Using the ISL6430 in DC-DC Converters for Microprocessors in Gateway Applications

Application Note | September 2001 | AN9974

Introduction

Today's high-performance microprocessors present many challenges to their power source. High power consumption, low bus voltages, and fast load changes are the principal characteristics which have led to the need for a switch-mode DC-DC converter local to the microprocessor. A common requirement of these and similar processors are decreasing supply voltages as the processor clock frequency increases.

The Intersil ISL6430 pulse-width modulator (PWM) controllers are targeted specifically for DC-DC converters powering high-performance microprocessors with varying core voltage requirements.

This device provides a cost-effective solutions for point-of-use switch-mode, DC-DC converters for many applications. This application note details the use of the ISL6430 in DC-DC converters for high-performance microprocessors with a fixed core voltage.

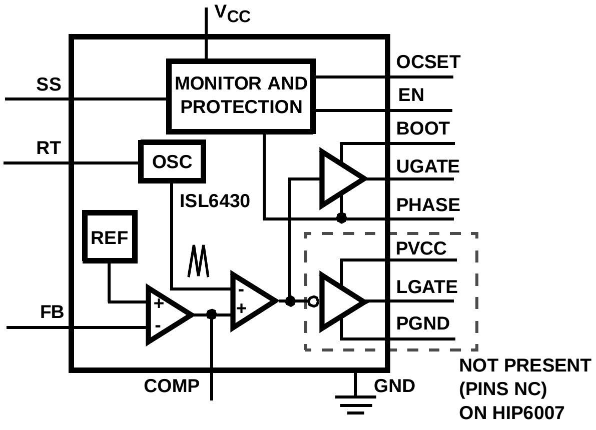


FIGURE 1. BLOCK DIAGRAM OF ISL6430

Intersil ISL6430

The Intersil ISL6430 is a voltage-mode controller with many functions needed for high-performance processors. Figure 1 shows a simple block diagram of the ISL6430. The device contains a high-performance error amplifier, a high-accuracy reference, a programmable free-running oscillator, and overcurrent protection circuitry. The ISL6430 has two MOSFET drivers for use in synchronous-rectified buck converters. A more complete description of the parts can be found in their data sheets.

ISL6430EVAL1

The ISL6430EVAL1 is a synchronous buck converter capable of providing up to 9A of current at a fixed 2.5V output voltages. Simple resistor value changes allow for outputs as low as 1.3V. The schematic and bill-of-materials for this design can be found in the appendix.

Efficiency

Figure 2 displays the ISL6430EVAL1 efficiency versus load current for both 5V and 12V inputs with 100 linear feet per minute (LFM) of airflow. For a given output voltage and load, the efficiency is lower at higher input voltages. This is due primarily to higher MOSFET switching losses and is displayed in Figure 2.

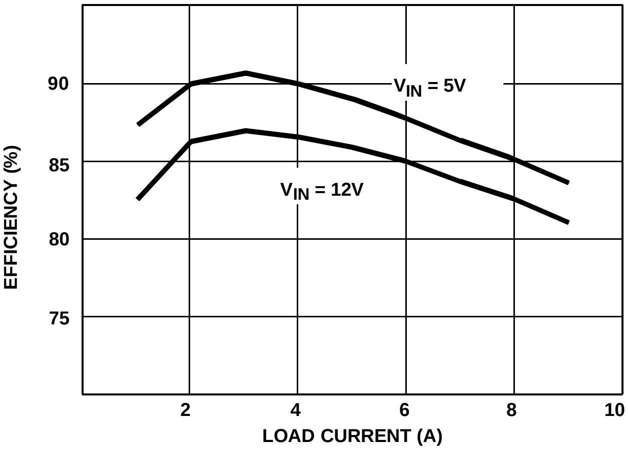


FIGURE 2. ISL6430EVAL1 EFFICIENCY vs LOAD

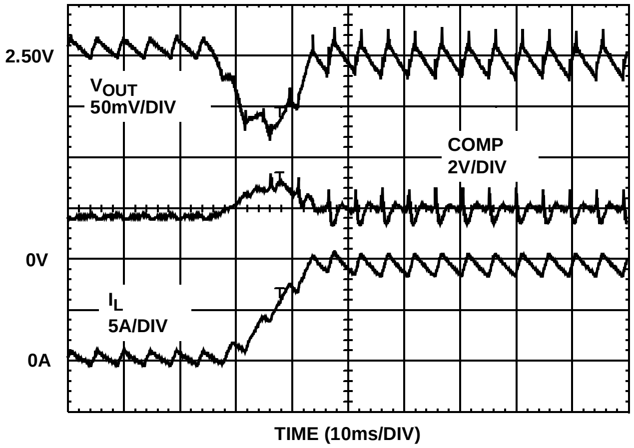


FIGURE 3. ISL6430EVAL1 TRANSIENT RESPONSE WITH V_{IN} = 12V

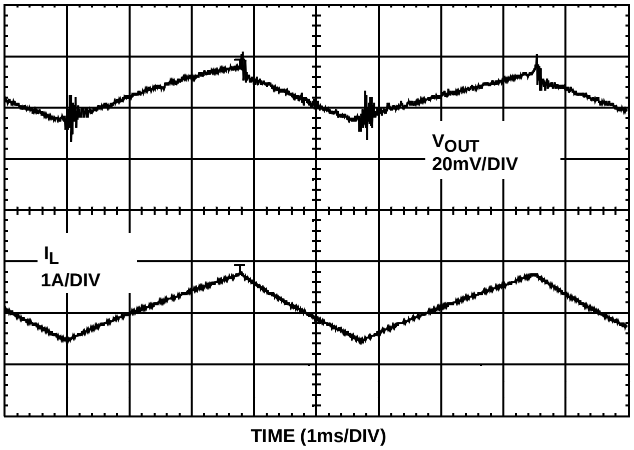


FIGURE 4. ISL6430EVAL1 OUTPUT VOLTAGE RIPPLE

Transient Response

Figure 3 shows a laboratory oscillogram of the ISL6430EVAL1 in response to a 0-9A load transient application. The output voltage responds rapidly and is within 1% of its nominal value in less than 15µs. Check the *Feedback Compensation* section of the data sheet for details on loop compensation design. Table 1 details simulated closed-loop bandwidth and phase margin for both reference boards at both +5V and +12V input sources.

TABLE 1. CONTROL LOOP CHARACTERISTICS

	ISL6430EVAL1	
	V_{IN} = 5V	V_{IN} = 12V
f_{0dB}	27kHz	61kHz
φ_{MARGIN}	72^{o}	62^{o}

OC Protection

The ISL6430EVAL1 has lossless overcurrent (OC) protection. This is accomplished via the current-sense function, which senses converter load current by monitoring the drop across the upper MOSFET (Q1 in the schematics). By selecting the appropriate value of the OCSET resistor (R6), an overcurrent protection scheme is employed without the cost and power loss associated with an external current-sense resistor. See the *Over-Current Protection* section of the ISL6430 data sheet for details on the design procedure for the OCSET resistor.

Customization of Reference Designs

The ISL6430EVAL1 reference design provides solutions for microprocessors with current demands of up to 9A. One basic design is employed to meet many different applications. The evaluation board can be powered from +5V or +12V and a synchronous buck topology may be employed. Employing one basic design for numerous applications involves some trade-offs. These trade-offs are discussed below to help the user optimize for a given application.

Control Loop Bandwidth/Transient Response

Table 1 shows how the control loop characteristics vary with line voltage and topology. The line voltage determines the amount of DC gain, which directly affects the modulator (control-to-output) transfer function. The topology (standard buck or synchronous buck) is important because we have chosen to use a larger output inductor for the standard buck (HIP6005) design. This lowers the boundary of continuous conduction mode (ccm) and discontinuous conduction mode (dcm) operation. Staying in ccm at light loads can have an adverse affect on transient response of the converter. The ISL6430EVAL1 design will not go into dcm operation because the lower MOSFET conducts current even at light or zero load conditions.

From Table 1, we see that the highest control loop bandwidth is with V_{IN} = 12V. The transient response of the converter for this case is shown in Figure 3. The other cases have slower responding loops and can be improved with value changes in the compensation components. Table 2 details suggested changes and the improved control loop characteristics for the three applications with slower control loops.

TABLE 2. MODIFICATIONS TO CONTROL LOOP

	ISL6430EVAL1	
	V_{IN} = 5V	V_{IN} = 12V
R5	30.1K	no change
C14	no change	no change
f_{0dB}	47kHz	61kHz
φ_{MARGIN}	53^{o}	62^{o}

Ripple Voltage

The amount of ripple voltage on the output of the DC-DC converter varies with input voltage, switching frequency, output inductor, and output capacitors. For a fixed switching frequency and output filter, the voltage ripple increases with higher input voltage. The ripple content of the output voltage can be estimated with the following simple equation:

$$\Delta V_{OUT} = \Delta I_L \bullet ESR$$

where

$$\Delta I_L = \frac{(V_{IN} - V_{OUT}) \bullet \frac{V_{OUT}}{V_{IN}} \bullet Ts}{L_{OUT}}$$

ESR = equivalent series resistance of output capacitors

Ts = switching period (1/Fs)

L_{OUT} = output inductance

Therefore, for equivalent output ripple performance at V_{IN} = 12V as at 5V, the output filter or switching frequency must change. Assuming 200kHz operation is desired, either the output inductor value should increase or the number of parallel output capacitors should increase (to decrease the effective ESR).

Increased Output Power Capability

The ISL6430EVAL1 printed circuit board is laid out with flexibility to increase the power level of the DC-DC converter beyond 9A. Locations for additional input capacitors and output capacitors are provided. In conjunction with higher current MOSFETs, Schottky rectifiers, and inductors, the evaluation board can be tailored for applications requiring upwards of 15A. The ISL6430 data sheet's *Component Selection Guidelines* section helps the user with the design issues for these applications. Of course, the ISL6430EVAL1 can be modified for more cost-effective solutions at lower currents as well.

MOSFET Selection

As a supplement to the data sheets' application information on *MOSFET Selection Considerations*, this section shows graphically that a larger, lower $r_{DS(ON)}$ MOSFET does not always improve converter efficiency. Figure 8 shows that smaller RFP25N05 MOSFETs are more efficient over most of the line and load range than larger RFP45N06 MOSFETs. The RFP25N05 (used on the ISL6430/7EVAL1) has a $r_{DS(ON)}$ equal to 47mΩ (maximum at 25^{O}C) versus 28mΩ for the RFP45N06. In comparison to the RFP25N05, the RFP45N06 MOSFETs increased switching losses are greater than its decreased conduction losses at load currents up to about 7A with a 5V input and about 9A with a 12V input.

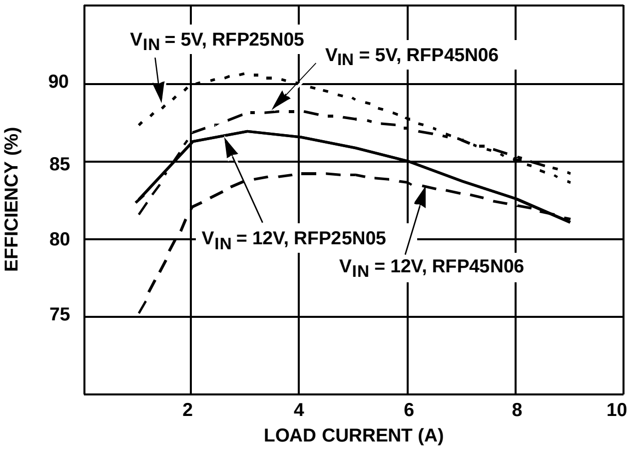


FIGURE 5. ISL6430EVAL1 EFFICIENCY WITH EITHER RFP25N05 MOSFETs OR RFP45N06 MOSFETs

Conclusion

The ISL6430EVAL1 is a DC-DC converter reference design for microprocessors with fixed core voltages and current requirements of up to 9A. In addition, the design can be modified for applications with different requirements. The printed circuit board is laid out to accommodate the necessary components for operation at currents up to 15A.

References

For Intersil documents available on the web, see http://www.intersil.com/

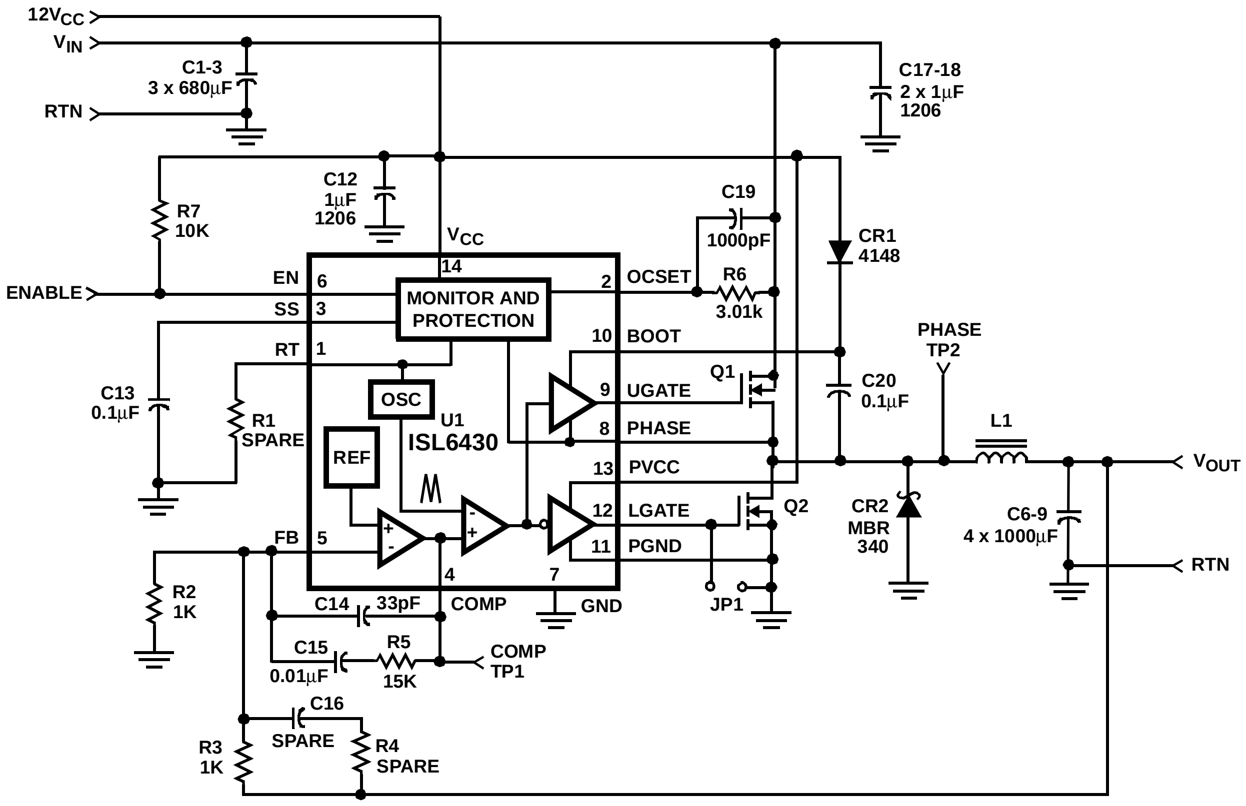
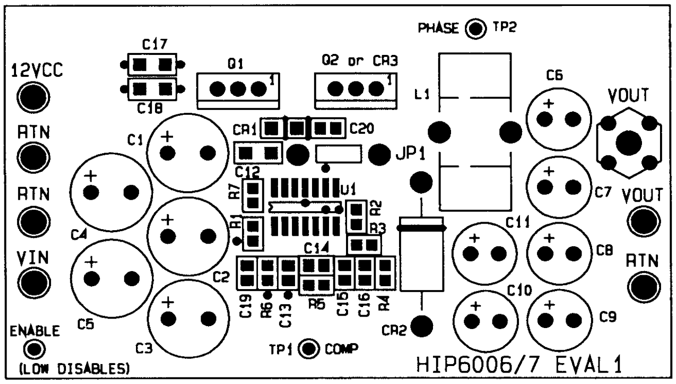


FIGURE 6. ISL6430EVAL1 SCHEMATIC

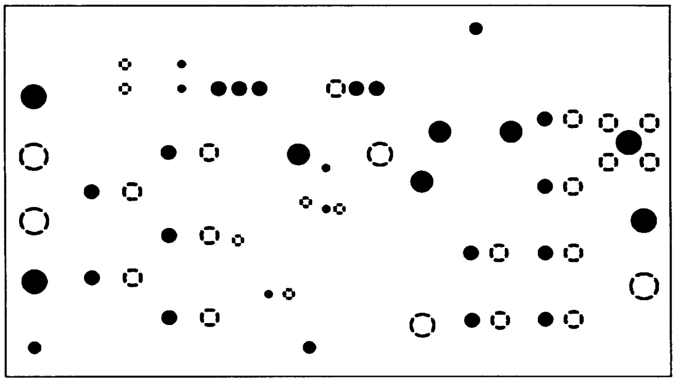
Bill of Materials for ISL6430EVAL1

PART NUMBER	DESCRIPTION	PACKAGE	QTY	REF	VENDOR
25MV680GX	680µF, 25V Aluminum Capacitor	Radial 10 x 22	3	C1 - C3	Sanyo
6MV1000GX	1000µF, 6.3V Aluminum Capacitor	Radial 8 x 20	4	C6 - C9	Sanyo
1206YZ105MAT1A	1.0µF, 16V, X7S Ceramic Capacitor	1206	3	C12, C17-C18	AVX
1000pF Ceramic	1nF, X7R Ceramic Capacitor	0805	1	C19	Various
0.1uF Ceramic	0.1µF, 25V X7R Ceramic Capacitor	0805	2	C13, C20	AVX/Panasonic
0.01uF Ceramic	0.01µF, X7R Ceramic Capacitor	0805	1	C15	Various
33pF Ceramic	33pF, X7R Ceramic Capacitor	0805	1	C14	Various
Spare	Spare Ceramic Capacitor	0805		C16	
1N4148	Rectifier 75V	DO35	1	CR1	Various
MBR340	3A, 40V, Schottky	Axial	1	CR2	Motorola
CTX09-13313-X1 PO343	5.3µH, 12A Inductor T50-52B Core, 10 Turns of 16 AWG Wire	Wound Toroid	1	L1	Coiltronics Pulse
RFP25N05	47mΩ, 50V MOSFET	TO220	2	Q1, Q2	Intersil
ISL6430	Synchronous Rectified Buck Controller	SOIC-14	1	U1	Intersil
10kΩ	10kΩ, 5% 0.1W, Resistor	0805	1	R7	Various
Spare	Spare 0.1W, Resistor	0805		R1,R4	
15kΩ	15kΩ, 5%, 0.1W, Resistor	0805	1	R5	Various
1kΩ	1kΩ, 5%, 0.1W, Resistor	0805	2	R2-R3	Various
3.01kΩ	3.01kΩ, 1%, 0.1W, Resistor	0805	1	R6	Various
576802B00000	TO-220 Clip-on Heatsink		2		AAVID
1514-2	Terminal Post		6	V_{IN}, 12V_{CC}, V_{OUT}, RTN	Keystone
1314353-00	Scope Probe Test Point		1	V_{OUT}	Tektronics
SPCJ-123-01	Test Point		3	ENABLE, TP1, TP2	Jolo

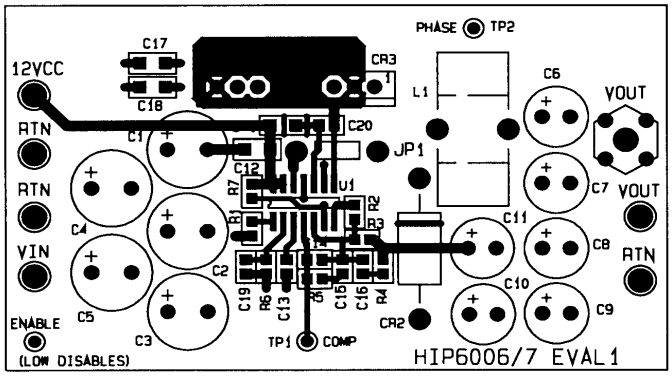
TOP
SILK SCREEN



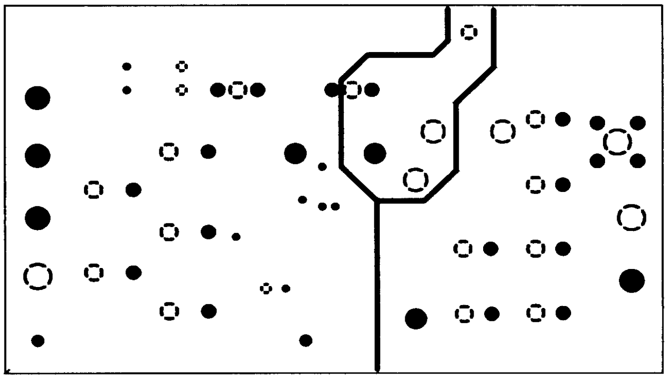
INT. GND. PLANE



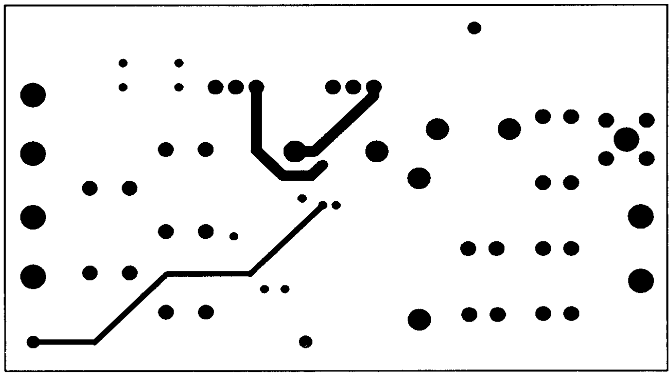
COMPONENT SIDE



INTERNAL ONE



SOLDER SIDE



For information regarding Intersil Corporation and its products, see www.intersil.com

Sales Office Headquarters

NORTH AMERICA
Intersil Corporation
7585 Irvine Center Drive
Suite 100
Irvine, CA 92618
TEL: (949) 341-7000
FAX: (949) 341-7123

Intersil Corporation
2401 Palm Bay Rd.
Palm Bay, FL 32905
TEL: (321) 724-7000
FAX: (321) 724-7946

EUROPE
Intersil Europe Sarl
Ave. C - F Ramuz 43
CH-1009 Pully
Switzerland
TEL: +41 21 7293637
FAX: +41 21 7293684

ASIA
Intersil Corporation
Unit 1804 18/F Guangdong Water Building
83 Austin Road
TST, Kowloon Hong Kong
TEL: +852 2723 6339
FAX: +852 2730 1433