

## DIO260X

# High Voltage Rail-to-Rail Output Operational Amplifiers

### Features

- Supply voltage range: 4.5 V to 36 V
- Low supply current:
  - 0.95 mA/channel at  $V_S = 36\text{ V}$
  - 0.75 mA/channel at  $V_S = 4.5\text{ V}$
- Input voltage range:  $-0.1\text{ V} \sim (+V_S - 1.5\text{ V})$
- Low offset voltage: 3.5 mV (max)
- Rail-to-rail output:  $-V_S \sim +V_S$
- 3.5 MHz high gain-bandwidth product
- High slew rate: 2.5 V/ $\mu\text{s}$
- Settling time to 0.1% with 2 V step: 0.9  $\mu\text{s}$
- Packages:
  - DIO2601 available in: SOT23-5/SOIC-8
  - DIO2602 available in:
    - SOIC-8/MSOP-8/TSSOP-8/DFN2\*2-8
  - DIO2604 available in: TSSOP-14/SOP14

### Descriptions

The DIO2601 (single), DIO2602 (dual) and DIO2604 (quad) are operational amplifiers with very low noise, high voltage, and low power. The DIO2601/2/4 has a high gain-bandwidth product of 3.5 MHz, a slew rate of 2.5 V/ $\mu\text{s}$ , and a quiescent current of 0.75 mA/amplifier at 4.5 V typically.

The DIO2601/2/4 is designed to provide optimal performance in low voltage and low noise systems. All these chips provide rail-to-rail output swing into heavy loads. The input common-mode voltage range includes ground, and the maximum input offset voltage is 3.5 mV for DIO2601/2/4.

They are specified over the extended industrial temperature range  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ . The operating range is from 4.5 V to 36 V.

### Applications

- Portable equipment
- Active filters
- Data acquisition
- Test equipment
- Broadband communication
- Industrial control
- Audio and video processing

### Ordering Information

| Part Number | Top Marking | RoHS  | T <sub>A</sub>               | Package  |                   |
|-------------|-------------|-------|------------------------------|----------|-------------------|
| DIO2601ST5  | YWAH        | Green | $-40$ to $125^\circ\text{C}$ | SOT23-5  | Tape & Reel, 3000 |
| DIO2601SO8  | DIO61AH     | Green | $-40$ to $125^\circ\text{C}$ | SOIC-8   | Tape & Reel, 2500 |
| DIO2602SO8  | DIO62AH     | Green | $-40$ to $125^\circ\text{C}$ | SOIC-8   | Tape & Reel, 2500 |
| DIO2602MP8  | DIO62AH     | Green | $-40$ to $125^\circ\text{C}$ | MSOP-8   | Tape & Reel, 3000 |
| DIO2602TP8  | DIO62AH     | Green | $-40$ to $125^\circ\text{C}$ | TSSOP-8  | Tape & Reel, 3000 |
| DIO2602CN8  | BF0B        | Green | $-40$ to $125^\circ\text{C}$ | DFN2*2-8 | Tape & Reel, 3000 |
| DIO2604SO14 | DIO64AH     | Green | $-40$ to $125^\circ\text{C}$ | SOP-14   | Tape & Reel, 2500 |
| DIO2604TP14 | DIO64AH     | Green | $-40$ to $125^\circ\text{C}$ | TSSOP-14 | Tape & Reel, 2500 |

### Pin Assignments

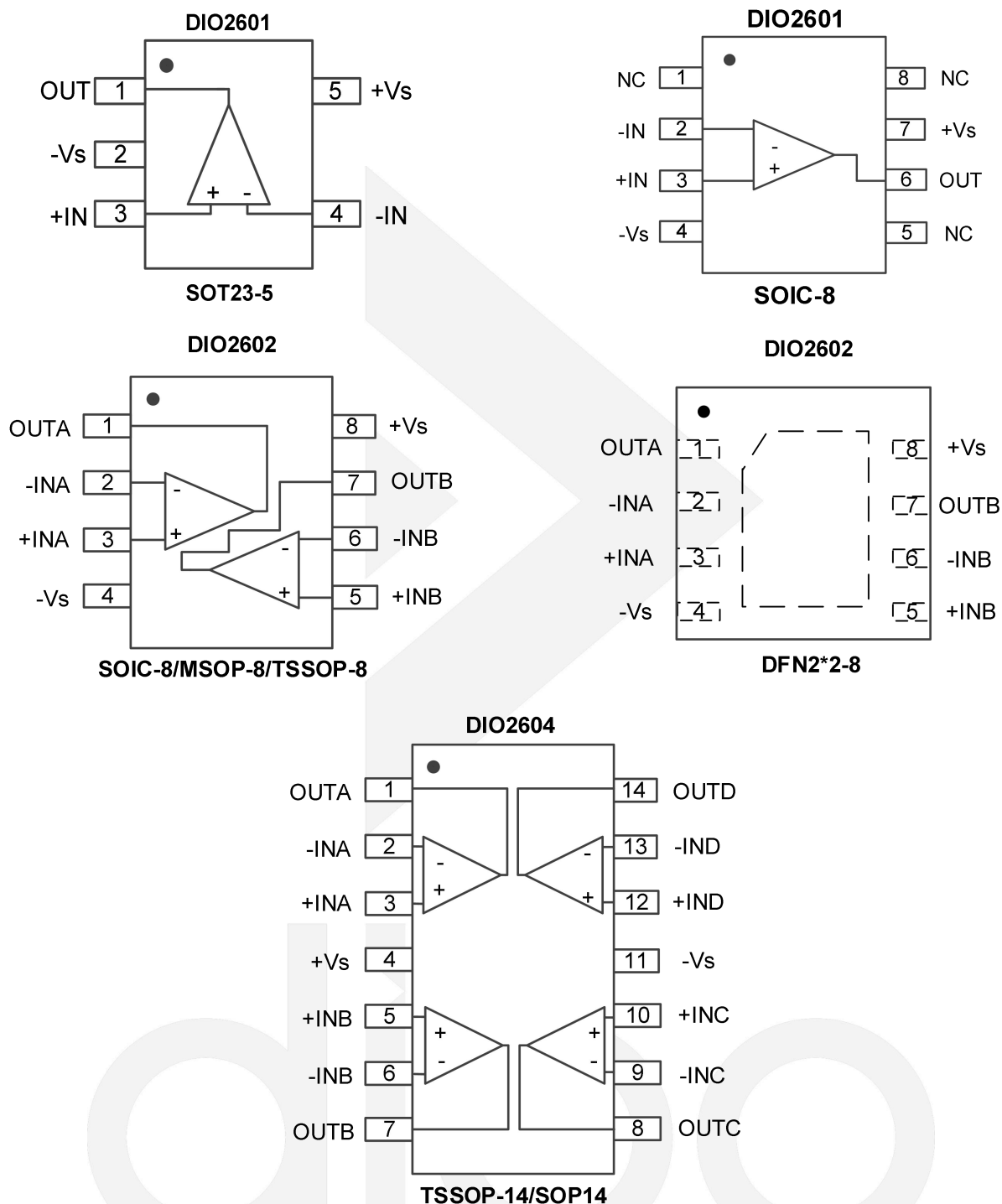


Figure 1. Pin assignment (Top view)

### Pin Description

| Pin name                  | Description                      |
|---------------------------|----------------------------------|
| +V <sub>S</sub>           | Positive supply                  |
| -V <sub>S</sub>           | Negative supply                  |
| +IN (+INA/+INB/+INC/+IND) | Positive input (channel A/B/C/D) |
| -IN (-INA/-INB/-INC/-IND) | Negative input (channel A/B/C/D) |
| OUT (OUTA/OUTB/OUTC/OUTD) | Output (channel A/B/C/D)         |
| NC                        | Not connect                      |

### Absolute Maximum Ratings

Stresses beyond those listed under "Absolute Maximum Rating" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. DIOO does not recommend exceeding them or designing to Absolute Maximum Ratings.

| Symbol           | Parameter                 | Rating                                               | Unit |
|------------------|---------------------------|------------------------------------------------------|------|
| V <sub>S</sub>   | Supply voltage            | 40                                                   | V    |
| V <sub>IN</sub>  | Input voltage             | (-V <sub>S</sub> ) - 0.3 to (+V <sub>S</sub> ) + 0.3 | V    |
| T <sub>STG</sub> | Storage temperature range | -65 to 150                                           | °C   |
| T <sub>J</sub>   | Junction temperature      | 150                                                  | °C   |
| T <sub>L</sub>   | Lead temperature range    | 260                                                  | °C   |
| ESD              | Human body model          | ±2                                                   | kV   |
|                  | Charged device model      | ±500                                                 | V    |

### Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation to ensure optimal performance to the datasheet specifications.

| Symbol          | Parameter                   | Rating                             | Unit |
|-----------------|-----------------------------|------------------------------------|------|
| V <sub>CC</sub> | Supply voltage              | 4.5 to 36                          | V    |
| V <sub>IN</sub> | Input voltage               | -0.1 V ~ (+V <sub>S</sub> - 1.5 V) | V    |
| T <sub>A</sub>  | Operating temperature range | -40 to 125                         | °C   |

### Electrical Characteristics

Typical value:  $T_A = 25^\circ\text{C}$ ,  $+V_S = 30\text{ V}$ ,  $-V_S = 0\text{ V}$ ,  $R_L = 10\text{ k}\Omega$ , unless otherwise specified.

| Symbol                         | Parameter                            | Conditions                                                                                         | Min  | Typ    | Max                      | Unit              |
|--------------------------------|--------------------------------------|----------------------------------------------------------------------------------------------------|------|--------|--------------------------|-------------------|
| Power supply                   |                                      |                                                                                                    |      |        |                          |                   |
| V <sub>S</sub>                 | Operating voltage range              |                                                                                                    | 4.5  |        | 36                       | V                 |
| PSRR                           | Power supply rejection ration        |                                                                                                    |      | 120    |                          | dB                |
| I <sub>Q</sub>                 | Supply current per channel/amplifier | V <sub>S</sub> = 4.5 V                                                                             |      | 0.75   |                          | mA                |
|                                |                                      | V <sub>S</sub> = 36 V                                                                              |      | 0.95   |                          | mA                |
| Input characteristics          |                                      |                                                                                                    |      |        |                          |                   |
| V <sub>OS</sub>                | Input offset voltage                 | V <sub>CM</sub> = +V <sub>S</sub> /2, T <sub>A</sub> = 25°C                                        | -3.5 |        | 3.5                      | mV                |
| I <sub>B</sub>                 | Input bias current                   | +V <sub>S</sub> = 4.5 V to 36 V                                                                    |      | 10     |                          | pA                |
| I <sub>OS</sub>                | Input offset current                 | -40°C ≤ T <sub>A</sub> ≤ 125°C,<br>+V <sub>S</sub> = 4.5 V to 36 V                                 |      | 8      |                          | pA                |
| V <sub>CM</sub>                | Common mode voltage range            |                                                                                                    | -0.1 |        | (+V <sub>S</sub> ) - 1.5 | V                 |
| CMRR                           | Common mode rejection ratio          | -40°C ≤ T <sub>A</sub> ≤ 125°C,<br>+V <sub>S</sub> = 36 V, V <sub>CM</sub> = 0.5 V to 28 V         |      | 90     |                          | dB                |
| A <sub>OL</sub> <sup>(1)</sup> | Open loop voltage gain               |                                                                                                    |      | 155    |                          | dB                |
| V <sub>O</sub>                 | Output swing high from supply rail   | R <sub>L</sub> = 50 kΩ, rising                                                                     |      | 20     |                          | mV                |
|                                | Output swing low from supply rail    | R <sub>L</sub> = 50 kΩ, falling                                                                    |      | 15     |                          | mV                |
| ΔV <sub>OS</sub> /ΔT           | Input offset voltage drift           | -40°C ≤ T <sub>A</sub> ≤ 125°C                                                                     |      | 5      |                          | μV/°C             |
| Output characteristics         |                                      |                                                                                                    |      |        |                          |                   |
| I <sub>SC</sub>                | Output short-circuit current         | Sink current                                                                                       |      | 14     |                          | mA                |
|                                |                                      | Source current                                                                                     |      | 14     |                          | mA                |
| Dynamic performance            |                                      |                                                                                                    |      |        |                          |                   |
| GBP                            | Gain bandwidth product               | f = 1 kHz                                                                                          |      | 3.5    |                          | MHz               |
| SR                             | Slew rate                            | A <sub>V</sub> = 1, 10 V step                                                                      |      | 2.5    |                          | V/μs              |
| t <sub>S</sub>                 | Settling time                        | A <sub>V</sub> = -1, 2 V step, 0.1%                                                                |      | 0.9    |                          | μs                |
|                                |                                      | A <sub>V</sub> = -1, 2 V step, 0.01%                                                               |      | 1.2    |                          | μs                |
| t <sub>OR</sub>                | Positive overload recovery time      |                                                                                                    |      | 1.4    |                          | μs                |
|                                | Negative overload recovery time      |                                                                                                    |      | 1      |                          | μs                |
| Noise performance              |                                      |                                                                                                    |      |        |                          |                   |
| THD+N                          | Total harmonic distortion and noise  | f = 1 kHz, A <sub>V</sub> = 1 V,<br>R <sub>L</sub> = 2 kΩ ,V <sub>OUT</sub> = 3.5 V <sub>RMS</sub> |      | 0.0005 |                          | %                 |
| e <sub>n</sub>                 | Input voltage noise density          | f = 1 kHz                                                                                          |      | 32     |                          | nV/√Hz            |
| V <sub>n</sub>                 | Input voltage noise                  | f = 0.1 Hz to 10 Hz                                                                                |      | 2.35   |                          | μV <sub>RMS</sub> |
| X <sub>talk</sub>              | Channel separation                   | f = 1 kHz, R <sub>L</sub> = 1 kΩ                                                                   |      | -100   |                          | dB                |

#### Note:

- (1) Guaranteed by design.
- (2) Specifications subject to change without notice..

### Typical Application

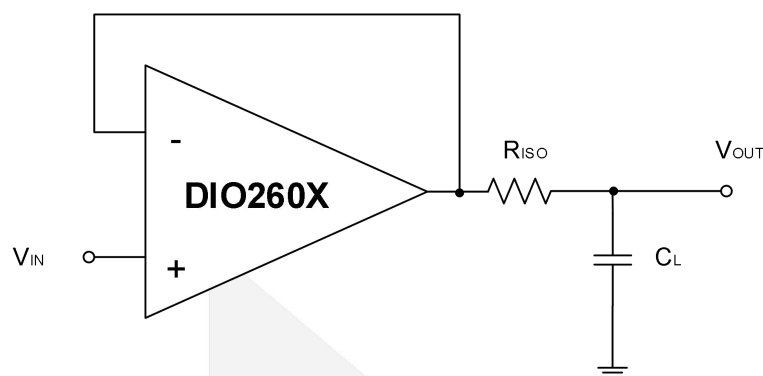


Figure 2. Indirectly driving heavy capacitive load

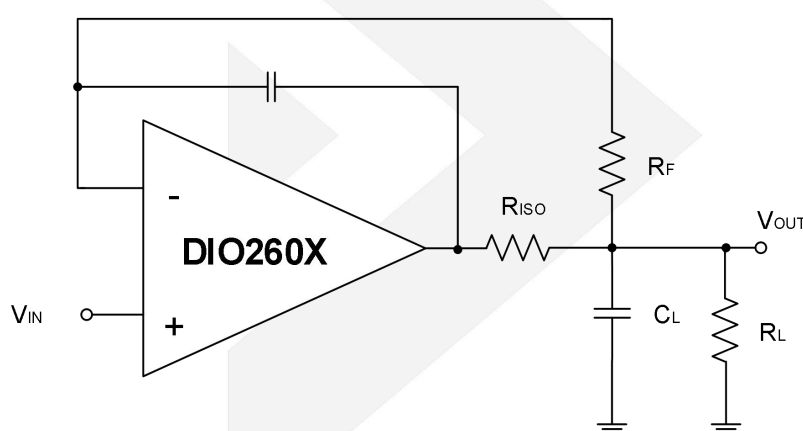


Figure 3. Indirectly driving heavy capacitive load with DC accuracy

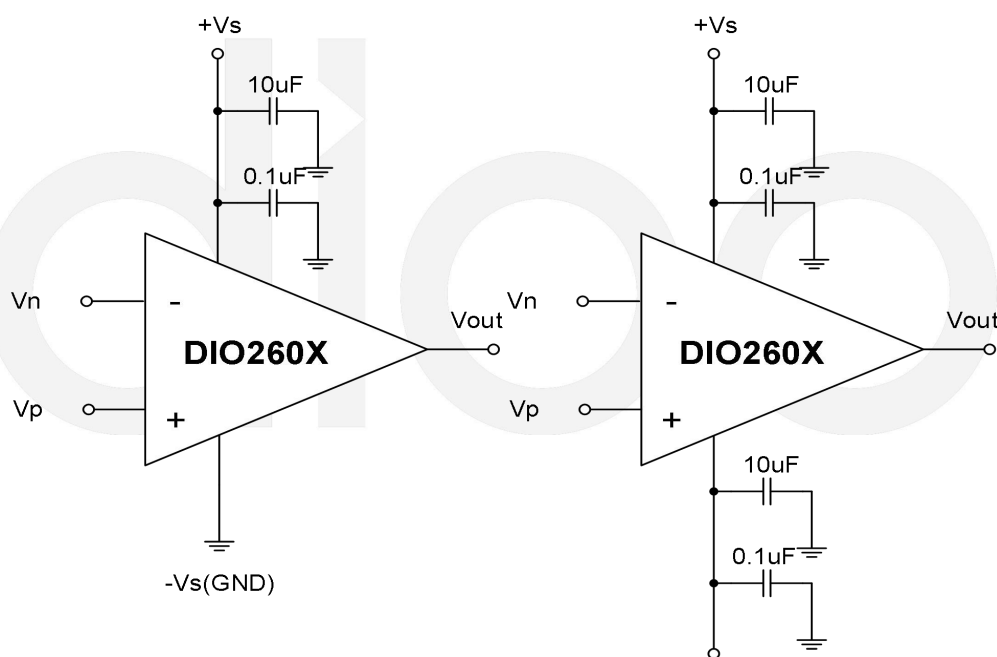


Figure 4. Amplifier with bypass capacitors

### Typical Performance Characteristics

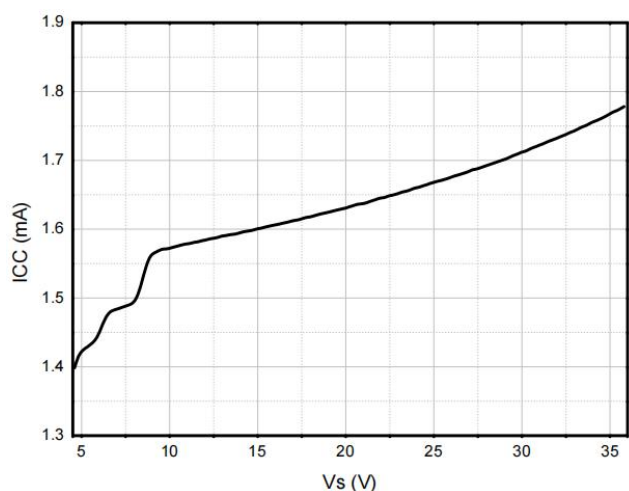


Figure 5. Quiescent current vs. Supply voltage

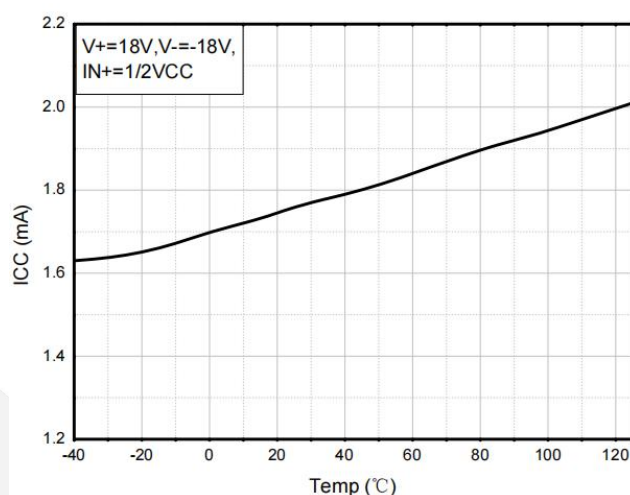


Figure 6. Quiescent current vs. Temperature

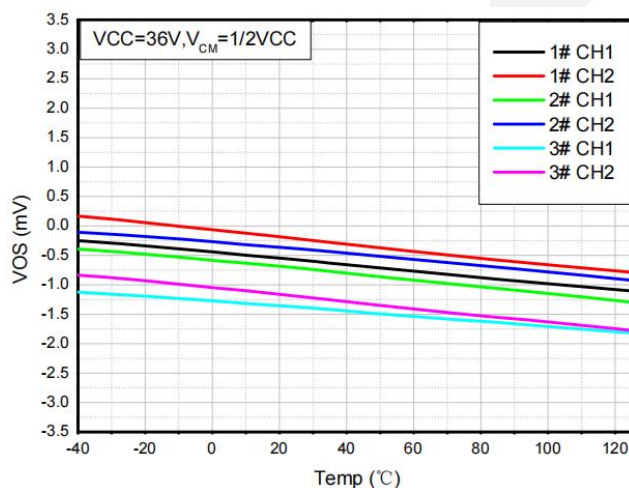


Figure 7. VOS vs. Temperature

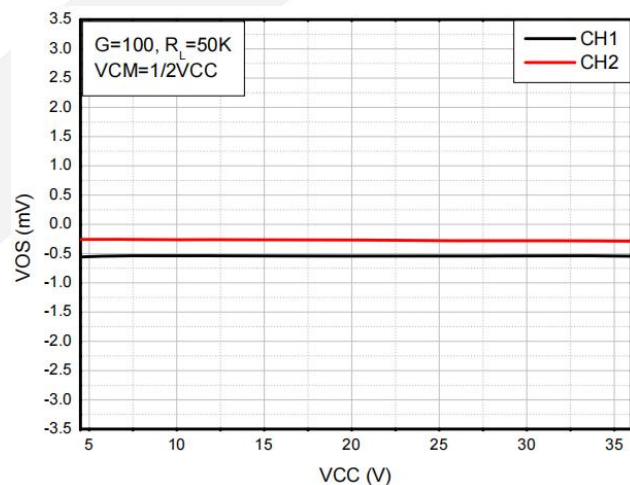
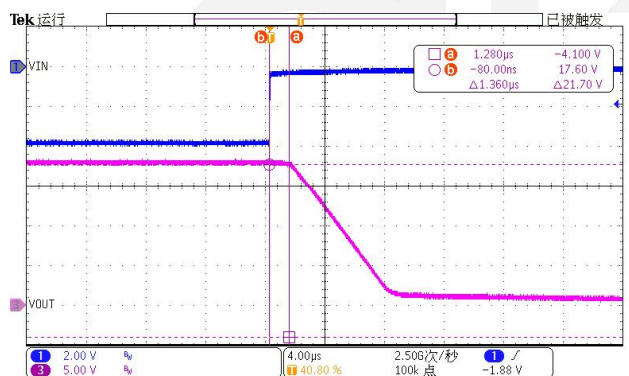
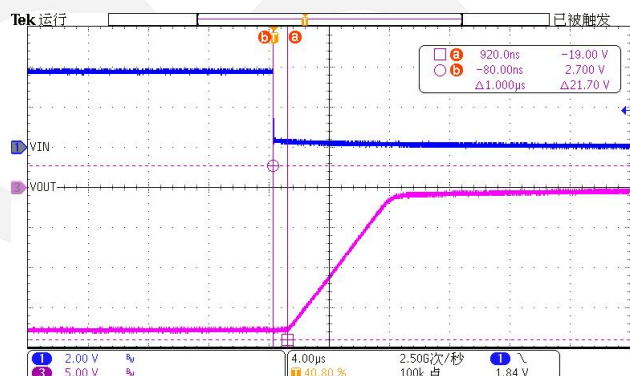


Figure 8. VCC vs. VOS



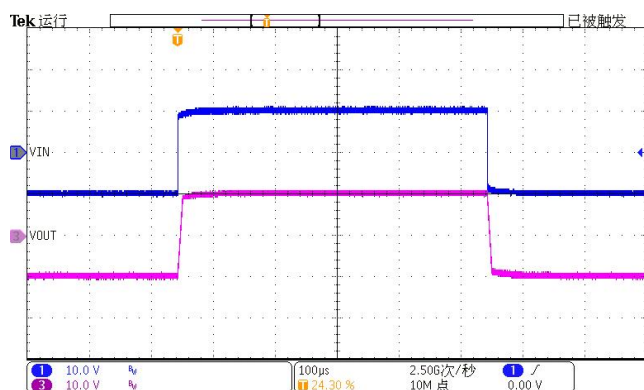
$V_+ = 18\text{ V}, V_- = -18\text{ V}, G = 10, R_L = 2\text{ K}, C_L = 100\text{ pF},$   
 $V_{IN} = 3.8\text{ Vpp at } 1.9\text{ V}$

Figure 9 Positive overload recovery



$V_+ = 18\text{ V}, V_- = -18\text{ V}, G = 10, R_L = 2\text{ K}, C_L = 100\text{ pF},$   
 $V_{IN} = 3.8\text{ Vpp at } -1.9\text{ V}$

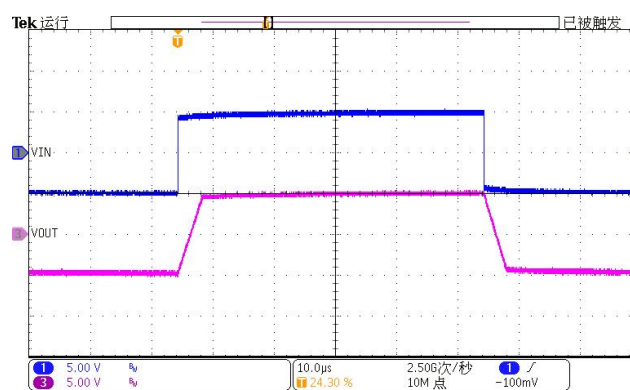
Figure 10 Negative overload recovery



$V_+ = 18\text{ V}$ ,  $V_- = -18\text{ V}$ ,  $G = 1$ ,  $R_L = 2\text{ K}$ ,  $C_L = 100\text{ pF}$

$V_{IN} = 10\text{ Vpp}$  at  $1\text{ kHz}$   $0\text{ V}$  Bias

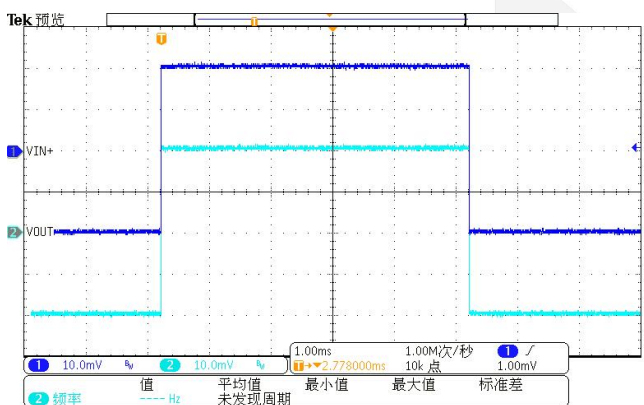
**Figure 11 Signal step response**



$V_+ = 18\text{ V}$ ,  $V_- = -18\text{ V}$ ,  $G = 1$ ,  $R_L = 2\text{ K}$ ,  $C_L = 100\text{ pF}$

$V_{IN} = 10\text{ Vpp}$  at  $10\text{ kHz}$   $0\text{ V}$  Bias

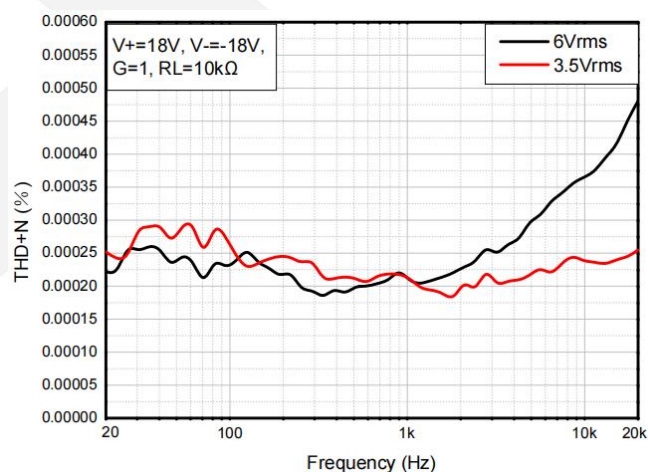
**Figure 12 Signal step response**



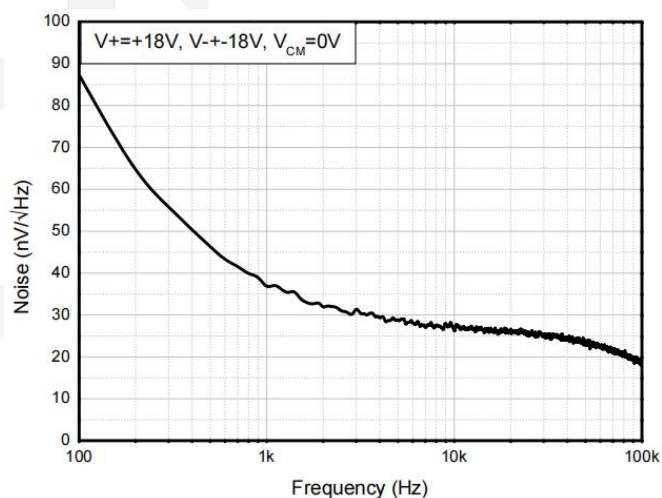
$V_+ = 18\text{ V}$ ,  $V_- = -18\text{ V}$ ,  $G = 1$ ,  $C_L = 100\text{ pF}$ ,  $R_L = 2\text{ K}$  to GND,

$40\text{ mVpp}$  at  $0\text{ V}$  bias,  $100\text{ Hz}$

**Figure 13 Small-signal response**

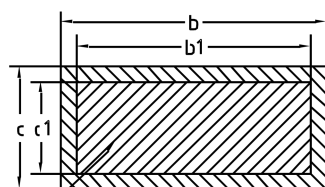
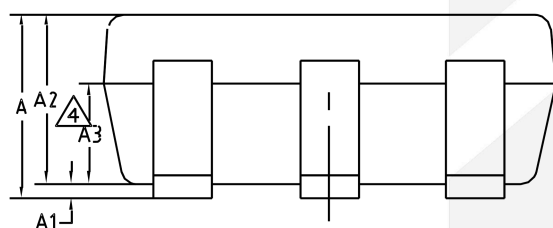
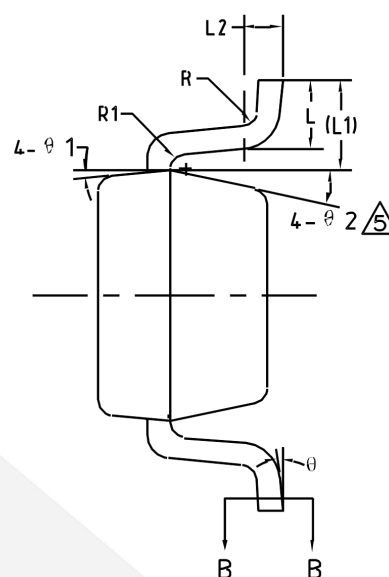
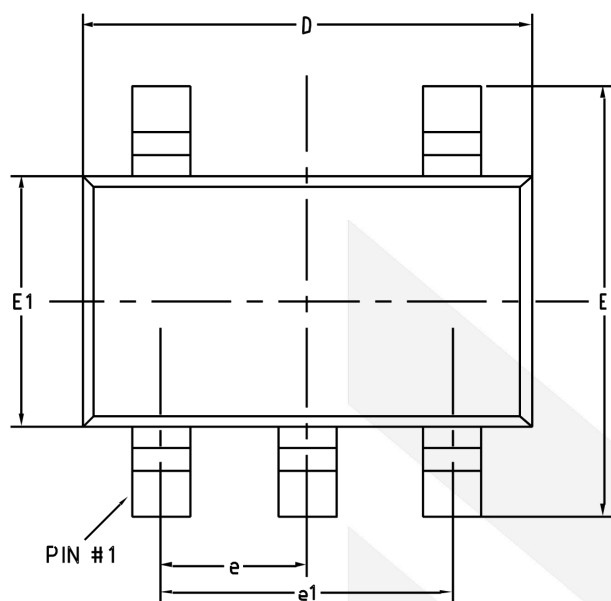


**Figure 14 THD+N vs. Frequency**



**Figure 15 Voltage noise spectral density vs. Frequency**

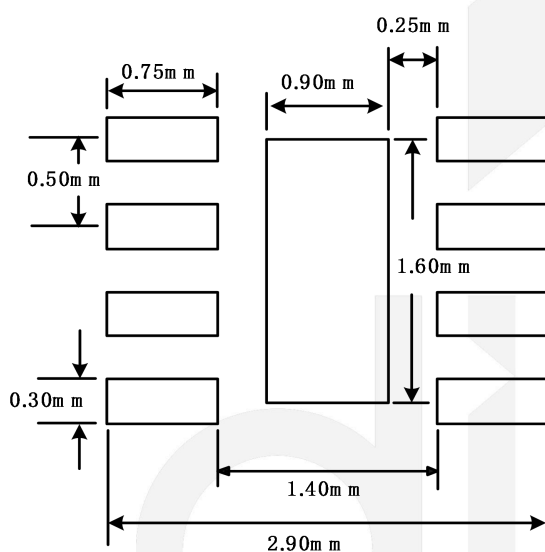
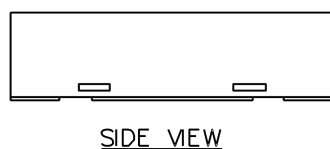
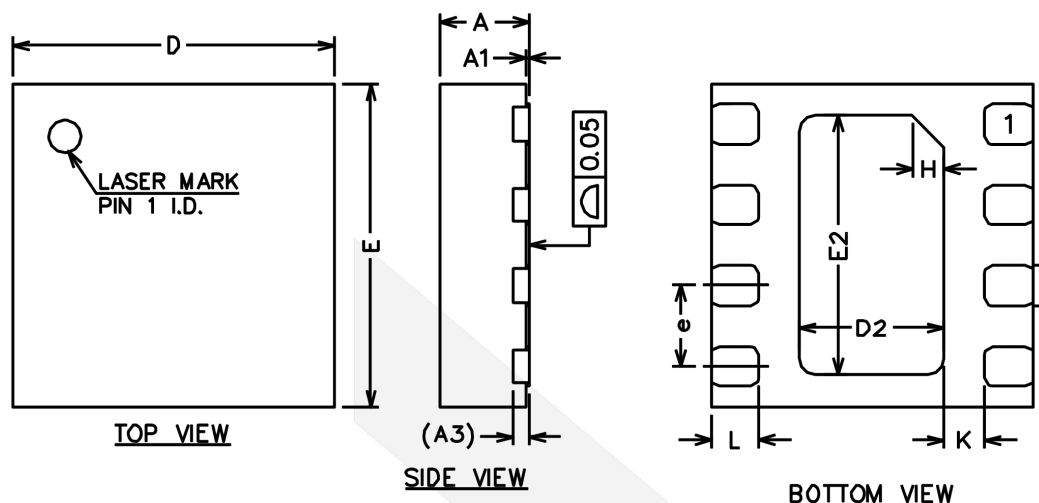
## Physical Dimensions: SOT23-5



BASE METAL  
SECTION B-B

| Common dimensions<br>Units of measure = millimeter |          |       |       |
|----------------------------------------------------|----------|-------|-------|
| Symbol                                             | Min      | Nom   | Max   |
| A                                                  | -        | -     | 1.25  |
| A1                                                 | 0        | -     | 0.15  |
| A2                                                 | 1.00     | 1.10  | 1.20  |
| A3                                                 | 0.60     | 0.65  | 0.70  |
| b                                                  | 0.36     | -     | 0.50  |
| b1                                                 | 0.36     | 0.38  | 0.45  |
| c                                                  | 0.14     | -     | 0.20  |
| c1                                                 | 0.14     | 0.15  | 0.16  |
| D                                                  | 2.826    | 2.926 | 3.026 |
| E                                                  | 2.60     | 2.80  | 3.00  |
| E1                                                 | 1.526    | 1.626 | 1.726 |
| e                                                  | 0.90     | 0.95  | 1.00  |
| e1                                                 | 1.80     | 1.90  | 2.00  |
| L                                                  | 0.35     | 0.45  | 0.60  |
| L1                                                 | 0.59 REF |       |       |
| L2                                                 | 0.25 BSC |       |       |
| R                                                  | 0.10     | -     | -     |
| R1                                                 | 0.10     | -     | 0.25  |
| θ                                                  | 0°       | -     | 8°    |
| θ1                                                 | 3°       | 5°    | 7°    |
| θ2                                                 | 6°       | -     | 14°   |

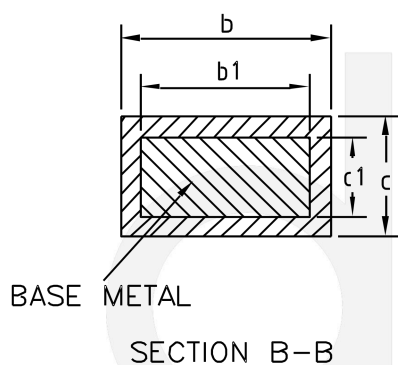
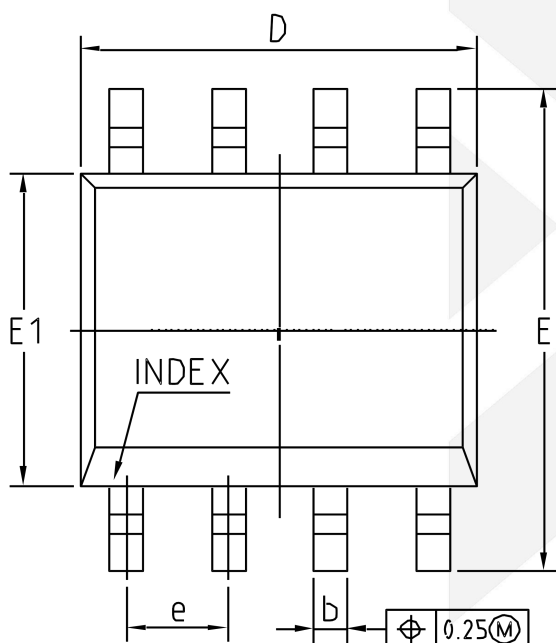
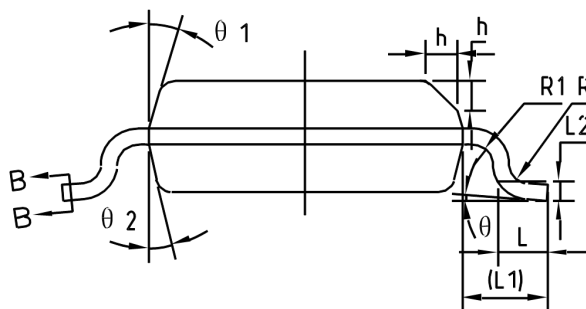
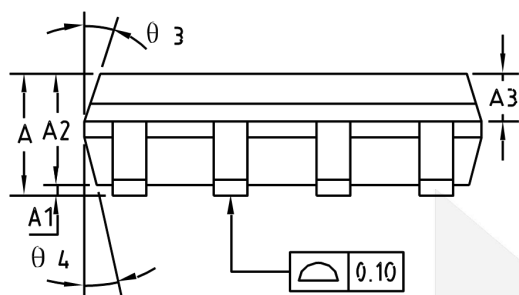
### Physical Dimensions: DFN2\*2-8



RECOMMENDED LAND PATTERN

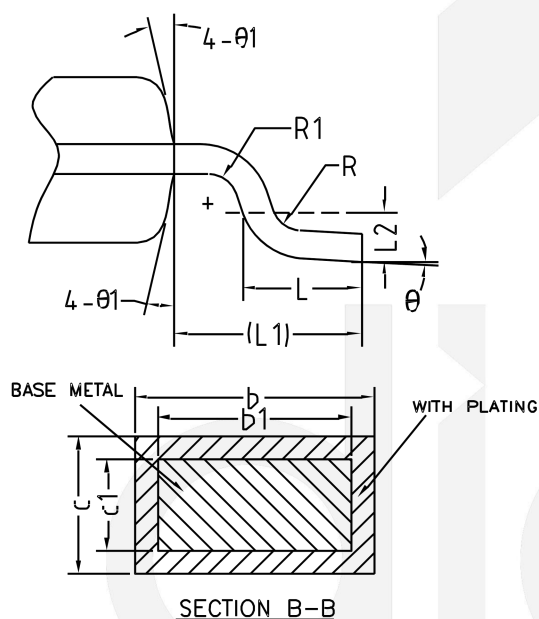
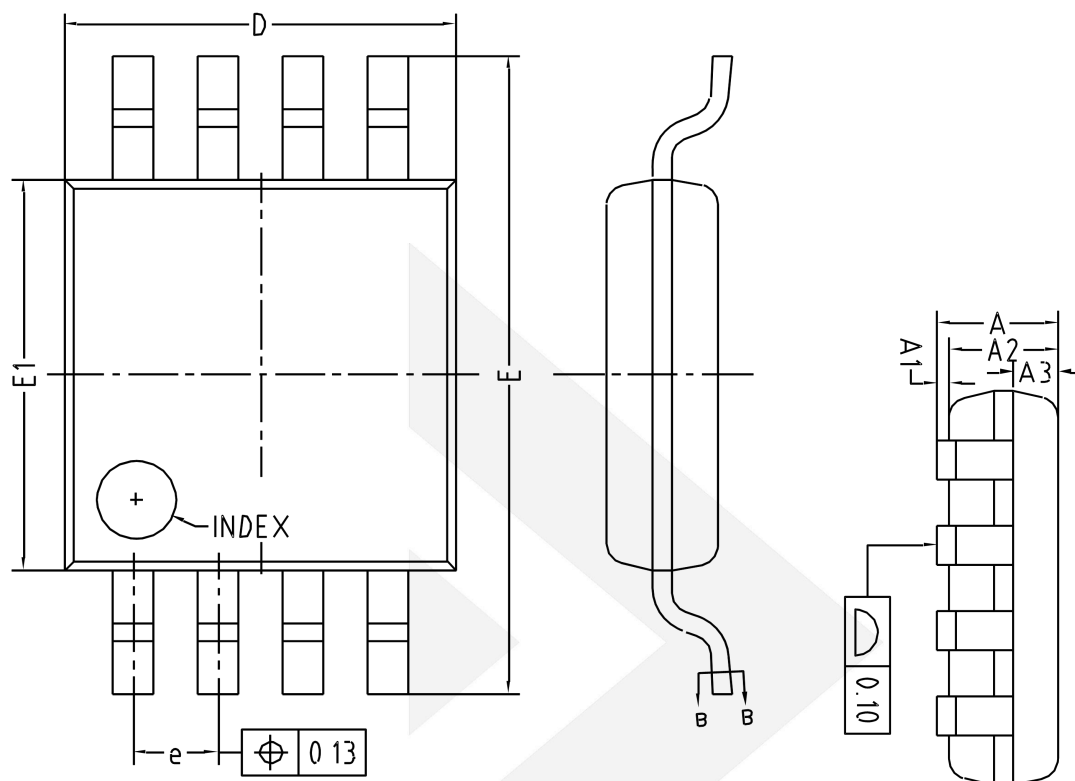
| Common dimensions<br>Units of measure = millimeter |          |      |      |
|----------------------------------------------------|----------|------|------|
| Symbol                                             | Min      | Nom  | Max  |
| A                                                  | 0.50     | 0.55 | 0.60 |
| A1                                                 | 0.00     | 0.02 | 0.05 |
| A3                                                 | 0.10 REF |      |      |
| b                                                  | 0.20     | 0.25 | 0.30 |
| D                                                  | 1.90     | 2.00 | 2.10 |
| E                                                  | 1.90     | 2.00 | 2.10 |
| D2                                                 | 0.80     | 0.90 | 1.00 |
| E2                                                 | 1.50     | 1.60 | 1.70 |
| e                                                  | 0.40     | 0.50 | 0.60 |
| H                                                  | 0.20 REF |      |      |
| K                                                  | 0.15     | 0.25 | 0.35 |
| L                                                  | 0.25     | 0.30 | 0.35 |

## Physical Dimensions: SOIC-8



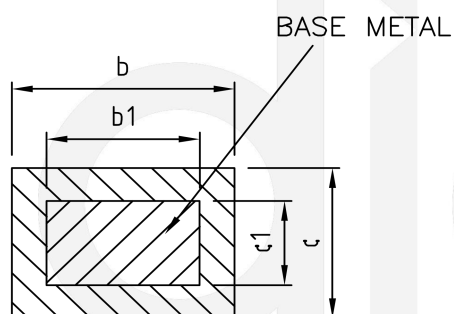
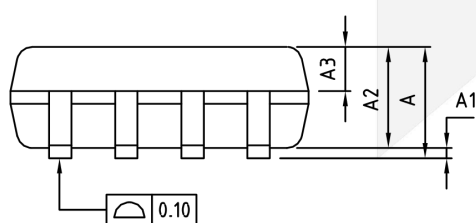
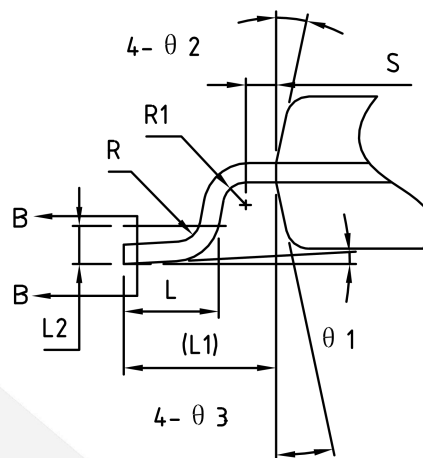
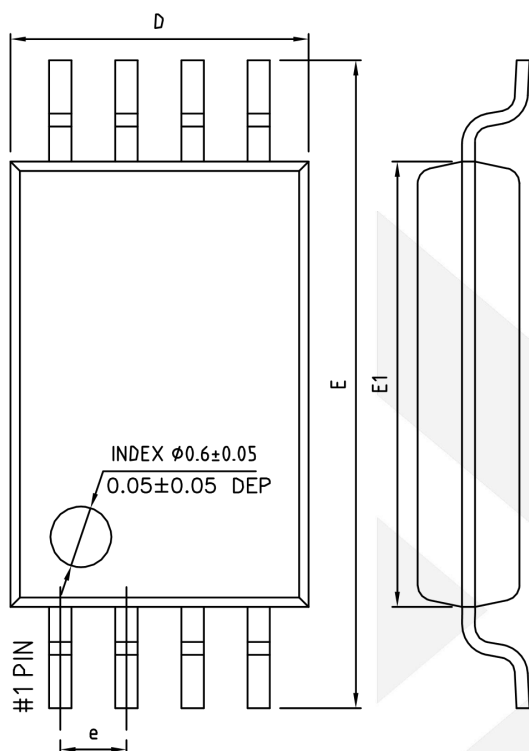
| Common dimensions<br>Units of measure = millimeter |          |      |      |
|----------------------------------------------------|----------|------|------|
| Symbol                                             | Min      | Nom  | Max  |
| A                                                  | 1.35     | 1.55 | 1.75 |
| A1                                                 | 0.10     | 0.15 | 0.25 |
| A2                                                 | 1.25     | 1.40 | 1.65 |
| A3                                                 | 0.50     | 0.60 | 0.70 |
| b                                                  | 0.38     | -    | 0.51 |
| b1                                                 | 0.37     | 0.42 | 0.47 |
| c                                                  | 0.17     | -    | 0.25 |
| c1                                                 | 0.17     | 0.20 | 0.23 |
| D                                                  | 4.80     | 4.90 | 5.00 |
| E                                                  | 5.80     | 6.00 | 6.20 |
| E1                                                 | 3.80     | 3.90 | 4.00 |
| e                                                  | 1.27 BSC |      |      |
| L                                                  | 0.45     | 0.60 | 0.80 |
| L1                                                 | 1.04 REF |      |      |
| L2                                                 | 0.25 BSC |      |      |
| R                                                  | 0.07     | -    | -    |
| R1                                                 | 0.07     | -    | -    |
| h                                                  | 0.30     | 0.40 | 0.50 |
| θ                                                  | 0°       | -    | 8°   |
| θ1                                                 | 15°      | 17°  | 19°  |
| θ2                                                 | 11°      | 13°  | 15°  |
| θ3                                                 | 15°      | 17°  | 19°  |
| θ4                                                 | 11°      | 13°  | 15°  |

### Physical Dimensions: MSOP-8



| Common dimensions<br>Units of measure = millimeter |          |      |      |
|----------------------------------------------------|----------|------|------|
| Symbol                                             | Min      | Nom  | Max  |
| A                                                  | -        | -    | 1.10 |
| A1                                                 | 0        | -    | 0.15 |
| A2                                                 | 0.75     | 0.85 | 0.95 |
| A3                                                 | 0.25     | 0.35 | 0.39 |
| b                                                  | 0.28     | -    | 0.37 |
| b1                                                 | 0.27     | 0.30 | 0.33 |
| c                                                  | 0.15     | -    | 0.20 |
| c1                                                 | 0.14     | 0.15 | 0.16 |
| D                                                  | 2.90     | 3.00 | 3.10 |
| E                                                  | 4.70     | 4.90 | 5.10 |
| E1                                                 | 2.90     | 3.00 | 3.10 |
| e                                                  | 0.55     | 0.65 | 0.75 |
| L                                                  | 0.40     | 0.60 | 0.80 |
| L1                                                 | 0.95 REF |      |      |
| L2                                                 | 0.25 BSC |      |      |
| R                                                  | 0.07     | -    | -    |
| R1                                                 | 0.07     | -    | -    |
| θ                                                  | 0°       | -    | 8°   |
| θ1                                                 | 9°       | 12°  | 15°  |

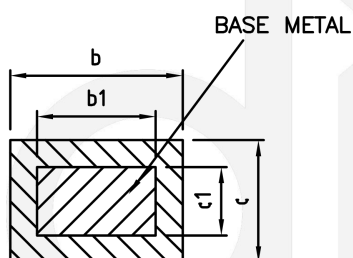
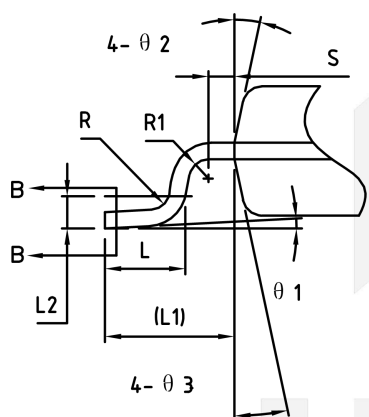
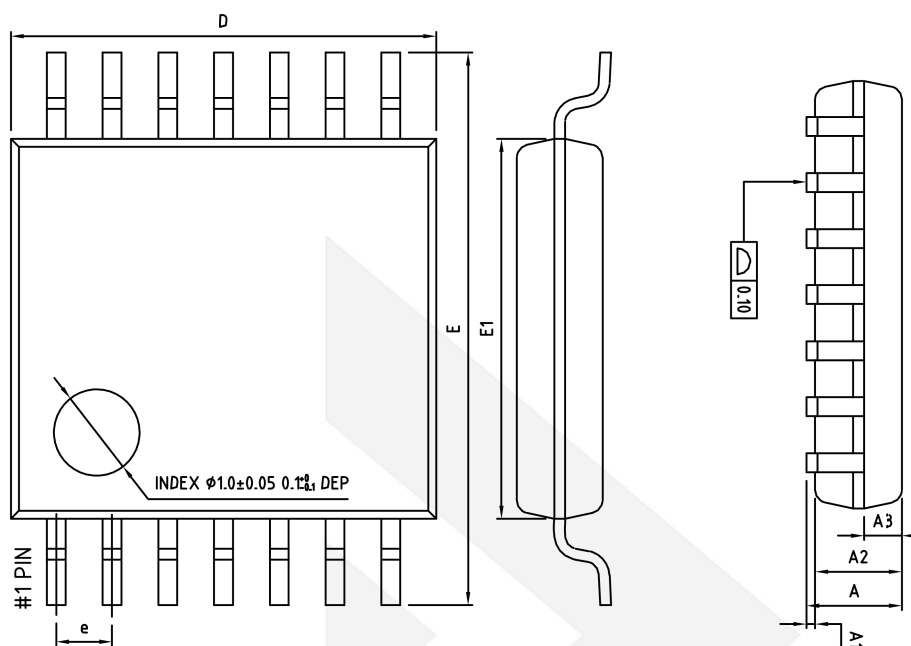
## Physical Dimensions: TSSOP-8



SECTION B-B

| Common dimensions             |          |      |      |
|-------------------------------|----------|------|------|
| Units of measure = millimeter |          |      |      |
| Symbol                        | Min      | Nom  | Max  |
| A                             | -        | -    | 1.20 |
| A1                            | 0.05     | -    | 0.15 |
| A2                            | 0.90     | 1.00 | 1.05 |
| A3                            | 0.34     | 0.44 | 0.54 |
| b                             | 0.20     | -    | 0.28 |
| b1                            | 0.20     | 0.22 | 0.24 |
| c                             | 0.10     | -    | 0.19 |
| c1                            | 0.10     | 0.13 | 0.15 |
| D                             | 2.83     | 2.93 | 3.03 |
| E                             | 6.20     | 6.40 | 6.60 |
| E1                            | 4.30     | 4.40 | 4.50 |
| e                             | 0.65 BSC |      |      |
| L                             | 0.45     | 0.60 | 0.75 |
| L1                            | 1.00 REF |      |      |
| L2                            | 0.25 BSC |      |      |
| R                             | 0.09     | -    | -    |
| R1                            | 0.09     | -    | -    |
| S                             | 0.20     | -    | -    |
| θ1                            | 0°       | -    | 8°   |
| θ2                            | 10°      | 12°  | 14°  |
| θ3                            | 10°      | 12°  | 14°  |

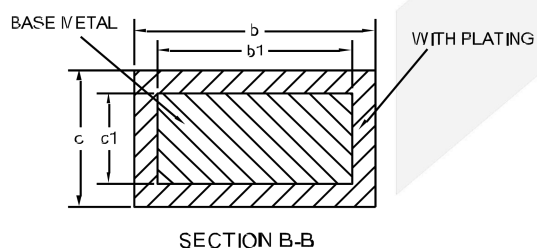
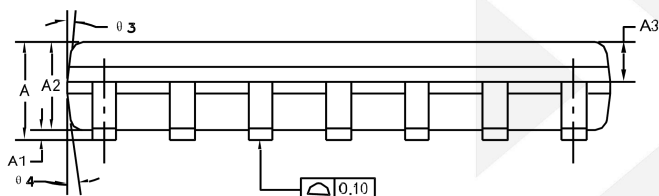
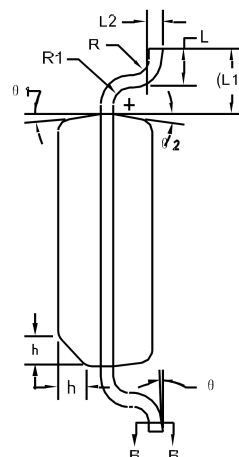
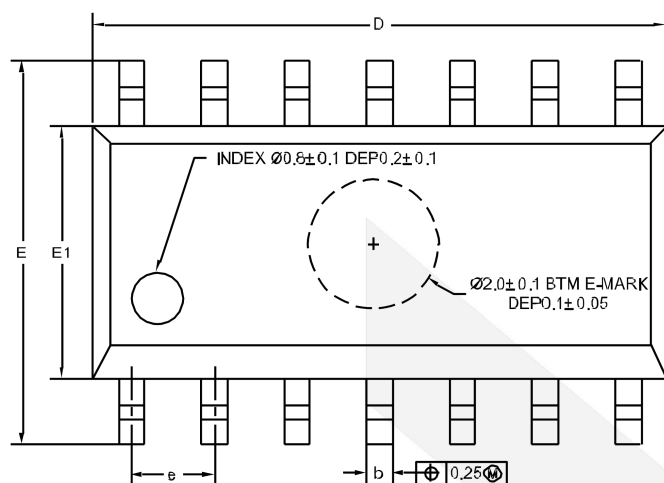
## Physical Dimensions: TSSOP-14



SECTION B-B

| Common dimensions             |          |      |      |
|-------------------------------|----------|------|------|
| Units of measure = millimeter |          |      |      |
| Symbol                        | Min      | Nom  | Max  |
| A                             | -        | -    | 1.20 |
| A1                            | 0.05     | -    | 0.15 |
| A2                            | 0.90     | 1.00 | 1.05 |
| A3                            | 0.34     | 0.44 | 0.54 |
| b                             | 0.20     | -    | 0.28 |
| b1                            | 0.20     | 0.22 | 0.24 |
| c                             | 0.10     | -    | 0.19 |
| c1                            | 0.10     | 0.13 | 0.15 |
| D                             | 4.86     | 4.96 | 5.06 |
| E                             | 6.20     | 6.40 | 6.60 |
| E1                            | 4.30     | 4.40 | 4.50 |
| e                             | 0.65 BSC |      |      |
| L                             | 0.45     | 0.60 | 0.75 |
| L1                            | 1.00 REF |      |      |
| L2                            | 0.25 BSC |      |      |
| R                             | 0.09     | -    | -    |
| R1                            | 0.09     | -    | -    |
| S                             | 0.20     | -    | -    |
| θ1                            | 0°       | -    | 8°   |
| θ2                            | 10°      | 12°  | 14°  |
| θ3                            | 10°      | 12°  | 14°  |

## Physical Dimensions: SOP14



| Common dimensions<br>Units of measure = millimeter |          |      |      |
|----------------------------------------------------|----------|------|------|
| Symbol                                             | Min      | Nom  | Max  |
| A                                                  | 1.35     | 1.60 | 1.75 |
| A1                                                 | 0.10     | 0.15 | 0.25 |
| A2                                                 | 1.25     | 1.45 | 1.65 |
| A3                                                 | 0.55     | 0.65 | 0.75 |
| b                                                  | 0.36     | -    | 0.49 |
| b1                                                 | 0.35     | 0.40 | 0.45 |
| c                                                  | 0.17     | -    | 0.25 |
| c1                                                 | 0.17     | 0.20 | 0.23 |
| D                                                  | 8.53     | 8.63 | 8.73 |
| E                                                  | 5.80     | 6.00 | 6.20 |
| E1                                                 | 3.80     | 3.90 | 4.00 |
| e                                                  | 1.27 BSC |      |      |
| L                                                  | 0.45     | 0.60 | 0.80 |
| L1                                                 | 1.04 REF |      |      |
| L2                                                 | 0.25 BSC |      |      |
| R                                                  | 0.07     | -    | -    |
| R1                                                 | 0.07     | -    | -    |
| h                                                  | 0.30     | 0.40 | 0.50 |
| θ                                                  | 0°       | -    | 8°   |
| θ1                                                 | 6°       | 8°   | 10°  |
| θ2                                                 | 6°       | 8°   | 10°  |
| θ3                                                 | 5°       | 7°   | 9°   |
| θ4                                                 | 5°       | 7°   | 9°   |

## CONTACT US

Dioo is a professional design and sales corporation for high-quality and performance analog semiconductors. The company focuses on industry markets, such as, cell phone, handheld products, laptop, and medical equipment and so on. Dioo's product families include analog signal processing and amplifying, LED drivers and charger IC. Go to <http://www.dioo.com> for a complete list of Dioo product families.

For additional product information, or full datasheet, please contact with our Sales Department or Representatives.