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### Executing Measurements Automatically

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# About This Manual

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The *DIAdem: Data Acquisition and Visualization* manual describes how to create a block diagram for your measurement task and how to design the visualization of the measurement.

In the first chapter, you create a block diagram step by step, without measurement hardware. You select a data source and display instruments and operating instruments and define a condition to control when the data is saved.

The second chapter describes how to configure measurement hardware and to register the hardware in DIAdem. You can use one of the interfaces that DIAdem supports, to communicate with external measurement devices.

The third chapter describes how to select a block for each function, and how to connect the blocks to suit the task. DIAdem distinguishes between data buses, control buses, system buses, packet buses, alarm buses, and text buses, each of which transports different signals. You can group subtasks of a block diagram into subblock diagrams.

The fourth chapter describes the visualization associated with the block diagram and explains the available display and operating functions. In DIAdem VISUAL you position the display instruments and the input instruments and you group the instruments on VISUAL pages. In DIAdem DAC you connect display blocks to create event-related visualizations.

The fifth chapter describes how to use packet processing to acquire data in packets, to execute mathematical operations on packet data, and to show packet data in 3D display. With packet processing you can increase the throughput, use special measurement hardware, or use manual display instruments during a measurement.

The sixth chapter describes the alarm system that you use to monitor processes, by generating alarms, displaying alarms, sending alarms in e-mails, and recording alarms. The user can delete the alarms as soon as the cause has been found and eliminated.

The seventh chapter deals with the basics of digital data acquisition and discusses topics such as the resolution, the measurement range, and the sampling rate. The chapter also describes the measurement modes available in DIAdem.

# Conventions

---

The following conventions are used in this manual:

<>

Angle brackets indicate a key you press to perform a function, for example, <Ctrl> for the control key.

»

The » symbol leads you through nested menu items and dialog box options to a final action. The settings **Help»Examples** instruct you to open the **Help** menu and select the menu item **Examples**. DIAdem opens the ExampleFinder, where you can run examples for various DIAdem functions.



This icon denotes a tip, which alerts you to advisory information.



This icon denotes a note, which alerts you to important information.

**bold**

Bold text denotes items that you must select or click in DIAdem, such as menu items and dialog box options. Parameters are also in bold type.

*italic*

Italic text denotes variables, emphasis, cross references, or an introduction to important concepts.

monospace

Text in this font denotes text or characters that you should enter from the keyboard, such as sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, folders, programs, subprograms, subroutines, device names, channel names, functions, operations, commands, variables, controls, events, methods, filenames and extensions, and code excerpts.

**monospace bold**

Bold text in this font denotes the messages and responses that the computer automatically outputs to the screen.

## Related Documentation

---

For more information on DIAdem, refer to the following documentation:

- *Getting Started with DIAdem*  
You can use this DIAdem manual to familiarize yourself with DIAdem features and how to use them. The manual includes exercises for mining, analyzing, presenting data, and combining several steps into a script.
- *DIAdem: Data Mining, Analysis, and Report Generation*  
This DIAdem manual explains the structure of DIAdem and how to use DIAdem to mine data, to run analyses, to create reports, and to combine all functions in a script.
- *DIAdem Help*, which you open by selecting **Help»Contents**, or <F1>. The DIAdem help offers you procedures and dialog box help for each panel, as well as references to functions, commands, and variables for programmers.
- *DataFinder Server Edition: Search Engine for Technical Data*  
This manual describes how you use the DataFinder server to index data files in networks. Users connect DIAdem with a DataFinder server to search for the indexed data.

---

# Getting Started with DIAdem DAC

With DIAdem DAC and DIAdem VISUAL you can acquire data, control processes, and visualize data. In DIAdem DAC you create block diagrams to acquire measured values, and to process and to output the data. In DIAdem VISUAL you design the visualization to display the acquired and calculated measured values and to influence the measurement with input instruments.

DIAdem is also the interactive National Instruments software for finding and managing technical data, for mathematically and graphically-interactively analyzing data, and for presenting the data in reports. In a uniform environment, DIAdem offers a unique combination of tools that are tailored to the requirements of technicians, engineers, and scientists. You can adjust all the tools to your tasks and automate them in scripts, which drastically reduces evaluation times.

## Acquiring Measurement Data

---

In DIAdem DAC you select function blocks from the various function groups and connect them with signal buses, to create block diagrams. The measurement data is transferred from data sources to processing blocks, display instruments, and output blocks.

To create a block diagram with a simulated signal source, complete the following steps:



**Note** You can later replace the simulated signals with measured sensor signals.



1. Select **DIAdem DAC**.



2. Click **New Block Diagram**.



3. Click **Simulation Inputs** on the group bar.



4. Click **Function Generator** in this function group.

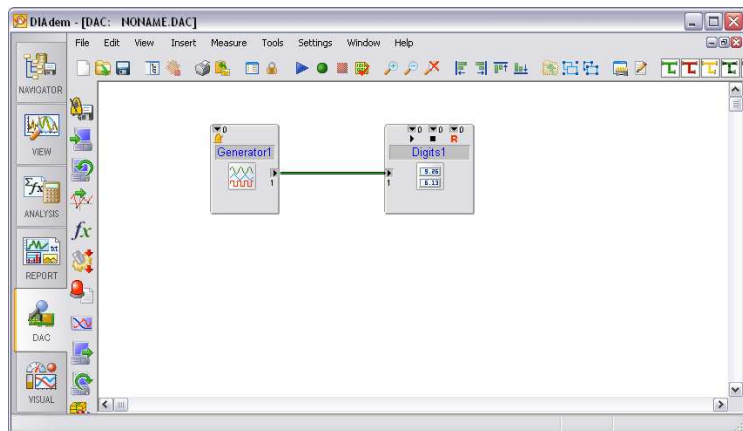
5. Click **Display Instruments** on the group bar.

6. Click **Digits** in this function group.

DIAdem inserts every new block in the top left corner of the workspace in DIAdem DAC.

7. Drag the **Digits1** block to the right of the **Generator1** block.
8. Click the output on the right side of the **Generator1**. Click and drag the green bus to the input on the left side of the **Digits1** block. As soon as **OK** appears on the cursor, you can release the mouse button.

The data source and the display instrument are now linked with a green data bus as shown in the following figure.



**Figure 1-1.** Block Diagram with Function Generator and Digits Display



9. Click **Start Display** on the toolbar.

DIAdem opens the DIAdem VISUAL panel and displays the simulated sine values in Digits display.



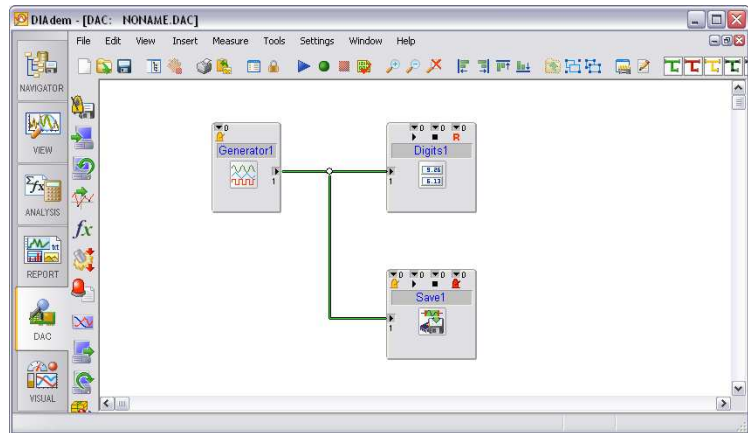
10. Click **Stop Measurement**.

## Saving Measurement Data

Until now you have displayed the signal values, but the values are not yet saved. To document processes and to check results, DIAdem must save measurement values.

To save the measurement data, complete the following steps.

1. Select **DIAdem DAC**.
2. Click **System** on the group bar.
3. Click **Save Data with Trigger** in this function group.
4. Position the **Save1** block below the Digits display.
5. Click the green data bus and drag the bus to the data input of the Save block as shown in the following figure.



**Figure 1-2.** Extended Block Diagram with Data Storage

6. Double-click the **Save1** block.
  - a. Enter 1000 as the **Number of values**.
  - b. Click **OK**.
7. Click **Start Measurement**.

DIAdem stops the measurement as soon as 1,000 values are saved.

8. Select **DIAdem NAVIGATOR**.

The new channels **Time1** and **Generator1\_1** are now visible in the default group of the Data Portal.

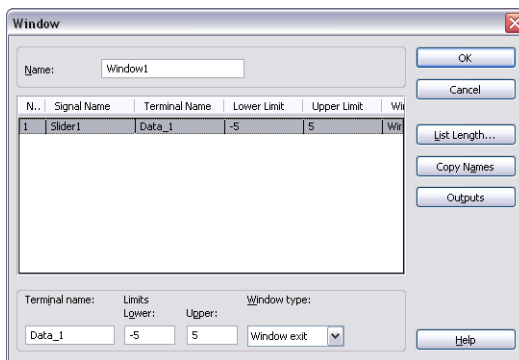


# Monitoring Measurement Signals

In control blocks you define conditions for monitoring and controlling measurement tasks. To save measurement values in relation to a condition, complete the following steps.



1. Select **DIAdem DAC**.
2. Click **Simulation Inputs** on the group bar.
3. Click **Slider Control** in this function group.
4. Position the **Slider1** block below the Generator.
5. Click **Control** on the group bar.
6. Click **Window** in this function group.
7. Position the **Window1** block next to the Slider control.
8. Drag a green bus from the output on the Slider control to the input on the Window condition.
9. Double-click the **Window1** block.
  - a. Enter -5 as the lower limit, 5 as the upper limit, and Window exit as the **Window type**, as shown in the following figure.



**Figure 1-3.** Setting the Window Condition

- b. Click **OK**.

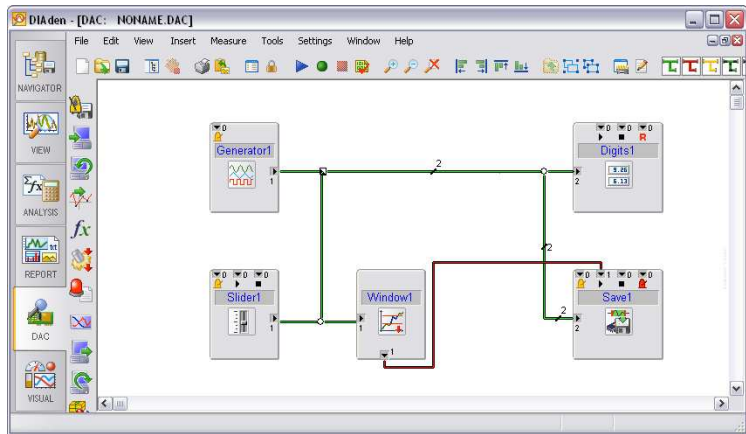
10. Click the data bus between the **Slider1** block and the **Window1** block, and drag a new bus to the green bus between the **Generator1** block and the **Digits1** block.

The 2 at the input of the Digital display indicates that you have connected two signals from the data bus to the block.



11. Drag a bus from the output of the Window condition to the second input on the top edge of the Save block, as shown in the following figure.

This creates a red control bus that DIAdem uses to trigger data storage. You connect control buses at the top or at the bottom of a block.



**Figure 1-4.** Extended Block Diagram with Slider Control and Window Condition

## Displaying Events

The data storage occurs in the background. To display a graphic when data storage starts, complete the following steps.



1. Click **Display Instruments** on the group bar.
2. Click **Graphics** in this function group.
3. Position the graphic to the right of the **Save1** block.





4. Click the red bus on the Save block and drag a bus to the control input at the top of the **Graphics1** block as shown in the following figure.

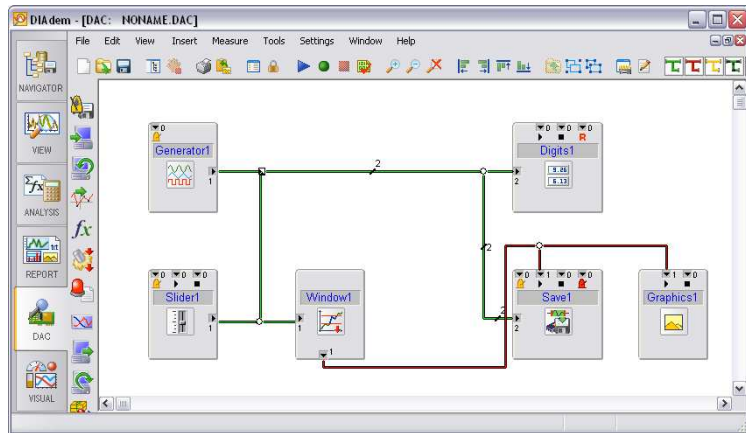


Figure 1-5. Extended Block Diagram with a Storage Display

## Visualizing Measurements

In DIAdem VISUAL you align the input instruments and the display instruments that you use in the block diagram. You can configure each instrument separately.

To design the visualization complete the following steps.

1. Select **DIAdem VISUAL**.
2. Position the Slider control, the Digits display, and the Graphics next to each other.

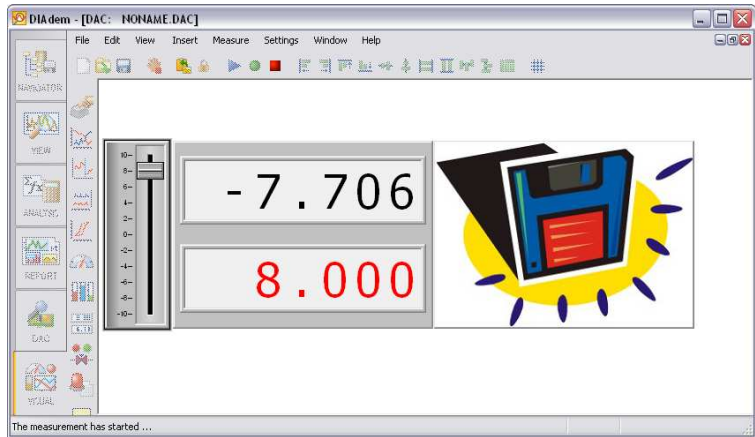
Drag the small squares at the corners of the instruments to resize the instruments.

3. Double-click the empty display instrument **Graphics1**.
  - a. Click **Browse** and load the file `Saving.jpg`.
  - b. Select the **Keep ratio** checkbox.
  - c. Click **OK**.
4. Click **Start Measurement**.



5. Drag the slider control up and down.

As soon as the slider control leaves the specified window range of -5 to 5, DIAdem starts saving the measurement values and displaying the visualization as shown in the following figure.



**Figure 1-6.** Visualization with Input Instruments and Display Instruments



6. Click **Stop Measurement** or wait until DIAdem measures the specified 1,000 values and saves the values in new channels in the Data Portal.



Click **Save Block Diagram As** to save the block diagram.

---

# Installing Measurement Hardware and Communicating via Interfaces

To use DIAdem for measurements and open and closed-loop control, you need a measurement acquisition board that you can plug into the computer, or an external measurement device that you connect to the computer via an interface. You use the associated driver to access the measurement hardware. The function groups for the inputs and outputs contain blocks with prepared functions for connecting hardware and communicating via interfaces.

## Installing Measurement Hardware

---

First you install the plug-in board in the computer, then you install the driver from the hardware manufacturer. Next you register the associated DIAdem driver, which communicates with the hardware driver, in DIAdem DAC. You can then assign driver functions to function groups in DIAdem DAC.

### Installing the Hardware Drivers

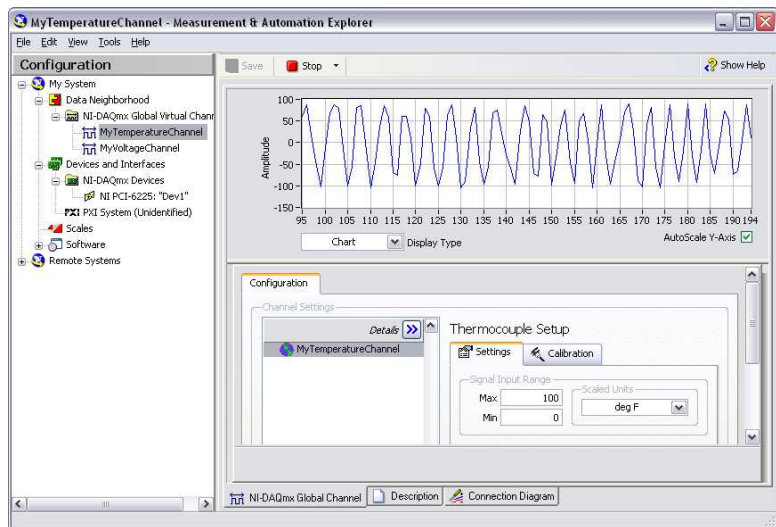
Install DIAdem and the driver libraries supplied with your hardware, to register the installed hardware on the Windows operating system.



To use National Instruments hardware, install the NI-DAQmx driver. The driver also installs the Measurement & Automation Explorer (MAX), where you configure the device parameters and the channel parameters for the hardware. You open MAX in the Windows Start menu. In the **Configuration** column, MAX lists the installed hardware and software in a tree hierarchy. Double-click **Devices and Interfaces** to display the installed acquisition boards. If you select an item, MAX displays the board properties. Click **Self-Test** to test the installation. Click **Test Panels** to check the board functions.

To access National Instruments hardware with DIAdem, you create channels in MAX for all the required inputs and outputs. In DIAdem, you use the channel names specified in MAX to access these channels. To

create a global NI-DAQmx channel, right-click **Data Neighborhood** in the tree and select **New** from the shortcut menu. Select **Global NI-DAQmx Virtual Channel**. The Channel Wizard guides you through the configuration and specifies the measurement mode and the terminal. MAX lists all the virtual channels in the **Data Neighborhood** branch of the tree hierarchy. You can change the settings later as required. A wizard helps you define a two-point calibration on the **Calibration** tab. Scaling data delays data acquisition, which means that the channels are no longer real-time. To acquire data in real time, you can scale the measured values later in DIAdem, instead of in MAX.



**Figure 2-1.** Creating a NI-DAQmx Channel in the Measurement & Automation Explorer (MAX)

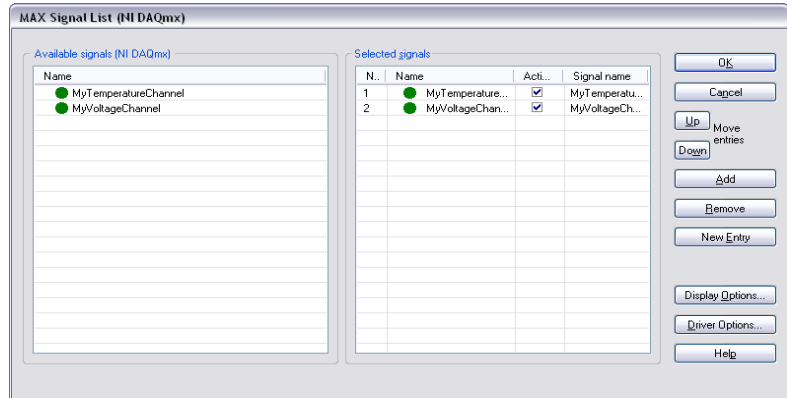
## Registering and Configuring DIAdem Drivers

The DIAdem driver links the hardware driver to DIAdem DAC. DIAdem drivers are in DLLs (DLL: Dynamic Link Library), which you register in DIAdem by selecting **Settings»Options»Extensions»GPI Extensions**. Click **Default** to check whether the DLL that is required for your hardware is already registered in DIAdem. Click **Add** to load a DLL. You can obtain the DIAdem driver and the hardware driver from the hardware manufacturer.



The DLL `GfSnidaq.dll` is required for communication between the hardware driver NI-DAQmx and DIAdem, and is registered by default, which means that the associated driver block is already in the driver inputs

and driver outputs. To use the channels that are defined in MAX for data acquisition, open the **Driver Inputs** function group and click **NI-DAQ Driver**. Double-click the block to open the block dialog box and select the channels you want.



**Figure 2-2.** Using NI-DAQmx Channels in DIAdem

After you register a new DIAdem driver in DIAdem DAC, select **Settings»Single Point Processing»Driver Function Groups** to specify which acquisition and output functions this driver offers. Here you can add, delete, and configure DIAdem drivers, signal inputs, signal outputs, and processing functions that the driver executes on the measurement hardware. Double-click a registered device to open the list of supported driver functions and click **Options** to change the parameters of the driver function selected in the list. Make sure that the device parameters such as the base address or the input voltage range are the same as the settings on the measurement hardware.

You usually use Plug&Play to specify system resources such as base address, IRQs, or DMA channels. The operating system and the hardware that is already installed ensure that the new hardware is integrated correctly. If you specify the system resources that the hardware is to use, you must assign unique communication addresses and ensure that the other resources cause as few conflicts as possible.



**Note** You can generally access installed hardware with different applications alternately but not simultaneously. National Instruments hardware recognizes this type of conflict at the driver level and displays an error message.

In DIAdem DAC you can assign 15 driver functions to each of the function groups **Driver Inputs** and **Driver Outputs**, and six more driver functions

to the **Processing** function group. DIAdem saves the registered DLLs and the configurations of the driver functions in a parameter file that has the same name as the associated desktop file and the filename extension `.par`.

DIAdem saves the driver block settings in the block diagram. If you change the predefined settings or the assignments in the driver function groups later, you do not change the driver block settings in the block diagram. If you use different hardware, you can replace the driver blocks in the block diagram with the driver inputs and driver outputs from the new hardware. To do this, drop the driver blocks of the new hardware onto the blocks you want to replace in the block diagram.

## Communicating via Interfaces

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You communicate with external measurement devices, which you connect to the computer via an interface, either directly with the OPC driver and the CAN driver, or indirectly with a control file or a VBS script.

### Using OLE for Process Control

Via the OPC (OLE for Process Control) interface, DIAdem can communicate as the OPC client with each OPC server that is registered on the computer, and can access either local measurement hardware or, via an OPC server, hardware that is located on the network. This enables you to connect DIAdem to field bus systems and the associated hardware.

DIAdem DAC can provide multiple access to one OPC server and can access several OPC servers simultaneously.



Open the dialog box of the OPC block to register OPC servers, which can be either on the same computer or on another computer on the network.

When the OPC servers are registered, you can select the signals (items) to be measured, in the OPC Browser. Drag and drop the signals into the signal list. You configure the communication on the tabs **Parameters** and **OLE**.

### Using CAN Drivers

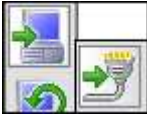
The NI-CAN (Controller Area Network) driver transfers data to and from DIAdem via the interface boards CAN Application Controller 2 (CAN-AC2) and CANcard. You use these interface boards to send and receive measurement data on two CAN systems. To connect DIAdem to CAN, select **Settings»Single Point Processing»Interfaces»CAN Bus** and configure the CAN interface, and establish CAN channels, for example, in the Measurement & Automation Explorer. Branch to **My System»Data**

**Neighborhood»CAN Channels** in MAX, and click **Create Message** on the function bar. Select the created CAN message and click **Create Channel** on the function bar. Then you configure the CAN channels.

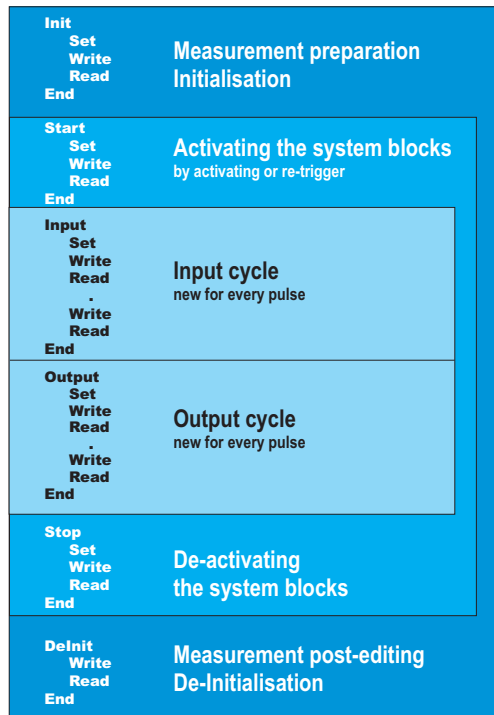


The CAN block in DIAdem accesses the CAN channels using the channel names. Double-click the block to open the block dialog box and select the channels you want.

## Using Control File Drivers



You can use the control file driver to access external measurement devices in DIAdem via the RS-232 interface or GPIB (General Purpose Interface Bus). This communication is based on a simply-structured text file in which a communication protocol for linking devices is defined. Use the `Example.atr` control file as an example.



**Figure 2-3.** Structure of a Control File

A control file consists of the measurement preparations, the actual measurement, and post-measurement action, as the figure above shows. The Init procedure starts the communication with the measurement device

and the Start procedure starts a measurement. During the measurement, DIAdem calls the Input procedure for data input, and the Output procedure for data output, cyclically in the specified measurement clock. The Stop procedure stops the measurement and the DeInit procedure resets the measurement device.

You can use several control file driver blocks in one block diagram, and you can address several external devices in one control file.

The interface monitor on the toolbar guides you through an interactive dialog box with external devices via the serial interfaces COM1 to COM9 and via GPIB (DIN IEC 625 or IEEE 488). You can send character strings to a device and read the replies on the screen. The interface monitor is useful for testing and commissioning programmable measurement devices and for programming control files. In the hexadecimal display mode, you can see all the control characters the device sends.

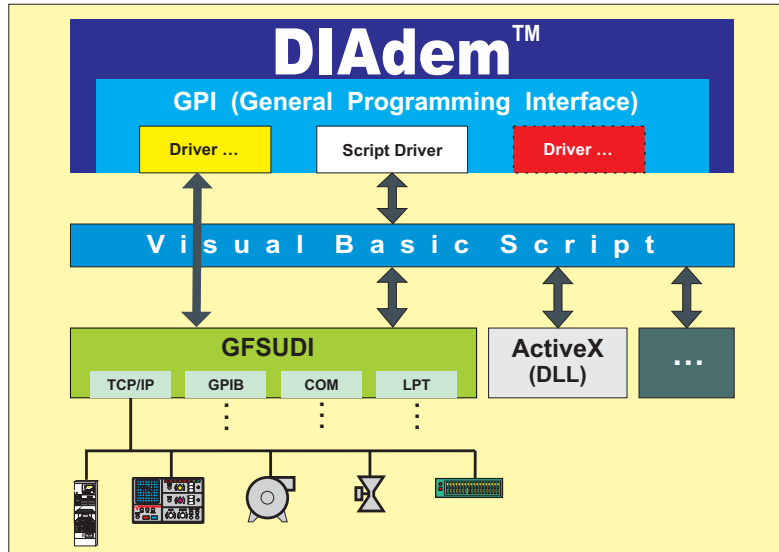
## Using Script Drivers

The Script driver uses Visual Basic Script (VBS) for data acquisition, processing, and output, on external measurement devices. You can use VBS for complex tasks such as test sum calculations, which you cannot execute with the control file driver. The GFSUDI communication layer communicates with the interfaces RS-232, GPIB, and TCP/IP, to exchange data with external devices, as the following figure shows. If you use VBS, you can access other program modules such as ActiveX components.





In the Script block you specify the inputs and outputs and you load the script. To create a script, click **Script Template**. DIAdem opens a wizard where you select the interface and specify the script functions. DIAdem creates a template, which you can edit in DIAdem SCRIPT.



**Figure 2-4.** External Devices Can Communicate with DIAdem via VBScript

# The Block Diagram Describes the Measurement Task



Use DIAdem DAC to create block diagrams to acquire, to process, to visualize, and to output measurement values. For each function you select a block from a function group, position the block in the workspace, and connect the block to other blocks according to the task. Double-click a block to configure the block in dialog boxes.

## Creating Block Diagrams

You start a block diagram on the left with a data source, for example a driver input from the installed hardware, use blocks for scaling and processing, and the data flows to the display instruments on the right. The data in the block diagram does not always flow from left to right, but it always flows from block outputs to block inputs.



A simple block diagram consists of a data source and a display instrument. If you want to use an inbuilt National Instruments measurement board as the data source, click **NI-DAQ Driver** in the **Driver Inputs** function group. Then click **Curve** in the **Display Instruments** function group. DIAdem inserts the blocks in the top left-hand corner of the workspace. Position the Curve display block to the right of the driver block. Click the data output on the right edge of the driver block and drag the crosshair to the data input on the left edge of the Curve display. Click the data input of the Curve display when **OK** appears next to the crosshair. DIAdem connects the two blocks with a green data bus. Double-click the **NI-DAQ** driver block and select the signals to be displayed, from the channels defined in the Measurement & Automation Explorer.



To display the measurement values, click **Start Display** on the toolbar. DIAdem switches to the VISUAL panel and displays the selected signals as curves. To stop the display, click **Stop Measurement** on the toolbar. You also can press <Esc> to abort a measurement.



If you use a block to save the measurement values in the block diagram, you must click **Start Measurement** for DIAdem to visualize measurement values and to save the measurement values in the Data Portal or in a file. To save the measurement values without visualizing them, select **Measure»Measurement (Without Display)**. In the Save block you specify where to save the data and also the maximum number of measurement values to be saved. Before you start a measurement, you can click **Check Block Diagram** to detect errors while you create the block diagram. DIAdem displays errors in messages. Select **Measure»Last Measurement Status** to see how long the last measurement with data storage took and how many values DIAdem saved.



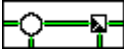
To create and test a block diagram independently of the measurement hardware, open the function group **Simulation Inputs** first, and use the blocks **Random**, **Noise**, or **Function Generator** as data sources. You also can use input instruments, data files, single data channels, and calculation results as hardware-independent data sources. In the second step you exchange the simulation blocks for driver blocks. To replace a block, drop the driver input onto the simulation input in the block diagram. DIAdem replaces the simulation block with the driver block and transfers the common settings, such as the block name and the number of signals.

You select blocks in the function groups and insert the blocks into the block diagram according to the measurement task. Double-click the blocks to edit the settings in dialog boxes. If the Data Portal is visible in DIAdem DAC, you can drag channels from the Data Portal and drop them, for example, in the **Free Linearization** dialog box.

## Buses Connect Blocks to Create a Block Diagram

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You not only select the blocks according to your task, you also decide how to connect the blocks in a block diagram according to your task. You can connect blocks to blocks, blocks to buses, and buses to buses. If you click an output or an input terminal on a block, the beginning of the new bus appears with a crosshair at the tip. Click and drag a bus to create a new bus. Drag the crosshair over an input terminal or a bus that is the same color, until DIAdem displays **OK** at the crosshair. Click the terminal for DIAdem to establish the connection. As long as DIAdem displays a crossed out crosshair, you cannot make a connection.



If you drag a bus away from another bus, DIAdem displays the branch as a circle. When you join two buses, DIAdem displays a small square at the input node. The black triangles in the square indicate which buses deliver signals.



If the block diagram is very complex, DIAdem might continue the bus in the background. Then the bus ends with a black point which displays the name of the bus, for example, D11 for the eleventh data bus. At a different position in the block diagram, a second black point appears with the same name, D11, from which DIAdem continues the bus.

## Buses Differ According to the Signals They Transport

When you make connections, DIAdem distinguishes between data buses, control buses, system buses, packet buses, alarm buses, and text buses, each of which transports different signals. You only can connect buses and block terminals that are the same type, for example, you cannot connect data buses to control buses. To distinguish between the various buses, DIAdem displays each type of bus in a different color. Single point processing buses are monochrome and packet processing buses have two colors. Refer to Chapter 5, [Working with Packet Processing](#), for more information on single point processing and packet processing.



DIAdem organizes the different bus types in separate display layers. To keep a block diagram clear and easy to understand, and to make it easier to make connections, you can hide the layers using the symbols on the toolbar or in the **View** menu.

- The system layer contains the yellow system buses, which transport clock rate information between the blocks.
- The control layer contains the red control buses, which respond to conditions and activate, deactivate, or reset blocks.
- The data layer contains the green data buses, which transfer analog signals or digital signals, depending on the data source.
- The packet layer contains the green and black striped packet buses, which transport data packets.
- The alarm layer contains the blue and black striped alarm buses, which transport alarm information.
- The text layer contains the gray and black striped text buses, which transport text information.



The blocks have different input terminals and output terminals. Data leaves a block on the right side of the block and reaches a block on the left side of the block. This also applies for data packets, alarms, and texts. You connect

the control buses and system buses on the horizontal edges of the block: the inputs at the top and the outputs at the bottom. Control blocks can have several control inputs and control outputs. Display instruments and manual input instruments have the control inputs **Start** and **Stop** or **Reset**, to enable, to disable, or to reset the visualization. Packet blocks can have several data input and data output terminals.

## Buses Contain Multiple Signals

All the buses between the blocks transport multiple signals. For example, a green data bus between two blocks can transport the measured values from 20 sensors. If you connect the signal from another sensor to this data bus, the data bus contains 21 sensor signals after the input node. DIAdem displays the number of transported signals along the bus and at the input terminals and the output terminals.

Double-click a bus to obtain a list of the signals transported in the bus. The signal list includes the names of the block outputs and the names of the signals.

You specify the number of signals in the dialog boxes of the blocks. For example, to increase the number of signals generated by a function generator, click the **List Length** button in the dialog box of the function generator. Increase the number of outgoing signals to five, for example. After you close the dialog box, the function generator displays the number five at the data output terminal. If you connect a Curve display, the display instrument shows five curves underneath each other. So that display instruments automatically display all the connected signals, DIAdem selects the checkbox **Automatically increasing** in the list length by default.



**Note** For the driver inputs, the list length must be the same as the number of terminals on the installed hardware.

Data sources, data outputs, and several processing functions enable you to deactivate signals without changing the signal list. Open the dialog box of the Function generator. Click the fifth line in the **Active** column and select **No** for the fifth channel. When you close the dialog box, the number five is still on the Curve display bus. However, if you start a display, the display instrument displays only four curves.



You select the signals that a block is to process, in the dialog box of an input terminal. Double-click the data input terminal to disconnect signals from the Curve display, for example. DIAdem displays a list of the

five connected signals in the dialog box that opens. Select a signal and click **Disconnect**. You can select several non-consecutive signals to disconnect them all in one step. As shown, DIAdem displays an unplugged plug next to the disconnected signals and a plugged-in plug next to the connected signals. When you close the input dialog box, the number four appears at the data input terminal.

You can reconnect signals in the same dialog box. To connect single signals, you first select the terminal in the signal list and then the signal under **Connect signal**. If you want to connect several signals in one step, select all the terminals you want to connect, in the same dialog box. Click **Connect Signals** to open a list with the names of the connected blocks. When you double-click a block name, DIAdem displays a list of signals you can choose from.

## Combining Subtasks into Subblock Diagrams

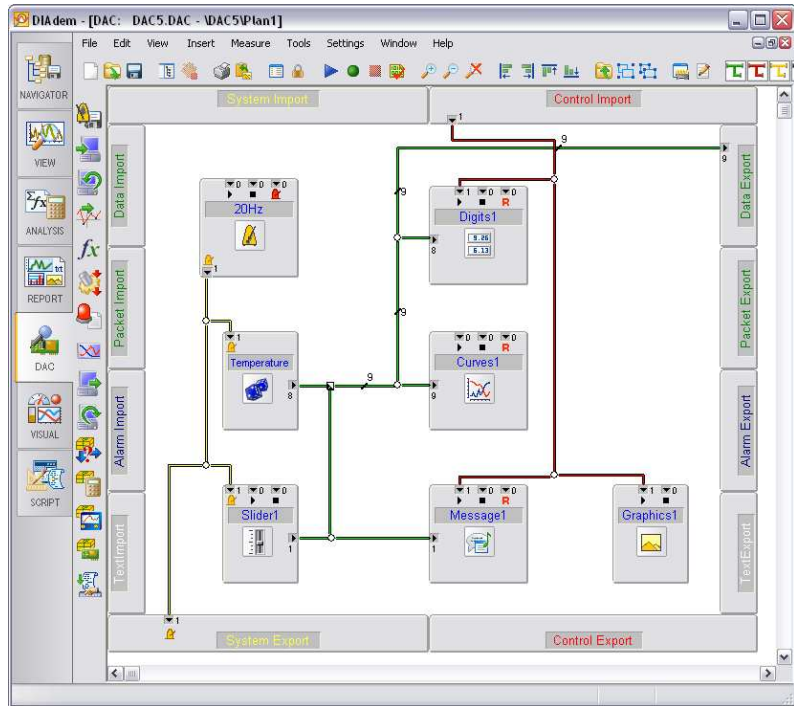
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The more blocks you insert and connect in a block diagram, the more complex the block diagram becomes. To keep the block diagram easy to understand, you can group sections of the task into subblock diagrams. In the block diagram, a subblock diagram looks like a block with signal inputs and signal outputs. You can include other subblock diagrams in a subblock diagram and in this way, establish a hierarchy with several levels. You can export subblock diagrams to reuse the task sections in other block diagrams.



To create a subblock diagram, you select the blocks and the buses that you want to group together, and click **Group Subblock Diagram** on the toolbar. DIAdem packs the blocks and the buses into one subblock diagram block and creates inputs and outputs for the buses to the blocks outside the subblock diagram. Double-click to open a subblock diagram. In the

following figure, you recognize the open subblock diagram by the surrounding terminal bars for importing and exporting the various types of signals. You can move and extend the terminal bars to enlarge the workspace of the subblock diagram.



**Figure 3-1.** Subblock Diagram with the Terminal Bars of the Various Bus Types

You use the connection bars to connect blocks inside and outside the subblock diagram with each other. Double-click the terminal fields at the edges of the subblock diagram to open the dialog boxes with lists of the imported or exported signals. You can add or delete connections in these dialog boxes. If you add a new import connection for data, the respective import field of the subblock diagram displays another connection. The subblock diagram displays another data input terminal where you can connect more signals. If you add export connections, DIAdem also generates the respective terminals in the subblock diagram and in the subblock diagram block. You only can delete existing connections if no signal buses are connected to the terminals that you want to delete in the subblock diagram or in the subblock diagram block.



Click the **Close Subblock Diagram** button on the toolbar to display the subblock diagram again as a single block in the main block diagram.



To integrate the blocks of a subblock diagram in a block diagram, select the subblock diagram block and click **Ungroup Subblock Diagram** on the toolbar. Before you ungroup a subblock diagram, you must connect each import and export terminal inside and outside the subblock diagram with buses that are the same length as the list length, otherwise DIAdem will not be able to completely unpack the subblock diagram.

You can save subblock diagrams as a file to store partial solutions for other tasks. Open the subblock diagram and select **File»Save Subblock Diagram**. To save a brief description of a subblock diagram, click **Block Diagram Parameters** on the toolbar. DIAdem saves block diagrams with the filename extension `.dac` and subblock diagrams with the filename extension `.sub` in the same file format. You also can load a block diagram as a subblock diagram and use a subblock diagram as a template for a block diagram. Select **File»Load Subblock Diagram** to import subblock diagrams. After you select the file name, DIAdem imports the subblock diagram without changing the global settings such as the system clock, interfaces, data storage, and measurement parameters of the main block diagram.

## Editing Block Diagrams

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In the DIAdem DAC workspace you can select and position one or more blocks. Use the alignment functions and the grid, which you activate on the toolbar, to position the blocks in relation to each other. When you move the blocks, DIAdem recalculates the buses. To move buses independently of the blocks in the block diagram, move branches and input nodes. Press `<Del>` to delete selected objects. To delete a bus between two blocks, for example, select the bus and press `<Del>`. To deselect all objects, click anywhere in the worksheet, or press the `<Esc>` key.



If you move a block to the right or down over the edge of the workspace, you move the visible section of the block diagram. Use the scroll bars to move the visible section anywhere in the workspace. To view the entire workspace, click **Zoom Out**. To enlarge a section of the block diagram overview, click **Zoom In**. DIAdem displays a cursor with a rectangle, which you use to specify the section you want. You can use this function repeatedly until you have the view you want. You can now click **Zoom Out** to undo the zoom step by step and click **Zoom Off** to restore the normal view.



In complex block diagrams, you can select **Edit»Find** to search for blocks and signals. When DIAdem finds a block, you can open the block properties and terminals from the search dialog box. At the same time, DIAdem selects the block in the block diagram.



You can prevent changes being made in block diagrams in DIAdem DAC. Click **Lock Editing** on the toolbar. DIAdem saves this setting with the block diagram. However, you can still change the parameters for the display and input instruments in DIAdem VISUAL.

In the DIAdem DAC settings you specify the maximum size of the block diagram and the display of the block diagram editor. Select **Settings»Options»DAC»Measurement Kernel** to specify the maximum number of blocks and signals for one block diagram. Select **Settings»Options»DAC»Block Diagram** to change the color of the background, the block display, the bus layers, and the labels for the blocks and buses.



Select **Settings»Single Point Processing»Default System Clock** to specify the basic sampling rate for the block diagram. DIAdem sets the default system clock for all blocks for which you do not set a specific clock signal. Use system clock blocks in the block diagram to assign a clock rate that is different to the default system clock to individual blocks. The blocks that are not connected to the system clock block continue to work with the default system clock. If you use several clock blocks, you can create subsystems that have different sampling rates. The measurement mode you set in the system clock block specifies whether only the DAC kernel controls the measurement, or whether the kernel and the measurement hardware control the measurement together. Refer to the section on *The Various DIAdem Measurement Modes* in Chapter 7, *The Basics of Process Measuring and Control Technology with DIAdem*, for more information about the measurement modes. If you also use packet blocks in a block diagram, select **Settings»Packet Processing»Default System Clock** to specify the sampling rate of the packet blocks. Refer to Chapter 5, *Working with Packet Processing*, for more information on single point processing and packet processing.

In a block diagram file with the filename extension `.dac`, you save the description of the blocks, the buses, the hardware settings, the interfaces in DIAdem, the system settings, and the visualization settings. If you use a graphic for visualization, DIAdem saves the filename including the path, in the block diagram. Select **Settings»Options»DAC** to save a block diagram in ANSI format that was used in earlier DIAdem versions, instead of in Unicode.

Enter a brief description of the block diagram in the **Block Diagram Parameters** to make it easier to recognize the purpose and context of the diagram later. In the block diagram parameters you can also include user commands so that you can use functions you defined in a script, before and after a block diagram check and before and after a measurement. Select **Settings»Options»Extensions»User Commands** and register script files that contain user commands, for DIAdem to add the user commands contained in the files to the collection of commands. Refer to Appendix A, *Executing Measurements Automatically*, for more information about scripts for DIAdem DAC. Refer to Chapter 6, *Automating Work Sequences*, in the DIAdem manual *Data Mining, Analysis, and Report Generation*, for general information about creating scripts.

## DIAdem DAC Function Groups

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DIAdem provides an extensive library of functions as blocks for signal acquisition, processing, and visualization. These blocks are arranged by category in the DIAdem DAC function groups:

- Driver Inputs and Outputs
- Simulation Inputs and Outputs
- Scaling
- Processing
- Control
- System
- Display Instruments
- Packet Processing
- Alarm System

The display instruments are described in the section on *DIAdem VISUAL Function Groups* in Chapter 4, *Visualizing Data and Operating Facilities*, the packet functions are in the section on *Packet Processing Functions* in Chapter 5, *Working with Packet Processing*, and the alarm functions are in the section on *Alarm System Functions* in Chapter 6, *Monitoring Processes with the Alarm System*.

## Driver Inputs and Driver Outputs



The function groups **Driver Inputs** and **Driver Outputs** include functions for registered measurement hardware and interface functions. Use the function group **Driver Inputs** to insert signal acquisition blocks into a block diagram. Use the **Driver Outputs** function group to insert blocks that you use to output signals via the measurement hardware, into a block diagram. These function groups contain the functions of the registered measurement hardware that you install on your computer. If you do not register any measurement hardware in DIAdem, some of the buttons have a question mark.

Both of the function groups have default blocks for the OPC interface, the DDE interface, and device drivers. With the **OPC driver** (OLE for Process Control), DIAdem can communicate as an OPC client with any OPC servers registered on your computer. With the **DDE driver** (Dynamic Data Exchange), you can establish a client/server link via DDE. The **NI-CAN driver** (Controller Area Network) enables access to signals via the CAN bus and the **NI-DAQ driver** enables access to the National Instruments hardware that you define in the Measurement & Automation Explorer, which is the National Instruments device configurator. DIAdem uses the **Script driver** to communicate with external measurement devices via the interfaces RS-232, GPIB, and TCP/IP. DIAdem uses the **Control file driver** to communicate with external measurement devices on the basis of ASCII control files, via the RS-232 interface or the GPIB bus.

Refer to Chapter 2, [Installing Measurement Hardware and Communicating via Interfaces](#), for more information on how to register measurement hardware in DIAdem or how to access external devices via interfaces.

## Simulation Inputs and Simulation Outputs

The function groups **Simulation Inputs** and **Simulation Outputs** include functions for generating signals without measurement hardware. You can use simulation blocks to create and to test block diagrams without hardware, and you can later replace the data sources with hardware blocks.



The function group **Simulation Inputs** includes the blocks **Random**, **Noise**, and **Function Generator**, for generating continuous signals. You operate the input instruments **Switch**, **Push Button**, **Slider Control**, **Dial**, and **Numeric Input** in DIAdem VISUAL using the mouse or the keyboard, to generate signals interactively. You can trigger control signals in relation to conditions. The blocks **Read Channel from Data Portal**, **Read Channel from DAT File**, and **Read Channel from DAT Measurement**

**File**, read data from the Data Portal or from a data file that can originate from a measurement that has finished or is still running.

To display the date and time during a measurement, use the **Absolute Time** with a digital display. Because DIAdem displays the time in seconds since the year zero, you must enter the digital date display in days, hours, seconds, and milliseconds, for example, in the format `#dd hh:nn:ss.ffff`. Use the **Date** block if you want to display only the day, the month, or the year of the current date, and use the **Time** block to display the current hour, minute, or second. In the connected digital display, you do not specify a time format to display the date or the hour, you specify the number of decimal places, for example, `dddd` for the date. You use the **Stopwatch** to measure the duration of events in seconds, by starting, stopping, and resetting the stopwatch with control signals.

You use the **Counter** to simulate a counter component that has a control input `Clock Release`, which starts counting synchronously with the system clock, and a control input `Reversion`, which changes the counting direction. The **Buffer Monitor** monitors the filling of the measurement value buffer to give you an idea of the load the measurement subjects the computer to.



The function group **Simulation Outputs** includes the **Loudspeaker**, which outputs measured values as acoustic signals to the computer loudspeakers. Use the **Execute Application** block to start other applications in relation to events. Use the **Open Application** block to display and to hide executing programs on the screen.

## Scaling Function Group



The **Scaling** function group includes blocks for converting the incoming signals from the measurement hardware into the measured physical quantities. Scaling blocks convert, for example, the voltage recorded on temperature sensors into the original measured temperature, with the unit degrees Celsius.

**Linear Scaling** scales signals linear, using the linear equation  $ax+b$ , and **Two-Point Scaling** scales signals using two specified points. You can execute a calibration measurement to determine the two points. With **Free Linearization** you use two imported channels to define data points for any non-linear scaling.

The **PT100 Linearization** calculates the temperature from the measured resistance. The **Thermo Linearization** block calculates the temperature from the voltage measured on a thermocouple. If you execute external

pre-amplification, DIAdem must convert the incoming voltage values to the voltage range on the thermocouple used, so that the linearization function processes the measured values correctly.

## Processing Function Group



The function group **Processing** includes blocks for calculating data signals and controlling processes.

In the processing block **Formula** you define formulas for connecting data signals to control signals, in the same way as in the DIAdem Calculator. As the formula result, DIAdem outputs data signals such as the power, calculated from the current and the voltage. The **Signal Copy** creates as many copies of the input signal as the block has data outputs, and the **Signal Multiplexer**, which is controlled by the selection input, groups measured values from several input signals, into one data signal. You use the block **Control Signal→Data Signal** to convert control signals into data signals, for example, to visualize the status of control signals. The processing block supplies data signals with the values 0 and 1.

Use the **PID Controller**, the **Two-Point Controller**, or the **Three-Point Controller** to calculate actuating values from the difference between the reference value and the actual value. In the non-linear blocks **Two-Point Controller** and **Three-Point Controller**, you can specify a hysteresis by entering different values for the on and off levels. With the **PID Controller** you must ensure that the proportional part, the integral part, and the differential part correspond, to ensure good control behavior.

Use the **Bit Bundling** block to bundle up to 32 single-bit signals into one 32-bit signal, and the **Bit Extraction** block to divide a signal with up to 32 bits, into single-bit signals. The processing block **Mean of N Signals** calculates the arithmetic mean of all the input signals and the processing block **Floating Mean** calculates the floating mean for each signal at an interval that you specify. The processing blocks **Binary Code→Gray Code** and **Gray Code→Binary Code** convert measured values from binary code to Gray code and vice versa.



Create your own processing functions in scripts, to use the functions in the processing block **VBS Script** in block diagrams. You also can create function libraries (DLLs) that you register in DIAdem by selecting **Settings»Options»Extensions»GPI Extensions**. These functions are then assigned to the six free blocks in the function group **Processing**. Use the processing block **AUT Script** to use scripts from earlier DIAdem versions.

## Control Function Group



The function group **Control** includes blocks for monitoring data signals, system signals, and control signals. DIAdem generates control impulses when data signals exceed thresholds, for example, or when periods of time elapse, or when a key is pressed. Control signals have the value 1 if a condition is true and the value 0 if a condition is not true. Use control signals to start or to stop the storage of measured values, to switch display instruments on and off, or to adjust the sampling rate during the measurement.



You can add inverted block outputs to control blocks, where the inverted signals of the related control signals arrive. To add an inverted output, click **Outputs** in the dialog box of the control block and select the **Inverted outputs** checkbox.

Use the control block **Window**, **Slope**, and **Signal Alteration** to monitor data signals. The **Window** generates a control impulse when data signals enter or leave a specified value range. The **Slope** block checks whether data signals exceed a threshold in the ascending or the descending direction, and the **Signal Alteration** block monitors the difference between consecutive values.

In the control block **Formula** you define formulas for connecting data signals to control signals and for outputting control signals as the formula result, in the same way as in the DIAdem Calculator. You can execute comparison operations and Boolean operations in the formula, for example. When you use formula blocks, remember that DIAdem processes predefined conditions, such as the Window block, faster than formulas.

The **Push Button** generates a control impulse when the user presses a specific function key or the corresponding button is pressed in DIAdem VISUAL. With the Start and Stop control inputs, you can block and release the operation of the push button in relation to events. The **Time** block realizes an on/off delay or generates a periodic control impulse, and the **Absolute Time** generates a time condition with the date and time.

Use the control blocks **AND** and **OR** to execute operations on control signals, and use the **NOT** block to invert a control signal. The **Impulse Delay** control block forwards a control signal, with a delay, as an impulse.

The Mono Flop and the Flip Flops work the same as the electrical engineering components. The **Mono Flop** is a single-shot circuit that outputs a control signal for a specific hold time, as soon as a control impulse arrives at the set input. The **RS Flip Flop** and the **JK Flip Flop** are

bi-stable circuits that, after a control impulse, continue to output a control signal at the set input until a new control impulse arrives at a reset input. The **Switch** is similar to the RS flip flop, but DIAdem monitors only one control input: only the reset condition for a set switch and only the set condition for a switch that is not set.

Use the control blocks **System Clock Status**, **Trigger Sequence Status**, and **Number of Values** to monitor system signals. The **System Clock Status** checks the status of a system clock and the **Trigger Sequence Status** checks the status of a trigger sequence of a system clock rate. You can use this control information to start other clock systems or trigger sequences consecutively. The control block **Number of Values** generates a control impulse after a specific number of clock cycles.

## System Function Group



The function group **System** includes the blocks **Save Data**, **Save Data with Trigger**, and **Save in Variables**, for saving measured values. The blocks **Save Data** and **Save Data with Trigger** save channel group properties and channel properties with the measured values, in the Data Portal or to a file.

To save measured values in relation to events, you can define a start trigger and a stop trigger in the system block **Save Data with Trigger**, and you can define consecutive triggers in the system block **Trigger Sequence**. For the start trigger and the stop trigger you can define a pre-range and a post-range, to save or to reject the measured values that come directly before or after a trigger. For each trigger sequence you can define a data reduction, to save only the first value, the minimum, the maximum, or the arithmetic mean, of the specified interval. Select **Settings»Options»DAC»Measurement Kernel»Triggers** to change the maximum number of trigger sequences in a block.



Use the **System Clock** to create subsystems with different sampling rates. DIAdem sets the default system clock for all blocks for which you do not set a specific clock signal. The measurement mode you set in the system clock block specifies whether only the DAC kernel controls the measurement, or whether the kernel and the measurement hardware control the measurement together. Refer to the section on *The Various DIAdem Measurement Modes* in Chapter 7, *The Basics of Process Measuring and Control Technology with DIAdem*, for more information about the measurement modes.

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# Visualizing Data and Operating Facilities

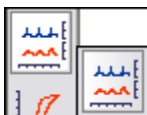


You use DIAdem VISUAL to design the visualization of block diagrams that you create with DIAdem DAC. When a measurement starts, DIAdem automatically switches to DIAdem VISUAL to display measurement data, open or closed loop control data, or monitoring data. The display and input instruments can be positioned freely and pictures and audio files used, allowing you to design all kinds of visualizations appropriate for your task.

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## Creating a Visualization

When you create the block diagram in DIAdem DAC, you select, configure, and connect the blocks and decide which display instruments show which signals. In DIAdem VISUAL you then design the visualization by arranging and configuring the display instruments and the input instruments. You save the definition of the visualization with the block diagram. You also can add display instruments and input instruments from the function groups in DIAdem VISUAL. With each instrument you add, you also add a block to the block diagram in DIAdem DAC, where you connect data buses, control buses, and system buses to the block.



For example, to display the data of the **NI-DAQ** driver input as curves on a recorder, open the **Recorder Display** function group in DIAdem VISUAL and click the **Horizontal Recorder Display with N Systems** button shown on the left. DIAdem inserts the display instrument in the top left corner of the workspace. Move and resize the recorder display to position the display instrument. Double-click the instrument to edit the settings. In the **Parameters** subdialog box you make the settings for the instrument, such as the y-scaling for the Curve display, and in the **General Layout** subdialog box you specify the appearance of the instrument, such as the colors, the labels, or the legend display. To connect data to the display instrument, open DIAdem DAC and connect the data input of the **Recorder** block to the data output of the **NIDAQ-In** block.





To display the measurement values, click the **Start Display** button on the toolbar. DIAdem displays the connected signals as curves. To stop the display, click **Stop Measurement** on the toolbar. While a measurement is running, you cannot move or edit the instruments, you only can operate the input instruments in the workspace and click **Stop** on the toolbar. In DIAdem VISUAL you can not only start a block diagram, you also can load it and save it.



Use the full-screen mode to hide the DIAdem VISUAL user interface and display the workspace contents on the entire screen. Press <Ctrl-U> for the full-screen mode. Then press <Ctrl-F5> to start a measurement. Hit the <Esc> key to stop the measurement. Press <Ctrl-U> to disable the full-screen mode. You can neither enable nor disable the full-screen mode while a measurement is running.

## Editing a Visualization

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You can position display instruments, input instruments, and graphics anywhere in the visible workspace. However, you cannot move instruments over the edge of the screen as you can in DIAdem DAC, because the DIAdem VISUAL workspace is limited to the visible area. Enable the grid, for example, to position instruments exactly next to each other or above one another.

When you select an instrument, DIAdem marks the instrument with a dashed frame and small squares in the corners and at the sides. Move the squares at the sides to change the width and the height. Drag the squares at the corners to resize the object while maintaining the proportions. Press <Ctrl> at the same time, to change the size but keep the center.

You can select several instruments and move and resize them together. You can use the alignment functions to align selected objects to each other and to align the size of the objects. The dashed frame around the object group is the reference point for DIAdem. To align three instruments evenly spaced underneath each other, click the **Align Vertical Intervals** button shown on the left, on the toolbar. If the selection frame is smaller than the total height of all three instruments, DIAdem positions the instruments underneath each other with the edges touching, without changing the height of each instrument. If you position an instrument incorrectly, or if you use the wrong alignment function, press <Ctrl-Z> to undo steps.



If you cannot select an instrument with the mouse in the workspace, because the instrument is hidden by another object, click the object and select **Edit»Outline** to make the hidden instrument visible. To edit hidden instruments, select one instrument after another with the <Tabulator>. DIAdem marks the selected instrument and brings it to the foreground.

The display instruments and the input instruments have a specific value range, which is  $\pm 10$  by default. You can change the value range separately for each signal.



You can prevent changes being made in visualizations in DIAdem VISUAL. Click **Lock Editing** on the toolbar. DIAdem saves this setting with the block diagram. However, you can still change the visualization block parameters in DIAdem DAC.

## Working with VISUAL Pages

You position the instruments that you want to view simultaneously when the block diagram starts, next to each other. However, if you want to view either one instrument or another, in relation to an event, you must position the instruments on top of each other. You use the conditions that are defined in control blocks to specify in DIAdem DAC when DIAdem displays which instrument. If you connect a control bus to the start input of the Curve display, DIAdem does not show this display instrument until the associated condition at the control input is true, not as soon as the measurement starts.

To make it easier to select display instruments and input instruments in complex block diagrams, which makes it easier to edit the visualization, you can group instruments together into VISUAL pages. You can display, hide, and lock VISUAL pages for editing. To define VISUAL pages in DIAdem VISUAL, select **View»Page Management**. Then you must open the block dialog box for each instrument, click **General Layout**, and assign a VISUAL page. To hide a group while you edit the visualization screen, click **View** and disable the appropriate VISUAL page.

By default, each subblock diagram uses its own VISUAL page, which has the same name as the subblock diagram. To assign another VISUAL page to a subblock diagram, you open the subblock diagram in DIAdem DAC and select **Block Diagram Parameters»VISUAL Page** on the toolbar. To regroup the individual instruments of the subblock diagram, click **General Layout** in the block dialog boxes and select a different VISUAL page.

## Setting Up the Visualization

To specify basic visualization properties, select **Settings»Block Diagram Parameters»Visualization**. You specify whether DIAdem hides deactivated display instruments during the measurement, and select the VISUAL background color. DIAdem saves the sizes and positions of the instruments in relation to the workspace, to automatically adjust the visualization to different screen sizes or changed window sizes. For identical display of the sizes and positions of instruments on any screen, specify the display area for the visualization, for example, as  $800 \times 600$ . DIAdem then shows the same visualization screen, regardless of the screen resolution.

## DIAdem VISUAL Function Groups

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DIAdem provides various display and input instruments. These functions are arranged by category in the DIAdem VISUAL function groups:

- Manual Input
- Curve Display
- Wiper and Spike Display
- Recorder Display
- XY Display
- Gauge Display
- Bar Display
- Alphanumeric Display
- Binary and Status Display
- Alarm System Display
- Graphics

DIAdem DAC includes blocks for displaying measurement values in the function group **Display Instruments** and the blocks for the manual instruments in the function group **Simulation Inputs**. The alarm system displays are described in the section on [\*Alarm System Functions\*](#) in Chapter 6, [\*Monitoring Processes with the Alarm System\*](#).

## Manual Input



The function group **Manual Input** includes the instruments **Switch**, **Push Button**, **Slider Control**, **Dial**, and **Numeric Input**, which you can use to create data signals manually. To manually create a control impulse, open the **Control** function group in DIAdem DAC and select the **Push Button**. You can operate the manual input instruments with the mouse or the keyboard or you can remote-control them with a data signal. After you enable remote control in the dialog box, the block receives another control input and data input. The additional data signal does not control the manual input instrument unless there is an active control signal at the remote control input. You cannot control manual instruments manually and via a data input at the same time.

You use the arrow keys on the keyboard to operate the **Slider Control** and the **Dial**, and you use an assigned function key to operate the **Switch** and the **Push Button**. For **Numeric Entry** you enter numbers on the keyboard and press <Enter>. If you enter a value that is outside the set value range, DIAdem uses the corresponding limit value instead.

## Curve Display, Recorder Display, Wiper Display, and Spike Display

The function groups **Curve Display**, **Recorder Display**, and **Wiper and Spike Display** include display instruments that display signals as time-related curves.



Use the **Curve Display** function group to display signals as time-related curves, which DIAdem plots from left to right. The Curve display deletes when the curve reaches the end of the window, refreshes, and repots from the left.



Use **Recorder Display** to display signals as a continuous horizontal curve from right to left, or as a vertical curve from the top to the bottom. The recorder displays the signals as curves as if they were recorded on paper by a needle on a roller.



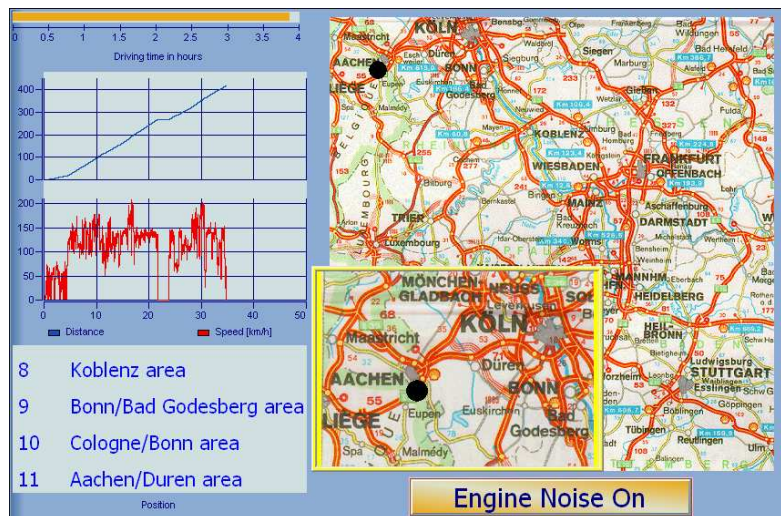
Use the **Wiper** to display signals as continuous time-related curves, and use the **Spike** display instrument to display signals as vertical lines over the time axis. In both of these display instruments, a vertical line moves across the instrument from left to right and deletes and replots the curve. Wiper and Spike display, for example, display the values measured in the last ten seconds, and the current values are to the left of the vertical line and the previous values are to the right of the line. This enables you to see signal changes as soon as they occur.

In these display instruments, you can display all the curves in one axis system or each curve in a separate axis system. To scale the time axis you specify a time segment, which DIAdem labels with the measurement time, with the current time, or with a fixed scale. To scale the y-axis, you can choose between a scale with the percentages of the display area, and a scale with the physical values. Grid lines, legends, and warning and alarm ranges make it easier to monitor the signals.

## XY Display



Use **XY Display** to display the relation between two signals as an xy-curve. The display instrument plots a curve or moves a symbol, such as a circle or a triangle, across the display area. You can, for example, embed a road map in the display area to follow a test drive as shown in the following figure. The dot indicates the position of the test car on the road map in the background.



**Figure 4-1.** Using XY Display to Monitor a Test Drive

To scale the x-axis and the y-axis, you can choose between a scale with the percentages of the display area, and a scale with the physical values. Grid lines, legends, and warning and alarm ranges facilitate signal monitoring.

## Gauge Display



The function group **Gauge Display** includes display instruments such as the **Tachometer**, **Analog Instruments**, and **Cylinder Tachometers**, to display the current signal values in gauges. The **Analog Instrument** uses a quadrant, the **Gauge Display** uses a semicircle, and the **Tacho Display** uses a three-quarter circle as the scale that the gauge moves in. You can modify the size and position of the scale for the gauge and for the tachometer.

In **Cylinder Tachometer** display, the scale moves, not the pointer. The cylinder can move vertically or horizontally and DIAdem can display the pointer as a line or as a double arrow. You specify the scale on the cylinder as a percentage that is the size of the visible segment of the value range.

Use **Polar Display** to display two signals in one polar axis system. The x-values contain the angles around which the pointer rotates and the y-values contain the amplitudes that specify the length of the pointer.

The Cylinder tachometer displays a separate display instrument for each signal, whereas you can display all the signals together in each of the other gauge displays. You can choose between a scale with the percentages of the display area, and a scale with the physical values. Legends and warning and alarm ranges make it easier to monitor the signals.

## Bar Display



Use the **Bar Displays** to display the current signal values as horizontal or vertical bars. The reference line specifies whether the bars display on one side or on both sides of the axis. To distinguish between positive values and negative values, set the reference line in the middle of the value range. Positive values move a vertical bar upwards and negative values move the bar down.

The **Container** bar displays specify the filling level in different-shaped containers. The level corresponds to the current measured value. You can choose between three cylindrical forms and one round form or a graphic of the container used. To do this, select a graphic file in the dialog box of the container, and specify the transparency color. The graphic area for the bar display must be the same as the transparency color.

You can choose between a scale with the percentages of the display area, and a scale with the physical values. You can change the color of the bars when limits are exceeded.

## Alphanumeric Display



The **Alphanumeric Display** function group includes the digital displays **Digits** and **Table**, for numeric display of the current signal values. You can manually enter the numeric format and the font, and you can use color changes to indicate when limits are exceeded.

Use **Message Display** to display events visually or acoustically. DIAdem reads the messages from a text file and displays each measured value in a separate line. Instead of text, DIAdem can also display graphics and play audio files. To display graphics, enter `@graphic` in the first line of the text file and enter the paths with the graphic files in the subsequent lines. To run audio files, you must enter `@sound` and the audio files instead. To combine graphics with audio files, use two **Message** blocks in the block diagram.

Use **Text** to display a description or instructions in relation to an event. DIAdem distinguishes between static text and dynamic text. Dynamic text contains formula expressions and variables that DIAdem periodically updates. You can double-click to open the text editor, for example, to enter `@@CurrTime@@` for the current time display.

## Binary and Status Display



The instruments in the function group **Binary and Status Display** do not show measured values, they divide the measurement range into two or more states. Use the binary displays **Valve** and **Switch** to display a valve or a switch opening or closing. If you select the **Rectangle** or the **Light** instead, a color change indicates whether the signal is inside or outside the display range.

The **Status** shows more than two states. You enter a color, a graphic, or an audio file for each status.

Use the **Color Matrix**, for example, to show the temperature distribution on a workpiece. The temperature sensors must be positioned in a regular grid on the workpiece. The color palette that you define as the value range determines the color shading for the signals in DIAdem.

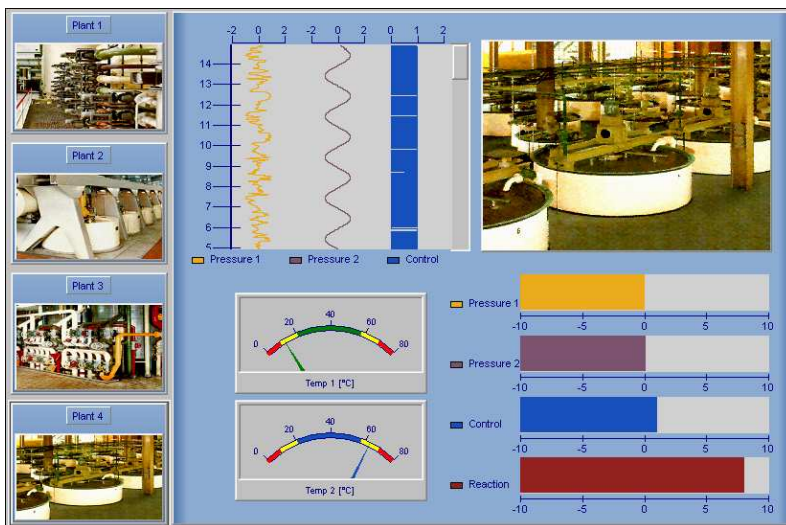
## Graphics



Use the function group **Graphics** to integrate a picture of the test rig, the company logo, or a video, in the visualization. To integrate graphics in the customary formats and videos in the AVI file format and the MPEG file format, select **Load Graphics**. If you load a graphic or a video, DIAdem creates a link to the file. DIAdem saves the link with the path definition in

the block diagram. If you want to use the block diagram on another computer, you must also copy the graphic or the video to the computer in addition to the block diagram.

In the following figure, the pictures on the switches make it easier to switch from one part of the facility to another, and the enlarged graphic makes it easier to associate the measured values with the part of the facility.



**Figure 4-2.** Monitoring a Facility at Four Critical Points



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# Working with Packet Processing

DIAdem provides two different methods for measuring and visualizing data: single point processing and packet processing. In single point processing, the DAC kernel controls the timing for point-by-point data acquisition, processing, and output. In packet processing, DIAdem handles the data in packets. The data flow controls the processes, which means that a function block must process an entire data packet before the subsequent function blocks can start to process the packet. You can combine single point processing and packet processing in one block diagram, for example, to execute an online FFT in the packet section and to use the maximum values of the frequency analysis for control in the single point section.

## Single Point Processing

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In single point processing, the DAC kernel controls all functions. This centralized control decides when DIAdem executes which functions, and controls the sampling rates, triggers, and conditions. The DAC kernel requests values from the device drivers or forwards values to device drivers for output, and displays the values on the screen. At any point in time, the current acquired or calculated value is at each function block. Data is acquired on all A/D convertor boards that have the same type of functions. The DAC kernel makes these data values available for all other functions simultaneously.

### Special Features

In single point processing, data acquisition is executed in Hardware clock or Software clock. This enables you to execute long-term measurements and high-speed measurements. You can use plug-in boards to execute open and closed loop control without signal processors. Refer to the [The Various DIAdem Measurement Modes](#) section in Chapter 7, [The Basics of Process Measuring and Control Technology with DIAdem](#), for more information about Hardware clock and Software clock.

## Used For

- Slow acquisition of individual data values
- Event-controlled data acquisition
- Open and closed control tasks with moderate real-time requirements
- Computer-controlled test rig applications

## Packet Processing

In packet processing, DIAdem does not process single values separately: DIAdem groups the single values into packets that pass through each of the processing steps. As soon as a data packet arrives, DIAdem forwards the data packet to the first processing function. The function processes, visualizes, saves, duplicates, or rejects the values. This function then forwards the resulting data packet to the next processing function.

The data packet flow works like a letter shoot. The data packets go physically from one function to the next. The reduced amount of administration effort increases the data throughput compared to single point processing. Each function works automatically as soon as a data packet arrives. This makes it possible to execute calculations such as Fourier analyses, which require a certain number of values simultaneously.

## Special Features

The measured values are acquired in data packets with data flow control. The measurement hardware determines which additional functions you have, for example, removing mathematical functions or complex testing tasks with short response times to boards with signal processors, which reduces the computing load during processing.

## Used For

- Data acquisition with high data throughput
- Fast online visualization
- Complex online mathematical functions
- Special hardware features

## Using Packet Functions in the Block Diagram

Packet processing has its own functions for signal processing, signal analysis, visualization, signal acquisition, and signal output. To combine single values and data packets in one block diagram, use the **Pack** block, which groups single values into data packets, and the **Unpack** block, which divides the data packets into separate values.



For example, to display a signal from the single point **NI-DAQ** driver input defined in the block diagram as a waterfall diagram, open the function group **Signal Processing (Packet Processing)** and click the **Pack** button shown here. Position the packet block below the existing block diagram and connect the green data bus that is connected to the driver input, to the data input on the **Pack** block. Double-click this block to specify the number of values in one data packet in the block dialog box.



To display the data packets as a waterfall diagram, open the function group **Display and I/O (Packet Processing)** and click **Oscilloscope (3D Display)**. Position the Oscilloscope block next to the Pack block and connect both packet blocks. DIAdem connects the two packet blocks with a green and black striped packet bus. Together with the Oscilloscope block, DIAdem displays a new window which you can position anywhere on the screen, not just in the DIAdem VISUAL workspace.



When you start a measurement, the window displays axes and measurement curves as soon as the Oscilloscope block receives data. DIAdem automatically adapts the scaling to the data. In the Oscilloscope window, DIAdem displays the curve of the current data packet in the foreground and the curves of the old data packets in the background, which creates a three-dimensional waterfall display. While a measurement is running, you can move the window around on the screen and you can modify the display of the measured values using the menus or the toolbar in the window. Click **Stop Measurement** on the toolbar to stop the measurement.



Unlike the display instruments in single point processing, the display of the windows is specified only in the menus or on the toolbar, and the functions of the input instruments are specified in the shortcut menus. In the packet block dialog boxes, you only make the settings for the data flow. In DIAdem VISUAL you have no access to the packet processing display windows and input instruments.

Unlike the single point processing function blocks, which distinguish between data buses and control buses, you connect packet buses to the control inputs, not control buses. DIAdem monitors the packet buses to check whether the condition is true.

## Block Size and Sampling Rate Determine the Data Packet Flow

Packet processing transports data packets from one packet block to the next in the block diagram. Data packets are generated, for example, by hardware inputs, input instruments from packet processing, or the Pack block. DIAdem does not forward a data packet to the subsequent packet block until the data packet is completely filled with data. The subsequent packet block does not work until all the block inputs have data packets and the block outputs are vacant.

How many values a data packet contains depends on the size of the block. The maximum block size depends on the measurement hardware you use. Many packet blocks, such as the scaling functions, output data packets that are the same size as the incoming data packets. Several packet blocks output data packets with a smaller block size, for example, the FFT data packets are half the size of the incoming data packets.

The statistics function generates multi-channel data packets with only one value per channel. DIAdem arranges the data of the individual channels in multi-channel data packets value-wise. DIAdem first enters all first values, then all second values, and so on, into one data packet. The number of channels a data packet contains is indicated at the beginning of the multi-channel data packet. The packet blocks **Oscilloscope**, **File-I/O**, **Relay Switch**, **Arithmetic**, **Copy**, **Voltmeter**, and **Protocol list** can process multi-channel data packets.

The size of the data packets and the sampling rate determine the processing speed, which in turn determines the data flow in the block diagram. The sampling rate determines how fast DIAdem generates data or requests data from the data acquisition board. The response time in the block diagram depends on the ratio between the block size and the sampling rate. A data acquisition block that is to measure 100 values at a sampling rate of 100 Hertz, can return only one data packet per second.

The default clock rate is used as the processing speed for all packet blocks for which you cannot specify the block size or the sampling rate in the dialog box. If you select **Settings»Packet Processing»Default System Clock** you can specify the packet call clock as well as the block size and the sampling rate. The packet call clock is the rate at which DIAdem calls the packet blocks. At every call, DIAdem checks whether a packet block is

prepared for work. If a data packet is located at all block inputs and no data packet is blocking the block outputs, a block is prepared for work. As long as a packet block is working, the packet block ignores the packet call clock.

## Packet Processing Functions

All the packet processing functions in DIAdem DAC are grouped by category into four function groups. The Complete Selection button in the function group **Signal Processing (Packet Processing)** contains other packet functions that you can use in your block diagram.

- Signal Processing (Packet Processing)
- Signal Analysis (Packet Processing)
- Display and I/O (Packet Processing)
- Driver (Packet Processing)



**Note** The NI License Manager only provides the packet functions if your license contains packet processing. If not, the buttons in the packet function groups are dimmed. To use the packet functions you might have to obtain a license for a different DIAdem edition.

## Packet Functions for Signal Processing



The function group **Signal Processing (Packet Processing)** includes the functions **Unpack** and **Pack**, for combining packet processing with single point processing. The **Unpack** packet block divides the data packets of a packet bus into single values and outputs the values to a data bus in single point processing. The **Pack** packet block combines values from one data bus in single point processing and outputs data packets to a packet bus.

You use the **Merge** packet block to combine data packets from several packet buses to a new multi-channel data packet. The data packets from the input signals must have the same packet size and sampling frequency. You use the **Manager** packet block to filter channels from multi-channel data packets. To create single-channel data packets, enter only one channel in the channel list. This packet block forwards the unaltered input signal together with the selected channels.

Use the **Multiplexing** packet block to output data packets from several data inputs in alternating order from a block output, and the **Demultiplexing** packet block to output data packets from one input signal to several block outputs in alternating order. You can use a signal at the control input to specify the order of the inputs used with the Multiplexing packet block or the outputs used with the Demultiplexing packet block.

The **Relay Switch** packet block works as an on/off switch or as a toggle switch, to interrupt data packet transport or to assign the transport to two block outputs. The signal at the control input controls the relay switch. The **Trigger** packet block outputs data packets in relation to events, and DIAdem monitors whether the data signal or a second signal overshoot thresholds. The Trigger block rejects all data packets before the event.

You use the **Ignore** packet block to reduce the amount of incoming data. The Ignore block can reject values, change packet sizes, or output specified sections of data depending on a control signal. The **Replicator** packet block repeatedly outputs a data packet, for example, for recurring use of a data packet with set points or comparative data, or to synchronize data signals that have seldom and irregularly incoming data packets with fast data signals. You use the **Offset Register** packet block to reduce the block size by dividing large data packets into smaller subpackets.

You use the scaling functions to convert values, for example, to display the values in a different unit. **Linear Scaling** uses a linear equation with a factor and an offset for calculations, whereas **2-Point Scaling** uses two points to determine the linear equation. **Thermo Linearization** converts the voltages measured with thermocouples and with PT100 resistance into temperatures. **Multi-Point Scaling** scales data with a non-linear calibration curve, which the packet block reads in at a second data input, during the measurement. To change the calibration dynamically, you can exchange the calibration curve during the measurement.

Use the **Clock** packet block with the single point block **System Clock** to change the packet call rate in the block diagram. Enter the sampling rate at which DIAdem calls the packet blocks, in the system clock block. Use the packet block **Stop** to stop the block diagram packet blocks or the complete measurement after a specified number of data packets.

## Packet Functions for Signal Analysis



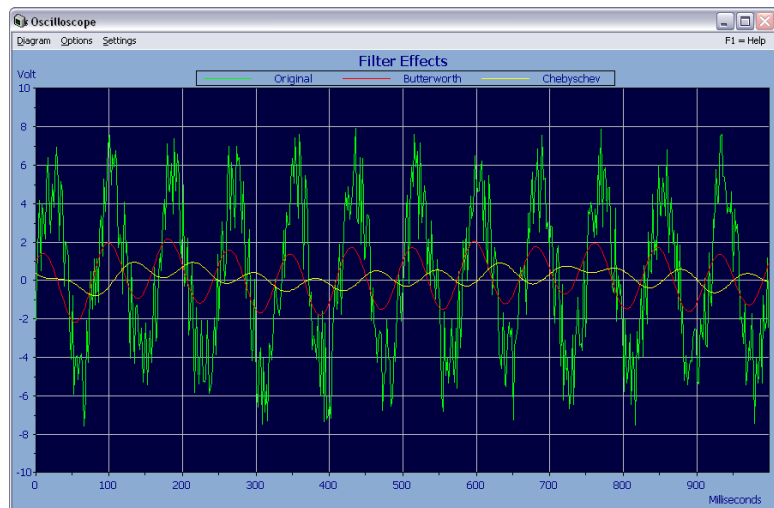
The function group **Signal Analysis (Packet Processing)** includes the packet block **Formula Parser**, which executes mathematical functions on data packets from several packet buses, with a specified formula. DIAdem links the data packets of each block input value-by-value and outputs the results in a data packet that is the same size as the first data input.

You use the **Mean Value** packet block to calculate the arithmetic mean or the floating mean for entire data packets or for sections of the data packets and you use the **Counter** packet block to count measured values, data packets, or time ranges. The **Statistics** packet block calculates characteristic statistical values for data packets and the **Online**

**Classification** block specifies the frequency distributions for the measured values in the data packets. DIAdem divides the data packets into classes, and counts how many measured values each class contains.

The function group **Signal Analysis (Packet Processing)** includes functions such as Fast Fourier Transformation (FFT), Third/Octave Analysis, and Digital Filters, which you use to monitor frequency sections of oscillations during measurements. The **FFT** block transfers signals from the time domain to the frequency domain, the **Inverse FFT** block reverts signals from the frequency domain to the time domain, and the **FFT of Two Time Signals** analyzes two signals with a common time channel, by calculating cross spectra and transfer functions. You use the **Third/Octave Analysis** to check the exact frequency distribution in the frequency domains, not in the signal. To do this, the third/octave analysis sums up the amplitude values of an FFT in standardized logarithmic frequency intervals.

With the **Digital Filters** packet block, you can attenuate or amplify selected frequency ranges of a time-related signal. You can choose from various filter types, such as lowpass, bandpass, and bandstop, which transfer only certain frequency ranges of the signal. You can use the various filters as IIR filters and FIR filters. The following figure shows the results from the IIR filters Butterworth and Chebyshev.



**Figure 5-1.** Signals Filtered with Different Digital Filters, Displayed in the Oscilloscope

## Packet Functions for Display and File Access



The function group **Display and I/O (Packet Processing)** includes the oscilloscope and the voltmeter for visualizing data packets, and packet blocks for manual input and output of data packets. These blocks have their own windows, which you can configure separately and position anywhere on the screen.

The **Oscilloscope** block displays data packets as curves, bars, or spikes. The display mode depends on the block size. You can display the chronological profile of signals as a three-dimensional surface or in recorder display. You use the menus and the toolbar in the display window to specify the appearance of the display, which you also can change during measurements.

Click the **Cursor** button on the toolbar to show two cursor lines for measuring curve profiles and the cursor window. You can move the cursor lines with the mouse during the measurement and enlarge the range between the two cursor lines. The cursor window shows, for example, the point numbers and the x-values and the y-values, of both cursors.

The **Voltmeter** block displays measured values with gauges, digital instruments, horizontal or vertical bars, and text. If the voltmeter contains multi-channel data packets, the window displays a separate instrument for each data channel. Use the shortcut menu of the display window to specify the display mode for the incoming signals and to show the warning and alarm limits, the drag indicator, and the trend display.

The **Generator** packet block generates signals such as sine signals and noise signals. The **Manual Input** blocks generate data packets with a slider control, a dial, a switch, a push button, or a bit switch. You use the shortcut menu of the instrument to specify the instrument display. If you generate several signals with a manual input instrument, DIAdem displays an input instrument for each channel in the display window. Manual input generates data blocks that have a block size of 1. Use the bit switch to output integer data values and use the slider control and the dial to output any data values. Use the push button and the switch to output control signals. The Push Button and the Switch blocks return the value 0 when they are off and the value 5 when they are on, whereas the slider control, the dial, and the bit switch output the set value.

The **Data Write** packet block saves measured data in the Data Portal and the **Data Read** packet block reads data from the Data Portal, for example, as the reference channel. The **File I/O** packet block writes data to files and reads data from files. In the window of the **File Player** you read consecutive



data packets or overlapping data packets forwards and backwards in data files. You use the packet blocks **Network Server** and **Network Client** to exchange data packets between DIAdem installations on a network.

## Packet Functions for Data Acquisition and Output



The function group **Driver (Packet Processing)** includes the functions of the packet sound driver **Analog On**, which acquires signals with the sound board in the computer, and **Analog Off**, which emits signals on the computer loudspeakers. For more driver functions, register the packet driver of the measurement hardware by selecting **Settings»Options»Extensions»GPI Extensions**. For the acquisition, output, and processing driver functions, select **Settings»Packet Processing»Driver Function Group**. Refer to the [Installing Measurement Hardware](#) section in Chapter 2, [Installing Measurement Hardware and Communicating via Interfaces](#), for more information about registering DIAdem drivers.

## Complete Selection of Packet Functions



If you open the **Signal Processing (Packet Processing)** function group and click **Complete Selection**, you get packet functions that are not contained in the function groups. Use the **Scaling** packet block to convert data packets into a different physical unit using a linear characteristic curve. You specify two points each for the characteristic curve of the measured values and for the characteristic curve of the time values.

Use the **Level Calculation** packet block to calculate characteristic values for describing surrounding noise, from a time-related acoustic signal. Use a bit switch at the control input to control the level calculation.

You use the **Protocol list** to create and to print a list of the first value of each data packet in the protocol window. The **Copy** block outputs the data packets of an input signal on several packet buses simultaneously. The **Buffer** block collects data to output large data packets. The **Timer** block outputs control signals time-related, and the **Trigger Finder** also monitors a data channel in multi-channel data packets, to output a control signal.

# Monitoring Processes with the Alarm System



You use the alarm system to monitor whether signals overshoot or undershoot limits. You can define limits in two stages, to trigger alarms with increasing priorities of importance. DIAdem displays the alarms continuously on the screen. You can comment on and record alarms online as they occur. The alarm log can function as an operation report that DIAdem sends straight to those in charge so they are informed about alarms that occur.

The following figure shows how the alarm generator monitors measured values from connected packet buses. According to the alarm definition, the alarm generator displays alarms in the alarm table when limits are exceeded. To record the alarms in a file or to send them in an e-mail, DIAdem converts the alarm information into text. With each alarm, the alarm generator also outputs numeric data packets with the status of the alarms.

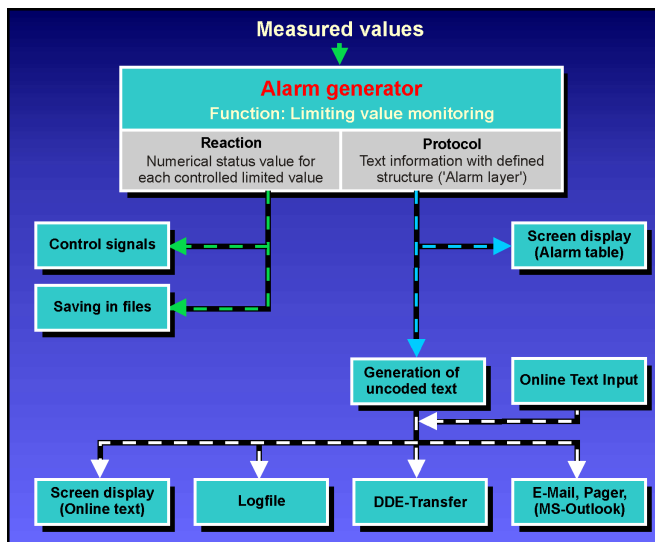


Figure 6-1. Alarm System Structure



The alarm blocks are packet blocks and work data-controlled. For example, the alarm generator does not work until a data packet arrives at the input, and the subsequent alarm table does not work until an alarm packet arrives from the alarm generator. The alarm generator monitors the green and black striped packet buses and outputs alarms on the blue and black striped alarm buses. DIAdem transports text on the gray and black striped text buses.

## Defining Alarms

To monitor packet buses and generate alarms, you need the alarm generator and the alarm table. In the alarm generator you specify the channels to be monitored and you define the limit conditions and the alarms to be output. The alarm table shows the alarms with the color-coded priority and enables you to confirm alarms, which deletes the alarms from the table.



For example, to use the alarm system to monitor signals from the **NI-DAQ** driver input, which is already defined in the block diagram, open the function group **Alarm System** and click the **Alarm Generator** button shown here. Position the alarm block below the packet block **Pack** and connect the green and black striped packet bus to the data input E on the alarm generator block. Double-click the block to open the dialog box where you can define alarms or change default settings.



Then click the **Alarm Table** button in the same function group and position this alarm block to the right of the alarm generator. Connect output A on the alarm generator to input E in the alarm table. DIAdem connects the two alarm blocks with a blue and black striped alarm bus.



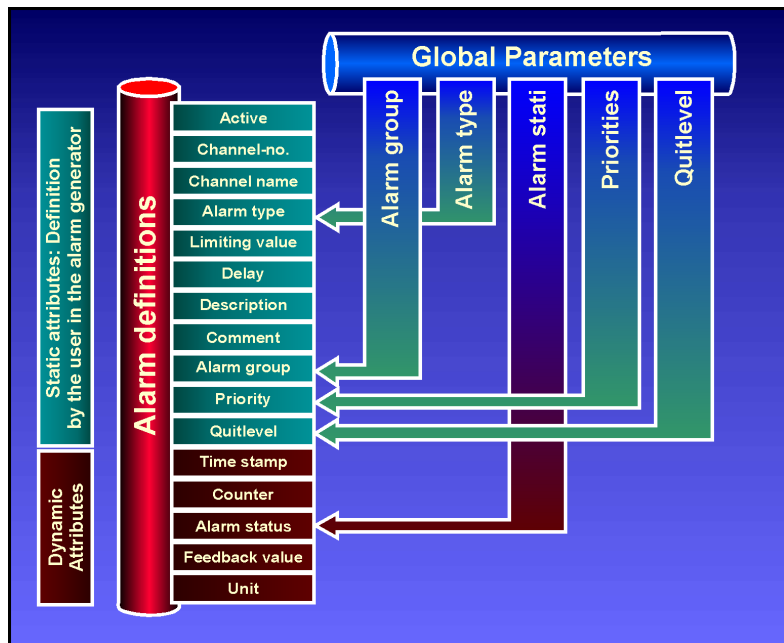
Select DIAdem VISUAL to position the display instrument for the alarm table in the DIAdem VISUAL workspace. Click **Start Display** on the toolbar to display the alarms. As soon as the measured values exceed the limit specified in the alarm generator, the alarm table shows an alarm with a time stamp and a description, in each row. As soon as the limit is no longer exceeded, DIAdem deletes the alarm from the alarm table.



**Note** You should match the block size of the data packets you want to monitor, with the acquisition rate. If the block is substantially larger than the acquisition rate in Hertz, the alarm generator waits a long time for the data packet that is to be monitored. If, on the other hand, the block is much smaller than the acquisition rate, the alarm generator has to monitor many small data packets.

## Specifying Alarm Attributes

In the alarm generator you define single alarms by specifying the attributes shown in the following figure. DIAdem distinguishes between static attributes and dynamic attributes. You specify static attributes when you configure the alarm system and DIAdem determines the dynamic attributes during runtime. Static attributes are, for example, the name and number of the channel that is to be monitored, or the limit, the delay, or the comment. Dynamic attributes are the time stamp, the current measured value, or the alarm status. DIAdem manages the five attributes alarm group, alarm type, priority, quit level, and alarm status for all blocks, so that alarms can be filtered with these global parameters, and colors and graphics can be assigned to the alarms for visualization.



**Figure 6-2.** Static and Dynamic Attributes Describe Alarms

When a limit is overshot, DIAdem groups the related attributes into a formatted data packet, which is the alarm. DIAdem transports this data packet via alarm buses to the alarm table and to the alarm/text convertor.

During a measurement, you can confirm alarms that occur in the alarm table, for example, if it was a false alarm or if the cause of the alarm is rectified during the measurement. DIAdem then changes the associated alarm status. For this purpose, you connect output A on the alarm table in

the block diagram to input T on the alarm generator. You must also open the Display dialog box of the alarm table and select the checkbox **Display button for alarm confirmation**.

## Creating Protocols

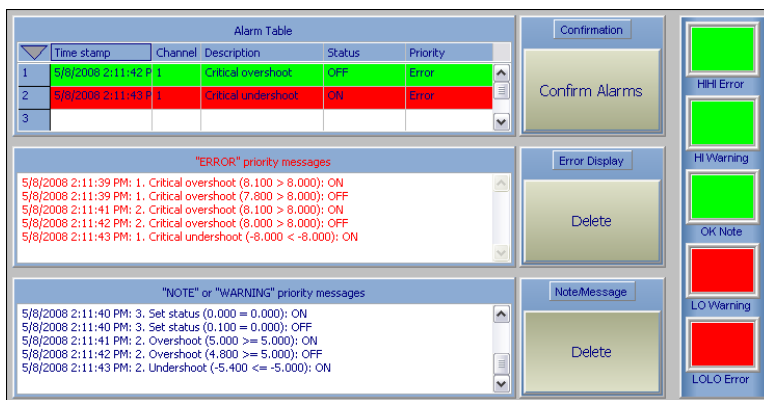


To record the alarms in a file or to send them in an e-mail, DIAdem must convert the alarms into text. To do this, use the alarm block **Alarm→Text** and connect this block to the alarm bus. In the dialog box of the alarm/text convertor, select the alarm attributes that you want DIAdem to forward to the subsequent protocol blocks on the text bus. DIAdem creates a format string that consists of the appropriate variables, which are indicated by the @ characters, and text.

The following format string records for each alarm the time stamp, the alarm counter, the name, the measured value that caused the alarm, the alarm type, the limit, and the current alarm status.

```
@PKALTIMESTAMP@ @PKALCOUNTER@ @PKALNAME@
(@PKALVALUE@ @PKALTYPE@: @PKALREFVALUE@)—@PKALSTATE@
```

You can record alarms in three ways. To display the text for each alarm immediately on the screen, use the **Dynamic Text Display** shown in the following figure. To save the text for reuse later, use the **Logfile**. To send an e-mail with the alarm details, use the **Text Output Outlook**.



**Figure 6-3.** Visualization with Alarm Table, Text Display, and Buttons for Confirming Alarms

# Setting Up the User Management

With the alarms system you can confirm limit overshoots in the alarm table. The system administrator provides the necessary rights in user accounts in the user management system, so that only authorized users can confirm alarms. DIAdem saves the user accounts in an encrypted file with the filename extension `.adm` and saves the access rights with the block diagram. Each time a measurement starts, DIAdem checks whether the user that is logged on has the rights required to confirm the alarms.

To set up or modify user accounts or user rights, select **Settings»Alarm System»User Management**. To log on as the administrator, you must first enter the user name `administrator` and the password `diadem`. You can enter the text in uppercase or lowercase because DIAdem is not case-sensitive here.

To change the standard password, click **Password**. To open the user management, click **Register**. In the user management you create new user accounts, change access data of user accounts, and grant or revoke rights. Click **Save** to create a new ADM file and click **OK** to save the settings in the current ADM file and close the user management. Select **Settings»Alarm System»User Log On/Log Off** to log off.

## Alarm System Functions



The function group **Alarm System** includes all the functions you need to define, generate, display, and record alarms and to send alarms as e-mails.



**Note** The NI License Manager only provides the alarm functions if your license contains the alarm system. If not, the buttons in the alarm function groups are dimmed. To use the alarm system you might have to obtain a license for a different DIAdem edition.

Use the **Alarm Generator** to define alarms and to monitor packet signals for limit overshoots. Use the **Alarm Table** to display or to confirm alarms output by the alarm generator. Use the alarm block **Log User On/Off** to allow the users registered in the user management to log on and off during measurements.

The alarm block **Alarm→Text** converts selected alarm attributes into text packets, which the text block **Dynamic Text Display** displays on the screen and the text block **Logfile** saves to a text file. Use the text block **Text Input** to enter comments from the keyboard during measurements, and to

display the comments in a separate window in DIAdem VISUAL. If you display the button for confirming the text input, this text block displays the comment on the text bus.

Use the **Text Multiplexer** to combine the alarm texts from the converter with the comments, and to forward them in alternating order to the subsequent text blocks, on a text bus. Use the **Alarm Multiplexer** to combine alarms from various alarm buses. Alarm blocks can process only data packets from an alarm bus or a text bus.

Use the block **Text Output Outlook** to send text packets as e-mails with Microsoft Outlook. For DIAdem to establish an OLE connection to MS Outlook, you must install MS Outlook and set it up as an active e-mail program. Use the block **Text Output DDE** to transfer text packets via the DDE (Dynamic Data Exchange) interface with fax software, e-mail software, or paging software, or to archive the packets in a database. You enter the DDE server as the recipient of the text packets.

You use the alarm blocks **Alarm Server** and **Alarm Client** to exchange alarm packets, and the text blocks **Text Server** and **Text Client** to exchange text packets between DIAdem installations on one network.

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# The Basics of Process Measuring and Control Technology with DIAdem

For computer-based data acquisition of measured signals you need to be aware of the phenomena involved in a measurement chain, so that you can choose and set the individual components correctly to minimize or avoid errors. This chapter gives you a brief outline of the basics of process measuring and control technology, and describes the measurement modes and sampling rates that are available in DIAdem.

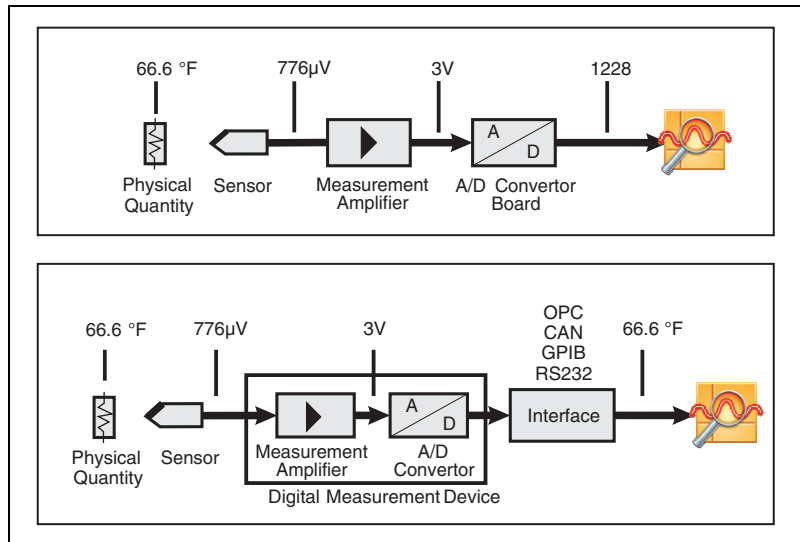
## Computer-Based Signal Acquisition

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The following figure shows the basic processes involved in the acquisition of temperature measurement values with DIAdem DAC, on a computer. The top figure executes the task with a data acquisition board as the measurement hardware which is plugged into the computer, and the bottom figure executes the task with an external measurement device that is connected to the computer with a digital interface such as GPIB or USB.

For measured value acquisition, sensors first convert the physical quantities that are to be measured, into voltage or current. This creates, for example, a temperature-related voltage at a thermocouple. The values are then transferred to a measurement amplifier and converted into numeric values for the computer, using an A/D convertor. The A/D convertor converts the continuous, analog signal into measured values that are time-discrete and amplitude-discrete. DIAdem can reconvert the measured values into the original physical quantities or save the values for later offline analyses.





**Figure 7-1.** Temperature Measurement Using a Plug-In Board or an Interface

## Communication with Measurement Hardware

DIAdem DAC communicates with the measurement hardware via the DIAdem drivers, which are available for many different kinds of measurement hardware. If no driver is available for specific measurement hardware that you require, you can use a DLL-based driver interface to create and implement the driver for DIAdem yourself.

In most cases, DIAdem automatically provides the capabilities of the supported hardware when you select the device driver. Generally, you only have to make the basic settings for the measurement hardware used. To do this, you enter the parameters in dialog boxes.

Refer to Chapter 2, *Installing Measurement Hardware and Communicating via Interfaces*, for more information on how to register measurement hardware in DIAdem or how to access external devices via interfaces.

## Parameters for A/D Conversion

The following is not a detailed description of the Analog/Digital (A/D) conversion properties. However, we have included several key factors that influence the quality of digitized signals.

## The Measurement Mode

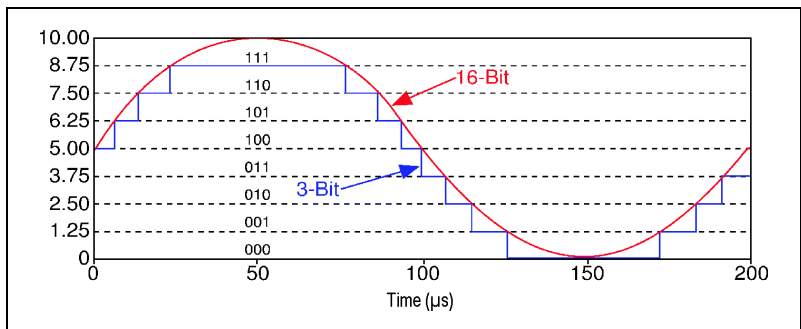
If a measurement system is unilaterally grounded, all inputs are connected to one grounding point (single-ended). Use this system for voltages <1 Volt, for short signal cables (<4 m), and if all the input channels are grounded at the same point.

In all other cases, use a differential measurement system, where each input has its own reference potential. A differential system basically has two important advantages compared to a single-ended system: ground circuits cannot cause measurement errors, and most disturbances that affect both measurement cables of a signal are suppressed. On the other hand, unilaterally grounded systems have twice as many measurement channels.

## The Resolution

An analog signal is digitized into a discrete signal. The amplitude of the signal is represented in discrete steps, which results in a digitization error called the quantization error.

The number of bits the A/D convertor uses determines the number of steps the analog signal is digitized with. The greater the number of steps, the better the resolution of the data acquisition device, and the less the measurable signal change and the quantization error. A 3-bit A/D convertor, for example, divides its input voltage range into  $2^3 = 8$  stages. A binary or digital code between 000 and 111 represents the eight subsections.



**Figure 7-2.** Resolution of a 3-Bit and a 16-Bit A/D Converter

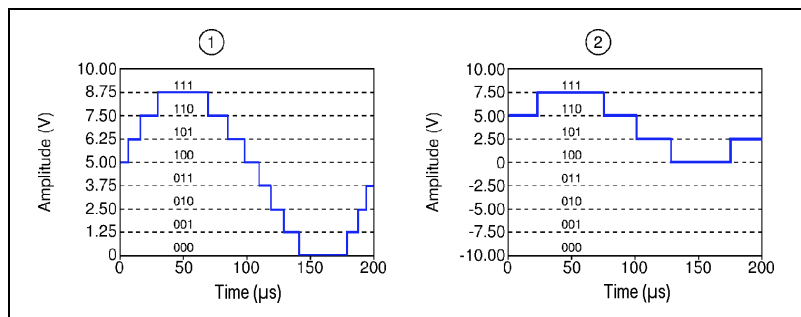
The figure above shows a 5 kHz sine oscillation digitized by a 3-bit A/D convertor. The digital signal does not adequately represent the original signal, because the convertor does not have enough digital subsections. If you increase the resolution to 16 bits, to increase the number of subsections

in the A/D convertor from 8 ( $2^3$ ) to 65,536 ( $2^{16}$ ), you achieve a precise representation of the analog signal.

## The Measurement Range

The measurement range refers to the minimum and the maximum analog signal levels that the A/D convertor can digitize. Many devices have selectable measurement ranges (usually from 0 to 10 Volt or from -10 to 10 Volt), so you can adjust the range of the A/D convertor to the signal range. This makes optimal use of the available resolution for an exact signal measurement.

In the following figure, the 3-bit A/D convertor in the left diagram (1) has 8 digital subsections in the measurement range from 0 to 10 Volt. However, if you select the measurement range -10 to 10 Volt, as shown in diagram (2), the same A/D convertor divides the 20 V measurement range into eight subsections. The lowest measurable voltage increases from 1.25 to 2.5 Volt, which means the right diagram displays the signal much less precisely.



**Figure 7-3.** How the Measurement Range Affects Precision:  
(1) 0 to 10 Volt, (2) -10 to 10 Volt

## The Amplification

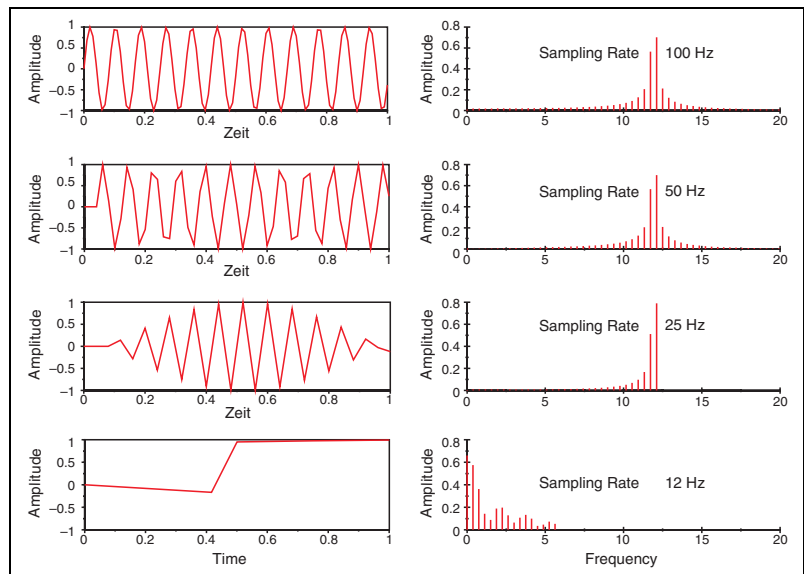
The amplification factor includes all amplifications and attenuations that affect a signal before the signal is digitized. If you adjust the amplification factor to the signal level, you make the best use of the resolution of an A/D convertor. Therefore, it is just as important to set the correct amplification as it is to set the right measurement range.

## The Sampling Rate

We have shown that digital signals have discrete steps to display the amplitudes, and we have described how to minimize the resulting quantization errors. However, we have not taken into account the fact that after A/D conversion, the signal is no longer continuous along the time axis. This is due to the fact that the signal is sampled only at specific times, and the samples are stored as numbers. Random sampling never gives an exact representation of the data.

The more frequent the samples, the more precisely you can reconstruct the original analog signal as a series of digital numeric values. However, this greatly increases the required sampling rate, especially for high-frequency signals, which in turn results in increasingly large amounts of data per unit of time.

This correlation results in the following requirement: you need a sampling rate that meets the requirements with as few samples as possible.



**Figure 7-4.** How a Low Sampling Rate Affects Data Acquisition

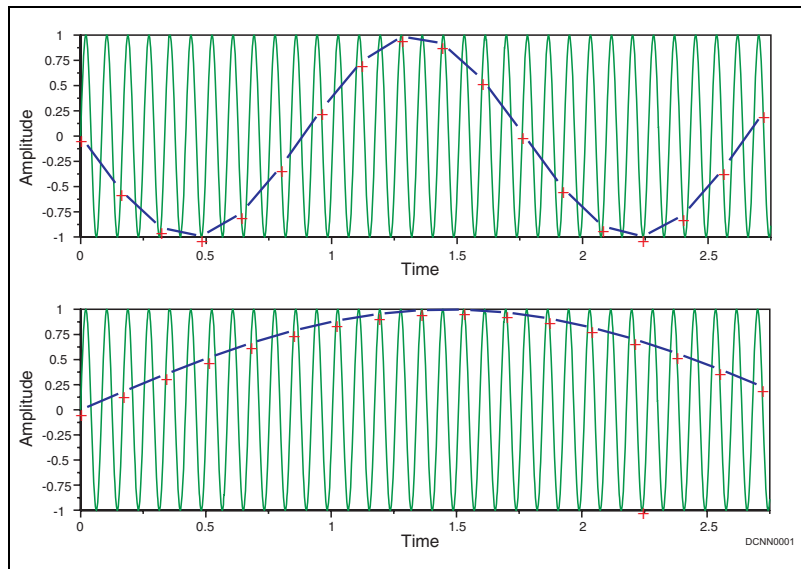
According to the Nyquist theory, the sampling rate should be at least twice as high as the highest frequency in the signal. The digitized signal then contains enough information to resolve the frequencies of the acquired signal after a transformation to the frequency domain (FFT), for example. However, as shown in the figure above, this does not in any way provide an

exact reconstruction of the signal profile. Neither the exact signal form nor the amplitude heights can be reconstructed for all points in time.

As this figure shows, a multiple of the Nyquist frequency is necessary if you want to display the correct shape of the signal as well as the frequency.

## Anti-Aliasing Filter

If the sampling rate is lower than the sampling rate determined according to the Nyquist theory, an effect called Aliasing occurs. This effect causes digitized signal forms or signal frequency parts that are essentially different from the actual analog signal (alias frequencies). This undersampling creates data with frequency contents that are substantially lower than the original signal, as shown in two examples in the following figure:



**Figure 7-5.** Aliasing Effects Caused by Undersampling a Signal

You cannot distinguish between these apparent signal sections of the digitized signal and the real signal frequencies. Therefore, you cannot correct errors caused by aliasing.

If you cannot attain the sampling frequency that is required to measure a signal, or if the highest frequency in the signal is unknown, you must filter the analog signal with lowpass filters (anti-aliasing filters) before the A/D conversion. Alternatively, you can increase the sampling frequency by using other measurement hardware or a different type of measurement.

According to the Nyquist criterion, an appropriate lowpass filter must only let through signals that have frequencies lower than half the sampling rate for the A/D conversion. In this case, filters that have very steep slopes are most suitable.



**Note** Do not confuse anti-aliasing filters with a digital filter on the digital side after the A/D conversion.

## Filtering and Averaging

Unwanted noise distorts the analog signal before the signal is converted into a digital signal. You can limit external influences by using suitable signal conditioning such as filtering and amplification before digitization. Another way to reduce noise distortion is to oversample the signal, which means using a higher sampling rate for the data acquisition and then averaging the digitized values.

## Computer-Based Signal Output

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With the right hardware, DIAdem can output acquired data, generated data, and calculated data, as voltage or current. You can use analog or digital outputs to control processes with DIAdem, or to create closed loops with control blocks.

The following figure shows signal output for temperature control. DIAdem converts the actuating variable, which is determined from the comparison between the room temperature and the set point, into the manipulated variable for the heating valve. DIAdem transfers a numeric value to the D/A convertor, on a plug-in board for example, which outputs the proportional voltage. A power stage transfers the voltage to the heating valve. Assuming the set temperature is 20 °C, the heating valve opens wider and releases more hot water into the heating system.

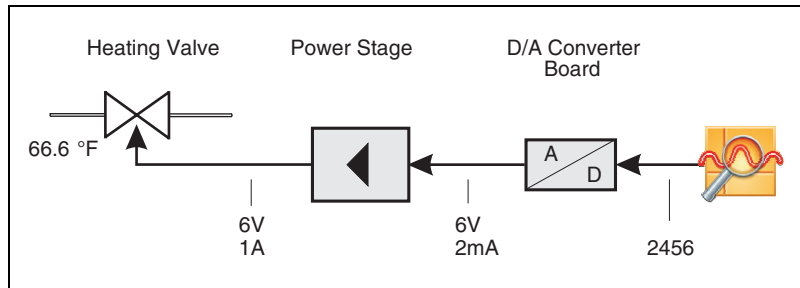


Figure 7-6. Temperature Control with a Plug-In Board

## The Various DIAdem Measurement Modes

You select the sampling rate and the measurement mode in the System Clock block. DIAdem distinguishes between the Software clock and the Hardware clock. DIAdem and Windows generate the rate for the Software clock and the measurement hardware generates the rate for the Hardware clock. DIAdem supports the measurement modes HighSpeed measurement, DMA measurement, and Disk measurement, for earlier measurement hardware. DIAdem offers the Hardware clock to execute these tasks on modern measurement hardware.

The standard DIAdem clock is the Software clock, which fully supports the entire range of DIAdem functions. In the **Software clock** measurement mode, the DAC kernel controls the complete measurement procedure. You can use the Software clock in Windows timing or in Soft timing, which you set by selecting **Settings»Single Point Processing»Measurement Parameters»Timer** in DIAdem DAC.

In the **Hardware clock**, the measurement hardware generates the clock and the DAC kernel controls the measurement procedure. This measurement mode supports the entire range of DIAdem functions with a few limitations, which include not being able to output signals in the Hardware clock.



**Note** When DIAdem measures with several system clocks, DIAdem uses the lowest common multiple of the single sampling rates as the total sampling rate. If the total sampling rate is too high, DIAdem tries to adjust the single sampling rates. If the DAC kernel cannot find a solution for the computer and the measurement hardware used, DIAdem aborts the measurement preparations.

## Software Clock with Windows Timing

If you set Software clock with Windows timing, DIAdem uses the computer Multimedia timer for the clock rate. This mode processes analog and digital values synchronously. In this mode you can run measurements with many types of hardware and different devices simultaneously. This setting allows channel sampling rates of up to 1 Kilohertz and latency times of a few milliseconds.

You can use Windows timing to execute measurements with different sampling rates simultaneously on one measurement hardware. DIAdem requests the measurement values from the hardware at a clock rate that Windows generates. DIAdem processes the measured values, displays the results, and outputs signals. Other programs or the internal Windows management might require the operating system and prevent an accurate clock rate. The inaccuracy can be in the millisecond range. You can avoid such delays by running as few processes as possible on the computer.

For most process measurement and control tasks, Windows timing is completely adequate for clock rate generation, which is why most hardware drivers support only this type of timing. However, for time-critical processes that require more precise reaction times, you must use Software clock with Soft timing.

## Software Clock with Soft Timing

In Software clock with Soft timing, the DIAdem DAC kernel uses real hardware interrupts to control the clock rate. Measurements in Soft timing in interrupt mode maintain the clock rate much more accurately than measurements in Windows timing. Measurement with Soft timing supports all the DIAdem functions that are also available in Windows timing. Ask your hardware manufacturer whether your measurement hardware driver supports this type of timing.



**Note** On Windows Vista, only Windows timing is available in the Software clock. If you cannot avoid using Windows Vista and the performance in Windows timing is not good enough, use the Hardware clock.



With Soft timing in interrupt mode, an extremely accurate internal PC timer generates signals, which immediately interrupt all Windows functions to run DIAdem measurements and to maintain the clock rate as accurately as possible. During this interruption DIAdem runs only operations that are time-critical, to avoid delaying Windows functions for too long. That is why drivers do not use this timing for hardware access via interfaces that have long reaction times, for example, via the serial interface. Screen display or measured data storage are not time-critical processes and are executed outside an interruption.

## **Interrupts for Measured Data Acquisition**

The computer has interrupt mechanisms for reacting to external events such as keyboard entries. These mechanisms prevent constant keyboard entry requests. If a relevant event occurs, the computer processor receives an interrupt request. The processor then interrupts its current activities and processes the function associated with the event. DIAdem uses this mechanism to acquire data, to execute calculations, and to output set values at the clock times set by the user, and undisturbed by other programs.

However, as the processor first has to save the status of the current program when an interrupt request comes in, there is a delay between the arrival of an interrupt and the interrupt actually being processed. This delay is called *latency time*. For periodic processes, such as data acquisition and open and closed loop control, each sampling step has a different latency time, because the latency time depends on the current status of the processor when the interrupt occurs: for example, a measurement that is executed with 100 Hertz over a period of 1 second, results in 100 different values for the latency time. The difference between the minimum latency time and the maximum latency time is called the *jitter*. The jitter thus indicates the degree of precision of the periodicity of the clock times.

What jitter level is acceptable depends on the particular task at hand. In visualization tasks, tests have shown that delays of up to 100 Milliseconds are not actually perceived as delays. Therefore, it is acceptable for an alarm light to respond with a delay of up to 100 Milliseconds after the time the alarm occurs. On the other hand, the periods between the output times have to be precise in digital closed loop control. The output time is the time when the D/A convertor is accessed to output the manipulated variable. If the controller output is to be made with 1 Kilohertz and the periodicity error of the output time is less than 5%, the maximum valid jitter is 100 Microseconds.

## Hardware Clock

In the Hardware clock measurement mode, timers on the measurement hardware generate the clock rate. Use the Hardware clock to acquire data at high sampling rates. The maximum clock rate depends on the hardware used and almost always reaches the specified maximum sampling rate of the measurement hardware. You can generally only use Hardware clock with analog inputs, because digital inputs usually work with no clock rate on the hardware. Drivers then cannot use digital inputs in Hardware clock.

The Hardware clock achieves very high sampling rates. During the measurement preparations, DIAdem transfers the specified sampling rate and the channel list to the measurement hardware and then starts the measurement. The measured data first goes into the measurement hardware buffer. The data is read from this buffer at regular intervals and forwarded to DIAdem. Data output has first priority, because the device buffer is limited. DIAdem buffers the data again if the data is not processed immediately. This computer buffer can expand to several Megabytes for very fast measurements.

The Hardware clock delivers data that is acquired at a guaranteed high-speed sampling rate. However, processing is always briefly delayed, because the data can never be read from the buffer in real time. In many applications, it is irrelevant whether data is displayed or saved a few milliseconds slower, as long as the end-result and the time reference are correct. However, if immediate reactions are required during the measurement, the delay can lead to unacceptable results.

Because digital signals cannot be recorded in the Hardware clock, the signals must be measured parallel in the Software clock. This can lead to delays, because the timers on the computer and the measurement hardware cannot be synchronized at the start of or during the measurement. Because two timers never start at exactly the same time and never run at exactly the same speed, the times in the time channels are not exactly the same after a measurement. The deviation usually amounts to a few milliseconds.

---

# Executing Measurements Automatically

You use scripts to automate recurring work sequences such as starting a measurement and then evaluating the saved measurement values. You create scripts in the script editor in DIAdem SCRIPT.

Use the panel-specific object commands and variables to access the blocks of a block diagram in a script. The central DAC object is a DAC block or a subblock diagram. Subobjects are signal connections in DAC blocks and subblock diagrams, and labels on display instruments and manual instruments. The object access in DIAdem DAC is not typical for VBS. You must first open the main object and then the subobject, make your changes, and then close the objects in the reverse order.

Use the `SchemeLoad` command to load a block diagram. Use the commands `DACObjOpen` and `DACObjClose` to configure a DAC block. In the `DACObjOpen` command you enter the object name to open this object and to then change the object properties. The following script loads the `Example.dac` block diagram and the `BlPinSigCountSet` command increases the number of terminals at the signal input of the `Bars` DAC block to 21.

```
Call SchemeDel()  
Call SchemeLoad("Example")  
Call DACObjOpen("Bars")  
    Call DACObjOpen("Display data")  
        Call BlPinSigCountSet(21)  
    Call DACObjClose("Display data")  
Call DACObjClose("Bars")
```

To use the object access in the script, double-click the block to open the dialog box, and press <Ctrl-A>. Switch to DIAdem SCRIPT and press <Ctrl-V> to paste the clipboard contents to your script. The script editor displays the commands with the object names and the variable assignments from the dialog box that was open.

To open a DAC object, you need the name of the object. If you select a block of the block diagram on the screen, DIAdem displays the name of the DAC block in the status bar. When you click a block terminal, DIAdem displays the name of the main DAC object and the name of the DAC subobject, separated by a point, in the status bar.

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