Precision, Low Noise, CMOS, RRIO Operational Amplifier

Features

- Wide supply range: 2.7 V to 5.5 V
- Unity-gain bandwidth: 18 MHz
- Low offset voltage:
  - 1.2 μV (typ.)
  - Low input offset voltage drift: ±0.01 μV/°C
- Ultra-low input-referred voltage noise/density:
  - 9 nV/√Hz at f = 1 kHz
  - 180 nV_{PP} at f = 0.1 ~ 10 Hz
- High output slew rate: 11 V/μs
- Rail-to-rail input and output
- Wide operating temperature range:
  - -40°C to 125°C

Applications

- Photodiode amplification
- Gas sensor
- Solar inverter

Package Information

Part Number	Package	Body Size
DIO25581	SC70-5	2.0 mm × 1.3 mm
	SOT23-5	2.9 mm × 1.6 mm
	SOT23-6	2.9 mm × 1.6 mm
DIO25582	MSOP8	3.0 mm × 3.0 mm
	DFN-8	2.0 mm × 2.0 mm
	WLCSP-8	1.43 mm × 1.77 mm
	MSOP-10	3.0 mm × 3.0 mm
DIO25584	SOP-14	8.6 mm × 3.9 mm
	TSSOP14	5.0 mm × 4.4 mm

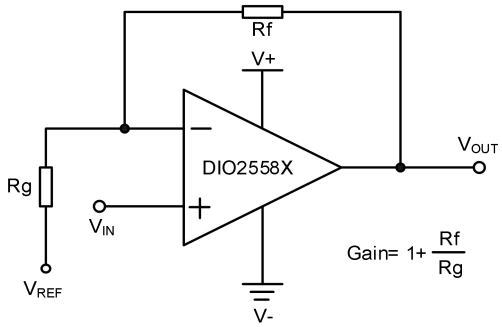
Description

The DIO25581/2/4 are single, dual, and quad rail-to-rail input and output, shutdown option single/dual-supply amplifiers. They feature very low offset voltage, low input voltage and current noise, and wide signal bandwidth.

The combination of low offsets, low noise, very low input bias currents, and high speed makes these amplifiers useful in a wide variety of applications. Filters, integrators, photodiode amplifiers, and high impedance sensors all benefit from the combination of performance features. Audio and other ac applications benefit from the wide bandwidth and low distortion. Applications for these amplifiers include optical control loops, portable and loop-powered instrumentation, and audio amplification for portable devices.

The DIO2558X is specified over the extended industrial temperature range (-40°C to 125°C). The DIO25581 (single) is available in 5-lead SC70, 5-lead SOT23 and 6-lead SOT-23 packages. The DIO25582 (dual) is available in an 8-lead MSOP, a 8-lead WLCSP, a 10-lead SOP and an 8-lead DFN package. The DIO25584 (quad) is available in a 14-lead TSSOP package and a 14-lead SOP package.

Simplified Schematic



Non-inverting amplifier

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Ordering Information

Ordering Part No.	Top Marking	MSL	RoHS	T_A	Package	
DIO25581SC5	MAYW	3	Green	-40 to 125 °C	SC70-5	Tape & Reel, 3000
DIO25581ASC5	MBYW	3	Green	-40 to 125 °C	SC70-5	Tape & Reel, 3000
DIO25581ST5	MAYW	3	Green	-40 to 125 °C	SOT23-5	Tape & Reel, 3000
DIO25581ST6	MAYW	3	Green	-40 to 125 °C	SOT23-6	Tape & Reel, 3000
DIO25582MP8	DIOE5HB	3	Green	-40 to 125 °C	MSOP-8	Tape & Reel, 3000
DIO25582WL8	E5HB	1	Green	-40 to 125 °C	WLCSP-8	Tape & Reel, 3000
DIO25582MP10	DIOE5HB	3	Green	-40 to 125 °C	MSOP-10	Tape & Reel, 3000
DIO25582CN8	E5HB	3	Green	-40 to 125 °C	DFN2*2-8	Tape & Reel, 3000
DIO25584SO14	DIOE5HD	3	Green	-40 to 125 °C	SOP-14	Tape & Reel, 2500
DIO25584TP14	DIOE5HD	3	Green	-40 to 125 °C	TSSOP-14	Tape & Reel, 2500

If you encounter any issue in the process of using the device, please contact our customer service at marketing@dioo.com or phone us at (+86)-21-62116882. If you have any improvement suggestions regarding the datasheet, we encourage you to contact our technical writing team at docs@dioo.com. Your feedback is invaluable for us to provide a better user experience.

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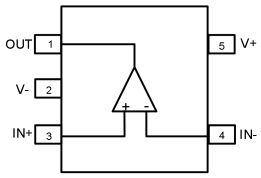
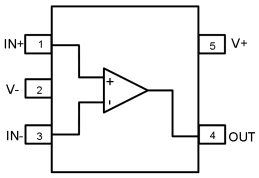
1. Pin Assignment and Functions



SC70-5 (DIO25581)



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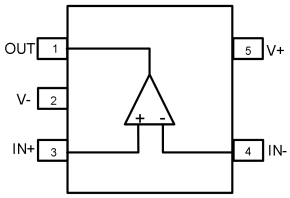
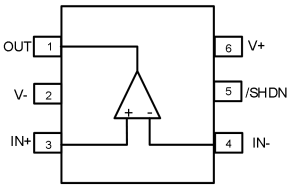
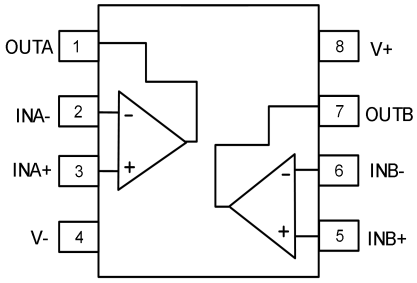


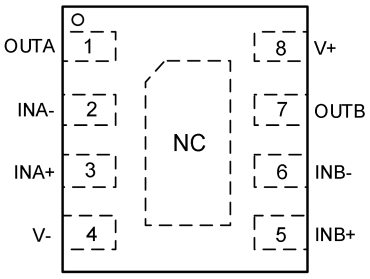
SOT23-5 (DIO25581)



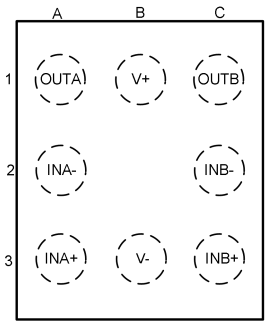
SOT23-6 (DIO25581)



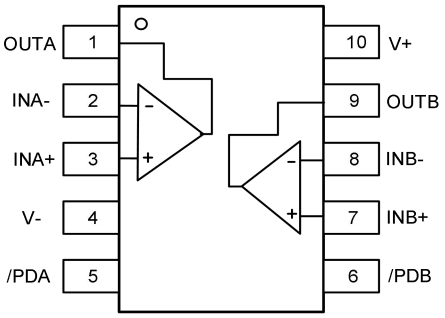
MSOP8 (DIO25582)



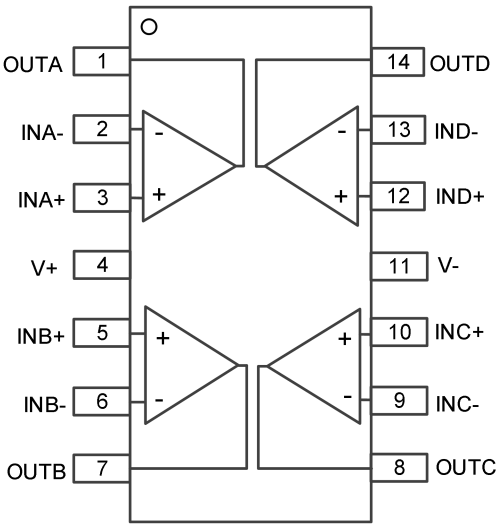
DFN2*2-8 (DIO25582)



WLCSP-8 (DIO25582)



MSOP10 (DIO25582)



SOP14 / TSSOP-14 (DIO25584)

Figure 1. Pin assignments (Top view)

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Pin Name	Description
IN+ (INA+/B+/C+/D+)	Positive input (channel A/B/C/D)
IN- (INA-/B-/C-/D-)	Negative input (channel A/B/C/D)
OUT (OUTA/B/C/D)	Output (channel A/B/C/D)
V+	Positive supply
V-	Negative supply
/SHDN	Shut down input. Only for DIO25581ST6. When the low level input voltage is on the input, the device is shut down. When the high level input voltage is on the input, the device is active (default) with a 3 MΩ internal pull-up resistor.
/PDA	Shut down input (channel A). Only for DIO25582MP10. When the low level input voltage is on the input, the device is shut down. When the high level input voltage is on the input, the device is active (default) with a 3 MΩ internal pull-up resistor.
/PDB	Shut down input (channel B). Only for DIO25582MP10. When the low level input voltage is on the input, the device is shut down. When the high level input voltage is on the input, the device is active (default) with a 3 MΩ internal pull-up resistor.

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2. Absolute Maximum Ratings

Exceeding the maximum ratings listed under Absolute Maximum Ratings when designing is likely to damage the device permanently. Do not design to the maximum limits because long-time exposure to them might impact the device's reliability. The ratings are obtained over an operating free-air temperature range unless otherwise specified.

Symbol	Parameter	Rating	Unit
	Maximum supply voltage, (V+) – (V-)	6.5	V
	Input voltage	(V-) – 0.3 to (V+) + 0.3	V
	Differential input voltage	(V-) − (V+) to (V+) − (V-)	V
	Input current: IN+, IN– (1)	−10 to 10	mA
V_{OUT}	Output voltage	(V-) − 0.3 to (V+) + 0.3	V
	Output short-circuit duration (2)	Infinite	
T_J	Maximum operating junction temperature	150	°C
T_A	Operating temperature range	−40 to 125	°C
T_{STG}	Storage temperature range	−65 to 150	°C
T_L	Maximum lead temperature (Soldering, 10 sec)	260	°C

Note:

(1) The inputs are protected by ESD protection diodes to negative power supply. If the input extends more than 300 mV beyond the negative power supply, the input current should be limited to less than 10 mA.

(2) A heat sink may be required to keep the junction temperature below the absolute maximum. This depends on the power supply voltage and how many amplifiers are shorted. Thermal resistance varies with the amount of PC board metal connected to the package. The specified values are for short traces connected to the leads.

3. Recommended Operating Conditions

Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. The ratings are obtained over an operating free-air temperature range unless otherwise specified.

Symbol	Parameter	Rating	Unit
V_S	Supply voltage, (V+) – (V-)	2.7 to 5.5	V
T_A	Operating temperature range	-40 to 125	°C

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4. ESD Ratings

When a statically-charged person or object touches an electrostatic discharge sensitive device, the electrostatic charge might be drained through sensitive circuitry in the device. If the electrostatic discharge possesses sufficient energy, damage might occur to the device due to localized overheating.

Model	Condition	Value	Unit
HBM	ANSI/ESDA/JEDEC JS-001	±4	kV
CDM	ANSI/ESDA/JEDEC JS-002	±2	kV

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5. Electrical Characteristics

T_A = -40 to 125 °C, V_S = 5 V, R_L = 10 kΩ, C_L = 100 pF. Typical values are at T_A = 25 °C, unless otherwise noted.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_S	Supply voltage	T_A = 25 °C	2.7		5.5	V
I_Q	Quiescent current per amplifier	V_S = 2.7 V to 5.5 V		1.35		mA
	Shutdown current (1)	V_S = 2.7 to 5.5 V, /SHDN = 0 V		7		μA
	Input logic high of shutdown		0.7 × V_S			V
	Input logic low of shutdown				0.3 × V_S	V
PSRR	Power supply rejection ratio	V_S = 2.7 V to 5.5 V		124		dB
Input						
V_{OS}	Input offset voltage	V_S = 5 V, V_{CM} = 2.5 V, T_A = 25 °C	−10	1.2	10	μV
dV_{OS}/dT	Input offset voltage drift			0.01		μV/°C
I_B	Input bias current	V_S = 5 V, V_{CM} = 2.5 V, T_A = 25 °C	-800	200	800	pA
I_{OS}	Input offset current	V_S = 5 V, V_{CM} = 2.5 V, T_A = 25 °C	-800	120	800	pA
C_{IN}	Input capacitance	Differential mode		2		pF
		Common mode		5		pF
Av (1)	Open-loop voltage gain	V_O = 0.5 V to 4.5 V		150		dB
V_{CMR}	Common-mode input voltage range		(V-)− 0.1		(V+)+ 0.1	V
CMRR	Common-mode rejection ratio	V_{CM} = 0 V to 5 V		124		dB
Output						
V_{OH}	Output voltage swing from positive rail	R_{LOAD} = 10 kΩ to V_S/2		6.5		mV
		R_{LOAD} = 2 kΩ to V_S/2		32		
V_{OL}	Output voltage swing from negative rail	R_{LOAD} = 10 kΩ to V_S/2		16.5		mV
		R_{LOAD} = 2 kΩ to V_S/2		55		

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I_{SC}	Output short−circuit current	Sink		78		mA
		Source		120		
AC specifications						
GBW	Gain−bandwidth product			18		MHz
SR	Slew rate	G = 1, 2 V step		11		V/µs
t_{OR}	Overload recovery			1		µs
t_S	Settling time, 1%	G = 1, 2 V step		4		µs
	Settling time, 0.1% (1)			4		
PM (1)	Phase margin	R_L = 10 kΩ, C_L = 100 pF		56		°
GM (1)	Gain margin	R_L = 10 kΩ, C_L = 100 pF		14		dB
X_{TALK}	Channel to channel crosstalk	f = 1 kHz		117		dB
Noise						
EN	Input voltage noise	f = 0.1 Hz to 10 Hz		0.18		μV_{PP}
e_N	Input voltage noise density	f = 1 kHz		9		nV/√Hz
THD+N	Total harmonic distortion and noise	G = 1, f = 1 kHz, V_O = 1 V_{RMS}, RL = 2 kΩ, A-wt.		0.0004		%

Note:

(1) Guaranteed by design.

(2) Specifications subject to change without notice.

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6. Typical Characteristics

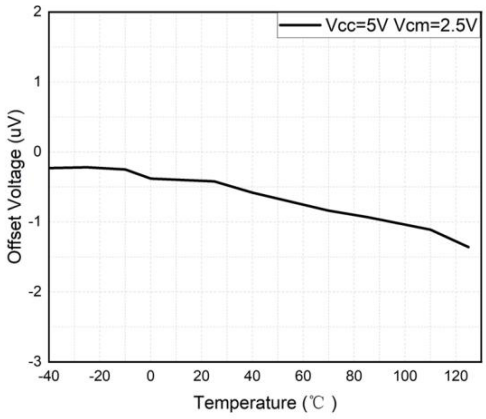


Figure 2. Offset voltage vs. Temperature

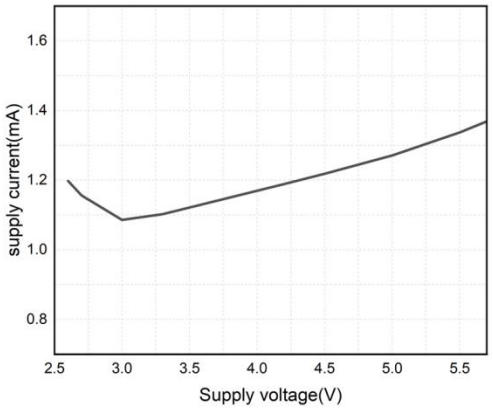


Figure 3. Supply current vs. Supply voltage

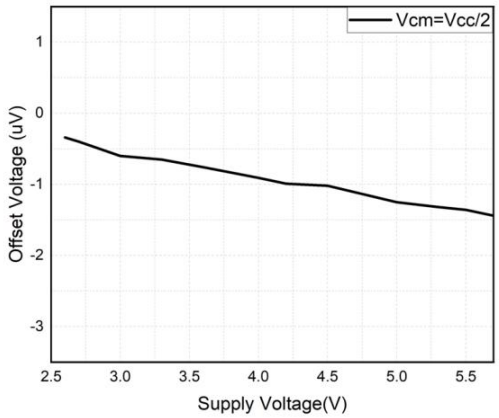


Figure 4. Offset voltage vs. Supply voltage

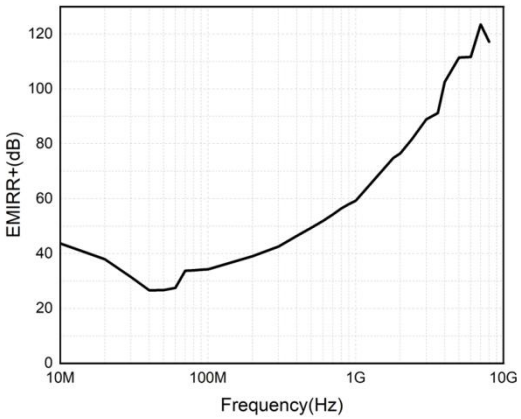
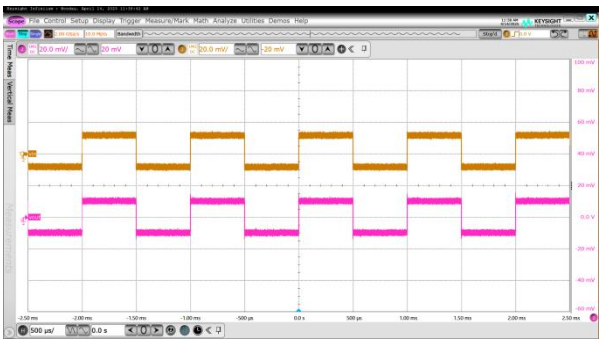


Figure 5. EMRR vs. Frequency

V_{CC} = ±2.5 V，C_L = 100 pF

Figure 6. Lager signal response



V_{CC} = ±2.5 V，C_L = 100 pF

Figure 7. Small signal response

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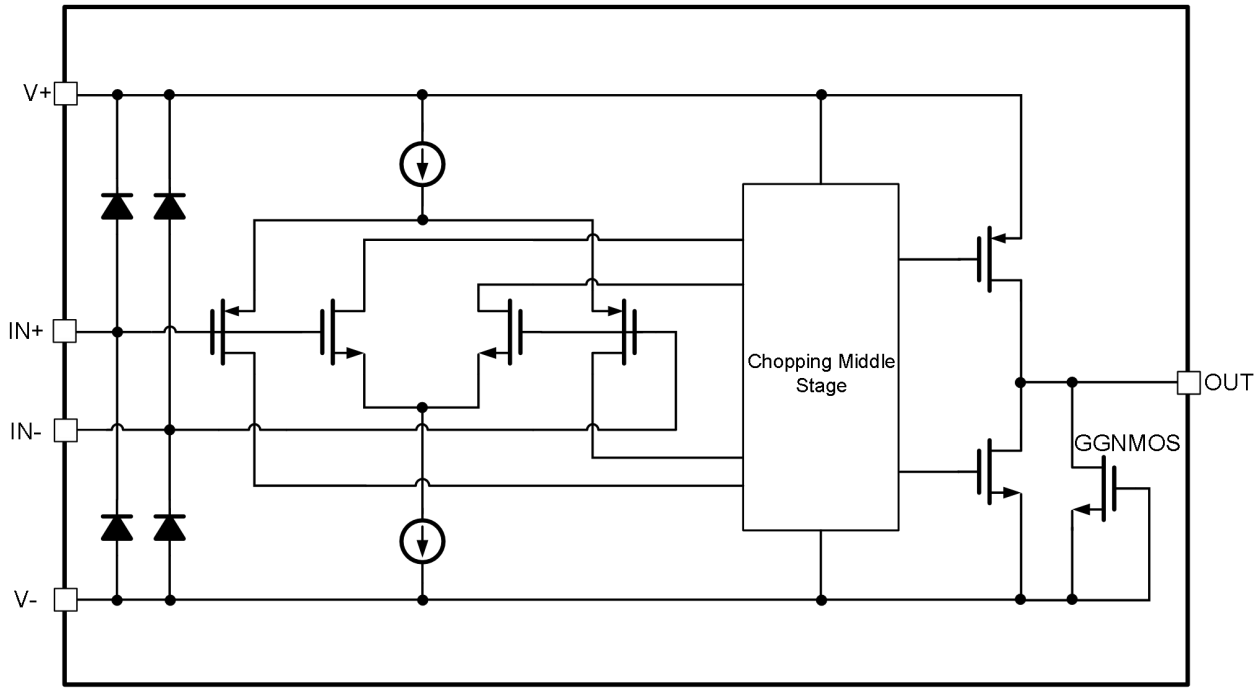
7. Block Diagram



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8. Function Description

The DIO25581/2/4 are single, dual, and quad rail-to-rail input and output, shutdown option single/dual-supply amplifiers. They feature very low offset voltage, low input voltage and current noise, and wide signal bandwidth.

8.1. Residual voltage ripple

Due to the internal notch filter, the chopping technique can be employed in amplifier design. However, while the voltage ripple related to chopping is suppressed, a higher noise spectrum remains at the chopping frequency and its harmonics because of the residual ripple. The chopping frequency is set at 400 kHz for these devices. When the input signal frequency is close to the chopping frequency, interference from the residual ripple may occur. Therefore, it is advisable to place a post filter at the output of the amplifier to suppress the noise at the chopping frequency.

8.2. Rail-to-Rail input and output

For Rail-to-Rail input, the DIO2558X family boasts an input common-mode voltage range that extends 100 mV beyond the supply rails. This is achieved through a complementary input stage, which includes a P-channel input differential pair in parallel with an N-channel differential pair. When the device transitions from N-channel to P-channel (or from P-channel to N-channel), there exists a transition region. Compared to when operating outside this transition region, parameters including PSRR, CMRR, offset voltage, offset drift, and THD may degrade within this transition region.

For Rail-to-Rail output, the DIO2558X family features a class-AB output stage that enables rail-to-rail output swing capability. The ability of the amplifier to swing close to the rails varies under different load conditions.

8.3. Shutdown

The shutdown function is only for DIO25581ST6 and DIO25582MP10. This voltage level is referenced to the operational amplifier’s supply voltage. The operational amplifier is enabled by a valid high voltage, and it is shut down by a valid low voltage. When using a single supply, a valid high level is defined as 0.7 × (V+) and a valid low level as 0.3 × (V+) of the positive supply. For instance, with V+ at 5 V and V- at 0 V, a valid high level is 3.5 V and a valid low level is 1.5 V. When dual or split power supplies are used, ensure that the valid high or low input signals are correctly referenced to the positive supply voltage. For example, with V+ at 2.5 V and V- at −2.5 V, a valid high level is 1 V and a valid low level is -1 V.

The /SHDN, /PDA, /PDB pins are internally pulled up to a valid high level when left open, enabling the amplifier initially if nothing is connected to the shutdown pin. When shut down, the amplifier’s output assumes a high-impedance state.

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9. Application Information

Important notice: Validation and testing are the most reliable ways to confirm system functionality. The application information is not part of the specification and is for reference purposes only.

The device is configured for a low-side current sensing application, refer to figure below. In this setup, a sense resistor is positioned between the load and the circuit ground. The voltage drop across this resistor is amplified by various amplifier circuits within the device. Additionally, V_{REF} can be employed to introduce a bias voltage to the output voltage. It is crucial to ensure the matching and precision of resistors R_1, R_2, R_3, and R_4 in order to optimize the accuracy of the measurement.

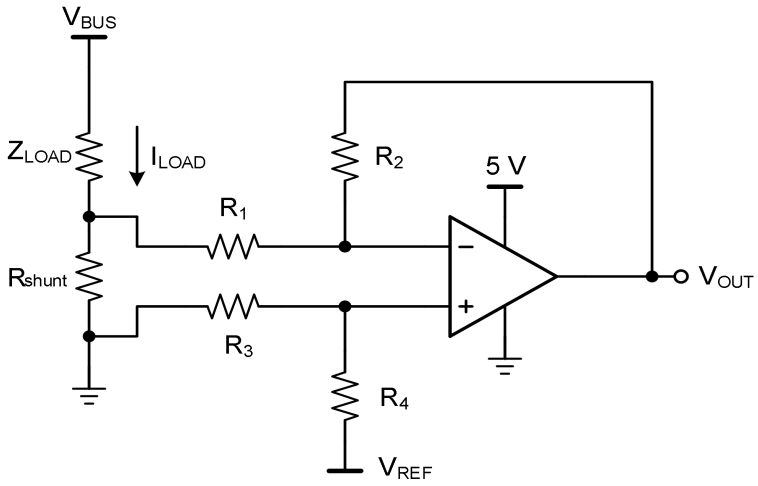

Figure 8. Low-side current sensing application

To calculate the value of V_{OUT}, refer to the equation below:

$$V_{OUT} = (I_{LOAD} \times R_{SHUNT}) \times (R_2/R_1) + V_{REF} \quad (1)$$

Where,

$R_3 = R_1$, $R_2 = R_4$, $R_{SHUNT} << R_1$

In addition, for reducing coupling errors from the noisy or high-impedance power supplies, it's recommended to place 0.1 μF bypass capacitors close to the power supply pins .

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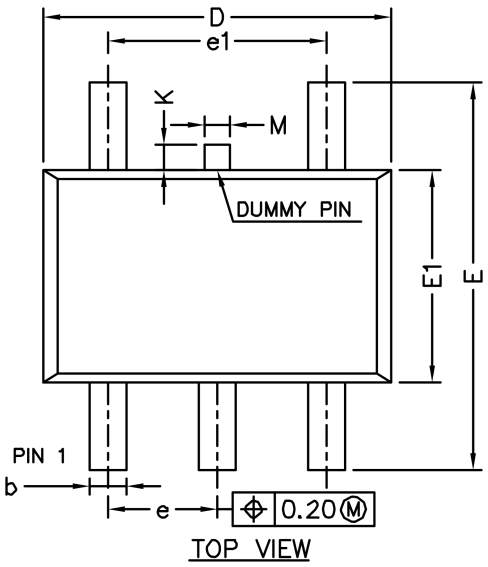
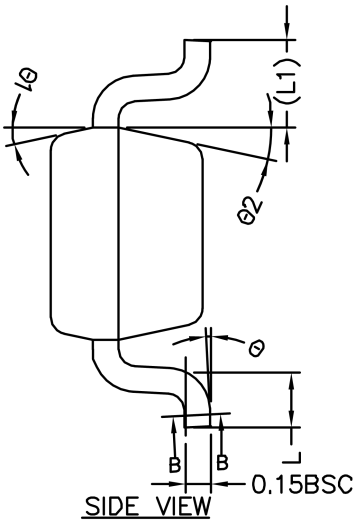
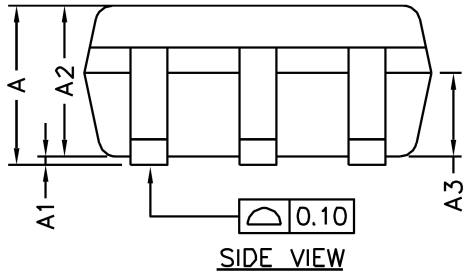
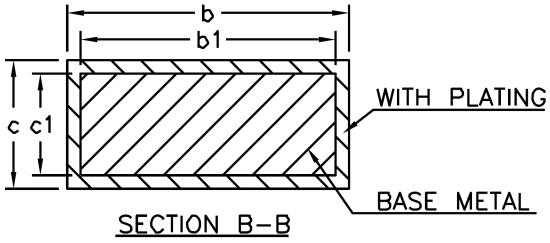
10. Physical Dimensions

10.1. SC70-5









Common Dimensions (Units of measure = Millimeter)			
Symbol	**Min**	**Nom**	**Max**
A	0.80	-	1.10
A1	0	-	0.10
A2	0.80	0.90	1.00
A3	0.40	0.50	0.60
b	0.17	-	0.30
b1	0.17	0.22	0.25
c	0.12	-	0.20
c1	0.12	0.15	0.16
D	2.02	2.07	2.12
E	2.20	2.30	2.40
E1	1.21	1.26	1.31
e	0.60	0.65	0.70
e1	1.20	1.30	1.40
L	0.26	0.33	0.46
L1	0.52 REF		
M	0.10	0.15	0.20
K	0	-	0.20
θ	0°	-	8°
θ1	10°	12°	14°
θ2	10°	12°	14°

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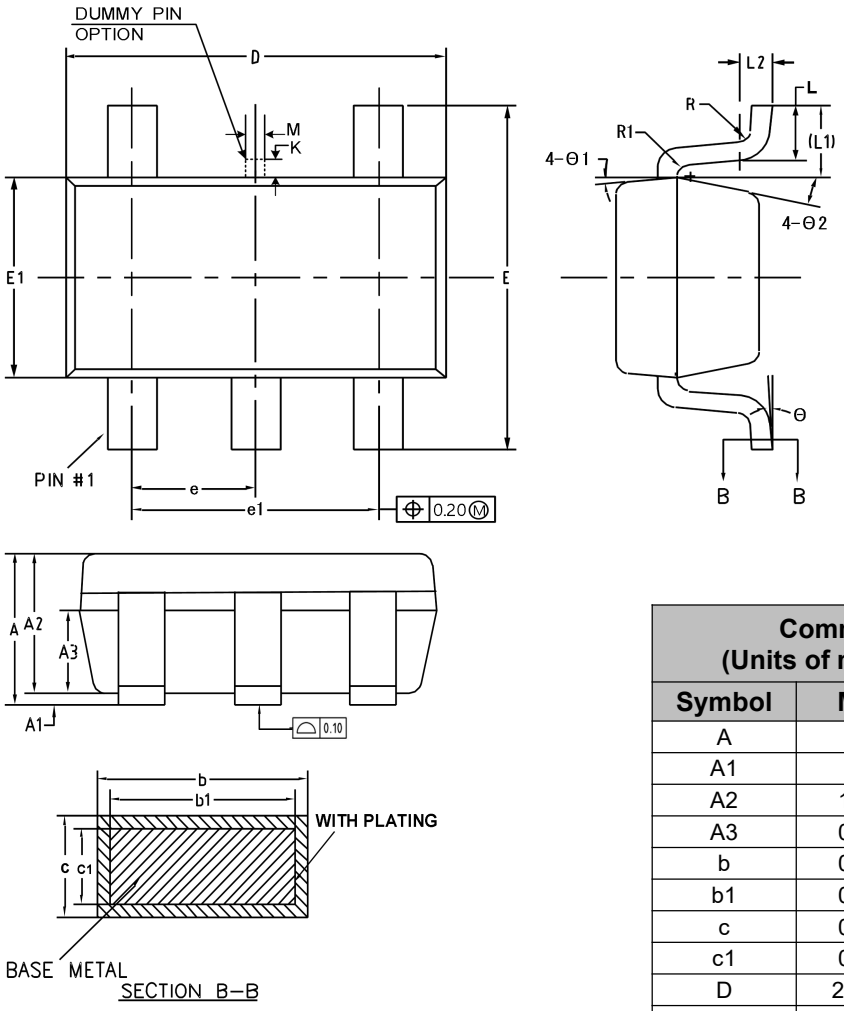
10.2. SOT23-5



Common Dimensions (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	-	0.45
b1	0.35	0.38	0.41
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
K	0	-	0.25
L	0.30	0.40	0.60
L1	0.59 REF		
L2	0.25 BSC		
M	0.10	0.15	0.25
R	0.05	-	0.20
R1	0.05	-	0.20
θ	0°	-	8°
θ1	8°	10°	12°
θ2	10°	12°	14°

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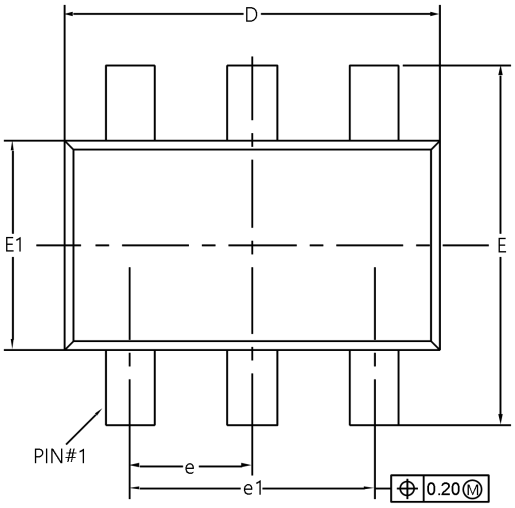
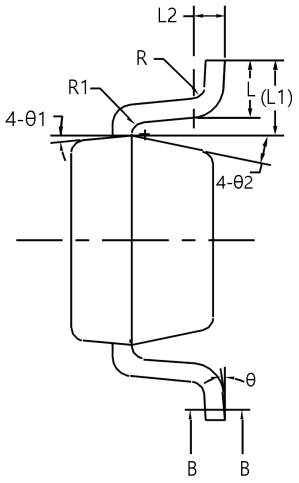
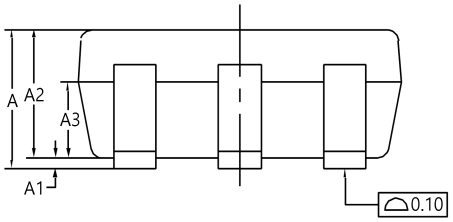
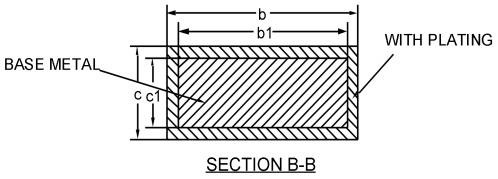
10.3. SOT23-6









Common Dimensions (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	0.34	-	0.45
b1	0.34	0.38	0.41
c	0.12	-	0.20
c1	0.12	0.15	0.16
D	2.826	2.926	3.026
E	2.60	2.80	3.00
E1	1.526	1.626	1.700
e	0.90	0.95	1.00
e1	1.80	1.90	2.00
L	0.30	0.40	0.60
L1	0.59 REF		
L2	0.25 BSC		
R	0.05	-	0.20
R1	0.05	-	0.20
θ	0°	-	8°
θ1	8°	10°	12°
θ2	10°	12°	14°

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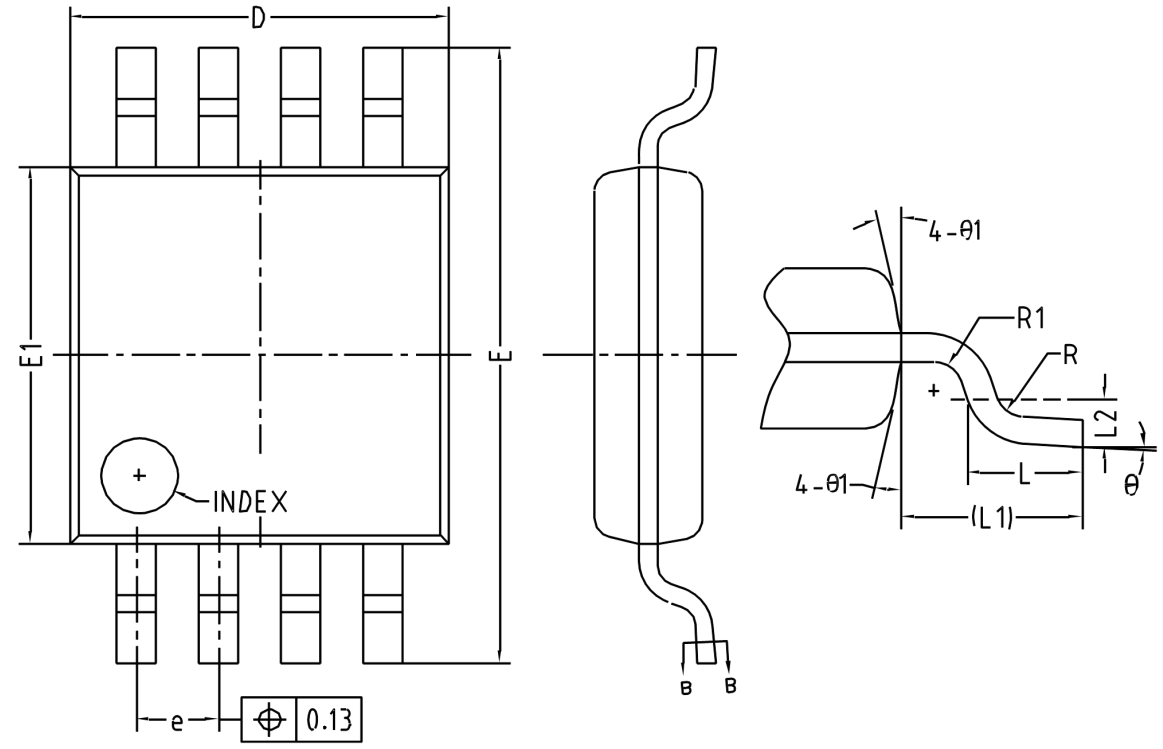
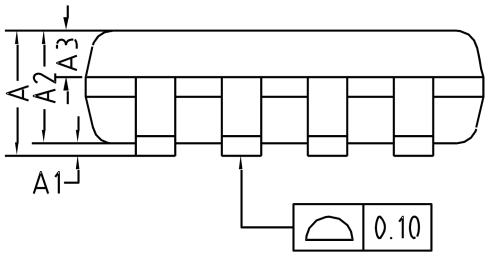
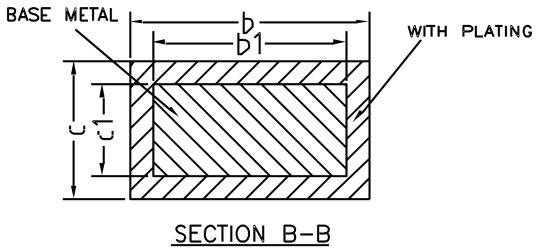
10.4. MSOP8







SECTION B-B

Common Dimensions (Units of measure = Millimeter)			
Symbol	**Min**	**Nom**	**Max**
A	-	-	1.10
A1	0.05	0.10	0.15
A2	0.75	0.85	0.95
A3	0.30	0.35	0.40
b	0.25	-	0.38
b1	0.24	0.30	0.33
c	0.15	-	0.20
c1	0.14	0.15	0.16
D	2.90	3.00	3.10
E	4.75	4.90	5.05
E1	2.90	3.00	3.10
e	0.55	0.65	0.75
L	0.40	0.55	0.70
L1	0.95 REF		
L2	0.25 BSC		
R	0.07	-	-
R1	0.07	-	-
θ	0°	-	8°
θ1	9°	12°	15°

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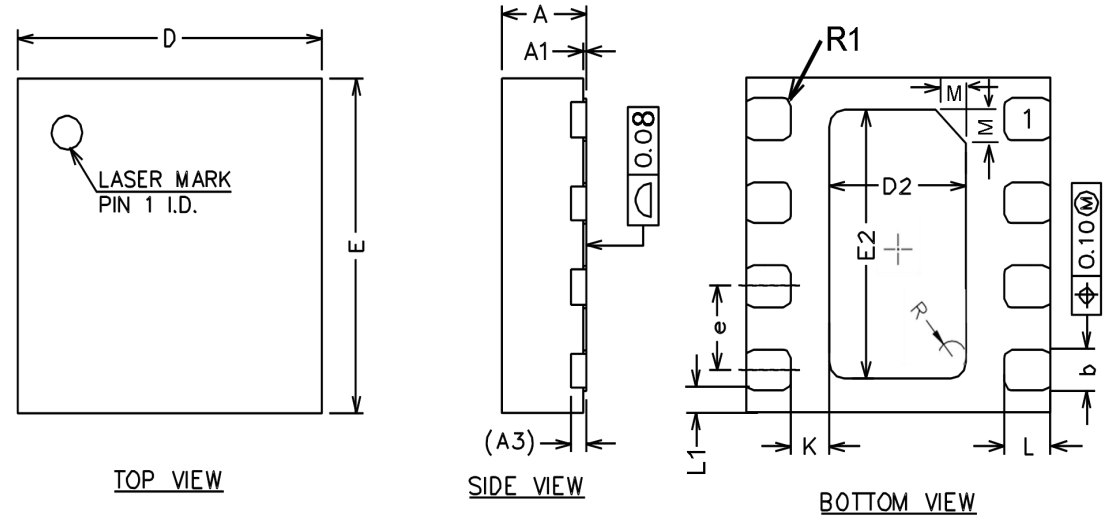
10.5. DFN2*2-8



SIDE VIEW

Common Dimensions (Units of measure = Millimeter)			
Symbol	**Min**	**Nom**	**Max**
A	0.50	0.55	0.60
A1	0.00	0.02	0.05
A3		0.127 REF	
b	0.20	0.25	0.30
D	1.95	2.00	2.05
E	1.95	2.00	2.05
D2	0.80	0.90	1.00
E2	1.50	1.60	1.70
e	0.45	0.50	0.55
K	0.15	0.25	0.35
L	0.25	0.30	0.35
L1	0.075	0.125	0.175
M		0.20 REF	
R		0.10 REF	
R1		0.05 REF	

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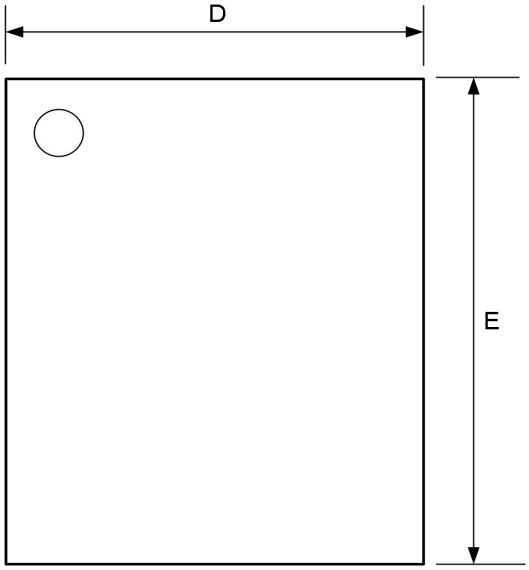
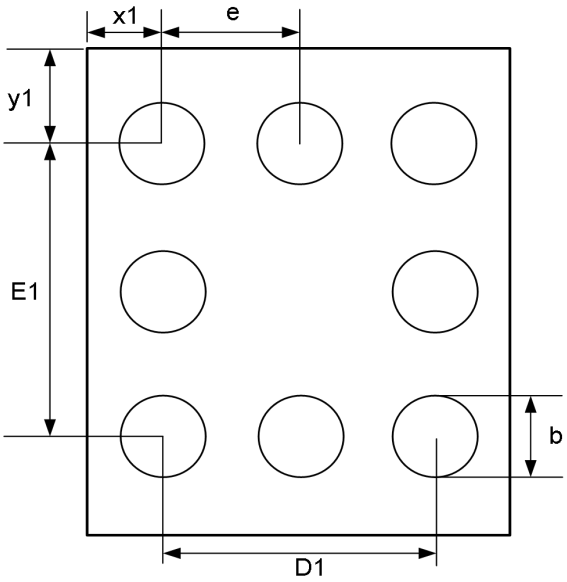
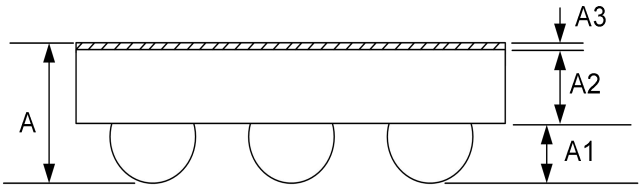
10.6. WLCSP-8



TOP VIEW



BOTTOM VIEW



SIDE VIEW

Common Dimensions (Units of measure = Millimeter)			
Symbol	**Min**	**Nom**	**Max**
A	0.5575	0.595	0.6325
A1	0.220	0.240	0.260
A2	0.3175	0.330	0.3425
A3	0.020	0.025	0.030
D	1.405	1.430	1.455
E	1.750	1.775	1.800
D1	1.000 BSC		
E1	1.000 BSC		
b	0.300	0.320	0.340
e	0.500 BSC		
x1	0.215 REF		
y1	0.3875 REF		

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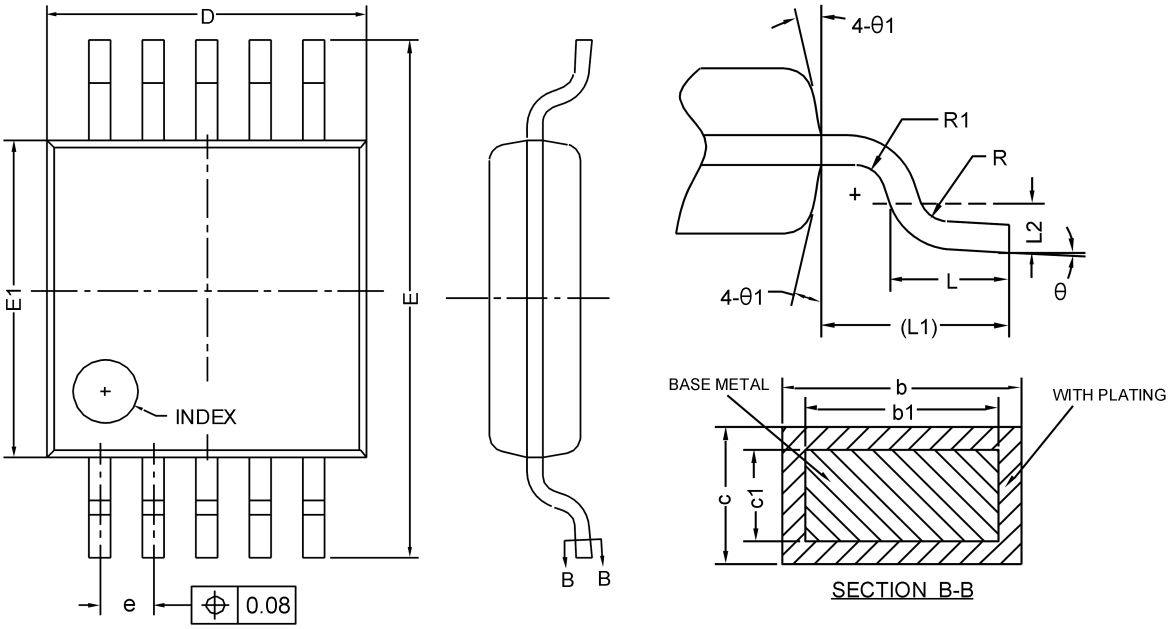
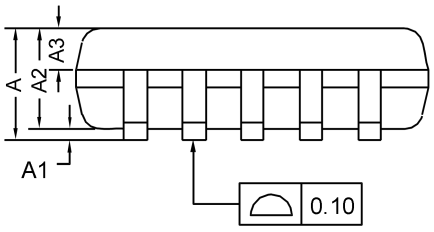
10.7. MSOP-10





Common Dimensions (Units of measure = Millimeter)			
Symbol	**Min**	**Nom**	**Max**
A	-	-	1.10
A1	0.05	0.10	0.15
A2	0.75	0.85	0.95
A3	0.30	0.35	0,40
b	0.18	-	0.27
b1	0.17	0.20	0.23
c	0.15	-	0.20
c1	0.14	0.15	0.16
D	2.90	3.00	3.10
E	4.75	4.90	5.05
E1	2.90	3.00	3.10
e	0.40	0.50	0.60
L	0.40	0.55	0.70
L1	0.95 REF		
L2	0.25 BSC		
R	0.07	-	-
R1	0.07	-	-
θ	0°	-	8°
θ1	9°	12°	15°

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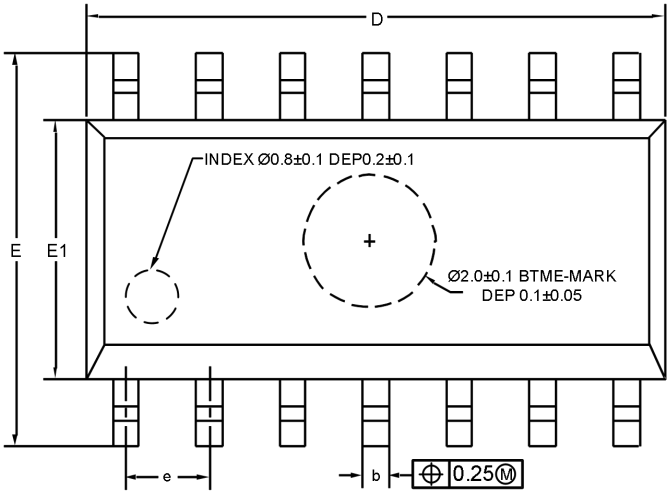
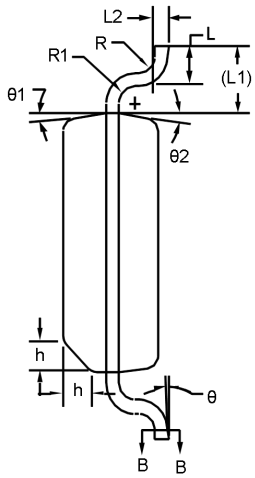
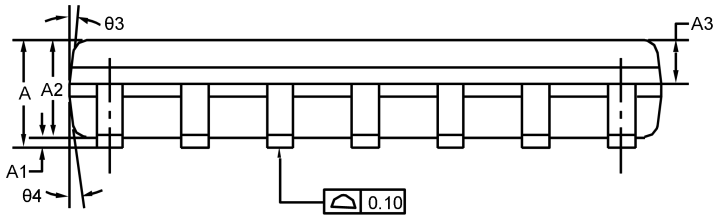
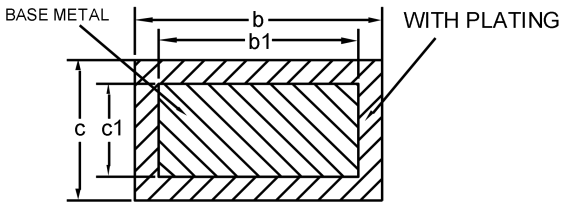
10.8. SOP-14









SECTION B-B

Common Dimensions (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°

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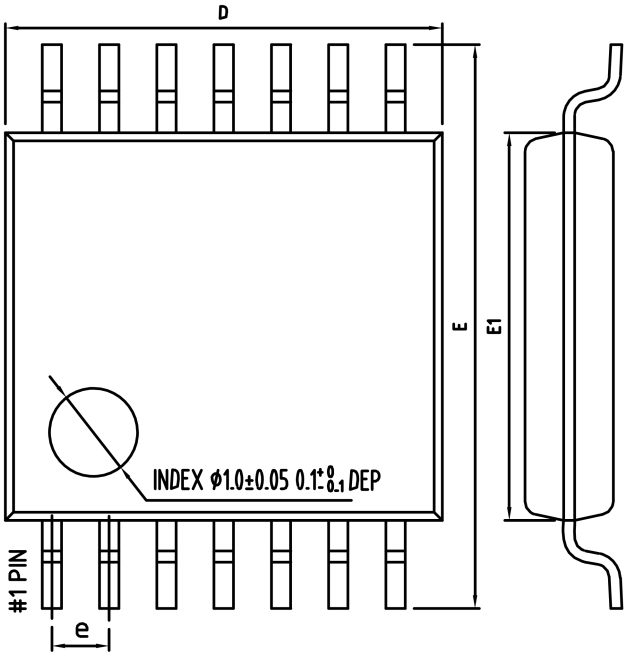
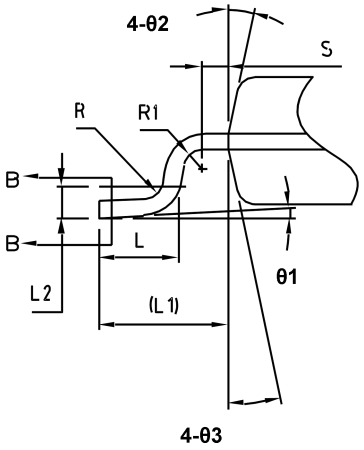
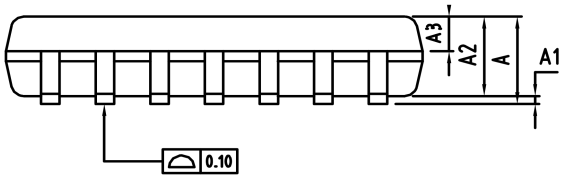
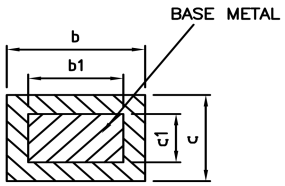
10.9. TSSOP14









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°

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