Getting Started with the LabVIEW™ Embedded Module for ARM Microcontrollers 1.0

For the Luminary Micro EK-LM3S8962

The LabVIEW Embedded Module for ARM Microcontrollers is a comprehensive graphical development environment for embedded design. Jointly developed by Keil–An ARM Company and National Instruments, this module seamlessly integrates the LabVIEW graphical development environment and ARM microcontrollers. You can lower development costs and achieve faster development times by using the Embedded Module for ARM Microcontrollers to program ARM targets.

This module builds on NI LabVIEW Embedded technology, which facilitates dataflow graphical programming for embedded systems and includes hundreds of analysis and signal processing functions, integrated I/O, and an interactive debugging interface. With the Embedded Module for ARM Microcontrollers, you can optimize linking and view live front panel updates using JTAG, serial, or TCP/IP. The Embedded Module for ARM Microcontrollers includes the LabVIEW C Code Generator, which generates C code from the LabVIEW block diagram.

This manual includes system requirements, installation instructions, and a step-by-step tutorial that shows you how to build, run, and debug an ARM application.

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Features

The Embedded Module for ARM Microcontrollers includes the following features:

- **RealView Microcontroller Development Kit**—Includes the Keil µVision3 integrated development environment (IDE) and debugger, as well as the ARM RealView Compilation Tools.
- **Elemental I/O support**—Takes advantage of the Elemental I/O framework to access analog input, analog output, digital I/O, and PWM abilities on the ARM target.
- **VI-level C code generation options**—Allow you to set code generations options for individual VIs.
- **Expression folding**—Generates better-performing and more efficient code by collapsing groups of nodes into single expressions that C compilers easily recognize.

Refer to the *LabVIEW Help*, available by selecting **Help»Search the LabVIEW Help** in LabVIEW, for more information about using the Embedded Module for ARM Microcontrollers.

System Requirements

The Embedded Module for ARM Microcontrollers has the following requirements:

- A desktop computer with Windows Vista/XP/2000
- RealView Microcontroller Development Kit including Keil µVision3
- LabVIEW 8.5.1 with embedded support
- Keil ULINK2 USB-JTAG adaptor

Refer to the *LabVIEW Release Notes*, available by selecting **Start» All Programs»National Instruments»LabVIEW»LabVIEW Manuals** and opening `LV_Release_Notes.pdf`, for information about LabVIEW development system requirements.

Installing the Embedded Module for ARM Microcontrollers

The Embedded Module for ARM Microcontrollers installer includes LabVIEW 8.5.1 with embedded support. If you have LabVIEW 8.5.*x* already installed, you can install LabVIEW with embedded support without first uninstalling LabVIEW 8.5.*x*. However, you must install the RealView Microcontroller Development Kit before you install the Embedded Module for ARM Microcontrollers.

Complete the following steps to install the RealView Microcontroller Development Kit and the Embedded Module for ARM Microcontrollers.

1. Log in as an administrator or as a user with administrator privileges.
2. Insert the LabVIEW Embedded Module for ARM Microcontrollers installation DVD and select to install the RealView Microcontroller Development Kit.

Tip If the installer does not automatically begin, double-click `MDK_LV.exe` on the DVD to begin installation of the RealView Microcontroller Development Kit.

3. Follow the instructions on the screen for installing the RealView Microcontroller Development Kit.
4. Activate the Keil µVision License ID Code (LIC). Complete the following steps to activate the LIC.
    a. Launch Keil µVision by selecting **Start»All Programs»Keil uVision3**.
    b. Select **File»License Management** to display the **License Management** dialog box.
    c. Click the **Help** button to open the *ARM Development Tools* help file.
    d. Follow the instructions for obtaining a single-user license. You need an internet connection and a product serial number (PSN) to activate the license. The PSN is an alphanumeric value located on the Certificate of Ownership or license card included with purchased products.
    e. After you add the LIC to the **License Management** dialog box, click the **Close** button to close the dialog box.
    f. Exit Keil µVision before installing the Embedded Module for ARM Microcontrollers.

    Refer to the Keil Web site at `www.keil.com/license` for more information about activating Keil µVision.

5. If the installer welcome screen is still visible, select to install the Embedded Module for ARM Microcontrollers. If the installer welcome screen is not visible, double-click `setup.exe` on the DVD to begin installation of the Embedded Module for ARM Microcontrollers.
6. Follow the instructions on the screen for installing the Embedded Module for ARM Microcontrollers. The installation DVD installs both LabVIEW with embedded support and the Embedded Module for ARM Microcontrollers.

   (Luminary Micro EK-LM3S8962) On the **Features** page of the installer, select to install the **Luminary Micro Driver for EK-LM3S8962** to install the drivers for the Luminary Micro evaluation board. A **Software Installation** alert might appear during the driver installation. Click the **Continue Anyway** button to continue with the installation.
7. Follow the activation instructions that appear on the screen.

   You also can use the NI License Manager, available by selecting **Start»All Programs»National Instruments»NI License Manager**, to activate National Instruments products. Refer to the *National Instruments License Manager Help*, available by selecting **Help»Contents** in the NI License Manager, for more information about activating NI products.
8. Restart the computer when the installer prompts you and log in as an administrator or as a user with administrator privileges.

Installing the LM3S8962 Evaluation Board

You need the following items to use the LM3S8962 evaluation board with JTAG emulation.

- LM3S8962 evaluation board
- An IBM-compatible PC with two unused USB ports: one to supply power to the board and the other to perform ULINK2 USB-JTAG downloading and debugging
- ULINK2 USB-JTAG adaptor
- Two USB serial cables, each no longer than 10 feet

Refer to the hardware documentation for required accessories such as cables and adaptors.

Caution Be careful when removing the board from the package and handling the board to avoid the discharge of static electricity, which might damage some components.

Complete the following steps to install the LM3S8962 board. You do not have to open the computer case to install the board.

1. Verify that you have Keil µVision3 installed. µVision is a part of the RealView Microcontroller Development Kit.

   You can look for the `Keil\uv3` directory on the hard disk or select **Start»All Programs** and locate the shortcut to Keil µVision3. Do not launch µVision3 from the shortcut if you are going to use LabVIEW.

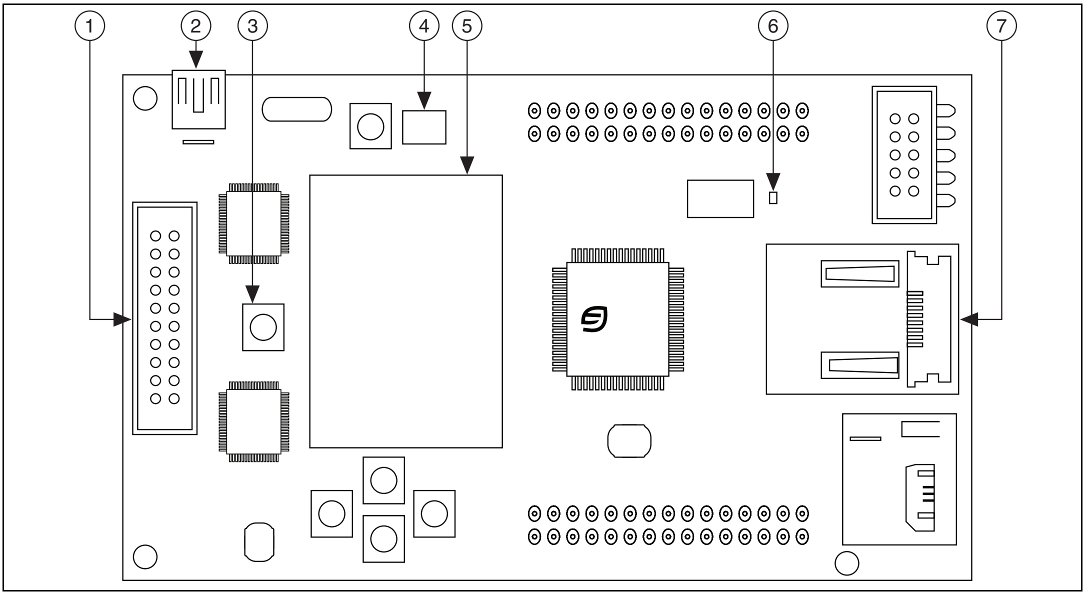
   Refer to the *Installing the Embedded Module for ARM Microcontrollers* section for information about installing the RealView Microcontroller Development Kit.

2. Connect the ULINK2 USB-JTAG adaptor to a USB port on the host computer.

   If this is the first time connecting the ULINK2 USB-JTAG adaptor to the computer, the connection activates the Windows Found New Hardware icon in Windows. A Windows message notifies you when the new device is ready for use and the hardware installation is complete.

3. Connect the ULINK2 USB-JTAG adaptor to the JTAG connector on the LM3S8962 board.

   Figure 1 shows the location of the JTAG connector and other parts on the LM3S8962 evaluation board.



1 JTAG connector	4 Speaker	6 Power LED
2 USB connector	5 Organic LED display	7 Ethernet connector
3 Reset button		

Figure 1. Locating Parts on the LM3S8962 Evaluation Board

4. Connect the USB connector on the LM3S8962 board to a USB port on the host computer.

   This USB connection provides power to the LM3S8962 board. The USB is capable of sourcing up to 500 mA for each attached device, which is sufficient for the evaluation board. On the board, the power LED illuminates.

Note The LM3S8962 board remembers the last program that ran because you must program the flash memory on the board to run an application. Therefore, the LM3S8962 board begins running the last application as soon as the board receives power. You must download a new application to change the start-up behavior of the board.

5. Install the three drivers for the LM3S8962 evaluation board when the **Found New Hardware Wizard** prompts you.
   a. In the **Found New Hardware Wizard** welcome page, select **No, not this time** so that Windows does not connect to Windows Update to search for the software.
   b. Click the **Next** button.
   c. Select **Install the software automatically (Recommended)**. If you did not install the Luminary Micro drivers during the software installation, you must insert the installation DVD before the wizard begins to scan the hard drive.
   d. Click the **Next** button.
   e. Click the **Continue Anyway** button when the **Hardware Installation** alert window opens.
   f. Click the **Finish** button when Windows finishes installing the driver.
   g. Repeat steps a through f to install the other two drivers.

Note The Luminary Micro drivers create a virtual serial port over the USB connection. If you unplug the evaluation board and then plug the evaluation board into another USB port on the host, the Luminary Micro drivers create additional virtual COM ports.

Refer to the *Stellaris LM3S8962 Evaluation Board User's Manual*, available at the Luminary Micro Web site, `www.luminarymicro.com`, for more detailed information about the LM3S8962 evaluation board.

Tutorial for the Embedded Module for ARM Microcontrollers

Use this tutorial to learn how to build, run, and debug an application for the ARM target.

Creating the LabVIEW Project

Use LabVIEW projects to group together LabVIEW files and non-LabVIEW files, create build specifications for building ARM VIs into ARM applications, and run the applications on ARM targets. You must use a project to build ARM VIs into ARM applications.

LabVIEW project files have a `.lvproj` file extension. Project files contain target-specific build options and other information necessary for the LabVIEW C Code Generator to generate C code from the VIs.

Complete the following steps to create a project with an EK-LM3S8962 target and a blank VI.

1. Launch LabVIEW.
2. Select **ARM Project** from the **Targets** pull-down menu in the **Getting Started** window.
3. Click the **Go** button to display the **Create New ARM Project** wizard.
4. Select **New ARM project, blank VI** in the **Project type** pull-down menu.
5. Click the **Next** button to display the **Select ARM target type** page.
6. Select **EK-LM3S8962** from the **Target type** pull-down menu.
7. Click the **Next** button to display the **System preview** page.
8. Verify the **Create a build specification** checkbox contains a checkmark.
9. (Optional) Place a checkmark in the **Run on simulator** checkbox if you want to use the µVision simulator instead of the ARM evaluation board to run the application.
10. Click the **Finish** button.
11. Click the **Save** button when LabVIEW prompts you to save the project.
12. Click the **Yes** button when LabVIEW prompts you to save the new files in the project.
13. Save the project as `Tutorial.lvproj` when LabVIEW prompts you.
14. Save the ARM VI as `Tutorial.vi`.
15. (Optional) Save the simulated I/O VI as `Simulated IO` if you chose to use the µVision simulator in step 9.

The project now appears in the **Project Explorer** window.

16. Expand the EK-LM3S8962 target in the **Project Explorer** window. LabVIEW automatically adds **Dependencies** under the target. SubVIs appear under **Dependencies** when you add a VI that contains subVIs to a project.
17. Expand the **Build Specifications** section under the EK-LM3S8962 target in the **Project Explorer** window. The wizard labels the build specification **Application**.
18. Rename the build specification to `Debug Build`. Complete the following steps to rename the build specification.
    a. Right-click **Application** and select **Rename** from the shortcut menu.
    b. Enter `Debug Build` and press the <Enter> key.

Tip Most users create a debug and a release build specification for a project. For example, if you create a build specification with debug options, you can change the name to Debug Build. If you create a build specification with release options, you can change the name to Release Build. Refer to the *Editing the EK-LM3S8962 Build Specification* section for more information about using build specifications.

Creating the Front Panel

The front panel is the user interface for a VI. You can use the front panel as a debugging interface for ARM applications you create with LabVIEW. In this tutorial you create a VI with an LED indicator that lights on the front panel if the input exceeds a threshold value you define.

Complete the following steps to create the front panel for this tutorial.

1. Add the following controls to the front panel window of the Tutorial VI:
    - Two numeric controls, located on the **Numeric** palette.
    - One numeric indicator, located on the **Numeric** palette.
    - One round LED, located on the **Boolean** palette.

Tip If you cannot find the object you want, click the **Search** button on the **Controls** palette toolbar. Type the name of the object for which you want to search. LabVIEW searches as you type and displays any matches in the search results text box.

2. Rename the controls by double-clicking the labels and entering new names.
    - Rename one of the numeric controls to **input**.
    - Rename the other numeric control to **threshold**.

- Rename the numeric indicator to **output**.
- Rename the round LED to **threshold exceeded?**.

Tip Double-click to select a single word in a label. Triple-click to select the entire label.

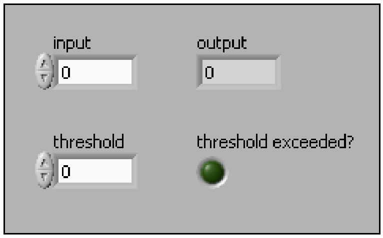


Figure 2. Changing the Labels

Creating the Block Diagram

The block diagram is the source code for a VI and contains a pictorial description or representation of an application. Wires carry data between the objects, or nodes, on the block diagram. The controls and indicators you added in the *Creating the Front Panel* section appear as terminals on the block diagram.

Complete the following steps to build a block diagram that multiplies an input value by 2 and then lights an LED if the product is greater than the threshold value you specify.

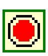
1. Switch to the block diagram by clicking the block diagram if it is visible or selecting **Window»Show Block Diagram**.

Tip You also can switch to the block diagram by pressing the <Ctrl-E> keys.

2. Select **Help»Show Context Help** to display the **Context Help** window. The **Context Help** window displays basic information about LabVIEW objects when you move the cursor over each object.

Tip You also can press the <Ctrl-H> keys to open and close the **Context Help** window.

3. Place a While Loop, located on the **Structures** palette, around the controls and indicator on the block diagram. While Loops repeat the inner subdiagram until the conditional terminal receives a particular Boolean value.



4. Right-click the conditional terminal, shown at left, in the lower right corner of the While Loop and select **Create Constant** from the shortcut menu. The default Boolean constant in the While Loop is FALSE.

5. Place a Multiply function, located on the **Numeric** palette, on the block diagram inside the While Loop.
6. Wire the **input** control to the **x** input of the Multiply function.
7. Right-click the **y** input of the Multiply function and select **Create»Constant** from the shortcut menu.
8. Enter `2` to multiply the value of the **input** control by two.
9. Place a Greater? function, located on the **Comparison** palette, on the block diagram.
10. Wire the **x*y** output of the Multiply function to the **x** input of the Greater? function.
11. Wire the **threshold** control to the **y** input of the Greater? function.
12. Wire the **x > y?** output of the Greater? function to the **threshold exceeded** indicator.
13. Wire the **output** indicator to the wire connecting the Multiply function and the Greater? function.
14. Place a Wait Until Next ms Multiple function, located on the **Time, Dialog & Error** palette, inside the While Loop.
15. Right-click the **millisecond multiple** input and select **Create»Constant** from the shortcut menu.
16. Enter `100` to wait 100 milliseconds between loop iterations.

    The block diagram should appear similar to Figure 3.

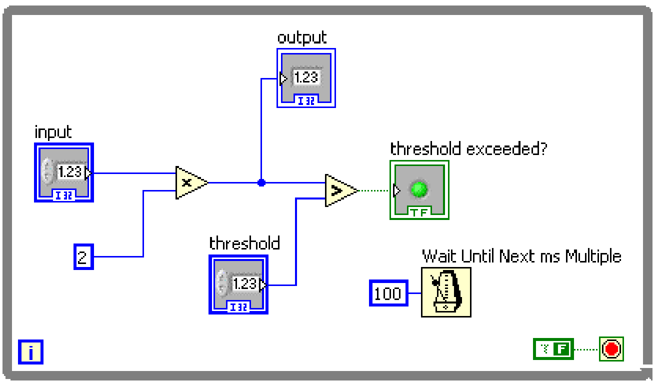


Figure 3. Creating the Block Diagram

17. Save the VI.

Editing the EK-LM3S8962 Build Specification

Use build specifications to specify how the LabVIEW C Code Generator generates C code and how to build the ARM VI into an application.

You can have multiple build specifications for the same target. For example, you might want one build specification that generates debugging information and another build specification that does not generate this extra information.

Complete the following steps to create a build specification for this tutorial.

1. Right-click the **Debug Build** build specification in the **Project Explorer** window and select **Properties** from the shortcut menu to display the **Build Specification Properties** dialog box.
2. Select the **Application Information** category, if necessary.

Tip You can click the **Help** button in any dialog box to open the *LabVIEW Help* and read descriptions of the available settings.

3. Verify that the **Enable debugging** checkbox contains a checkmark.
4. Select **Run on target using ULINK2** in the **Debug Options** section to run the application on the target, or select **Run on host computer using simulator** to run the application on the host computer.

5. Select the **Source Files** category and verify that **Tutorial.vi** is in the **Top-level VI** text box. Click the blue right arrow button, shown at left, to move a VI from the source files list to the **Top-level VI** text box.

   When the ARM project contains other files, such as `.c` and `.lib` files, you can add these files to the list of files to build into the application on the **Source Files** page.
6. Click the **OK** button to close the dialog box.
7. Select **File»Save All** in the **Project Explorer** window to save the build specification with the project.

Building and Running the ARM Application

After you develop the ARM VI on the host computer, you build the ARM VI into an application you can run on an ARM target. When you build an ARM application, the LabVIEW C Code Generator generates C code from the LabVIEW block diagram using the settings you configure.

Complete the following steps to build and run an ARM application.

1. Right-click **Debug Build** in the **Project Explorer** window and select **Build** from the shortcut menu to build the ARM VI into an application. LabVIEW displays the status of the building and linking process.

Note You must activate the Keil µVision License ID Code (LIC) before you can build an ARM application with LabVIEW. If the LIC is not activated, you receive an error when you try to build the application. Refer to the *Activating the Keil µVision License ID Code Readme*, available by selecting **Start»All Programs»National Instruments» LabVIEW»Readme** and opening `readme_ARM_uVision_Licensing.html`, for information about activating the LIC.

2. Right-click **Debug Build** again and select **Debug** from the shortcut menu to download the application to the ARM target and run the application with front panel updates. The application automatically runs on the ARM target when you select **Debug** from the shortcut menu.

Note Click the **OK** button if a dialog box appears notifying you about an updated µVision template.

3. Enter a value in the **threshold** numeric control of the Tutorial VI on the host computer.
4. Enter different values in the **input** numeric control. In Figure 4, the **output** value on the left does not exceed the **threshold** value. If you change the **input** value so that the **output** value is greater than the **threshold** value, the **threshold exceeded?** LED lights.

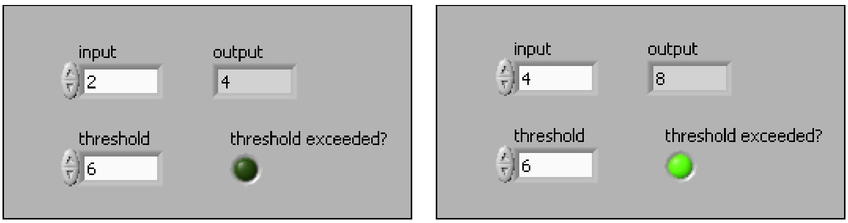
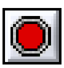


Figure 4. LED Lights when Output Exceeds Threshold

Tip LabVIEW uses default values for controls and indicators when building an ARM VI into an ARM application. To change the initial values, enter the new values in the front panel controls and then select **Edit»Make Current Values Default** to change the initial values. You must rebuild the ARM application after you change the initial values of the controls.

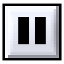


5. Click the **Abort Execution** button, shown at left, to stop the ARM application.

Debugging with Breakpoints and Probes

Complete the following steps to debug the ARM tutorial application with breakpoints and probes.

1. Switch to the block diagram if it is not visible.
2. Right-click the Multiply function and select **Set Breakpoint** from the shortcut menu. The breakpoint is highlighted with a red border around the function. This breakpoint specifies to pause execution just before the function executes. If you are using JTAG for debugging, LabVIEW might prompt you to halt the processor.
3. Right-click **Debug Build** in the **Project Explorer** window and select **Debug** from the shortcut menu. LabVIEW prompts you to save changes to the VI. LabVIEW also prompts you if you need to rebuild or redownload the ARM application to the ARM target.



The ARM tutorial application begins running on the ARM target. When the application reaches the breakpoint during execution, the ARM target halts all operation, the application pauses, and the **Pause** button, shown at left, appears red and changes to a **Continue** button.

4. Add probes to see the values on the wires coming into the Multiply function.
   a. Click the wire coming into the **x** input.
   b. Click the wire coming into the **y** input.

   A floating **Probe** window appears after you create each probe. LabVIEW numbers the **Probe** windows automatically and displays the same number in a glyph on the wire you click.

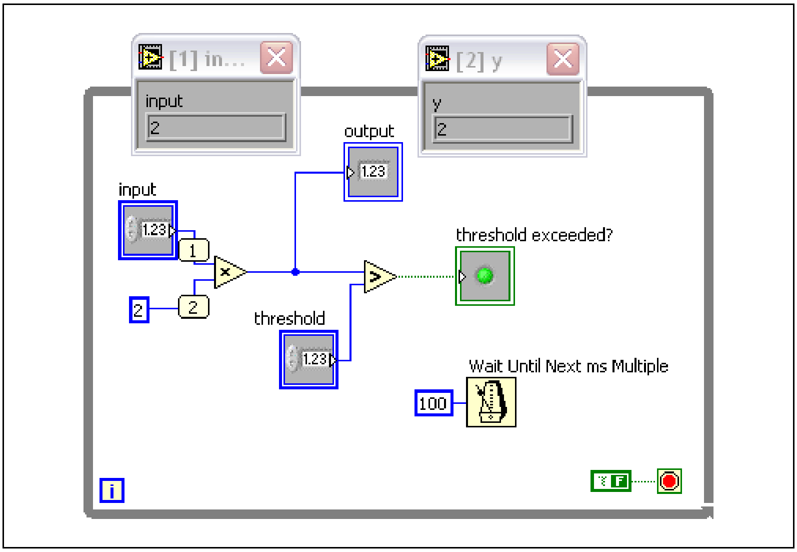


Figure 5. Creating Probes

5. Enter a different value in the **input** numeric control.

6. Click the **Continue** button, shown at left, and enter different values in the **input** numeric control to see the value in the first **Probe** window change as the ARM application executes additional iterations of the While Loop.

7. Click the **Step Over** button, shown at left, to execute the Multiply function and pause at the Greater? function, which blinks when it is ready to execute.
8. Continue clicking the **Step Over** button to step through the rest of the block diagram.
9. Click the **Abort Execution** button to stop the application.
10. Right-click the Multiply function and select **Clear Breakpoint** from the shortcut menu to remove the breakpoint.

Using Elemental I/O

Elemental I/O resources are fixed elements of ARM targets that you use to transfer data among the different parts of the target. Each Elemental I/O resource has a specific type, such as digital, analog, or PWM. For example, you can use digital Elemental I/O resources to manipulate the LED on the ARM target. Refer to the *LabVIEW Help* for more information about using Elemental I/O with ARM targets.

The following sections describe how to use Elemental I/O to light an LED on the ARM target when the threshold is exceeded.

Adding Elemental I/O Items to the Project

You must add Elemental I/O items to the project before you can use Elemental I/O in an ARM VI. Complete the following steps to add Elemental I/O items to the project.

1. Right-click **EK-LM3S8962** in the **Project Explorer** window and select **New»Elemental I/O** from the shortcut menu to display the **New Elemental I/O** dialog box.
2. Expand **Digital Output** in the **Available Resources** tree.
3. Click LED1.
4. Click the **Add** button to add LED1 to the **New Elemental I/O** list.
5. Click the **OK** button to add the Elemental I/O item to the LabVIEW project.

Using Elemental I/O on the Block Diagram

You can use Elemental I/O on the block diagram after you add Elemental I/O items to the project. Complete the following steps to use Elemental I/O on the block diagram of the ARM VI to light the LED on the target.

1. Drag LED1 from the **Project Explorer** window to the block diagram above the **threshold exceeded?** indicator.
2. Wire the **x > y?** output of the Greater? function to the LED1 item in the Elemental I/O Node.

   Refer to the *Using Elemental I/O Nodes* topic in the *LabVIEW Help* for more information about using Elemental I/O Nodes.

Building and Running the Application with Elemental I/O

Note Before you can see the LED light up on the target, verify that LabVIEW is downloading to the target and not to the simulator. In the **Build Specification Properties** dialog box, select **Run on target using ULINK2** in the **Debug Options** section of the **Application Information** page to specify the target and not the simulator.

Complete the following steps to run the ARM application with Elemental I/O.

1. Click the **Run** button. When you click the **Run** button, LabVIEW prompts you if you need to rebuild the embedded application.
2. Click the **Save** button when LabVIEW prompts you to save the VI.
3. Click the **Yes** button when LabVIEW prompts you to rebuild the embedded application.
4. Enter different values in the **input** numeric control until the **threshold exceeded?** indicator lights on the front panel. When the **threshold exceeded?** indicator lights, LED1 on the ARM target also lights.
5. Click the **Abort Execution** button to stop the ARM application.

Where to Go from Here

National Instruments provides many resources to help you succeed with your NI products. Use the following related documentation as you continue exploring LabVIEW and the Embedded Module for ARM Microcontrollers.

- *LabVIEW Help*, available by selecting **Help»Search the LabVIEW Help** in LabVIEW, provides information about LabVIEW programming, step-by-step instructions for using LabVIEW, and reference information about LabVIEW VIs, functions, palettes, menus, and tools. Refer to the **Embedded Module for ARM Microcontrollers** book on the **Contents** tab of the *LabVIEW Help* for information specific to the Embedded Module for ARM Microcontrollers and the applications you create.
- Context help provides brief descriptions of VIs and functions with a link to the complete reference for a VI or function. Select **Help» Show Context Help** to display the **Context Help** window.
- Examples, available in the `labview\examples\lvemb\ARM` directory, can help you get started creating applications.
- The readme file, available by selecting **Start»All Programs»National Instruments»LabVIEW»Readme** and opening `readme_ARM.html`, contains known issues and last-minute information.
- *Getting Started with LabVIEW* manual, available by selecting **Start»All Programs»National Instruments»LabVIEW» LabVIEW Manuals** and opening `LV_Getting_Started.pdf`, provides information about the LabVIEW graphical programming environment and the basic LabVIEW features you use to build data acquisition and instrument control applications.

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