NC2650 series

Ultra-low Quiescent Current (I_{QVIN} = 85nA) 1A Step-down Switching Regulator

FEATURES

- Input Voltage Range (Maximum Rating): 1.8 V to 5.5 V (6.5 V)
- Output Voltage Range: 0.8 V to 3.3 V (internally fixed)
- Output Voltage Accuracy: ±1 % (V_{SET} ≥ 1.2 V)
  ±1.5 % (V_{SET} < 1.2 V)
- Quiescent Current: Typ. 85 nA
- Efficiency: Typ. 80 %
  (V_{IN}=3.6V, V_{OUT}=1.8V, I_{OUT}=1uA)
- Ripple Voltage: Typ. 10mVpp (I_{OUT}=500mA)
- UVLO Detection Voltage: Typ. 1.45 V
- Soft-Start Time: Typ. 170 µs
- Thermal Shutdown Function:
  Detection Temperature: Typ. 150 °C
  Release Temperature: Typ. 120 °C
- Auto Discharge Function

GENERAL DESCRIPTION

The NC2650 is a synchronous rectification step-down switching regulator using CMOS-based with PWM/PFM automatic alternating function.

This product achieves ultra-low power consumption of only 85 nA in quiescent current, so it is ideal for battery-powered portable devices such as wearable devices and IoT devices.

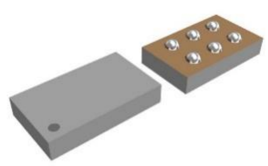
Because it exhibits high efficiency under light load conditions, it extends battery life in intermittent operation applications and allows the use of a small inductor (0.47µH), contributing to space savings.

It also achieves low ripple voltage and fast load transient response, providing stable power quality. Shutdown function is possible by switching the EN pin and auto-discharge can be selected, so that enables flexible power supply design.

APPLICATIONS

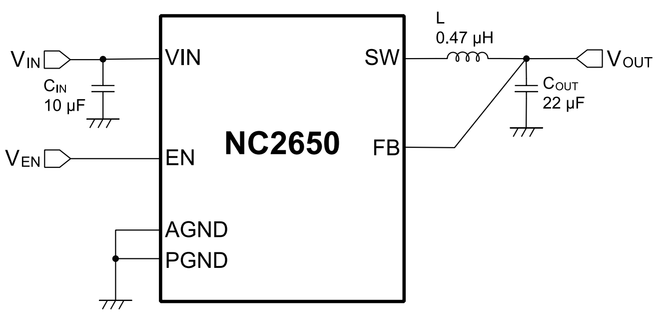
- IoT Edge Terminals
- Devices Powered by Coin/Button/Dry Batteries.
- Alarms, Smart Watches etc.

PACKAGE

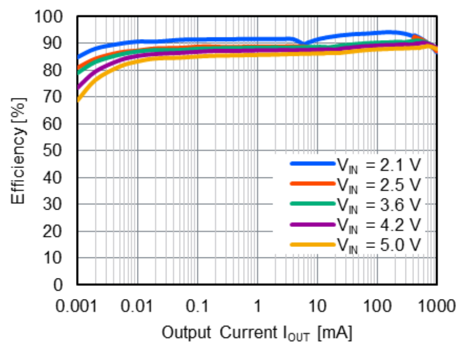


WLCSP-6-ZA2 1.47 x 0.87 x 0.4 (mm)

TYPICAL APPLICATIONS



EFFICIENCY TYPICAL CHARACTERISTICS



NC2650ZA V_{OUT} = 1.8V

■PRODUCT NAME INFORMATION

NC2650 aa bbb c dd e

Description of the configuration

Composition	item	Description
aa	Package Code	Indicates the package. Refer to the order information. ZA: WLCSP
bbb	Output Voltage	Set Output Voltage (V_{SET}) The internal fixed output voltage type has a lineup of main voltages in the range of 0.8 V (080) to 3.3 V (330) in 0.1 V Step.
c	Version	Indicates the selection of auto discharge function
dd	Packing	E2 : Refer to the packing specifications.
e	Grade	Indicates the quality grade. S: Standard

Version

c	Auto Discharge Function
A	✓
B	-

Grade

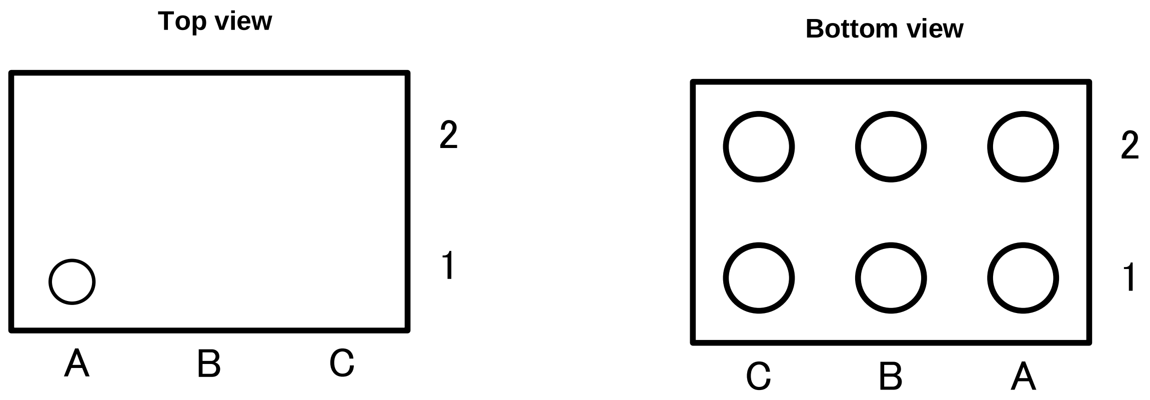
e	Applications	Operating Junction Temperature Range	Test Temperature
S	Standard	-40 °C to 125 °C	25 °C

■ORDER INFORMATION

PRODUCT NAME	PACKAGE	RoHS	HALOGEN-FREE	SOLDER BALL	WEIGHT (mg)	QUANTITY (pcs/reel)
NC2650ZAbbbcE2S	WLCSP-6-ZA2	✓	✓	Sn3Ag0.5Cu	1	5,000

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

■PIN DESCRIPTIONS (NC2650ZA)



WLCSP-6-ZA2 Pin Configuration

NC2650ZA (WLCSP-6-ZA2) Pin Descriptions

Pin No.	Pin Name	I/O	Description
A1	FB	I	Feedback Pin Connect it to the VOUT node as an output voltage feedback pin.
B1	SW	O	Switching Output Pin Internal MOSFET Drain Connect an inductor between the VOUT node and the SW pin.
C1	VIN	Power	Power Supply Input Pin
A2	AGND	-	Analog GND Pin of Internal Circuit Be sure to connect to the GND pin on the board.
B2	EN	I	Enable Pin Can set the active state with the "High" input and the shutdown state with the "Low" input.
C2	PGND	-	Power Ground Pin of Internal Circuit Be sure to connect to the GND pin on the board.

■ABSOLUTE MAXIMUM RATINGS

	Symbol	Ratings	Unit
VIN pin Voltage	V_{IN}	-0.3 to 6.5	V
FB pin Voltage	V_{FB}	-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
Storage Temperature Range	T_{stg}	-55 to 125	°C
Junction Temperature [*1]	T_j	-40 to 125	°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-ZA2	Thermal Resistance (θja)	156	°C/W
	Thermal Characterization Parameter (ψjt)	33	

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

For details, refer to "*THERMAL CHARACTERISTICS*".

■ELECTROSTATIC DISCHARGE RATINGS

	Conditions	Protection Voltage
HBM	C = 100 pF, R = 1.5 kΩ	±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}	1.8 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

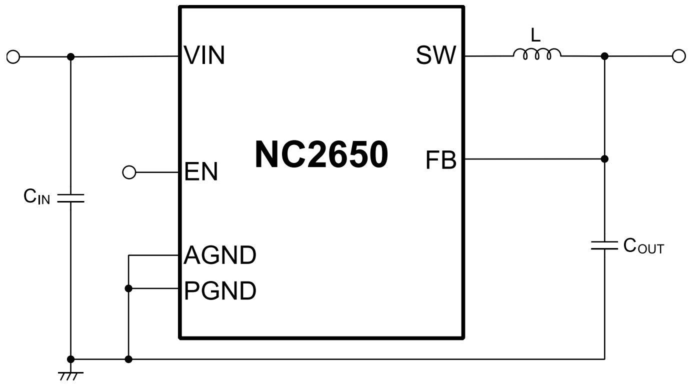
V_{IN} = 3.6 V unless otherwise specified.
For parameter that do not describe the temperature condition, the MIN / MAX value under the condition of −40 °C ≤ T_j ≤ 125 °C is described.

Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
Output Voltage	V_{OUTCCM}	PWM, V_{SET} ≥ 1.2V, T_j = 25 °C	× 0.99	-	× 1.01	V
		PWM, V_{SET} ≥ 1.2V, -40°C ≤ T_j ≤ 125°C	× 0.98	-	× 1.02	V
		PWM, V_{SET} < 1.2V, T_j = 25 °C	× 0.985	-	× 1.015	V
		PWM, V_{SET} < 1.2V, -40°C ≤ T_j ≤ 125°C	× 0.975	-	× 1.025	V
VIN pin Quiescent Current	I_{QVIN}	V_{OUT} = V_{SET}, no switching T_j = 25 °C	-	85	170	nA
Shutdown Current	I_{SD}	V_{IN} = 1.8~5.5V, V_{EN} = 0V T_j = 25 °C	-	4	100	nA
EN "H" Input Current	I_{ENH}	V_{IN} = V_{EN} = 5.5V -40°C ≤ T_j ≤ 85°C	-40	0	40	nA
EN "L" Input Current	I_{ENL}	V_{IN} = 5.5V, V_{EN} = 0V -40°C ≤ T_j ≤ 85°C	-40	0	40	nA
On-resistance for Discharger	R_{ONDIS}	NC2650xxxxxA	-	60	-	Ω
EN pin "H" Input Voltage	V_{ENH}	V_{IN} = 5.5 V	0.8	-	5.5	V
EN pin "L" Input Voltage	V_{ENL}	V_{IN} = 1.8 V	0	-	0.3	V
On-resistance of High Side MOSFET	R_{ONH}	I_{sw} = 100mA	-	150	-	mΩ
On-resistance of Low Side MOSFET	R_{ONL}	I_{sw} = 100mA	-	125	-	mΩ
Thermal Shutdown Detection Temperature	T_{SDDET}		-	150	-	°C
Thermal Shutdown Release Temperature	T_{SDREL}		-	120	-	°C
High Side Current Limit	I_{LIMHS}		1.4	1.8	2.2	A
High Side Current Limit at Soft-Start	I_{LIMHS_SS}	V_{SET} = 1.8V	0.26	0.5	0.76	A
Start-up Delay Time	$t_{STARTUP}$	from EN = low to high until device starts switching -40°C ≤ T_j ≤ 85°C	-	100	250	µs
Soft-Start Time	t_{SS}	I_{OUT} = 0mA, Vset = 1.8V	-	170	-	µs
UVLO Detection Voltage [*1]	$V_{UVLODET}$	V_{IN} = Falling	1.35	1.45	1.55	V
UVLO Release Voltage [*1]	$V_{UVLOREL}$	V_{IN} = Rising	1.4	1.5	1.6	V

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

[*1] Due to the circuit configuration, $V_{UVLODET}$ ≥ $V_{UVLOREL}$ does not hold. The hysteresis is Typ.50 mV.

■TYPICAL APPLICATION CIRCUIT



Recommended external parts

Symbol	Capacitance	Tolerance	Protection Voltage	Temperature characteristics
C_{IN}	10 µF	±20 %	6.3 V	X5R
C_{OUT}	22 µF	±20 %	10 V	X5R

Symbol	Inductance	Tolerance	Rated Current
L	0.47 µH	±20 %	3 A

●Cautions for Selecting External Components

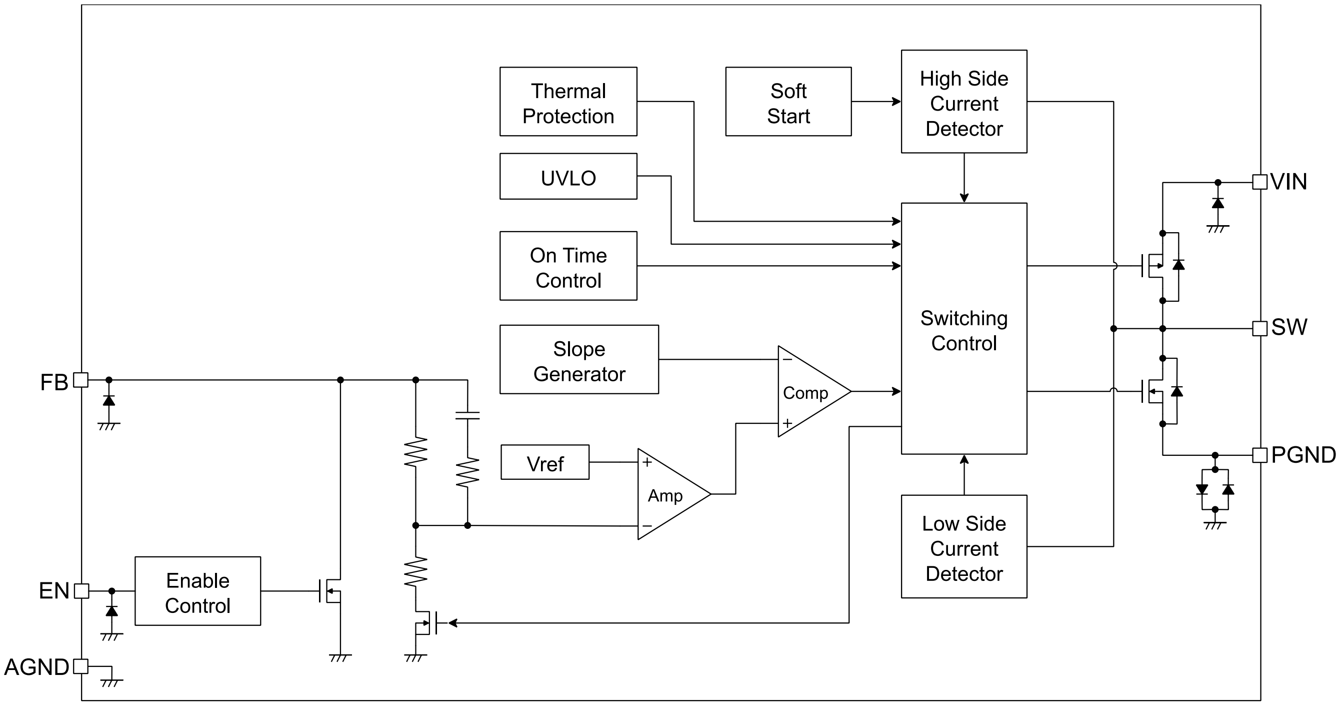
The performance of a power source circuit using this device is highly dependent on a peripheral circuit. A peripheral component or the device mounted on PCB should not exceed a rated voltage, a rated current or a rated power.

Choose a low ESR ceramic capacitor. The input capacitor (C_{IN}) between VIN pin 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.

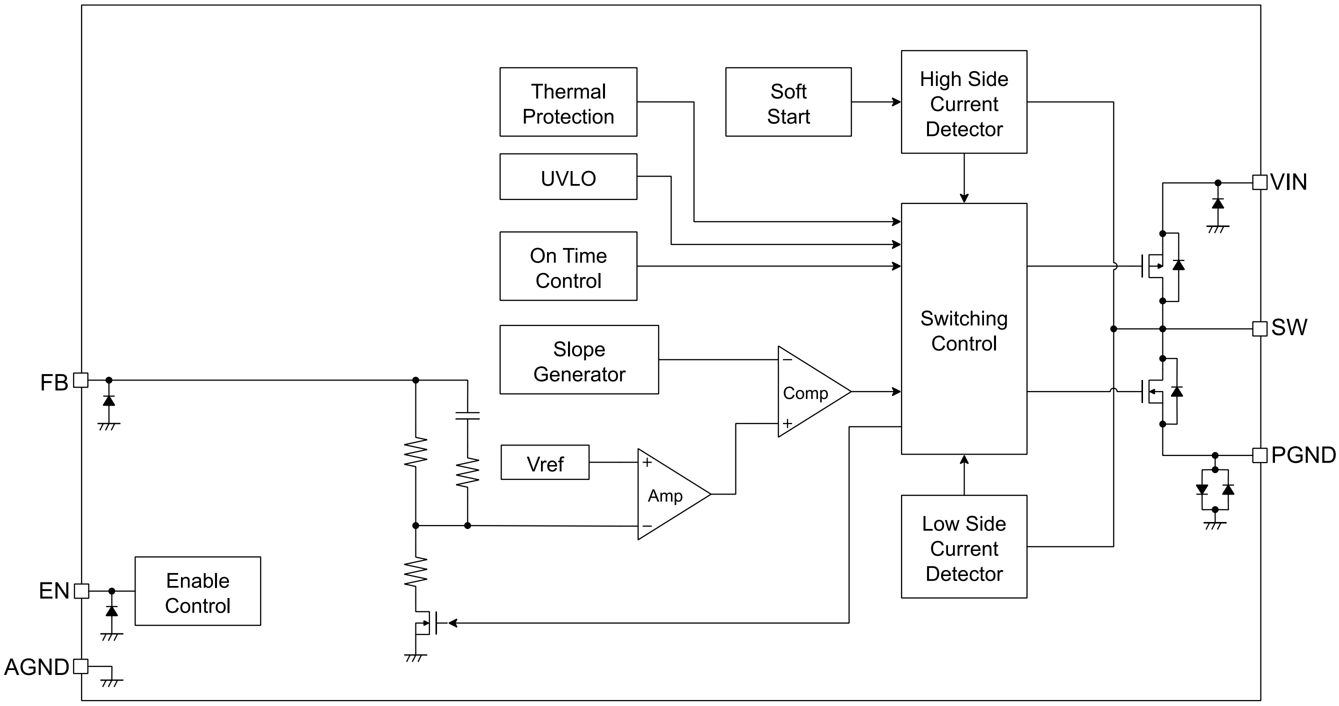
Use an inductor with an inductance value of 0.47 µH. Choose an inductor that has small DC resistance, has enough permissible current and is hard to cause magnetic saturation. If the inductance value of the inductor becomes extremely small under the load conditions, the peak current of inductor may increase along with the load current. As a result, the current limit circuit may start to operate before the peak current of inductor reaches to load current range. Therefore, choose an inductor with consideration for the value of I_{SWMAX}.

Refer to "Calculation Conditions of SW Pin Maximum Output Current (I_{SWMAX})" of the data sheet.

■BLOCK DIAGRAMS



NC2650xxxxxA Block Diagram



NC2650xxxxxB Block Diagram

■THEORY OF OPERATION

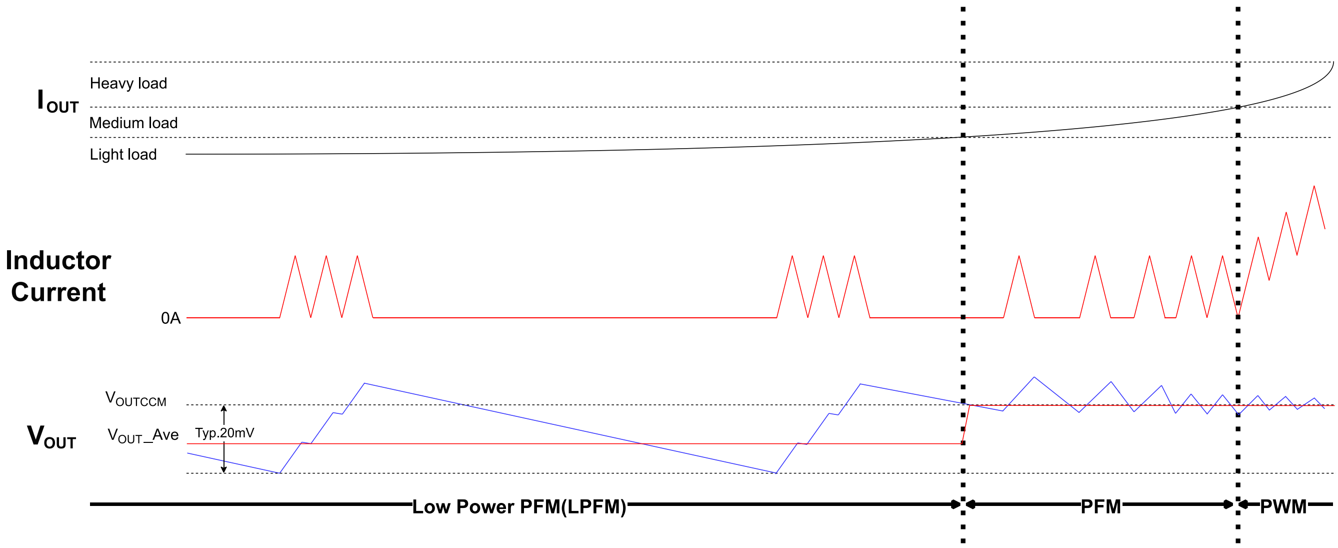
●NC2650 Control Method

The NC2650 uses the PWM/PFM auto-alternating method. 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} (Step-down ratio), and as the step-down ratio becomes lower, the boundary shifts toward smaller load currents (I_{OUT}). For the range where LPFM operation is no longer possible when the step-down ratio is too low, refer to the Input Current vs. Input Voltage in the TYPICAL CHARACTERISTICS section of the datasheet.

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

In LPFM operation, switching operation begins when V_{OUT} drops by a certain voltage (Typ. 20mV) from V_{OUTCCM}.
Switching operation is repeated until the output voltage exceeds the V_{OUTCCM} voltage, at which point switching stops and the V_{OUT} begins to drop. This process is repeated to keep the output voltage constant.
The alternating threshold currents for LPFM and PFM depend on V_{IN} and V_{OUT}; the alternating thresholds for PFM and PWM are highly dependent on V_{IN} and V_{OUT}.
In both cases, the smaller the difference between the VIN pin voltage and the output voltage, the lower the alternating threshold current.

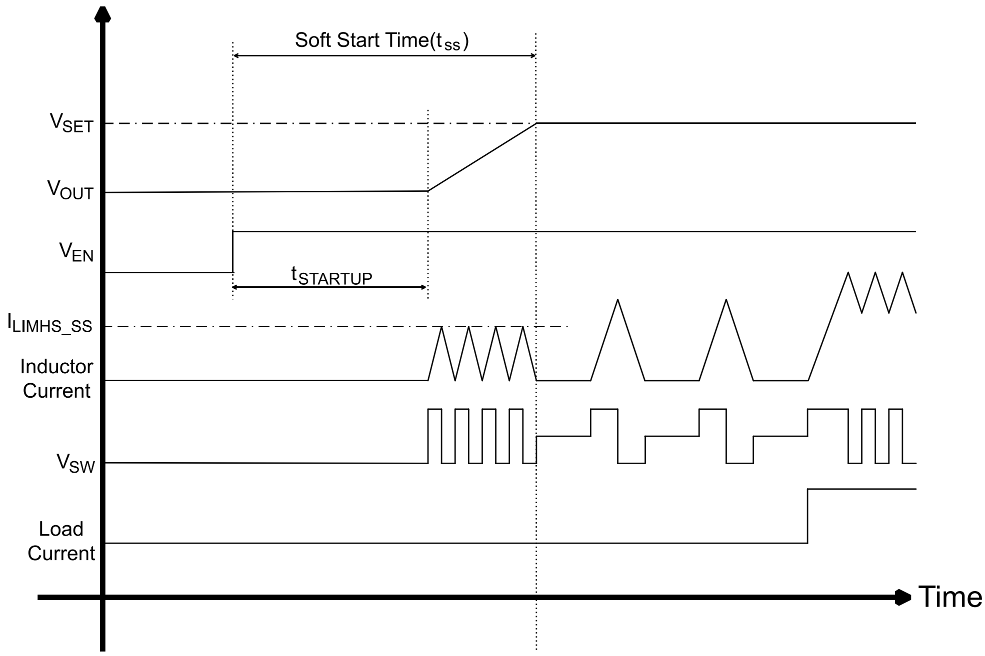
For the above-mentioned V_{OUTCCM}, please refer to the TYPICAL CHARACTERISTICS section of the datasheet.



Load Current (I_{OUT}) vs Regulation Operation

●Soft-Start Operation

When EN is switched to the active polarity, the output voltage rises in boundary mode after a delay time (t_{START}) (Typ. 100 µs). During Soft-Start operation, the inductor peak current is suppressed by the I_{LIMHS_SS} value (Typ. 500 mA) and does not increase further. Soft-Start operation is released when the output voltage reaches V_{SET}. 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.
UVLO function and thermal shutdown function are effective even during the Soft-Start time.

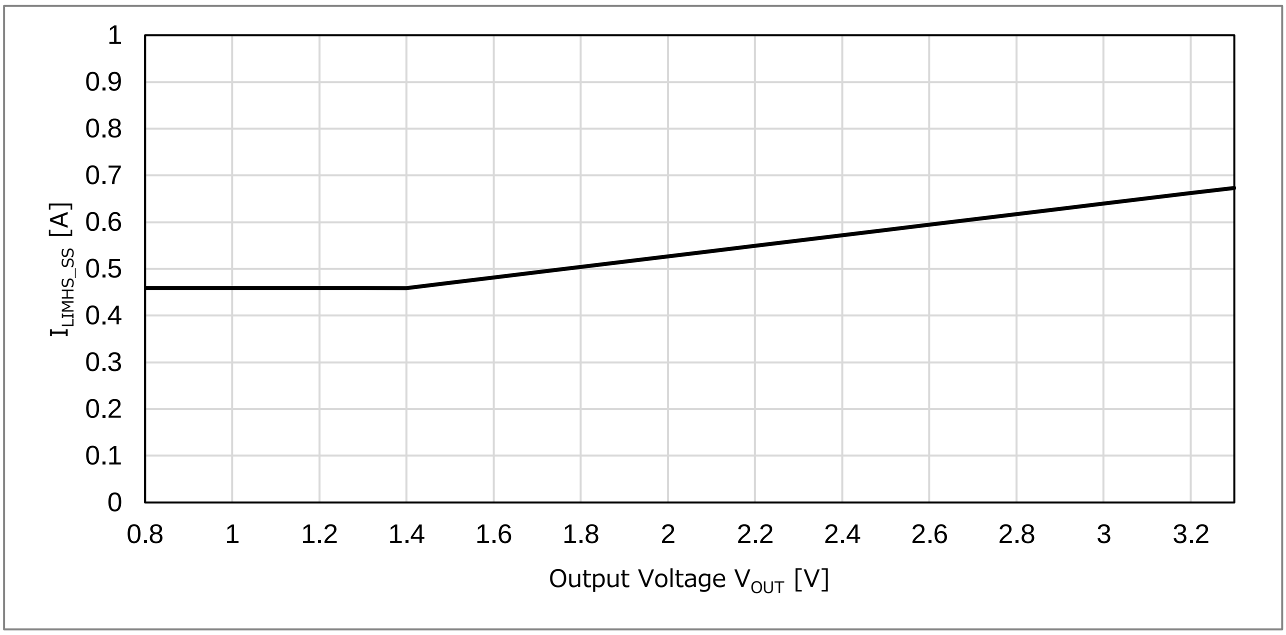


Soft-Start Operation Timing Chart

The Soft-Start time (t_{SS}) can be easily calculated using the following formula

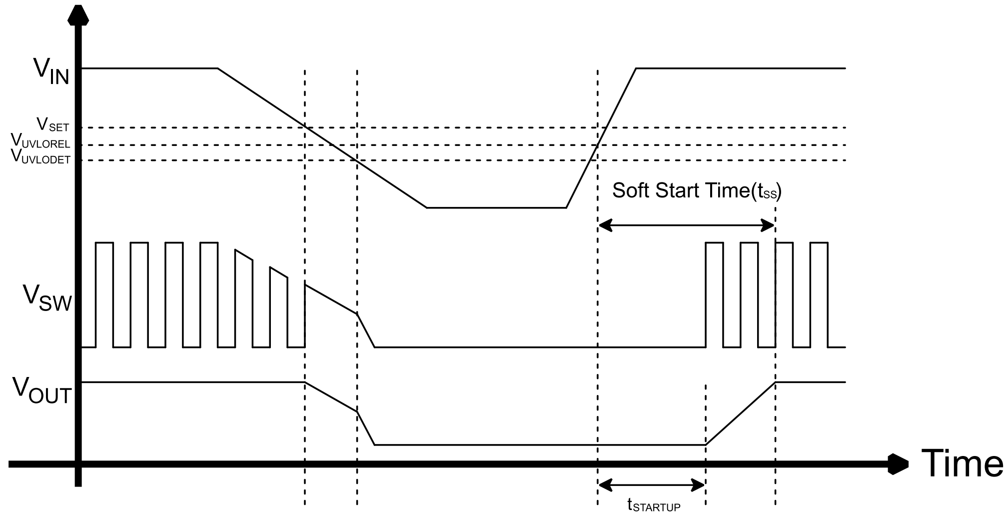
$$t_{SS} = t_{STARTUP} + V_{OUT} / (I_{LIMHS\_SS} / 2 - I_{OUT}) \times C_{OUT} / 2$$

※I_{LIMHS_SS} depends on V_{OUT}, so please refer to the graph below.($t_{STARTUP}$ is 100µs (TYP), C_{OUT} is the nominal value.)



●Undervoltage Lockout (UVLO) Circuit

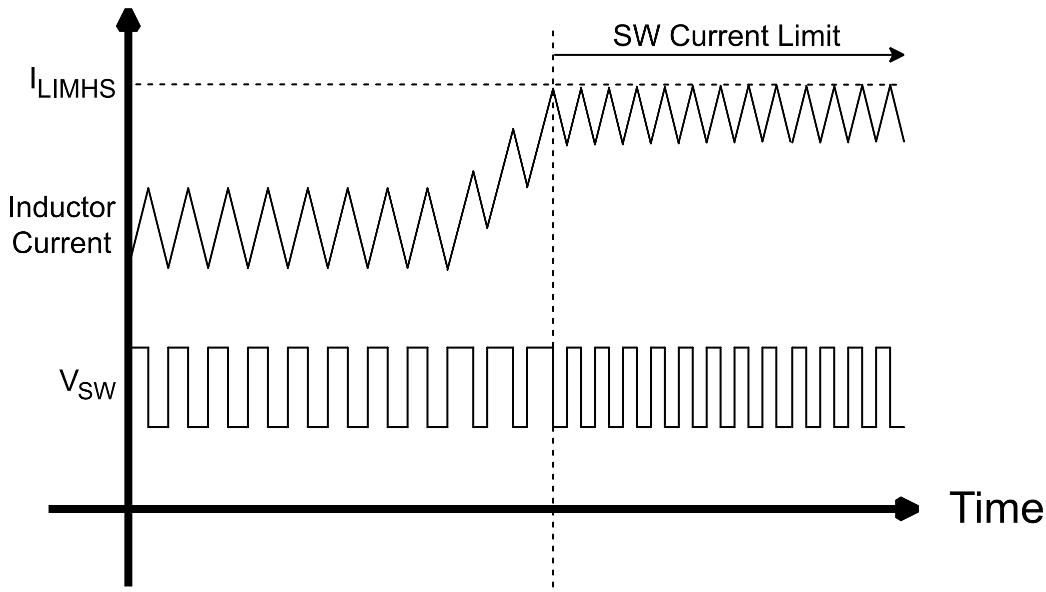
When V_{IN} becomes lower than V_{SET}, the step-down switching regulator stops its switching operation and ON duty becomes 100%, then V_{OUT} gradually falls according to V_{IN}. When the V_{IN} drops below the UVLO detection voltage ($V_{UVLODET}$), the UVLO operates, and high side MOSFET and low side MOSFET turn "OFF". As a result, V_{OUT} decreases according to the capacitance value of C_{OUT}, the load current and discharge FET on-resistance (NC2650xxxxxA).
To restart the operation, V_{IN} needs to exceed $V_{UVLOREL}$.
The timing chart below shows the V_{OUT} voltage waveforms when the V_{IN} value changes. The falling-edge (detecting) and rising-edge (releasing) waveforms of V_{OUT} may be affected by the initial voltage of C_{OUT} and the output current of V_{OUT}.



Timing Chart with Variations in Input Voltage (V_{IN})

●SW Current Limit Circuit

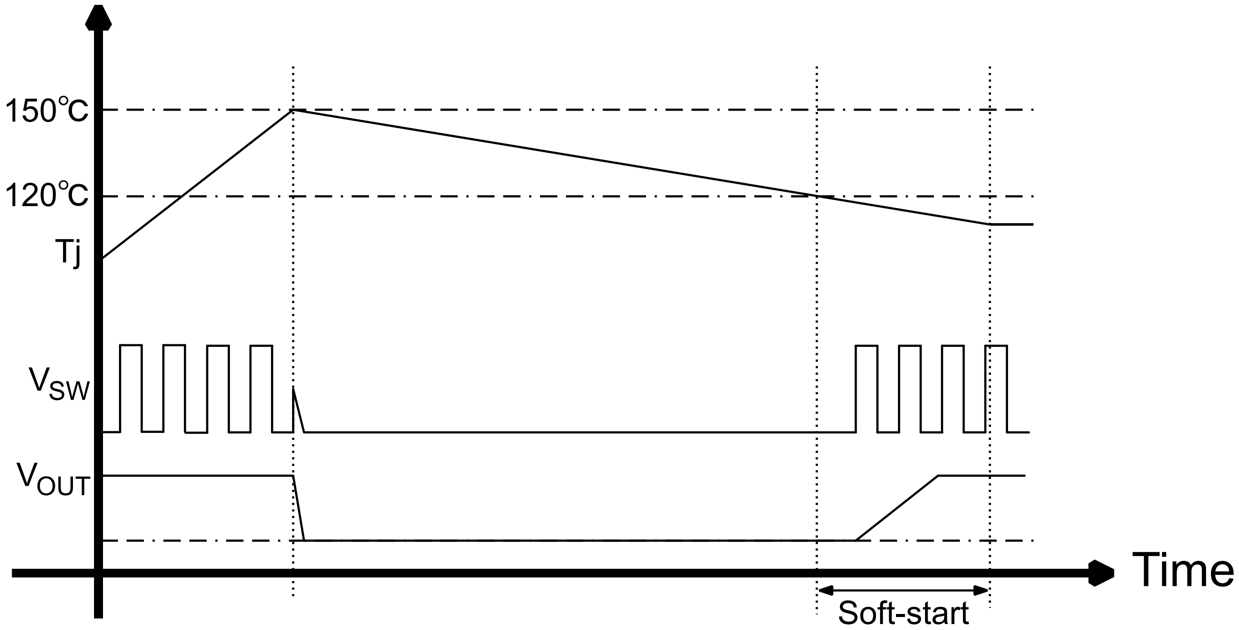
The current limit circuit supervises the inductor peak current (the peak current flowing through the high-side MOSFET) in each switching cycle, and if the current exceeds the SW current limit (I_{LIMHS}), the high-side MOSFET turns off. The SW current limit of the NC2650xxxxx is set to typ.1.8 A.



Timing chart of SW Current Limit

●Thermal Shutdown

When the junction temperature exceeds the thermal shutdown detection temperature (Typ.150°C), switching stops and self-heating is suppressed. This IC will restart when the junction temperature drops below the thermal shutdown release temperature (Typ.120°C). Then, the Soft-Start function is activated.



Thermal Shutdown Function Timing Chart

●Pass-Through Mode

When the input voltage falls below the threshold and the duty cycle reaches 100%, this product operates in pass-through mode. In this operating state, the high side MOSFET is always on and the low side MOSFET is always off. This function helps to hold output voltage and to lengthen operation time of application longest even when battery voltage drops. In this operating state, the output voltage is calculated by the following equation using the on-resistance of the high side MOSFET (R_{ONP}) and the DC resistance of the inductor (R_L).

$$V_{OUT} = V_{IN} - (R_{ONP} + R_L) \times I_{OUT}$$

●Enable Function

Forcing above designated "High" voltage to EN pin, the NC2650 becomes active. Forcing below designated "Low" voltage to EN pin shuts down the NC2650. In shutdown condition, all functions are disabled except auto discharge function. With auto discharge option, the MOSFET to discharge the output capacitor turns on and the output is pulled down to GND. Without auto discharge option, the output becomes "Hi-Z". EN pin can accept input range voltage regardless of the input of VIN pin.
Do not open the EN pin because it is not pulled up or down inside the IC.
If Enable function is not necessary, tie EN pin to VIN pin or other designated "High" voltage node at start-up.

●Auto Discharge Function

When turned off, the V_{OUT} voltage drops rapidly to near 0 V by discharging the charge stored in the output capacitor through the MOSFET connected between the FB pin and GND pins. The auto discharge function is enabled when the EN pin = "low", UVLO detection or the thermal shutdown detection. On-resistance of MOSFET is Typ. 60 Ω.

■THERMAL CHARACTERISTICS (WLCSP-6-ZA2)

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).

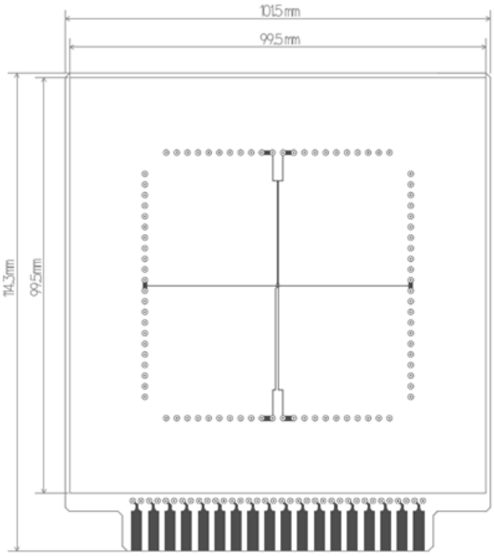
Measurement Result

Item	Measurement Result
Thermal Resistance (θja)	156 °C/W
Thermal Characterization Parameter (ψjt)	33 °C/W

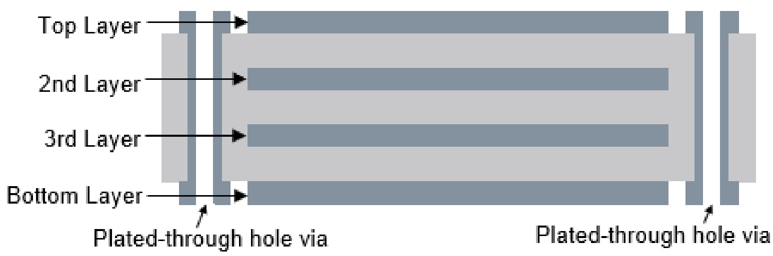
θja : Junction-to-Ambient Thermal Resistance
ψjt : Junction-to-Top Thermal Characterization Parameter

Measurement Conditions

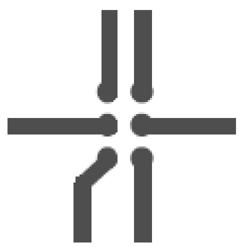
Item		Specification
Measurement Condition		Mounting on Board (Still Air)
Board material		FR-4
Board size		101.5 mm × 114.3 mm × t 1.6 mm
Copper foil layer	1	99.5 mm × 99.5 mm (coverage rate 5%), t 0.050 mm
	2	99.5 mm × 99.5 mm (coverage rate 100%), t 0.035 mm
	3	99.5 mm × 99.5 mm (coverage rate 100%), 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.

$$Tj = Ta + \theta ja \times P$$
$$Tj = Tc\ (top) + \psi jt \times P$$

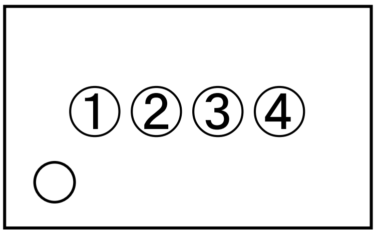
Where: Ta : Ambient temperature
Tc (top) : Package mark side center temperature
P : Power consumption under user's conditions

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

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（NC2650ZA）

①②: Product Code
③④: Lot No. ··· Alphanumerical Serial Number



WLCSP-6-ZA2 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 distributor before attempting to use AOI.

NC2650 Marking List

Product Name	①②	Product Name	①②
NC2650ZA080A	10	NC2650ZA080B	30
NC2650ZA100A	12	NC2650ZA100B	32
NC2650ZA120A	14	NC2650ZA120B	34
NC2650ZA180A	1A	NC2650ZA180B	3A
NC2650ZA250A	1K	NC2650ZA250B	3K
NC2650ZA280A	1P	NC2650ZA280B	3P
NC2650ZA330A	1X	NC2650ZA330B	3X

■APPLICATION NOTES

● Operation of Step-down Switching Regulator and Output Current

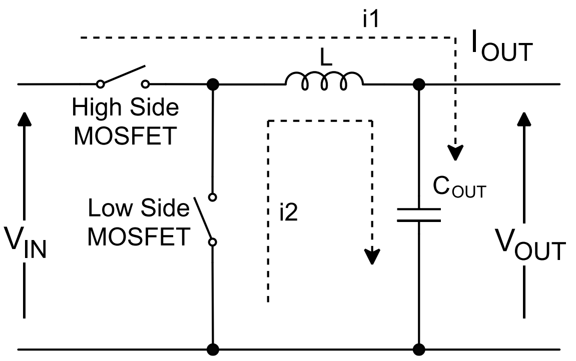
The operation in PWM mode of the step-down switching regulator is explained.

Step1. The high side MOSFET turns on and the inductor current I_L = i1 flows, storing energy in the inductor and at the same time charging to the C_{OUT}. Then, the inductor current I_L = i1 increases from I_{LLOW} in proportion to the time when the high side MOSFET turns on and reaches I_{LHIGH}.

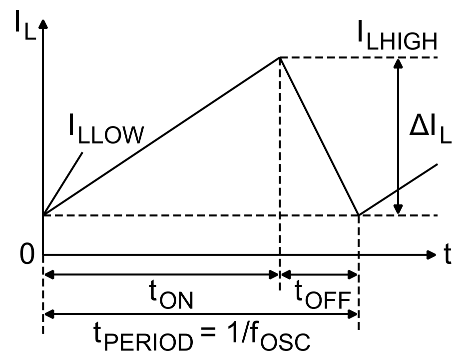
Step2. When the high side MOSFET turns off and the Low Side MOSFET turns on, the inductor operates to hold the inductor current $I_L = I_{LHIGH}$. At this time, the inductor uses the energy stored in Step 1 to flow the inductor current I_L = i2.

Step3. i2 gradually decreases until the low side MOSFET is turned off. When the next cycle, it returns to Step 1 again and the high side MOSFET turns on.

By performing Step 1 to 3 above cyclically, an arbitrary output voltage is obtained according to the ratio of on time for one cycle.



Basic Circuit of Step-down Switching Regulator



Current Through Inductor

When the maximum current of the inductor is I_{LHIGH} and the minimum value is I_{LLOW}, the difference between I_{LHIGH} and I_{LLOW} ΔI_L is called the current ripple, $\Delta I_L = I_{LHIGH} - I_{LLOW}$. The current ripple ΔI_L during Step 1 is shown by using t_{ON} (on-time), V_{IN}, V_{OUT}, and L (inductor value) as follows.

$\Delta I_L = (V_{IN} - V_{OUT}) \times t_{ON} / L$ ··················(2)

On the other hand, during Step2, it is represented by the following equation using t_{OFF} (off-time).

$\Delta I_L = V_{OUT} \times t_{OFF} / L$ ··················(3)

Since In the static state, the values of equations (2) and (3) are the same,

$(V_{IN} - V_{OUT}) \times t_{ON} / L = V_{OUT} \times t_{OFF} / L$ ··················(4)

Therefore, t_{ON} / t_{PERIOD} is shown by following equation.

$t_{ON} / t_{PERIOD} = V_{OUT} / V_{IN}$ ··················(5)

Where t_{PERIOD} is the period and is shown by the following equation.

$t_{PERIOD} = t_{ON} + t_{OFF} = 1 / f_{OSC}$ ··················(6)

f_{OSC} is the switching frequency.

Duty is the ratio of the time that the high side MOSFET is on during one cycle and can be calculated by the following equation.

Duty (%) $= t_{ON} / t_{PERIOD} \times 100 = V_{OUT} / V_{IN} \times 100$ ··················(7)

● Calculation Conditions of SW Pin Maximum Output Current (I_{SWMAX})

The following equations explain the calculation to determine I_{SWMAX} at the ideal operation of the ICs in continuous conduction mode.
The p-p value of the ripple current is I_{RP}, the on-resistance of the high side MOSFET and low side MOSFETs is R_{ONP} and R_{ONN}, respectively, and the DC resistance of the inductor is R_L.

First, define t_{ON} be the time when the high side MOSFET is on.

$$V_{IN} = V_{OUT} + (R_{ONP} + R_L) \times I_{OUT} + L \times I_{RP} / t_{ON} \quad \cdots (8)$$

Next, define t_{OFF} be the time when the high side MOSFET is off (low side MOSFET is on).

$$L \times I_{RP} / t_{OFF} = R_{ONN} \times I_{OUT} + V_{OUT} + R_L \times I_{OUT} \quad \cdots (9)$$

Put Equation (9) into Equation (8) to solve $D_{ON} = t_{ON} / (t_{OFF} + t_{ON})$ that is on-duty of high side MOSFET.

$$D_{ON} = (V_{OUT} + R_{ONN} \times I_{OUT} + R_L \times I_{OUT}) / (V_{IN} + R_{ONN} \times I_{OUT} - R_{ONP} \times I_{OUT}) \quad \cdots (10)$$

Ripple Current (I_{RP}) is as follows.

$$I_{RP} = (V_{IN} - V_{OUT} - R_{ONP} \times I_{OUT} - R_L \times I_{OUT}) \times D_{ON} / f_{OSC} / L \quad \cdots (11)$$

The peak current flowing through the inductor and high side MOSFET can be calculated by the following equation.

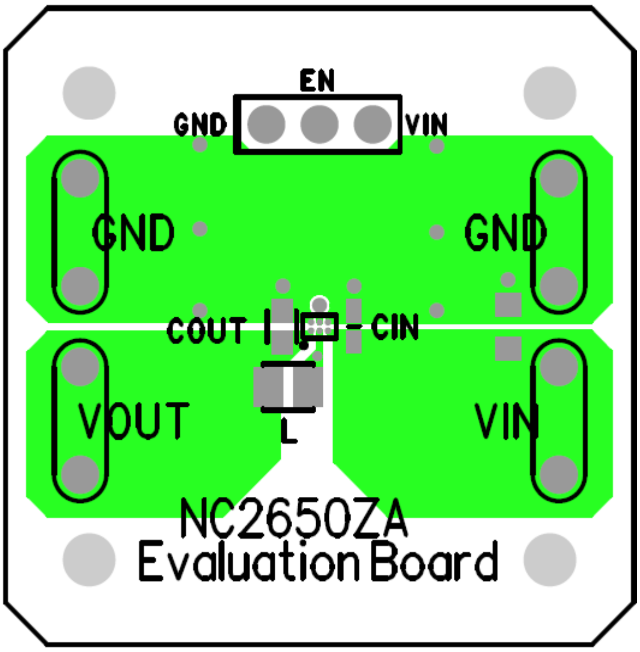
$$I_{SWMAX} = I_{OUT} + I_{RP} / 2 \quad \cdots (12)$$

Please refer to " *TYPICAL CHARACTERISTICS* " for the switching frequency (f_{OSC}).

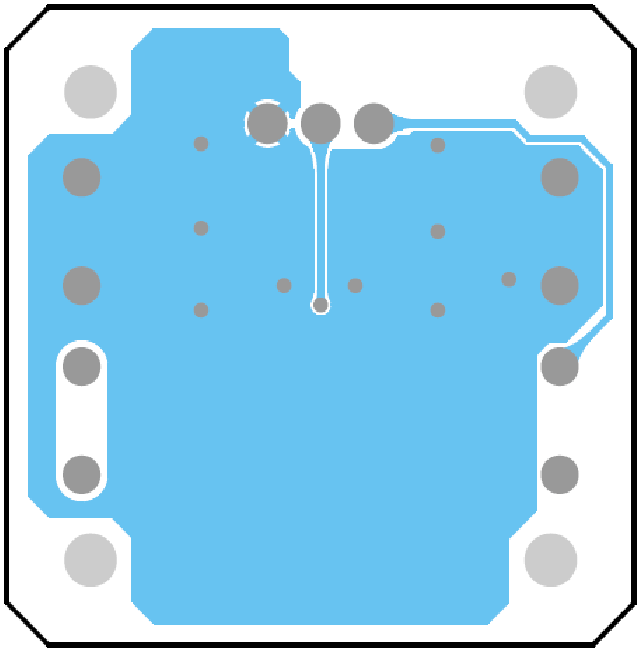
■Evaluation Board / PCB Layout Pattern Example

NC2650ZA（WLCSP-6-ZA2）

Top Layer



Bottom Layer



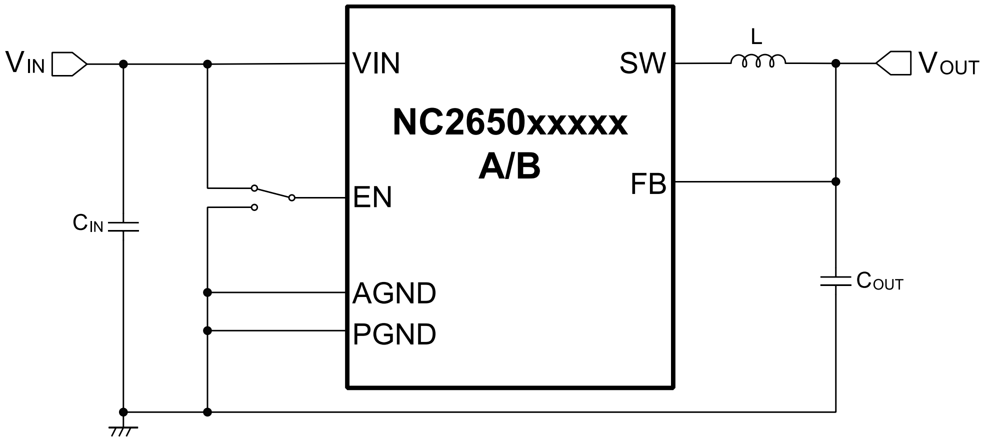
When designing PCB layout patterns, pay close attention to the following items.

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 CIN connected between VIN and PGND and the capacitor COUT connected between FB and AGND 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.

■TEST CIRCUIT



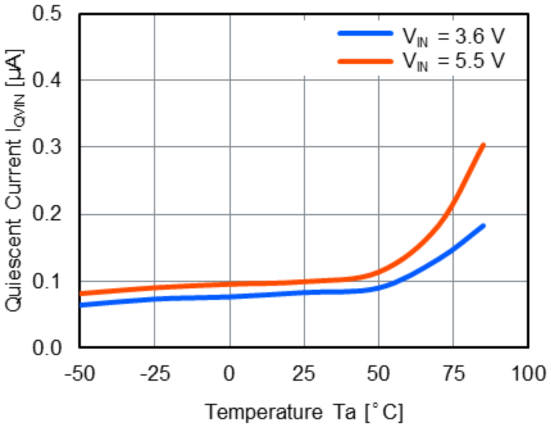
【Components List for Our Evaluation】

Symbol	Specification	Part Number
C_{IN}	10 µF	GRM155R60J106ME18
C_{OUT}	22 µF	MSASL168BB5226MTNA01
L	0.47 µH	DFE201612E-R47M

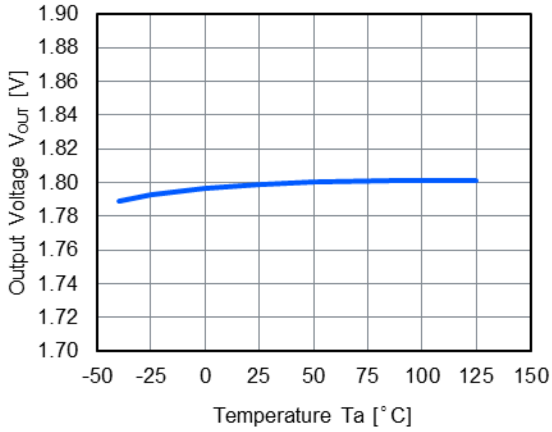
■TYPICAL CHARACTERISTICS

Typical characteristics are intended to be used as reference data, they are not guaranteed.
Unless otherwise specified, T_a = 25 °C, C_{OUT} = 22 µF, L = 0.47 µH

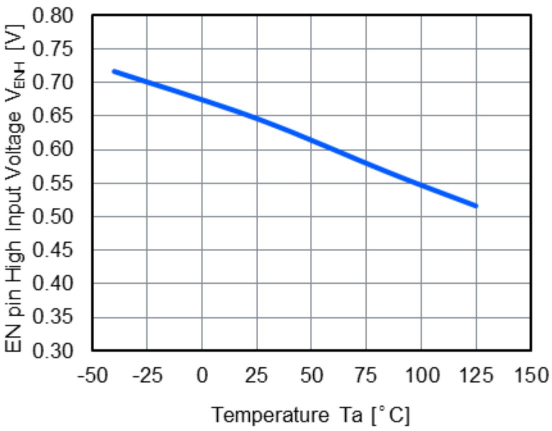
1) Quiescent Current vs Temperature
NC2650ZA180x



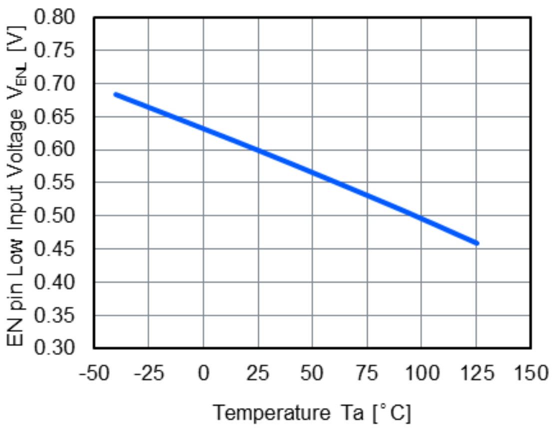
2) Output Voltage vs Temperature
NC2650ZA180x, V_{IN} = V_{EN} = 3.6 [V], I_{OUT} =100[mA]



3) EN pin "High" / "Low" Input Voltage vs Temperature
EN = "High" , V_{IN} = 5.5 V

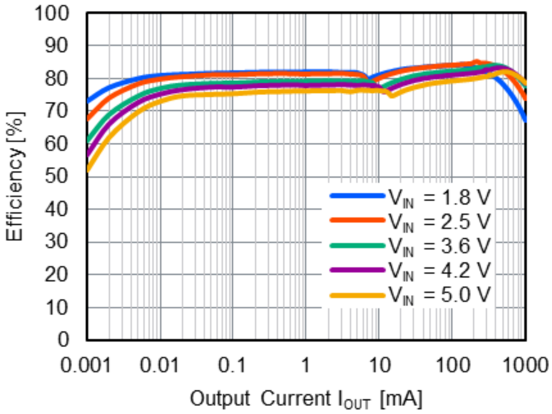


EN = "Low" , V_{IN} = 1.8 V

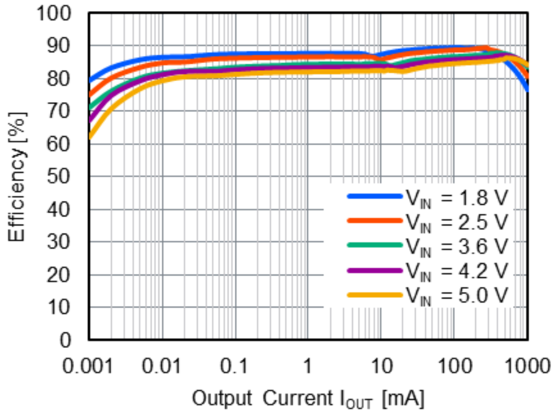


4) Efficiency vs Output Current

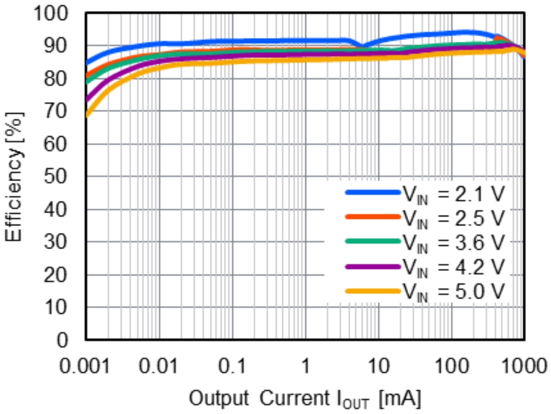
NC2650ZA080x



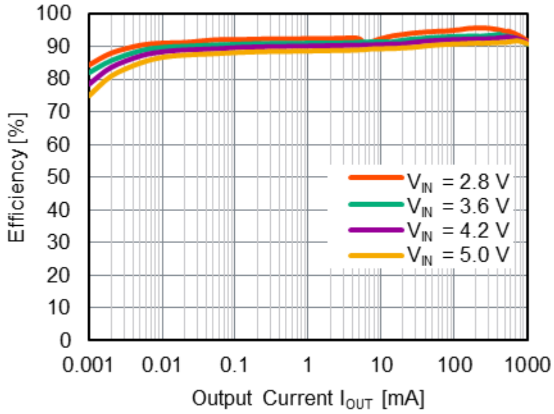
NC2650ZA120x



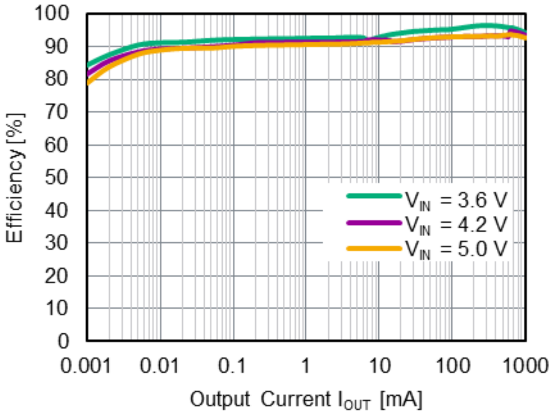
NC2650ZA180x



NC2650ZA250x

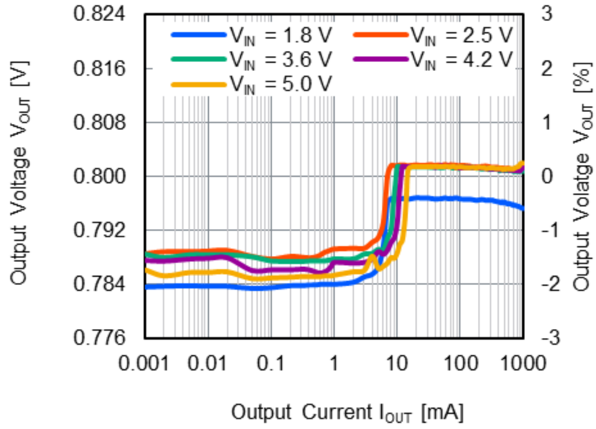


NC2650ZA330x

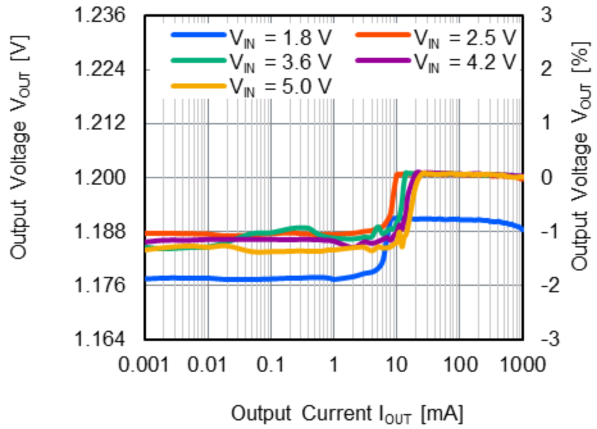


5) Load Regulation

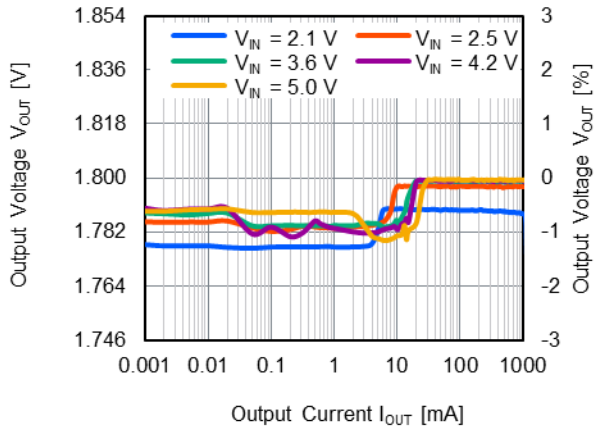
NC2650ZA080x



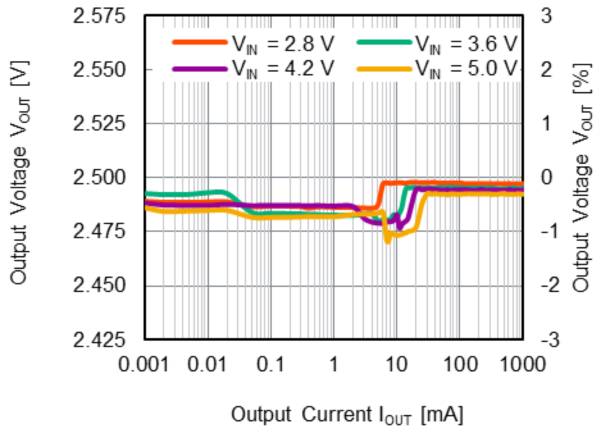
NC2650ZA120x



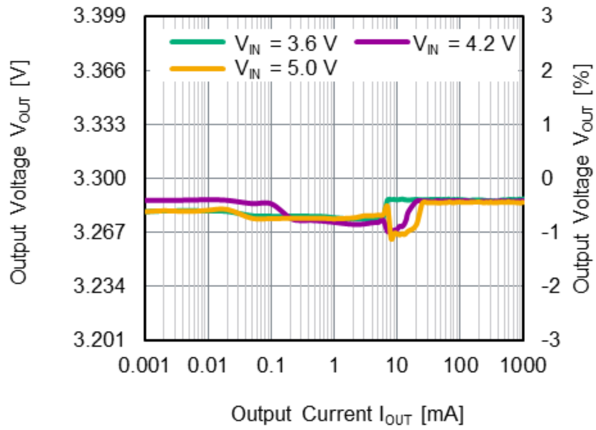
NC2650ZA180x



NC2650ZA250x

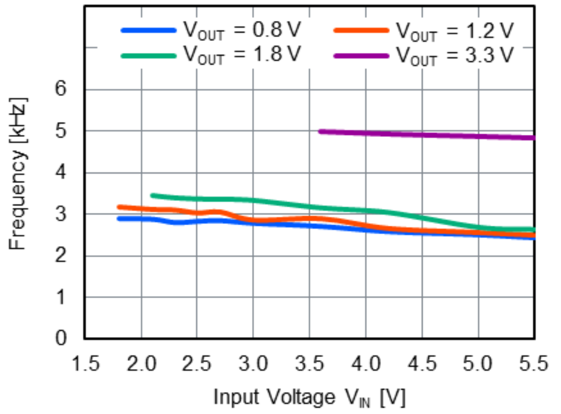


NC2650ZA330x

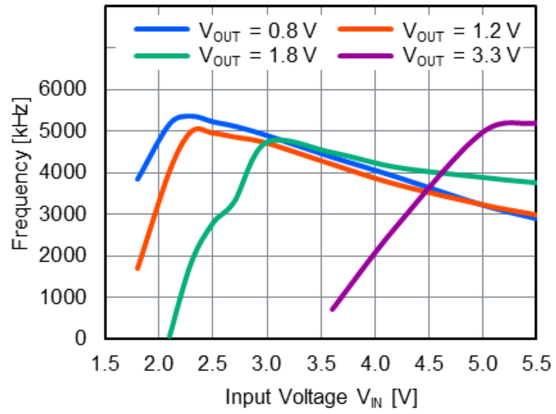


6) Switching Frequency vs Input Voltage

I_{OUT} = 1[mA]

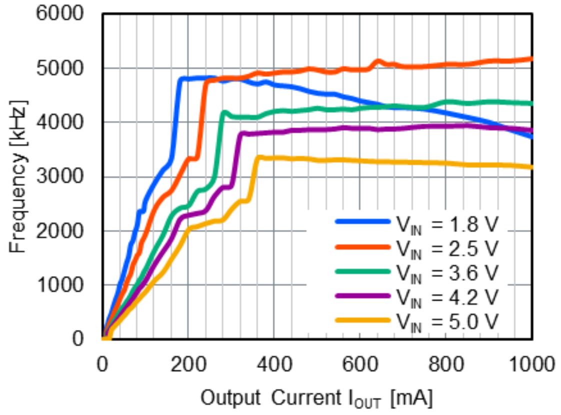


I_{OUT} = 1000[mA]

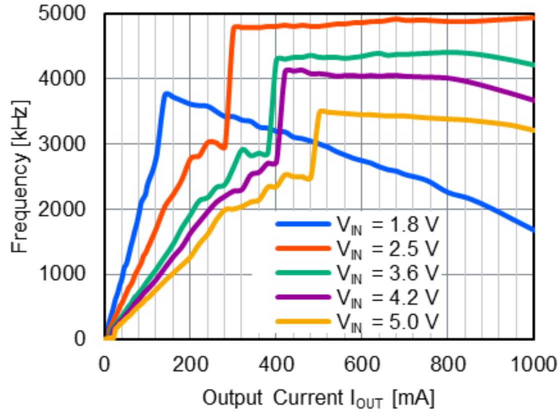


7) Switching Frequency vs Output Current

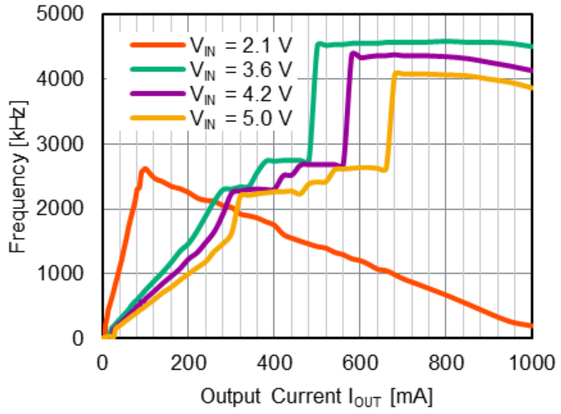
NC2650ZA080x



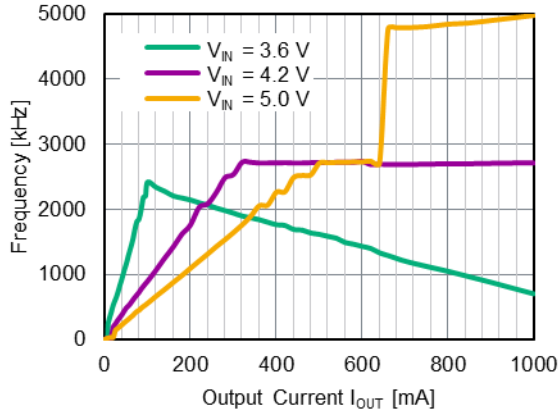
NC2650ZA120x



NC2650ZA180x

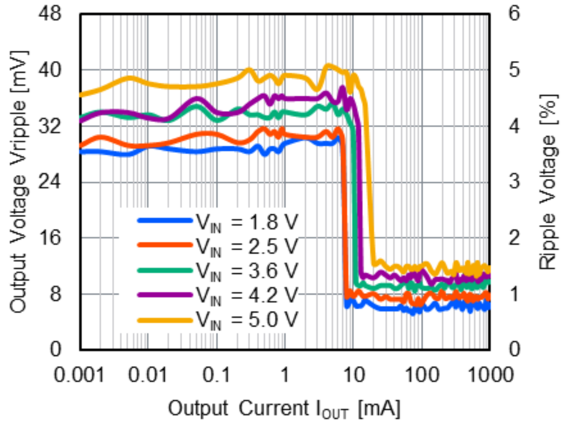


NC2650ZA330x

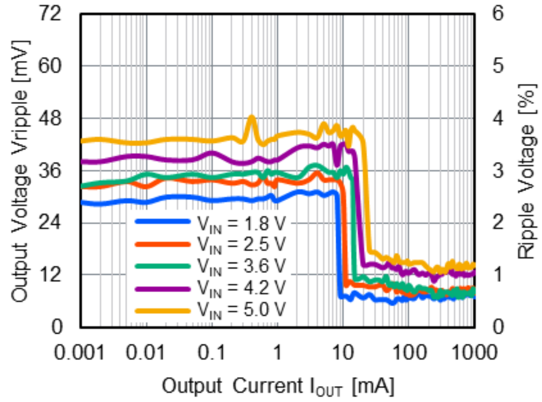


8) Ripple Voltage vs Output Current

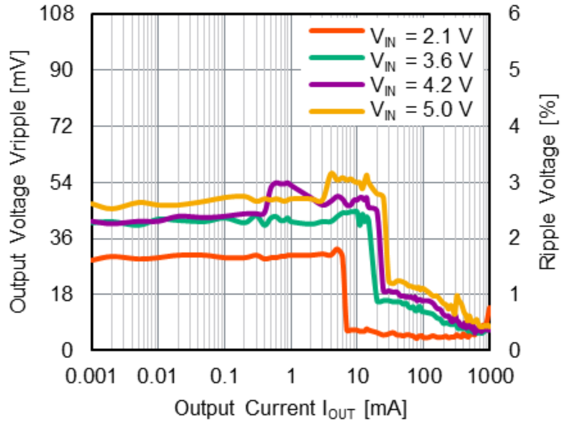
NC2650ZA080x



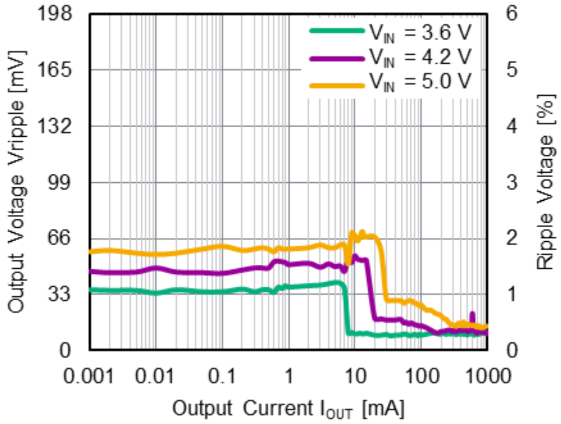
NC2650ZA120x



NC2650ZA180x

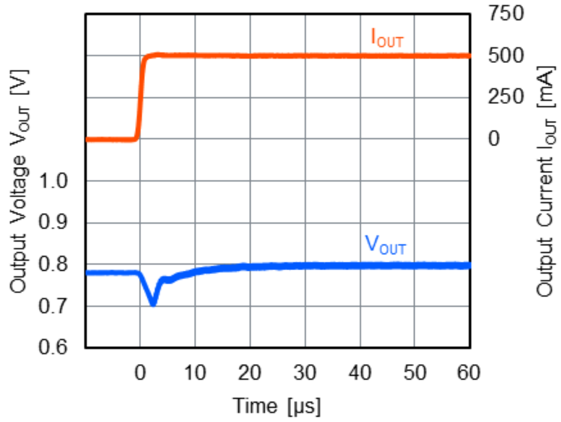


NC2650ZA330x

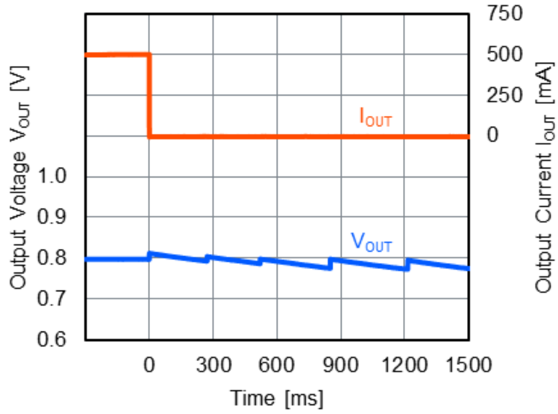


9) Load Transient
NC2650ZA080x, V_{IN} = V_{EN} = 3.6 [V]

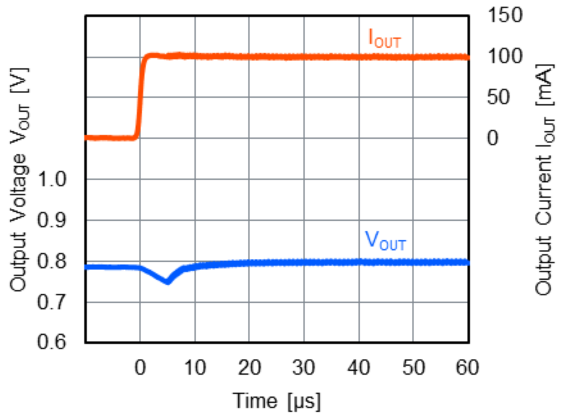
I_{OUT} = 1 [μA] -> 500 [mA], t_R = 1 [μs]



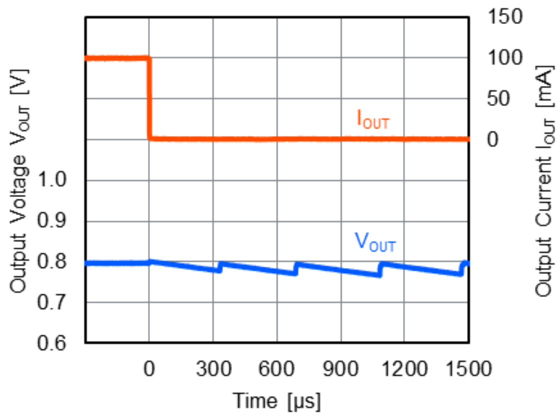
I_{OUT} = 500 [mA] -> 1 [μA], t_F = 1 [μs]



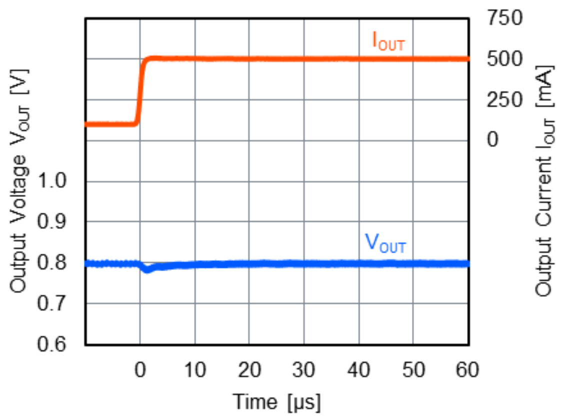
I_{OUT} = 1 [mA] -> 100 [mA], t_R = 1 [μs]



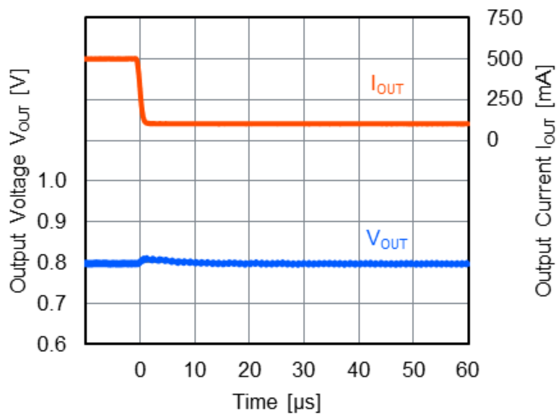
I_{OUT} = 100 [mA] -> 1 [mA], t_F = 1 [μs]



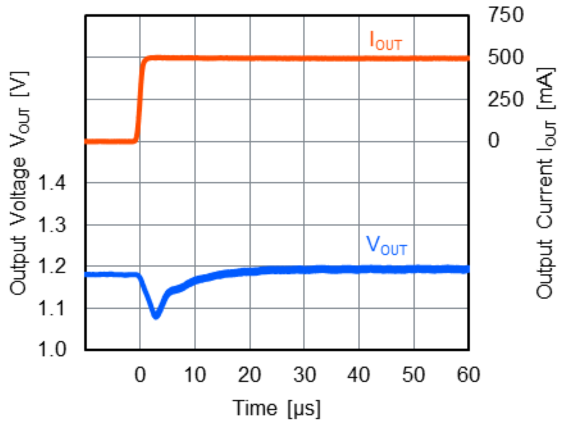
I_{OUT} = 100 [mA] -> 500 [mA], t_R = 1 [μs]



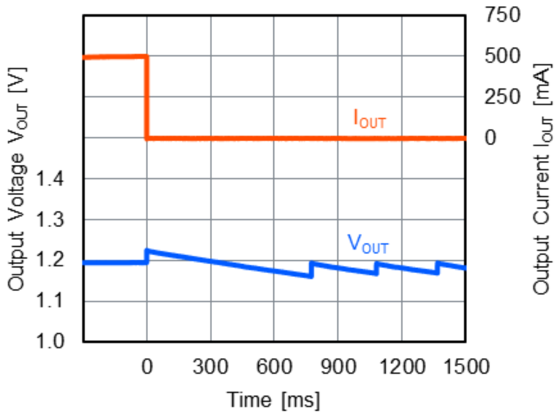
I_{OUT} = 500 [mA] -> 100 [mA], t_F = 1 [μs]



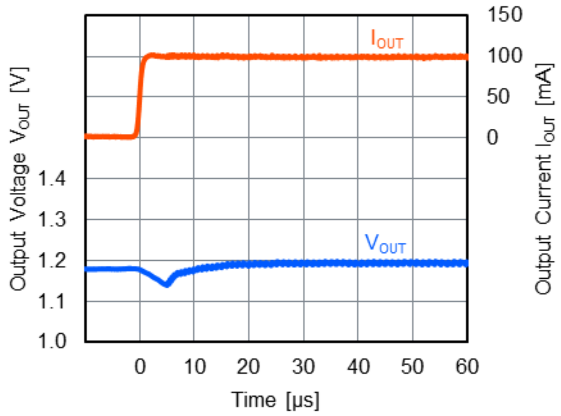
NC2650ZA120x, V_{IN} = V_{EN} = 3.6 [V]
I_{OUT} = 1 [µA] -> 500 [mA], t_R = 1 [µs]



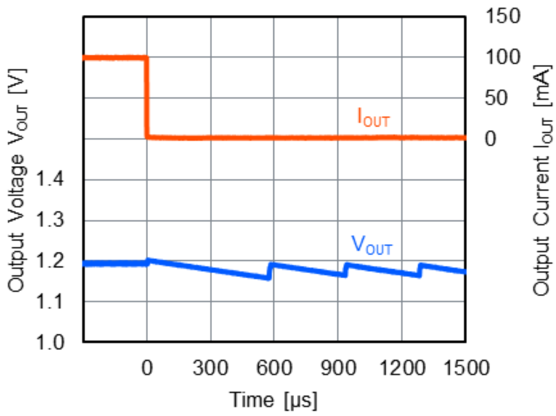
I_{OUT} = 500 [mA] -> 1 [µA], t_F = 1 [µs]



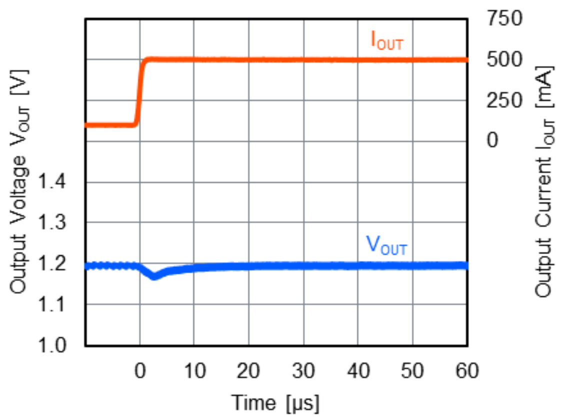
I_{OUT} = 1 [mA] -> 100 [mA], t_R = 1 [µs]



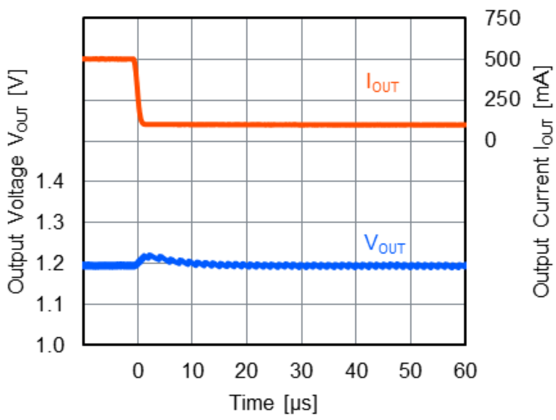
I_{OUT} = 100 [mA] -> 1 [mA], t_F = 1 [µs]



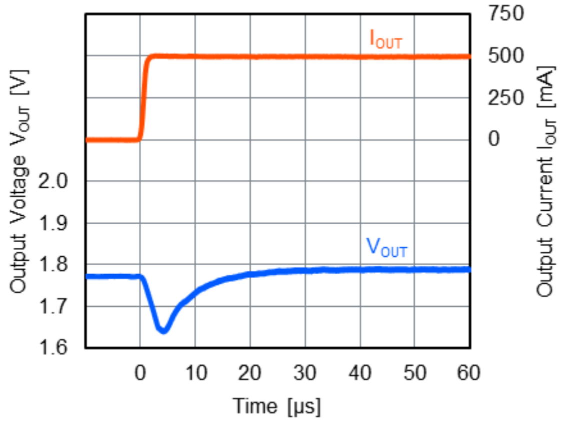
I_{OUT} = 100 [mA] -> 500 [mA], t_R = 1 [µs]



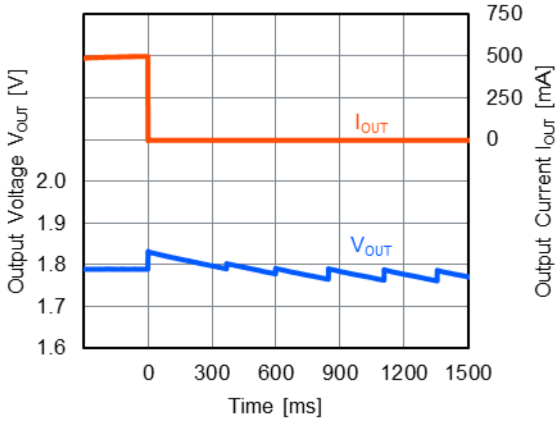
I_{OUT} = 500 [mA] -> 100 [mA], t_F = 1 [µs]



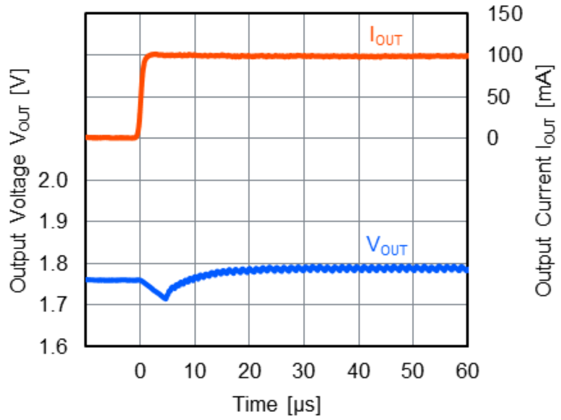
NC2650ZA180x, $V_{IN} = V_{EN} = 3.6$ [V]
I_{OUT} = 1 [µA] -> 500 [mA], t_R = 1 [µs]



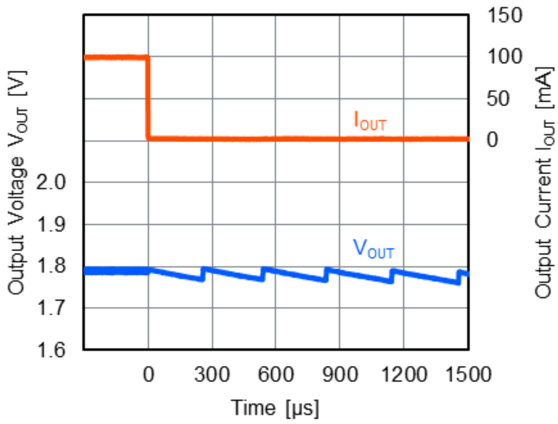
I_{OUT} = 500 [mA] -> 1 [µA], t_F = 1 [µs]



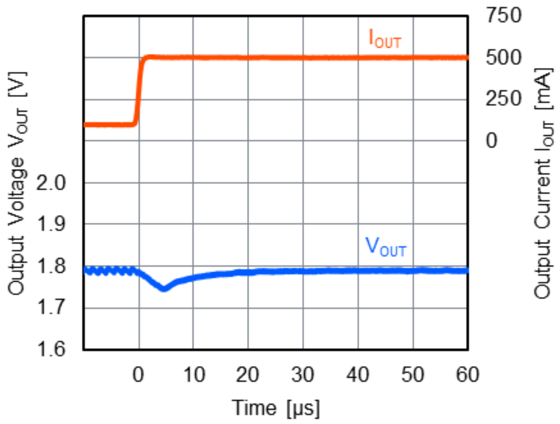
I_{OUT} = 1 [mA] -> 100 [mA], t_R = 1 [µs]



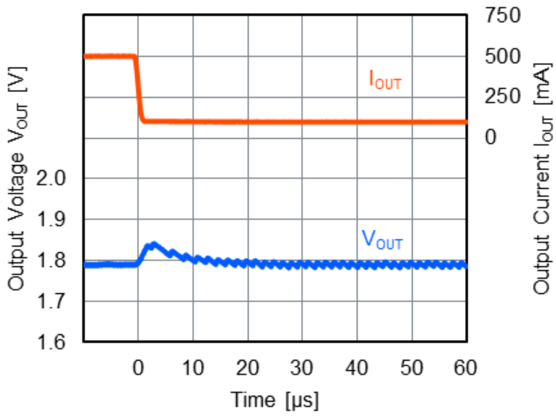
I_{OUT} = 100 [mA] -> 1 [mA], t_F = 1 [µs]



I_{OUT} = 100 [mA] -> 500 [mA], t_R = 1 [µs]

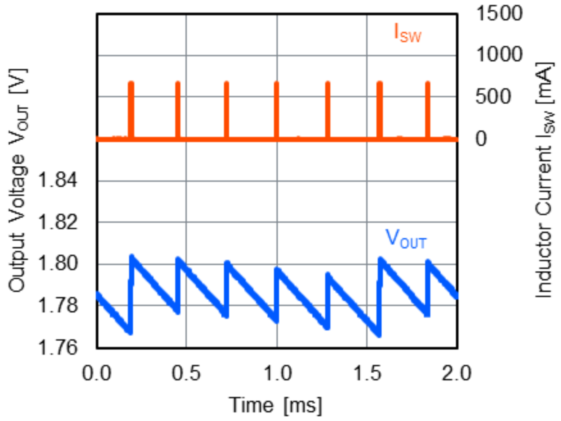


I_{OUT} = 500 [mA] -> 100 [mA], t_F = 1 [µs]

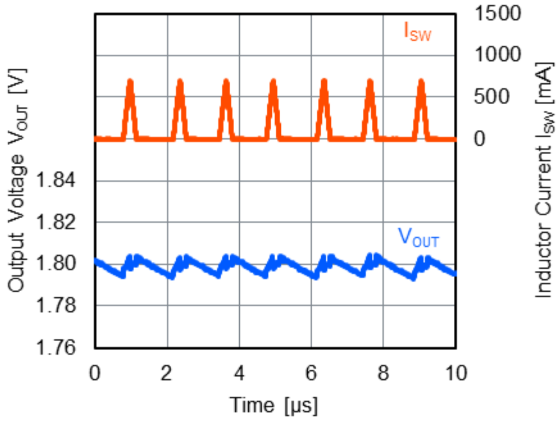


10) Output Voltage Waveform
NC2650ZA180x, $V_{IN} = V_{EN} = 3.6$ [V]

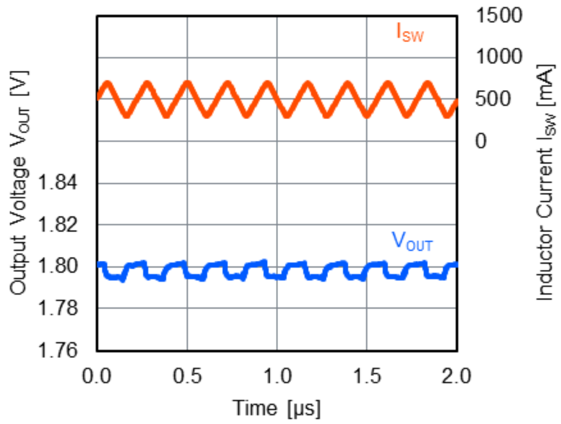
$I_{OUT} = 1$ [mA]



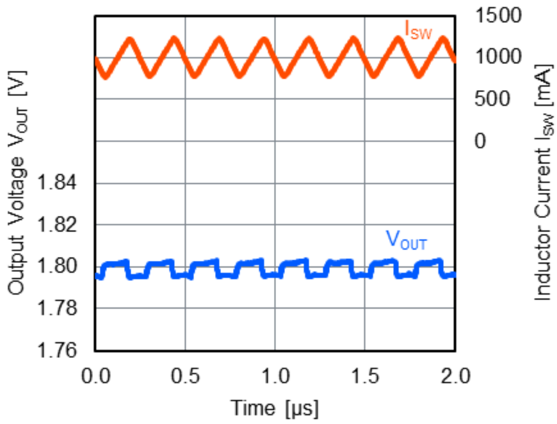
$I_{OUT} = 100$ [mA]



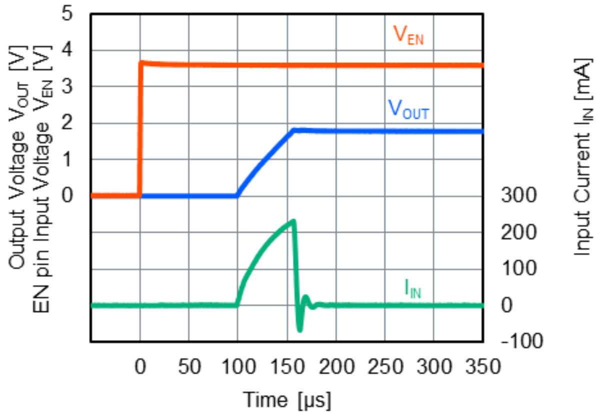
$I_{OUT} = 500$ [mA]



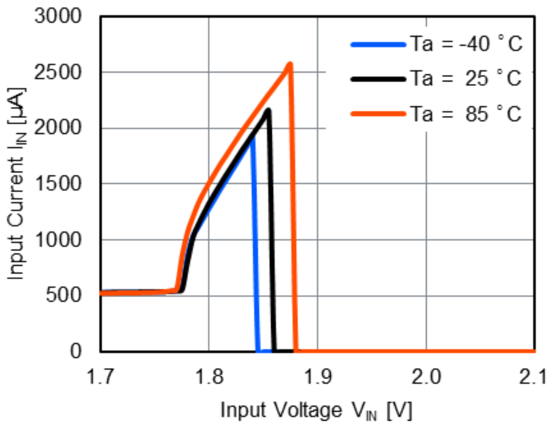
$I_{OUT} = 1000$ [mA]



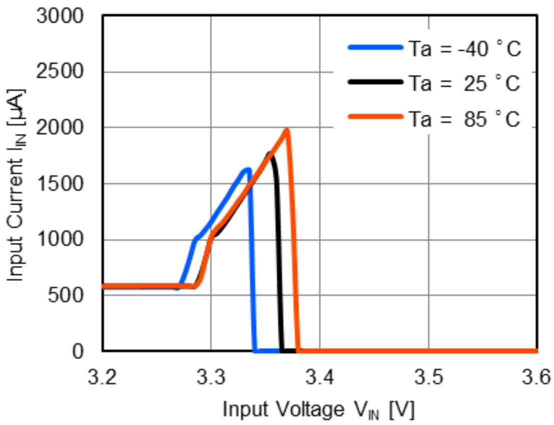
11) Soft-Start Waveform
NC2650ZA180x, V_{IN} = 3.6 [V], I_{OUT} = 0 [mA]



12) Input Current vs Input Voltage
NC2650ZA180x, I_{OUT} = 1 [μA]

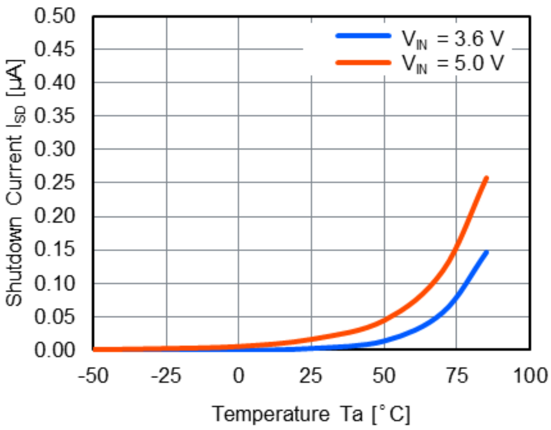


NC2650ZA330x, I_{OUT} = 1 [μA]

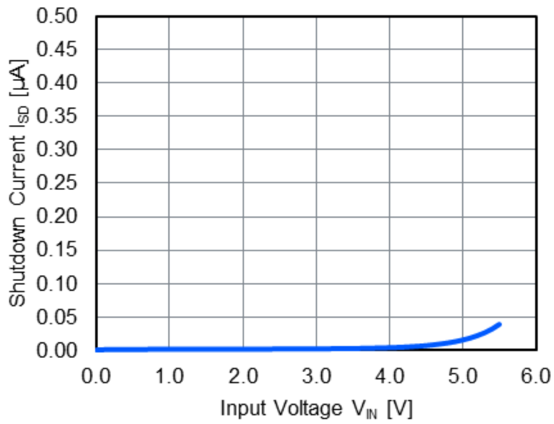


*Note that if the voltage difference between V_{IN} and V_{OUT} decreases, switching current increases regardless of I_{OUT}.

13) Shutdown Current vs Temperature
NC2650ZA180A



14) Shutdown Current vs Input Voltage
NC2650ZA180A

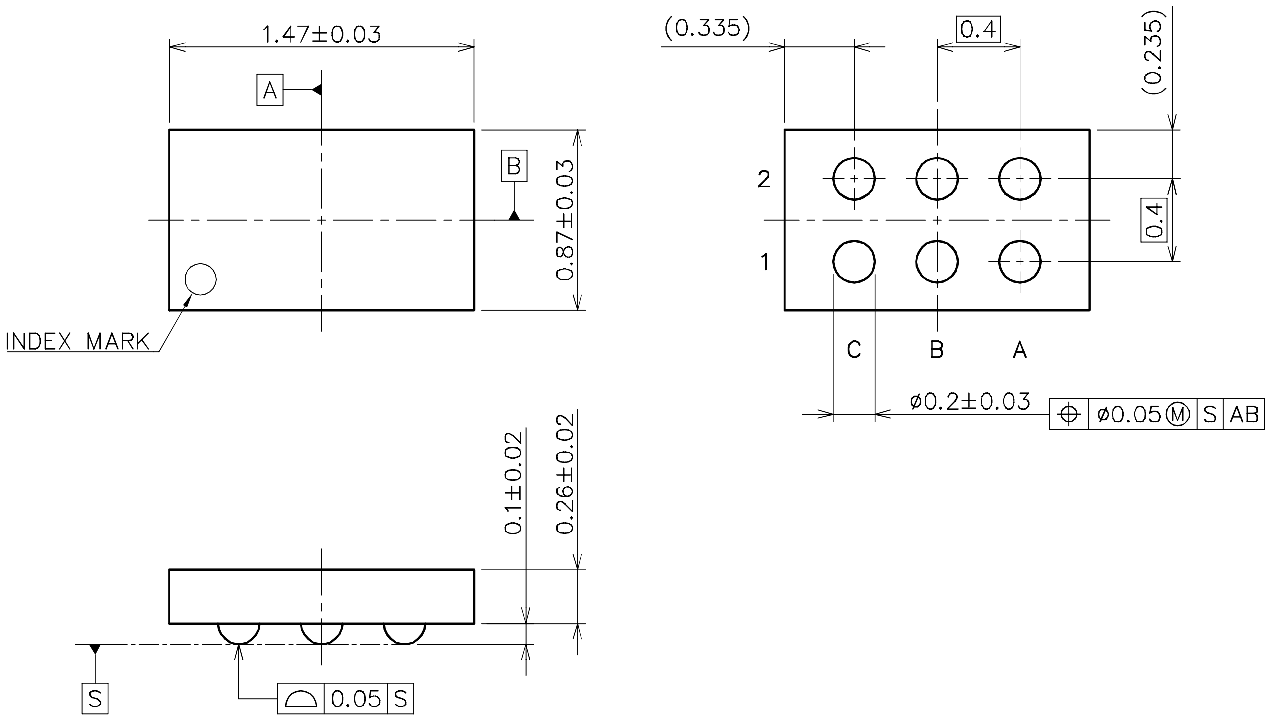


Nisshinbo Micro Devices Inc.

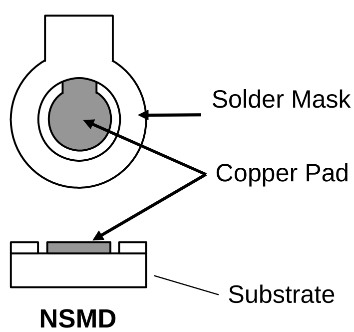
WLCSP-6-ZA2

■ PACKAGE DIMENSIONS

UNIT: mm



■ RECOMMENDED LAND PATTERN

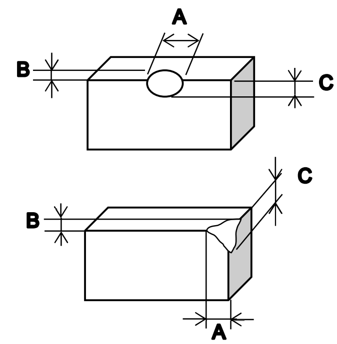


NSMD Pad Definition

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: ϕ 0.26mm

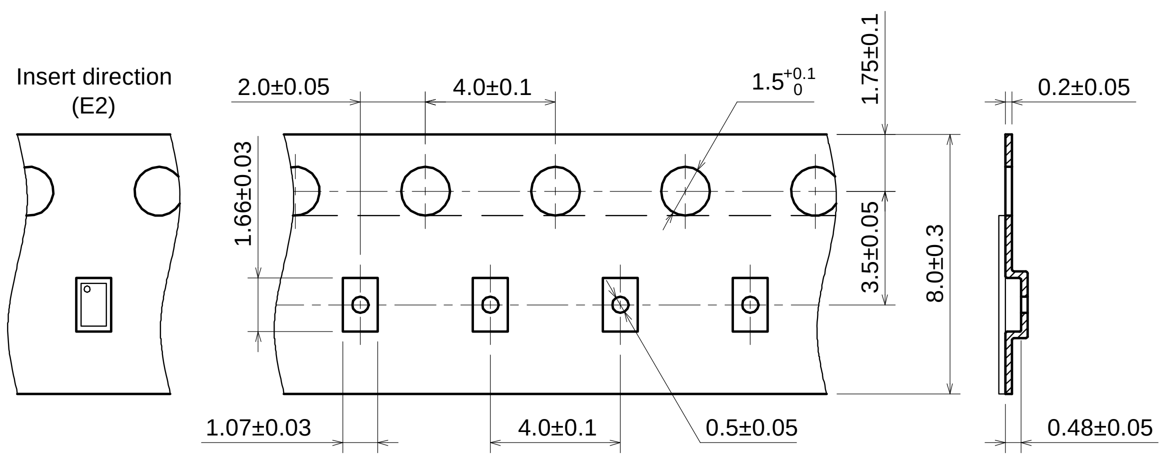
■ VISUAL INSPECTION CRITERIA

No.	Inspection Items	Inspection Criteria	Figures
1	Package chipping	A ≥ 0.2mm is rejected B ≥ 0.2mm is rejected C ≥ 0.2mm is rejected And, Package chipping to Si surface and to bump is rejected.	
2	Si surface chipping	A ≥ 0.2mm is rejected B ≥ 0.2mm is rejected C ≥ 0.2mm is rejected But, even if A ≥ 0.2mm, B ≤ 0.1mm is acceptable.	
3	No bump	No bump is rejected.	
4	Marking miss	To reject incorrect marking, such as another product name marking or another lot No. marking.	
5	No marking	To reject no marking on the package.	
6	Reverse direction of marking	To reject reverse direction of marking character.	
7	Defective marking	To reject unreadable marking. (Microscope: X15/ White LED/ Viewed from vertical direction)	
8	Scratch	To reject unreadable marking character by scratch. (Microscope: X15/ White LED/ Viewed from vertical direction)	
9	Stain and Foreign material	To reject unreadable marking character by stain and foreign material. (Microscope: X15/ White LED/ Viewed from vertical direction)	

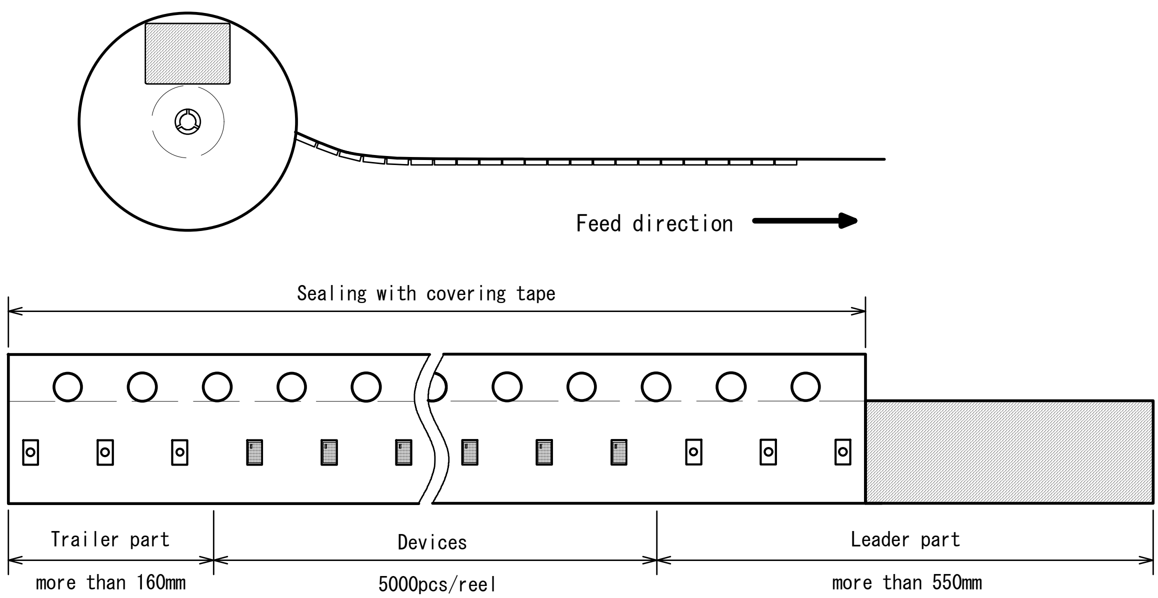
■ PACKING SPEC

UNIT: mm

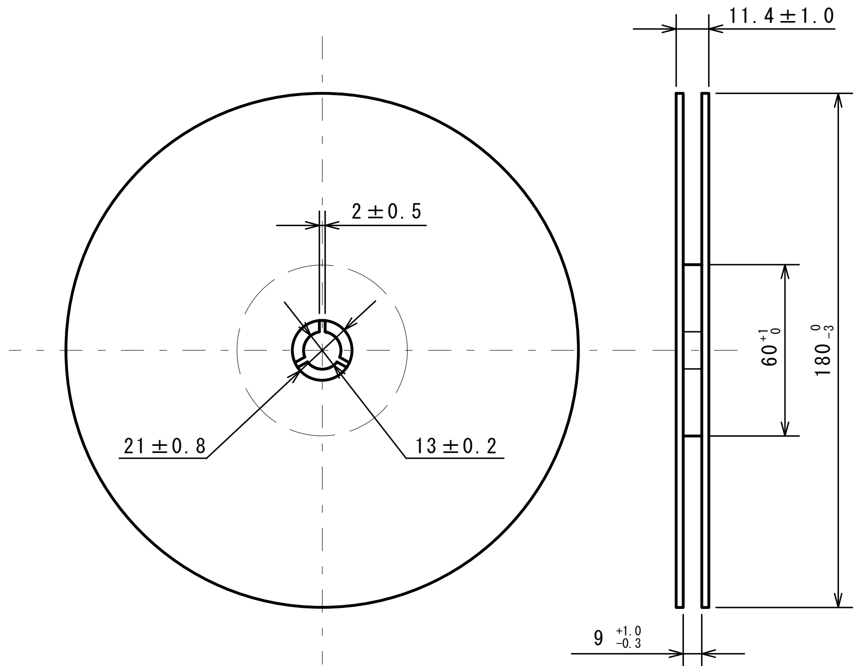
(1) Taping dimensions / Insert direction



(2) Taping state



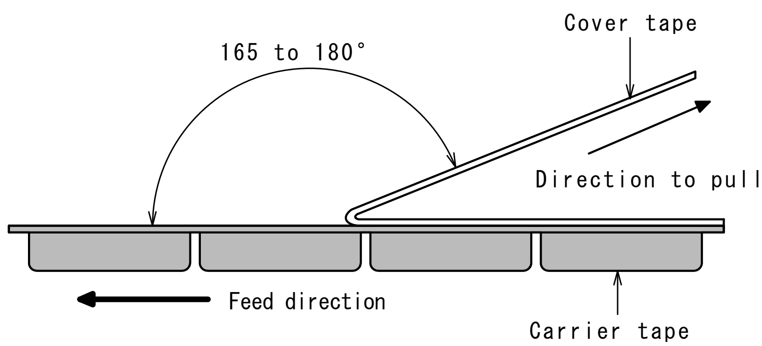
(3) Reel dimensions



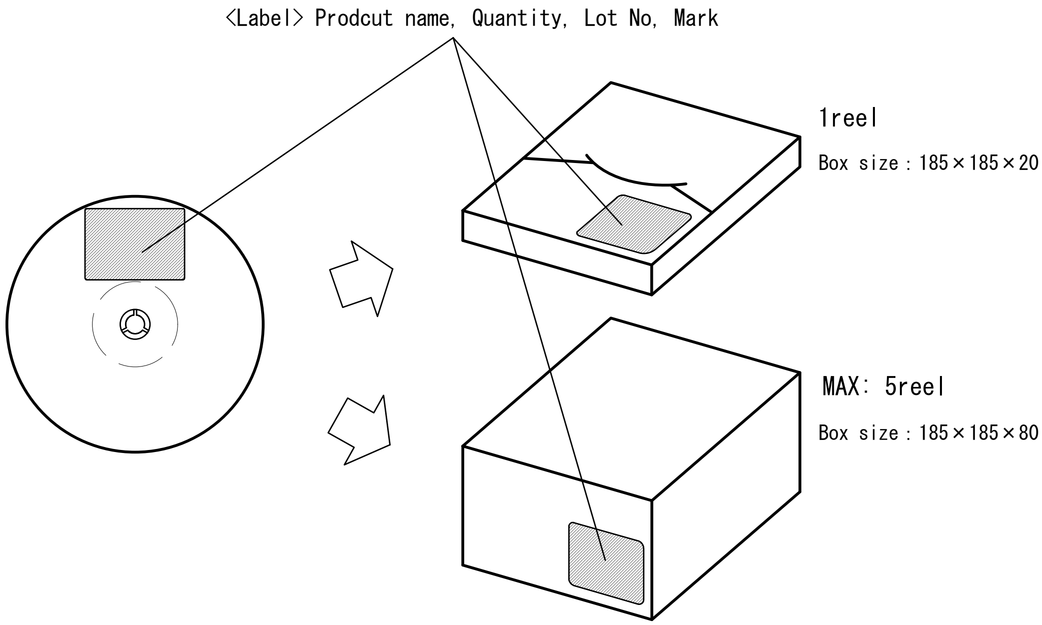
(4) Peeling strength

Peeling strength of cover tape

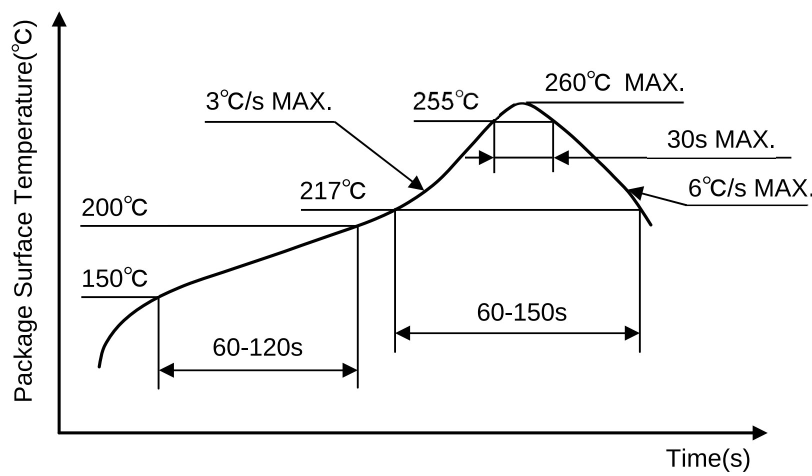
･Peeling angle	165 to 180° degrees to the taped surface.
･Peeling speed	300mm/min
･Peeling strength	0.1 to 1.0N



(5) Packing state



■ **HEAT-RESISTANCE PROFILES**



Reflow profile

REVISION HISTORY

Date	Revision	Changes
February 20, 2026	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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    - 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.

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Nisshinbo Micro Devices Inc.

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