NO_x Sensor Module Kit User's Manual
D000018 Rev A
D000019 Rev A

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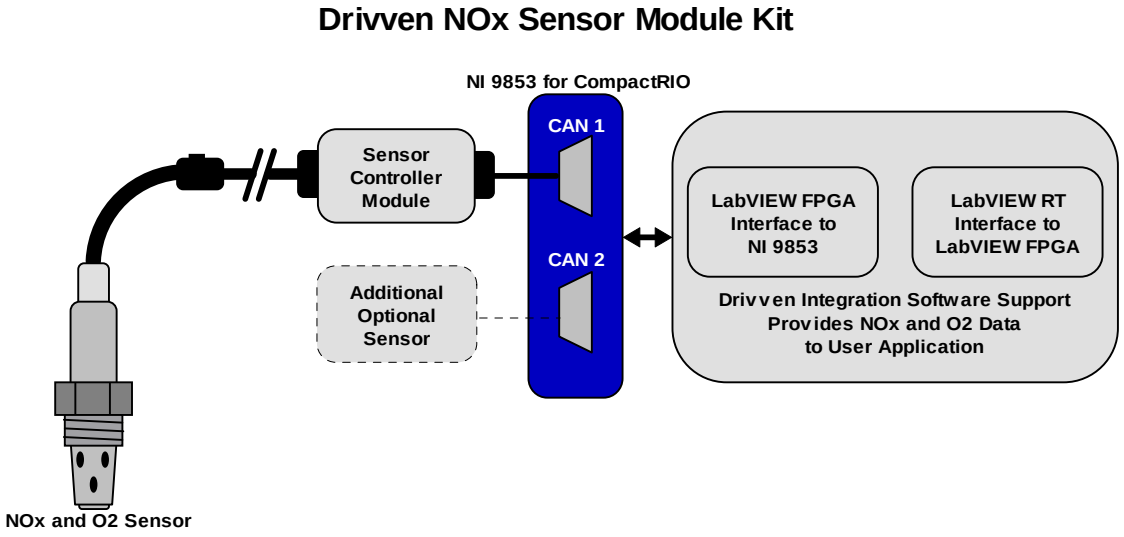
Introduction

The Drivven cRIO NO_x Sensor Module Kit provides an interface for one or two NO_x and O_2 exhaust gas sensors.

Features:

- 1-Ch. or 2 Ch. system
- Triple signal output:
  - NO_x concentration (ppm)
  - O_2 concentration (%)
- Sensor controller supply voltage of 12V to 32V
- Reverse battery protection on sensor controller module
- Integrated with LabVIEW FPGA and LabVIEW RT to provide real-time data
- LabVIEW FPGA and RT VIs included for quick integration with application
- Wide range of applications:
  - Gasoline / Diesel
  - Passenger car / Truck
- Helps to achieve emissions requirements
- Includes sensor controller module connector kit

System Diagram



Hardware

This kit provides the following hardware:

One or two NO_x sensors with integrated sensor controller modules
Connector kit for each NO_x sensor controller module
One NI 9853 CompactRIO CAN module

The end user must provide wiring for connecting the sensor controller module to a power supply and the NI 9853 CAN module. A connector kit is provided for the sensor controller interface. The end user must provide DB9 connector kits for connecting to the NI 9853 CAN module.

Powering the Hardware

The NO_x Sensor Controller Module requires power from a range of 12V to 32V with a continuous current of 0.6A and a peak current of 12A. The maximum power requirement is 20W.

For power requirements of the NI 9853 CompactRIO CAN module, please refer to the National Instruments website for documentation.

Product and Performance Specifications

Table 1. NO_x Sensor Performance Specifications

Output Type	Measurement Range	Accuracy	Response Time (33-66%)	Data Update Rate
NO_x	0 – 3000 ppm	@ 0 ppm: ±10 ppm @ 100 – 1500 ppm: ±10% @ 1500 – 3000 ppm: undefined	1300 ms (fresh) 1650 ms (aged)	50 ms interval @ 250 kBaud
O_2	-12 – 21 [%]	@ λ=0.90: ±1.4% (fresh) @ 0% (λ=1.00): ±0.13% (fresh) @ 0% (λ=1.00): ±0.25% (aged) @13% (λ=2.65): ±0.32% (fresh)	1000 ms (fresh) 1300 ms (aged)	

NO_x Sensor Light-off times (Conditions: Air T = 25 ±5°C, BattV = 28V, Heater turned ON)
NO_x < 100 sec
O_2 < 80 sec

NO_x Sensor Preheating Function
If power supply is on, the sensor is in preheating mode until the **Heater** boolean is set to TRUE. If the **Heater** boolean is set to FALSE, the sensor returns to preheating mode. The preheating mode protects the sensor from mechanical cracks caused by water splash.

NO_x Sensor Operating Temperature Ranges

Minimum sensor module controller temperature	-40°C
Maximum sensor module controller temperature	105°C

Sensor module controller temperature range of 85°C to 100°C allowed for up to 10 minutes

Minimum storage temperature	-40°C
Maximum storage temperature	120°C
Maximum storage time	2 years
Maximum exhaust gas temperature	800°C

Exhaust gas temperature of 950°C allowed up to 100 hours

Maximum sensor hexagon screw temperature	620°C

Sensor hexagon screw temperature of 650°C allowed for up to 100 hours

Maximum sensor grommet temperature	200°C

Sensor grommet temperature of 230°C allowed for up to 100 hours

Minimum preheating sensor temperature	80°C
Maximum preheating sensor temperature	120°C
Lifespan approved by life cycle pattern	2000 hours or 120K miles

NO_x Sensor Electrical Characteristics

NO_x Sensor Supply Voltage

Minimum supply voltage	12 V
Maximum supply voltage	32 V

If supply voltage > 32 V, sensor is not operated

NO_x Sensor Supply Current

Average supply current	0.6 A
Peak supply current at switch on	12 A
Inrush current	20 A

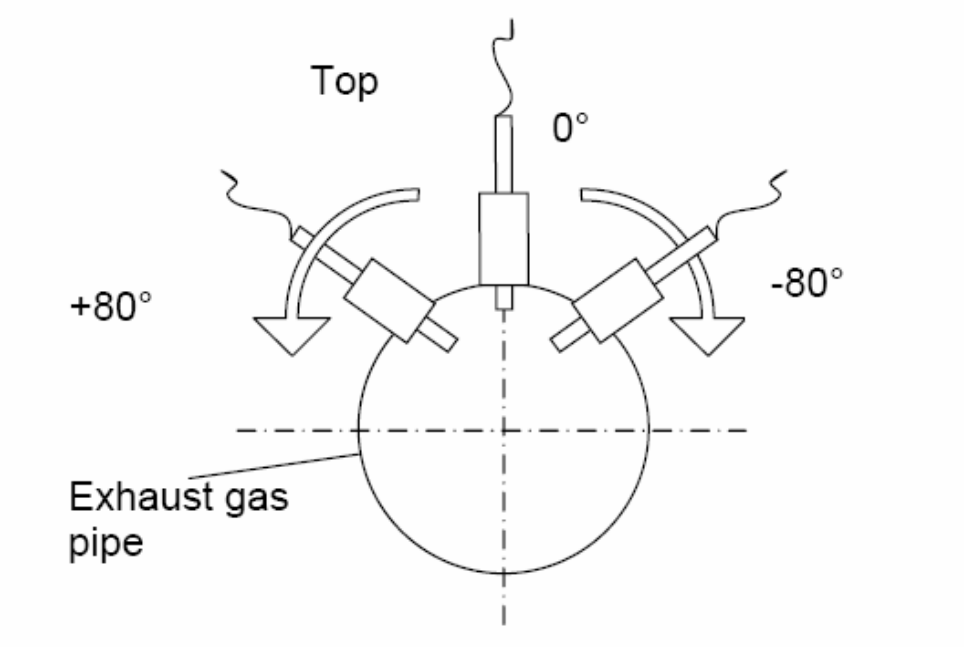
Supply Power

Maximum supply power	20 W

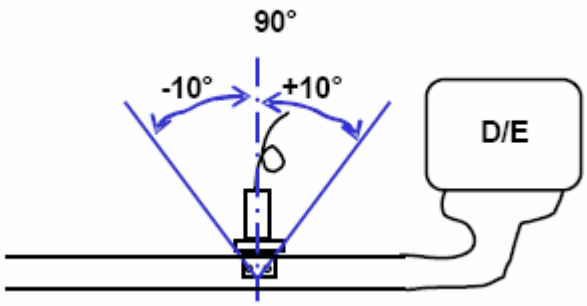
NO_x Sensor Misc.

Thread Torque	50 Nm
Lubrication	Anti-Seize Compound

Installation Position:



Tilt Angle in Gas Flow Direction:



NO_x Sensor Controller Module Connector

Type of connector	Hirschmann MLK 872-860-501
Number of pins	5
Connector pin assignment	Pin 1: Battery Pin 2: Ground Pin 3: CAN Low Pin 4: CAN High Pin 5: Not Used

Platform Compatibility

CompactRIO modules from National Instruments are compatible within two different platforms from National Instruments. One platform is CompactRIO, consisting of a CompactRIO controller and CompactRIO chassis as shown in Figure 1a below.

Figure 1a. CompactRIO platform compatible with Drivven/NI CompactRIO modules.

The other platform is National Instruments PXI which consists of any National Instruments PXI chassis along with a PXI RT controller and PXI-78xxR R-Series FPGA card. An R-Series expansion chassis must be connected to the PXI FPGA card via a SHC68-68-RDIO cable. The CompactRIO modules insert into the R-Series expansion chassis. This platform is shown in Figure 1b below.

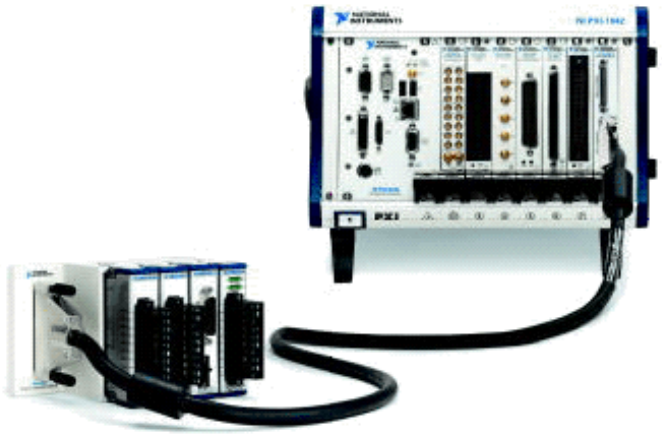


Figure 1b. PXI platform compatible with Drivven/NI CompactRIO modules.

National Instruments NI 9853 CompactRIO modules are not compatible with the National Instruments CompactDAQ chassis.

Drivven CompactRIO modules REQUIRE one of the hardware support systems described above in order to function. The modules may not be used by themselves and/or interfaced to third party devices at the backplane HD15 connector. These efforts will not be supported by Drivven or National Instruments.

Software

The NO_x Sensor Module Kit is provided with both a LabVIEW FPGA VI for interfacing to the NI cRIO 9853 CAN module and a LabVIEW RT VI for interfacing with the FPGA VI and managing and reporting sensor results.

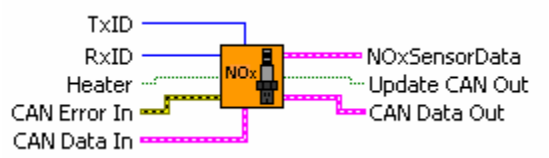


Figure 2. nox_revx.vi icon with leads.

VERY IMPORTANT NOTES:

The FPGA VI requires:

- LabVIEW 8.2 Full Development or later
- LabVIEW FPGA Module 8.2 or later
- NI-RIO 2.1 or later

The NO_x Sensor Module Kit includes a NI CRIO-9853 2 channel high speed CAN module. This module must be added to your LabVIEW project under your FPGA target. You must also add the appropriate CAN I/O to the project. An expanded example project is shown below in figure 3.

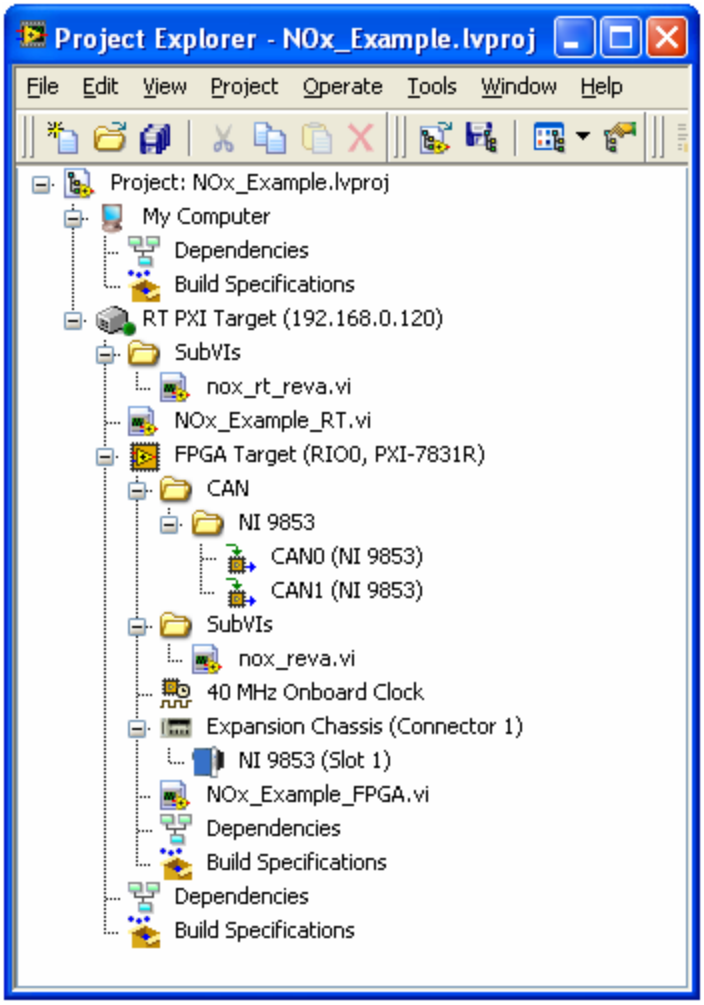


Figure 3. Example expanded project explorer of NOx_Example.lvproj.

Use the NOx_Example_FPGA.vi as an example to implement a NO_x sensor interface into your own application. Just copy and paste one of the while loops, as shown below in figure 4, into your application.

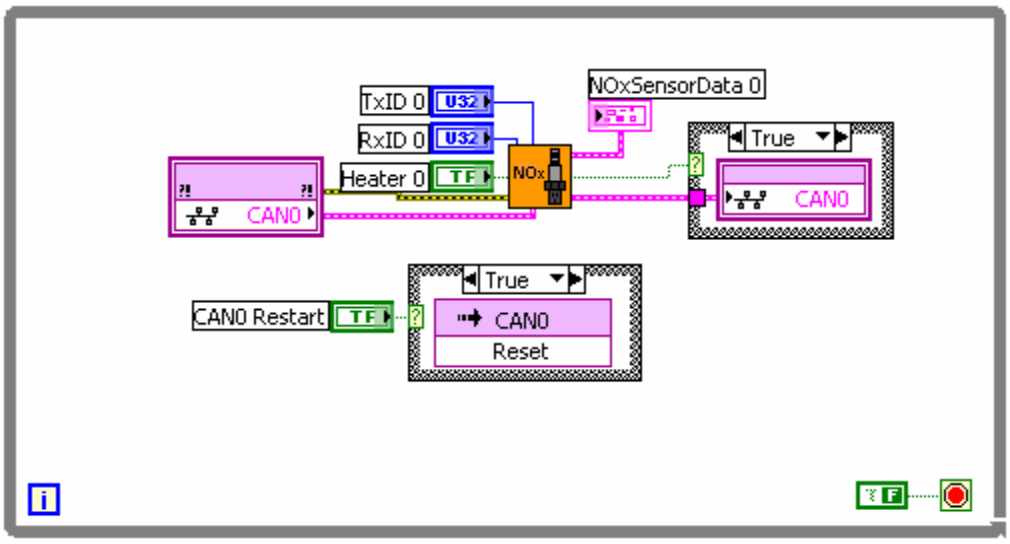


Figure 4. Example block diagram implementation of NO_x VI.

Please follow the guidelines below for adding the nox_reva.vi to your FPGA application:

1.) The NO_x sensor interface vi, nox_reva.vi, should be placed in its own while loop.
2.) Do not place more than one NO_x sensor interface vi within the same while loop.
3.) Do not place the NO_x sensor interface within a single cycle loop.
4.) The cRIO 9853 CAN Module properties should be set to the following:
    a. Baud Rate = 250 Kbps
    b. Auto Start = Checked
    c. Listen Only = Unchecked
    d. Input Timeout > 50 msec (100 msec recommended)
    e. Output Timeout < 10 msec (0 recommended)
    f. Input Filter = Receive All
5.) Other CAN nodes may be connected to the same CAN bus, as long as they conform to the above properties.
6.) Use the CANX Restart button to re-establish connection with the NO_x sensor module if the CAN bus is disconnected and then connected again.
7.) NO_x bits must be converted to NO_x ppm at the RT level according to:
    a. NO_x ppm = (bits * 0.05) – 200.
    b. Data type of bits is I16.
    c. The above conversion is performed by nox_rt_reva.vi.
8.) O_2 bits must be converted to O_2% at the RT level according to:
    a. O_2% = (bits * 0.000514) – 12.
    b. Data type of bits is U16.
    c. The above conversion is performed by nox_rt_reva.vi.

Right click on the NI 9853 module within your project explorer and select **Properties**. A dialog will open and allow you to make the CAN module settings listed in item 4 above. The property dialogs are shown below in figure 5a and 5b.

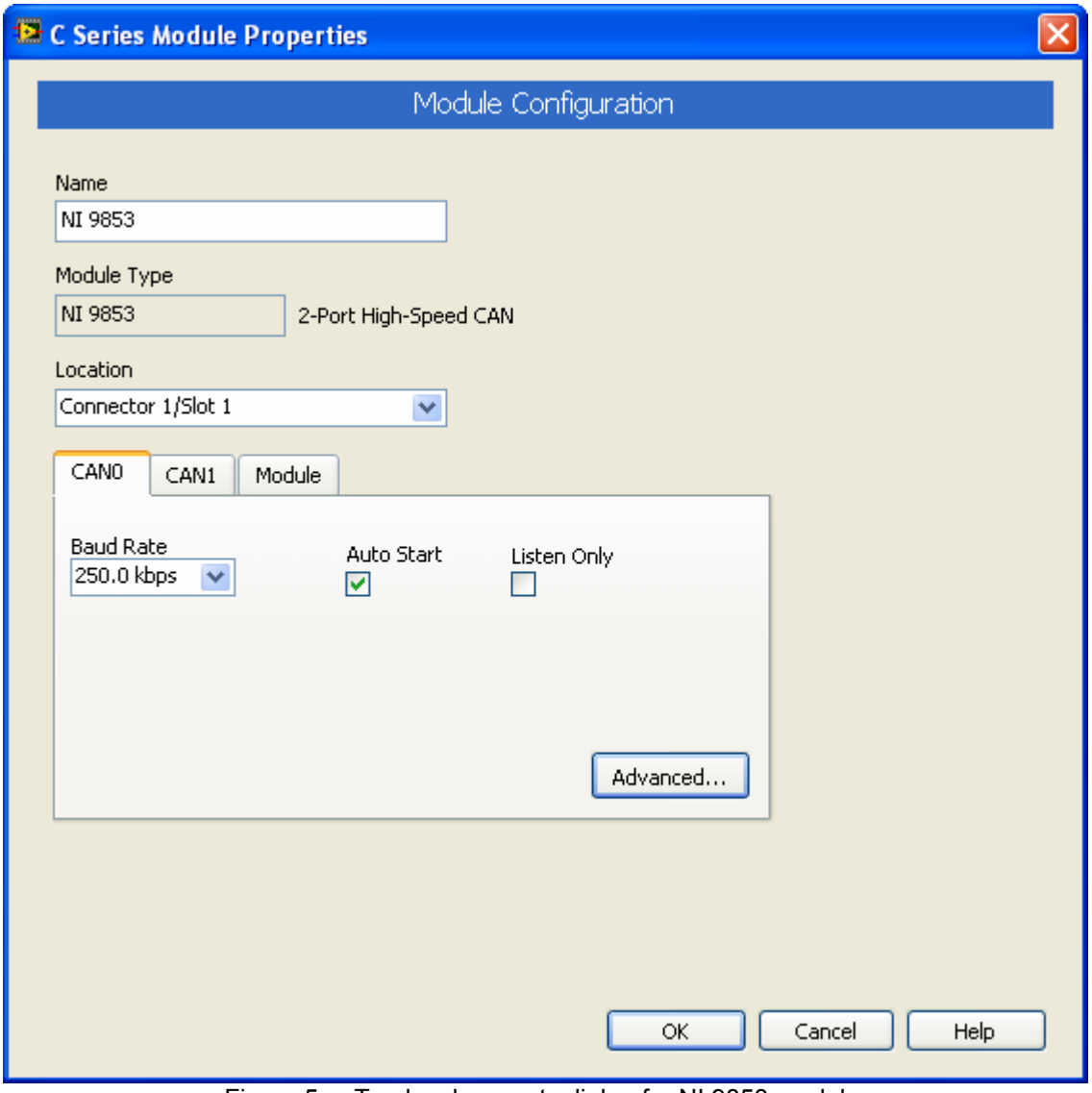


Figure 5a. Top level property dialog for NI 9853 module.

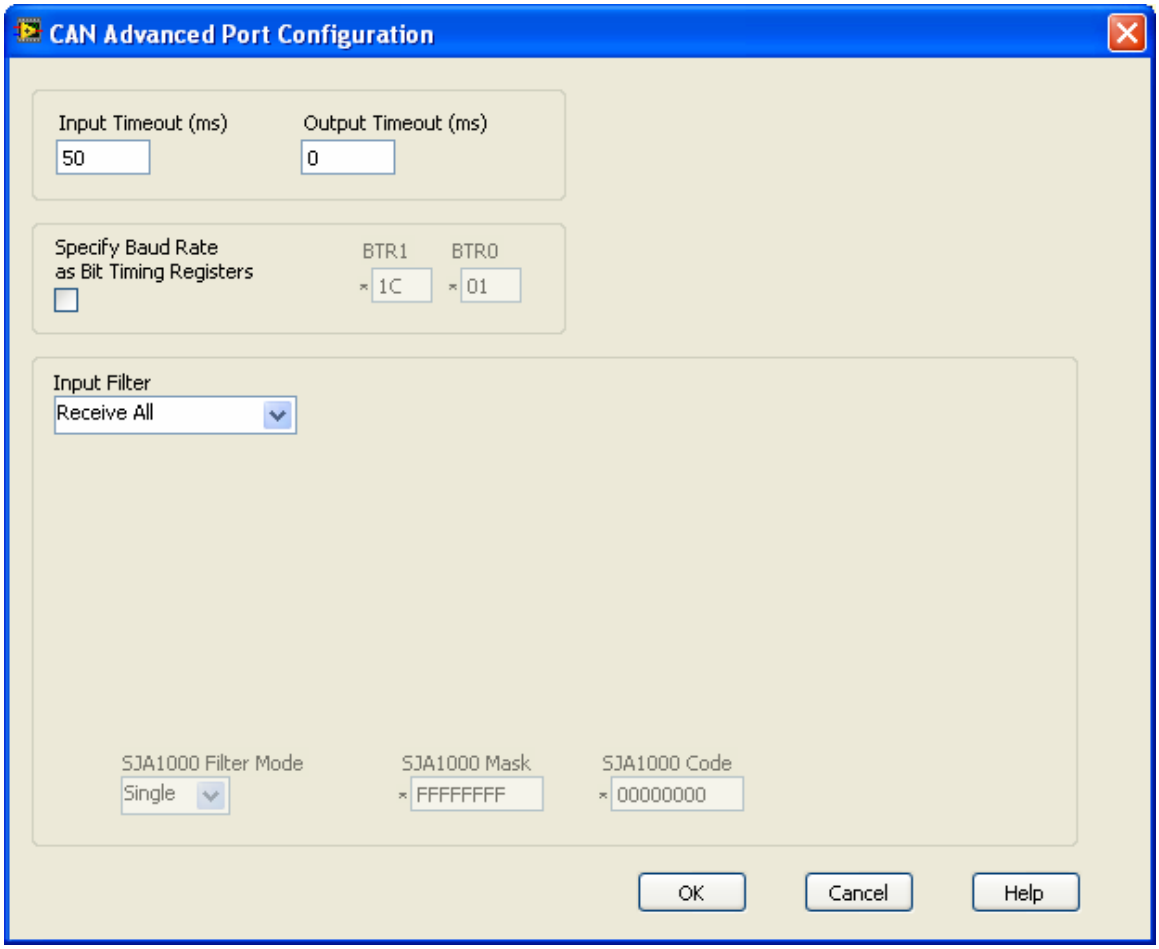


Figure 5b. Advanced property dialog for NI 9853 module.

The nox_reva.vi has the following terminals:

TxID (uint32): The message ID of the CAN messages sent to the NO_x Sensor Module. This value is 0x38FEDF00 by default.

RxID (uint32): The message ID of the CAN messages received from the NO_x Sensor Module. This value is 0x 38F00F52 by default.

Heater (boolean): When TRUE, the NO_x sensor module is requested to turn on the sensor heater and begin controlling the sensor to high temperature. When FALSE, the NO_x sensor module is requested to place the heater circuit in preheating mode and begin controlling to 80 C to 120 C.

CAN Error In (cluster): Receives the wire from the error output terminal of the CAN Input node. Right click on the CAN I/O Node and click on **Show Error Terminals**.

CAN Data In (cluster): Receives the wire from the CAN input node data terminal.

Update CAN Out (boolean): Must be wired to the selector terminal of a case statement structure. The TRUE case of the case statement must contain a CAN output node.

CAN Data Out (cluster): Must be wired to the CAN output node within the TRUE case of a case statement, and selected by the **Update CAN Out** boolean.

If the CAN connection is expected to be disconnected at times while the NI 9853 CAN module is active, then it may be necessary to implement a method to reset the CAN channel being used. Do this by placing a FPGA I/O Method node which resets the CAN channel. The method node should be placed within a case statement and selected by a boolean control. This boolean control can be operated from the RT level programmatically.

Follow the NOx_Example_RT.vi to properly interface to your FPGA application. Use the nox_rt_reva.vi to convert the data cluster from the nox_reva.vi to engineering units. It is not necessary to access the TxID or RxID. They should never change. In fact, they can be replaced by constants at the FPGA level.

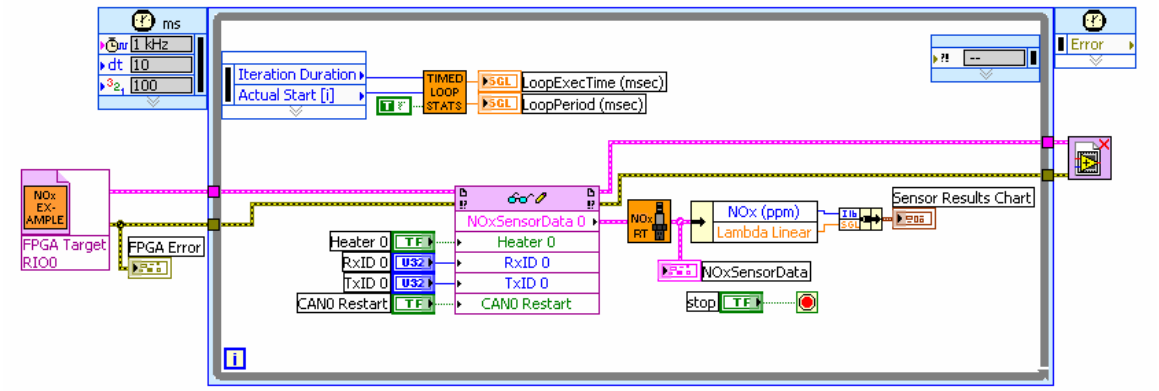


Figure 4. Example LabVIEW RT interface to LabVIEW FPGA NOx_Example_FPGA.vi.

NOxSensorData From FPGA (cluster): Receives the wire from NOxSensorData cluster terminal of an FGPA Read/Write control.

NOxSensorData (cluster): Final result from the NO_x Sensor:
NOx (ppm) (int16): Parts per million of oxides of nitrogen measured in the exhaust gas.
O2 (%) (SGL) Percent oxygen content of exhaust gas.
Sensor Supply Status (uint8): NOT IN RANGE, SUPPLY IN RANGE, ERROR, NOT AVAILABLE.
Sensor Temperature Status (uint8): NOT AT TEMPERATURE, AT TEMPERATURE, ERROR, NOT AVAILABLE.
NOx Signal Status (uint8): NOT VALID, VALID, ERROR, NOT AVAILABLE.
O2 Signal Status (uint8): NOT VALID, VALID, ERROR, NOT AVAILABLE.
Heater Mode Status (uint8): AUTO MODE, HEATUP SLOPE 3 OR 4, HEATUP SLOPE 1 OR 2, HEATER OFF / PREHEAT.
Heater Circuit Status (uint8): OPEN WIRE, SHORT CIRCUIT, NO ERROR.
NOx Circuit Status (uint8): OPEN WIRE, SHORT CIRCUIT, NO ERROR.
O2 Circuit Status (uint8): OPEN WIRE, SHORT CIRCUIT, NO ERROR.

Examples

Please refer to the NOx_Example.lvproj included with the NO_x Sensor Module Kit.