# Green Mode Buck Switch for Low Power Consumption

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#### Abstract

Fairchild Green Mode off line buck switch for low standby power consumption and high reliability is presented. By reducing operating current and optimizing switching frequency, 20mW power consumption is achieved. High performance trans-conductance amplifier and green mode function improve the ripple and regulation in the output voltage. The conventional FPS<sup>TM</sup> buck and novel Fairchild buck switch are compared to show the improvement of performance. Experimental results are showed using 2W evaluation board.

### 1. Introduction

Buck converter has been accepted an effective and visible topology for non-isolated power supply due to its small component counts, small space and simple design. Moreover the straightforward in operation of buck converter allow the user to have the chance to design in many applications. Together with low standby power consumption and the ruggedness in power system request in the market, buck converter still deserves extended application circuit. One promising candidate for buck is the auxiliary power supply of home appliance and metering system. Fairchild has manufactured power switch, so called FPS switch) which merges PWM controller and Power Switch into one package for long time. Despite the conventional FPS switch is also able to design buck converter as shown in Figure 1, but it needs many external components and especially not suitable for low standby power consumption and reliable system solution since FPS switch was originally designed for the galvanic isolation requirements which can match well with photo coupler and shunt regulator together. Hence error amplifier doesn't exist internally. As the market request, Fairchild semiconductor has designed and developed the brand new buck switch. This paper introduces why and how Fairchild Green Mode Buck Switch makes compact and cost effective design be possible. This brand new power switch has enhanced the functionality of conventional Fairchild FPS switch and improved other features, such as simple feedback control design and increased reliability through builtin trans-conductance amplifier and new conceptual protections, respectively. Besides, an integrated high voltage regulator for IC power supply reduces the number of additional components since some of them composing external bias are saved. The most notable feature among these advantages is that it achieves very low standby power consumption less than 20mW while also keeping small output voltage ripple.

#### 2. Fairchild Green Mode Buck Switch

Although buck converter can be designed with conventional Fairchild FPS power switch, but it needs additional components for feedback circuitry compared to Buck FPS switch, such as one zener diode as reference device, one transistor for amplification and a few passive components. The Fairchild Green Mode buck switch removes one zener diode, one transistor and some of passive components by adopting a trans-conductance amplifier, resulting in simple and compact design, as illustrated in Figure 1.



Figure 1. Typical buck converter application circuit with new Fairchild Green Mode Buck Switch



The internal circuit consists of PWM block including error amp, PWM comparator, and gate drive circuit, start up and bias circuit block and protection blocks, as illustrated in Figure2.



Figure3. GM Amplifier Operation

Newly adopted Green Mode operation reduces the switching frequency gradually as output load is decreased, as illustrated in Figure 4. The frequency modulation is employed to meet EMI requirement easily with the small input filter.



Figure4. Green Mode Operation

As illustrated in Figure5, the output regulation test results of new Fairchild Green Mode buck switch show the better performance than the conventional FPS switch. The entering power of burst mode is one of key factor to affect the output voltage regulation performance and the ripple as well.



The Green Mode operation also contributes to reduce the output voltage ripple performance as well as better the output voltage regulation performance. Usually the low switching frequency causes large output voltage ripple as

equation (1) and (2). However, it is relevant to out of the burst mode operation, as illustrated in Figure 6.

$$\Delta v_{OUT} by C_{OUT} = \frac{\Delta I}{8C_{OUT}f_s} = \frac{(V_{IN} - V_{OUT})D}{8C_{OUT} \cdot L \cdot f_s^2}$$
(1)

$$\Delta v_{OUT} \ by \ R_{ESR} = R_{ESR} \Delta I = R_{ESR} \cdot \frac{(V_{IN} - V_{OUT})D}{L \cdot f_S}$$
(2)



Figure6. Waveform of burst mode operation

The new Fairchild Green Mode buck switch designs buck converter with below 20mW standby power consumption at universal input voltage range. The actual test data is on the Table 1 and it has 22mW power consumption at  $265V_{AC}$  and no load condition, where 10kohm dummy resistor loss is ignored.

Table1. Test data of standby power consumption

| Vac                   | 85 | 110 | 230 | 265 | Unit |
|-----------------------|----|-----|-----|-----|------|
| With<br>dummy loss    | 25 | 26  | 29  | 32  | mW   |
| Without<br>dummy loss | 10 | 11  | 14  | 16  | mW   |

## 3. Conclusion

The very low standby power consumption achieves less than 20mW below energy star's 5-star level as a adoption high voltage regulator using direct supplied power from drain pin of switch. Proposed green mode buck switch could reduce the overall board size and weight while increasing efficiency, productivity, and system reliability. Adopting linear frequency reduction for improving output ripple and standby power consumption is experimented using 2W buck demo board.

### Reference

- <u>http://www.fairchildsemi.com</u> : Off-line & Isolated DC-DC converters, FSL306LRN, Green Mode Fairchild Buck Switch.
- [2]Voltage Regulator Handbook National Semiconductor Corporation Publication, 1982.