31VPP OUTPUT PIEZO SOUNDER DRIVER WITH BOOST CONVERTER

Description

The PAM8907 is a piezoelectric horn driver with built-in boost converter, capable of driving a ceramic/piezo sounder with up to 31V_{PP} output. With integrated boost converter, the PAM8907 can provide an optimized solution with higher Sound Pressure Level (SPL) for louder output sound, lower quiescent current for longer standby time, and auto turn-on/off feature for extended operating lifetime. The PAM8907 provides clear benefits for battery-operated tracker, piezoelectric horn or alarm related applications.

The PAM8907 integrates a boost converter that operates at a typical frequency of 1.8MHz. With integrated boost converter and unique piezo sounder driver technology, the PAM8907 provides small inrush current, low EMI and yet highly efficient system performance. PAM8907 boost converter output can be set to either 11V or 15.6V with minimum external components for various application usages.

The PAM8907 has built-in automatic shutdown and wake-up functions for longer operating lifetime requirement. It also features thermal shutdown protection, overcurrent protection, overvoltage protection and undervoltage lockout protection to assure safe system operation.

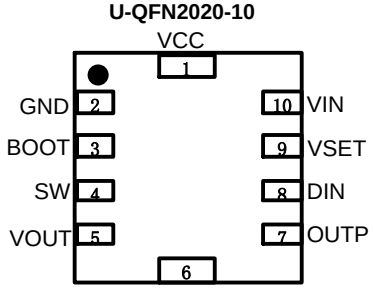
The PAM8907 is available in U-QFN2020-10 package.

Features

- Supply Voltage Range from 1.8V to 5.5V
- Intergraded Boost Converter V_{OUT} = 11V or 15.6V
- Drive Piezo Sounder with up to 31V_{PP}
- High-Speed Driver Designed with Very Short Turn-On/Turn-Off
- No Voltage Cross Output at Shutdown Mode
- High Impendence Output at Shutdown Mode
- Low Current Consumption, with Shutdown Current < 1μA
- Automatic Shutdown and Wake-Up Control
- Available in Space-Saving U-QFN2020-10 package
- **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

U-QFN2020-10

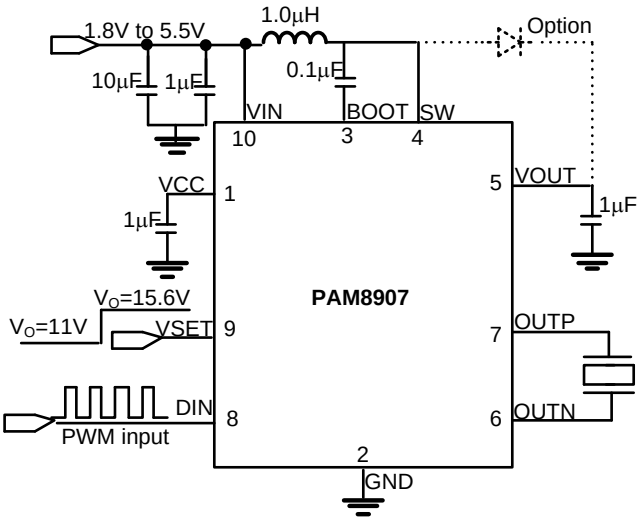


(Top View)

Applications

- Bluetooth or wireless location trackers
- Air humidifier or ultrasonic related piezo driver applications
- Security devices, home appliances
- Haptic feedbacks

Typical Applications Circuit



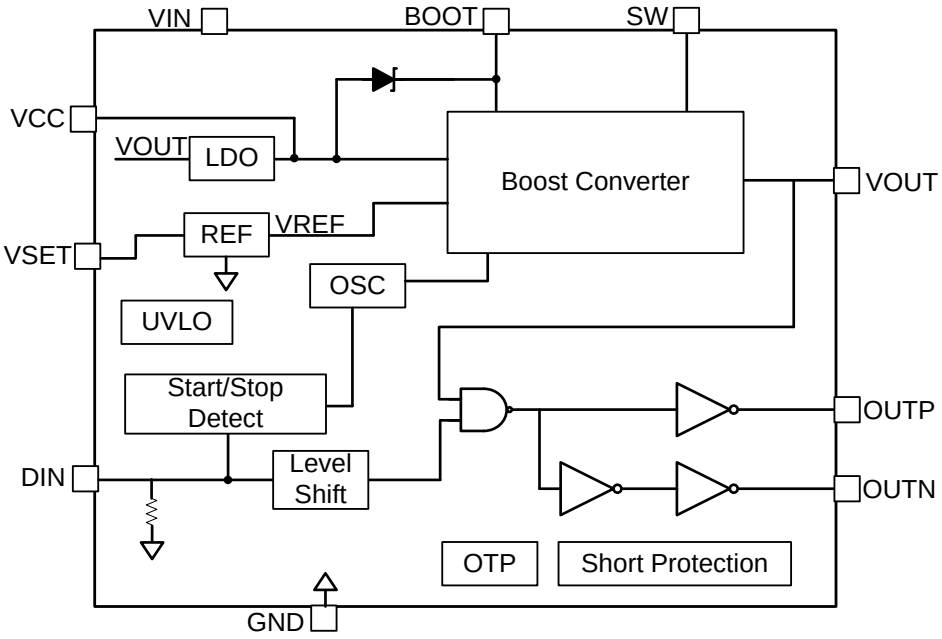
Note: Schottky diode is optional. If added, it can save 20% of power consumption.

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.

Pin Descriptions

Pin Number	Pin Name	I/O/P	Function
1	VCC	O	LDO Output
2	GND	P	Ground
3	BOOT	O	Bootstrap Cap Connection
4	SW	I/O	Switch Pin Connect with External Inductor Pin
5	VOUT	O	Boost Output
6	OUTN	O	Negative Output
7	OUTP	O	Positive Output
8	DIN	I	PWM Signal Input, then End Signal Should be “L” to Disable the Chip
9	VSET	I	TTL Low V_{OUT} = 11V, TTL High V_{OUT} = 15.6V
10	VIN	I	Battery Voltage Input
—	Epoxy Pad	P	Connect to GND

Functional Block Diagram



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

Symbol	Characteristics	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
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

Recommended Operating Conditions (@ T_A = +25°C, unless otherwise specified.)

Symbol	Characteristics		Min	Max	Unit
V_{IN}	Supply Voltage	—	1.8	5.5	V
V_{IH}	High-Level Input Voltage	DIN	1.2 to V_{IN}+ 0.3		V
V_{IL}	Low-Level Input Voltage	DIN	-0.3	0.4	V
T_A	Operating Free-Air Temperature		-40	+85	°C

Thermal Information

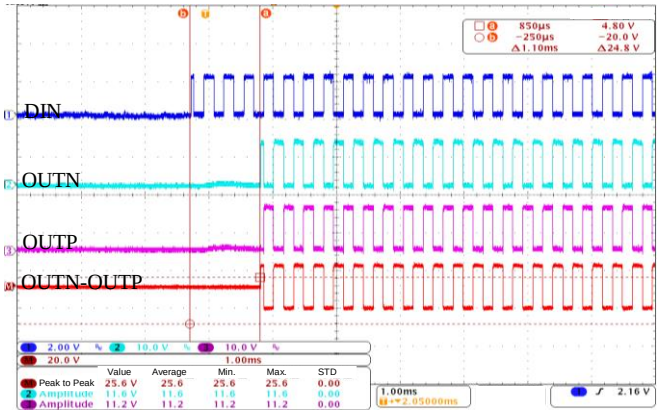
Parameter	Symbol	Package	Maximum	Unit
Thermal Resistance (Junction to Ambient)	θ_{JA}	U-QFN2020-10	68	°C/W
Thermal Resistance (Junction to Case)	θ_{JC}	U-QFN2020-10	25	°C/W

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

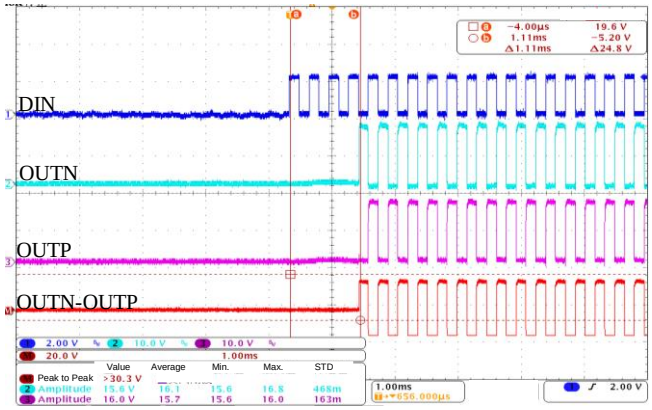
Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Supply Voltage	V_{IN}	—	1.8	—	5.5	V
Output Voltage Range	V_{OUT}	Boost Output Voltage (VSET Pin L/H)	—	11 15.6	—	V
Shutdown Current	I_{SD}	V_{DIN} = 0V	0	0.03	1	μA
Oscillating Frequency	f_{OSC}	Boost Frequency	—	1.8	—	MHz
Static Drain to Source On-State Resistor	$R_{DS(ON)}$	High Side, I = 100mA	—	7.5	—	Ω
		Low Side, I = 100mA	—	3	—	Ω
VOUT Start Delay Time	t_{ON}	From DIN Signal High to 90% V_{OUT} Steady State	—	1.1	—	ms
Shutdown Delay Time	t_{OFF}	From DIN = H- > L, V_{OUT} to GND	—	104	—	ms
Output Short-Circuit Current	I_{SC}	OUTP and OUTN short	—	14	—	mA
Control Terminal Voltage H	V_{IH}	DIN Pin	1.5	—	V_{IN}	V
Control Terminal Voltage L	V_{IL}	DIN Pin	0	—	0.4	V
Control Terminal Current H	I_{IH}	DIN = V_{IN}	—	2	10	μA
Control Terminal Current L	I_{IL}	DIN = 0	—	0.01	1	μA
Over Temperature Threshold	OTP	—	—	+150	—	°C
Over Temperature Protection Hysteresis	—	—	—	+30	—	°C

Performance Characteristics (V_{DD} = 3V, f_{DIN} = 3.2kHz, V_{SET} = L/H, C_{LOAD} = 15nF/33nF, unless otherwise specified.)

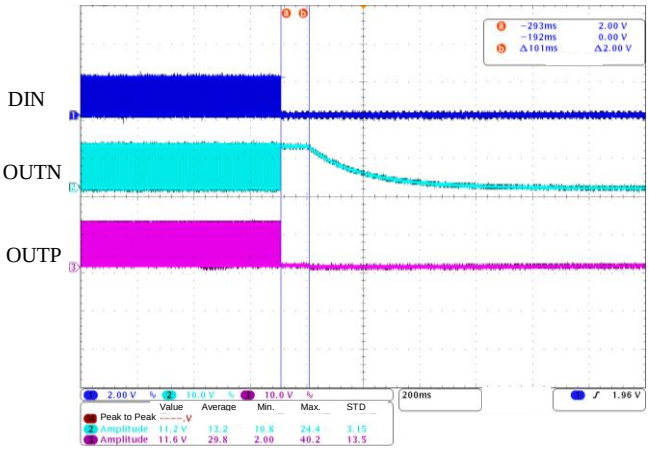
1. **Turn-on waveform at V_{OUT} = 11V**



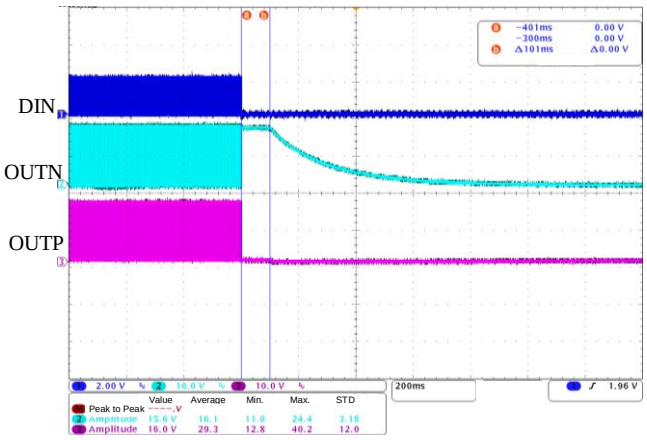
2. **Turn-on waveform at V_{OUT} = 15.6V**



3. **Turn-off waveform at V_{OUT} = 11V**



4. **Turn-off waveform at V_{OUT} = 15.6V**



Application Information

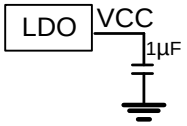
Overview:

The PAM8907 is a piezo sounder driver with integrated boost switch, power diodes, and fully differential amplifier. This versatile device is capable of driving piezo sounder for a variety of applications, including location tracker, air humidifier or haptic feedback related applications. The PAM8907 supports selectable boost voltage output by VSET pin for low/high-voltage output. A typical start-up time of 1.1ms makes the PAM8907 an ideal piezo driver with fast response. PAM8907 has built-in thermal overload protection, current limit and various protection features to prevent the device from damage when overdriven.

Major functions of PAM8907 along with application information is described in the following sections.

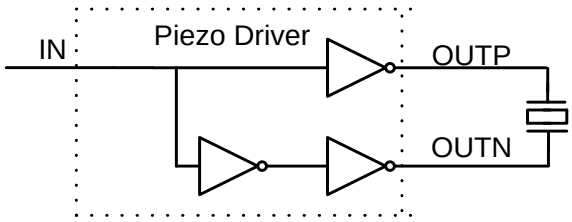
LDO Regulator

The PAM8907 has a built-in 5V LDO regulator to supply 5V to the internal blocks. It is recommended to add 1μF capacitor at pin 1 VCC (LDO).



Piezo Driver

As illustrated below, the PAM8907 has a built-in Piezo driver circuitry with Diodes Incorporated's proprietary design. This is to enable easy system configuration for driving piezo sounder with less external components and yet optimized performance.



DIN Control

The PAM8907 designs a binary control logic circuit internally for the automatic shutdown and wake-up control, when DIN is set low and continue for longer than 100ms (Typ.) period, PAM8907's boost and Piezo driver block will be disabled and the device automatically enters shutdown mode. The PAM8907's operation current is less than 1μA under this shutdown mode. When DIN is set high or provided with pulsed-clock input, PAM8907's boost and Piezo driver block will be enabled again & resumed back to normal operation mode.

Application Information (continued)

Boost Regulator

The PAM8907 boost regulator is a conventional current-mode controller with the following enhanced features:

- **Undervoltage Lockout (ULVO)**: When the input supply (VIN) drops below the UVLO value, the boost regulator will switch off. Typical UVLO value is 1.6V.
- **Over Temperature Protection (OTP)**: When PAM8907 die temperature is higher than OTP threshold, the boost regulator will switch off, and restart after OTP condition is removed. Typical OTP value is set at +160°C.
- **VOUT Undervoltage (UV) Protection:** When the boost regulator output voltage is lower than the preset threshold, it will trigger VOUT UV protection, and the device will go to hiccup mode in order to reduce power-supply current.
- **VOUT Overvoltage (OV) Protection:** When the boost regulator output voltage is higher than the preset threshold, it will trigger VOUT OV protection, and the device will switch off until VOUT OV condition is removed.
- **Soft-Start:** The boost regulator voltage setting is designed to always operate under soft-start operation, which can reduce inrush current. Typical soft-start time is set around 1.1ms.
- **Overcurrent Protection (OCP)**: The boost regulator has a built-in cycle-by-cycle overcurrent protection.
- **SLEEP:** The boost regulator will go to sleep mode under light-load condition.

The PAM8907 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 is turned on using the DIN input, the NMOS switch is turned on and the inductor current ramps up to its peak value, approximately 1600mA 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 is disabled 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, and etc.

In PAM8907, when logic high is asserted on the DIN pin, the boost regulator is enabled. However, the Piezo driver output is not enabled until the output voltage reaches its nominal set point (total soft-start time around 1.1ms). This ensures the output voltage rises quickly to the necessary drive voltage for the Piezo.

The boost regulator has been optimized to work with the external components as shown in the Typical Application circuit. It is crucial to select an appropriate inductor value for the boost converter to operate efficiently with expected transient behavior and loop stability under a limited board space condition. 0.68µH to 1.5µH (typical 1.0µH) inductor with saturation current rating of 1A is recommended to optimize PAM8907 performance.

Application Information (continued)

Capacitor Selection Guide

The external capacitors are required to use low ESR ceramic capacitors. It is highly recommended to place them at the same layout layer as PAM8907.

- **Power Supply Decoupling – VIN (Pin 10)**

  Capacitor Value: 1μF +10μF

  Voltage Rating: 2 x VIN

  Capacitor layout: place the 1μF capacitor close to VIN (Pin 10), and 10μF close to the inductor

  If the application uses the battery like CR2032 which cannot support higher current, it is highly recommended to change 10μF to 47μF or above.

- **External LDO – VCC (Pin 1)**

  Capacitor Value: 1μF

  Voltage Rating: 10V or 16V

  Capacitor layout: place the capacitor close to VCC (Pin 1)

  If the application uses the battery like CR2032 which cannot support higher current, it is highly recommended to change 1μF to 0.47μF.

- **Bootstrap – BOOT (Pin 3)**

  Capacitor Value: 0.1μF

  Voltage Rating: 25V or higher

  Capacitor layout: place the capacitor close to BOOT (Pin 3)

- **Boost Output – VOUT (Pin 5)**

  Capacitor Value: 1μF or 2.2μF, for smoke alarm application, if loading is higher than 100nF, put a 10μF capacitor at the V_{OUT} pin.

  Voltage Rating: 25V or higher

  Capacitor layout: place the capacitor close to VOUT (Pin 5)

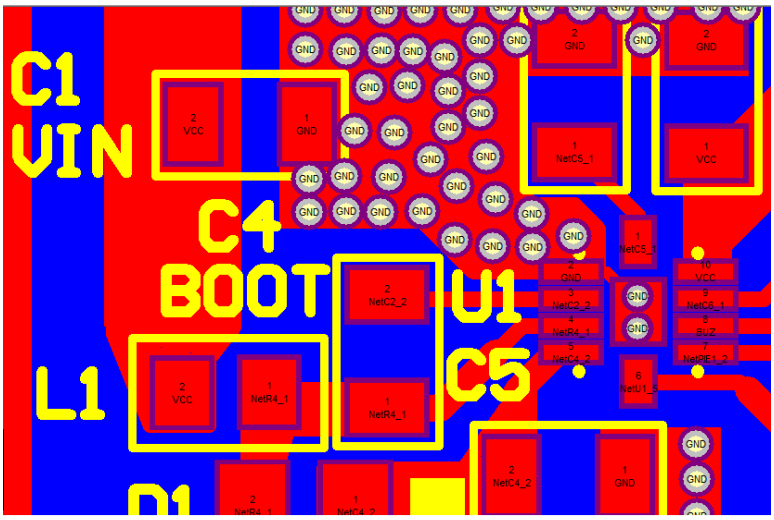
  If the application uses the battery like CR2032 which cannot support higher current, it is highly recommended to change the 1μF to 0.47μF.

Schottky Diode

This is optional. A Schottky diode between SW and VOUT (in parallel with high-side FET of the boost converter) can reduce the power consumption by approximately 20%. A 20V Schottky with current rating of 1A is preferred.

GND Layout Guideline

The GND layout is important to enable PAM8907 to operate under optimal conditions. Suggested layout for GND is illustrated below. Please consult with Diodes Incorporated's technical support team or field representative for any further assistance, if necessary.



Connect first GND (Pin 2) to PAM8907's epoxy pad, expand the GND line to VCC/VIN's capacitor's GND and place many vias on the GND trace, then connect with VOUT pin's CAP GND. Place these capacitors as close as possible to PAM8907.

Ordering Information

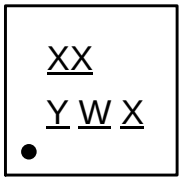
PAM8907 XXXX - X

Package	Packing
SB10: U-QFN2020-10	7: 7" Tape & Reel

Part Number	Package	Voltage	Packing	
			Qty.	Carrier
PAM8907SB10-7	U-QFN2020-10	11V/15.6V	3,000	Tape & Reel

Marking Information

(Top View)



XX : Identification Code

Y : Year : 0 to 9

W : Week : A to Z : 1 to 26 Week;
a to z : 27 to 52 Week; z Represents 52 and 53 Week

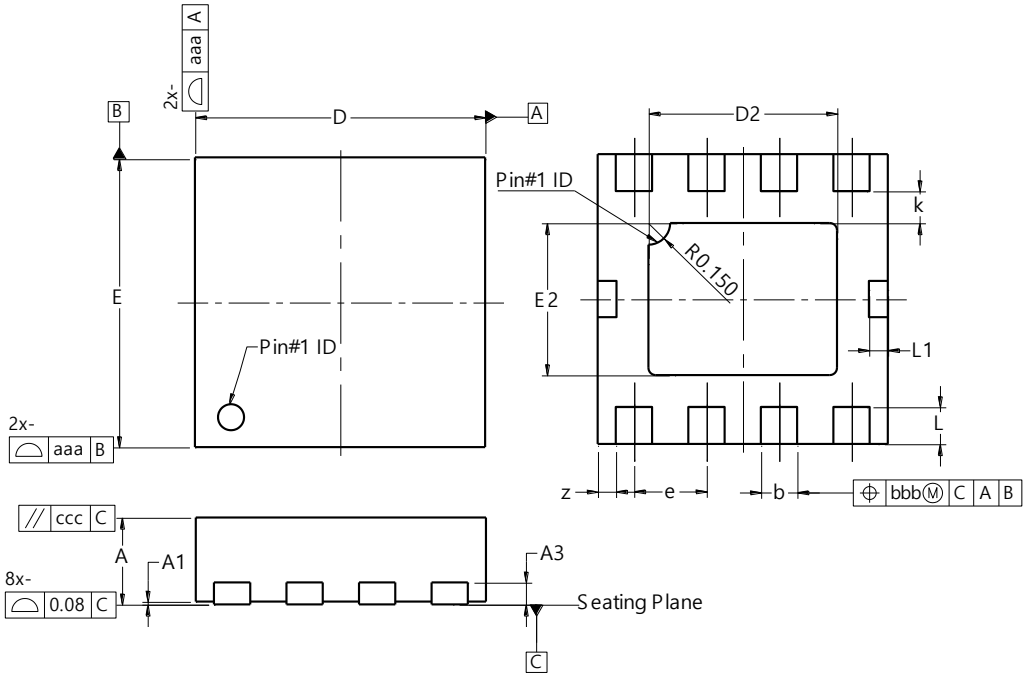
X : Internal Code

Part Number	Package	Identification Code
PAM8907SB10-7	U-QFN2020-10	PJ

Package Outline Dimensions

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

U-QFN2020-10

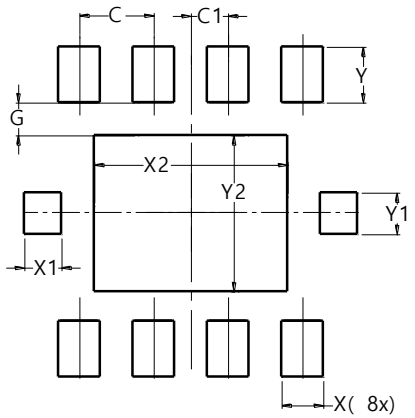


U-QFN2020-10			
Dim	**Min**	**Max**	**Typ**
A	0.57	0.63	0.60
A1	0.00	0.05	0.02
A3	--	--	0.152
b	0.20	0.30	0.25
D	1.950	2.05	2.00
D2	1.20	1.40	1.30
E	1.950	2.05	2.00
E2	0.95	1.15	1.05
e	--	--	0.50
k	--	--	0.23
L	0.205	0.305	0.255
L1	0.100	0.160	0.130
z	--	--	0.125
aaa	0.25		
bbb	0.10		
ccc	0.10		
All Dimensions in mm			

Suggested Pad Layout

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

U-QFN2020-10



Dimensions	Value (in mm)
C	0.500
C1	0.250
G	0.220
X	0.280
X1	0.250
X2	1.300
Y	0.375
Y1	0.280
Y2	1.050

Mechanical Data

- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish – NiPdAu, Solderable per J-STD-002, Test B1 (e4)
- Weight: 13.67mg (Approximate)

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