AND8265/D

Typical FETKY Applications

Prepared by: Han Zou
ON Semiconductor

ON Semiconductor®

http://onsemi.com

APPLICATION NOTE

Introduction

In consumer power electronics, it is not unusual to see both power MOSFETs and Schottky diodes operating side by side as main circuit elements. The reasons of placing power MOSFETs in conjunction with the Schottky diodes can be versatile, such as reverse current protection, DC/DC converter free−wheeling rectification (Asynchronous), switching efficiency improvement and so on. Working together, they could provide a more desirable system performance.

Needless to say, the integration of these two devices into one standard package could bring benefits. From circuit design point of view, it can minimize the parasitic influence, save the board space, add convenience of PCB routing, and lowers down the total system cost. The integration results in a new device category: FETKY. This short note tries to cover typical applications of the FETKY devices in brief.

Applications

- **DC/DC circuits: MOSFET + Schottky free−wheeling diode**

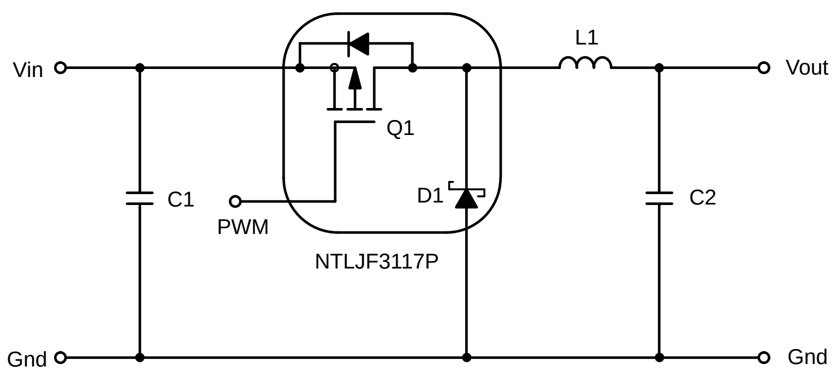

Figure 1. Buck Converter Circuit with μCool™ NTLJF3117P FETKY device

Two simple topologies frequently seen in the portable electronic DC/DC circuits probably are asynchronous buck and boost circuit where the integrated Schottky diode acts as a free−wheeling rectification diode to carry the current during the time the FET is turned off. A low gate charge MOSFET and a low forward voltage Schottky diode ensure both fast switching and minimum power loss when the loading current is high.

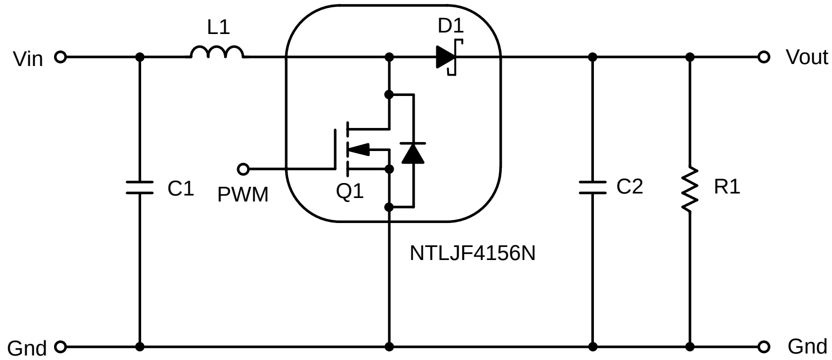

Figure 2. Boost Converter Circuit µCool™ NTLJF4156N FETKY device

The following example describes the method to estimate and evaluate the FETKY performance in an asynchronous DC/DC circuit design:

The objective is to design a 5 V input and 2.5 V output converter with a 45°C ambient temperature and 2 A maximum loading. The PWM controller operates at 700 kHz constant frequency with conversion duty cycle calculated as:

$$D = \frac{V_{out}}{V_{in}} = 50\% \quad \text{(eq. 1)}$$

For a 700 kHz operating frequency with 50% duty cycle, the on−time is 0.7 µs.

Referring to the thermal transient response curve in the FETKY device datasheet (WDFN6 2x2 NTLJF3117P), the thermal resistance for 50% duty cycle and 0.7 µs on−time would be 80°C/W.

The elevated ambient temperature is 45°C, therefore, the max power loss on the FET is:

$$P_{dmax} = \frac{T_{j(max)} - T_A}{R_{\theta JA}} = \frac{150 - 45}{80} = 1.31\text{ W} \quad \text{(eq. 2)}$$

Assume that the gate voltage allows P−channel MOSFET to be fully conducted, the maximum $R_{DS(on)}$ according to the datasheet is 100 mΩ. With a 45°C ambient temperature, $R_{DS(on)}$ will be 8% higher than normal which is about 108 mΩ (Figure 5 in the datasheet). The maximum loading current for the converter is 2 A. Therefore the real power consumption on the device can be calculated as:

$$P_{FET} = R_{DS(on)} \cdot I_{max}{}^2 = 0.45\text{ W} \quad \text{(eq. 3)}$$

In conclusion, the FET would work in a safe region. From Figure 13 in the datasheet, the typical forward voltage dropped on the Schottky diode at 2 A is less than 0.55 V, so the Schottky diode also works in its safe region. Overall, it is an applicable design if there is a secure thermal contact between FETKY and the PC board.

Routing of FETKY device in a DC/DC buck circuit:

In order to achieve good power efficiency, the drain pin of MOSFET needs to be placed as close as possible to the cathode pin of the Schottky diode to minimize the switching transient caused by the parasitic inductance. A recommendation for routing the FETKY device properly is illustrated as below:

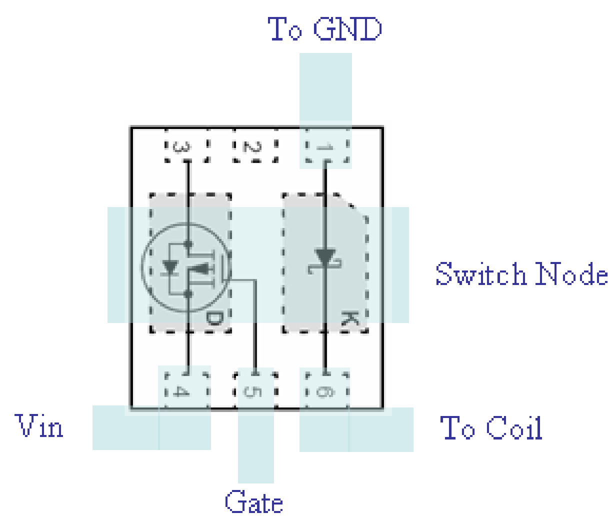

Figure 3. Recommended routing for the FETKY (WDFN6 2x2, NTLJF3117P) in a buck converter

Load Switches and Charging Circuits with Reverse Protection

A Schottky can be used in series with a power MOSFET as a blocking unit as shown in Fig. 4. This topology is often used in the Li−ion battery linear charging circuit for cellular phones. The power MOSFET acts as a charging element and the voltage across it varies with the battery voltage. The Schottky diode is then used to prevent the reverse current flow on the battery side when the charge input becomes shorted accidentally. The routing for FETKY in charging circuit is a bit different from the DC/DC circuit with drain pin of the P−channel MOSFET connected to the anode of the Schottky diode from outside of the package, no switch node exists, but the distance between Drain and Anode needs to be as short as possible. A recommended routing scheme for this application is presented in Fig. 5.

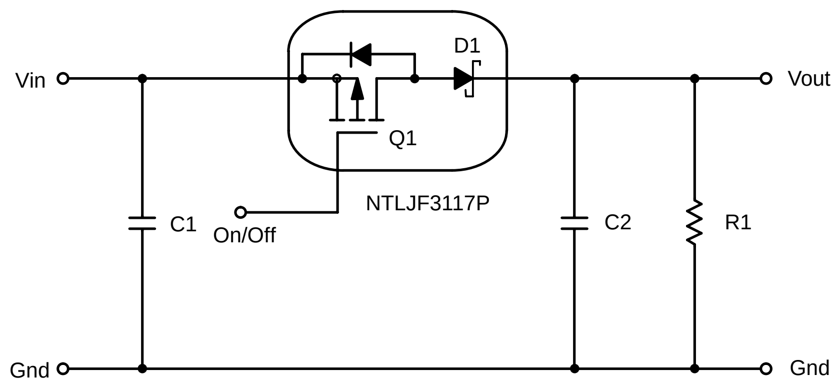

Figure 4. FETKY load switch with blocking diode

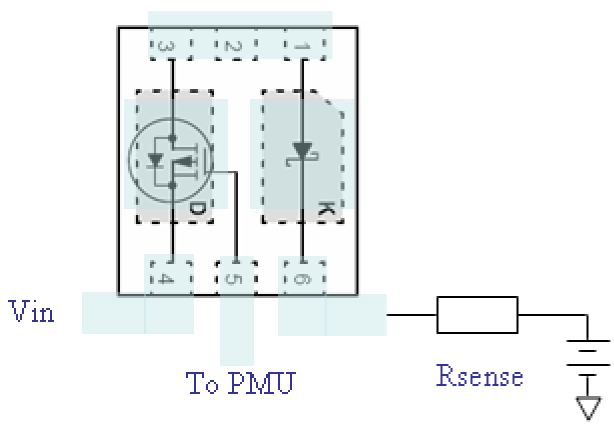

Figure 5. Recommended routing for FETKY (WDFN6 2x2, NTLJF3117P) in a linear battery charging circuit

The FETKY structure can also be utilized to protect itself from being damaged. If multiple power sources exist or the output voltage could be higher than the input voltage, the reverse current may flow through the body diode of the P−channel MOSFET causing irreversible damage to the MOSFET. A low voltage Schottky diode (0.4 V @ 1 A) in parallel with the FET will bypass the current and keep the reverse voltage across the switch less than a diode voltage drop, therefore greatly reduce the risk of damaging the power device.

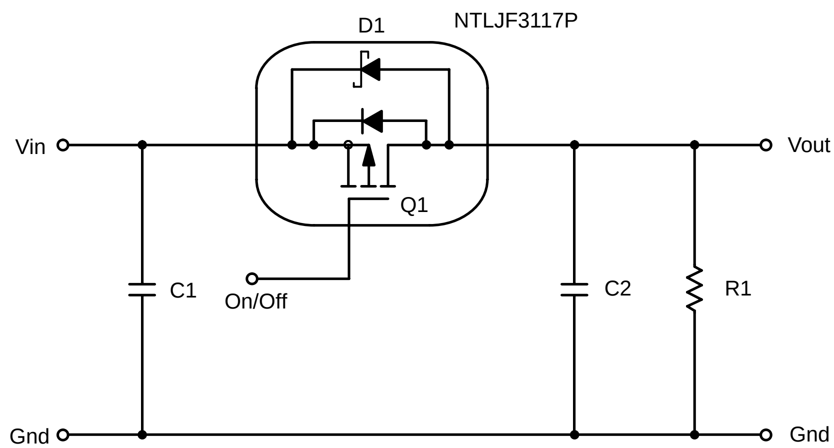

Figure 6. FETKY load switch with by−pass diode

Switching Efficiency Improvement

In synchronous DC/DC buck converter circuit, a Schottky diode is placed in parallel with the synchronous rectifying MOSFET to improve efficiency. Due to the fast recovering feature of the Schottky diode, it becomes conducted first during the dead−time between the conduction of the two power MOSFETs. This prevents the body diode of the bottom MOSFET from turning on and storing charge during the dead−time, which could cost as much as 2% in efficiency.

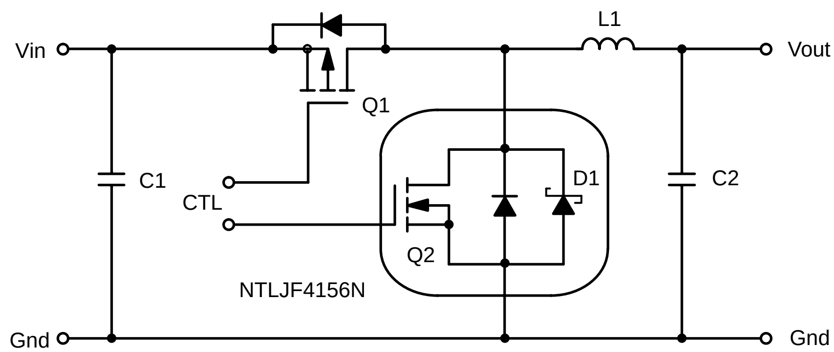

Figure 7. FETKY for efficiency improvement of synchronous DC/DC converter

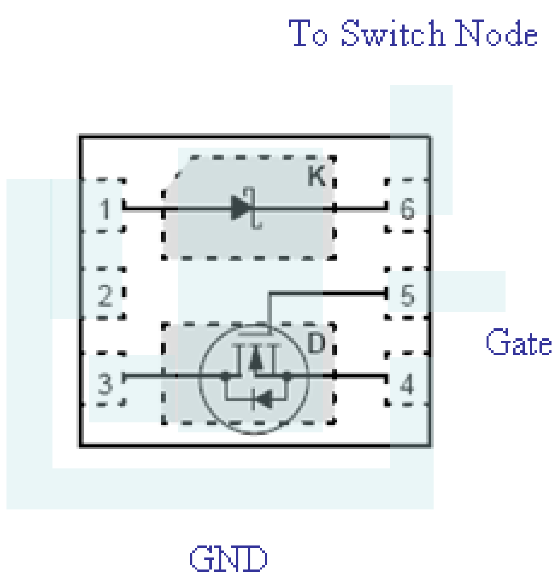

Figure 8. Recommended layout for FETKY (WDFN6 2x2, NTLJF4156N) in a synchronous converter

Featured Devices:

μCOOL™ 2x2 mm

P−channel:

NTLJF3117P

MOSFET: 20 VDS/8 VGS, 75 mΩ $R_{DS(on)}$,

Schottky: 0.4V@1A, 2 A maximum current

NTLJF1103P

MOSFET: 8 VDS/6 VGS, 70 mΩ $R_{DS(on)}$,

Schottky: 0.4V@1A−channel:, 2 A maximum current

N−channel

NTLJF4156N

MOSFET: 30 VDS/8 VGS, 47 mΩ $R_{DS(on)}$,

Schottky: 0.4V@1A, 2 A maximum current, 30 V reverse voltage

NTLJF3118N

MOSFET: 20 VDS/12 VGS, 50 mΩ $R_{DS(on)}$,

Schottky: 0.4V@1A, 2 A maximum current

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:
Literature Distribution Center for ON Semiconductor
P.O. Box 5163, Denver, Colorado 80217 USA
Phone: 303−675−2175 or 800−344−3860 Toll Free USA/Canada
Fax: 303−675−2176 or 800−344−3867 Toll Free USA/Canada
Email: orderlit@onsemi.com

N. American Technical Support: 800−282−9855 Toll Free USA/Canada
Europe, Middle East and Africa Technical Support:
Phone: 421 33 790 2910
Japan Customer Focus Center
Phone: 81−3−5773−3850

ON Semiconductor Website: **www.onsemi.com**

Order Literature: http://www.onsemi.com/orderlit

For additional information, please contact your local Sales Representative