1.7MHz, 600mA synchronous step-down converter

FEATURES

- High Efficiency: Up to 95%
- 2.5V to 6V Input Voltage Range
- 600mA available Load Current
- 1.7MHz Constant Switching Frequency
- Output Voltage as Low as 0.6V
- 100% Duty Cycle in Dropout
- ON/OFF Control
- Cycle By Cycle Current Limit
- Auto Recovery Short Circuit Protection
- Thermal Fault Protection
- Input Under Voltage Lockout
- Integrated Soft-start
- <1uA Shutdown Current
- Space Saving 5-Pin SOT23 Package

APPLICATION

- Portable Instrument
- MP3 Players
- Digital Still and Video Cameras
- Microprocessors and DSP Core Supplies
- Cellular and Smart Phones
- PDA

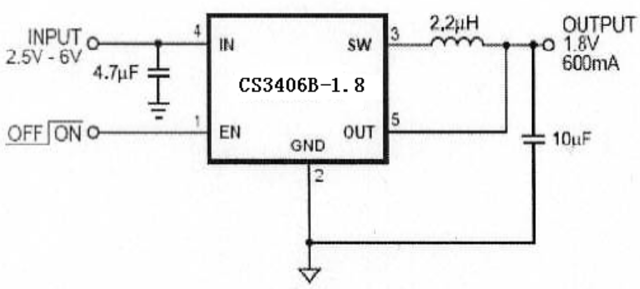
DESCRIPTION

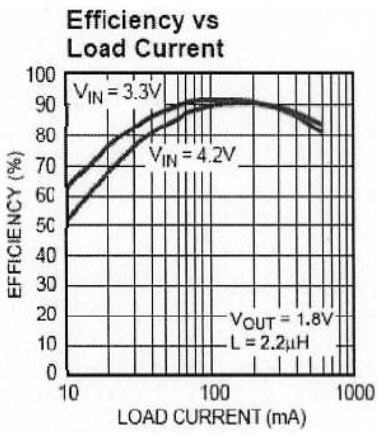
The **CS3406B** is a high efficiency synchronous rectifier current mode PWM regulator. The device is available in an adjustable version and fixed output voltages of 0.6V, 1.5V and 1.8V. The output of **CS3406B** is adjustable over a wide range of 0.6V to 6V. The load current is up to 600mA. The 2.5V to 6V input voltage range makes the CS3406B ideally suited for single Li-Ion battery-powered applications. 100%duty cycle provides low dropout operation, extending battery life in portable systems. PWM pulse skipping mode operation provides very low output ripple voltage for noise sensitive applications.

The **CS3406B** switches at a fixed 1.7MHz frequency which allows designers to use small, low cost inductor and capacitor. The internal synchronous switch increases efficiency and eliminates the need for an external Schottky diode.

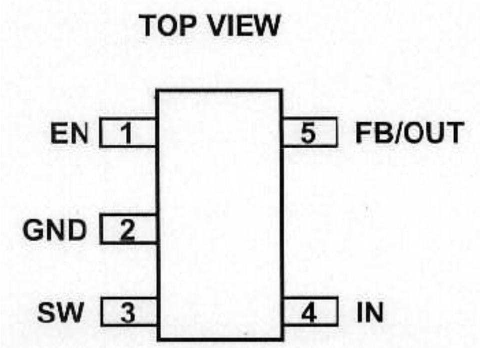
It is ideal for portable devices that driver by a single cell Lithium(Li+) battery.

TYPICAL APPLICATION





PACKAGE REFERENCE



ORDER INFORMATION

Part Number	Ambient Temp.	Output Voltage(V)	Package	Marking
CS3406B	-40℃--80℃	0.6---6	SOT-23	B06
CS3406B-1.5	-40℃--80℃	1.5	SOT-23	B15
CS3406B-1.8	-40℃--80℃	1.8	SOT-23	B18

PIN DESCRIPTIONS

Pin#	Name	Description
1	EN	Regulator Enable Control Input. Drive EN above 1.5V to turn on the CS3406B. Drive EN below 0.3V to turn it off (shutdown current <1uA).
2	GND	Ground.
3	SW	Power Switch Output. Inductor connection to drains of the internal PFET and NFET switches.
4	IN	Supply Input. Bypass to GND with a 2.2uF or greater ceramic capacitor.
5	FB	Feedback Input (CS3406B). Connect FB to the center point of the external resistor
5	OUT	Output Voltage Sense Input (CS3406B-1.5 and CS3406B-1.8). An internal resistor divider is connected to this pin to set the proper output voltage.

ABSOLUTE MAXIMUM RATINGS

Parameter	Min.	Max.	Unit
V_{IN} to GND	-0.3	+6.5	V
Vsw to GND	-0.3	Vin+0.3	V
V_{FB}, V_{EN} to GND	-0.3	+6.5	V
SW Peak Current		1.4	A
Junction Temperature		+150	℃
Lead Temperature		+260	℃
Storage Temperature	-65	150	℃

Notes: Exceeding these ratings may damage the device.

Recommended Operating Conditions

Parameter	Min.	Max.	Unit
Supply Voltage V_{IN}	2.5	6	V
Output Voltage V_{OUT}	0.6	6	V
Operating Temperature	-40	85	℃

Notes: The device is not guaranteed to function outside of its operating conditions.

ELECTRICAL CHARACTERISTICS

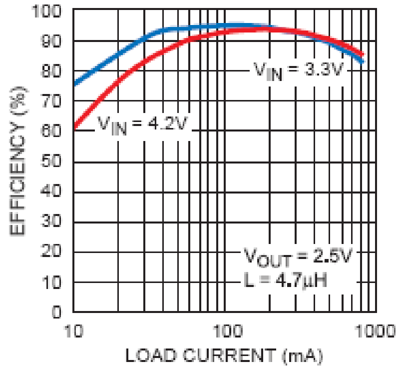
V_{IN}=V_{EN}=3.6V, T_A=+25℃, unless otherwise noted.

Parameter	Conditions	Min.	Type	Max.	Unit
Supply Current	V_{EN}=V_{IN},V_{FB}=0.65V		400	600	uA
Shutdown Current	V_{EN}=0V,V_{IN}=6V		0.01	1	uA
IN Under Voltage Lockout Threshold	Rising Edge	2.10	2.27	2.45	V
IN Under Voltage Lockout Hysteresis			55		mV
Regulated FB Voltage	TA=+25℃,CS3406B	0.588	0.600	0.612	V
	-40℃ ≤ T_A ≤ +85℃	0.582	0.600	0.618	
FB Input Bias Current	V_{FB}=0.65V,CS3406B	-50	0.5	+50	nA
Regulated Output Voltage	CS3406B-1.5 I_{OUT} = 50mA -40℃ ≤ T_A ≤ +85℃	1.455	1.500	1.545	V
	CS3406B-1.8 I_{OUT} = 50mA -40℃ ≤ TA ≤ +85℃	1.746	1.800	1.854	
PFET On Resistance	I_{SW} = 100mA		0.44		Ω
NFET On Resistance	I_{SW} = -100mA		0.29		Ω
SW Leakage Current	V_{EN} = 0V, V_{IN} = 6V V_{SW} = 0V or 6V	-1		+1	UA
Thermal Resistor	Junction To Case		110		℃/W
	Junction to Ambient		220		
PFET Current Limit	Duty Cycle = 100%, Current Pulse Width<1ms	0.7	1.0	1.35	A
Oscillator Frequency		1.26	1.70	2.08	MHz
Thermal Shutdown Trip Threshold			145		℃
EN Trip Threshold	-40℃ ≤ TA ≤ +85℃	0.3	0.96	1.5	V
EN Input Current	V_{EN} = 0V to 6V	-1		+1	uA

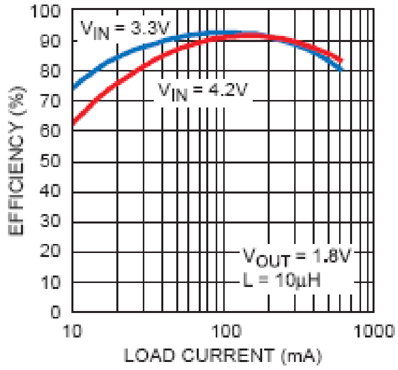
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN}=3.3V,V_{OUT}=1.8V,L1=10uH,C_{IN}=4.7uF,C_{OUT}=10uF,T_A=+25℃,unless otherwise noted

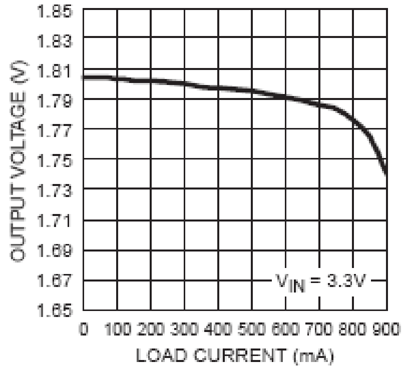
Efficiency vs Load Current



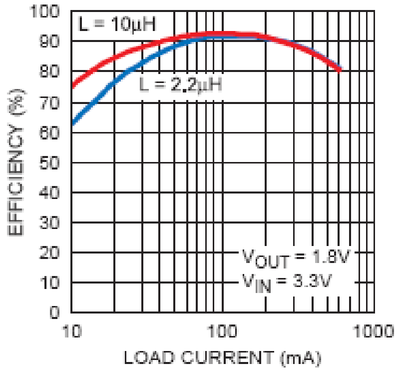
Efficiency vs Load Current



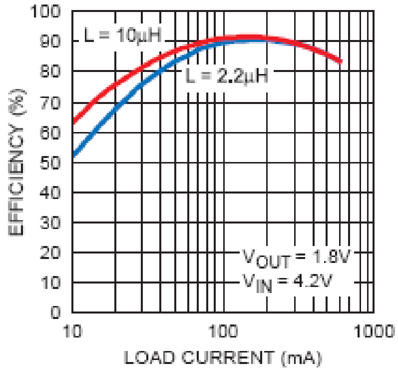
Output Voltage vs Load Current



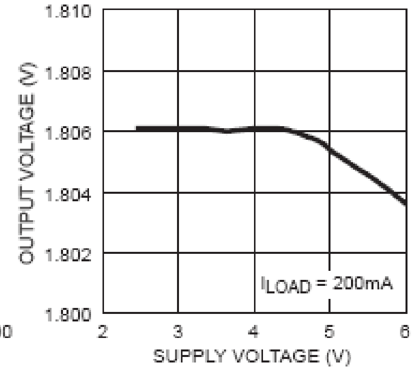
Efficiency vs Load Current



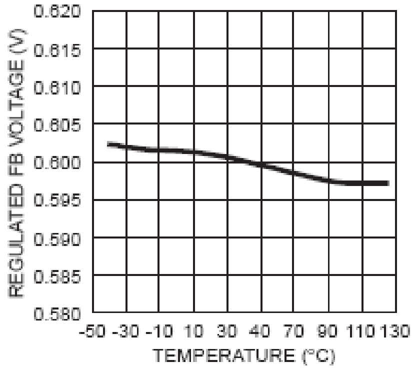
Efficiency vs Load Current



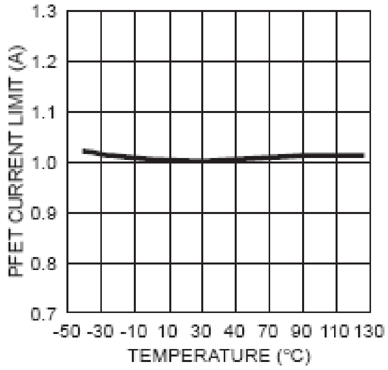
Output Voltage vs Supply Voltage



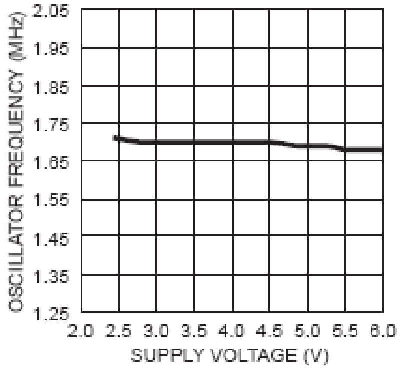
Regulated FB Voltage vs Temperature



PFET Current Limit vs Temperature



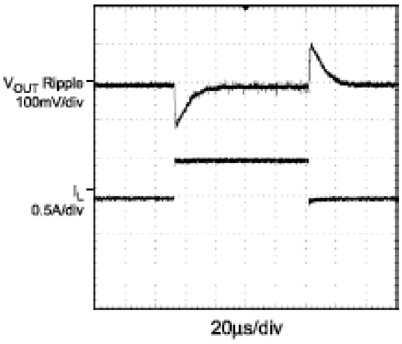
Oscillator Frequency vs Supply Voltage



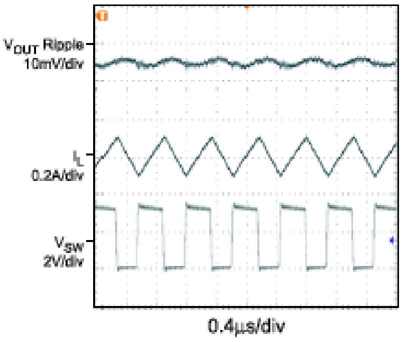
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN}=3.3V,V_{OUT}=1.8V,L1=10uH,C_{IN}=4.7uF,C_{OUT}=10uF,T_A=+25℃,unless otherwise noted

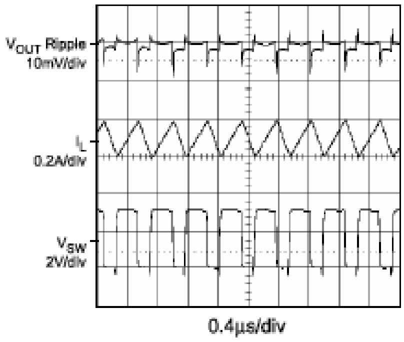
Load Transient
V_{IN} = 3.3V, V_{OUT} = 1.8V,
I_{LOAD} = 0 - 500mA Step



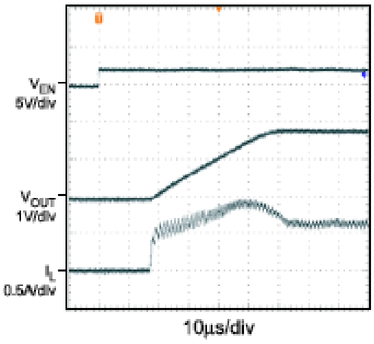
Light Load Operation
V_{IN} = 3.3V, V_{OUT} = 1.8V,
I_{LOAD} = 0A



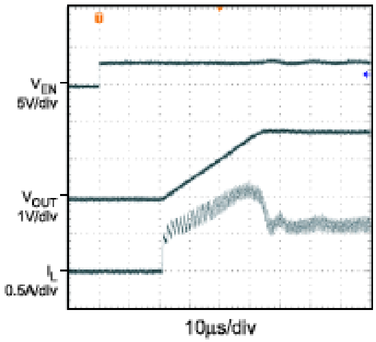
Heavy Load Operation
V_{IN} = 3.3V, V_{OUT} = 1.8V,
I_{LOAD} = 600mA



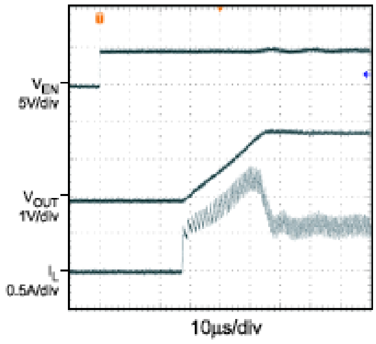
Startup from Shutdown
V_{IN} = 2.5V, V_{OUT} = 1.8V,
I_{LOAD} = 600mA Resistive



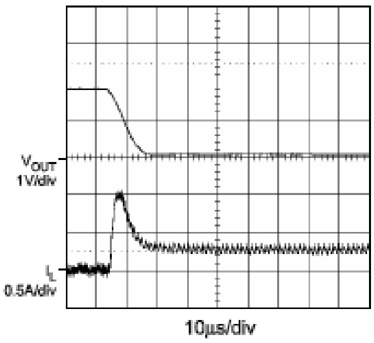
Startup from Shutdown
V_{IN} = 3.3V, V_{OUT} = 1.8V,
I_{LOAD} = 600mA Resistive



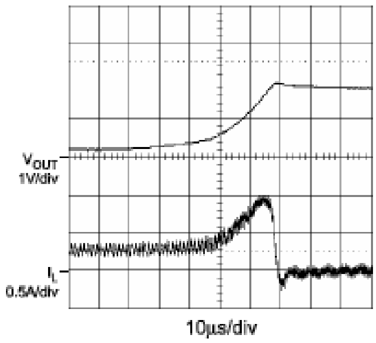
Startup from Shutdown
V_{IN} = 5V, V_{OUT} = 1.8V,
I_{LOAD} = 600mA Resistive



Short Circuit Protection
V_{IN} = 3.3V, V_{OUT} = 1.8V,
No Load



Short Circuit Recovery
V_{IN} = 3.3V, V_{OUT} = 1.8V,
No Load



FUNCTION BLOCK DIAGRAM

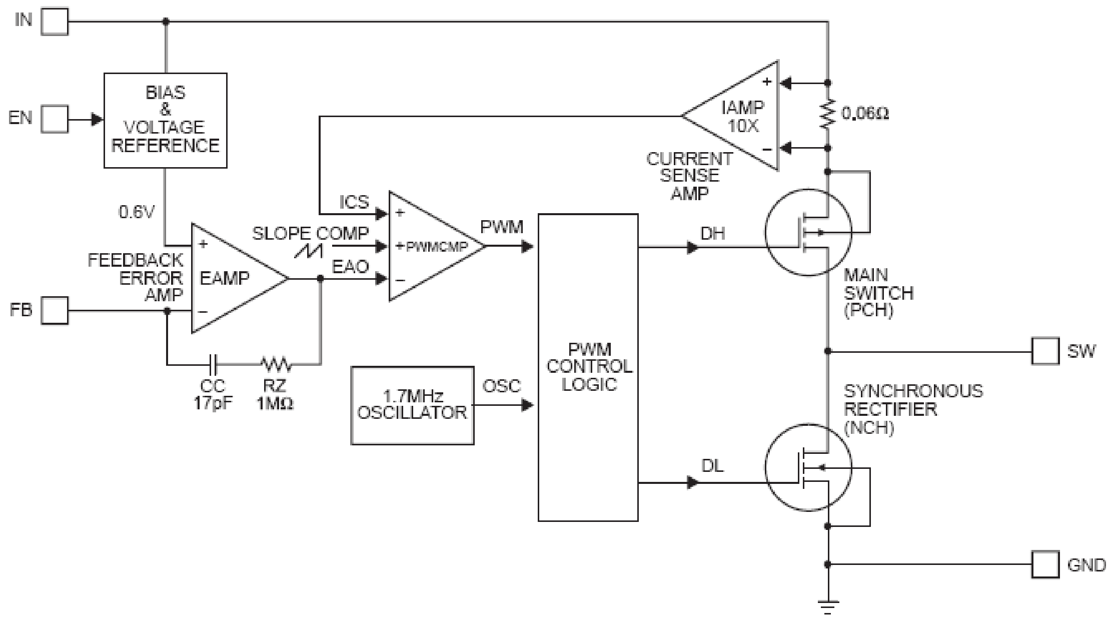


Figure 1: CS3406B Block Diagram

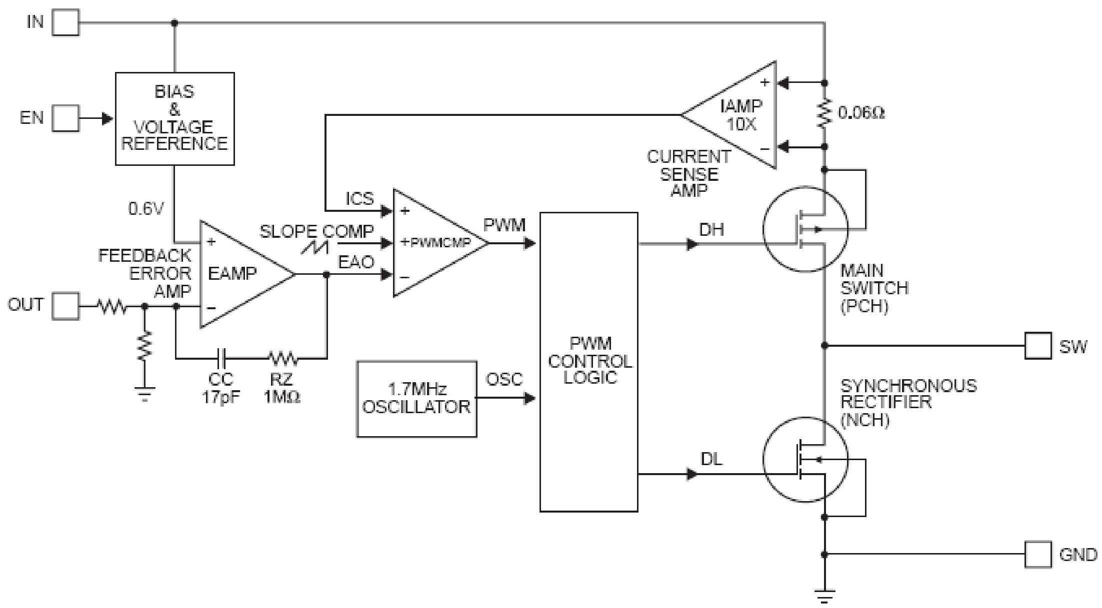


Figure 2: CS3406B-1.5/1.8 Block Diagram

FUNCTION DESCRIPTION

The CS3406B is a step-down, fixed 1.7MHz frequency, Synchronous rectifier converter. The output voltage of CS3406B can be regulated from 0.6V to Vin by external resistor divider. It integrates a main switch PFET and a synchronous rectifier NFET for high efficiency without a external Scottky.

Current Mode PWM Control

The CS3406B switches at 1.7MHz frequency and Regulates the output voltage. The PWM regulates the energy transferred to the output by changing the inductor current based on the feedback error voltage. At the rising edge of each cycle, the main Switch PFET is turned on and the inductor current ramps up until PWM comparator trips or the current limit is reached. After the main switch is turned off, the synchronous rectifier NFET is turned on, and the inductor current ramps down until the cycle ends. The CS3406B integrates slope compensation for more stable switching.

Short Circuit Protection

The CS3406B has short circuit protection. When the output is shorted to ground the oscillator frequency is reduced to prevent the inductor current from increasing beyond the PFET current limit. The PFET current limit is also reduced to lower the short circuit current. The frequency and current limit will return to the normal values once the short circuit condition is removed and the feedback voltage reached 0.6V.

Maximum Load current

The CS3406B can operate down to 2.5V input voltage, however the maximum load current decreases at lower input due to large IR drop on the main switch and synchronous rectifier. The slope compensation signal reduces the peak inductor current as a function of the duty cycle to prevent sub-harmonic oscillations at duty cycles greater than 50%. Conversely the current limit increases as the duty cycle decreases.
When Vin is approach to Vout, the duty cycle increases. The CS3406B can achieve 100% duty cycle. The duty cycle of a step-down converter is defined as:

$$D = T_{ON} \times f_{osc} \times 100\% \approx \frac{V_{OUT}}{V_{IN}} \times 100\%$$

Where Ton is the main switch on time, f_{osc} is the oscillator frequency (1.7MHz), Vout is the output voltage and V_{IN} is the input voltage.

ON/OFF Control

When EN Pin goes high, the internal function is Enable, and begin to start up. When it goes low, the CS3406B is disable.

Soft Start

CS3406B has an internal soft-start circuit that limits the in-rush current during start-up. This Eliminate the output voltage overshoot and prevent the possible input voltage drops.

Output Capacitor Selection

The output capacitor determines the output voltage ripple and transient response. Ceramic capacitor with X5R, X7R dielectrics are recommended because of low-ESR. The output ripple ΔV_{OUT} is approximately.

$$\Delta V_{OUT} \le \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times f_{osc} \times L} \times \left[ESR + \frac{1}{8 \times f_{OSC} \times C_{OUT}} \right]$$

Output Voltage setting (CS3406B)

The internal reference voltage is 0.6V. The output is set by a resistor divider. The feedback loop bandwidth with the internal compensation capacitor. (See figure 1.)

Choose R1 around 300kΩ for optimal transient Response. R2 is given by:

$$R2 = \frac{R1}{\frac{V_{OUT}}{0.6V} - 1}$$

Thermal Shutdown

When the junction temperature of the CS3406B reaches 145℃, the IC will shutdown for protection.

UVLO

The CS3406B is disable until the input voltage reaches 2.25V.

APPLICATION INFORMATION

Input Capacitor Selection

For best performance, a low-ESR capacitor is highly recommended. When the impendence of Capacitor is less than the input capacitor impedance, it prevents high switching noise passing to the input and reduces the surge current drawn from the input. Some capacitors with X5R,X7R dielectrics has very low ESR and small temperature coefficients. For most applications, a 4.7uF capacitor is sufficient.

PCB layout

The high frequency and high peak current paths demands careful PCB layout. The resistor that sets the output voltage should be routed away from the inductor to avoid RF coupling, and next to FB pin. For best performance, use wide, direct and short traces for high peak current paths such as IN, GND, SW.

Inductor Selection

The inductor parameters directly related to the device performance are saturation current and DC resistance. A 1uH to 10uH inductor with DC current at least 25% higher than the max. load current is recommended for most applications. The lower the DC resistance, the higher the efficiency. Recommended inductor and manufactures are list in Table 1:

For most designs, the inductance value can be derived from the following equation:

$$L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times \Delta I_L \times f_{OSC}}$$

Where ΔI_L is the inductor ripple current approximately 30% of the maximum load current, 600mA.

The maximum inductor peak current is:

$$I_{L(MAX)} = I_{LOAD} + \frac{\Delta I_L}{2}$$

In order to improve efficiency under light load current under 100mA, high inductance value is recommended. See Table 2 for reference.

APPLICATION INFORMATION

Table 1—Suggested Surface Mount Inductors

Manufacturer	Part Number	Inductance (μH)	Max DCR (Ω)	Saturation Current (A)	Dimensions LxWxH (mm^3)
Coilcraft	LP1704-222M	2.2	0.07	1.7	6.5x5.3x2
Toko	D312C	2.2	0.14	1.0	3.6x3.6x1
Sumida	CDRH3D16	2.2	0.072	1.2	4x4x1.8
Taiyo Yuden	LBC2518	2.2	0.13	0.6	2.5x1.8x1.8

Table 2—Inductor for Improved Efficiency under 100mA load

Manufacturer	Part Number	Inductance (μH)	Max DCR (Ω)	Saturation Current (A)	I_{RMS} (A)
Coilcraft	DO1605T-103MX	10	0.3	1.0	0.9
Murata	LQH4C100K04	10	0.2	1.2	0.8
Sumida	CMD4D06-100	10	0.3	0.7	0.5
Sumida	CR32-100	10	0.2	1.0	0.7
Sumida	CR54-100	10	0.1	1.2	1.4

Table 3—Resistor Selection vs. Output Voltage Setting

V_{OUT}	R1	R2
1.2V	300kΩ (1%)	300kΩ (1%)
1.5V	300kΩ (1%)	200kΩ (1%)
1.8V	300kΩ (1%)	150kΩ (1%)
2.5V	300kΩ (1%)	95.3kΩ (1%)

APPLICATION INFORMATION(PCB LAYOUT)

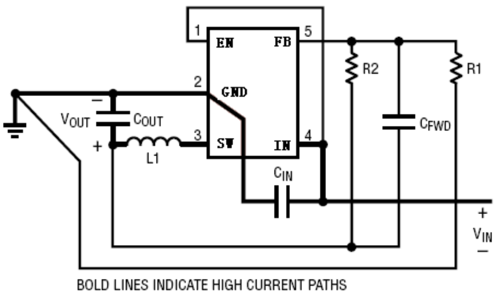


Figure 3a. CS3406B Layout Diagram

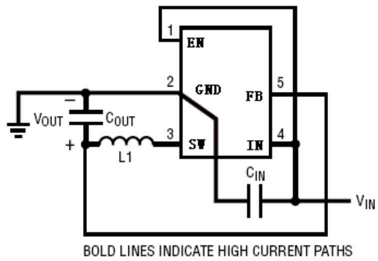


Figure 4a. CS3406B-1.8 Layout Diagram

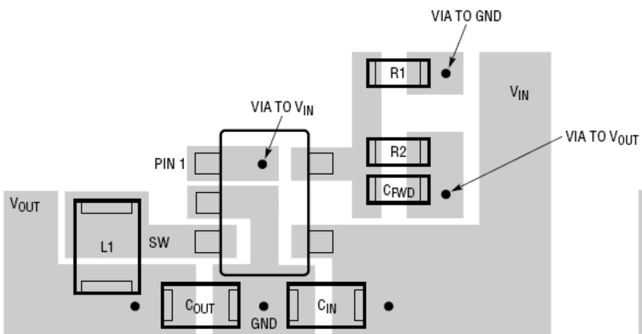


Figure 3b. CS3406B Suggested Layout

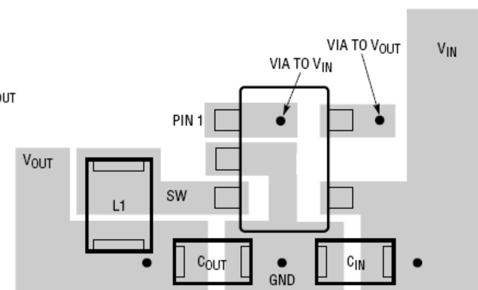


Figure 4b. CS3406B-1.8 Layout Diagram

TYPICAL APPLICATION

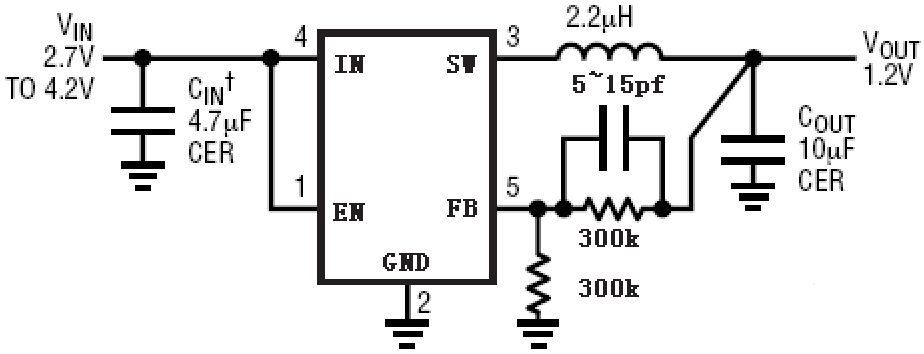
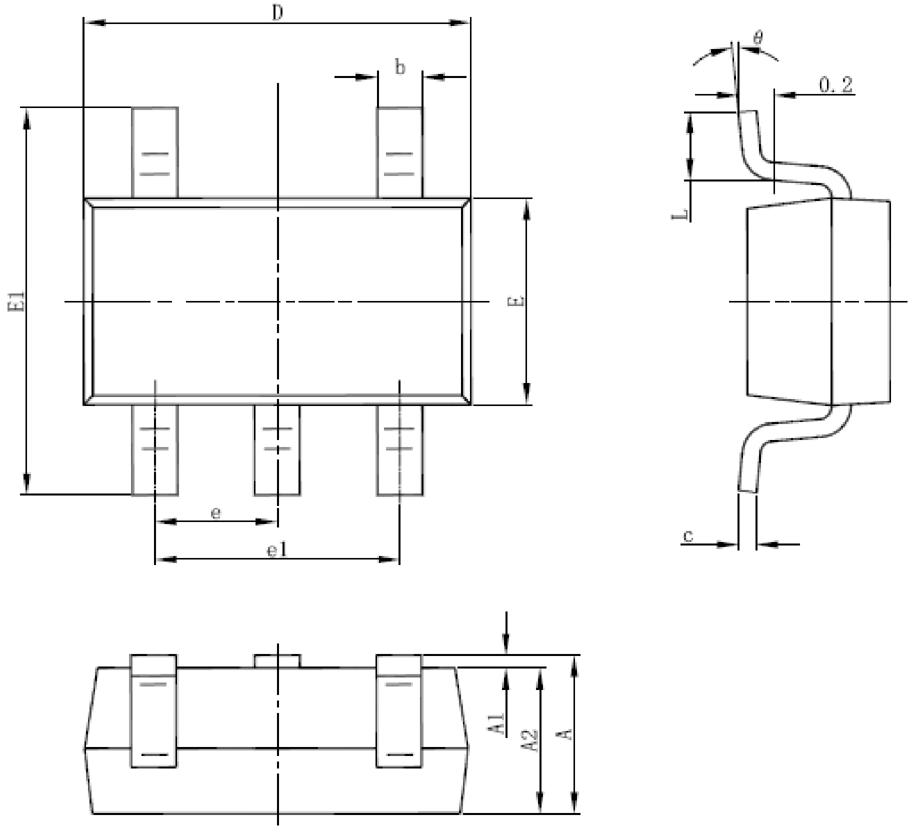


Figure 5. CS3406B Single Li-ion 1.2V/600mA Regulator for High Efficiency and Small Footprint

PACKAGE DESCRIPTION

SOT-23-5L PACKAGE OUTLINE DIMENSIONS



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	0.500	0.012	0.020
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	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

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