General Description

The EC1457 is a current mode monolithic buck switching regulator. Operating with an input range of 4.5-40V, the EC1457 delivers 3A of continuous output current with an integrated high side N-Channel MOSFET. At light loads, EC1457 operates in low frequency to maintain high efficiency and low output voltage ripple. Current mode control provides tight load transient response and cycle-by-cycle current limiting. The EC1457 guarantees robustness with input under-voltage lockout, start-up current run-away protection, output short protection, feedback short protection and thermal protection. The EC1457 is available in 8-pin ESOP package.

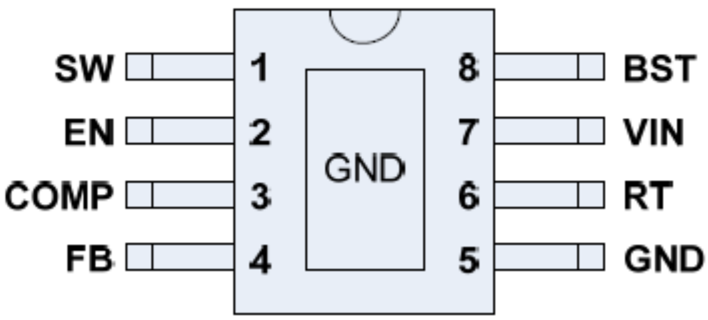
Features

◆4.5V to 40V operating input range 3A output current
◆ Up to 94% efficiency
◆ High efficiency (>78%) at light load
◆Internal Soft-Start
◆Adjustable switch frequency from 100kHz to 900kHz
◆Input under-voltage lockout
◆ Start-up current run-away protection
◆Output short protection
◆Feedback short protection
◆ Thermal protection
◆ Available in ESOP8 package

Applications

◆Distributed Power Systems
◆Networking Systems
◆FPGA, DSP, ASIC Power Supplies
◆Green Electronics/ Appliances
◆Notebook Computers

Pin Configurations



(Top view)

Pin Description

Pin Number	Pin Name	Description
1	SW	SW is the switching node that supplies power to the output. Connect the output LC filter from SW to the output load.
2	EN	Drive EN pin high to turn on the regulator and low to turn off the regulator.
3	COMP	Compensation pin. Comp is used to compensate the regulation control loop. Connect a series RC network from COMP to GND to compensate the regulation control loop. One ceramic cap such as several tens pF is usually connected from COMP to GND to decouple the voltage noise.
4	FB	Output feedback pin. FB senses the output voltage and is regulated by the control loop to FB reference voltage 0.8V. Connect a resistive divider at FB.
5	GND	Ground.
6	RT	Voltage at the RT pin is regulated at 1.2V. Switch frequency of the regulator can be adjusted by connecting a resistor at the RT pin to ground
7	VIN	Input voltage pin. VIN supplies power to the IC. Connect a 3.8V to 40V supply to VIN and bypass VIN to GND with a suitably large capacitor to eliminate noise on the input pin to the IC.
8	BST	Bootstrap pin for top switch. A 0.1uF or larger capacitor should be connected between this pin and SW pin to supply current to the top switch and top switch driver.

Ordering/Marking Information

EC1457 XX X X

R: Tape & Reel

Package Type: G: Green

M1: ESOP-8

Part Number	Package	Marking	Marking Information
EC1457M1GR	ESOP-8	EC1457 LLLLL YYWWT	LLLLL is Lot Number YYWW is date code T is internal tracking code

Function Block

Figure1 Function Block Diagram of EC1457

Typical Application Circuit

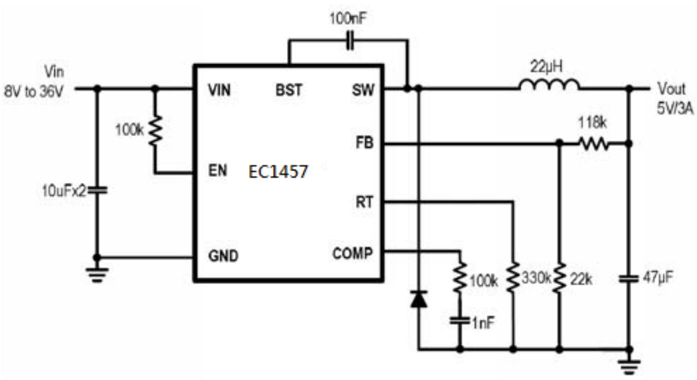


Figure2 Vin: 8V~36V Vout: 5V Iout: 0~3A(RT=330KΩ)

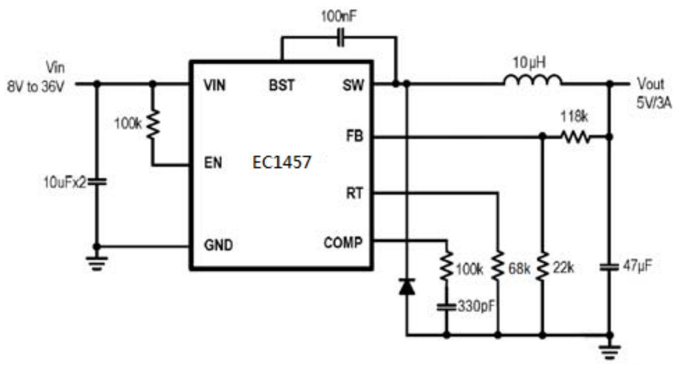


Figure3 Vin: 8V~36V Vout: 5V Iout: 0~3A(RT=68KΩ)

Absolute Maximum Ratings (at T_A=25℃)

Symbol	Parameter	Rating	Unit
	VIN,EN,SW Pin	-0.3 to 45	V
	BST Pin	SW-0.3 to SW+5	
	All other	-0.3 to 6	V
T_J	Junction Temperature	150	°C
T_{STG}	Storage Temperature	-65 ~ 150	°C
T_{SDR}	Maximum Lead Soldering Temperature (10 Seconds)	260	°C

Electrical Characteristics
Unless otherwise specified, these specifications apply over VIN=12V, T_A=25°C

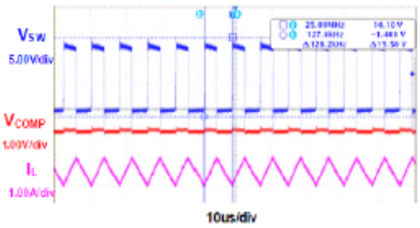
Characteristics	Symbol	Conditions	Min	Typ	Max	Units
VIN Under-voltage Lockout Threshold	V_{IN_MIN}	V_{IN} falling	3.6	3.8	4	V
V_{IN} Under-voltage Lockout Hysteresis	$V_{IN\_MIN\_HYST}$	V_{IN} rising	200	400	600	mV
Shutdown Supply Current	I_{SD}	V_{EN}=0V	-	1.6	3	μA
Supply Current	I_Q	V_{EN}=5V, V_{FB}=1V	30	65	90	μA
Feedback Voltage	V_{FB}	3.6V<V_{VIN}<40V	0.784	0.8	0.816	V
Top Switch Resistance1	$R_{DS(ON)T}$		-	63	78	mΩ
Top Switch Leakage Current	I_{LEAK_TOP}	V_{IN}=40V, V_{EN}=0V,V_{SW}=0V	-	-	0.1	μA
Top Switch Current Limit1	I_{LIM_TOP}	Minimum Duty Cycle	3.8	4.5	-	A
Switch Frequency	F_{SW}	R_{RT} = 330k	100	160	220	KHz
Minimum On Time1	T_{ON_MIN}		-	117	-	ns
Minimum Off Time	T_{OFF_MIN}	V_{FB}=0V	100	150	200	ns
EN Shutdown Threshold	V_{EN_TH}	V_{EN} falling, FB=1V	1	1.2	1.4	V
EN shut down hysteresis	V_{EN_HYST}	V_{EN} rising, FB=1V	50	100	150	mV
Thermal Shutdown1	T_{TSD}		-	137	-	°C
Thermal Shutdown Recovery Hysteresis1	T_{TSDR}		-	13	-	°C

Note1: Guaranteed by design.

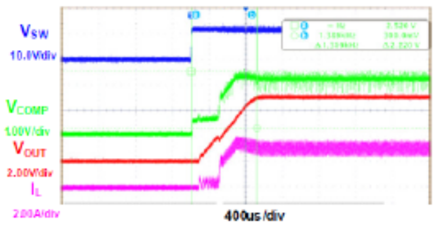
Typical Operating Characteristics

Vin = 12V, Vout = 5V, L = 22μH, Cout = 47μF, Cin = 20μF, T_A = +25°C, unless otherwise noted

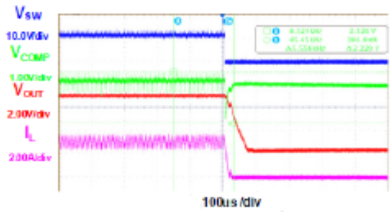
Steady State
Iout=0.5A



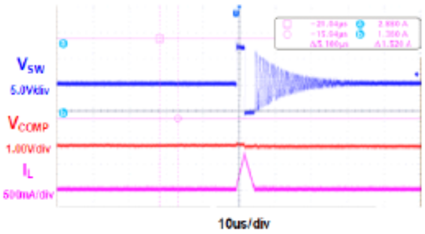
Startup through Enable
Iout=3A



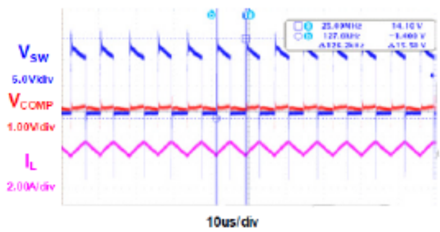
Shutdown through Enable
Iout=3A



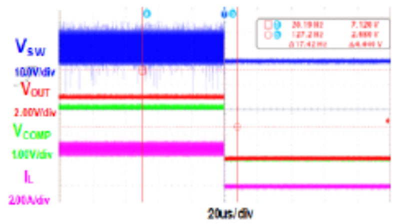
No load
Iout=0A



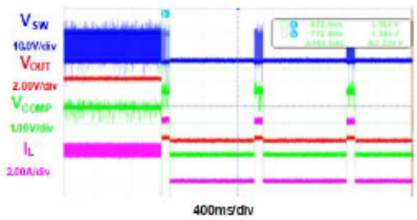
Full load
Iout=3A



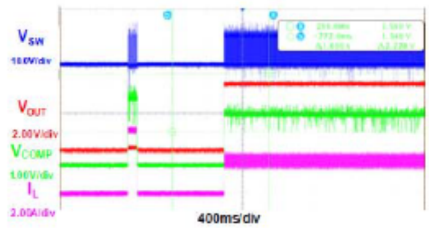
FB Short Protection
Iout=3A



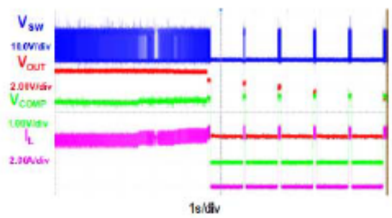
SCP Entry
Iout=0A



SCP Recovery
Iout=3A



Over Load Protection



Function Description

The EC1457 is an asynchronous, current-mode, step-down regulator. It regulates input voltages from 3.8V to 40V down to an output voltage as low as 0.8V, and is capable of supplying up to 3A of load current.

Current-Mode Control

The EC1457 utilizes current-mode control to regulate the output voltage. The output voltage is measured at the FB pin through a resistive divider and the error is amplified by the internal transconductance error amplifier. The output of internal error amplifier is compared to the switch current measured internally to control the output current limit.

PFM Mode

The EC1457 operates in PFM mode at light load. In PFM mode, switch frequency is continuously controlled in proportion to the load current, i.e. switch frequency is decreased when load current drops to boost power efficiency at light load by reducing switch-loss, while switch frequency is increased when load current rises, minimizing both load current and output voltage ripples.

Power Switch

An N-Channel MOSFET switch is integrated on the EC1457 to down convert the input voltage to the regulated output voltage. Since the top MOSFET needs a gate voltage great than the input voltage, a boost capacitor connected between BST and SW pins is required to drive the gate of the top switch. The boost capacitor is charged by the internal 3.3V rail when SW is low.

VIN Under-Voltage Protection

EC1457 can regulate a wide range input voltage down to an output voltage. If the input voltage decreases to under voltage lockout threshold, the regulator enters into UVLO protection to shutdown internal logic and function blocks.

Enable Pin

EN pin is a digital control pin that turns the regulator on and off. Drive EN pin high to turn on the regulator and drive it low to turn it off. A resistor such as 100KΩ can be connected between EN pin and VIN pin for automatic startup.

COMP Voltage

The current limit is decided by the maximum comp voltage which is around 2.5V. Comp voltage is also adjusted with the output current. The comp voltage decreases as load current drop. When comp voltage keeps the maximum value for around 12480 cycle, the over load protection is triggered. IC enters into the hiccup mode during the OLP.

Output Current Run-Away Protection

At start-up, due to the high voltage at input and low voltage at output, current inertia of output inductance can be easily built up, resulting in a large start-up output current. COMP value is limited and rise up slowly for a period of time when start up. By such control mechanism, the output current at start-up is well controlled.

Output Short Protection

When the output is shorted to ground, output current rapidly rises and if it hits the OCP (over current protection) limit, which is 1.3A above the normal peak current limit, switch frequency is halved to allow time for the inductor current to fall to a safe level. If the OCP limit is hit again in the next cycle, switch frequency is halved again. In the extreme case, switch frequency can be decreased to 1/128 of the original frequency set by the resistor at the RT pin.

Feedback Short Protection

If the FB pin is detected to be short to ground for more than 15 switch cycles, the EC1457 is latched off. The regulator can be reactivated again through recycling VIN or EN voltage.

Thermal Protection

When EC1457 inner temperature rises above the Over Temperature Protection threshold, it is forced into thermal shut-down. Only when IC inner temperature drops below Over Temperature Recovery threshold can the regulator becomes active again.

APPLICATION INFORMATION

Setting the Output Voltage

The output voltage is set using a resistive divider from the output voltage to FB pin as Figure 1. The voltage divider divides the output voltage down to the feedback voltage by the ratio:

$$V_{FB} = V_{OUT} * \frac{R2}{R2 + R5}$$

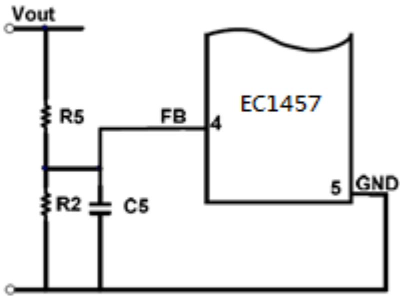


Figure 1: Output Voltage Setup

Where V_{FB} is the feedback voltage and VOUT is the output voltage.
The output voltage is:

$$V_{OUT} = V_{FB} * \frac{R2 + R5}{R2}$$

V_{FB} is 0.8V reference. R2 can be as high as 100KΩ, but a typical value is 10 KΩ~20 KΩ. For example, R2 is 22 KΩ, R5 is determined by:

$$R5 = 27.5 * (V_{OUT} - 0.8)(K\Omega)$$

One ceramic cap (C5) such as 100nF/6.3V is suggested to parallel with R2 to decouple noise voltage for feedback loop stability in some practical application.

Operating Frequency

EC1457 working frequency can be adjusted in different application. Set the resistor connected to RT pin to setup the working frequency as Figure 2 and following expression.

$$f_s = \frac{1}{22.77 * 10^{-12} R_4 + 0.315 * 10^{-6}} Hz$$

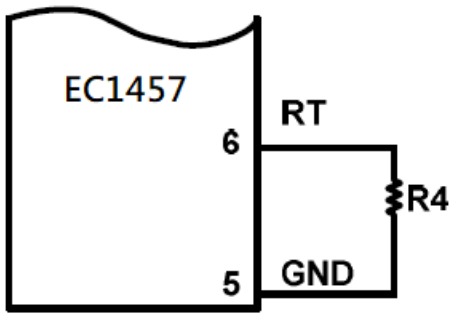


Figure 2: Operating Frequency Setup

EN Function

EN pin is a digital input that turns the regulator ON or OFF. Drive EN pin high to turn on the regulator and drive it low to turn off regulator. Usually, pull up with 100KΩ(R1) resistor for automatic startup (R6=NC). Low input voltage protection can be setup through EN pin to adjust the R1 and R6 as Figure 3. EN pin voltage below 1.2V to turn off EC1457 when low input voltage.

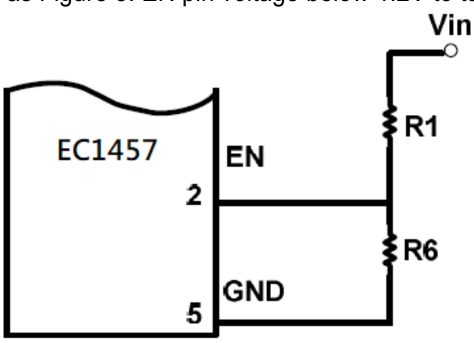


Figure 3: Input Voltage UVLO Setup

For example, Vin=12V, setup the Vin=10V to trigger the low input voltage protection. So, R1 and R6 can be configured as R1=1MΩ and R6=136.3KΩ.

BST Capacitor
BST cap supplies the drive for the high-side N-MOSFE switch, connected from the BST pin to SW pin as Figure 4.

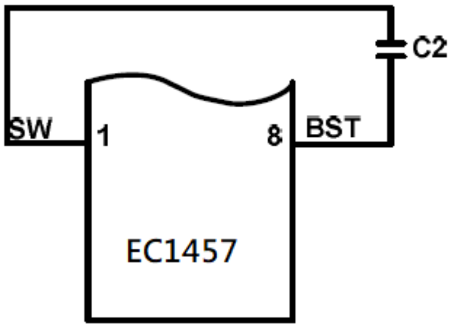


Figure 4: BST Cap

The BST cap is charged by the internal 3.3V rail when SW is low. Usually, one ceramic cap 0.1uF or greater capacitor is ok for high side MOS driver.

Compensation Loop
COMP is used to compensate the regulation control loop for system stability and transient response. Connect a series RC network (Pole-zero combination) from COMP to GND to optimize the control loop as Figure 5.

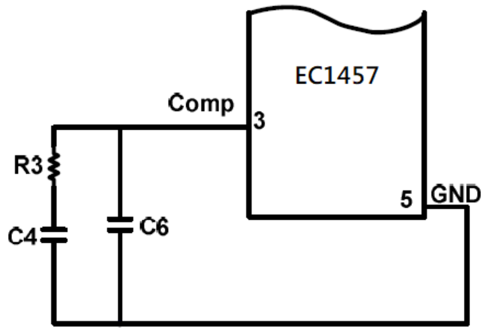


Figure 5: Compensation Loop

In some cases, an additional ceramic capacitor (C6 such as 47pF) from COMP to GND is required to eliminate the high frequency noise influence. Normally application with 5V/3.3V output, 12V/24V input, the below table parameter is recommended.

R3	C4	C6
50~200KΩ	330~1nF	NC/22~100pF

Power Inductor
The inductor is required to supply constant current to the output load. A larger value inductor results in less current ripple and also lower output ripple. However, the larger value inductor has a larger physical size, bigger series resistance, high cost or lower saturation current. A good rule to determining the inductance is to allow the peak-to-peak ripple current in the inductor. It's recommended to allow inductor ripple current △IPP of 30% maximum peak current. So we can get the proper inductor value as follow.

$$L = \frac{V_{OUT}}{f_S * \Delta I_{PP}} * (1 - \frac{V_{OUT}}{V_{IN}})$$

Where VOUT is output voltage, VIN is input voltage, fS is switching frequency and △IPP is the peak-to-peak inductor ripple current.Choose an inductor that will not be saturate under the maximum inductor peak current. The peak inductor current can be calculated by following expression:

$$I_{LP} = I_{OUT} + \frac{V_{OUT}}{2 * f_s * L} * (1 - \frac{V_{OUT}}{V_{IN}})$$

Where IOUT is the load current.

Freewheel Diode
Freewheel diode supply the current route when high side MOS turns off. The system efficiency is worse if the forward voltage drop is high. So, this diode is recommended to use the schottky diode with lower forward voltage drop to improve overall efficiency. For example, the B540 (5A/40V) schottky diode performs well in application.

Input Capacitor
Use low ESR capacitors for the best performance. Ceramic capacitors are preferred, but tantalum or low-ESR electrolytic capacitors may also suffice. It's recommended to choose X5R or X7R dielectrics when using ceramic capacitors. The RMS current in the input capacitor can be estimated by following expression:

$$I_{Cinput} = I_{OUT} * \sqrt{\frac{V_{OUT}}{V_{IN}} * (1 - \frac{V_{OUT}}{V_{IN}})}$$

Choose the input capacitor whose RMS current rating greater than ICinput. Input voltage ripple for low ESR capacitors can be estimated as follow:

$$\Delta V_{IN} = \frac{I_{OUT}}{C_{INPUT} * f_s} * \frac{V_{OUT}}{V_{IN}} * (1 - \frac{V_{OUT}}{V_{IN}})$$

It should increase the input capacitor if the input voltage ripple is big. Besides, one ceramic cap such as 0.1uF is suggested to be placed as close to the IC as possible

Output Capacitor
The output capacitor is required to maintain the DC output voltage. The output voltage ripple can be estimated by following.

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_s * L} * \left(1 - \frac{V_{OUT}}{V_{IN}}\right) * (R_{ESR} + \frac{1}{8 * f_s * C_{OUT}})$$

Where COUT is the output capacitance value and RESR is the equivalent series resistance (ESR) value of the output capacitor.
Ceramic, tantalum, or low ESR electrolytic capacitors are recommended. Low ESR capacitors are preferred to keep the output voltage ripple low.

PCB Layout Note

PCB layout is very important to achieve stable operation. It is highly recommended to duplicate EVB layout as follow these guidelines.
1. Keep the path of switching current short and minimize the loop area formed by input cap, high-side MOSFET and freewheel diode.
2. Bypass ceramic capacitors are suggested to be put close to the Vin Pin.
3. Ensure all feedback connections are short and direct. Place the feedback resistors and compensation components as close to the chip as possible.
4. Route SW away from sensitive analog areas such as FB.
5. Connect IN, SW, and especially GND respectively to a large copper area to cool the chip to improve thermal performance and long-term reliability. The 2os copper thickness is suggested for better thermal performance in real application.

Package Information

ESOP-8 Package Outline Dimensions