WP8111

A Single Li-ion/Lithium Polymer Battery Protection IC

1. General Description

The WP8111 is a high integration solution for Li-ion/Li-Polymer battery protection IC. The WP8111 contains an advanced power MOSFET, high-accuracy voltage detection circuits and delay circuits.

The WP8111 is put into a DFN1*1-4 package and only one external component makes it an ideal solution in limited space of battery pack. The WP8111 has all the protection functions required in the battery application including overcharge, over discharge, over current and load short-circuiting protection etc. The accurate overcharge detection voltage ensures safe and full utilization charging. The low static current drains little current from the cell while in storage.

The WP8111 is not only targeted for digital cellular phones, but also for any other Li-ion applications requiring long-term battery life.

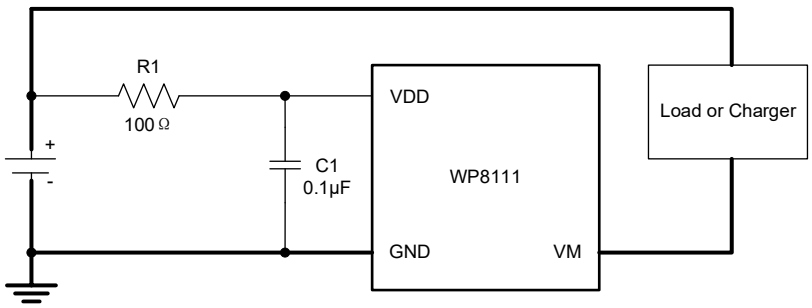
2. Features

- Protection of Charger Reverse Connection
- Protection of Battery Cell Reverse Connection
- Integrate Advanced Power MOSFET with Equivalent of 54 mΩ $R_{DS(ON)}$
- Over-temperature Protection
- Overcharge Current Protection
- Two-Step Over Current Detection:
  Over Discharge Current
  Load Short-Circuiting
- Charger Detection Function
- 0V Charge Function
- Delay Time is Preset Inside
- High-Accuracy Voltage Detection
- Low Current Consumption: 1.5μA Typ.
- RoHS Compliant and Lead (Pb) Free

3. Applications

- Single-cell Li-ion Battery Pack
- Li-ion Polymer Battery Pack
- Wearable Device
- Bluetooth Earphone

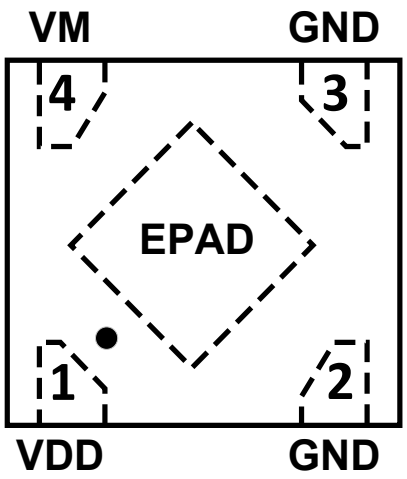
4. Typical Application Circuit



***NOTE:** The wide line is the high density current path which must be kept as short as possible, mass metal is better. For thermal management, ensure that these trace widths are adequate. C1 & R1 is a decoupling capacitor & resistor which should be placed as close as possible to WP8111.

5. Pin Configuration

(Top View)



DFN1*1-4

6. Pin Description

PIN NUMBER	PIN NAME	PIN FUNCTION
1	VDD	Power input pin, cell positive.
2,3	GND	Ground, Cell negative.
4	VM	Negative terminal of the charger or load, which is connected to GND via an internal MOSFET.
EPAD	NC	Cooling PAD, recommend connect to the GND.

7. Product Model List

Part Number	Overcharge Detection Voltage, V_{OC}	Overcharge Release Voltage, V_{OCR}	Over-discharge Detection Voltage, V_{OD}	Over-discharge Release Voltage, V_{ODR}	Power Down	V_{BAT} =0V Charging
WP8111-AFF4R	4.275V±25mV	4.075V±50mV	2.80V±100mV	3.0V[1] ±100mV	YES	YES
WP8111-BFF4R	4.425V±25mV	4.25V±50mV	2.80V±100mV	3.0V[1] ±100mV	YES	YES

NOTE1: Enter Power Down Mode after over-discharge, needs charging to activate normal discharge state.

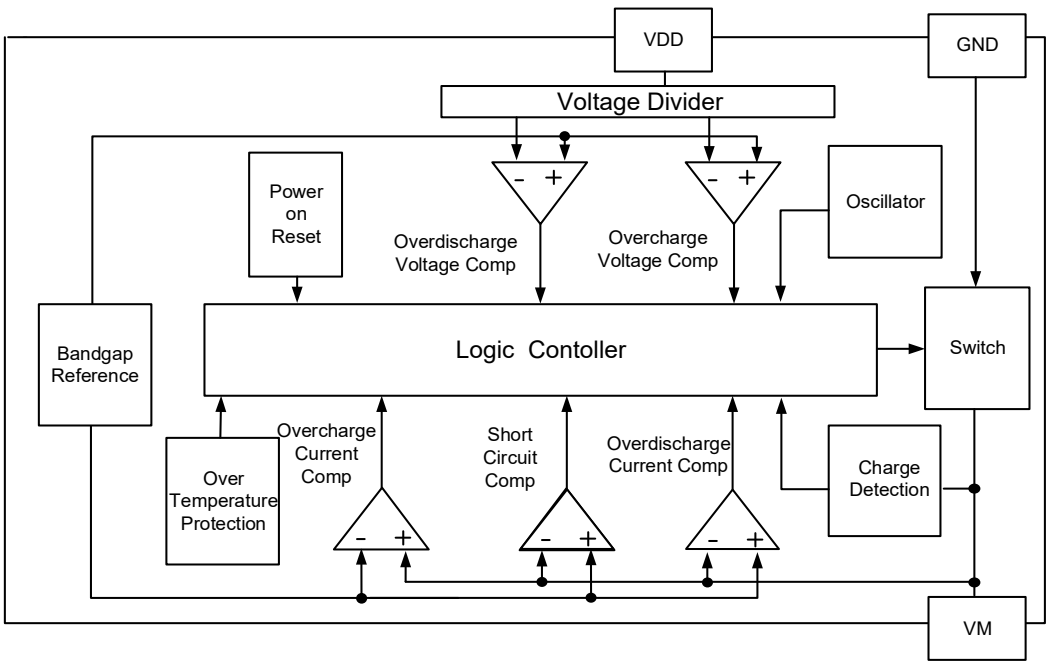
8. Absolute Maximum Ratings [2]

Operating free-air temperature range (unless otherwise noted)

PARAMETER	SYMBOL	RATING	UNIT
VDD input voltage	VDD	-0.3~6	V
VM input voltage	VM	-6~10	V
Power Dissipation (T_A=25℃)	P_D	0.3	W
Storage Temperature	T_{STG}	-55~150	℃
Ambient Temperature	T_A	-40~85	℃
Package Dissipation Class	θ_{JA}	250	℃ /W
Human Body Model, ANSI/ESDA/JEDEC JS-001-2017	ESD	4	kV
Charged Device Model, ANSI/ESDA/JEDEC JS-002-2018		2	kV

NOTE2: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

9. Structure Diagram



10. Electrical Characteristics

(T_A=25℃, unless otherwise noted)

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP.	MAX	UNIT
Detection Current						
I_{DOC}	Discharge Overcurrent Detection Current	VDD=3.6V	0.25	0.4	0.5	A
I_{COC}	Charge Overcurrent Detection Current	VDD=3.6V	0.25	0.4	0.5	A
I_{SC}	Load Short Circuit Detection Current	VDD=3.6V	0.6	0.75	0.9	A
Current Consumption						
I_Q	Quiescent Current	VDD=3.6V		1.5	2.3	μA
VM Internal Resistance						
R_{VMD}	Internal Resistance Between VM & VDD	VDD=2.0V, VM floating	200	300	400	kΩ
R_{VMS}	Internal Resistance Between VM & GND	VDD=3.6V, VM=3.6V	10	20	30	kΩ
V_{RIOV}[3]	Over-discharge current Release Voltage	VDD=3.6V		VDD-1.0		V
FET On-Resistance						
$R_{DS(ON)}$[3]	Equivalent FET on Resistance	VDD=3.6V, I_{VM}=200mA		54		mΩ
Over-Temperature Protection						
T_{SHD+}[3]	Over-Temperature Protection			135		℃
T_{SHD-}[3]	Over-Temperature Recover			110		
Detection Delay Time						
t_{OC}	Overcharge Detection Delay		80	170	240	ms
t_{OD}	Over-Discharge Detection Delay		20	40	60	ms
t_{DOC}	Discharge Overcurrent Detection Delay	VDD=3.6V	5	10	20	ms
t_{COC}	Charge Overcurrent Detection Delay	VDD=3.6V	5	10	20	ms
t_{SC}	Load Short Circuit Detection Delay	VDD=3.6V	80	180	300	μs

NOTE3: Parameter is guarantee by design.

11. Function Description

11.1 Normal Operation Mode

The IC continuously detects the battery voltage connected between the VDD and GND terminals and the current flowing between the VM and GND terminals to control charging and discharging. When the battery voltage is above the over discharge protection voltage (V_{OD}) and below the overcharge protection voltage (V_{OC}), and the current flowing from the VM terminal to GND is within the charge over current protection threshold (I_{COC}) and discharge over current protection threshold (I_{DOC}). In between, the MOSFET inside the IC is turned on, and this state is called “normal working state”. In this state, you can charge and discharge normally.

NOTE: When the battery is connected for the first time, it may not be able to discharge. At this time, it needs to be connected to the charger for activation. The activation voltage of the charger is 4.5V-5V, and the activation time cannot be less than 10ms. After activation, it can return to normal working state.

11.2 Overcharge Condition

When the battery voltage becomes higher than the overcharge detection voltage (V_{OC}) during charging under normal condition and the state continues for the overcharge detection delay time (t_{OC}) or longer, the WP8111 turns the charging control FET off to stop charging. This condition is called the overcharge condition.

The overcharge condition is released in the following two cases:

1) When the battery voltage drops below the overcharge release voltage (V_{OD}), the WP8111 turns the charging control FET on and returns to the normal condition.
2) When a load is connected and discharging starts, the WP8111 turns the charging control FET on and returns to the normal condition. The release mechanism is as follows: the discharging current flows through an internal parasitic diode of the charging FET immediately after a load is connected and discharging starts, and the VM pin voltage increases about the forward voltage of the diode from the GND pin voltage momentarily. The WP8111 detects this voltage and releases the overcharge condition. Consequently, in the case that the battery voltage is equal to or lower than the overcharge detection voltage (V_{OC}), the WP8111 returns to the normal condition immediately, but in the case the battery voltage is higher than the overcharge detection voltage (V_{OC}), the chip does not return to the normal condition until the battery voltage drops below the overcharge detection voltage (V_{OC}) even if the load is connected. In addition, if the VM pin voltage is equal to or lower than the over current detection voltage when a load is connected and discharging starts, the chip does not return to the normal condition.

NOTE: If the battery is charged to a voltage higher than the overcharge detection voltage (V_{OC}) and the battery voltage does not drop below the overcharge detection voltage (V_{OC}) even when a heavy load, which causes an over current, is connected, the over current does not work until the battery voltage drops below the overcharge detection voltage (V_{OC}). Since an actual battery has, however, an internal impedance of several dozens of mΩ, and the battery voltage drops immediately after a heavy load which causes an over current is connected, the over current work. Detection of load short-circuiting works regardless of the battery voltage.

11.3 Over-Discharge Condition

When the battery voltage drops below the over discharge detection voltage (V_{OD}) during discharging under normal condition and it continues for the over discharge detection delay time (t_{OD}) or longer, the WP8111 turns the discharging control FET off and stops discharging. This condition is called over discharge condition.

After the discharging control FET is turned off, the VM pin is pulled up by the R_{VMD} resistor between VM and VDD in WP8111. Meanwhile when the WP8111 is in over discharge state for 600ms, the current of the chip is reduced to the power-down current (I_{PD}). This condition is called power-down condition. The VM and VDD pins are shorted by the R_{VMD} resistor in the IC under the over discharge and power-down conditions. The power-down condition is released when a charger is connected. At this time, the FET is still off. When the battery voltage becomes the over discharge detection voltage (V_{OD}) or higher (see note), the WP8111 turns the FET on and changes to the normal condition from the over discharge condition.

NOTE: If the VM pin voltage is no less than the charger detection voltage (V_{CHA}), when the battery under over discharge condition is connected to a charger, the over discharge condition is released (the discharging control FET is turned on) as usual, provided that the battery voltage reaches the over discharge release voltage (V_{ODR}) or higher.

11.4 Overcurrent Condition

When the discharging current becomes equal to or higher than a specified value (the VM pin voltage is equal to or higher than the over current detection voltage) during discharging under normal condition and the state continues for the over current detection delay time or longer, the WP8111 turns off the discharging control FET to stop discharging. This condition is called over current condition. (The over current includes over current, or load short-circuiting).

The VM and GND pins are shorted internally by the R_{VMS} resistor under the over current condition. When a load is connected, the VM pin voltage equals the VDD voltage due to the load. The over current condition returns to the normal condition when the load is released and the impedance between the B+ and B- pins becomes higher than the automatic recoverable impedance. When the load is removed, the VM pin goes back to the GND potential since the VM pin is shorted the GND pin with the R_{VMS} resistor. Detecting that the VM pin potential is lower than the over current release voltage (V_{RIVO}), the IC returns to the normal condition.

11.5 Abnormal Charge Current Condition

If the VM pin voltage drops below the charger detection voltage (V_{CHA}) during charging under the normal condition and it continues for the overcharge detection delay time (t_{OC}) or longer, the WP8111 turns the charging control FET off and stops charging. This action is called abnormal charge current detection.

Abnormal charge current detection works when the discharging control FET is on and the VM pin voltage drops below the charger detection voltage (V_{CHA}). When an abnormal charge current flows into a battery in the over discharge condition, the WP8111 consequently turns the charging control FET off and stops charging after the battery voltage becomes the over discharge detection voltage and the overcharge detection delay time (t_{OC}) elapses. Abnormal charge current detection is released when the voltage difference between VM pin and GND pin becomes lower than the charger detection voltage (V_{CHA}) by separating the charger. Since the 0V battery charging function has higher priority than the abnormal charge current detection function, abnormal charge current may not be detected by the product with the 0 V battery charging function while the battery voltage is low.

11.6 Load Short-Circuiting Condition

If voltage of VM pin is equal or below short-circuiting protection voltage (V_{SC}), the WP8111 will stop discharging and battery is disconnected from load. The maximum delay time to switch current off is t_{SC}. This status is released when voltage of VM pin is higher than short protection voltage (V_{SC}), such as when dis connecting the load.

11.7 0V Battery Charging Function

This function enables the charging of a connected battery whose voltage is 0V by self-discharge. When a charger having 0V battery start charging charger voltage(V_{0CHA}) or higher is connected between B+ and B- pins, the charging control FET gate is fixed to VDD potential. When the voltage between the gate and the source of the charging control FET becomes equal to or higher than the turn-on voltage by the charger voltage, the charging control FET is turned on to start charging. At this time, the discharging control FET is off and the charging current flows through the internal parasitic diode in the discharging control FET. If the battery voltage becomes equal to or higher than the over discharge release voltage (V_{ODR}), the normal condition returns.

NOTE1: Some battery providers do not recommend charging of completely discharged batteries. Please refer to battery providers before the selection of 0V battery charging function.

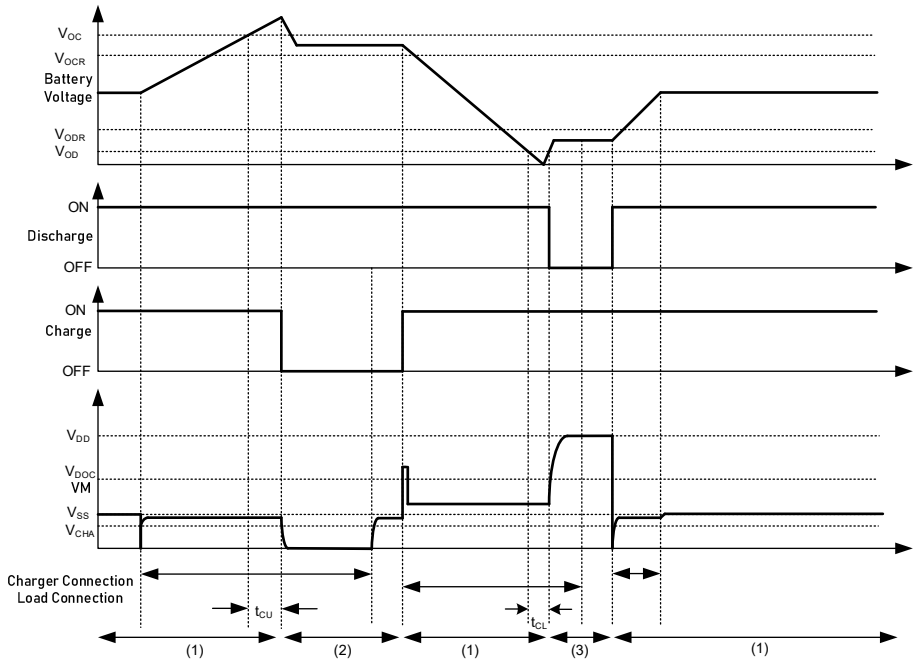
NOTE2: The 0V battery charging function has higher priority than the abnormal charge current detection function. Consequently, a product with the 0V battery charging function charges a battery and abnormal charge current cannot be detected during the battery voltage is low (at most 1.8V or lower).

NOTE3: When a battery is connected to the IC for the first time, the IC may not enter the normal condition in which discharging is possible. In this case, set the VM pin voltage equal to the GND voltage (short the VM and GND pins or connect a charger) to enter the normal condition.

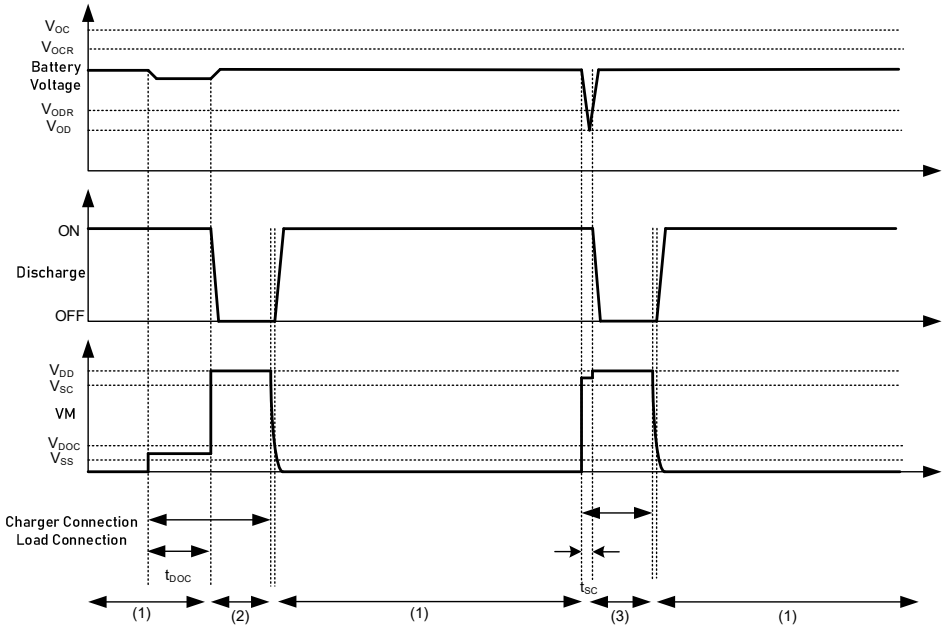
NOTE4: If < 50 mA Li-ion Battery is shorted, the voltage of battery maybe drop down to 0V~1V quickly so that the short-circuiting protection logic may not work properly. Increasing the value of resistor and capacitor can solve this problem, such as 1kΩ and 1μF.

12. Timing Diagram

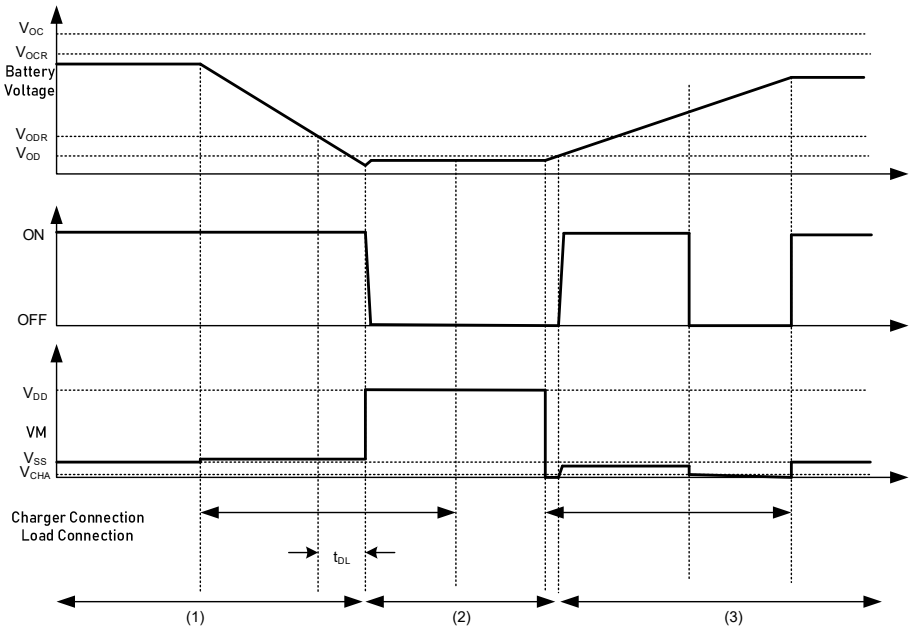
12.1 Overcharge & Over-discharge Voltage Detection



12.2 Discharge Overcurrent Detection



12.3 Abnormal Charger Detection



NOTE: $V_{SC}=I_{SC}*R_{DS(ON)}$

$V_{DOC}=I_{DOC}*R_{DS(ON)}$

REMARK: (1) Normal condition

(2) Overcharge voltage condition

(3) Over-discharge voltage condition

13. Naming Conventions

WP A B C D - E FFF G

WP: WAYON Regulator

A: 8 – Li-ion Battery Protection

B: 1 – Number of cells

C: 1 – Protection Type, Primary Protection

D: Serial Number

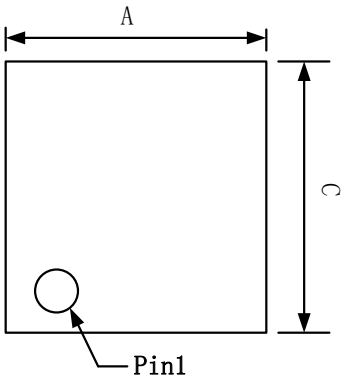
E: Model Number

FFF: FF4- Package, DFN1*1-4

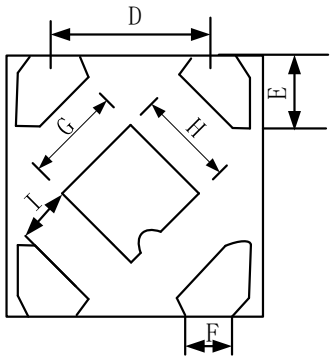
G: R-Reel

14. Package Information

DFN1*1-4



Top View



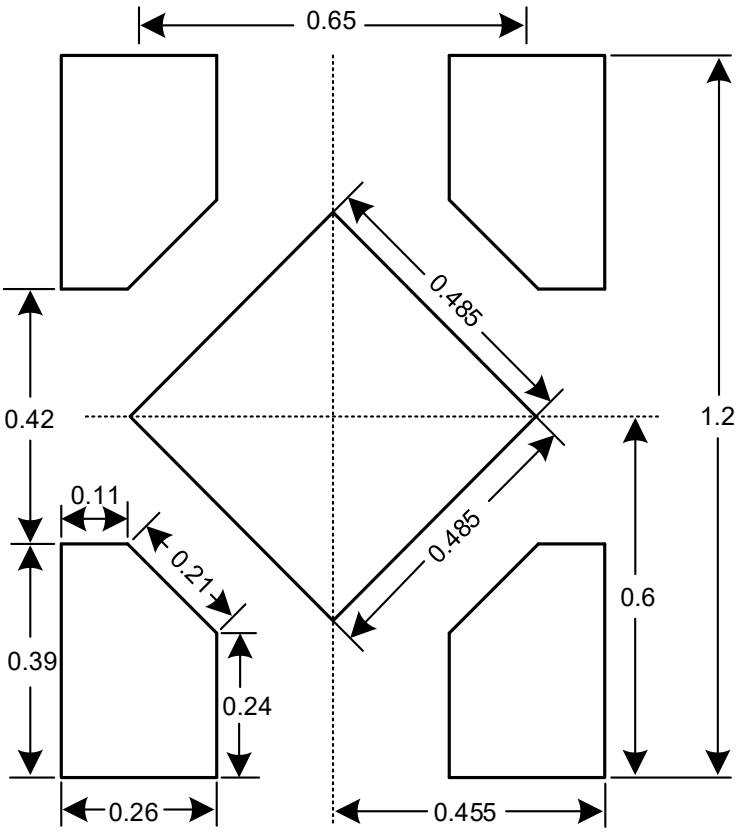
Bottom View



Side View

SYMBOL	DIMENSIONS IN MILLIMETERS		
	MIN	NOM	MAX
A	0.950	1.000	1.050
B	0.320	0.370	0.420
C	0.950	1.000	1.050
D		0.650BSC	
E	0.170	0.270	0.370
F	0.130	0.235	0.300
G	0.430	0.485	0.540
H	0.430	0.485	0.540
I		0.200REF	

Suggested Pad Layout: DFN1*1-4



NOTE: Dimensions in Millimeters

15. Ordering Information

PART NUMBER	PACKAGE	PACKING QUANTITY
WP8111-AFF4R	DFN1*1-4	10k/Reel
WP8111-BFF4R	DFN1*1-4	10k/Reel

Contact Information

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Product Specification Statement

1.The product specification aims to provide users with a reference regarding various product parameters, performance, and usage. It presents certain aspects of the product's performance in graphical form and is intended solely for users to select product and make product comparisons, enabling users to better understand and evaluate the characteristics and advantages of the product. It does not constitute any commitment, warranty, or guarantee.

2.The product parameters described in the product specification are numerical values, characteristics, and functions obtained through actual testing or theoretical calculations of the product in an independent or ideal state. Due to the complexity of product applications and variations in test conditions and equipment, there may be slight fluctuations in parameter test values. WAYON shall not guarantee that the actual performance of the product when installed in the customer's system or equipment will be entirely consistent with the product specification, especially concerning dynamic parameters. It is recommended that users consult with professionals for product selection and system design. Users should also thoroughly validate and assess whether the actual parameters and performance when installed in their respective systems or equipment meet their requirements or expectations. Additionally, users should exercise caution in verifying product compatibility issues, and WAYON assumes no responsibility for the application of the product.

3.WAYON strives to provide accurate and up-to-date information to the best of our ability. However, due to technical, human, or other reasons, WAYON cannot guarantee that the information provided in the product specification is entirely accurate and error-free. WAYON shall not be held responsible for any losses or damages resulting from the use or reliance on any information in these product specifications. WAYON reserves the right to revise or update the product specification and the products at any time without prior notice, and the user's continued use of the product specification is considered an acceptance of these revisions and updates. Prior to purchasing and using the product, users should verify the above information with WAYON to ensure that the product specification is the most current, effective, and complete. If users are particularly concerned about product parameters, please consult WAYON in detail or request relevant product test reports. Any data not explicitly mentioned in the product specification shall be subject to separate agreement.

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5.The design of the product is intended to meet civilian needs and is not guaranteed for use in harsh environments or precision equipment. It is not recommended for use in systems or equipment such as medical devices, aircraft, nuclear power, and similar systems, where failures in these systems or equipment could reasonably be expected to result in personal injury. WAYON shall assume no responsibility for any consequences resulting from such usage.

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