NC2600 series

Datasheet

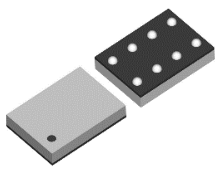
2A Low Quiescent Current PWM/PFM Step-down Switching Regulator

FEATURES

- Input Voltage Range (Maximum Rating): 2.3 V to 5.5 V (6.5 V)
- Operating Temperature Range: −40 °C to 85 °C
- Output Voltage Range:
  - Fixed Output Voltage Type: 0.6 V to 3.3 V
  - Adjustable Output Voltage Type: 0.6 V to 5.5 V
- Output Voltage Accuracy: ±1.5% (V_{SET} ≥ 1.2 V)
  ±18 mV (V_{SET} < 1.2 V)
- Feedback Voltage Accuracy: ±9 mV
- Quiescent Current: Typ. 17 µA
- Switching Frequency: Typ.4.0 MHz (V_{SET} = 1.8 V)
- UVLO Detection Voltage: Typ.2.0 V
- Soft-Start Time: Typ. 0.15 ms When CSS is open.
- Thermal Shutdown Function:
  Detection Temperature Typ. 150 °C
  Release Temperature Typ. 120 °C
- Auto Discharge Function
- Latch Protection Function

GENERAL DESCRIPTION

The NC2600 is a low quiescent current PWM / PFM 2A step-down switching regulator IC using CMOS-based.
The NC2600 is available in WLCSP-8-P11 and DFN2020-8-GT, and it is suitable for use in wearable and IoT devices that require miniaturization and long-lifetime of battery.



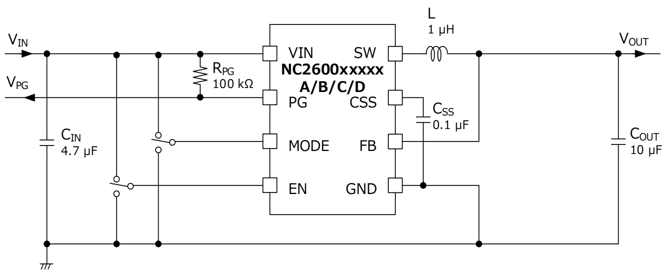
WLCSP-8-P11
1.62 x 0.98 x 0.4 (mm)

DFN2020-8-GT
2.0 x 2.0 x 0.6 (mm)

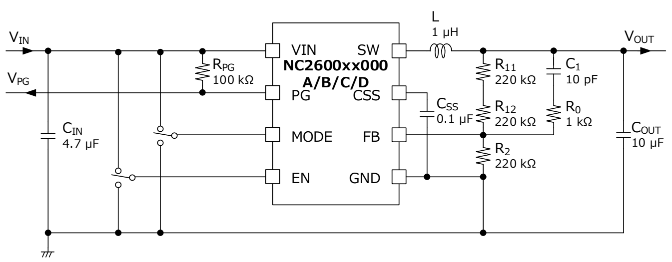
APPLICATIONS

- Portable Communication Devices: Mobile Phones / Smartphones
- Digital Cameras and Note-PCs
- Li-ion Battery-used Equipment

TYPICAL APPLICATIONS

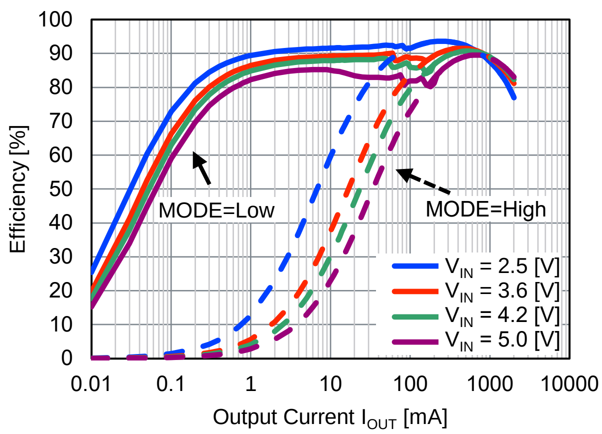


Fixed Output Voltage Type



Adjustable Output Voltage Type (V_{SET} = 1.8V)

EFFICIENCY TYPICAL CHARACTERISTICS



NC2600ZA
V_{OUT} = 1.8 [V]

PRODUCT NAME INFORMATION

NC2600 aa bbb c dd e

Description of configuration

Composition	Item	Description
aa	Package Code	Indicates the package. Refer to the order information.
bbb	Output Voltage	Set Output Voltage (V_{SET}) Adjustable Output Voltage Type (000) The internal fixed output voltage type has a lineup of main voltages in the range of 0.6 V (060) to 3.3 V (330).
c	Version	Indicates the selection of auto discharge function and latch protection function.
dd	Packing	Refer to the packing specifications.
e	Grade	Indicates the quality grade.

Version

c	Latch Protection Function	Auto Discharge Function
A	Yes	Yes
B	Yes	No
C	No	Yes
D	No	No

Grade

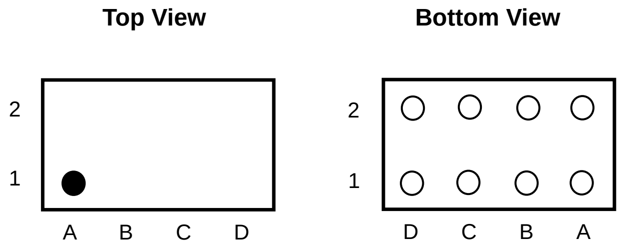
e	Applications	Operating Temperature Range	Test Temperature
S	Consumer	−40 °C to 85 °C	25 °C

ORDER INFORMATION

PRODUCT NAME	PACKAGE	RoHS	HALOGEN-FREE	PLATING COMPOSITION	MARKING	WEIGHT (mg)	Quantity per Reel(pcs)
NC2600ZA bbbc E2S	WLCSP-8-P11	Yes	Yes	Sn3Ag0.5Cu	Reference	1.1	5000
NC2600GT bbbc E4S	DFN2020-8-GT	Yes	Yes	Sn	Reference	7.0	3000

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

PIN DESCRIPTIONS (NC2600ZA)



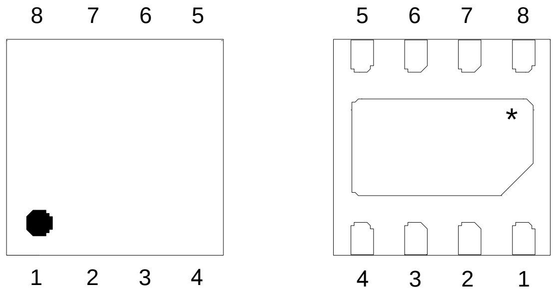
WLCSP-8-P11 Pin Configuration

NC2600ZA (WLCSP-8-P11) Pin Descriptions

Pin No.	Pin Name	I/O	Description
A1	VIN	Power	Power Supply Input Pin
B1	SW	O	Switching Output Pin Internal MOSFET Drain Connect the inductor between the VOUT node and the SW pin.
C1	EN	I	Enable Pin Can set the active state with the "High" input and the shutdown state with the "Low" input.
D1	PG	O	Power-good Output Pin NMOS open drain output. In normal operation, "High" (pull-up voltage) is output.
A2	GND	-	Ground Pin
B2	CSS	I	Soft-Start Adjustment Pin Soft-Start time can be adjusted by connecting a capacitor between the CSS pin and GND.
C2	MODE	I	Mode Control Pin High: Forced PWM Control, Low: PWM/PFM Auto Switching Control.
D2	FB	I	Feedback Pin When using NC2600xx000x (adjustable output voltage type), connect an external resistor as the feedback input pin for the error amplifier and set the output voltage. When using the internal fixed output voltage type, connect it to the VOUT node as an output voltage feedback pin.

For details, refer to " *Typical Application Circuit* " and " *THEORY OF OPERATION* ".

PIN DESCRIPTIONS (NC2600GT)



DFN2020-8-GT Pin Configuration

* The tab on the bottom of the package is the silicon substrate level. It is recomended to connect to GND level on the board.

NC2600GT (DFN2020-8-GT) Pin Descriptions

Pin No.	Pin Name	I/O	Description
1	GND	-	Ground pin
2	CSS	I	Soft-Start Adjustment Pin Soft-Start time can be adjusted by connecting a capacitor between the CSS pin and GND.
3	MODE	I	Mode Control Pin High: Forced PWM Control, Low: PWM/PFM Auto Switching Control.
4	FB	I	Feedback Pin When using NC2600xx000x (adjustable output voltage type), connect an external resistor as the feedback input pin for the error amplifier and set the output voltage. When using the internal fixed output voltage type, connect it to the VOUT node as an output voltage feedback pin.
5	PG	O	Power-good Output Pin NMOS open drain output. In normal operation, "High" (pull-up voltage) is output.
6	EN	I	Enable Pin Can set the active state with the "High" input and the shutdown state with the "Low" input.
7	SW	O	Switching Output Pin Internal MOSFET Drain Connect the inductor between the VOUT node and the SW pin.
8	VIN	Power	Power Supply Input Pin

For details, refer to " *Typical Application Circuit* " and " *THEORY OF OPERATION* ".

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Ratings	Unit
Input Voltage	V_{IN}	−0.3 to 6.5	V
SW pin voltage	V_{SW}	−0.3 to V_{IN} + 0.3	V
EN pin voltage	V_{EN}	−0.3 to 6.5	V
CSS pin voltage	V_{CSS}	−0.3 to 6.5	V
PG pin voltage	V_{PG}	−0.3 to 6.5	V
MODE pin voltage	V_{MODE}	−0.3 to 6.5	V
FB pin voltage	V_{FB}	−0.3 to 6.5	V
Junction Temperature Range *1	T_j	−40 to 125	°C
Storage Temperature Range	T_{stg}	−55 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-8-P11	Thermal Resistance (θja)	131	°C/W
	Thermal Characterization Parameter (ψjt)	38	
DFN2020-8-GT	Thermal Resistance (θja)	71	
	Thermal Characterization Parameter (ψjt)	33	

θja : Junction-to-Ambient Thermal Resistance
ψjt : Junction-to-Top Thermal Characterization Parameter
The above values are reference data under measurement conditions based on JEDEC STD.51.

ELECTROSTATIC DISCHARGE RATINGS

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

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

Parameter	Symbol	Ratings	Unit
Input Voltage	V_{IN}	2.3 to 5.5	V
Operating Temperature Range	T_a	−40 to 85	°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

NC2600xx060x to 330x（Internal Fixed Output Voltage Type）

V_{IN} = 3.6V (V_{SET} ≤ 2.6V) or V_{SET} + 1 V (V_{SET} > 2.6V) unless otherwise specified.
For parameter that do not describe the temperature condition, the MIN / MAX value under the condition of −40 °C ≤ T_a ≤ 85 °C is described.

Parameter	Symbol	Conditions		MIN	TYP	MAX	Unit
Output Voltage	V_{OUT}	Ta = 25 °C	V_{SET} ≥ 1.2 V	x 0.985	-	x 1.015	V
			V_{SET} < 1.2 V	−0.018	-	+0.018	
Switching Frequency	f_{OSC}	V_{MODE} =3.6 V		-	4.0	-	MHz
Quiescent Current	I_Q	V_{FB} = V_{SET} × 1.05, V_{MODE} = 0 V, no switching		-	17	25	µA
Shutdown current	I_{SD}	V_{IN} = 5.5 V, V_{EN} = 0 V		-	0	5	µA
EN "H" Input Current	I_{ENH}	V_{IN} = V_{EN} = 5.5 V		−1	0	1	µA
EN "L" Input Current	I_{ENL}	V_{IN} = 5.5 V, V_{EN} = 0 V		−1	0	1	µA
MODE "H" Input Current	I_{MODEH}	V_{IN} = V_{MODE} = 5.5 V		−1	0	1	µA
MODE "L" Input Current	I_{MODEL}	V_{IN} = 5.5 V, V_{MODE} = 0 V		−1	0	1	µA
VFB "H" Input Current	I_{FBH}	V_{IN} = V_{FB} = 5.5 V, V_{EN} = 0 V		−1	0	1	µA
VFB "L" Input Current	I_{FBL}	V_{IN} = 5.5 V, V_{EN} = V_{FB} = 0 V		−1	0	1	µA
On-resistance for Discharger	R_{ONDIS}	NC2600xxxxxA/C		-	60	-	Ω
EN pin "H" Input Voltage	V_{ENH}	V_{IN} = 5.5 V		1.0	-	-	V
EN pin "L" Input Voltage	V_{ENL}	V_{IN} = 2.3 V		-	-	0.4	V
MODE "H" Input Voltage	V_{MODEH}	V_{IN} = 5.5 V		1.0	-	-	V
MODE "L" Input Voltage	V_{MODEL}	V_{IN} = 2.3 V		-	-	0.4	V
On-resistance of High Side MOSFET	R_{ONH}	I_{SW} = 100 mA	NC2600ZA	-	0.13	-	Ω
			NC2600GT	-	0.15	-	Ω
On-resistance of Low Side MOSFET	R_{ONL}	I_{SW} = 100 mA	NC2600ZA	-	0.09	-	Ω
			NC2600GT	-	0.12	-	Ω
Soft-Start Time 1	t_{START1}	CSS = OPEN		-	150	300	µs
Soft-Start Time 2	t_{START2}	CSS = 0.1 µF		15	30	45	ms
SW Current Limit	I_{SWLIM}			2.3	-	4.7	A
Protection Delay Time	t_{PROT}	NC2600xxxxxA/B		10	20	40	µs
UVLO Detection Voltage *1	$V_{UVLODET}$	V_{IN} = Falling		1.85	2.00	2.20	V
UVLO Release Voltage *1	$V_{UVLOREL}$	V_{IN} = Rising		1.90	2.05	2.25	V
On resistance at PG "L" Output	R_{ONPG}	V_{FB} = 0 V		-	45	-	Ω
OV Detection Voltage	V_{OVD}	V_{FB} = Rising		V_{SET} x 1.1	V_{SET} x 1.2	-	V
UV Detection Voltage	V_{UVD}	V_{FB} = Falling		-	V_{SET} x 0.8	V_{SET} x 0.9	V
Thermal Shutdown Detection Temperature	T_{SDDET}	T_j = Rising		-	150	-	°C
Thermal Shutdown Release Temperature	T_{SDREL}	T_j = Falling		-	120	-	°C

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.0.05 V.

NC2600xx000x（Adjustable Output Voltage Type）

V_{IN} = 3.6V unless otherwise specified.
For parameter that do not describe the temperature condition, the MIN / MAX value under the condition of −40 °C ≤ T_a ≤ 85 °C is described.

Parameter	Symbol	Conditions		MIN	TYP	MAX	Unit
Feedback voltage	V_{FB}	Ta = 25 °C		0.591	0.600	0.609	V
Switching Frequency	f_{OSC}	V_{MODE} =3.6 V		-	4.0	-	MHz
Quiescent Current	I_Q	V_{FB} = 0.63 V, V_{MODE} = 0 V, no switching		-	17	25	µA
Shutdown current	I_{SD}	V_{IN} = 5.5 V, V_{EN} = 0 V		-	0	5	µA
EN "H" Input Current	I_{ENH}	V_{IN} = V_{EN} = 5.5 V		−1	0	1	µA
EN "L" Input Current	I_{ENL}	V_{IN} = 5.5 V, V_{EN} = 0 V		−1	0	1	µA
MODE "H" Input Current	I_{MODEH}	V_{IN} = V_{MODE} = 5.5 V		−1	0	1	µA
MODE "L" Input Current	I_{MODEL}	V_{IN} = 5.5 V, V_{MODE} = 0 V		−1	0	1	µA
FB "H" Input Current	I_{FBH}	V_{IN} = V_{FB} = 5.5 V, V_{EN} = 0 V		−1	0	1	µA
FB "L" Input Current	I_{FBL}	V_{IN} = 5.5 V, V_{EN} = V_{FB} = 0 V		−1	0	1	µA
On-resistance for Discharger	R_{ONDIS}	NC2600xx000A/C		-	60	-	Ω
EN pin "H" Input Voltage	V_{ENH}	V_{IN} = 5.5 V		1.0	-	-	V
EN pin "L" Input Voltage	V_{ENL}	V_{IN} = 2.3 V		-	-	0.4	V
MODE "H" Input Voltage	V_{MODEH}	V_{IN} = 5.5 V		1.0	-	-	V
MODE "L" Input Voltage	V_{MODEL}	V_{IN} = 2.3 V		-	-	0.4	V
On-resistance of High Side MOSFET	R_{ONH}	I_{SW} = 100 mA	NC2600ZA	-	0.13	-	Ω
			NC2600GT	-	0.15	-	Ω
On-resistance of Low Side MOSFET	R_{ONL}	I_{SW} = 100 mA	NC2600ZA	-	0.09	-	Ω
			NC2600GT	-	0.12	-	Ω
Soft-Start Time 1	t_{START1}	CSS = OPEN		-	150	300	µs
Soft-Start Time 2	t_{START2}	CSS = 0.1 µF		15	30	45	ms
SW Current Limit	I_{SWLIM}			2.3	-	4.7	A
Protection Delay Time	t_{PROT}	NC2600xx000A/B		10	20	40	µs
UVLO Detection Voltage *1	$V_{UVLODET}$	V_{IN} = Falling		1.85	2.00	2.20	V
UVLO Release Voltage *1	$V_{UVLOREL}$	V_{IN} = Rising		1.90	2.05	2.25	V
On resistance at PG "L" Output	R_{ONPG}	V_{FB} =0 V		-	45	-	Ω
OV Detection Voltage	V_{OVD}	V_{FB} = Rising		0.66	0.72	-	V
UV Detection Voltage	V_{UVD}	V_{FB} = Falling		-	0.48	0.54	V
Thermal Shutdown Detection Temperature	T_{SDDET}	T_j = Rising		-	150	-	°C
Thermal Shutdown Release Temperature	T_{SDREL}	T_j = Falling		-	120	-	°C

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

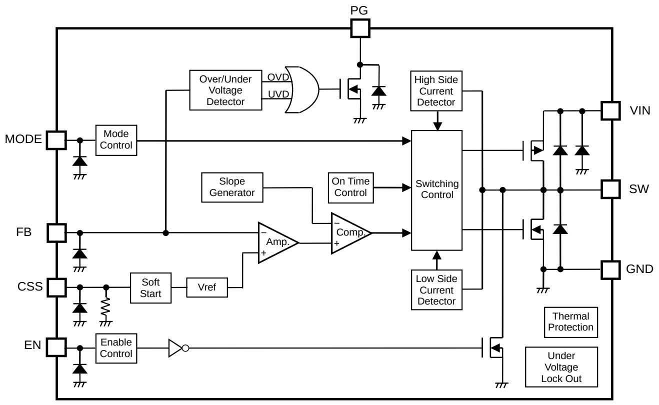
*1 Due to the circuit configuration, $V_{UVLODET} \geq V_{UVLOREL}$ does not hold. The hysteresis is Typ.0.05 V.

PRODUCT-SPECIFIC ELECTRICAL CHARACTERISTICS

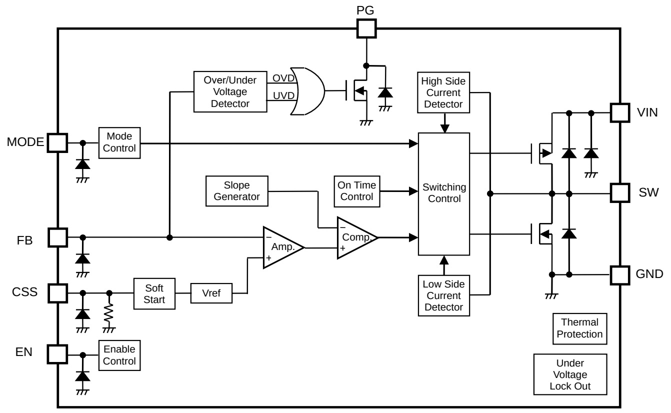
PRODUCT NAME	V_{OUT} (T_a = 25 °C)			Unit
	MIN	TYP	MAX	
NC2600xx060xxxx	0.582	0.6	0.618	V
NC2600xx070xxxx	0.682	0.7	0.718	
NC2600xx080xxxx	0.782	0.8	0.818	
NC2600xx090xxxx	0.882	0.9	0.918	
NC2600xx100xxxx	0.982	1.0	1.018	
NC2600xx110xxxx	1.082	1.1	1.118	
NC2600xx120xxxx	1.182	1.2	1.218	
NC2600xx130xxxx	1.280	1.3	1.320	
NC2600xx140xxxx	1.379	1.4	1.421	
NC2600xx150xxxx	1.477	1.5	1.523	
NC2600xx160xxxx	1.576	1.6	1.624	
NC2600xx170xxxx	1.674	1.7	1.726	
NC2600xx180xxxx	1.773	1.8	1.827	
NC2600xx190xxxx	1.871	1.9	1.929	
NC2600xx200xxxx	1.970	2.0	2.030	
NC2600xx210xxxx	2.068	2.1	2.132	
NC2600xx220xxxx	2.167	2.2	2.233	
NC2600xx230xxxx	2.265	2.3	2.335	
NC2600xx240xxxx	2.364	2.4	2.436	
NC2600xx250xxxx	2.462	2.5	2.538	
NC2600xx260xxxx	2.561	2.6	2.639	
NC2600xx270xxxx	2.659	2.7	2.741	
NC2600xx280xxxx	2.758	2.8	2.842	
NC2600xx290xxxx	2.856	2.9	2.944	
NC2600xx300xxxx	2.955	3.0	3.045	
NC2600xx310xxxx	3.053	3.1	3.147	
NC2600xx320xxxx	3.152	3.2	3.248	
NC2600xx330xxxx	3.250	3.3	3.350	

Above parameters are all tested under the following conditions:
$T_j \approx T_a$ = 25 °C

BLOCK DIAGRAMS



NC2600xxxxxA/C Block Diagram



NC2600xxxxxB/D Block Diagram

THEORY OF OPERATION

Enable Function

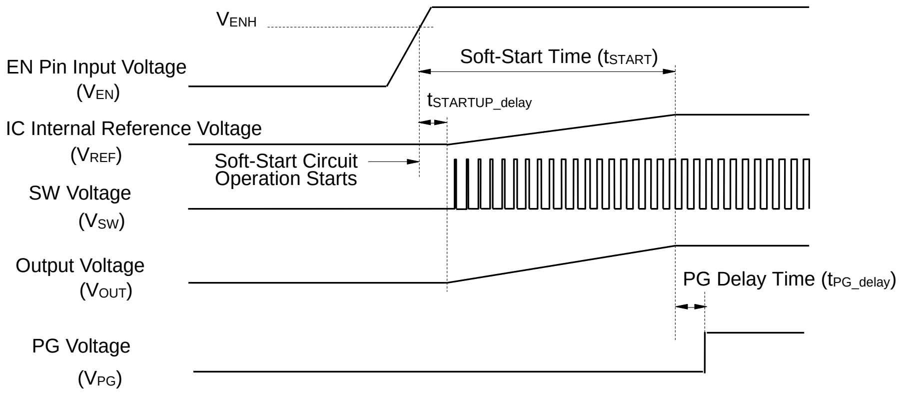
Forcing above designated "High" voltage to EN pin, the NC2600 becomes active. Forcing below designated "Low" voltage to EN pin shuts down the NC2600. In shutdown condition, all functions are disabled except auto discharge function. With auto discharge option, the MOSFET to discharge the output capacitor 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

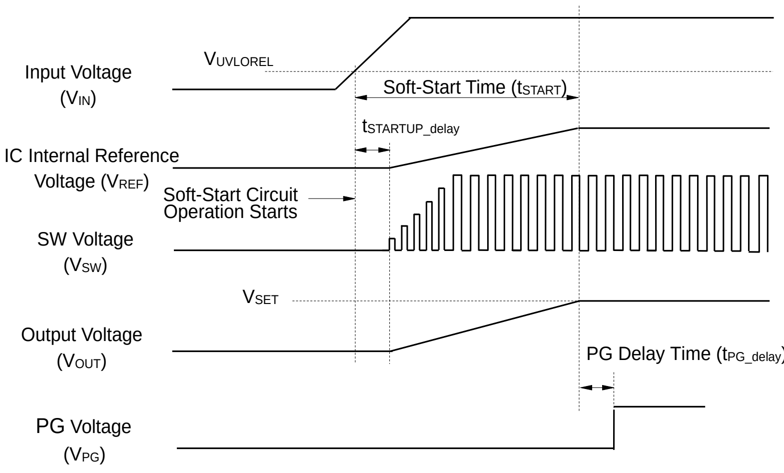
When turned off, the Vout voltage drops rapidly to near 0V by discharging the charge stored in the output capacitor through the MOSFET connected between the SW pin and GND pins. The auto discharge function is enabled when the EN pin = "low" ,UVLO detection or the thermal shutdown detection. On-resistance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

Soft-Start

When the input voltage (V_{IN}) exceeds the UVLO release voltage ($V_{UVLOREL}$) and the EN pin is input with a voltage higher than the EN "High" input voltage (V_{ENH}), the Soft-Start circuit starts operation. After the Soft-Start circuit starts operating and the delay time ($t_{STARTUP\_delay}$) Typ.45µsec, the IC internal reference voltage (V_{REF}) starts rising, and after the Soft-Start time (t_{START})*1, the V_{REF} reaches the specified value.
The output of the PG pin (V_{PG}) confirms that the output voltage (V_{OUT}) is between the UV detection voltage (V_{UVD}) and the OV detection voltage (V_{OVD}), and becomes "High" after the PG delay time (t_{PG_delay}=Typ.10µsec).



Timing Chart when Starting-up with EN pin



Timing Chart when Starting-up with VIN = EN

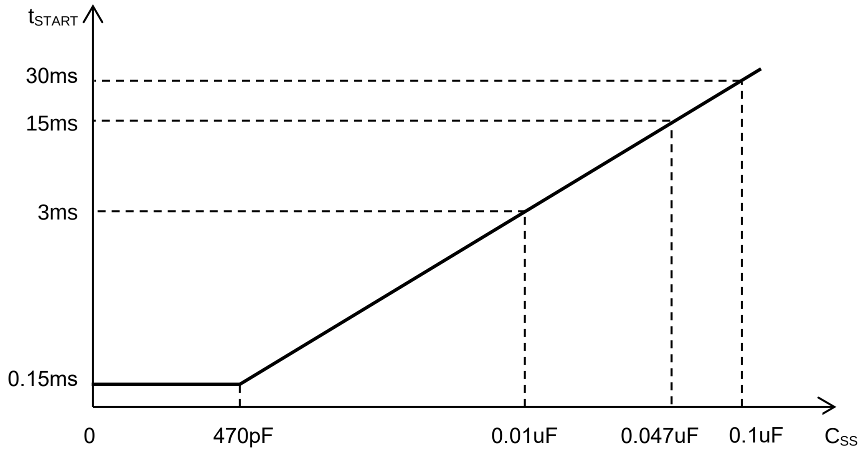
The current limiting function, latch type protection function (NC2600xxxxxA/B), UVLO function, and thermal shutdown function are effective even during the Soft-Start time. When the thermal shutdown is released, the Soft-Start function is effective.
When starting with a large load current or when a large capacitance is used in the C_{OUT}, the above protection functions may be activated. In such a case, adjust the C_{SS} and increase the Soft-Start time in order to avoid such an abnormal situation.

*1 Soft-Start time (t_{START}) indicates the duration until the reference voltage (V_{REF}) reaches the specified voltage after Soft-Start circuit's activation.

Soft-Start Time Adjustment

Soft-Start time t_{START} can be adjusted as shown in the figure below by connecting a capacitor C_{SS} to the CSS pin. When C_{SS} is 0.1 μF, the Soft-Start time is Typ.30 ms. If you do not need to adjust the Soft-Start time, open the CSS pin to start up with the built-in Soft-Start time (Typ.0.15 ms). Soft-Start time can be calculated using the following equation.
There is no limit to the capacitance value of the C_{SS}.

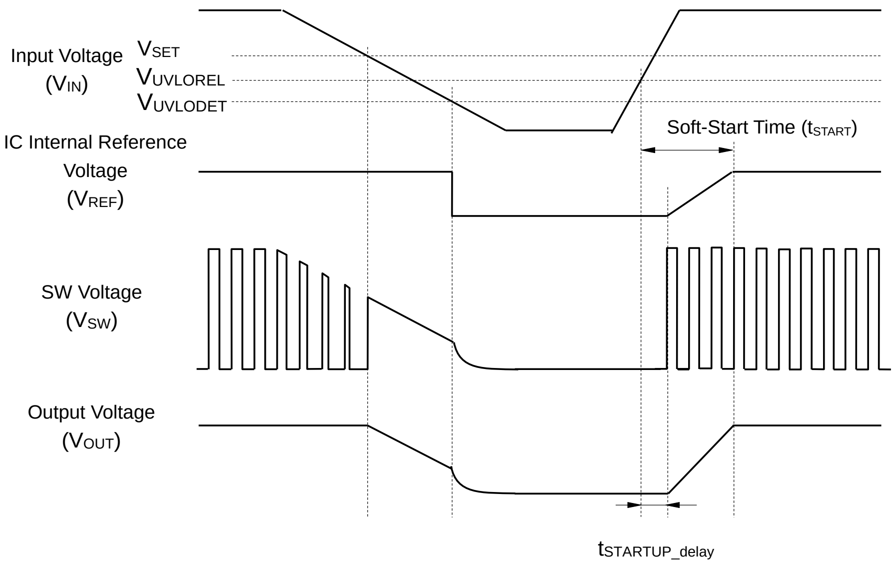
C_{SS} [μF] = t_{START} [ms] x 0.0033



C_{SS} vs. t_{START} (Typ)

Under Voltage Lockout (UVLO) Circuit

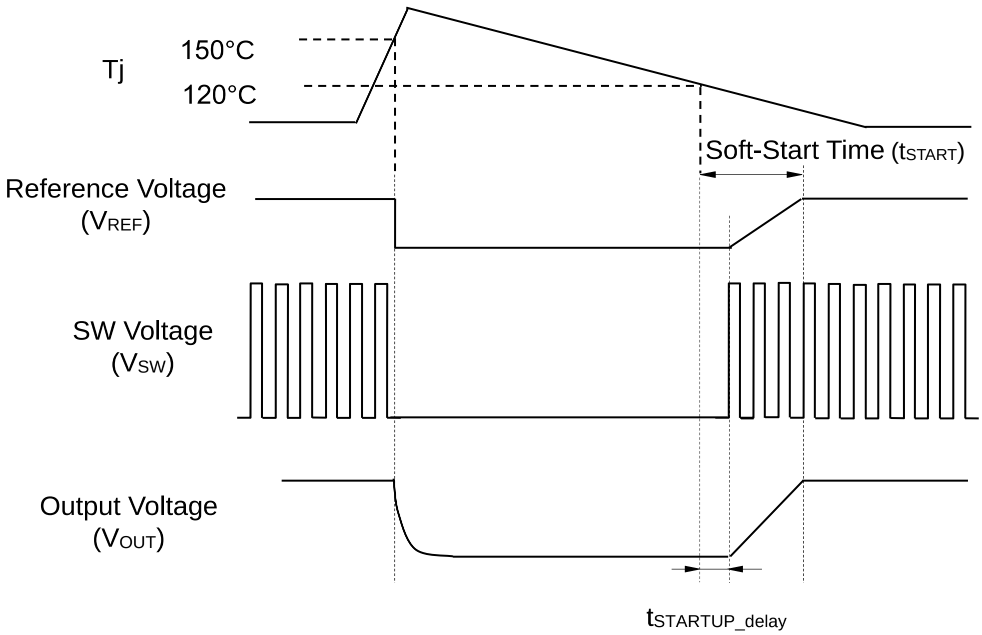
When V_{IN} becomes lower than V_{SET}, the step-down switching regulator stops its switching operation and ON duty becomes 100%, then V_{OUT} gradually falls according to V_{IN}.
When the V_{IN} drops below the UVLO detection voltage ($V_{UVLODET}$), the UVLO operates, V_{REF} stops, and high side MOSFET and low side MOSFET turn "OFF".
As a result, the output voltage decreases according to the capacitance value of C_{OUT}, load current, and discharge FET on-resistance (NC2600xxxxxA/C).
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 is changed Falling edge (detecting) and rising edge (releasing) waveforms of V_{OUT} could 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})

Thermal Shutdown

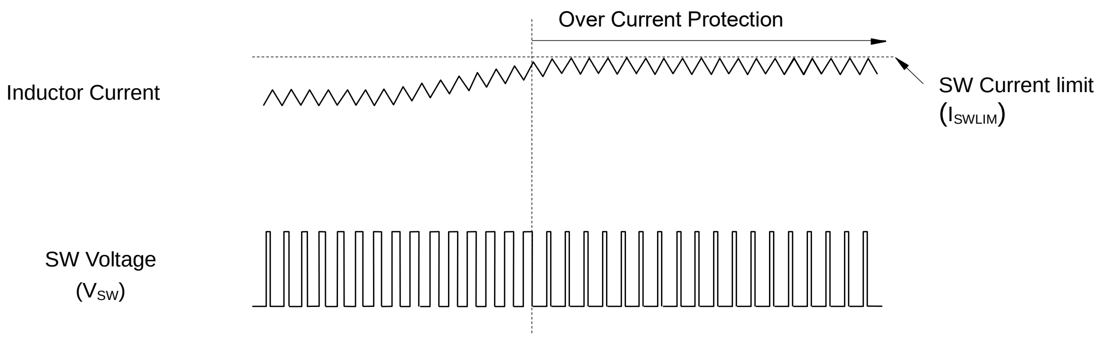
When the junction temperature exceeds the thermal shutdown detection temperature (Typ.150°C), switching stops and self-heating is suppressed.
This IC will restart when the junction temperature drops below the thermal shutdown release temperature (Typ.120°C). Then, the Soft-Start function is activated.



Current Limit Circuit、Latch Type Protection Circuit

Current limit circuit supervises the peak current flowing through the inductor in each switching cycle. If the current exceeds the SW current limit (Typ.3.4 A), High Side MOSFET is turned off and the upper limit of the inductor peak current is imposed.

The latch-type protection circuit latches the built-in driver off and shuts down the switching regulator if this overcurrent condition lasts for the protection delay time (t_{PROT}). To release the latch type protection state, restart the device by inputting "Low" signal to the EN pin or making the Input Voltage lower than UVLO detection voltage ($V_{UVLODET}$).



Over-Current Protection Operation

Forced PWM Mode and PWM / PFM Auto Switching Mode

Output voltage controlling method is selectable between a forced PWM mode type and PWM/PFM Auto Switching mode. The operation mode can be set by the MODE pin. The forced PWM mode operates with fixed switching frequency to reduce noise in low output current. The PWM/PFM Auto Switching mode automatically enters PFM control to achieve high efficiency at light load current.
The above control types operate differently depending on the relationship between the load current (I_{OUT}) and the current ripple (ΔI_L) calculated by the following equation.

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

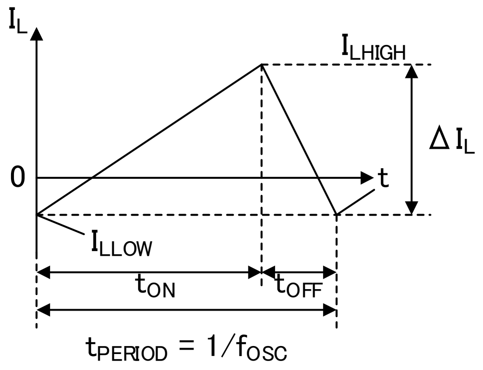
t_{ON} : ON time of high side MOSFET

Do not open the MODE pin because it is not pulled up or down inside the IC.

MODE = "High" (Forced PWM Mode)

When a "High" signal is input to the MODE pin, the device enters a forced PWM mode in which the high side MOSFET and low side MOSFET are turned on alternately. During this operation, it operates with fixed switching frequency regardless of the load current. This reduces output voltage ripple and responds quickly to load current transitions.

If $I_{OUT} < \Delta I_L / 2$, I_{LLOW} becomes 0 A or less, and the charge stored in C_{OUT} flows back to the IC side.
Refer to the figure below.



Forced PWM Mode

MODE = "Low" (PWM/PFM Auto Switching Mode)

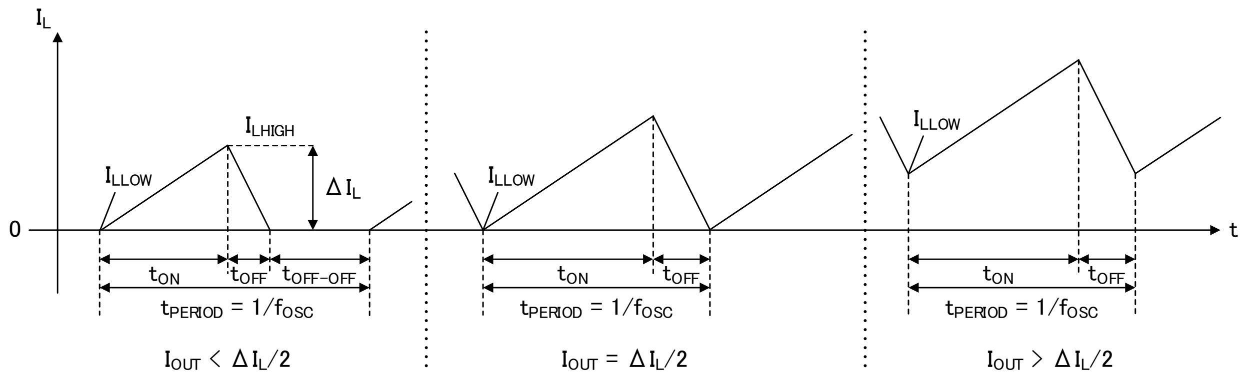
When a "Low" signal is input to the MODE pin, when I_L = 0 A under a light load condition, the operation mode is set to $t_{OFF-OFF}$ which turns off the high side MOSFET and the low side MOSFET at the same time. Such an operation in which $t_{OFF-OFF}$ exists in one cycle is called PFM operation.
$t_{OFF-OFF}$ during PFM operation reduces power consumption by minimizing the operating circuits inside the IC.
This realizes highly efficient operation at light loads conditions.

The cycle during PFM operation is defined by the following equation.

$$t_{PERIOD} = t_{ON} + t_{OFF} + t_{OFF-OFF} = 1 / f_{OSC} \quad \cdots\cdots (1)$$

At light load conditions ($I_{OUT} < \Delta I_L / 2$), I_{LLOW} = 0 A and the I_L waveform is as shown on the left in the figure.
During PFM operation, if the load current is increases from a light load, $t_{OFF-OFF}$ becomes shorter.
When $t_{OFF-OFF}$ becomes 0 sec ($I_{OUT} = \Delta I_L / 2$), the IC enters PWM operation, and when the load current increases further, I_{LLOW}> 0 A.
Refer to the figure below.

In this way, when the MODE pin is fixed to "Low", PWM operation and PFM operation are automatically switched according to the load current.



PWM/PFM Auto Switching Mode

Switching Frequency

The minimum on-time / the minimum off-time for this product is determined by the circuit. If the on-time / the off-time calculated under the input/output voltage conditions at 4 MHz are less than the minimum on-time / minimum off-time determined by the circuit, the switching frequency falls below 4 MHz.

The on-time under no load is calculated by the following equation according to the input / output voltage conditions.

t_{ON} = 250 ns x V_{OUT} / V_{IN}

Example 1: Switching frequency with minimum on-time (60 ns) under the following input / output conditions.

condition1: V_{IN} = 3.6 V, V_{OUT} = 1.2 V

1/4 MHz × 1.2 V/3.6 V = 83 ns > minimum on-time (60 ns)

Operates with 4 MHz.

condition2: V_{IN} = 5.5 V, V_{OUT} = 1.0 V

1/4 MHz × 1.0 V/5.5 V = 55 ns < minimum on-time (60 ns)

Switching frequency falls below 4 MHz.

Example 2: Switching frequency with minimum off-time (50 ns) under the following input / output conditions.

condition1: V_{IN} = 5.0 V, V_{OUT} = 3.3 V

1/4 MHz × (1 - 3.3 V/5.0 V) = 77 ns > minimum off-time (50 ns)

Operates with 4 MHz.

condition2: V_{IN} = 4.0 V, V_{OUT} = 3.3 V

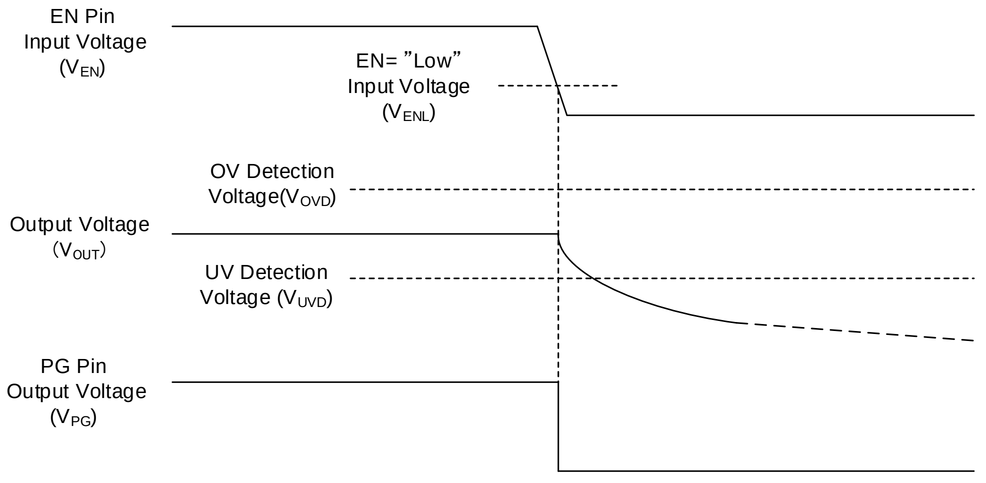
1/4 MHz × (1 - 3.3 V/4.0 V) = 44 ns < minimum off-time (50 ns)

Switching frequency falls below 4 MHz.

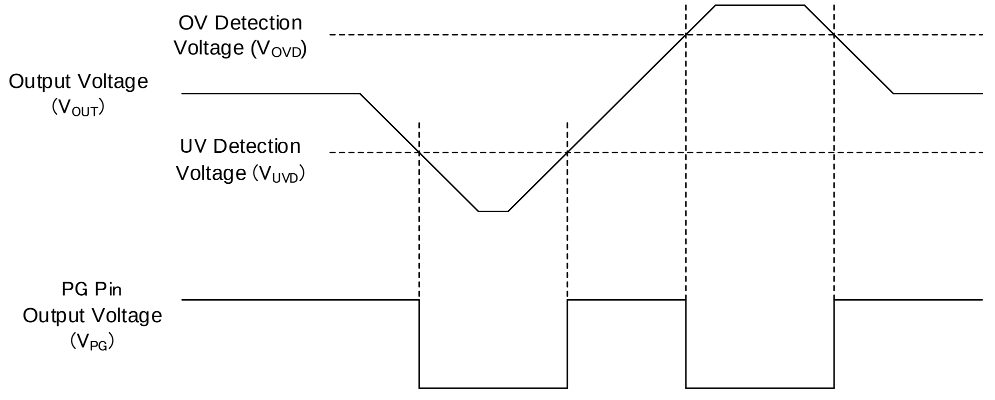
Power Good Function

This product has a power good (PG) function, and the output type is NMOS FET open drain. When EN = "Low" is detected, the NMOS FET turns on and sets the power good output to "Low".
Figure: Refer to PG Output When EN = "Low".
Also, when the IC detects Over Voltage (OV) or Under Voltage (UV), the power good output is set to "Low" as well.
Figure: Refer to PG Output When OV or UV is Detected.
When the IC is released from these conditions, the NMOS FET is turned off and the power good output is set to "High".

The pull-up resistor (R_{PG}) of the PG pin should be between 10 kΩ and 100 kΩ. The PG pin must be open or connected to GND if the power good function is not used.



PG Output When EN = "Low"



PG Output When OV or UV is Detected

Pass-Through Mode

This product enters pass-through mode when the input / output voltage difference drops. 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).

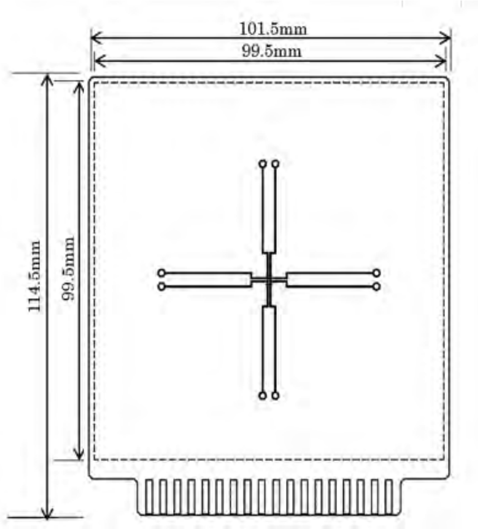
$$V_{OUT} = V_{IN} – (R_{ONP} + R_L) \times I_{OUT}$$

THERMAL CHARACTERISTICS (WLCSP-8-P11)

Thermal characteristics depend on the mounting conditions.
The following measurement conditions are based on JEDEC STD. 51.

Measurement Conditions

Parameter	Measurement Conditions
Measurement status	Mounting on Board (Wind Velocity = 0 m/s)
Board material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board size	101.5 mm × 114.5 mm × 1.6 mm
Copper Ratio	Outer Layers (First and Fourth Layers): 60% Inner Layers (Second and Third Layers): 100%



Measurement Board Pattern (WLCSP-8-P11)

Measurement Result

Parameter	Measurement Result	Unit
Thermal Resistance (θja)	131	°C/W
Thermal Characterization Parameter (ψjt)	38	

θja : Junction-to-Ambient Thermal Resistance

ψjt : Junction-to-Top Thermal Characterization Parameter

CALCULATION METHOD OF JUNCTION TEMPERATURE

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

$T_j = T_a + \theta ja \times P$
$T_j = Tc\ (top) + \psi jt \times P$

T_a : 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]

THERMAL CHARACTERISTICS (DFN2020-8-GT)

Thermal characteristics depend on the mounting conditions.
The following measurement conditions are based on JEDEC STD. 51.

Measurement Conditions

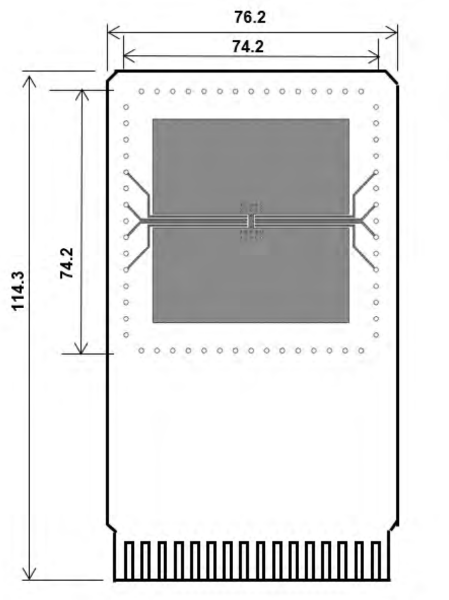
Parameter	Measurement Conditions
Measurement status	Mounting on Board (Wind Velocity = 0 m/s)
Board material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board size	76.2 mm × 114.3 mm × 0.8 mm
Copper Ratio	Outer Layer (First Layer): Less than 95% of 50 mm Square Inner Layers (Second and Third Layers): Approx. 100% of 50 mm Square Outer Layer (Fourth Layer): Approx. 100% of 50 mm Square
Through hole	ϕ 0.3 mm × 23 pcs.

Measurement Result

Parameter	Measurement Result	Unit
Thermal Resistance (θja)	71	°C/W
Thermal Characterization Parameter (ψjt)	33	

θja : Junction-to-Ambient Thermal Resistance

ψjt : Junction-to-Top Thermal Characterization Parameter



Measurement Board Pattern (DFN2020-8-GT)

CALCULATION METHOD OF JUNCTION TEMPERATURE

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

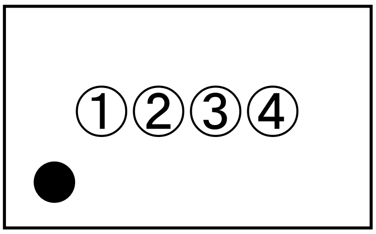
$T_j = T_a + \theta ja \times P$
$T_j = Tc\,(top) + \psi jt \times P$

T_a : 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（NC2600ZA）

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



WLCSP-8-P11 Marking

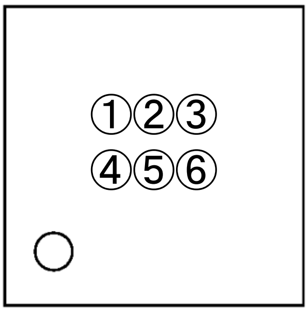
NOTICE
There can be variation in the marking when different AOI (Automated Optical Inspection) equipment is used. In the case of recognizing the marking characteristic with AOI, please contact our sales or distributor before attempting to use AOI.

NC2600ZA Marking List

Product Code	①	②	Product Code	①	②	Product Code	①	②
NC2600ZA000A	A	A	NC2600ZA150B	E	P	NC2600ZA250C	H	F
NC2600ZA060A	A	C	NC2600ZA160B	E	R	NC2600ZA260C	H	G
NC2600ZA070A	A	E	NC2600ZA170B	E	T	NC2600ZA270C	H	H
NC2600ZA080A	A	F	NC2600ZA180B	E	U	NC2600ZA280C	H	J
NC2600ZA090A	A	G	NC2600ZA190B	E	V	NC2600ZA290C	H	K
NC2600ZA100A	A	H	NC2600ZA200B	E	X	NC2600ZA300C	H	L
NC2600ZA110A	A	J	NC2600ZA210B	E	Y	NC2600ZA310C	H	N
NC2600ZA120A	A	K	NC2600ZA220B	F	A	NC2600ZA320C	H	P
NC2600ZA130A	A	L	NC2600ZA230B	F	C	NC2600ZA330C	H	R
NC2600ZA140A	A	N	NC2600ZA240B	F	E	NC2600ZA000D	J	A
NC2600ZA150A	A	P	NC2600ZA250B	F	F	NC2600ZA060D	J	C
NC2600ZA160A	A	R	NC2600ZA260B	F	G	NC2600ZA070D	J	E
NC2600ZA170A	A	T	NC2600ZA270B	F	H	NC2600ZA080D	J	F
NC2600ZA180A	A	U	NC2600ZA280B	F	J	NC2600ZA090D	J	G
NC2600ZA190A	A	V	NC2600ZA290B	F	K	NC2600ZA100D	J	H
NC2600ZA200A	A	X	NC2600ZA300B	F	L	NC2600ZA110D	J	J
NC2600ZA210A	A	Y	NC2600ZA310B	F	N	NC2600ZA120D	J	K
NC2600ZA220A	C	A	NC2600ZA320B	F	P	NC2600ZA130D	J	L
NC2600ZA230A	C	C	NC2600ZA330B	F	R	NC2600ZA140D	J	N
NC2600ZA240A	C	E	NC2600ZA000C	G	A	NC2600ZA150D	J	P
NC2600ZA250A	C	F	NC2600ZA060C	G	C	NC2600ZA160D	J	R
NC2600ZA260A	C	G	NC2600ZA070C	G	E	NC2600ZA170D	J	T
NC2600ZA270A	C	H	NC2600ZA080C	G	F	NC2600ZA180D	J	U
NC2600ZA280A	C	J	NC2600ZA090C	G	G	NC2600ZA190D	J	V
NC2600ZA290A	C	K	NC2600ZA100C	G	H	NC2600ZA200D	J	X
NC2600ZA300A	C	L	NC2600ZA110C	G	J	NC2600ZA210D	J	Y
NC2600ZA310A	C	N	NC2600ZA120C	G	K	NC2600ZA220D	K	A
NC2600ZA320A	C	P	NC2600ZA130C	G	L	NC2600ZA230D	K	C
NC2600ZA330A	C	R	NC2600ZA140C	G	N	NC2600ZA240D	K	E
NC2600ZA000B	E	A	NC2600ZA150C	G	P	NC2600ZA250D	K	F
NC2600ZA060B	E	C	NC2600ZA160C	G	R	NC2600ZA260D	K	G
NC2600ZA070B	E	E	NC2600ZA170C	G	T	NC2600ZA270D	K	H
NC2600ZA080B	E	F	NC2600ZA180C	G	U	NC2600ZA280D	K	J
NC2600ZA090B	E	G	NC2600ZA190C	G	V	NC2600ZA290D	K	K
NC2600ZA100B	E	H	NC2600ZA200C	G	X	NC2600ZA300D	K	L
NC2600ZA110B	E	J	NC2600ZA210C	G	Y	NC2600ZA310D	K	N
NC2600ZA120B	E	K	NC2600ZA220C	H	A	NC2600ZA320D	K	P
NC2600ZA130B	E	L	NC2600ZA230C	H	C	NC2600ZA330D	K	R
NC2600ZA140B	E	N	NC2600ZA240C	H	E			

MARKING SPECIFICATION（NC2600GT）

①②③④: Product Code
⑤⑥: Lot No. … Alphanumerical Serial Number



DFN2020-8-GT Part Markings

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.

NC2600GT Marking List

Product Code	① ② ③ ④
NC2600GT000A	1 A 0 0
NC2600GT060A	1 A 0 1
NC2600GT070A	1 A 0 2
NC2600GT080A	1 A 0 3
NC2600GT090A	1 A 0 4
NC2600GT100A	1 A 0 5
NC2600GT110A	1 A 0 6
NC2600GT120A	1 A 0 7
NC2600GT130A	1 A 0 8
NC2600GT140A	1 A 0 9
NC2600GT150A	1 A 1 0
NC2600GT160A	1 A 1 1
NC2600GT170A	1 A 1 2
NC2600GT180A	1 A 1 3
NC2600GT190A	1 A 1 4
NC2600GT200A	1 A 1 5
NC2600GT210A	1 A 1 6
NC2600GT220A	1 A 1 7
NC2600GT230A	1 A 1 8
NC2600GT240A	1 A 1 9
NC2600GT250A	1 A 2 0
NC2600GT260A	1 A 2 1
NC2600GT270A	1 A 2 2
NC2600GT280A	1 A 2 3
NC2600GT290A	1 A 2 4
NC2600GT300A	1 A 2 5
NC2600GT310A	1 A 2 6
NC2600GT320A	1 A 2 7
NC2600GT330A	1 A 2 8

Product Code	① ② ③ ④
NC2600GT000B	1 B 0 0
NC2600GT060B	1 B 0 1
NC2600GT070B	1 B 0 2
NC2600GT080B	1 B 0 3
NC2600GT090B	1 B 0 4
NC2600GT100B	1 B 0 5
NC2600GT110B	1 B 0 6
NC2600GT120B	1 B 0 7
NC2600GT130B	1 B 0 8
NC2600GT140B	1 B 0 9
NC2600GT150B	1 B 1 0
NC2600GT160B	1 B 1 1
NC2600GT170B	1 B 1 2
NC2600GT180B	1 B 1 3
NC2600GT190B	1 B 1 4
NC2600GT200B	1 B 1 5
NC2600GT210B	1 B 1 6
NC2600GT220B	1 B 1 7
NC2600GT230B	1 B 1 8
NC2600GT240B	1 B 1 9
NC2600GT250B	1 B 2 0
NC2600GT260B	1 B 2 1
NC2600GT270B	1 B 2 2
NC2600GT280B	1 B 2 3
NC2600GT290B	1 B 2 4
NC2600GT300B	1 B 2 5
NC2600GT310B	1 B 2 6
NC2600GT320B	1 B 2 7
NC2600GT330B	1 B 2 8

NC2600GT Marking List

Product Code	① ② ③ ④	Product Code	① ② ③ ④
NC2600GT000C	1 C 0 0	NC2600GT000D	1 D 0 0
NC2600GT060C	1 C 0 1	NC2600GT060D	1 D 0 1
NC2600GT070C	1 C 0 2	NC2600GT070D	1 D 0 2
NC2600GT080C	1 C 0 3	NC2600GT080D	1 D 0 3
NC2600GT090C	1 C 0 4	NC2600GT090D	1 D 0 4
NC2600GT100C	1 C 0 5	NC2600GT100D	1 D 0 5
NC2600GT110C	1 C 0 6	NC2600GT110D	1 D 0 6
NC2600GT120C	1 C 0 7	NC2600GT120D	1 D 0 7
NC2600GT130C	1 C 0 8	NC2600GT130D	1 D 0 8
NC2600GT140C	1 C 0 9	NC2600GT140D	1 D 0 9
NC2600GT150C	1 C 1 0	NC2600GT150D	1 D 1 0
NC2600GT160C	1 C 1 1	NC2600GT160D	1 D 1 1
NC2600GT170C	1 C 1 2	NC2600GT170D	1 D 1 2
NC2600GT180C	1 C 1 3	NC2600GT180D	1 D 1 3
NC2600GT190C	1 C 1 4	NC2600GT190D	1 D 1 4
NC2600GT200C	1 C 1 5	NC2600GT200D	1 D 1 5
NC2600GT210C	1 C 1 6	NC2600GT210D	1 D 1 6
NC2600GT220C	1 C 1 7	NC2600GT220D	1 D 1 7
NC2600GT230C	1 C 1 8	NC2600GT230D	1 D 1 8
NC2600GT240C	1 C 1 9	NC2600GT240D	1 D 1 9
NC2600GT250C	1 C 2 0	NC2600GT250D	1 D 2 0
NC2600GT260C	1 C 2 1	NC2600GT260D	1 D 2 1
NC2600GT270C	1 C 2 2	NC2600GT270D	1 D 2 2
NC2600GT280C	1 C 2 3	NC2600GT280D	1 D 2 3
NC2600GT290C	1 C 2 4	NC2600GT290D	1 D 2 4
NC2600GT300C	1 C 2 5	NC2600GT300D	1 D 2 5
NC2600GT310C	1 C 2 6	NC2600GT310D	1 D 2 6
NC2600GT320C	1 C 2 7	NC2600GT320D	1 D 2 7
NC2600GT330C	1 C 2 8	NC2600GT330D	1 D 2 8

APPLICATION NOTES

Operation of Step-down Switching Regulator and Output Current

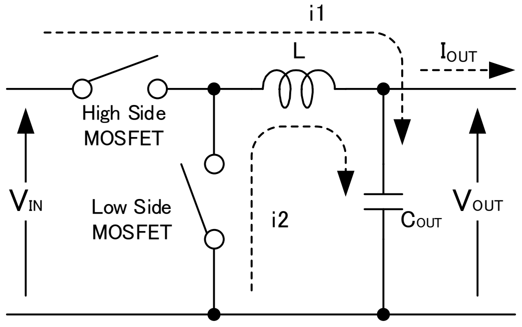
The operation of the step-down switching regulator is explained.

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}.

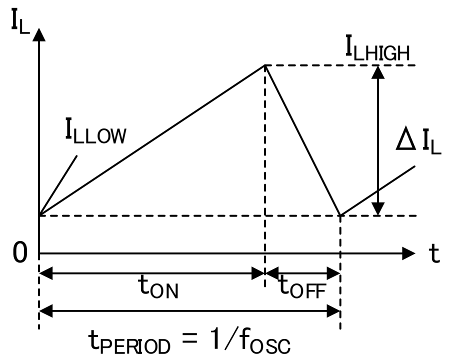
Step2. When the high side MOSFET turns off and the low side MOSFET turns on, the inductor operates to hold the inductor current $I_L = I_{LHIGH}$. At this time, the inductor uses the energy stored in Step 1 to flow the inductor current I_L = i2.

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.

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

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

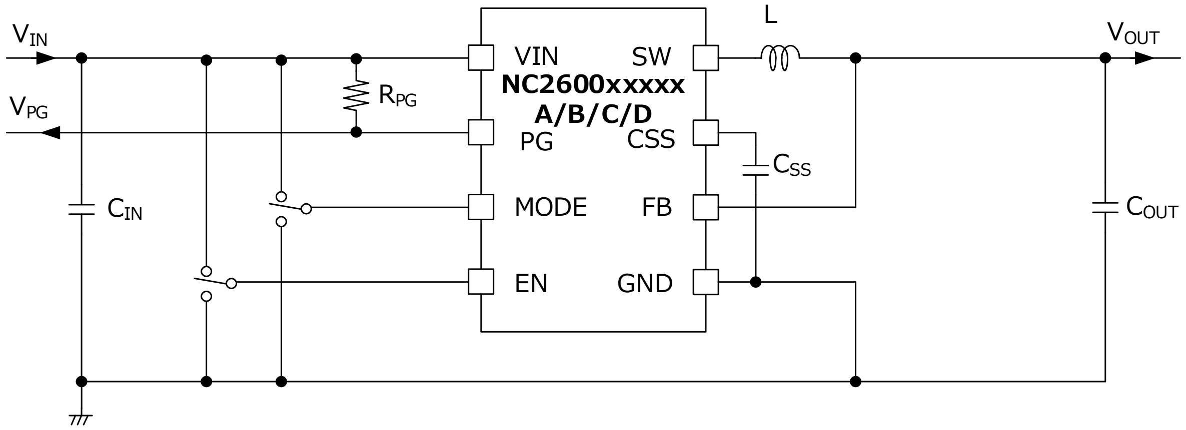
Ripple Current (I_{RP}) is as follows.

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

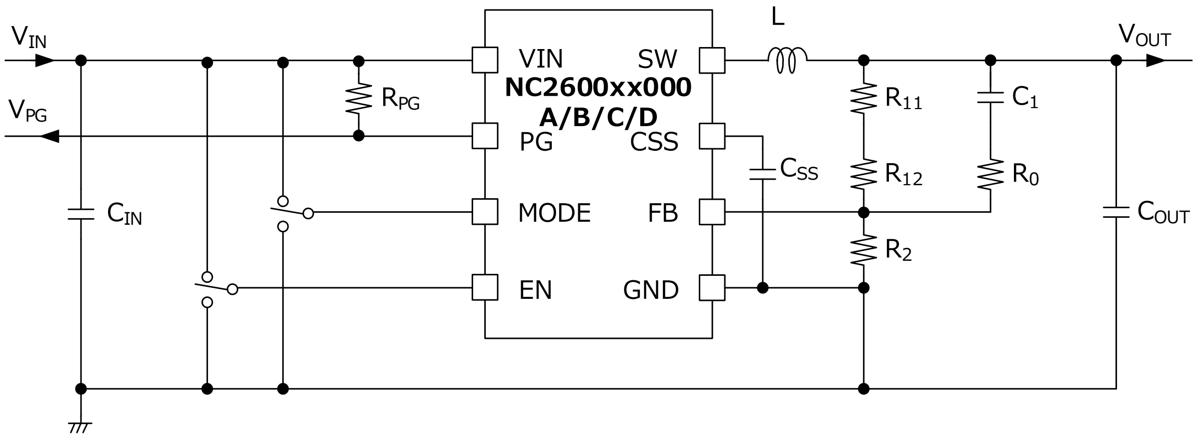
The peak current flowing through the inductor and high side MOSFET can be calculated by the following equation.

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

Typical Application Circuit



NC2600xxxxx (Fixed Output Voltage Type)



NC2600xx000 (Adjustable Output Voltage Type)

Recommended external parts

Symbol	Capacitance	Tolerance	Protection Voltage	Temperature characteristics
C_{IN}	4.7 µF	±20%	6.3 V	X5R
C_{OUT}	10 µF	±20%	6.3 V	X5R
C_{SS}	-	±20%	6.3 V	X5R

Symbol	Inductance	Tolerance	Rated Current
L	1.0 µH	±20%	2.0A

External Resistor for Setting Output Voltage (NC2600xx000x)

The output voltage can be set by the external resistors (R1, R2) connected to the FB pin as shown in the following equation.

$V_{SET} = V_{FB} \times (R1 + R2) / R2$
$R1 = R11 + R12$

The reference voltage (V_{FB}) of this IC is set 0.6 V. The V_{FB} accuracy and output voltage setting range are as follows.

V_{FB} Accuracy : 0.6 V ± 9 mV
Output Voltage Setting Range : $0.6\ V \leq V_{SET} \leq 5.5\ V$

Recommended values for R1, R2, and C1 are shown below.

Set Output Voltage (VSET) vs. R1,R2,C1 (Adjustable Output Voltage Type)

V_{SET} [V]	R1 [kΩ]	R2 [kΩ]	C1 [pF]
0.6	0	220	Open
$0.6 < V_{SET} \leq 2.1$	$R1 = (V_{SET} / V_{FB} - 1) \times R2$	220	10
$2.1 < V_{SET} \leq 4.0$		47	6.8
$4.0 < V_{SET} \leq 5.5$		33	3.3

When using R2 other than the above table, adjust C1 according to the table below and check that there is no problem with the actual application.

Set Output Voltage (VSET) vs. R2/C1 (Adjustable Output Voltage Type)

V_{SET} [V]	C1 [pF]
0.6	Open
$0.6 < V_{SET} \leq 2.1$	2200 / R2 [kΩ]
$2.1 < V_{SET} \leq 4.0$	319.6 / R2 [kΩ]
$4.0 < V_{SET} \leq 5.5$	108.9/ R2 [kΩ]

R0 prevents against the effects of noise. Noise varies depending on the board layout. R0 is not required for optimized boards, but if you are concerned about spikes, use about 1 kΩ.

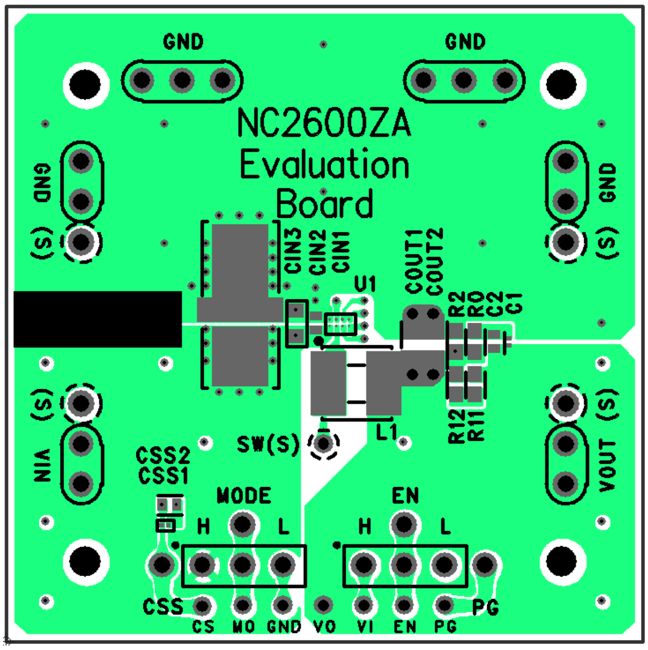
Cautions for Selecting External Components

- Choose a low ESR ceramic capacitor. The input capacitor (C_{IN}) between VIN and GND should be more than 4.7 μF, and the output capacitor (C_{OUT}) should be used of 10 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.
- The phase compensation of this device is designed according to the C_{OUT} and L values. The inductance value of an inductor should be 1.0 μH to gain stability.
- 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 the data sheet "Calculation Conditions of SW Pin Maximum Output Current (I_{SWMAX})".

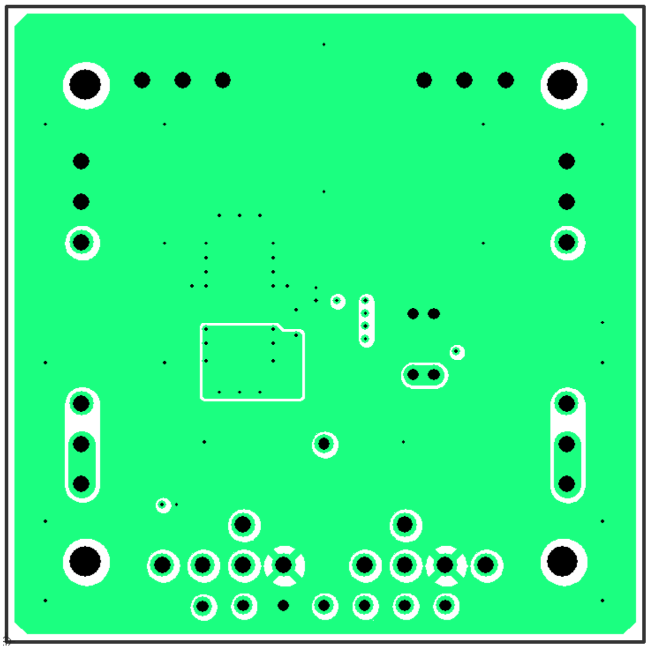
Evaluation Board / PCB Layout

NC2600ZA [WLCSP-8-P11]

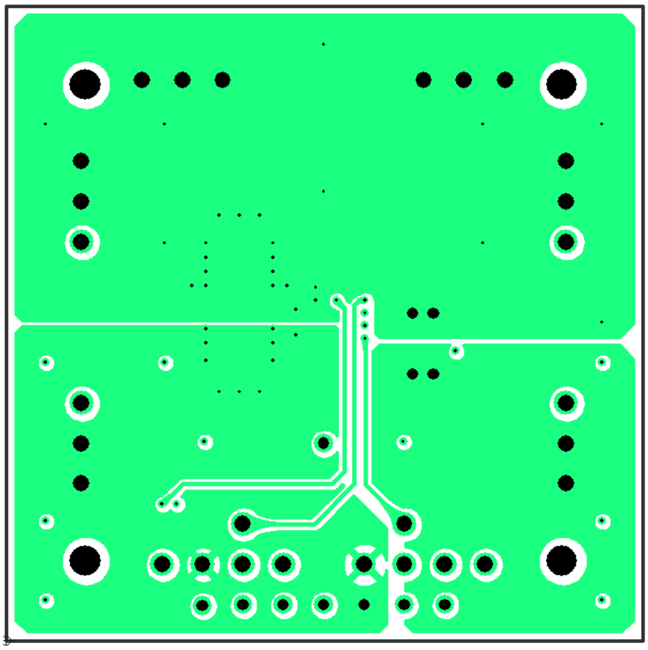
Layer 1



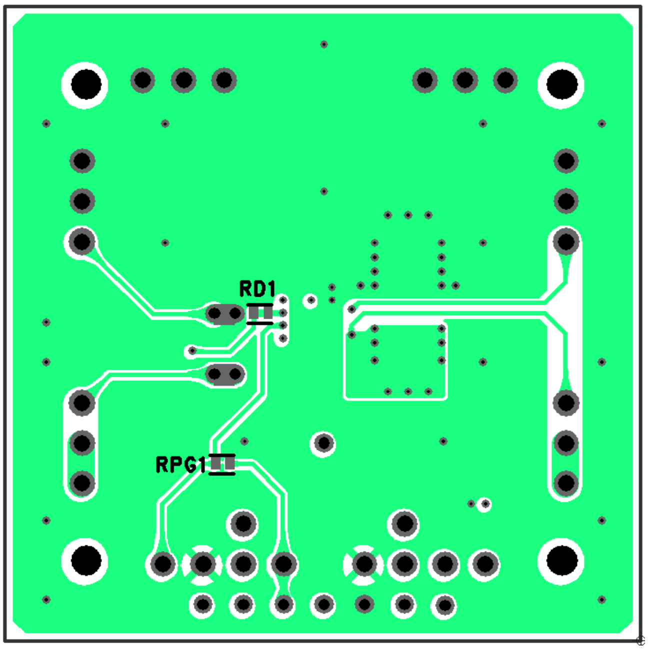
Layer 2



Layer 3

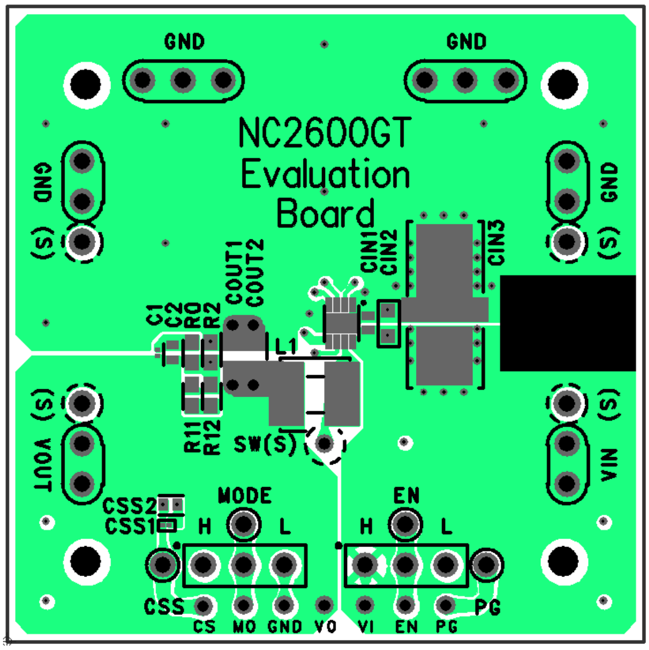


Layer 4

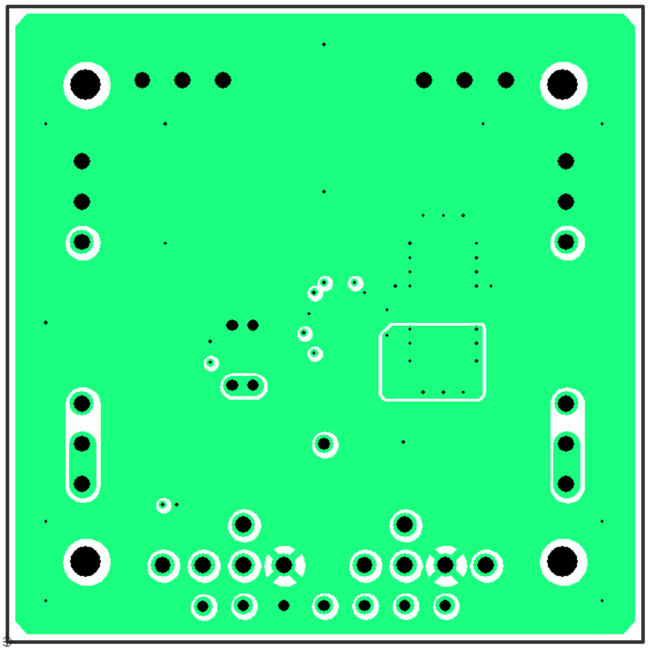


NC2600GT [DFN2020-8-GT]

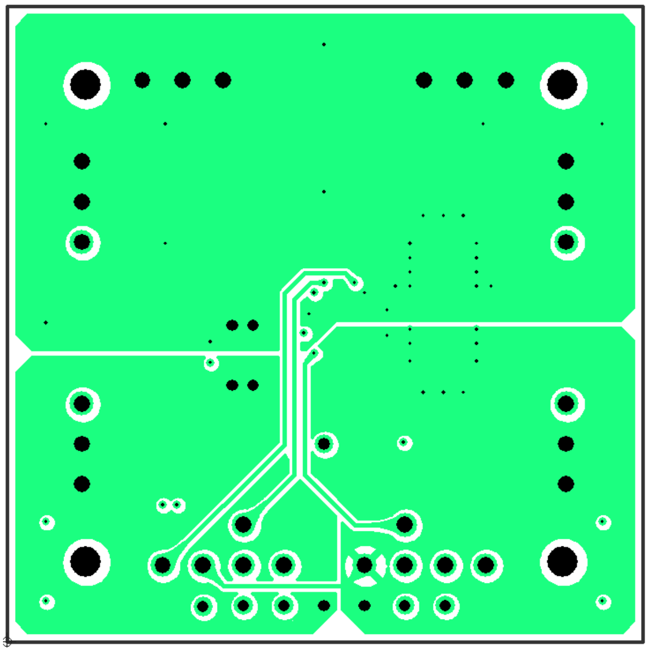
Layer 1



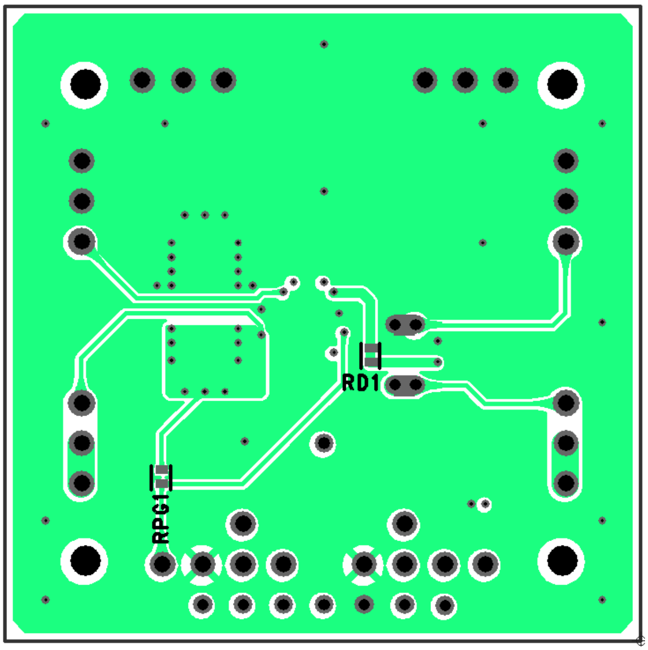
Layer 2



Layer 3



Layer 4



TECHNICAL NOTES

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. When designing a peripheral circuit, please be fully aware of the following points.

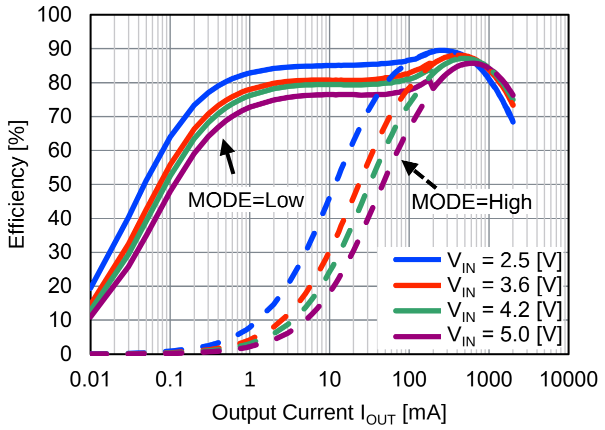
- External components must be connected as close as possible to the ICs and make wiring as short as possible and on the same side of the IC. Especially, the capacitor connected in between VIN pin and GND pin must be wiring the shortest.
- The VIN line, the GND line, and SW pin should make special considerations for the large switching current flows. If their impedance is high, internal voltage of the IC may shift by the switching current, and the operating may be unstable. Make the power supply and GND lines as wide and short as possible. The wiring from the SW pin to the inductor becomes a noise source, so ensure that the current capacity is secured and that the wiring is not wider or longer than necessary so that the noise does not increase.
- Connect C_{OUT} to the wiring between the FB pin and the inductor(L), or between the output voltage setting resistor (R1) and L. Also, keep them as far away as possible from noise sources such as inductors to prevent noise from being mixed in.
- The thermal shutdown function prevents the IC from fuming and ignition but does not ensure the IC’s reliability or keep the IC below the absolute maximum ratings. The thermal shutdown function does not operate on the heat generated by other than the normal IC operation such as latch-up and overvoltage application. The thermal shutdown function operates in a state over the absolute maximum ratings, therefore the thermal shutdown function should not be used for a system design.
- The tab on the bottom side of the DFN-Package is recommended to be connected to GND. It will work even if it is open, but please note that the heat dissipation and mounting strength will decrease.

TYPICAL CHARACTERISTICS

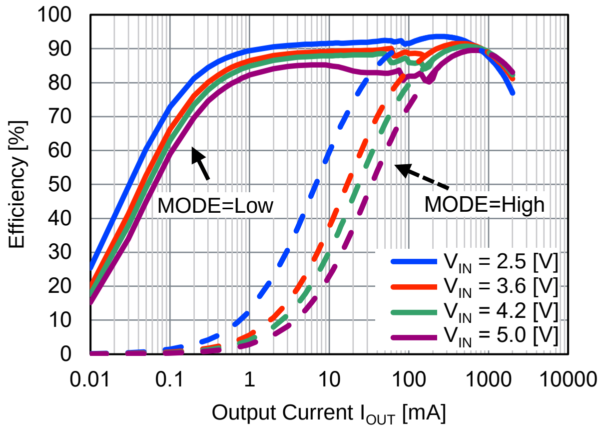
Typical characteristics are intended to be used as reference data, they are not guaranteed.

1)Efficiency vs Output Current

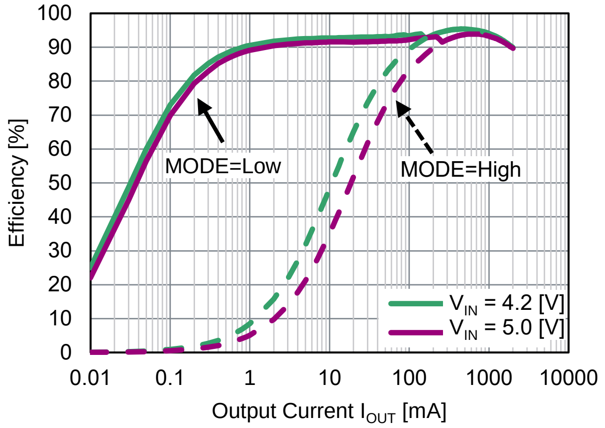
NC2600ZA
V_{OUT} = 1.2 [V]



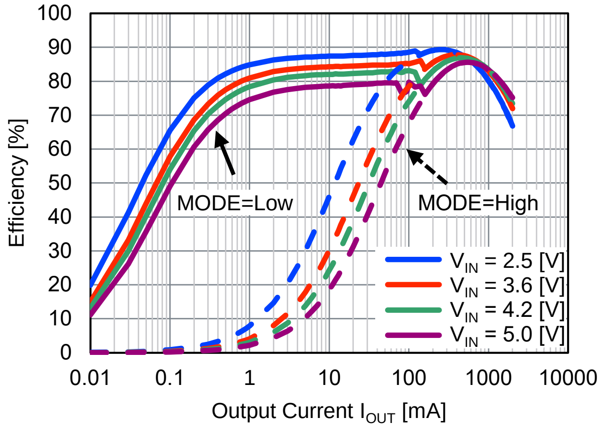
NC2600ZA
V_{OUT} = 1.8 [V]



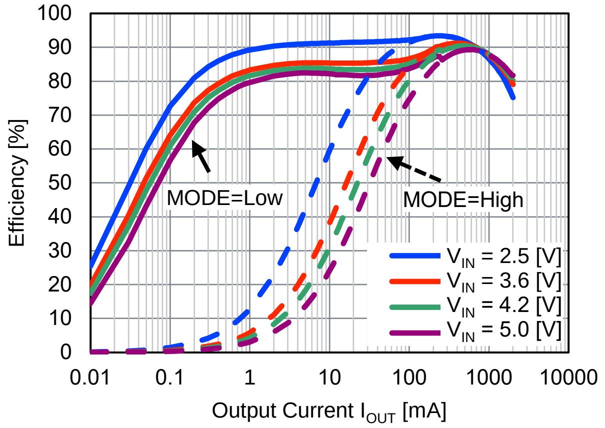
NC2600ZA
V_{OUT} = 3.3 [V]



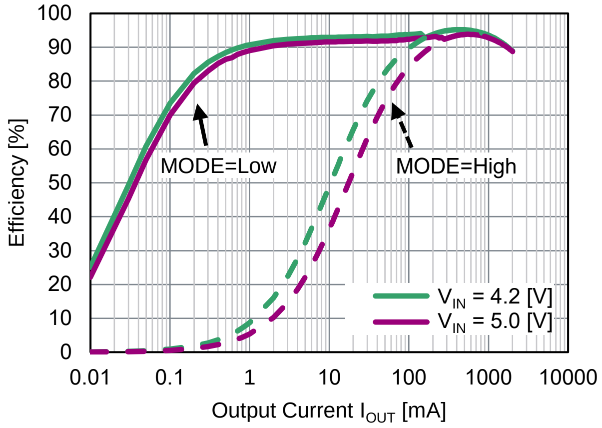
NC2600GT
V_{OUT} = 1.2 [V]



NC2600GT
V_{OUT} = 1.8 [V]

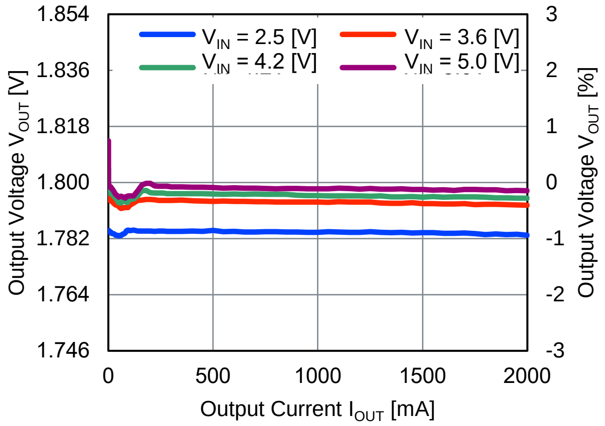


NC2600GT
V_{OUT} = 3.3 [V]

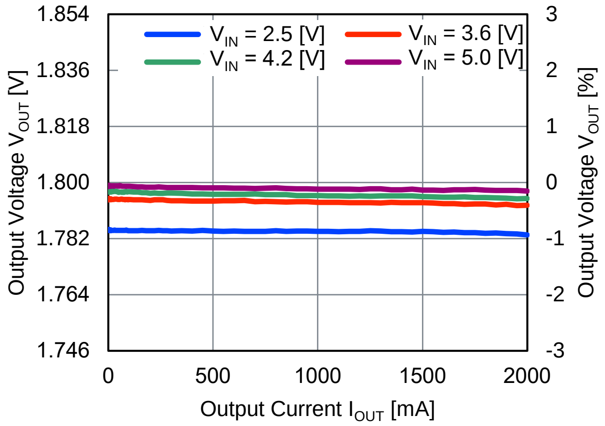


2)Output Voltage vs Output Current
NC2600ZA
V_{OUT} = 1.8 [V]

MODE = Low

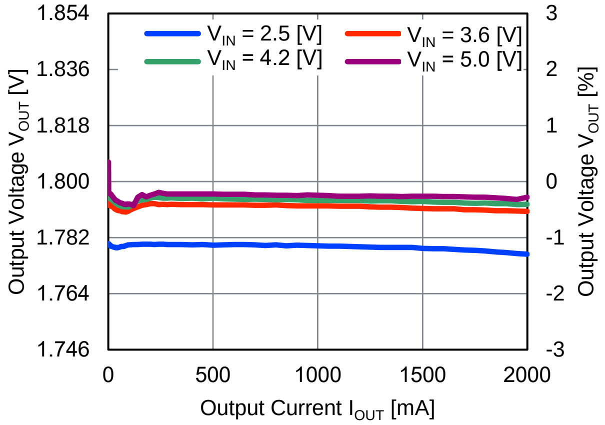


MODE = High

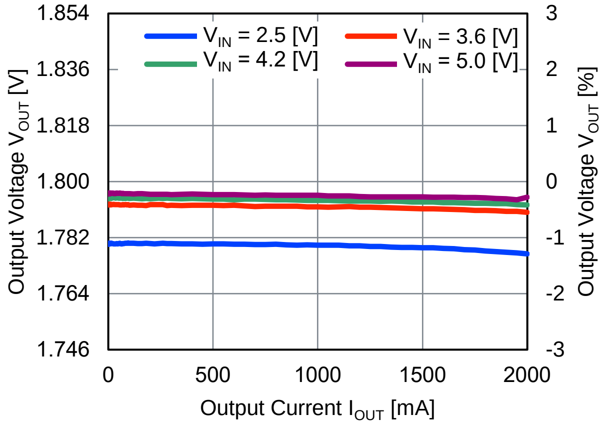


NC2600GT
V_{OUT} = 1.8 [V]

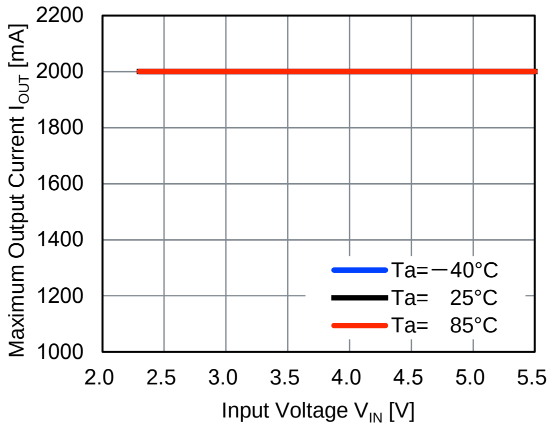
MODE = Low



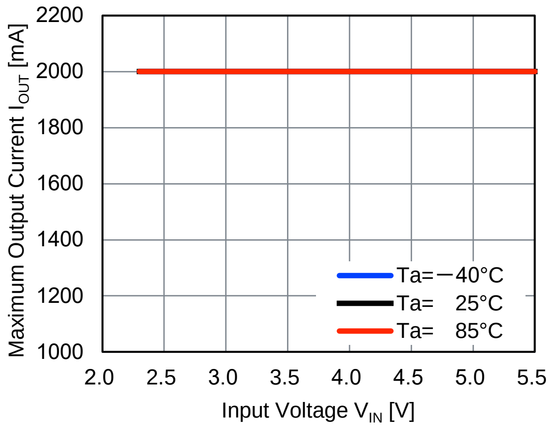
MODE = High



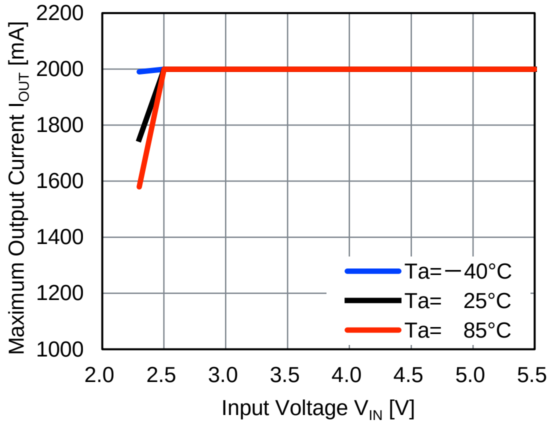
3)Maximum Output Current vs V_{IN}
MODE = High
NC2600ZA
V_{OUT} = 0.6 [V]



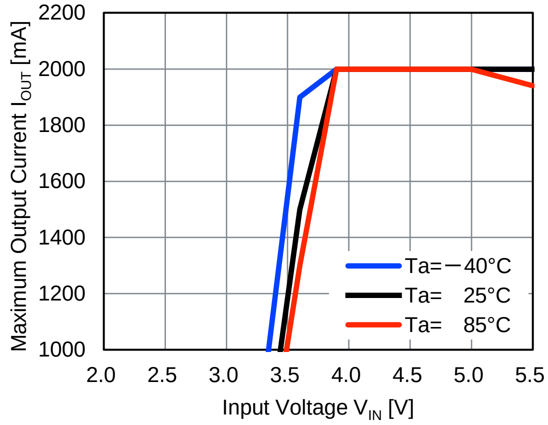
V_{OUT} = 1.2 [V]



V_{OUT} = 1.8 [V]

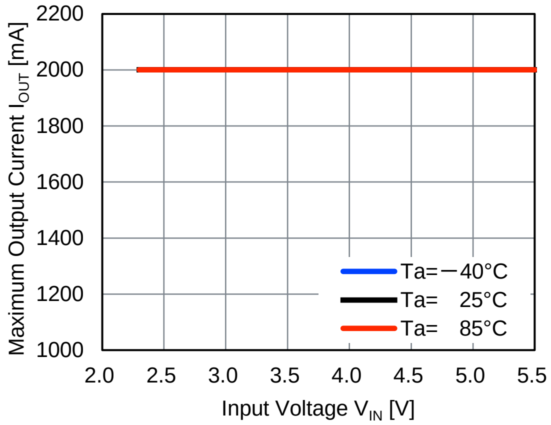


V_{OUT} = 3.3 [V]

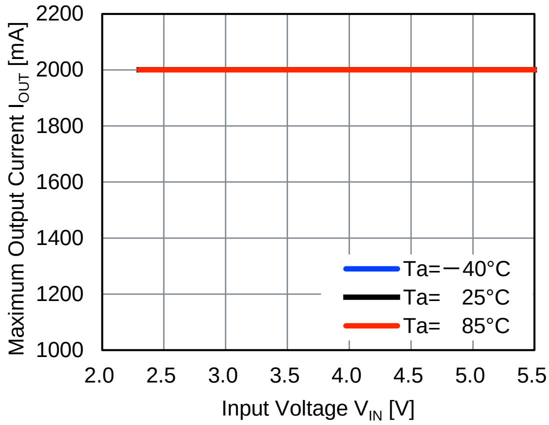


NC2600GT

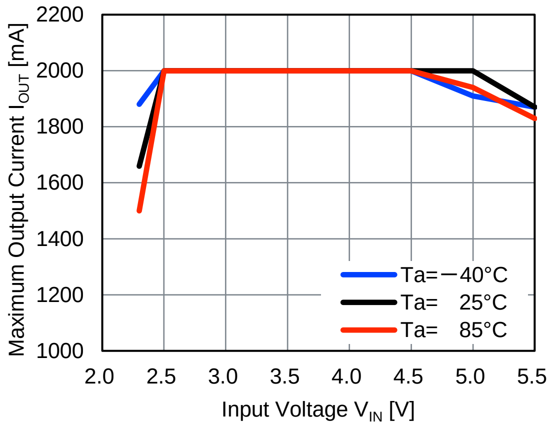
V_{OUT} = 0.6 [V]



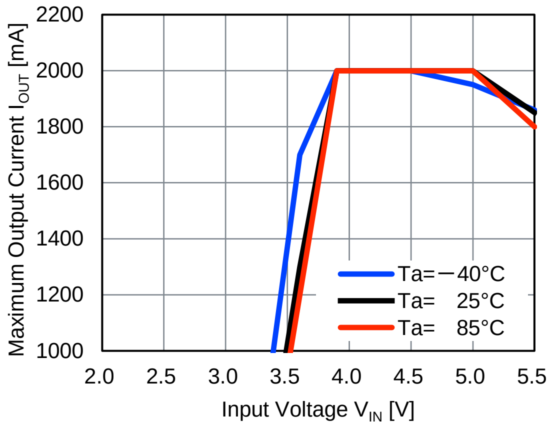
V_{OUT} = 1.2 [V]



V_{OUT} = 1.8 [V]

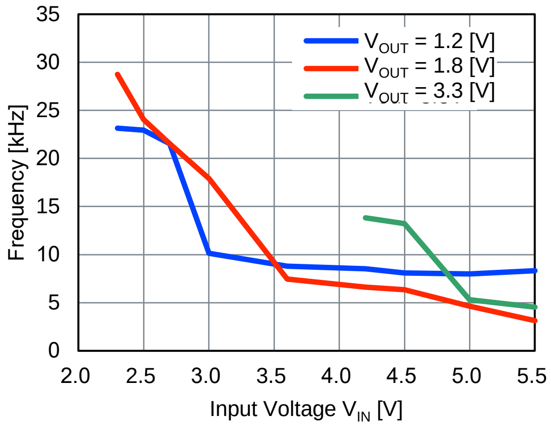


V_{OUT} = 3.3 [V]

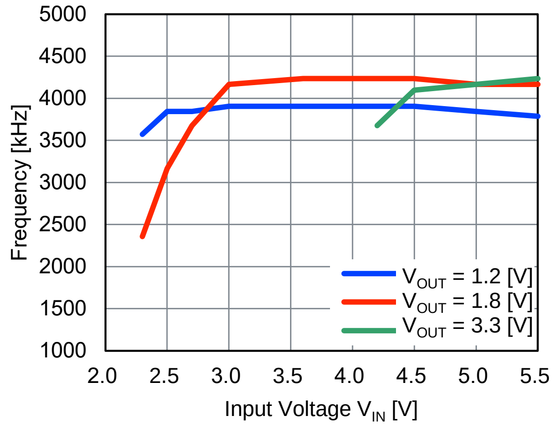


4)Switching Frequency vs Input Voltage

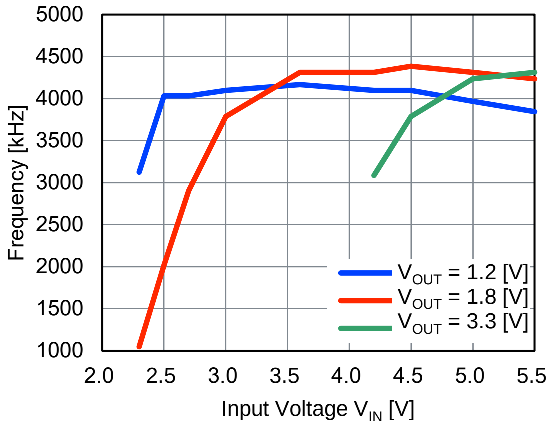
I_{OUT} = 1 [mA]
MODE = Low



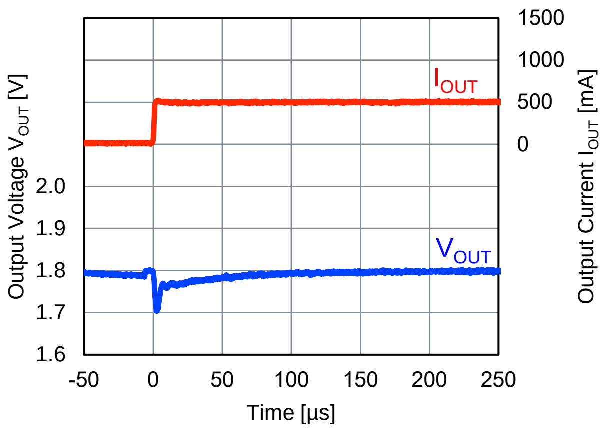
I_{OUT} = 1 [mA]
MODE = High



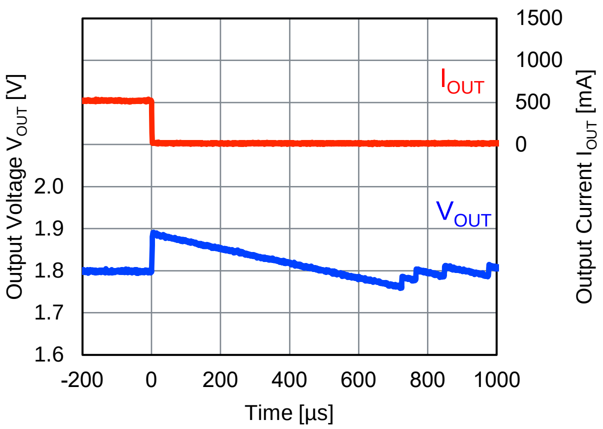
I_{OUT} = 1000 [mA]
MODE = Low



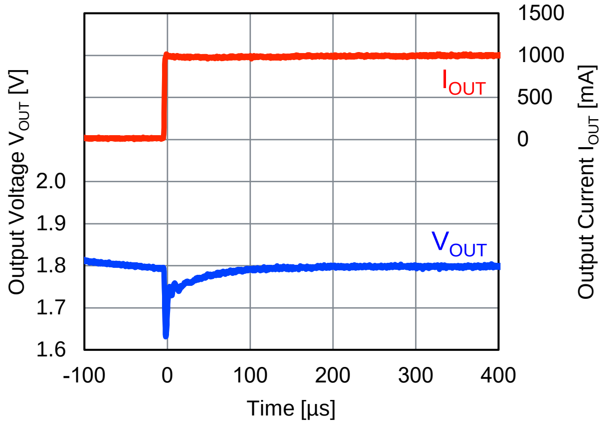
5)Load Transient Response
V_{IN} = V_{EN} = 3.6 [V] , V_{OUT} = 1.8 [V]
MODE = Low
I_{OUT} = 1 [mA] -> 500 [mA]



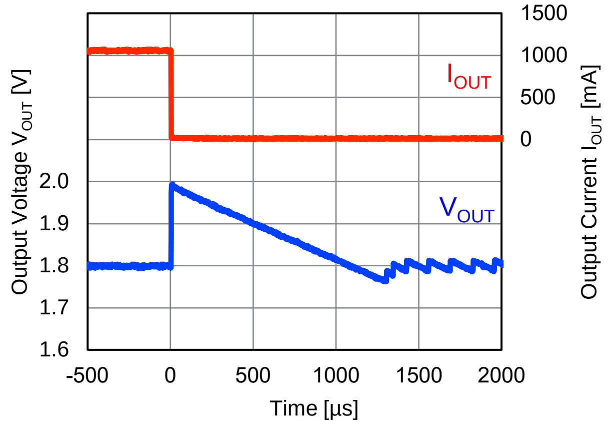
I_{OUT} = 500 [mA] -> 1 [mA]



I_{OUT} = 1 [mA] -> 1000 [mA]

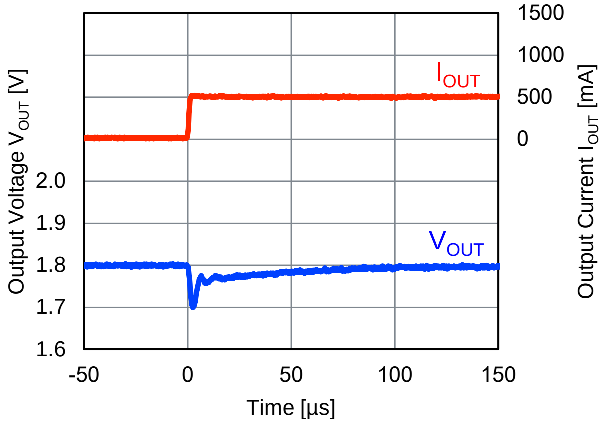


I_{OUT} = 1000 [mA] -> 1 [mA]

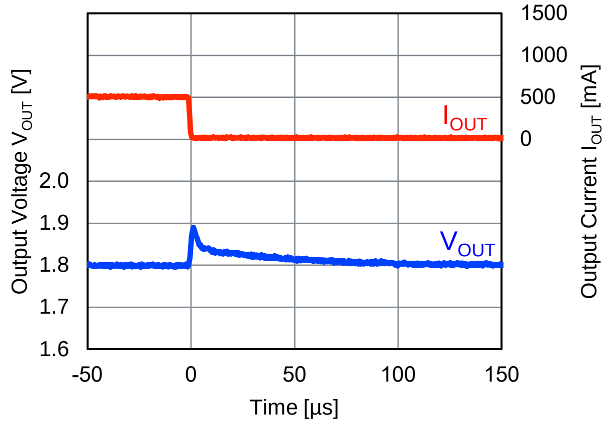


MODE = High

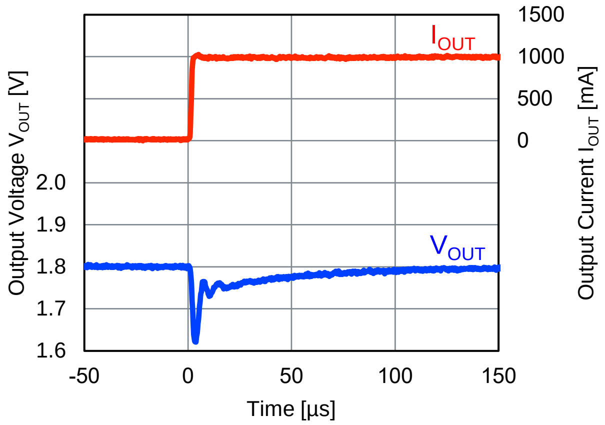
I_{OUT} = 1 [mA] -> 500 [mA]



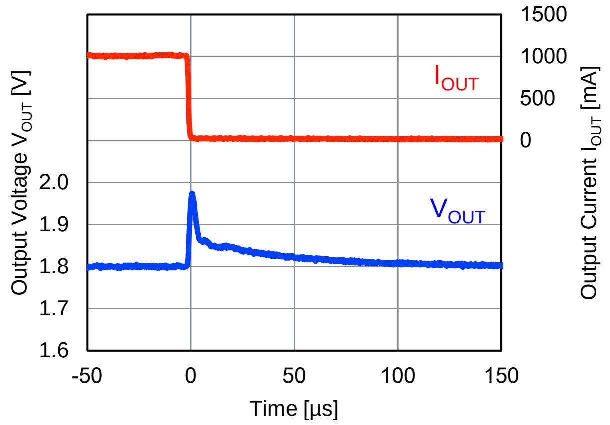
I_{OUT} = 500 [mA] -> 1 [mA]



I_{OUT} = 1 [mA] -> 1000 [mA]

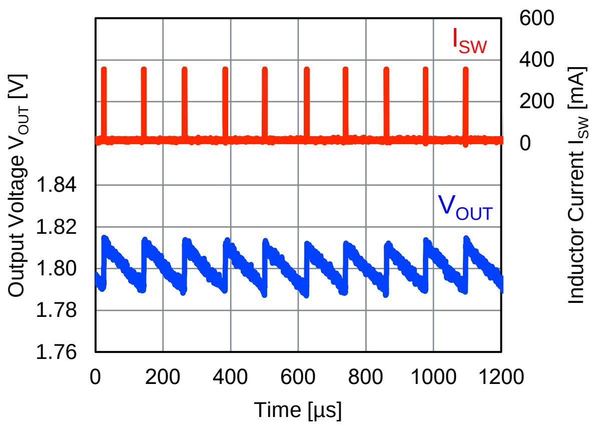


I_{OUT} = 1000 [mA] -> 1 [mA]

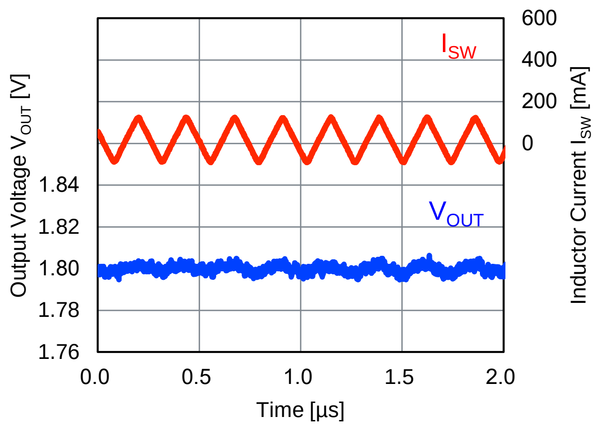


6)Output Voltage Waveform
$V_{IN} = V_{EN} = 3.6$ [V] , $V_{OUT} = 1.8$ [V]
$I_{OUT} = 1$ [mA]

MODE = Low

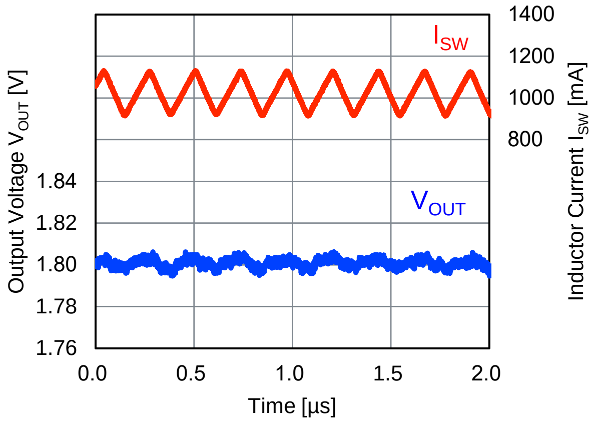


MODE = High

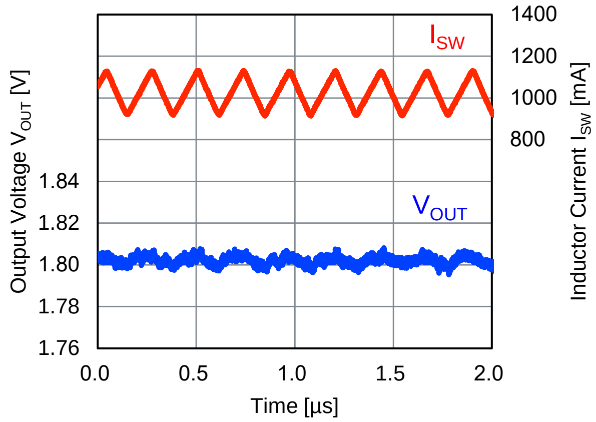


$I_{OUT} = 1000$ [mA]

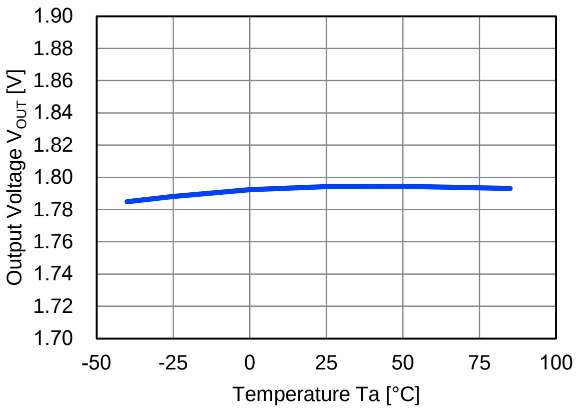
MODE = Low



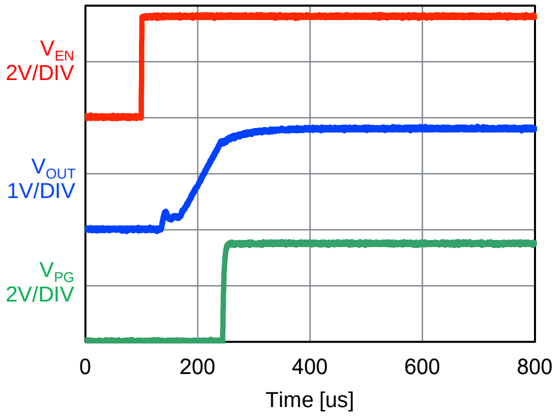
MODE = High



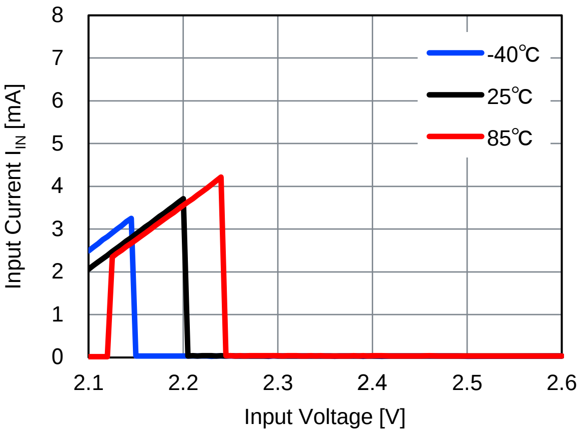
7)Output Voltage vs Temperature
$V_{IN} = V_{EN} = 3.6$ [V] , $V_{OUT} = 1.8$ [V]
$I_{OUT} = 0$ [mA]
MODE = High



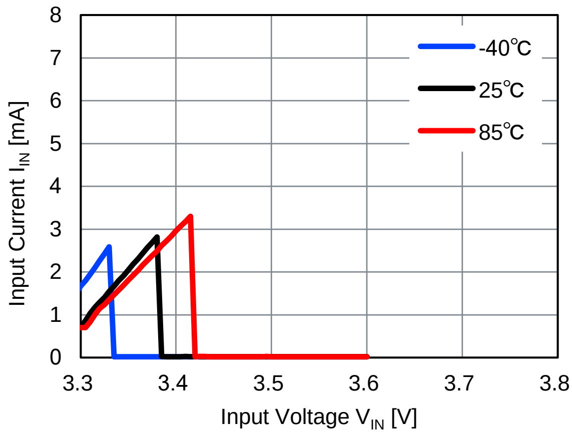
8)Soft-Start Waveform
V_{OUT} = 1.8 [V], MODE = High, C_{SS} = open, I_{OUT} = 0 [mA]
V_{IN} = 3.6 [V], V_{EN} = 0 -> 3.6 [V]



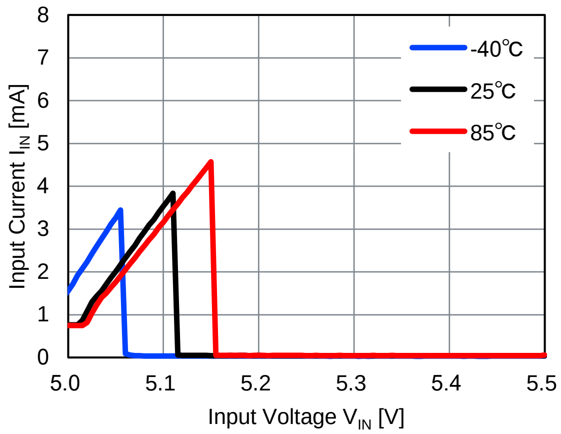
9)Input Current vs Input Voltage
MODE = Low
V_{OUT} = 2.1 [V]



V_{OUT} = 3.3 [V]

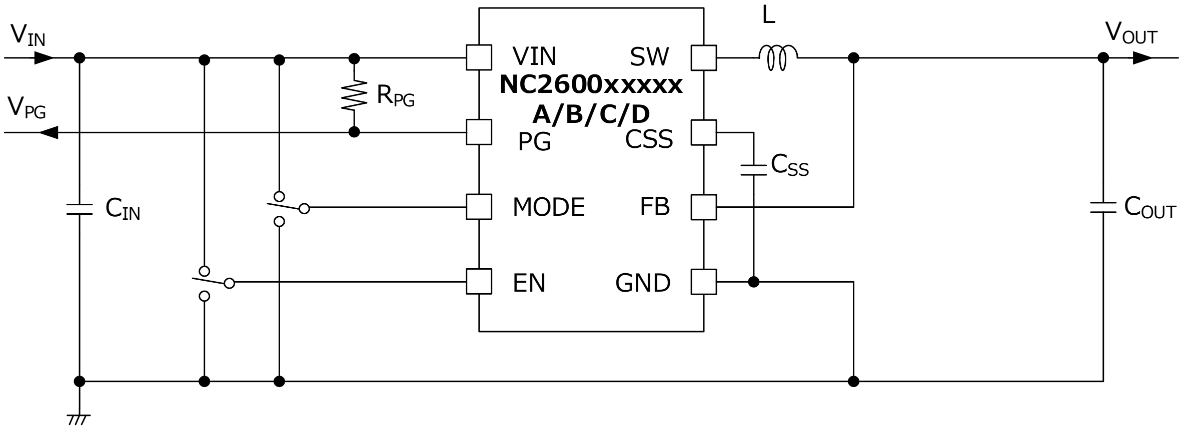


V_{OUT} = 5.0 [V]



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

TEST CIRCUIT



NC2600xxxxx (Fixed Output Voltage Type) Test Circuit

【Components List for Our Evaluation】

Symbol	Specification	Parts Number
C_{IN}	4.7 µF	GRM035R60J475ME
C_{OUT}	10 µF	GRM155R60J106ME44
L	1.0 µH	TFM201610ALM-1R0MTAA

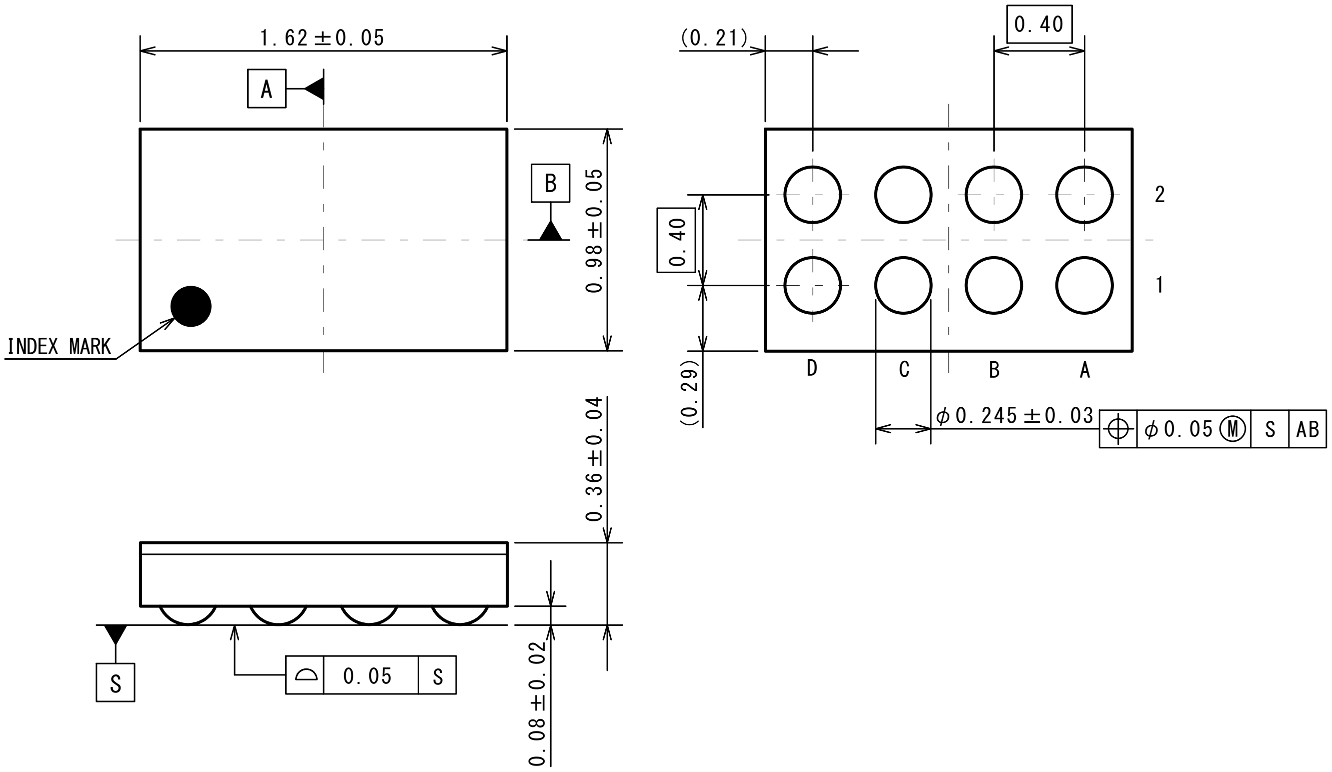
Nisshinbo Micro Devices Inc.

WLCSP-8-P11

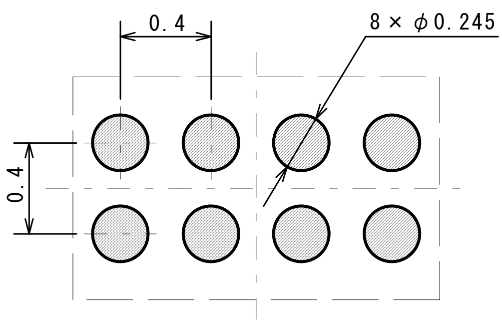
PI-WLCSP-8-P11-E-C

■ PACKAGE DIMENSIONS

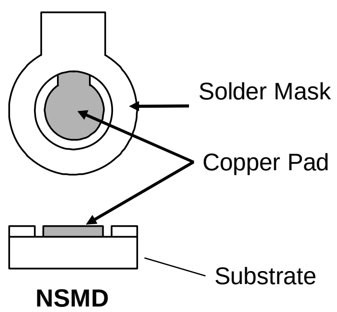
UNIT: mm



■ EXAMPLE OF SOLDER PADS DIMENSIONS



Recommended Land Pattern



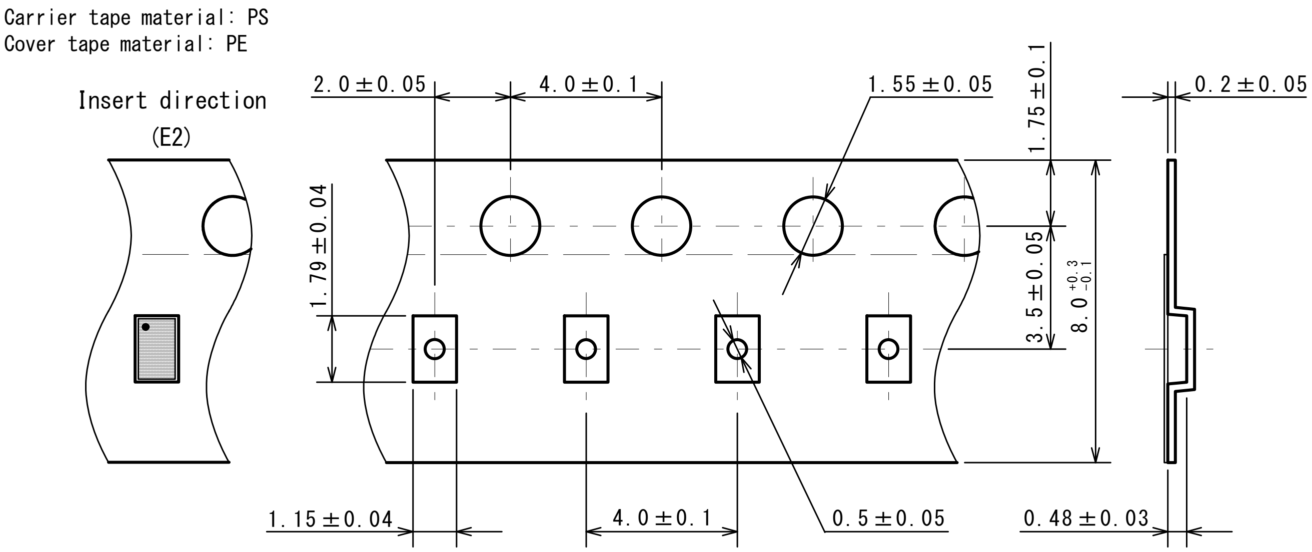
NSMD Pad Definition		
Pad definition	Copper Pad	Solder Mask Opening
NSMD (Non-Solder Mask defined)	0.245mm	MIN. 0.345mm

*) Pad Layout and size can modify by customers material, equipment and method.
*) Please adjust pad layout according to your conditions.
*) Recommended Stencil Aperture Size: ϕ0.245mm

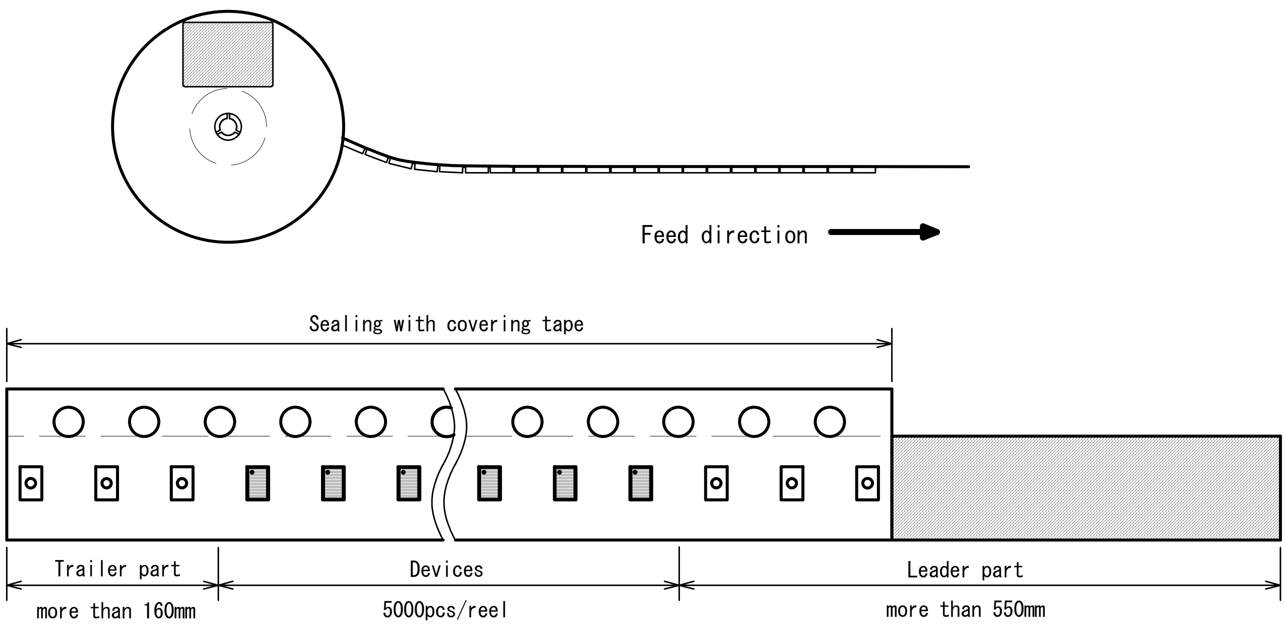
■ **PACKING SPEC**

UNIT: mm

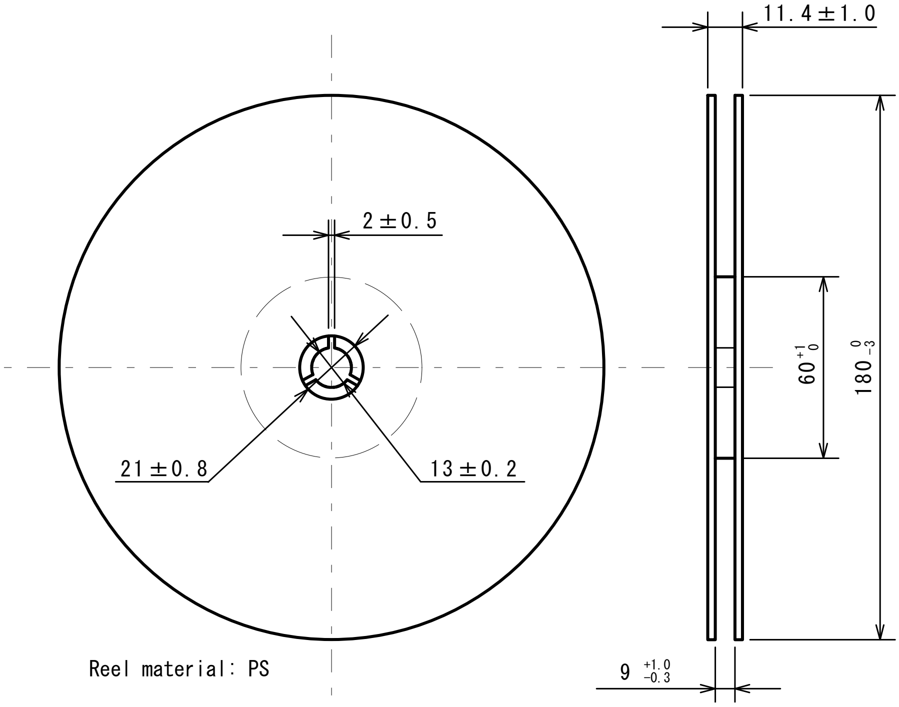
(1) Taping dimensions / Insert direction



(2) Taping state



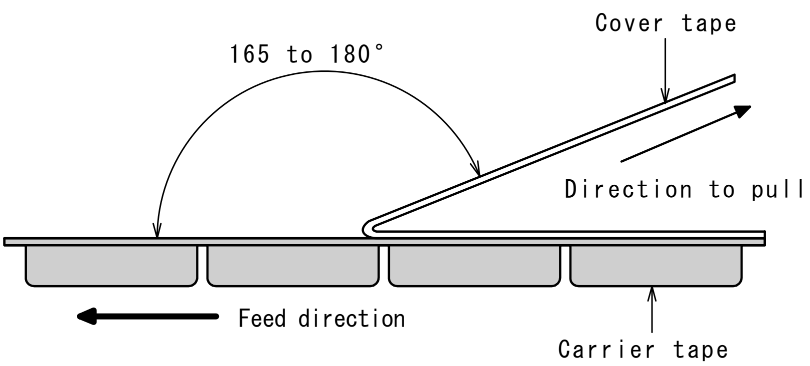
(3) Reel dimensions



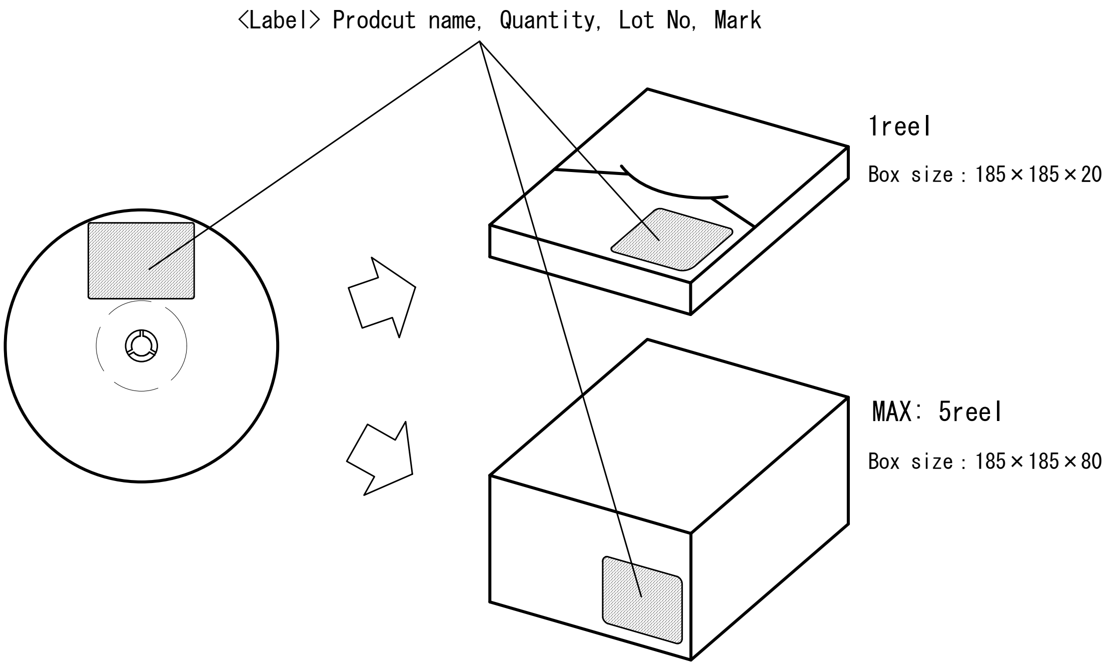
(4) Peeling strength

Peeling strength of cover tape

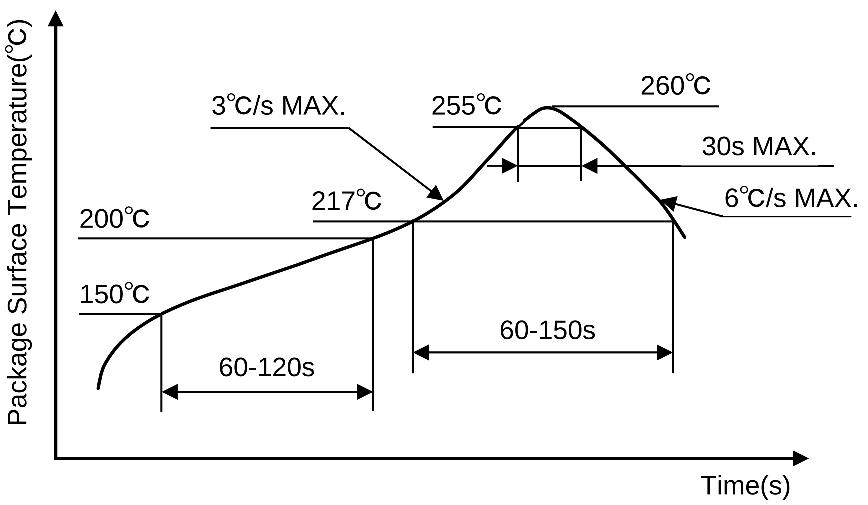
・Peeling angle	165 to 180° degrees to the taped surface.
・Peeling speed	300mm/min
・Peeling strength	0.1 to 1.0N



(5) Packing state



■ **HEAT-RESISTANCE PROFILES**



Reflow profile

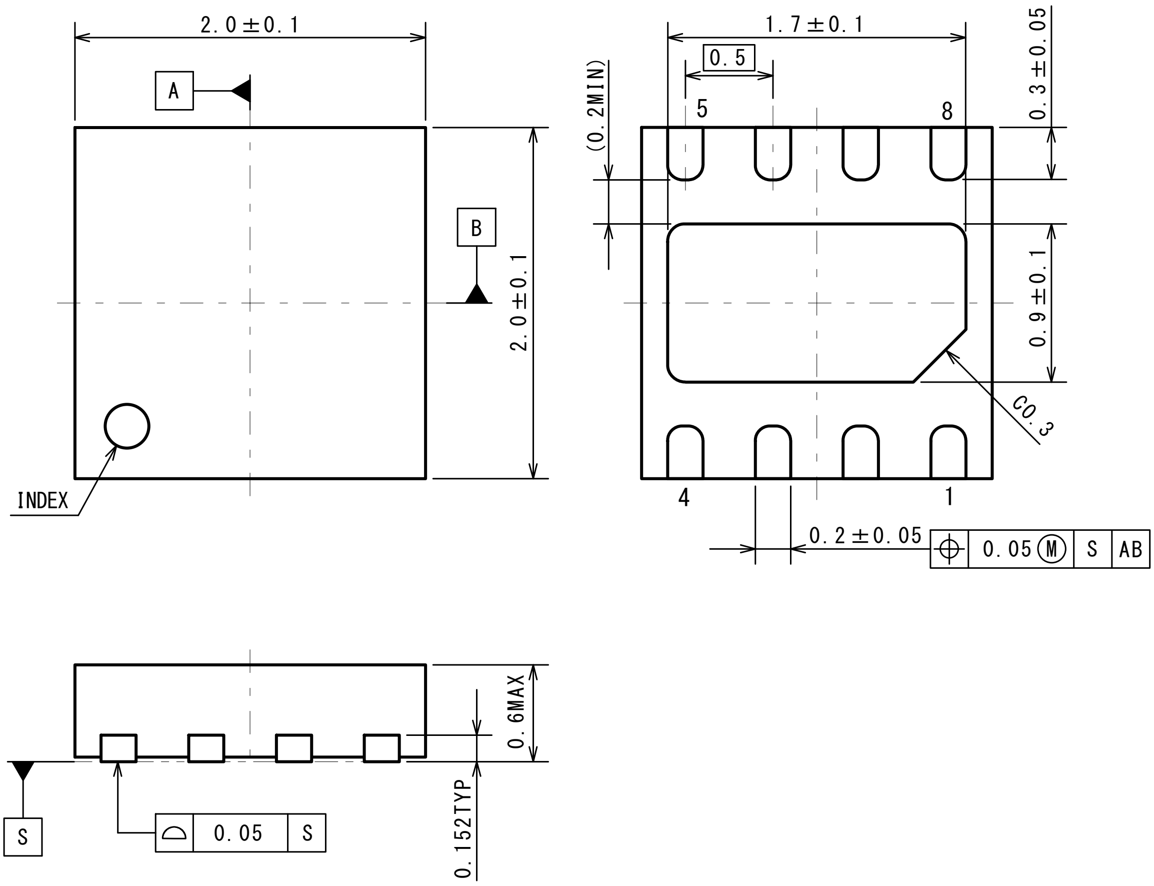
Nisshinbo Micro Devices Inc.

DFN2020-8-GT

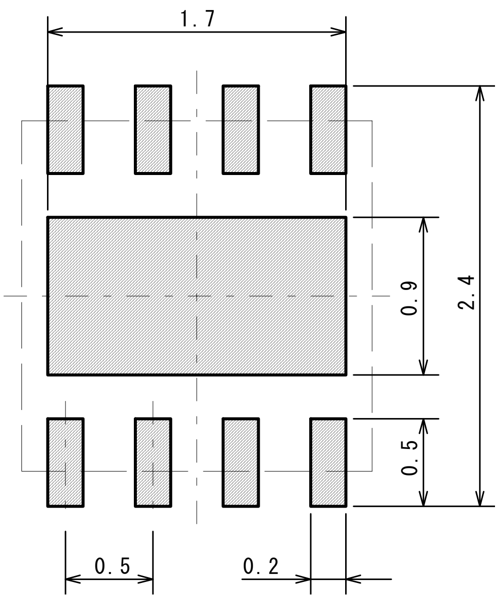
PI-DFN2020-8-GT-E-A

■ PACKAGE DIMENSIONS

UNIT: mm



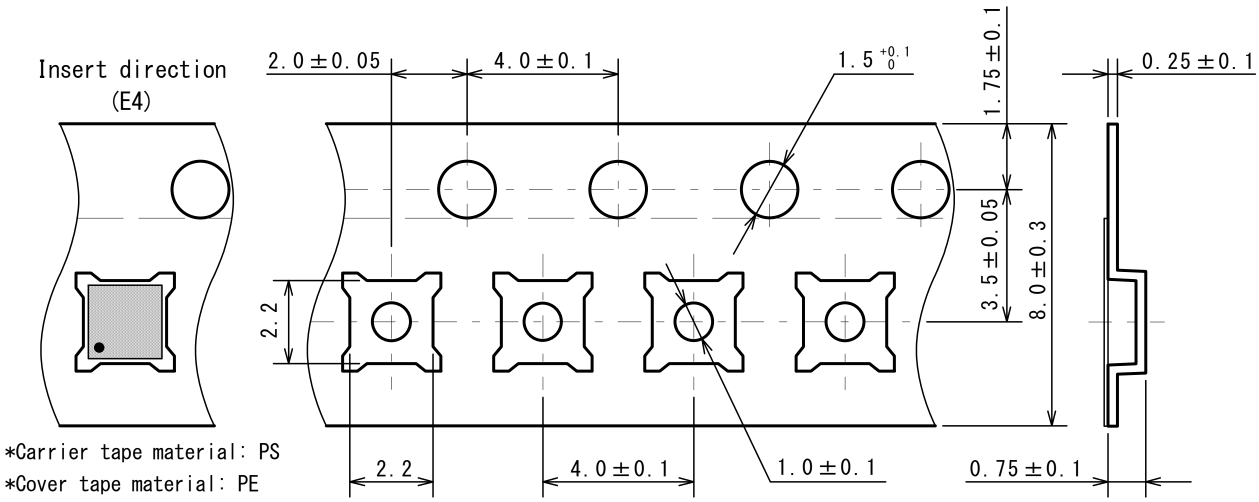
■ EXAMPLE OF SOLDER PADS DIMENSIONS



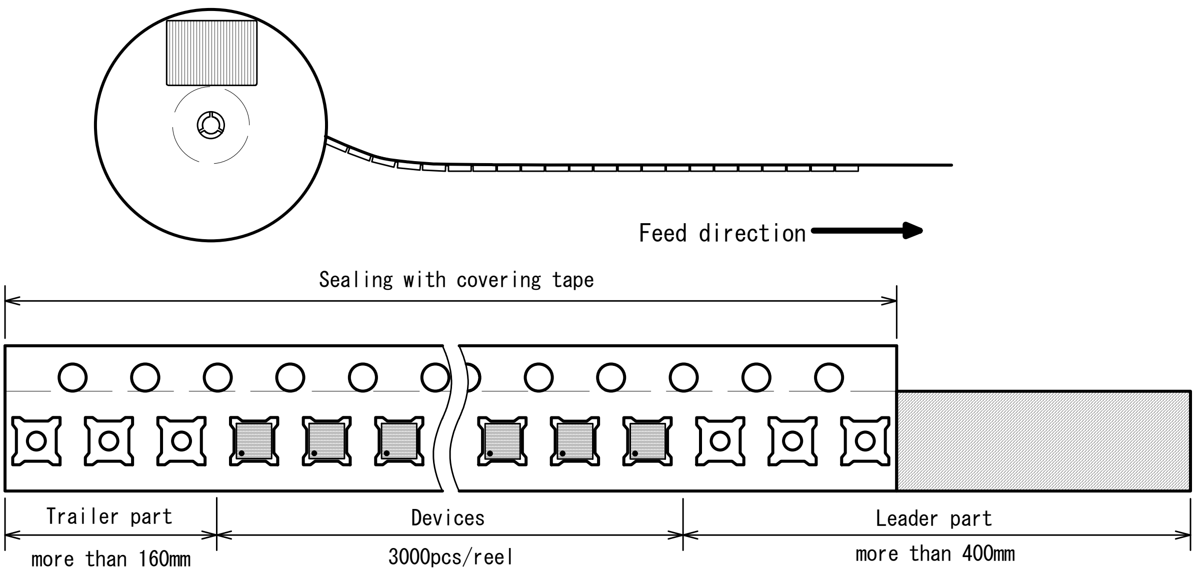
■ **PACKING SPEC**

UNIT: mm

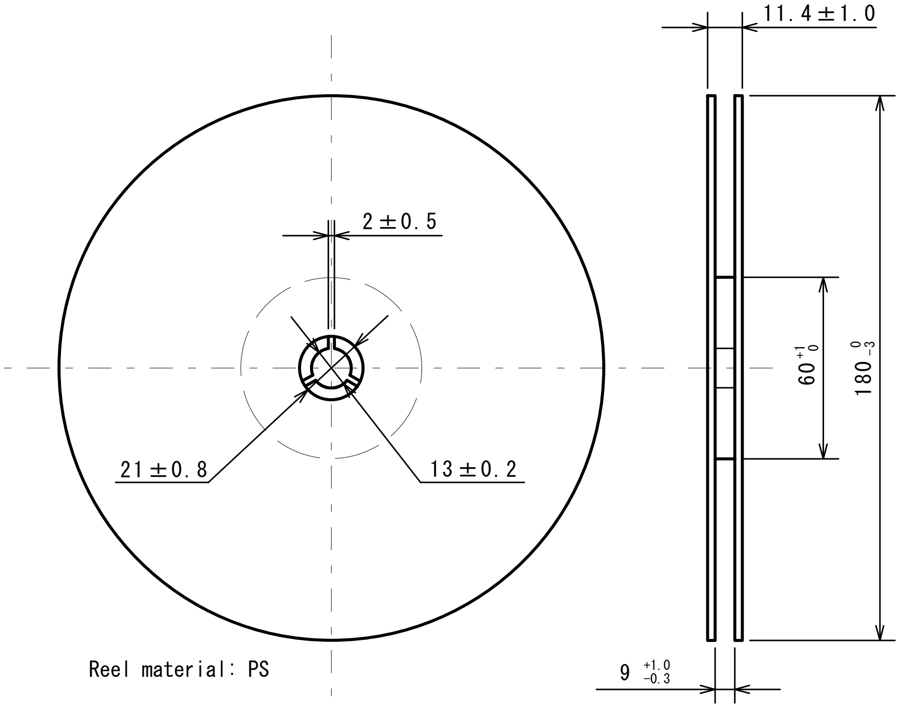
(1) Taping dimensions / Insert direction



(2) Taping state



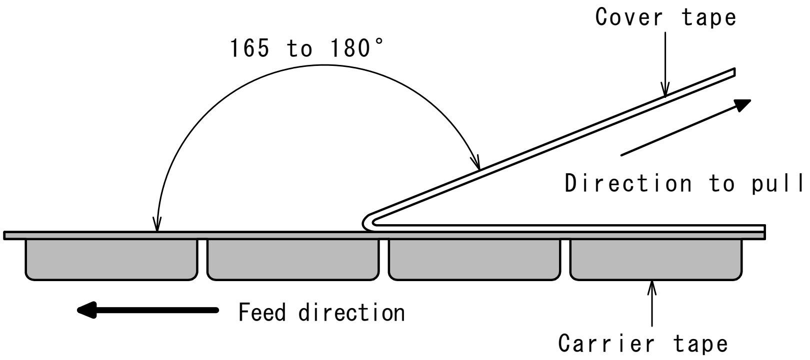
(3) Reel dimensions



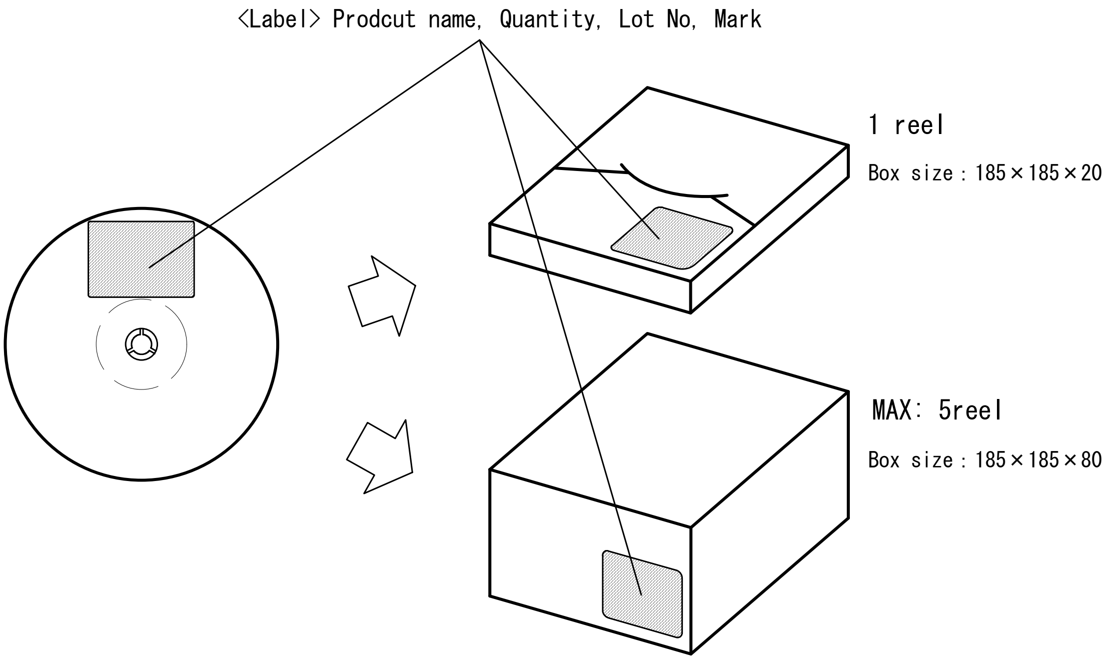
(4) Peeling strength

Peeling strength of cover tape

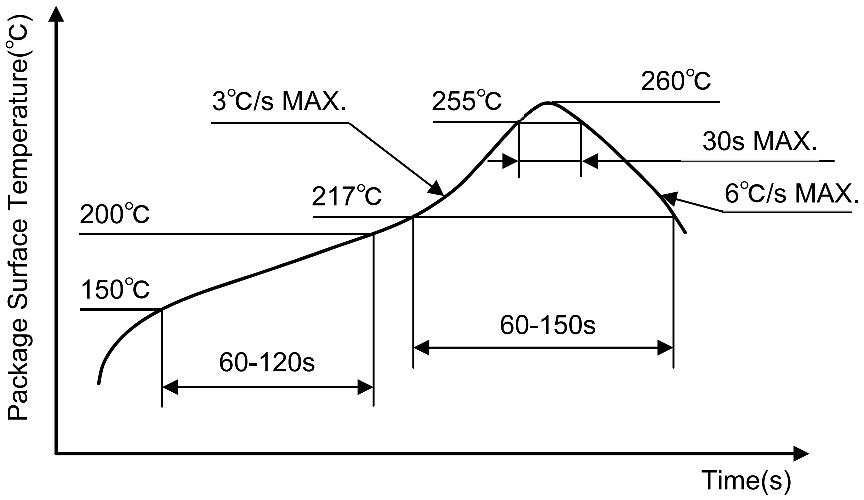
- ・Peeling angle 165 to 180° degrees to the taped surface.
- ・Peeling speed 300mm/min
- ・Peeling strength 0.1 to 1.0N



(5) Packing state



■ **HEAT-RESISTANCE PROFILES**



Reflow profile

Revision History

Date	Version	Contents of Changes
August 26.2022	1.0	Initial release
October 18.2022	1.1	・Corrected the size thickness of DFN2020-8-GT to 0.6 (mm). ・Added page for marking specification.
February 22.2023	1.2	・In NC2600GT lineup added. ・In NC2600ZA, the mark specification was corrected (addition of NC2600ZA100B, correction of mark numbering) and the format was changed.
March 24, 2023	1.3	・In NC2600GT lineup added. ・In NC2600ZA, the mark specification was corrected (addition of NC2600ZA100B, correction of mark numbering) and the format was changed.

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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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