LDO with Reverse Current Protection / Soft Start / Discharge Function

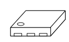
■ GENERAL DESCRIPTION

The NJM12877 is a low dropout regulator which achieves high ripple rejection, low noise and high speed response with the bipolar technology.

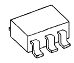
Adjustable soft-start function is useful for reducing inrush current and controlling power-on sequence. Moreover the discharge function makes effective sequence control with the soft-start function.

In addition, the reverse current protection makes external SBD unnecessary.

■ PACKAGE OUTLINE



NJM12877KG1

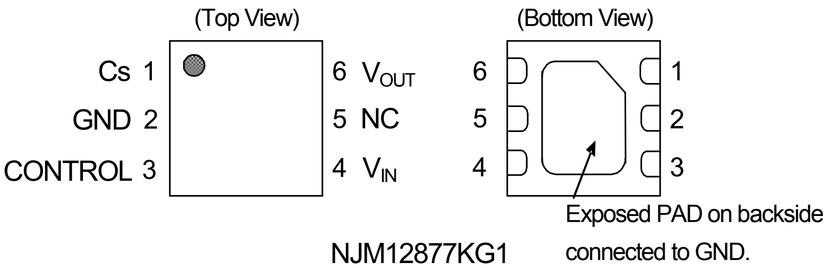


NJM12877F

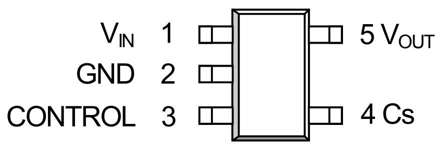
■ FEATURES

- Operating Voltage Range 2.3V to 6.5V
- Output Voltage Accuracy V_O ±1.0%
- Output Current I_O(min.)=200mA
- Reverse Current Protection
- Adjustable soft-start Function
- Discharge Function
- ON/OFF Control
- Correspond to Low ESR capacitor (MLCC)
- Thermal Shutdown Circuit
- Over Current Protection Circuit
- Package Outline DFN6-G1(ESON6-G1), SOT-23-5

■ PIN CONFIGRATION

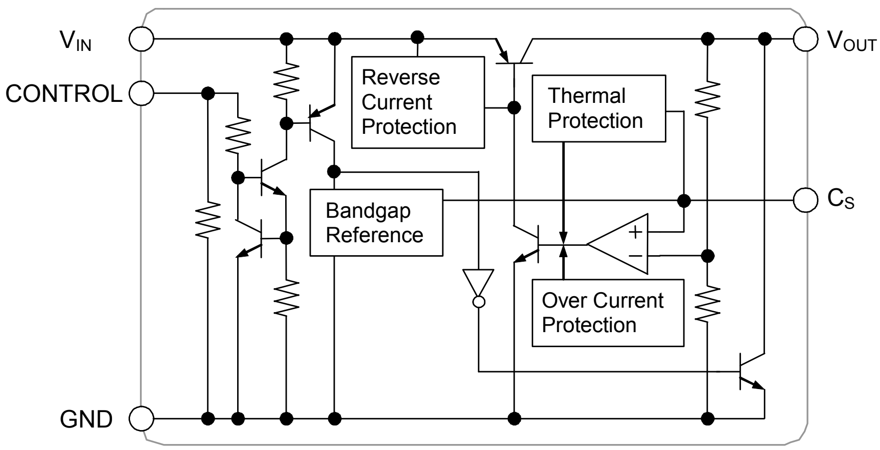


NJM12877KG1



NJM12877F

■ BLOCK DIAGRAM



■ OUTPUT VOLTAGE RANK LIST

DFN6-G1(ESON6-G1) SOT-23-5

Device Name	Output Voltage	Device Name	Output Voltage
NJM12877KG1-15	1.5V	NJM12877F15	1.5V
NJM12877KG1-18	1.8V	NJM12877F18	1.8V
NJM12877KG1-25	2.5V	NJM12877F25	2.5V
NJM12877KG1-33	3.3V	NJM12877F33	3.3V
NJM12877KG1-05	5.0V	NJM12877F05	5.0V

■ ABSOLUTE MAXIMUM RATINGS (Ta=25°C)

PARAMETER	SYMBOL	MAXIMUM RATING		UNIT
Input Voltage	V_{IN}	-0.3 ~ +7		V
Control Pin Voltage	V_{CONT}	-0.3 ~ +7		V
Output Voltage	V_{OUT}	Vo≤1.8V	-0.3 ~ +5.5	V
		Vo>1.8V	-0.3 ~ +7	V
Soft start Pin Voltage	V_{CS}	-0.3 ~ +4		V
Power Dissipation	P_D	ESON6-G1	420(*1)	mW
			1200(*2)	
		SOT-23-5	480(*3)	
			650(*4)	
Junction Temperature Range	Tj	-40 ~ +150		°C
Operating Temperature Range	Topr	-40 ~ +125		°C
Storage Temperature Range	Tstg	-50 ~ +150		°C

(*1): Mounted on glass epoxy board. (101.5×114.5×1.6mm: based on EIA/JEDEC standard, 2Layers FR-4, with Exposed Pad)

(*2): Mounted on glass epoxy board. (101.5×114.5×1.6mm: based on EIA/JEDEC standard, 4Layers FR-4, with Exposed Pad)

(For 4Layers: Applying 99.5×99.5mm inner Cu area and a thermal via hole to a board based on JEDEC standard JESD51-5)

(*3): Mounted on glass epoxy board. (76.2 × 114.3 × 1.6mm:based on EIA/JDEC standard, 2Layers)

(*4): Mounted on glass epoxy board. (76.2 × 114.3 × 1.6mm:based on EIA/JDEC standard, 4Layers), internal Cu area: 74.2x74.2mm

■ Operating Voltage Range : V_{IN}=2.3V ~ 6.5V

■ ELECTRICAL CHARACTERISTICS

Unless other noted,

V_{IN} = V_O + 1V, C_{IN} = 0.1µF, C_O =0.1µF :4.4V<Vo≤5.0V, C_O = 0.22µF :2.9V<Vo≤4.4V, C_O = 0.47µF :2.3V<Vo≤2.9V , C_O = 1.0µF :Vo≤2.3V Cs=0.01µF, T_a = 25°C)

PARAMETER	SYMBOL	TEST CONDITION		MIN.	TYP.	MAX.	UNIT
Output Voltage	V_O	I_O=30mA		-1.0%	-	+1.0%	V
Quiescent Current	I_Q	I_O = 0mA, except I_{CONT}		-	160	210	µA
Quiescent Current at OFF-state	$I_{Q(OFF)}$	V_{CONT} = 0V		-	-	10	µA
Output Current	I_O	$V_O \times 0.9$		200	-	-	mA
Line Regulation	$\Delta V_O/\Delta V_{IN}$	V_{IN} = V_O + 1V ~ 6.5V, Io=30mA		-	-	0.1	%/V
Load Regulation	$\Delta V_O/\Delta I_O$	I_O = 0 ~ 200mA	Vo=1.5V	-	-	0.018	%/mA
			Vo=1.8V		-	0.016	
			Vo=2.5V		-	0.014	
			Vo=3.3V		-	0.012	
			Vo=5.0V		-	0.010	
Dropout Voltage (*5)	ΔV_{IO}	I_O = 100mA		-	0.12	0.2	V
Average Temperature Coefficient of Output Voltage	$\Delta V_O/\Delta Ta$	Ta = -40 ~ +125°C, I_O=30mA		-	± 50	-	ppm/°C
Ripple Rejection	RR	ein=200mVrms, f=1kHz, Io=10mA	Vo=1.5V	-	70	-	dB
			Vo=1.8V	-	69	-	
			Vo=2.5V	-	66	-	
			Vo=3.3V	-	64	-	
			Vo=5.0V	-	60	-	
Output Noise Voltage	V_{NO}	f=10Hz ~ 80kHz, Io=10mA	Vo=1.5V	-	19	-	µVrms
			Vo=1.8V	-	24	-	
			Vo=2.5V	-	29	-	
			Vo=3.3V	-	33	-	
			Vo=5.0V	-	42	-	
Control Current	I_{CONT}	V_{CONT} =1.6V		-	3	12	µA
Control Voltage at ON-state	$V_{CONT(ON)}$			1.6	-	-	V
Control Voltage at OFF-state	$V_{CONT(OFF)}$			-	-	0.6	V
Soft Start Time	$t_{S(ON)}$	V_{CONT}=L→H, Io=30mA, Cs=0.022µF		-	1.2	-	msec
Discharge Current at OFF-state	I_{DIS}	V_{IN}=2.3V, V_{CONT}=0V, V_O =0.5V		2	9	-	mA
		V_{IN}=6.5V, V_{CONT}=0V, V_O =0.5V		15	25	-	

(*5): Except Output Voltage Rank less than 2.1V

The above specification is a common specification for all output voltages.

Therefore, it may be different from the individual specification for a specific output voltage.

■ THERMAL CHARACTERISTICS

PARAMETER	SYMBOL	VALUE		UNIT
Junction-to-ambient thermal resistance	θja	DFN6-G1 (ESON6-G1)	298 (*6) 104 (*7)	°C/W
		SOT-23-5	260 (*8) 192 (*9)	
Junction-to-Top of package characterization parameter	ψjt	DFN6-G1 (ESON6-G1)	52 (*6) 26 (*7)	°C/W
		SOT-23-5	70 (*8) 60 (*9)	

(*6): Mounted on glass epoxy board. (101.5×114.5×1.6mm: based on EIA/JEDEC standard, 2Layers FR-4, with Exposed Pad)

(*7): Mounted on glass epoxy board. (101.5×114.5×1.6mm: based on EIA/JEDEC standard, 4Layers FR-4, with Exposed Pad)

(For 4Layers: Applying 99.5×99.5mm inner Cu area and a thermal via hole to a board based on JEDEC standard JESD51-5)

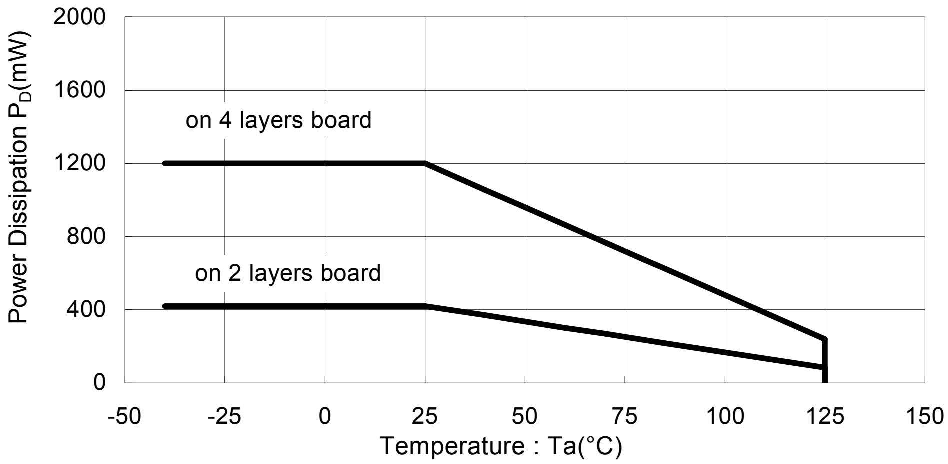
(*8): Mounted on glass epoxy board. (76.2 × 114.3 × 1.6mm:based on EIA/JDEC standard, 2Layers)

(*9): Mounted on glass epoxy board. (76.2 × 114.3 × 1.6mm:based on EIA/JDEC standard, 4Layers), internal Cu area: 74.2x74.2mm

■ POWER DISSIPATION vs. AMBIENT TEMPERATURE

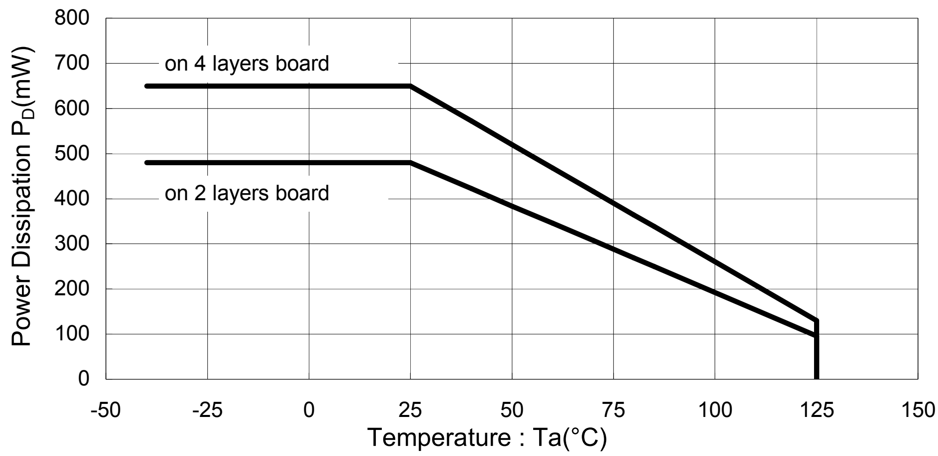
NJM12877KG1 Power Dissipation

(Topr= -40~+125°C, Tj=150°C)

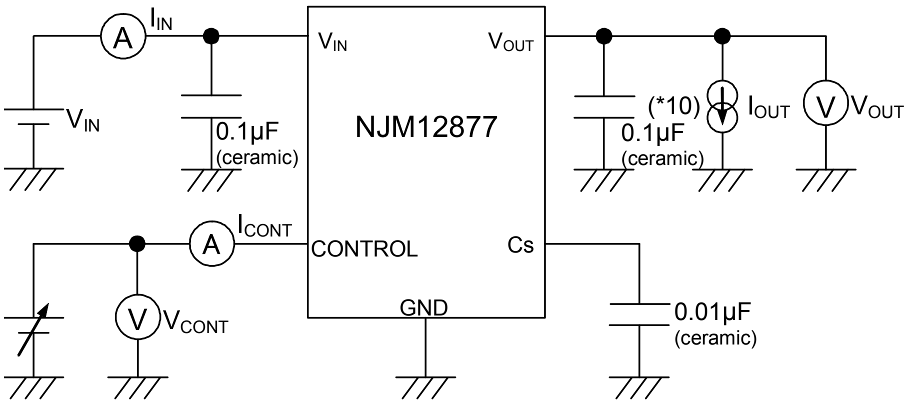


NJM12877F PowerDissipation

(Topr=-40~+125°C,Tj=150°C)



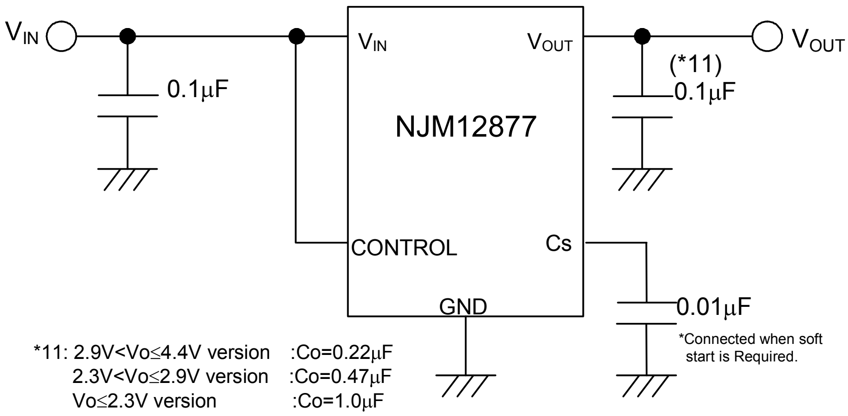
■ TEST CIRCUIT



*10: 2.9V<Vo≤4.4V version :Co=0.22µF(Ceramic)
2.3V<Vo≤2.9V version :Co=0.47µF(Ceramic)
Vo≤2.3V version :Co=1.0µF(Ceramic)

■ TYPICAL APPLICATION

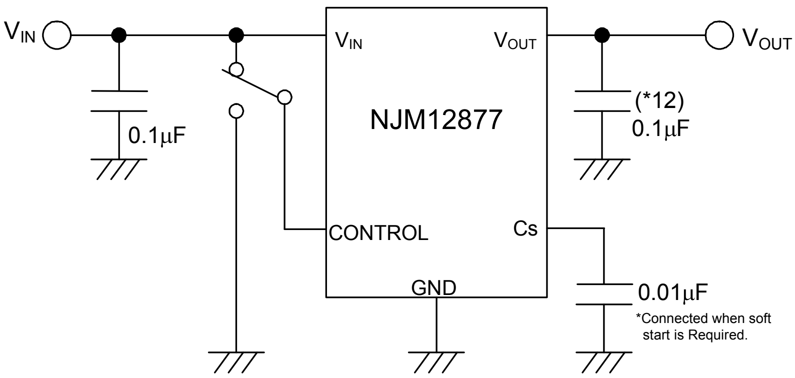
1. In the case where ON/OFF Control is not required



*11: 2.9V<Vo≤4.4V version :Co=0.22µF
2.3V<Vo≤2.9V version :Co=0.47µF
Vo≤2.3V version :Co=1.0µF

Connect CONTROL pin to V_{IN} pin

2. In use of ON/OFF CONTROL



*12: 2.9V<Vo≤4.4V version :Co=0.22µF
2.3V<Vo≤2.9V version :Co=0.47µF
Vo≤2.3Vversion :Co=1.0µF

State of CONTROL pin:
"H" → output is enabled.
"L" or "open" → output is disabled

*Reverse Current Protection

The NJM12877 has built-in Reverse Current Protection circuit.
This circuit prevents the large reverse current when output voltage is higher than input voltage.
Therefore external schottky-barrier diode(SBD) is not required.

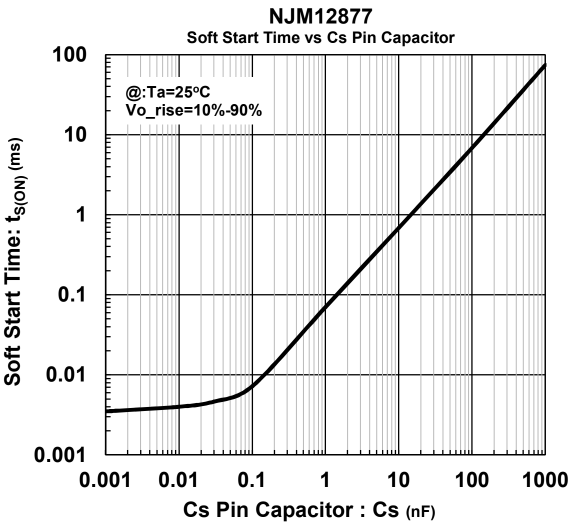
*Soft Start capacitor Cs

The Soft Start function can control the rise time of Output Voltage and reduce the inrush current by connecting the Cs capacitor.

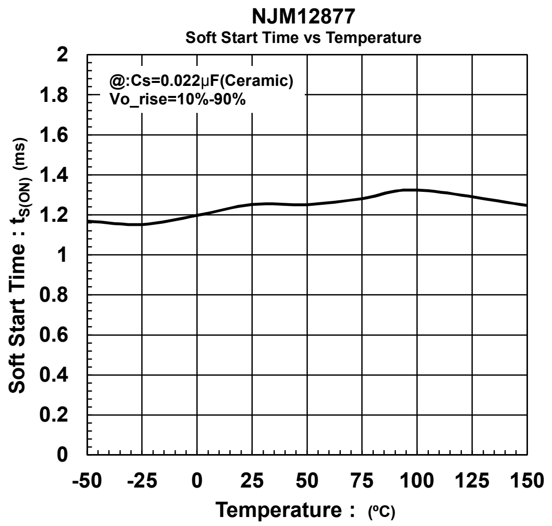
The Soft Start time is defined as 10% to 90% of the Output Voltage.

The Cs capacitor is not essential, but it used for noise bypass of bandgap reference either. Therefore Output Noise Voltage increases when the capacitor isn't connected.

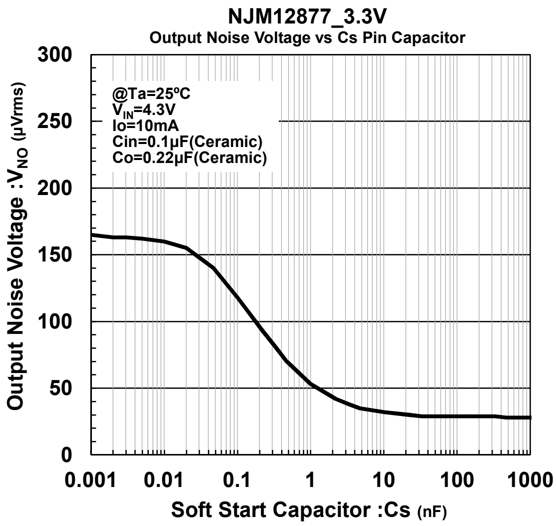
If the Cs capacitor is not used, the Cs pin should be OPEN.



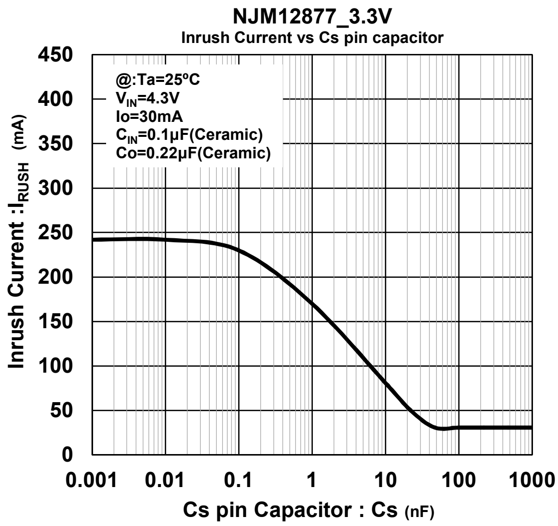
Soft-Start Time vs. Cs Pin Capacitor



Soft-Start Time (0.022µF) vs. Temperature



Output Noise Voltage vs. Cs Pin Capacitor

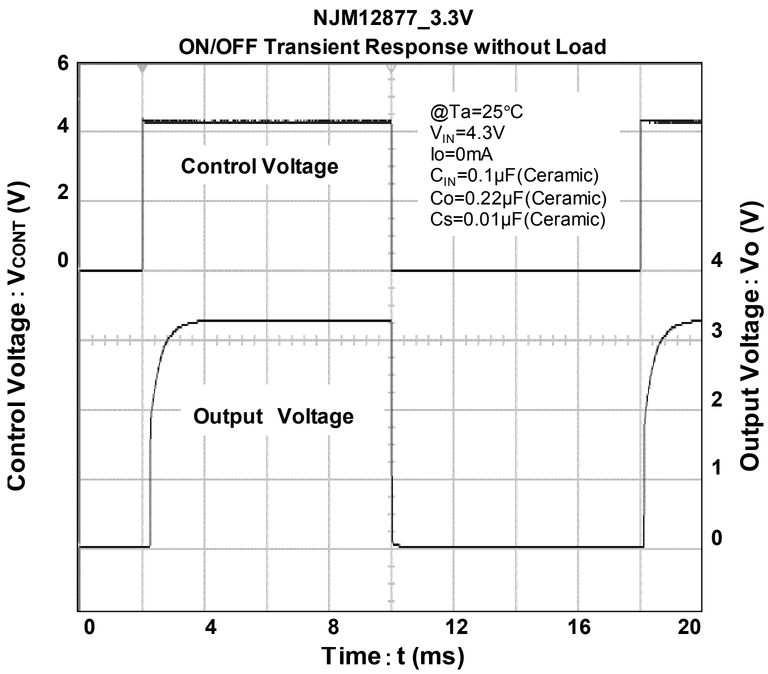


Inrush Current vs. Cs Pin Capacitor

*Discharge Function

The NJM12877 has a built-in discharge circuit to discharge the charged output capacitors.

Discharge circuit operates when the CONTROL pin is set in LOW level. The circuit discharges the charged output capacitors rapidly.



Output Voltage sweep down characteristics by Discharge function

*Transient response characteristic of Output Voltage

In general, overshoot or undershoot of output voltage may occur due to the transient response characteristic of an internal error amplifier.

Especially, low current consumption regulator may have overshoot or undershoot due to slow feedback caused by current saving design.

Therefore, design validation is important in the following cases:

1. Input voltage or output current change sharply
2. Output capacitors is small
3. Output load is light
4. A regulator starts up with very low dropout voltage operation.

Increasing the value of input and/or output capacitor is a common countermeasure for improving a transient response characteristic.

A transient response characteristic may vary with operating conditions and external components value.

Please check it with the actual environment.

*Input Capacitor C_{IN}

The input capacitor C_{IN} is required to prevent oscillation and reduce power supply ripple for applications when high power supply impedance or a long power supply line.

Therefore, use the recommended C_{IN} value (refer to conditions of ELECTRIC CHARACTERISTIC) or larger and should connect between GND and V_{IN} as shortest path as possible to avoid the problem.

*Output Capacitor C_O

The output capacitor C_O will be required for a phase compensation of the internal error amplifier.

The capacitance and the equivalent series resistance (ESR) influence to stable operation of the regulator.

Use of a smaller C_O may cause excess an output noise or an oscillation of the regulator due to lack of the phase compensation.

On the other hand, use of a larger C_O reduces an output noise and a ripple output, and also improves an output transient response when a load rapidly changes.

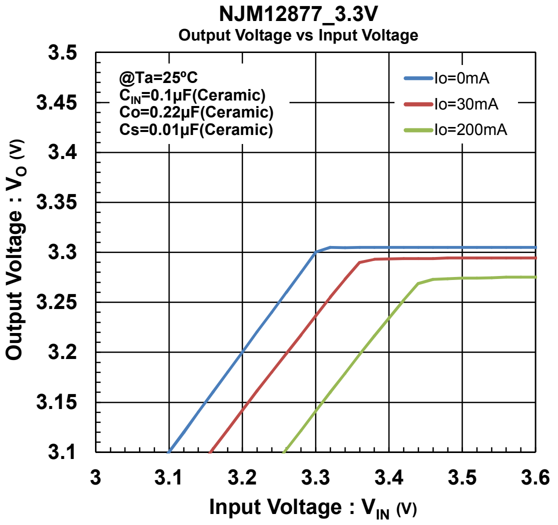
Therefore, use the recommended C_O value (refer to conditions of ELECTRIC CHARACTERISTIC) or larger and should connect between GND and V_{OUT} as shortest path as possible for stable operation

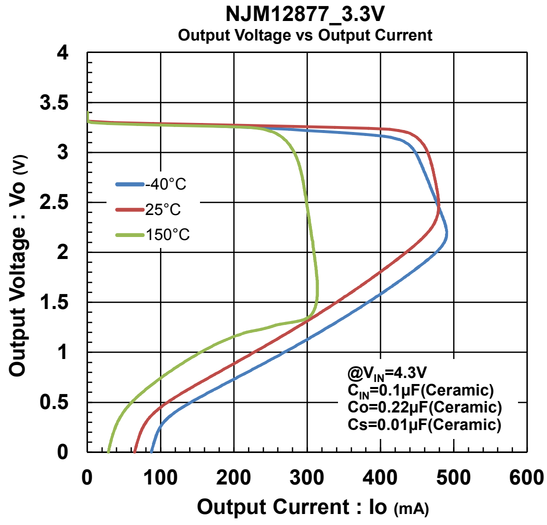
The recommended capacitance depends on the output voltage rank. Especially, a low voltage regulator requires larger C_O value.

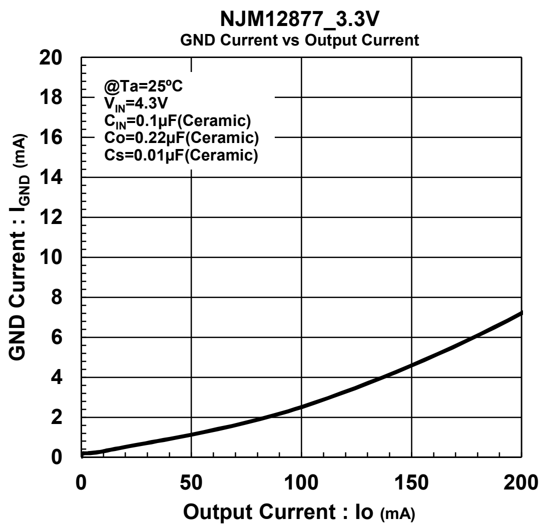
In addition, you should consider varied characteristics of capacitor (a frequency characteristic, a temperature characteristic, a DC bias characteristic and so on) and unevenness peculiar to a capacitor supplier enough.

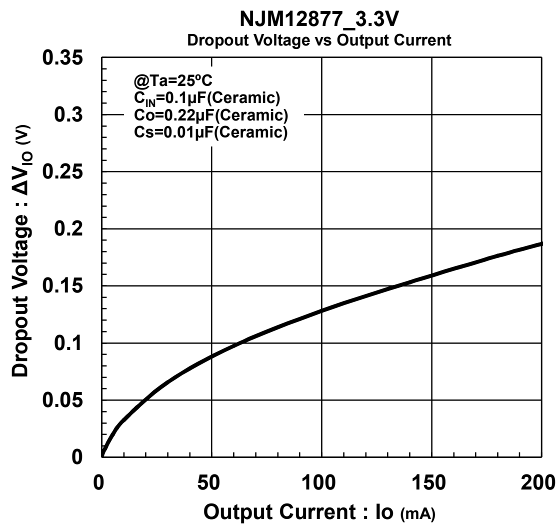
When selecting $C_{O,}$ recommend that have withstand voltage margin against an output voltage and superior temperature characteristics though this product is designed stability works with wide range ESR of capacitor including low ESR products.

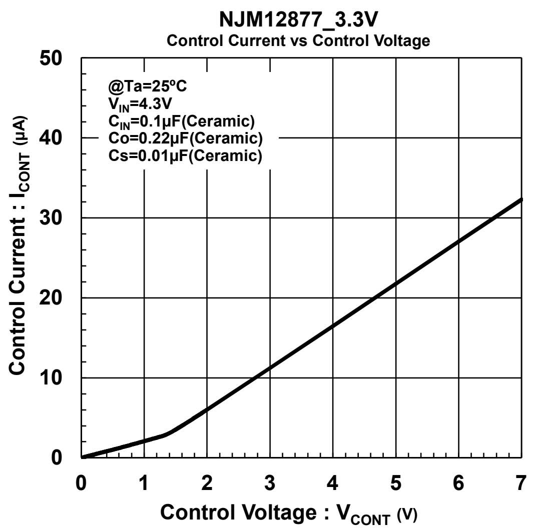
■ TYPICAL CHARACTERISTICS

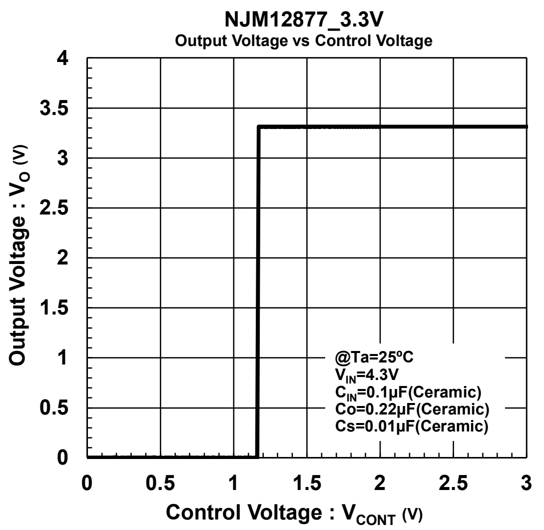


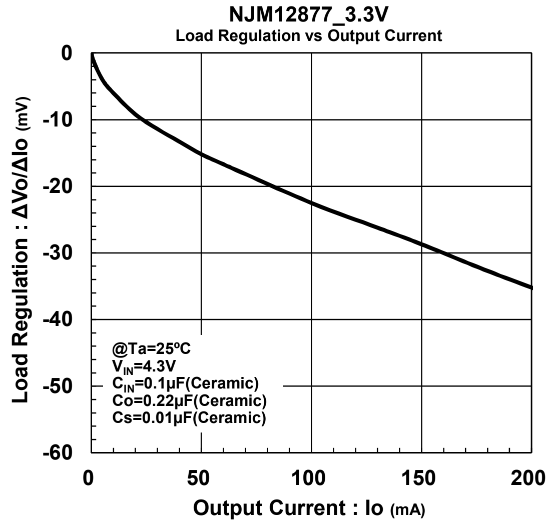


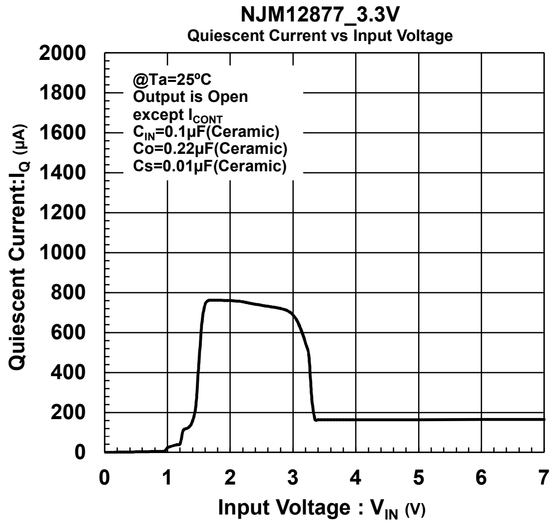


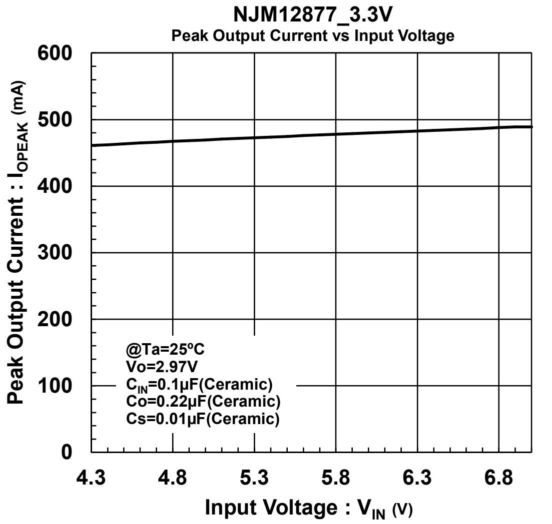


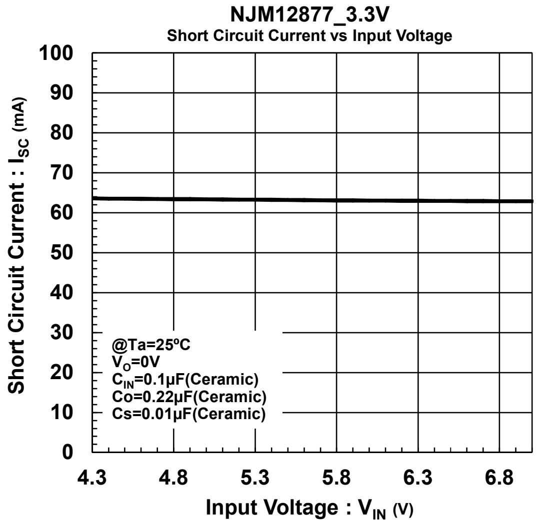


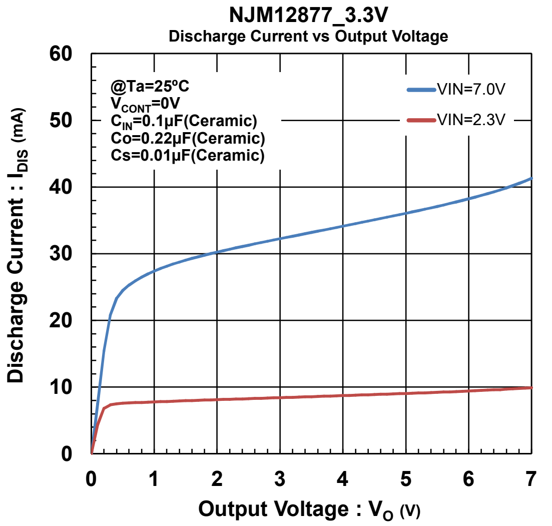


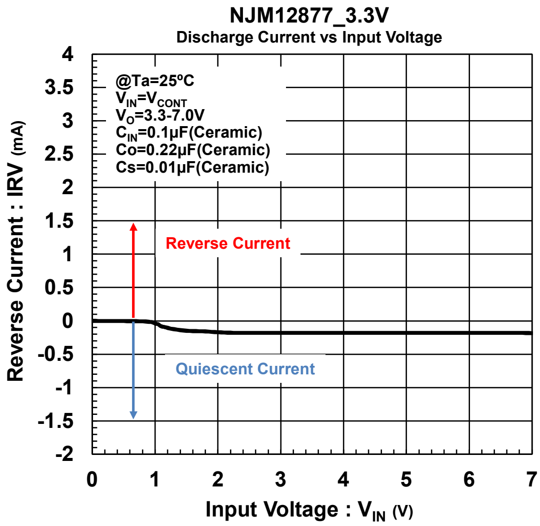

NJM12877_3.3V
Load Regulation vs Output Current
@Ta=25ºC
VIN=4.3V
CIN=0.1µF(Ceramic)
Co=0.22µF(Ceramic)
Cs=0.01µF(Ceramic)
Load Regulation : ΔVo/ΔIo (mV)
Output Current : Io (mA)

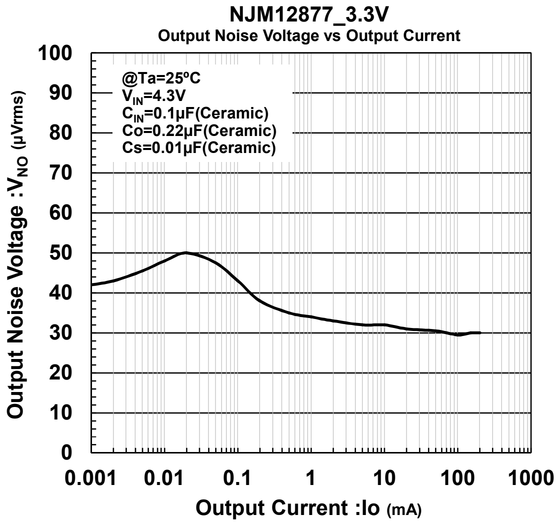

NJM12877_3.3V
Quiescent Current vs Input Voltage
@Ta=25ºC
Output is Open
except ICONT
CIN=0.1µF(Ceramic)
Co=0.22µF(Ceramic)
Cs=0.01µF(Ceramic)
Quiescent Current:IQ (µA)
Input Voltage : VIN (V)

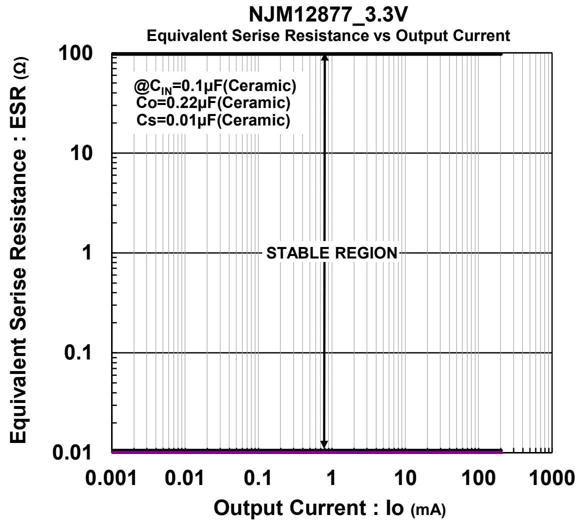

NJM12877_3.3V
Peak Output Current vs Input Voltage
@Ta=25ºC
Vo=2.97V
CIN=0.1µF(Ceramic)
Co=0.22µF(Ceramic)
Cs=0.01µF(Ceramic)
Peak Output Current : IOPEAK (mA)
Input Voltage : VIN (V)

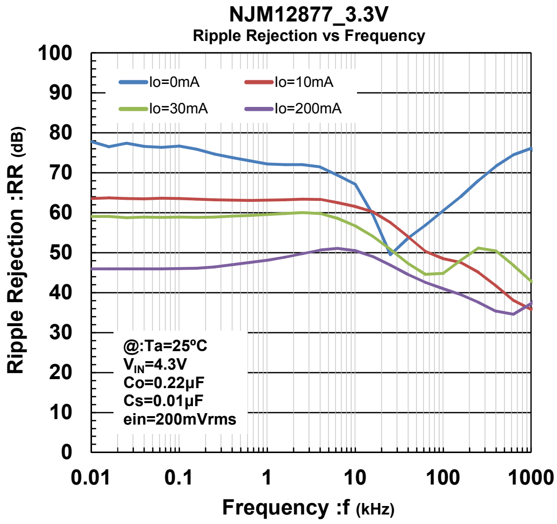

NJM12877_3.3V
Short Circuit Current vs Input Voltage
@Ta=25ºC
VO=0V
CIN=0.1µF(Ceramic)
Co=0.22µF(Ceramic)
Cs=0.01µF(Ceramic)
Short Circuit Current : ISC (mA)
Input Voltage : VIN (V)

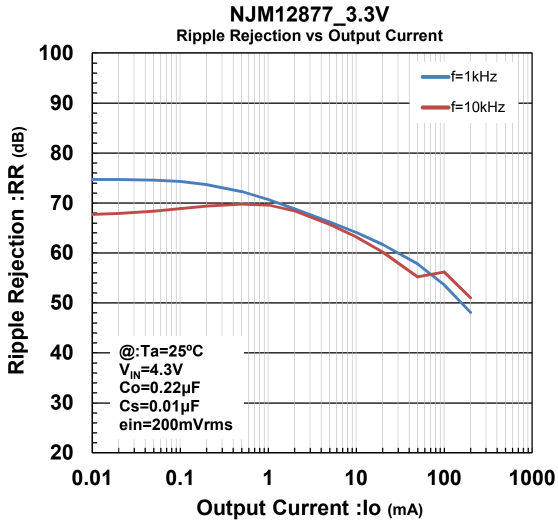

NJM12877_3.3V
Discharge Current vs Output Voltage
@Ta=25ºC
VCONT=0V
CIN=0.1µF(Ceramic)
Co=0.22µF(Ceramic)
Cs=0.01µF(Ceramic)
VIN=7.0V
VIN=2.3V
Discharge Current : IDIS (mA)
Output Voltage : VO (V)

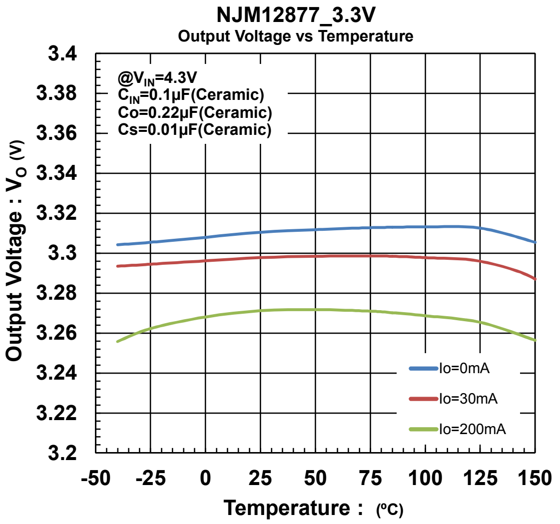

NJM12877_3.3V
Discharge Current vs Input Voltage
@Ta=25ºC
VIN=VCONT
VO=3.3-7.0V
CIN=0.1µF(Ceramic)
Co=0.22µF(Ceramic)
Cs=0.01µF(Ceramic)
Reverse Current
Quiescent Current
Reverse Current : IRV (mA)
Input Voltage : VIN (V)

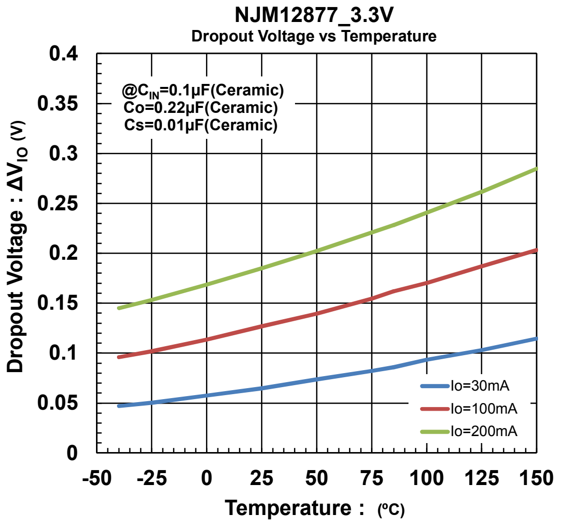

NJM12877_3.3V
Output Noise Voltage vs Output Current
@Ta=25ºC
VIN=4.3V
CIN=0.1µF(Ceramic)
Co=0.22µF(Ceramic)
Cs=0.01µF(Ceramic)
Output Noise Voltage :VNO (µVrms)
Output Current :Io (mA)

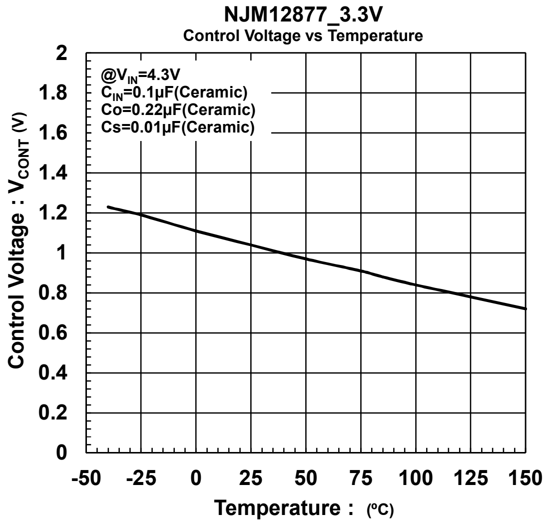

NJM12877_3.3V
Equivalent Serise Resistance vs Output Current
@CIN=0.1µF(Ceramic)
Co=0.22µF(Ceramic)
Cs=0.01µF(Ceramic)
STABLE REGION
Equivalent Serise Resistance : ESR (Ω)
Output Current : Io (mA)

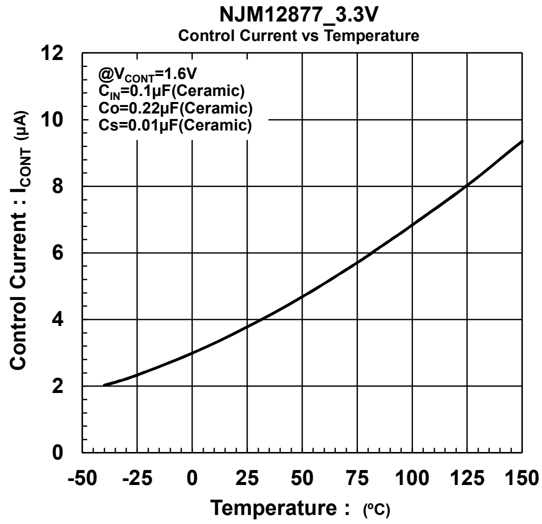

NJM12877_3.3V
Ripple Rejection vs Frequency
Io=0mA
Io=10mA
Io=30mA
Io=200mA
@:Ta=25ºC
VIN=4.3V
Co=0.22µF
Cs=0.01µF
ein=200mVrms
Ripple Rejection :RR (dB)
Frequency :f (kHz)

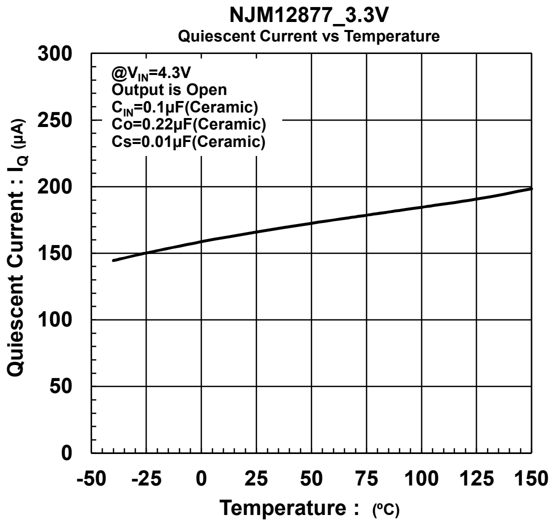

NJM12877_3.3V
Ripple Rejection vs Output Current
f=1kHz
f=10kHz
@:Ta=25ºC
VIN=4.3V
Co=0.22µF
Cs=0.01µF
ein=200mVrms
Ripple Rejection :RR (dB)
Output Current :Io (mA)

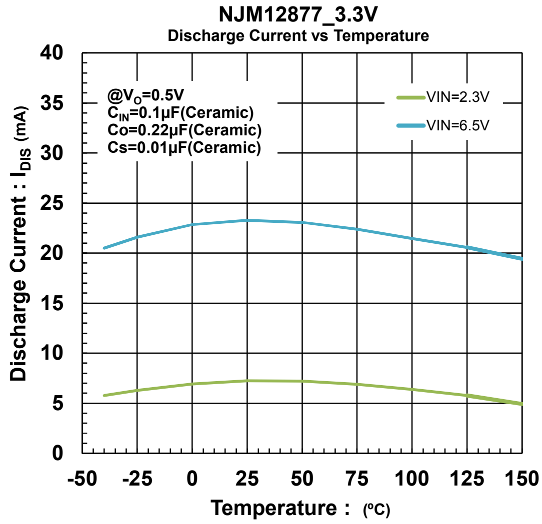

NJM12877_3.3V
Output Voltage vs Temperature
@VIN=4.3V
CIN=0.1µF(Ceramic)
Co=0.22µF(Ceramic)
Cs=0.01µF(Ceramic)
Io=0mA
Io=30mA
Io=200mA
Output Voltage : VO (V)
Temperature : (ºC)

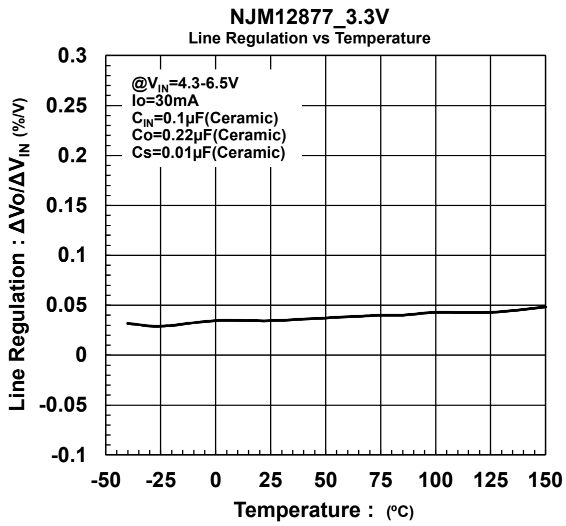

NJM12877_3.3V
Dropout Voltage vs Temperature
@CIN=0.1µF(Ceramic)
Co=0.22µF(Ceramic)
Cs=0.01µF(Ceramic)
Io=30mA
Io=100mA
Io=200mA
Dropout Voltage : ΔVIO (V)
Temperature : (ºC)

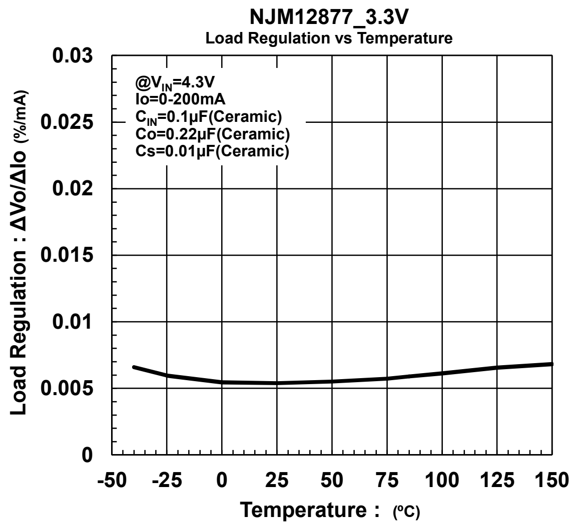

NJM12877_3.3V
Control Voltage vs Temperature
@VIN=4.3V
CIN=0.1μF(Ceramic)
Co=0.22μF(Ceramic)
Cs=0.01μF(Ceramic)
Control Voltage : VCONT (V)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-50 -25 0 25 50 75 100 125 150
Temperature : (ºC)

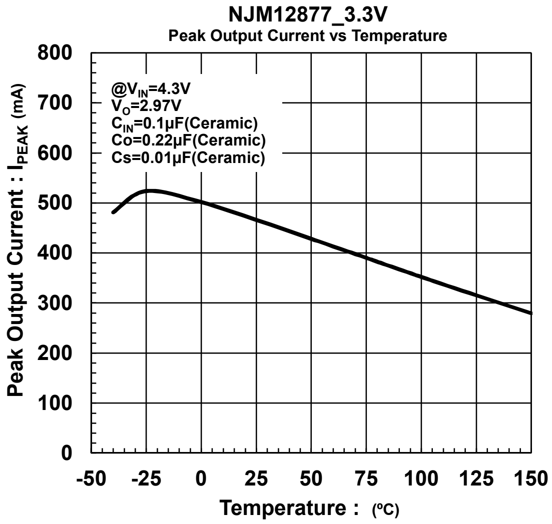

NJM12877_3.3V
Control Current vs Temperature
@VCONT=1.6V
CIN=0.1μF(Ceramic)
Co=0.22μF(Ceramic)
Cs=0.01μF(Ceramic)
Control Current : ICONT (μA)
12
10
8
6
4
2
0
-50 -25 0 25 50 75 100 125 150
Temperature : (ºC)

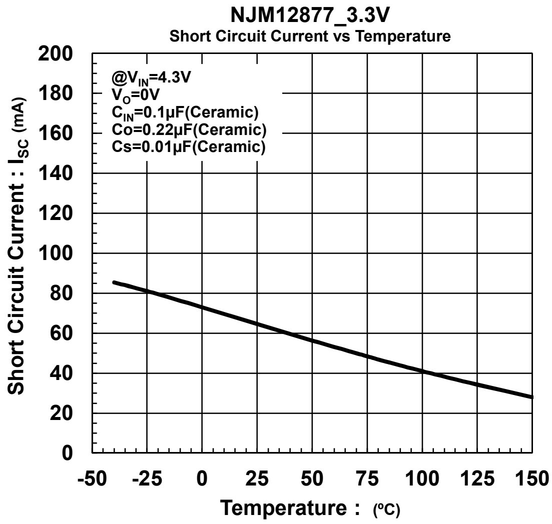

NJM12877_3.3V
Quiescent Current vs Temperature
@VIN=4.3V
Output is Open
CIN=0.1μF(Ceramic)
Co=0.22μF(Ceramic)
Cs=0.01μF(Ceramic)
Quiescent Current : IQ (μA)
300
250
200
150
100
50
0
-50 -25 0 25 50 75 100 125 150
Temperature : (ºC)

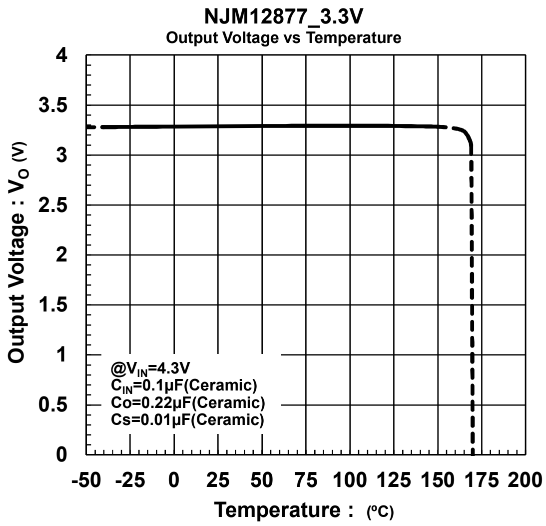

NJM12877_3.3V
Discharge Current vs Temperature
@VO=0.5V
CIN=0.1μF(Ceramic)
Co=0.22μF(Ceramic)
Cs=0.01μF(Ceramic)
VIN=2.3V
VIN=6.5V
Discharge Current : IDIS (mA)
40
35
30
25
20
15
10
5
0
-50 -25 0 25 50 75 100 125 150
Temperature : (ºC)

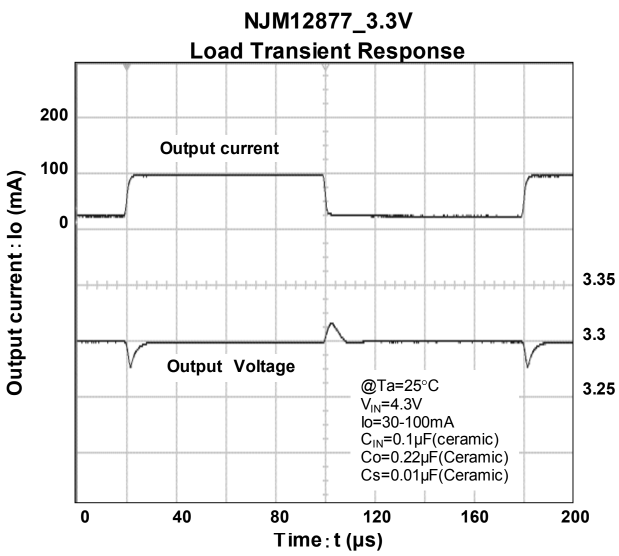

NJM12877_3.3V
Line Regulation vs Temperature
@VIN=4.3-6.5V
Io=30mA
CIN=0.1μF(Ceramic)
Co=0.22μF(Ceramic)
Cs=0.01μF(Ceramic)
Line Regulation : ΔVo/ΔVIN (%/V)
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-50 -25 0 25 50 75 100 125 150
Temperature : (ºC)

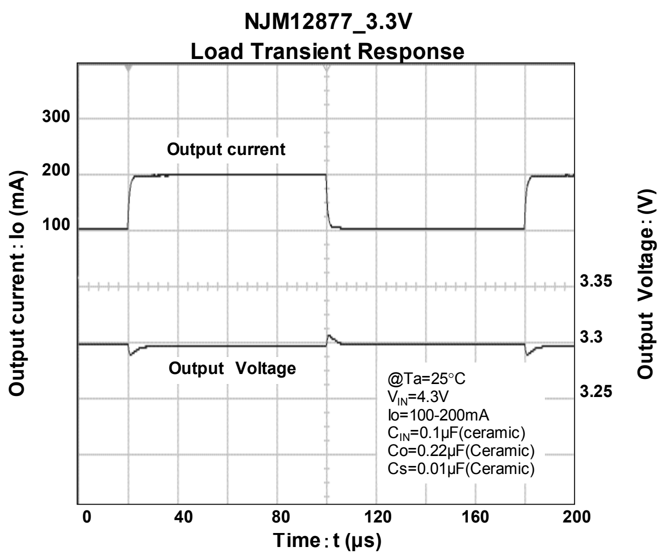

NJM12877_3.3V
Load Regulation vs Temperature
@VIN=4.3V
Io=0-200mA
CIN=0.1μF(Ceramic)
Co=0.22μF(Ceramic)
Cs=0.01μF(Ceramic)
Load Regulation : ΔVo/ΔIo (%/mA)
0.03
0.025
0.02
0.015
0.01
0.005
0
-50 -25 0 25 50 75 100 125 150
Temperature : (ºC)

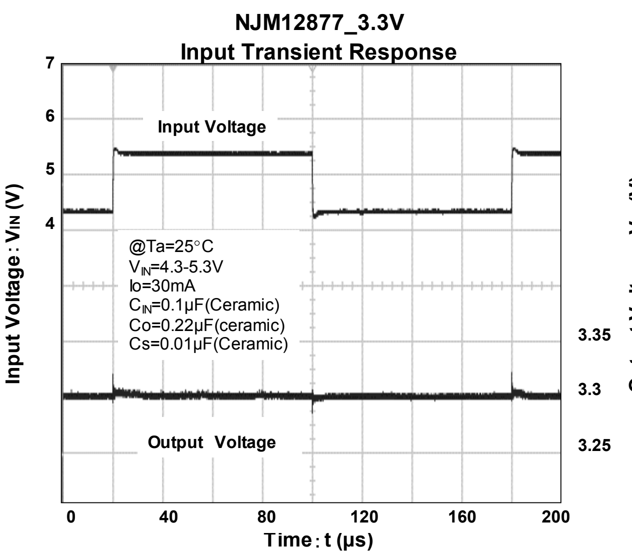

NJM12877_3.3V
Peak Output Current vs Temperature
@VIN=4.3V
VO=2.97V
CIN=0.1µF(Ceramic)
Co=0.22µF(Ceramic)
Cs=0.01µF(Ceramic)
Peak Output Current : IPEAK (mA)
800
700
600
500
400
300
200
100
0
-50 -25 0 25 50 75 100 125 150
Temperature : (ºC)

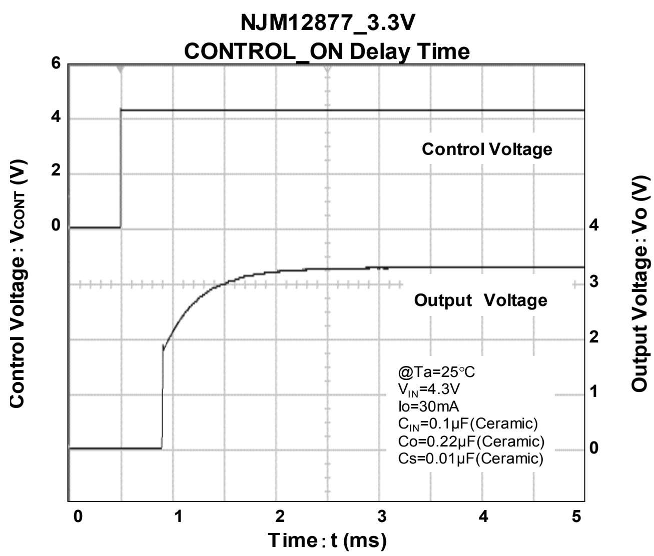

NJM12877_3.3V
Short Circuit Current vs Temperature
@VIN=4.3V
VO=0V
CIN=0.1µF(Ceramic)
Co=0.22µF(Ceramic)
Cs=0.01µF(Ceramic)
Short Circuit Current : ISC (mA)
200
180
160
140
120
100
80
60
40
20
0
-50 -25 0 25 50 75 100 125 150
Temperature : (ºC)


NJM12877_3.3V
Output Voltage vs Temperature
@VIN=4.3V
CIN=0.1µF(Ceramic)
Co=0.22µF(Ceramic)
Cs=0.01µF(Ceramic)
Output Voltage : VO (V)
4
3.5
3
2.5
2
1.5
1
0.5
0
-50 -25 0 25 50 75 100 125 150 175 200
Temperature : (ºC)


NJM12877_3.3V
Load Transient Response
Output current
Output Voltage
@Ta=25°C
VIN=4.3V
Io=30-100mA
CIN=0.1µF(ceramic)
Co=0.22µF(Ceramic)
Cs=0.01µF(Ceramic)
Output current : Io (mA)
Output Voltage : Vo (V)
Time : t (µs)
200
100
0
3.35
3.3
3.25
0
40
80
120
160
200


NJM12877_3.3V
Load Transient Response
Output current
Output Voltage
@Ta=25°C
VIN=4.3V
Io=100-200mA
CIN=0.1µF(ceramic)
Co=0.22µF(Ceramic)
Cs=0.01µF(Ceramic)
Output current : Io (mA)
Output Voltage : (V)
Time : t (µs)
300
200
100
3.35
3.3
3.25
0
40
80
120
160
200


NJM12877_3.3V
Input Transient Response
Input Voltage
@Ta=25°C
VIN=4.3-5.3V
Io=30mA
CIN=0.1µF(Ceramic)
Co=0.22µF(ceramic)
Cs=0.01µF(Ceramic)
Output Voltage
Input Voltage : VIN (V)
Output Voltage : Vo (V)
Time : t (µs)
7
6
5
4
3.35
3.3
3.25
0
40
80
120
160
200


NJM12877_3.3V
CONTROL_ON Delay Time
Control Voltage
Output Voltage
@Ta=25°C
VIN=4.3V
Io=30mA
CIN=0.1µF(Ceramic)
Co=0.22µF(Ceramic)
Cs=0.01µF(Ceramic)
Control Voltage : VCONT (V)
Output Voltage : Vo (V)
Time : t (ms)
6
4
2
0
4
3
2
1
0
0
1
2
3
4
5