DIO2140

2.8 W, Monaural Filter-Free, Class-D Audio Amplifier

Features

- Maximum output: > 2.5 W, output under 4 Ω load
- Distortion rate (THD):
  0.05% (V_{DD} = 5.0 V, P_O = 1 W)
- High efficiency up to 83% at 400 mW
- Filter-free Class-D architecture
- Needs only three external components
- Short circuit protection function
- Thermal shutdown function
- Under voltage lockout function
- Green package: DFN-8 and MSOP-8

Descriptions

The DIO2140 is a 2.8 W high-efficiency filter-free Class-D audio amplifier, which needs only three external components. Its optimized PWM output stage eliminates the LC output filter.

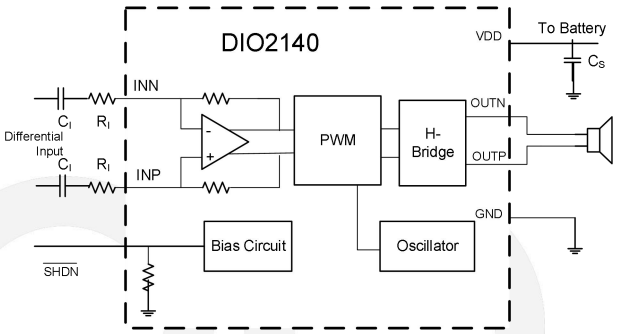
The DIO2140 features its filter-free Class-D architecture, which leads to a reduction of peripheral components amount, PCB board area, and system cost. And high efficiency of up to 90% makes it suitable for cell phones and other mobile device applications.

Moreover, the DIO2140 is also equipped with protection functions, such as a short circuit protection function for the speaker output terminal, thermal shutdown function for inside of the device, and under voltage lockout.

Applications

- Wireless or cellular handsets and PDAs
- Personal navigation devices
- General portable audio devices

Block Diagram



Ordering Information

Part Number	Top Marking	RoHS	MSL	T_A	Package	
DIO2140CD8	D2140	Green	Level-3	-40 to +85°C	DFN-8	Tape & Reel, 3000
DIO2140CM8	DIO2140	Green	Level-3	-40 to +85°C	MSOP-8	Tape & Reel, 3000

Pin Assignment

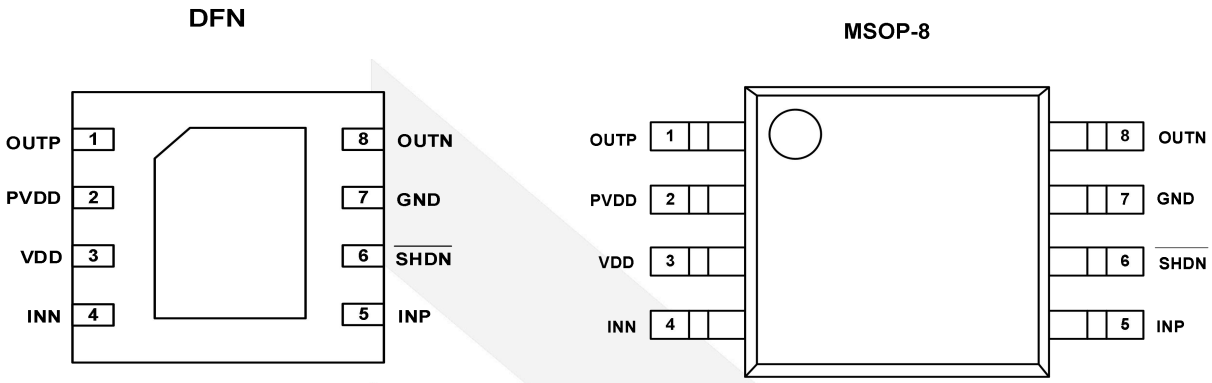


Figure 1 Pin Assignment (Top View)

Pin Descriptions

Number	Name	I/O	Function
1	OUTP	Output terminal	Positive output terminal (differential +)
2	PVDD	Power	Power supply
3	VDD	Power	Power supply
4	INN	Analog terminal	Negative input terminal (differential -)
5	INP	Analog terminal	Positive input terminal (differential +)
6	$\overline{\text{SHDN}}$	Input terminal	Shutdown terminal (active low logic)
7	GND	GND	High-current ground
8	OUTN	Output terminal	Negative output terminal (differential -)

Absolute Maximum Ratings

Stresses beyond those listed under the Absolute Maximum Rating table 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.

Symbol	Parameter		Rating	Unit
V_{DD}	Supply voltage	In active mode	-0.3 to 6	V
		In $\overline{SHDN}$ mode	-0.3 to 7	
V_I	Input voltage		-0.3 to V_{DD} + 0.3	V
T_A	Operating free-air temperature		-40 to 85	°C
T_{STO}	Storage temperature		-65 to 150	°C
Lead temperature rating			260	°C
ESD	HBM		6	kV
θ_{JA}	Package thermal resistance	DFN-8	47.9	°C/W
		MSOP-8	180	
θ_{JC}	Thermal Resistance	MSOP-8	75	

Recommend Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended Operating conditions are specified to ensure optimal performance to the datasheet specifications. Does not Recommend exceeding them or designing to Absolute Maximum Ratings.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{DD}	Power supply voltage	In package MSOP and DFN, 4 Ω load	2.5		5.5	V
T_A	Operating ambient temperature		-40		85	°C
V_{IH}	High-level input voltage	$\overline{SHDN}$	1.3		V_{DD}	V
V_{IL}	Low-level input voltage	$\overline{SHDN}$	0		0.35	V
R_I	Input resistance	Gain ≤ 20 V/V (26 dB)	15			kΩ
V_{IC}	Common mode input voltage range	V_{DD} = 2.5 V, 5.5 V, CMRR ≤ -49 dB	0.5		V_{DD} - 0.8	V
T_J	Junction temperature range		-40		125	°C

Electrical Characteristics

Typical value: T_A = 25°C, Gain = 2 V/V, R_L = 8 Ω, unless otherwise specified.

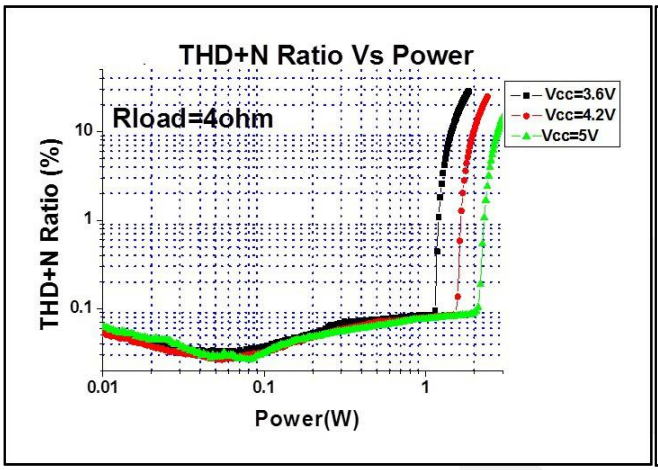
Symbol	Parameters	Conditions		Min	Typ	Max	Unit
I_Q	Quiescent current	V_{DD} = 5 V, no load			4.6	6	mA
		V_{DD} = 3.6 V, no load			3.5		mA
I_{SD}	Consumption current in shutdown mode	V_{DD} = 3.6 V, CTRL = 0 V				1	μA
V_{IH}	High-level input threshold voltage	V_{DD} = 5 V		1.2			V
V_{IL}	Low-level input threshold voltage	V_{DD} = 5 V				0.7	V
$R_{DS(ON)}$	Static drain-source on-state resistance	V_{DD} = 5 V, no load			400		mΩ
		V_{DD} = 3.6 V, no load			500		
		V_{DD} = 2.5 V, no load			700		
CMRR	Common mode rejection ratio	V_{DD} = 2.5 V to 5.25 V, V_{IC} = V_{DD}/2 to 0.5 V, V_{IC} = V_{DD}/2 to V_{DD} – 0.8 V			-88	-49	dB
PSRR	Power supply rejection ratio	V_{DD} = 2.5 V to 5.25 V			-75	-55	dB
f_{SW}	Switching frequency	V_{DD} = 2.5 V to 5.25 V		650	750	800	kHz
A_V	Gain	V_{DD} = 2.5 V to 5.25 V		$\frac{285k\Omega}{R_I}$	$\frac{300k\Omega}{R_I}$	$\frac{315k\Omega}{R_I}$	$\frac{V}{V}$
	Resistance from shutdown to GND				300		kΩ
$\|V_{OS}\|$	Output offset voltage	V_I = 0 V, A_V = 2 V/V, V_{DD} = 2.5 V to 5.25 V			1	10	mV
P_O	Output power	THD + N = 10%, f = 1 kHz, R_L = 4 Ω,	V_{DD} = 5 V		2.8		W
			V_{DD} = 3.6 V		1.45		
			V_{DD} = 2.5 V		0.52		
		THD + N = 1%, f = 1 kHz, R_L = 4 Ω,	V_{DD} = 5 V		2.08		W
			V_{DD} = 3.6 V		1.16		
			V_{DD} = 2.5 V		0.42		
		THD + N = 10%, f = 1 kHz, R_L = 8 Ω,	V_{DD} = 5 V		1.7		W
			V_{DD} = 3.6 V		0.86		
			V_{DD} = 2.5 V		0.33		
		THD + N = 1%, f = 1 kHz, R_L = 8 Ω,	V_{DD} = 5 V		1.19		W
			V_{DD} = 3.6 V		0.69		
			V_{DD} = 2.5 V		0.28		
THD+N	Total harmonic distortion + noise	V_{DD} = 5 V, P_O = 1 W, R_L = 8 Ω, f = 1 kHz			0.07		%

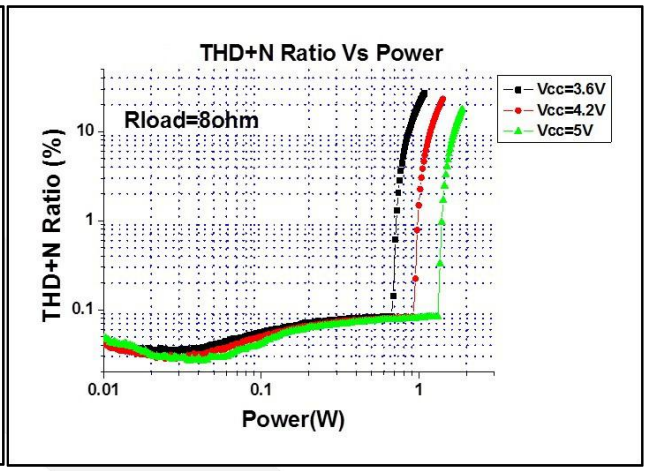
		V_{DD} = 3.6 V, P_O = 0.5 W, R_L = 8 Ω, f = 1 kHz			0.08		%
		V_{DD} = 2.5 V, P_O = 200 mW, R_L = 8 Ω, f = 1 kHz			0.10		%
η	Efficiency	P_O = 1 W, R_L = 8 Ω, f = 1 kHz			86		%
K_{SVR}	Supply ripple rejection ratio	V_{DD} = 3.6 V, input ac-grounded with C_I = 2 Mf, f = 217 Hz, $V_{(RIPPLE)}$ = 200 mV_{PP}			-87		dB
SNR	Signal-to-noise ratio	V_{DD} = 5 V, P_O = 1 W, R_L = 8 Ω			97		dB
V_n	Output voltage noise	V_{DD} = 3.6 V, f = 20 Hz to 20 kHz, inputs ac-grounded with C_I = 2 μF	Noweighting		48		$μV_{RMS}$
			A -weighting		36		
Z_I	Input impedance			142	150	158	kΩ
	Start-up time from shutdown	V_{DD} = 3.6 V			1		mS

Specifications subject to change without notice.

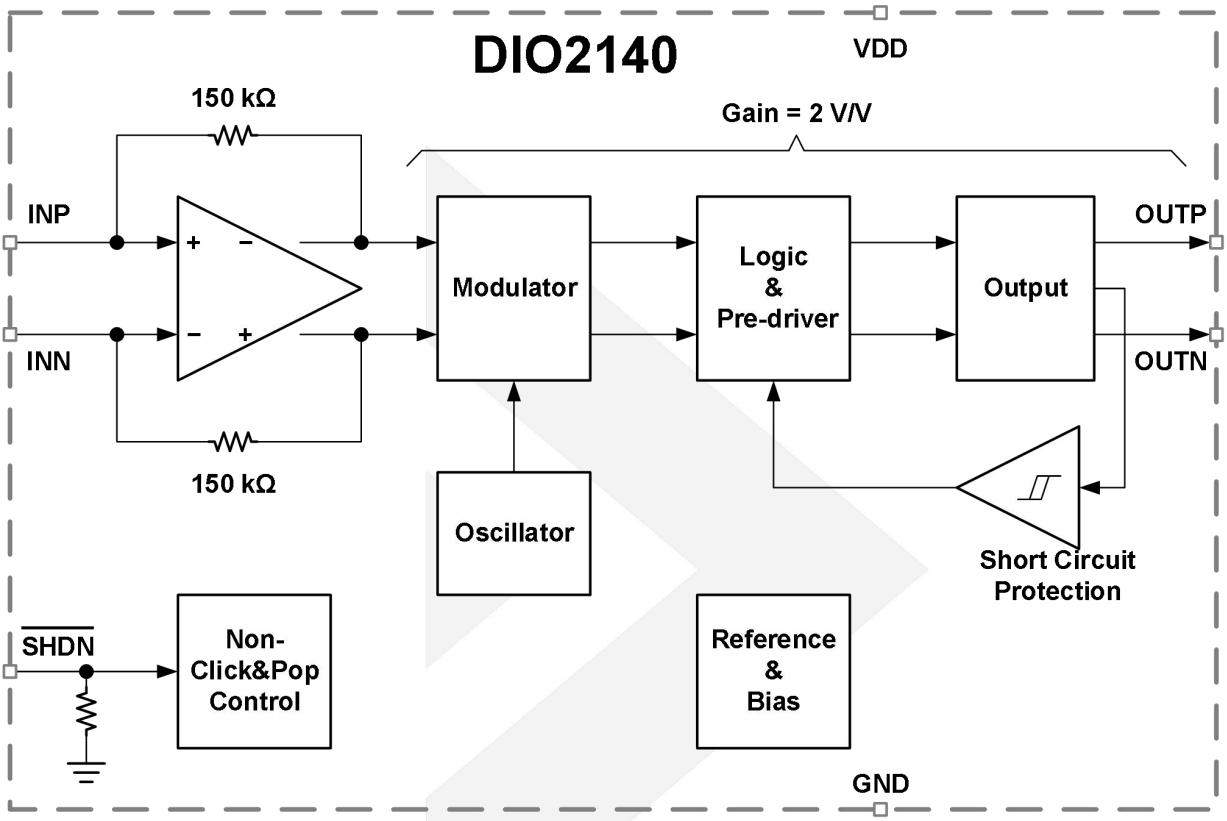
Typical Performance Characteristics

All typical value: T_A = 25°C, Gain = 2 V/V, unless otherwise specified.





Block Diagram



Application Information

Fully Differential Amplifier

The DIO2140 is a fully differential amplifier with differential inputs and outputs. The fully differential amplifier consists of a differential amplifier and a common-mode amplifier. The differential amplifier ensures that the amplifier outputs a differential voltage that is equal to the differential input times the gain. The common-mode feedback ensures that the common-mode voltage at the output is biased around $V_{DD}/2$ regardless of the common-mode voltage at the input. The fully differential DIO2140 can still be used with a single-ended input; however, the DIO2140 should be used with differential inputs when the device in a noisy environment, like a wireless handset, to ensure maximum noise rejection.

Advantages of Fully Differential Amplifiers

-Output-coupling capacitors are not required
-Mid-supply bypass capacitor not required
-Better RF-immunity

Analog signal input

For a differential input, input signals to P and N pins via DC-cut capacitors (C_I). And, with an input impedance of 150 kΩ (typ.), a lower cut-off frequency of an input signal becomes 32.1 Hz at C_I = 33 nF.

For a signal-ended input, input a signal to P via a DC-cut capacitor (C_I). At this time, N pin should be connected to AVSS via a DC-cut capacitor (C_I) with the same capacitance. Gain and a lower Cut-off frequency are the same as in the above case.In addition, the output impedance (Z_{OUT}) of the former source circuit, including signal paths up to P terminal and N terminal should be designed to become 600 Ω or lower.

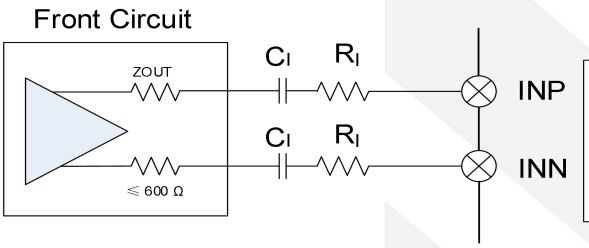


Figure 2. Differential input with coupling capacitors

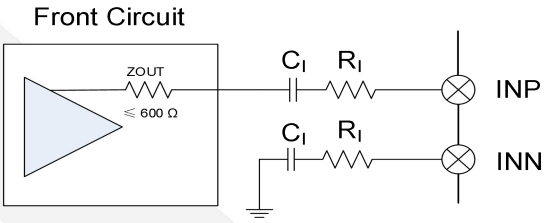
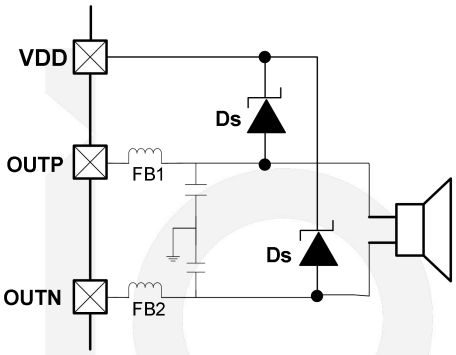


Figure 3. Single input with coupling capacitors

REF DES	Value	EIA Size
R_I	150 kΩ (±5%)	0402
C_I	33 nF (±10%)	0201

Recommended Protection Diode

It is necessary to connect the backward diode with the output terminal to prevent IC destruction by the output self-excitation phenomenon when using it on the conditions of 4.5 V < VDD ≤ 5.25 V.



Component Selection

Figure 2 shows a DIO2140 with differential inputs and input capacitors, and Figure 3 shows a DIO2140 with single-ended inputs. Differential inputs should be used whenever possible because single-ended inputs are much more susceptible to noise.

Input Resistors (R_I)

The input resistors set the gain of the amplifier according to Equation 1.

$$Gain = \frac{2\times150k\Omega}{R_I}(\frac{V}{V}) \qquad 1$$

Resistor matching is very important in fully differential amplifiers. The balance of the output on the reference voltage depends on matched ratios of the resistors. CMRR, PSRR, and cancellation of the second harmonic distortion diminish if resistor mismatch occurs. Therefore, it is recommended to use 1% tolerance resistors or better to keep the performance optimized. Matching is more important than overall tolerance. Resistor array with 1% matching can be used with a tolerance greater than 1%.

Decoupling Capacitor (C_S)

The DIO2140 is a high-performance class-D audio amplifier that requires adequate power supply decoupling to ensure the efficiency is high and total harmonic distortion (THD) is low. For higher frequency transients, spikes, or digital hash on the line, a good low equivalent-series-resistance (ESR) ceramic capacitor, typically 1 μF, placed as close as possible to the device V_{DD} lead works best.

Input Capacitors (C_I)

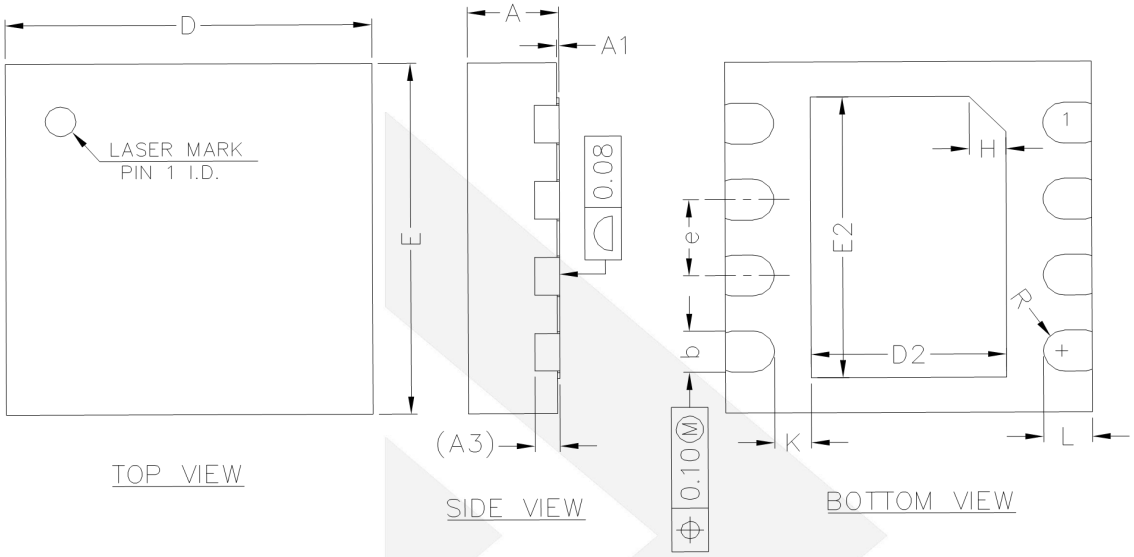
The DIO2140 does not require input coupling capacitors if the design uses a different source that is biased from 0.5 V to V_{DD} - 0.8 V. If the input signal is not biased within the recommended common-mode input range, if needing to use the input as a high pass filter, or if using a single-ended source, input coupling capacitors are required. The input capacitors and input resistors form a high-pass filter with the corner frequency, f_C, determined in Equation 2,

$$fc = \frac{1}{(2\pi R_I C_I)} \qquad 2$$

Thermal Protection Function

This is the function to establish the thermal protection mode when detecting excessive high temperature of the DIO2140 itself. In the thermal protection mode, the differential output terminal becomes Weak Low state. And when the DIO2140 gets out of such condition, the protection mode is canceled.

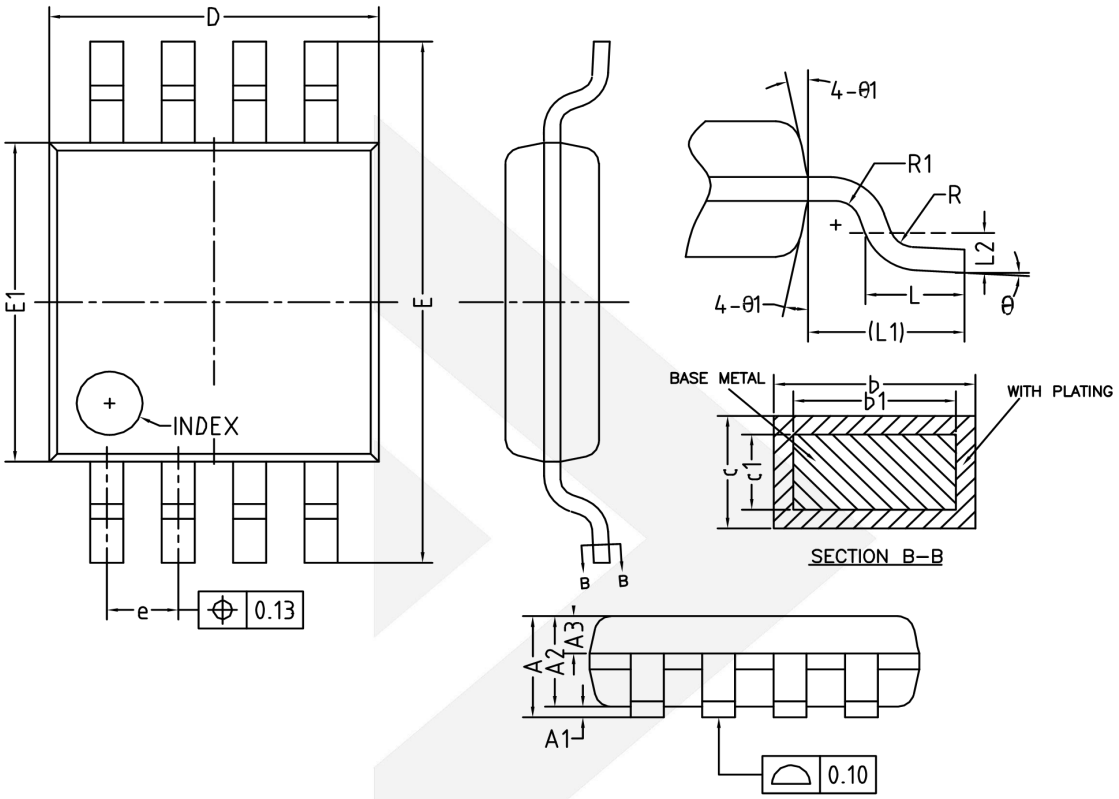
Physical Dimensions: DFN3*3-8



SIDE VIEW

Common Dimensions (Units of measure = Millimeter)			
Symbol	**Min**	**Nom**	**Max**
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A3		0.20 REF	
b	0.30	0.35	0.40
D	2.90	3.00	3.10
E	2.90	3.00	3.10
D2	1.50	1.60	1.70
E2	2.30	2.40	2.50
e	0.55	0.65	0.75
H		0.30 REF	
K	0.20	0.30	0.40
L	0.30	0.40	0.50
R	0.16	-	-

Physical Dimensions: MSOP-8



Common Dimensions (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	0.45	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°

CONTACT US

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

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