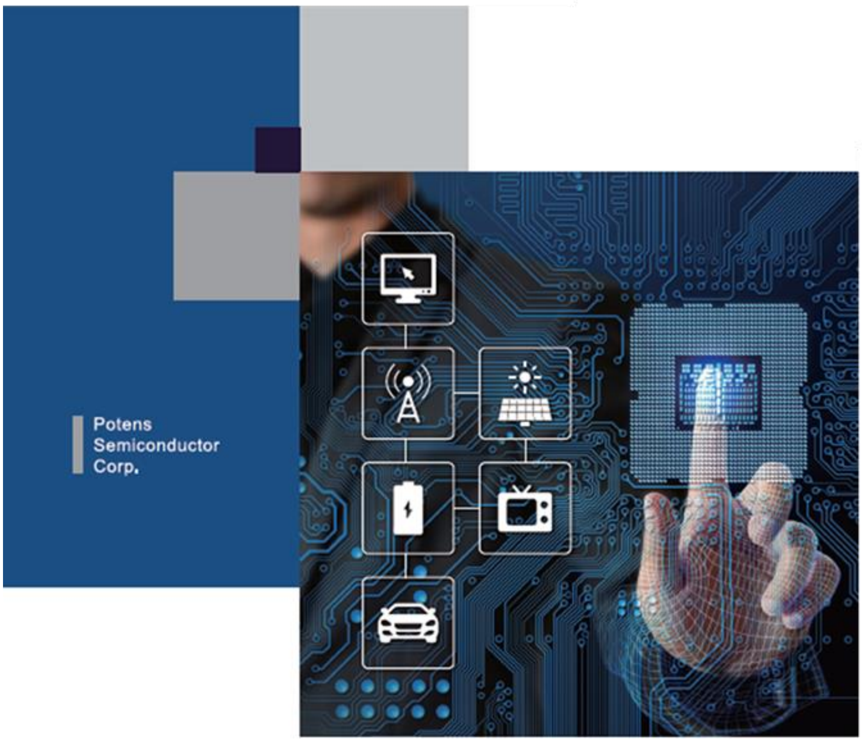
# Application Information

## Battery Management System Application

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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.

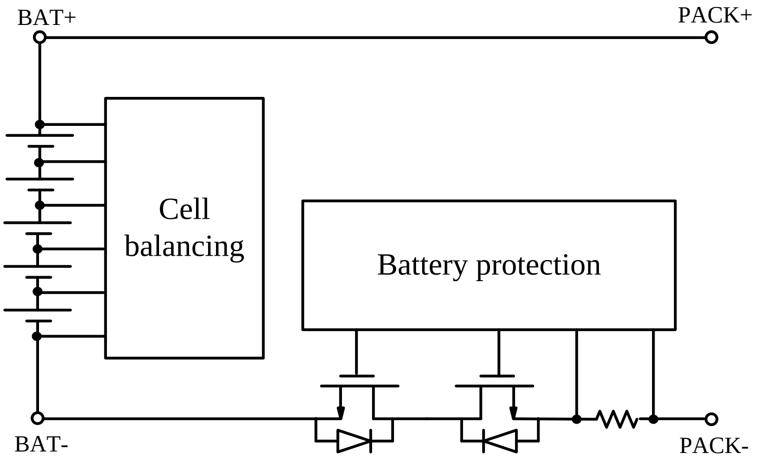


Fig. 1 The battery management system

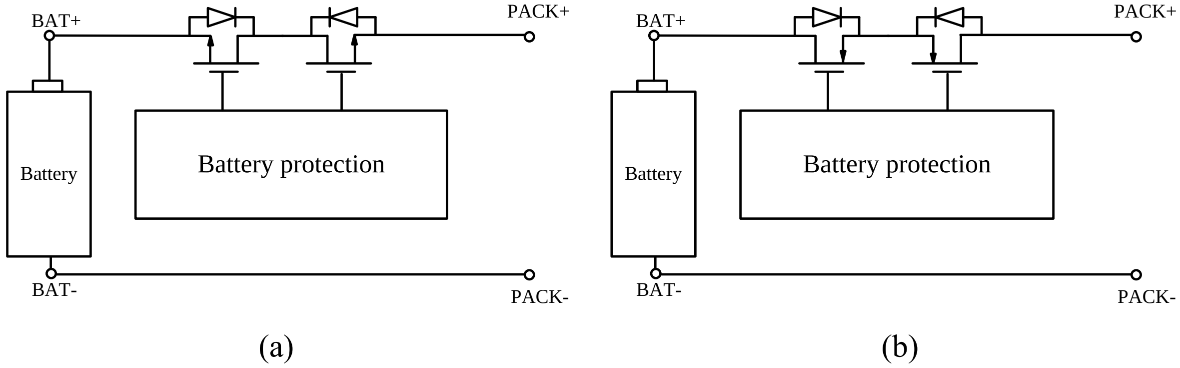


Fig. 2 High side MOSFETs application (a) N-ch (b) P-ch

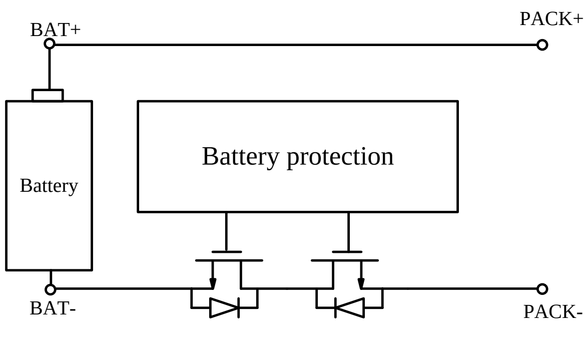


Fig. 3 Low side MOSFETs application

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:

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

   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:

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

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

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

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

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

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 | mΩ |
| | | $V_{GS}$=4V , $I_D$=5.5A | 4.7 | 6.2 | 8.5 | mΩ |
| | | $V_{GS}$=3.7V , $I_D$=5.5A | 5 | 6.5 | 9 | mΩ |
| | | $V_{GS}$=3.1V , $I_D$=5.5A | 5.5 | 7 | 9.4 | mΩ |
| | | $V_{GS}$=2.5V , $I_D$=5.5A | 6 | 8.2 | 11 | mΩ |
| $V_{GS(th)}$ | Gate Threshold Voltage | $V_{GS}$= $V_{DS}$ , $I_D$=250uA | 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°C) | 11 | A |
| | Drain Current – Continuous ($T_C$=70°C) | 8.8 | A |
| $P_D$ | Power Dissipation ($T_C$=25°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

| VDS (V) | Part No | PKG Type | Ron(max) @4.5V (mΩ) |
|---|---|---|---|
| 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.