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AN-9748

The Smallest Integrated Slew Rate Switch for Peripheral Load Management in Smart Phones and Tablet PCs

Introduction

Smart phones and tablet PCs are popular today and widely used — anywhere and anytime. Those smart devices are adding more powerful functions (such as Wi-Fi, GPS, high-pixel camera, and so on), as well as getting thinner and lighter. One of the challenges in system design is to reduce leakage current from peripherals to extend operating time under limited battery capacitance. To save leakage power, integrated load switches are usually adopted.

This note introduces IntelliMAX™ FPF1203 and FPF1204, ultra-small, slew-rate-controlled load switches. They offer optimized peripheral load management meeting key electrical requirements, such as low on resistance, wide operating input voltage range, small package size, and low inrush current.

Design Challenge

Figure 1 shows general power architecture in a smart phone or tablet PC, focusing on peripherals. There are many peripherals requiring different voltage input, from below 1V for AP (Application Processor) core to 4.2V battery, or even 5V TA (Travel Adapter) for LED driver.

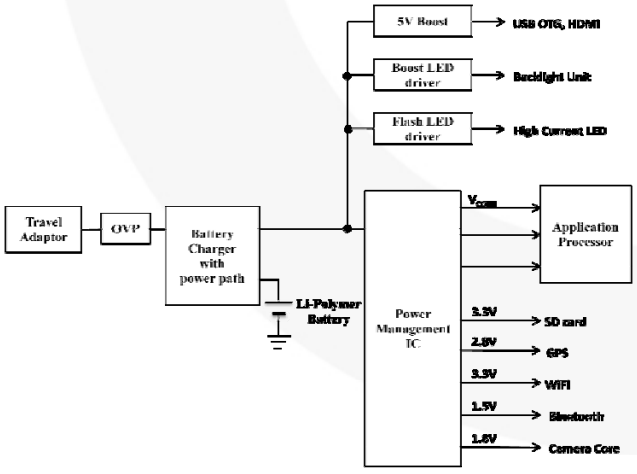

Figure 1. Simplified Power Architecture of Smart Phone and Tablet PC

One case using a load switch to reduce leakage current is an LED backlight application, as shown in Figure 2.

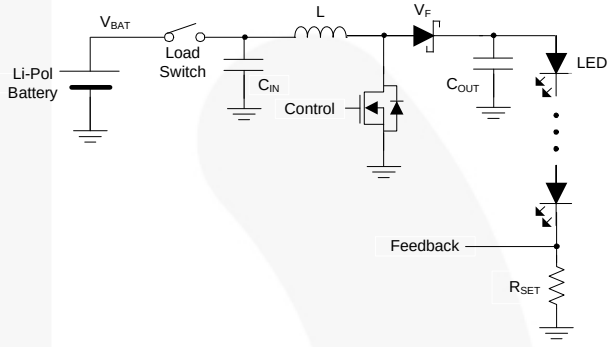

Figure 2. Simplified LED Backlight Drive Application with Load Switch

A simplified-asynchronous-boost-topology-based LED driver power circuit with load switch is shown in Figure 2. A problem often starts when the LED driver is turned off without the load switch. Leakage current flows from the battery to C_{OUT} via Schottky diode and C_{OUT} is being charged and maintained V_{BAT} - V_F during OFF state. The unwanted leakage path can be disconnected when the LED driver is not in use by adding a load switch between the battery and the LED driver input.

In addition, lower inrush current, lower on resistance, smaller size, and simpler design are criteria required for the load switch.

Figure 3 is a functional block diagram of the FPF1203 and FPF1204 IntelliMAX™ ultra-small, slew-rate-controlled load switch. It has 100µs of slew rate control and 45mΩ at 5.5V of on resistance.

FPF1204 has 65Ω output discharge path to turn off the output load quickly. It is also housed in 0.76mm x 0.76mm WLCSP (Wafer-Level Chip-Scale Package) with four bumps, the smallest form factor currently in industry.

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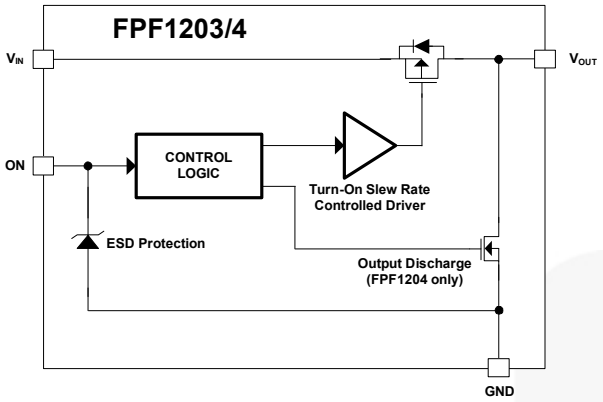

Figure 3. FPF1203/4 Functional Block Diagram

Reliable ON/OFF Operation

One key performance of the load switch is reliable turn-on and turn-off operation. Slew rate control is essential to reduce inrush current when the switch is about to be ON.

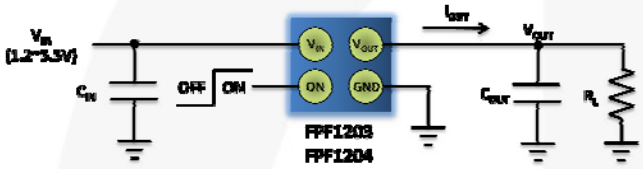

Figure 4. Typical Application

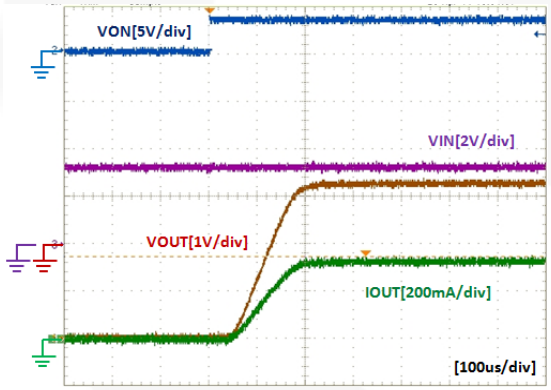

Figure 5. ON Behavior (V_{IN}=3.3V, C_{OUT}=0.1µF, R_L=10Ω)

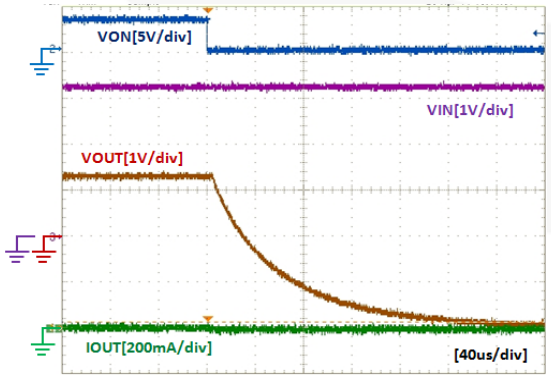

Figure 6. OFF Behavior without Output Discharge (V_{IN}=3.3V, C_{OUT}=0.1µF, R_L=500Ω)

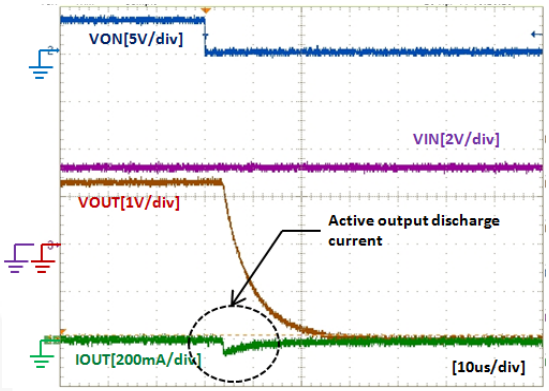

Figure 7. OFF Behavior with Output Discharge (V_{IN}=3.3V, C_{OUT}=0.1µF, R_L=500Ω)

Figure 4 through Figure 7 show actual turn-on and off behaviors with FPF1203 and FPF1204. Figure 4 is a typical application circuit requiring only C_{IN} and C_{OUT}. It makes the circuit design simple.

There is no inrush current nor input voltage drop during turn-on due to the 100µs slew-rate-control feature shown in Figure 5.

Figure 6 and Figure 7 show the difference between FPF1203 and FPF1204. Falling time of FPF1203 is 115µs, while FPF1204 is 11µs. FPF1204 turns off output load faster by about ten times due to 65Ω of active output discharge path during OFF state. Negative current can be seen with FPF1204 in Figure 7.

Low On Resistance

FPF1203/4 support input voltage from 1.2V to 5.5V. This wide input operating voltage range provides design flexibility for a variety of voltage rails for peripherals.

On resistance is a critical factor during ON state to reduce power loss and input voltage drop.

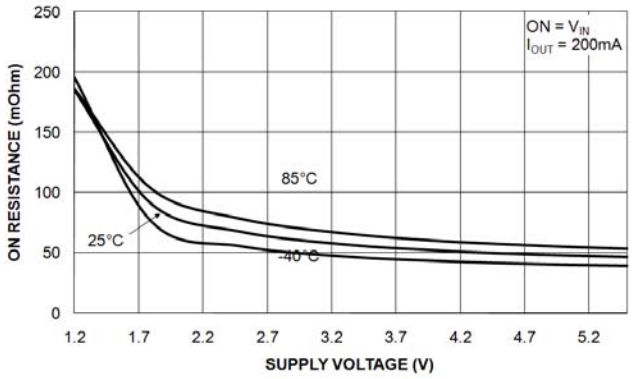

Figure 8. On Resistance vs. V_{IN}

Table 1. R_{ON} at Main V_{IN}

V_{IN}	Typical On Resistance [mΩ]
5.5V	45
3.3V	55
1.8V	90
1.2V	185

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Table 1 shows on resistance by V_{IN}. Basically, R_{ON} is highly proportional to die size or package size. FPF1203/4 achieves lower on resistance in a small package size of 0.76mm x 0.76mm with advanced PMOS technology.

Small Form Factor

Load switches in 2mm x 2mm MLP-6L have been widely used to date. In the last two to three years, a 1mm x 1.5mm WLCSP with six bumps has been part of the miniaturized system trend.

Today, the smallest form factor package in the industry is being introduced with FPF1203 and FPF1204. FPF1203/4 is in a 0.76mm x 0.76mm WLCSP with four bumps.

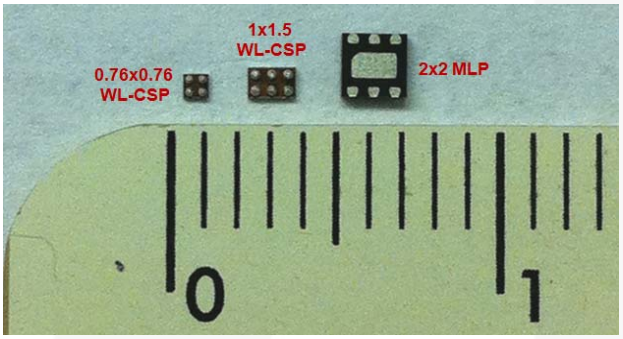

Figure 9. Actual Package Picture

Table 2. Package Size Comparison

Package	0.76x0.76 WLCSP	1.0x1.5 WLCSP	2.0x2.0 MLP
Solution Area [mm^2]	0.580	1.500	4.000
Ratio	0.145	0.375	1.000
	0.387	1.000	

Figure 9 is an actual package photograph. Table 2 shows how small a solution area FPF1203/4 can offer compared to existing package solutions. About 85% of the solution size can be reduced with FPF1203/4 compared with a load switch in a 2x2mm MLP package.

Load Management

FPF1203/4 is optimized as peripheral load management switch in terms of smaller size, low on-resistance, wide operating input voltage, and design simplicity.

An example of peripheral load management with FPF1203/4 is shown in Figure 10.

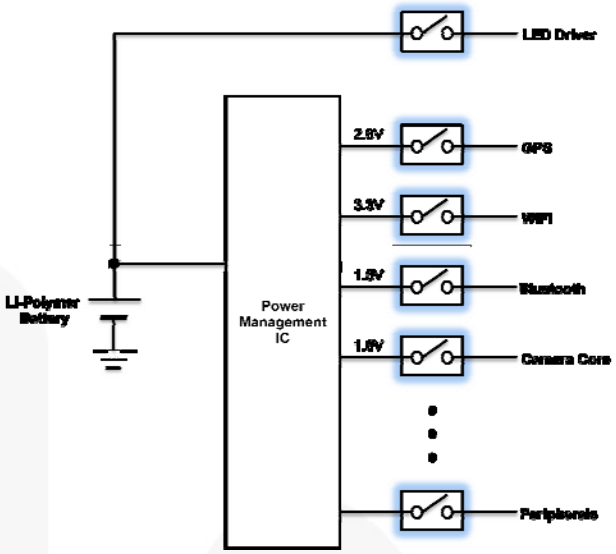

Figure 10. Peripherals with FPF1203/4

Evaluation Board

FPF1203/4 performance can be tested with an evaluation boards. Figure 11 shows an actual board in 30mm x 25mm with the schematic provided in Figure 12.

Figure 11. FPF1203/4 Evaluation Board

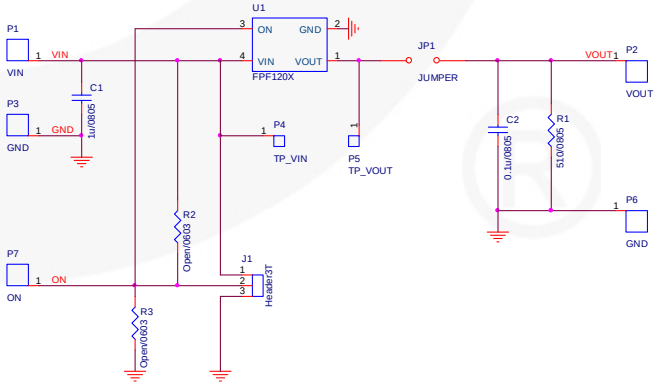

Figure 12. FPF1203/4 Evaluation Board Schematic

Conclusion

IntelliMAX™ FPF1203 and FPF1204 ultra-small, slew rate controlled load switch is optimized for peripheral load management in smart phones and tablet PCs in term of small size, stable ON/OFF operation, wide operating input voltage range, design simplicity, and active output discharge for easy power sequence.

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Related Datasheets

FPF1203 / FPF1204 – IntelliMAX·™ Ultra-Small, Slew-Rate-Controlled Load Switch

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