36VPP OUTPUT PIEZO SOUNDER DRIVER WITH SELF-EXCITATION MODE

Description

The DIODES™ PAM8906 is a piezoelectric sounder driver with built-in boost converter, capable of driving a piezo sounder with up to 36V_{PP} output. With integrated boost converter, the PAM8906 can provide an optimized solution with higher Sound Pressure Level (SPL) for louder output sound, and lower quiescent current along with auto turn-on/off feature for extended battery runtime. PAM8906 provides clear benefits for battery-operated piezoelectric sounder or alarm related applications.

With the integrated boost converter and unique piezo sounder driver technology, PAM8906 provides small inrush current, low EMI and yet delivers high system efficiency. The integrated boost converter switches at a fixed frequency of 1.8MHz and as a result, it can operate with a small 0.47µH inductor.

The PAM8906 comes in three different Output Voltage (V_{OUT}) options: 10V, 12V, and 18V.

The PAM8906 can operate with an external PWM input or operate in self-excitation mode (only 10V and 12V supported in this mode) for various piezo sounder applications. It also features thermal shutdown protection, over-current protection, over-voltage protection and under-voltage-lockout protection to ensure safe system operation.

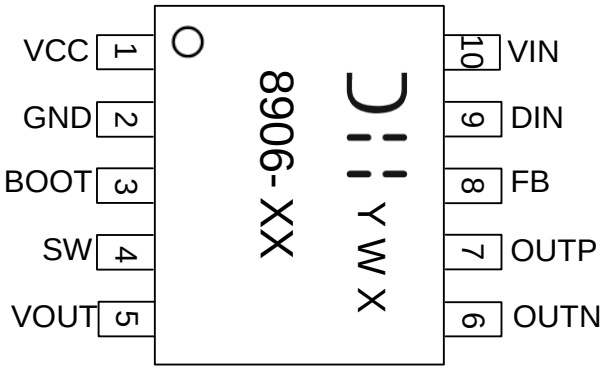
The PAM8906 is available in MSOP-10 package for smaller PCB footprint and higher SMT yield.

Features

- Supply Voltage Range from 2.1V to 5.5V
- Intergraded Boost Converter with V_{OUT} = 10V, 12V or 18V
- Automatic Shutdown and Wake-Up Control
- Support External PWM Input or Self-Excitation Mode
- Low Operating Current, with Shutdown Current < 1µA
- High-Speed Driver Designed with Very Short Turn-On/Turn-Off
- High-Impendence Output in Shutdown Mode
- Available in Space-Saving MSOP-10 Packages
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **For automotive applications requiring specific change control (i.e. parts qualified to AEC-Q100/101/104/200, PPAP capable, and manufactured in IATF 16949 certified facilities), please contact us or your local Diodes representative.**
  https://www.diodes.com/quality/product-definitions/

Pin Assignments

(Top View)



MSOP-10

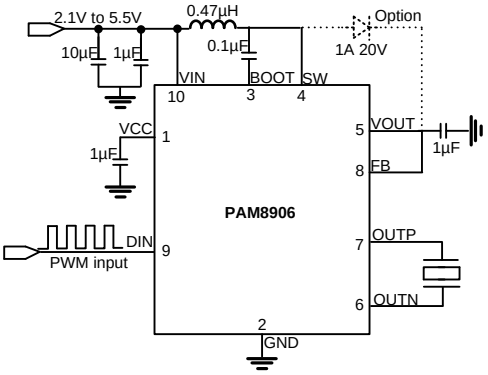
Applications

- Smoke / gas / water alarms, or industrial security alarms
- Air humidifiers or ultrasonic related piezo driver applications
- Security devices, home appliances
- Haptic feedbacks

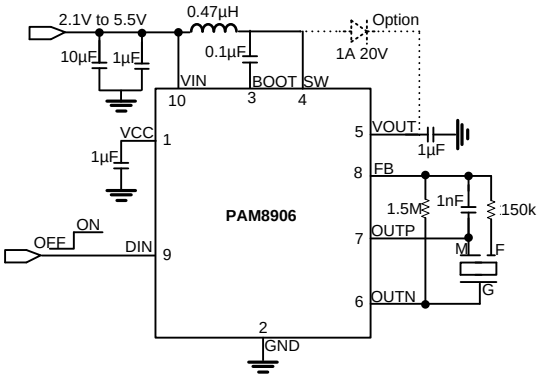
Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

Typical Application Circuits

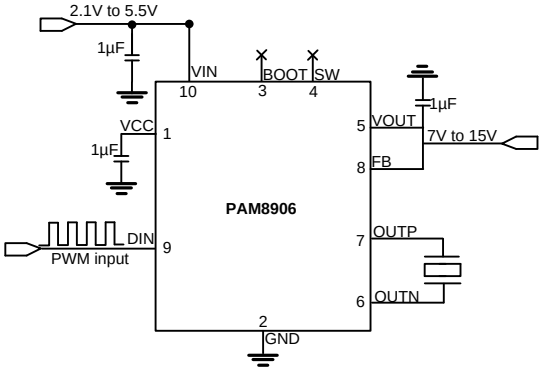
(I) External PWM Input:



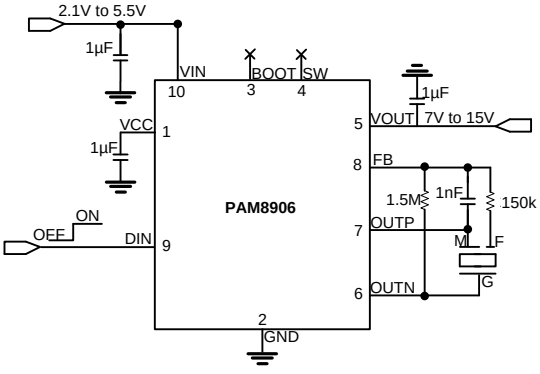
(II) Self-Excitation Mode for Applications like Smoke/Gas Alarms (10V and 12V Versions Only):



(III) 9V Battery Alarms (Showing the 10V Version):



External PWM Drive

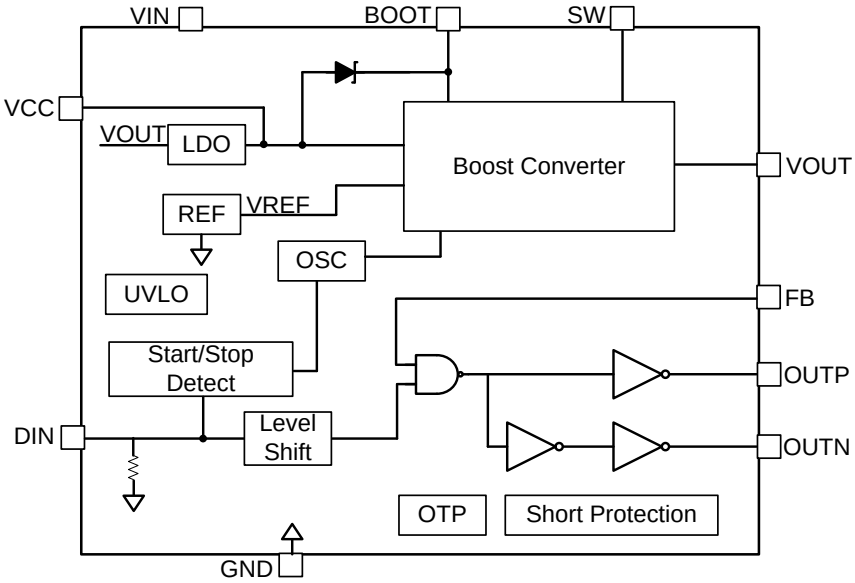


Self-Excitation Mode with DIN as High to Enable

Pin Descriptions

Pin Number	Pin Name	I/O/P	Function
1	VCC	O	Internal LDO Output
2	GND	P	Ground
3	BOOT	P	Bootstrap Capacitor Connection
4	SW	I/O	Switch Pin of the Boost Converter. Connect to External Inductor
5	VOUT	O	Boost Output
6	OUTN	O	Negative Sounder Output
7	OUTP	O	Positive Sounder Output
8	FB	I	Feedback Pin for 3 Terminal Sounder. Connect to VOUT if Using 2 Terminal Sounder
9	DIN	I	PWM Signal Input
10	VIN	I	Battery Supply Input

Functional Block Diagram



Absolute Maximum Ratings (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Value	Unit
V_{IN}	Supply Voltage	-0.3 to 6.0	V
V_{IH}	High-Level Input Voltage	-0.3 to 6.0	V
V_{IL}	Low-Level Input Voltage	-0.3 to 6.0	V
OUTP, OUTN, V_{OUT}	High Voltage Pins	-0.3 to 25	V
T_A	Operating Free-Air Temperature Range	-40 to +125	°C
T_J	Operating Junction Temperature Range	-40 to +150	°C
T_{STG}	Storage Temperature Range	-65 to +150	°C

Thermal Information

Parameter	Symbol	Package	Maximum	Unit
Thermal Resistance (Junction to Ambient)	θ_{JA}	MSOP-10	104	°C/W
Thermal Resistance (Junction to Case)	θ_{JC}	MSOP-10	16	°C/W

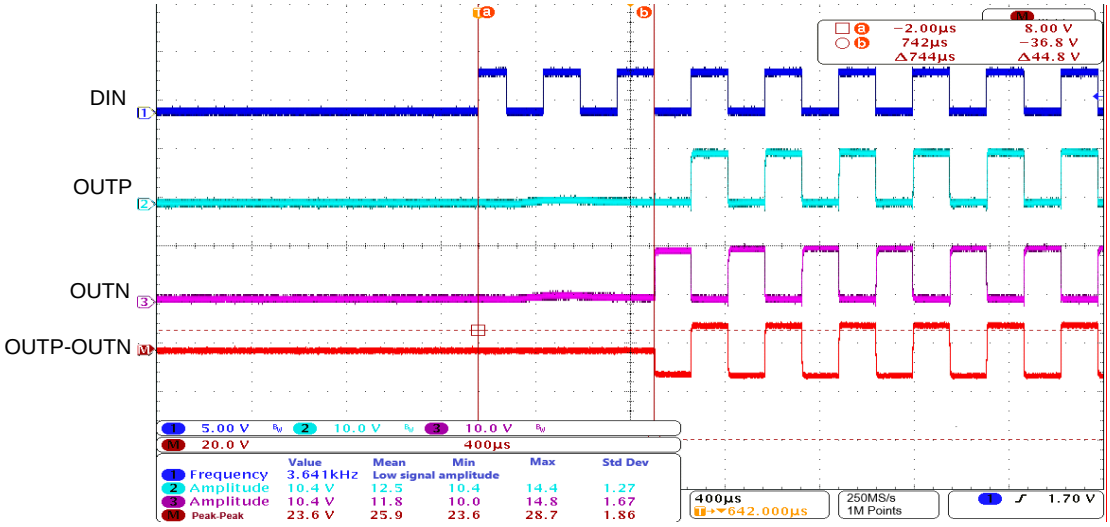
Electrical Characteristics (@T_A = +25°C, V_{IN} = 3.0V, C_{PIEZO} = 33nF, f_{DIN} = 3.2kHz, unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{IN}	Supply Voltage	—	2.1	—	5.5	V
V_{OUT}	Boost Output Voltage	Three Options	—	10/12/18	—	V
I_{DD1}	Operating Current 1	C_{PIEZO} = No Load, f_{DIN} = 3.2kHz, V_{OUT} = 12V	—	1.3	—	mA
I_{DD2}	Operating Current 2 (Note 4)	C_{PIEZO} = 33nF, f_{DIN} = 3.2kHz, V_{OUT} = 12V	—	27	—	mA
I_{SD}	Shutdown Current	V_{DIN} = 0V	—	0.01	1	μA
f_{DIN}	Piezo Input Signal Frequency (Note 5)	—	0.2	—	10	kHz
C_{Load}	Max Piezo Loading	—	—	—	150	nF
f_{OSC}	Boost Switching Frequency	—	—	1.8	—	MHz
I_{OCP}	Cycle-by-Cycle Over Current Protection	—	—	1	—	A
$R_{DS(ON)}$	Piezo Driver On-State Resistance	High Side, I = 100mA	—	7.5	—	Ω
		Low Side, I = 100mA	—	3	—	Ω
t_{ON}	VOUT Start Delay Time	From DIN Signal High to 90% V_{OUT} Steady State	—	770	—	μs
t_{OFF}	Shutdown Delay Time	From DIN = H- > L, V_{OUT} to GND	—	100	—	ms
V_{IH}	Control Terminal Voltage H	DIN Pin	1.5	—	V_{IN}	V
V_{IL}	Control Terminal Voltage L	DIN Pin	0	—	0.4	V
I_{IH}	Control Terminal Current H	DIN = V_{IN}	—	—	10	μA
I_{IL}	Control Terminal Current L	DIN = 0	—	0.01	1	μA
OTP	Over Temperature Threshold	—	—	+150	—	°C
—	Over Temperature Protection Hysteresis	—	—	+30	—	°C

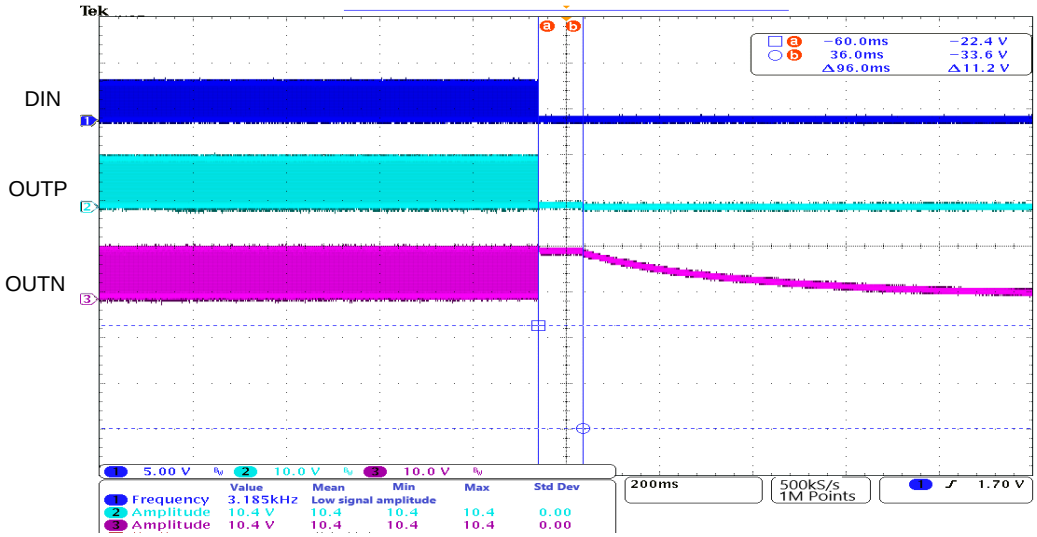
Notes: 4. Operating Current is a function of Piezo Load Capacitance and Input Frequency. With external Schottky diode, power dissipation can be reduced by 20%.
5. For Ultrasonic applications, the input frequency can be over 100kHz, but the Piezo Sounder capacitance ≤ 10nF.

Performance Characteristics (V_{DD} = 3V, f_{DIN} = 3.2kHz, V_{OUT} = 10V/12V/18V, C_{LOAD} = 33nF, unless otherwise specified.)

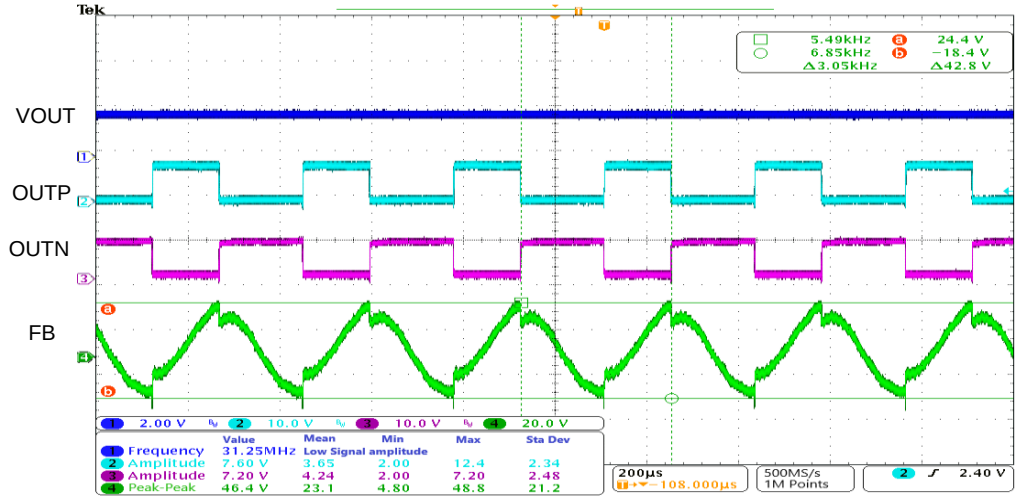
1. Turn-On Waveform



2. Turn-Off Waveform



3. Self-Excitation Waveform



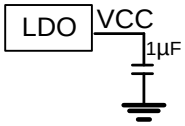
Application Information

Overview

The PAM8906 is a piezo sounder driver with integrated boost converter. This versatile device is capable of driving piezo sounder for a variety of applications, including smoke/gas alarm, air humidifier and haptic-feedback related applications. PAM8906 comes in three different Boost output voltage versions: 10V, 12V, and 18V. A typical start-up time of 770µs makes the PAM8906 an ideal piezo driver with fast response. PAM8906 has a built-in thermal overload protection, current limit and various other protection features to prevent the device from damage when overdriven.

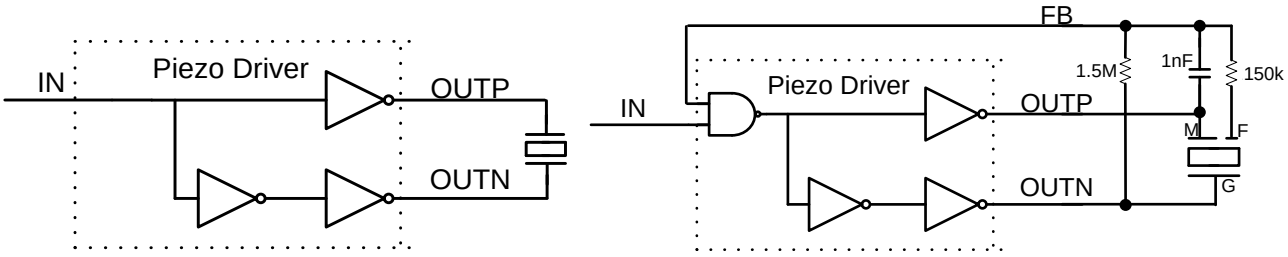
LDO Regulator

The PAM8906 has a built-in internal LDO regulator to supply 5V to the internal boost and piezo driver blocks. It is recommended to add 1µF capacitor at pin 1 VCC (LDO).



Piezo Driver

As illustrated below, PAM8906 has a built-in Piezo driver circuitry to enable easy system configuration for driving a two-terminal or three-terminal piezo sounder with few external components. For three-terminal based piezo sounder configuration (supported only by 10V and 12V versions), the external resistance might vary by piezo sounder manufacturer's suggestion. Please consult with Diodes Incorporated's technical support team or field representative for any further assistance, if necessary.



DIN Control

DIN pin serves two functions:

1. Automatic Wake-Up and Shutdown Control

   When DIN is set above V_{IH} or provided with a PWM input, PAM8906's Boost and Piezo driver block will be enabled and the Boost output will be ready in 770µs (Typ) followed by PWM output on OUTP and OUTN pins.

   When DIN is set below V_{IL} the piezo sounder driver will stop immediately.

   When DIN is set below V_{IL} for longer than 100ms (Typ), PAM8906's Boost and Piezo driver will be disabled and the device automatically enters shutdown mode. PAM8906's shutdown current is less than 1µA under this mode.

2. External PWM Control

   For external PWM configuration, DIN pin also serves as the PWM input pin. In this configuration, PWM input is amplified and driven to OUTP and OUTN pins.

Application Information (continued)

Boost Regulator

The PAM8906 boost regulator employs conventional current-mode control methodology with the following features:

- **Under-Voltage Lockout (UVLO)**: When the Boost power supply VIN drops below UVLO value (1.5V Typ), the Boost regulator will be switched off.
- **Over Temperature Protection (OTP)**: When PAM8906 die temperature is higher than OTP threshold (+150°C Typ), the Boost regulator will be switched off. Hysteresis is set at +30°C.
- **VOUT Under-Voltage (UV) Protection:** When the Boost regulator output voltage is lower than the pre-set threshold, it will trigger VOUT UV protection, and the device will go to hiccup mode in order to reduce power supply current.
- **VOUT Over-Voltage (OV) Protection:** When the Boost regulator output voltage is higher than the pre-set threshold, it will trigger VOUT OV protection, and the device will switch off until VOUT OV condition is removed.
- **Soft-Start:** The Boost regulator has a typical soft-start time of 770μs. Soft-start helps to reduce in-rush currents and voltage over-shoot at start-up.
- **Over Current Protection (OCP)**: The Boost regulator has a built-in cycle-by-cycle over-current protection.

PAM8906 has designed the boost regulator as current-mode controller with two control loops, which work together in maintaining a constant output voltage and supply the required load current. The inner current control loop provides cycle-by-cycle current limiting, while the output control loop provides output voltage control. When the boost converter turns on with the DIN input, the NMOS switch will turn on and the inductor current ramps up to its peak value, approximately 1A nominally.

The current comparator turns off the NMOS switch for a fixed period of time to allow energy to be transferred to the output capacitor. When the voltage on the output capacitor equals or exceeds the desired output voltage, the current loop will disable until the load discharges the output capacitor to a voltage lower than the desired output voltage. Every time the output voltage falls below the desired value, the switching cycle starts and continues until the desired value is reached. The constant switching resulting in the charging and discharging of the output capacitor causes a ripple on the output voltage. The ripple on the output voltage depends on the external component parameters, such as the value of external capacitor, its ESR etc.

In PAM8906, when logic high asserted on the DIN pin, the boost regulator will be enabled. However, the Piezo driver output cannot be enabled until the output voltage reaches its nominal set point (total soft start time around 770μs). This ensures the output voltage rises quickly to the necessary drive voltage for the Piezo.

The boost regulator is optimized to work with the external components as shown in the *Typical Application Circuits*. It is crucial to select an appropriate inductor value for the Boost converter to operate efficiently with the expected transient behavior and loop stability. Typical, an inductor with saturation current rating of 2A is recommended.

The inductor selection for PAM8906 depends on the V_{IN} value and the V_{OUT} version chosen for a given application. Although minimum V_{IN} is 2.1V, if the input supply droops down to 1.8V, this can still be supported with a lower inductor value. Refer to the table below:

—	Recommend Inductor		
V_{IN} Min	L@V_{OUT} = 10V	L@V_{OUT} = 12V	L@V_{OUT} = 18V
1.8V	0.47μH	0.22μH	0.22μH
2.1V	1.0μH	0.47μH	0.47μH

Application Information (continued)

Capacitor Selection Guide

For external capacitors, use low ESR ceramic capacitors. It is strongly recommended to place them at the same layout layer as PAM8906.

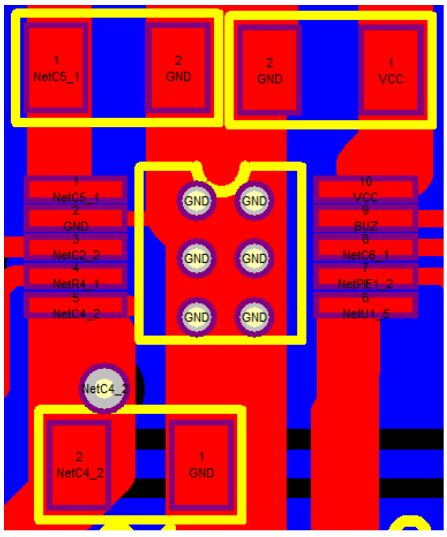
- **Power Supply Decoupling Capacitor – VIN (Pin 10)**
  Capacitor Value: 1μF + 10μF
  Voltage Rating: 3 x VIN
  Capacitor Layout: place the 1μF capacitor close to VIN (Pin 10), and 10μF close to the inductor
- **External LDO Capacitor – VCC (Pin 1)**
  Capacitor Value: 1μF
  Voltage Rating: 16V
  Capacitor Layout: place the capacitor close to VCC (Pin 1)
- **Bootstrap Capacitor – BOOT (Pin 3)**
  Capacitor Value: 0.1μF
  Voltage Rating: 25V or higher
  Capacitor Layout: place the capacitor close to BOOT (Pin 3)
- **Boost Output Capacitor – VOUT (Pin 5)**
  Capacitor Value: 1μF to 2.2μF, for smoke alarm application, if loading higher than 100nF, put a 10μF cap at the VOUT pin.
  Voltage Rating: 3 x VOUT
  Capacitor Layout: place the capacitor close to VOUT (Pin 5)

Schottky:

- This is optional.
- Place between SW and VOUT.
- Schottky diode can help to reduce power consumption by approximately 20%.
- Use a 20V Schottky with 1A or greater current rating.

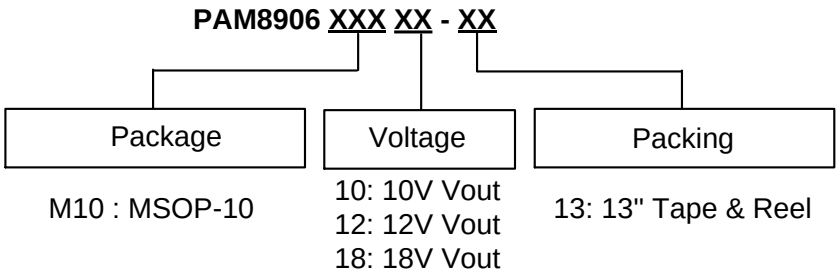
GND Layout Guideline

The GND layout is very important for PAM8906 to operate under optimal conditions. Suggested ground layout is illustrated below. Please consult with Diodes Incorporated's technical support team or field representative for any further assistance, if necessary.



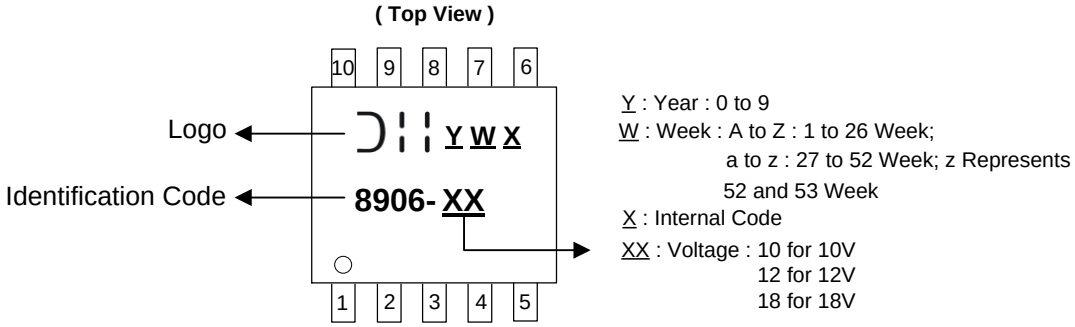
Connect GND (Pin 2) to the bottom of IC, then expand to VCC/VIN/VOUT's capacitor GND. Put more via on the other layer then connect to power GND.

Ordering Information



Part Number	Package	Voltage	Identification Code	Packing	
				Qty.	Carrier
PAM8906M1010-13	MSOP-10	10V	8906-10	2,500	13" Tape & Reel
PAM8906M1012-13	MSOP-10	12V	8906-12	2,500	13" Tape & Reel
PAM8906M1018-13	MSOP-10	18V	8906-18	2,500	13" Tape & Reel

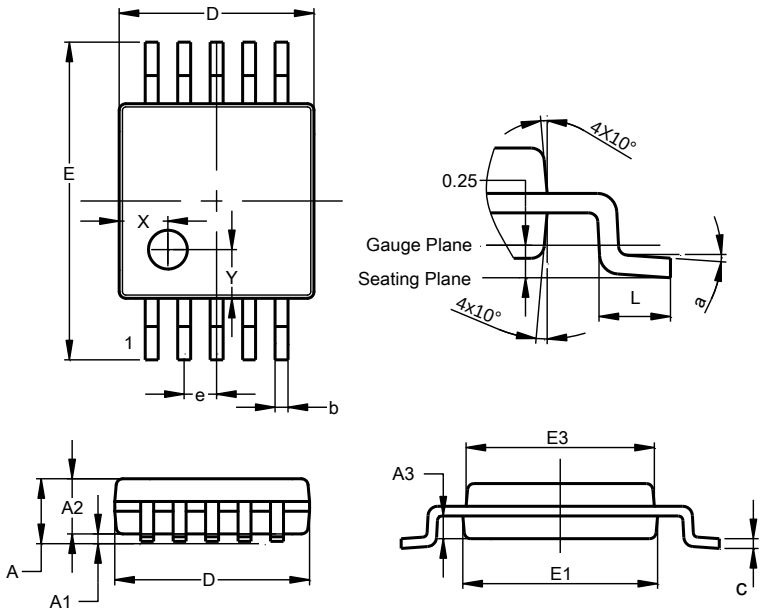
Marking Information



Package Outline Dimensions

Please see http://www.diodes.com/package-outlines.html for the latest version.

MSOP-10

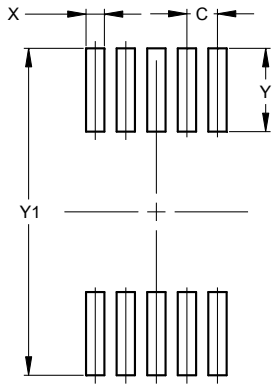


MSOP-10			
Dim	**Min**	**Max**	**Typ**
A	-	1.10	-
A1	0.05	0.15	0.10
A2	0.75	0.95	0.86
A3	0.29	0.49	0.39
b	0.17	0.27	0.20
c	0.08	0.23	0.15
D	2.95	3.05	3.00
e	-	-	0.50
E	4.80	5.00	4.90
E1	2.95	3.05	3.00
E3	2.85	3.05	2.95
L	0.40	0.80	0.60
X	--	--	0.750
Y	--	--	0.750
a	0°	8°	4°
All Dimensions in mm			

Suggested Pad Layout

Please see http://www.diodes.com/package-outlines.html for the latest version.

MSOP-10



Dimensions	Value (in mm)
C	0.50
X	0.30
Y	1.35
Y1	5.30

Mechanical Data

MSOP-10

- Moisture Sensitivity: Level 3 per J-STD-020
- Terminals: Finish – Matte Tin Plated Leads, Solderable per MIL-STD-202, Method 208 e3
- Weight: 0.026 grams (Approximate)

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