A 230 Watt Buck Regulator With HEXSense™ Current-Mode Control

(HEXSense and HEXFET are trademarks of International Rectifier)

by R. Pearce, D. Grant

Introduction

International Rectifier's range of HEXSense Power MOSFETs with integral current sensing are ideal switching devices for current-mode control switched-mode power supplies (SMPS). The current sensing facility of these HEXFETs can be used to provide the current feedback signal required by the pulse-width modulation (PWM) controller, thereby eliminating the series resistor or current transformer normally required in such applications.

The general use and basic characteristics of current sense HEXFETs are described in Application Note AN-959, "An Introduction to the HEXSense Current-Sensing Device," and the use of these devices in switched-mode power supplies is described in Application Note AN-960, "Using HEXSense Current-Sense HEXFets in Current-Mode Control Power Supplies" [References 1 and 2].

This application note provides further illustration of how the current sense facility of the HEXSense devices may be used to implement current-mode control in an SMPS.

Description of the SMPS

The power supply is a 230 Watt buck regulator. The targetted performance for the supply is as follows:

Input voltage: 110V ac 60 Hz

Output voltage: 48V dc

Output current: 4.8 Amps

Switching frequency: 100 kHz

Full load efficiency: 78% (83% at 1/3 full load)

Output regulation: 5% (1/3 full load to full load)

Current-mode control is implemented by the use of the popular 3842 integrated circuit (IC) as controller and the International Rectifier IRC830 Current Sense HEXFET for current-sensing.

Circuit Description

The schematic outline of the power supply is shown in Figure 1.

The circuit is that of a conventinal buck regulator. Power for the control IC and the voltage feedback signal are derived from an auxiliary winding on the output choke. This winding operates in the "flyback" mode. The control circuit uses the 3842 PWM controller with the duty cycle limited to 50% (by R4).

The feedback voltage is derived via D4, R1, R2 and C1. R3 and C2 provide compensation to ensure loop stability. D5, C5 and C6 provide power for the 3842 during normal running. R6 is used to bleed current from the 155V dc rail for start-up. R4 and C3 are the oscillator timing components. Q1 and R5 are used to sample the oscillator waveform, thereby providing a ramp waveform which is added to the current-sense waveform for slope compensation.

Current-Sense Signal

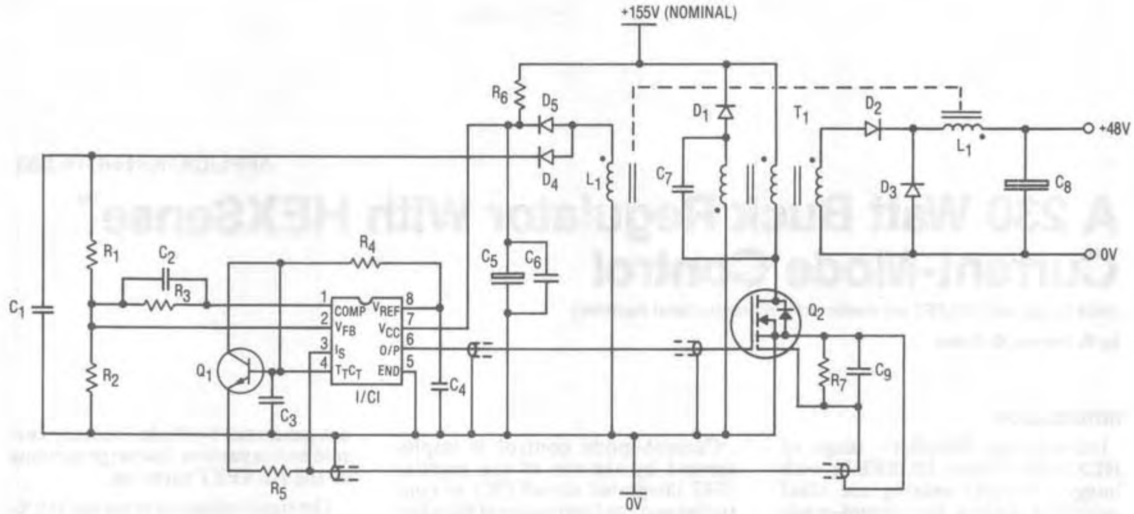
The current sense signal is derived from the Current Sense HEXFET Q2. A small fraction of the drain current is diverted through R7 to provide a voltage proportional to the drain current. C9 suppresses spikes at the leading edge of the current pulse which could cause premature toggling of the controller. These spikes are generated by diode recovery current and capacitive discharge currents as the HEXFET turns on.

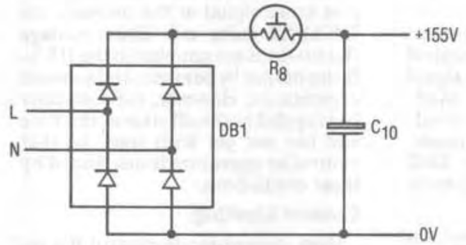
The signal obtained from the HEXSense device is shown in Figure 2. Figure 2a shows the waveforms obtained without ramp feedback whereas in Figure 2b ramp compensation has been added. Ringing in the power circuit results in an oscillatory current sense signal at the moment the HEXFET turns off. Drain voltage fluctuations are coupled to the HEXSense output by parasitic drain-source capacitance. However, the controller has toggled to the off state at this time and has not yet been reset, so that controller operation is unaffected by these oscillations.

Current Limiting

Most current-mode control ICs incorporate limiting of the current pulse amplitude. The accuracy of the current limit can only be as accurate as the current sensing. When using the resistor sensing method the sensing accuracy is principally determined by the expected variation in the HEXFET operating temperature since changes in the Rds(on) of the sense cells and the main body of cells will alter the current sensing ratio.

The variation of sensing accuracy as a function of temperature for a particular value of sensing resistor is discussed in Reference 2. Figure 3 shows the variation of sense ratio with die temperature for the value of sense resistor used in this application. The change in loop gain as a result of, for example, a 100 degree C change in die temperature, (3 dB) can easily be accommodated by the gain margin of the control loop (–14 dB).





Components List

R1	10 kΩ	C1	100 nF	IC_1	CS 3842
R2	2.2 kΩ	C2	220 nF	D1	BYT 03-400
R3	100 kΩ	C3	10 nF	D2	BYV 32-200
R4	750Ω	C4	100 nF	D3	BYV 32-200
R5	2.7 kΩ	C5	100 μF	D4	1N4148
R6	100 kΩ	C6	100 nF	D5	1N4148
R7	680Ω	C7	470 nF	Q1	IRC830
R8	SG4	C8	2 x 100 μF, 63V, low ESR	Q2	2N3904
		C9	100 pF	DB1	100JB4L
		C10	330 pF, 200V		

T1 ETD34 (3C8)
Primary: 68T of 0.5 mm dia. bifilar
Secondary: 60T of 0.71 mm dia.
(The transformer operates at the limit of its throughput and greater efficiency may be obtained with ETD39.)

L1 ETD34 (3C8) Gap = 0.6 mm
Main wdg: 30T of 1.5 mm dia.
L = 140 μH
Auxiliary wdg: 8T of 0.25 mm dia.

Figure 1. Circuit diagram of supply.

If current limiting of greater accuracy is required, it is necessary either to reduce the value of sense resistor or use the virtual-earth operational amplifier method of generating the current sense signal (Reference 1).

RFI and EMI Control

A further advantage of Current Sense HEXFETs is to be found in the area of EMI and RFI control. In order to control the amount of electromagnetic interference produced by a circuit it is necessary to minimize the size of loops that carry high current pulses. The elimination of the bulky series current sensing resistor or current transformer permit a reduction in the area of the loop comprising the power switch, the power transformer, the supply decoupling capacitor and the current sensing element.

Conclusion

This application note is intended as an illustration of the feasibility of using HEXSense devices in current-mode control power supplies and should not be regarded as an infalible power supply design. However, it does show that the Current Sense HEXFET provides the designer of current-mode control power supplies with a method of current-sensing that has significant advantages over other methods. The Current Sense HEXFET can provide a signal of the required quality with negligible power loss and without the need for magnetic components. □

References

1. "An Introduction to the HEXSense Current-Sensing Device," International Rectifier Application Note AN-959.
2. "Using HEXSense Current Sense HEXFETs in Current-Mode Control Power Supplies," International Rectifier Application Note AN-960.
3. "A 70W Boost-Buck (Cuk) Converter Using HEXSense Current-Mode Control," International Rectifier Application Note AN-962.

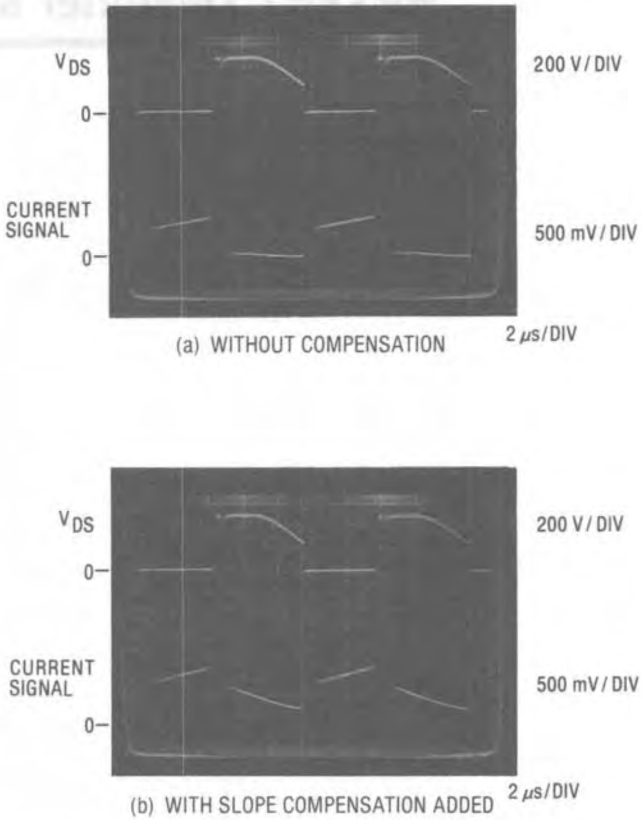


Figure 2. Current sense signals at full load (I_L = 3.8A)

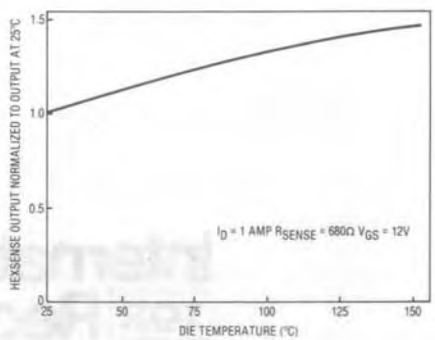


Figure 3. Variation of sensing accuracy with temperatures for IRC830 with 680Ω sensing resistor.