

## 400KHZ 2A STEP-DOWN DC-DC CONVERTER

### DESCRIPTION

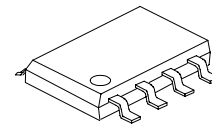
The SD46520 is a step-down PWM control converter with a built-in internal power MOSFET. It achieves 2A continuous output current over a wide input supply range with excellent load and line regulation.

Current mode operation provides fast transient response and eases loop stabilization.

It provides cycle-by-cycle current limiting and thermal shutdown. In shutdown mode, the current is only 23 $\mu$ A.

### FEATURES

- \* 2A output current
- \* 0.2 $\Omega$  internal power MOSFET
- \* Stable with low ESR output ceramic capacitor
- \* Up to 95% conversion efficiency
- \* shutdown mode
- \* 400kHz fixed frequency
- \* Thermal shutdown
- \* Cycle-by-cycle over current protection
- \* 4.75—18V input voltage range
- \* 1.22—16V output voltage range
- \* Programmable under voltage control



SOP-8-225-1.27

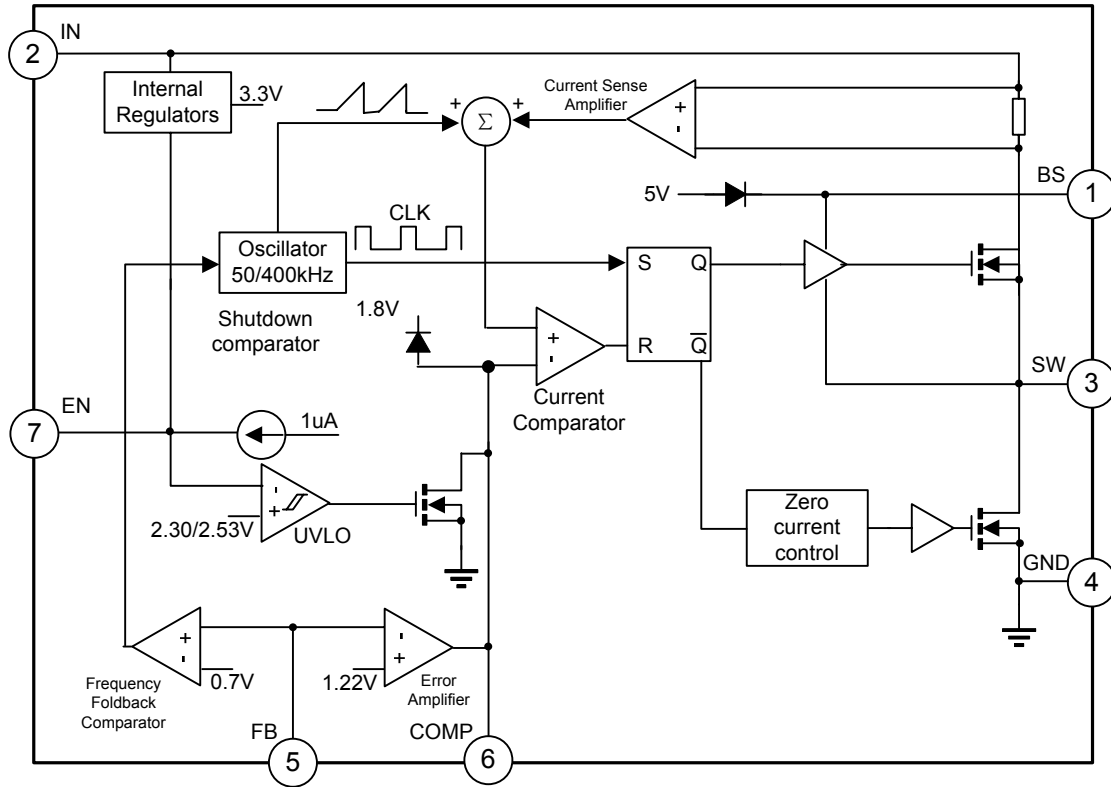
### ORDERING INFORMATION

Device	Package	Seal
SD46520	SOP-8-225-1.27	SD46520

### APPLICATIONS

- \* Distributed power system
- \* Battery charger
- \* TFT LCD Monitors
- \* Portable DVD
- \* Set-Top Box

**BLOCK DIAGRAM**



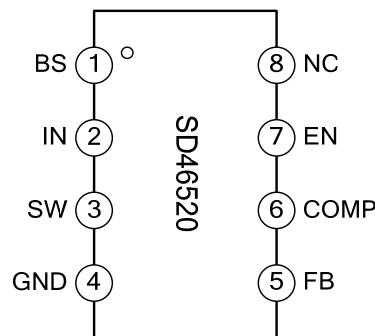
**ABSOLUTE MAXIMUM RATINGS**

Characteristics	Symbol	Ratings	Unit
Input Voltage	V <sub>IN</sub>	20	V
Switch Voltage	V <sub>SW</sub>	-1~V <sub>IN</sub> +1	V
Boost Voltage	V <sub>BS</sub>	V <sub>SW</sub> +6	V
Feedback Voltage	V <sub>FB</sub>	-0.3~6	V
Enable Voltage	V <sub>EN</sub>	-0.3~6	V
Comp Voltage	V <sub>COMP</sub>	-0.3~6	V
Junction Temperature	T <sub>j</sub>	150	°C
Lead Temperature	T <sub>L</sub>	260	°C
Storage Temperature	T <sub>stg</sub>	-65~150	°C

**ELECTRICAL CHARACTERISTICS** (Unless otherwise specified,  $V_{IN}=12V$ ,  $T_{amb}=25^{\circ}C$ )

Characteristics	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Feedback Voltage	VFB	$4.75 \leq V_{IN} \leq 18V$ $V_{COMP} < 2V$	1.220	1.244	1.268	V
Input Voltage	VIN		4.75		18	V
Upper Switch On Resistance	RONH		--	0.2	--	$\Omega$
Lower Switch On Resistance	RONL		--	10	--	$\Omega$
Upper Switch Leakage	ILEAK	$V_{EN}=0V$ ; $V_{SW}=0V$	--	0	10	$\mu A$
Current Limit	ILIM		2.4	2.85	3.3	A
Current Limit Gain. Output Current to Comp Pin Voltage	GCS		--	1.95	--	A/V
Error Amplifier Voltage Gain	Av		--	400	--	V/V
Error Amplifier Transconductance	Gm	$\Delta I_C = \pm 10\mu A$	500	770	1100	$\mu\Omega$
Oscillator Frequency	fs		360	400	440	KHz
Short Circuit Frequency	fsshort	$V_{FB}=0V$	46	58	70	KHz
Maximum Duty Cycle	Dmax	$V_{FB}=1.0V$	--	90	--	%
Minimum Duty Cycle	Dmin	$V_{FB}=1.5V$	--	--	5	%
Enable Threshold Voltage	VEN	$I_{CC} > 100\mu A$	0.7	1.0	1.3	V
Enable Pull-up Current	IENPUP	$V_{EN}=0V$	1.5	2.5	3	$\mu A$
Under Voltage Lockout Threshold Voltage	VUVLO		2.37	2.495	2.62	V
Under Voltage Lockout Threshold Hysteresis Voltage	VUVLOH		--	210	--	mV
Supply Current (Quiescent)	IIN1	$V_{EN} \leq 0.4V$	--	23	36	$\mu A$
Supply Current (Operating)	IIN2	$V_{EN} \geq 2.6V$ ; $V_{FB}=1.4V$	--	3	3.5	mA
Thermal Shutdown	TOT		--	180	--	$^{\circ}C$

**PIN CONFIGURATION**



**PIN DESCRIPTIONS**

Pin No.	Pin Name	I/O	Description
1	BS	I/O	Bootstrap pin. Connect 10nF capacitor to SW pin.
2	IN	I	Input supply voltage.
3	SW	I/O	Switch pin. Connect with inductor.
4	GND	G	Ground.
5	FB	I	Feedback voltage input pin.
6	COMP	I/O	Compensation pin.
7	EN	I	Enable input pin.
8	NC	I	No connection.

**FUNCTION DESCRIPTIONS**

SD46520 is a current mode DC-DC convertor with PWM control. The working process is as follows.

At the beginning of a cycle, the switching MOSFET is off, the freewheeling MOSFET is on, SW is connected to the ground; the external bootstrap capacitor between BS and SW is charged by 5V voltage via internal Schottky diode. The bootstrap capacitor voltage is used as the power supply of the driver of switch MOSFET to make it work normally.

When the bootstrap capacitor voltage is higher than the switching MOSFET's threshold voltage, the control loop circuit starts to work. The rising edge of the 400kHz clock signal sets the RS Flip-Flop. Its output turns on the switching MOSFET, the input supply is connecting to the output capacitor via the inductor, and the inductor current is increasing linearly and charges the output capacitor. The inductor current is sensed and amplified by the current sense amplifier. Ramp compensation is summed to current sense amplifier's output and compared to the error amplifier output by the current comparator.

When the sum of current sense amplifier's output plus slope compensation signal exceeds the comp pin voltage, the RS Flip-Flop is reset. If the sum of current sense amplifier's output plus slope compensation signal does not exceed the comp voltage during one cycle, the falling edge of the CLK resets the Flip-Flop. After RS Flip-flop is reset, the switching MOSFET is off, the freewheeling MOSFET is on, and the external Schottky diode is on at the same time which carries most of the inductor current, the inductor current decreases linearly. When the next rising edge of the clock arrives, sets the RS Flip-flop again, the switching MOSFET is on, which is cycled and the output capacitor is charged to the output voltage setting.

The voltage of COMP pin is the integral of the voltage difference between FB feedback voltage and 1.22V reference voltage. It is proportional to the peak inductor current. If COMP voltage increases, the inductor current and the output current also increase. When COMP voltage is rising to the high clamp voltage 2.3V, the output current is up to the limited value.

**Enable control**

Enable pin EN has the enable and under voltage lock two functions. When EN voltage is lower than 1V, the chip is off; when EN voltage is higher than 1V but lower than 2.495V, the chip is enable, while COMP is pulled down to the ground and the switching MOSFET is not working, so this is under voltage lock state; When EN voltage is

higher than 2.495V, the chip works normally.

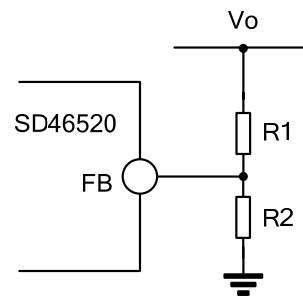
### Short protection

When the output voltage is short connected to the ground, FB feedback voltage is pulled down to the ground, and the oscillator frequency will decrease to 50kHz from normal 400kHz, which also decreases the inductor current average value, that is the output current is decreased.

## APPLICATION NOTE

### Output voltage setting

As right figure shows, the output voltage is determined by the feedback resistors ratio of R1 and R2. Generally, R2=10KΩ, R1 is decided by:  $R1=R2 \cdot (V_O/1.22-1)$ .



### Inductor selection

When output current is large, the regulator is working under continuous current mode that is inductor current is continuous and will not decrease to zero. The inductor value will affect the ripple of inductor current, and the relationship between them is as follows:

$$L = \frac{V_o \cdot (V_i - V_o)}{V_i \cdot f_s \cdot \Delta I}$$

Where,  $V_i$  is input voltage,  $V_o$  is output voltage,  $f_s$  is on-off frequency,  $\Delta I$  is the peak-peak value of inductor current ripple. In general,  $\Delta I$  is no larger than 30% of the maximum output current, thus to decide the inductor value.

At the same time, the peak inductor current should be less than 2.4A, the value is decided by:

$$I_{LMAX} = I_o + \frac{1}{2} \cdot \Delta I_L = I_o + \frac{1}{2} \cdot \frac{V_o \cdot (V_i - V_o)}{V_i \cdot f_s \cdot L}$$

### Input capacitor selection

The input current of step-down DC-DC is not successive, an additional input capacitor  $C_i$  is needed to keep input voltage stable. The input capacitor should be low ESR, and ceramic capacitor is the best choice, tantalum capacitor or low ESR electrolytic capacitor is all right. The input capacitor value should be larger than 10μF.

### Output capacitor selection

The output capacitor  $C_o$  is decided by the ripple requirement of output voltage. The output voltage ripple is decided by:

$$\Delta V_o = \Delta I_L \left( ESR + \frac{1}{8f_s \cdot C_o} \right)$$

Where,  $\Delta V_O$  is output voltage ripple,  $\Delta I_L$  is inductor current ripple, ESR is the equivalent serial resistor of output capacitor.

### The freewheeling diode selection

Select the schottky diode as freewheeling diode to reduce the loss caused by forward voltage drop of the diode. At the same time, the maximum current of schottky should be higher than 2.4A.

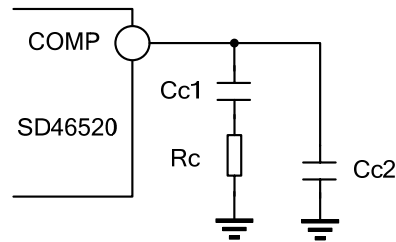
### Compensation network

The resistor-capacitor compensation network connected to COMP pin make sure the stability of the control loop circuit.

As the right figure:

The DC gain of the control loop is:

$$A_{VDC} = \frac{V_{FB}}{V_O} \cdot A_{VEA} \cdot G_{CS} \cdot R_L$$



Where,  $V_{FB}$  is feedback voltage, 1.22V;  $V_O$  is setting output voltage;  $A_{VEA}$  is the voltage gain of error amplifier, 400V/V;  $G_{CS}$  is the trans-conductance of current sense (about the value of the output current divided by COMP pin voltage), 1.95A/V;  $R_L$  is load resistor.

The control loop has two poles of importance.

The first pole  $P_1$  is decided by the following formula:  $f_{P1} = \frac{1}{2\pi \cdot R_{OEA} \cdot C_{C1}}$ ,

where,  $R_{OEA} = \frac{A_{VEA}}{G_{EA}}$ ,  $G_{EA}$  is the trans-conductance of error amplifier, 770uA/V.

The second pole  $P_2$  is decided by:  $f_{P2} = \frac{1}{2\pi \cdot R_L \cdot C_O}$ .

The control loop has a main zero  $Z_1$ , which is decided by:  $f_{Z1} = \frac{1}{2\pi \cdot R_C \cdot C_{C1}}$ .

When the output capacitor ESR is large, another zero  $Z_2$  is introduced which is decided by:

$$f_{Z2} = \frac{1}{2\pi \cdot ESR \cdot C_O}$$

At this time, it needs to add another compensation capacitor  $C_{C2}$  to introduce an additional pole  $P_3$  compensate

this zero, and this pole is decided by:  $f_{P3} = \frac{1}{2\pi \cdot R_C \cdot C_{C2}}$

The system crossover frequency  $f_c$  is very important. If it's too high, it will cause the system unstable. If it's too low, it will slower the system transient response. In general,  $f_c$  is about 1/8~1/10 of the switch frequency.

Use the following procedure to choose the value of the compensation components.

First, according to the selected crossover frequency  $f_c$ , choose the value of compensation resistor  $R_c$ :

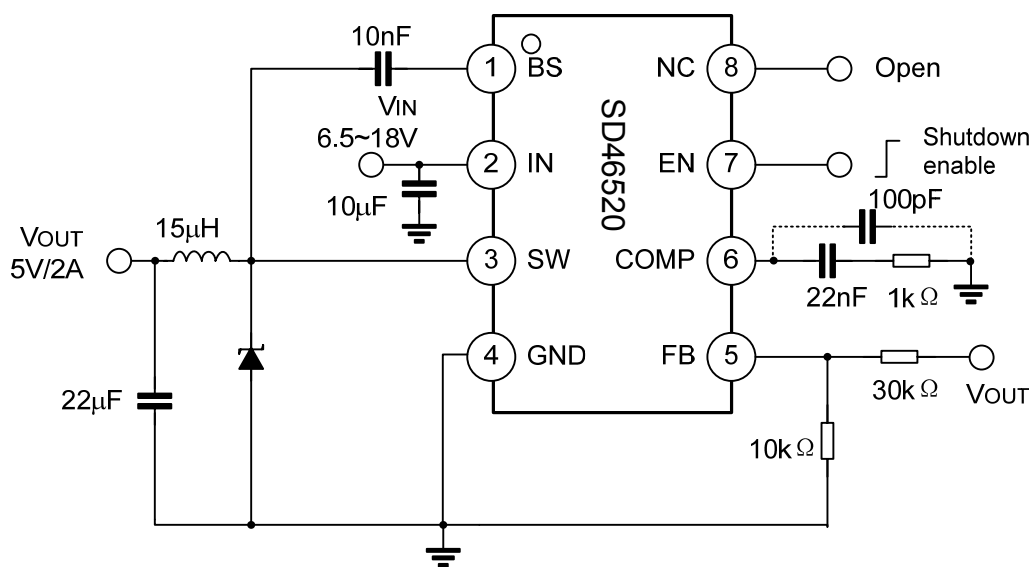
$$R_C = \frac{2\pi \cdot C_O \cdot V_O \cdot f_C}{G_{EA} \cdot G_{CS} \cdot V_{FB}}$$

Second, select Z1 as about 1/5~1/4 of crossover frequency to confirm the compensation capacitor Cc1

$$\text{value: } C_{C1} = \frac{1}{2\pi \cdot R_C \cdot f_{Z1}}$$

When compensation capacitor Cc2 is needed, the value of it is decided by:  $C_{C2} = \frac{ESR \cdot C_O}{R_C}$ .

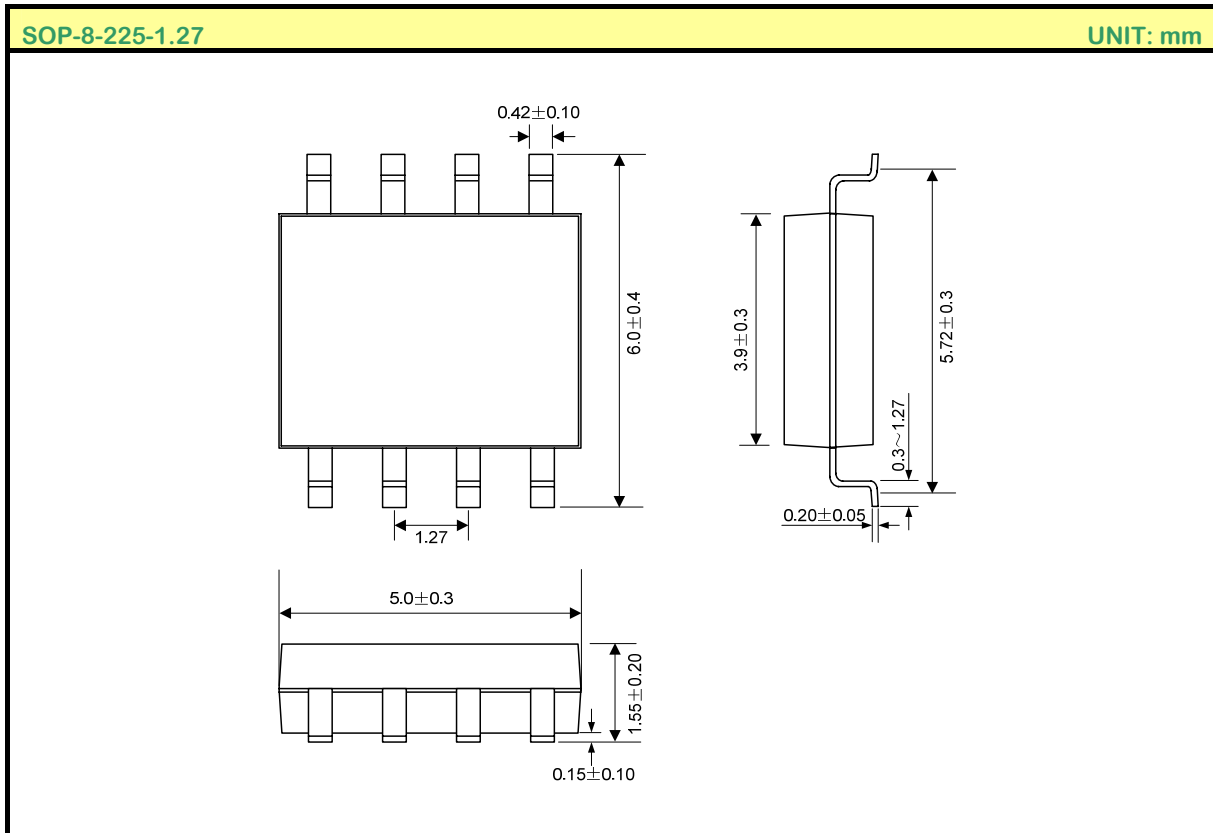
### TYPICAL APPLICATION CIRCUIT



**PACKAGE OUTLINE**

SOP-8-225-1.27

UNIT: mm



**MOS DEVICES OPERATE NOTES:**

Electrostatic charges may exist in many things. Please take following preventive measures to prevent effectively the MOS electric circuit as a result of the damage which is caused by discharge:

- The operator must put on wrist strap which should be earthed to against electrostatic.
- Equipment cases should be earthed.
- All tools used during assembly, including soldering tools and solder baths, must be earthed.
- MOS devices should be packed in antistatic/conductive containers for transportation.

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