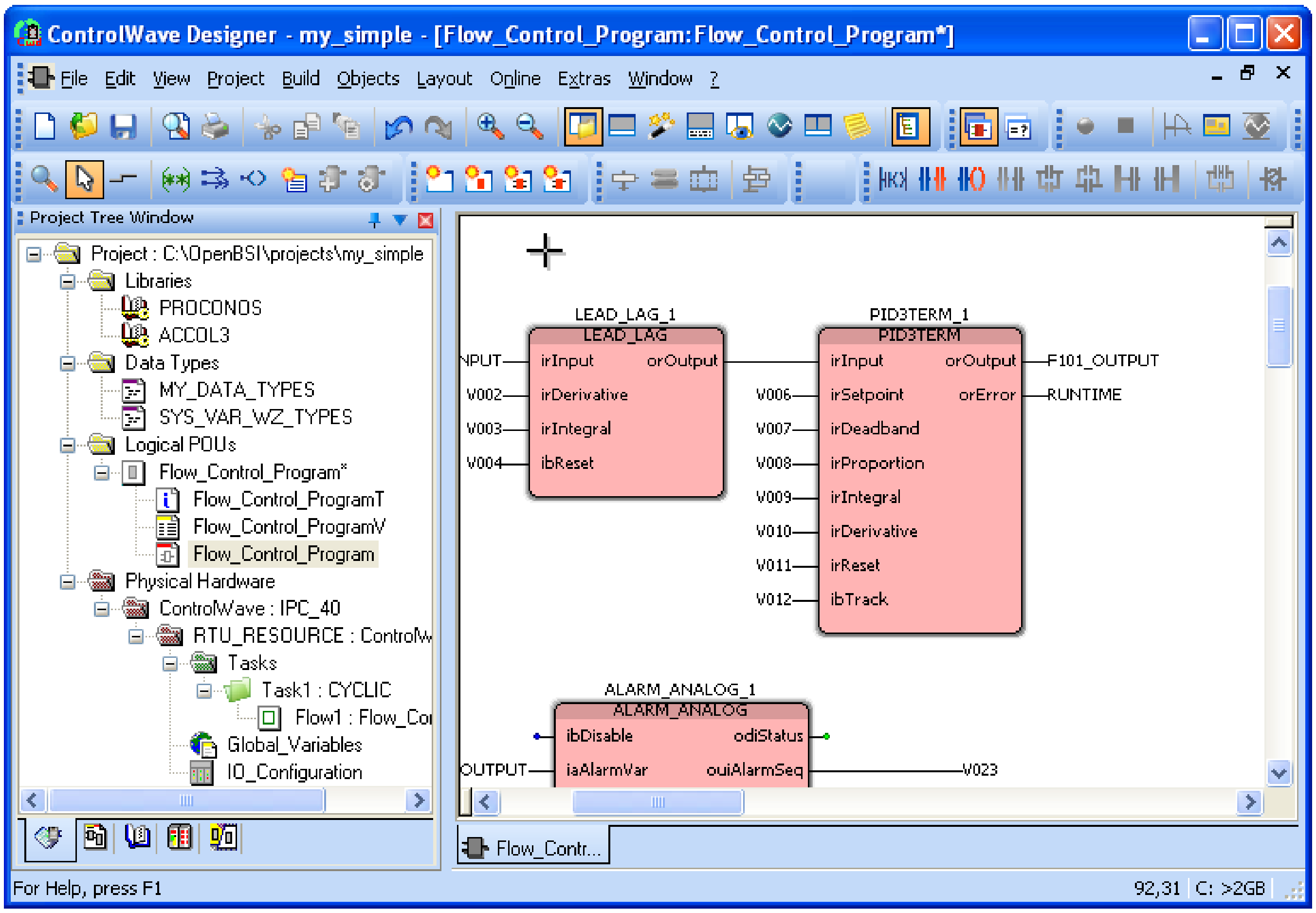
**User Manual**
Document: D5085
Part: D301416X012
May, 2010

# Getting Started with ControlWave Designer



EMERSON Process Management

## IMPORTANT! READ INSTRUCTIONS BEFORE STARTING!

Be sure that these instructions are carefully read and understood before any operation is attempted. Improper use of this device in some applications may result in damage or injury. The user is urged to keep this book filed in a convenient location for future reference.

These instructions may not cover all details or variations in equipment or cover every possible situation to be met in connection with installation, operation or maintenance. Should problems arise that are not covered sufficiently in the text, the purchaser is advised to contact Emerson Process Management, Remote Automation Solutions division (RAS) for further information.

## EQUIPMENT APPLICATION WARNING

The customer should note that a failure of this instrument or system, for whatever reason, may leave an operating process without protection. Depending upon the application, this could result in possible damage to property or injury to persons. It is suggested that the purchaser review the need for additional backup equipment or provide alternate means of protection such as alarm devices, output limiting, fail-safe valves, relief valves, emergency shutoffs, emergency switches, etc. If additional information is required, the purchaser is advised to contact RAS.

## RETURNED EQUIPMENT WARNING

When returning any equipment to RAS for repairs or evaluation, please note the following: The party sending such materials is responsible to ensure that the materials returned to RAS are clean to safe levels, as such levels are defined and/or determined by applicable federal, state and/or local law regulations or codes. Such party agrees to indemnify RAS and save RAS harmless from any liability or damage which RAS may incur or suffer due to such party's failure to so act.

## ELECTRICAL GROUNDING

Metal enclosures and exposed metal parts of electrical instruments must be grounded in accordance with OSHA rules and regulations pertaining to "Design Safety Standards for Electrical Systems," 29 CFR, Part 1910, Subpart S, dated: April 16, 1981 (OSHA rulings are in agreement with the National Electrical Code).

The grounding requirement is also applicable to mechanical or pneumatic instruments that include electrically operated devices such as lights, switches, relays, alarms, or chart drives.

## EQUIPMENT DAMAGE FROM ELECTROSTATIC DISCHARGE VOLTAGE

This product contains sensitive electronic components that can be damaged by exposure to an electrostatic discharge (ESD) voltage. Depending on the magnitude and duration of the ESD, this can result in erratic operation or complete failure of the equipment. Read supplemental document S14006 for proper care and handling of ESD-sensitive components.

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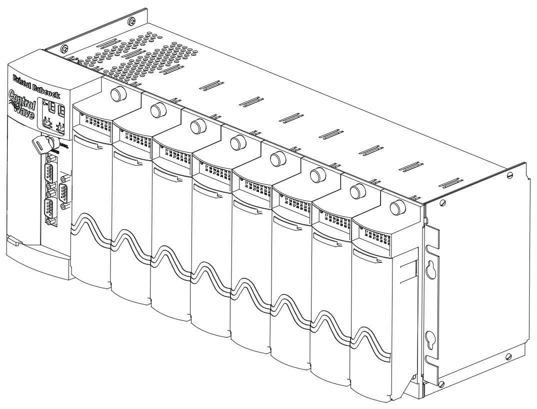
**Emerson Process Management**

***Training***

## GET THE MOST FROM YOUR EMERSON INSTRUMENT OR SYSTEM



- Avoid Delays and problems in getting your system on-line
- Minimize installation, start-up and maintenance costs.
- Make the most effective use of our hardware and software.
- Know your system.

As you know, a well-trained staff is essential to your operation. Emerson offers a full schedule of classes conducted by full-time, professional instructors. Classes are offered throughout the year at various locations. By participating in our training, your personnel can learn how to install, calibrate, configure, program and maintain your Emerson products and realize the full potential of your system.

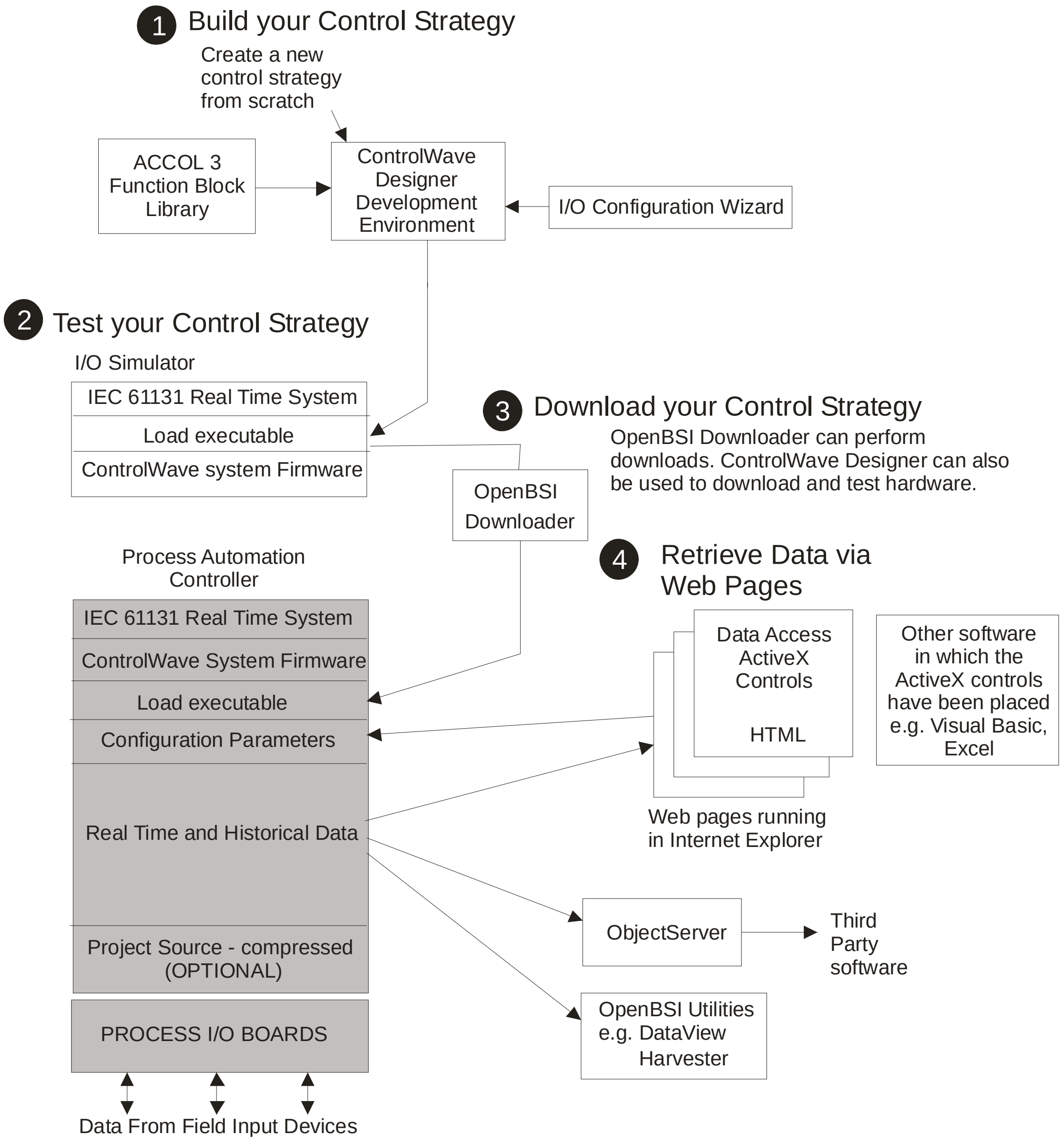
For information or to enroll in any class, go to http://www.EmersonProcess.com/Remote and click on "Educational Services" or contact our training department in Watertown at (860) 945-2200.

# Table of Contents

# Introduction – What is ControlWave?

The ControlWave programming environment uses industry-standard tools and protocols to provide a flexible, adaptable approach for various process control applications in the industrial automation business.

The ControlWave Programming Environment consists of a set of integrated software tools which allow a user to create, test, implement, and download complex control strategies for use with the **ControlWave** series of Process Automation Controllers.


1 Build your Control Strategy
Create a new control strategy from scratch
ACCOL 3 Function Block Library
ControlWave Designer Development Environment
I/O Configuration Wizard
2 Test your Control Strategy
I/O Simulator
IEC 61131 Real Time System
Load executable
ControlWave system Firmware
3 Download your Control Strategy
OpenBSI Downloader can perform downloads. ControlWave Designer can also be used to download and test hardware.
OpenBSI Downloader
4 Retrieve Data via Web Pages
Process Automation Controller
IEC 61131 Real Time System
ControlWave System Firmware
Load executable
Configuration Parameters
Real Time and Historical Data
Project Source - compressed (OPTIONAL)
PROCESS I/O BOARDS
Data From Field Input Devices
Data Access ActiveX Controls
HTML
Other software in which the ActiveX controls have been placed e.g. Visual Basic, Excel
Web pages running in Internet Explorer
ObjectServer
Third Party software
OpenBSI Utilities e.g. DataView Harvester

The tools which make up the environment are:

- **ControlWave Designer** load building package offers several different methods for generating and debugging control strategy programs including function blocks, ladder logic, structured languages, etc. The resulting process control strategy programs (projects) are fully compatible with **IEC 61131** standards. Various communication methods are offered, including TCP/IP, serial links, as well as communication to **OpenBSI** software and networks. ControlWave Designer incorporates the KW MULTIPROG wt IEC 61131 programming tool.[1]

- The **I/O Configuration Wizard**, accessible via a menu item in ControlWave Designer, allows you to define **process I/O boards** in the ControlWave-series controller, and configure the individual mapping of I/O points for digital and analog inputs and outputs.

- The **ACCOL3 Function Block Library** which is imported into ControlWave Designer, includes a series of ControlWave-specific **function blocks**. These pre-programmed function blocks accomplish various tasks common to most user applications including alarming, historical data storage, as well as process control algorithms such as PID control.

- The **I/O Simulator** allows the control strategy programs (projects) generated through ControlWave Designer to be tested on a PC, with simulated analog and digital inputs and outputs. The I/O Simulator utilizes the identical IEC 61131 real time system used in the ControlWave controller; this allows initial I/O testing and debugging to be performed in a safe, isolated environment, without the need for a running ControlWave-series controller and process I/O boards.

- The **ObjectServer –** a package you purchase separately that allows real-time data access by any OPC compliant third-party software package.

- A series of **Web Page Controls** are also available for retrieval of real-time data values, historical data values, and communication statistics. The web controls utilize **ActiveX** technology and are called through a set of fixed Web pages, compatible with Microsoft® Internet Explorer. Alternatively, developers can place the controls in third-party ActiveX compatible applications such as Visual BASIC or Microsoft® Excel, or in their own user-defined web pages to provide a customized human-machine interface (HMI).

[1] *KW MULTIPROG wt is an industry-standard tool developed by Klӧpper und Weige Software GmbH. KW MULTIPROG wt is used by various PLC and RTU vendors for generating IEC 61131 code.*

## Installing the Software

ControlWave Designer software is included on the OpenBSI CD-ROM.

To install it, choose **“Install OpenBSI”** from the choices provided in the CD browser, and then select **“ControlWave Designer with ACCOL III”**. For more information on the installation process, see Chapter 2 of the *OpenBSI Utilities Manual* (document# D5081).

## Starting ControlWave Designer

**ControlWave Designer** is your IEC 61131 program development tool. It allows you to create a control strategy (project) in any of five standard IEC 61131 languages, compile the program, debug it, and download it into your ControlWave controller.

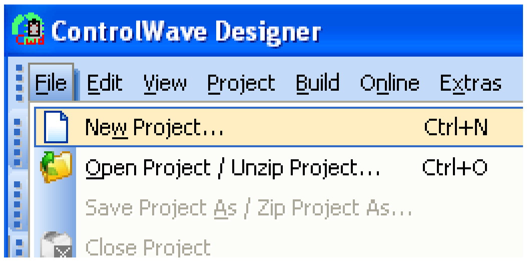
To start ControlWave Designer click on:

**Start→Programs→OpenBSI Tools → ControlWave Tools → ControlWave Designer**

**IMPORTANT: If this is the very first time ControlWave Designer has been started on this particular computer, you will be reminded to register the software. Otherwise, the software can only be used for a maximum of 60 days. For more information on the registration process, see Chapter 2 of the** *OpenBSI Utilities Manual* **(document# D5081).**

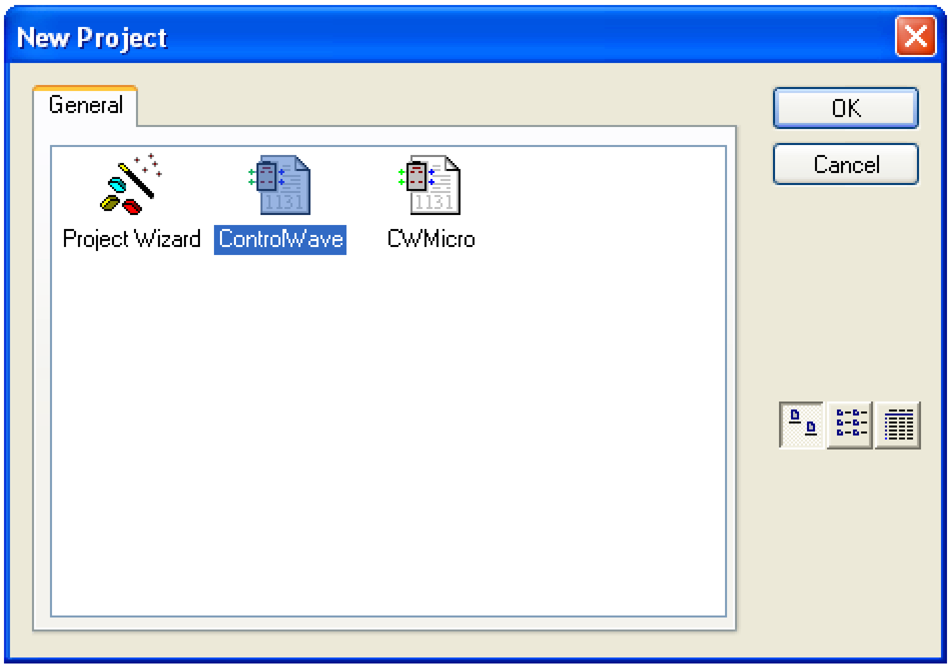
## Opening A New Project

ControlWave Designer will start. Then, click on the New Project icon, shown above, or click on **File→New Project**.

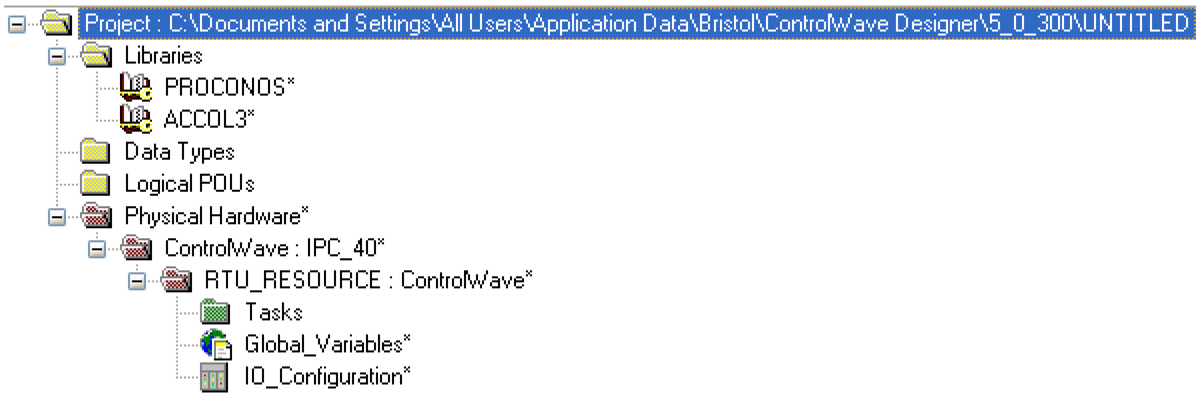

ControlWave Designer
File Edit View Project Build Online Extras
New Project... Ctrl+N
Open Project / Unzip Project... Ctrl+O
Save Project As / Zip Project As...
Close Project

# Starting ControlWave Designer, Opening A Project

The New Project dialog box will appear.



Double-click on the ‘ControlWave’ icon (or the ‘CWMicro’ icon if you are using a ControlWave Micro-series unit) and a **project tree** will be created which automatically includes the ACCOL3 function block library.



```
Project : C:\Documents and Settings\All Users\Application Data\Bristol\ControlWave Designer\5_0_300\UNTITLED
  Libraries
    PROCONOS*
    ACCOL3*
  Data Types
  Logical POUs
  Physical Hardware*
    ControlWave : IPC_40*
      RTU_RESOURCE : ControlWave*
        Tasks
        Global_Variables*
        IO_Configuration*
```

We will briefly discuss some of the terminology associated with the project tree. The project tree includes a series of folders and **worksheets** which define the various elements of your project. Among the most important elements of the project tree are:

**Logical POUs**

Program Organization Units (POUs) hold the program code for your project. They are defined on three separate worksheets. One worksheet can optionally contain a textual description of the POU, a second worksheet lists the variables associated with the POU, and a third worksheet defines the POU code. POUs can be up to 640 K bytes in size, and there is an enforced limit of 512 POUs per project. There are three types of POUs:

**Functions** - Sometimes the term function is abbreviated as ‘FU’. These are the simplest type of POU. They can take multiple inputs, but they generate only one output. The memory allocated for a function’s data is not persistent; i.e. once the function completes execution, that memory is released. Functions are generally used to perform mathematical operations; an example of a function is R_INT which truncates a real number to an integer. Functions can only call other functions. Functions can only be executed when included as part of a program POU.

**Function Blocks** - Sometimes the term function block is abbreviated as ‘FB’. Function blocks can take multiple inputs, and they can generate multiple outputs. Unlike functions, they can have persistent memory. Most of the POUs provided in the ACCOL3 library are function blocks, for example, the AVERAGER, the INTEGRATOR, the PID3TERM, the LEADLAG, etc. User-defined function blocks can be created which consist of logical connections of various functions and function blocks. Function blocks can only be executed when included as part of a program POU.

**Programs –** Programs are essentially groups of functions and function blocks which have been logically connected together to perform some task. Programs are the only type of POU which can actually be executed. Users can create more than one program in a project, and in fact, they can create multiple **instances** of the same program. Programs can contain persistent memory.

**Libraries**

There are two types of libraries: **Firmware libraries** are libraries of functions and function blocks created specifically for this controller model. The ACCOL3 library is a firmware library containing functions and function blocks created specifically for the ControlWave-series of controllers. It is automatically loaded when you choose the ControlWave Template in the New Project dialog box. **User libraries** are optionally created by the user. They are libraries of programs, functions, and function blocks called in from *other* previously saved projects.

**Data Types**

The Data Type worksheets can be used to define customized data type structures. For example, arrays of numbers. NOTE: The data entered here only defines the data type, it doesn't actually set aside memory for storing the data - - that occurs in a variable declaration.

**Physical Hardware** Physical hardware defines details of the actual controller which will execute the project. It is divided into several sections:

**RTU_CFG** is the type of code generation required for the controller – for ControlWave this always begins with IPC, and it is always configured via the IO Configuration Wizard.

**RTU_RESOURCE** defines the type of run-time system used – in this case, it is always 'ControlWave'.

**Tasks** are the actual mechanism by which programs are executed. When you have completely defined a program, you must associate a program instance with an executing task, and define the rate of execution.

**Global_Variables** is where any user-created global variables are defined.

**IO_Configuration** defines the inputs and outputs of the process I/O boards in the ControlWave-series controller and optionally the ControlWave Remote Ethernet I/O, and/or ControlWave I/O Expansion Rack(s). This section should only be edited via the IO Configuration Wizard; do NOT attempt to edit it manually.

Additional worksheets are added to the project tree as you build your project. Some of these are added automatically, others must be manually added by the user.

IMPORTANT

*Do not rename* items in the project tree created automatically by ControlWave Designer, such as the 'IO_Configuration' item. ControlWave Designer looks for worksheets under specific items of the tree, and if you rename those items, ControlWave Designer will be unable to locate those worksheets.

*NOTE: We have introduced a lot of terminology in this section. Don't worry about absorbing all of it now. The most important parts should become clearer to you as you proceed through the 'Configuring I/O' and Example sections, later in this manual.*

# Configuring I/O

In order to reference **I/O points** on the process I/O boards of your controller, you need to configure them within your project.

Although it is *possible* to manually edit the **"IO_Configuration"** section of the project tree, we strongly recommend you use the I/O Configuration Wizard, as it will perform syntax checking, and is easier for most users.

The I/O Configuration Wizard is accessible from within ControlWave Designer by clicking as follows: **View→IO Configurator**

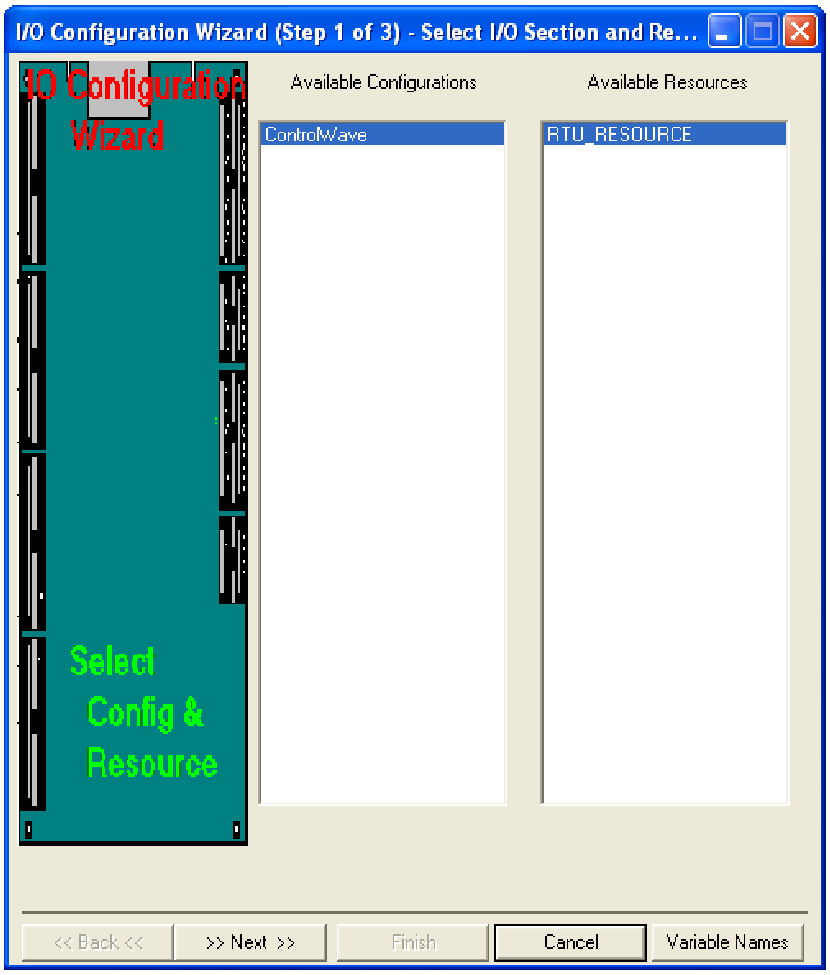
When started, any existing I/O configuration data will be read and displayed in the I/O Configuration Wizard. The Configuration Wizard is a multi-page tool; **[>>Next>>]** and **[<<Back<<]** buttons are provided to allow you to move between the pages. A **[Settings]** push button allows the user to rename default variable names, if necessary. (See *'Changing Default Variable Names'*, later in this section.) NOTE: Page 1 allows the user to define multiple resources. Typically, only a single resource is used, so by default, page 2 will appear first since most users do not need to use Page 1.

IMPORTANT

The IO Configuration Wizard will add a variable group to the Global_Variables worksheet called IO_GLOBAL_VARIABLES. Both the IO_GLOBAL_VARIABLES group in the Global_Variables worksheet and the IO_Configuration worksheet should *never* be manually edited by the user; these should only be modified through the IO Configuration Wizard.

## I/O Configuration Wizard (Step 1 of 3): (Most users can skip to Step 2)

The first page of the I/O Configuration Wizard allows the user to select from the available I/O configurations and I/O resources. *NOTE: Because most projects utilize a single configuration and resource, this page is skipped when first starting the I/O Configuration Wizard. It is accessible, however, by clicking on the* ***[<<Back<<]*** *button from the second page of the Wizard.*

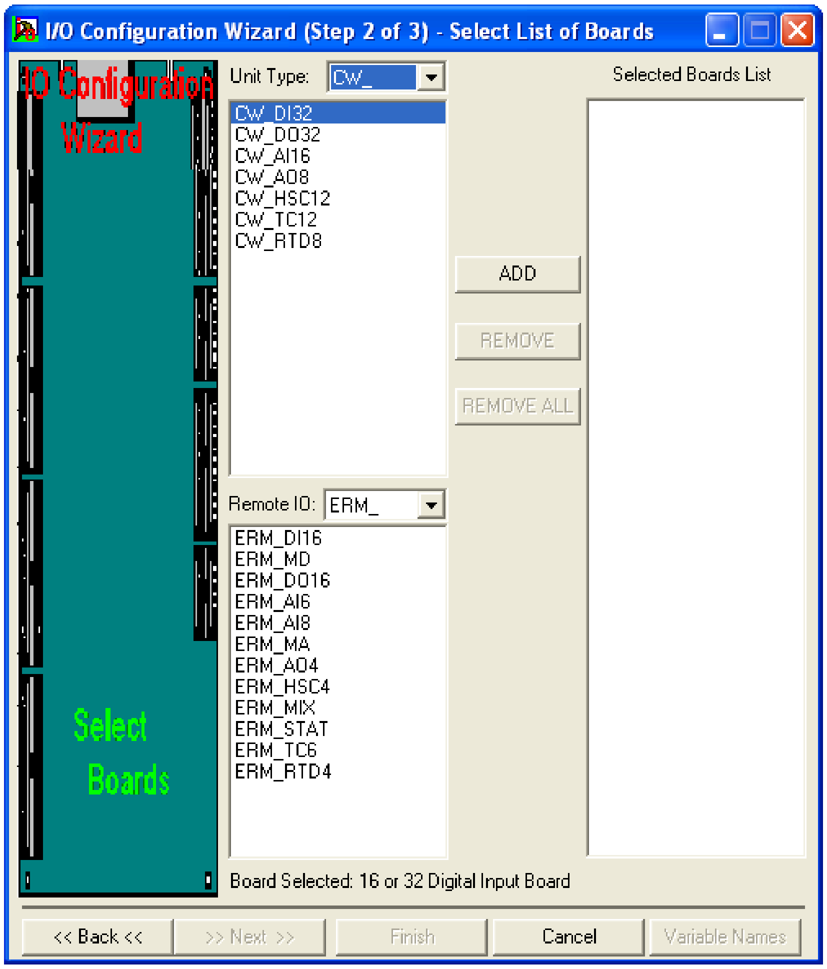


| | |
|---|---|
| **Available Configurations** | This lists all configurations in the current project. Select the I/O Configuration Section for which you are defining the I/O. *NOTE: Typically, projects utilize a single I/O configuration section.* |
| **Available Resources** | This lists all resources for the selected I/O configuration. Choose the resource for which I/O is to be defined. *NOTE: Typically, projects utilize a single resource.* |

Click on **[Next>]** to proceed to the next step.

## I/O Configuration Wizard (Step 2 of 3):

The second page of the I/O Configuration Wizard allows the user to specify which process I/O boards are actually installed in the ControlWave-series controller, as well as boards which are installed in separate devices such as I/O Expansion Racks, or Remote Ethernet I/O units.



Unit Type: CW_

CW_DI32
CW_DO32
CW_AI16
CW_AO8
CW_HSC12
CW_TC12
CW_RTD8

Remote IO: ERM_

ERM_DI16
ERM_MD
ERM_DO16
ERM_AI6
ERM_AI8
ERM_MA
ERM_AO4
ERM_HSC4
ERM_MIX
ERM_STAT
ERM_TC6
ERM_RTD4

Board Selected: 16 or 32 Digital Input Board

Boards should be selected from the selection boxes in the ascending order of their slot number.

First, use the **"Unit Type"** list box to identify which type of ControlWave controller you are configuring, then select the desired boards, and click on **[ADD]**.

If this controller has associated I/O racks, or Remote Ethernet I/O units, choose those boards in the **"Ext Rack Board"** and **"Remote IO Boards"** selection boxes and click on **[ADD]**.

For more information on the various fields, see below:

**Unit Type** This field allows you to identify the type of ControlWave-series controller you are configuring, so that the proper board types can be displayed for it. The types of controllers include:

| | |
|---|---|
| CW_ | ControlWave Process Automation Controller |
| CWM_ | ControlWave MICRO Process Automation Controller |
| LP_ | ControlWave Low Power (LP) Process Controller |
| CXX_ | ControlWave CW_30 or CW_10 Controller |

Once you select the type of controller, the boards which can be installed in that unit will be displayed as possible choices.

For ease of configuration, select the boards from the list in ascending order of their slot number in the ControlWave unit. Clicking once on the board abbreviation will cause a description of the board to be displayed at the bottom of the Wizard page. Double-clicking on the board abbreviation (or clicking *once* on the board and then clicking on **[ADD])** will add the board to the **"Selected Boards List"**. The '*I/O Configurator'* section of the *ControlWave Designer Programmer's Handbook* (document# D5125) lists the various types of boards.

**Ext Rack Boards** This lists boards which may be installed in the ControlWave I/O Expansion Rack. If this ControlWave-series controller is configured to use an I/O Expansion rack, select the appropriate boards in ascending order of their slot number in the rack.

Double-clicking on the board abbreviation (or clicking *once* on the board and then clicking on **[ADD])** will add the board to the **"Selected Boards List"**

**Remote IO Boards** This lists boards used in ControlWave Remote Ethenet I/O units. If this ControlWave controller is configured to use Remote Ethernet I/O, select the appropriate boards.

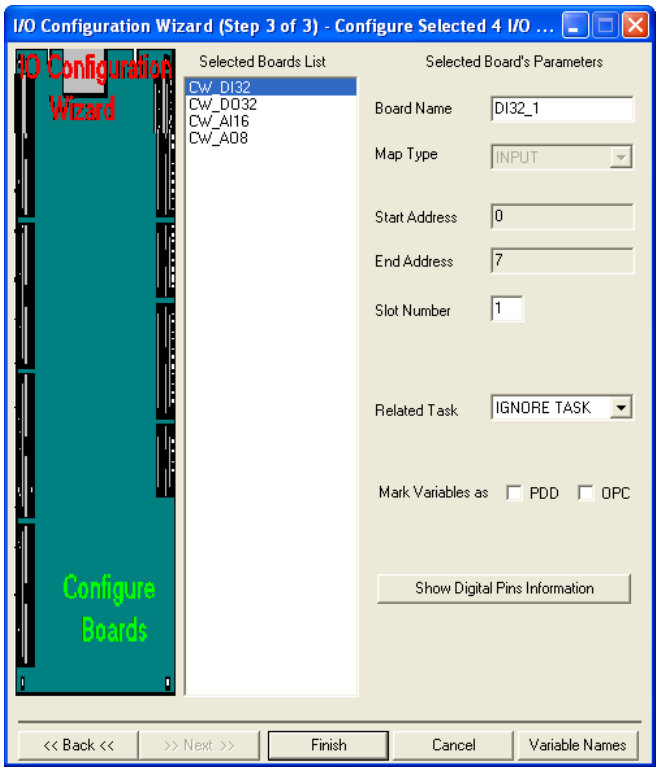
Double-clicking on the board abbreviation (or clicking *once* on the board and then clicking on **[ADD]**) will add the board to the **"Selected Boards List"**

**Selected Boards List** This list allows the user to declare which boards reside in the ControlWave controller or its configured ControlWave Remote Ethernet I/O unit(s), or ControlWave I/O Expansion Racks. To remove a board from the **"Selected Boards List"** double-click on it, or click on it once, and then click on **[REMOVE]**. To remove all boards click on **[REMOVE ALL]**.

Click on **[Next]** to verify configuration information, adjust slot numbering, define zeros and spans for analog inputs, etc.

## I/O Configuration Wizard (Step 3 of 3):

The third page of the I/O Configuration Wizard displays configuration details for each board. To see the details, click on the board abbreviation, and the configuration details will be displayed on the right hand side of the page. NOTE: The fields available for particular boards vary from platform to platform.



Board Name: DI32_1
Map Type: INPUT
Start Address: 0
End Address: 7
Slot Number: 1
Related Task: IGNORE TASK
Mark Variables as: PDD [ ] OPC [ ]

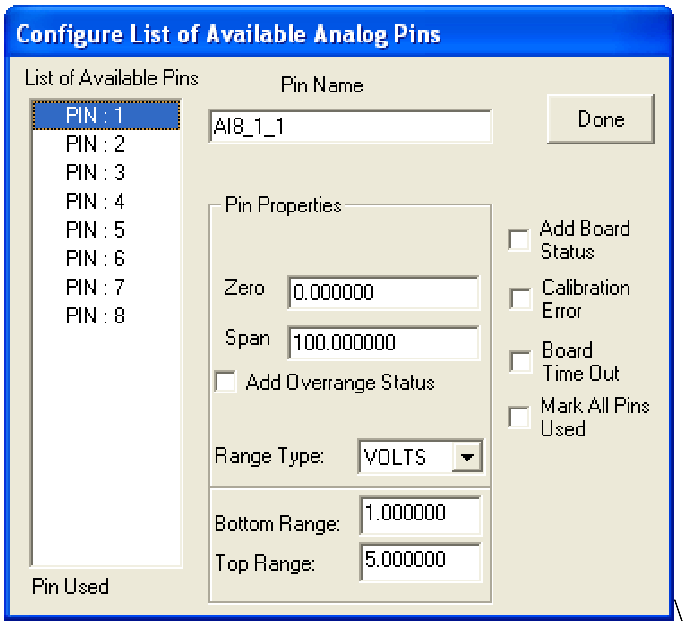
| | |
|---|---|
| **Selected Boards List** | Displays all boards selected on the previous page. Click on a particular board abbreviation to display configuration details for the board. |
| **Board Name** | A name for the board can be specified here. This name will be used when configuring pins for the board. |
| **Map Type** | (Information Only) Depending upon the type of board, separate memory areas (called maps) are reserved for either inputs or outputs. Some boards have both an input map *and* an output map. For example, a digital output board has outputs (DOs) in its output map, but it may also have inputs which indicate board status conditions and errors. For more detailed information on the input and output maps for various boards, see the '*I/O Mapping*' section of the *ControlWave Designer Programmer's Handbook* (document# D5125).<br><br>*NOTE: If you have an older ControlWave project in which you changed the map type from the default choice, this may cause errors to be* |

| | |
|---|---|
| | *generated when the project is rebuilt. If this occurs, you should delete the board definition and re-define the board.* |
| **Start… End Address** | Displays the range of memory addresses used by the board. |
| **Slot Number** | Displays either the physical I/O slot in the ControlWave controller which holds the board, or if this is a Mixed I/O Board (MIOB) it displays a board selection number. For ControlWave and ControlWave Micro, I/O slot numbers are positive integers, e.g. 1, 2, 3, etc. For the ControlWaveLP, the slot number is 0 for all boards except for the AO; for the AO the slot can be 8 to 13. *NOTE: I/O Slot number is NOT the same as the chassis slot number. Chassis slots which hold the power supply and CPU boards are not considered to be I/O slots, so the first I/O slot is typically the third chassis slot.* |
| **IP Address** | ControlWave Remote Ethernet I/O boards are identified by their Internet Protocol (IP) address, instead of the I/O slot number. The same is true for boards residing in a ControlWave I/O Expansion Rack. |
| **Related Task** | Shows the name of the task which uses this board. In some cases, for example, when using Ethernet I/O, or analog boards in an RTU 3340, it is important to associate a board with the task which uses the board. When a board is associated with a task, that board will be read / written to, at the rate cycle associated with the task, thereby ensuring up-to-date information for calculations performed in the task. When no task is associated with the board, board execution is associated with the default task, which runs at a lower priority, and therefore may not provide sufficient up-to-date I/O information when it is required by a task. |
| **Mark Variables as PDD OPC** | This determines how values of the I/O variables associated with this board will be made available to other software programs. Checking **"PDD"** allows the controller to reference variables by name, which is necessary if you intend to access a variable by external software which requires 'read-by-name' access, such as DataView, or one of the other OpenBSI Utilities. Checking **"OPC"** adds this variable to a collection list used by the ObjectServer or by the OpenBSI Signal Extractor. This is necessary when data is to be extracted, and sent to a database. |

When edits have been made to this page, click on the **[Show *xxx* Information]** button. The name on this button, and the pin configuration details, vary depending on the type of board being configured. See the pages that follow for the standard board types.

NOTE: If you are using RIO Open Modbus board types, please see the *'I/O Configurator'* section of the *ControlWave Designer Programmer's Handbook* (document# D5125).

Analog Boards


Configure List of Available Analog Pins

List of Available Pins: PIN : 1, PIN : 2, PIN : 3, PIN : 4, PIN : 5, PIN : 6, PIN : 7, PIN : 8

Pin Used

Pin Name: AI8_1_1

Done

Pin Properties

Zero: 0.000000

Span: 100.000000

☐ Add Overrange Status

Range Type: VOLTS

Bottom Range: 1.000000

Top Range: 5.000000

☐ Add Board Status

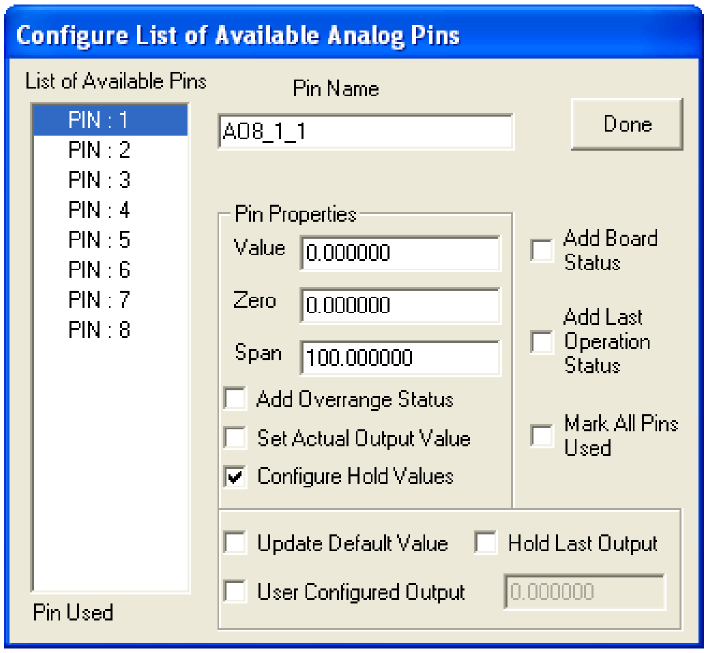
☐ Calibration Error

☐ Board Time Out

☐ Mark All Pins Used

Analog Input Board Page (CWM_AI8 board)

*(some of these fields do NOT appear for other models)*


Configure List of Available Analog Pins

List of Available Pins: PIN : 1, PIN : 2, PIN : 3, PIN : 4, PIN : 5, PIN : 6, PIN : 7, PIN : 8

Pin Used

Pin Name: AO8_1_1

Done

Pin Properties

Value: 0.000000

Zero: 0.000000

Span: 100.000000

☐ Add Overrange Status

☐ Set Actual Output Value

☑ Configure Hold Values

☐ Add Board Status

☐ Add Last Operation Status

☐ Mark All Pins Used

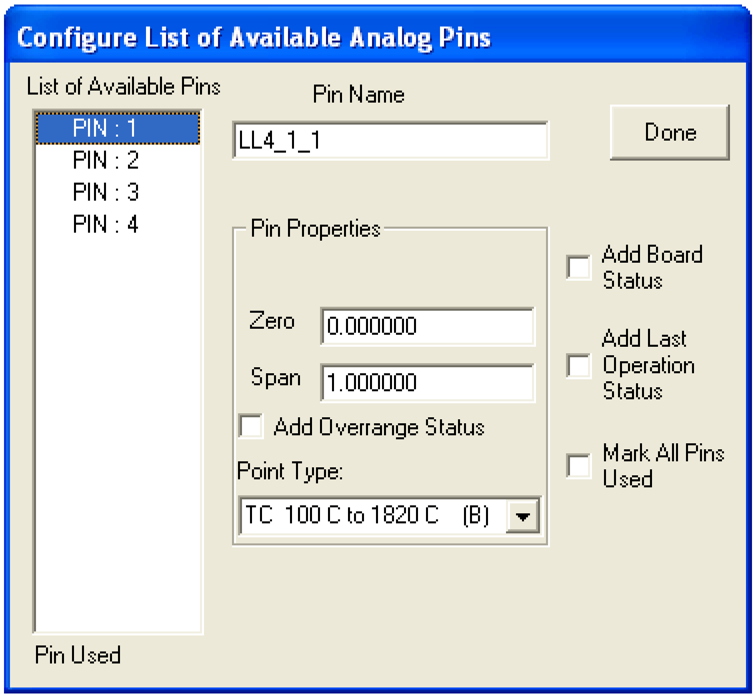
☐ Update Default Value

☐ Hold Last Output

☐ User Configured Output: 0.000000

Analog Output Board Page (CW_AO8 board)

*(some of these fields do NOT appear for certain models)*



Pin Name: LL4_1_1

Zero: 0.000000

Span: 1.000000

Point Type: TC 100 C to 1820 C (B)

Low Level Analog Input Board (CXX_LL4 Board)

| | |
|---|---|
| **List of Available Pins** | Displays a list of the individual pins (I/O points) on this process I/O board. If the pin is displayed in RED, that pin is active. If the pin is left grayed out, that pin is considered unused. |
| **Pin Name** | Defines a name identifying this pin. IMPORTANT: This name is used as a variable name to reference the I/O pin in your POU. |
| **Value** | Defines the initial value for this I/O pin, in floating point format. NOTE: This is not available for analog input pins. |
| **Zero** | Defines the lowest value of the range for this I/O pin. Used to scale the input/output value. |
| **Span** | Span is added to the ZERO value to define the highest value of the range for this I/O pin. Used to scale the input/output value. |
| **Add Over Range Status** | When selected, will cause a variable to be created to store the value of the overrange status bit. Over range conditions occur when an attempt is made to drive the variable associated with this pin outside the range defined by the zero and span. When this occurs, the over range status bit will be set to TRUE. |

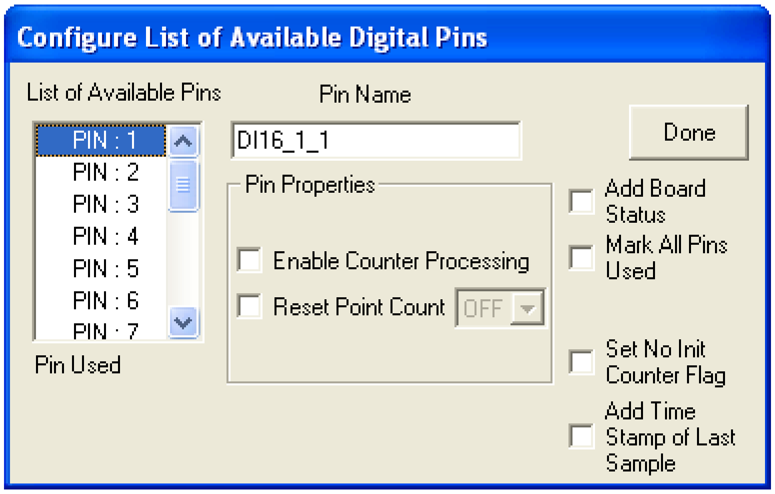
| | |
|---|---|
| **Range Type** | For some boards, you can specify whether the board input is in current or voltage. Choose ‘VOLTS’ or ‘AMPS’. NOTE: For example, if 4 to 20 milliamps of current drive the board, you would choose ‘AMPS’, then enter 0.004 for the **“Bottom Range”** value, and 0.020 for the **“Top Range”** value. |
| **Bottom Range** | The lowest usable value for VOLTS or AMPS for this board input. For example, if the board input can range from 1 to 5 VOLTS, the **“Bottom Range”** would be set to 1.0. If this board input can range from 4 to 20 milliamps, **“Bottom Range”** would be set to 0.004. Other ranges are possible as well. |
| **Top Range** | The highest usable value for VOLTS or AMPS for this board input. For example, if the board input can range from 1 to 5 VOLTS, the **“Top Range”** would be set to 5.0. If this board input can range from 4 to 20 milliamps, **“Top Range”** would be set to 0.020. Other ranges are possible as well. |
| **Set Actual Output Value** | When selected, this will cause a variable to be created which *displays* the actual value which was written to the output pin. |
| **Add Board Status** | When selected, will cause a variable to be created to store board status information. |
| **Add Last Operation Status** | When selected, will cause a variable to be created to store the status of the last conversion operation information. |
| **Calibration Error** | This is only present for certain platforms. When checked, will cause a variable to be created to store error information. This variable will be set to TRUE whenever there is bad calibration data in the EEPROM. |
| **Board Time Out** | This is only present for certain platforms. When checked, will cause a variable to be created to store information about board time out errors. Board time outs occur if there is a problem with conversion operations. |
| **Mark All Pins Used** | When checked, will activate all pins on this I/O board. They will all appear in RED. |
| **Configure Hold Values** | When checked, enables other fields on the page for configuring a hold value for this pin. A **hold value** is the value used by the I/O card if it detects a watchdog of the ControlWave CPU. The I/O board maintains this value at the pin until the unit is restarted. |
| **Update Default** | When checked, allows the **"User Configured Output"** hold value to |

| | |
|---|---|
| **Value** | be changed on-line; otherwise the hold value can only be set in the I/O Configurator. |
| **Hold Last Output** | When checked, specifies that during a watchdog failure, the hold value for this pin will be whatever value was on the pin when the failure occurred. NOTE: **"Hold Last Output"** and **"User Configured Output"** are mutually exclusive. Either one may be configured for a particular pin, but NOT both. |
| **User Configured Output** | When checked, allows the user to enter a value for this pin which will be used as the hold value in the event there is a watchdog failure of the ControlWave. NOTE: **"Hold Last Output"** and **"User Configured Output"** are mutually exclusive. Either one may be configured for a particular pin, but NOT both. |
| **Point Type** | (Not Shown) Appears for CXX_LL4 Low Level Analog Input Board only. Specifies the type of low-level analog input. See the table, below, for a list of supported temperature/voltage ranges for inputs to the CXX_LL4 board. |

| Point Type | Range |
|---|---|
| Thermocouple Type B | 100$^o$ C to 1820$^o$ C |
| Thermocouple Type E | -270$^o$ C to 1000$^o$ C |
| Thermocouple Type J | -210$^o$ C to 1200$^o$ C |
| Thermocouple Type K | -270$^o$ C to 1370$^o$ C |
| Thermocouple Type R | -50$^o$ C to 1720$^o$ C |
| Thermocouple Type S | -50$^o$ C to 1760$^o$ C |
| Thermocouple Type T | -270$^o$ C to 400$^o$ C |
| Resistance Temperature Device (RTD) | -220$^o$ C to 850$^o$ C |
| Voltage | -10 mV to 10 mV |

When all pins have been configured, click on **[Done]**. You can then proceed to select and configure pins for *another* board.

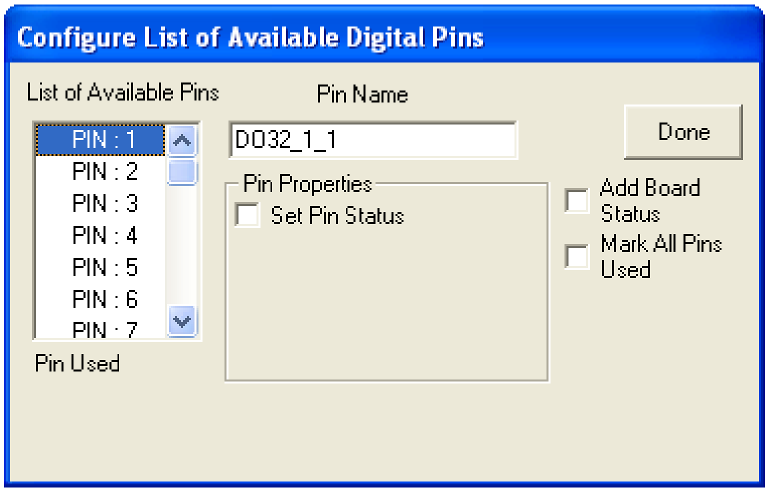
Digital Boards



Pin Name: DI16_1_1

Digital Input Board Page

*(Not all fields are present for all board types)*



Pin Name: DO32_1_1

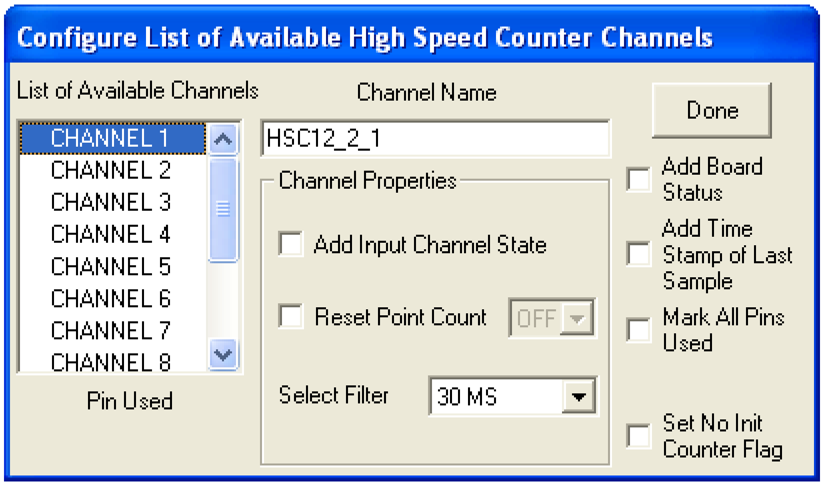
Digital Output Board Page

| | |
|---|---|
| **List of Available Pins** | Displays a list of the individual pins (I/O points) on this process I/O board. If the pin is displayed in RED, that pin is active. If the pin is left grayed out, that pin is considered unused. |
| **Pin Name** | Is a name identifying this pin. This name is used as a variable name to reference the I/O pin in your POU. |
| **Set Pin Status** | Sets the initial value for this digital output (DO). NOTE: This option is not available for digital inputs. |
| **Enable Counter Processing** | Turns on or off the counters associated with the digital input (DI) process I/O board. Counters are used in certain applications. For |

| | |
|---|---|
| | example, if a mixed I/O board is used with a ControlWaveLP, a digital input (DI) can be used as a low speed counter (30 millisecond filter). Enabling counter processing in such a case will allow interrupt processing to occur for that DI. NOTE: This option does not apply to all board types and platforms. |
| **Add Board Status** | When selected, will cause a variable to be created to store board status information. |
| **Mark All Pins Used** | When checked, will activate all pins on this I/O board. They will all appear in RED. |
| **Turn off Leds** | This option is only available on certain boards. When checked, it will create a variable which allows you to turn OFF the I/O board's diagnostic LEDs to save on power. LEDs are turned OFF when the variable is set ON. *NOTE: For this to work, the LED enable jumper on the board must be in position 2-3; otherwise, the software cannot disable the LEDs, only a hardware jumper can. See manual CI-ControlWaveMICRO for details.* |
| **Reset Point Count** | When set to ON, allows the number of counts to be reset. This occurs automatically whenever the board is restarted. NOTE: This function only applies when a CXX_DI16 board is used as a low speed counter. |
| **Set No Init Counter Flag** | When checked, counters on the board will NOT be initialized to zero on a warm start of the unit. NOTE: This function only applies when a CXX_DI16 board is used as a low speed counter. |
| **Add Time Stamp of Last Sample** | When selected, will cause a variable to be created to store the timestamp of the last sample collected by this I/O board. NOTE: This function only applies when a CXX_DI16 board is used as a low speed counter. |

When all pins have been configured, click on **[Done]**. You can then proceed to select and configure pins for *another* board.

<u>High Speed Counter (HSC) Boards</u>



Channel Name: HSC12_2_1
Reset Point Count: OFF
Select Filter: 30 MS

High Speed Counter Page
*(Not all fields are present for all board types)*

| | |
|---|---|
| **List of Available Channels** | Displays a list of the individual channels (counter I/O points) on this process I/O board. If the channel is displayed in RED, that channel is active. If the channel is left grayed out, that channel is considered unused. |
| **Channel Name** | Is a name identifying this channel. This name is used as a variable name to reference the channel in your POU. |
| **Add Input Channel State** | When selected, displays the TRUE/FALSE value of the channel. |
| **Reset Point Count** | When set to ON, allows the number of counts to be reset. NOTE: This occurs automatically whenever the board is restarted. |
| **Select Filter** | Specifies how the board will operate for this channel: |

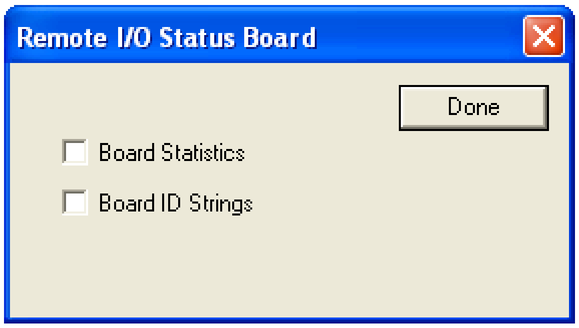
| | |
|---|---|
| 'None' | Defaults to 30 millisecond filtering. |
| '30 ms' | Turns on 30 millisecond filter. Typically used for push-button debouncing. |
| '1 ms' | Turns on 1 millisecond filter. Used for low speed counter applications. |
| 'HSC Channel' | High Speed Counter (Default for CWM_RTU board) |

| | |
|---|---|
| **Add Board Status** | When selected, will cause a variable to be created to store board status information. |

| | |
|---|---|
| **Add Time Stamp of Last Sample** | When selected, will cause a variable to be created to store the timestamp of the last sample collected by this I/O board. |
| **Mark All Pins Used** | When checked, will activate all channels on this I/O board. They will all appear in RED. |
| **Set No Init Counter Flag** | When checked, counters on the board will NOT be initialized to zero on a warm start of the unit. Requires 04.41 or newer firmware. |
| **Turn off Leds** | (Not Shown) This option is only available on certain boards. When checked, it will create a variable which allows you to turn OFF the I/O board's diagnostic LEDs to save on power. LEDs are turned OFF when the variable is set ON. *NOTE: For this to work, the LED enable jumper on the board must be in position 2-3; otherwise, the software cannot disable the LEDs, only a hardware jumper can. See manual CI-ControlWaveMICRO for details.* |

<ins>Remote I/O Status Board</ins>

The Remote I/O Status Board is a 'virtual' board, i.e. there is no actual physical board. By including it within your ControlWave project, global variables will be created to store communication statistics information, and board ID strings for the ControlWave I/O Expansion Rack.

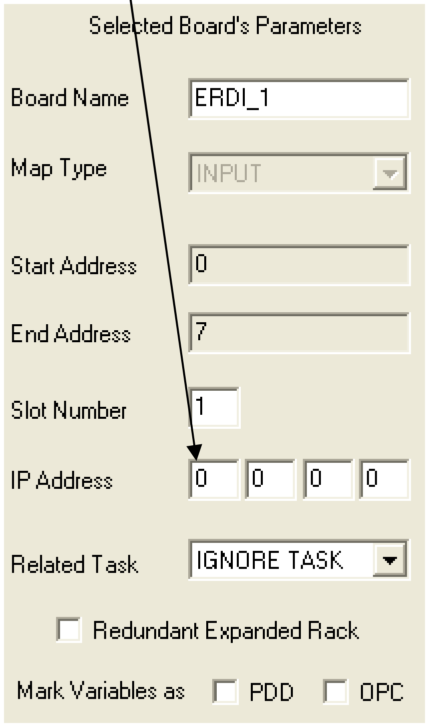


For more information about these variables, and the software configuration for the ControlWave I/O Expansion Rack, please see the *ControlWave I/O Expansion Rack Quick Setup Guide* (document# D5122).

<u>Notes About Ethernet I/O Boards</u>

Unlike process I/O boards which are physically installed in the ControlWave controller, ControlWave Remote Ethernet I/O boards are in a separate location, and communicate to the ControlWave unit using TCP/IP. (The IP address for the Ethernet I/O board is configured from the third page of the I/O Configuration Wizard.)

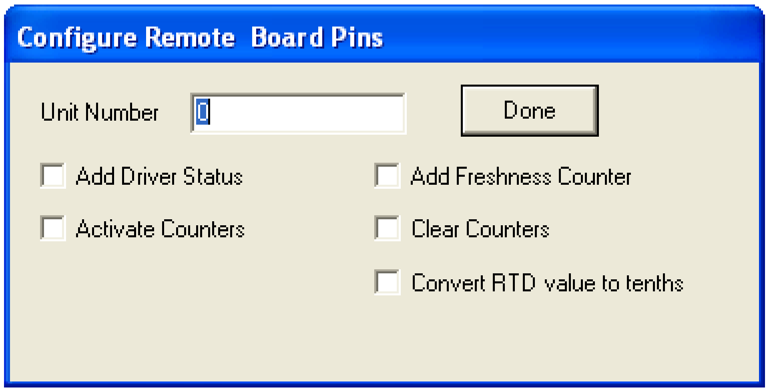
**IP address is defined here.**



Board Name: ERDI_1
Map Type: INPUT
Start Address: 0
End Address: 7
Slot Number: 1
IP Address: 0 0 0 0
Related Task: IGNORE TASK
☐ Redundant Expanded Rack
Mark Variables as ☐ PDD ☐ OPC

Certain parameters must be specified for the Ethernet I/O units which hold the boards. Once this is done, however, the configuration of the individual board pins is identical to that described earlier.

NOTE: The dialog box shown at right includes possible fields for the ControlWave Remote Ethernet I/O, however, not all of these fields are visible in all cases.



Unit Number: 0
☐ Add Driver Status
☐ Add Freshness Counter
☐ Activate Counters
☐ Clear Counters
☐ Convert RTD value to tenths

| | |
|---|---|
| **Unit Number** | Specifies the Modbus unit address number associated with this ControlWave Remote Ethernet I/O unit. |
| **Add Driver Status** | When selected, will cause a variable to be created to store I/O driver status information. |
| **Activate Counters** | Creates / disables a variable which allows the user to control the starting / stopping of the counters in the ControlWave Remote |

| | |
|---|---|
| | Ethernet I/O board. These counters are used with digital inputs (DI). |
| **Add Freshness Counter** | When selected, will cause a variable to be created to store a ‘freshness’ counter value. The freshness counter represents the number of program executions since new data has been collected through this Ethernet I/O board. A value of 0, indicates the data is as new (fresh) as possible. |
| **Clear Counters** | Sets all counter values associated with this board to 0. |
| **Convert RTD value to tenths** | (For RIO 4RTD - 4 Digital Input Board ONLY) - When checked, causes values from the Resistance Temperature Device board to be divided by 10, thereby providing greater precision. |
| **[Show Pins], [Analog Pins], [Digital Pins]** | When clicked on, calls up a dialog box for configuring the individual pins for the board. |
| **[Done]** | Click here when configuration for this board is complete. |

Additional Configuration For ControlWave Remote Ethernet I/O

Besides the I/O configuration within ControlWave Designer, additional configuration for Ethernet I/O hardware must be performed using the Remote I/O Toolkit software (*not to be confused with what used to be known as the OpenBSI Technician Toolkit*). Documentation on the Remote I/O Toolkit software is provided in the form of on-line help screens.

The Remote I/O Toolkit software is included as an installation option on the OpenBSI CD ROM.

- To use counters (DI) you must enable counters in the Remote I/O Toolkit software.
- The IP address entered for a ControlWave Remote Ethernet I/O board in the ControlWave Designer I/O Configuration Wizard must MATCH the IP address entered in the Remote I/O Toolkit.
- If you are using high speed counters, 32 bit counters must be enabled within Remote I/O Toolkit.
- For analog inputs/outputs (AI, AO) you must NOT change the default scaling within Remote I/O Toolkit. Changes should only be made within the ControlWave Designer I/O Configuration Wizard.
- Be aware that if you are using counters (Digital Input or High Speed Counter), restarting of

the ControlWave Remote Ethernet I/O will cause a large jump in counts.

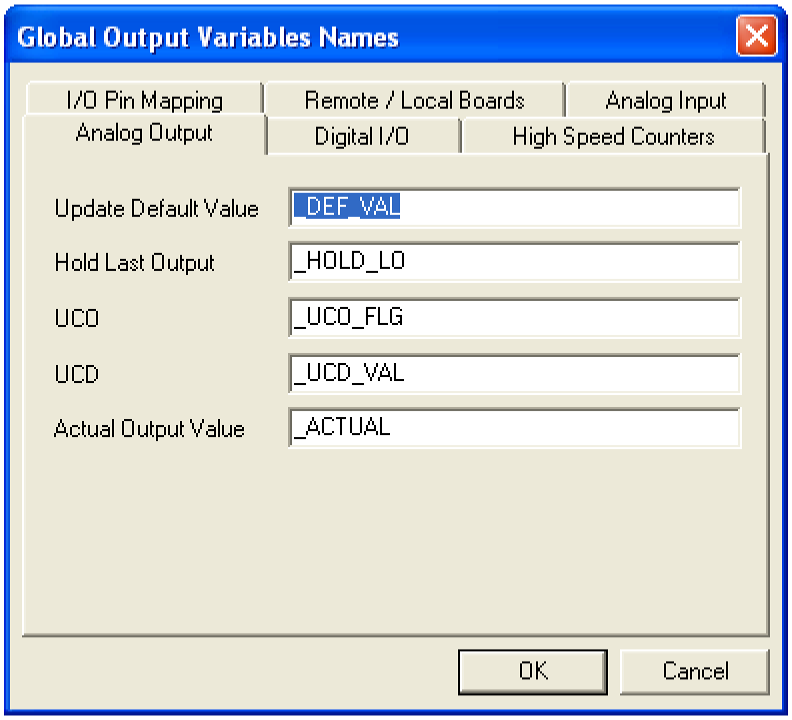
- If you intend to use TPO (Time Proportioned Outputs) for any point, you must enable TPO for those points.

<u>Changing Default Variable Names (All board types)</u>

As you proceed to define your I/O, the I/O Configuration Wizard will automatically create variable names associated with the I/O board to store status information, zeros and spans, etc.

These variable names are based on the pin name you define with an appropriate suffix added. To see the default suffix, click on the **[Variable Names]** button (previously called **[Settings]**) visible on certain pages of the I/O Configuration Wizard.

While NOT recommended, the variable suffixes can be altered by the user, if desired. The different pages of the Global Output Variables Names dialog box are accessible by clicking on the tabs. Make changes on the various pages, then click on **[OK]** to save all the changes.



| | |
|---|---|
| Update Default Value | _DEF_VAL |
| Hold Last Output | _HOLD_LO |
| UCO | _UCO_FLG |
| UCD | _UCD_VAL |
| Actual Output Value | _ACTUAL |

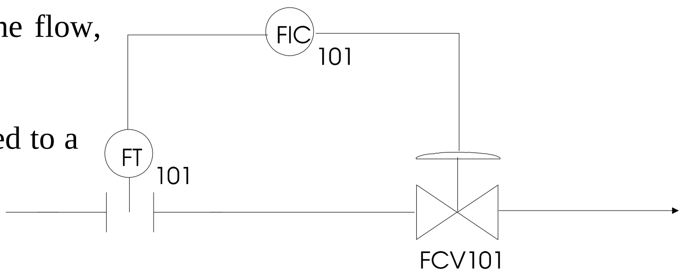
# Example – Creating A Simple Project

NOTE: This example shows one possible way to approach a problem. There are many different solutions available.

The fictitious Sunken Valley Water Company wants to set up a PID (proportional, integral, derivative) loop for controlling the flow of liquid through a pipeline.

They have a flow control valve to vary the flow, and a flowmeter to measure it.

Both the valve and flowmeter are connected to a ControlWave controller.



Before trying to create a project which will perform the PID control, we need to make a list of each thing the project will be doing.

- Bring in the flow data from the pipeline.

  The flow in the pipeline is measured by the flowmeter FT101. The flow rate ranges from 0 to 500 gallons per minute. This data will come in through an analog input process I/O board.

- Slow down reaction to flow changes so as to reduce the amount of wear and tear on the valve.

  We want to ensure that we don’t wear out the control valve trying to respond too quickly to changes in flow. To do this, we need to delay response to the input flow data using a LEAD_LAG function block.

- Perform the actual PID calculation.

  To perform the actual PID control, we can use the pre-defined PID3TERM function block.

- Send data to the control valve.

  The controller will have to send data out to the flow control valve (FIC101/FCV101), in order to vary the position of the valve to regulate the flow. This will require an analog output process I/O board.

Now that we know, roughly, what we’re trying to do, let’s create our project.

## Step 1. Start ControlWave Designer:

Click as follows:

**Start→Programs→OpenBSI Tools→ ControlWave Tools → ControlWave Designer**

## Step 2. Open A New Project:

Click as follows: **File→New Project**

Choose the 'ControlWave' template (or 'CWMicro' if you have a ControlWave MICRO) in the new project dialog box, and click on **[OK].**

## Step 3. Start the I/O Configuration Wizard:

Click as follows: **View→IO Configurator**

## Step 4. Define Process I/O boards.

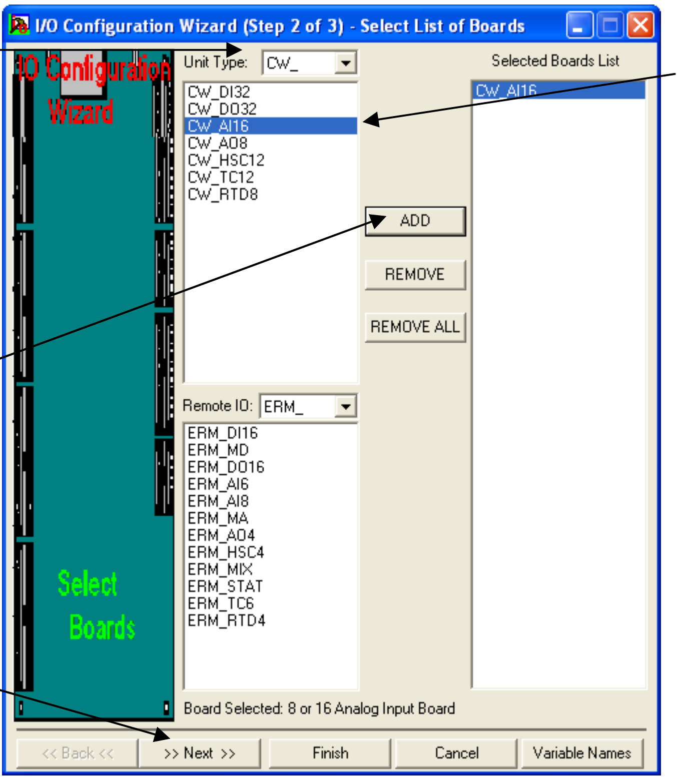
*NOTE: By default, the I/O Configuration Wizard will skip the first page of the dialog box because most applications, including this example, use a single configuration and a single resource.*

**First, choose the type of ControlWave-series controller you are configuring in the "Unit Type" list box.**

**Next, select the board you want to use from the list of boards for that controller type.**

**Then, click on "Add" to add the board to the "Selected Boards List."**

**Finally, click on "Next."**


I/O Configuration Wizard (Step 2 of 3) - Select List of Boards

Unit Type: CW_

CW_DI32
CW_DO32
CW_AI16
CW_AO8
CW_HSC12
CW_TC12
CW_RTD8

Remote IO: ERM_

ERM_DI16
ERM_MD
ERM_DO16
ERM_AI6
ERM_AI8
ERM_MA
ERM_AO4
ERM_HSC4
ERM_MIX
ERM_STAT
ERM_TC6
ERM_RTD4

Selected Boards List

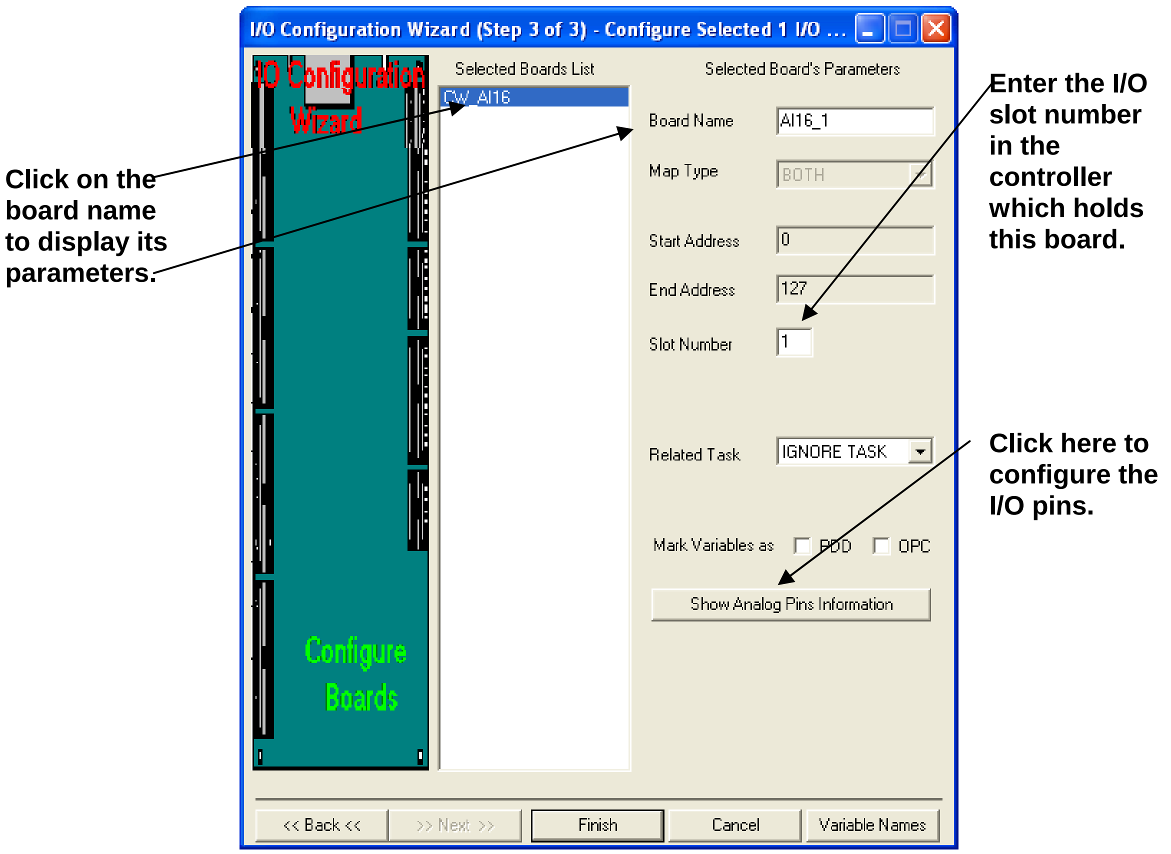
CW_AI16

Board Selected: 8 or 16 Analog Input Board

Our particular project will require two different process I/O boards. An analog input board is needed to handle the analog input which provides the flow data. An analog output board is also needed to send control data out to the valve. We will describe in detail how to define the analog input board; once it is done, the analog output board should be defined by the same basic approach.

First, choose the type of ControlWave controller you are using in the **“Unit Type”** field (‘CW_’ = ControlWave, ‘LP_’ =ControlWaveLP, ‘CWM_’ =ControlWave MICRO, ‘CXX_’= CW10 or CW30. Choose the analog input board used in your unit, then click on **[ADD]**. Then click on **[Next>>]**.

On the third page, click on the board in the **“Selected Boards List”** and its parameters will be displayed on the right hand side of the dialog box. Enter the proper slot number for the board in the **“Slot Number”** field. Then click on **[Show Analog Pins Information]** to configure the individual I/O pins.


Click on the board name to display its parameters.
Enter the I/O slot number in the controller which holds this board.
Click here to configure the I/O pins.
I/O Configuration Wizard (Step 3 of 3) - Configure Selected 1 I/O ...
IO Configuration Wizard
Configure Boards
Selected Boards List
CW_AI16
Selected Board's Parameters
Show Analog Pins Information
<< Back <<
>> Next >>
Finish
Cancel
Variable Names

Board Name: AI16_1
Map Type: BOTH
Start Address: 0
End Address: 127
Slot Number: 1
Related Task: IGNORE TASK
Mark Variables as ☐ PDD ☐ OPC

To activate a particular pin, double-click on it in the **“List of Available Pins”**. Active pins are shown in red. Then select the pin, and configure it. You can change the default name in the **“Pin Name”** field. Analog inputs should have **“Zero”** and **“Span”** values defined, as well.

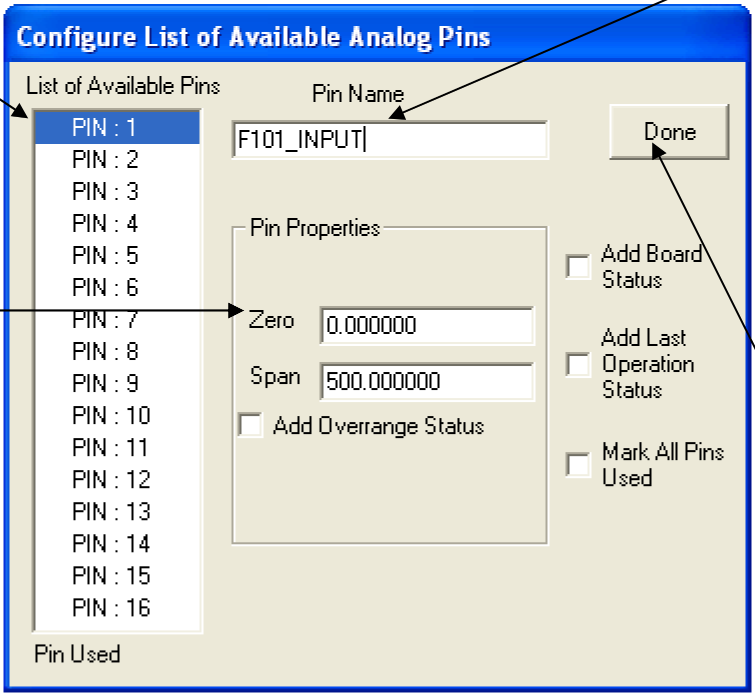
**Double-click on the pin name to activate it. Active pins show in red.**

**You can change the pin name here; ControlWave Designer uses the name you enter here to reference the pin in the rest of the program.**

**To configure a particular pin, click on it in the list.**

**You must define a “Zero” and “Span” here. If not, the program uses a default of 0 to 100.**

**Click on “Done” when you finish.**



Pin Name: F101_INPUT

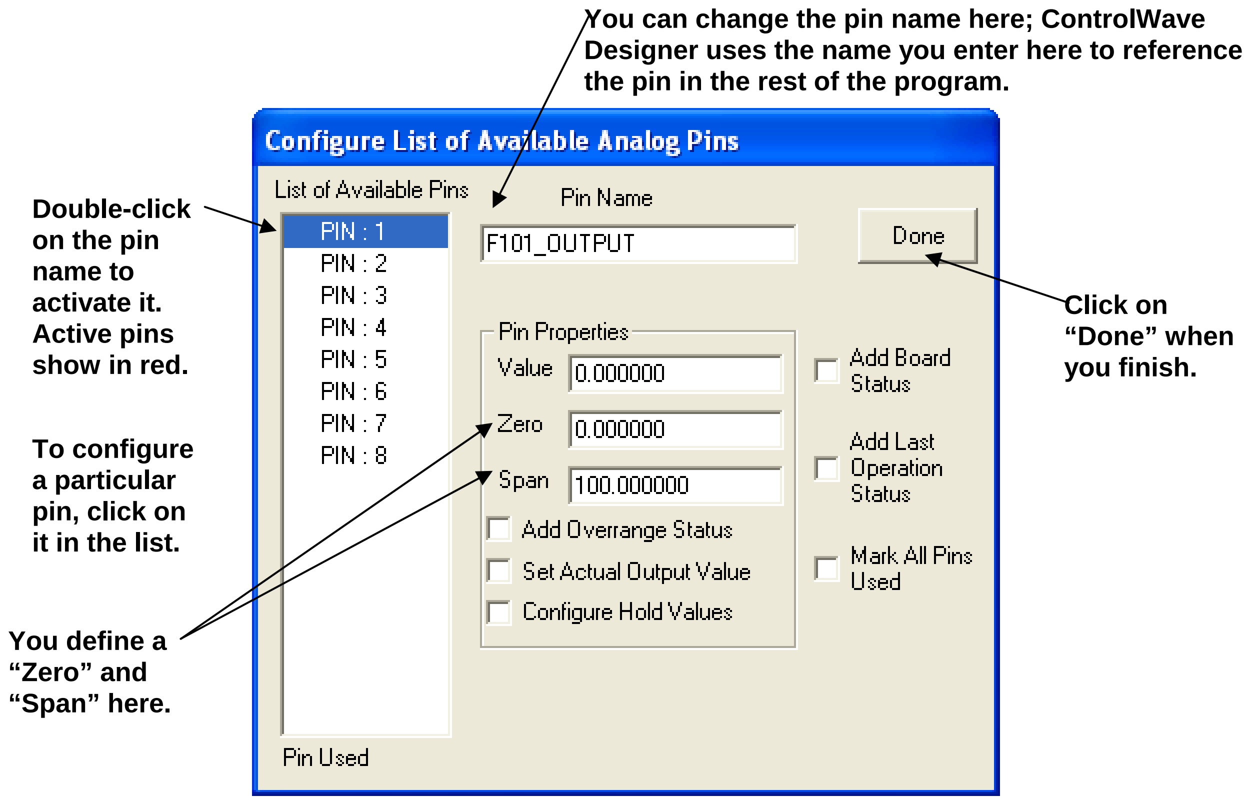
Zero: 0.000000

Span: 500.000000

When finished, click on **[Done]** to return to page 3 of the I/O Configuration Wizard, then click on **[<<Back<<]** to return to page ‘Step 2 of 3’, and add another board.

Now define an Analog Output board. Repeat the same general process used to create the Analog Input board. Be sure you use a *different* I/O slot number for the Analog Output board, and be sure you specify a unique pin name for the analog output, and set its zero and span.

The figure, below, shows the pin definition for the analog output. We have set a zero and span of 0 and 100 respectively; this range covers the percentage at which the control valve is to be opened.


Configure List of Available Analog Pins

List of Available Pins: PIN : 1, PIN : 2, PIN : 3, PIN : 4, PIN : 5, PIN : 6, PIN : 7, PIN : 8

Pin Name: F101_OUTPUT

Pin Properties
Value: 0.000000
Zero: 0.000000
Span: 100.000000

Done
Add Overrange Status
Set Actual Output Value
Configure Hold Values
Add Board Status
Add Last Operation Status
Mark All Pins Used
Pin Used
You can change the pin name here; ControlWave Designer uses the name you enter here to reference the pin in the rest of the program.
Double-click on the pin name to activate it. Active pins show in red.
To configure a particular pin, click on it in the list.
You define a "Zero" and "Span" here.
Click on "Done" when you finish.

When you finish with the I/O configuration, go to page 'Step 3 of 3' and click on the **[Finish]** button.

**Some notes about choosing variable names:**

- Variable names consist of a combination of letters (A-Z, a-z), numbers (0-9) and the underscore character '_'.

- The first character of a variable name CANNOT be a number.

- Variables are NOT case sensitive, i.e. MY_VARIABLE, my_variable, and mY_vAriaBLe are all considered to be the same variable name.

- Although you won't always see it, in addition to the variable name you enter, the system automatically precedes every variable by one or more instance names, separated by periods, depending upon where the variable was defined ('@GV.' for global variables, task and function block instance names for local variables) e.g. @GV.F101_INPUT or Flow1.V003

- If you have OpenBSI Utilities Version 4.0 or earlier, we recommend your variable names be limited to 20 characters or less (including the instance name or '@GV.' described above). This is recommended because prior to OpenBSI Version 4.1, tools such as DataView only recognized the first 20 characters; and so, that is the only portion of the variable name those tools will display. Newer versions recognize up to 64 characters.

- If you decide to use longer variable names (up to 128 characters are allowed), only the first 30 characters will be recognized within ControlWave Designer. If you have variables in your ControlWave POU worksheet with more than 30 characters, however, make sure there are no two variables in which the first 30 characters are the same, or else those two variables will be treated as the same variable.

  For example, two variables named: COMPRESSOR_STATION_FOUR_STATUS_ON
  *and* COMPRESSOR_STATION_FOUR_STATUS_OFF
  should not be included in the same worksheet because the first 30 characters 'COMPRESSOR_STATION_FOUR_STATUS' are the same, and therefore the difference between the '_ON' and '_OFF' would not be recognized by the compiler.

Here are some legal variable names:

COMPRESSOR_4_STATUS
_PUMP_START
tank_level_hi_alarm

Here are some ILLEGAL variable names, and the reason they are illegal:

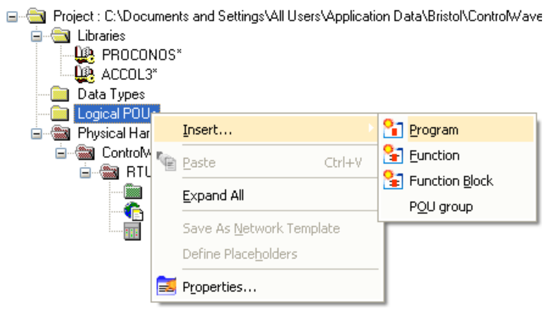
|  |  |
|---|---|
| 1_STATION4_MAINSWITCH | (*illegal because it starts with a number*) |
| PUMP#4_START | (*illegal because the '#' character is NOT allowed*) |

# Example – Creating A Simple Project

## Step 5. Create A Program Which Implements Your Control Strategy

Now that we have our I/O configuration completed, we can create a program which uses the I/O we have defined.

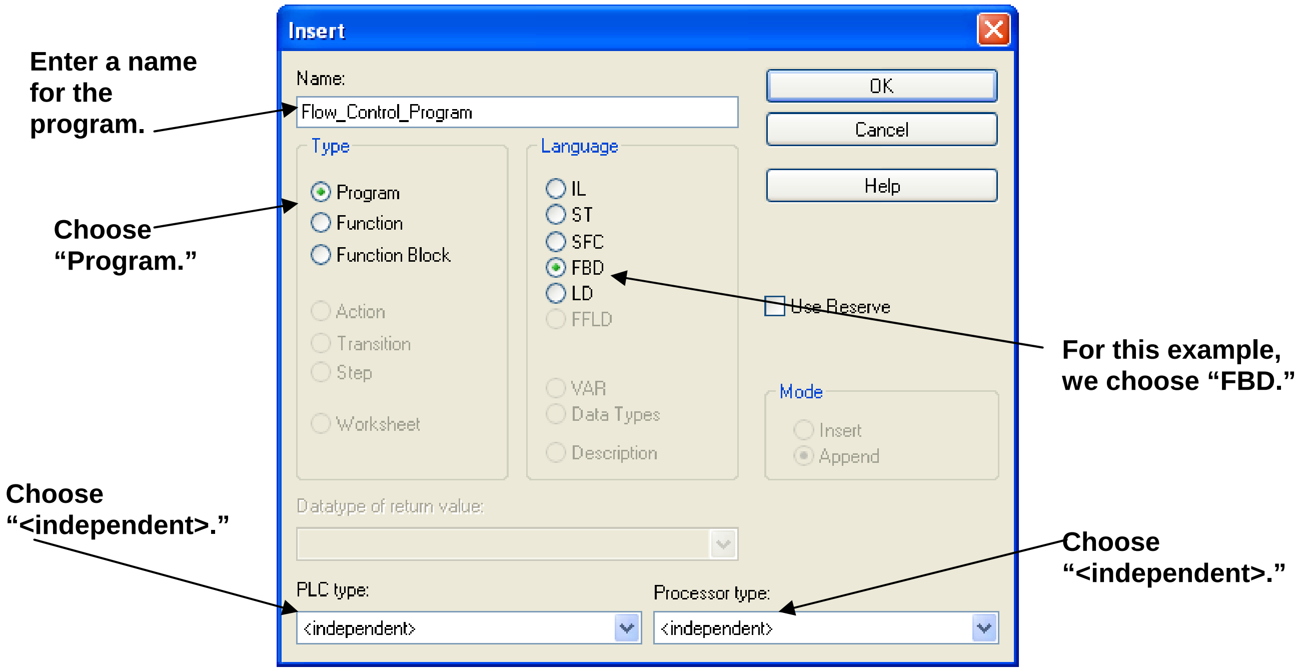
To start, locate the **"Logical POUs"** object in the Project Tree. Right-click on it and choose **"Insert→Program"** from the pop-up menu.



*(**POU** stands for Program Organizational Unit – it basically means a 'program or sub-program' in an IEC 61131 language. IEC-61131 supports five different programming languages; this example uses FBD – Function Block Diagram language, however, you can choose any of the five languages when you create your own programs.)*

## Creating A Program

The Insert dialog box opens.



Name: Flow_Control_Program

Type: [✓ Program] Function / Function Block / Action / Transition / Step / Worksheet

Language: IL / ST / SFC / [✓ FBD] / LD / FFLD / VAR / Data Types / Description

Datatype of return value:

PLC type: <independent>

Processor type: <independent>

For this example, choose **"Program"** for the type and **"FBD"** for the Language.

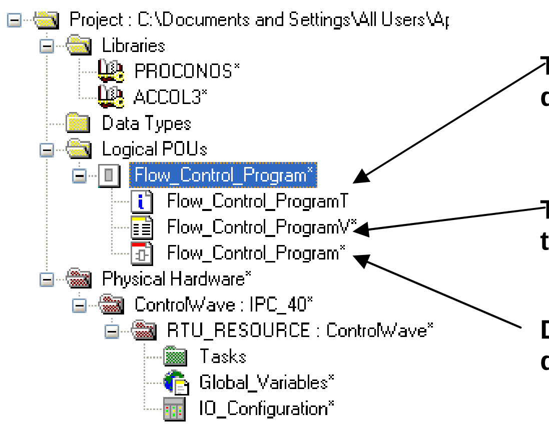
Enter a name for the program we are defining. In this case we have decided on the name 'Flow_Control_Program'.

The PLC type should be **"<independent>"** and the Processor Type should also be specified as

**"<independent>".**

Click on **[OK]** when finished.

A new ‘empty’ program will be added to the Project Tree. Double-click on the ‘Flow_Control_Program*’ icon to define the program.



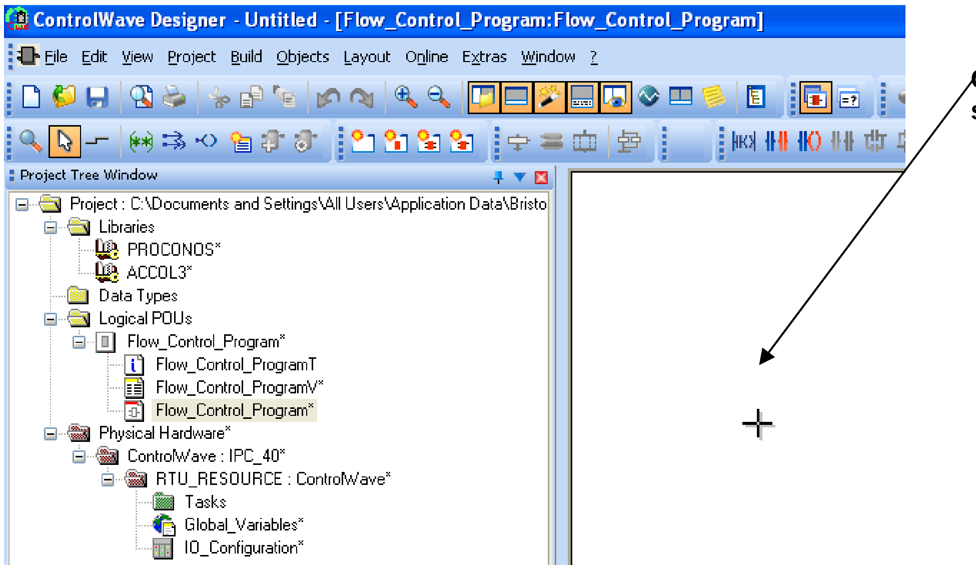
**This part allows you to enter a textual description of the program (optional).**

**This part lists variables associated with the program.**

**Double-click on this part to actually define the program.**

## Inserting Function Blocks in the program

Now click in the right-most portion of the screen.


ControlWave Designer - Untitled - [Flow_Control_Program:Flow_Control_Program]
File Edit View Project Build Objects Layout Online Extras Window ?
Project Tree Window
Project : C:\Documents and Settings\All Users\Application Data\Bristo
Libraries
PROCONOS*
ACCOL3*
Data Types
Logical POUs
Flow_Control_Program*
Flow_Control_ProgramT
Flow_Control_ProgramV*
Flow_Control_Program*
Physical Hardware*
ControlWave : IPC_40*
RTU_RESOURCE : ControlWave*
Tasks
Global_Variables*
IO_Configuration*

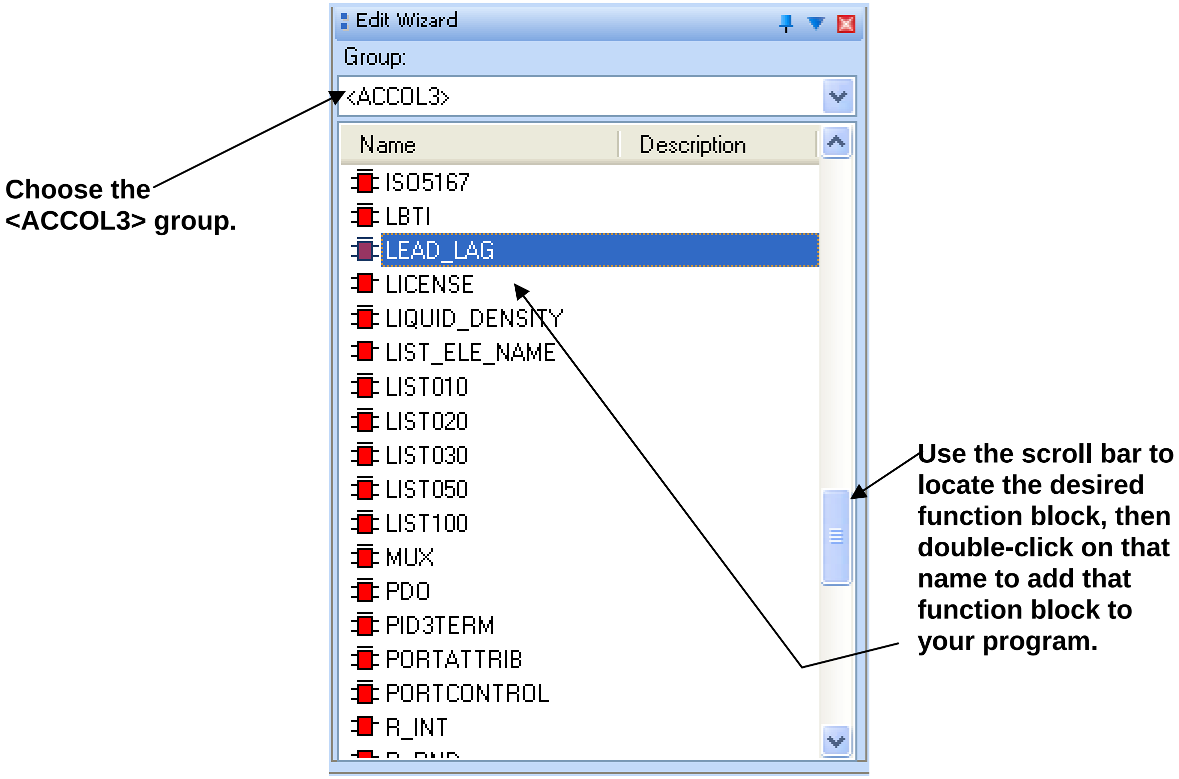
**Click in this portion of the screen**

## Example – Creating A Simple Project

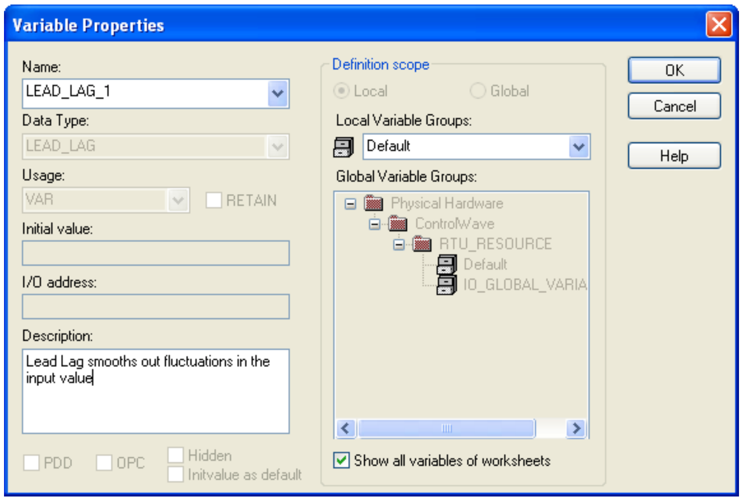
Now you must use the Edit Wizard located in the lower-left corner of the screen. (If the Edit Wizard is not visible, click on the icon shown at left, to activate it.)

Choose the 'ACCOL3' **"Group"**, to access the ACCOL3 function block library, then use the scroll bar to see which function blocks belong to the library.

In order to smooth out fluctuations of the flow input (and protect the flow control valve) we want to feed our flow input into a LEAD_LAG function block. Locate the function block named 'LEAD_LAG' then double-click on it.



The Variable Properties dialog box, shown at right, opens.

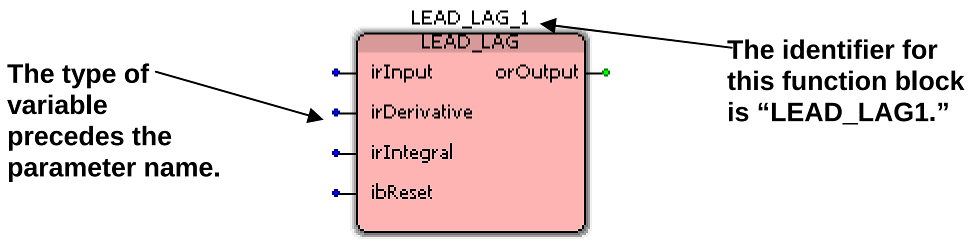


Name: LEAD_LAG_1
Data Type: LEAD_LAG
Usage: VAR
☐ RETAIN
Initial value:
I/O address:
Description: Lead Lag smooths out fluctuations in the input value
☐ PDO ☐ OPC ☐ Hidden ☐ Initvalue as default
Definition scope: (● Local) ○ Global
Local Variable Groups: Default
Global Variable Groups:
☑ Show all variables of worksheets

You might ask at this point, 'Why is the function block being called a variable?' The reason is that the function block is referred to in the program by an instance name, which is like a variable name. The instance name allows the program to distinguish between different instances of the same type of function block, for example, if you had two different LEAD_LAG function blocks in the same POU. You can optionally enter a name of your choice for the function block, or just use the default. You can also enter a comment in the **“Description”** field, as we have done. Now click on the **[OK]** push button.

A graphical representation of the LEAD_LAG function block will be displayed on the screen.

Each parameter name for the function blocks in the ACCOL3 library begins with two or more lowercase letters. These lowercase letters (which we will call the **prefix**) identify whether the parameter is an input, an output, or both an input and output, followed by the possible data types for the parameter.


The type of variable precedes the parameter name.
LEAD_LAG_1
LEAD_LAG
irInput
orOutput
irDerivative
irIntegral
ibReset
The identifier for this function block is “LEAD_LAG1.”

The first letter is always an **'i'** for INPUT, *or* an **'o'** for OUTPUT. If a parameter can be both an INPUT and an OUTPUT, the second letter is an **'o'**. Otherwise, the second, and any other letters in the prefix indicate the various data types allowed for this parameter. The possible types are:

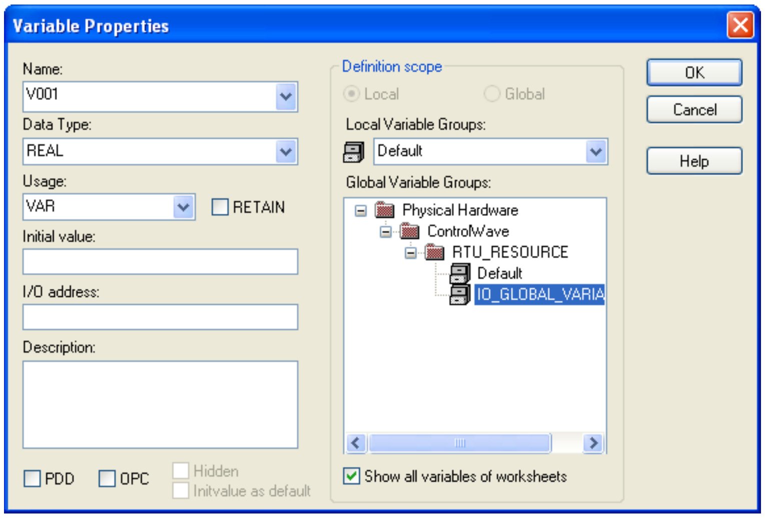
| | |
|---|---|
| ab | BOOL variable required. NO constants allowed. |
| ais | STRING or INT variable required, depending on the usage. No constants allowed. |
| ar | REAL variable required. NO constants allowed. |
| arb | REAL or BOOL variable required. NO constants allowed. |
| aus | USINT variable or array of USINT required. No constants allowed. |
| b | BOOL variable or constant |
| di | DINT variable or constant |
| i | INT variable or constant |
| r | REAL variable or constant |
| s, si | SINT variable or constant |
| s, str | STRING (Note: Character strings must be surrounded by single quotes.) |
| ud,udi | UDINT variable or constant |
| ui | UINT variable or constant |
| us | USINT variable or constant |
| a, any | *if not followed by any other prefix letters*, then any of the following variable types: REAL, SINT, INT, DINT are valid, however, NO constants allowed |

The table, below, summarizes the meaning of the letters in the parameter name prefix.

| **Parameter Name Prefix** | **Input or Output** | **Valid Data Types:** |
|---|---|---|
| ia, iany | INPUT | REAL, SINT, INT, DINT<br>NOTE: You CANNOT use constants on parameters with the 'ia' or 'iany' prefix; only variables may be used. |
| iab | INPUT | BOOL variable - NO constants allowed. |
| iais | INPUT | STRING or INT variable. No constants. |
| iar | INPUT | REAL variable - NO constants allowed. |
| iarb | INPUT | REAL or BOOL variable. NO constants allowed. |
| iaus | INPUT | USINT variable or array of USINT. No constants. |
| ib | INPUT | BOOL variable or constant |
| idi | INPUT | DINT variable or constant |
| ii | INPUT | INT variable or constant |
| ioab | INPUT & OUTPUT | BOOL variable - NO constants allowed. |
| ioar | INPUT & OUTPUT | REAL variable - NO constants allowed. |
| ir | INPUT | REAL variable or constant |
| is, isi | INPUT | SINT variable or constant |
| is, istr | INPUT | STRING  (must be surrounded by single quotes) |
| iudi | INPUT | UDINT variable or constant |
| iui | INPUT | UINT variable or constant |
| ius | INPUT | USINT variable or constant |
| ob | OUTPUT | BOOL variable or constant |
| odi | OUTPUT | DINT variable or constant |
| oi | OUTPUT | INT variable or constant |
| or | OUTPUT | REAL variable or constant |
| oud | OUTPUT | UDINT variable or constant |
| oui | OUTPUT | UINT variable or constant |
| Ous | OUTPUT | USINT variable or constant |

Click on the dot feeding into the **irInput** parameter of the LEAD_LAG function block, then go to the menu bar and click as follows: **Objects→Variable** (Alternatively, you could just double-click on the dot.)

The Variable Properties dialog box opens. A default variable name of 'V001' appears as well. However, the LEAD_LAG function block must receive its input from the F101_INPUT pin on the Analog Input process I/O board (defined earlier in Step 4); *that* is the variable we want.



Variable Properties

Name: V001
Data Type: REAL
Usage: VAR ☐ RETAIN
Initial value:
I/O address:
Description:
☐ PDD ☐ OPC ☐ Hidden ☐ Initvalue as default

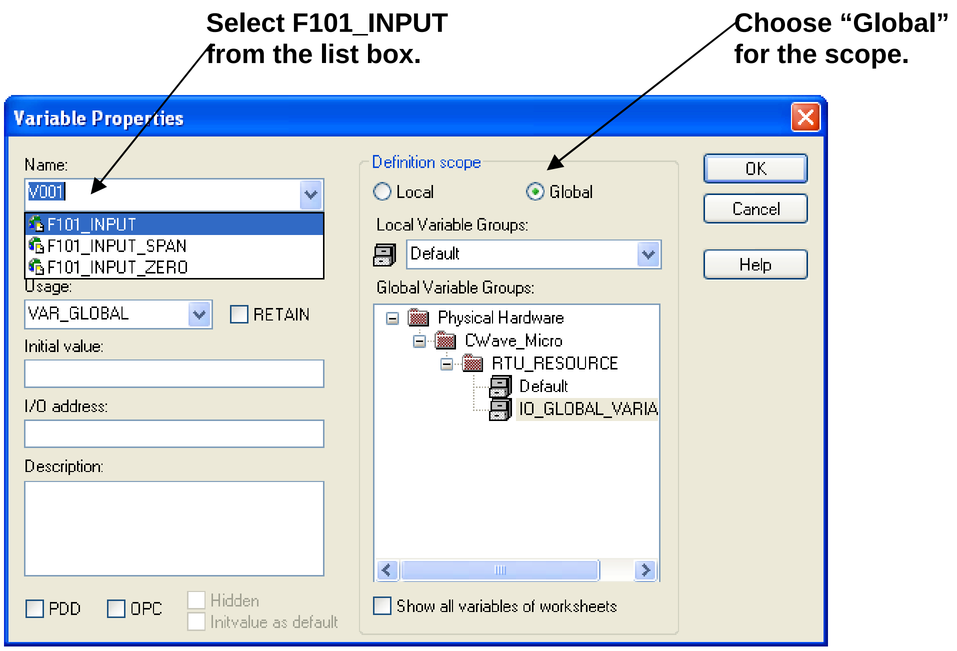
Definition scope: ● Local ○ Global
Local Variable Groups: Default
Global Variable Groups:
- Physical Hardware
  - ControlWave
    - RTU_RESOURCE
      - Default
      - IO_GLOBAL_VARIA

☑ Show all variables of worksheets

In the 'Global Variable Groups' section of the dialog box, click on the '+' signs to expand the folder tree. Continue this until you have highlighted the 'IO_GLOBAL_VARIABLES' item. We want to highlight this item because it will contain the I/O variable defined earlier.

In the 'Scope' section, click on the **"Global"** button. ('Global' refers to anything that is accessible to all POUs in this ControlWave project; 'Local' refers to something that is confined to the current POU.)

Click in the **Name** list box to see a list of variables. Select F101_INPUT from the list box, since that is the variable we want. Finally, click on **[OK]**.


Select F101_INPUT from the list box.
Choose "Global" for the scope.
OK
Cancel
Help

Variable Properties

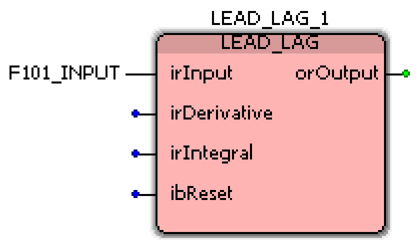
Name: V001
- F101_INPUT
- F101_INPUT_SPAN
- F101_INPUT_ZERO

Usage: VAR_GLOBAL ☐ RETAIN
Initial value:
I/O address:
Description:
☐ PDD ☐ OPC ☐ Hidden ☐ Initvalue as default

Definition scope: ○ Local ● Global
Local Variable Groups: Default
Global Variable Groups:
- Physical Hardware
  - CWave_Micro
    - RTU_RESOURCE
      - Default
      - IO_GLOBAL_VARIA

☐ Show all variables of worksheets

The 'F101_INPUT' variable will now be displayed on the **irInput** parameter of the LEAD_LAG function block.

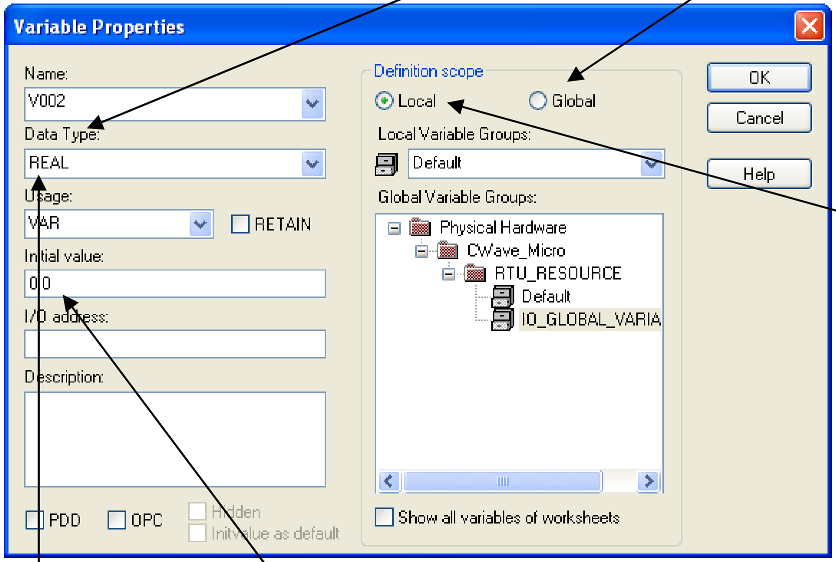


Next, we can proceed to define variable names for the other inputs (**irDerivative**, **irIntegral**, and **ibReset**).

Double-click on the **IrDerivative** parameter. A variable name will automatically be assigned, in this case 'V002'. You can enter a different name, or accept V002. *Alternatively, you can just enter a constant value here, instead of a variable name, if this parameter does not have an 'ia' or 'iany' prefix (see table on page 34) and you know that this value will never need to be changed, and you don't intend to collect/display it at the PC. (If you encounter the error 'Operand not implemented or area exceeded' at download, this indicates that you should NOT have used a constant because this parameter has an 'ia' or 'iany' prefix.)*

**This is a default name ControlWave Designer assigns automatically. You can change it if desired, or leave it as is.**

**You can reference a "Global" variable outside of this POU. Any I/O variable must be "Global." If you want to define a non-I/O variable as "Global" we recommend you do NOT mix I/O and non-I/O in the same variable worksheet.**



Name: V002
Data Type: REAL
Usage: VAR
☐ RETAIN
Initial value: 0.0
I/O address:
Description:
☐ PDD ☐ OPC ☐ Hidden ☐ Init value as default
Definition scope: [✓ Local] Global
Local Variable Groups: Default
Global Variable Groups:
☐ Show all variables of worksheets

**You can only reference a "Local" variable within this POU. Typically, you should choose "Local" *unless* this is an I/O variable which references data going directly form/to an I/O board, or it is being shared among more than one POU.**

**Enter an initial value here.**

**Choose the data type based on the prefix letters for the parameter name:**
**r = REAL**
**b = BOOL**

NOTE: You'll notice that you have the option of defining the new variable as either 'Local' or 'Global' . (If the Local/Global options are "grayed out," de-select the **Show all variables of worksheets** button to access them.)

As we noted before, Local variables are only accessible within this POU. If you define a variable as a local variable, and you create *another* POU, you will NOT be able to access the local variables in the first POU; they are completely unknown to the second POU. If you define a variable as global, it is accessible in the current POU, *and* in any other POUs you define for this project. This distinction isn't too important for this particular example, however, it is discussed in detail in the *ControlWave Designer Programmer's Handbook* (document# D5125).

We recommend, however, that if you are NOT defining an I/O variable for an I/O board that you choose **"Local"**. Alternatively, if you *do* choose **"Global"**, make sure you choose the 'Default' variable group, or some other variable group you have defined. Do NOT choose the 'IO_GLOBAL_VARIABLES' group for any non-I/O variables.

Choose the proper **"Data type"**, in this case 'REAL', and enter an **"Initial value"**, if desired. (In this case the initial value is the default value of 0.0, some of the other variables in this example will require initial values).

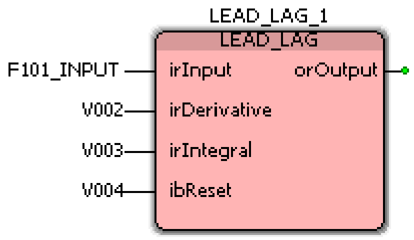
Although we aren't using them in this example the **"RETAIN"**, **"PDD"** and **"OPC"** fields are useful. The **"RETAIN"** box is checked if you want the last value of this variable to be used on re-start after a power failure or warm download.

Checking the **"PDD"** box allows the controller to reference this variable by name. Reference by name is necessary if you intend to access this variable by external software which requires 'read-by-name' access, such as DataView, or other OpenBSI Utilities.

Checking the **"OPC"** box adds this variable to a collection list used by the ObjectServer, or by the OpenBSI Signal Extractor. This is necessary when data is to be extracted and sent to a database.

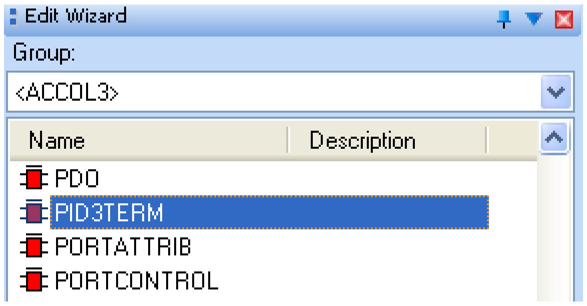
Finally, click on **[OK]** when finished.

Repeat this process for the other input variables in the LEAD_LAG function block **- -irIntegral**, and **ibReset**. The **irIntegral** will be of the REAL data type and should be assigned an initial value of 0.7. The **ibReset** will be of the BOOL data type and should be assigned an initial value of FALSE (i.e. OFF). When finished, the LEAD_LAG function block should appear similar to the figure shown at right.



Notice that we have *not* defined the **orOutput** parameter yet. This Output parameter will actually send data out to another function block - - the PID3TERM function block. Let's add that function block now.

To insert the PID3TERM function block, click in an open area of the window pane. Again, in the Edit Wizard you must choose '<ACCOL3>' for the **"Group"**, then scroll down to locate the PID3TERM function block, and double-click on it.

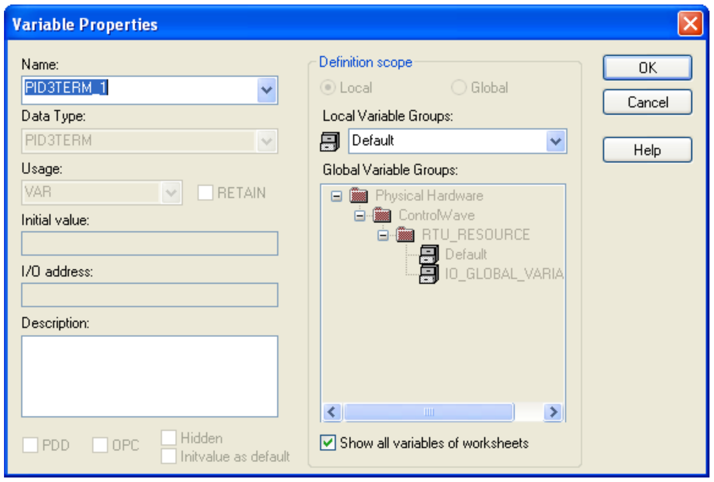


Edit Wizard

Group: <ACCOL3>

| Name | Description |
|---|---|
| PDO | |
| PID3TERM | |
| PORTATTRIB | |
| PORTCONTROL | |

The Variable Properties dialog box will appear. You can optionally enter a name other than the default. You can also, optionally, enter a comment in the **"Description"** field. Then just click on **[OK]**.



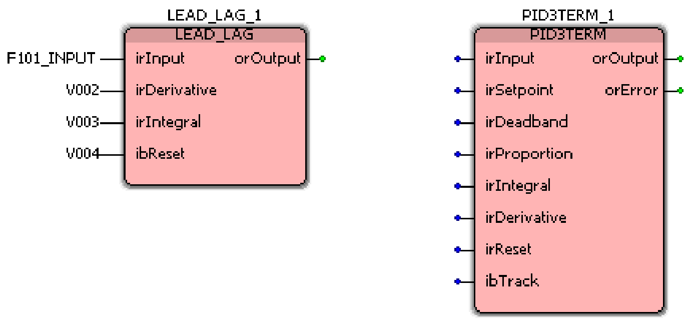
Variable Properties

Name: PID3TERM_1
Data Type: PID3TERM
Usage: VAR [ ] RETAIN
Initial value:
I/O address:
Description:
[ ] PDD [ ] OPC [ ] Hidden [ ] Initvalue as default

Definition scope: (●) Local ( ) Global
Local Variable Groups: Default
Global Variable Groups:
Physical Hardware
ControlWave
RTU_RESOURCE
Default
IO_GLOBAL_VARIA
[✓] Show all variables of worksheets

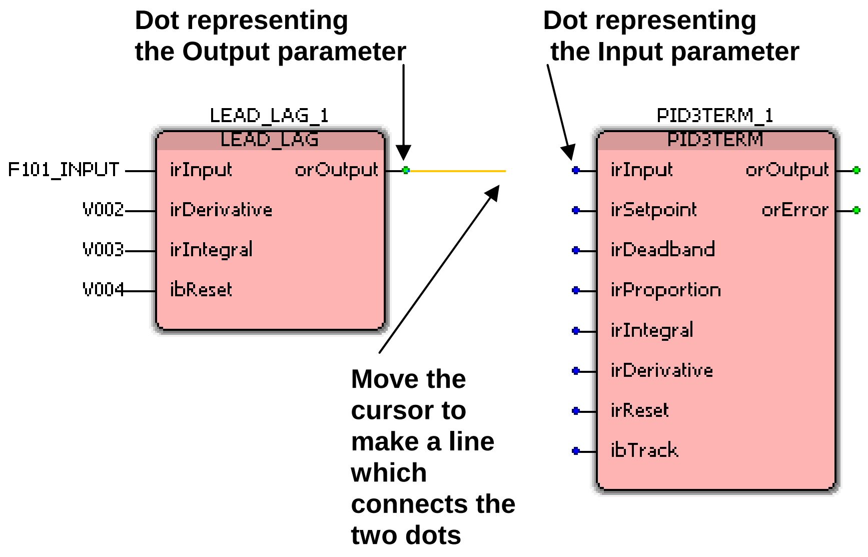
**Now we have two different function blocks:**

The PID3TERM function block will appear. We now have two function blocks, LEAD_LAG and PID3TERM.



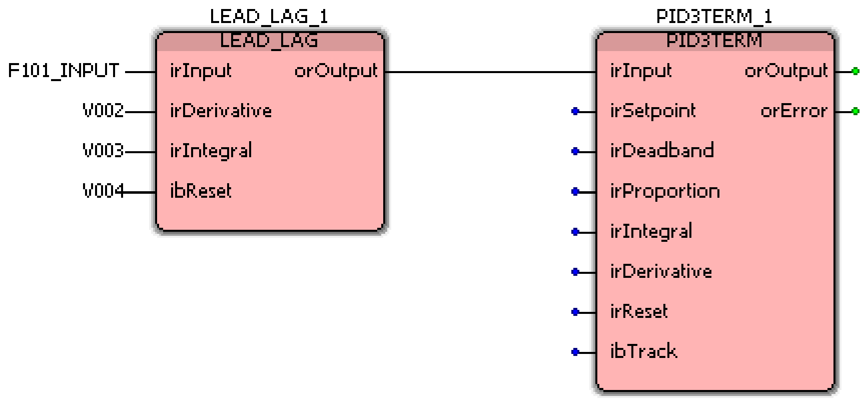
## Connecting Function Blocks Together – Method 1

We want to feed the output of the LEAD_LAG function block (i.e. a smoothed out flow value) into the input of the PID3TERM. There are various ways to do this; in this method, click on the 'Connect Objects' icon (shown above), then click on the green dot representing the **orOutput** parameter of the LEAD_LAG function block. Move the mouse horizontally and you will notice that a red line is drawn as you move the cursor.



Position the cursor on the blue dot representing the **irInput** parameter of the PID3TERM function block and click. The connection has now been made.

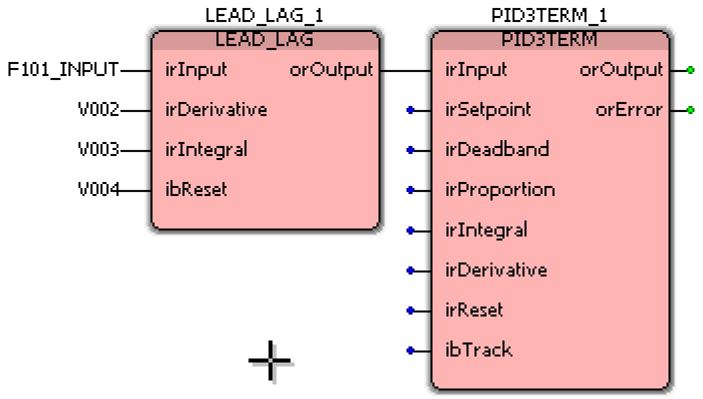
**A connection has now been established.**



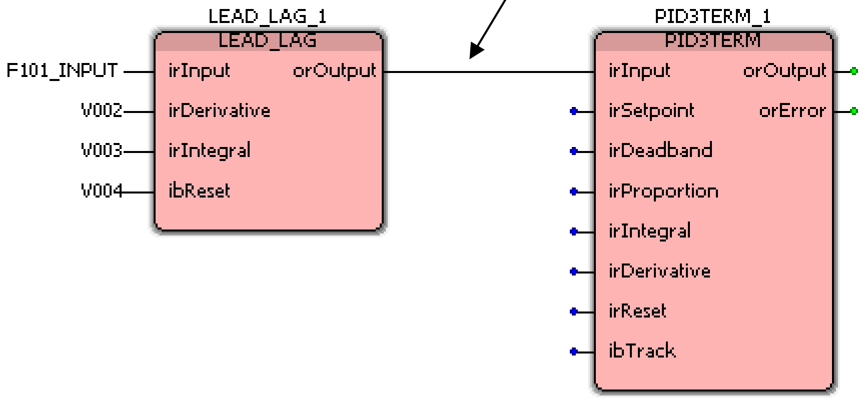
## Connecting Function Blocks Together – Method 2

Another method for making the connection would have been to drag the PID3TERM function block over to the LEAD_LAG function block so that the **orOutput** of the LEAD_LAG connects with the **irInput** of the PID3TERM.

**Drag the PID3TERM function block over to the LEAD_LAG function block so that the "orOutput" of LEAD_LAG connects with the "irInput" of PID3TERM.**



**Drag the PID3TERM back over to its previous position. This stretches the connection between the two function blocks.**

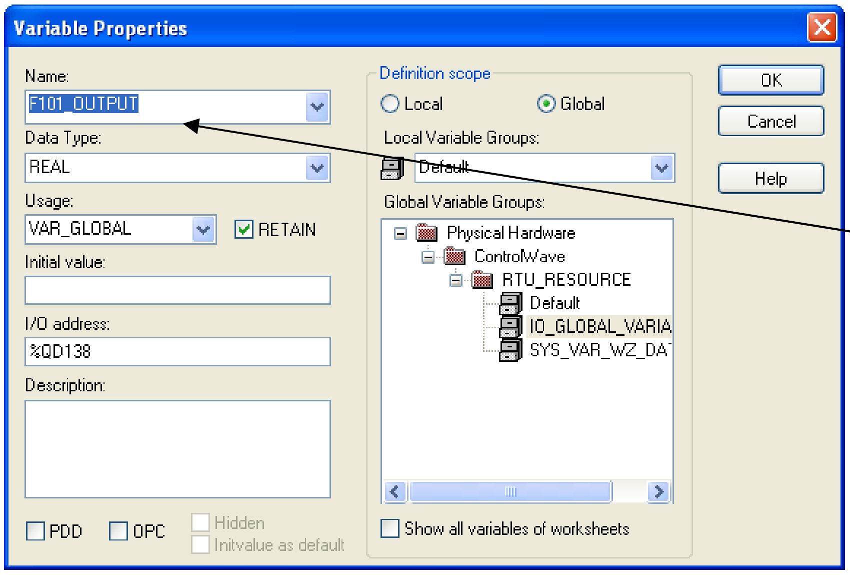


Once the connection has been established, the PID3TERM can be dragged back to its previous location; the connection between them will stretch accordingly.

NOTE: This method is only appropriate if you have a small number of function blocks, and a small number of connections to make.

Now you can proceed to define the **irSetpoint**, **irDeadband**, **irProportion**, **irIntegral, irDerivative**, **irReset**, **ibTrack**, and **orError** variables of the PID3TERM by double clicking on each parameter (see previous examples of this process on pages 35 to 37). Don't forget to choose the correct data type (in this case 'REAL' or 'BOOL'), and, for the input variables, assign appropriate initial values for this example. The table, below, shows the correct data types and some recommended initial values for this example:

| **PID3TERM Parameter Name** | **Data Type** | **Initial Value for this example** |
|---|---|---|
| **IrSetpoint** | REAL | 40.0 |
| **IrDeadband** | REAL | 0.0 |
| **IrProportion** | REAL | 2.0 |
| **IrIntegral** | REAL | 0.5 |
| **IrDerivative** | REAL | 0.0 |
| **IrReset** | REAL | 0.0 |
| **IbTrack** | BOOL | FALSE |
| **OrError** | REAL | Not applicable |

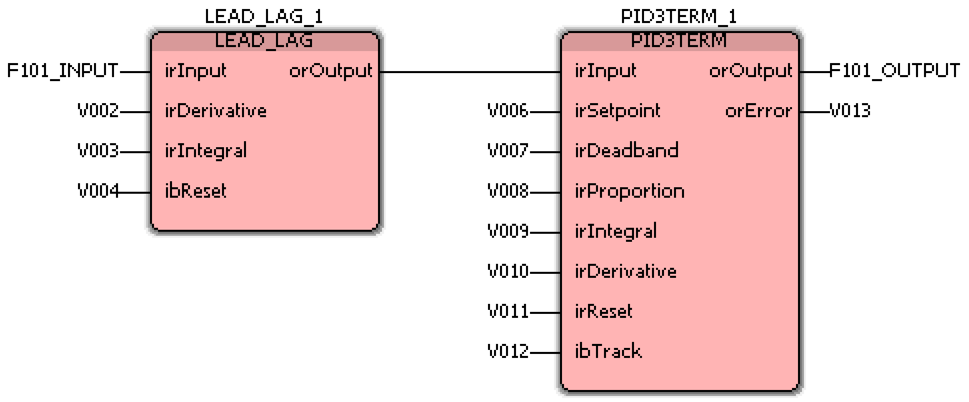


Name: F101_OUTPUT
Data Type: REAL
Usage: VAR_GLOBAL ☑ RETAIN
Initial value:
I/O address: %QD138
Description:
☐ PDD ☐ OPC ☐ Hidden ☐ Initvalue as default
Local Variable Groups: Default
Global Variable Groups:
☐ Show all variables of worksheets

**Choose F101_OUTPUT which is the name of PIN1 on the analog output board.**

That just leaves the **orOutput** parameter of the PID3TERM. Remember that we need to feed the output of the PID controller out to the analog output process I/O board, so it can actuate the flow control valve, thereby controlling the flow in the pipeline. We defined the output pin for this purpose to be F101_OUTPUT; we can reference that now. Double-click on the **orOutput** and choose F101_OUTPUT from the **"Name"** field in the Variable Properties dialog box. *(Remember that to do this, you have chosen the IO_GLOBAL_VARIABLES group from the tree, and clicked on the* ***"Global"*** *button.*

So now we have defined data types for all of our variables, entered initial values where necessary, etc.

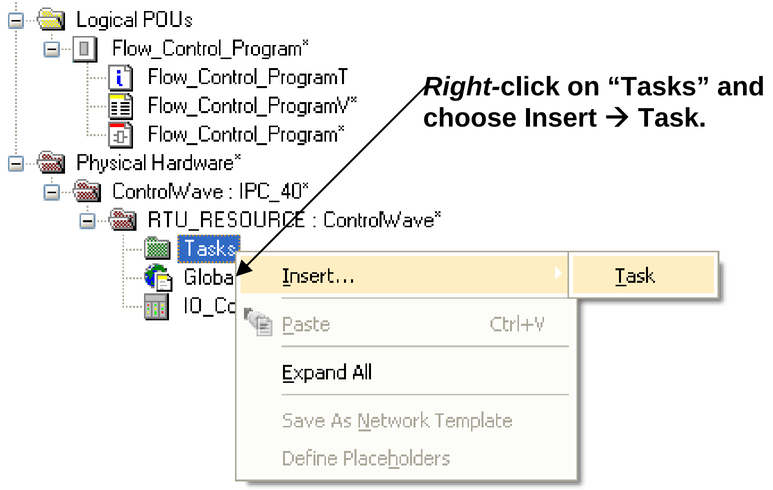


Our program (POU) is done! In order to make it do anything, however, it has to be associated with a **task**.

## Step 6. Create A Task Which Can Run The Program

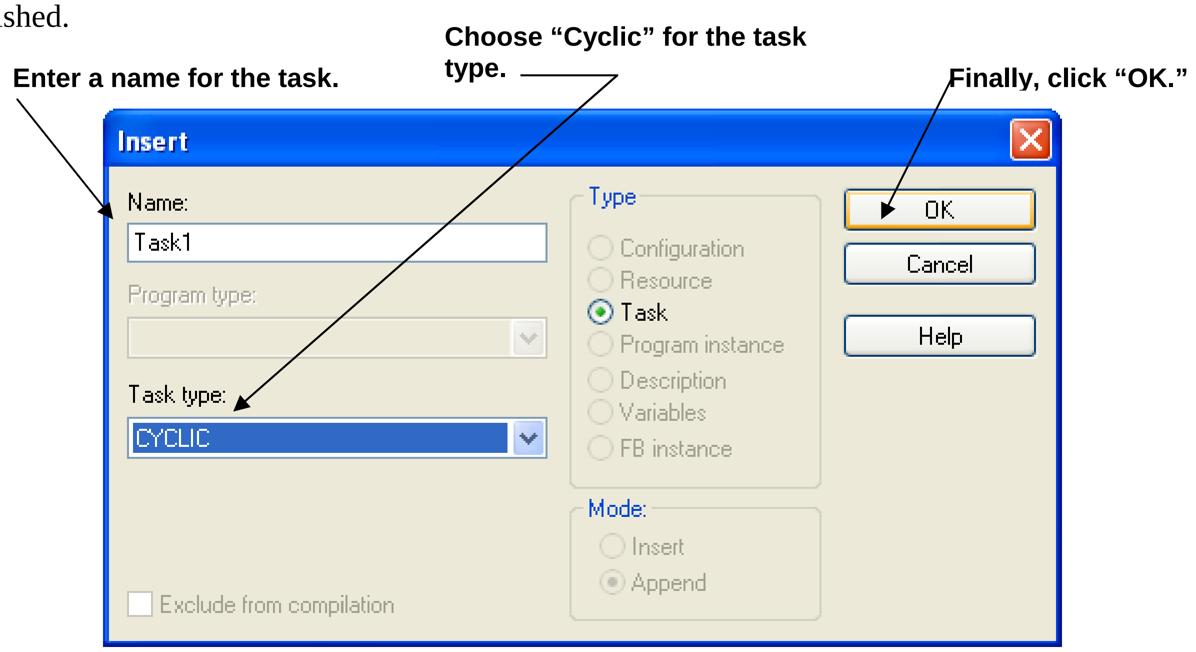
**Tasks** determine how fast a program, or program(s) are executed. When a task is started, it reads all inputs from the input process I/O boards, it then performs all calculations in the programs of a task, and then it writes output data out through the output process I/O boards.

Tasks are found below the **“Physical Hardware”** branch of the Project Tree. To create a task, *right*-click on the **“Tasks”** icon in the project tree, and choose **“Insert”** and **“Task’** from the pop-up menu.



The Insert dialog box opens.

Enter a **"Name"** for the task. In this case we have chosen 'Task1'. If you enter 'DEFAULT' for the name, the task will run whenever time is available - this is sometimes referred to as the 'idle task.' In general, 'CYCLIC' should be chosen for the **"Task type"**. Click on **[OK]** when finished.


Enter a name for the task.
Choose "Cyclic" for the task type.
Finally, click "OK."
Insert
Type
OK
Cancel
Help
Mode:

Name: Task1

Program type:

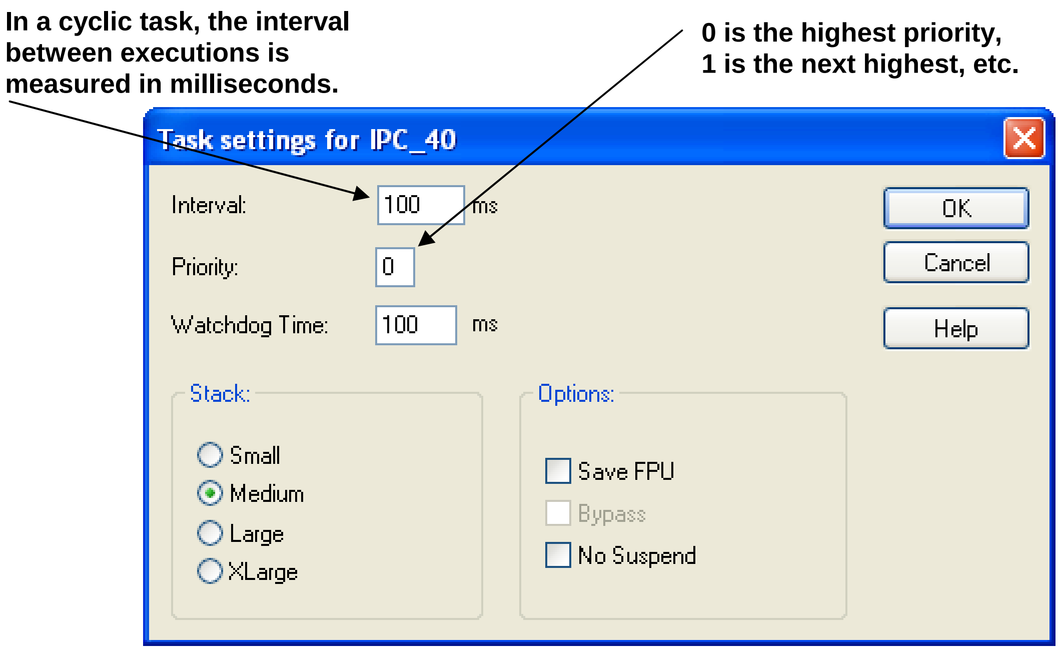
Task type: CYCLIC

Type: Configuration, Resource, [✓ Task], Program instance, Description, Variables, FB instance

Mode: Insert, [✓ Append]

Exclude from compilation

The Task Settings dialog box opens. Choose the rate of execution of the task by entering a value in the **"Interval"** field. The interval is measured in milliseconds. Generally, **"Watchdog Time"** is set to the same value as the **"Interval"**. A Watchdog condition is reported if the task does not execute within the watchdog time. This allows task slippage to be detected.


In a cyclic task, the interval between executions is measured in milliseconds.
0 is the highest priority, 1 is the next highest, etc.
Task settings for IPC_40
OK
Cancel
Help

Interval: 100 ms

Priority: 0

Watchdog Time: 100 ms

Stack: Small, [✓ Medium], Large, XLarge

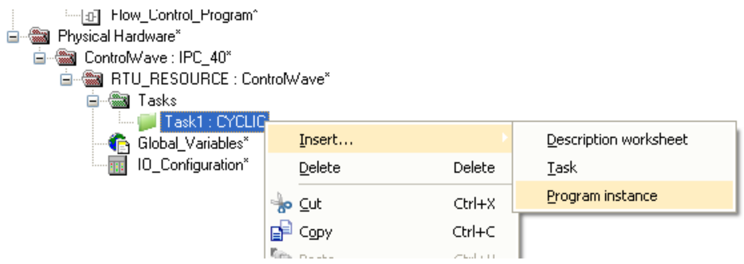
Options: Save FPU, Bypass, No Suspend

If desired, specify a **“Priority”** for the task. ‘0’ is considered the highest priority. ‘1’ is the next highest priority, and so on.

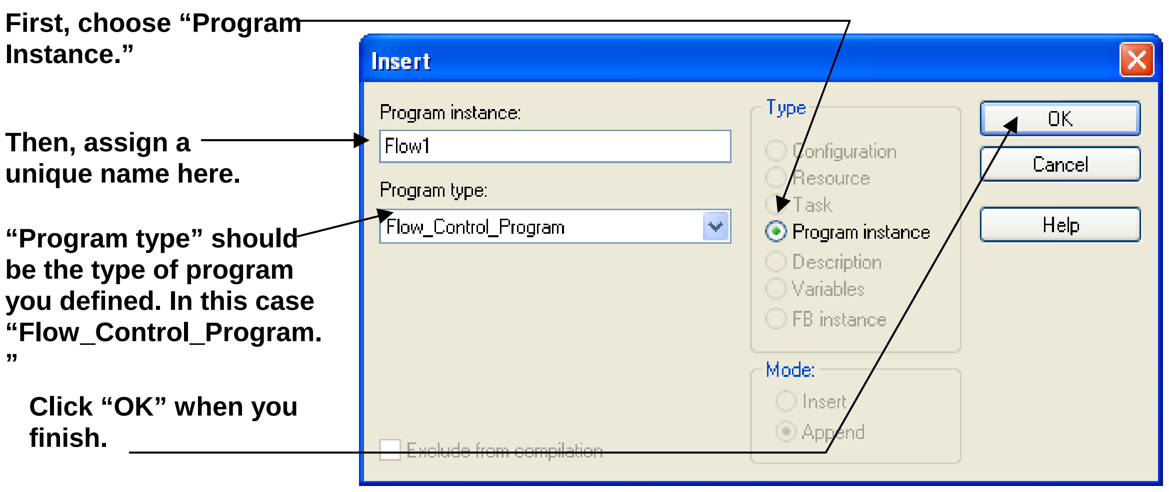
NOTE: If you chose ‘DEFAULT’ as the task name, the task will NOT execute according to an interval, but instead, will be executed whenever time is available. It serves as the idle task.

When finished, click on **[OK]** and the task will have been defined.

Now that the task exists, however, it is necessary to associate the program that we wrote with the task. Otherwise we will just have an empty task executing. To associate the program with the task, *right*-click on the icon for the task in the project tree, and choose **“Insert”** and **“Program instance”** from the pop-up menu.



The Insert dialog box opens. Choose **“Program instance”** as the **“Type”**.


First, choose “Program Instance.”
Then, assign a unique name here.
“Program type” should be the type of program you defined. In this case “Flow_Control_Program.”
Click “OK” when you finish.
Insert
Type
Configuration
Resource
Task
Description
Variables
FB instance
Mode:
Insert
Append
Exclude from compilation
OK
Cancel
Help

Program instance: Flow1

Program type: Flow_Control_Program

Type: [✓ Program instance]

Mode: [✓ Append]

When we insert the program, we are actually creating something called a **program instance**. Each program instance must be assigned a unique name - - in this case we chose ‘Flow1’. The program instance is essentially a copy of the ‘Flow_Control_Program’ program we created. Copies are used because, theoretically, you might want to use the same program in different tasks, and if you didn’t use a copy there would not be available memory for internal (local) variables for each separate copy.

All local variables created in a POU are only for a particular instance. This becomes very important if you want to create a user defined function block from one of your POUs. (*User defined function blocks are discussed in the ControlWave Designer Programmer's Handbook, document# D5125.)*

Click on **[OK]** when finished.

## Step 7. Compile the Program and, if necessary, correct any errors

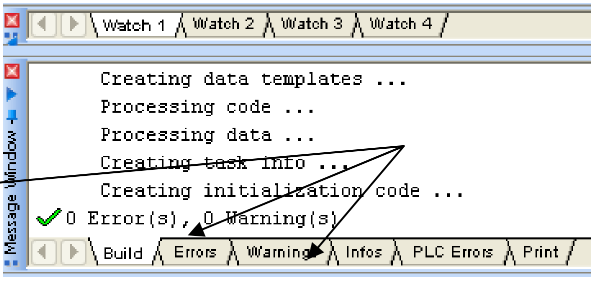
Now the program can be compiled. The compilation process takes your project (programs, function blocks, tasks, etc.) and generates machine-readable code from it, that can be run in your ControlWave controller, or in the I/O Simulator.

The compilation process checks for any syntactical errors in your program, and also issues warnings about possible problems with the structure of the program. It does NOT check for logic errors in your control strategy, however.

To compile the program, click on the icon shown at left, or go to the menu bar, and click as follows: **Build→Make**

Various messages scroll by on the screen.

**If there are errors or warnings, click on the "Errors" or "Warnings" tab for more information.**

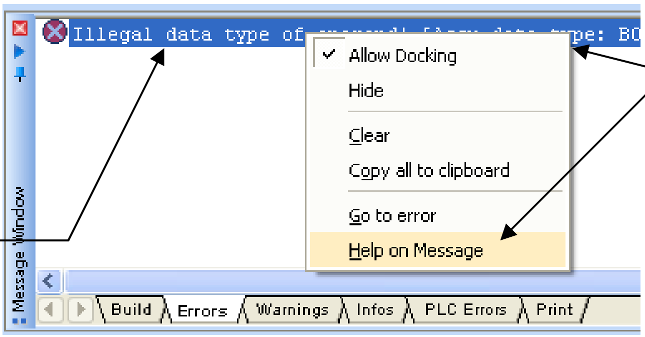


```
Creating data templates ...
Processing code ...
Processing data ...
Creating task info ...
Creating initialization code ...
0 Error(s), 0 Warning(s)
```

If there are errors or warnings generated during the compilation, you can view them by clicking on the 'Errors' or 'Warnings' tabs, respectively.

Often, you can double-click on the error listed in the error window, and the compiler identifies its location in the project.

**Double-click on the error message to jump to the location in the file where the compiler detects the error.**



```
Illegal data type of
```

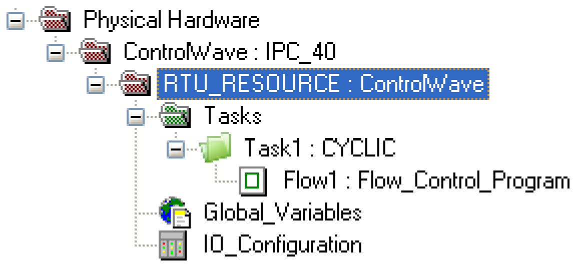
**Right-click on the error and choose "Help on Message" from the pop-up menu to view more information about the error.**

For more information about what a particular error message means, *right*-click on the error message, then choose **"Help on Message"** from the pop-up menu (if it is available.)

## Step 8. Download the program into your ControlWave unit, or the I/O Simulator

WARNING

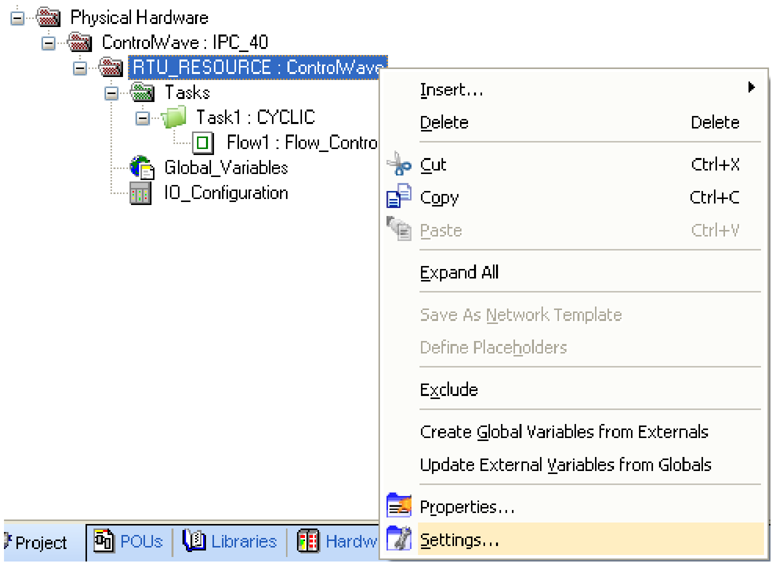
Users should never attempt to download an *untested* program into a controller if the controller is currently connected to a running plant or industrial process. Safeguards must be taken prior to downloading to ensure that the controller is isolated from the process and I/O is disconnected. Failure to take such precautions could result in injury to persons or damage to property.



Before a download can be performed, the resource which will receive the download must be properly configured.

The IEC 61131 real-time system which will execute your compiled program code runs either in the PC-resident I/O Simulator or in the ControlWave controller.

If the I/O Simulator will receive the download, only the choice of simulation must be made.



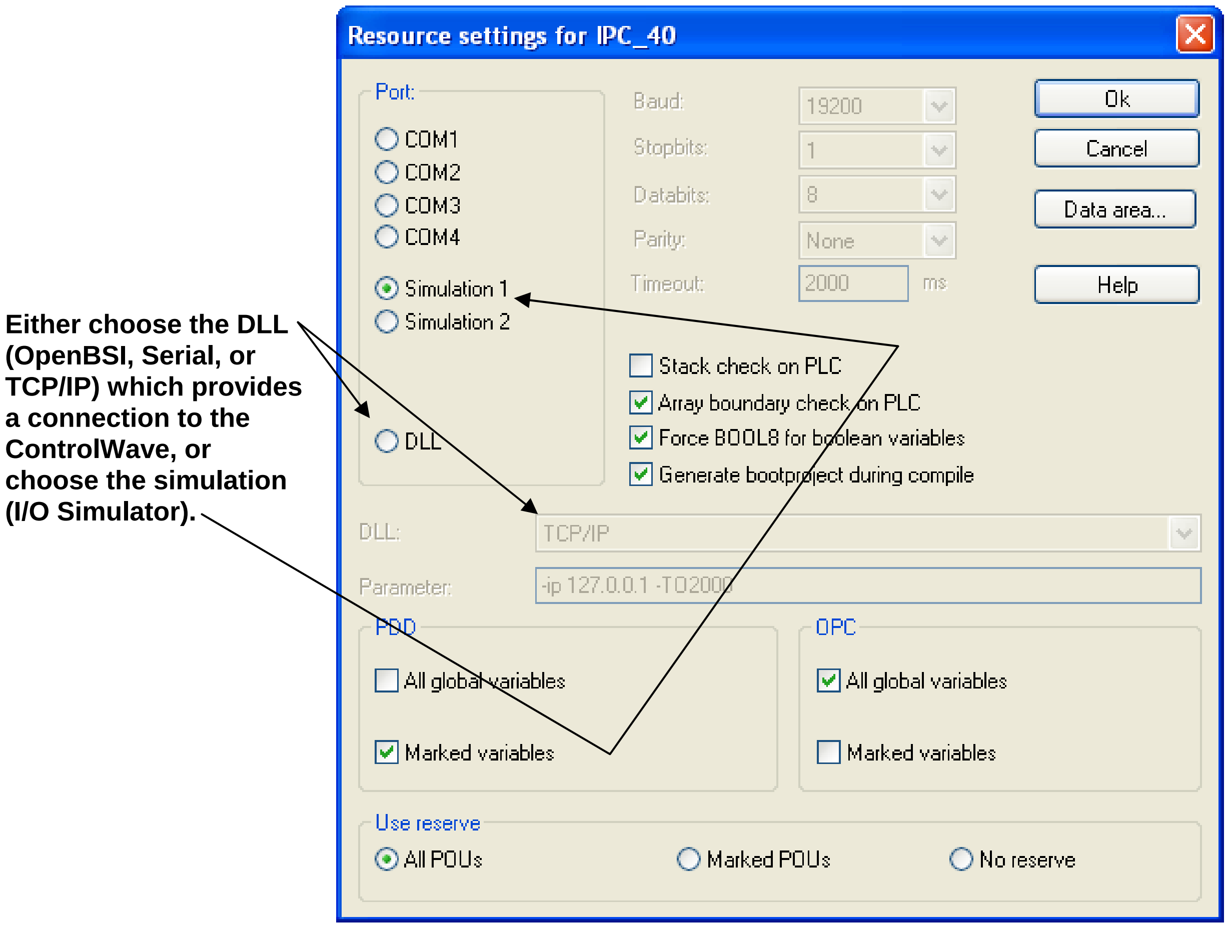
If the ControlWave controller will receive the download, the DLL which will be used to perform the download must be identified.

To choose the resource, *right* click on the resource and choose **"Settings"** from the pop-up menu.

The Resource Settings dialog box opens. If you will initially be downloading into the I/O Simulator, choose **"Simulation 1"**.

If, instead, you will be downloading directly into a ControlWave controller, choose **"DLL"** and use the DLL list box to choose the DLL which will provide your desired type of connection (OpenBSI connection, serial connection, or TCP/IP connection).

Click on **[Ok]** when you have made your choices.



**Either choose the DLL (OpenBSI, Serial, or TCP/IP) which provides a connection to the ControlWave, or choose the simulation (I/O Simulator).**

Resource settings for IPC_40

Port: ( ) COM1 ( ) COM2 ( ) COM3 ( ) COM4 [✓ Simulation 1] ( ) Simulation 2 ( ) DLL

Baud: 19200
Stopbits: 1
Databits: 8
Parity: None
Timeout: 2000 ms

☐ Stack check on PLC
☑ Array boundary check on PLC
☑ Force BOOL8 for boolean variables
☑ Generate bootproject during compile

DLL: TCP/IP
Parameter: -ip 127.0.0.1 -TO2000

PDD: ☐ All global variables ☑ Marked variables

OPC: ☑ All global variables ☐ Marked variables

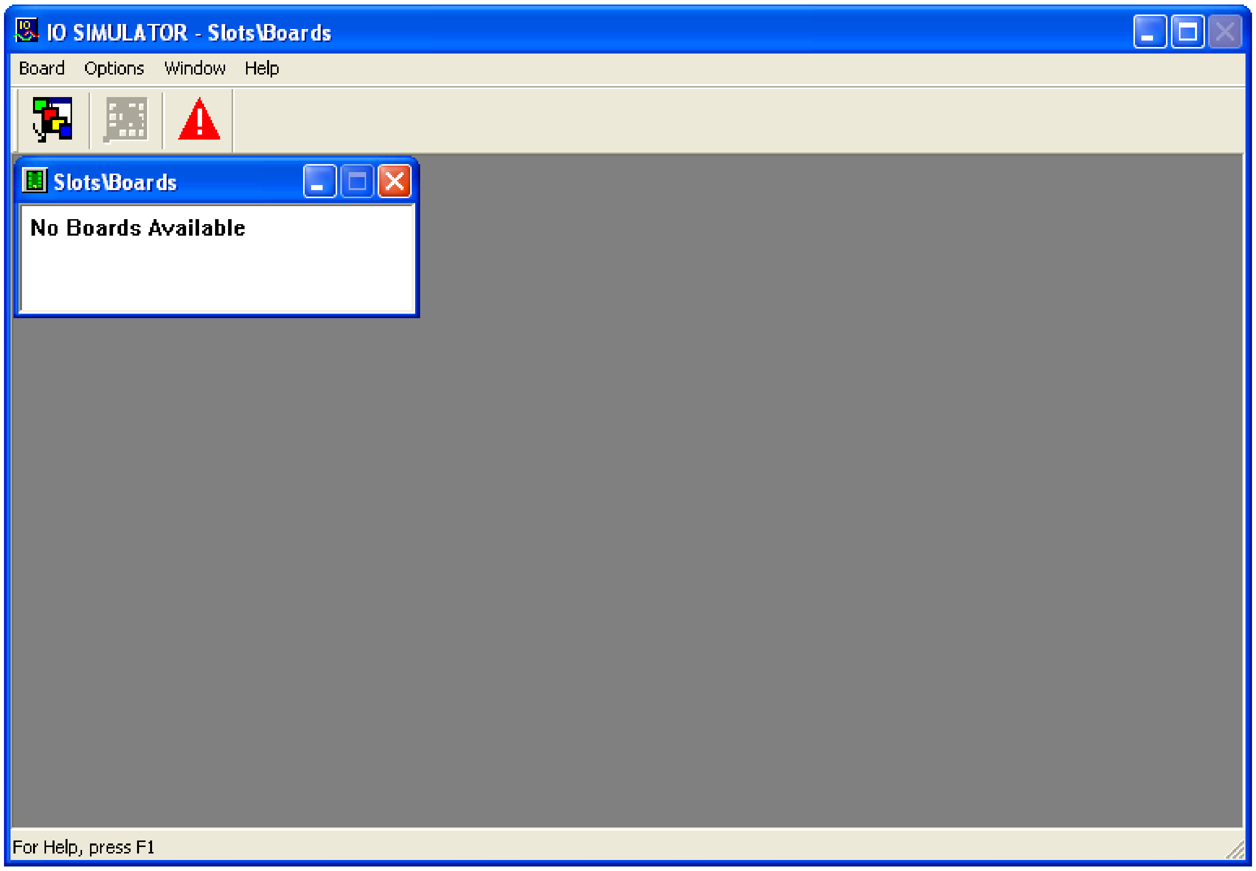
Use reserve: [✓ All POUs] ( ) Marked POUs ( ) No reserve

*NOTE: For purposes of this example, we will use the I/O Simulator.*

# Example – Creating A Simple Project

Next, click as follows: **Online→Project Control**

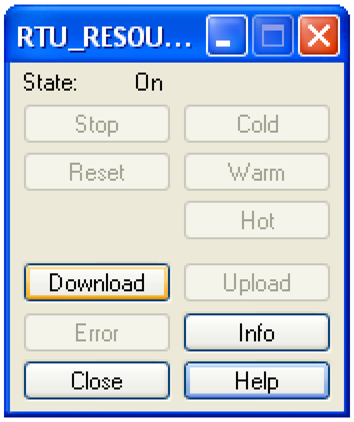
The I/O Simulator opens. If necessary, minimize the I/O Simulator in order to uncover the RTU Resource dialog box.



No Boards Available

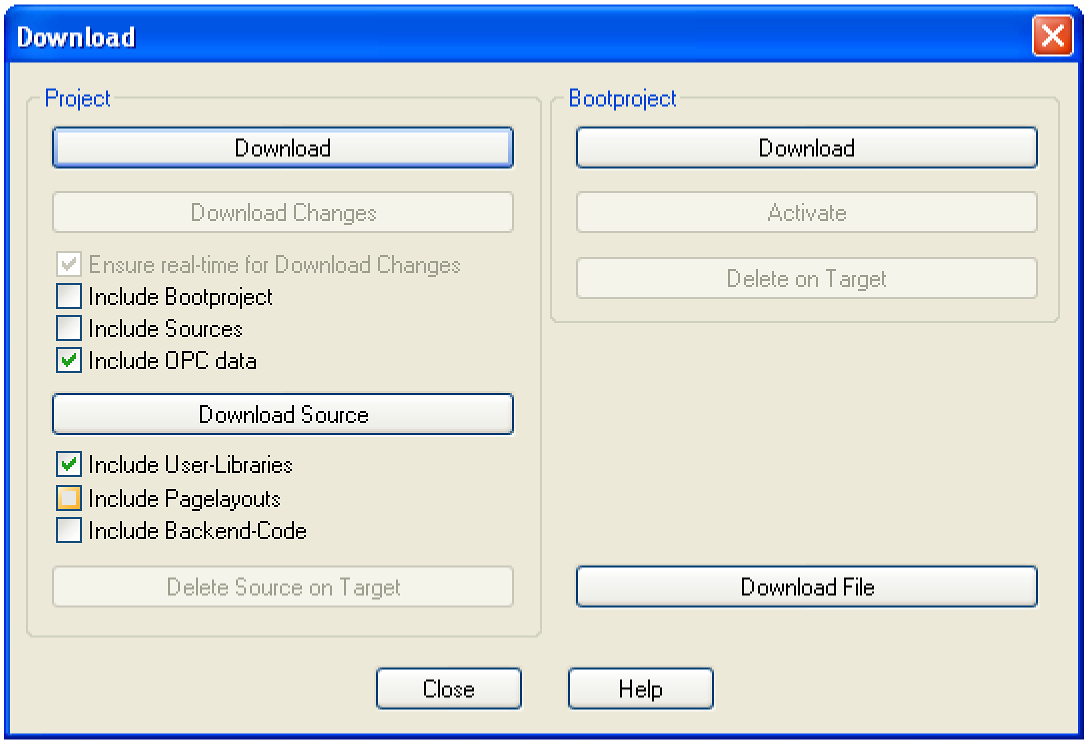
For Help, press F1

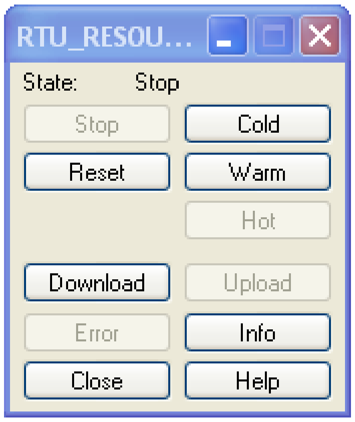
Click on the **[Download]** button in the RTU Resource dialog box.



State: On

The Download dialog box opens.



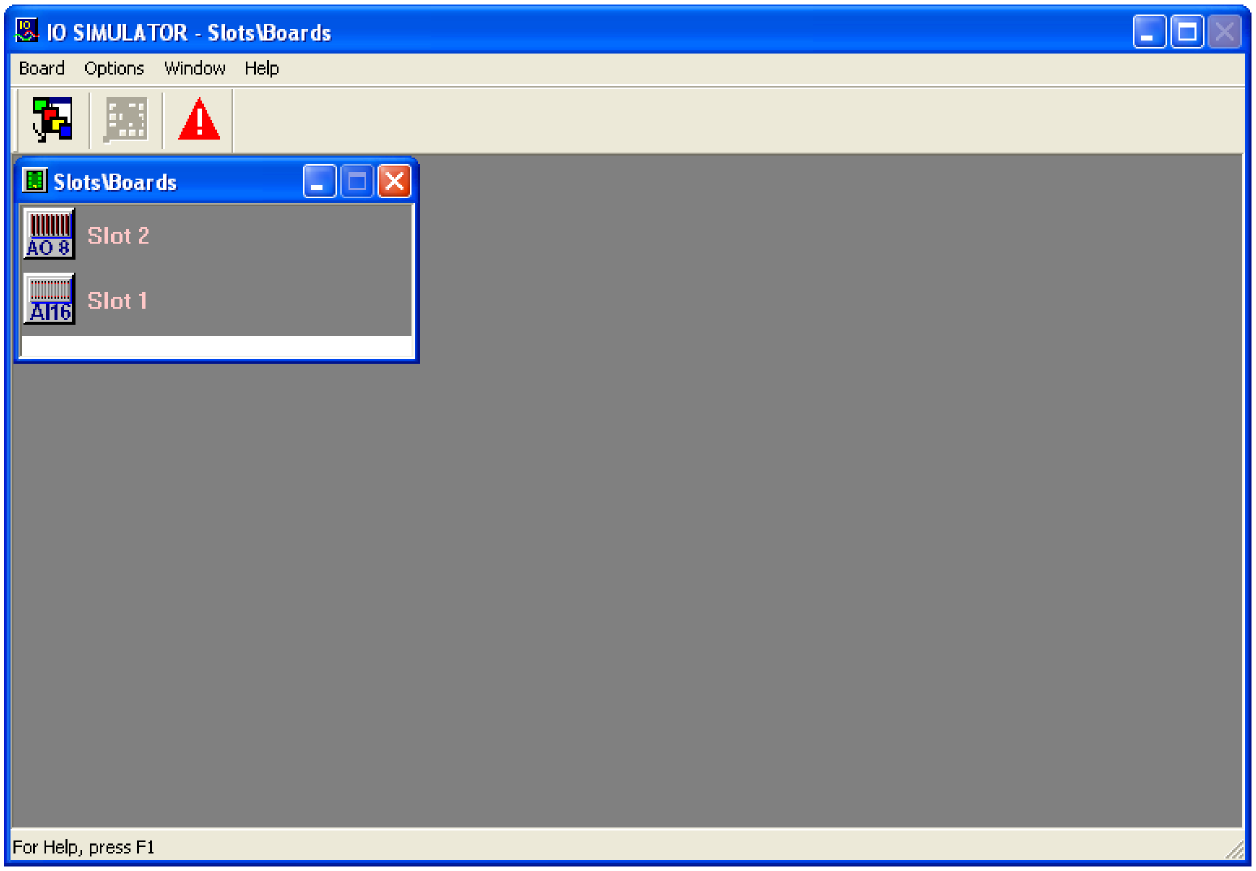


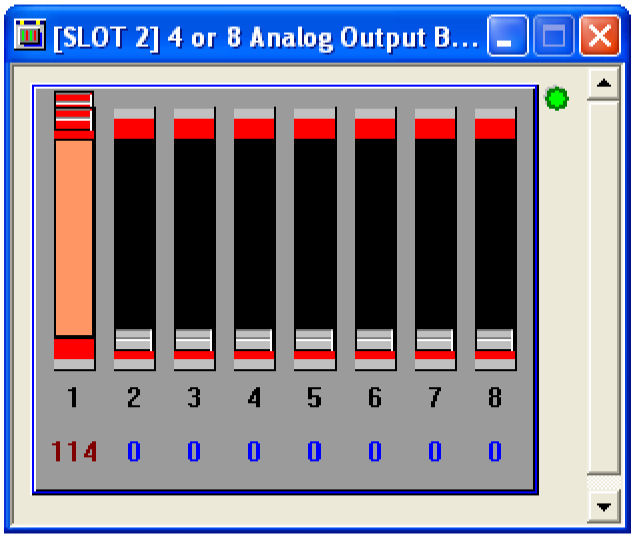
Click on the **[Download]** button in the Project section of the Download dialog box. *(NOTE: The* ***[Download]*** *button in the Bootproject portion of the dialog box is ONLY used if you want to download into the boot area of the ControlWave unit; the bootproject is a project which will start whenever the controller is re-booted or power is restored following a power failure.)*

The RTU_Resource dialog box will re-appear. Click on either the **[Warm]** or **[Cold]** buttons. The **[Warm]** button only re-initializes non-retentive variables. The **[Cold]** button re-initializes all variables.

If desired, execution can be stopped by clicking on the **[Stop]** button. Then, execution can be re-started using either the **[Warm]** or **[Cold]** buttons.

In the I/O Simulator, icons will now appear for all configured process I/O boards. In this example, we have two process I/O boards – one analog input board, and one analog output board. In the figure, below, they are shown as Slot 1 and Slot 2, respectively.

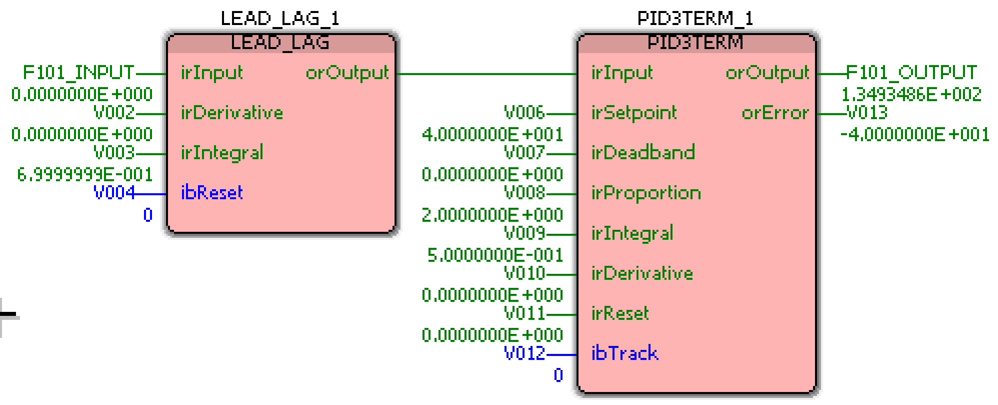




Click on either of the board icons, and a graphical representation of the board, showing simulated values for all pins on the board will appear.

In addition, you can view the values of other variables in your program by entering Debug Mode. To do this, click on: **Online→Debug**. (NOTE: The same command *again* allows you to exit Debug Mode.)

If you then examine the graphical representation of the project, values for each of the variables will be displayed next to the parameter names of each function block, and the F101_OUTPUT variable should change as you modify the F101_INPUT.



## Step 9  Save Your Project

You can now exit Debug Mode (if you haven't already) by clicking on **Online→Debug** again, and save your project.

To save the project, click on **File→Save Project As/Zip Project As** and specify a path and filename for the project.

Beginning with OpenBSI 5.8, you can include spaces in the path and filename. Prior to that, they were prohibited.

If you save the project 'as is' i.e. uncompressed, it will have a file extension of *.Mwt, and will also have a sub-directory of files associated with it with the same name as the project. If you choose to zip the project (i.e. compress it), it will have a file extension of *.Zwt.

NOTE: If you intend to copy the project to a different location, or a different PC, it is strongly recommended you zip the project first to ensure that all files are copied.

NOTE: If you are using the Variable Extension Wizard (see the *ControlWave Designer Programmer's Handbook – D5125)* and you rename your project (File→Save Project As/Zip Project As), you must re-run the Variable Extension Wizard and save your initialization files again.

NOTE: If, after unzipping a project, you try to save it and you encounter a message 'Cannot copy file *file_path\filename*.TXT. Command aborted!', go in Windows Explorer to the path and filename listed, and delete the named file(s). Then try to save the project again. If a similar message appears, repeat this process, as necessary. You will then be able to successfully save the project.

# Getting Started with ControlWave Designer

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