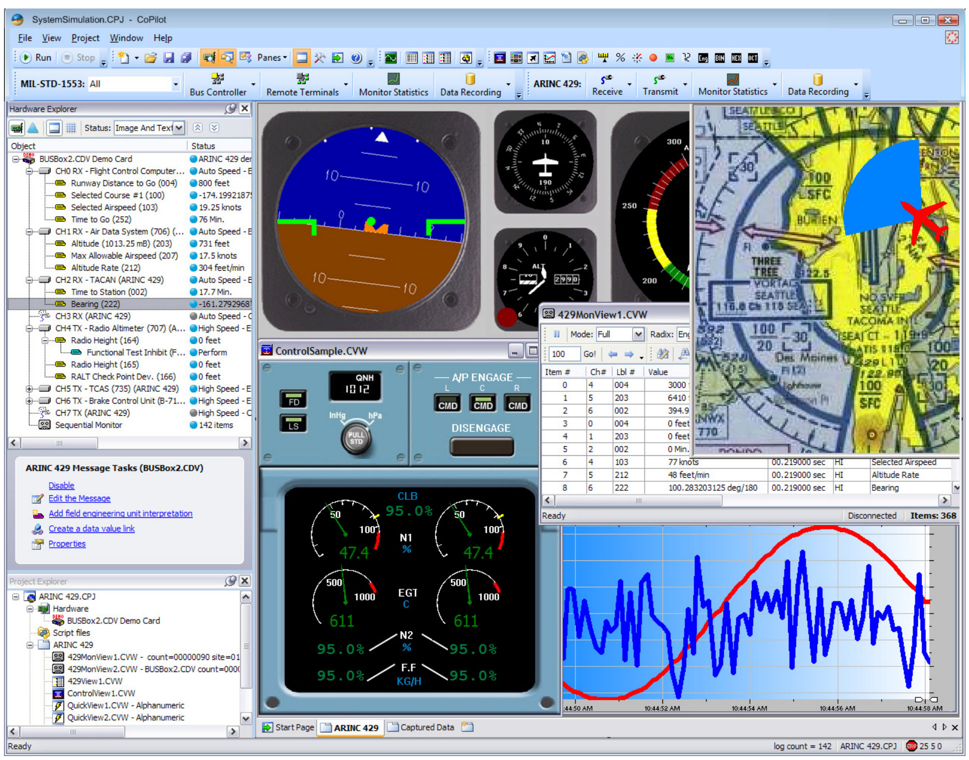
Getting Started Guide to

CoPilot 429

Version 5
Rev B



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Introduction

CoPilot 429

The term "CoPilot 429" is used throughout this manual to identify the ARINC 429 specific features available with CoPilot. CoPilot 429 is part of the multi-protocol CoPilot System, a Windows®-based software program developed by Ballard Technology, Inc. to simplify the simulation and testing of MIL-STD-1553, ARINC 429, ARINC 708, AFDX/ARINC 664 and other avionics protocols. Using CoPilot with ARINC 429, you can transmit and receive messages to equipment on the ARINC 429 bus, collect and analyze databus information through the powerful Sequential Monitor, and create or view information in engineering units in edit mode or while the bus is running. The tools and filters built into CoPilot assist in locating and analyzing bus activity. Although CoPilot is capable of simultaneously supporting multiple protocols and multiple hardware interfaces, this getting started guide focuses on the operation of a single ARINC 429 demonstration device (a.k.a. 429 Demo Card).

Ballard 429 Interface Boards

CoPilot 429 operates in conjunction with Ballard's OmniBus (PCI, cPCI, USB, Ethernet, PMC, VME), Avionics BusBox (Ethernet), CM429-1 (PCMCIA), LP429-3 (PCI), LC429-3 (cPCI), and BUSBox (USB) family of products. Ballard ARINC 429 interface boards can be ordered with a variety of channel configurations.

CoPilot Standard and Professional Versions

The first two sections of this guide describe features available in the CoPilot Standard version. CoPilot Professional features are described in the third section of this document. CoPilot Standard software can be upgraded to CoPilot Professional. CoPilot Professional has all the capability of the standard version with additional features that include graphical displays, Python powered ATE (Automated Test Environment), and VB (Visual Basic) scripting.

About this Guide

The *Getting Started Guide to CoPilot 429* is a tutorial designed to help you quickly learn the basics of CoPilot for ARINC 429 and introduce you to the optional features available with CoPilot Professional. This guide is composed of sixteen brief lessons in three sections. Sections A and B of this guide describe features available in CoPilot Standard. Section C of this guide describes CoPilot Professional features. Because each lesson builds logically to the next, new users are encouraged to work through this guide sequentially. Advanced users can easily jump ahead to a particular lesson using the built-in lesson projects.

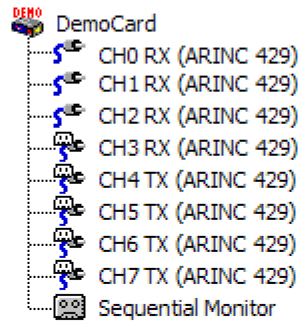
Note: This guide assumes the reader is familiar with ARINC 429, the avionics databus protocol used in commercial applications. No effort has been made to define terms that are part of the ARINC 429 specification.

429 Lesson Projects

Template lesson projects for each of the lessons in this guide are built into CoPilot and are accessible from the Samples and Templates panel of the CoPilot Start Page. Because each lesson builds on the previous ones, opening the project for a specific lesson saves you the trouble of completing all the preceding lessons to obtain the data and configurations you need.

429 Demo Card

The lessons in this guide use the built-in 429 demonstration card (see figure on next page). Using this demonstration card, you can duplicate on your screen what is described in the following lessons. This allows you to "try out" the features and capabilities of CoPilot without the need for a keyed Ballard 429 card or access to an active ARINC 429 databus. The 429 Demo card emulates a BUSBox 429 4R/4T card with a CoPilot Professional hardware license key. The demo board also emulates three external 429 devices transmitting labels and data on receive channels 0, 1, and 2.



Demo card shown in the Hardware Explorer tree

Before You Begin

Install and Open CoPilot

- To install CoPilot, insert the CoPilot CD into your drive. A menu screen will automatically open. Click the **Install CoPilot** link and follow the directions. If the menu screen does not automatically launch, run the **INSTALL.EXE** program in the INSTALL folder on the CoPilot CD.

If you already have a version of CoPilot installed on your machine, the old version of CoPilot (version 4 or earlier) can remain on your computer and the new CoPilot version 5 can be installed along side this prior version.

Note that files and projects saved in CoPilot version 5 will not be able to be opened by previous version of CoPilot. Be sure to save a copy of the files you still intend to open with the previous version.

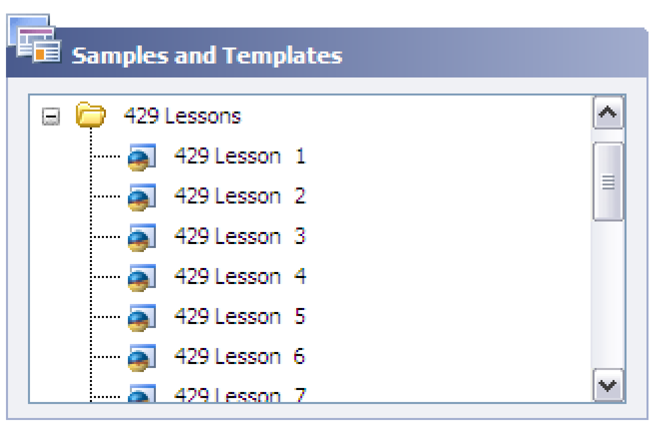
Opening a Lesson

After installation is complete, open CoPilot from the Start | Programs menu or by double clicking the CoPilot icon on your desktop.

For all lessons except Lesson 1, opening a lesson project is the first step of the lesson. For example, to load the second Getting Started lesson project:

► Expand **429 Lessons** from the Samples and Templates panel on the Start Page (see figure below)

► Choose **429 Lesson 2**

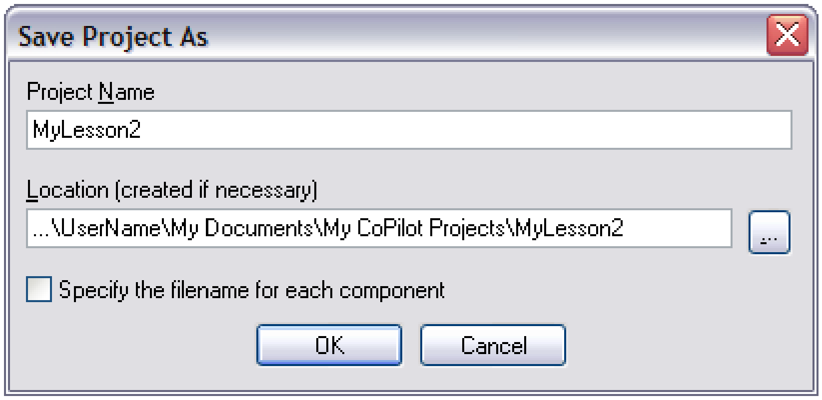


Create Your Personal Project

You can open a lesson project using 'Samples and Templates' on the Start Page (as shown above), or you can save your work as you progress in a single project. To do this, you will use a template project to create your own working project.

To save a project for a template lesson:

- ► Open the lesson from the Start Page
- ► Select **File | Save Project As…** to open the Save Project As dialog (see figure on next page)
- ► Enter a unique name (e.g., MyLesson2) in the Project Name field
- ► (Optional) Type in or browse to a different file location (the dialog defaults to the CoPilot Projects folder)
- ► Click **OK** to save the new project (you will be prompted to confirm creation of a new folder)



- ► The new project name will appear in CoPilot's title bar. To reopen this project later, choose **File | Open | Open Project…** and browse to your project. A list of recently used projects is available in the Start Page. Also, a list of recent projects is available in the file menu of CoPilot. As you progress through the lessons, you can continue to add to and save your project.

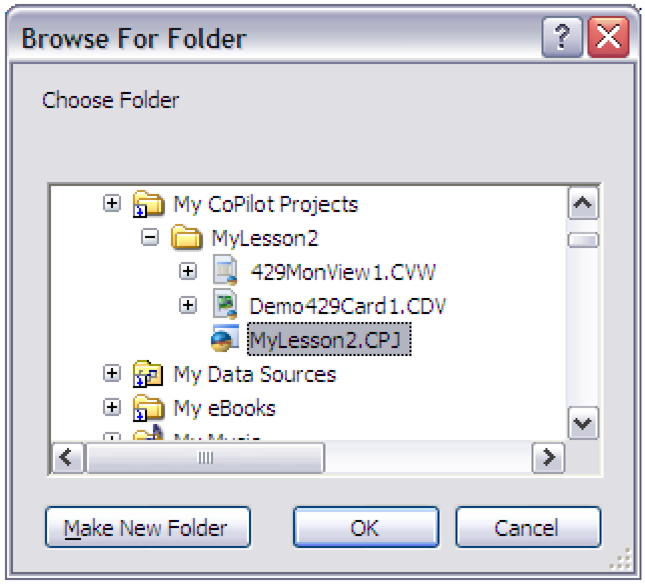
Begin the Lessons

Before you begin each lesson, be sure that you have read the section introductions. These introductions give an overview of larger concepts and provide background information for lessons in the section. Important configuration steps are placed in the introduction rather than duplicating them in each lesson.

Maintain Your Personal Project

To update your personal project with your latest work, you will need to browse to and overwrite the previous version.

- ► Select **File | Save Project As…** to open the Save Project As dialog (see figure above)
- ► Click the **Browse** [...] button to open the Browse for Folder dialog (see figure below)
- ► Use the scroll bar to find your project folder, click the plus ⊞ icon to expand the folder contents, and select your project file (for example, "MyLessons.CPJ")
- ► Click **OK** to close the Browse for Folder dialog and click **OK** again to close the Save Project As dialog (you will be prompted to confirm the overwriting of your project)



As you work through the lessons that follow, anytime you need to initialize a lesson from the lesson projects or save your work to your personal folder, you can refer back to this Introduction to review these procedures.

Other Resources

In order to be focused and brief, the lessons in this guide are not exhaustive. You are encouraged to refer to other resources for more detailed information. These include:

- The *CoPilot User's Manual* (on the CoPilot CD)
- Samples and Templates available from the Start Page
- The 429 example projects and scripts (on the CoPilot CD)

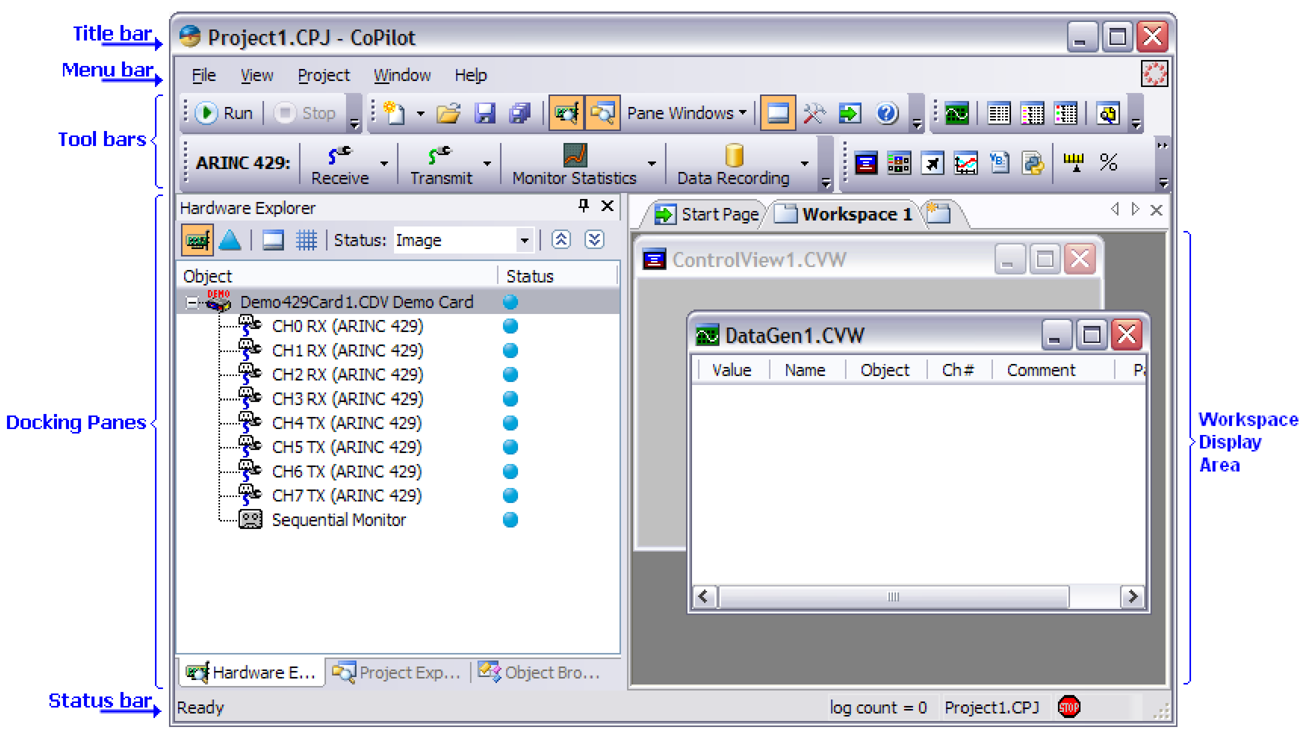
Section A: ARINC 429 Basics

The lessons in this section demonstrate how CoPilot 429 facilitates communication with one or more ARINC 429 databuses. The topics covered are Quick Start Analyzer, configuring boards, channels, and labels; selecting Equipment IDs and labels from the database, transmit schedules, defining and viewing labels in engineering units, and monitoring, recording, and displaying bus activity. All of the functionality in this section is available with CoPilot Standard. Before you begin the lessons, take a moment to get acquainted with the CoPilot environment and learn the principles of CoPilot operation.

The CoPilot Environment

The CoPilot environment consists of an integrated set of windows, menus, toolbars, panes, workspaces, and other elements that allow you to create, edit, organize, and run a CoPilot project (see figure below).

The Hardware Explorer pane is used to configure one or more hardware devices. The Project Explorer pane manages the component files (hardware devices and view windows) that are part of the project. Panes are dockable windows used for display and configuration that may be moved around or undocked from the CoPilot application to change the display layout (see the CoPilot User's Manual for additional information). Various types of view windows, such as the Data Generator, are hosted in the Workspace Display area. Workspaces are used to group and sort display view windows in the display area as shown by 'Workspace 1' in the image below.



The menu bar across the top contains drop down menus. The project menus are File, View, Project, Window, and Help. Other menus appear when items in the Hardware Explorer or other displays are in focus (selected). Multiple toolbars sort the numerous shortcuts to commonly used commands. You can identify the toolbar buttons using tool tip displays (as described later in this section). The status bar along the bottom of the CoPilot desktop displays status information, project location, and run time state and duration. The toolbars and pane locations are fully customizable to suit your specific requirements.

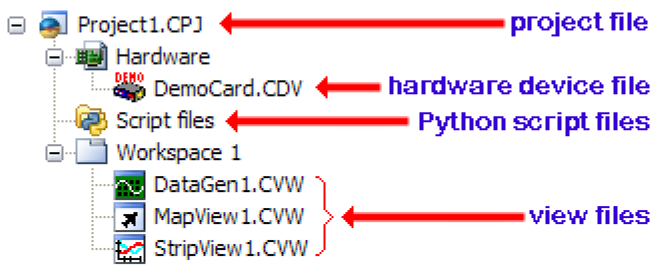
The CoPilot Project

Users interface with CoPilot through a project. The project records user actions and can be saved, closed, and reopened. Only one project at a time may be open in the CoPilot environment.

Project Files

The project is saved as several files stored within a single project folder (see figure below). This allows device and view files to be shared between projects. The file types in an ARINC 429 CoPilot project include:

- A single **Project file (.CPJ)** organizes the project components and records project settings
- **Device files (.CDV)** are created for each Ballard hardware interface card (or demo card)
- Optional **View files (.CVW)** are created for each view window
- Optional **Hardware Playback files (.CPB)** contain information extracted from a Sequential Monitor file to be retransmitted through the ARINC 429 board to the databus
- Optional **Python script files (.PY)** contain Python script code to perform the specified operations and extend the functionality of CoPilot



When a new CoPilot project is first saved, a project folder is created on the hard drive and the initial project file (.CPJ) is placed in that folder. As device and display components are defined and saved, they are added to the project folder.

Running a Project

CoPilot supports two basic operational modes: Edit mode and Simulation mode. When a CoPilot project is activated through the Run button, the configuration defined in the Hardware Explorer is loaded onto the Ballard hardware and CoPilot displays are activated. CoPilot reverts to Edit mode when the Stop button is pressed.

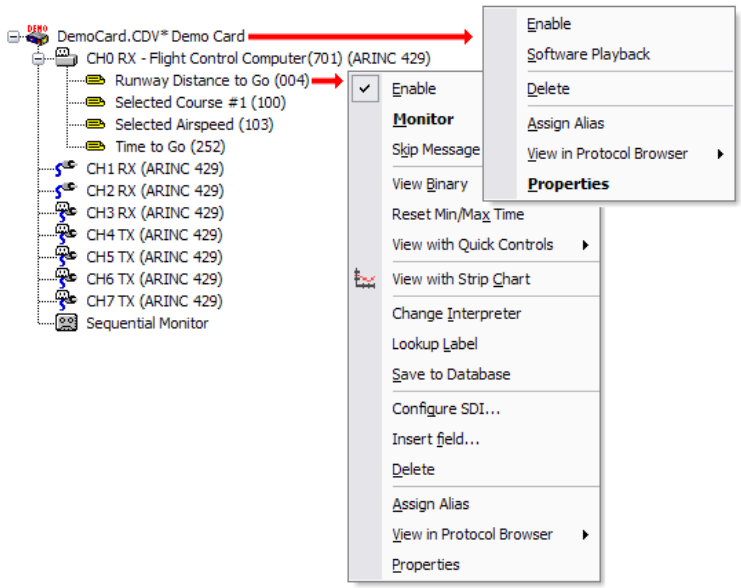
- **Edit Mode—**This mode is the default state for CoPilot during which most data initialization, configurations, and other settings are specified. No interaction with the databus or Ballard board takes place in Edit mode.
- **Simulation Mode—**When Simulation mode is initiated through the Run button, active objects (configured in Edit mode) are transferred to the Ballard avionics board(s). CoPilot actively transmits or receives on the databus and all displays, controls, and windows are animated during the simulation. While the project is running, users can modify data, pause and restart channels, add and delete items from view windows, and perform many other operations.

CoPilot Principles of Operation

There are certain consistent principles used throughout the CoPilot environment. Understanding these principles will help you use CoPilot effectively.

Context Menus

You can interact with objects in the Hardware Explorer and view windows in the Workspace display area using context menus, or “shortcut menus.” Right click on items to access their context menu (see figure on next page).



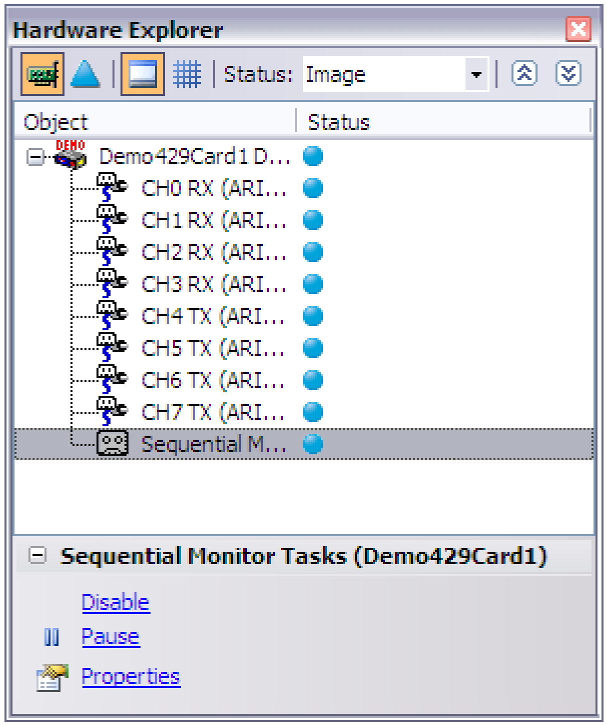
Context Menus are shown from a Right Mouse Click

Default Commands

The default command in each context menu is bolded (see figure on previous page). Simply double-clicking the item (without opening the context menu) will perform the bold entry from the context menu. The default commands for many items may change between simulation (running) and design (not running) to reflect the commands most likely to be used.

Hardware Explorer Tasks

Selecting an item in the Hardware Explorer shows a list of available "quick tasks" for that item. These tasks lists contain the actions most commonly performed on that item. However, if more than one item is selected, then the task list will reflect those common tasks that can be performed by all the selected objects. The <Shift> and <Ctrl> keys are used for multi-selecting items in the Hardware Explorer. Objects can be deleted with the <Delete> key.



Hardware Explorer Task for a Sequential Monitor Object

Configuration using Property Pages

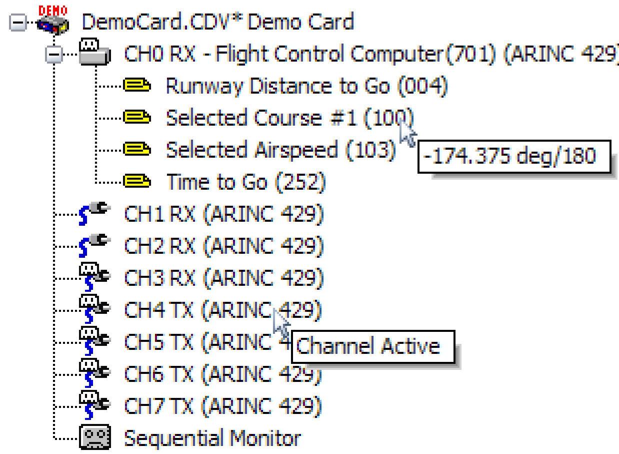
Most objects in both the Hardware Explorer and the display pane can be configured and customized through Properties dialogs. These are usually opened by a command in the context menu of the object (see the Properties commands in the context menus above). The Properties windows are often divided into tabbed subsections. Many options in a Properties dialog are duplicated in the associated context menu.

Drag and Drop

The "drag and drop" procedure is used throughout CoPilot to link objects, copy configurations, and automate functions. You can drag and drop objects from the Hardware Explorer into windows in the Workspace Display Area. Equipment definitions, Labels, and fields can be copied to other locations in the Hardware Explorer by dragging and dropping. If you attempt to drag an item to an area that cannot accept it, a warning dialog will appear and the action will not be completed.

Tool Tips

Objects in the Hardware Explorer pane use tool tips to display additional information. In addition, many properties pages, buttons, and other objects and windows throughout CoPilot use tool tip displays. To display the tool tip for an item, hover the mouse over the item without moving. A popup will appear with status, configuration, or data information. (see figure on next page).



Introduced in This Section

The lessons in this section (ARINC 429 Basics) demonstrate how CoPilot 429 facilitates communication with one or more ARINC 429 databuses. The following section will demonstrate additional features of CoPilot that simplify the configuration and analysis of information sent and received over the databus.

- Lesson 1 The ARINC 429 Quick Start Analyzer is used to discover and analyze databus activity.
- Lesson 2 The ARINC 429 Demo board used throughout these lessons demonstrates how boards, channels, and labels are presented through the Hardware Explorer pane.
- Lesson 3 Transmit schedules are created by selecting Equipment ID and labels from the ARINC 429 database.
- Lesson 4 Labels can be defined and viewed in engineering units based on definitions in the 429 database.
- Lesson 5 Databus traffic is recorded to file, filtered and displayed using a Sequential Monitor view.

Lesson 1: 429 Quick Start Analyzer

The fastest way to determine the current activity on your ARINC 429 databus is by launching the ARINC 429 Quick Start Analyzer from the Start Page in CoPilot. This feature configures the hardware to capture and record all databus activity to file, view the sequential monitor record file as it is being captured, and monitor the databus activity using the Protocol Browser. The Analyzer Setup allows for the configuration of multiple 429 channels for hardware installed in the system.

Note: If you have not already done so, please read the Introduction to this guide, especially the "Before You Begin" section (page 2), for instructions on opening 429 lesson projects and maintaining a personal cumulative project.

Introduced in This Lesson

Start Page, ARINC 429 Quick Start Analyzer, Protocol Browser

Objective

Setup ARINC 429 channels to quickly view the databus activity and analyze Equipment and label statistics.

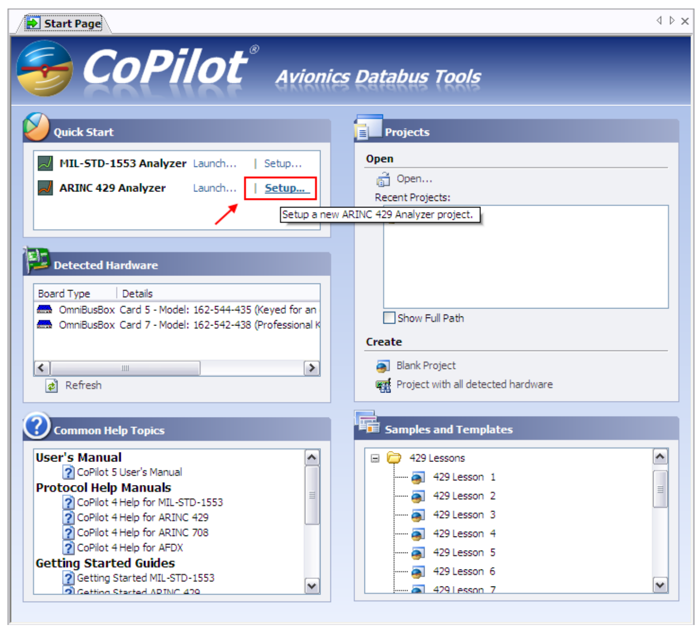
Show the Start Page

This first lesson is the only lesson that does not begin with opening a template lesson. To begin this lesson, be sure that the CoPilot Start Page is shown:

► Select **View | Start Page**

The Page should then be shown in CoPilot as shown in the figure at right.

Note that the Start Page can always be shown even after it is closed or CoPilot is running.



The CoPilot Start Page

Setup the 429 Analyzer

First, the ARINC 429 Quick Start Analyzer needs to be configured.

► Select **Setup…** next to the ARINC 429 Analyzer item from the Quick Start panel of the Start Page

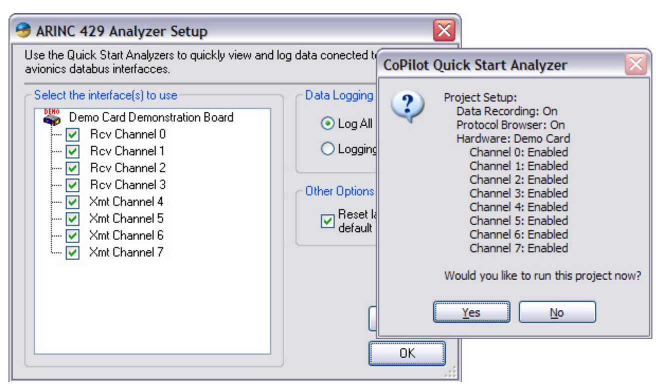
The figure on the lower right shows the ARINC 429 Analyzer Setup dialog. To configure the ARINC 429 Analyzer setup:

► Verify all databus channels are checked

► Click **Log All to file** to specify that all databus traffic will be recorded to file

► Verify **Reset layout to default** on start is checked to ensure optimal window positioning

► Click the **OK** button to accept the configuration



Configuring the 429 Analyzer

Run the Quick Start Analyzer

After the 429 Quick Start Analyzer is configured, the setup is displayed. This information lists the configuration and prompts before the analyzer is started.

- ▶ Click the **Yes** button to begin the analysis (run the project)

Notice that because this is demonstration hardware, activity on receive channels 0, 1, and 2 is automatically created to show meaningful bus activity.

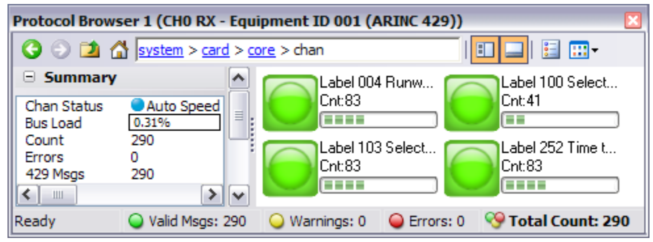
Analyze Activity on the Bus

The Quick Start Analyzer has configured the hardware and the Protocol Browser should be displayed (see figure to right). Protocol Browser panes allow you to drill in and out of the various levels of the hardware. The same protocol browser can be used to browse between multiple channels or protocols (such as ARINC 429 and MIL-STD-1553) if more than one exists in a project.

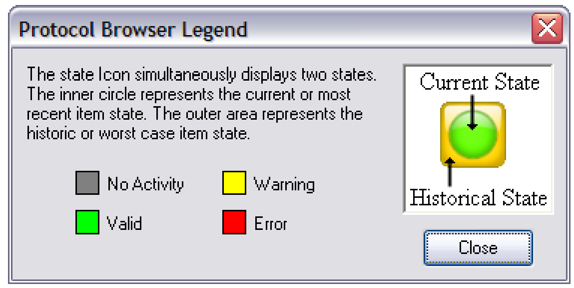
- ▶ Click CH0 Rx to “Drill-In” and display the details and Labels defined for this channel
- ▶ Notice the state of Label 004 is shown with a green icon to show both the current state and the historical state have no warnings or errors
- ▶ Click the **Display Legend** button in the toolbar of the Protocol Browser to show the Protocol Browser legend that defines the icon states (see figure middle right)
- ▶ Click the **Close** button to close the Legend

Additional information is available with the summary information (on the parent sidebar) of the Protocol Browser and with item tooltips.

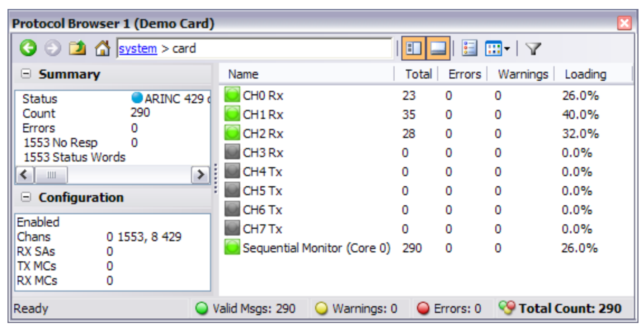
- ▶ Change the view mode by clicking the **View** button on the toolbar, then select the **Report Mode** menu item
- ▶ Click the **Up** button in the toolbar to display all channels of the card
- ▶ To complete this lesson, click the **Stop** button



Protocol Browser pane for 429 Receive Channel 0



Protocol Browser Legend



Protocol Browser Showing Channels in Report Mode

Related Topics

- It is possible to show/hide the Parent Information Sidebar with the button
- The status bar of Protocol Browser panes can be shown/hidden by clicking the button
- Click hyperlinks in the Protocol Browser to drill into items or drag and drop items from the Hardware Explorer
- Protocol Browser panes can be undocked (floated), pinned, moved, or even shown on another monitor

Summary

In this lesson you learned…

- how to display the Start Page
- how to setup a 429 Quick Start Analyzer project
- how to navigate the displayed items in the Protocol Browser
- how to analyze databus activity with the Protocol Browser

Lesson 2: Create a New Hardware Project

Ballard ARINC 429 hardware devices provide access to data transmitted over an ARINC 429 databus. Before the Ballard device is linked to that databus, however, several details must be established. Which Ballard 429 hardware will be used? What are the Equipment IDs of devices connected to each 429 channel? Do those devices transmit at high or low speed? If equipment is being simulated through the ARINC 429 hardware, then labels, label properties, and data must be defined to build transmit schedules. Finally, how should the data be created and displayed?

In many cases, CoPilot 429 supplies the necessary information based on built-in initialization criteria and automation features. In this lesson, you will discover how to activate CoPilot 429, open a new project, and identify the labels of all receive channels with just a few clicks of the mouse.

Introduced in This Lesson

CoPilot icon, New Hardware and Views dialog, Hardware Explorer pane, channel context menu, Run and Stop simulation buttons

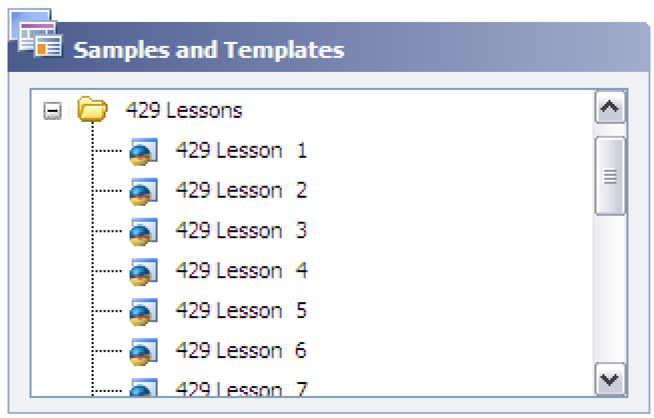
Objective

Start the CoPilot application, create a project using the ARINC 429 demo card, and run the project in simulation mode.

Start a CoPilot 429 Session

Note: Please be sure to read the introduction to this guide, especially the "Before You Begin" section, for instructions on CoPilot installation, the lesson folders, and maintaining a personal project.

Double click the CoPilot icon on the Windows desktop if CoPilot is not already open. If a Ballard 429 hardware device is installed in the host computer, it will be displayed in the Detected Hardware panel of the Start Page. If CoPilot did not detect a Ballard board, the "No hardware was found" message will be displayed.



Samples and Templates panel on the Start Page

Create a 429 Demo Card Project

Start a new project

► Select **429 Lesson 2** from the Start Page Samples and Templates panel to create a new lesson project

Ensure the Explorer panes are visible

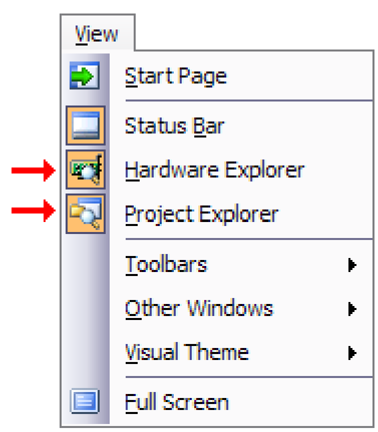
If the Hardware Explorer is not visible:

► Click **View | Hardware Explorer**

If the Project Explorer is not visible:

► Click **View | Project Explorer**

The eight-channel Demo card should be visible in the Hardware Explorer pane. All of the lessons in this Getting Started tutorial are based on the ARINC 429 Demonstration Card.



Ensure the Hardware and Project Explorer Panes are visible

Use a Context Menu

Board, sequential monitor, channel, label, and field objects in the Hardware Explorer can be defined through a context menu.

► Position the mouse over a receive channel in the Hardware Explorer and click the right mouse button to access the channel context menu.

Typically, one of the commands is shown in bold type. The bolded option can be selected by double clicking the object in the tree. All other commands must be selected through the context menu.

Run the CoPilot Project

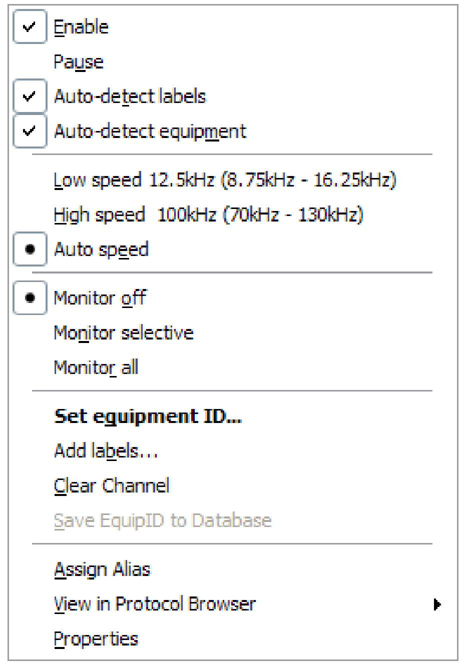
Because of the automated features associated with receive channels, the CoPilot 429 project can be run based on pre-selected channel option defaults. This includes auto-detection of labels, equipment, and channel speed.

► Click the CoPilot **Run** button

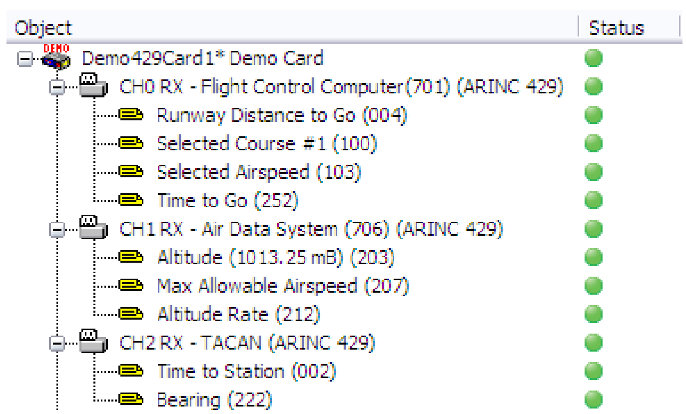
The ARINC 429 Demo board is simulated in software to represent a real board with connections to receive channels 0, 1, and 2. When a real Ballard 429 board is used, CoPilot specifications are uploaded to the board when the Run button is pressed.

Since the Auto-detect labels option is selected, labels are added to the tree as they are received. If the transmitting equipment is identified through the "Auto-detect equipment" option or specified by the user, CoPilot displays the name of each label based on information in the CoPilot ARINC 429 database.

► To complete this lesson, click the **Stop** button



Receive channel context menu



Hardware Explorer tree expanded through auto-detection

Related Topics

- Help documents, templates, and new or existing projects can always be accessed from the Start Page
- Options and settings for the ARINC 429 Demo board and labels can be seen through their respective context menus

Summary

In this lesson you learned…

- how the Ballard 429 board is selected or detected
- how objects in the tree are controlled through context menus
- how the auto-detection features of CoPilot populate the Hardware Explorer tree from bus activity
- how the database is used to translate equipment IDs and octal label identifiers into meaningful names

Building on this information, Lesson 3 will demonstrate how to select Equipment IDs and transmit specific labels.

Lesson 3: Build a Transmit Schedule

The content of receive channels is established by the external device to which that channel is attached. In Lesson 2 you discovered how CoPilot could be used to discover these attributes. Transmit channels are used to represent an external device through a CoPilot simulation. Consequently, the user must specify the Equipment ID of the device being simulated, the label selection, label properties, and data to be transmitted. This is simplified through the use of the ARINC 429 database supplied with CoPilot 429.

In this lesson, we will simulate an Air Data System with the same labels as those received on channel 1. Using the same equipment ID and labels will help illustrate the similarities and differences between transmit and receive channels.

Introduced in This Lesson

Choose Equipment, Choose Labels dialog, Transmit context menu, label context menu, label Properties dialog

Objective

Simulate an Air Data System (006) on channel 4 and transmit labels 203, 207, and 212.

Specify Equipment ID and Labels

Each lesson in this tutorial builds on the previous. If you are beginning the sequence at this point, or if the results of Lesson 2 are no longer available:

- ► Choose **429 Lesson 3** from the **Samples and Templates panel** on the Start Page to open the Lesson 3 project.

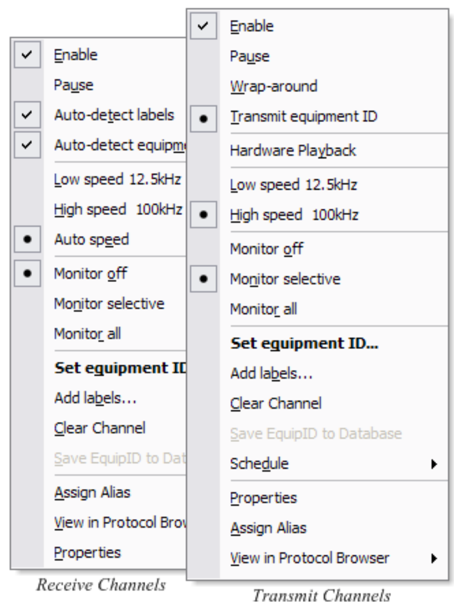
This optional procedure is available with each lesson. Alternately, you can use a saved project from Lesson 2.

View and Compare Channel Context Menus

Transmit channels, like receive channels, are defined through the channel context menu.

- ► Right click transmit channel 4 to view the channel context menu

Since transmit channels are used to simulate real equipment, the auto-detect labels, equipment, and speed options are not available.



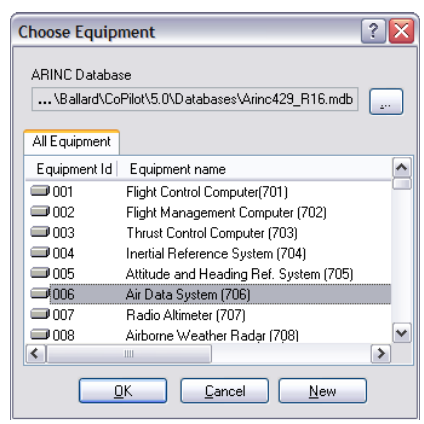
Right click channels to access context menus

Choose Equipment

ARINC 429 Equipment IDs and labels are stored in the CoPilot 429 database. To assign Equipment 006 properties to transmit channel 4:

- ► Double click CH4 TX (ARINC 429) or right click to access the transmit channel context menu and select **Set equipment ID...**
- ► In the Choose Equipment dialog, select **Air Data System (706)** and click **OK** (see figure at right)

Once the equipment is set, a list of labels will appear.



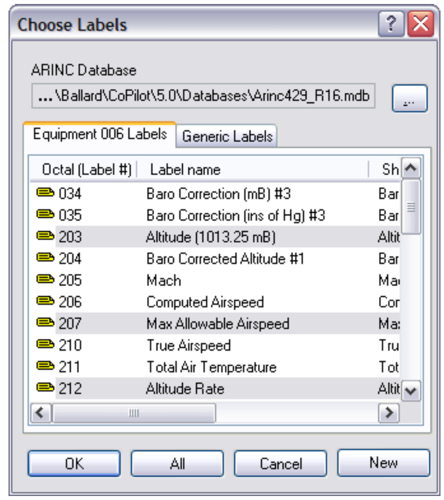
Select Air Data System

Choose Labels

The official list of labels associated with each ARINC device is stored in the CoPilot 429 database and is displayed in the two-tabbed Choose Labels window. This window can also be accessed through the Add labels… command in the channel context menu.

- ► In the Equipment 006 Labels tab, click on label **203**, then hold down the **CTRL** key and click on **207** and **212** to select all three labels
- ► Click the **OK** button to close the dialog

A range of labels can be selected in the Choose Labels dialog using the SHIFT key. Double clicking a single line will select that label and close the window.

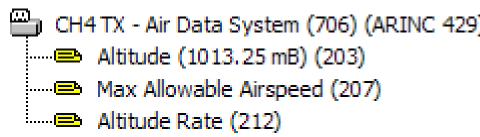


Select labels 203, 207, and 212

Examine Label Properties

When a CoPilot 429 simulation is started, the transmit specifications are uploaded to the Ballard 429 board and a transmit schedule is constructed. The timing requirements for each label are specified through label properties. To access, view, and change properties for label 203 (Altitude):

- ► Right click label 203 (on CH4) and select **Properties** from the context menu (see figure at right)



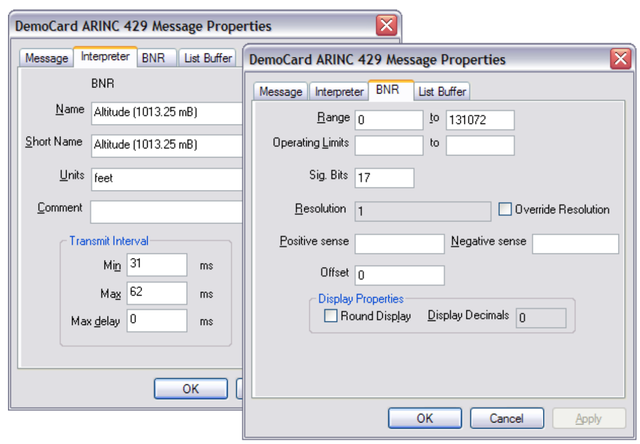
Channel 4 with equipment ID defined and three labels added

The tabbed properties window defines label names, unit descriptors, transmit intervals, and interpreter specifications.

The transmit interval of each label is used to build a transmit schedule. Based on the minimum and maximum values of 31 ms and 62 ms, the Ballard 429 board will transmit the Altitude label 16 to 32 times per second.

The settings in the BNR tab are used to interpret and display label values in engineering units.

- ► To complete this lesson, click the **OK** button to close the Properties dialog



Altitude Properties (label 203)

Related Topics

- The Active option in the channel and label context menus controls which specifications are loaded onto the board
- The equipment and label order in Choose Equipment and Choose Label dialogs can be sorted by clicking the title
- Label properties and interpreters can be modified by the user and saved in the ARINC 429 database (see Lesson 9)

Summary

In this lesson you learned…

- how to start a lesson creating a new project with a 429 lesson template
- how to select the equipment ID and labels for the transmitting equipment being simulated
- how to access label specifications from the ARINC 429 database

The next lesson explains how interpreter properties are used to create and view information in engineering units.

Lesson 4: Define and View Label Values

In Lessons 2 and 3, transmit and receive channels were defined through user specifications, automated features, and label properties. In this lesson, label properties will be customized to simplify the display of information and allow labels to be viewed in an engineering unit format.

Introduced in This Lesson

Label context menu, Engineering Unit Editor, Engineering View, New Hardware and Views dialog, drag and drop assignments

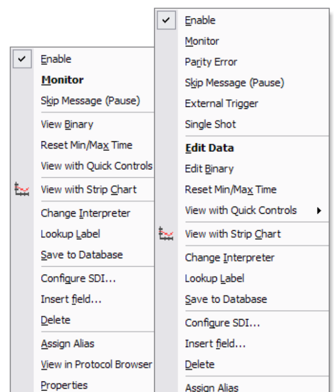
Objective

Set the Altitude value (channel 4, label 203) to 30,800 and display selected receive labels in an engineering unit format.

Examine Label Properties

Like all other objects in the Hardware Explorer, labels and label options are defined through a context menu.

- ▶ Right click a receive label in the Hardware Explorer to access and examine the context menu
- ▶ Repeat the process for a transmit label and note the differences and similarities between transmit and receive label menus (see figure at right)



Receive Label Context Menu

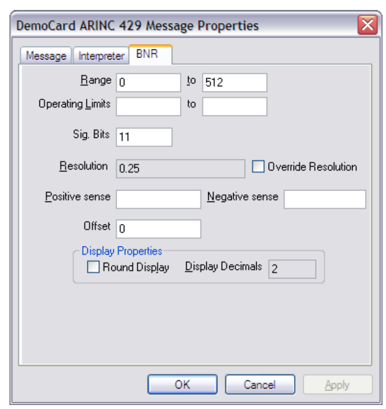
Transmit Label Context Menu

Encoding rules for 429 label values are expressed on the third tab of the Message Properties dialog.

- ▶ Right click on label 203 (on CH4) and select **Properties**
- ▶ Click the **BNR** tab to view the interpreter options

Altitude (label 203), with a range 0 to 131,072 feet, is defined through a 17-bit BNR value (see figure).

- ▶ Click **OK** to close the Message Properties dialog

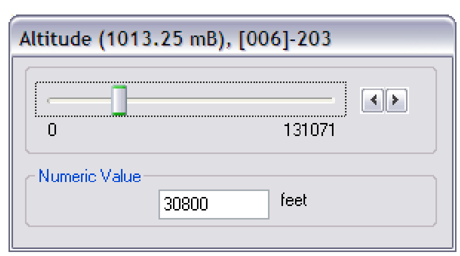


Message Properties dialog

Define Transmit Label Values

- ▶ Right click label 203 (on CH4) and choose **Edit Data** to open the Engineering Units Editor
- ▶ Drag the slide bar or click to the right of the position marker until the value is close to **30,800**
- ▶ Press the ◀ ▶ buttons to get the exact number and click outside the slide bar editor to close

The value can also be set by entering 30800 in the Numeric Value textbox and pressing the Enter key.



Data is set through the slide control or the Numeric Value text box

View Receive Label Values

Labels can be viewed in an engineering unit format through Engineering Views.

- ▶ Click the **New Hardware and Views** button, click the **Standard Views** tab and double click **Engineering View** to add a new view window

- ▶ Add a second Engineering View by clicking the button on the **Standard Views toolbar**

Assign Objects from the Hardware Explorer

- ▶ Select the **Window | Tile Horizontally** menu option to align the Engineering View windows
- ▶ Drag and drop the Altitude (1013.25 mB) (203) branch from CH4 into the EngrView2 window
- ▶ Drag and drop the CH2 RX - TACAN (ARINC 429) branch (CH2) to the EngrView2 window
- ▶ Drag and drop the Demo429Card1 icon to the EngrView1 window

When an object is assigned to the Engineering View, its subordinate objects are also assigned.

Observe Changing Values

- ▶ Click the **Run** button to start the simulation and view the changing values in the two views

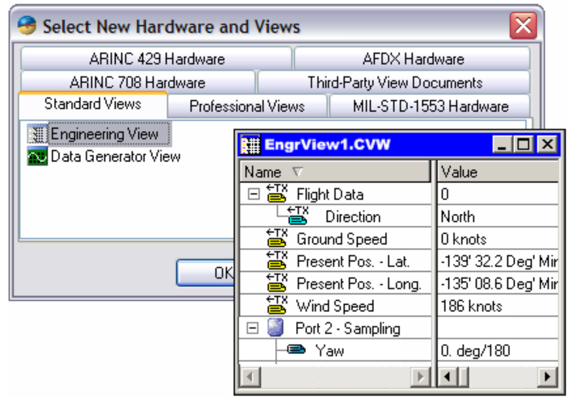
---

Note: Although we are not connected to a databus, the ARINC 429 Demo board supplies data values and time-tags for receive channels. The objective is to simulate a card connected to a databus but no attempt is made to present realistic values.

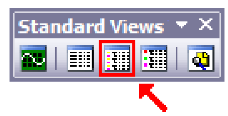
Alternate Link to Labels through Views

Label properties and data editors are accessible through the views. Properties and label values can be set from the tree or a view.

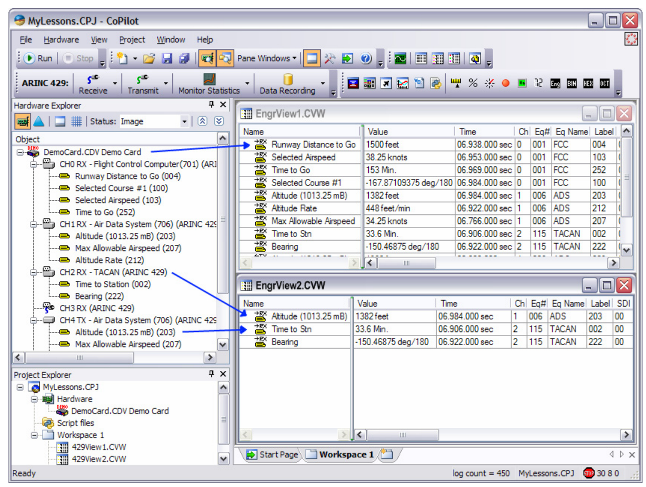
- ▶ Right click any label in a Engineering View window to access the label context menu
- ▶ To complete this lesson, click the **Stop** button



New Hardware and Views dialog (Stardard Views tab shown)



The Engineering View button on the Standard Views toolbar



Assign labels by dragging Hardware Explorer objects to a view

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Related Topics

- A binary data editor is available through the label context menu (see Lesson 7)
- A CoPilot Data Generator can be used to create a sequence of data values (also in Lesson 7)
- The columnar content, position, and row order of Engineering View windows is configurable

Summary

In this lesson you learned…

- how to define and modify labels through the label context menu
- how to specify the value of transmit labels through an engineering units data editor
- how to open view components in the display pane
- how to assign and view labels through one or more Engineering View windows

Engineering View windows display the latest value of labels and fields. In the next lesson, a Sequential Monitor View will be used to collect and display a sequence of values for each label.

Lesson 5: Viewing Sequential Monitor File

It is difficult to observe all the critical information in real time. Frequently, you may not even know what to look for until after the event has occurred. The CoPilot Sequential Monitor allows users to collect and preserve data in a Monitor Data file and analyze it after the run is complete. Users may capture all labels on the bus or capture selectively based on channel and label filters. Display filters limit what is shown, but do not affect the stored data. Right clicking the Sequential Monitor provides access to the context menu and properties dialogs.

Introduced in This Lesson

Monitor context menu and properties, Monitor View, monitor data (MonData) files, display filtering

Objective

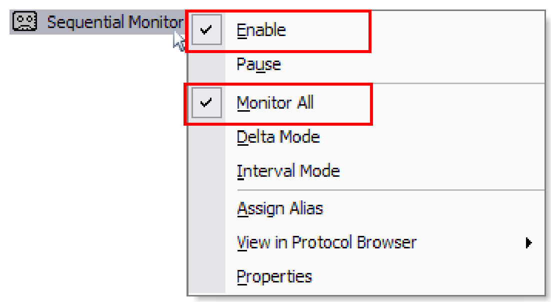
Capture all bus traffic in a MonData file and view the results. Then repeat the process by creating another MonData file, viewing this data, and change the Monitor View display using display filters.

Monitor All Channels

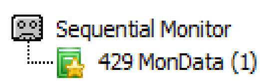
Although you can control which data is placed in the monitor record through label, channel and monitor filters, the simplest approach is to capture all 429 data.

- ► Right click the **Sequential Monitor** icon and select **Enable** and **Monitor All** (if not already checked)
- ► Click the **Run** button to start the simulation

A new Monitor Data Icon is added under the Sequential Monitor holding the newly captured data. The status column text displays the record count.



Sequential Monitor context menu



Sequential Monitor with one 429 Monitor Data File

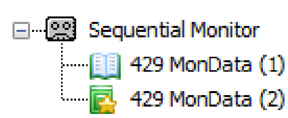
Open a Monitor View Window

- ► Right click on the **429 Monitor Data** icon and choose **View Monitor Data**

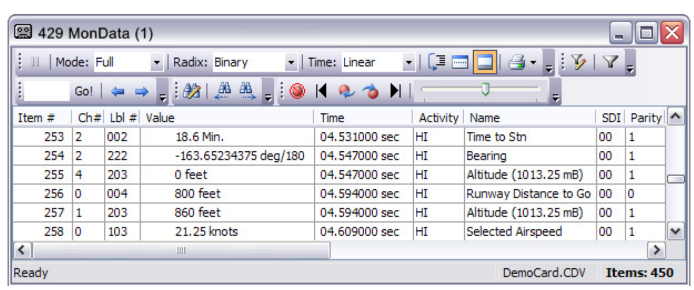
The 429 Monitor View display can be configured easily through the display settings (see figure at right).

- ► Change any of the settings in the 429 Monitor Toolbar to configure the mode, radix, timetag, or split the view to scroll to different locations

In a few cases, format differences will be subtle and may not be apparent until the contents of the monitor record are exported to Microsoft Excel® or a text file.



Sequential Monitor with two 429 Monitor Data Files



Monitor View (change Mode, Radix, and Time display options)

Creating Multiple MonData Files

Data can be routed into separate data files and views while the sequential monitor is recording.

- ► Click the **Minimize** button for EngrView1 and EngrView2 to hide them to the Project Explorer
- ► Right click the active **429 MonData** icon and select **Disconnect**

▶ Right-click the newly created **429 MonData** to show the context menu

▶ Select **View Monitor Data** from the context menu

▶ Select **Window | Cascade** to align the open views

▶ Click the **Stop** button to stop the simulation

Use Display Filters

Data accumulates quickly when several channels are monitored. Although the file may be large, the display can be limited to data of interest using Monitor View display filters.

▶ Click the **Edit Filter** button from the 429 MonData (1) Filter toolbar

▶ Click the **Search** button in the Monitored Messages tab

The Monitored Messages list is initialized with a Monitor All condition (all labels are selected). To filter the display, deselect those labels you do not wish to view.

▶ Click the **None** None button to clear all the labels, select labels **203**, **207**, and **212** from Channel 1

▶ Click **OK** to close the dialog and view the results

Display filters affect the display of information but not the content or size of the sequential file.

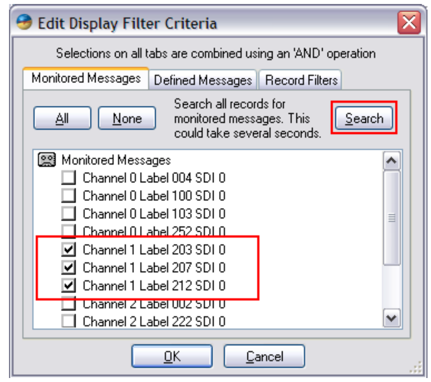
▶ Toggle the **display filter** button to disable the filters so all messages are seen again

Finish this lesson by changing the recording mode:

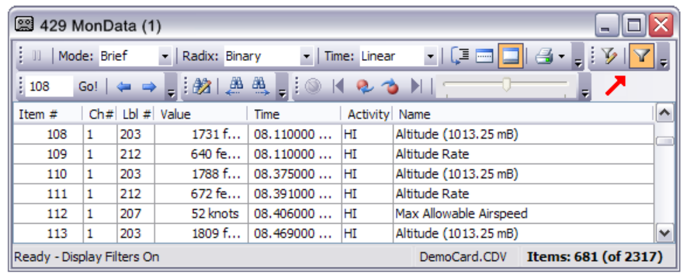
▶ Right click the **Sequential Monitor** and select **Properties**

▶ Change the **Data Collection Mode** to **Create New Recording**

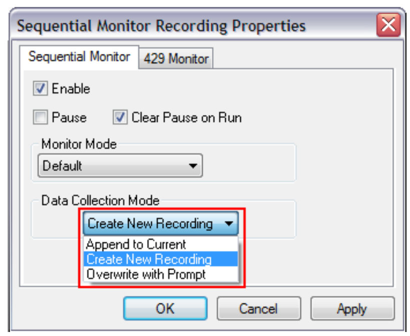
▶ Click **OK** to close the properties dialog



Display Filter limited to CH1 labels



429 Monitor View with Active Display Filters



Sequential Monitor View property page

Related Topics

- Delta Mode eliminates redundant values and Interval Mode reduces the file size through sampling
- Export and Import capabilities offer further analysis features and integration with other applications

Summary

In this lesson you learned…

- how to record all databus traffic to a monitor data file
- how to view logged data from a monitor data file in a Monitor View
- how to limit data displayed in a Monitor View to selected labels using display filters

Additional monitor features are covered in Lessons 6 and 7 and in the following section.

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Section B: Additional Features

Review

In the preceding section, you learned how to use the 429 Quick Start Analyzer, open a CoPilot project, specify the Ballard 429 board, use CoPilot's automated features to identify the Equipment ID and labels being received from external devices, select the labels and Equipment ID of devices to be simulated, monitor bus activity, and view the monitor record. The lessons in Section B will guide you through the process of collecting, searching, exporting, encoding, interpreting, modifying, displaying, and playing back ARINC 429 data in the CoPilot environment.

Introduced in This Section

All of the features described in this section and in Section A are available in the standard version of CoPilot for ARINC 429. (Section C discusses CoPilot 429 Professional features.) We have called the tools and windows in this section "advanced features" to differentiate them from the basic concepts introduced in the first section, but they are just as easy to use. The first two lessons in this section are an expanded discussion of the CoPilot Sequential Monitor introduced in Lesson 5. Playback features associated with the Sequential Monitor will be discussed in Lessons 10 and 11.

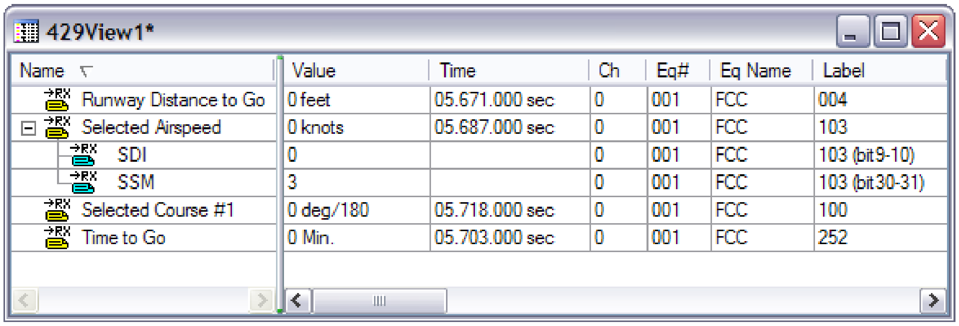
- Lesson 6 Controls in the Sequential Monitor view allow the monitor to be paused, and searched for information and records to be bookmarked for future reference.
- Lesson 7 Through the use of display filters and highlighting, selected portions of the Sequential Monitor view can be printed or exported for use in other applications.
- Lesson 8 The Binary Editor and Data Generator allow field and label values to be edited and dynamically modified.
- Lesson 9 Information in the ARINC 429 database can be viewed through channel or label properties and database definitions can be created or modified and saved for future use.
- Lesson 10 Captured data may be replayed on the databus by retransmitting it through a 429 transmit channel.
- Lesson 11 Captured data may also be reexamined within the software only (isolated from the hardware and the bus) and slowed to "human speed" for detailed analysis.

Looking ahead

Before you begin the lessons in this section, read on to learn about engineering units in CoPilot, how to work with view windows, and important information about the various files in a CoPilot project. CoPilot Standard also provides the ability to playback on the databus. Although hardware playback is not possible with a demonstration card, the operation of hardware playback with real hardware functions similarly to the software playback feature described in this guide. For more information on retransmitting recorded data with hardware playback, please refer to the CoPilot User's Manual or the online help.

Engineering Units

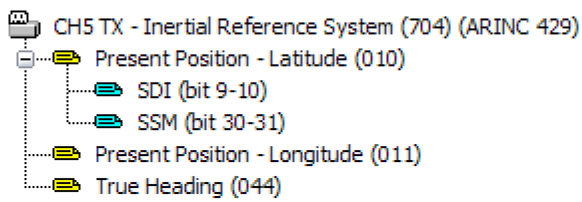
With CoPilot, there is no need for the user to engage in mathematical calculations and conversions to create or interpret the raw binary values passed on the ARINC 429 databus. CoPilot converts the ones and zeros (raw data) that come across the bus into recognizable "engineering units" based on label/field and interpreter definitions supplied by the CoPilot database or user.



In this way, data is given meaning within the context of the CoPilot simulation. This meaning can be preserved and refined by saving to, loading from, or modifying the CoPilot 429 database.

Data Fields

Data fields are used within CoPilot to associate meaning with a bit or sequence of bits within an ARINC 429 message. Each field can be named, assigned units of measurement, and associated with an interpreter so that its bits may be accurately deciphered. The figure below illustrates data fields (SDI and SSM) on a transmit label.



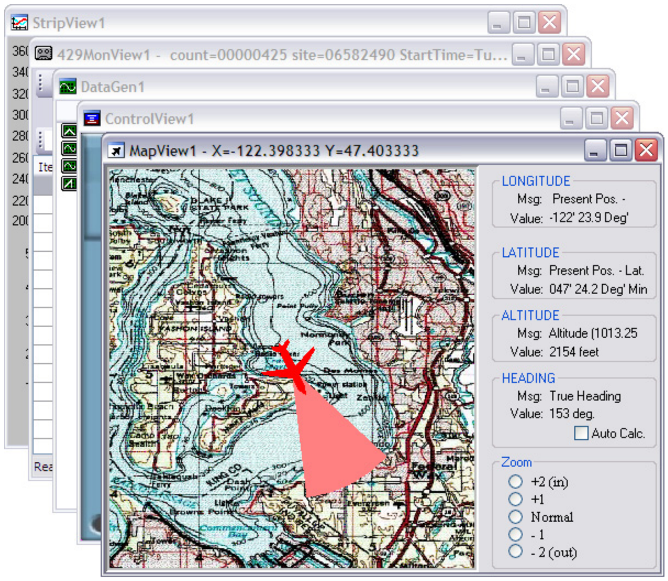
Data Interpreters

The data interpreters built into CoPilot 429 allow you to customize how data is encoded and translated. For example, you could encode data in 2's complement or BCD (Binary Coded Decimal) format, encode alphanumeric characters in ASCII format, or indicate conditions or codes using discretes.

View Window Components

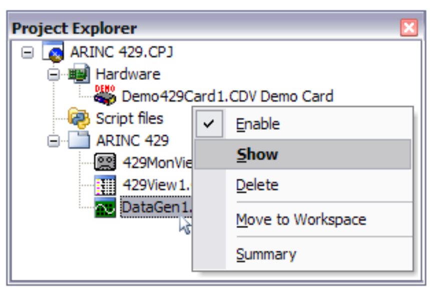
CoPilot Windows hosted in the Workspace display area are added using the View toolbars, the "Select New Hardware and Views" dialog, and through objects in the Hardware Explorer. The 429 transmit Schedule View is an example of an object-generated window. These windows are not saved as part of a CoPilot project because their information is saved as part of objects in the Hardware Explorer.

Beginning in Lesson 4, you have learned about a variety of windows (also called "components" and "views") opened through the "Select New Hardware and Views" dialog. Independent views can be saved as part of a CoPilot project, closed, reopened, and even shared between projects. They are not tied to any specific object in the Hardware Explorer and can interact with many objects. The Data Generator View is discussed in Lesson 8 and the Professional components are discussed in Section C (Strip View, Quick View, Control View, Map View, Python Editor View, and Script View). Once activated, they are listed in the Project Explorer pane.



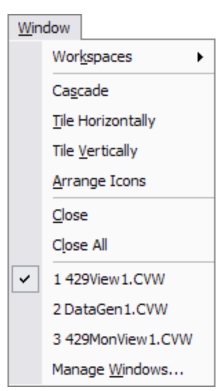
Working with View Windows

View windows can be managed through commands in the Project Explorer and the Window menu. Project Explorer menu commands (see figure below) allow the user to enable/disable, show (in the Workspace display area), delete, and record summary information for view windows. By clicking its **Minimize** button, a view is removed from the display area but its icon is still available in the Project Explorer. A hidden/minimized window can be restored to the workspace display area by double clicking its icon in the Project Explorer or right clicking its icon to access the context menu and choosing **Show**.



Note that hidden views continue to run and affect other parts of the project (for example, the Data Generator continues to source data to fields in the Hardware Explorer). Unnecessary views may consume processing power. To disable a view without deleting it from the Project Explorer, right click on its icon and clear the checkmark by Enable (see figure above).

View windows can also be selected or arranged through the Window menu (see figure below).



Hiding View Windows

The **Minimize** button in the title bar of a view window is often used in CoPilot to remove the window from the screen but preserve it in the project. Throughout this document, we refer to this as “hiding” the window.

Hidden windows continue to operate or receive updates when the CoPilot project is running, without cluttering the screen. They can be restored, placed into an active or inactive state, or deleted from the project through context menu options in the Project Explorer.

- **Hide**—To hide a window, click the Minimize button in the window title bar. The window will disappear from the display area, but its icon will remain in the Project Explorer and it will continue to run invisibly. To show it, double click its icon in the Project Explorer or right click its icon to access the context menu and choose **Show**.
- **Disable**—To disable a view (visible or hidden), right click on the view icon in the Project Explorer and clear the **Enable** checkmark. The view will cease to run, but will remain in the Project Explorer (and in the display area, if it is visible). To reenable it, select the Enable option.
- **Close**—To completely close a view, click the Close button in the window title bar. This can also be accomplished through the Delete command, accessed by right clicking on the view icon in the Project Explorer and selecting **Delete (**or press the <Delete> key). The view will be removed from the Project Explorer and if needed a prompt will appear to optionally save the view to file. To reopen a saved file, choose File | Open | Open Hardware or View Files… and browse to its location.

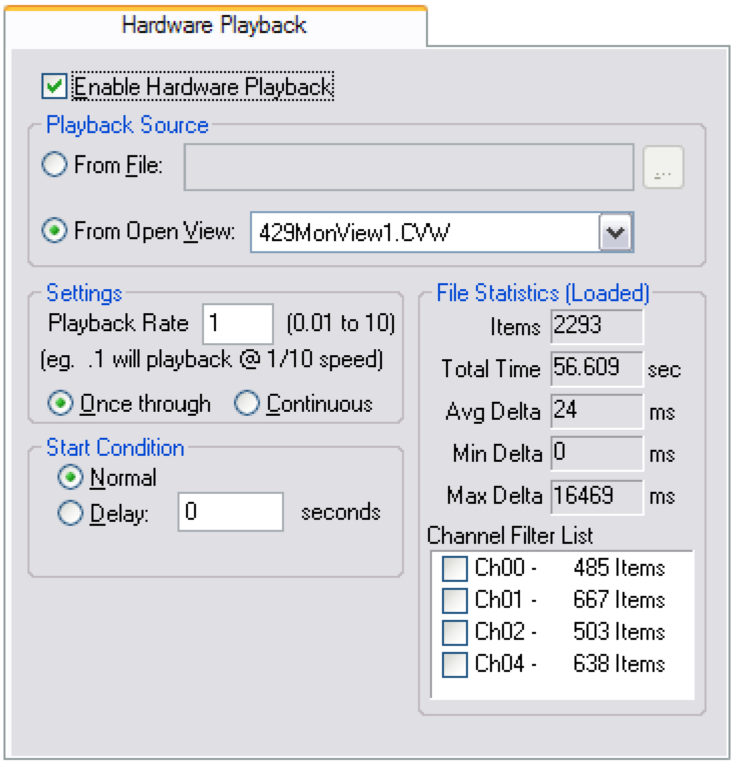
Saving View Windows

When a new view is created, CoPilot assigns a default name, for example, “DataGen1” (see figure on previous page). When the view window is saved to disk, the .CVW extension is added. When developing a new project, it is often helpful to save view windows to file as you go along.

- To save a view window for the first time, choose **File | Save <*component name*> As** or click the **Save** button. You will be prompted for a file name. Although assigning descriptive names is recommended, throughout these lessons we have accepted the default file name supplied by CoPilot.
- You can also save all the open components to the project folder of the current project using the **Save Project** button or **File | Save Project**. You will be prompted confirm the addition of new components or overwriting of saved components.

Playback

The CoPilot software supports both software and hardware playback. Software playback is the replaying of recorded sequential monitor data through the displays and hardware objects to analyze the databus values and activity as if it were being transmitted again, with the ability to start/stop/pause and control the playback rate. Although the 429 demonstration card does not support hardware playback, hardware playback is used with real hardware to replay previously recorded information on the bus to communicate with and test external equipment. See the user's manual for additional information about the operation and advanced features of hardware playback.



Hardware playback configuration (not available with the 429 demo card)

Lesson 6: Capture Monitor Filtering and Analysis

ARINC 429 labels can accumulate quickly. For example, if 10 labels are transmitted every 100 milliseconds (a typical rate); at that rate, with eight channels, the monitor file would grow at the rate of one megabyte per minute. In this lesson we will explore ways to limit data capture and analyze the recorded monitor information.

Introduced in This Lesson

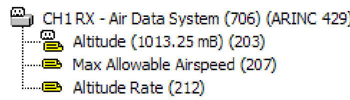
Monitor capture filtering, pausing the monitor, Edit Search Criteria, Monitor View context menu, bookmarking records

Objective

Discover ways to limit unnecessary or redundant information through filtering and analyze the results.

Channel / Label Capture Filtering

The monitor filter icon appears in the Hardware Explorer on labels tagged for monitoring (see figure at right). By default, the monitor capture filter settings for channels are set to 'selective.' Label capture filter settings are disabled. Enabling the monitor capture for a label will allow that label to be recorded.

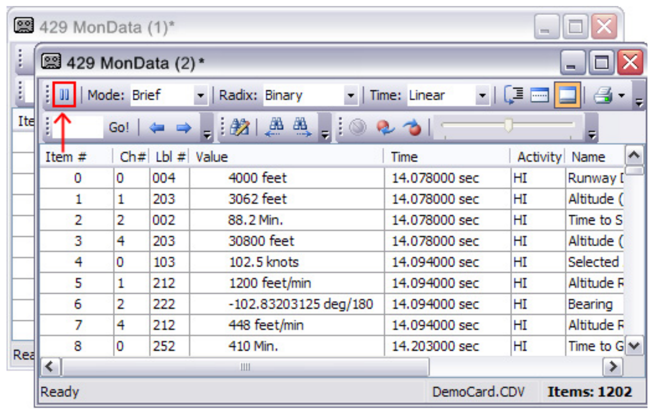


Transmit CH1 after filter change

Note: Channel and label filter choices are ignored if Monitor All is selected for the Sequential Monitor.

- ► Right click the **Sequential Monitor** icon and deselect **Monitor All** so that filtering can be defined by channels and labels
- ► Right click Altitude (1013.25 mB) (203) in CH1 and click **Monitor** to enable monitoring

Now, only label 203 will be recorded.



Create multiple views from the MonData files

Pause the Recording

Pausing the data logging is done to limit the amount of recorded data and to eliminate unwanted data from the recording.

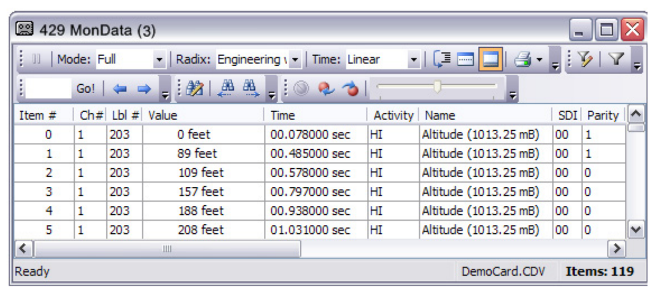
- ► Click the **Run** button to start recording and create a new 429 MonData file
- ► Double click the new **MonData** file for viewing

The Monitor View's Pause button can control the recording state. Capture of new data is suspended when Paused.

- ► After a short time, click the **Pause** button

A pause symbol appears on the Sequential Monitor and the recording of data is suspended.

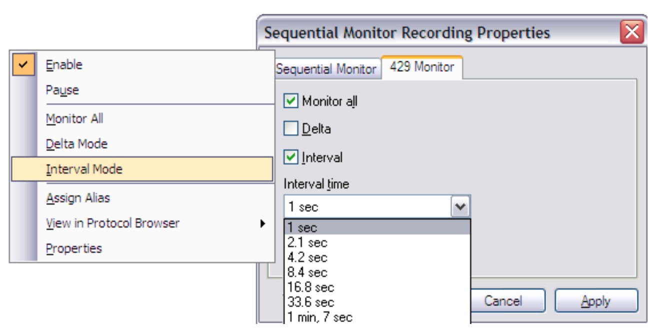
- ► Click **Pause** again to resume recording



429 Monitor View (capture selectively by channel and label)

Sampling Bus Traffic

The Sequential Monitor records every instance of each label when filters are enabled. Sampling the data and eliminating unnecessary records with identical data values rereduce the file size and simplify analysis. Although not



Define Interval Mode or Delta Mode through monitor properties implemented for the 429 Demo Card, with actual Ballard hardware (licensed for CoPilot) the following data reduction methods are available:

- *Interval Mode*—each label is added to the view only once during the interval selected by the user
- *Delta Mode*—each label is only added to the Monitor View when the data value changes

The context menu and sequential monitor property page allow for changing these options as shown on the previous page.

▶ Click the **Stop** button to halt the simulation

Search and Analyze

A variety of post-capture analysis tools are provided.

▶ Click the **Define** button in the Search toolbar of one of the Monitor Views to open the Edit Search Criteria dialog (see figure)

▶ Click the **None** button, then **Channel 1 Label 203**

▶ Click the **Engr Value** option, select **greater than** >, type **5000** in the textbox, and click **OK**

▶ Click **Forward** to locate next matching record

The matching record will be highlighted. This record can be tagged for future reference.

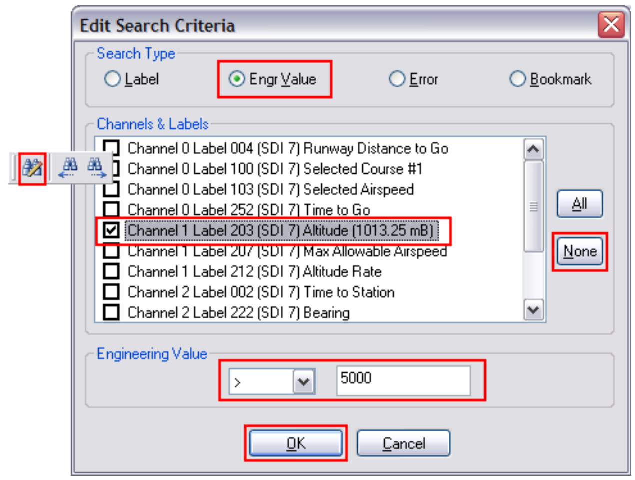
▶ Right click on the highlighted row and select **Bookmark Record** from the context menu

▶ Type **1** in the Go To Message textbox, press the **Go!** button, and bookmark that row as above

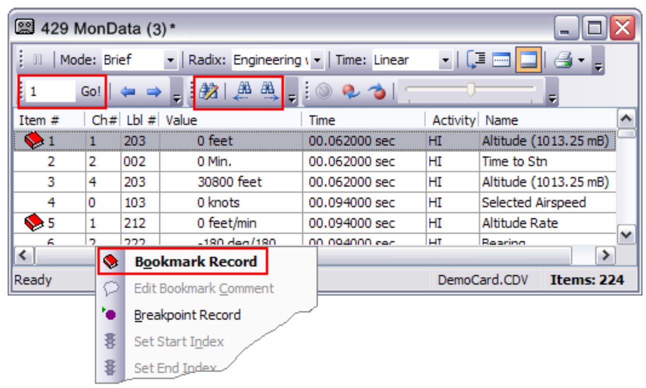
The lines will be marked by a bookmark icon.

▶ Click the Search **Define** button, select **Bookmark** in the Search Type frame, and click **OK**

▶ Navigate through the Monitor View for bookmarks with the Fwd/Back buttons



Defining search criteria to analyze monitored data



Monitor View: go!, searching, and bookmarking records

Related Topics

- Lesson 7 explains how to print and export data from a Monitor View
- Lesson 10 explains how to replay monitored data onto the databus
- Lesson 11 illustrates how to play back monitored data through CoPilot software for analysis
- Lesson 16 demonstrates how to control monitor recording through scripting routines

Summary

In this lesson you learned…

- how to use the monitor pause controls, capture filters, and sampling to limit data
- how to specify and engage monitor search capabilities
- how to define and search for specific message records
- how to bookmark records of interest

The next lesson will illustrate how to print and export monitor records from the monitor file.

Lesson 7: Print and Export Sequential Data

Lesson 6 provided a brief introduction to searching for and marking information within a Monitor View. This lesson will demonstrate how to print and export monitored information for use in Microsoft Excel or other applications.

Introduced in This Lesson

Monitor record highlighting, print selection, export selection, loading Excel file

Objective

Print recorded sequential monitor data with print preview, export a subset of the captured data (information in lines 20 through 40) and then import that data into Excel.

Print Preview Monitor Records

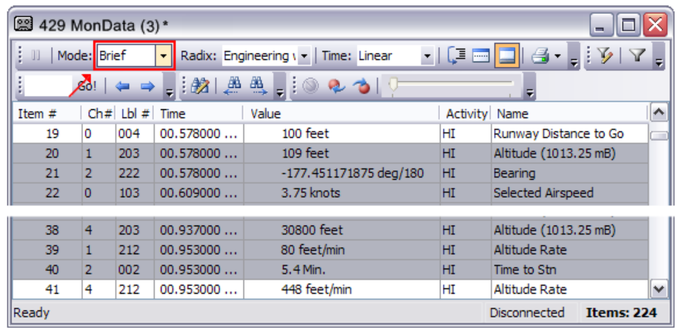
Print and Export features are based on the Monitor display, not the monitor record. Consequently, you can control the results through highlighting and choices in the display frame, display filter, or column order. Printing works best when the display is in Brief mode.

- ► Right click the **Sequential Monitor** icon and uncheck **Enable** to disable it
- ► Verify **Brief** from the **Mode** display settings for the view displaying 429 MonData (3) file is set
- ► Drop down the menu next to the Print button and select **Print Preview**

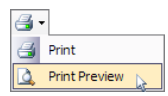
Notice that the print preview window displays the columns, selection, and bookmarks just as they are in the Monitor View.

- ► Click the **Close** button on the Print Preview

Monitor data can also be exported to and printed from other applications (e.g., Notepad or Excel).



Specify the print range by highlighting lines 20 through 40



Select Print Preview From the 429 Monitor Toolbar

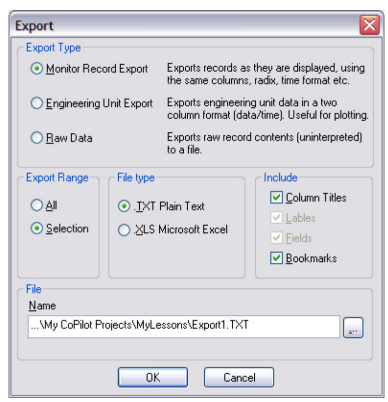
Export a Text File

Exporting monitored data allows ARINC 429 information to be combined with other data or examined in Excel or other applications. First, prepare the data so that it is compatible with the target system.

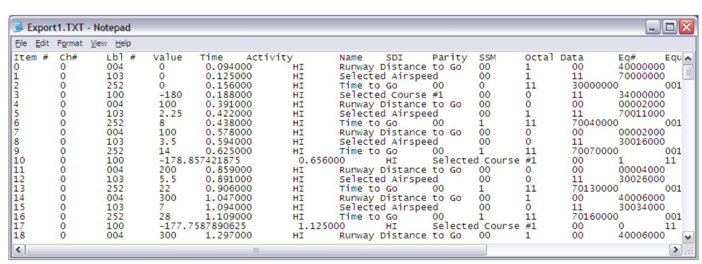
- ► Set the Display **Mode** to **Full**, the **Radix** to **Engineering**, and the **Time** to **Seconds** for the view displaying 429 MonData (3) file

Note: Engineering and Seconds options format data/time values without alphanumeric descriptors. Consequently, Excel will translate them as numbers rather than text.

- ► Click the Display Filter **Define** button, then click the **Search** button to search for recorded messages
- ► Scroll down and uncheck all labels from CH4, and then click **OK** to close the filter dialog



Set export file name and path



The Export1.txt file shown in Notepad

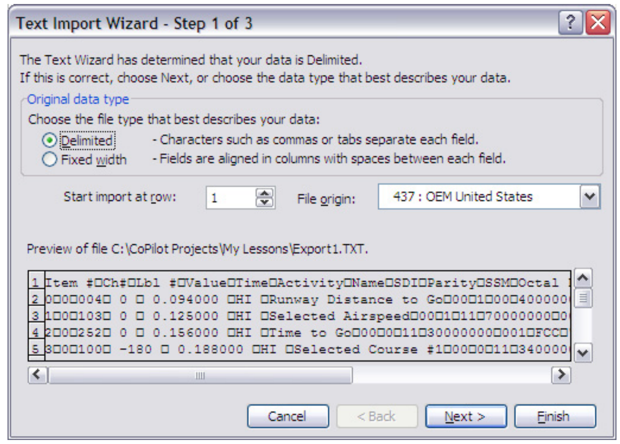
► Click item **20**, then hold the **SHIFT** key and click item **40** to select a range of records

► Right click the highlighted rows and choose **Export** to access the Export dialog (see figure on previous page)

► Verify that the Export Type is set to **Monitor Record Export**, the Export Range is set to **Selection**, the Include choice is **Column Titles**, and the File type is set to **.TXT Plain Text**

► Click the **Browse** button, browse to …\My Documents\My CoPilot Projects (or another location), type **Export1.TXT** in the File name field, click **Open**, and then click **OK** to complete the export

► Browse to **Export1.TXT** and open it in Notepad as shown on previous page



Excel Text Import Wizard (select Finish to accept)

Import the File into Excel

► Launch Microsoft Excel and click the **Open** button or select **File | Open** from the Excel menu

► Select **All Files (*.*)** in the Files of Type text box

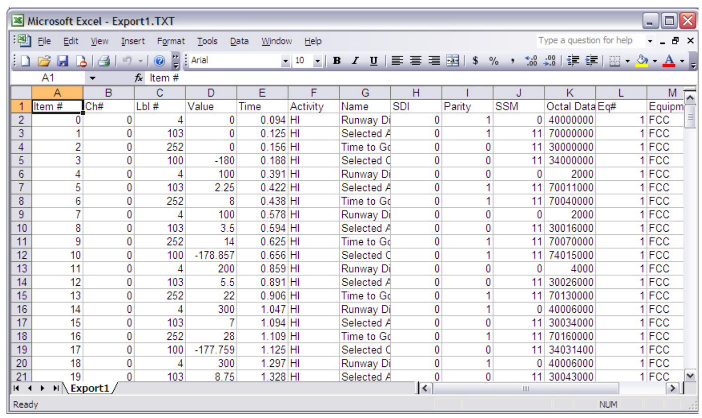
► Browse to and open **Export1.txt** (the Text Import Wizard will open; see middle figure at right)

► Click **Finish** to accept the default choices

► Double click the right edge of column titles to optimize the column width (see figure at right)

Records can also be exported in an Excel .XLS format.

► Click the **Close** button for all Monitor Views.



	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Item #	Ch#	Lbl #	Value	Time	Activity	Name	SDI	Parity	SSM	Octal Data	Eq#	Equipm
2	0	0	4	0	0.094	HI	Runway Di	0	1	0	40000000	1	FCC
3	1	0	103	0	0.125	HI	Selected A	0	1	11	70000000	1	FCC
4	2	0	252	0	0.156	HI	Time to Gc	0	0	11	30000000	1	FCC
5	3	0	100	-180	0.188	HI	Selected C	0	0	11	34000000	1	FCC
6	4	0	4	100	0.391	HI	Runway Di	0	0	0	2000	1	FCC
7	5	0	103	2.25	0.422	HI	Selected A	0	1	11	70011000	1	FCC
8	6	0	252	8	0.438	HI	Time to Gc	0	1	11	70040000	1	FCC
9	7	0	4	100	0.578	HI	Runway Di	0	0	0	2000	1	FCC
10	8	0	103	3.5	0.594	HI	Selected A	0	0	11	30016000	1	FCC
11	9	0	252	14	0.625	HI	Time to Gc	0	1	11	70070000	1	FCC
12	10	0	100	-178.857	0.656	HI	Selected C	0	1	11	74015000	1	FCC
13	11	0	4	200	0.859	HI	Runway Di	0	0	0	4000	1	FCC
14	12	0	103	5.5	0.891	HI	Selected A	0	0	11	30026000	1	FCC
15	13	0	252	22	0.906	HI	Time to Gc	0	1	11	70130000	1	FCC
16	14	0	4	300	1.047	HI	Runway Di	0	1	0	40006000	1	FCC
17	15	0	103	7	1.094	HI	Selected A	0	0	11	30034000	1	FCC
18	16	0	252	28	1.109	HI	Time to Gc	0	1	11	70160000	1	FCC
19	17	0	100	-177.759	1.125	HI	Selected C	0	0	11	34031400	1	FCC
20	18	0	4	300	1.297	HI	Runway Di	0	1	0	40006000	1	FCC
21	19	0	103	8.75	1.328	HI	Selected A	0	0	11	30043000	1	FCC

Imported monitor records in Excel

Import Records into Monitor View

The Raw Data export option creates a special CoPilot Monitor .RAW file (see the Export dialog figure on the previous page). This .RAW file can then be filtered, edited, or rearranged and then re-imported into a Monitor View file using the Import command to create a customized hardware playback source.

Related Topics

- Data can also be transferred directly to external files through scripting
- Closing a Monitor View displaying data from a 429 MonData file does not remove the data from the project

Summary

In this lesson you learned…

- how to print/print preview and export Sequential Monitor information
- how to focus the print or export content through highlighting, display choices, and display filters
- how to import Delimited text files into Excel

The last three lessons demonstrated the power of the Sequential Monitor. Lessons 10 and 11 will show that monitored data can also be played back on the ARINC 429 databus or replayed, viewed, and analyzed through CoPilot software.

Lesson 8: Generate Dynamic Data

The Engineering Unit Editor introduced in Lesson 4 provides a simple method for defining transmit label values. Alternatively, you could edit a single value through the Binary Editor or continuously modify engineering unit values using a CoPilot Data Generator.

Introduced in This Lesson

Raw Binary Data Editor, tool tips, Data Generator window, Data Generator Properties

Objective

Simulate an Inertial Reference System (004) with Latitude (010), Longitude (011) and Heading (044), and define data values through the Binary Editor and Data Generator.

Use the Raw Binary Editor

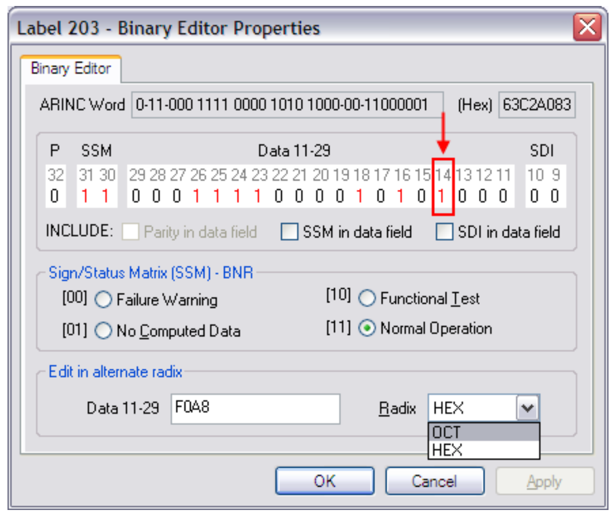
In Lesson 3, Altitude was set to 30,800 feet through the Engineering Unit Editor. Now, change the value at the bit level through the Binary Editor.

- ▶ Right click Altitude (1013.25 mB) (203) in CH4 and select **Edit Raw**

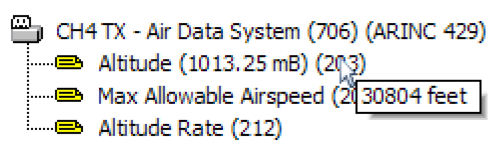
The Binary Editor allows all elements of the ARINC 429 word, including the parity, SSM, and SDI values, to be specified. Data can also be entered through SSM options or in octal or hexadecimal (see figure at right).

The data value of the Altitude BNR label is defined in bits 11-28, and the sign is in bit 29.

- ▶ Double click bit **14** to change it to **1** and click **OK**
- ▶ Position the mouse pointer over label 203 to view the new value of 30,804 in the tool tip display



Binary Editor showing a value of 30,804



Hover over label 203 to see the change in value

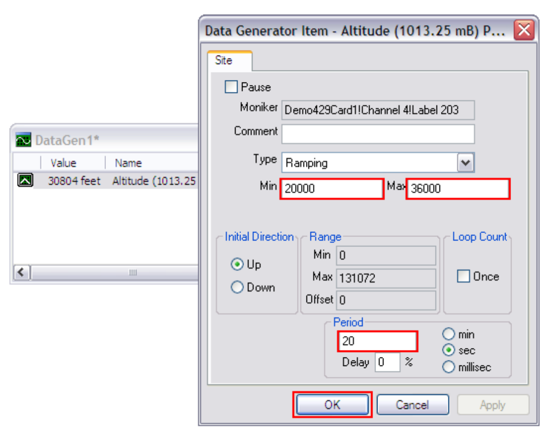
Use the Data Generator

You can also modify Altitude data in a dynamic pattern that continuously updates while the CoPilot simulation is running.

- ▶ Click the **Data Generator** button on the **CoPilot Standard Views Toolbar**

A Data Generator view will open in the current workspace.

- ▶ Drag and drop the **Altitude** label (203) in CH4 into the Data Generator window
- ▶ Double click the **Altitude** label in the Data Generator to open the Properties dialog
- ▶ Enter **20,000** in Min, **36,000** in Max, **20** in Period, and click **OK** (see figure at right)
- ▶ Click the **Run** button and view changing values in the Data Generator



Set Data Generator properties for label 203

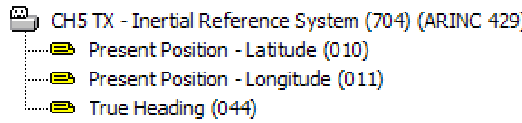
Simulate Position and Heading

In Lesson 15 you will use aircraft position and heading to drive a Moving Map display. The highly configurable Data Generator can produce the precise data values that will be needed.

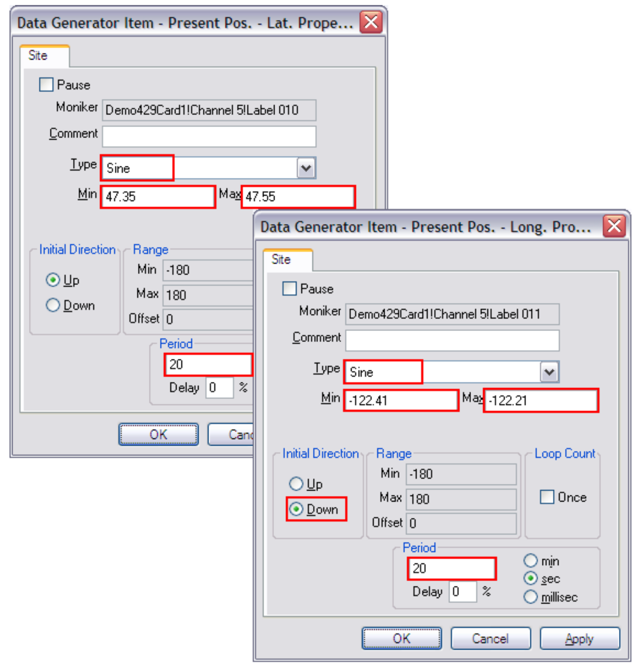
- ▶ Click the **Stop** button to halt simulation
- ▶ Double click transmit **CH5,** select **Inertial Reference System (704)**, and click **OK**
- ▶ Hold down the **CTRL** key and select **Latitude (010)**, **Longitude (011)**, and **True Heading (044)**, and then click **OK** (see results at right)

The Data Generator is used to simulate a holding pattern over the SeaTac airport at 47º 27' (47.45º) Lat. and –122º 18' (–122.31º) Long.

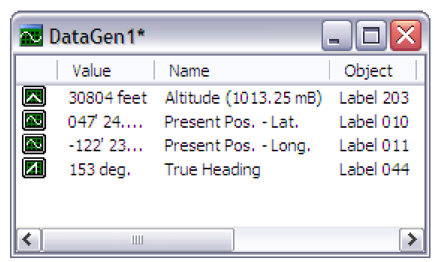
- ▶ Drag and drop **CH5** into the Data Generator to add all three transmit labels
- ▶ Double click **Present Pos. - Lat.** In the DataGen1 window to configure it
- ▶ Change the generator Type to **Sine**, enter **47.35** in the Min box, **47.55** in the Max box, enter **20** in the Period box, and click **OK** (see example at right)
- ▶ Double click **Present Pos. -Long**
- ▶ Change the Type to **Sine**, the Initial Direction to **Down**, enter **–122.41** in Min, **–122.21** in Max, **20** in Period, and click **OK** (see figure at right)
- ▶ Double click **True Heading**
- ▶ Change the Type to **Sawtooth**, Initial Direction to **Down**, period to **20**, and click **OK**
- ▶ Click **Run** to view changing data values in the data generator
- ▶ Press **Stop** to end the simulation
- ▶ Note: If you are maintaining a personal, cumulative project, **Save** and **Minimize** the Data Generator to the Project Explorer (it is needed for subsequent lessons).



Equipment ID and three labels added for use in Lesson 12



Generator properties are set to simulate a circular holding pattern



Configure changing values with a Data Generator window

Related Topics

- The Data Generator types include: ramping, sawtooth, sine, approach, square, data list, random, and complex ramp
- Additional CoPilot Professional views are available in the Professional Displays tab of the New Hardware and Views dialog

Summary

In this lesson you learned…

- how to define label values through the Binary Editor
- how to view static data values through tool tips
- how to assign and define dynamic values through the Data Generator

In the next two lessons you will take a closer look at label properties and interpreters, learn how they can be changed and saved in the ARINC 429 database, and then how to play back recorded data files on the databus.

Lesson 9: Modify and Save Label Definitions

The latest release of ARINC 429 labels and Equipment IDs specifications is defined and saved in the ARINC 429 database. The official ARINC document has purposefully left some label definitions to the end-user. All label and equipment definitions can be viewed and changed through the CoPilot label and equipment editors. ARINC labels are translated into engineering units through BNR, BCD, discrete, and other interpreters.

Introduced in This Lesson

Assign New Equipment, Create New Label dialog, BCD, BNR Angular and Discrete Interpreters, Save to Database

Objective

Define a new Equipment ID, add new and existing labels, and save the result in the ARINC 429 database for future use.

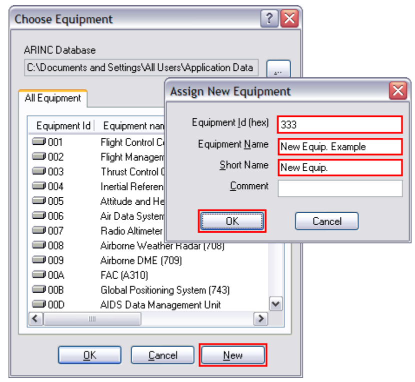
Define New Equipment

Before assigning a new Equipment ID, explore the list of equipment already defined.

- ▶ Double click CH6 TX (ARINC 429) to access the Choose Equipment dialog

The equipment list can be sorted by clicking column titles for Equipment ID or Equipment Name in the Choose Equipment dialog (see figure at right).

- ▶ Press the **New** button, complete the fields (as shown in the Assign New Equipment dialog at right) and press **OK** to open Choose Labels dialog

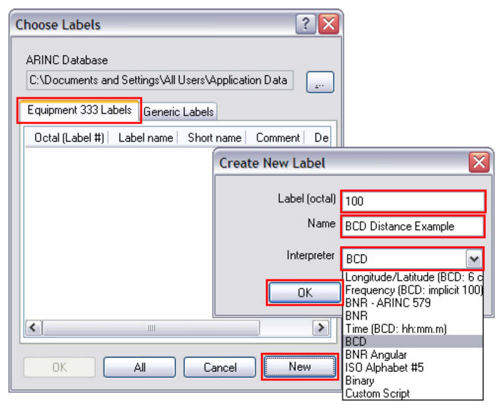


Add Eq. ID 333 (Eq. order inverted by clicking Equipment. ID title)

Define New Labels

The Choose Labels dialog lists several generic labels. Generic labels are typically not assigned but are sometimes used on a variety of equipment.

- ▶ Click the **Equipment 333 Labels** tab (since the equipment is newly defined, no labels are listed)
- ▶ Press the **New** button to access the Create New Label dialog
- ▶ Enter **100** in the Label (octal) box, **BCD Distance Example** in the Name box, select **BCD** from the Interpreter listbox, and click **OK**



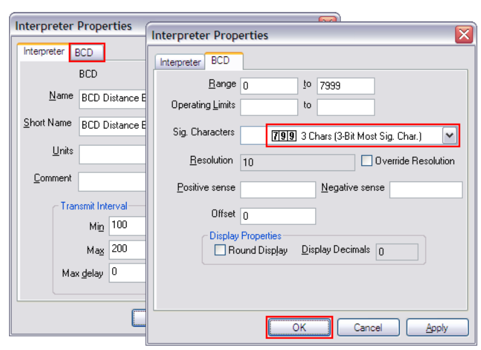
Add New Label (BCD label 100)

BCD interpretation parameters are predefined. Some of the parameters are linked, so changing one of them may affect the others.

- ▶ Select **BCD** tab, choose 799 3 Chars (3-Bit Most Sig. Char.) from the listbox, and click **OK**

Note: The range of 0 to 7999 is unchanged but the resolution changed from 1 to 10.

ARINC 429 labels often convey more than one value. Bits 11–29 of the 429 words are reserved for data values. The three-character BCD value occupies the upper portion of that range leaving bits 11–18 available for other uses.

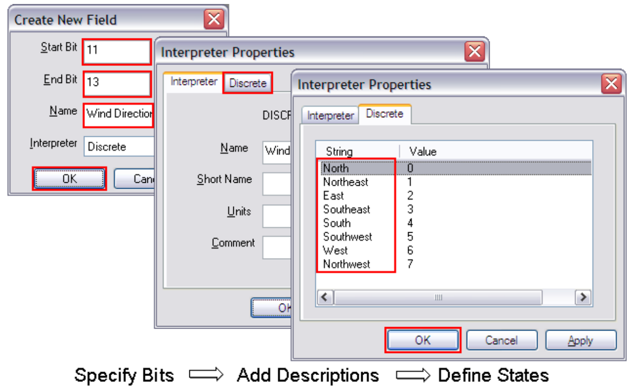


Specify BCD title and Interpreter for Label 100

Define New Fields

Fields can be assigned to a range of bits within a label (or labels) and be defined by an interpreter.

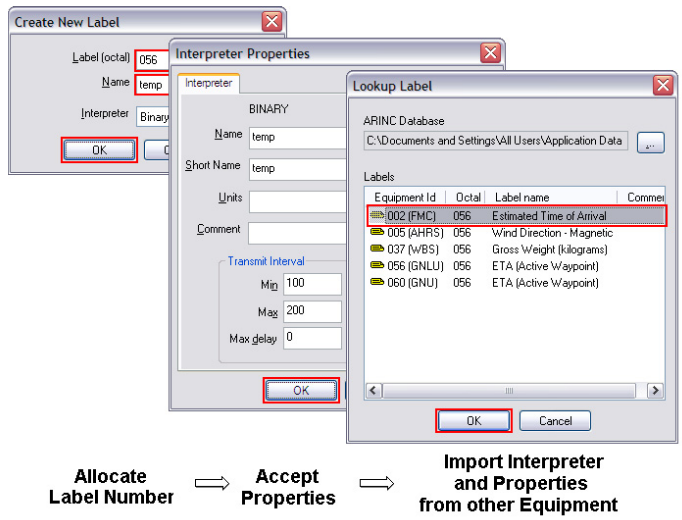
- ▶ Right click BCD Distance Example (100) and select **Insert field** to access the Create New Field dialog
- ▶ Enter a Start Bit of **11**, End Bit of **13**, **Wind Direction** as the Name, and click **OK** to close
- ▶ Select the **Discrete** tab, enter the 8 states shown at right by clicking each string
- ▶ Click **OK** to close the dialog



Import an Existing Label

Existing labels can be assigned to a new Equipment ID.

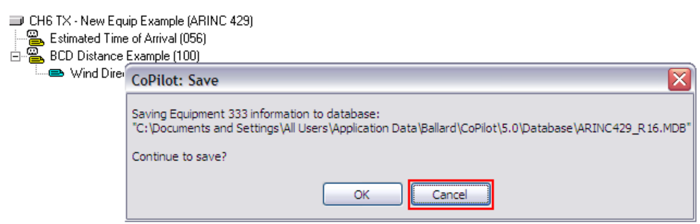
- ▶ Right click the CH6 TX - New Equip. Example branch, select **Add labels**, and click **New**
- ▶ Type **056** in the Label (octal) box, **temp** in the Name box, click **OK** to close the Create New Label dialog, and then click **OK** to close the Interpreter Properties dialog
- ▶ Right click label temp (056), select **Lookup Label**, and double click **002 FMC** to import that label description and interpreter



Save to the Database

To save the completed equipment definition in the ARINC 429 database (for example only):

- ▶ Right click CH6 TX – New Equip. Example and select Save EquipID to Database (**do not click OK**)
- ▶ Click **Cancel** to keep this example out of the database



Click Cancel to keep this example out of the database

Related Topics

- Existing equipment and label definitions can also be modified and resaved in the database
- Labels can be linked to a virtual instrument (e.g., altitude to altimeter) and that link can be saved to the database

Summary

In this lesson you learned…

- how to define new Equipment IDs
- how to define new labels through properties and interpreters
- how to save those equipment and label specifications in the ARINC 429 database

In the next two lessons you will learn how to use the playback features of CoPilot.

Lesson 10: Test with Hardware Playback

Testing is easier and more reliable when it is done in a stable environment. CoPilot allows recorded data to be played back (replayed) onto the databus through one or more ARINC 429 transmit channels, allowing users to create repeatable tests. You can even modify the recorded data to test for specific situations. Since you do not have access to actual hardware or an active databus through the 429 Demo Card, this lesson demonstrates the procedures used with actual Ballard 429 cards.

Introduced in This Lesson

Channel Properties (Hardware Playback tab), Playback Export dialog

Objective

Learn how to configure a transmit channel for hardware playback and replay data from an open Monitor View or a hardware playback file.

Replay from a Monitor View

A transmit channel is configured for hardware playback through its Properties dialog.

- ► Right click the CH7 TX icon and choose **Properties** to open the Channel Properties dialog
- ► Select the **Hardware Playback** tab and choose the **Enable Hardware Playback** option

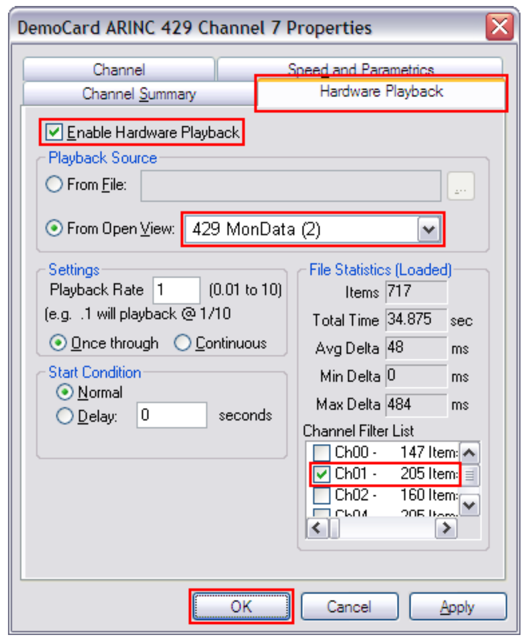
We'll use one of the Monitor View files created earlier as the data source for hardware playback. (Other options include Settings and Start Conditions.)

- ► In the Playback Source frame, select the **From Open View** option and choose **429 MonData(2)** from the list (see figure)
- ► Click the **Apply** button to load the channel information for the selected playback source

The Channel Filter list is populated with the channels found in the playback source. Although CoPilot can play back data from multiple recorded channels, playback is usually limited to a single channel. We will replay the recorded data from CH1 (Air Data System – 706) on CH7.

- ► Click to select **CH01** from the Channel Filter List (see figure)
- ► Click **OK** to close the Channel Properties dialog

CH7 is now configured to simulate this system. Notice the green hardware playback icon that appears: CH7 TX.

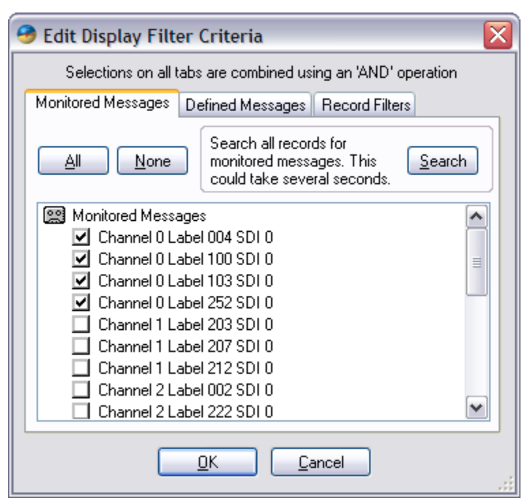


Hardware Playback tab for transmit channel 7

Retransmit from a Playback File

To play back Flight Control data on CH6, we could use the same Monitor View and just select CH0 instead of CH1 when we configure CH6. However, let's use an alternate data source: a hardware playback file.

- ► Right click **429 MonData (1)** in the Hardware Explorer and select **View Monitor Data**



Display Filter dialog for 429MonView2

► Click the **Edit Filter** button to open the Display Filter dialog and click the Search button in the Monitored Messages tab

► Click the None button, then select labels **004**, **100**, **103**, and **252** from Channel 0 and press **OK** (see figure on previous page)

Now that only CH0 records are displayed, we are ready to save them as a hardware playback file.

► Right click in the Monitor View window and select **Create HW Playback File** (see figure)

► In the Export dialog, enter the path to the **My CoPilot Projects Folder** followed by **\FlightControl.CPB** in the File Name field and click **OK**

► Right click on CH6, select **Properties**, select the Hardware Playback tab, and choose the **Enable Hardware Playback** option

► Click the **Browse** button, navigate to and select the **FlightControl.CPB** file you just created, and click the **Apply** button

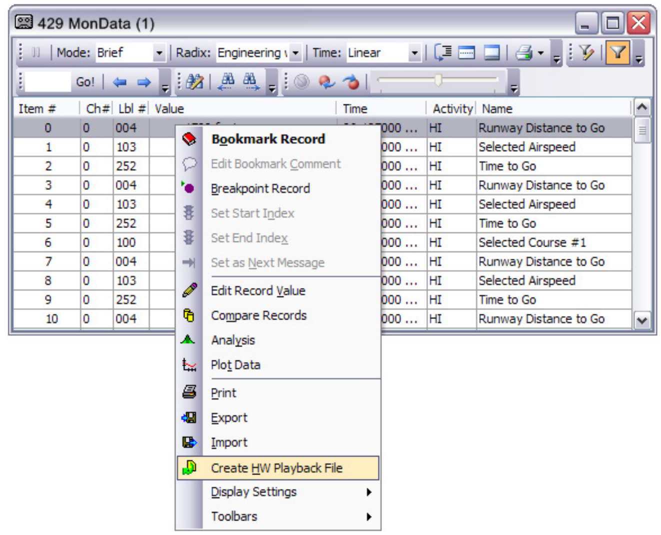
► Select **CH0** in Channel Filter List and click **OK**

If labels and fields had been defined on CH6 they would be ignored (not transmitted) as long as the channel was configured for playback.

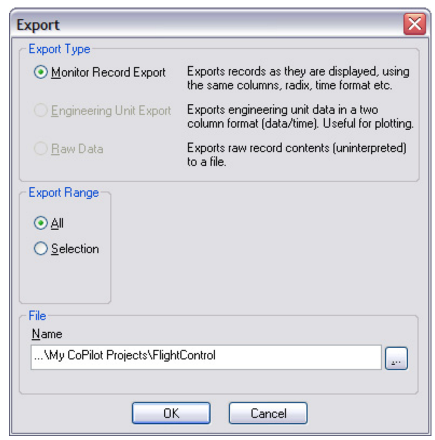
► Right click CH6 and deselect **Hardware Playback**, then repeat for CH7

Replaying using Real Hardware

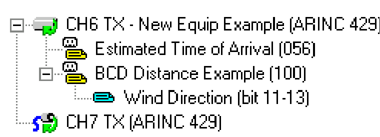
If you were running a real Ballard 429 hardware, you could now press the Run button to retransmit Flight Control Computer data on channel 6 and data representing the Air Data System on channel 7.



Filtered Monitor View with Create HW Playback File command



Hardware playback file export dialog



Transmit channels marked with hardware playback icons

Related Topics

- Channels not assigned to playback will continue to operate normally while hardware playback is occurring
- The hardware playback rate, start condition, and loop options can be specified in the Channel Properties dialog

Summary

In this lesson you learned…

- how to configure and enable a transmit channel for hardware playback
- how to select a playback data source and select channel(s) from a Monitor View source
- how to create a special hardware playback file

In this lesson you learned how to replay captured data back onto the databus. In the next lesson, you will discover that monitored data can also be replayed through the CoPilot software and that all CoPilot views and features can be used to analyze that information.

Lesson 11: Analyze Data with Software Playback

Although many of the features and controls are the same, the objectives of hardware and software playback are very different. Hardware playback is used to retransmit monitored data on the databus to test an external component through transmit channel(s). The purpose of software playback is to analyze information already collected. In software playback mode, links to the external databus are temporarily suspended and the monitored data is routed through CoPilot as though it were coming from an external source. Users can use all CoPilot views to study the information and set boundaries for software playback, control the playback speed, and step through the data one record at a time.

Introduced in This Lesson

Software playback mode, Card Properties dialog (software playback tab), software playback controls in Monitor View

Objective

Analyze monitored data through software playback using a variety displays and control playback from Monitor View.

Configure CoPilot for Playback

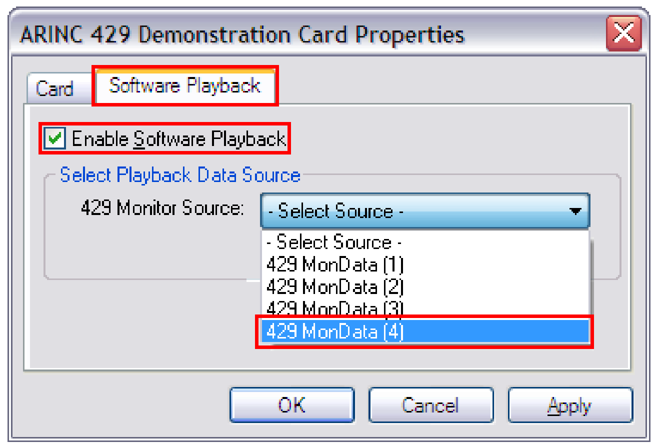
Create a new monitor record using the views and Data Generator settings created in earlier lessons.

- ▶ Right click the **Sequential Monitor** icon and check **Enable**
- ▶ Click **Run** to start the simulation
- ▶ Click **Stop** (after collecting at least 200 records) and right click the most recent **429 MonData** icon and select **View Monitor Data** to view the data
- ▶ Right click the **Sequential Monitor** icon and uncheck the **Enable** option to disable monitoring

Software playback mode is configured and enabled in the card Properties dialog.

- ▶ Right click the **Demo429Card1** icon and select **Properties** from the context menu
- ▶ In the Properties dialog, select the Software Playback tab, click the **Enable Software Playback** option
- ▶ If necessary, select the last item from the list (i.e. 429MonData (4)) that you just created and click **OK** (see figure)

Notice the playback icon that appears on the card.

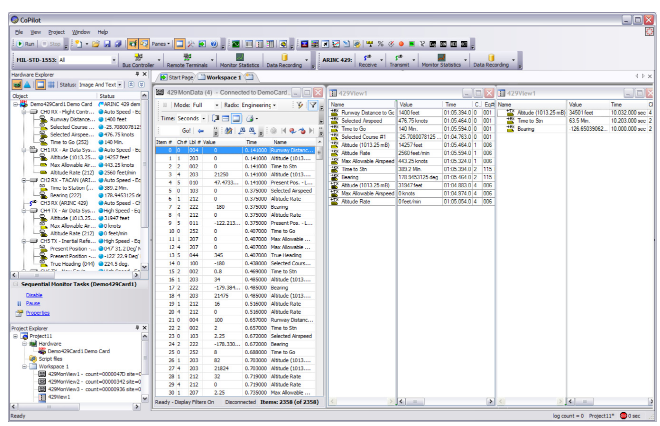


Demo card context menu and Software Playback tab

Run and Observe Playback

As each message is played back, values are updated for objects in the Hardware Explorer and all views.

- ▶ Click the **Maximize** button on the CoPilot title bar to maximize the CoPilot workspace
- ▶ Click the **Minimize** button on each open view
- ▶ Double click **EngrView1**, and **EngrView2** from the Project Explorer to show the views
- ▶ From the Hardware Explorer , double click the playback file you selected (i.e. **429 MonData (4)**)
- ▶ Select **Window | Tile Vertically** to organize the desktop (see figure on right)



Software playback of 429MonView4 data through CoPilot views

► Click **Run** to start software playback

Note: The Data Generator is automatically paused during software playback to prevent the data in view windows from being driven by two sources.

Control Playback during Run

During runtime, playback is controlled from the Monitor View using the Playback toolbar and other controls (see figure). The row highlight advances to indicate which message is being replayed (see figure at right).

► Move the speed control to various positions and observe the effect in the monitor and other views

► Click the **Pause** button to suspend playback

► Press the buttons to back up or advance playback a single step at a time

By default, software playback loops continuously through the entire monitor file. Alternatively, you can specify breakpoints and start/end points.

► Scroll to record **100**, right click to access the playback context menu and select **Set Start Index**

► Scroll to record **150**, right click, and select **Breakpoint Record**, then repeat for record **155**

► Scroll to record **200**, right click, and select **Set End Index**

► Click the **Pause** button to resume playback

Playback will loop until it meets the first breakpoint.

► Click the **Seek End Index** button in the Playback tool bar

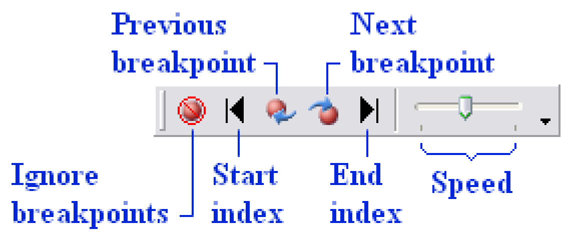
This moves the playback resume point to record 200.

► Click the **Ignore Breakpoints** button

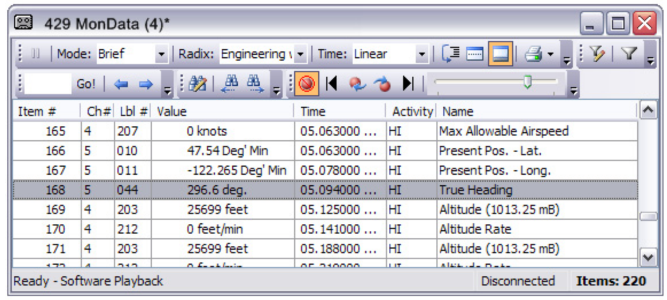
This action resumes playback, which picks up at record 200 and continues without stopping at breakpoints.

► Click the **Stop** button to end the simulation

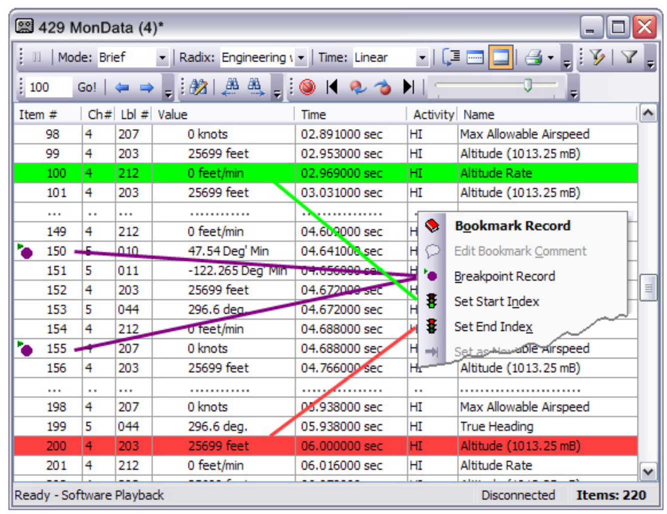
► Right click the **Demo429Card1** icon and deselect **Software Playback** in the context menu to return the card to normal operation



The Playback tool bar in the Monitor View window



Messages highlighted to show which message is being replayed



Playback file marked with breakpoints and start/end points

Summary

In this lesson you learned…

- how to engage the software playback mode and replay a monitor record
- how to control playback speed and use breakpoints and Go To commands during a playback
- how to view and analyze recorded information using CoPilot features and views

CoPilot 429's software playback provides a practical way for users to analyze the equipment and information transmitted on a 429 databus. For additional information, please refer to the *CoPilot User's Manual*. The next section will demonstrate the powerful features available with CoPilot Professional.

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Section C: CoPilot Professional

You have now completed the CoPilot Standard portion of this guide. In the first two sections you learned how to collect and display labels and fields in the Sequential Monitor and Engineering View windows. The information was defined and displayed using engineering units. The ARINC 429 database was used for defining equipment IDs, labels and fields. In this section, the ARINC 429 database is also used to store and retrieve graphical virtual instrument definitions for displaying engineering units. The additional CoPilot Professional capabilities described in this *Getting Started Guide* include scripting, strip charts, and moving map displays. Refer to the *CoPilot User's Manual* for additional Professional features not discussed in this guide such as ATE (Automated Test Environment) Test Manager, the Script Debugger and the Command Prompt.

CoPilot Professional

CoPilot is licensed as either CoPilot Standard or CoPilot Professional. CoPilot Professional contains all the features of CoPilot Standard plus powerful graphical displays, ATE (using Python scripting technology), Test Manager, and Visual Basic Scripting. CoPilot Professional features described in this getting started guide include…

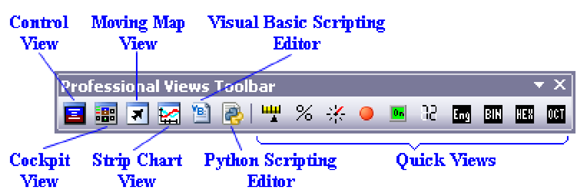
- graphical strip chart displays (Strip View, Lesson 12)
- a library of virtual controls and aircraft instruments (Quick View and Control View, Lessons 13 and 14)
- moving map displays (Map View, Lesson 15)
- flexible script routines used to extend the capabilities of CoPilot for running advanced simulations, generating complex data, creating reports, running tests and more (Python Code Editor, Lesson 16)
- VBScript routines (Script View, Lesson 17)

Professional Mode

To run CoPilot Professional components, CoPilot requires all hardware devices (included in the project) to have Professional license keys. The 429 Demo card is enabled with Professional capability (and does not require a physical hardware key). Unkeyed hardware devices will not be run when professional components are part of a project.

Professional Views Toolbar

The Professional Views Toolbar provides quick access for creating new display views. The Professional Views Toolbar and other toolbars, can be shown/hidden from the **View | Toolbars** menu item. Users can also customize and add additional toolbars as described in the CoPilot User's Manual.



Introduced in This Section

The lessons in this section demonstrate the professional features available in CoPilot Professional. Professional features include graphical display components, and scripting capabilities.

- Lesson 12 — Strip charts can be used to display a history of one or more streams of data.
- Lesson 13 — Simulated aircraft instruments can be automatically generated from labels, customized, and permanently associated with a specific label through the 429 database.
- Lesson 14 — Simulated controls can also be custom designed and explicitly linked to a label value.
- Lesson 15 — Positional data may be used to display an aircraft position on a moving map display.
- Lesson 16 — CoPilot can be customized and controlled through script routines that access and modify the properties of CoPilot objects.

Lesson 12: Create a Strip Chart Display

The Strip View window is a dynamic, two-dimensional charting control for displaying one or more streams of real-time data. The Strip View displays the engineering value history of the selected parameters. The zoom function allows for quick review of the data set and in-depth analysis of data trends. Strip charts can be launched from individual fields during a simulation and additional parameters can be added from the Hardware Explorer through a drag-and-drop operation.

Introduced in This Lesson

Strip View, Strip View context menu, Strip View Properties

Objective

View two labels in a Strip View and explore the display options.

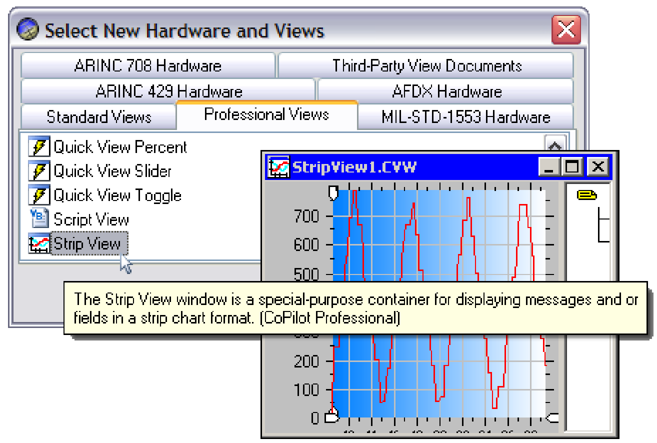
View Data with a Strip Chart

Note: If you are working from your own project instead of opening this lesson from the Samples and Lessons panel, be sure the Data Generator is present and configured to drive the data fields (see Lesson 7).

- ▶ Click the **New** button to open the New Hardware and Views dialog
- ▶ Click on the **Professional Views** tab select **Strip View**, and click **OK**

Note: Labels can be added to and deleted from this view while CoPilot is running.

- ▶ Click the **Run** button to start the simulation

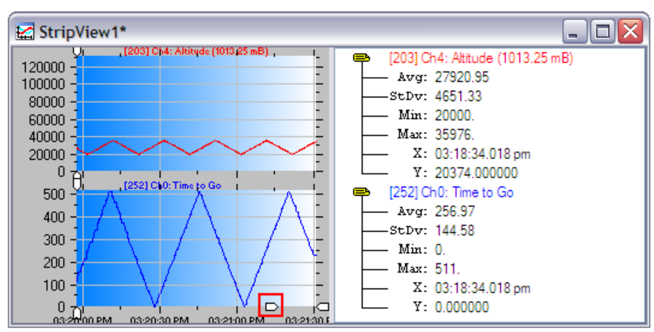


New Hardware and Views dialog with Strip View selected

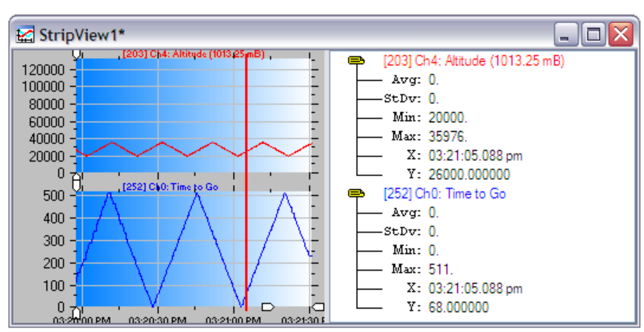
Add Labels to Strip View

- ▶ Drag and drop **Altitude** from CH4 into Strip View
- ▶ Drag and drop **Time to Go** from CH0 to Strip View and resize to match the figure at right
- ▶ Place the mouse over the left scale handle until the pointer changes to a left arrow, then click and drag the handle to the right to reduce the scale of the display area to match figure at right

Each message is displayed in a separate chart (see figure). The vertical scale of each chart is defined by their label interpreter. Average, standard deviation, and minimum/maximum values for each label are displayed on the right. Clicking in the chart area produces a movable cursor line that can be used to examine the X: (time of day) and Y: (data) values of each label (see figure).



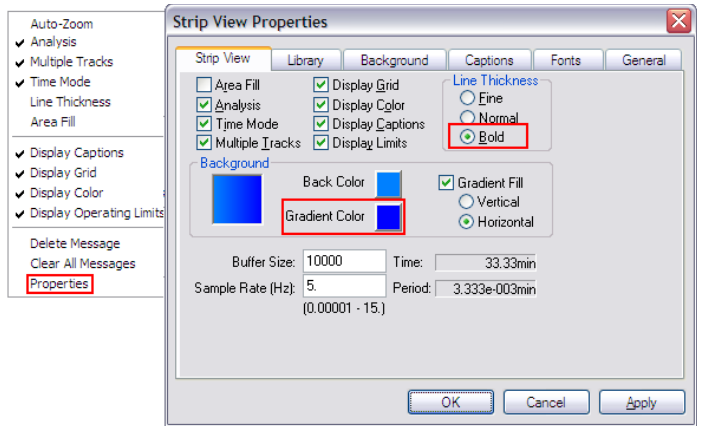
Strip View with multiple tracks



Strip View with cursor coordinates

Modify Strip View Properties

A variety of customizing options are available through the context menu or properties. Options are selected one at a time through the context menu but can be selected in groups through the Properties dialog.



Strip View context menu and Properties

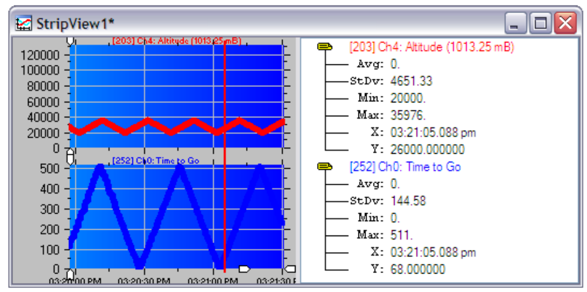
Change the Appearance

- ▶ Right click the Strip View window and select **Properties**
- ▶ Select **Bold** in the Line Thickness frame
- ▶ Click the **Gradient Color** button, select a medium blue color, click **OK** to close the color palette, and **OK** again to close the property dialog

Reset the Zoom Ranges

Since the min/max range of labels are used to set the value scale, the incoming values may not fill the available space. For example, Altitude values may range from 0 to 131,072 but the data in our chart goes from 20,000 to 36,000.

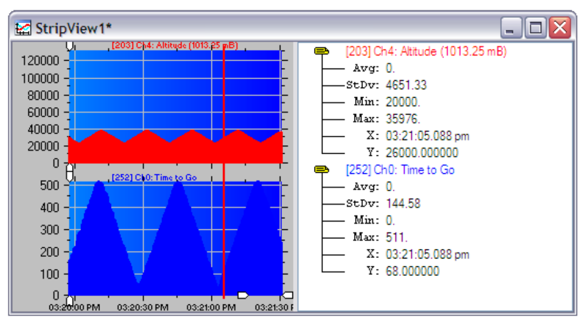
- ▶ Right click and choose **Auto-Zoom** to resize the display to fit the range of actual values
- ▶ Click the **Stop** button to end the simulation
- ▶ Click the **Minimize** button on each view to hide all open views, then **Close** all open Monitor Views
- ▶ Strip View to the Project Explorer



Strip View with changes from the property page

Other Options

- Delete individual labels through the context menu or by right clicking labels in the right pane
- Clear all messages through the context menu to clear the view for new labels
- Change divisions on the x-axis through properties to date and time (prior to simulation). Move the horizontal handles to adjust the time from days to a more precise clock time



Strip View with Time Display and Fill options

Related Topics

- Operating limit ranges defined for labels are displayed in Strip Views
- There is also a strip control available through the Control View palette (Lessons 11 and 12)

Summary

In this lesson you learned…

- how to open a Strip View window
- how to assign one or more labels to the view
- how to customize Strip View through properties
- how to use handles on the chart to refocus the data range

In this lesson you were introduced to Strip View, one of many CoPilot Professional graphical display components. The next two lessons introduce Quick Views and Control Views, displays that host virtual instruments and ActiveX controls.

Lesson 13: Generate Controls Automatically

A variety of graphical controls and virtual instruments are available in CoPilot for displaying and modifying data. In this lesson, you will learn how to generate automatic controls in Quick View and Control View from labels and data fields in the Hardware Explorer. Quick Views are pre-configured controls that can be launched in one step from data fields in the Hardware Explorer. Control View is a display window that can host multiple controls and instruments. You can add controls to Control View automatically through a simple drag-and-drop or build and link custom controls manually (described in the following lesson).

Introduced in This Lesson

Quick Controls submenu (for labels), Quick View, Control View

Objective

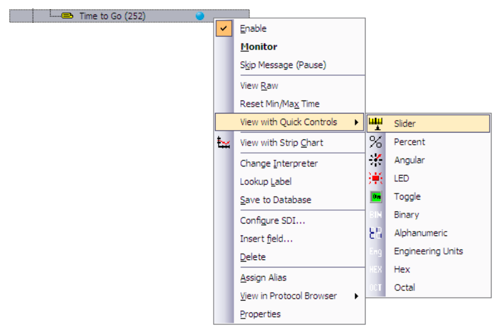
Generate a slider Quick Control from a label. Open a Control View window and add an altimeter control and a slider from two labels. Modify the label value with a data source control and learn about saving controls to the database.

Generate a Quick View Control

Note: First open the 429 Lesson 13 project (from Samples and Templates on the Start Page).

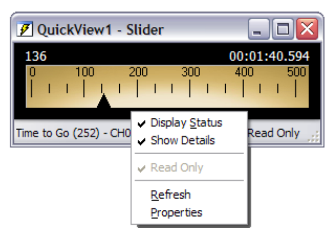
The easiest way to view and/or modify parameters graphically is with CoPilot Professional Quick Views.

- ► Click the **Run** button to start the simulation
- ► Right click on **Time to Go (252)** from CH0, point to **View with Quick Controls** to expand the submenu, and click on **Slider** (see figure at right)



The Quick Controls menu for the Time to Go label

A Quick View slider control will open in the display area. Because Time to Go on CH0 is a receive label, the slider defaults to a data display (Read Only).



Quick View slider for Time to Go (label 252)

There are many Quick Controls available for displaying different types of data. For example, an LED or Toggle control could be selected to represent a two-state discrete field. The Engineering Units control will display both the value and the units of measurement (for example, "182 degrees").

Generate Control View Controls

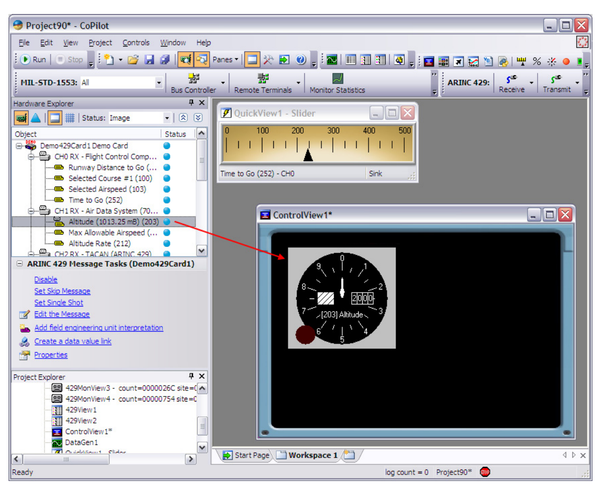
Next, let's produce similar results in Control View.

- ► Click the **Stop** button to halt the simulation
- ► Click the **New** button, select the **Professional Views** tab, choose **Control View**, and click **OK**

A blank Control View will open in the display area.

- ► Drag and drop **Altitude (203)** from CH1 into the upper-left of the Control View window

(The upper-left corner of the control will be positioned at the point where you release the mouse. We'll reposition this control in the next lesson.) An altimeter control appears for label 203.



Altimeter control generated from an Altitude label

► Click the **Run** button to start the simulation

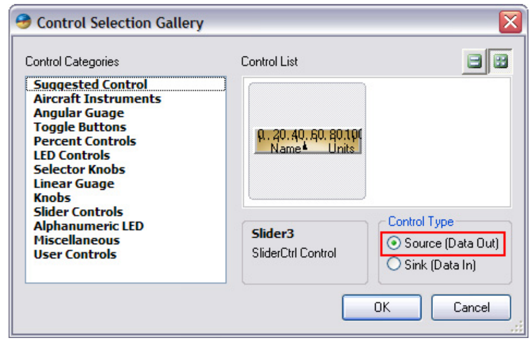
The value of label 203 (Altitude) is displayed in the altimeter control.

Controls can be added to Control View from the Hardware Explorer while the simulation is running.

► Drag and drop **Max Allowable Airspeed (207)** from CH4 just below the altimeter (see figure)

The Control Selection Gallery will open

► Set the Control Type to **Source** and accept the suggested control by clicking the **OK** button



Selection Gallery showing a suggested control

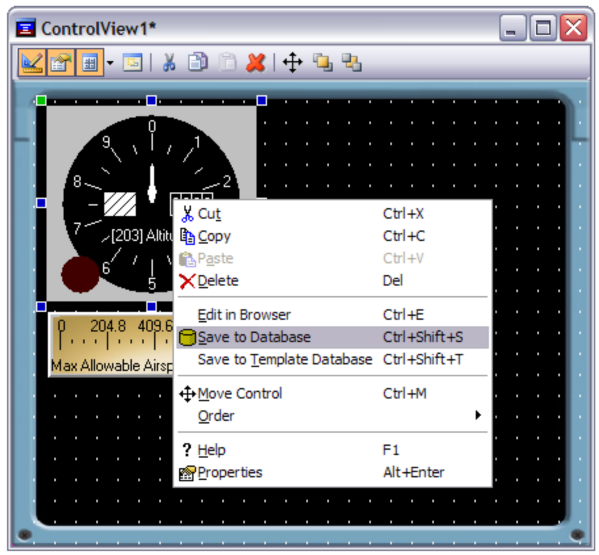
Modify Data through a Control

Because CH4 is a transmit channel, the control for label 207 is a data source.

► Drag the slider needle to change the value (in knots) of Max Allowable Airspeed

► Click the **Stop** button to halt the simulation

► If you are maintaining a cumulative project, save the Control View window (for the next lesson)



Control context menus are accessible in Design Mode

Saving a Control Link to the ARINC 429 Database

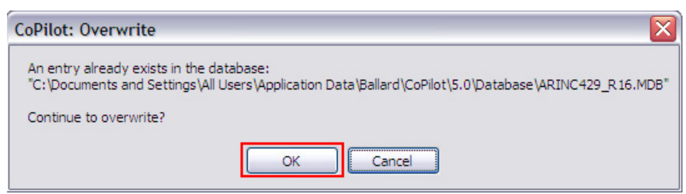
An altimeter was generated from the Altitude (203) label because that label was associated in the ARINC 429 database with an altimeter control. Labels without control links in the database are represented by a default control, which varies by interpreter type.

You can save control preferences to the ARINC 429 database in association with a specific label. That assignment replaces the default control or the control previously assigned.

► Right click in the Control View background and select **Design Mode** from the context menu

► Right click the altimeter control and select Save to Database (**do not click OK**)

► Click the **Cancel** button since in this case we do not want to change the database



Select Cancel so this example is not saved in the ARINC database

Related Topics

- Two controls are assigned to labels in the database: one defining the label as a source and the other as a sink

Summary

In this lesson you learned…

- how to automatically generate a Quick View control
- how to open Control View and add a control by dragging a label from the Hardware Explorer tree
- how to save label-control links to the ARINC 429 database

The next lesson will illustrate how to create a control using the Controls Palette, customize control properties, and link a control to a specific label.

Lesson 14: Design Custom Controls

In the last lesson, controls were created based on CoPilot defaults or ActiveX controls specified in the database. In this lesson you will design and link a custom control and learn how to position and customize controls.

Introduced in This Lesson

Edit Links, Control Selection Gallery, Controls Palette, Aircraft Instruments family of controls, Select Sources and Sink

Objective

Create an Airspeed Indicator and link it to Selected Airspeed (103). Then, position and rename the controls.

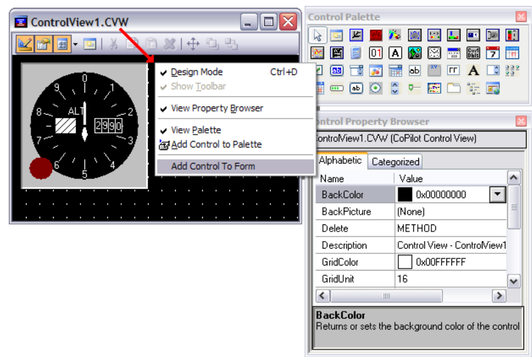
Create a Control Manually

Note: Before you begin this lesson, open the 429 Lesson 14 project (File | New | New Project | 429 Lessons) or use the project you saved from Lesson 13.

- ▶ Click on the **Design Mode** button in the View toolbar

The Control Palette and Property Browser appear.

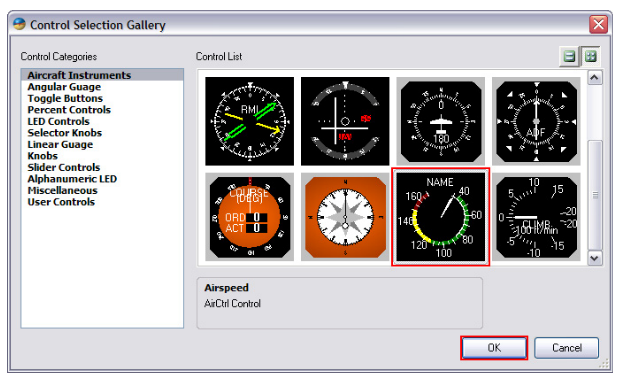
- ▶ Right click on the View near the top right corner of the Altimeter control and select **Add Control To Form** from the context menu



Open the Control Picker Dialog Window

(The upper-left corner of the new control will be positioned at the point where you right clicked the view.) The Control Picker dialog appears, displaying categories of preconfigured controls.

- ▶ Select the **Airspeed** from the **Aircraft Instruments** Category (see figure)
- ▶ Click **OK** to close the Control Picker and add the new control to the view



Control Picker with Airspeed Selected

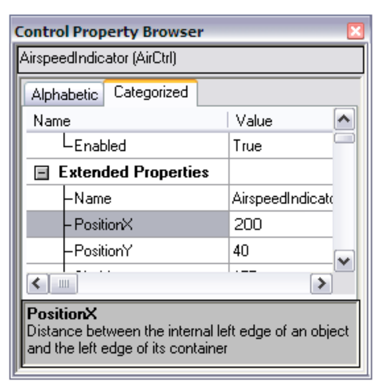
Configure Control Properties

The Control Property Browser provides an alternate way to configure controls. The Browser contains the same properties as the dialog you just used, plus additional properties.

- ▶ Click on the altimeter (from Lesson 12) to select it

When the altimeter control is selected (green and blue handles appear), its properties are loaded into the Control Property Browser and its name (AirCtrl1) appears at the top of the browser window.

- ▶ In the Control Property Browser, click on the **Categorized** tab
- ▶ Scroll to **Extended Properties**, enter **10** in PositionX, **50** in PositionY, and **150** in SizeX and Y
- ▶ Select the Airspeed Indicator (AirCtrl2), rename it to **AirspeedIndicator** (the scriptable name)
- ▶ Enter **190** for PositionX, **50** for PositionY, and **150** in SizeX and SizeY

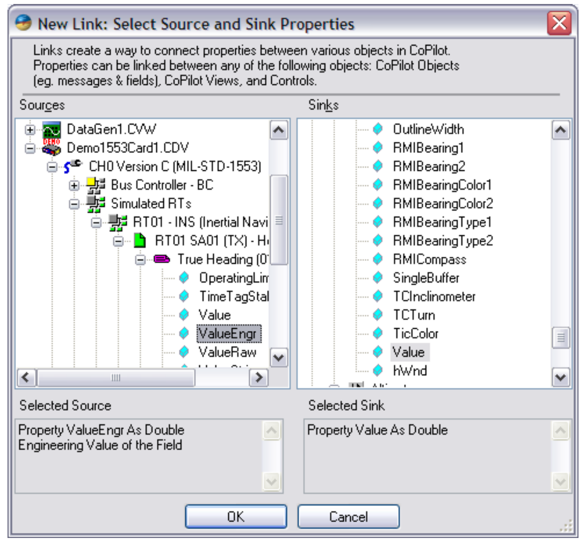


The AirspeedIndicator in the Control Property Browser

Link Control to Data Source

- ► Click **Project | New Link…** to open the Select Source and Sink dialog (see figure)
- ► In the *Sources* pane on the left, click the plus ⊞ symbol to expand **Demo429Card1**, then expand **CH0 RX**, then **Selected Airspeed (103)**
- ► Under label 103, choose **ValueEngr**
- ► In the *Sinks* pane on the right, click the plus ⊞ symbol to expand **ControlView1**, then expand **AirspeedIndicator**
- ► Scroll down and select the **Value** property and click **OK** to close the Source and Sink dialog

The ValueEngr is most often used for label and the Value property works for many of the controls. A reference to each control and its properties is contained in the *CoPilot User's Manual* and help documentation.



Select Source and Sink dialog linking the label and control

Run the Simulation

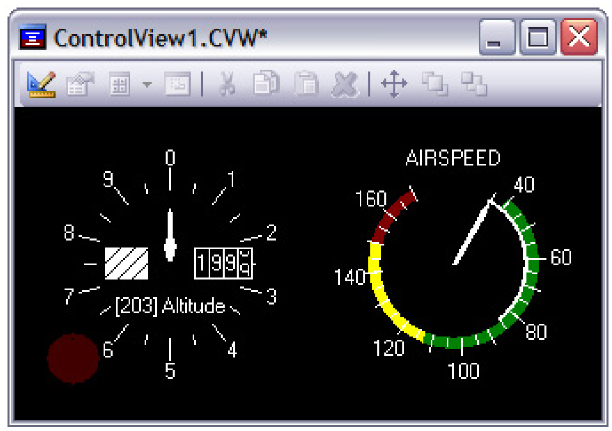
Note: Be sure the Data Generator is in the Project Explorer and configured to drive the True Heading field (Lesson 8).

- ► Click the **Run** button to start the simulation

Now you can now observe airspeed data through your custom control (the needle will move after a brief delay). There are dozens of other controls available that can be customized and linked to one or more labels. By creating and positioning multiple controls in Control View, you could create a virtual instrument panel.

- ► Click the **Stop** button to halt the simulation.

You can also link names, ranges, and other properties.



Linked and operational Airspeed control

Related Topics

- The Edit Links dialog (Project | Links Status...) allows you to view, modify, and delete links
- Besides the Aircraft Instruments button, there are many other control buttons in the Control Palette
- Control View can host third-party ActiveX controls, and you can add buttons for third-party controls to the Palette

Summary

In this lesson you learned…

- how to select a control from the Controls Palette
- how to modify control properties
- how to link a label to a control

This lesson showed how to link a single label to a control. In the next lesson, you will learn how to use a moving map window to graphically display aircraft position.

Lesson 15: Create a Moving Map Display

Map View is a container for displaying aircraft position and other objects (like waypoints) on a fixed or moving map image. The Map View window links positional data to a real-time moving map display. Latitude, longitude, heading, and altitude are used to display positions on the map. This example uses data streams from the Data Generator (created in Lesson 8) to demonstrate how Map View displays incoming data. The initial Map View background is a view of SeaTac airport. CoPilot users may supply their own unique background images or utilize the topographical and satellite images through the provided Microsoft TerraServer® web service.

Introduced in This Lesson

Map View, Map View Properties, TerraServer Properties

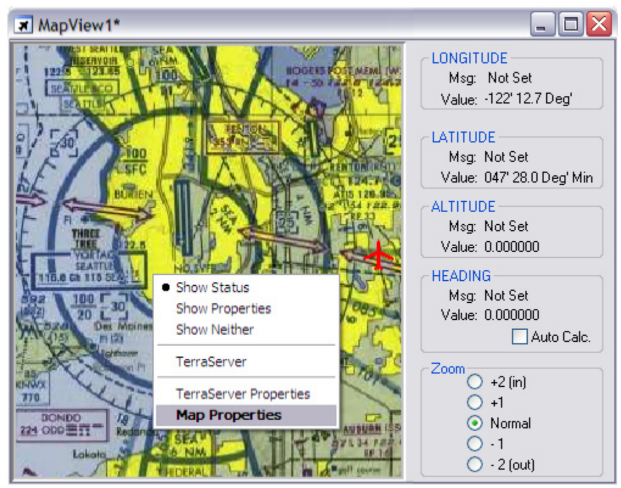
Objective

Create a moving map display of a holding pattern (over SeaTac airport) by configuring a Map View window, linking positional data fields, and running the simulation. Then, change settings and maps while the simulation is running.

Open a Map View Window

- ► Click the **New** button to open the New Hardware and Views dialog
- ► Select the **Professional Views** tab and double click **Map View**

The Map View window is divided into the map display (Map pane) and the data links (Status pane). Map View defaults to a Seattle, Washington sectional map with a center point of 47.47° latitude and –122.35° longitude over SeaTac airport. The background bitmap may be changed at any time, but the data values created through the Data Generator relate to this map.



Map View (corrected for distortion) shown with context menu

Link Data and View Moving Map

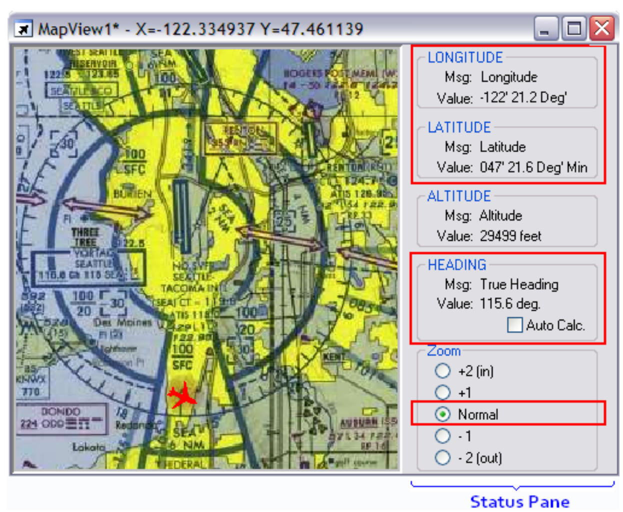
Note: Be sure the Data Generator is present and configured to drive three of the data fields (see Lesson 8). If extra views are open from previous lessons, you can hide them to the Project Explorer with the **Minimize** button.

- ► Drag the **Latitude** label (CH5) and drop it in the Latitude frame in Map View

Notice how the plane object reacts to each new link.

- ► Repeat the process with **Longitude** and **True Heading**, dropping them in the appropriate frames
- ► Select the **Normal** zoom range
- ► Resize the Map View by dragging the outside edges and the pane divider to resemble the figure at right
- ► Click the **Run** button to start the simulation

Observe how the plane is flying in a circular holding pattern around the airport.



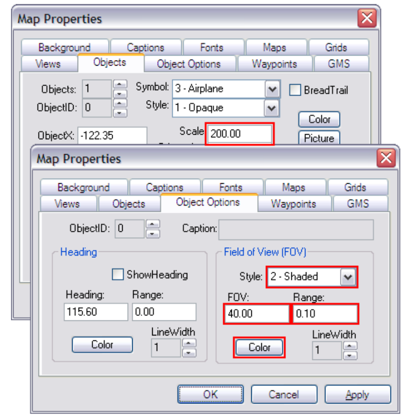
Holding pattern moving map display in the Map View window

Configure Map View

The Map View Properties dialog contains many options to customize the display. Let's make the airplane object easier to observe.

- ▶ Right click in the map display area and choose **Map Properties** from the context menu
- ▶ Click on the **Objects** tab and change the scale of the default object (an airplane) to **200.00**
- ▶ Click on the **Object Options** tab
- ▶ In the *Field of View* frame, enter **40.00** in FOV, **0.10** in Range, click the **Color** button, choose **light red**, click **OK** to close the color dialog, and choose a style of **2 - Shaded**
- ▶ Click **OK** to close the Map Properties dialog

There are many other options listed under other tabs.



Objects and Object Options tabs with settings described in text

Display TerraServer Maps

Map View can link to Microsoft's TerraServer® web service to download topographical maps or black-and-white satellite photomaps for the defined coordinates.

Note: You must be connected to the Internet (with a reasonably fast connection) to use this feature.

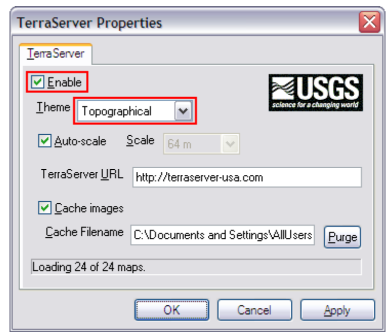
- ▶ Right click in the map pane and choose **TerraServer Properties** from the context menu
- ▶ Click the **Enable** checkbox and choose **Topographical** from the Theme listbox (see figure) and click **OK** to the close TerraServer Properties dialog

After the maps are loaded (the CoPilot status bar will report on loading maps), they will appear (see figure).

- ▶ Right click in the map pane and choose **Map Properties** from the context menu
- ▶ Click on the **Maps** tab, change the mapping mode to **Floating**, and click **OK**

Observe how the map display tracks the path of the airplane when in Floating mode.

- ▶ Click the **Stop** button to end the simulation



TerraServer Properties windows with specified settings

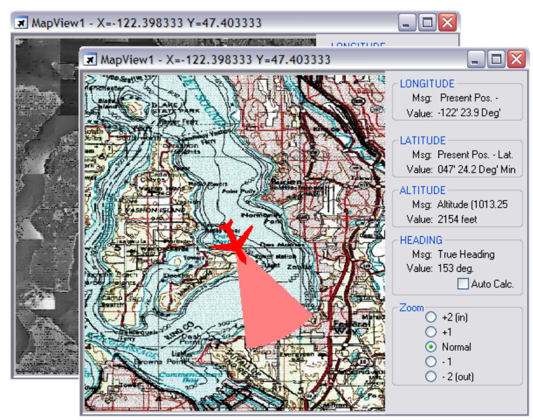


Photo (behind left) and topographical TerraServer maps

Related Topics

- A Map View could be used to display other label combinations against a unique background

Summary

In this lesson you learned…

- how to activate and link a Map View with labels in the Hardware Explorer
- how to modify the behavior or display characteristics through Map Properties
- how to access topographical or satellite images from the Microsoft TerraServer

In the next lesson, you will discover how to customize CoPilot with scripting using ATE.

Lesson 16: Customizing through ATE Scripting

ATE (Automated Test Environment) is a framework for creating and running tests in the CoPilot software. Python scripts are used to perform the innumerable tasks possible using the framework in conjunction with the CoPilot Object Model, which allows logical access to much of the functionality in CoPilot via ATE. This lesson shows just one possibility of how to use the tools available in CoPilot ATE to accomplish a simple automated task. Additional features of ATE not described in this Getting Started Guide include a Script Debugger, Output Pane, Command Prompt and Output Pane.

Introduced in This Lesson

ATE (Automated Test Environment), Python Code Editor, Object Browser, Alias properties, methods and events

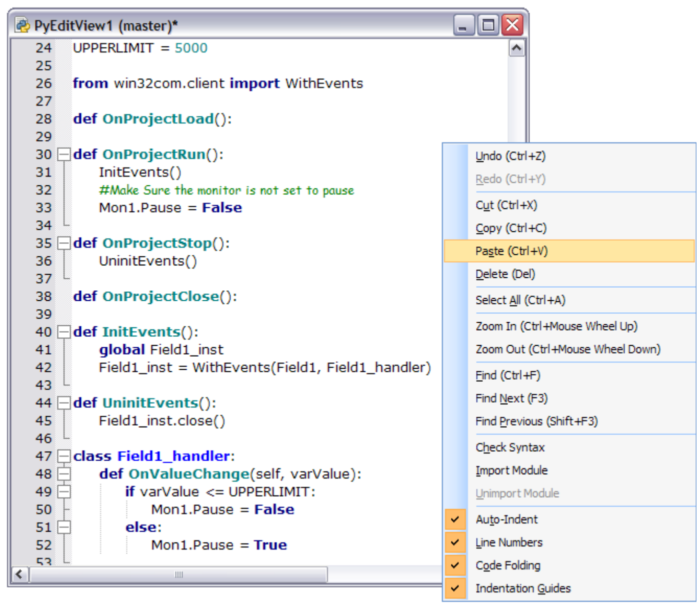
Objective

Use ATE Python scripting to control the monitor so bus traffic is only recorded during takeoff and landing conditions.

Open View and Copy Script

- ► Click the **New** button, select the **Professional Views** tab, choose **Python Code Editor**, and click **OK**
- ► Open the example script **MonitorControl.py** by right clicking the file folder (copied to "…\My Documents\My CoPilot Projects\Samples\Scripts" during first run) and selecting "Edit with IDLE"
- ► Copy the entire file and replace the contents of the Python Editor in CoPilot (through the "Select All" and "Paste" context menu commands)

The Scripts folder (copied to "…\My Documents\My CoPilot Projects\Samples\Scripts" during first run) contains example scripts that you can use or modify.



The Python Editor with Monitor Control script and context menu

Translate Objectives into Code

The Monitor Control script records bus traffic during takeoff and landing only. Examine the code in the Python Editor (top figure at right). The event handler subroutine (OnValueChange) is triggered each time the Altitude value (Field1) is changed. When the value of Field1 is above 5,000 feet (UPPERLIMIT), the Sequential Monitor (Mon1) is paused. When it is below 5,000 feet, monitor recording is resumed.

Access Objects via Script

In Lesson 6 you used the Pause button in the Monitor View window to control monitor recording. Although it may not have been obvious, "Pause" is a property of the monitor object. In Lesson 14, you linked the "ValueEngr" property of the True Heading field to a control. Now we will use Python scripting to access those same properties.

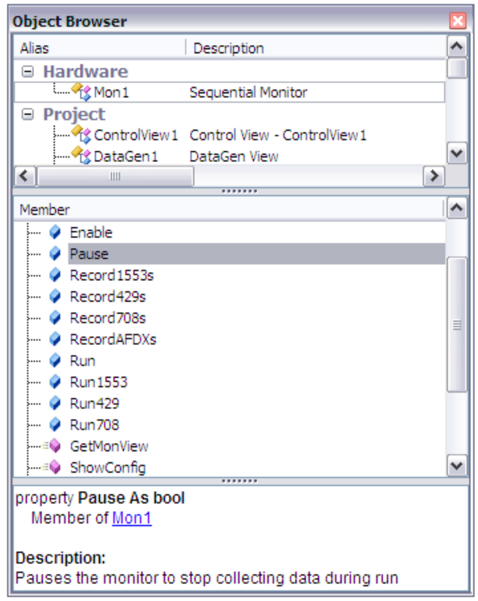
- ► If the Object Browser is not active , show it by selecting **View** | **Other Window** | **Object Browser**
- ► Drag the **Sequential Monitor** object into the Object Browser and rename the alias **Mon1**

The Sequential Monitor object being assigned an alias

To make code easier to reuse, example scripts refer to aliases by generic names (such as Mon1) and aliases in the Object Browser are renamed to match. Look at the center pane of the Object Browser. The Pause property (teal icon) is used in the script (see figure). (Methods are represented by a magenta icon and events by yellow icons.)

- ▶ Drag **Altitude** (label 203) from CH1 (*not CH4*) into the Object Browser and rename it **Field1**

If you browse to the OnValueChange method for Field1, you will notice that the icon is the yellow lightning bolt indicating that the method is called in response to an event.



The Pause property of the Mon1 object

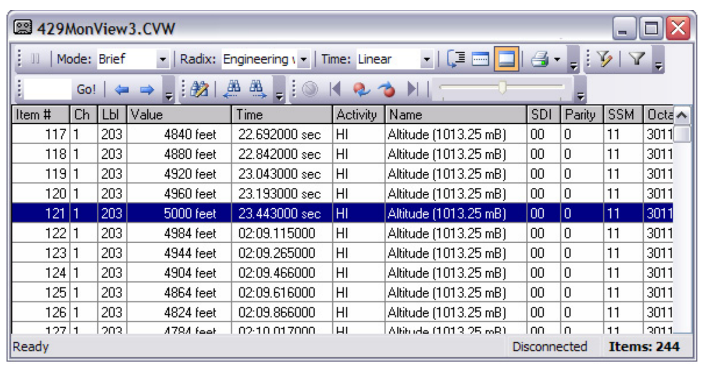
Note: The ARINC 429 Demo card creates a stream of values for label 203 (Altitude) that ramps up slowly from 0 to 16,368 and descends slowly back to 0. Consequently, after the initial capture, the monitor will remain in a long pause state until the altitude descends again to the 5,000-foot level.

Execute the Script

- ▶ Double click the **EngrView1** icon in the Project Explorer to open the view and show the current value of label 203 on CH1
- ▶ Right click the **Sequential Monitor** icon and verify that **Monitor All** is selected
- ▶ Click the **Run** button to start the simulation and trigger the OnProjectRun function

The monitor will pause when Altitude exceeds 5,000.

- ▶ Click **View Monitor Data** from the context menu of the newly created MonData file in the Hardware Explorer (as done in lesson 5)
- ▶ Click the **Edit** button in the filter toolbar of the new 429 Monitor View to open the Display Filter dialog
- ▶ Click the **Search** button in the Monitored Messages tab of the Display Filter dialog
- ▶ Click **None**, select **Channel 1 Label 203**, and click **OK** to close the Display Filter dialog
- ▶ Scroll through the Monitor View and notice that label values are limited to 5,000 feet or less
- ▶ Click the **Stop** button to end the simulation and trigger the Script Stop subroutine.



Monitor View limited to label 203 through display filters

Related Topics

- Example scripts (both Python and VB) and detailed scripting instructions are included with CoPilot documentation

Summary

In this lesson you learned…

- how to open a Python Editor window and copy a script
- how to add and rename aliases
- how to run a script and see the results

Now that you have completed these introductory lessons, you are ready to use CoPilot 429! To learn more about the topics introduced in this guide, please refer to the *CoPilot User's Manual*.

Lesson 17: Legacy CoPilot Scripting

This lesson included for legacy purposes and has been replaced by lesson 16.

Scripting allows users to customize and extend the functionality of the CoPilot. Scripts could be used to automate configuration tasks, respond to bus events, start and stop monitor recording, create a sequence of unique data responses based on the value of incoming messages, or perform other tasks. Scripts could also be used to transfer information between CoPilot objects and between other applications (such as Microsoft Excel or LabView).

Introduced in This Lesson

Script View, Script Objects, Object Properties, Open Component

Objective

Use a script to control the CoPilot monitor so that 429 databus information is recorded only during takeoff and landing.

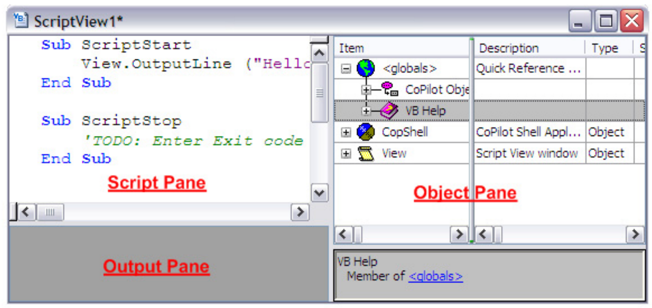
Open View and Import Script

- ► Click **New**, select **Professional Views**, choose **Script View**, and click **OK**

Script View is divided into three panes (see figure).

- ► Right click in the Script Pane to access the context menu, point to **Import Script** and select **Overwrite** from the submenu (see figure below)
- ► In the Select Import File dialog, click the **Browse** button, navigate to the Scripts folder, select the **MonitorControl.txt** script, and click **OK**

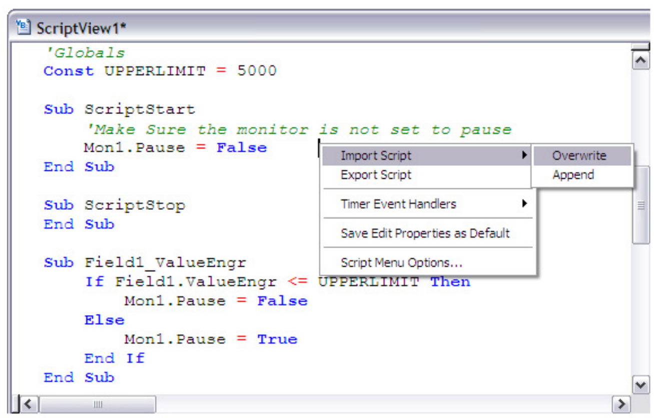
The Scripts folder (copied to "…\My Documents\My CoPilot Projects\Samples\Scripts" during installation) contains many example scripts that you can use or modify.



An example Script View window with each pane labeled

Translate Objectives into Code

The Monitor Control script records bus traffic during takeoff and landing only. Examine the code in the Script Pane (middle figure at right). The event handler subroutine (Field1_OnValueChange) is triggered each time the Altitude value (Field1) is changed. When the value of Field1 is above 5,000 feet (UPPERLIMIT), the Sequential Monitor (Mon1) is paused. When it is below 5,000 feet, monitor recording is resumed.

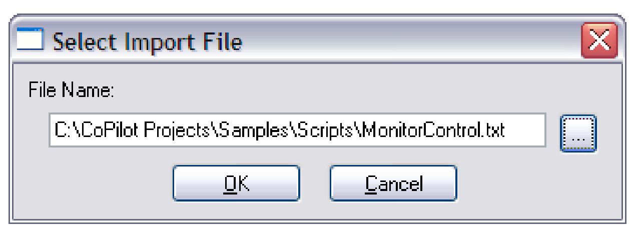


The Script pane with Monitor Control script and context menu

Access Objects via Script

In Lesson 6 you used the Pause button to control the Sequential Monitor. Although it may not have been obvious, "Pause" is a property of the monitor object. In Lesson 14, you linked the "ValueEngr" property of a label to a control. Both of these properties are also used in this script.

- ► Drag and drop the **Sequential Monitor** icon from the Hardware Explorer into the Object pane
- ► Double click on the default name (DemoMon1) and rename it **Mon1** (as identified in the script)

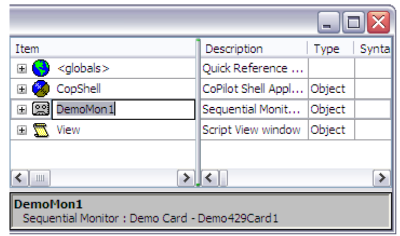


The import dialog with the default path to MonitorControl.txt

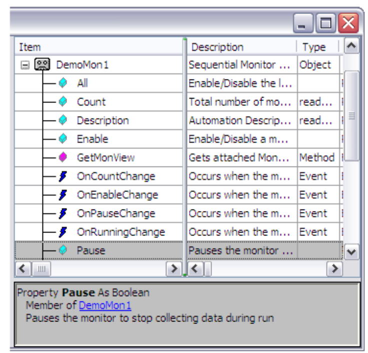
To make code easier to reuse, example scripts refer to objects by generic names (such as Mon1) and objects in the Object pane are renamed to match. Click the plus icon for Mon1 in the Object pane to see its properties. The Pause property (teal icon) is used in the script (see figure). (Methods are represented by a magenta icon and events by blue icons.)

- ▶ Drop **Altitude** (label 203) from CH1 (*not CH4*) into the Object pane and rename it **Field1**

If you browse to the OnValueChange method for Field1, you will notice that the icon is the blue lightning bolt indicating that the method responds to an event.



The Sequential Monitor object being renamed in the Object pane



The Pause property of the Mon1 object

Note: The ARINC 429 Demo card creates a stream of values for label 203 (Altitude) that ramps up slowly from 0 to 16,368 and descends slowly back to 0. Consequently, after the initial capture, the monitor will remain in a long pause state until the altitude descends again to the 5,000-foot level.

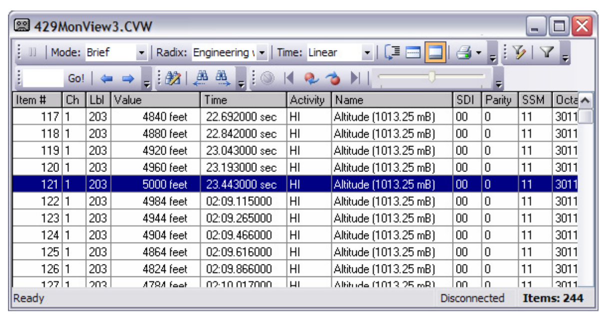
Execute the Script

In order to compare the value of the Altitude label against the pause state of the Sequential Monitor, arrange the CoPilot workspace so that both are visible.

- ▶ Double click the **EngrView1** icon in the Project Explorer to open the view and show the current value of label 203 on CH1
- ▶ Right click the **Sequential Monitor** icon and verify that **Monitor All** is selected
- ▶ Click the **Run** button to start the simulation and trigger the OnProjectRun function

The monitor will pause when Altitude exceeds 5,000.

- ▶ Click **View Monitor Data** from the newly created MonData file (as done in lesson 5)
- ▶ Click the **Edit** button in the filter toolbar of the new 429 Monitor View
- ▶ Click the **Search** button in the Monitored Messages tab of the Display Filter dialog
- ▶ Click **None**, select **Channel 1 Label 203**, and click **OK** to close the Display Filter dialog
- ▶ Scroll through the Monitor View and notice that label values are limited to 5,000 feet or less
- ▶ Click the **Stop** button to end the simulation and trigger the Script Stop subroutine.



Monitor View limited to label 203 through display filters

Related Topics

- Example scripts (both Python and VB) and detailed scripting instructions are included with CoPilot documentation

Summary

In this lesson you learned…

- how to open a Script View window
- how to import a saved script
- how to assign and rename objects
- how to run and verify the results of the script

This lesson included for legacy purposes and has been replaced by lesson 16.

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Appendix

ARINC 429 Overview

Point-to-Point Communication

ARINC 429 is a specification that defines a local area network used on commercial aircraft and is the industry's standard for transfer of digital data between avionics system elements. The specification describes how an avionics system transmits information over a single twisted and shielded pair of wires (the databus) to as many as 20 receivers connected to that databus. Bi-directional data flow on a given databus (pair of wires) is not permitted.

Equipment Identifier

Each transmitting device ("source") is given a unique Equipment ID number. The Equipment ID number corresponds to a particular device on an aircraft. This number, along with the message label, is used to determine the meaning of the data. CoPilot 429 allows you to choose the equipment you wish to analyze and automatically assigns to it the correct ID number as specified by ARINC 429.

Data Types

There are five different data types in the ARINC 429 specification: BCD, BNR, Discrete data, Maintenance/Acknowledgement data, and ISO Alphabet No. 5. The majority of ARINC 429 labels are encoded in BCD or BNR format. In addition, CoPilot 429 extends the list of data types along with providing a user customizable data type (Custom Script).

- **BCD** (Binary Coded Decimal): The BCD data field is defined within bits 11–29, where bit 29 is the Most Significant Bit (MSB). Bits 30–31 form the SSM for BCD data types.
- **BNR** (2's complement binary): The BNR data field is defined within bits 11–28. Bits 29–31 form the SSM for BNR data types.
- **Discrete**: Discrete words are used when non-standard labels are required.
- **Custom Script**: When the provided data types don't match your specification, CoPilot allows you to create your own.

Transmit Rate

There are two transmission rates called for in the ARINC 429 specification, high speed (100 Kbps) and low speed (12.5 Kbps). CoPilot 429 can automatically detect the speed of receive channels attached through Ballard Technology's Ethernet, USB, PCI, and cPCI ARINC 429 boards. The bus speed must be defined for transmit channels because they are initiating the transmission.

CoPilot 429 and the Ballard 429 board will combine all labels for a particular channel to achieve a transmit schedule.

ARINC 429 Data Words

The basic element of ARINC 429 is a 32-bit data word, which consists of five fields as shown in the diagram below:

32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
P	**SSM**		**DATA FIELD**																			**SDI**		**LABEL**							

LABEL

The 8-bit label at the beginning of an ARINC 429 word identifies what type of information is included in the word. Usually expressed in octal form, the label is transmitted MSB (most significant bit) first.

SDI

The Source Destination Identifier (SDI) is optional and when used assumes bits 9 and 10. The SDI function is used when specific words need to be directed to a specific subset of a system or when a specific source of a system needs to be recognizable from the word content. When the SDI is not used, the bits should be padded with zeros.

SSM

The Sign/Status Matrix (SSM) serves two purposes. The primary purpose is to express the sign (plus/minus, north/south, etc.) of the data field. The SSM may also be used to report hardware equipment condition (fault or normal) and operational mode or validity of data word content (verified or no computer data). The SSM uses bits 30 and 31. BNR uses bits 29 through 31.

DATA FIELD

The Data field carries the actual message or information that is being transmitted. The data field consists of bits 11 through 28 or 29, and is transmitted LSB first. Unused bit positions are padded with zeros.

PARITY

The Parity bit is used for odd parity and is always bit 32 in an ARINC 429 data word.

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Your Source for Avionics Databus Tools

Protocols Supported

- MIL-STD-1553
- ARINC 429/575
- ARINC 629
- ARINC 664/AFDX
- ARINC 708/453
- ARINC 717/573
- Space Shuttle (MIA and MDM)
- Custom and non-standard protocols

Platforms

- PCI
- cPCI
- PMC
- PCMCIA
- USB
- Ethernet
- PC/104 and PC/104 plus
- ISA
- VMEbus
- Industry Pack
- Handheld

Software

- CoPilot for 1553, 429, AFDX/664, and 708 boards
- BTIDriver™ universal API
- ARINC 708 Utility GUI
- ARINC 717 Monitor GUI
- Drivers for DOS® and Windows® (all versions)

Increase your Productivity with CoPilot 429

Just the Beginning

In these brief lessons, you learned how easy it is to simulate and test ARINC 429 terminals using CoPilot 429, and you have only scratched the surface! If you look back at the windows, menus, and dialogs shown in these lessons, you will discover numerous options that were not demonstrated. For further information, refer to the *CoPilot User's Manual*. In addition, you can count on additional features being added to CoPilot to meet the emerging requirements of CoPilot users around the world.

Take a CoPilot Test Drive

The best way to discover how CoPilot 429 can increase your own productivity is to try it. Ballard Technology would be happy to send you a free evaluation copy of CoPilot. If you already have a Ballard ARINC 429 board, we can also install a temporary license key that will allow you to evaluate the full capability of the hardware and software.

Expand Use to Other Databuses

Today's complex avionics systems often utilize multiple protocols, drawing on the strengths of each one. The examples in this document illustrate the use of CoPilot for ARINC 429 systems but this same CoPilot system supports ARINC 664/AFDX, ARINC 708 and MIL-STD-1553 systems just as well. Consequently, with the appropriate Ballard Technology avionics databus cards and CoPilot software, users can monitor, simulate, analyze, compare, and integrate activity on several databuses at the same time. In CoPilot, users have the advantage of a common environment with features and tools suited to the unique characteristics of each avionics protocol.

Contact Ballard

Our experienced engineering and customer support staff is available to discuss your requirements for avionics databus tools and interfaces. For more information about our products or support in the use of this product, call Customer Service. Our hours are 8:00 AM to 5:00 PM Pacific Time, though support and sales engineers are often available outside those hours. We invite your questions, suggestions, and comments on any of our products.

Ballard TECHNOLOGY

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