Total Solution for Energy Efficient Home Appliance Power Supply

Energy efficiency is crucial to both consumers and environment

As much as half of the energy used in home goes to heating and cooling. So making smart decisions about heating, ventilating, and air conditioning system can have a big effect on utility bills. Saving energy at home also can help to protect the environment. It is at this critical moment that semiconductor suppliers are playing an important role in developing technologies that improve energy efficiency.

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Introduction
Most industry experts agree that motor control, lighting, computing, and power supplies are areas where new power technologies can have a significant impact on energy consumption. The combination of improved products with an in-depth understanding of systems and applications can result in solutions that maximize efficiency. By reducing wasted energy, tremendous energy savings can be realized without sacrificing consumer choice. In this article, total solution for home appliance power is proposed. By combining the state-of-the-art technologies, best-in-class switched-mode power supply is designed and it gained huge interest from system designers. This article describes the features and benefits of each product and shows board level evaluation results.

Flyback Converter I.C
The FSL176MRT is an integrated pulse width modulation (PWM) controller and SenseFET specially designed for offline switched-mode power supplies with minimal external components. The PWM controller includes an integrated fixed frequency oscillator, under-voltage lockout, leading edge blanking, optimized gate driver, internal soft start, temperature-compensated precise current sources for loop compensation, and self protection circuitry. The protection functions it provides are over-load protection, over-voltage protection, internal thermal shutdown with hysteresis, pulse-by-pulse current limit, and output short protection. It also offers random frequency fluctuation for low EMI as shown in Figure 1. The amount of EMI noise is directly related to the switching frequency. In the FSL176MRT, the operating frequency is determined randomly by external feedback voltage and internal free-running oscillator at every switching instance. Therefore, EMI noise is spread around typical switching frequency and can be reduced. It is also possible to reduce the cost of the input filter required to meet the EMI regulations such as EN55022.

Synchronous Rectifier Controller
FAN6204 is a secondary-side synchronous rectification controller to drive synchronous rectification MOSFET for improved efficiency. It utilizes an innovative linear-predict timing control to determine the turn-on and turn-off instances of synchronous rectification MOSFET. This control technique detects the voltage of the transformer winding and output voltage instead of current flowing through the MOSFET. Therefore, better noise immunity can be guaranteed. In addition, this technique does not require a communication approach.
signal from the primary side so can reduce external components and simplify board layout. It also provides various protection functions for abnormal conditions. Fault causal timing protection, gate expand limit protection, and RES dropping protection are used for load change. LPC and RES pins’ open/short protection is provided to prevent fault operation of the controller when resistors connected to LPC or RES pins are damaged. Internal over temperature protection and Vdd over voltage protection are also included. It is also equipped with mWSaver™ technology that stops switching in green mode to improve no load or light load efficiency. Power consumption is kept minimum level in this condition.

**PowerTrench® MOSFET**
The trench gate MOSFETs are the most preferred power devices for medium to low voltage applications. The new mid-voltage power MOSFET, PowerTrench MOSFET is highly optimized for synchronous rectification. It employs a shielded-gate structure, where the shield electrode is connected to the source as shown in Figure 2. The shield electrode, along with the thicker oxide between electrode and drift region, provides charge balance for drift region. This enables the use of higher doping in the drift region, resulting in reduced drift resistance.

The specific resistance of MOSFET has been significantly improved compared to the previous generation. This very low $R_{DS(ON)}$ directly reduces conduction loss of synchronous rectification MOSFET. During light load conditions, conduction losses are minimal, and the driving losses are even more important. A gate charge parameter is the most important factor for the driving loss in power MOSFET point of view. The MOSFET has less than half of gate charge value compared to conventional trench MOSFET and can dramatically reduce driving loss at light load condition. Apart from $R_{DS(ON)}$ and gate charge, other parameter, such as like the body diode reverse recovery charge ($Q_{rr}$), internal gate resistance and the output charge of the MOSFET ($Q_{oss}$) are now becoming more relevant in synchronous rectification. The importance of these loss components rises at higher switching frequencies. The switching loss in the synchronous rectification MOSFET is defined as below equation.

$$P_{sw} = (Q_{rr} - Q_{oss}) V_{ds} f_{sw}$$

It is clear that smaller reverse recovery charge of body diode is really important to better efficiency. The MOSFETs are now being optimized to minimize the reverse recovery charge of body diode.

**System Performance**
The Fairchild solution is evaluated in a 40W rated multi-output switched-mode power supply. It has 4 outputs and main output is 13.2VDC, 2.8A. Others are two 5V and 15V outputs rated at 0.1A each. This is typical configuration for mainstream refrigerator power. Fig. 3 shows system efficiency of two solutions. The proposed solution shows better efficiency over entire load range compared to existing competitor solution at 220VAC input. It provides similar efficiency at 115VAC input. It should be noted that the proposed solution offers very good light load efficiency that is becoming great concern in the industry. Fig. 4 shows peak voltage across the primary switching device. The proposed solution shows much lower voltage spike that is related to both system reliability and power loss in the snubber. The test also verified operating temperature of major components can be lowered with the proposed solution.

**Conclusions**
The refrigerator is powered up 24 hours, 7 days and therefore energy efficiency of the appliance is crucial to both consumers and environment. Fairchild provides leading technologies for primary switch, secondary controller, and power device. The combined solution demonstrated superior system efficiency.

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**Figure 4:** Voltage spike at 265VAC input, full load condition

**Figure 3:** System efficiency test results