

## Description

The PAM8904 is a piezo sounder driver with integrated charge pump boost converter. The PAM8904 is capable of driving a ceramic/piezo sounder with 24V<sub>PP</sub> from a 5.5V power supply. The charge pump can operate in a 1x, 2x, or 3x mode.

The boost converter operates at a fixed frequency of 1.0MHz and provides a 12V output with a minimum number of external components. The PAM8904 can drive up to 15nF loading. Diodes Incorporated's unique drive technology provides a small inrush current, low EMI and high efficiency.

The PAM8904 includes built-in automatic shutdown and wake up that guarantees longer battery life. The PAM8904 features thermal shutdown, overcurrent protection, overvoltage protection and undervoltage lock-out.

The PAM8904 is available in a 16-pin U-QFN3030-16 (Type B) package, a 12-pin U-QFN3030-12 (Type A) package, or a 12-pin U-QFN2020-12 (Type UX) package.

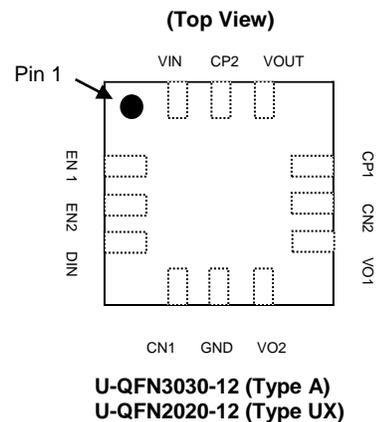
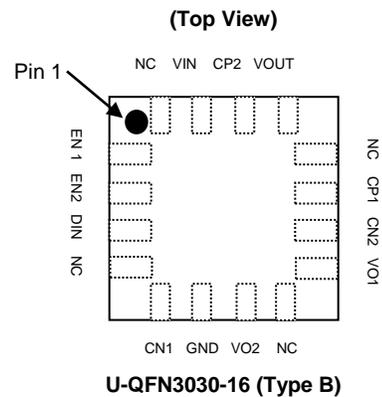
## Features

- Supply Voltage Range from 1.8V to 5.5V
- 18V<sub>PP</sub> Output from a 3V Supply
- Integrated Boost Converter Generates Up to 12V Supply
- No Voltage Cross Output at Shutdown Mode
- Low Current Consumption
- Automatic Standby and Wake-Up Control
- Available in Space-Saving Packages:
  - 16-Pin U-QFN3030-16 (Type B)
  - 12-Pin U-QFN3030-12 (Type A)
  - 12-Pin U-QFN2020-12 (Type UX)
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **An Automotive-Compliant Part is Available Under Separate Datasheet ([PAM8904Q](#))**

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.

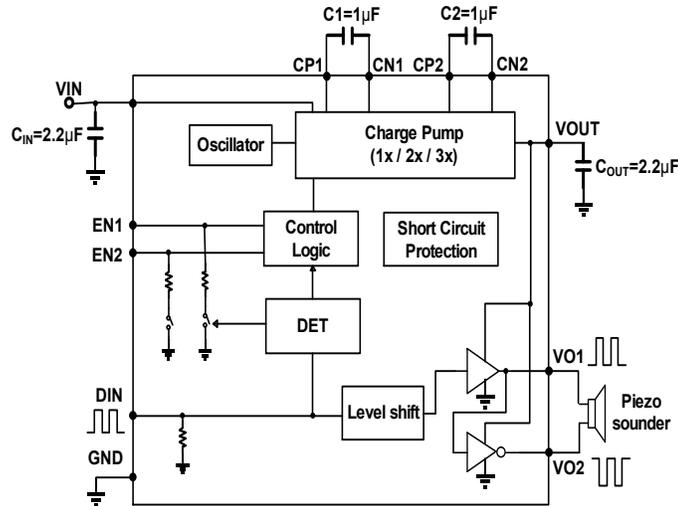
## Pin Assignments



## Applications

- Health care systems
- Alarm clocks
- Security devices
- Home appliances

## Typical Applications Circuit



## Pin Descriptions

Pin Number		Pin Name	I/O/P	Function
U-QFN3030-16 (Type B)	U-QFN3030-12 (Type A) U-QFN2020-12 (Type UX)			
1	1	EN1	I	Charge pump mode select 1
2	2	EN2	I	Charge pump mode select 2
3	3	DIN	I	Signal Input
4	—	NC	—	No Connection
5	4	CN1	I	Capacitor 1 Negative Terminal
6	5	GND	P	Ground
7	6	VO2	O	Positive Output
8	—	NC	—	No Connection
9	7	VO1	O	Negative Output
10	8	CN2	I	Capacitor 2 Negative Terminal
11	9	CP1	I	Capacitor 1 Positive Terminal
12	—	NC	—	No Connection
13	10	VOUT	O	Boost Output
14	11	CP2	I	Capacitor 2 Positive Terminal
15	12	VIN	P	Power Supply
16	—	NC	—	No Connection

### Absolute Maximum Ratings (@ $T_A = +25^\circ\text{C}$ , unless otherwise specified.) (Note 4)

Symbol	Characteristics	Value	Unit
$V_{IN}$	Supply Voltage	-0.3 to +6.0	V
$V_{OUT}$	Output Voltage	15	V
$V_{EN1}, V_{EN2}$	EN1, EN2 Voltage	GND -0.3 to $V_{IN} +0.3$	V
$T_A$	Operating Free-Air Temperature Range	-40 to +85	$^\circ\text{C}$
$T_J$	Operating Junction Temperature Range	-40 to +150	$^\circ\text{C}$
$T_{STG}$	Storage Temperature Range	-65 to +150	$^\circ\text{C}$

Note 4: Stresses greater than those listed under "Absolute Maximum Ratings" can cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "Recommended Operating Conditions" is not implied. Exposure to "Absolute Maximum Ratings" for extended periods can affect device reliability.

### Recommended Operating Conditions (@ $T_A = +25^\circ\text{C}$ , unless otherwise specified.)

Symbol	Characteristics	Min.	Max.	Unit	
$V_{IN}$	Supply Voltage	—	1.8	5.5	V
$V_{IH}$	High-Level Input Voltage	EN1, EN2	$0.5 * V_{IN}$ to $V_{IN} +0.3$		V
$V_{IL}$	Low-Level Input Voltage	EN1, EN2	-0.3	+0.4	V
$T_A$	Operating Free-Air Temperature	-40	+85	$^\circ\text{C}$	

### Thermal Information

Parameter	Symbol	Package	Max.	Unit
Thermal Resistance (Junction to Ambient)	$\theta_{JA}$	U-QFN3030-16 (Type B)	35	$^\circ\text{C/W}$
		U-QFN3030-12 (Type A)	35	
		U-QFN2020-12 (Type UX)	68	
Thermal Resistance (Junction to Case)	$\theta_{JC}$	U-QFN3030-16 (Type B)	14	$^\circ\text{C/W}$
		U-QFN3030-12 (Type A)	14	
		U-QFN2020-12 (Type UX)	25	

**Electrical Characteristics** (@T<sub>A</sub> = +25°C, V<sub>IN</sub> = 3.0V, C<sub>PIEZO</sub> = 15nF, f<sub>DIN</sub> = 4kHz, unless otherwise specified.)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Voltage Range	V <sub>OUT</sub>	(Note 5)	1.8	—	13.5	V
Output Voltage	V <sub>OUT1</sub>	1x Mode	2.8	—	3	V
	V <sub>OUT2</sub>	2x Mode	5.2	—	6	V
	V <sub>OUT3</sub>	3x Mode (Note 6)	7.2	—	9	V
Operating Current 1	I <sub>DD11</sub>	1x Mode, C <sub>PIEZO</sub> = No Load	—	50	—	μA
	I <sub>DD12</sub>	2x Mode, C <sub>PIEZO</sub> = No Load	—	720	—	μA
	I <sub>DD13</sub>	3x Mode, C <sub>PIEZO</sub> = No Load	—	1,700	—	μA
Operating Current 2	I <sub>DD21</sub>	1x Mode, Single-Ended Application	—	0.3	—	mA
	I <sub>DD22</sub>	2x Mode, Single-Ended Application	—	1.4	—	mA
	I <sub>DD23</sub>	3x Mode, Single-Ended Application	—	3.9	—	mA
Operating Current 3	I <sub>DD31</sub>	1x Mode, Differential Application	—	0.9	—	mA
	I <sub>DD32</sub>	2x Mode, Differential Application	—	3.6	—	mA
	I <sub>DD33</sub>	3x Mode, Differential Application	—	7.9	—	mA
Shutdown Current	I <sub>SD</sub>	DIN = 0V	—	—	1	μA
Input Frequency	f <sub>IN</sub>	Rectangular Pulse	—	4	—	kHz
Oscillating Frequency	f <sub>OSC</sub>	—	—	1	—	MHz
V <sub>OUT</sub> Start Delay Time	t <sub>ON1</sub>	1x Mode, From DIN Signal High to 90% V <sub>OUT</sub> Steady State	—	270	—	μs
	t <sub>ON2</sub>	2x Mode, From DIN Signal High to 90% V <sub>OUT</sub> Steady State	—	320	—	μs
	t <sub>ON3</sub>	3x Mode From DIN Signal High to 90% V <sub>OUT</sub> Steady State	—	350	—	μs
Shutdown Delay Time	t <sub>OFF</sub>	DIN = H- > L	—	42	—	ms
Output Short-Circuit Current	I <sub>SC</sub>	—	—	40	—	mA
Control Terminal Voltage H	V <sub>IH</sub>	EN1, EN2, DIN Pins	0.5*V <sub>IN</sub>	—	V <sub>IN</sub>	V
Control Terminal Voltage L	V <sub>IL</sub>	EN1, EN2, DIN Pins	0	—	0.4	V
Control Terminal Current 1	I <sub>IH1</sub>	DIN = 3V	—	—	1	μA
Control Terminal Current 2	I <sub>IH2</sub>	V <sub>EN1</sub> , V <sub>EN2</sub> = 3V, DIN = 3V	—	—	1	μA
Control Terminal Current 3	I <sub>IH3</sub>	V <sub>EN1</sub> , V <sub>EN2</sub> = 3V, DIN = 0V	—	—	1	μA

Notes: 5. It is possible to drive V<sub>OUT</sub>, VO1 and VO2 to 3x V<sub>DD</sub>. A supply voltage of 4.5V or more should not be used in 3x mode as this will exceed the maximum output voltage rating.

6. When designed under 3x mode, it should be carefully noted that the V<sub>OUT</sub> absolute maximum value should not exceed 13.5V.

## Application Information

### Charge Pump Mode Setting

The Charge Pump Mode (CPM) pins EN1 and EN2 are used to set the charge pump into mode 1x V<sub>DD</sub>, 2x V<sub>DD</sub>, 3x V<sub>DD</sub> or they can be used to put the PAM8904 in to a forced low current shutdown mode.

DIN	EN1	EN2	MODE
0	—	—	Shutdown Mode
1	0	0	Shutdown Mode
1	0	1	1x Mode
1	1	0	2x Mode
1	1	1	3x Mode

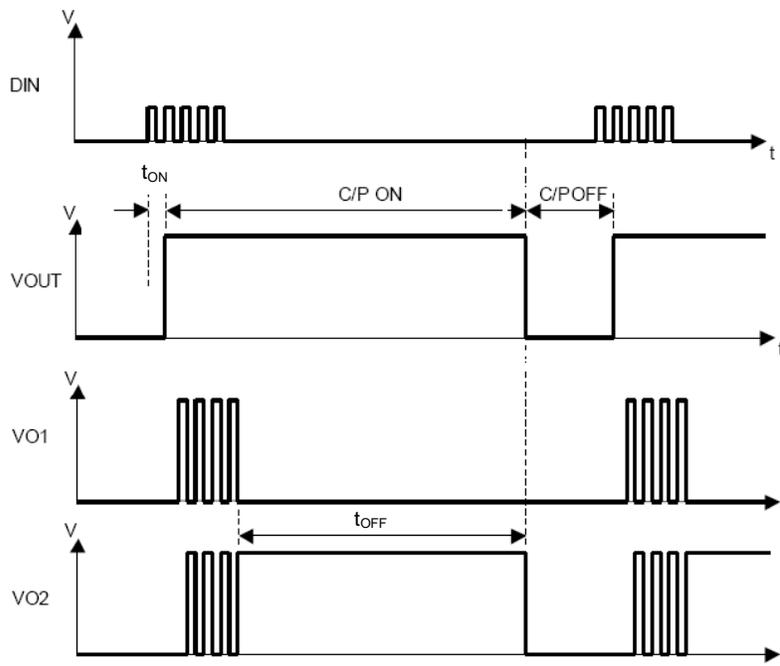
Care must be taken when using the 3x mode with a V<sub>DD</sub> supply of 4.5V or more, as this will force the V<sub>OUT</sub> to exceed its Absolute Maximum specification (13.5V).

V <sub>DD</sub> Range	Mode
1.8V to 5.5V	1x, 2x
1.8V to 4.5V	1x, 2x and 3x

### Timing Chart and Device Operation

When one or both of the EN pins are pulled high, the device enters normal operation mode, refer to the above table for the mode selection. Once the PAM8904 senses a valid signal on the DIN pin, the charge pump will start and provide the desired voltage on the V<sub>OUT</sub> pin and the output drive VO1 and VO2 start to function after time t<sub>ON</sub> which is typically between 270μs and 350μs depending on the mode chosen. Once the input signal on DIN is removed, the PAM8904 senses this and waits typically 42ms to ensure the signal has been removed. If there is no further valid signal within the time period t<sub>OFF</sub>, the PAM8904 enters into a low current standby mode.

### Timing Chart



**Application Information** (continued)

**Output Configuration**

The PAM8904 is able to be configured either in a differential or a single-ended configuration.

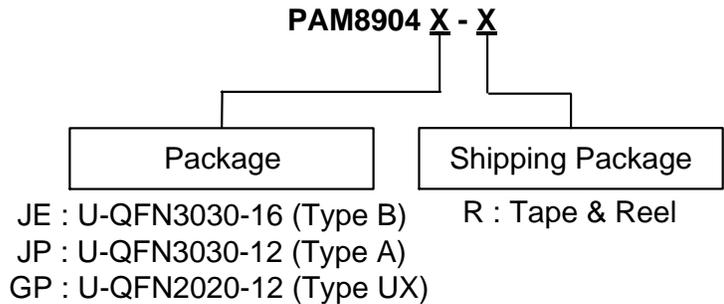
**Short-Circuit Protection**

The PAM8904 has short-circuit protection circuitry on the outputs to prevent damage. Once a short circuit is detected on the outputs the chip will limit the total current to protect the output device. This is not a latched fault; once the short is removed the normal operation is restored.

**Thermal Protection**

If the junction temperature of the PAM8904 exceeds +150°C the device will enter overtemperature shutdown. The outputs and the charge pump will be switched off. Once the junction temperature cools down to its normal operating condition, the IC will restart automatically.

**Ordering Information**



Part Number	Package	Packing	
		Qty.	Carrier
PAM8904JER	U-QFN3030-16 (Type B)	3,000	Tape & Reel (13inch)
PAM8904JPR	U-QFN3030-12 (Type A)	3,000	Tape & Reel (13inch)
PAM8904GPR	U-QFN2020-12 (Type UX)	3,000	Tape & Reel (7inch)

**Marking Information**

U-QFN3030-16 (Type B) / U-QFN3030-12 (Type A)  
(Top View)

P8904: Product Code  
 XXX: Internal 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

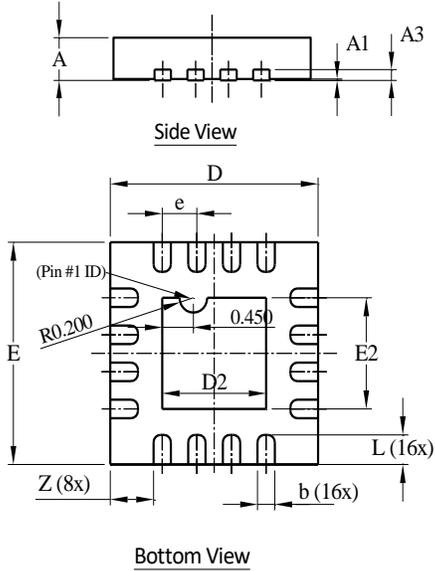
U-QFN2020-12 (Type UX)  
(Top View)

BP: 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

**Package Outline Dimensions**

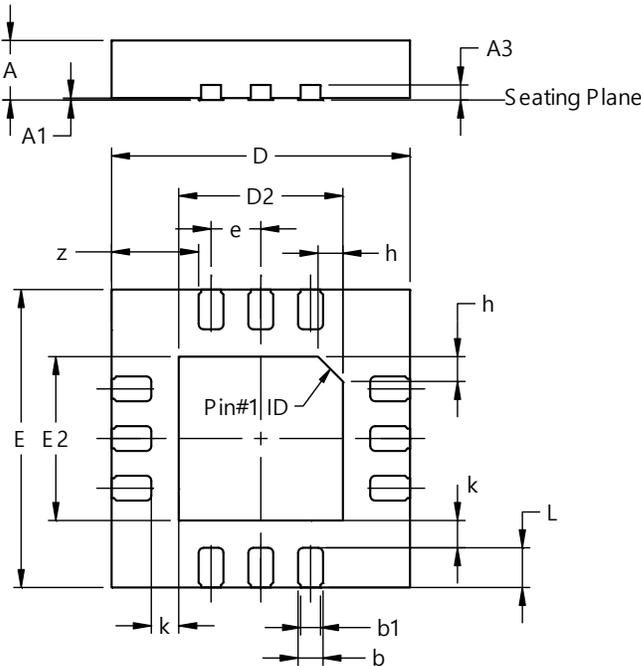
Please see <http://www.diodes.com/package-outlines.html> for the latest version.

**(1) Package Type: U-QFN3030-16 (Type B)**



U-QFN3030-16 Type B			
Dim	Min	Max	Typ
A	0.55	0.65	0.60
A1	0	0.05	0.02
A3	-	-	0.15
b	0.18	0.28	0.23
D	2.95	3.05	3.00
D2	1.40	1.60	1.50
E	2.95	3.05	3.00
E2	1.40	1.60	1.50
e	-	-	0.50
L	0.35	0.45	0.40
Z	-	-	0.625
All Dimensions in mm			

**(2) Package Type: U-QFN3030-12 (Type A)**

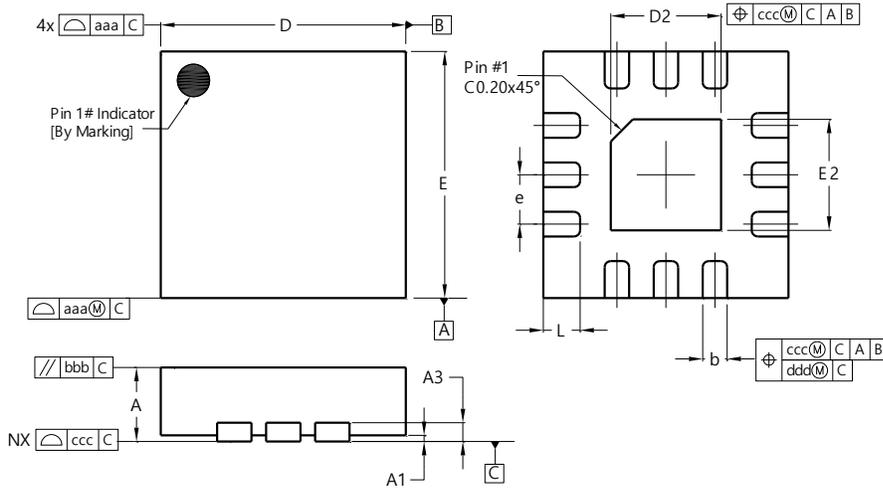


U-QFN3030-12 (Type A)			
Dim	Min	Max	Typ
A	0.55	0.65	0.60
A1	0.00	0.05	0.02
A3	--	--	0.152
b	0.20	0.35	0.25
b1	0.15	0.25	0.20
D	2.95	3.05	3.00
D2	1.55	1.75	1.65
E	2.95	3.05	3.00
E2	1.55	1.75	1.65
e	--	--	0.50
h	--	--	0.25
L	0.35	0.45	0.40
k	--	--	0.275
z	--	--	0.875
All Dimensions in mm			

**Package Outline Dimensions** (continued)

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

**(3) Package Type: U-QFN2020-12 (Type UX)**

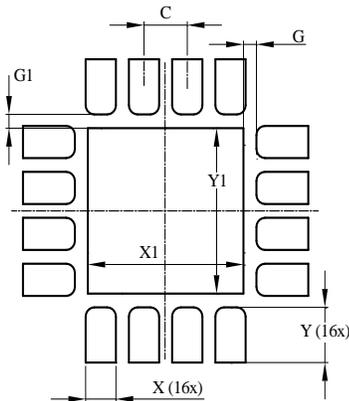


U-QFN2020-12 (Type UX)			
Dim	Min	Max	Typ
A	0.550	0.650	0.600
A1	—	0.05	—
A3	0.127 REF		
b	0.180	0.280	0.230
D	1.950	2.050	2.00
D2	0.850	0.950	0.900
E	1.950	2.050	2.00
E2	0.850	0.950	0.900
e	0.400 BSC		
L	0.250	0.350	0.300
aaa	0.10		
bbb	0.10		
ccc	0.05		
ddd	0.05		
All Dimensions in mm			

**Suggested Pad Layout**

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

**(1) Package Type: U-QFN3030-16 (Type B)**

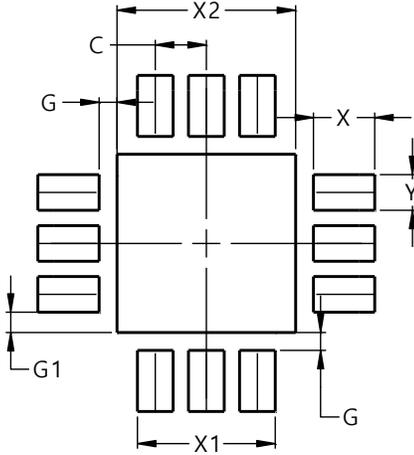


Dimensions	Value (in mm)
C	0.500
G	0.150
G1	0.150
X	0.350
X1	1.800
Y	0.600
Y1	1.800

## Suggested Pad Layout

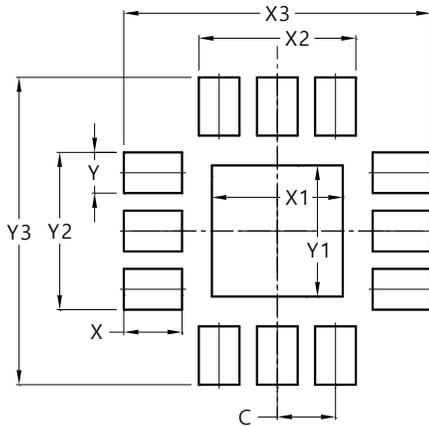
Please see <http://www.diodes.com/package-outlines.html> for the latest version.

### (2) Package Type: U-QFN3030-12 (Type A)



Dimensions	Value (in mm)
C	0.500
G	0.175
G1	0.200
X	0.600
X1	1.350
X2	1.750
Y	0.350
Y1	1.750

### (3) Package Type: U-QFN2020-12 (Type UX)



Dimensions	Value (in mm)
C	0.400
X	0.400
X1	0.900
X2	1.080
X3	2.110
Y	0.280
Y1	0.900
Y2	1.080
Y3	2.110

## Mechanical Data

### U-QFN3030-16 (Type B)/U-QFN3030-12 (Type A)

- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish—NiPdAu Leads, Solderable per MIL-STD-202, Method 208 (e4)
- Weight: 0.016 grams (Approximate)

### U-QFN2020-12 (Type UX)

- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish—NiPdAu Leads, Solderable per MIL-STD-202, Method 208 (e4)
- Weight: 0.0068 grams (Approximate)

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