

# SC8703 High Efficiency, Synchronous Buck-Boost Controller

## 1 Description

The SC8703 is a synchronous 4-switch buck-boost controller. It is able to effectively output voltage no matter it is higher, lower or equal to the input voltage.

The SC8703 supports very wide input and output voltage range. It can support applications from 2.7V to 36V input range. The driver voltage is set to 10V to fully utilize external MOSFETs for highest efficiency.

The SC8703 supports input current limit, output current limit, dynamic adjustable input power, internal current limit, short current protection and over temperature protections to ensure safety under different abnormal conditions.

The SC8703 adopts 32 pin QFN 4x4 package.

## 2 Features

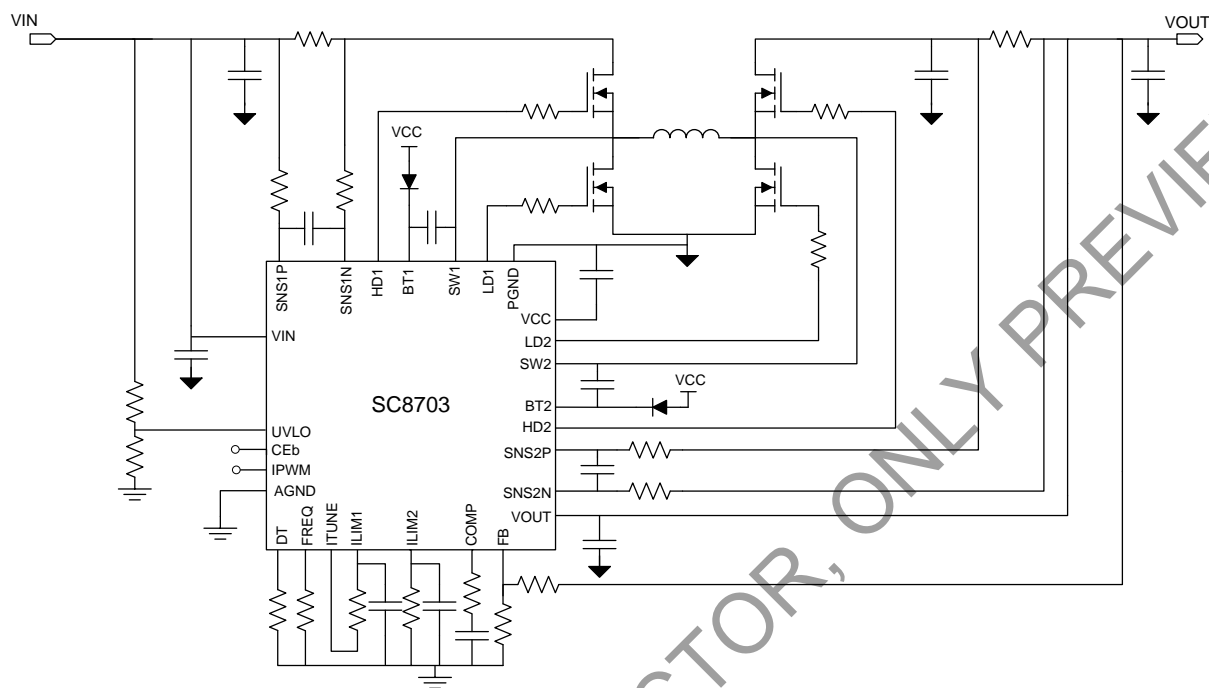
- High efficient buck-boost operation
- Wide input voltage range: 2.7 V to 36 V
- Wide output range: 2.5V to 36V
- Integrated 10V, 2A gate driver
- Adjustable frequency 200kHz to 600kHz
- Internal Inductor current limit
- Dynamic adjustable Input and Output current limit
- Auto PFM mode in light load
- Under voltage protection
- QFN-32 Package

## 3 Applications

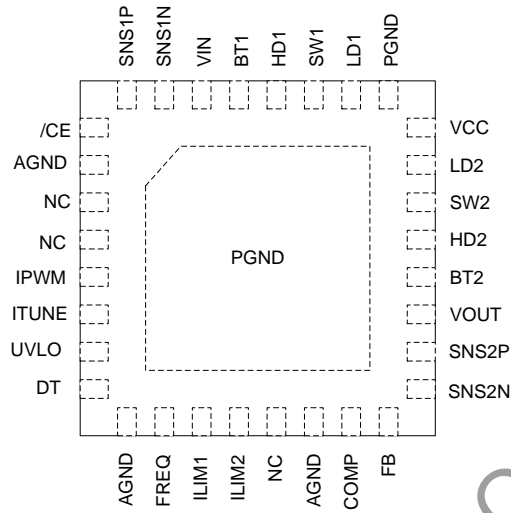
- Smart USB Socket
- USB PD
- USB HUB
- Car Charger
- Industrial applications

## 4 Device Information

ORDER NUMBER	PACKAGE	BODY SIZE
SC8703QDER	32 pin QFN	4mm x 4mm x 0.75mm



## 6 Terminal Configuration and Functions



TERMINAL		I/O	DESCRIPTION
NUMBER	NAME		
1	/CE	I	Chip Logic Enable, CE=Low, chip enable. Internal pull low
2	AGND	IO	Analog ground.
3	NC	I	Floating.
4	NC	I	Floating.
5	IPWM	I	<p>IPWM pin is used together with ITUNE pin to adjust the current limit value of either ILIM1 or ILIM2. The ITUNE pin is used to select the control object between ILIM1 and ILIM2, and IPWM signal is to adjust the limit value.</p> <p>IPWM pin accepts PWM waveform from 20kHz to 100kHz, and the current limit value is proportional to its duty cycle.</p> <p>For example, if ITUNE pin selects ILIM1, then the input current limit is set by:</p> $I_{IN} = I_{LIM1\_SET} \times D$ <p>In the equation above, <math>I_{LIM1\_SET}</math> is the current limit value set by the resistor at ILIM1 pin, D is the duty cycle of the IPWM signal.</p> <p>Similarly, if ITUNE pin selects ILIM2, then the output current limit is set by:</p> $I_{OUT} = I_{LIM2\_SET} \times D$
6	ITUNE	IO	<p>ITUNE pin selects the IPWM control object between ILIM1 and ILIM2. .</p> <p>If ILIM1 current limit needs to be controlled, connect the ILIM1 resistor between ILIM1 pin and ITUNE pin. If ILIM2 current limit is to be controlled, connect the ILIM2 resistor between ILIM2 pin and ITUNE pin.</p> <p>Only one current limit can be selected by ITUNE pin.</p> <p>If IPWM function is not needed, leave ITUNE pin and IPWM pin floating, and connect the ILIMx resistor from the ILIMx pin to AGND accordingly.</p>
7	UVLO	I	Under voltage protection threshold setting pin. Connect to a resistor divider with reference voltage 1.22V. If this pin voltage is lower than 1.22V, the IC doesn't work.

8	DT	I	Dead Time selection. Short to ground: 20ns; 68kΩ: 40ns; 270kΩ: 60ns; Open: 80ns
9	AGND	IO	Analog ground.
10	FREQ	I	Frequency selection Short to ground: 200kHz; 68kΩ: 400kHz; Open: 600kHz
11	ILIM1	I	<p>Connect a resistor to set the current limit value of input current.</p> $I_{LIM1\_SET} = \frac{V_{REF}}{R_{ILIM1}} \times \frac{R_{SS1}}{R_{SNS1}}$ <p><math>V_{REF}</math> is the internal reference voltage 1.21V;  <math>R_{ILIM1}</math> is the resistor from ILIMT1 to ground or to ITUNE;  <math>R_{SNS1}</math> is the current sense resistor. Recommended 5mΩ-20mΩ, typical 10mΩ;  <math>R_{SS1}</math> are the resistors connected to SNS1P, SNS1N. The two resistors must be equal and the recommended value is 1kΩ.  A 2.2nF capacitor to ground is needed to bypass noise. If IPWM function is applied to ILIM1, increase the capacitor value to 10nF. If current limiting function is not needed, please short ILIM1 to ground.</p>
12	ILIM2	I	<p>Connect a resistor to set the current limit value of output current.</p> $I_{LIM2\_SET} = \frac{V_{REF}}{R_{ILIM2}} \times \frac{R_{SS2}}{R_{SNS2}}$ <p><math>V_{REF}</math> is the internal reference voltage 1.21V;  <math>R_{ILIM2}</math> is the resistor from ILIM2 to ground or to ITUNE;  <math>R_{SNS2}</math> is current sensing resistor. Recommended 5mΩ-20mΩ, typical 10mΩ;  <math>R_{SS2}</math> are the resistors connected to SNS2P, SNS2N. The two resistors must be equal and the recommended value is 1kΩ.  A 2.2nF capacitor to ground is needed to bypass noise. If IPWM function is applied to ILIM2, increase the capacitor value to 10nF. If current limiting function is not needed, please short ILIM2 to ground.</p>
13	NC	I	Floating
14	AGND	IO	Analog Ground
15	COMP	O	Compensation for the control loop.
16	FB	I	<p>Feedback for output voltage.</p> $V_{OUT} = V_{REF} \times \left(1 + \frac{R_{UP}}{R_{DOWN}}\right)$ <p><math>V_{REF}</math> equals to 1.22V. <math>R_{UP}</math> and <math>R_{DOWN}</math> are the value of voltage divider.</p>
17	SNS2N	I	Negative input of current sense amplifier. Connect an external current sense resistor between SNS2P and SNS2N. Current flows from SNS2P to SNS2N.
18	SNS2P	I	Positive input of current sense amplifier. Connect an external current sense resistor between SNS2P and SNS2N. Current flows from SNS2P to SNS2N.

19	VOUT	I	Output node of the converter.
20	BT2	PWR	Connect a capacitor between BT2 pin and SW2 pin to bootstrap a voltage to provide the bias voltage for high side MOSFET gate driver2.
21	HD2	PWR	High side MOSFET gate driver2 output
22	SW2	PWR	Switching Node 2
23	LD2	PWR	Low side MOSFET gate driver2 output
24	VCC	PWR	Output of internal regulator to provide 10V voltage for the bias voltage of internal gate drivers. Connect a 1 $\mu$ F ceramic capacitor from VCC to PGND pin.
25	PGND	PWR	Power Ground
26	LD1	PWR	Low side MOSFET gate driver1 output
27	SW1	PWR	Switching Node 1
28	HD1	PWR	High side MOSFET gate driver1 output
29	BT1	PWR	Connect a capacitor between BT1 pin and SW1 pin to bootstrap a voltage to provide the bias voltage for high side MOSFET gate driver1.
30	VIN	I	Input node of the converter
31	SNS1N	I	Negative input of current sense amplifier. Connect an external current sense resistor between SNS1P and SNS1N. Current flows from SNS1P to SNS1N.
32	SNS1P	I	Positive input of current sense amplifier. Connect an external current sense resistor between SNS1P and SNS1N. Current flows from SNS1P to SNS1N.
	Thermal Pad		For thermal dissipation. Connect to AGND or PGND.

## 7 Specifications

### 7.1 Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted) <sup>(1)</sup>

		MIN	MAX	UNIT
Voltage range at terminals <sup>(2)</sup>	VIN, VOUT, SNS1P, SNS1N, SNS2P, SNS2N, /CE	-0.3	42	V
	SW1, SW2	-1	42	V
	VCC, IPWM, UVLO	-0.3	20	V
	FREQ, ILIM1, ILIM2, COMP, DT, FB, ITUNE	-0.3	5.5	V
	LD1, LD2	-0.3	12	V
	BT1, HD1 to SW1	-0.3	12	V
	BT2, HD2 to SW2	-0.3	12	V
	BT1, BT2	-0.3	50	V
Temperature Range	Operating Junction, T <sub>J</sub>	-40	150	°C
	Storage temperature range, T <sub>stg</sub>	-65	150	°C

(1) 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-rated conditions for extended periods may affect device reliability.

(2) All voltage values are with respect to network ground terminal.

### 7.2 Thermal Information

THERMAL RESISTANCE <sup>(1)</sup>		QFN-32 (4mm x 4mm)	UNIT
Θ <sub>JA</sub>	Junction to ambient thermal resistance	35	°C/W
Θ <sub>JC</sub>	Junction to case resistance	7	°C/W

(1) Measured on JESD51-7, 4-layer PCB.

### 7.3 Handling Ratings

PARAMETER	DEFINITION	MIN	MAX	UNIT
ESD <sup>(1)</sup>	Human body model (HBM) ESD stress voltage <sup>(2)</sup>	-2	2	kV
	Charged device model (CDM) ESD stress voltage <sup>(3)</sup>	-750	750	V

(1) Electrostatic discharge (ESD) to measure device sensitivity and immunity to damage caused by assembly line electrostatic discharges into the device.

(2) Level listed above is the passing level per ANSI, ESDA, and JEDEC JS-001. JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(3) Level listed above is the passing level per EIA-JEDEC JESD22-C101. JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 7.4 Recommended Operating Conditions

		MIN	TYP	MAX	UNIT
V <sub>IN</sub>	Input voltage range	2.7		36	V
V <sub>OUT</sub>	Output voltage range	2		36	V
C <sub>IN</sub>	Input Capacitance	30			μF
C <sub>OUT</sub>	Output capacitance	30			μF

L	Inductance	2.2		10	$\mu\text{H}$
$R_{\text{SNS}1/2}$	Current Sensing Resistor	5		20	$\text{m}\Omega$
$f_{\text{sw}}$	Operating frequency range	200		600	$\text{kHz}$
$f_{\text{PWM}}, f_{\text{IPWM}}$	PWM signal frequency range	20		100	$\text{kHz}$
$D_{\text{PWM}}, D_{\text{IPWM}}$	PWM signal duty cycle range	0		100	%
$T_{\text{J}}$	Operating junction temperature	-40		125	$^{\circ}\text{C}$

## 7.5 Electrical Characteristic

$T_J = 25^{\circ}\text{C}$  and  $V_{IN} = 12\text{V}$ ,  $V_{OUT} = 5\text{V}$ ,  $R_{SS1} = R_{SS2} = 1\text{k}\Omega$  unless otherwise noted.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SUPPLY VOLTAGE (VIN, VOUT)						
VIN	Operating voltage		2.7		36	V
VOUT	Operating voltage		2.5		36	V
Iq	Standby current into VIN or VOUT pin (whichever is higher)	/CE = low, controller non-switching		0.7	2	mA
ISD	Shutdown current into VIN or VOUT pin (which is higher)	/CE = high		6	10	μA
	Shutdown current into VIN or VOUT pin (which is lower)	/CE = high			2	μA
VCC AND DIRVER						
VCC	VCC clamp voltage		9.4	10	10.6	V
IVCC_LIM	VCC current limit	VCC = 2V ~10V	50	75	100	mA
RHVx_pu	High side driver pull up resistor			1.5		Ω
RHVx_pd	High side driver pull down resistor			1		Ω
RLVx_pu	Low side driver pull up resistor			1.5		Ω
RLVx_pd	Low side driver pull down resistor			1		Ω
ERROR AMPLIFIER						
VFB_REF	FB reference voltage		1.214	1.22	1.226	V
VILIMx_REF	ILIMx reference voltage		1.196	1.212	1.228	V
VUVLO_REF	UVLO reference voltage		1.196	1.226	1.244	V
GMEA	Error amplifier gm			0.16		mS
ROUT	Error amplifier output resistance <sup>(1)</sup>			20		MΩ
IBIAS(FBx)	FBx pin input bias current	FBx in regulation			100	nA
CURRENT LIMIT						
ILIMx	ILIMx current limit accuracy	IN_LIM RSNS1 ≥ 30 mV IOUT_LIM RSNS2 ≥ 30 mV	-5%		5%	
SWITCHING FREQUENCY						
fsw	Switching frequency	RFREQ = 0Ω	180	210	240	kHz
		RFREQ = 68kΩ (±10%)	360	410	460	kHz
		RFREQ = 270kΩ (±10%)	540	600	660	kHz
LOGIC CONTROL						
RPD	/CE internal pull down resistor			1		MΩ
	IPWM pin internal pull down resistor			1		MΩ
VIL	/CE, PWM, IPWM input low voltage				0.4	V
VIH	/CE, PWM, IPWM input high voltage		1.2			V
Soft Start						
tss	Internal soft-start time	From /CE low to 90% VOUT		8	15	ms
THERMAL SHUTDOWN						
TSD	Thermal shutdown temperature <sup>(1)</sup>			165		°C
	Thermal shutdown hysteresis <sup>(1)</sup>			15		°C



- (1) Guarantee by design

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## 8 Detailed Description

The SC8703 is a synchronous four-switch buck-boost controller with a wide 2.7V to 29V input/output voltage range. The SC8703 also supports input/output current limit.

### 8.1 VOUT voltage setting (FB)

The VOUT voltage is set by external resistor divider at FB pin and is calculated as:

$$V_{OUT} = V_{FB\_REF} \times \left(1 + \frac{R_{UP}}{R_{DOWN}}\right) \text{ Where:}$$

$V_{FB\_REF}$  = Internal reference voltage 1.22V

$R_{UP}$  and  $R_{DOWN}$  = Resistor divider at FB connected to VOUT and AGND.

### 8.2 Input/output current setting (ILIMx)

The SC8703 can adjust the current limit of both input side and output side by resistors at ILIM1 and ILIM2 pins.

Control Pins	Description
ILM1	Set the input current limit ( $I_{IN\_LIM}$ )
ILM2	Set the output current limit ( $I_{OUT\_LIM}$ )

The SC8703 senses the input and output current by monitoring  $R_{SNS1}$  and  $R_{SNS2}$  respectively as below figure shows.

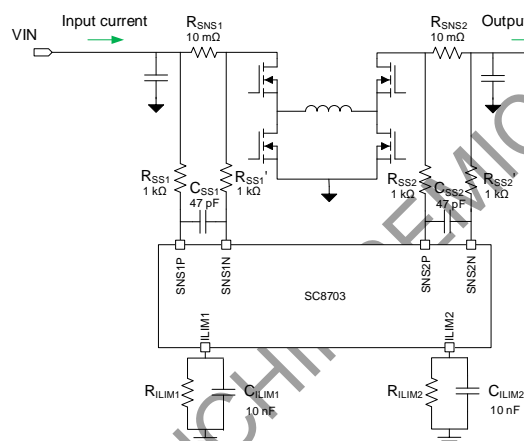


Figure 3 Input/output current monitoring circuit

$R_{SNSx}$  is the current sense resistor (x means 1 or 2) at input/output. The SC8703 monitors the voltage across the sense resistors  $R_{SNSx}$  through  $R_{SSx}$  and  $R_{SSx'}$  and calculates the input and output current.  $C_{SSx}$  is the filter capacitor and typically 47pF is sufficient.

The ILIMx pin is used to set the current limit. Connect the  $R_{ILIMx}$  resistor between ILIMx pin and GND (or ITUNE pin if IPWM function is used).

The current limit is calculated as:

$$I_{IN\_LIM} = \frac{V_{LIM\_REF}}{R_{ILIM1}} \times \frac{R_{SS1}}{R_{SNS1}}$$

$$I_{OUT\_LIM} = \frac{V_{LIM\_REF}}{R_{ILIM2}} \times \frac{R_{SS2}}{R_{SNS2}}$$

Where:

$V_{LIM\_REF}$  = Internal reference voltage 1.21V;

$R_{ILIMx}$  = Resistors at ILIMx pin;

$R_{SNSx}$  = Current sense resistors;

$R_{SSx}$  = Resistors between current sense resistor and the SC8703 pins (SNSxP, SNSxN).

$R_{SNS1}$  should be placed between MOSFET and input capacitor.  $R_{SNS2}$  can be placed either between the MOSFET and output capacitor or behind the output capacitor.

$R_{SS1}$  and  $R_{SS1'}$  should have the same value;  $R_{SS2}$  and  $R_{SS2'}$  also the same. Typically 1kΩ resistor is used.

If  $R_{SNSx}$  is changed,  $R_{SSx}/R_{SNSx}$  values need to be adjusted accordingly with below calculation:

$$\frac{R_{SNSx}}{R_{SSx}} = \frac{10 \text{ m}\Omega}{1 \text{ k}\Omega}$$

For example, If  $R_{SNSx}$  is 20mΩ, then  $R_{SSx}/R_{SNSx}$  should be 2kΩ; if  $R_{SNSx}$  is 5mΩ, then  $R_{SSx}/R_{SNSx}$  should be 500Ω.

If both VIN and VOUT current limits are programmed, the SC8703 controls the current which reaches its current limit first.

If the input/output current limit is not required, connect ILIM1/ILIM2 pin to GND.

### 8.3 Real-Time current control (IPWM)

The SC8703 is able to control the input/output current dynamically by applying a PWM signal to IPWM pin.

The IPWM signal should be in the range of 20kHz ~ 100kHz, and the input/output current is proportional to its duty cycle as:

$$I_{LIMx} = I_{LIM\_SET} \times D$$

Where:

$I_{LIM\_SET}$  =  $I_{LIMx}$  Input or output current limit value (x=1: input, x=2: output);

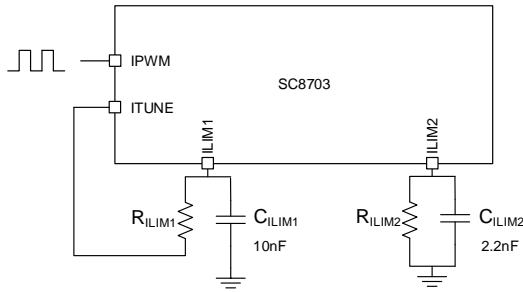
D = IPWM duty cycle;

$I_{LIMx}$  = Target current limit of input/output current.

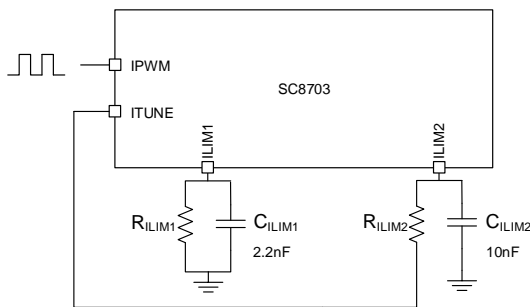
ITUNE pin selects the target which is controlled by IPWM. If input current should be controlled, the resistor at ILIM1 should be connected between ILIM1 and ITUNE pins; If output current should be controlled, the resistor at ILIM2 should be connected between ILIM2 and ITUNE pins.

Only one target can be selected by ITUNE pin.

Refer to Figure 2. IPWM real-time input/output current control.



a. IPWM controls input current,  $ILIM1 = ILIM1\_set \times D$ , as above



b. IPWM controls output current,  $ILIM2 = ILIM2\_set \times D$ , as above

Figure 2. IPWM real-time input/output current control.

When the IPWM signal is logic high, which means the duty cycle is 100%, the current limit is then the  $ILIMx$  set value.

For the  $ILIMx$  pin which is controlled by IPWM signal, its filter capacitor should still be connected to ground. If the IPWM frequency is low, higher capacitance should be applied. For example, 22nF capacitor is suggested for 20kHz frequency.

If real-time current control is not required, connect  $ILIMx$  resistor to GND and float IPWM and ITUNE pins.

Do not leave IPWM pin float if the ITUNE pin is connected to one  $ILIMx$  resistor; otherwise, the SC8703 cannot operate normally.

It is not allowed to set any of the current limits to 0A. Keep the minimum current limit above 0.3A.

#### 8.4 Under voltage protection(UVLO)

SC8703 supports under voltage protection function. Set the minimum operation voltage by the resistor divider connected at UVLO pin. When IC detects the voltage of UVLO pin is higher than reference voltage 1.226V, the IC starts switching.

The minimum input voltage can be set as below:

$$VIN\_min = V_{UVLO\_REF} \times \left(1 + \frac{R_{UP}}{R_{DOWN}}\right)$$

Where:

$V_{UVLO\_REF}$  is the internal reference voltage 1.226V.  $R_{UP}$  and  $R_{DOWN}$  is the resistor divider.

If this function is not required, connect this pin to VCC.

#### 8.5 PFM Mode

SC8703 will enter into PFM mode automatically to reduce quiescent current when working under light load condition. In PFM mode, the ripple of output is larger than PWM mode and the switching frequency is changed according to the load. Audible noise might be generated when the switching frequency enters in audio frequency range. To reduce the noise, MLCC capacitor is not suggested to use for the input capacitor or output capacitor. Solid states capacitor or tantalum capacitor will help reduce the voltage ripple and reduce the noise effect.

#### 8.6 Chip Enable (/CE)

The SC8703 is enabled or disabled by /CE signal. When /CE input is "L", the SC8703 is enabled; when /CE input is "H", the SC8703 is disabled

#### 8.7 Switching frequency setting (FREQ)

The switching frequency can be set by resistor connected at FREQ pin as below:

FREQ resistor	Switching frequency $f_{sw}$
0Ω	200kHz
68kΩ (±10%)	400kHz
Open	600kHz

The accuracy of the resistor is allowed to be ±10%. The switching frequency will not change in real time; the new setting will be applied in next power on cycle.

#### 8.8 Dead time setting (DT)

The one of four dead times is selectable by resistor value at DT pin:

DT resistor	Dead time
0Ω	20ns
68kΩ (±10%)	40ns
270kΩ (±10%)	60ns
Open	80ns

The accuracy of the resistor at DT is allowed ±10%. DT does not support the real-time change and new resistor value change will be applied in next turn on.

When driving large power MOSFET with high  $C_{iss}$  value, or adding driver resistors at LDx or HDx to adjust the MOSFET turning on/off time, it is suggested to check and change the dead time to prevent MOSFET shoot-through.

#### 8.9 VCC driver voltage

The SC8703 generates the driver voltage VCC internally. The VCC is selected higher voltage between VIN and VOUT, and clamped to 10V if the higher voltage is above 10V.

The driving signal LDx to drive low side MOSFET (Q2 and Q3) is directly supplied from VCC; the driving signal HDx to

drive high side MOSFET (Q1 and Q4) is supplied by the bootstrap circuit with bootstrap capacitor between BTx and SWx.

### 8.10 Feedback compensation (COMP)

The feedback loop can be compensated by adjusting the external components to the COMP pin. Typically, the values in Figure 4 are used. If faster loop response is required, user can increase the resistor to like 10kOhm or 20kOhm. After changing the compensation, check and make sure the loop is stable under the application operation conditions.

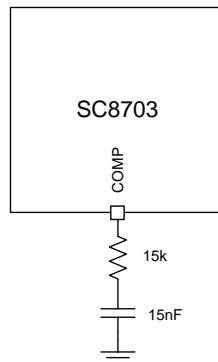


Figure 4 Feedback loop compensation setting

## 9 Application Information

### 9.1 Input and output capacitor selection

The switching frequency of the SC8703 is in the range of 200kHz ~ 600kHz. Since MLCC ceramic capacitor has good high frequency filtering with low ESR, above 60μF X5R or X7R capacitors with higher voltage rating than operating voltage with margin is recommended. For example, if the highest operating  $V_{in}$  or  $V_{out}$  voltage is 12V, select at least 16V capacitor and to secure enough margin, 25V voltage rating capacitor is recommended.

The high capacitance electrolytic capacitor and tantalum capacitor can be used for stable input and output but capacitor voltage rating should be higher than the highest operating voltage. When the tantalum capacitor is used, at least 1μF ceramic capacitor is placed in parallel. If the electrolytic capacitor is used, much more ceramic capacitors are required. For example, if a 47μF electrolytic capacitor is used, the ceramic capacitors' capacitance is allowed to reduce to 30μF ~ 40μF. Even higher capacitance electrolytic capacitor is used, at least 20μF ceramic capacitor is required.

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### 9.2 Inductor selection

For the SC8703 system stability, the inductance of 2.2μH ~ 10 μH inductor is required. High inductance (4.7μH ~ 10μH) is used in the system where the input voltage and output voltage difference is big, such as 5V  $V_{in}$  and 20V  $V_{out}$  or the switching frequency is low; Low inductance (2.2μH) is used in the system which the input voltage and output voltage difference is small but high current is required. Typically, 3.3μH inductor is recommended. The inductance can be adjusted for high efficiency and optimization in application.

The inductor DC resistance value (DCR) affects the conduction loss of switching regulator, so around 10mΩ DCR is recommended for the first selection. If the power is relatively small, high DCR inductor can be selected. But if switch current is high, just like around 10A, then select the lowest DCR inductor as much as possible because 10mΩ DCR also causes 1W power loss.

The inductor saturation current  $I_{SAT}$  should be higher than input / output current with sufficient margin.

### 9.3 Current sense resistor

The RSNS1 and RSNS2 are current sense resistors and 5mΩ ~ 20mΩ resistor value is recommended.

Higher resistor value leads to higher current limit accuracy but using higher resistor value in high current application causes higher conduction loss. Typically, 10mΩ is recommended. Resistor value can be adjusted depending on current limit and target power efficiency. If  $R_{SNSx}$  valued is adjusted, related  $R_{SSx}$  value should be adjusted simultaneously.

Please refer to [8.2 Input/output current setting \(ILIMx\)](#) for proper  $R_{SNSx}$  and  $R_{SSx}$  values. The resistor power rating and temperature coefficient should also be considered. The power dissipation is roughly calculated as  $P=I^2R$ , and  $I$  is the highest current flowing through the resistor. The resistor power rating should be higher than roughly calculated power dissipation. The resistor value can be varied if the temperature increased and the variation is decided by temperature coefficient along with temperature change. If high accuracy of current limit is required, select lower temperature coefficient resistor as much as possible.

### 9.4 MOSFET selection

The SC8703 is a synchronous 4-switch buck-boost controller and it requires 4 NMOS for power switching circuit.

The  $V_{DS}$  of MOSFET should be higher than the highest operating voltage with enough margin (recommend more than 10V higher). For example, if the highest operating voltage is 20V, at least 30V rated  $V_{DS}$  MOSFET should be selected; If the highest operating voltage is 24V, 40V  $V_{DS}$  voltage rating should be selected.

In the application, if the input and output voltage are higher than 10V, driver circuit voltage can reach 10V, and  $V_{GS}$  voltage rating of MOSFET should be selected higher than ±10V.

Considering PCB parasitic parameters during operation, driver voltage can be higher than VCC due to transient overshoot, and ±20V  $V_{GS}$  is recommended to secure sufficient margin.

The MOSFET current  $I_D$  should be higher than the highest input and output current with enough margin.

To ensure the sufficient current capability in relatively high temperature circumstance, the current rate at  $T_A=70^{\circ}\text{C}$  or  $T_C=100^{\circ}\text{C}$  should be considered. In addition, the power dissipation value  $P_D$  should also be considered and higher  $P_D$  is better in applications. Make sure that MOSFET power consumption must not exceed  $P_D$  value.

The MOSFET  $R_{DS(ON)}$  and input capacitor  $C_{ISS}$  impact power efficiency directly. Typically, lower  $R_{DS(ON)}$  MOSFET has higher  $C_{ISS}$ . The  $R_{DS(ON)}$  is related to conduction loss. Higher  $R_{DS(ON)}$  results in higher conduction loss, thus lower efficiency and higher thermal dissipation; the  $C_{ISS}$  is related to MOSFET switch on/off time, and longer on/off time results

in higher switching loss and lower efficiency. The proper MOSFET should be selected based on tradeoff between the  $R_{DS(ON)}$  and  $C_{ISS}$ .

Normally, if the output power is around 20W ~ 30W, the MOSFET with around  $10m\Omega$  of  $R_{DS(ON)}$  and lower than 1000pF of  $C_{ISS}$  is recommended. If the output power is increased, the MOSFET with lower  $R_{DS(ON)}$  and under 2000pF  $C_{ISS}$  is recommended. The highest  $C_{ISS}$  is suggested not to exceed 3000pF.

If high  $C_{ISS}$  MOSFET is selected, the switching on and off time become longer, then the dead time should be adjusted with DT pin to avoid simultaneous turn on for both high side and low side MOSFETs.

### 9.5 Driver resistor and SWx snubber circuit

For a convenient adjustment of MOSFET switching time and transient overshoot at EMI debugging, recommend to add 0603 series resistor between driver pins (LD1, LD2, HD1, HD2) and MOSFET Gate pins, and add RC snubber (0603) circuit at SW1 and SW2 (refer to Figure 5 Driver resistor and SWx snubber circuit)

The driver resistor should be placed near to MOSFET Gate

pin. At first, add  $0\Omega$  and adjust the resistor value appropriately within  $10\Omega$ . After increasing the driver resistor value, the on time of high side and low side MOSFET should be monitored. If the dead time is insufficient, adjust dead time accordingly.

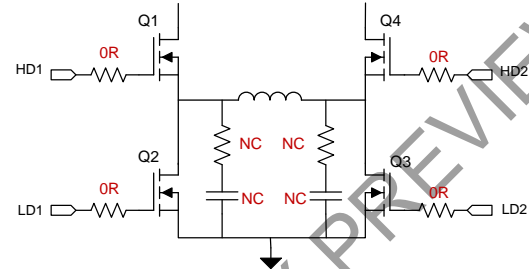
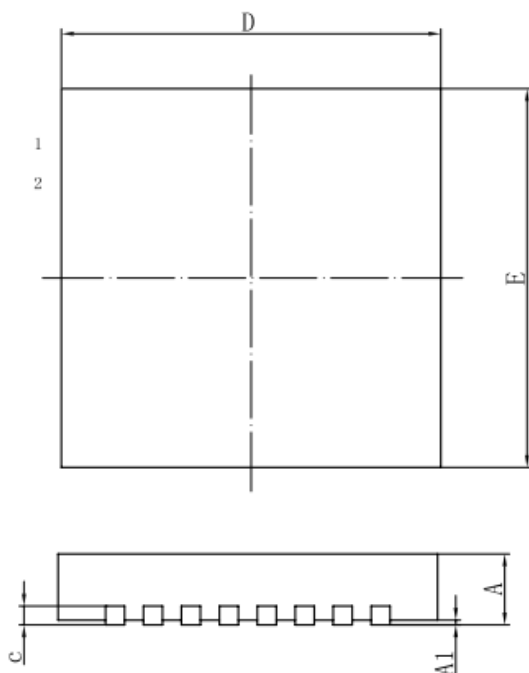


Figure 5 Driver resistor and SWx snubber circuit

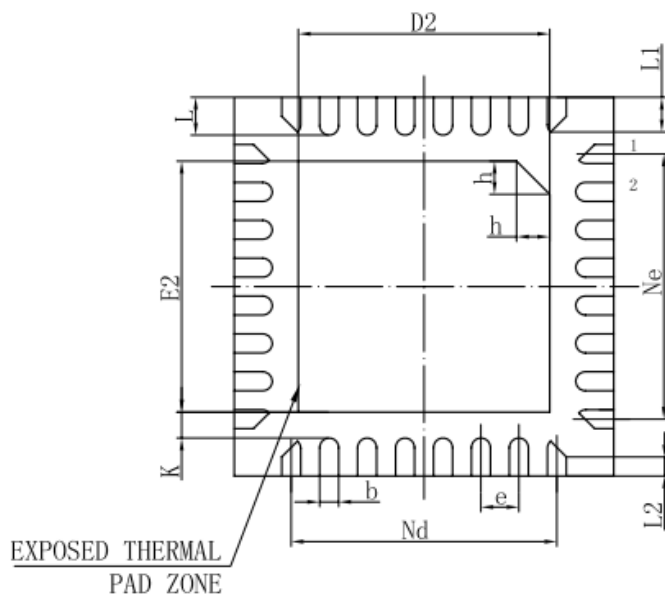
The RC snubber circuit is required when the overshoot at SWx needs to be suppressed. Leave RC snubber circuit as NC at the first time

## Packaging Information

QFN32L(0404x0.75-0.40)



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0	0.02	0.05
b	0.15	0.20	0.25
c	0.18	0.20	0.25
D	3.90	4.00	4.10
D2	2.60	2.65	2.70
e	0.40BSC		
Nd	2.80BSC		
E	3.90	4.00	4.10
E2	2.60	2.65	2.70
Ne	2.80BSC		
K	0.20	-	-
L	0.35	0.40	0.45
L1	0.30	0.35	0.40
L2	0.15	0.20	0.25
h	0.30	0.35	0.40
L/P 载体尺寸 (mm)	112*112		



BOTTOM VIEW