NR1644 series

Low Noise High RR Low Dropout 2A 0.4V Output Voltage Regulator

FEATURES

- Operating Junction Temperature Range: -40 ºC to 125 ºC
- Input Voltage Range (Absolute Maximum Rating):
  V_{IN}: V_{SET} + V_{DO} to V_{BIAS} (6.5 V)
  V_{BIAS}: V_{SET} + 1.5V(≥2.4V) to 5.5V (6.5 V)
- Output Voltage Range: 0.4 V to 1.5 V
- Output Voltage Accuracy: ±1.0% (T_a = 25 ºC)
- Output Current: 2.0 A
- Quiescent Current (Automatic Mode Alternative version): Typ. 75 µA
- Quiescent Current (Fast-mode Fixed version): Typ. 1.0 mA
- Output Noise Voltage (10 Hz to 100 kHz):Typ. 5 µVrms
- VIN pin Ripple Rejection:
  Typ. 110 dB (f = 1 kHz, I_{OUT} = 1 A)
  Typ. 50 dB (f = 1 MHz, I_{OUT} = 1 A)
- Dropout Voltage: Typ. 90 mV (I_{OUT} = 1 A)
  Typ. 180 mV (I_{OUT} = 2 A)
- Ceramic Capacitors are Recommended:
  C_{OUT} ≥ 10 µF, C_{IN} ≥ 4.7 µF, C_{NR} = 0.1 µF to 2.2 µF
- Protection Function: Thermal Shutdown Function, UVLO Function (VIN)
- Soft-start Function, Discharge Function, Power-Good Function

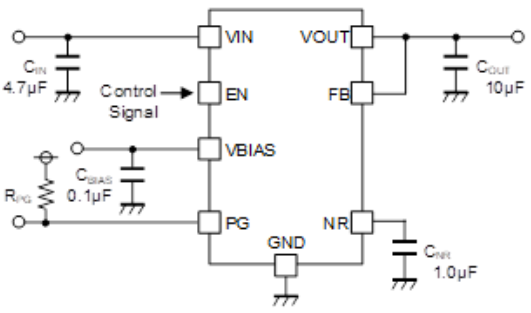
GENERAL DESCRIPTION

The NR1644 series is CMOS based low-dropout voltage regulator.
This device is characterized by ultra-low output noise, high ripple rejection, high-speed response characteristics, and low current quiescent current.
By automatic alternative between Fast-mode and Low-power-mode according to the load current, the current consumption at light loads is reduced.
For responsive applications, the Fast-mode fixed version is available.
The NR1644 series has the Soft-start function that allows the rise time to be set by changing the capacitance of the external capacitor (C_{NR}).
NR1644 achieves the low current consumption, ultra-low output noise, and high ripple rejection, so it is suitable for applications including IoT devices, battery-powered devices, and analog components that require attention to noise.

APPLICATIONS

- CMOS image sensor
- Communication devices such as RF modules, Clock generation device such as VCO or PLL
- High accuracy ADC, DAC
- Low power consumption SoC, FPGA

TYPICAL APPLICATION CIRCUIT

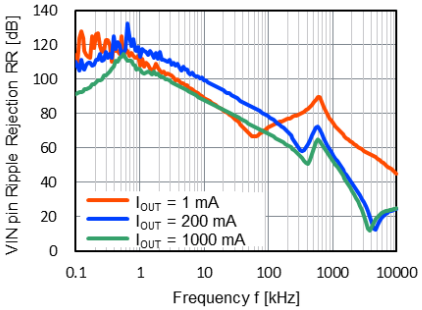


Package (unit: mm)

DFN2020-8-GA
2.0 x 2.0 x 0.8

TYPICAL CHARACTERISTICS

VIN Pin Ripple Rejection vs Frequency



NR1644xx040B, V_{IN}=0.9 V, V_{BIAS}=3.6 V,
C_{IN} = none, C_{BIAS} = 0.1 µF, C_{NR} = 1.0 µF, C_{OUT} = 10 µF

■ PRODUCT NAME INFORMATION

NR1644 aa bbb c dd e

Description of the configuration

Composition	Item	Description
aa	Package code	Indicates the package. GA : DFN2020-8-GA
bbb	Output Voltage	Set Output Voltage (V_{SET}). The lineup ranges from 0.4 V (040) to 1.5 V (150) in 0.1 V steps.
c	Version	Automatic mode alternative between Fast-mode and Low-power-mode, and Fast-mode fixing can be selected. A: Automatic mode alternative version B: Fast-mode fixed version
dd	Packing	E4 : Insert Direction. Refer to the packing specifications.
e	Grade	Indicates the quality grade. S: Standard

Version

c	Automatic Mode Alternative / Fast-mode Fiexed
A	Automatic Mode Alternative
B	Fast-mode Fixed

Grade

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

■ ORDER INFORMATION

PRODUCT NAME	PACKAGE	RoHS	HALOGEN FREE	PLATING COMPOSITION	WEIGHT (mg)	QUANTITY PER REEL (pcs)
NR1644GA bbb c E4S	DFN2020-8-GA	✓	✓	NiPdAu	9	3000

Please contact us if you require a voltage other than the line-up product.

Refer to “ *MARKING SPECIFICATION* “ for details.

■ PIN DESCRIPTIONS

DFN2020-8-GA Pin Configuration

Pin No.	Pin Name	I/O	Description
1	VIN	Power	Power Supply Input Pin Connect the input capacitor (C_{IN}) between the VIN pin and GND.
2	EN	I	Enable Pin Input “Low” to this pin shuts down the IC. Input "High" to this pin enables the IC. This pin is pulled down with an internal constant current.
3	VBIAS	Power	Bias Supply Input PIN Connect a capacitor (C_{BIAS}) between the VBIAS pin and GND.
4	PG	O	Power-Good Output Pin NMOS open-drain output. This pin outputs "High" (pull-up voltage) when the output voltage becomes PG pin “High” Threshold Voltage (V_{PGH}) or more.
5	NR	-	Noise Reduction Capacitor Connection Pin Connect a capacitor (C_{NR}) between the NR pin and GND. This capacitor reduces output noise and enables adjustment of the soft-start time.
6	GND	-	Ground Pin
7	FB	I	Feedback Input Pin Connect to the VOUT pin.
8	VOUT	O	Output Voltage Pin Connect the output capacitor (C_{OUT}) between VOUT pin and GND.

*1 The tab on the bottom of the package is the silicon substrate voltage. It is recomended to connect to GND on PCB.
For details, refer to " *TYPICAL APPLICATION CIRCUIT* " and " *THEORY OF OPERATION* ".

■ ABSOLUTE MAXIMUM RATINGS

Item	Symbol	Ratings	Unit
VBIAS pin Voltage	V_{BIAS}	−0.3 to 6.5	V
VIN pin Voltage	V_{IN}	−0.3 to 6.5	V
EN pin Voltage	V_{EN}	−0.3 to 6.5	V
VOUT pin Voltage	V_{OUT}	−0.3 to V_{IN} + 0.3 ≤ 6.5	V
FB pin Voltage	V_{FB}	−0.3 to V_{OUT} + 0.3 ≤ 6.5	V
PG pin Voltage	V_{PG}	−0.3 to 6.5	V
NR pin Voltage	V_{NR}	−0.3 to 6.5	V
Junction Temperature Range *1	T_j	−40 to 150	°C
Storage Temperature Range	T_{stg}	−55 to 150	°C

ABSOLUTE MAXIMUM RATINGS

Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause permanent damage and, may degrade the lifetime and safety for both device and system using the device in the field. The functional operation at or over these absolute maximum ratings are 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*" below for the thermal resistance under our measurement board conditions.

■ THERMAL CHARACTERISTICS

Package	Item	Measurement Result	Unit
DFN2020-8-GA	Thermal Resistance (θja)	32	°C/W
	Thermal Characterization Parameter (ψjt)	5	

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

■ ELECTROSTATIC DISCHARGE RATINGS

Item	Condition	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

Item	Symbol	Ratings	Unit
Bias Supply Voltage	V_{BIAS}	2.4 to 5.5 (V_{SET} < 0.9) V_{SET} + 1.5 to 5.5 (V_{SET} ≥ 0.9)	V
Input Voltage	V_{IN}	V_{SET} + V_{DO} to V_{BIAS} (Max. 5.5)	V
EN pin Input Voltage	V_{EN}	0 to 5.5	V
Output Current	I_{OUT}	0 to 2000	mA
Operating 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_{BIAS} = 3.6 V, V_{IN} = V_{SET} + 0.5 V, V_{EN} = V_{BIAS}, I_{OUT} = 1 mA, C_{IN} = 4.7 µF, C_{BIAS} = 0.1 µF, C_{OUT} = 10 µF, C_{NR} = 1.0 µF unless otherwise specified.
For items without temperature conditions, TYP values are T_a = 25 °C and MIN / MAX values are applied to all the temperature range of −40 °C ≤ T_j ≤ 125 °C.

NR1644GAxxxx

Parameter	Symbol	Conditions		MIN	TYP	MAX	Unit
Output Voltage Accuracy	V_{OUT}	T_a = 25 ºC V_{IN} = V_{SET} + 0.5 V to V_{BIAS} V_{BIAS} = V_{SET} + 1.5 V (Min. 2.4 V) to 5.5 V	0.4 V ≤ V_{SET} < 0.8 V	-8	-	8	mV
			0.8 V ≤ V_{SET} ≤ 1.5 V	-1.0	-	+1.0	%
		-40 ºC ≤ T_j ≤ 125 ºC V_{IN} = V_{SET} + 0.5 V to V_{BIAS} V_{BIAS} = V_{SET} + 1.5 V (Min. 2.4 V) to 5.5 V	0.4 V ≤ V_{SET} < 0.8 V	-16	-	16	mV
			0.8 V ≤ V_{SET} ≤ 1.5 V	-2.0	-	+2.0	%
VBIAS pin Quiescent Current	I_{QB}	V_{BIAS} = 5.5 V, I_{OUT} = 0 A	NR1644GAxxxA	-	75	90	µA
			NR1644GAxxxB	-	1000	1300	µA
VIN pin Quiescent Current	I_{QI}	V_{IN} = V_{BIAS} = 5.5 V, I_{OUT} = 0 A		-	6	11	µA
VBIAS pin Shutdown Current	I_{SDB}	V_{IN} = 5.5 V, V_{EN} = 0 V, Ta = 25 ºC		-	0.01	0.2	µA
VIN pin Shutdown Current	I_{SDI}	V_{IN} = 5.5 V, V_{EN} = 0 V, Ta = 25 ºC		-	0.01	0.2	µA
VBIAS pin Line Regulation	$\Delta V_{OUT}/\Delta V_{BIAS}$	V_{BIAS} = V_{SET} + 1.5 V (Min. 2.4 V) to 5.5 V		-	0.05	-	%/V
VIN pin Line Regulation	$\Delta V_{OUT}/\Delta V_{IN}$	V_{IN} = V_{SET} + 0.5 V to 3.6 V		-	0.01	-	%/V
Load Regulation*1	$\Delta V_{OUT}/\Delta I_{OUT}$	I_{OUT} = 1 mA to 2000 mA	NR1644GAxxxA	-1.25	0.1	0.75	%
			NR1644GAxxxB	-0.5	0.1	0.5	
Dropout Voltage*2	V_{DO}	I_{OUT} = 1000 mA, 2000mA		Refer to SPECIFIC ELECTRICAL CHARACTERISTICS			
VIN pin Ripple Rejection	RR	Ripple 0.2 Vp-p, I_{OUT} = 1000 mA	f = 1 kHz	-	110	-	dB
			f = 100 kHz	-	70	-	
Output Noise Voltage	V_{NOISE}	I_{OUT} = 1000 mA, f = 10 Hz to 100 kHz	0.4 V ≤ V_{SET} < 0.8 V	-	4.2	-	µVrms
			0.8 V ≤ V_{SET} ≤ 1.2 V	-	4.7	-	
			1.2 V ≤ V_{SET} ≤ 1.5 V	-	5.2	-	
Fast-mode Alternative Current	I_{OUTH}	I_{OUT} = Rising	NR1644GAxxxA	-	60	100	mA
Low-power-mode Alternative Current	I_{OUTL}	I_{OUT} = Falling		10	30	-	mA
Output Current Limit	I_{LIM}	V_{OUT} = V_{SET} × 90 %		2000	2500	-	mA
Short-circuit Current	I_{SC}	V_{OUT} = 0 V		-	500	-	mA
Start-up Current limit	$I_{LIMRISE}$	V_{OUT} = 0 V		-	500	-	mA
NR pin Charging Current	I_{NR}	V_{NR} = 0 V		0.64	1.0	1.44	mA

All electrical characteristic parameters are tested under the condition of $T_j \approx T_a$ = 25 °C, except for VIN pin Ripple Rejection and Output Noise Voltage.

*1 Load Regulation is the value calculated with V_{OUT}(@I_{OUT} = 1 mA) − V_{OUT}(@I_{OUT} = 2000 mA).
*2 Dropout Voltage is specified as the minimum voltage difference between Input Voltage (V_{IN}) and Set Output Voltage (V_{OUT}) required to obtain 95% of V_{SET} at specified load current.

■ ELECTRICAL CHARACTERISTICS (CONTINUED)

Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
EN pin current	I_{EN}	V_{BIAS} = V_{EN} = 5.5 V	-	0.25	0.65	µA
EN pin High Input Voltage (enable device)	V_{ENH}	V_{BIAS} = V_{SET} + 1.5 V (Min. 2.4 V)	0.78	-	5.5	V
EN pin Low Input Voltage (disable device)	V_{ENL}	V_{BIAS} = 5.5 V	0	-	0.4	V
Discharge FET On-resistance	R_{ONDIS}	V_{BIAS} = 3.6 V, V_{EN} = 0 V, V_{OUT} = 0.1 V	-	85	-	Ω
PG pin High Threshold Voltage	V_{PGH}	V_{OUT} = V_{FB} = Rising	-	V_{SET} ×0.90	V_{SET} ×0.95	V
PG pin Low Threshold Voltage	V_{PGL}	V_{OUT} = V_{FB} = Falling	V_{SET} ×0.80	V_{SET} ×0.85	-	V
PG pin On-resistance	R_{ONPG}	V_{BIAS} = 2.4 V, V_{EN} = 0 V, V_{PG} = 0.1 V	-	128	555	Ω
PG pin Leakage Current	I_{LEAKPG}	V_{BIAS} = V_{EN} = 5.5 V, V_{PG} = 5.5 V	-	-	1.0	µA
UVLO Detection Voltage	$V_{UVLODET}$	V_{IN} = Falling	V_{SET} ×0.45	V_{SET} ×0.50	-	V
UVLO Release Voltage	$V_{UVLOREL}$	V_{IN} = Rising	-	V_{SET} ×0.75	V_{SET} ×0.80	V
Thermal Shutdown Detection Temperature	T_{SDDET}	Tj = Rising	-	165	-	ºC
Thermal Shutdown Release Temperature	T_{SDREL}	Tj = Falling	-	140	-	ºC

All electrical characteristic parameters are tested under the condition of $T_j \approx T_a$ = 25 °C, except for VIN pin Ripple Rejection and Output Noise Voltage.

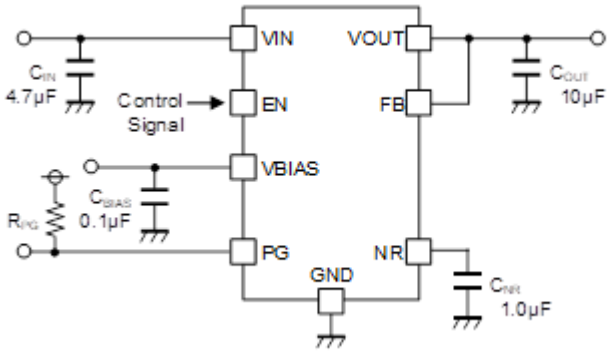
● PRODUCT-SPECIFIC ELECTRICAL CHARACTERISTICS

NR1644GAxxxx

Product Name	V_{OUT} [V]					V_{DO} [mV]			
	TYP	T_a = 25 °C		-40 °C ≤ T_a ≤ 125 °C		I_{OUT} = 1000mA		I_{OUT} = 2000mA	
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
NR1644xx040x	0.4	0.392	0.408	0.384	0.416	82	143	164	286
NR1644xx050x	0.5	0.492	0.508	0.484	0.516	82	143	164	286
NR1644xx060x	0.6	0.592	0.608	0.584	0.616	83	144	166	288
NR1644xx070x	0.7	0.692	0.708	0.684	0.716	84	146	168	292
NR1644xx080x	0.8	0.792	0.808	0.784	0.816	84	148	168	296
NR1644xx090x	0.9	0.891	0.909	0.882	0.918	85	150	170	300
NR1644xx100x	1.0	0.990	1.010	0.980	1.020	85	152	170	304
NR1644xx110x	1.1	1.089	1.111	1.078	1.122	86	154	172	308
NR1644xx120x	1.2	1.188	1.212	1.176	1.224	87	156	174	312
NR1644xx130x	1.3	1.287	1.313	1.274	1.326	88	158	176	316
NR1644xx140x	1.4	1.386	1.414	1.372	1.428	89	160	178	320
NR1644xx150x	1.5	1.485	1.515	1.470	1.530	90	163	180	326

All of the above electrical characteristics are inspected under the condition of Tj ≈ T_a = 25 °C.

■ TYPICAL APPLICATION CIRCUIT



NR1644 TYPICAL APPLICATION CIRCUIT

● EXTERNAL COMPONENTS INFORMATION

This product requires four external capacitors: C_{IN}, C_{BIAS}, C_{OUT}, and C_{NR}. Please refer to the followings when selecting parts.

Input capacitors (C_{IN}, C_{BIAS})

Connect a 4.7 µF or more input capacitor (C_{IN}) between the VIN pin and GND with shortest-distance wiring. In addition, connect a 0.1 µF or more input capacitor (C_{BIAS}) between the VBIAS pin and GND with shortest-distance wiring. It is recommended to using a ceramic capacitor of 6.3 V or more such as X7R having small temperature dependence of ESR, ESL and capacitance.

Output Capacitor (C_{OUT})

Phase compensation is provided to secure stable operation even when the load current is varied. Connect a output capacitor (C_{OUT}) of 10 µF or more and 1000 µF or less between the VOUT pin and GND with shortest-distance wiring. It is recommended to use a ceramic capacitor of X7R having small temperature dependence to ESR, ESL,and capacitance. Besides, set for the output capacitor to ensure the following effective capacitance in consideration of the dependence of temperature, DC bias, and package size.

Set Output Voltage vs. Effective Capacitance

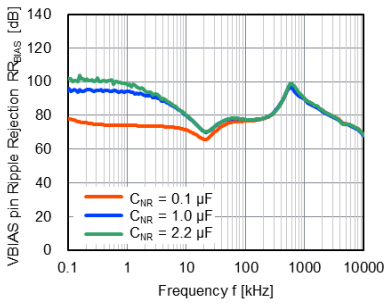
Set Output Voltage (V_{SET})	Effective Capacitance
0.4 V ≤ V_{SET} ≤ 1.5 V	6 µF ≤ C_{OUT} ≤ 1000 µF

When using a capacitor other than a ceramic capacitor, select a component with an ESR of 1 Ω or less and ensure the above effective capacitance.

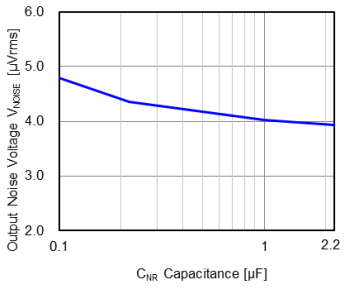
Noise Reduction Capacitor (C_{NR})

Connect a noise reduction capacitor (C_{NR}) of 0.1 µF or more and 2.2 µF or less between the NR pin and GND with shortest-distance wiring. In order to achieve the VBIAS pin Ripple Rejection and Output Noise Voltage characteristics described in "*ELECTRICAL CHARACTERISTICS*", it is recommended to use a capacitor of 1.0 µF or more with good DC bias characteristics. For the dependence of Ripple Rejection and Output Noise Voltage on C_{NR}, refer to below.

(TYPICAL CHARACTERISTICS: C_{NR} dependence of VBIAS Ripple Rejection and Output Noise Voltage)



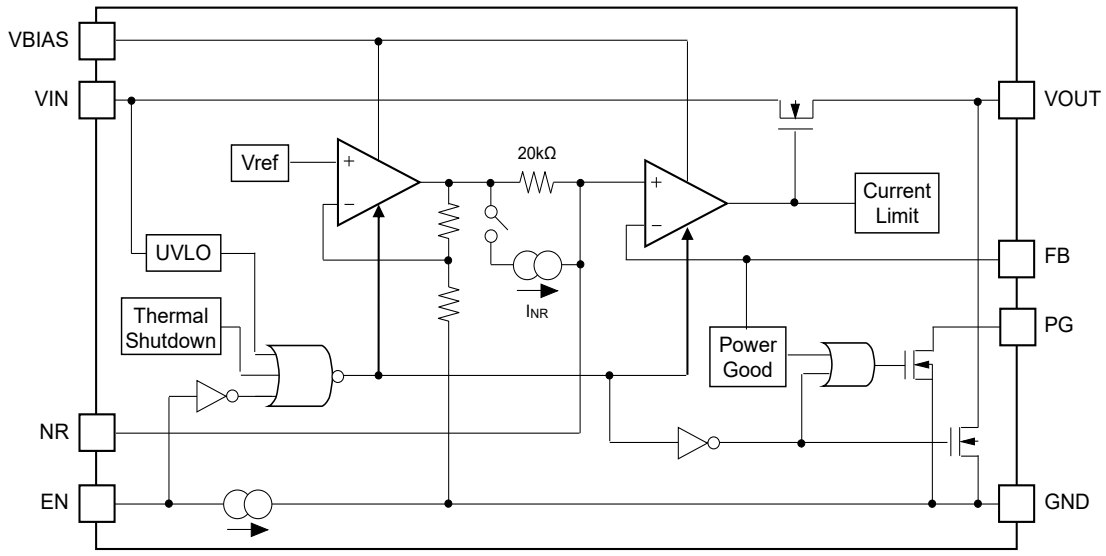
VBIAS pin Ripple Rejection vs Frequency
NR1644xx040B, I_{OUT} = 1 mA, C_{OUT} = 10 µF



Output Noise Voltage vs C_{NR} Capacitance
NR1644xx040B, I_{OUT} = 1 mA, C_{OUT} = 10 µF

For the relationship between the effective capacitance of C_{NR} and the Soft-start time, refer to "*Soft-start Function*".

■ BLOCK DIAGRAM



NR1644 Block Diagram

■ THEORY OF OPERATION

● Enable Function

Forcing above designated "High" voltage to EN pin, the NR1644 becomes active. Forcing below designated "Low" voltage to EN pin shuts down the NR1644. The EN pin is pulled down with a constant current of Typ.0.25 µA inside the IC.
When the EN pin is open, the IC enters the shutdown state. In the shutdown state, the discharge FET turns on and the charge in the output capacitor (C_{OUT}) is discharged. If control by the EN pin is not possible or is not required, connect the EN pin to the VBIAS pin, etc, so that "High" is always input to EN pin. Even if voltage is applied to the EN pin before the VBIAS and VIN pins, the IC will not fail.

● Discharge Function

This function turns on the FET connected between the VOUT pin and the GND pin discharges the charge stored in the output capacitor (C_{OUT}) and quickly reduce the output voltage to near 0V. This function is enabled when the EN pin is "Low", UVLO is detected, or thermal shutdown is detected. The FET on-resistance is Typ. 85 Ω (V_{BIAS} = 3.6 V). This function is enabled when the VBIAS pin voltage (V_{BIAS}) is within the recommended operating conditions. When the VBIAS pin voltage (V_{BIAS}) and the EN pin Input Voltage (V_{EN}) are used in common, the Discharge Function is never enabled. Because the VBIAS pin voltage (V_{BIAS}) falls outside the recommended operating conditions, when the EN pin Input Voltage (V_{EN}) is within the EN pin Low Input Voltage.

● Automatic Mode Alternative Function

The NR1644xxxxxA has two modes: Fast-mode and Low-power-mode. The Fast-mode has with high quiescent current for high RR, ultra-low noise, and high-speed transient response. Compared to the Fast-mode, the Low-power-mode has lower transient response characteristics, but achieves low quiescent current.
The NR1644xxxxxA alternates to Fast-mode when the output current (I_{OUT}) exceeds the Fast-mode Alternative Current (I_{OUTH}), and alternates to Low-power-mode when the output current (I_{OUT}) drops below the Low-power-mode Alternative Current (I_{OUTL}). The Alternative Currents (I_{OUTH}, I_{OUTL}) have hysteresis and will never be the same value. Note that there may be a voltage difference of about 1 mV between the output voltage of the Fast-mode and the Low-power-mode.
The NR1644xxxxxB does not have the Low-power-mode and always operates in Fast-mode regardless of the output current (I_{OUT}) in the active state. In the load current range of NR1644xxxxxA's Fast-mode region, the characteristics are equivalent to those of NR1644xxxxxB.

● Soft-start Function

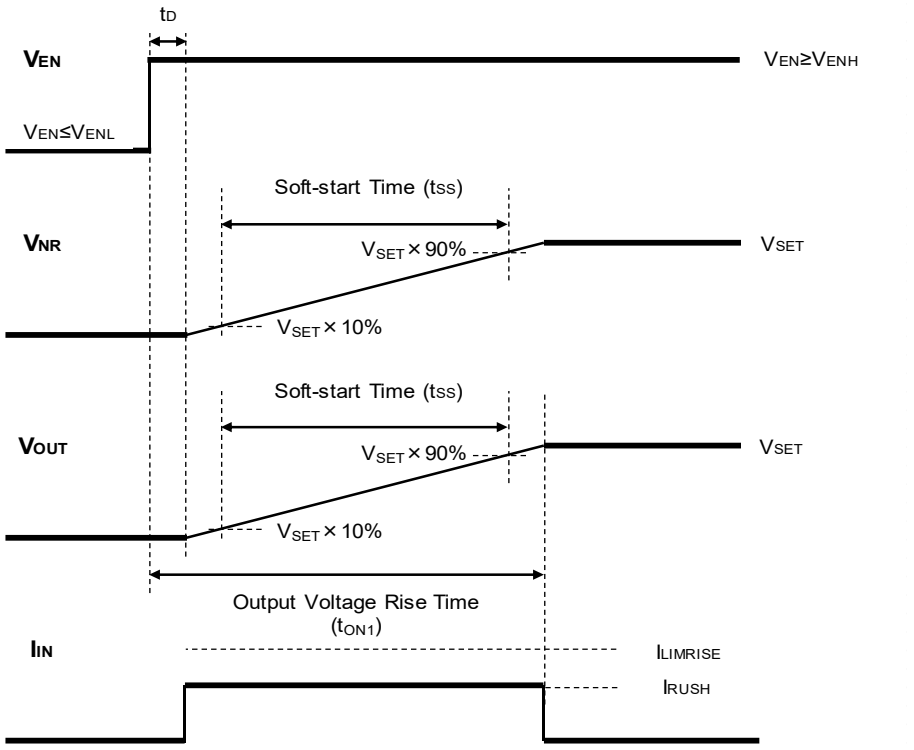
This function starts up the IC's output voltage (V_{OUT}) along the slope generated by the NR pin charging current (I_{NR}, Typ. 1 mA) and the external capacitor (C_{NR}) connected to the NR pin, within the soft-start time (t_{SS} , V_{OUT} 10% to 90%). When the VBIAS pin voltage (V_{BIAS}) and input voltage (V_{IN}) are within the recommended operating conditions, the soft-start operation begins after the output delay time (t_D) once a "High" is applied to the EN pin. If the VBIAS pin voltage (V_{BIAS}) is within the recommended operating condition and a "High" is applied to the EN pin before the input voltage (V_{IN}) is supplied, the soft-start operation will begin when the input voltage (V_{IN}) exceeds the UVLO Release Voltage ($V_{UVLOREL}$). Once the soft-start operation begins, the output voltage (V_{OUT}) begins to rise according to the effective capacitance of the noise reduction capacitor (C_{NR}), and the IC completes start-up after t_{SS} / 0.8.
The output voltage Soft-start Time (t_{SS}, V_{OUT} 10% to 90%) and rise time (t_{ON1}) can be calculated using the following formula:

$$t_{SS} = C_{NR} \times V_{SET} / I_{NR}$$
$$t_{ON1} = t_D + t_{SS} / 0.8$$

t_D : Output Delay Time Typ. 100 µs
C_{NR} : Effective Capacitance of Noise Reduction Capacitor
V_{SET} : Set Output Voltage
I_{NR} : NR pin Charging Current Typ. 1 mA

To enable the soft-start function, either apply a "High" to the EN pin after supplying the input voltage (V_{IN}) while the VBIAS pin voltage (V_{BIAS}) is within the recommended operating conditions, or apply the Input Voltage (V_{IN}) after supplying a "High" to the EN pin under the same condition where the VBIAS pin voltage (V_{BIAS}) is within the recommended operating conditions. If the VBIAS pin voltage (V_{BIAS}) is not within the recommended operating conditions and a "High" is applied to the EN pin, the IC may start up without activating the Soft-start Function.

When the IC's temperature drops below the Thermal Shutdown Release Threshold (T_{SDREL}) from the thermal shutdown detection state and returns to the active state, the Soft-start Function will be activated.



Soft-Start Start-Up Timing Chart

Start-up Inrush Current (I_{RUSH}) is expressed by the following formula, which uses the load current (I_{LOAD}) during start-up and the charging current (I_{CHG}) to the output capacitor (C_{OUT}). Based on the following formula, the Start-up Inrush Current (I_{RUSH}) can be adjusted by setting the Soft-start Time (t_{SS}), according to the effective capacitance of the noise reduction capacitor (C_{NR}).

$$I_{RUSH} = I_{CHG} + I_{LOAD} = (C_{OUT} \times V_{SET} / t_{SS} \times 0.8) + I_{LOAD}$$

I_{CHG}: Charging Current to Output Capacitor
I_{LOAD}: Load Current

In addition, if the load current (I_{LOAD}) during start-up or the charging current (I_{CHG}) to the output capacitor (C_{OUT}) is large, and the Start-up Inrush Current (I_{RUSH}) satisfies the following formula, the Soft-start Function will not be enabled. Refer to *"Inrush Current Suppression Function."*

$$I_{RUSH} > I_{LIMRISE}$$

$I_{LIMRISE}$: Start-up Current Limit Typ. 500 mA

For the operation of the PG pin after the soft-start, refer to the "Power-Good Function" for more details.

● Inrush Current Suppression Function

This function limits the Start-up Inrush Current (I_{RUSH}), which is the sum of the Charge Current (I_{CHG}) to the output capacitor (C_{OUT}) and the load current (I_{LOAD}), to the Start-up Current Limit ($I_{LIMRISE}$, Typ. 500 mA).

When the Start-up Inrush Current (I_{RUSH}) reaches the Start-up Current Limit ($I_{LIMRISE}$, typ. 500 mA), the rise time (t_{ON2}) will be longer than the rise time (t_{ON1}) determined by the configured Soft-start Time.
The rise time (t_{ON2}) determined by the Inrush Current Suppression Function can be calculated using the following formula:

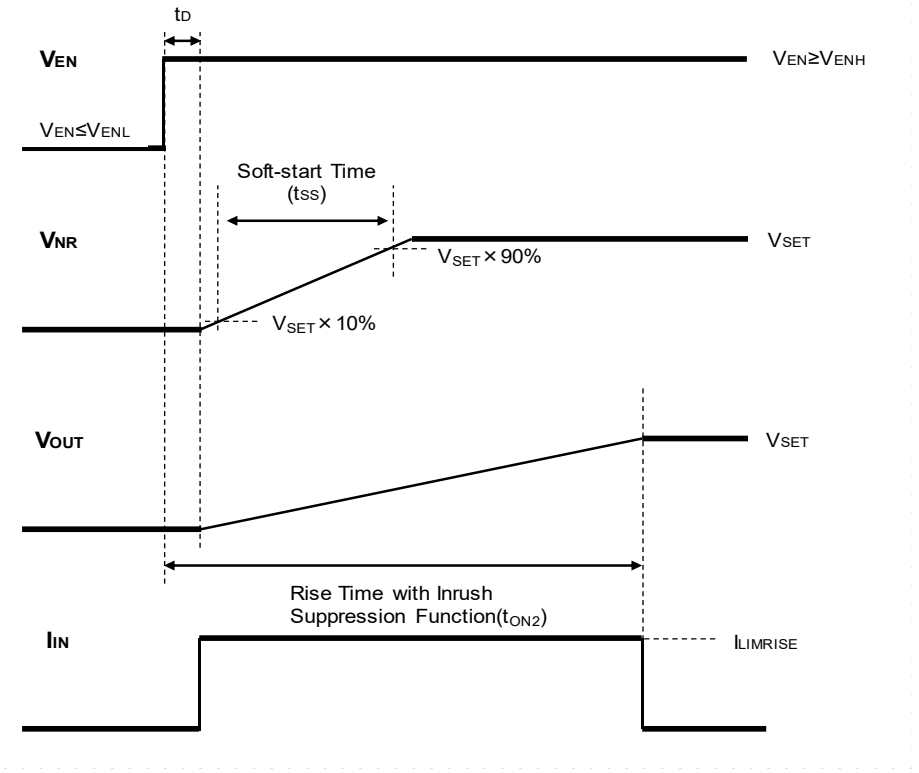
$$t_{ON2} = t_D + C_{OUT} \times V_{SET} / (I_{LIMRISE} - I_{LOAD})$$

t_D : Output Delay Time Typ. 100 µs
C_{OUT} : Effective Capacitance of Output Capacitor
V_{SET} : Set Output Voltage
$I_{LIMRISE}$: Start-up Current Limit Typ. 500 mA
I_{LOAD} : Load Current

The Start-up Current Limit ($I_{LIMRISE}$) is valid until the output voltage (V_{OUT}) reaches the set output voltage (V_{SET}). After start-up, Output Current ILmit (I_{LIM}) and Short-circuit Current (I_{SC}) provide protection against overcurrent.

To enable the inrush current limit, applying the recommended operating conditions (2.4 V or V_{SET} + 1.5 V or higher) for the VBIAS pin voltage (V_{BIAS}) and then applying a “High” to the EN pin. When the VBIAS pin voltage (V_{BIAS}) is not within the recommended operating conditions and a “High” is applied to the EN pin, the IC may start up without the Inrush Current Limit Function being activated.
If the load current (I_{LOAD}) exceeds the start-up current limit ($I_{LIMRISE}$) during start-up, the output voltage (V_{OUT}) does not reach the set output voltage (V_{SET}).

The UVLO Function and thermal Shutdown Function are still valid during the output voltage start-up. These protection functions may be activated during start-up involving load current or when a large output capacitor (C_{OUT}) is connected. In such a case, adjust the output capacitor (C_{OUT}) and start-up timing to suppress inrush current and heat generation.



Timing chart when the Inrush Current reaches the Start-up Current Limit

● Power-Good Function

It monitors the output voltage (V_{OUT}) and outputs the signal from the PG pin in the NMOS open-drain configuration.
During soft-start, the output voltage (V_{OUT}) exceeds the PG pin High Threshold Voltage (V_{PGH}, Typ. 90 % × V_{SET}) and then the PG signal goes "High" after the Start-up PG Delay Time (t_{DON_PG}).
The Start-up PG Delay Time can be calculated using the following formula:

$$t_{DON\_PG} = 0.07 \times C_{NR} \times V_{SET} / I_{NR} + 20\mu s$$

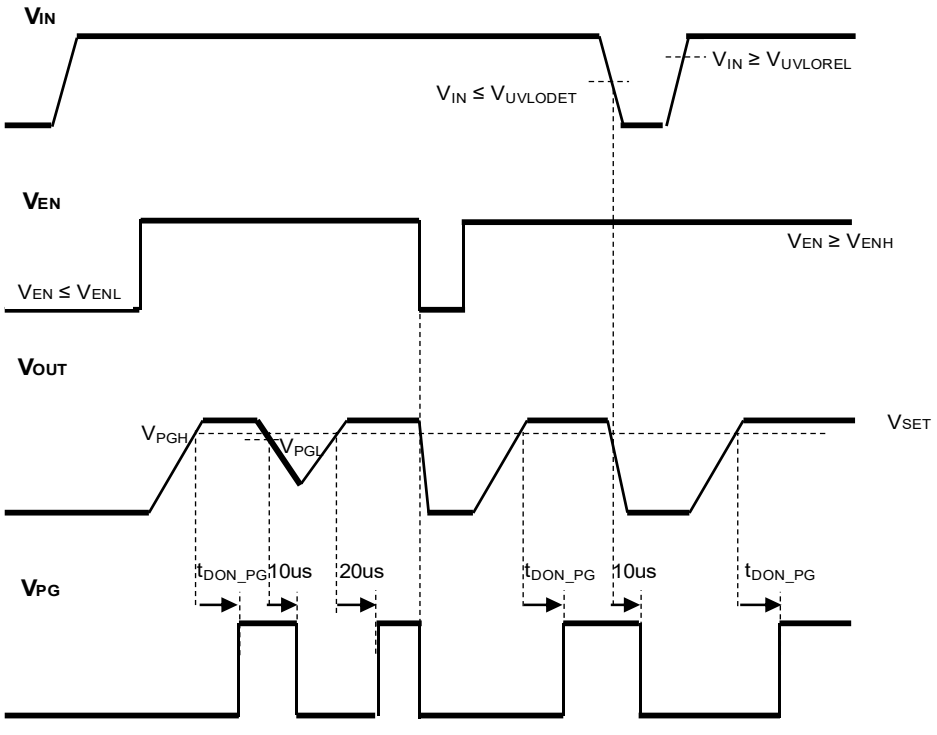
V_{SET} : Set Output Voltage

I_{NR} : NR pin Charging Current Typ. 1 mA

After soft-start sequence is completed, if the output voltage (V_{OUT}) drops below the PG pin Low Threshold Voltage (V_{PGL}, Typ. 85 % × V_{SET}), the PG signal will go "Low" after the PG pin Low Delay Time (Typ. 10 µs). Subsequently, if the Output Voltage (V_{OUT}) exceeds the PG pin High Threshold Voltage (V_{PGH}, Typ. 90 % × V_{SET}), the PG signal returns to "High" after the PG High Delay Time (Typ. 20 µs).

When the VBIAS pin voltage (V_{BIAS}) is within the recommended operating condition, the PG signal will be pulled “Low” regardless of the Output Voltage (V_{OUT}), when any of following conditions become active: the EN pin is "Low," UVLO is detected or thermal shutdown is detected.

The "High" level of the PG signal drops from the pull-up voltage by the amount of the PG pin Leakage Current (I_{LEAKPG}) flowing through the pull-up resistor (R_{PG}). The "Low" level is the voltage divided between the pull-up resistor (R_{PG}) of the PG pin and the PG pin On-resistance (R_{ONPG}) with respect to the pull-up voltage. If the Power-Good Function is not necessary, open the PG pin or connect the PG pin to GND.



Timing Chart for Power-Good Function

- **Under Voltage Lockout (UVLO) Function**

  This is an auxiliary function that monitors the input voltage (V_{IN}) and stops the IC operation when the input voltage (VIN) drops to a level at which the IC cannot operate normally (Typ. V_{SET} × 0.5 V or less). When this function is activated, the VOUT pin is pulled down by a discharge FET. To resume IC operation, the input voltage (V_{IN}) must be Typ. V_{SET} × 0.75 V or more.
  When restarting, the Soft-start Function will be activated, just as it is when the IC is started with Enable Function. This function is enabled when the VBIAS pin voltage (V_{BIAS}) is within the recommended operating conditions (2.4V or V_{SET} + 1.5V or higher).

- **Thermal Shutdown Function**

  When the junction temperature exceeds the Thermal Shutdown Detection Temperature (T_{SDDET}, Typ. 165 °C), the output transistor is shut off to suppress self-heating. When the junction temperature drops below the Thermal Shutdown Release Temperature (T_{SDREL}, Typ. 140 °C), operation will restart. When restarting, the Soft-start Function will be activated, just as it is when the IC is started with Enable Function.

■ THERMAL CHARACTERISTICS (DFN2020-8-GA)

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).

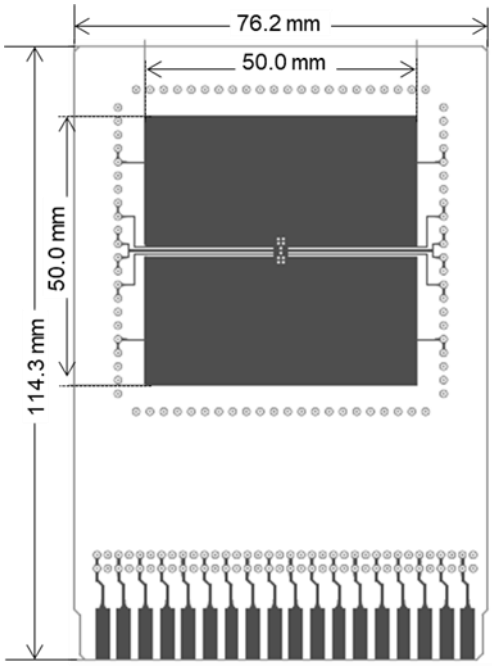
Measurement Result

Item	Measurement Result
Thermal Resistance (θja)	32 °C/W
Thermal Characterization Parameter (ψjt)	5 °C/W

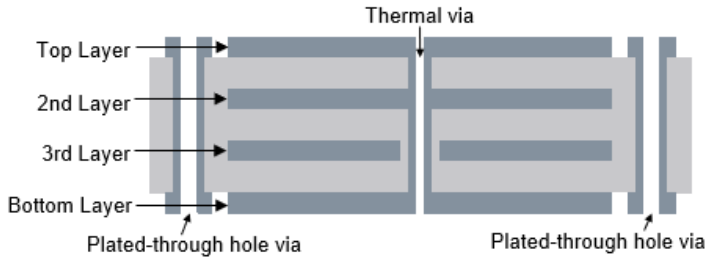
θja : Junction-to-Ambient Thermal Resistance
ψjt : Junction-to-Top Thermal Characterization Parameter

Measurement Conditions

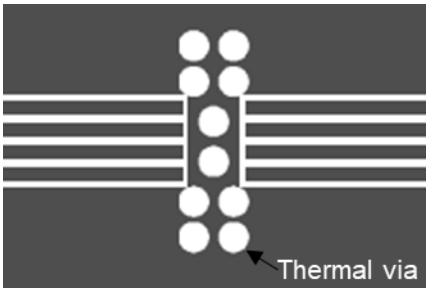
Item		Specification
Measurement Condition		Mounting on Board (Still Air)
Board material		FR-4
Board size		76.2 mm × 114.3 mm × t 1.6 mm
Copper foil layer	1	50 mm × 50 mm (coverage rate 95%), t 0.070 mm
	2	74.2 mm × 74.2 mm (coverage rate 100%), t 0.035 mm
	3	74.2 mm × 74.2 mm (coverage rate 100%), t 0.035 mm
	4	50 mm × 50 mm (coverage rate 100%), t 0.070 mm
Thermal vias		ϕ 0.3 mm × 10 pcs



Measurement Board Pattern



Cross section view of layers and vias



Enlarged view of IC mounting area

● CALCULATION METHOD OF JUNCTION TEMPERATURE

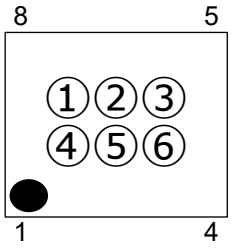
The junction temperature (Tj) can be calculated from the following formula.

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

Where: Ta : Ambient temperature
Tc (top) : Package mark side center temperature
$P = (V_{IN}\text{-}V_{OUT}) \times I_{OUT}$ (Power consumption under user's conditions)

■ MARKING SPECIFICATION

①②③④: Product Code ⋯Refer to **the following table**
⑤⑥: Lot No. ⋯Alphanumeric serial number.



DFN2020-8-GA Marking Specifications

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.

Marking List

Product Name	①②③④
NR1644GA040A	5A00
NR1644GA050A	5A01
NR1644GA060A	5A02
NR1644GA070A	5A03
NR1644GA080A	5A04
NR1644GA090A	5A05
NR1644GA100A	5A06
NR1644GA110A	5A07
NR1644GA120A	5A08
NR1644GA130A	5A09
NR1644GA140A	5A10
NR1644GA150A	5A11

Product Name	①②③④
NR1644GA040B	5B00
NR1644GA050B	5B01
NR1644GA060B	5B02
NR1644GA070B	5B03
NR1644GA080B	5B04
NR1644GA090B	5B05
NR1644GA100B	5B06
NR1644GA110B	5B07
NR1644GA120B	5B08
NR1644GA130B	5B09
NR1644GA140B	5B10
NR1644GA150B	5B11

■ APPLICATION NOTE

● Technical Notes

The performance of the power supply circuit using this product is highly dependent on the peripheral circuits. A peripheral component or the device mounted on PCB should not exceed a rated voltage, a rated current or a rated power. When designing peripheral circuits, please be fully aware of the following points.

- Ensure that the VIN, VBIAS, and GND lines are sufficiently reinforced, as high impedance can lead to noise intrusion and unstable operation. In addition, place external components such as C_{IN} and C_{OUT} as close to the IC as possible, preferably on the same PCB layer, and connect them to the IC with the shortest possible traces. Furthermore, connect the FB and VOUT pins with the shortest possible traces as well.

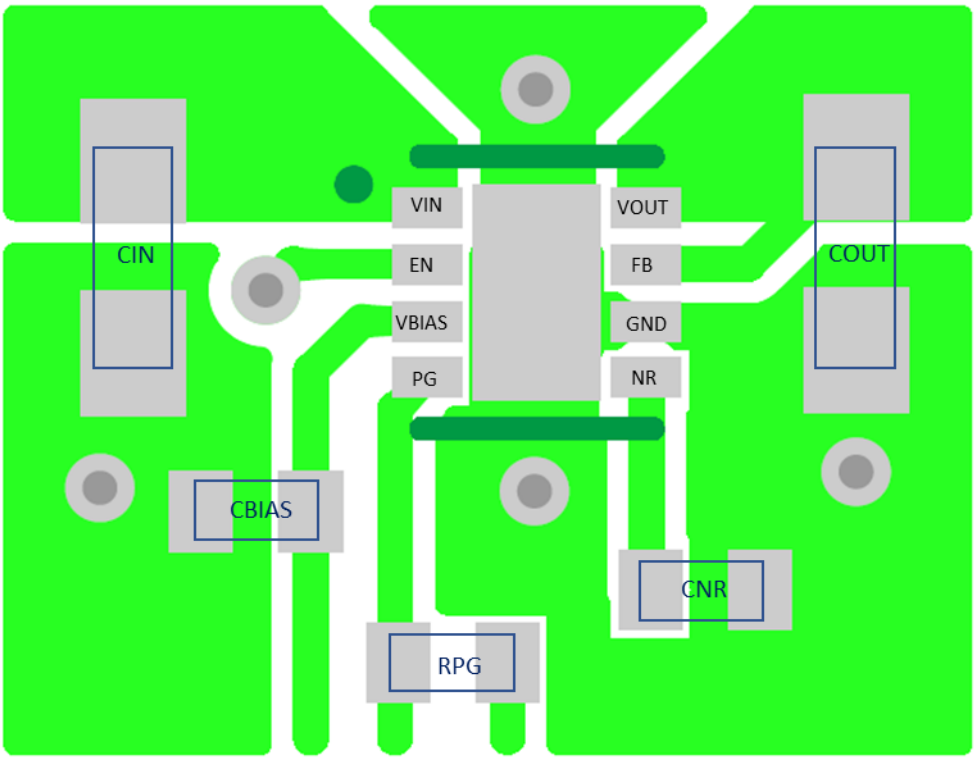
- When using a C_{OUT} with a large capacitance, the operation may become unstable due to the influence of the impedance of the VIN traces, as a large charge/discharge current flows through VIN. To minimize the impact of the impedance of the VIN traces, it is recommended to use a C_{IN} with a capacitance comparable to that of C_{OUT}.

- If the Input Voltage (V_{IN}) drops below the Set Output Voltage (V_{SET}), current will flow from the VBIAS pin to the VIN pin through the inside of the IC. (However, current will not flow under conditions where V_{BIAS} also decreases at the same time as V_{IN}). This behavior does not affect the IC's reliability. In addition, the order in which V_{IN} and V_{BIAS} are applied during start-up and shutdown does not affect the IC's reliability.

- The Thermal Shutdown Function prevents the IC from fuming and ignition but does not ensure the IC's reliability or to keep it within the absolute maximum ratings. In addition, it is not effective against heat generation caused outside of the IC's normal operation, such as latch-up and overvoltage application. Since the Thermal Shutdown Function operates beyond the absolute maximum rating, avoid system designs that rely on this IC's Thermal Shutdown Function.

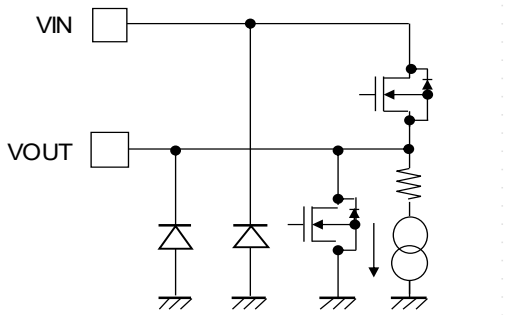
- The tab on the bottom side of DFN2020-8-GA package is recommended to be connected to GND. It will work even if it is open, but please note that heat dissipation and mounting strength may be reduced.

● **Example of Evaluation Board/PCB Layout Pattern**

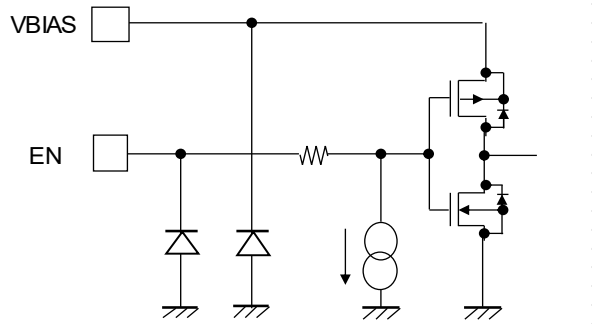


NR1644GA

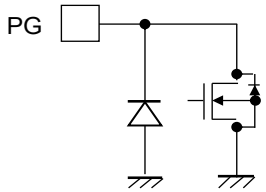
● **Internal Equivalent Circuit Diagram of Pin**



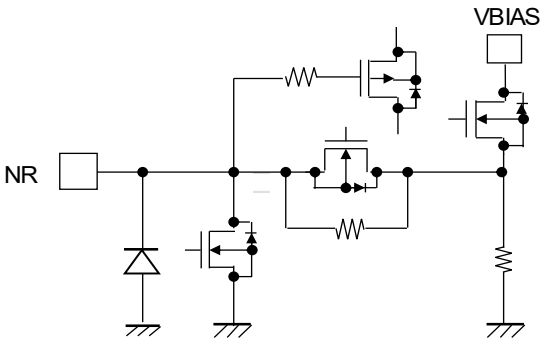
VIN pin, VOUT pin



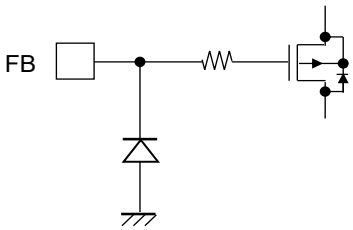
VBIAS pin, EN pin



PG pin



NR pin



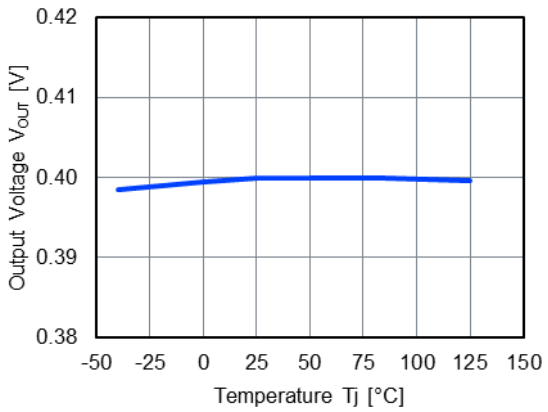
FB pin

■ TYPICAL CHARACTERISTICS

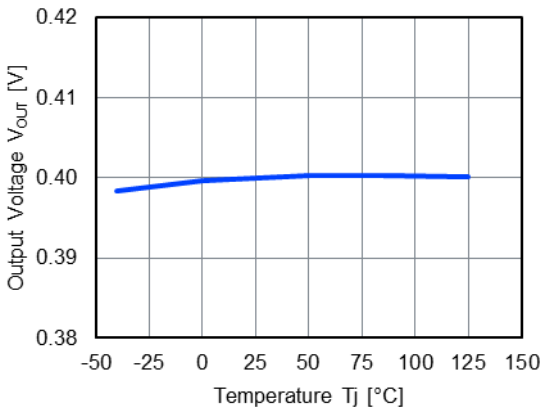
Note: Typical Characteristics are intended to be used as reference data; they are not guaranteed.
Unless otherwise specified, Ta = 25 °C, V_{IN} = V_{SET} + 0.5 V, V_{BIAS} = 3.6 V, V_{EN} = V_{BIAS}, C_{IN} = 4.7 µF, C_{BIAS} = 0.1 µF, C_{OUT} = 10 µF, C_{NR} = 1.0 µF

1) Output Voltage vs Temperature
I_{OUT} = 1 mA

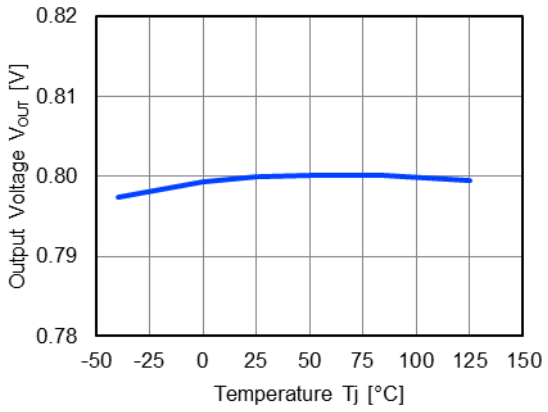
NR1644xx040A



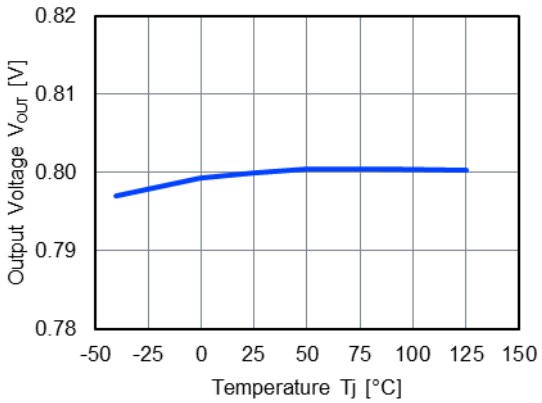
NR1644xx040B



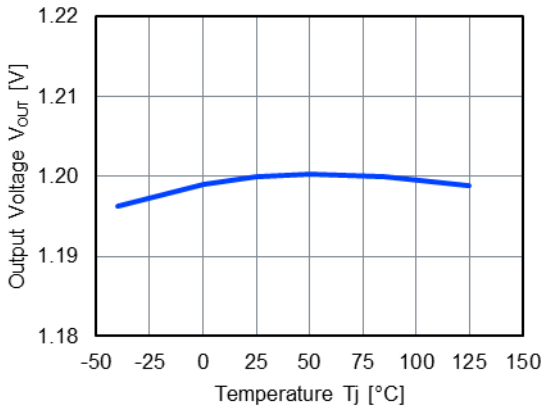
NR1644xx080A



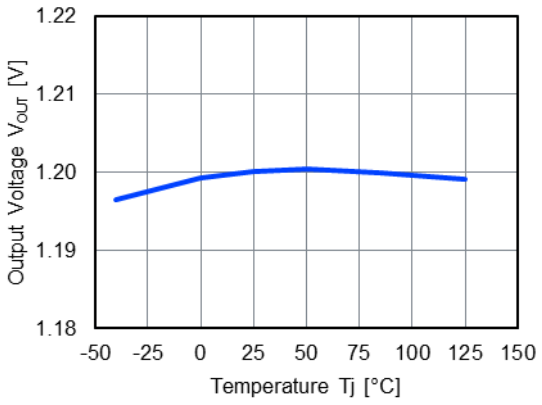
NR1644xx080B



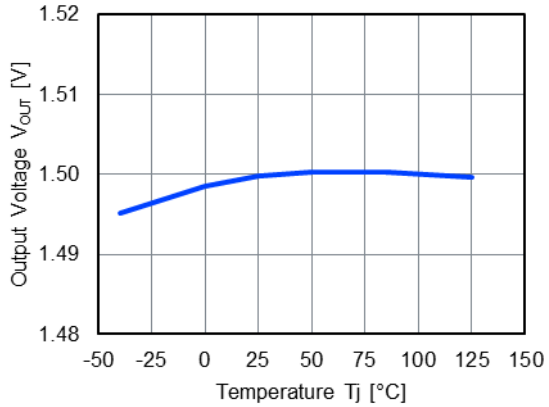
NR1644xx120A



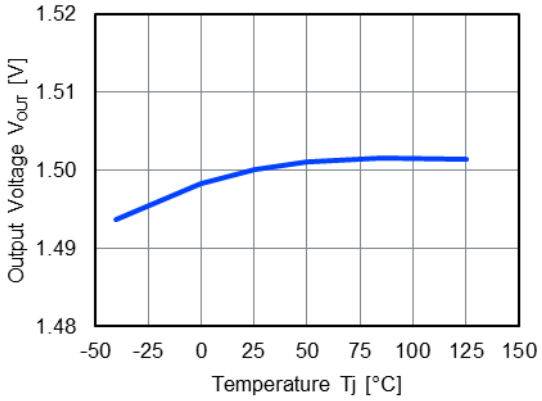
NR1644xx120B



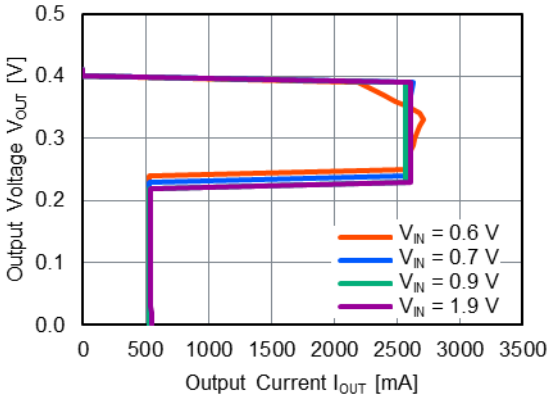
NR1644xx150A



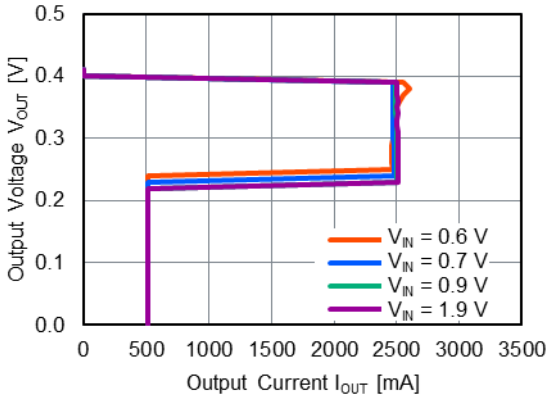
NR1644xx150B



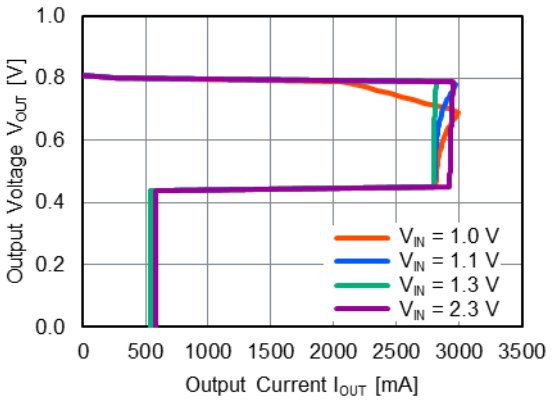
2) Output Voltage vs Output Current (Current Limit)
Tj = 25 °C
NR1644xx040x
V_{BIAS} = 2.4 V



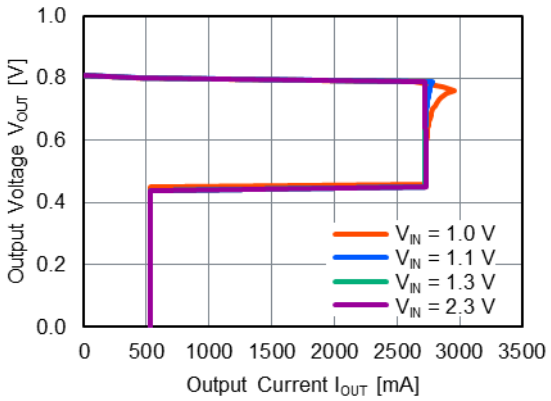
V_{BIAS} = 5.5 V



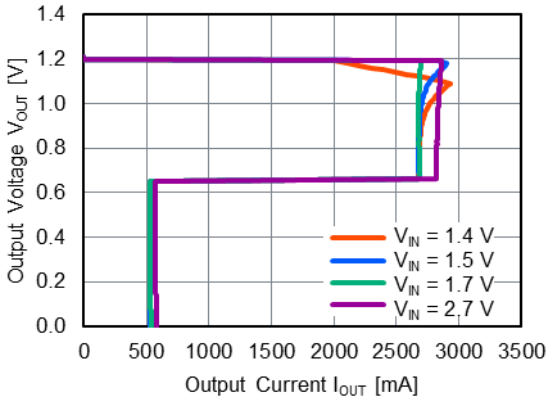
NR1644xx080x
V_{BIAS} = 2.4 V



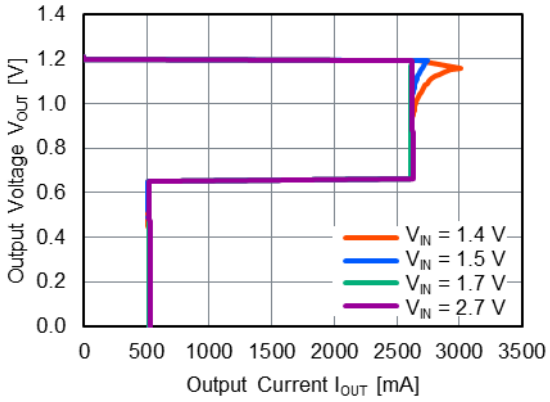
V_{BIAS} = 5.5 V



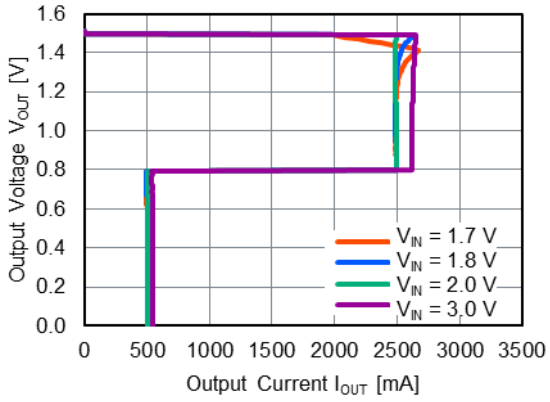
NR1644xx120x
V_{BIAS} = 2.7V



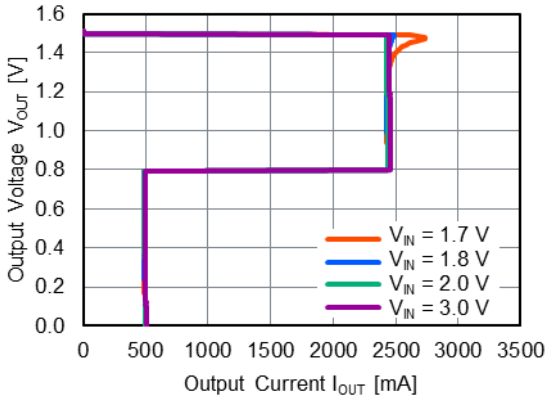
V_{BIAS} = 5.5 V



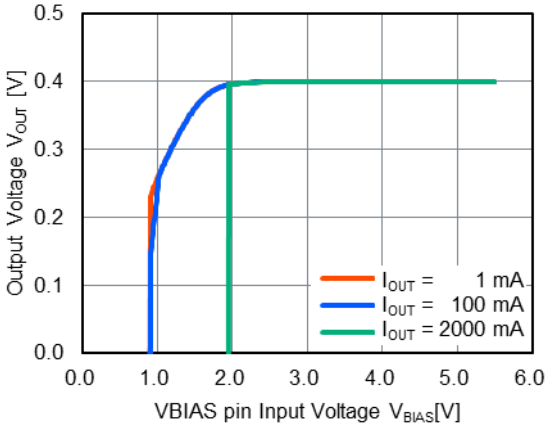
NR1644xx150x
V_{BIAS} = 3.0 V



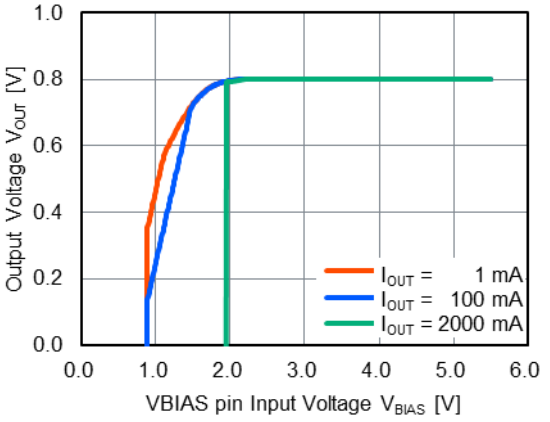
V_{BIAS} = 5.5 V



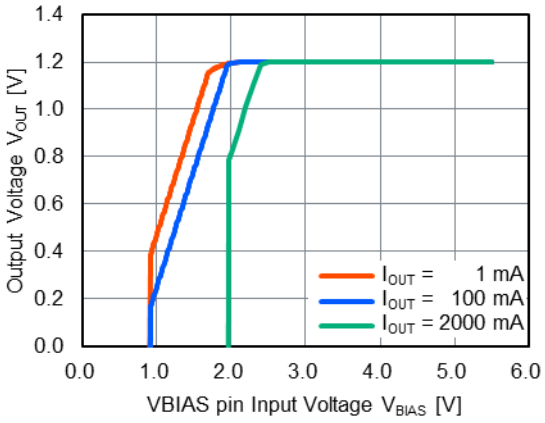
3) Output Voltage vs VBIAS pin Input Voltage
V_{BIAS} = 5.5 V to 0 V, V_{EN} = 5.5 V, Tj = 25 °C
NR1644xx040x



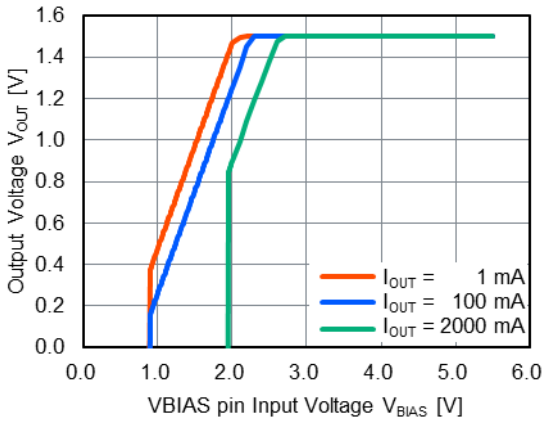
NR1644xx080x



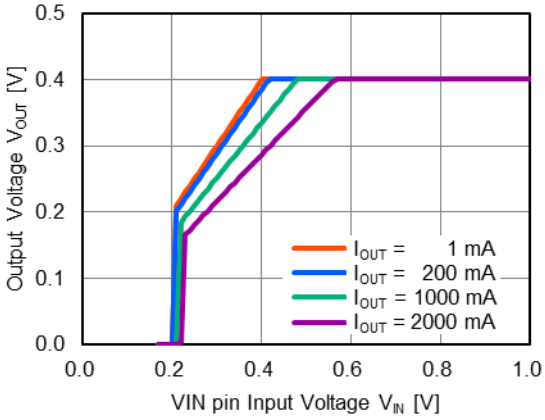
NR1644xx120x



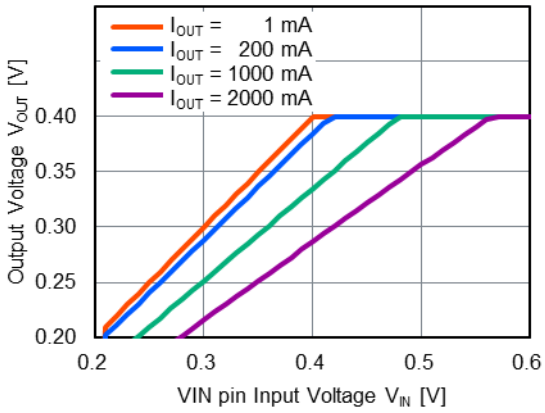
NR1644xx150x



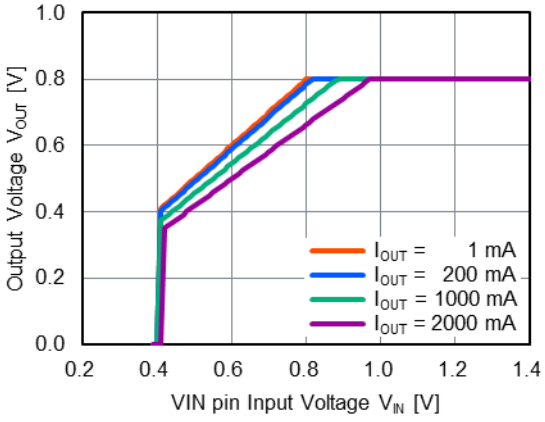
4) Output Voltage vs VIN pin Input Voltage
V_{IN} = V_{SET} + 1 V to 0 V, Tj = 25 °C
NR1644xx040x
Overall View



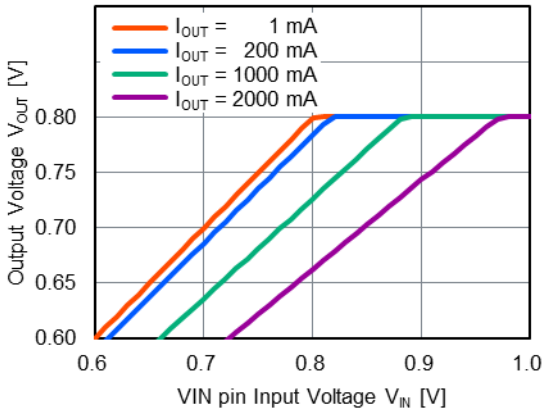
Enlarged View



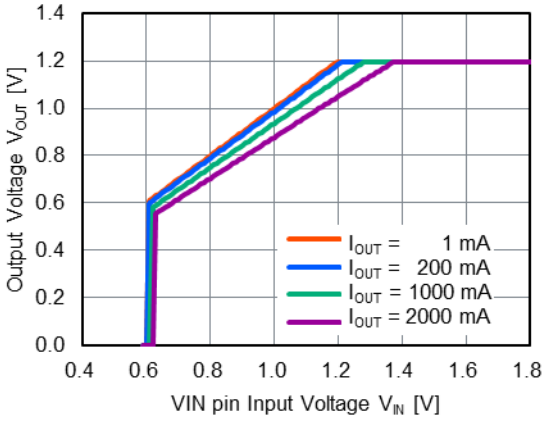
NR1644xx080x
Overall View



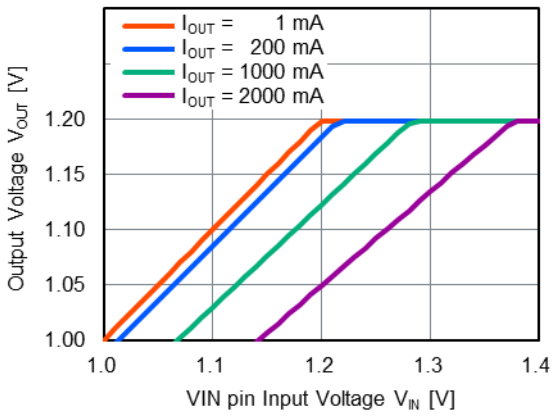
Enlarged View



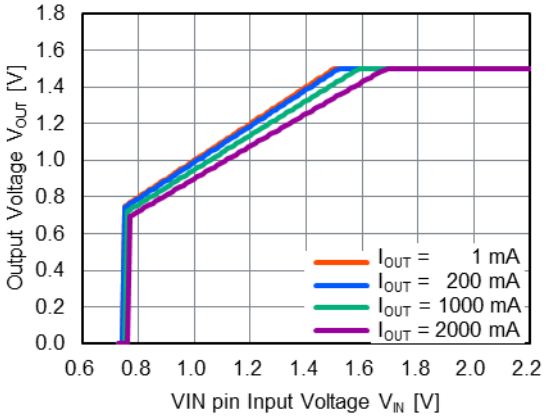
NR1644xx120x
Overall View



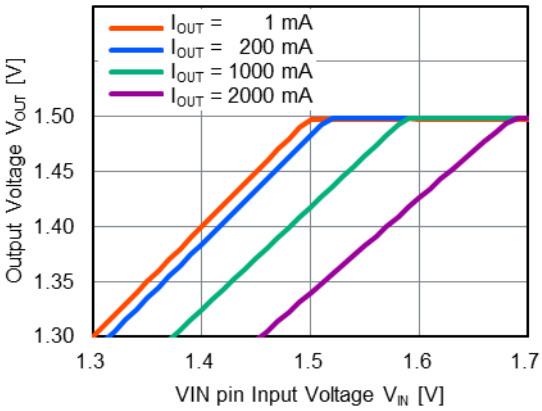
Enlarged View



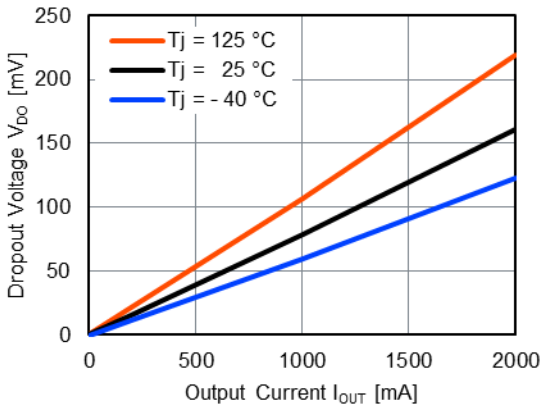
NR1644xx150x
Overall View



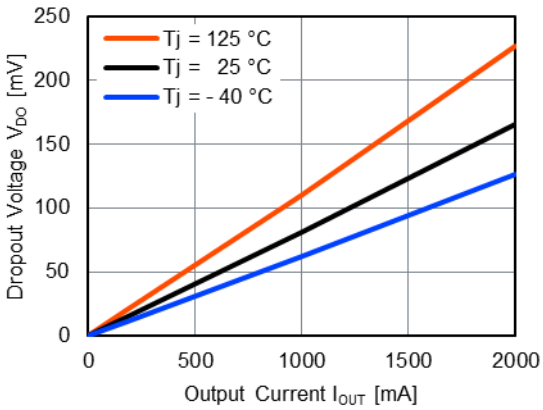
Enlarged View



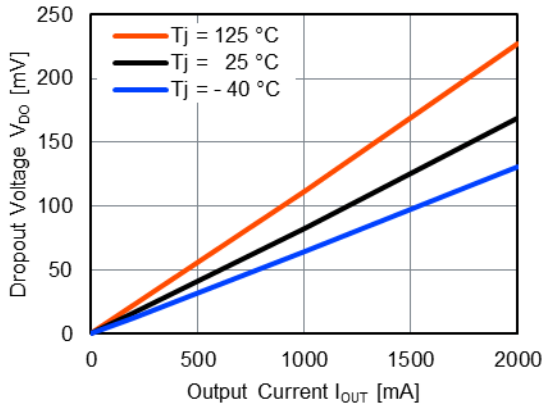
5) Dropout Voltage vs Output Current
V_{IN} = Sweep
NR1644xx040x



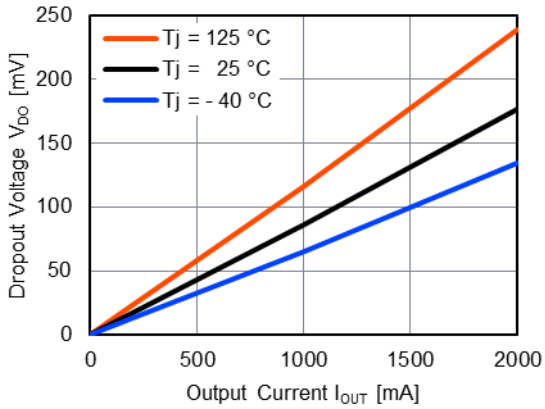
NR1644xx080x



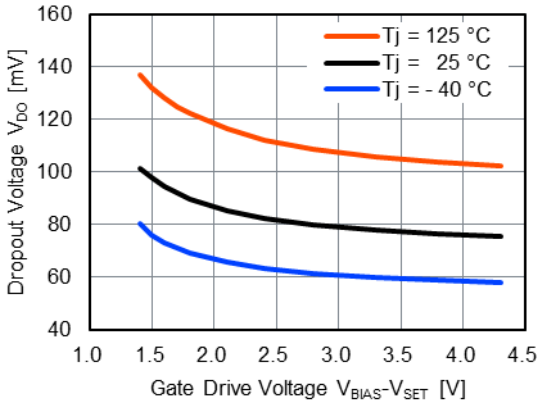
NR1644xx120x



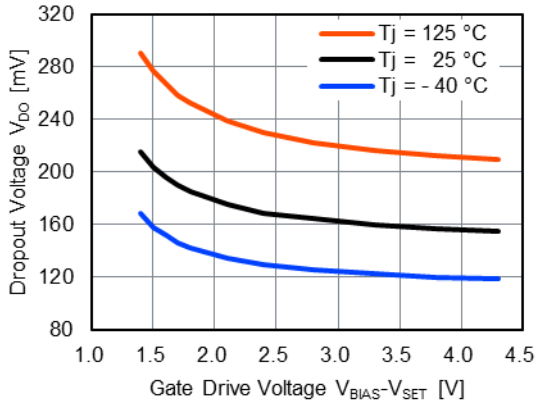
NR1644xx150x



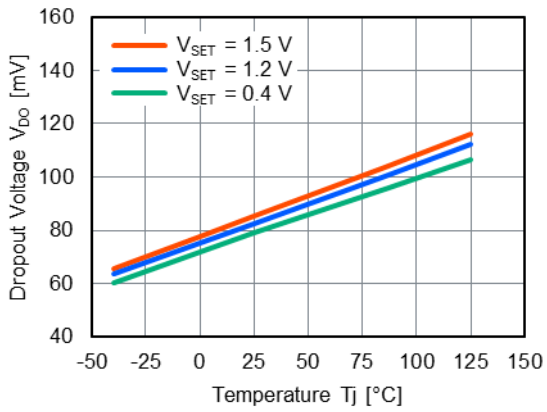
6) Dropout Voltage vs Gate Drive Voltage
NR1644xx120x
I_{OUT} = 1000 mA



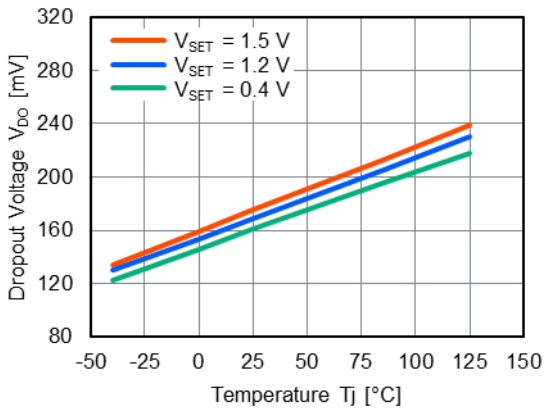
I_{OUT} = 2000 mA



7) Dropout Voltage vs Temperature
NR1644xxxxxx
I_{OUT} = 1000 mA

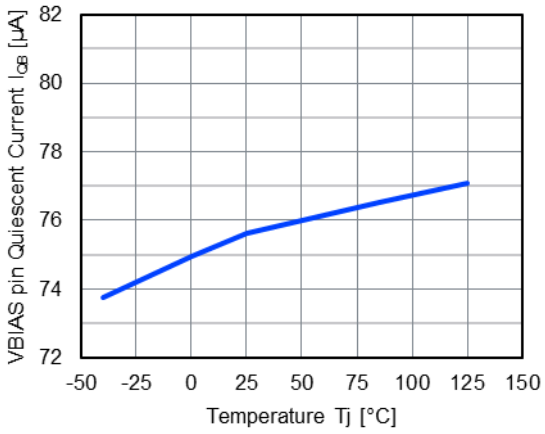


I_{OUT} = 2000 mA

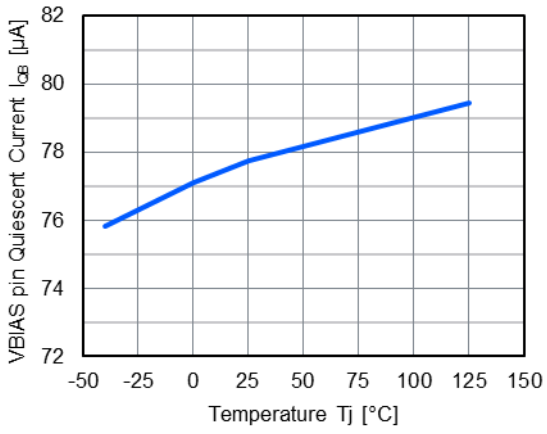


8) VBIAS pin Quiescent Current vs Temperature
V_{IN} = V_{SET} + 0.5 V, V_{BIAS} = 5.5 V, I_{OUT} = 0 mA

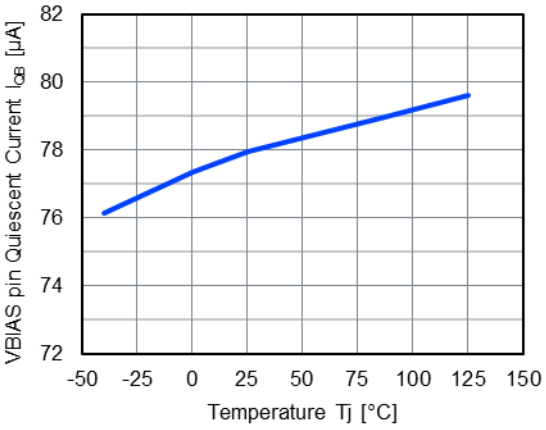
NR1644xx040A



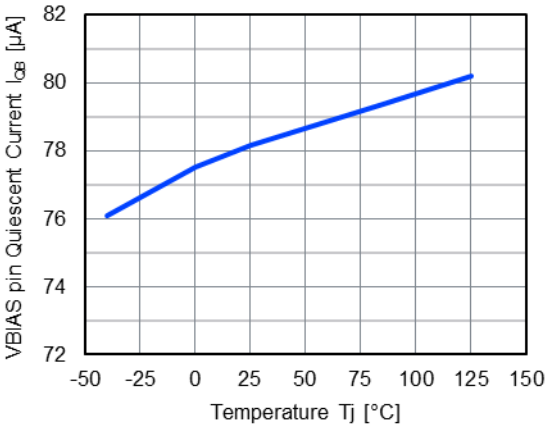
NR1644xx080A



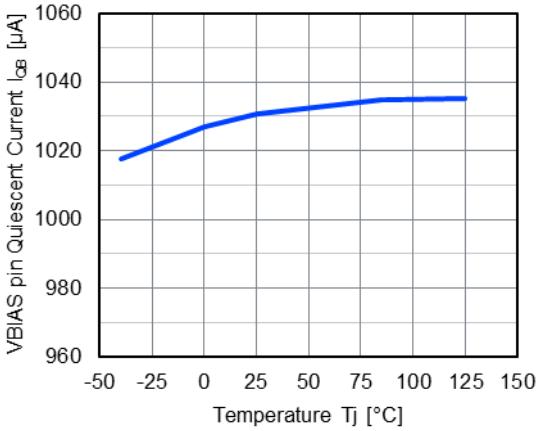
NR1644xx120A



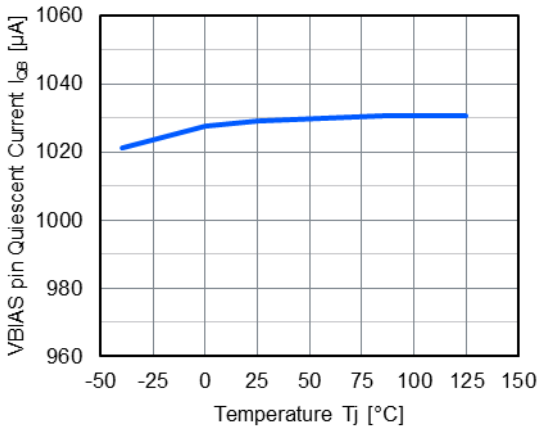
NR1644xx150A



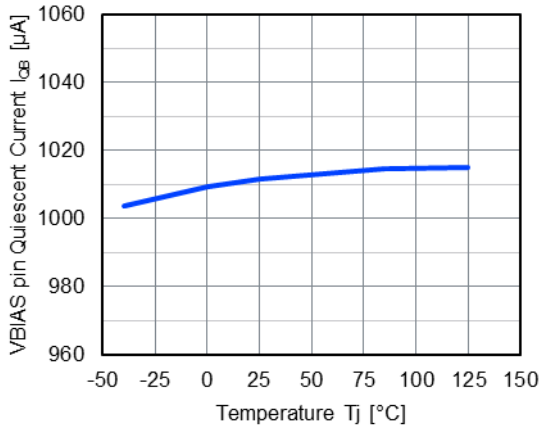
NR1644xx040B



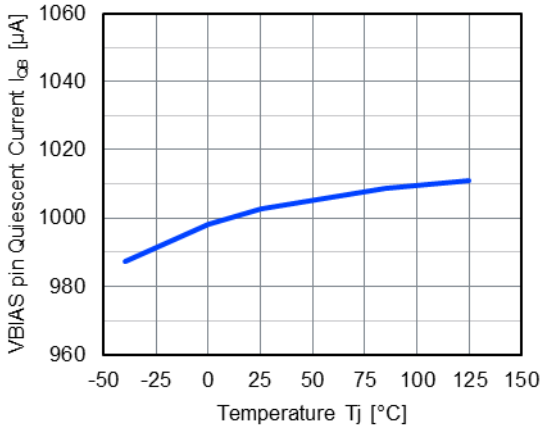
NR1644xx080B



NR1644xx120B

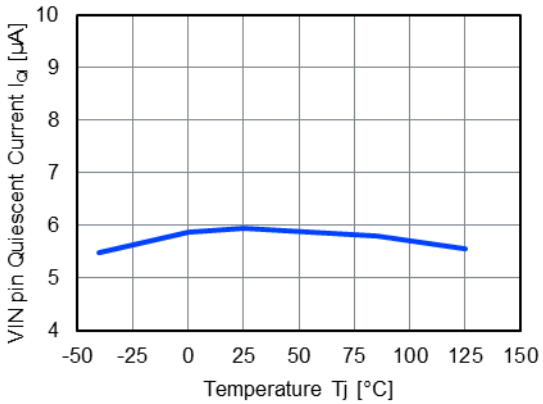


NR1644xx150B

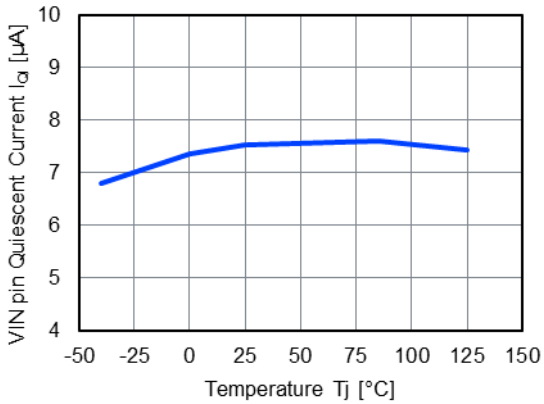


9) VIN pin Quiescent Current vs Temperature
V_{IN} = V_{SET} + 0.5 V, V_{BIAS} = 5.5 V, I_{OUT} = 0 mA, C_{IN} = none

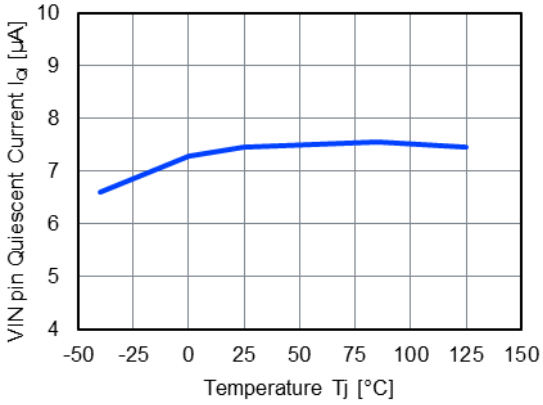
NR1644xx040x



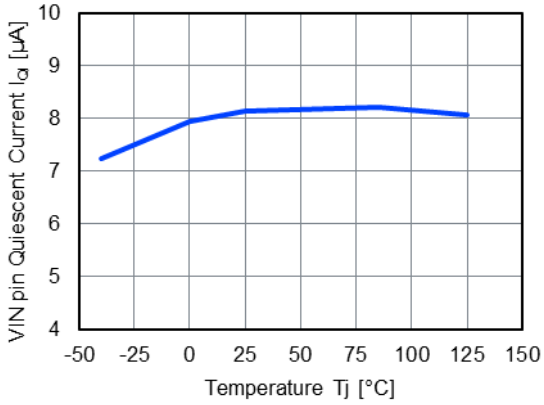
NR1644xx080x



NR1644xx120x

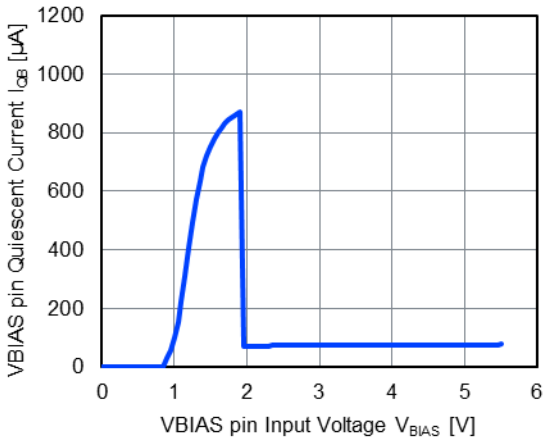


NR1644xx150x

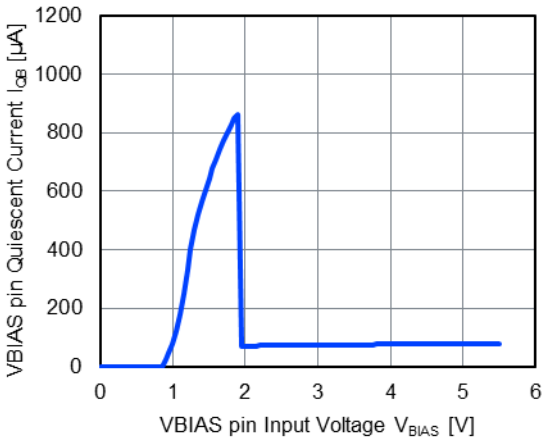


10) VBIAS pin Quiescent Current vs VBIAS pin Input Voltage
V_{BIAS} = 5.5 to 0 V

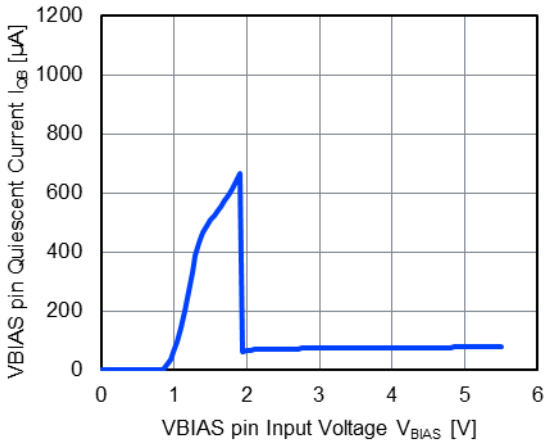
NR1644xx040A



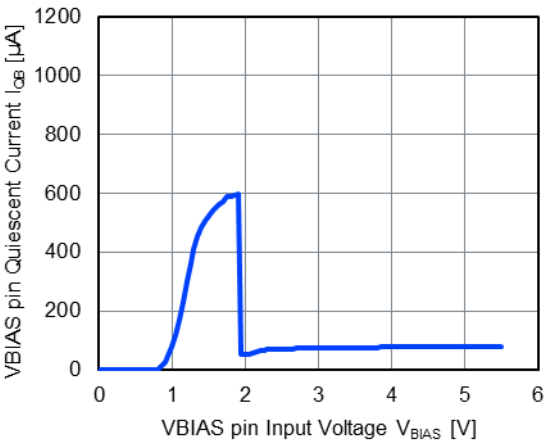
NR1644xx080A



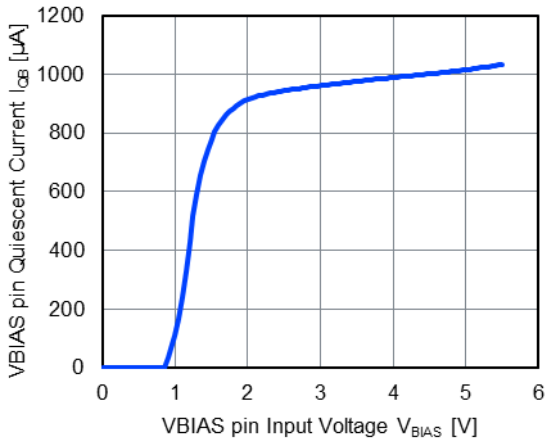
NR1644xx120A



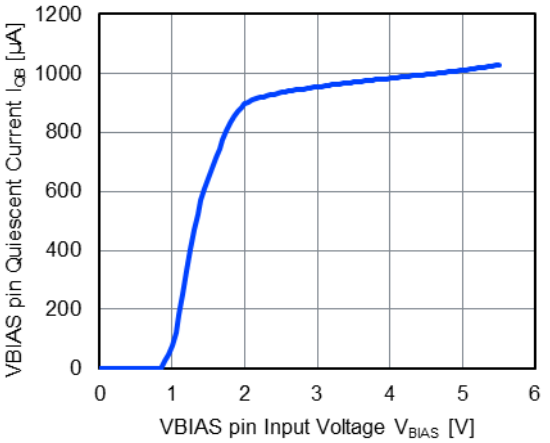
NR1644xx150A



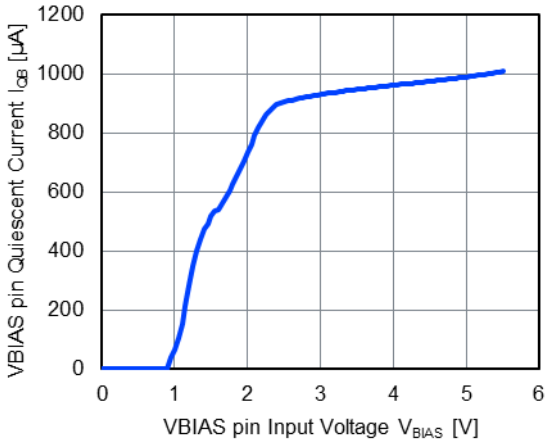
NR1644xx040B



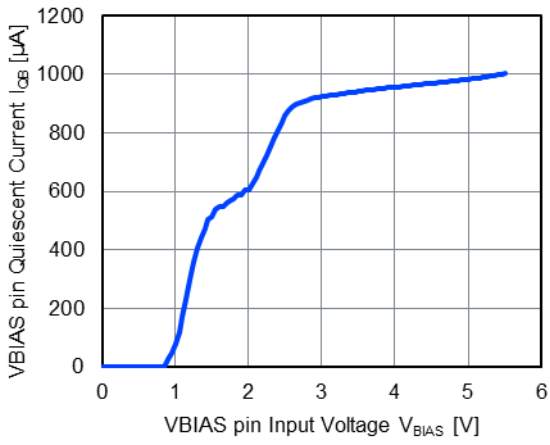
NR1644xx080B



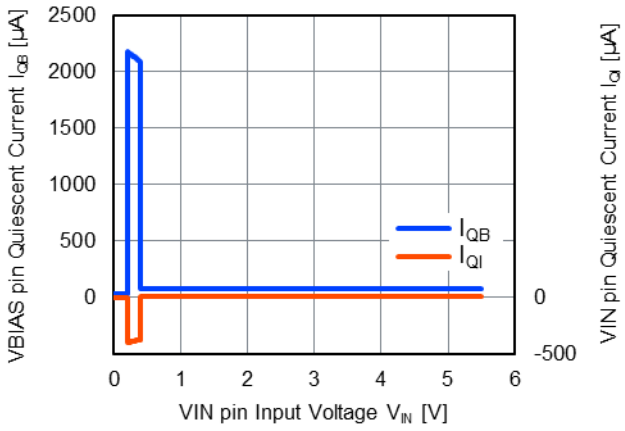
NR1644xx120B



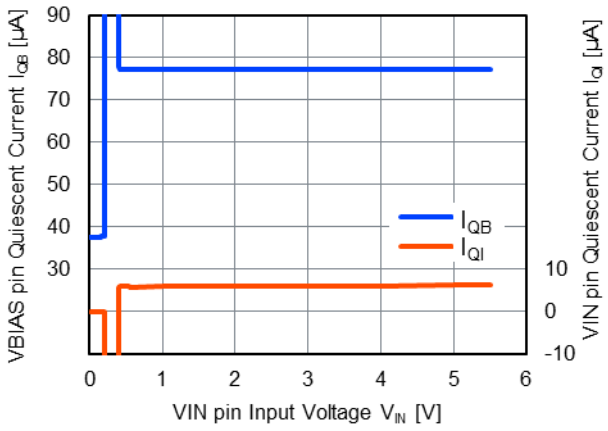
NR1644xx150B



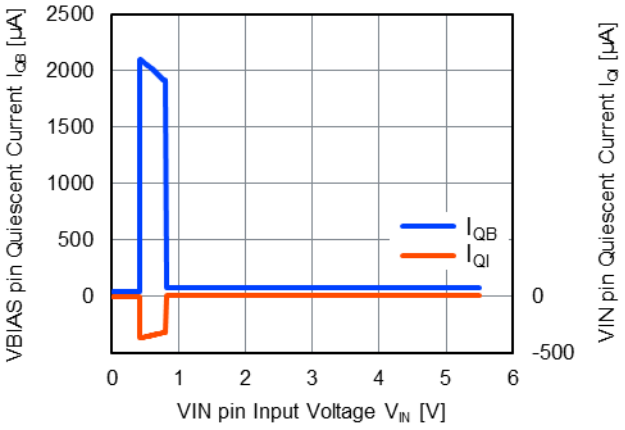
11) VBIAS / VIN pin Quiescent Current vs VIN pin Input Voltage
V_{IN} = 5.5 V to 0 V, V_{BIAS} = 5.5 V
NR1644xx040A
Overall View



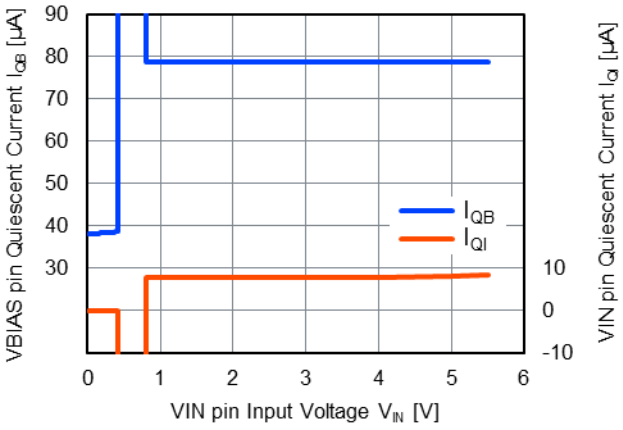
Enlarged View



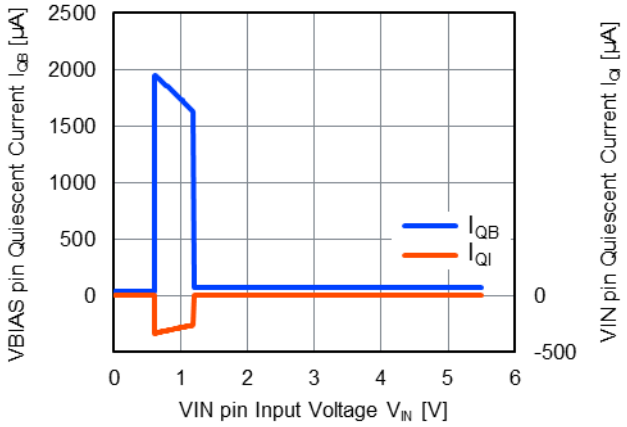
NR1644xx080A
Overall View



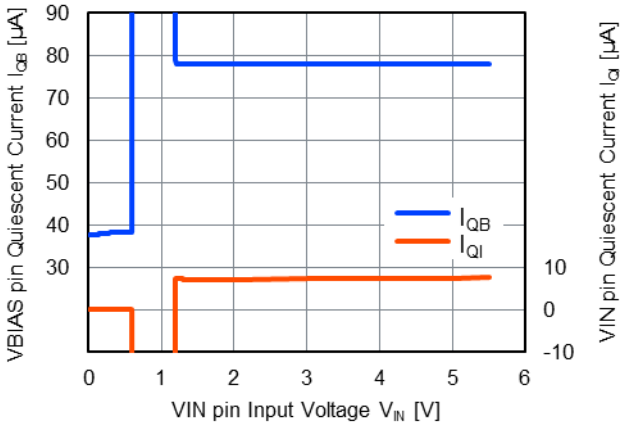
Enlarged View



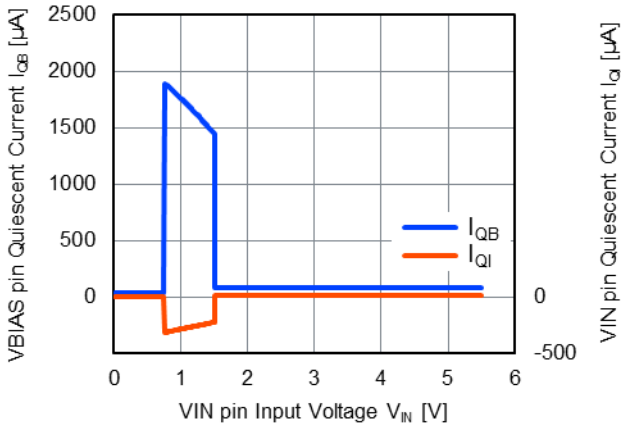
NR1644xx120A
Overall View



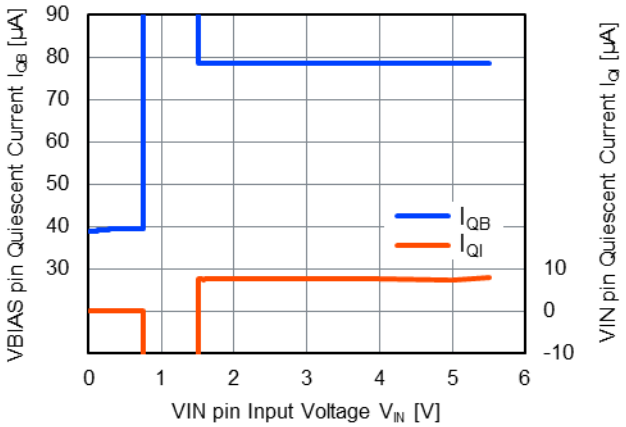
Enlarged View



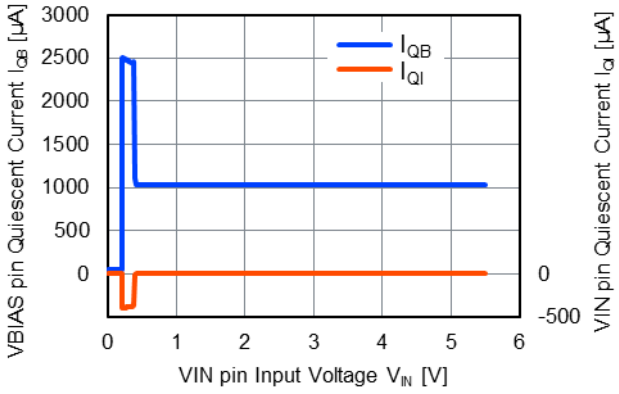
NR1644xx150A
Overall View



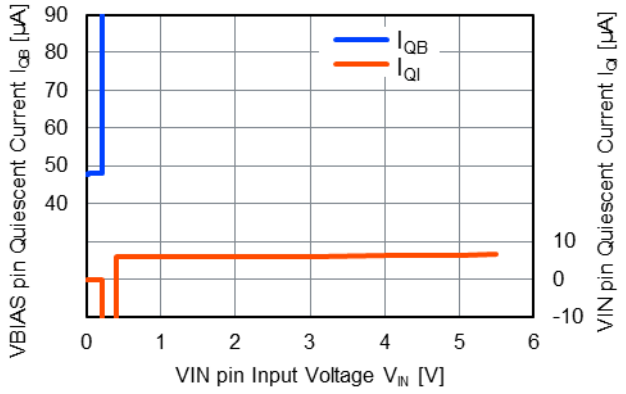
Enlarged View



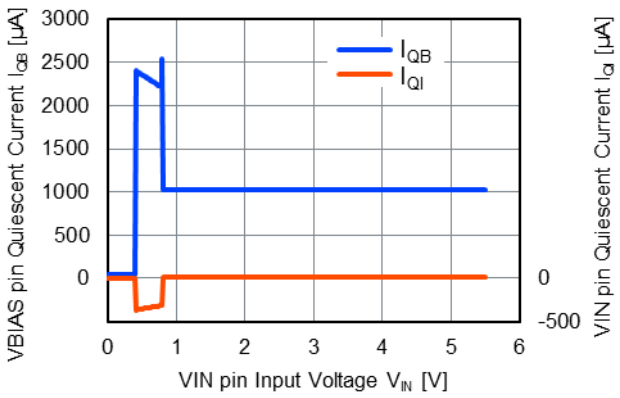
NR1644xx040B
Overall View



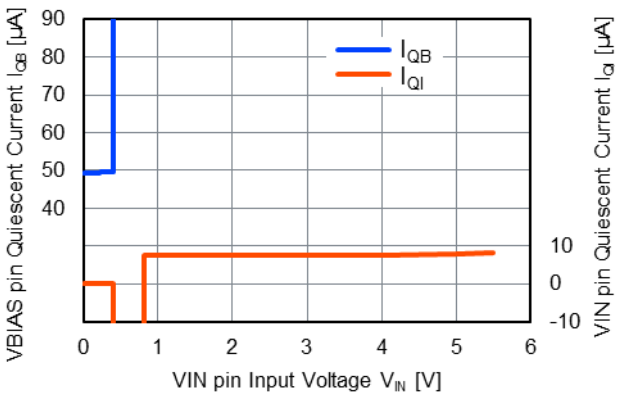
Enlarged View



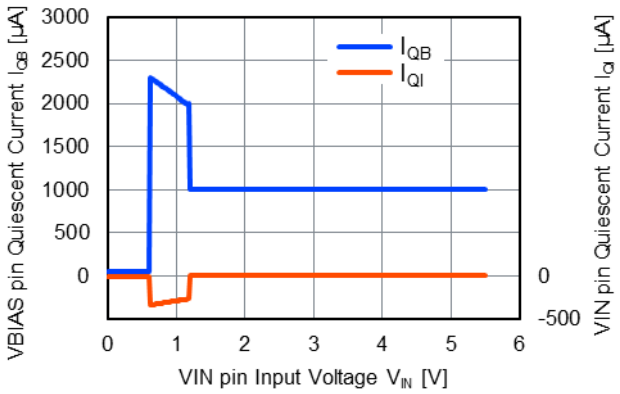
NR1644xx080B
Overall View



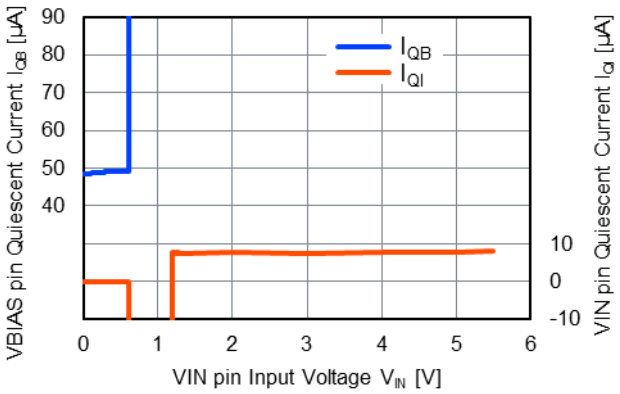
Enlarged View



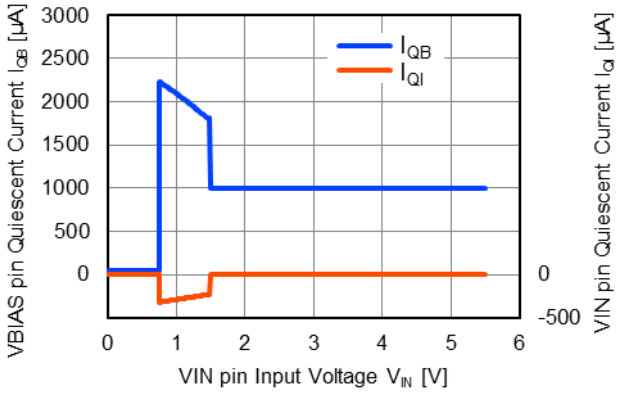
NR1644xx120B
Overall View



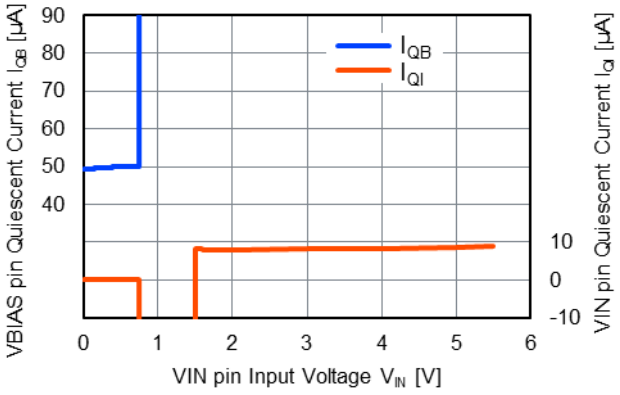
Enlarged View



NR1644xx150B
Overall View



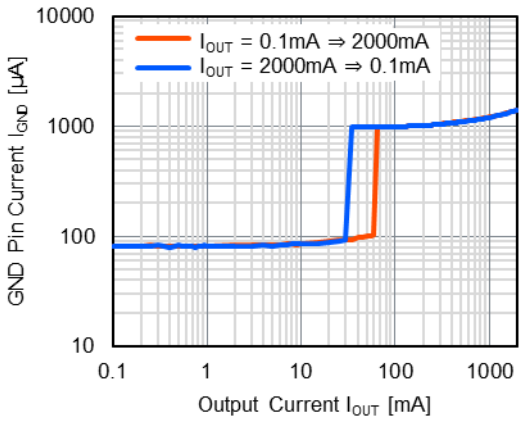
Enlarged View



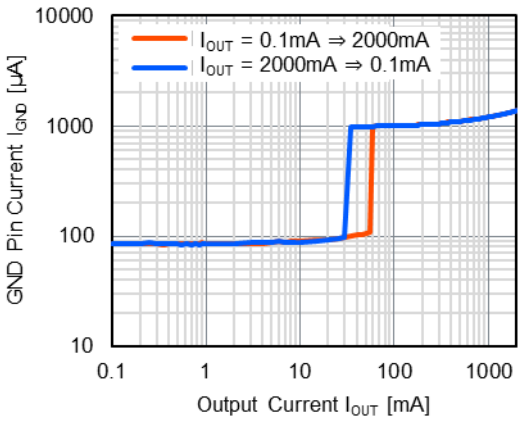
*Please note that if the Input Voltage (V_{IN}) drops below the Set Output Voltage (V_{SET}), current will flow from the VBIAS pin to the VIN pin through the inside of the IC. (However, current will not flow under conditions where V_{BIAS} also decreases at the same time as V_{IN})

12) GND pin Current vs Output Current
Tj = 25 °C

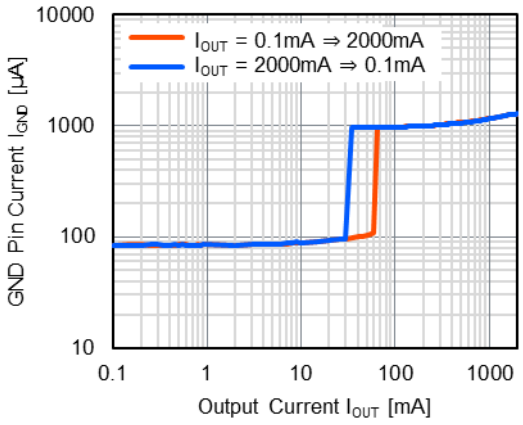
NR1644xx040A



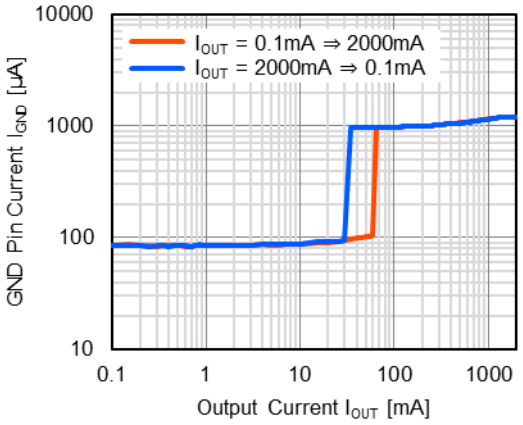
NR1644xx080A



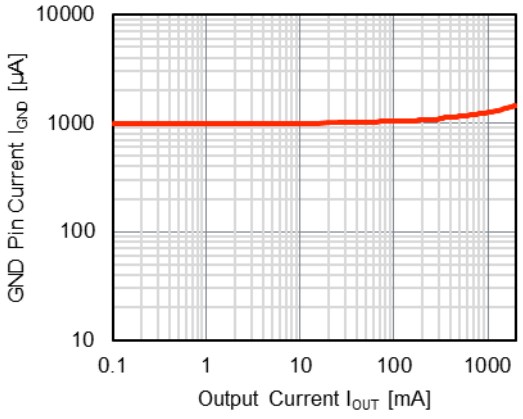
NR1644xx120A



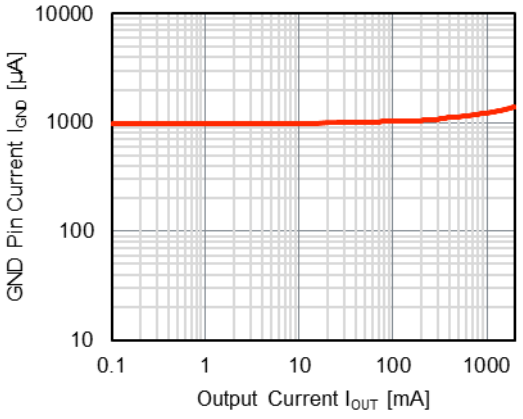
NR1644xx150A



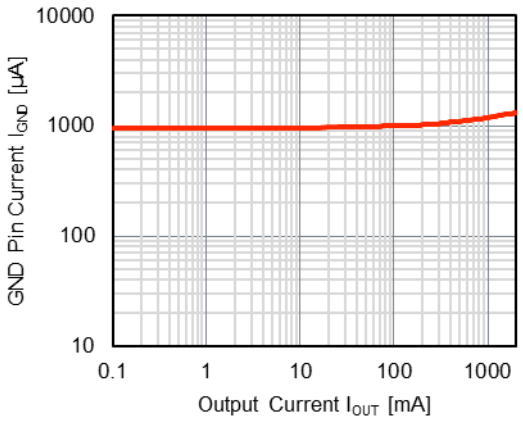
NR1644xx040B, I_{OUT} = 0.1 mA to 2000 mA



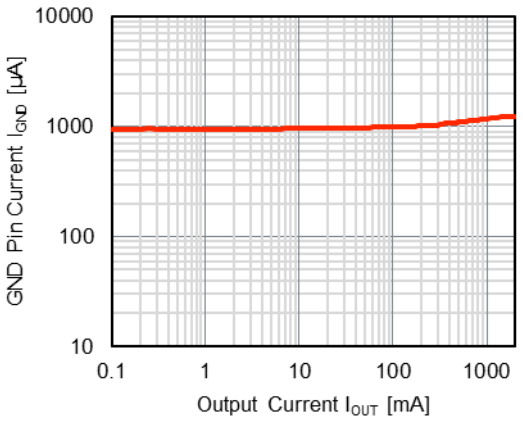
NR1644xx080B, I_{OUT} = 0.1 mA to 2000 mA



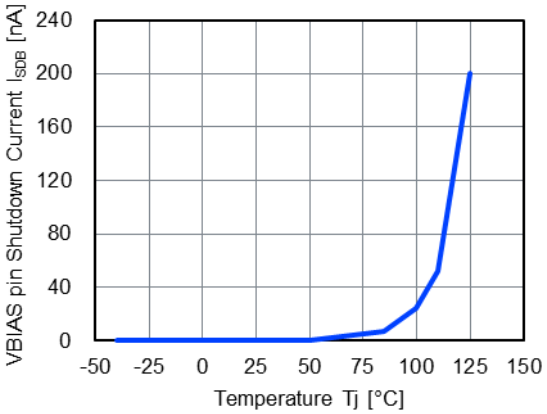
NR1644xx120B, I_{OUT} = 0.1 mA to 2000 mA



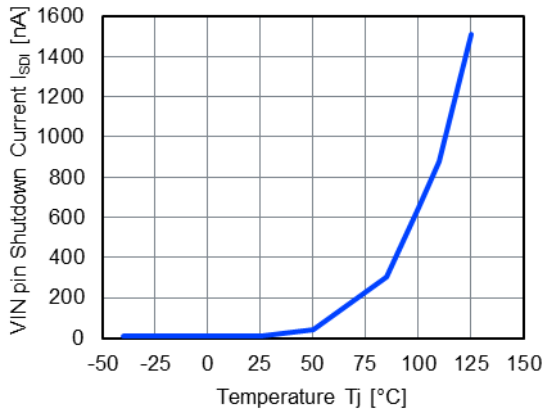
NR1644xx150B, I_{OUT} = 0.1 mA to 2000 mA



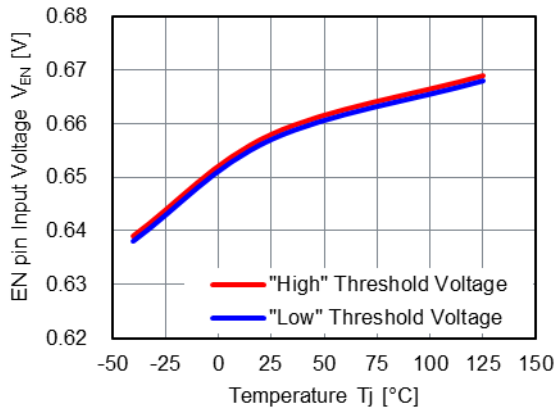
13) VBIAS pin Shutdown Current vs Temperature
V_{IN} = 5.5 V, V_{BIAS} = 5.5 V, V_{EN} = 0 V, C_{BIAS} = none
NR1644xxxxxx



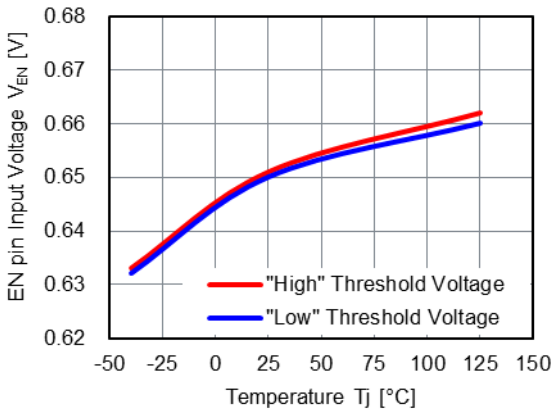
14) VIN pin Shutdown Current vs Temperature
V_{IN} = 5.5 V, V_{BIAS} = 5.5 V, V_{EN} = 0 V, C_{IN} = none
NR1644xxxxxx



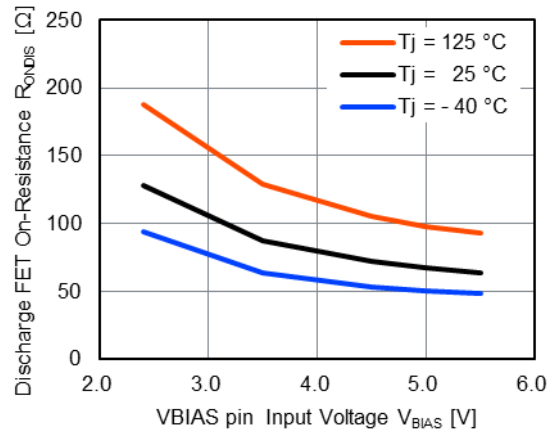
15) EN pin "High / Low" Threshold Voltage vs Temperature
NR1644xxxxxx
V_{BIAS} = 2.4 V



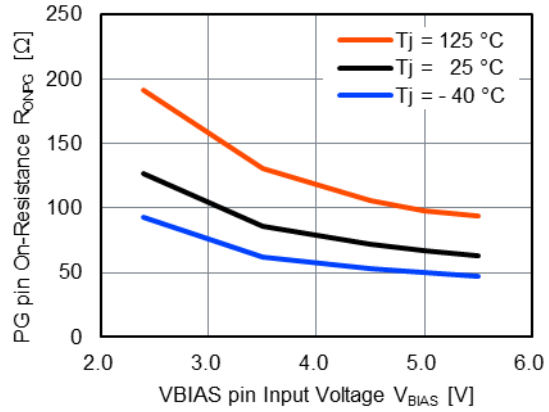
V_{BIAS} = 5.5 V



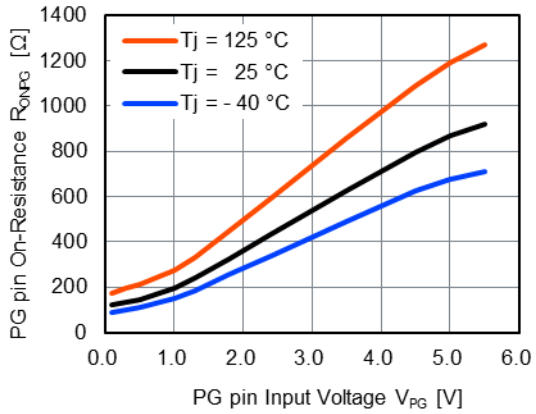
16) Discharge FET On-Resistance vs VBIAS pin Input Voltage
V_{BIAS} = 2.4 V to 5.5 V, V_{OUT} = 100 mV, V_{EN} = 0 V
NR1644xxxxxx



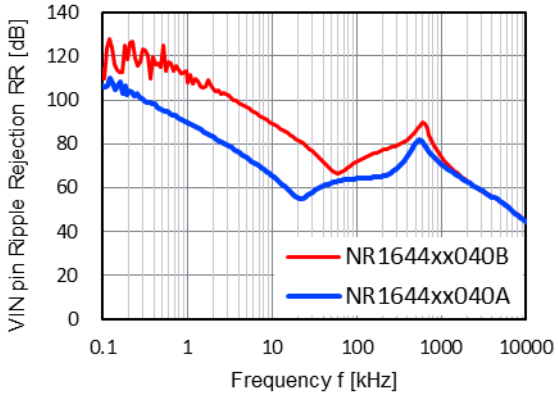
17) PG pin On-Resistance vs VBIAS pin Input Voltage
V_{BIAS} = 2.4 V to 5.5 V, V_{PG} = 100 mV, V_{EN} = 0 V
NR1644xxxxxx



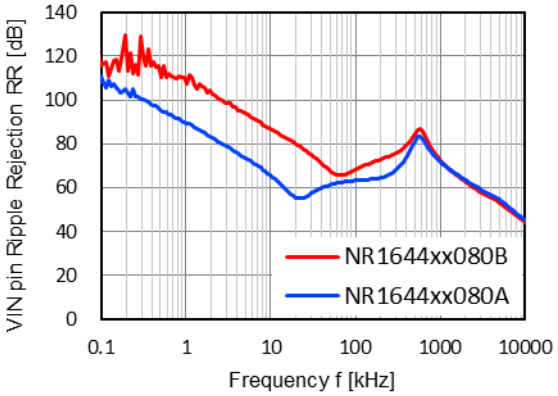
18) PG pin On-Resistance vs PG pin Input Voltage
V_{BIAS} = 2.4 V, V_{EN} = 0 V
NR1644xxxxxx



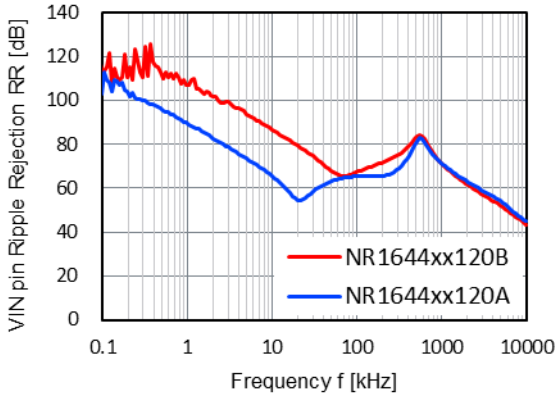
19) VIN pin Ripple Rejection vs Frequency
V_{IN} = V_{SET} + 0.5 V (V_{Ripple} = 0.2 V_{P-P}), C_{IN} = none
NR1644xx040x, I_{OUT} = 1 mA, C_{OUT} = 10 µF



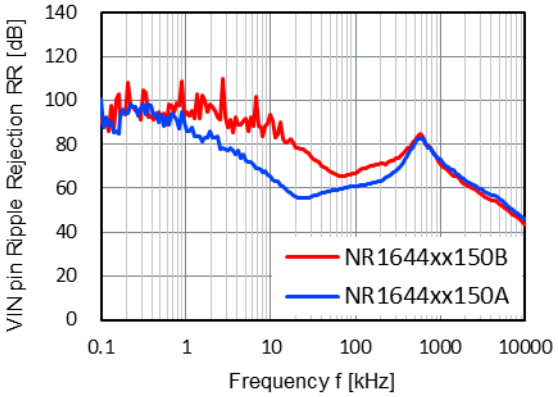
NR1644xx080x, I_{OUT} = 1 mA, C_{OUT} = 10 µF



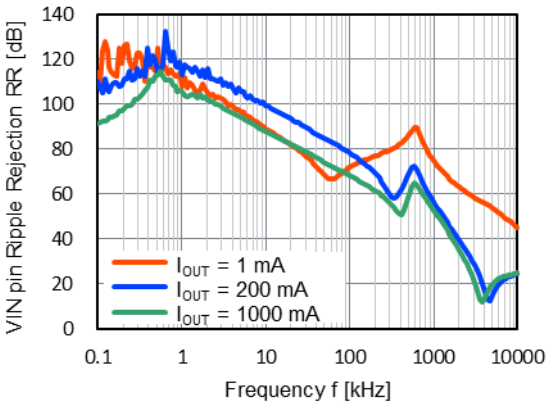
NR1644xx120x, I_{OUT} = 1 mA, C_{OUT} = 10 µF



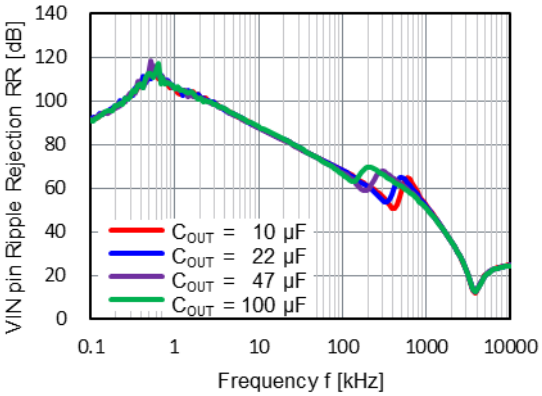
NR1644xx150x, I_{OUT} = 1 mA, C_{OUT} = 10 µF



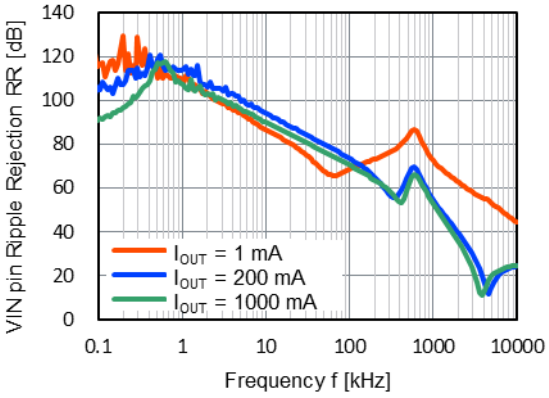
NR1644xx040B, C_{OUT} = 10 µF



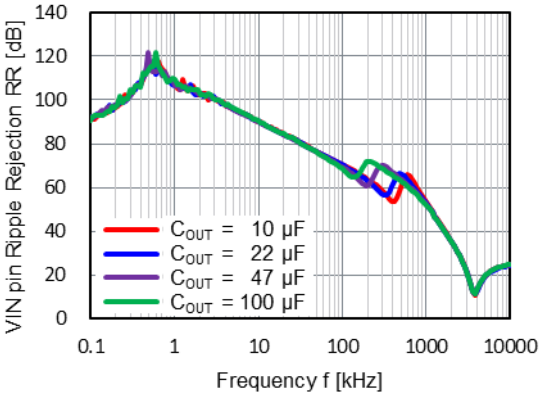
NR1644xx040x, I_{OUT} = 1000 mA



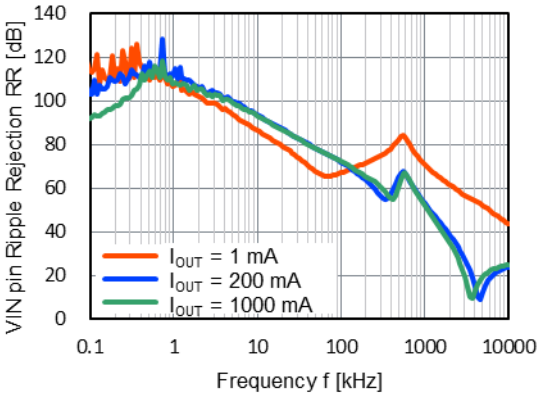
NR1644xx080B, C_{OUT} = 10 µF



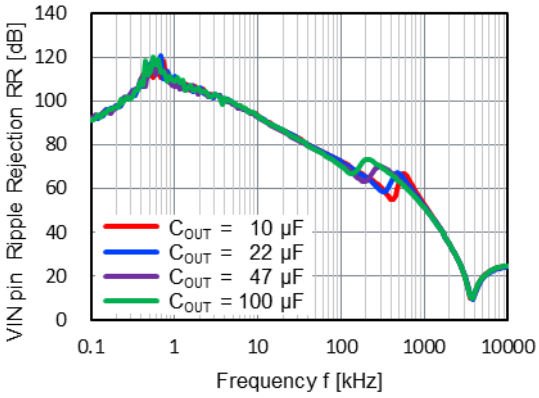
NR1644xx080x, I_{OUT} = 1000 mA



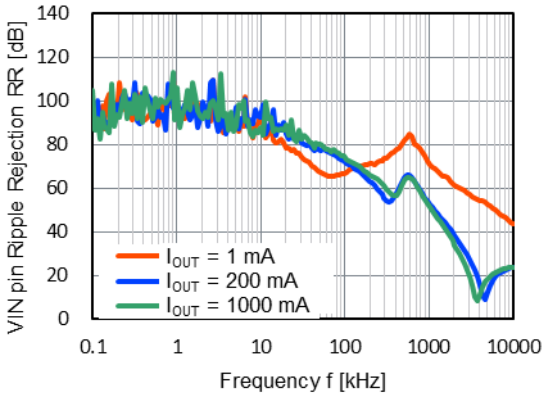
NR1644xx120B, C_{OUT} = 10 µF



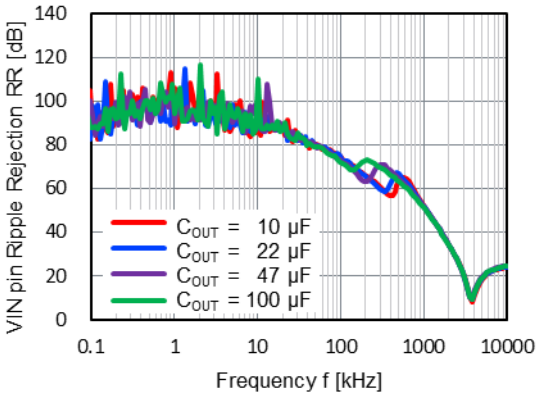
NR1644xx120x, I_{OUT} = 1000 mA



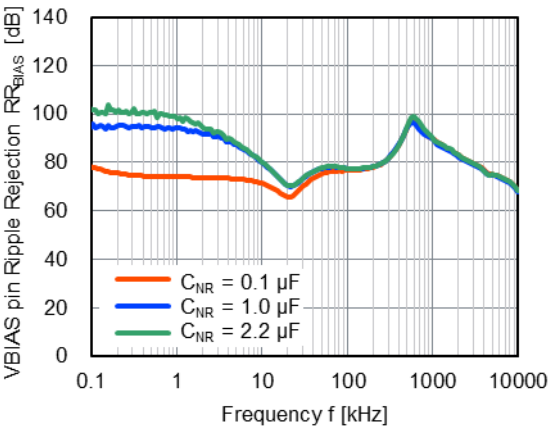
NR1644xx150B, C_{OUT} = 10 µF



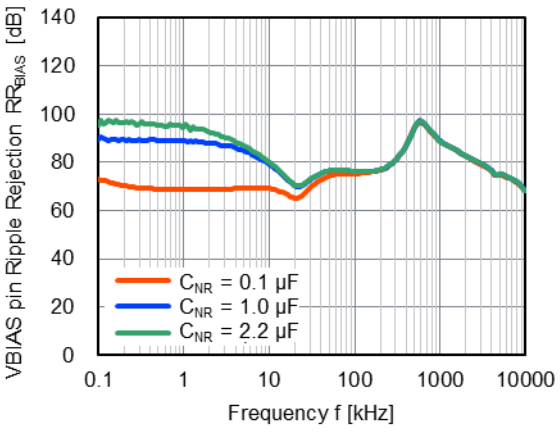
NR1644xx150x, I_{OUT} = 1000 mA



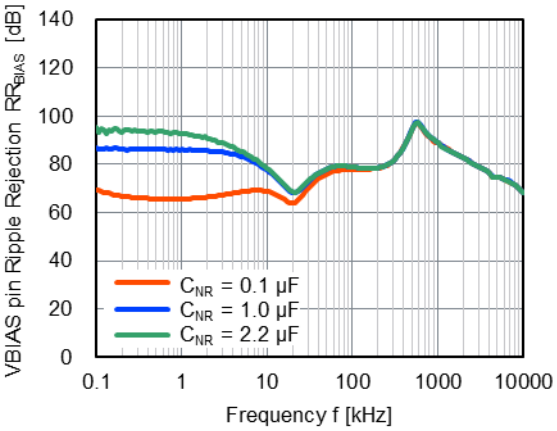
20) VBIAS pin Ripple Rejection vs Frequency
V_{BIAS} = 3.6 V (V_{Ripple} = 0.2 V_{P-P}), C_{BIAS} = none
NR1644xx040A, I_{OUT} = 1 mA



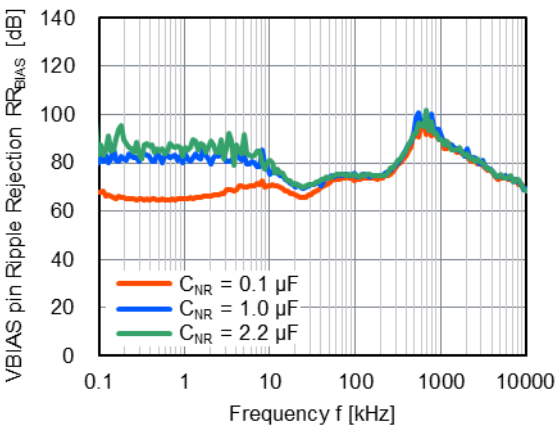
NR1644xx080A, I_{OUT} = 1 mA



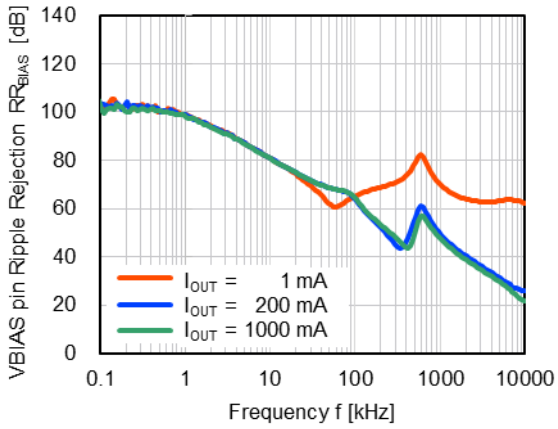
NR1644xx120A, I_{OUT} = 1 mA



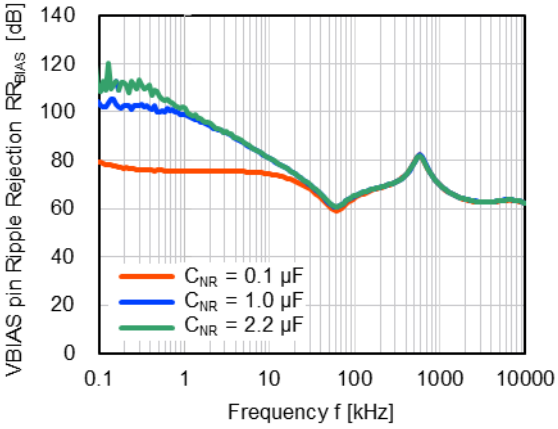
NR1644xx150A, I_{OUT} = 1 mA



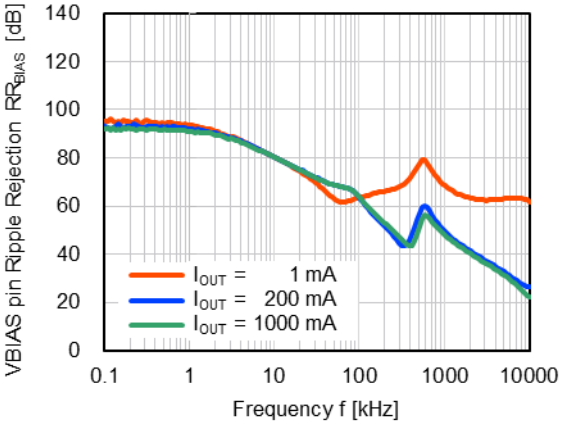
NR1644xx040B, C_{NR} = 1.0 µF



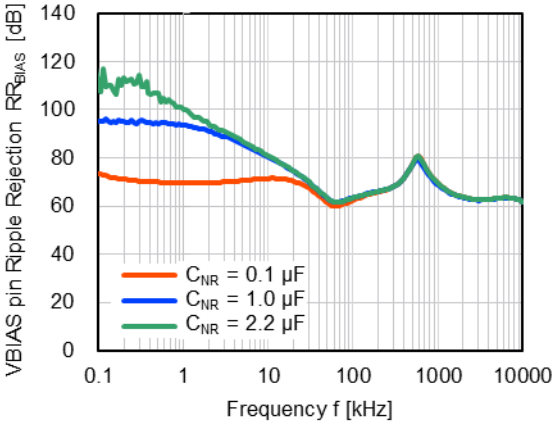
NR1644xx040B, I_{OUT} = 1 mA



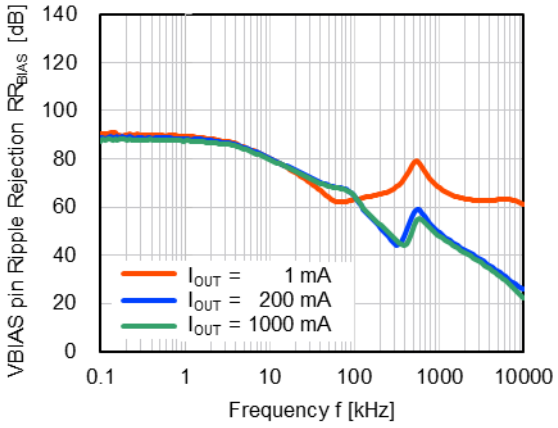
NR1644xx080B, C_{NR} = 1.0 µF



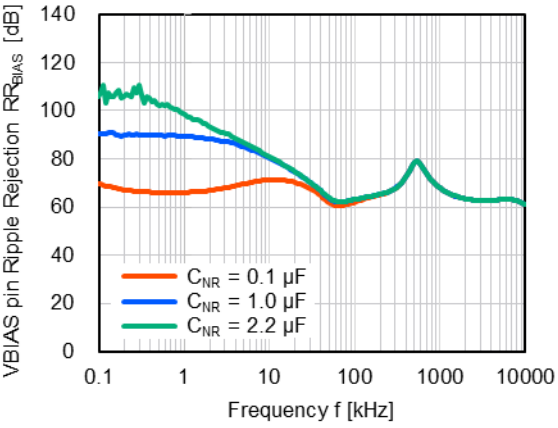
NR1644xx080B, I_{OUT} = 1 mA



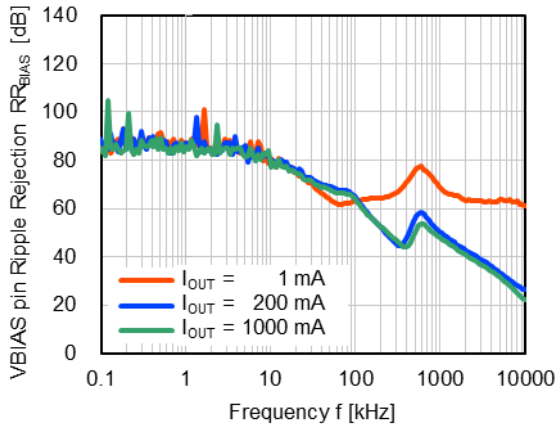
NR1644xx120B, C_{NR} = 1.0 µF



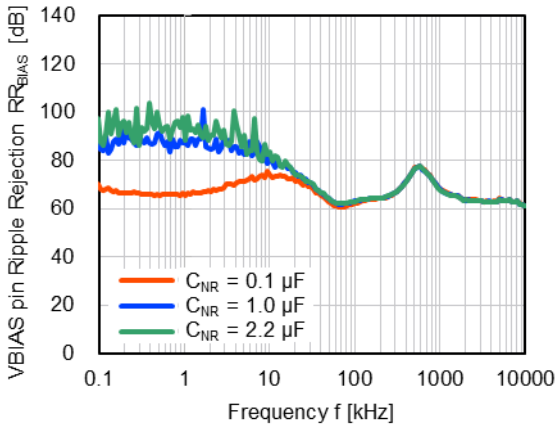
NR1644xx120B, I_{OUT} = 1 mA



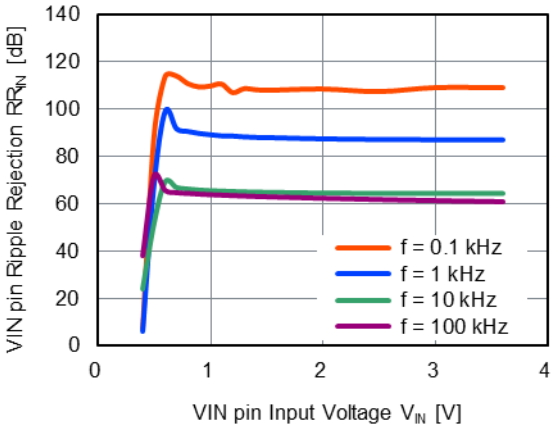
NR1644xx150B, C_{NR} = 1.0 µF



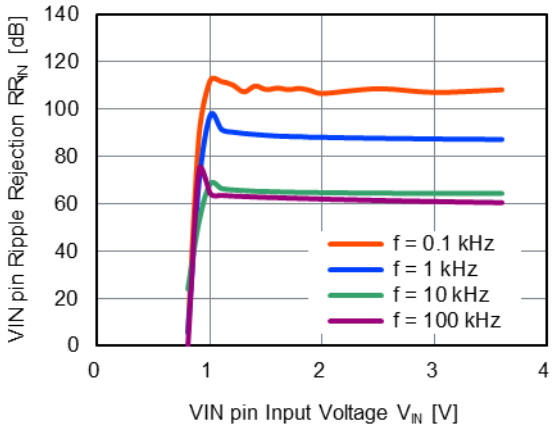
NR1644xx150B, I_{OUT} = 1 mA



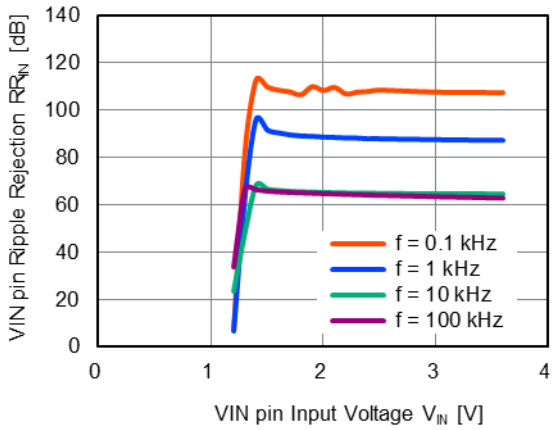
21) VIN pin Ripple Rejection vs VIN pin Input Voltage
V_{IN} = V_{SET} to 3.6 V, V_{BIAS} = 3.6 V (V_{Ripple} = 0.2 V_{P-P}), C_{IN} = none
NR1644xx040A, I_{OUT} = 1 mA



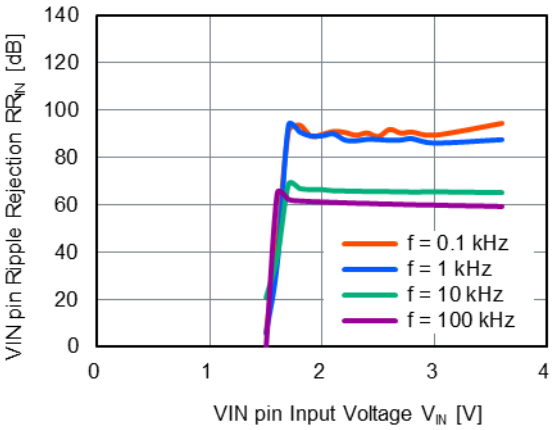
NR1644xx080A, I_{OUT} = 1 mA



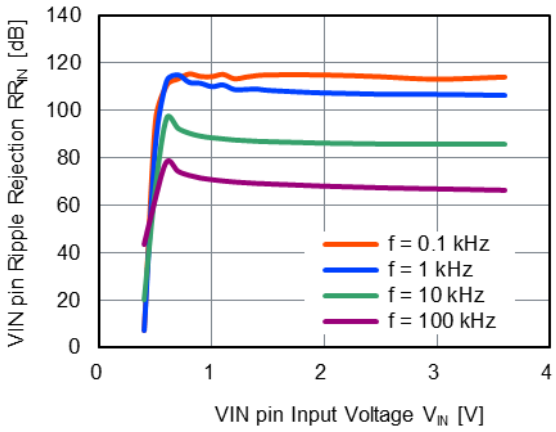
NR1644xx120A, I_{OUT} = 1 mA



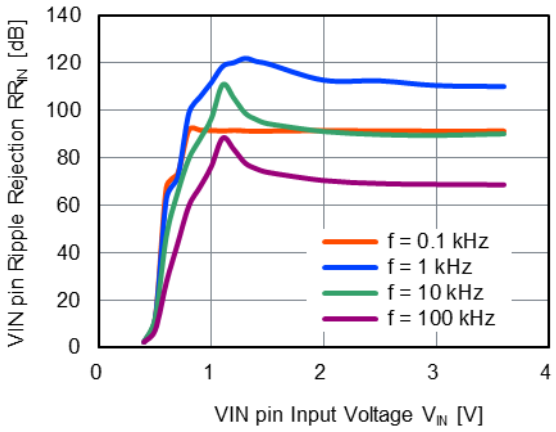
NR1644xx150A, I_{OUT} = 1 mA



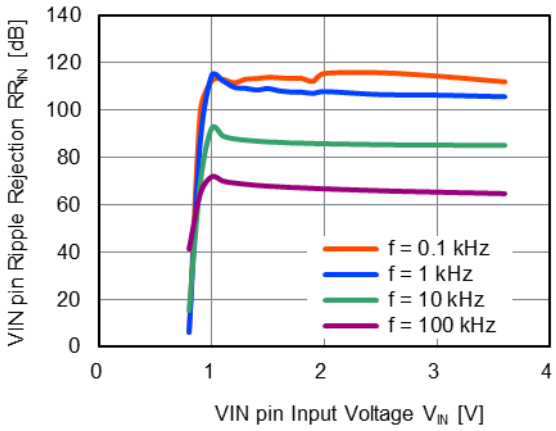
NR1644xx040B, I_{OUT} = 1 mA



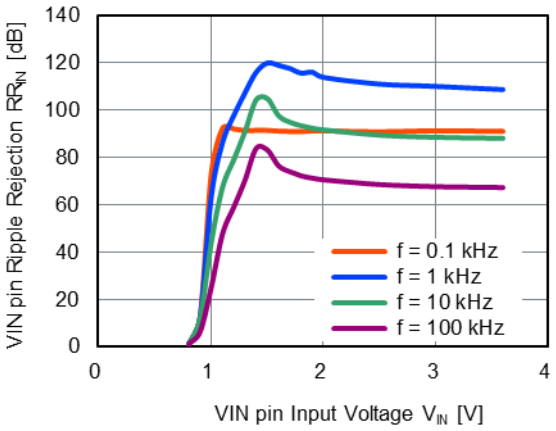
NR1644xx040B, I_{OUT} = 1000 mA



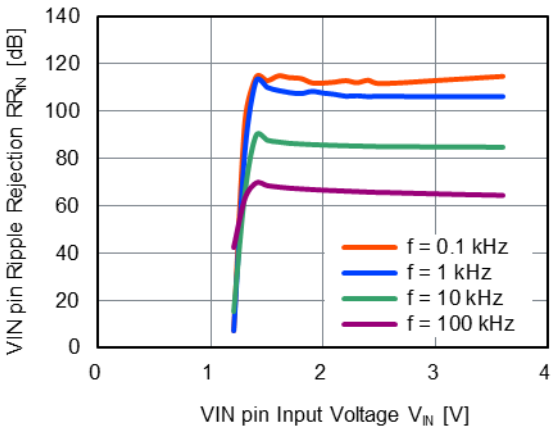
NR1644xx080B, I_{OUT} = 1 mA



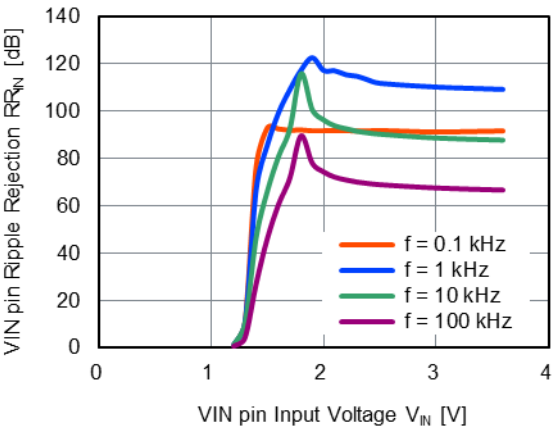
NR1644xx080B, I_{OUT} = 1000 mA



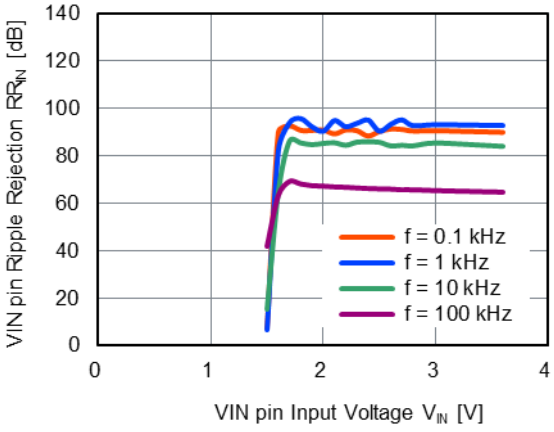
NR1644xx120B, I_{OUT} = 1 mA



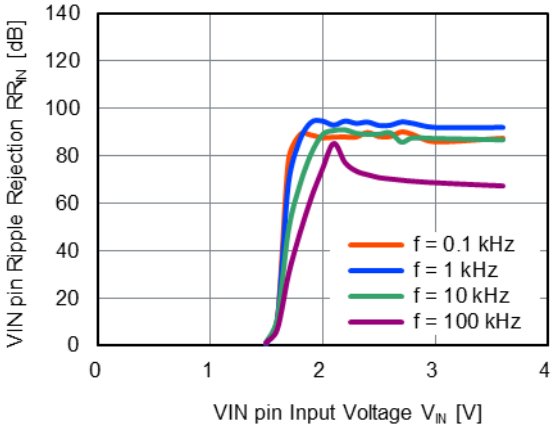
NR1644xx120B, I_{OUT} = 1000 mA



NR1644xx150B, I_{OUT} = 1 mA

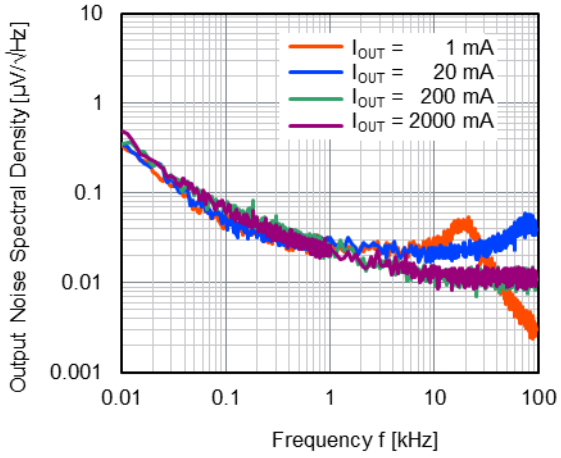


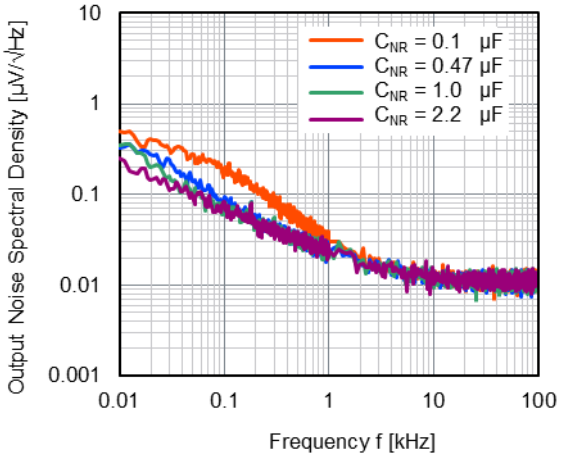
NR1644xx150B, I_{OUT} = 1000 mA



22) Output Noise Spectral Density vs Frequency
NR1644xx040A
C_{NR} = 1.0 µF

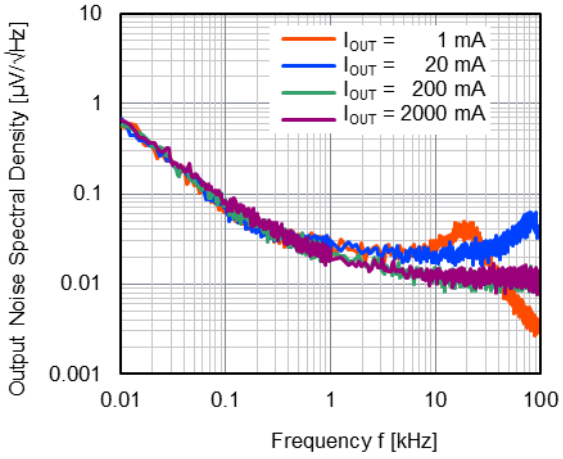
I_{OUT} = 200 mA

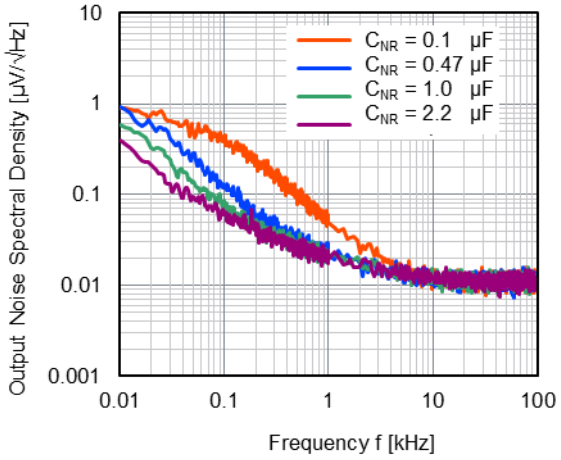




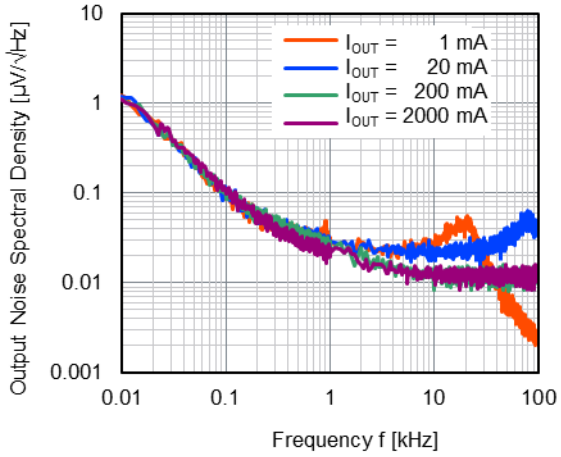
NR1644xx080A
C_{NR} = 1.0 µF

I_{OUT} = 200 mA

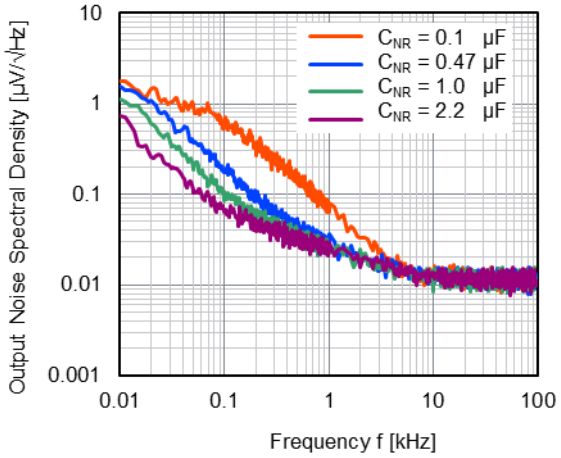




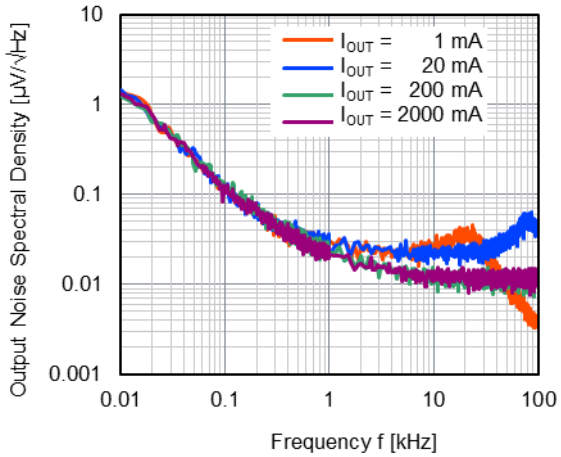
NR1644xx120A
C_{NR} = 1.0 µF



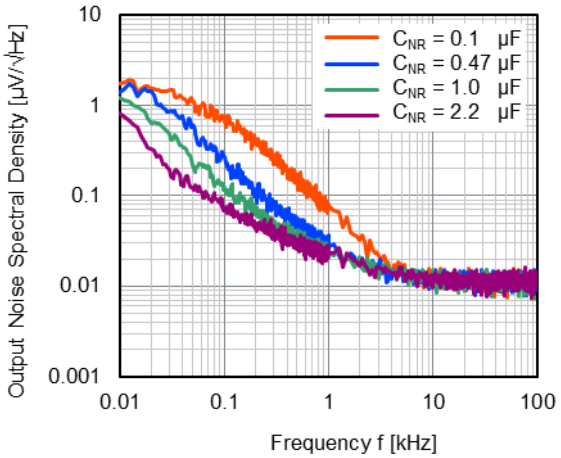
I_{OUT} = 200 mA



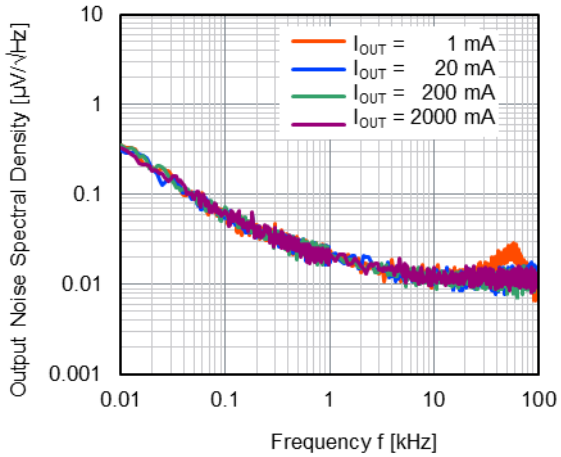
NR1644xx150A
C_{NR} = 1.0 µF



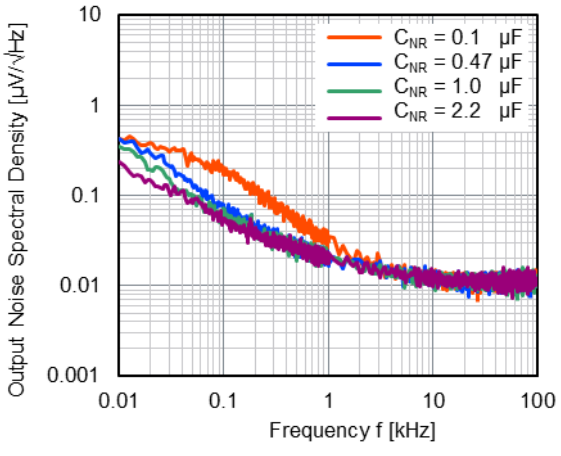
I_{OUT} = 200 mA



NR1644xx040B,
C_{NR} = 1.0 µF

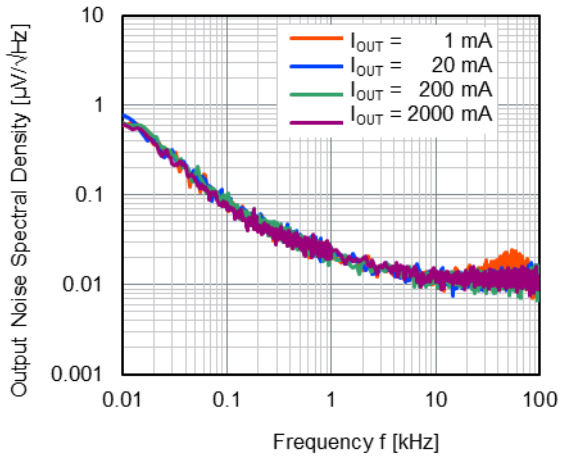


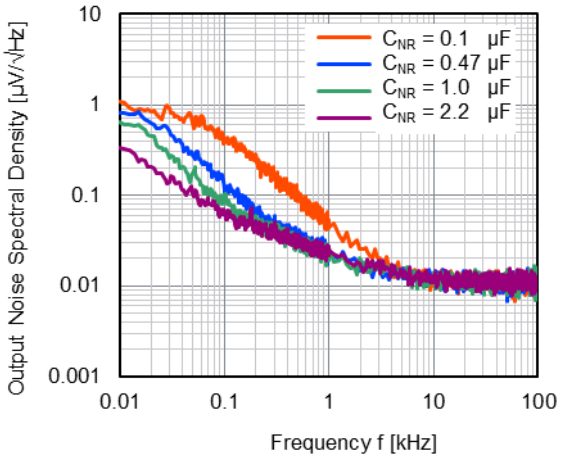
I_{OUT} = 200 mA



NR1644xx080B
C_{NR} = 1.0 µF

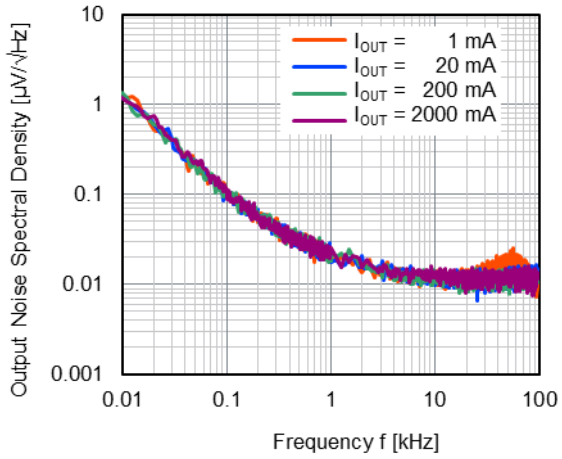
I_{OUT} = 200 mA

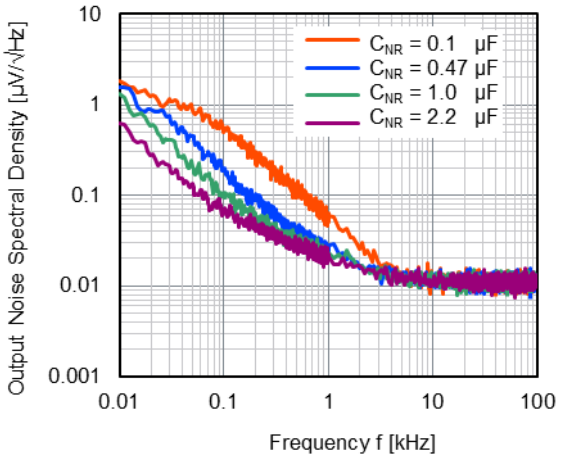




NR1644xx120B
C_{NR} = 1.0 µF

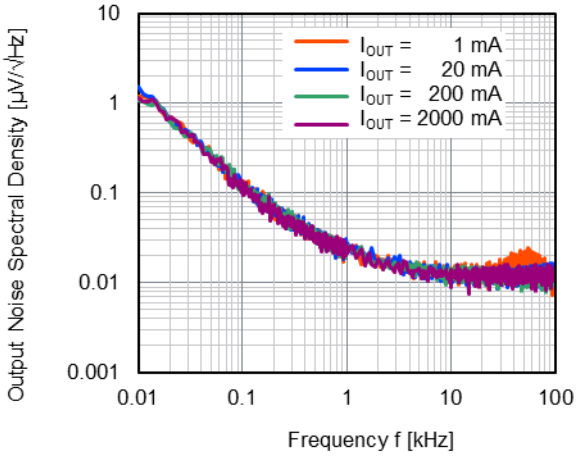
I_{OUT} = 200 mA

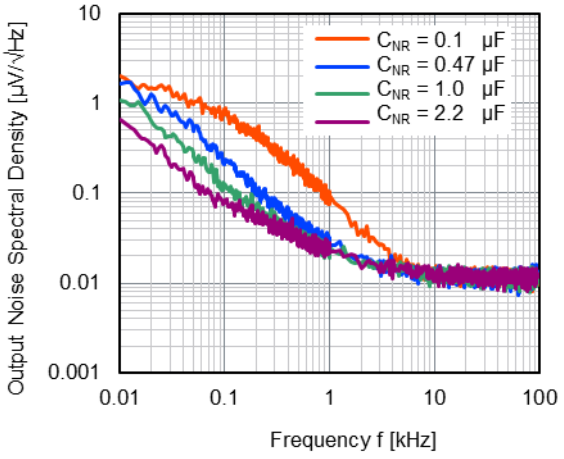




NR1644xx150B
C_{NR} = 1.0 µF

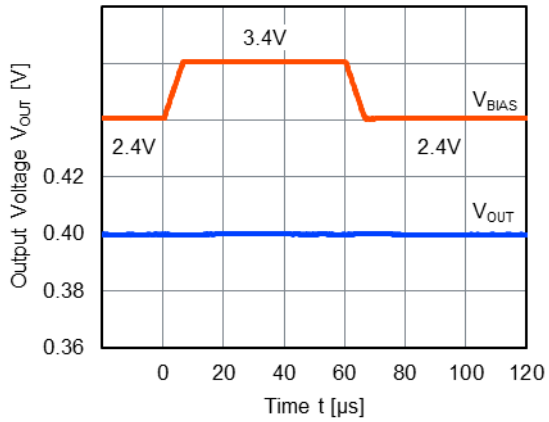
I_{OUT} = 200 mA



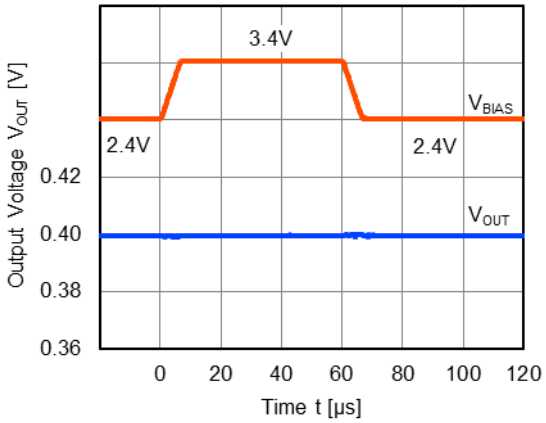


23) VBIAS pin Line Transient Response
V_{BIAS} = V_{SET} + 2 V ⇔ V_{SET} + 3 V (t_R = t_F = 5 µs)

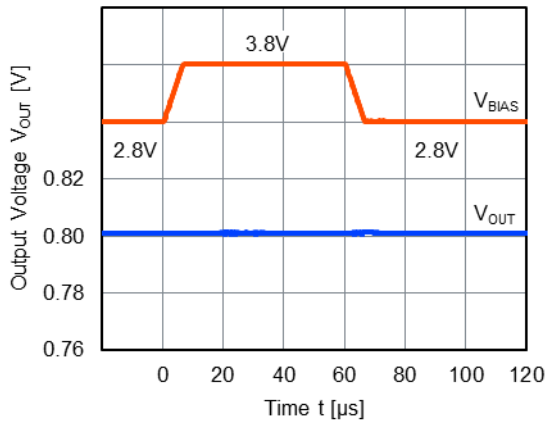
NR1644xx040x, I_{OUT} = 1 mA



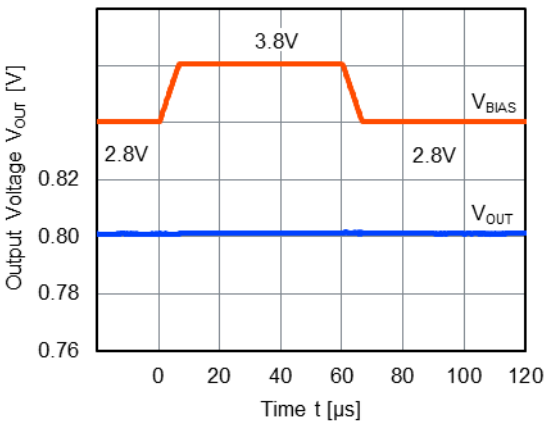
NR1644xx040x, I_{OUT} = 200 mA



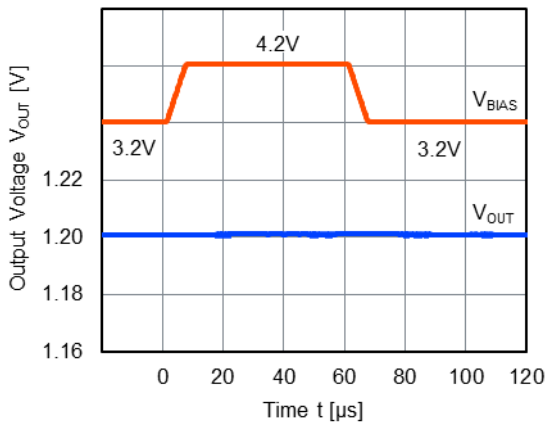
NR1644xx080x, I_{OUT} = 1 mA



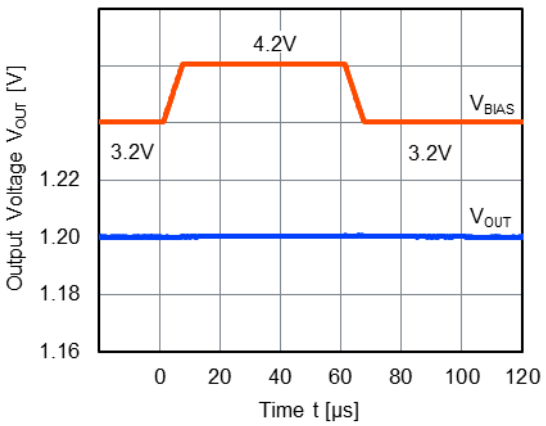
NR1644xx080x, I_{OUT} = 200 mA



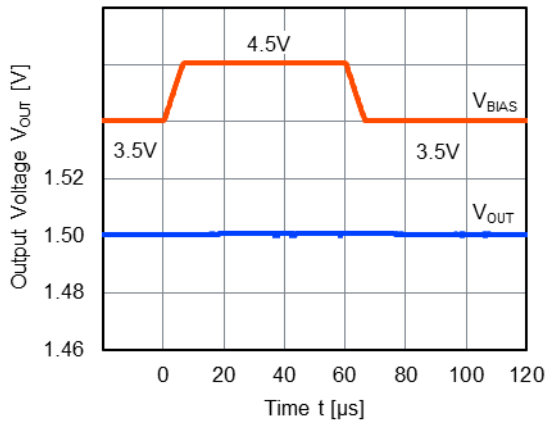
NR1644xx120x, I_{OUT} = 1 mA



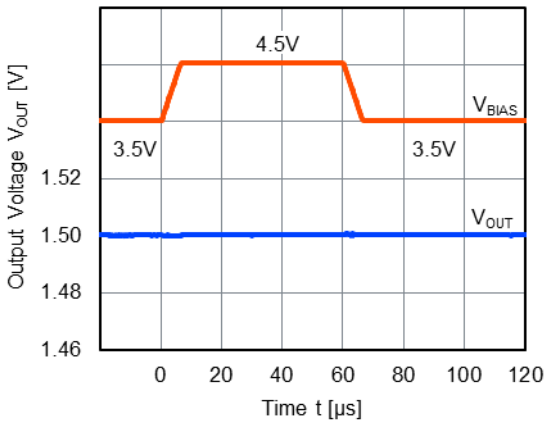
NR1644xx120x, I_{OUT} = 200 mA



NR1644xx150x, I_{OUT} = 1 mA



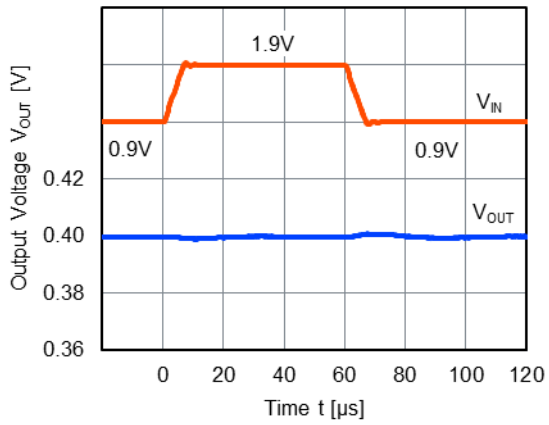
NR1644xx150x, I_{OUT} = 200 mA



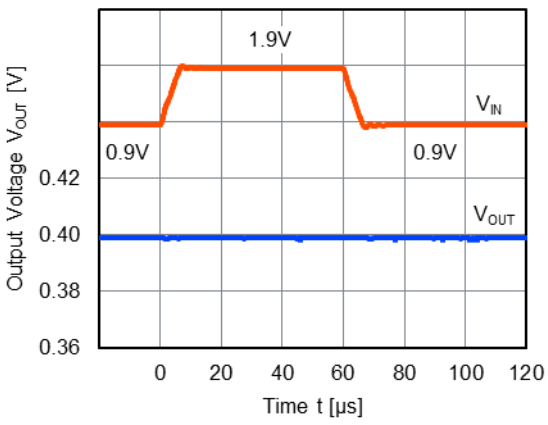
24) VIN pin Line Transient Response

V_{IN} = V_{SET} + 0.5 V ⇔ V_{SET} + 1.5 V (t_R = t_F = 5 µs), C_{IN} = 0.47 µF

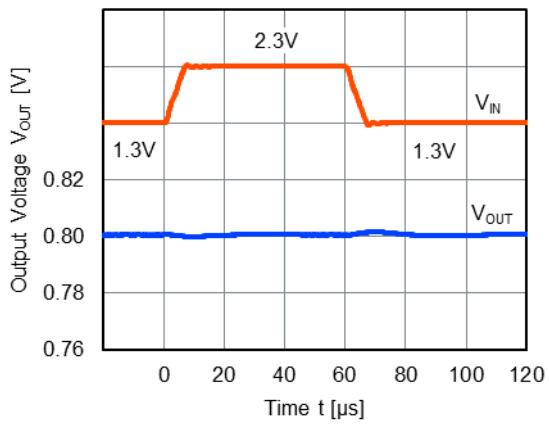
NR1644xx040x, I_{OUT} = 1 mA



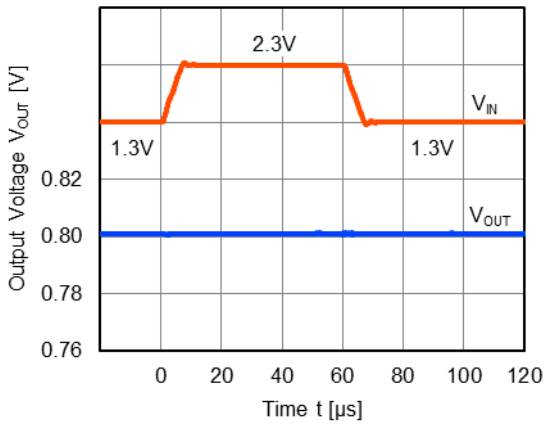
NR1644xx040x, I_{OUT} = 200 mA



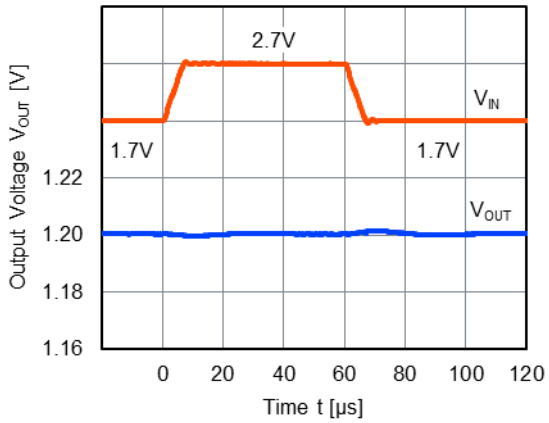
NR1644xx080x, I_{OUT} = 1 mA



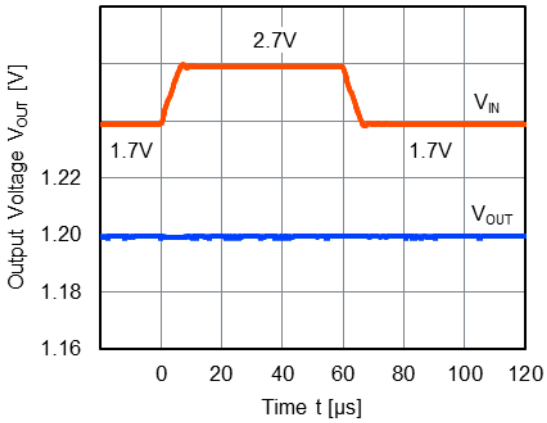
NR1644xx080x, I_{OUT} = 200 mA



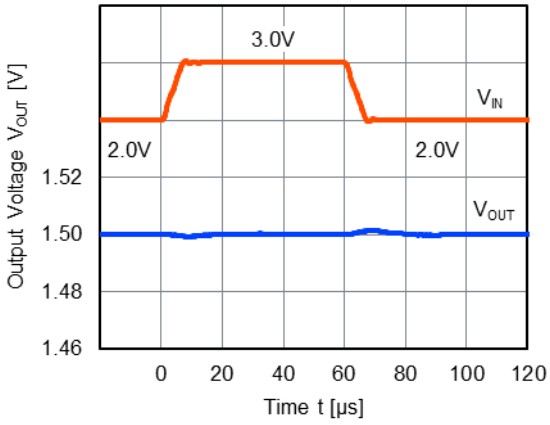
NR1644xx120x, I_{OUT} = 1 mA



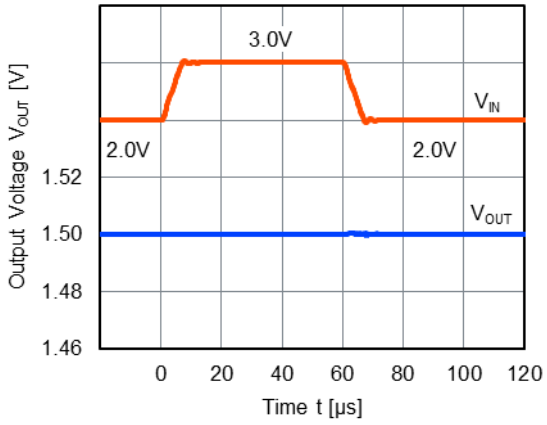
NR1644xx120x, I_{OUT} = 200 mA



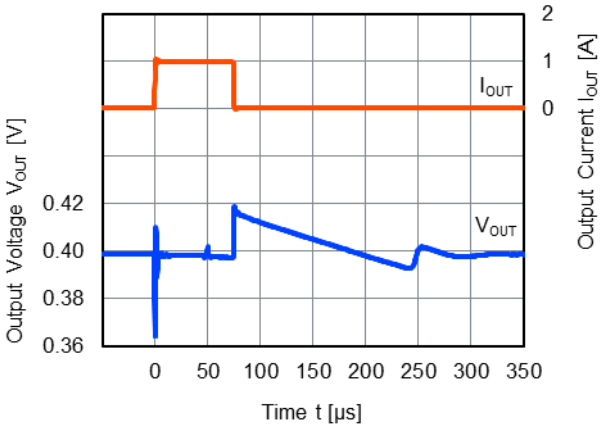
NR1644xx150x, I_{OUT} = 1 mA



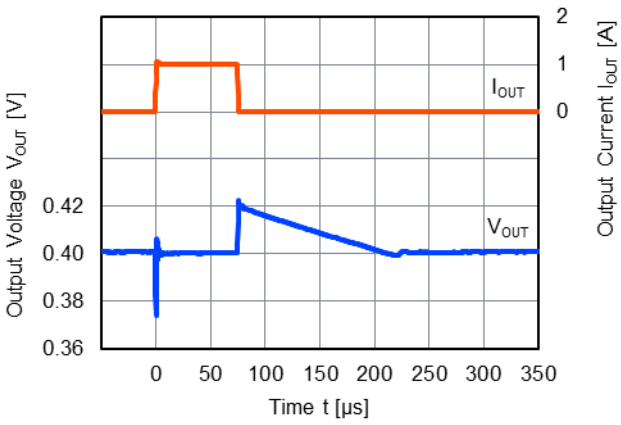
NR1644xx150x, I_{OUT} = 200 mA



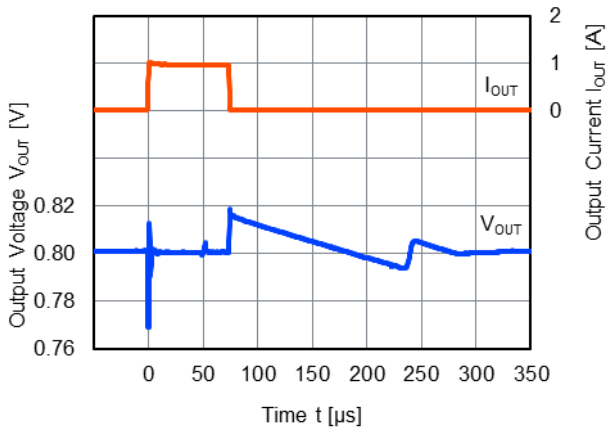
25) Load Transient Response
I_{OUT} = 1 mA ⇔ 1000 mA (t_R = t_F = 1 µs)
NR1644xx040A,



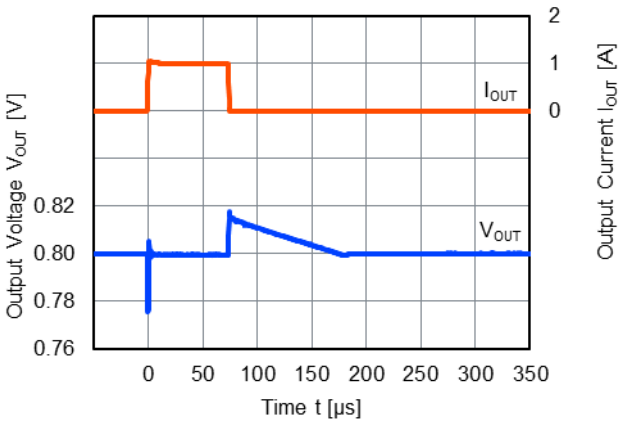
NR1644xx040B



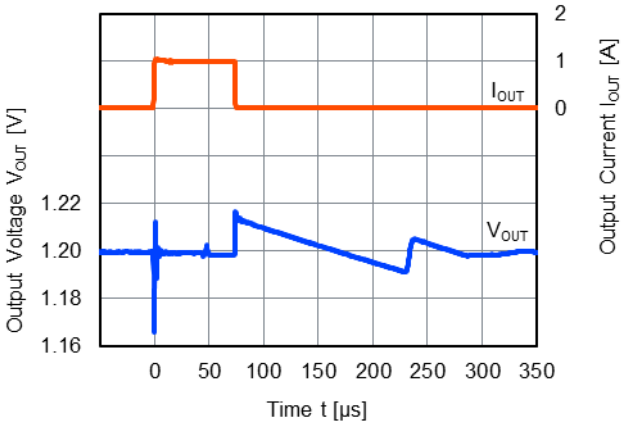
NR1644xx080A



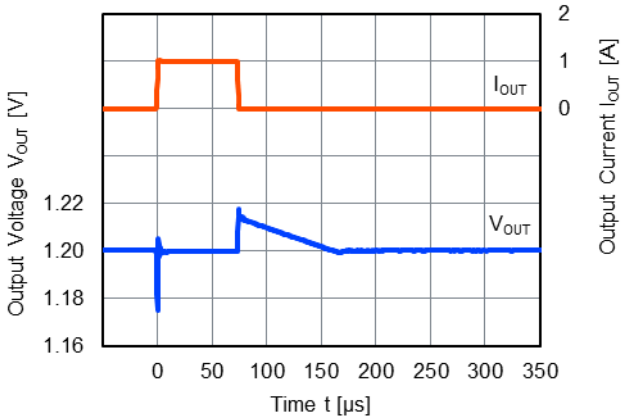
NR1644xx080B



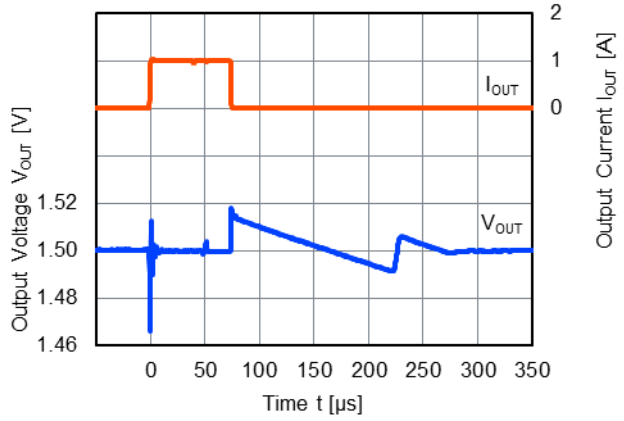
NR1644xx120A



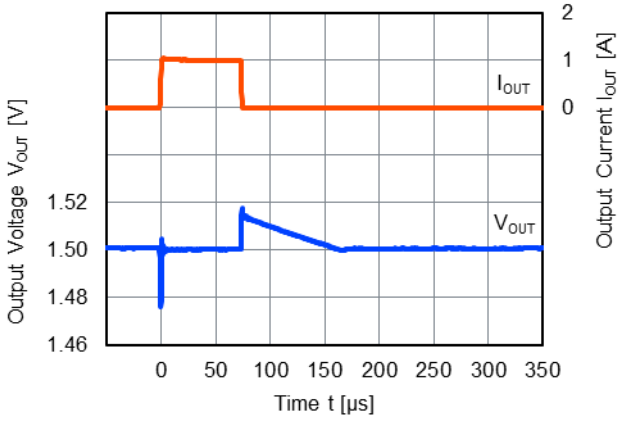
NR1644xx120B



NR1644xx150A

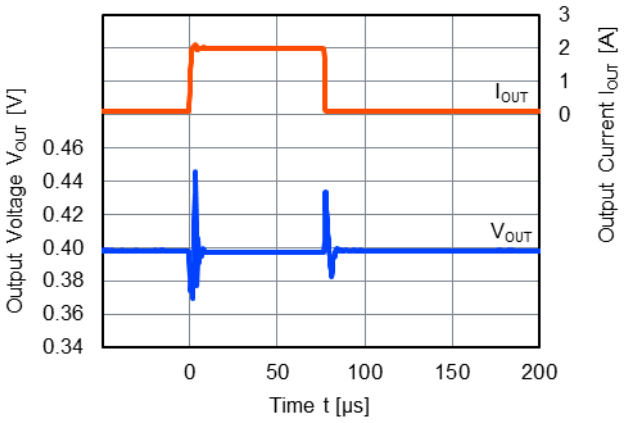


NR1644xx150B

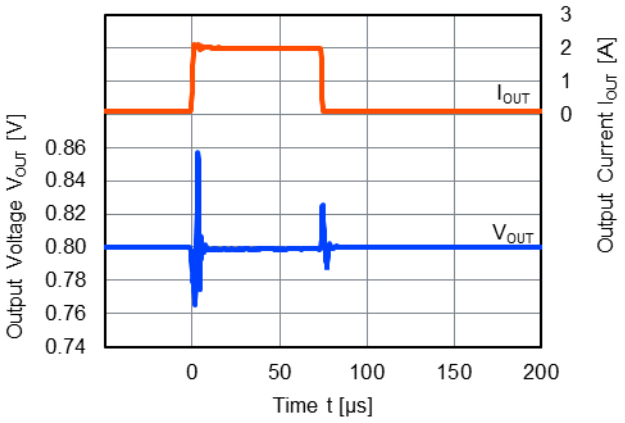


I_{OUT} = 100 mA ⇔ 2000 mA ($t_R = t_F$ = 1 µs)

NR1644xx040B



NR1644xx080B



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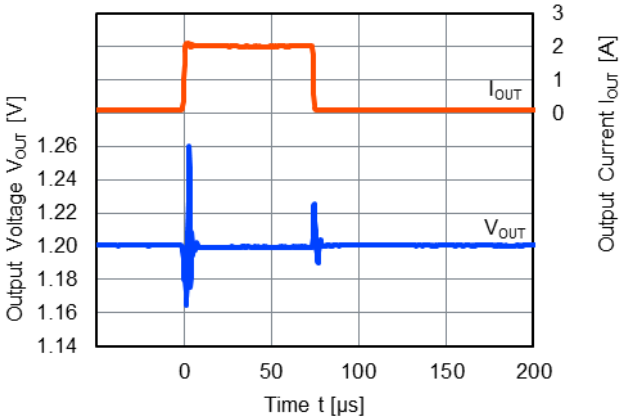
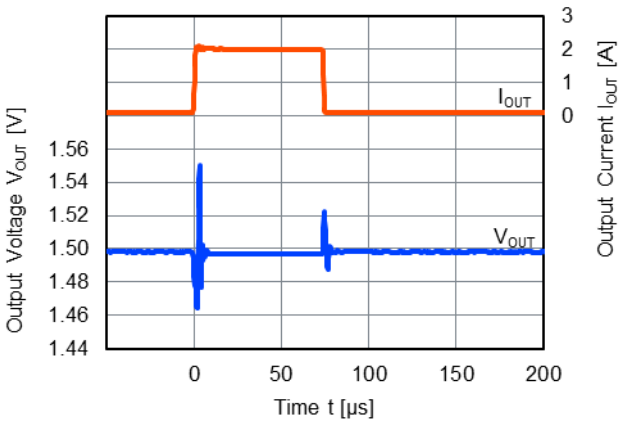


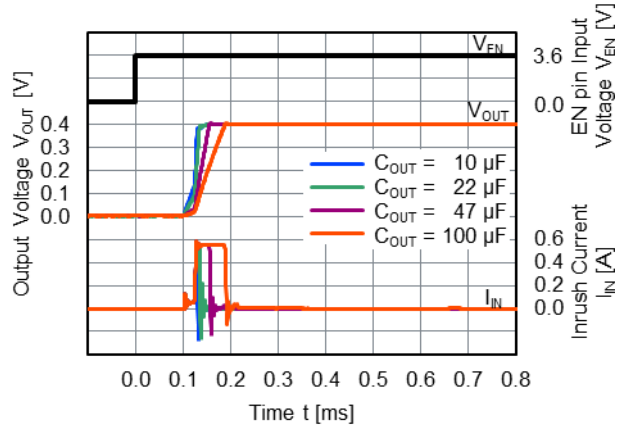
NR1644xx150B



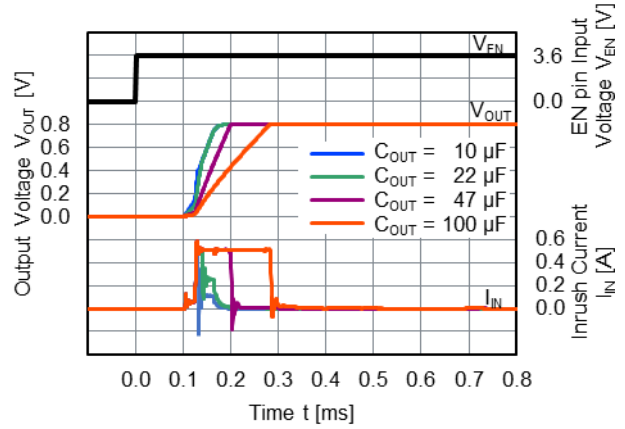
26) Inrush Current

V_{EN} = 0 V to 3.6 V, C_{NR} = 0.1 µF

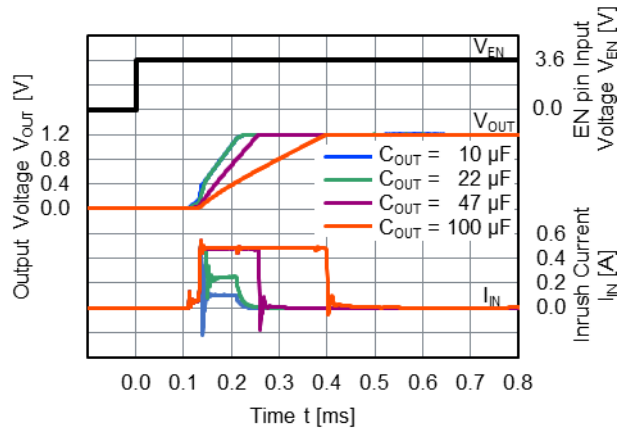
NR1644xx040x



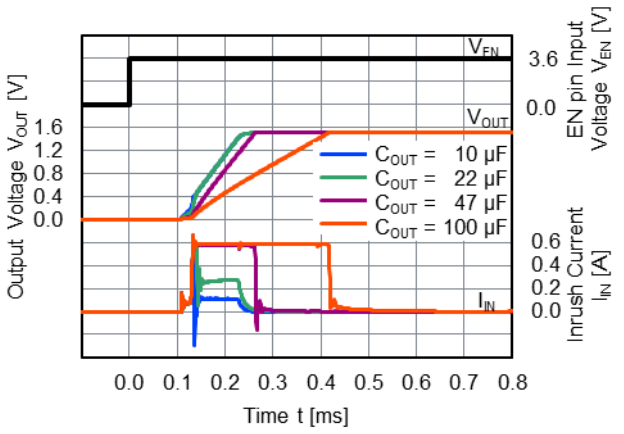
NR1644xx080x



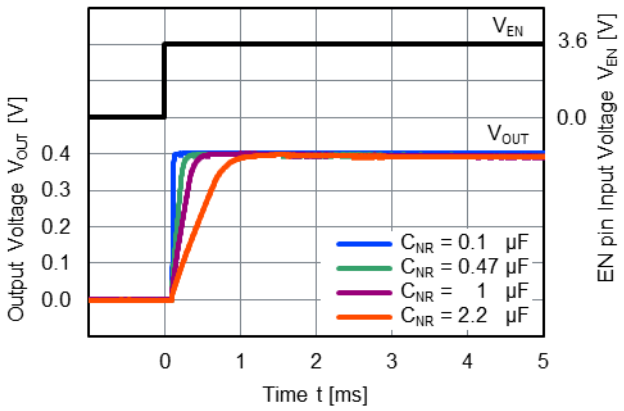
NR1644xx120x



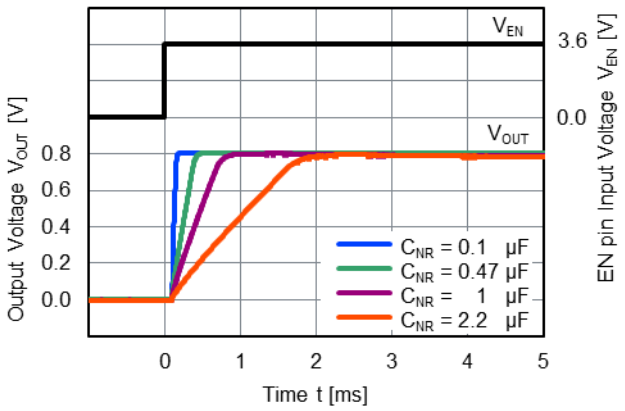
NR1644xx150x



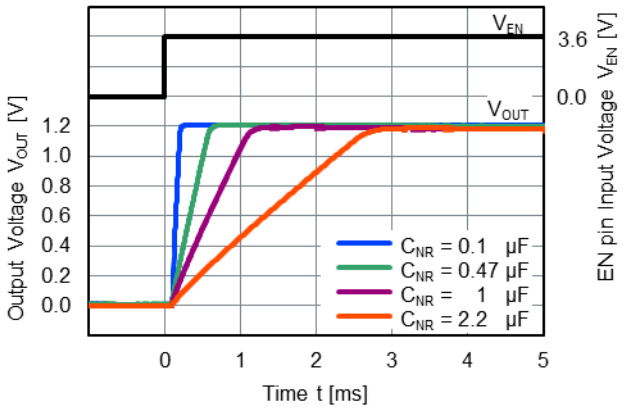
27) Soft-start time
V_{EN} = 0 V to 3.6 V
NR1644xx040x



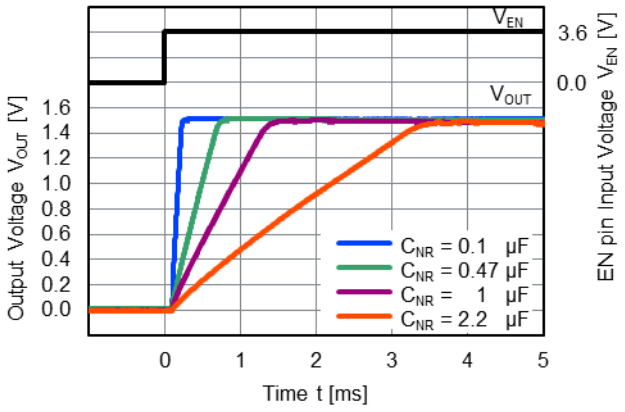
NR1644xx080x



NR1644xx120x

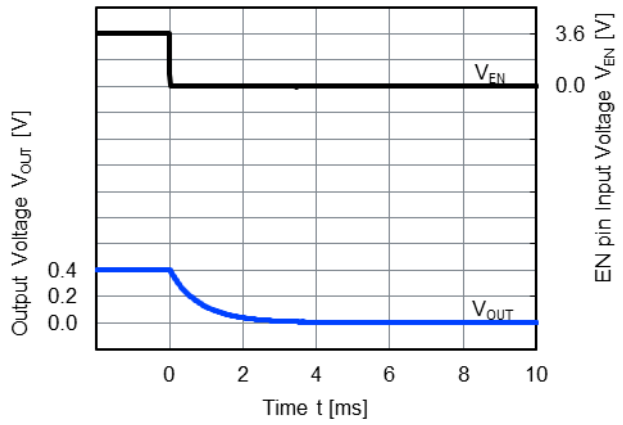


NR1644xx150x



28) Turn off Speed with EN pin
V_{EN} = 3.6 V to 0 V

NR1644xx040x



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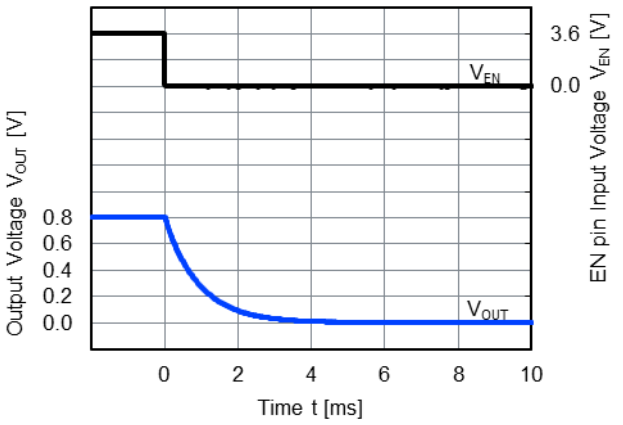
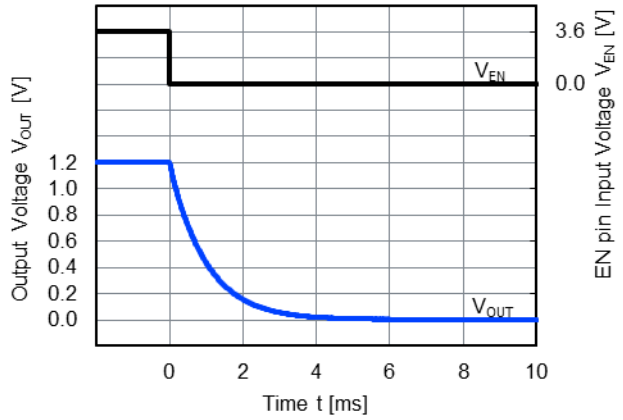
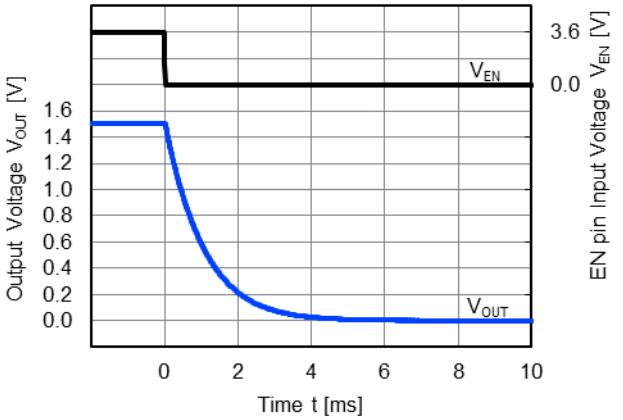


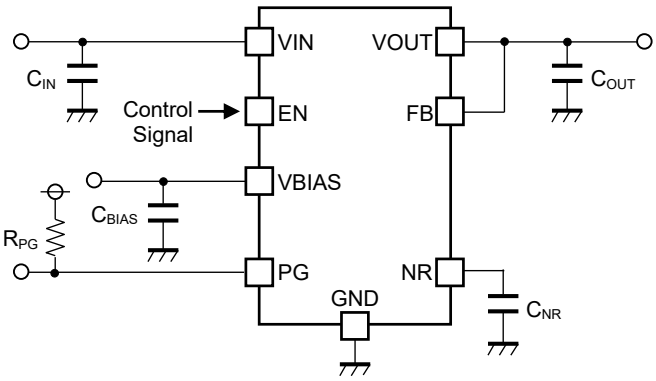
NR1644xx120x



NR1644xx150x



■ TEST CIRCUIT



NR1644 Test Circuit

【Components List for Our Evaluation】

Symbol	Capacitance	Parts Number
C_{IN}	4.7 µF	GRM188Z71A475KE15D
C_{BIAS}	0.1 µF	GRM155R71A104KA01D
C_{NR}	1.0 µF	GRM155C70J105KE11D
C_{OUT}	10 µF	GRM188Z71A106KA73D

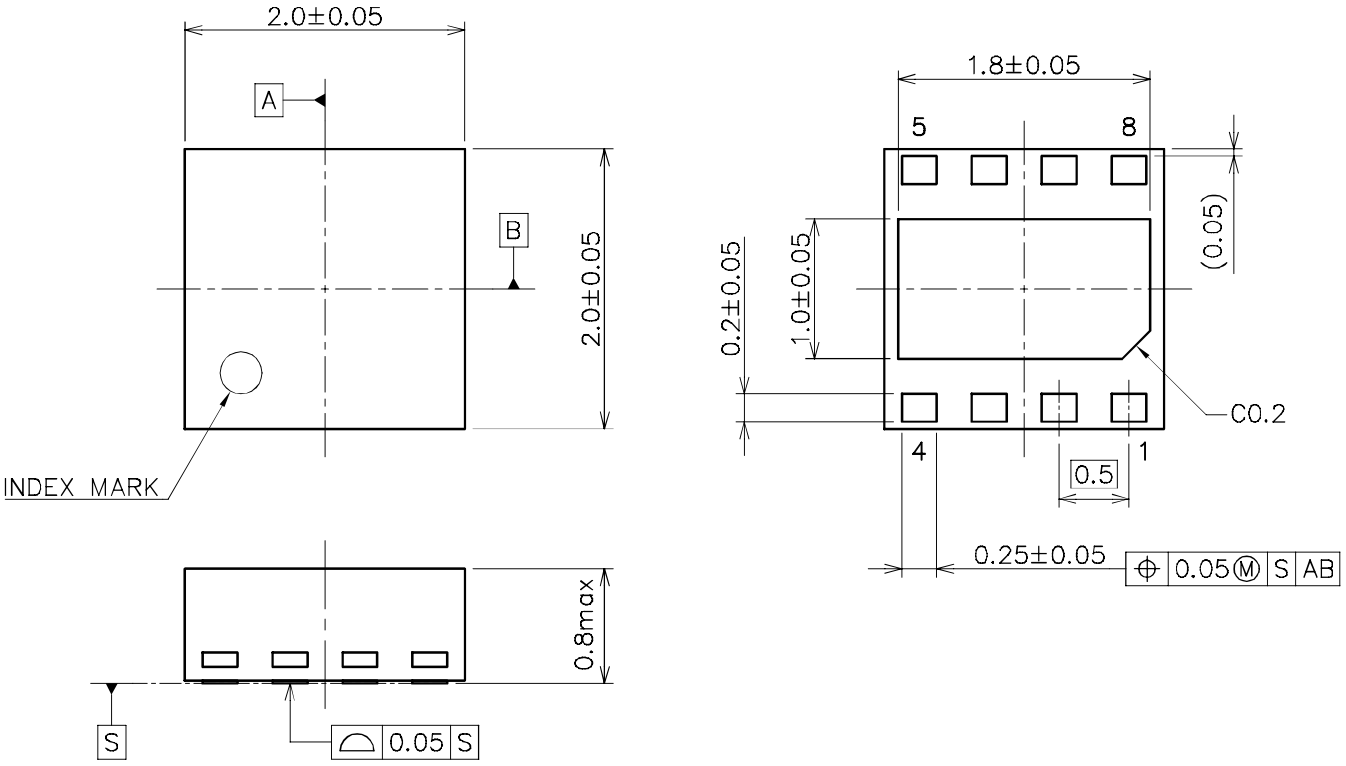
Nisshinbo Micro Devices Inc.

DFN2020-8-GA

PI-DFN2020-8-GA-E-A

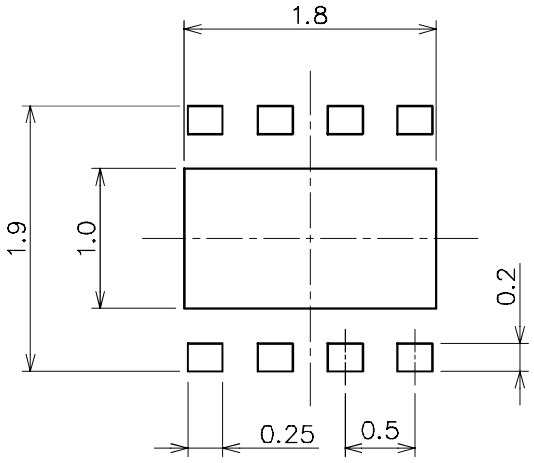
■ PACKAGE DIMENSIONS

UNIT: mm



■ EXAMPLE OF SOLDER PADS DIMENSIONS

UNIT: mm



Nisshinbo Micro Devices Inc.

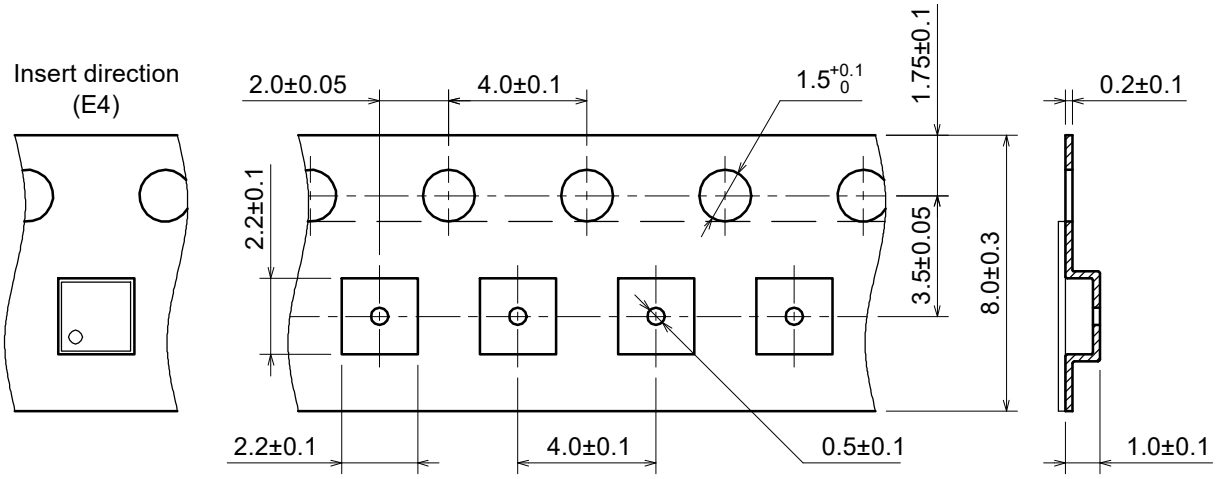
DFN2020-8-GA

PI-DFN2020-8-GA-E-A

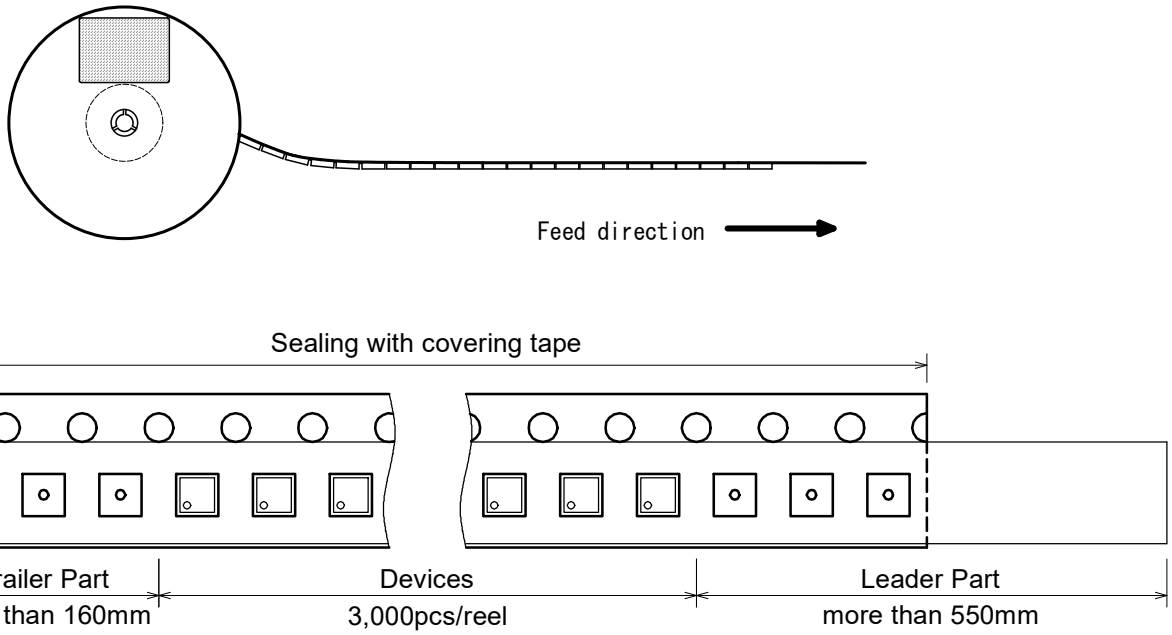
■ PACKING SPEC

UNIT: mm

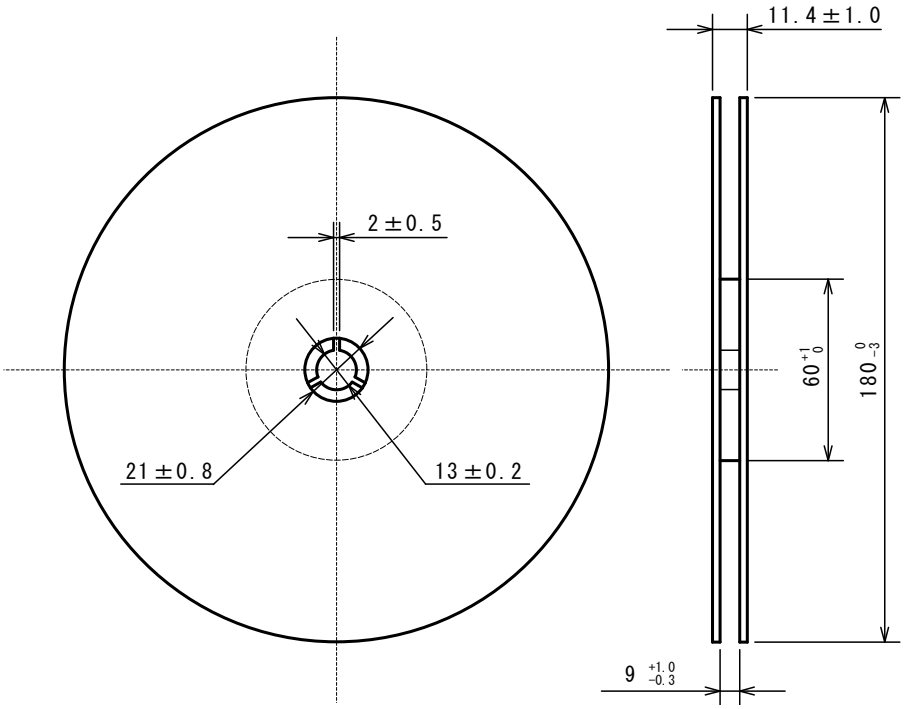
(1) Taping dimensions / Insert direction



(2) Taping state



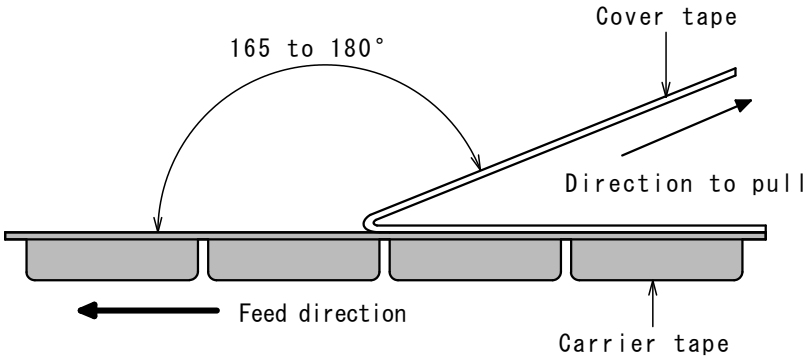
(3) Reel dimensions



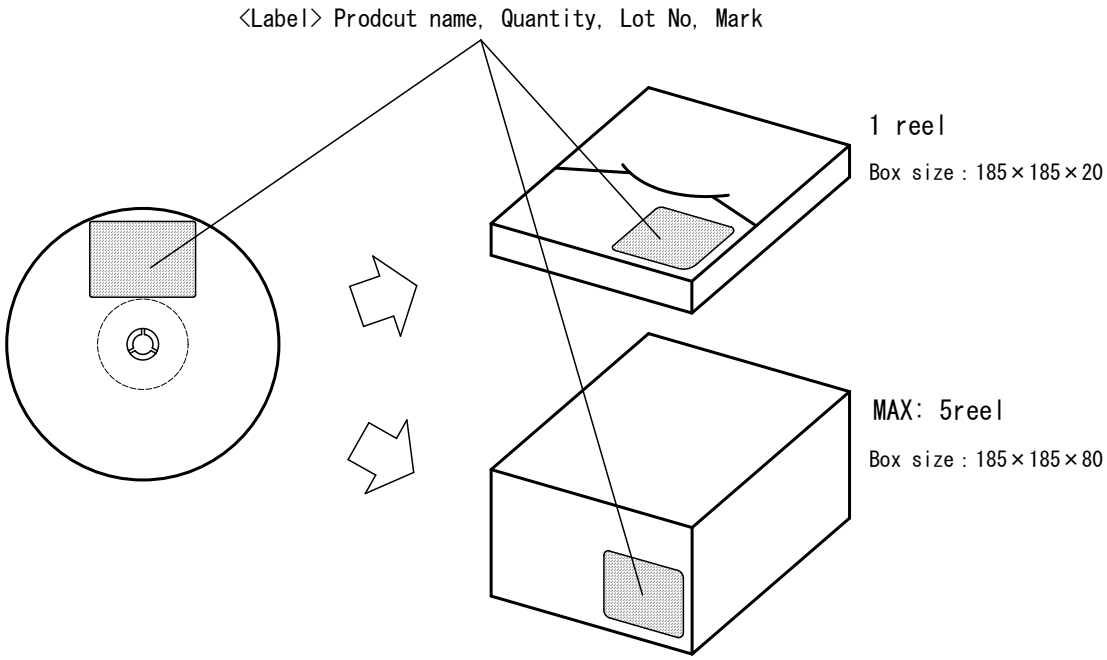
(4) Peeling strength

Peeling strength of cover tape

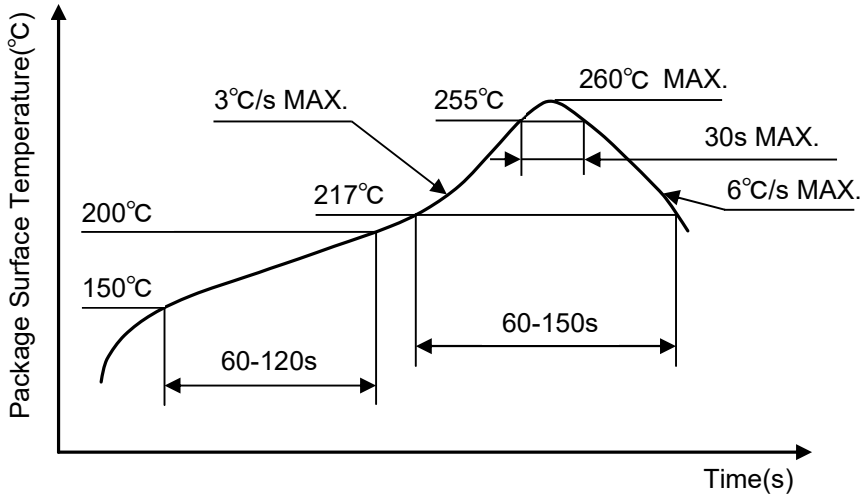
- Peeling angle 165 to 180° degrees to the taped surface.
- Peeling speed 300mm/min
- Peeling strength 0.1 to 1.0N



(5) Packing state



■ **HEAT-RESISTANCE PROFILES**



Reflow profile

■Revision History

Date	Revision	Changes
Feb 14, 2025	Ver. 1.0	Initial release

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

    In case your company desires to use this product for any applications other than general electronic equipment mentioned above, make sure to contact our company in advance. Note that the important requirements mentioned in this section are not applicable to cases where operation requirements such as application conditions are confirmed by our company in writing after consultation with your company.
6. We are making our continuous effort to improve the quality and reliability of our products, but semiconductor products are likely to fail with certain probability. In order to prevent any injury to persons or damages to property resulting from such failure, customers should be careful enough to incorporate safety measures in their design, such as redundancy feature, fire containment feature and fail-safe feature. We do not assume any liability or responsibility for any loss or damage arising from misuse or inappropriate use of the products.
7. The products have been designed and tested to function within controlled environmental conditions. Do not use products under conditions that deviate from methods or applications specified in this datasheet. Failure to employ the products in the proper applications can lead to deterioration, destruction or failure of the products. We shall not be responsible for any bodily injury, fires or accident, property damage or any consequential damages resulting from misuse or misapplication of the products.
8. Quality Warranty
    8-1. Quality Warranty Period
    In the case of a product purchased through an authorized distributor or directly from us, the warranty period for this product shall be one (1) year after delivery to your company. For defective products that occurred during this period, we will take the quality warranty measures described in section 8-2. However, if there is an agreement on the warranty period in the basic transaction agreement, quality assurance agreement, delivery specifications, etc., it shall be followed.
    8-2. Quality Warranty Remedies
    When it has been proved defective due to manufacturing factors as a result of defect analysis by us, we will either deliver a substitute for the defective product or refund the purchase price of the defective product.
    Note that such delivery or refund is sole and exclusive remedies to your company for the defective product.
    8-3. Remedies after Quality Warranty Period
    With respect to any defect of this product found after the quality warranty period, the defect will be analyzed by us. On the basis of the defect analysis results, the scope and amounts of damage shall be determined by mutual agreement of both parties. Then we will deal with upper limit in Section 8-2. This provision is not intended to limit any legal rights of your company.
9. Anti-radiation design is not implemented in the products described in this document.
10. The X-ray exposure can influence functions and characteristics of the products. Confirm the product functions and characteristics in the evaluation stage.
11. WLCSP products should be used in light shielded environments. The light exposure can influence functions and characteristics of the products under operation or storage.
12. Warning for handling Gallium and Arsenic (GaAs) products (Applying to GaAs MMIC, Photo Reflector). These products use Gallium (Ga) and Arsenic (As) which are specified as poisonous chemicals by law. For the prevention of a hazard, do not burn, destroy, or process chemically to make them as gas or power. When the product is disposed of, please follow the related regulation and do not mix this with general industrial waste or household waste.
13. Please contact our sales representatives should you have any questions or comments concerning the products or the technical information.

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Nisshinbo Micro Devices Inc.

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