

DIO2140

2.8W, Monaural Filter-free, Class-D audio Amplifier

Features

- Maximum Output: >2.5W output under 4Ωload
- Distortion Rate (THD): 0.05% ($V_{DD}=5.0V$, $P_O=1W$)
- High Efficiency up to 83% at 400mW
- 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

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

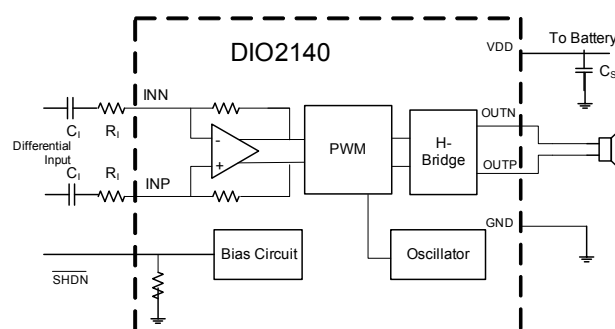
DIO2140 features its Filter-Free Class D architecture, which leads to a reduction of Peripheral components amount, PCB board area and system cost. And high efficiency up to 90% makes it suitable for cell phone and other mobile device application.

Moreover, DIO2140 is also equipped with protection functions, such as short circuit protection function for 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

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

Pin Assignment

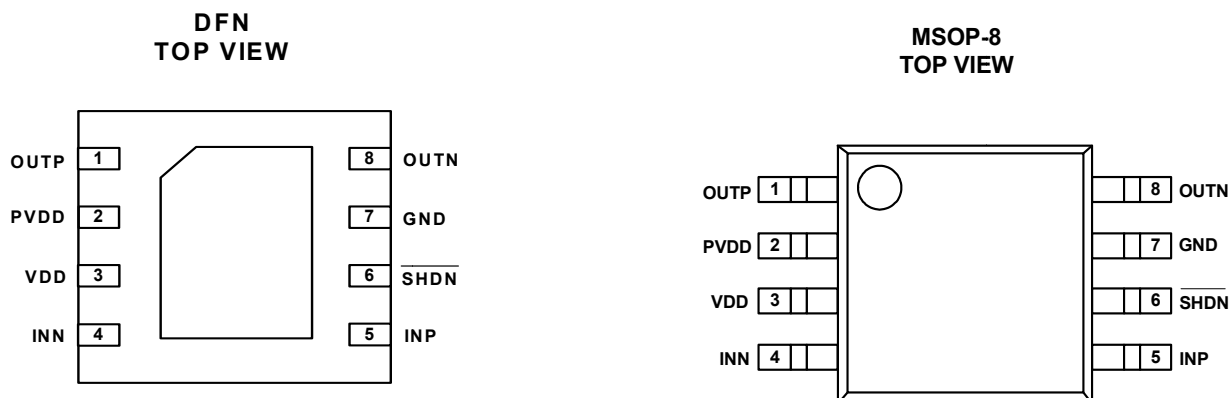


Figure 1 Pin Assignment (Top View)

Pin Descriptions

Name	I/O	Function
OUTP	Output terminal	Positive output terminal (differential +)
PVDD	Power	Power Supply
VDD	Power	Power Supply
INN	Analog terminal	Negative input terminal (differential -)
INP	Analog terminal	Positive input terminal (differential +)
SHDN	Input terminal	Shutdown terminal (active low logic)
GND	GND	High-current Ground
OUTN	Output terminal	Negative output terminal (differential -)



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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.

Parameter		Rating	Unit
Supply Voltage/ V_{DD}	In active mode	-0.3 to 6	V
	In $\overline{\text{SHDN}}$ mode	-0.3 to 7	
Input Voltage/ V_i		-0.3 to $V_{DD}+0.3$	V
Operating Free-air Temperature/ T_A		-40 to 85	°C
Storage Temperature/ T_{STO}		-65 to 150	°C
Lead Temperature Rating		260	°C
ESD	HBM	5	kV

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. DIOO does not Recommend exceeding them or designing to Absolute Maximum Ratings.

Item	Symbol	Conditions	Min	Typ	Max	Unit
Power Supply Voltage	V_{DD}	In Package MSOP and DFN, 4 Ω Load	2.5		5.5	V
Operating Ambient Temperature	T_A		-40		85	°C
High-level input voltage	V_{IH}	$\overline{\text{SHDN}}$	1.3		V_{DD}	V
Low-level input voltage	V_{IL}	$\overline{\text{SHDN}}$	0		0.35	V
Input resistance	R_i	Gain $\leq$ 20V/V(26dB)	15			k Ω
Common mode input voltage range	V_{IC}	V_{DD} =2.5V, 5.5V, CMRR $\leq$ -49dB	0.5		$V_{DD}-0.8$	V



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Electrical Characteristics

Typical value: $T_A = 25^\circ\text{C}$, Gain=2V/V, $R_L=8\Omega$, unless otherwise specified.

Symbol	Parameters	Conditions	Min	Typ.	Max	Unit
I_Q	Consumption Current, i.e. Quiescent Current	$V_{DD}=5V$, no load		4.6	6	mA
		$V_{DD}=3.6V$, no load		3.5		mA
I_{SD}	Consumption Current in Shutdown Mode	$V_{DD}=3.6V$, CTRL=0V			1	μA
V_{IH}	High-level Input threshold voltage	$V_{DD}=5V$	1.2			V
V_{IL}	Low-level Input threshold voltage	$V_{DD}=5V$			0.7	V
$R_{DS(ON)}$	Static drain-source on-state resistance	$V_{DD}=5V$, no load		400		m Ω
		$V_{DD}=3.6V$, no load		500		
		$V_{DD}=2.5V$, no load		700		
CMRR	Common Mode Rejection Ratio	$V_{DD}=2.5V$ to $5.25V$, $V_{IC}=V_{DD}/2$ to $0.5V$, $V_{IC}=V_{DD}/2$ to $V_{DD} - 0.8V$		-88	-49	dB
PSRR	Power Supply Rejection Ratio	$V_{DD}=2.5V$ to $5.25V$		-75	-55	dB
f_{SW}	Switching Frequency	$V_{DD}=2.5V$ to $5.25V$	650	750	800	kHz
A_V	Gain	$V_{DD}=2.5V$ to $5.25V$	$\frac{285k\Omega}{R_1}$	$\frac{300k\Omega}{R_1}$	$\frac{315k\Omega}{R_1}$	$\frac{V}{V}$
	Resistance from shutdown to GND			300		k Ω
$ V_{OS} $	Output Offset Voltage	$V_I=0V$, $A_V=2V/V$, $V_{DD}=2.5V$ to $5.25V$		1	10	mV
P_O	Output power	THD+N=10%, $f=1\text{kHz}$, $R_L=4\Omega$,	$V_{DD}=5V$		2.8	W
			$V_{DD}=3.6V$		1.45	
			$V_{DD}=2.5V$		0.52	
		THD+N=1%, $f=1\text{kHz}$, $R_L=4\Omega$,	$V_{DD}=5V$		2.08	W
			$V_{DD}=3.6V$		1.16	
			$V_{DD}=2.5V$		0.42	
		THD+N=10%, $f=1\text{kHz}$, $R_L=8\Omega$,	$V_{DD}=5V$		1.7	W
			$V_{DD}=3.6V$		0.86	
			$V_{DD}=2.5V$		0.33	



DIO2140

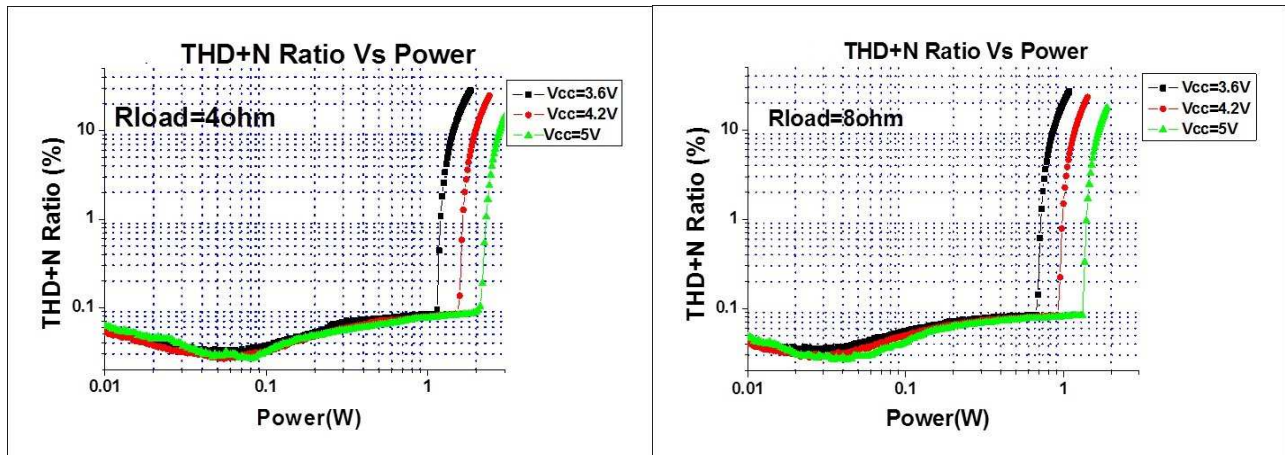
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		THD+N=1%, f=1kHz, $R_L=8\Omega$,	$V_{DD}=5V$		1.19		W
			$V_{DD}=3.6V$		0.69		
			$V_{DD}=2.5V$		0.28		
THD+N	Total harmonic distortion + Noise	$V_{DD}=5V$, $P_O=1W$, $R_L=8\Omega$, f=1kHz			0.07		%
		$V_{DD}=3.6V$, $P_O=0.5W$, $R_L=8\Omega$, f=1kHz			0.08		%
		$V_{DD}=2.5V$, $P_O=200mW$, $R_L=8\Omega$, f=1kHz			0.10		%
η	Efficiency	$P_O=1W$, $R_L=8\Omega$, f=1kHz			86		%
K_{SVR}	Supply ripple rejection ratio	$V_{DD}=3.6V$, Input ac-grounded with $C_i=2\mu F$, f=217Hz, $V_{(RIPPLE)}=200mV_{PP}$			-87		dB
SNR	Signal-to-noise ratio	$V_{DD}=5V$, $P_O=1W$, $R_L=8\Omega$			97		dB
V_n	Output voltage noise	$V_{DD}=3.6V$, f=20Hz to 20kHz, Inputs ac-grounded with $C_i=2\mu F$	No weighting		48		μV_{RMS}
			A-weighting		36		
Z_i	Input impedance			142	150	158	k Ω
	Start-up time from shutdown	$V_{DD}=3.6V$			1		mS

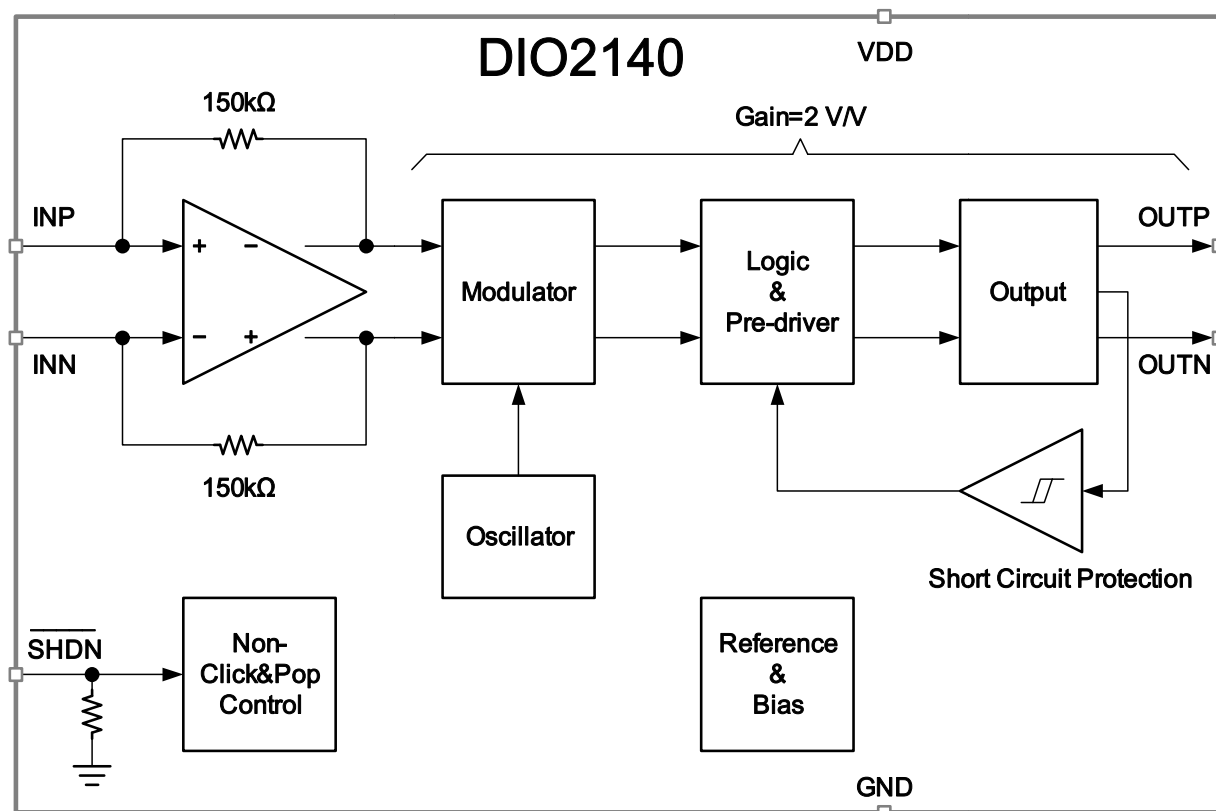
Specifications subject to change without notice.

Typical Performance Characteristics

All typical value: $T_A = 25^\circ C$, Gain=2V/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 on the output 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 in a noisy environment, like a wireless handset, to ensure maximum noise rejection.

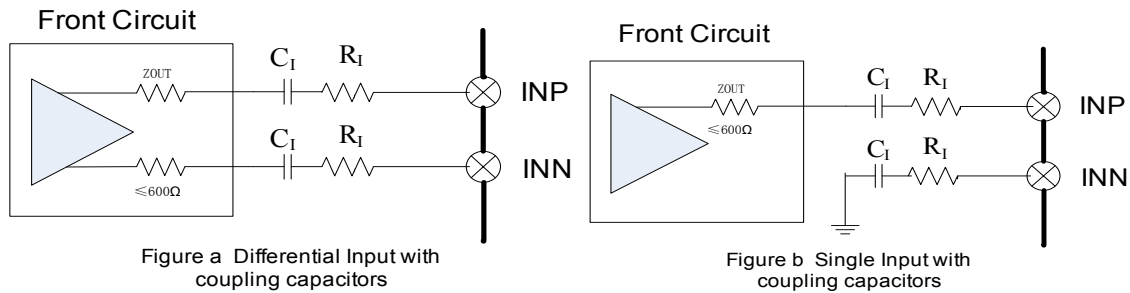
Advantages of Fully Differential Amplifiers

- 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 $150k\Omega$ (typ.), a lower cut-off frequency of an input signal becomes 32.1Hz at $C_I=33\text{nF}$.

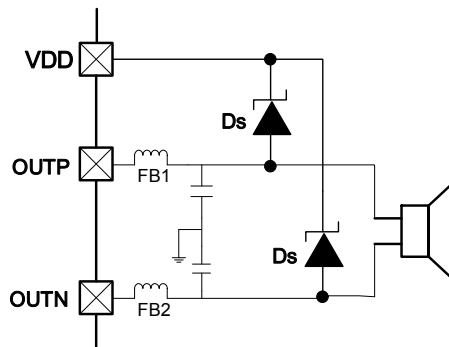
For a signal-ended input, input a signal to P via a DC-cut capacitor (C_I). At this time, N pin should be connected to AVSS via a DC-cut capacitor (C_I) with the same capacitance. Gain and a lower Cut-off frequency are the same as the above case. In addition, the output impedance (Z_{out}) of the former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



REF DES	Value	EIA Size
R_I	$150k\Omega(\pm 5\%)$	0402
C_I	$33\text{nF}(\pm 10\%)$	0201

Recommended Protection Diode

It is necessary to connect backward diode with the output terminal to prevent IC destruction by the output self-excitation phenomenon when using it on the conditions of $4.5\text{V} < V_{DD} \leq 5.25\text{V}$.





DIO2140

Component Selection

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

Input Resistors (R_I)

The input resistors set the gain of the amplifier according to the below equation.

$$Gain = \frac{2 \times 150k\Omega}{R_I} \left(\frac{V}{V} \right)$$

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 μ F, 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 differential source that is biased from 0.5V to $V_{DD} - 0.8V$. 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 below equation,

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

Thermal Protection function

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



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