

# NCV7471 EVB

## NCV7471 System Basis Chip Evaluation Board User's Manual



ON Semiconductor®

<http://onsemi.com>

### EVAL BOARD USER'S MANUAL

#### Introduction

This document describes the NCV7471 EVB board for the ON Semiconductor NCV7471 System basis chip with a high-speed CAN and two LIN transceivers with boost-buck converter and low-drop voltage regulator. The functionality and major parameters can be evaluated with the NCV7471 EVB board.

NCV7471 is a System Basis Chip (SBC) integrating functions typically found in automotive Electronic Control Units (ECUs) in the body domain. NCV7471 provides and monitors the low-voltage power supplies for the application microcontroller and other loads, monitors the application software via a watchdog and includes high-speed CAN and LIN transceivers allowing the ECU to host multiple communication nodes or to act as a gateway unit. The on-chip state controller ensures safe power-up sequence and supports low-power modes with a configurable set of features including wakeup from the communication buses or by a local digital signal WU. The status of several NCV7471 internal blocks can be read by the microcontroller through the serial peripheral interface or can be used to generate an interrupt request.

#### Evaluation Board Features

- One-row Pin Header, Providing the Circuit Signals, Enables Easy Insertion of the Evaluation Board into a more Complex Application Setup
- Oscilloscope Test-points on All Important Signals
- Reverse Protection and Decoupling on the Main (Battery) Supply
- All the Necessary VOUT Converter External Components – Assembly Options Available
- Decoupling on VOUT Converter and VOUT2 Regulator Outputs
- Additional Pull-up Resistors on the Open-drain Digital Outputs (RSTN, INTN, UVN\_VOUT)
- Filtering Circuit on the Switch-monitoring WAKE Input
- On-board Local Wakeup Switch
- CAN/LIN-bus Terminations
- Good Thermal Connection of the Circuit's Exposed Pad to the Bottom Ground Plane
- Basic Standalone Functionality using Software Development Mode

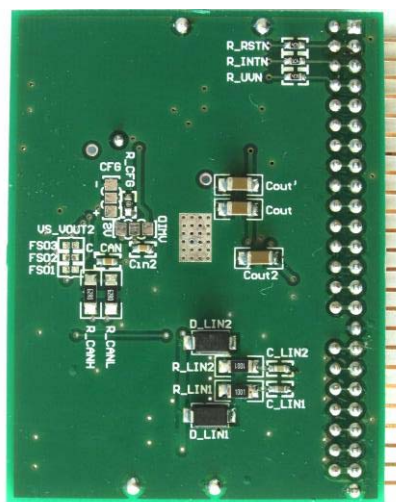


Figure 1. Evaluation Board Photo

# NCV7471 EVB

## SCHEMATIC

Complete schematic with all the assembly options are shown in Figure 2. Depending on VOUT maximum current and minimum battery operation voltage, few assembly options are available. Values of components may be

customized according to specific requirements. Equations with example calculations can be found in the application note [2].

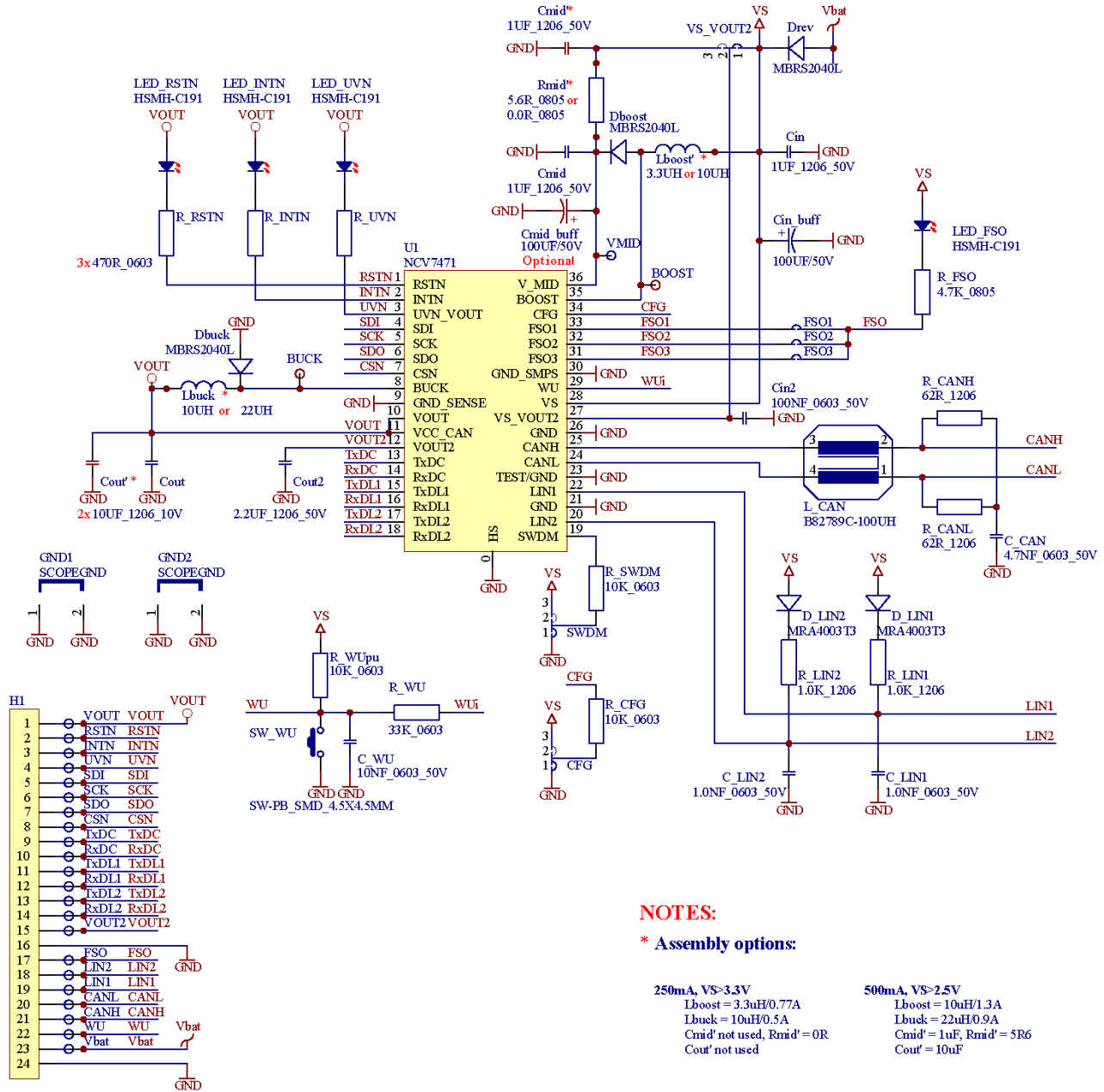


Figure 2. NCV7471 Evaluation Board Schematic

# NCV7471 EVB

**Table 1. ABSOLUTE MAXIMUM RATINGS**

| Rating                       | Pins  | Min  | Max                | Unit |
|------------------------------|---|------|--------------------|------|
| Supply voltage               | Vbat  | -40  | 40                 | V    |
| VOUT output voltage          | VOUT  | -0.3 | 6                  | V    |
| VOUT output current          | VOUT  | 0    | internally limited | mA   |
| VOUT2 output voltage         | VOUT2   | -1   | 40                 | V    |
| VOUT2 output current         | VOUT2   | 0    | internally limited | mA   |
| Digital inputs voltage       | RSTN, INTN, UVN, SDI, SCK, CSN, TxDC, TxDL1/2 | -0.3 | 6                  | V    |
| Digital outputs voltage      | SDO, RxDC, RxDL1/2                            | -0.3 | VOUT+0.3           | V    |
| Fail-safe pin output voltage | FSO   | -0.3 | 40                 | V    |
| LIN bus lines voltage        | LIN1, LIN2                                    | -45  | 45                 | V    |
| CAN bus lines voltage        | CANH, CANL                                    | -50  | 50                 | V    |
| Wake-up input voltage        | WU  | -40  | 40                 | V    |
| NCV7471 junction temperature |   | -40  | +170               | °C   |
| Board temperature            |   | -40  | +125               | °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 2. RECOMMENDED BOARD OPERATING CONDITIONS**

| Rating                       | Pins  | Min           | Max           | Unit |
|------------------------------|---|---------------|---------------|------|
| Supply voltage (Vbat)        | Vbat  | 3.0 / 3.8 (*) | 28            | V    |
| Supply voltage (VS)          | VS (board internal node)                      | 2.5 / 3.3 (*) | 28            | V    |
| VOUT output voltage          | VOUT  | 4.9           | 5.1           | V    |
| VOUT output current          | VOUT  | 0             | 250 / 500 (*) | mA   |
| VOUT2 output voltage         | VOUT2   | 4.9           | 5.1           | V    |
| VOUT2 output current         | VOUT2   | 0             | 50            | mA   |
| Digital inputs voltage       | RSTN, INTN, UVN, SDI, SCK, CSN, TxDC, TxDL1/2 | 0             | VOUT          | V    |
| Digital outputs voltage      | SDO, RxDC, RxDL1/2                            | 0             | VOUT          | V    |
| FSO pin output voltage       | FSO   | 0             | VS            | V    |
| LIN bus lines voltage        | LIN1, LIN2                                    | 0             | VBAT          | V    |
| CAN bus lines voltage        | CANH, CANL                                    | 0             | 5             | V    |
| Wake-up input voltage        | WU  | 0             | VBAT          | V    |
| NCV7471 junction temperature |   | -40           | +150          | °C   |
| Board temperature            |   | -40           | +105          | °C   |

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

\*See assembly options

# NCV7471 EVB

## OPERATIONAL GUIDELINES

NCV7471 is complex SCB device, which needs external MCU, connected through H1 connector, to control all functions and settings. However, with basic function of the converter, LIN and CAN operation, NCV7471 may work in so called Software Development Mode (SWDM). To configure NCV7471 into this mode, SWDM pin has to be tight to VS. Details about board configuration can be found in the following chapter.

Behavior of NCV7174 in Software Development mode is following:

- Buck converter is active, delivering +5 V on VOUT.
- Boost converter may be disabled/enabled by connecting CFG pin to GND/VS (“-”/“+” positions of CFG soldering strap)
- VOUT2 LDO is disabled by default

- CAN transceiver is configured into LIN Normal mode – receiver and transmitter are enabled.
- LIN1/2 transceiver is configured into LIN Normal mode – receiver and transmitter are enabled.
- Watchdog does not need to be served, the device remains in Normal mode, until it is changed via SPI command.
- RSTN, INTN, VOUT\_UVN, FSO1–3 provide their standard functionality, except of RSTN and FSO1–3 pins, which are not active due to not-serving the watchdog.

### Board Configuration

The NCV7471 evaluation board provides few hardware configuration options, using soldering straps. Their functions are described in the table below.

**Table 3. SOLDERING STRAPS FUNCTIONS**

| Solder Strap    | Position                   | Function   |
|-----------------|----------------------------|--|
| <b>SWDM</b>     | “-” or not connected (GND) | Normal operation mode with external MCU connected (Watchdog service needed)  |
|                 | “+” (VS)                   | Software Development Mode (Watchdog does not need to be served, CAN and LIN1/2 enabled in Normal mode by default)  |
| <b>CFG</b>      | “-” or not connected (GND) | <b>SWDM = GND:</b> Config2/4 (Fail-safe mode entered after 1 <sup>st</sup> /2 <sup>nd</sup> watchdog service failure)<br><b>SWDM = VS:</b> Boost stage disabled    |
|                 | “+” (VS)                   | <b>SWDM = GND:</b> Config1/3 (Fail-safe mode not entered after 1 <sup>st</sup> /2 <sup>nd</sup> watchdog service failure)<br><b>SWDM = VS:</b> Boost stage enabled |
| <b>VS_VOUT2</b> | VS                         | Input of VOUT2 LDO regulator connected to VS   |
|                 | VMID                       | Input of VOUT2 LDO regulator connected to V_MID  |
| <b>FSO1–3</b>   | FSO1                       | FSO constantly Low at failure  |
|                 | FSO2                       | FSO Low for 50%, frequency of 1.25 Hz at failure   |
|                 | FSO3                       | FSO Low for 20%, frequency of 100 Hz at failure  |

Special care has to be taken for Standby or Sleep mode quiescent consumption measurements. Both SWDM and CFG pins have internal pull-down resistors (typ. 100 kΩ), which influence input supply current if they are connected to VS (typically Software Development Mode with Boost

stage enabled). To measure pure NCV7471 consumption, these pins should stay Low (GND) or may be pulled up by external voltage source.

Four on-board LEDs indicate faulty states of the board, as described in the Table 4.

# NCV7471 EVB

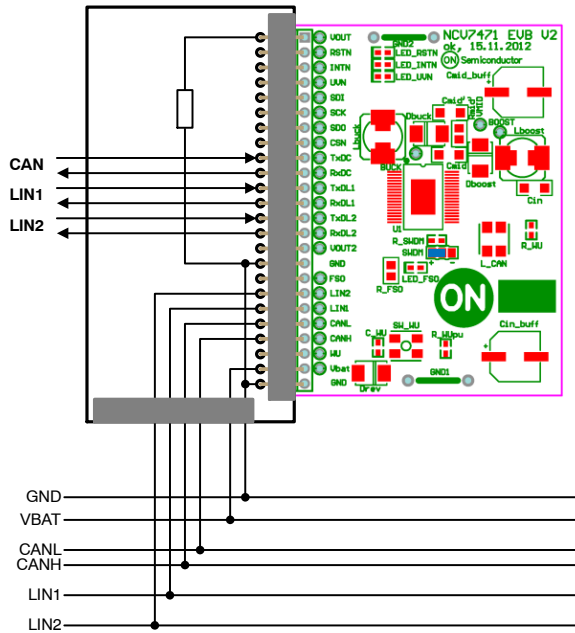
**Table 4. LED FUNCTIONS**

| LED Name | Function   |
|----------|--|
| LED_RSTN | Indicates activation of RSTN pin due to the following reasons: <ul style="list-style-type: none"> <li>• Sleep/Fail-safe mode (LED_RSTN off due to missing VOUT supply),</li> <li>• Reset mode (internal or external activation) (5 ms on)</li> </ul>   |
| LED_INTN | Indicates activation of INTN pin due to the following reasons: <ul style="list-style-type: none"> <li>• Sleep/Fail-safe mode (LED_INTN off due to missing VOUT supply),</li> <li>• Wake-up event (CAN, LIN1/2, WU, Timer) – configurable via SPI</li> <li>• Interrupt request – has to be enabled via SPI (1 ms on, 5 ms off)</li> </ul> |
| LED_UVN  | Indicates activation of VOUT_UVN pin due to the following reasons: <ul style="list-style-type: none"> <li>• Sleep/Fail-safe mode (LED_UVN off due to missing VOUT supply),</li> <li>• Undervoltage on VOUT pin (VOUT &lt; 4.65 V)</li> </ul>   |
| LED_FSO  | FSOx pin active due to failure condition (depends on CFG and SPI configuration): <ul style="list-style-type: none"> <li>• Thermal Shutdown</li> <li>• Fatal VOUT failure</li> <li>• RSTN clamped Low / High</li> <li>• Watchdog failure (ignored if SWDM is High)</li> <li>• SPI control bit FSO_ON is set</li> </ul>                    |

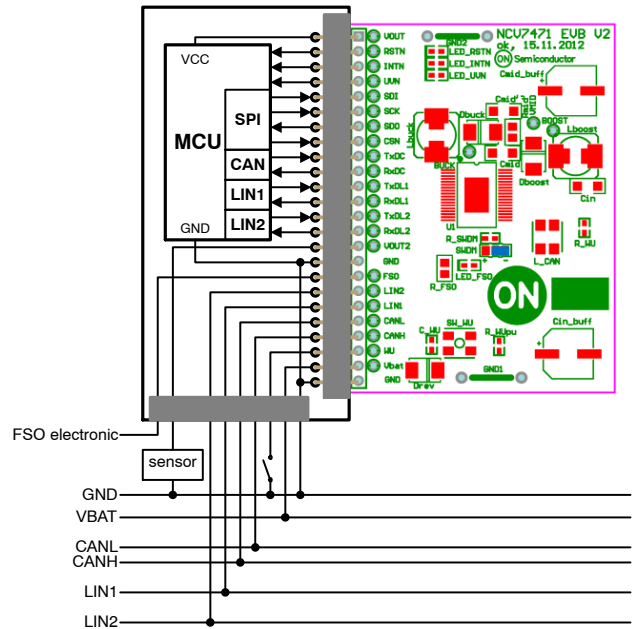
## External Board Connections

Configuration with and without the control MCU is shown in the figures below. SWDM and CFG soldering straps need to be configured to work correctly in both setups.

For basic evaluation, the board may operate without external control in the Software Development Mode (Figure 3). If full functionality is needed, an external microcontroller has to be attached to the board (Figure 4).



**Figure 3. Standalone NCV7471 Evaluation Setup (Software Development Mode used, limited functionality)**



**Figure 4. NCV 7471 Full Evaluation Setup**

## FUNCTIONAL DESCRIPTION

### VS Supply Input

VS pin of NCV7471 is typically connected to the car battery through a reverse-protection diode and can be exposed to all relevant automotive disturbances (ISO7637 pulses, system ESD ...). VS supplies mainly the integrated LIN transceivers.

### VOUT DC/DC Converter

The main application low-voltage supply is provided by an integrated boost-buck DC/DC converter, delivering a 5 V output VOUT. The converter can work in two modes:

- **Buck-only mode** is the default mode of the VOUT power-supply. In this mode, the boosting part of the converter is never activated and the resulting VOUT voltage can be only lower than the input line voltage. Buck-only mode is applied during the initial power-up (after the VS connection), wakeup from Sleep-mode and also recovery from the Fail-safe mode, as well as in the Software Development Mode with CFG pin at Low level.
- **Boost-buck mode** ensures that the correct VOUT voltage is generated even if the input line voltage falls below the required VOUT level. This mode can be requested through the corresponding SPI control register. If selected, the boost-buck mode is used during Reset, Start-up, Normal, Standby, and Flash modes. It is also preserved during VOUT under-voltage recovery through Power-up mode. In SW Development configuration, boost-buck mode can be additionally enabled by High level on CFG pin. No SPI communication is therefore necessary to select the DC/DC mode in SW Development (see Table 5).

**Table 5. CONTROL OF DC/DC CONVERTER MODES**  
("X" means "Don't care")

| Device Configuration | SPI bit en-BOOST | CFG Pin Signal | Applied DC/DC Mode |
|----------------------|------------------|----------------|--------------------|
| Config 1, 2, 3, 4    | Low              | X              | <b>Buck-Only</b>   |
|                      | High             |                | <b>Boost-Buck</b>  |
| SW Development       | Low              | Low            | <b>Buck-Only</b>   |
|                      |                  | High           | <b>Boost-Buck</b>  |
|                      | High             | X              | <b>Boost-Buck</b>  |

By default, the converter works with a fixed switching frequency 485 kHz nominal. Through the SPI settings, a switching frequency modulation can be applied with fixed

modulation frequency of 10 kHz and three SPI-selectable modulation depth values – 10%, 20% or 30% of the nominal frequency.

VOUT level is monitored by an under-voltage detector with multiple thresholds:

- Comparison with selectable threshold *VOUT\_RESx*. By default, the lowest threshold (typ. 3.1 V) applies for the state machine control and the activation of the RSTN signal (LED\_RSTN on). This reset threshold can be changed via SPI to any of the four programmable values.
- A second monitoring signal – UVN\_VOUT (LED\_UVN on) – is generated based on comparison of the VOUT level with the highest monitoring level (typ. 4.65 V).
- VOUT is compared with a fixed threshold *VOUT\_FAIL* (typ. 2 V). If VOUT stays below *VOUT\_FAIL* level for longer than *t\_VOUT\_powerup* (typ. 1.5 s), a VOUT short-circuit is detected and Fail-safe mode is entered (LED\_FSO on, if connected).

Both UVN\_VOUT and RSTN pins provide an open drain output with integrated pull-up resistor. The split between reset-generating level *VOUT\_RESx* and an under-voltage indication allows coping with VOUT dips in case of high loads coinciding with low input line voltages.

### VOUT2 Low-drop Regulator

An integrated low-drop regulator provides a second 5 V supply VOUT2 to external loads, typically sensors. The regulator's input is taken from a dedicated pin VS\_VOUT2, which does not feature an explicit under-voltage monitoring. VS\_VOUT2 would be typically connected to the VS pin or might be taken from other nodes like, e.g., the DC/DC converter's auxiliary node V\_MID. "VS\_VOUT2" soldering strap allows connecting VOUT2 LDO input supply to the VS or the V\_MID point.

After a power-up or a reset event, as well as in Sleep mode, VOUT2 regulator is switched off. In Start-up, Normal, Standby and Flash modes, it can be freely activated or deactivated via SPI control register.

### Operating States

NCV7471 provides five static operating modes and three transition states – see Figure 5. Mode setting is done via SPI registers. Additional details of the NCV7471 operation and parameters can be found in the corresponding datasheet [1].

# NCV7471 EVB

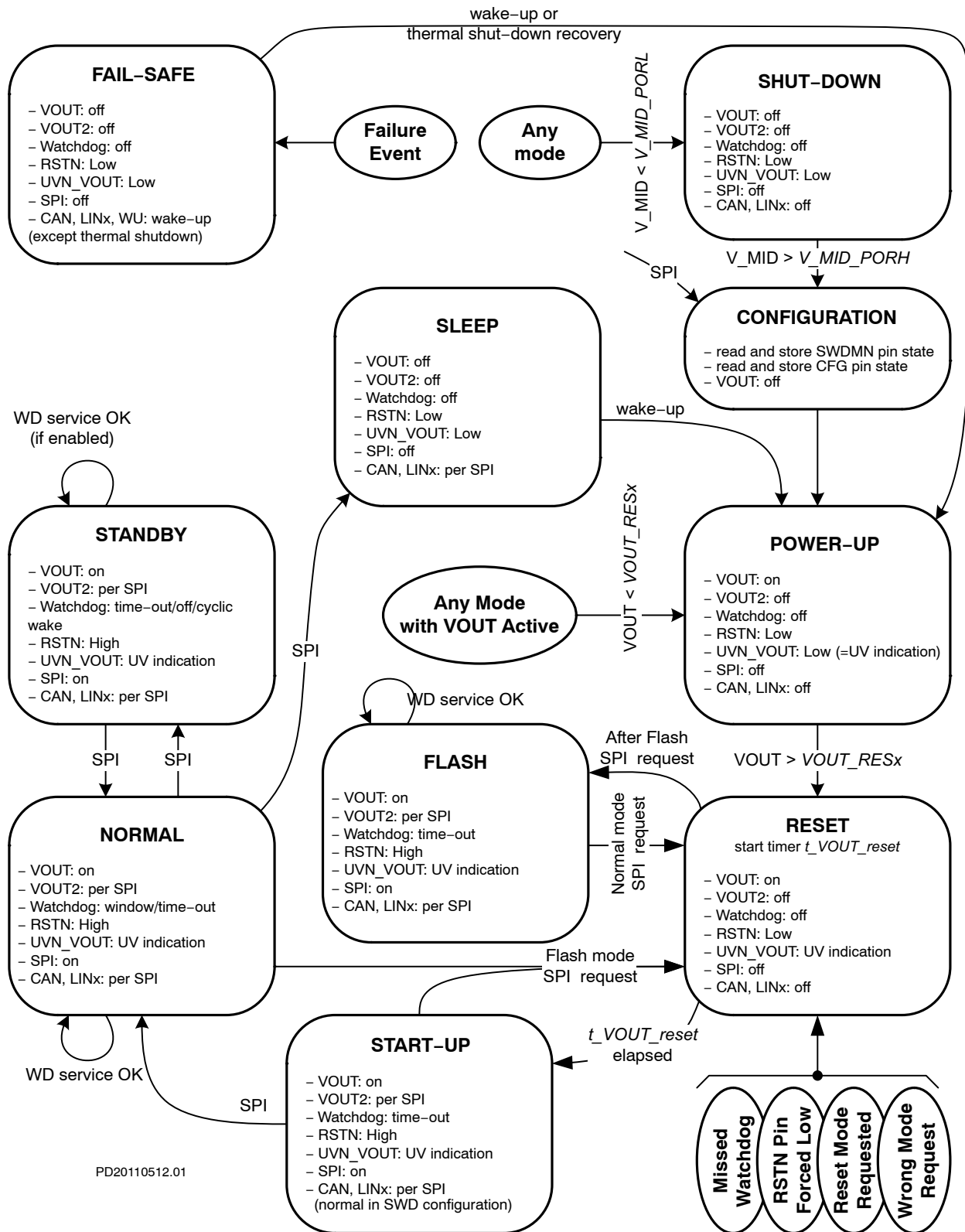


Figure 5. NCV7471 State Diagram

# NCV7471 EVB

## PCB DRAWINGS

### Assembly Drawings

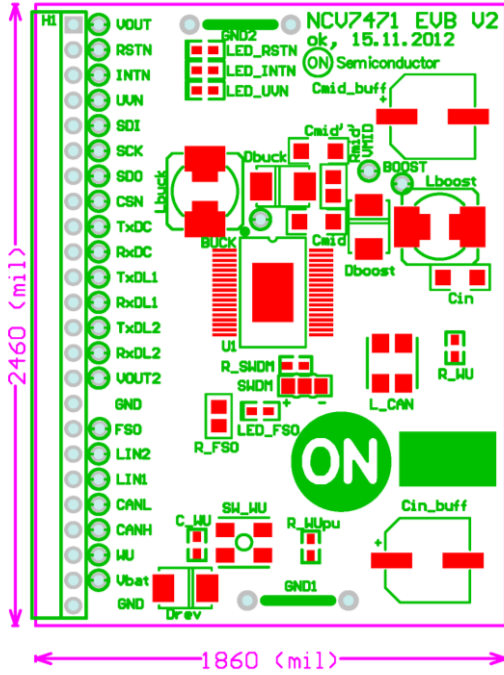


Figure 6. NCV7471 EVB PCB Top Assembly Drawing

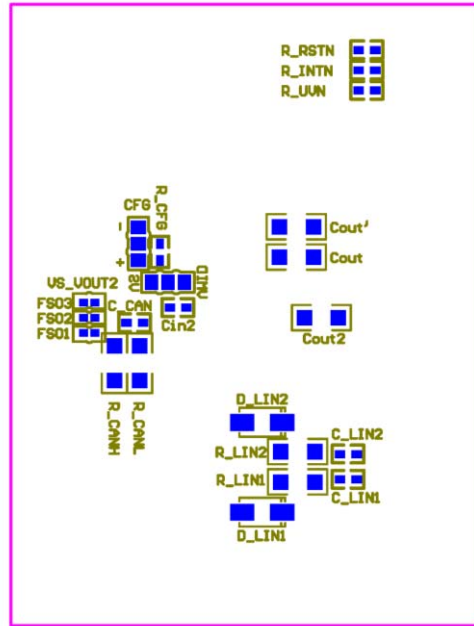


Figure 7. NCV7471 EVB PCB Bottom Assembly Drawing (bottom view)

### Composite Drawings

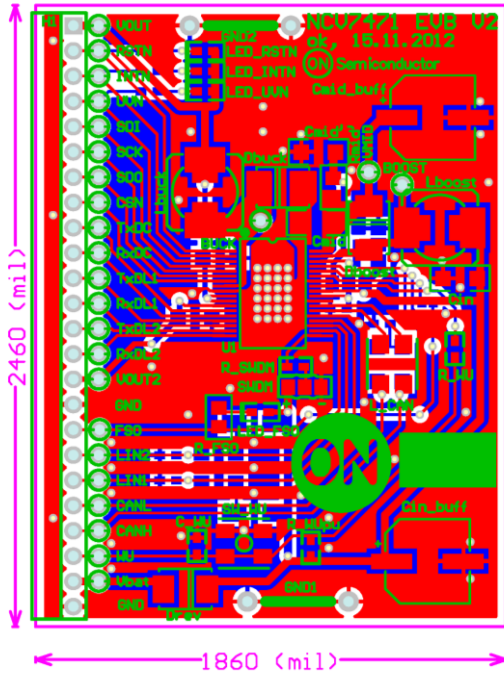


Figure 8. NCV7471 EVB PCB Top Composite Drawing

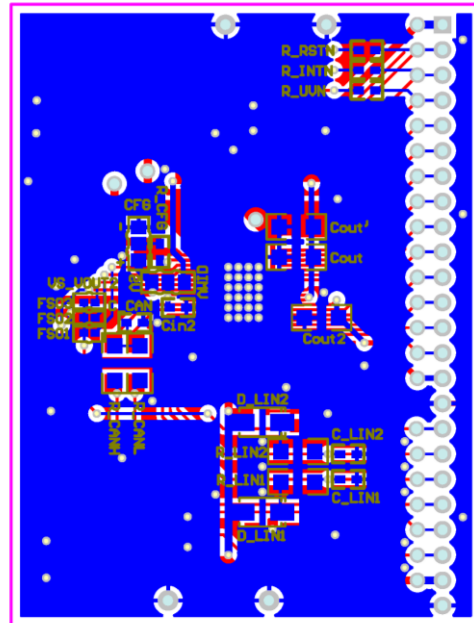



Figure 9. NCV7471 EVB PCB Bottom Composite Drawing (bottom view)



# NCV7471 EVB

## References

- [1] On Semiconductor, NCV7471 Product Datasheet Rev.2, September 2013
- [2] On Semiconductor, NCV7471 Application Note i0.8, September 2013

**ON Semiconductor** and  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](http://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](mailto:orderlit@onsemi.com)

**N. American Technical Support:** 800-282-9855 Toll Free  
USA/Canada  
**Europe, Middle East and Africa Technical Support:**  
Phone: 421 33 790 2910  
**Japan Customer Focus Center**  
Phone: 81-3-5817-1050

**ON Semiconductor Website:** [www.onsemi.com](http://www.onsemi.com)  
**Order Literature:** <http://www.onsemi.com/orderlit>  
For additional information, please contact your local  
Sales Representative

## Данный компонент на территории Российской Федерации

### Вы можете приобрести в компании MosChip.

Для оперативного оформления запроса Вам необходимо перейти по данной ссылке:

<http://moschip.ru/get-element>

Вы можете разместить у нас заказ для любого Вашего проекта, будь то серийное производство или разработка единичного прибора.

В нашем ассортименте представлены ведущие мировые производители активных и пассивных электронных компонентов.

Нашей специализацией является поставка электронной компонентной базы двойного назначения, продукции таких производителей как XILINX, Intel (ex.ALTERA), Vicor, Microchip, Texas Instruments, Analog Devices, Mini-Circuits, Amphenol, Glenair.

Сотрудничество с глобальными дистрибьюторами электронных компонентов, предоставляет возможность заказывать и получать с международных складов практически любой перечень компонентов в оптимальные для Вас сроки.

На всех этапах разработки и производства наши партнеры могут получить квалифицированную поддержку опытных инженеров.

Система менеджмента качества компании отвечает требованиям в соответствии с ГОСТ Р ИСО 9001, ГОСТ РВ 0015-002 и ЭС РД 009

### Офис по работе с юридическими лицами:

105318, г.Москва, ул.Щербаковская д.3, офис 1107, 1118, ДЦ «Щербаковский»

Телефон: +7 495 668-12-70 (многоканальный)

Факс: +7 495 668-12-70 (доб.304)

E-mail: [info@moschip.ru](mailto:info@moschip.ru)

Skype отдела продаж:

moschip.ru

moschip.ru\_4

moschip.ru\_6

moschip.ru\_9