

# NCV73830V1GEVB

## NCV7383 FlexRay® Bus Driver Evaluation Board User's Manual

### Introduction

This document describes the NCV7383EVB Evaluation board for the ON Semiconductor NCV7383 FlexRay Bus Driver. The functionality and major parameters can be evaluated with the NCV7383EVB board.

The NCV7383 is a single-channel FlexRay bus driver compliant with the FlexRay Electrical Physical Layer Specification Version 3.0.1, capable of communicating at speeds of up to 10 Mb/s. It provides differential transmit and receive capability between a wired FlexRay communication medium on one side and a protocol controller and a host on the other side.

NCV7383 mode control functionality is optimized for nodes without the need of extended power management provided by transceivers with permanent connection to the car battery as is on NCV7381.

NCV7383 is primarily intended for nodes switched off by ignition. Additional details can be found in the NCV7383 datasheet.

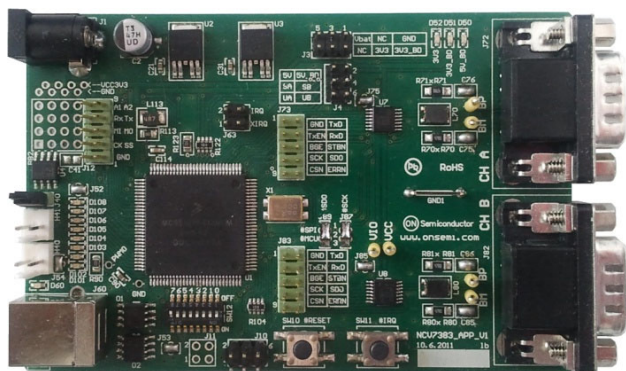


Figure 1. Evaluation Board Photo

The NCV7383EVB Evaluation board is a reference design for stand-alone 2-channel FlexRay node. The board is intended to give designers easy, quick and convenient means for evaluation of NCV7383 FlexRay bus drivers. The design incorporates complete node solution with possibility of modifications and small board size. A set of two boards



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### EVAL BOARD USER'S MANUAL

allows users immediately start with the NCV7383 FlexRay Bus Driver. The MCU is preprogrammed with a firmware which provides simple mode control and FlexRay communication. With use of Freescale™ BDM programmer and a suitable development environment, the MCU firmware can be freely modified and reprogrammed.

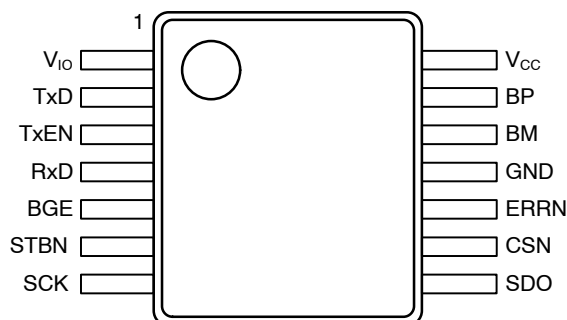


Figure 2. NCV7383 Pin Connections

### Board Hardware

The board consists of MCU with integrated 2-channel FlexRay communication controller interconnected with two separate FlexRay bus drivers (NCV7383), two voltage regulators and peripherals. The board is prepared for various modifications in power supply concept and FlexRay bus termination, and allows simple extension of the system by unused MCU pins. USB interface provides compatibility with standard PC. The address of each board can be easily modified by address switch what allows to create complex FlexRay network without the need of reprogramming the MCU. Implemented High Speed CAN interface can be used as a diagnostic interface in a network built from several nodes. For evaluation purposes NCV7383 is populated with several LED diodes and most of the bus driver signals are comfortable accessible to oscilloscope probes.

# NCV73830V1GEVB

## GENERAL FEATURES

### FlexRay Transceiver

- Two separate FlexRay channels with NCV7383 Bus Driver compliant with the FlexRay Electrical Physical Layer Specification Version 3.0.1,
- Reconfigurable bus termination – End node / Middle node
- Common mode Choke and additional ESD protection footprint
- SUBD-9 connectors – FlexRay bus

### MCU

- Freescale™ 16-bit MC9S12XF family MCU
- Integrated FlexRay Communication Controller (Protocol Specification Rev. 2.1)
- Integrated CAN 2.0 A, B Controller
- Background Debug Module – single-wire communication with host development system
- 512 k byte Flash
- 32 k byte RAM
- 50 MHz maximum CPU bus frequency
- Relatively small 112-pin LQFP package

### Peripherals

- Optical isolated USB interface (USB to UART converter)
- Additional CAN interface

- All NCV7383 digital I/O pins connected to test points – easy connection to Logic Analyzer
- 8 general purpose LEDs
- Address switch
- External Interrupt switch

### Other

- Two Automotive Voltage regulators (Input battery voltage up to 42 V)
- Power supplies voltage monitoring
- Instant 2-nodes FlexRay network with running communication by connecting two NCV7383 EVBs.
- PC configuration software under development (available upon request)

### PCB Layout

- The FlexRay transceiver, the ESD protection and the common mode choke are placed near to the FlexRay the ECU connector
- The FlexRay signal lines (BP, BM) are decoupled from disturbances on the ECU board
- The routing of the FlexRay lines (BP, BM, TxD and TxEN) is symmetric
- The distance between the lines BP and BM resp. TxD and TxEN is minimized

## GETTING STARTED

The NCV7383EVB board is fully assembled, pre-programmed and can be immediately used for evaluation. Only a few steps need be proceeded to get fully working simple FlexRay network.

Connect the evaluation boards as follows:

1. Set the boards to default configuration according to Jumpers and Default Configuration section.
2. Select one of the bus termination type (Bus Termination Configuration section) and adapt the respective devices. End node termination type is recommended for 2-node network.
3. Set a different board address on each board. One of the boards must be set with address 1 and is

considered as Master Board. Node address is configured by address switch SW12 – see Address Switch for details.

4. Connect the boards according to Figure 3. Up to 5 boards with addresses 1 to 5 can be connected together.
5. Connect the oscilloscope to any test-point as needed.
6. When power supply is applied, MCU automatically configures the FlexRay Communication Controller setting based on the current node address and initiates FlexRay communication.

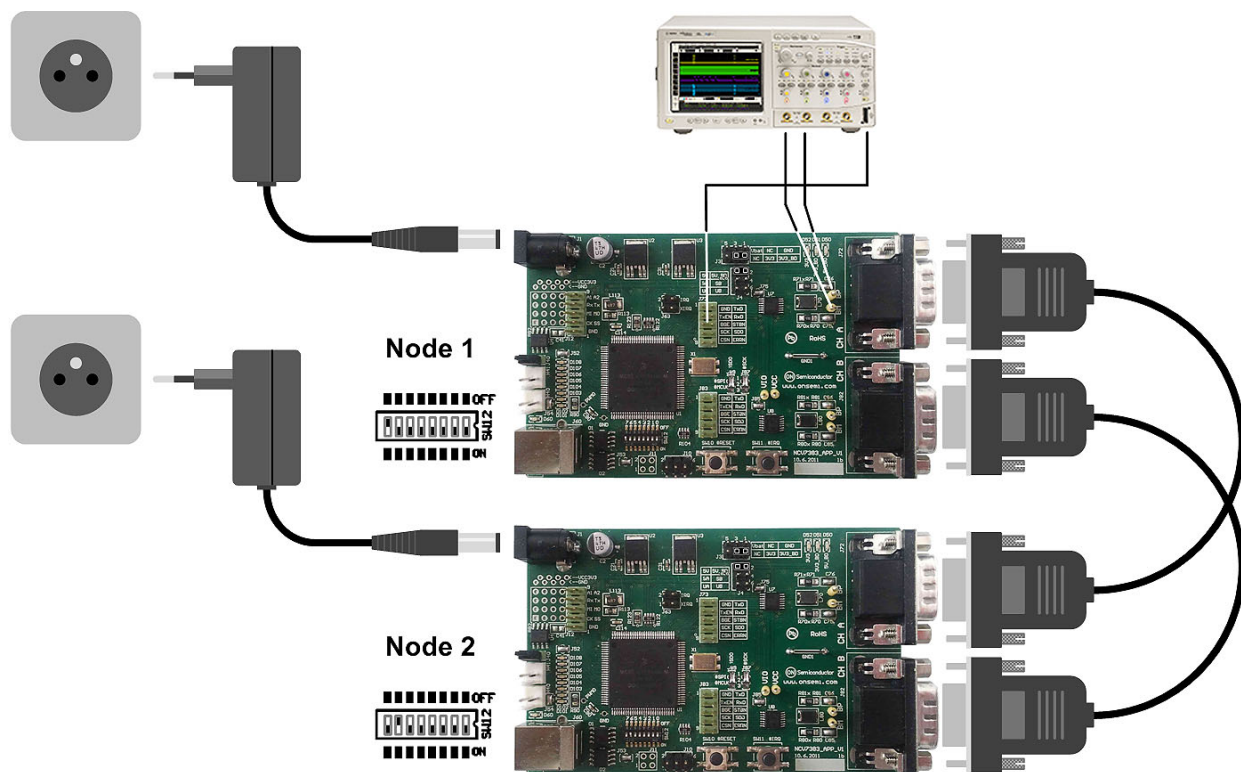


Figure 3. Basic NCV7383 Evaluation Board connection

#### Power Modes

The nodes can operate in two different power modes:

- Normal mode – all the nodes continuously communicates over the FlexRay bus.
- Standby mode – the communication is suspended. Both NCV7383 FlexRay transceivers are switched to Low Power Standby operating mode. Indication LEDs are switched off. The MCU is operating in low power STOP mode where the oscillator is stopped and the current consumption is substantially reduced.

#### Enter Standby Mode Sequence

A transition to Standby mode can be initiated by the node with address 1:

- Press and hold the Node1 #IRQ button for more than 3 seconds. The GO\_TO\_STANDBY signal is transmitted over the FlexRay bus. All the nodes then synchronously stop the communication and switch to Standby mode.

#### Wakeup Sequence

The network operating in Standby mode can be woken-up by any node:

- Press the #IRQ button on any node connected to the network. The MCU is woken-up from STOP mode by an external interrupt (#IRQ button pressed), resume operation in Normal mode and automatically wake up the rest of the network by the FlexRay Remote Wakeup Pattern sent over the bus. Once all the nodes are initialized, the FlexRay communication is restarted.

#### Normal Mode LED Signaling

The properly running setup should signal following (Figure 4):

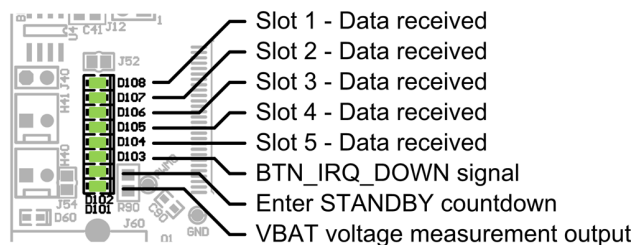
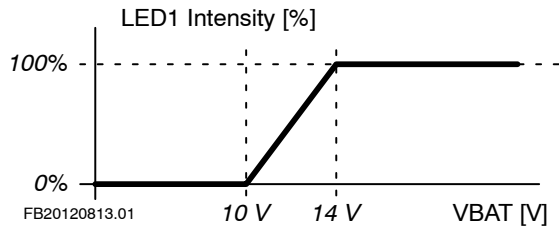


Figure 4. LEDs Signaling Description

- LED8 - LED4 – Toggling LED signals data was received correctly in the particular slot (Slot 1 – Slot 5)
- LED3 – Each node transmits its own #IRQ Button status (BTN\_IRQ\_DOWN signal). This LED signals that one of the nodes in the network detected the #IRQ button pressed.
- LED2 – When the #IRQ button is pressed and held down, the LED2 is gradually decreasing intensity indicating the time remaining to ENTER STANDBY MODE event (100% to 0% in 2.4 seconds).
- LED1 – LED1 changes intensity according to input battery voltage.
  - The LED intensity is directly proportional to the battery voltage in range of 10 V to 14V.

- Battery voltage being below 10 V is indicated by LED1 OFF state.
- Battery voltage exceeding 14 V is indicated by LED1 full intensity (Figure 5).



**Figure 5. LED1 Intensity vs. Battery Voltage**

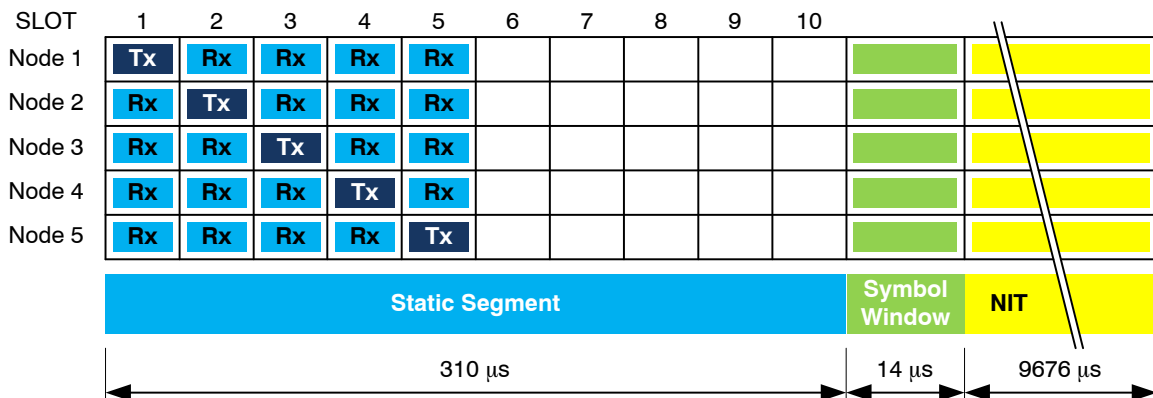
## Standby Mode LED Signaling

In Standby mode, all the LEDs except LED8 are switched OFF. The LED8 is turned ON with very low intensity, signaling the MCU is correctly operating in the low power STOP mode and is ready to be woken-up.

## FlexRay Communication Cycle Configuration

Cycle Length: 10000  $\mu$ s  
 Number of Static Slots: 10 (5 slots active)  
 Static Slot Length: 31  $\mu$ s  
 Static Slot Payload Length: 6 Words  
 Dynamic Segment: Not used  
 Symbol Window Length: 14  $\mu$ s

Each node is assigned to one communication slot. The Slot number corresponds to particular Node address.



**Figure 6. FlexRay Communication Cycle Configuration (Tx – Transmitter Buffer, Rx – Receive Buffer)**

## BOARD OVERVIEW

### Basic Interface

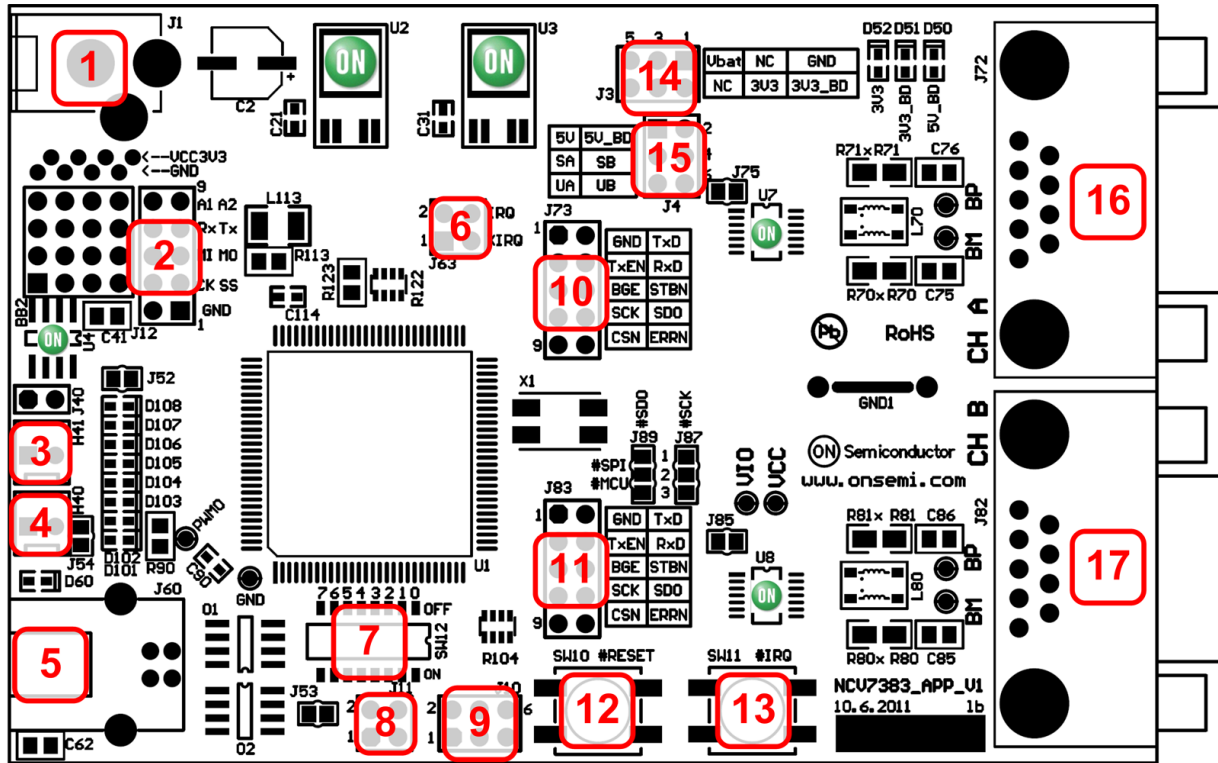


Figure 7. NCV7383EVB Connectors and Switches

### Legend:

1. Power supply input connector
2. Aux digital I/O connector
3. CAN backbone connector 1
4. CAN backbone connector 2
5. USB interface
6. MCU Interrupt Request connector
7. Address switch
8. FlexRay CC Strobe output signals

9. BDM Connector (MCU debugging interface)
10. Power supply input connector
11. Aux digital I/O connector
12. CAN backbone connector 1
13. CAN backbone connector 2
14. USB interface
15. MCU Interrupt Request connector
16. Address switch
17. FlexRay CC Strobe output signals

### Power Supply Input Connector

Power supply input socket. Plug diameter 2.1 mm, length 14 mm. Maximum input voltage 42 V (Limited by onboard voltage regulators input voltage range).

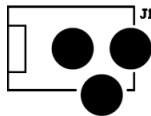


Figure 8. Power Supply Input Connector

signals can be also used as general Input / Output signals for debugging or other purposes.

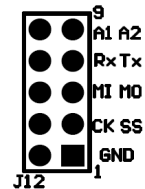


Figure 9. Aux Digital I/O Connector

### Aux Digital I/O Connector

These pin header contains 8 auxiliary MCU signals – one complete SPI interface (4 pins), one UART interface (2 pins) and 2 signals connected to MCU ADC interface. These

### CAN Backbone Connectors

CAN backbone network is created as parallel connection of several boards. Each board contains two equivalent

connectors in parallel, so whole network can be prepared using only simple point-to-point twisted pair.

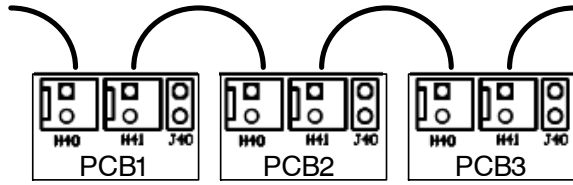


Figure 10. CAN Backbone Connectors

#### USB Interface

Standard B type USB socket is used for connection to PC. USB interface is bus powered and electrically isolated from the rest of the board, so it is not possible to supply this board via USB.

#### FlexRay CC Strobe Output Signals

The MCU FlexRay block provides a number of strobe signals for observing internal protocol timing related signals in the protocol engine.

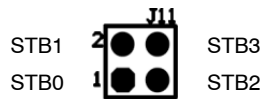


Figure 11. FlexRay CC Strobe Output Signals

#### BDM Connector (MCU Debugging Interface)

The BDM module provides a single-wire communication with host development system (Programming and debugging interface).

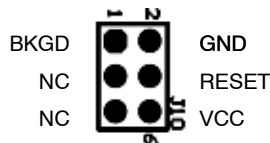


Figure 12. BDM Connector

#### FlexRay BD Digital Signals Test Points Headers

These headers are intended to be used as a test points for digital probes. Headers contain all FlexRay BD digital input and output signals.

Test points for both FlexRay channel A and channel B are placed on separated headers (J73 – channel A, J83 – channel B).

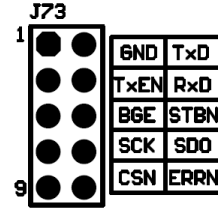


Figure 13. FlexRay BD Digital Signals Test Points

#### FlexRay BD Analog Signals Test Points

There are 6 analog test points on the board:

- BP – FlexRay Bus Plus terminal (Channel A)
- BM – FlexRay Bus Minus terminal (Channel A)
- VIO – Bus Driver VIO Power Supply input
- BP – FlexRay Bus Plus terminal (Channel B)
- BM – FlexRay Bus Minus terminal (Channel B)
- VCC – Bus Driver VCC Power Supply input

#### FlexRay Bus Connectors

FlexRay EPL Specification [2] does not prescribe certain connectors for FlexRay systems. Common used 9-pin D-Sub connectors were chosen as a suitable connector, whose electrical characteristics satisfy the specification.

Table 1. FLEXRAY CONNECTOR

Pin #	Signal	Description	Connection	ESD Protection
1	-	Reserved	Not Connected	
2	FR_BM	BM bus line	BM	Yes (Optional)
3	FR_GND	Ground	GND	
4	-	Reserved	Not Connected	
5	-	Reserved	Not Connected	
6	-	Reserved	Not Connected	
7	FR_BP	BP bus line	BP	Yes (Optional)
8	-	Reserved	Not Connected	
9	(FR_Vbat)	Optional FR external supply	Main supply line	Yes

NOTE: **Connector Type:** 9-pin D-sub (DIN 41652 or corresponding international standard), plug (male)

# NCV73830V1GEVB

## Jumpers and Default Configuration

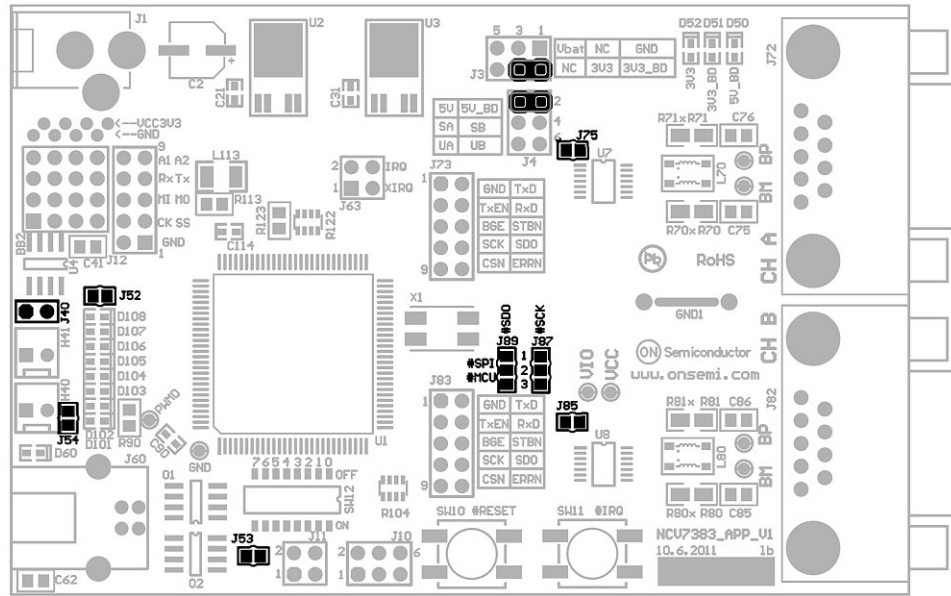


Figure 14. Jumpers and Soldering Straps

Table 2. 2-PIN JUMPER

		Open
		Closed

Table 3. 3-PIN JUMPER

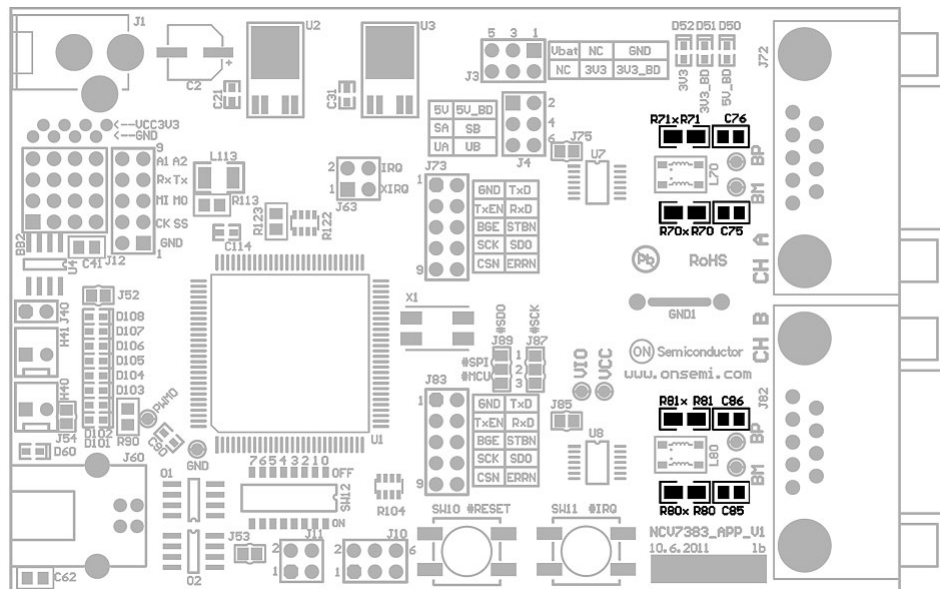
1 2 3	
	Open
	Closed position 1-2
	Closed position 2-3

# NCV73830V1GEVB

**Table 4. NCV7383 EVB JUMPERS CONFIGURATION**

Jumper	Function	Configuration	Description	Default
J3	Bus Driver VIO supply	Open	Bus Driver VIO unsupplied	Closed 3V3 – 3V3_BD
		Closed	Bus Driver VIO connected to voltage regulator output	
J4	Bus Driver VCC supply	Open	Bus Driver VCC unsupplied	Closed 5V – 5V_BD
		Closed	Bus Driver VCC connected to voltage regulator output	
J40	CAN bus termination	Open	CAN bus without termination	Closed
		Closed	CAN bus with 120 $\Omega$ termination	
J52	General purpose LED	Open	LEDs Disabled	Closed
		Closed	LEDs Enabled	
J53	UART power supply	Open	UART Disabled	Open
		Closed	UART Enabled	
J54	MCU output mcu_PP0 function	Open	LED D101 not used	Closed
		Closed	LED D101 connected to PWM0 output	
J87	Channel B SCK pin connection	Open	SCK_B disconnected	Closed 1-2
		Closed 1-2	SCK_B connected to common hardware SPI interface	
		Closed 2-3	SCK_B connected to separated software SPI interface	
J89	Channel B SDO pin connection	Open	SDO_B disconnected	Closed 1-2
		Closed 1-2	SDO_B connected to common hardware SPI interface	
		Closed 2-3	SDO_B connected to separated software SPI interface	
J75	Channel A Bus Driver digital input pull-ups	Open	TxEN, SCN and SCK pull-ups disconnected from VIO	Closed
		Closed	TxEN, SCN and SCK pull-ups connected to VIO	
J85	Channel B Bus Driver digital input pull-ups	Open	TxEN, SCN and SCK pull-ups disconnected from VIO	Closed
		Closed	TxEN, SCN and SCK pull-ups connected to VIO	

## Bus Termination Configuration





## NCV73830V1GEVB

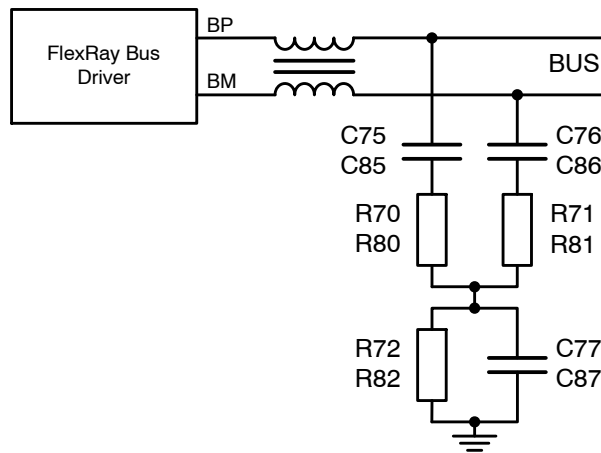


Figure 16. FlexRay Bus Termination Connection (Channel A: R7x, C7x; Channel B: R8x, C8x)

Table 5. FLEXRAY BUS TERMINATION CONFIGURATION AND PARAMETERS

Component	End node (Low-Ohmic termination)	Middle node – Variant 1 (High-Ohmic termination)	Middle node – Variant 2 (Custom termination)
Ch. A: C75, C76 Ch. B: C85, C86	Short	Short	100 pF
Ch. A: R70, R71 Ch. B: R80, R81	47 $\Omega$	1300 $\Omega$	24 $\Omega$
Ch. A: R72 Ch. B: R82	Not Assembled	Not Assembled	47 $\Omega$
Ch. A: C77 Ch. B: C87	4.7 nF	4.7 nF	4.7 pF

## Switches and Pushbuttons

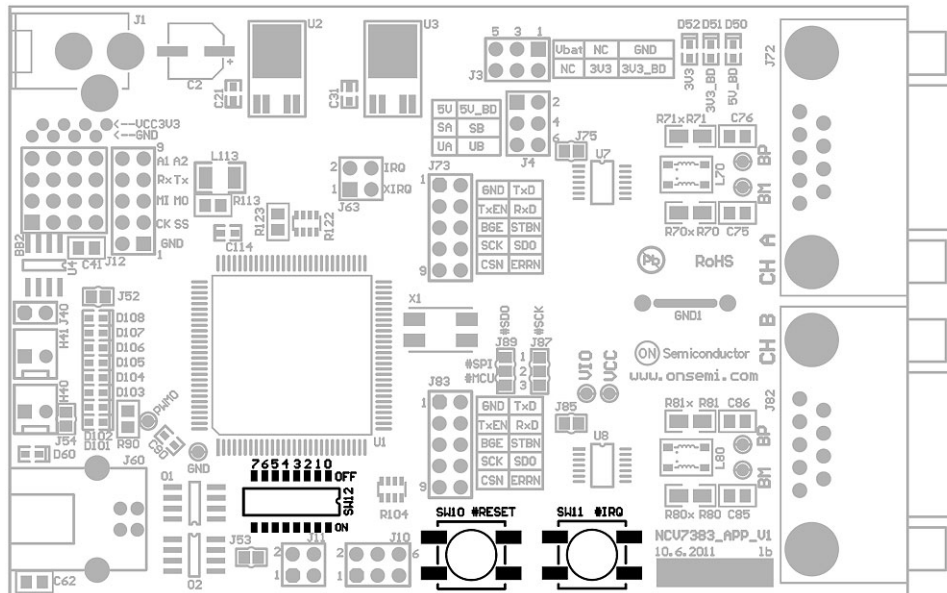


Figure 17. Switches Description

- SW10...MCU Reset button
- SW11...MCU External interrupt button
- SW12...8-way DIP switch. The function depends on the MCU program. As default it is used for setting a node address.

# NCV73830V1GEVB

## Address Switch

This switch is used for setting a node number. Each board is programmed with the same firmware, so every node in the network must be configured with different unique number.

Be careful:

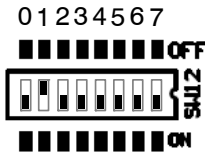


Figure 18. Address Switch

- LSB is situated on the left.
- ON means the particular switch is closed and output is *Logical 0*!
- OFF means the particular switch is open and output is *Logical 1*!

## MCU Reset Button

This button is connected directly to MCU RESET pin.

## MCU External Interrupt Button

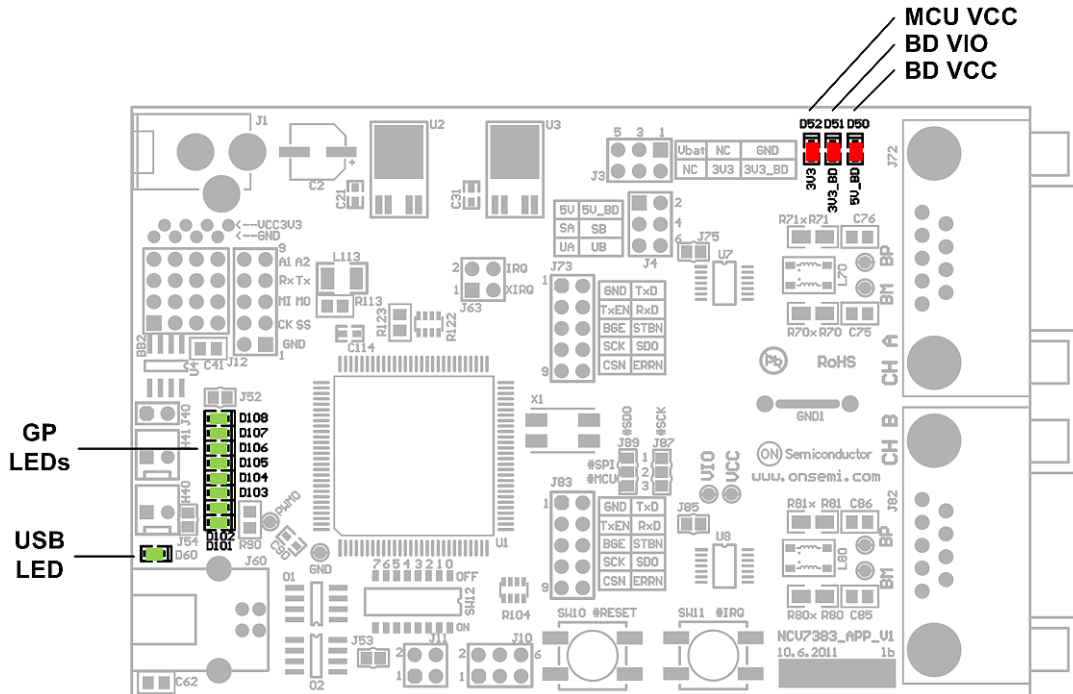
The MCU interrupt module support one maskable interrupt input. This input is connected to SW11.

## LEDs

Three power LEDs indicate proper function of voltage regulators. In case the MCU and the NCV7381 bus drivers IO cells use the same power supply (as by default) MCU VCC LED and BD VIO LED signalling is also the same.

The board contains a bank of eight general purpose LEDs (Green). Their function depends on the MCU program.

There is also USB indication LED which is used to signal ongoing USB data transmission.



# NCV73830V1GEVB

## BLOCK DIAGRAM

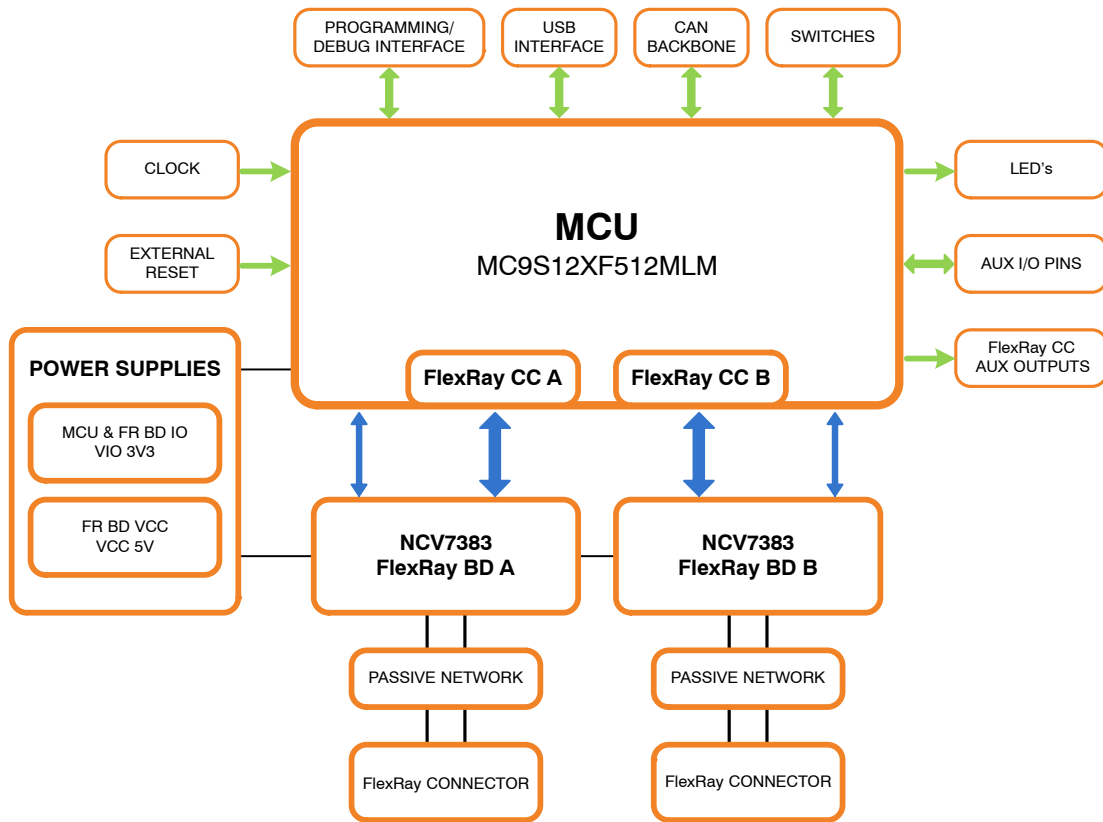


Figure 20. NCV7383 Evaluation Board Block Diagram

## NCV7383 TYPICAL APPLICATION DIAGRAM

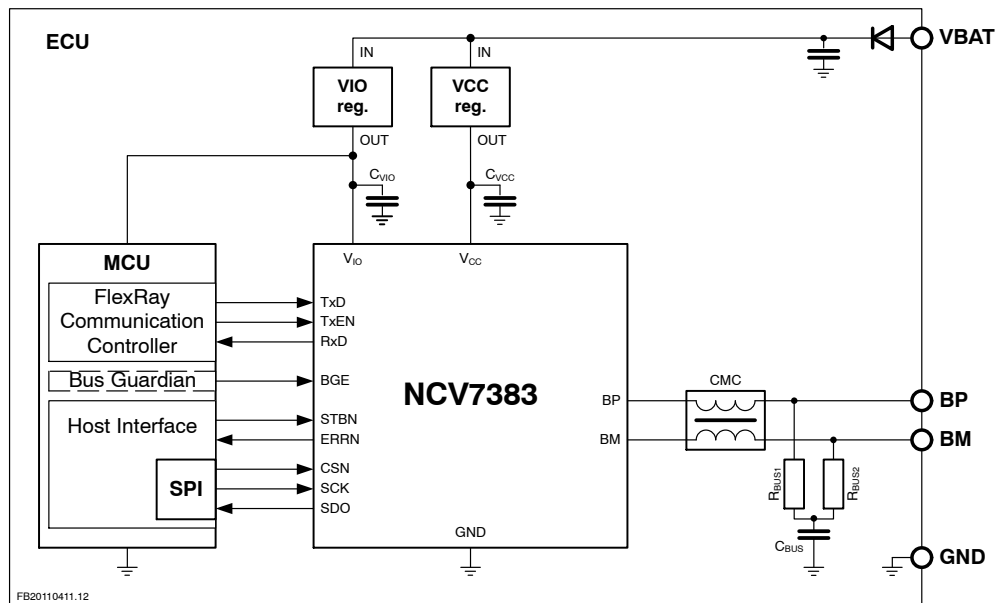


Figure 21. NCV7383 FlexRay Bus Driver Typical Application Diagram

**Table 6. RECOMMENDED EXTERNAL COMPONENTS FOR THE APPLICATION DIAGRAM**

Component	Function	Min.	Typ.	Max.	Unit	Note
C <sub>VCC</sub>	Decoupling capacitor on V <sub>CC</sub> supply line, ceramic		100		nF	
C <sub>VIO</sub>	Decoupling capacitor on V <sub>IO</sub> supply line, ceramic		100		nF	
R <sub>BUS1</sub>	Bus termination resistor		47.5		Ω	(1)
R <sub>BUS2</sub>	Bus termination resistor		47.5		Ω	(1)
C <sub>BUS</sub>	Common-mode stabilizing capacitor, ceramic		4.7		nF	(2)
CMC	Common-mode choke		100		μH	

1. Tolerance ±1%, type 0805. The value R<sub>BUS1</sub> + R<sub>BUS2</sub> should match the nominal cable impedance.
2. Tolerance ±20%, type 0805.

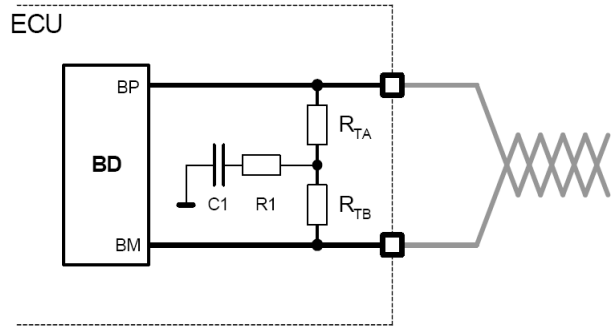
## SPECIFICATIONS

### Power Supply

The Evaluation board can be powered either via DC power supply input socket with plug diameter 2.1 mm and length 14 mm or by one of the FlexRay bus connectors (See the connector description Table 1). Maximum input voltage (42 V) is limited by on-board voltage regulators input voltage range.

### Split Termination

In order to achieve a better EMC performance, it is recommended to make use of a so-called split termination in all ECUs, where the Termination resistance R<sub>T</sub> is split into two equal parts R<sub>TA</sub> and R<sub>TB</sub> [2].



**Figure 22. ECU with Split Termination [2]**

The serial RC combination (R1; C1) at the centre tap of the split termination provides a termination to GND for common mode signals. R1 is preferably omitted. Typical values are given in the following table:

**Table 7. TERMINATION PARAMETERS**

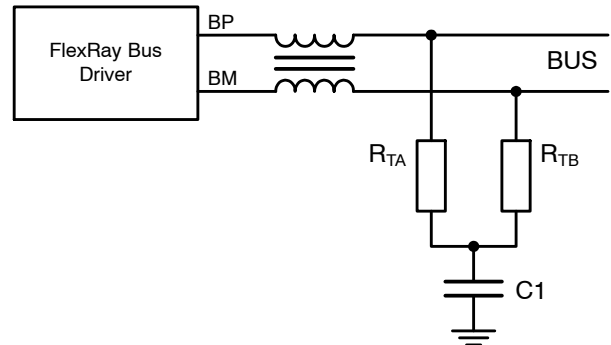
Name	Description	Typ	Units
R1	Resistor	< 10	Ω
C1	Capacitor	4700	pF
$2 \times  R_{TA} - R_{TB}  / (R_{TA} + R_{TB})$	Matching of termination resistors	≤ 2	%

For R<sub>TA</sub> and R<sub>TB</sub> the use of 1% tolerated resistors leads to a matching of 2%.

The better the matching of the split termination resistors R<sub>TA</sub> and R<sub>TB</sub>, the lower the electromagnetic emission.

### Standard Termination

Recommended bus split termination is shown in the Figure 23. Considering passive network, without active stars, proper termination should be applied at the two nodes that have the maximum electrical distance on the bus. The sum of termination resistors values should match the nominal cable impedance. At other nodes a high-ohmic split termination should be applied.



**Figure 23. Basic Split Termination**

Table 8. BASIC SPLIT TERMINATION PARAMETERS

Name	Description	Value		Units
		End node	Middle node	
$R_{TA}$ , $R_{TB}$	Termination resistors	47	1300	$\Omega$
C1	Capacitor	4700	4700	pF

#### Custom Termination

In some cases a specific termination topology is required for middle modes. Such a termination connection and typical values are shown in Figure 25 and Table 9.

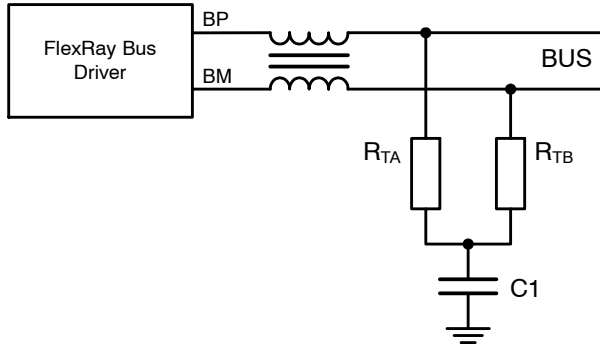


Figure 24. End Node Split Termination

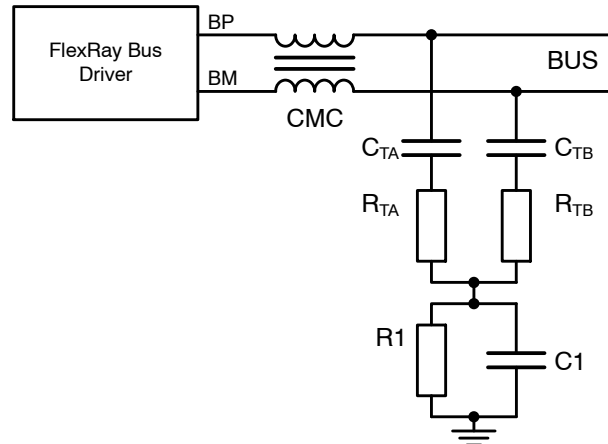


Figure 25. Middle Node Split Termination

Table 9. CUSTOM SPLIT TERMINATION PARAMETERS

Name	Description	Value		Units
		End node	Middle node	
$R_{TA}$ , $R_{TB}$	Termination resistors	47	24	$\Omega$
C1	Capacitor	4700	4.7	pF
R1	Resistor	–	47	$\Omega$
$C_{TA}$ , $C_{TB}$	Termination capacitors	–	100	pF

#### Common Mode Choke

A common mode choke is used to improve the emission and immunity performance. The function of the common mode choke is to force the current in both signal wires to be of the same strength, but opposite direction. Therefore, the

choke represents high impedance for common mode signals. The parasitic stray inductance should be as low as possible in order to keep oscillations on the bus low. The common mode choke is placed between transceiver and split termination [2].

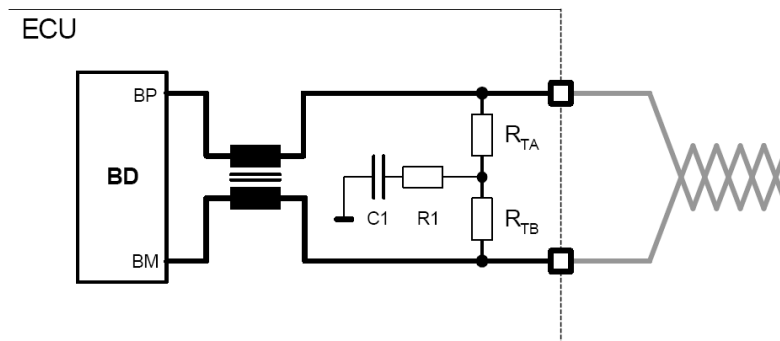


Figure 26. ECU with Split Termination and Common Mode Choke [2]

## NCV73830V1GEVB

**Table 10. COMMON-MODE CHOKE REQUIREMENTS [2]**

Name	Description	Typ	Units
$R_{CMC}$	Resistance per line	$\leq 1$	$\Omega$
$L_{CMC}$	Main inductance	$\geq 100$	$\mu H$
$L_{\sigma}$	Stray inductance	$< 1$	$\mu H$

### MCU PROGRAMMING INTERFACE

The NCV7383 EVB firmware can be freely reprogrammed using MCU programming and debugging interface (J10). The used Freescale MC9S12XF Family MCU can be programmed with P&E USB Multilink BDM module.



**Figure 27. P&E USB Multilink BDM module**

#### P&E USB MULTILINK BDM MODULE DISTRIBUTORS:

Distributor	Telephone	Email
<a href="#">Arrow Electronics</a>	(877) 237-8621	<a href="mailto:onlinesales@arrow.com">onlinesales@arrow.com</a>
<a href="#">Avnet Electronics</a>	(800) 408-8353	<a href="mailto:customer.care@avnet.com">customer.care@avnet.com</a>
<a href="#">Digi-Key Corporation</a>	(800) 344-4539	<a href="mailto:webmaster@digkey.com">webmaster@digkey.com</a>
<a href="#">Future Electronics</a>	(800) 675-1619	<a href="mailto:e_services@FutureElectronics.com">e_services@FutureElectronics.com</a>
<a href="#">Mouser Electronics</a>	(800) 346-6873	<a href="mailto:sales@mouser.com">sales@mouser.com</a>
<a href="#">Newark</a>	(800) 463-9275	<a href="mailto:sales@newarkinc.com">sales@newarkinc.com</a>

Suitable development tool allowing programming and debugging Freescale microcontrollers is CodeWarrior™

Development Studio ([www.freescale.com](http://www.freescale.com)). The P&E USB Multilink BDM module is directly supported.

## NCV73830V1GEVB

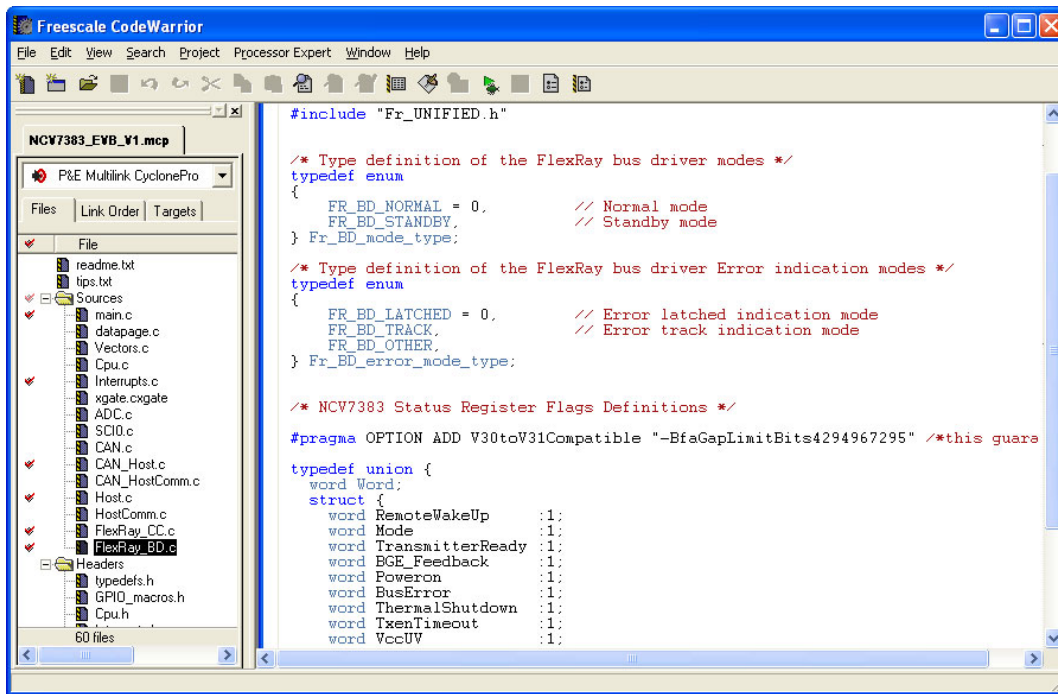
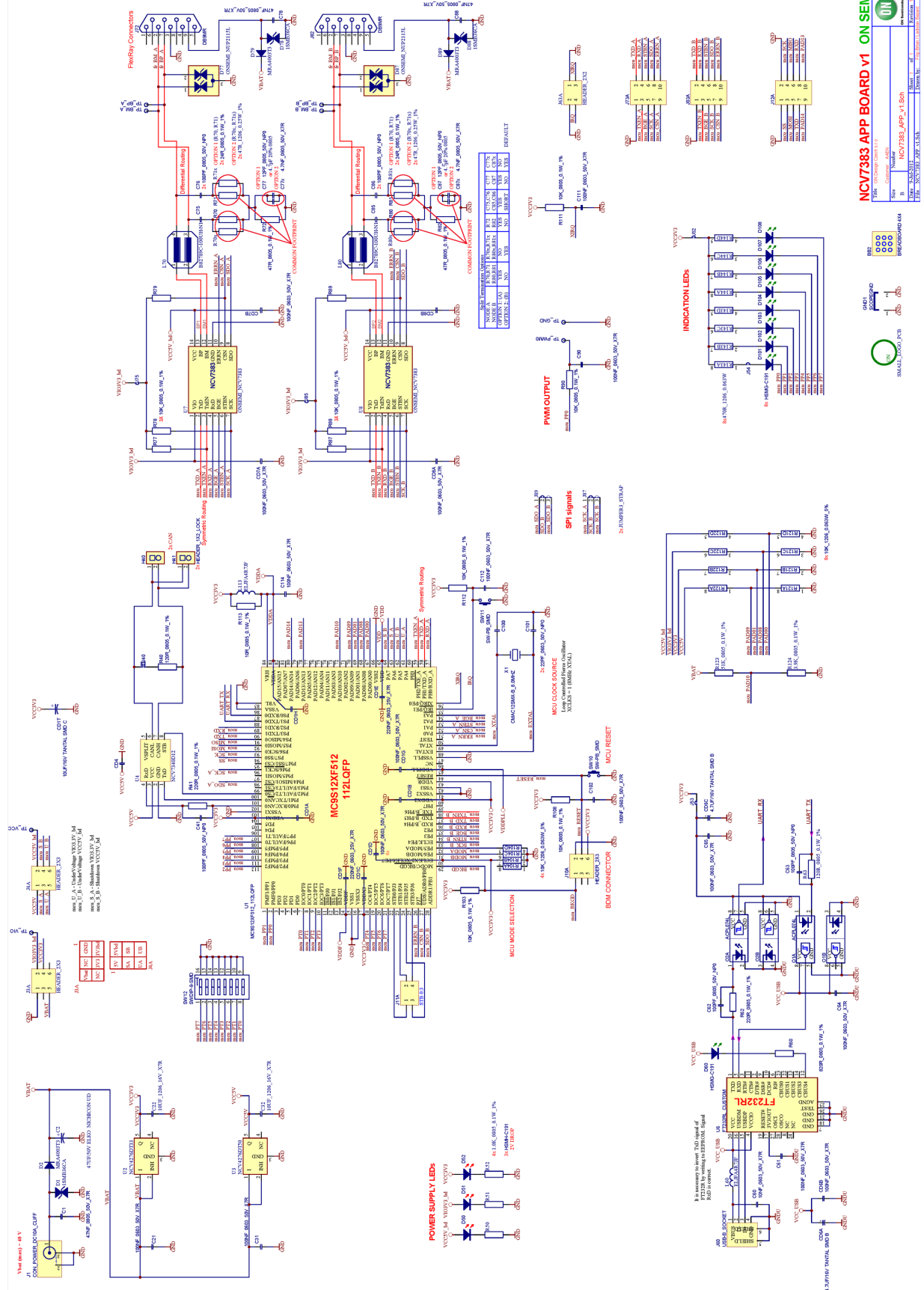


Figure 28. Freescale CodeWarrior Development Tool

The NCV7383 EVB firmware can be downloaded from  
ON Semiconductor web site ([www.onsemi.com](http://www.onsemi.com)).

## SCHEMATIC





# NCV73830V1GEVB

## PCB DRAWINGS

### Assembly Drawings

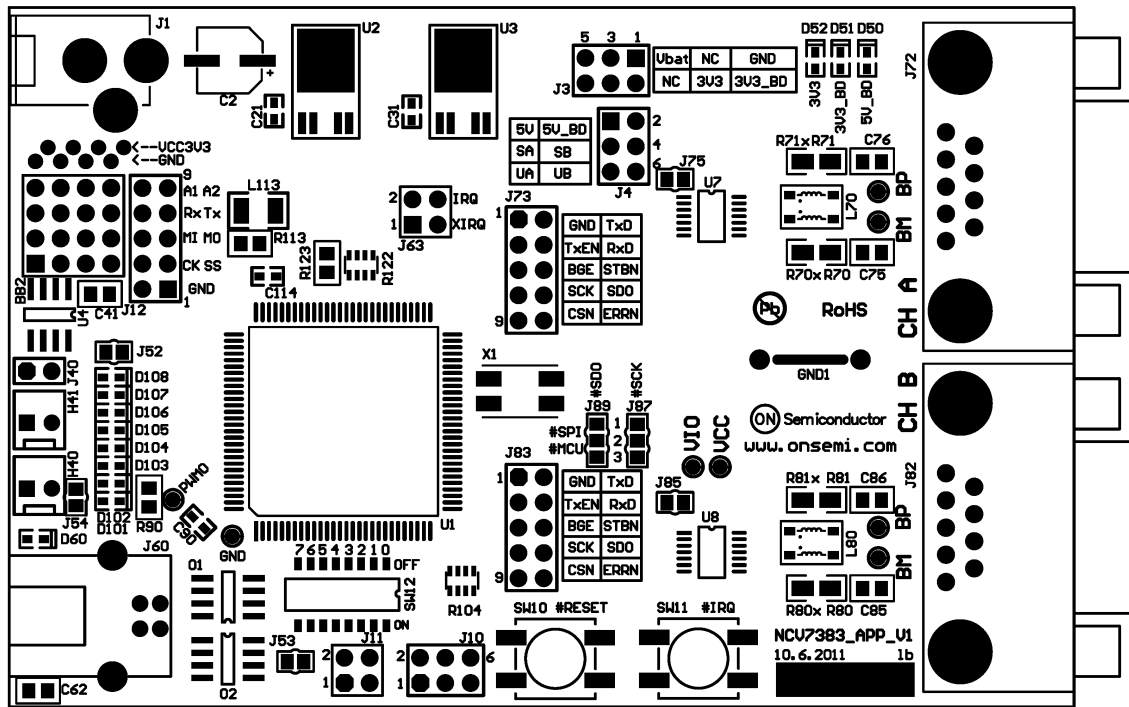


Figure 29. NCV7383 EVB PCB Top Assembly Drawing

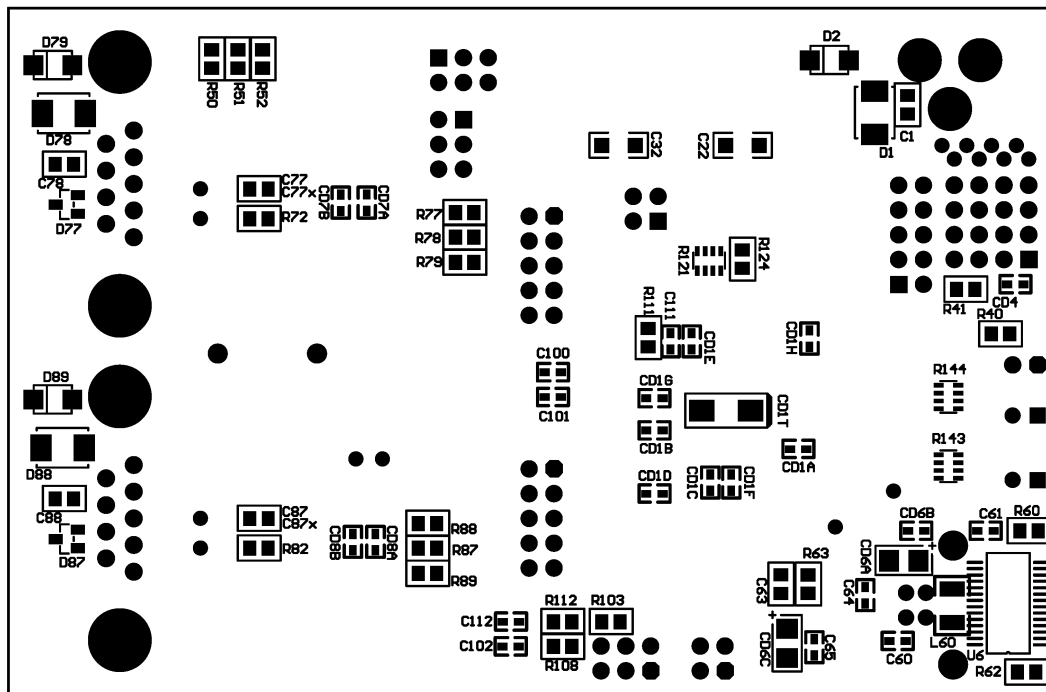


Figure 30. NCV7383 EVB PCB Bottom Assembly Drawing



## REFERENCES

- [1] ON Semiconductor, NCV7383 FlexRay Bus Driver – Product Datasheet, Rev.0, January 2013
- [2] FlexRay Consortium. FlexRay Communication System – Electrical Physical Layer Specification, V3.0.1, October 2010
- [3] FlexRay Consortium. FlexRay Communication System – Physical Layer EMC Measurement Specification, V3.0.1, October 2010

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