General Description

The EC4514 is a asynchronous rectifier, fixed switching frequency (600kHz or 1.2MHz typical), and current-mode step-up regulator. The device allows use of small inductors and output capacitors. The current-mode control scheme provides fast transient response and good output voltage accuracy.

At light loads, the EC4514 will automatically enter in Pulse Skip Mode (PSM) operation to reduce the dominant switching losses. During PSM operation, the IC consumes very low quiescent current and maintains high efficiency over the complete load range.

The EC4514 also includes current-limit and over-temperature shutdown to prevent damage in the event of an output overload.

Features

- •Wide 2.6V to 6V Input Voltage Range
- Built-in 125mΩ N-Channel MOSFET
- Built-in Adjustable Soft-Start Function
- High Efficiency up to 90%
- Current-Mode Operation
  -Stable with Ceramic Output Capacitors
  -Fast Transient Response
- Current-Limit Protection
- Over-Temperature Protection with Hysteresis
- Built in EN Function For Timing Control
- Selectable Frequency 600kHz/1.2MHz
- Available in DFN3x3-10 Package
- Lead Free and Green Devices Available (RoHS Compliant)

Applications

- Panel
- IEEE1394 Port
- Thunderbolt Application
- Boost Regulators

Pin Configurations

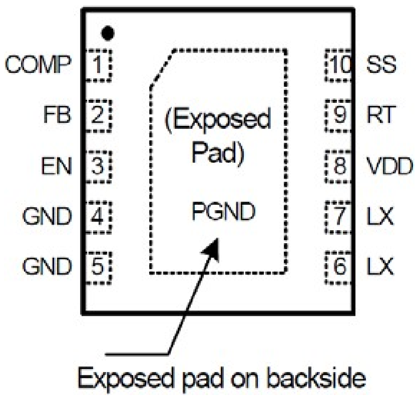
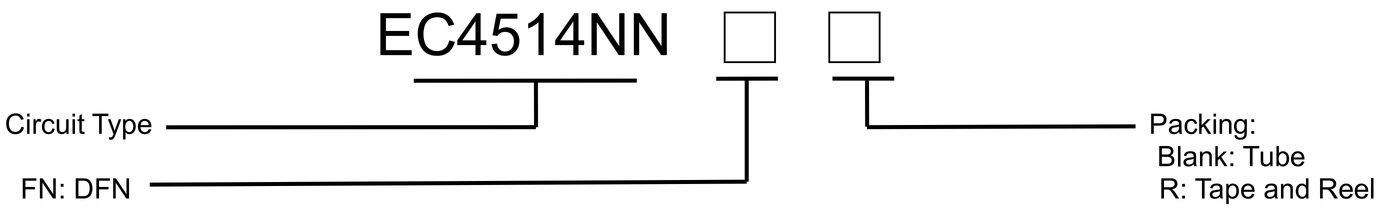


Figure1 Pin Configuration of EC4514(Top View)

Pin Description

Pin Number	Pin Name	Description
1	COMP	Error Amplifier Output. Use this pin in combination with the FB pin to compensate the voltage-control feedback loop of the converter.
2	FB	Converter Feedback Input.
3	EN	Device Enable Control Input. Force V_{EN} exceed 1.8V enable the device. Left V_{EN} below 0.8V to shutdown.
4,5	GND	Signal and Power Ground. Connect this pin to exposed pad.
6,7	LX	Converter Switch Pin. Connect inductor and diode here.
8	VDD	Device Input Supply Voltage.
9	RT	Operation Frequency Setting. Force V_{RT} exceeds 1.8V set the oscillator operates at 1.2MHz. Pull V_{RT} below 0.8V at 600kHz
10	SS	Soft Start Output. Connect a capacitor to GND to set the soft start interval.
Exposed Pad(11)	GND	Signal Ground. Tie this pin to the GND.

Ordering Information



Marking rule:

Part Number	Package	Marking	Marking Information
EC4514NNFNR	DFN 3x3-10	4514 LLLL	1.LLLL：Last four number of Lot No

Function Block

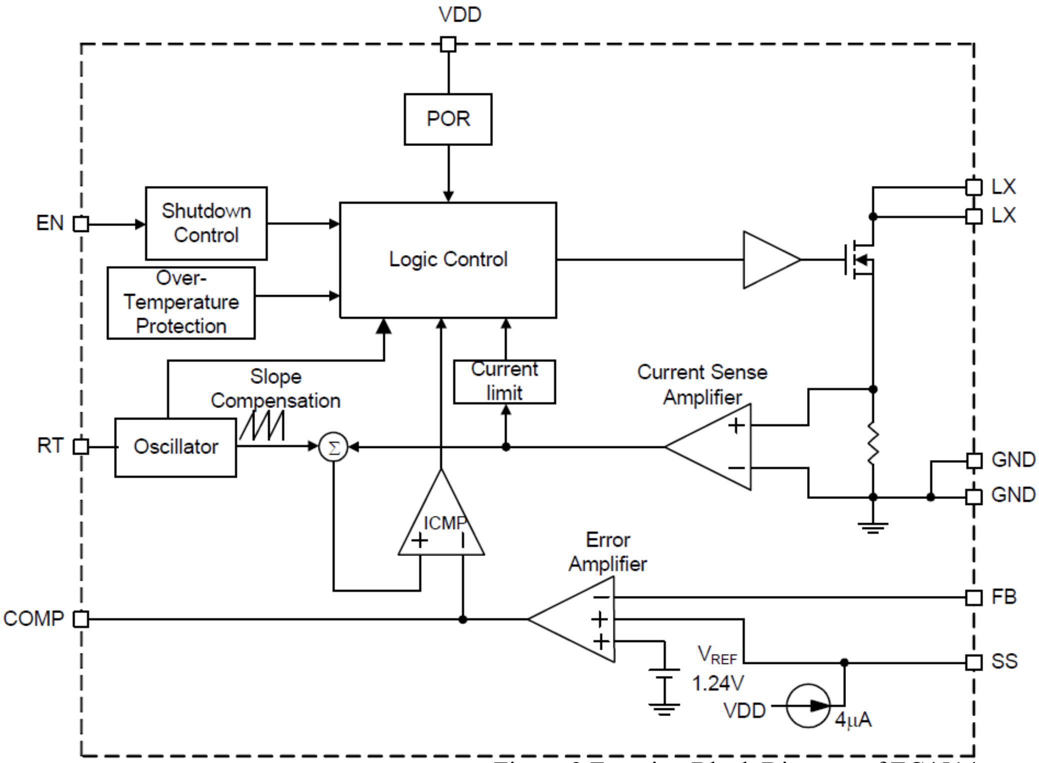


Figure 2 Function Block Diagram of EC4514

Absolute Maximum Ratings(Note 1)

Symbol	Parameter	Rating	Unit
V_{DD}	Converter Supply Voltage (V_{DD} to GND)	-0.3 to 7	V
V_{LX}	LX to GND Voltage	-0.3 to 28	V
	COMP, FB, EN, RT, SS to GND Voltage	-0.3 to 7	V
	PGND to GND (4,11: Signal GND, 5: PGND)	-0.3 to +0.3	V
P_D	Power Dissipation	Internally Limited	W
T_J	Maximum Junction Temperature	150	°C
T_{STG}	Storage Temperature Range	-65 to 150	°C
T_{SDR}	Maximum Lead Soldering Temperature, 10 Seconds	260	°C

Note1: Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Recommended Operating Conditions(Note 3)

Symbol	Parameter	Range	Unit
V_{OUT}	Output and IC Supply Voltage (VOUT to GND)	2.6 to 24	V
V_{DD}	Converter Supply Voltage (VDD to GND)	2.6 to 5.5	V
T_A	Ambient Temperature	-40 to 85	°C
T_J	Junction Temperature	-40 to 125	°C

Note 3: Please refer to the typical application circuit.

Thermal Characteristics

Symbol	Parameter	Typical Value	Unit
θ_{JA}	Junction-to-Ambient Resistance in free air (Note 2)	DFN3x3-10	55
θ_{JC}	Junction-to-Case Resistance	DFN3x3-10	20

Note 2: θ_{JA} is measured with the component mounted on a high effective thermal conductivity test board in free air.

Electrical Characteristics

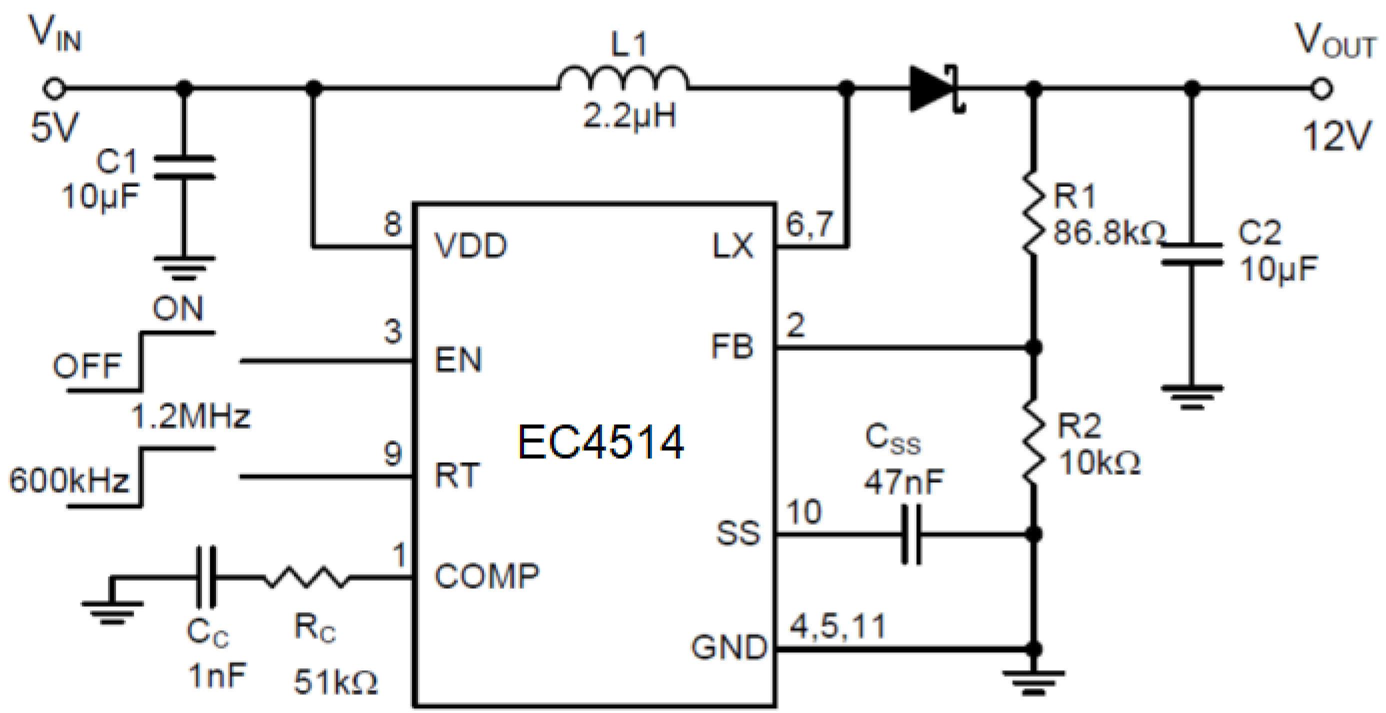
Refer to the typical application circuits. These specifications apply over. V_{DD}=3.3V, V_{OUT}=12V, T_A=25°C.

Symbol	Parameters	Test Condition	Min.	Typ.	Max.	Unit
SUPPLY VOLTAGE AND CURRENT						
	Converter Supply Voltage Range		2.6	-	5.5	V
V_{DD}	Converter Supply Voltage Range	18V < VOUT < 24V	4	-	5.5	V
V_{OUT}	Converter Output Voltage		2.6	-	24	V
	V_{DD} Under Voltage Lockout	V_{DD} Rising				
	Threshold		2.2	2.4	2.6	V
V_{UVLO}	V_{DD} Under Voltage Lockout	V_{DD} Falling				
	Hysteresis		-	0.2	-	V
IDD1	No Switching Quiescent Current	V_{FB} = 1.3V	-	0.5	-	mA
IDD2	Switching Quiescent Current	V_{FB} = 1V	-	4	-	mA
IDD3	Shutdown Quiescent Current	EN=GND	-	0.2	4	uA
ERROR AMPLIFIER						
V_{REF}	Regulated Feedback Voltage		1.22	1.24	1.26	V
I_{FB}	FB Input Leakage Current	V_{FB}=1.3V	-100	-	100	nA
	FB Line Regulation	V_{DD}=2.7~5.5V, I_{OUT}=0.2A	-	-0.05	-	%/V
R_{SENSE}	Current Sense Transresistance		-	0.25	-	V/A
gm	Compensation Network	V_{DD}=3.3V~5V	-	135	-	uA/V
	COMP Pull Low Resistance	EN=GND	-	1	-	kΩ
INTERNAL POWER SWITCH						
F_{OSC}	Switching Frequency	RT=GND	450	600	750	kHz
		RT=V_{DD}	900	1200	1500	kHz
R_{N-FET}	N-FET Switch On Resistance	V_{DD}=3.3V	-	125	150	mΩ
	N-FET Current Limit	V_{DD}=3V~5.5V	4	5	6	A
D_{MAX}	SW Maximum Duty Cycle		85	90	95	%
	Minimum On-time		-	150	-	ns
	LX Leakage Current	V_{LX}=24V, V_{FB}=1.3V	-	1	10	uA
SOFT-START						
I_{SS}	SS Charge Current		-	4	-	uA
CONTROL STAGE						
EN	EN Input Low Threshold		-	-	0.8	V
	EN Input High Threshold		1.8	-	-	V

RT	RT Input Low Threshold		-	-	0.8	V
	RT Input High Threshold		1.8	-	-	V
PROTECTION						
T_{OTP}	Over Temperature Protection (note 4)	T_J Rising	-	150	-	℃
	Over Temperature Protection Hysteresis(note 4)	T_J Falling	-	30	-	℃

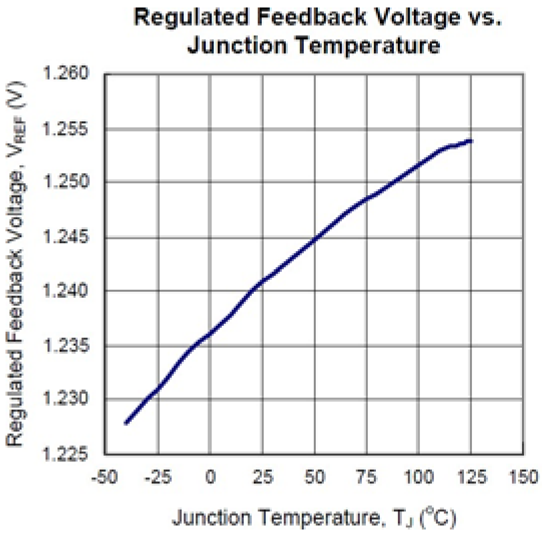
Note 4: Guaranteed by design, not production tested.

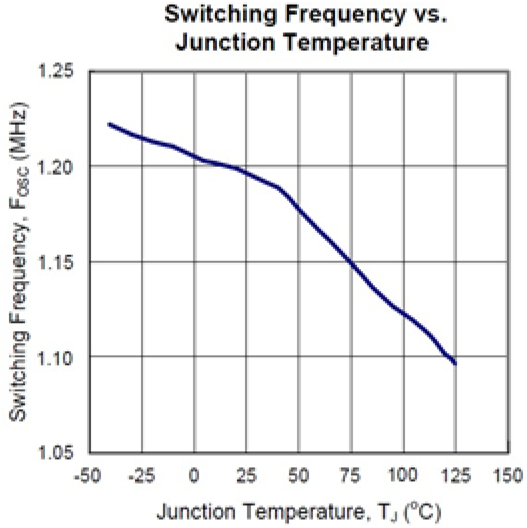
Typical Application Circuit

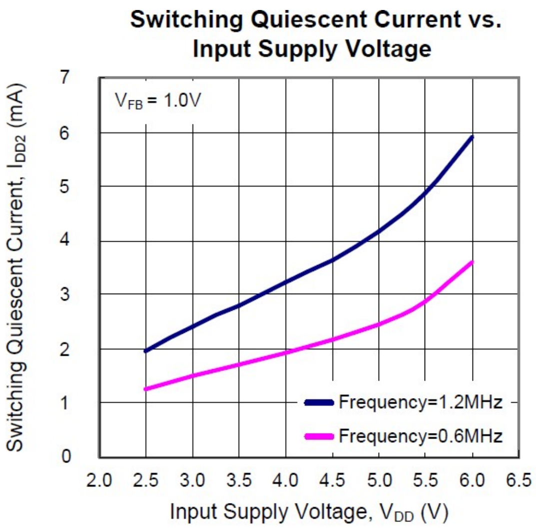


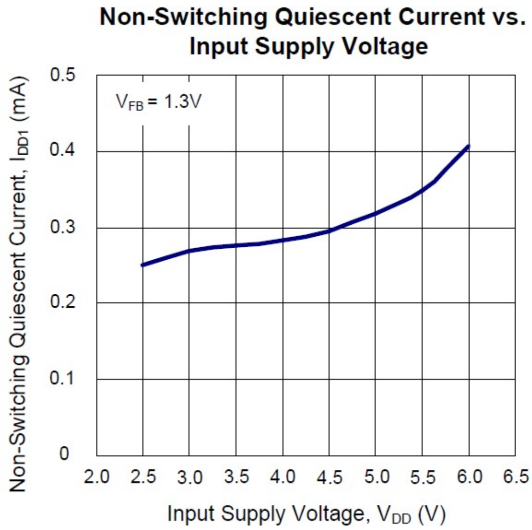
V_{IN}(V)	V_{OUT}(V)	L1(H)	V_{OSC}(Hz)	R_C(Ω)	C_C(F)
5	12	4.7μ	1.2M	100k	1n
5	12	4.7μ	1.2M	51k	1n
5	12	4.7μ	600k	100k	1n
5	12	2.2μ	1.2M	180k	680p
5	12	2.2μ	600k	180k	680p
3.3	12	4.7μ	1.2M	180k	680p
3.3	12	4.7μ	600k	180k	680p
3.3	12	2.2μ	1.2M	180k	680p
3.3	12	2.2μ	600k	180k	680p
3.3	13.6	3.6μ	1.2M	56k	330p
3.3	5	1.5μ	1.2M	60k	220p
3.3	5	2.2μ	600k	40k	680p

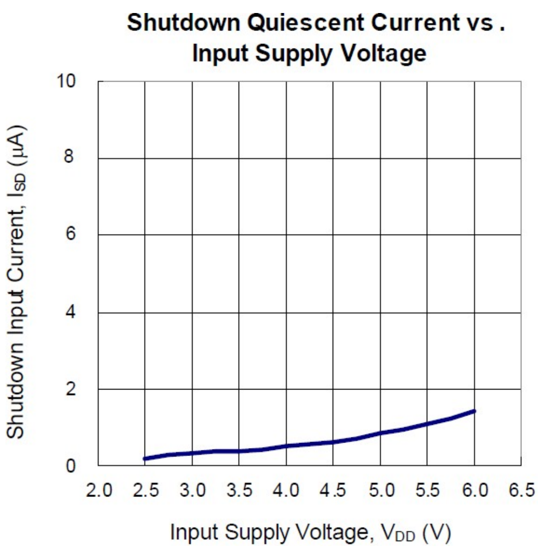
Typical Operating Characteristics

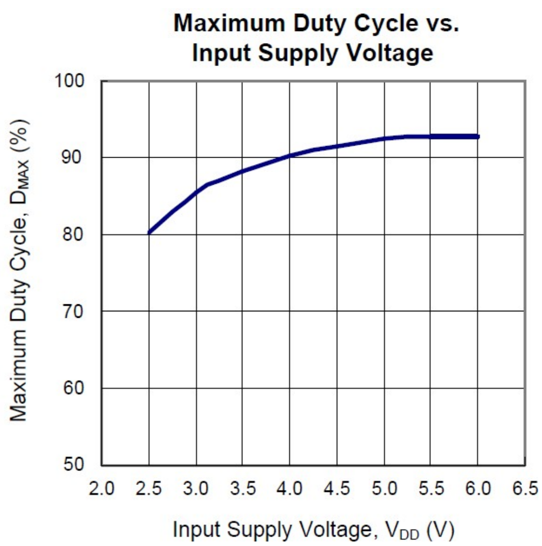






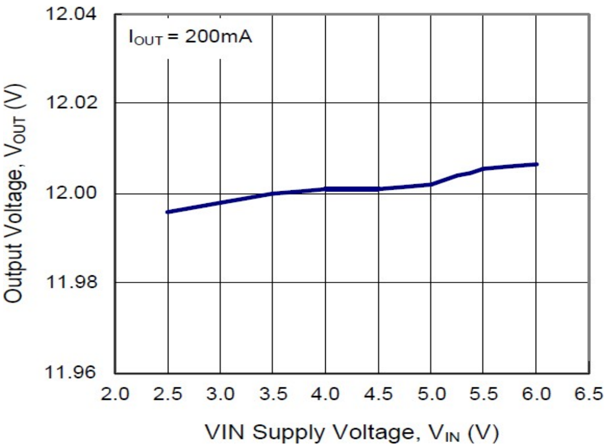




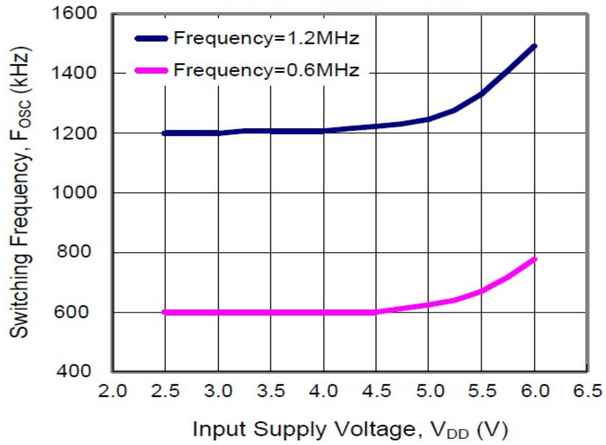


Typical Operating Characteristics(Cont.)

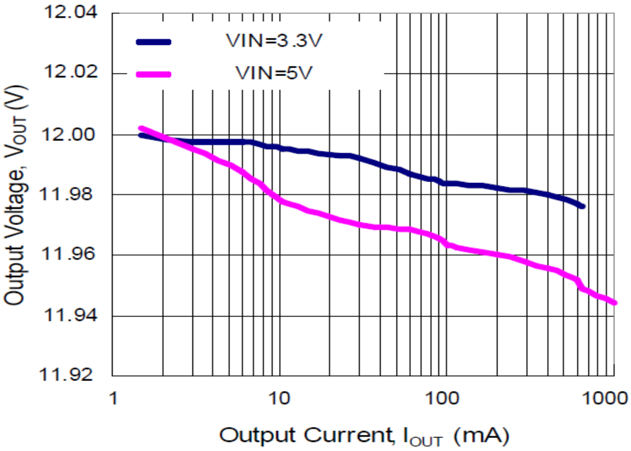
Output Voltage vs. VIN Supply Voltage



Switching Frequency vs. Input Supply Voltage



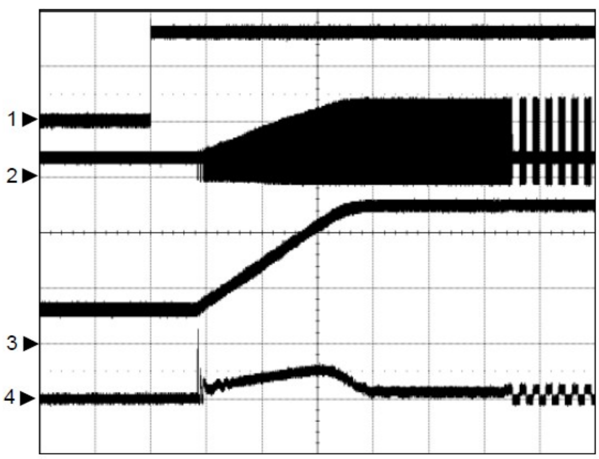
Output Voltage vs . Output Current



Operating Waveforms

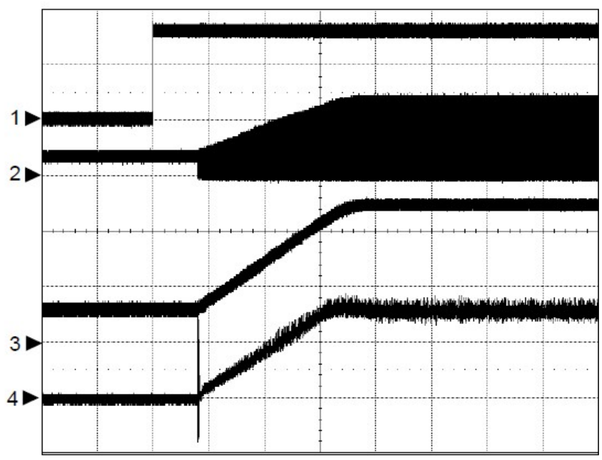
(Refer to the section "Typical Application Circuits", VIN=3.3V, TA=25℃, unless otherwise specified)

Start-up at PSM Condition



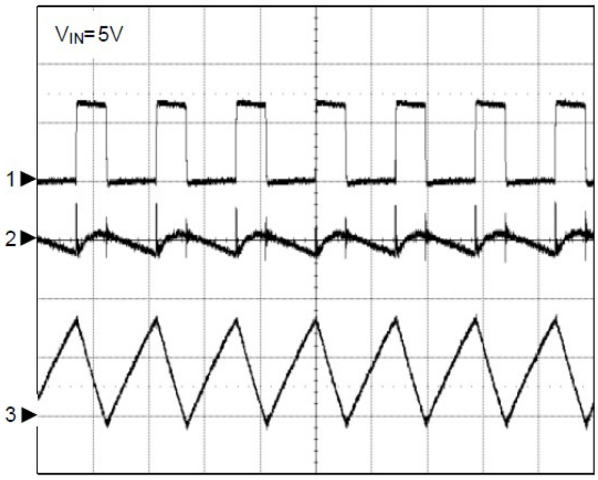
CH1: V_{EN}, 2V/Div, DC
CH2: V_{LX}, 10V/Div, DC
CH3: V_{OUT}, 5V/Div, DC
CH4: I_{IN}, 0.1A/Div, DC
TIME: 5ms/Div

Start-up at PWM Condition



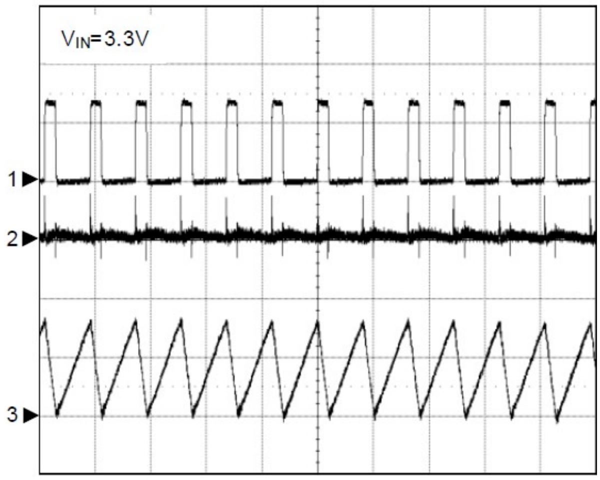
CH1: V_{EN}, 2V/Div, DC
CH2: V_{LX}, 10V/Div, DC
CH3: V_{OUT}, 5V/Div, DC
CH4: I_{IN}, 0.2A/Div, DC
TIME: 5ms/Div

Normal Operation at 600kHz



CH1: V_{LX}, 10V/Div, DC
CH2: V_{OUT}, 50mV/Div, AC
CH3: I_L, 1A/Div, DC
TIME: 1 μs/Div

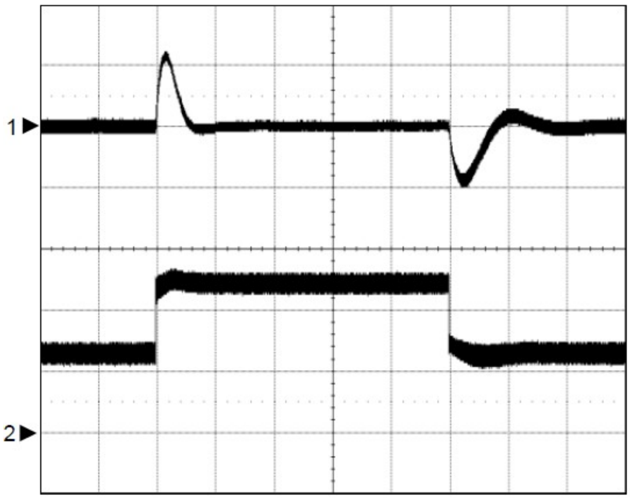
Normal Operation at 1.2MHz



CH1: V_{LX}, 10V/Div, DC
CH2: V_{OUT}, 50mV/Div, AC
CH3: I_L, 0.5A/Div, DC
TIME: 1 μs/Div

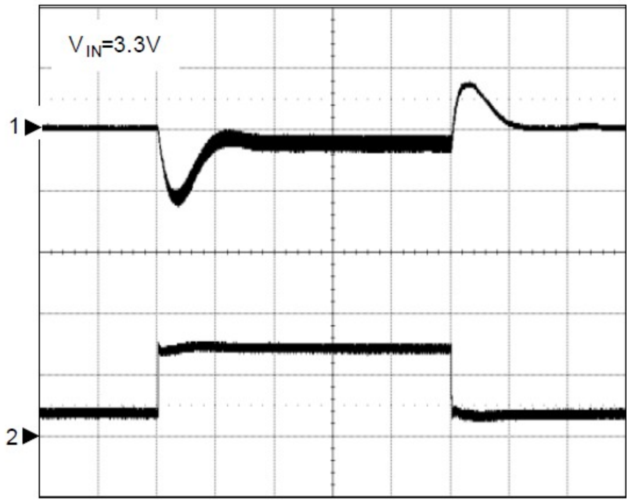
Operating Waveforms(Cont.)

Line Transient Response



CH1: V_{OUT}, 500mV/Div, AC
CH2: V_{IN}, 2V/Div, DC
TIME: 200 μs/Div

Load Transient Response



CH1: V_{OUT}, 500mV/Div, AC
CH2: I_{OUT}, 500mA/Div, DC
TIME: 100 μs/Div

Function Description

Main Control Loop

The EC4514 is a constant frequency and current-mode switching regulator. In normal operation, the internal N-channel power MOSFET is turned on each cycle when the oscillator sets an internal RS latch, and then turned off when an internal comparator (ICMP) resets the latch. The peak inductor current at which ICMP resets the RS latch is controlled by the voltage on the COMP node which is the output of the error amplifier (EAMP). An external resistive divider connected between V_{OUT} and ground allows the EAMP to receive an output feedback voltage V_{FB} at FB pin. When the load current increases, it causes a slightly to decrease in V_{FB} associated with the 1.24V reference, which in turn, it causes the COMP voltage to increase until the average inductor current matches the new load current.

VIN Under-Voltage Lockout (UVLO)

The Under-Voltage Lockout (UVLO) circuit compares the input voltage at VDD with the UVLO threshold to ensure the input voltage is high enough for reliable operation. The 200mV (typ) hysteresis prevents supply transients from causing a restart. Once the input voltage exceeds the UVLO rising threshold, startup begins. When the input voltage falls below the UVLO falling threshold, the controller turns off the converter.

Soft-Start

The EC4514 provides the programmed soft-start function to limit the inrush current. The soft-start time can be programmed by the external capacitor between SS and GND. Typical charge current is 4uA, and the soft-start time is about 15ms with 47nF capacitor.

Current-Limit Protection

TheEC4514 monitors the inductor current, flows through the N- channel MOSFET, and limits the current peak at

current- limit level to prevent loads and the EC4514 from damaging during overload or short- circuit conditions.

Over-Temperature Protection (OTP)

The over-temperature circuit limits the junction temperature of the EC4514. When the junction temperature exceeds 150℃, a thermal sensor turns off the power MOSFET allowing the devices to cool. The thermal sensor allows the converters to start a soft-start process and regulates the output voltage again after the junction temperature cools by 30℃. The OTP is designed with a 30℃ hysteresis to lower the average Junction Temperature (TJ) during continuous thermal overload conditions increasing the lifetime of the device.

Enable/Shutdown

Driving EN to the ground places the EC4514 in shutdown mode. When in shutdown, the internal power MOSFET turns off, all internal circuitry shuts down, and the quiescent supply current reduces to 10μA maximum.

Frequency Selection

When VRT is above the RT high threshold (1.8V, minimum), the frequency is for 1.2MHz operation. When VRT is below the RT low threshold (0.8V, maximum), the frequency is for 1.2MHz operation. The internal pull low resistance is connected between RT and GND.

Application Information

Input Capacitor Selection

The input capacitor (CIN) reduces the ripple of the input current drawn from the input supply and reduces noise injection into the IC. The reflected ripple voltage will be smaller when an input capacitor with larger capacitance is used. For reliable operation, it is recommended to select the capacitor with maximum voltage rating at least 1.2 times of the maximum input voltage. The capacitors should be placed close to the VIN and the GND.

Inductor Selection

Selecting an inductor with low dc resistance reduces conduction losses and achieves high efficiency. The efficiency is moderated whilst using small chip inductor which operates with higher inductor core losses. Therefore, it is necessary to take further consideration while choosing an adequate inductor. Mainly, the inductor value determines the inductor ripple current: larger inductor value results in smaller inductor ripple current and lower conduction losses of the converter. However, larger inductor value generates slower load transient response. A reasonable design rule is to set the ripple current, ΔIL, to be 30% to 50% of the maximum average inductor current, IL(AVG). The inductor value can be obtained as below,

$$L \geq \left(\frac{V_{IN}}{V_{OUT}}\right)^2 \times \frac{V_{OUT}-V_{IN}}{F_{SW}\cdot I_{OUT(MAX)}} \times \frac{\eta}{\left(\frac{\Delta I_L}{I_{L(AVG)}}\right)}$$

where

VIN = input voltage VOUT = output voltage

FSW = switching frequency in MHz

IOUT = maximum output current in amp.

η = Efficiency

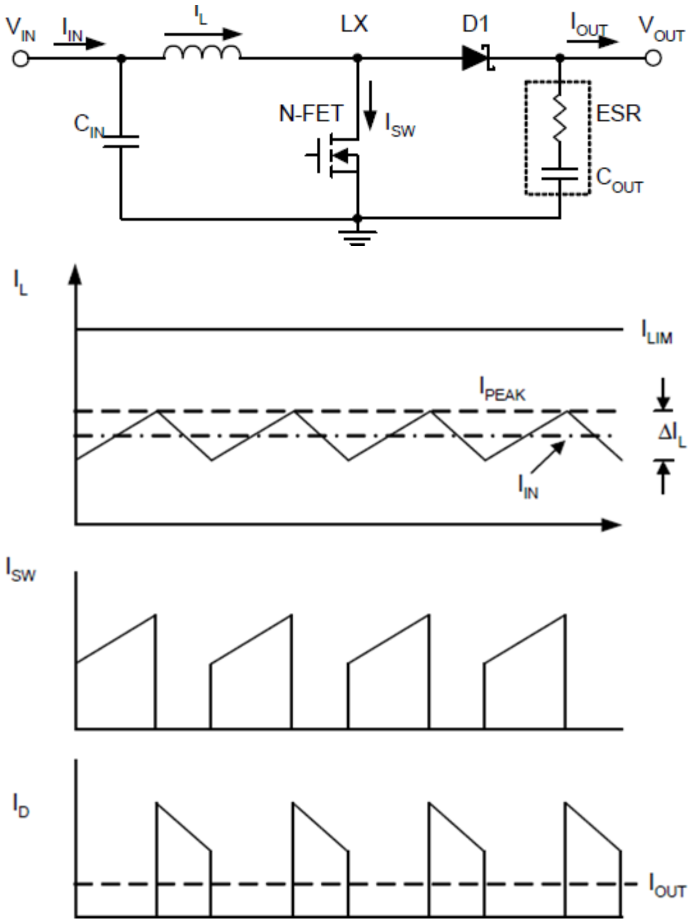
△IL /IL(AVG) = inductor ripple current/average current (0.3 to 0.5 typical)

To avoid the saturation of the inductor, the inductor should be rated at least for the maximum input current of the converter plus the inductor ripple current. The maximum input current is calculated as below:

$$I_{IN(MAX)} = \frac{I_{OUT(MAX)}\cdot V_{OUT}}{V_{IN}\cdot \eta}$$

The peak inductor current is calculated as the following equation:

$$I_{PEAK} = I_{IN(MAX)} + \frac{1}{2}\cdot\frac{V_{IN}\cdot(V_{OUT}-V_{IN})}{V_{OUT}\cdot L\cdot F_{SW}}$$



Output Capacitor Selection

The current-mode control scheme of the EC4514 allows the usage of tiny ceramic capacitors. The higher capacitor value provides good load transients response. Ceramic capacitors with low ESR values have the lowest output voltage ripple and are recommended. If required,

tantalum capacitors may be used as well. The output ripple is the sum of the voltages across the ESR and the ideal output capacitor

Application Information (Cont.)

Output Capacitor Selection (Cont.)

$$\Delta V_{OUT} = \Delta V_{ESR} + \Delta V_{COUT}$$

$$\Delta V_{COUT} \approx \frac{I_{OUT}}{C_{OUT}} \cdot \left(\frac{V_{OUT} - V_{IN}}{V_{OUT} \cdot F_{SW}} \right)$$

$$\Delta V_{ESR} \approx I_{PEAK} \cdot R_{ESR}$$

where I_{PEAK} is the peak inductor current.

For ceramic capacitor application, the output voltage ripple is dominated by the ΔVCOUT. When choosing the input and output ceramic capacitors, the X5R or X7R with their good temperature and voltage characteristics are recommended.

Output Voltage Setting

The output voltage is set by a resistive divider. The external resistive divider is connected to the output which allows remote voltage sensing as shown in "Typical Application Circuits". A suggestion of the maximum value of R1 is 2MΩ and R2 is 200kΩ for keeping the minimum current that provides enough noise rejection ability through the resistor divider. The output voltage can be calculated as below:

$$V_{OUT} = V_{REF} \cdot \left(1 + \frac{R1}{R2}\right) = 1.24\left(1 + \frac{R1}{R2}\right)$$

Diode Selection

To achieve the high efficiency, a Schottky diode must be used. The current rating of the diode must meet the peak current rating of the converter.

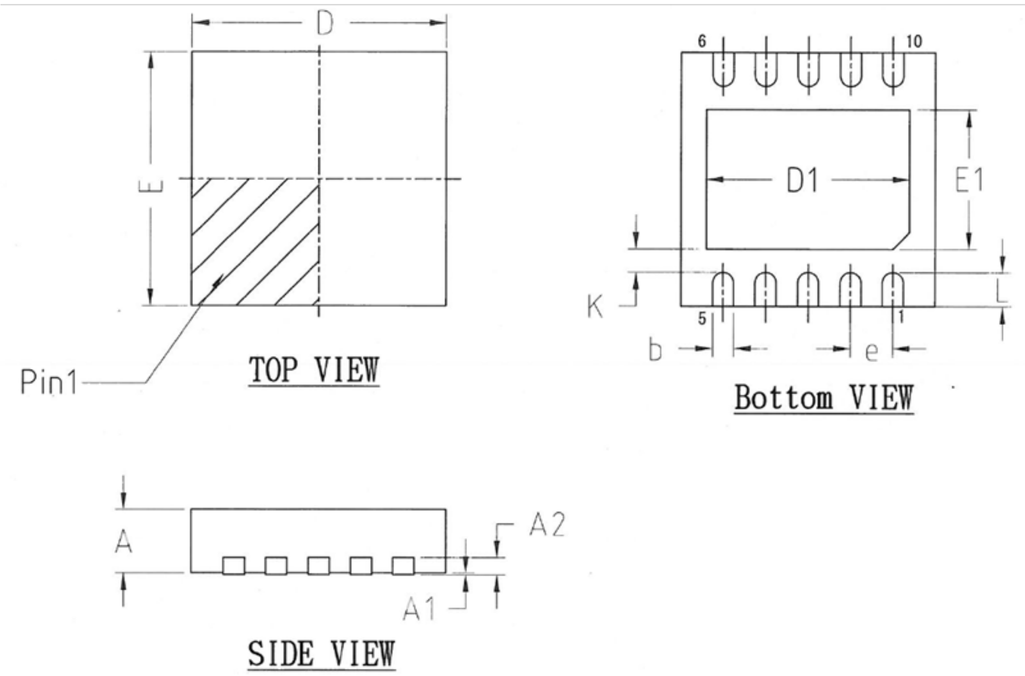
Layout Consideration

For all switching power supplies, the layout is an important step in the design especially at high peak currents and switching frequencies. If the layout is not carefully done, the regulator might show noise problems and duty cycle jitter.

1. The input capacitor should be placed close to the VIN and the the GND without any via holes for good input voltage filtering.
2. To minimize copper trace connections that can inject noise into the system, the inductor should be placed as close as possible to the LX pin to minimize the noise coupling into other circuits.
3. Since the feedback pin and network is a high impedance circuit the feedback network should be routed away from the inductor. The feedback pin and feedback network should be shielded with a ground plane or trace to minimize noise coupling into this circuit.
4. A star ground connection or ground plane minimizes ground shifts and noise is recommended.

Package Information

DFN3x3- 10 Package Outline Dimensions



SYMBOL	COMMON					
	DIMENSIONS MILIMETER			DIMENSIONS INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.7	0.75	0.8	0.028	0.003	0.031
A1	0	0.02	0.05	0	0.001	0.002
A2	0.20REF			0.008REF		
b	0.2	0.25	0.3	0.008	0.01	0.012
D	3.00BSC			0.118BSC		
D1	2.3	2.4	2.6	0.091	0.094	0.098
E	3.00BSC			0.118BSC		
E1	1.45	1.65	1.75	0.061	0.065	0.069
e	0.5BSC			0.020BSC		
L	0.3	0.4	0.5	0.012	0.015	0.02
K	0.225	-	-	0.009	-	-