A TRUE POWER EFFICIENCY BOOSTER

Efficiency ratings for power supplies at full load do not adequately reflect the unit's power consumption under actual operating conditions. Simple Light Load Mode (SLLM) control optimises power efficiency in Point-of-Load regulators.

To extend the length of operation of portable products on a single battery charge, power must be reduced in all operating modes. Improved efficiency at all operating points including more typical situations such as very light loads is an important concern in the design of next generation "green" products.

Devices typically not operating at high power levels under all circumstances could benefit from Point-Of-Load (POL) control with improved efficiency over the entire range. This concerns a huge number of products such as set-top boxes, digital tuners, liquid crystal displays, portable digital players, wireless LAN modules, PCs, microprocessor power supplies, GPS, and mobile phones etc.

Before discussing SLMM, it will be helpful to first review the basic operation of current mode, step-down switching regulators designed for POL applications. System designers typically utilise high-efficiency POL switching regulators to convert the 5 V power source in electronics products to other common voltages such as 3.3 V, 2.0 V, 1.8 V or lower required for high-performance microprocessors and their peripherals. Many POL switching regulators employ Current-Mode (CM) control to provide both efficiency and fast response to load changes.

The current mode switching regulator combines a current feedback loop with voltage feedback for improved PWM control. In contrast to a "controller IC", these switching regulators integrate the power MOSFETs as well as the control circuitry into a single integrated circuit.

With a fixed PWM oscillation frequency of 0.5 to 2 MHz, a SET signal from OSC turns ON the high-side MOSFET with the low-side MOSFET OFF and the inductor current, I_L increases.

The current comparator receives both a current feedback control signal (SENSE) that is I_L converted to a voltage and a voltage feedback control signal (FB). If both input

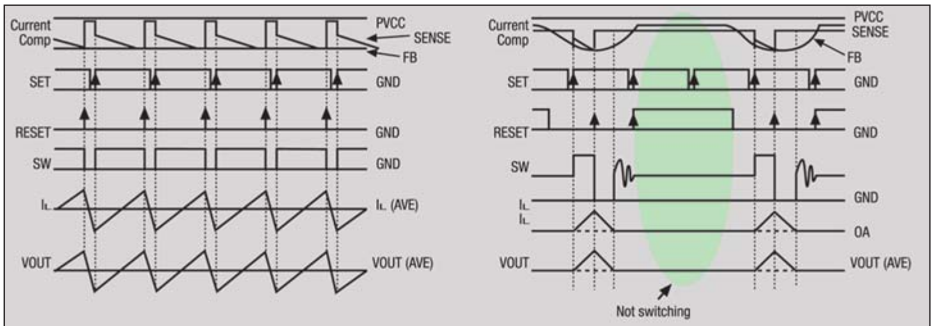

Figure 1: Comparing SLLM to traditional PWM control.

signals are identical, the comparator generates a RESET signal, turning OFF the high-side MOSFET and turning ON the low-side MOSFET for the rest of the fixed period. The PWM control repeats this operation. This process provides improved response time for lower voltage swings under varying load conditions.

In the design of POL devices, the voltage drop when the load on the POL regulator increases and how fast the regulator responds are key factors in a well-designed system. In fact, tight load regulation can be critical to avoid operational performance problems and even failure in voltage-sensitive

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devices, especially in circuits with supply voltages of 1.8 V or less.

Principals of SLLM – Advanced control of light loads

To keep pace with the rapidly improving capability and performance of high-speed ICs in the system, previous POL regulators could not provide a completely acceptable solution. While CM control "solves" the load regulation problem, the demand for efficiency and extended battery life calls for a two-tiered control strategy. The advanced capability to respond quickly to load changes and provide improved efficiency at light loads is the basis of a new switching regulator series.

To improve the efficiency of products in the previously ignored low-power operating regime, ROHM Semiconductor engineers have developed a technique called Simple Light Load Mode Control. Figure 1 shows the comparison of SLLM to traditional PWM control.

Rather than dissipating unnecessary power, the SLLM technique allows the regulator to function normally when required and to shut off to save power at low load conditions

Under higher load levels, normal current mode PWM control is utilised. When a light load is detected, the switching pulse (SW) turns OFF the normal PWM control loop allowing linear operation without an excessive voltage drop or deterioration in transient response during the switching from light load to heavy load or vice versa.

The PWM control loop continues to operate with a SET signal from OSC and a RESET signal from the current comparator. However, the RESET signal is not issued in the light-load mode so switching does not occur. This intermittent activation or discontinuous mode of operation reduces the switching dissipation and improves the efficiency. Rather than dissipating unnecessary power, the SLLM technique allows the regulator to function normally when required and to shut off to save power at low load conditions. While this sounds rather straightforward, the circuitry to do this requires precise timing and an understanding of the application requirements.

Figure 2 shows the improvements in the lower power range through the use of the SLLM control. This pulse skip control technology is an integral part of a new series of highly efficient switching regulators.

Solutions for higher overall efficiency and performance

ROHM Semiconductor has implemented SLLM with advanced synchronous rectification and other energy saving techniques in its latest BD91x series of step-down switching regulators. While the operation is simple and easy to describe, the circuitry behind SLLM requires a level of sophistication to avoid problems during the transition between SLLM and standard PWM control. This light-load control method ensures low power consumption and high efficiency under varying load conditions even in the "not switching" or suspension mode.

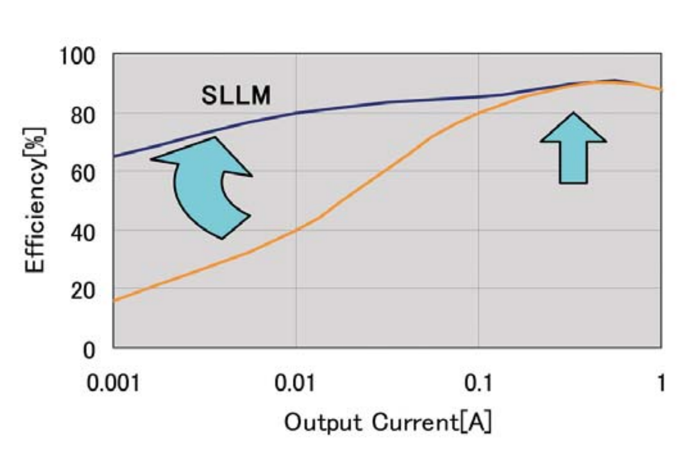

Figure 2: The improvements in the lower power range through the use of the SLLM control.

- **High efficiency**

In addition to synchronous rectification, the BD91x series devices' integrated power MOSFETs low on-resistance and high-speed switching capability provide even greater efficiency in all operating ranges. The efficiency can be higher in both low current and high current modes when compared to other MOSFET switching regulator designs. SLLM technology reduces dissipation for power switching, gate charge/discharge dissipation, ESR dissipation of output capacitors and on-resistance dissipation to increase efficiency at light loads.

- **High performance**

The quick response of the current sense/feedback loop in the BD91x series to any change in load current reduces the voltage variation by as much as 50%. The output variation using different approaches can easily be as much as 20 mV higher.

- **High reliability**

In addition to expected protection circuitry for faults including under-voltage lockout, thermal shutdown, over-current and short-circuit protection, the BD91x series includes a stand-by function where the standby current is essentially zero, a soft-start function and high output voltage accuracy of ±1.5% to ±2.0%.

- **Fewer and smaller external components**

The BD91x series devices require less than ten passive components to implement power conversion. In addition, the inductor's size can also be reduced providing another advantage to space-constrained applications.

- **Packaging- The small solution**

The packaging for the BD91x series addresses the needs of space-constrained designs that benefit from the regulator's improved efficiency. These small outline and wafer-level packages address a wide range of applications. The small form factor packages combined with a minimal number of additional passive components reduce both the space required for the total solution as well as the system cost.

Conclusion

The BD91x series from ROHM Semiconductor combines SLLM technology with synchronous rectifier design and other circuitry techniques to provide exceptional load regulation and high efficiency at both low and high power operating modes, addressing the emerging needs for "green" product designs. With SLLM technology, system designers can provide longer, problem-free operation of portable devices as well as reduced energy consumption. For high-power/high-current applications future products of the series will provide a slightly larger package to handle the increased heat dissipation. Other products will continue to focus on smaller footprint packages such as chip-scale-package for mobile applications.

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