

AXOP32121/2/4

0.45 μ V Input Noise, 24V
Operational Amplifiers (Single/Dual/Quad)



Datasheet – Dec 2024

Description

The AXOP32121 (single), AXOP32122 (dual) and AXOP32124 (quad) are ultra-low noise, ultra-low offset dual, quad and single mid voltage (3V to 24V) operational amplifiers (opamps) with rail-to-rail output swing capabilities. These devices are very suitable for applications where ultra-low noise, high voltage operation and a small footprint.

Features

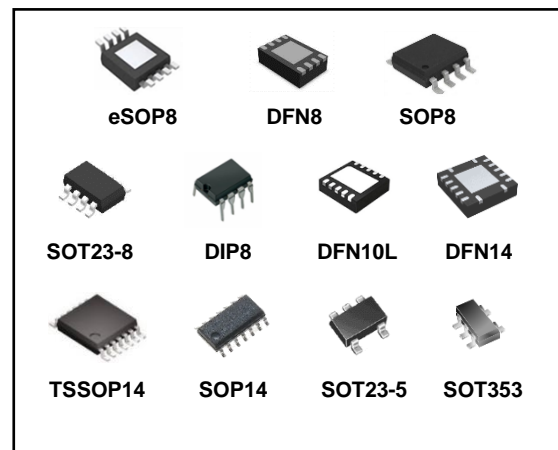
- Supply voltages from 3V to 24V
- Ultra-low input voltage noise (20Hz to 20kHz) $G=+1$, 0.45 μ V
- Excellent THD 114dB
- Excellent SNR 120dB
- Output rail-to-rail
- Low input offset voltage: ± 0.1 mV typ
- Unity-gain bandwidth: 30MHz
- Low quiescent current (per opamp): 1.2mA typ @14V, 0.5mA typ @3.3V

Applications

- Infotainment system
- HVAC: heating, ventilating, and air conditioning
- Industrial control
- Test equipment
- Portable Equipment
- Active filters
- Data acquisition system

Table 1 Device Summary

| Order code | Package | Packing | MOQ |
|------------|---------|---------|------|
| AXOP32122A | eSOP8 | Reel | 2500 |
| AXOP32122B | DFN8 | Reel | 3000 |
| AXOP32122C | SOP8 | Reel | 4000 |
| AXOP32122D | SOT23-8 | Reel | 3000 |
| AXOP32122E | DIP8 | Tube | 2000 |
| AXOP32122F | DFN10L | Reel | 3000 |
| AXOP32124A | QFN14 | Reel | 6000 |
| AXOP32124B | TSSOP14 | Reel | 3000 |
| AXOP32124C | SOP14 | Reel | 2500 |
| AXOP32121A | SOT23-5 | Reel | 3000 |
| AXOP32121C | SOT353 | Reel | 3000 |



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1 Block Diagram and Application Circuit

Figure 1 Block Diagram

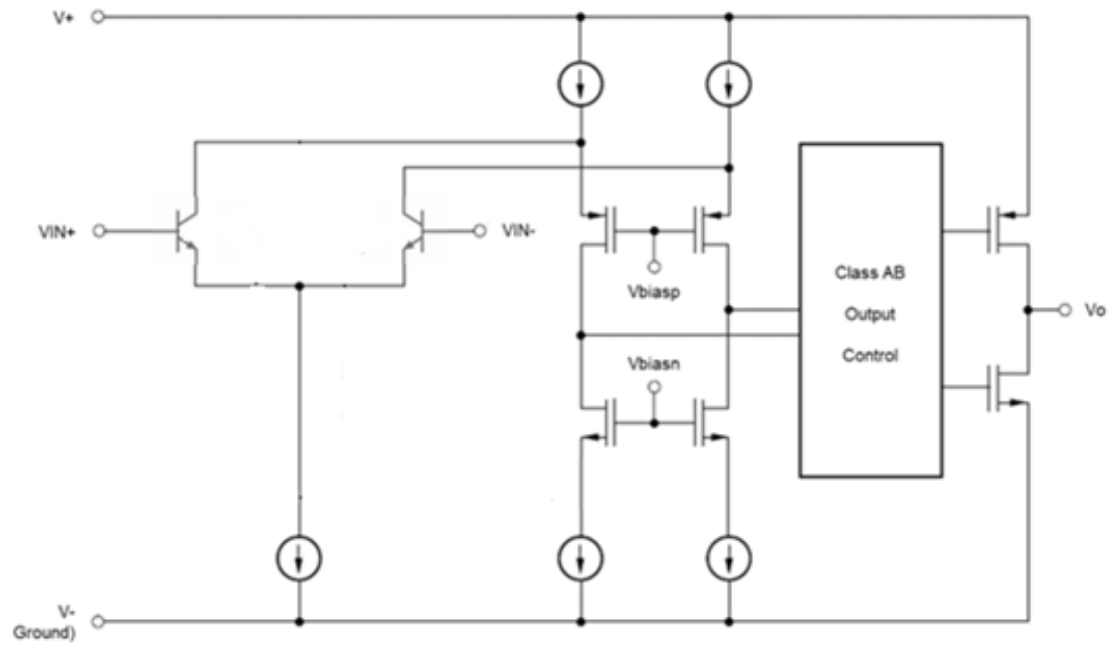
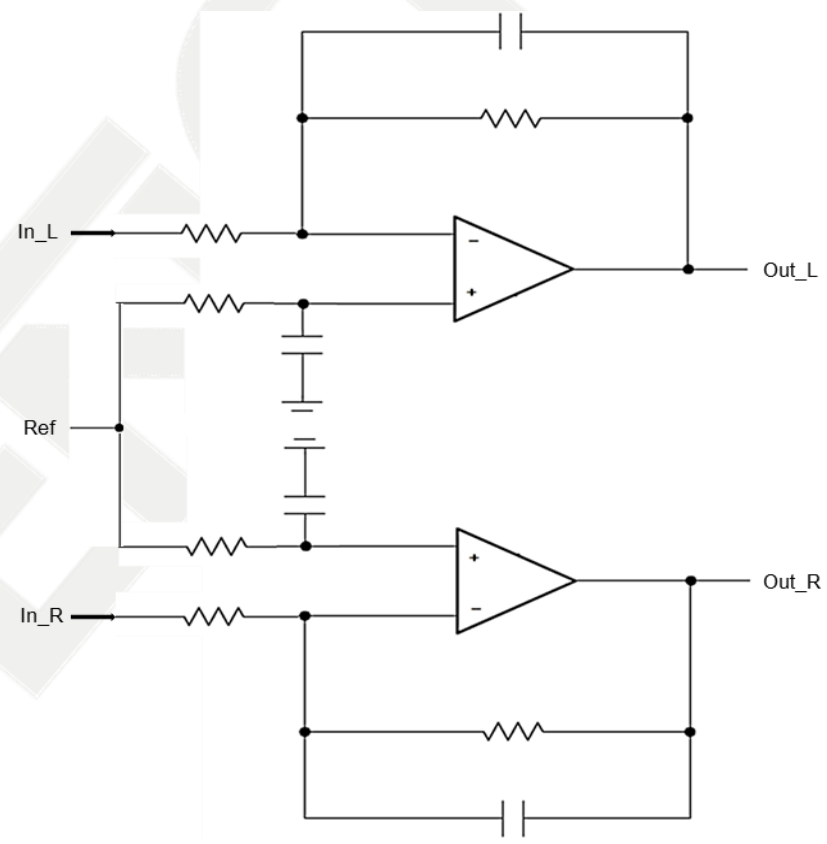


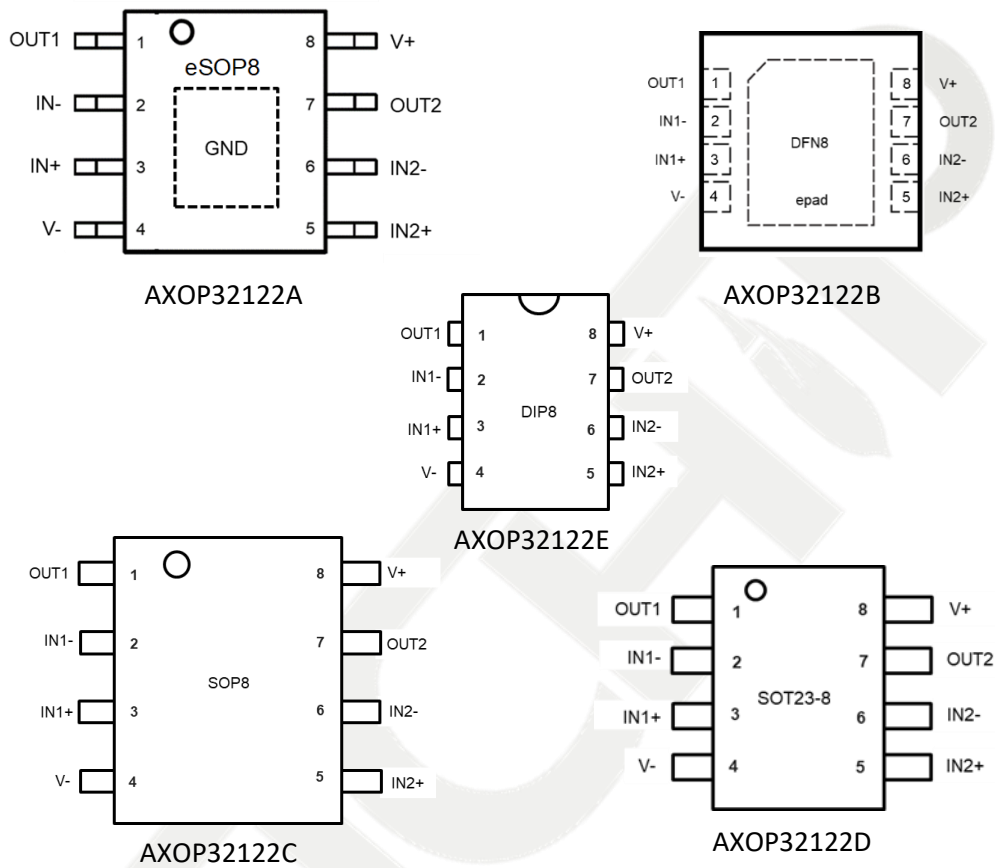
Figure 2 Typical Application Circuit (Stereo Sound Input Amplifier)



2 Pin Description

2.1 AXOP32122A/B/C/D/E Pinouts

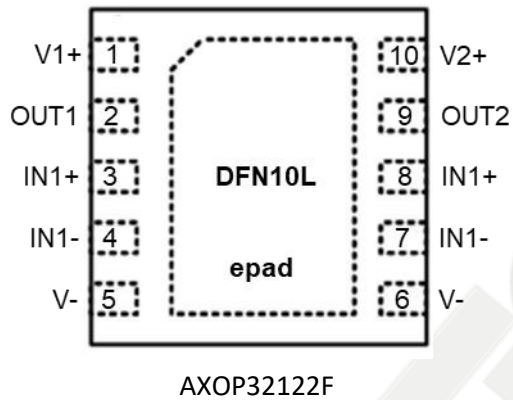
Figure 3 AXOP32122A/B/C/D/E Pinouts



| Pin number | Pin name | Description |
|------------|----------|---------------------------|
| 1 | OUT1 | Output 1 |
| 2 | IN1- | Inverting input 1 |
| 3 | IN1+ | Non-inverting input 1 |
| 4 | V- | Negative supply or ground |
| 5 | IN2+ | Non-inverting input 2 |
| 6 | IN2- | Inverting input 2 |
| 7 | OUT2 | Output 2 |
| 8 | V+ | Positive supply |

2.2 AXOP32122F Pinout

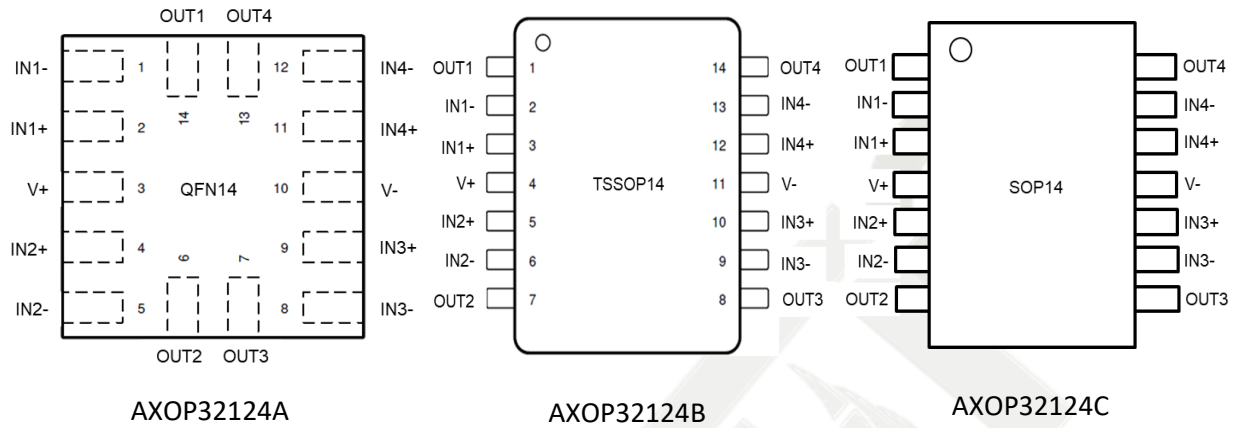
Figure 4 AXOP32122F Pinout



| Pin number | Pin name | Description |
|------------|----------|-------------------------------------|
| 1 | V1+ | Positive supply channel 1 |
| 2 | OUT1 | Output channel 1 |
| 3 | IN1+ | Non-inverting input channel 1 |
| 4 | IN1- | Inverting input channel 1 |
| 5 | V1- | Negative supply or ground channel 1 |
| 6 | V2- | Negative supply or ground channel 2 |
| 7 | IN2- | Inverting input channel 2 |
| 8 | IN2+ | Non-inverting input channel 2 |
| 9 | OUT2 | Output channel 2 |
| 10 | V2+ | Positive supply channel 2 |

2.3 AXOP32124A/B/C Pinouts

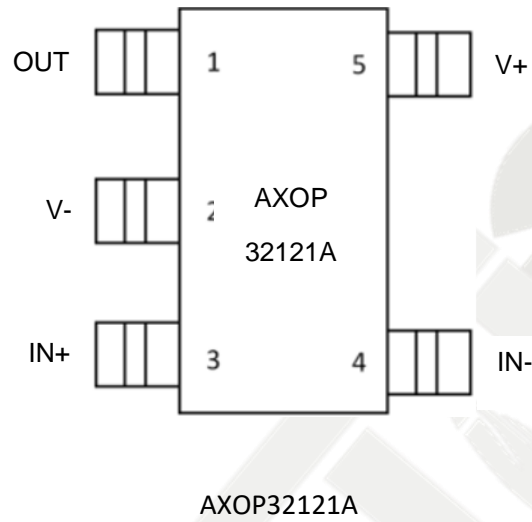
Figure 5 AXOP32124A/B/C Pinouts



| Pin number | AXOP32124A | | AXOP32124B/C | |
|------------|----------------|---------------------------|------------------------|---------------------------|
| | QFN14 Pin name | QFN14 Description | TSSOP14/SOP14 Pin name | TSSOP14/SOP14 Description |
| 1 | IN1- | Inverting input 1 | OUT1 | Output 1 |
| 2 | IN1+ | Non-inverting input 1 | IN1- | Inverting input 1 |
| 3 | V+ | Positive supply | IN1+ | Non-inverting input 1 |
| 4 | IN2+ | Non-inverting input 2 | V+ | Positive supply |
| 5 | IN2- | Inverting input 2 | IN2+ | Non-inverting input 2 |
| 6 | OUT2 | Output 2 | IN2- | Inverting input 2 |
| 7 | OUT3 | Output 3 | OUT2 | Output 2 |
| 8 | IN3- | Inverting input 3 | OUT3 | Output 3 |
| 9 | IN3+ | Non-inverting input 3 | IN3- | Inverting input 3 |
| 10 | V- | Negative supply or ground | IN3+ | Non-inverting input 3 |
| 11 | IN4+ | Non-inverting input 4 | V- | Negative supply or ground |
| 12 | IN4- | Inverting input 4 | IN4+ | Non-inverting input 4 |
| 13 | OUT4 | Output 4 | IN4- | Inverting input 4 |
| 14 | OUT1 | Output 1 | OUT4 | Output 4 |

2.4 AXOP32121A Pinout

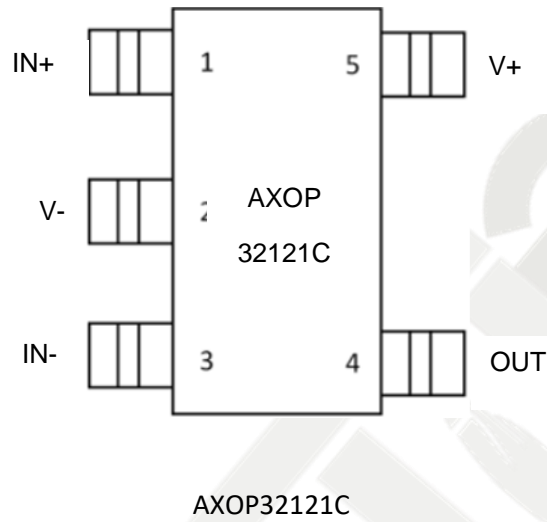
Figure 6 AXOP32121A Pinouts



| Pin number | Pin name | Description |
|------------|----------|---------------------------|
| 1 | OUT | Output |
| 2 | V- | Negative supply or ground |
| 3 | IN+ | Non-inverting input |
| 4 | IN- | Inverting input |
| 5 | V+ | Positive supply |

2.5 AXOP32121C Pinout

Figure 7 AXOP32121C Pinouts



| Pin number | Pin name | Description |
|------------|----------|---------------------------|
| 1 | IN+ | Non-inverting input |
| 2 | V- | Negative supply or ground |
| 3 | IN- | Inverting input |
| 4 | OUT | Output |
| 5 | V+ | Positive supply |

3 Electrical Specifications

3.1 Absolute Maximum Ratings

Table 2 Absolute Maximum Ratings

| Symbol | Parameter | Value | Unit |
|----------|----------------------------|-------------------------|------|
| Vs | Supply voltage (V+) - (V-) | -0.3 to +26 | V |
| IN+, IN- | Input pin voltage | (V-) - 0.5 to (V+) +0.5 | V |
| OUT | Output pin voltage | (V-) - 0.5 to (V+) +0.5 | V |
| Tj | Junction temperature | 150 | °C |
| Tstg | Storage temperature | -55 to +150 | °C |

3.2 Thermal Data

Table 3 Thermal Data

| Package | Rth j-amb | Rth j-case | Unit |
|---------|-----------|------------|------|
| eSOP8 | 60 | 10 | °C/W |
| DFN8 | 43 | 5 | °C/W |
| SOP8 | 136 | 77 | °C/W |
| SOT23-8 | 184 | 100 | °C/W |
| DIP8 | 85 | 41 | °C/W |
| DFN10L | 45 | 10 | °C/W |
| QFN14 | 47 | 4 | °C/W |
| TSSOP14 | 113 | 62 | °C/W |
| SOP14 | 106 | 64 | °C/W |
| SOT23-5 | 184 | 100 | °C/W |
| SOT353 | 184 | 100 | °C/W |

3.3 ESD

Table 4 ESD0

| Symbol | Parameter | Value | Unit |
|----------|-----------|--------|------|
| All pins | ESD (HBM) | ±6,000 | V |

3.4 Electrical Characteristics

For $V_s = (V_+) - (V_-) = 14V$ at $T_a = 25^\circ C$, $R_L = 10k\Omega$ connected to $V_s/2$, $V_{cm} = V_s/2$, and $V_{out} = V_s/2$ (unless otherwise noted).

Table 5 Electrical Characteristics

| Symbol | Parameter | Test condition | Min | Typ | Max | Unit |
|----------------------------|--------------------------------------|-------------------------------|-----|------------|-----------|------------------|
| V_s | Supply voltage (V_+) - (V_-) | | 3 | | 24 | V |
| T_a | Operating ambient temperature | | -40 | | 85 | $^\circ C$ |
| Power Supply | | | | | | |
| I_q | Quiescent current per amplifier | $V_s=14V, I_o=0mA$ | | 1.2 | 1.6 | mA |
| | | $V_s=24V, I_o=0mA$ | | 1.6 | 2.2 | |
| | | $V_s=5.0V, I_o=0mA$ | | 1.0 | | |
| | | $V_s=3.3V, I_o=0mA$ | | 0.5 | | |
| | | all temp | | | 3.0 | |
| Offset Voltage | | | | | | |
| V_{os} | Input offset voltage | | | ± 0.1 | ± 0.5 | mV |
| | | all temp | | | ± 1 | mV |
| dV_{os}/dT | Drift | all temp | | ± 0.2 | | $\mu V/^\circ C$ |
| PSRR | Power-supply rejection ratio | At DC | | 120 | | dB |
| Csep | Channel separation | At DC | | 120 | | dB |
| Input Voltage Range | | | | | | |
| V_{cm} | Common mode voltage range | $V_s=3V$ to $24V$ | 1 | | V_s | V |
| CMRR | Common mode rejection ratio | At DC | | 100 | | dB |
| Input Bias Current | | | | | | |
| I_b | Input bias current | | | 0.4 | | μA |
| I_{os} | Input offset current | | | ± 0.01 | | μA |
| Noise | | | | | | |
| E_n | Input voltage noise | $f=20Hz$ to $20kHz$ $G=+1$ | | 0.45 | | μV |
| Open Loop Gain | | | | | | |
| A_{ol} | Open loop voltage gain | | | 130 | | dB |
| Frequency Response | | | | | | |
| GBP | Gain bandwidth product | $G=+1, C_L=10pF$ | | 30 | | MHz |
| SR | Slew rate | $G=+1, C_L=10pF$ | | 12 | | $V/\mu s$ |

| | | | | | | |
|---------------|--|--|--|------|-----|----|
| Ts | Settling time | To 0.1%, 2V step, G=+1, CL=10pF | | 0.25 | | μs |
| THD | Total harmonic distortion (3 rd order filter; BW= 80kHz at -3dB.) | Vs=24V, Vcm=12V, Vo=1Vp, G=+1, f=1kHz, no load | | 114 | | dB |
| | | Vs=3V, Vcm=1.5V, Vo=0.5Vp, G=+1, f=1kHz, no load | | | | |
| SNR | Signal to Noise Ratio | Vs=24V, Vin=1Vrms, G=+1, f=1kHz | | 120 | | dB |
| Output | | | | | | |
| Vo | Voltage output swing from supply rails | RL=10kΩ | | 25 | 40 | mV |
| | | RL=2kΩ | | 110 | 150 | |
| Vs,sc | Max Vs for output short circuit protection | G=+1 | | | 14 | V |
| | | G=non-unity | | | 24 | |
| Isc | Short circuit current | | | ±20 | | mA |
| | | AXOP32122A only eSOP8 package | | ±100 | | mA |

3.5 Typical Electrical Characteristics

Figure 8 Vos Distribution

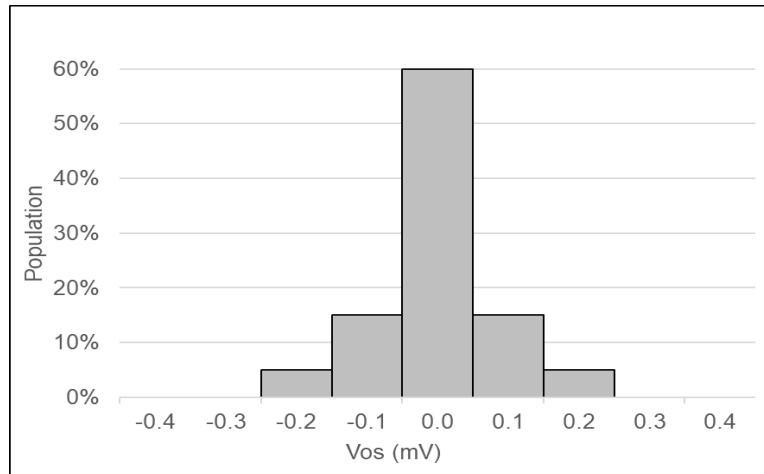


Figure 9 Vos vs Input Common Mode Voltage

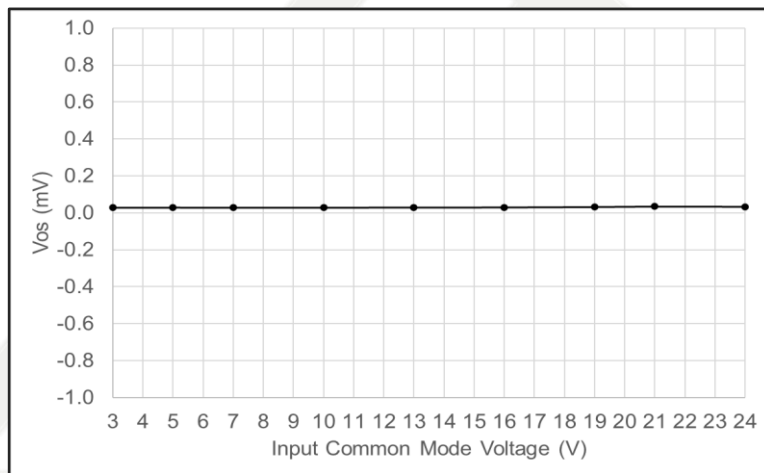


Figure 10 Vos vs Vs

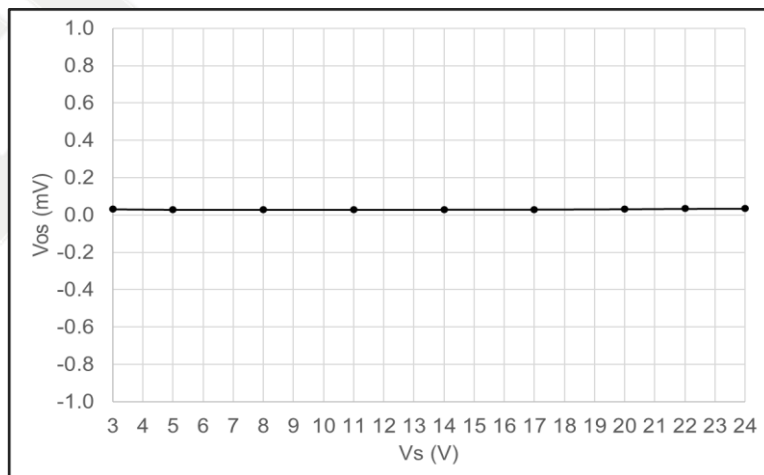


Figure 11 Iq (per opamp) vs Input Common Mode Voltage

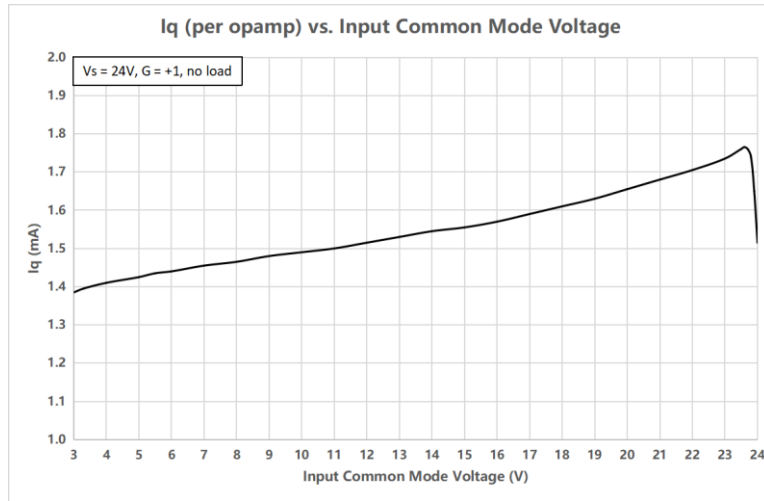


Figure 12 Iq (per opamp) vs Vs

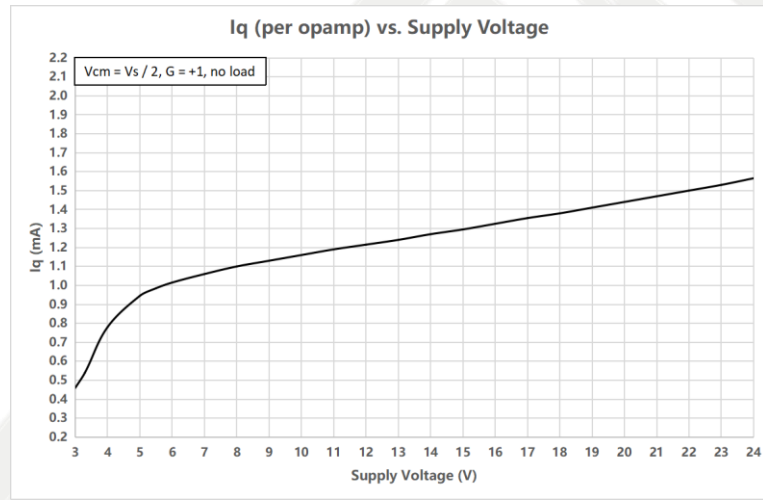


Figure 13 THD vs Output Voltage

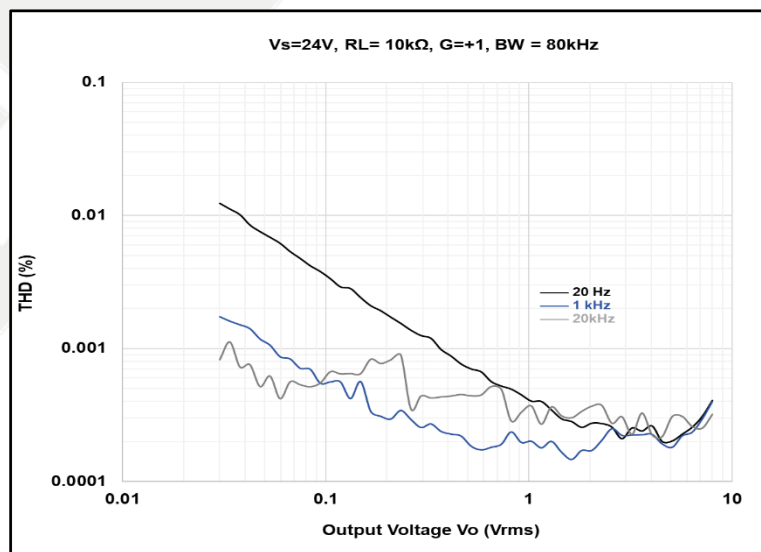


Figure 14 Voltage Noise Spectral Density

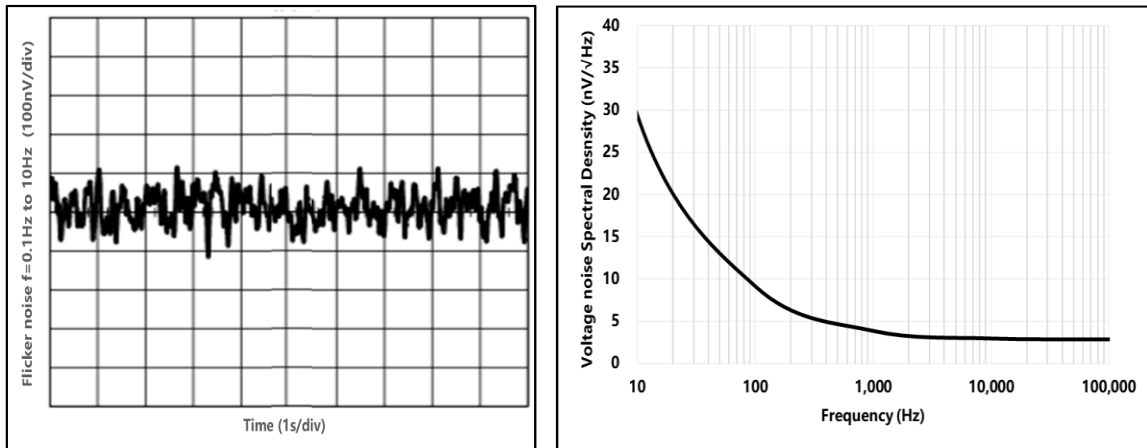
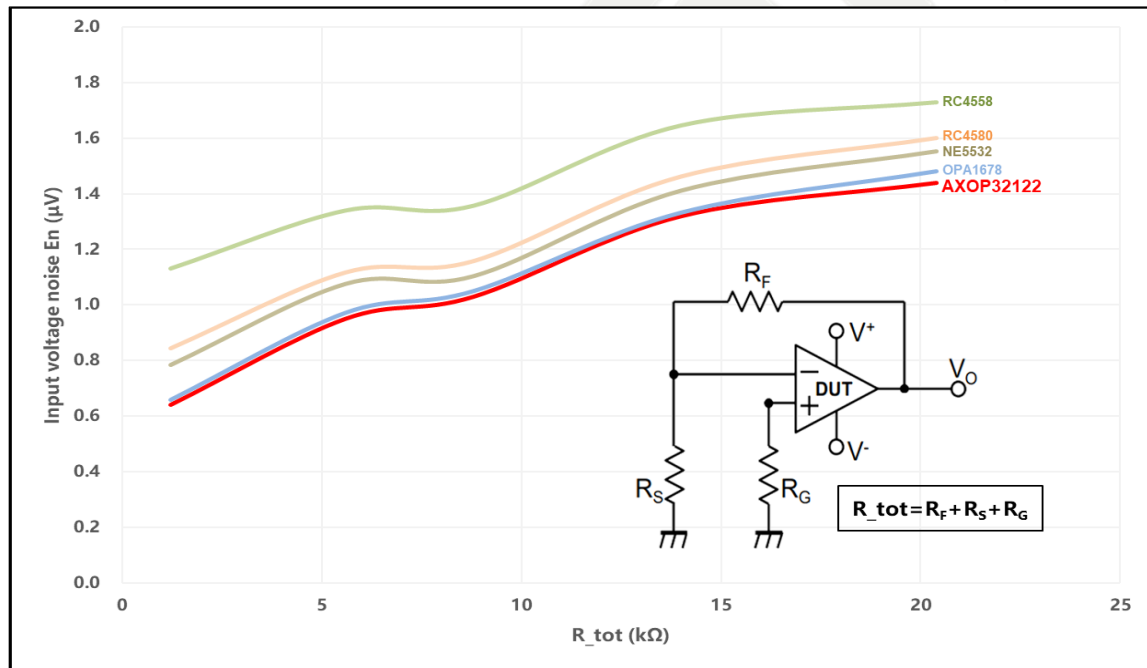


Figure 15 Input Voltage Noise Comparison



4 Functional Description

4.1 Overview

The AXOP3212x devices are a family of mid voltage, rail-to-rail output opamps. These devices operate from 3V to 24V, are unity gain stable, and are designed for a wide range of applications and used in virtually any single supply application.

4.2 Rail to Rail Output

The input common mode voltage range of the AXOP3212x family extends from 1V to V_s for the full supply voltage range of 3V to 24V. This performance is achieved with a NPN input differential pair, as shown in Figure 1.

Designed as a high voltage operational amplifier, the AXOP3212x series delivers a robust output drive capability. A class AB output stage with common source Mosfets achieves full rail-to-rail output swing capability. For resistive loads of 10k Ω , the output swings to within 25mV (typ) 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.

4.3 Overload Recovery

Overload recovery is defined as the time required for the opamp output to recover from a saturated state to a linear state. The output devices of the opamp enter a saturation region when the output voltage exceeds the rated operating voltage, because of the high input voltage or the high gain. After the device enters the saturation region, the charge carriers in the output devices require time to return to the linear state. After the charge carriers return to the linear state, the device begins to slew at the specified slew rate. The overload recovery time for the AXOP3212x family is approximately 20ns.

4.4 EMI Rejection

The AXOP3212x uses integrated electromagnetic interference (EMI) filtering to reduce the effects of EMI from sources such as wireless communications and densely populated boards with a mix of analog signal chain and digital components.

5 Package Information

5.1 Package Dimensions

Figure 16 eSOP8 Mechanical Data and Package Dimensions

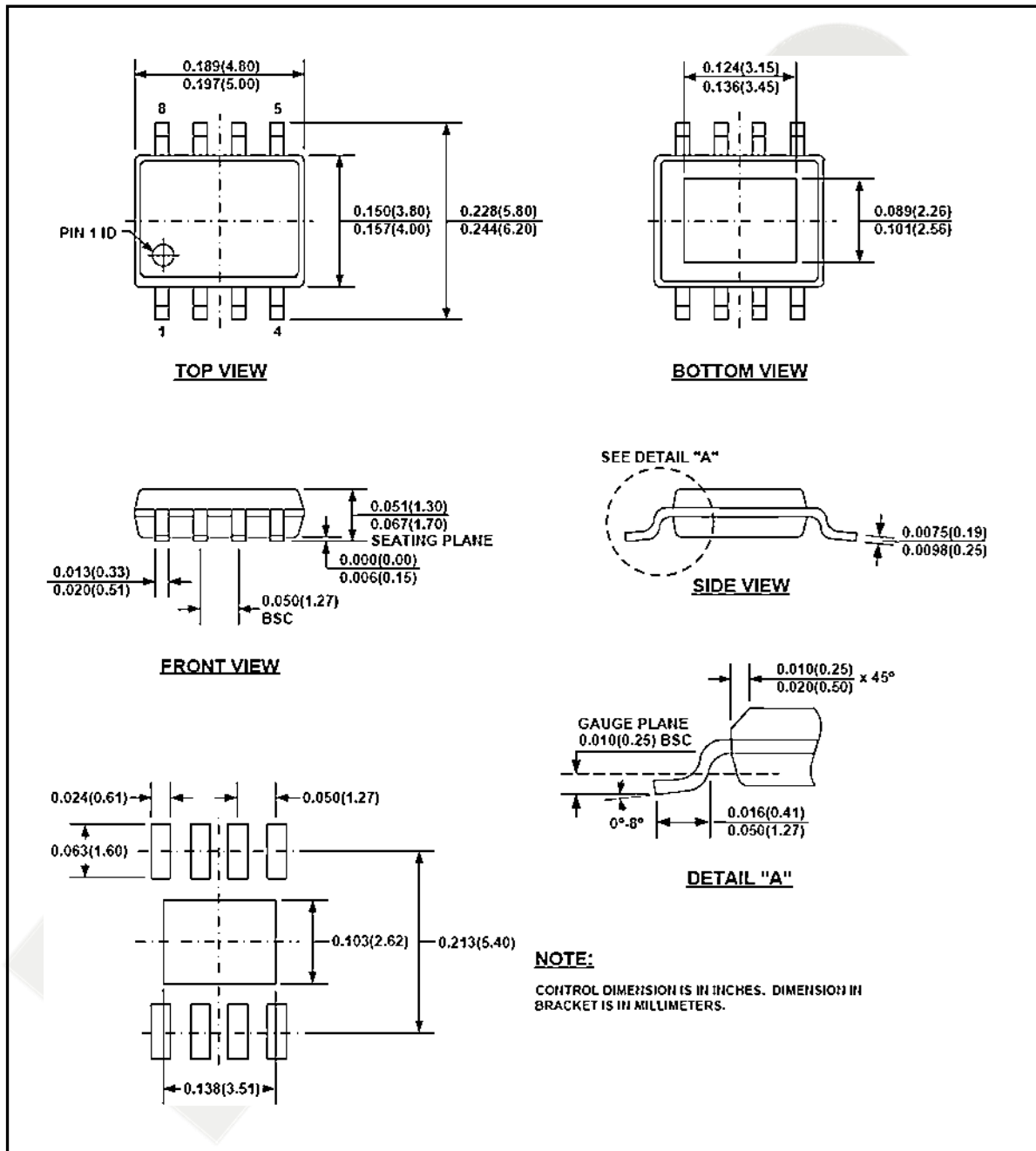
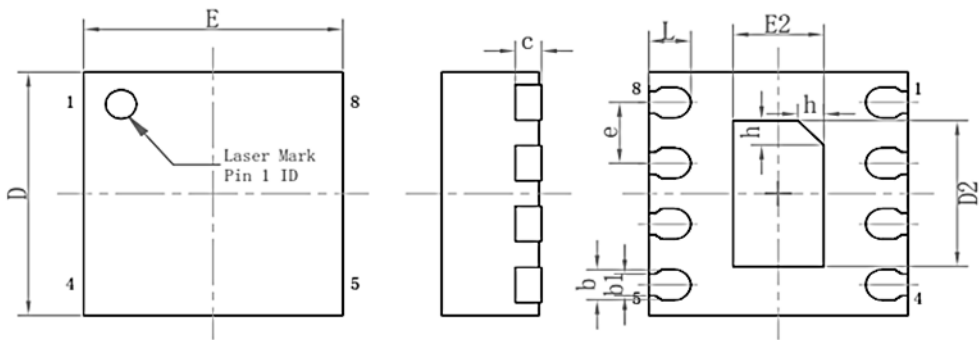


Figure 17 DFN8 Mechanical Data and Package Dimensions

| | Min (mm) | Typ (mm) | Max (mm) | | Min (mm) | Typ (mm) | Max (mm) |
|----|----------|----------|----------|----|----------|----------|----------|
| A | 0.70 | 0.75 | 0.80 | e | 0.50BSC | | |
| A1 | 0.00 | 0.02 | 0.05 | E | 1.95 | 2.00 | 2.05 |
| b | 0.18 | 0.25 | 0.30 | E2 | 0.65 | 0.70 | 0.75 |
| b1 | 0.18REF | | | L | 0.25 | 0.30 | 0.35 |
| c | 0.20REF | | | h | 0.15 | 0.20 | 0.25 |
| D | 1.95 | 2.00 | 2.05 | | | | |
| D2 | 1.15 | 1.20 | 1.25 | | | | |



bottom view

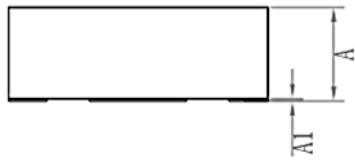


Figure 18 SOP8 Mechanical Data and Package Dimensions

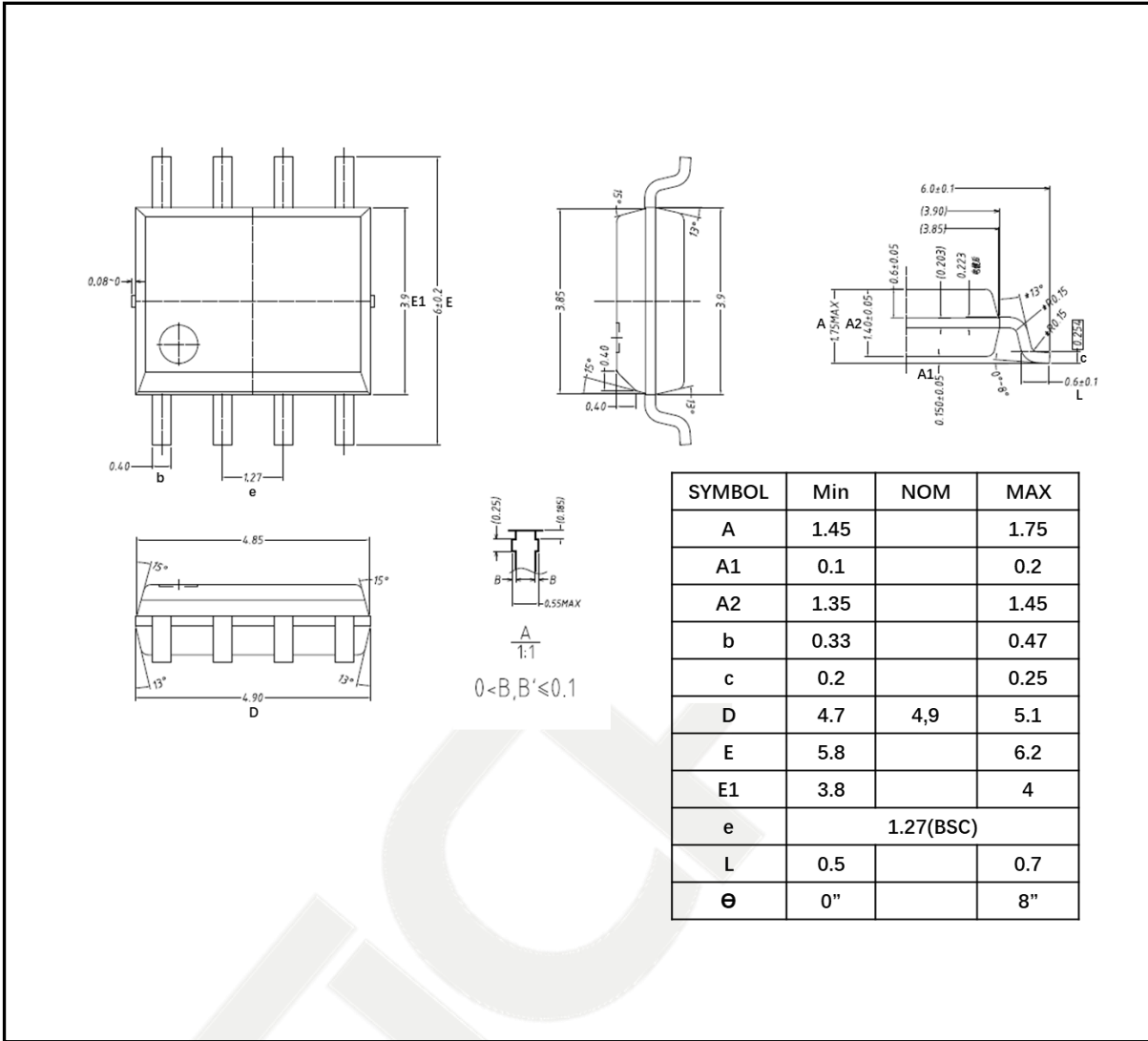
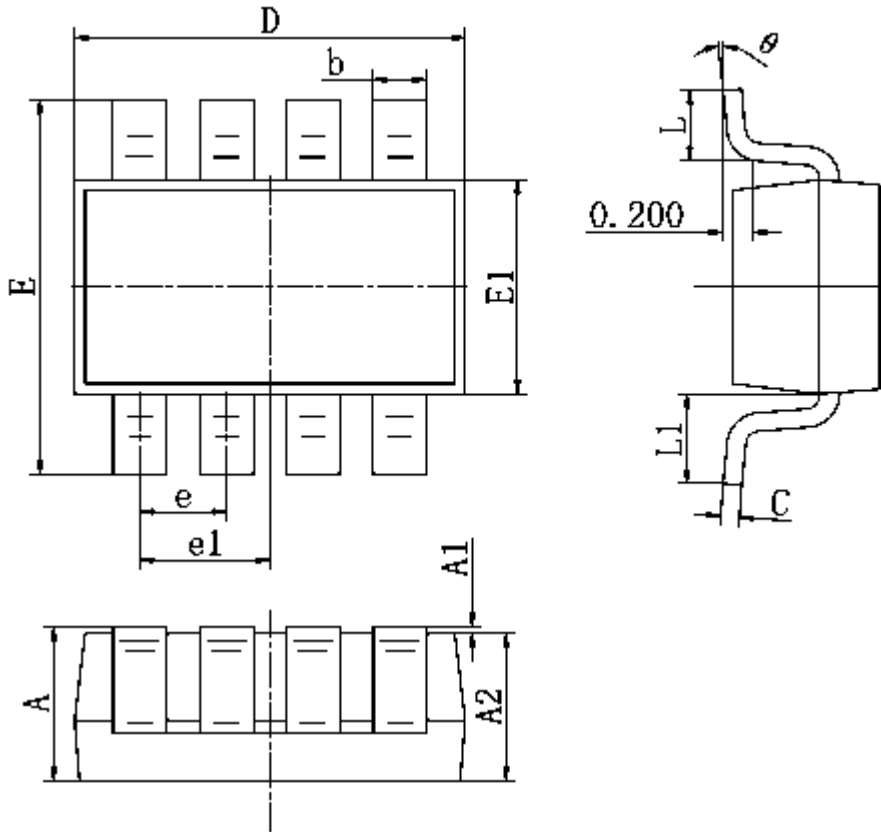
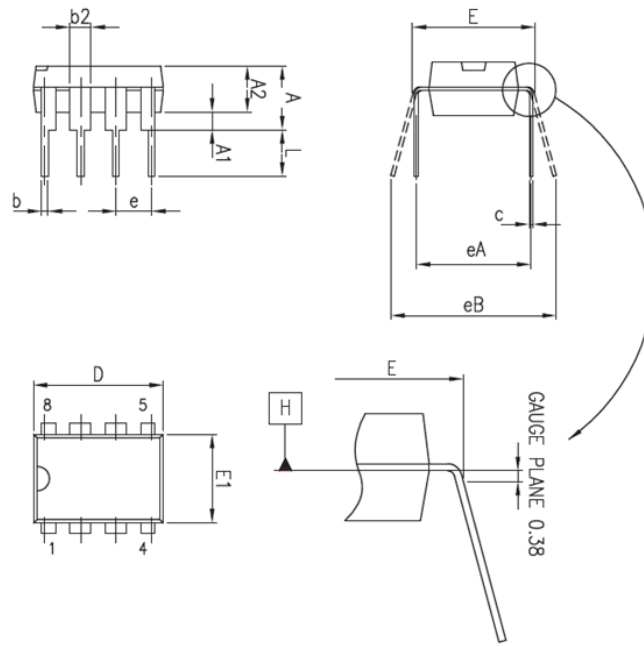


Figure 19 SOT23-8 Mechanical Data and Package Dimensions



| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|--------|---------------------------|-------|----------------------|-------|
| | Min. | Max. | Min. | Max. |
| A | 1.050 | 1.250 | 0.041 | 0.049 |
| A1 | 0.000 | 0.100 | 0.000 | 0.004 |
| A2 | 1.050 | 1.150 | 0.041 | 0.045 |
| b | 0.300 | 0.500 | 0.012 | 0.020 |
| c | 0.100 | 0.200 | 0.004 | 0.008 |
| D | 2.820 | 3.020 | 0.111 | 0.119 |
| E1 | 1.500 | 1.700 | 0.059 | 0.067 |
| E | 2.650 | 2.950 | 0.104 | 0.116 |
| e | 0.650BSC. | | 0.026BSC. | |
| e1 | 0.975BSC. | | 0.038BSC. | |
| L | 0.300 | 0.600 | 0.012 | 0.024 |
| L1 | 0.600REF. | | 0.024REF. | |
| theta | 0° | 8° | 0° | 8° |

Figure 20 DIP8 Mechanical Data and Package Dimensions



| Ref. | Dimensions | | | | | |
|------|-------------|------|-------|--------|-------|-------|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 5.33 | | | 0.210 |
| A1 | 0.38 | | | 0.015 | | |
| A2 | 2.92 | 3.30 | 4.95 | 0.115 | 0.130 | 0.195 |
| b | 0.36 | 0.46 | 0.56 | 0.014 | 0.018 | 0.022 |
| b2 | 1.14 | 1.52 | 1.78 | 0.045 | 0.060 | 0.070 |
| c | 0.20 | 0.25 | 0.36 | 0.008 | 0.010 | 0.014 |
| D | 9.02 | 9.27 | 10.16 | 0.355 | 0.365 | 0.400 |
| E | 7.62 | 7.87 | 8.26 | 0.300 | 0.310 | 0.325 |
| E1 | 6.10 | 6.35 | 7.11 | 0.240 | 0.250 | 0.280 |
| e | | 2.54 | | | 0.100 | |
| eA | | 7.62 | | | 0.300 | |
| eB | | | 10.92 | | | 0.430 |
| L | 2.92 | 3.30 | 3.81 | 0.115 | 0.130 | 0.150 |

Figure 21 DFN10L Mechanical Data and Package Dimensions

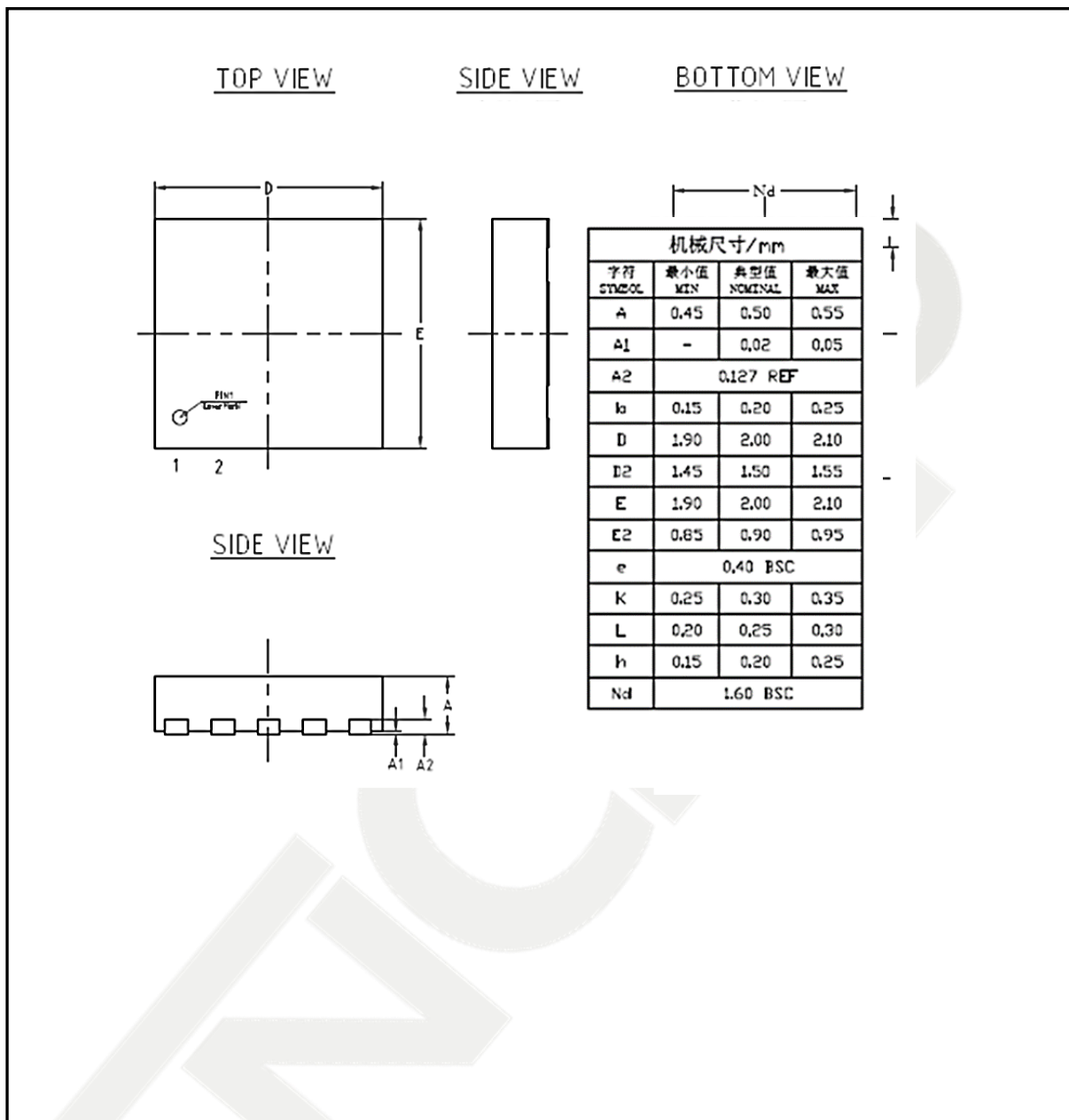


Figure 22 QFN14 Mechanical Data and Package Dimensions

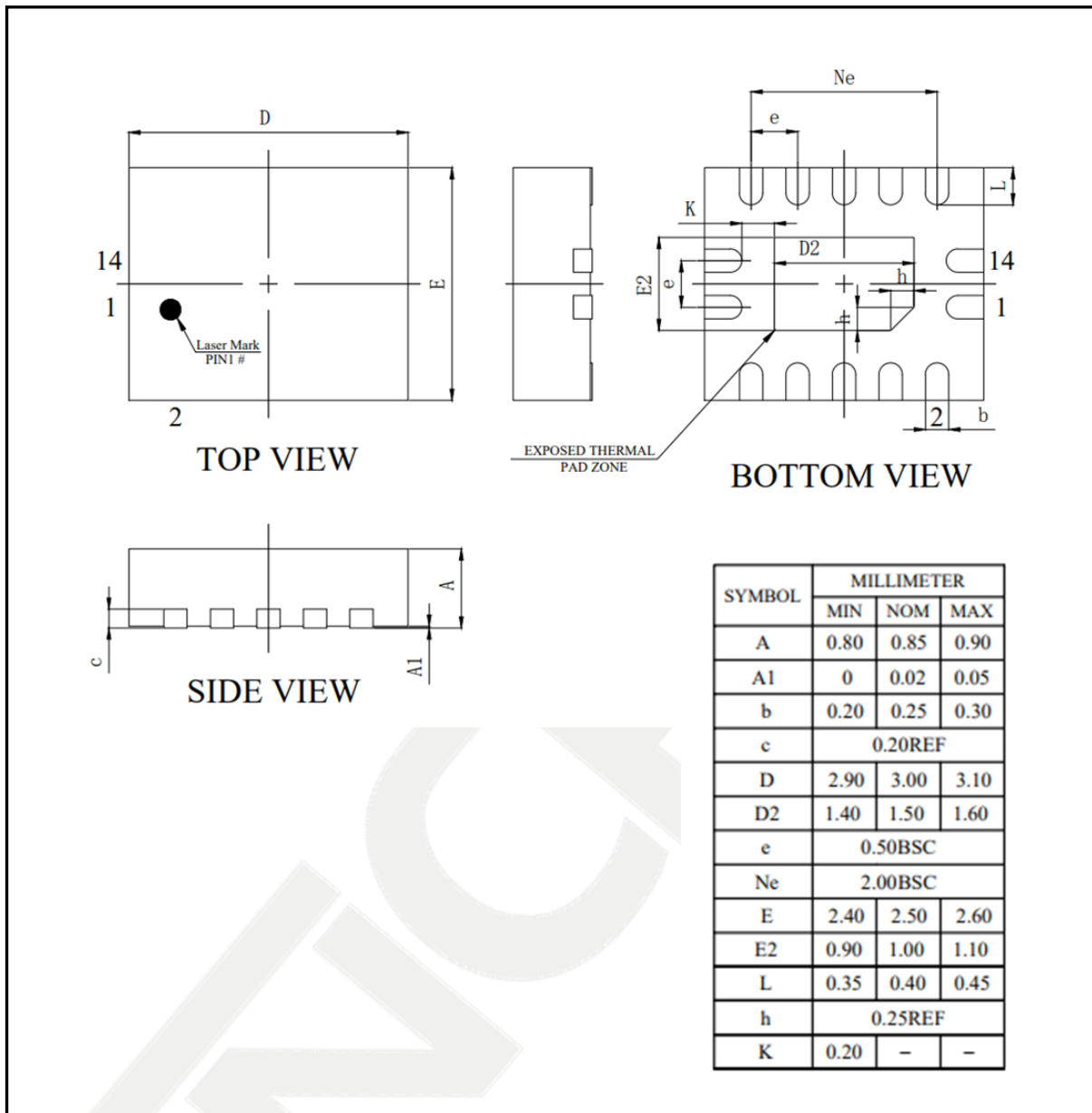


Figure 23 TSSOP14 Mechanical Data and Package Dimensions

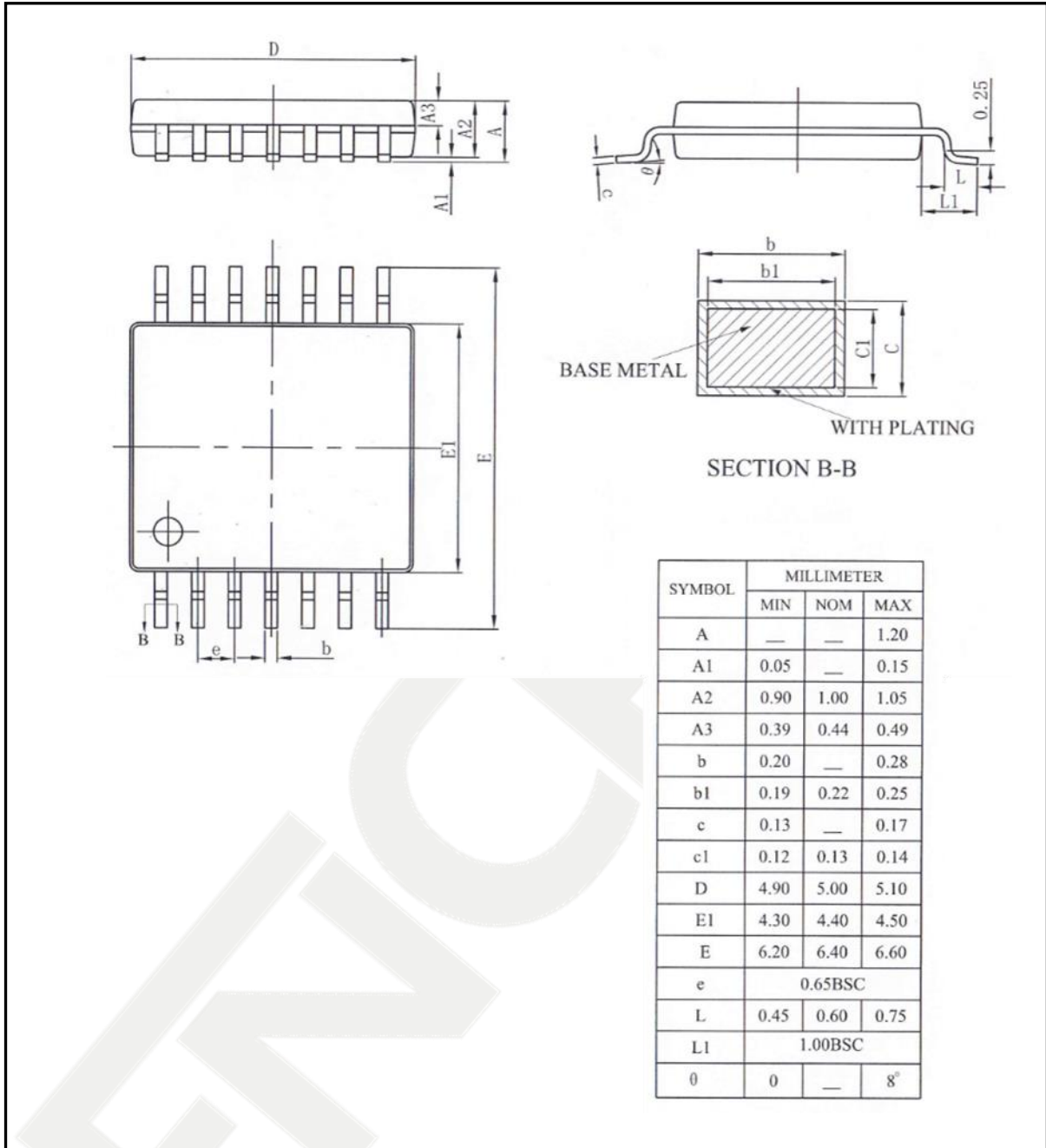
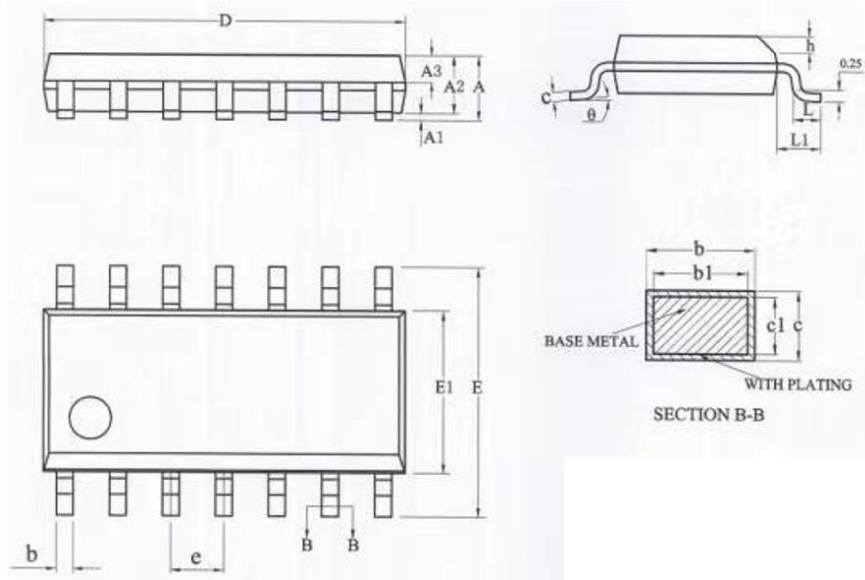


Figure 24 SOP14 Mechanical Data and Package Dimensions



| SYMBOL | MILLIMETER | | |
|-------------|------------|------|-----------|
| | MIN | NOM | MAX |
| A | — | — | 1.75 |
| Δ A1 | 0.10 | — | 0.225 |
| A2 | 1.30 | 1.40 | 1.50 |
| A3 | 0.60 | 0.65 | 0.70 |
| Δ b | 0.39 | — | 0.47 |
| Δ b1 | 0.38 | 0.41 | 0.44 |
| Δ c | 0.20 | — | 0.24 |
| c1 | 0.19 | 0.20 | 0.21 |
| Δ D | 8.55 | 8.65 | 8.75 |
| E | 5.80 | 6.00 | 6.20 |
| Δ E1 | 3.80 | 3.90 | 4.00 |
| e | 1.27BSC | | |
| h | 0.25 | — | 0.50 |
| L | 0.50 | — | 0.80 |
| L1 | 1.05REF | | |
| θ | 0 | — | 8° |

Figure 25 SOT23-5 Mechanical Data and Package Dimensions

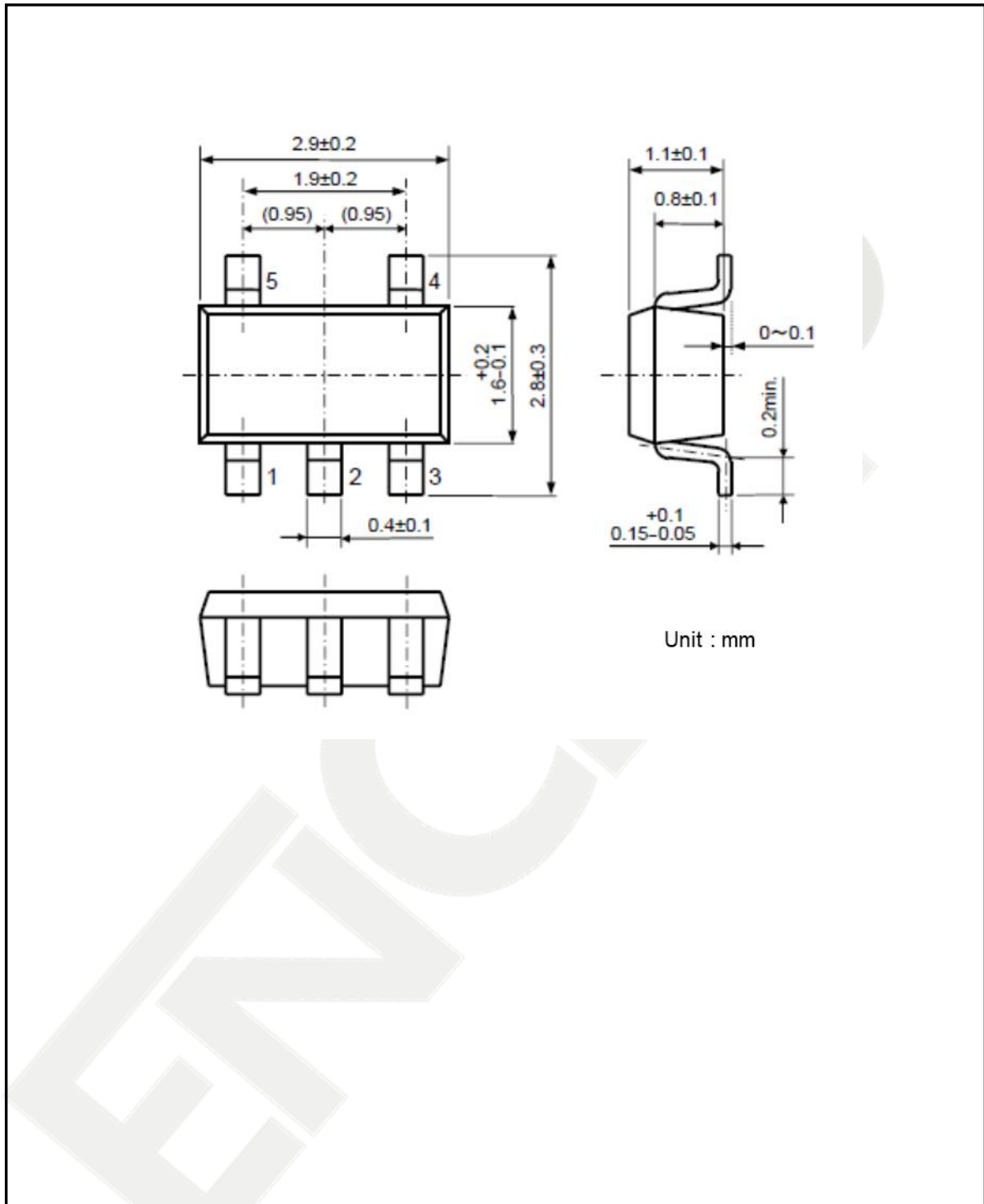
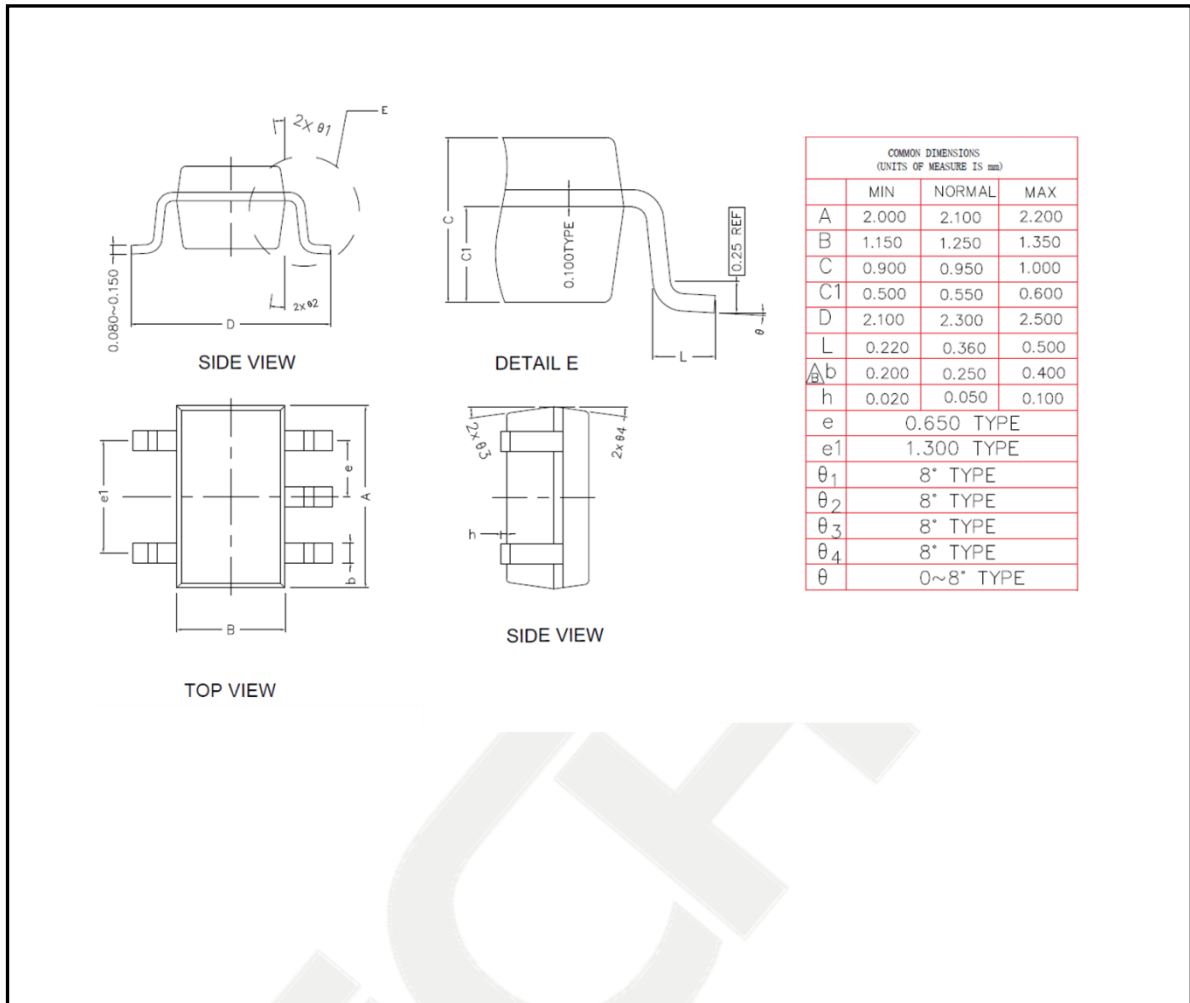


Figure 26 SOT353 Mechanical Data and Package Dimensions



5.2 Marking Information

Figure 27 eSOP8 Marking Information

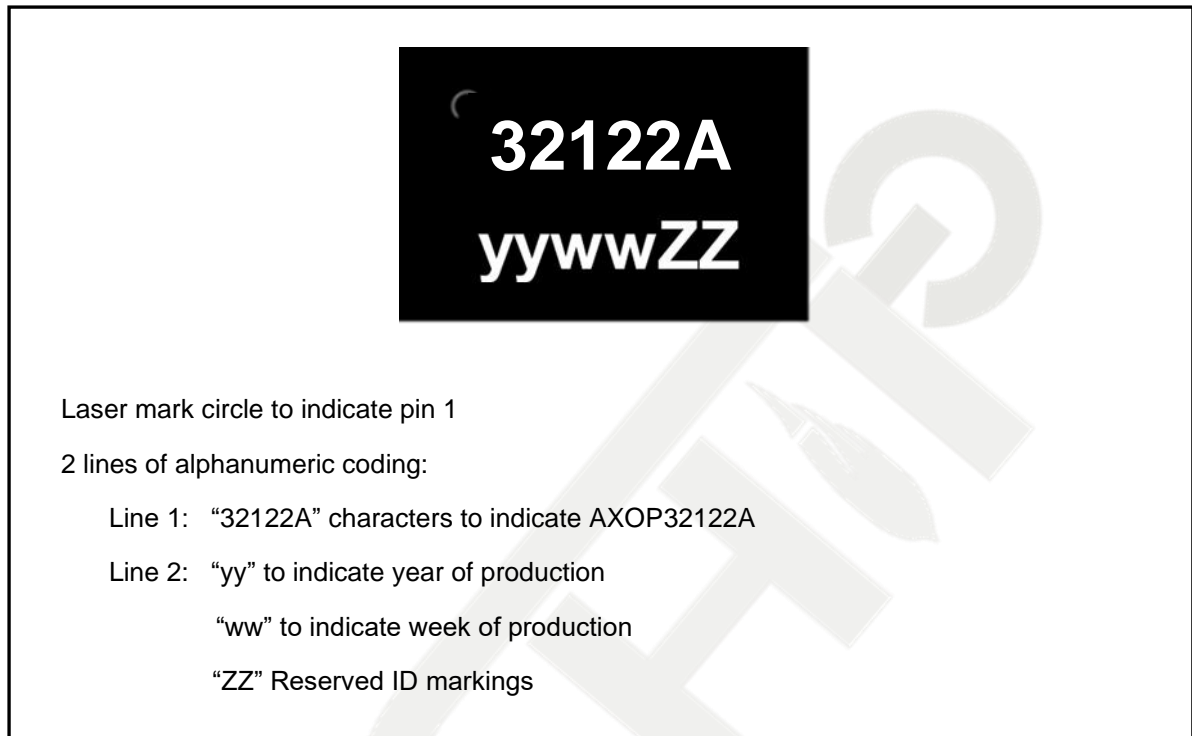


Figure 28 DFN8 Marking Information

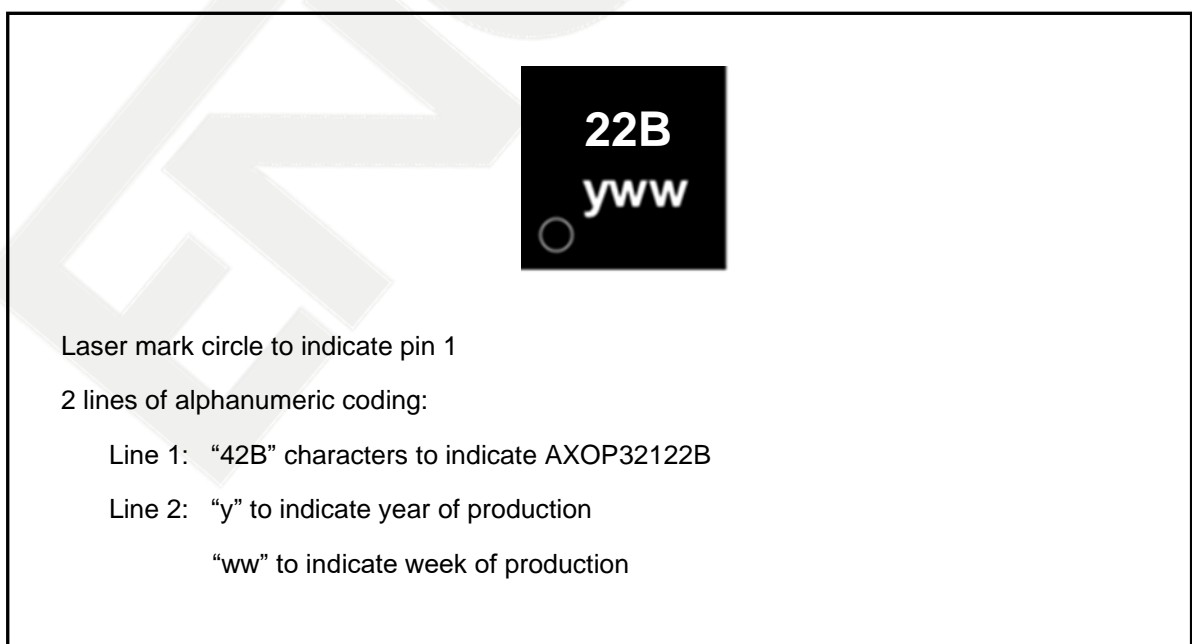


Figure 29 SOP8 Marking Information

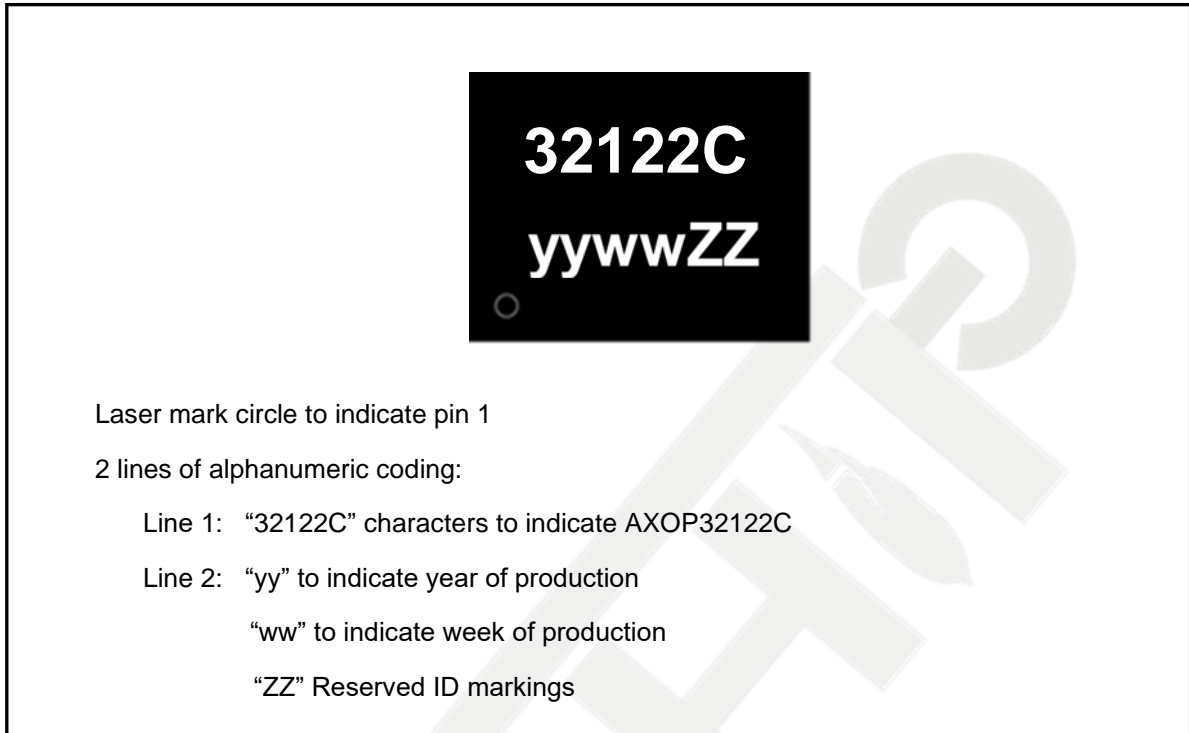


Figure 30 SOT23-8 Marking Information

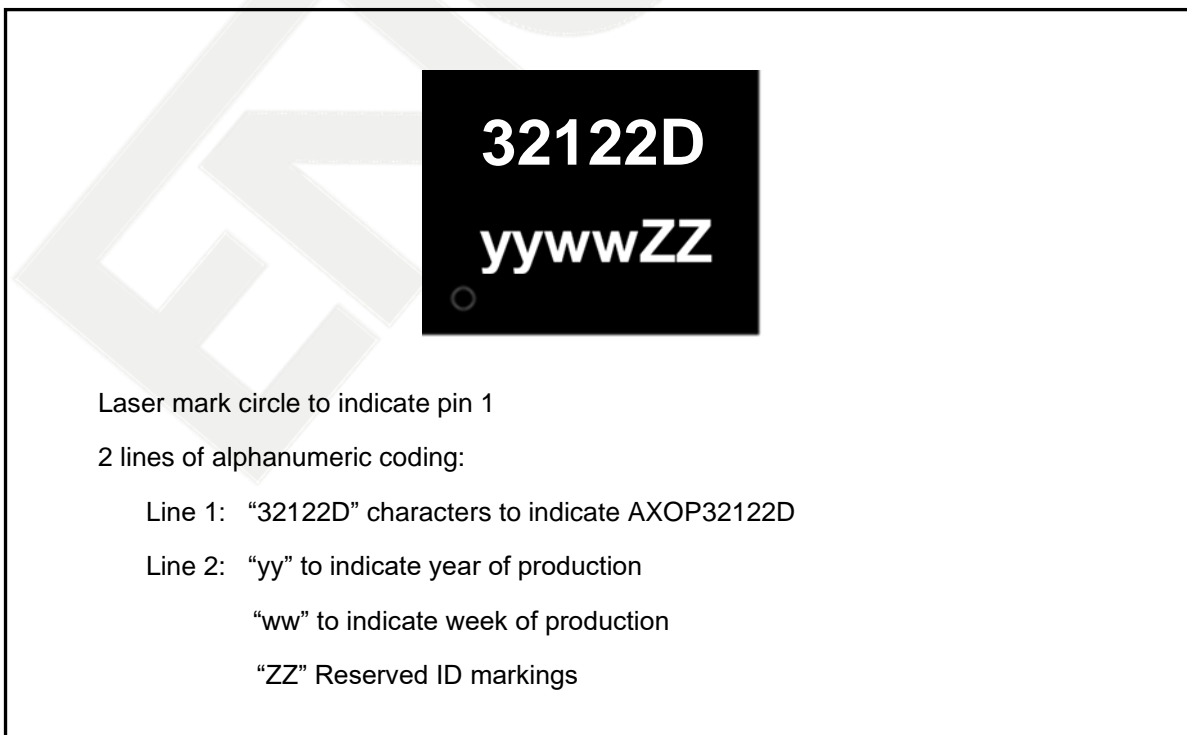
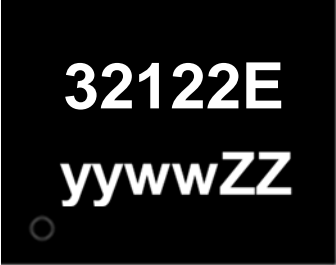


Figure 31 DIP8 Marking Information

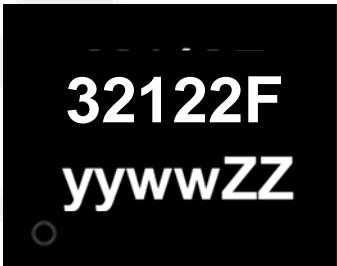


Laser mark circle to indicate pin 1

2 lines of alphanumeric coding:

- Line 1: “32122E” characters to indicate AXOP32122E
- Line 2: “yy” to indicate year of production
“ww” to indicate week of production
“ZZ” Reserved ID markings

Figure 32 DFN10L Marking Information



Laser mark circle to indicate pin 1

2 lines of alphanumeric coding:

- Line 1: “32122F” characters to indicate AXOP32122F
- Line 2: “yy” to indicate year of production
“ww” to indicate week of production
“ZZ” Reserved ID markings

Figure 33 QFN14 Marking Information

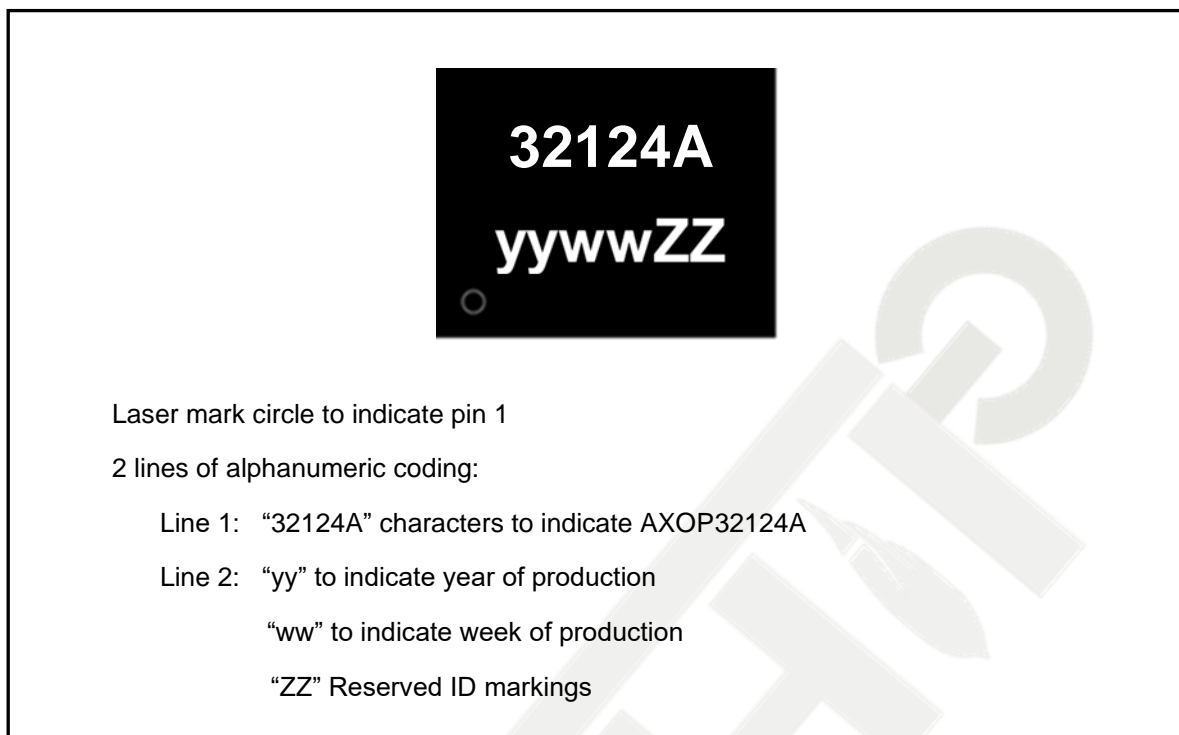


Figure 34 TSSOP14 Marking Information

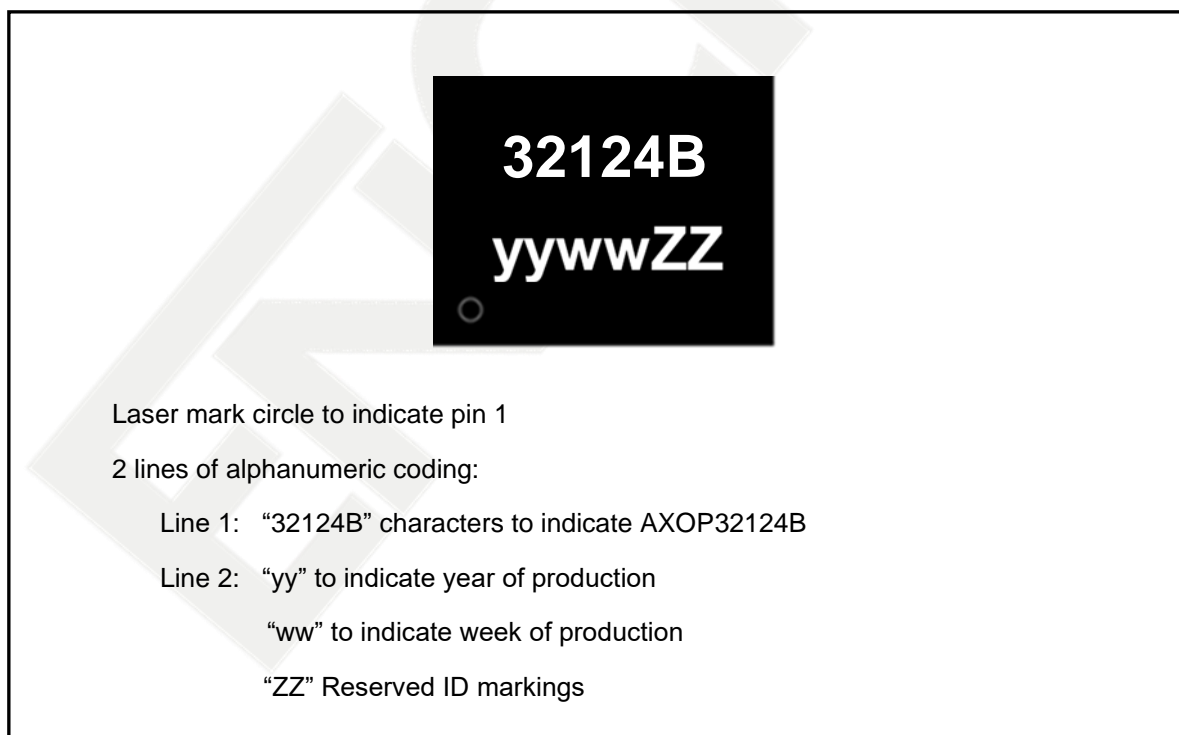


Figure 35 SOP14 Marking Information

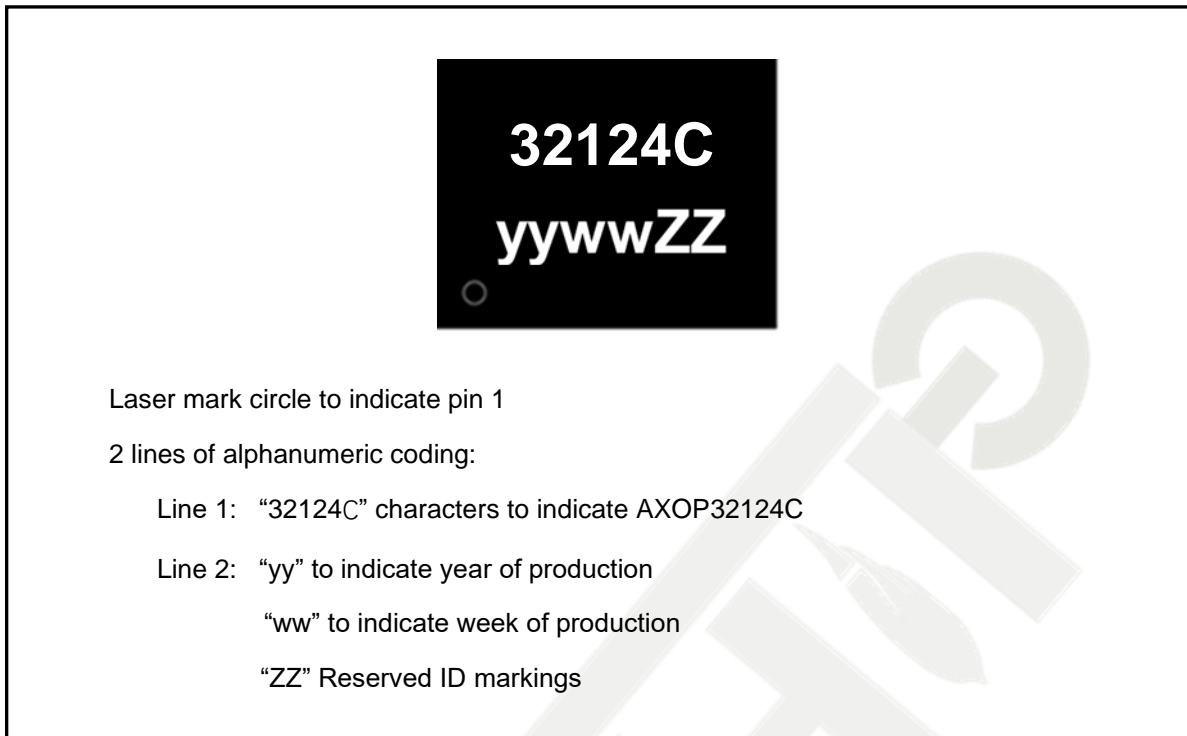


Figure 36 SOT23-5 Marking Information

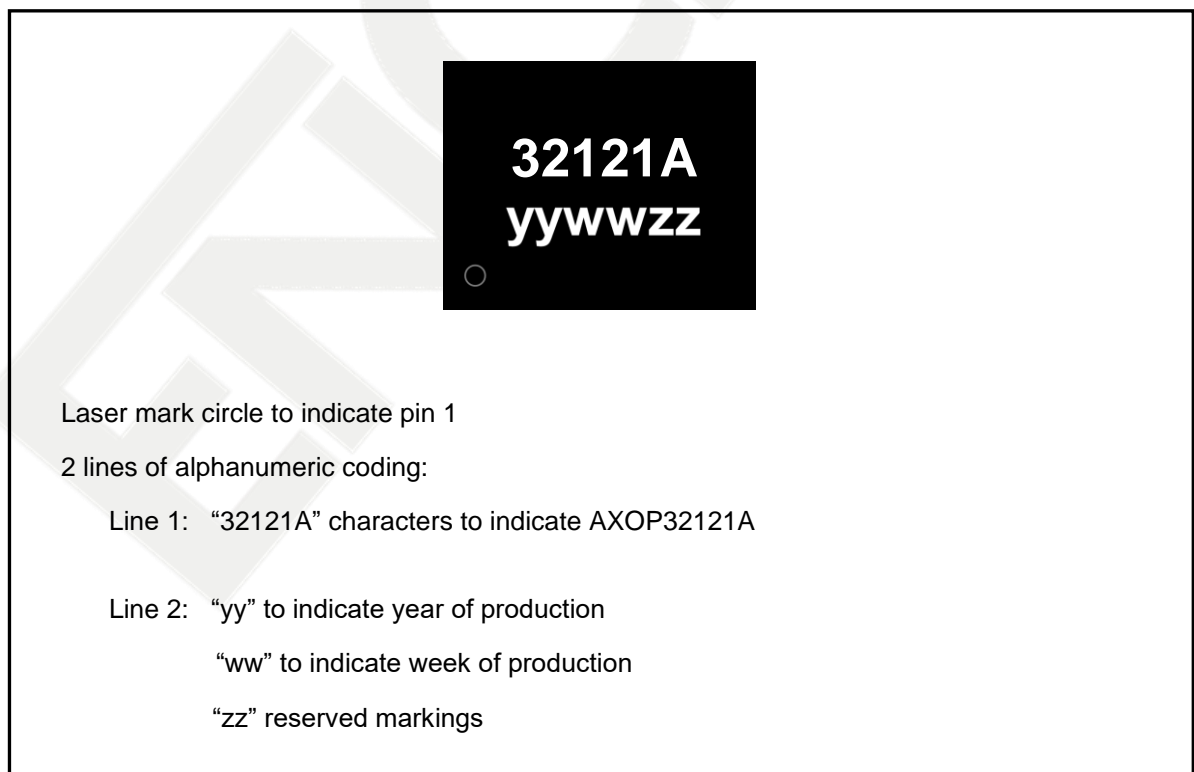
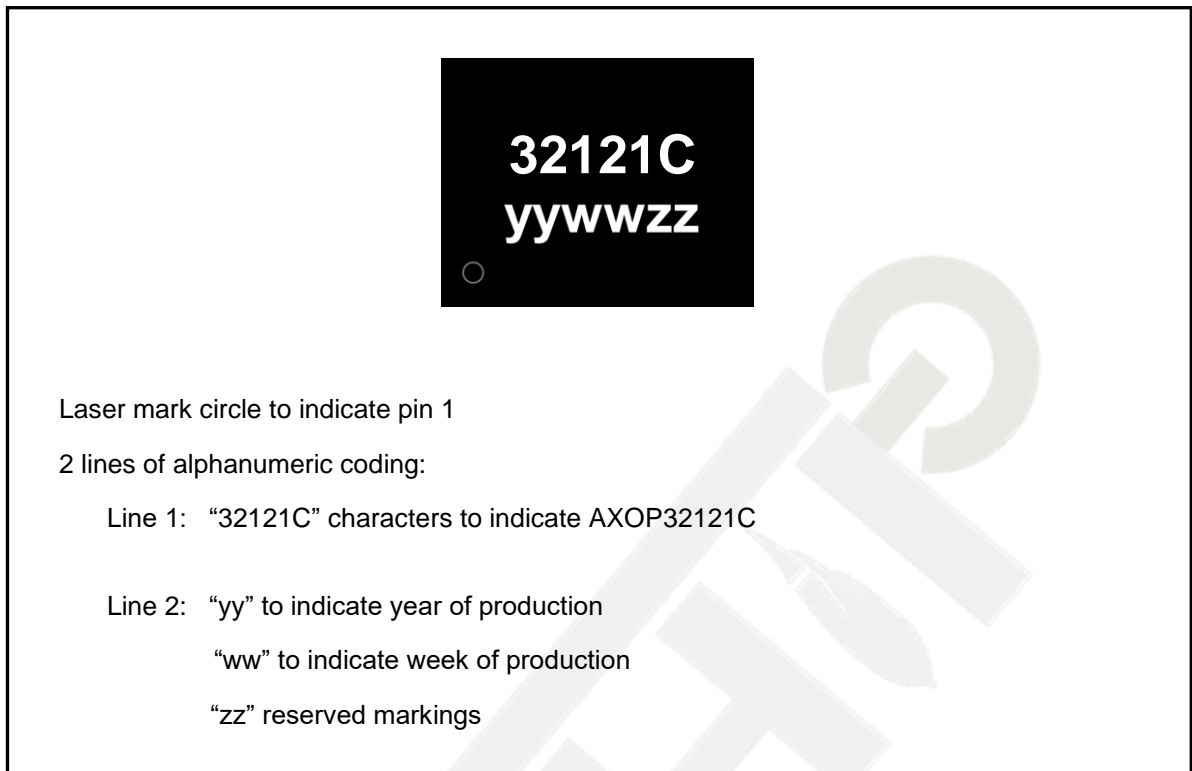
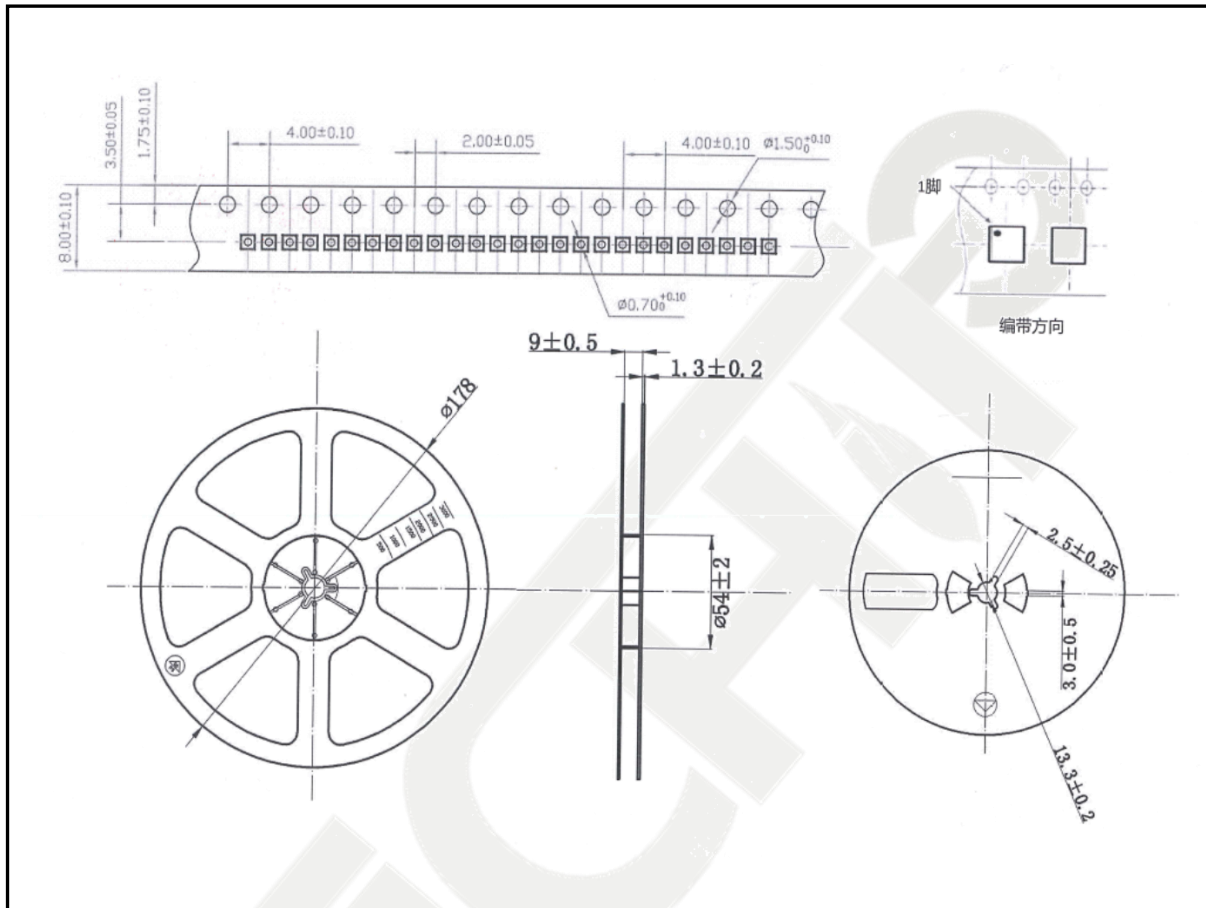


Figure 37 SOT353 Marking Information



6 Packing Information

Figure 38 Reel Packing Information



7 Revision History

Table 6 Document Revision History

| Date | Version | Description |
|----------|---------|---|
| Jun 2024 | 1.00 | V1.00 version. |
| Jul 2024 | 1.01 | Updated Figure 11 |
| Aug 2024 | 1.02 | Replaced Figure 12: Large Signal Step Response by Figure 12: Voltage Noise Spectral Density |
| Sep 2024 | 1.03 | Added THD test at $V_s=3V$ |
| Oct 2024 | 1.04 | Added in SOT353 and DFN10L |
| Dec 2024 | 1.05 | Added I_q for $V_s=5.0V$ and $3.3V$ |