NCV73812037EVB

NCV7381 FlexRay® Bus Driver Evaluation Board User's Manual

ON Semiconductor®

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EVAL BOARD USER'S MANUAL

Introduction

This document describes the NCV7381 APP V2 Evaluation board for the ON Semiconductor NCV7381 FlexRay® Bus Driver. The functionality and major parameters can be evaluated with the NCV7381_APP_v2 board.

The NCV7381 is a single-channel FlexRay® bus driver compliant with the FlexRay® Electrical Physical Layer Specification Rev. 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.

NCV7381 mode control functionality is optimized for nodes permanently connected to car battery.
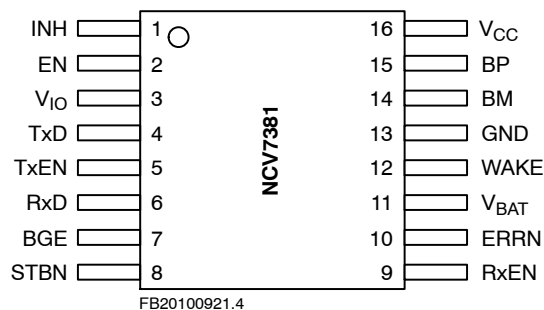
Additional details can be found in the NCV7381 datasheet.
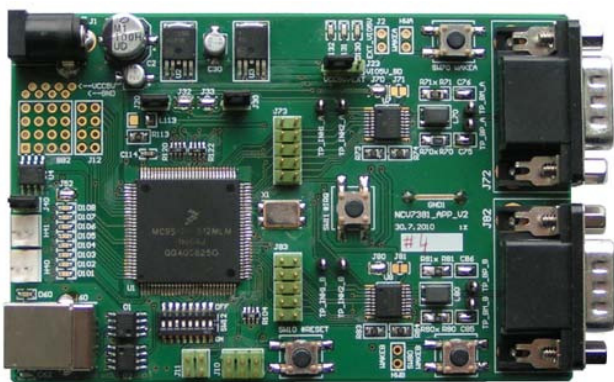
The NCV7381_APP_V2 Evaluation board is a reference design for stand-alone 2-channel FlexRay® node. The board is intended to give designers easy, quick and convenient means for evaluation of NCV7381 FlexRay bus drivers. The design incorporates complete node solution with possibility of modifications and small board size. A set of two boards

allows users immediately start with the NCV7381 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.

NCV7381 Pin Connections

INH	1	16 V_{CC}
EN	2	15 BP
V_{IO}	3	14 BM
TxD	4	13 GND
TxEN	5	12 WAKE
RxD	6	11 V_{BAT}
BGE	7	10 ERRN
STBN	8	9 RxEN

NCV7381

FB20100921.4

Board Hardware

The board consists of MCU with integrated 2-channel FlexRay communication controller interconnected with two separate FlexRay bus drivers (NCV7381), two switchable 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 creating complex FlexRay network without 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 NCV7381 is populated with several LED diodes and most of the bus driver signals are comfortable accessible to oscilloscope probes.

GENERAL FEATURES

FlexRay Transceiver
- Two Separate FlexRay® Channels with NCV7381 Bus Driver Compliant with the FlexRay Electrical Physical Layer Specification Rev. 3.0.1
- Reconfigurable Bus Termination – End Node/Middle Node
- Common Mode Choke and Additional ESD Protection Footprint
- SUBD-9 Connectors – FlexRay bus
- Local Wakeup Switch

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 Modul – Single-wire Communication with Host Development System
- 512 kB Flash
- 32 kB 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 NCV7381 Digital I/O Pins Connected to Test Points – Easy Connection to Logic Analyzer
- 8 General Purpose LEDs
- Address Switch

Other
- Two Automotive Voltage Regulators with Inhibit Function (Input Battery Voltage Up to 42 V)
- Power Supplies Voltage Monitoring
- Instant 2-nodes FlexRay Network with Running Communication by Connecting Two NCV7381 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, TX and TXEN) is Symmetric
- The Distance between the Lines BP and BM resp. TX and TXEN is Minimized

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GETTING STARTED

The NCV7381EVB 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. 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 configurable by address switch (SW12) – see Address Switch section for details
3. Connect the boards according to figure below
4. Optionally connect an oscilloscope to any test-point as needed
5. After the power supply is applied, FlexRay communication is automatically initialized
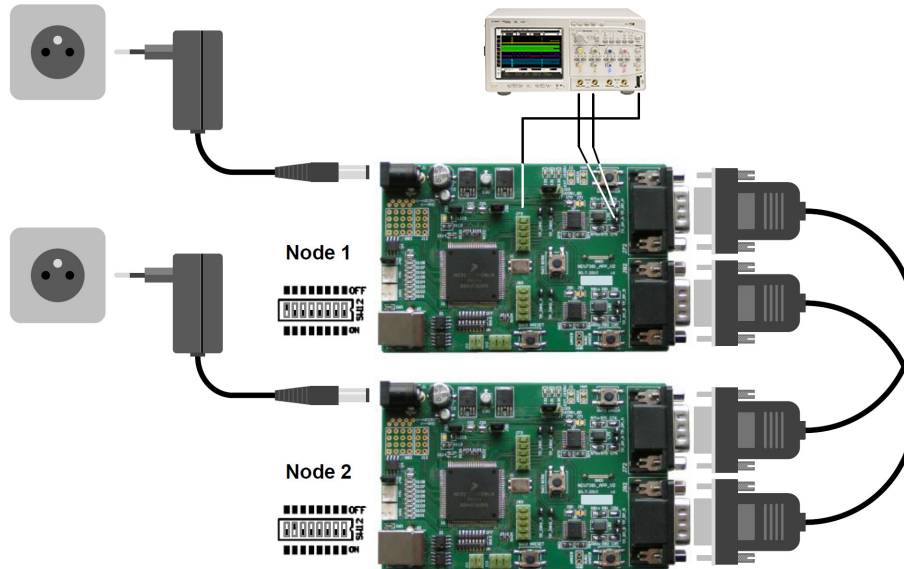
With properly running setup, button SW11 (#IRQ) has following functions:

- Press the button shortly to read-out Bus Driver status register (Only in Bus Driver status indication mode)

- Press and hold the button for approximately 2 seconds to change LED bar indication mode. Three modes are available:
    - ♦ FlexRay communication indication – each LED is assigned to one slot according to LED number. The LED is blinking if the respective slot in FlexRay communication is active
    - ♦ Bus Driver status indication – Channel A,
    - ♦ Bus Driver status indication – Channel B:
        - LED1 – Local Wake-Up status
        - LED2 – Remote Wake-Up status
        - LED3 – TxEN-BGE Timeout status
        - LED4 – Bus Error status
        - LED5 – Vio Undervoltage status
        - LED6 – Vcc Undervoltage status
        - LED7 – Vbat Undervoltage status
        - LED8 – Power On status
    - ♦ Press and hold the button for more than 5 seconds – Both nodes are switched to SLEEP mode and can be woken-up by one of the Local Wake-up switches. Only Node 1 is allowed to send the rest of network to SLEEP mode

In SLEEP mode, NCV7381 is supplied only from VBAT supply. VCC and VIO power supplies are switched off by NCV7381 INH output. MCU is not running and the board can be woken-up only with one of the Local Wakeup buttons (SW70, SW80).

- NCV7381 Local Wakeup function – Wake-up one of the nodes by any Local Wakeup button

- NCV7381 Remote Wakeup function – Second node is woken-up by Remote Wakeup pattern sent over the FlexRay bus by first node during initialization phase after Local Wakeup

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NCV73812037EVB

## BOARD OVERVIEW

Basic Interface
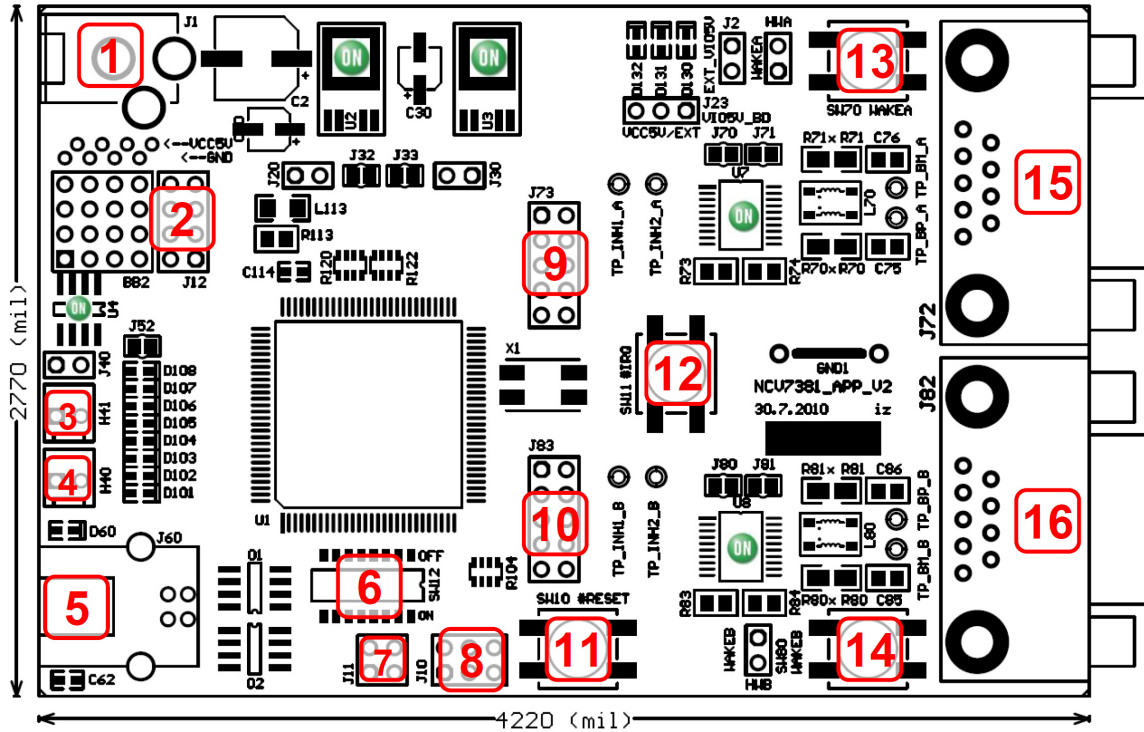
Legend:

1 Power Supply Input Connector	9 FlexRay BD Signals Test Points (Channel A)
2 Aux Digital I/O Connector	10 FlexRay BD Signals Test Points (Channel B)
3 CAN Backbone Connector 1	11 MCU Reset Switch
4 CAN Backbone Connector 2	12 MCU External Interrupt Switch
5 USB Interface	13 BD Local Wakeup Switch (Channel A)
6 Address Switch	14 BD Local Wakeup Switch (Channel B)
7 FlexRay CC Strobe Output Signals	15 FlexRay Bus Connector (Channel A)
8 BDM Connector (MCU Debugging Interface)	16 FlexRay Bus Connector (Channel B)

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).
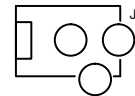
Aux Digital I/O Connector

These pin header contains 6 auxiliary MCU signals – one complete SPI interface (4 pins) and one UART interface (2 pins). These signals can be also used as general Input/Output signals for debugging or other purposes.
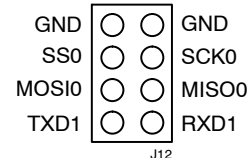
CAN Backbone Connectors

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.
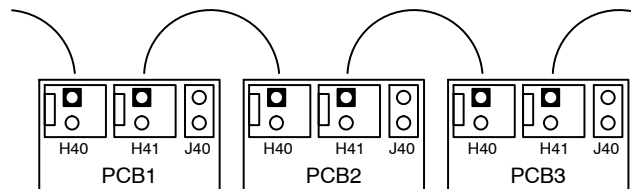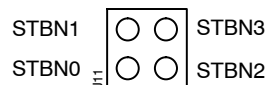
USB Interface

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.
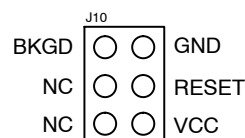
FlexRay CC Strobe Output Signals

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

These signals are connected to STBN pin header:

```
STBN1  O O  STBN3
STBN0  O O  STBN2
```

BDM Connector (MCU Debugging Interface)

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

```
        J10
BKGD  O O  GND
NC    O O  RESET
NC    O O  VCC
```

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).

```
        J83
GND   O O  GND
EN    O O  TXD
TXEN  O O  RXD
BGE   O O  STBN
ERRN  O O  RXEN
```
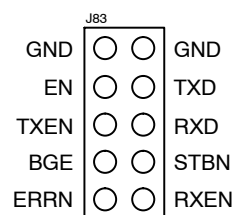
FlexRay BD Analog Signals Test Points

Each FlexRay channel contains 4 analog test points:

- INH1 – Bus Driver Inhibit 1 output
- INH2 – Bus Driver Inhibit 2 output
- BP – FlexRay Bus Plus terminal
- BM – FlexRay Bus Minus terminal

FlexRay Bus Connectors

FlexRay EPL Specification [1] 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

Connector type: 9-pin D-Sub (DIN 41652 or corresponding international standard), plug (male)
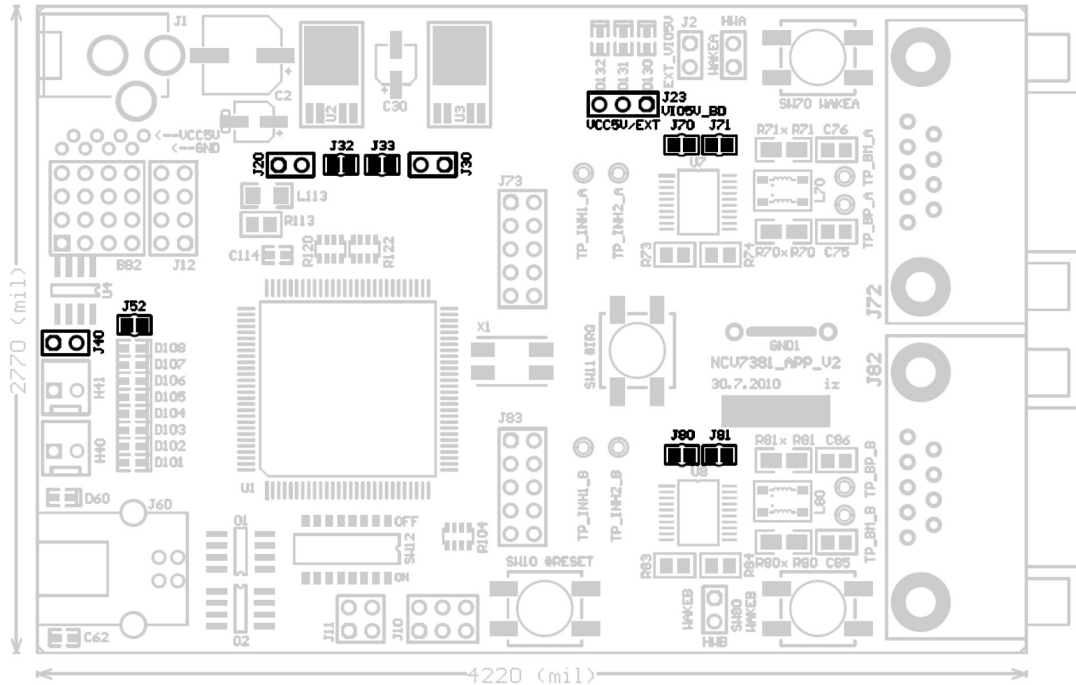
Jumpers and Default Configuration

Figure 1. 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

Table 4. NCV7381 EVB JUMPERS CONFIGURATION

Jumper	Function	Configuration	Description	Default
J20	MCU VCC 5 V State	Open	Controlled by bd_INH1_x	Open
		Closed	Always On	
J23	BC VIO Power Supply Selection	Open	BD VIO Disconnected	Closed 1–2
		Closed 1–2	BD VIO Connected to MCU VCC	
		Closed 2–3	BD VIO – External VIO Power Supply	
J30	BD VCC State	Open	Controlled by MCU	Closed
		Closed	Controlled by bd_INHx_x	
J32	BD VCC Inhibit Source (Ch A)	Open	bd_INH2_A	Closed
		Closed	bd_INH1_A	
J33	BD VCC Inhibit Source (Ch B)	Open	bd_INH2_B	Closed
		Closed	bd_INH1_B	
J40	CAN Bus Termination	Open	Without Termination	Closed
		Closed	With 120 Ω Termination	
J52	General Purpose LED	Open	LEDs Disabled	Closed
		Closed	LEDs Enabled	

Table 4. NCV7381 EVB JUMPERS CONFIGURATION

Jumper	Function	Configuration	Description	Default
J70	Bus Driver VBAT Supply (Ch A)	Open	BD VBAT Disconnected	Closed
		Closed	BD VBAT Connected	
J71	Bus Driver VBUF Supply (Ch A)	Open	BD VBUF Disconnected	Open
		Closed	BD VBUF Connected to BD VCC	
J80	Bus Driver VBAT Supply (Ch B)	Open	BD VBAT Disconnected	Closed
		Closed	BD VBAT Connected	
J81	Bus Driver VBUF Supply (Ch B)	Open	BD VBUF Disconnected	Open
		Closed	BD VBUF Connected to BD VCC	

Switches and Pushbuttons
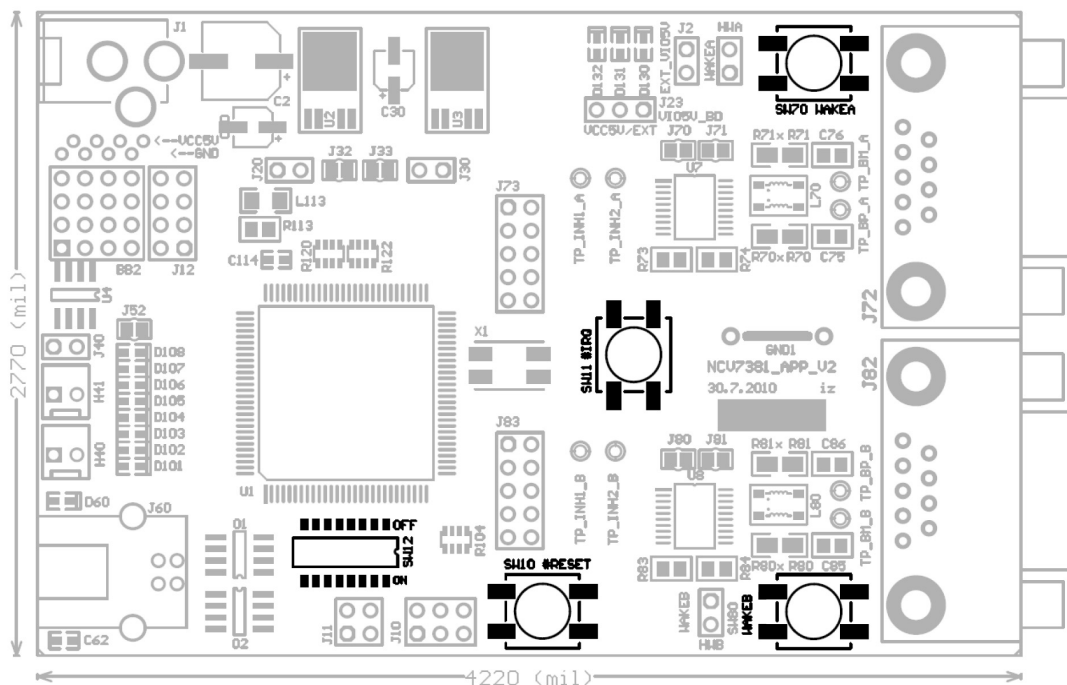
Figure 2. Switches Description

- SW10…MCU Reset button
- SW11…MCU External interrupt button
- SW12…8-way DIP switch. The function depends on the MCU program. As default ti it used for setting a node address
- SW70…FlexRay Transceiver Local Wakeup button (Channel A)
- SW80…FlexRay Transceiver Local Wakeup button (Channel B)

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:
 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*!
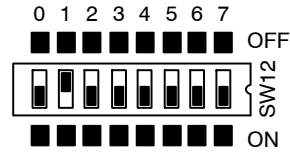
MCU Reset Button

This switch is used for generating low level at the MCU Reset pin. If MCU detects low level at the RESET pin external reset is performed.

MCU External Interrupt Button

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

BD Local Wakeup Buttons

The FlexRay Bus drivers support Local Wakeup event detection. If a falling edge is recognized on WAKE pin, a local wakeup is detected. These switches (each for one FlexRay channel) are used for simulation of Local wakeup event normally generated by e.g. mechanical switch.

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.
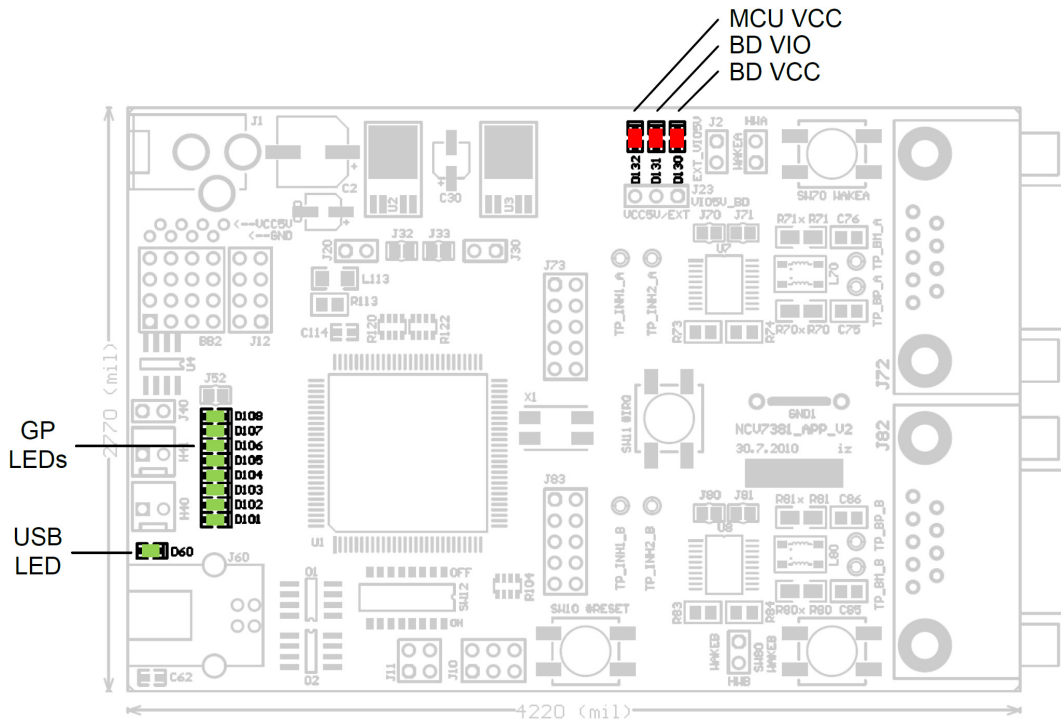
Figure 3. LEDs Description

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BLOCK DIAGRAM
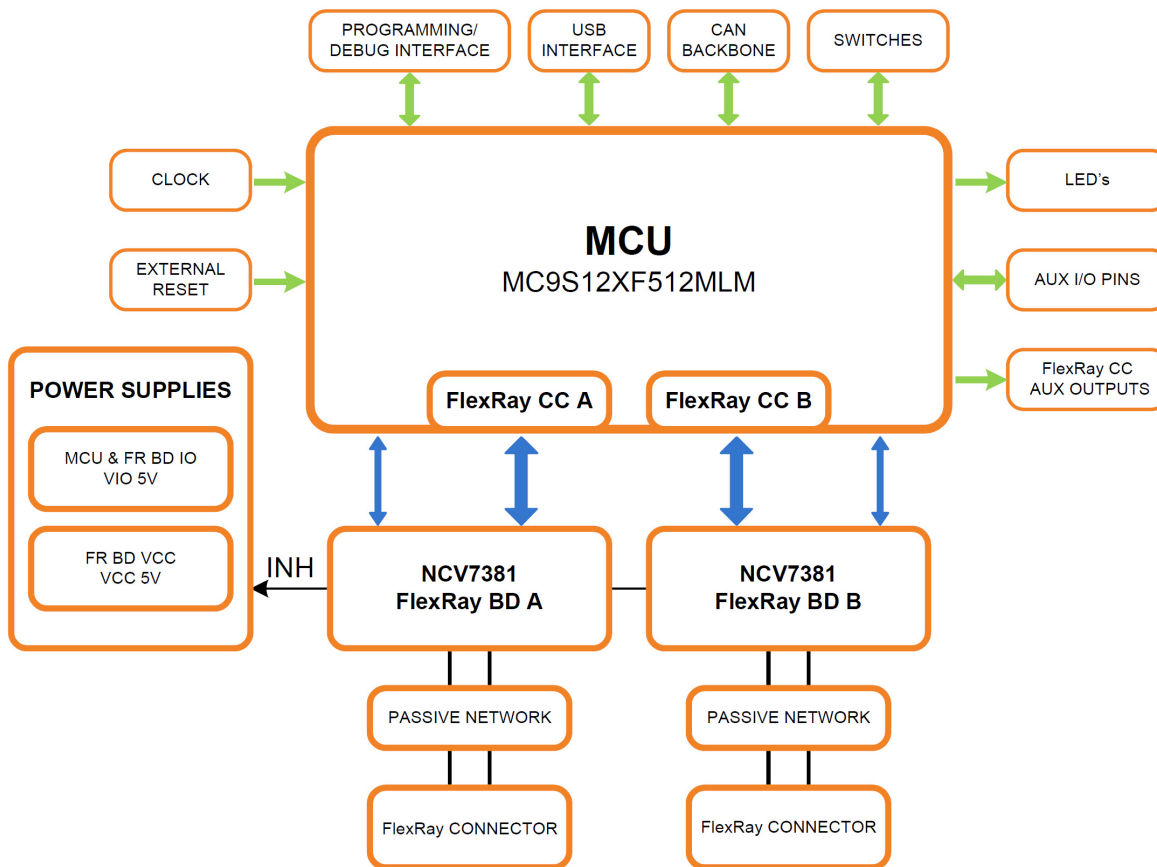
Figure 4. NCV7381 Evaluation Board Block Diagram

NCV7381 Typical Application Diagram
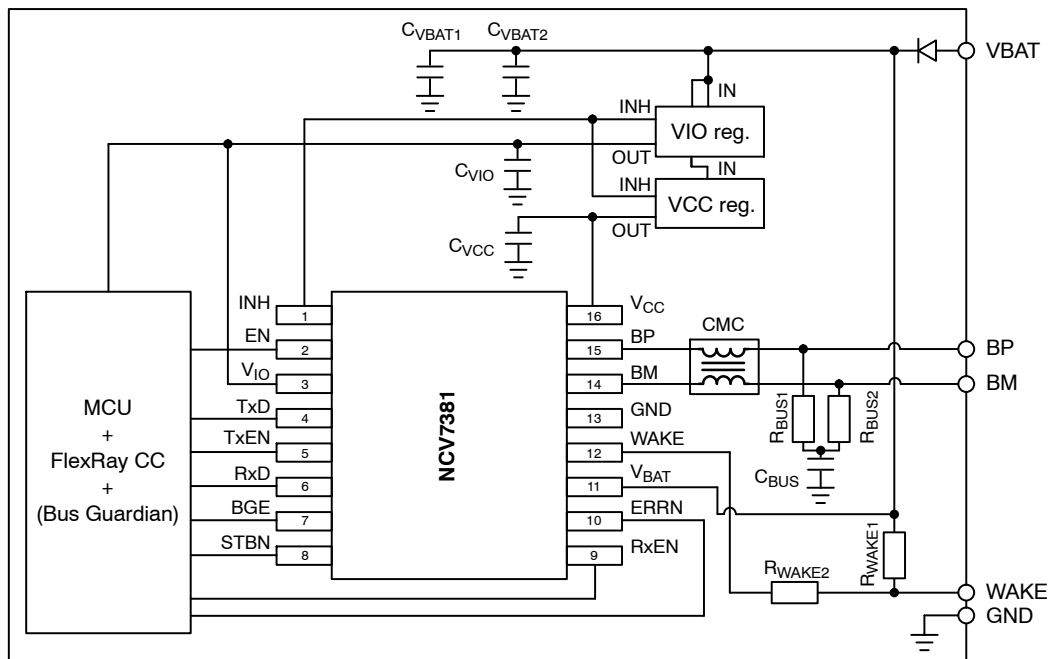
Figure 5. NCV7381 FlexRay Bus Driver Typical Application Diagram

Component	Function	Min	Typ	Max	Units
C_{VBAT1}	Decoupling Capacitor on Battery Line, Electrolytic		10		μF
C_{VBAT2}	Decoupling Capacitor on Battery Line, Ceramic (XR7)		100		nF
C_{VCC}	Decoupling Capacitor on V_{CC} Supply Line, Ceramic (XR7) (Note 1)		100		nF
C_{VIO}	Decoupling Capacitor on V_{IO} Supply Line, Ceramic (XR7) (Note 1)		100		nF
R_{WAKE1}	Pull–up Resistor on WAKE Pin		33		kΩ
R_{WAKE2}	Serial Protection Resistor on WAKE Pin		3.3		kΩ
R_{BUS1}	Bus Termination Resistor (Note 2)		47.5		Ω
R_{BUS2}	Bus Termination Resistor (Note 2)		47.5		Ω
C_{BUS}	Common–mode Stabilizing Capacitor (Note 3)		4.7		nF
CMC	Common–mode Chokes (Note 4)		100		μH

1. To improve EMC performance, 2.2 μF ceramic decoupling capacitor is recommended.
2. Type 1206 ±1%
3. Type 0805 ±1%
4. Recommended common-mode chokes: EPCOS B82789C0104N00x, EPCOS B82799C0104N001, TDK ACT45R-101-2P-TLxxx, TDK ACT45B-101-2P-TLxxx (x= don't care).

SPECIFICATIONS

Power Supply

The Evaluation board can be power 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 section). 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_T is split into two equal parts R_{TA} and R_{TB} [2].
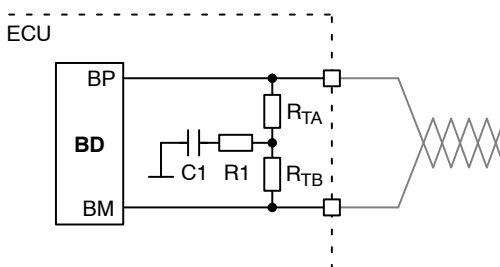
Figure 6. ECU with Split Termination [2]

The serial RC combination (R_1; C_1) at the centre tap of the split termination provides a termination to GND for common mode signals. R_1 is preferably omitted. Typical values are given in the following table:

Table 5. TERMINATION PARAMETERS

Name	Description	Typ	Units
R1	Resistor	< 10	Ω
C1	Capacitor	4700	pF
2 x $|R_{TA} - R_{TB}|$ / ($R_{TA} + R_{TB}$)	Matching of Termination Resistors	≤ 2	%

For R_{TA} and R_{TB} the use of 1% tolerated resistors leads to a matching of 2%.

The better the matching of the split termination resistors R_{TA} and R_{TB}, the lower the electromagnetic emission.

Standard Termination

Recommended bus split termination is shown in the Figure 7. 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.
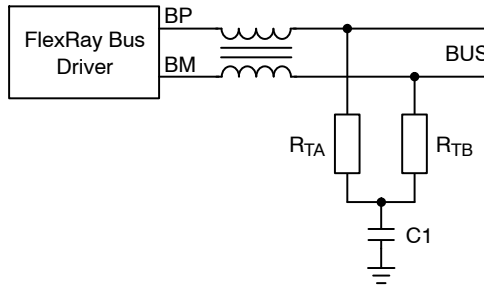

Figure 7. Basic Split Termination

Table 6. BASIC SPLIT TERMINATION PARAMETERS

Name	Description	Value		Units
		End Node	Middle Node	
R_{TA}, R_{TB}	Termination Resistors	47	1300	Ω
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 9 and Table 7.
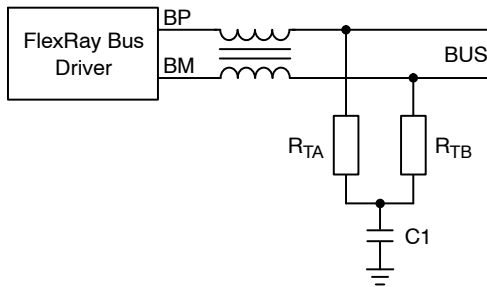
Figure 8. End Node Split Termination
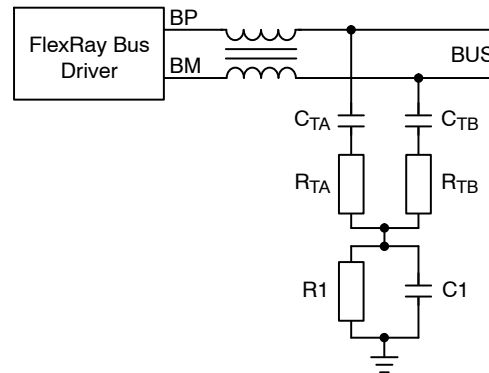
Figure 9. Middle Node Split Termination

Table 7. CUSTOM SPLIT TERMINATION PARAMETERS

Name	Description	Value		Units
		End Node	Middle Node	
R_{TA}, R_{TB}	Termination Resistors	47	24	Ω
C1	Capacitor	4700	4.7	pF
R1	Resistor	–	47	Ω
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].
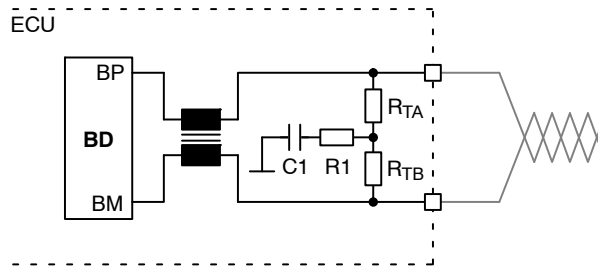
Figure 10. ECU with Split Termination and Common Mode Choke [2]

Table 8. COMMON MODE CHOKE REQUIREMENTS [2]

Name	Description	Typ	Units
R_{CMC}	Resistance per Line	≤ 1	Ω
L_{CMC}	Main Inductance	≥ 100	μH
L_σ	Stray Inductance	< 1	μH

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MCU PROGRAMMING INTERFACE

The NCV7381 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.

P&E USB Multilink BDM Module Distributors

Distributor	Telephone	Email
Arrow Electronics	(877) 237−8621	onlinesales@arrow.com
Avnet Electronics	(800) 408−8353	customer.care@avnet.com
Digi−Key Corporation	(800) 344−4539	webmaster@digikey.com
Future Electronics	(800) 675−1619	e_services@FutureElectronics.com
Mouser Electronics	(800) 346−6873	sales@mouser.com
Newark	(800) 463−9275	sales@newarkinone.com

Software Development Tool

Suitable development tool allowing programming and debugging Freescale microcontrollers is CodeWarrior™ Development Studio (www.freescale.com). The P&E USB Multilink BDM module is directly supported.
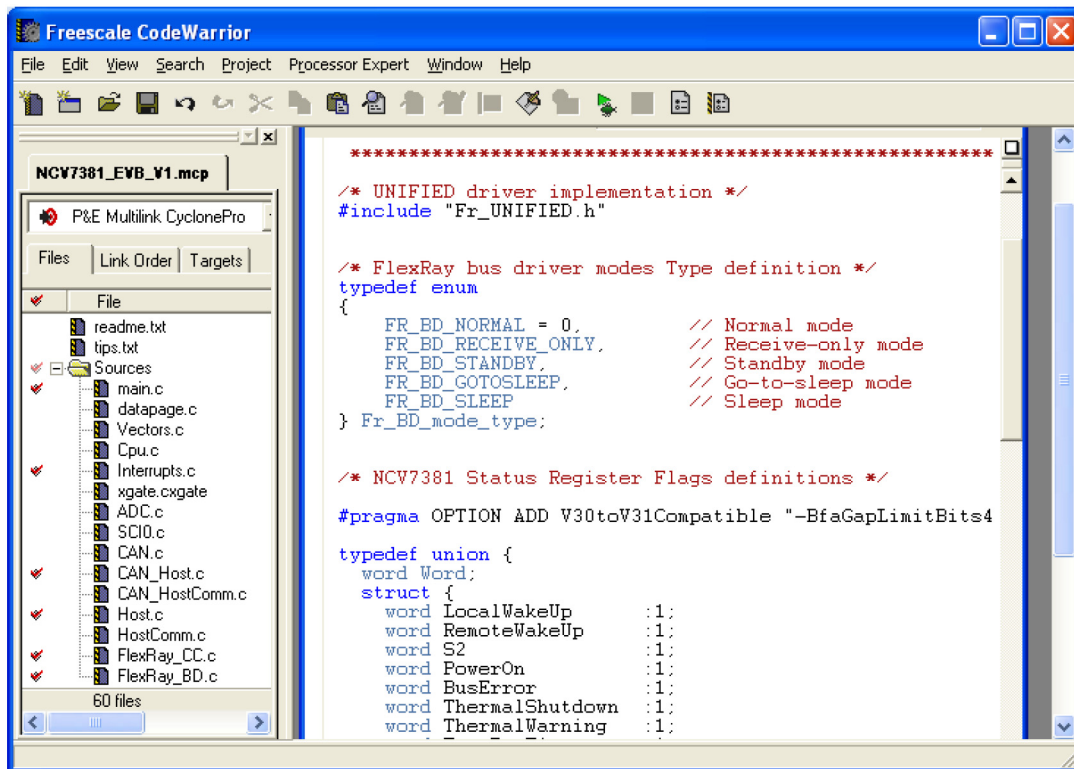
The NCV7381 EVB firmware can be downloaded from ON Semiconductor web site (**www.onsemi.com).**

SCHEMATIC
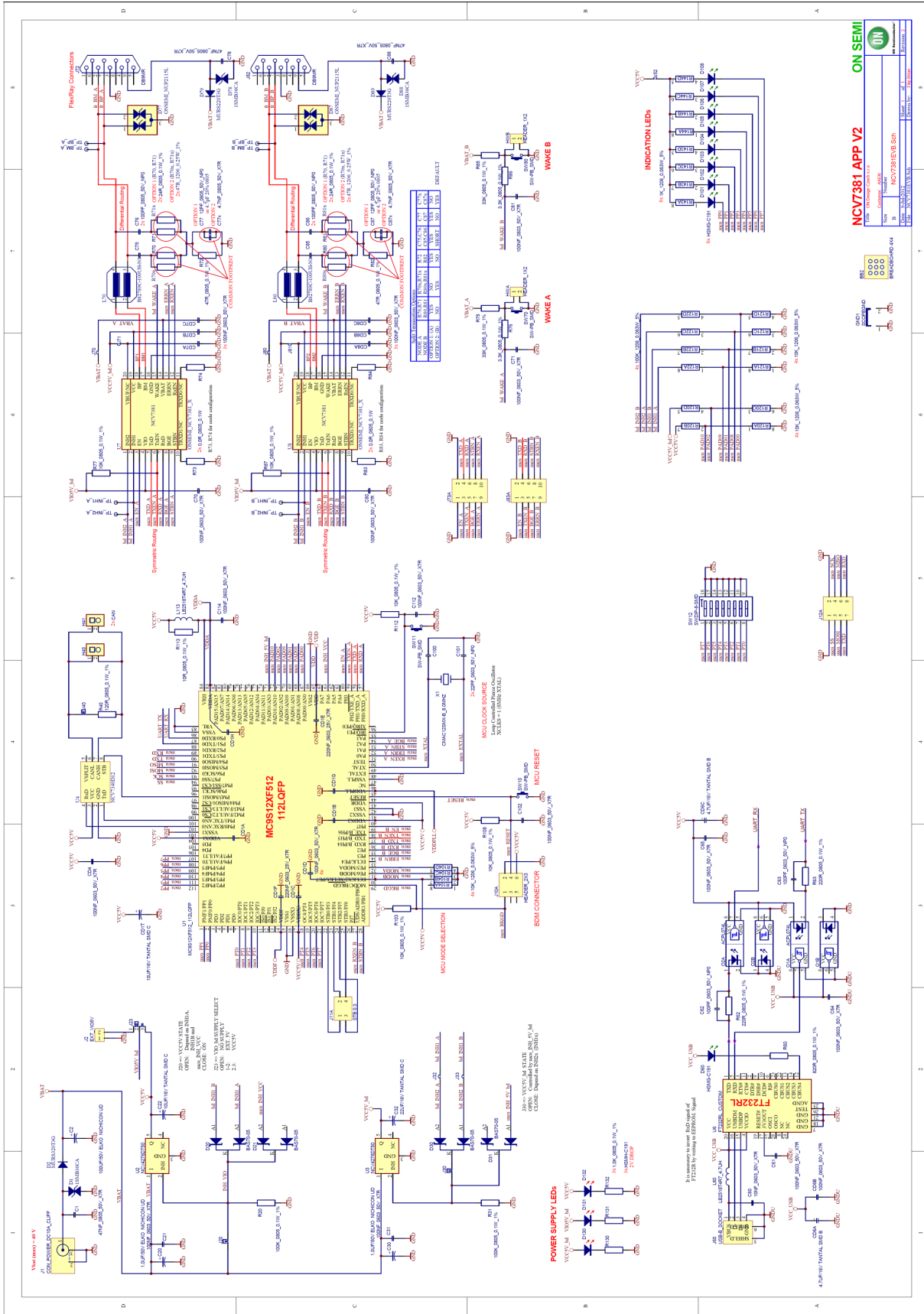
PCB DRAWINGS

Assembly Drawings
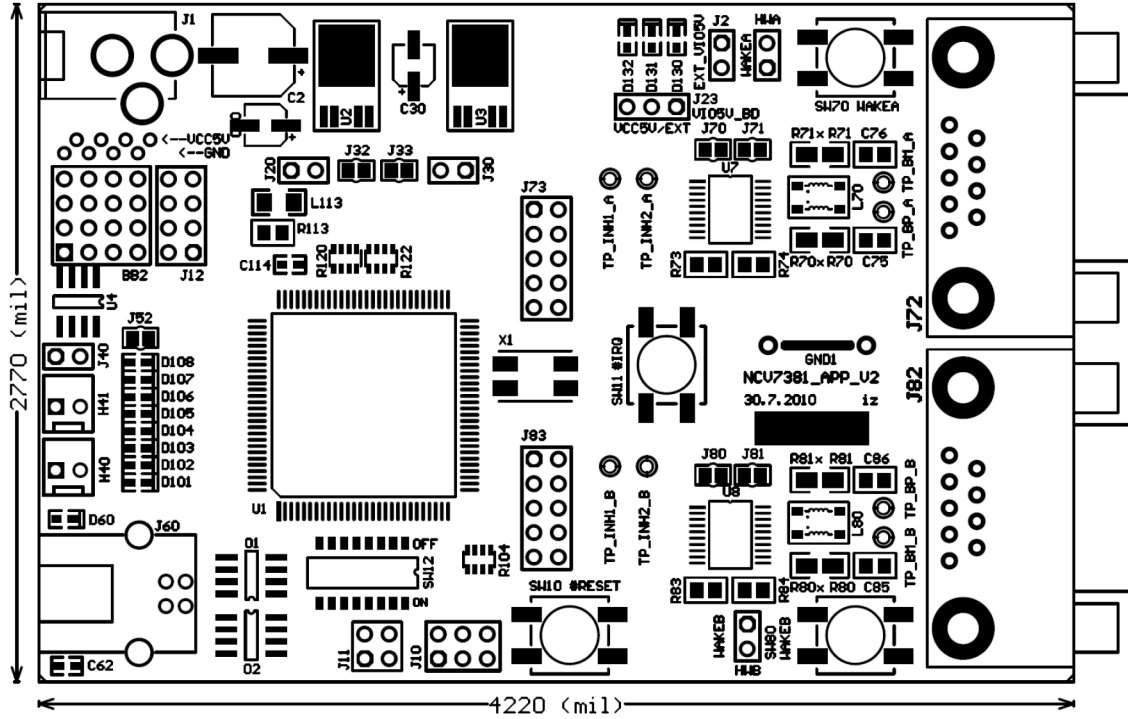
Figure 11. NCV7381 EVB PCB Top Assembly Drawing
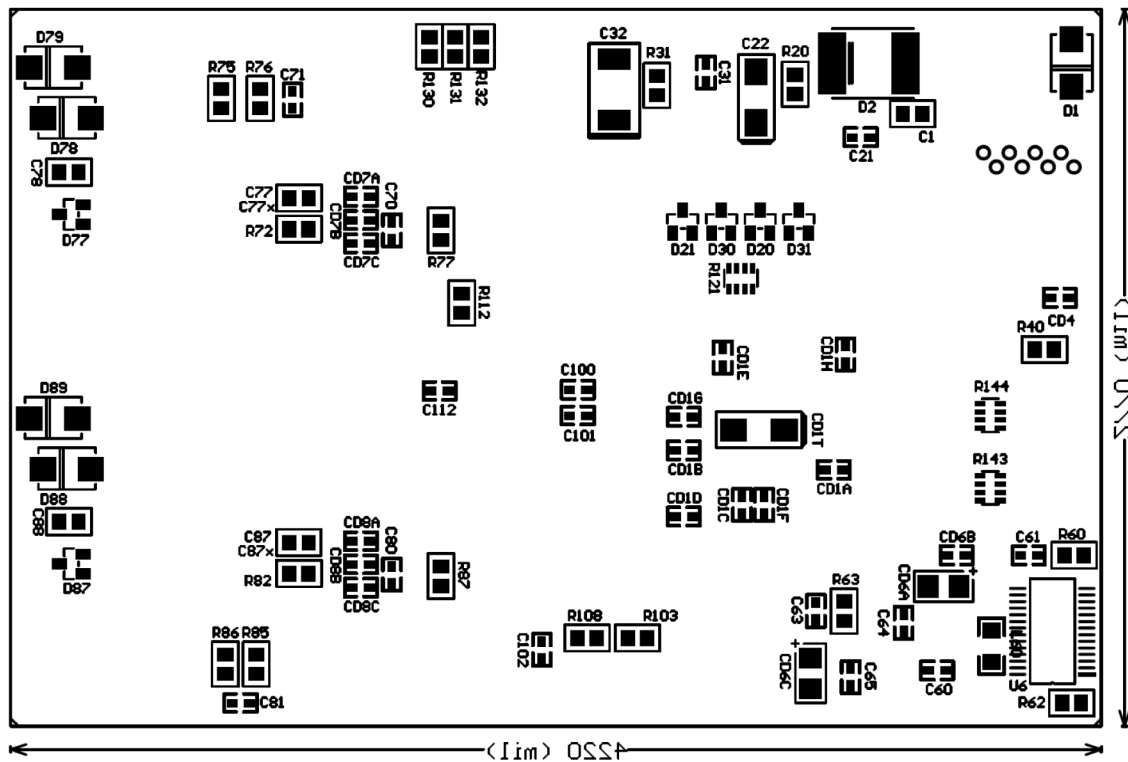
Figure 12. NCV7381 EVB PCB Bottom Assembly Drawing

Composite Drawings
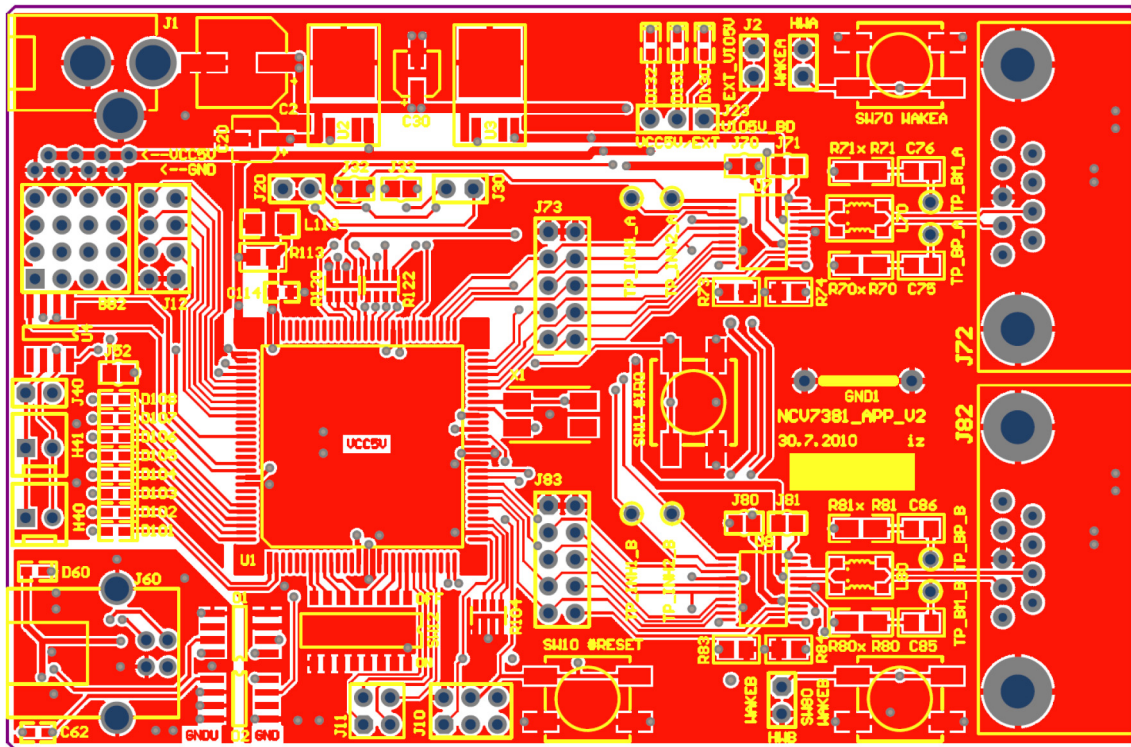
Figure 13. NCV7381 EVB PCB Top Composite Drawing
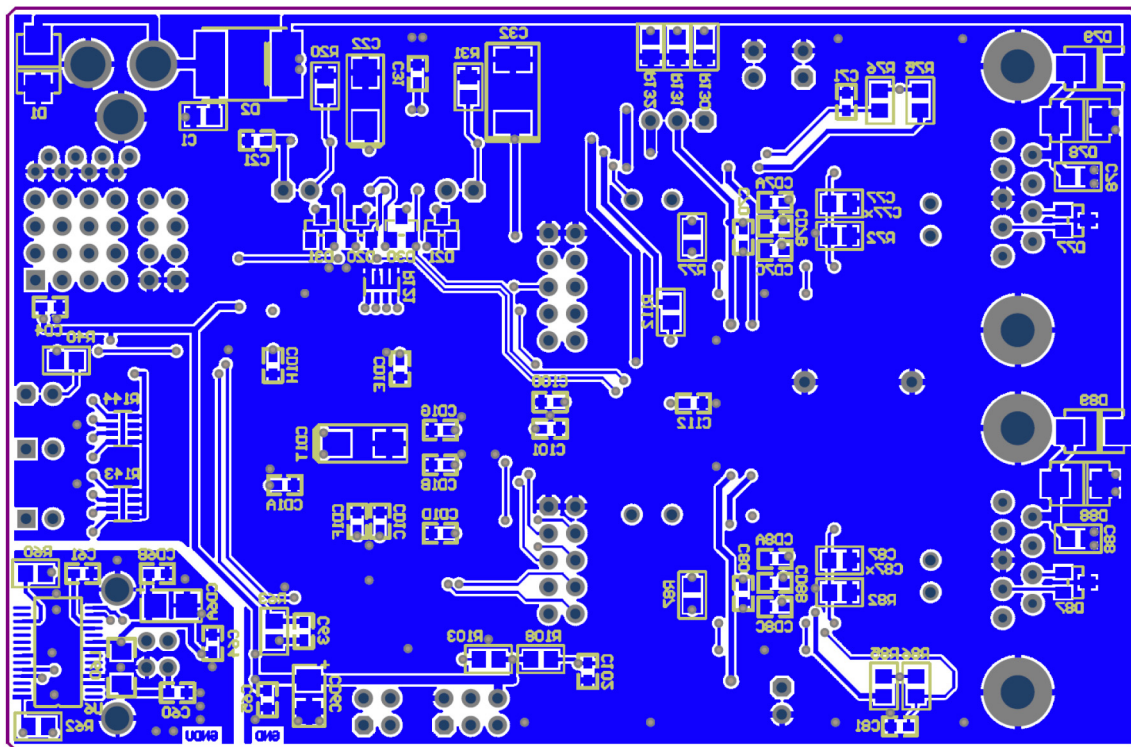
Figure 14. NCV7381 EVB PCB Bottom Composite Drawing (Mirrored)

PCB General Parameters

- Material: FR4
- Cu Plating Thickness: 18 μm 0.5 oz
- Surface Treatment: Au
- Solder Resist: Green, Both Sides

Dimensions

- Length: 107.2 mm 4220 mil
- Width: 70.4 m 2770 mil
- Thickness: 1.5 mm
- Minimum Clearance: 0.25 mm 9.842 mil

REFERENCES

[1] On Semiconductor, NCV7381 FlexRay™ Transceiver, Rev. 0, May 2012.
[2] FlexRay Consortium. FlexRay Communications System – Electrical Physical Layer Specification, V3.0.1, October 2010.
[3] FlexRay Consortium. FlexRay Communications System – Physical Layer EMC Measurement Specification, V3.0.1, October 2010.

PACKAGE DRAWING AND DIMENSIONS

16 LEAD SSOP
CASE 940B–03
ISSUE D
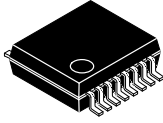
SCALE 2:1
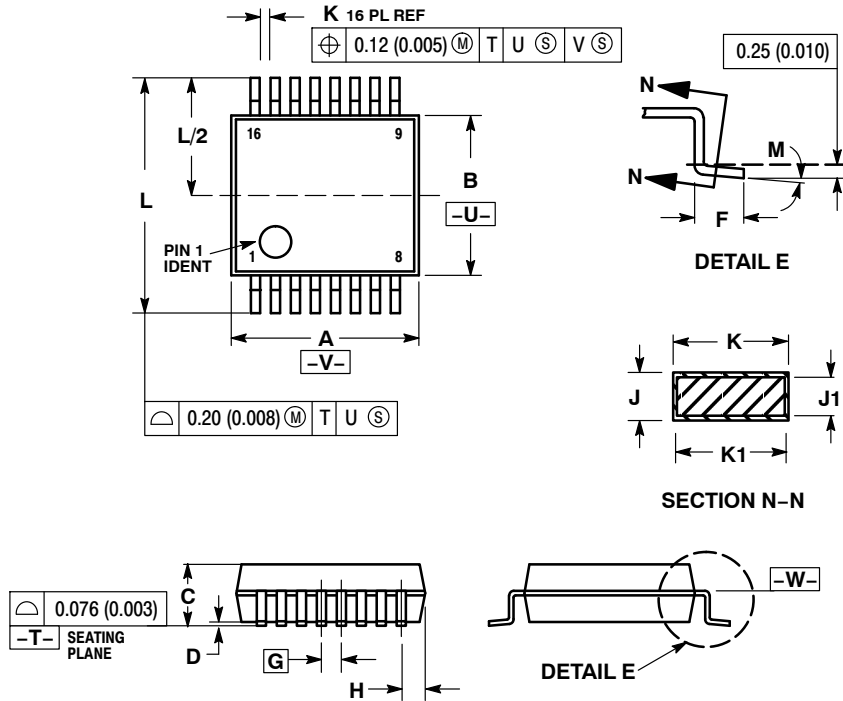
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
5. DIMENSION K DOES NOT INCLUDE DAMBAR PROTRUSION/INTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.13 (0.005) TOTAL IN EXCESS OF K DIMENSION AT MAXIMUM MATERIAL CONDITION. DAMBAR INTRUSION SHALL NOT REDUCE DIMENSION K BY MORE THAN 0.07 (0.002) AT LEAST MATERIAL CONDITION.
6. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
7. DIMENSION A AND B ARE TO BE DETERMINED AT DATUM PLANE –W–.

DETAIL E

SECTION N–N

SEATING PLANE

DETAIL E

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	6.07	6.33	0.238	0.249
B	5.20	5.38	0.205	0.212
C	1.73	1.99	0.068	0.078
D	0.05	0.21	0.002	0.008
F	0.63	0.95	0.024	0.037
G	0.65 BSC		0.026 BSC	
H	0.73	0.90	0.028	0.035
J	0.09	0.20	0.003	0.008
J1	0.09	0.16	0.003	0.006
K	0.25	0.38	0.010	0.015
K1	0.25	0.33	0.010	0.013
L	7.65	7.90	0.301	0.311
M	0 °	8 °	0 °	8 °

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