High Efficiency, 18V Input, 6A, Sync DC-DC BUCK Converter

Description

FC3114 is a synchronous BUCK DC-DC converter IC, which integrates two NMOSFET power switches with low on-resistance. And RDSON of the high side and low side switches are 22mΩ and 40mΩ respectively. This product is capable of delivering 6A load current. FC3114 works in the PWM mode which has good acoustic performance. Cycle by cycle current limiting on the high-side FET protects the device in overload situations and is enhanced by a low-side sourcing current limit which prevents current runaway. There is also a low-side sinking current limit which turns off the low-side MOSFET to prevent excessive reverse current.

FC3114 incorporates OTP, input UVLO, cycle by cycle current limit protection and output short circuit protection to improve reliability.

Features

- Input Voltage Range：4V ~ 18V
- Shutdown Current：3uA
- R_{DSON}(LSD/HSD)：22mΩ/40mΩ
- Switching Frequency：200kHz-1.6MHz
- Reference Voltage：0.6V ± 2%
- Cycle by Cycle Current Limit：Peak 10A, Valley 8A
- Short Circuit Protection：Hiccup Mode
- Thermal shutdown protection：160°C
- Adjustable slow start

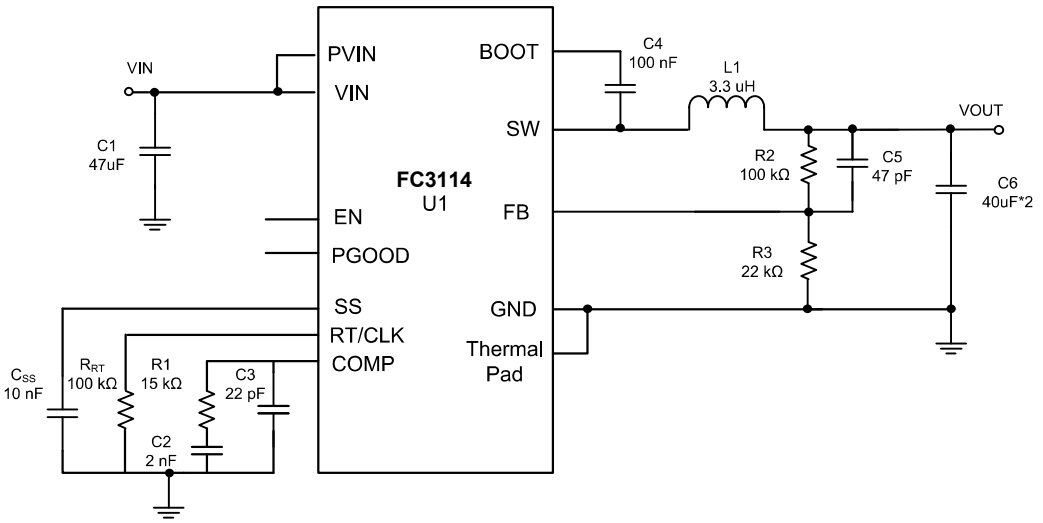
Applications

- Set Top Box
- Digital TV Power Supplies
- High Performance Point of Load Regulation

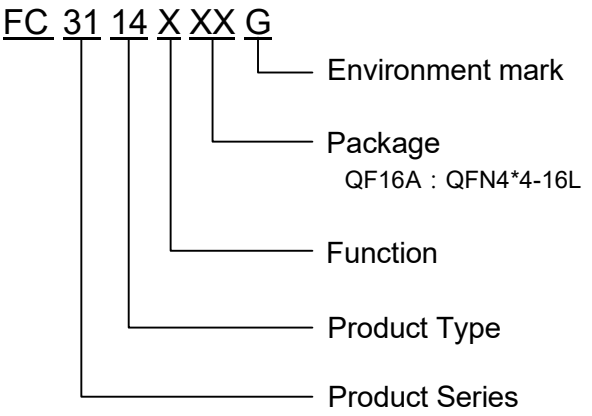
Package

- 16-Pin QFN4*4-16L

Typical Application Circuit

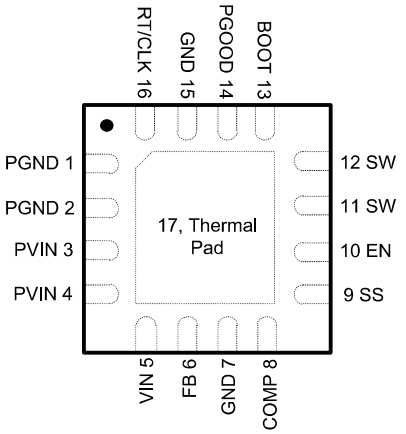


Selection Guide



product series	product description
FC3114AQF16AG	Package：QFN4*4-16L

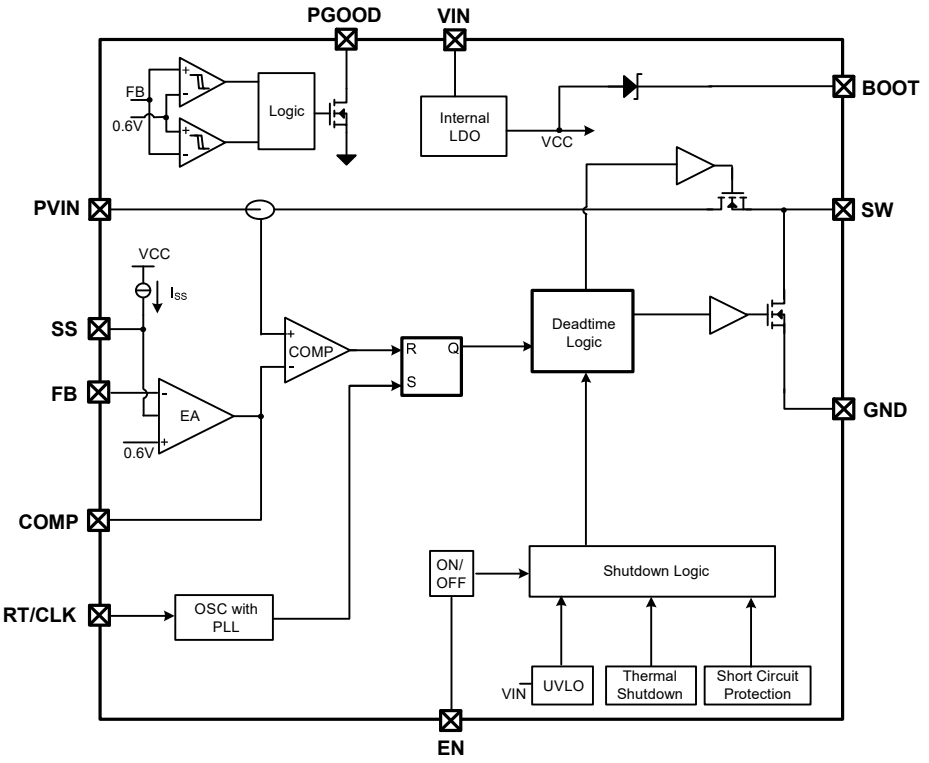
Pin Configuration



Pin Assignment

Pin Number	Pin name	Function
1, 2	PGND	Power ground
3, 4	PVIN	Power input. Supplies the power switches of the power converter.
5	VIN	Supplies the control circuitry of the power converter.
6	FB	Feedback voltage pin. Inverting input port of error amplifier.
7, 15	GND	Reference ground.
8	COMP	Error amplifier output, and input to the output switch current comparator. Connect frequency compensation to this pin.
9	SS	Slow-start and tracking. An external capacitor connected to this pin sets the internal voltage reference rise time. The voltage on this pin overrides the internal reference.
10	EN	Enable input pin. High logic enables the IC.
11, 12	SW	Switch node and connecting inductor.
13	BOOT	A ceramic capacitor more than 0.1 uF is needed between BOOT and LX. Power supply for driver of high side switch.
14	PGOOD	Power Good fault pin. Asserts low if output voltage is low due to thermal shutdown, dropout, over voltage, EN shutdown or during slow start.
16	RT/CLK	Automatically selects between RT mode and CLK mode. An external timing resistor adjusts the switching frequency of the device; In CLK mode, the device synchronizes to an external clock.
17	Thermal Pad	Thermal pad of the package and signal ground and it must be soldered down for proper operation.

Block Diagram



Absolute Maximum Ratings

Parameter	Symbol	Ratings	Unit
RT pin voltage range	V_{RT}	-0.3 ~ 5	V
PVIN pin voltage range	V_{PVIN}	-0.3 ~ 18	V
VIN pin voltage range	V_{IN}	-0.3 ~ 18	V
FB pin voltage range	V_{FB}	-0.3 ~ 5	V
COMP pin voltage range	V_{COMP}	-0.3 ~ 5	V
SS pin voltage range	V_{SS}	-0.3 ~ 5	V
EN pin voltage range	V_{EN}	-0.3 ~ 5	V
SW pin voltage range	V_{SW}	-0.3 ~ 18	V
voltage between BOOT pin and SW pin	V_{BOOT_SW}	-0.3 ~ 5	V
PGOOD pin voltage range	V_{PGOOD}	-0.3 ~ 5	V
Internal Power Dissipation	P_d	2.5	W
Thermal resistance (Junction to air)	θ_{JA}	50	℃/W
Operating Temperature Range	T_A	-40 ~ +85	℃
Storage Temperature Range	T_{STG}	-55 ~ +150	℃
Maximum junction temperature	T_J	-40 ~ +160	℃

Attention : Stresses beyond those listed under **Absolute Maximum Ratings** may cause permanent damage to the device

Recommended Operating Conditions

Symbol	Description	Min	Typ	Max	Unit
V_{IN}	Input voltage	4	12	18	V
V_{OUT}	Output voltage	0.6	3.3	12	V
L	Inductor value	1.2	3.3	10	uH
C_{OUT}	Output capacitor	30	60	-	uF
T_A	Operating ambient temperature	-40	-	85	ºC

Electrical Characteristic

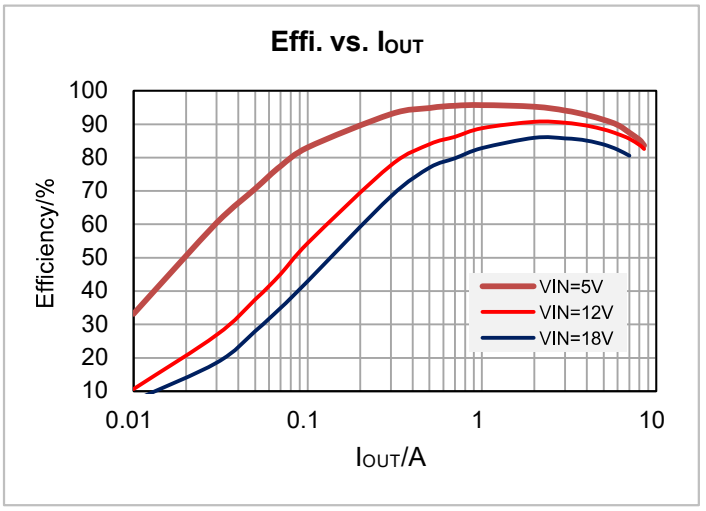
FC3114 test conditions：V_{IN}= 12 V，V_{OUT}= 3.3 V，T_A= 25℃，unless otherwise noted。

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Input voltage range	V_{IN}		4		18	V
Input UVLO threshold	V_{IN_UVLO}	V_{IN} rises.		3.85	4	V
Input UVLO hysteresis	V_{IN_HYS}			170		mV
EN rising threshold	V_{ENH}	V_{EN} rises.			1.2	V
EN falling threshold	V_{ENL}	V_{EN} falls.	0.6			V
Shutdown current	I_{SD}	V_{IN} = 18 V, IC is enabled.		3	5	uA
Feedback reference voltage	V_{REF}		0.588	0.6	0.612	V
High side on-resistance	R_{DSON_HSD}			40		mΩ
Low side on-resistance	R_{DSON_LSD}			22		mΩ
Peak current limit	I_{LIM_HSD}		8.5	10	11.5	A
Valley source current limit	I_{LIM_SOURCE}		7	8.5	10	A
Valley sink current limit	I_{LIM_SINK}		2.5	3.5	4.5	A
Error amplifier source/sink current	I_{COMP}			±42		uA
Error amplifier transconductance	G_{EA}			300		uA/V
COMP to I_L transconductance	G_{PWR_STG}			10		A/V
Minimum on time	T_{MIN_ON}			155	200	ns
Switching frequency	f_{SW}	R_{RT}=100 kΩ	425	500	575	kHz
Output overvoltage threshold	V_{OVH}			107		$\%V_{REF}$

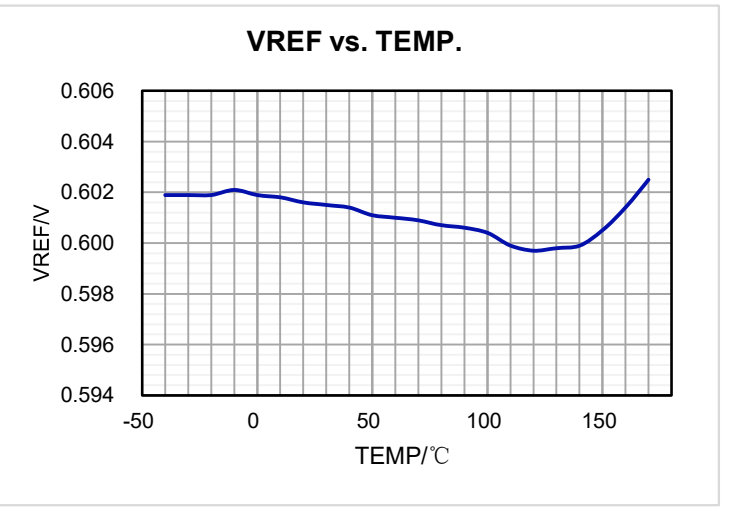
Output overvoltage threshold	V_{OVL}			105		$\%V_{REF}$
Output undervoltage threshold	V_{UVL}			92		$\%V_{REF}$
Output undervoltage threshold	V_{UVH}			94		$\%V_{REF}$
Soft start charging current	I_{ss}			2.2		uA
Thermal shutdown	T_{SD}			160		°C
Thermal shutdown hysteresis	T_{HYS}			40		°C

Typical Performance Characteristics

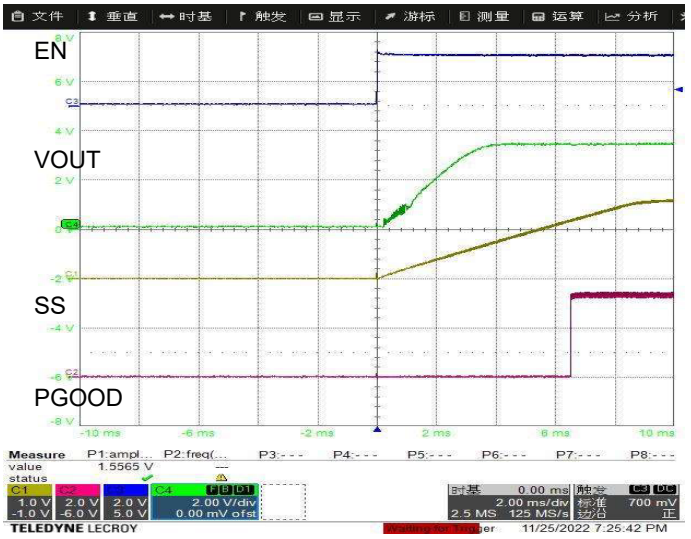
Efficiency vs. IOUT(V_{OUT}=3.3V)



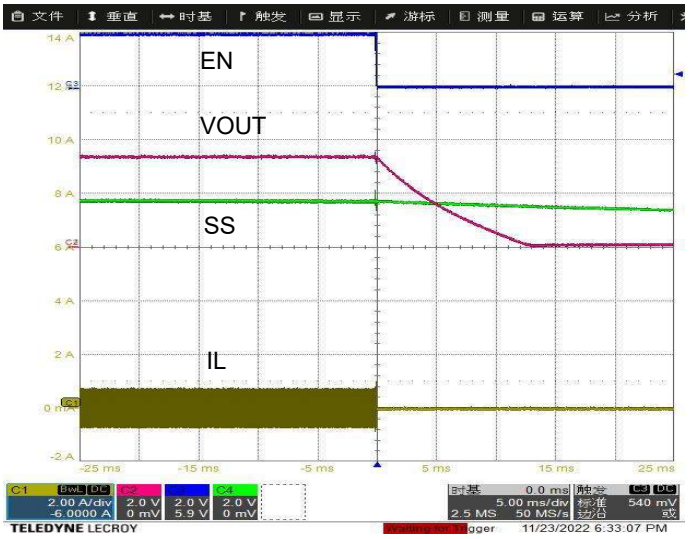
Reference Voltage vs. Temp.



Soft Startup(V_{IN}=12V,V_{OUT}=3.3V,I_{OUT}=3A)

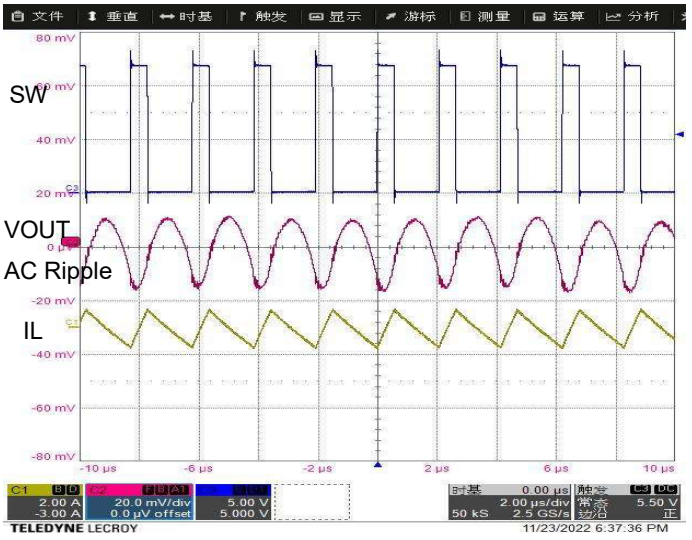


Shutdown



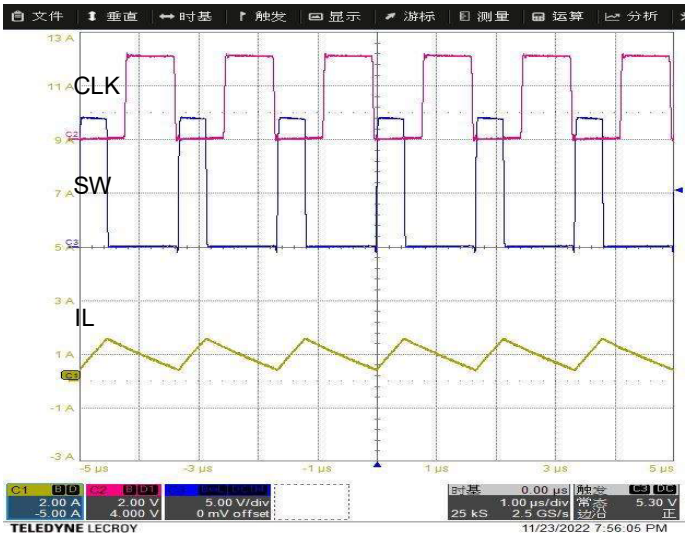
Switching Waveform

(V_{IN}=12V,V_{OUT}=3.3V,I_{OUT}=0A)



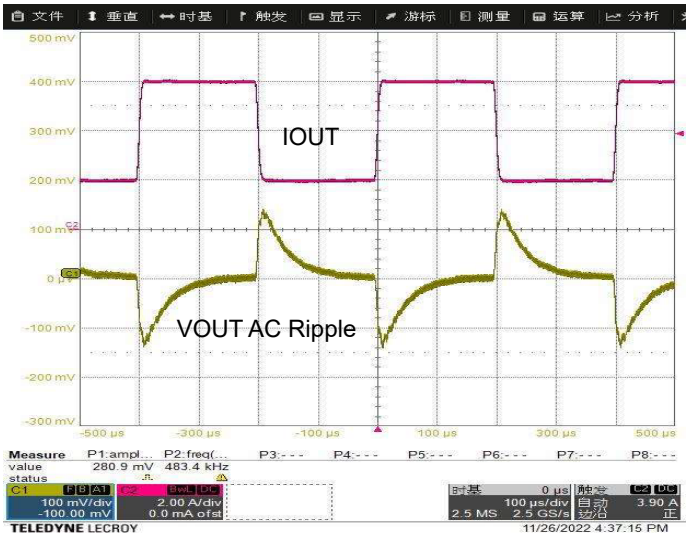
Synced switching Waveform

(f_{CLK}=600kHz)

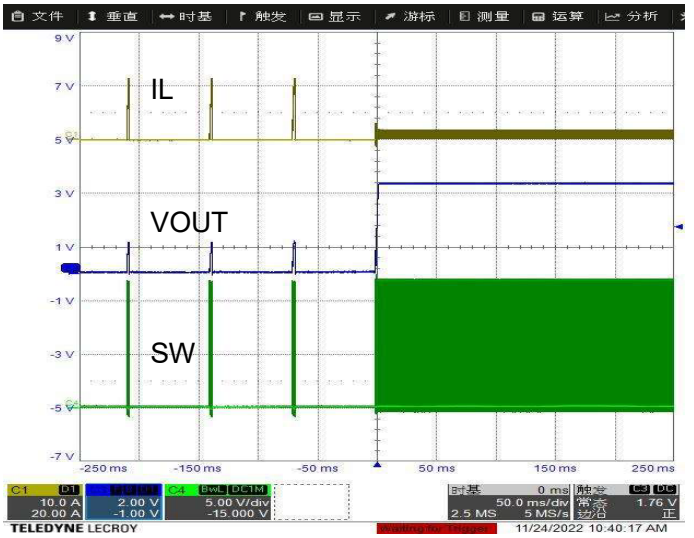


Load Transient Response

(V_{IN}=12V,V_{OUT}=3.3V,I_{OUT}:2A-6A)



Short Circuit Protection and Recovery



Operation

The device is a 18V, 6A, synchronous step-down (buck) converter with two integrated n-channel MOSFETs. To improve performance during line and load transients the device implements a constant frequency, peak current mode control which also simplifies external frequency compensation. The wide switching frequency of 200 kHz to 1600 kHz allows for efficiency and size optimization when selecting the output filter components. The switching frequency is adjusted using a resistor to ground on the RT/CLK pin. The device also has an internal phase lock loop (PLL) controlled by the RT/CLK pin that can be used to synchronize the switching cycle to the falling edge of an external system clock.

Shot Circuit Protection

When output is short to the ground, the device will shutdown for a fixed time(32768 cycles). Then the chip can

resume soft startup automatically. If the device is still in the short circuit condition, it will stop switching again. The device will repeat to shutdown and resume soft startup until the output short condition is removed. Then output voltage will softly start up to the setting value..

Application Information

FC3114 can be used in applications in which power supply is converted from high level to low level. Because of the integrated power switches in the chip, only input capacitor C_{IN}, output inductor L, output capacitor C_{OUT} and feedback resistors are selected for the desired application.

Setting Soft Startup

When the EN pin is pulled high, the blocks in the IC start to work in order. After the 0.6 V reference voltage settles down, a small current charges the external soft startup capacitor. And the voltage of soft startup capacitor is used to control error amplifier. During the soft startup phase, the soft startup voltage rises to 0.6 V gradually and V_{OUT} ramps up to the setting point accordingly. Soft startup can avoid large inrush current and V_{OUT} overshoot.The calculations for the slow start time (t_{ss}) and slow start capacitor (C_{ss}) are shown in the following equation.

$$t_{SS} = \frac{C_{SS} \times 0.6V}{I_{SS}}$$

Where I_{SS} = 2.8uA.

Setting Output Voltage

The output voltage can be set by selecting proper feedback resistors R1 and R2. To achieve good noise and power performance, it's recommended to using resistors between 1 kΩ and 1 MΩ. The resistor R1 can be calculated by the following equation.

$$R_1 = R_2 \times \left(\frac{V_{OUT}}{0.6V} - 1 \right)$$

Setting Switching Frequency

The switching frequency f_{SW} can be set by the external resistor R_{RT} between the RT pin and ground. The frequency ranges from 200kHz to 1.6MHz. And the relationship between f_{SW} and R_{RT} can be referred to the following equation.

$$f_{SW} = \frac{500kHz \times 100\,k\Omega}{R_{RT}}$$

Inductor Selection

To guarantee the normal work of the power system, the output inductor peak current should be below the peak

current limit of 5.5 A. The inductor peak current can be calculated by the following equation. In consideration of magnetic saturation of inductor, the peak current should be also smaller than the saturate current of the inductor. And low DCR can help to meet desired power efficiency requirement.

$$I_{PEAK} = I_{OUT} + \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{2 \times V_{IN} \times L} \times T$$

Bootstrap Capacitor

A 0.1 uF ceramic capacitor connected between the LX pin and the BOOT pin is required to supply power for the high side switch in applications based on FC3114.

Input Capacitor

In the BUCK converter system, severe interference exists between the VIN pin and ground. The input capacitor CIN can help to reduce interference and improve system stability. Because the effective capacitance can be reduced significantly at the DC biasing voltage, so the rated voltage of input capacitor should exceed the highest input voltage. And ME recommends the input capacitor should be placed as closely as possible to the VIN pin of the FC3114.

Output Capacitor

The step down DC-DC converter needs output filter capacitor. Small output capacitor may result in system instability. When output short circuit condition is released, the output voltage may overshoot the safe level, which can damage the following devices permanently.

Layout Guidelines

1）BUCK converter implemented by FC3114 is sensitive to PCB layout. For reducing nonideality, external components such as inductor, input capacitor, output capacitor and resistor divider should be placed as nearly as possible to the chip.

2）For reducing EMI caused by high frequency switching, the trace connected to LX pin should be as short as possible. It is recommended to use ground plane to shield signal from interplane coupling.

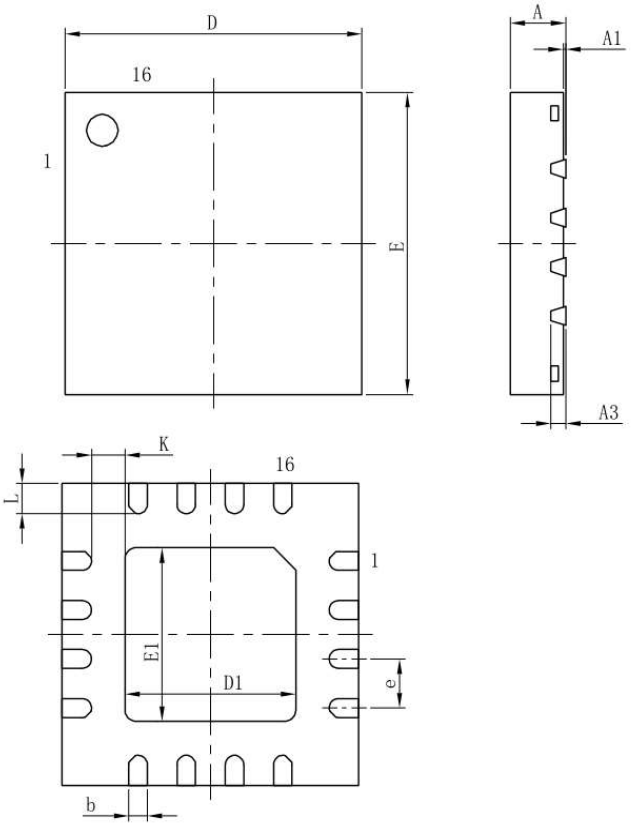
3）To improve thermal dissipation and power efficiency, it is recommended to cover the back of PCB with ground plane. More thermal vias and thick PCB copper are desirable.

Package Quantity

Package Type	Minimum Packing QTY	UNITS	Small Box	Large BOX
QFN4*4-16L	3000	Tape & Reel	30K	120K

Package Information

- **Package Type: QFN4*4-16L**



DIM	Millimeters		Inches	
	Min	Max	Min	Max
A	0.7	0.8	0.0276	0.0315
A1	-	0.05	-	0.0020
A3	0.18	0.25	0.0083(TYP)	
b	0.2	0.35	0.0079	0.0138
D	3.9	4.1	0.1535	0.1614
E	3.9	4.1	0.1535	0.1614
D1	2.2	2.4	0.0866	0.0945
E1	2.2	2.4	0.0866	0.0945
e	0.65(TYP)		0.0256(TYP)	
L	0.3	0.65	0.0118	0.0256
K	0.2	-	0.0079	-