

Application Information

Battery Management System Application



Enhancing everyday life

The battery management system (BMS) with the multi-cells, the cell-balancing control (fuel gauge method) and protection control with the charge-discharge function is shown in Fig. 1. Different voltage applications have different numbers of battery cells in series. There are two kind applications. One is high side MOSFETs application shown in Fig.2. Fig. 2(a) is applying N-ch MOSFETs and Fig. 2(b) is applying P-ch MOSFETs. Another is applying low side MOSFETs shown in Fig. 3. This application information is focus on selection of two MOSFETs for the charge-discharge function and battery protection.

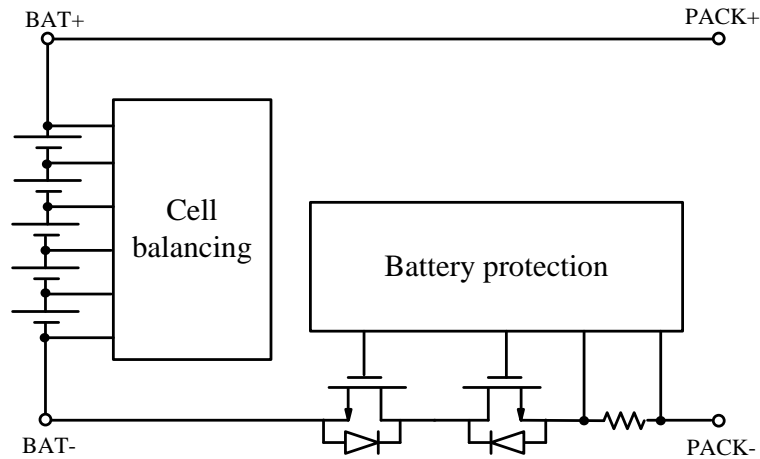


Fig. 1 The battery management system

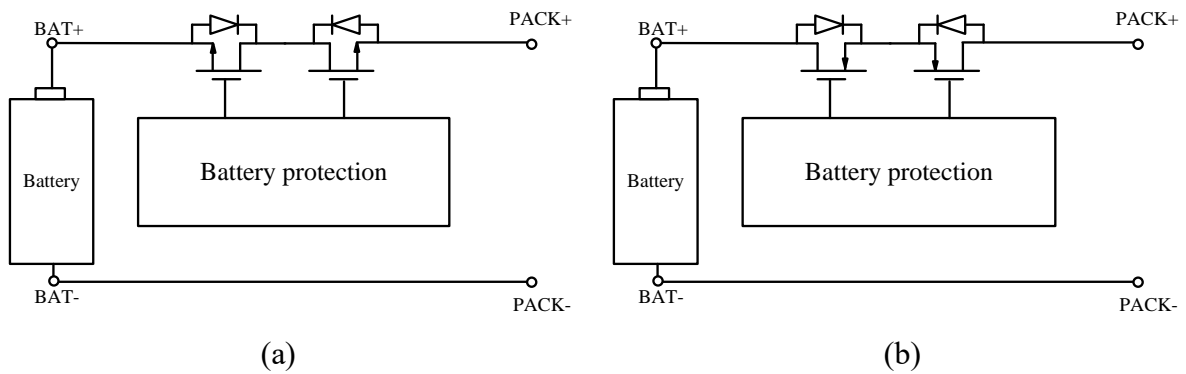


Fig. 2 High side MOSFETs application (a) N-ch (b) P-ch

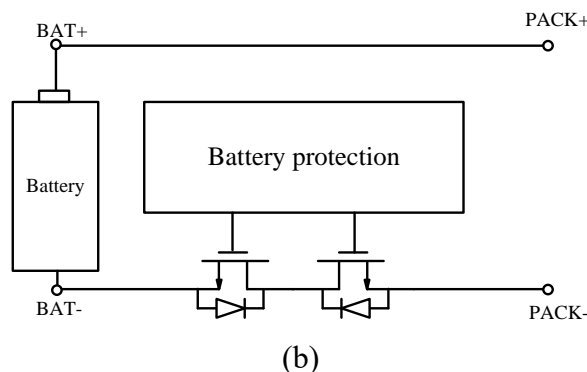


Fig. 3 Low side MOSFETs application

The BMS is not a fast switching application which make the selection criteria of the MOSFET similar to the load switch application. The switching parameters when considering MOSFETs can be neglected due to the battery-protection MOSFETs are continuously conducting current. It is like selecting load-switch MOSFETs based on their current/power capability, on-resistance, gate leakage current, gate threshold voltage, gate-source voltage, drain-source voltage and package type. These important considerations are shown as following:

1. Current/power capability and on-resistance

Battery capacity is measured in amps × hours (Ah) or watts × hours (Wh). It can consume less battery power capacity if the on-resistance is smaller. Potens recommends using a low on-resistance MOSFET. The power dissipation of the MOSFET can be expressed as:

$$P_D = I_D^2 \times R_{DS(ON)} \quad (1)$$

It should be ensured that the power dissipation is not allowed to rise above the recommended maximum level.

2. Gate leakage current

Another important power dissipation is caused by gate leakage current. Fig. 4 shows the gate driving circuit. Considering the consumption of the battery, Potens recommends using a MOSFET with a low gate leakage current for battery protection function.

3. Gate threshold voltage

The gate threshold voltage is the lowest V_{GS} at which a specified small amount of I_D flows. For the voltage applied to the gate, refer to the test condition voltage for drain-source on-state resistance in the datasheet. Therefore, the gate driving voltage from the protection IC or general purpose I/O of MCU should be 1.5~2 times higher than the maximum gate threshold voltage to ensure that the MOSFET is operating in the linear/ohmic region.



Fig. 4 The gate driving circuit

4. Gate-source voltage

The gate driver of the battery protection device limits the gate-source voltage. This means the device can work under an absolute maximum rating of the gate-source voltage.

5. Drain-source voltage

The maximum voltage or charge voltage of the battery pack is related to the selection of the maximum drain-source voltage. After considering voltage derating, it is recommended to choose twice the maximum voltage of the battery pack as the maximum drain-source voltage.

6. Package type

The package type is an important factor affecting thermal performance. For the thermal estimation of the MOSFET using thermal resistance relation by analogy to an electrical circuit, the equations can be derived as:

$$T_{J(max)} = P_D \times R_{\theta JA} + T_a \quad (2)$$

For example, there is a battery pack and its specification shown as Table I. Table II is the main parameters of the battery-protection MOSFET (PMEB2516Q) [1]. Table III is N-CH MOSFETs for BMS application and Table IV is P-CH MOSFETs for BMS application for reference. Then we check the power dissipation, gate-source voltage rating, drain-source voltage rating and thermal estimation for selection of PMEB2516Q. The rapid check results are shown as following:

1. The power dissipation

$$P_D = 1.3^2 \times 9m = 15.21mW < 1.5W$$

2. The gate threshold voltage

$$V_{GS} = 3V > 1.5 \times 1.5V$$

3. The gate-source voltage rating

$$V_{GS} = 12V > 3V$$

4. The drain-source voltage rating

$$V_{DS} = 20V > 2 \times 4.2V$$

5. The thermal estimation

$$T_{J(max)} = 15.21m \times 80 + 25 = 26^\circ C$$

Table I. Battery pack specification

1	Nominal voltage	3.7V
2	Max charge voltage	4.2V
3	Standard charge current	0.52A
4	Rapid charge current	1.3A
5	Standard discharge current	0.52A
6	Rapid discharge current	1.3A
7	Drive voltage of Protection IC	3.0V

Table II. Electrical Characteristics of PMEB2516Q

On Characteristics

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$R_{DS(ON)}$	Static Drain-Source On-Resistance	$V_{GS}=4.5V, I_D=5.5A$	4.5	6	8.2	$m\Omega$
		$V_{GS}=4V, I_D=5.5A$	4.7	6.2	8.5	$m\Omega$
		$V_{GS}=3.7V, I_D=5.5A$	5	6.5	9	$m\Omega$
		$V_{GS}=3.1V, I_D=5.5A$	5.5	7	9.4	$m\Omega$
		$V_{GS}=2.5V, I_D=5.5A$	6	8.2	11	$m\Omega$
$V_{GS(th)}$	Gate Threshold Voltage	$V_{GS}=V_{DS}, I_D=250\mu A$	0.5	0.72	1.5	V

Absolute Maximum Ratings

Symbol	Parameter	Rating	Units
V_{DS}	Drain-Source Voltage	20	V
V_{GS}	Gate-Source Voltage	± 12	V
I_D	Drain Current – Continuous ($T_C=25^\circ C$)	11	A
	Drain Current – Continuous ($T_C=70^\circ C$)	8.8	A
P_D	Power Dissipation ($T_C=25^\circ C$)	1.56	W

Thermal Characteristics

Symbol	Parameter	Typ.	Max.	Unit
$R_{\theta JA}$	Thermal Resistance Junction to ambient	---	80	V

Table III. N-CH MOSFETs for BMS application

V_{DS} (V)	Part No	PKG Type	$R_{on(max)}$ @4.5V ($m\Omega$)
20	PDC2306AZ	PPAK3X3	4.6
	PDC2306Z	PPAK3X3	4.9
	PDC2604Z	PPAK3X3	3.5
	PDN2314S	SOT23-3S	25
30	PDC3056CX	PPAK5X6	4.9
	PDC3904Z	PPAK3X3	5.5
	PDC3906Z	PPAK3X3	9
	PDC3908Z	PPAK3X3	12
	PDC3910Z	PPAK3X3	18
	PDC3960X	PPAK5X6	2.7
	PDC3964X	PPAK5X6	6.4
	PDC3964Z	PPAK3X3	6.4

	PDC3984X	PPAK5X6	3.3
	PDD3960	TO252	3.4
	PDN3612S	SOT23-3S	36
	PDN3914S	SOT23-3S	45
40	PDC4904Z	PPAK3X3	7
60	PDC6990BX	PPAK5X6	2
	PDD6902	TO252	4.5
	PDEN2N7002S	SOT23-3S	3000
	PDS6904	SOP8	12
65	PDC6982BX-5	PPAK5X6	4.4
	PDD6986B-5	TO252	8.8
100	PDC09D8BHX	PPAK5X6	4.1
	PDD0960	TO252	17
	PDEN09A8S	SOT23-3S	5500
	PDN0910S	SOT23-3S	200

Table IV. P-CH MOSFETs for BMS application

VDS (V)	Part No	PKG Type	Ron(max) @4.5V (mΩ)
-30	PDC3903X	PPAK5X6	8.5
	PDC3903AZ	PPAK3X3	8.2
	PDN3611S	SOT23-3S	65
	PDS3903	SOP8	9.5
-60	PDD6901	TO252	9.2
	PDS6903	SOP8	30
-100	PDD0959	TO252	45
	PDN0953S	SOT23-3S	650
-150	PDN02P15S	SOT23-3S	750

Reference

- [1] Potens Semiconductor, “20V Dual N-channel MOSFETs,” PMEB2516Q datasheet.
<https://www.potens-semi.com/upload/product/PMEB2516Q.pdf>.