BYD Microelectronics Co., Ltd.

BF1210 Series

PWM/PFM Control
Step-Down DC/DC Converter

GENERAL DESCRIPTION

The BF1210 series is a step-down DC/DC converter with PWM/PFM control. It contains oscillation circuit, error amplifier, voltage reference, soft-start circuit, etc. The soft-start circuit is used to prevent inrush current at start-up.
The BF1210 series has the characteristics of low ripple and high efficiency. It works with PWM/PFM control, and can switch automatically between them. Normally, it operates with the PWM control mode, which gets a steady output voltage by adjusting the duty cycle of control pulse. Under light load, it switches PWM to PFM mode automatically. While at heavy load, it will keep working with a high duty cycle. This working mode ensures high efficiency over a wide range.
With the addition of a P-channel MOSFET, an inductor, capacitors, and a diode connected externally, the BF1210 can work as a step-down DC/DC converter. It is available in SOT23-5 package, and serves as an ideal power management unit for many devices.

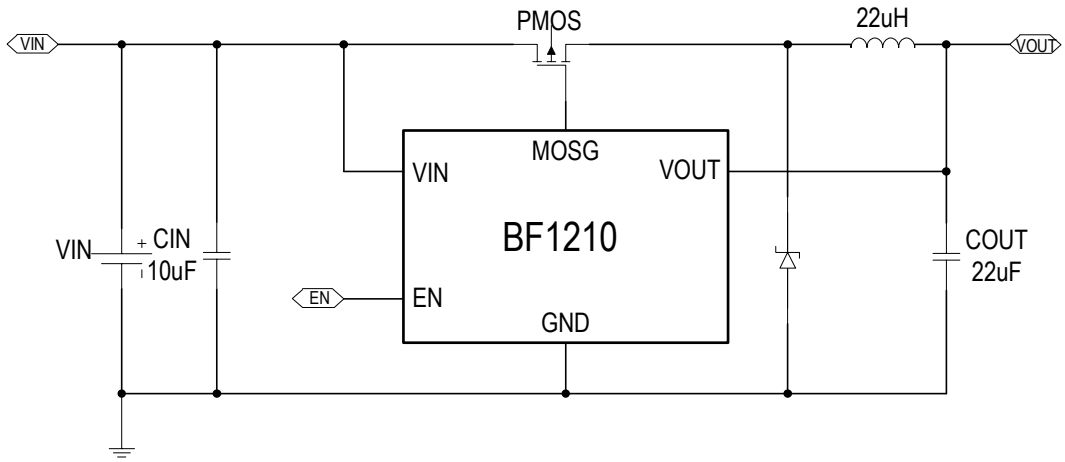
FEATURES

- 4V to 16 V wide input voltage range
- 5V/3.3V output voltage
- 450KHz constant operation frequency
- PWM/PFM switching control mode
- Soft-start function

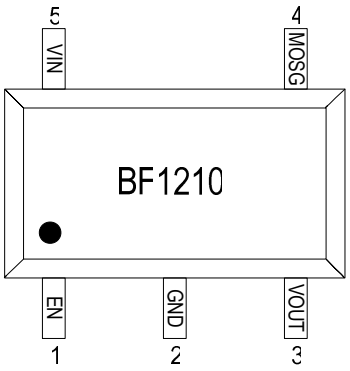
APPLICATIONS

- On-board power supplies of battery devices for PDAs, portable telephones and electronic notebooks.
- Fixed voltage power supply for digital cameras, video and communication equipment.
- Power supplies for PDVDs and microcomputers
- Applied to two lithium-ion cells power system
- Conversion of AC adapter input to 5V/3.3V

TYPICAL APPLICATION



PIN CONFIGURATION

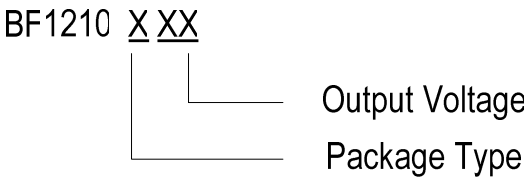


PIN DEFINITION

PIN	NAME	DESCRIPTION
1	EN	On/Off control pin
2	GND	Ground
3	VOUT	Output voltage monitoring pin
4	MOSG	Connection pin for external MOSFET
5	VIN	Power

PRODUCT NAME STRUCTURE

- **PRODUCT NAME**



- **PRODUCT NAME DESCRIPTION**

Part Number	Top Mark	Package Type	Output Voltage
BF1210Y50	DAAYW	SOT23-5	5V
BF1210Y33	DABYW	SOT23-5	3.3V
BF1210Y	DACYW	SOT23-5	Adjustable(3V-5.5V)

*Note: Y=Manufacturing Year Code
W=Manufacturing Week Code

ELECTRICAL CHARACTERISTICS

(T_A = 25°C, unless otherwise noted)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYPICAL	MAX	UNITS
V_{IN}	Input voltage	V_{OUT}(S)=5V	5.5	---	16	V
		V_{OUT}(S)=3.3V	4	---	16	
V_{OUT} (E)	Output voltage	---	V_{OUT}(S) x0.976	---	V_{OUT}(S) x1.024	

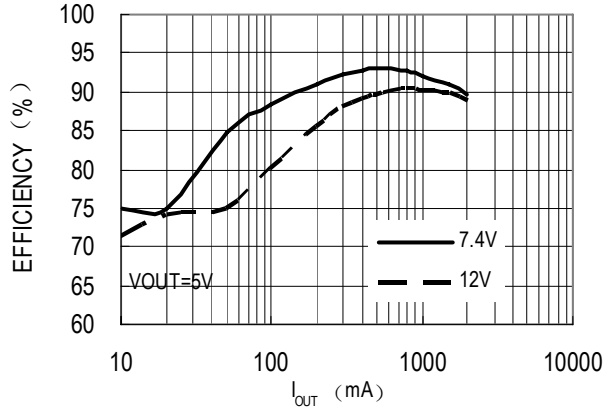
I_Q	Static current	EN=1, no-load	---	200	400	μA
I_{SHUT}	Shutdown current	EN=0	---	90	350	
the output current of MOSG pin	I_{MOSGH}	V_{IN}=7.4V、V_{MOSG}=V_{IN}-0.4V	-8	-11	---	mA
	I_{MOSGL}	V_{IN}=7.4V、V_{MOSG}=0.4V	+16	+22	---	
ΔV_{OUT1}	Line regulation	V_{IN}=10~14V、load current=1A, V_{OUT}(S)=5V	---	40	60	mV
		V_{IN}=8~12V、load current=1A, V_{OUT}(S)=3.3V	---	30	50	
ΔV_{OUT2}	Load regulation	V_{IN}=10V、load current=0~2A, V_{OUT}(S)=5V	---	60	80	
		V_{IN}=8V、load current=0~2A, V_{OUT}(S)=3.3V	---	40	60	
f_{OSC}	Oscillation frequency	---	---	450	520	KHz
t_{soft}	Soft start time	V_{OUT}(S)=5V	1	1.2	1.5	ms
		V_{OUT}(S)=3.3V	0.8	1	1.4	
V_{ENH}	Power-on voltage of EN pin	V_{IN}=10V	7	---	---	V
V_{ENL}	Power-off voltage of EN pin	V_{IN}=10V	---	---	3	
V_{ripple}	Ripple voltage	V_{IN}=10V、load current=1A, V_{OUT}(S)=5V	---	15	40	mV
		V_{IN}=8V、load current=1A, V_{OUT}(S)=3.3V	---	20	40	
EFFI	Efficiency	V_{OUT}(S)=5V	---	---	93	%
		V_{OUT}(S)=3.3V	---	---	90	

Notes:

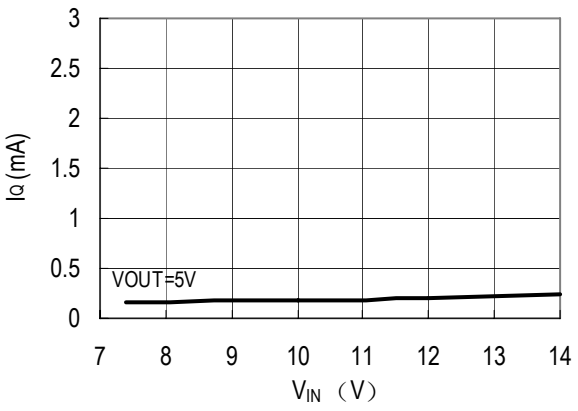
1. V_{OUT}(E) Actual output voltage value.
2. V_{OUT}(S) Specified output voltage value.

TYPICAL PERFORMANCE CHARACTERISTICS (T_A = 25°C, unless otherwise noted)

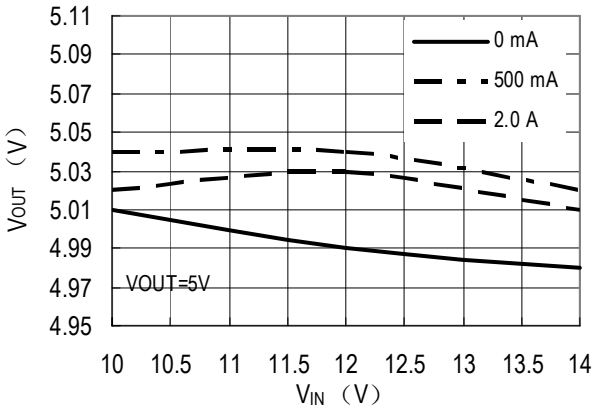
Ouput Current vs Efficiency



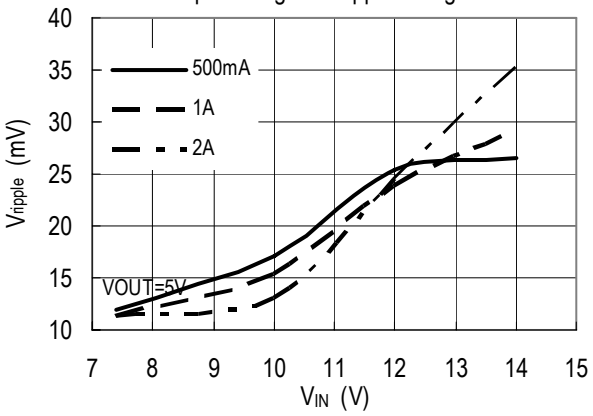
Input Voltage vs Quiescent Current



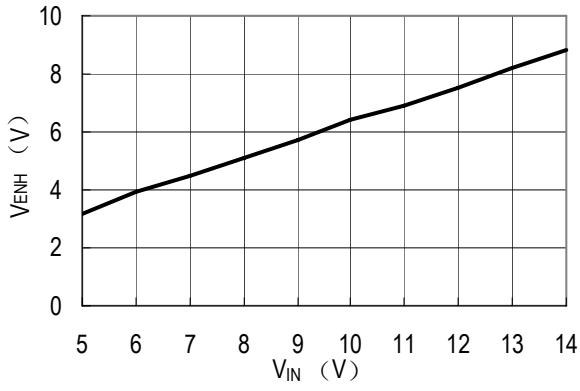
Input Voltage vs Output Voltage



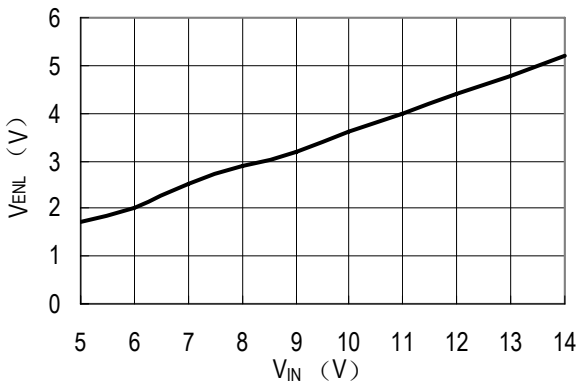
Input Voltage vs Ripple Voltage



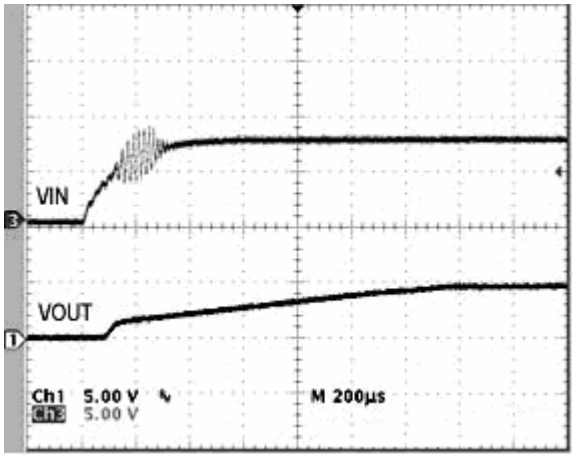
Input Voltage vs Power-on Voltage of EN



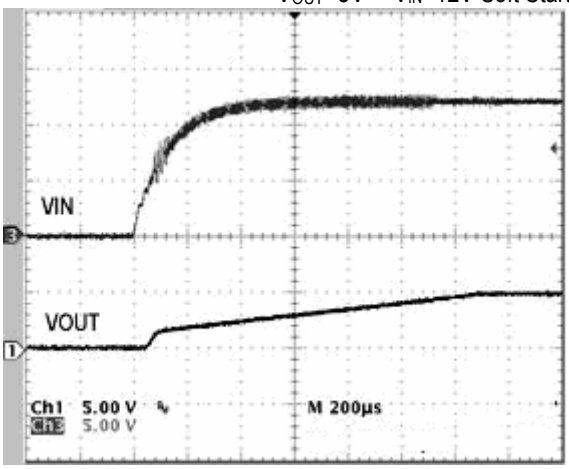
Input Voltage vs Power-off Voltage of EN



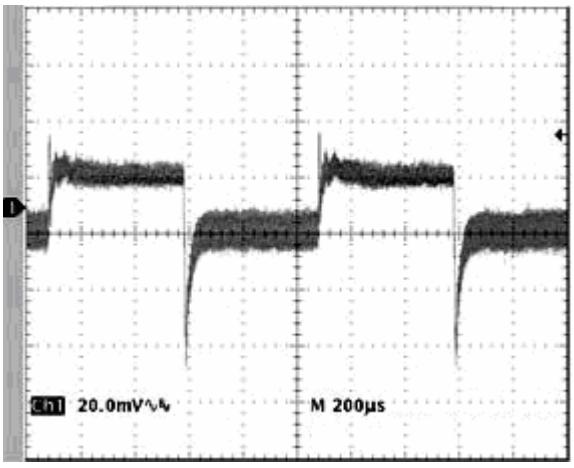
V_{OUT}=5V V_{IN}=7.4V Soft Start



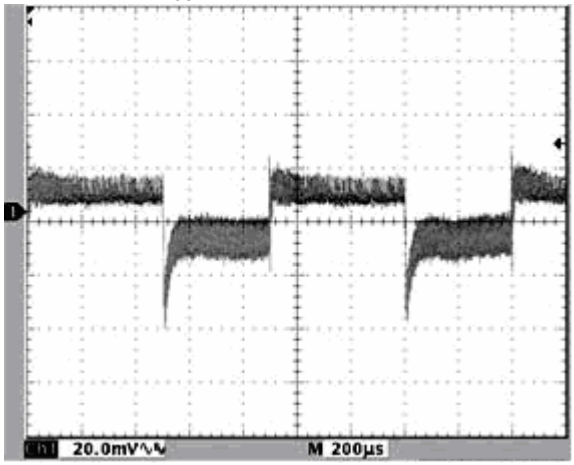
V_{OUT}=5V V_{IN}=12V Soft Start



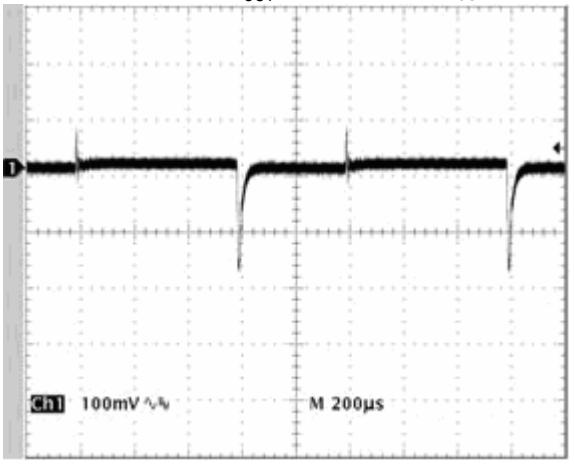
V_{OUT}=5V V_{IN}=10V I_{OUT}=10mA→500mA



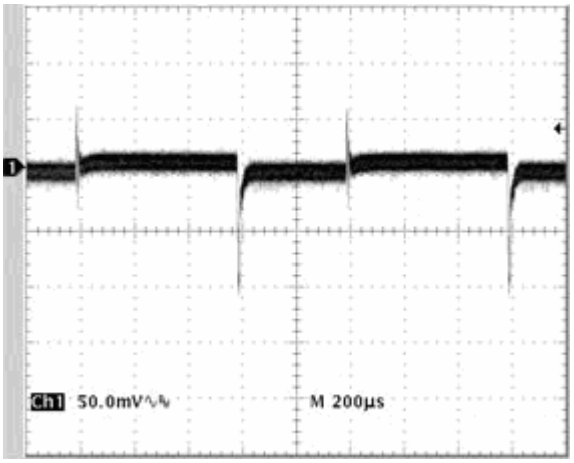
V_{OUT}=5V V_{IN}=12V I_{OUT}=10mA→500mA



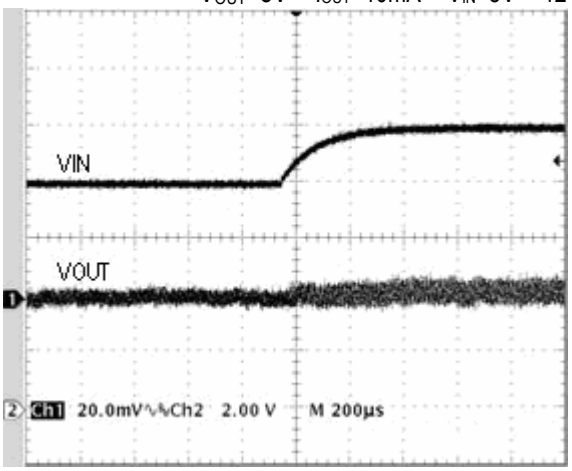
V_{OUT}=5V V_{IN}=10V I_{OUT}=1A→2A



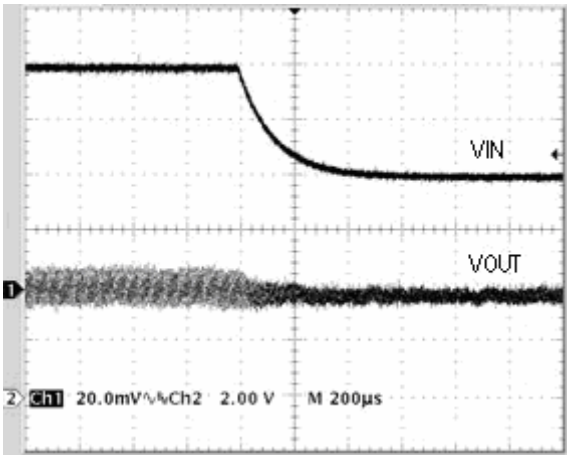
V_{OUT}=5V V_{IN}=12V I_{OUT}=1A→2A



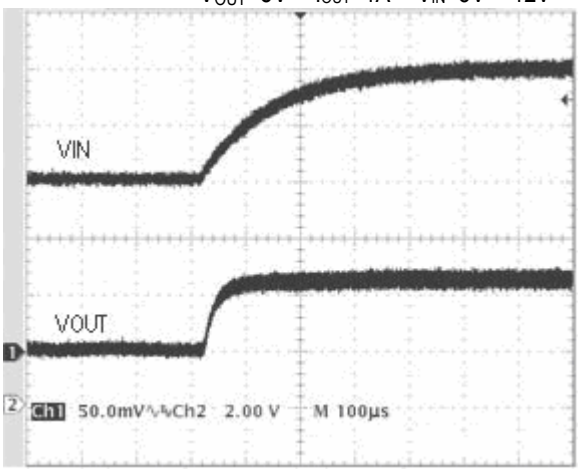
V_{OUT}=5V I_{OUT}=10mA V_{IN}=8V→12V



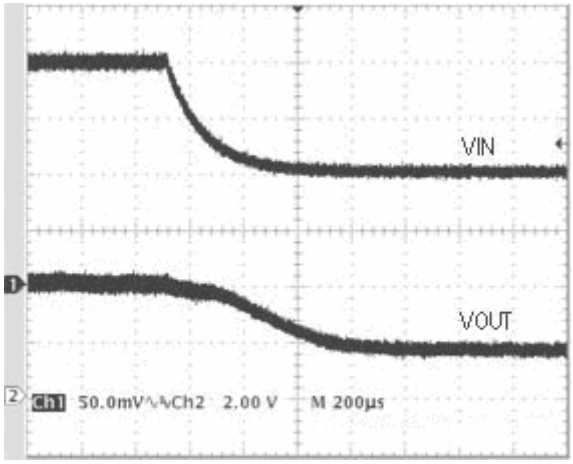
V_{OUT}=5V I_{OUT}=10mA V_{IN}=12V→8V



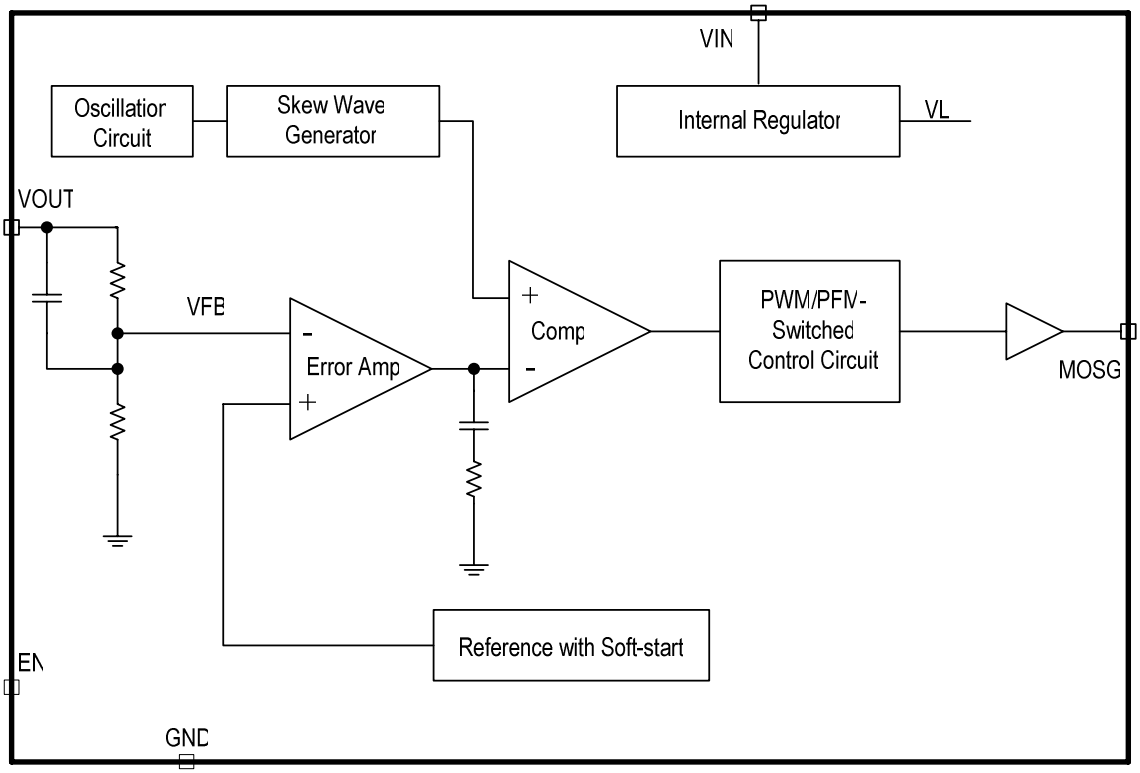
V_{OUT}=5V I_{OUT}=1A V_{IN}=8V→12V



V_{OUT}=5V I_{OUT}=1A V_{IN}=12V→8V



FUNCTIONAL DIAGRAM



OPERATION

The BF1210 series is a step-down DC/DC converter with PWM/PFM control. Its diagram is shown above. It consists of reference, error amplifier, oscillation circuit and so on. In the region of high output load current, the BF1210 series operates with PWM mode and fix frequency to gain low output ripple. For certain low output load current, the converter will switch over to PFM control mode to reduce current consumption and improve efficiency, and the pulses will be skipped depending on the load current, this cause the oscillation circuit to produce intermittent oscillation.

Soft-start Function

All inductive step-down converters exhibit high inrush current during start-up if no special precaution is made. In order to prevent inrush current during start-up, the BF1210 series has a build-in soft-start circuit. At power on, while EN state changes from “L” to “H”, the output voltage will raise gradually over the specified soft-start time. This prevents the output voltage from overshooting.

PWM/PFM Switching Control

In case of high load current, the BF1210 series will work in the PWM control mode, which helps keeping the ripple voltage low. But for a certain low load current, in order to maintain high efficiency, the BF1210 series will switch over to PFM control mode, and the oscillation circuit produce intermittent oscillation. As a result, current consumption is reduced and efficiency is improved. The switching point is related to the Input voltage and external parts like inductor, diode, etc.

APPLICATIONS INFORMATION

Inductor Selection

The inductance (L) affects the maximum output current I_{OUT} and the efficiency η. Normally, as the L decreases, the peak current I_{PK} will increase, and that is available to improve the circuit stability and increase the maximum output current I_{OUT}. But if L is even smaller than a certain point, I_{OUT} will begin decreasing because the current that drives the capacitor of switching transistor becoming insufficient, and the efficiency will be low.
Conversely, as the L increases, the power consumption caused by peak current I_{PK} of switch transistor will decrease, and the efficiency is maximized at a certain L value. Then if L is made even larger, efficiency and I_{OUT} will reduce due to the power dissipation which results from resistance of the coil. Besides, if the L increases, the output voltage may become unstable, depending on conditions such as input voltage, output voltage and load current. So we should select an inductor with a proper inductance according to the application, 22μH is recommended.
When selecting an inductor, it is need to pay more attention to its rated current (maximum allowable current). Exceeding the rated current will result in lower efficiency and IC disrepair. Therefore, select an inductor of which the peak current I_{PK} will not surpass its maximum allowable current at any moment. The peak current I_{PK} is represented by the following equation in continuous operation mode:

$$I_{PK} = I_{OUT} + \frac{(V_{OUT} + V_F) \times (V_{IN} - V_{OUT})}{2 \times f_{OSC} \times L \times (V_{OUT} + V_F)}$$

Where: f_{OSC} = oscillation frequency
V_F = forward voltage of the diode

Capacitance Selection

The input capacitor (C_{IN}) can reduce power impedance and average the input current for better efficiency. The selection of input capacitance should base on the impedance of power supplied. The capacitance of C_{IN} between 10μF to 47μF is recommended.

For smoothing the ripple voltage, a low ESR output capacitor is required. A ceramic capacitor is recommended, and the value can be from 22μF to 47μF. In order to maintain a stable output voltage when the load current is high, an electrolytic capacitor of 220μF should be used, and it is recommended that the electrolytic capacitor should be paralleled with ceramic capacitor to reduce ringing, switching losses, and output voltage ripple.

Diode Selection

To achieve high efficiency, a Schottky diode should be used. The diode used should meet the following conditions: low forward voltage, high switching speed, higher reverse direction voltage than V_{IN} and higher current rating than the peak current I_{PK}.

MOSFET Selection

The MOSG pin is capable of driving a P-channel MOSFET, which main parameters include threshold voltage, breakdown voltage between gate and source, breakdown voltage between drain and source, gate capacitance, on- resistance and current rating.

The voltage of MOSG pin changes from V_{SS} to V_{IN}. If the input voltage is low, select a MOSFET with low threshold voltage so that the MOSFET will come on as required. Conversely, if the input voltage is high, select a MOSFET whose breakdown voltage between gate and source is higher than the input voltage by at least several volts.

After power on, since the input voltage will be imposed across the drain and the source of the MOSFET, the breakdown voltage between gate and source should be also several volts higher than the input voltage.

Because of the switching of P-channel MOSFET, the power loss for charging and discharging the gate capacitor will increase, when the gate capacitance becomes larger and the input voltage rises higher. Therefore the gate capacitor affects the efficiency and becomes a matter of particular concern in a low load current region. If the efficiency under light loads is important, select a MOSFET with a small gate capacitance.

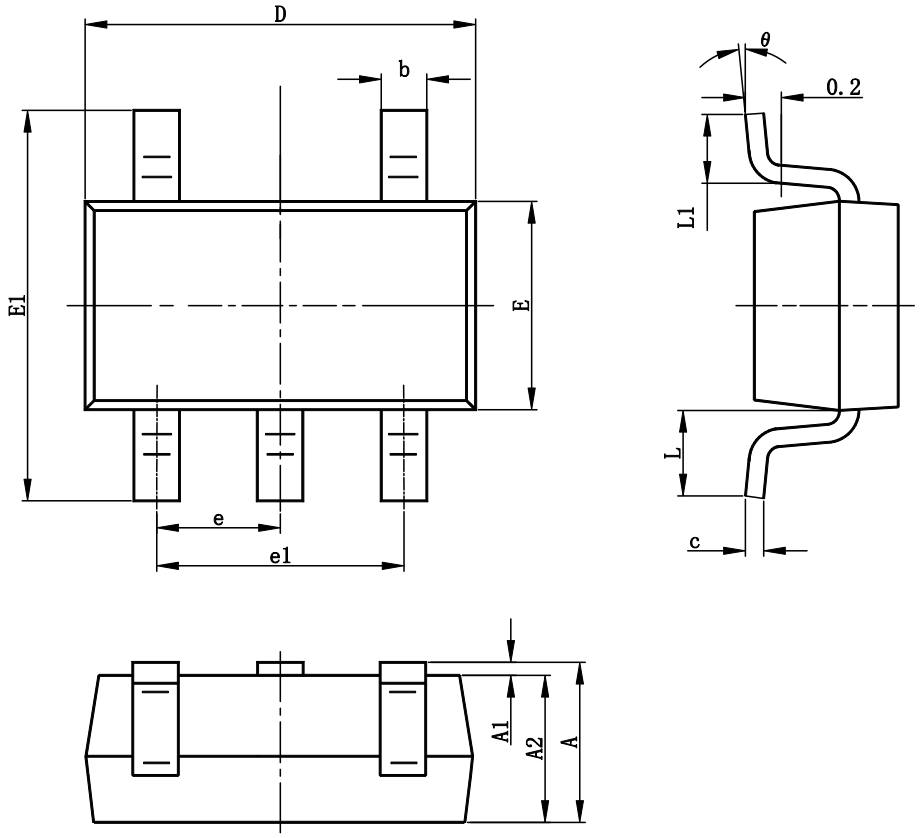
In regions where the load current is high, the efficiency is affected by power losses caused by the on-resistance. Therefore, if the efficiency under heavy loads is particularly important, select a MOSFET with low on-resistance.

For current rating, select the MOSFET whose maximum continuous drain current rating is higher than the peak current I_{PK}.

External Parts Recommendation

Device	Manufacturer's Name	Product Name	Main Performance Characteristics
Inductor	FENGHUA	PIO105-220M	L-Value: 22μH DCR: 0.1Ω Rated DC Current: 2.5A
Capacitor			Input Capacitor: 10μF Ceramic Capacitor Output Voltage: 22μF Ceramic Capacitor (+ 220μF electrolytic Capacitor)
Diode	FENGHUA	FH1N5822	IF(AV) =3A VFA=500mV (1.0A)
MOSFET	BYD	BF9024SPZ-X	V_{GS-max}=12V V_{DS-max}=20V I_{D-max}=2A C_{iss}=340pF R_{on}=150mΩ SOT23-3 Package
		BF92301P	V_{GS-max}=8V V_{DS-max}=20V I_{D-max}=2.3A R_{on}=100mΩ SOT23-3 Package
	Onsemi	NTR4502PT1G	V_{GS-max}=20V V_{DS-max}=30V I_{D-max}=1.95A C_{iss}=200pF R_{on}=200mΩ SOT23-3 Package

PACKAGE DESCRIPTION



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.400	0.012	0.016
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950TYP		0.037TYP	
E1	1.800	2.000	0.071	0.079
L	0.700REF		0.028REF	
L1	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

RESTRICTIONS ON PRODUCT USE

- The information contained herein is subject to change without notice.

- BYD Microelectronics Co., Ltd. (short for BME) exerts the greatest possible effort to ensure high quality and reliability. Nevertheless, semiconductor devices in general can malfunction or fail due to their inherent electrical sensitivity and vulnerability to physical stress. It is the responsibility of the buyer, when utilizing BME products, to comply with the standards of safety in making a safe design for the entire system, including redundancy, fire-prevention measures, and malfunction prevention, to prevent any accidents, fires, or community damage that may ensue. In developing your designs, please ensure that BME products are used within specified operating ranges as set forth in the most recent BME products specifications.

- The BME products listed in this document are intended for usage in general electronics applications (computer, personal equipment, office equipment, measuring equipment, industrial robotics, domestic appliances, etc.). These BME products are neither intended nor warranted for usage in equipment that requires extraordinarily high quality and/or reliability or a malfunction or failure of which may cause loss of human life or bodily injury (“Unintended Usage”). Unintended Usage include atomic energy control instruments, airplane or spaceship instruments, transportation instruments, traffic signal instruments, combustion control instruments, medical instruments, all types of safety devices, etc.. Unintended Usage of BME products listed in this document shall be made at the customer’s own risk.

- BME is not responsible for any problems caused by circuits or diagrams described herein whose related industrial properties, patents, or other rights belong to third parties. The application circuit examples explain typical applications of the products, and do not guarantee the success of any specific mass-production design.