CHIPNEXT

CN4514
125KHz 4.0A/40V CC/CV Step-Down DC/DC Converter

Description

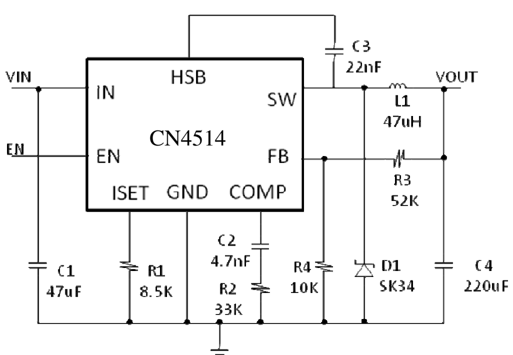
CN4514 is a wide input voltage, high efficiency step-down DC/DC converter which operates in either CV (Constant Voltage) mode or CC (Constant Current) mode. This device includes a reference voltage source, oscillation circuit, error amplifier, integrated high-side power mos, a pwm controller and a constant current controller. CN4514 provides up to 4.0A output current at 125 KHz switching frequency. CC eliminates the expensive, high accuracy current sense resistor, making it ideal for battery charging applications and adaptors with accurate current limit. CN4514 achieves higher efficiency than traditional constant current switching regulators by eliminating its associated power loss. Standard protection features include cycle by cycle current limit, thermal shutdown, and frequency fold-back at short circuit. The devices are available in a SOP-8EP package and require few external devices for operation.

Features

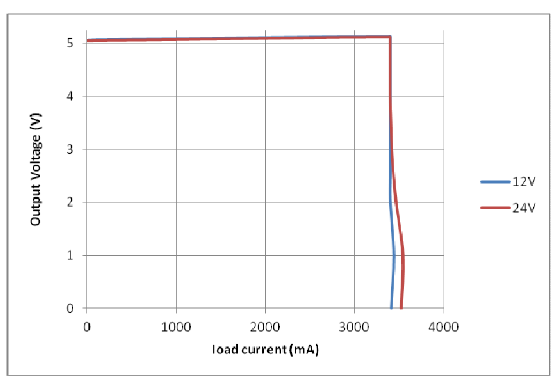
- 40V Input Voltage Surge
- 32V Steady State Operation
- 4.0A output current
- Output Voltage up to 12V
- 125kHz Switching Frequency Eases EMI Design
- Sensor-less Constant Current Control
- Resistor Programmable
  - Current Limit from 1.0A to 4.0A
  - Cable Compensation
- ±5.0% CC Accuracy
- ±2.5% Feedback Voltage Accuracy
- Up to 95% Efficiency
- Extra Features
  - Integrated Soft Start
  - Thermal Shutdown
  - Cycle-by-Cycle Current Limit
  - ISET Short Protection
- SOP-8EP Package

Applications

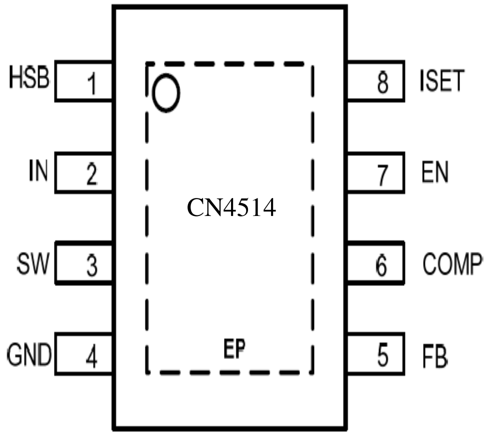
- Car Charger/ Adaptor
- Rechargeable Portable Devices
- General-Purpose CC/CV Supply



CN4514 CC/CV Curve at 3.4A



Pin Assignment



SOP-8EP

Pin Description

Pin Name	Pin Number	Description
HSB	1	High Side Bias Pin. This provides power to the internal high-side MOSFET gate driver. Connect a 22nF capacitor from HSB pin to SW pin.
IN	2	Power Supply Input. Bypass this pin with a 10μF ceramic capacitor to GND, placed as close to the IC as possible.
SW	3	Power Switching Output to External Inductor.
GND	4	Ground. Connect this pin to a large PCB copper area for best heat dissipation. Return FB, COMP, and ISET to this GND, and connect this GND to power GND at a single point for best noise immunity.
FB	5	Feedback Input. The voltage at this pin is regulated to 0.808V. Connect to the resistor divider between output and GND to set the output voltage
COMP	6	Error Amplifier Output. This pin is used to compensate the converter.
EN	7	Enable Input. EN is pulled up to 5V with a 4μA current, and contains a precise 1.6V logic threshold. Drive this pin to a logic-high or leave unconnected to enable the IC. Drive to a logic-low to disable the IC and enter shutdown mode.
ISET	8	Output Current Setting Pin. Connect a resistor from ISET to GND to program the output current.
	Exposed Pad	Heat Dissipation Pad. Connect this exposed pad to large ground copper area with copper and vias.

Ordering Information

Order Part Number	Top Marking	Pb-Free	T_A	Package	
CN4514SO8EP		Yes	-40 to +125°C	SOP-8EP	Tape & Reel, 3000

Absolute Maximum Ratings

Stresses beyond those listed under "Absolute Maximum Rating" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maxim rating conditions for extended periods may affect device reliability.

Parameter	Rating	Unit
IN to GND	-0.3 to 40	V
SW to GND	-1.0 to V_{IN} + 1.0	V
HSB to GND	V_{SW} - 0.3 to V_{SW} + 7.0	V
FB, EN, ISET, COMP to GND	-0.3 to + 6.0	V
Junction to Ambient Thermal Resistance	46	°C/W
Operating Junction Temperature	-40 to 150	°C
Storage Junction Temperature	-55 to 150	℃
Lead Temperature (***Soldering***, 10 sec.)	300	°C
ESD HBM (Human Body Mode)	2	KV
Operating Temperature Range...	-40 to 125	V

Recommend Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation to ensure optimal performance to the datasheet specifications. CHIPNEXT does not recommend exceeding them or designing to Absolute Maximum Ratings.

Parameter	Min.	Typ.	Max.	Unit
Supply Input Voltage	10		32	V
Junction Temperature Range	-40		125	V
Ambient Temperature Range	-40		85	°C

Electrical Characteristics

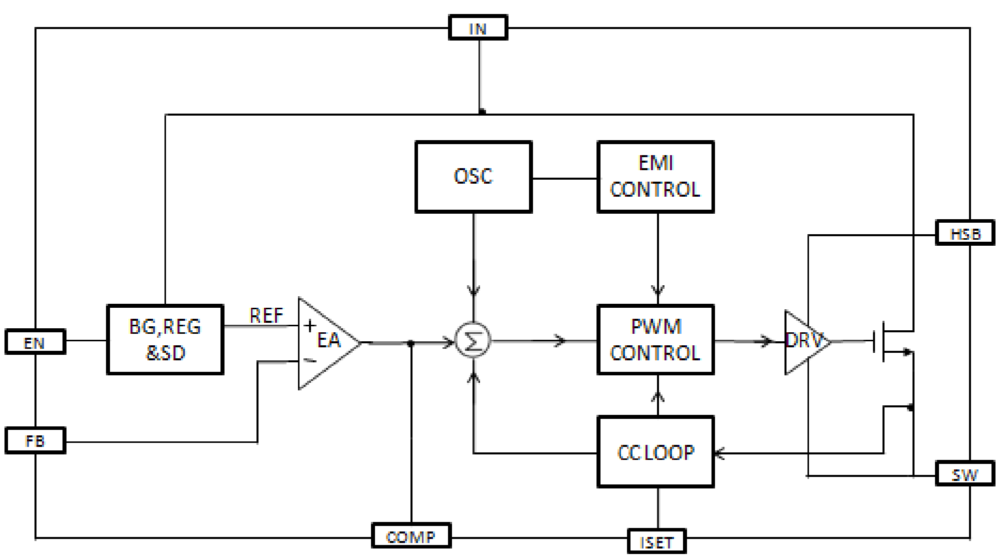
(V_{IN} = 12V, V_{OUT} = 5.0V, T_A = 25°C, unless otherwise specified)

Parameter	Test Conditions	Min.	Typ.	Max.	Unit
Input Voltage		10		32	V
Input Voltage Surge		40			V
V_{IN} UVLO Turn-On Voltage	Input Voltage Rising	8.0	8.5	9.0	V
V_{IN} UVLO Hysteresis	Input Voltage Falling		2.0		V
Standby Supply Current	V_{EN} = 3V, V_{FB} = 1V		0.8	1.3	mA
	V_{EN} = 3V, V_{OUT} = 5V, No load		4.5		mA
Shutdown Supply Current	V_{EN} = 0V		55		μA
Feedback Voltage		792	808	824	mV
Internal Soft-Start Time			400		μs
Error Amplifier Transconductance	V_{FB} = V_{COMP} = 0.8V, ΔI_{COMP} = ± 10μA		650		μA/V
Error Amplifier DC Gain			4000		V/V
Switching Frequency	V_{FB} = 0.808V		125		kHz
Foldback Switching Frequency	V_{FB} = 0V		30		kHz
Maximum Duty Cycle			80		%
Minimum On-Time			200n		ns
COMP to Current Limit Transconductance	V_{COMP} = 1.2V		5.0		A/V
Secondary Cycle-by-Cycle Current Limit	Duty Cycle = 0%		4.5		A
Slope Compensation	Duty = D_{MAX}		1.2		A
ISET Voltage			1		V
ISET to IOUT DC Room Temp Current Gain	IOUT / ISET, R_{ISET} = 10kΩ		34000		A/A
CC Controller DC Accuracy	R_{ISET} = 10kΩ, V_{OUT} = 4.5V Open-Loop DC Test	3200	3400	3600	mA
EN Threshold Voltage	EN Pin Rising	1.47	1.6	1.73	V

EN Hysteresis	EN Pin Falling		125		mV
EN Internal Pull-up Current			4		μA
High-Side Switch ON-Resistance			0.06		Ω
SW Off Leakage Current	$V_{EN} = V_{SW} = 0V$		1	10	uA
Thermal Shutdown Temperature	Temperature Rising		150		℃
Thermal Shutdown Temperature Hysteresis	Temperature Falling		20		℃

Note 1: Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

Function Block Diagram



Applications Information

Output Voltage Setting

Figure 1 shows the connections for setting the output voltage. Select the proper ratio of the two feedback resistors R_{FB1} and R_{FB2} based on the output voltage. Typically, use $R_{FB2} \approx 10k\Omega$ and determine R_{FB1} from the following equation:

$$R_{FB1} = R_{FB2}\left(\frac{V_{OUT}}{0.808V} - 1\right) \qquad (1)$$

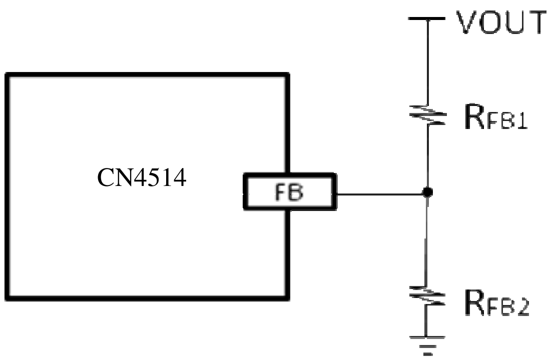


Figure 1 Output Voltage Setting

CC Current Setting

CN4514 constant current value is set by an external resistor connected between the ISET pin and GND. The CC output current is linearly proportional to the current flowing out of the ISET pin. The voltage at ISET is roughly 1.0V and the current gain from ISET to output is roughly 34000 (34mA/1μA). To determine the proper resistor for a desired current, using the following equation:

$$I_{CC} = 34000 \times \left(\frac{V(ISET)}{R_{ISET}}\right) \qquad (2)$$

CC Current Line Compensation

When operating at constant current mode, the current limit increase slightly with input voltage. For wide input voltage applications, a resistor RC is added to compensate line change and keep output high CC accuracy, as shown in Figure 2.

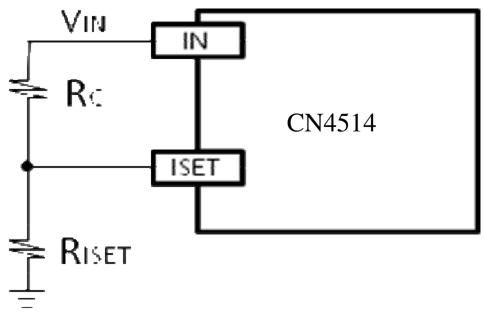


Figure 2 Input Line Compensation

Inductor Selection

The inductor maintains a continuous current to the output load. This inductor current has a ripple that is dependent on the inductance value:

Higher inductance reduces the peak-to-peak ripple current. The trade off for high inductance value is the increase in inductor core size and series resistance, and the reduction in current handling capability. In general, select an inductance value L based on ripple current requirement:

$$L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} f_{SW} I_{OUTMAX} K_{RIPPLE}} \qquad (3)$$

where V_{IN} is the input voltage, V_{OUT} is the output voltage, fsw is the switching frequency, I_{OUTMAX} is the maximum load current, and K_{RIPPLE} is the ripple factor. Typically, choose K_{RIPPLE} = 30% to correspond to the peak-to-peak ripple current being 30% of the maximum load current.

With a selected inductor value the peak-to-peak inductor current is estimated as:

$$I_{LPK-PK} = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{L \times V_{IN} f_{SW}} \qquad (4)$$

The peak inductor current is estimated as:

$$I_{LPK} = I_{OUTMAX} + \frac{1}{2} I_{LPK-PK} \qquad (5)$$

The selected inductor should not saturate at I_{LPK}. The maximum output current is calculated as:

$$I_{OUTMAX} = I_{LIM} - \frac{1}{2} I_{LPK-PK} \qquad (6)$$

L_{LIM} is the internal current limit, which is typically 4.5A.

External High Voltage Bias Diode

It is recommended that an external High Voltage Bias diode be added when the system has a 5V fixed input or the power supply generates a 5V output. This helps improve the efficiency of the regulator. The High Voltage Bias diode can be a low cost one such as IN4148 or BAT54. This diode is also recommended for high duty cycle operation and high output voltage applications.

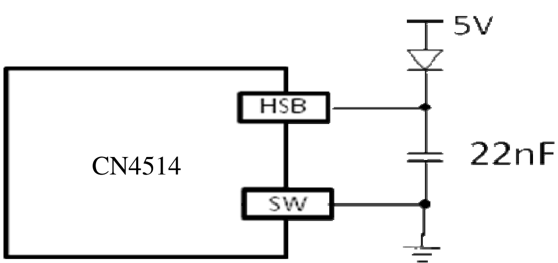


Figure 3 External High Voltage Bias Diode

Input Capacitor

The input capacitor needs to be carefully selected to maintain sufficiently low ripple at the supply input of the converter. A low ESR capacitor is highly recommended. Since large current flows in and out of this capacitor during switching, its ESR also affects efficiency. The input capacitance needs to be higher than 10µF. The best choice is the ceramic type, however, low ESR tantalum or electrolytic types may also be used provided that the RMS ripple current rating is higher than 50% of the output current. The input capacitor should be placed close to the IN and GND pins of the IC, with the shortest traces possible.

In the case of tantalum or electrolytic types, they can be further away if a small parallel 0.1µF ceramic capacitor is placed right next to the IC.

Output Capacitor

The output capacitor also needs to have low ESR to keep low output voltage ripple. The output ripple voltage is:

$$V_{RIPPLE} = I_{OUTMAX} K_{RIPPLE} R_{ESR} + \frac{V_{IN}}{28 \times L \times C_{OUT} f_{SW}{}^{2}} \qquad (7)$$

Where I_{OUTMAX} is the maximum output current, K_{RIPPLE} is the ripple factor, R_{ESR} is the ESR of the output capacitor, fsw is the switching frequency, L is the inductor value, and C_{OUT} is the output capacitance. In the case of ceramic output capacitors, R_{ESR} is very small and does not contribute to the ripple. Therefore, a lower capacitance value can be used for ceramic type. In the case of tantalum or electrolytic capacitors, the ripple is dominated by R_{ESR} multiplied by the ripple current. In that case, the output capacitor is chosen to have sufficiently low ESR.

For ceramic output capacitor, typically choose a capacitance of about 22µF. For tantalum or electrolytic capacitors, choose a capacitor with less than 50mΩ ESR.

Rectifier Diode

Use a Schottky diode as the rectifier to conduct current when the High-Side Power Switch is off. The Schottky diode must have current rating higher than the maximum output current and a reverse voltage rating higher than the maximum input voltage.

Stability Compensation

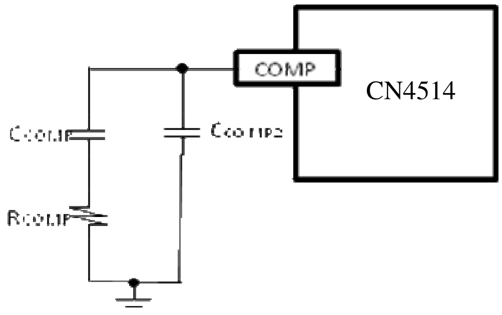


Figure 4 COMP Stability Compensation

The feedback loop of the IC is stabilized by the components at the COMP pin, as shown in Figure 4. The DC loop gain of the system is determined by the following equation:

$$A_{VDC} = \frac{0.808 A_{VEA} \times G_{COMP}}{I_{OUT}} = \frac{0.808 A_{VEA} \times G_{COMP} \times R_{OUT}}{V_{OUT}} \qquad (8)$$

The dominant pole P1 is due to CCOMP:

$$f_{P1} = \frac{G_{EA}}{2\pi A_{EA} C_{COMP}} \qquad (9)$$

The second pole P2 is the output pole due to COUT:

$$f_{P2} = \frac{I_{OUT}}{2\pi V_{OUT} C_{OUT}} \qquad (10)$$

The first zero Z1 is due to RCOMP and CCOMP:

$$f_{z1} = \frac{1}{2\pi R_{COMP} C_{COMP}} \qquad (11)$$

And finally, the third pole is due to RCOMP and CCOMP2 (if CCOMP2 is used):

$$f_{P3} = \frac{1}{2\pi R_{COMP} C_{COMP2}} \qquad (12)$$

The following steps should be used to compensate the IC:

STEP 1: Set the cross over frequency at 1/10 of the switching frequency via RCOMP:

$$R_{COMP} = \frac{2\pi V_{OUT} \times C_{OUT} f_{SW}}{10 G_{EA} G_{COMP} \times 0.808} = 5.12 \times 10^{7} V_{OUT} C_{OUT} \qquad (13)$$

STEP 2: Set the zero fZ1 at 1/4 of the cross over frequency. If RCOMP is less than 15kΩ, the equation for CCOMP is:

$$C_{COMP} = \frac{40}{2\pi R_{COMP} f_{SW}} = \frac{2.83 \times 10^{-5}}{R_{COMP}} \qquad (14)$$

If RCOMP is limited to 15kΩ, then the actual cross over frequency is 6.58 / (VOUTCOUT). Therefore:

$$C_{COMP} = 6.45 \times 10^{-6} V_{OUT} C_{OUT} \qquad (15)$$

STEP 3: If the output capacitor's ESR is high enough to cause a zero at lower than 4 times the cross over frequency, an additional compensation capacitor CCOMP2 is required. The condition for using CCOMP2 is:

$$R_{ESRCOUT} \geq Min\left(\frac{1.77 \times 10^{-6}}{2\pi C_{OUT}}, 0.006 * V_{OUT}\right) \qquad (16)$$

And the proper value for CCOMP2 is:

$$C_{COMP2} = \frac{C_{OUT} R_{ESROUT}}{R_{COMP}} \qquad (17)$$

Though C_{COMP2} is unnecessary when the output capacitor has sufficiently low ESR, a small value C_{COMP2} such as 100pF may improve stability against PCB layout parasitic effects.

Table 1 shows some calculated results based on the compensation method above.

V_{OUT} (V)	C_{OUT} (μF)	Rcomp (kΩ)	Ccomp (nF)
5	47	8.2	3.3
5	47	12.2	2.2
5	100	15	4.7
5	220	15	7.2
5	220	33	4.7

In the case of high R_{FB1} used, the frequency compensation needs to be adjusted correspondingly. As show in Figure 5, adding a capacitor in parallel with R_{FB1} or increasing the compensation capacitance at COMP pin helps the system stability.

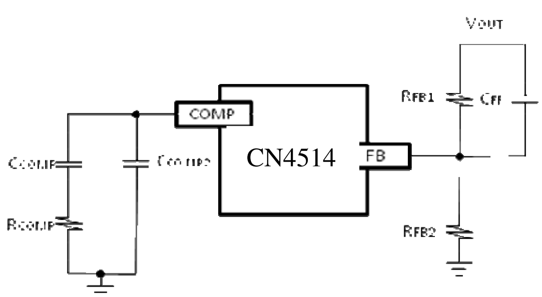


Figure 5 Frequency Compensation for High R_{FB1}

CC Loop Stability

The constant-current control loop is internally compensated over the 1000mA-4000mA output range. No additional external compensation is required to stabilize the CC current.

Output Cable Resistance Compensation

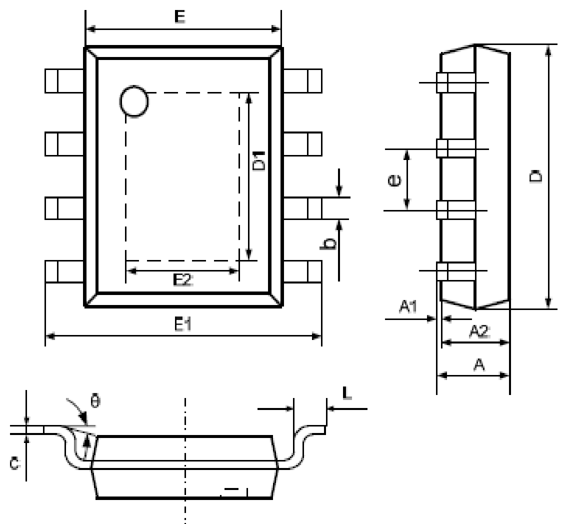
To compensate for resistive voltage drop across the charger's output cable, the CN4514 integrates a simple, user-programmable cable voltage drop compensation using the impedance at the FB pin.

PC Board Layout Guidance

When laying out the printed circuit board, the following checklist should be used to ensure proper operation of the IC.

1) Arrange the power components to reduce the AC loop size consisting of C_{IN}, IN pin, SW pin and the schottky diode.
2) Place input decoupling ceramic capacitor C_{IN} as close to IN pin as possible. C_{IN} is connected power GND with vias or short and wide path.
3) Return FB, COMP and ISET to signal GND pin, and connect the signal GND to power GND at a single point for best noise immunity. Connect exposed pad to power ground copper area with copper and vias.
4) Use copper plane for power GND for best heat dissipation and noise immunity.
5) Place feedback resistor close to FB pin.
6) Use short trace connecting HSB-C_{HSB}-SW loop.

Package Outline And Physical Dimensions: SOP-8EP



SYMBOL	DIMENSION IN MILLIMETERS		DIMENSION IN INCHES	
	MIN	MAX	MIN	MAX
A	1.350	1.700	0.053	0.067
A1	0.000	0.100	0.000	0.004
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.200
D1	3.202	3.402	0.126	0.134
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
E2	2.313	2.513	0.091	0.099
e	1.270 TYP		0.050 TYP	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°