NC4650ZA500D-EV

Ultra-Low Quiescent Current (Iq = 70nA) Boost Switching Regulator with Low Ripple Mode

FEATURES

- Operating Junction Temperature Range: -40 ºC to 125 ºC
- Input Voltage Range (Maximum Rating): 0.6 V to 5.5 V (6.5 V)
- Startup Voltage: Typ. 0.8 V
- Output Voltage Range:1.8 V to 5.0 V (Int.Fixed)
- Quiescent Current (V_{OUT}): Normal Mode: Typ. 70 nA, Low Ripple Mode: Typ. 90 µA
- Shutdown Current: Typ. 50 nA
- Efficiency (V_{IN}=1.5 V,V_{OUT}=3.3 V,I_{OUT}=10 µA): Typ. 85 %
- Switch Current Limit: Typ. 1 A (V_{SET} ≥2.5 V), Typ. 0.65 A (V_{SET} < 2.5 V)
- Thermal Shutdown Function: Detection Temperature: Typ. 150 °C, Release Temperature: Typ. 100 °C
- Soft Start Function
- Buck Operation or Pass-Through when $V_{IN} > V_{OUT}$
- Manual switching between Normal Mode and Low Ripple Mode via MODE Pin
- Multiple versions for shutdown behavior

APPLICATIONS

- IoT Edge Devices
- Devices Powered by Coin/Button/Dry Batteries
- Alarms, Smartwatches etc.

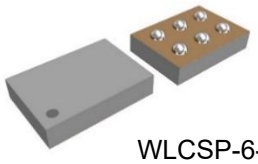
GENERAL DESCRIPTION

The NC4650 is a synchronous rectification boost switching regulator featuring ultra-low quiescent current of 70nA, utilizing a CMOS process. It is optimal for portable devices powered by coin or button batteries.

With high efficiency under light load conditions, it is ideal for intermittent operation applications, ensuring long battery life.

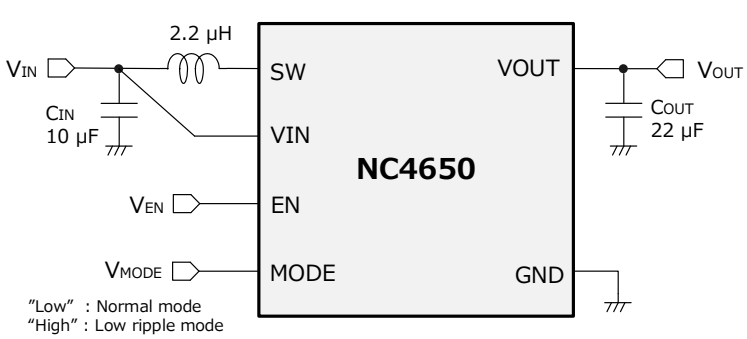
The MODE pin enables the selection of "Low Ripple Mode" for improved load transient response and reduced ripple. The EN pin allows shutdown operations, with options such as V_{IN}-V_{OUT} Complete Disconnect, V_{OUT} discharge, and Pass-Through. Selecting the optimal version according to system sleep conditions enables system optimization.

Package

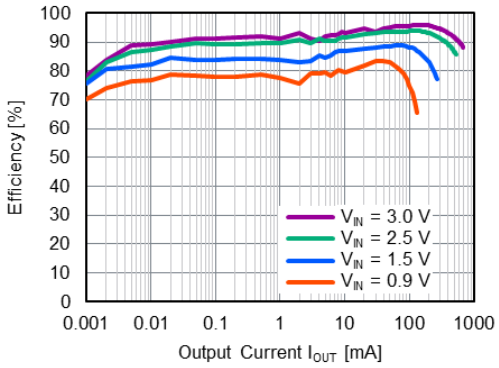


WLCSP-6-ZA1
1.3 x 0.92 x 0.4 (mm)

TYPICAL APPLICATION



EFFICIENCY TYPICAL CHARACTERISTICS



NC4650ZA V_{OUT} = 3.3V MODE = "Low"

■ PRODUCT NAME INFORMATION

Product Name	Package
NC4650ZA500D	WLCSP-6-ZA1

Description of configuration

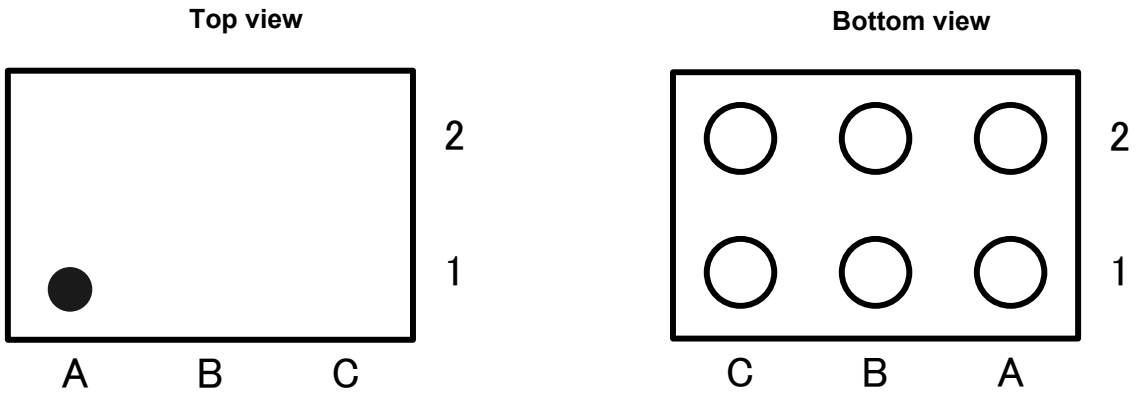
	Item	Description
500	Output Voltage	Set Output Voltage (V_{SET}): 5.0 V

Version

	EN Pin Function	Operation when Shutdown
D	EN="High" : Shutdown EN="Low" : Active	V_{IN} - V_{OUT} Pass-Through Seamless Pass-Through Function

- For more details on NC4650 IC, please refer to
https://www.nisshinbo-microdevices.co.jp/en/products/dc-dc-switching-regulator/spec/?product=nc4650

■ PIN DESCRIPTION (NC4650ZA)



WLCSP-6-ZA1 Pin Configuration

NC4650ZA (WLCSP-6-ZA1) Pin Descriptions

Pin No.	Pin Name	I/O	Description
A1	VOUT	Power	Output Pin
B1	GND	-	Ground Pin
C1	VIN	Power	Power Supply Pin
A2	SW	-	Switching Output Pin Connect to Internal MOSFET Drain
B2	MODE	I	Mode Control Pin Low: Normal Mode, High: Low Ripple Mode
C2	EN	I	Enable Pin NC4650ZAxxxD: Can set the active state with the "Low" input and the shutdown state with the "High" input.

■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Ratings	Unit
VIN pin Voltage	V_{IN}	-0.3 to 6.5	V
VOUT pin Voltage	V_{OUT}	-0.3 to 6.5	V
SW pin Voltage	V_{SW}	-0.3 to 6.5	V
EN pin Voltage	V_{EN}	-0.3 to 6.5	V
MODE pin Voltage	V_{MODE}	-0.3 to 6.5	V
Storage Temperature Range	T_{stg}	-55 to 150	°C
Junction Temperature [*1]	T_j	-40 to 150	°C

ABSOLUTE MAXIMUM RATINGS
Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause permanent damage and may degrade the lifetime and safety for both device and system using the device in the field. The functional operation at or over these absolute maximum ratings is not assured.

[*1] Calculate the power consumption of the IC from the operating conditions, and calculate the junction temperature with the thermal resistance.

Please refer to "*THERMAL CHARACTERISTICS*" for the thermal resistance under our measurement board conditions

■ RECOMMENDED OPERATING CONDITIONS

	Symbol	Ratings	unit
VIN pin Voltage	V_{IN}	0.6 to 5.5	V
Operating Temperature Range	T_a	-40 to 85	°C
Junction Temperature Range	T_j	-40 to 125	°C

RECOMMENDED OPERATING CONDITIONS
All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating conditions. The semiconductor devices cannot operate normally over the recommended operating conditions, even if when they are used over such conditions by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions.

■ ELECTRICAL CHARACTERISTICS

For parameter that do not describe the temperature condition, the MIN / MAX value under the condition of −40 °C ≤ Tj ≤ 125 °C is described.

Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
Output Voltage	V_{OUTCM}	PWM, V_{SET} ≥ 2.5V, Tj = 25 °C	x 0.985		x 1.015	V
		PWM, V_{SET} < 2.5V, Tj = 25 °C,	x 0.98		x 1.02	V
		PWM, V_{SET} ≥ 2.5V, -40°C ≤ Tj ≤ 85°C	x 0.975		x 1.025	V
		PWM, VSET < 2.5V, -40°C ≤ Tj ≤ 85°C	x 0.97		x 1.03	V
	V_{OUTDCM}	PFM, V_{IN} = 1.5V		V_{OUTCM} x 1.02		V
Startup Voltage	V_{START}	-40°C ≤ Tj ≤ 85°C		0.8	0.9	V
VIN UVLO	$V_{VINUVLO}$	V_{IN} = falling, V_{OUT} = V_{SET}		0.4	0.6	V
VIN pin Quiescent Current	I_{QVIN}	V_{OUT} = V_{SET}, V_{IN} = 1.5V, V_{MODE} = 0 V, no switching,		0		nA
VOUT pin Quiescent Current	I_{QVOUT}	V_{OUT} = V_{SET}, V_{IN} = 1.5V, V_{MODE} = 0 V, no switching, -40°C ≤ Tj ≤ 85°C		70	300	nA
		V_{OUT} = V_{SET}, V_{IN} = 1.5V, V_{MODE} = V_{IN}, no switching, -40°C ≤ Tj ≤ 85°C		90	180	μA
VIN pin Shutdown Current*1	I_{SDVIN}	V_{IN} = 5.5V V_{EN} = 0V (A, B Version) V_{EN} = 5.5V (C, D Version) -40°C ≤ Tj ≤ 85°C		50	200	nA
VOUT pin Shutdown Current*1	I_{SDVOUT}	V_{IN} = 0V, V_{OUT} = V_{SET} V_{EN} = 0V (A Version) V_{EN} = V_{SET} (C, D Version) -40°C ≤ Tj ≤ 85°C		40	250	nA
EN pin "H" Input Current	I_{ENH}	V_{IN} = V_{EN} = 5.5V -40°C ≤ Tj ≤ 85°C	-40	0	40	nA
EN pin "L" Input Current	I_{ENL}	V_{IN} = 5.5V, V_{EN} = 0V -40°C ≤ Tj ≤ 85°C	-40	0	40	nA
MODE pin "H" Input Current	I_{MODEH}	V_{IN} = V_{MODE} = 5.5V -40°C ≤ Tj ≤ 85°C	-40	0	40	nA
MODE pin "L" Input Current	I_{MODEL}	V_{IN} = 5.5V, V_{MODE} = 0V -40°C ≤ Tj ≤ 85°C	-40	0	40	nA
EN pin "H" Input Voltage *2	V_{ENH}		0.9		5.5	V
EN pin "L" Input Voltage *2	V_{ENL}		0		0.3	V
MODE pin "H" Input Voltage *2	V_{MODEH}		1.0		5.5	V
MODE pin "L" Input Voltage *2	V_{MODEL}		0		0.3	V
SW pin "H" Input Current	I_{SWH}	V_{IN}=V_{SW}=5V, V_{OUT}=0V -40°C ≤ Tj ≤ 85°C		1	350	nA
SW pin "L" Input Current	I_{SWL}	V_{IN}=V_{SW}=0V, V_{OUT}=5V -40°C ≤ Tj ≤ 85°C	-200	-1		nA
On-resistance of High Side MOSFET	R_{ONH}	V_{OUT}=3.3V		0.28		Ω
On-resistance of Low Side MOSFET	R_{ONL}	V_{OUT}=3.3V		0.22		Ω
Thermal Shutdown Detection Temperature	T_{SDDET}			150		°C
Thermal Shutdown Release Temperature	T_{SDREL}			100		°C
Inductor Ripple Current	I_{RIP}	V_{IN} = 1.5V, V_{OUT} = V_{SET}		250		mA

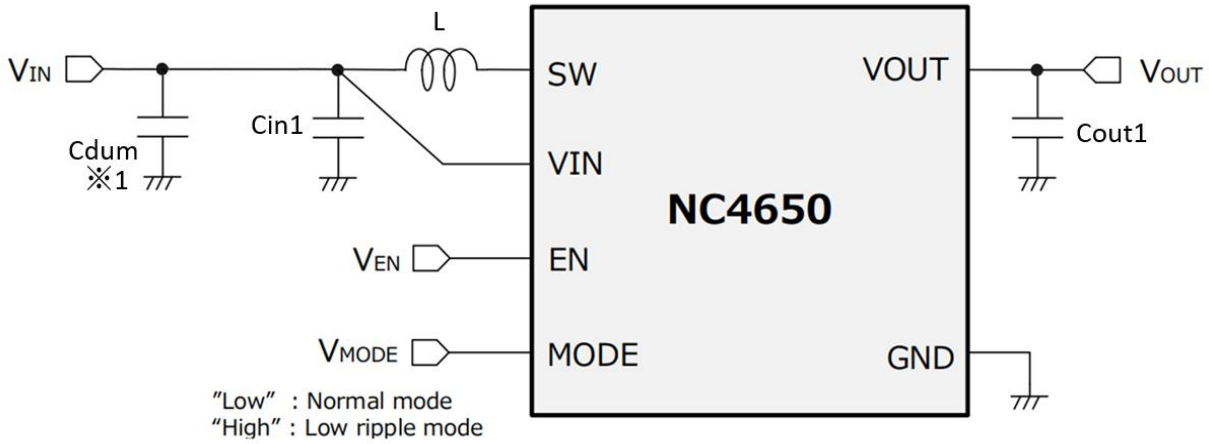
Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
SW Current Limit	I_{SWLIM}	$V_{SET} \geq 2.5V$, $V_{IN} = 1.5V$	700	1000	1500	mA
		$V_{SET} < 2.5V$, $V_{IN} = 1.5V$	450	650	950	mA
On-resistance for Discharger	R_{ONDIS}	$V_{IN} = 1.5V$, B Version only		55		Ω
Soft-Start Time	t_{START}			0.8	1.5	ms
Pass-Through Mode Detection Voltage	V_{PTHD}	$V_{IN} - V_{OUT}$		0.6	0.8	V
Pass-Through Mode Release Voltage	V_{PTHR}	V_{OUT}		V_{OUTCM} x 1.02		V
Pass-Through Mode Quiescent Current	I_{QPTML}	$V_{MODE} = 0V$, $V_{IN} = V_{SET}+0.4V$		70		nA
	I_{QPTMH}	$V_{MODE} = V_{IN}$, $V_{IN} = V_{SET}+0.4V$		90		μA
Buck Mode Detection Voltage	V_{BKDML}	V_{IN} = Rising or V_{OUT} = Falling, $V_{BKDML} = V_{IN} - V_{OUT}$, $V_{MODE} = 0V$		-0.05		V
	V_{BKDMH}	V_{IN} = Rising or V_{OUT} = Falling, $V_{BKDMH} = V_{IN} - V_{OUT}$, $V_{MODE} = V_{IN}$		-0.1		V
Buck Mode Release Voltage	V_{BKRML}	V_{IN} = Falling or V_{OUT} = Rising, $V_{BKRML} = V_{IN} - V_{OUT}$, $V_{MODE} = 0V$		-0.1		V
	V_{BKRMH}	V_{IN} = Falling or V_{OUT} = Rising, $V_{BKRMH} = V_{IN} - V_{OUT}$, $V_{MODE} = V_{IN}$		-0.2		V

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

*1 On the VIN and VOUT pins, the shutdown current flows only from the pin with the higher voltage. The pin with the lower voltage is Typ. 0 nA.

*2 When the EN and MODE pins are fixed to the V_{IN} pin, the polarity is forced to be “H” as long as VIN pin voltage within the recommended operating condition. (The A and B version)

Typical Application Circuit



※1 Testing with this EV board, an external attachment might be necessary for evaluation of the correct performance of the NC4650 and already has been attached as Cdum.
For evaluation, wiring for power supply or GND will be used. Considering the voltage drop or noise by the wiring, Cdum has been mounted on the EV board to obtain the right performance of the NC4650 in the actual PCB layout or measurement unit's wire is very short, and Cdum will be unnecessary.

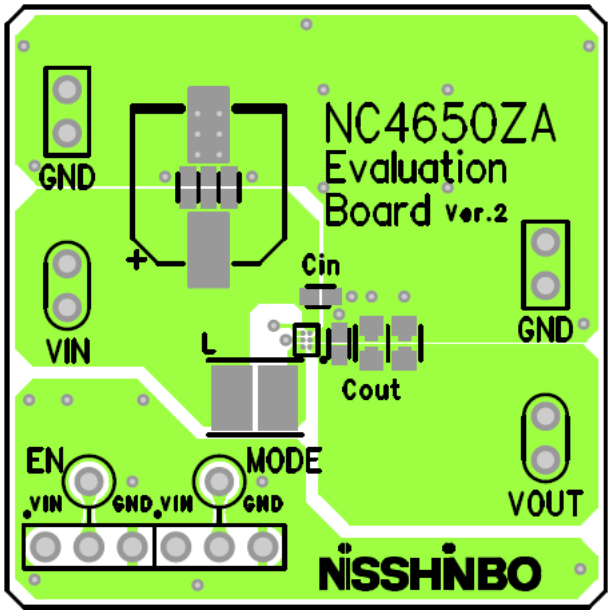
Recommended values for components

Symbol	Capacitance
Cin1	10 µF
Cout1	22 µF
L	2.2 µH
Cdum(※1)	10 µF*3

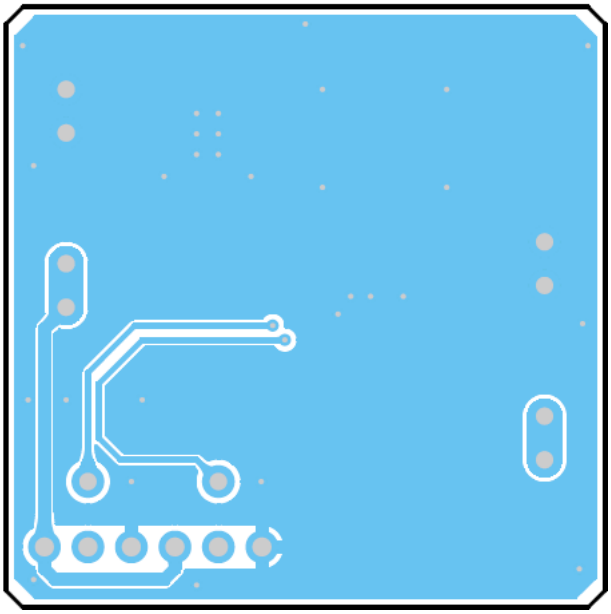
The bill of materials will be attached on the shipment of each purchased evaluation board.

■ Evaluation Board / PCB Layout Pattern Example

NC4650ZA（WLCSP-6-ZA1）



Top Layer



Bottom Layer

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

- External components should be placed as close as possible to the IC and on the same side, and the wiring from the IC to the components should be short. In particular, the capacitor C_{IN} connected between V_{IN} and GND and the capacitor C_{OUT} connected between V_{OUT} and GND should be placed at the shortest possible distance from the terminals.
- Current due to switching flows through the power supply wiring, ground wiring and SW pins. If the impedance of the power and ground wiring is high, the potential inside the IC may fluctuate due to the switching current, causing the IC to operate unstable. Therefore, the power and ground wiring should be short and thick.
- The wiring from the SW pin to the inductor is a noise source, so ensure that the current capacity is sufficient to prevent the noise from increasing and that the wiring is not thicker and longer than necessary.

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