## NCV890204GEVB

## NCV890204 Evaluation Board User's Manual

## Description

The NCV890204 is a fixed-frequency, monolithic, Buck switching regulator intended for Automotive, battery-connected applications that must operate with up to a 36 V input supply. The regulator is suitable for systems with low noise and small form factor requirements often encountered in automotive driver information systems. The NCV890204 is capable of converting the typical 4.5 V to 18 V automotive input voltage range to outputs as low as 3.3 V at a constant switching frequency above the sensitive AM band, eliminating the need for costly filters and EMI countermeasures. A Reset pin signals when the output is in regulation, and a pin is provided to adjust the delay before the RSTB signal goes high. The NCV890204 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 an all-ceramic output filter capacitor - forming a space-efficient switching regulator solution.


Figure 1. NCV890204 Evaluation Board

## ON Semiconductor ${ }^{\circledR}$

http://onsemi.com

## EVAL BOARD USER'S MANUAL

## Key Features

- Internal N-channel Power Switch
- Low $\mathrm{V}_{\mathrm{IN}}$ Operation Down to 4.5 V
- High $\mathrm{V}_{\mathrm{IN}}$ Operation to 36 V
- Withstands Load Dump to 40 V
- 2 MHz Free-running Switching Frequency
- Adjustable Spread Spectrum
- Reset with Adjustable Delay
- Logic level Enable Input Can be Directly Tied to Battery
- 2.0 A (min) Cycle-by-Cycle Peak Current Limit
- Short Circuit Protection enhanced by Frequency Foldback
- $\pm 1.75 \%$ Output Voltage Tolerance
- Output Voltage Adjustable Down to 0.8 V
- 1.4 Millisecond Internal Soft-Start
- Thermal Shutdown (TSD)
- Low Shutdown Current
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable
- Wettable Flanks DFN (Pin Edge Plating)
- These Devices are Pb -Free and are RoHS Compliant


## Typical Applications

- Audio, Infotainment, Safety - Vision Systems, Instrumentation


Figure 2. NCV890204 Block Diagram

## TYPICAL APPLICATION



Figure 3. Typical Application

## NCV890204GEVB

Table 1. EVALUATION BOARD TERMINALS

| Pin Name |  |
| :---: | :--- |
| VIN | Positive dc Input Voltage |
| GND | Common dc Return |
| VOUT | Positive dc Output Voltage |
| EN | Master Enable Input |
| RST3B | Reset with Adjustable Delay |

Table 2. ABSOLUTE MAXIMUM RATINGS (Voltages are with respect to GND)

| Rating | Value | Unit |
| :--- | :---: | :---: |
| Dc Supply Voltage (VIN, EN) | -0.3 to 40 | V |
| Dc Supply Voltage (RSTB) | -0.3 to 6 | V |
| Storage Temperature Range | -55 to +150 | ${ }^{\circ} \mathrm{C}$ |

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.

Table 3. ELECTRICAL CHARACTERSITICS

| Characteristic | Conditions | Typical Value | Unit |
| :---: | :---: | :---: | :---: |
| REGULATION |  |  |  |
| Output Voltage (VOUT) |  | 5.0 | V |
| Line Regulation (VOUT) | I ${ }_{\text {OUT }}=1.0 \mathrm{~A}$ | 0.1 | \% |
| Load Regulation (VOUT) | $\mathrm{V}_{\text {IN }}=13.2 \mathrm{~V}$ | 0.1 | \% |
| SWITCHING |  |  |  |
| Switching Frequency |  | 2.0 | MHz |
| Soft-start Time |  | 1.4 | ms |
| CURRENT LIMIT |  |  |  |
| Peak Current Limit (VOUT) | $\mathrm{EN}=5 \mathrm{~V}$ | 3.25 | A | PROTECTIONS


| Input Undervoltage Lockout (UVLO) | $\mathrm{V}_{\text {IN }}$ Decreasing | 3.4 | V |
| :--- | :---: | :---: | :---: |
| Thermal Shutdown | $\mathrm{T}_{\mathrm{J}}$ Rising | 170 | ${ }^{\circ} \mathrm{C}$ |

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.


Figure 4. NCV890204GEVB Evaluation Board Schematic

## NCV890204GEVB

## OPERATIONAL GUIDELINES

1. Connect a dc input voltage, within the 6.0 V to 36 V range, between VIN and GND.
2. Connect a dc enable voltage, within the 2.0 V to 36 V range, between EN and GND. This will
power up the switcher. The VOUT signal should be 3.3 V .
3. Add a load to VOUT - up to 2.0 A .


Figure 5. NCV890204 Board Connections

## ADDITIONAL GUIDELINES

## Output Voltage Selection

The voltage output for the switcher is adjustable and can be set with a resistor divider. The FB reference for the switcher is 0.8 V .


Use the following equation:

$$
R_{\text {UPPER }}=R_{\text {LOWER }} \frac{V_{\mathrm{OUT}}-\mathrm{V}_{\mathrm{FB}}}{\mathrm{~V}_{\mathrm{FB}}}
$$

Some common setups are listed below:

| Desired <br> Output (V) | VREF (V) | $\mathbf{R}_{\text {UPPER }}$ <br> $\mathbf{( k \Omega , 1 \% )}$ | $\mathbf{R}_{\text {LOWER }}$ <br> $\mathbf{( k \Omega , 1 \% )}$ |
| :---: | :---: | :---: | :---: |
| 1.2 | 0.8 | 5.11 | 10.0 |
| 1.5 | 0.8 | 8.87 | 10.0 |
| 1.8 | 0.8 | 12.7 | 10.0 |
| 2.5 | 0.8 | 21.5 | 10.0 |
| 3.3 | 0.8 | 31.6 | 10.0 |
| 5.0 | 0.8 | 52.3 | 10.0 |

## Spread Spectrum

In SMPS devices, switching translates to higher efficiency. Unfortunately, the switching leads to a much noisier EMI profile. We can greatly decrease some of the radiated emissions with some spread spectrum techniques. Spread spectrum is used to reduce the peak electromagnetic emissions of a switching regulator.


The spread spectrum used in the NCV890204 is an "up-spread" technique, meaning the switching frequency is spread upward from the 2.0 MHz base frequency. For example, a $5 \%$ spread means that the switching frequency is swept (spread) from 2.0 MHz up to 2.1 MHz in a linear fashion - this is called the modulation depth. The rate at which this spread takes place is called the modulation frequency. For example, a 10 kHz modulation frequency means that the frequency is swept from 2.0 MHz to 2.1 MHz in $50 \mu \mathrm{~s}$ and then back down from 2.1 MHz to 2.0 MHz in $50 \mu \mathrm{~s}$.


The modulation depth and modulation frequency are each set by an external resistor to GND. The modulation frequency can be set from 5 kHz up to 50 kHz using a resistor from the RMOD pin to GND. The modulation depth can be set from $3 \%$ up to $30 \%$ of the nominal switching frequency using a resistor from the RDEPTH pin to GND. Please see the curves below for typical values:


Figure 6. Modulation Frequency vs. RMOD Value


Figure 7. Modulation Depth vs. RDEPTH Value
Spread spectrum is automatically turned off when there is a short to GND or an open circuit on either the RMOD pin or the RDEPTH pin. Please be sure that the ROSC pin is an open circuit when using spread spectrum.

## NCV890204GEVB

TYPICAL PERFORMANCE

## Efficiency



Figure 8. Efficiency with a 3.3 V Output


Figure 9. Efficiency with a 5.0 V Output

## Line Regulation



Figure 10. Line Regulation for a 3.3 V Output


Figure 11. Line Regulation for a 5.0 V Output

## NCV890204GEVB

## Load Regulation



Figure 12. Load Regulation with a 3.3 V Output


Figure 13. Load Regulation with a 5.0 V Output

SCHEMATIC


Figure 14. Schematic

PCB LAYOUT

NCV890204 Demo Board Rev. 1 - 02/10/14
TOP Layer


Figure 15. Top View

NCV890204 Demo Board Rev. 1 - 02/10/14 BOTTOM Layer (mirrored)


Figure 16. Bottom View

## BILL OF MATERIALS

Table 4. BILL OF MATERIALS

| Reference Designator(s) | Qty. | Description | Value | Tolerance | Footprint | Manufacturer | Manufacturer's Part Number | Substitution Allowed |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CBST, CDRV | 2 | CAP $10 \mu \mathrm{~F}$ 10 V CERAMIC X7R 0603 | $0.1 \mu \mathrm{~F}$ | 10\% | 603 | Kemet | C0603C104K8RACTU | Yes |
| CCOMP | 1 | $\begin{gathered} \text { CAP CER } \\ 330 \mathrm{pF} 50 \mathrm{~V} \\ \text { COG } 0603 \end{gathered}$ | 330 pF | 10\% | 603 | Murata Electronics North America | GCM1885C1H331JA16D | Yes |
| CDLY | 1 | $\begin{gathered} \text { CAP CER } \\ 0.47 \mu \mathrm{~F} 25 \mathrm{~V} \\ 10 \% \text { X7R } 0603 \end{gathered}$ | $0.47 \mu \mathrm{~F}$ | 10\% | 603 | Murata Electronics North America | GCM188R71E474KA64D | Yes |
| CFLT1, CFLT2, CVIN1 | 3 | $\begin{gathered} \text { CAP CER } \\ 4.7 \mu \text { F } 50 \text { V } \\ 10 \% \text { X7R } 1210 \end{gathered}$ | $4.7 \mu \mathrm{~F}$ | 10\% | 1210 | Murata Electronics North America | GRM32ER71H475KA88L | Yes |
| COUT1, COUT2 | 2 | $\begin{gathered} \text { CAP CER } \\ 10 \mu \mathrm{~F} 10 \mathrm{~V} \text { X7R } \\ 1206 \end{gathered}$ | $10 \mu \mathrm{~F}$ | 10\% | 1206 | Murata Electronics North America | GRM31CR71A106KA01L | Yes |
| CVIN2 | 1 | $\begin{gathered} \text { CAP CER } \\ 1.0 \mu \mathrm{~F} 50 \mathrm{~V} \\ \text { X5R } 0805 \end{gathered}$ | $1.0 \mu \mathrm{~F}$ | 10\% | 805 | Murata Electronics North America | UMK212BJ105KG-T | Yes |
| DBST | 1 | DIODE SWITCH 200 mA 75 V SOD323 | $75 \mathrm{~V} / 0.2 \mathrm{~A}$ | N/A | SOD_323 | ON Semiconductor | BAS16HT1G | No |
| DFW | 1 | $\begin{gathered} \text { DIODE } \\ \text { SCHOTTKY } \\ 4.0 \mathrm{~A} 40 \mathrm{~V} \text { SMB } \end{gathered}$ | $40 \mathrm{~V} / 4.0 \mathrm{~A}$ | N/A | SMB_DIODE | ON Semiconductor | NRVB440MFST1G | No |
| L1 | 1 | $\begin{aligned} & \text { INDUCTOR } \\ & \text { POWER } 4.7 \mu \mathrm{H} \\ & \text { 4.5 A SMD } \end{aligned}$ | $4.7 \mu \mathrm{H}$ | 4.5A | XAL4030-472 | Coilcraft | XAL4030-472ME | No |
| L2* | 1 | RES $0.0 \Omega$ 1/4 W JUMP 1206 SMD | $0 \Omega$ | 5\% | 1206 | Yageo | RC1206JR-070RL | Yes |
| RCOMP | 1 | $\begin{aligned} & \text { RES } 6.98 \mathrm{k} \Omega \\ & 1 / 10 \mathrm{~W} 1 \% \\ & 0603 \mathrm{SMD} \end{aligned}$ | $6.98 \mathrm{k} \Omega$ | 1\% | 603 | Vishay/Dale | CRCW06036K98FKEA | Yes |
| RFB1 | 1 | RES $100 \Omega$ <br> 1/10 W 1\% <br> 0603 SMD | $100 \Omega$ | 1\% | 603 | Vishay/Dale | CRCW0603100RFKEA | Yes |
| RFB2 | 1 | RES $31.6 \Omega$ 1/10 W 1\% 0603 SMD | $31.6 \Omega$ | 1\% | 603 | Vishay/Dale | CRCW060331R6FKEA | Yes |
| RRDEP, RRMOD, RRSTB | 3 | RES $10.0 \mathrm{k} \Omega$ OHM 1/10 W 1\% 0603 SMD | $10.0 \mathrm{k} \Omega$ | 1\% | 603 | Vishay/Dale | CRCW060310K0FKEA | Yes |
| ZFB1 | 1 | CAP CER 4700 pF 50 V 10\% X7R 0603 | 4700 pF | 10\% | 603 | Murata Electronics North America | GRM188R71H472KA01D | Yes |
| CSNB | 1 |  | Do Not Populate |  | 603 |  |  | Yes |
| RMIN1, RMIN2 | 2 |  | Do Not Populate |  | 1206 |  |  | Yes |
| RSNB | 1 |  | Do Not Populate |  | 603 |  |  | Yes |
| ```BST, COMP, DLY, FB, RDEP, RMOD, SW``` | 7 | CIRCUIT PIN PRNTD .020"D $.425^{\prime \prime}$ | Do Not Populate | N/A | TPA | Mill-Max Manufacturing Corp. | 3128-2-00-15-00-00-08-0 | Yes |
| GND1, GND2, VIN, VOUT | 4 | CONN JACK BANANA UNINS PANEL MOU | N/A | N/A | BANANA | Emerson Network Power Connectivity Soultions | 108-0740-001 | Yes |

Table 4. BILL OF MATERIALS (continued)

| Reference Designator(s) | Qty. | Description | Value | Tolerance | Footprint | Manufacturer | Manufacturer's Part Number | Substitution Allowed |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| GND3-GND6 | 4 | TERM SOLDER TURRET .219" .109"L | N/A | N/A | TURRET | Mill-Max Manufacturing Corp. | 2501-2-00-44-00-00-07-0 | Yes |
| EN, RSTB | 2 | PIN INBOARD 042" HOLE 1000/PKG | N/A | N/A | TP | Vector Electronics | K24C/M | Yes |
| NCV890204 | 1 | 1.2 A 2 MHz Automotive Buck Switching Regulator | NCV890204 | N/A | 12PINDFN4x4p65 | ON Semiconductor | NCV890204MWR2G | No |

*L2 is a placeholder footprint for an optional input inductor filter component. Boards are shipped with a shorting jumper installed to complete the input path.
NOTE: All devices are RoHS Compliant.

ON Semiconductor and (UiN are registered trademarks of Semiconductor Components Industries, LLC (SCILLC). SCILLC owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of SCILLC's product/patent coverage may be accessed at www.onsemi.com/site/pdf/Patent-Marking.pdf. SCILLC reserves the right to make changes without further notice to any products herein. SCILLC makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does SCILLC assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. "Typical" parameters which may be provided in SCILLC data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. SCILLC does not convey any license under its patent rights nor the rights of others. SCILLC products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the SCILLC product could create a situation where personal injury or death may occur. Should Buyer purchase or use SCILLC products for any such unintended or unauthorized application, Buyer shall indemnify and hold SCILLC and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that SCILLC was negligent regarding the design or manufacture of the part. SCILLC is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

## PUBLICATION ORDERING INFORMATION

## LITERATURE FULFILLMENT:

Literature Distribution Center for ON Semiconductor
P.O. Box 5163, Denver, Colorado 80217 USA

Phone: 303-675-2175 or 800-344-3860 Toll Free USA/Canada
Fax: 303-675-2176 or 800-344-3867 Toll Free USA/Canada Email: orderlit@onsemi.com
N. American Technical Support: 800-282-9855 Toll Free USA/Canada
Europe, Middle East and Africa Technical Support:
Phone: 421337902910
Japan Customer Focus Center
Phone: 81-3-5817-1050

ON Semiconductor Website: www.onsemi.com
Order Literature: http://www.onsemi.com/orderlit
For additional information, please contact your local Sales Representative

