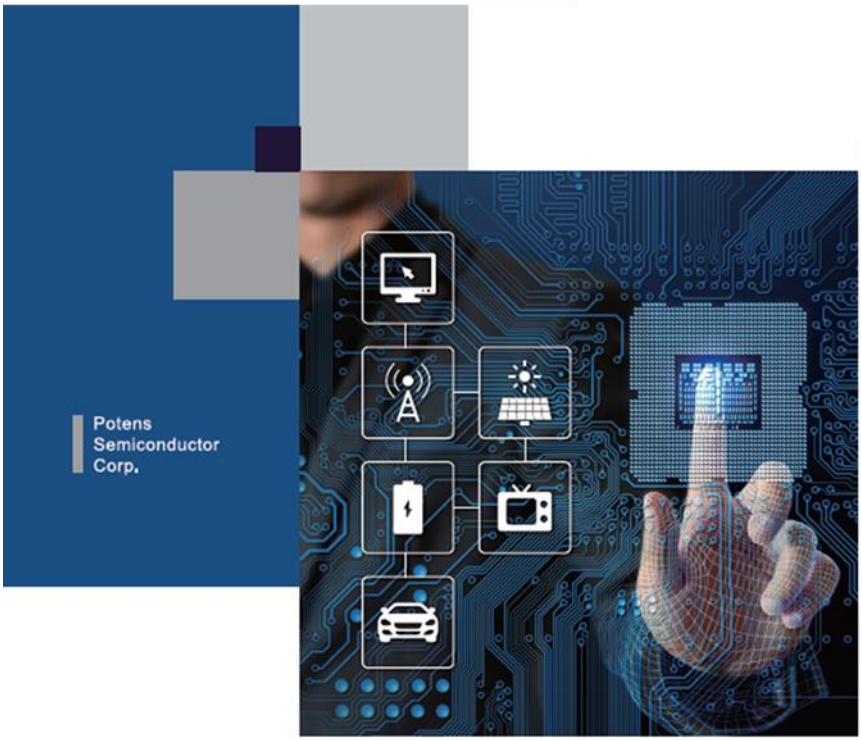
Application Information

Power Loss Estimation



Enhancing everyday life

When applying MOSFETs as a fast power switches, the effect of conduction loss and switching loss should be considered and estimated. We take a synchronous buck converter as a power loss calculation example. Fig. 1 shows the synchronous buck converter. The synchronous buck converter includes high side and low side MOSFETs. The high side MOSFET is working in very short period if applying into the V-core circuit. The switching loss would dominate the total power loss of the high side MOSFET. On the other hand, the conduction loss would dominate the total power loss of the low side MOSFET. However, the switching loss of the low side MOSFET is also important factor for high switching frequency(>300kHz).

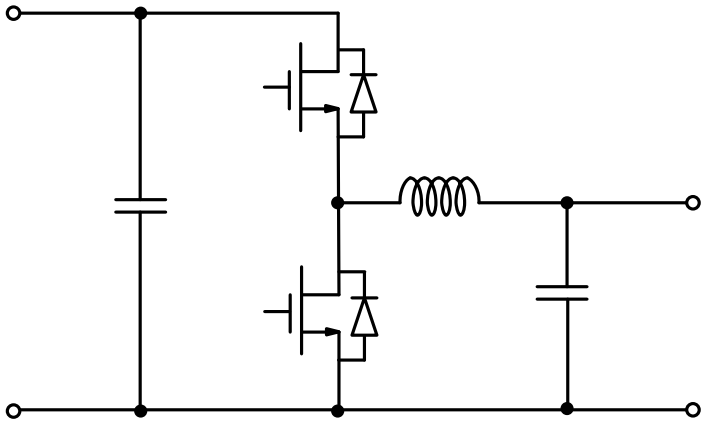


Fig. 1 Synchronous buck converter

For example, we take two MOSFETs (PDC3805R(D/C: XP1ME3) and PDC3805LR(D/C: XP1ME4)) as the high and low side MOSFETs. The high side MOSFET parameters comparison of the PDC3805R and PDC3805LR is shown as table I and Fig. 2. The low side MOSFET parameters comparison of the PDC3805R and PDC3805LR is shown as table II. and Fig. 3.

Table I. The high side MOSFET parameters comparison

High side MOSFET	PDC3805R (D/C: XP1ME3)	PDC3805LR (D/C: XP1ME4)
BVDSS(V)	34.56	34.31
VGS_{th}(V)	1.64	1.67
R_{DS}(ON) (mΩ) @4.5V	6.32	6.41
C_{iss}(pF)	819	822
C_{oss}(pF)	580	577
C_{rss}(pF)	5.8	6.0
Q_g(nC) @4.5V	6.3	6.4
Q_{gs}(nC)	1.3	1.5
Q_{gd}(nC)	5.7	5.2

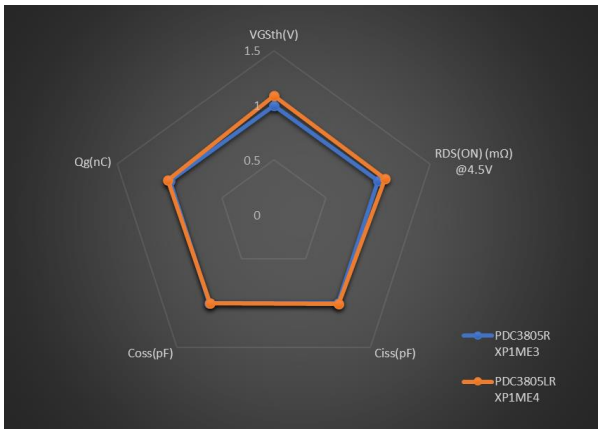


Fig. 2 The high side MOSFET parameters comparison

Table II. The low side MOSFET parameters comparison

Low side MOSFET	PDC3805R (D/C: XP1ME3)	PDC3805LR (D/C: XP1ME4)
BVDSS(V)	34.61	33.73
VGS_{th}(V)	1.58	1.24
R_{DS}(ON) (mΩ) @4.5V	3.29	2.75
C_{iss}(pF)	1820	2370
C_{oss}(pF)	1145	1061
C_{rss}(pF)	4.7	4.5
Q_g(nC) @4.5V	15.6	19.3
Q_{gs}(nC)	3.3	3.3
Q_{gd}(nC)	5.5	4.7

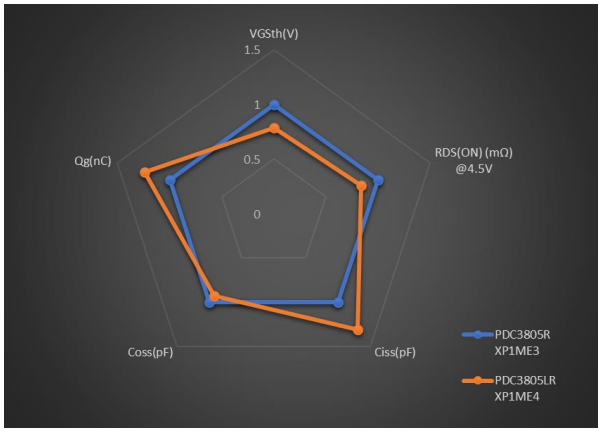


Fig. 3 The low side MOSFET parameters comparison

From table I , we can observe that the parameters of high side MOSFETs are in the same level. From table II, we can find that $R_{DS(ON)}$ of the PDC3805LR is low than $R_{DS(ON)}$ of the PDC3805R and C_{iss} and Q_g of the PDC3805LR is higher than C_{iss} and Q_g of the PDC3805R. So we can conclude that the conduction loss of the PDC3805LR should be lower than the conduction loss of the PDC3805R. and the switching loss of the PDC3805LR should be higher than the switching loss of the PDC3805R.

For the estimation of the power loss, conduction, switching loss and output capacitance loss would be considered mostly. The conduction loss can be derived as:

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

The switching loss can be expressed as

$$P_{SW} = \frac{1}{2} \times V_{DS} \times I_D \times f_S \times (t_r + t_f) \quad (2)$$

The output capacitance loss can be expressed as

$$P_{CAP} = \frac{1}{2} \times C_{oss} \times V_{DS} \times f_S \quad (3)$$

where I_D is the drain current, $R_{DS(ON)}$ is the drain-source on-resistance, V_{DS} is the drain-source voltage, f_S is the switching frequency, t_r is the rise time, t_r is the fall time and C_{oss} is the output capacitance. Assume that the switching frequency of the synchronous buck converter is about 420kHz, the input voltage is 19V, the output voltage is 1.2V, and output current is 12A. From above equations and conditions, the power losses of the high side and low MOSFETs can be estimated as table III and table IV. Table V shows the high and low side MOSFETs power loss. Fig. 4 shows the high and low side MOSFETs power loss comparison. The total power loss of the PDC3805LR is larger than the total power loss of the PDC3805R due to the deviation of the switching losses dominates the power loss.

Table III. The high side MOSFET power loss

High side MOSFET	PDC3805R XP1ME3	PDC3805LR XP1ME4
P_{CON}	0.003	0.004
P_{SW}	0.046	0.046
P_{CAP}	0.044	0.044
Total Power Loss(W)	0.093	0.093

Table IV. The low side MOSFET power loss

Low side MOSFET	PDC3805R XP1ME3	PDC3805LR XP1ME4
P_{CON}	0.416	0.348
P_{SW}	0.563	0.738
P_{CAP}	0.087	0.080
Total Power Loss(W)	1.065	1.166

Table V. The high and low side MOSFETs power loss

High and low side MOSFETs	PDC3805R XP1ME3	PDC3805LR XP1ME4
P_{CON}	0.477	0.400
P_{SW}	0.608	0.783
P_{CAP}	0.131	0.124
Total Power Loss(W)	1.216	1.307

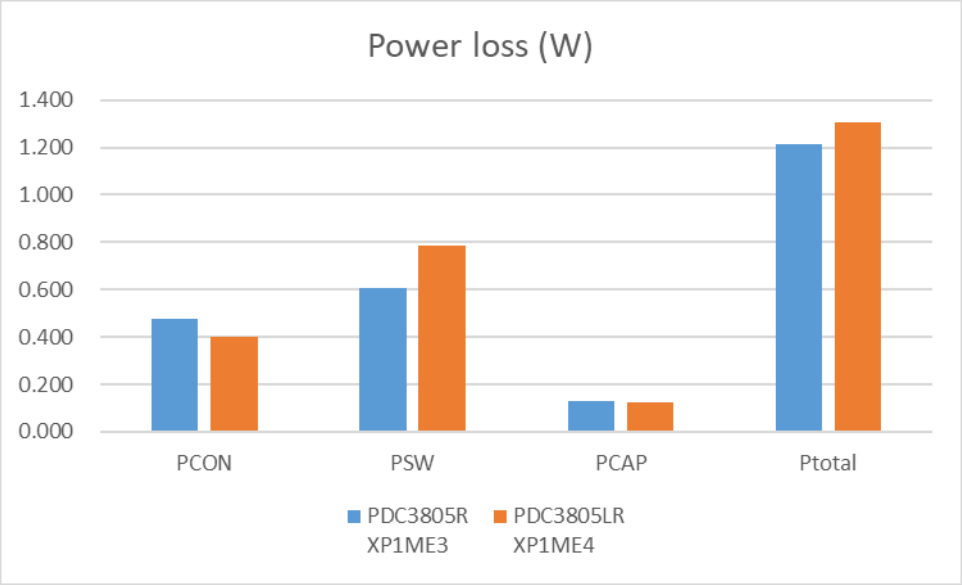


Fig. 4 the high and low side MOSFETs power loss comparison

Reference

[1] Potens Semiconductor, “30V N-channel Asymmetric Dual MOSFETs,” PDC3805R datasheet. https://www.potens-semi.com/upload/product/PDC3805R.pdf.

[2] Potens Semiconductor, “30V N-channel Asymmetric Dual MOSFETs,” PDC3805LR datasheet. https://www.potens-semi.com/upload/product/PDC3805LR.pdf.