Lead-free Green

AUR9811D

1A LI-ION/LI POLYMER BATTERY LINEAR CHARGER

Description

The AUR9811D is a highly-integrated battery charger for single-cell Li-ion or Li-polymer batteries capable of operating with an input voltage reached 2.5V. It is a complete charger device designed to work with an USB port or 5V output AC adapter.
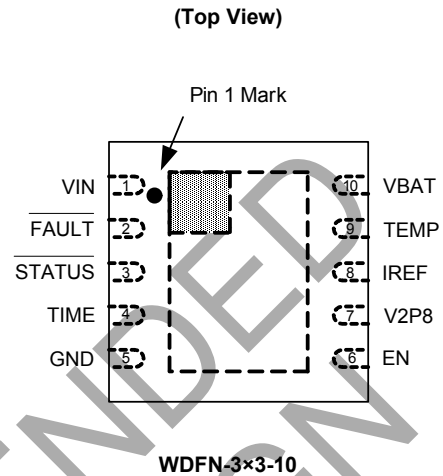
The AUR9811D operates with CC (constant current) mode and CV (constant voltage) mode profiles. A low-current preconditioning charge mode is also provided as a trickle charging operation. The charge current is programmable up to 1A with an external resistor or a logic input. The charge voltage is 1% accurate over the full application range.

When operating with a current-limited adapter, the charger minimizes the thermal dissipation with pulsed operations to prevent overheat conditions that is commonly occurred with conventional linear chargers. The AUR9811D reduces charge current for thermal fold-back to ensure product safe operation. The charger automatically re-charges the battery when the battery voltage drops below a recharge threshold. The chip includes a safety timer for setting the fast charge time limit in case of charging a dead battery.

Additional features include preconditioning of an over-discharged battery and charging the battery in a safe temperature range with an NTC thermistor interface. The thermally enhanced DFN package is offered for space limited handheld applications.

The AUR9811D is available in WDFN-3X3-10 package.

Pin Assignments

(Top View)

Pin 1 Mark

Pin	Name		Pin	Name
1	VIN		10	VBAT
2	FAULT		9	TEMP
3	STATUS		8	IREF
4	TIME		7	V2P8
5	GND		6	EN

WDFN-3×3-10

Features

- Complete Charger for Single-Cell Li-Ion Batteries
- Charges from Either AC Adapter or USB Port
- Integrated Power Pass Device with Current Sensing
- No External Blocking Diode Required
- Pre-charge Condition with Safety Timing
- Charger Voltage Accuracy: 1%
- Programmable Current Limit up to 1A
- Sleep Mode for Power Saving
- Charge Current Thermal Fold-back
- NTC Thermistor Interface for Battery Temperature Monitor
- Stand-Alone or Integrated Charger
- Ambient Temperature Range: -40°C to +85°C
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**

Applications

- PDAs, Cell Phones and Smart Phones
- Digital Camera, MP3 and Handheld Gamming
- Portable Instruments Including Medical Handhelds
- Self-Charging Battery Packs
- Stand-Alone Chargers or USB Port Chargers

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.
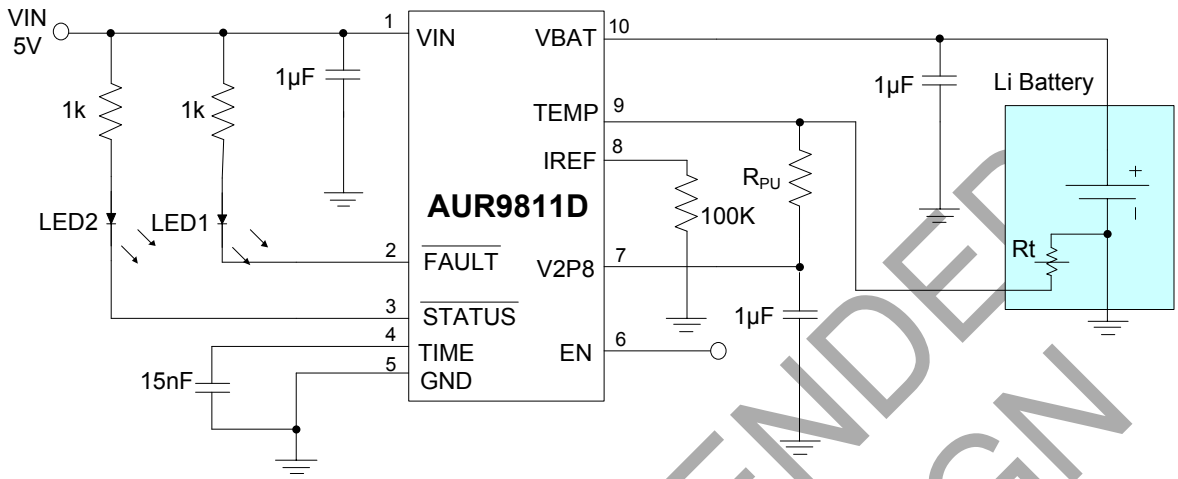
AUR9811D
Document number: DS39015 Rev. 3 - 3

1 of 14
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AUR9811D

Typical Applications Circuit

Figure 1.Typical Application of AUR9811D

$$\frac{200K \cdot 150K}{200K + 150K} = 85.7K$$

$I_{IREF} \approx 940mA$
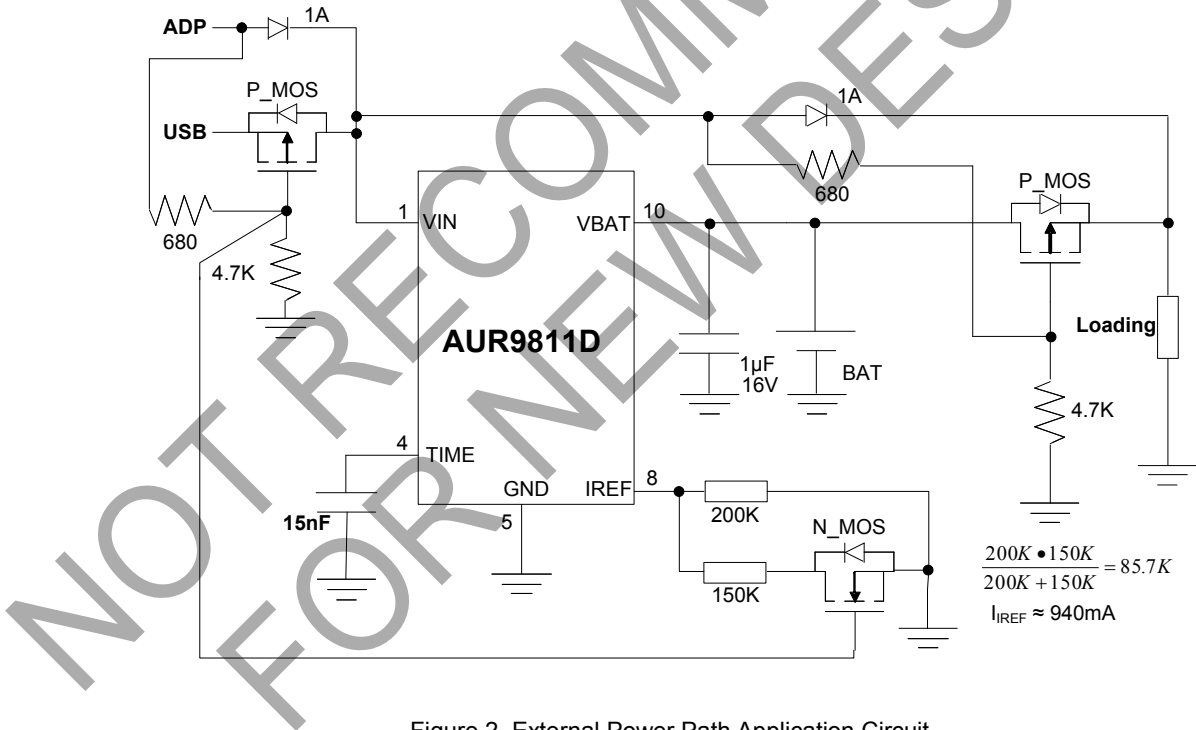
Figure 2. External Power Path Application Circuit

AUR9811D
Document number: DS39015 Rev. 3 - 3

2 of 14
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Pin Descriptions

Pin Number	Pin Name	Pin Type	Pin Function
1	VIN	POWER	Charger input supply voltage
2	$\overline{\text{FAULT}}$	O	Active-low, open-drain output, capable of sinking 5mA current
3	$\overline{\text{STATUS}}$	O	Open-drain pin to show charging and Inhibit states, capable of sinking 5mA current
4	TIME	I	Timing capacitor pin for connecting a capacitor to set internal clocking and charger time reference
5	GND	GROUND	Ground pin
6	EN	I	Chip enable control, high to activate the chip with internal 800kΩ pull-up resistor
7	V2P8	O	2.8V reference voltage output, capable of driving up to 2mA
8	IREF	I	A resistor can be connected at this pin to set the charge current
9	TEMP	I	Battery Temperature input for NTC thermistor input, can be used for battery removal detection
10	VBAT	O	Connection to the battery positive node
—	Thermal pad	—	Connected with ground

Functional Block Diagram

AUR9811D
Document number: DS39015 Rev. 3 - 3

3 of 14
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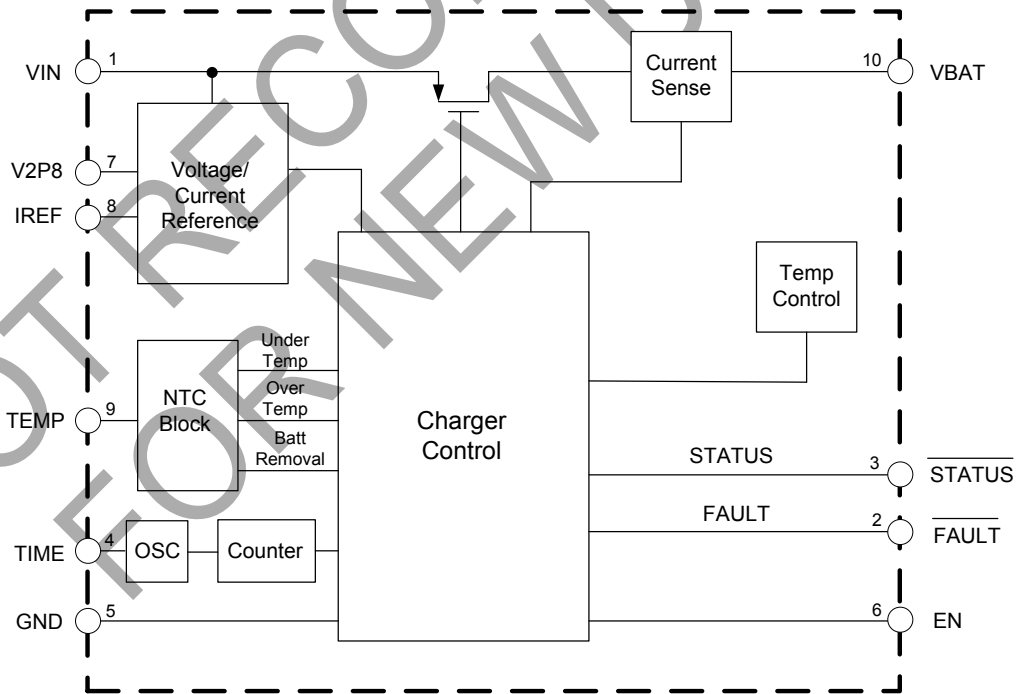
Absolute Maximum Ratings (Note 4)

Symbol	Parameter	Value	Unit
V_{IN}	Supply Input Voltage	-0.3 to 6.5	V
V_{EN}	Enable Input voltage	-0.3 to V_{IN}+0.3	V
V_{BAT}	Output Voltage	-0.3 to V_{IN}+0.3	V
—	Other Pin Voltage ($\overline{FAULT}$, $\overline{STATUS}$, TIME, TEMP, IREF, V2P8)	-0.3 to V_{IN}+0.3	V
θ_{JA}	Thermal Resistance (Simulation)	45.13	°C/W
T_J	Operating Junction Temperature	+160	°C
T_{STG}	Storage Temperature	-65 to +150	°C

Note: 4. Stresses greater than those listed under "Absolute Maximum Ratings" may 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 may affect device reliability.

Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
V_{IN}	Supply Voltage	4.6	5.5	V
T_A	Ambient Temperature Range	-40	+85	°C

AUR9811D
Document number: DS39015 Rev. 3 - 3

4 of 14
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August 2019
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Electrical Characteristics (V_{IN}=5V and T_A=+25°C for the typical values. The maximum and minimum values are over -40°C to +85°C ambient temperature with a supply voltage in the range of 4.6V to 5.5V, unless otherwise noted.)

Symbol	Parameter	Test Condition	Min	Typ	Max	Unit
Power-On Reset						
—	VIN Rising Voltage	—	3.2	3.6	3.9	V
—	VIN falling Voltage	—	2.25	2.5	2.7	V
Standby Current						
$I_{STANDBY}$	VBAT Pin Sink Current	VIN floating or EN=LOW	—	—	3.3	µA
I_{IN}	VIN Pin Supply Current	VBAT floating and EN pulled low	—	150	—	µA
		VBAT and EN floating	—	—	1	mA
VIN-VBAT Offset Voltage						
V_{OS}	Offset Voltage	V_{BAT}=4.2V, I_{BAT}= 20mA, use STATUS pin	45	80	100	mV
Voltage Regulation						
V_{BAT}	Output Voltage	Tested at 50mA load, 5V input, and +25°C	4.158	4.2	4.242	V
—	Dropout Voltage	V_{BAT}=4.0V, charge current = 0.35A	—	175	—	mV
Charge Current						
I_{CHG}	Constant Charge Current	R_{IREF}=100kΩ, V_{BAT}=3.0V to 4.0V	760	800	840	mA
$I_{TRICKLE}$	Trickle Charge Current	R_{IREF}=100kΩ, V_{BAT}=2.5V	—	120	—	mA
I_{MIN}	End-of-Charge Threshold	R_{IREF}=100kΩ	70	80	90	mA
V2P8 Pin Output						
V_{2P8}	V2P8 Pin Output Voltage	Load current less than 1mA	2.8	2.9	3.0	V
Recharge Threshold						
V_{RECHG}	Recharge Threshold	—	3.97	4.05	4.13	V
$V_{RECHG-HYS}$	Recharge Threshold Hysteresis	—	—	50	—	mV
Trickle Charge Threshold						
V_{MIN}	Trickle Threshold Voltage	—	2.7	2.8	2.9	V
V_{MINHYS}	Trickle Threshold Hysteresis	—	50	100	150	mV

AUR9811D
Document number: DS39015 Rev. 3 - 3

5 of 14
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August 2019
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Electrical Characteristics (Cont. V_{IN}=5V and T_A=+25°C for the typical values. The maximum and minimum values are over -40°C to +85°C ambient temperature with a supply voltage in the range of 4.6V to 5.5V, unless otherwise noted.)

Symbol	Parameter	Test Condition	Min	Typ	Max	Unit
Temperature Monitoring						
V_{TMAX}	High Voltage Threshold	V_{2P8}=3.0V	—	1.51	—	V
V_{TMIN}	Low Voltage Threshold	V_{2P8}=3.0V	—	0.38	—	V
T_{FOLD}	Thermal Foldback Threshold	—	—	+110	—	°C
Oscillator						
f_{OSC}	Oscillation Frequency	C_{TIME}= 15nF	305	333	370	Hz
Logic Input and Output						
—	EN Pin Logic Input High	—	2.0	—	—	V
—	EN Pin Logic Input Low	—	—	—	0.8	V
—	EN Pin Internal Pull-Up	—	—	800	—	kΩ
—	($\overline{FAULT}$, $\overline{STATUS}$, Output Voltage	10mA Current	—	—	0.8	V

AUR9811D
Document number: DS39015 Rev. 3 - 3

6 of 14
www.diodes.com

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Performance Characteristics (V_{IN}=5V, T_A=+25°C, R_{IREF}=100kΩ, V_{BAT}=3.7V, unless otherwise noted.)

Charge Output Voltage vs. Charge Current
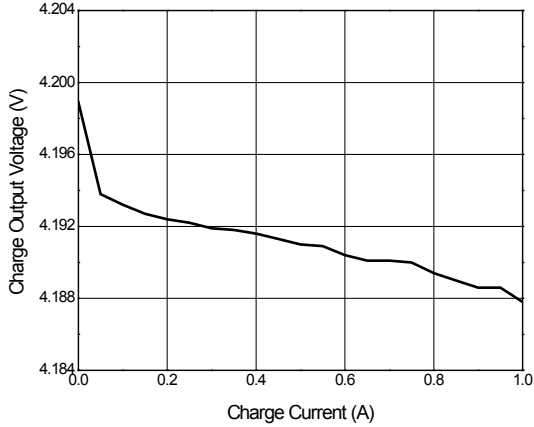
Charge Output Voltage vs. Input Voltage

Charge Current=50mA
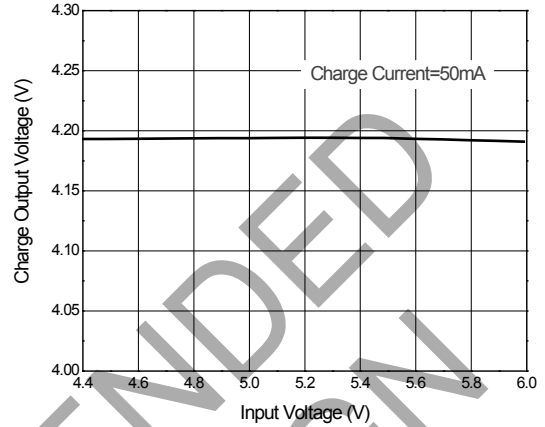
Charge Current vs. Charge Output Voltage

V_{IN} = 4.6V

V_{IN} = 5V
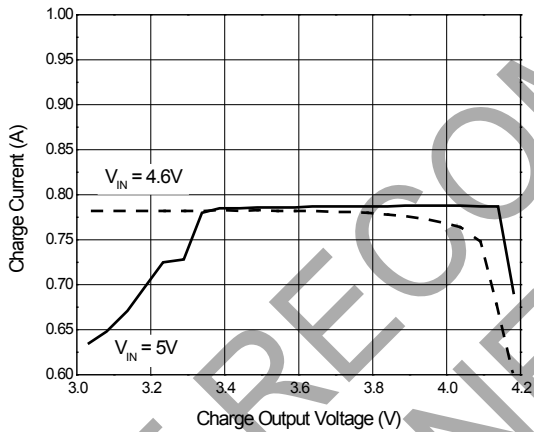
Charge Current vs. Input Voltage
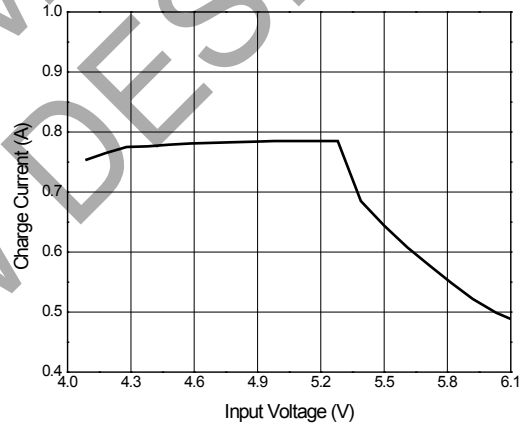
V2P8 Output Voltage vs. Input Voltage
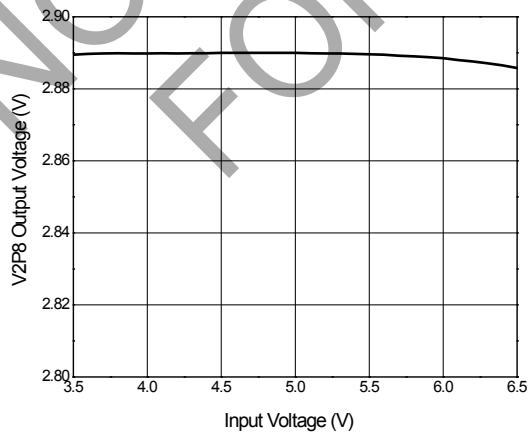
V2P8 Output Voltage vs. V2P8 Load Current

AUR9811D
Document number: DS39015 Rev. 3 - 3

7 of 14
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August 2019
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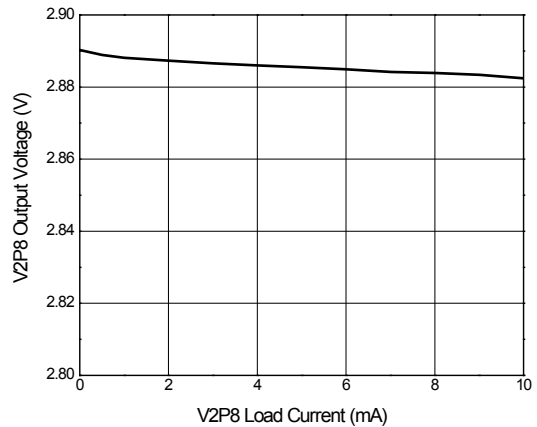
Description of Charge Operation

The AUR9811D initiates a charger operation when attached with a voltage source device or adaptor. Figure 3 shows a typical charge profile when the chip operates as a conventional linear charger with a constant voltage source. The charging current is set by an external resistor up to 1A. The target charging voltage is 1% accurate over the specified range.

The charger IC resets internal operational circuits when internal Power-On-Reset (POR) signal becomes valid. V2P8 presents a voltage reference output source capable of driving 2mA current after POR. Other indication output pins are $\overline{STATUS}$ and $\overline{FAULT}$. The $\overline{STATUS}$ is active low as an open-drain type to indicate a charging cycle and valid till the End-Off-Charge (EOC). The $\overline{FAULT}$ output signal becomes low to signal any occurred fault conditions such as a charging time fault, battery temperature fault or when the battery is detached.

When charge with a current-limited adapter, AUR9811D should be programmed with I_{REF} over the upper limit of I_{LIM}. A typical charge profile is displayed in Figure 4 for minimizing power dissipation during CC mode. The worst power dissipation is often at the start of CV mode, although thermal fold-back conditions could still occur in this application case.
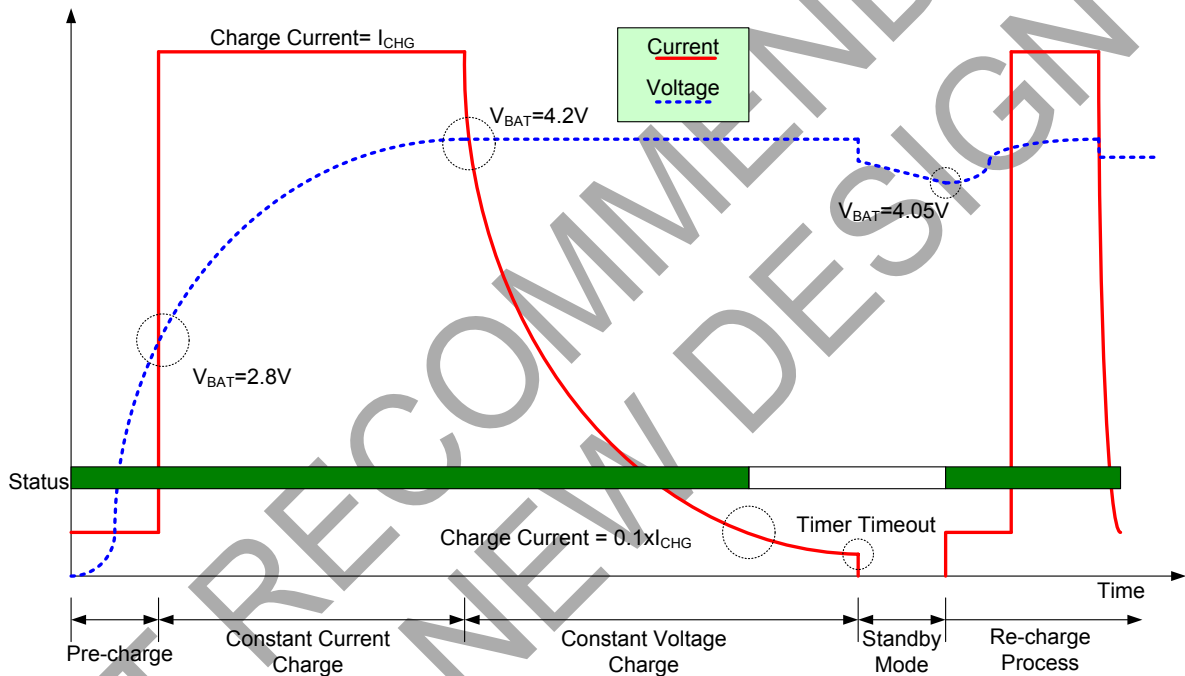
Figure 3. A Typical Charge Profile as a Conventional Linear Charger

AUR9811D
Document number: DS39015 Rev. 3 - 3

8 of 14
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Description of Charge Operation (Cont.)
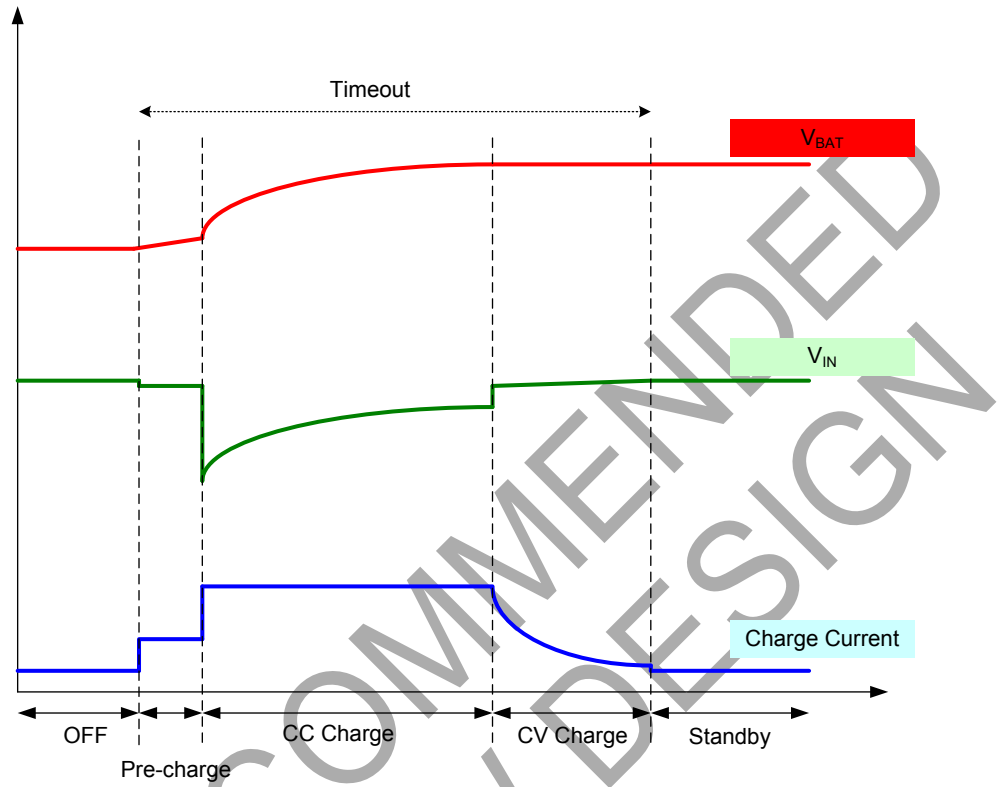
Figure 4. A Typical Charge Profile with a Current-Limited Adapter

AUR9811D
Document number: DS39015 Rev. 3 - 3

9 of 14
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Operation Overview

For linear charging case, the AUR9811D performs either constant current (CC) and constant voltage (CV) profiles. The charging current is set by an external resistor up to 1A for package options. The target charging voltage is 1% accurate over the specified range. AUR9811D enters a trickle mode for preconditioning operation each time when a charging cycle starts till that the minimum charging voltage is reached and verified in 15 clock cycles.

A thermal-foldback function offers thermal protection during linear charging operations. When the internal temperature of AUR9811D goes up above +100°C, the charger automatically reduces the charging current. TEMP pin is examined for battery surface temperature during the charging operation. During VTMIN < VTEMP < VTMAX, AUR9811D performs normal charging operation; VTEMP > VTMAX, low temperature protection will be detected, the AUR9811D will stop charging operation and timer will also be stopped, then fault indication will be issued;. VTEMP <VTMIN, high temperature protection will be detected, AUR9811D will stop charging operation and timer will also stop, thus fault indication will be issued.

The temperature range is determined with an external NTC thermistor. The NTC need have 7:1 for R_{COLD} to R_{HOT}, once user choose a NTC, the temperature range will be fixed also, then we will have

$1.51 = 3.0 \times R_{COLD} / (R_{PU} + R_{COLD})$……….
$0.38 = 3.0 \times R_{HOT} / (R_{PU} + R_{HOT})$………..

Using these two formulas, we can get R_{PU}, and also can get R_{COLD} and R_{HOT} refer to the NTC table (resistance-temperature table).

The AUR9811D provides a TIMEOUT limit to prevent charging a dead battery for extensive time. Recharging is automatically started when battery voltage drops to the recharging threshold point.

The AUR9811D enters the shutdown mode in case no voltage adapter is attached.

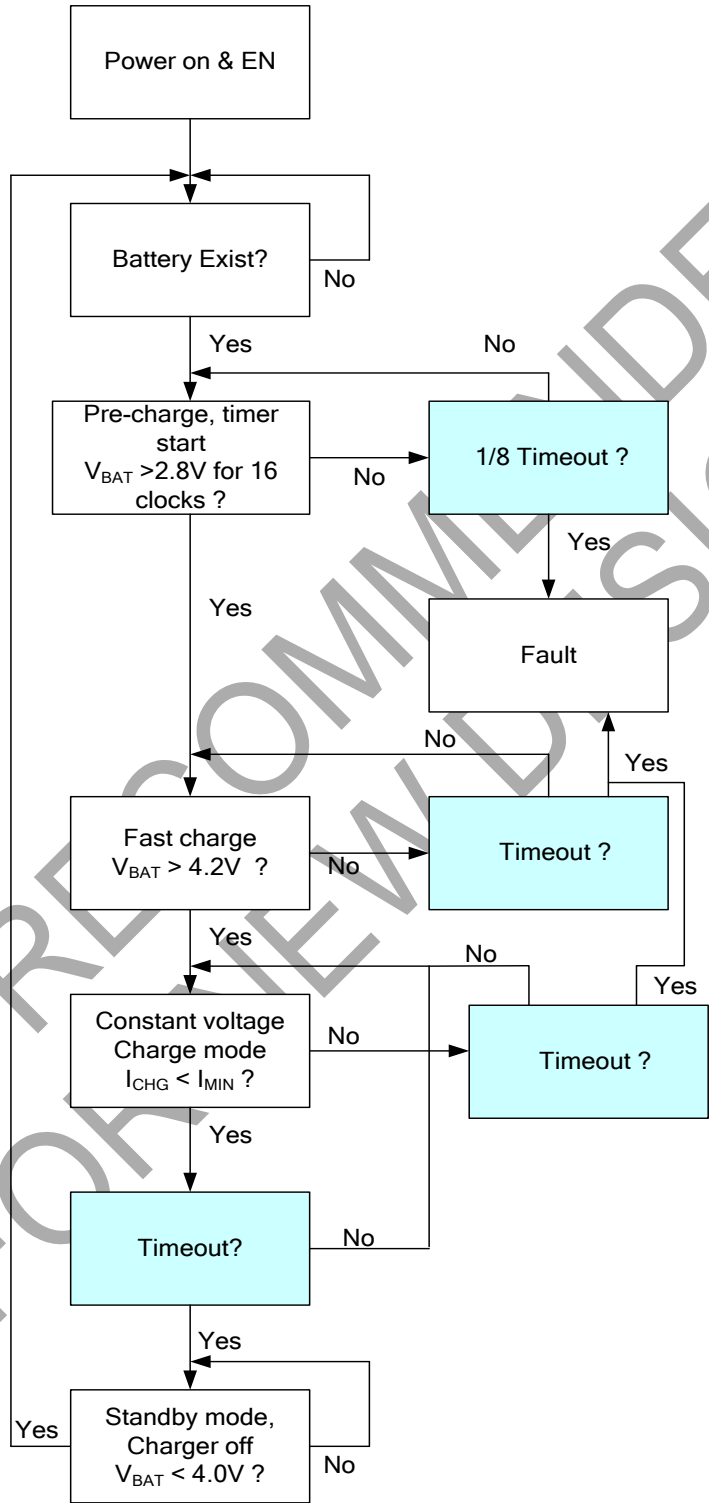| $\overline{STATUS}$	$\overline{FAULT}$	Condition
High	High	Power-down, charging is suspended or interrupted
Low	High	Charging
High	Low	Bad battery (Safety timer expired)

Charge current setting

$$I_{CHG} = 0.8 \times \left(\frac{10^5}{R_{IREF}} \right)$$ Where R_{IREF} in kΩ

Charge timer setting
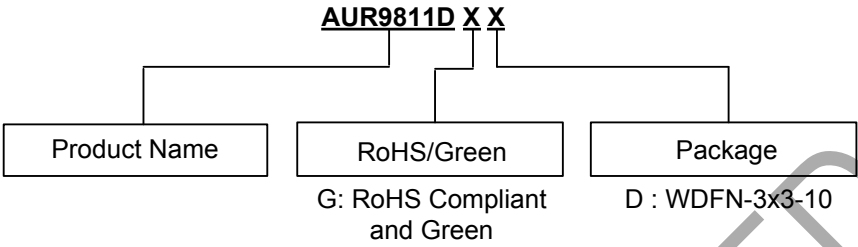
$$Time = 14 \times \frac{C_{TIME}}{1nF}$$ Where *Time* in Minutes

AUR9811D
Document number: DS39015 Rev. 3 - 3

10 of 14
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Flow Chart

```
            ┌─────────────────┐
            │  Power on & EN  │
            └─────────────────┘
                     │
                     ▼
            ┌─────────────────┐
            │ Battery Exist?  │──── No
            └─────────────────┘
                     │ Yes
                     ▼
            ┌─────────────────┐  No    ┌──────────────┐
            │ Pre-charge, timer│──────▶│ 1/8 Timeout ?│
            │ start            │       └──────────────┘
            │ V_BAT >2.8V for 16│            │ Yes
            │ clocks ?         │            ▼
            └─────────────────┘       ┌──────────────┐
                     │ Yes             │    Fault     │
                     │                 └──────────────┘
                     ▼                      
            ┌─────────────────┐  No    ┌──────────────┐
            │   Fast charge   │──────▶│   Timeout ?  │── Yes
            │  V_BAT > 4.2V ? │       └──────────────┘
            └─────────────────┘            No
                     │ Yes
                     ▼
            ┌─────────────────┐  No    ┌──────────────┐
            │ Constant voltage│──────▶│   Timeout ?  │── Yes
            │ Charge mode     │       └──────────────┘
            │ I_CHG < I_MIN ? │            No
            └─────────────────┘
                     │ Yes
                     ▼
            ┌─────────────────┐  No
            │    Timeout?     │────
            └─────────────────┘
                     │ Yes
                     ▼
            ┌─────────────────┐
            │ Standby mode,   │
    Yes ────│ Charger off     │── No
            │ V_BAT < 4.0V ?  │
            └─────────────────┘
```

AUR9811D
Document number: DS39015 Rev. 3 - 3

11 of 14
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Ordering Information

AUR9811D X X

Product Name	RoHS/Green	Package
	G: RoHS Compliant and Green	D : WDFN-3x3-10

Package	Temperature Range	Part Number	Marking ID	13" Tape and Reel Quantity
WDFN-3x3-10	-40 to +85°C	AUR9811DGD	9811D	5000/Tape & Reel

Marking Information

```
9811D
99YWW
•
```

9811D: Identification Code
99: Lot Number
Y: Year Code
WW: Week Code

Part Number	Package	Identification Code
AUR9811DGD	WDFN-3x3-10	9811D

AUR9811D
Document number: DS39015 Rev. 3 - 3

12 of 14
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Package Outline Dimensions (All dimensions in mm (inch).)

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

(1)   Package Type: WDFN-3×3-10

2.900(0.114)
3.100(0.122)

2.900(0.114)
3.100(0.122)

Pin 1 Mark

2.000(0.079)
REF

N6   N10

1.550(0.061)
1.800(0.071)

2.250(0.089)
2.500(0.098)

Pin 1 Mark
See DETAIL A

0.300(0.012)
0.500(0.020)

N5   N1

0.500(0.020)
BSC

0.180(0.007)
0.300(0.012)

DETAIL A

0.153(0.006)
0.253(0.010)

0.700(0.028)
0.800(0.031)

0.000(0.000)
0.050(0.002)

2 1   2 1

Pin 1 Mark options
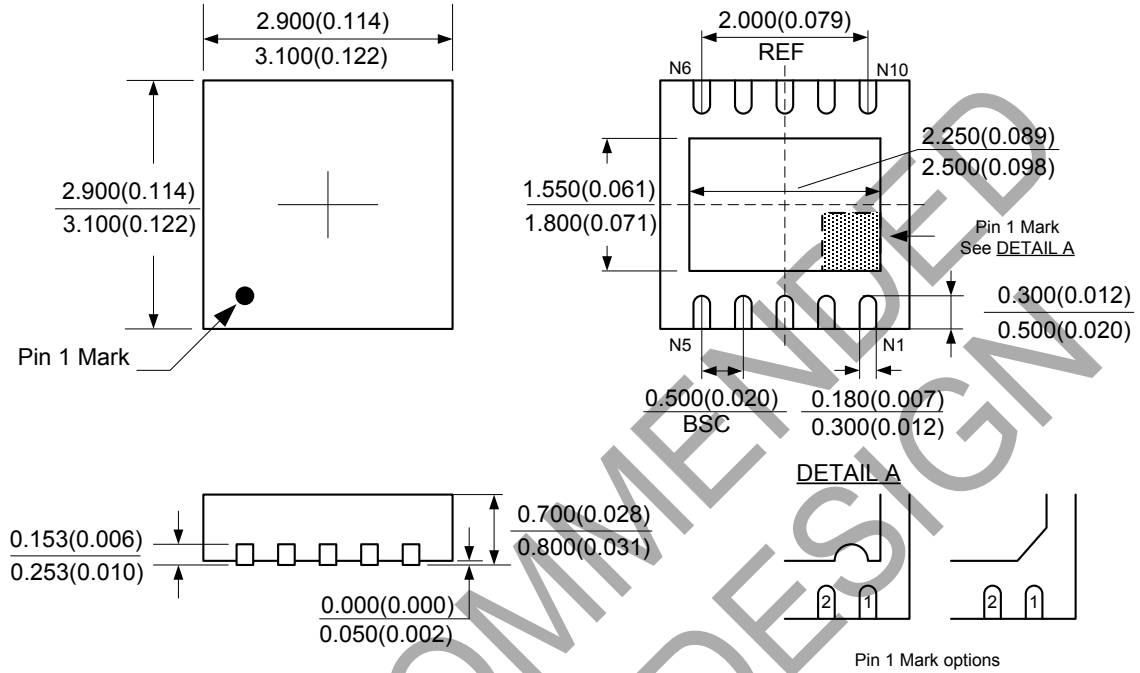
Suggested Pad Layout

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

(1)   Package Type: WDFN-3×3-10

E

Y2

X2

Y

Y1

X1
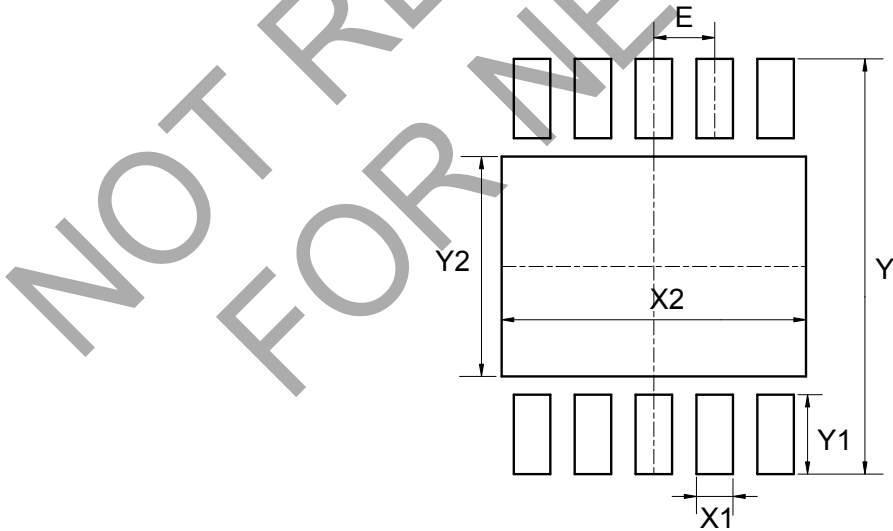
Dimensions	Y (mm)/(inch)	X1 (mm)/(inch)	Y1 (mm)/(inch)	X2 (mm)/(inch)	Y2 (mm)/(inch)	E (mm)/(inch)
Value	3.400/0.134	0.300/0.012	0.650/0.026	2.500/0.098	1.800/0.071	0.500/0.020

AUR9811D
Document number: DS39015 Rev. 3 - 3

13 of 14
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August 2019
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    2. support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in significant injury to the user.

B. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or to affect its safety or effectiveness.

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AUR9811D
Document number: DS39015 Rev. 3 - 3

14 of 14
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