Evaluation Kit for the NCV77320 Inductive Position Sensor Interface Chip

EVBUM2863/D

INTRODUCTION

This document describes the NCV77320 Inductive Position Sensor Interface Evaluation kit and its properties. The Evaluation kit is intended for demonstration of the measurement capabilities of the NCV77320. The kit can be used for first evaluations and is not intended for use at low and high automotive specified temperatures.

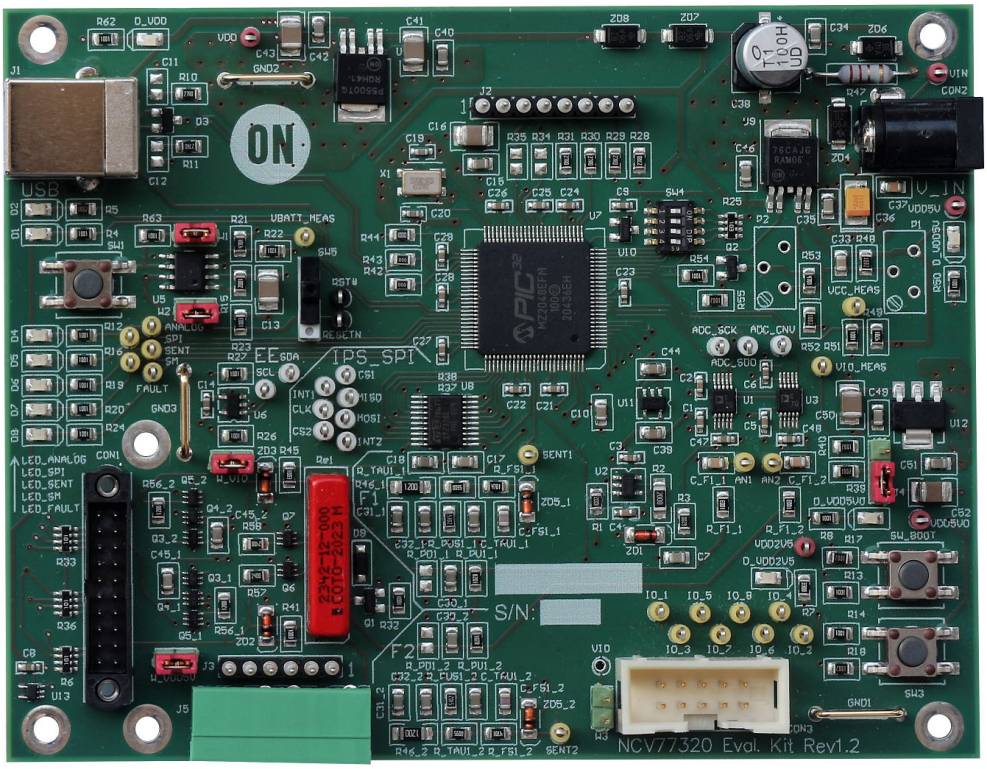


Figure 1. Evaluation Board Photo

Features

- PC GUI Operation via USB
- Based on the NCV77320 Inductive Position Sensor
- Two NCV77320 Chips on Piggyback Connected to Evaluation Kit
- Switchable ANALOG and SENT Output through Relay
- Bootloader Application for Updating Firmware

Typical Applications

- Demonstration of the NCV77320 Performance
- Evaluation Platform Assisting Software
- Programing NCV77320 in Service Mode

Revision History

- **GUI**
  1.1 first silicon version (obsolete)
  1.2 second silicon version (active)
- **FW**
  1.1 first silicon version (obsolete)
  1.2 second silicon version (active)

General Description

The Evaluation kit is intended for use with the NCV77320 Inductive Position Sensor chip.

A Small piggyback board with rotor and two NCV77320 chips is connected to the Evaluation kit. Both chips can be programmed and controlled from the PC GUI via USB

In Operating mode it is possible to set the chip to ANALOG or SENT output. If the output is set to ANALOG, the output voltages of the chips are measured by an on−board ADC and send to the GUI, if the output is set to SENT, it is possible to read the position from the output pins through this protocol. Complementary to ANALOG or SENT operation, it is possible to use the SPI interface to access the chip(s) internal registers as well.

In Service mode it is possible to communicate with the chips via the serial interface through the output pin or by SPI. In this mode it is possible to calibrate the chip and program the registers into the EEPROM.

The Evaluation kit is operated through a windows−based GUI (Graphical User Interface) and is connected via a USB cable to the microcontroller of the evaluation board. The microcontroller handles the translation from USB to the NCV77320 devices.

For the description and capabilities of the NCV77320, refer to the datasheet of this devices.

PC Software Requirements

The GUI works with Microsoft Windows 7, 8, 10 and 11 platforms.

The GUI software is a part of the install package, which can be downloaded from the EVK product page: https://www.onsemi.com/design/evaluation−board/NCV77320R1GEVK . It can be installed by executing the file: Install_NCV77320_EVK_GUI.exe.

Powering up the Evaluation kit:

1. Install the GUI software at the appropriate Windows platform with a free USB channel. Follow the instruction on the screen for installation. After successful installation, the Evaluation kit can be powered up.
2. Connect the USB cable from the Evaluation kit to the PC.
3. Connect +12 Vdc supply to the V_IN connector.
4. Wait until the drivers for the Evaluation kit are found (if not, install the USB CDC driver manually).
5. Launch the NCV77320_EVK GUI.

The Evaluation kit should connect automatically.

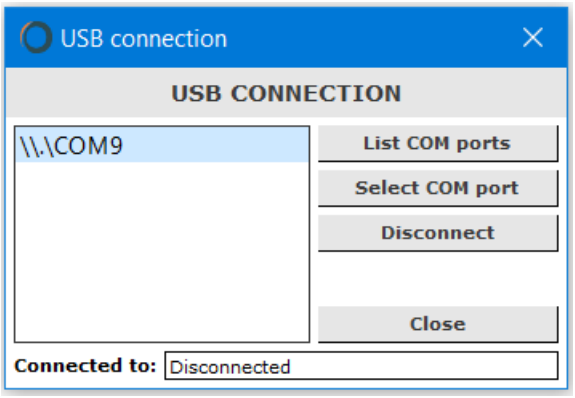
USB Connection

If the connection is established, the USB connect button is green and it is possible to see the COM port which is connected.

If the Evaluation board is not connected or the GUI just didn't find it, USB Disconnect button is orange.

If the GUI is launched before connecting the Evaluation kit or the power supply is turned on later, clicking to USB Connect button should connect the evaluation kit to the COM port. Clicking to USB Disconnect should disconnect the Evaluation kit.

If Connect automatically is checked in the Menu bar → USB connection, the GUI will try to connect to the COM port automatically. It is possible to connect to the COM port manually by clicking Menu Bar → USB connection → Manage manually.



Click on the COM port in the list to choose the correct one and then click on the Select COM port button. The bottom should change the text to **Connected to:** COM port.

If Manage manually is clicked, in Menu Bar → USB connection → Connect automatically is unchecked. It is possible to click on it and "check" it, so the GUI will try to connect automatically again.

Main Screen

The picture below shows the main Operation mode screen of the GUI. On the top there is a Menu bar, where several tabs can be selected (Green marked area):

- Operation mode: Read and show the output data, evaluation kit information
- Service mode: Enter/Exit Service mode, easy device configuration
- REGs [address]: Detailed EEPROM memory content
- Runtime memory: Contains the real time information: the actual position, ADC data and diagnostics
- Fail Flags: Decoded diagnostic information

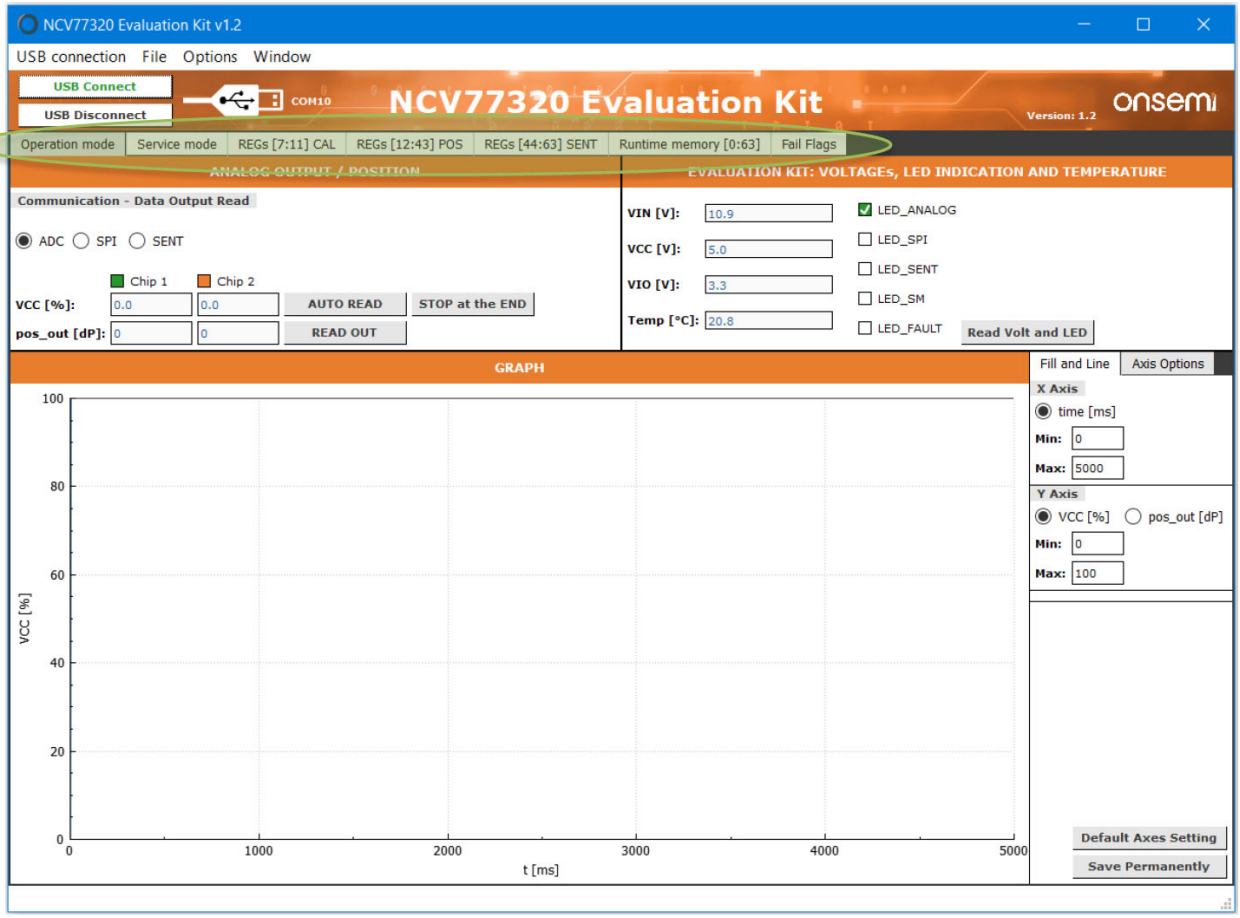
Menu Bar

- **USB connection**

  Gives options for automatic and manual USB connection.
- **File**

  Save registers or data graph to .csv. It is also possible to save the content of the memory to .cnf file or load a previously saved configuration.
- **Options**

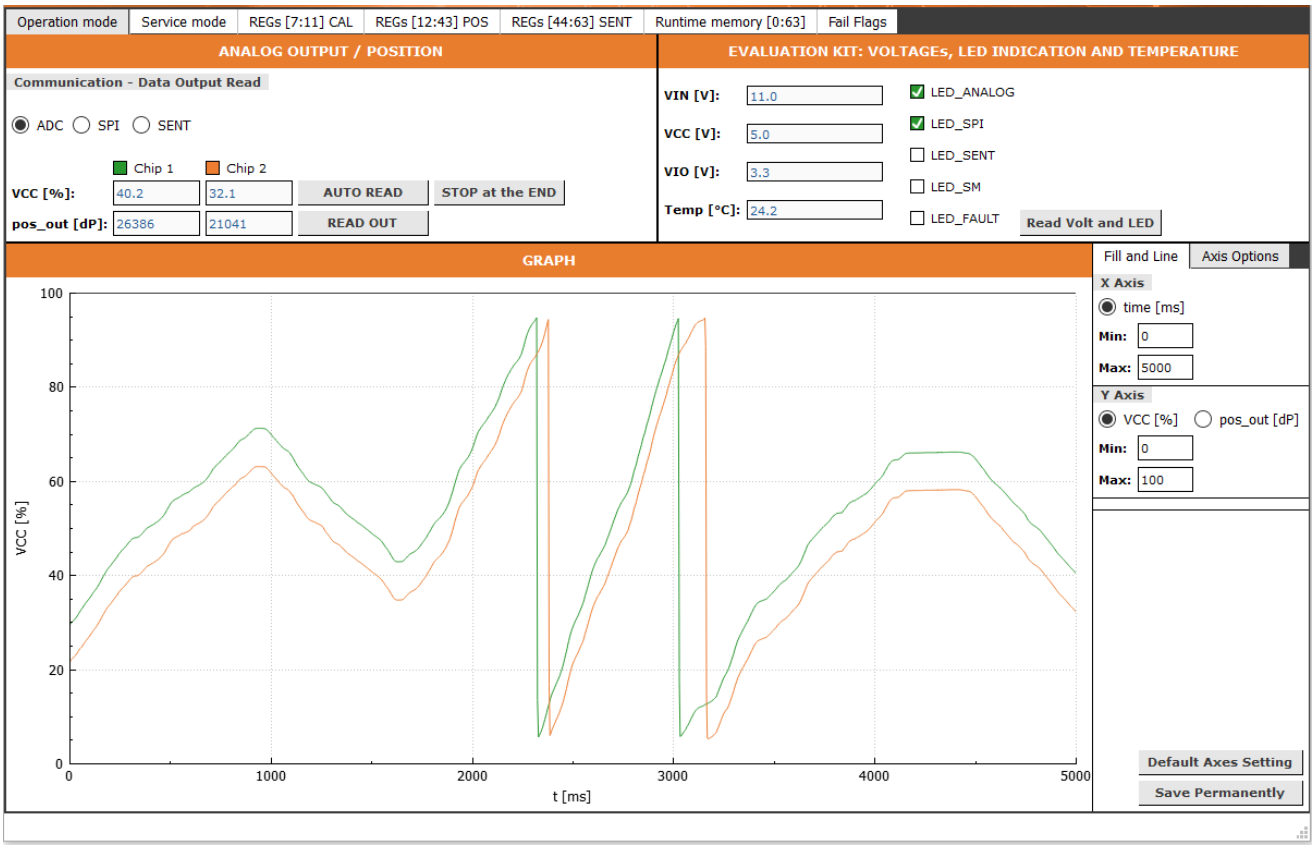
  The Customer can turn on or off the tool tips in the GUI.
- **Window**
  - WatchDog – setting up the periodic watchdog kick when watchdog is enabled
  - SENT messages – read fast and slow SENT messages
  - Calibration – automatic dcc calibration without the rotor
  - Direct ADC sampling – periodic sampling of the rec32 and rec21 registers for the 2 coil sine/cosine sensors
  - PIC32 bootloader – launches the program tool for flashing new firmware to the micro controller
  - Help – show help window



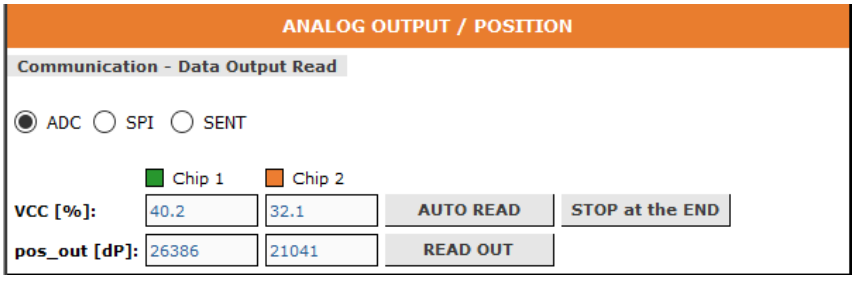
Operation Mode Tab:

In Operation mode tab there are three main parts:

- “ANALOG OUTPUT / POSITION”
- “EVALUATION KIT: VOLTAGES, LED INDICATION AND TEMPERATURE”
- “GRAPH”



ANALOG OUTPUT / POSITION



In “ANALOG OUTPUT / POSITION” it is possible to read the position data from two chips. First it is necessary to choose the communication interface for reading the data:

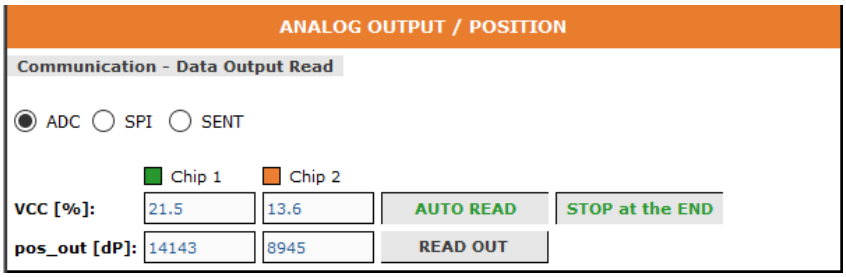
- **ADC** – Data readout through the ADCs which are on the Evaluation Kit. Each chip has its dedicated ADC
- **SPI** – Data readout through the SPI interface. It is necessary to enable this option in EEPROM – ADDRESS [8], spi_ena [2]
- **SENT** – Data readout through the SENT interface

ANALOG or SENT output option has to be programmed in EEPROM – ADDRESS [8], sent_drv [12]. Each chip can be set differently. If a chip is programmed for ANALOG output but the communication is set to SENT in the GUI, it is not possible to read proper data, and vice versa.

The position data is displayed in four Line Edits – two for both chips. Pos_out is the 16 bit digital position data and the VCC is the recalculated value to the percentage of the VCC because of the ratiometric output.

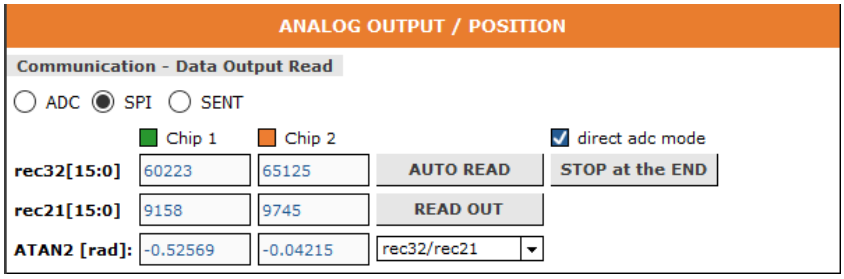
There are three push buttons:

- **READ OUT**– Read the data from both chips and display them to line edits
- **AUTO READ** – Continuous position data readout and plotting them in the graph
- **STOP at the END** – Stops auto read when the data reach the end of the graph



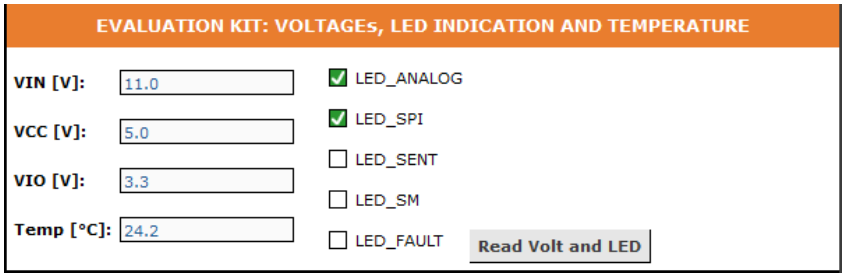
If the AUTO READ button is pushed, the GUI gets the data from the chips and shows it in the graph. Pushed buttons give green text. If a button is clicked again, AUTO READ stops. The same applies for the STOP at the END button.

When SPI communication is set, additional check box direct adc mode appears right above the STOP at the END button. This mode is intended to use with 2 coils sensors (sine and cosine) and direct adc readout from the chip. When checked, readout is changed from Vcc [%] and pos_out [dP] to registers rec32 [15:0] and rec21 [15:0]. For proper readout, it is necessary to program bit 4 in register 8 (direct_adc) in the chip EEPROM memory.



The Position is then calculated with function ATAN2 [rad] and the user can select if it is calculated as rec32/rec21 or rec21/rec32.

EVALUATION KIT: VOLTAGES, LED INDICATION AND TEMPERATURE

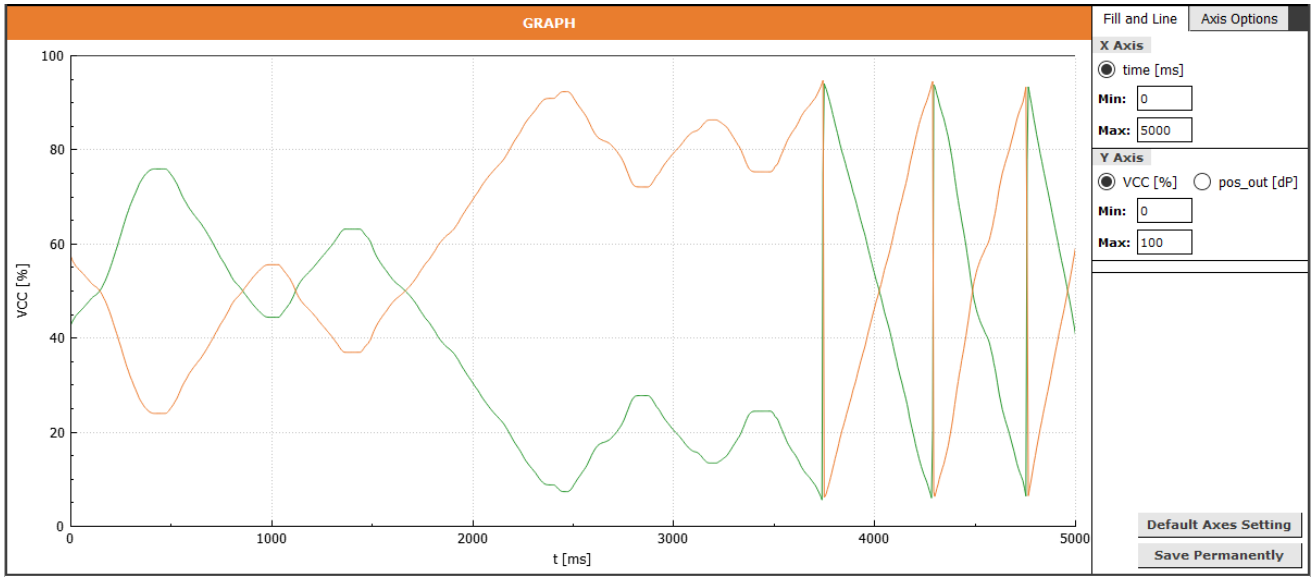


There are four readable values from the Evaluation Kit:

- **VIN [V]** – input voltage
- **VCC [V]** – power supply for the chip
- **VIO [V]** – 5 V or 3V3 regulator voltage
- **Temp [°C]** – temperature measured on the Evaluation Kit

There are also LED_xx indicators. They indicate selected interface, Service mode entered (SM) and Faults. Those indicators present the same state as the physical LEDs on the Evaluation Kit. After clicking Read Volt and LED, all data is read and presented.

GRAPH



In the GRAPH part it is possible to see the data from chips which are read when AUTO READ button is pressed. On the right there is a panel for graphical settings. It is possible to set:

- **X axis** – set min and max time value
- **Y axis** – set min and max value and it is possible to choose what is showed in the graph – VCC% or Position in dP (datapoints)
- **Axis option** – set color and line style for each curve

It is possible to save these settings permanently by clicking the Save Permanently button. If you want to set the default values, click Default Axes Setting or delete the file **format.cnf** in GUI folder.

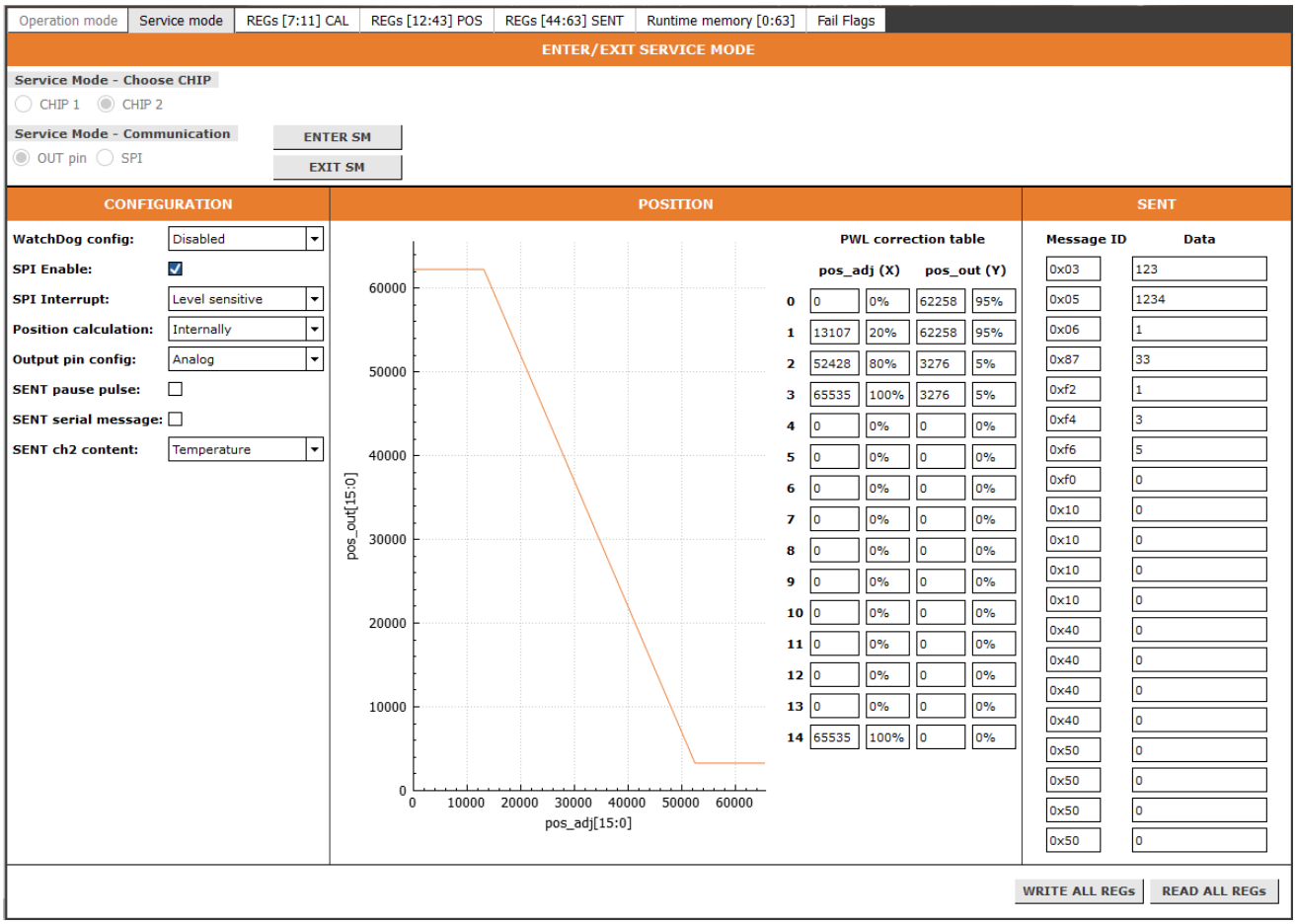
Service Mode Tab:

In Service mode tab there are four main parts:

- ENTER/EXIT SERVICE MODE
- CONFIGURATION
- POSITION
- SENT

There are also two buttons for Write all registers or Read all registers.

- WRITE ALL REGs button is disabled if NCV77320 is in Operation mode. It is enabled after entering Service mode only
- READ ALL REGS button is enabled all the time, but for successful readout in operational mode it is necessary to enable SPI in EEPROM (spi_ena = 1). Without SPI enabled, all values are read as 0xFFFF

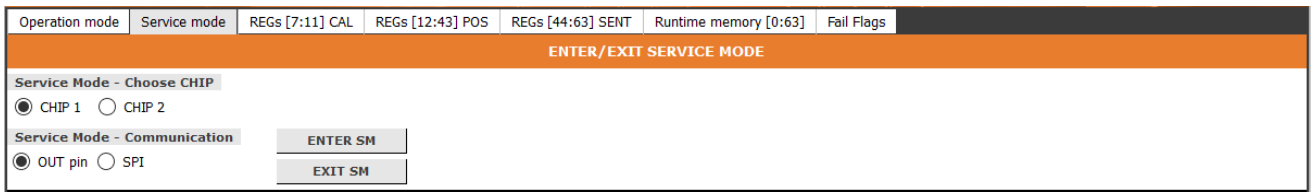


Parts CONFIGURATION, POSITION and SENT are disabled until the Service mode is entered. After entering Service mode, they are enabled for write.

All registers accessed in this Service mode tab can be approached via the other tabs with the detailed memory map (REGs [7:11] CAL, REGs [12:43] POS, REGs [44:63] SENT, Runtime memory [0:63]).

This tab displays the data in more user−friendly format, but it is not possible to set all the registers there. Calibration data, position zero offset, diagnostics disable and lock bit for calibration part of the EEPROM needs to be set in REGs [7:11] CAL.

ENTER/EXIT SERVICE MODE

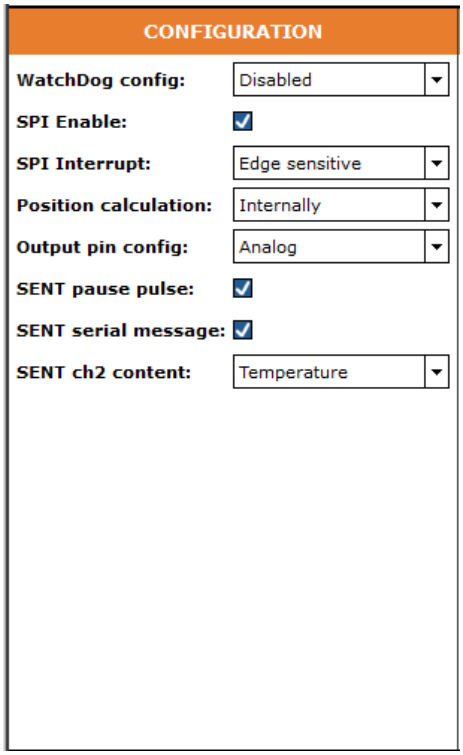


This part is used to enter and exit the Service mode. It is necessary to select which chip and which interface should be used to enter the Service mode. After clicking on the ENTER SM, the chip which is chosen is brought into Service mode.

If the chip is in Service mode, all Write buttons are enabled so almost all registers are possible to program. For more information about setting registers see below – Registers.

EXIT SM leaves the Service mode and brings the chip to the Operation mode.

CONFIGURATION

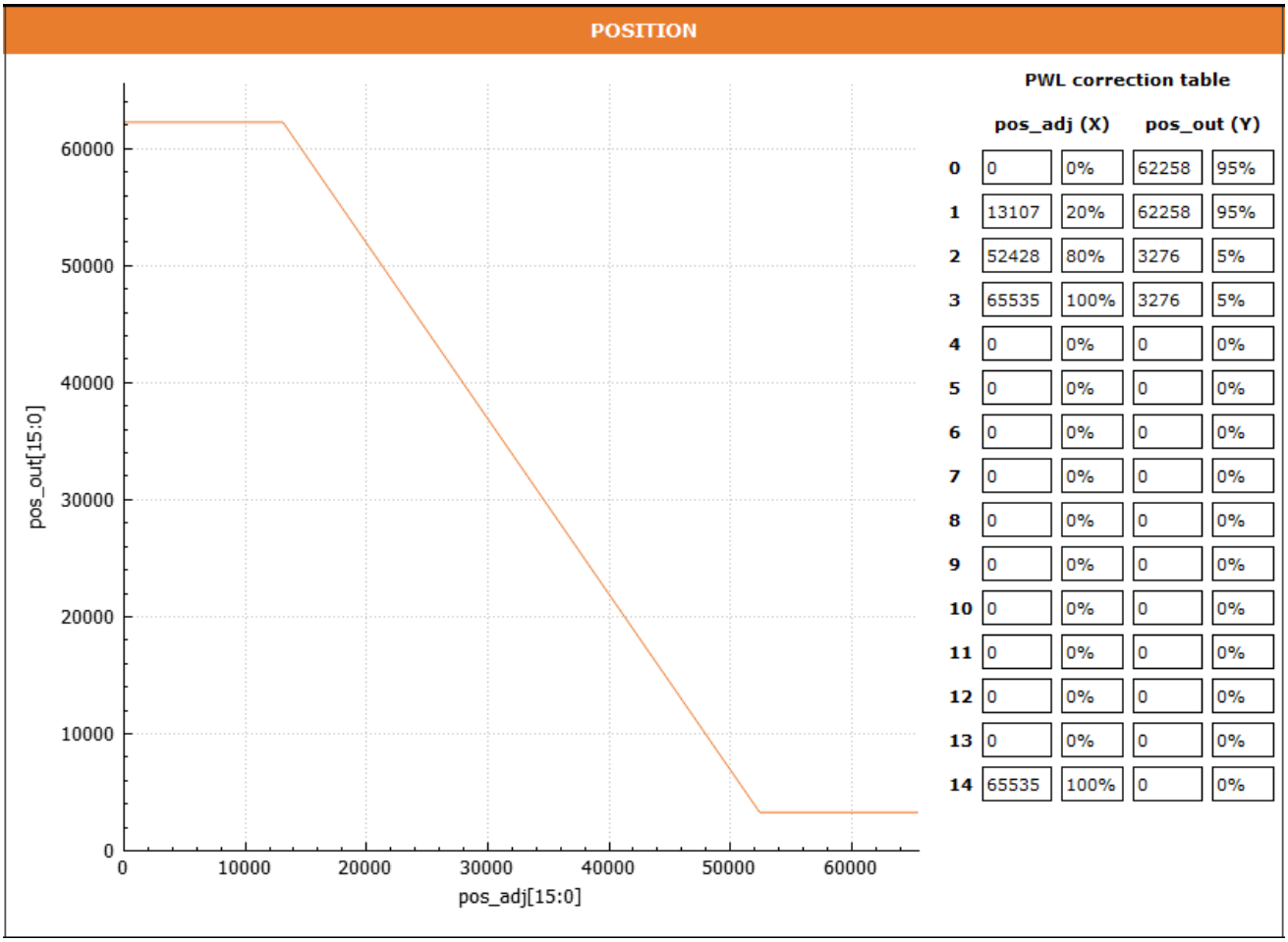


This sets the basic parameters in registers [7:11] CAL. It is possible to enable or configure:

- WatchDog configuration
  - Disabled
  - 5 ms initial watchdog window
  - 20 ms initial watchdog window
  - 200 ms initial watchdog window
- SPI
  - Enable/disable
  - SPI interrupt level or edge sensitive
- Position calculation
  - Internally or externally (just RAW ADC data are available through SPI)
- Output pin configuration
  - ANALOG
  - SENT
- SENT
  - Pause pulse enable
  - Serial messages enable
  - Fast channel 2 content – temperature or secure frame counter (H.1 or H.4 formats)

For more settings it is necessary to go to the REGs [7:11] CAL tab.

POSITION



	pos_adj (X)		pos_out (Y)	
0	0	0%	62258	95%
1	13107	20%	62258	95%
2	52428	80%	3276	5%
3	65535	100%	3276	5%
4	0	0%	0	0%
5	0	0%	0	0%
6	0	0%	0	0%
7	0	0%	0	0%
8	0	0%	0	0%
9	0	0%	0	0%
10	0	0%	0	0%
11	0	0%	0	0%
12	0	0%	0	0%
13	0	0%	0	0%
14	65535	100%	0	0%

In this part it is possible to set the PWL correntionn table. On the left there is a graph which shows the programmed output curve. On the right it is possible to set pos_adj and pos_out in dP or in percentage.

Pos_adj on the first position (zero) and last position (fourteen) is not possible to set. First position is always set to zero and the last is always 65535. Last position is used only if all positions before are set. New pos_adj X has to be always higher then previous and the last point used must be 65535 to close the table.

With the PWL table it is possible to program a desired transfer function, clamp the position output for certain minimum and maximum levels and remaining PWL points can be used for further linearization of the transfer function durring the calibration process.

To check detailed memory content with calculated CRC values it is necessary to go to the REGs [12:43] POS tab.

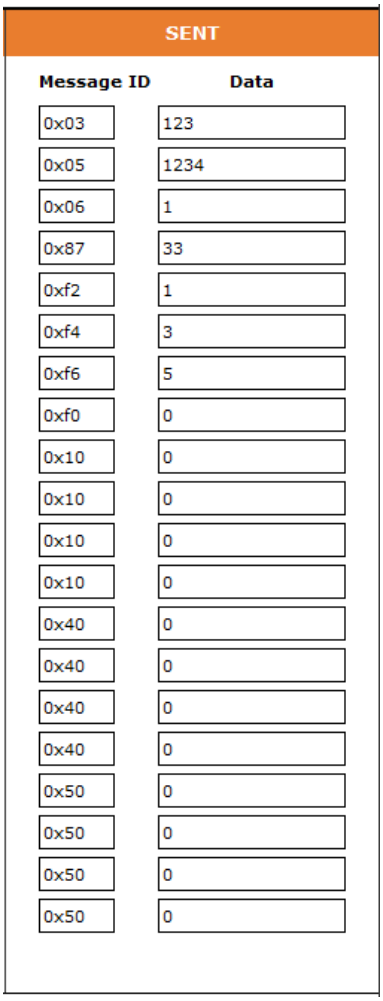
For more information please refer to the datasheet.

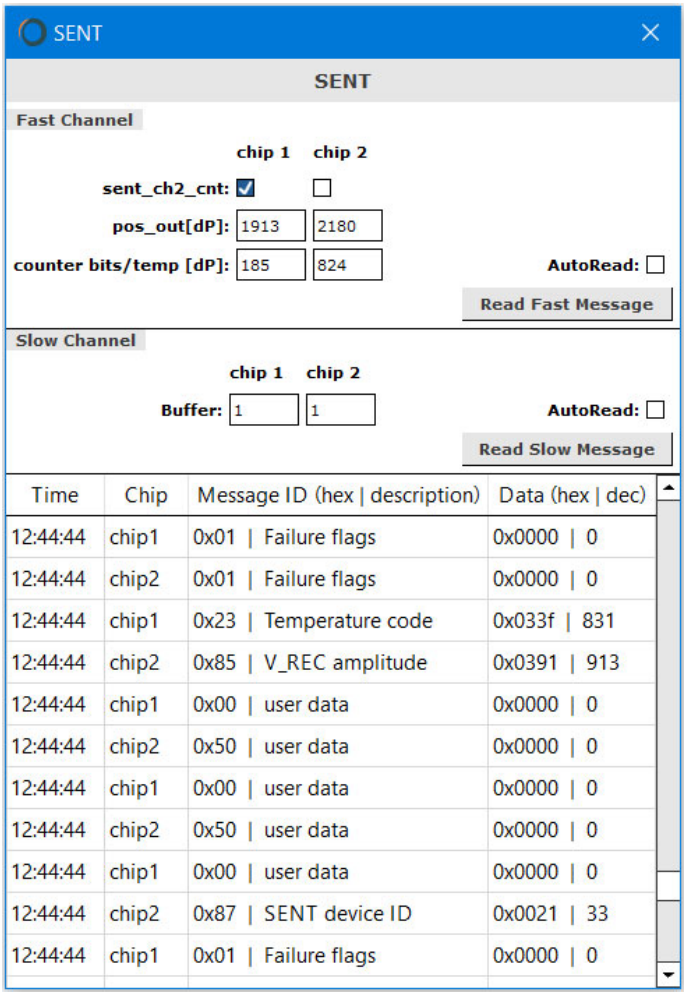
SENT

Here it is possible to configure the SENT slow channel messages. First it is necessary to program the Message ID. It is in Hex format. Then it is possible to program the Data in the range 0 to 4095.

In the SENT settings part of the Service mode tab it is possible to set easily the Message ID and Data. Message ID is folded from two programmable registers. The first hex place is sent_idpgx and the second is sent_idxx. It is the reason why there is always the same hex number on the first nibble of Message ID for four messages. For further explanation please check the datasheet – Table 15: Enhanced Serial Message Sequence.

The user can read this data in the SENT window. It is shown by clicking the Menu Bar → Window → SENT messages. If SENT communication is turned off, the GUI will ask if the user wants to turn it on.





It reads two channels: fast channel and slow channel. Clicking on Read Fast Message button will read the data and shows it in the line edits. For auto read there is a checkbox AutoRead. When checked, the data is read automatically.

For slow channel there is also the Read Slow Message button for single message read, for auto read it is necessary to check the AutoRead check box. Data is written in the table at the bottom of this window. For transmitting and reading SENT slow channel messages, it is necessary to enable this option in registers – ADDRESS [8], bit 14 [sent_ser_msg].

Sent_ch2_cnt (ADDRESS [8], bit [15]) sets the SENT format. The first channel always contains the position but the second channel can be configured as either temperature or secure counter with first nibble inversion.

Detailed memory map is in the REGs [44:63] SENT tab.

Registers:

When SPI is enabled, it is possible to read all registers from the chips even in operation mode. If SPI is disabled it reads 0xFFFF data on all addresses.

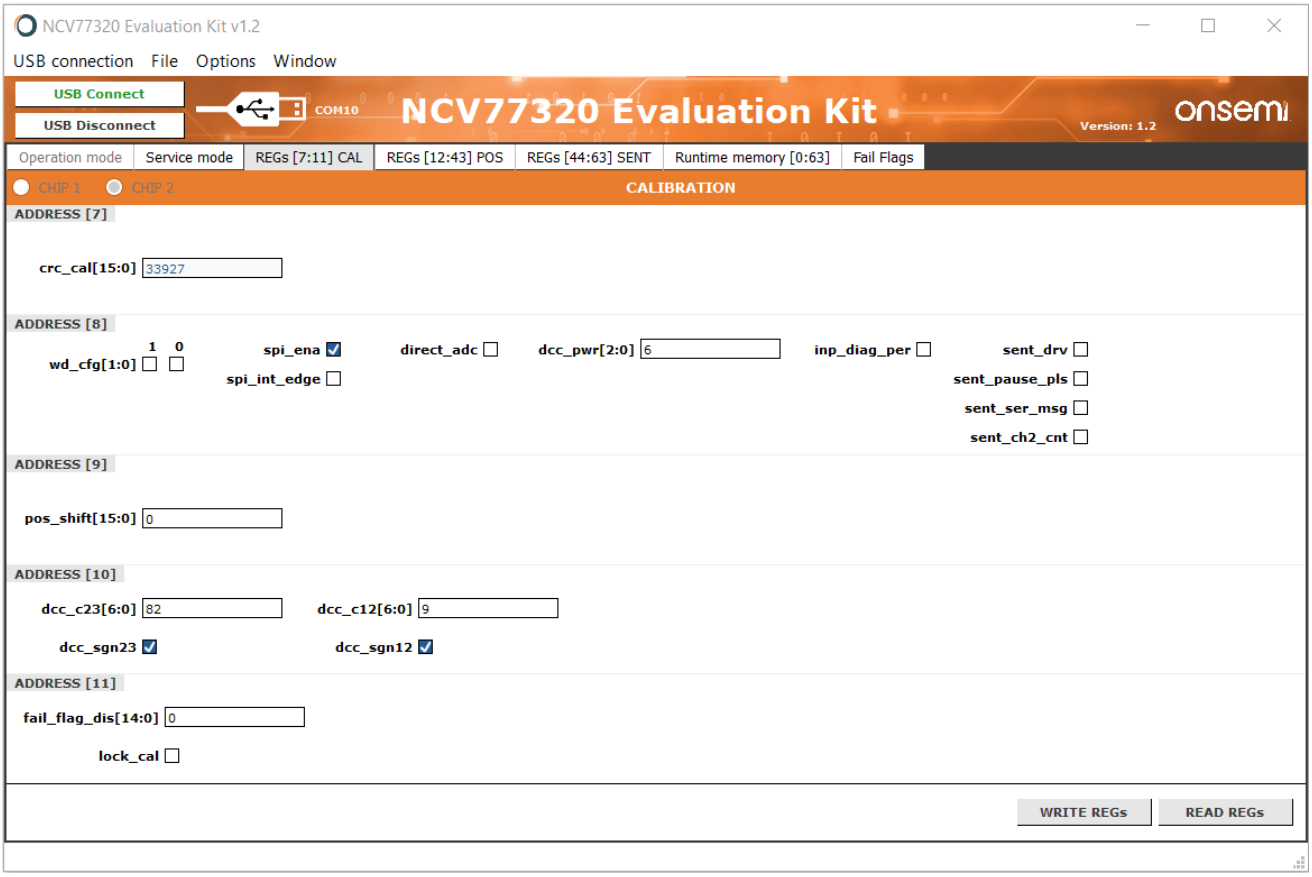
On the top the user can choose between CHIP1 / CHIP2 and on the bottom there are two buttons. One for reading the registers and the other for writing the registers. Every tab for specific registers has its own button to read and write registers on that tab. The Write button is disabled in the Operation mode and is enabled in the Service mode.

CRC values are not possible to change. Correct values are automatically calculated by the software in the GUI according to the EEPROM content.

If Lock bit is checked, the GUI will notify the user before writing the registers because after writing the lock bit, it is not possible to reprogram the values in EEPROM anymore.

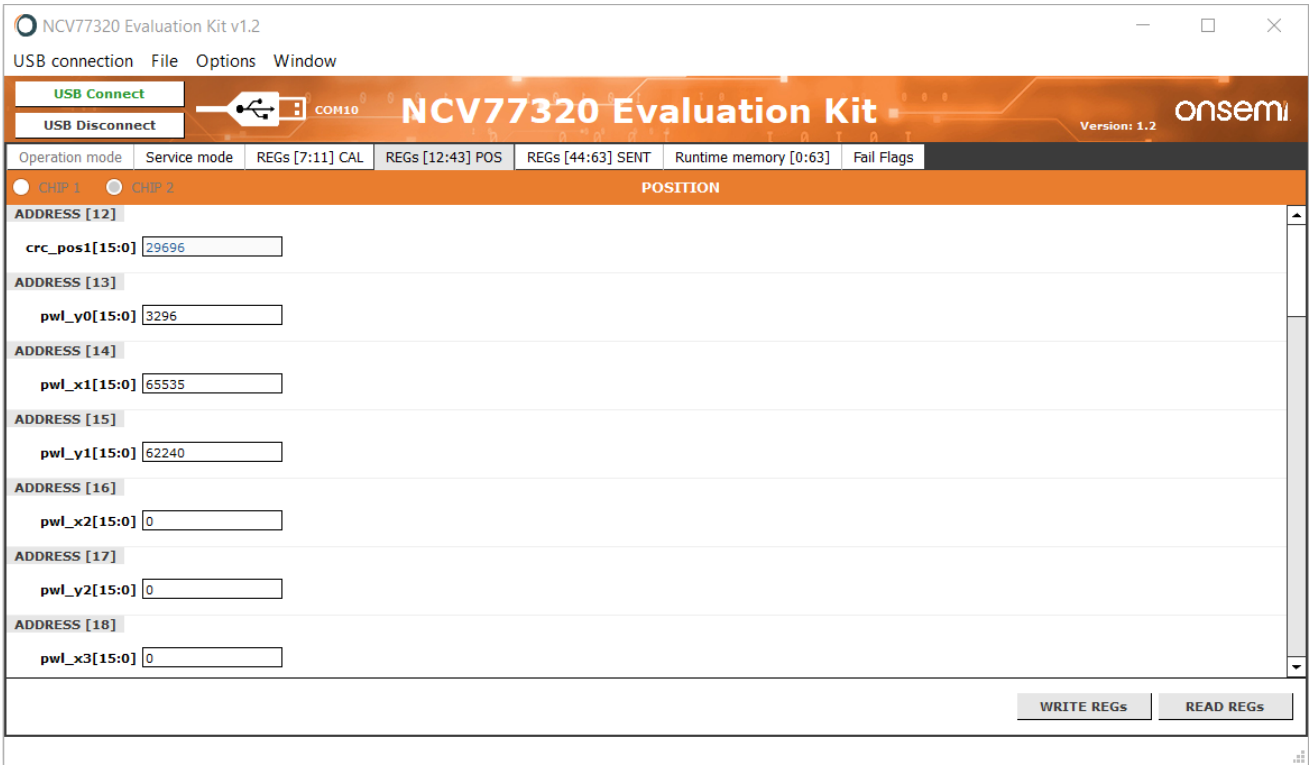
REGs [7:11] CAL

This tab shows registers at the addresses [7:11]; calibration parameters



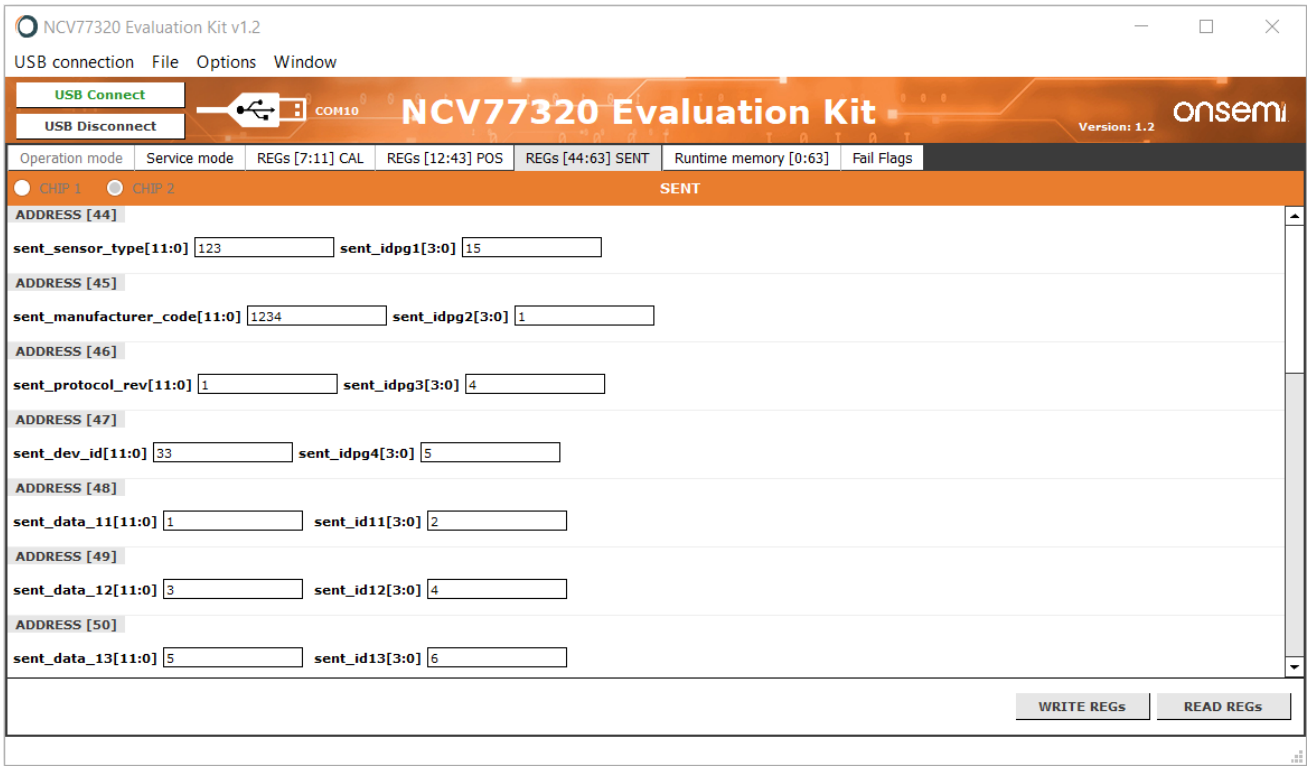
REGs [12:43] POS

This tab shows registers at the addresses [12:43]; PWL correction table



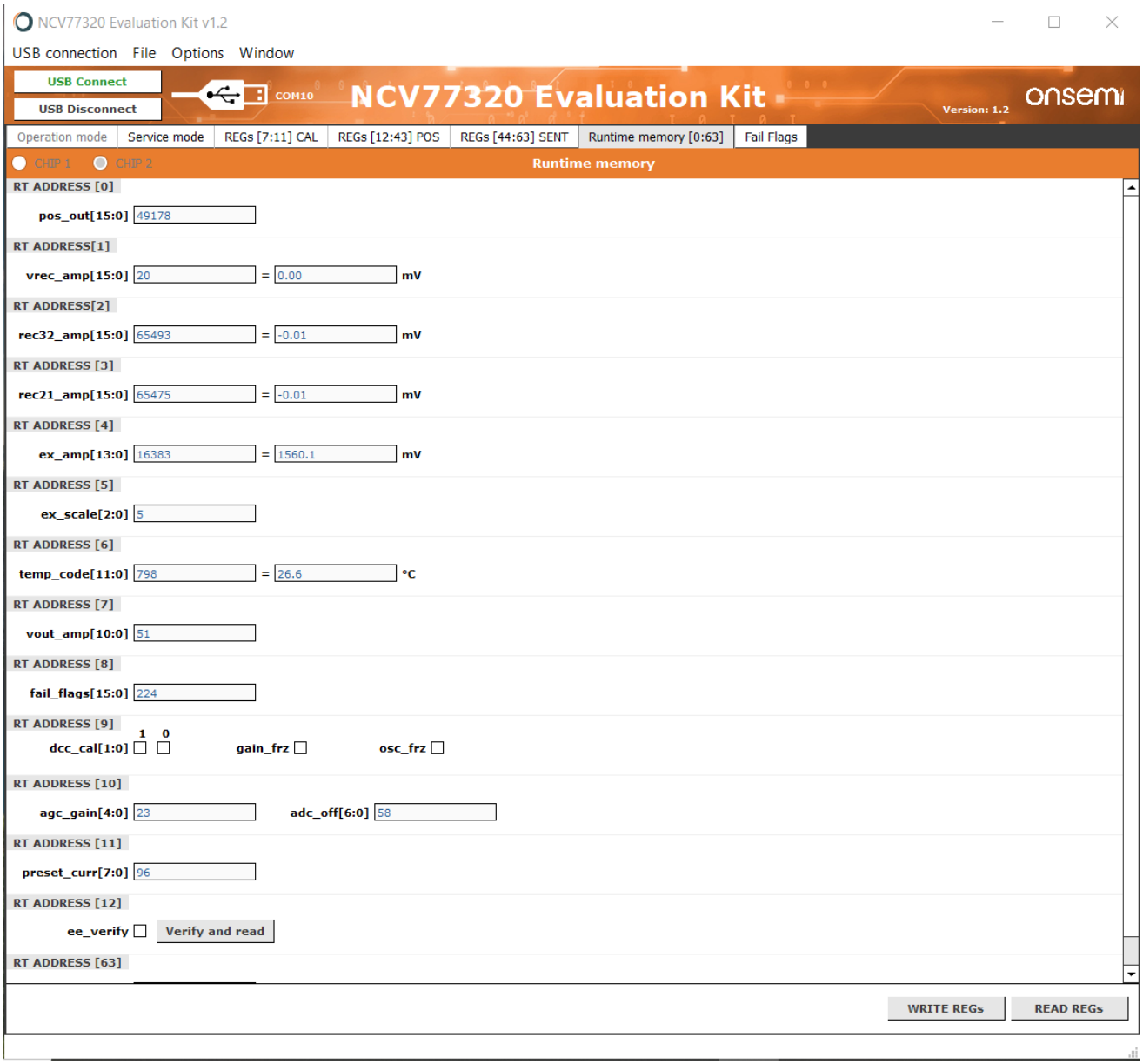
REGs [44:63] SENT

This tab shows registers at the addresses [44:63]; the SENT slow channel messages settings.



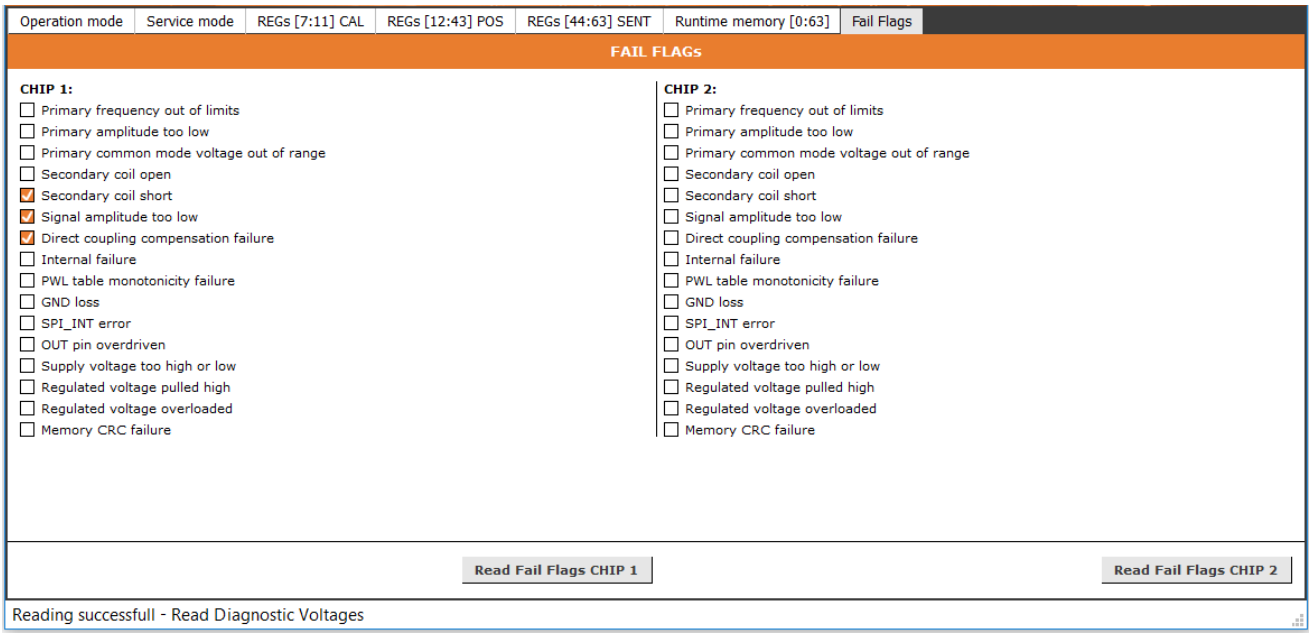
Runtime Memory [0:63]

This tab shows runtime memory registers address [0:63]. Most of these registers are read only. In this tab it is possible to read the position output, Vrec amplitude, excitation coil amplitude and more. It is possible to set dcc_cal for getting different parameters at the same address (RT_ADDRESS 2 and 3) for the calibration purposes. For more information, please refer to the datasheet. In service mode, the Verify and read command is available. It compares the configuration memory with the EEPROM. If successful, bit ee_verify is set after automatic readout.



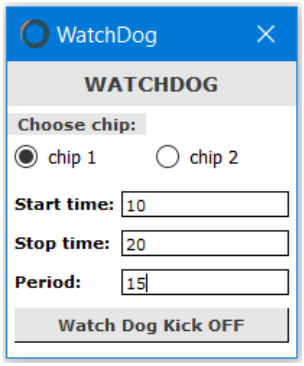
Fail Flags:

In the Fail flags tab there are all fail flags shown for both chips. Outside the service mode, it is possible to read failure flags only via SPI. When the SPI is disabled, all fail flags will be checked. For the chip in the Service mode, failure flags can be read out via both interfaces (OUT interface or SPI).



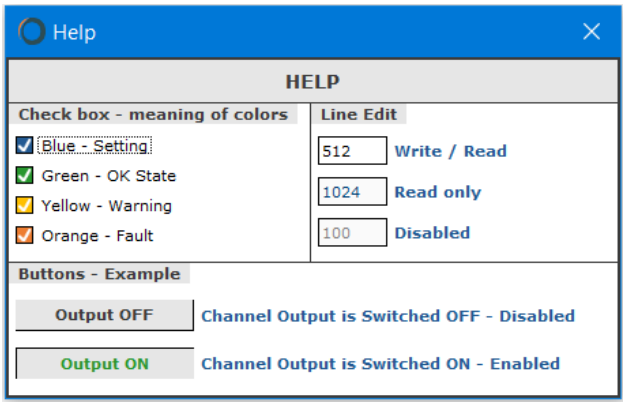
WatchDog:

The user can set the acceptance window start time [ms] (early refresh), stop time [ms] (late refresh) and the period [ms] for each chip separately. For successful watchdog refresh, the period must be between start time and stop time.



Help

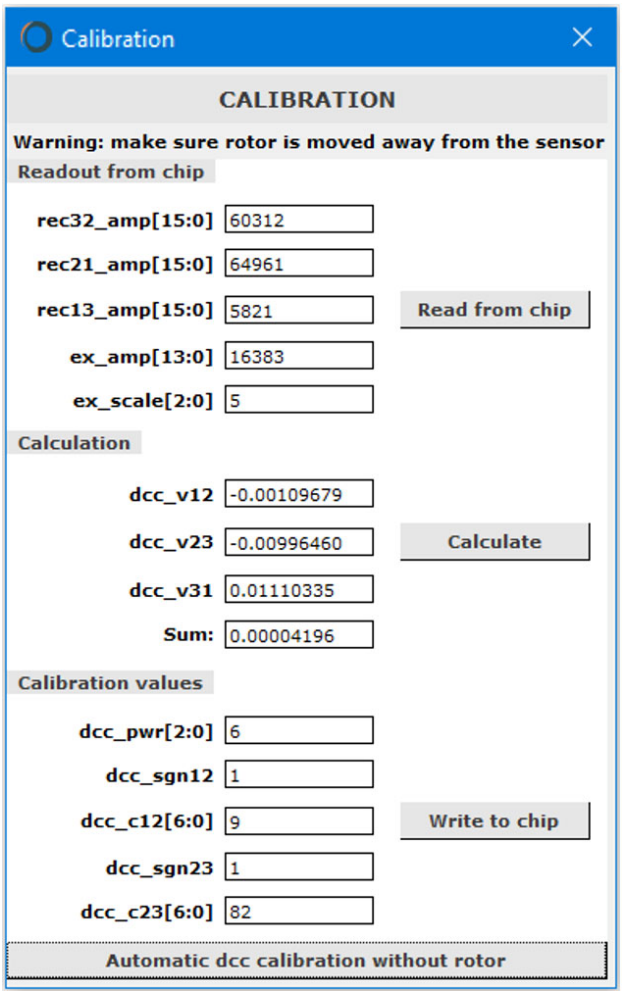
In Menu Bar → Window → Help there is window with some help for objects in the GUI



Calibration:

Calibration window can be opened only if chip 1 or chip 2 is in service mode. It can perform automatic dcc calibration without the rotor. For further details, please refer to the application note AND90226. The user can use buttons Read from chip, Calculate and then Write to chip or simply click Automatic dcc calibration without rotor and all steps are done automatically.

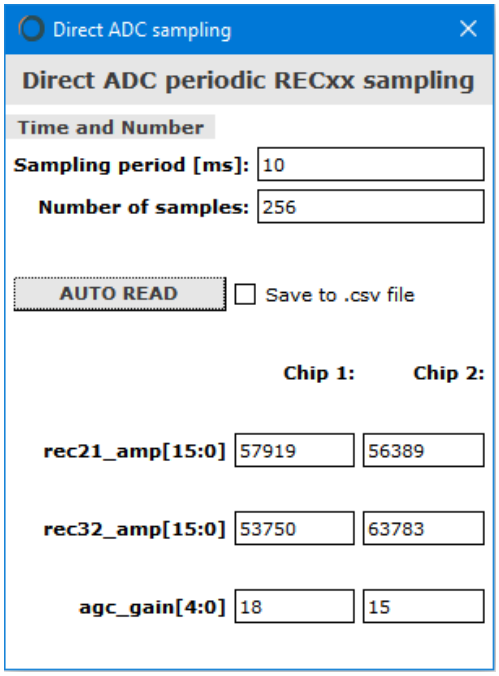
For this type of the calibration, it is necessary, that no previous calibration coefficients are programmed in the EEPROM memory. If calibration registers are not all programmed to 0, the calculator should display a warning with an offer to clear the calibration registers, but this means the previous calibration coefficients will be lost.



Direct ADC Sampling:

This window can be found in Menu Bar → Window → Direct ADC sampling. It is dedicated for the 2 coils (sine/cosine) systems where the NCV77320 is used for input sample acquisition and the position is calculated externally. For more information, please refer to the datasheet of the NCV77320. Bits direct_adc (ADDRESS [8], bit [4]) and spi_ena (ADDRESS [8], bit [2]) must be set for proper function.

The user can set the sampling period and the number of samples to be acquired. If the user wants to save the sampled data, before starting the measurement by pressing the Auto read button, save to .csv file must be checked and the file name and the file path needs to be selected in the popup window.

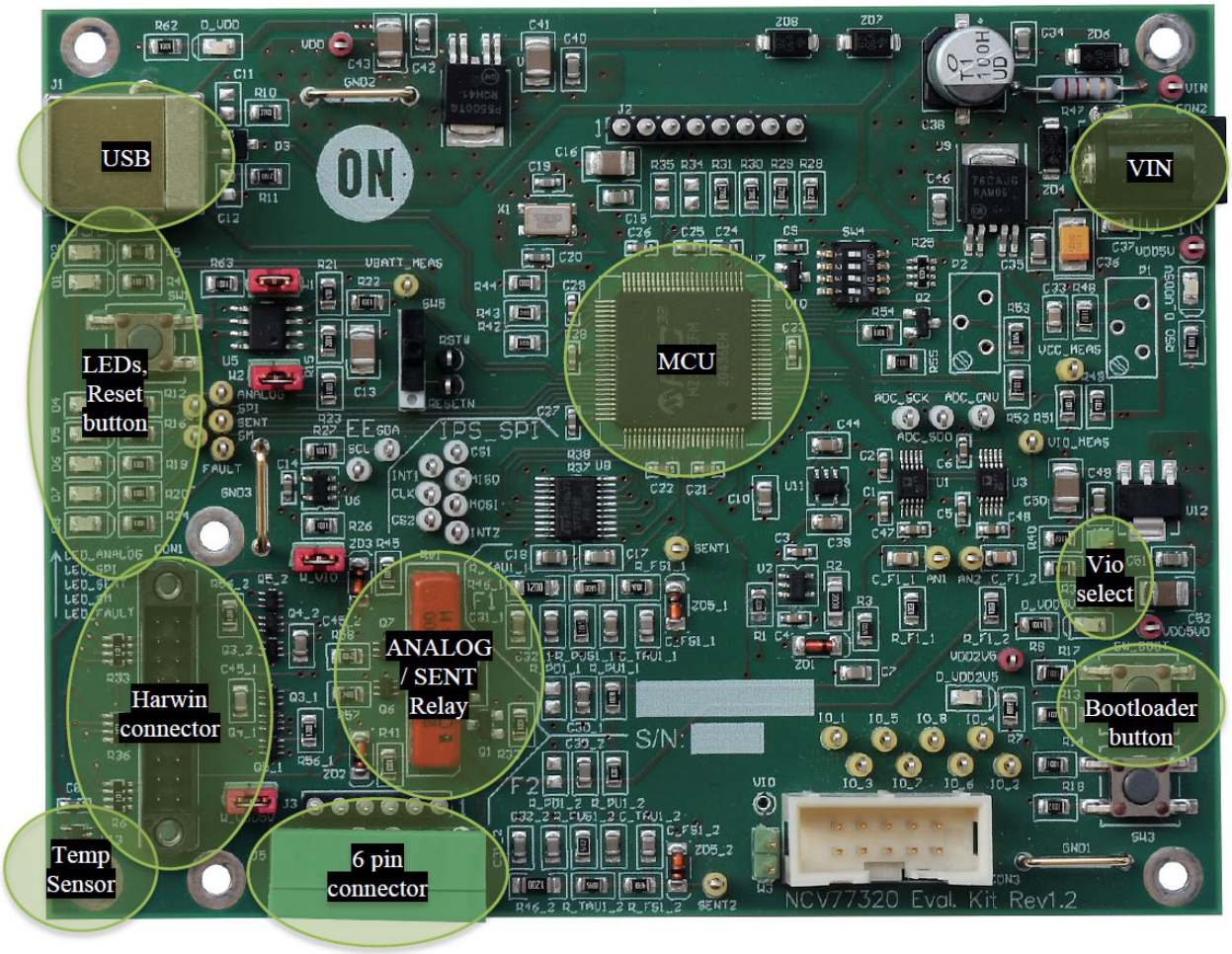


Evaluation Kit Hardware:

The Evaluation kit is built around the PIC32 micro controller. The NCV77320 sensors can be connected to the Evaluation kit by a 20 pin HARWIN connector or by a 6 pin connector, but only one of those two can be used at the time. The 6 pin connector contains only the power supply, GND and output (analog or SENT), while the HARWIN connector is equipped with all interfaces including SPI and supply lines for a dual channel sensor.

Several jumpers are installed to enable the user to measure currents on the piggyback with HARWIN connector (W_VIO, W_VDD5V), set VIO voltage (3.3 V or 5 V) or to disconnect the microcontroller supervisory circuit (W1 and W2). Ground bars and test points are installed for simple connection of measurement probes.

The picture below shows the board layout of the Evaluation kit motherboard. Major functional blocks are marked in green with the description below.



- **VIN** – input voltage connector 12 V
- **USB** – USB B connector for connection with the PC
- **MCU** – microcontroller PIC32MZ EF family
- **LEDs, Reset button** – LED indicators for communication, selected output interface, Service mode entered and Faults. Reset button for resetting the board and the microcontroller
- **HARWIN connector** – connection of the piggyback sensor board with two NCV77320's. SPI, ANALOG and SENT interfaces are possible to use
- **6 pin connector** – sensor connector with two NCV77320, only VCC, GND and OUT pin for each chip is possible
- **Temp sensor** – temperature sensor for measuring temperature close to the piggyback board
- **ANALOG / SENT Relay** – for switching between ANALOG and SENT input filters
- **Vio select** – 3.3 or 5 V selectable by the jumper position
- **Bootloader button** – for entering the bootloader mode for updating the firmware in microcontroller

Connector PIN layout

PJ5: 6 PIN IMO PRECISION CONTROLS Connector:
use 20.1550M/6−E type to interface
(Farnell number: 2575219)

1	VCC1
2	OUT1
3	GND1
4	GND2
5	OUT2
6	VCC2

CON1: 20 pole HARWIN Connector:
use M80−4002042 type to interface
(Farnell number: 1144527)

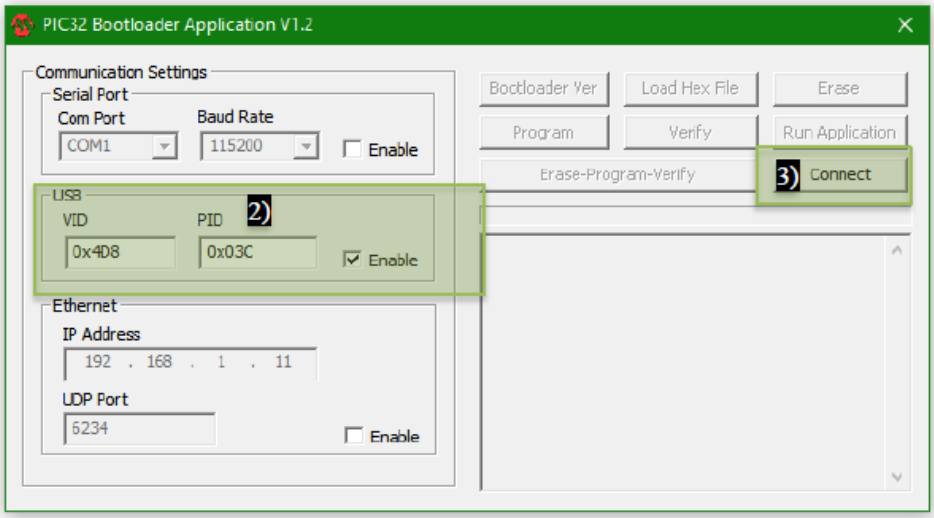
1	SPI INT2
2	SPI CS2
3	SPI_MOSI2
4	SPI_CLK2
5	SPI_MISO2
6	SPI_INT1
7	SPI_CS1
8	SPI_MOSI1
9	SPI_CLK1
10	SPI_MISO1
11	GND2
12	OUT2
13	VCC2
14	VIO2
15	NC
16	NC
17	VIO1
18	VCC1
19	OUT1
20	GND1

Schematics and further documentation

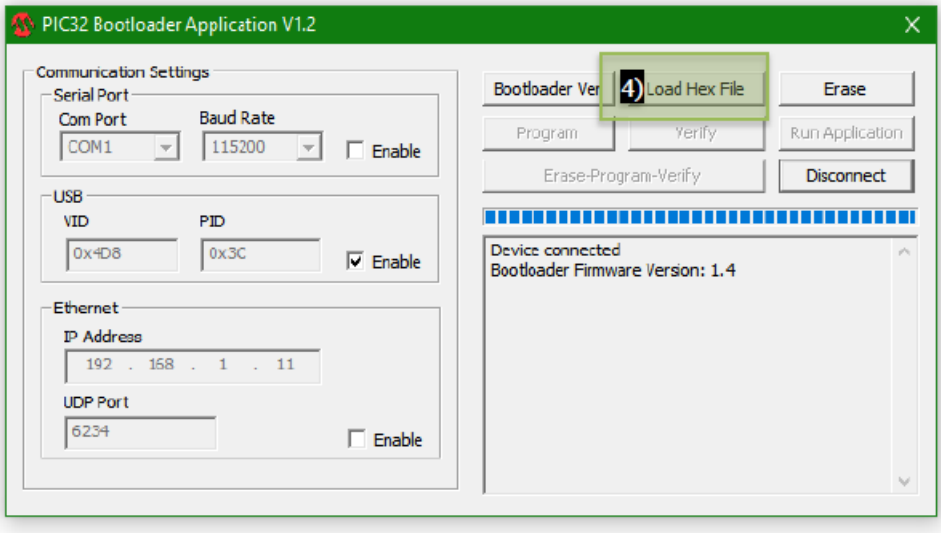
For the schematics of the Evaluation kit we refer to the file NCV77320_Schematics.pdf
For the latest datasheet version of the NCV77320, please contact your local sales representative.

PIC32 Bootloader:

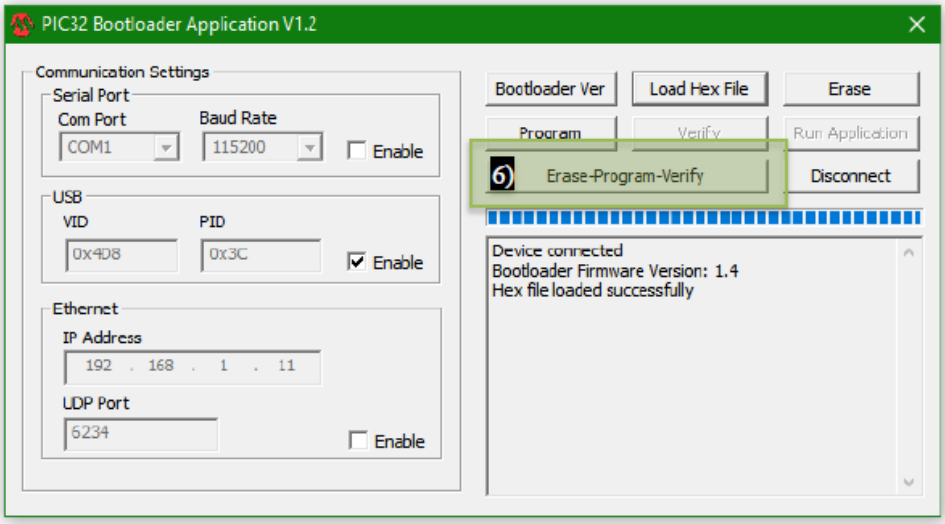
Clicking Menu Bar → Window → PIC32 Bootloader Application V1.2 should launch the bootloader application. If not, bootloader application can be found in the installation folder. It can be used to download new firmware to the microcontroller. Normally updates are delivered by onsemi, but the Evaluation board can be customized by the customer for specific use.



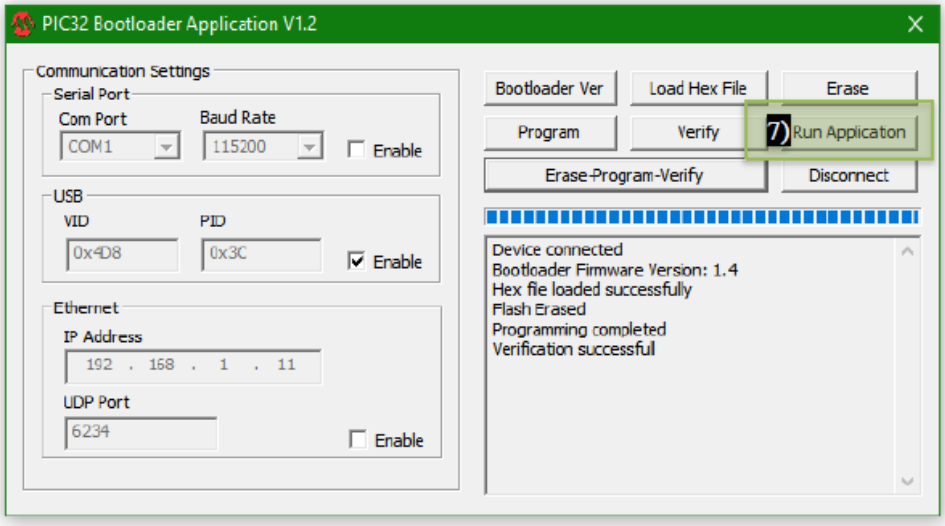
1. On the Evaluation kit motherboard it is necessary to push button SW_BOOT and hold it, then push and hold button SW1 (Reset button). When LED_FAULT (D8) is turned on and LED_SM (D7) starts blinking, the board is prepared for the firmware update. To be able to stay in bootloader mode, jumper W1 must be disconnected. If unable to perform reset, make sure jumper W2 is connected and SW5 is in upper position.
2. In PIC32 bootloader application it is necessary to choose USB –> enable.
3. Click the Connect button. If connection is not successful, reconnect the USB cable or reset the board again into bootloader mode.



4. Click the “Load Hex File” button
5. Choose the Hex file



6. Click to “Erase−Program−Verify” button



7. Click to “Run Application” button

ADDITIONAL INFORMATION

TECHNICAL PUBLICATIONS:
Technical Library: www.onsemi.com/design/resources/technical−documentation
onsemi Website: www.onsemi.com

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