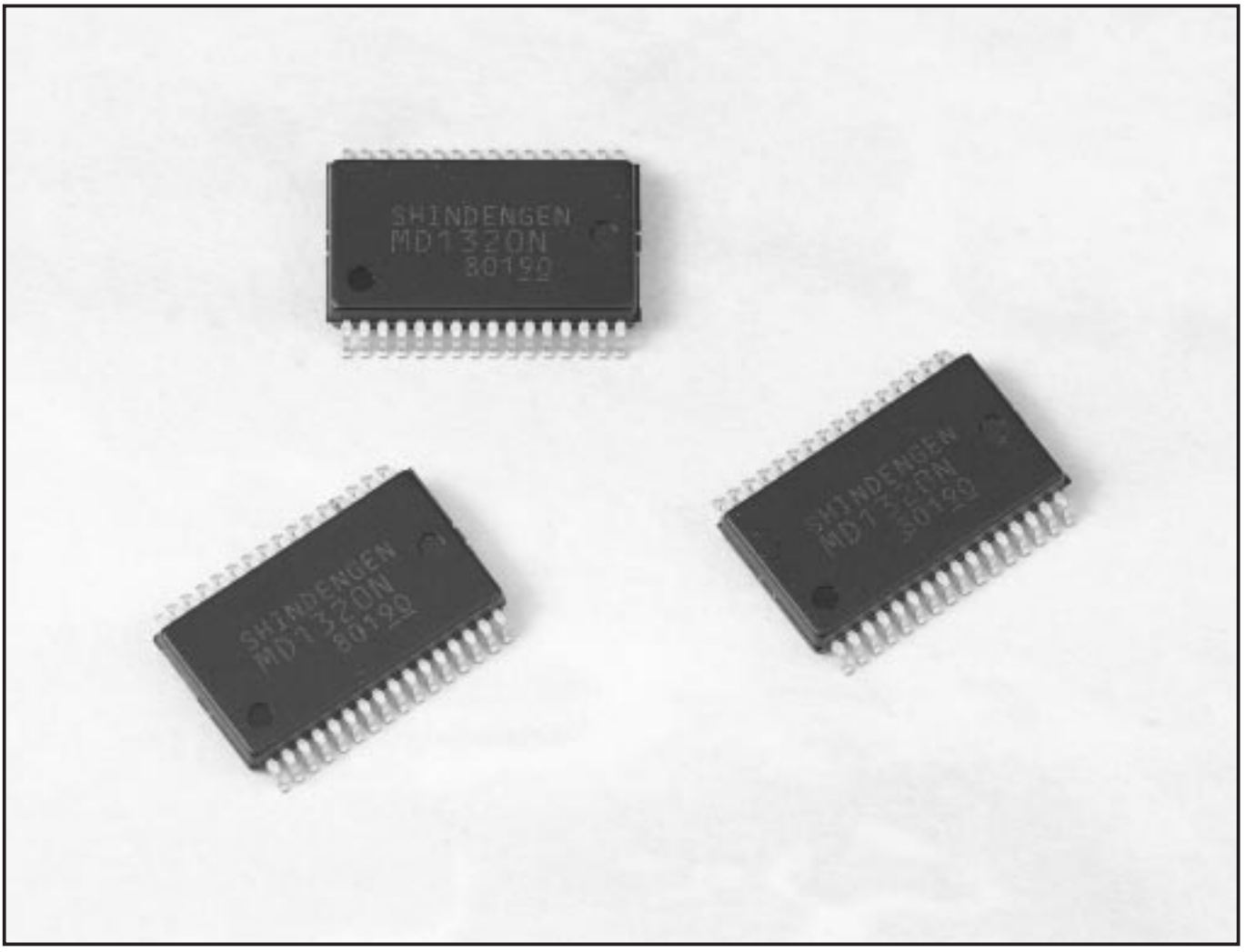
CAT.No.U085

3.3V/5V Stepdown

DC to DC Converter Power IC MD1320N

Application Manual



SHINDENGEN ELECTRIC MFG. CO., LTD.

1 Using the MD1320N DC to DC Converter Power IC

Thank you for purchasing the MD1320N DC to DC Converter Power IC. This manual contains important information on the safe use of the MD1320N. Your safety is most important to our company. Please read these instructions carefully before using this device.

CAUTION ⚠	The improper use of this device can result in serious injury or death. Expensive damage to this and other equipment can result. Failure to observe the cautions in this Manual can also result in minor injuries and annoying equipment damage.

CAUTION	⚠	The MD1320N is intended for use with general electronic equipment (office automation, communication, measurement, household, etc.) It is not intended for use with equipment whose failure might result in the death or injury of those depending upon it (medical treatment, air navigation, railroad, cargo handling, nuclear power, etc.) If you intend to use the MD1620F with other than the general equipment listed above, please consult with our company.
	⚠	Under no conditions attempt to repair or modify this device by yourself. Doing so can result in electric shock, equipment breakage, fire, and unreliable (and dangerous) equipment operation.
	⚠	Abnormal operating conditions may result in excessive voltage at the output terminal or excessive voltage drops elsewhere in the device. Take steps to prevent load mishandling and breakage (overvoltage and overcurrent prevention) at the final point in the equipment chain.
	⚠	Overvoltage protection The MD1320N is not equipped with an overvoltage protection function. In the event excessive voltage appears within a module, the high input voltage may remain together with a high output voltage even when the equipment is turned off. Smoke and flame may appear. To prevent this, be sure to install some sort of overvoltage protection circuitry before using the equipment.
	⚠	Before providing electrical power to the device, check that the polarity of the input and output terminals is correct (check for misconnections). If circuit protection circuitry is cut off from the rest of the equipment, smoke and flames may appear.
	⚠	Be sure that input voltage level is maintained at the specified level. This may require the installation of a voltage regulator to the input line. Voltage fluctuations may result in the appearance of smoke and flames.
	⚠	If a breakdown or other abnormal condition occurs during equipment use, immediately stop power to the equipment. Contact our company at your earliest possible convenience.

■This device fully meets the reliability and quality control standards described in our company's catalog. If this device is to be used in a situation where its misuse or failure might cause serious injury or death, consult with our company.

■Reliability and quality control standards for this device are considered adequate when it is used with the following types of end equipment.

Computer - Office automation - Communication terminal - Measurement・Machine tools - Audio-visual - Games and other amusements - Household appliance - Personal items - Industrial robot.

Special applications where the device may or may not be suitable include the following.

Transportation and conveyance (cargo loading) equipment- Primary communications equipment- Traffic signal control equipment - Fire and burglary alarms - Various safety devices - Medical equipment

Other special applications where the device reliability is not considered high enough include the following.

Atomic energy control systems - Aviation equipment- Aeronautics and space equipment - Ocean depth sounding equipment - Life supportequipment

■Our company makes a constant effort to improve the quality and reliability of our products. However, it is the customer's responsibility to provide safety. Take the appropriate steps to prevent personal injury, fire, and damage by providing redundancy equipment, fire containment equipment, and devices to protect personnel and equipment from operational mistakes.

DC to DC Converter Power IC
MD1320N Application Manual Table of Contents

CONTENTS

2 General description of the DC to DC Converter Power IC MD1320N

The MD1320N is a non-isolated step-down DC to DC converter power IC with built-in main switch MOSFET and SBD flywheel. The maximum output is 7.5W (5V, 3.5A). The highly efficient power IC can be used over a wide range of applications. Furthermore, the output switching function permits optional selection of 3.3 and 5V.
The use of a surface mounted type SSOP-32 package permits controls with minimal externally mounted parts. As a result, the overall size of DC-DC converter power IC as a power supply unit is reduced and made as thin as possible.

◆ 2 – 1 Features

- Input voltage range: 8∼30V
- Output voltage: 3.3V/5V (Output switching function permits optional selection of output voltages)
- Maximum output current: 1.5A
- Main switch MOSFET and built-in SBD flywheel
- Oscillation frequency: 250 kHz (Built-in oscillator does not require external capacitors or resistors)
- Overcurrent protection function
- Heat protection function
- Built-in low-voltage protection (UVLO) function

◆ 2 – 2 Applications

- Information distribution equipment
- Office automation equipment
- Electronic measuring instruments
- Home appliances
- Telecommunications equipment
- Factory automation equipment (Process control)
- Audio-video devices

◆ 2 – 3 Nomenclature

Device name and packaging specification codes are provided. Shipping conditions are determined according to these specifications.
Entry example: MD1320N 4072
Specification code: Shows package configuration and product name

◆ 2 – 4 Peripheral functions

1) Internal reference voltage (Vref)

IC internal circuitry reference voltage is provided by the temperature compensation reference voltage (5.0V). This reference voltage (Vref) provides a maximum external output current measured at the terminal of 1 mA.

2) Oscillation circuit (OSC)

The oscillation circuit is built into the device. No external oscillation capacitor nor resistor is required. The oscillation frequency (250 kHz) is set internally and has a sawtooth wave pattern. The sawtooth wave pattern cannot be outputted externally.

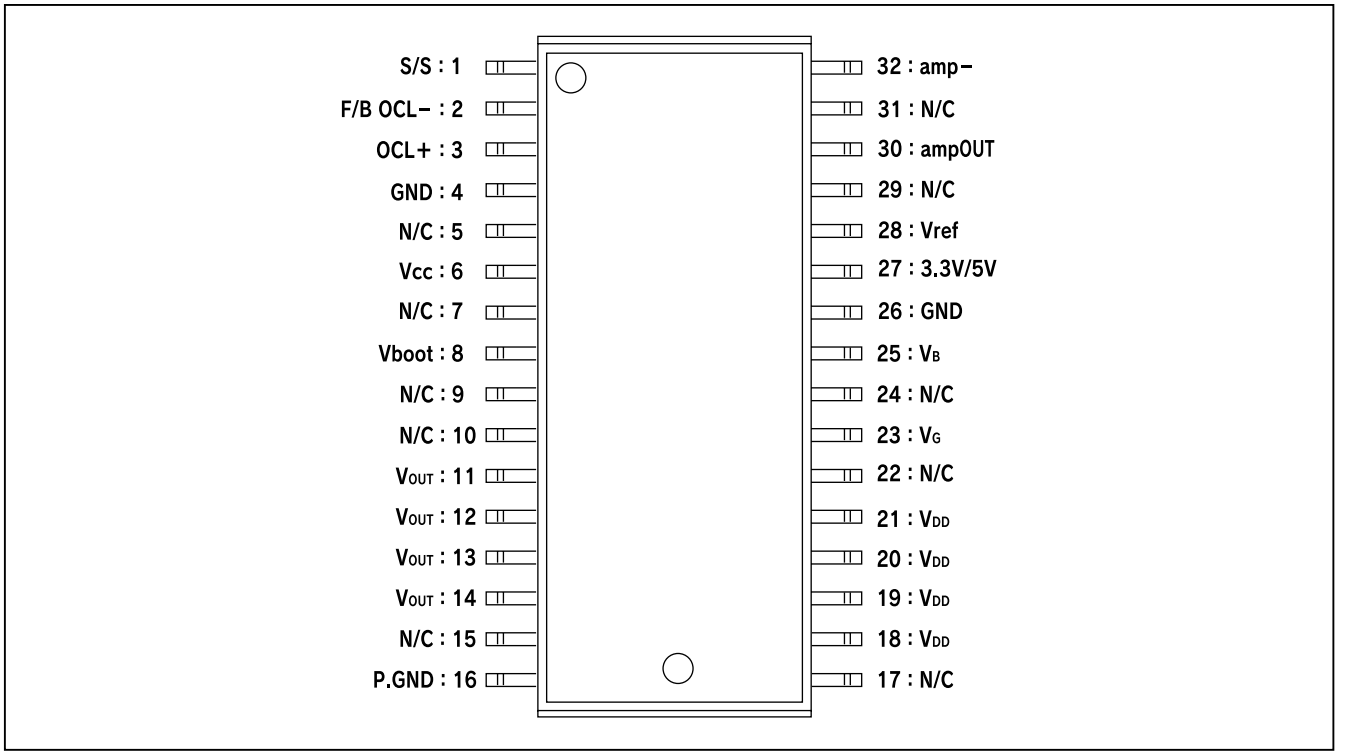
3) Error amplifier (Error Amp.)

The error amplifier senses the DC to DC converter voltage and provides a PWM control signal output. Loop gain between the error amplifier ampOUT terminal and the negative amp terminal is determined by the connections between the feedback resistor and the capacitor. This provides stable loop compensation throughout the system.

4) Overcurrent sensor (OCL)

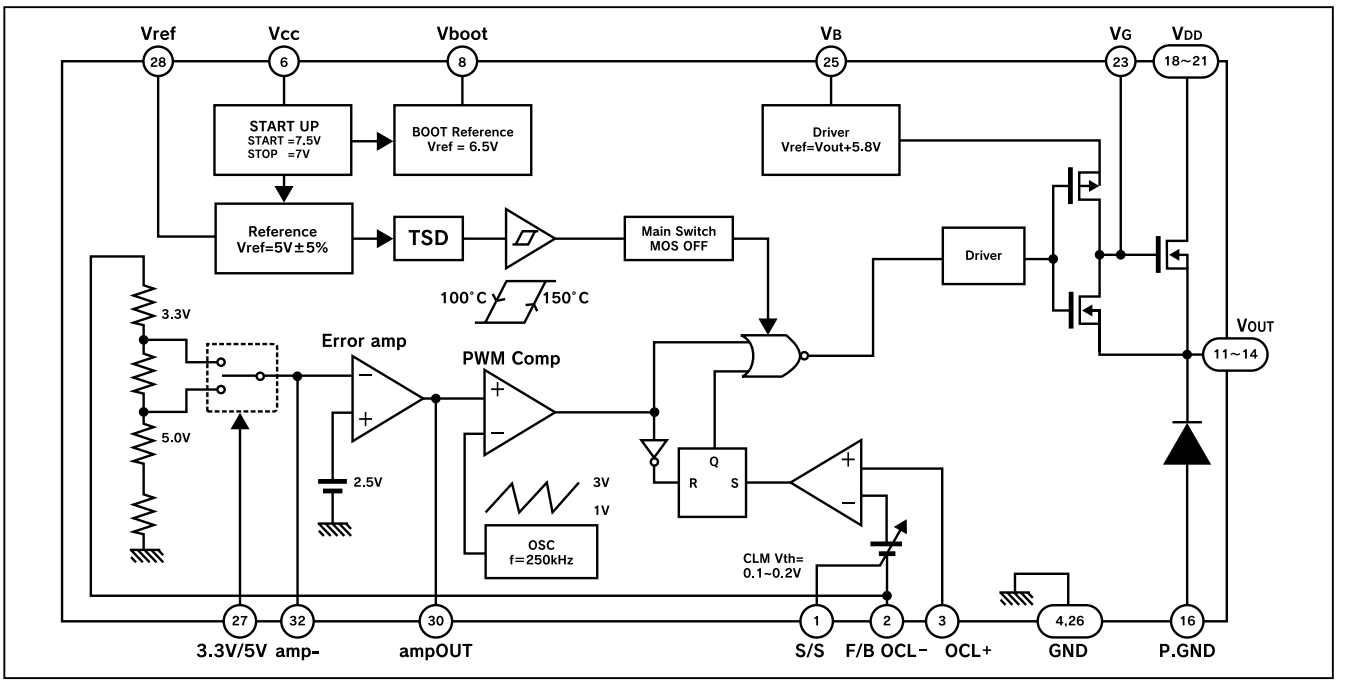
The OCL is a pulse-by-pulse overcurrent sensor. The voltage drop across the external current sensing resistor is measured between the negative and positive terminals of the OCL. If the voltage drop exceeds ≒ 0.19V, the main switch (MOSFET) opens.

◆ 2 – 5 Terminal functions

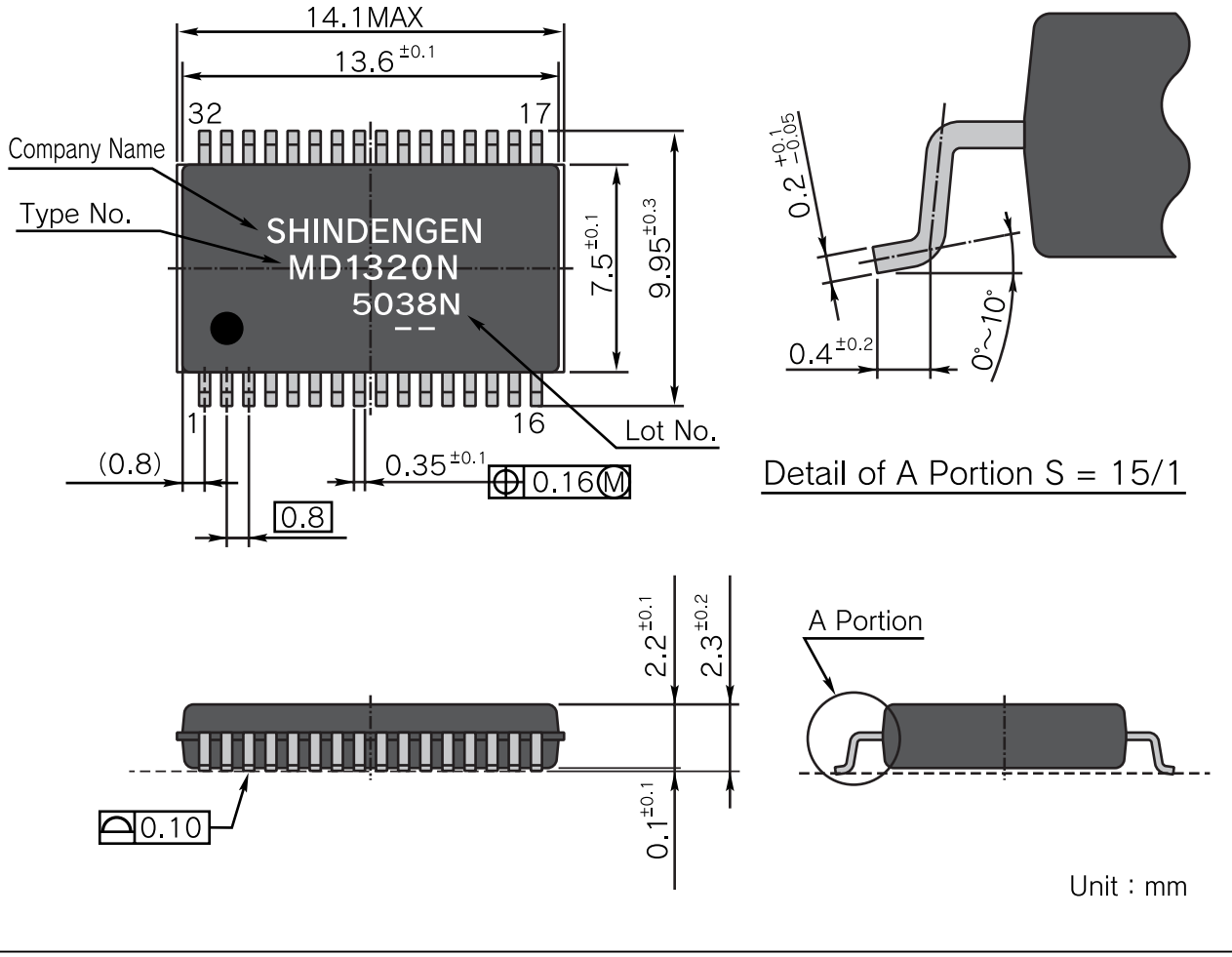


Terminal No.	Terminal symbol	Function
1	S／S	Soft-start capacitor terminal
2	F／B OCL—	Overcurrent detection terminal (–) /feedback terminal
3	OCL＋	Overcurrent detection terminal (+)
4,26	GND	Ground terminal
6	Vcc	Control circuit power supply terminal
8	Vboot	Main switch MOSFET control circuit power supply terminal
11～14	VOUT	Power supply output terminal
16	P.GND	Output circuit ground terminal
18～21	VDD	Main switch MOSFET power supply terminal
23	VG	Main switch MOSFET gate terminal
25	VB	Output boot strap terminal. Used for connecting condenser across VB and VOUT terminals to boot strap IC internal main switch MOSFET control circuit.
27	3.3V／5V	Output voltage switching terminal Output can be controlled at 5.0V when switched to 3.3V/5V "H" level terminal. Output can also be controlled at 3.3V when switched to 3.3/5V "H" level terminal.
28	Vref	Internal reference voltage output terminal
30	ampOUT	Internal error amplifier output terminal
32	amp—	Internal error amplifier reversing input terminal
5,7,9,10,15,17,22,24,29,31	N／C	No connection terminal (N/C terminal)

◆ 2 – 6 Block diagrams



3 External dimensions(Diagram)(SSOP-32)



4 Characteristics

1) Absolute maximum rating (Ta=25℃)

Item	Symbol	Rated value	Unit
Line voltage	V_{IN}	32	V
Output MOS input voltage	V_{DD}	32	V
Output current (AVE)	$I_{OUT}ave$	1.5	A
Output current (PEAK)	$I_{OUT}peak$	2	A
Storage temperature	Tstg	−40～150	℃
Junction temperature	Tj	150	℃

2) Recommended operating conditions

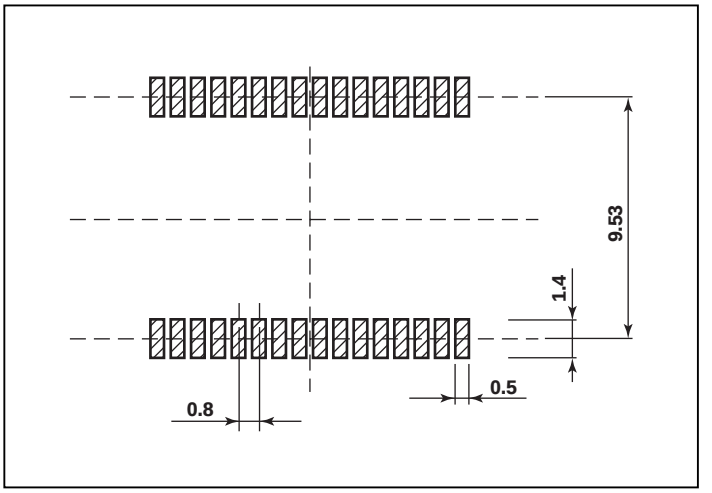
Item	Recommended value	Unit
Input voltage	8～30	V
Operating temperature	−10～80	℃

3) Electrical characteristics (Ta=25℃)

Item	Symbol	Conditions	MIN	TYP	MAX	Unit
HighsideMOS Drain-source breakdown voltage	Vdss	I_D=1mA,V_{GS}=0V	32	−	−	V
HighsideMOS Drain interruption current	Idss	V_{DS}=30V,V_{GS}=0V	−	−	10	μA
HighsideMOS Drain-source ON resistance	Ron	I_D=1.2A,V_{GS}=4V	−	140	250	mΩ
HighsideMOS Source-drain Di forward voltage	V_{SD}	I_S=1.2A,V_{DS}=0V	−	−	1.5	V
LowSideSBD Peak reverse voltage	V_{RM}	−	40	−	−	V
LowSideSBD Forward voltage	V_F	I_F=1.2A	−	−	0.55	V
LowSideSBD Reverse current	I_R	V_R=V_{RM}	−	−	2	mA
Start voltage	Vcc_start	−	7	7.5	8	V
Stop voltage	Vcc_stop	−	6.5	7	7.5	V
Start-stop voltage hysteresis	Vcc_hys	−	−	0.5	−	V
Current consumption	Icc	Vcc=8V～30V	−	8	10	mA
BOOT terminal voltage	Vboot	Vcc=8V～30V	6	6.5	7	V
Internal reference voltage	Vref	Vcc=8V～30V	4.75	5	5.25	V
Internal oscillation frequency	fosc	Vcc=24V	212.5	250	287.5	kHz
Overcurrent threshold voltage	Vth_OCL	Vcc=24V	0.162	0.19	0.218	V
SoftStart terminal current	$I_{S/S}$	Vcc=24V	−20	−12.5	−5	μA
"H" CHG terminal input voltage	V_{CHGH}	−	4.5	−	Vref	V
"L" CHG terminal input voltage	V_{CHGL}	−	GND	−	0.5	V
Overcurrent protection operating temperature	T_TSD	−	−	150	−	℃

5 Mounting

◆ 5 – 1 Soldering pattern reference (Reflow-type)



◆ 5 – 2 Mounting cautions

1) Mounting

Vibration and other mechanical disturbances can exert stress on the internal parts of the device. Carefully examine your equipment and place the device where vibration and other shock is minimal.

2) Soldering cautions

●Infrared reflow method

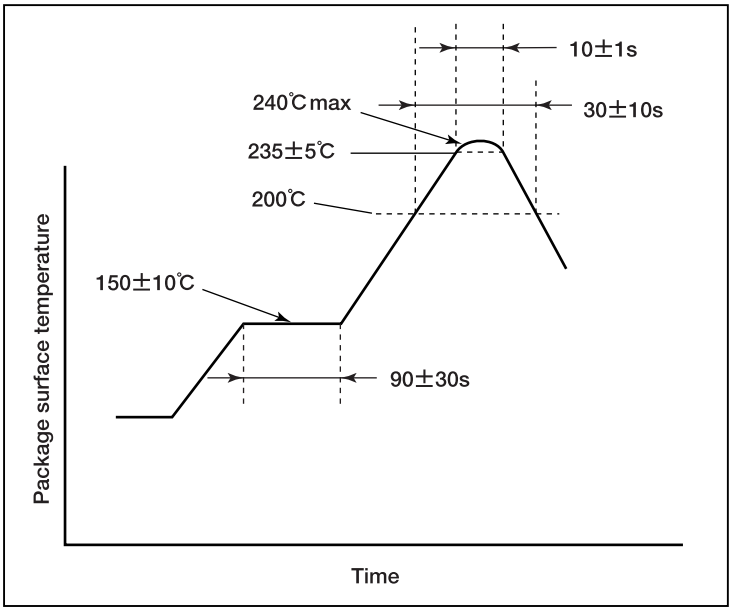
This method provides very high temperature soldering. The chart at the right shows the recommended temperature profiles for the Infrared reflow soldering method.

●Soldering iron

When using a soldering iron, observe the following.

Soldering iron temperature: Not to exceed 300℃

Soldering iron contact time: Not to exceed 5 seconds



(Figure 5-A)

3) Cleaning cautions

Carefully remove all flux. Allow time for the soldered areas to completely dry before using the device.

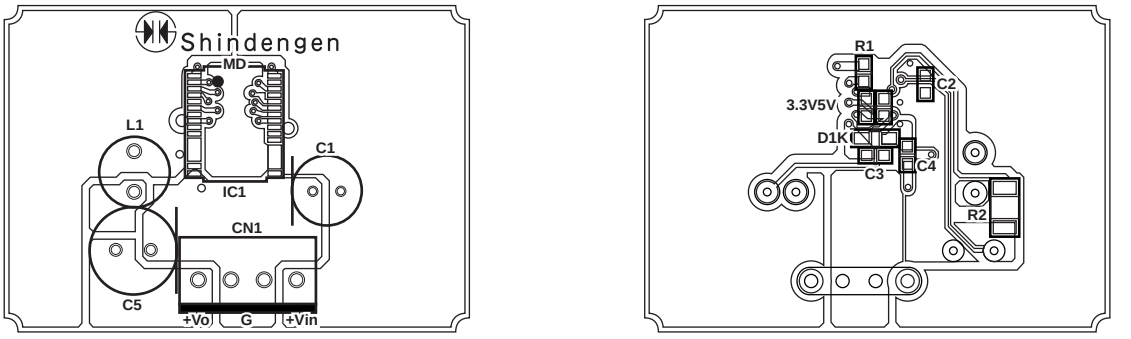
4) Secondary mold cautions

After installation of the device to a board, remolding using plastic may be required. During this process, stress on the device will depend on the type of plastic used. The best plastic (that which causes the least stress on the device) has a minimum contraction ratio and high flexibility. Hardening temperatures should not exceed the storage temperature. Carefully check the plastic characteristics before use.

※ Static electricity can damage the device. The person and clothing of personnel working with the device should be grounded to prevent the build-up of static electricity. It is recommended that personnel stand on rubber mats (electrical safety mats) having a resistance greater than 1MΩ when working with the device. This will prevent damage to the device from static electricity discharge and protect the personnel form electrical shock.

◆ 5 – 3 Printed circuit board patterns and design considerations(Reference)

Typical 1.5A surface mounted parts model



Typical 1.5A lead parts model

※ The device does not have a voltage surge protection circuit or an input fuse. The user should install an input fuse to protect the device and equipment before using the device.

- For optimum thermal efficiency, maintain the copper foil pattern as much as possible.
- Connect the F/B OCL negative terminal (Pin 2) as close as possible to the output capacitor (C5).
- Connect the input capacitor (C1), output capacitor (C5), choke (L1), and dropping resistor (R2) as close as possible to the power IC device.
- Separate the ground terminals (Pin 4 and Pin 26) and the P and ground terminals (Pins 16). Connect each of them as close as possible to output capacitor (C5).

6 Operating instructions

The MD1320N power IC device uses chopper circuitry and can be referred to as a chopper type DC to DC converter. The device requires an external choke and capacitor to be connected to it. The characteristics of these external parts and the way they are packaged and connected will greatly affect the performance of the device and its circuits. Carefully select these external parts to provide optimum device performance.
Neither the device input side nor output side is isolated.

◆ 6 – 1 Basic input and output terminal connections

Power IC device connection and use involves the rated output voltage and the maximum current output range.

1) If an output voltage of 3.3V is required, connect Pins 27 and 28. If an output voltage of 5V is required, connect Pins 26 and 27.

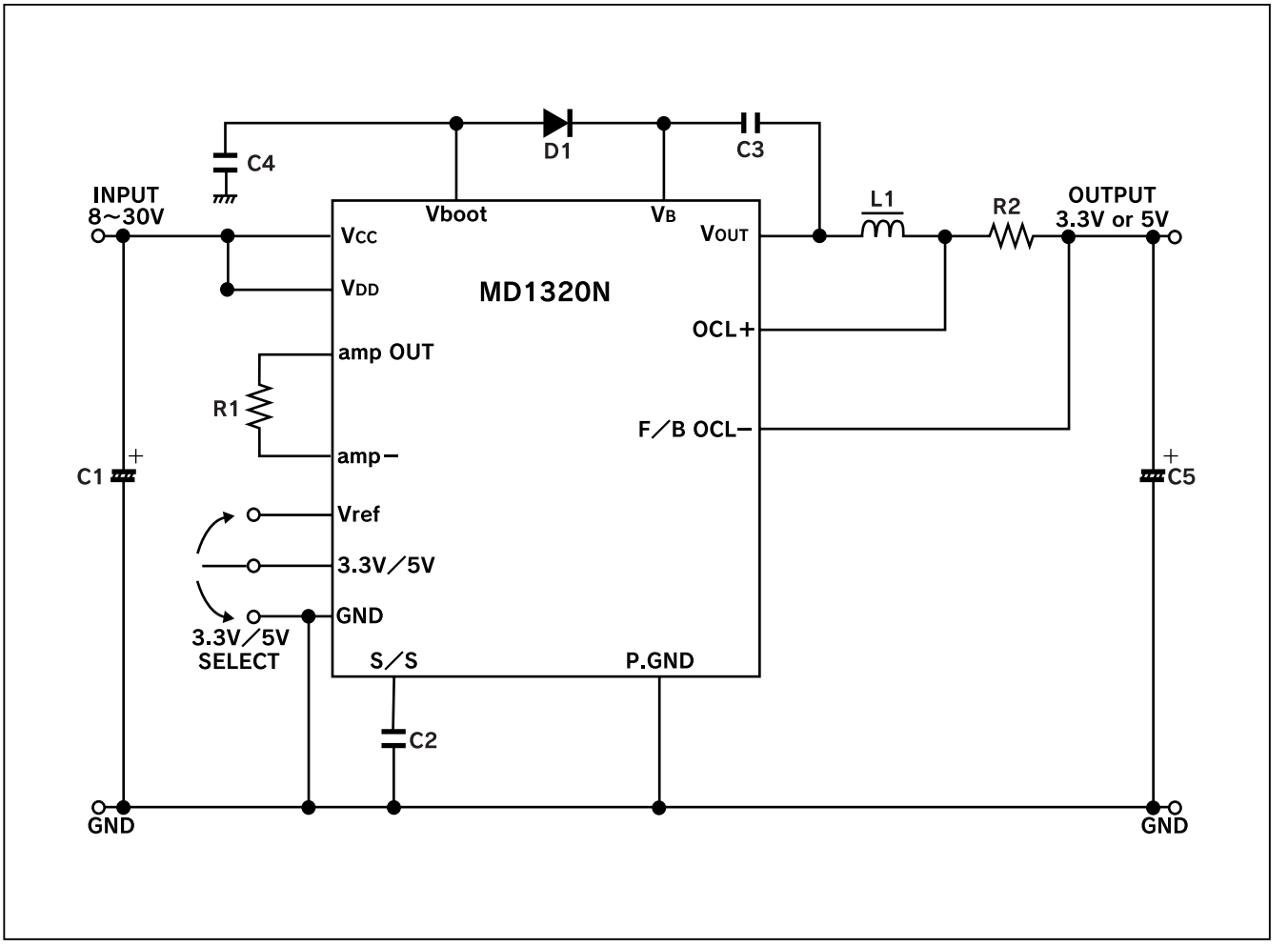
2) Pin 23 is the test terminal and must be left open.

3) Pins 5, 7, 9, 10, 15, 17, 22, 24, 29, and 31 are internal non-connecting pins (N/C terminals).

4) Figure 6-A shows the external parts and their connections. Be sure to prepare and connect these items before using the device.

5) Output capacitor (C5) minimizes switching frequency ripple and provides a smooth and stable output voltage. The use of a low-impedance capacitor is recommended (low impedance provides minimum ripple).

●Standard connections (Figure 6-A)



◆ 6 – 2 Input protection element connection

⚠ Caution

The MD1320N device has an output current drop function. In the event of power IC device malfunction resulting in excessive input current flow, smoke and flame may be emitted from the equipment. To prevent this, install a fuse or protective circuitry to the power IC device input line.

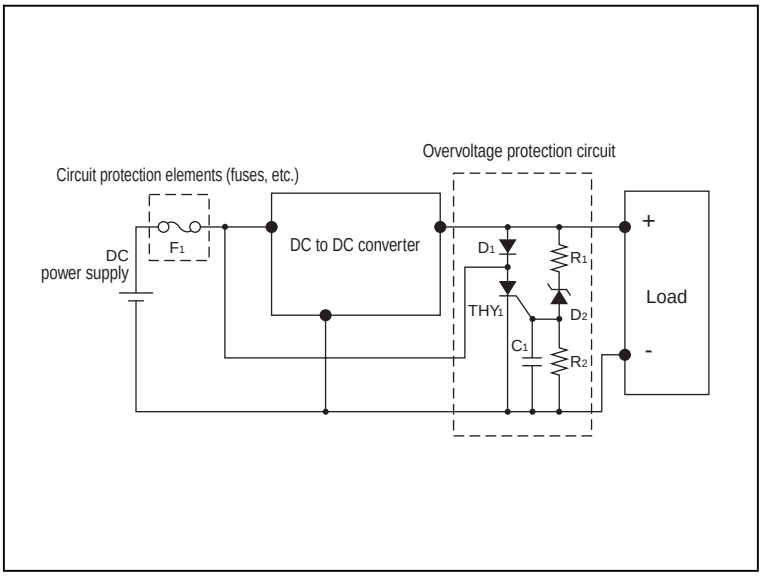
Install the fuse or protective circuitry to the positive side of the input line(Figure 6-2, DC input). Be sure that the fuse or protective circuitry is not too large to effectively protect the circuitry (the input line must be capable of carrying enough current to blow the fuse).

◆ 6 – 3 Overvoltage protection

The MD1320N power IC device does not have an overvoltage (voltage surge) protection function. If a malfunction occurs in the device internal circuitry, there may be a voltage surge. Output will reflect this surge and damage to equipment may result. Smoke and flame may be emitted from the equipment. To prevent this, be sure to install voltage surge sensing and protection circuitry.

There are a number of ways to protect against voltage surge. Figure 6-B shows a typical voltage surge protection set-up. The voltage surge sensing and protection circuit should be installed as close as possible to the load (away from the output smoothing capacitor).

● Reference part example (Figure 6-B)



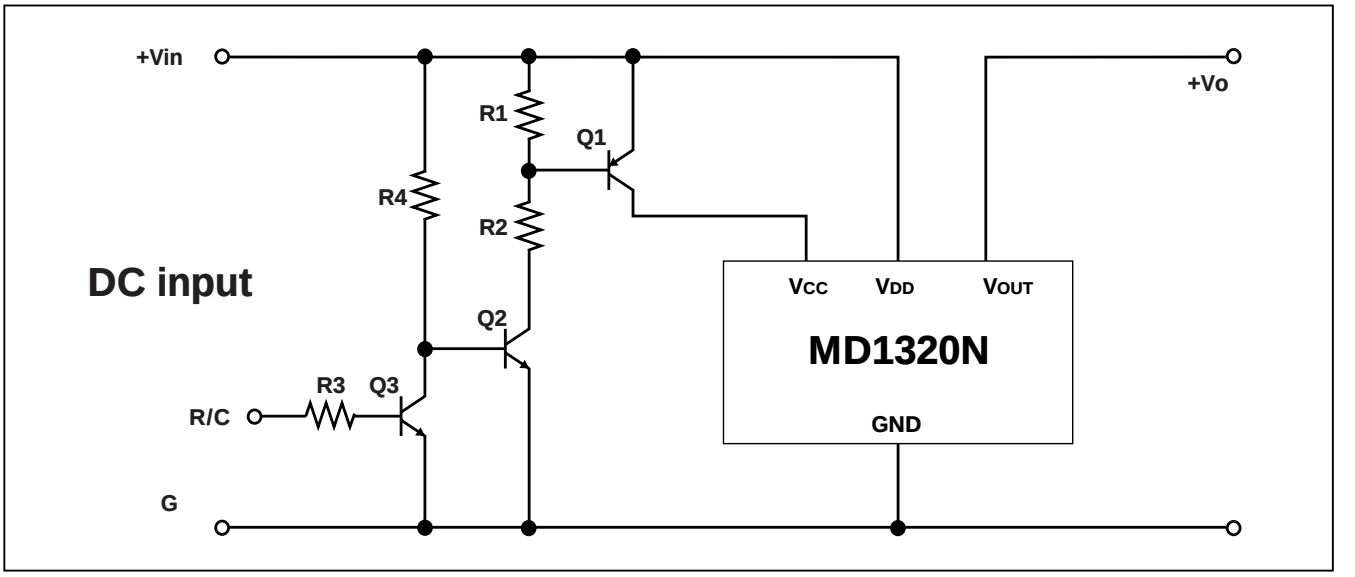
		3.3V	5V
F 1	Circuit protection elements (fuses, etc.)	1.5A	
R 1	Resistance	1／10 W 22Ω	
R 2	Resistance	1／10 W 1kΩ	
C 1	Ceramic capacitor	CM316 334K 10AT 10V 0.33μF	
D 1	Diode	M1F L 20U 200V 1.1A	
D 2	Zener diode	HZM3.6N B1 3.4～3.65V （5mA）	HZM5.6N B1 5.31～5.55V （5mA）
THY1	Thyrister	3P4J—Z 400V 3A	

Conditions: At rated output current

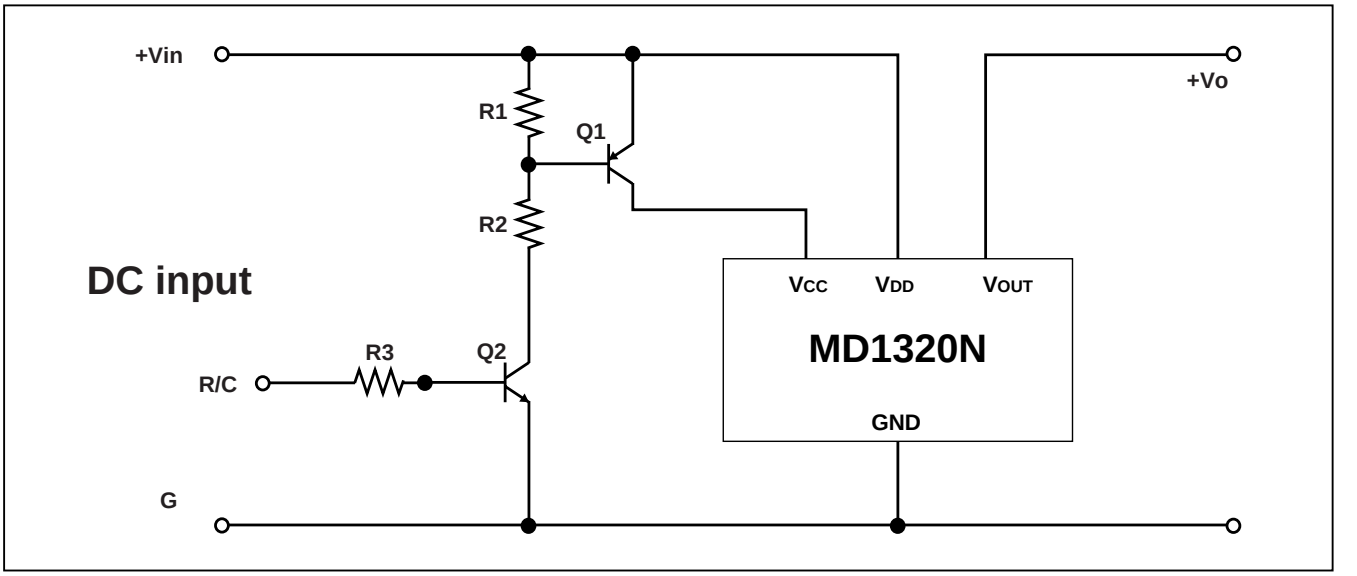
◆ 6 – 4 Remote ON/OFF Control

The MD1320N is not provided with remote ON/OFF control functions. When necessary, be sure to add the recommended circuit shown below. The use of remote control (R/C) circuit turns the output ON and OFF without making or breaking the input. The R/C circuit can also be employed in systems such as sequence control for a power supply system.

1) R/C terminal When turning ON power supply on the low side (connection to ground), be sure to add the circuit shown in Fig. 6 - C, and turn the power supply OFF when the R/C circuit is on the high side.
2) R/C terminal When turning ON power supply on the high side (open), be sure to add the circuit shown in Fig. 6-D, and turn power supply OFF when the R/C terminal is on the low side.



(Figure 6-C)



(Figure 6-D)

◆ 6 – 5 Reference parts used with standard circuits

Part No.	Nomenclature	Applicable voltage 3.3V/5V reference parts		
		Output current example		
		0.5 A	1 A	1.5 A
L 1	Choke	120 μH 0.5A	68 μH 1A	47 μH 1.5A
D 1	Low-loss diode	M1FL20U(200V 1.1A)	M1FL20U(200V 1.1A)	M1FL20U(200V 1.1A)
C 1	Electrolyte capacitor	35V 33 μF 250mA	35V 68 μF 500mA	35V 150μF 760mA
C 2	Ceramic capacitor	25V 0.01 μF	25V 0.01 μF	25V 0.01 μF
C 3	Ceramic capacitor	25V 0.1 μF	25V 0.1 μF	25V 0.1 μF
C 4	Ceramic capacitor	25V 0.1 μF	25V 0.1 μF	25V 0.1 μF
C 5	Electrolyte capacitor	10V 220 μF 130mΩ	10V 470 μF 72mΩ	10V 680 μF 53mΩ
R 1	Resistance	0.1W 330kΩ	0.1W 330kΩ	0.1W 330kΩ
R 2	Resistance	0.25W 0.3Ω ±5%	0.5W 0.15Ω ±5%	0.75W 0.1Ω ±5%

◆ 6 – 6 Electrical characteristics (Ta = 25℃)

Efficiency and ripple are measured according to external reference parts circuit configuration that is based on standard circuit configuration.

Item	Output current example					
	0.5A		1A		1.5A	
Output voltage (V)	3.3	5	3.3	5	3.3	5
Input voltage (V)	8～30					
Output current (A)	0～0.5		0～1		0～1.5	
Voltage regulation accuracy (%)	±5					
Efficiency Typ. (%)	83	88	83	88	82	88
Oscillation frequency Typ. (kHZ)	250					
Ripple voltage p-p Typ. (mV)	25					
Overcurrent protection	Operated at rated current, min./automatic return					
Thermal protection Typ. (℃)	150					
Operating (ambient) temperature (℃)	−10～80					

Efficiency and ripple voltage conditions: Vin = 12V and Io = rated output current

7 Basic device set-up standards

Set-up sequence below
Areas that must be carefully considered in the set-up of the device include the overcurrent detecting resistor, circuit inductance, output capacitor, input capacitor, and thermal characteristics.

◆ 7 – 1 Overcurrent detecting resistor (R1) selection

Detects a peak voltage across the resistor of 0.19V±15%

$$R1 = \frac{V_R}{I_R} [\Omega]$$

※ Switching noise and other factors may cause some variation in the calculated drop point value. Check your own equipment and calculate the value accordingly.

V_R : Average voltage level
I_R : Drop point

◆ 7 – 2 Inductance (L1) selection

The selected inductance sets the cut-off current at 15% of the rated output current.

$$L1 = \frac{(Vi(max) - Vo) \times (Vo + V_F)}{\Delta I \times (Vi(max) + V_F) \times f} [H]$$

V_i (max) = Maximum input voltage
V_O : Output voltage
V_F : SBD flywheel forward voltage (0.5V)
ΔI : Cut-off current $\times 2$ ($I_O \times 0.15 \times 2$) (Cut-off current flows through the choke coil. Current value is intermittent.)
f : Oscillation frequency (250 kHz)
I_O : Output current

Calculated inductance values (L1) shown here represent those used in previously manufactured devices and may not be applicable to your device. The use of an actual value somewhat higher than the measured value is standard procedure. However, actual values lower than the measured value may be used where the rated current is low. Use the formula to back-calculate the ΔI using the selected L1 value. The recommended value is $0.2 \times I_O \leqq \Delta I \leqq 0.4 \times I_O$ (Cut-off at 10 to 20 percent).

◆ 7 – 3 Output capacitor selection

If an electrolytic capacitor is used, output ripple is determined by ΔI and capacitor impedance. Use the formula below to calculate the value. Select a device providing an impedance (Z_C) lower than the calculated value.

$$Z_C \leqq \frac{Vrip}{\Delta I} [\Omega]$$

Vrip : Output ripple voltage (Ex: 25m V_{P-P})
ΔI : Cut-off current × 2

◆ 7 – 4 Input capacitor selection

A large ripple current flows through the input capacitor. Use the formula below to calculate the value. Select a device providing a higher ripple current capacity (Irip) than the calculated value.

$$D = \frac{V_O + V_F}{V_i (min) + V_F}$$

$$Irip \geqq \sqrt{D(1-D)} \times I_O [A]$$

D : Duty
V_O : Output voltage
V_i (min) : Minimum input voltage
V_F : SBD flywheel forward voltage (0.5V)
I_O : Output current

◆ 7 – 5 Thermal management

The MD1320N is so designed that heat is radiated when Pins 11, 12, 13, 14, and Pins 18, 19, 20 and 21 are connected to the substrate pattern. The necessary area of heat radiation pattern differs according to the material and size, but be sure to check with an actually operating piece of equipment and referring to the data given in Fig. 7 - A.
Since the temperature rise also differs according to the conditions of I/O voltage and output current, use 105 degrees maximum as the design target for the surface temperature of case.

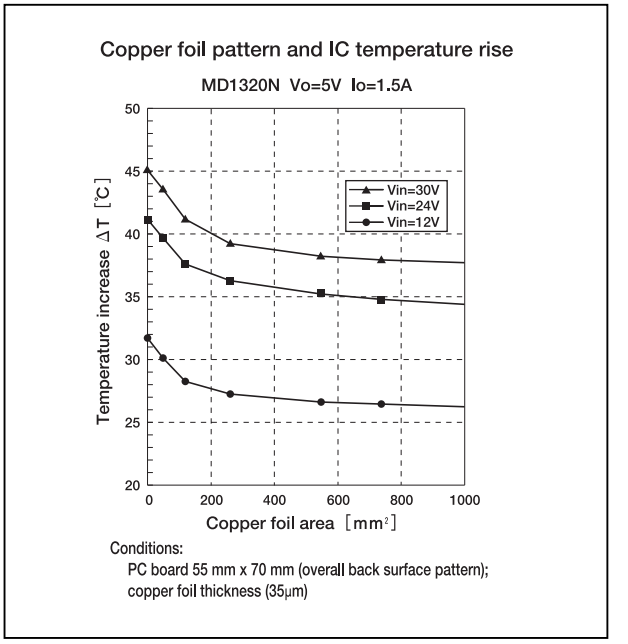


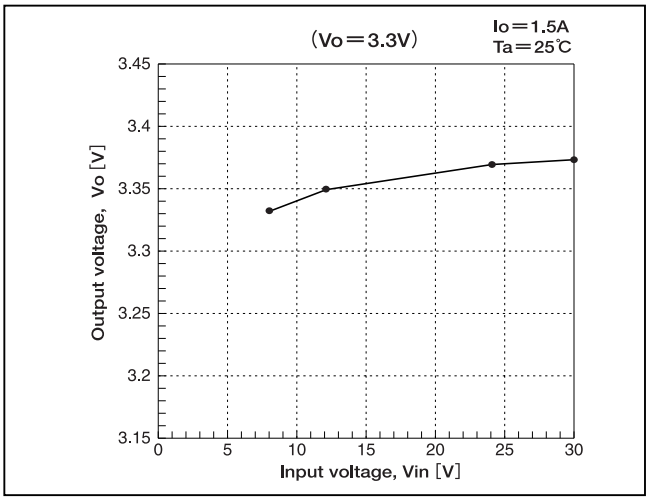
Figure 7-A

8 Electrical data measurement

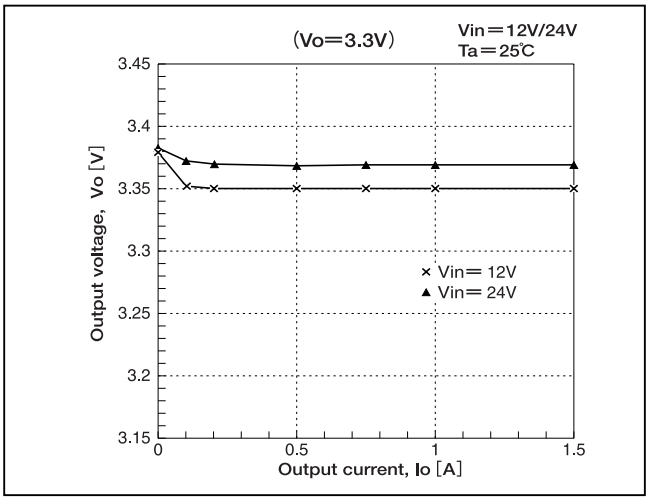
This data results from measurements taken using equipment connected as shown in the standard connection diagram and using reference part and reference circuitry patterns.

◆ 8 – 1 Output voltage - 3.3V

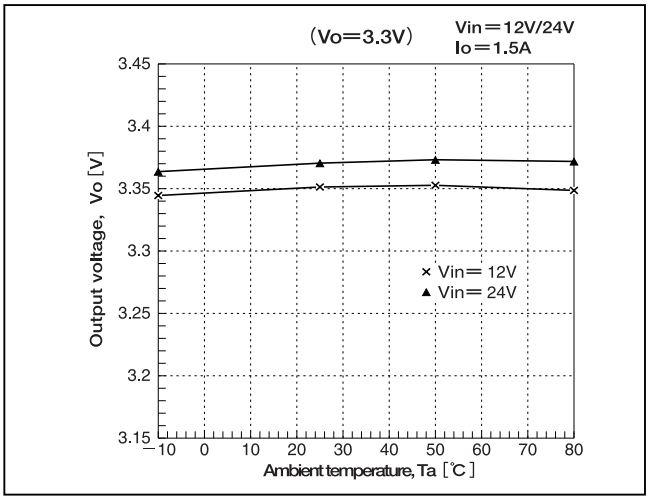
● Line regulation



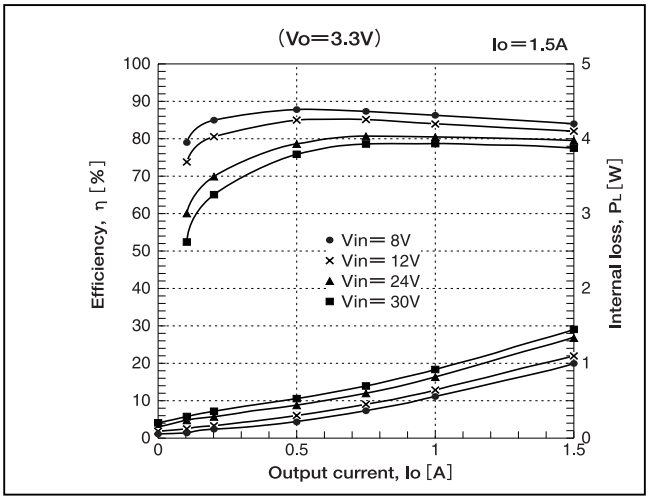
● Load regulation



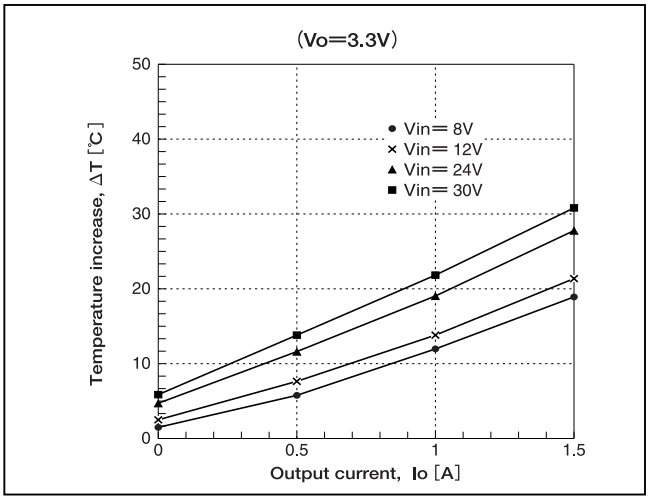
● Temperature drift



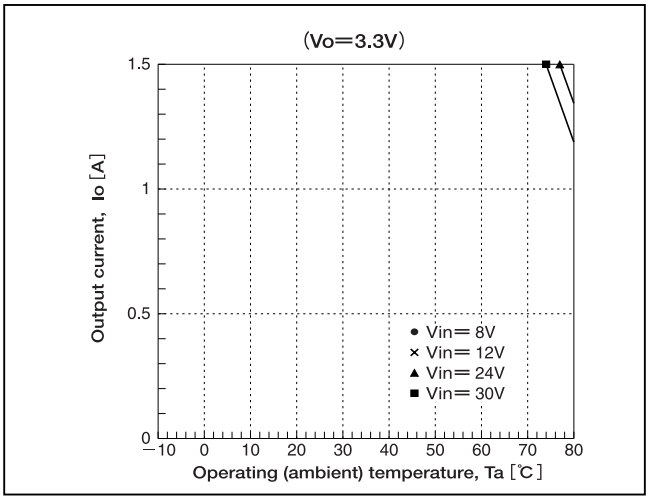
● Efficiency and loss characteristics



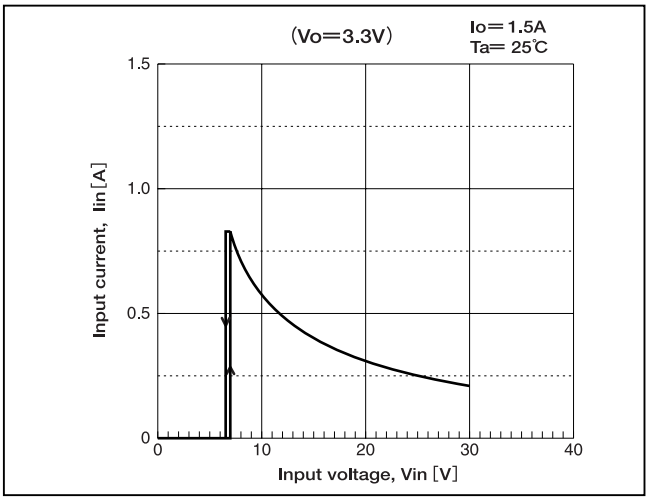
● IC temperature increase



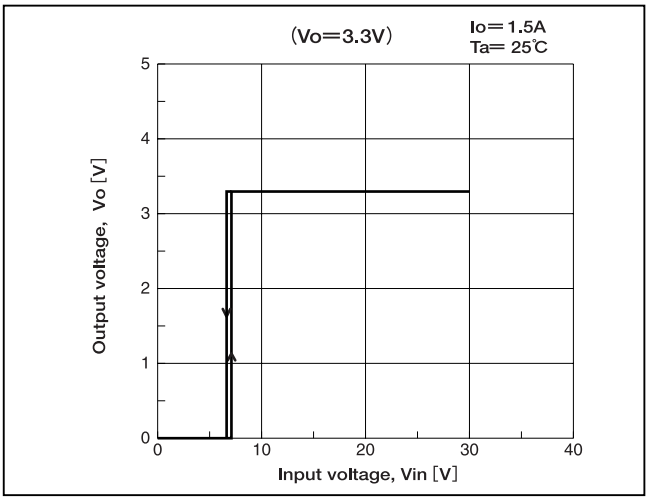
● Derating curve



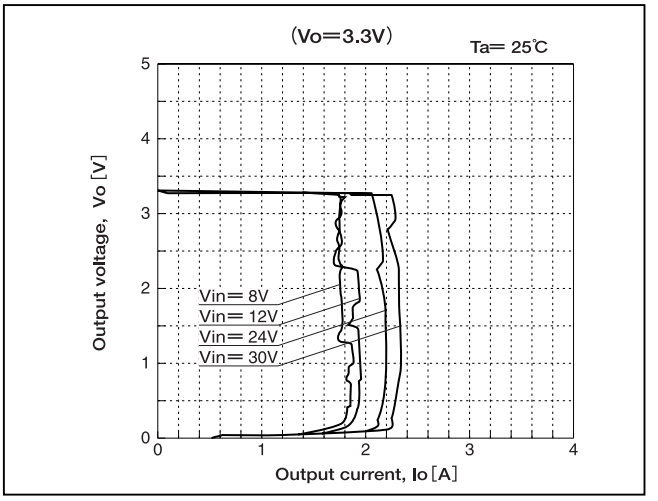
● Input curreent/input voltage characteristics



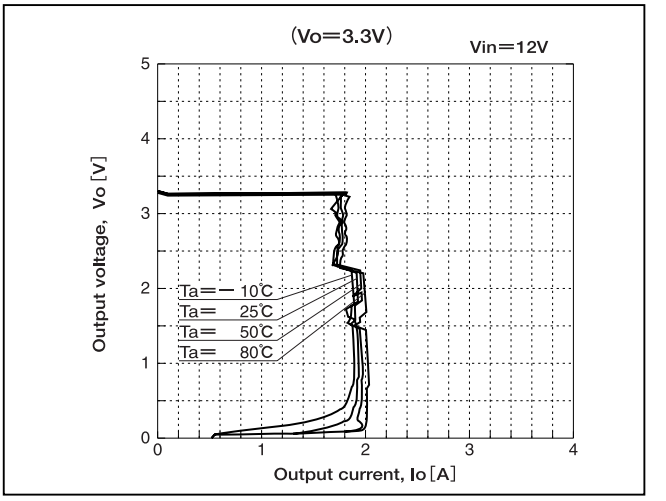
● Input voltage/output voltage characteristics



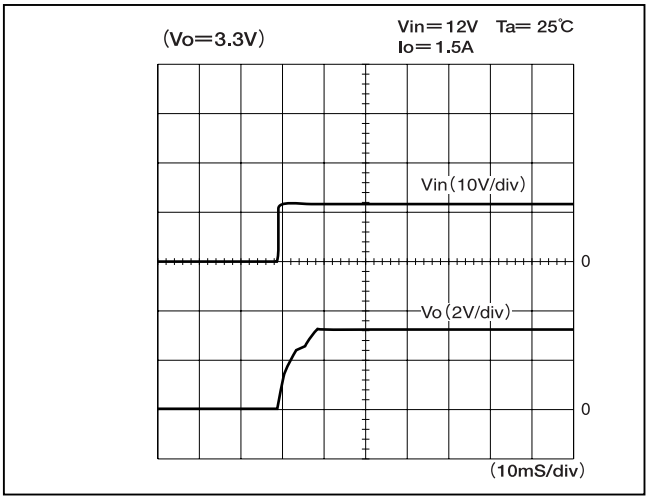
● Current limit characteristic (Input fluctuation)



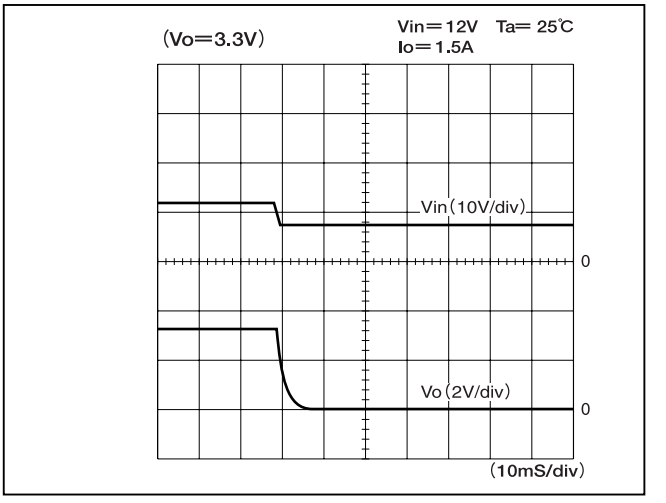
● Current limit characteristic (Temperature fluctuation)



● Start-up rising characteristics

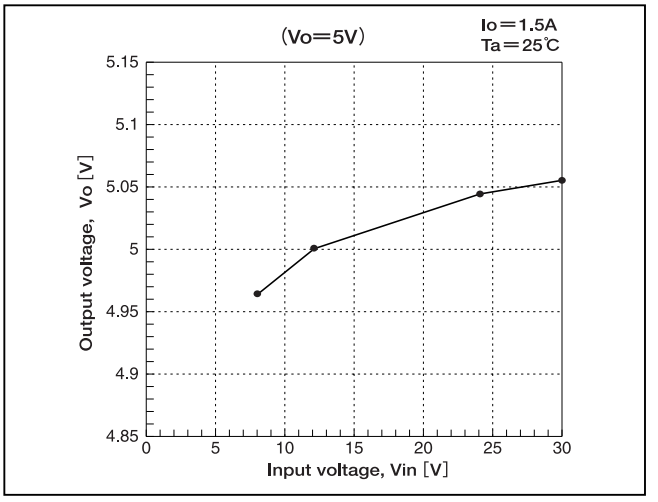


● Shut-down falling characteristics

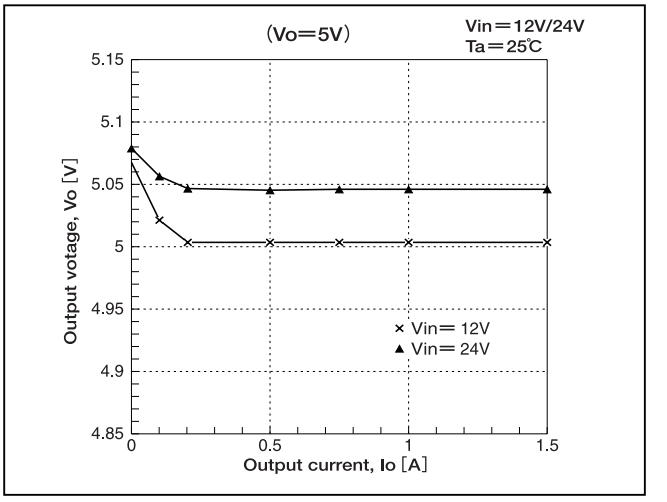


◆ 8 – 1　Output voltage - 5V

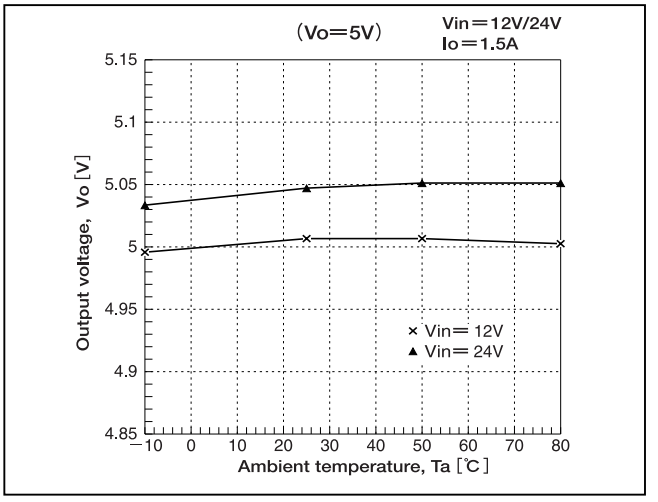
● Line regulation



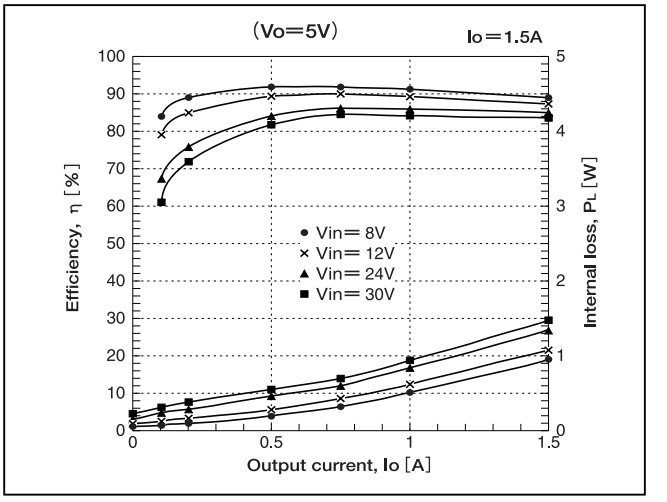
● Load regulation



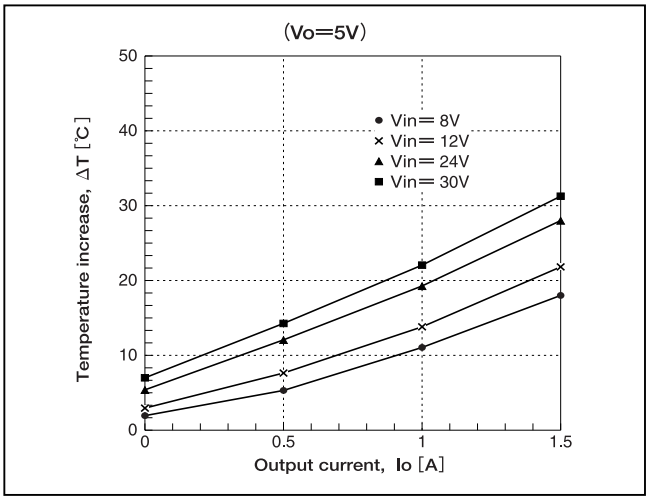
● Temperature drift



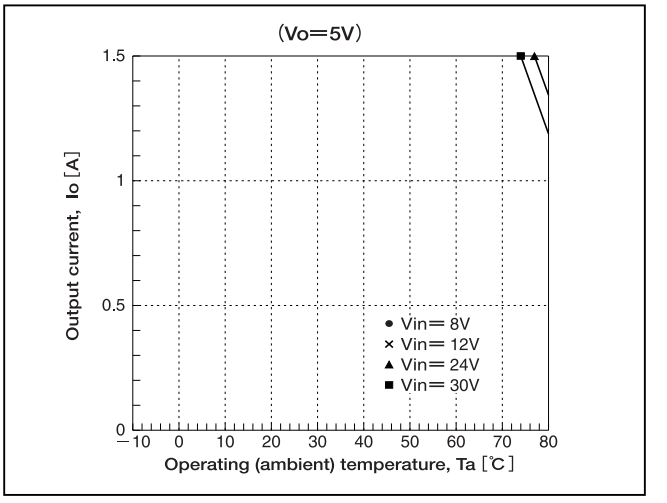
● Efficiency and loss characteristics



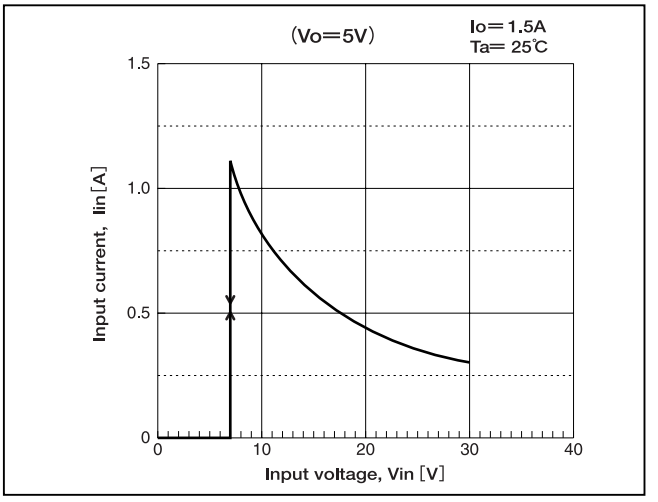
● IC temperature increase



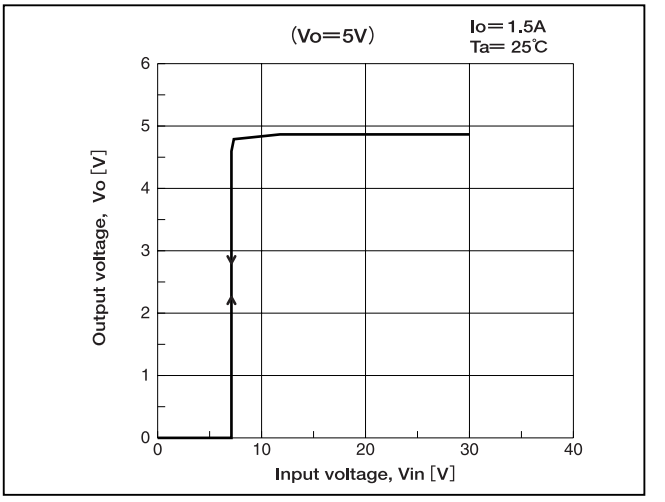
● Derating curve



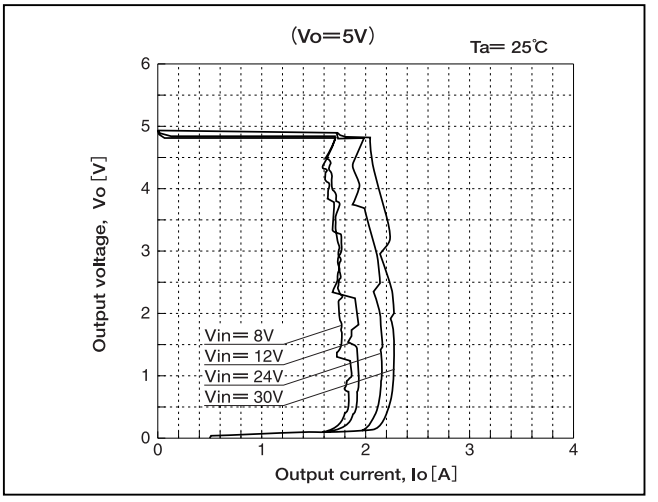
● Input curreent/input voltage characteristics



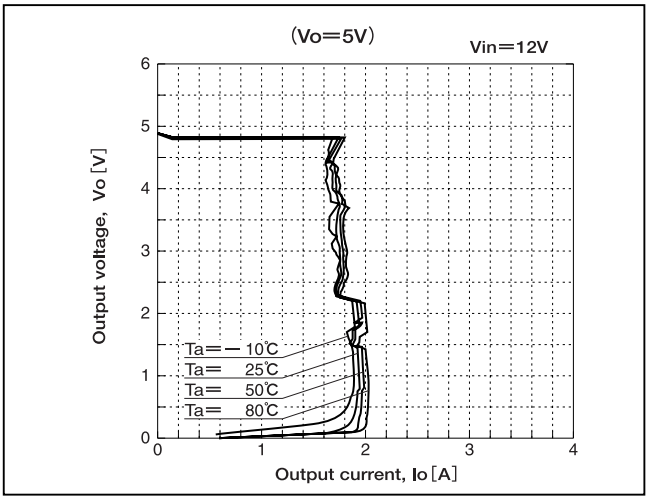
● Input voltage/output voltage characteristics



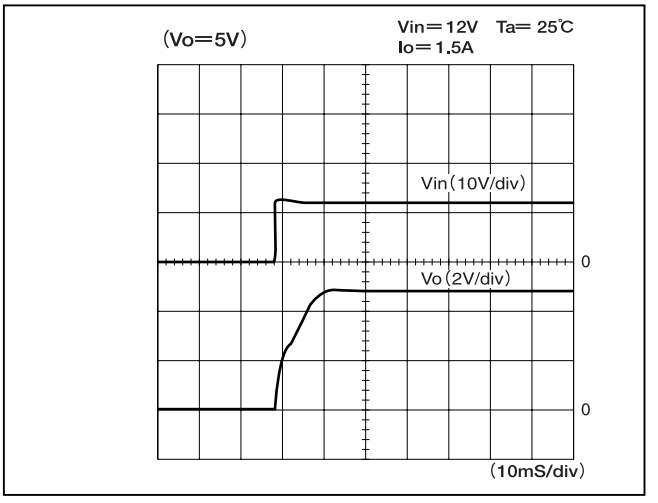
● Current limit characteristic (Input fluctuation)



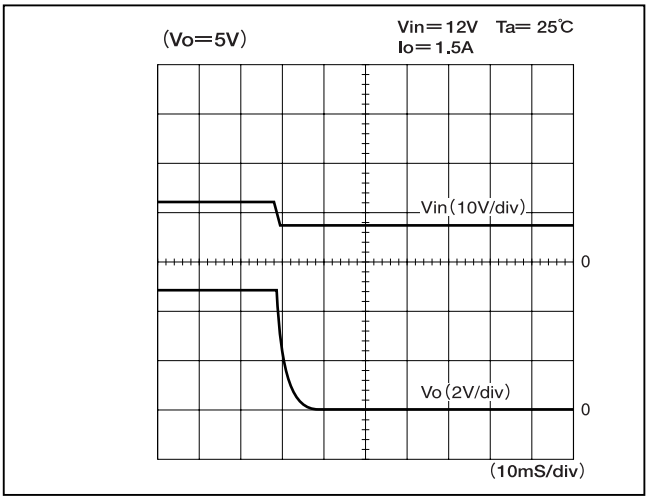
● Current limit characteristic (Temperature fluctuation)



● Start-up rising characteristics



● Shut-down falling characteristics



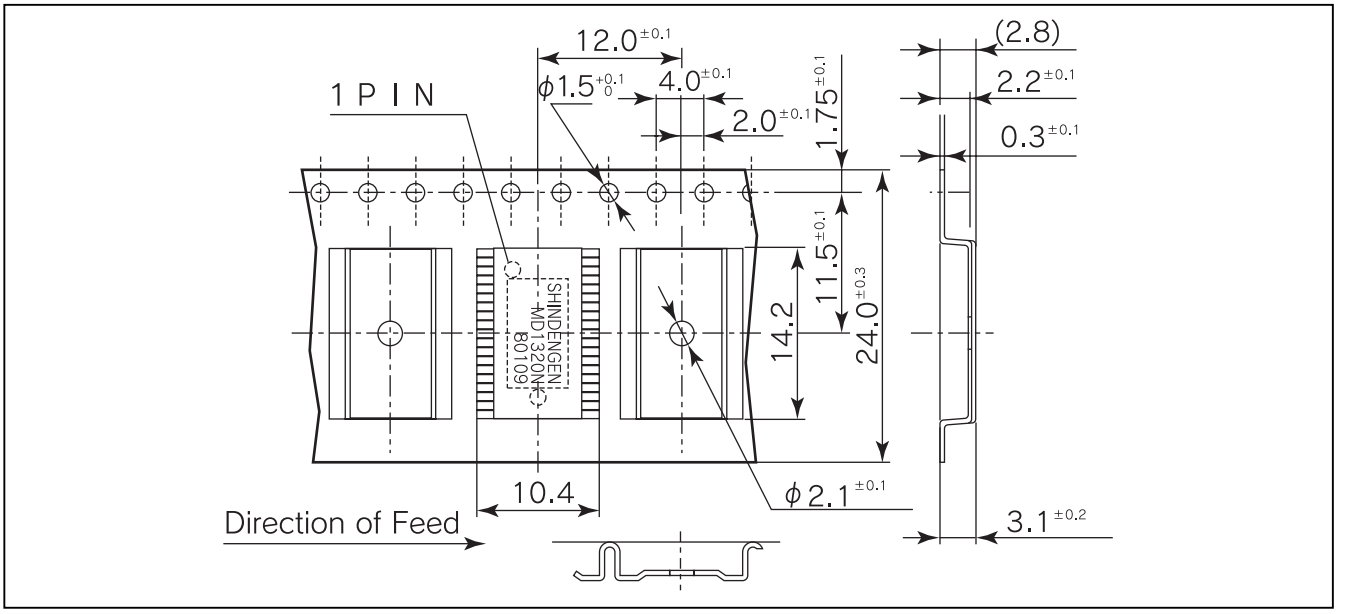
9 Packing

◆ 9 – 1 Tape & Reel

1） Tape

・Material : PVC

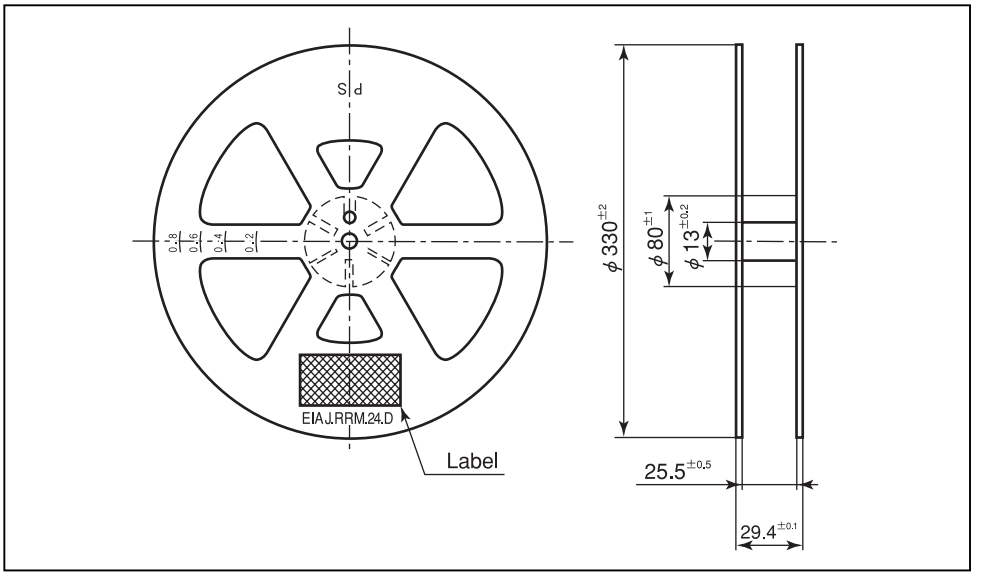
・Dimensions Comply with JIS, C-0806



2） Reel

・Material : Polystyrene

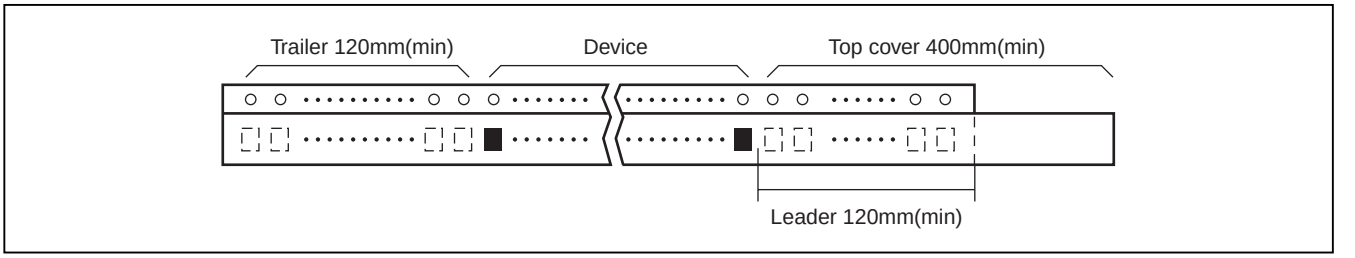
・Demensions Comply with EIAJ, ETX-7001



・Label

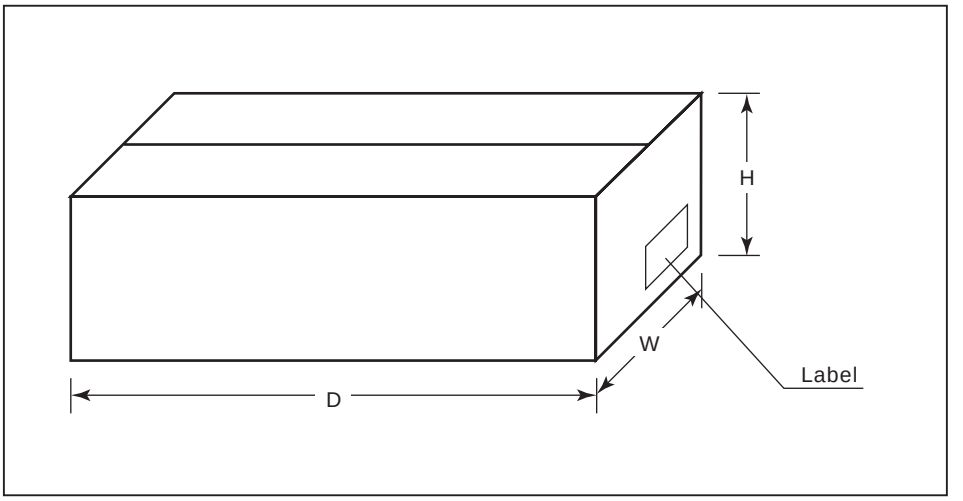
Type No.
Code No.
Date Code
Quantity
Manufacturer

3） Leader and Trailer



◆ 9 – 2 Packing

・Tape & Reel : 6,000pcs (3 Reels) / Outer Carton
・Stick : 4,000pcs (160 Sticks) / Outer Carton



・Marking
Type No. ・Code No. ・Date Code ・Quantities

◆ 9 – 3 Ordering and Dimensions

Package	Code No.	Minimum Ordering Quantities	Quantities Per Inner Carton (pcs.)	Quantities per Outer Carton		Outer Carton (mm)		
				pcs. / Carton	Weight (kg)	D	W	H
SSOP-32	4072	2000	2000	6000	7.6	363	363	160

MEMO

MEMO

∗All specificafions are subject to change without notice.

Please note that the information contained in this catalog may change for improvement or other purpose without notice.
Issued: October 2000
Export regulations of strategic materials, etc.
This product is classified as the integrated circuit specified in Item 7 in the Attached Table No. 1 to the Export Trade Control Order and in Article 6 of the Ordinance of the Ministry of International Trade and Industry.
This product is subject to the KNOW regulation.
October 2000

Shindengen America, Inc.
Head Office
2985 E. Hillcrest Drive, Suite 140
Westlake Village, CA91362, U.S.A.
Phone : (1)-805-373-1130 Fax : (1)-805-373-3710

Chicago Office
411 Business Center Drive, Suite 112
Mt. Prospect, IL 60056 U.S.A.
Phone : (1)-847-827-7100 Fax : (1)-847-827-7122

Shindengen UK Ltd.
Howard Court, 12 Tewin Road,
Welwyn Garden City, Hertfordshire. AL7 IBW
Phone : (44)-1707-332-992 Fax : (44)-1707-332-955

German Representative Office
Kaiser-Strasse 25, D-40479 Dusseldorf, Germany
Phone : (49)-211-491968-0 Fax : (49)-211-4986499

SHINDENGEN
ELECTRIC MFG. CO., LTD.

Ikebukuro office:
RECRUIT Ikebukuro Bldg., 1-13-23, Minami-Ikebukuro,
Toshima-ku, Tokyo 171-0022, Japan
Phone : (81)-03-5951-8106
Fax : (81)-03-5951-8099

Printed in Japan 00O20(NP)