SM8172A

2-output Power Supply IC

1. OVERVIEW

The SM8172A is a 2-output power supply IC that incorporates a step-down DC/DC converter and series regulator with built-in reset circuit. The DC/DC converter is a PWM-type synchronous rectifier. The SM8172A has soft start, overcurrent detection, supply undervoltage lockout, and thermal shutdown circuits built-in, making it ideal as a supply voltage source IC for large-scale LSIs that operate from a 5V supply.

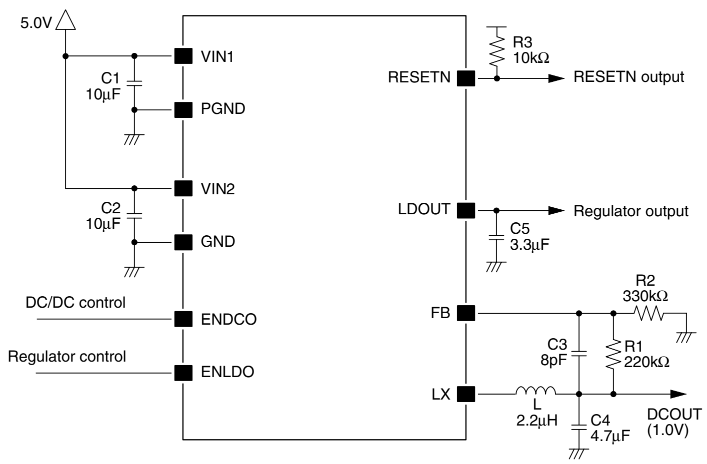
2. FEATURES

- Input voltage range: 4.5 to 5.5V
- Standby current: 0.01µA (typ)
- Series regulator
  - Feedback-type current limiter to reduce output current when outputs are short-circuit
  - Output voltage: 3.3V (available for optional setting from 2.1 to 3.6V by 0.1V-step)
  - Maximum output current: 450mA
  - Voltage accuracy: ± 2% (VIN = 5.0V, Ta = 25°C)
- DC/DC converter
  - Current-mode operation for excellent transient response
  - Output voltage: 0.8 to 1.8V (typ, selectable by external resistor)
  - Maximum output current: 900mA
  - Operating frequency: 2MHz (typ)
  - Voltage accuracy: ± 2% (FB pin, VIN = 5.0V, Ta = 25°C, DCOUT = 1.0V)
- Reset circuit built-in
  - Reset detection voltage: 3.7V (typ) (available for optional setting from 3.2 to 4.2V by 0.1V-step)
  - Reset return delay time: 65ms (typ) (50ms, 32ms, 16ms, and 8ms selectable with option)
- Various protection circuit built-in
  - Startup soft start circuit built-in
  - Overtemperature thermal shutdown (TSD) circuit built-in
  - Supply undervoltage lockout (UVLO) circuit built-in
- Package: 10-pin SON

3. APPLICATIONS

- ODD
- DVD player/recorder
- Next-generation DVD player/recorder
- Electronic equipment

4. TYPICAL APPLICATION CIRCUIT



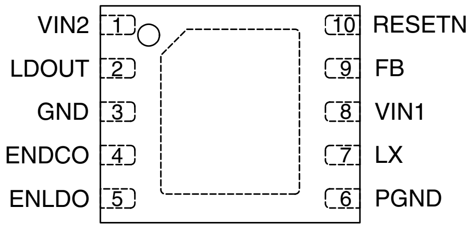
Note. RESETN is open-drain, therefore, please take care so that the High level signal does not exceed the absolute maximum rating of IC which receives the reset signal. Besides, if the rest signal is not used, RESETN should be connected to GND.

5. ORDERING INFORMATION

Device	Package
SM8172AD	10-pin SON

6. PINOUT

(Top view)

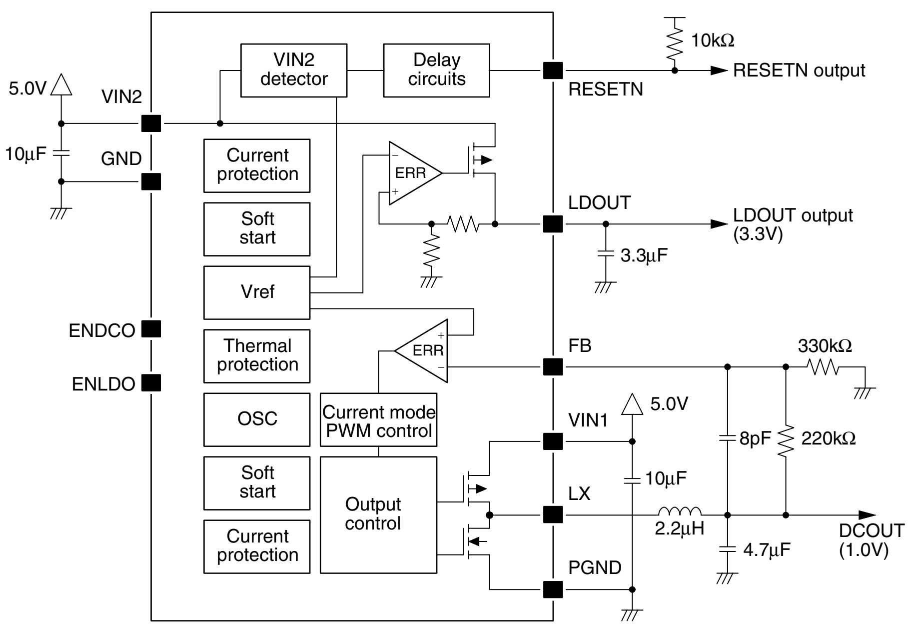


7. PIN DESCRIPTION

Number	Name	I/O	Function
1	VIN2	–	Supply voltage (series regulator, internal circuits)*1
2	LDOUT	O	Series regulator output*2
3	GND	–	Ground (internal circuits)
4	ENDCO	Ip*3	Output enable (DC/DC converter)
5	ENLDO	Ip*3	Output enable (series regulator)
6	PGND	–	Ground (DC/DC converter output circuit)
7	LX	O	DC/DC converter coil drive*4
8	VIN1	–	Supply voltage (DC/DC converter output circuit)*1
9	FB	I	DC/DC converter feedback connection*5
10	RESETN	O	Reset signal output (active-LOW, open-drain output)*6

*1. VIN1 and VIN2 should have the same voltage potential.
*2. When the series regulator is not used, LDOUT pin should be open and not be connected to GND.
*3. Ip = Input with pull-down resistor built-in
*4. When the DC/DC converter is not used, LX pin should be open and not be connected to GND or the supply.
*5. When the DC/DC converter is not used, FB pin should be connected to GND.
*6. When the reset signal is not used, RESETN pin should be connected to GND.

8. BLOCK DIAGRAM

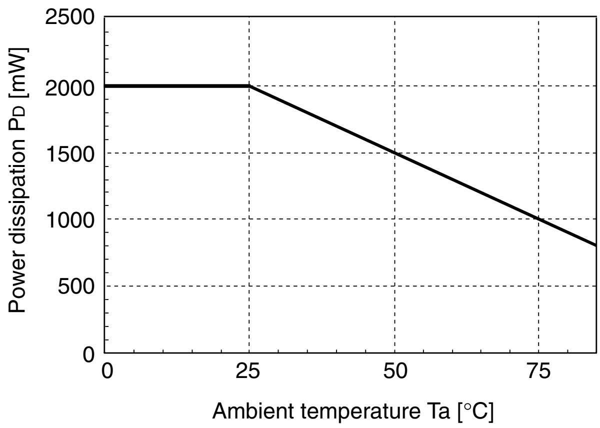


9. ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating	Unit
Supply voltage range	V_{IN}	–0.3 to 6.0	V
Input pin voltage range	V_{ENDCO}, V_{ENLDO}, V_{FB}	–0.3 to V_{IN} + 0.3	V
Output pin voltage range 1	V_{LX}, V_{LDOUT}	–0.3 to V_{IN} + 0.3	V
Output pin voltage range 2	V_{RESETN}	–0.3 to 6.0	V
LX output current	I_{LX}	1.5	A
LDOUT output current	I_{LDOUT}	700	mA
Power dissipation	P_D	2000 (Ta = 25°C)*1	mW
Junction temperature	T_{JMAX}	+125	°C
Storage temperature range	T_{stg}	–55 to +125	°C

*1. 101.5 × 105.0 × 1.6mm, wiring ratio 250%, FR-4, 4-layer board (thermal vias, die pad connections)
Note that the ratings will vary depending on the board specifications, footprint pattern, and other factors.

Note. The device may be damaged or deteriorated if any of the above parameter ratings is exceeded.



10. RECOMMENDED OPERATING CONDITIONS

Parameter	Pin	Symbol	Conditions	Rating			Unit
				min	typ	max	
Supply voltage	VIN1, 2	V_{IN}	VIN1 = VIN2	4.5	5.0	5.5	V
Operating ambient temperature	–	Ta		–20	+25	+85	°C

11. ELECTRICAL CHARACTERISTICS

Note. The specifications of "ELECTRICAL CHARACTERISTICS" are shown by using "TYPICAL APPLICATION CIRCUIT" on page 13.

11-1. Common Blocks

VIN1 = VIN2 = 5.0V, GND = PGND = 0V, Ta = 25°C unless otherwise noted.

Parameter	Pin	Symbol	Condition	Rating			Unit
				min	typ	max	
Standby current	VIN1, 2	I_{STB}	Standby mode (ENDCO = ENLDO = L), No load on inputs/outputs	–	0.01	1	μA
HIGH-level input voltage	ENDCO, ENLDO	V_{IH}		1.8	–	–	V
LOW-level input voltage	ENDCO, ENLDO	V_{IL}		–	–	0.6	V
HIGH-level input current	ENDCO, ENLDO	I_{IH}		–	5.0	10	μA
RESETN output current	RESETN	I_{RESETN}	V_{RESETN} = 1.0V	20	–	–	mA
Reset circuit operating voltage	VIN2	$V_{RESETNL}$	When VIN falls	3.5	3.7	3.9	V
		$V_{RESETNH}$	When VIN rises	3.7	3.9	4.1	V
Reset circuit return delay time	RESETN	t_{RESETN}	When VIN rises	–	65	–	ms
Under voltage lockout	VIN2	V_{UVLOL}	When VIN falls	2.7	3.0	3.3	V
		V_{UVLOH}	When VIN rises	2.9	3.2	3.5	V
TSD operating temperature	–	T_{SD}		–	170	–	°C
TSD hysteresis	–	T_{SDHYS}		–	20	–	°C

11-2. Series Regulator

VIN1 = VIN2 = 5.0V, GND = PGND = 0V, Ta = 25°C unless otherwise noted.

Parameter	Pin	Symbol	Condition	Rating			Unit
				min	typ	max	
Current consumption	VIN1, 2	I_{DD_LDO}	No load	–	0.1	0.25	mA
Soft start time	LDOUT	t_{SS_LDO}		0.5	1	2	ms
Output voltage	LDOUT	V_{LDO}	I_{LDO} = 10mA	3.23	3.3	3.37	V
Maximum output current*1	LDOUT	I_{LDO}	VIN2 = 4.5V, LDOUT = 3.3V	450	–	–	mA
Input stability	LDOUT	ΔV_{OUT1}	4.5V ≤ VIN2 ≤ 5.5V, I_{LDO} = 30mA	–	0.1	0.35	%/V
Load stability	LDOUT	ΔV_{OUT2}	VIN2 = 5.0V, 1mA ≤ I_{LDO} ≤ 300mA	–	40	–	mV
Overcurrent protection circuit operating current	LDOUT	I_{OS}		–	700	–	mA

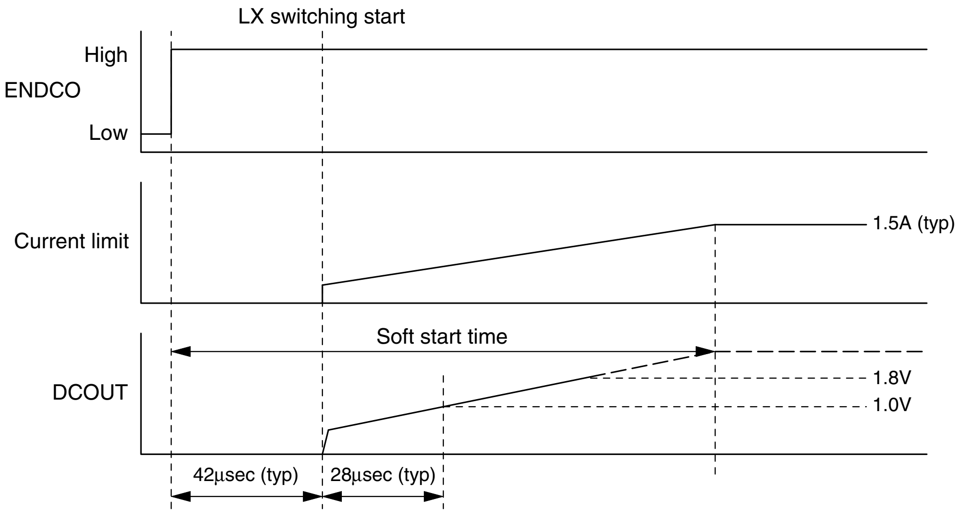
*1. The output voltage difference at I_{LDO} = 1mA and I_{LDO} = 450mA is within ± 3%.

11-3. DC/DC Converter

VIN1 = VIN2 = 5.0V, GND = PGND = 0V, Ta = 25°C unless otherwise noted.

Parameter	Pin	Symbol	Condition	Rating			Unit
				min	typ	max	
Current consumption 1	VIN1, 2	I_{DD1}	No load, switching stopped	–	0.35	0.75	mA
Current consumption 2	VIN1, 2	I_{DD2}	FB = VIN1, LX = Open	–	2.5	5.5	mA
Soft start time*1*2	–	t_{SS}		0.2	0.6	1.0	ms
Output voltage range*2	–	V_{DCO}		0.8	–	1.8	V
FB voltage	FB	V_{FB}		0.588	0.6	0.612	V
Maximum output current*2*3	–	I_{DCO}		900	–	–	mA
Switching frequency	LX	f_{OSC}		1.7	2.0	2.3	MHz
Supply-side switch ON resistance	LX	R_{ONP}	I_{DCO} = 50mA	–	0.3	–	Ω
GND-side switch ON resistance	LX	R_{ONN}	I_{DCO} = –50mA	–	0.3	–	Ω
LX leakage current	LX	I_{LEAKLX}	Standby mode, LX = 1/2VIN	–1.0	–	1.0	μA
Overcurrent protection circuit operating current	LX	$I_{LIMITLX}$	Supply-side switch	–	1.5	–	A

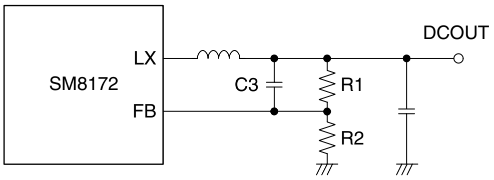
*1. The soft start time is the interval during which the output current is limited internally in the IC, and is different from the DC/DC converter output raise time. If the maximum load current is output after soft start time startup, the output voltage does not fall. But, if the maximum load current is output before soft start time startup, it should be careful that the output voltage may fall.



The LX starts the switching operation after 42μs from ENDCO rising. After switching operation startup, the output current limit operates like linear increase (load current = 0A). The DC/DC converter output voltage rise time varies with the load current, output capacitance, and other conditions.

*2. The DC/DC converter output voltage (DCOUT) is determined by the external resistors as given by the following equation. The SM8172A DC/DC converter controls the output to maintain the FB pin voltage of 0.6V.

$$DCOUT = \frac{0.6 \times (R1 + R2)}{R2}$$



Example settings

DCOUT [V]	R1 [kΩ]	R2 [kΩ]	C3 [pF]
0.8	200	600	8
1.000	200	300	8
1.200	200	200	8
1.502	200	133	8
1.800	200	100	8

The E-12 series usage example

DCOUT [V]	R1 [kΩ]	R2 [kΩ]	C3 [pF]
1.0	220	330	8
1.2	220	220	8
1.5	150	100	10

*3. The output voltage difference at I_{DCO} = 100mA and I_{DCO} = 900mA is within ± 3%.

■ Accuracy of output voltage

The accuracy of DCOUT output voltage is affected by the FB pin voltage accuracy (0.6V ± 2%) and the external resistor accuracy (R1, R2). If the external resistor of ± 1% accuracy is used, the accuracy of DCOUT output voltage shows ± 3% accuracy including the FB pin voltage accuracy ± 2%.

12. FUNCTIONAL DESCRIPTION

12-1. Series Regulator

12-1-1. Basic Operation

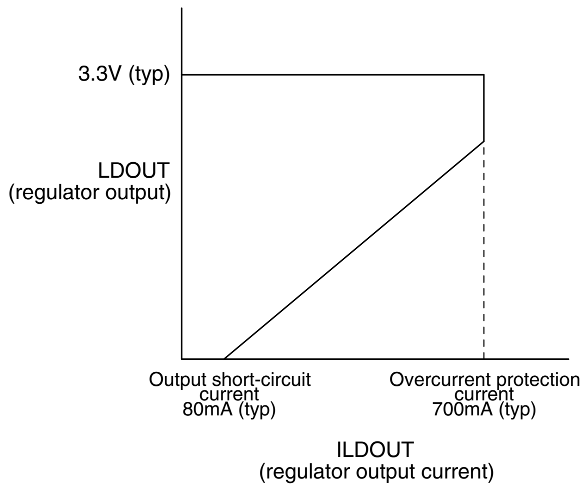
The SM8172A is equipped with a series regulator that drives a maximum 450mA load current at a fixed 3.3V output voltage.

12-1-2. Soft Start Function

A soft start circuit is built-in to prevent output voltage overshoot and inrush current at startup. The soft start time is the interval during which the output current is limited internally in the IC, and is different from the series regulator output voltage rise time. The time varies with the load current, output capacitance, and other conditions.

12-1-3. Overcurrent Protection Function

The series regulator overcurrent protection function uses a foldback method. When the output current exceeds the overcurrent protection circuit operating current limit value of 700mA (typ), the output current and output voltage are dropped, and the output short-circuit current is 80mA (typ). Normal operation is restored when the overcurrent condition is resolved.



12-2. DC/DC Converter

12-2-1. Basic Operation

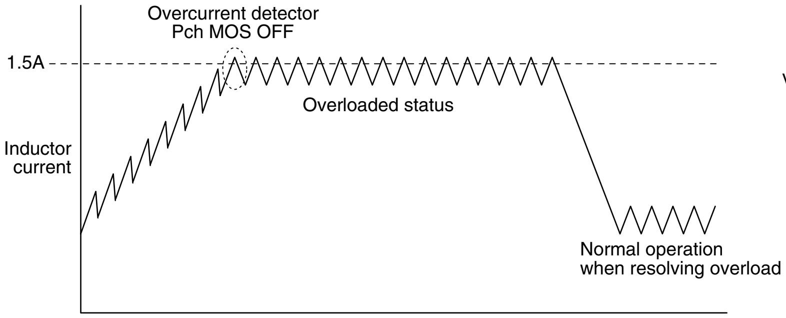
The SM8172A DC/DC converter is a step-down converter that is controlled using a 2MHz switching frequency current-mode PWM waveform, and which incorporates a MOSFET synchronous rectifier.

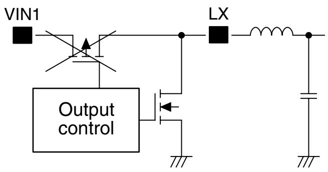
12-2-2. Soft Start Function

A soft start circuit is built-in to prevent output voltage overshoot and inrush current at startup. The soft start time is the interval during which the output current is limited internally in the IC, and is different from the DC/DC converter output voltage rise time. The time varies with the load current, output capacitance, and other conditions.

12-2-3. Overcurrent Protection Function

The P-channel MOSFET is turned OFF when the inductor current exceeds the current limit (1.5A). Normal operation is restored when the overcurrent condition is resolved.



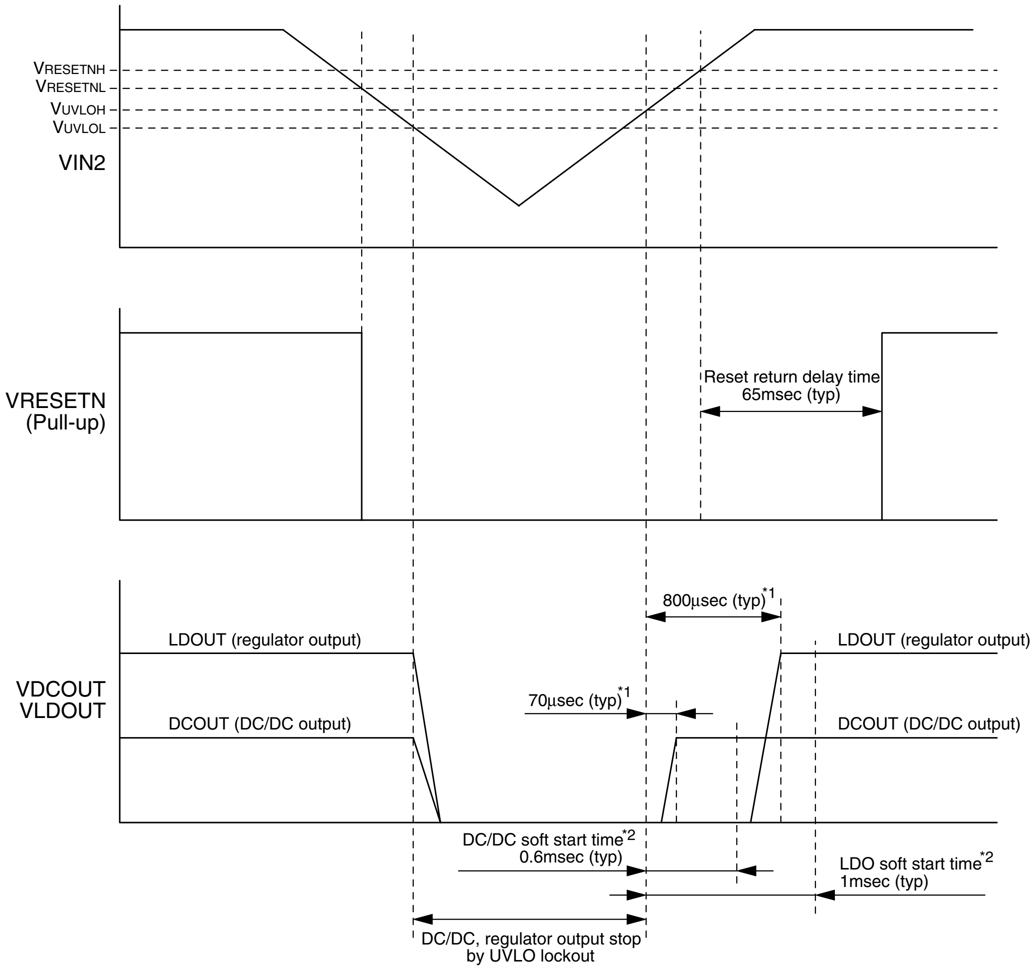


12-3. Reset Function

When the supply voltage is within the rated range, the RESETN output is high-impedance (Hi-Z). When the supply voltage falls below 3.7V (typ), the undervoltage detector circuit operates, setting the RESETN output LOW. When the supply voltage subsequently rises above 3.9V (typ), the RESETN output goes high-impedance again. However, when the supply voltage rises above 3.9V (typ), a built-in delay circuit sets the RESETN output to high-impedance after a delay of 65ms (typ). When at standby status, the RESETN output is LOW. When standby status is released, the RESETN output goes high-impedance after delay time if the supply voltage is more than 3.9V (typ).

12-4. Supply Undervoltage Lockout Function

In addition to the reset function, when the VIN2 supply falls below 3.0V (typ), the undervoltage lockout function operates, stopping the DC/DC converter and series regulator outputs. When the VIN2 supply subsequently rises above 3.2V (typ), the outputs start again.

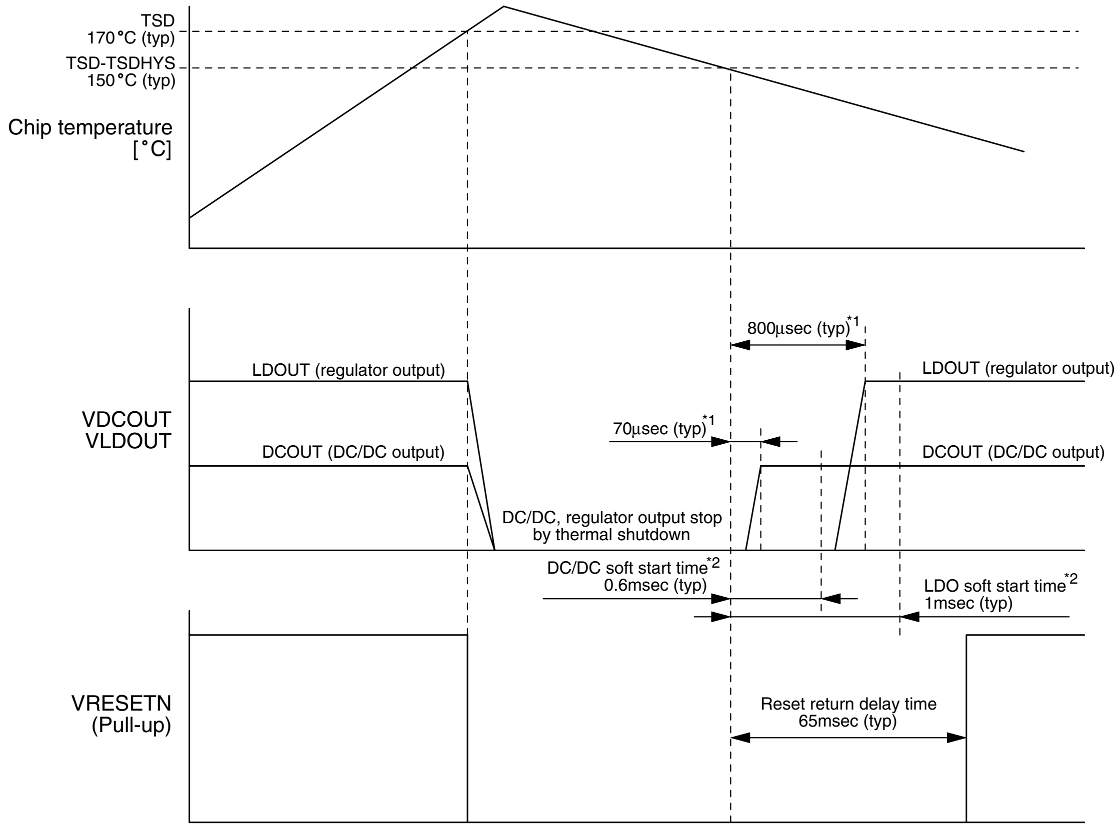


*1. A time interval example for a typical application circuit with no load. The series regulator and DC/DC converter output voltage rise times may vary with the load current, output capacitance, and other conditions.

*2. The soft start time is the interval during which the output current is limited internally in the IC, and is different from the series regulator and DC/DC converter output raise time.

12-5. Thermal Shutdown (TSD) Protection Circuit

When the chip temperature rises above approximately 170°C (typ) for any reason whatsoever, the thermal shutdown circuit operates, stopping all outputs. When the chip temperature falls below 150°C (typ), the outputs start again.



*1. A time interval example for a typical application circuit with no load. The series regulator and DC/DC converter output voltage rise times may vary with the load current, output capacitance, and other conditions.

*2. The soft start time is the interval during which the output current is limited internally in the IC, and is different from the series regulator and DC/DC converter output raise time.

12-6. State of Each Output when Protection Function Operates

The output states of RESETN, DCOUT, and LDOUT when various circuit protection functions operate are shown in the following table.

Pins	Normal operation	When various protection functions operate				
		RESET voltage VIN2 ≤ 3.9V (typ)	Under voltage lockout VIN2 ≤ 3.2V (typ)	TSD T_{SD} = 170°C (typ)	Series regulator overcurrent protection I_{OS} = 700mA (typ)	DC/DC converter overcurrent protection $I_{LIMITLX}$ = 1.5A (typ)
RESETN	Hi-Z	L	L	L	Hi-Z	Hi-Z
DCOUT*1	1.0V	1.0V	0V (Disable)	0V (Disable)	1.0V	< 1.0V
LDOUT	3.3V	3.3V	0V (Disable)	0V (Disable)	< 3.3V	3.3V

*1. When the DC/DC converter output voltage is set to 1.0V.

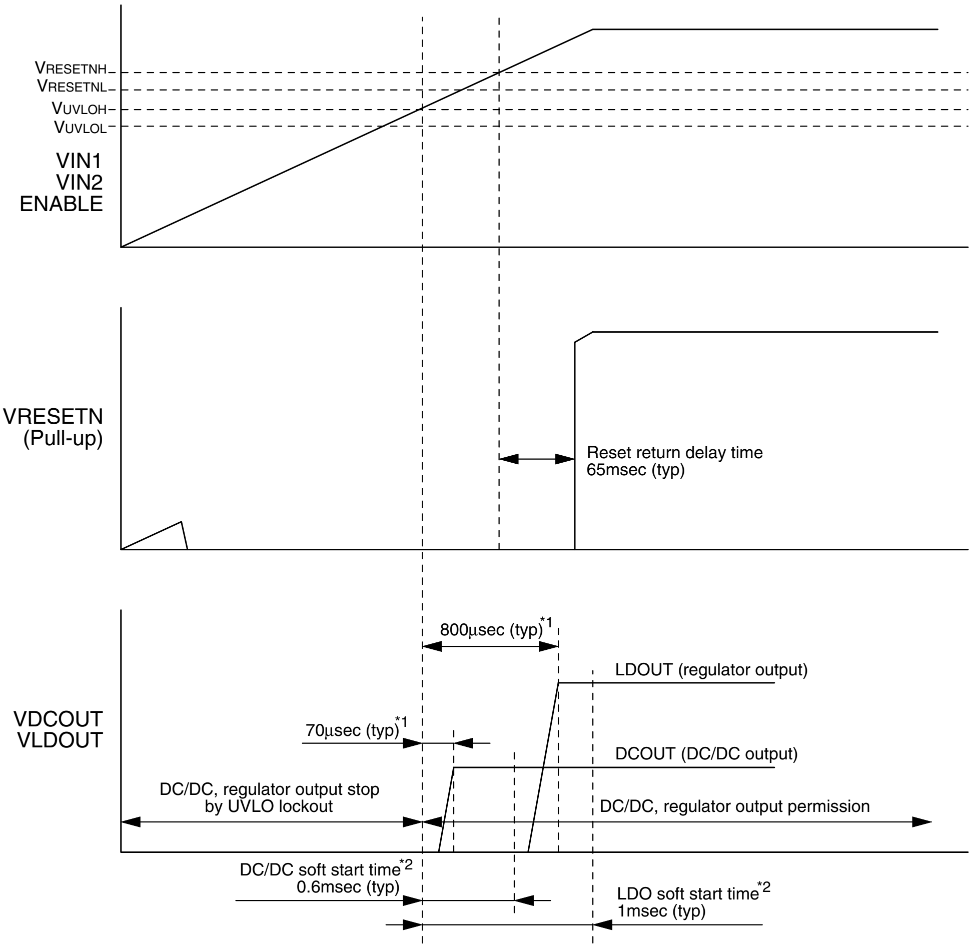
Note. The RESETN output is unaffected by the overcurrent protection function.
The DCOUT and LDOUT outputs are unaffected by the reset voltage.

12-7. Standby Mode

When both ENDCO and ENLDO are LOW, the device switches to standby mode, and all the RESETN, converter, and regulator outputs stop.

12-8. Timing Diagrams

12-8-1. Supply Voltage (VIN1 = VIN2 = ENDCO = ENLDO)

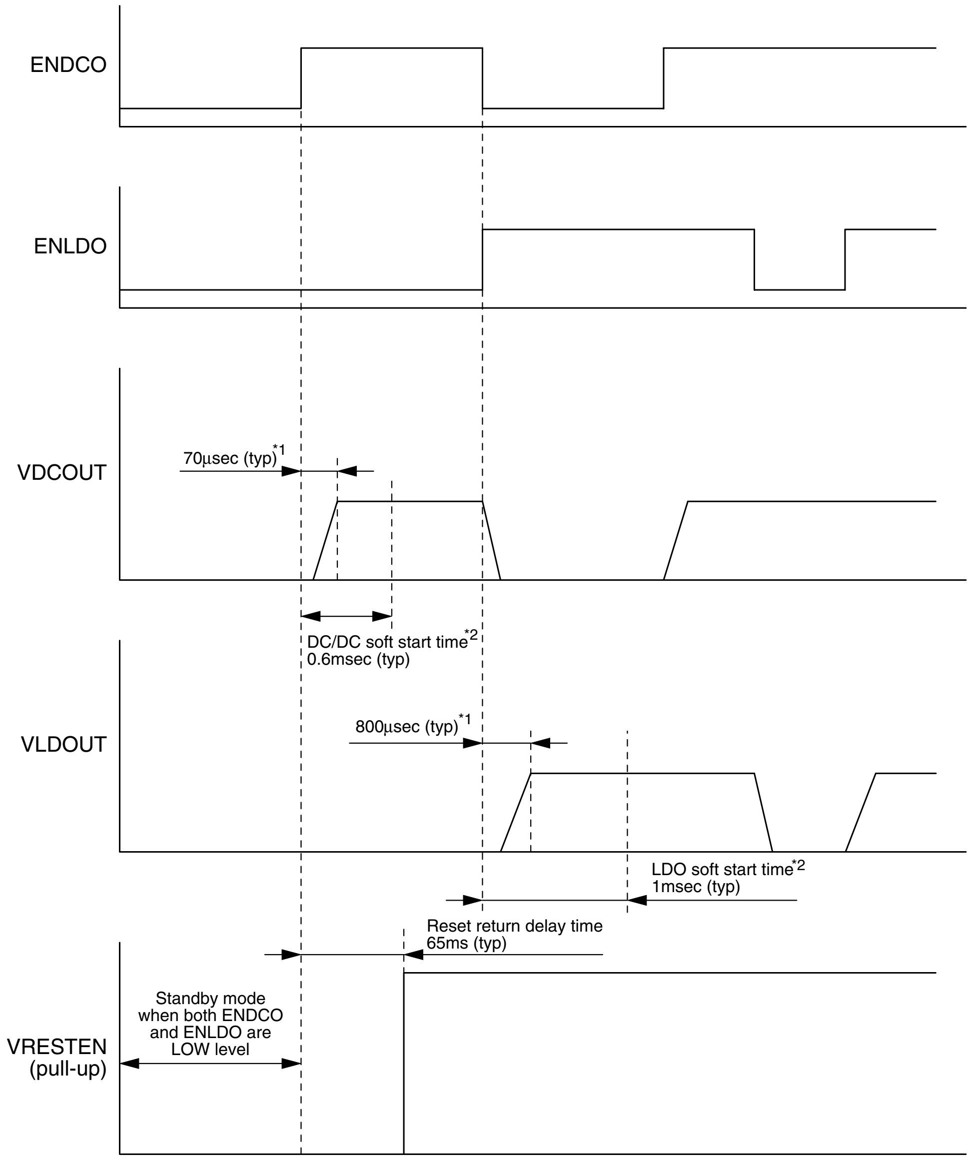


*1. A time interval example for a typical application circuit with no load. The series regulator and DC/DC converter output voltage rise times may vary with the load current, output capacitance, and other conditions.

*2. The soft start time is the interval during which the output current is limited internally in the IC, and is different from the series regulator and DC/DC converter output raise time.

Note. When the supply voltage is below approximately 0.8V, there is insufficient drive for the IC to operate normally and the RESETN output level is undefined. Normally, a pull-up resistor is connected to RESETN, which sets the RESETN output level to pull-up voltage.

12-8-2. Enable Control



*1. A time interval example for a typical application circuit with no load. The series regulator and DC/DC converter output voltage rise times may vary with the load current, output capacitance, and other conditions.

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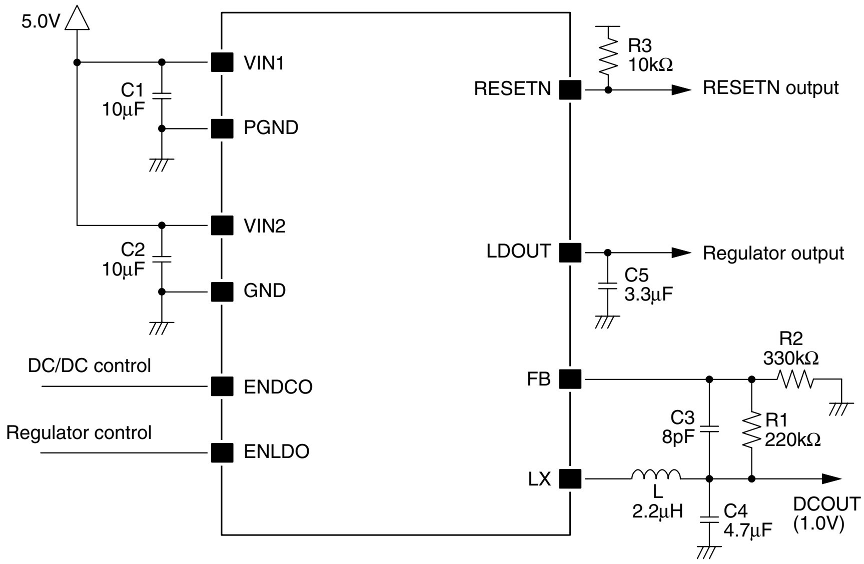
13. TYPICAL APPLICATION CIRCUIT



Recommended parts list

L	: 2.2µH	1002AS-2R2M (TOKO) NR4018T2R2M (TAIYO YUDEN) VLF4014ST2R2M1R9 (TDK)
R1, R2	: 220kΩ, 330kΩ	–
R3	: 10kΩ	–
C1, C2	: 10µF	Ceramic Capacitor C2012X5R1A106K (TDK) Ceramic Capacitor GRM219B31A106K (Murata)
C3	: 8pF	Ceramic Capacitor
C4	4.7µF	Ceramic Capacitor GRM219B31A475K (Murata)
C5	: 3.3µF	Ceramic Capacitor GRM219B31A335K (Murata)

Note. RESETN is open-drain, therefore, please take care so that the High level signal does not exceed the absolute maximum rating of IC which receives the reset signal. Besides, if the rest signal is not used, RESETN should be connected to GND.

14. USAGE NOTES

14-1. Select of Inductance (L)

It recommends 2.2μH of Inductance (L) for SM8172A. Since the DC resistance of inductance affects the power efficiency, we recommend the inductance of low DC resistance. Besides, please take care so that the inductance peak current (Ipeak) does not exceed the maximum allowable current of inductor.

14-2. External Capacitor Type

The external capacitors connected to the SM8172A should be multi-layer ceramic capacitors, with low temperature coefficient X5R or X7R class (EIA standard) multi-layer ceramic capacitors recommended. Use of high temperature coefficient Z5U or Y5V class multi-layer ceramic capacitors may cause an unstable output voltage condition and should be avoided.

Capacitor temperature coefficient 3-letter codes (EIA standard)

Lower category temperature	Upper category temperature	Maximum deviation in capacitance from +25°C (0V DC) value
X = –55°C	5 = +85°C	F = ± 7.5%
Y = –30°C	6 = +105°C	P = ± 10%
Z = +10°C	7 = +125°C	R = ± 15%
	8 = +150°C	S = ± 22%
		T = +22%/–33%
		U = +22%/–56%
		V = +22%/–82%

Selection : X5R characteristics

14-3. VIN Supply Input Capacitor

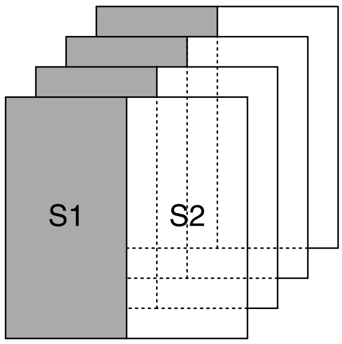
In some cases, the printed board component layout may affect the stability of the output voltages. In such cases, the VIN power supply capacitor should be increased or an additional capacitor connected.

14-4. Mounting

The package rear surface is metallic, and can be connected to the printed circuit board pattern as a heatsink. The connected pattern should be tied to GND level. Furthermore, use of a thermal via structure on the PCB or other technology should be used to provide sufficient heat dissipation. Use a printed circuit board with 4 or more layers. The PCB wiring ratio*1 should exceed 200%, where the wiring ratio is the sum total of printed wiring pattern surface area relative to the circuit board surface area.

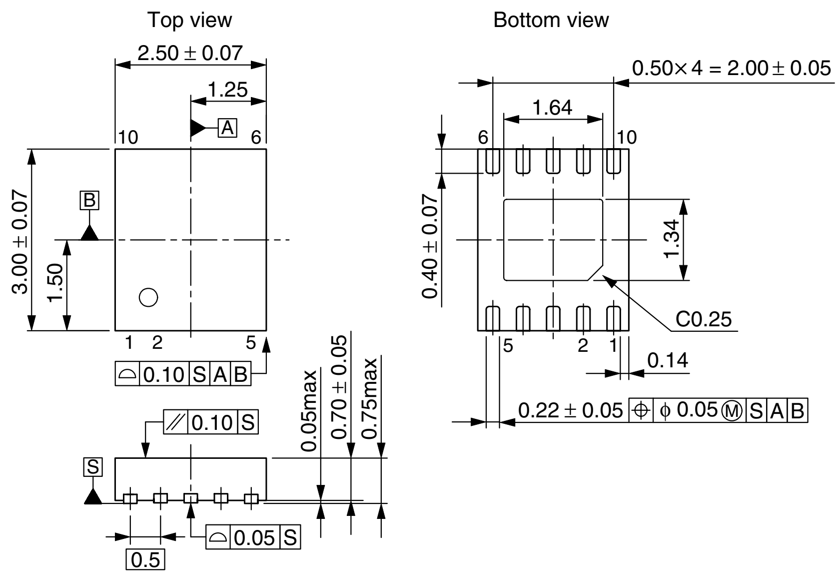
*1: Determining the wiring pattern ratio

Example: 4-layer board with the same wiring pattern on 4 layers (left), where the wiring pattern surface area on each layer is represented by S1, and the non-wired surface area is represented by S2. The wiring pattern is connected directly to the IC, and each layer's wiring pattern is connected to the IC by through holes. The circuit board surface area seen from above is S1 + S2. First, calculate the board surface area, here represented by S1 + S2. Next, calculate the wiring pattern surface area on each layer connected to the IC, represented here by S1. Calculate the total wiring pattern surface area for all 4 layers, in this example 4 × S1. Finally, calculate the wiring ratio percentage using the following equation: (Wiring ratio) = (Total wiring pattern surface area connected to the IC) / (PCB surface area) × 100. In this example, 4 × S1/(S1 + S2) × 100 [%], or a wiring ratio of 200% when S1 = S2.



15. PACKAGE DIMENSION

(Unit: mm)



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SEIKO NPC CORPORATION

1-9-9, Hatchobori, Chuo-ku,
Tokyo 104-0032, Japan
Telephone: +81-3-5541-6501
Facsimile: +81-3-5541-6510
http://www.npc.co.jp/
Email:sales@npc.co.jp

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