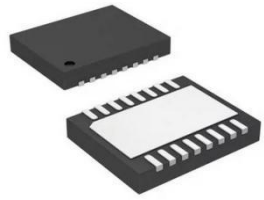
MORNSUN®

SCM1303A Buck Regulator With Delayed Output

Features

- 5V to 40V Input Range
- Output Current up to 1.2A
- Adjustable input current limit (typ 515mA)
- Output Delay time 2s
- 100mΩ High-Side MOSFET
- Peak Current Mode Control
- Adjustable Switching Frequency from 200kHz to 1.5MHz
- Internal Frequency Jitter
- Internal Soft-Start
- Under-voltage Lockout, Over-current Protection, and Thermal Protection
- DFN16L Package

Packaging



Product Package: DFN16L
(see “Ordering information” for details)

Application

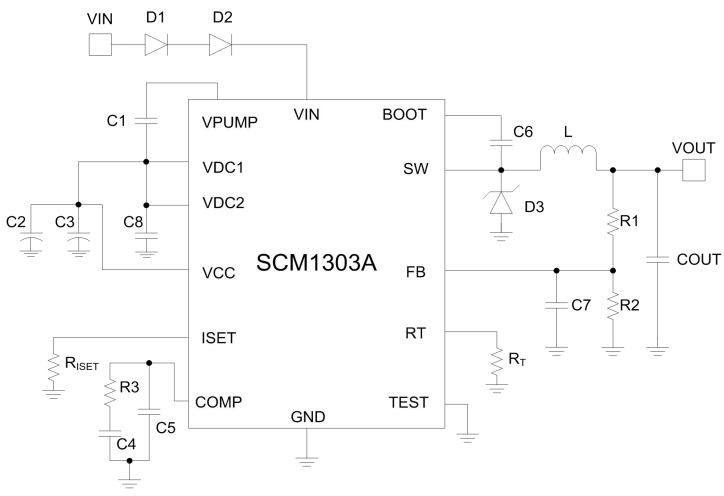
- Intrinsically Safe application
- Switch
- Sensor
- Controller

Description

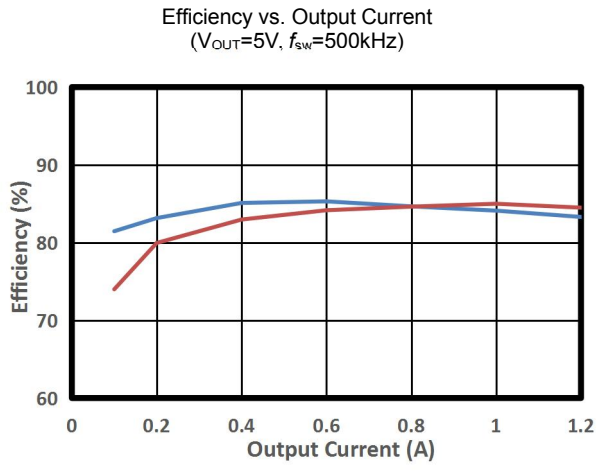
The SCM1303A is an output delayed asynchronous peak current mode step-down regulator. With a wide input range 5 V to 40 V, it is suitable for a wide range of applications such as switch, sensor and controller, especially in intrinsically safe power supplies. The SCM1303A have the functions of input current limit protection and output delay start-up . The typical delay time of internal output start-up is 2s, and the typical working frequency is 500kHz with jitter to achieve good EMI characteristics. Outputting current up to 1.2A. The device has built-in soft-start, input under-voltage lockout protection, thermal protection and short protection.

The SCM1303A is available in the DFN16L package (5.0mm × 4.0mm ×0.75mm).

Simplified Schematic



Functional curve



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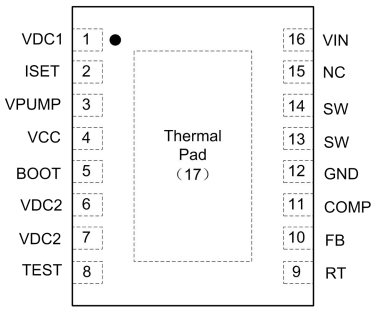
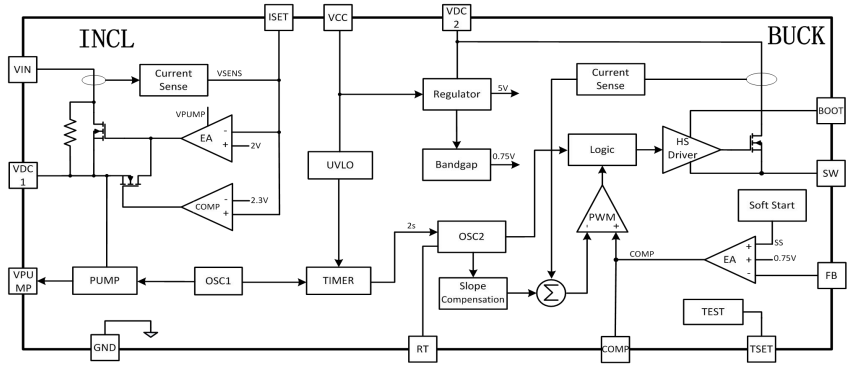
Pins

DFN16L Package
Top View



Functional Block Diagram



Pin Description

Pin No.	Pin Name	I/O	DESCRIPTION
1	VDC1	O	Output of current limit switch. Connect two 220μF storage capacitors.
2	ISET	I	Input over-current protection threshold program pin. Connect a resistor from this pin to ground.
3	VPUMP	O	Internal charge pump output voltage pin. Connect a 47μF capacitor between VPUMP and VDC1.
4	VCC	I	Storage capacitors under-voltage lockout sense pin. Need connect with VDC1.
5	BOOT	I	Bootstrap capacitor connection for high-side MOSFET driver. Connect C6 cap between BOOT and SW.
6, 7	VDC2	I	BUCK input voltage pin with 4.7μF bypass capacitor to ground. Need connect with VDC1.
8	TEST	I	TEST mode input pin.
9	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.
10	FB	I	Feedback Pin. Set feedback voltage divider ratio with $V_{OUT} = V_{FB}$ (1+(R1/R2)).
11	COMP	I	Compensation. External capacitor-resistor combination sets the compensation net.
12	GND	G	Ground pin.
13, 14	SW	O	Switching node. Connect to inductor, diode and C6 cap.
15	NC	I	No connect.
16	VIN	I	Power input voltage pin. Connect one terminal of input current limit switch.
17	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 to GND	-0.3	44	V
	BOOT to GND	-0.3	49	
	FB, COMP, ISET, TEST to GND	-0.3	6	
Output Voltages	BOOT to SW	-0.3	6	V
	SW to GND	-1.0	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) , all pins except PIN3(1)	2000		V
	Charged device model (CDM)	500		

Note(1): PIN3 passes 500V test.

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	5	40	V
	BOOT	0	45	
	BOOT to SW	0	5	
	SW	-0.7	40	
	COMP	0	5	
	FB	0	5	
Control	ISET	0	5	V
	RT	0	5	
	TEST	0	5	
Temperature	T_J	-40	125	℃

Electrical Characteristics

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

Symbol	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
VIN (INPUT POWER SUPPLY)						
V_{IN}	Operating input voltage		5		40	V
I_Q	Quiescent current	Power-down Mode, not switching, V_{FB}>0.8V		160	300	μA
I_{LIMIT}	Input current limit (INCL) threshold	R_{ISET}=8.2kΩ , 1% accuracy		515	660	mA
V_{UVLO}	Under-voltage lockout thresholds (BUCK)	Rising		4.1	4.4	V
		Falling	3.5	3.8		
V_{UVLO_ICL}	Under-voltage lockout thresholds (INCL)	Rising		4.3	4.7	
		Falling	3.6	3.9		
VOLTAGE REFERENCE (FB PIN)						
V_{FB}	Feedback voltage		0.735	0.75	0.765	V
SWITCHING CHARACTERISTICS						
f_{SW}	Switching frequency	R_T=49.9kΩ , 1% accuracy	400	500	600	kHz
Δf_{JITTER}	Switching frequency jitter			±3		%
t_{ON-MIN}	Minimum on time(1)	VIN=12V , BOOT－SW=5V		102		ns
D_{MAX}	Maximum duty cycle(1)			93		%
HIGH-SIDE MOSFET						
R_{DSON_H}	On-resistance	VIN=12V , BOOT－SW=5V		100	180	mΩ
I_{LIMIT}	Current limit threshold	VIN=12V		3.2		A
THERMAL PERFORMANCE						
$T_{SHUTDOWN}$	Thermal shutdown threshold(1)	Rising		170		℃
T_{HYS}	Hysteresis(1)			10		℃
START UP						
t_{DELAY}	Output delay(1)	From the release of INCL under-voltage lockout to the establishment fo output		2		s
t_{SS}	Soft start time(1)			15		ms

Note(1): Guaranteed by design.

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Thermal Information

PARAMETER(1)		VALUE	UNIT
Junction to ambient thermal resistance	θ_{JA}	43	℃/W
Junction to top characterization parameter	Ψ_{JT}	13	℃/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.

Typical Curves

T_A=+25℃, V_{IN}=24V, L=15μH, f_{sw}=500kHz, C_{OUT} = 22μF, unless otherwise noted.

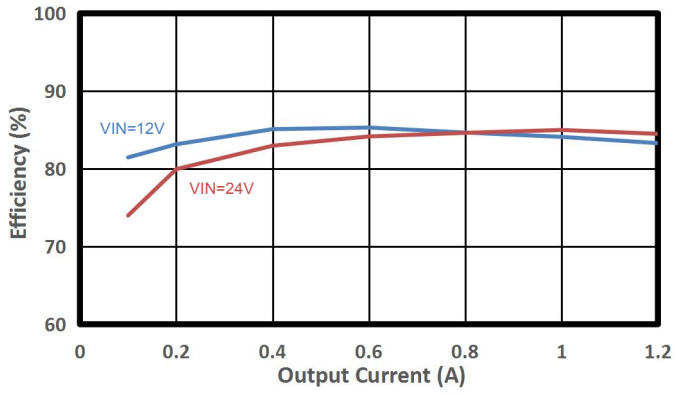

Figure 1. Efficiency vs. Load Current

(V_{OUT}=5V , f_{sw}=500kHz)

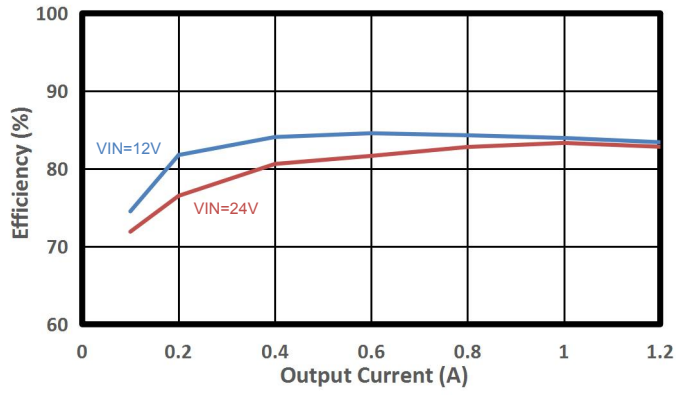

Figure 2. Efficiency vs. Load Current

(V_{OUT}=5V , f_{sw}=1.5MHz)

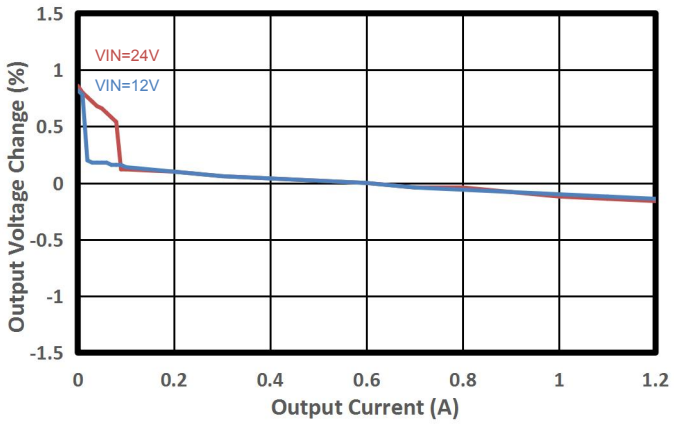

Figure 3. Load Regulation

(V_{OUT}=5V , f_{sw}=500kHz)

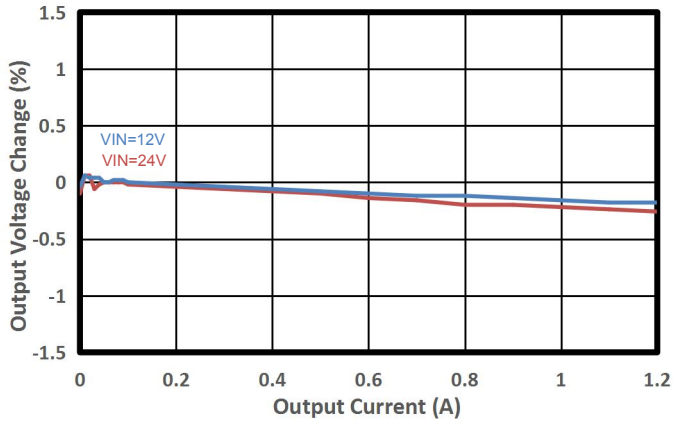

Figure 4. Load Regulation

(V_{OUT}=5V , f_{sw}=1.5MHz)

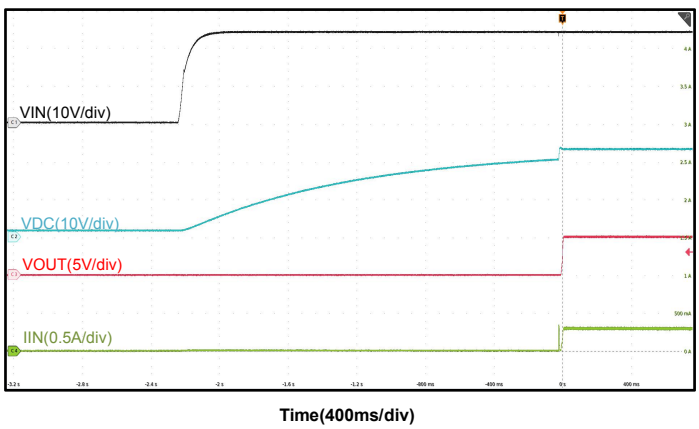

Figure 5. VIN Start-up Waveform-1

(VIN=24V, VOUT=5V, IOUT=1.2A)

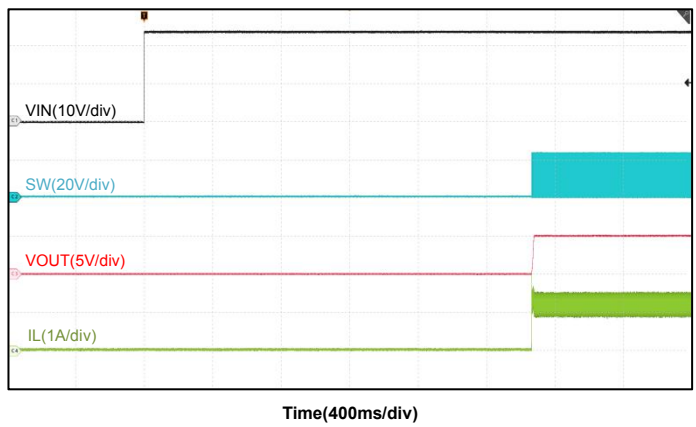

Figure 6. VIN Start-up Waveform-2

(VIN=24V, VOUT=5V, IOUT=1.2A)

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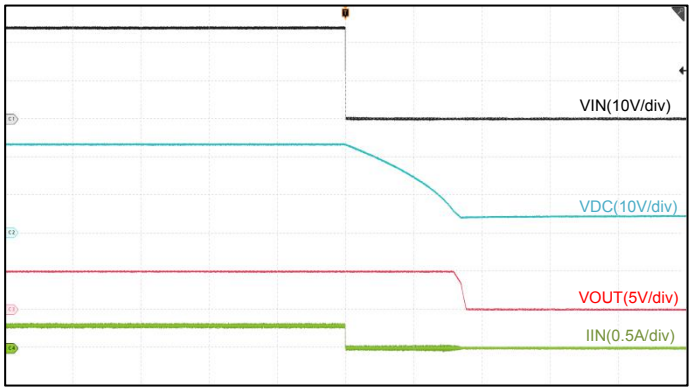

Figure 7. VIN Shutdown Waveform-1
(VIN=24V, VOUT=5V, IOUT=1.2A)

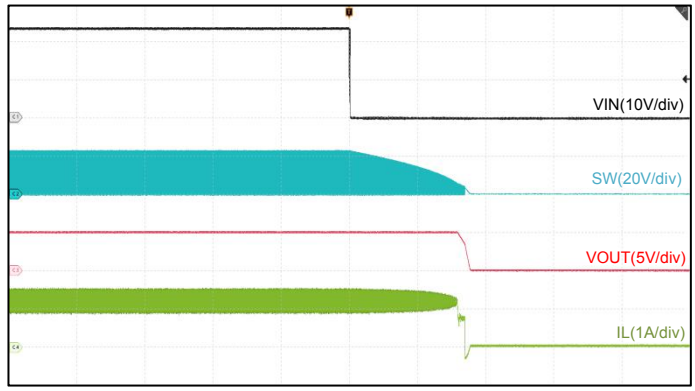

Figure 8. VIN Shutdown Waveform-2
(VIN=24V, VOUT=5V, IOUT=1.2A)

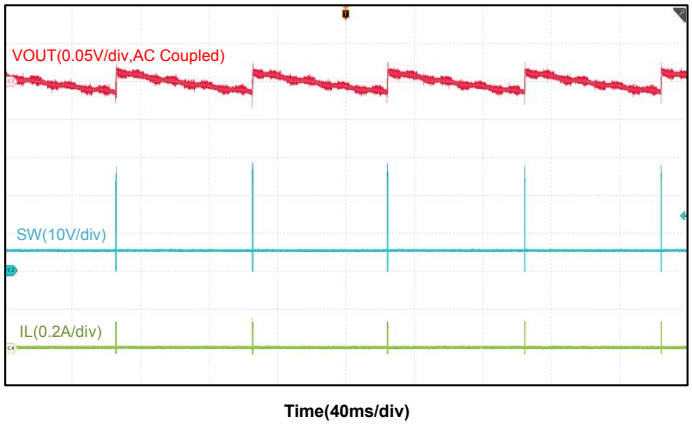

Figure 9. Light Load Mode Operation
(VIN=24V, VOUT=5V, IOUT=0A)

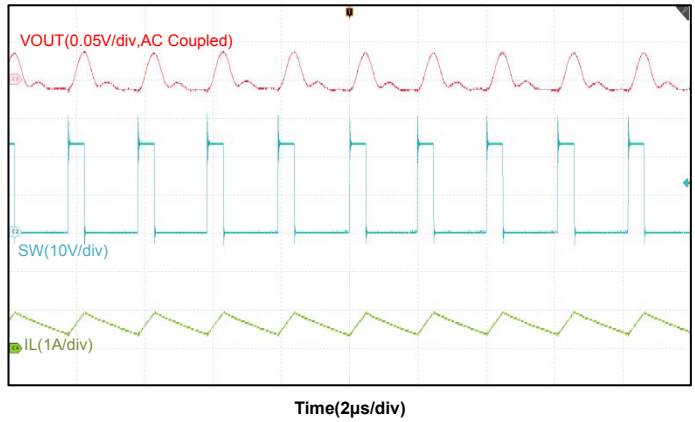

Figure 10. Switching Node and Output Voltage Waveform
(VIN=24V, VOUT=5V, IOUT=0.6A)

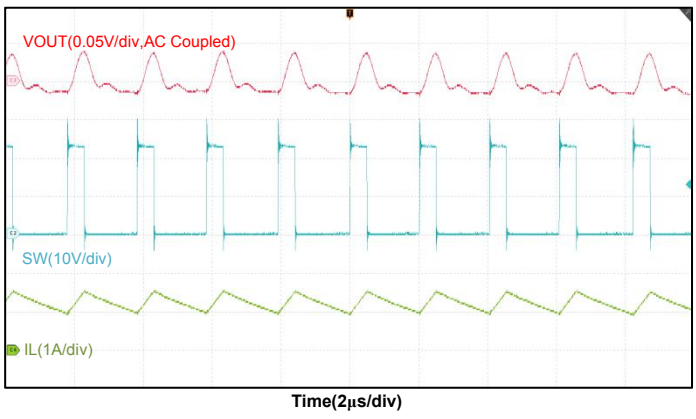

Figure 11. Switching Node and Output Voltage Waveform
(VIN=24V, VOUT=5V, IOUT=1.2A)

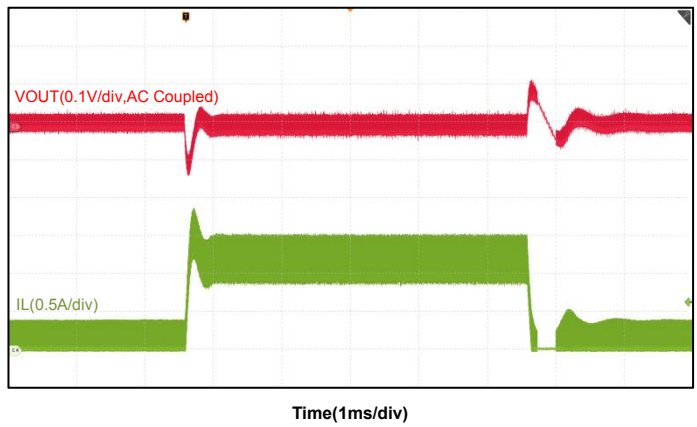

Figure 12. Load Transient Between 0.12A and 1.2A
(VIN=24V, VOUT=5V, Slew rate=100mA/μs)

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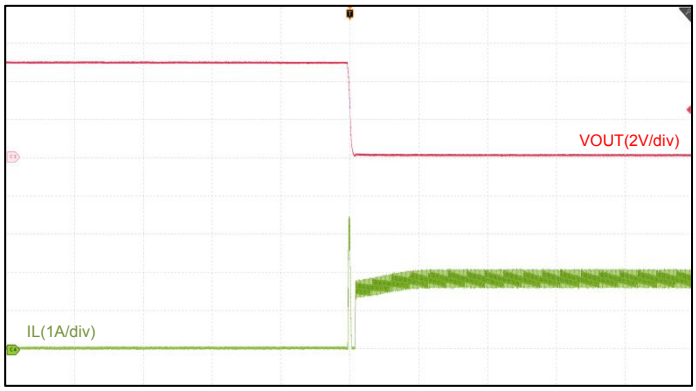
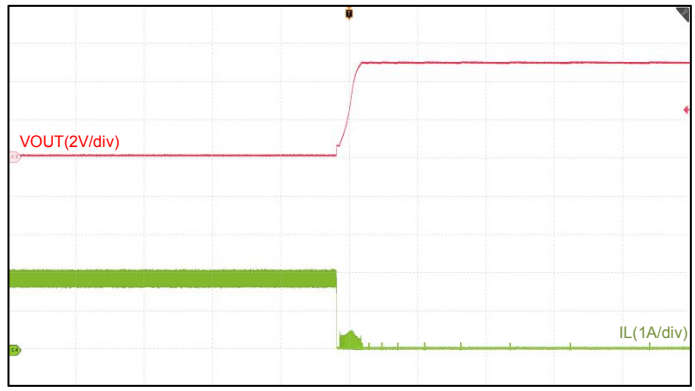


Time(1ms/div)

Figure 13. Short Circuit Test Waveform
(VIN=24V, VOUT=5V, IOUT=0A)



Time(40ms/div)

Figure 14. Short Circuit Recovery Waveform
(VIN=24V, VOUT=5V, IOUT=0A)

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Feature Description

The SCM1303A is a 40V, 1.2A step-down regulator, and integrates a 100mΩ(typ) high-side MSOFET, which can meet the requirement of intrinsic safety.

The SCM1303A has an input current limit protection, it is programmable with external resistor connected from ISET to ground. The device is featured with delayed start-up, when the under-voltage lockout is released after power up, the output begins to establish after the counter counts for 2s. Protection features include under-voltage lockout (UVLO), peak current limit, short circuit protection and over-temperature shutdown.

The SCM1303A implements peak current mode control with light load mode at light load to achieve high efficiency. The SCM1303A 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 SCM1303A 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. A ± 3% jitter is added to the switching frequency, which can achieve good EMI performance.

PWM Mode

The SCM1303A implements peak current mode control. The output voltage is compared through external resistors on the FB pin with 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 SCM1303A 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.

Input Current Limit

The SCM1303A integrates an input current limit switch. The current through the switch is sensed, and the sampling voltage is compared with an internal voltage reference by an error amplifier which drives the current limit switch. When sampling voltage increases, the V_{GS} of the switch MOSFET is decreased, keeping the input current limited at the threshold.

Light Load Mode

The SCM1303A operates in light load mode at light load current. For Light load mode operation, parts of modules are turned off to improve efficiency by reducing losses.

Bootstrap

The SCM1303A 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.

Output Current Limit

The SCM1303A 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 SCM1303A 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 trans-conductance, 790μA/V(typ).

Switching Frequency

The switching frequency of the SCM1303A can be programmed by the resistor from the RT pin to 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 re-initiates the power up sequence.

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Setting the Input Current Limit threshold

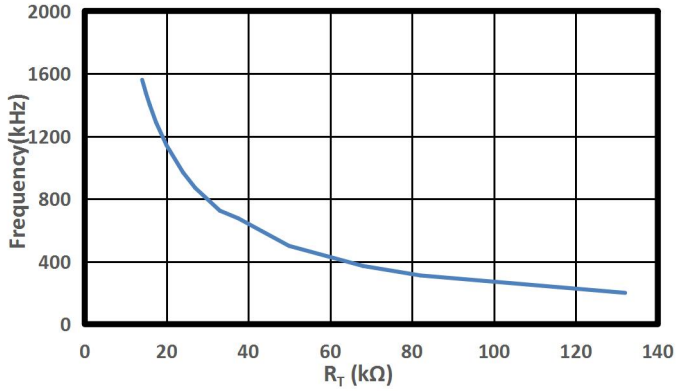
The input current limit threshold of the SCM1303A can be programmed by the resistor from ISET pin to GND pin.The corresponding relationship between R_{ISET} resistance and input current limit threshold is shown in the following curve. In specific applications, it is ensure that the input current limit value can meet the output load requirements to avoid abnormal operation caused by a small current limiting value.

The typical relationship between R_{ISET} resistance and input current limit threshold is shown in the following table.

R_{ISET} (kΩ)	ICL (mA)
4.7	935
5.1	857
5.6	774
6.8	628
7.5	566
8.2	515
10	416
12	342
15	270
18	222

Setting the Switching Frequency

The switching frequency of the SCM1303A 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

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ripple current to be 30% of the maximum DC output current, this will enable the SCM1303A 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 of VDC2 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 interference 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.

In addition, two 220μF electrolytic capacitor need be connected between VDC1 pin and GND pin. As the storage capacitor, it can ensure that the output voltage is not affected when the input voltage is powered down for a short time.The value of capacitance can also be calculated using the following equation:

$$C = \frac{2 * V_{OUT} * I_{OUT} * T_{HOLD}}{\eta * (VIN_{START}{}^2 - MAX(VIN_{UVLO\_DOWN}, V_{OUT})^2)}$$

V_{OUT} is the output voltage, I_{OUT} is the output current of VIN shutdown, T_{HOLD} is the power down holding time of VIN, η is system efficiency , V_{IN} is the input voltage , VIN_{UVLO_DOWN} is the under-voltage threshold of the converter .

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 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 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)	C5 (pF)	R3 (kΩ)	C4 (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

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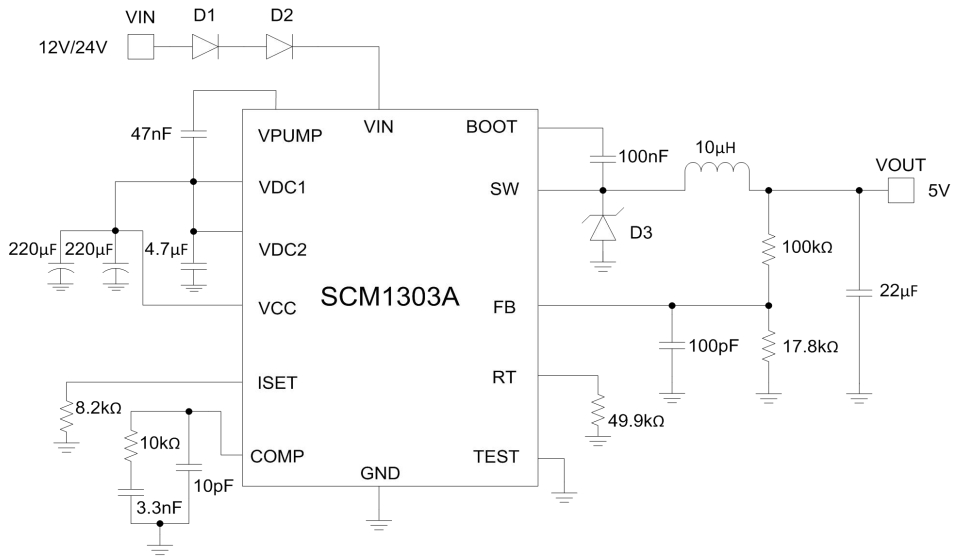

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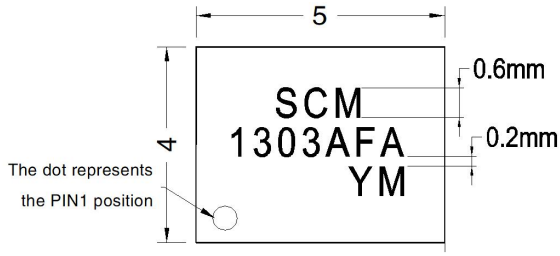
Ordering Information

Part number	Package	Number of pins	Product Marking	Tape & Reel
SCM1303AFA	DFN16L	16	SCM1303AFA YM	3k/Reel

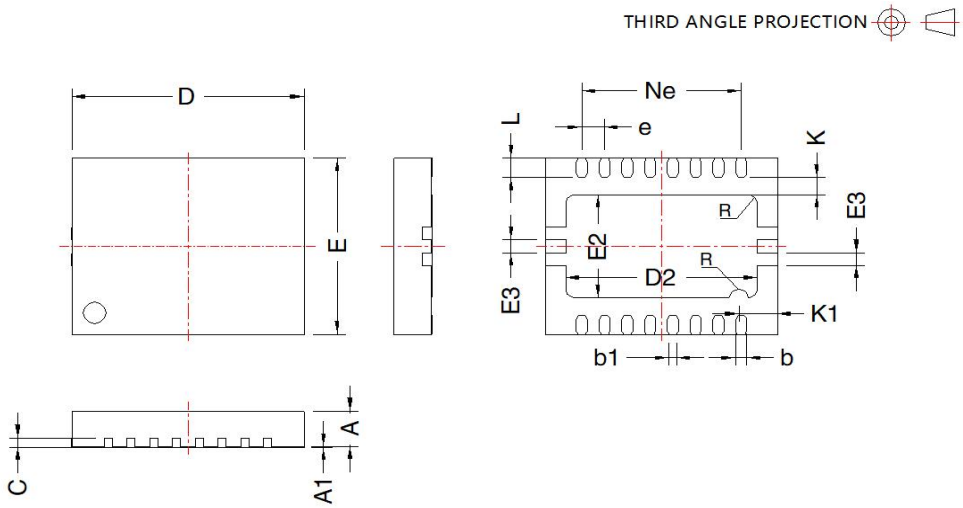
Product marking and data code:
SCM1303AFAYM：

(1) SCM1303, Product designation.
(2) A, Version code information.
(3) F, Packaging definition code; F: DFN 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



DFN16L						
Mark	Dimension(mm)			Dimension(inch)		
	Min	NOM	MAX	MIN	NOM	Max
A	0.7	0.75	0.8	0.028	0.030	0.031
A1	0	0.02	0.05	0	0.001	0.002
b	0.2	0.25	0.3	0.08	0.010	0.012
b1		0.18REF			0.007REF	
c		0.203REF			0.08REF	
D	4.9	5	5.1	0.193	0.197	0.201
D2	4.15	4.2	4.25	0.163	0.165	0.167
e		0.5BSC			0.020BSC	
Ne		3.5BSC			0.138BSC	
E	3.9	4	4.1	0.154	0.157	0.161
E2	2.35	2.4	2.45	0.093	0.094	0.096
E3	0.2	0.25	0.3	0.08	0.010	0.012
L	0.35	0.4	0.45	0.014	0.016	0.018
R		0.2REF			0.08REF	
K	0.35	0.4	0.45	0.014	0.016	0.018
K1		0.85REF			0.033REF	

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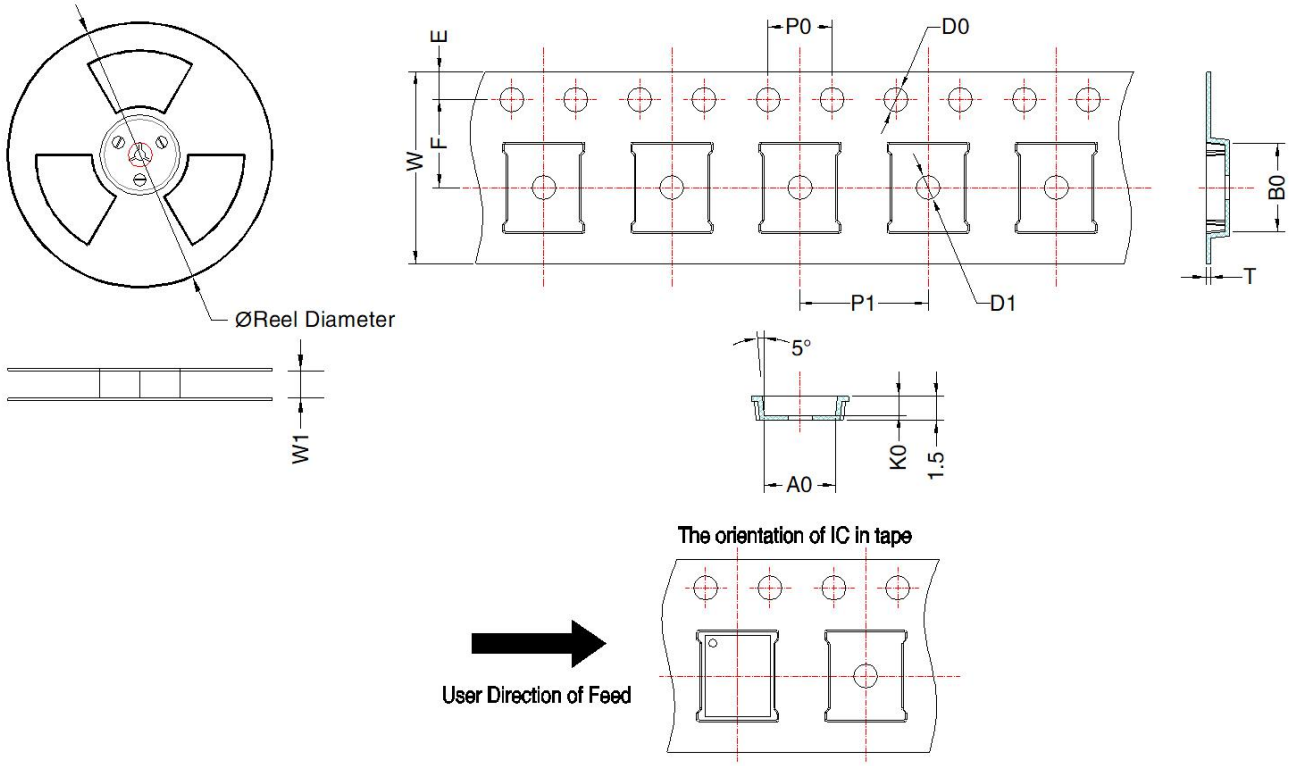
Tape & Reel Information

Packed in 13-inch reels, each reel is loaded with 3K IC.



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)
SCM1303AFA	DFN16L	3000	330.0	12.4	4.3 ± 0.1	5.3 ± 0.1	1.2 ± 0.1	0.3 ± 0.05	12.0 ± 0.3	1.75 ± 0.1	5.5 ± 0.05	8 ± 0.1	4 ± 0.1	$1.5_{0}^{0.1}$	1.5Min

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