

## White Paper

# Power Management Solutions for Modern Electronic Devices

---

## Introduction

Integrated circuits (ICs) are a vital component in almost all fields of the modern world. As a result, power management in these ICs has become more and more critical. From consumer products such as computers, tablets and TVs, to servers and industrial applications such as medical equipment, portable instruments and fitness equipment, modern electronic devices require efficient power management solutions. Some of the key requirements of today's power management solutions include less power consumption under various load conditions, less space, high reliability and wide input voltage. These requirements are driving the need for highly efficient, wide  $V_{IN}$ , low quiescent current ( $I_Q$ ) switching regulators in a broad range of applications.

Intersil's ISL85410/15/18 product family is designed to meet the power requirements of modern electronic devices. These ICs integrate the PWM control, power MOSFET, compensation network, protection and monitoring circuit into a tiny 4mmx3mm 12 LD DFN package for efficient, compact and cost-effective power conversion. With the proprietary current mode control scheme implemented, these ICs can precisely regulate output voltage for input voltage varying from 3V to 40V and load current up to 1A. With output voltage adjustable from 0.6V to 96% of  $V_{IN}$  and switching frequency adjustable from 300kHz to 2MHz, the ISL8541X product family provides the flexibility to design optimal power solutions.

The ISL8541X product family has internal compensation and the option to use external compensation to achieve fast transient performance. The protection and control logic circuit is well designed to ensure robust protection including OCP, OVP and OTP under severe operation conditions. These ICs have other important features such as synchronization with external clock, adjustable soft start, forced PFM for light load operation, up to 96% efficiency and low  $I_Q$  of 80 $\mu$ A. The pin-compatible ISL85415 (500mA), ISL85418 (800mA) and ISL85410 (1A) switching regulators are the ideal choice for implementing highly efficient, compact and cost-effective power solutions in a broad range of industrial, infrastructure and consumer applications.

## Typical Applications of ISL85410/15/18 Switching Regulators

The ISL8541X sync buck regulators can be used for a wide range of industrial and infrastructure products such as defibrillators, fitness equipment, portable instrumentation, distributed power supply, computer motherboards, data cards, network switches, satellite set top boxes, medical imaging systems, portable emergency communication equipment, car chargers, power tools battery powered data acquisition devices and more. Figure 1 shows the typical applications of the ISL85410/15/18 devices to convert wide  $V_{IN}$  power source to various low output voltage for various load conditions with current up to 1A.

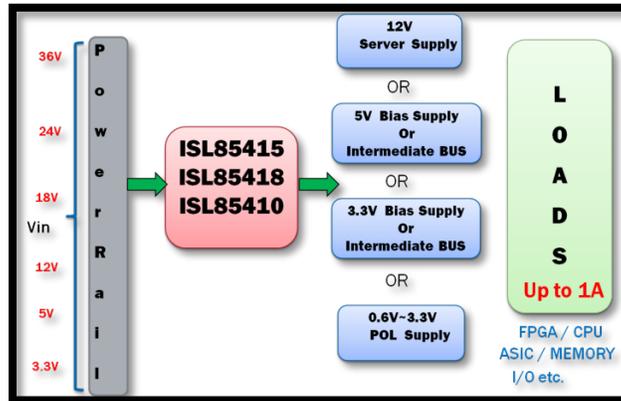


Figure 1. ISL8541X Family Applications

## High Efficiency Operation with Light Load Feature

The ISL8541X power management ICs combine a synchronous buck PWM controller with integrated power switches. With compensation circuit and other control functions integrated inside the IC, only a few external components are needed for an efficient DC-DC power supply (Figure 2).

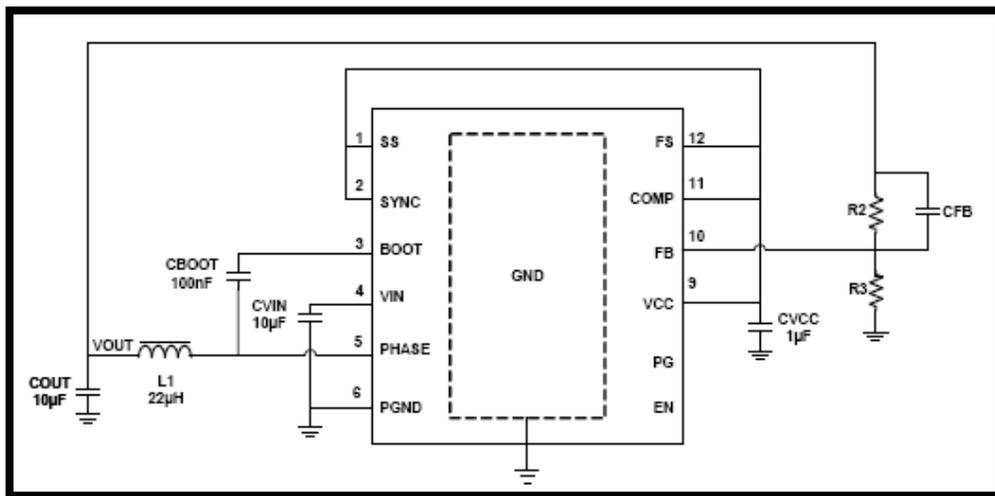


Figure 2. Default Application Schematic with Internal Compensation

To achieve high efficiency under heavy load conditions, the internal high-side and low-side N-channel MOSFETs of ISL85410/15/18 were designed with ultra-low resistance and low gate charge. In addition, the ON/OFF control of the switching FETs is optimized with very little dead time to reduce the power loss.

In the light load operation, the converter efficiency can be improved by enabling variable frequency operation (PFM). Connecting the SYNC pin to GND will allow the controller to choose such operation automatically when the load current is low. The IC enters the DCM mode of operation when 8 consecutive cycles of inductor current crossing zero are detected. Should load current rise beyond the limit,  $V_{OUT}$  will begin to decline. Once the output voltage drops to 99% of the set voltage, the converter will return to PWM operation. Figure 3 shows the transition from PFM to PWM mode in light load operation.

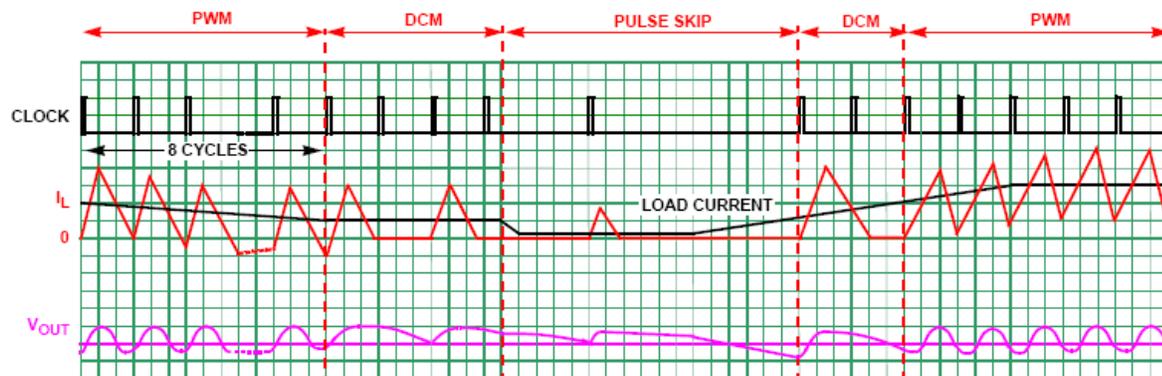


Figure 3. Transition of PFM to PWM for Light Load Efficiency Improvement

With optimal internal power circuit and light load operation mode, the DC-DC converter based on the ISL85410/15/18 product family can achieve superior efficiency over the entire operation range. Figure 4 shows the efficiency of a 3.3V<sub>OUT</sub> voltage regulator based on ISL85410 over the load and various V<sub>IN</sub> conditions.

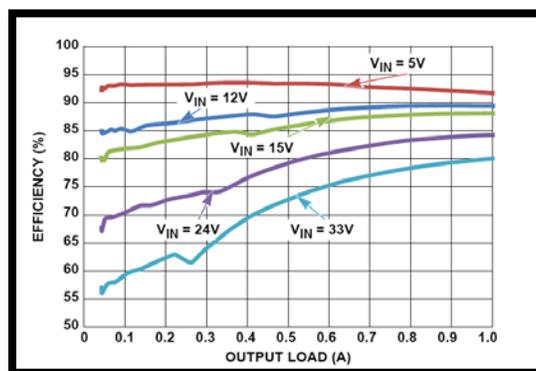


Figure 4. ISL85410 Efficiency at Light and Heavy Load (V<sub>OUT</sub>=3.3V)

## Robust Protection for Safe Operation

**Over-current Protection** – During PWM on-time, current through the upper FET is monitored and compared to the peak over-current limit. If the current reaches the limit and persists for 17 sequential clock cycles, the regulator will begin its hiccup sequence. In this case, both FETs will be turned off to protect the device and PG will be pulled low to indicate a fault condition. There is no danger even if the output is shorted during soft-start. If V<sub>OUT</sub> is shorted very quickly, the regulator recognizes this condition and will begin to lower its switching frequency proportional to the FB pin voltage. This ensures that under no circumstance (even with V<sub>OUT</sub> near 0V) will the inductor current run away.

**Negative Current Limit** – Should an external current be driven into V<sub>OUT</sub>, the controller will attempt to regulate V<sub>OUT</sub> by reversing its inductor current to absorb the externally sourced current. If the current is reversed to unacceptable levels, the controller will initiate its negative current limit protection. Similar to normal over-current, the negative current protection is realized by monitoring the current through the lower FET. When the valley point of the inductor current reaches negative current limit, the lower FET is turned “OFF” and the upper FET is forced “ON” until current reaches the POSITIVE current limit, when the lower FET is allowed to

---

operate. Should the current again be pulled to the negative limit on the next cycle, the upper FET will again be forced “ON” and current will be forced to 1/6th of the positive current limit. At this point the controller will turn “OFF” both FETs, applying a 100Ω load from PHASE to PGND in the attempt to discharge the output. Recovery is automatic.

**Over-Temperature Protection** – Over-temperature protection limits maximum junction temperature to +150°C, when both FETs are turned “OFF” and the controller waits for temperature to decrease by approximately 20°C. After that the controller will initiate a normal soft-start sequence.

**Boot Under-Voltage Protection** – If the boot capacitor voltage falls below 1.8V, the boot under voltage protection circuit will turn on the lower FET for 400ns to recharge the capacitor. This operation may arise during long periods of no switching operation in PFM mode. In PWM operation where the  $V_{OUT}$  is very close to  $V_{IN}$ , the lower FET is forced on for approximately 200ns every 10 clock cycles to prevent the boot capacitor from discharging. This mechanism ensures the safe operation of the switching regulator.

## Other Important Features

**Adjustable Soft Start** – To avoid large in-rush current,  $V_{OUT}$  is slowly increased at startup to its final regulated value. Soft-start time is determined by the SS pin connection. If SS is pulled to VCC, an internal 2ms timer is selected for soft-start. For other soft-start times, simply connect a capacitor from SS to GND. In this case, a 2μA current pulls up the SS voltage and the FB pin will follow this ramp until it reaches the 600mV reference level.

**Power-Good** – To indicate the operation condition of the switching regulator, a Power Good (PG) pin is implemented with open-drain output and internal pull-up resistor. PG is actively held low when EN is low and during the buck regulator soft-start period. After the soft-start period completes, PG becomes high impedance provided the FB pin is within the operating range. Should FB exit the specified window, or a fault condition occur, PG will be pulled low.

**Adjustable Operating Frequency** – Programmable frequency allows for optimization between efficiency and external component size. It also allows low frequency operation for low  $V_{OUT}$  when minimum on time would otherwise limit the operation. Default switching frequency is 500kHz if FS is tied to VCC; if a resistor is tied from FS to GND, the switching frequency can be programmed from 300kHz to 2MHz.

**Synchronization Control** – To minimize the input voltage ripple and reduce EMI, frequency synchronization is often required for applications with multiple DC-DC converters. The switching frequency of the ISL8541X product family can be synchronized up to 2MHz by an external signal (10% greater than the programmed free running IC frequency) applied to the SYNC pin. This will also allow two regulators to be synched together.

**Option to Use External Compensation** – The internal compensation parameters are carefully selected to ensure robust stability and good dynamic performance with a wide range of output inductor and capacitor combinations. In the case that further improvement on transient performance is needed, the external compensation circuit can be used via COMP pin to optimize the operation. If COMP pin is connected to VCC via an external resistor, internal compensation will be used. With both options, the ISL8541X product family provides extra flexibility for circuit design.

## Evaluation Platform

To provide users the flexibility to explore all features of the ISL8541X product family, a compact demo board is available and features component stuffing options as shown in Figure 5.

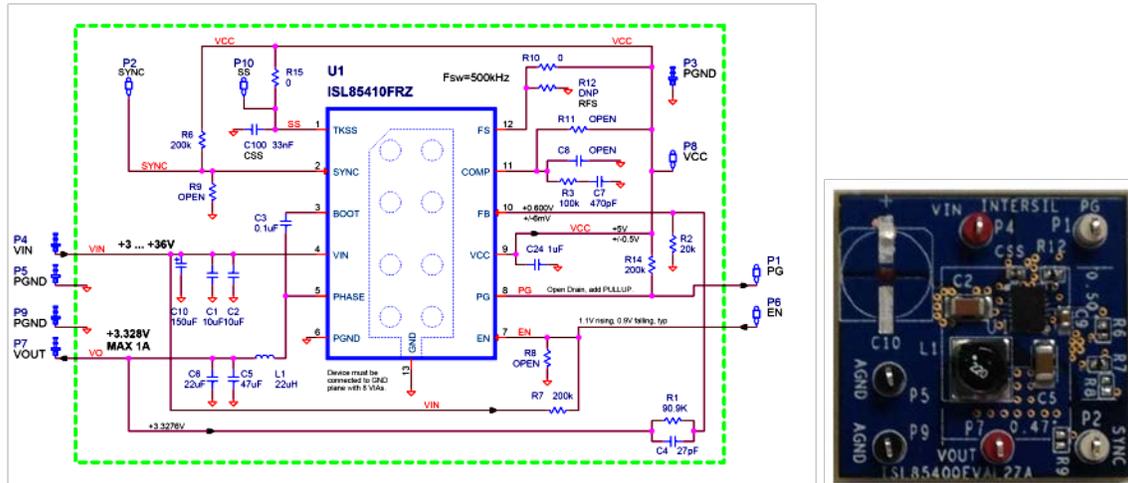


Figure 5. Schematic and Image of ISL8541X Demo Board

## Conclusion

The ISL85410/15/18 switching regulator family is designed for wide  $V_{IN}$  and low current POL DC-DC applications. The solutions offer high efficiency, flexibility, low quiescent current and robust stability over a wide range of  $V_{IN}$  and output conditions. The devices are highly reliable with complete protection features, making them ideal for highly efficient, compact power conversions in industrial, infrastructure, consumer and automotive applications. Find out more about Renesas' ISL8541x switching regulator family at [www.renesas.com/ISL8541x](http://www.renesas.com/ISL8541x).

## REFERENCES

[1] Renesas, ISL85410 Datasheet and ISL85410 Application Note

# # #

© 2018 Renesas Electronics America Inc. (REA). All rights reserved. All trademarks and trade names are those of their respective owners. REA believes the information herein was accurate when given but assumes no risk as to its quality or use. All information is provided as-is without warranties of any kind, whether express, implied, statutory, or arising from course of dealing, usage, or trade practice, including without limitation as to merchantability, fitness for a particular purpose, or non-infringement. REA shall not be liable for any direct, indirect, special, consequential, incidental, or other damages whatsoever, arising from use of or reliance on the information herein, even if advised of the possibility of such damages. REA reserves the right, without notice, to discontinue products or make changes to the design or specifications of its products or other information herein. All contents are protected by U.S. and international copyright laws. Except as specifically permitted herein, no portion of this material may be reproduced in any form, or by any means, without prior written permission from Renesas Electronics America Inc. Visitors or users are not permitted to modify, distribute, publish, transmit or create derivative works of any of this material for any public or commercial purposes.