NR1641 series

1A Equipped with Low Power Mode
Ultra-Low Noise Low Dropout Voltage Regulator

FEATURES

- Input Voltage Range (Maximum Rating):
  1.7 V to 5.5 V (6.5 V)
- Output Voltage Range: 1.0 V to 5.0 V
- Output Voltage Accuracy:
  ± 1.0% (V_{SET} ≥ 1.8 V, T_a = 25 °C)
- Output Current: 1.0 A
- Quiescent Current (V_{MODE} = "Low"): Typ. 17 µA
- Quiescent Current (V_{MODE} = "High"): Typ. 1.5 mA
- Output Noise Voltage (10 Hz to 100 kHz):
  Typ. 3.7 µVrms (I_{OUT} = 100 mA)
  Typ. 20 µVrms (I_{OUT} = 1 mA, V_{MODE} = "Low")
- Ripple Rejection: Typ. 75 dB (f = 1 kHz, V_{SET} = 2.8 V)
  Typ. 80 dB (f = 10 kHz, V_{SET} = 2.8 V)
  Typ. 85 dB (f = 100 kHz, V_{SET} = 2.8 V)
- Dropout Voltage:
  Typ. 0.10 V (I_{OUT} = 500 mA, V_{SET} = 2.8 V, NR1641GY)
  Typ. 0.20 V (I_{OUT} = 1000 mA, V_{SET} = 2.8 V, NR1641GY)
- Thermal Shutdown Function: Typ. 165 °C
- Slope of Output Voltage at Start-up:
  200 µs/V or 500 µs/V
- Start-up Inrush Current Limit: Typ. 250 mA
- Foldback Protection
- Fast / Low Power automatic mode alternative function:
  MODE pin "Low" Automatic alternative mode
  MODE pin "High" Fixed to fast mode
- Ceramic Capacitors are Recommended:
  C_{IN}, C_{OUT} 10 µF or greater
  (Built-in filter element eliminates the need
  for a capacitor for noise reduction)

GENERAL DESCRIPTION

The NR1641 series are CMOS based low dropout voltage regulator that achieves both ultra-low output noise, high ripple rejection, high-speed response characteristics, and low quiescent current.

The MODE pin input voltage can be used to select between the automatic alternative mode and the fixed fast mode. The automatic alternative mode changes the internal mode between low power mode and the fast mode according to the load current.

In addition, Slope of Output Voltage at Start-up can be selected from 200 µs/V or 500 µs/V.

By this option, depending on the capacitance connected to the output pin, the inrush current limit can be changed.

Since the NR1640 has low quiescent current, low noise, and high ripple rejection, it is suitable for IoT devices, battery-powered devices, and the noise sensitive analog application.
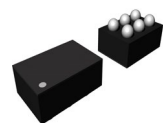
APPLICATIONS

- CMOS image sensor
- Communication device such as RF module, Clock generation device such as PLL or VCO
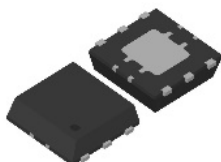- High accuracy ADC and DAC

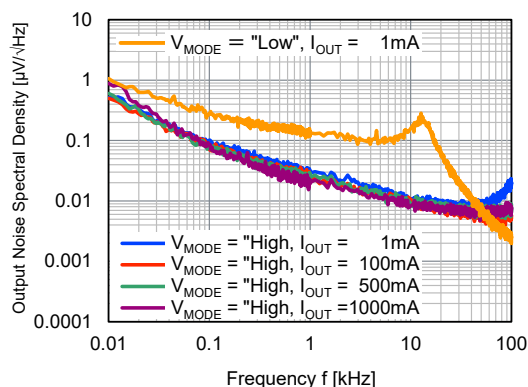## PACKAGE (unit: mm)
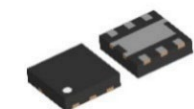
DFN1616-6-GY
1.6 x 1.6 x 0.4

WLCSP-6-P12
1.3 x 0.88 x 0.36
(Under Development)

HSON-6-GU
2.9 x 3.0 x 0.9
(Under Development)

OUTPUT NOISE SPECTRAL DENSITY

V_{SET} = 3.3 V, V_{IN} = V_{SET} + 1.0 V,
C_{IN} = 10 µF, C_{OUT} = 10 µF

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■ PRODUCT NAME INFORMATION

NR1641 aa   bbb   c dd e

Composition	Item	Description
aa	Package Code	GY: DFN1616-6-GY ZA: WLCSP-6-P12 GU: HSON-6-GU
bbb	Output Voltage	Output voltage (V_{SET}). The lineup ranges from 1.0 V (100) to 5.0 V (500).
c	Version	Slope of output voltage at start-up and with or without discharge function. See below for details.
dd	Packing	Taping direction. Please refer to the packaging specifications.
e	Grade	Indicates the quality grade. S: Consumer

Version

c	Slope of Output Voltage at Start-up	Discharge Function
A	200 µs/V	✓
B	500 µs/V	✓
C	200 µs/V	-
D	500 µs/V	-

Grade

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

■ ORDER INFORMATION

PRODUCT NAME	PACKAGE	RoHS	HALOGEN-FREE	PLATING COMPOSITION	WEIGHT (mg)	QUANTITY PER REEL (pcs)
NR1641GY bbb c E4S	DFN1616-6-GY	Yes	Yes	NiPdAu	3.08	5000
NR1641ZA bbb c E2S	WLCSP-6-P12	Yes	Yes	Sn3Ag0.5Cu	TBD	5000
NR1641GU bbb c E4S	HSON-6-GU	Yes	Yes	Sn	TBD	3000

* NR1641ZA, NR1641GU are under development.
  Please contact us if you require a voltage other than the existing fixed-output product.

  Refer to "*MARKING SPECIFICATION*" for details.

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■ **NR1641GY PIN DESCRIPTIONS**

Top View

6   5   4

1   2   3

Bottom View

4   5   6

*1

3   2   1
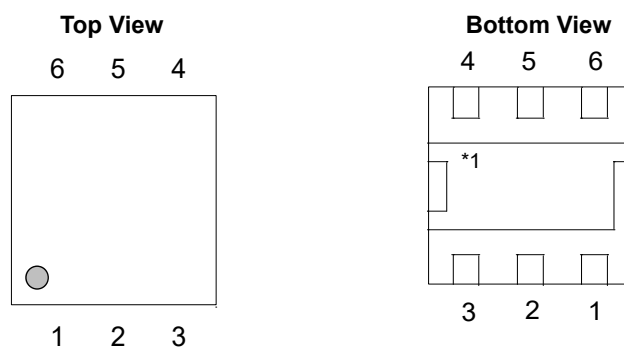
DFN1616-6-GY Pin Configuration

Pin No.	Pin Name	I/O	Description
1	VOUT	O	Output Voltage Pin Connect the output capacitor (C_{OUT}) between VOUT pin and GND.
2	FB	I	Feedback Input Pin Connect to VOUT pin.
3	GND	-	Ground Pin
4	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 circuit.
5	MODE	I	Mode Control Pin Input "Hight" to this pin fixes the fast mode. Input "Low" to this pin enables the automatic mode alternative function between fast mode and low power mode by the load current. This pin is pulled down with an internal constant current circuit.
6	VIN	Power	Power Supply Input Pin Connect the input capacitor (C_{IN}) between VIN pin and GND.

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

For details, refer to "*TYPICAL APPLICATION CIRCUIT*" and "*THEORY OF OPERATION*".

■ **NR1641ZA PIN DESCRIPTIONS**

Top View

Bottom View
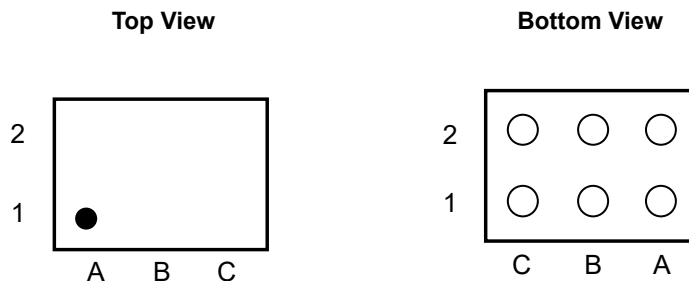
WLCSP-6-P12 Pin Configuration

Pin No.	Pin Name	I/O	Description
A1	VIN	Power	Power Supply Input Pin Connect the input capacitor (C_{IN}) between VIN pin and GND.
B1	MODE	I	Mode Control Pin Input "Hight" to this pin fixes the fast mode. Input "Low" to this pin enables the automatic mode alternative function between fast mode and low power mode by the load current. This pin is pulled down with an internal constant current circuit.
C1	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 circuit.
A2	VOUT	O	Output Voltage Pin Connect the output capacitor (C_{OUT}) between VOUT pin and GND.
B2	FB	I	Feedback Input Pin Connect to VOUT pin.
C2	GND	-	Ground Pin

For details, refer to "*TYPICAL APPLICATION CIRCUIT*" and "*THEORY OF OPERATION*".

■ **NR1641GU PIN DESCRIPTIONS**

Top View

Bottom View
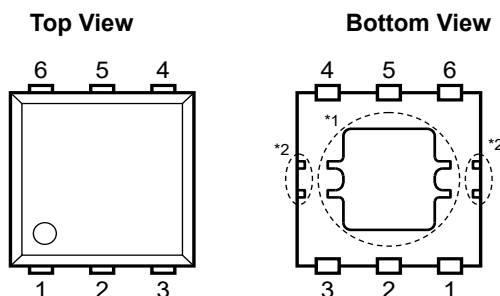
HSON-6-GU Pin Configuration

Pin No.	Pin Name	I/O	Description
1	VOUT	O	Output Voltage Pin Connect the output capacitor (C_{OUT}) between VOUT pin and GND.
2	FB	I	Feedback Input Pin Connect to VOUT pin.
3	GND	-	Ground Pin
4	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 circuit.
5	MODE	I	Mode Control Pin Input "Hight" to this pin fixes the fast mode. Input "Low" to this pin enables the automatic mode alternative function between fast mode and low power mode by the load current. This pin is pulled down with an internal constant current circuit.
6	VIN	Power	Power Supply Input Pin Connect the input capacitor (C_{IN}) between VIN pin and GND.

[*1] The tab on the bottom of the package is the silicon substrate level. It is recomended to connect to GND level.
[*2] The tab on the bottom of the package is the silicon substrate level.
   It is not necessary to mount it on the board, however, please be careful not to short it to the pattern other than GND level.

For details, refer to "*TYPICAL APPLICATION CIRCUIT*" and "*THEORY OF OPERATION*".

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■ ABSOLUTE MAXIMUM RATINGS

Item	Symbol	Ratings	Unit
Input Voltage	V_{IN}	−0.3 to 6.5	V
EN Pin Input Voltage	V_{EN}	−0.3 to 6.5	V
MODE Pin Input Voltage	V_{MODE}	−0.3 to 6.5	V
FB Pin Input Voltage	V_{FB}	−0.3 to 6.5	V
VOUT Pin Voltage	V_{OUT}	−0.3 to V_{IN} + 0.3	V
Junction Temperature Range[*1]	T_j	−40 to 125	°C
Storage Temperature Range	T_{stg}	−55 to 125	°C

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

■ THERMAL CHARACTERISTICS

Package	Item	Measurement Result	Unit
DFN1616-6-GY	Thermal Resistance (θja)	41	°C/W
	Thermal Characterization Parameter (ψjt)	11	
WLCSP-6-P12	Thermal Resistance (θja)	TBD	
	Thermal Characterization Parameter (ψjt)	TBD	
HSON-6-GU	Thermal Resistance (θja)	TBD	
	Thermal Characterization Parameter (ψjt)	TBD	

θja: Junction-to-Ambient Thermal Resistance
Ψjt: Junction-to-Top Thermal Characterization Parameter
For more information, click *here*.

■ **ELECTROSTATIC DISCHARGE RATINGS**

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

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

■ **RECOMMENDED OPERATING CONDITIONS**

Item	Symbol	Ratings	Unit
Input Voltage	V_{IN}	1.7 to 5.5	V
EN Pin Input Voltage	V_{EN}	0 to 5.5	V
MODE Pin Input Voltage	V_{MODE}	0 to 5.5	V
Operating Temperature Range	T_a	−40 to 85	°C
Output Current	I_{OUT}	0 to 1000	mA

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.

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■ ELECTRICAL CHARACTERISTICS

V_{IN} = V_{EN} = V_{MODE} = V_{SET} + 1 V (V_{IN} = 5.5 V for V_{SET} ≥ 4.5 V), I_{OUT} = 1 mA, C_{IN} = C_{OUT} = 10 μF unless otherwise specified.
For items without temperature conditions, TYP values are at T_a = 25 °C and MIN/MAX values are applied to all the temperature range of −40 °C ≤ T_a ≤ 85 °C.

NR1641xx100x to 500x

Parameter	Symbol	Conditions			MIN	TYP	MAX	Unit
Output Voltage	V_{OUT}	T_a = 25 °C	V_{SET} ≥ 1.8 V		×0.99	-	×1.01	V
			V_{SET} < 1.8 V		−18	-	+18	mV
		−40 °C ≤ T_a ≤ 85 °C	1.0 V ≤ V_{SET} < 1.2 V V_{IN} = 1.7 V to 5.5 V		Refer to the *OUTPUT VOLTAGE SPECIFICATION TABLE [1]*			
			1.2 V ≤ V_{SET} < 1.8 V V_{IN} = V_{SET} + 0.5 V to 5.5 V					
			1.8 V ≤ V_{SET} < 4.5 V V_{IN} = V_{SET} + 0.5 V to 5.5 V		×0.973	-	×1.027	V
			4.5 V ≤ V_{SET} ≤ 5.0 V V_{IN} = V_{SET} + 0.3 V to 5.5 V		×0.976	-	×1.024	
			V_{MODE} = 0 V		Refer to the *OUTPUT VOLTAGE SPECIFICATION TABLE [2]*			
Quiescent Current 1 [*1]	I_{Q1}	I_{OUT} = 0 mA, V_{MODE} = 0 V			-	17	30	μA
Quiescent Current 2 [*1]	I_{Q2}	I_{OUT} = 0 mA			-	1.5	2.5	mA
Shutdown Current	I_{SD}	V_{IN} = 5.5 V, V_{EN} = V_{MODE} = 0 V, T_a = 25 °C			-	0.01	0.3	μA
Dropout Voltage [*2]	V_{DO}	Refer to the *SPECIFICATION TABLE OF DROPOUT VOLTAGE*						
Load Regulation	$\Delta V_{OUT}/\Delta I_{OUT}$	I_{OUT} = 1 mA to 1000 mA			-0.5	0.2	0.5	%
Line Regulation	$\Delta V_{OUT}/\Delta V_{IN}$	1.0 V ≤ V_{SET} < 1.2 V	V_{IN} = 1.7 V to 5.5 V		-	0.02	-	%/V
		1.2 V ≤ V_{SET} < 4.5 V	V_{IN} = V_{SET} + 0.5 V to 5.5 V					
		4.5 V ≤ V_{SET} ≤ 5.0 V	V_{IN} = V_{SET} + 0.3 V to 5.5 V					
Ripple Rejection	RR	Ripple 0.1 Vp-p, I_{OUT} = 100 mA	f = 1 kHz		-	75	-	dB
			f = 10 kHz		-	80	-	
			f = 100 kHz		-	85	-	
Output Noise Voltage	V_{NOISE}	I_{OUT} = 100 mA	f = 10 Hz to 100 kHz		-	3.7	-	μVrms
		V_{MODE} = 0 V			-	20	-	μVrms
Output Current Limit [*3]	I_{LIM}	V_{OUT} = V_{SET} × 0.95 V			1.0	1.5	-	A
Short-circuit Current [*3]	I_{SC}	V_{OUT} = 0 V			-	500	-	mA
Start-up Inrush Current Limit	$I_{LIMRISE}$	V_{OUT} = 0 V			-	250	-	mA
EN pin High Input Voltage	V_{ENH}	V_{IN} = 5.5 V			1.0	-	-	V
EN pin Low Input Voltage	V_{ENL}	V_{IN} = 1.7 V			-	-	0.4	V
EN pin Current	I_{EN}				-	0.25	0.50	μA
MODE pin High Input Voltage	V_{MODEH}	V_{IN} = 5.5 V			1.0	-	-	V
MODE pin Low Input Voltage	V_{MODEL}	V_{IN} = 1.7 V			-	-	0.4	V
MODE pin Current	I_{MODE}				-	0.25	0.50	μA
Discharge FET On-resistance	R_{ONDIS}	V_{IN} = 4.0 V, V_{EN} = 0 V, V_{OUT} = 0.1 V	NR1641xxxxxA/B		-	50	-	Ω

All electrical characteristic parameters are tested under the condition of T_j ≈ T_a = 25 °C, except for Ripple Rejection and Output Noise Voltage.
[*1] VIN pin current.
[*2] Dropout voltage is the minimum input-to-output voltage difference required to achieve 95% of the set output voltage at a specified load current.
[*3] Output Current Limit is specified as the overcurrent after turning on the NR1641. Short-circuit Current is the current limit when the output is shorted to GND after turning on the NR1641. The output current at start-up is limited by the Start-up Inrush Current Limit.

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■ ELECTRICAL CHARACTERISTICS

V_{IN} = V_{EN} = V_{MODE} = V_{SET} + 1 V (V_{IN} = 5.5 V for V_{SET} ≥ 4.5 V), I_{OUT} = 1 mA, C_{IN} = C_{OUT} = 10 µF unless otherwise specified.
For items without temperature conditions, TYP values are at T_a = 25 °C and MIN/MAX values are applied to all the temperature range of −40 °C ≤ T_a ≤ 85 °C.

NR1641xx100x to 500x

Parameter	Symbol	Conditions		MIN	TYP	MAX	Unit
Fast Mode switch-over current	I_{OUTH}	I_{OUT} = Light load to Heavy load V_{MODE} = 0 V		-	22	-	mA
Low Power Mode switch-over current	I_{OUTL}	I_{OUT} = Heavy load to Light load V_{MODE} = 0 V		1.0	-	-	mA
Turn on Slope of the Output Voltage	V_{OUTSS}	V_{OUT} = V_{SET} × 0.1 to V_{SET} × 0.9	NR1641xxxxxA/C	100	200	400	µs/V
			NR1641xxxxxB/D	250	500	1000	µs/V
Thermal Shutdown Detection Temperature	T_{SDDET}	T_j = Rising		-	165	-	°C
Thermal Shutdown Release Temperature	T_{SDREL}	T_j = Falling		-	125	-	°C

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

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● **OUTPUT VOLTAGE SPECIFICATION TABLE**

[Unit: V]

PRODUCT NAME	V_{OUT} (T_a = 25 °C)			V_{OUT} (−40 °C ≤ T_a ≤ 85 °C)					
				[1] V_{MODE} = V_{IN}			[2] V_{MODE} = 0 V		
	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX
NR1641xx100x	0.982	1.000	1.018	0.961	1.000	1.039	0.922	0.975	1.028
NR1641xx110x	1.082	1.100	1.118	1.058	1.100	1.142	1.021	1.076	1.130
NR1641xx120x	1.182	1.200	1.218	1.156	1.200	1.244	1.121	1.177	1.232
NR1641xx130x	1.282	1.300	1.318	1.255	1.300	1.345	1.220	1.277	1.333
NR1641xx140x	1.382	1.400	1.418	1.353	1.400	1.447	1.320	1.378	1.435
NR1641xx150x	1.482	1.500	1.518	1.451	1.500	1.549	1.420	1.479	1.537
NR1641xx160x	1.582	1.600	1.618	1.549	1.600	1.651	1.519	1.579	1.638
NR1641xx170x	1.682	1.700	1.718	1.648	1.700	1.752	1.619	1.680	1.740
NR1641xx180x	1.782	1.800	1.818	1.751	1.800	1.849	1.719	1.780	1.841
NR1641xx190x	1.881	1.900	1.919	1.848	1.900	1.952	1.817	1.881	1.944
NR1641xx200x	1.980	2.000	2.020	1.946	2.000	2.054	1.916	1.982	2.047
NR1641xx210x	2.079	2.100	2.121	2.043	2.100	2.157	2.014	2.082	2.149
NR1641xx220x	2.178	2.200	2.222	2.140	2.200	2.260	2.113	2.183	2.252
NR1641xx230x	2.277	2.300	2.323	2.237	2.300	2.363	2.212	2.284	2.355
NR1641xx240x	2.376	2.400	2.424	2.335	2.400	2.465	2.310	2.384	2.457
NR1641xx250x	2.475	2.500	2.525	2.432	2.500	2.568	2.409	2.485	2.560
NR1641xx260x	2.574	2.600	2.626	2.529	2.600	2.671	2.508	2.585	2.662
NR1641xx270x	2.673	2.700	2.727	2.627	2.700	2.773	2.606	2.686	2.765
NR1641xx280x	2.772	2.800	2.828	2.724	2.800	2.876	2.705	2.787	2.868
NR1641xx290x	2.871	2.900	2.929	2.821	2.900	2.979	2.803	2.887	2.970
NR1641xx300x	2.970	3.000	3.030	2.919	3.000	3.081	2.902	2.988	3.073
NR1641xx310x	3.069	3.100	3.131	3.016	3.100	3.184	3.001	3.089	3.176
NR1641xx320x	3.168	3.200	3.232	3.113	3.200	3.287	3.099	3.189	3.278
NR1641xx330x	3.267	3.300	3.333	3.210	3.300	3.390	3.198	3.290	3.381
NR1641xx340x	3.366	3.400	3.434	3.308	3.400	3.492	3.297	3.390	3.483
NR1641xx350x	3.465	3.500	3.535	3.405	3.500	3.595	3.395	3.491	3.586
NR1641xx360x	3.564	3.600	3.636	3.502	3.600	3.698	3.494	3.592	3.689
NR1641xx370x	3.663	3.700	3.737	3.600	3.700	3.800	3.592	3.692	3.791
NR1641xx380x	3.762	3.800	3.838	3.697	3.800	3.903	3.691	3.793	3.894
NR1641xx390x	3.861	3.900	3.939	3.794	3.900	4.006	3.790	3.894	3.997
NR1641xx400x	3.960	4.000	4.040	3.892	4.000	4.108	3.888	3.994	4.099
NR1641xx410x	4.059	4.100	4.141	3.989	4.100	4.211	3.987	4.095	4.202
NR1641xx420x	4.158	4.200	4.242	4.086	4.200	4.314	4.085	4.195	4.304
NR1641xx430x	4.257	4.300	4.343	4.183	4.300	4.417	4.184	4.296	4.407
NR1641xx440x	4.356	4.400	4.444	4.281	4.400	4.519	4.283	4.397	4.510
NR1641xx450x	4.455	4.500	4.545	4.392	4.500	4.608	4.381	4.497	4.612
NR1641xx460x	4.554	4.600	4.646	4.489	4.600	4.711	4.480	4.598	4.715
NR1641xx470x	4.653	4.700	4.747	4.587	4.700	4.813	4.579	4.699	4.818
NR1641xx480x	4.752	4.800	4.848	4.684	4.800	4.916	4.677	4.799	4.920
NR1641xx490x	4.851	4.900	4.949	4.782	4.900	5.018	4.776	4.900	5.023
NR1641xx500x	4.950	5.000	5.050	4.880	5.000	5.120	4.874	5.000	5.125

Above parameters are all tested under the condition of T_j ≈ T_a = 25 °C.

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● **SPECIFICATION TABLE OF DROPOUT VOLTAGE**

[Unit: V]

| PRODUCT NAME | V_{DO} (I_{OUT} = 1000 mA) | | | | | |
| | NR1641GY | | NR1641ZA | | NR1641GU | |
	TYP	MAX	TYP	MAX	TYP	MAX
NR1641xx100x	(1)	0.905	TBD	TBD	TBD	TBD
NR1641xx110x	(1)	0.810	TBD	TBD	TBD	TBD
NR1641xx120x	(1)	0.720	TBD	TBD	TBD	TBD
NR1641xx130x	(1)	0.635	TBD	TBD	TBD	TBD
NR1641xx140x	0.370	0.550	TBD	TBD	TBD	TBD
NR1641xx150x	0.370	0.550	TBD	TBD	TBD	TBD
NR1641xx160x	0.330	0.500	TBD	TBD	TBD	TBD
NR1641xx170x	0.330	0.500	TBD	TBD	TBD	TBD
NR1641xx180x	0.290	0.450	TBD	TBD	TBD	TBD
NR1641xx190x	0.290	0.450	TBD	TBD	TBD	TBD
NR1641xx200x	0.290	0.450	TBD	TBD	TBD	TBD
NR1641xx210x	0.260	0.400	TBD	TBD	TBD	TBD
NR1641xx220x	0.230	0.340	TBD	TBD	TBD	TBD
NR1641xx230x	0.230	0.340	TBD	TBD	TBD	TBD
NR1641xx240x	0.230	0.340	TBD	TBD	TBD	TBD
NR1641xx250x	0.230	0.340	TBD	TBD	TBD	TBD
NR1641xx260x	0.230	0.340	TBD	TBD	TBD	TBD
NR1641xx270x	0.200	0.325	TBD	TBD	TBD	TBD
NR1641xx280x	0.200	0.325	TBD	TBD	TBD	TBD
NR1641xx290x	0.200	0.325	TBD	TBD	TBD	TBD
NR1641xx300x	0.200	0.325	TBD	TBD	TBD	TBD
NR1641xx310x	0.200	0.325	TBD	TBD	TBD	TBD
NR1641xx320x	0.200	0.325	TBD	TBD	TBD	TBD
NR1641xx330x	0.200	0.325	TBD	TBD	TBD	TBD
NR1641xx340x	0.200	0.325	TBD	TBD	TBD	TBD
NR1641xx350x	0.200	0.325	TBD	TBD	TBD	TBD
NR1641xx360x	0.200	0.325	TBD	TBD	TBD	TBD
NR1641xx370x	0.200	0.325	TBD	TBD	TBD	TBD
NR1641xx380x	0.200	0.325	TBD	TBD	TBD	TBD
NR1641xx390x	0.200	0.325	TBD	TBD	TBD	TBD
NR1641xx400x	0.200	0.325	TBD	TBD	TBD	TBD
NR1641xx410x	0.200	0.325	TBD	TBD	TBD	TBD
NR1641xx420x	0.200	0.325	TBD	TBD	TBD	TBD
NR1641xx430x	0.200	0.325	TBD	TBD	TBD	TBD
NR1641xx440x	0.200	0.325	TBD	TBD	TBD	TBD
NR1641xx450x	0.200	0.325	TBD	TBD	TBD	TBD
NR1641xx460x	0.200	0.325	TBD	TBD	TBD	TBD
NR1641xx470x	0.200	0.325	TBD	TBD	TBD	TBD
NR1641xx480x	0.200	0.325	TBD	TBD	TBD	TBD
NR1641xx490x	0.200	0.325	TBD	TBD	TBD	TBD
NR1641xx500x	0.200	0.325	TBD	TBD	TBD	TBD

Above parameters are all tested under the condition of $T_j \approx T_a$ = 25 °C.
[1] Input voltage must be equal or more than the minimum operating voltage of 1.7V.

■ **TYPICAL APPLICATION CIRCUIT**
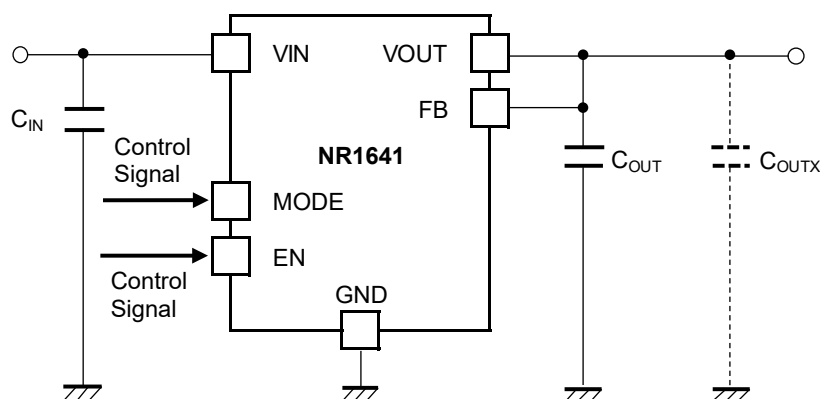
NR1641 TYPICAL APPLICATION CIRCUIT

● **EXTERNAL COMPONENTS INFORMATION**

Input Capacitor (C_{IN})

Connect a 10µF or more input capacitor (C_{IN}) between the VIN and GND pins with shortest-distance wiring.
We recommend using a ceramic capacitor with very low ESR (Equivalent Series Resistance) and ESL and good temperature characteristics such as X5R or X7R type.
Voltage rating of the capacitor is 6.3 V or more.

Output Capacitor (C_{OUT})

Phase compensation is provided to secure stable operation even when the load current is varied. We recommend to use a ceramic capacitors with very low ESR and ESL and good temperature characteristics such as X5R or X7R type. Voltage rating of the capacitor is 6.3 V or more.
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. C_{OUT} Effective Capacitance

Set Output Voltage (V_{SET})	C_{OUT}	
	MIN	TYP
1.0 V ≤ V_{SET} ≤ 5.0 V	7 µF	10 µF

The output may become unstable if a capacitor with a large effective capacitance value such as an electrolytic capacitor or a capacitor with a large ESR is used.
Even if a capacitor (C_{OUTX}) other than the recommended C_{OUT} is used, connect the aforementioned Typ. 10 µF (recommended) ceramic capacitor close to the IC and select components so that output capacitor to ensure the following effective capacitance in consideration.
Also, select a component with an ESR of C_{OUTX} of 20mΩ or less (frequency: 10 kHz to 3 MHz), and evaluate the IC characteristics including the frequency characteristics.

V_{MODE} Conditions vs. C_{OUTX} Effective Capacitance

V_{MODE} Conditions	C_{OUTX}
	MAX
V_{MODE} = "High"	1000 µF
V_{MODE} = "Low"	210 µF

■ BLOCK DIAGRAMS
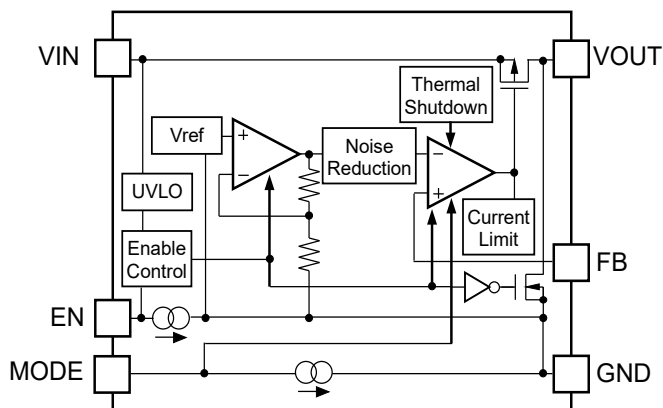
NR1641xxxxxA/B Block Diagram
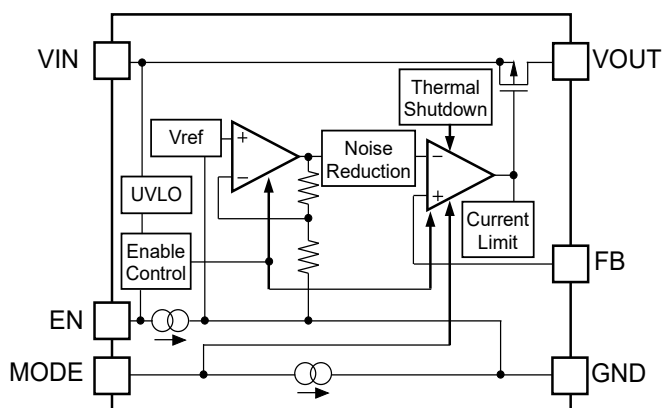
NR1641xxxxxC/D Block Diagram

■ THEORY OF OPERATION

● Enable Function

Forcing above designated "High" voltage to EN pin, the NR1641 becomes active. Forcing below designated "Low" voltage to EN pin shuts down the NR1641. The EN pin is pulled down with a constant current of Typ.0.25 µA inside the IC.

Products with a discharge function (NR1641xxxxxA/B) turn on the discharge FET in the shutdown state to discharge the output capacitor (C_{OUT}). Products without a discharge function (NR1641xxxxxC/D) discharge the charge of the output capacitor (C_{OUT}) in the load circuit in the shutdown state. If control by the EN pin is not possible or is not required, connect the EN pin to the VIN pin, etc., so that "High" is input at start-up.

EN pin can accept input range voltage regardless of the input of VIN pin. If Enable function is not necessary, connect EN pin to VIN pin or other designated "High" voltage node at start-up.

If the EN pin is connected to the VIN pin, the normal effect of the built-in discharge FET cannot be expected.

Even if voltage is applied to the EN pin before the VIN pin, the IC will not fail.

● Discharge Function (NR1641xxxxxA/B)

This function turns on the FET connected between the VOUT pin and GND pin to discharge the charge stored in the output capacitor (C_{OUT}) and quickly reduce the output voltage to near 0 V. This function is enabled when the EN pin is "Low" or when thermal shutdown is detected.

The FET on-resistance is Typ. 50 Ω (V_{IN} = 4.0 V). This function is effective when the input voltage (V_{IN}) is within the recommended operating conditions.

Please note that when the input voltage (V_{IN}) and the EN pin input voltage are used in common, the C_{OUT} charge cannot be discharged sufficiently when the input voltage (V_{IN}) drops.

● Thermal Shutdown

When the junction temperature exceeds the thermal shutdown detection temperature (Typ.165 °C), this IC cuts off the output transistor and suppresses the self-heating. When the junction temperature falls below the thermal shutdown release temperature (Typ. 125 °C), this IC will restart with the Soft-start operation.

● Under Voltage Lockout (UVLO) Circuit

The UVLO function is an auxiliary function that stops the operation of the IC when the input voltage is low, and the IC cannot operate normally. In versions with a discharge function, the output pin is pulled down by the discharge FET when this function works. To restart the operation, the input voltage (V_{IN}) must be higher than the recommended operating conditions (1.7 V).

● **Soft-start Function**

The Soft-start function is a function that makes the rise the internal reference voltage inside the IC with the constant slope of voltage at start-up (V_{OUTSS}). Either of (200 µs/V, 500 µs/V) is selectable depending on the version.
This function makes it possible to moderate the rising slope of the output voltage and suppress the inrush current at start-up.
If the input voltage (V_{IN}) is within the recommended operating conditions, when a "High" is input to the EN pin, the soft-start operation will start after the rising delay time(t_{D1}).
The output voltage rise time(t_{ON1}) can be calculated by the following formula.

$$t_{ON1} = t_{D1} + V_{OUTSS} \times V_{SET} + t_{D2}$$

t_{D1}:	Output Delay Time	Typ. 100 µs
t_{D2}:	Delay Time	Typ. 200 µs (Refer to *Inrush Current Suppression Function*)
V_{OUTSS}	Slope of Output Voltage at Start-up	
V_{SET}:	Set Output Voltage	

To enable the soft-start function, apply the recommended operating conditions (1.7 V or higher) as the input voltage (V_{IN}), and then input "High" to the EN pin to start. If the input voltage (V_{IN}) does not meet the recommended operating conditions and a "High" is input to the EN pin, the device may start without enabling the soft-start function.
Also, if the NR1641 turns on from with 0.4V or higher VOUT (V_{OUT}) condition, turn on slope (V_{OUTSS}) may not be effective.

Timing Chart; Start-Up
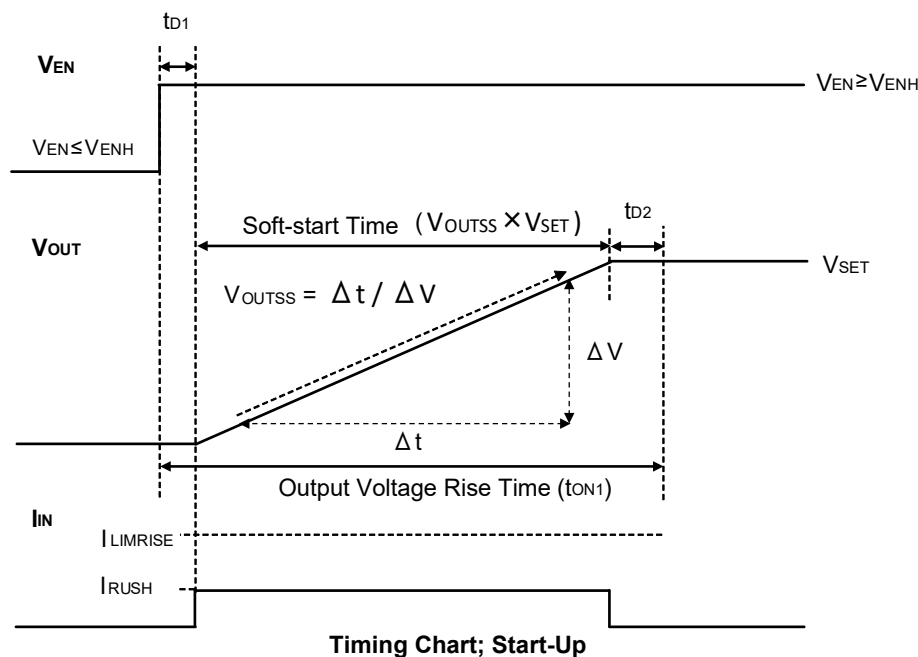
The inrush current (I_{RUSH}) at start-up is calculated by the following formula using the load current (I_{LOAD}) during start-up and the charge current (I_{CHG}) to the output capacitor (C_{OUT}). The start-up inrush current (I_{RUSH}) can be adjusted by selecting V_{OUTSS} from 200 µs/V or 500 µs/V according to the effective capacitance value of the output capacitor (C_{OUT}).

$$I_{RUSH}: \quad I_{CHG} + I_{LOAD} = (C_{OUT}/V_{OUTSS}) + I_{LOAD}$$

I_{CHG}:	Charge Current for The Output Capacitor
I_{LOAD}:	Load Current
$I_{LIMRISE}$:	Start-up Inrush Current Limit Typ. 250 mA (Refer to *Inrush Current Suppression Function*)

Also, if the load current (I_{LOAD}) during start-up or the charge current (I_{CHG}) to the output capacitor (C_{OUT}) is large and the inrush current (I_{RUSH}) at start-up satisfies the following formula, the soft-start function is not effective.
Refer to "*Inrush Current Suppression Function*".

$$I_{LIMRISE} < I_{RUSH}$$

● Inrush Current Suppression Function

The Inrush Current Suppression Function is that limits the inrush current at start-up (I_{RUSH}), which is the sum of the charge current (I_{CHG}) to the output capacitor (C_{OUT}) and the load current (I_{LOAD}), with the limit current value at start-up ($I_{LIMRISE}$, Typ. 250 mA).

The inrush current (I_{RUSH}) at start-up when starting with the soft-start function is expressed by the following formula.

$$I_{RUSH} = I_{CHG} + I_{LOAD} = (C_{OUT}/V_{OUTSS}) + I_{LOAD}$$

I_{CHG}:   Charge Current for The Output Capacitor
I_{LOAD}:   Load current

If the output capacitor (C_{OUT}) or load current (I_{LOAD}) is such that start-up inrush current (I_{RUSH}) reaches the Start-up Inrush Current Limit ($I_{LIMRISE}$, Typ. 250 mA), it rises at a slower slope than the slope of output voltage at start-up (V_{OUTSS}) of the version select.

The rise time (t_{ON2}) by the inrush current limiting function can be calculated by the following formula.

$$t_{ON2} = t_{D1} + t_{D2} + C_{OUT} \times V_{SET}/ (I_{LIMRISE} - I_{LOAD})$$

t_{D1}:   Output Delay Time   Typ. 100 μs
t_{D2}:   Delay Time   Typ. 200 μs
C_{OUT}:   Effective Capacitance of Output Capacitor
V_{SET}:   Set Output Voltage
$I_{LIMRISE}$:   Start-up Inrush Current Limit Typ. 250 mA
I_{LOAD}:   Load Current

The Start-up Inrush Current Limit ($I_{LIMRISE}$) is effective until the delay time (t_{D2}) elapses after the output voltage (V_{OUT}) reaches the set output voltage (V_{SET}). It is then protected against overcurrent by output current limit (I_{LIM}) and short circuit current (I_{SC}).

To enable the inrush current limit function, start by inputting "High" to the EN pin after applying the recommended operating conditions (1.7 V or higher) as the input voltage (V_{IN}).

If the input voltage (V_{IN}) does not meet the recommended operating conditions and the EN pin is set to "High", the NR1641 may start up without inrush current limit function.

If the load current (I_{LOAD}) exceeds the Start-up Inrush Current Limit ($I_{LIMRISE}$) during start-up, the output voltage (V_{OUT}) will not reach the set output voltage (V_{SET}).

The UVLO function and thermal shutdown function are valid even while the output voltage is starting. These protective functions may operate when starting with a load current or when a large output capacitor (C_{OUT}) is connected. In such cases, adjust the output capacitor (C_{OUT}) and start-up timing to suppress inrush current and heat generation.
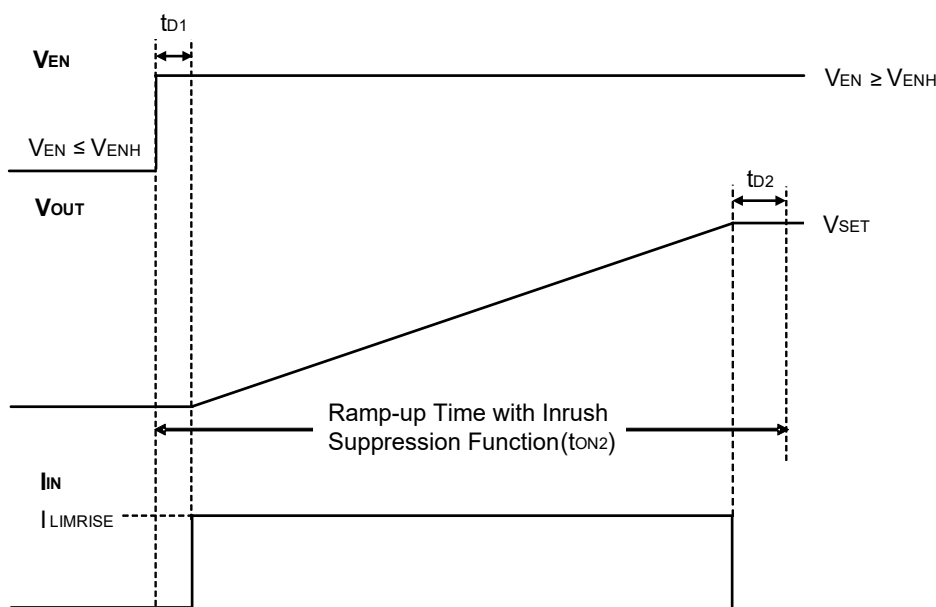
Timing Chart; Start-up inrush current is larger than the start-up inrush current limit

● **Automatic mode alternative function**

The automatic mode-alternative feature can lengthen battery life, especially in battery-powered applications with long-period intermittent operation.

The NR1641 has two modes, fast mode and low power mode. The fast mode consumes more current of the IC itself, but high PSRR, ultra-low noise, and fast transient response conditions are activated in this mode. The low power mode has slower transient response characteristics than the fast mode but achieves low consumption current of the IC itself.

When "High" is input to the MODE pin, the IC operates in fixed fast mode.

The automatic mode alternative function can be enabled by inputting "Low" to the MODE pin.

In automatic mode alternative, when the load current (I_{LOAD}) exceeds the Fast Mode switch-over current (I_{OUTH}), it changes to fast mode, and when it falls below the Low Power Mode switch-over current (I_{OUTL}), the NR1641 changes to low power mode.

In fast mode, the operation, characteristics, and functions of the IC are the same regardless of whether the MODE pin is "High/Low". Mode alternative switch-over current, I_{OUTH} and I_{OUTL} have hysteresis.

Note that there may be a difference between the output voltage in fast mode and low power mode. Please refer to the electrical characteristics for details.

A delay time (t_{D3}, Typ. 200 μs) exists to change from fast mode to low power mode. In addition, there is a period (Max. 2 ms) which the transient response characteristics deteriorate due to the operation inside the IC after the mode change to the low power mode.

After that period, the transient response characteristics recovers and be same as shown in the typical characteristics.

Fully evaluation is highly recommended to check these characteristics if automatic mode alternative function is necessary.

The operating state can be changed by the MODE pin at any time. Note that distortion occurs in the output voltage (V_{OUT}) if the MODE is changed during operation. (Refer to the figure below and typical characteristics)

The MODE pin is pulled down with a Typ. 0.25 μA constant current circuit inside the IC. If control by the MODE pin is not possible or unnecessary, tie the MODE pin to the VIN pin or GND.

Do not be the MODE pin left open.

There is no sequence regulation between MODE pin and VIN pin. MODE pin voltage can be set prior to VIN pin and vice.
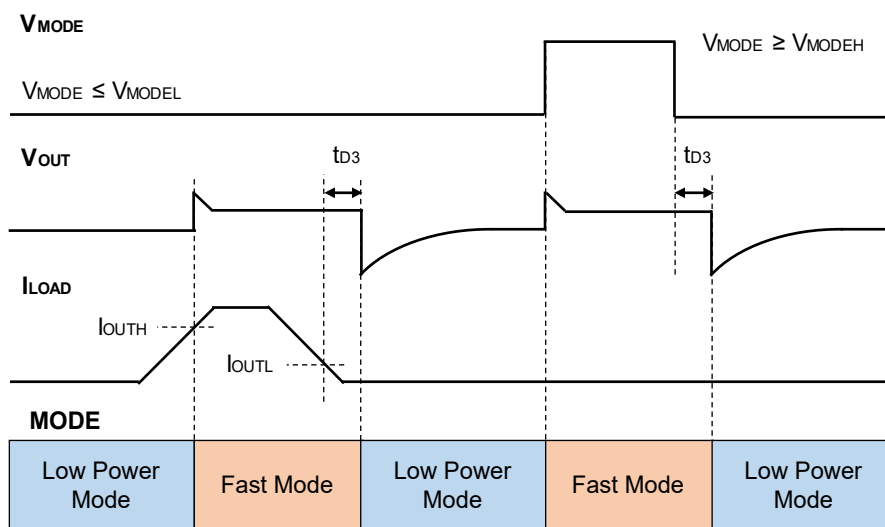
Timing Chart; Automatic mode alternative

While the automatic mode alternative function is enabled, if the input voltage (V_{IN}) falls below the fast mode output voltage, the operating state is fixed to low power mode even if a load current (I_{LOAD}) is higher than the Fast Mode switch-over current (I_{OUTH}).

In this state the output current limit (I_{LIM}) and short-circuit current (I_{SC}) are set to approximately a half of the normal value.

This function is effective if the input voltage (V_{IN}) becomes lower than the output voltage at fast mode. The delay time is typically 50 µs (t_{D4}). This function is disabled for the product whose set output voltage (V_{SET}) is lower than 1.7 V. When the input voltage (V_{IN}) rises above the fast mode output voltage, the normal automatic mode alternative feature is activated.

There is no hysteresis in the input voltage (V_{IN}) condition that returns to the automatic mode alternative state.

When the MODE pin is "High", the fast mode is maintained regardless of the input voltage (V_{IN}).
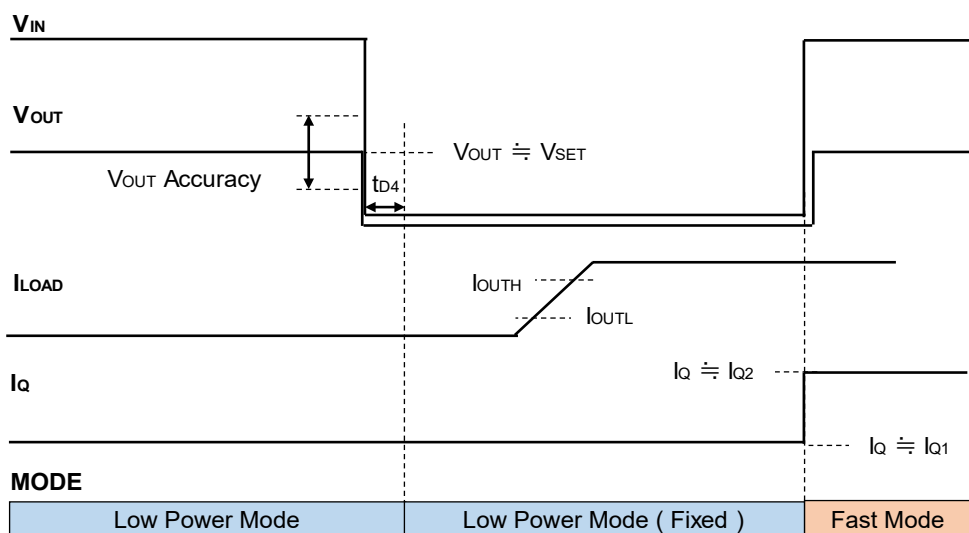
Timing Chart; The input voltage (V_{IN}) drops when the MODE pin is set to "Low"

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■ THERMAL CHARACTERISTICS (DFN1616-6-GY)

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

Measurement Conditions

Item	Measurement Conditions
Environment	Mounting on Board (Wind Velocity 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board Dimensions	76.2 mm × 114.3 mm × 0.8 mm

Copper Ratio	Outer Layer (First Layer):
	        Less than 95% of 50 mm Square
	Inner Layers (Second and Third Layers):
	        Approx. 100% of 50 mm Square
	Outer Layer (Fourth Layer):
	        Approx. 100% of 50 mm Square

Through-holes	ϕ 0.2 mm × 25 pcs

Measurement Result

Item	Measurement Result
Thermal Resistance (θja)	θja = 41 °C/W
Thermal Characterization Parameter (ψjt)	ψjt = 11 °C/W

θja: Junction-to-Ambient Thermal Resistance

ψjt: Junction-to-Top Thermal Characterization Parameter
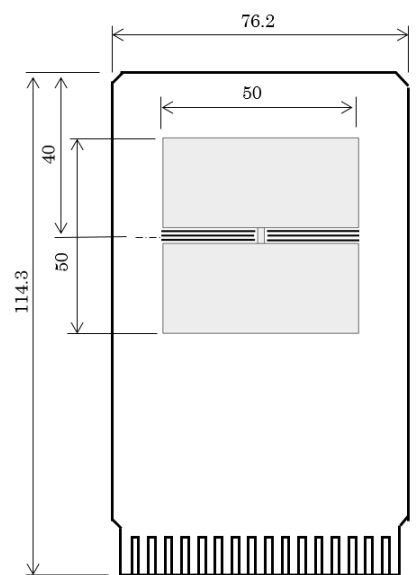
Measurement Board Pattern

● CALCULATION METHOD OF JUNCTION TEMPERATURE

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

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

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

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■ NR1641GY MARKING SPECIFICATION

①②③④: Product Code

⑤⑥: Lot Number … Alphanumeric Serial Number
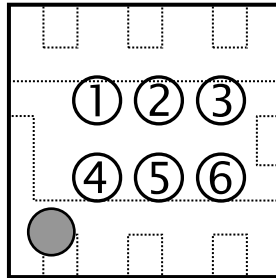
DFN1616-6-GY Part Markings

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

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NR1641GY Marking List

Product Code	① ② ③ ④	Product Code	① ② ③ ④
NR1641GY100A	A 0 0 0	NR1641GY330A	A 2 0 5
NR1641GY110A	A 0 0 1	NR1641GY340A	A 2 0 6
NR1641GY120A	A 0 0 2	NR1641GY350A	A 2 0 7
NR1641GY130A	A 0 0 3	NR1641GY360A	A 2 0 8
NR1641GY140A	A 0 0 4	NR1641GY370A	A 2 0 9
NR1641GY150A	A 0 0 5	NR1641GY380A	A 2 1 0
NR1641GY160A	A 0 0 6	NR1641GY390A	A 2 1 1
NR1641GY170A	A 0 0 7	NR1641GY400A	A 2 1 2
NR1641GY180A	A 0 0 8	NR1641GY410A	A 2 1 3
NR1641GY190A	A 0 0 9	NR1641GY420A	A 2 1 4
NR1641GY200A	A 0 1 0	NR1641GY430A	A 2 1 5
NR1641GY210A	A 0 1 1	NR1641GY440A	A 2 1 6
NR1641GY220A	A 0 1 2	NR1641GY450A	A 2 1 7
NR1641GY230A	A 0 1 3	NR1641GY460A	A 2 1 8
NR1641GY240A	A 0 1 4	NR1641GY470A	A 2 1 9
NR1641GY250A	A 0 1 5	NR1641GY480A	A 2 2 0
NR1641GY260A	A 0 1 6	NR1641GY490A	A 2 2 1
NR1641GY270A	A 0 1 7	NR1641GY500A	A 2 2 2
NR1641GY100B	B 0 0 0	NR1641GY280B	B 2 0 0
NR1641GY110B	B 0 0 1	NR1641GY290B	B 2 0 1
NR1641GY120B	B 0 0 2	NR1641GY300B	B 2 0 2
NR1641GY130B	B 0 0 3	NR1641GY310B	B 2 0 3
NR1641GY140B	B 0 0 4	NR1641GY320B	B 2 0 4
NR1641GY150B	B 0 0 5	NR1641GY330B	B 2 0 5
NR1641GY160B	B 0 0 6	NR1641GY340B	B 2 0 6
NR1641GY170B	B 0 0 7	NR1641GY350B	B 2 0 7
NR1641GY180B	B 0 0 8	NR1641GY360B	B 2 0 8
NR1641GY190B	B 0 0 9	NR1641GY370B	B 2 0 9
NR1641GY200B	B 0 1 0	NR1641GY380B	B 2 1 0
NR1641GY210B	B 0 1 1	NR1641GY390B	B 2 1 1
NR1641GY220B	B 0 1 2	NR1641GY400B	B 2 1 2
NR1641GY230B	B 0 1 3	NR1641GY410B	B 2 1 3
NR1641GY240B	B 0 1 4	NR1641GY420B	B 2 1 4
NR1641GY250B	B 0 1 5	NR1641GY430B	B 2 1 5
NR1641GY260B	B 0 1 6	NR1641GY440B	B 2 1 6
NR1641GY270B	B 0 1 7	NR1641GY450B	B 2 1 7
NR1641GY280A	A 2 0 0	NR1641GY460B	B 2 1 8
NR1641GY290A	A 2 0 1	NR1641GY470B	B 2 1 9
NR1641GY300A	A 2 0 2	NR1641GY480B	B 2 2 0
NR1641GY310A	A 2 0 3	NR1641GY490B	B 2 2 1
NR1641GY320A	A 2 0 4	NR1641GY500B	B 2 2 2

Nisshinbo Micro Devices Inc.

NR1641GY Marking List

Product Code	① ② ③ ④	Product Code	① ② ③ ④
NR1641GY100C	A 4 0 0	NR1641GY330C	A 6 0 5
NR1641GY110C	A 4 0 1	NR1641GY340C	A 6 0 6
NR1641GY120C	A 4 0 2	NR1641GY350C	A 6 0 7
NR1641GY130C	A 4 0 3	NR1641GY360C	A 6 0 8
NR1641GY140C	A 4 0 4	NR1641GY370C	A 6 0 9
NR1641GY150C	A 4 0 5	NR1641GY380C	A 6 1 0
NR1641GY160C	A 4 0 6	NR1641GY390C	A 6 1 1
NR1641GY170C	A 4 0 7	NR1641GY400C	A 6 1 2
NR1641GY180C	A 4 0 8	NR1641GY410C	A 6 1 3
NR1641GY190C	A 4 0 9	NR1641GY420C	A 6 1 4
NR1641GY200C	A 4 1 0	NR1641GY430C	A 6 1 5
NR1641GY210C	A 4 1 1	NR1641GY440C	A 6 1 6
NR1641GY220C	A 4 1 2	NR1641GY450C	A 6 1 7
NR1641GY230C	A 4 1 3	NR1641GY460C	A 6 1 8
NR1641GY240C	A 4 1 4	NR1641GY470C	A 6 1 9
NR1641GY250C	A 4 1 5	NR1641GY480C	A 6 2 0
NR1641GY260C	A 4 1 6	NR1641GY490C	A 6 2 1
NR1641GY270C	A 4 1 7	NR1641GY500C	A 6 2 2
NR1641GY100D	B 4 0 0	NR1641GY280D	B 6 0 0
NR1641GY110D	B 4 0 1	NR1641GY290D	B 6 0 1
NR1641GY120D	B 4 0 2	NR1641GY300D	B 6 0 2
NR1641GY130D	B 4 0 3	NR1641GY310D	B 6 0 3
NR1641GY140D	B 4 0 4	NR1641GY320D	B 6 0 4
NR1641GY150D	B 4 0 5	NR1641GY330D	B 6 0 5
NR1641GY160D	B 4 0 6	NR1641GY340D	B 6 0 6
NR1641GY170D	B 4 0 7	NR1641GY350D	B 6 0 7
NR1641GY180D	B 4 0 8	NR1641GY360D	B 6 0 8
NR1641GY190D	B 4 0 9	NR1641GY370D	B 6 0 9
NR1641GY200D	B 4 1 0	NR1641GY380D	B 6 1 0
NR1641GY210D	B 4 1 1	NR1641GY390D	B 6 1 1
NR1641GY220D	B 4 1 2	NR1641GY400D	B 6 1 2
NR1641GY230D	B 4 1 3	NR1641GY410D	B 6 1 3
NR1641GY240D	B 4 1 4	NR1641GY420D	B 6 1 4
NR1641GY250D	B 4 1 5	NR1641GY430D	B 6 1 5
NR1641GY260D	B 4 1 6	NR1641GY440D	B 6 1 6
NR1641GY270D	B 4 1 7	NR1641GY450D	B 6 1 7
NR1641GY280C	A 6 0 0	NR1641GY460D	B 6 1 8
NR1641GY290C	A 6 0 1	NR1641GY470D	B 6 1 9
NR1641GY300C	A 6 0 2	NR1641GY480D	B 6 2 0
NR1641GY310C	A 6 0 3	NR1641GY490D	B 6 2 1
NR1641GY320C	A 6 0 4	NR1641GY500D	B 6 2 2

■ **APPLICATION NOTE**

● **Internal Equivalent Circuit Diagram of Pin**
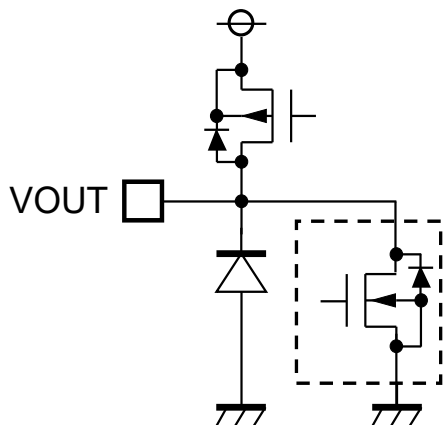
* Dotted frames correspond to (NR1641xxxxxA/B)

VOUT Pin
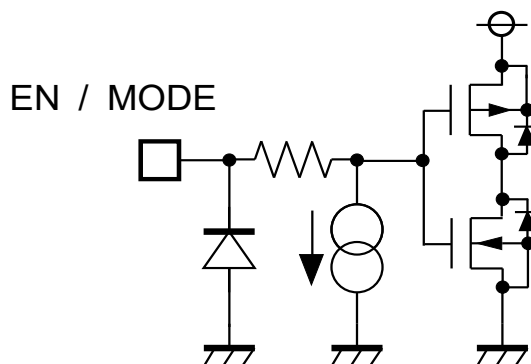
EN Pin/MODE Pin
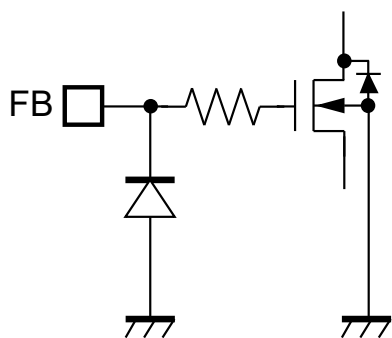
FB Pin

● **Evaluation Board/PCB Layout**
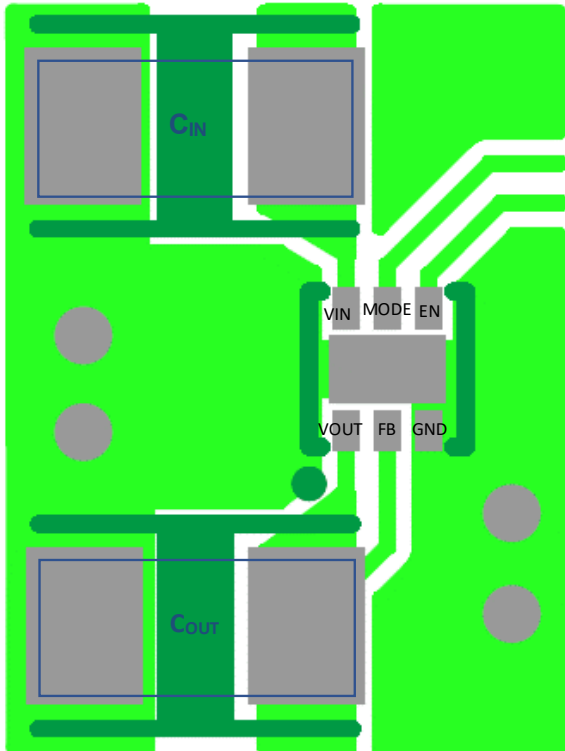
NR1641GY

● TECHNICAL NOTES

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

Ensure the VIN and GND lines are sufficiently robust. If their impedances are too high, noise pickup or unstable operation may result. Connect the input capacitor (C_{IN}) between the VIN and GND pins, on the same side as the IC and with shortest-distance wiring.

The thermal shutdown function prevents the IC from fuming and ignition but does not ensure the IC's reliability or keep the IC below the absolute maximum ratings. The thermal shutdown function does not operate on the heat generated by other than the normal IC operation such as latch-up and overvoltage application. The thermal shutdown function operates in a state over the absolute maximum ratings; therefore the thermal shutdown function should not be used for a system design.

The tab on the bottom side of the DFN and HSON-Package can operate even if it is electrically open, but it is recommended to connect it to GND potential.
Solder the rear tab to the printed circuit board to ensure heat dissipation and mounting strength.

■ **TYPICAL CHARACTERISTICS**

Note: Typical Characteristics are intended to be used as reference data; they are not guaranteed.
$V_{IN} = V_{EN} = V_{MODE} = V_{SET} +1$ V (Max = 5.5 V), I_{OUT} = 1 mA, T_a = 25 °C, C_{IN} = 10 µF, C_{OUT} = 10 µF,
C_{OUTX} = none unless otherwise noted.

1)   Output Voltage vs Temperature

NR1641xx120x
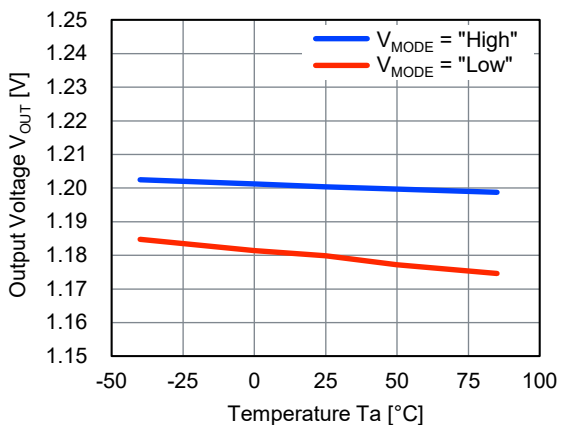
NR1641xx180x
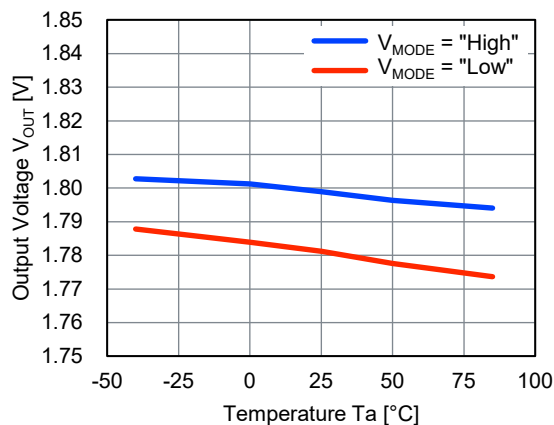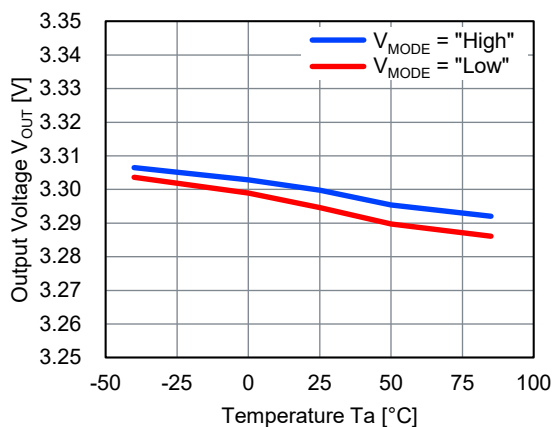
NR1641xx330x

2)   Output Voltage vs Output Current (Load Regulation)

NR1641xx330x
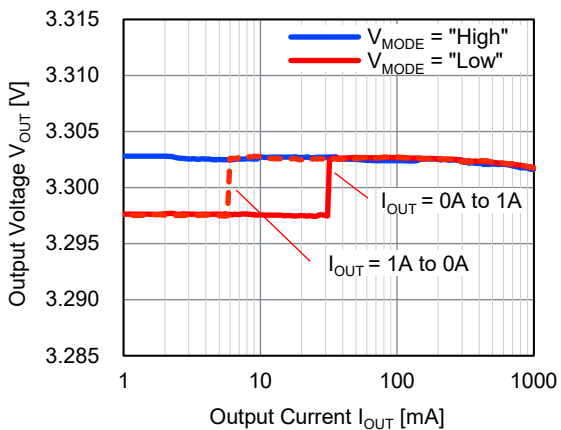
3) Output Voltage vs Output Current (Current Limit)

NR1641xx120x
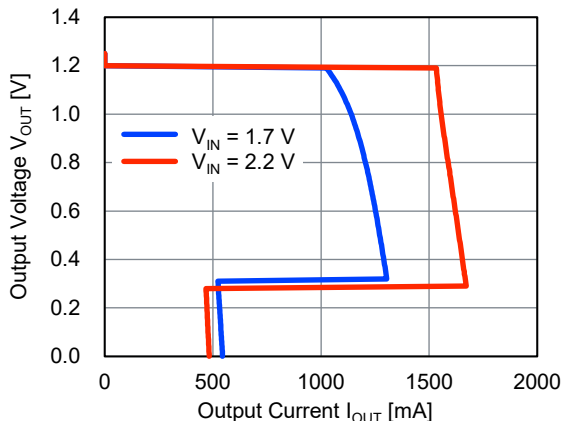
NR1641xx180x
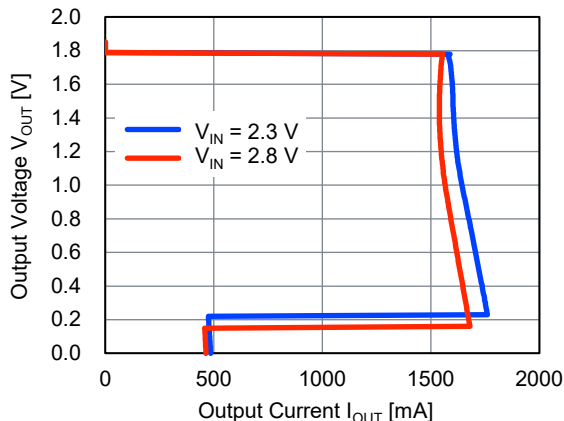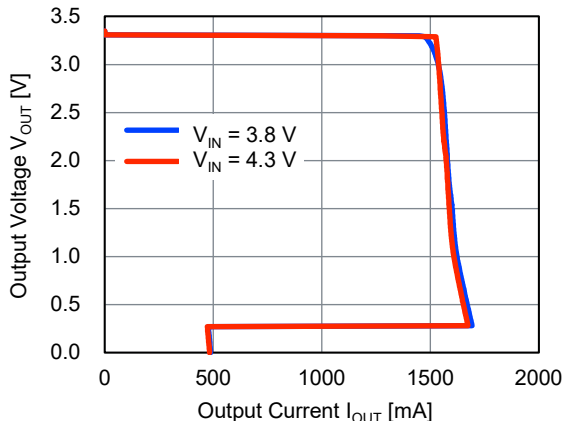
NR1641xx330x

NR1641xx500x
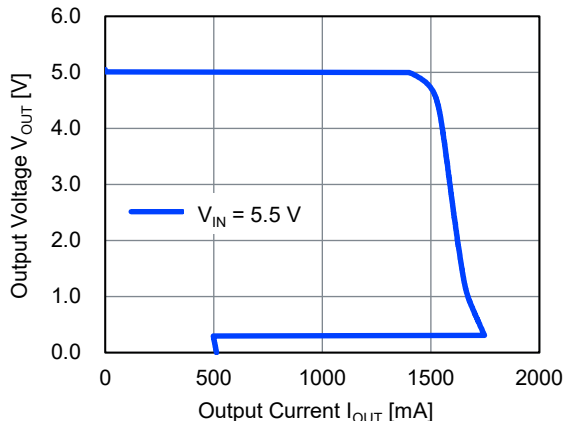
4) Output Voltage vs Input Voltage
$V_{IN} = V_{SET} + 1$ V to $V_{SET} - 0.2$ V

NR1641xx120x
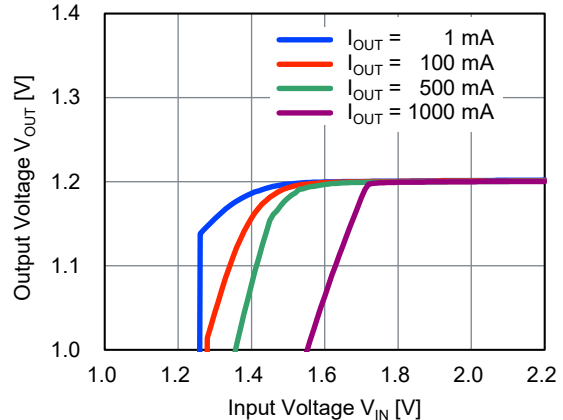
NR1641xx180x
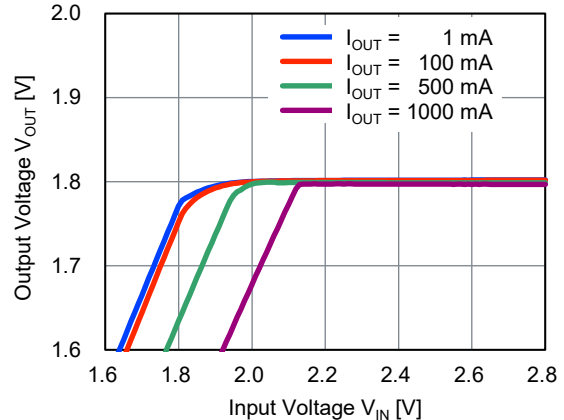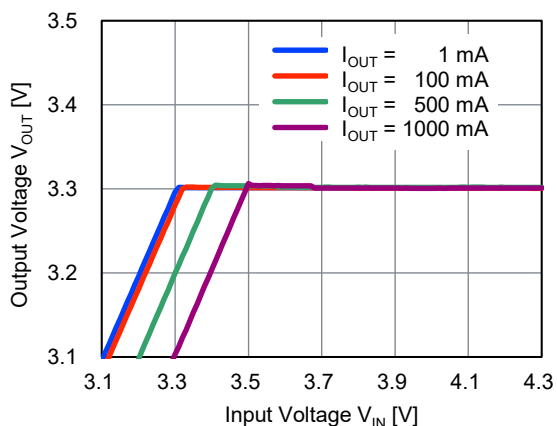
NR1641xx330x

5) Dropout Voltage vs Output Current

NR1641GY180x
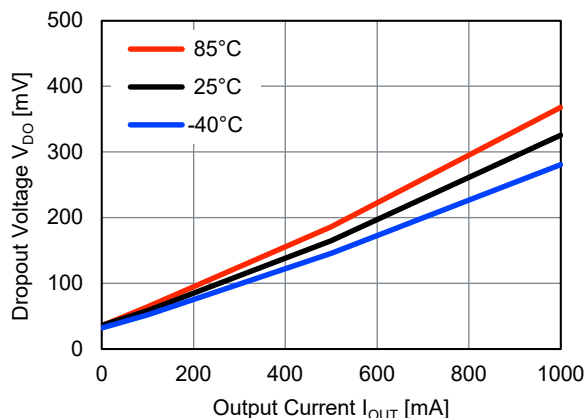
NR1641GY330x
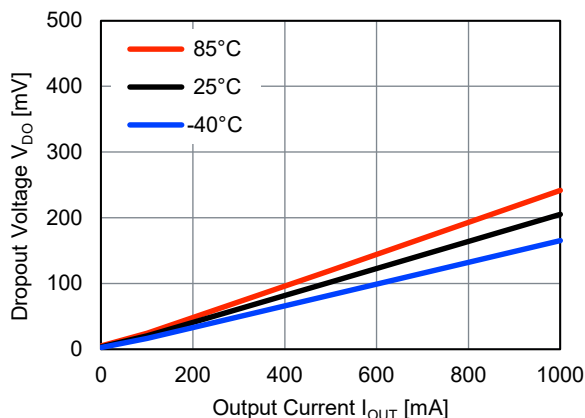
6) Dropout Voltage vs Set Output Voltage

NR1641GYxxxx
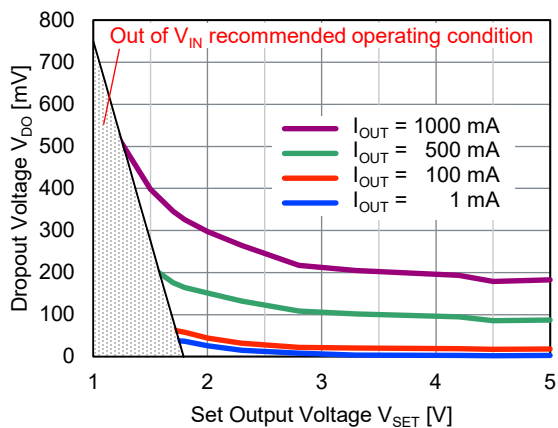
7) Quiescent Current vs Temperature
   I_{OUT} = 0 mA
   NR1641xx120x
   V_{MODE} = V_{IN}

V_{MODE} = 0 V
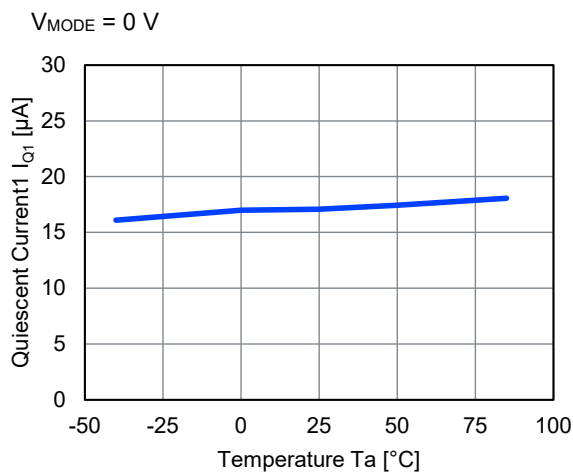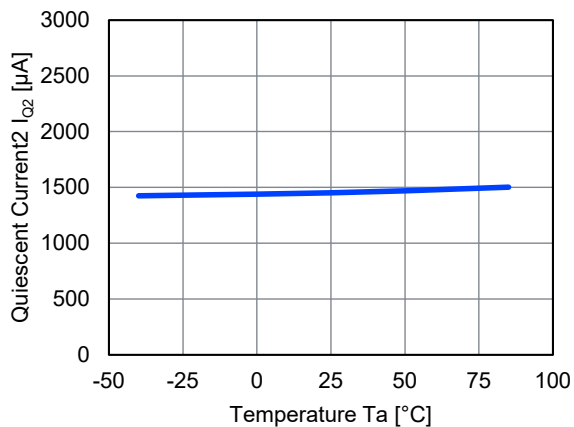
NR1641xx180x
V_{MODE} = V_{IN}

V_{MODE} = 0 V
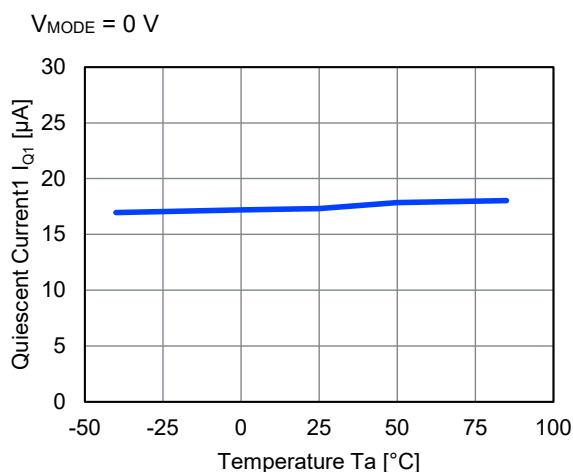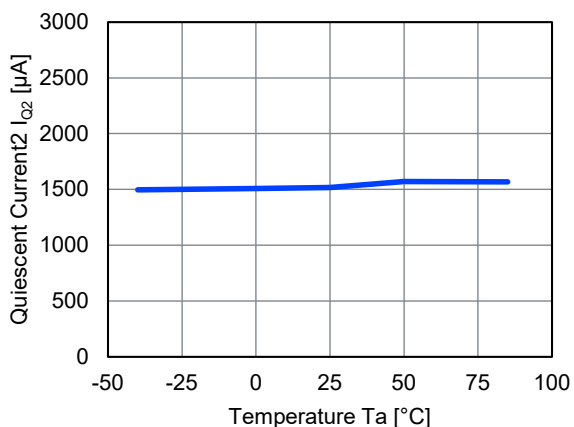
NR1641xx330x
V_{MODE} = V_{IN}

V_{MODE} = 0 V
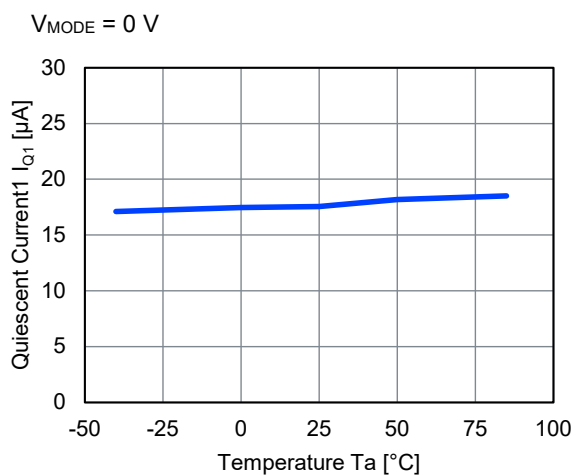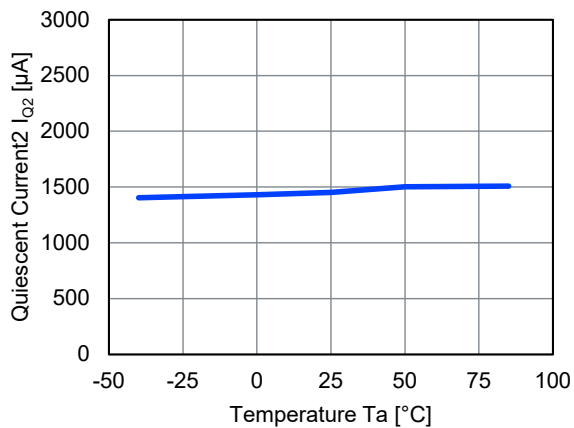
8) Quiescent Current vs Input Voltage
    I_{OUT} = 0 mA
    NR1641xx120x
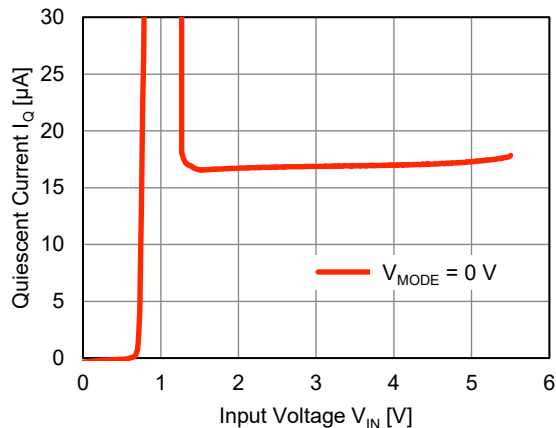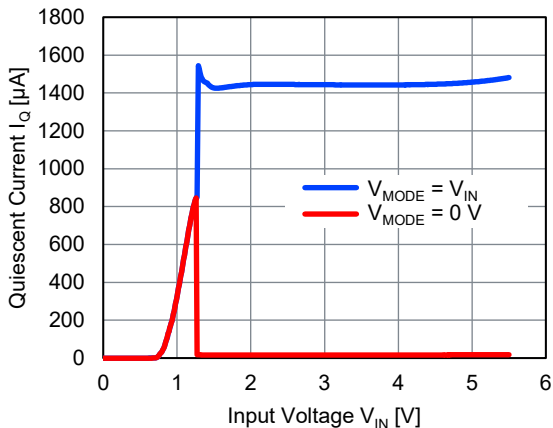
NR1641xx180x
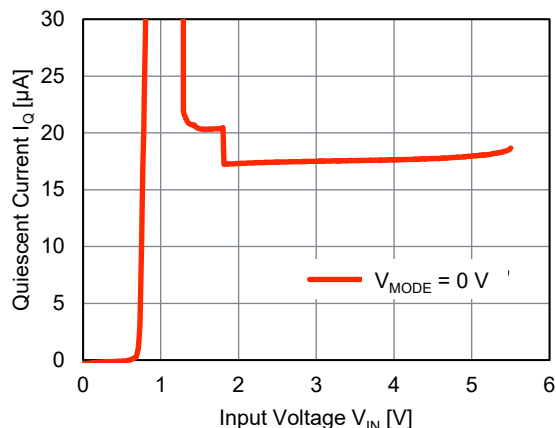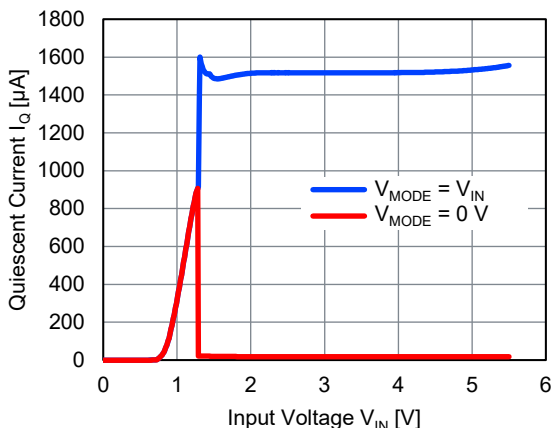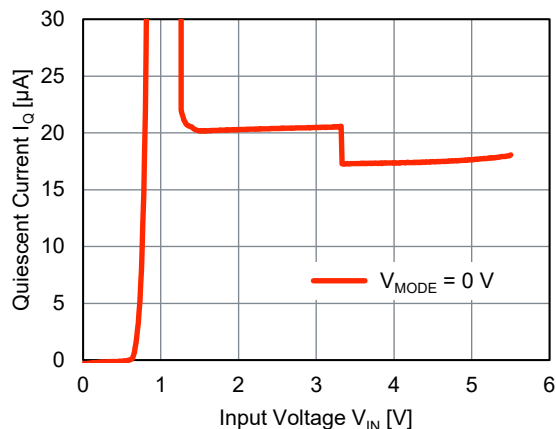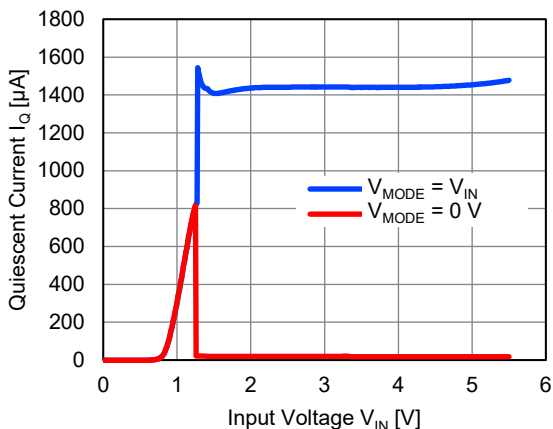
NR1641xx330x

9) GND Pin Current vs Output Current

NR1641xx120x
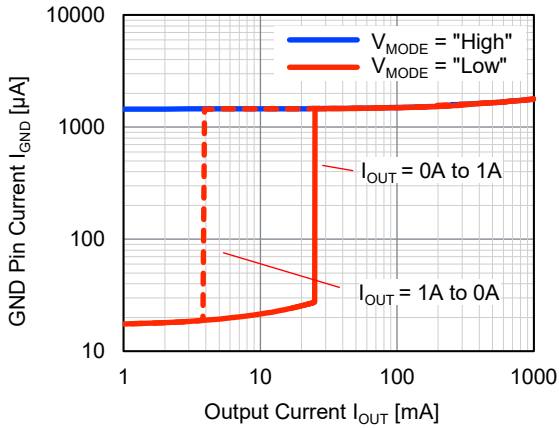
NR1641xx180x
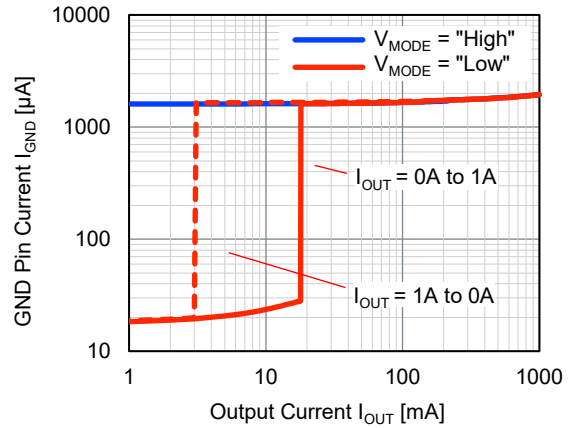
NR1641xx330x
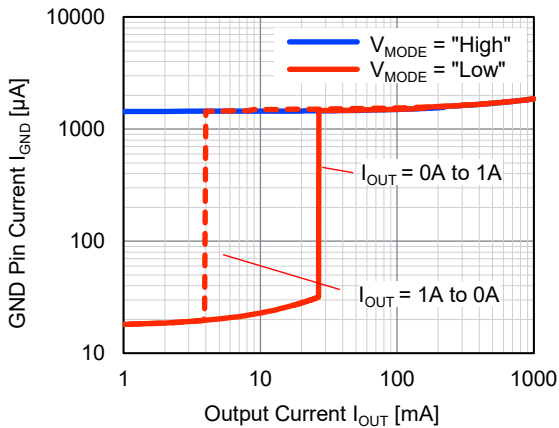
10) Shutdown Current vs Temperature
    $V_{IN} = 5.5$ V, $V_{EN} = 0$ V
    NR1641xxxxxA/B
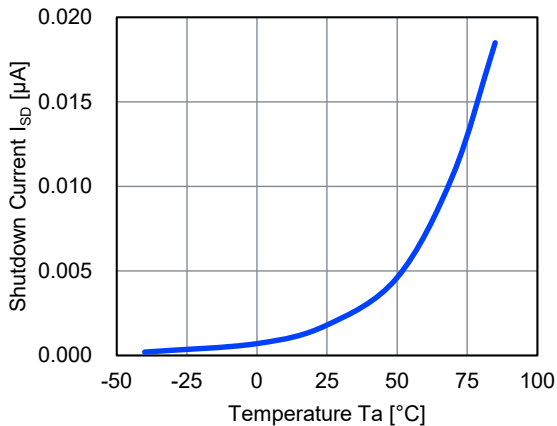
11) EN pin and MODE pin "High" / "Low" Input Voltage vs Temperature
 NR1641xxxxxx

V_{IN} = 5.5 V, "High" Input Voltage
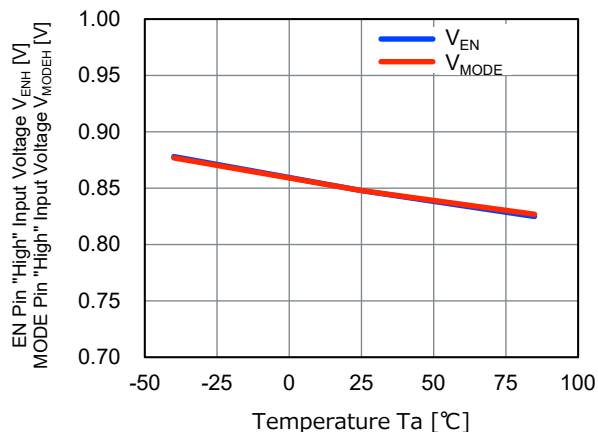
V_{IN} = 1.7 V, "Low" Input Voltage
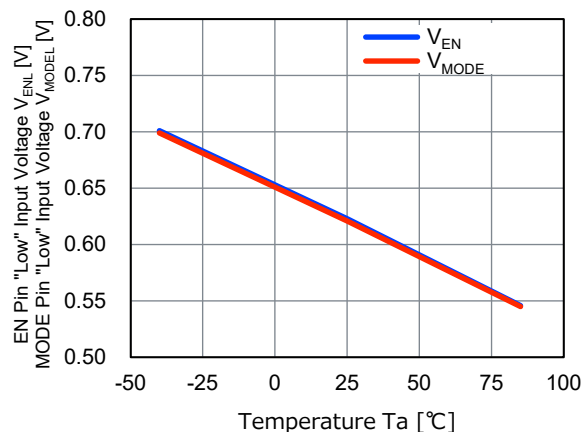
12) Discharge FET On-Resistance vs Input Voltage
 V_{OUT} = 0.1 V
 NR1641xxxxxA/B
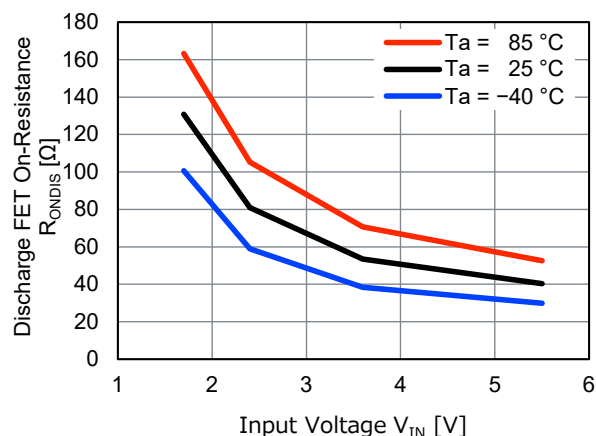
13) Ripple Rejection vs Frequency
 C_{IN}= none , Ripple 0.1 V_{P-P}
 NR1641xx120x
 V_{MODE} = "High"
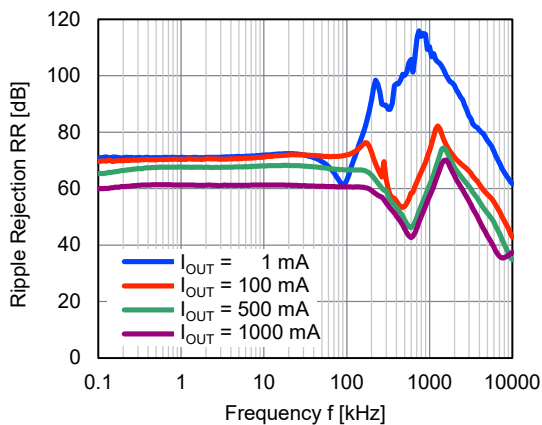
V_{MODE} = "Low"
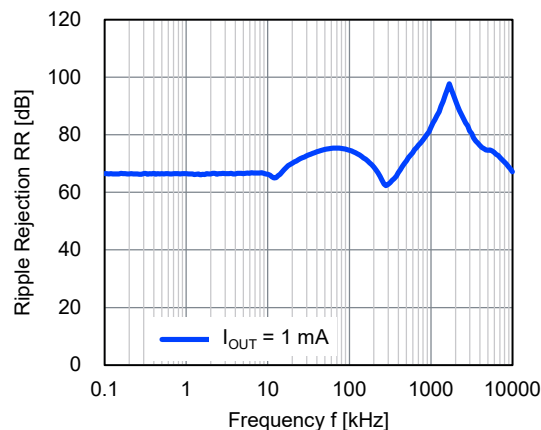
NR1641xx180x
V$_{MODE}$ = "High"
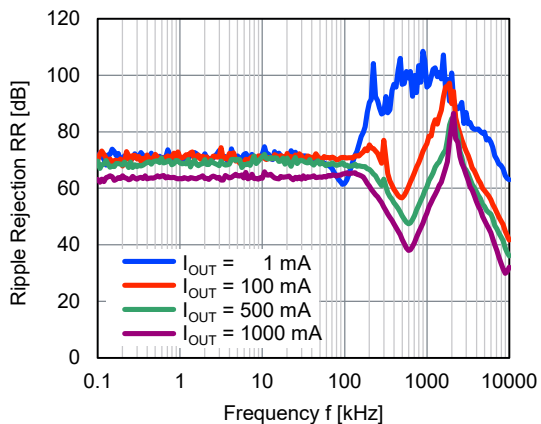
V$_{MODE}$ = "Low"
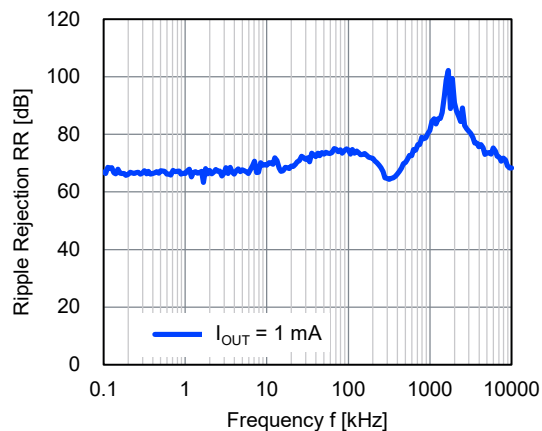
NR1641xx280x
V$_{MODE}$ = "High"
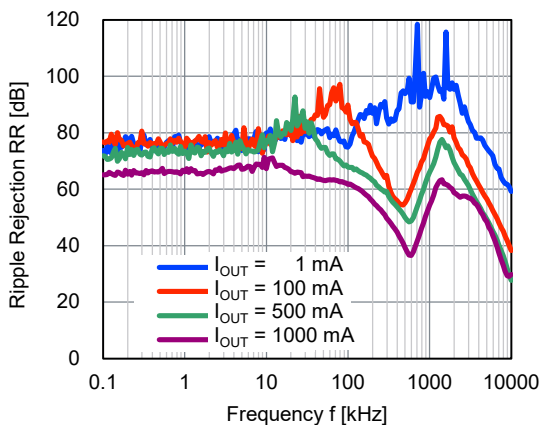
V$_{MODE}$ = "Low"
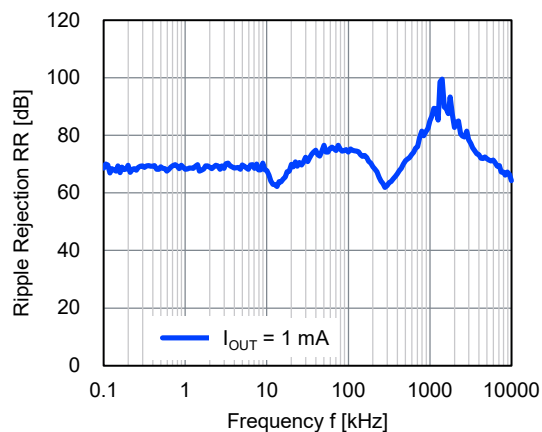
NR1641xx330x
V$_{MODE}$ = "High"
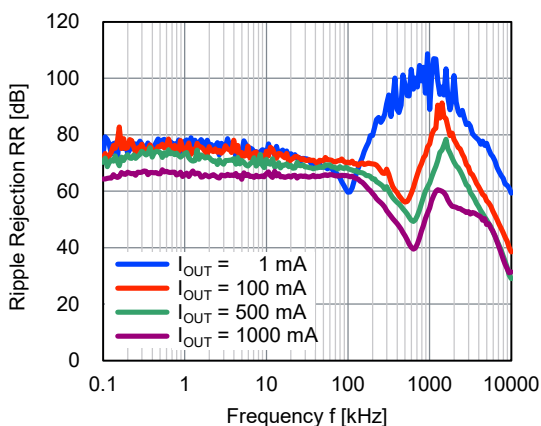
V$_{MODE}$ = "Low"
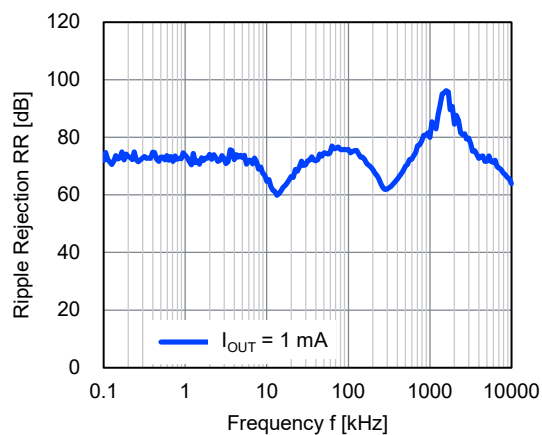
NR1641xx500x
V_{MODE} = "High"
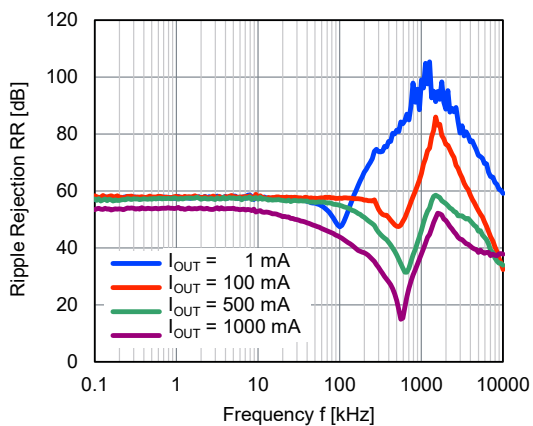
V_{MODE} = "Low"
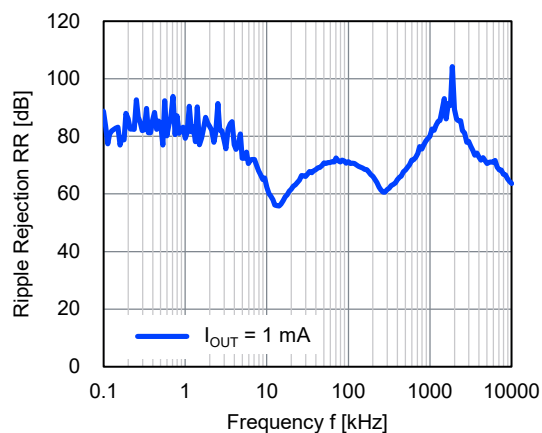
14) Ripple Rejection vs Input Voltage
C_{IN}= none , Ripple 0.1 V_{P-P}
NR1641xx120x
I_{OUT} = 1 mA
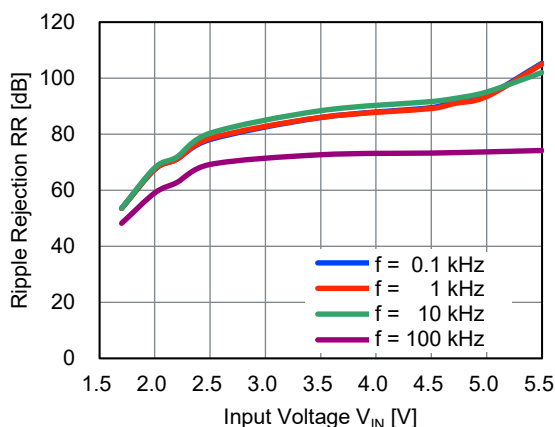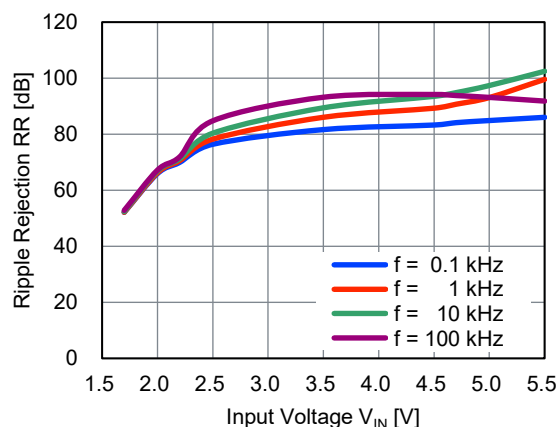
I_{OUT} = 100 mA

NR1641xx180x
I_{OUT} = 1 mA
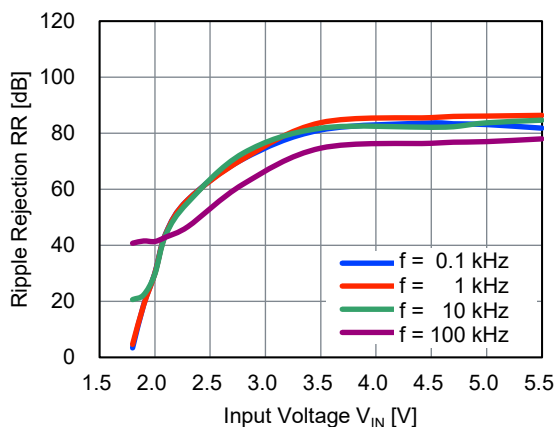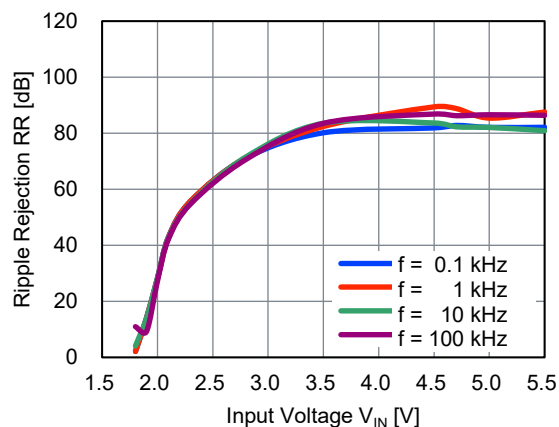
I_{OUT} = 100 mA

NR1641xx280x
I_{OUT} = 1 mA
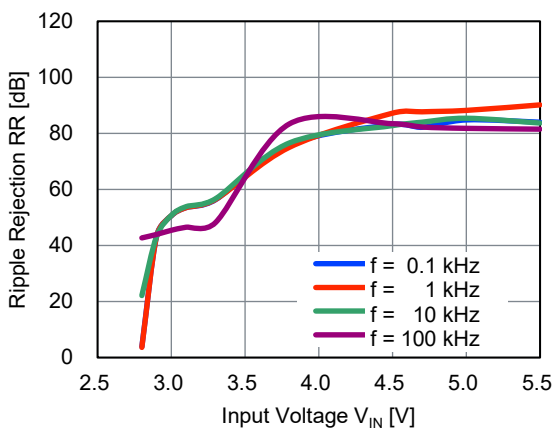
I_{OUT} = 100 mA
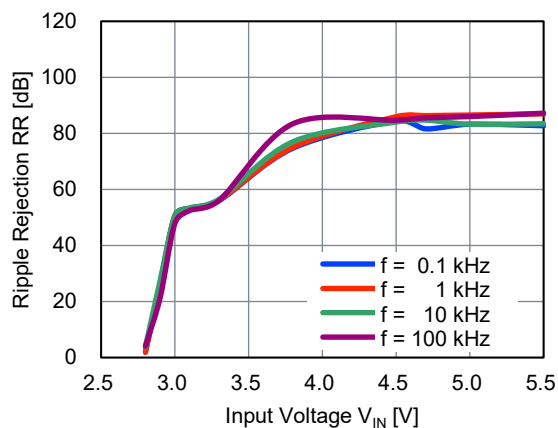
NR1641xx330x
I_{OUT} = 1 mA
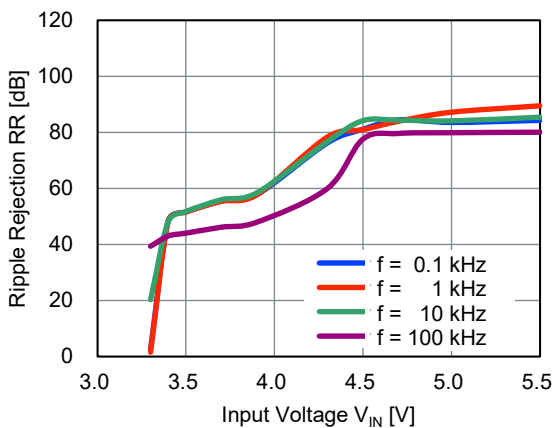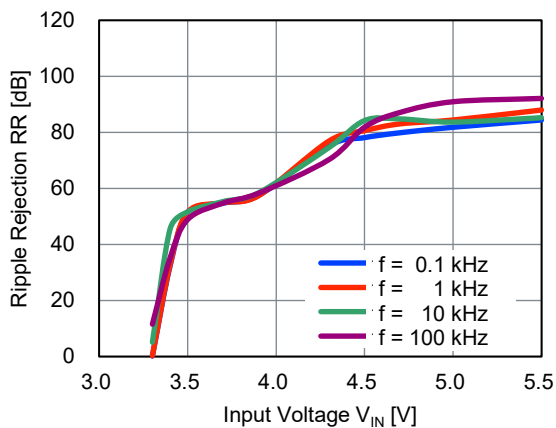
I_{OUT} = 100 mA

NR1641xx500x
I_{OUT} = 1 mA

I_{OUT} = 100 mA

NISSHINBO
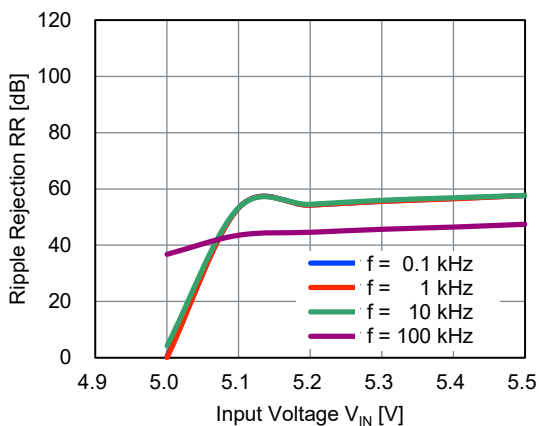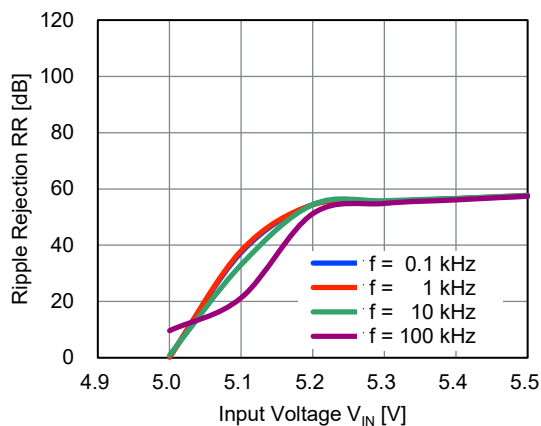
15) Output Noise Spectral Density vs Frequency

NR1641xx120x
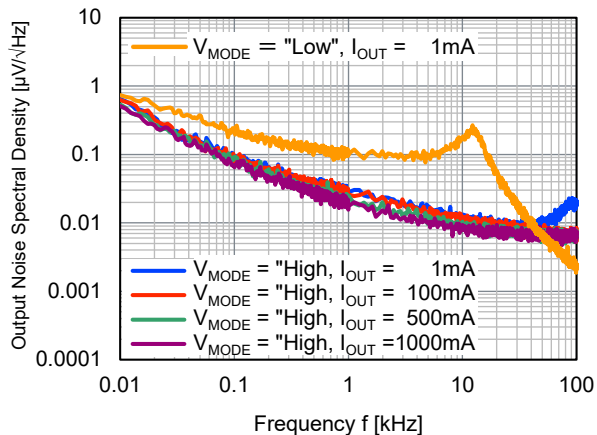
NR1641xx180x
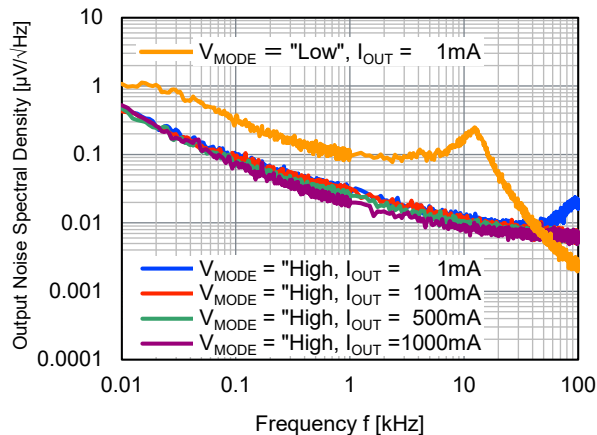
NR1641xx280x
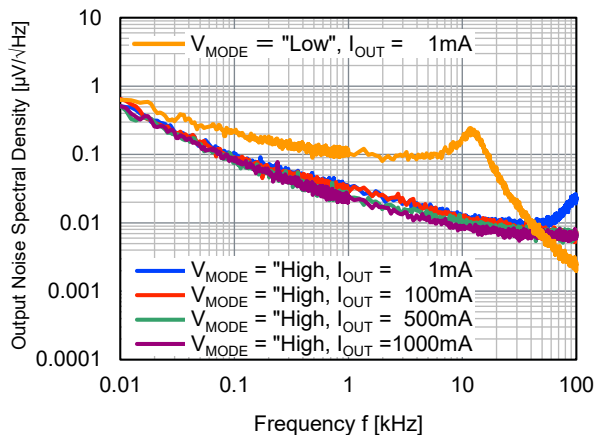
NR1641xx330x
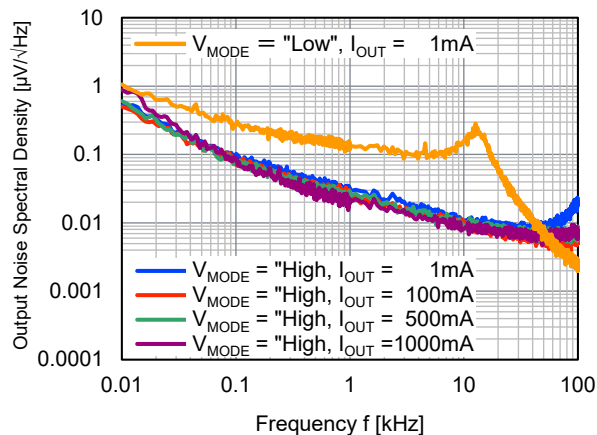
NR1641xx500x
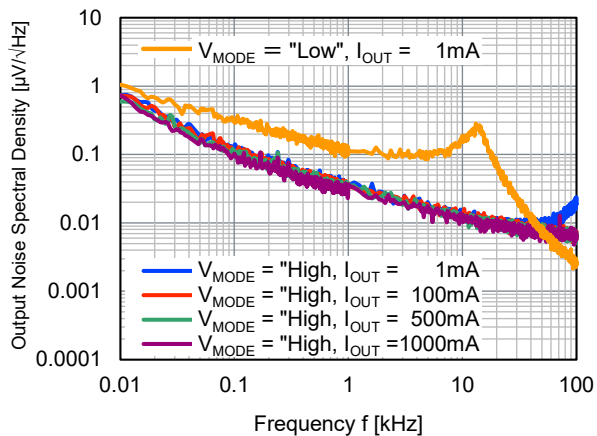
16) Line Transient Response
$t_R = t_F = 5$ µs, $V_{MODE} =$ "High"
NR1641xx120x
$I_{OUT} = 1$ mA
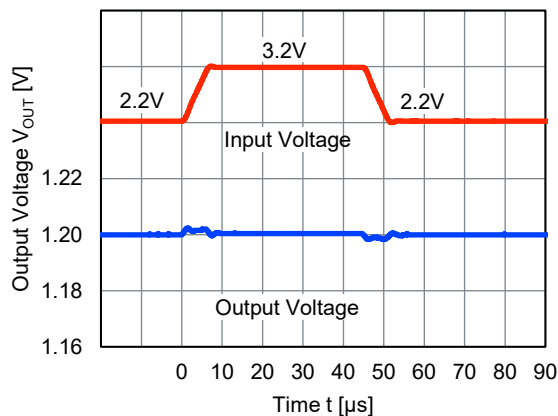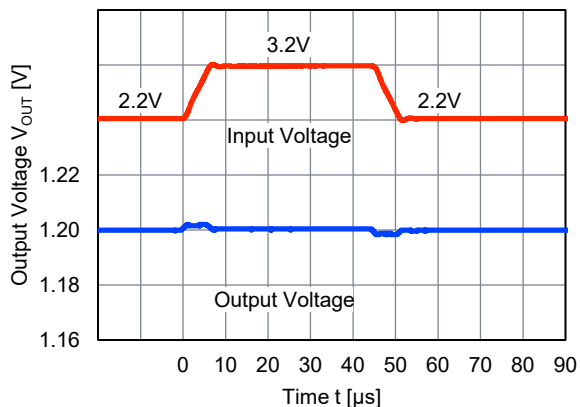
$I_{OUT} = 100$ mA

NR1641xx180x
$I_{OUT} = 1$ mA
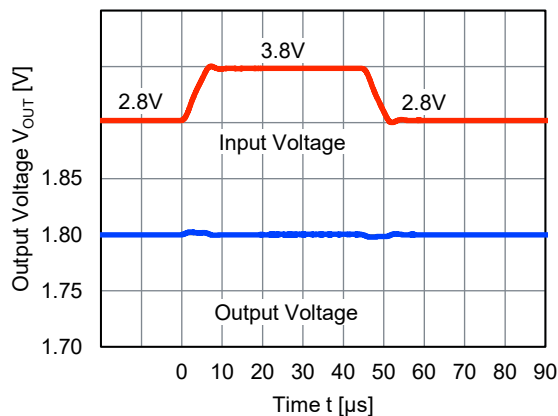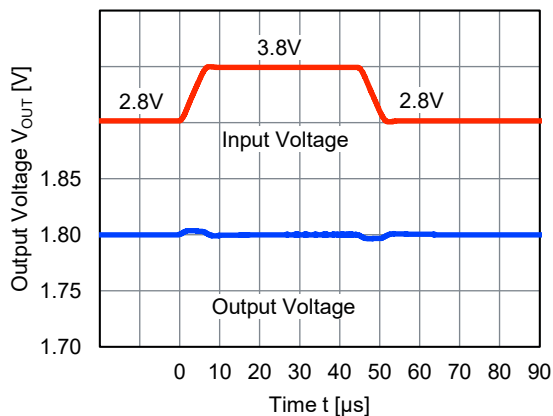
$I_{OUT} = 100$ mA

NR1641xx330x
$I_{OUT} = 1$ mA

$I_{OUT} = 100$ mA
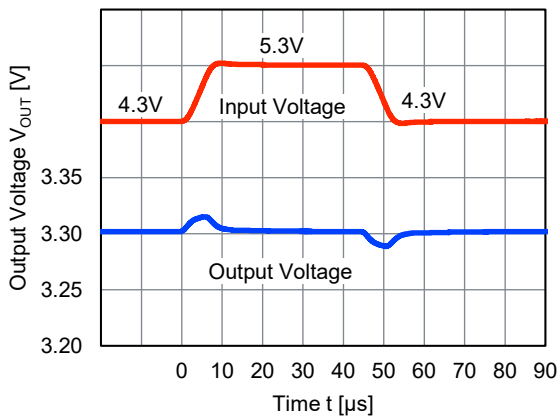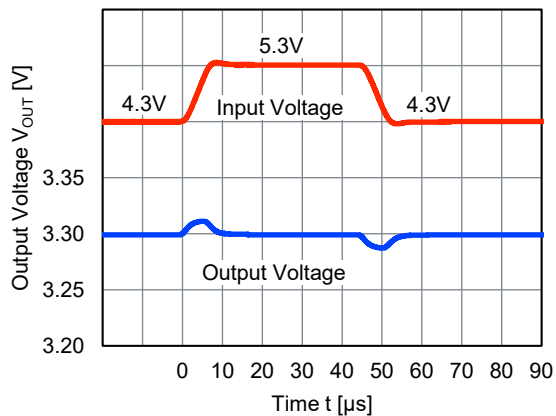
$t_R = t_F = 5$ µs, V_{MODE} = "Low"
I_{OUT} = 1 mA
NR1641xx120x
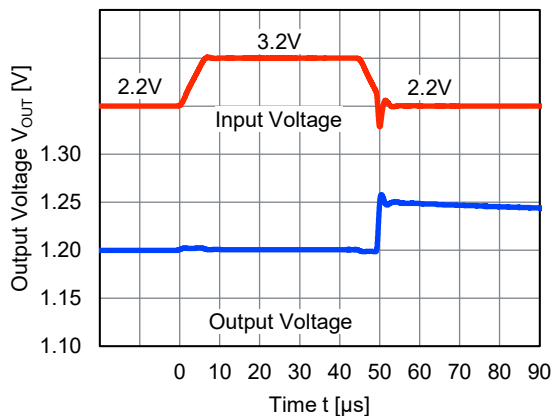
NR1641xx180x
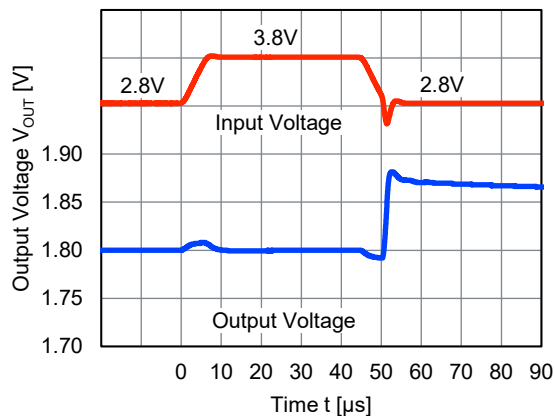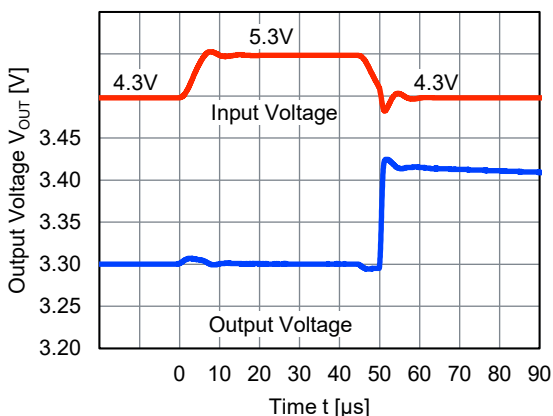
NR1641xx330x

17) Load Transient Response
$t_R = t_F = 0.5$ µs, V_{MODE} = "High"
NR1641xx120x
I_{OUT} = 1 mA ⇔ 500 mA
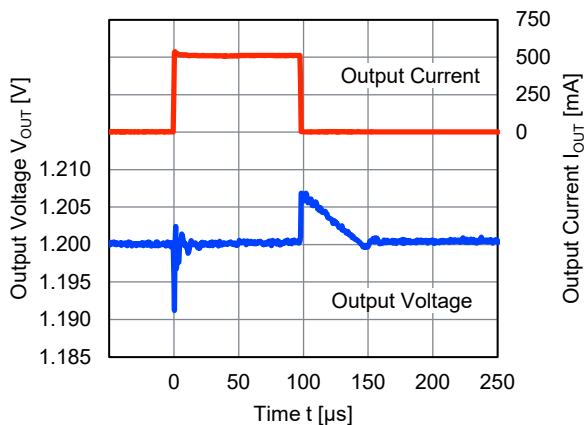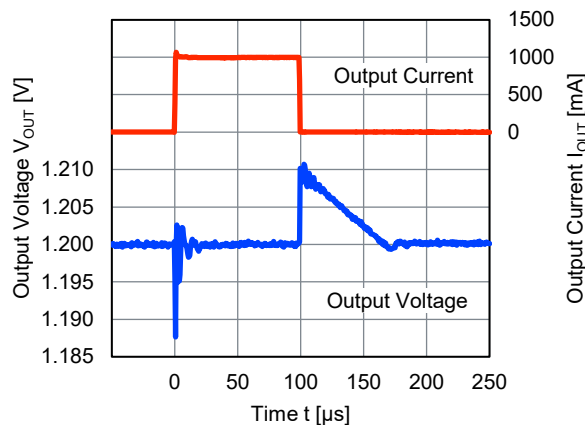
I_{OUT} = 1 mA ⇔ 1000 mA

NR1641xx180x
I_{OUT} = 1 mA ⇔ 500 mA
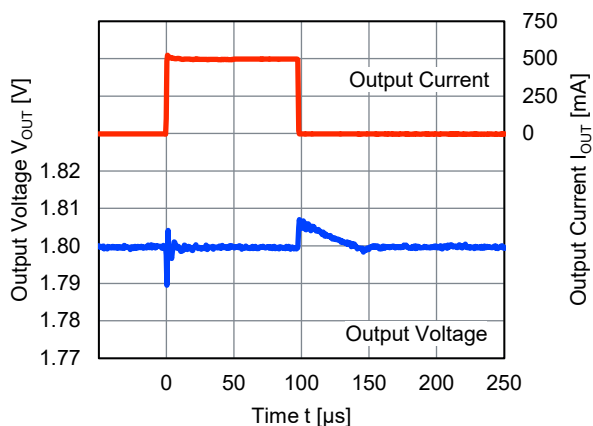
I_{OUT} = 1 mA ⇔ 1000 mA
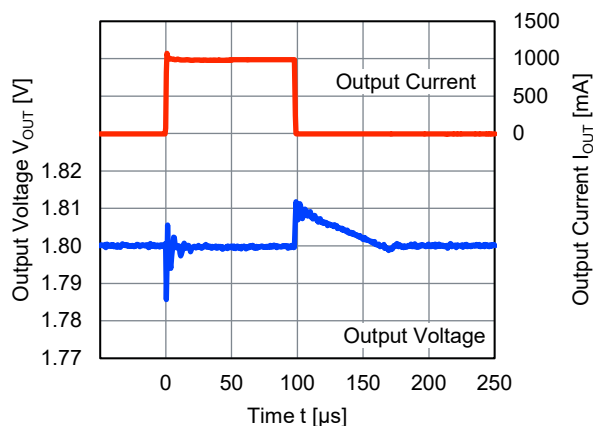
NR1641xx330x
I_{OUT} = 1 mA ⇔ 500 mA
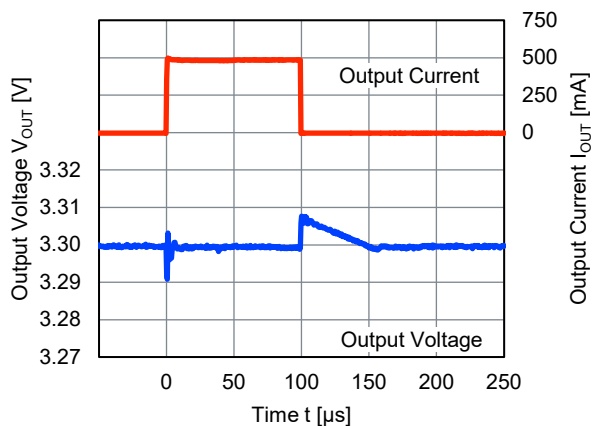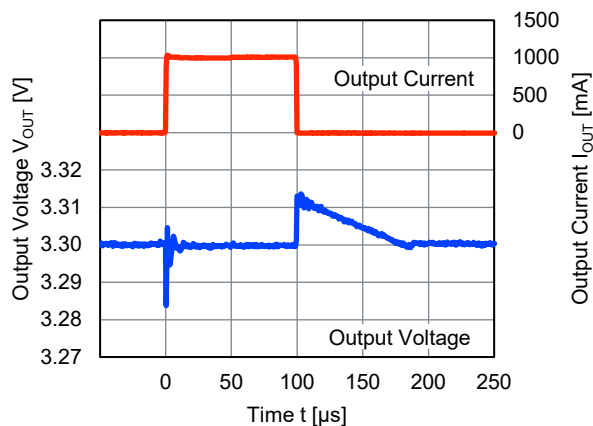
I_{OUT} = 1 mA ⇔ 1000 mA

$t_R = t_F$ = 0.5 µs, V_{MODE} = "Low"
NR1641xx120x
I_{OUT} = 1 mA ⇔ 500 mA
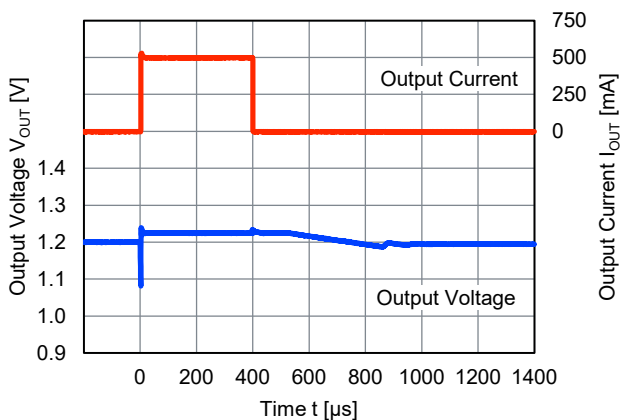
I_{OUT} = 1 mA ⇔ 1000 mA
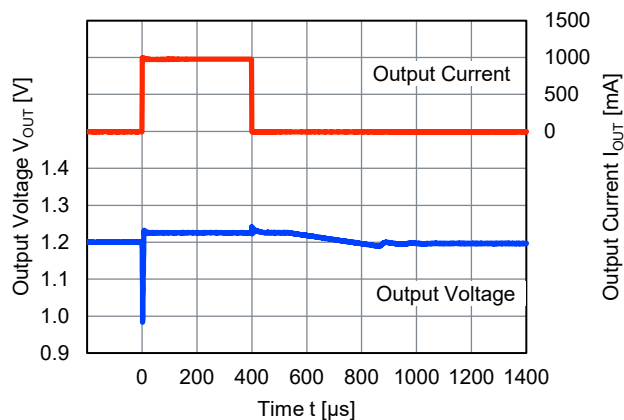
NR1641xx180x
I_{OUT} = 1 mA ⇔ 500 mA
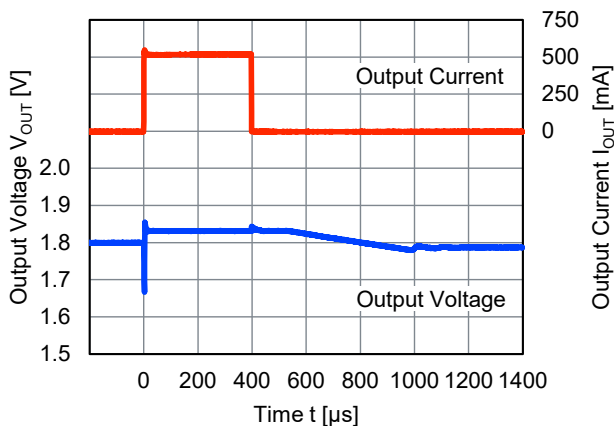
NR1641xx180x
I_{OUT} = 1 mA ⇔ 1000 mA
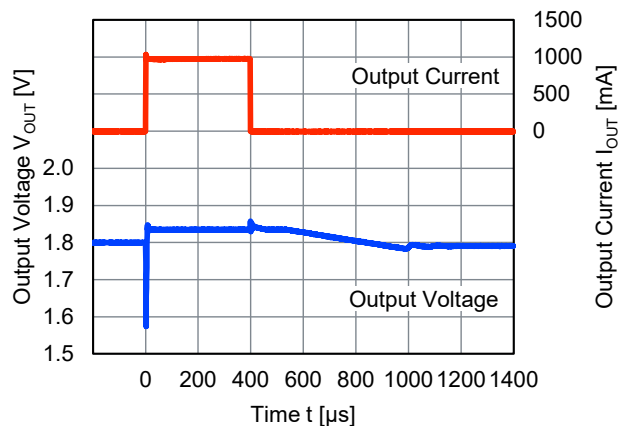
NR1641xx330x
I_{OUT} = 1 mA ⇔ 500 mA
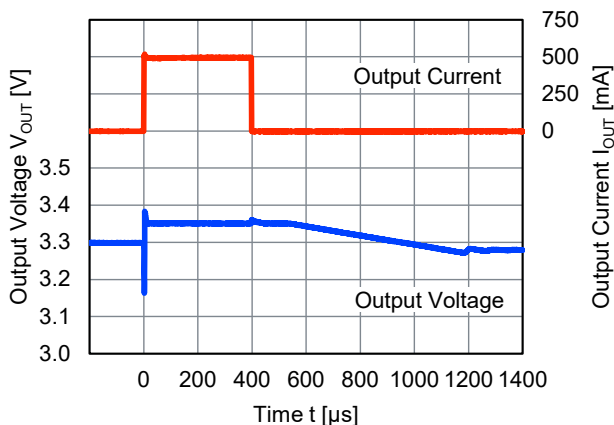
I_{OUT} = 1 mA ⇔ 1000 mA
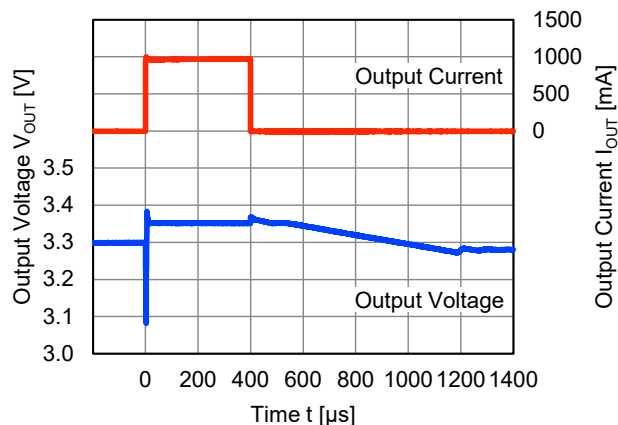
18) MODE pin Switching Transient Response

NR1641xx120x
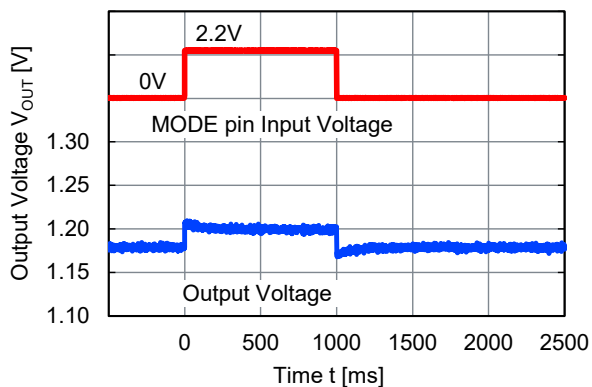
NR1641xx180x
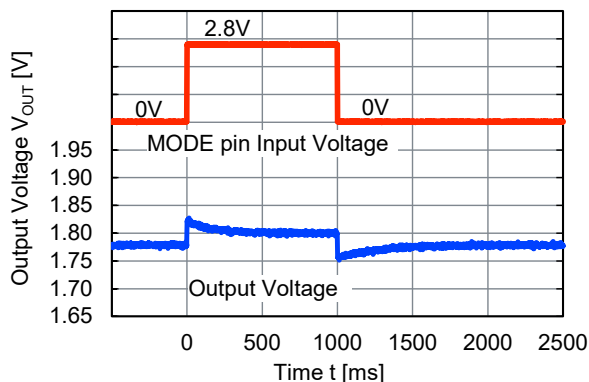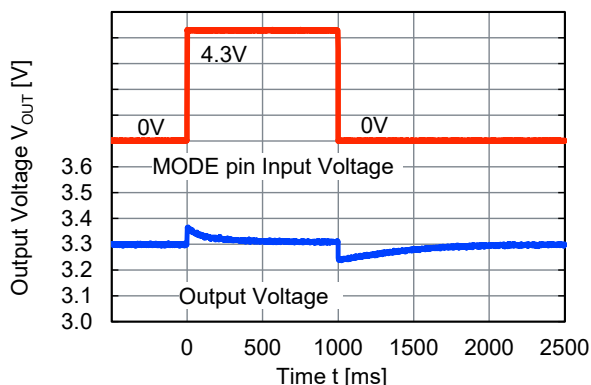
NR1641xx330x

19) Inrush Current

NR1641xx120B/D
V_{MODE} = "High"
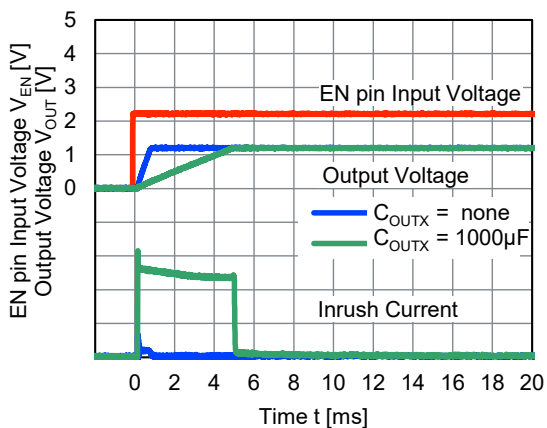
V_{MODE} = "Low"
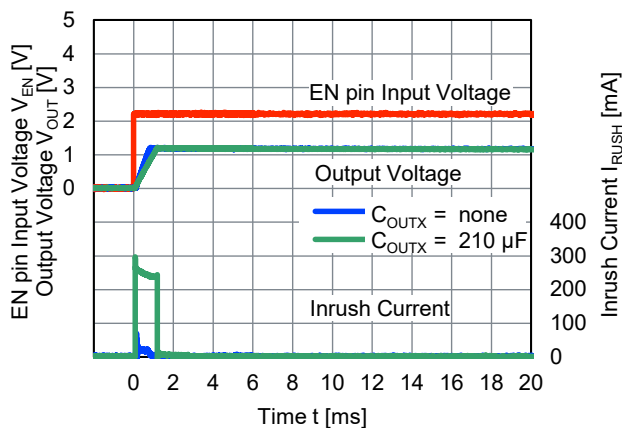
NR1641xx180B/D
V_{MODE} = "High"
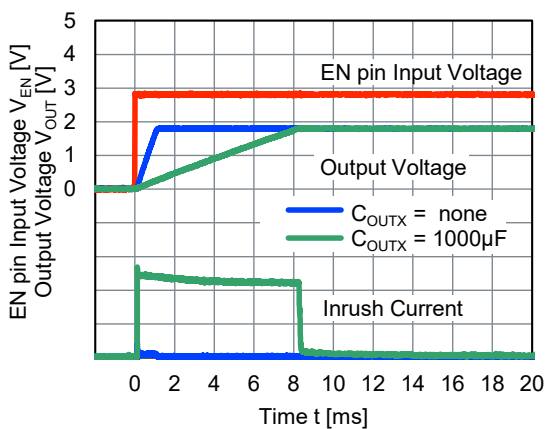
V_{MODE} = "Low"
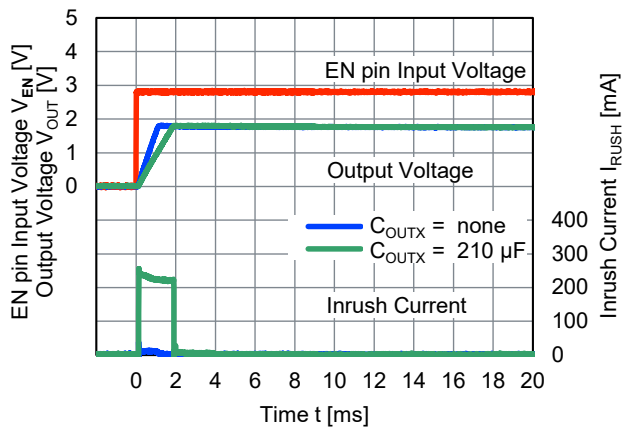
NR1641xx330A/C
V_{MODE} = "High"
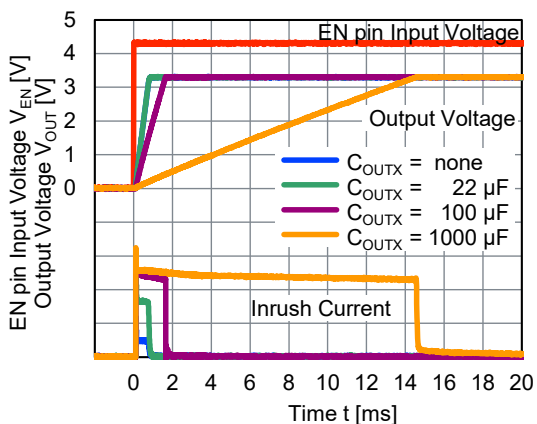
V_{MODE} = "Low"
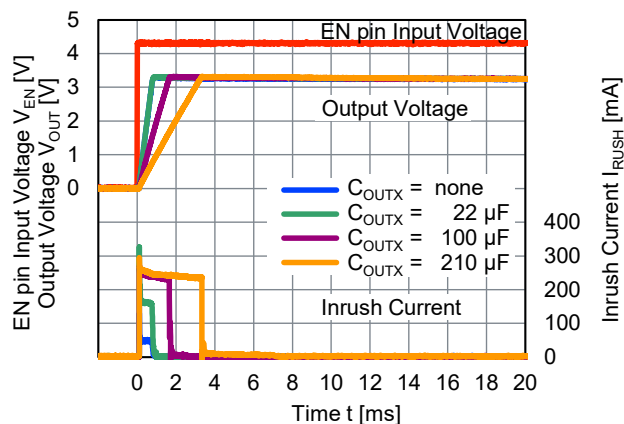
NR1641xx330B/D
V_{MODE} = "High"
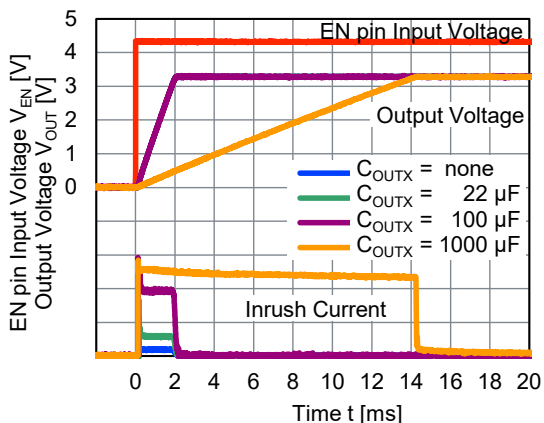
V_{MODE} = "Low"
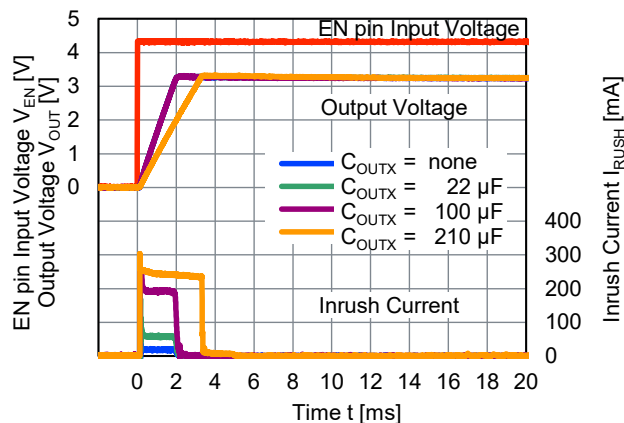
20) Soft-start time

NR1641xx330x
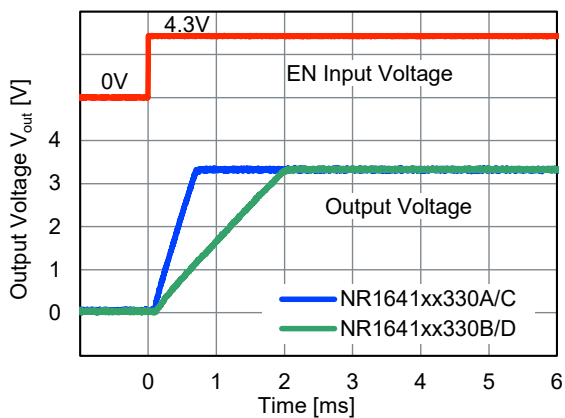
21) Turn off Speed with EN Pin

NR1641xx120A/B
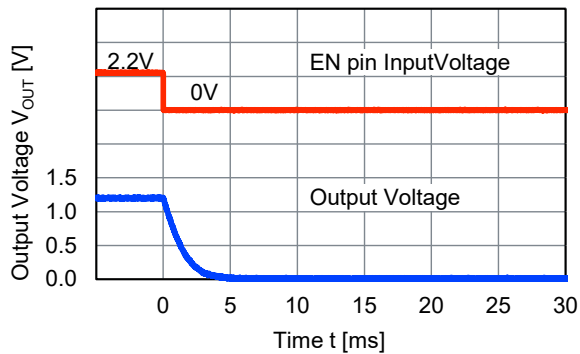
NR1641xx180A/B
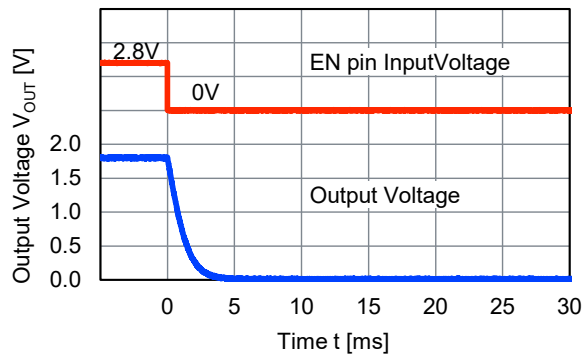
NR1641xx330A/B
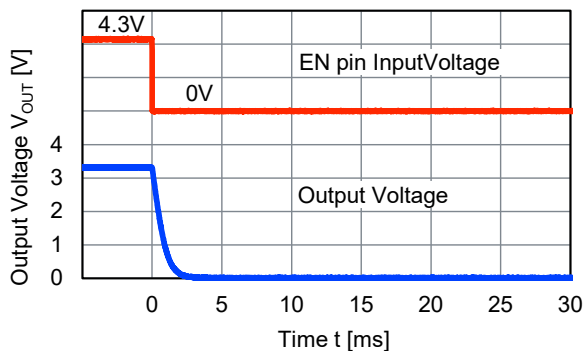
■ **TEST CIRCUIT**
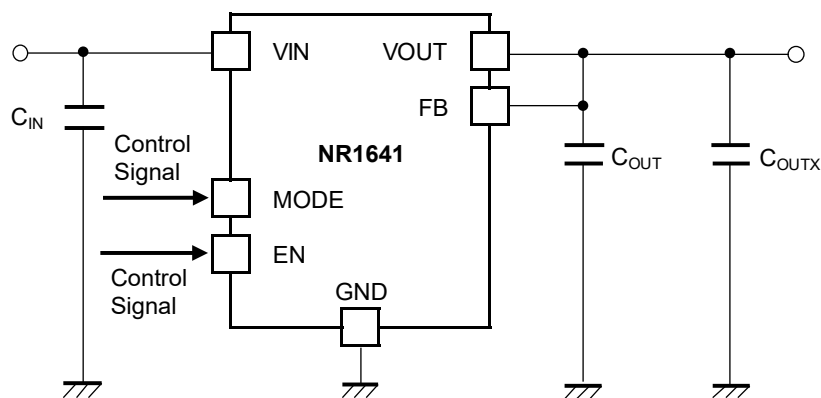
NR1641 Test Circuit

【Components List for Our Evaluation】

Symbol		Parts Number
C_{IN}	10 μF	C3216X5R1C106K
C_{OUT}	10 μF[*1]	C2012X7R1A106K125A
	10 μF[*2]	C3216X5R1C106K

[*1] Used for NR1641xx100x to 330x
[*2] Used for NR1641xx340x to 500x

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DFN1616-6-GY

■ **PACKAGE DIMENSIONS**

UNIT: mm
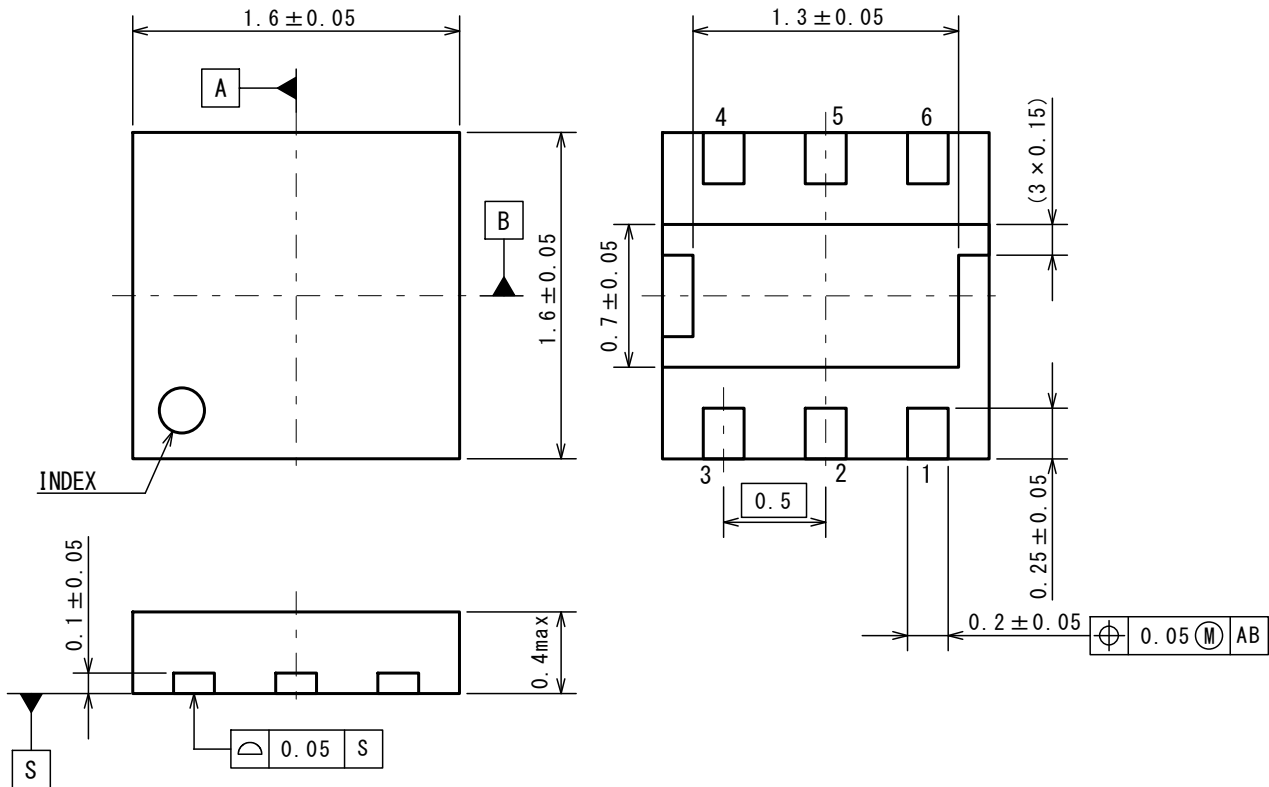
■ **EXAMPLE OF SOLDER PADS DIMENSIONS**
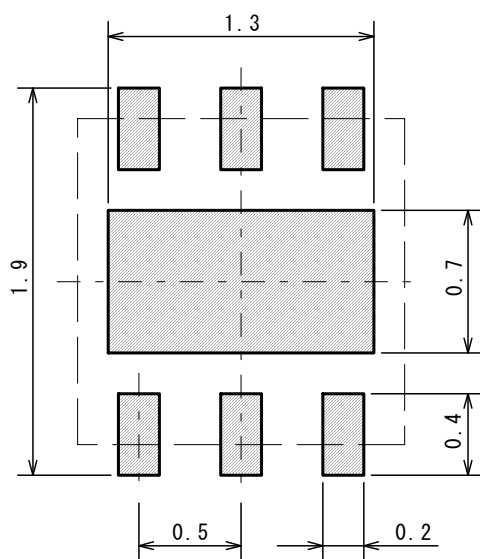
Nisshinbo Micro Devices Inc.

DFN1616-6-GY

■ **PACKING SPEC**

UNIT: mm

(1) Taping dimensions / Insert direction

Insert direction
(E4)

2.0 ± 0.05 4.0 ± 0.1 $1.5^{+0.1}_{0}$ 1.75 ± 0.1 0.2 ± 0.1

1.9 3.5 ± 0.05 8.0 ± 0.3

Carrier tape material: PS
Cover tape material: PE

1.9 4.0 ± 0.1 0.6 ± 0.1 1.0max

(2) Taping state

Feed direction

Sealing with covering tape

Trailer part	Devices	Leader part
more than 160mm	5000pcs/reel	more than 550mm

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DFN1616-6-GY   PI-DFN1616-6-GY-E-A

(3) Reel dimensions

11.4 ± 1.0

2 ± 0.5

21 ± 0.8   13 ± 0.2

60^{+1}_{0} 180^{0}_{-3}

Reel material: PS $9^{+1.0}_{-0.3}$
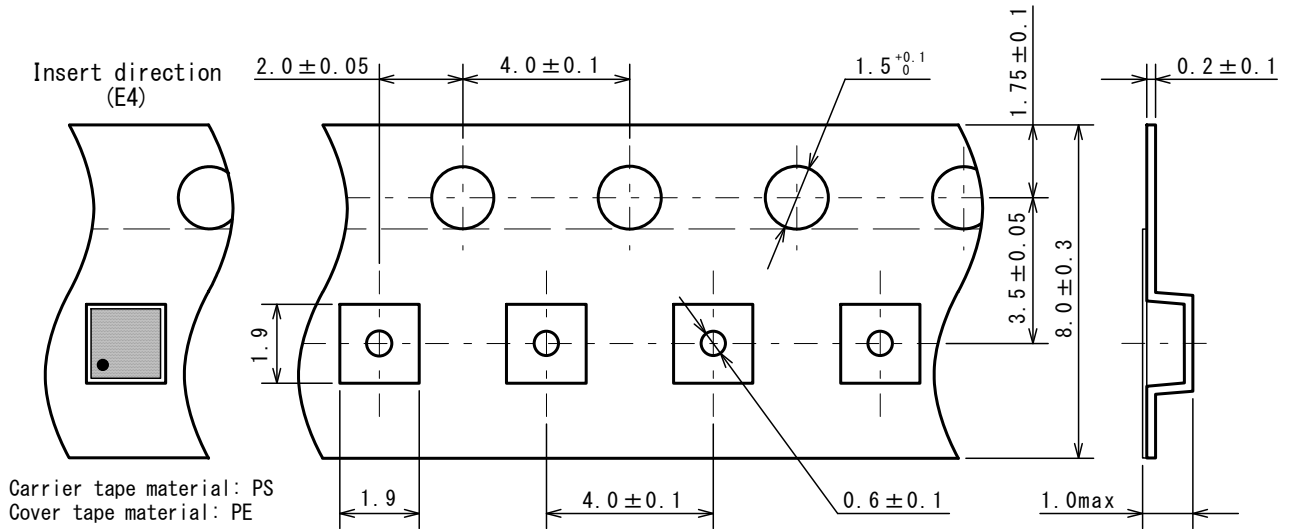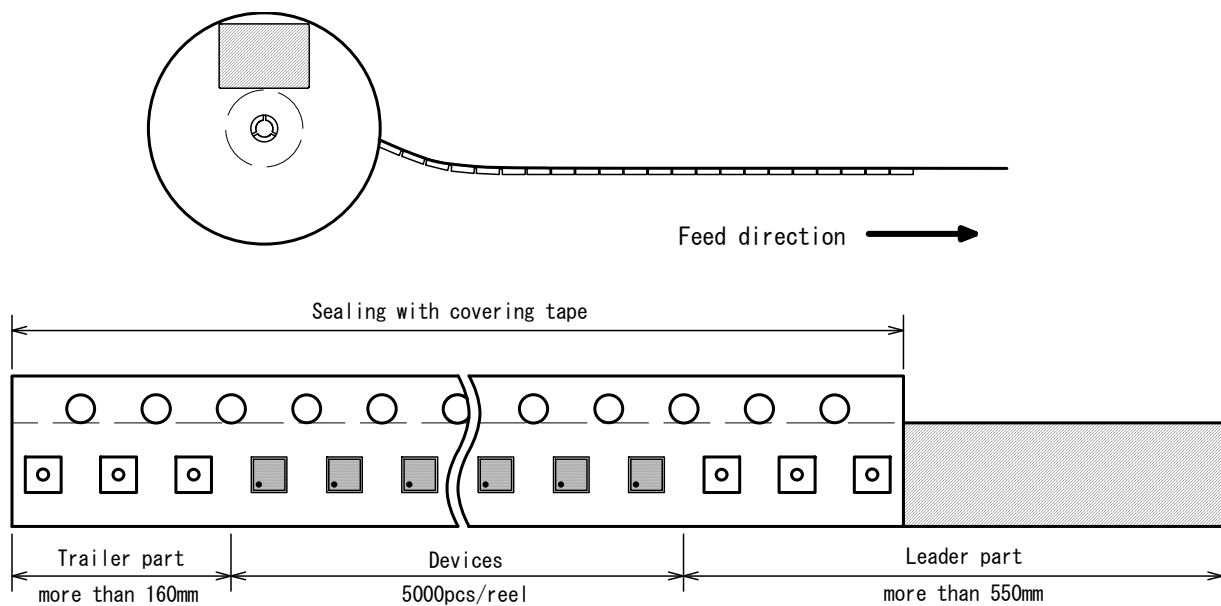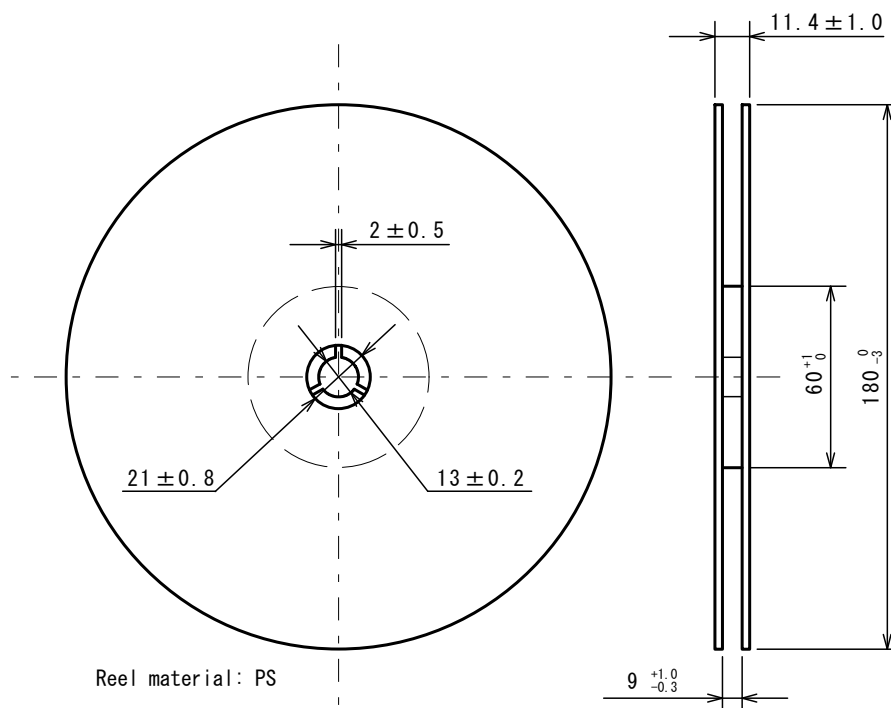
(4) Peeling strength

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

165 to 180°   Cover tape

Direction to pull

Feed direction

Carrier tape

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DFN1616-6-GY   PI-DFN1616-6-GY-E-A

(5) Packing state

〈Label〉 Prodcut name, Quantity, Lot No, Mark

1 reel

Box size : 185×185×20

MAX: 5reel

Box size : 185×185×80
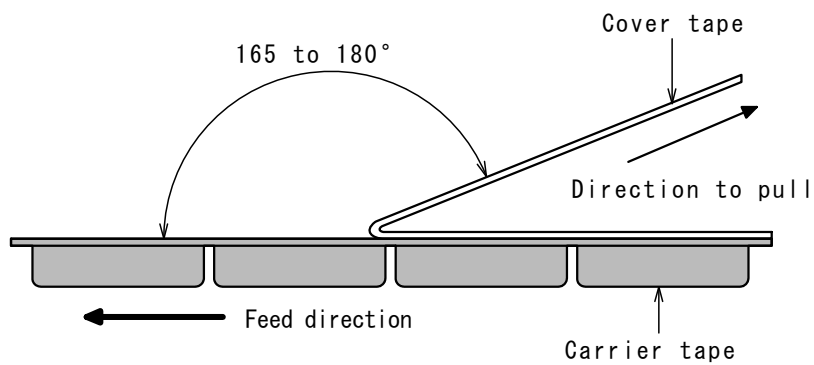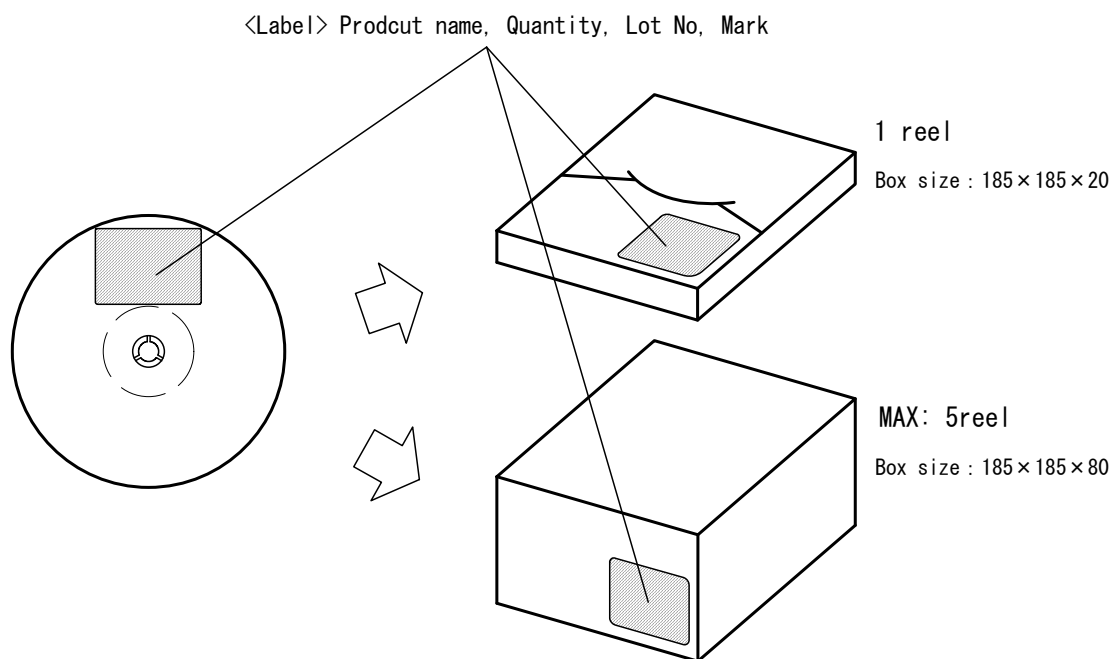
■ **HEAT-RESISTANCE PROFILES**

Package Surface Temperature(℃)

260℃

255℃

3℃/s MAX.

30s MAX.

217℃

6℃/s MAX.

200℃

150℃

60-150s

60-120s

Time(s)

Reflow profile

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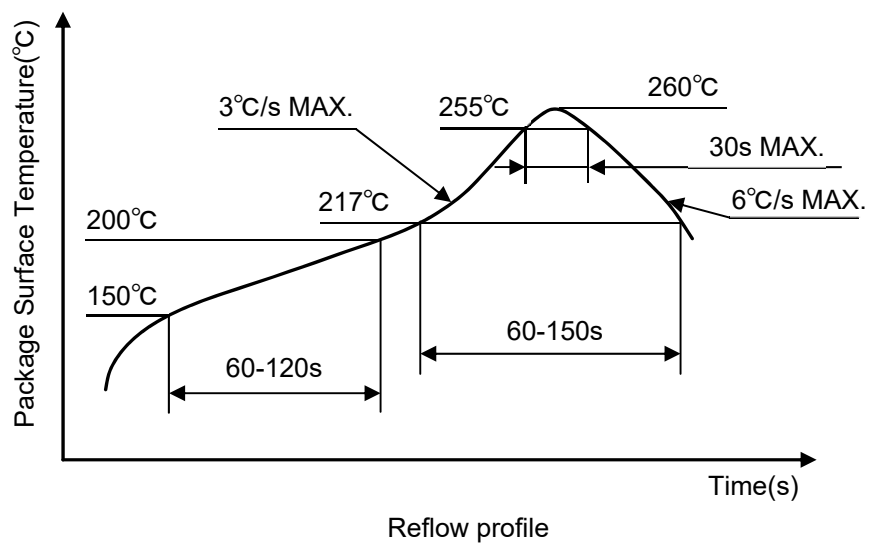
■ **REVISION HISTORY**

Date	Version	Contents of Changes
March 14, 2023	1.0	Initial release

May 11, 2023	1.1	・THERMAL CHARACTERISTICS (DFN1616-6-GY)
		 Through-holes φ 0.2 mm × 15 pcs
		  → φ 0.2 mm × 25 pcs
		・TYPICAL CHARACTERISTICS
		 14) Repple Rejection vs Input Voltage
		  → Ripple Rejection vs Input Voltage

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