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

## General Description

ET85604 is a quad low-voltage (1.8 V to 5.5 V) operational amplifier (op amp) with rail-to-rail input- and output- swing capabilities. The device is 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 ET85604 is 100 pF, the resistive open-loop output impedance makes stabilizing with higher capacitive loads simpler. The op amp is designed specifically for low-voltage operation (1.8 V to 5.5 V).

ET85604 is specified for the extended industrial/automotive temperature range (-40°C to +125°C). It is available in SOP14/TSSOP14/DFN14(3×2) packages.

## Features

- Rail-to-rail input and output
- Low input offset voltage: ±0.3 mV
- Unity-gain bandwidth: 10 MHz
- Low broadband noise: 10 nV/$\sqrt{Hz}$
- Low input bias current: ±1 pA
- Low quiescent current: 550 μA
- 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

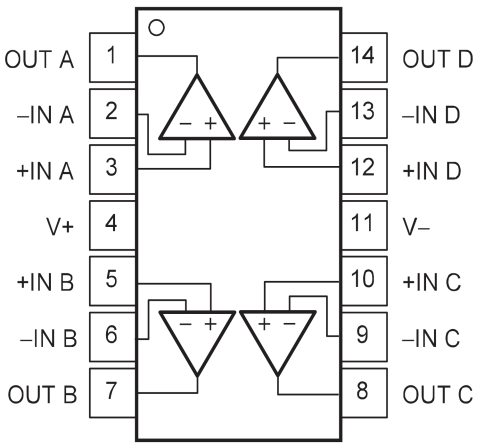
## Applications

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

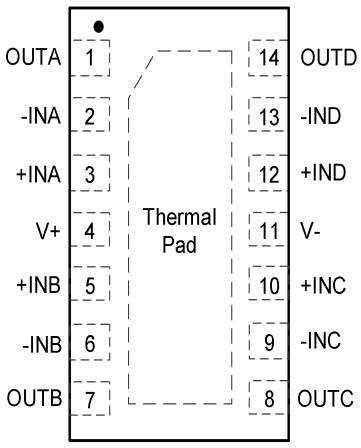
## Device information

| Part No. | Package | Packing Option | Marking | MSL |
|---|---|---|---|---|
| ET85604M | SOP14 | Tube , 50 | 84M<br>XXXXX | 3 |
| ET85604V | TSSOP14 | Tube , 50 | 84V<br>XXXXX | 3 |
| ET85604Y | DFN14(3×2) | Tape and Reel ,<br>3k/Reel | 84Y<br>XXXXX | 1 |

## Pin Configuration




SOP14/TSSOP14




DFN14(3×2)

Top View

## Pin Function

| Pin Number | Symbol | Descriptions |
|---|---|---|
| 1,7,8,14 | OUT | Output |
| 11 | V- | Negative supply |
| 3,5,10,12 | +IN | Non-inverting input |
| 2,6,9,13 | -IN | Inverting input |
| 4 | V+ | Positive supply |
| - | Thermal Pad | Connect thermal pad to V- |

## Functional Description

### Rail-to-Rail Input

The input common-mode voltage range extends 100 mV beyond the supply rails for the full supply voltage range of 1.8 V to 5.5 V. This performance is achieved with a complementary input stage.

### Rail-to-Rail Output

Designed as a low-power, low-voltage operational amplifier, the ET85604 delivers a robust output drive capability. A class AB output stage with common-source transistors achieves full rail-to-rail output swing capability. For resistive loads of 10 kΩ, the output swings to within 15 mV of either supply rail, regardless of the applied power-supply voltage. Different load conditions change the ability of the amplifier to swing close to the rails.

## 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.

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_S$ | Supply Voltage:(V+) - (V-) | 0 to 6 | V |
| $V_{IC}$ | Common-mode Input Voltage(1) | (V-)-0.5 to (V+)+0.5 | V |
| $V_{ID}$ | Differential Input Voltage(1) | (V+) - (V-)+0.2 | V |
| $I_{IN}$ | Signal input terminals Current(1) | -10 to +10 | mA |
| $I_{SC}$ | Output short-circuit current(2) | Continuous | mA |
| $V_{ESD}$ | ESD (Human Body Model) | ±2500 | V |
| | ESD (Charged Device Model) | ±1000 | V |
| $T_{STG}$ | Storage Temperature Range | -65 to +150 | °C |
| $T_{J(MAX)}$ | Max Junction Temperature Range | +150 | °C |

***Note1***: Input terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5 V beyond the supply rails should be current limited to 10 mA or less.

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

## Thermal Characteristics

| Symbol | Package | Ratings | Value | Unit |
|---|---|---|---|---|
| $R_{\theta JA}$ | SOP14 | Thermal Characteristics, Thermal Resistance, Junction-to-Air | 107 | °C/W |
| | TSSOP14 | | 136 | °C/W |
| | DFN14(3×2) | | 51 | °C/W |

## Recommended Operating Conditions

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_S$ | Supply Voltage: (V+) - (V-) | 1.8(±0.9) ~ 5.5(±2.75) | V |
| $T_A$ | Operating Temperature Range | -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 | |
| $\Delta V_{OS}/\Delta T$ | Input offset voltage vs temperature | $V_S$ = 5 V, $T_A$ = -40°C to 125°C | | ±0.53 | | µV/°C |
| PSRR | Input offset voltage vs power supply | $V_S$ = 1.8 to 5.5 V, $V_{CM}$ = (V-) | | ±7 | ±80 | µV/V |
| **INPUT VOLTAGE RANGE** | | | | | | |
| $V_{CM}$ | Common-mode voltage range | $V_S$ = 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 |

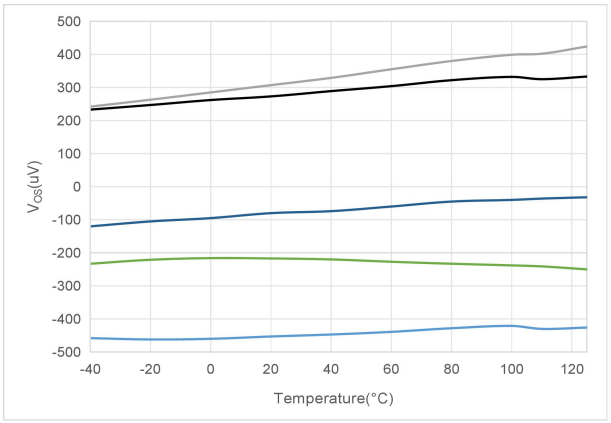
## Electrical Characteristics (Continued)

| 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 | |

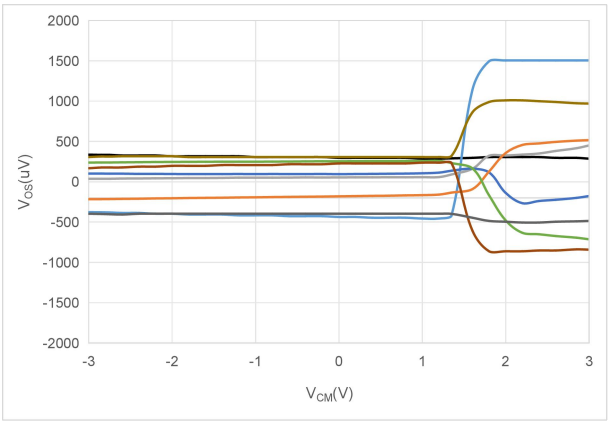
***Note3***: Guaranteed by design.

## Typical Characteristics

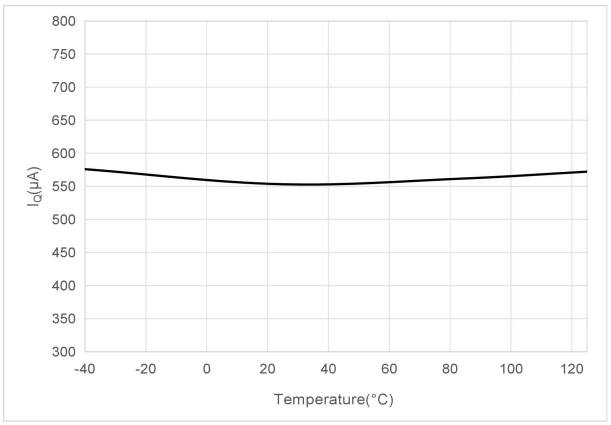
$V_S$ = 5.5 V(±2.75V), $V_{CM}$ = $V_{OUT}$ = $V_S$/2, and $R_L$ = 10kΩ connected to $V_S$/2,$T_A$ = 25°C (unless otherwise noted)



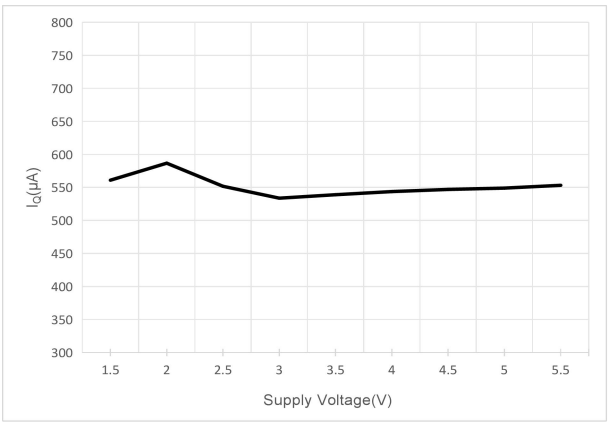

Offset Voltage vs Temperature



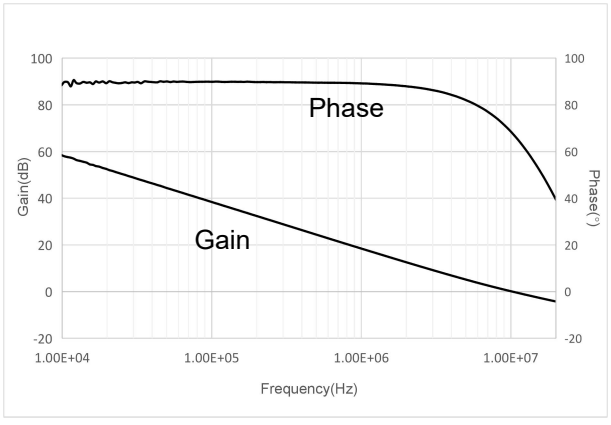

Offset Voltage vs Common-Mode Voltage



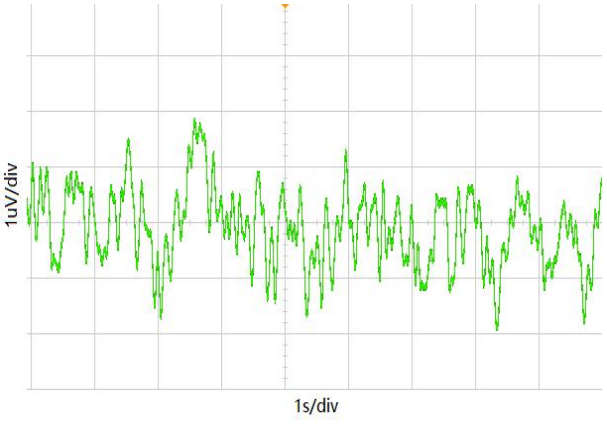

Quiescent Current vs Temperature




Quiescent Current vs Supply Voltage

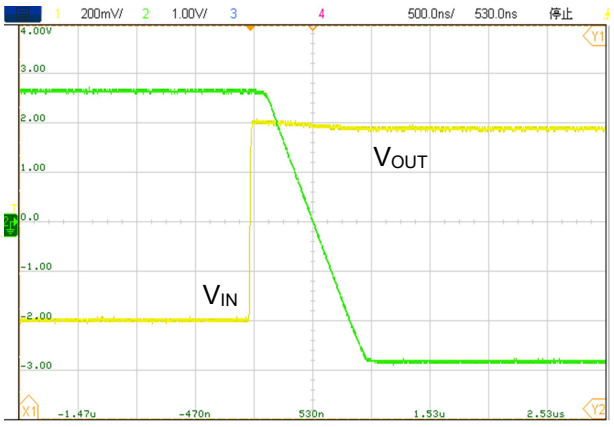



Open-Loop Gain and Phase vs Frequency



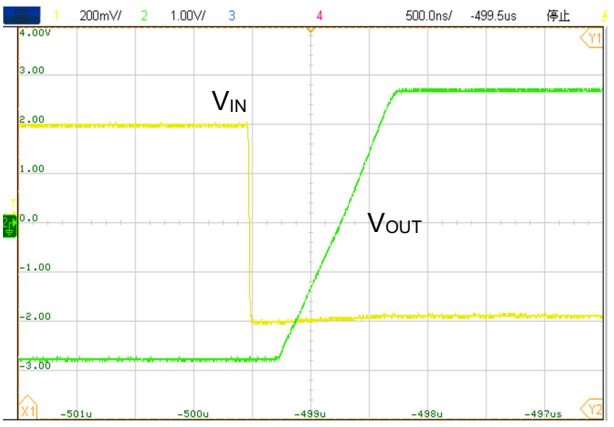

0.1 Hz to 10 Hz Noise

## Typical Characteristics (Continued)



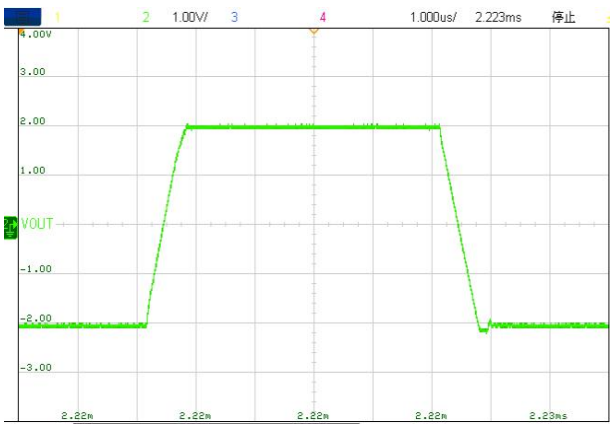

Positive Overload Recovery

(G = -10)



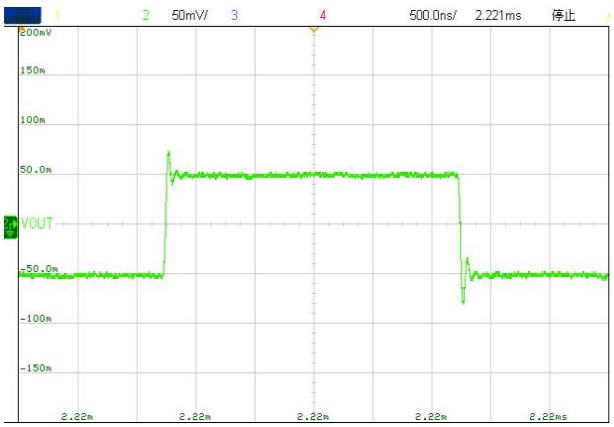

Negative Overload Recovery

(G = -10)




Large-Signal Step Response

(G = +1)




Small-Signal Step Response(100 mV)

(G = +1,$R_L$ = 10 kΩ,$C_L$ = 100 pF)

## Layout Guidelines

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

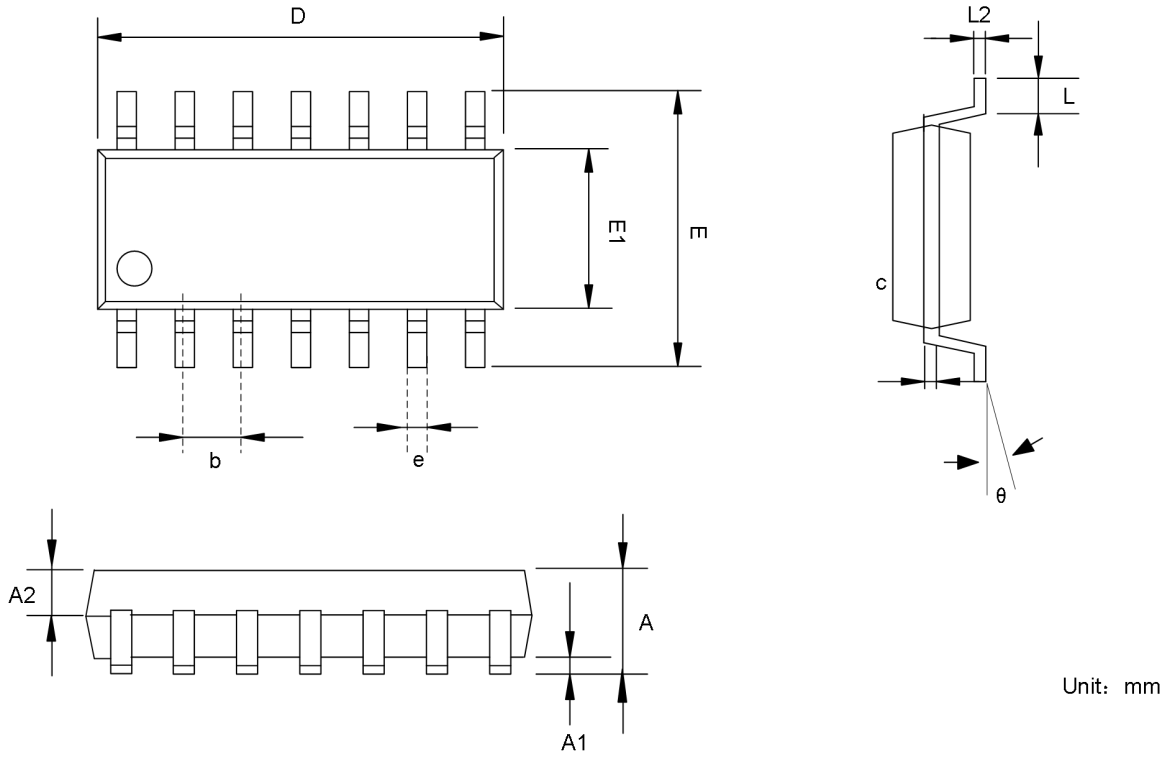
Place the external components as close to the device as possible. This configuration prevents parasitic errors (such as the Seebeck effect) from occurring.

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

SOP14

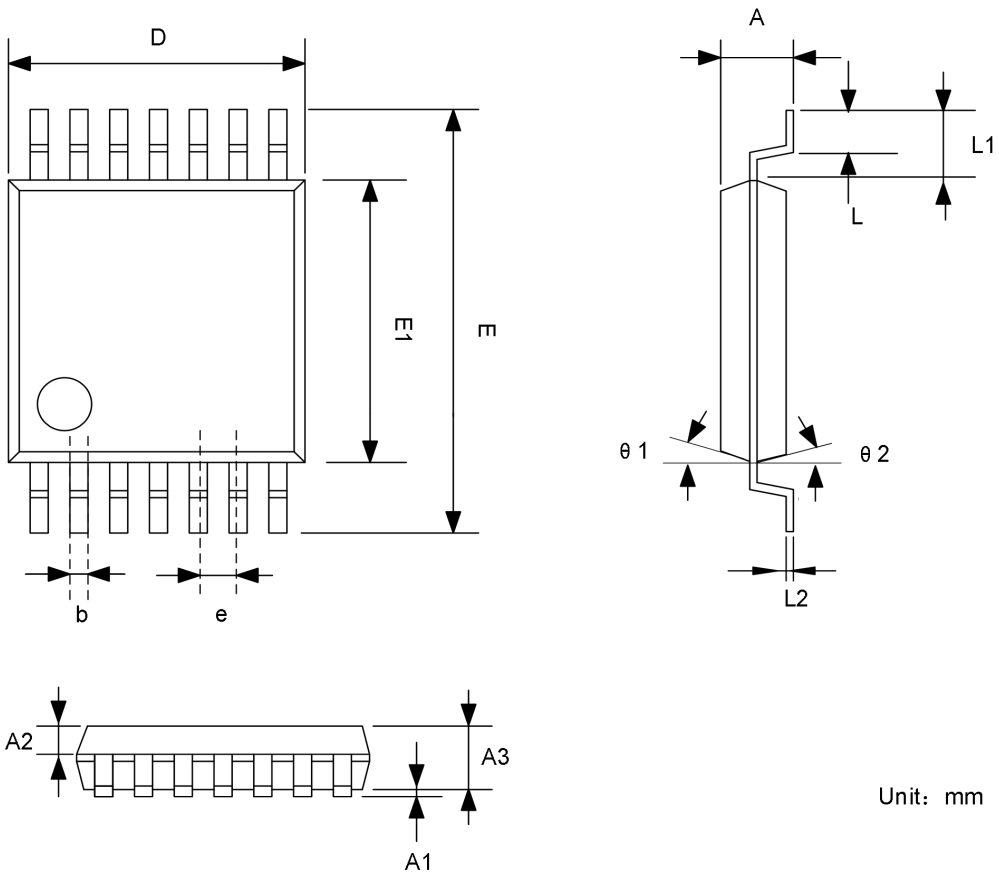



Unit：mm

COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

| SYMBOL | MIN | MAX |
|---|---|---|
| A | 1.40 | 1.50 |
| A1 | 0.10 | 0.20 |
| A2 | 0.65 | 0.75 |
| b | 1.270 | |
| c | 0.203 | |
| D | 8.48 | 8.58 |
| E | 6.05 | 6.25 |
| E1 | 3.75 | 3.85 |
| e | 0.406 | |
| L | 0.40 | 0.70 |
| L2 | 0.203 | |
| θ | 0° | 8° |

TSSOP14

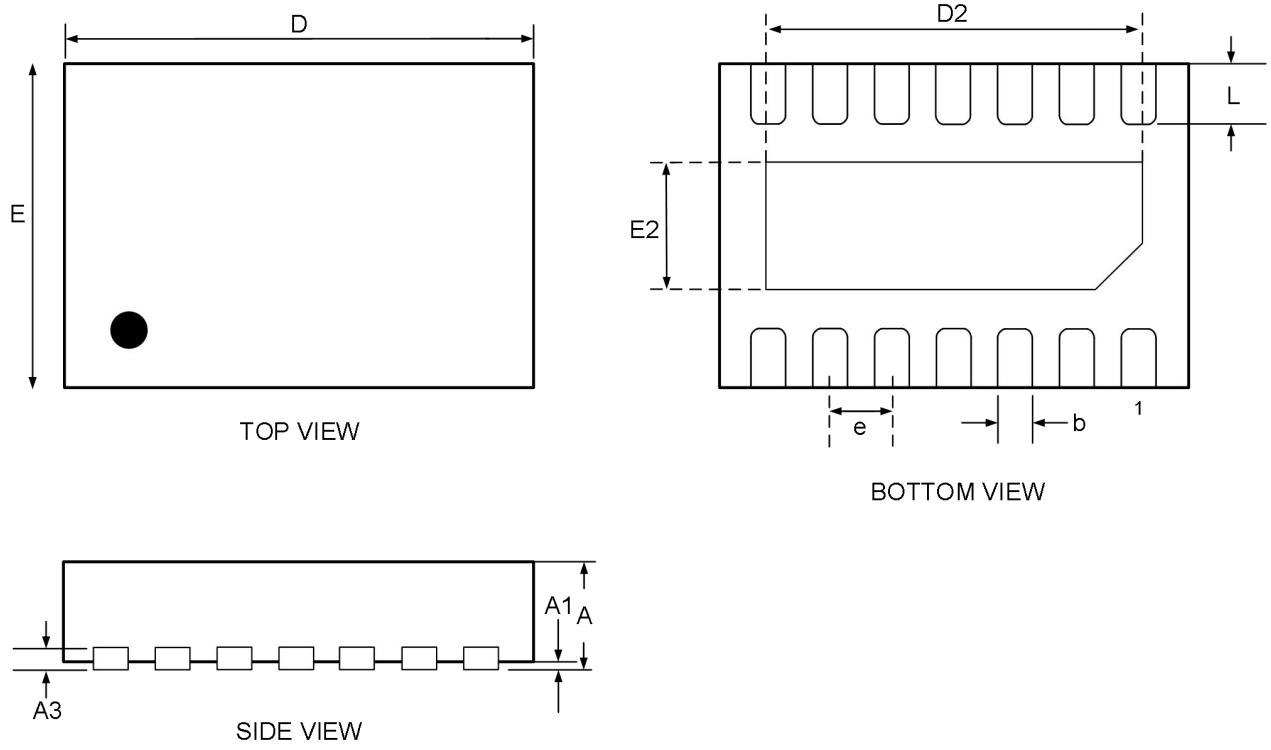



Unit：mm

COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

| SYMBOL | MIN | NOM | MAX |
|---|---|---|---|
| A | — | — | 1.20 |
| A1 | 0.05 | 0.08 | 0.11 |
| A2 | 0.39 | 0.44 | 0.49 |
| A3 | 0.95 | 1.00 | 1.05 |
| e | | 0.65 BSC | |
| D | 4.95 | 5.00 | 5.05 |
| E | 6.35 | 6.40 | 6.45 |
| E1 | 4.35 | 4.40 | 4.45 |
| b | 0.20 | — | 0.29 |
| L | 0.55 | 0.60 | 0.65 |
| L1 | | 1.00 BSC | |
| L2 | 0.13 | — | 0.18 |
| θ1 | — | 13° | — |
| θ2 | — | 12° | — |

DFN14(3×2)



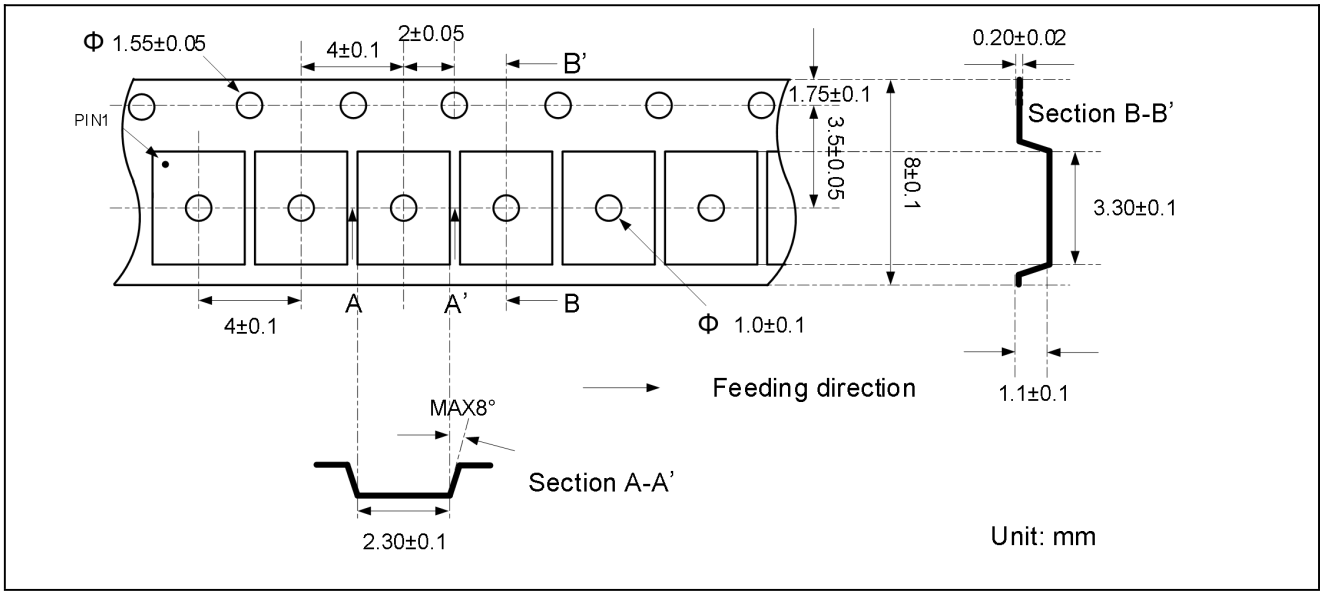

COMMON DIMENSIONS

(UNITS OF MEASURE=MILLIMETER)

| SYMBOL | MIN | NOM | MAX |
|---|---|---|---|
| A | 0.70 | 0.75 | 0.80 |
| A1 | 0.00 | - | 0.05 |
| A3 | | 0.20 REF | |
| b | 0.15 | 0.20 | 0.25 |
| D | 2.95 | 3.00 | 3.05 |
| E | 1.95 | 2.00 | 2.05 |
| D2 | 2.30 | 2.50 | 2.60 |
| E2 | 0.65 | 0.80 | 0.90 |
| e | | 0.40 BSC | |
| L | 0.25 | 0.35 | 0.45 |

## Tape Information

DFN14(3×2)




## Revision History and Checking Table

| Version | Date | Revision Item | Modifier | Function & Spec Checking | Package & Tape Checking |
|---|---|---|---|---|---|
| 1.0 | 2026-04-02 | Original Version | Huyt | Chenh | Liujy |
| | | | | | |