NCV890430

Product Preview

0.6 A 2 MHz 100% Duty Cycle Step-Down Synchronous Regulator for Automotive

The NCV890430 is a fixed-frequency Synchronous Buck regulator intended for Automotive, battery-connected applications that operate with up to a 45 V input supply. It is suitable for automotive systems with high efficiency, low noise and Low Shutdown Current requirements that also need to operate at low input voltage close to the output voltage. A reset pin (with adjustable delay) simplifies interfacing with a microcontroller. This part also features an enable input that can either be connected to a low voltage (such as a micro-controller output) or high voltage (such as the battery input), and a synchronization input.

The NCV890430 also provides several protection features expected in automotive power supply systems such as current limit, short circuit protection, and thermal shutdown. In addition, the high switching frequency produces low output voltage ripple even when using small inductor values and all-ceramic input output filter capacitors − forming a space-efficient switching regulator solution

Features

- Internal 500 mΩ P-channel and 250 mΩ N-channel Power Switches
- Capable of 100% Duty Cycle Operation
- V_{IN} Operating Range 3.5 V to 37 V
- Withstands Load Dump to 45 V
- 2 MHz Free-running Switching Frequency
- Low Shutdown Current < 10 μA
- High Voltage Enable Pin
- Synchronization Input Pin
- DC Output Current of at Least 0.6 A
- Fixed Output Voltage (5 V, 3.3 V, 2.5 V Versions)
- ±2% Output Voltage Accuracy
- DFN Package with Wettable Flanks (Pin Edge Plating per JEDEC MO220)
- NCV Prefix for Automotive Requiring Site and Control Changes
- These are Pb−Free Devices

Typical Applications

- Automotive Infotainment and Instrumentation
- Automotive Body Applications
- Linear Regulator Replacement
- Rear View Camera

This document contains information on some products that are still under development. ON Semiconductor reserves the right to change or discontinue these products without notice.

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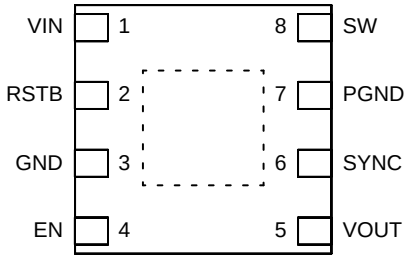
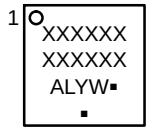
DFN8, 3x3, 0.65P
CASE 506CS

PIN CONNECTIONS



(DFN8 Top View)

MARKING DIAGRAM



XXXXX = Specific Device Code (TBD)
A = Assembly Location
L = Wafer Lot
Y = Year
W = Work Week
▪ = Pb−Free Package

(Note: Microdot may be in either location)

ORDERING INFORMATION

See detailed ordering, marking and shipping information on page 8 of this data sheet.

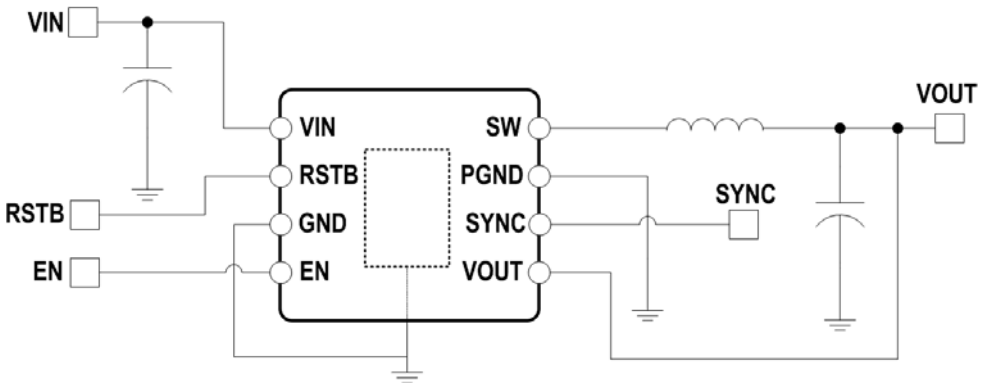


Figure 1. Typical Application Schematic

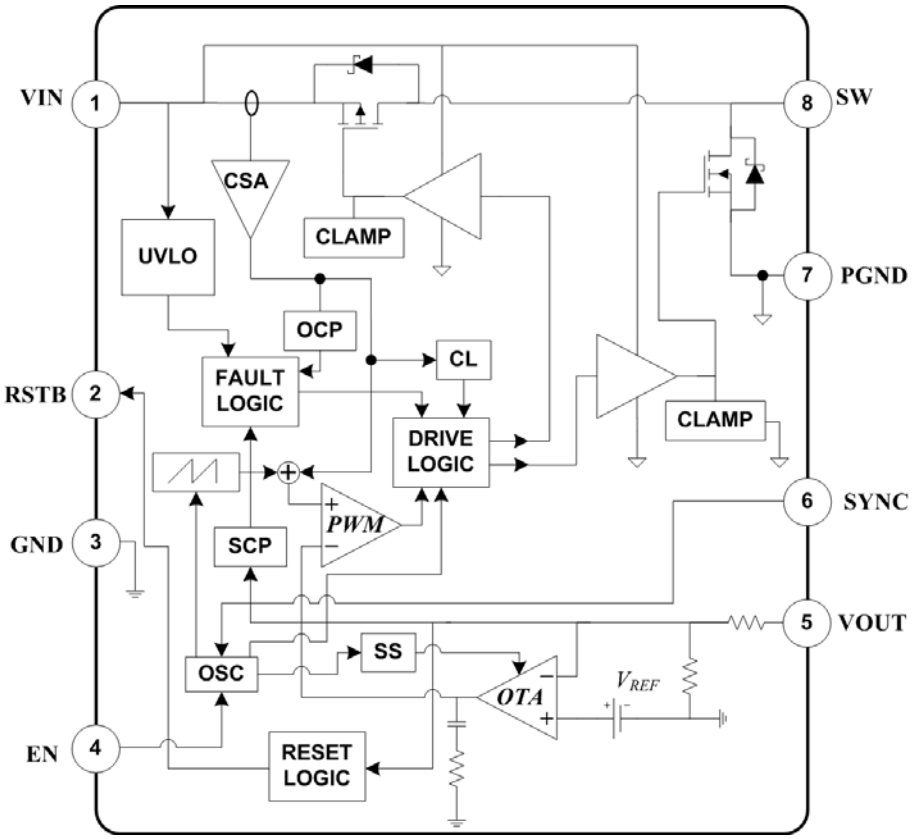


Figure 2. Simplified Block Diagram

Table 1. PIN FUNCTION DESCRIPTIONS

Pin No.	Pin Name	Description
1	VIN	Input voltage from battery. Place an input filter capacitor in close proximity to this pin.
2	RSTB	Reset reporting flag. Open drain output, pulling down to ground when the output voltage is out of regulation. The value of the external pull-up resistor determines the delay time that the Reset is held low.
3	GND	Analog ground reference − should be connected directly to the output capacitor ground and the exposed pad.
4	EN	Enable input. Connecting a “high” voltage (TTL compatible, battery voltage tolerant) to this pin turns on the regulator. A low voltage forces the part into a very low Iq shutdown mode.
5	VOUT	Output voltage sensing for regulation.
6	SYNC	Synchronization input. Connecting an external clock to this pin synchronizes switching to the rising edge of the SYNC signal.
7	PGND	Power ground, connect directly to the input capacitor ground and to the exposed pad.
8	SW	Switching node of the Regulator. Connect the output inductor to this pin.
Exposed Pad	EPAD	Must be connected to GND (pin 3, electrical ground) and to a low thermal resistance path to the ambient temperature environment..

Table 2. ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Min/Max Voltage VIN		−0.3 to 45	V
Max Voltage VIN to SW		45	V
Min/Max Voltage SW		−0.7 to 40 V	V
Min Voltage SW − 20 ns		−3.0	V
Min/Max Voltage EN		−0.3 to 40 V	V
Min/Max Voltage on SYNC, RSTB		−0.3 to 6	V
Min/Max Voltage VOUT		−0.3 to 18	V
Thermal Resistance, DFN8 Junction-to-Ambient (Note 1)	$R_{\theta JA}$	40	°C/W
Storage Temperature Range		−55 to +150	°C
Operating Junction Temperature Range	T_J	−40 to +150	°C
ESD withstand Voltage (Human Body Model)	V_{ESD}	2.0	kV
Moisture Sensitivity	MSL	Level 1	
Peak Reflow Soldering Temperature (Note 1)		260	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Mounted on 1 sq. in. of a 4-layer PCB with 1 oz. copper thickness.

Table 3. ELECTRICAL CHARACTERISTICS

(V_{IN} = 4.5 V to 28 V, EN = 5 V. Min/Max values are valid for the temperature range −40°C ≤ T_J ≤ 150°C unless noted otherwise, and are guaranteed by test, design or statistical correlation.)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
QUIESCENT CURRENT						
Quiescent Current, Enabled	V_{IN} = 13.2 V	I_{qEN}			3.0	mA
Quiescent Current, Shutdown	V_{IN} = 13.2 V, V_{EN} = 0 V, 25 °C	I_{qSD}		5.0	8.0	μA
UNDERVOLTAGE LOCKOUT − VIN						
UVLO Start Threshold	V_{IN} Rising	V_{UVLSTT}	4.1		4.5	V
UVLO Stop Threshold	V_{IN} Falling	V_{UVLSTP}	3.2		3.5	V
SOFT-START						
Soft-Start Completion Time		t_{SS}	0.8	1.4	2.0	ms
OUTPUT VOLTAGE						
Output Voltage during Regulation	100 μA < I_{OUT} < 0.6 A 5.0 V Option 3.3 V Option 2.5 V Option	V_{OUTreg}	 4.9 3.234 2.45	 5.0 3.3 2.5	 5.1 3.366 2.55	V
OSCILLATOR						
Frequency	4.5 V < V_{IN} < 18 V 20 V < V_{IN} < 28 V	f_{SW} $f_{SW(HV)}$	1.8 0.9	2.0 1.0	2.2 1.1	MHz
VBAT OVERVOLTAGE SHUTDOWN MONITOR						
Overvoltage Stop Threshold		V_{OV1SP}	37		40	V
Overvoltage Start Threshold		V_{OV1ST}	34.5			V
Overvoltage Hysteresis		V_{OV1HY}	0.9	1.7	2.5	V
VIN FREQUENCY FOLDBACK MONITOR						
Frequency Foldback Threshold	V_{IN} Rising V_{IN} Falling	V_{FLDUP} V_{FLDDN}	18.4 18		20 19.8	V
Frequency Foldback Hysteresis		V_{FLDHY}	0.2	0.3	0.4	V
PEAK CURRENT LIMIT						
Current Limit Threshold		I_{LIM}	1.5	1.7	1.9	A
Low-Side Current Limit Threshold	V_{SW} = 13.2 V	I_{LIMLS}	1.2	1.6	2.0	A
POWER SWITCHES						
High-Side Switch ON Resistance		$R_{DSON-HS}$			1000	mΩ
Low-Side Switch ON Resistance		$R_{DSON-LS}$			550	mΩ
Leakage Current V_{IN} to SW	V_{SW} = 0, −40°C ≤ T_J ≤ 85°C	I_{LKSWH}			10	μA
Leakage Current SW to GND	V_{SW} = V_{IN}, −40°C ≤ T_J ≤ 85°C	I_{LKSWL}			10	μA
Minimum ON Time	Measured at SW Pin	t_{ONMIN}	45		70	ns
Minimum OFF Time when Not 100% Duty Cycle	Measured at SW Pin at f_{SW} = 2 MHz	t_{OFFMIN}		30	50	ns
Non-Overlap Time		t_{NOVLP}		10		ns
SLOPE COMPENSATION						
Ramp Slope (Note 2) (With Respect to Switch Current)	4.5 V < V_{IN} < 18 V 20 V < V_{IN} < 28 V	S_{ramp} $S_{ramp(HV)}$	1.05 0.5	1.5 0.75	1.95 1.0	A/μs
SHORT CIRCUIT FREQUENCY FOLDBACK						
Switching Frequency in Short-Circuit Condition Lowest Foldback Frequency Lowest Foldback Frequency − High V_{IN}	 V_{OUT} = 0 V, 4.5 V < V_{IN} < 18 V V_{OUT} = 0 V, 20 V <V_{IN} < 28V	 f_{SWAF} f_{SWAFHV}	 450 225	 550 275	 650 325	kHz

Table 3. ELECTRICAL CHARACTERISTICS (continued)
(V_{IN} = 4.5 V to 28 V, EN = 5 V. Min/Max values are valid for the temperature range −40°C ≤ T_J ≤ 150°C unless noted otherwise, and are guaranteed by test, design or statistical correlation.)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
HICCUP MODE						
Hiccup Mode	V_{SW} = 0 V	f_{SWHIC}	24	32	40	kHz
Hiccup Mode 2 − SW Short to Battery	V_{SW} = 13.2 V	$f_{SWHICLS}$	24	32	40	kHz
SYNCHRONIZATION						
SYNC Input Resistance to Ground	V_{SYNC} = 5.0 V	$R_{H(SYNC)}$	50		200	kΩ
SYNC Input High Threshold Voltage		V_{HSYNC}	2.0			V
SYNC Input Low Threshold Voltage		V_{LSYNC}			0.8	V
SYNC High Pulse Width	V_{SYNC} > max V_{HSYNC}	t_{HSYNC}	40			ns
SYNC Low Pulse Width	V_{SYNC} < min V_{LSYNC}	t_{LSYNC}	40			ns
External SYNC Frequency		f_{SYNC}	1.8		2.5	MHz
Master Reassertion Time	Time from Last Rising SYNC Edge to First Un-synchronized Turn-on.	$t_{I(SYNC)}$		650		ns
RESET						
Reset Threshold	V_{OUT} Decreasing V_{OUT} Increasing	K_{RES_LO} K_{RES_HI}	91 91.5	93	95 97	%
Reset Hysteresis (Ratio of VOUT)		K_{RES_HYS}	0.5			%
Leakage Current into RSTB Pin					1.0	μA
Noise-Filtering Delay	From V_{OUT} < V_{RESET} to RSTB Pin Going Low	t_{RES_FILT}	10		25	μs
Reset Delay Time	I_{RSTB} = 1.1 mA I_{RSTB} = 500 μA I_{RSTB} = 100 μA	t_{RESET}	 4.0 19	1.0 5.0 24	 6.0 29	μs ms ms
Reset Delay Modes	Power Good Mode (No Delay) Delay Mode		1000		 600	μA
Reset Output Low Level	I_{RSTB} = 1.2 mA	V_{RESL}			0.4	V
ENABLE						
Logic Low Threshold Voltage		V_{ENlow}			0.8	V
Logic High Threshold Voltage		V_{ENhigh}	2.0			V
EN Pin Input Current		I_{ENbias}	8.0		30	μA
THERMAL SHUTDOWN						
Thermal Shutdown Activation Temperature (Note 2)		T_{SD}	155		190	°C
Hysteresis (Note 2)		T_{HYS}	5.0		20	°C

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.
2. Not tested in production. Limits are guaranteed by design.

TYPICAL CURVES

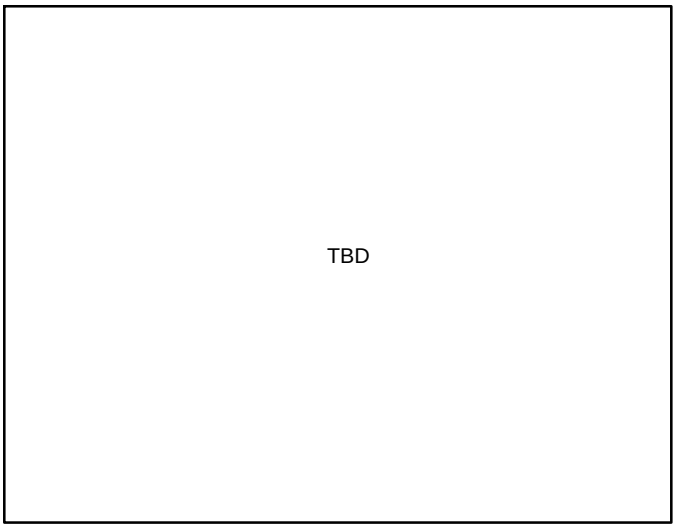


Figure 3. Typical Efficiency vs. Output Current at V_{IN} = 12 V

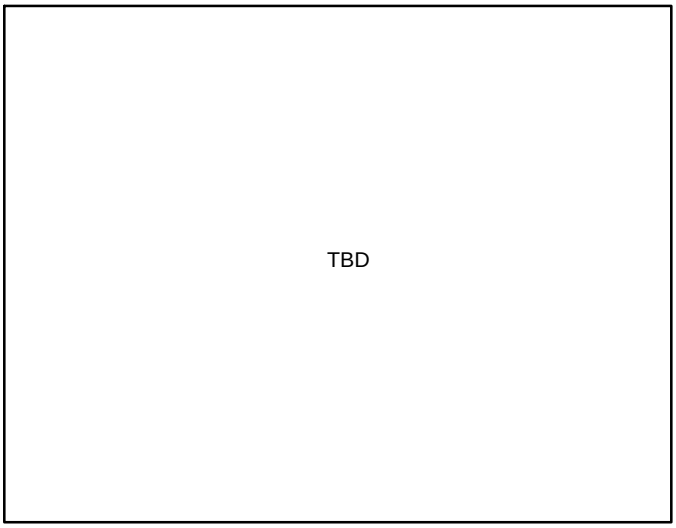


Figure 4. Typical Efficiency vs. Input Voltage at I_{OUT} = 0.5 A

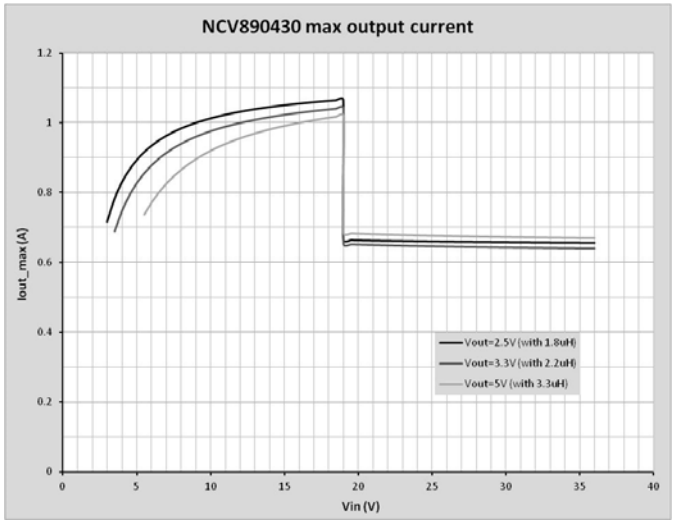


Figure 5. Worst Case Maximum Output Current vs. Input Voltage

APPLICATION INFORMATION

General Description

The NCV890430 is a high-frequency synchronous switch-mode regulator with current-mode control, fixed output voltage and fixed internal closed-loop compensation, accepting a wide input voltage range typical to automotive applications.

The use of a P-channel high-side MOSFET simplifies the driving scheme (no bootstrap circuitry needed), and enables a duty cycle of 100% for low dropout operation at low input voltage.

Input Voltage

An Undervoltage Lockout (UVLO) circuit monitors the input, and can inhibit switching and reset the soft-start circuit if there is insufficient voltage for proper regulation. Depending on the output conditions (voltage option and loading), the NCV890430 may lose regulation and run in drop-out mode before reaching the UVLO threshold: refer to the Minimum V_{IN} calculation tool for details. When the input voltage drops low enough that the part cannot regulate because it reaches its maximum duty cycle, the high-side MOSFET can turn on permanently (100% duty cycle operation), to help lower the minimum voltage at which the regulator loses regulation.

An overvoltage monitoring circuit automatically terminates switching if the input voltage exceeds 37 V (see Figure 6), but the NCV890430 can withstand input voltages up to 45 V.

To avoid skipping switching pulses and enter an uncontrolled mode of operation, the switching frequency is reduced by a factor of 2 when the input voltage exceeds the V_{IN} Frequency Foldback threshold (see Figure 6 below). Frequency reduction is automatically terminated when the input voltage drops back below the V_{IN} Frequency Foldback threshold. This also helps to limit the power lost in switching and generating the drive voltage for the Power Switches at high input voltage.

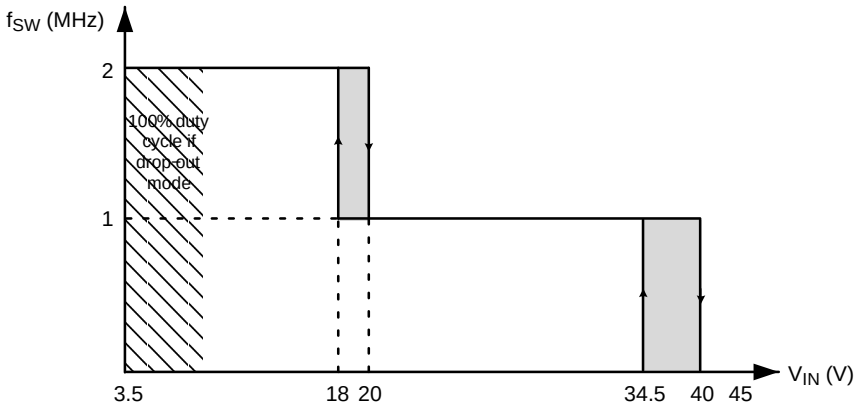


Figure 6. NCV890430 Worst-Case Switching Frequency Profile vs. Input Voltage

Soft-Start

Upon being enabled or released from a fault condition, a soft-start circuit ramps the switching regulator error amplifier reference voltage to the final value, forcing the output to follow the same soft-start ramp. During soft-start, the average switching frequency is lower until the output voltage approaches regulation.

Slope Compensation

A fixed slope compensation signal is generated internally and added to the sensed current to avoid increased output voltage ripple due to bifurcation of inductor ripple current at duty cycles above 50%. The fixed amplitude of the slope compensation signal requires the inductor to be greater than a minimum value, depending on output voltage, in order to avoid sub-harmonic oscillations. The recommended inductor value is between 1.8 and 3.3 μH, although other values are possible.

Current Limiting

Due to the ripple on the inductor current, the average output current of a buck converter is lower than the peak current set point of the regulator. See “typical curves” for how the variation of inductor peak current with input voltage affects the maximum dc current the NCV890430 can deliver to a load.

Short Circuit Protection

During severe output overloads or short circuits, the NCV890430 automatically reduces its switching frequency. This creates duty cycles small enough to limit the peak current in the power components, while maintaining the ability to automatically reestablish the output voltage if the overload is removed.

In more severe short-circuit conditions where the inductor current reaches the peak current limit during the minimum on time, the regulator enters a hiccup mode that further reduces the power dissipation and protects the system.

RESET Function

The RSTB pin is pulled low when the output voltage falls below 8% of the nominal regulation level, and floats when the output is properly regulated. A pull-up resistor tied to the output is needed to generate a logic high signal on this open-drain pin. The pin can be left unconnected when not used.

When the output voltage drops out of regulation, the pin goes low after a short noise-filtering delay (K_{RES_FILT}). It stays low for a delay time (adjustable) after the output goes back to regulation, simplifying the connection to a micro-controller.

The RSTB signal can either be used as a reset with delay or a power good (no delay). The delay is determined by the current into the RSTB pin, set by a resistor, as shown in Figure 7.

Use the following equation to determine the ideal reset delay time using currents less than 500 μA:

$$t_{delay} = \frac{2500}{I_{RSTB}} \qquad \text{(eq. 1)}$$

where: t_{delay} is the ideal reset delay time [ms]
I_{RSTB} is the current into the RSTB pin [μA]

Using I_{RSTB} = 1 mA removes the delay and allows the reset to act as a “power good” pin.

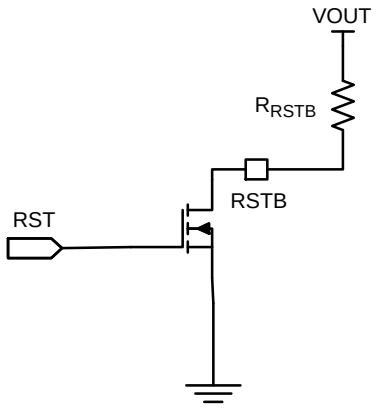


Figure 7. Reset with Adjustable Delay on a Single Pin

The RSTB resistor is commonly tied to VOUT. Depending on the output voltage option, typical delay times can be achieved with the following resistor values:

Table 4. TYPICAL DELAY TIMES

R_{RSTB} (kΩ)	t_{delay} (ms) – 5 V	t_{delay} (ms) – 3.3 V	t_{delay} (ms) – 2.5 V
5	–	–	5
10	5	7.6	10
20	10	15	20
30	15	23	–
50	25	–	–

Enable

The NCV890430 is designed to accept either a logic-level signal or battery voltage as an Enable signal. However, if voltages above 40 V are expected, EN should be tied to VIN through a 10 kΩ resistor in order to limit the current flowing into the overvoltage protection of the pin.

A low signal on Enable induces a shutdown mode which shuts off the regulator and minimizes its supply current to less than 5 μA by disabling all functions.

Once the switching regulator output is enabled, a soft-start is always initiated.

Thermal Shutdown

A thermal shutdown circuit inhibits switching and resets the soft-start circuit if internal temperature exceeds a safe level. Switching is automatically restored when temperature returns to a safe level.

Exposed Pad

The exposed pad (EPAD) on the back of the package must be electrically connected to both the analog and the power electrical ground GND and PGND pins for proper, noise-free operation. It is recommended to connect these 2 pins directly to the EPAD with a PCB trace.

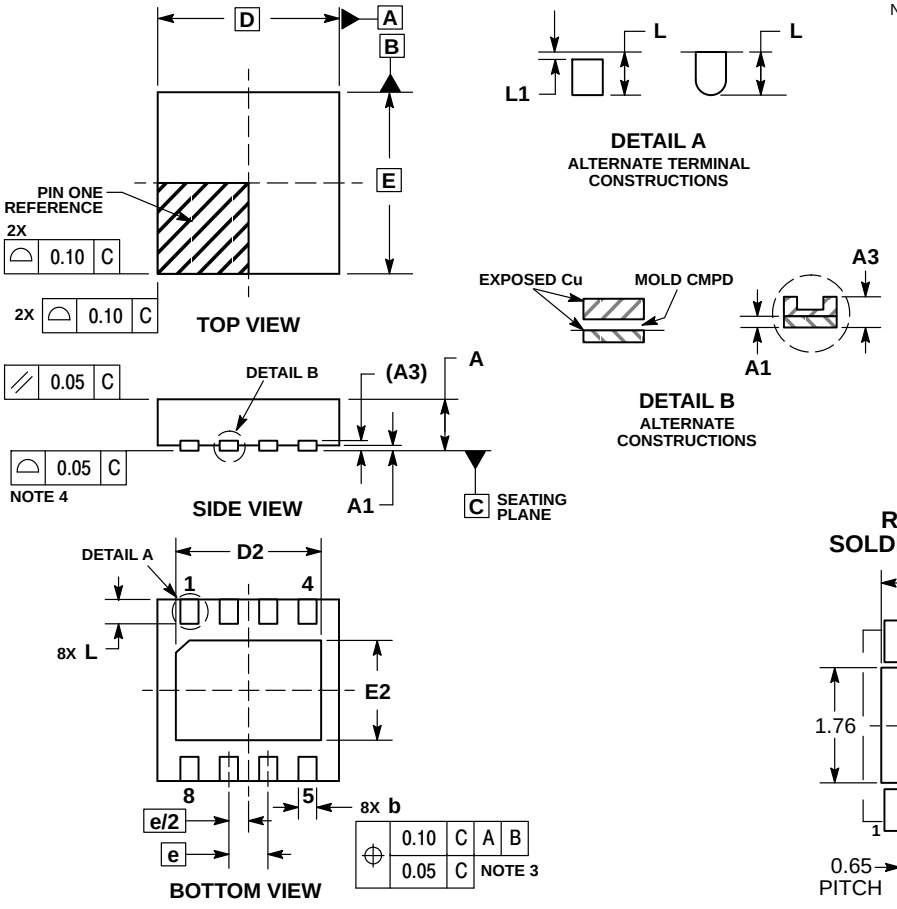
DEVICE ORDERING INFORMATION

Device	Output	Marking	Package	Shipping†
NCV890430MW50TXG	5.0 V	TBD	DFN8 (Pb−Free)	TBD / Tape & Reel
NCV890430MW33TXG	3.3 V	TBD		
NCV890430MW25TXG	2.5 V	TBD		

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

PACKAGE DIMENSIONS

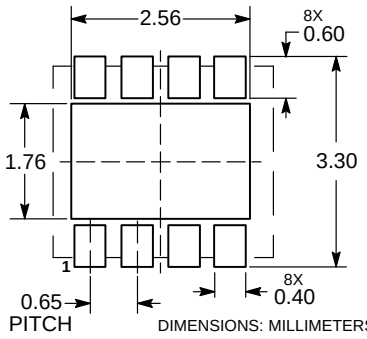
DFN8, 3x3, 0.65P
CASE 506CS
ISSUE O



NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30mm FROM THE TERMINAL TIP.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

	MILLIMETERS	
DIM	MIN	MAX
A	0.80	1.00
A1	0.00	0.05
A3	0.20 REF	
b	0.25	0.35
D	3.00 BSC	
D2	2.30	2.50
E	3.00 BSC	
E2	1.50	1.70
e	0.65 BSC	
L	0.30	0.40
L1	0.00	0.15

RECOMMENDED SOLDERING FOOTPRINT*



DIMENSIONS: MILLIMETERS

*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

PUBLICATION ORDERING INFORMATION

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