Nisshinbo Micro Devices Inc.

NC4650 Series

Datasheet

Ultra-Low Quiescent Current (Iq = 70nA) Boost Switching Regulator with Low Ripple Mode

FEATURES

- Operating Junction Temperature Range: -40 °C to 125 °C
- Input Voltage Range (Maximum Rating): 0.6 V to 5.5 V (6.5 V)
- Startup Voltage: Typ. 0.8 V
- Output Voltage Range:1.8 V to 5.0 V (Int.Fixed)
- Quiescent Current (V_{OUT}):
  Normal Mode: Typ. 70 nA
  Low Ripple Mode: Typ. 90 μA
- Shutdown Current: Typ. 50 nA
- Efficiency (V_{IN}=1.5 V,V_{OUT}=3.3 V,I_{OUT}=10 μA): Typ. 85 %
- Switch Current Limit: Typ. 1 A (V_{SET} ≥2.5 V)
  Typ. 0.65 A (V_{SET} < 2.5 V)
- Thermal Shutdown Function:
  Detection Temperature: Typ. 150 °C
  Release Temperature: Typ. 100 °C
- Soft Start Function
- Buck Operation or Pass-Through when V_{IN} > V_{OUT}
- Manual switching between Normal Mode and Low Ripple Mode via MODE Pin
- Multiple versions for shutdown behavior

APPLICATIONS

- IoT Edge Devices
- Devices Powered by Coin/Button/Dry Batteries
- Alarms, Smartwatches etc.

GENERAL DESCRIPTION

The NC4650 is a synchronous rectification boost switching regulator featuring ultra-low quiescent current of 70nA, utilizing a CMOS process. It is optimal for portable devices powered by coin or button batteries.

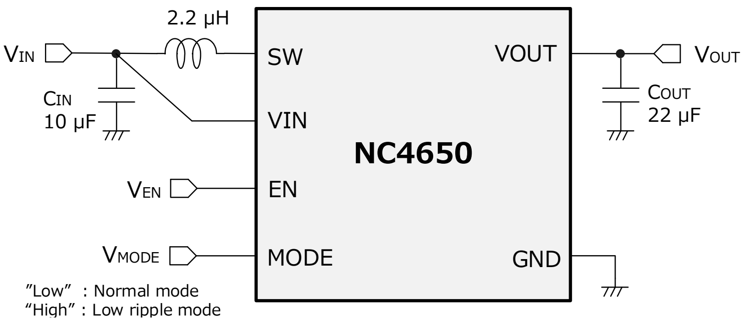
With high efficiency under light load conditions, it is ideal for intermittent operation applications, ensuring long battery life.

The MODE pin enables the selection of "Low Ripple Mode" for improved load transient response and reduced ripple. The EN pin allows shutdown operations, with options such as V_{IN}-V_{OUT} Complete Disconnect, V_{OUT} discharge, and Pass-Through. Selecting the optimal version according to system sleep conditions enables system optimization.

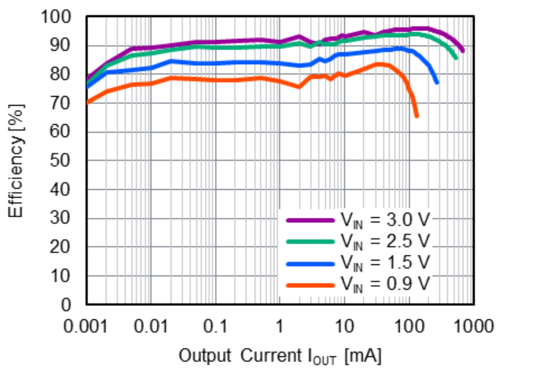
Package

WLCSP-6-ZA1
1.3 x 0.92 x 0.4 (mm)

TYPICAL APPLICATION



EFFICIENCY TYPICAL CHARACTERISTICS



NC4650ZA V_{OUT} = 3.3V MODE = "Low"

■ PRODUCT NAME INFORMATION

NC4650 aa bbb c dd e

Description of configuration

Composition	Item	Description
aa	Package Code	Indicates the package. Refer to the order information. ZA:WLCSP-6-ZA1
bbb	Output Voltage	Set Output Voltage (V_{SET}) The internal fixed output voltage:180 ~ 500 (1.8 V ~ 5.0 V, 0.1 V step)
c	Version	Indicates the selection of Shutdown Operation
dd	Packing	E2: Refer to the packing specifications.
e	Grade	Indicates the quality grade. S: Standard

Version

c	EN Pin Function	Operation when Shutdown
A	EN="High" : Active EN="Low" : Shutdown	V_{IN} - V_{OUT} Complete Disconnect
B	EN="High" : Active EN="Low" : Shutdown	V_{OUT} Discharge (Auto-Discharge Function)
C	EN="High" : Shutdown EN="Low" : Active	V_{IN} - V_{OUT} Complete Disconnect
D	EN="High" : Shutdown EN="Low" : Active	V_{IN} - V_{OUT} Pass-Through Seamless Pass-Through Function

Grade

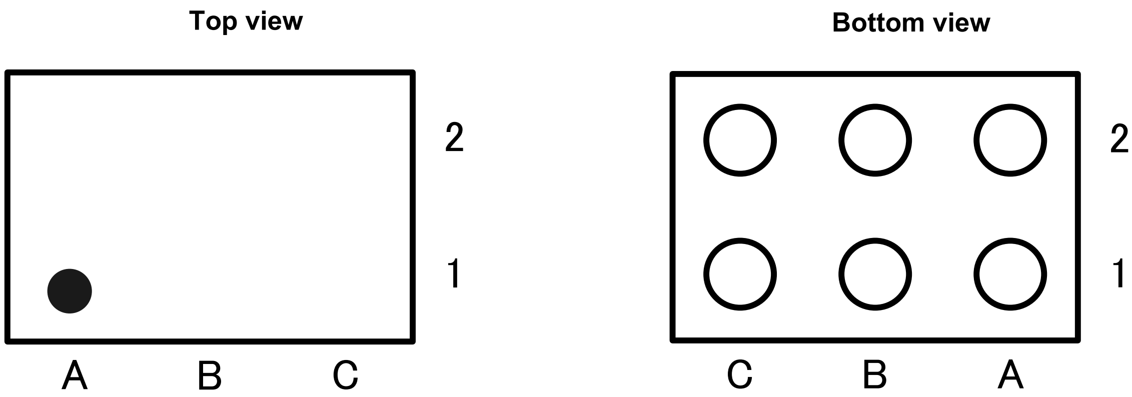
e	Application	Operating Junction Temperature Range	Test Temperature
S	Standard	-40°C to 125°C	25°C

■ ORDER INFORMATION

PRODUCT NAME	PACKAGE	RoHS	HALOGEN-FREE	SOLDER BALL	WEIGHT (mg)	QUANTITY (pcs/reel)
NC4650ZAbbbcE2S	WLCSP-6-ZA1	✓	✓	Sn3Ag0.5Cu	1	5000

Refer to the marking specifications for a detailed lineup of set output voltage and versions.

■ **PIN DESCRIPTION (NC4650ZA)**



WLCSP-6-ZA1 Pin Configuration

NC4650ZA (WLCSP-6-ZA1) Pin Descriptions

Pin No.	Pin Name	I/O	Description
A1	VOUT	Power	Output Pin
B1	GND	-	Ground Pin
C1	VIN	Power	Power Supply Pin
A2	SW	-	Switching Output Pin Connect to Internal MOSFET Drain
B2	MODE	I	Mode Control Pin Low: Normal Mode, High: Low Ripple Mode
C2	EN	I	Enable Pin NC4650ZAxxxA/B: Can set the active state with the "High" input and the shutdown state with the "Low" input. NC4650ZAxxxC/D: Can set the active state with the "Low" input and the shutdown state with the "High" input.

■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Ratings	Unit
VIN pin Voltage	V_{IN}	-0.3 to 6.5	V
VOUT pin Voltage	V_{OUT}	-0.3 to 6.5	V
SW pin Voltage	V_{SW}	-0.3 to 6.5	V
EN pin Voltage	V_{EN}	-0.3 to 6.5	V
MODE pin Voltage	V_{MODE}	-0.3 to 6.5	V
Storage Temperature Range	T_{stg}	-65 to 150	°C
Junction Temperature [*1]	T_j	150	°C

ABSOLUTE MAXIMUM RATINGS
Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause permanent damage and may degrade the lifetime and safety for both device and system using the device in the field. The functional operation at or over these absolute maximum ratings is not assured.

[*1] Calculate the power consumption of the IC from the operating conditions, and calculate the junction temperature with the thermal resistance.
Please refer to "*THERMAL CHARACTERISTICS*" for the thermal resistance under our measurement board conditions

■ THERMAL CHARACTERISTICS

Package	Parameter	Measurement Result	unit
WLCSP-6-ZA1	Thermal Resistance (θja)	179	°C/W
	Thermal Characterization Parameter (ψjt)	60	

θja : Junction-to-Ambient Thermal Resistance
ψjt : Junction-to-Top Thermal Characterization Parameter
For details, refer to "*THERMAL CHARACTERISTICS*"

■ ELECTROSTATIC DISCHARGE RATINGS

	Condition	Protection Voltage
HBM	C = 100pF, R = 1.5kΩ	±2000V
CDM		±1000V

ELECTROSTATIC DISCHARGE RATINGS
The electrostatic discharge test is done based on JESD47. In the HBM method, ESD is applied using the power supply pin and GND pin as reference pins.

■ RECOMMENDED OPERATING CONDITIONS

	Symbol	Ratings	unit
VIN pin Voltage	V_{IN}	0.6 to 5.5	V
Operating Temperature Range	T_a	-40 to 85	°C
Junction Temperature Range	T_j	-40 to 125	°C

RECOMMENDED OPERATING CONDITIONS
All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating conditions. The semiconductor devices cannot operate normally over the recommended operating conditions, even if when they are used over such conditions by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions.

■ ELECTRICAL CHARACTERISTICS

For parameter that do not describe the temperature condition, the MIN / MAX value under the condition of −40 °C ≤ Tj ≤ 125 °C is described.

Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
Output Voltage	V_{OUTCM}	PWM, V_{SET} ≥ 2.5V, Tj = 25 °C	x 0.985		x 1.015	V
		PWM, V_{SET} < 2.5V, Tj = 25 °C,	x 0.98		x 1.02	V
		PWM, V_{SET} ≥ 2.5V, -40°C ≤ Tj ≤ 85°C	x 0.975		x 1.025	V
		PWM, VSET < 2.5V, -40°C ≤ Tj ≤ 85°C	x 0.97		x 1.03	V
	V_{OUTDCM}	PFM, V_{IN} = 1.5V		V_{OUTCM} x 1.02		V
Startup Voltage	V_{START}	-40°C ≤ Tj ≤ 85°C		0.8	0.9	V
VIN UVLO	$V_{VINUVLO}$	V_{IN} = falling, V_{OUT} = V_{SET}		0.4	0.6	V
VIN pin Quiescent Current	I_{QVIN}	V_{OUT} = V_{SET}, V_{IN} = 1.5V, V_{MODE} = 0 V, no switching,		0		nA
VOUT pin Quiescent Current	I_{QVOUT}	V_{OUT} = V_{SET}, V_{IN} = 1.5V, V_{MODE} = 0 V, no switching, -40°C ≤ Tj ≤ 85°C		70	300	nA
		V_{OUT} = V_{SET}, V_{IN} = 1.5V, V_{MODE} = V_{IN}, no switching, -40°C ≤ Tj ≤ 85°C		90	180	μA
VIN pin Shutdown Current[*1]	I_{SDVIN}	V_{IN} = 5.5V V_{EN} = 0V (A, B Version) V_{EN} = 5.5V (C, D Version) -40°C ≤ Tj ≤ 85°C		50	200	nA
VOUT pin Shutdown Current[*1]	I_{SDVOUT}	V_{IN} = 0V, V_{OUT} = V_{SET} V_{EN} = 0V (A Version) V_{EN} = V_{SET} (C, D Version) -40°C ≤ Tj ≤ 85°C		40	250	nA
EN pin "H" Input Current	I_{ENH}	V_{IN} = V_{EN} = 5.5V -40°C ≤ Tj ≤ 85°C	-40	0	40	nA
EN pin "L" Input Current	I_{ENL}	V_{IN} = 5.5V, V_{EN} = 0V -40°C ≤ Tj ≤ 85°C	-40	0	40	nA
MODE pin "H" Input Current	I_{MODEH}	V_{IN} = V_{MODE} = 5.5V -40°C ≤ Tj ≤ 85°C	-40	0	40	nA
MODE pin "L" Input Current	I_{MODEL}	V_{IN} = 5.5V, V_{MODE} = 0V -40°C ≤ Tj ≤ 85°C	-40	0	40	nA
EN pin "H" Input Voltage [*2]	V_{ENH}		0.9		5.5	V
EN pin "L" Input Voltage [*2]	V_{ENL}		0		0.3	V
MODE pin "H" Input Voltage [*2]	V_{MODEH}		1.0		5.5	V
MODE pin "L" Input Voltage [*2]	V_{MODEL}		0		0.3	V
SW pin "H" Input Current	I_{SWH}	V_{IN}=V_{SW}=5V, V_{OUT}=0V -40°C ≤ Tj ≤ 85°C		1	350	nA
SW pin "L" Input Current	I_{SWL}	V_{IN}=V_{SW}=0V, V_{OUT}=5V -40°C ≤ Tj ≤ 85°C	-200	-1		nA
On-resistance of High Side MOSFET	R_{ONH}	V_{OUT}=3.3V		0.28		Ω
On-resistance of Low Side MOSFET	R_{ONL}	V_{OUT}=3.3V		0.22		Ω
Thermal Shutdown Detection Temperature	T_{SDDET}			150		°C
Thermal Shutdown Release Temperature	T_{SDREL}			100		°C
Inductor Ripple Current	I_{RIP}	V_{IN} = 1.5V, V_{OUT} = V_{SET}		250		mA

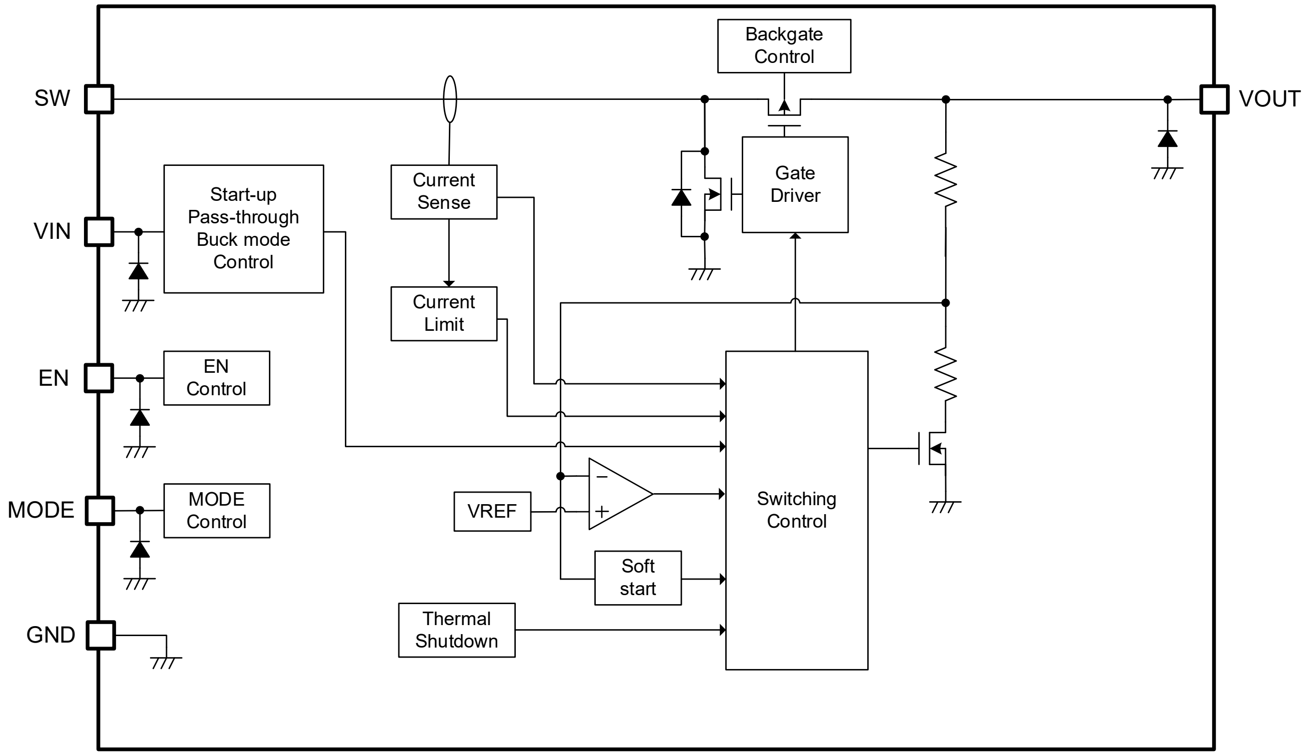
Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
SW Current Limit	I_{SWLIM}	$V_{SET} \geq 2.5V$, $V_{IN} = 1.5V$	700	1000	1500	mA
		$V_{SET} < 2.5V$, $V_{IN} = 1.5V$	450	650	950	mA
On-resistance for Discharger	R_{ONDIS}	$V_{IN} = 1.5V$, B Version only		55		Ω
Soft-Start Time	t_{START}			0.8	1.5	ms
Pass-Through Mode Detection Voltage	V_{PTHD}	$V_{IN} - V_{OUT}$		0.6	0.8	V
Pass-Through Mode Release Voltage	V_{PTHR}	V_{OUT}		V_{OUTCM} x 1.02		V
Pass-Through Mode Quiescent Current	I_{QPTML}	$V_{MODE} = 0V$, $V_{IN} = V_{SET}+0.4V$		70		nA
	I_{QPTMH}	$V_{MODE} = V_{IN}$, $V_{IN} = V_{SET}+0.4V$		90		μA
Buck Mode Detection Voltage	V_{BKDML}	V_{IN} = Rising or V_{OUT} = Falling $V_{BKDML} = V_{IN} - V_{OUT}$ $V_{MODE} = 0V$		-0.05		V
	V_{BKDMH}	V_{IN} = Rising or V_{OUT} = Falling $V_{BKDMH} = V_{IN} - V_{OUT}$ $V_{MODE} = V_{IN}$		-0.1		V
Buck Mode Release Voltage	V_{BKRML}	V_{IN} = Falling or V_{OUT} = Rising $V_{BKRML} = V_{IN} - V_{OUT}$ $V_{MODE} = 0V$		-0.1		V
	V_{BKRMH}	V_{IN} = Falling or V_{OUT} = Rising $V_{BKRMH} = V_{IN} - V_{OUT}$ $V_{MODE} = V_{IN}$		-0.2		V

All electrical characteristic parameters that specify the minimum and maximum specifications are tested under the condition of $T_j \approx T_a$ = 25 °C.

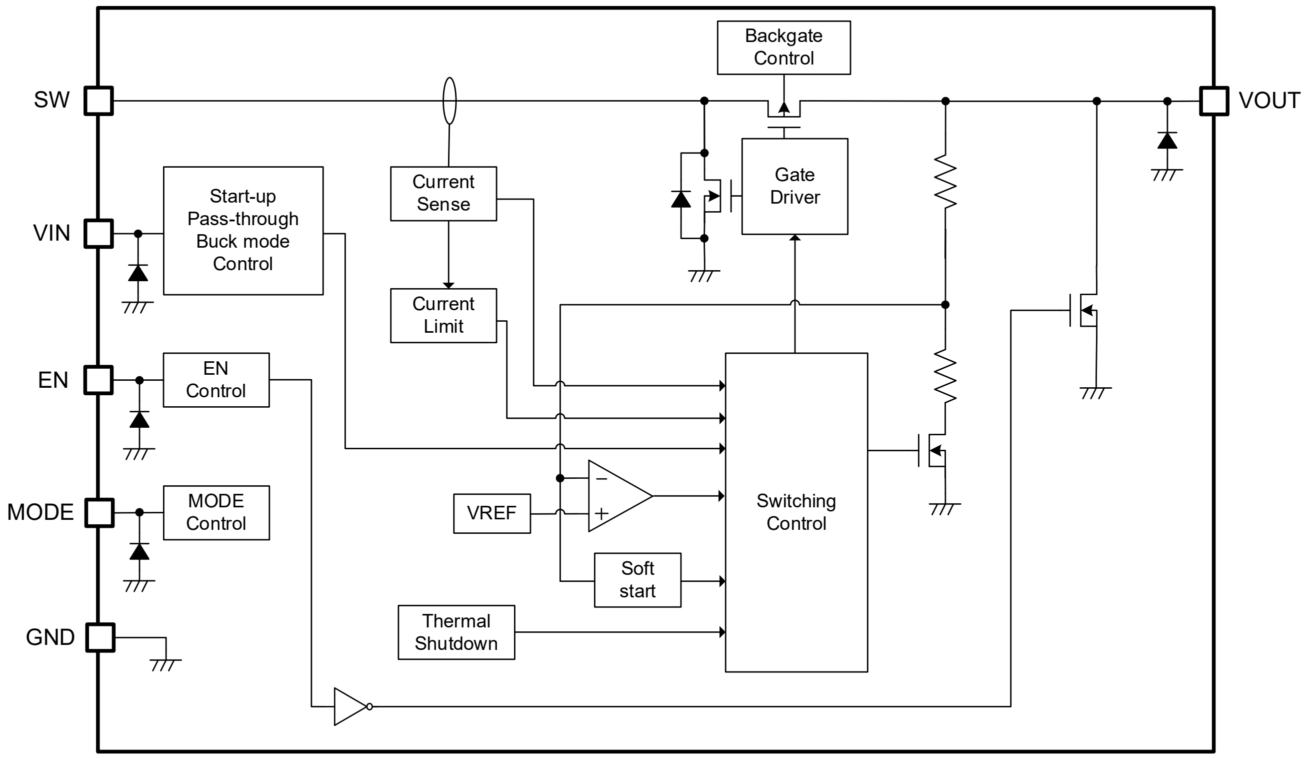
*1 On the VIN and VOUT pins, the shutdown current flows only from the pin with the higher voltage. The pin with the lower voltage is Typ. 0 nA.

*2 When the EN and MODE pins are fixed to the V_{IN} pin, the polarity is forced to be "H" as long as VIN pin voltage within the recommended operating condition. (The A and B version)

■ BLOCK DIAGRAMS



NC4650xxxxxA/C/D Block Diagram



NC4650xxxxxB Block Diagram

■ THEORY OF OPERATION

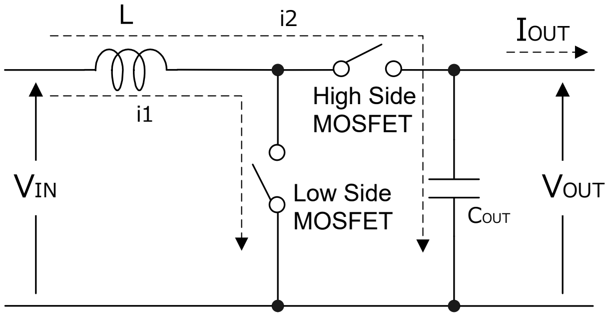
● Boost Switching Regulator Operation

Step 1. The high-side MOSFET is switched off, the low-side MOSFET is switched on and the inductor current I_L = i1 flows to store energy in the inductor. At this time, i1 increases from I_{L_LOW} in proportion to the time that the low-side MOSFET is on (t_{ON}).

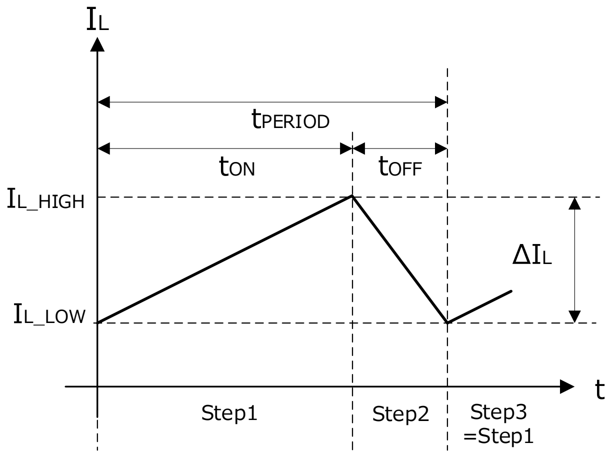
Step 2. i1 reaches I_{L_HIGH}, the low-side MOSFET is switched off and the high-side MOSFET is switched on. At this point, the inductor uses the energy stored in Step 1 to flow the inductor current I_L = i2. Due to the nature of the inductor, the inductor current tries to maintain $I_L = I_{L\_HIGH}$, but due to the relationship $V_{IN} < V_{OUT}$, it gradually decreases in proportion to the time that the high-side MOSFET is on (t_{OFF}).

Step 3. When the next cycle arrives, the high-side MOSFET turns off and the low-side MOSFET turns on, returning to Step 1 again.

By performing the above Step 1 to Step 3 operations periodically, the V_{IN} voltage can be boosted to obtain a desired V_{OUT} voltage.



Basic Circuit Diagram
Boost Switching Regulator



Inductor Current

● NC4650 Control Method

The NC4650 uses the PWM/PFM auto-switching method.
The inductor ripple current ΔI_L is fixed and t_{ON} and t_{OFF} are controlled to achieve the target value (Typ. 250mA).
As the inductor current I_L varies with V_{IN}, V_{OUT} and L value, both t_{ON}、t_{OFF} and t_{PERIOD} vary.

When the load current is low, the switch is automatically switched to PFM operation, and when the load current is high, the switch is automatically switched to PWM operation.
In PFM operation, the switching frequency varies with the load current, while in PWM operation, the switching frequency is fixed with respect to the load current variation.

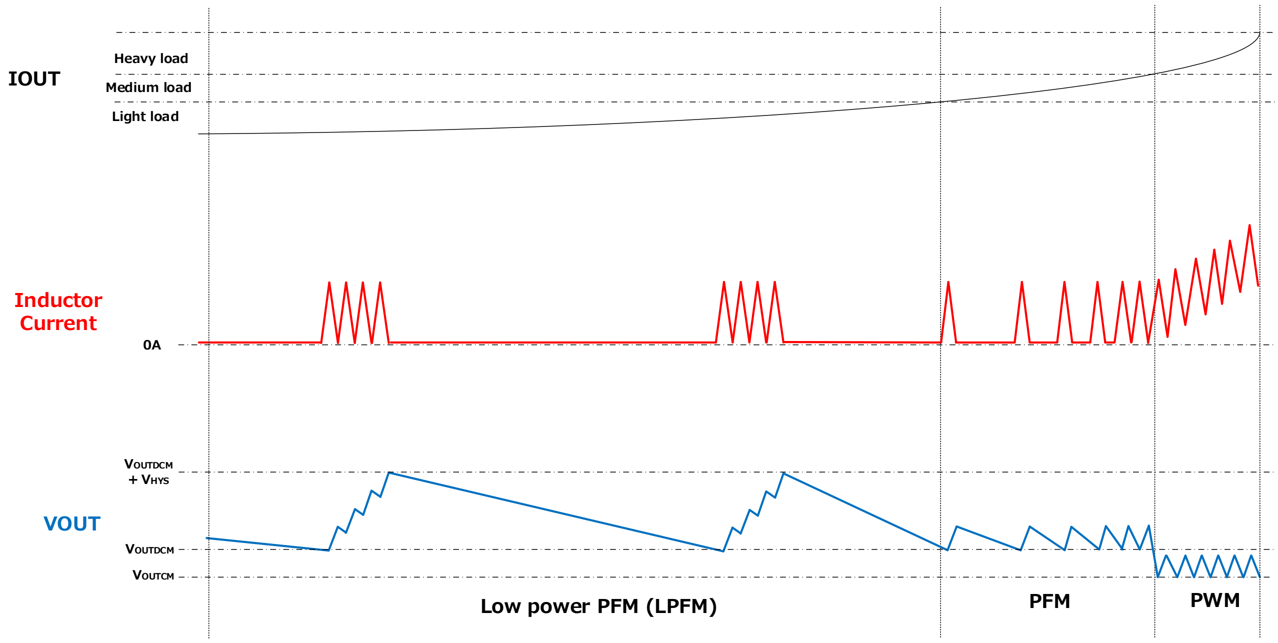
● **MODE = "Low" (Normal Mode) Regulation Operation**

Normal mode is the operation when a "Low" signal is input to the MODE pin. PWM operation is used for heavy loads, PFM operation for medium loads and Low Power PFM (LPFM) operation for light loads. The transition between light load and medium load and between medium load and heavy load depends on the V_{OUT}/V_{IN} (boost ratio); the higher the boost ratio, the smaller the load current shifts.

PWM operation controls the ON/OFF time of the power MOSFET so that the V_{OUT} pin voltage becomes V_{OUTCM}. The inductor current increases in line with the load current (I_{OUT}).
In PFM operation, switching operation starts when the V_{OUT} pin voltage falls below V_{OUTDCM}. Switching operation then stops once the V_{OUT} pin voltage exceeds V_{OUTDCM} and the V_{OUT} pin voltage starts to decrease. This is repeated to keep the V_{OUT} pin voltage constant.

LPFM operation, switching operation starts when the V_{OUT} pin voltage falls below V_{OUTDCM} as in PFM operation. Switching operation is repeated until the V_{OUT} pin voltage exceeds the V_{OUTDCM} + V_{HYS} voltage, at which point switching stops and the V_{OUT} pin voltage begins to fall. This is repeated to keep the V_{OUT} pin voltage constant.
The switching threshold currents for LPFM and PFM depend on the V_{IN} and V_{OUT} pin voltages; the switching thresholds for PFM and PWM are highly dependent on the V_{IN} and V_{OUT} pin voltages.
In both cases, the lower the V_{IN} pin voltage and the higher the V_{OUT} pin voltage, the lower the switching threshold current.

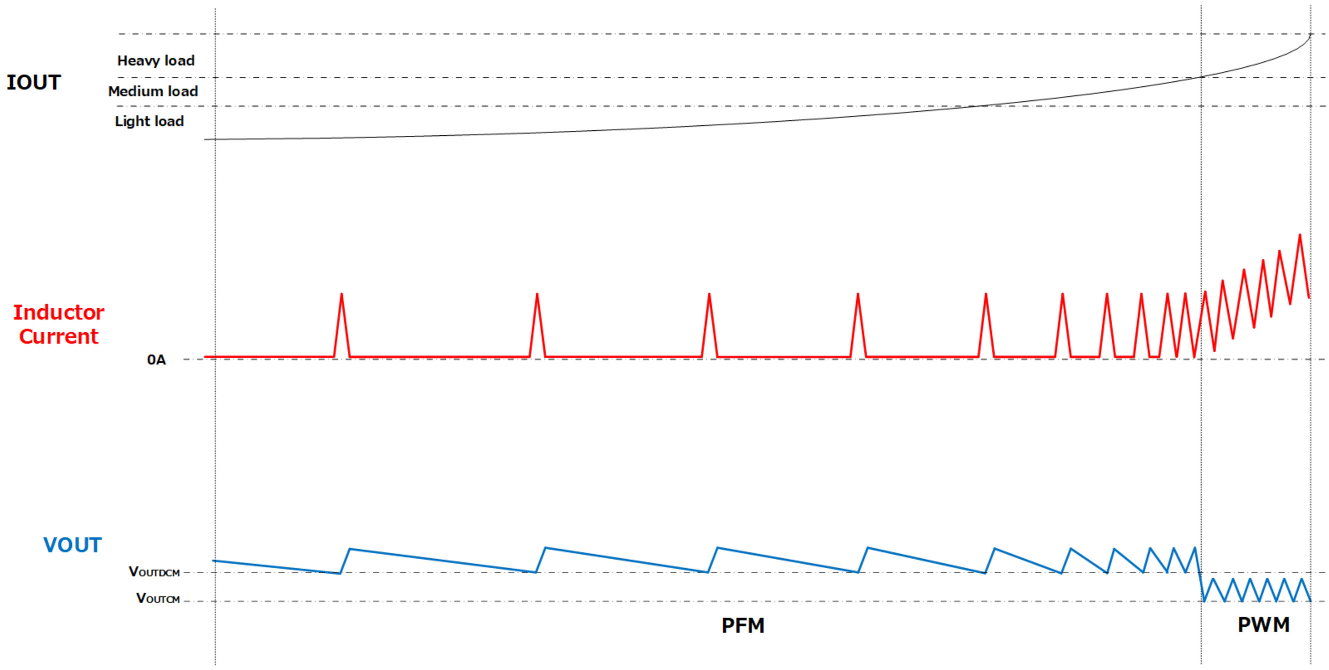
For the above-mentioned V_{OUTCM} and V_{OUTDCM}, please refer to the ELECTRICAL CHARACTERISTICS section.



MODE = "Low" Load Current (I_{OUT}) vs Regulation Operation

● MODE = "High" (Low Ripple Mode) Regulation Operation

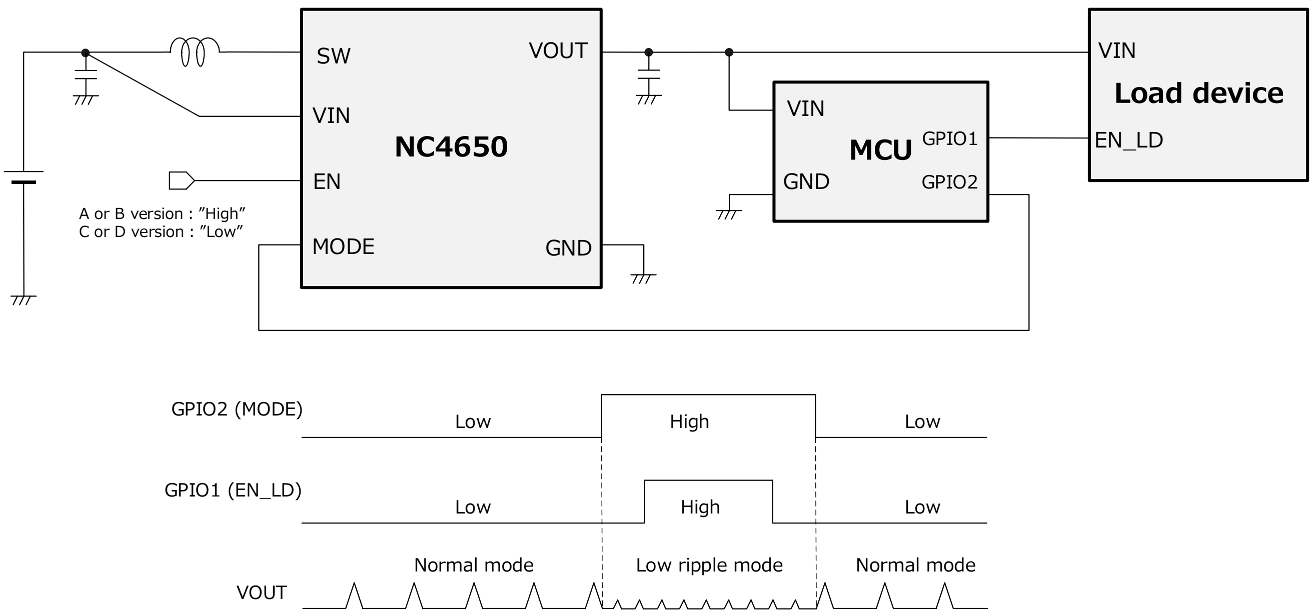
When a "High" signal is input to the MODE pin, low ripple mode is activated.
PWM operation at heavy loads and PFM operation at medium loads are the same as in normal mode, but PFM operation is also available at light loads. Compared to normal mode, the ripple voltage can be kept low and the average voltage accuracy is improved. The response characteristic to steep load changes from light to medium or light to heavy load is also improved.
On the other hand, the current at standstill is higher than in normal mode, so the efficiency at light loads is lower than in normal mode.



MODE = "High" Load Current (I_{OUT}) vs Regulation Operation

The good load transient response characteristics in low ripple mode can also be used to temporarily input the MODE pin to "High". The load transient response can be improved by setting the MODE pin to "High" in advance, immediately before increasing the load current. e.g. from a MCU in a subsequent stage.

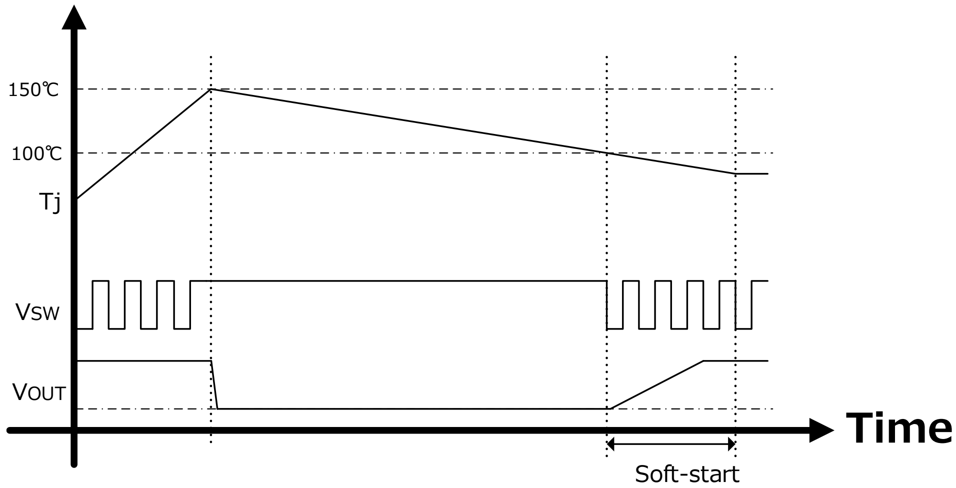
The above measures can also be used when a temporarily low ripple voltage is required during light loads.



Usage example with switching between normal mode and low ripple mode

● Thermal Shutdown

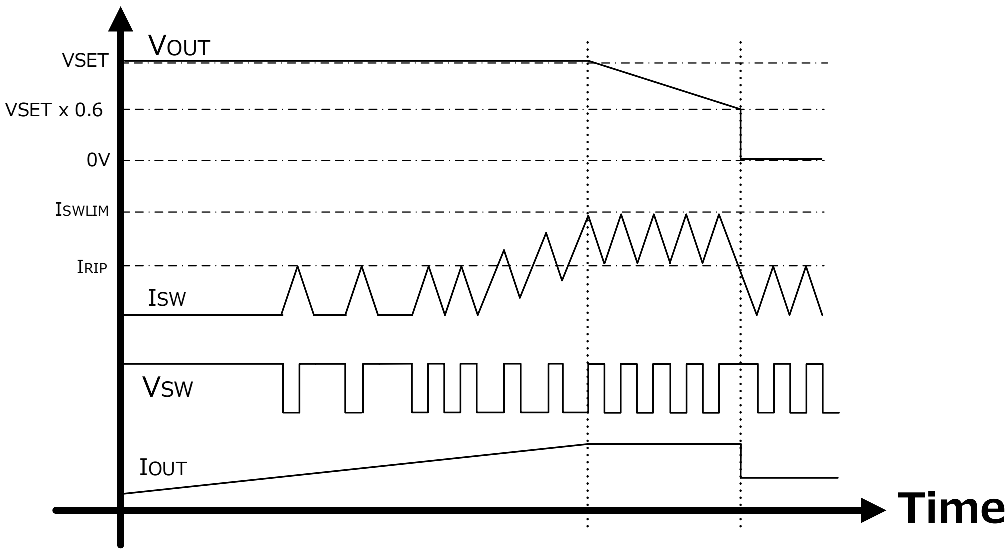
If the junction temperature exceeds the thermal shutdown detection temperature (Typ. 150°C), switching stops and self-heating is suppressed.
When the junction temperature drops below the thermal shutdown release temperature (Typ. 100°C), the switching restarts. When restarting, soft-start and start-up operation is performed depending on the V_{IN} and V_{OUT} pin voltages.
If the V_{IN} pin voltage is lower than Typ. 1.7V, the device will return to start-up operation when V_{OUT} drops above the detection temperature. Therefore, as long as the junction temperature does not fall below the release temperature, the operation repeats start-up restart and thermal shutdown detection.



Timing chart of Thermal Shutdown

● SW Current Limit

The diagram below shows the operation when the load resistance is gradually reduced.
As the load resistance is reduced, the operation shifts from PFM to PWM. As the load resistance is further reduced, the inductor peak current and bottom current rise. When the inductor peak current reaches the SW current limit, the NC4650 clamps the inductor current so that it does not go any higher. As a result, the V_{OUT} pin voltage drops as the load resistance is further reduced.
When the V_{OUT} pin voltage falls below a certain value (V_{SET} x 0.6), PWM operation is disabled and the inductor peak current is clamped at a smaller IRIP value. As a result, the V_{OUT} pin voltage is further reduced and I_{OUT} is kept small.

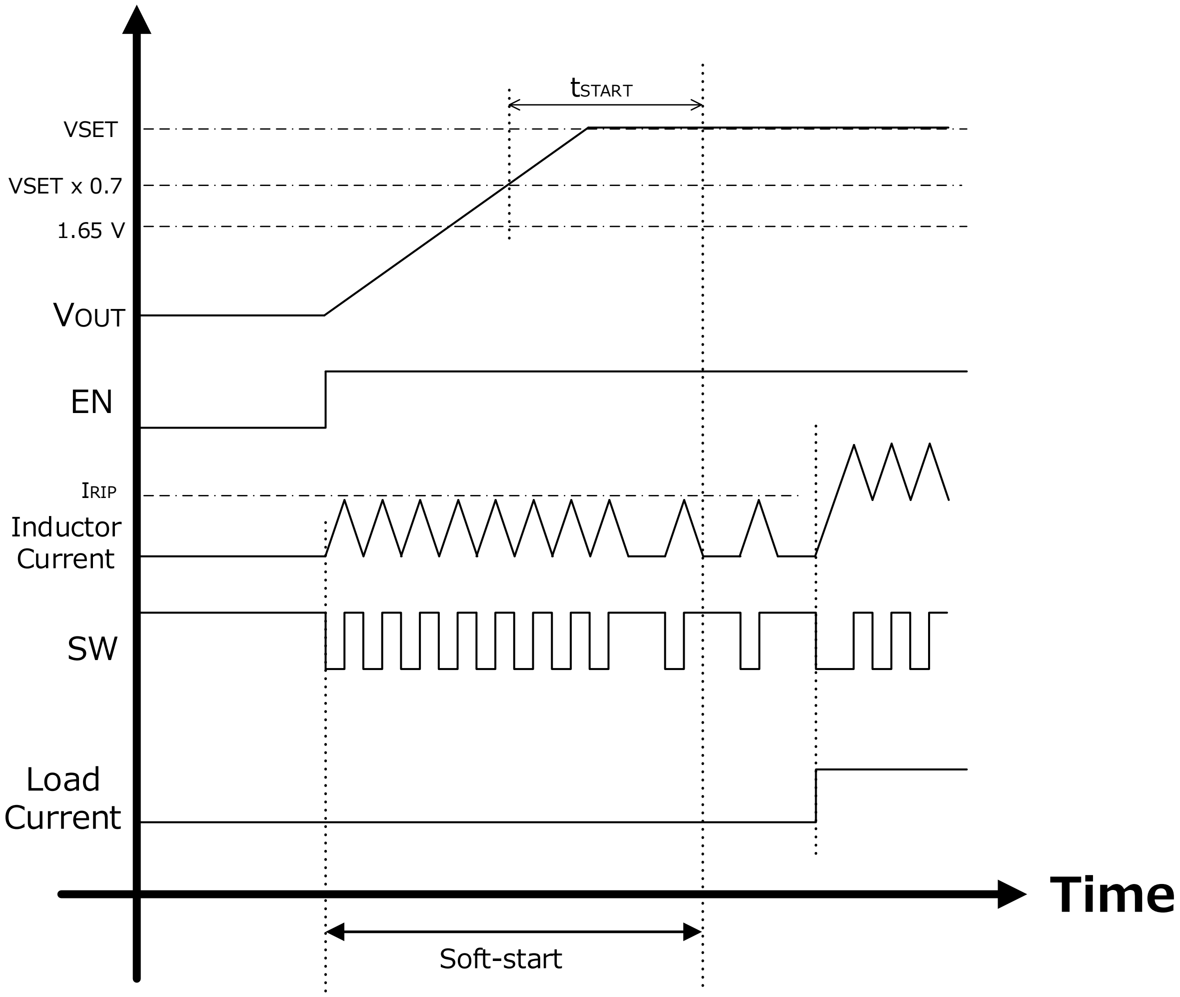


Timing chart of SW Current Limit

● **Soft-Start Operation**

When EN is switched to the active polarity, the V_{OUT} pin voltage rises: if the V_{OUT} pin voltage is below V_{SET} x 0.6 (Typ.) or 1.7V (Typ.), soft start operation is performed. During soft-start operation, the inductor starts up in boundary mode (*) and no PWM operation is performed. The inductor peak current is suppressed by the I_{RIP} value and does not rise any further.
Soft-start operation is released after a delay time (t_{START}) has elapsed after the V_{OUT} pin voltage exceeds V_{SET} x 0.7 (Typ.) and 1.7V (Typ.). Once the soft-start operation is released, PWM operation is enabled and the heavy load current can be output.

*Boundary mode refers to a mode in which the inductor current operates at the boundary between a discontinuous mode in which the inductor current goes to zero and a continuous mode in which it goes above zero.



NOTES:

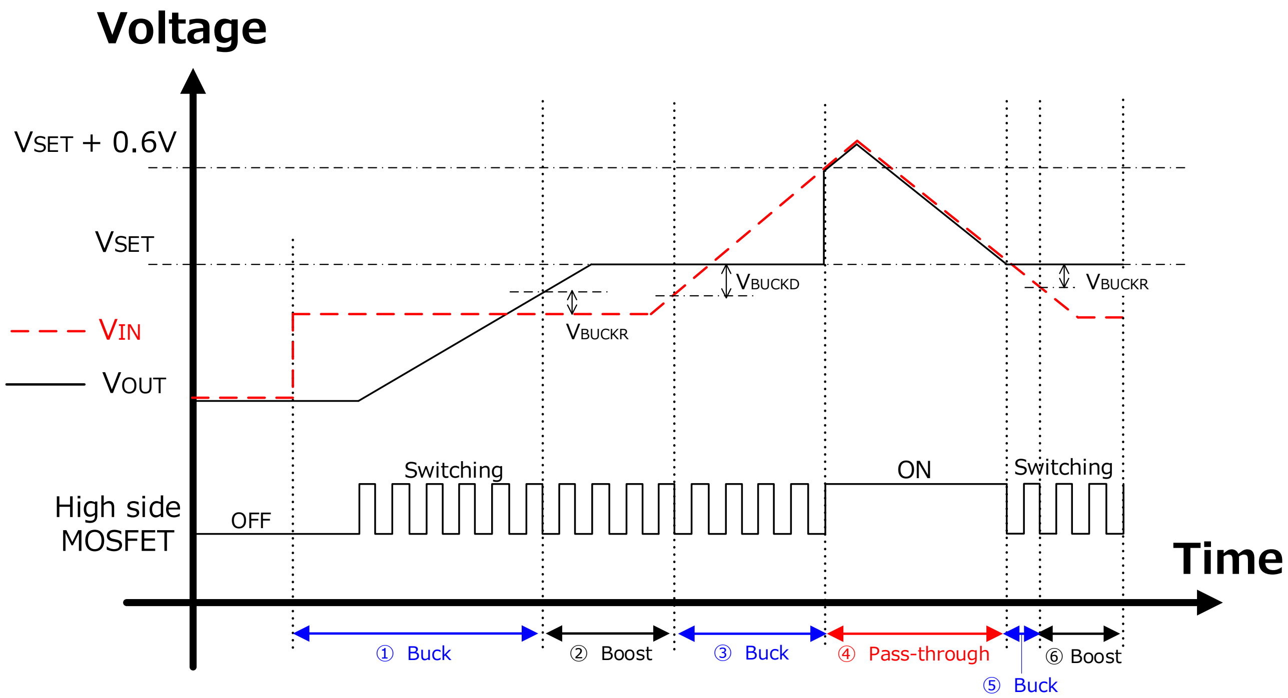
If C_{OUT} is large or V_{IN} pin voltage is low, the rise slew rate may drop and PWM operation may occur before V_{OUT} pin voltage reaches the set voltage. In such cases, the inductor peak current is limited by the SW limit current.

● **Start-Up Operation**

Start-up operation occurs when the V_{IN} pin voltage rises below Typ. 1.7V. During start-up operation, switching is performed by some restricted circuit blocks, so the load resistance must be 3kΩ or higher. Start-up operation is released when the V_{IN} or V_{OUT} pin voltage reaches Typ. 1.7V or more.
The V_{IN} pin voltage must be above the start-up voltage (V_{START}).After the V_{OUT} pin voltage reaches the set voltage and the soft start is terminated, switching operation is possible under MIN conditions with the V_{IN} pin voltage in the recommended operating voltage range.

● **Transition condition for each operation mode**

The NC4650 has two operating modes under V_{IN} > V_{OUT}: 'Buck Mode' and 'Pass-Through Mode'. For details of these modes, see other separate sections ('Buck Mode' and 'Pass-Through Mode'); for V_{IN} < V_{OUT}, the mode is defined as 'Boost Mode'. The transition conditions for each mode are shown in the diagram below.



(1) **Buck** mode: The V_{OUT} pin voltage is operated in buck mode until it exceeds the V_{IN} pin voltage from 0V. In this case, the Soft-Start function (refer to 'Soft-Start' section) is activated and the average inductor current is suppressed below a certain level. The slew rate of the rising V_{OUT} voltage depends on the V_{IN} pin voltage, C_{OUT} and load resistance.
(2) **Boost** mode: When the V_{OUT} pin voltage rises and V_{IN} < V_{OUT} - V_{BUCKR}, the converter switches to boost mode.
(3) **Buck** mode: After the V_{OUT} pin voltage reaches the set voltage, when the V_{IN} pin voltage rises to V_{IN} > V_{OUT} – V_{BUCKD}, the IC returns to buck mode. At this time, the V_{OUT} pin voltage is regulated to the set voltage.
(4) **Pass-through** mode: When the V_{IN} pin voltage is further increased to V_{IN} > V_{OUT} (=V_{SET}) + 0.6 V (Typ.), the device enters pass-through mode. In this mode, the high-side MOSFET is always on and the V_{OUT} pin voltage is equal to the V_{IN} and SW pin voltages. Pass-through in this active state differs from seamless pass-through.
(5) **Buck** mode: When the V_{IN} pin voltage is lowered and V_{IN} = V_{OUT} ≤ V_{SET}, the pass-through mode is shifted to buck mode.
(6) **Boost** mode: If the V_{IN} pin voltage is further reduced to V_{IN} < V_{OUT} - V_{BUCKR}, the mode switches back to boost mode.

For V_{BUCKD} and V_{BUCKR} setting values, see section 'Buck Mode'.

● Buck Mode

In buck mode, the V_{OUT} terminal voltage is regulated to the set voltage even under the condition of $V_{IN} > V_{OUT}$. Because efficiency is worse than boost mode, and heat generation tends to increase significantly with rising load current (I_{OUT}). Regulation operation is almost the same as in boost mode, but PWM operation is not possible under heavy loads. If the load resistance drops above a certain level, V_{OUT} cannot maintain regulation operation and drops. The transition conditions between boost and buck modes are as follows.

- **Buck Mode → Boost Mode:**

$V_{IN} < V_{OUT} – V_{BUCKR}$

MODE pin “Low”: V_{BUCKR} = Typ. 100mV
MODE pin “High”: V_{BUCKR} = Typ. 200mV

- **Boost Mode → Buck Mode**:

$V_{IN} > V_{OUT} – V_{BUCKD}$

MODE pin “Low” : V_{BUCKD} = Typ. 50mV
MODE pin “High”: V_{BUCKD} = Typ. 100mV

When the MODE pin is "High", the thresholds V_{BUCKR} and V_{BUCKD} are set to large values. This is because ripple tends to become large in boost mode when the difference between V_{IN} and V_{OUT} pin voltages is small, so the low ripple mode is set to boost mode when the difference between V_{IN} and V_{OUT} pin voltages is large.

● Pass-Through Mode

The pass-through mode transitions when $V_{IN} > V_{OUT}$ (= V_{SET}) + 0.6V (Typ.), and the high-side MOSFET remains continuously on. Therefore, the VOUT pin voltage is equal to the VIN pin and the SW pin voltage.
In Pass-Through mode, the current consumption is Typ. 100nA when the MODE pin is “Low” and Typ. 100μA when the MODE pin is "High". When the MODE pin is "High", the response to buck or boost mode is faster instead of increasing current consumption.
In addition, there is no overcurrent protection in pass-through mode, so if short-circuit protection is required, implement measures such as external fuses.
For high V_{SET} versions, use within a range where the V_{IN} pin voltage does not exceed 5.5V, the recommended operating conditions.

● Enable Function

The NC4650xxxxxxxAxxx/ NC4650xxxxxxxBxxx/ can be set to the active state by inputting "High" to the EN pin and to the shutdown state by inputting "Low". The NC4650xxxxxxCxxx/ NC4650xxxxxxDxxx/ can be set to the active state by inputting "Low" to the EN pin or to the shutdown state by inputting "High" to the EN pin.
The EN pin is not pulled down or pulled up inside the IC, so do not leave the EN pin open.
If the EN pin cannot be externally controlled or does not require control, connect the EN pin to the V_{IN} pin or GND etc. so that it is always active.
Applying voltage to the EN pin when there is no voltage applied to the V_{IN} pin will not result in IC failure.
When the EN and MODE pins are fixed to the V_{IN} pin, the polarity is forced to be “H” as long as VIN pin voltage within the recommended operating condition. (The A and B version)

● V_{IN} – V_{OUT} Complete Disconnect

The internal circuits are shut down and current consumption is kept low. Furthermore, by controlling the polarity of the parasitic diode of the high-side MOSFET for synchronous rectification, conduction in both directions between the V_{IN} and SW pins and the V_{OUT} pin is disconnected.

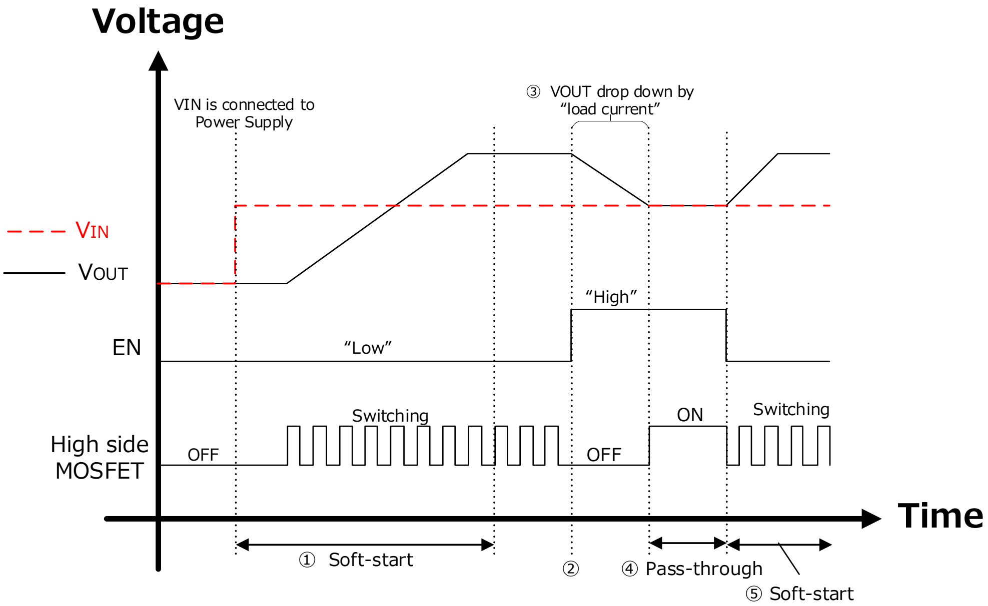
The V_{IN} - V_{OUT} Complete Disconnect function is available in the A and C versions. And is enabled in the A version when the EN pin = "Low" and in the C version when the EN pin = "High".

● Auto Discharge Function

The auto-discharge function turns on the MOSFET connected between the V_{OUT} pin and GND, discharges the charge stored in the output capacitor and quickly lowers the output voltage to near 0 V. The auto-discharge function is only available in the B version and is enabled when the EN pin is set to "Low".

● Seamless Pass-Through Function

The Seamless Pass-Through function suppresses voltage fluctuations on the V_{OUT} pin and reverse current to the SW pin during pass-through, while allowing the voltage on the V_{IN} and SW pins to be output directly to the V_{OUT} pin. The following steps must be taken before pass-through operation is possible.
Note that the seamless pass-through function is only available in the D version and differs from the pass-through mode which operates with $V_{IN} > V_{SET} + 0.6V$ when EN is active.



Seamless Pass-Through Timming Chart

(1) Set the EN pin to "Low" to make it active, and after start-up, the V_{OUT} pin voltage rises to the output setting voltage to complete the 'Soft-Start Operation'. (For details, refer to 'Soft Start Operation'.)
(2) Set the EN pin to "High" to put the device in a shutdown state.
(3) The V_{OUT} pin voltage drops due to the load of the subsequent device.
(4) When the V_{OUT} pin voltage becomes equal to the V_{IN} pin voltage, the high-side MOSFET between the SW and V_{OUT} pins turns ON and the device enters a seamless pass-through state without output voltage fluctuation.
(5) When the EN pin is set to "High" again, the pass-through function is disabled and the V_{OUT} pin voltage rises to the set voltage with soft-start operation.

Compared to the pass-through function of similar products, this function has the advantages of supporting soft-start operation when the power supply is connected, preventing backflow to the power supply side when the high-side MOSFET is on and preventing noise generation.

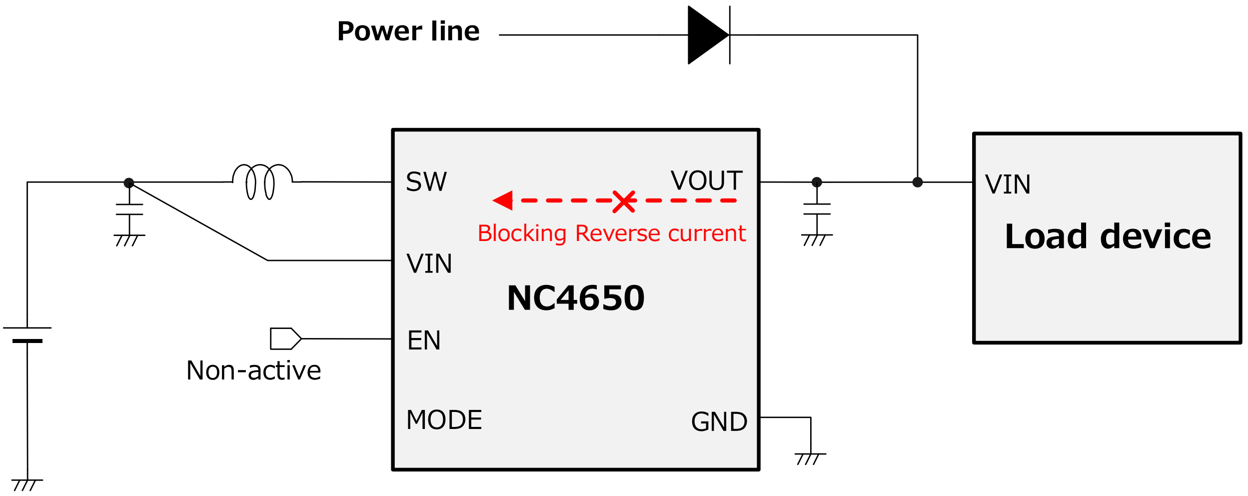
Usage Notes:

- The seamless pass-through function is recommended for use at $V_{IN} \geq 1.2$ V. If the voltage drops below 1.2 V, the VOUT pin voltage may drop significantly due to the high on-resistance of the high-side MOSFET.
- Do not use the device when the load current is large, as the system is designed to operate in the sleep state. If EN is set to "High" (shutdown) when the load current is large, the slew rate of the V_{OUT} pin voltage drop at (3) will be large. The high-side MOSFET may not be switched on in time for the transition from (3) to (4), resulting in the V_{OUT} pin voltage falling significantly below the V_{IN} pin voltage (undershoot).
- In pass-through mode, the thermal shutdown and overcurrent protection functions are switched off to reduce current consumption. If output short-circuit protection is required even during pass-through, take measures such as fuses.
- If EN is set from "Low" to "High" in pass-through mode when $V_{IN} > V_{SET}$ and EN is active, the pass-through state is maintained.

● **Usage Example**

- NC4650ZAxxxA

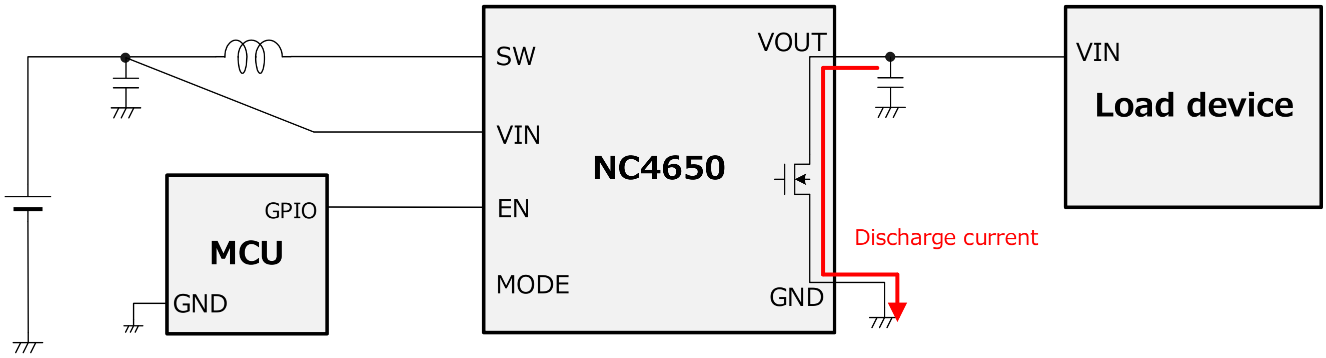
The A version can be set to the active state by inputting "High" to the EN pin and to the shutdown state by inputting "Low". In the shutdown state, switching operation is deactivated and current consumption is kept low.
In the shutdown state, switching operation is stopped and bi-directional conduction between the V_{IN} pin and the SW and V_{OUT} pins is interrupted by the 'V_{IN} - V_{OUT} Complete Disconnect' function.
Using the above characteristics, an external power supply can be OR-connected to the V_{OUT} pin, and the reverse current from the V_{OUT} pin to the V_{IN} and SW pins is interrupted. This is ideal when multiple power supplies are used, e.g. for back-up power supply applications.



A Version System Assumption and Usage Example

- NC4650ZAxxxB

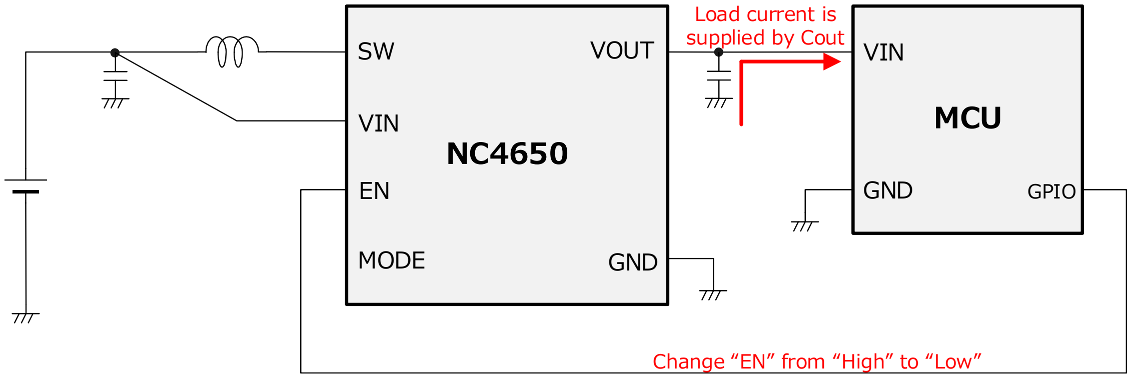
The B version can be set to the active state by inputting "High" to the EN pin and to the shutdown state by inputting "Low". In the shutdown state, switching operation is deactivated and current consumption is kept low.
In the shutdown state, the MOSFET connected between the V_{OUT} and GND pins is switched on and the charge stored in C_{OUT} is discharged by the 'Auto Discharge function'. As a result, the voltage on the V_{OUT} pin quickly becomes equal to the voltage on the GND pin. This is ideal for controlling the falling edge when a load device is switched off and the rising edge sequence when it is switched off and then immediately restarted.



B Version System Assumption and Usage Example

- NC4650ZAxxxC

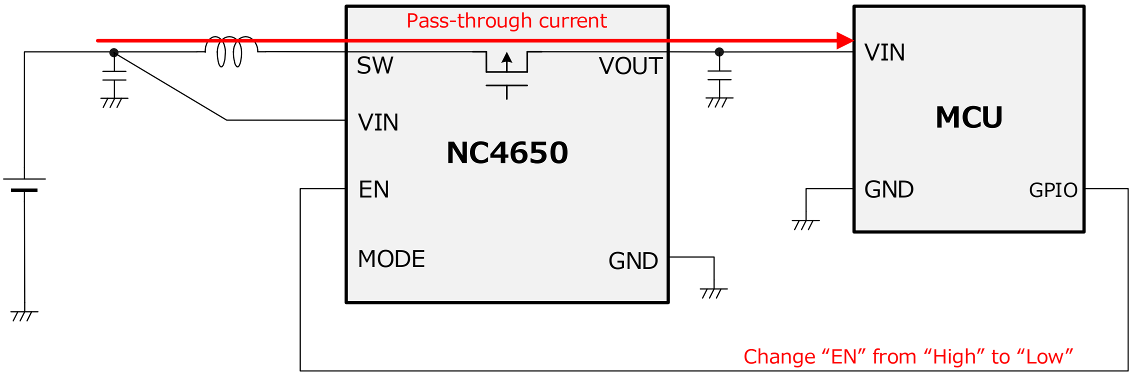
The C version can be set to the active state by inputting "Low" to the EN pin and to the shutdown state by inputting "High".
In the shutdown state, switching operation is stopped and bi-directional conduction between the V_{IN} pin and the SW and V_{OUT} pins is interrupted by the 'V_{IN} - V_{OUT} Complete Disconnect' function.
By utilizing the above characteristics, the switching operation can be temporarily stopped by setting the EN pin "High" from the MCU or other device at a later stage, and the charge held in the output capacitance can be used to operate the device at a later stage. This means that there is no switching noise and the device is suitable for use in RF devices.
However, the drop in the V_{OUT} pin voltage when switching operation is stopped must be kept to a level that does not cause any system problems.
Normally, when the system is in sleep mode, the control voltage on the EN pin is at a "Low" level, so simply connecting the power supply to the NC4650ZAxxxC, whose enable function is active "Low", is enough to start up the MCU. The MCU can be started up simply by connecting the power supply to the NC4650ZAxxxC, whose enable function is active "Low".



C Version System Assumption and Usage Example

- NC4650ZAxxxD

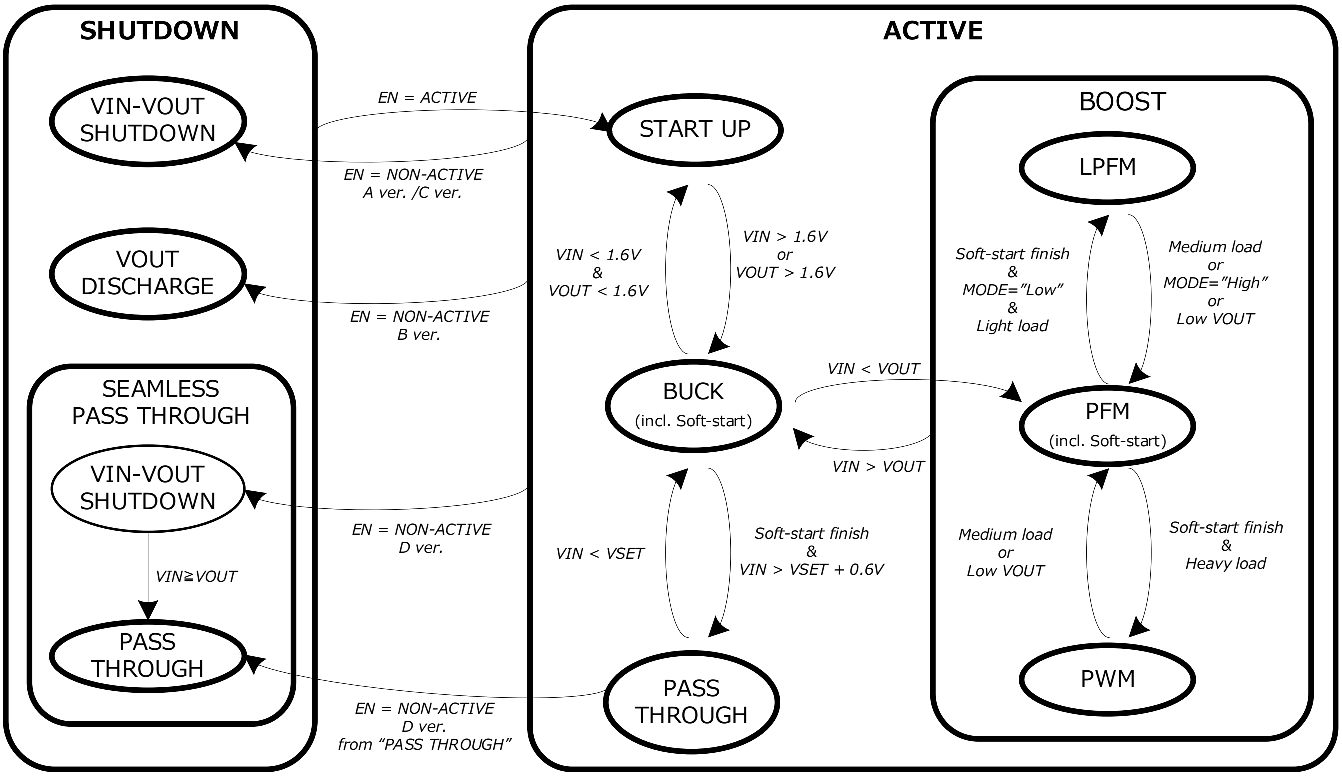
The D version can be set to the active state by inputting "Low" to the EN pin and to the shutdown state by inputting "High". In the shutdown state, switching operation is deactivated and current consumption is kept low.
Normally, when the system is in sleep mode, the control voltage on the EN pin is at a "Low" level, so simply connecting the power supply to the NC4650ZAxxxD, whose enable function is active "Low", is enough to start up the MCU. The MCU can be started up simply by connecting the power supply to the NC4650ZAxxxD with the enable function active "Low".
In the shutdown state, the 'Seamless Pass-Through' function allows the high-side MOSFET between the SW and V_{OUT} pins to be switched on continuously by following the prescribed procedure. Therefore, the voltage at the V_{IN} and SW pins is output directly to the V_{OUT} pin without switching operation (pass-through), allowing subsequent-stage devices to operate with minimal energy loss. This is ideal for use when the battery voltage is sufficiently high or when the load current is low, e.g. during system sleep.



D Version System Assumption and Usage Example

● **State Transition Diagram**

A state transition diagram summarizing the above operational description is shown in the diagram below. For detailed values of the transition conditions, refer to the electrical characteristics table and the operational description.



■ THERMAL CHARACTERISTICS

Thermal characteristics depend on mounting conditions. The thermal characteristics below are the results of measurements under measurement conditions determined by our company with reference to JEDEC STD. (JESD51).

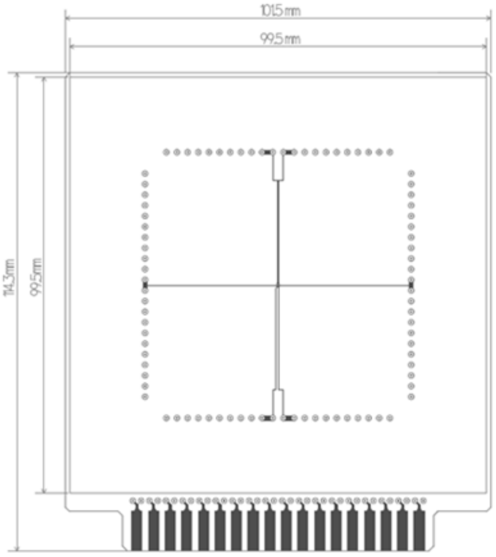
Measurement Result

Item	Measurement Result
Thermal Resistance (qja)	179 °C/W
Thermal Characterization Parameter (ψjt)	60 °C/W

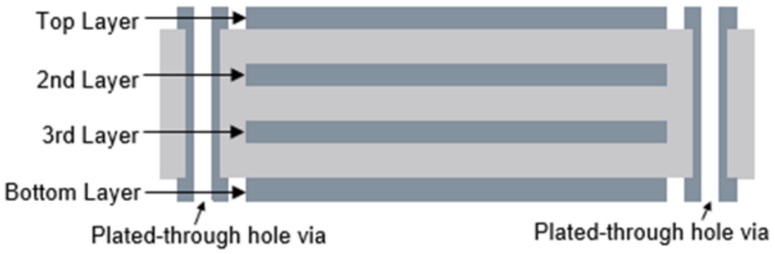
θja : Junction-to-Ambient Thermal Resistance
Ψjt : Junction-to-Top Thermal Characterization Parameter

Measurement Conditions

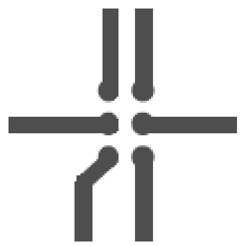
Item		Specification
Measurement Condition		Mounting on Board (Still Air)
Board material		FR-4
Board size		101.5 mm × 114.3 mm × t 1.6 mm
Copper foil layer	1	99.5 mm × 99.5 mm (coverage rate 5%), t 0.050 mm
	2	99.5 mm × 99.5 mm (coverage rate 100%), t 0.035 mm
	3	99.5 mm × 99.5 mm (coverage rate 100%), t 0.035 mm
	4	99.5 mm × 99.5 mm (coverage rate 5%), t 0.050 mm
Thermal vias		None



Measurement Board Pattern



Cross section view of layers and vias



Enlarged view of IC mounting area

● CALCULATION METHOD OF JUNCTION TEMPERATURE

The junction temperature (Tj) can be calculated from the following formula.

$$T_j = T_a + \theta_{ja} \times P$$
$$T_j = T_c(top) + \psi_{jt} \times P$$

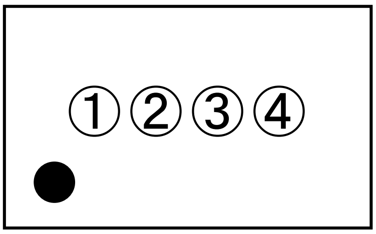
Ta : Ambient temperature
Tc (top) : Package mark side center temperature
P : Power consumption under user's conditions

$$P = (100 / \eta - 1) \times (V_{OUT} \times I_{OUT}) - DCR \times (V_{OUT} / V_{IN} \times I_{OUT})^2$$

η : Efficiency under user's conditions [%]
V_{OUT} : Output Voltage [V]
I_{OUT} : Output Current [A]
DCR : DC resistance of external inductor [Ω]

■ **Marking Specification（NC4650ZA）**

①②: Product Name
③④: Lot No. ···Alphanumeric serial No.



WLCSP-6-ZA1 Marking

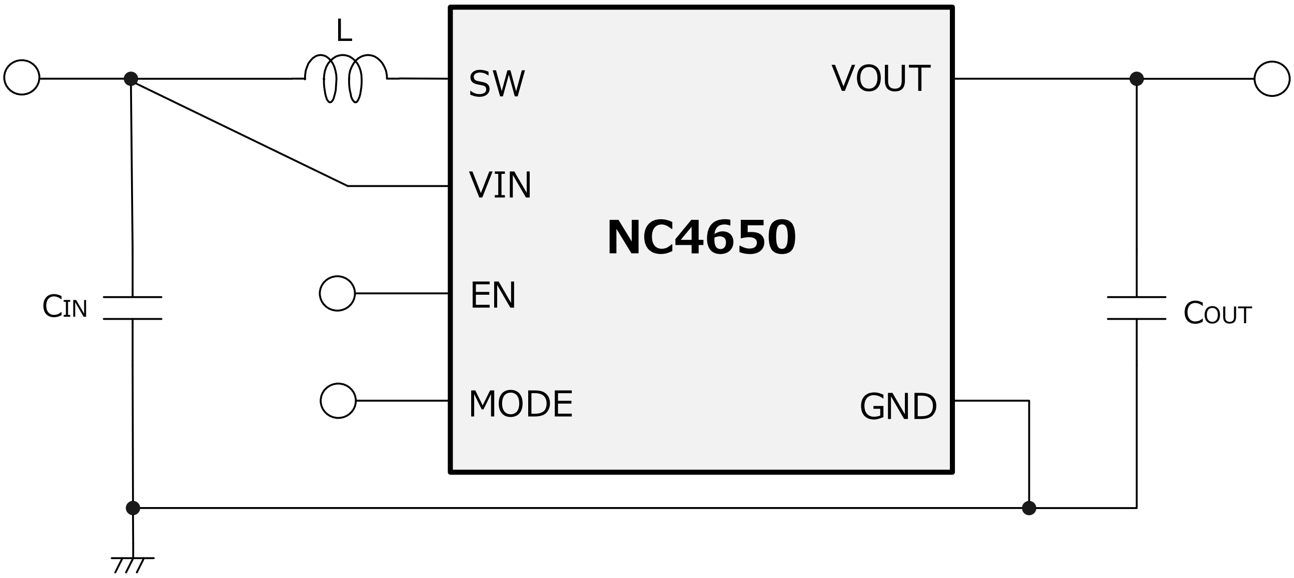
NOTICE
There can be variation in the marking when different AOI (Automated Optical Inspection) equipment is used. In the case of recognizing the marking characteristic with AOI, please contact our sales or our distributor before attempting to use AOI.

NC4650 Marking List

Product Name	①②	Product Name	①②	Product Name	①②	Product Name	①②
NC4650ZA090A	2 0	NC4650ZA090B	2 1	NC4650ZA090C	2 2	NC4650ZA090D	2 3
NC4650ZA100A	2 0	NC4650ZA100B	2 1	NC4650ZA100C	2 2	NC4650ZA100D	2 3
NC4650ZA110A	2 0	NC4650ZA110B	2 1	NC4650ZA110C	2 2	NC4650ZA110D	2 3
NC4650ZA120A	2 0	NC4650ZA120B	2 1	NC4650ZA120C	2 2	NC4650ZA120D	2 3
NC4650ZA130A	2 0	NC4650ZA130B	2 1	NC4650ZA130C	2 2	NC4650ZA130D	2 3
NC4650ZA140A	2 0	NC4650ZA140B	2 1	NC4650ZA140C	2 2	NC4650ZA140D	2 3
NC4650ZA150A	2 0	NC4650ZA150B	2 1	NC4650ZA150C	2 2	NC4650ZA150D	2 3
NC4650ZA160A	2 0	NC4650ZA160B	2 1	NC4650ZA160C	2 2	NC4650ZA160D	2 3
NC4650ZA170A	2 0	NC4650ZA170B	2 1	NC4650ZA170C	2 2	NC4650ZA170D	2 3
NC4650ZA180A	2 0	NC4650ZA180B	2 1	NC4650ZA180C	2 2	NC4650ZA180D	2 3
NC4650ZA190A	2 0	NC4650ZA190B	2 1	NC4650ZA190C	2 2	NC4650ZA190D	2 3
NC4650ZA200A	2 0	NC4650ZA200B	2 1	NC4650ZA200C	2 2	NC4650ZA200D	2 3
NC4650ZA210A	2 0	NC4650ZA210B	2 1	NC4650ZA210C	2 2	NC4650ZA210D	2 3
NC4650ZA220A	2 0	NC4650ZA220B	2 1	NC4650ZA220C	2 2	NC4650ZA220D	2 3
NC4650ZA230A	2 0	NC4650ZA230B	2 1	NC4650ZA230C	2 2	NC4650ZA230D	2 3
NC4650ZA240A	2 0	NC4650ZA240B	2 1	NC4650ZA240C	2 2	NC4650ZA240D	2 3
NC4650ZA250A	2 0	NC4650ZA250B	2 1	NC4650ZA250C	2 2	NC4650ZA250D	2 3
NC4650ZA260A	2 0	NC4650ZA260B	2 1	NC4650ZA260C	2 2	NC4650ZA260D	2 3
NC4650ZA270A	2 0	NC4650ZA270B	2 1	NC4650ZA270C	2 2	NC4650ZA270D	2 3
NC4650ZA280A	2 0	NC4650ZA280B	2 1	NC4650ZA280C	2 2	NC4650ZA280D	2 3
NC4650ZA290A	2 0	NC4650ZA290B	2 1	NC4650ZA290C	2 2	NC4650ZA290D	2 3
NC4650ZA300A	2 0	NC4650ZA300B	2 1	NC4650ZA300C	2 2	NC4650ZA300D	2 3

Product Name	①②	Product Name	①②	Product Name	①②	Product Name	①②
NC4650ZA310A	2 0	NC4650ZA310B	2 1	NC4650ZA310C	2 2	NC4650ZA310D	2 3
NC4650ZA320A	2 0	NC4650ZA320B	2 1	NC4650ZA320C	2 2	NC4650ZA320D	2 3
NC4650ZA330A	2 0	NC4650ZA330B	2 1	NC4650ZA330C	2 2	NC4650ZA330D	2 3
NC4650ZA340A	2 0	NC4650ZA340B	2 1	NC4650ZA340C	2 2	NC4650ZA340D	2 3
NC4650ZA350A	2 0	NC4650ZA350B	2 1	NC4650ZA350C	2 2	NC4650ZA350D	2 3
NC4650ZA360A	2 0	NC4650ZA360B	2 1	NC4650ZA360C	2 2	NC4650ZA360D	2 3
NC4650ZA370A	2 0	NC4650ZA370B	2 1	NC4650ZA370C	2 2	NC4650ZA370D	2 3
NC4650ZA380A	2 0	NC4650ZA380B	2 1	NC4650ZA380C	2 2	NC4650ZA380D	2 3
NC4650ZA390A	2 0	NC4650ZA390B	2 1	NC4650ZA390C	2 2	NC4650ZA390D	2 3
NC4650ZA400A	2 0	NC4650ZA400B	2 1	NC4650ZA400C	2 2	NC4650ZA400D	2 3
NC4650ZA410A	2 0	NC4650ZA410B	2 1	NC4650ZA410C	2 2	NC4650ZA410D	2 3
NC4650ZA420A	2 0	NC4650ZA420B	2 1	NC4650ZA420C	2 2	NC4650ZA420D	2 3
NC4650ZA430A	2 0	NC4650ZA430B	2 1	NC4650ZA430C	2 2	NC4650ZA430D	2 3
NC4650ZA440A	2 0	NC4650ZA440B	2 1	NC4650ZA440C	2 2	NC4650ZA440D	2 3
NC4650ZA450A	2 0	NC4650ZA450B	2 1	NC4650ZA450C	2 2	NC4650ZA450D	2 3
NC4650ZA460A	2 0	NC4650ZA460B	2 1	NC4650ZA460C	2 2	NC4650ZA460D	2 3
NC4650ZA470A	2 0	NC4650ZA470B	2 1	NC4650ZA470C	2 2	NC4650ZA470D	2 3
NC4650ZA480A	2 0	NC4650ZA480B	2 1	NC4650ZA480C	2 2	NC4650ZA480D	2 3
NC4650ZA490A	2 0	NC4650ZA490B	2 1	NC4650ZA490C	2 2	NC4650ZA490D	2 3
NC4650ZA500A	2 0	NC4650ZA500B	2 1	NC4650ZA500C	2 2	NC4650ZA500D	2 3

■ Typical Application Circuit



Recommended external parts

Symbol	Capacitance	Tolerance	Protection Voltage	Temperature characteristics
C_{IN}	10 μF	±20%	10 V	X5R
C_{OUT}	22 μF	±20%	10 V	X5R

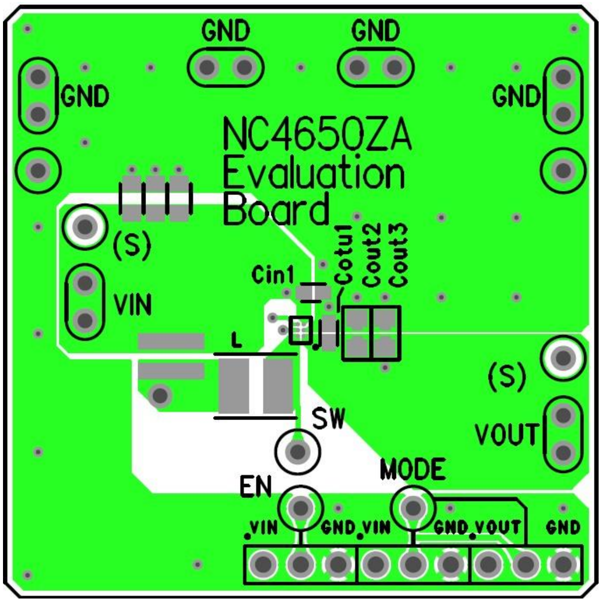
Symbol	Inductance	Tolerance	Rated Current
L	2.2 μH	±20%	2.3A

■ Cautions for Selecting External Components

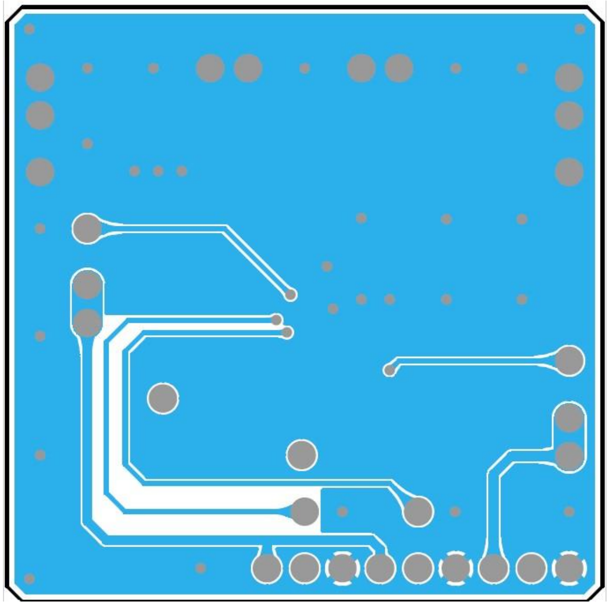
- The performance of a power source circuit using this device is highly dependent on a peripheral circuit. A peripheral component or the device mounted on PCB should not exceed a rated voltage, a rated current or a rated power.
- Choose a low ESR ceramic capacitor. The input capacitor (C_{IN}) between V_{IN} and GND should be more than 10 μF, and the output capacitor (C_{OUT}) should be used of 22 μF. Also, choose the capacitor with consideration for bias characteristics and input/output voltages. Even when using a capacitor other than a ceramic capacitor such as aluminum electrolytic, connect a ceramic capacitor with shortest-distance wiring.
- Use an inductor with an inductance value of 2.2 μH. Choose an inductor that has small DC resistance, has enough permissible current and is hard to cause magnetic saturation. Note that due to the characteristics of the boost switching regulator, the inductor peak current increases as the V_{IN} pin voltage falls during PWM operation.

■ Evaluation Board / PCB Layout Pattern Example

NC4650ZA（WLCSP-6-ZA1）



Top Layer



Bottom Layer

When designing PCB layout patterns, pay close attention to the following items.

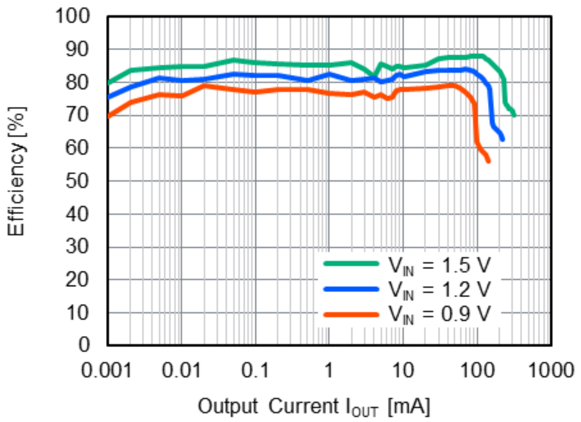
- External components should be placed as close as possible to the IC and on the same side, and the wiring from the IC to the components should be short. In particular, the capacitor C_{IN} connected between V_{IN} and GND and the capacitor C_{OUT} connected between V_{OUT} and GND should be placed at the shortest possible distance from the terminals.
- Current due to switching flows through the power supply wiring, ground wiring and SW pins. If the impedance of the power and ground wiring is high, the potential inside the IC may fluctuate due to the switching current, causing the IC to operate unstable. Therefore, the power and ground wiring should be short and thick.
- The wiring from the SW pin to the inductor is a noise source, so ensure that the current capacity is sufficient to prevent the noise from increasing and that the wiring is not thicker and longer than necessary.

■ TYPICAL CHARACTERISTICS

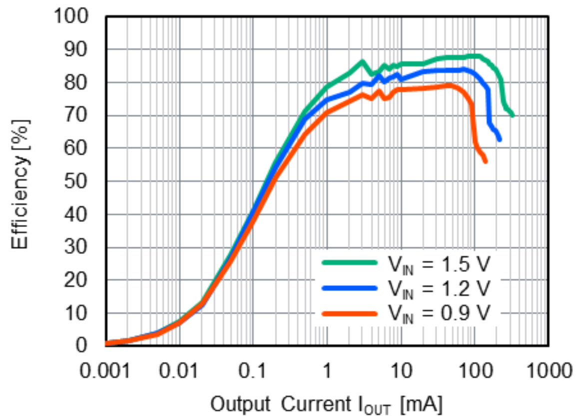
※Typical characteristics are intended to be used as reference data, they are not guaranteed.
Ta = 25 °C, C_{OUT} = 22 µF, L = 2.2 µH, unless otherwise specified.

1) Efficiency vs Output Current
NC4650ZA180A

V_{MODE} = "Low"

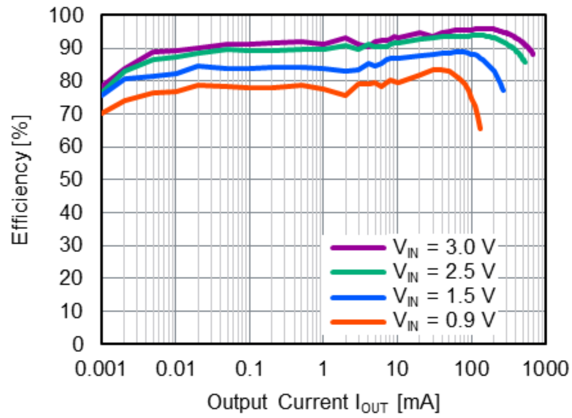


V_{MODE} = "High"

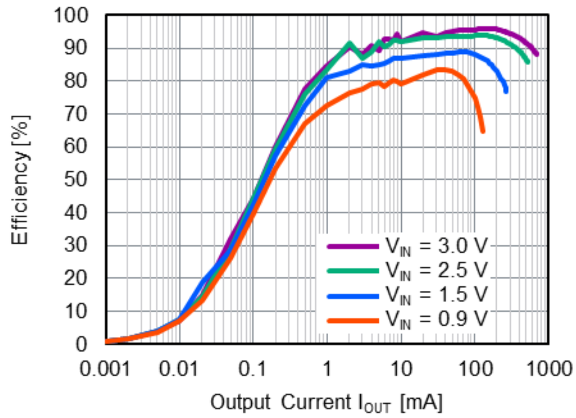


NC4650ZA330A

V_{MODE} = "Low"

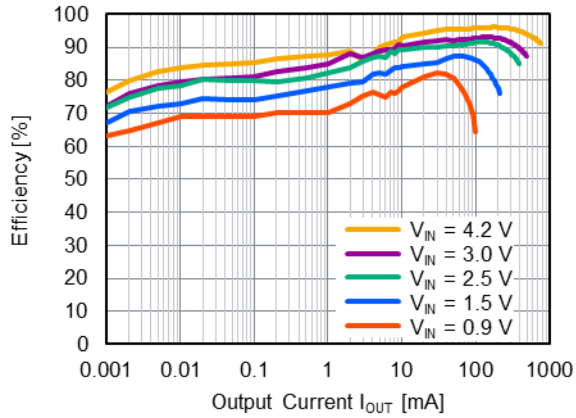


V_{MODE} = "High"

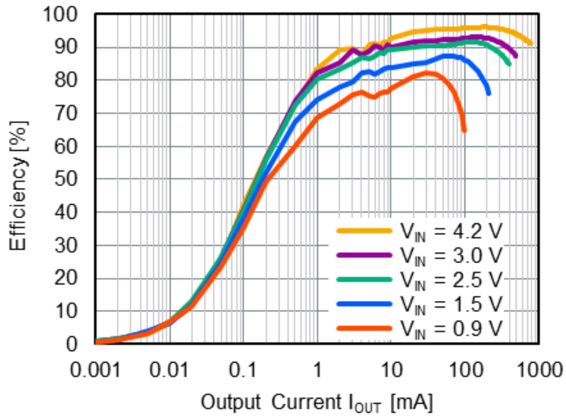


NC4650ZA500A

V_{MODE} = "Low"



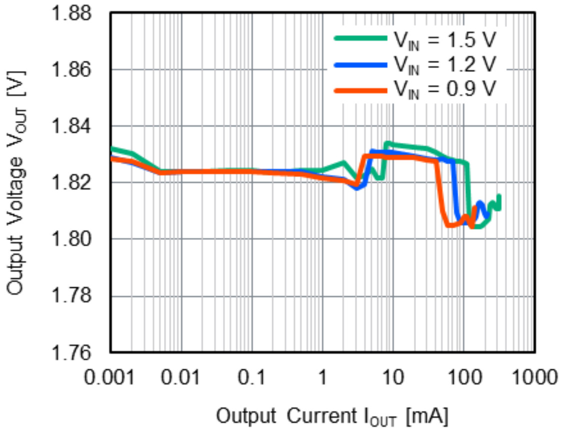
V_{MODE} = "High"



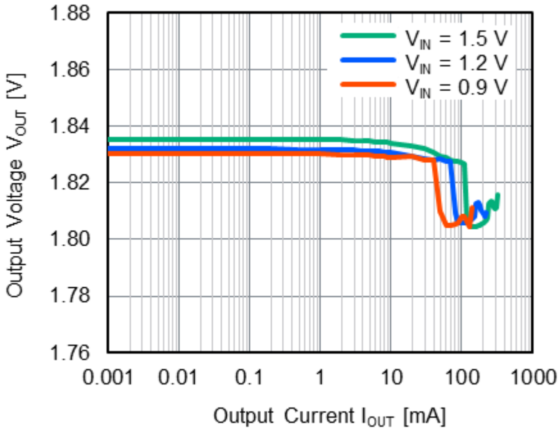
2) Load Regulation

NC4650ZA180A

V_{MODE} = "Low"

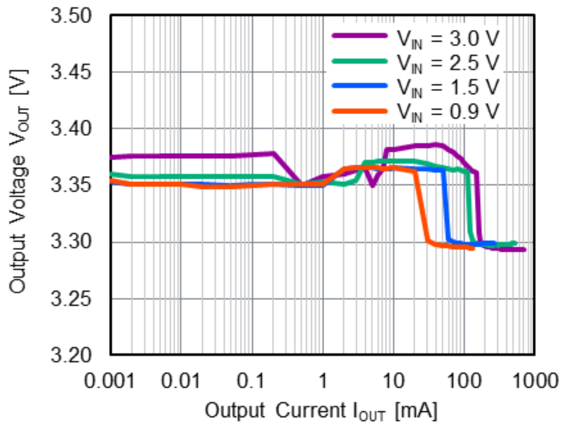


V_{MODE} = "High"

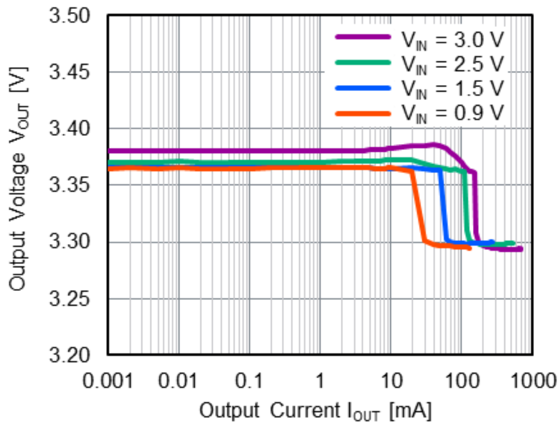


NC4650ZA330A

V_{MODE} = "Low"

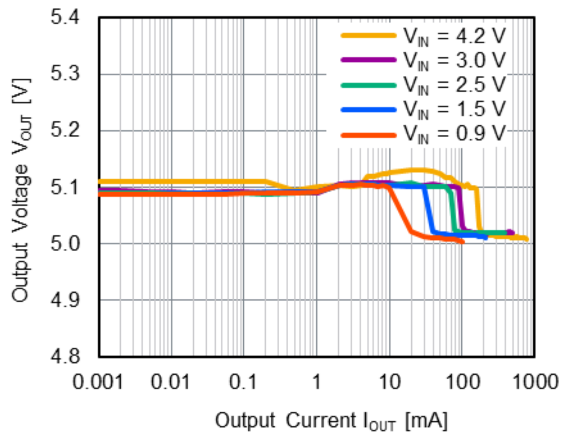


V_{MODE} = "High"

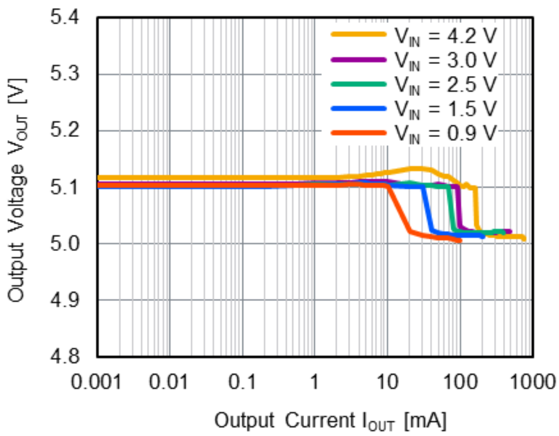


NC4650ZA500A

V_{MODE} = "Low"



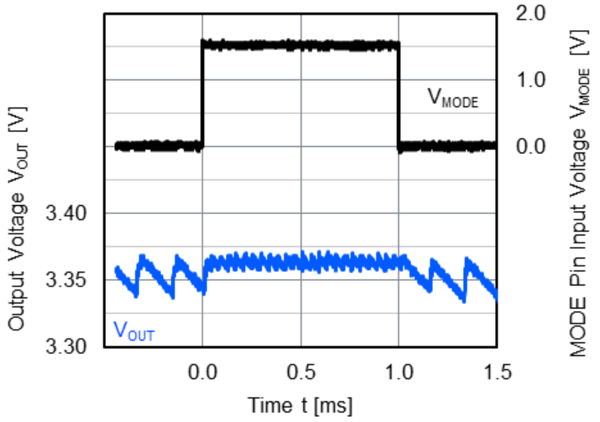
V_{MODE} = "High"



3) MODE Transient Response

V_{IN} = 1.5 V, V_{MODE} = "Low" ⇔ "High", I_{OUT} = 1 mA, V_{EN} = "High"

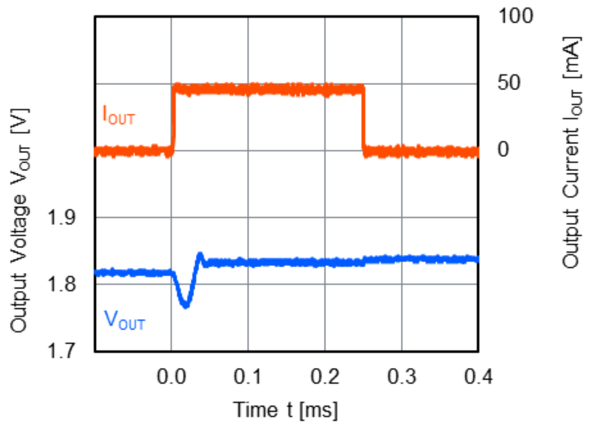
NC4650ZA330A



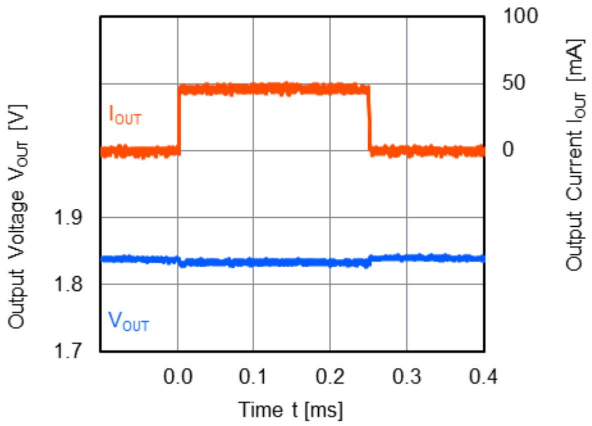
4) Load Transient Response

NC4650ZA180A, V_{IN} = 0.9 V, I_{OUT} = 10 μA ⇔ 50 mA, t_R = t_F = 1 μs

V_{MODE} = "Low"

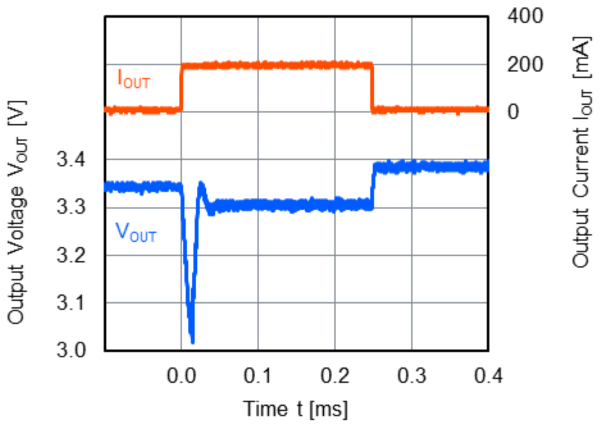


V_{MODE} = "High"

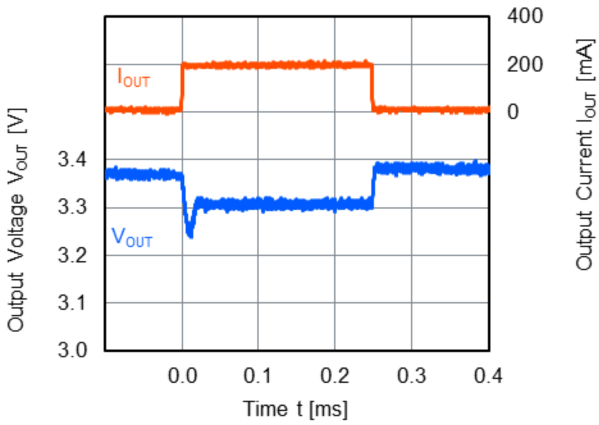


NC4650ZA330A, V_{IN} = 1.8 V, I_{OUT} = 10 μA ⇔ 200 mA, t_R = t_F = 1 μs

V_{MODE} = "Low"

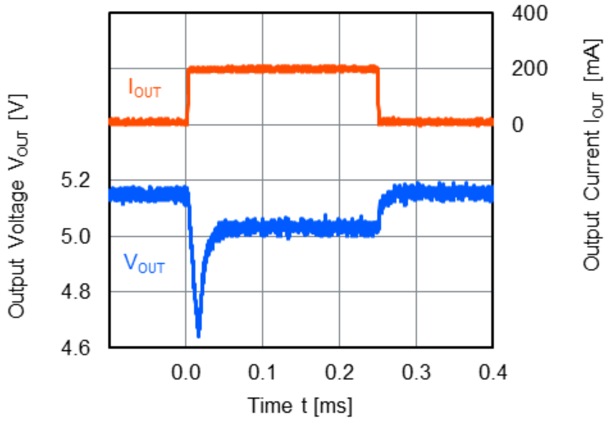


V_{MODE} = "High"

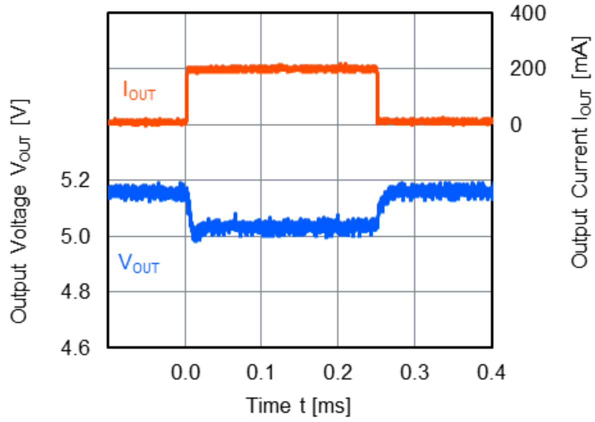


NC4650ZA500B, V_{IN} = 3.0 V, I_{OUT} = 10 μA ⇔ 200 mA, t_R = t_F = 1 μs

V_{MODE} = “Low”

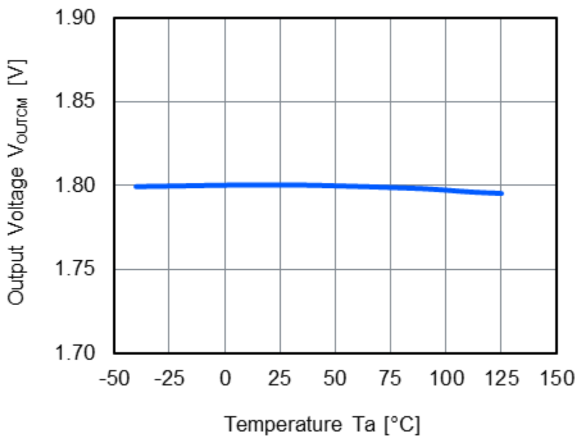


V_{MODE} = “High”

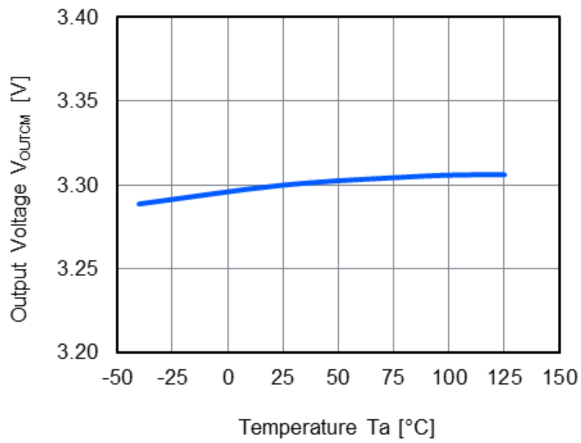


5) Output Voltage vs Temperature

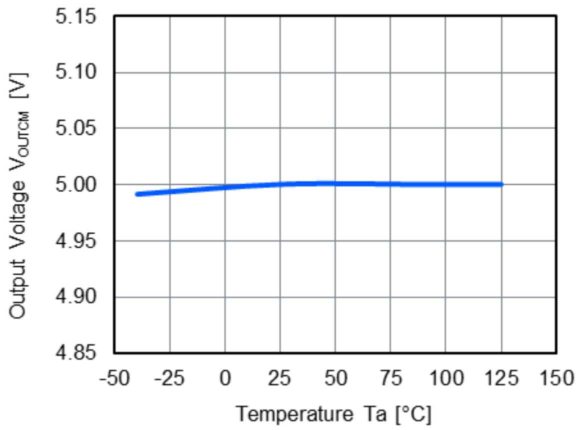
NC4650ZA180x



NC4650ZA330x

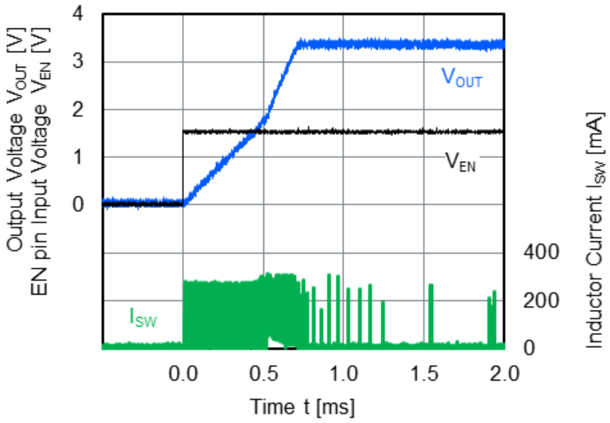


NC4650ZA500x

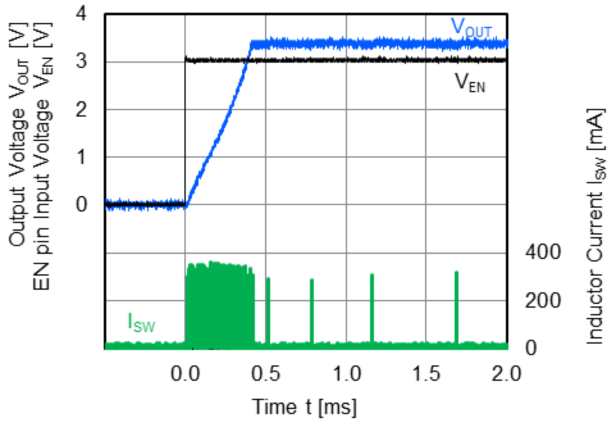


6) Turn on Speed with EN pin
R_{OUT} = 10 kΩ, V_{MODE} = "Low"
NC4650ZA330A/B

V_{IN} = 1.5 V

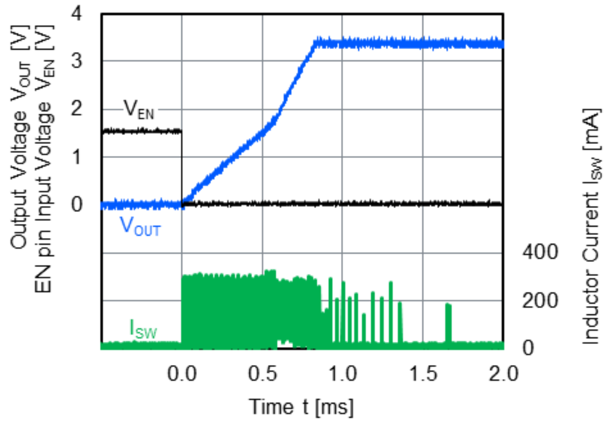


V_{IN} = 3.0 V

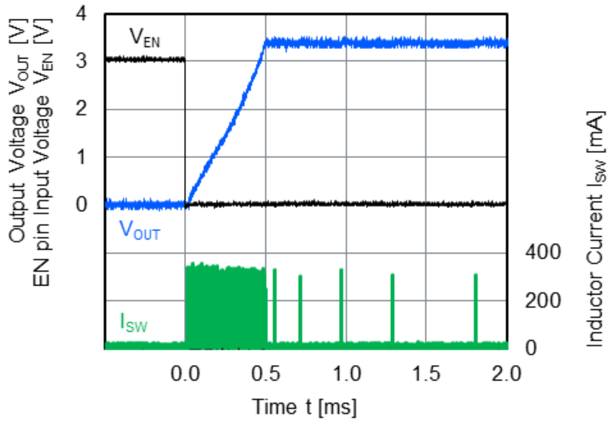


NC4650ZA330D, R_{OUT} = 10 kΩ, V_{MODE} = "Low"

V_{IN} = 1.5 V

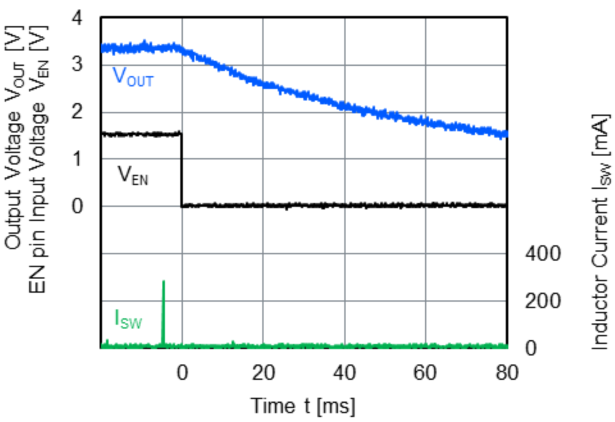


V_{IN} = 3.0 V

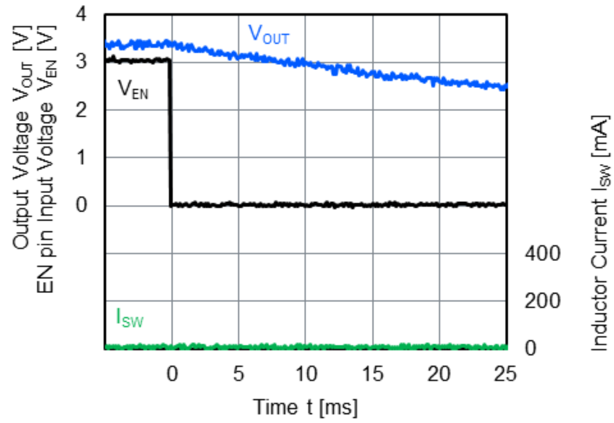


7) Turn off Speed with EN pin
NC4650ZA330A, R_{OUT} = 10 kΩ

V_{IN} = 1.5 V

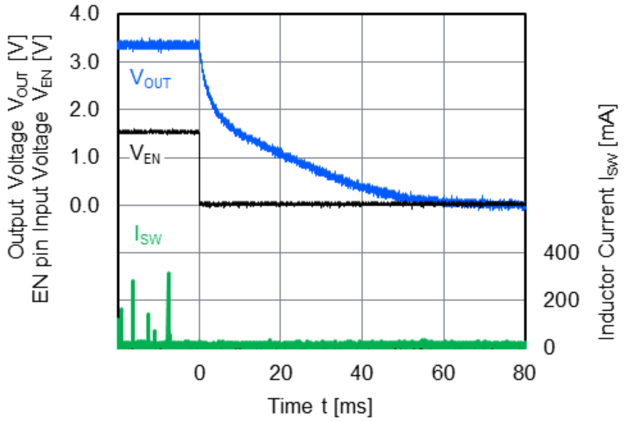


V_{IN} = 3.0 V

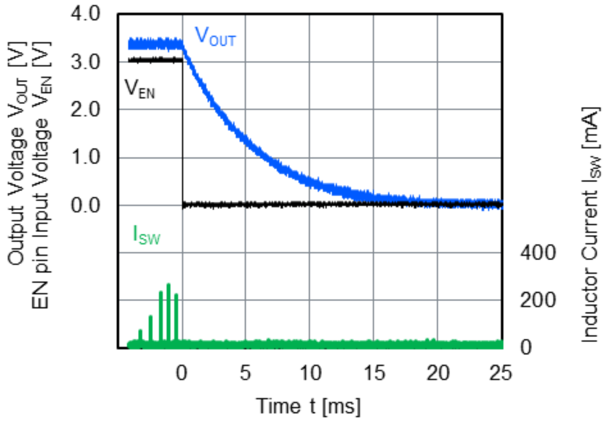


NC4650ZA330B, R_{OUT} = 10 kΩ, V_{MODE} = “Low”

V_{IN} = 1.5 V

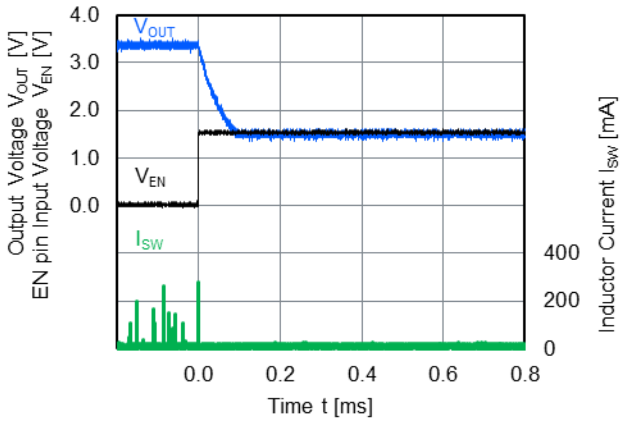


V_{IN} = 3.0 V

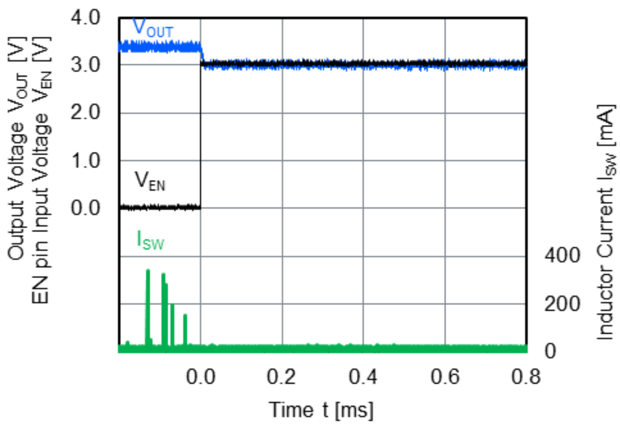


NC4650ZA330D, R_{OUT} = 10 kΩ, V_{MODE} = “Low”

V_{IN} = 1.5 V



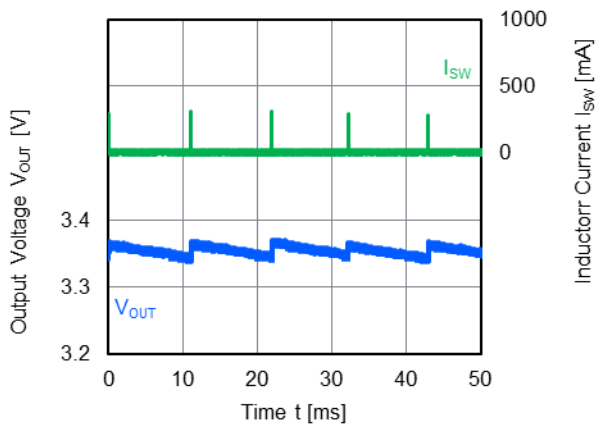
V_{IN} = 3.0 V



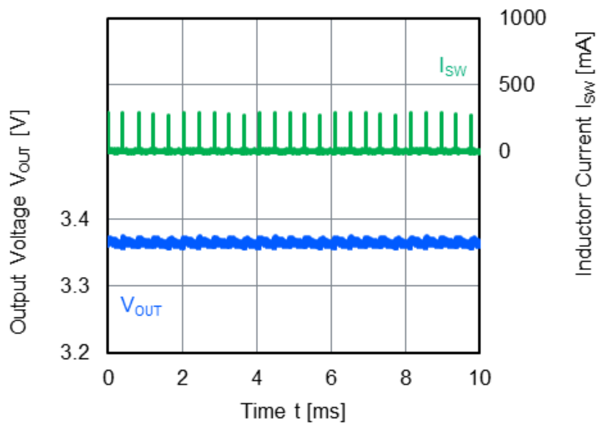
8) Output Ripple Waveform

NC4650ZA330A, V_{IN} = 1.5 V, I_{OUT} = 10 μA

V_{MODE} = “Low”

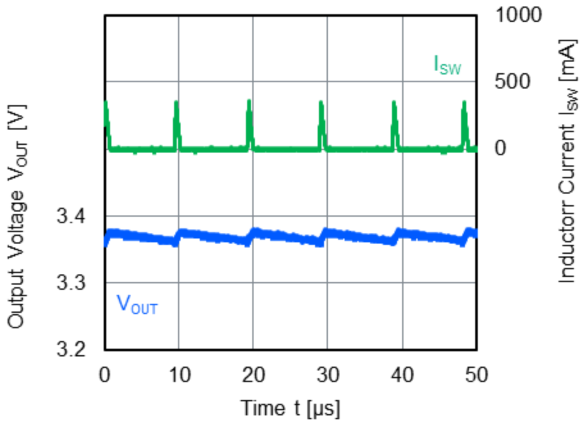


V_{MODE} = “High”

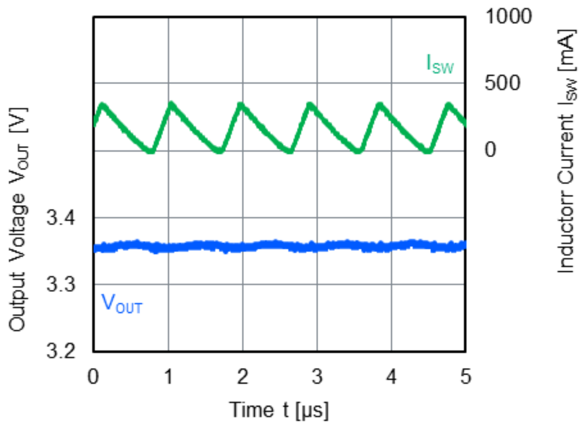


NC4650ZA330A, V_{MODE} = “Low”, V_{IN} = 1.5 V

I_{OUT} = 10 mA

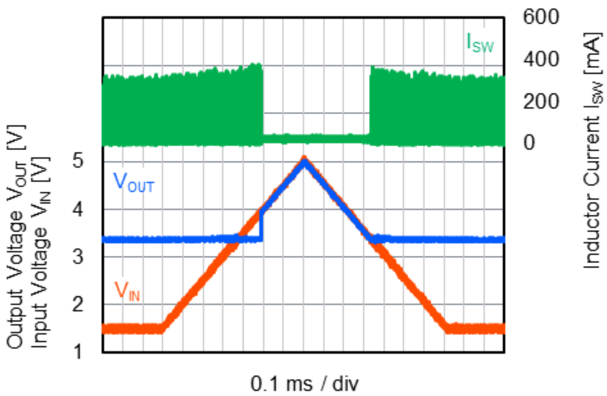


I_{OUT} = 100 mA



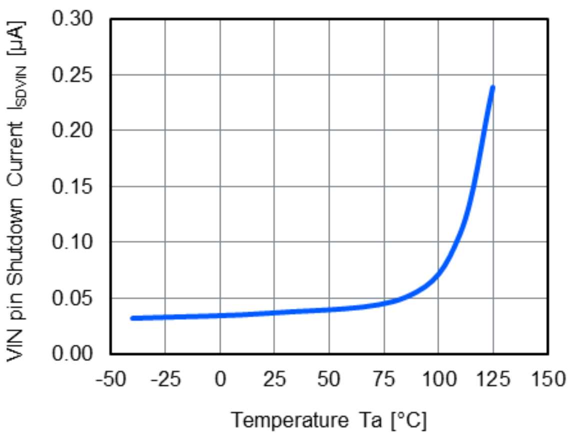
9) Line Regulation vs Time

NC4650ZA330A, V_{IN} = 1.5 V ⇔ 5.0 V, I_{OUT} = 10 mA, V_{MODE} = “Low”

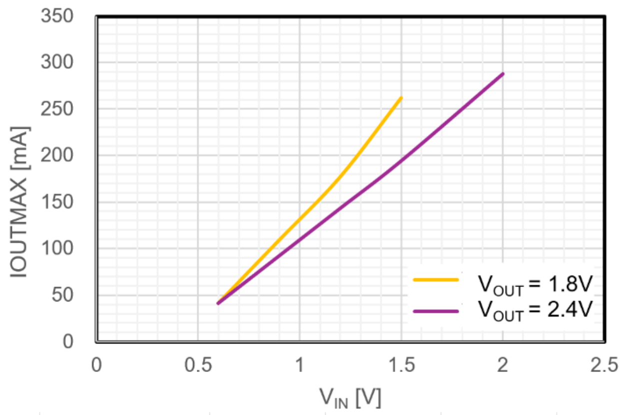


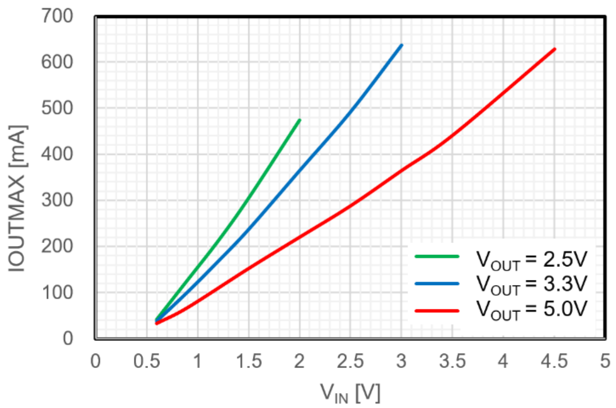
10) VIN pin Shutdown Current vs Temperature

NC4650ZA330A, V_{IN} = 3.0 V, V_{EN} = “Low”, V_{MODE} = “Low”, V_{OUT} = open

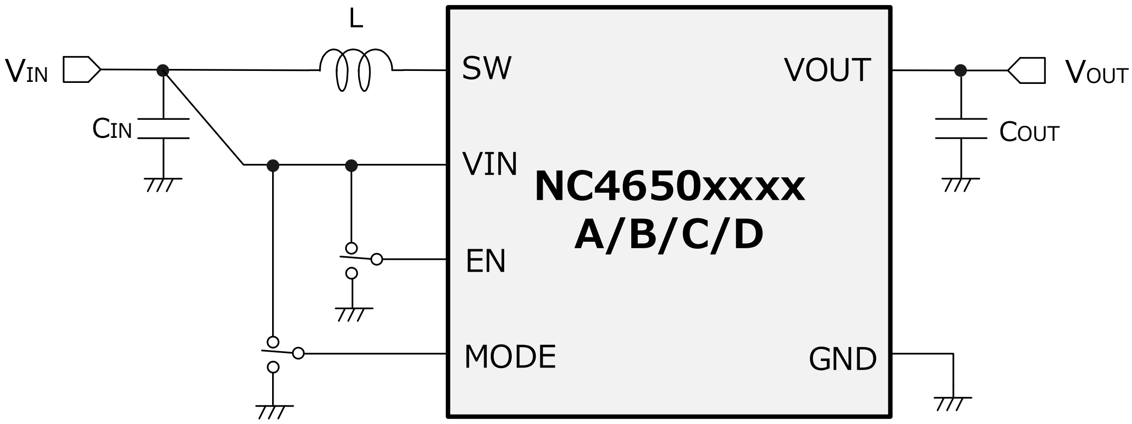


11) Maximum Output Current vs Input Voltage





■ **TEST CIRCUIT**



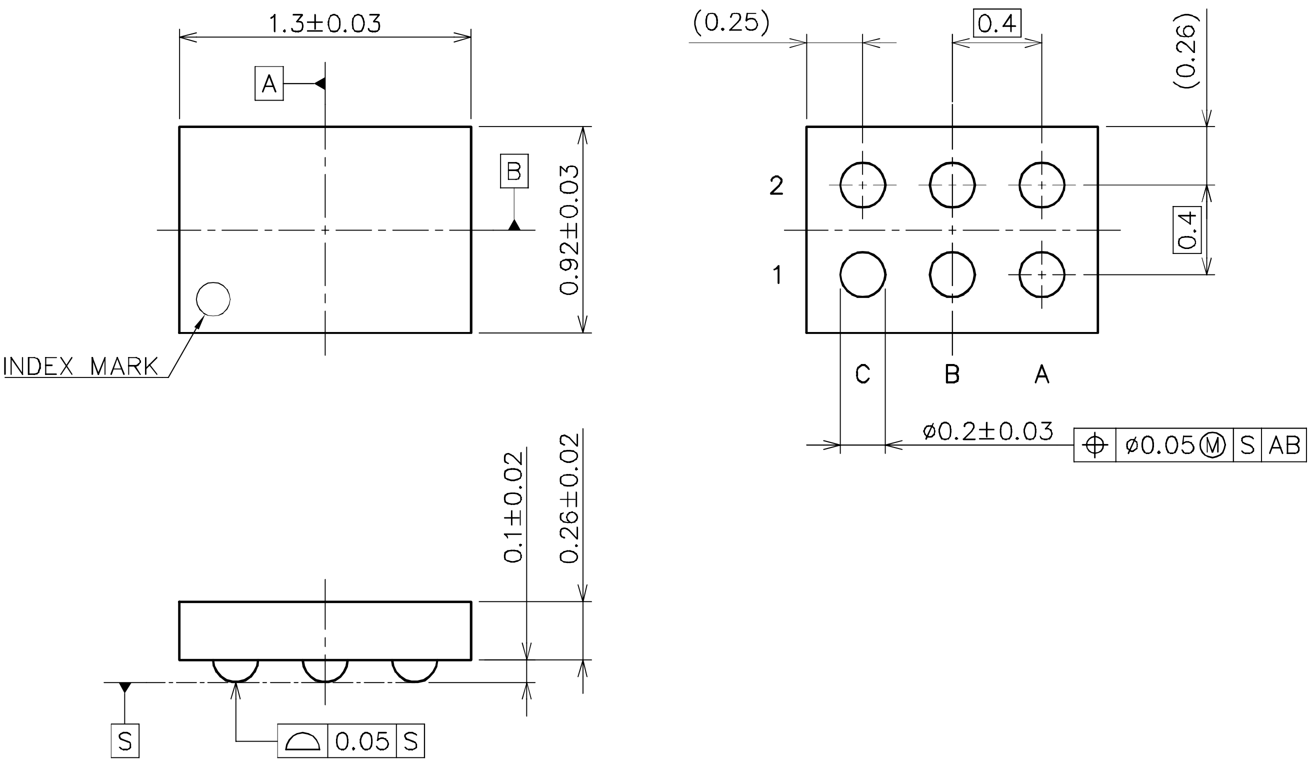
【Components List for Our Evaluation】

Symbol	Specification	Part Number
C_{IN}	10 µF	GRM188R61A106MAAL
C_{OUT}	22 µF	GRM188R61A226ME15
L	2.2 µH	DFE252012F-2R2M

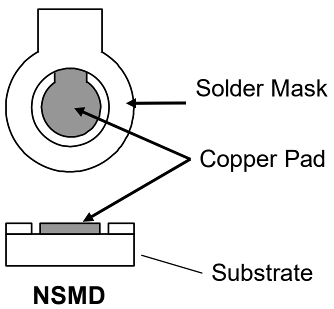
Nisshinbo Micro Devices Inc.

■ PACKAGE DIMENSIONS

UNIT: mm



■ Recommended Land Pattern



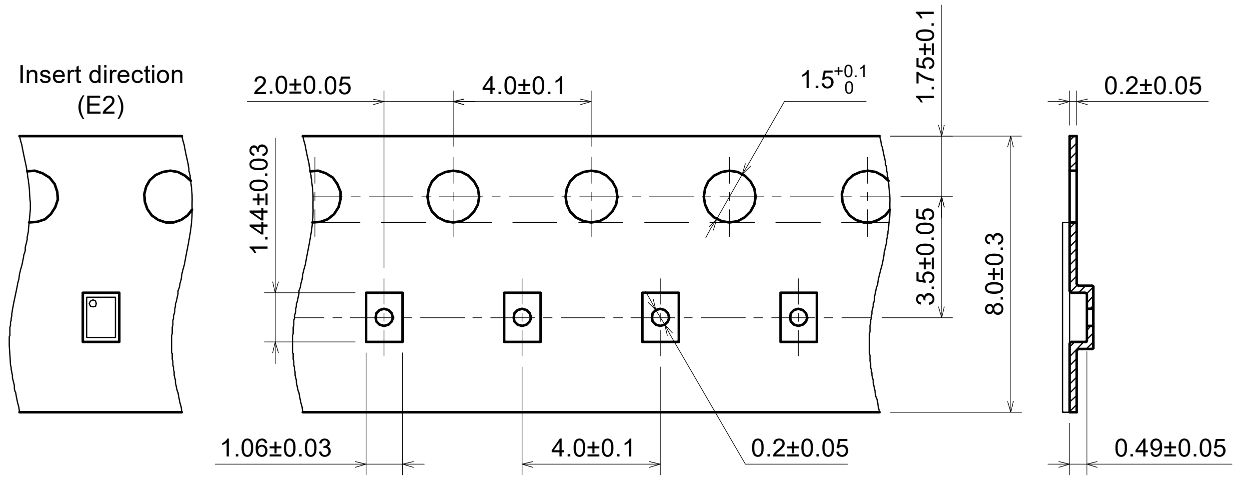
NSMD Pad Definition		
Pad definition	Copper Pad	Solder Mask Opening
NSMD (Non-Solder Mask defined)	0.2mm	MIN. 0.3mm

*) Pad Layout and size can modify by customers material, equipment and method.
*) Please adjust pad layout according to your conditions.
*) Recommended Stencil Aperture Size: ϕ0.26mm

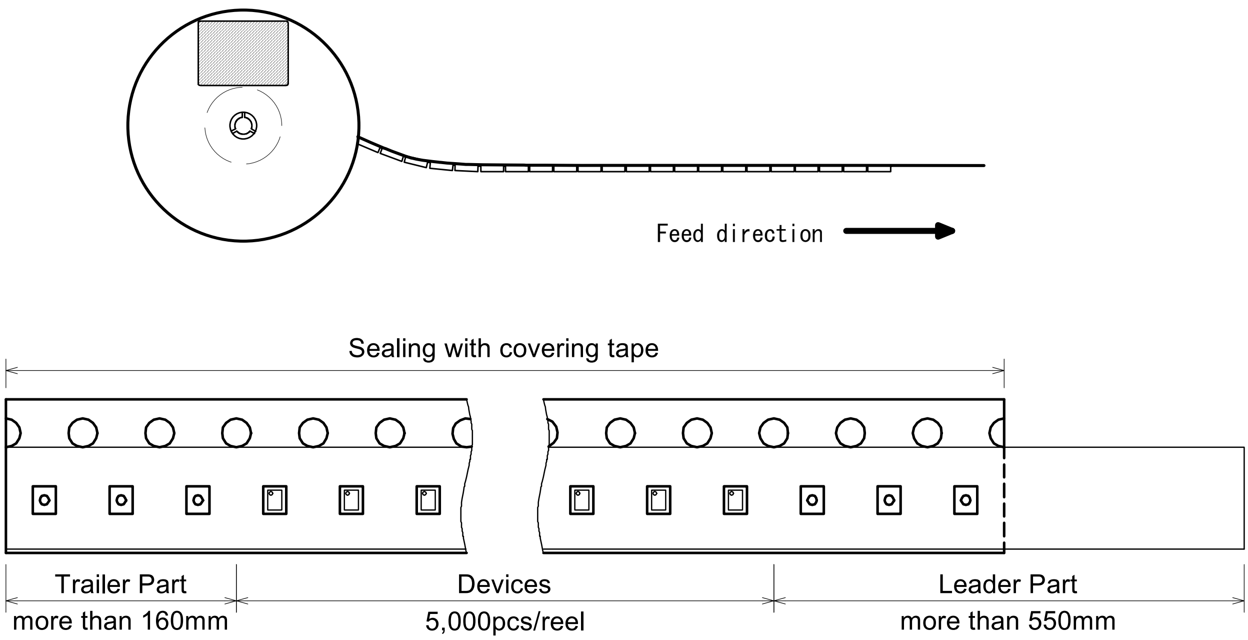
■ **PACKING SPEC**

UNIT: mm

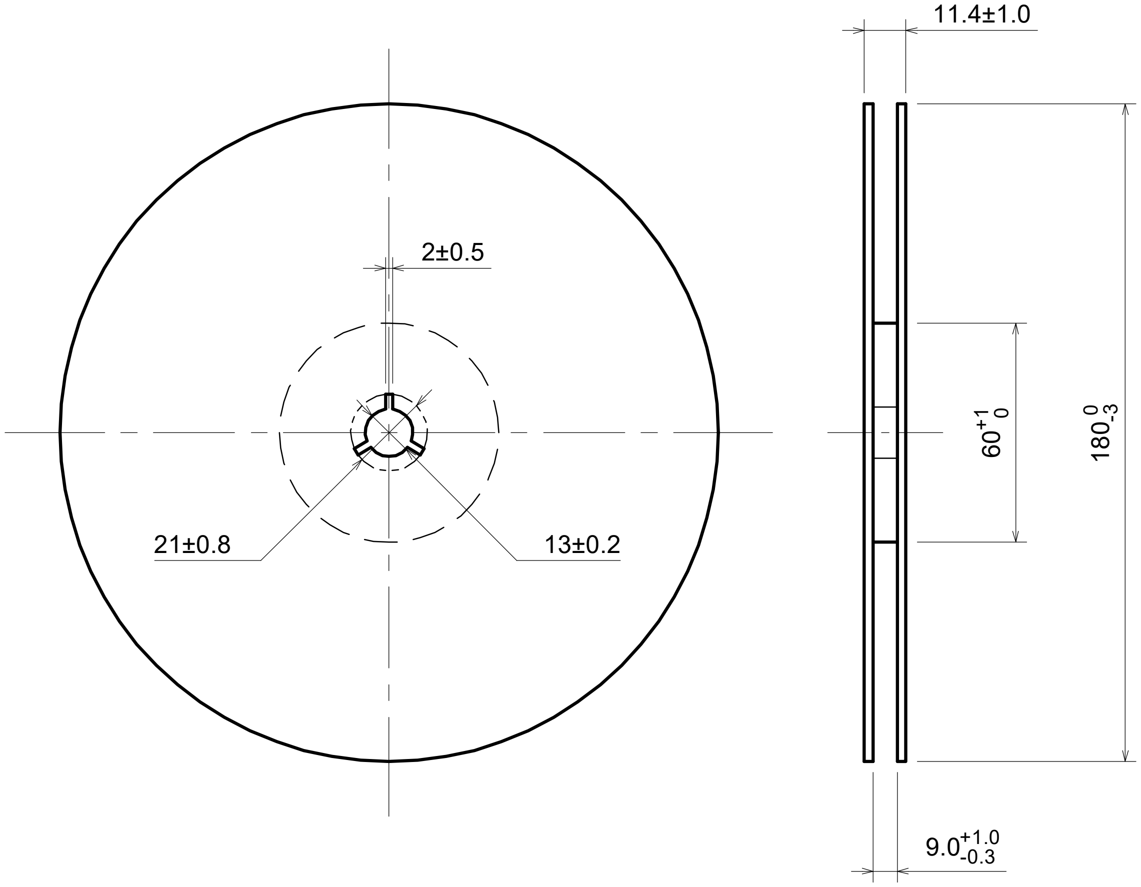
(1) Taping dimensions / Insert direction



(2) Taping state



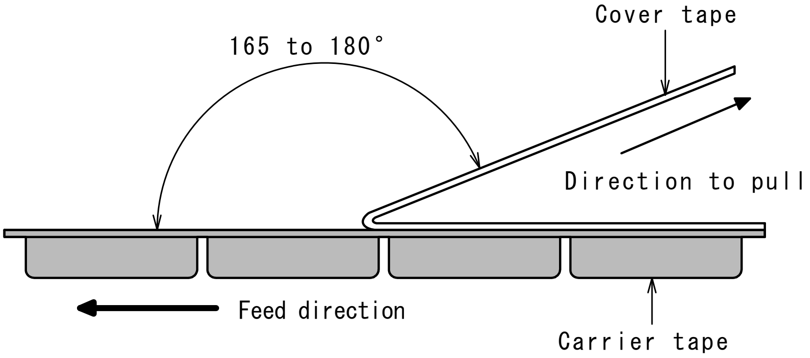
(3) Reel dimensions



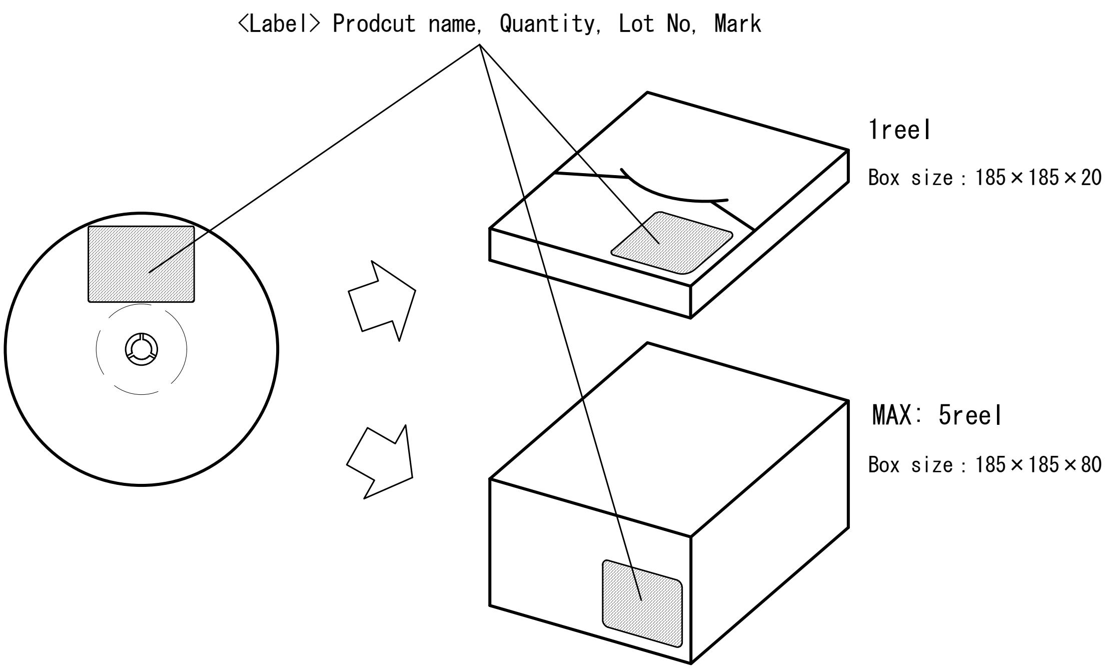
(4) Peeling strength

Peeling strength of cover tape

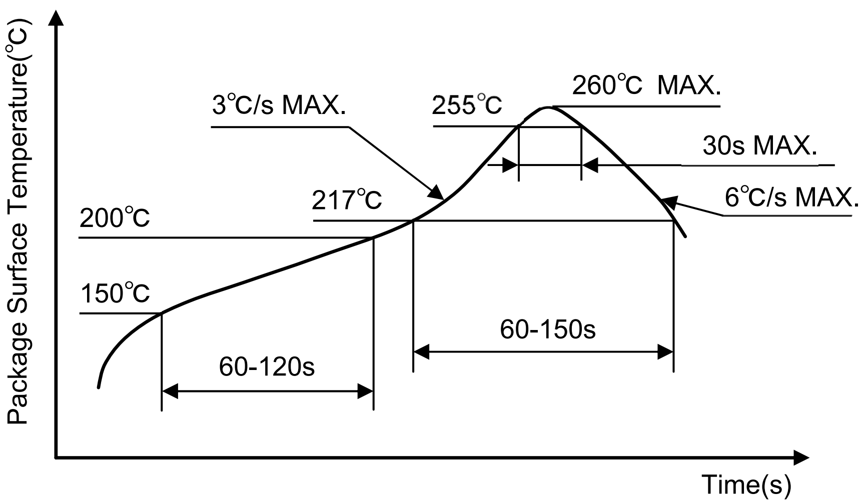
･Peeling angle	165 to 180° degrees to the taped surface.
･Peeling speed	300mm/min
･Peeling strength	0.1 to 1.0N



(5) Packing state



■ **HEAT-RESISTANCE PROFILES**



Reflow profile

Revision History

Date	Revision	Changes
February 28, 2025	Ver. 1.0	Initial release

1. The products and the product specifications described in this document are subject to change or discontinuation of production without notice for reasons such as improvement. Therefore, before deciding to use the products, please refer to our sales representatives for the latest information thereon.
2. The materials in this document may not be copied or otherwise reproduced in whole or in part without the prior written consent of us.
3. This product and any technical information relating thereto are subject to complementary export controls (so-called KNOW controls) under the Foreign Exchange and Foreign Trade Law, and related politics ministerial ordinance of the law. (Note that the complementary export controls are inapplicable to any application-specific products, except rockets and pilotless aircraft, that are insusceptible to design or program changes.) Accordingly, when exporting or carrying abroad this product, follow the Foreign Exchange and Foreign Trade Control Law and its related regulations with respect to the complementary export controls.
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5. The products listed in this document are intended and designed for use as general electronic components in standard applications (office equipment, telecommunication equipment, measuring instruments, consumer electronic products, amusement equipment etc.). Those customers intending to use a product in an application requiring extreme quality and reliability, for example, in a highly specific application where the failure or misoperation of the product could result in human injury or death should first contact us.
   - Aerospace Equipment
   - Equipment Used in the Deep Sea
   - Power Generator Control Equipment (nuclear, steam, hydraulic, etc.)
   - Life Maintenance Medical Equipment
   - Fire Alarms / Intruder Detectors
   - Vehicle Control Equipment (automotive, airplane, railroad, ship, etc.)
   - Various Safety Devices
   - Traffic control system
   - Combustion equipment

   In case your company desires to use this product for any applications other than general electronic equipment mentioned above, make sure to contact our company in advance. Note that the important requirements mentioned in this section are not applicable to cases where operation requirements such as application conditions are confirmed by our company in writing after consultation with your company.
6. We are making our continuous effort to improve the quality and reliability of our products, but semiconductor products are likely to fail with certain probability. In order to prevent any injury to persons or damages to property resulting from such failure, customers should be careful enough to incorporate safety measures in their design, such as redundancy feature, fire containment feature and fail-safe feature. We do not assume any liability or responsibility for any loss or damage arising from misuse or inappropriate use of the products.
7. The products have been designed and tested to function within controlled environmental conditions. Do not use products under conditions that deviate from methods or applications specified in this datasheet. Failure to employ the products in the proper applications can lead to deterioration, destruction or failure of the products. We shall not be responsible for any bodily injury, fires or accident, property damage or any consequential damages resulting from misuse or misapplication of the products.
8. Quality Warranty

   8-1. Quality Warranty Period

   In the case of a product purchased through an authorized distributor or directly from us, the warranty period for this product shall be one (1) year after delivery to your company. For defective products that occurred during this period, we will take the quality warranty measures described in section 8-2. However, if there is an agreement on the warranty period in the basic transaction agreement, quality assurance agreement, delivery specifications, etc., it shall be followed.

   8-2. Quality Warranty Remedies

   When it has been proved defective due to manufacturing factors as a result of defect analysis by us, we will either deliver a substitute for the defective product or refund the purchase price of the defective product.

   Note that such delivery or refund is sole and exclusive remedies to your company for the defective product.

   8-3. Remedies after Quality Warranty Period

   With respect to any defect of this product found after the quality warranty period, the defect will be analyzed by us. On the basis of the defect analysis results, the scope and amounts of damage shall be determined by mutual agreement of both parties. Then we will deal with upper limit in Section 8-2. This provision is not intended to limit any legal rights of your company.
9. Anti-radiation design is not implemented in the products described in this document.
10. The X-ray exposure can influence functions and characteristics of the products. Confirm the product functions and characteristics in the evaluation stage.
11. WLCSP products should be used in light shielded environments. The light exposure can influence functions and characteristics of the products under operation or storage.
12. Warning for handling Gallium and Arsenic (GaAs) products (Applying to GaAs MMIC, Photo Reflector). These products use Gallium (Ga) and Arsenic (As) which are specified as poisonous chemicals by law. For the prevention of a hazard, do not burn, destroy, or process chemically to make them as gas or power. When the product is disposed of, please follow the related regulation and do not mix this with general industrial waste or household waste.
13. Please contact our sales representatives should you have any questions or comments concerning the products or the technical information.

NISSHINBO

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