# NCV7535EVB

# NCV7535 SPI Controlled H-Bridge Pre-Driver Evaluation Board User's Manual

ON Semiconductor®

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## EVAL BOARD USER'S MANUAL

### Introduction

This document describes the NCV7535 EVB board for the ON Semiconductor NCV7535 SPI controlled H−bridge and Dual−Half Bridge pre−driver. The functionality and major parameters can be evaluated with the NCV7535 EVB board.

The NCV7535 is a monolithic SPI controlled chip with enhanced feature set useful in automotive systems. Besides the SPI bus interface, the IC features an H−bridge pre−driver to control a DC−motor. This allows a highly integrated solution.

### Evaluation Board Features

- N−MOSFET Reverse Protection and Decoupling on the Main (Battery) Supply
- On−board +5 V LDO
- MCU with USB Interface Controlling NCV7535
- One−row Pin Header, providing the Circuit Signals, enables Easy Insertion of the Evaluation Board into a more Complex Application Setup
- On−board Current Sensing Shunt Resistor and Operational Amplifier
- Good Thermal Connection of the Power MOSFETs allowing High Current Capability
- Oscilloscope Test−points on all Important Signals
- M4 Screw Connectors for Power Signals (Battery, Ground, Output)

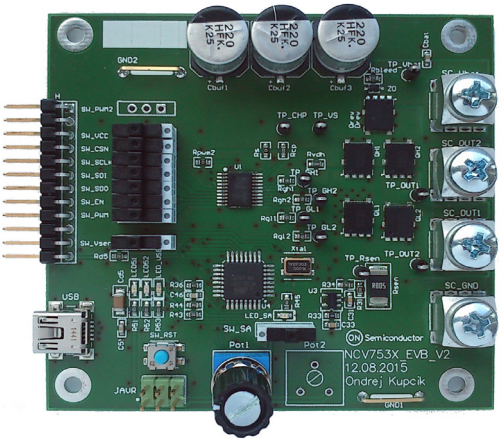


**Figure 1. Evaluation Board Photo**

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## SCHEMATIC

The evaluation board consists of two main blocks: NCV7535 application and control MCU including USB interface (see Figure 2).

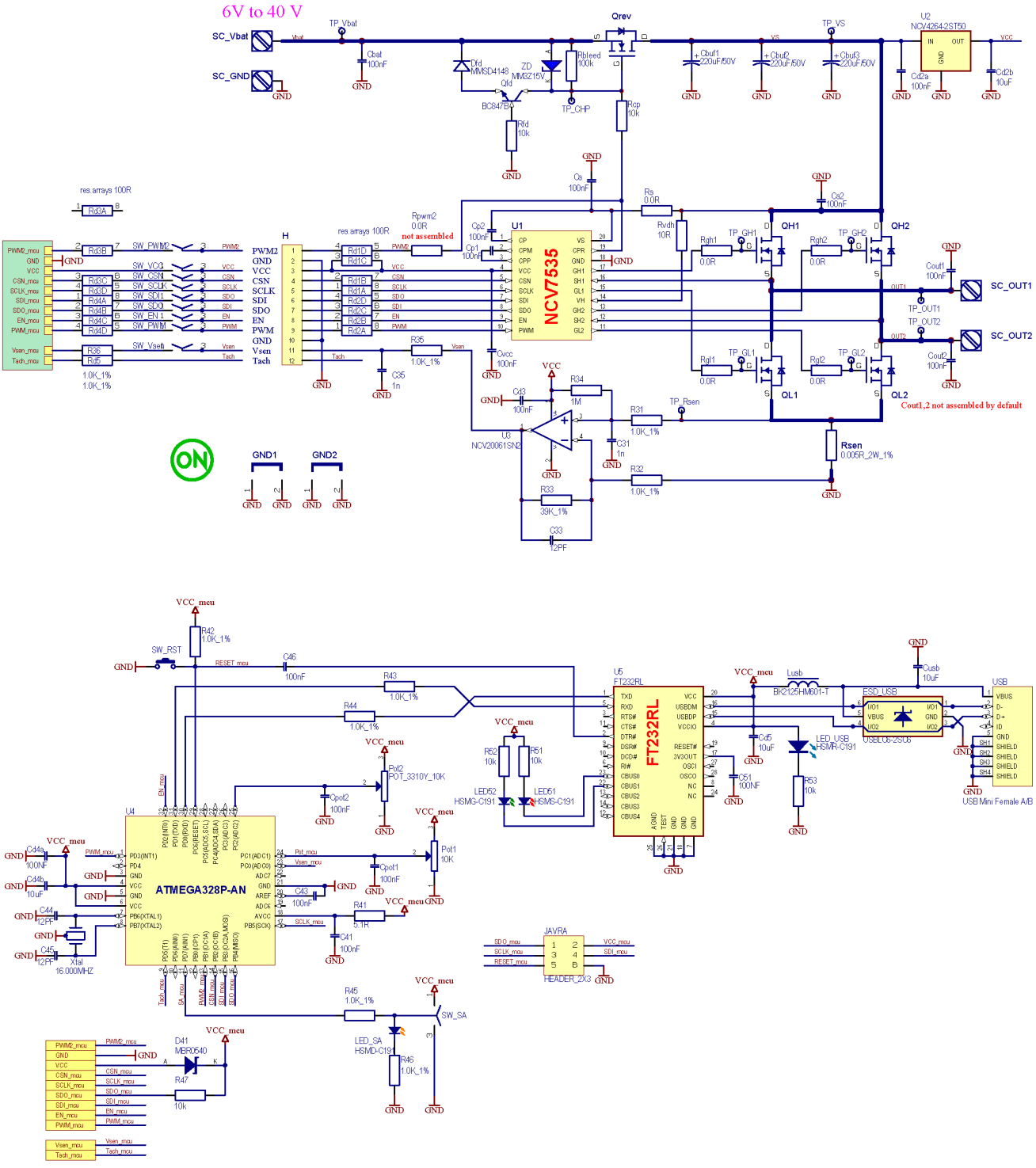


**Figure 2. NCV7535 Evaluation Board Schematic**

**Table 1. ABSOLUTE MAXIMUM RATINGS**

| Rating | External Pin | Min | Max | Unit |
|---|---|---|---|---|
| Power Supply voltage | Vbat | −40 | 40 | V |
| Digital Supply voltage | VCC | −0.3 | 5.5 | V |
| Digital inputs/outputs voltage | CSB, SCLK, SDI, SDO, EN, PWM | −0.3 | VCC + 0.3 | V |
| Current sense output voltage | Vsen | −0.3 | VCC + 0.3 | |
| Current sense output current | Vsen | Internally limited | | A |
| H−bridge outputs DC voltage | OUT1,2 | −0.3 | Vbat + 0.3 | V |
| H−bridge outputs DC current | OUT1,2 | −20 | 20 | A |
| NCV7535 junction temperature | | −40 | 150 | °C |
| Qrev, QH1/2, QL1/2 junction temperature | | −55 | 175 | °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 | External Pin | Min | Max | Unit |
|---|---|---|---|---|
| Supply voltage | Vbat | 6 | 28 | V |
| Digital Supply voltage | VCC | 5 V ± 5% (on−board supply) | | V |
| Digital inputs/outputs voltage | CSB, SCLK, SDI, SDO, EN, PWM | 0 | VCC | V |
| Current sense output voltage | Vsen | Generated internally | | |
| Current sense output current | Vsen | Internally limited | | A |
| H−bridge outputs voltage | OUT1,2 | 0 | Vbat | V |
| H−bridge outputs current | OUT1,2 | Limited by max. junction/board temperature | | A |
| NCV7535 junction temperature | | −40 | 150 | °C |
| Qrev, QH1/2, QL1/2 junction temperature | | −55 | 175 | °C |
| Board temperature | | −40 | 125 | °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.

## OPERATIONAL GUIDELINES

NCV7535 is a monolithic SPI controlled H−bridge pre−driver for a DC−motor with enhanced feature set useful in automotive systems.

The evaluation board contains all the components necessary for NCV7535 application: a control MCU, USB interface, +5 V LDO supply for VCC and current sensing operational amplifier.

An external MCU can be connected through H connector to controls all functions and settings of NCV7535.

### Board Configuration

The NCV7535 evaluation board allows two modes of operation:

- Standalone / full−demonstration using on−board MCU
  - All the slide switches (incl. SW_SA) have to be set to the position as shown in Figure 3.
  - MCU is controlled via mini USB connector “USB”
  - NCV7535 digital signals are still accessible via “H” connector
- NCV7535 evaluation only; external control
  - All the switches (incl. SW_SA) have to be set to the position as shown in Figure 3.
  - External SPC control has to be connected via “H” USB connector

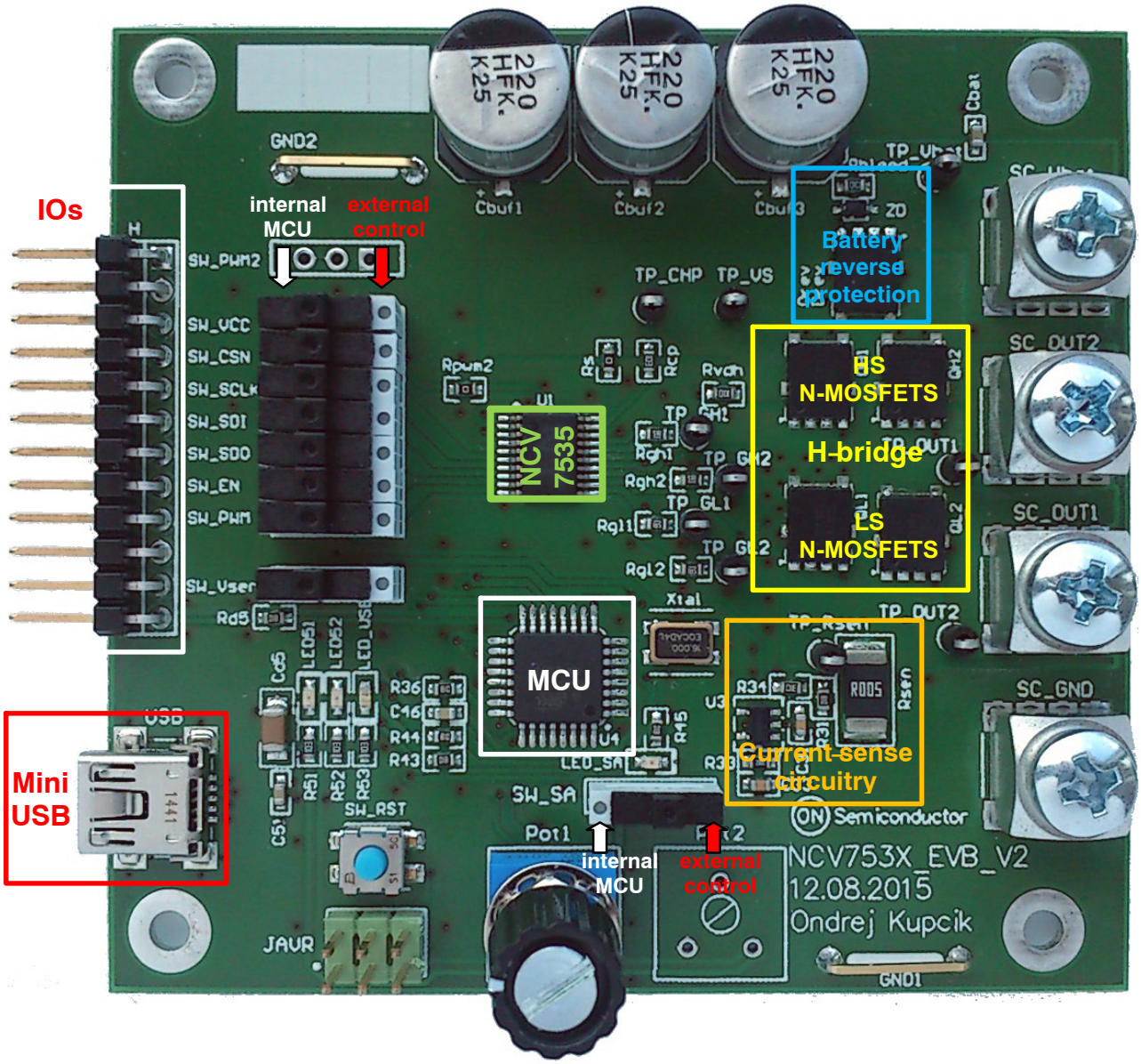


**Figure 3. NCV7535 Evaluation Board Picture, Top Side**

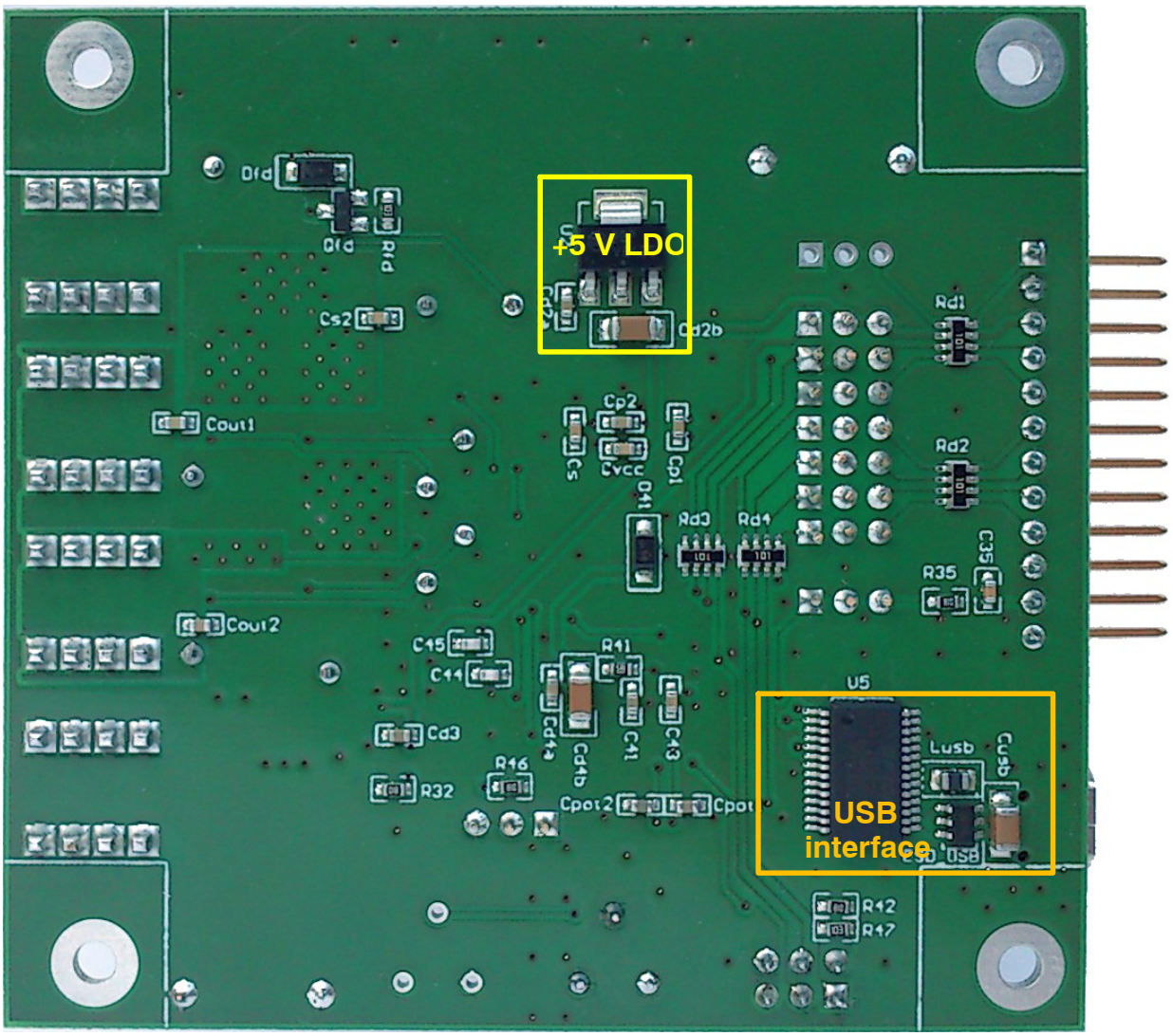


**Figure 4. NCV7535 Evaluation Board Picture, Bottom Side**

## FUNCTIONAL DESCRIPTION

### Power Supply

The output stage of NCV7535 pre−driver is supplied via VS pin. Normally, this pin is directly connected to the H−bridge supply. N−MOSFET Qrev ensures battery−reverse protection.

By default, H−bridge power supply is buffered by three 220 μF capacitors covering high current peaks caused by the inrush current or PWM operation.

The VS pin of NCV7535 can be filtered using a non−zero value of Rs resistor.

### Current Sensing Amplifier

NCV7535 evaluation board contains low−side sense resistors and operational amplifier for H−bridge current sensing.

The power MOSFETs as well as sensing resistor Rsen value are selected according to maximum application DC current. Higher current is possible for limited time as long as the junction temperatures are not exceeded.

The current−sensing amplifier has a fixed gain of 40 and the output is referenced to GND. The maximum offset of used operational amplifier (NCV20061) is ±4 mV, which is equivalent to the load current of 0.8 A (with Rsen = 5 mΩ). To sense low currents (< 1 A), a positive offset can be is introduced via R34. MCU can then cancel the input offset by measuring Vsen voltage with H−bridge disabled. The resulting A−V ratio (with Rsen = 5 mΩ) is:

Vsen = 0.2 x Iout + 0.2 V (can be calibrated on fly)

### Operating States

NCV7535 provides two static operating modes selectable via SPI registers and EN pin.

After power−up, the device enters low−power Standby mode with the H−bridge disabled.

To enter the Active mode, EN pin has to be pulled high and CONTROL_0.MODE bit set. Typically, EN pin can be controlled the MCU reset signal to ensure the motor is running under MCU supervision only.

Additional details of the NCV7535 operation and parameters can be found in the corresponding datasheet [1].

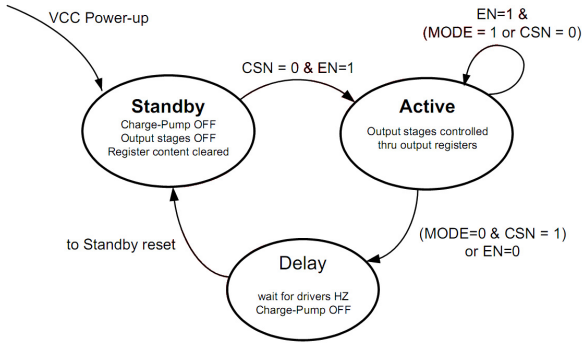


**Figure 5. NCV7535 State Diagram**

## GETTING STARTED

The board supports three ways of NCV7535 device control:

1. PC control – the user have full control over NCV7535 settings using PC connected to the board via USB.
2. Standalone mode – PWM duty−cycle (motor speed) can be changed via on−board potentiometers. Mo other device setting is available.
3. External MCU control – external MCU controls the all the NCV7535 settings directly via SPI and PWM pins.

### PC Control Mode

1. Move slide switches “SW_xx” to the left position (see Figure 3.)
2. Move slide switch “SW_SA” to the left position
3. Connect the load to “OUT1/2” bush connectors
4. Connect the main supply to “Vbat” and “GND” bush connectors
5. Connect the board by Mini−USB connector to the PC, wait for drivers installation, if needed
6. Run the “Motor GUI” software
7. In the startup window select “NCV7535” controller
8. The software should connect to the board. If the connection was successful, the controller window opens.
9. To control the load, use “Hardware Controls” and “Demo” (See Figures 6 and 8). Here is an example of the settings:
   a. Check “PWM On/Off” in “Hardware Controls”,
   b. Set “Speed Control” to > 0% in “Demo”,
   c. Check “Forward” or “Reverse” in “Demo”

### Standalone Mode

1. Move slide switches “SW_xx” to the left position (see Figure 3.)
2. Move slide switch “SW_SA” to the right position
3. Connect the load to “OUT1/2” bush connectors
4. Connect the main supply to “Vbat and “GND” bush connectors
5. “LED_SA” indicates the Standalone mode
6. The motor speed (PWM duty−cycle) can be changed by “Pot1”

When changing the mode, the supply of the board needs to be disconnected of MCU reset by “SW_RST” button.

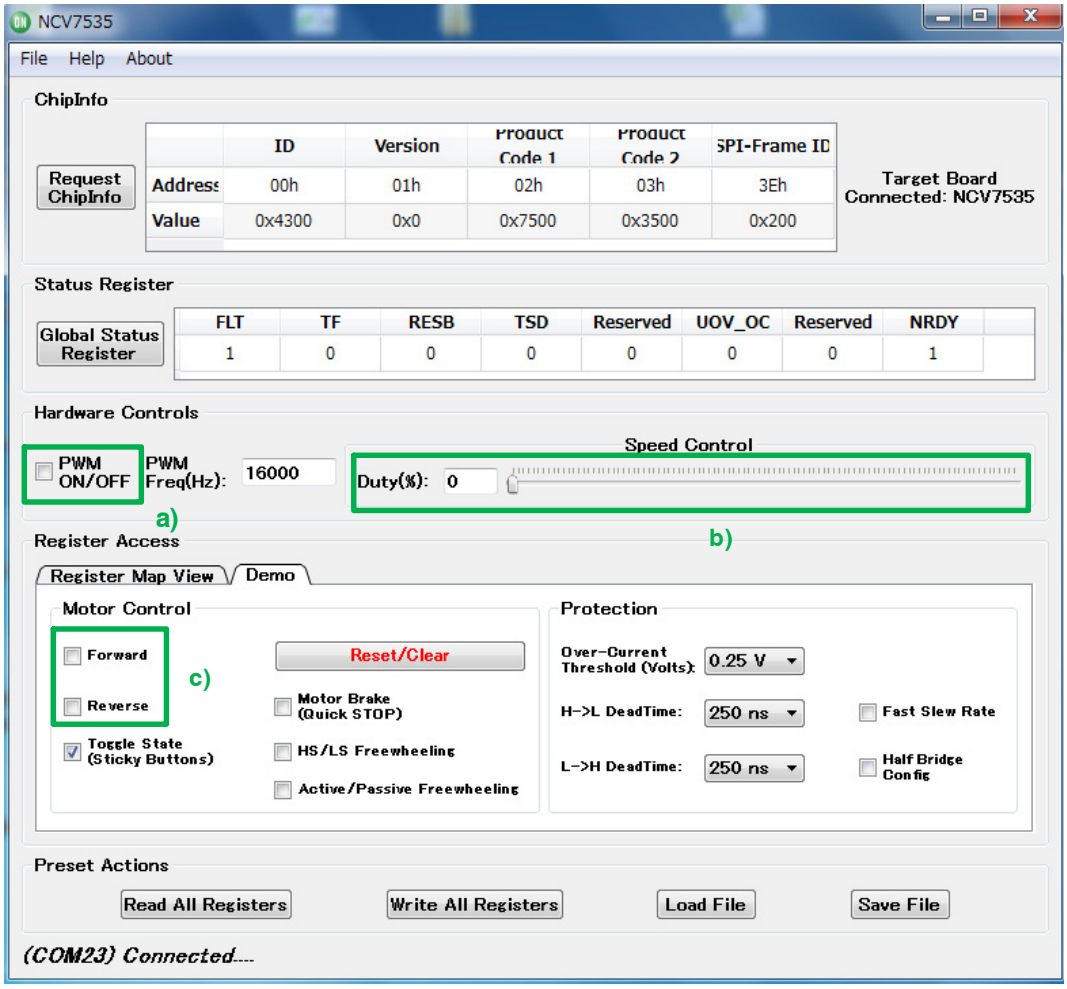


**Figure 6. NCV7535 Controller Window**

## PCB DRAWINGS

### Assembly Drawings

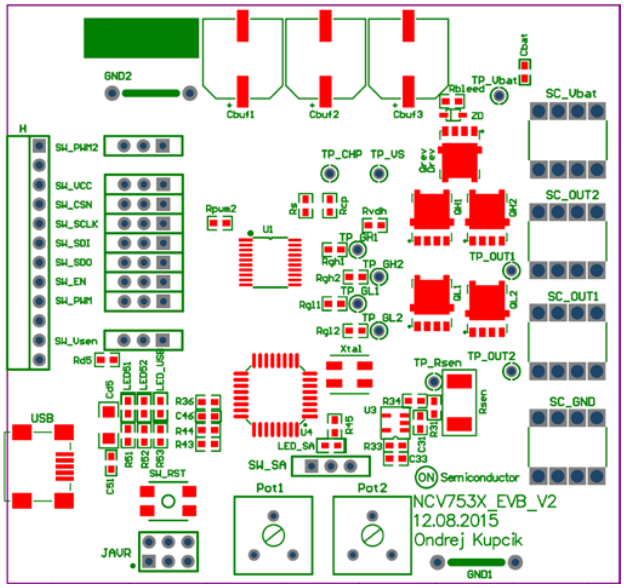


**Figure 7. NCV7535 EVB PCB Top Assembly Drawing**

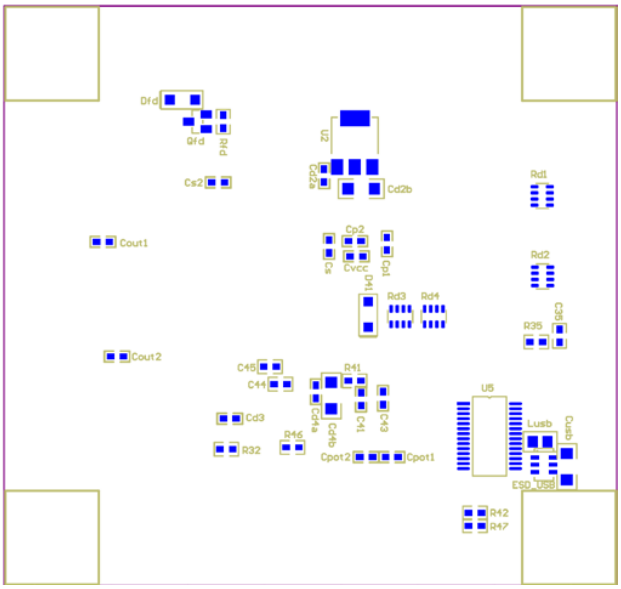

**Figure 8. NCV7535 EVB PCB Bottom Assembly Drawing**

### Composite Drawings

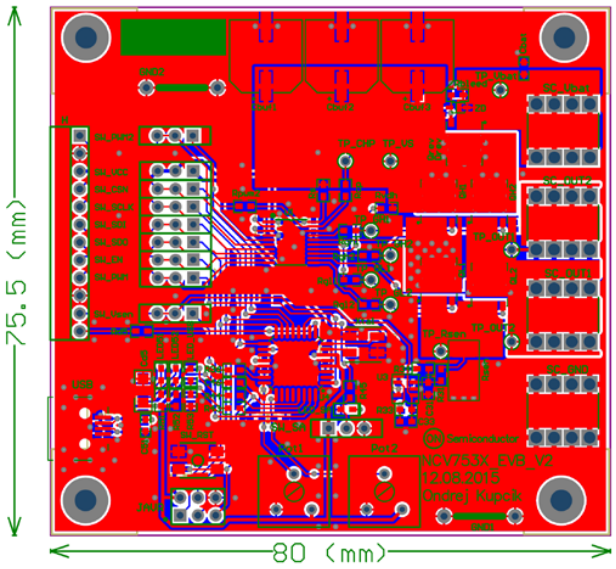


**Figure 9. NCV7535 EVB PCB Top Composite Drawing**

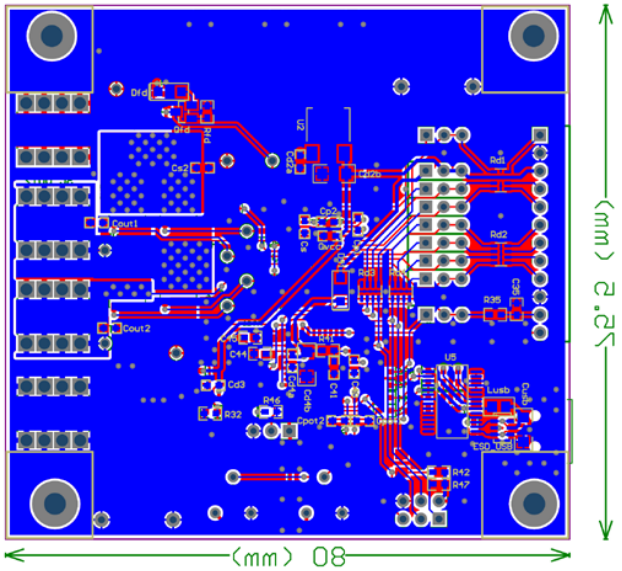


**Figure 10. NCV7535 EVB PCB Bottom Composite Drawing**

### References

[1] ON Semiconductor, NCV7535 Product Datasheet Rev.P0, November 2016.

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