AXBM20490x

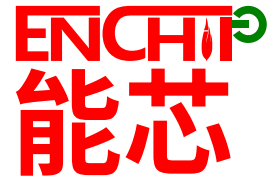## 0.4A One Cell Lithium-ion/Polymer Battery Protection IC with 1nA Deep Sleep mode for shipping

Datasheet – Jun 2022

Description

AXBM20490x is a high integration solution for lithium ion/polymer battery protection designed in BCD (Bipolar, CMOS, DMOS) technology with special attention to enhanced safety and low current consumption. Integrated are smart power mosfet, high-accuracy voltage detection circuits, and protection detection delay circuits. AXBM20490x integrates a transport mode circuit and can be commanded into Deep Sleep power down mode with 1nA I_{PD} during shipping, to be awaken on charger connect detection or external button control. Along with ultra-low operation Iq of 0.85µA, reverse battery protection and zero voltage charging, it is ideal for any Li-Ion and Li Poly battery-powered information appliances such as wearables requiring long term battery life. Packaged into an DFN4,1X1x0.37 package, it makes an ideal solution in limited space of battery pack.

Features

- Integrated smart power mosfet, with Rdson 100mΩ (typ).
- Charging and discharging current 0.4A (typ).
- Low current consumption: 0.85µA (typ) in operation; 1nA (typ) in Deep Sleep power-down.
- Charger connect detection.
- High accuracy voltage detection.
- Protections: over-charge voltage, over-discharge voltage, over-charge current, over-discharge current, load short, over-temperature.

- Zero volt battery charging.
- 4kV ESD (HBM).
- Reverse Battery protection without external resistor and capacitor.
- External control for entering and awakening from Deep Sleep power-down shipping mode.
- Optional external capacitor and resistor for stable power supply application.

Applications

- TWS
- Wearables
- Any Li-ion / Polymer battery powered appliances

Packaging

Order code	Package	Packing
AXBM20490x x: A=4.28V V_{OC} B=4.42V V_{OC}	 DFN4 epad 1.0 x 1.0 x 0.37	Reel

Contents

List of Figures

List of Tables

1 Block Diagram and Application Circuit

Figure 1 Block Diagram
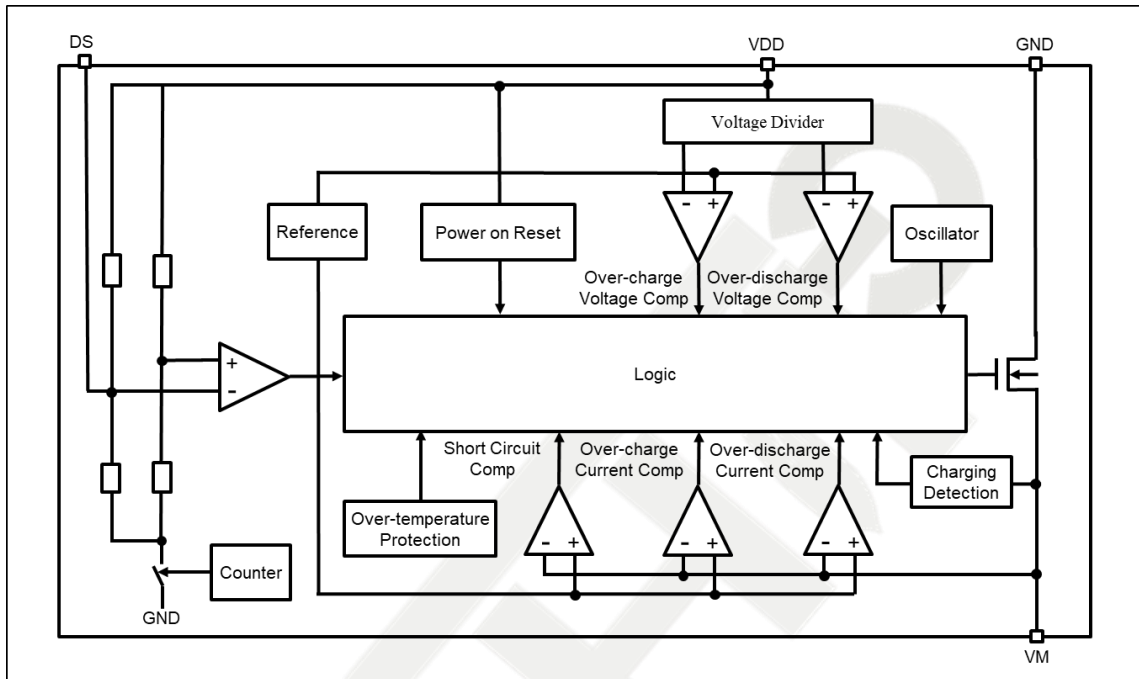
Figure 2 Application Circuit
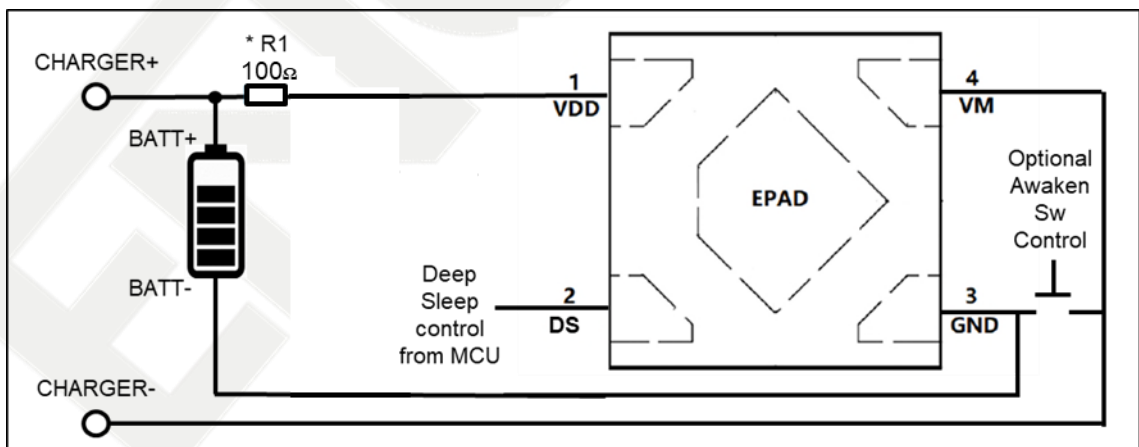
* Only R1 is needed.

2   Pin Description

2.1   Pin Names

Figure 3 Pin Connection
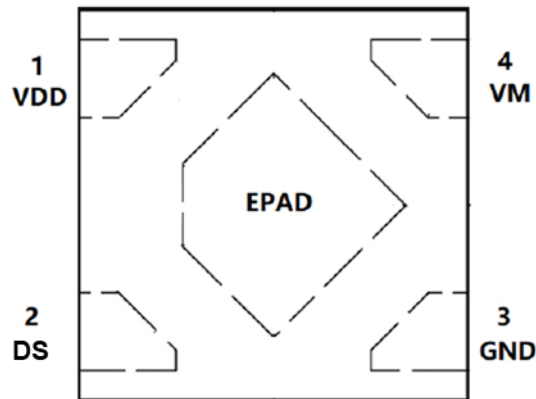
2.2   Pin Functions

Table 1 Pin Functions

Pin number	Pin name	Description
1	VDD	Power Supply.
2	DS	Deep Sleep Control Open collector IO from MCU
3	GND	Ground. Connect the negative terminal of the battery to this pin.
4	VM	The internal mosfet switch connects this terminal to GND.
EPAD		Not used. Suggest connecting it to GND.

3 Electrical Specifications

3.1 Absolute Maximum Ratings

Table 2 Absolute Maximum Ratings

Symbol	Parameter	Value	Unit
VDD	Supply voltage	-0.3 to +6	V
VM	Input pin voltage	-6 to +10	V
Ptot	Power dissipation Tamb = +25°C	0.3	W
Tj	Junction temperature	150	°C
Tstg	Storage temperature	-55 to +150	°C

3.2 Thermal Data

Table 3 Thermal Data

Symbol	Parameter	Value	Unit
Rth j-case	Thermal resistance junction-to-case max.	130	°C/W

3.3 ESD and Latch Up

Table 4 ESD and Latch up

Symbol	Parameter	Value	Unit
VDD, VM, GND	ESD HBM	4,000	V
VDD, VM	Latch Up JESD78, Class A	≥ 100	mA

3.4 Electrical Characteristics

VDD = 3.6V; Tamb = +25°C; unless otherwise specified.

Table 5 Electrical Characteristics

Symbol	Parameter	Test condition	Min	Typ	Max	Unit
Detection Voltage						
Voc	Over-charge detection voltage	AXBM20490A	4.25	4.28	4.31	V
		AXBM20490B	4.39	4.42	4.45	
Vocr	Over-charge release voltage	AXBM20490A	4.03	4.08	4.13	V
		AXBM20490B	4.17	4.22	4.27	
Vod	Over-discharge detection voltage		2.7	2.8	2.9	V
Vodr	Over-discharge release voltage		2.9	3.0	3.1	V
Detection Current						
Ioc	Over-charge current detection	VDD=3.6V	0.25	0.4	0.55	A
Iod	Over-discharge current detection	VDD=3.6V	0.25	0.4	0.55	A
Ishort	Load short detection	VDD=3.6V	0.7	1.0	1.3	A
Current Consumption						
Iop	Current consumption in normal operation	VDD=3.6V VM=0V		0.85	1.0	µA
Ipd	Current consumption in power down and Deep Sleep	VDD=2.0V VM float		1	10	nA
VM Internal Resistance						
Rvmd	Internal resistance between VM and VDD	VDD=2.0V VM float		300		kΩ
Rvms	Internal resistance between VM and GND	VDD=3.6V VM=1.0V		100		kΩ
Power Mosfet On-resistance						
Rdson	Equivalent mosfet on-resistance	VDD=3.6V IVM=0.2A	67	100	133	mΩ
Over Temperature Protection						
Tshd+	Over-temperature protection			130		°C
Tshd-	Over-temperature recovery			110		°C
Detection Delay Time						
Tvoc	Over-charge voltage detection delay time		70	100	150	ms
Tvod	Over-discharge voltage detection delay time		60	80	120	ms
Tioc	Over-charge current detection delay time	VDD=3.6V	6	12	18	ms
Tiod	Over-discharge current detection delay time	VDD=3.6V	5	10	15	ms
Tshort	Load short detection delay time	VDD=3.6V	130	180	300	µs

4 Functional Description

4.1 Overview

AXBM20490x monitors the voltage and current of a battery and provides high accuracy protection for:
- Over-charge voltage
- Over-discharge voltage
- Over-charge current
- Over-discharge current
- Short circuit conditions by disconnecting the battery from the load or charger.

These functions are required to operate the battery cell within specified limits. The power mosfet is integrated and its Rdson is as low as 100mΩ (typical). External Capacitor and resistor are optional for stable supply voltage applications.

4.2 Normal Operating Mode

If no exceptional condition is detected, charging and discharging can be carried out freely. This condition is called normal operating mode.

4.3 Over-charge Condition

When the battery voltage becomes higher than the over-charge detection voltage (Voc) during charging under normal condition and, the state continues for the over-charge detection delay time (Tvoc) or longer, AXBM20490x will turn off the charging control mosfet to stop charging. This condition is called over-charge condition.

The over-charge condition is released in the following two cases:
1. When the battery voltage drops below the over-charge release voltage (Vocr), AXBM20490x will turn on the charging control mosfet and return to normal condition.
2. When a load is connected and discharging starts, AXBM20490x will turn on the charging control mosfet and return to normal condition.

4.4 Over-discharge Condition

When the battery voltage drops below the over-discharge detection voltage (Vod) during discharging under normal condition and, it continues for the over-discharge detection delay time (Tvod) or longer, AXBM20490x will turn off the discharging control mosfet and stop discharging. This condition is called over-discharge condition.

After the discharging control mosfet being turned off, VM pin will be pulled up by the resistor Rvmd between VM and VDD within AXBM20490x. 1.5s later, AXBM20490x will go into power-down mode with current (Ipd) reduced to 1nA.

This condition is called power-down condition. The VM and VDD pins are shorted by Rvmd under the over-discharge and power-down conditions.

The power-down condition is released when a charger is connected and the potential difference between VM and VDD becomes 1.3V (typ) or higher (load short detection voltage). During this time, the mosfet is still off.

When the battery voltage reaches the over-discharge release voltage (Vodr) or higher, AXBM20490x will turn on the mosfet and change to normal condition from the over-discharge condition.

4.5 Over-current 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, AXBM20490$_X$ will turn off the discharging control mosfet so as to stop discharging. This condition is called over-current condition. (The over-current includes over-current or load short) The VM and GND pins are shorted internally by Rvms under over-current condition. When a load is connected, the VM pin voltage is equal to VDD voltage due to the load. The over-current condition returns to normal condition when the load is released and the impedance between Pack+ and Pack- pins becomes higher than the automatic recoverable impedance. When the load is removed, the VM pin goes back to GND potential since it is shorted to GND via Rvms. Detecting that the VM pin potential is lower than the over-current detection voltage (Voc), AXBM20490$_X$ returns to normal condition.

4.6 Abnormal Charge Current Detection

If the VM pin voltage drops below the charger detection voltage (Vcha) during charging under the normal condition and, it continues for the delay time of Tioc or longer, AXBM20490x will turn off the charging control mosfet and stop charging. This action is called abnormal charge current detection.

Abnormal charge current detection starts working when the discharging control mosfet is turned on and the VM pin voltage drops below the charger detection voltage (Vcha). When an abnormal charge current flows into a battery in over-discharge condition, AXBM20490x will turn off the charging control mosfet and stop charging.

Abnormal charge current detection is released when the voltage difference between the VM pin and GND pin becomes lower than the charger detection voltage (Vcha) 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 0V battery charging function while the battery voltage is low.

4.7 Load Short Condition

If voltage of VM pin is equal or below short protection voltage (Vshort), AXBM20490$_X$ will stop discharging and battery will be disconnected from load. The maximum delay time to switch off the current is Tshort. This status is released when VM voltage is higher than the short protection voltage (Vshort), such as when disconnecting the load.

Precaution:

If < 50mAh Li-Battery is shorted, the voltage of battery may be pulled down to 0V~1V quickly so that the short-circuiting protection logic may not work properly.

4.8 Deep Sleep

The DS pin commands transport mode DeepSleep. When pulsed to 0V three times, it sends the device into a Deep Sleep power-down mode for shipping purposes. During the Deep Sleep I$_{PD}$ is at 1nA typ drawing ultralow shipping mode current from the battery. The application scenario is that upon decision to enter shipping mode, the MCU will command 3 low pulses to the AXBM20490$_X$. It will turn off the integrated mosfet, effectively cutting off all supply to the system. The 3 low pulses before entering Deepsleep ensures robustness against accidental triggering. When the system needs to re-awaken, it can do so by connecting a charger to the system. AXBM20490$_X$ will auto detect the charger and turn back on the integrated mosfet if no

other fault protection is detected. Alternatively, the system can also reawaken by connecting VM to GND momentarily to simulate a charger connect condition.

4.9 Delay Circuits

The detection delay time for over-discharge current and load short-circuiting starts when over-discharge current is detected. As soon as over-discharge current or load short is detected over detection delay, AXBM20490$_X$ will stop discharging. When battery voltage falls below over-discharge detection voltage due to over-discharge current, AXBM20490$_X$ will stop discharging by over-discharge current detection. In this case the recovery of battery voltage is so slow that if battery voltage after over-discharge voltage detection delay time is still lower than over-discharge detection voltage, AXBM20490$_X$ will shift to power-down mode.

4.10 0V Battery Charging Function

This function enables the charging of a connected battery whose voltage is 0V due to self-discharge. When a charger having 0V battery starts charging charger voltage (V0cha) or higher is connected between Pack+ and Pack- pins, the charging control mosfet gate is fixed to VDD potential. When the voltage between the gate and the source of the charging control mosfet becomes equal to or higher than the turn-on voltage by the charger voltage, the charging control mosfet is turned on to start charging. At this time, the discharging control mosfet is turned off and the charging current flows through the internal parasitic diode in the discharging control mosfet. If the battery voltage becomes equal to or higher than the over-discharge release voltage (Vodr), normal condition returns.

Note:
(1) Some battery providers do not recommend charging of completely discharged batteries. Please refer to battery providers before the selection of 0V battery charging function.
(2) When a battery is connected to the device for the first time, the device 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.

4.11 Timing Diagrams

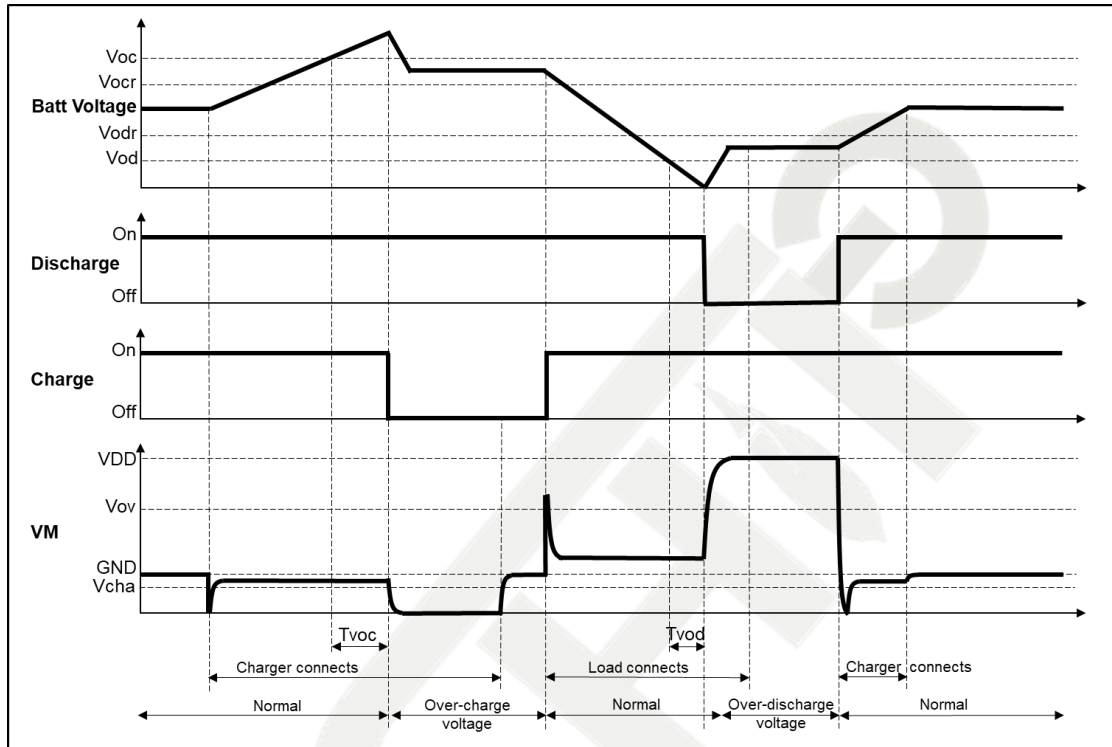**Figure 4 Over-charge and Over-discharge Voltage Detection**
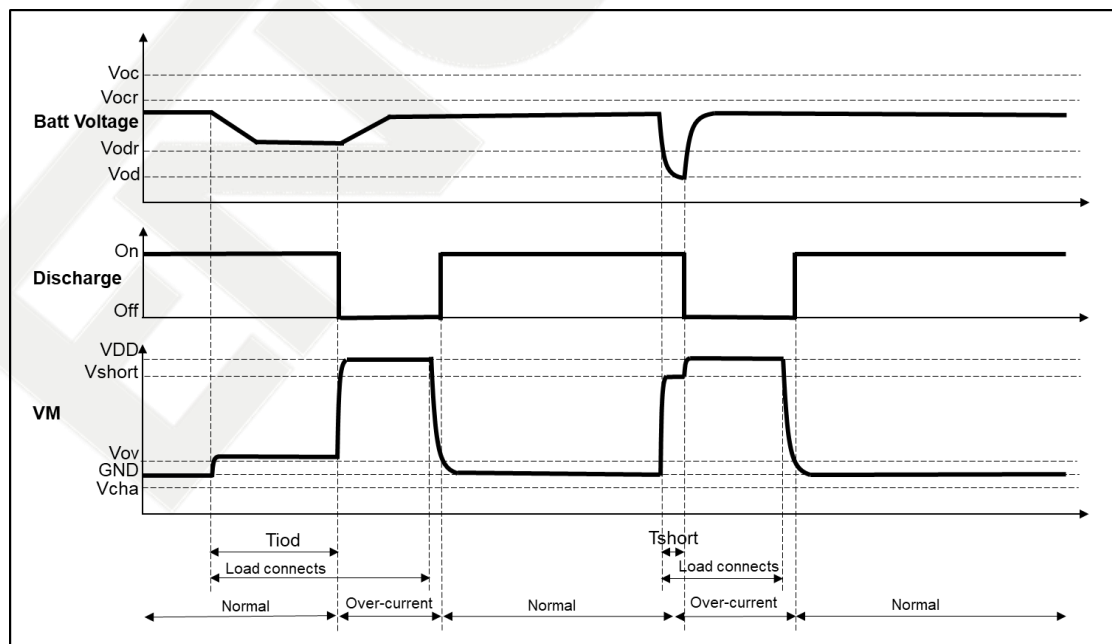

Figure 5 Over-discharge Current Detection

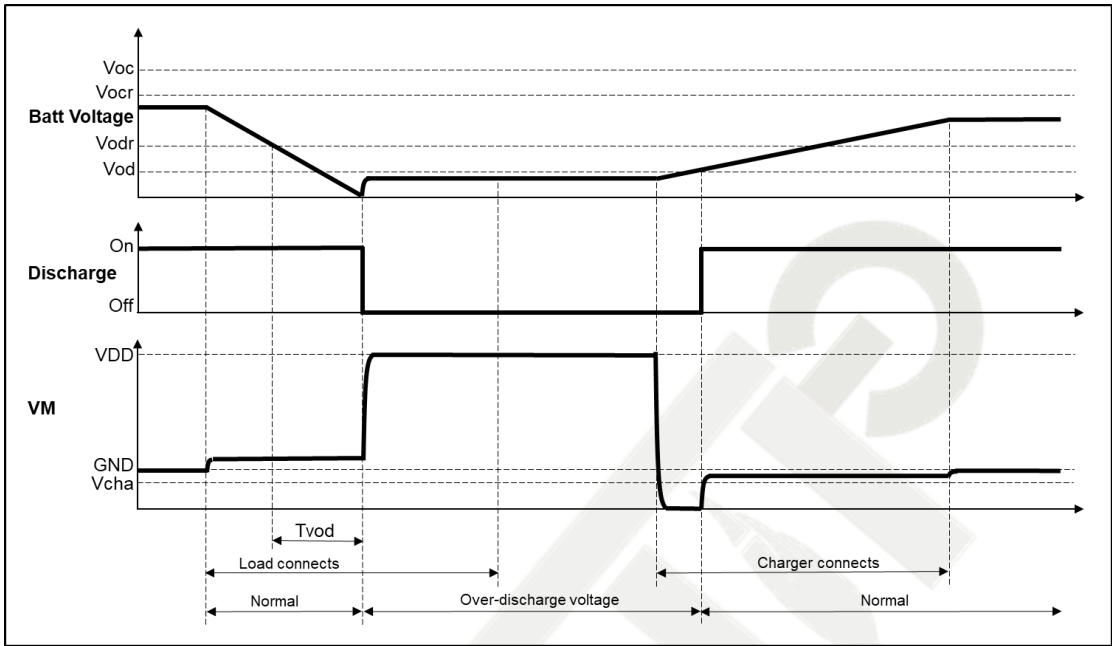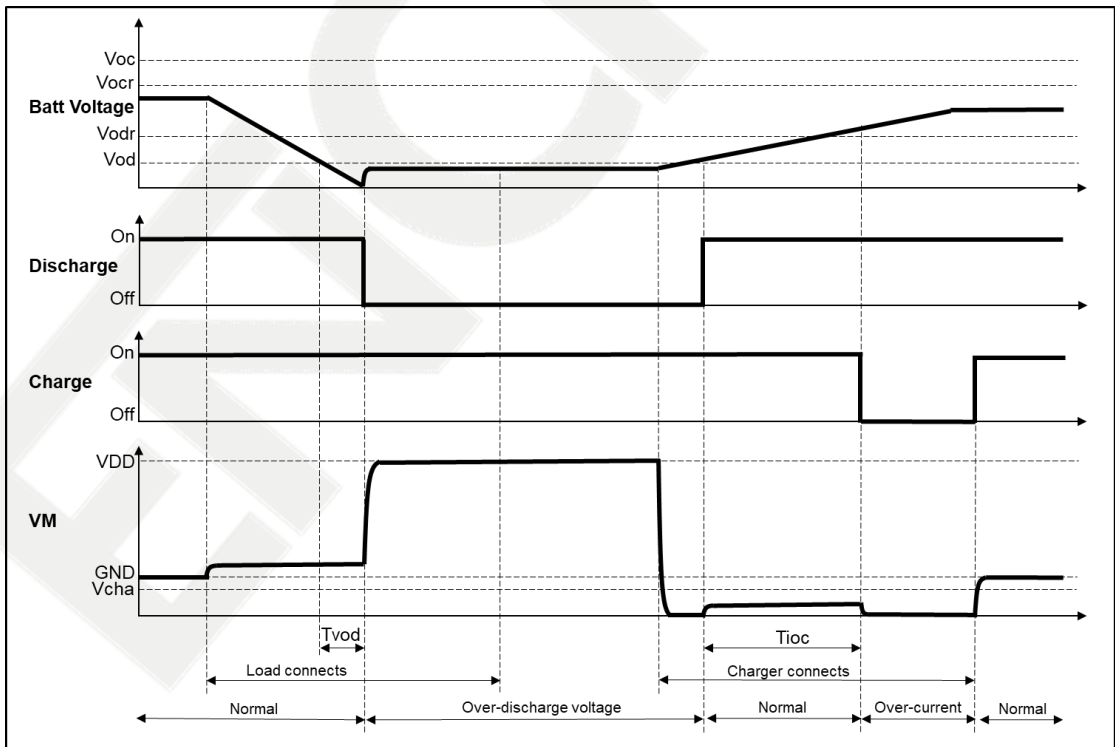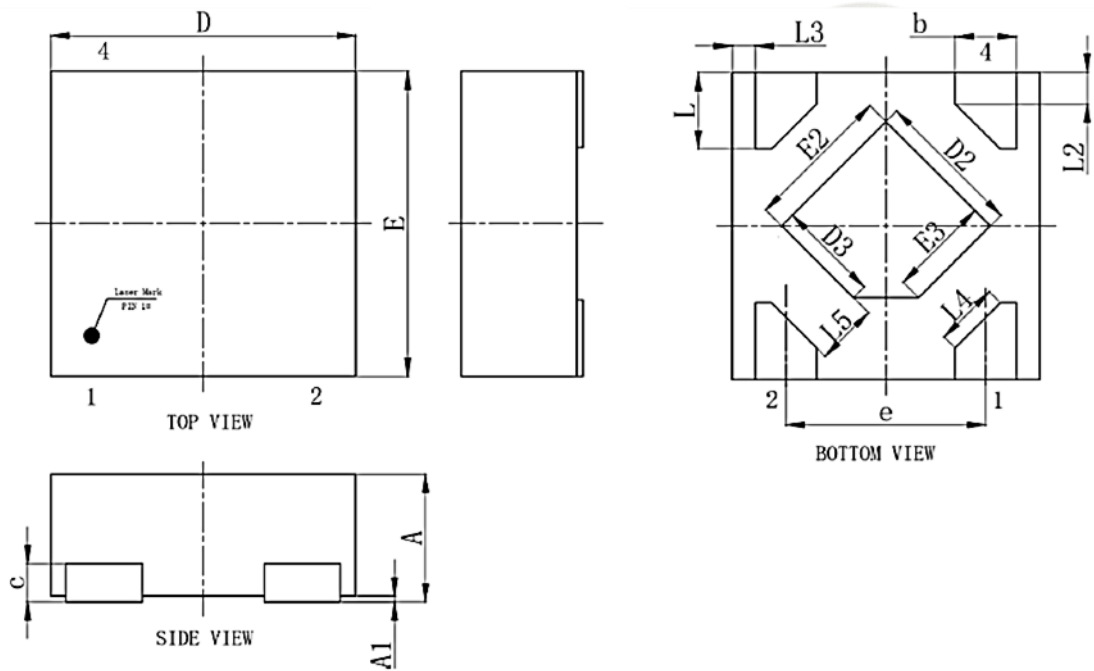**Figure 6 Charger Detection**

Figure 7 Abnormal Charger Detection

5 Package Information

5.1 Package Outline Dimensions

**Figure 8 DFN4 EPAD 1.0 x 1.0 x 0.37 mm Mechanical Data and Package Dimensions**

SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.35	-	0.40
A1	0.00	0.02	0.05
b	0.15	0.20	0.25
c	0.127REF		
D	0.95	1.00	1.05
D2	0.38	0.48	0.58
D3	0.23	0.33	0.43
e	0.65BSC		

SYMBOL	MILLIMETER		
	MIN	NOM	MAX
E	0.95	1.00	1.05
E2	0.38	0.48	0.58
E3	0.23	0.33	0.43
L	0.20	0.25	0.30
L2	0.103REF		
L3	0.075REF		
L4	0.208REF		
L5	0.200REF		

Copyright © 2022, Shenzhen EnChip Semiconductor Co. Ltd

5.2 Package Marking Information

Figure 9 DFN4 EPAD 1.0 x 1.0 x 0.37 mm Marking Information
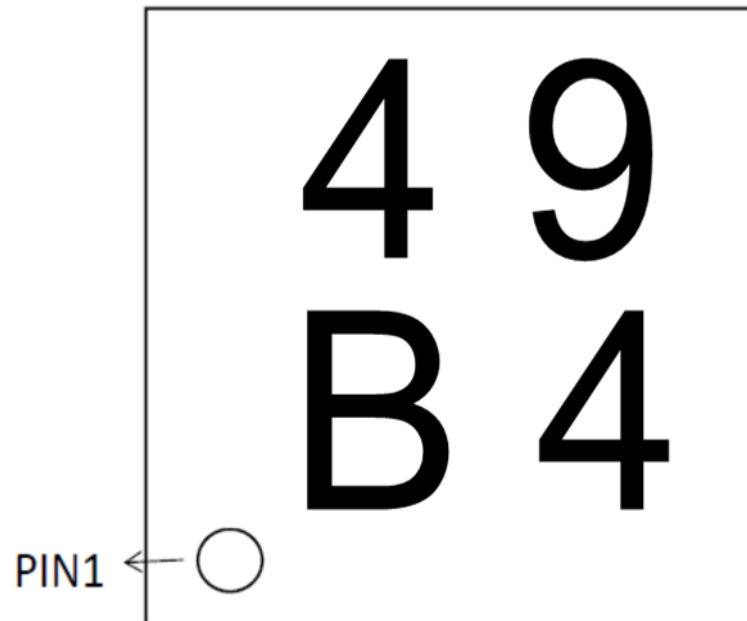
Laser mark circle to indicate pin 1

2 lines of alphanumeric coding:

    Line 1:   49 to indicate AXBM20490 device

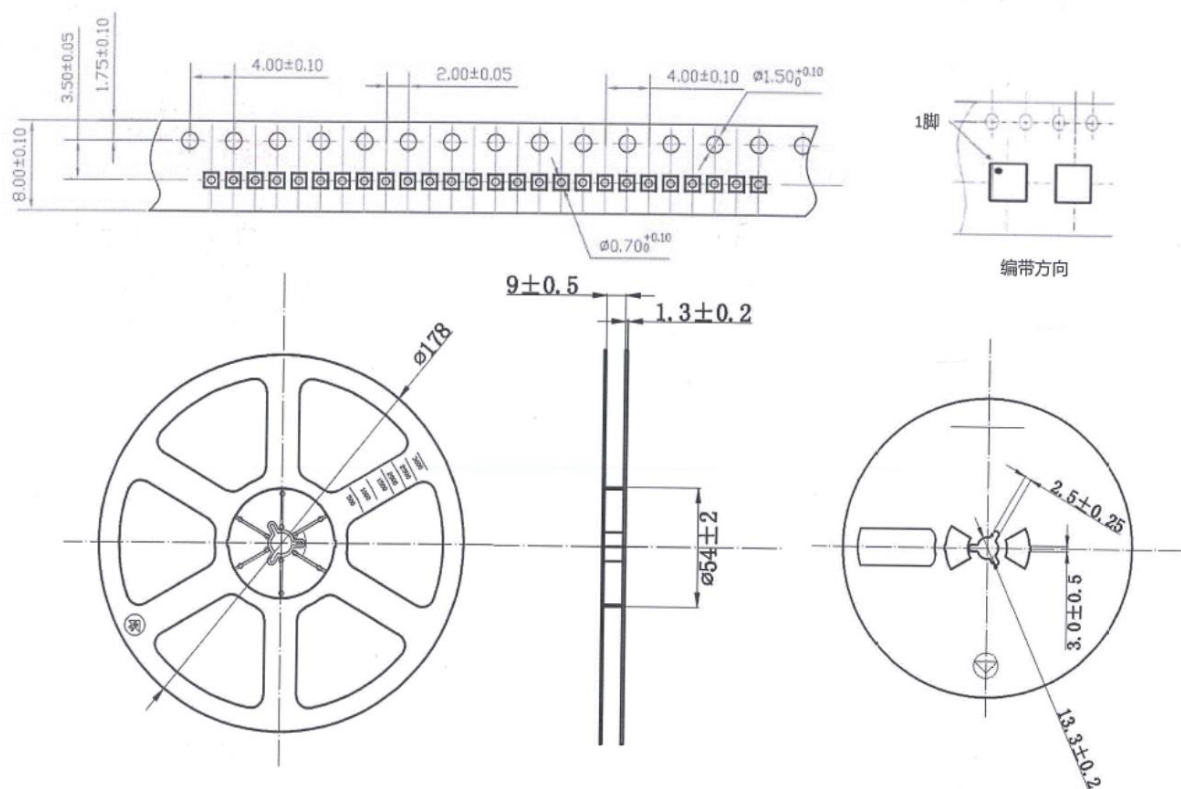   Line 2:   1st character to indicate device options

          "B" = AXBM20490A with 4.28V V_{OC}

          "Z" = AXBM20490B with 4.42V V_{OC}

          2nd character to indicate production month number: 1,2,3,4,5,6,7, A, C, D, E, F

6   Packing Information

Figure 10 Reel Packing Information

7   Revision History

Table 6 Document Revision History

Date	Version	Description
Aug 2020	1.00	First version.
Aug 2021	1.10	Added package marking information and reel packing information.
Jan 2022	1.11	Added Rdson and Vod tolerance
Jun 2022	1.12	C1 not used in typical application. C1 removed from application diagram