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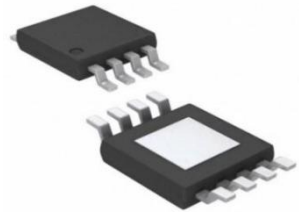
SCM1302A High-Efficiency Wide Input-Voltage-Range 2A Buck Regulator

Features

- 4.5V to 40V Input Range
- Output Current up to 2 A
- 100mΩ High-Side MOSFET
- Minimum On Time: 102ns
- Peak Current Mode Control
- Adjustable Switching Frequency from 200kHz to 1.5MHz
- Internal Soft-Start
- 2μA Shutdown Current
- Under-voltage Lockout, Over-current Protection, and Thermal Protection
- eSOP-8 Package

Packaging



Product Package: eSOP-8

(see “Ordering information” for details)

Application

- Automotive Battery Regulation
- Industrial Power Supplies
- Telecom and Datacom Systems
- Battery-Powered Systems

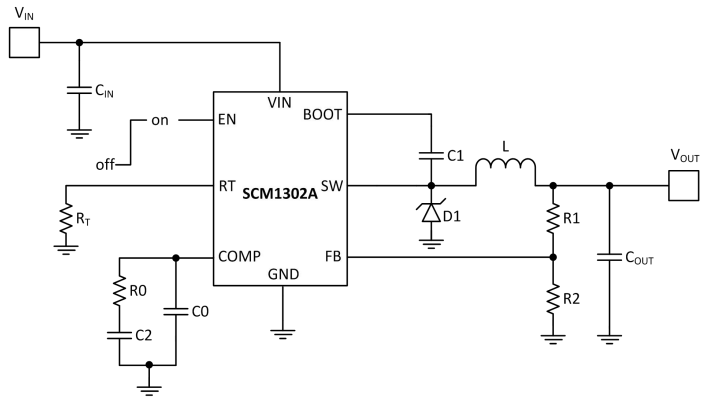
Description

The SCM1302A is a step-down regulator. With a wide input range 4.5 V to 40 V, it is suitable for a wide range of applications from industry to automotive. An ultra-low shutdown current (Typ=2μA) prolongs the battery life. A wide adjustable switching frequency range allows either efficiency or external component size to be optimized. Soft start is implemented internally, and this allows the device to be used with minimum external components .

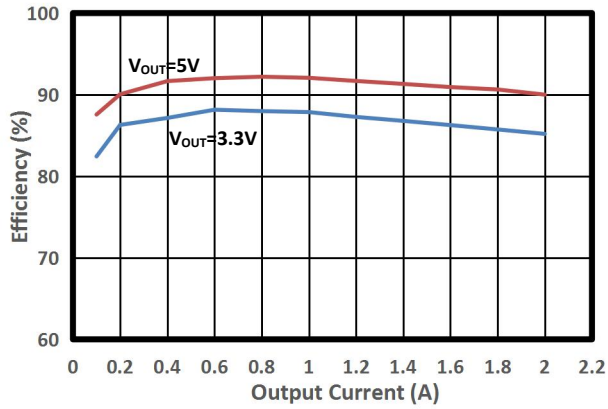
The SCM1302A is optimized for up to 2 A load current, and has a 0.75 V nominal feedback voltage.

The device has built-in thermal protection and short protection, and is available in the eSOP-8 package (4.9mm × 6.0mm ×1.5mm) .

Simplified Schematic



Efficiency vs. Output Current
(V_{IN}=12V, f_{sw}=500kHz)



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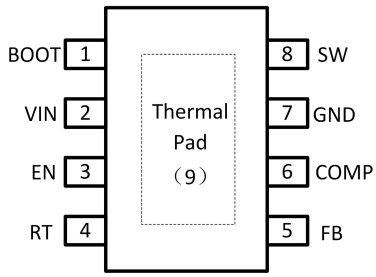
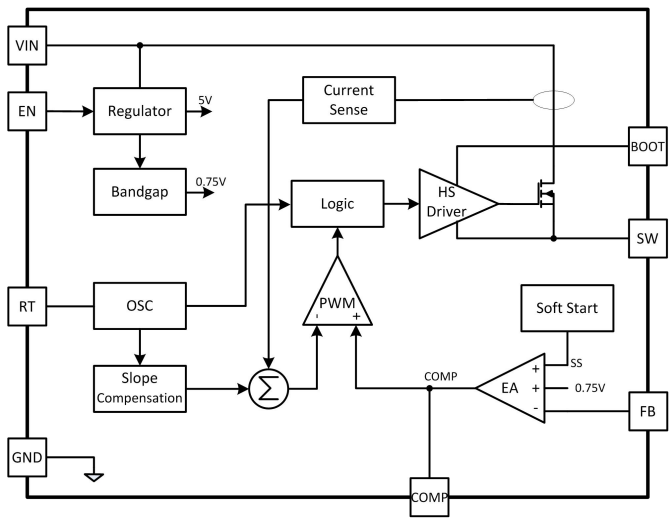
Contents

Pins

eSOP-8 package
(Top view)



Functional Block Diagram



Pin Description

Pin No.	Pin Name	I/O	DESCRIPTION
1	BOOT	I	Bootstrap capacitor connection for high-side MOSFET driver. Connect C1 cap between BOOT and SW.
2	VIN	I	Power input voltage pin.
3	EN	I	Enable and disable input pin. Pulling this pin below the specified threshold shuts the device down. Pulling it up above the specified threshold or leaving it floating enables the device.
4	RT	I	Switching frequency program input. Connect a resistor from this pin to ground to set the switching frequency, and the device operates at 500kHz when leaving it floating.
5	FB	I	Feedback Pin. Set feedback voltage divider ratio with $V_{OUT} = V_{FB}$ (1+(R1/R2)).
6	COMP	I	Compensation. External capacitor-resistor combination sets the compensation net.
7	GND	G	Ground pin.
8	SW	O	Switching node. Connect to inductor, diode and C1 cap.
9	Thermal PAD	G	Major heat dissipation path of the die. Must be connected to ground plane on PCB.

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Absolute Maximum Ratings

General test conditions: free-air, normal operation temperature range (unless otherwise noted).

Parameters		MIN	MAX	UNIT
Input Voltages	VIN ,EN to GND	-0.3	44	V
	BOOT to GND	-0.3	49	
	FB,COMP,RT to GND	-0.3	6	
Output Voltages	BOOT to SW	-0.3	6	V
	SW to GND	-1	44	
Operating junction temperature	T_J	-40	150	℃
Storage temperature range	T_{STG}	-55	150	
Lead Temperature, Soldering for 10 seconds	Distance 0.6mm from case		260	
Moisture sensitivity level	MSL	MSL3		
Electrostatic discharge (ESD)	Human body model (HBM)	2000		V
	Charged device model (CDM)	1000		

Note: Stresses at or beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. Exposure to absolute maximum rated conditions for extended periods may affect device reliability. All voltage values are based on the ground.

Recommended Operating Conditions

T_A=+25℃, unless otherwise noted.

Parameters		MIN	MAX	UNIT
Buck regulator	VIN	4.5	40	V
	BOOT	0	45	
	BOOT to SW	0	5	
	SW	-0.7	40	
	COMP	0	5	
	FB	0	5	
Control	EN	0	40	V
	RT	0	5	
Frequency	Frequency range using external resistor	200	1500	kHz
Temperature	T_J	-40	125	℃

Electrical Characteristics

T_A=+25℃ , V_{IN}=12V , V_{EN}=V_{IN} , unless otherwise noted.

Symbol	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
VIN (INPUT POWER SUPPLY)						
V_{IN}	Operating input voltage		4.5		40	V
I_{SHDN}	Shutdown supply current			2	5	μA
V_{UVLO}	Under-voltage lockout thresholds	Rising			4.4	V
		Hysteresis		0.3		V
I_Q	Quiescent current	Power-down Mode, not switching, V_{FB}>0.8V		56		μA
ENABLE (EN PIN)						
V_{EN}	EN Threshold Voltage	Rising			2.5	V
		Falling	0.8			
I_{EN}	EN PIN current	V_{EN}=0		0.3		μA
VOLTAGE REFERENCE (FB PIN)						
V_{FB}	Feedback voltage		0.735	0.75	0.765	V
HIGH-SIDE MOSFET						
R_{DSON_H}	On-resistance	V_{IN}=12V , BOOT - SW =5V		100	180	mΩ
I_{LIMIT}	Current limit threshold	V_{IN}=12V		3.2		A
SWITCHING CHARACTERISTICS						
f_{SW}	Switching frequency	R_T=49.9kΩ , 1% accuracy	400	500	600	kHz
t_{ON-MIN}	Minimum on time(1)	V_{IN}=12V , BOOT - SW =5V , I_{LOAD} =1A		102		ns
D_{MAX}	Maximum duty cycle(1)			93		%
THERMAL PERFORMANCE						
$T_{SHUTDOWN}$	Thermal shutdown threshold(1)	Rising		170		℃
T_{HYS}	Hysteresis(1)			10		℃

Note(1): Guaranteed by design.

Thermal Information

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PARAMETER(1)		数值	UNIT
Junction to ambient thermal resistance	θ_{JA}	50	℃/W
Junction to top characterization parameter	Ψ_{JT}	10	℃/W

Note(1): All numbers apply for packages soldered directly onto a 7.62cm x 7.62cm PC board with 4 layers in still air.

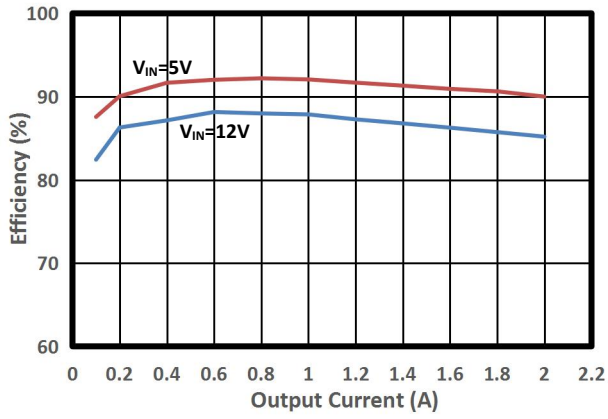

Figure 1. Efficiency vs. Load Current
(V_{OUT}=3.3V , f_{sw}=500kHz)

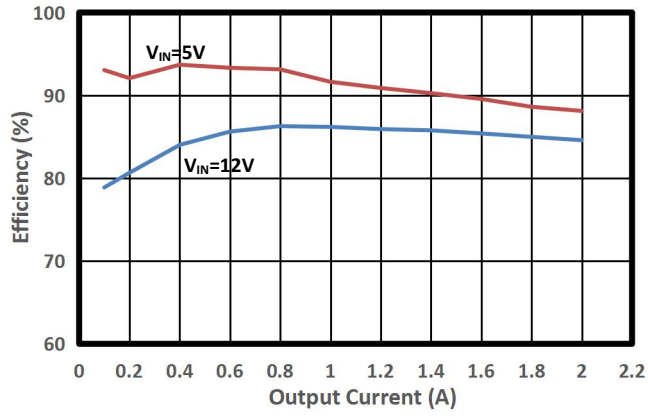

Figure 2. Efficiency vs. Load Current
(V_{OUT}=3.3V , f_{sw}=1.5MHz)

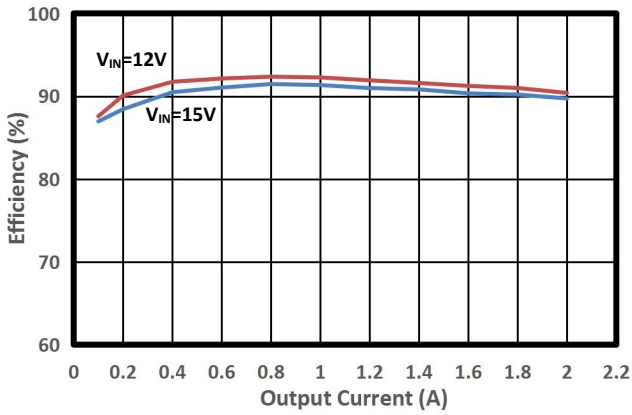

Figure 3. Efficiency vs. Load Current
(V_{OUT}=5V , f_{sw}=500kHz)

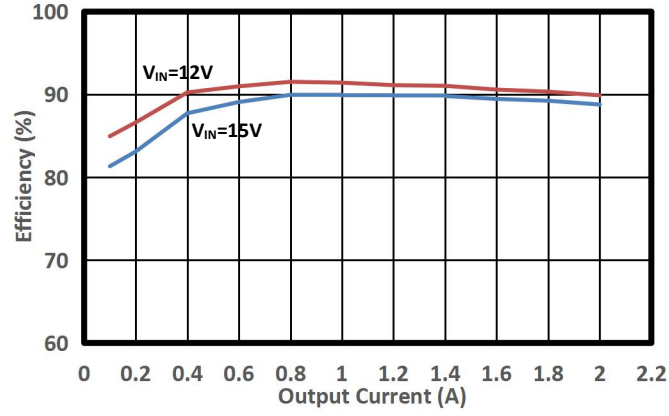

Figure 4. Efficiency vs. Load Current
(V_{OUT}=5V , f_{sw}=1.5MHz)

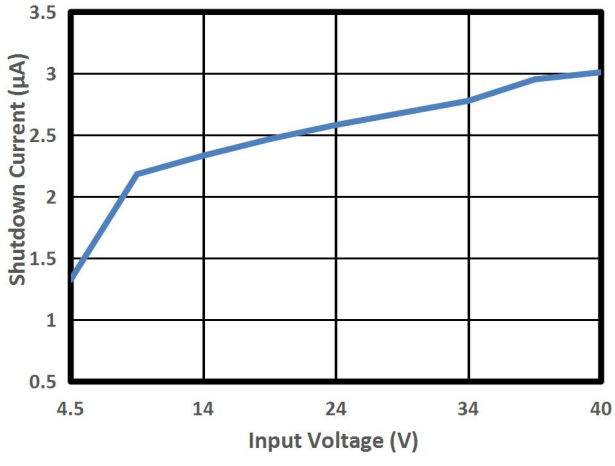

Figure 5. Input Voltage vs.Shutdown Current
(V_{OUT}=5V)

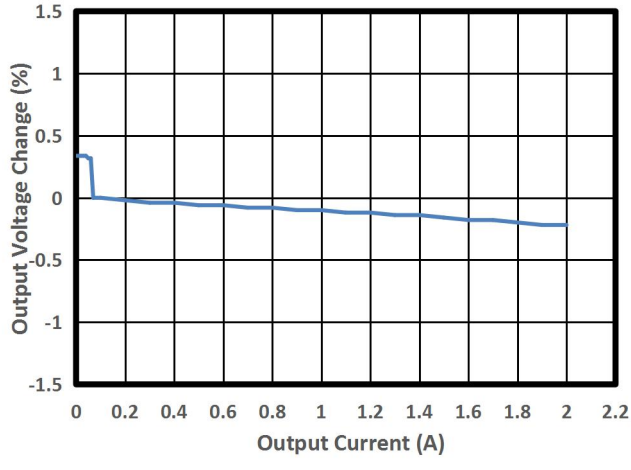

Figure 6. Load Regulation
(V_{OUT}=5V)

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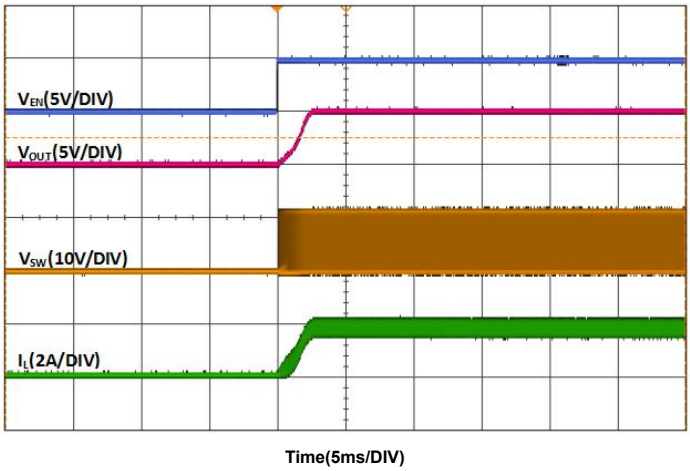

Figure 7. EN Start-up Waveform
(V_{IN}=12V, V_{OUT}=5V, I_{LOAD}=2A)

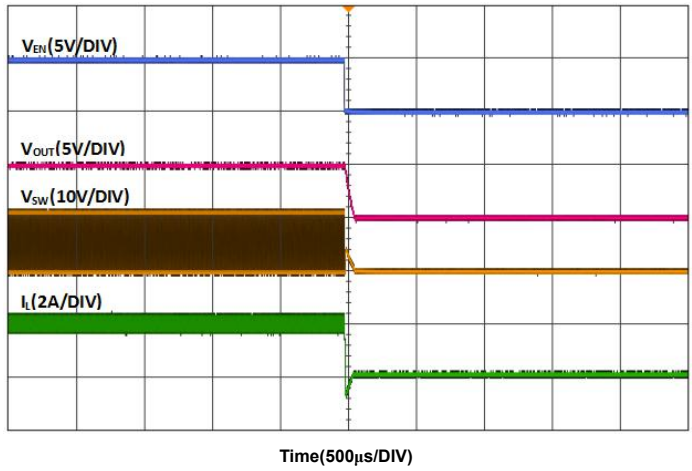

Figure 8. EN Shutdown Waveform
(V_{IN}=12V, V_{OUT}=5V, I_{LOAD}=2A)

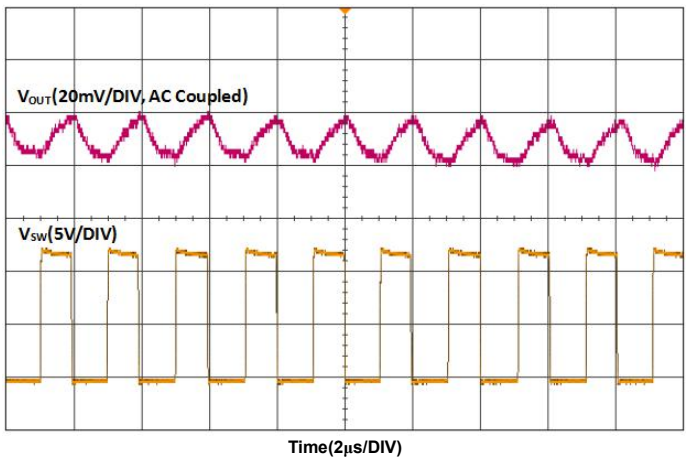

Figure 9. Switching Node and Output Voltage Waveform
(V_{IN}=12V, V_{OUT}=5V, I_{LOAD}=2A)

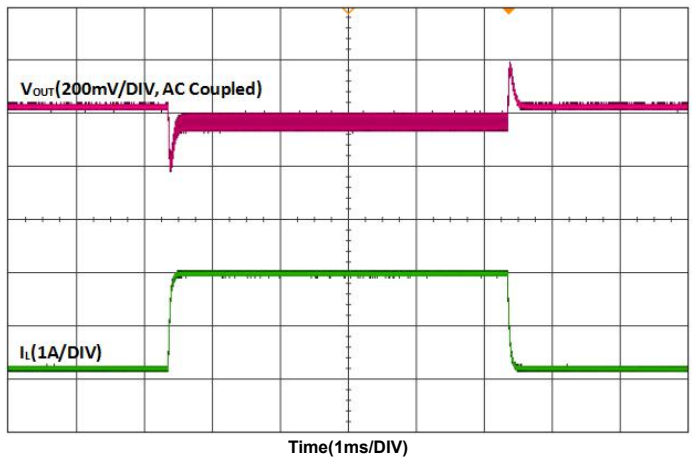

Figure 10. Load Transient Between 0.2A and 2A
(V_{IN}=12V, V_{OUT}=5V, Slew rate=100mA/μs)

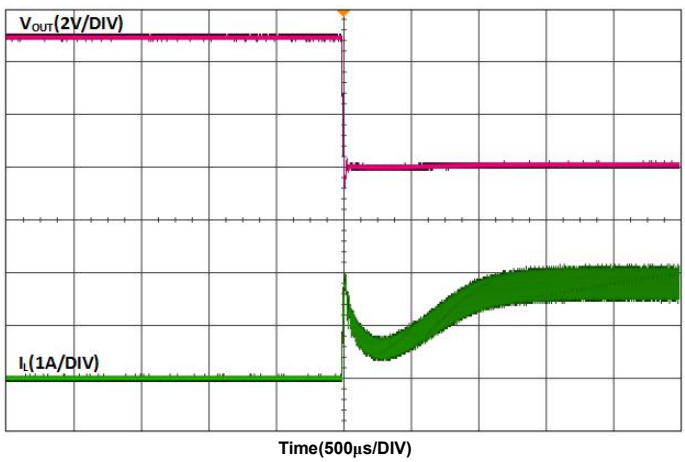

Figure 11. Short Circuit Test Waveform
(V_{IN}=12V, V_{OUT}=5V, No Load)

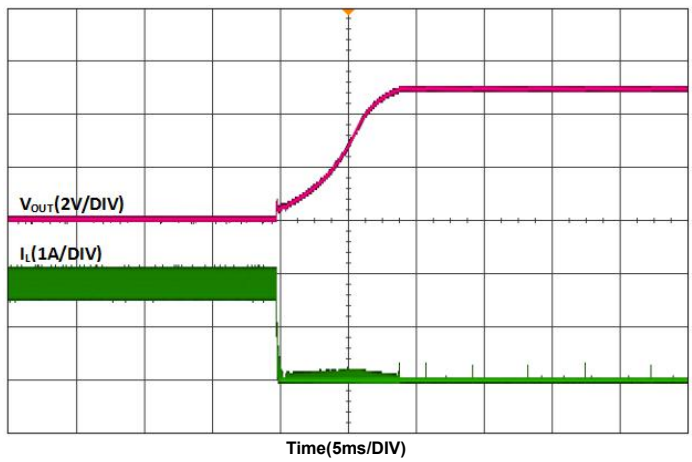

Figure 12. Short Circuit Recovery Waveform
(V_{IN}=12V, V_{OUT}=5V, No Load)

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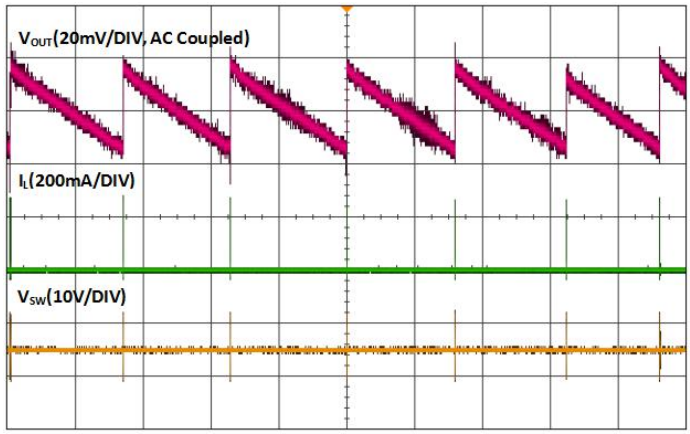

Figure 13. Light Load Mode Operation

(V_{IN}=12V, V_{OUT}=5V, No Load)

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Feature Description

The SCM1302A is a 40V, 2 A step-down (buck) regulator, and integrates a 100mΩ(typical) high-side MSOFET. The buck regulator has a very low quiescent current during the light load to prolong the battery life.

The SCM1302A implements peak current mode control with light load mode at light load to achieve high efficiency. The SCM1302A has an integrated 5V regulator to provide the power for bootstrap capacitor. When the bootstrap voltage drops below the specified threshold, the high-side MOSFET is turned off using an UVLO circuit which allows the freewheeling diode to conduct and refresh the charge on the BOOT capacitor. The SCM1302A can operate at high duty cycle with the bootstrap refresh function. Internal soft start is featured to minimize input inrush currents. The switching frequency is programmable from 200kHz to 1.5MHz by an external resistor.

Protection features include under-voltage lockout (UVLO), peak current limit, short circuit protection and over-temperature shutdown.

PWM Mode

The SCM1302A implements peak current mode control. The output voltage is compared through external resistors on the FB pin to an internal voltage reference by an error amplifier which drives the internal COMP node. An internal oscillator initiates the turn on of the high side MOSFET, and the inductor current increases linearly. The SCM1302A senses the peak current, and high side MOSFET is turned off when the peak current reaches the threshold, which allows the freewheeling diode to conduct, and the current through the inductor falls linearly to zero or the value when next cycle restarts.

Light Load Mode

The SCM1302A operates in light load mode at light load current. For Light load mode operation, most modules are turned off to improve efficiency by reducing losses.

EN and Internal Power Conversion

The internal power conversion circuit can be enabled when the EN pin is higher than 2.5V, then the high side MOSFET starts to switch. That will produce an output voltage and the device also be turned on. When EN is pulled down to 0 V, the device is turned off and enters the lowest shutdown current mode. In shutdown mode the supply current will be decreased to approximately 2 μA. The enable pin implements with pull-up current source, so the device is enable if the EN pin is floating, and the maximum voltage to the EN pin should not exceed 40 V.

Bootstrap

The SCM1302A has an integrated boot regulator, and requires a small ceramic capacitor between the BOOT and SW pins to provide the gate drive voltage for the high side MOSFET. The boot capacitor is refreshed when the high side MOSFET is off and the freewheeling diode conducts. When the bootstrap voltage drops below threshold, the high-side MOSFET is turned off using an UVLO circuit.

Current Limit

The SCM1302A implements current mode control which uses the internal COMP voltage to turn off the high side MOSFET on a cycle by cycle basis. Each cycle the switch current and internal COMP voltage are compared, when the peak switch current intersects the COMP voltage, the high side MOSFET is turned off. During over-current conditions that pull the output voltage low, the error amplifier will respond by driving the COMP node high, increasing the switch current. The error amplifier output is clamped internally, and the switch current will be limited on a cycle by cycle basis.

External Compensation

The SCM1302A implements current mode control for easy compensation and fast transient response. The loop stability is controlled through the COMP pin. The COMP pin is the output of the internal error amplifier. External capacitor-resistor combination through the COMP pin sets the pole-zero points to control the loop stability. Determine the output resistance of error amplifier by the following equation:

$$R_{EA} = A_{VEA} / G_{EA}$$

Where A_{VEA} is the error amplifier voltage gain, 490V/V(typ); G_{EA} is the error amplifier transconductance, 790μA/V(typ).

Switching Frequency

The switching frequency of the SCM1302A can be programmed by the resistor from the RT pin and GND pin. The switching frequency is 500 kHz if the RT pin is left floating. The RT pin can not be shorted to ground.

Thermal Shutdown

The device implements an internal thermal shutdown to protect itself if the junction temperature exceeds 170°C (typ). Once the junction temperature decreases below 160°C (typ), the device reinitiates the power up sequence.

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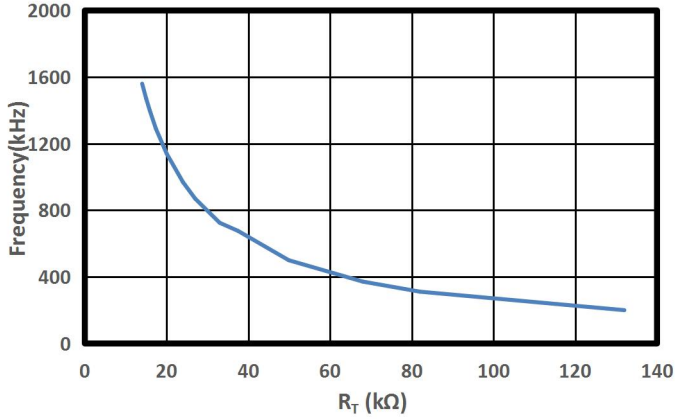
Setting the Switching Frequency

The switching frequency of the SCM1302A can be programmed by the resistor from RT pin to GND pin.The corresponding relationship between R_T resistance and switching frequency is shown in the following curve.



The typical relationship between R_T resistance and switching frequency is shown in the following table.

R_T (kΩ)	f_{SW} (kHz)
132	200
68	370
49.9	500
33	725
24	970
14.6	1500

Setting the Output Voltage

The output voltage is set using a feedback resistor divider (R1 and R2) as shown on the simplified schematic.

$$V_{FB} = V_{OUT} \times R2/(R1+R2) = 0.75V$$

The output voltage according to the following equation:

$$V_{OUT} = 0.75V \times (R1+R2)/R2$$

To solve for R1 given R2 and VOUT uses the following equation:

$$R1 = R2 \times (V_{OUT}/0.75 - 1)$$

Output Inductor Selection

The output inductor will produce a steady current when the high-side MOSFET is turned off. Lower ripple current and output voltage ripple will require a larger value of inductance, but the larger value of inductance means larger size, larger ESR, lower saturation current. A reasonable value is setting the ripple current to be 30% of the maximum DC output current, this will enable the SCM1302A to current limit without saturating the inductor. The value of inductance can be calculated using below equation:

$$L = V_{OUT} \times (V_{IN} - V_{OUT})/(V_{IN} \times f \times \Delta I)$$

V_{OUT} is the output voltage, V_{IN} is the input voltage , f is the switching frequency, ΔI is the peak-to-peak inductor ripple current.

Input Capacitor Selection

The input current of buck regulator is discontinuous, so the input capacitor is needed to stabilize the input voltage. A low ESR capacitor , for example, ceramic capacitor, tantalum capacitor or low ESR electrolytic capacitor, is needed to prevent the noises and interferences appearing at the input. One 4.7μF input capacitor with X7R or X5R dielectric is needed at least. Using the larger the capacitance to accomplish the better filtering result is reasonable. The input capacitor must be placed close to the VIN pin in order to achieve the best performance when users design a PCB.

Output Capacitor Selection

The output capacitor will determine the DC output voltage and the loop stability. A low ESR capacitor will meet the better output voltage ripple. One 22μF output capacitor is needed at least. Using the larger the capacitance to accomplish the better output voltage ripple and transient load response is reasonable.

The Schottky Diode Selection

The diode works as a freewheeling diode and supplies the current to the inductor when the high side MOSFET is turned off. To reduce losses due to the diode forward voltage, use a Schottky diode. Choose a diode whose maximum reverse voltage rating is greater than the maximum input voltage(transient overshoot voltage), and whose current rating is greater than the maximum load current.

Bootstrap Capacitor Selection

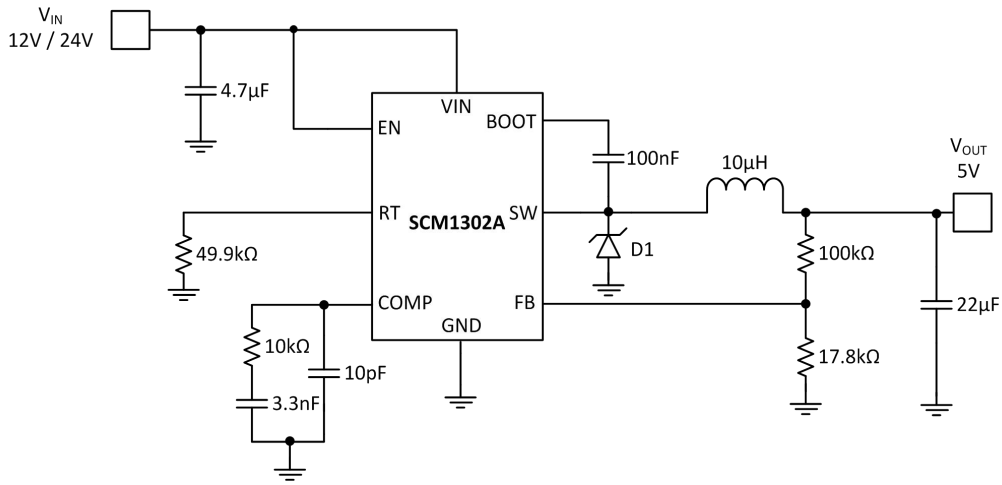
A 0.1μF~1μF capacitor , X7R or X5R dielectric and a voltage rating is greater than 10V , is recommended, and a large value is preferable at high duty cycle.

Compensation Components

External capacitor-resistor combination through the COMP pin sets the pole-zero points to control the loop stability. External capacitor-resistor combination through the COMP pin is recommended according to the different V_{OUT} in the following table.

V_{OUT} (V)	C0 (pF)	R0 (kΩ)	C2 (nF)
1.5	10	2.2	3.3
1.8	10	2.8	3.3
2.5	10	3.9	3.3
3.3	10	5.6	3.3
5	10	10	3.3
9	10	15	3.3
12/15	10	20	3.3

Application Circuit



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Ordering Information

Part number	Package	Number of pins	Product Marking	Tape & Reel
SCM1302ASA	eSOP-8	8	SCM1302ASA YM	3k/Reel

Product marking and data code:

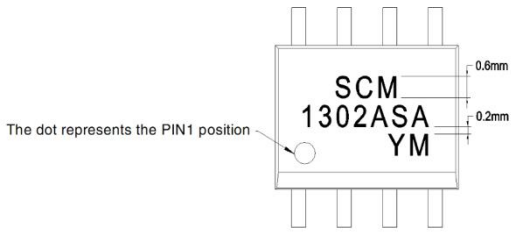
(1) SCM1302, Product designation.

(1) A, Version code information.

(3) S, Packaging definition code; S: eSOP-8 package.

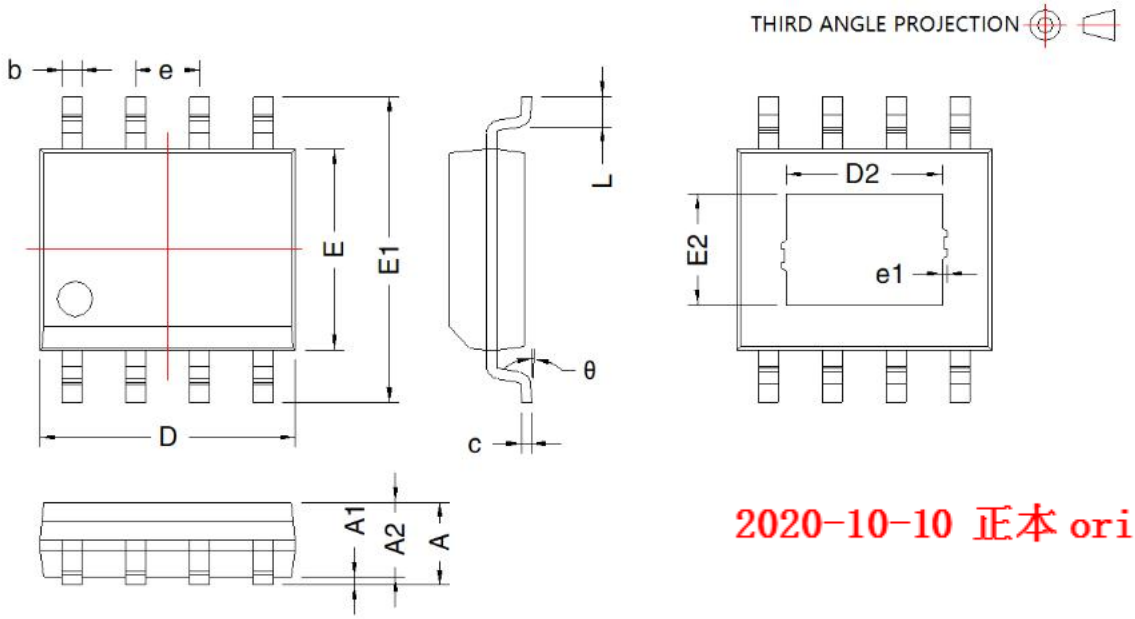
(4) A, Operating temperature range; C: 0℃-70℃, I: -40℃-85℃, A: -40℃-125℃, M: -55℃-125℃.

(5) YM, Data code for product traceability.



Note:
1、Typeface: Arial;
2、Character size:
Height: 0.6mm, Spacing: 0.1mm, LineSpacing: 0.2mm;

Package Information



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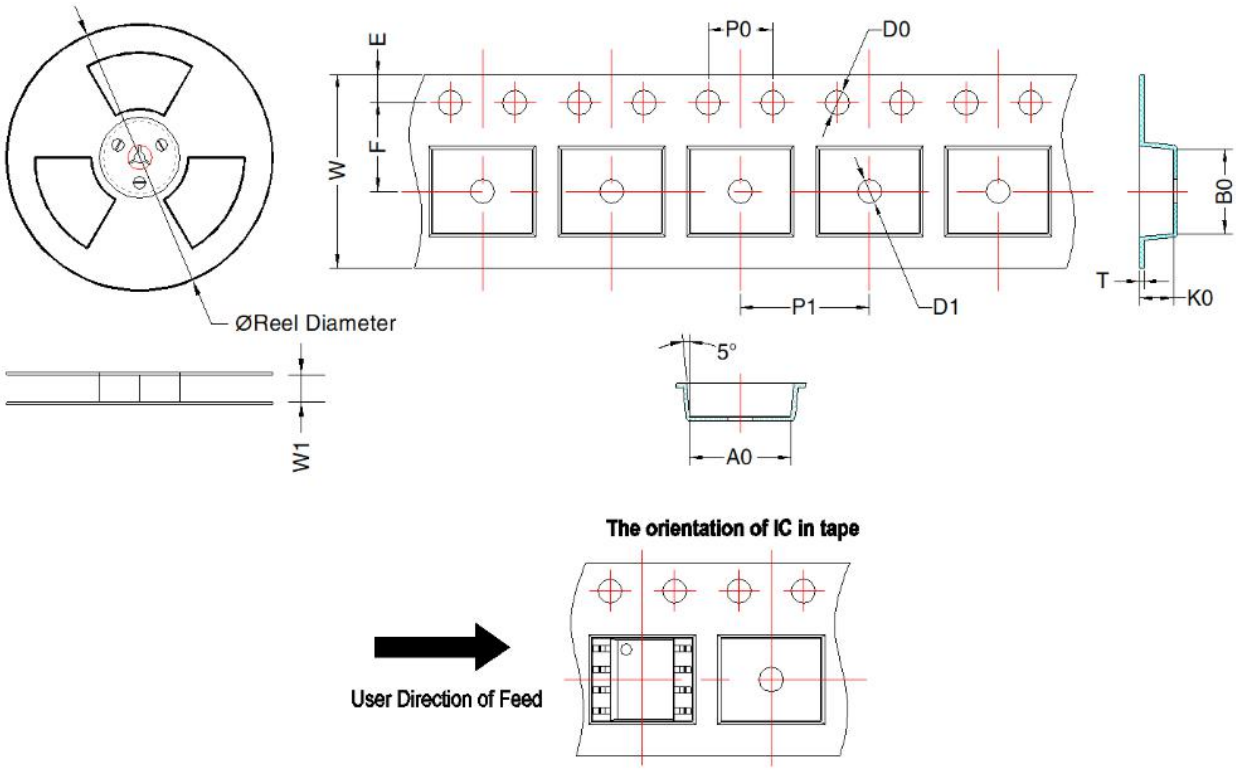
Mark	ESOP-8			
	Dimension(mm)		Dimension(inch)	
	Min	Max	Min	Max
A	—	1.65	—	0.065
A1	0.05	0.15	0.002	0.006
A2	1.30	1.50	0.051	0.059
D	4.80	5.00	0.189	0.197
E	3.80	4.00	0.150	0.157
E1	5.80	6.20	0.228	0.244
L	0.50	0.80	0.020	0.031
b	0.39	0.47	0.015	0.019
e	1.27TYP		0.05TYP	
c	0.20	0.24	0.008	0.009
θ	0°	8°	0°	8°
D2	3.10		0.122	
E2	2.21		0.087	
e1	0.10		0.004	



Device	Package Type	MPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	T (mm)	W (mm)	E (mm)	F (mm)	P1 (mm)	P0 (mm)	D0 (mm)	D1 (mm)
SCM1302ASA	ESOP-8	3000	330.0	12.4	6.5 ± 0.2	5.45 ± 0.2	2.0 ± 0.2	0.3 ± 0.05	12.0 ± 0.3	1.75 ± 0.1	5.5 ± 0.1	8.0 ± 0.1	4 ± 0.1	1.5 ± 0.1	1.5 ± 0.1

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