ECHELON®

2.0

NodeBuilder® FX/PL Examples Guide

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Preface

The NodeBuilder® FX/PL Development Tool includes a Neuron C example application that you can load into your LTM-10A Platform. You can use this example to test the I/O devices on the Gizmo 4 I/O Board, and create a simple managed LONWORKS® network. You can follow the instructions in this document to create the example device application from scratch.

Purpose

This document describes how to load and use the Neuron C example application included with the NodeBuilder FX/PL Development Tool.

Audience

This guide is intended for device and system designers with an understanding of control networks.

System Requirements

Requirements for computers running the NodeBuilder PL examples are listed below:

- Microsoft® Windows Vista or Microsoft Windows XP. Echelon recommends that you install the latest service pack available from Microsoft for your version of Windows.
- Intel® Pentium® III 600MHz processor or faster, and meeting the minimum Windows requirements for the selected version of Windows.
- 300 to 550 megabytes (MB) free hard-disk space, plus the minimum Windows requirements for the selected version of Windows.
    - The NodeBuilder tool requires 100 MB of free space.
    - The LonMaker® Integration Tool, which is included with the NodeBuilder software and is required to install the NodeBuilder tool, requires 172 MB of free space.
    - The LonScanner™ Protocol Analyzer, which is included with the NodeBuilder software, requires 26 MB of free space.
    - Microsoft .NET Framework 3.5 SP1, which is required to run the NodeBuilder tool, requires 30 MB of free space.
    - If you install Acrobat® Reader 9.1 from the NodeBuilder FX Development Tool CD, you need an additional 204 MB of free space.
- 512 MB RAM minimum.

  Note: Vista testing for the NodeBuilder tool has been performed on computers that have a minimum of 2 GB of RAM. For complete Vista requirements, refer to *www.microsoft.com/windows/windows-vista/get/system-requirements.aspx*. You can use Microsoft's Vista Upgrade Advisor to determine upgrade requirements for a particular computer. To download this tool, go to the Microsoft Web site at *www.microsoft.com/windows/windows-vista/get/upgrade-advisor.aspx*.
- CD-ROM drive.
- 1024x768 or higher-resolution display with at least 256 colors.
- Mouse or compatible pointing device.
- LNS® network interface or IP-852 router. If an LNS network interface is used, it may be a local or remote interface.
    - Compatible local network interfaces include the U20 USB network interface (included with the NodeBuilder FX/PL Development Tool.
    - Compatible remote network interfaces include the *i*.LON® SmartServer, *i*.LON 100 *e*3 Internet Server, *i*.LON 600 LONWORKS-IP Server, or *i*.LON 10 Ethernet Adapter.
    - Compatible IP-852 routers include the *i*.LON SmartServer with IP-852 routing, *i*.LON 100 *e*3 Internet Server with IP-852 routing, or an *i*.LON 600 LONWORKS-IP Server. If you are using

an IP-852 router, your computer must have an IP network interface such as an Ethernet card or modem with PPP software. In addition, the *i*.LON software must be installed on your computer, and the IP-852 channel must be configured using the LONWORKS-IP Configuration Server application software.

The LonMaker tool, which is included with the NodeBuilder software, automatically installs drivers for all local and remote network interfaces, except the SLTA-10 Serial LonTalk Adapter. The LonMaker CD includes an option for installing the driver for the SLTA-10 Serial LonTalk Adapter.

Note: You must run the NodeBuilder software on the same computer with the LNS Server which is installed by the LonMaker installer. You cannot run the NodeBuilder tool as a remote client to an LNS Server running on another computer.

Content

This guide includes the following content:

- *Using the NodeBuilder FX/PL Example*. Introduces the Neuron C example application that you can run on an LTM-10A Platform and test with the Gizmo 4 I/O Board. Describes how to load the pre-built example application on an LTM-10A Platform using the LonMaker Integration Tool, which is included with the NodeBuilder FX Development tool, and describes how to use the I/O devices on the Gizmo 4 I/O Board to test the example application. Includes a detailed nine-step exercise that you can follow to create the example device application from scratch.

Related Manuals

The documentation related to the NodeBuilder tool is provided as Adobe PDF files and online help files. The PDF files for the NodeBuilder tool are installed in the **Echelon NodeBuilder** program folder when you install the NodeBuilder tool. You can download the latest NodeBuilder and documentation, including the latest version of this guide, from Echelon's website at *www.echelon.com/docs*.

Gizmo 4 User's Guide	Describes how to use the I/O devices on the Gizmo 4 I/O Board, and how to use the Gizmo 4 I/O Board to build your own I/O hardware. The Gizmo 4 I/O Board is included with the NodeBuilder FX/PL Development Tool.
Introduction to the LONWORKS® Platform	Provides a high-level introduction to LONWORKS networks and the tools and components that are used for developing, installing, operating, and maintaining them.
LNS®Plug-in Programmer's Guide	Describes how to write plug-ins using .NET programming languages such as C# and Visual Basic .NET
LonMaker® User's Guide	Describes how to use the LonMaker Integration Tool to design, commission, modify, and maintain LONWORKS networks.
LONMARK® SNVT and SCPT Guide	Documents the standard network variable types (SNVTs), standard configuration property types (SCPTs), and standard enumeration types that you can declare in your applications.
LONWORKS® USB Network Interface User's Guide	Describes how to install and use the U20 USB Network Interfaces, which is included with NodeBuilder FX/PL Development Tool.

LTM-10A User's Guide	Describes how to use the LTM-10A Platform for testing your applications and I/O hardware prototypes. Also describes how you can design the LTM-10A flash Control Module into your products. The LTM-10A Platform is included with the NodeBuilder FX/PL Development Tool.
Neuron® C Programmer's Guide	Describes how to write programs using the Neuron C Version 2.2 language.
Neuron® C Reference Guide	Provides reference information for writing programs using the Neuron C language.
Neuron® Tools Error Guide	Provides reference information for Neuron C errors.
NodeBuilder® FX User's Guide	Describes how to use the NodeBuilder tool to develop LONWORKS device applications and build and test prototype and production LONWORKS devices
NodeBuilder® Resource Editor User's Guide	Describes how to use the NodeBuilder Resource Editor to create and edit resource file sets and resources such as functional profile templates, network variable types, and configuration property types.

For More Information and Technical Support

The **NodeBuilder ReadMe** file provides descriptions of known problems, if any, and their workarounds. To view the **NodeBuilder ReadMe**, click **Start**, point to **Programs**, point to **NodeBuilder**, and then select **NodeBuilder ReadMe First**. You can also find additional information about the NodeBuilder tool at the NodeBuilder Web page at *www.echelon.com/nodebuilder*.

If you have technical questions that are not answered by this document, the NodeBuilder online help, or the NodeBuilder ReadMe file, you can contact technical support. To receive technical support from Echelon, you must purchase support services from Echelon or an Echelon support partner. See *www.echelon.com/support* for more information on Echelon support and training services.

You can also enroll in training classes at Echelon or an Echelon training center to learn more about developing devices. You can find additional information about device development training at *www.echelon.com/training*.

You can obtain technical support via phone, fax, or e-mail from your closest Echelon support center. The contact information is as follows:

Region	Languages Supported	Contact Information
The Americas	English Japanese	Echelon Corporation Attn. Customer Support 550 Meridian Avenue San Jose, CA 95126 Phone (toll-free): 1-800-258-4LON (258-4566) Phone: +1-408-938-5200 Fax: +1-408-790-3801 *lonsupport@echelon.com*

Region	Languages Supported	Contact Information
Europe	English German French Italian	Echelon Europe Ltd. Suite 12 Building 6 Croxley Green Business Park Hatters Lane Watford Hertfordshire WD18 8YH United Kingdom Phone: +44 (0)1923 430200 Fax: +44 (0)1923 430300 *lonsupport@echelon.co.uk*
Japan	Japanese	Echelon Japan Holland Hills Mori Tower, 18F 5-11-2 Toranomon, Minato-ku Tokyo 105-0001 Japan Phone: +81-3-5733-3320 Fax: +81-3-5733-3321 *lonsupport@echelon.co.jp*
China	Chinese English	Echelon Greater China Rm. 1007-1008, IBM Tower Pacific Century Place 2A Gong Ti Bei Lu Chaoyang District Beijing 100027, China Phone: +86-10-6539-3750 Fax: +86-10-6539-3754 *lonsupport@echelon.com.cn*
Other Regions	English Japanese	Phone: +1-408-938-5200 Fax: +1-408-328-3801 *lonsupport@echelon.com*

1

Using the NodeBuilder FX/PL Example

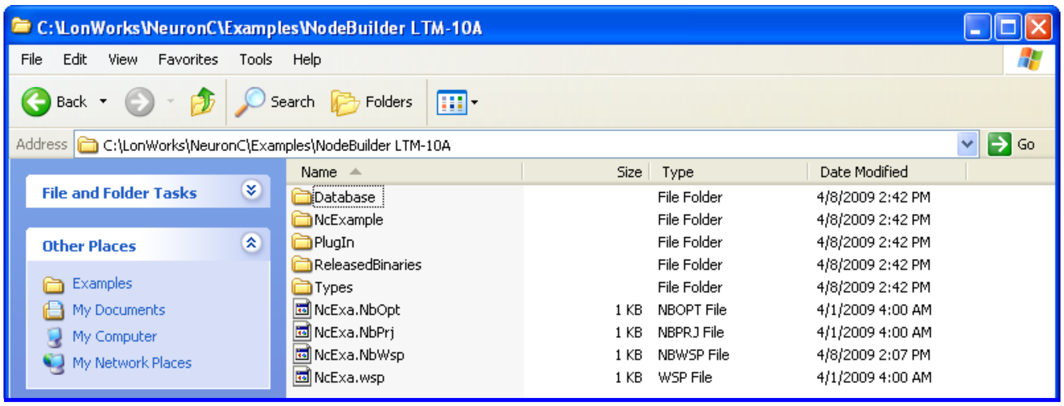
This chapter introduces the Neuron C example application that you can run on an LTM-10A Platform and test with the Gizmo 4 I/O Board. It describes how to load the pre-built example application on an LTM-10A Platform using the LonMaker Integration Tool, which is included with the NodeBuilder FX Development tool, and how to use the I/O devices on the Gizmo 4 I/O Board to test the example application. It includes a detailed nine-step exercise that you can follow to create the example device application from scratch.

Introduction to the NodeBuilder FX/PL Example

The NodeBuilder FX/PL Development Tool includes a Neuron C example application, *NcExample*, that you can load into your LTM-10A Platform. You can use this example application to test the I/O devices on the Gizmo 4 I/O Board, and create simple managed LONWORKS networks.

The example application is designed to run on a Gizmo 4 I/O Board attached to an LTM-10A Platform. If you do not have a Gizmo 4 I/O Board, you can still use the NodeBuilder tool to create and compile the application, but you cannot observe how the device application interacts with the I/O devices Gizmo 4 I/O Board.

The *NcExample* device application is stored the C:\LonWorks\NeuronC\Examples\NodeBuilder LTM-10A directory. Note that the default LONWORKS folder on your computer is typically C:\LonWorks or C:\Program Files\LonWorks.



The NodeBuilder LTM-10A folder contains the following files and subfolders:

Database

This folder contains a LonMaker network backup file (**.zip**) that includes an LNS database and LonMaker drawing containing the example device and all the functional blocks and network variables in the device's external interface. You can restore this backup file with the LonMaker tool. When you restore this backup, the LNS database and LonMaker drawing are placed in the **C:\Lm\Db** and **C:\Lm\Drawings** folders, respectively.

After you restore the network, you can use the LonMaker tool to download the example application to your LTM-10A Platform and test the I/O devices on the Gizmo 4 I/O Board.

NcExample

This folder contains the example NodeBuilder project and all source code files and header files used by the *NcExample* device application.

PlugIn

This folder contains the LNS device plug-in used to configure the *NcExample* device application.

Released Binaries

The *NcExample* device application includes a pre-built binary application image file (.**apb** extension) that you can download to your LTM-10A Platform using the LonMaker tool. This folder also contains a pre-built text device interface file (.**xif** extension) that exposes the example application's device interface so that the LonMaker tool can manage the example application.

After you restore the backup and load the *NcExample* device application, you can test the I/O devices on the Gizmo 4 I/O Board in a simple managed LONWORKS network (see *Testing the I/O Devices on the Gizmo 4 I/O Board* later in this chapter for how to do this).

Types

This folder contains the user-defined functional profiles (UFPTs), network variable types (UNVTs), and configuration property types (UCPTs) developed for the *NcExample* device application.

NodeBuilder Project Files (**.NbOpt** and **.NbPrj**)

The example includes a NodeBuilder project that you can open with the NodeBuilder tool in order browse the example application and learn how to develop your own device applications. The NodeBuilder project includes the following files:

- **Options File (*.NbOpt)**. Contains the NodeBuilder project options for a project. There is one options file per project.
- **Project File (*.NbPrj)**. Contains a project definition including the project version and a list of the device templates and the hardware templates for a project. There is one project file per project.

You can use the pre-built *NcExample* device application to observe how network variable values are updated when you use the I/O devices on the Gizmo 4 I/O Board. To do this, you restore a LonMaker network backup, commission the example device in the LonMaker drawing, and press the buttons on the Gizmo 4 I/O Board.

When you are done using the *NcExample* device application, you can create your own example device application. You can create a simple device application following the quick-start exercise in Chapter 3 of the *NodeBuilder User's Guide*; you can create a more complex device application following the steps described in *Creating the Example Device Application* later in this chapter. In both exercises, you will go through all the steps of creating a device, including creating the NodeBuilder project, the device template, the device interface, and the Neuron C code that implements your device interface; implementing device functionality in the Neuron C code; building and downloading the device application; and testing the device in a LONWORKS network.

In the quick-start exercise in the *NodeBuilder User's Guide*, you will develop a simple device with one sensor and one actuator. The sensor is a simple sensor that monitors a push button on the Gizmo 4 I/O Board and toggles a network variable output each time the button is pressed. The actuator drives the state of an LED on the Gizmo 4 I/O Board based on the state of a network variable input.

In the exercise later in this chapter, you will create the *NcExample* device application from scratch. This is a more complex device that uses all the I/O devices on the Gizmo 4 I/O Board: the push buttons, LEDs, temperature sensor, LCD, and quadrature shaft encoder.

The following sections describe how to do the following:

1. Use the pre-built *NcExample* device application with the LonMaker tool.
2. Create the *NcExample* device application from scratch using the NodeBuilder tool and the LonMaker tool.

Using the Pre-Built Example Device Application

You can use the LonMaker tool to download the *NcExample* device application to the LTM-10A Platform and install it in a LONWORKS network. To do this, you restore the **NcExa.zip** file in the LonWorks\NeuronC\Examples\NodeBuilder LTM-10A\Database folder, load the pre-built binary application image file (**.apb** extension) for the *NcExample* application to the device, and then commission the example device. After you install the example device, you can use the I/O devices on the Gizmo 4 I/O Board and observe how network variable values are updated.

Restoring the LonMaker Network Backup

To restore the LonMaker network backup, follow these steps:

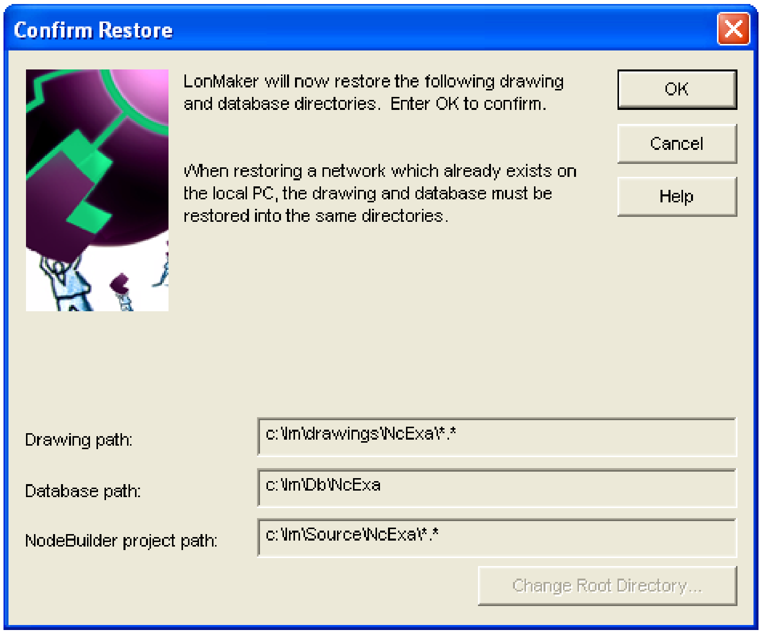
1. Connect your LTM-10A and Gizmo 4 I/O Board following Chapter 2 of the *NodeBuilder User's Guide* or the Quick-Start Guide included with your NodeBuilder FX/PL Development Tool.

2. Verify that you have installed and activated the LonMaker tool following Chapter 2 of the *LonMaker User's Guide*.

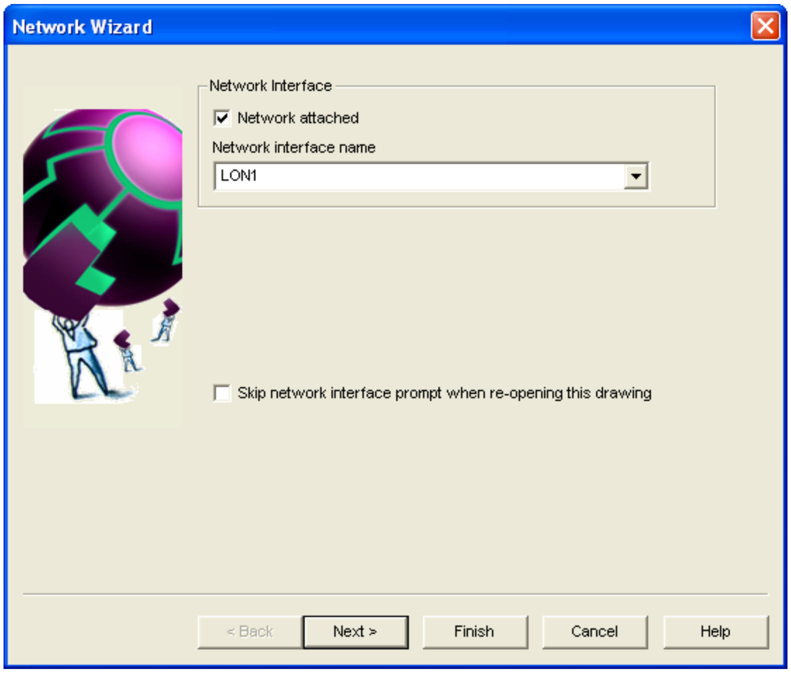
3. Start the LonMaker tool. To do this, click **Start** on the taskbar, point to **Programs**, point to the **Echelon LonMaker** folder, and then click **LonMaker**. The LonMaker Design Manager opens.

4. Click **Restore**. The **Select Backup File** dialog opens. Browse to the LonWorks\NeuronC\Examples\NodeBuilder LTM-10A\Database folder, and then double-click the **NcExa.zip** backup file (**.zip** extension).

5. The **Confirm Restore** dialog opens.



6. Click **OK**.
7. By default, the LonMaker tool will prompt you to select whether to install any new files in the Import folder (includes LONMARK® resource files) and then any new files in the Types folder (includes XIF and application image files [**.apb** extension]). Click **Yes** to restore the files.
8. A message appears informing you that the network restore operation has been completed, and prompting you to select whether to open the LonMaker network in order to recommission devices that have changed since the network was backed up. Click **Yes**.
   - A message may appear informing you that Visio must be launched and initialized so that it can work with the LonMaker tool. Click **OK**.
   - A warning may appear asking you if you want to enable macros. You must enable macros for the LonMaker tool to function.
9. The Network Wizard opens with the Network Interface window displayed.

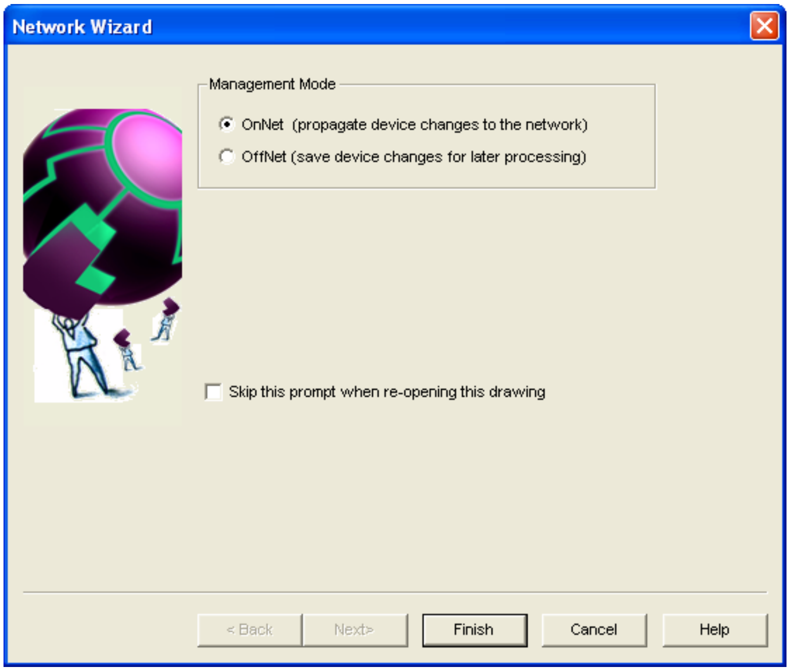


10. Select the **Network Attached** check box. In the **Network Interface Name** property select the network interface to be used for communication between the LonMaker tool and the LTM-10A Platform over the LONWORKS channel. Click **Next**.

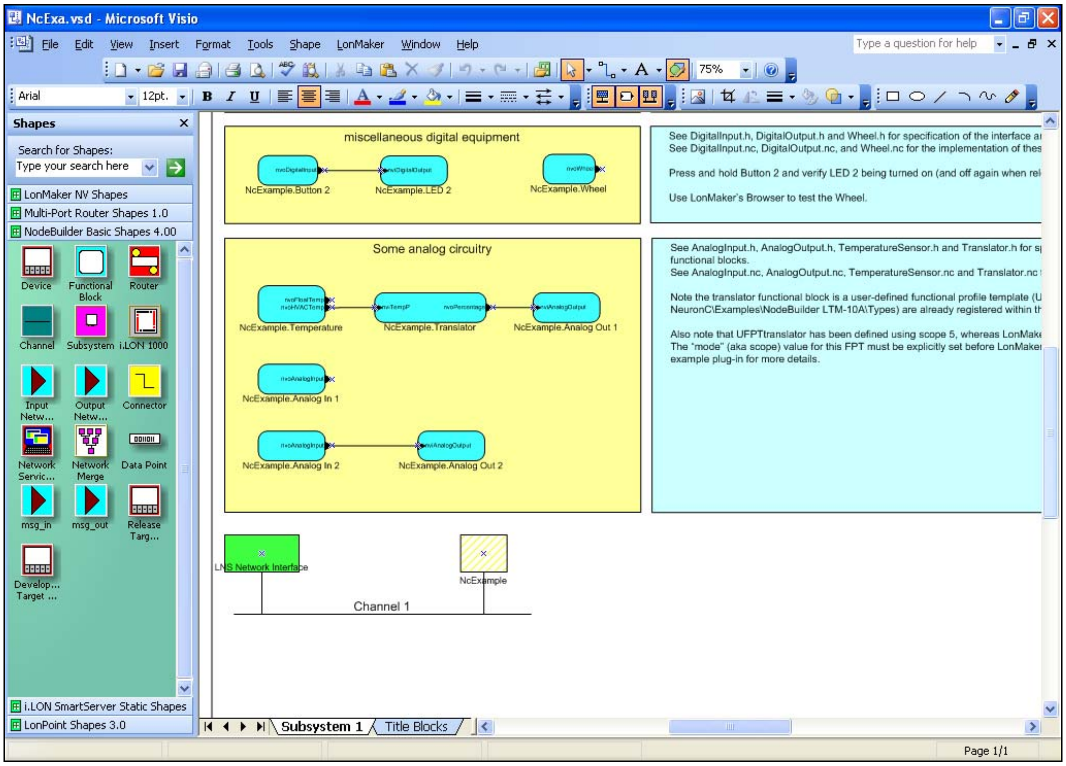
    You can use the U20 USB Network Interface included with the NodeBuilder FX/PL Development Tool, or you can use another network interface such as an *i*.LON SmartServer or an *i*.LON 100 *e*3 Internet Server. If you are using the U20 USB Network Interface included with the NodeBuilder FX/PL Development Tool and you have not installed any other network interfaces on your computer, select **LON1**.

    For more information on installing and configuring the U20 USB Network Interface, and on using it to attach your computer to a network channel, see the *LONWORKS USB Network Interface User's Guide*.

11. The Management Mode window opens.



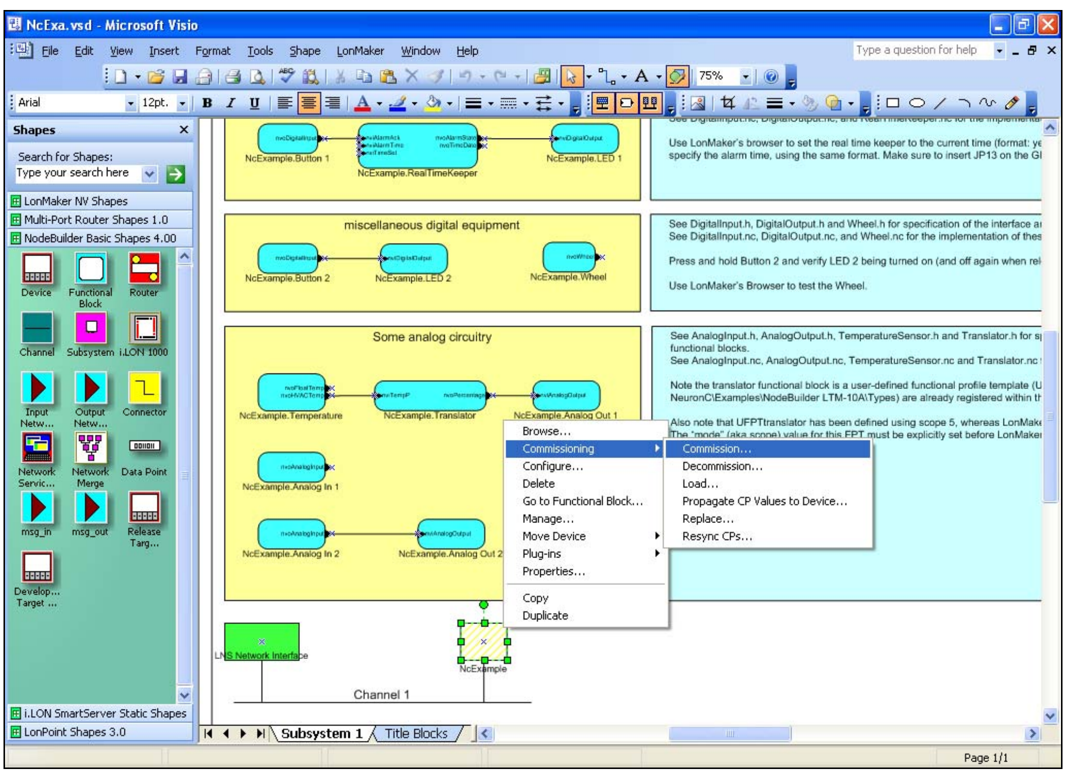
12. Select **OnNet** to immediately propagate changes you make to the example device in the LonMaker drawing to the physical device on the network. Click **Finish**.
13. A message appears recommending that you recommission devices that have changed since the network was backed up. Click **No**.
14. The LonMaker drawing for the example application opens. The LonMaker drawing includes a commissioned LNS Network Interface device shape, an uncommissioned device shape representing the example application, and functional block and network variable shapes for all the functional blocks and network variables defined in the device interface.



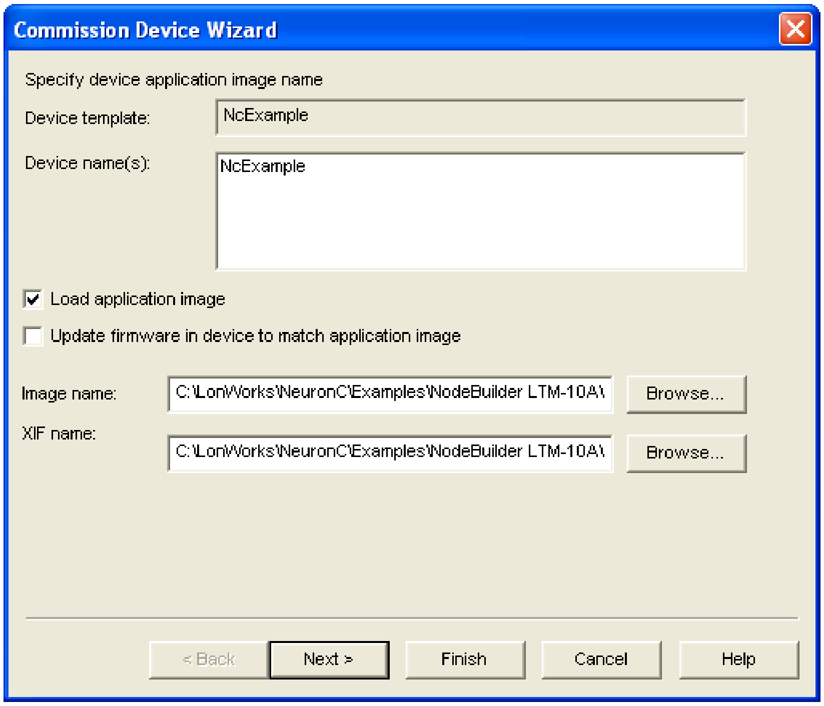
Downloading the Example Application

To download the example application to the LTM-10A Platform, follow these steps:

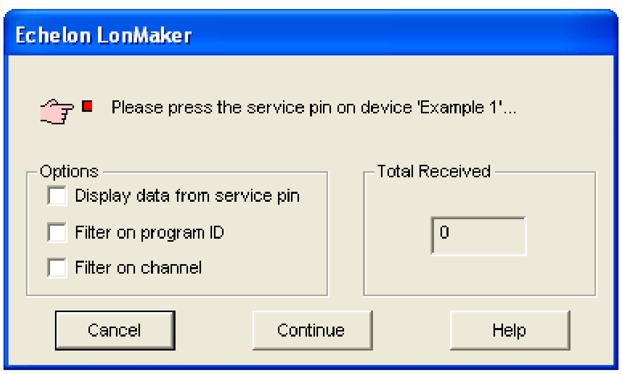
1. Right-click the yellow cross-hatched device shape representing your uncommissioned example device, point to **Commission**, and then click **Commission** on the shortcut menu.



2. The Commission Device Wizard opens with the Application Image window displayed. Select the **Load Application Image** check box. This specifies that you will download the pre-built binary application image file for the *NcExample* application (**NcExample.apb**) to the device. The **NcExample.apb** file is stored in the LonWorks\NeuronC\Examples\NodeBuilder LTM-10A\ReleasedBinaries\Release folder.

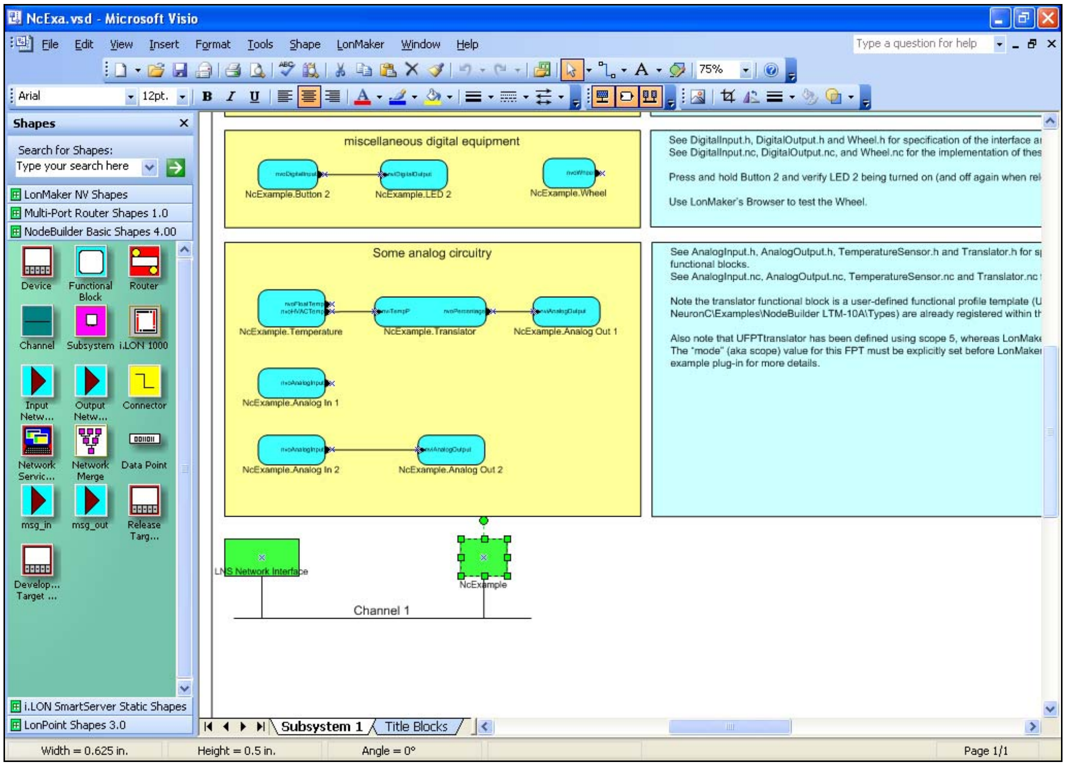


3. Click **Finish**. The Press Service Pin window appears.



4. Press the service pin on the Gizmo 4 I/O Board. The service pin on the Gizmo 4 I/O Board is a black button that is located on the right side of the board and is labeled “**SERVICE**.”

5. The LonMaker tool loads the application image for your example application to the Gizmo 4 I/O Board and makes it operational. When the LonMaker tool is done commissioning, it will return to the LonMaker drawing. The device shape will be will be solid green indicating that the device has been commissioned and is online, and the LCD on the Gizmo 4 I/O Board will display “Echelon NEURON C Example Application”. The device application will not do anything until you test the device or connect it to other devices.



Testing the I/O Devices on the Gizmo 4 I/O Board

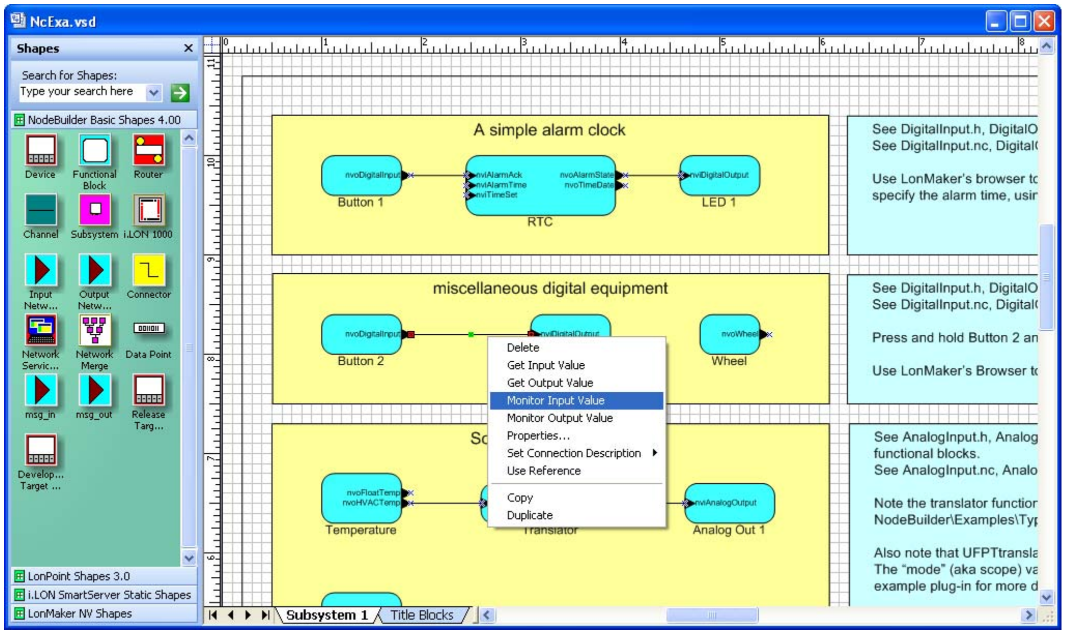
You can use the I/O devices on the Gizmo 4 I/O Board to observe how network variable connections enable devices to exchange data. You can use a switch device to control a lamp device on the Gizmo 4 I/O Board. You can then set an alarm condition, trigger the alarm and activate the piezo buzzer and an LED on the Gizmo 4 I/O Board, and then use a switch device on the Gizmo 4 I/O Board to acknowledge the alarm and turn off the buzzer and LED.

A connection may be between a single output network variable and a compatible (same type) input network variable, or it may be between a single output or input network variable and multiple compatible input or output network variables, respectively. Once you create a connection, the input network variables will receive all updates from the output network variables in the connection.

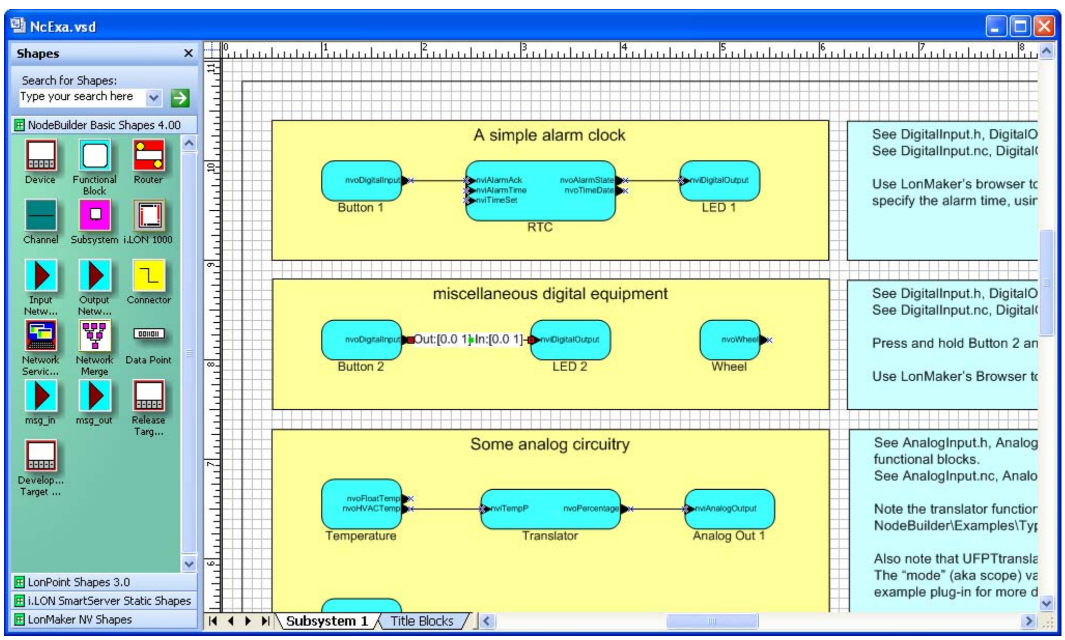
Testing Switch and Lamp Devices

To test the network variable connection between switch and lamp devices on the Gizmo 4 I/O Board, follow these steps:

1. In the **Miscellaneous Digital Equipment** box, right-click the connector shape between Button 2 and LED2, and click **Monitor Output Value** on the shortcut menu. Right-click the connector shape again and click **Monitor Input Value** on the shortcut menu.



2. Press and hold the SW2 button at the bottom left side of the Gizmo 4 I/O Board (**Button 2**). Observe that LED2 above the SW2 button (**LED 2**) turns on. Also, observe that input and output values displayed on the connector shape in the LonMaker drawing are 0.0 1. This means that the Switch and LED are at their minimum values (0%) and on (1).



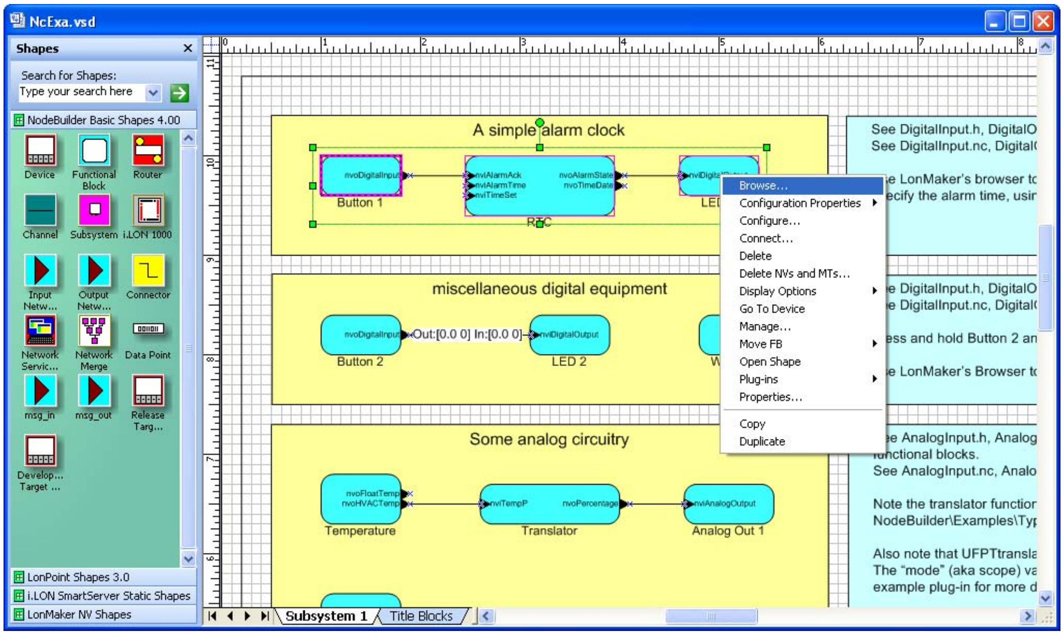
3. Release the **SW2** button to turn off **LED2**. Also, observe that input and output values displayed on the connector shape in the LonMaker drawing are now 0.0 0. This means that the switch and LED are off.

Testing Alarm Devices

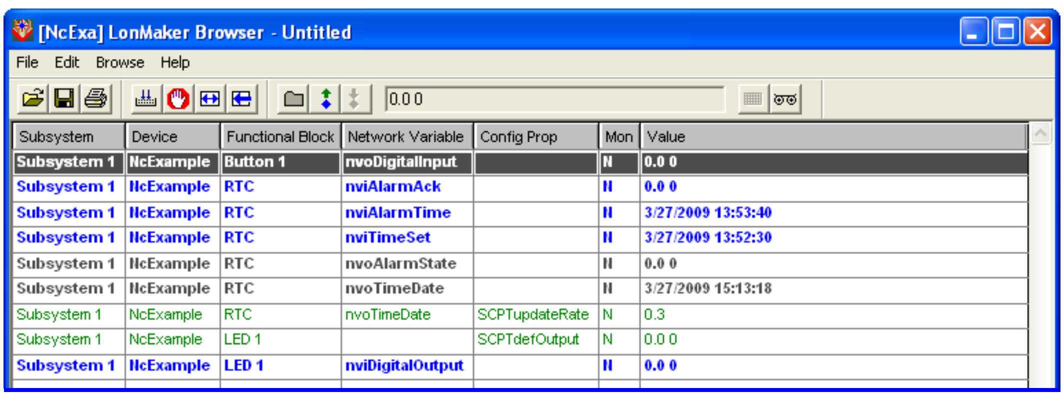
To test the network variable connection between the switch, LED, and piezo buzzer devices on the Gizmo 4 I/O Board, follow these steps:

1. Open the LonMaker Browser. To do this, click the **Button 1** functional block shape in the **A Simple Alarm Clock** box, hold down CTRL, click the **RTC** and **LED 1** functional block shapes

so that they are all selected, right-click one of the selected functional block shapes, and click **Browse** on the shortcut menu.

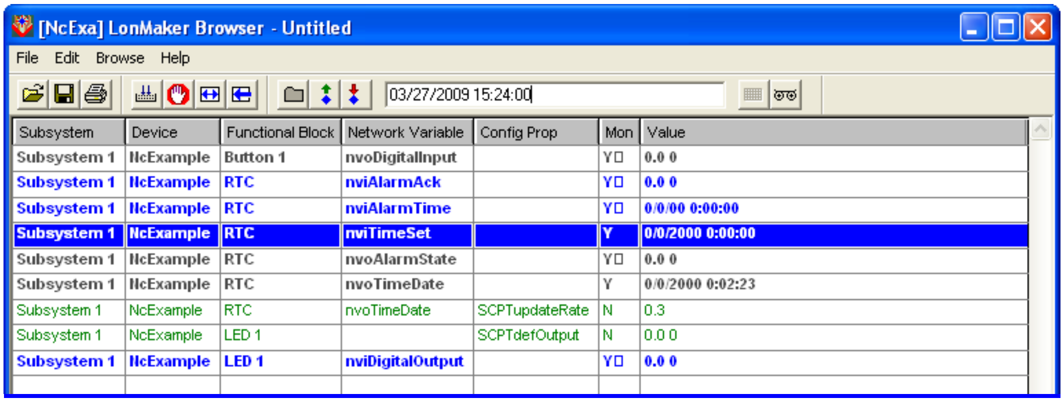


2. The LonMaker Browser opens. It displays the three selected functional blocks (**Button 1**, **RTC**, and **LED 1**) and the network variables and configuration properties within each functional block. Note that you can only write values to the input network variables (blue) and writable configuration properties (green).



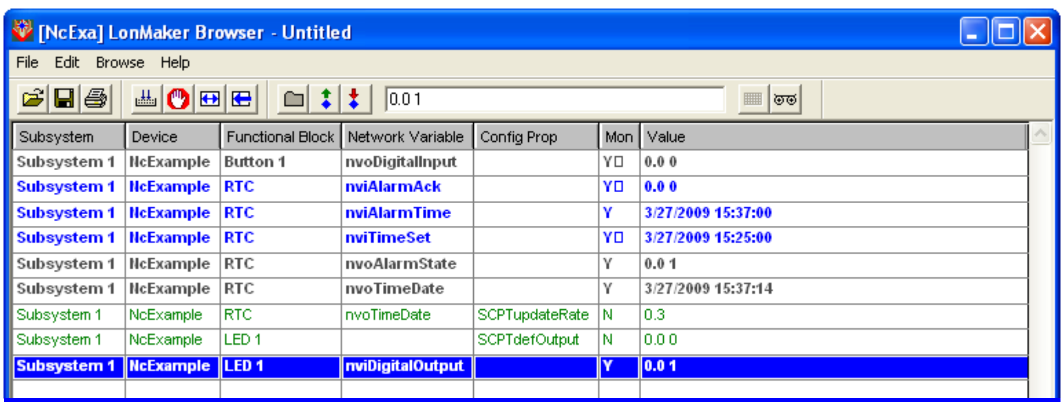
3. Click the **Monitor All** button (icon) on the toolbar to start polling all values.

4. Click anywhere in the **nviTimeSet** row and enter the current time in the **Value** box at the top of the Browser in the following format: mm/dd/yy hh:mm:ss. The **RTC.nvoTimeDate** network variable is set to this time and starts.

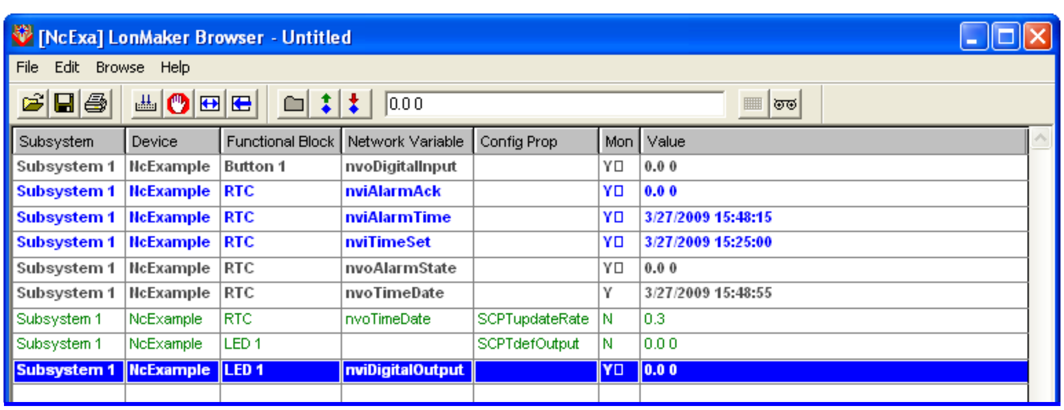


5. Click anywhere in the **nviAlarmTime** row and enter a time in the **Value** box at the top of the Browser that is a few seconds later than the current time in **nvoTimeDate**. The device application evaluates whether the current time in **nvoTimeDate** is later than the alarm time in **nviAlarmTime**, and triggers an alarm if it is.

6. When the alarm time you set passes, the piezo buzzer will generate audio feedback and **LED1** on the bottom left side of the Gizmo I/O Board will turn on. In addition, you can observe in the Browser that the **RTC**.**nvoAlarmState** and **LED 1**.**nviDigitalOutput** network variables are set to 0.0 1, meaning that the piezo buzzer and LED are on.



7. Press the **SW1** button on the bottom left side of the Gizmo 4 I/O Board (Button 1) to acknowledge the alarm and turn off the buzzer and LED1. In addition, you can observe in the Browser that the **RTC**.**nvoAlarmState** and **LED 1**.**nviDigitalOutput** network variables are returned to 0.0 0, meaning that the piezo buzzer and LED are off.



Creating the Example Device Application

This section details how to create the *NcExample* device application from scratch. It describes how each part of the example was developed using the NodeBuilder tool and the LonMaker tool. The example is divided into the nine steps, which introduce different parts of the device development process. You should complete these steps in order because each step assumes that you have successfully completed the previous one. The nine steps to creating the *NcExample* device application are as follows:

1. Create the LonMaker network, NodeBuilder project, and NodeBuilder device template.
2. Configure the Node Object.
3. Add digital I/O.
4. Implement analog inputs.
5. Implement a simple type translator.
6. Enhance the type translator.
7. Implement the temperature sensor.
8. Implement the real-time clock.
9. Implement the wheel input

Note: This section includes a number of code examples. Many of these examples show code that is generated by the Code Wizard as well as the code to be added. In these examples, code that is generated by the Code Wizard is shown in *italics* and code which has been added is shown in **bold**. See the *Neuron C Programmer's Guide* and *Neuron C Reference Guide* for more information on programming in Neuron C.

Step 1: Creating the NodeBuilder Project

In this step, you will create a LonMaker network that contains the device to be developed, create the NodeBuilder project, and create the NodeBuilder device template. To accomplish this, follow these steps:

1. Start the LonMaker tool and create a new LonMaker network named **NcExa**. Ensure that the LonMaker tool is attached to the network and in the OnNet management mode. See the *LonMaker User's Guide* for more information on creating and opening a LonMaker network.

2. Drag the **Development Target Device** shape from the **NodeBuilder Basic Shapes** stencil to the LonMaker drawing. The LonMaker New Device Wizard opens.

3. Choose a name for the new device, set **Commission Device**, and then click **Next**. The second window of the New Device Wizard opens.

4. Click the **Start NodeBuilder** button. The NodeBuilder Project Manager appears. When prompted, indicate that you want to create a new NodeBuilder project. The New NodeBuilder Project Wizard opens.

5. Name the new NodeBuilder project **NcExa** (this will be the default name if you named the LonMaker network this) and click **Next**. The Project Default Setting window opens.

6. In the **Project Default Settings** window, add the location of the Gizmo 4 utility files (e.g., **Gizmo4.h**) to **Include Search Path**. By default, the Gizmo 4 utility files are located in the LonWorks\NeuronC\Examples\NodeBuilder LTM-10A\NcExample folder. Set **Run NodeBuilder device template wizard** and click **Next**. The Device Template Wizard opens.

7. In the first window of the Device Template Wizard, name the new Device Template **NcExample**. Click **Next**. The Program ID window opens.

8. Leave automatic Program ID management enabled and use the **Standard Program ID Calculator** to generate a Program ID. The example provided with the NodeBuilder project uses 9F:FF:FF:05:00:8A:04:00, but the Program ID you use should use your company's manufacturer ID. See *Specifying the Program ID* in Chapter 5 of the *NodeBuilder User's Guide* for more information about the **Standard Program ID Calculator**. When you build you will get a

warning that you have a mismatch between the Program ID and the transceiver type. For purposes of the example, you can ignore this warning. If you want to change the Program ID to the appropriate transceiver value, you must set the scope of the resource file created in *Step 5: Implementing a Simple Type Translator* to 4 so that the Program ID of the resource file set will match the Program ID of the device. Click **Next**. The Target Platforms window opens.

9. Set the development target hardware to **LTM-10A RAM**, and the release target hardware to **LTM-10A FLASH**. See *Creating Hardware Templates* in Chapter 5 of the *NodeBuilder User's Guide* for more information about hardware templates. Select the **Run NodeBuilder Code Wizard** check box and then click **Finish**. The NodeBuilder Code Wizard opens.

Step 2: Configuring the Node Object

You can create an empty but fully functioning LONWORKS device with just a Node Object functional block. The Node Object functional block is used by network tools to manage all the functional blocks on a device. In this step, you will use the Code Wizard to configure the device's Node Object functional block and add code to initialize the Gizmo 4 I/O Board.

1. Click **Generate and Close**. The Code Wizard generates code and returns you to the NodeBuilder Project Manager.

2. Double-click the `common.h` file contained in the NcExample device template in the Project pane to open it. Add the following line at the top of the list of include files:

```
#include "Gizmo4.h"
```

   This statement makes the Gizmo 4 utility functions and I/O declarations available to all components of the example application. You must have included the folder containing the Gizmo 4 header files in **Include Search Path**. If you did not, right-click the device template, select **Settings** from the shortcut menu, open the **Paths** tab, and update **Include Search Path**.

3. In `NxExample.nc`, in the "when (reset)" step, add the following lines shown in bold:

```
when (reset)
{
    GizmoReset();
    GizmoBuzz(TRUE);
    GizmoDisplayString(2,0, "Echelon NEURON C");
    GizmoDisplayString(0,1, "Example Application");
    initAllFblockData();
    executeOnEachFblock(FBC_WHEN_RESET);
    GizmoBuzz(FALSE);
}
```

   This code change initializes the Gizmo 4 I/O Board.

4. Save the file by selecting **Save** from the **File** menu.

5. Right-click the **Development** folder and then select **Build** from the shortcut menu. This builds only the development target which is all that is necessary for this example.

6. Once the build has completed, click the LonMaker tool Taskbar button in the Taskbar to return to the LonMaker tool. The New Device Wizard opened in *Step 1: Creating the NodeBuilder Project* will still be open.

7. In the **NodeBuilder Device Template** property, select the **NcExample** NodeBuilder device template.

8. Continue through the New Device Wizard in the LonMaker tool (see the *LonMaker User's Guide* for more information). Set **Load Application Image**, and set **State** to **Online**.

   When prompted, press the service pin on the LTM-10A Platform. The application, including the Node Object functional block and the Gizmo utilities, is loaded into the device. The application download takes up to 30 seconds.

Now that you have added the device to the LonMaker drawing and loaded the device with its application, the NodeBuilder Project Manager and the LonMaker tool will automatically load new builds of the application into the device.

9. The Gizmo display shows an "Echelon NEURON C Example Application" message after loading and commissioning has been completed.
10. Use the LonMaker tool to test the device. For example, you can add a Node Object functional block and confirm that it has the appropriate network variables and configuration properties.

Step 3: Adding Digital I/O

You can add digital input and output functionality to your device. In this step, you will add a pair of digital actuators and sensor functional blocks to the device, and connect them using the LonMaker tool. Once you complete this step, you can use the buttons on the Gizmo 4 to turn on the LEDs.

After completing this step, you will have a fully functioning LONWORKS device. This step and the functional blocks added in this step are kept simple in order to focus on the essential steps. More sophisticated examples follow in subsequent steps.

1. Click the NodeBuilder tool Taskbar button in the Taskbar to return to the NodeBuilder Project Manager.
2. Right-click the **NcExample** device template and select **Code Wizard** from the shortcut menu. The Code Wizard opens.
3. Right-click the **Functional Blocks** folder and select **Add Functional Block** from the shortcut menu. The **Add Functional Block** dialog opens.
4. Add an array of two **SFPTopenLoopSensor** functional blocks to the device. Name the functional blocks **DigitalInput**. These two functional blocks will be used to control the two push-buttons on the Gizmo 4.
5. Open the **DigitalInput** functional block's **Mandatory NVs** folder, right-click the network variable contained in the folder, and select **Properties** from the shortcut menu. The **NV Properties** dialog opens.
6. Rename the network variables to **nvoDigitalInput**, and set the type to **SNVT_switch**. The network variable is implemented as an array of size 2. These network variables will be used to send the value of the digital input on the network (for example, whether the button is being pressed).
7. Repeat steps 3 and 4, but add an array of two **SFPTopenLoopActuator** functional blocks, and name them **DigitalOutput**. These functional blocks will be used to control the two LEDs on the Gizmo 4.
8. Repeat steps 5 and 6 but rename the **DigitalOutput** functional block's mandatory network variable to **nviDigitalOutput**, and change the type to **SNVT_switch**. These two network variables will be used to receive values from the network to drive the LEDs (for example, turn them on and off).
9. Right-click the **DigitalOutput** functional block's **Optional CPs** folder and select **Implement Optional CP** from the shortcut menu. The **Implement Optional CP** dialog opens.
10. Select **nciDefault** from the **FPT Member Name** dialog to implement this configuration property. Name the configuration property **cpDigitalDefault**. A single configuration property will be created for each member of the functional block array (the **Static CP** option is used to create a single configuration property that applies to all functional blocks in the array; this option is discussed in *Step 4: Implementing Analog Inputs*).

    This configuration property will be used to control the initial state of the physical output lines after power-up or reset. Since it is applied to an actuator, the type of this configuration property is the same as the type of the primary input network variable of the functional block (**nviDigitalOutput**).

11. Click **Generate and Close**.
12. Open the device template's Source Files folder and open **ncexample.h** by double clicking it. Add the following lines of code shown in bold:

```
#ifndef _NcExample_H_
#define _NcExample_H_

#define SWITCH_ON  0x01
#define SWITCH_OFF 0x00
```

This code defines enumerations to use for on and off values for the buttons and LEDs.

13. Open **DigitalOutput.nc** from the **Source Files** folder and add the following lines of code shown in bold to the `DigitalOutputProcessNV()` method:

```
void DigitalOutputprocessNV(void)
{
    // drive the LED as appropriate:
    GizmoSetLed(deviceState.nvArrayIndex,
nviDigitalOutput[deviceState.nvArrayIndex].state);
}
```

This code causes the LED to be updated whenever the input network variable on the associated **DigitalOutput** functional block receives an update.

14. Open the **DigitalInput.nc** file from the **Source Files** folder and add the following lines of code:

```
void setDOutValue(unsigned uIndex) {
    // set the nvo to reflect the input line state.
    if (fblockNormalNotLockedOut(DigitalInput[uIndex]::global_index)) {
        nvoDigitalInput[uIndex].state
            = input_value ? SWITCH_OFF : SWITCH_ON;
    }
}

when (io_changes(ioButton1)) {
    setDOutValue(0);
}
when (io_changes(ioButton2)) {
    setDOutValue(1);
}
```

This code causes the output network variables on the **DigitalInput** functional blocks to be updated whenever the value from the hardware (for example, the push-buttons) changes.

The `fblockNormalNotLockedOut()` function ensures that the functional block is enabled. Alternatively, the following clause can also be used for the argument of the `fblockNormalNotLockedOut()` function to retrieve the current functional block index:

```
fblock_index_map[nv_table_index(nvoDigitalInput[uIndex])]
```

The `DigitalInput[uIndex]::global_index` clause is used to demonstrate the scope operator ('`::`'), and because this clause is more efficient.

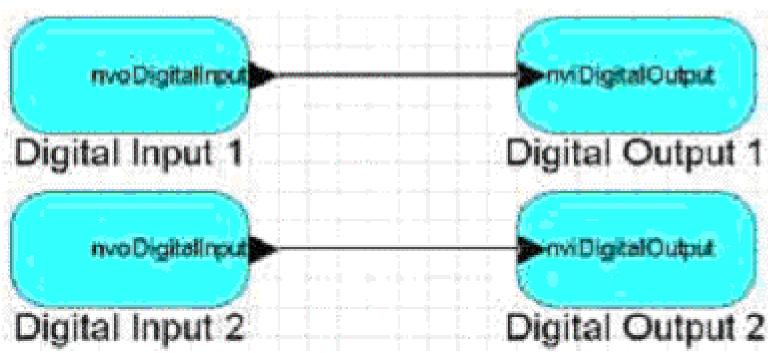
15. Open **DigitalOutput.nc** from the **Source Files** folder. Add the following code in bold to the `FBC_WHEN_RESET` else-if statement:

```
else if ((TFblock_command)iCommand == FBC_WHEN_RESET)
    {
```

```
        // initialize output lines:
        GizmoSetLed(0, DigitalOutput[0]::cpDigitalDefault.state);
        GizmoSetLed(1, DigitalOutput[1]::cpDigitalDefault.state);
        setLockedOutBit(uFblockIndex, FALSE);
    }
    else if ((TFblock_command)iCommand == FBC_DISABLED)
```

This code causes LEDs to be set to the value specified in the **cpDigitalDefault** configuration property when the device is reset.

16. Build the development target. To do this, right click the **Development** target, and then click **Build** on the shortcut menu. The LonMaker tool automatically reloads the application into the device.
17. Click the LonMaker tool Taskbar button in the Taskbar to return to the LonMaker tool.
18. Drag four functional block shapes to your drawing, one for each of the **DigitalOutput** and **DigitalInput** functional blocks. Select the **Create Shapes for all Network Variables** check box for each functional block.
19. Connect each input network variable to the corresponding output network variable. See the *LonMaker User's Guide* for more information on performing these operations. When you are done, your LonMaker drawing should look something like this:



20. Press the SW1 and SW2 buttons on the Gizmo 4 I/O Board to verify that these now control the LEDs.
21. Use the LonMaker tool to verify the functional blocks behave as expected.

Step 4: Implementing Analog Input and Output

In this step, you will add a pair of analog input and output functional blocks to the device, and you will add an implementation-specific configuration property to a functional block.

1. Click the NodeBuilder tool Taskbar button in the Taskbar to return to the NodeBuilder tool.
2. Right-click on the device template and select **Code Wizard** from the shortcut menu. The Code Wizard opens.
3. Right-click the device template's **Functional Blocks** folder and select **Add Functional Block** from the shortcut menu. The **Add Functional Block** dialog opens.
4. Add an array of two **SFPTanalogInput** functional blocks. Name the functional block array **AnalogInput**.
5. Open the **AnalogInput** functional block's **Mandatory NVs** folder, right-click the **nvoAnalog** network variable in the folder, and select **Properties** from the shortcut menu. The **NV Properties** dialog opens.
6. Rename the network variable to **nvoAnalogInput**.
7. Repeat steps 2 and 3, but add an array of two **SFPTanalogOutput** functional blocks, and name the array **AnalogOutput**.

8. Repeat steps 3 and 4, but rename the **nviAnalog** network variable to **nviAnalogOutput**.

9. Right-click the **AnalogInput** functional block's **Implementation-specific CPs** folder and select **Add CP** from the shortcut menu. The **Add Configuration Property** dialog opens.

10. Add an implementation-specific **SCPTupdateRate** configuration property. Name the new configuration property **cpUpdateRate**. Set **Static CP** for this configuration property; this will cause a single configuration property to be added that applies to all functional blocks in the **AnalogInput** functional block array. Set **Initial Value** to **5**. This configuration property will be used to specify how often each **AnalogInput** functional block will read the analog-to-digital converter (ADC) hardware inputs.

    Setting the **InitialValue** field to 5 will cause the value of this configuration property to be set to 5 when the application is loaded into the device. The value of "5" is the unscaled value, representing 500ms or 0.5s.

11. Click **OK**.

12. Click **Generate and Close**.

13. Open the **AnalogOutput.nc** file from the **Source File** folder and add the following code in bold to the `FBC_WHEN_RESET` else-if statement in the `AnalogOutputDirector()` function:

```
else if ((TFblock_command)iCommand == FBC_WHEN_RESET)
        // init output signals to 0
        GizmoWriteAnalog(0, 0L);
        GizmoWriteAnalog(1, 0L);
        // get going:
        setLockedOutBit(uFblockIndex, FALSE);
```

    This code causes the analog output signals to be set to 0 when the device is reset. You could add a default value implementation specific configuration property for a more flexible solution then a hard-coded 0V output after power-up and reset. This has not been implemented in this step because you already implemented such a configuration property in *Step 3: Adding Digital I/O*.

14. Still in the `AnalogOutput.nc` file, add the following code in bold to the `AnalogOutputprocessNV()` function:

```
void AnalogOutputprocessNV(void)
{
    signed long slOutputValue;

    slOutputValue  = nviAnalogOutput[deviceState.nvArrayIndex];
    slOutputValue /= 20L;

    GizmoWriteAnalog(deviceState.nvArrayIndex, abs(slOutputValue));
}
```

    This code computes the output value. The **SNVT_lev_percent** network variable type has a valid range of -163.84% to 163.83% in steps of 0.005%. The value expected by the `GizmoWriteAnalog()` function, however, has a value range of 0.0 to 100.0% in steps of 0.1%.

    The **slOutputValue** variable has the correct value but is still a signed variable, and could have the correct absolute value but the incorrect sign. This example uses the `abs()` function to ignore the sign.

15. Open the **AnalogInput.nc** file from the **Source Files** folder. Add the following declarations in bold at the top of the file:

```
#ifndef _AnalogInput_NC_
#define _AnalogInput_NC_

#include "common.h"
#include "AnalogInput.h"
```

```
#define AI_FILTERSIZE   4
#define AI_CHANNELS     AnalogInput_FBLOCK_COUNT

mtimer  ai_timer;
// the buffer for the averaging filter:
unsigned long ai_rawdata[AI_CHANNELS][AI_FILTERSIZE];
// recent value (required to detect changes for minimum NV updates)
unsigned long ai_rawrecent[AI_CHANNELS];

//{{NodeBuilder Code Wizard Start
```

The Gizmo 4's PIC controller does not provide an interrupt upon the availability of new analog data. Therefore, this example reads both channels every **cpUpdateRate** interval, which defaults to 1 minute (the PIC converts every 100ms). The minimum sample rate is 0.1s, which matches the PIC controller's real sample rate. This example averages the last `AI_FILTERSIZE` values obtained for an improved signal quality, where the filter size defaults to 4 and should not be less than two. This implementation will only update the output network variable if the value has been changed.

16. Still in **AnalogInput.nc**, add the following code in bold to the `FBC_WHEN_RESET` else/if statement in the `AnalogInputDirector()` function:

```
else if ((TFblock_command)iCommand == FBC_WHEN_RESET)
    // reset filter and start sampling timer
    memset(ai_rawdata, 0, sizeof(ai_rawdata));
    memset(ai_rawrecent, 0, sizeof(ai_rawrecent));
    ai_timer = AnalogInput[0]::cpUpdateRate * 100L;
    // get going:
    setLockedOutBit(uFblockIndex, FALSE);
```

This code clears out the filter and starts sampling the hardware input when the device is reset.

17. Still in **AnalogInput.nc**, add the following code in bold to the `FBC_WHEN_ONLINE` else-if statement in the `AnalogInputDirector()` function:

```
else if ((TFblock_command)iCommand == FBC_WHEN_ONLINE)
    // start sampling timer:
    ai_timer = AnalogInput[0]::cpUpdateRate * 100L;
```

This code starts the sampling the hardware input when the device is set online.

18. Still in **AnalogInput.nc**, add the following code in bold to the `FBC_WHEN_OFFLINE` else/if statement in the `AnalogInputDirector()` function:

```
else if ((TFblock_command)iCommand == FBC_WHEN_OFFLINE)
    // stop sampling timer:
    ai_timer = 0L;
```

This code stops sampling the hardware input when the device is set offline.

19. Still in **AnalogInput.nc**, add the following code in bold to process expiry of the sampling timer:

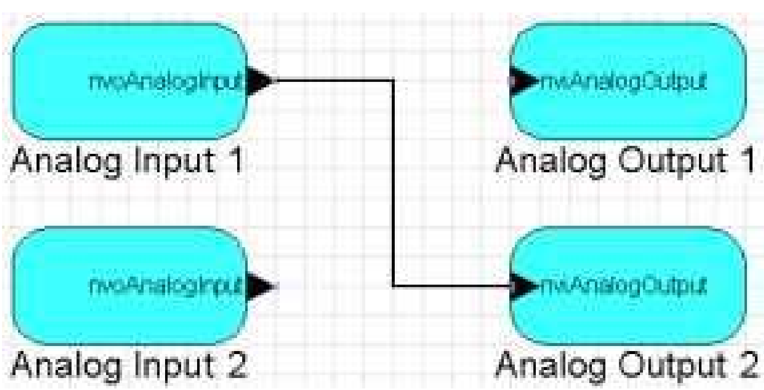
```
#endif  //_HAS_INPUT_NV_

when (timer_expires(ai_timer)) {
    int iIndex;
    int iChannel;
    unsigned long ulValue;

    // are we in business?
    if (fblockNormalNotLockedOut(AnalogInput[0]::global_index)) {
        // yes we are.  Repeat for each channel.

        for (iChannel = 0; iChannel < AI_CHANNELS; ++iChannel) {
            // Move historic data:
            for (iIndex = 0; iIndex < AI_FILTERSIZE-1; ++iIndex) {
```

```
                ai_rawdata[iChannel][iIndex] =
                ai_rawdata[iChannel][iIndex + 1];
            }

            // fetch current value (store in filter history and also
            // use current value to initialize current result
            ulValue = ai_rawdata[iChannel][AI_FILTERSIZE-1] =
            GizmoReadAnalog(iChannel);

            // compute average over averaging window:
            for (iIndex = 0; iIndex < AI_FILTERSIZE-1; ++iIndex) {
                ulValue += ai_rawdata[iChannel][iIndex];
            }
            // now we've got the sum, let's divide in a reasonable
            // way.  That is, we divide and round if appropriate:
            if ((ulValue % AI_FILTERSIZE) >= (AI_FILTERSIZE / 2)) {
                ulValue = ulValue / AI_FILTERSIZE + 1L;
            } else {
                ulValue /= AI_FILTERSIZE;
            }

            // has it changed?
            if (ulValue != ai_rawrecent[iChannel]) {
                // it has indeed.  Update history and network variable
                ai_rawrecent[iChannel] = ulValue;
                nvoAnalogInput[iChannel] =
                    ((SNVT_lev_percent)ulValue)* 20L;

            }
        } // next channel
    } // not in business

    // re-load timer.  We do not use auto-reloading ("mtimer
    // repeating...") because we want the update frequency to be
    // adjustable through cpUpdateRate.
    ai_timer = AnalogInput[0]::cpUpdateRate * 100L;
}
```

20. Build the development target. To do this, right click the **Development** target, and then click **Build** on the shortcut menu. The LonMaker tool automatically loads the new application into the device hardware.

21. Drag four new functional blocks to your drawing, one for each **AnalogInput** and **AnalogOutput** functional block. Select the **Create Shapes for all Network Variables** check box for each functional block.

22. Connect **AnalogInput[0]** to **AnalogOutput[1]**. See the *LonMaker User's Guide* for more information. When you are done, your LonMaker drawing should look something like this:



23. Insert jumpers between pins 1 and 2 of JP7 and JP8 in the lower right-hand corner of the Gizmo 4 board. These jumpers connect the AOUT1 output to the AIN1 input, and the AOUT2 output to the AIN2 input.

24. Browse the **Analog Output 1** and **Analog Input 2** functional blocks using the LonMaker Browser. Verify that an update to the **nviAnalogOutput** network variable on **Analog Output 1** gets reflected in the **nvoAnalogInput** network variable on **Analog Input 2**. Allow a generous conversion error—the Gizmo 4 I/O Board has a 10-bit ADC and an 8-bit DAC converter that are daisy-chained, which causes conversion errors to be multiplied. Also verify correct operation by changing the **cpUpdateRate** configuration property value, disabling one or more functional blocks in the loop.

Step 5: Implementing a Simple Type Translator

You can create a simple user-defined functional profile (**UFPTtranslator**) that translates an input network variable of type **SNVT_temp_p** into an output network variable of type **SNVT_lev_percent**. This enables you to connect a temperature sensor functional block to the analog output functional blocks on this example device. For more information about the resource editor, see the *NodeBuilder Resource Editor User's Guide*.

In this step, you will use the NodeBuilder Resource Editor to create the **UFPTtranslator** functional profile, which is a basic implementation of a very simple UFPT. You will implement a number of improvements in the design of this UFPT in *Step 6: Enhancing the Type Translator*.

1. Click the NodeBuilder tool Taskbar button in the Taskbar to return to the NodeBuilder tool. Right-click the **NcExample** device template and select **Code Wizard** from the shortcut menu. The Code Wizard opens.
2. In the Resource pane on the left side of the Code Wizard, expand the **NcExample** functional profile template below the **LonWorks\NeuronC\Examples\NodeBuilder LTM-10A\Types** folder. The **UFPTtranslator** functional profile template is displayed.
3. Right-click the **UFPTtranslator** functional profile and select **Open** from the shortcut menu. The **Modify Resource File Set** dialog opens.
4. In the Available Types pane on the left side of this dialog, expand the C:\LonWorks\Types\Standard resource file set folder, and browse to the **SNVT_lev_percent** network variable type. Drag this network variable type to the **UFPTtranslator** functional profile's **Mandatory NVs** folder in the Functional Profile pane in the center of the dialog. The network variable will be added to the **Mandatory NVs** folder with the name **nviManNV1**.
5. Repeat step 4 but add a **SNVT_temp_p** network variable to the **UFPTtranslator** functional profile's **Mandatory NVs** folder. The new network variable will be named **nviManNV2**.
6. Click **nviManNV1** (the **SNVT_lev_percent** type network variable added in step 4). The Member Details pane on the right side of the dialog displays the network variable properties. Change **Name** to **nvoPercentage** and set **Output** to indicate that it is an output network variable.
7. Repeat step 6 for **nviManNV2** (the **SNVT_temp_p** type network variable added in step 5). Change Name to **nviTempP**, set **Input** to indicate that it is an input network variable, and set **Principal NV** to make this the functional profile's principal network variable.
8. Click **OK**.
9. In the Program Interface pane on the right side of the Code Wizard, right-click the device template's Functional Blocks folder and add a single **UFPTtranslator** functional block to the device. Set **User-defined** and set **Scope** to 3 in the **Add Functional Block** dialog to access the new resource file set.
10. Click **OK**. Click **Generate and Close** to generate code and exit the Code Wizard.
11. Build the development target. To do this, right click the **Development** target, and then click **Build** on the shortcut menu. The LonMaker tool automatically loads the new application into the device hardware.
12. Add the **Translator** functional block to the LonMaker drawing.

13. Use the LonMaker Browser to browse the translator. Enable monitoring for **nvoPercentage**, and force **nviTempP** to several values within and outside the supported range of 0-+30°C.
14. Connect the **nvoPercentage** output network variable to the input network variable of one of the analog output functional block blocks, connect a multimeter to the relevant analog output.
15. Use the LonMaker Browser to change the **nviTempP** value, and observe the results.

Step 6: Enhancing the Type Translator

You cam refine and enhance the **UFPTtranslator** functional profile you defined in *Step 5: Implementing a Simple Type Translator*. The **UFPTtranslator** functional profile, with hardcoded input and output limits, is very specialized for this step. In this step, you will add two configuration properties for the input range (replacing the hard-coded minimum and maximum of 0 and 30 degrees Celsius) and two configuration properties to define the minimum and the maximum output signal values.

The configuration properties used for setting the minimum and maximum output will use the **SCPTminRnge** and **SCPTmaxRnge** types. These configuration properties are used to limit the minimum value of the primary output network variable for the object.

You need to create your own user-defined configuration property types (UCPTs) because there are no appropriate standard configuration property types (SCPTs) that can limit the input signal range (you can not use **SCPThighTemp** because this configuration property indicates the high alarm set point for the **nvoAlarmAirTemp**).

1. Click the NodeBuilder tool Taskbar button in the Taskbar to return to the NodeBuilder tool.
2. Right-click the device template and select **Code Wizard** from the shortcut menu. The Code Wizard opens.
3. In the Resource pane, browse to the **UFPTtranslator** functional profile created in *Step 5: Implementing a Simple Type Translator*. Right-click the functional profile and select **Open** from the shortcut menu. The **Modify Functional Profile Template** dialog opens.
4. Select the **nviTempP** network variable in the **Mandatory NVs** folder and clear **Principal NV**.
5. Select the **nvoPercentage** network variable in the **Mandatory NVs** folder and set **Principal NV**. This must be done because the **SCPTminRange** and **SCPTmaxRange** standard configuration property types should apply to the principal network variable, as stated in the SCPT description above.
6. In the Available Types pane in the left-hand side of this dialog, expand the LonWorks\types\STANDARD resource file set folder, and browse to the **SCPTminRnge** configuration property type. Drag the configuration property to the **UFPTtranslator** functional profile's **Mandatory CPs** folder in the Functional Profile pane in the center of this dialog. The configuration property will be added to the **Mandatory CPs** folder with the name **nciManCP1**.
7. Repeat step 6 but add a **SCPTmaxRnge** configuration property to the **UFPTtranslator** functional profile's **Mandatory CPs** folder. The new configuration property will be named **nciManCP2**.
8. Click **nciManCP1** (the **SCPTminRnge** configuration property added in step 6). The Member Details pane in the right-hand side of the dialog displays the configuration property properties. Change **Name** to **cpTransOutMin**.
9. Repeat step 8 for **nviManCP2** (the **SCPTmaxRnge** network variable added in step 7. Change **Name** to **cpTransOutMax**.
10. Click **OK**.
11. Right-click NcExample resource file set's **Configuration Property Types** folder and select **New CPT** from the shortcut menu. The **New Configuration Property Type** dialog opens.
12. Set **CP Name** to **UCPTminTemp**, set **Inherited from a network variable**.

13. Repeat steps 11 and 12, but set **CP Name** to **UCPTmaxTemp**.
14. Right-click the **UFPTtranslator** functional profile and select **Open**. The **Modify Functional Profile Template** dialog opens.
15. Add one configuration property of each of the new types to the **Mandatory CPs** folder. Name them **cpTransInMin** and **cpTransInMax**, respectively.
16. Change the "Applies To" setting so that the **cpTransInMin**/**cpTransInMax** properties apply to the input network variable, and **cpTransOutMin**/**cpTransOutMax** to the output network variable. Click **OK**.
17. In the Program Interface pane of the Code Wizard, right-click the **Translator** functional block and select **Refresh** from the shortcut menu. The functional block will be refreshed to include the new configuration properties that you added to the functional profile.
18. Assign default values to each new configuration property on the **Translator** functional block. The following values will cause the functional block to behave just as it did after *Step 5: Implementing a Simple Type Translator*.

    cpTransInMin 0
    cpTransInMax 3000
    cpTransOutMin 0
    cpTransOutMax 10000

    This step sets defaults for the configuration properties on this device only. This is different than setting the defaults in the functional profile, which will set the defaults for all functional blocks created from that functional profile unless they are otherwise specified.
19. Click Generate and Close.
20. Click **Yes** to generate resource files.
21. Open **Translator.nc** from the Source Files folder and add the following code in bold to the `TranslatorprocessNV()` function:

```
void TranslatorprocessNV(void)
{
long lValue;

    // get scaled value:
    lValue = Translator::nviTempP;

    // limit temperature to supported range 0-30.00 Celcius
    lValue = max(Translator::nviTempP::cpTransInMin,
        min(lValue, Translator::nviTempP::cpTransInMax));
    Translator::nvoPercentage = (short)muldiv(2L*lValue,
    Translator::nvoPercentage::cpTransOutMax,
        Translator::nviTempP::cpTransInMax);
```

This code takes a `SNVT_temp_p` value, which has a range of -273.17 to 327.66 in steps of 0.01, and converts it into a `SNVT_lev_percent` value, which has a range of 163.84% to +163.83% in steps of 0.005%. See the *SNVT and SCPT Master List* for more information.

This particular application limits the output signal range to between 0 and 100%. It also limits the range of the valid input values from 0 to 30° Celsius for room temperature values (for example, 30° C or more results in a 100% output signal; 0° C or less results in a 0% output signal.

In this step, all the above limits are hardcoded. Step 6 shows how to make these limits changeable.

With hard-coded factors, and using unscaled network variable values, the formula for conversion is:

```
percentage = (tempP * 2) * ( 100 / 30 ) = tempP * 20 / 3
```

The `(tempP * 2)` term transforms an unscaled **SNVT_temp_p** value into an equivalent unscaled **SNVT_lev_percent** value, and the second `100/30` term adjusts so that 30° C converts to 100% of the output signal range. Both terms could be combined in a single factor, but this example uses both for double-precision intermediate results.

22. Build the development target. To do this, right click the **Development** target, and then click **Build** on the shortcut menu. The LonMaker tool automatically loads the new application into the device hardware.
23. Add the **Translator** functional block to the LonMaker drawing.
24. Use the LonMaker Browser to browse the translator. Set the new configuration properties to various values, enable monitoring for **nvoPercentage**, and force **nviTempP** to several values within and outside the set range of 0-+30°C. Connect **nvoPercentage** to the input network variable of one of the analog output functional block blocks, connect a voltmeter to the relevant analog output, use the LonMaker Browser to change the **nviTempP** value, and observe the results.

Step 7: Implementing the Temperature Sensor

You can implement a standard temperature sensor profile [**SFPThvacTempSensor (1040)**] to provide a temperature sensor implementation for the Gizmo 4 I/O Board's temperature sensor hardware. In this step, you will observe the difference between floating-point vs. fixed-point arithmetic in Neuron C. To perform this step, follow these steps:

1. Click the NodeBuilder tool Taskbar button in the Taskbar to return to the NodeBuilder tool. Right-click on the device template and select **Code Wizard** from the shortcut menu. The Code Wizard opens.
2. Right-click the device template's **Functional Blocks** folder and select **Add Functional Block** from the shortcut menu. The **Add Functional Block** dialog appears.
3. Add a single **SFPThvacTempSensor** functional block. Name the new functional block **TempSensor**. Click **OK**.
4. Right-click the **TempSensor** functional block's **Optional NVs** folder and select **Implement Optional NV** from the shortcut menu. The **Implement Optional NV** dialog appears.
5. Implement the **nvoFloatTemp** network variable. This network variable has the **SNVT_temp_f** type. Click **OK**.
6. Change the names of the three mandatory configuration properties to **cpMaxSendTime**, **cpMinDelta**, and **cpMinSendTime**, respectively.
7. Click **Generate and Close**.
8. Open **TempSensor.h** from the **Source Files** folder and add the following code in bold:

```
#include "common.h"

SNVT_temp_p HVACTempOld;       // most recent value, used for heartbeats
#define HVAC_CORETICK  500UL   // internal sampling rate
                               //and minimum heartbeat interval
mtimer repeating hvac_coretick = HVAC_CORETICK;

unsigned long HvacMinSendTimer;
unsigned long HvacMaxSendTimer;
float_type f100 = {0, 0x42, 0x01, 0x48, 0 }; // 100.0 - see NXT.EXE
                                               //utility for initializer

//{{NodeBuilder Code Wizard Start
```

9. Open **TempSensor.nc** from the **Source Files** folder add the following code in bold to the `FBC_WHEN_RESET` else-if statement in the `TempSensorDirector()` function:

```
        else if ((TFblock_command)iCommand == FBC_WHEN_RESET)
            HVACTempOld = 0;
            UpdateTemperature();
            // get going:
            setLockedOutBit(uFblockIndex, FALSE);
            break;
```

10. Still in **TempSensor.nc**, add the following functions to the code:

```
#endif //_HAS_INPUT_NV_

int cmptime ( const SNVT_elapsed_tm * const a, const unsigned long b ) {
    unsigned long ulA;
    int iResult;

    // convert SNVT_elapsed_tm_a into a value of type(b).
    ulA = a->millisecond;
    ulA += (1000uL / HVAC_CORETICK)
        * ( a->second + 60UL * (a->minute + 60ul
        * (a->hour + 24ul * a->day)));

    if (b > ulA) {
        iResult = -1;
    } else if (b < ulA) {
        iResult = +1;
    } else {
        iResult = 0;
    }
    return iResult;
}

void PropagateTemp(const SNVT_temp_p Value) {
    float_type fTemp, fResult;

    // set the temp_p type nvo:
    TempSensor::nvoHVACTemp = Value;

    // convert to float.

    // Get the float_type representation of the scaled
    //temp_p value:
    fl_from_slong(Value, &fTemp);
    // Get it right by correcting the fixed decimal point:
    fl_div(&fTemp, &f100, &fResult);
    // That's it!
    TempSensor::nvoFloatTemp = fResult;

    // restart the minsend/maxsend timers
    HvacMinSendTimer = HvacMaxSendTimer = 0L;
}

void UpdateTemperature(void) {
    // Get new value
    SNVT_temp_p NewValue;
    NewValue = GizmoReadTemperature(FALSE, TRUE);
    // Transmit if new value varies by more than nciMinDelta from
    // old value:
    if ((NewValue < (HVACTempOld - TempSensor::nvoHVACTemp::cpMinDelta))
        || (NewValue > (HVACTempOld
        + TempSensor::nvoHVACTemp::cpMinDelta))) {
        // Even so, only transmit if nciMinSendTimer allows:
        if (cmptime((const SNVT_elapsed_tm * const)
            &(TempSensor::cpMinSendTime), HvacMinSendTimer) <= 0 ) {
            // min send time has expired, really send data now:
            PropagateTemp(NewValue);
        }
    }
    // In either case, make sure to keep record of the latest value:
    HVACTempOld = NewValue;
}
```

```
when (timer_expires(hvac_coretick)) {
    // advance the timers:
    HvacMinSendTimer += HVAC_CORETICK;
    HvacMaxSendTimer += HVAC_CORETICK;

    // get new value and re-transmit if needed
    UpdateTemperature ();

    // transmit most recent value if needed due to heartbeat timer:
    if (cmptime((const SNVT_elapsed_tm * const)
        &(TempSensor::cpMaxSendTime), HvacMaxSendTimer) <= 0 ) {
        PropagateTemp( HVACTempOld );
    }
}

void TempSensorDirector(unsigned uFblockIndex, int iCommand )
```

The `cmptime(a,b)` function compares the **a** and **b** values. It returns `sign(a-b)`, for example, `- 1` if `b > a`, `+1` if `b < a`, and `0` if `b == a`. The value of **b** is assumed to tick at the rate defined by the **HVAC_CORETICK** value in milliseconds.

The `PropagateTemp()` function is used to propagate the output network variable. It includes code to perform the necessary conversion to maintain the `FLOAT` type network variable, and to administrate the functional block's timers. This function mostly operates on fixed-point values and converts to floating-point values when needed. This minimizes the number of floating-point operations and thus maximizes the performance of the LONWORKS device.

The `UpdateTemperature()` function is used to obtain new temperature readings from the Gizmo 4 temperature sensor hardware. It includes logic to decide whether this new value should be made available to the network immediately or at a later time, based on the minimum update interval defined in the `nciMinSendTime` configuration property.

The when statement uses the `HVAC_CORETICK` value to maintain the min/max send timers, looks after regular conversions, and assures that updates are sent no further apart then the time specified by the nciMaxSendTime configuration property (the heartbeat).

11. Build the development target. To do this, right click the **Development** target, and then click **Build** on the shortcut menu. The LonMaker tool automatically loads the new application into the device hardware.
12. Add the new functional block and network variables to the LonMaker drawing and use the LonMaker tool and LonMaker Browser to verify correct operation.

Step 8: Implementing the Real Time Keeper

In this step, you will implement the standard real time keeper functional profile template [**SFPTrealTimeKeeper (3300)**]. You will add implementation-specific configuration properties and network variables to this functional block. In addition, you will observe how network variable updates are processed for a functional block with multiple input network variables.

1. Click the NodeBuilder tool Taskbar button in the Taskbar to return to the NodeBuilder tool.
2. Right-click the device template and select **Code Wizard** from the shortcut menu. The Code Wizard opens.
3. Right-click the device template's Functional Blocks folder and select **Add Functional Block** from the shortcut menu. The **Add Functional Block** dialog appears.
4. Add a single **SFPTrealTimeKeeper** functional block. Name the new functional block **RealTimeKeeper**.
5. Right-click the **RealTimeKeeper** functional block's **Optional NVs** folder and select **Implement Optional NV** from the shortcut menu. The **Implement Optional NV** dialog appears.
6. Implement the **nviTimeSet** network variable.

7. Right-click the **RealTimeKeeper** functional block's **Optional CPs** folder and select **Implement Optional CP** from the shortcut menu. The **Implement Optional CP** dialog appears.

8. Implement the **nciUpdateRate** configuration property. Name the new configuration property **cpRtcUpdRate**. Set **Initial Value** to 3L.

9. Right-click the **RealTimeKeeper** functional block's **Implementation-specific NVs** folder and select **Add NV** from the shortcut menu. The **Add NV to Functional Block** dialog appears.

10. Add a **SNVT_time_stamp** network variable. Set the direction to **Input**. Name the new network variable **nviAlarmTime.**

11. Right-click the **RealTimeKeeper** functional block's **Implementation-specific NVs** folder and select **Add Implementation-specific NV** from the shortcut menu. The **Add NV** dialog appears.

12. Add a **SNVT_switch** network variable. Set the direction to **Output**. Name the new network variable **nvoAlarmState.**

13. Right-click the **RealTimeKeeper** functional block's **Implementation-specific NVs** folder and select **Add NV** from the shortcut menu. The **Add NV to Functional Block** dialog appears.

14. Add a **SNVT_switch** network variable. Set the direction to **Input**. Name the new network variable **nviAlarmAck.**

15. Click **Generate and Close**.

16. Open the **RealTimeKeeper.nc** file from the Source Files folder and add the following code in bold:

```
#define RTC_CORETICK   250L
mtimer  rtc_coretick;
enum {
    rtc_alarm_idle, rtc_alarm_armed, rtc_alarm_alarm
} eeprom rtc_alarmstate = rtc_alarm_idle;

//{{NodeBuilder Code Wizard Start
```

This code adds a core timer to the device, which is used to poll the Gizmo 4's real-time clock hardware on a regular interval. The `RTC_CORETICK` enumeration is used to control the state engine within the alarm clock. The states are: *alarm disabled, waiting for alarm condition*, and *alarm currently on* (awaiting acknowledgement).

Sending a value to the **nviAlarmTime** network variable specifies the alarm time. The `second`, `minute` and `hour` fields of the network variable are used to input the alarm time. The `date`, `month`, and `year` fields can be set to `0` to disable the alarm, or to any non-zero value to arm the alarm clock.

17. Still in **RealTimeKeeper.nc**, add the following code in bold:

```
#endif  //_HAS_INPUT_NV_

when (timer_expires(rtc_coretick)) {
    SNVT_time_stamp current;
    if (fblockNormalNotLockedOut(RealTimeKeeper::global_index)) {
        GizmoGetTime(&current);
        RealTimeKeeper::nvoTimeDate = current;

        switch(rtc_alarmstate ) {
            case   rtc_alarm_idle:
                // alarm is off
                break;
            case  rtc_alarm_armed:
                // waiting for alarm condition to occur
                if ((current.second
                    == RealTimeKeeper::nviAlarmTime.second)
                    && (current.minute
                    == RealTimeKeeper::nviAlarmTime.minute)
```

```
                    && (current.hour
                    == RealTimeKeeper::nviAlarmTime.hour) ) {
                    // raise alarm
                    rtc_alarmstate = rtc_alarm_alarm;
                    RealTimeKeeper::nviAlarmState.state
                        = SWITCH_ON;
                }
                break;
            case    rtc_alarm_alarm:
                // alarm currently visible/audible,
                // awaiting acknowledgement
                break;
        }
    }
    rtc_coretick
        = RealTimeKeeper::nvoTimeDate::cpRtcUpdRate * 100UL;
}

void RealTimeKeeperDirector(unsigned uFblockIndex, int iCommand)
```

This code controls timer processing.

18. Still in **RealTimeKeeper.nc**, add the following code in bold:

```
void RealTimeKeeperprocessNV(void)
{
    if (deviceState.nvIndex
        == nv_table_index(RealTimeKeeper::nviAlarmAck)) {
        // alarm acknowledgement:
        if (rtc_alarmstate == rtc_alarm_alarm) {
            rtc_alarmstate = rtc_alarm_armed;
            RealTimeKeeper::nvoAlarmState.state = SWITCH_OFF;
        }
    } else if (deviceState.nvIndex
        == nv_table_index(RealTimeKeeper::nviAlarmTime)) {
        // alarm spec:
        if ((RealTimeKeeper::nviAlarmTime.year == 0)
            && (RealTimeKeeper::nviAlarmTime.month == 0)
            && (RealTimeKeeper::nviAlarmTime.day == 0)) {
            // stop the nonsense!
            rtc_alarmstate = rtc_alarm_idle;
        } else {
            // start/restart the nonsense
            rtc_alarmstate = rtc_alarm_armed;
        }
    } else if (deviceState.nvIndex
        == nv_table_index(RealTimeKeeper::nviTimeSet)) {
        // set time:
        GizmoSetTime(&RealTimeKeeper::nviTimeSet);
    }
}

#endif  //_HAS_INPUT_NV_
```

This code processes input network variable updates to the network variable handler function. This can be implemented in a number of ways. The solution presented here minimizes the number of when statements and thereby limits the scheduler latency. This is at the expense of extra processing time when the event occurs, since the function has to find out what network variable generated the event.

Other ways to approach the problem would be processing both input network variables at all times (for example, whenever either one of them has been updated, or implementing one `when (nv_update_occurs(....))` step for each input network variable. To implement the latter solution, you would have to remove or comment out the Code Wizard start/end tags around the existing when statement. The following code shows how this would be implemented:

```
//--{{NodeBuilder Code Wizard Start
// disabled the above to prevent CodeWizard from re-generating
// the associated code
// the NodeBuilder Code Wizard will add and remove code here.
// DO NOT EDIT the NodeBuilder Code Wizard generated code in these blocks!
```

```
//<Input NV Define>
#ifdef _HAS_INP_NV_6
//
//<Fblock NV When>
when(nv_update_occurs(nviTimeSet)) {
if (fblockNormalNotLockedOut( fblock_index_map[nv_in_index]) )
{
        updateDeviceState(nv_in_index, nv_array_index,
            fblock_index_map[nv_in_index]);
        // TODO: process nviTimeSet event here
    }
}

when(nv_update_occurs(nviAlarmAck))
//
//--}}NodeBuilder Code Wizard End
// disabled the above to prevent CodeWizard from re-generating
// associated code
{

    if (fblockNormalNotLockedOut(fblock_index_map[nv_in_index]) ) {
        updateDeviceState(nv_in_index, nv_array_index,
            fblock_index_map[nv_in_index]);
        // TODO: process nviAlarmAck event here
    }
}
```

19. Still in **RealTimeKeeper.nc**, add the following code in bold to the `FBC_WHEN_RESET` else-if clause in the `realtimekeeperdirector()` function:

```
else if ((TFblock_command)iCommand == FBC_WHEN_RESET)
            rtc_coretick = nvoTimeDate::cpRtcUpdRate * 100UL;
            if (rtc_alarmstate == rtc_alarm_alarm) {
                RealTimeKeeper::nviAlarmState.state
                    = SWITCH_ON;
            }
            setLockedOutBit(uFblockIndex, FALSE);
```

20. Build the development target. To do this, right click the **Development** target, and then click **Build** on the shortcut menu. The LonMaker tool automatically loads the new application into the device hardware.

21. Add the new functional block and network variables to the LonMaker drawing and use the LonMaker tool and LonMaker Browser to verify correct operation.

Step 9: Implementing the Wheel Input

You can complete the device application by implementing an open loop sensor where the principal network variable reports the status of the quadrature hardware input. In this step, you will use a more comprehensive implementation of a functional profile by supporting more of the functional profile's optional features. To perform this step, follow these steps:

1. Click the NodeBuilder tool Taskbar button in the Taskbar to return to the NodeBuilder tool. Right-click the device template and select **Code Wizard** from the shortcut menu. The Code Wizard opens.

2. Right-click the device template's **Functional Blocks** folder and select **Add Functional Block** from the shortcut menu. The **Add Functional Block** dialog appears.

3. Add a single **SFPTopenLoopSensor** functional block. Name the new functional block **Wheel**. Click **OK**.

4. When prompted, indicate that you do not want to create the new functional block as part of an array.

5. Open the **Wheel** functional block's **Mandatory NVs** folder. Right-click the **nvoValue** network variable and select **Properties** from the shortcut menu. The **NV Properties** dialog opens.
6. Set **NV Type** to **SNVT_lev_percent** and **Name** to **nvoWheel**.
7. Right-click the **Wheel** functional block's **Optional CPs** folder and select **Implement Optional CP** from the shortcut menu. The **Implement Optional CP** dialog appears.
8. Implement the **nciGain** configuration property. Name the new configuration property **cpWhGain**. Set **Initializer** to **{1,1}**. This configuration property holds the gain value between the physical input and the **nvoWheel** network variable.
9. Right-click the **Wheel** functional block's **Optional CPs** folder and select **Implement Optional CP** from the shortcut menu. The **Implement Optional CP** dialog appears.
10. Implement the **nciLocation** configuration property. Name the new configuration property **cpWhLocation**. This configuration property holds the location of the sensor device.
11. Right-click the **Wheel** functional block's **Optional CPs** folder and select **Implement Optional CP** from the shortcut menu. The **Implement Optional CP** dialog to appears.
12. Implement the **nciOverBehave** configuration property. Name the new configuration property **cpWhOvrBehave**. Set the **Initial Value** field to **OV_RETAIN**. This configuration property determines the override behavior of the device. See the *LONMARK SNVT and SCPT Master List* for more information about the **SCPTovrBehave** configuration property.
13. Right-click the **Wheel** functional block's **Optional CPs** folder and select **Implement Optional CP** from the shortcut menu. The **Implement Optional CP** dialog appears.
14. Implement the **nciOvrValue** configuration property. Name the new configuration property **cpWhOvrValue**.. This configuration property determines the override value of the device. See the `SCPTovrValue` configuration property in the LONMARK *SNVT and SCPT Master List* for more information.
15. Right-click the **Wheel** functional block's **Optional CPs** folder and select **Implement Optional CP** from the shortcut menu. The **Implement Optional CP** dialog appears
16. Implement the **nciMaxSendT** configuration property. Name the new configuration property **cpWhMaxSendT**. Set **Initializer** to **{0,0,0,0,0}**. This configuration property determines the maximum time between network variable updates for the functional block (the heartbeat).
17. Right-click the **Wheel** functional block's **Optional CPs** folder and select **Implement Optional CP** from the shortcut menu. The **Implement Optional CP** dialog appears.
18. Implement the **nciMinSendT** configuration property. Name the new configuration property **cpWhMinSendT** and set **Initializer** to **{0,0,0,0,0}**. This configuration property determines the minimum time between network variable updates for the functional block (the throttle).
19. Right-click the **Wheel** functional block's **Optional CPs** folder and select **Implement Optional CP** from the shortcut menu. The **Implement Optional CP** dialog appears.
20. Implement the **nciOverValue** configuration property. Name the new configuration property **cpWhOvrValue**. This configuration property determines the override value for the **nvoWheel** network variable.
21. Click **Generate and Close**.
22. Open the **Wheel.nc** file from the Source Files folder. Add the `Cp2Tick()` utility function and a when statement to handle I/O processing as shown below:

```
unsigned long Cp2Tick (const SNVT_elapsed_tm *const pSnvt) {
    unsigned long ulResult;
    ulResult = ((pSnvt->minute * 60UL) + pSnvt->second)
        * (1000UL/WHEEL_HBCORE)
        + (pSnvt->millisecond / WHEEL_HBCORE);
    return ulResult;
```

```
}

priority when (io_changes(ioWheel)) {
    if (fblockNormalNotLockedOut( Wheel::global_index)) {
        if (Wheel::cpWhGain.divisor) {
            // No division by zero.  Use gain factor and send new
            // incremental value to heartbeat/throttle handler
            WheelIncrValue(muldivs(input_value,
                Wheel::cpWhGain.multiplier,
                Wheel::cpWhGain.divisor));
        }
    }
}
```

The `Cp2Tick()` function converts a **SNVT_elapsed_tm** value into a tick count (a tick occurs each `WHEEL_HBCORE` milliseconds). It uses the **seconds**, **milliseconds**, and **minutes** fields of the **SNVT_elapsed_tm** value but ignores the **hours** and **days** fields. The function is only used in conjunction with heartbeat and throttle intervals, which typically do not have values as large as an hour, and therefore this partial implementation is used for performance reasons.

A priority *when*-task is used due to the nature of this physical input, which is to provide an incremental reading. You should normally avoid the use of priority statements except for critical processing. This *when*-task is critical since this function must not miss any hardware events as they occur.

23. Open the **wheel.h** file from the **Source Files** folder, and then add the following declarations for heartbeat/throttle handling:

```
#ifndef USE_QUADRATURE
#error  "You must enable the use of quadrature input in the gizmo4.h header
file!"
#endif

#define WHEEL_HBCORE   100L    // heartbeat/throttle timer ticks
                                   //with 100ms period

mtimer repeating WheelTimer = WHEEL_HBCORE;

long lWheelValue = 0L;    // last known real value,
                              //see the .nc file for details on
                              // heartbeat/throttle implementation
long lWheelPhysical = 0L; // same as lWheelValue,
                              // but limited to data coming from
                              // physical sensor.  See .nc file for
                              // details on override and rmv_override
unsigned long ulMinSendT = 0L;    // number of WHEEL_HBCORE ticks
                                      // expired on cpMinSendT
unsigned long ulMaxSendT = 0L;    // number of WHEEL_HBCORE ticks
                                      // expired on cpMaxSendT

// forward declaration:
void WheelIncrValue (long Value);
```

24. Open the **`wheel.nc`** file from the **Source Files** folder and add the following function to handle the network variable throttle:

```
void WheelIncrValue (long Value) {
    // maintain internal mirror of most recent value - remember the
    // quadrature input provides incremental data.  We cannot lose
    // a single signal update.
    lWheelValue += Value;

    // also maintain a copy of the last known value coming from the
    // physical sensor (as opposed to override values).  This data
    // is used when leaving override mode, see director function
    // for more details.
    lWheelPhysical = lWheelValue;
```

```
        // Manage the throttle preferences.  Note the throttle tick
        // counter is maintained by the WheelTimer routine.
        if (ulMinSendT >= Cp2Tick(&Wheel::nvoValue::cpWhMinSendT)) {
            ulMinSendT = 0;
            ulMaxSendT = 0;
            nvoWheel = lWheelValue;
        }
    }
```

25. Still in **wheel.nc**, add the following function to handle the network variable heartbeat:

```
    when (timer_expires(WheelTimer)) {
        // update throttle timer:
        if (ulMinSendT < Cp2Tick(&Wheel::nvoValue::cpWhMinSendT)) {
            ++ulMinSendT;
        }

        // manage heartbeats:
        if (ulMaxSendT < Cp2Tick(&Wheel::nvoValue::cpWhMaxSendT)) {
            ++ulMaxSendT;
        } else {
            // propagate the latest value.  Note that we should not use
            // the propagate() function here, as propagate() would only
            // re-propagate the last NV value.  There could have been
            // value updates internally since then, which have not made
            // it into the NV value due to the throttle.  We do
            // therefore use an internal mirror of the truly most
            // recent value:
            Wheel::nvoValue = lWheelValue;
            ulMaxSendT = 0L;
        }
    }
```

26. Still in **wheel.nc**, implement the override behavior by adding the following code in bold to the `wheelDirector()` function's `FBC_OVERRIDE` else/if statement:

```
    else if ((TFblock_command)iCommand == FBC_OVERRIDE)
            setFblockOverride( uFblockIndex, TRUE );
            switch (Wheel::cpWhOvrBehave) {
                case OV_RETAIN:    // do nothing, keep last value
                    break;
                case OV_SPECIFIED:
                    // override with specified override value.  We
                    // still must honor heartbeats, but we must
                    // switch to override value immediately
                    // (ignoring throttle preferences)
                    nvoWheel = lWheelValue =
                        Wheel::nvoValue::cpWhOvrValue;
                    break;
                case OV_DEFAULT:
                    // override with sensor-specific default value
                    // (zero).  We must continue to honour
                    // heartbeats, but we must switch to override
                    // value immediately (ignoring throttle
                    // preferences)
                    nvoWheel = lWheelValue = 0L;
                    ulMinSendT = ulMaxSendT = 0L;
                    break;
            }
```

27. Complete the implementation of the override behavior by adding the following code in bold to the `wheelDirector()` function's `FBC_RMV_OVERRIDE` else-if statement:

```
    else if ((TFblock_command)iCommand == FBC_RMV_OVERRIDE)
            setFblockOverride(uFblockIndex, FALSE);
            nvoWheel = lWheelValue = lWheelPhysical;
            // ignore throttle but re-start heartbeat:
            ulMinSendT = ulMaxSendT = 0L;
```

This code updates the output network variable with recent physical data to wipe out the override value. This implementation ignores any value updates received during the override period, but re-sets the output to the last known value when the device entered the override state. This allows the device to be set into override while the sensor unit is replaced or while diagnosing the network. The interpretation of correct override behavior is device-dependent and subject to the device implementation. Different, but equally acceptable implementations would be to await new readings from the sensor, or to save value changes during the override state.

28. Build the development target. To do this, right click the **Development** target, and then click **Build** on the shortcut menu. The LonMaker tool automatically loads the new application into the device hardware.

29. Add the new functional block and network variables to the LonMaker drawing and use the LonMaker tool and LonMaker Browser to verify correct operation.

Continuing with the NodeBuilder Example

You have completed the implementation of the Neuron C portion of the example development project. See the *LNS Plug-in Programmer's Guide* for more information on creating a plug-in for this example device.

For additional practice with the NodeBuilder tool, you could improve the Neuron C application by doing the following:

- Implement override features, self-test features, and many of the traffic-control configuration properties (heartbeat, throttle, and heartbeat control on the input side) in the functional profiles. These features were not implemented in this exercise in order to keep it simple.
- Implement a **UFPTdisplay** functional profile. This functional block would display data received from input network variables in a configurable manner.
- Implement a more generic translator object using changeable-type input and output network variables. See the *Neuron C Programmer's Guide* for more details.

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