



# CD8605 CD8606 CD8608

Precision, Low Noise, CMOS, Rail-to-Rail, Input/Output Operational Amplifiers

Version: Rev 1.0.0 Date: 2025-5-26

## Features ■■

- Low Offset Voltage: 65 $\mu$ V (max)
- Low input bias currents: 1 pA (max)
- Low noise: 12 nV/ $\sqrt{\text{Hz}}$
- Wide bandwidth: 8.7 MHz
- High open-loop gain: 1000 V/mV
- Unity gain stable
- Single-supply operation: 2.7 V to 5.5 V

## Application ■■

- Photodiode amplification
- Battery-powered instrumentation
- Multipole filters
- Sensors
- Barcode scanners
- Audio

## Description ■■

The CD8605, CD8606, and CD8608 are single, dual, and quad rail-to-rail input and output, single-supply amplifiers. They feature very low offset voltage, low input voltage and current noise, and gain bandwidth product characteristic of up to 8.7MHz.

The CD8605, CD8606, and CD8608 are specified over the extended industrial temperature range ( $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ ). The CD8605 single is available in 5-lead SOT-23 and 5-ball WLCSP packages. The CD8606 dual is available in an 8-lead MSOP, an 8-ball WLSCP, and a narrow SOIC surface-mounted package. The CD8608 quad is available in a 14-lead TSSOP package and a narrow 14-lead SOIC package. The 5-ball and 8-ball WLCSP offer the smallest available footprint for any surface-mounted operational amplifier. The WLCSP, SOT-23, MSOP, and TSSOP versions are available in tape-and-reel only.

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Pin Configurations

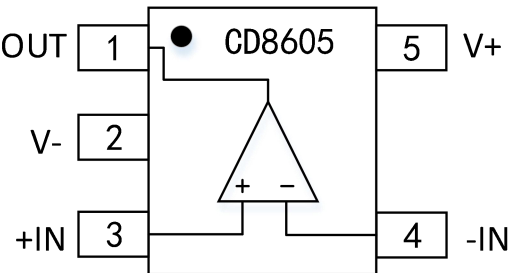


Figure 1.SOT23 Pin Configuration

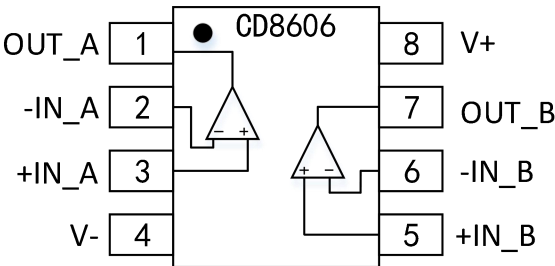
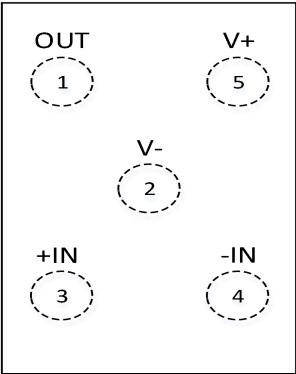
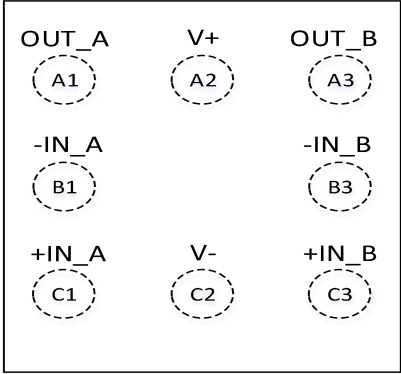


Figure 2. MSOP/SOP Pin Configuration



CD8605  
(TOP VIEW)

Figure 3.WLCSP\_5 Pin Configuration



CD8606  
(TOP VIEW)

Figure 4.WLCSP\_5 Pin Configuration

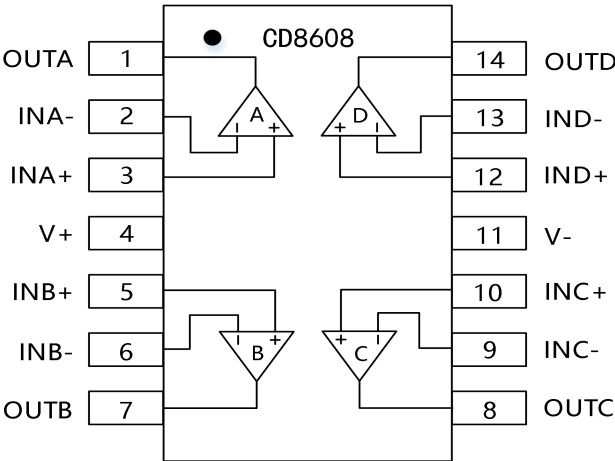


Figure5.TSSOP/SOP Pin Configuration

## Pin Description

| Pin_N | Symbol SOT23 (CD8605)     | Input/Output | Function               |
|-------|---------------------------|--------------|------------------------|
| 1     | OUT                       | O            | Output                 |
| 2     | V-                        | --           | Negative power supply  |
| 3     | +IN                       | I            | None Inverting input   |
| 4     | -IN                       | I            | Inverting input        |
| 5     | V+                        | --           | Positive power supply  |
| Pin_N | Symbol MSOP/SOP (CD8606)  | Input/Output | Function               |
| 1     | OUT_A                     | O            | Output A               |
| 2     | -IN_A                     | I            | Inverting input A      |
| 3     | +IN_A                     | I            | None Inverting input A |
| 4     | V-                        | --           | Negative power supply  |
| 5     | +IN_B                     | I            | None Inverting input B |
| 6     | -IN_B                     | I            | Inverting input B      |
| 7     | OUT_B                     | O            | Output B               |
| 8     | V+                        | --           | Positive power supply  |
| Pin_N | Symbol WLCSP (CD8605)     | Input/Output | Function               |
| 1     | OUT                       | O            | Output                 |
| 2     | V-                        | --           | Negative power supply  |
| 3     | +IN                       | I            | None Inverting input   |
| 4     | -IN                       | I            | Inverting input        |
| 5     | V+                        | --           | Positive power supply  |
| Pin_N | Symbol WLCSP (CD8606)     | Input/Output | Function               |
| 1     | OUT_A                     | O            | Output A               |
| 2     | V+                        | --           | Positive power supply  |
| 3     | OUT_B                     | O            | Output B               |
| 4     | -IN_A                     | I            | Inverting input A      |
| 5     | -IN_B                     | I            | Inverting input B      |
| 6     | +IN_A                     | I            | None Inverting input A |
| 7     | V-                        | --           | Negative power supply  |
| 8     | +IN_B                     | I            | None Inverting input B |
| Pin_N | Symbol TSSOP/SOP (CD8608) | Input/Output | Function               |
| 1     | OUT_A                     | O            | Output A               |
| 2     | -IN_A                     | I            | Inverting input A      |
| 3     | +IN_A                     | I            | None Inverting input A |
| 4     | V+                        | --           | Positive power supply  |
| 5     | +IN_B                     | I            | None Inverting input B |
| 6     | -IN_B                     | I            | Inverting input B      |
| 7     | OUT_B                     | O            | Output B               |
| 8     | OUT_C                     | O            | Output C               |
| 9     | -IN_C                     | I            | Inverting input C      |
| 10    | +IN_C                     | I            | None Inverting input C |
| 11    | V-                        | --           | Negative power supply  |
| 12    | +IN_D                     | I            | None Inverting input D |

|    |       |   |                   |
|----|-------|---|-------------------|
| 13 | -IN_D | I | Inverting input D |
| 14 | OUT_D | O | Output D          |

## Absolute Maximum Ratings

| Parameter                                | Range                    |
|------------------------------------------|--------------------------|
| Supply Voltage                           | 6V                       |
| Input Voltage                            | V- to V+                 |
| Differential Input Voltage               | 6 V                      |
| Storage Temperature Range All Packages   | -65°C to +150°C          |
| Operating Temperature Range All Packages | -40°C to +125°C          |
| Junction Temperature Range All Packages  | -65°C to +150°C          |
| SOT23-5                                  | 240°C/W                  |
| MSOP-8                                   | 206°C/W                  |
| SOP-8                                    | 157°C/W                  |
| Lead Temperature                         | (Soldering, 60s) : 300°C |

## Electrical characteristics

( $V_S = 5\text{ V}$ ,  $V_{CM} = V_S/2$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise noted.)

Table1.

| PARAMETER                                         | CONDITION                                                        | MIN | TYP      | MAX | UNIT                         |
|---------------------------------------------------|------------------------------------------------------------------|-----|----------|-----|------------------------------|
| <b>INPUT CHARACTERISTICS</b>                      |                                                                  |     |          |     |                              |
| Input Offset Voltage ( $V_{OS}$ )                 | $V_S = 3.5\text{ V}$ , $V_{CM} = 3\text{ V}$                     | --  | 20       | 65  | $\mu\text{V}$                |
|                                                   | $V_S = 2.7\text{ V}$ , $V_{CM} = 0\text{ V to } 2.7\text{ V}$    | --  | 80       | 300 | $\mu\text{V}$                |
| Offset Voltage Drift ( $\Delta V_{OS}/\Delta T$ ) | --                                                               | --  | 1        | 4.5 | $\mu\text{V}/^\circ\text{C}$ |
| Input Bias Current ( $I_B$ )                      | --                                                               | --  | 0.2      | 1   | pA                           |
| Input Offset Current ( $I_{OS}$ )                 | --                                                               | --  | 0.1      | 0.5 | pA                           |
| Input Voltage Range                               | --                                                               | 0   |          | 5   | V                            |
| Common-Mode Rejection Ratio (CMRR)                | $V_{CM} = 0\text{ V to } 5\text{ V}$                             | 85  | 100      | --  | dB                           |
| Open-Loop Voltage Gain ( $A_{OL}$ )               | $R_L = 2\text{ K}\Omega$ , $V_O = 0.5\text{ V to } 4.5\text{ V}$ | 300 | 100<br>0 | --  | dB                           |
| <b>INPUT CAPACITANCE</b>                          |                                                                  |     |          |     |                              |
| Differential ( $C_{DIFF}$ )                       | --                                                               | --  | 2.6      | --  | pF                           |
| Common-Mode ( $C_{COM}$ )                         | --                                                               | --  | 8.8      | --  | pF                           |
| <b>OUTPUT CHARACTERISTICS</b>                     |                                                                  |     |          |     |                              |

|                                         |                                              |      |          |     |                              |
|-----------------------------------------|----------------------------------------------|------|----------|-----|------------------------------|
| Output Voltage High ( $V_{OH}$ )        | $I_L = 1\text{ mA}$                          | 4.96 | 4.98     | --  | V                            |
|                                         | $I_L = 10\text{mA}$                          | 4.7  | 4.79     | --  | V                            |
| Output Voltage Low ( $V_{OL}$ )         | $I_L = 1\text{ mA}$                          | --   | 20       | 40  | mV                           |
|                                         | $I_L = 10\text{mA}$                          | --   | 170      | 210 | mV                           |
| Output Current ( $I_{OUT}$ )            |                                              | --   | $\pm 80$ | --  | mA                           |
| <b>POWER SUPPLY</b>                     |                                              |      |          |     |                              |
| Power Supply Rejection Ratio (PSRR)     | $V_{CM} = 2.7\text{V to } 5.5\text{V}$       | 75   | 89       | --  | dB                           |
| Supply Current/Amplifier ( $I_{SY}$ )   | $I_{OUT} = 0\text{ mA}$                      | --   | 0.8      | 1.2 | mA                           |
| <b>NOISE PERFORMANCE</b>                |                                              |      |          |     |                              |
| Peak-to-Peak Noise ( $e_n\text{ p-p}$ ) | $f = 0.1\text{ Hz to } 10\text{ Hz}$         | --   | 2.3      | 3.5 | $\mu\text{Vp-p}$             |
| Voltage Noise Density ( $e_n$ )         | $f = 1\text{ kHz}$                           | --   | 8        | 12  | $\text{nV}/\sqrt{\text{Hz}}$ |
| Voltage Noise Density ( $e_n$ )         | $f = 10\text{KHz}$                           | --   | 6.5      | --  | $\text{nV}/\sqrt{\text{Hz}}$ |
| Current Noise Density ( $i_n$ )         | $f = 1\text{kHz}$                            | --   | 0.01     | --  | $\text{pA}/\sqrt{\text{Hz}}$ |
| <b>DYNAMIC PERFORMANCE</b>              |                                              |      |          |     |                              |
| Slew Rate (SR)                          | $R_L = 2\text{ k}\Omega, C_L = 16\text{ pF}$ | --   | 5        | --  | $\text{V}/\mu\text{s}$       |
| Gain-Bandwidth Product (GBW)            | --                                           | --   | 8.7      | --  | MHz                          |
| Settling Time                           | To 0.01%, 0 V to 2 V step, $A_v = 1$         | --   | <1       | --  | us                           |

( $V_S = 2.7\text{V}$ ,  $V_{CM} = V_S/2$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise noted.)

Table 2.

| PARAMETER                                         | CONDITION                                                  | MIN | TYP  | MAX | UNIT                         |
|---------------------------------------------------|------------------------------------------------------------|-----|------|-----|------------------------------|
| <b>INPUT CHARACTERISTICS</b>                      |                                                            |     |      |     |                              |
| Input Offset Voltage ( $V_{OS}$ )                 | $V_S = 3.5\text{ V}, V_{CM} = 3\text{ V}$                  | --  | 20   | 65  | $\mu\text{V}$                |
|                                                   | $V_S = 2.7\text{ V}, V_{CM} = 0\text{ V to } 2.7\text{ V}$ | --  | 80   | 300 | $\mu\text{V}$                |
| Offset Voltage Drift ( $\Delta V_{OS}/\Delta T$ ) | --                                                         | --  | 1    | 4.5 | $\mu\text{V}/^\circ\text{C}$ |
| Input Bias Current ( $I_B$ )                      | $V_{CM} = V_S/2$                                           | --  | 0.2  | 1   | pA                           |
| Input Offset Current ( $I_{OS}$ )                 | --                                                         | --  | 0.1  | 0.5 | pA                           |
| Input Voltage Range                               | --                                                         | 0   |      | 2.7 | V                            |
| Common-Mode Rejection Ratio (CMRR)                | $V_{CM} = 0\text{V to } 2.7\text{V}$                       | 70  | 89   | --  | dB                           |
| Open-Loop Voltage Gain ( $A_{OL}$ )               | $R_L = 2\text{K}\Omega, V_O = 0.5\text{V to } 2.2\text{V}$ | 110 | 350  | --  | $\text{V/mV}$                |
| <b>INPUT CAPACITANCE</b>                          |                                                            |     |      |     |                              |
| Differential ( $C_{DIFF}$ )                       | --                                                         | --  | 2.6  | --  | pF                           |
| Common-Mode ( $C_{COM}$ )                         | --                                                         | --  | 8.8  | --  | pF                           |
| <b>OUTPUT CHARACTERISTICS</b>                     |                                                            |     |      |     |                              |
| Output Voltage High ( $V_{OH}$ )                  | $I_L = 1\text{ mA}$                                        | 2.6 | 2.66 | --  | V                            |

|                                          |                                                |    |          |     |                              |
|------------------------------------------|------------------------------------------------|----|----------|-----|------------------------------|
| Output Voltage Low ( $V_{OL}$ )          | $I_L = 1 \text{ mA}$                           | -- | 25       | 40  | mV                           |
| Output Current ( $I_{OUT}$ )             |                                                | -- | $\pm 30$ | --  | mA                           |
| <b>POWER SUPPLY</b>                      |                                                |    |          |     |                              |
| Power Supply Rejection Ratio (PSRR)      | $V_{CM} = 2.7\text{V to } 5.5\text{V}$         | 75 | 89       | --  | dB                           |
| Supply Current/Amplifier ( $I_{SY}$ )    | $I_{OUT} = 0 \text{ mA}$                       | -- | 0.8      | 1.4 | mA                           |
| <b>NOISE PERFORMANCE</b>                 |                                                |    |          |     |                              |
| Peak-to-Peak Noise ( $e_n \text{ p-p}$ ) | $f = 0.1 \text{ Hz to } 10 \text{ Hz}$         | -- | 2.3      | 3.5 | $\mu\text{Vp-p}$             |
| Voltage Noise Density ( $e_n$ )          | $f = 1 \text{ kHz}$                            | -- | 8        | 12  | $\text{nV}/\sqrt{\text{Hz}}$ |
| Voltage Noise Density ( $e_n$ )          | $f = 10\text{kHz}$                             | -- | 6.5      | --  | $\text{nV}/\sqrt{\text{Hz}}$ |
| Current Noise Density ( $i_n$ )          | $f = 1\text{kHz}$                              | -- | 0.01     | --  | $\text{pA}/\sqrt{\text{Hz}}$ |
| <b>DYNAMIC PERFORMANCE</b>               |                                                |    |          |     |                              |
| Slew Rate (SR)                           | $R_L = 2 \text{ k}\Omega, C_L = 16 \text{ pF}$ | -- | 5        | --  | $\text{V}/\mu\text{s}$       |
| Gain-Bandwidth Product (GBW)             | --                                             | -- | 8.7      | --  | MHz                          |
| Settling Time                            | To 0.01%, 0 V to 1 V step, $A_v = 1$           | -- | <0.5     | --  | $\mu\text{s}$                |

## Typical Characteristics

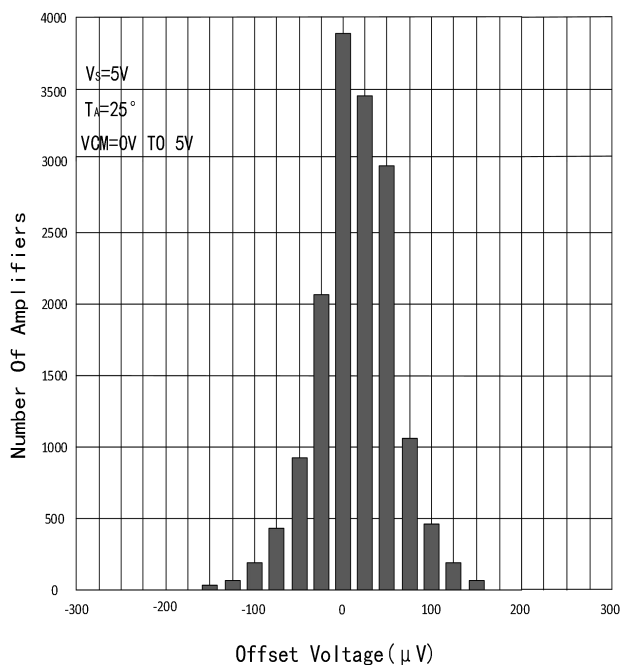


Figure 6. Input Offset Voltage Distribution

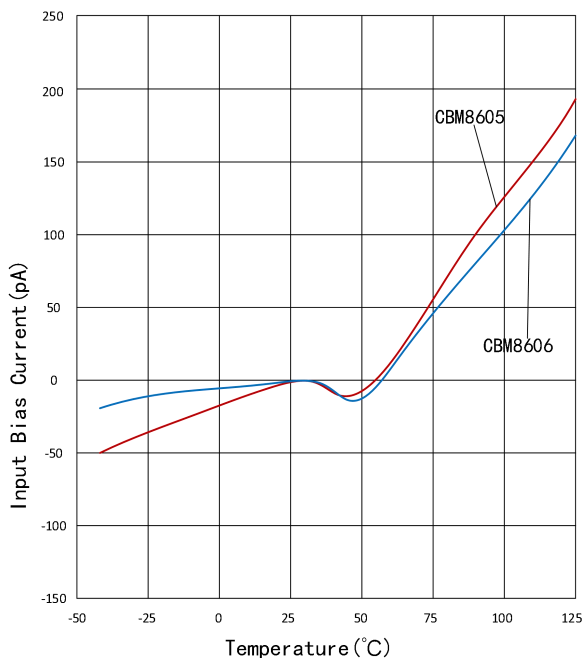


Figure 7. Input Bias Current vs. Temperature

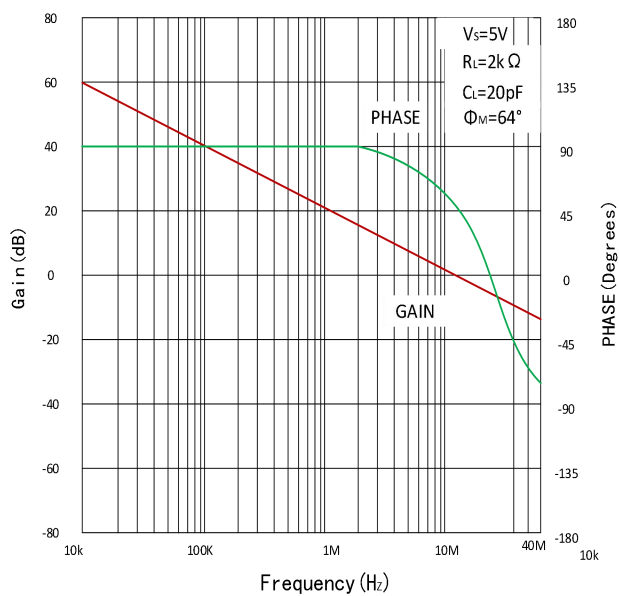


Figure 8. Open-Loop Gain and Phase vs. Frequency

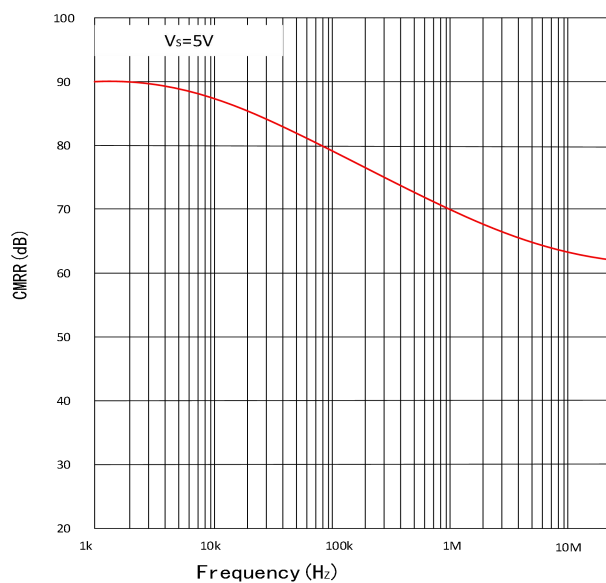


Figure 9. Common-Mode Rejection Ratio (CMRR) vs. Frequency

## Application Information

### Output phase reversal

Phase reversal is defined as a change in polarity at the output of the amplifier when a voltage that exceeds the maximum input common-mode voltage drives the input. Phase reversal can cause permanent damage to the amplifier; it can also cause system lockups in feedback loops. The CD8605 does not exhibit phase reversal even for inputs exceeding the supply voltage by more than 2 V INPUT

### Overvoltage protection

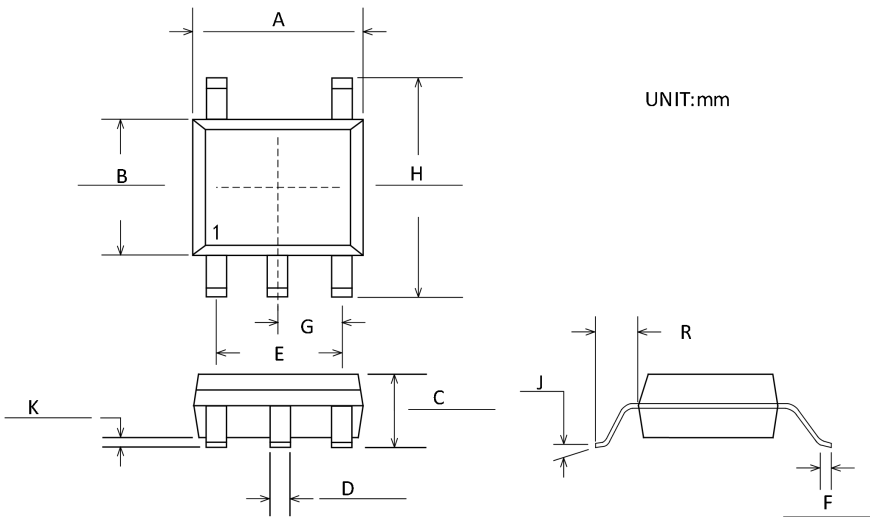
The CD860x has internal protective circuitry. However, if the voltage applied at either input exceeds the supplies by more than 0.5 V, external resistors should be placed in series with the inputs. The resistor values can be determined by

$$(V_{IN}-V_S)/R_S \leq 5\text{mA}$$

The remarkable low input offset current of the CD860x (<1 pA) allows the use of larger value resistors. With a 10 kΩ resistor at the input, the output voltage has less than 10 nV of error voltage. A 10 kΩ resistor has less than 13 nV/√Hz of thermal noise at room temperature.

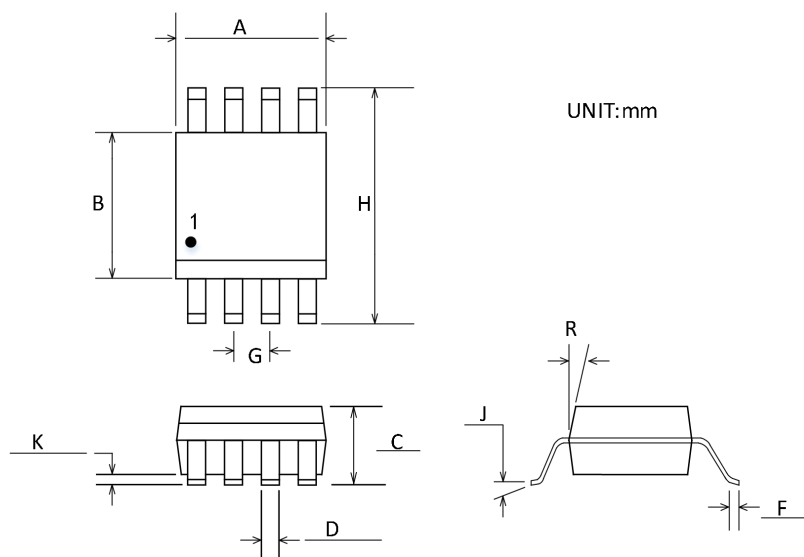
Package Outline Dimensions

SOT23-5



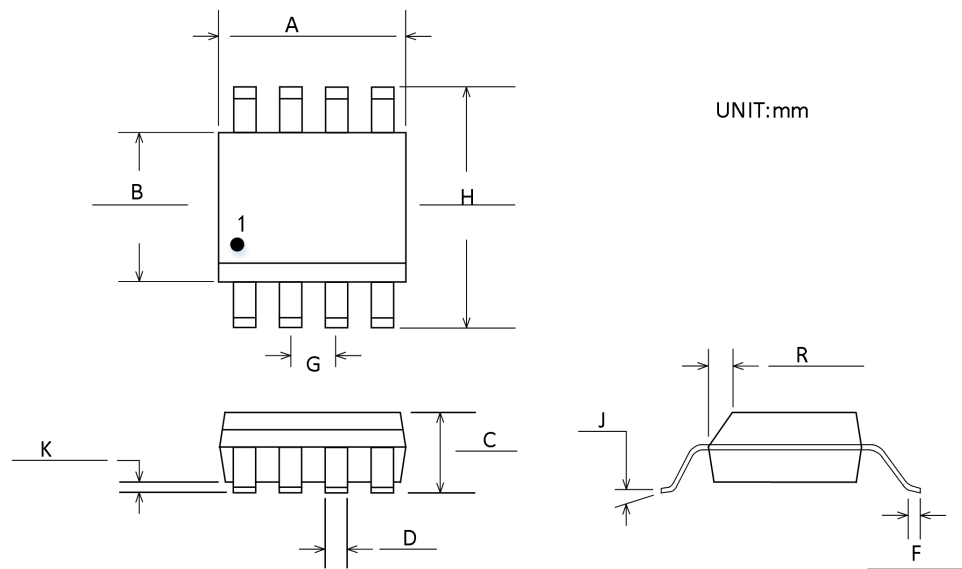
| Symbol | Dimensions In Millimeters |      |
|--------|---------------------------|------|
|        | Min                       | Max  |
| A      | 2.80                      | 3.00 |
| B      | 1.50                      | 1.70 |
| C      | 0.95                      | 1.45 |
| D      | 0.35                      | 0.50 |
| E      | 1.90BSC                   |      |
| F      | 0.35                      | 0.55 |
| G      | 0.95BSC                   |      |
| H      | 2.60                      | 3.00 |
| J      | 0°                        | 10°  |
| K      | 0.05                      | 0.15 |
| R      | 0.60BSC                   |      |

MSOP-8



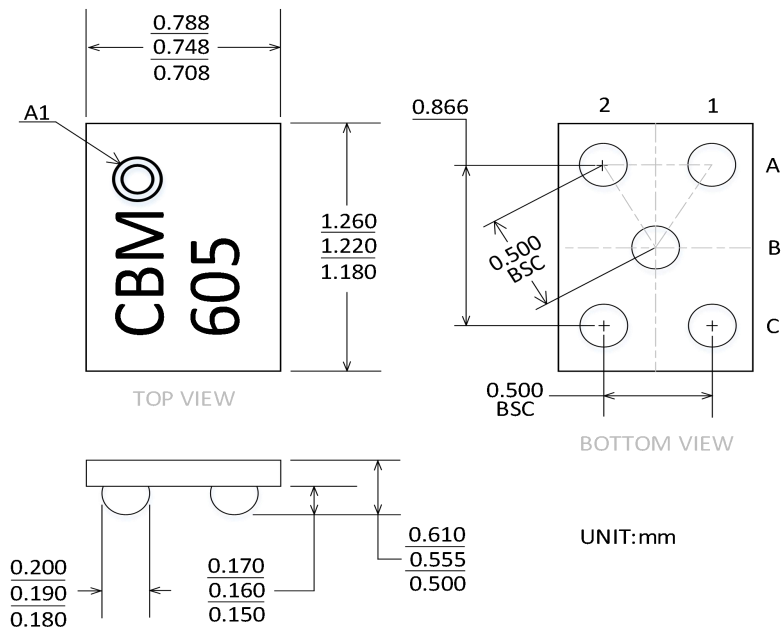
| Symbol | Dimensions In Millimeters |      |
|--------|---------------------------|------|
|        | Min                       | Max  |
| A      | 2.80                      | 3.20 |
| B      | 2.80                      | 3.20 |
| C      | 1.10MAX                   |      |
| D      | 0.25                      | 0.40 |
| F      | 0.40                      | 0.80 |
| G      | 0.65BSC                   |      |
| H      | 4.65                      | 5.15 |
| J      | 0°                        | 6°   |
| K      | 0.05                      | 0.15 |
| R      | 15°MAX                    |      |

SOP-8

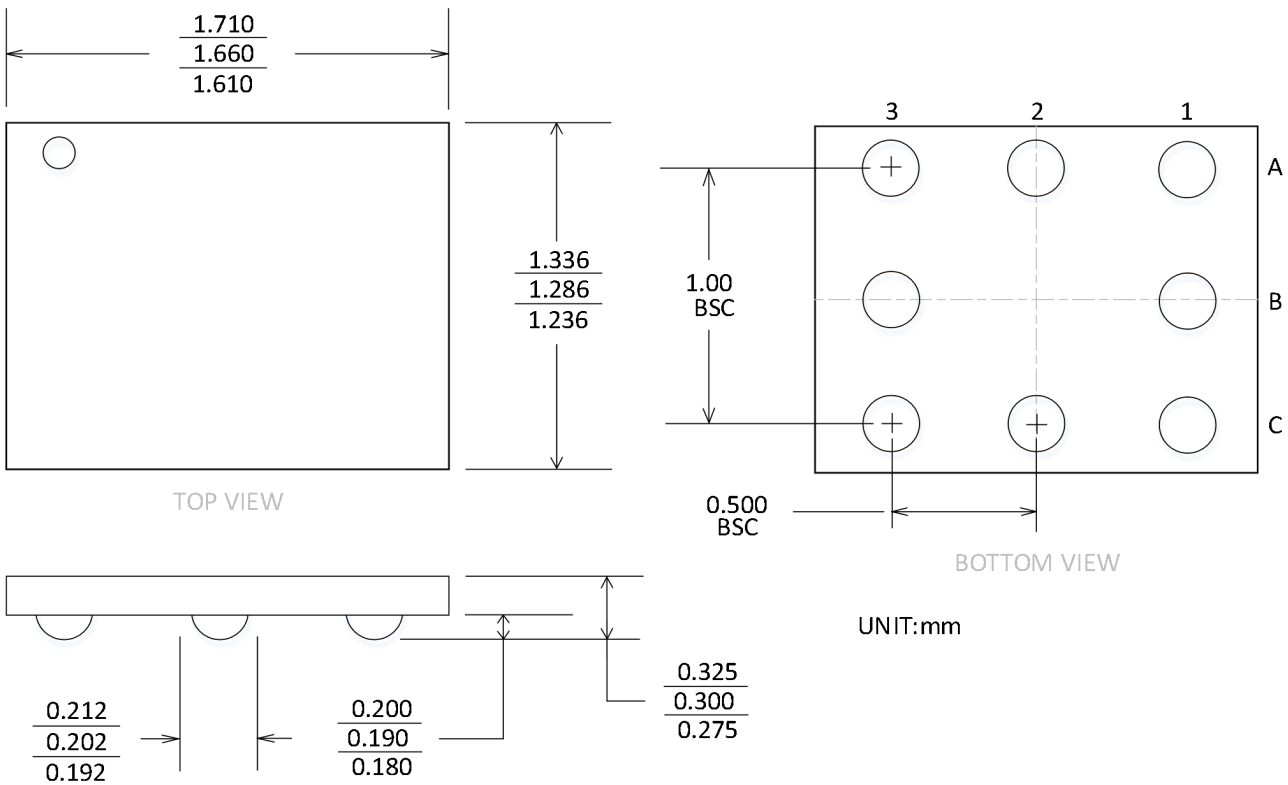


| Symbol | Dimensions In Millimeters |      |
|--------|---------------------------|------|
|        | Min                       | Max  |
| A      | 4.80                      | 5.00 |
| B      | 3.80                      | 4.00 |
| C      | 1.35                      | 1.75 |
| D      | 0.31                      | 0.51 |
| F      | 0.40                      | 1.27 |
| G      | 1.27BSC                   |      |
| H      | 5.80                      | 6.20 |
| J      | 0°                        | 8°   |
| K      | 0.10                      | 0.25 |
| R      | 0.25                      | 0.50 |

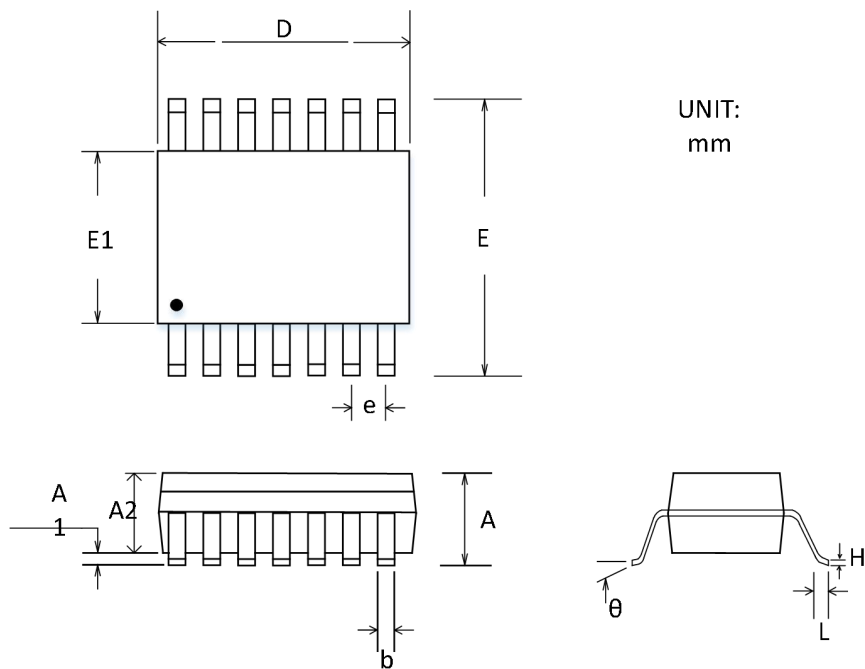
WLCSP-5 (CD8605)



WLCSP-8 (CD8606)

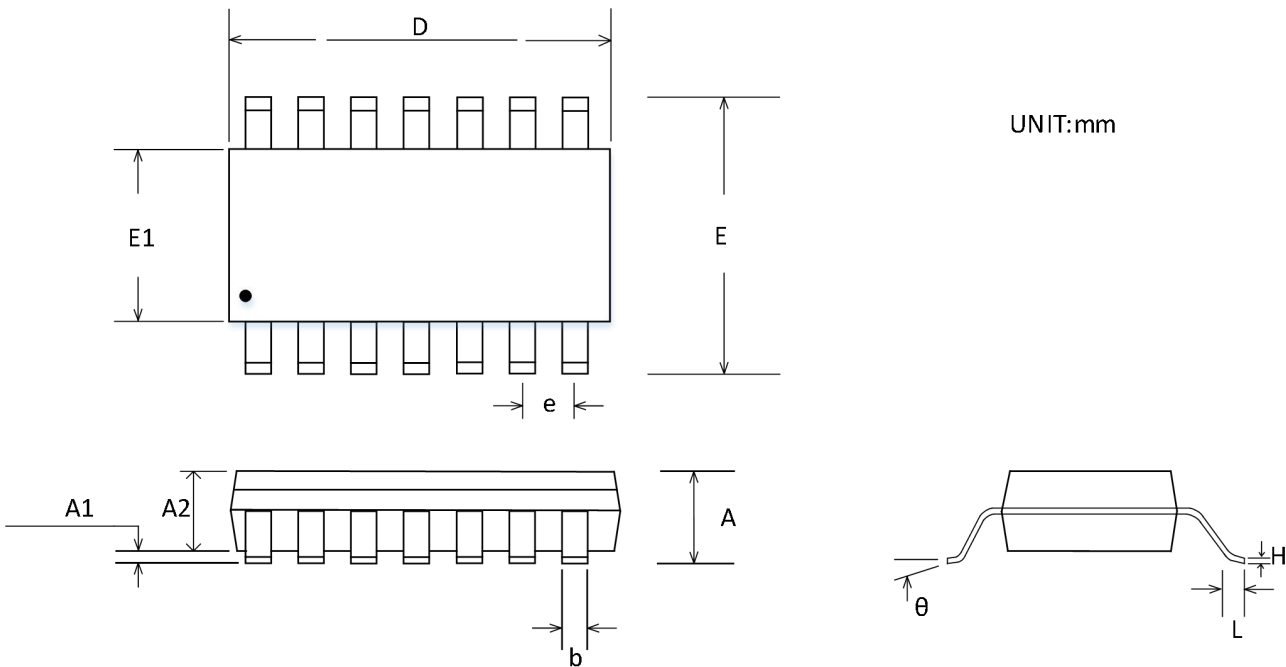


TSSOP-14



| Symbol | Dimensions In Millimeters |      |
|--------|---------------------------|------|
|        | Min                       | Max  |
| A      | 1.20MAX                   |      |
| A1     | 0.05                      | 0.15 |
| A2     | 0.80                      | 1.05 |
| b      | 0.19                      | 0.30 |
| D      | 4.90                      | 5.10 |
| E      | 6.40BSC                   |      |
| E1     | 4.30                      | 4.50 |
| e      | 0.65BSC                   |      |
| H      | 0.09                      | 0.20 |
| L      | 0.45                      | 0.75 |
| θ      | 0°                        | 8°   |

SOP-14



| Symbol | Dimensions In Millimeters |      |
|--------|---------------------------|------|
|        | Min                       | Max  |
| A      | 1.35                      | 1.75 |
| A1     | 0.10                      | 0.25 |
| A2     | 1.25                      | 1.50 |
| b      | 0.31                      | 0.51 |
| D      | 8.55                      | 8.75 |
| E      | 5.80                      | 6.20 |
| E1     | 3.80                      | 4.00 |
| e      | 1.27BSC                   |      |
| H      | 0.17                      | 0.25 |
| L      | 0.40                      | 1.27 |
| θ      | 0°                        | 8°   |

### Package/Ordering Information

| MODEL            | TEMPERATURE | PACKAGE DESCRIPTION | PACKAGE OPTION      |
|------------------|-------------|---------------------|---------------------|
| CD8605AWS5       | -40°C~125°C | WLCSP-5             | Tape and Reel, 3000 |
| CD8605AST5       | -40°C~125°C | SOT23-5             | Tape and Reel, 3000 |
| CD8606AMS8       | -40°C~125°C | MSOP-8              | Tape and Reel, 3000 |
| CD8606AS8        | -40°C~125°C | SOP-8               | Tape and Reel, 2500 |
| CD8606AS8-RL     | -40°C~125°C | SOP-8               | Tape and Reel, 3000 |
| CD8606AS8-REEL   | -40°C~125°C | SOP-8               | Tape and Reel, 4000 |
| CD8606AWS8       | -40°C~125°C | WLCSP-8             | Tape and Reel, 3000 |
| CD8608ATS14      | -40°C~125°C | TSSOP-14            | Tape and Reel, 2500 |
| CD8608ATS14-RL   | -40°C~125°C | TSSOP-14            | Tape and Reel, 3000 |
| CD8608ATS14-REEL | -40°C~125°C | TSSOP-14            | Tape and Reel, 4000 |
| CD8608AS14       | -40°C~125°C | SOP-14              | Tape and Reel, 2500 |
| CD8608AS14-RL    | -40°C~125°C | SOP-14              | Tape and Reel, 3000 |
| CD8608AS14-REEL  | -40°C~125°C | SOP-14              | Tape and Reel, 4000 |

### Revision Log

| Version | Revision date | Change content  | Reason for Change | Modified by | Reviewed By | Note |
|---------|---------------|-----------------|-------------------|-------------|-------------|------|
| V1.0    | 2025.5.26     | Initial version | Regular update    | WW          | LYL         |      |