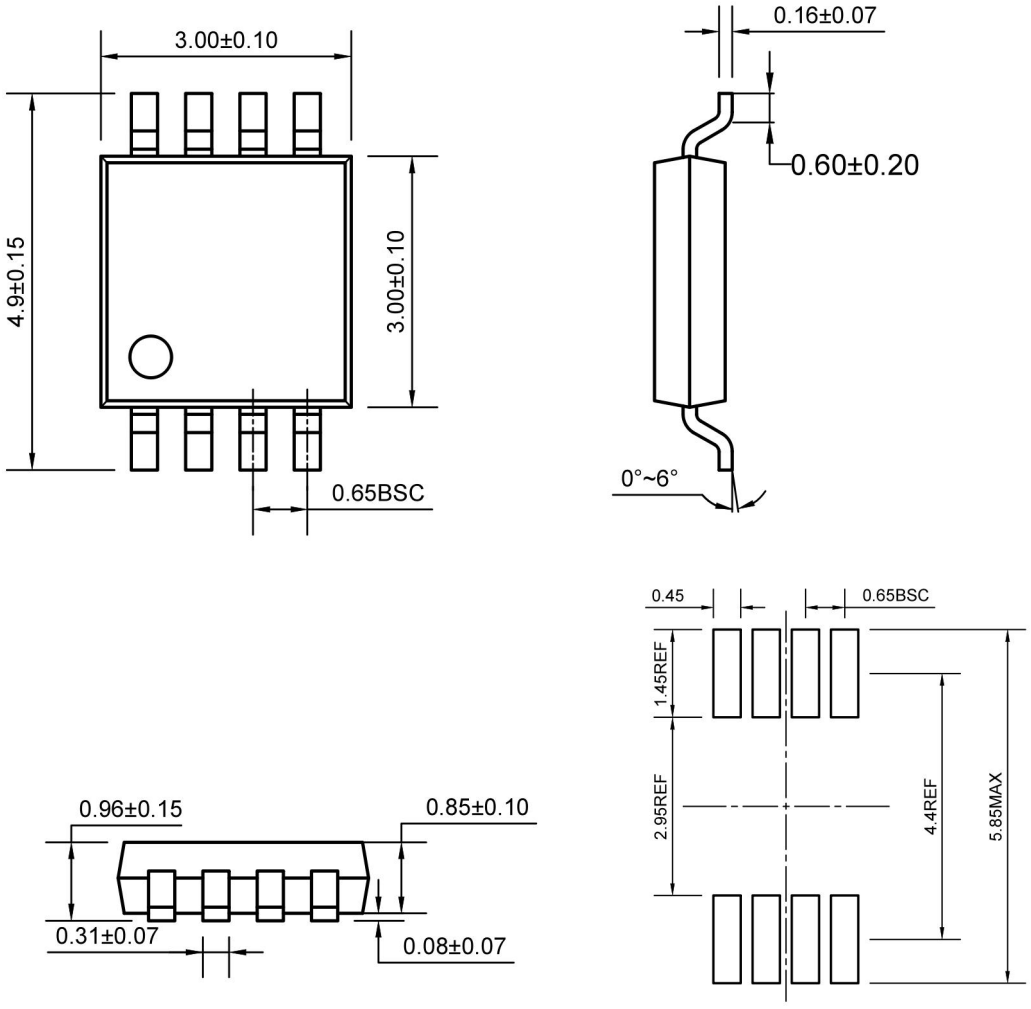
SOP8




**Recommended Land Pattern**

Unit: mm

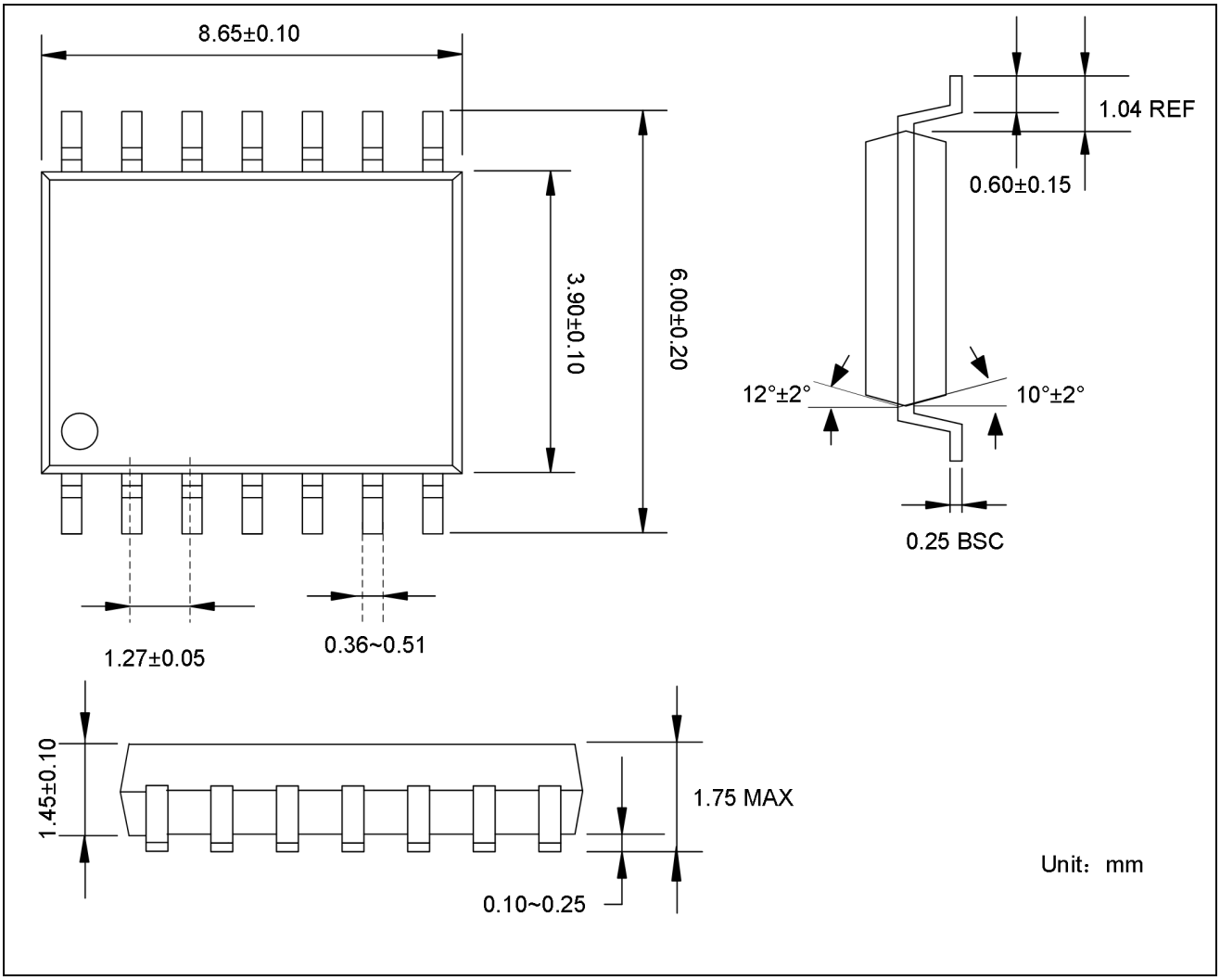
MSOP8



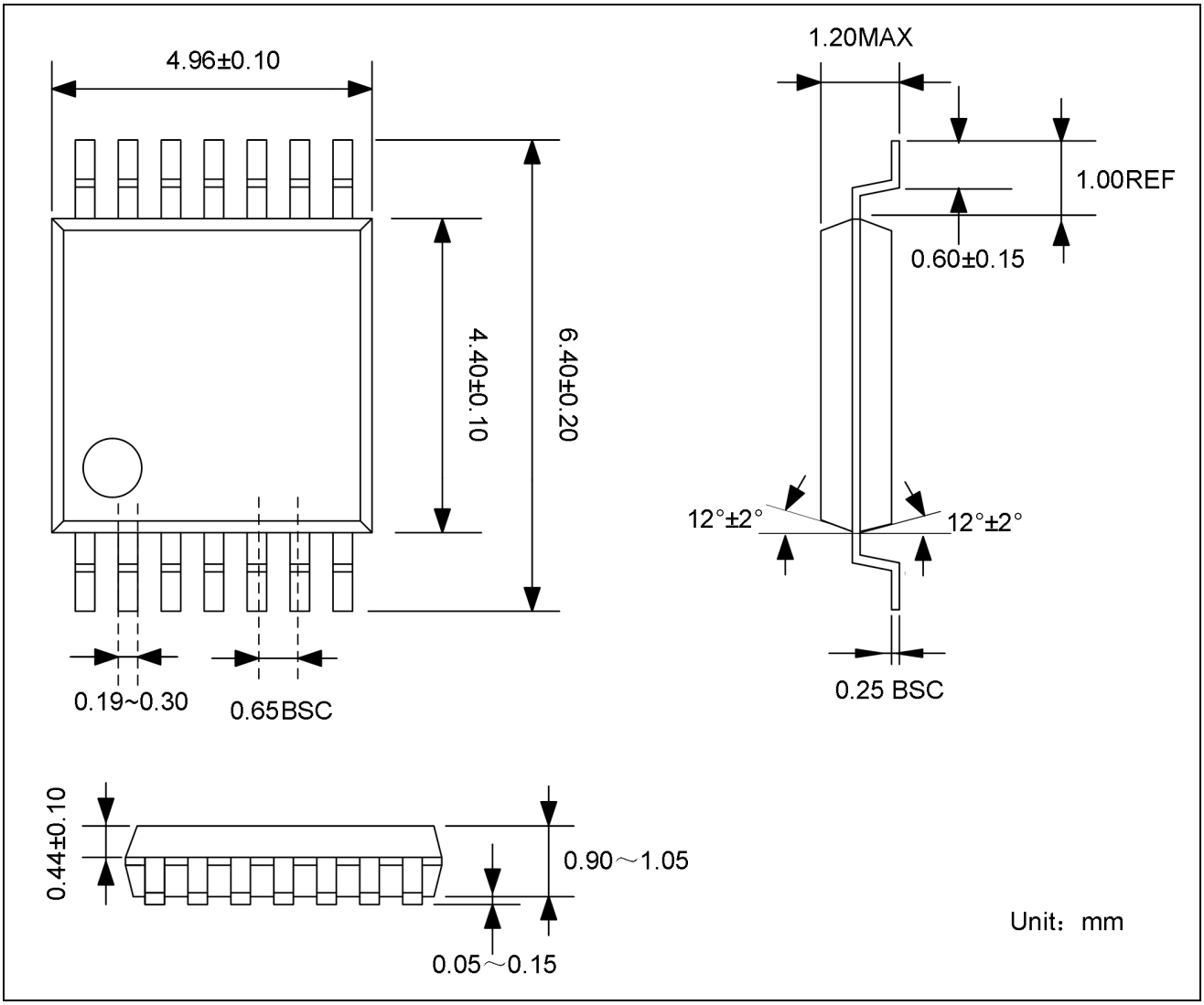

**Recommended Land Pattern**

Unit: mm

SOP14


8.65±0.10
3.90±0.10
6.00±0.20
1.27±0.05
0.36~0.51
1.04 REF
0.60±0.15
12°±2°
10°±2°
0.25 BSC
1.45±0.10
1.75 MAX
0.10~0.25
Unit：mm

TSSOP14


4.96±0.10
6.40±0.20
4.40±0.10
0.19~0.30
0.65BSC
1.20MAX
1.00REF
0.60±0.15
12°±2°
12°±2°
0.25 BSC
0.44±0.10
0.90～1.05
0.05～0.15
Unit：mm

## Revision History and Checking Table

| Version | Date | Revision Item | Modifier | Function & Spec Checking | Package & Tape Checking |
|---|---|---|---|---|---|
| 0.0 | 2023-04-21 | Preliminary Version | Huyt | Wanggp | Liujy |
| 1.0 | 2023-08-31 | Original Version | Huyt | Chenh | Liujy |
| 1.1 | 2023-09-28 | Naming updates | Huyt | Wanggp | Liujy |
| 1.2 | 2025-4-2 | Add TSOT23-8 | Huyt | Wanggp | Liujy |
| 1.3 | 2025-4-11 | Update MSL Grade | Huyt | Chenh | Liujy |
| 1.4 | 2025-4-17 | Update Typical Characteristics | Huyt | Tangyx | Liujy |