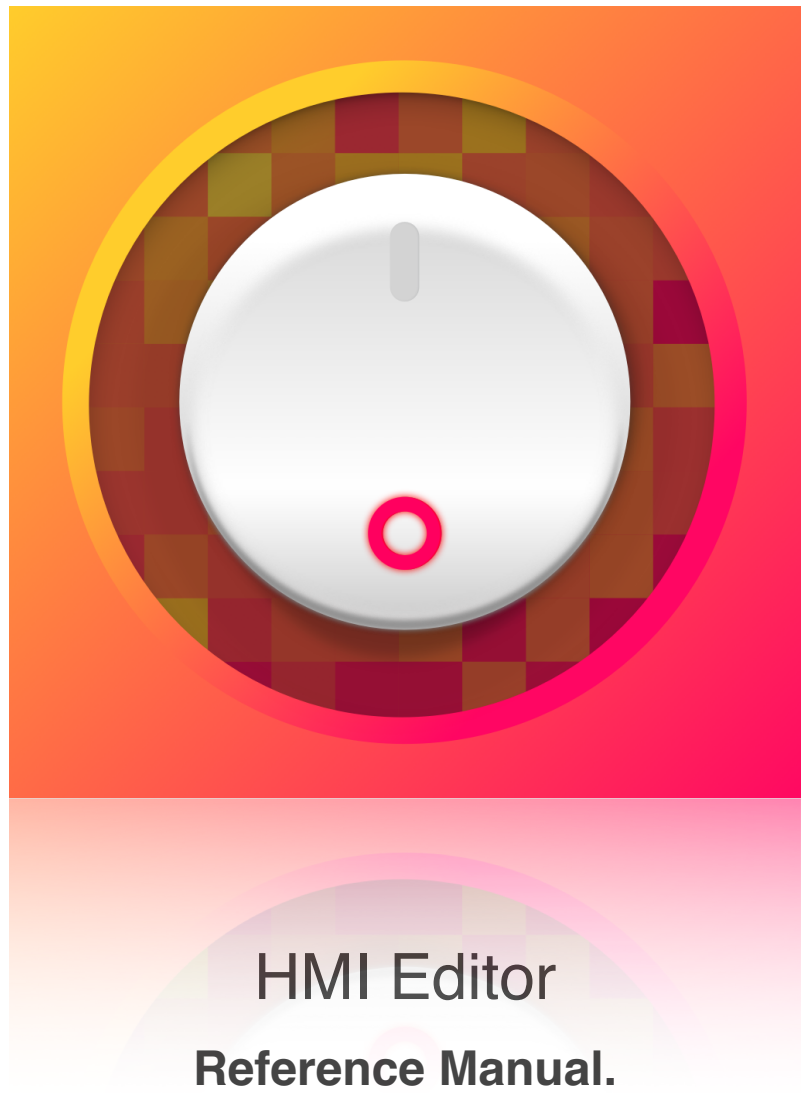
HMI EDITOR

Reference Manual.

Version 1.0



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What is HMI Editor.

The HMI Editor app is the developer component of the HMI Pad system for creating Human Machine Interfaces for real time monitoring of industrial PLC based systems and processes. The other two components are the HMI app and the HMI Pad Service.

Main features.

- ✓ Very fast native app, launches and connects immediately regardless of project size, not a web based app.
- ✓ All data types supported including Boolean, Integer and Floating Point values.
- ✓ Advanced Expressions Engine supporting a number of data types including Strings, Arrays and Dictionaries.
- ✓ Projects can be fully edited on-screen as you run and monitor your process. Or can be exported and edited as a text file.
- ✓ Configurable User Accounts allow for project storage in the cloud and easy deployment to end users.
- ✓ The app connects to PLCs directly using native communication protocols. Connections are performed without any intermediate servers or boxes.
- ✓ TCP/IP based security.

The concept behind the HMI Pad apps.

The HMI Editor and HMI apps are built on top of two main modules: the *Communications Module* and the *Expressions Engine*. These modules interact with each other and to the user interface to provide most of the underlying capabilities and many advanced features.

The **HMI Editor** lets Integrators build fully customizable HMI interfaces by adding visual items or other objects to pages. Objects have properties that can be connected between them or with PLC tags through expressions. Virtually all properties can be linked through expressions. This architecture provides an extremely powerful environment for Integrators to create advanced HMI interfaces.

HMIs can be fully created and deployed from the app by dragging and connecting items together. Integrators can also chose to edit project files on a text editor. The app also fully supports copy/paste/duplicate of items, tags, connections etc, and has unlimited undo/redo capabilities.

The app comes with a free service on the cloud, the **HMI Pad Service**, for convenient storage of projects and associated assets and further deployment to End Users.

The complementary **HMI** app let automation integrators to safely and securely deploy projects to end users devices with no physical access to them. Projects on the HMI app are installed as encrypted, non-editable instances of your projects, thus helping you to safely keep your work and know how.

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1 The HMI Pad System Components

The HMI Pad System is made up of 3 components:

HMI Editor.

This the app Integrators use to create and deploy HMI projects.

HMI Pad Service.

The HMI Pad app is designed to work with a service in the cloud named the HMI Pad Service.

The app seamlessly integrates this service to provide storage options in the cloud and convenient distribution and deployment of your HMI projects to your End Users or customers. The HMI Pad Service uses Apple's CloudKit infrastructure as the physical media to store data in the cloud.

Refer to the "***HMI Pad Deployment Guide***" for more information on what options you have available to work with the HMI Pad Service as you develop HMI projects.

HMI Pad View.

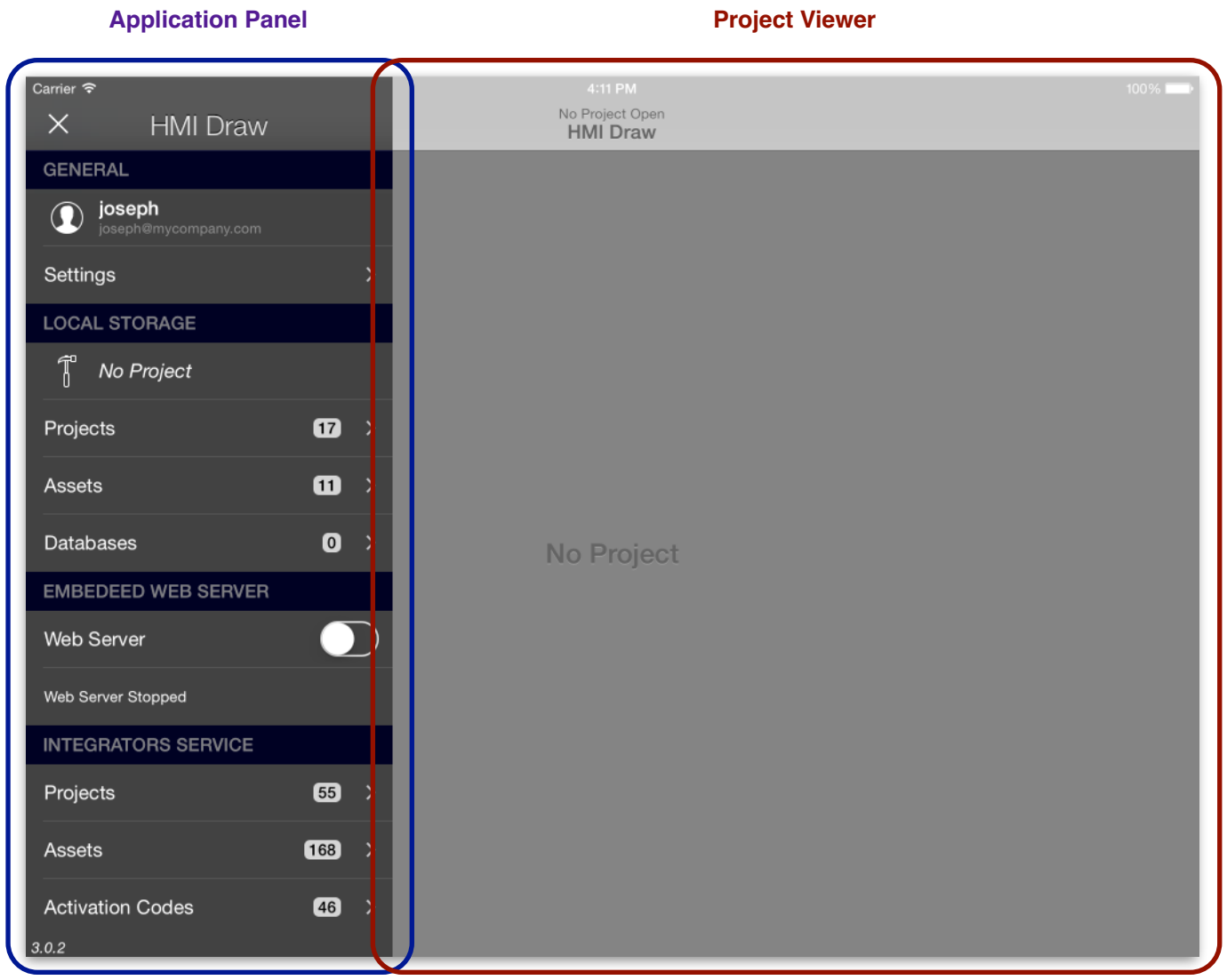
This is the app where end users run HMI projects developed by integrators. Projects on the HMI app are installed through the HMI Pad Service and are stored as encrypted instances that can not be edited or moved to other devices.

2 The HMI Editor app main user Interface

The HMI Editor app interface consists of two main draggable panels, the *Application Panel* and the *Project Viewer.*

The Application Panel is shown on the left and there you will find options and settings related with the app.

The Project Viewer is on the right and lets you edit, review and run your project. The Project Viewer can be made full screen by closing the Application Panel.



2.1 The Application Panel

The Application Panel lets you create and manage the following aspects of the app

- User Accounts and Settings.
- Projects and Assets stored locally.
- Projects and Assets stored on the HMI Pad Service
- Remote Deployment.

2.2 The Project Viewer

The Project Viewer is where you create, configure, edit and run projects. From the Project Viewer you get access to Pages, Connections, Alarms and the internal aspects of your project. You can also set some editing properties and edit objects on screen using common gestures.

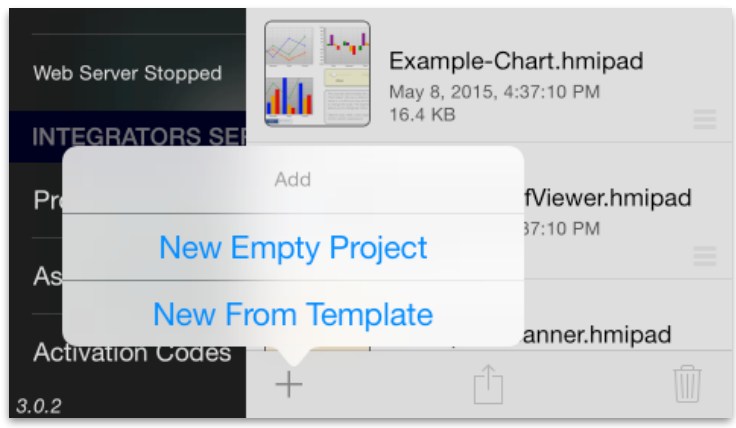
Several sub-panels provide means to navigate through your project to obtain detailed information. You may find the following panels that will appear at appropriate times or upon particular actions as you edit your project:

- **Page Viewer**, shows the current page. The **Page Navigator** appears from the left and displays the list of pages.
- **Inspector Panel**, appears from the right and contains the Connections Panel, the **Tag Viewer** and the **Alarms Viewer**.
- **Model Browser**, appears as a floating window you can drag around the screen.
- **Object Configurator**, appears as a floating window when you tap on 'configure' for an object.
- **Expressions Keyboard**, appears on the bottom of the screen, when editing Object Properties.
- **PLCs and TAGs Configuration Panels**, appear as floating windows, accessible from the Model Browser
- **Model Seeker,** appears as a floating window, accessible from the Object Configurators or the Expressions Keyboard

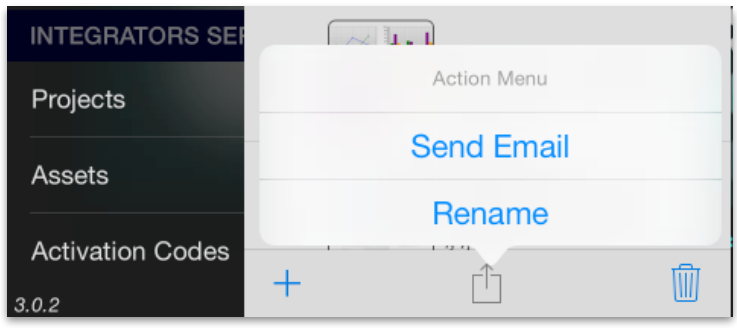
3 Creating and opening Projects

To create a new project go to "Local Storage -> Projects" on the "Application Panel" and tap on "+", then chose "New Empty Project". A new project with a default name will appear on the list. Alternatively, you can tap on "New From Template" and the app will show you a list of already made simple projects you can use to start from.

You can open the project you just created by "sliding" to the right the row in the list containing its name.



It is recommended to rename your projects with suitable names that clearly identifies them to you. To do so set the list to edit mode by tapping on "Edit", then select the project you want to rename, and choose the appropriate option from the "Actions" menu on the bottom of the panel.



4 Editing Projects in the Project Viewer

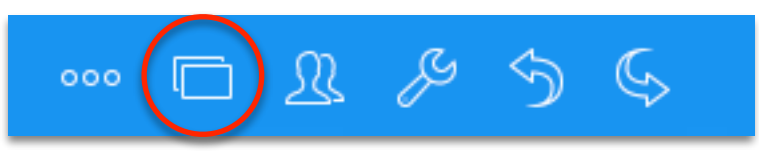
With the HMI Editor app you can fully edit your HMI projects on the "Project Viewer". When the project viewer is fully visible tap on the"Edit" button on the top-right of the panel to start editing your project.

It is not a purpose of this manual to fully describe all and every editing option available, but just to provide a guide on what is at your disposal to complete your editing and where to look at for a specific editing need. For the most part the app interface follows commonly recognized patterns and provide built-in help that should be enough for the common cases.

The Project Viewer features a toolbar on the top with the following options from left to right:

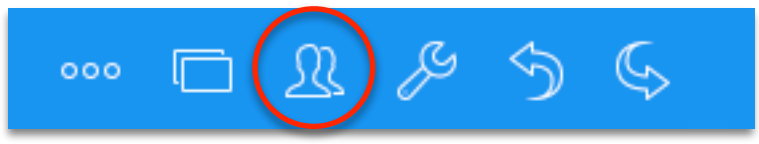
Pages toolbar icon.

The pages tab bar icon toggles the **Page Viewer.** From the Page Viewer you can navigate to a particular page in order to open it. The Page Viewer can also be shown/dismissed with a drag gesture over it or from the left edge of the Project Viewer.



User toolbar icon.

The User toolbar icon presents a project user login screen. For more information on project users look at the $UsersManager and Users sections in this manual.

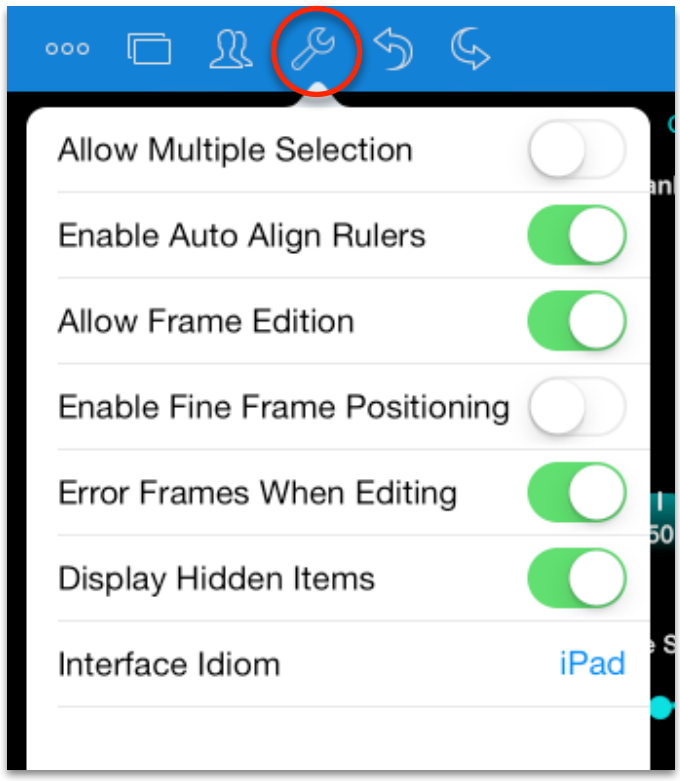


Tools toolbar icon (edit mode only).

Several tools are available for helping on positioning items on pages and editing frames. You will find options to enable or disable auto align rulers, to lock frame editing and to enable multiple selection. You can also enable/disable visual reporting of error conditions while in edit mode or make hidden items visible while in edit mode.

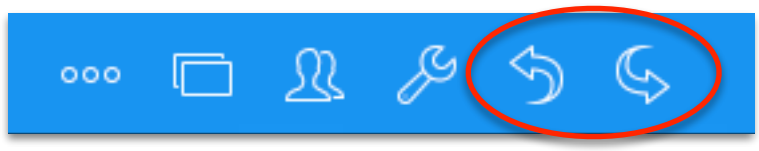
A number of editing tools are available:

- **Allow Multiple Selection.** When enabled, multiple item selection will be active, allowing for multiple selection of items for example for grouping. Default is Off.
- **Enable Auto Align Rulers.** Determines whether auto-alignment rulers and alignment magnets are enabled. Switch it to off to allow free layout of items. Default is On.
- **Allow Frame Editing.** By setting this to off any layout changes of items will be globally disabled. You still will be able to set item properties. You can disable frame editing on particular items by locking them individually. Default is On.
- **Enable Fine Frame Positioning.** Determines whether a joy-stick tool will appear for selected items allowing for fine positioning and resizing of items. When arranging items using this tool, auto-alignment rulers will still display on screen for a second but no alignment magnets will be in effect. Default is Off.
- **Error Frames When Editing.** Determines whether error frames are displayed around objects with undefined values also on edit mode. Disabling this eliminates page clutter while editing in case you do not have a life PLC connection or your object properties contain broken links. Default is On.
- **Display Hidden Items.** Items with their hidden property set to Off are still partially visible on edit mode. However you can override this behavior by setting this to Off. Default is On
- **Interface Idiom.** Represents the Interface Idiom you are working on. Chose *iPad* for building screens for the iPad native resolution or *iPhone* for working on interfaces designed for iPhone or iPod touch.



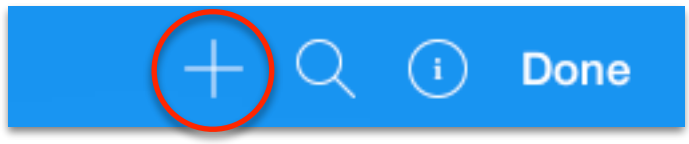
Undo/Redo toolbar icons (edit mode only).

The app has unlimited undo-redo capabilities that are supported on virtually all changes performed on projects.



New Item toolbar icon (edit mode only).

From this toolbar icon you create new pages or new visual items that you can place on pages or use on your HMI projects. Items are arranged in categories such as Controls, Indicators, Images and so on. New items are created with default properties and placed on the center of the page, you can then move them to the desired position and configure their properties. The application also features intelligent copy/paste/duplicate of Objects, Pages, Connectors, Tags , including among different projects.

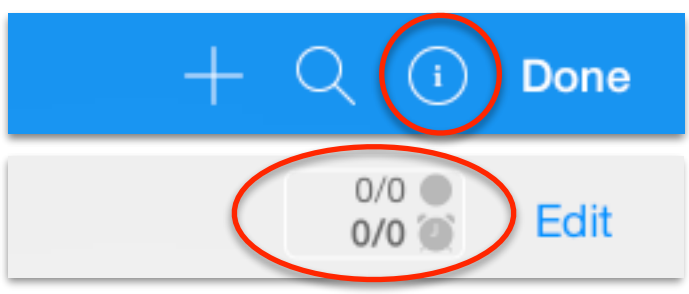


Model Browser toolbar icon (edit mode only).

The model browser icon toggles the **Model Browser**.

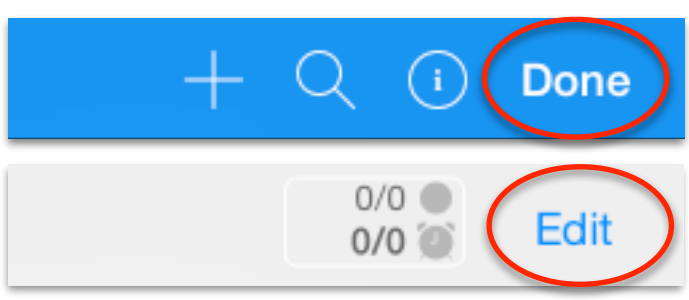
Inspector toolbar icon

The Inspector toolbar icon toggles the **Inspector Panel** The Inspector Panel can also be shown/dismissed with a drag gesture over it or from the right edge of the screen. In view mode the toolbar button is replaced by a clickable area that shows the number of active/number PLC connectors, and the number of active/total alarms



Edit/Done toolbar icon

The Edit/Done toolbar icon toggles the project from Edit to View mode. As a visual effect the entire toolbar becomes blue while in edit mode.



4.1 Editing Projects in a Text Editor

Project Files in HMI Editor are plain text files that can be manually edited on a text editor. Project Files can be exported and imported to HMI Editor through the Mail application. They have a .hmipad extension and HMI Editor recognizes any Mail attachment with this extension as a HMI Editor Project File.

If you open an HMI Project file (extension .hmipad) on a text editor you will be able to identify all the Objects and Properties of your project as they were configured in the application. Indeed, a Project File is a text representation of everything in a project and a direct description of what you see on the Model Browser. This of course includes all Visual Items on Pages, Background Items, Alarms, Connectors and PLC Tags.

For example, a knob control on a page may look like this in the .hmipad file

```
knob_1 = SWKnobItem.new;
knob_1.framePortrait = SM.rect(29, 27, 175, 189);
knob_1.frameLandscape = SM.rect(99, 243, 171, 175);
knob_1.backgroundColor = "ClearColor";
knob_1.hidden = 0;
knob_1.continuousValue = 738.846130371094;
knob_1.enabled = 1;
knob_1.verificationText = "";
knob_1.style = 0;
knob_1.thumbStyle = 0;
knob_1.value = source.max_setpoint;
knob_1.minValue = 0;
knob_1.maxValue = 1000;
knob_1.majorTickInterval = 100;
knob_1.minorTicksPerInterval = 4;
knob_1.format = "%g";
knob_1.label = "";
knob_1.tintColor = "gray";
knob_1.thumbColor = "black";
knob_1.borderColor = "red";
```

a PLC Tag may look like this in the .hmipad file

```
source_tags19 = SWSourceNode.new;
source_tags19.name = "max_setpoint";
source_tags19.tag = SWObject.new(source_tags19_tag);
source_tags19.write_expression = max_setpoint.value,knob_1.value;
source_tags19_tag = SWPlcTag.new;
source_tags19_tag.address = "DM10";
source_tags19_tag.type = "REAL";
source_tags19_tag.scale_rmin = 0;
source_tags19_tag.scale_rmax = 0;
source_tags19_tag.scale_emin = 0;
source_tags19_tag.scale_emax = 0;
```

The ability to manually editing your projects using a Text Editor is an advanced feature that you can use to create and store project templates, quickly add/replace tags in bulk, find objects and properties for debugging purposes, configure pages or groups of objects with repetitive patterns, and more.

IMPORTANT NOTE: This is a very advanced feature that brings a lot of power, but it also carries the risk of accidentally breaking Project functionality or introducing syntax errors on Project Files that would prevent them from being opened by HMI Editor.

HMI Editor will attempt to report syntax or other errors on imported files in an accurate way but still you may fail at attempting to fix a particular issue after incorrect manual editing of a file. Therefore, it is strongly recommended to always keep a working copy of your projects in safe place, so you can recover from them in case something goes really wrong.

5 Objects, Properties and the Project Object Model

As you build your HMI project you create Pages, Visual Items, PLC connections, PLC Tags, Alarms and so on. Everything you place on pages and the remaining objects you use to build a project are stored in the Object Model. The Object Model also contains object configurations and all the expressions you used to link objects.

The HMIDraw app is entirely based on **Objects**, everything is achieved through connecting objects, and every aspects of your HMI project development is based on managing objects of different kinds.

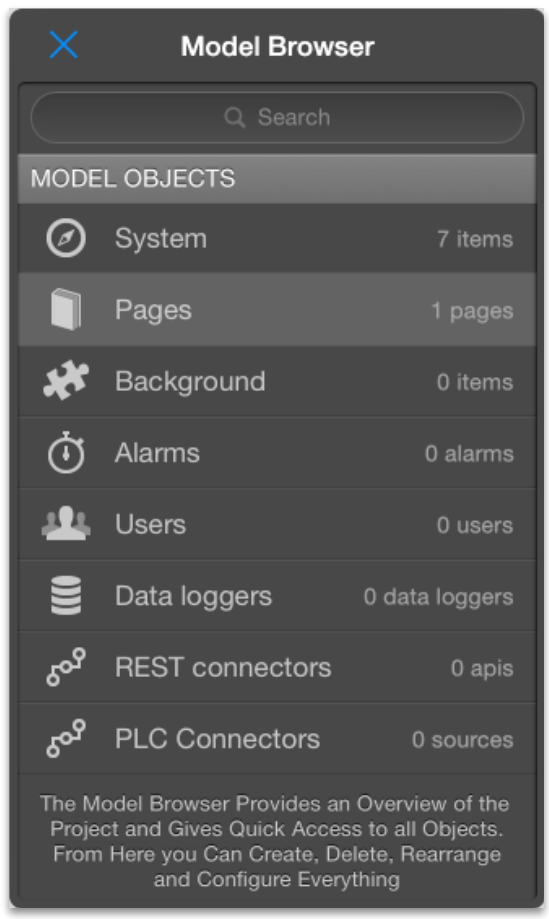
In HMI Editor there is not a separate concept for generating displays and constructing control logic. There are not either separate procedures for each kind of task. Instead, you concentrate all your development on one single easy concept. It is very likely that you already understand the concept because it is not new to you. You already know how to link cells on an Excel spreadsheet using formulas to produce results that depend on other cell values, so this is it.

Objects in the HMI Editor app have **Properties**. Going back to the spreadsheet analogy, object properties are the equivalent to spreadsheet cells.

To create an HMI project with HMI Editor you simply create objects and link their properties together using expressions, just as you would do to link cells on a spreadsheet program. This concept extends to the whole app and includes the way objects are linked to PLC tags. Effectively, tags are just properties of a special kind of object called Connector.

The Object Model is internally architected as a tree-like graph of objects connected through expressions. When something changes at some point of the model, for example due to an user action or a PLC tag change, a change event is propagated only to the affected object properties. The application is even-driven to its core, which means that this also applies to display updating, alarming and control logic, and it makes the app very efficient.

The Object Model is fully visible and accessible through the **Model Browser**.



5.1 The Model Browser and Main Object Types

From the Model Browser you access the Object Model of your project. This is equivalent to say that all the objects of your projects are accessible from the Model Browser.

Furthermore, the Model Browser presents a hierarchical view of your project. In the section named 'Objects Reference' a description of each object type and its properties is provided in more detail.

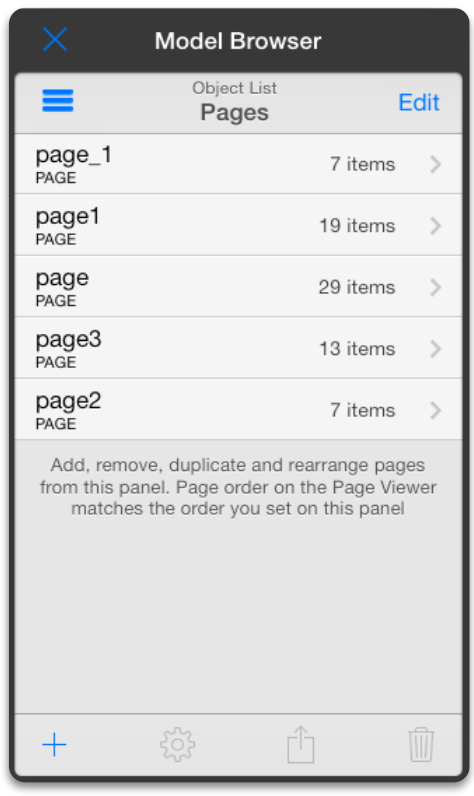
The available main object types are listed next:

System Objects.

Represent objects that provide real time iPad sensor information or access to project related properties.

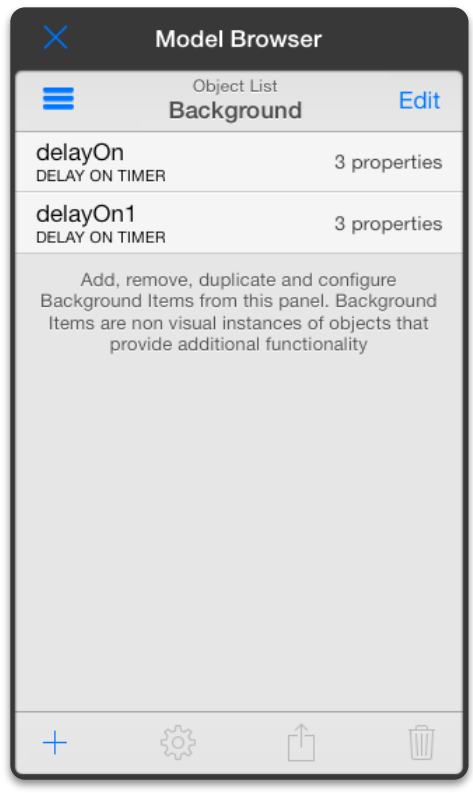
Pages.

The pages that your project contains. In pages you place visual items that can be of a variety of types.



Background.

They are objects that do not have a visual component but you can use on your project.



Alarms.

You set alarm or any arbitrary event conditions that will be displayed on the Inspector Panel when triggered.

Users.

You can create users on a project basis.

Data Loggers.

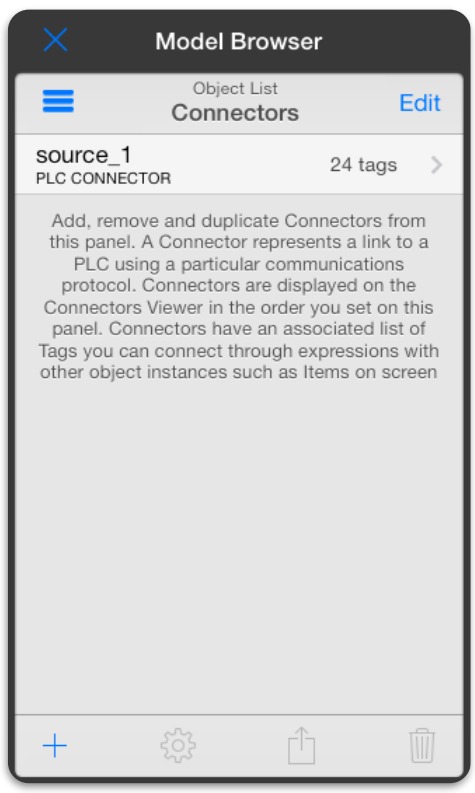
Data Loggers allow you to log historical values on database files.

REST Connectors.

REST Connectors represent connections to web services that may adopt the REST architecture.

PLC Connectors.

PLC Connectors represent connections to PLCs. A connector includes PLC communication settings and PLC tags.



5.2 Object Properties

Objects in the HMI Editor app have **Properties.**

Particular properties may represent object states or visual conditions.

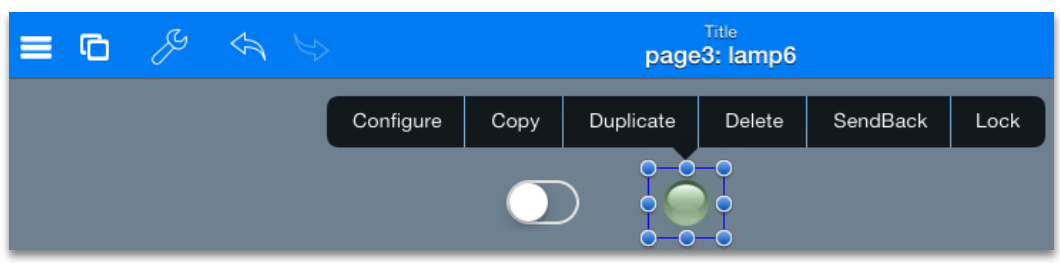
Properties are identified in expressions by object name followed by a dot and the property name.

objectName.property

You connect object properties together to add dynamic functionality to your HMI projects. Properties are connected through expressions.

Example:

Let's suppose we have on a page a *switch* control and a *lamp* indicator which are named as such. We want to turn the lamp on/off with the switch control. To do so we need to enter the switch value on the value property of the lamp.



By entering the *switch.value* into the *value* property of the *lamp* we achieve the desired effect because when the *switch* changes a change event will propagate a change to the *value* property of the *lamp*

> *Notice that we entered this in the value property of the lamp, not the switch. This may seem odd before you are used to it or if you come from traditional HMI systems, but you just need to think on terms of a spreadsheet to see why this works. On a spreadsheet let's assume you want cell 'A1' to follow the value of cell 'A0'. You would enter '=A0' in cell 'A1'. This is exactly how the HMI Editor app works, we enter 'switch.value' in 'lamp.value' because we want the lamp to follow the switch.*

Object Properties are accessible through the **Object Configurator** which is available from the "Configure" menu item upon selecting an object on screen or by tapping the "gear" icon for an object on the Model Browser.

5.2.1 Property Kinds

Object Properties can be *read/write* but some of them are *read only*,(particularly on system items) or *constants.* You identify the kind of properties by how they are presented or what is allowed for them on the *Object Configurator.*

Read Only.

Read only properties are mostly used on system objects. They usually provide real time information that can not be set by users or in general any data value that can not be edited.

An example of a Read Only property is '$System pulse1s'

Read / Write.

Most properties on regular objects are Read/Write. On the Object Configurator they provide a field where you can enter an expression. In particular, Read/Write properties are identified because they present an entry field with light yellow background.

An example of a Read/Write property is '$Project currentPageIdentifier'

Constants.

Constant properties are similar to Read/Write properties except that any expression or value entered on them can not be changed at runtime. Constant properties are identified by the presence of an entry field with white background.

An example of a Read/Write property is '$Project title'

5.2.1 Property Data Types

Object Properties can be of a variety of data types, such as *Integer*, *Double*, *String* and so on.

It is important not to confuse Property Data Types with Expression Result Types as they may not always be related. Particularly, Property Data Type represents the type that semantically best describes the Property, while Expression Result Types do carry a semantically agnostic meaning.

For example, a string representing a color name can be assigned to a Property of type *Color*, but it will still remain a String and will be simply treated as such by the Expressions Engine.

The concept of Property Data Types abstracts expression result types from their intended actions on properties, thus adding a flexibility layer on the use of data types in expressions. For example a Color can be physically represented by a String or by a Number in expressions, and yet be assigned to the same property of type *Color*.

Property Data Types are shown just below Property Names on the Object Configurator. Some of the most used are *Integer*, *Bool*, *Color*, *Double*, *Range*, *Url*, *FontName*, *FormatString*, *Orientation*, *TextAlignment*, and more.

Property Data Types are enumerated and explained in more detail for particular objects on the Object Reference section when relevant.

6 Expressions

Expressions can be entered on read/write properties and provide an advanced way to customize various aspects of the interface and behavior of HMI Pad projects.

You can combine Object Properties with *operators* and *methods* to produce custom results and assign them to other Properties. Object Properties are referred in expressions by using a dot notation as described in the Object Properties section

Event Driven Architecture.

Expressions in HMI Pad System are stored in a compiled form and are executed by an event-driven engine. The execution engine keeps expression reference information in a way that value changes trigger expression evaluation. The engine is not endlessly executing 'for' loops but only *change events*.

References to dependent expressions create a tree like network where all expressions may have links to other expressions. When a PLC tag changes, or an user interacts on a control, a *change event* is originated. This event, that occurs at some point in the expressions network, is propagated through the relevant links to reach only the expressions that need to know about it, generally only a few.

The result is that expressions execution time is basically independent of project sizes or the total number of expressions defined in projects. The Event Driven Architecture is specially suitable for running HMI projects in the constrained environment of a mobile device and still be able to support very big projects with no noticeable performance penalties.

Another responsibility of the Expressions Engine is to determine the minimum set of data that is required at a given time to keep a consistent interface. This is translated to the minimum set of tags to poll and is notified to the Communications Module so no tags are polled unnecessary at any given time. The Communications Engine then automatically groups and optimizes command requests to PLCs for minimum communication overhead. All these processes, including communications, happen on a secondary execution thread so users never feel or notice them.

The ultimate result is highly responsible HMI projects with controls that respond and react quickly to user actions and fast updates of interface elements.

Analogy with an Excel Spreadsheet

To help to understand the whole concept of the app it may be helpful to think on it as a Excel spreadsheet and compare what Excel and HMI Editor do. Indeed the behavior of the expressions engine on Excel and HMI Editor are very similar in concept.

In the case of Excel you have Cells where you enter formulas. Excel Cells connect to other cells through expressions. For example, in cell *A2* you can write *=B1+B4*. In the context of Excel, when the value of *B1* or *B2* changes the value of *A2* is automatically updated.

So this is exactly what HMiPad does. Instead of Cells we have Objects with Properties. On the HMI Editor app an Object Property is the equivalent of an Excel Cell. You connect Object Properties as you would Excel Cells. On Excel you refer to Cells by Column-Row (example *B1*) On HMI Editor you refer to Object Properties by their names using a dot notation (example *numberField.value*).

Unless Excel Cells HMI Editor Object Properties have a meaning and perform a particular action, thus when you make them to change there is an effect, possibly a visual one such as changing a Color.

Basically, understanding the concept unlocks the full power of the app. Expressions can be very simple or extremely complex, and as we evolve the app more Objects with more Properties will be added.

Using Expressions.

HMI Editor expression syntax is based on the open source Ruby scripting language syntax. For basic operations this syntax is similar to that of the ‘C’ programming language and virtually identical to all modern scripting languages.

The Ruby language was chosen because it features a clean, easy to learn, object-oriented syntax with a particular focus on expressions allowing for practical ways to represent and dealt with several data types and formats with great flexibility. HMI Editor supports most operators including all common Logical, Arithmetic and Comparison operators, as well as commonly used Ruby functions and methods.

Support of Ruby expressions in HMI Editor is a subset of the Ruby language. Expressions are not, and do not pretend to be a complete implementation of Ruby. In some cases we provided a single way to accomplish something that on Ruby can be done in several ways, and in other cases we integrated several functionalities in single methods instead of implementing all of them. So it is important to refer to this manual if you are also using a Ruby tutorial to determine what it is actually supported on HMI Editor and which behavior differences may apply.

For those who already used Ruby, one of the most obvious differences between 'real' Ruby and HMI Editor is the treatment of boolean values. Ruby treats everything as object pointers, including numbers, while HMI Editor keeps the traditional 'C' like behavior. For example, in Ruby any number used in a boolean expression is a *true* value even if it holds a zero, just because it exists as a pointer. HMI Editor, on the other hand, will still take 0 (zero) as *false* and non-zero as *true*, in the traditional sense of earlier programming languages, and hopefully in accordance to what PLC programmers would expect or feel more comfortable with.

You should always use values expressed in engineering units when using expressions in HMI Editor. The HMI Pad expressions engine does not have a notion of PLC raw values, as this is handled by the communications component of the app.

When using expressions in your project you must be aware of the following:

* **Object and Property names in expressions are case sensitive**. This means that an object property named `textField.value` will not be the same than another one named `textfield.value`.
* **Logical or Comparison operators assume non-zero values to be *true* and zero values to be *false***. The result of a Logical or Comparison operator, however, is always a value of 0 or 1.
* **Comparison operators are non-associative**. This means that expressions such as `a<b<c` are not valid. You must use `a<b && b<c` instead.
* **Assignments in expressions are not supported**. Therefore expressions such as `condition && (intProperty = 3 )` will cause a syntax error on the assignment operator. Do not confuse the *assignment* operator = with the the *equality* operator == which *is* fully supported.
* **An expression is executed only when at least one of the referred object properties *change***. The process is totally transparent and integrators might not need to know about how it works underneath. However, keeping the event driven nature of HMI Pad in mind can help integrators to understand why and when dependent object properties including PLC tags will be written or alarms will trigger as a consequence of an user interaction or a PLC Tag change that originated a cascade of change events.
* **Expressions containing Logical operators are no exception to the event driven design**. They will be fully executed even if a change occurs on the right side of the Logical operator. For example the expression `condition1 && condition2` would be always *false* if `condition1` is *false*, however it will execute anyway as a consequence of a change on `condition2`. Although the expression result will not change (it will remain *false*), the engine will still send a *change event* to any depending expressions, which could potentially cause other effects such as a PLC tag rewrite if the expression was linked to a PLC tag.
* **Expressions can not create circular or recursive references**. This means that a result of an expression can not be refitted to another expression that ultimately would send a *change event* to the originating expression. This is not allowed at any level on the expressions execution chain. For example the following expression `textField.value+1` on the `value` property of an object named `textField` is not valid because `textField.value` creates a circular reference around the `value` property. Note that HMI Editor essentially behaves as a SpreadSheet program and this restriction also applies on SpreadSheet programs..

6.1 Data Types in Expressions

Expressions in HMI Editor support the following primitive data types: **Number**, **String**, **Array, Dictionary**, **AbsoluteTime**, and **Range**. other native types include **Point**, **Size**, and **Rect**,

Appropriate *operators* and *methods* allow for conversion among types and to perform custom operations with great flexibility. See the following sections for a discussion on methods and operators.

Mixing different data types such as Numbers, Strings or Arrays is only possible through the use of the appropriate *operators* and *methods* that result in compatible types. A direct consequence is, for instance, that you can not concatenate a number to a string unless you convert the number to a string first. Also, some operators have particular semantics depending on type. This is just like most modern scripting languages including Ruby. On the following sections we discuss further on this and on other subjects.

Numeric values.

Numeric values in expressions are internally stored as Double Float values (64 bits) All Arithmetic, Logical and Comparison operations are performed as Double Float operations. You may never expect to obtain truncated values from arithmetic calculations.

The above statement may change in the future to give support for true integer arithmetic. Currently, an implicit conversion to an integer type is only performed for bit or bitwise operations on numbers, and indexed access to string or array elements. In other cases you can use the to_i method to explicitly get the integral part of a numeric value according to your needs.

Constant numbers can be represented with optional decimal point and a base 10 exponent. Additionally, hexadecimal and binary notations are supported by using the *0x* or *0b* prefixes. The special forms *true*, *false +inf* and *-inf* are supported as well.

Examples:

-1.42 (decimal representation)
1.1666e+2 (decimal representation with exponent)
0xe0af (hexadecimal representation)
0b011011101 (binary representation)
true (same as 1)
false (same as 0)
-inf (very big negative number)
+inf (very big positive number)

Strings.

Strings are arbitrary sequences of characters that are manipulated as a whole,. Several operations can be performed on strings such as concatenate, split or substring extraction by using the appropriate *operators* or *methods*. String literals are represented enclosed in double quotes. Strings are internally encoded in a compatible type (usually UTF8)

Examples :

"This is a literal string"
"Дискретные датчики"
"ピーエルシーのアラーム表示"

Arrays.

Arrays are-indexed collections of data values. Each element in an array is associated with and referred to by an index.

Array indexing starts at 0. A negative index is assumed relative to the end of the array, that is, an index of -1 indicates the last element of the array, -2 is the next to last element in the array, and so on.

Arrays can hold values of any data type such as Numbers, Strings, Dictionaries, Arrays and so on. Arrays can be created in expressions by using its implicit form consisting on separating their elements by commas and enclosing them in square brackets.

Example:

["element at index 0", 123.4, [33, obj.value]]

The above expression represents an array of three elements.

At index 0 we have a literal string: "element at index 0".

At index 1 we have a numeric value: 123,4.
At index 2 we have an array of 2 elements with the number 33 and the variable ‘temperature’ as their components

Elements of the referred array can be accessed by index as shown next:

["element at index 0", 123.4, [33, obj.value]][1] would return 123.4

["element at index 0", 123.4, [33, obj.value]][-3] would return "element at index 0"

["element at index 0", 123.4, [33, obj.value]][-1][0] would return 33

["element at index 0", 123.4, [33, obj.value]][2][1] would return the actual value of *obj.value*

or assuming that the array is stored on an Object Property named exp.value the above is equivalent to:

exp.value[1] would return 123.4

exp.value[-3] would return "element at index 0"

exp.value[-1][0] would return 33

exp.value[2][1] would return the actual value of *obj.value*

Dictionaries.

Dictionaries are collections of unique keys and their values. They have some similarity to Arrays but where an array uses an integer as in index, a Dictionary allows you to use any data type as a key to retrieve a value.

Keys on a dictionary can be any data type but Strings, Numbers and Absolute Times are the most obvious choices.

Values on a dictionary can be of any data type such as Numbers, Strings, Dictionaries, Arrays and so on. Dictionaries can be created in expressions by using its implicit form consisting on separating their key:value elements by commas and enclosing them in curly brackets.

Example 1:

{"red":"rojo", "blue":"azul"}

The above expression represents a dictionary of two elements.

For key "red" we have the string "rojo"
For key "blue" we have the string "azul"

Elements of the referred dictionary can be accessed by key as shown next:

{"red":"rojo", "blue":"azul"}["red"] would return "rojo"

{"red":"rojo", "blue":"azul"}["blue"] would return "azul"

or assuming that the dictionary is stored on an Object Property named exp.value the above is equivalent to:

exp.value["red"] would return "rojo"

exp.value["blue"] would return "azul"

Example 2:

{"red":["rojo", "rouge"], "blue":["azul", "bleu"]}

The above expression represents a dictionary of two elements.

For key "red" we have the array ["rojo", "rouge"]
For key "blue" we have the array ["azul", "bleu"]

Assuming that the dictionary is stored on an Object Property named exp.value elements can be accessed by key as shown below:

exp.value["red"] would return ["rojo", "rouge"]

exp.value["blue"] would return ["azul", "bleu"]

exp.value["red"][0] would return "rojo"

exp.value["red"][1] would return "rouge"

Example 3

{"red":{"sp":"rojo", "fr":"rouge"}, "blue":{"sp":"azul", "fr","bleu"}}

The above expression represents a dictionary of two elements.

For key "red" we have the dictionary {"sp":"rojo", "fr":"rouge"}
For key "blue" we have the dictionary {"sp":"azul", "fr","bleu"}

Assuming that the dictionary is stored on an Object Property named exp.value elements can be accessed by key as shown below:

exp.value["red"] would return {"sp":"rojo", "fr":"rouge"}

exp.value["red"]["sp"] would return "rojo"

exp.value["red"]["fr"] would return "rouge"

Absolute Time values.

Absolute Times are similar to Numeric values with a special meaning.

An Absolute time is measured in seconds relative to the absolute reference date of January 1 1970 00:00:00 GMT. A positive value represents a date after the reference date, a negative value represents a date before it. For example, the Absolute Time 1,000,000,000 seconds translates into the calendar time 9 September 2001 01:46:40 GMT

A Specific variable, $System.absoluteTime is provided to obtain the current time. Specific methods are also provided to extract interesting calendar fields from an Absolute Time value, as well as to get custom string representations of calendar dates.

Examples

$System.absoluteTime may return 1355481788 (seconds count since the reference date)

$System.absoluteTime.year may return 2013

$System.absoluteTime.timeformatter("yyyy-MM-dd HH:mm:ss") may return the string "2013-01-20 10:15:34"

Ranges.

A Range represents an interval of numeric values with a beginning and an end. A range can be created with its implicit form consisting on the lower and upper values separated by two points

Examples

0..100 represents the interval from 0 to 100 inclusive

-10..30 represents the interval from -10 to 30 inclusive

6.2 Supported Operators and Operator precedence

The following table shows the available operators and its precedence. The table lists all operators from highest precedence to lowest.

OPERATOR	Description	Associativity
()	Parentheses (grouping).	from inner to outer
. () []	Method/Property selection, Method/Function call, Array or String subscript	left-to-right
! ~ + -	Logical NOT, Bit Complement, Unary plus, Unary minus.	left-to-right
* / %	Multiply, Divide, Modulo	left-to-right
+ -	Addition/concatenation, Subtraction	left-to-right
&	Bitwise AND	left-to-right
^ |	Bitwise XOR, Bitwise OR	left-to-right
< <= > >= != ==	Comparison operators	not associative
&&	Logical AND	left-to-right
||	Logical OR	left-to-right
..	Range operator	not associative
?:	Ternary conditional operator	right-to-left
if then else	Selective if then else clause	right-to-left
,	Expression List Operator (see The Expression List Operator section below)	right-to-left

Operators are used in the usual way as per the Ruby or “C” language. Depending on data types involved the same operator may have a different meaning. See Methods, Expressions and more about Operators.for further information.

The Expression List Operator (or comma operator) is not available on regular Ruby and it has a different meaning on "C"

6.3 Functions, Methods and more about Operators

Methods can be applied to intermediate expressions or object properties to perform type conversions or to achieve particular requirements. They are like computer language functions that perform particular tasks. Not all *methods* are applicable to all types and their meaning can vary depending on type. *Methods* are invoked by appending a dot (*method selector operator*) followed by its name to the variable or subexpression they apply to.

O*perators* can also have a different meaning depending on the data type they are applied to.

In the following tables we describe the function of the applicable operators and methods depending on data type.

6.3.1 Numeric Operators and Methods

NUMERIC	Description
num *operator* num2	Arithmetic, comparison, logical operators produce the expected usual results. Available operators are listed on the operators precedence table shown earlier. The bitwise and complement operators extract the integral part of the operands before computing the result Example: 2+2 returns 4 Example: 0b1000 + 0b0001 returns 0b1001 (this is 17(dec)) Example: 0b1000 & 0b0001 returns 0b0000 (this is 0(dec)) Example: switch.value ll switch2.value returns 1 (true) if one of them is true
num[n]	Returns bit *n* from the integral part of *num*. Bit 0 is the least significant bit. The result can be only 0 or 1. For example, number 3 is 0b011: Example: 3[0] returns 1 Example: 3[1] returns 1 Example: 3[2] returns 0
num.to_i	Returns the integral part of *num*. Example: 3.666.to_i returns 3 Example: 2.78.to_i returns 2
num.to_f	Returns the same *num.*
• num.to_s • num to_s(fmt)	Returns a string representation of *num* optionally formatted according to *fmt*. For a description of possible format specifiers refer to the *format* function. Example: 3.666.to_s("%03d") results in “003” Example: 3.666.to_s(“%04.1f") results in “03.7" Example: 3.666.to_s results in "3.666" Example: 25.to_s("%02.1f ºC") results in "25.0 ºC" (Note that specifying a format in *to_s* is not a standard feature of Ruby)
num.chr	Returns a string containing a single character represented by the Unicode character code *num*. Example: 72.chr would return "H"
num.abs	Returns the absolute value of *num*. Example: (-3.66).abs would return 3.66

NUMERIC	Description
num.round	Returns *num* rounded to the nearest integer. Example: (3.66).round would return 4
num.floor	Returns the largest integer that is less than or equal to *num*. Example: (3.66).floor would return 3
num.ceil	Returns the smallest integer that is greater than or equal to *num*. Example: (3.66).ceil would return 4 Example: (3.1).ceil would return 4

6.3.2 String Operators and Methods

STRING	Description
"*characters*"	Creates and returns a string containing the sequence of characters written between quotes.
str[n]	Gets the Unicode representation of the character at index *n* in *str.* If *n* is negative indexes start at the last character. Generates an error when attempting an out of bounds access. Example: "Hello world"[0] returns 72 (72 is the Unicode character representation of 'H') Unicode representation of English Language characters fully match the 7 bit standard ASCII character representation.
str[n,m]	Substring. Returns a substring of *str* starting at *n* and continuing for *m* elements. Always returns a string. Returns an empty string "" when access is out of bounds, *m* can not be negative. If *n* is negative indexes start at the last character. Example: "Hello world"[0,4] results in "hell" Example: "Hello world"[-5,5] results in "world" Example: "Hello world"[6,5] results in "world"
str+other_str	Concatenation. Example "hello" + "world" will give "hello world"
str1 *comparison_operator* str2	String Comparison. Returns 1 or 0 (true or false) when comparing two strings for equality or as if they were sorted in a dictionary. Example "alpha"<"beta" returns *true* because "alpha" is before "beta" in a word dictionary. Example "alpha"=="beta" returns *false* because "alpha" is different than "beta". Example "alpha"!="beta" returns *true* because "alpha" is different than "beta".
str.to_i	Parses a *str* into an integer value or returns 0 if not possible Example: "3".to_i returns 3
str.to_f	Parses a *str* into a floating point number or returns 0 if the conversion is not possible Example: "3.2".to_f returns 3.2
• str.to_s • str.to_s(fmt)	Returns *str*. formatted according to *fmt* if specified, or *str* otherwise. Only the "s" format specifier is relevant for strings. Example: "World".to_s("Hello %s") would give " Hello World "
str.split(str2) str.split	Creates an array of strings by splitting *str* using *str2* as a delimiter but not including it. If *str2* is an empty string it splits *str* into each one of its characters. If *str2* is not given it returns an array with *str* as the single element. Example "Hello World".split(" ") returns ["Hello","World"] Example "08-04-2014".split("-") returns ["08","04","2014"] Example "08-04-2014".split("") returns ["0","8","-","0","4","-","2","0","1","4"] Example "Hello World".split("") returns ["H","e","l","l","o"," ","W","o","r","l","d"] Example "08-04-2014".split returns ["08-04-2014"]

STRING	Description
str.length	Returns the number of characters in *str* Example "Hello".length returns 5

6.3.3 Array Operators and Methods

ARRAY	Description
[d1,d2,...]	Creates an Array with the elements *d1*, *d2* and so on. Array elements can be any data types including numbers, strings, ranges, dictionaries or other arrays. Example: ["one","two","three"] would create an array containing three string elements. Example: [1,4,6] would create an array containing three integer elements. Example: ["one",2,"three"] would create an array containing three mixed type elements. Example: the following expression [1,"two",[10,"eleven"]] would create an array containing three elements: the array will have a number at position 0, a string at position 1 and a two elements array at position 2.
arr[n]	Get element at index *n* from *arr*. If 'n' is negative indexes start at the last character. Generates an error when attempting an on out of bounds access Example: ["one","two","three","four"][0] returns "one" Example: ["one","two","three","four"][1] returns "two" Example: ["one","two",”three","four"][-1] returns “four" Example: ["one","two",”three","four"][3] returns “four" Example: [“one”,”two”,["three","four"]][2][1] returns "four"
arr[n,m]	Subarray. Returns a subarray of *arr* starting at *n* and continuing for *m* elements. Always returns an array. It will return an empty array [] when access is beyond limits. *m* can not be negative. Example: ["one","two","three","four"][0,2] returns ["one","two"] Example: ["one","two","three","four"][-3,1] returns ["two"] Example: ["one","two","three","four"][2,2] returns ["three","four"] Example: [“one”,”two”,["three","four"]][1,2] returns ["two",["three","four"]]
arr + arr1	Returns a new array built by concatenating the two arrays together Example: ["one","two"]+["three","four"] returns ["one","two","three","four"] Example: [0,["one","two"]]+["three"] returns [0,["one","two"],"three"]
arr.join(str)	Returns a string created by converting each element of *arr* into a string, and concatenating them using *str* as a separator Example: ["one","two",3,4].join(":") returns "one:two:3:4" Example: [“Hello”,"World"].join(" ") returns “Hello World"
arr.fetch(n,d)	Returns the element at position *n* or returns *d* if *n* goes outside the array bounds. *n* must be numeric value representing the element index. Negative values of *n* count from the end of the array. *d* can be any numeric, string or array value. Example: ["one","two","three","four"].fetch(0,"none") returns "one" Example: ["one","two","three","four"].fetch(4,"none") returns "none"
arr.length	Returns the number of elements in *arr*. Example: ["one","two"].length results in 2

ARRAY	Description
arr.min	Returns the smaller element in *arr*. Elements in the array must all be the same time, such as all Strings or Numbers. Example: [3, 2, 1].min results in 1 Example: ["alpha","beta"].min results in "alpha"
arr.max	Returns the bigger element in *arr*. Elements in the array must all be the same time, such as all Strings or Numbers. Example: [3, 2, 1].max results in 3 Example: ["alpha","beta"].max results in "beta"

6.3.4 Dictionary Operators and Methods

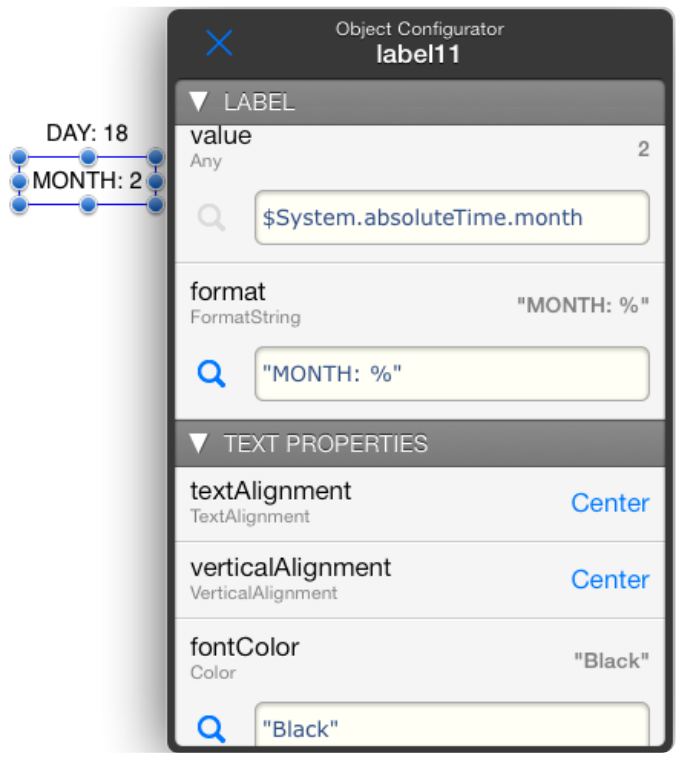
DICTIONARY	Description
{k1:v1,k2:v2, k3:v3,...}	Creates a Dictionary with the specified key:value pairs (*k1*:*v1*, *k2*:*v2* and so on) and returns it. Keys can be any data type but most often you will use numbers, strings or absolute times. Values can be any data type including numbers, strings, ranges, arrays or other dictionaries Keys can not be repeated in a dictionary, so if two or more keys are identical only the last one appearing on the comma separated list will be used. Example1: the following expression {1:"one", 2:"two"} would create a dictionary containing two elements, the dictionary will have the string "one" for key 1 and the string "two" for key 2
dict[k]	Get value for key *k* from *dict*. Generates an error if *k* is not in the dictionary. Example: {1:"one", 2:"two"}[1] returns "one" Example: {"one":1, "two":2}["one"] returns 1
dict1 + dict1	Returns a new dictionary containing all key:value pairs of *dict1* and *dict2* If the same key is present in *dict1* and *dict2* the resulting dictionary will get the value in *dict2* for that key Example: {1:"one", 2:"two"} + {3:"three", 4:"four"} returns {1:"one", 2:"two", 3:"three", 4:"four"} Example: {"age":23, "name":"Mary"} + {"age":24} returns {"age":24, "name":"Mary"}
dict.fetch(k,d)	Returns the value for key *k* or returns *d* if the dictionary does not contain *k* Example: {1:"one", 2:"two"}.fetch(1,"none") returns "one" Example: {1:"one", 2:"two"}.fetch(3,"none") returns "none"
dict.length	Returns the number of elements -same as key:value pairs- in *dict*. Example: {1:"one", 2:"two"}.length results in 2
dict.keys	Returns an array containing all the keys in *dict.* The length of the returned array will be the same as the length of *dict* .Since dictionaries are not an ordered collection the order of elements in the returned array is undefined. You should never assume that keys will be returned on a particular order. Since keys are unique on a dictionary the returned array will contain unique elements too. Example: {1:"one", 2:"two"}.keys returns [1,2] Example: {"one":1, "two":2}.keys returns ["one","two"]
dict.values	Returns an array containing all the keys in *dict.* The length of the returned array will be the same as the length of *dict*. Since dictionaries are not an ordered collection the order of elements in the returned array is undefined. You should never assume that values will be returned on a particular order. Repeated values in the dictionary will result in repeated elements in the returned array. Example: {1:"one", 2:"two"}.values returns ["one","two"] Example: {"one":1, "two":2}.values returns [1,2]

6.3.5 Absolute Time Operators and Methods

ABSOLUTE TIME	Description
time + num num + time	Adding a number *num* to an absolute time *time* results in the absolute time incremented by the number of seconds specified in *num*. Note that it is not possible adding two absolute times Example: $System.absoluteTime + 0.1 will return a time that is 100 milliseconds ahead of now.
• time - num • time2 - time1	Subtracting a number *num* to an absolute time *time* results in the absolute time decremented by the number of seconds specified in *num*. Subtracting two absolute times will result in a number representing the elapsed time between the two expressed in seconds Example: $System.absoluteTime - 60 will return the time that was 1 minute ago.
t1 *comparison_operator* t2	Absolute Time Comparison. Returns 1 or 0 (true or false) when comparing two absolute times. In the context of absolute times a time is greater than a base time if it is a time that happened or will happen after the base time.
time.to_f	Converts an absolute time to a number representing the seconds count since the reference date Example $System.absoluteTime.to_f may return 1355481788
time.timeformatter(fmt)	The *timeformatter* method returns a string representation of an absolute time given a format string. When applying this method *time* is a numeric value meant to hold a specific point in time expressed in seconds relative to 1-Jan-1970, for example an absolute time value provided by the '$System.absoluteTime' object property. The *fmt* parameter is a format sting as specified in the 'Unicode Technical Standard #35, Appendix F'. The method will return a string representation of the date and time for the given absolute time taking into account the current time zone location of the device. For more information on valid format strings for the *fmt* parameter you can have a look at: http://unicode.org/reports/tr35/tr35-6.html#Date_Format_Patterns When looking at this spec be aware that character symbols in the format string are case sensitive and thus they may have different meaning depending on case, for instance 'yy' will represent a year whereas 'YY' will represent a week of year. Example: $System.absoluteTime.timeformatter("yyyy-MM-dd HH:mm:ss") may return the string "2012-12-28 10:15:26"
time.year	Returns the Gregorian Calendar year for an absolute time *time* at the current time zone location
time.month	Returns the Gregorian Calendar month for an absolute time *time* at the current time zone location. Range of returned values is 1 to 12
time.day	Returns the Gregorian Calendar day for an absolute time *time* at the current time zone location. Range of returned values is 1 to 31
time.wday	Returns the day of the week for an absolute time *time* at the current time zone location, 0 is Sunday, 1 is Monday and 6 is Saturday.

ABSOLUTE TIME	Description
time.yday	Returns the day of the year for an absolute time *time* at the current time zone location. Range of returned values is 1 to 366
time.week	Returns the week of the year for an absolute time *time* at the current time zone location. Range of returned values is 1 to 53
time.hour	Returns the Gregorian Calendar hour for an absolute time *time* at the current time zone location. Range of returned values is 0 to 23
time.min	Returns the Gregorian Calendar minutes for an absolute time *time* at the current time zone location. Range of returned values is 0 to 59
time.sec	Returns the Gregorian Calendar seconds for an absolute time *time* at the current time zone location. Range of returned values is 0 to 59

The following illustration demonstrates the use of a time expression on a label item.



6.3.6 Range Operators and Methods

RANGE	Description
num1..num2	Creates and returns a *range* starting at *num1* and ending at *num2* inclusive
range.begin	Returns the staring value a *range* Example: (0..9).begin returns 0
range.end	Returns the staring value a *range* Example: (0..9).end returns 9

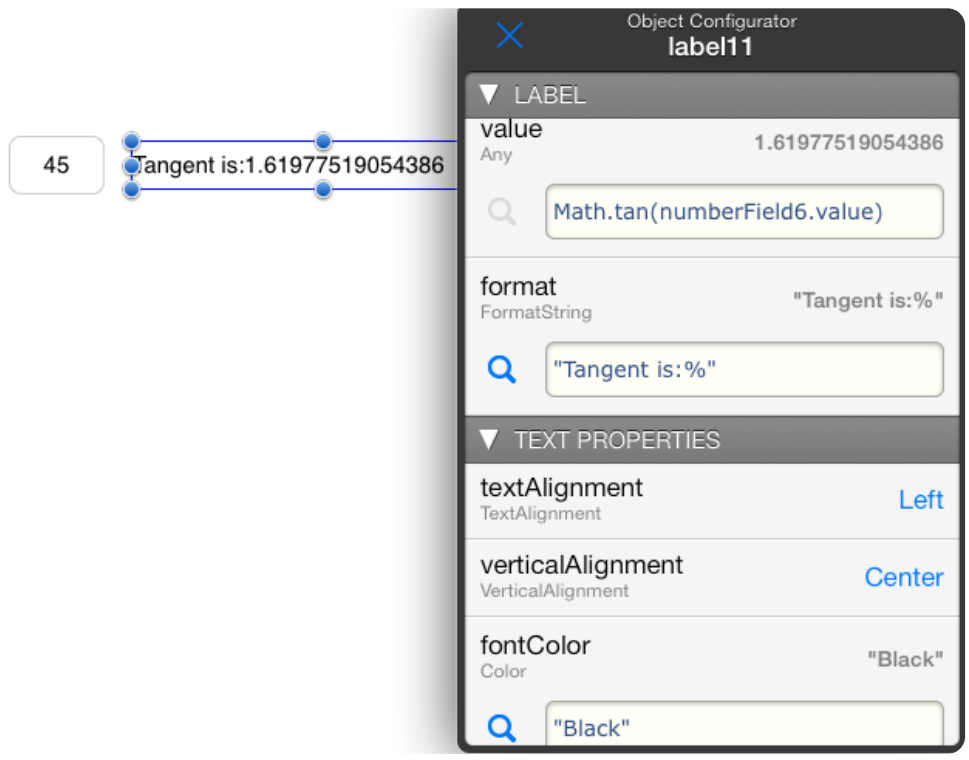
6.3.7 Rect, Point and Size Methods

RANGE	Description
rect.origin	Returns a point type value representing the top left coordinates of *rect*
rect.size	Returns a size type value representing the width and height of *rect*
point.x	Returns the x coordinate of *point* as a number
point.y	Returns the y coordinate of *point* as a number
size.width	Returns the width of *size* as a number
size.height	Returns the height of *size* as a number

6.3.8 MATH Methods

MATH	Description
Math.atan2(y,x)	Computes the principal value of the arc tangent of *y*/*x*, using the signs of both arguments to determine the quadrant of the return value. The *atan2()* function is used mostly to convert from rectangular (*x*,*y*) to polar (*r*,*θ*) coordinates that will satisfy *x = r*Math.cos(θ)* and *y = r*Math.sin(θ)*. In general, conversions to polar coordinates are computed in this way: r = Math.sqrt(x*x+y*y) *θ* = Math.atan2(y,x)
Math.cos(x)	Computes the cosine of *x* (measured in radians)
Math.exp(x)	Calculates an exponential function (e raised to the power of x)
Math.log(x)	Calculates the natural logarithm of x.
Math.log10(x)	Calculates the base 10 logarithm of x.
Math.sin(x)	Computes the sine of *x* (measured in radians)
Math.sqrt(x)	Computes the non-negative square root of *x*
Math.tan(x)	Computes the tangent of *x* (measured in radians)
Math.PI	Returns the π constant number
Math.floor(x)	Returns the largest integer less than or equal to *x*. ** Deprecated starting from version 2.1. Please use **num.floor** instead
Math.ceil(x)	Returns the smallest integer greater than or equal to *x*. ** Deprecated starting from version 2.1. Please use **num.ceil** instead

The following illustration uses a MATH expression to display a value on a label item.



6.3.9 Built-in Functions

FUNCTIONS	Description
format(fmt,...)	Returns a string where the list of arguments following *fmt* is formatted according to *fmt*, *fmt* is a Formating specification string. Formatting specifications in *fmt* are essentially the same as those of the sprintf function in the C programming language. Conversion specifiers in *fmt* begin with % and are replaced by a formatted string of the corresponding argument. A % character followed by another % will yield the '%' character. A list of supported conversion fields is given on the next section. Examples: format("Room Temperature is: %4.1f", 25) will return the string "Room Temperature is: 25.0" format("%02d:%02d:%02d",hours,minutes,seconds) may return the string "01:15:48" assuming the variables 'hours' 'minutes' and 'seconds' contain the given values. format("Throughput: %4.1f%%", 25) will return the string "Throughput: 25.0%"
• rand • rand(n)	Returns a semi-random number on a specific interval. When no argument is given it returns a numeric floating point value 'r' in the range 0 <= r <1 When an integer argument is given it returns an integer value 'i' in the range 0 <= i < n Examples: rand may return 0.28384618 rand(10) may return 7

6.3.10 System Methods

SYSTEM	Description
• SM.color(r,g,b) • SM.color(r,g,b,a) • SM.color(str)	Returns a numeric representation of a color. You provide the RGB color coordinates as values ranging from 0 to 255 in *r*, *g* and *b*, with optional alfa *a* from 0 to 1 Alternatively you can provide a string with the color name in *str.*
SM.deviceID	Returns an unique identifier string representing the iOS device the app is running on. The returned string is always the same for the same device but a different value is returned for different devices. Returned values will look like this: "846AB563-760E-45BA-8E9E-88BE1D0A5ED7"
SM.point(x,y)	Returns a point type value from its *x*, *y* coordinates
SM.size(w,h)	Returns a size type value.with width *w*, and height *h*.
SM.rect(x,y,w,h)	Returns a rect type value.with *x*, *y* top left coordinates, width *w*, and height *h*.
SM.allFonts()	Returns an array of strings with all the available font names.
SM.allColors()	Returns an array of strings with all the available color names.
SM.encrypt(s,key)	Returns a string representing the encrypted version of the string *s* by applying a symmetric AES256 algorithm using *key* as the encryption key. Example: SM.Encrypt("myString","aPassword") will encrypt "myString" using "aPassword"
SM.decrypt(s,key)	Returns the original unencrypted string from the encrypted string *s* by applying an AES256 decryption algorithm based on *key.* This method will return the original string that was passed as the first parameter to *SM.encrypt* provided the same key was used. Example: SM.decrypt(SM.encrypt("myString,"pass"), "pass") will return "myString"
• SM.mktime(y) • SM.mktime(y,m) • SM.mktime(y,m,d) • SM.mktime(y,m,d,h) • SM.mktime(y,m,d,h,mn) • SM.mktime(y,m,d,h,mn,s)	Returns an absolute time that is a representation of the time period that is implicit on the parameters. In particular, it returns the absolute time of the first instant of the intended passed in time period. You can use this method to provide a custom time reference to **data presenter** objects. Examples SM.mkTime(2014) will return the first instant of year 2014 as an absolute time SM.mkTime(2014,2) will return the first second of February, 2014 as an absolute time SM.mkTime(2014,2,3) will return the first second of February, 3rd, 2014 SM.mkTime(2014,2,3,12) will return midday time on February, 3rd, 2014 SM.mkTime(2014,2,3,12,5) will return time on February, 3rd, 2014 at 12:05:00 SM.mkTime(2014,2,3,12,5,45) will return time on February, 3rd, 2014 at 12:05:45

6.4 Format specifiers for ‘format’ and ‘to_s’

The built-in function *format* returns a string formatted according to a format string following the usual printf conventions of the C language. In addition, *format* accepts *%b* for binary. The *to_s* method also support formatting when applied to numbers or strings.

HMI Editor. format specifiers adopt the following form:

%<flags><width><.precision>specifier

Where *specifier* is the most significant one and defines the type and the interpretation of the value of the corresponding argument (‘<‘ and ‘>’ denote optional fields).

For types supporting the *to_s* method format specifiers are also applicable

The following format conversion specifiers are available:

FORMAT SPECIFIER	Description	*format* function support	*to_s* method support
b	Binary integer	YES	YES
c	Single character	YES	YES
d,i	Decimal integer	YES	YES
e	Exponential notation (e.g., 2.44e6)	YES	YES
E	Exponential notation (e.g., 2.44E6)	YES	YES
f	Floating-point number (e.g., 2.44)	YES	YES
g	Use the shorter of e or f	YES	YES
G	Use the shorter of E or f	YES	YES
o	Octal integer	YES	YES
s	String or any object converted using *to_s*	YES	YES
u	Unsigned decimal integer	YES	YES
x	Hexadecimal integer (e.g., 39ff)	YES	YES
X	Hexadecimal integer (e.g., 39FF)	YES	YES

For the meaning and possible contents of the optional *flags*, *width*, and *precision* fields refer to the sprintf specification:

http://www.cplusplus.com/reference/cstdio/printf/

Since there is no need for the *length* field it is not available neither in Ruby or HMI Editor.

6.5 The ternary conditional operator

The ternary conditional operator provide conditional execution of expressions. Its syntax is the following:

```
expr ? expr1 : expr2
```

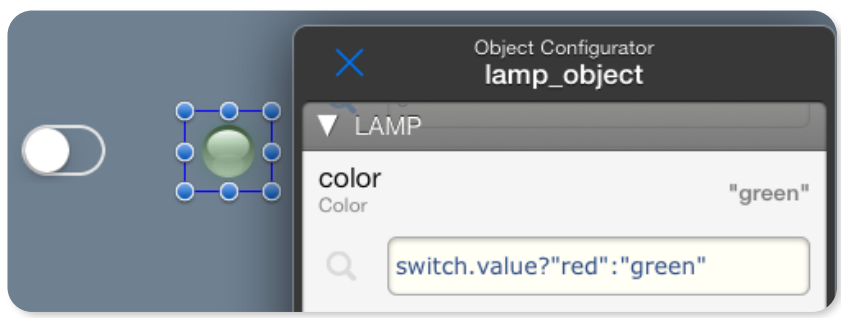
The expression above returns *expr1* if *expr* is not zero (true) or *expr2* otherwise.

The ternari conditional operator executes when any of *expr*, *expr1*, *expr2* generate a change event. The result is always updated and will be consistent with the values of *expr*, *expr1* and *expr2* at all times. The execution will in turn trigger relevant change events up the expressions tree just as any expression would do.

Consider the following case

switchColorSelection.value ? color1.value : color2.value ;

The resulting color will be always updated according to *switchColorSelection* upon any change on *switchColorSelection*, *color1* or *color2* values



6.6 The 'if-then-else' clause

The *if-then-else* clause provide conditional choice of expressions. It is used as follows:

```
if expr [then] expr1 [else expr2] [end]
```

Executes *expr1* if *expr* is not zero (true). If *expr* is zero (false) *expr2* is executed instead. Items between brackets are optional.

> The if-then-else clause only attends to *expr* change events. Any changes in *expr1* or *expr2* will not have an effect until *expr* executes. Furthermore, if *expr* is *false* and *expr2* was not specified, the execution tree is trimmed at this stage and no further execution up the expresion tree will happen.
>
> You should only use the if-then-else clause when the above is required, otherwise use the ternary conditional operator.

The if-then-else clause is useful in cases where you want to achieve a differential effect, for example to trigger an event when a condition goes from *false* to *true* but not the opposite. This is not possible with the ternary conditional operator because it will always execute both ways.

Consider the following expression entered on the *value* property of a *lamp* object:

if startButton.value then 1 else (if stopButton.value then 0)

The previous lines asume the existence of a start button *startButton* and a stop button *stopButton*. When the start button is touched 1 will be written to *lamp.value*. When the stop button is touched 0 will be written to *lamp.value*. Because we are using the if-then-else clause, no change event will be sent to *lamp.value* upon release of the buttons.

Another use of the *if then else* clause is the implementation of a counter.

Consider a background item named *counter* and the following expression entered on its *value* property

if resetButton.value then 0 else (if incrementButton.value then counter.value+1)

The *resetButton* and *incrementButton* buttons provide in this case the interface for incrementing the *counter* value.

> NOTE: We recommend to restrict the use of the 'if-then-else' clause to cases where it is strictly necessary as described above and only where the ternary conditional operator would not work.
>
> Ab-using or mis-understanding the purpose and consequences of using it of may create uninitialized values or properties specially on first project launch or update. It is important to always foresee such circumstance and provide an initializer to values that otherwise would never be valid.
>
> For example on the counter example provided above, we incorporated a reset button to allow users to initialize the counter to a valid initial known state.

6.7 The Expression List Operator

The Expression List Operator is an advanced feature that enables you to selectively execute one of several expressions based on the actual flow of change events in the Expression Engine.

Its purpose is similar to the *if-then-else* clause but in this case the result does not depend on a explicit condition but on the last expression on the list that received a change.

Consider the following expression list.

exp1, exp2, exp3

We have a list of three expressions separated by commas. The result of the above will be either *exp1*, *exp2* or *exp3* depending on the one that last changed. For instance if *exp1* just received a change, then the result of the list will be *exp1* If now *exp3* changes then the result will be *exp3*

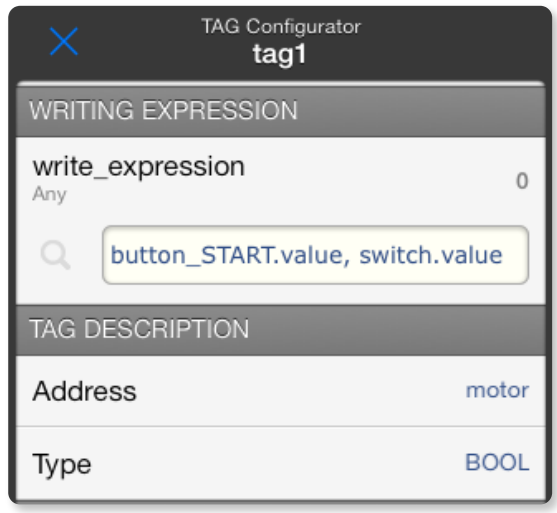
Note that the result is always the first expression in the list that changed, For example the following expression list *exp1+1, exp1+2* will always return *exp1+1* upon a change of *exp1* because it s the first in the list to change .

One particularly interesting use case of the Expression List Operator is when you need to write a value to a PLC tag based on more than one item on screen. For example you want to write a set-point value on a PLC Tag based on user action on a slider or on entering a value on a number field on the interface.

You can enter the following on the *write_expression* field of the PLC tag

slider.value, numberField.value

In this case, a change on *slider.value* or the *numberField.value* will result on the writing or the resulting value to your PLC Tag



6.8 Putting it all together. Advanced Expressions Examples

You can use expressions in your HMI Editor project in many advanced ways. Expressions provide a lot of power and flexibility and most of the features of HMI Editor are unveiled through the advanced use of expressions.

We present next some examples of advanced expressions involving several operators, methods and data types to obtain particular results. This is of course not exhaustive as you can use expressions for tasks that we could not even imagine.

Converting an arbitrary number of seconds to hh:mm:ss format

The following expression shows how to get a string in the form 'hh:mm:ss' from a numeric value containing seconds.In this example *x* contains the total number of seconds to be converted to the desired format.

```
[(x/3600).to_s("%02d"), ((x%3600)/60).to_s("%02d"), (x%60).to_s("%02d")].join(":")
```

The operators % and / are used to calculate hours, minutes, seconds as numeric values. These are then truncated to integer with the *to_i* method and successively converted to formatted strings with *to_s*. The resulting individual strings are embedded into an array and then joined by means of the the *join* method using ':' as separator.

Instead of using the *join* method we could have used the *format* function as a more convenient way. Consider the following:

```
format("%02d:%02d:%02d", x/3600, (x%3600)/60, x%60)
```

in this case the format specifiers in the format string are just replaced with the relevant time values.

Calculating seconds from a string having the hh:mm:ss format.

Just to illustrate what expressions allow to do let's try now to get the original seconds value from a string already in the hh:mm:ss format. To do so we can use the following expression:

```
3600*t.split(":").fetch(-3,0).to_i + 60*t.split(":").fetch(-2,0).to_i + t.split(":").fetch(-1,0).to_i
```

In this case we extract separately the hours, minutes and seconds as numeric values from the string, we multiply them by 3600, 60 and 1 respectively and then add them to get the total number of seconds. The extraction of each value from the original string is performed by the *split* method using ':' as delimiter. The relevant element from the split array is obtained with the *fetch* method. We use 0 as the default value for fetching.

Note that we could have used simple array indexing such as `t.split(":")[-3]` to get each part of the original string but this would lead to potential out of bound errors in case the original string had some missing part. Particularly, if the original string did only contain minutes and seconds, such as "50:30" (50 minutes, 30 seconds) the referred indexed expression would give an out of bounds error as it would attempt to access a non existing element (the one before the first one).

Note also that in all cases we use negative indexing because we interpret that the last part is always meant to be the seconds, the previous to the last one the minutes and so on.

The proposed expression can be optionally optimized by storing the split string in a temporary variable (background expression) so that the splitting is only performed once. If we apply this optimization.the final solution would look as follows:

t.split(":") <- we store this on the value property of tspt

3600*tspt.value.fetch(-3,0).to_i + 60*tspt.value.fetch(-2,0).to_i + tspt.value.fetch(-1,0).to_i

Creating a label that alternates between displaying the current time and an arbitrary value

In this example we will create a label that shows a living digital clock showing the current time. Every 5 seconds the time is alternated with a temperature value given in an item named *temperature*. In order to achieve this we enter the following expression in the *value* property of a label item.

```
$System.pulse10s ? "Time: "+$System.date.split(" ")[1] : "Temp: "+temperature.value.to_s("%3.1f")+" ºC"
```

We use the ternary operator to switch between the time and the temperature depending on the *$System.pulse10* pulsating property. For the clock we take *$System.date* and discard the date portion by splitting it out. The temperature is presented formatted with a custom prefix and suffix appended to the actual value.

We can alternatively use the format function to simplify a bit some portions of the expression

```
$System.pulse10s ? format("Time: %s", $System.date.split(" ")[1]) : format("Temp: %3.1f ºC", temperature.value)
```

7 Object Properties Reference

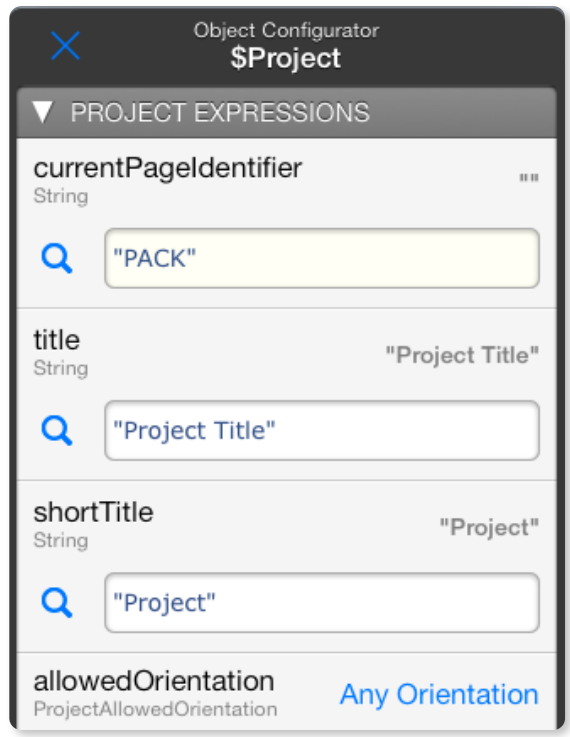
Refer to this section for reference of all Object Property descriptions.For classes of objects that share similar properties they are presented hierarchically. The same hierarchy is shown in most cases in form of table sections in the Object Configuration panel.

7.1 System Objects

They are special objects that provide device sensor data, and other system or project related information.

7.1.1 $Project

The $Project Object contains properties that may affect the entire project.

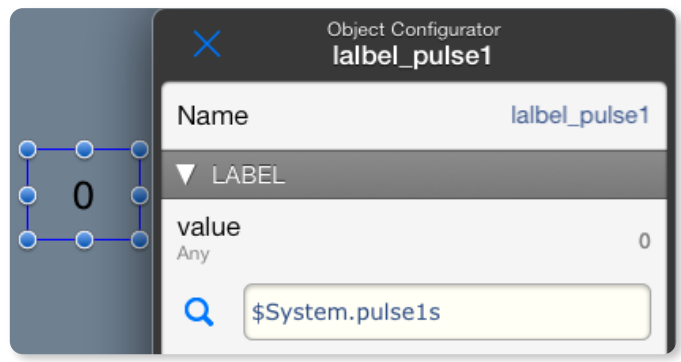


PROPERTY	TYPE	DESCRIPTION
currentPageIdentifier	String (read/write String)	When you set a string to this property the system searches for a page with a matching *pageIdentifier* .If found, the system moves to that page. Nothing happens if no page has a pageIdentifier matching the string **Example:** If you have two pages with pageIdentifiers "PAGE1" and "PAGE2" and two buttons named *button1* and *button2* you can use the ternary conditional operator like this. button1.value ? "PAGE1" : button2.value ? "PAGE2" : ""
title	(constant String)	The Title that will appear on the tool bar when this project is open.You can use this value for your own purposes as well.
shortTitle	(constant String)	Reserved for future use. You can still use this for your own purposes.
allowedOrientation	(constant number)	Determines which orientations are available for the project on the iPad interfaceIdiom. When you chose an allowed orientation, the project is forced to display on that orientation. This property allows you to design projects that do not support multiple orientations. • **Any Orientation**: Project pages will rotate and display using their settings on both orientations. • **Landscape Only**: Project pages will keep Landscape mode regardless of device orientation. • **Portrait Only**: Project pages will keep Portrait mode regardless of device orientation

PROPERTY	TYPE	DESCRIPTION
allowedOrienta-tionPhone	(constant number)	This property has the same meaning than *allowedOrientation* except that it refers to the iPhone/iPod interface idioms.

7.1.2 $System

The $System object provides the interface for using system or project related info on your project:



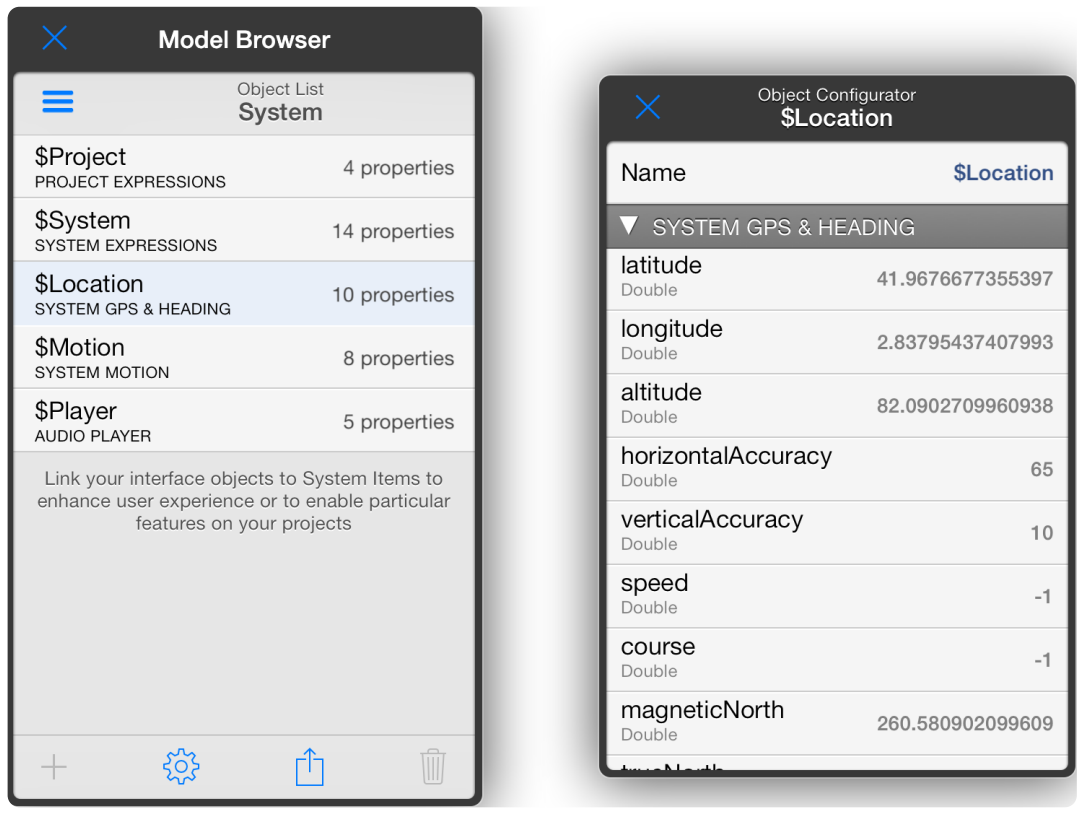
PROPERTY	TYPE	DESCRIPTION
SMPulse1s **SMPulse10s** **SMPulse30s** **SMPulse60s**	Bool (read only Number)	They generate a square wave signal with the period implicit on the variable name. They can be used to implement a Keep-Alive tag, to write periodically a value on a PLC, or to trigger periodic events for any purpose.
SMPulseOnce	Bool (read only Number)	Provides a pulse output that is triggered only once upon first project launch. This can be used for initialization purposes, for example in combination with the 'if then' clause
date	String (read only String	Text representation of the current date and time in the following format: "yyyy-MM-dd HH:mm:ss"
absoluteTime	Double (read only Absolute Time)	Current absolute time. Absolute time is measured in seconds relative to the absolute reference date of Jan 1 1970 00:00:00 GMT. You can use this variable in combination with *Time* methods to obtain string representations or to get calendar parts as numeric values.

PROPERTY	TYPE	DESCRIPTION
commState	Integer (read only Number)	A value indicating the current communication state of HMI Editor. Possible values are the following: 0 - Communications running with all PLC connections linked. 1 - Monitor is switched off. 2 - One or more PLC are not linked or a new connection is in course. Partial link state. 3 - General communications error. No communication is established. This variable can be used to implement alarms related to PLC reachability or to show/hide interface elements depending on PLC availability.
commRoute	Integer (read only Number)	A value indicating the current communications route. Possible values are the following: 0 - No remote communications are active, but some local connections can still be running. 1 - All active communication links are running through local connection settings. 2 - At least one PLCs is linked through remote connection settings. 3 - All available PLC connections are active and linked through remote connection settings. This variable can be used to implement behavior dependent on local/remote connections type. For example you may want that some interface elements or project features are not available when accessing from remote locations.
networkName	String (read only String	For WiFi networks it will provide the Name of the wireless network the iOS device is connected. Returned Names may look like this: "StarBucks"
networkBSSID	String (read only String	For WiFi networks it will provide the BSSID of the wireless router the iOS device is connected. This can be used to filter some interface elements or to perform special actions based on physical connection to particular WiFi spots. Returned BSSID may look like this: "0:24:36:a7:e6:9b"
currentUserAccessLevel	Integer (read only Number)	Access Level of the currently logged user. Currently, this is always 9.
currentUserName	String (read only String	User Name of the currently logged user.
interfaceOrientation	Integer (read only Number)	A value of 1 if the current Interface Orientation is Landscape, or a value of 2 if it is Portrait. This variable can be used to implement behavior or visual changes depending on orientation. For example you can decide to hide particular visual item on pages depending on orientation.

PROPERTY	TYPE	DESCRIPTION
interfaceIdiom	Integer (read only Number)	A value of 1 if the current Interface Idiom is an iPad, or a value of 2 if it is an iPhone or iPod. This variable can be used to implement behavior or visual changes depending on the device.

7.1.3 $Location

The $Location object provide the gateway for the delivery of location and heading related events to your project.

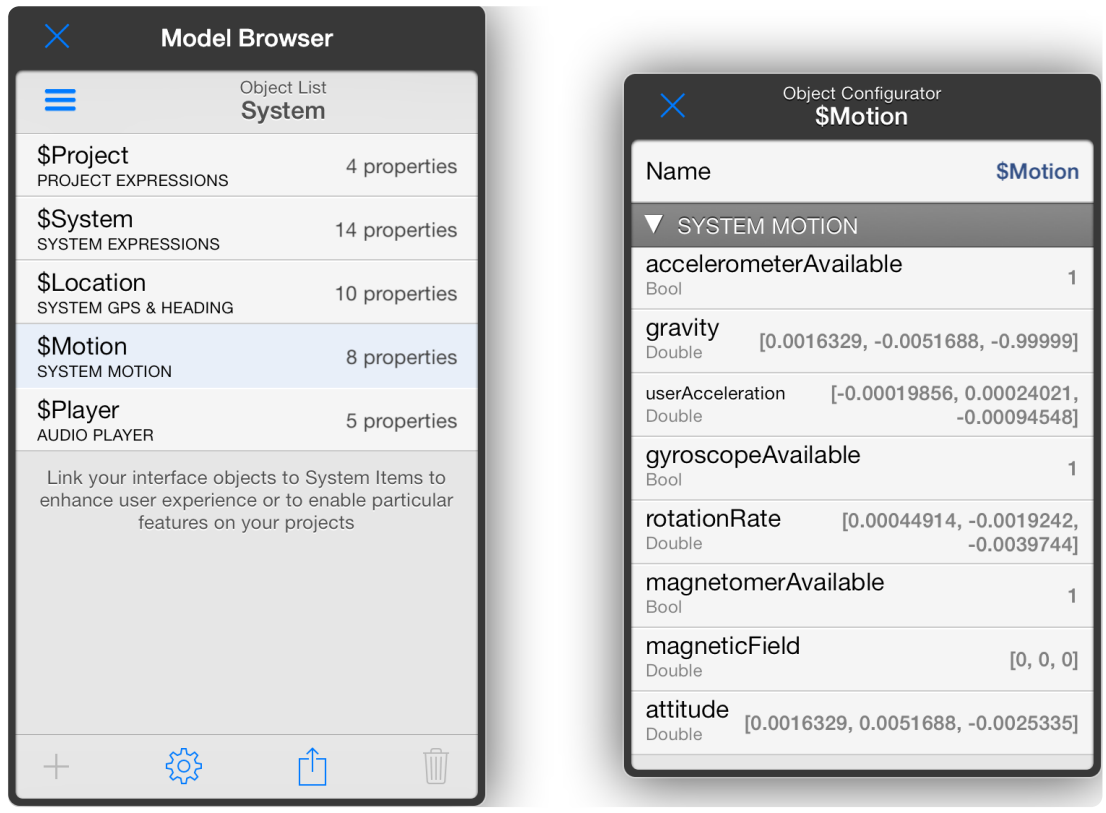


PROPERTY	TYPE	DESCRIPTION
latitude	Double (read only Number)	The latitude in degrees. Positive values indicate latitudes north of the equator. Negative values indicate latitudes south of the equator.
longitude	Double (read only Number)	The longitude in degrees. Measurements are relative to the zero meridian, with positive values extending east of the meridian and negative values extending west of the meridian.
horizontalAccuracy	Double (read only Absolute Time)	The radius of uncertainty for the location, measured in meters. The location's latitude and longitude identify the center of the circle, and this value indicates the radius of that circle. A negative value indicates that the location's latitude and longitude are invalid.
verticalAccuracy	Double (read only Number)	The accuracy of the altitude value in meters. The value in the *altitude* property could be plus or minus the value indicated by this property. A negative value indicates that the altitude value is invalid.
speed	Double (read only Number)	The instantaneous speed of the device in meters per second. This value reflects the instantaneous speed of the device in the direction of its current heading. A negative value indicates an invalid speed. Because the actual speed can change many times between the delivery of subsequent location events, you should use this property for informational purposes only.

PROPERTY	TYPE	DESCRIPTION
course	Double (read only Double	The direction in which the device is traveling. Course values are measured in degrees starting at due north and continuing clockwise around the compass. Thus, north is 0 degrees, east is 90 degrees, south is 180 degrees, and so on. Course values may not be available on all devices. A negative value indicates that the direction is invalid.
magneticNorth	Double (read only Double	The heading (measured in degrees) relative to magnetic north. The value in this property represents the heading relative to the magnetic North Pole, which is different from the geographic North Pole. The value 0 means the device is pointed toward magnetic north, 90 means it is pointed east, 180 means it is pointed south, and so on.
trueNorth	Double (read only Number)	The heading (measured in degrees) relative to true north. The value in this property represents the heading relative to the geographic North Pole. The value 0 means the device is pointed toward true north, 90 means it is pointed due east, 180 means it is pointed due south, and so on. A negative value indicates that the heading could not be determined.
headingAccuracy	Double (read only Double	The maximum deviation (measured in degrees) between the reported heading and the true geomagnetic heading. A positive value in this property represents the potential error between the value reported by the *magneticNorth* property and the actual direction of magnetic north. Thus, the lower the value of this property, the more accurate the heading. A negative value means that the reported heading is invalid, which can occur when the device is uncalibrated or there is strong interference from local magnetic fields.

7.1.4 $Motion

The $Motion Object is the gateway to the motion services provided by iOS. These services provide accelerometer data, rotation-rate data, magnetometer data, and other device-motion data such as attitude.



PROPERTY	TYPE	DESCRIPTION
accelerometerA-vailable	Bool (read only Number)	A value of 0 or 1 value that indicates whether an accelerometer is available on the device.
gravity	Doubles (read only Array ofNumbers)	An array of 3 elements containing the gravity acceleration vector expressed in the device's reference frame.
userAcceleration	Doubles (read only Array of Numbers)	An array of 3 elements containing the acceleration that the user is giving to the device around the three axes.
gyroscopeAvail-able	Bool (read only Number)	A value of 0 or 1 that indicates whether a gyroscope is available on the device.
rotationRate	Doubles (read only Array of Numbers)	An array of 3 elements containing the rotation rate of the device around the three axes

PROPERTY	TYPE	DESCRIPTION
magnetometerAvailable	Bool (read only Number)	A value of 0 or 1 that indicates whether a magnetometer is available on the device
magneticField	Doubles (read only Array of Numbers)	An array of 3 elements containing the magnetic field vector with respect to the device.
attitude	Doubles (read only Array of Numbers)	An array of 3 elements containing the attitude as Euler Angles. The attitude is a representation of the the orientation of the device relative to the direction of travel. The returned array contains the 'roll', the 'pitch' and the 'yaw' components. A **roll** is a rotation around a longitudinal axis that passes through the device from its top to bottom. A **pitch** is a rotation around a lateral axis that passes through the device from side to side. A **yaw** is a rotation around an axis that runs vertically through the device. It is perpendicular to the body of the device, with its origin at the center of gravity and directed toward the bottom of the device.

7.1.5 $Player

The $Player Object provides the interface for playing audio in your project.

PROPERTY	TYPE	DESCRIPTION
play	Bool (read/write Number)	When this property transitions to true (non zero) a player will initialize and will start playing.
stop	Bool (read/write Number)	When this property transitions to true (non zero) any playing audio will stop.
repeat	Bool (read/write Number)	When this property is true (non zero) playing will repeat after reaching the end.
title	String (read/write String)	The String that will show as title in the player
url	Url (read/write String)	The String assigned to this property provides the name of an audio asset from the device iPod Library, an audio file from an external url, or an audio file in the Local Assets section. To play an audio file in the Local Assets you simply enter its file name with extension as a string: **Example** : “myAudioFile.mp3” iPod Library items must be moved into a Playlist named “HMiPad” to be playable by this app. You identify assets on the iPod Library with the "iPod-Library://" url schema preceding the asset name. **Example** : "iPod-Library//Animal Instinct” You can also point to an audio file on a remote http server by using the “http://“ prefix. **Example** : "http//Animal Instinct"

7.1.6 $Scanner

The $Scanner Object provides the interface for bar code scanning.

The following bar code types are supported:

UPC-A
UPC-E
Code 39
Code 39 mod 43
Code 93
Code 128
EAN-8
EAN-13
Aztec
PDF417
QR

PROPERTY	TYPE	DESCRIPTION
scan	Bool (read/write Number)	When this property transitions to true (non zero) the scanner will initialize and will start using the device built-in camera for bar code reading.
scanResult	String (read only)	After a successful scan this property contains a string with the last scanned code.

7.1.7 $UsersManager

The $UsersManager object provides the interface for presenting a Log In screen for project users. It also provides a set of properties to determine the currently logged in user and her/his associated access level.

Project Users are created from the Model Browser on the 'Users' section. The $UsersManager is the central controller to manage a Log In screen and to retrieve information on the current user.

PROPERTY	TYPE	DESCRIPTION
login	Bool (read/write Number)	When this property transitions to true (non zero) the project users login screen will appear. After an user entered her credentials the remaining (read only) properties will update accordingly.
enableAutoLogin	Bool (read/write Number)	When this property is false and users are defined on the current project the Log In screen will always appear after app startup or device wake up. You can prevent this by setting it to true, the default
adminUserPassword	String (read/write String)	Specifies the password for the default "admin" user. In View mode, the admin user gives access to the Application Panel. If your project contains users, you you should chose an undisclosed password for the admin user. The default password is "admin"
currentUserName	String (read only)	Contains the user name of the currently logged in user.
currentUserLevel	Number (read only)	Contains the access level of the currently logged in user. Access levels can be used for the purposes of hiding or enabling interface elements, giving restricted access to pages, setting limits on input fields or controls based on user level, and so on. NOTE: This property is implicitly set to 9 when no Project User is logged in. This will happen when you log into a HMI Pad Service user. Following the usual convention for user access levels (0..9) this means full access rights to HMI features. If this is not desirable or convenient you may set user levels above 9 on your project in order to provide restricted access to HMI Pad Service users.
backgroundColor	Color (read/write String or Number)	The color to be applied as a background for the Log In screen. If no color is provided or the property is left blank, the system will use a semitransparent blurred effect partially showing the project contents as a background. See description of the *color* property on the **page** object for a discussion on possible values. See also note below on the use of dark/bright or transparent backgrounds colors.
backgroundImage	ImagePath (read/write String)	Image to be shown as a background on the Log In Screen. If the image contains transparency, the color or effect specified on the *backgroundColor* property will still show underneath. The image will automatically scale to the screen size using an **Aspect Fit** mode.

PROPERTY	TYPE	DESCRIPTION
companyTitle	String (read/write)	A title to be presented on the Log In screen. This can be your company name or a text identifying your project. Short titles of no more than 12 or so characters work well on this property.
companyLogo	ImagePath (read/write String)	Image to be shown next to the *companyTitle* on the Log In screen. The presented image will not be scaled on any way, so it must have already the right size. Recommended size is about 200 pixels wide and 40 pixels height for non-retina displays (iPad 2) and 400x80 for retina displays. A default image will be shown if you leave this field empty. If you want to remove the default image pass a string containing a single space to this property.
NOTE: Some text displayed on the Log In screen will be drawn in White or in a Dark Grey color depending on the specified *backgroundColor*. See note on *backgroundColor* on Item Properties for more information		

Transferring project users to the HMI Pad Service.

Project users are transferred along with your project when you upload it to the HMI Pad Service. However no login information is kept on the HMI Pad Service.

An user with username "admin" is implicitly available as long as you created at least one user. When you log into an user while in view mode, the Application Panel is not available, particularly on HMI. This allows you to create a closed application that will run only your project.

By convention, every time a project is downloaded from the server the app will start with the implicit admin user logged in. The same applies when projects are redeemed or updated on the HMI app.

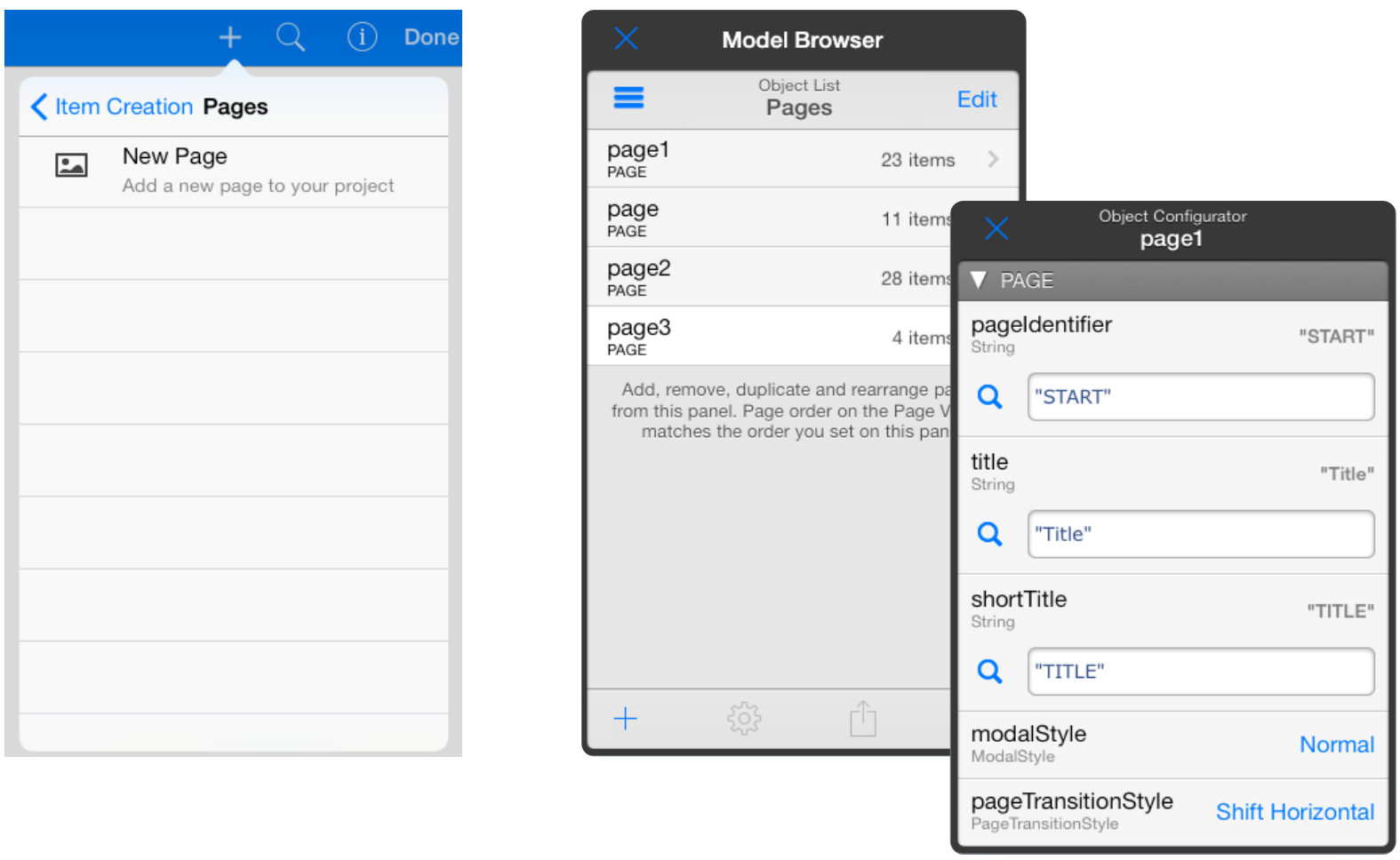
Only the admin user is allowed to redeem or update projects on HMI. However, once a project user is logged in, the app prevents further access to the Application panel and thus no integrator server related options are available.

To gain access to the Application panel and full app features in HMI you must log into the admin user. Therefore, it is important that the password associated with the admin user is only known for those who are responsible of project updates or the management of projects in HMI.

For more information about users and user accounts refer to the **HMI Pad Deployment Guide**

7.2 Page Object

You can place visual items on a pages. Pages themselves have their own properties.

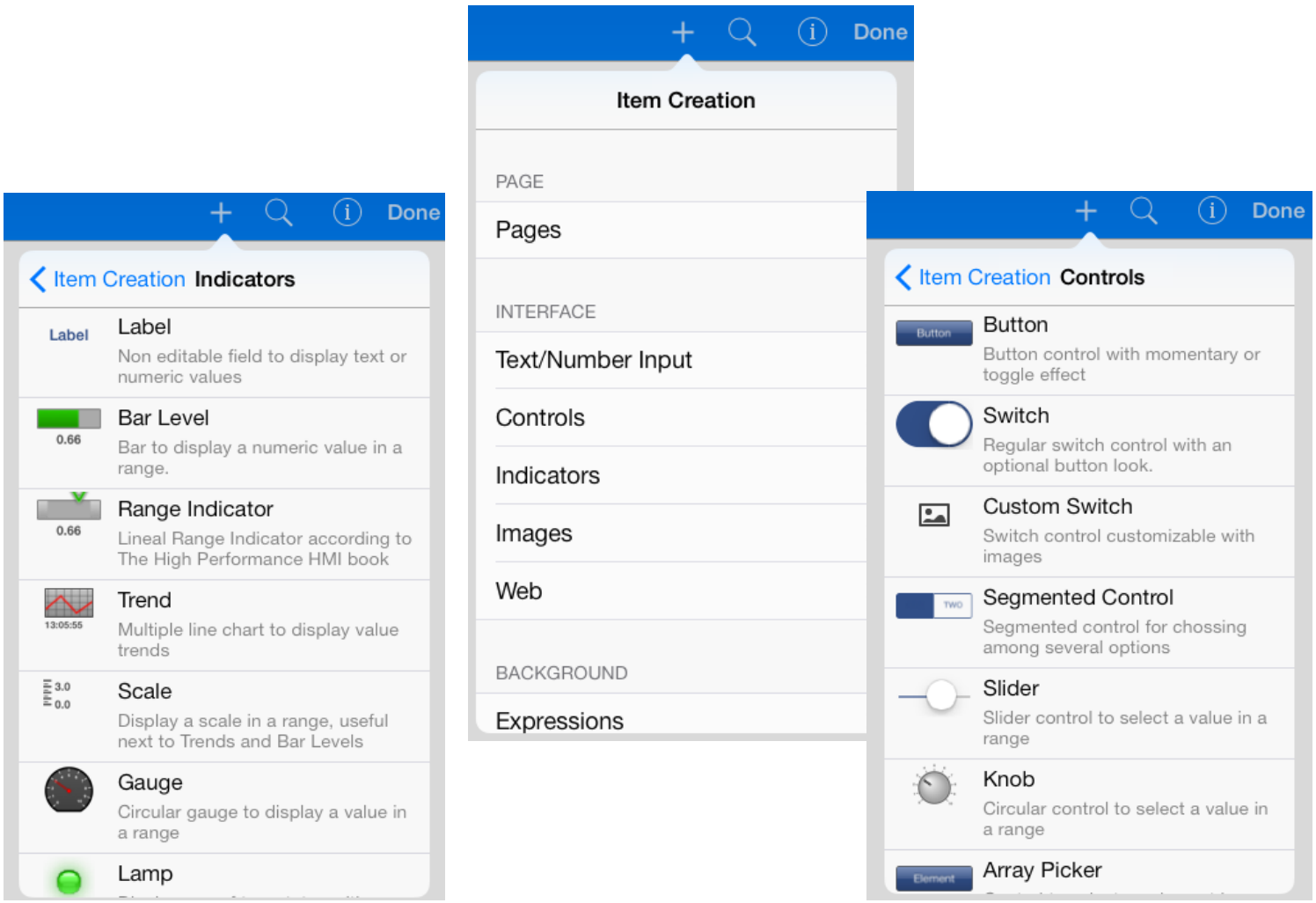


PROPERTY	TYPE	DESCRIPTION
pageIdentifier	(constant String)	String identifying the page for the purposes of programatic page navigation. Adding unique texts to this property on different pages is the basis for programmatic page navigation. You can cause a page switch by setting a particular page identifier to the $Project.currentPageIdentifer property through expressions, or by entering page identifiers on the linkToPage or linkToPages properties of Buttons, Segmented Controls or Array Pickers.
title	(constant String)	Shown at the center of the project viewer toolbar when this page is the visible one.
shortTitle	(constant String)	Shown below the page thumbnail on the Page Navigator panel
modalStyle	(constant Number)	Identifies whether the page should behave modally. Pages with this property set to 'Modal' will always animate in and out taking into account its own transitionStyle. Otherwise page transitions will be automatically animated with the transitionStyle of the in or out page accounting for the actual order of pages in the Page Navigator

PROPERTY	TYPE	DESCRIPTION
pageTransition-Style	(constant Number)	Identifies the transition style applicable to the page. Possible values are: **None**, **Fade**, **Curl**, **Shift Horizontal**, **Shift Vertical** and **Flip**.
enabledInterfacel-diom	(constant Number)	Determines which interface idioms this page will be available for. Possible values are **iPad & iPhone**, **iPad**, **iPhone**. When setting this property to only one family of devices, such as iPhone, you prevent this page to appear on the page navigator for other device families.
color	Color (read/write String or Number	A color to be applied to the page. Colors can be given as a text string identifying the color by name as listed in http://www.w3schools.com/cssref/css_colornames.asp.or given as RGBA coordinates in one of the forms "#RRGGBB", "#RRGGBB/AA". Possible color names are available through the Model Seeker. Tap on the loupe next to the property and then select 'Color List' for a list of colors. Colors can be also be given as a Number resulting from the SM.Color() system method.
image	ImagePath (read/write String)	Image to be shown as a background on the page. If the image is or contains transparency, the color specified on the *color* property will still show underneath.
aspectRatio	(constant Number)	Aspect ratio to be applied to the image. The aspect ratio determines how the image is resized and scaled when the size of its container changes. Possible Values are: • **None**: Centers the image in its container bounds, keeping the original size and proportions. • **Aspect Fill**: Scales the image to fill the size its container. Some portion of the image will be clipped to fill its container bounds • **Aspect Fit**: Scales the image to fit the size of its container by maintaining the aspect ratio. Any remaining area of the container bounds is transparent. • **Scale to Fill**: Scales the content to fit the size of itself by changing the aspect ratio of the content if necessary.
hidden	Bool (read/write Number)	When zero (or false) the page thumbnail is visible on the page navigator. This is the default. Otherwise the page will not appear on the page navigator when the app is in view mode. Hiding pages enable you to prevent end users from moving to a particular page -or all of them- except through your own page flow implementation.

7.3 Interface Objects

In this section we cover Items with a visual component that can be placed on pages



Visual Items placed on Pages have the following properties:

PROPERTY	TYPE	DESCRIPTION
framePortrait	(constant Rect)	A Rect with the coordinates of the item on screen.when the interface is in portrait orientation The (x, y) are the top left point coordinates and (width, height) are what they imply expressed in points.
frameLandscape	(constant Rect)	A Rect representing the coordinates of the item on screen.when the interface is in landscape orientation.
backgroundColor	Color (read/write String or Number)	The color to be applied as a background for the item. See description of the *color* property on the **page** object for a discussion on possible values. See note below on the use of dark/bright or transparent backgrounds on some objects.
hidden	Bool (read/write Number)	When zero (or false) the item is shown and visible on the page. Otherwise it is hidden.

NOTE:

Some visual Items use the brightness of the color specified on *backgroundColor* to modify or select the color that is used to draw certain elements. For example a trend indicator will draw times in black or in white line depending on the brightness of its background. White text will be drawn for dark backgrounds, and black text will be drawn for bright backgrounds. This is also applicable to transparent backgrounds if "ClearWhite" or "ClearBlack" is set as *backgroundColor*

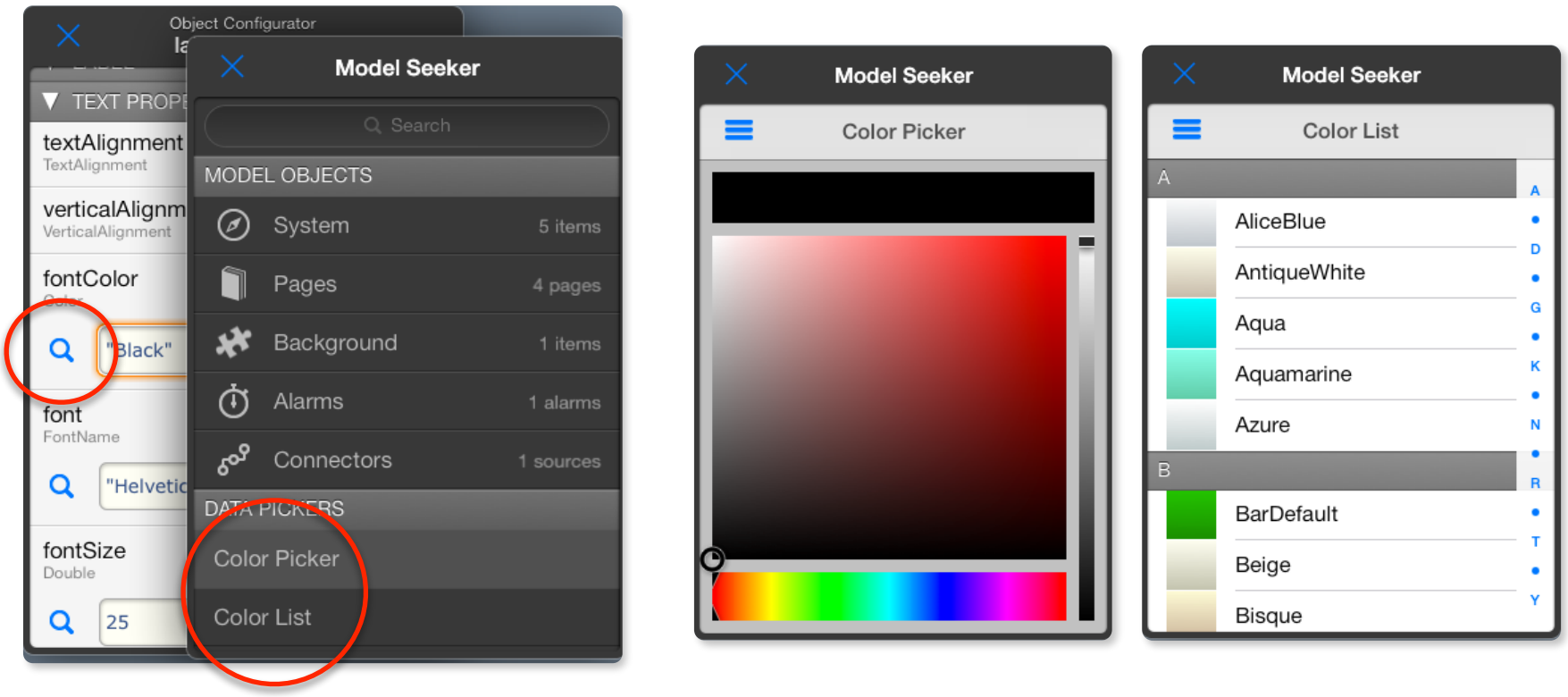
7.3.2 Controls

Control items are visual objects you place on pages that can be operated by users. They all have the following properties.

PROPERTY	TYPE	DESCRIPTION
continuousValue	Any (read only Value)	This property contains the same value of the *value* property, however the *continuousValue* property tracks user action as it happens and before the *value*.is actually updated. For example when an user slides a slider control, the *continuosValue* property will continuously reflect the position of the slider, while the value property will be updated on release of the slider. The *continuousValue* can be used in combination with *verificationText* to catch undesired user actions or ask for confirmation before the control *value* actually changes.
enabled	Bool (read/write Number)	When false (the default is true) the control will be disabled for user action. When a control is disabled its value can still be changed through expressions but user action on it is ignored or disabled.
verificationText	String (read/write String)	You can provide a verification text can to ask for confirmation before an user action is accepted. Controls will display a Confirmation Alert with a Verification Text if specified. Example: "Are you Sure?" With conditional expressions you can check against the *continuousValue* property to provide appropriate messages or to implement conditional verification of values. For example consider the following mySetPointControl.continuousValue>80?"This can be dangerous, are you sure?":"" in this case a Verification Alert will only be presented for values above 80. If dismissed, the *value* will remain the previous one and no change event will be sent.
active	Bool (read/write Number)	When this property is **false** user interaction will be disabled for this control. For some controls appearance is also changed to a flatter style.

7.3.2.1 Input Fields

The following properties are common on several visual Items that present text or are related with text.

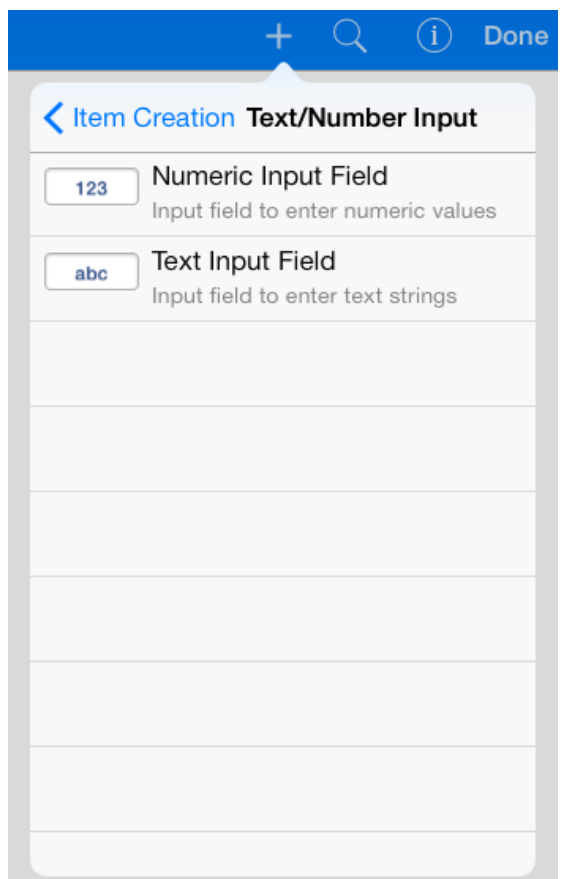


PROPERTY	TYPE	DESCRIPTION
textAlignment	(constant Number)	Horizontal alignment of text. Possible values are **Left, Center** and **Right**
verticalTextAlign-ment	(constant Number)	Vertical alignment of text. Possible values are **Top, Middle** and **Bottom**

PROPERTY	TYPE	DESCRIPTION
fontColor	Color (read/write String or-Number)	Color of the Font for this Item. See description of the *color* property on the **page** object for a discussion on possible values.
font	FontName (read/write String)	A String with a Typography Font name. Possible font names are available through the Model Seeker. Tap on the loupe next to the property and then select 'Font Picker' for a list of fonts. Example: "Helvetica"
fontSize	Double (read/write Number)	A Number representing the font size.

7.3.2.1.1 Text Field

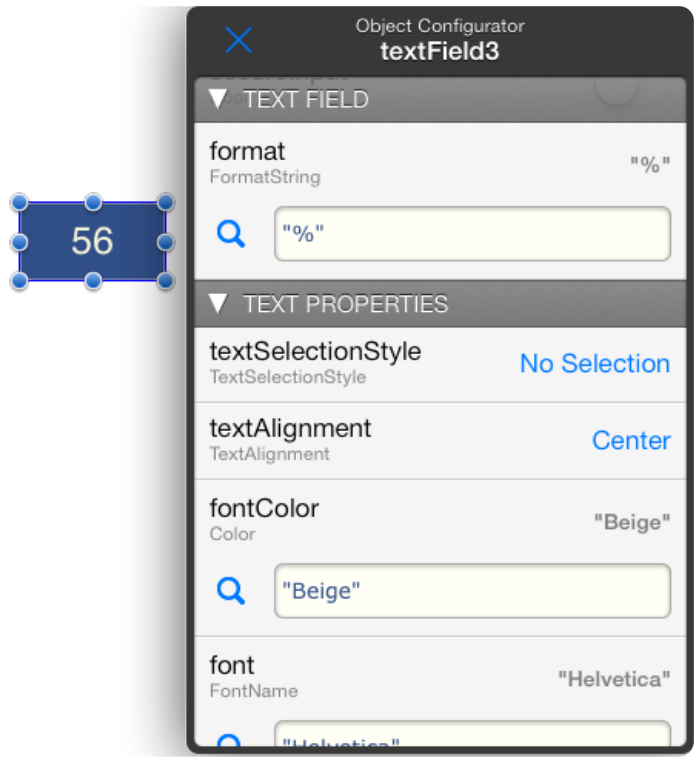
A control item providing the interface for entering a text on a field.



PROPERTY	TYPE	DESCRIPTION
value	String (read/write String)	The String representing the text displayed or entered by the user
style	(constant Number)	A style for the control. Possible values are **Plain** and **Bezel**
secureInput	Bool (constant Number)	Identifies whether the text object should hide the text being entered. Useful for entering passwords or data that should not be left immediately visible.
format	FormatString (read/write String)	A format String for the text displayed by the control. Format strings entered here must apply to strings. See format specifiers and the format function for a complete discussion on possible values.

7.3.2.1.2 Numeric Field

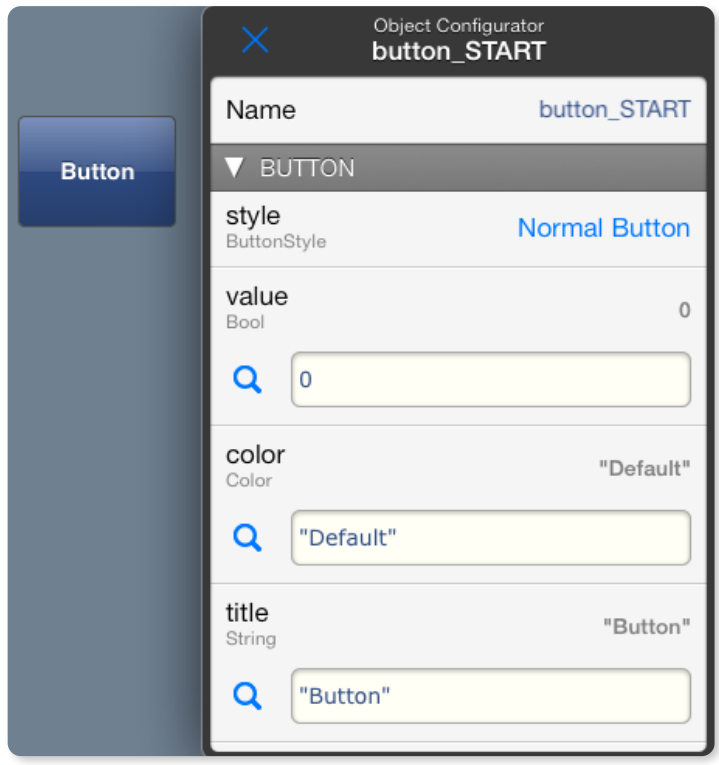
A control item providing the interface for entering a number on a text field..



PROPERTY	TYPE	DESCRIPTION
value	Double (read/write Number)	The Number that is displayed by the control.
style	(constant Number)	A style for the control. Possible values are **Plain** and **Bezel**
secureInput	Bool (constant Number)	Identifies whether the text object should hide the text being entered. Useful for entering passwords or data that should not be left immediately visible.
format	FormatString (read/write String)	A format String for the value displayed by the control. Format strings entered here should apply to numeric data representations. See format specifiers and the format function for a complete discussion on possible values. Example: "%1.2f"
minValue	Double (read/write Number)	The minimum admissible value on user input. An entry of a value below this will be set to the minimum.
maxValue	Double (read/write Number)	The maximum admissible value on user input. An entry of a value above this will be set to the maximum.

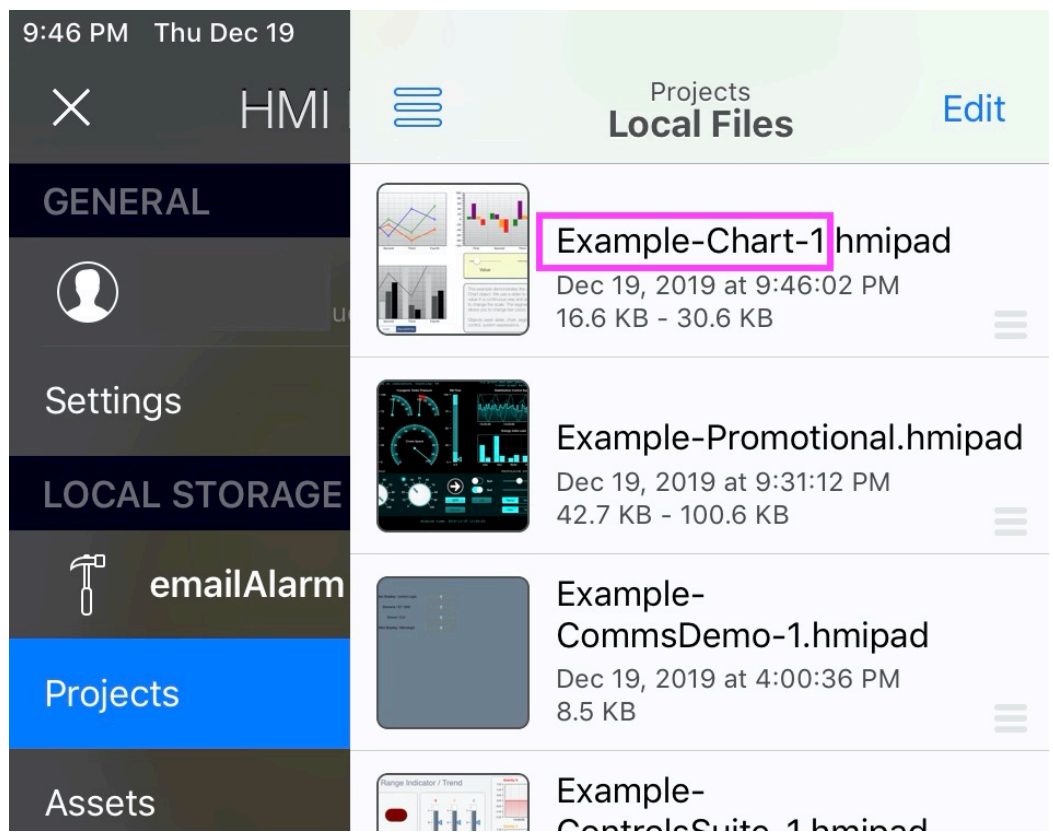
7.3.2.2 Button

A control providing the interface of a button.



PROPERTY	TYPE	DESCRIPTION
style	(constant Number)	A style for the button control. Possible values are: • **Normal Button:** Normal behavior of a regular button. The button value is 1 as it is pressed (down) and returns to 0 when released. • **Toggle Button:** The button switches its previous state just like a switch control. Particularly, the button goes to 0 (released) if it was pressed. Or the button goes to 1 (pressed) if it was released. The actual action occurs on the touch up gesture of the user on the button. • **Touch Up Button:** The button quickly goes to 1 and then to 0 upon user tap. The actual action occurs on the touch up gesture of the user on the button.
value	Bool (read/write Number)	The current value (0 or 1) of the button.
color	Color (read/write String or Number)	A color applied to the button control. See description of the *color* property on the **page** object for a discussion on possible values.
title	String (read/write String	The text title that will show in the button.

PROPERTY	TYPE	DESCRIPTION
image	ImagePath (read/write String)	Image to show for the button. Note that since this is a writable property you can use expressions to perform any custom image change depending on button properties or others.
aspectRatio	(constant Number)	Aspect ratio to be applied to the button image. See description of the *aspectRatio* property for the **page** object for detailed information on possible values.
linkToPage	String (read/write String)	Any non empty string matching a page *pageIdentifier* will cause a page switch to the referring page upon button touch. Page switch will be made on the onset of the 1 state of the button, thus the Touch Up Button button *style* is recommended to mimic the standard behavior of iOS touch buttons. **Example**: "PageOne" Upon tapping on the button the interface will switch to a page with identifier "PageOne".
linkToProject	String (read/write String)	Any non empty string matching a Project Name will cause a project switch to the referring Project upon button touch. Project switch will be made on the onset of the 1 state of the button, thus the Touch Up Button button *style* is recommended to mimic the standard behavior of iOS touch buttons. **Note:** Button *Style* property has to be set to *Normal Button* for *linkToProject* to work. **Example**: “Example-Chart-1“ Upon tapping on the button the interface will switch to a Project with name “Example-Chart-1".



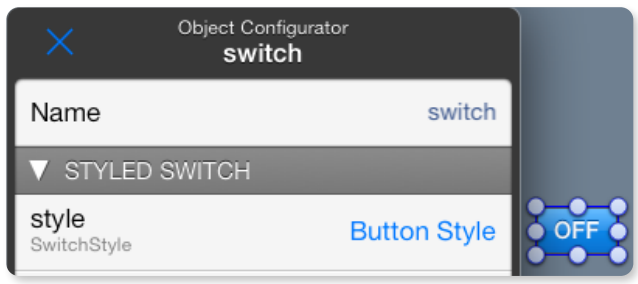
7.3.2.3 Switch

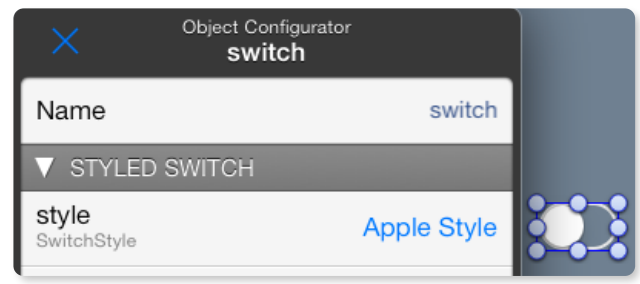
Properties common to switch controls

PROPERTY	TYPE	DESCRIPTION
value	Bool (read/write Number)	The current value (0 or 1) of the switch.

7.3.2.3.1 Styled Switch

A control providing the interface of a regular switch.

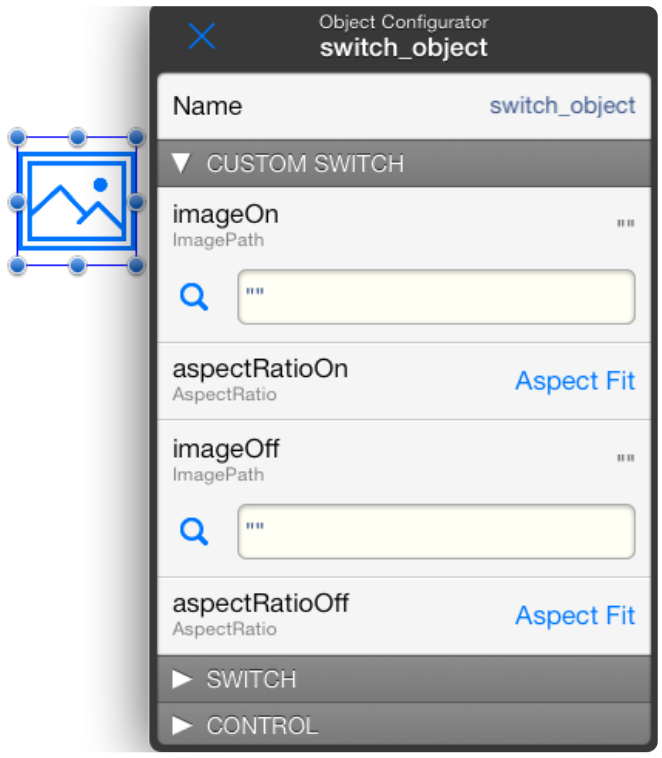


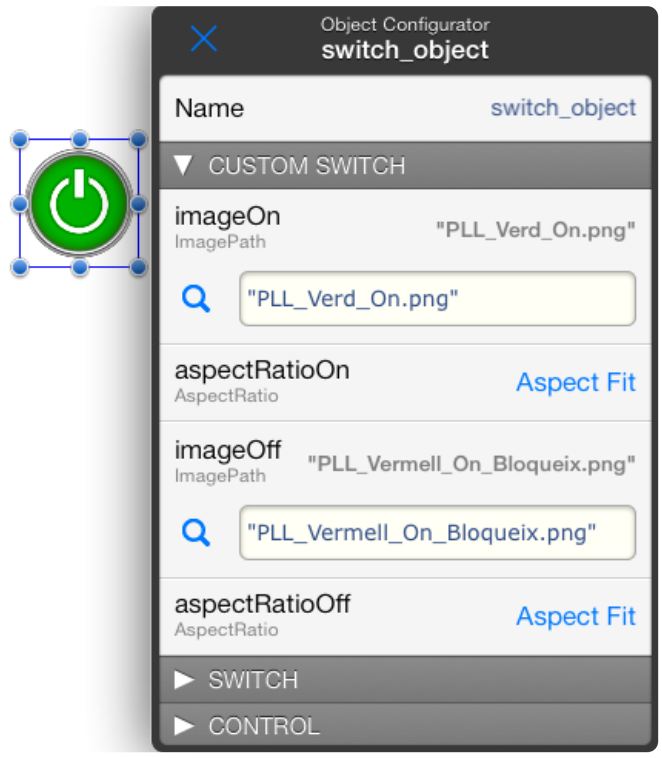


PROPERTY	TYPE	DESCRIPTION
style	(constant Number)	A style for the switch control. Possible values are **Apple Style** and **Button Style**. An Apple Style button looks and behaves as a regular iOS Switch. A Button Style switch looks like a button with two states
color	Color (read/write String or Number)	The color of the switch control. See description of the *color* property on the **page** object for a discussion on possible values.

7.3.2.3.2 Custom Switch

A control providing the interface of a Switch made of custom images.

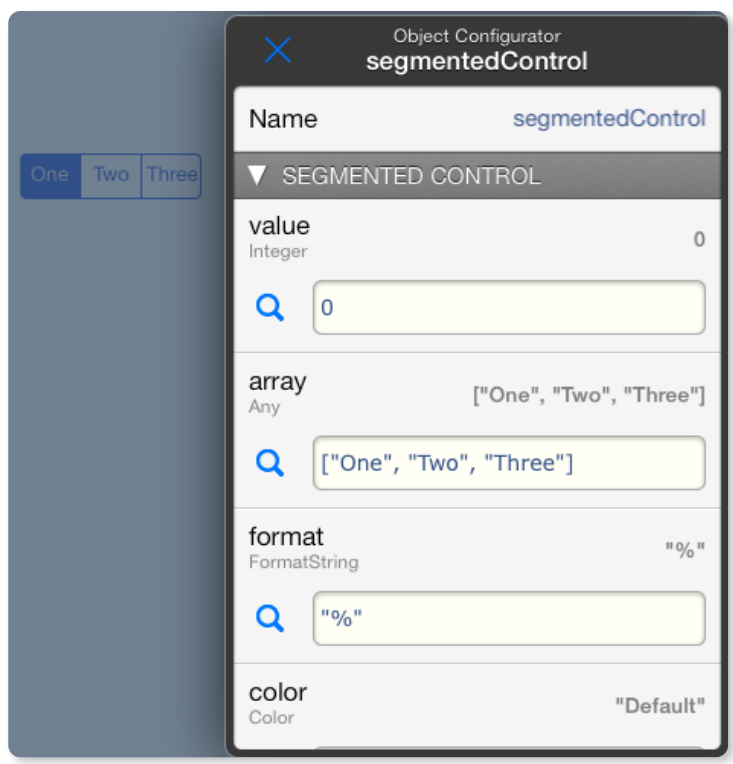




PROPERTY	TYPE	DESCRIPTION
imageOn	ImagePath (read/write String)	Image to show for the 'On' state of the control.
aspectRatioOn	(constant Number)	Aspect ratio to be applied to the 'On' image. See description of the *aspectRatio* property for the **page** object for detailed information on possible values.
imageOff	ImagePath (read/write String)	Image to show for the 'Off' state of the control.
aspectRatioOff	(constant Number)	Aspect ratio to be applied to the 'Off' image. See description of the *aspectRatio* property for the **page** object for detailed information on possible values.

7.3.2.4 Segmented Control

An object providing the interface for a segmented control.

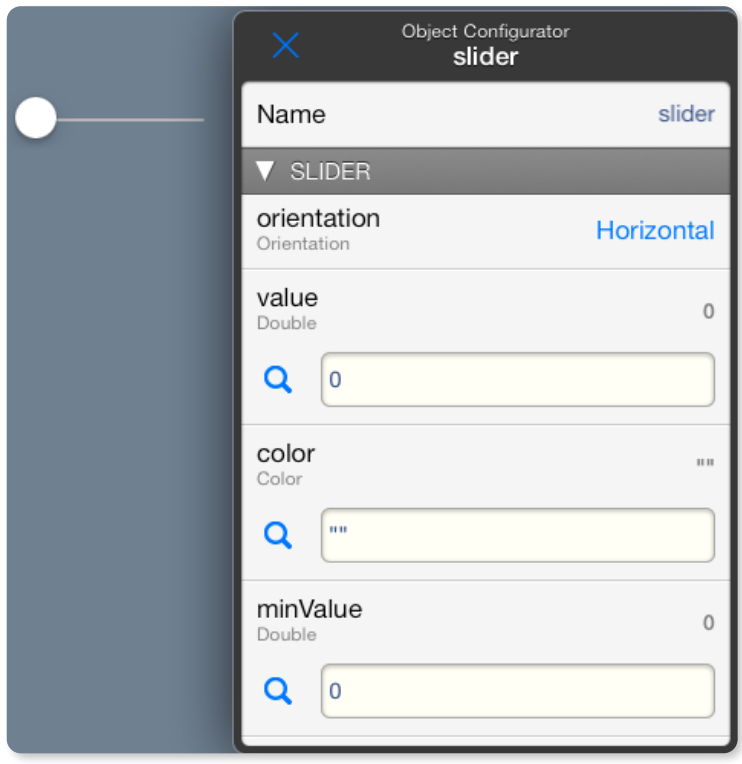


PROPERTY	TYPE	DESCRIPTION
value	Integer (read/write Number)	The index of the currently selected segment starting with 0 and going left to right
array	Array (read/write Array)	An array containing Strings or other data types. The number of elements in the array determine the number of segments on the segmented control. Array elements are displayed as text titles on segments. Example: ["One","Two","Three"]
format	FormatString (read/write String)	A format String for text titles on segments. Format strings entered here must apply to numeric data representations. See format specifiers and the format function for a complete discussion on possible values. Example: "Segment %s"
color	Color (read/write String or Number)	The color of the segmented control. See description of the *color* property on the **page** object for a discussion on possible values.

PROPERTY	TYPE	DESCRIPTION
linkToPages	Array (read/write Array)	An array of strings matching page *pageIdentifier.* Any change on the segmented control value will cause the interface to switch to the page matching the identifier at the value index. Example: ["PageOne","PageTwo","PageThree"] Upon tapping on the first segment (the value property is 0) the interface will switch to page with identifier "PageOne" and so on.

7.3.2.5 Slider

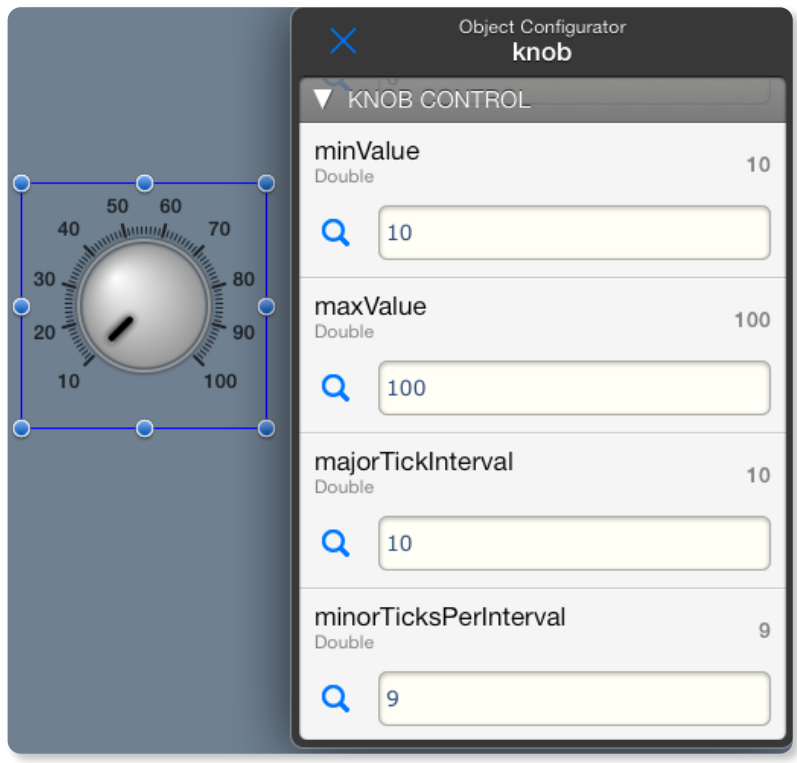
An object providing the interface of a slider control.



PROPERTY	TYPE	DESCRIPTION
orientation	(constant Number)	The orientation of the slider control. Possible values are **Horizontal** and **Vertical**
value	Double (read/write Number)	The current value of the slider control
color	Color (read/write String or Number)	The color of the slider control. See description of the *color* property on the **page** object for a discussion on possible values.
minValue	Double (read/write Number)	The minimum value of the range presented by the control.
maxValue	Double (read/write Number)	The maximum value of the range presented by the control.
format	FormatString (read/write String)	This property is currently unused/reserved

7.3.2.6 Knob Control

A control providing the interface of a rotary knob.

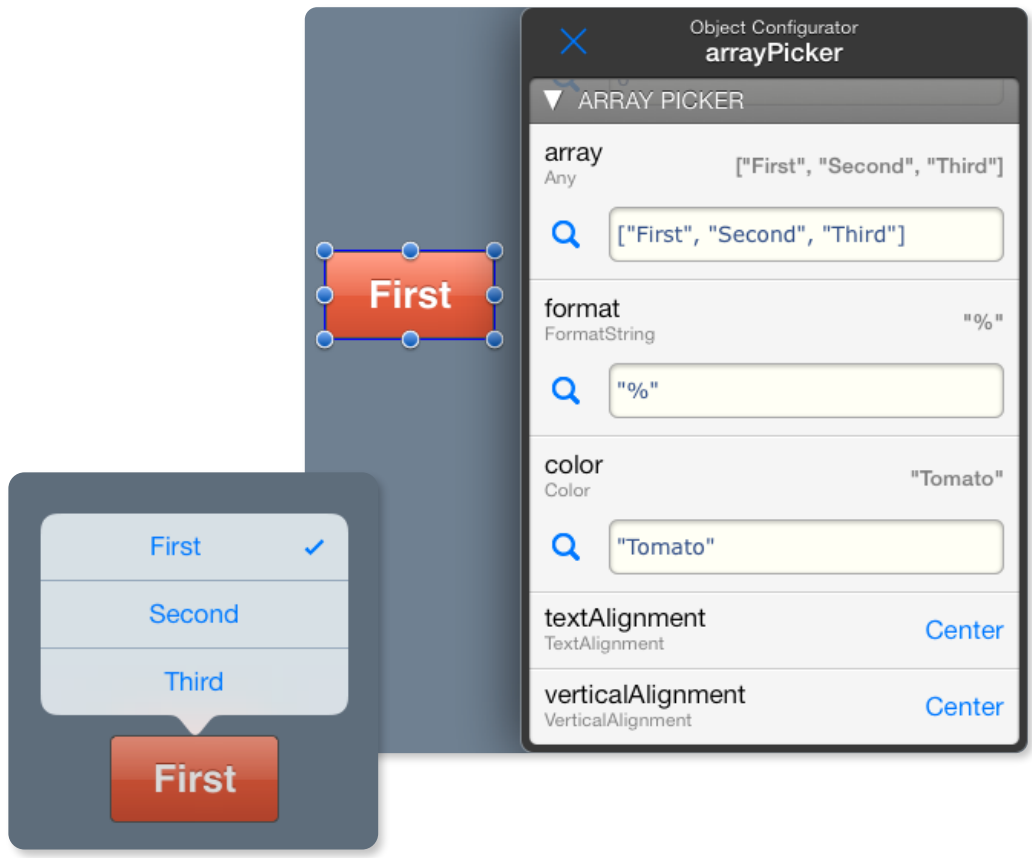


PROPERTY	TYPE	DESCRIPTION
style	(constant Number)	This property is currently unused/reserved
thumbStyle	(constant Number)	A style for the thumb element of the knob control control. Possible values are **Segment** and **Thumb**.
value	Double (read/write Number)	The current value of the knob control
minValue	Double (read/write Number)	The minimum value of the range presented by the control.
maxValue	Double (read/write Number)	The maximum value of the range presented by the control.
majorTickInterval	Double (read/write Number)	The value interval between major ticks. For example for a knob control ranging from 0 to 100 you could set *majorTickInterval* to 20 to space each tick by 20 units. If *majorTickInterval* is set to 0 (zero) no ticks will be drawn.
minorTicksPerInterval	Integer (read/write Number)	The number of minor ticks that must be displayed between major ticks. If *minorTicksPerInterval* is set to 0 no minor ticks will be drawn.

PROPERTY	TYPE	DESCRIPTION
format	FormatString (read/write String)	The format string to be applied to the interval values that presented next to major tick intervals.
label	String (read/write String	An optional text label that will show in the control.
tintColor	Color (read/write String or Number)	A tint color to apply to the control. See description of the *color* property on the **page** object for a discussion on possible values.
thumbColor	Color (read/write String or Number)	A color to apply to the thumb element of the control. See a description of the *color* property on the **page** object for a discussion on possible values.
borderColor	Color (read/write String or Number)	The color of the border of the control. See description of the *color* property on the **page** object for a discussion on possible values.
NOTE: Tick lines and interval values texts will be drawn in White or in Black color depending on the specified *backgroundColor*. See note on *backgroundColor* on Item Properties for more information		

7.3.2.7 Array Picker

A control providing the interface for selecting an array element.



PROPERTY	TYPE	DESCRIPTION
index	Integer (read/write Number)	The index of the currently selected element on the array starting with 0
element	Any (read only)	The currently selected element in the array.
array	(read/write Array)	An array containing Strings or other data types. The elements in the array determine the available options for selection using this control. Array elements are displayed as text on a list that pops up on taping the control. The selected element is displayed as a text label in the control. Example: ["One","Two","Three"]
format	FormatString (read/write String)	A format String for texts on the pop up list and the text label displayed by the control. See format specifiers and the format function for a complete discussion on possible values. Example: "Option %s"

PROPERTY	TYPE	DESCRIPTION
color	Color (read/write String or Number)	The color of the array picker control. See description of the *color* property on the **page** object for a discussion on possible values.
linkToPages	Array (read/write Array)	An array of strings matching page *pageIdentifier.* Any change on the array picker value will cause the interface to switch to the page matching the identifier at the value index. Example: ["PageOne","PageTwo","PageThree"] Upon selecting the first segment (the value property is 0) the interface will switch to page with identifier "PageOne" and so on.

7.3.2.8 Dictionary Picker

A control providing the interface for selecting an entry in a dictionary.

PROPERTY	TYPE	DESCRIPTION
key	Any (read/write Value)	The key of the currently selected entry in the dictionary
value	(read only Value)	The value associated with the selected key in the dictionary
dictionary	(read/write Dictionary)	A dictionary containing key:value pairs. The entries in the dictionary determine the available options for selection using this control. Dictionary keys are displayed as text on a list that pops up on taping the control. The value associated with the selected key is displayed as a text label in the control. Example: {"Second":2, "Third":3, "First":1}
format	FormatString (read/write String)	A format String for the text label displayed by the control. This format applies to the value on display associated with the selected key. See format specifiers and the format function for a complete discussion on possible values. Example: "Value %s"
color	Color (read/write String or Number)	The color of the dictionary picker control. See description of the *color* property on the **page** object for a discussion on possible values.

7.3.2.9 Tap Gesture Recognizer

An control providing the interface for a tap gesture recognizer

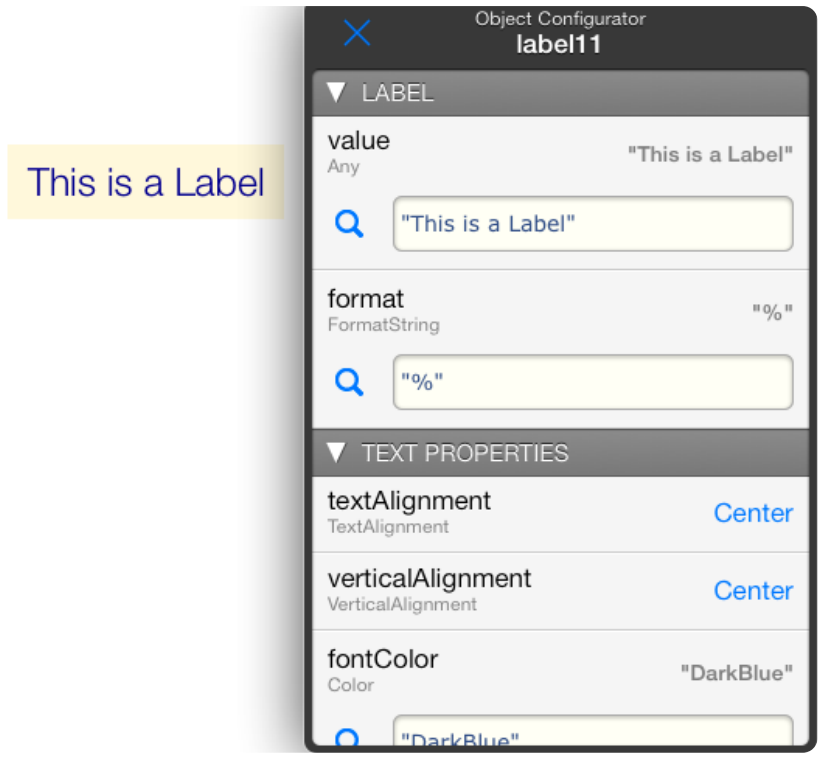
PROPERTY	TYPE	DESCRIPTION
tap	(read only Number)	The recognized status of the control. This value is 0 on stand-and goes to 1 to indicate that a tap gesture on the control has just been recognized. The behavior is similar to a Touch UP style button. When a tap gesture is recognized the property value goes to 1 for an instant and then quickly returns to 0.
numberOfTaps	Integer (constant Number)	The number of taps for the gesture to be recognized. This means how many taps the user needs to perform on the control to trigger an action. For instance set this to 2 to implement a control requiring a double tap to perform an action.
numberOfTouches	Integer (constant Number)	The number of fingers required to tap for the gesture to be recognized. For instance set this to 2 to implement a control requiring a two-fingers tap to perform an action.

7.3.3 Indicators

Indicators are visual objects on pages designed to present information in specific ways.

7.3.3.1 Label

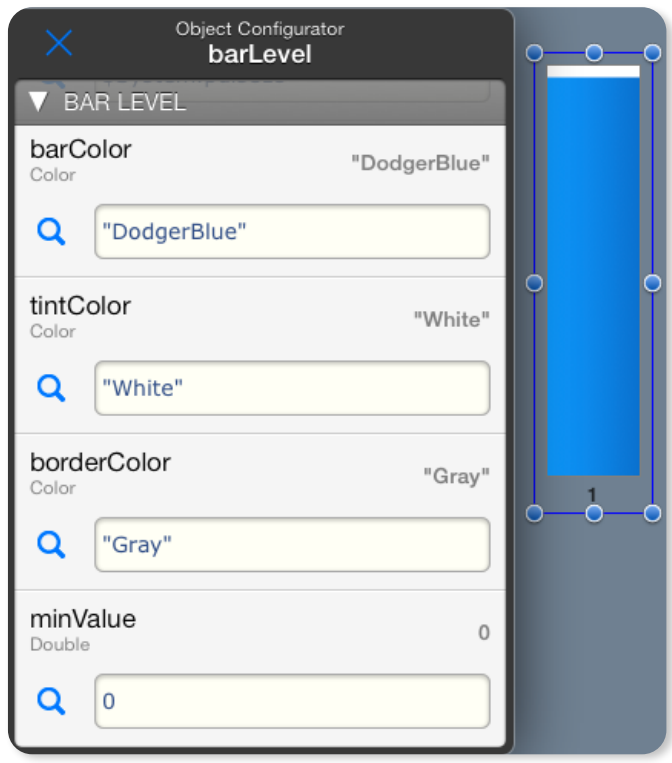
An indicator item providing the interface for displaying a text label.



PROPERTY	TYPE	DESCRIPTION
value	Any (read/write Value)	The value displayed by the control.
format	FormatString (read/write String)	A format String for the value displayed by the control. Format strings entered here apply to the actual type of the value. See format specifiers and the format function for a complete discussion on possible values.

7.3.3.2 Bar Level

An Indicator presenting a numeric value as a dynamic bar.

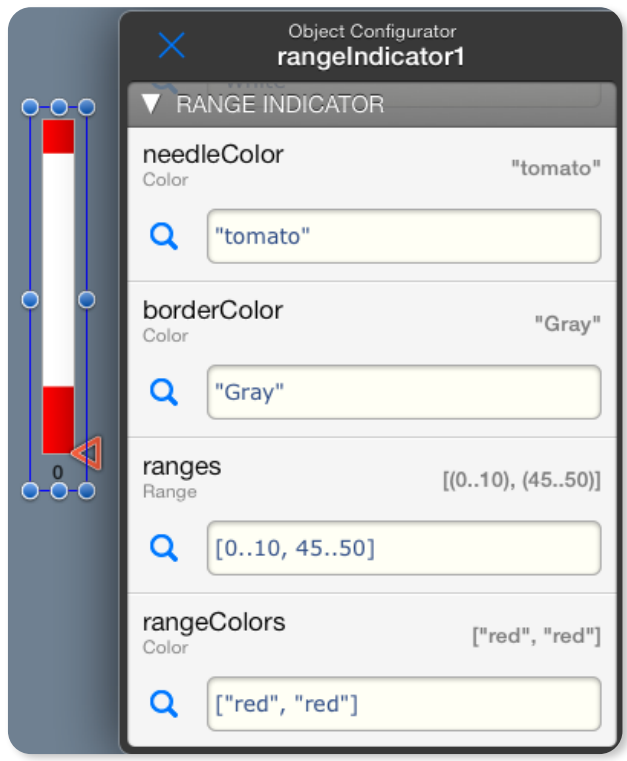


PROPERTY	TYPE	DESCRIPTION
direction	(constant Number)	The direction of the bar control for forward value changes. Possible values are **Left**, **Up**, **Right**, and **Down**
value	Double (read/write Number)	The current value of the bar level indicator
barColor	Color (read/write String or Number)	The color of the bar. See description of the *color* property on the **page** object for a discussion on possible values.
tintColor	Color (read/write String or Number)	The color of the area below the bar. See description of the *color* property on the **page** object for a discussion on possible values.
borderColor	Color (read/write String or Number)	The color of the border line. See description of the *color* property on the **page** object for a discussion on possible values.
minValue	Double (read/write Number)	The minimum value of the range presented by the indicator.

PROPERTY	TYPE	DESCRIPTION
maxValue	Double (read/write Number)	The maximum value of the range presented by the indicator.
format	FormatString (read/write String)	A format String for the value displayed by the control next to the bar. Set this to an empty string if no text must be displayed. Format strings entered here apply to the actual type of the value. See format specifiers and the format function for a complete discussion on possible values.
NOTE: The displayed text value will be drawn in White or in Black color depending on the specified *backgroundColor*. See note on *backgroundColor* on Item Properties for more information		

7.3.3.3 Range Indicator

An advanced Indicator presenting a numeric value such as a set point in the context of several ranges. Also called a High Performance Indicator.



PROPERTY	TYPE	DESCRIPTION
direction	(constant Number)	The direction of the bar control for forward value changes. Possible values are **Left**, **Up**, **Right**, and **Down**
value	Double (read/write Number)	The presented current value of the range indicator
minValue	Double (read/write Number)	The minimum value of the total range presented by the indicator.
maxValue	Double (read/write Number)	The maximum value of the total range presented by the indicator.
format	FormatString (read/write String)	A format String for the text value displayed by the control next to the range bars. Set this to an empty string if no text must be displayed. Format strings entered here apply to the actual type of the value. See format specifiers and the format function for a complete discussion on possible values.
tintColor	Color (read/write String or Number)	The color of the area below the range bars. See description of the *color* property on the **page** object for a discussion on possible values.

PROPERTY	TYPE	DESCRIPTION
needleColor	Color (read/write String or Number)	The color of the triangular needle representing current value of the indicator. See description of the *color* property on the **page** object for a discussion on possible values.
borderColor	Color (read/write String or Number)	The color of the border line. See description of the *color* property on the **page** object for a discussion on possible values.
ranges	Array of Ranges (read/write)	An array containing ranges. Ranges as presented as colored bars. Example: [0..15, 85..100]
rangeColors	Array of Colors (read/write)	An array containing colors. The size of the *rangeColors* should match the size of *ranges*. If *rangeColors* is shorter than *ranges*, default colors will be applied, if it is larger the excess colors will be ignored.
NOTE: The displayed text value will be drawn in White or in Black color depending on the specified *backgroundColor*. See note on *backgroundColor* on Item Properties for more information		

7.3.3.4 Data Presenter

A Data Presenter allows you to present historical data from a SQLite database. Databases on HMI Pad are created with the Data Logger object (see section Historical data and Data Logger objects and the Data Logger object for more information).

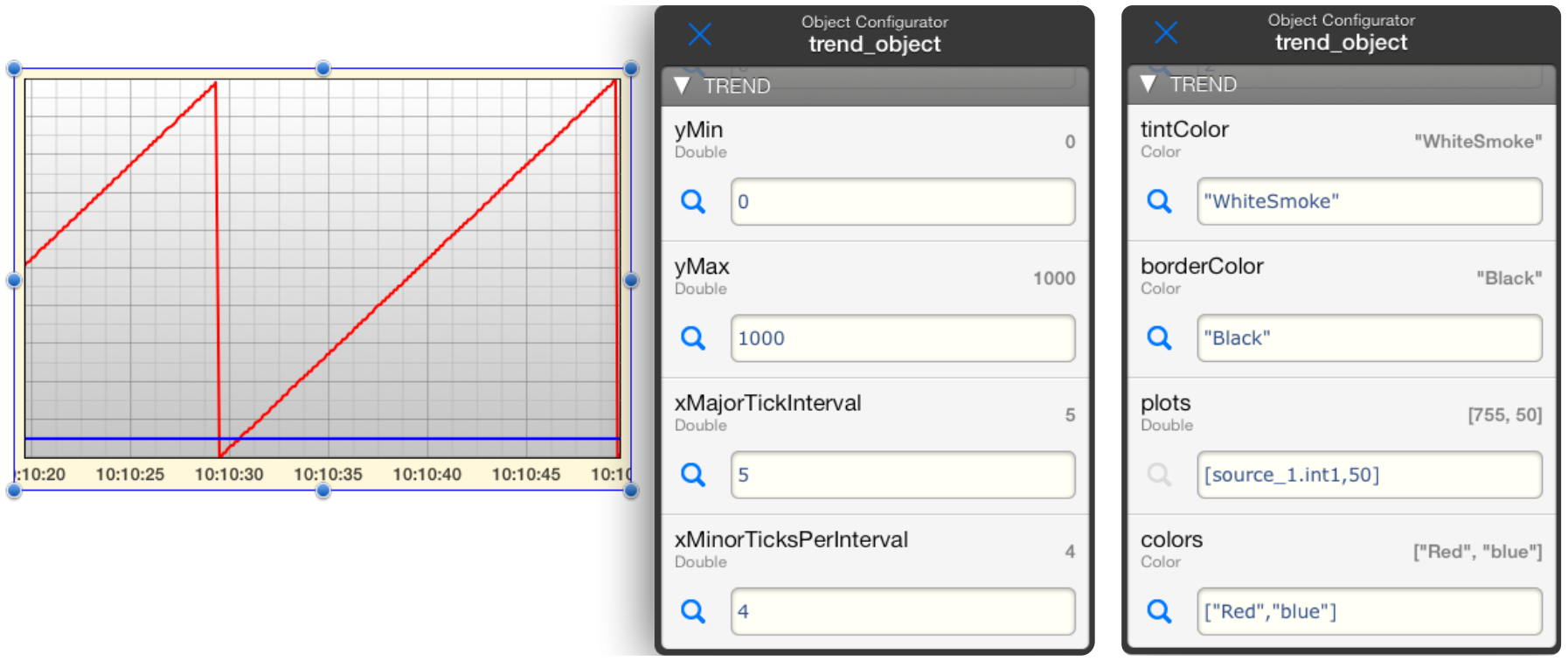
Data can be presented as it is being generated on a real time basis, or can be picked from any time in the past.

The following properties are available to objects acting as data presenters.

PROPERTY	TYPE	DESCRIPTION
databaseTimeRange	(constant Number)	Provides the time range for the database. For possible values see description of the same property name for the **data logger** object.
databaseName	(constant String)	The base name for the SQLite database file associated with this object. See description for the same property name on the **data logger** object.
referenceTime	Absolute Time (read/write)	Provides a reference time to search for the appropriately named database file to use. The object will attempt to open a database with the file name implicit on *databaseName* property composed with the *databaseTimeRange* and *referenceTime* properties. TO DO
databaseFile	(read only String	Contains the full database file name that is currently being updated by this data logger. TO DO

7.3.3.4.1 Trend

An Indicator providing the interface for a time based trend for presenting real time data.



PROPERTY	TYPE	DESCRIPTION
style	(constant Number)	This property is currently unused/reserved
updatingStyle	(constant Number)	The updating style for the trend indicator. Possible values are: • **Continuous:** The trend moves smoothly. Note that this is very CPU intensive, -specially for big sized trends- and may drain your battery faster than usual. • **Discrete**: The trend moves or updates every half a second.
options	Dictionary (read/write	An options dictionary. Supported keys are: • **colorFills**: Contains an array of colors to decorate plots by drawing a gradient below their lines.
plotInterval	Double (read/write Number)	The number of seconds -or time interval-. plots are visible on the trend. As time passes plots move from right to left. A negative *plotInterval* value will cause the trend to move in reverse direction.
intervalOffset	Double (read/write Number)	The time offset for the trend window presenting plots. A value or zero means real time updates. A positive value fixes the trend window in the past by *intervalOffset* seconds.

PROPERTY	TYPE	DESCRIPTION
yMin	Double (read/write Number)	Minimum value on the vertical axis range.
yMax	Double (read/write Number)	Maximum value on the vertical axis range.
xMajorTickInterval	Double (read/write Number)	The time interval between major ticks for the horizontal -time- axis. If x*MajorTick-Interval* is set to 0 (zero) no ticks will be drawn.
xMinorTicksPerIn-terval	Integer (read/write Number)	The number of minor ticks drawn between major ticks on the horizontal axis. If x*MinorTicksPerInterval* is set to 0 no minor ticks will be drawn.
yMajorTickInterval	Double (read/write Number)	The value interval between major ticks for the vertical axis. If y*MajorTickInterval* is set to 0 (zero) no ticks will be drawn.
yMinorTicksPerIn-terval	Integer (read/write Number)	The number of minor ticks drawn between major ticks on the vertical axis. If y*Mi-norTicksPerInterval* is set to 0 no minor ticks will be drawn.
tintColor	Color (read/write String or Number)	A color to apply to the time window of the trend. See description of the *color* prop-erty on the **page** object for a discussion on possible values.
borderColor	Color (read/write String or Number)	The color of the border of the trend indicator. See description of the *color* property on the **page** object for a discussion on possible values.
plots	Array of Numbers (read/write)	An array containing the real time values of the plot lines. The number of elements in the array identifies the number of plot lines drawn. Example : [source.tag1, source.tag2]
colors	Array of Colors (read/write)	An array containing colors. The size of the *colors* should match the size of *plots*. If *colors* is shorter than *plots*, default colors will be applied, if it is larger the excess colors will be ignored.
NOTE: Tick lines and time texts will be drawn in White or in Black color depending on the specified *backgroundColor*. See note on *backgroundColor* on Item Properties for more information		

Performance Considerations when using trends

PLC communications. Because trends follow value changes at all times, any PLC tags that ultimately are directly or indirectly involved in trends are continuously polled in order to keep consistence. Also, HMI Editor may continue polling tags while running in the background. Thus, special care should be taken when deciding what tags will be involved in trending. Particularly, it is recommended to setup tags involved in trends as contiguous as possible. Observing this recommendation will lead to shorter communication patterns and less network overhead, ultimately improving the end user experience.

Graphic rendering on screen. Setting the updatingStyle property to *continuous* may also lead to some performance degradation due to increased graphic rendering pressure, specially on devices with lower GPU or CPU specs such as iPods or earlier generation iPads. It is recommended to check your project on the real field before setting trend updating to *continuous.* Even if performance looks fine, the extra required rendering cycles will decrease battery life compared with the *discrete* setting. So this is also something that bust be balanced.

7.3.3.5 Chart

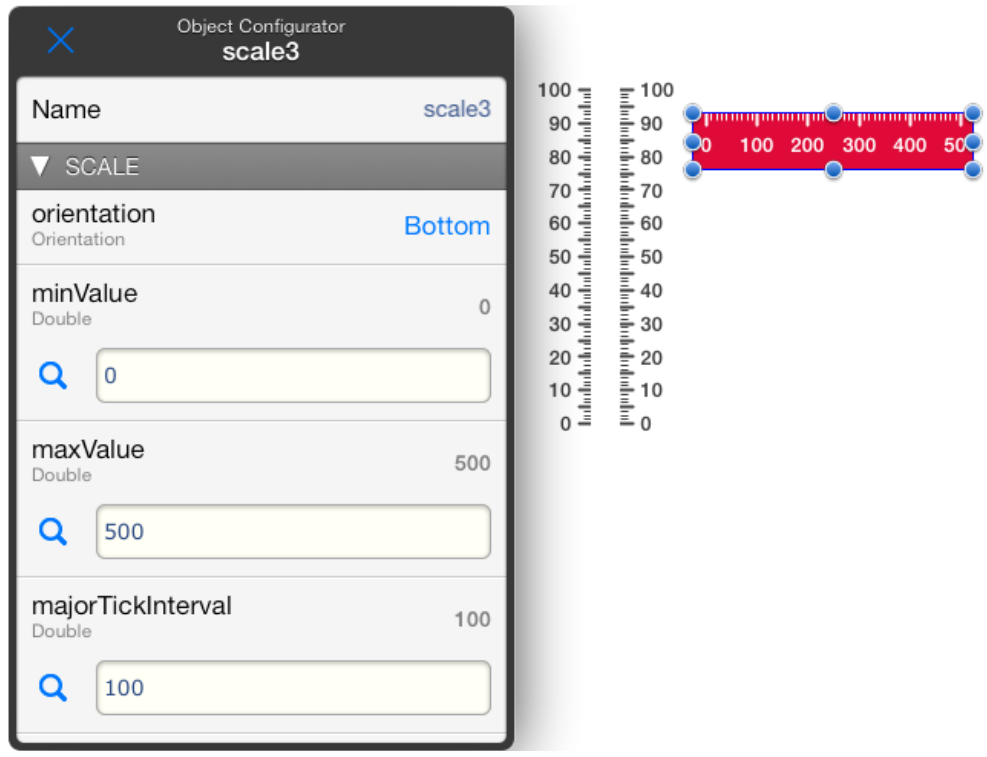
An Indicator providing the interface for presenting an array of values on a chart .

PROPERTY	TYPE	DESCRIPTION
style	(constant Number)	This property is currently unused/reserved
updatingStyle	(constant Number)	This property is currently unused/reserved
charType	(constant Number)	Indicates the type of chart. Possible values are: • **Line**: Will displays plot regions as lines. • **Bar**: Will display plot regions as bars. • **Mixed**: Points for the first region will be displayed as a line, the rest as bars.
options	Dictionary (read/write	An options dictionary. Supported keys are: • **colorFills**: Contains an array of colors to decorate plots by drawing a gradient below their lines. • **pointSymbols**: An array of boolean numbers indicating whether circular point symbols should be drawn to decorate plot values when the *chartType* is 'Line'. By default point symbols are drawn.
yMin	Double (read/write Number)	Minimum value on the vertical axis range.
yMax	Double (read/write Number)	Maximum value on the vertical axis range.
xFirstTick	Double (read/write Number)	First numeric value for labels on the horizontal axis range. Label numbers are incremented by one for each new value. Alternatively, you can specify custom label texts on the *labels* property.
xMajorTickInterval	Double (read/write Number)	The interval between major ticks for the horizontal -time- axis. If x*MajorTickInterval* is set to 0 (zero) no ticks will be drawn.
xMinorTicksPerInterval	Integer (read/write Number)	The number of minor ticks drawn between major ticks on the horizontal axis. If x*MinorTicksPerInterval* is set to 0 no minor ticks will be drawn.
yMajorTickInterval	Double (read/write Number)	The value interval between major ticks for the vertical axis. If y*MajorTickInterval* is set to 0 (zero) no ticks will be drawn.

PROPERTY	TYPE	DESCRIPTION
yMinorTicksPerInterval	Integer (read/write Number)	The number of minor ticks drawn between major ticks on the vertical axis. If y*MinorTicksPerInterval* is set to 0 no minor ticks will be drawn.
tintColor	Color (read/write String or Number)	A color to apply to the time window of the chart. See description of the *color* property on the **page** object for a discussion on possible values.
borderColor	Color (read/write String or Number)	The color of the border of the chart indicator. See description of the *color* property on the **page** object for a discussion on possible values.
format	FormatString (read/write String)	A format String for numbers displayed below bars or data points on the horizontal axis. Set this to an empty string if nothing must be displayed. See format specifiers and the format function for a complete discussion on possible values.
labels	Array of Strings (read/write)	An array of strings to be displayed below bars or data points on the horizontal axis. This optional, if you leave it blank numbers starting at *xFirstTick* and counting by *xMajorTickInterval* will the shown instead. Example : ["January", "February", "March", "April"]
colors	Array of Colors (read/write)	An array containing colors. The size of the *colors* should match the size of *plots*. If *colors* is shorter than *plots*, default colors will be applied, if it is larger the excess colors will be ignored. Example : ["green", "orange"]
regions	Array of Array or Numbers (read/write)	An array containing value regions to be plotted. Each region consists of an array of numeric values. Regions will be displayed on separate plots depending on the Example : [[source.tag1, source.tag2, source.tag3, source.tag4],[20,30,40,50]] This example will display two plot regions with 4 points each. The fist region is made of PLC values, the second region is made of constant numeric values.
NOTE: Tick lines and label texts will be drawn in White or in Black color depending on the specified *backgroundColor*. See note on *backgroundColor* on Item Properties for more information		

7.3.3.6 Scale

An Indicator providing the interface for presenting a drawing of a lineal scale.

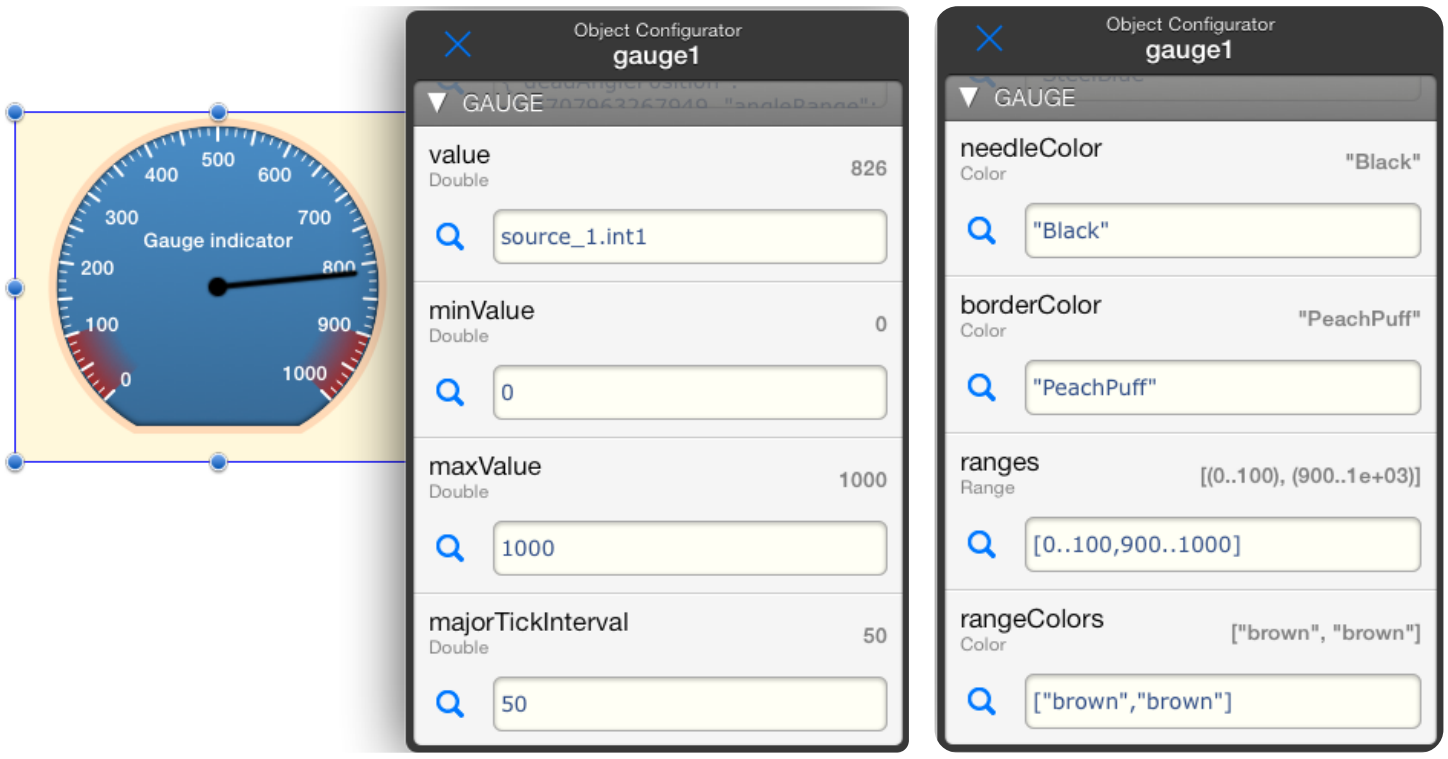


PROPERTY	TYPE	DESCRIPTION
orientation	(constant Number)	The direction of the bar control for forward value changes. Possible values are **Left**, **Top**, **Right**, and **Bottom**
minValue	Double (read/write Number)	Minimum value of the scale indicator.
maxValue	Double (read/write Number)	Maximum value of the scale indicator
majorTickInterval	Double (read/write Number)	The value interval between major ticks for the scale indicator.
minorTicksPerIn-terval	Integer (read/write Number)	The number of minor ticks drawn between major ticks.
format	FormatString (read/write String)	The format string to be applied to the interval values presented next to major tick intervals.

PROPERTY	TYPE	DESCRIPTION
backgroundColor	Color (read/write String or Number)	The color of the background of the scale indicator. See description of the *color* property on the **page** object for a discussion on possible values.
NOTE: Tick lines and interval value texts will be drawn in White or in Black color depending on the specified *background-Color*. See note on *backgroundColor* on Item Properties for more information		

7.3.3.7 Gauge

An indicator providing the interface of a rotary gauge

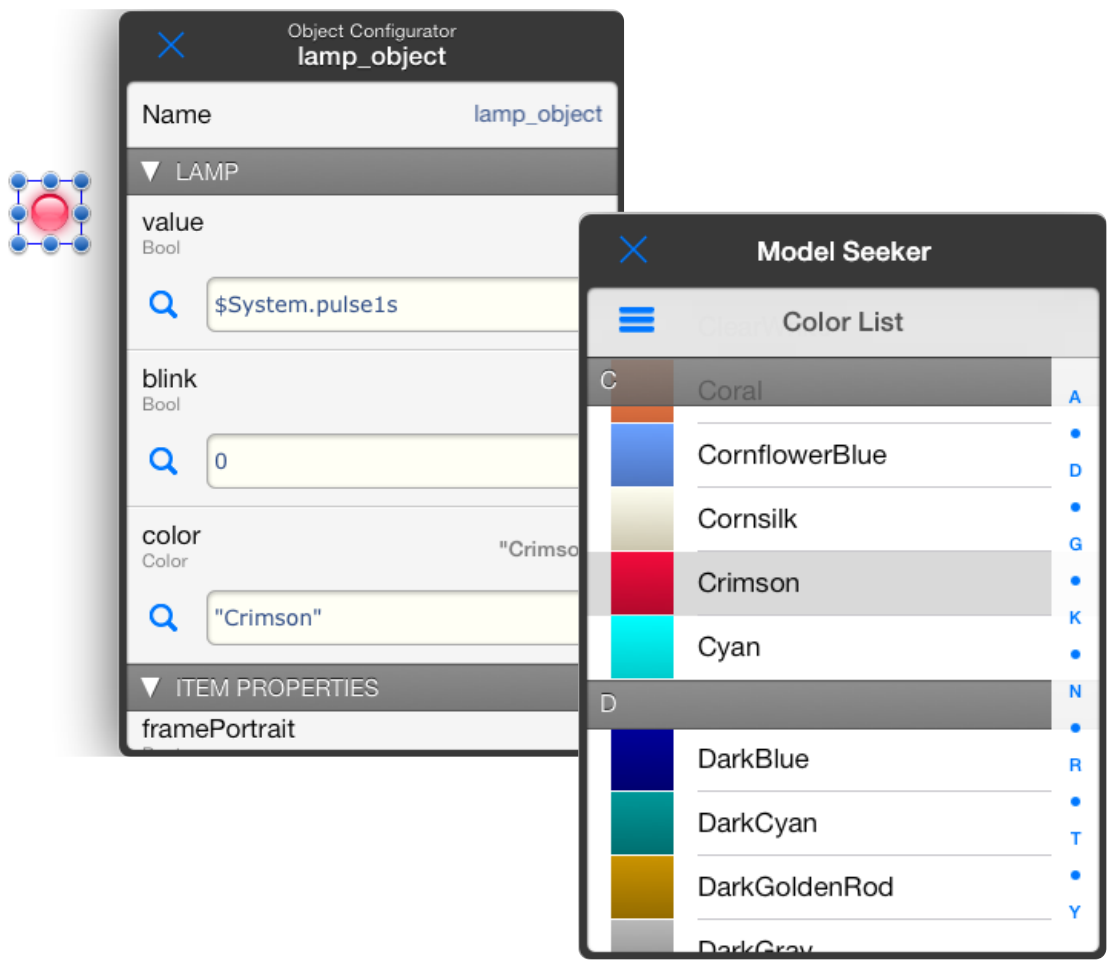


PROPERTY	TYPE	DESCRIPTION
style	(constant Number)	This property is currently unused/reserved
options	Dictionary (read/write	An options dictionary. Supported keys are the following: • **angleRange**: Contains a Number representing the angle range in radians for displacement of the gauge needle. Default is π*3/2 (or 270°) which means a range covering 3/4 of a circumference. • **deadAnglePosition**: Contains a Number representing the center of the dead angle (unused angle range) for the gauge expressed in radians. Default is -π/2 which means the dead angle is on the bottom (negative vertical axis) of the control.
value	Double (read/write Number)	The current value of the gauge indicator
minValue	Double (read/write Number)	The minimum value of the range presented by the indicator.
maxValue	Double (read/write Number)	The maximum value of the range presented by the indicator.

PROPERTY	TYPE	DESCRIPTION
majorTickInterval	Double (read/write Number)	The value interval between major ticks. For example for a gauge indicator ranging from 0 to 100 you could set *majorTickInterval* to 20 to space each tick by 20 units. If *majorTickInterval* is set to 0 (zero) no ticks will be drawn.
minorTicksPerInterval	Integer (read/write Number)	The number of minor ticks that must be displayed between major ticks. If *minorTicksPerInterval* is set to 0 no minor ticks will be drawn.
format	FormatString (read/write String)	The format string to be applied to the interval values displayed next to major tick intervals.
label	String (read/write String	An optional text label that will show on the indicator.
tintColor	Color (read/write String or Number)	A tint color to apply to the indicator. See description of the *color* property on the **page** object for a discussion on possible values.
needleColor	Color (read/write String or Number)	A color to apply to the needle element of the control. See a description of the *color* property on the **page** object for a discussion on possible values.
borderColor	Color (read/write String or Number)	The color of the border of the control. See description of the *color* property on the **page** object for a discussion on possible values.
ranges	(read/write Array of Ranges)	An array containing ranges. Ranges as presented as colored segments around the ticks of the gauge indicator. Example: [0..15, 85..100]
rangeColors	(read/write Array of Colors)	An array containing colors. The size of the *rangeColors* should match the size of *ranges*. If *rangeColors* is shorter than *ranges*, default colors will be applied, if it is larger the excess colors will be ignored.
NOTE: Tick lines and interval values texts will be drawn in White or in Black color depending on the specified *backgroundColor*. See note on *backgroundColor* on Item Properties for more information		

7.3.3.8 Lamp

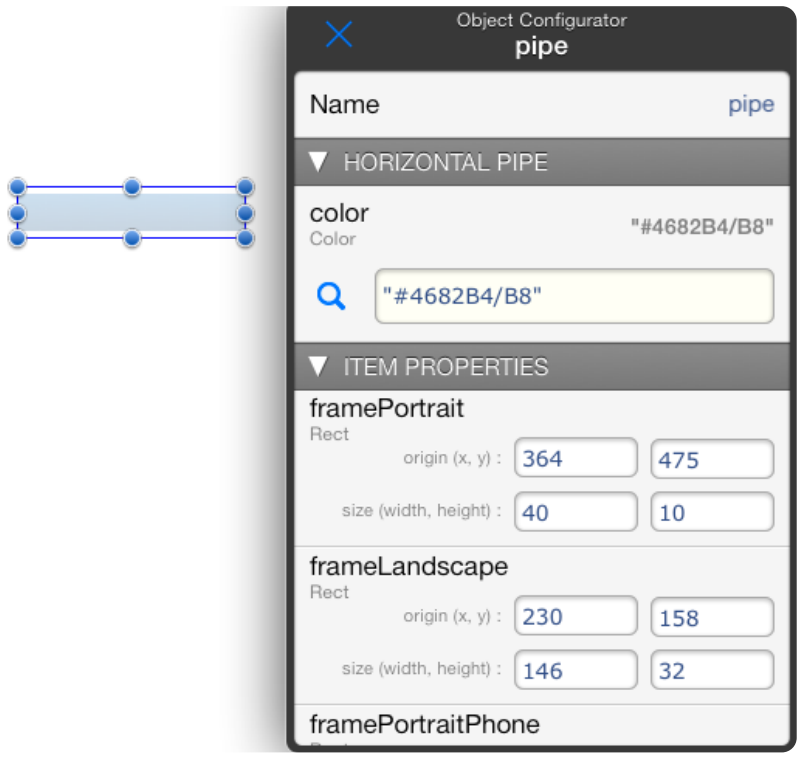
An indicator for presenting the interface of a led like lamp.



PROPERTY	TYPE	DESCRIPTION
value	Bool (read/write Number)	The current value of the lamp indicator. A non zero value (true) will display the indicator energized.
blink	Bool (read/write Number)	A value indicating whether the indicator should blink when it is energized.
color	Color (read/write String or Number)	The color to apply to the indicator See description of the *color* property on the **page** object for a discussion on possible values.

7.3.3.9 Horizontal Pipe

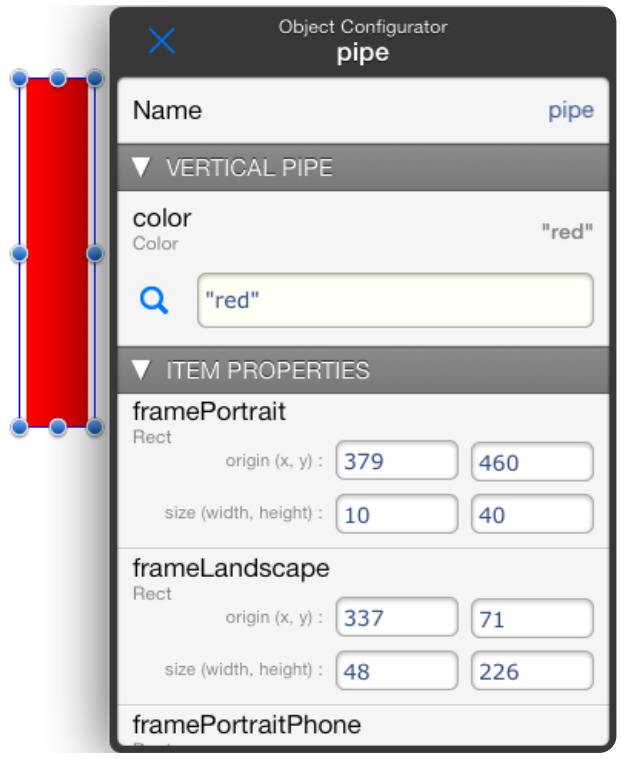
An indicator for presenting the interface of a horizontal line with custom color.



PROPERTY	TYPE	DESCRIPTION
color	Color (read/write String or Number)	The color to apply to the indicator See description of the *color* property on the **page** object for a discussion on possible values.

7.3.3.10 Vertical Pipe

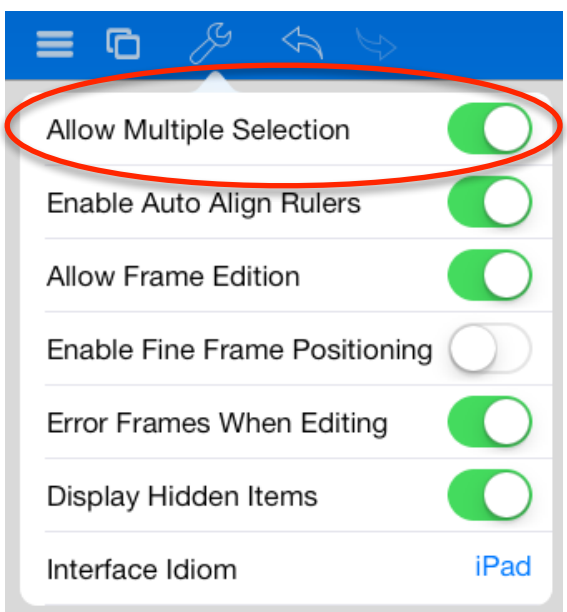
An indicator for presenting the interface of a vertical line with custom color.

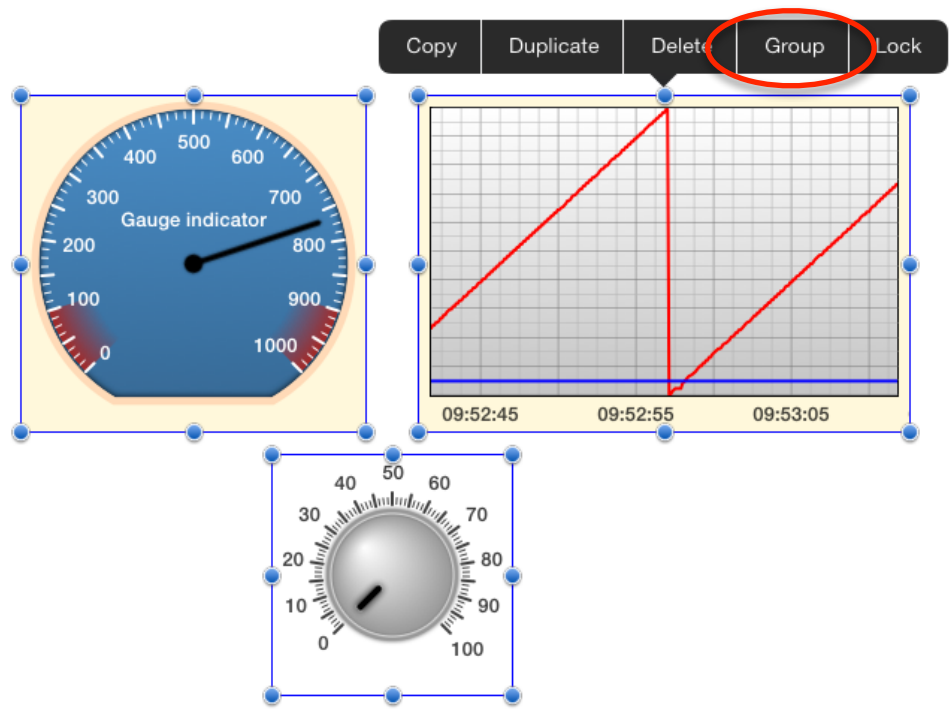


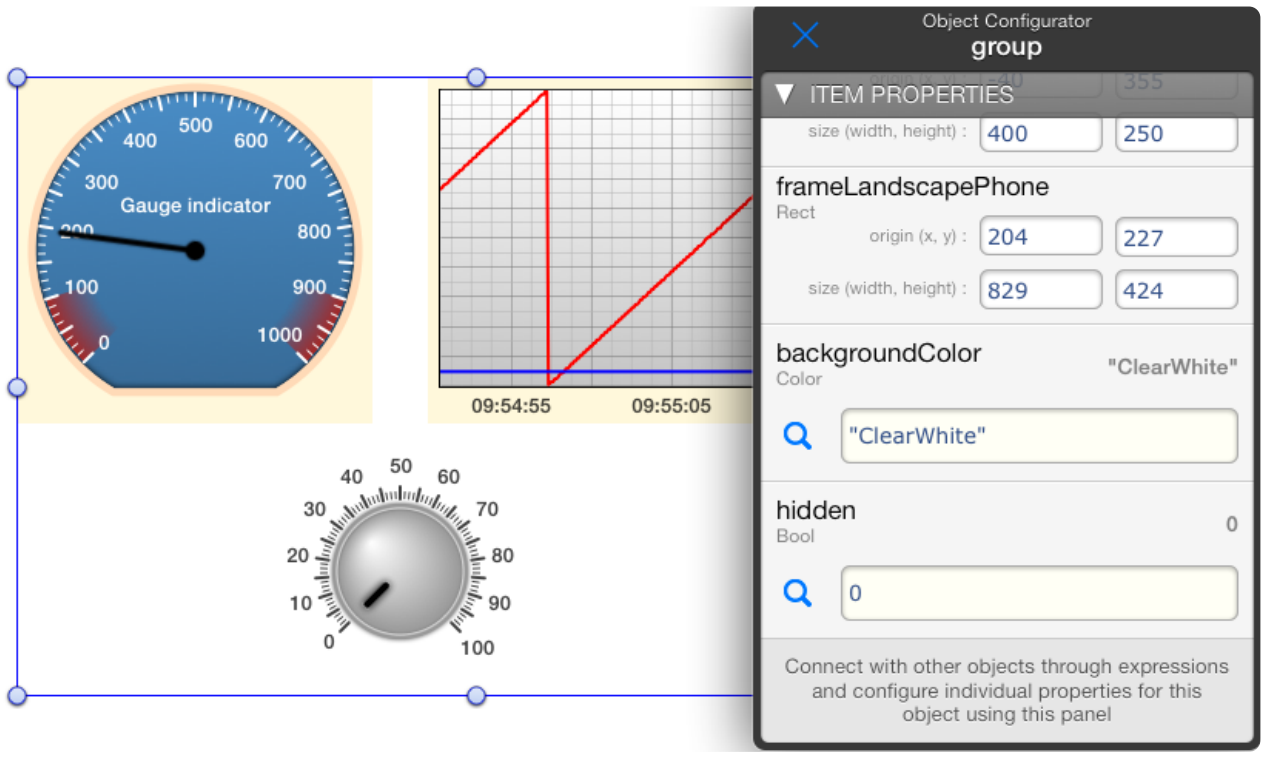
PROPERTY	TYPE	DESCRIPTION
color	Color (read/write String or Number)	The color to apply to the indicator See description of the *color* property on the **page** object for a discussion on possible values.

7.3.3.11 Group

Items can be grouped together by enabling multiple selection and choosing 'Group' on the popover menu. A new interface item will be created that acts as a container of the selected elements.A group of objects is in itself an interface item so it has the basic properties described in Item Properties. For example an useful property for groups is the *hidden* property.





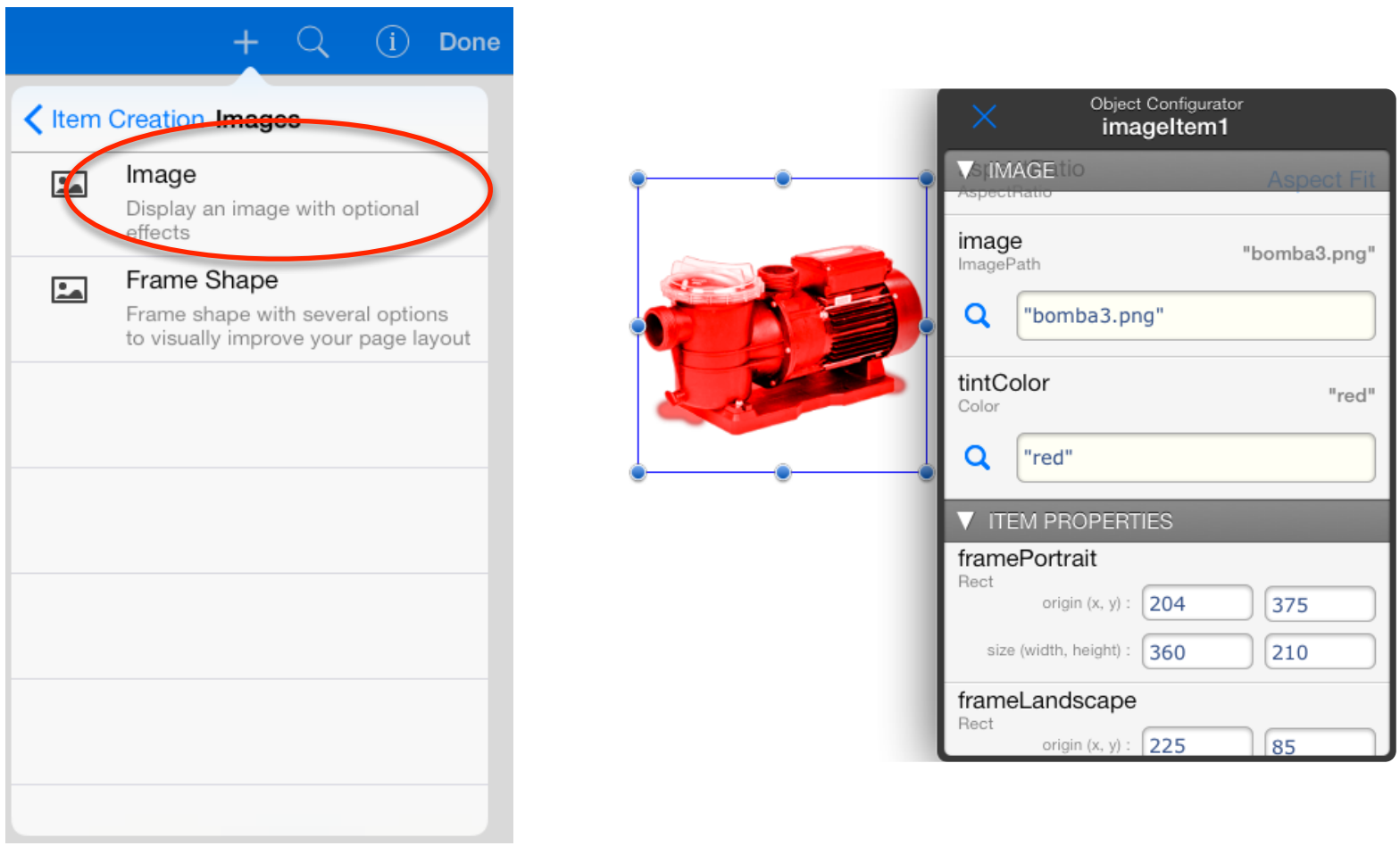


7.3.4 Image Objects

Image Objects are Visual Items that are related or cover aspects related with presenting custom images on the interface.

7.3.4.1 Image

An object providing the interface for presenting custom images.



PROPERTY	TYPE	DESCRIPTION
aspectRatio	(constant Number)	Aspect ratio to be applied to the image. See description of the *aspectRatio* property for the **page** object for detailed information on possible values.
image	ImagePath (read/write String or Array)	Image name to show for the object. You can optionally provide an array of image names to be animated in sequence at a rate defined by the animationDuration property. Animated "gif" files are also supported.
animationDuration	Number (read/write String)	The number of seconds to apply between image transitions. For example to set the animation duration to 100 milliseconds you should enter 0.1 for this property.
tintColor	Color (read/write String or Number)	A tint color to apply to the entire image to visually change its appearance. You can use this property to effectively set a custom color to an image based on any condition. **Example:** switch.value?"Red":"Green" this will set the image to "Red" when the switch is on or "Green" otherwise.

7.3.4.2 Frame Shape

An object providing the interface for presenting custom advanced frames for incorporating into your page designs..

PROPERTY	TYPE	DESCRIPTION
animate	(constant Number)	This property is currently unused/reserved
fillStyle	(constant Number)	The style used to fill the frame. Possible values are the following: • **Flat Color**: The frame will be filled with a single flat color, *fillColor1*. • **Solid Color**: The frame will be filled with a single color, *fillColor1*, displaying a very slight gradient. • **Gradient Color**: The frame will be filled with a color gradient starting at *fillColor1* and ending at *fillColor2* and the *gradientDirection* direction • **Image**: The frame will be filled with an image.
strokeStyle	(constant Number)	The style used to stroke the border of the frame. Possible values are the following: • **Line**: A continuos line will be used to stroke the frame border. • **Dash**: A dashed line will be used to stroke the frame border.
shadowStyle	(constant Number)	The style used to add a shadow to the frame: Possible values are the following: • **None**: No shadow will be applied. • **Alpha Channel**: Shadow will be applied to the entire frame taking into account the alpha channel of what is shown in it. This applies as well to images with transparency to achieve shadow effects in the interior of images. • **Inner Fill**: An inner shadow will be applied to the frame.. • **Outer Fill**: An outer shadow will be applied to the frame..

PROPERTY	TYPE	DESCRIPTION
gradientDirection	(constant Number)	The direction to be used when drawing gradients. Possible values are **Left**, **Up**, **Right**, and **Bottom**.
aspectRatio	(constant Number)	Aspect ratio to be applied to the image if specified. See description of the *aspect-Ratio* property for the **page** object for detailed information on possible values.
fillColor1	Color (read/write String or Number)	A color to fill the frame.
fillColor2	Color (read/write String or Number)	A secondary color to fill the frame when gradient is used.
fillImage	ImagePath (read/write String)	Image to show for the object in case *fillStyle* is set to **image**.
cornerRadius	Double (read/write Number)	The radius in points for the frame corners.
lineWidth	Double (read/write Number)	The width in points of the frame border line. A value of 0 prevents a border to be drawn.
gridColumns	Integer (read/write Number)	If greater than 1 it will draw evenly spaced vertical lines on the item. Lines will be drawn using the specified *lineWidth*, s*trokeColor* and *shadow* options.
gridRows	Integer (read/write Number)	If greater than 1 it will draw evenly spaced horizontal lines on the item. Lines will be drawn using the specified *lineWidth*, s*trokeColor* and *shadow* options.
strokeColor	Color (read/write String or Number)	A color for the border line.
shadowOffset	Double (read/write Number)	A vertical offset in points for the shadow if present.

PROPERTY	TYPE	DESCRIPTION
shadowBlur	Double (read/write Number)	The amount of blur to apply to the shadow if present.
shadowColor	Color (read/write String or Number)	The shadow color.
opacity	Double (read/write Number)	A value from 0 to 1 indicating a opacity to be applied to the frame object. A value of 0 means fully transparent, 1 is fully opaque. Any value in the middle will add transparency to some extent.
blink	Bool (read/write Number)	A value indicating whether the indicator should blink. Non zero values (true) will activate blinking for the indicator.

7.3.5 Web Objects

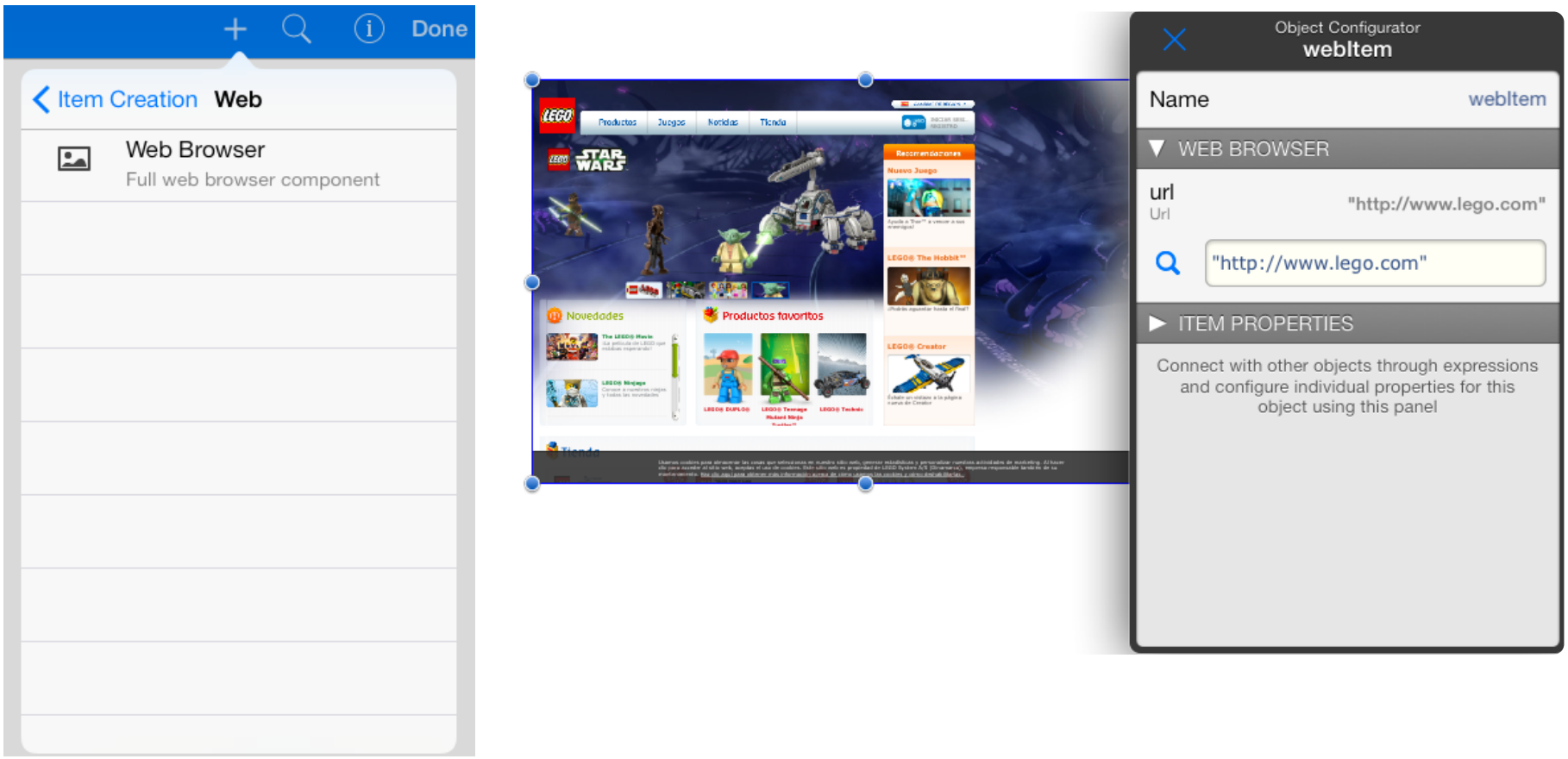
Web Objects are Visual Items for presenting web content or web related information.

7.3.5.1 Web Browser

An object providing the interface for displaying a web browser.

On the web browser component you can display any content You can present any web related content such as web sites, web based cameras, or even run a web based SCADA in it.

In addition you can display any content stored on the Assets section such as pdf files, doc documents, text files and more.



PROPERTY	TYPE	DESCRIPTION
url	Url (read/write String)	The String assigned to this property provides the full url of a web site. Alternatively, you can provide custom content previously stored on the Assets section such as pdf files. In such case you omit the url schema from the string. **Example** : "http://www.google.com" **Example** : "http://www.myweb.com/myWebBasedScadaSystem" **Example** : "machineManual.pdf"

7.4 Background Objects

Objects that are not visually presented on pages but intervene on the flow execution of your project are named Background Objects.

7.4.1 Expression Object

An Expression Object allows you to store intermediate results or to centralize operations in a single place. It also provides an opportunity to optimize or normalize your project by reducing the need to repeat some subexpressions that otherwise would be present in several places.

An Expression Object has a single property

PROPERTY	TYPE	DESCRIPTION
value	Any (read/write Value)	The expression value.

7.4.2 Recipe Sheet Object

A Recipe Sheet Object provides the interface for retrieving data from a csv file. In the csv file data is organized in rows representing recipes, and columns representing ingredients.

On the first column we place recipe names (or numeric keys).
On the first row we enter ingredient names (or keys).
The cell on the first row and column contains an identifier for the entire recipe sheet.

An example of such a csv file is represented below:

My Recipe Identifier	Ingredient 1	Ingredient 2	Ingredient 3
Recipe 1	10	20	300
Recipe 2	40	45	320
Recipe 3	30	35	310

Recipe Keys can be strings or numbers. Ingredient keys can be strings or numbers. Recipe ingredient data can be a string or a number.

The Recipe Sheet object can read the above file in csv format and make it available through its properties. The following properties are available.

PROPERTY	TYPE	DESCRIPTION
recipes	(read only Dictionary)	This property provides access to recipes and its ingredient values. It contains a dictionary of recipes. Valid dictionary keys are available in the *recipeKeys*. Each value in this dictionary contains a dictionary of ingredient values accessed through ingredient keys. **Example:** Based on the recipe sheet file above the contents of this property look as follows: {"Recipe 1" : {"Ingredient 1":10, "Ingredient 2":20,"Ingredient 3":300}, "Recipe 2" : {"Ingredient 1":40, "Ingredient 2":45,"Ingredient 3":320}, "Recipe 3" : {"Ingredient 1":30, "Ingredient 2":35,"Ingredient 3":310}}
recipeIdent	(read only Number or String)	Contains the recipe identifier that is present on the first row and column of the associated recipe sheet file. **Example:** Based on the recipe sheet file above the contents of this property look as follows: "My Recipe Identifier"
recipeKeys	(read only Array)	Contains an array with all the recipe key entries in the associated recipe sheet file. You can use this array as is on an array picker object for the purpose of selecting a recipe. **Example:** Based on the recipe sheet file above the contents of this property look as follows: ["Recipe 1", "Recipe 2", "Recipe 3"]

PROPERTY	TYPE	DESCRIPTION
ingredientKeys	(read only Array)	Contains an array with all the ingredient key entries in the associated recipe sheet file. You can use this array as is on an array picker object for the purpose of selecting an ingredient. **Example:** Based on the recipe sheet file above the contents of this property look as follows: ["Ingredient 1", "Ingredient 2", "Ingredient 3"]
sheetFilePath	Recipe-SheetPath (read/write String)	The String assigned to this property provides the file source of the recipe sheet. Recipe files are stored on the Assets section if they must not be editable by end users, in this case just enter the file name. This is an effective way to provide pre-configured setups to your projects. The file itself should be selected on Assets to make it available to the project before deployment. If you want end users to edit or add recipe sheets, you must make them available on the Database area. To do so you prefix your file name with "databases://". Alternatively, you can set the stored on the Assets section such as pdf files. In such case you omit the url schema from the string. **Example** : "myRecipesSheet.csv" **Example** : "databases://myRecipesSheet.csv"

7.4.3 Data Snap Object

A Data Snap object allows you to capture snap shots of data in an efficient way. Particularly, this object can be used to capture data from a PLC based on a custom trigger -such as the press of a button- instead of the usual connector based polling interval.

For example you may want to efficiently represent a big array of data from a PLC on a chart graph, but not on a chart that is continuously refreshing, but based on user action. In such case you can link your PLC data to the *inputValue* of a **dataSnap** object, link a push button to the *snap* property, and then use the *snapValue* as the input to a **chart** object. Provided that the referred PLC data is only used in the context of this dataSnap object, the system will perform a single PLC read each time an user taps the button. This is in contrast to having your PLC data directly connected to a chart object where updates will be made real-time as data changes in the PLC.

PROPERTY	TYPE	DESCRIPTION
snapValue	Any (read only Value)	The result (or output) of the snap shot
snap	Bool (read/write Value)	The trigger of the snap action. When *snap* transitions to true (non zero) a data snap of *inputValue* is performed and moved to *snapValue* conserving the same data type and values. For *inputValues* that are directly or indirectly linked to PLC tags, the snap shot is performed by reading PLC data only once before moving the result to the *snapValue* property.
inputValue	Any (read/write Value)	The source (or input) data for the object.

7.4.4 On Timer

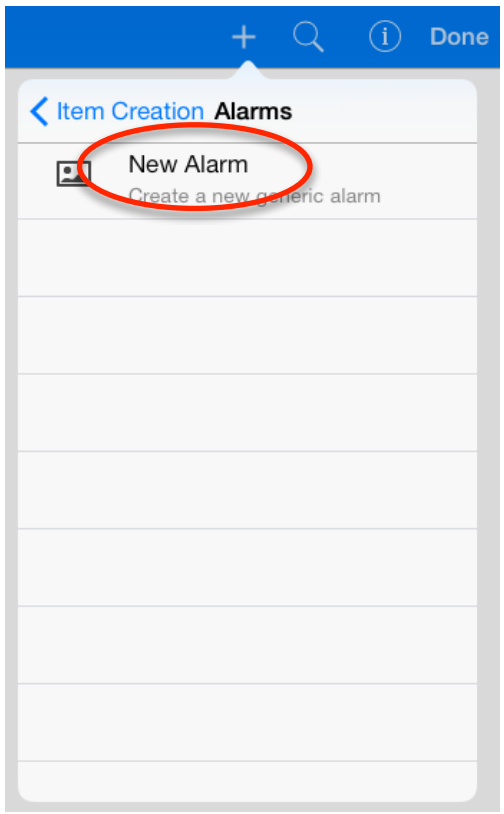
An On Timer object allows you to implement delays on actions or to program delayed operations. It is similar to a timer.

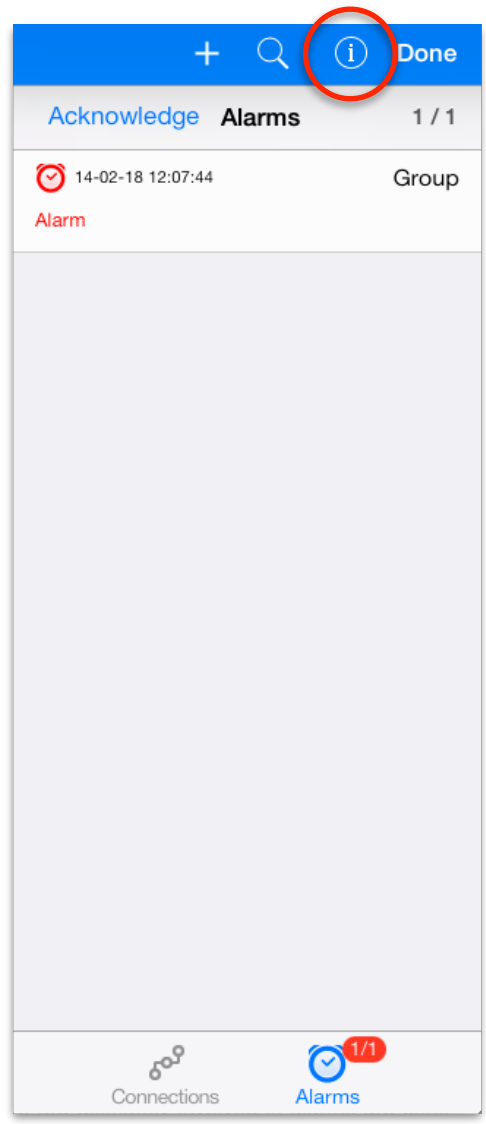
The On Timer object can be used to allow one operation to complete before another begins, or to require a condition to exist for a period of time before an alarm is activated.

PROPERTY	TYPE	DESCRIPTION
delayedValue	Bool (read only Value)	Output signal for the internal timer as described on the *value* property.
value	Bool (read/write Value)	The object value. When *value* transitions to true (non zero) the internal timer starts counting, after *time* has passed *delayedValue* is activated (set to 1). If *value* is set to 0 the internal timer is reset and *delayedValue* is immediately set to 0.
time	Double (read/write Value)	The time expressed in seconds.

7.5 Alarm Objects

Alarm objects are designed to present eventual information on the Alarms Viewer.





When an alarm condition is triggered, alarm information such as their *group* and *comment* properties are displayed in an ordered list on the Alarms Viewer. Alarms will remain on the list as long as they are active or otherwise if they have not been acknowledged. Their current state is shown by small icons next to the alarm text:

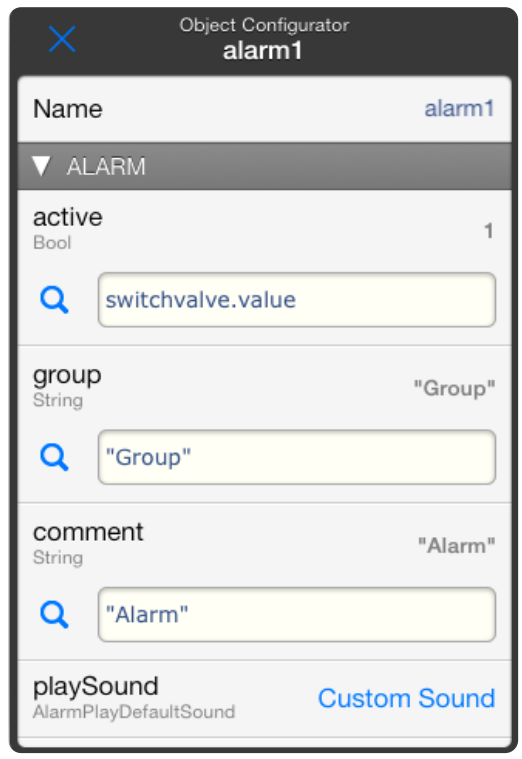
- Bright Red Alarm Clock icon means active and not acknowledged
- Dark Red Icon means active and acknowledged
- Gray Clock Icon means inactive and not acknowledged

Performance Considerations

PLCCommunications. Because alarms do track eventual events at all times, any PLC tags that are ultimately involved in alarms are continuously polled. Also, HMI Editor may continue polling tags while running in the background. Thus, special care should be taken when deciding what tags will be reserved for alarms. Particularly, it is recommended to chose tags involved in alarms to be as contiguous as possible. It is also more efficient to have alarms depending on boolean tags than on scalar values. For protocols supporting arrays of BOOL, they will be the best choice. Observing this recommendation will lead to shorter communication patterns and less network overhead, ultimately improving the end user experience.

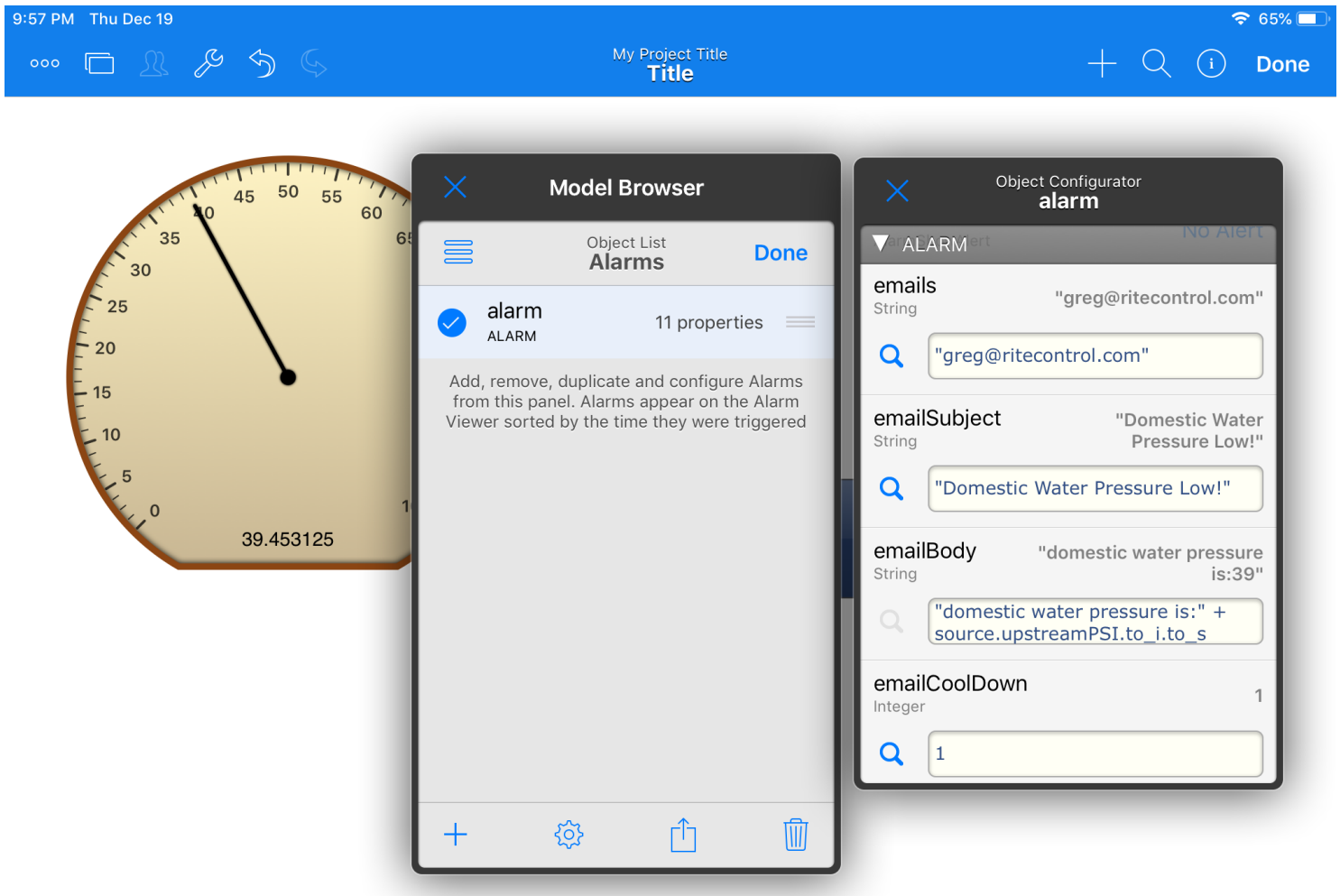
7.5.1 Alarm

An alarm object keeps eventual information and appears on the Alarms Viewer when it is first activated.



PROPERTY	TYPE	DESCRIPTION
active	Bool (read/write Number)	State of the alarm. Set this to true (non zero) when you want to signal an event described by this alarm object. **Example:** source.alarm1 **Example:** source.temperature>45
group	String (read/write String)	The group string that will appear on the Alarms Viewer when this alarm is shown
comment	String (read/write String)	The comment string that will appear on the Alarms Viewer when this alarm is shown
playSound	(Constant Number)	The type of sound that the alarm will play. Possible values are **Custom Sound** and **Default Sound**. When a default sound is specified a Horn Alarm sound will play when the alarm transitions to active.
url	Url (read/write String)	When *playSound* is set to **Custom Sound** the alarm will use the audio asset specified in this property instead of the default sound. If this property contains an empty string no audio will play. See the *$Player* object for a discussion on the valid contents of the *url* property for playing audio files.

PROPERTY	TYPE	DESCRIPTION
showAlert	(Constant Number)	Possible values are No alert and Show Alert. When the later is selected the alarm will display an alert message to the user when its state becomes active.
emails	String (read/write String)	The email Address' that the alarm will send emails to when it goes true. This can be set to multiple email address if needed. **Example:** "email1@host.com, email2@host.com"
emailSubject	String (read/write String)	The Subject of the email. Can be combined with expressions to make the email Subject more useful. **Example:** "Water Pressure is: " + source.waterPressure.to_s + "psi" Providing the *waterPressure* value is 5, this would create the Subject: "*Water Pressure is: 5psi"*
emailBody	String (read/write String)	The Body of the email. Much Like the *emailSubject*, the *emailBody* can contain Expressions to make it more useful.
emailCoolDown	Number (read/write Integer)	Email Cool Down specifies the number of minutes between sending emails. If the cool down is set to 3, the alarm will send an email as soon as the alarm is triggered. But if the alarm goes to false and then true again within 3 minutes, it won't send another email till the 3 minutes have expired.



7.6 Users

You can create user accounts on a project basis.

By creating user accounts you can provide restricted or personalized access to selected features on your project. To do so you must assign a differentiated *accessLevel* to users. On your project, you use the *$UsersManager.currentUserLevel* property to determine the *accessLevel* of the currently logged in user and enable or disable specific features based on expressions.

7.6.1 User

An User object stores Log In information of a project user account and assigns an *accessLevel* to it.

PROPERTY	TYPE	DESCRIPTION
userName	(constant String)	Sets the user name this user will have to enter on the Log In screen
password	(constant String)	Sets the password this user will have to enter on the Log In screen
accessLevel	(constant Number)	Sets the access level for this user. As an *accessLevel* you can use any numeric value. The app does not perform any check on the used range. It is up to you to interpret accessLevels the way that fits best your app needs. An usual practice is to use numbers ranging from 0 to 9. For example you can disable features on your project based on levels that at below a particular value. You determine the currently logged in user access level by watching at the *$UsersManager.currentUserLevel*

7.7 Historical data and Data Logger objects

HMI Pad uses the open source SQLite database format to store historical data. SQLite is convenient and extensively used for storing large data sets. It comes with built in searching capability and filtering. Databases are stored locally by HMI Editor/View and can be exported to a desktop computer for further analysis. You will find database files on the Databases section of the HMI Editor/View application panel.

Several software tools are readily available for opening and extracting data from SQLite files. You can apply filters and convert data to alternative file formats such as csv files if needed.

On HMI Pad you use **data logger** objects for data storage, and **data presenters** for data retrieval.

Data loggers on HMI Pad are linked to physical SQLite database files by specifying a database name and a time range for the database. See Data Logger object below. Based on *databaseName* and *databaseTimeRange* a suitable file name for the database file will be composed. If a database file for a given time period is not present at the time a data logger attempts to store historical data, a new one will be created.

7.7.1 Data Logger

Data Logger objects provide an interface to store historical data on SQLite databases. Data provided on the *values* property is stored in table rows in the SQLite database.

PROPERTY	TYPE	DESCRIPTION
databaseTimeRange	(constant Number)	Provides the time range for the database. Along with the *databaseName* it provides a hint for the actual database file name. Possible values for this property are **Hourly**, **Daily**, **Weekly**, **Monthly**, **Yearly.** A new database file will automatically be created after the *databaseTimeRange* expires. For example 'monthly' based data loggers will create a new database file per month. See also the *databaseName* property description for more information.
databaseName	(constant String)	The base name for the SQLite database file associated with this object. The actual database file name will be a composition of this property and the databaseTimeRange. For example: If you set "MyData" to *databaseName* and 'Monthly' to *databaseTimeRange* you will get database file names with the following pattern :"MyData_yyyy_mm.db" where 'yyyy_mm' will identify the year and month when the data was recorded.
databaseFile	(read only String	Contains the full database file name that is currently being updated by this data logger after composing *databaseName* with *databaseFileRange*. This corresponds to the actual database file name on disk.
fieldNames	(constant Array of Strings)	An array of strings to set database field names for the stored values. Based on the strings in this array, a database table will be created or updated with equivalently named table columns. Upon change of this property, the app will attempt to update the linked database tables with the newly provided names, however any field name which is replaced by a different one will cause irreversible loss of the previously named database column.

PROPERTY	TYPE	DESCRIPTION
values	Array of Numbers (read/write)	An array containing trend values to store on the database. The length of the array should match the length of the *fieldNames* array, but if no field names are provided or the number of values is greater than the number of fields then default names based on index will be used for the database table columns. Also see note on table insertion below.
NOTE: Insertion of data in the database file is triggered by changes on the *values* property, however updates that occurred faster than 0.5 seconds will be ignored. (This may be user selectable on a future release)		

7.8 Connector Objects

Connectors represent PLCs. For each PLC you want to communicate with you must create a connector.

Connectors have a list of PLC Tags. For each PLC tag you create on a connector an implicit property with the same name is added to the connector.

For example if you want to communicate with a particular PLC with 3 tags you create a Connector Object configured as appropriated for the PLC, then add to it your 3 tags. If you named your connector *myPlc* and you named your tags *var0*, *var1*, *var2* you will be able to refer these tag values anywhere in the app by using *myPlc.var0*, *myPlc.var1*, *myPlc.var2*.

When you create a Connector you must specify its particular type.and set appropriate parameters.

Each tag you create must be configured appropriately by setting its PLC address and data type.

A connector object is created starting from the model browser.

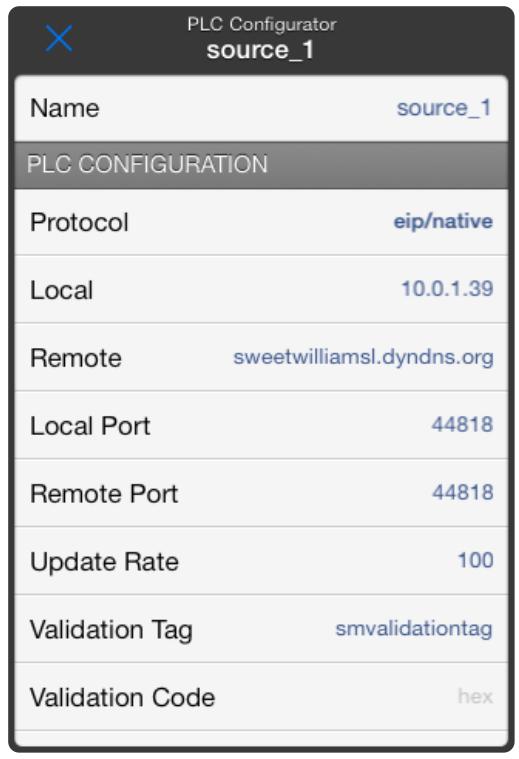
7.8.1 Supported PLC Connector Types

Upon creation of a connector you must indicate its type. The following connectors for Industrial PLC communications are supported.

PROTOCOL NAME	SUPPORTED PLCs or Brands (Not exhaustive)	REMARKS
EIP/Native	Allen Bradley ControlLogix and CompactLogix	Native CIP communications using Ethernet/IP explicit messaging
EIP/PCCC	Allen Bradley SCL505 and Micrologix controllers, other controllers through 1761-NET-ENI	PCCC commands (DF1) encapsulated in Ethernet/IP.
FINS/TCP	Omron CS1, CJ1 and newest	For communication with Omron PLCs with ethernet communication capabilities.
MELSEC/TCP	Mitsubishi FX Series	For communication with Mitsubishi FX Series PLCs with ethernet communication capabilities using MC (1E) frames.
Modbus/TCP	Schneider Electric, Automation Direct, Phoenix Contact, Wago...	For communication with PLCs and RTUs adopting the Modbus/TCP specification
Modbus over TCP	Serial Modbus RTU devices.	You can connect to Modbus devices through a simple Ethernet to Serial gateway.
Opto22/Native	Opto22 PAC controllers	Native communications protocol for Opto22 PAC controllers
Siemens/ISO_TCP	Siemens Simatic S7-1200, S7-300, S7-400 controllers	RFC 2126, ISO Transport Service on top of TCP for Siemens Step 7 programmable controllers.

7.8.2 PLC Connector Parameters

PLC Connectors have the following parameters.



PLC CONNECTOR PARAMETERS	KIND	MEANING
Protocol	-	This is an Implicit property chosen upon connector creation.
Local	text	Source address in text format for local access (LAN). Example: **192.168.1.40**
Remote	text	Source address or symbolic DNS host name for remote connections. Example: **myhost.dyndns.org**
Local Port	number	TCP port used for local connections (LAN) to this source. If left blank HMI Editor will use the standard port for the protocol of the current Connector type. (For example 502 for Modbus. Example: **502**
Remote Port	number	TCP port used for remote connections to this source (WAN-Internet). If left blank HMI Editor will use the standard port for the protocol of the current Connector type. Example: **504**
Update Rate	number	You can specify the desired polling rate for communications expressed in seconds. The default is 2 seconds. A value of zero (0) is also possible, this means top speed, i.e. no delay between reads. Example: **0.1**

PLC CONNECTOR PARAMETERS	KIND	MEANING
Validation Tag	text	Allows for using a custom validation tag on protocols supporting it. • For EIP/NATIVE the validation tag name is always **SMValidationTag**, it can not be changed. • For EIP/PCCC use **Nx:y** only N files can be used and the code is stored as an INT (default is N98:0). • For MODBUS a validation tag is not supported. • For FINS/TCP use **Dx** only DM area can be used and the code is stored as a WORD (default is D19998). • For MELSEC/TCP use **Dx** only D area can be used and the code is stored as a WORD (default is D8085). • For OPTO22/NATIVE the validation tag name is always an OptoControl Numeric variable (Integer32) with the tag name **SMValidationTag**, it can not be changed. • For SIEMENS/ISO_TCP use **MWx;** only MW can be used and the code is stored as a WORD (default is MW998)
Validation Code	number (hex)	Hexadecimal 16 bit value that is queried to the PLC on each connection to prevent further communication in case of mismatch. This value must be present in your PLC as a 16 bit hexadecimal value (0 to FFFF) and must match the value for connections to that PLC to succeed. See Section The Default Validation Tag below for more information
PLC String Encoding	selection text	Identifies which String Encoding is used for strings in PLCs. Default is WindowsLatin1 (See International Languages Support)

Additional Parameters for Modbus connectors.

The Modbus specification does not exactly define how the data should be stored in registers or in which order the bytes or words are sent. The following global attributes help to deal with it. Swapped words/bytes options for modbus are global.

MODBUS PARA-METERS	KIND	MEANING
RTU Mode	number (boolean)	HMI will use "Modbus/RTU over TCP" instead of "Modbus/TCP". This will allow for accessing serial modbus/RTU devices behind an Ethernet-to-serial gateway not supporting MBAP. Use the 'slave_id' property on tags to route commands to the right modbus slave node.
Word Swap	number (boolean)	Swaps words for 32 bit data (such as DINT or REAL) before sending to or upon receiving from a modbus device. Default value is ‘false’.
Byte Swap	number (boolean)	Swaps bytes for 16 or 32 bit data before sending or upon receiving from a modbus device. Default value is ‘false’.
String Byte Swap	number (boolean)	Swaps bytes for string data before sending or upon receiving from a modbus device. Default value is ‘false’.
Register Grouping Limit	number	Specifies the maximum number of Registers that will be read at any given time on a single modbus command. For example, if your controller will not allow any reads of more than 16 registers on a single command you can set this property to 16. The default is 0 (zero) meaning no artificial limit. For most controllers you should leave this property to the default, as this will enable maximum communications performance.

The combined effect for swap parameters is as follows:

Assuming a default of 'ABCD' for byte order where 'A' is the Most Significative Byte (MSB) and 'D' is the the Less Significative Byte (LSB), you can combine 'word_swap' and 'byte_swap' with the following results:

1- 'word_swap=false, byte_swap=false' will give 'ABCD' for 32 bit values and 'AB' for 16 bit values.
2- 'word_swap=false, byte_swap=true' will give 'BADC' for 32 bit values and 'BA' for 16 bit values.
3- 'word_swap=true, byte_swap=false' will give 'CDAB' for 32 bit values and 'AB' for 16 bit values.
4- 'word_swap=true, byte_swap=true' will give 'DCBA'. for 32 bit values and 'BA' for 16 bit values.:

‘string_byte_swap’ is only attended in combination with the CHAR or STRING data type. It provides a way to swap odd and even bytes on character strings without affecting behavior for numeric data types.

Additional Parameters for Allen Bradley connectors.

Allen Bradley ControlLogix controllers can be plugged in any slot on the backplane. Ethernet/IP messages can be sent “connected” or “unconnected”. The following attributes can be used to determine these characteristics. These are global attributes.

EIP/NATIVE PARAMETERS	KIND	MEANING
Controller Slot	number	Identifies the slot where the Logix controller is located. Default value is 0. It is ignored for EIP/PCCC communications (SLC and Micrologix)
Connected Mode	number (boolean)	When true, HMI Pad will use "connected messaging" instead of the default "unconnected messaging" for retrieving data from Ethernet/IP enabled PLCs. Look below for a discussion on what possible effects you might expect. Default value is ‘false’.

HMI Editor supports two EIP mechanisms to send commands to AB PLCs:
(1) For a Micrologix or SLC it will send PCCC commands (DF1) embedded in EIP using a direct path.
(2) For a ControlLogix/CompactLogix it will send native CIP commands using a Backpane, Slot-Number path. The Backpane defaults to 1 and the Slot number is given in *controller_slot*.

HMI Editor uses CIP Explicit Messages to retrieve and send data from/to Ethernet/IP enabled PLCs. Explicit messages can be sent "unconnected" or "connected". "Connected" messages require a Connection ID which is first asked to the PLC before sending other messages, while "unconnected" messages identify the specific path to the destination in the same message. Connected messaging is generally considered to be more reliable than unconnected because it reserves buffer space in the PLC for the message, and is therefore less likely to be blocked by other message traffic. However, if the TCP link between the message originator and the receiver is weak or prone to fail, unconnected messaging may be a better choice. Wireless spots or carrier networks can easily drop due to lack of coverage or weak signal, in these cases connected messaging communications may take longer to reestablish after a fault, resulting in less overall reliability and more user perceived delays than unconnected messaging. HMI Editor uses unconnected messaging by default, but you can set it to use connected messaging for a source file by setting the *connected_mode* attribute to true.

Additional Parameters for Siemens S7 connectors.

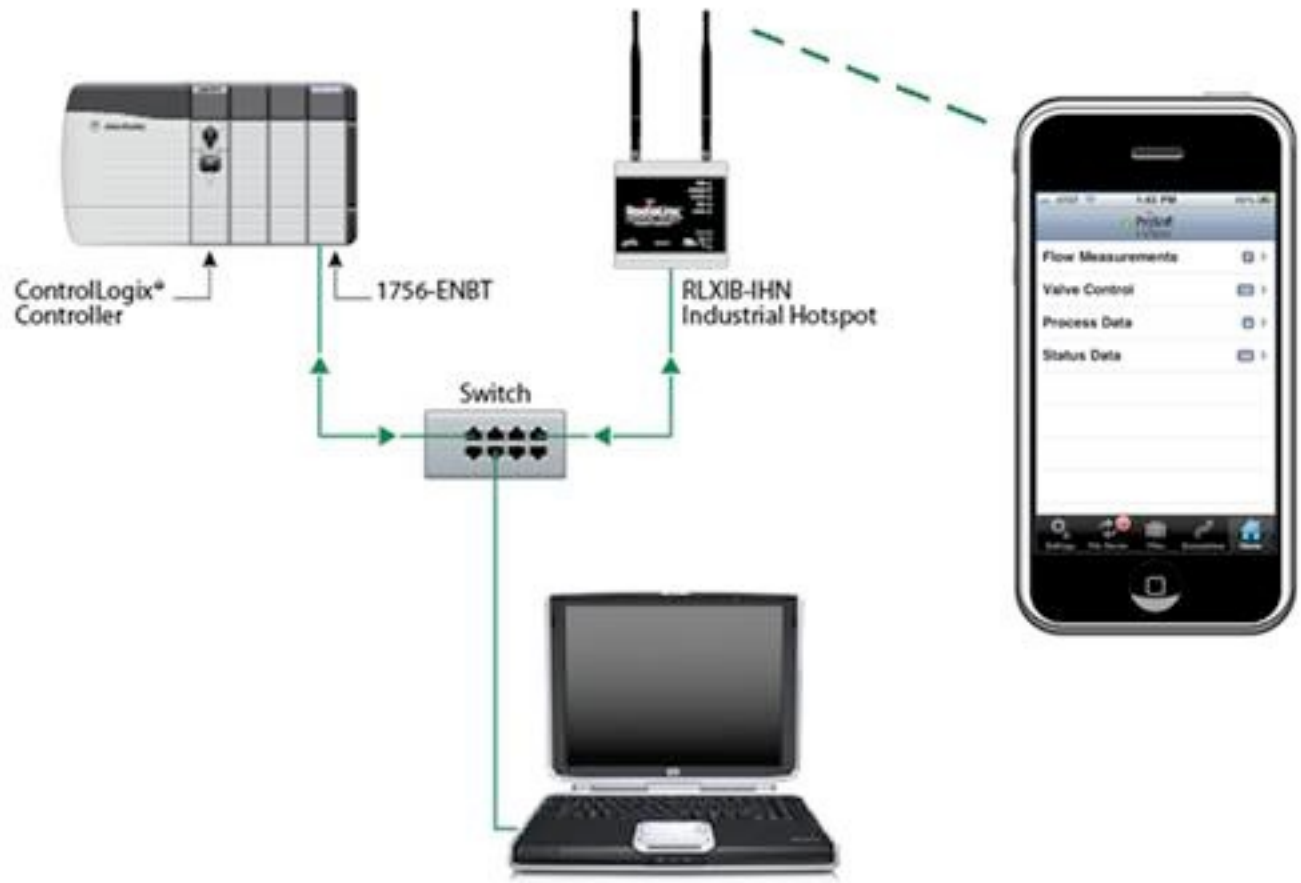
For Siemens S7 controllers you can set ‘Controller Slot’ and give an appropriate ‘rack’ and ‘slot’ number

SIEMENS/S7 PARAMETERS	KIND	MEANING
Controller Slot	number	Identifies the rack and slot where the S7 controller is located. Bits 0-4 of this attribute value identify the slot number, while bits 5-7 identify the rack. Default value is 0.

7.8.3 Network Settings for local access.

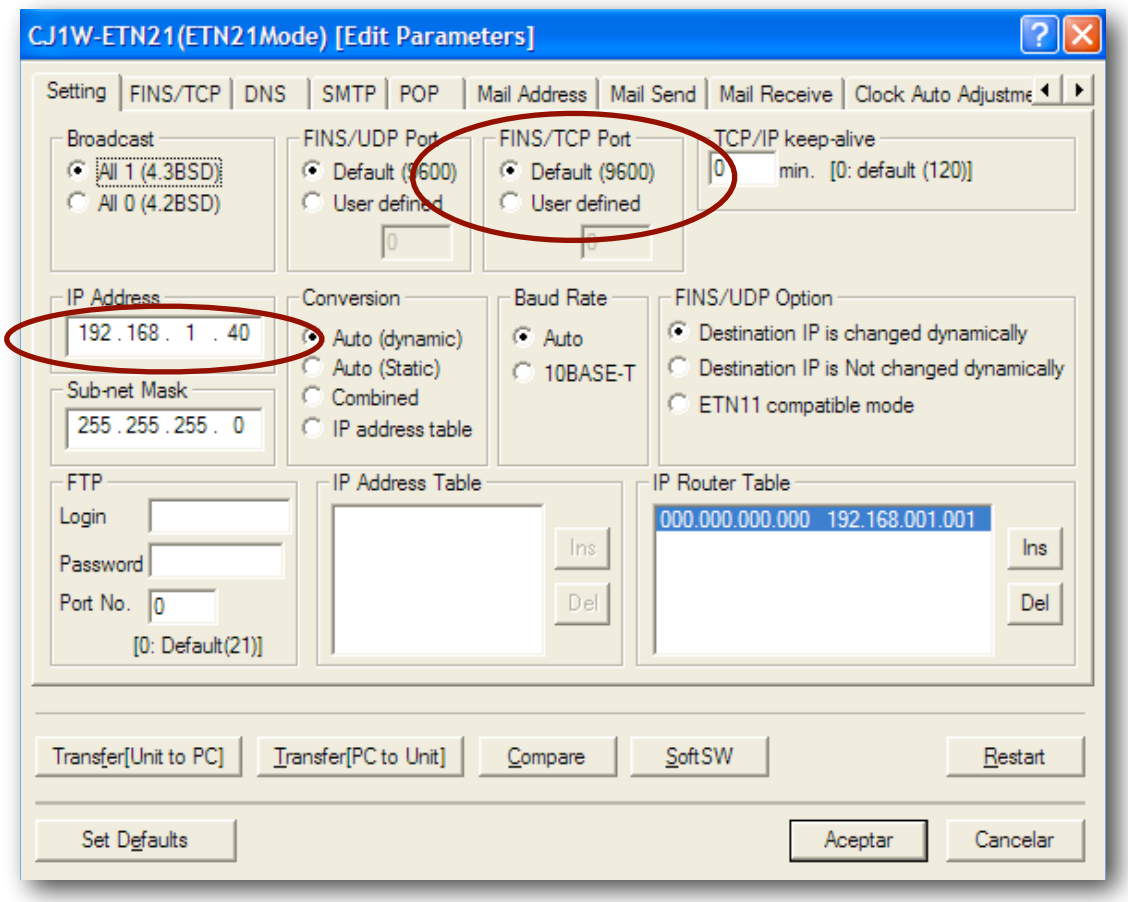
HMI Pad uses wireless TCP/IP technology to connect and to communicate with PLCs. Direct access from a Local Network requires that both devices be in the same subnet. The PLC acts as the communications server and the iOS device is the client.

The following picture shows a typical setup using the recommended industrial wireless hardware, but basically any WiFi router will do it.



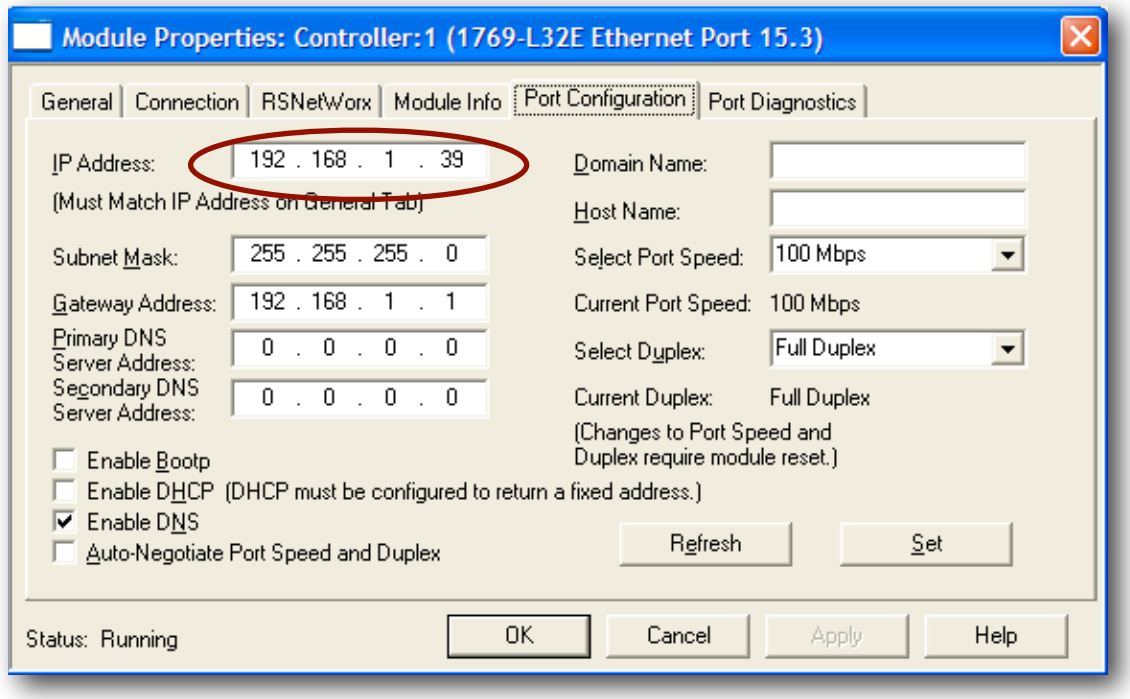
7.8.3.1 PLC Settings for local access.

1. In case of Omron's **Fins/TCP** protocol use CX-Programmer tool to set a fixed local IP and Port for the PLC on the ethernet configuration panel.



2. For **EIP/Native** protocol and Allen Bradley controllers use RS-Logix 5000 tool to set a fixed local IP for the PLC on the ethernet module properties panel.

3. For **EIP/PCCC** protocol use Allen Bradley's RS-Logix 500 tool and set a fixed local IP for the PLC on the Channel Configuration panel



4. For other PLCs or devices based on the **Modbus/TCP** protocol, **Siemens/ISO_TCP** or Mitsubishi's **MelIssec/TCP** consult the relevant vendor documentation to know how to set ports and addresses.

5. The relevant PLC Connector parameters for local connections are *local* and *local port*.

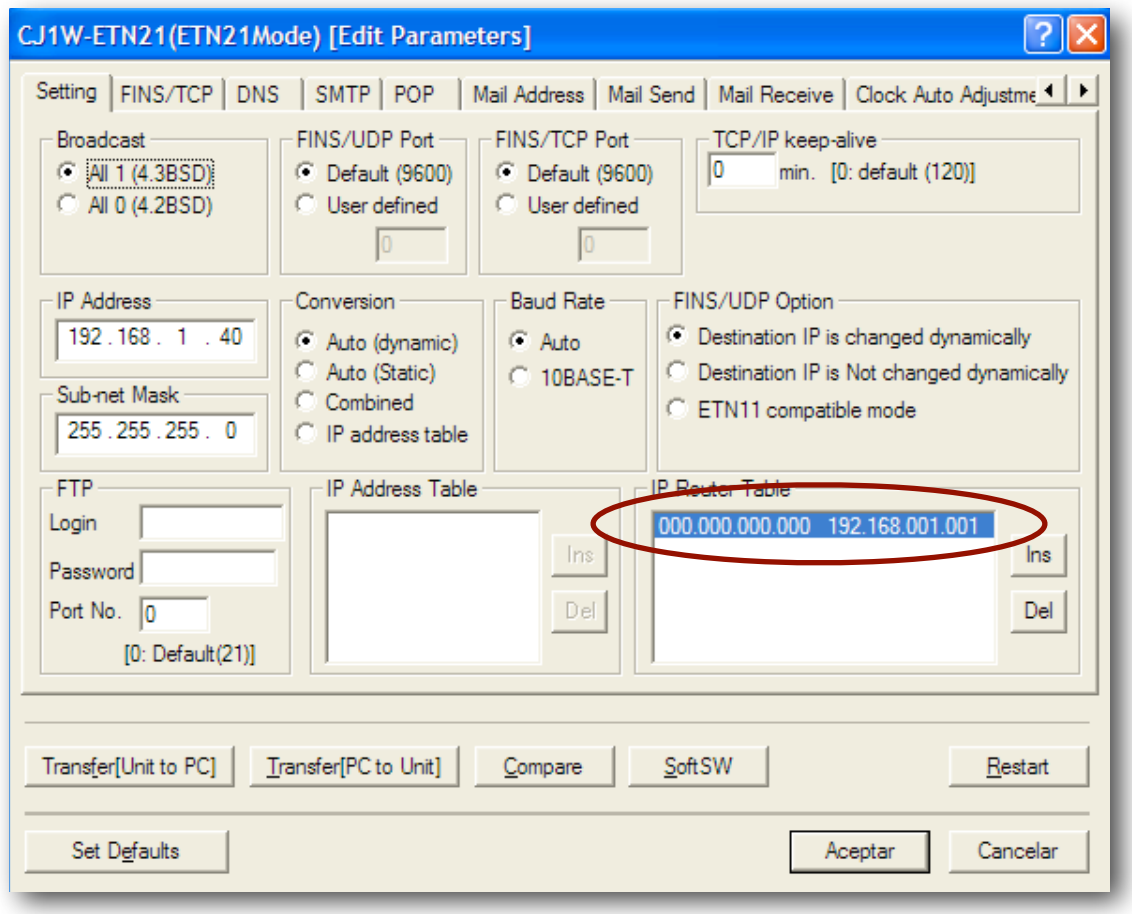
7.8.4 Network Settings for remote access.

HMI Editor is designed to communicate with PLCs without using dedicated servers or any specific software installed on a PC. Communications with PLCs are made by using industrial protocol commands.

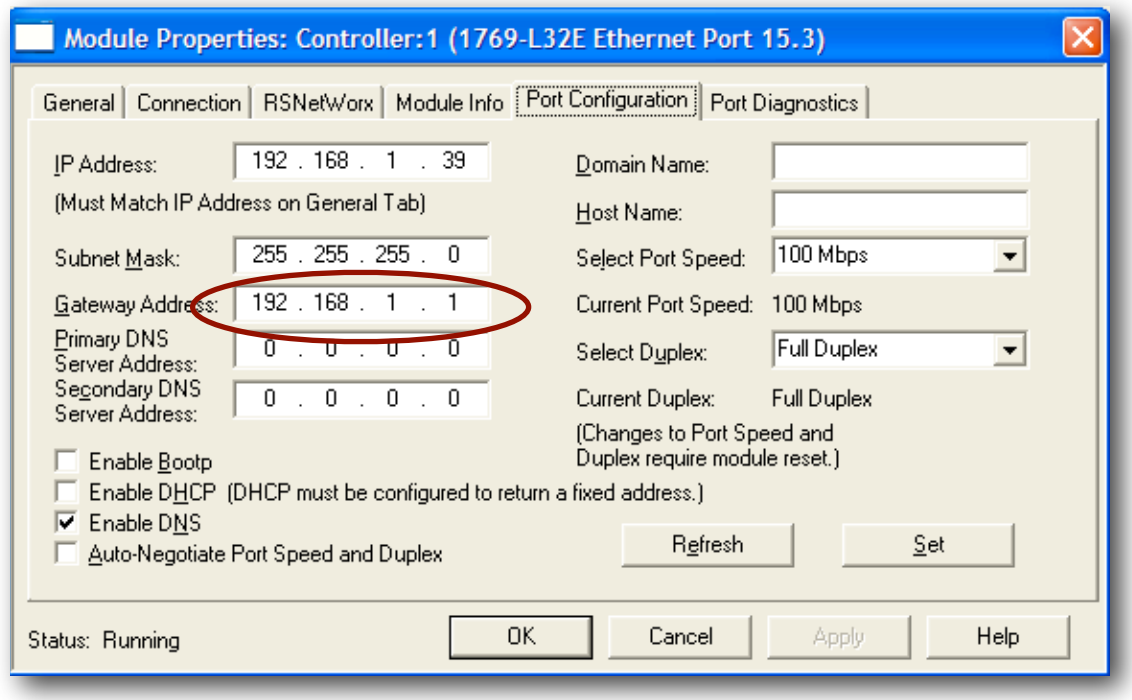
To establish a remote connection, a GPRS or DSL router is needed at the PLC site, which will act as a bridge between the LAN (Local Network) where the PLC is physically wired and the WWAN or WAN (Internet) to which a remote iPhone or iPod Touch will have access to. This figure shows a standard setup.

First determine the LOCAL IP address of the GPRS or ADSL router. PLCs need to know the router address as it is the gateway to the internet.

1. In case of **Omron Fins/TCP** copy the router address in the 'IP Route Table' field of the ethernet configuration panel for the PLC in CX-Programmer.



2. For **EIP/Native** protocol and Allen Bradley controllers use RS-Logix tool to set the fixed local router IP (gateway) on the ethernet module properties panel.
3. For **EIP/PCCC** protocol use Allen Bradley's RS-Logix 500 tool and set the gateway IP on the Channel Configuration panel



4. For **Modbus/TCP** based devices **Siemens S7** or **Mitsubishi** controllers refer to the vendor's documentation.
5. Now log into the GPRS or DSL Router and configure NAT options to set up a bridge between the WAN and your PLC local address and port. Note that the default port number is 44818 for Ethetnet/IP, 502 for Modbus/TCP, and 9600 for Omron PLCs. Protocol on the router must be set to TCP/IP. Look at your router documentation for details.
6. If you have a fixed IP address enter it as such in the *remote* parameter of your PLC Connector in HMI Editor. .
7. If your router access the WAN through a dynamic IP then you must create an account with a dynamic DNS services provider such as www.dyndns.org, and configure your router to notify of IP changes. In this case, enter in the *remote* parameter the name you chose for your dynamic DNS. The *remote port* number must still be the one configured in the NAT section of your router.

7.8.5 Network Security.

HMI Editor networking security is based on TCP/IP technology and depends in part on the security features available in the router installed at the PLC location.

For local connections through WiFi security is given by the wireless network security protocol in use. WPA and WPA2 with a strong password is the recommended security protocol.

For remote connections, an iPhone or iPad is able to make use of secure data tunnels by enabling VPN. If your router supports L2TP/IPSEC or PPTP then you will be able to create this kind of connection. Most medium to high-end DSL or Cable routers support at least PPTP. VPNs client connections are configured on the iOS device with the General Settings App.

For most protocols, HMI Editor provides an independent way to protect users from undesired access of persons using uncontrolled HMI Editor or ScadaMobile copies. This is done by setting a Validation Code both in the PLCs and HMI Editor which will prevent the app to access PLCs unless both codes match. Next section describes validation codes and how you can set them.up.

Finally, physical access can compromise security. It is relatively easy for an unauthorized user to gather physical access to a device and run a remote monitoring application. To fight this possibility, HMI Editor user accounts provide password based security. You can set the 'automatic login' switch off in the HMI Editor or HMI settings tab, and a password key will be asked each time the app is launched, thus preventing unauthorized people from using the app. Additionally Apple provides a service for blocking lost or stolen devices so that no one is able to access to data or execute apps in them until the real owner reactivates them.

7.8.6 The Default Validation Tag .

For most protocols HMI Editor requires a validation code being held by the PLC, which is queried on each connection. This password must be stored in your PLC as a 16 bit hexadecimal value (0 to FFFF) and must match the value specified in 'Validation Code' for connections to a PLC to succeed. In most cases this security measure alone is enough for simple applications.

Validation Codes are stored in PLCs in the following Memory Address or Tag depending on protocol.

PROTOCOL	DEFAULT VALIDATION TAG	REMARKS
EIP/Native	SMValidationTag	Any INT value. This tag **must be present** in order for HMI Editor to communicate. Set initially to '0' to avoid having to enter it on HMI Editor during development stages.
EIP/PCCC	N98:0	Any INT value. This tag **must be present** in order for HMI Editor to communicate. You may have to create a Data File number 98 of type Integer with at least 1 element
FINS/TCP (Omron)	D19998	Any value from 0000 hex to FFFF hex is valid.
Melsec/TCP (Mitsubishi)	D8085	Any value from 0000 hex to FFFF hex is valid.
Modbus/TCP Modbus over TCP	(Not Available)	See note below.
Opto22/Native	SMValidationTag	Integer32 Numeric variable that **must be configured** in the PAC Control strategy in order to allow HMI Editor to communicate with it. The valid range for its value is 0-65535 (0xFFFF). Set initially to '0' to avoid having to enter it on HMI Editor during development stages.
Siemens/ISO_TCP	MW998	Any value from 0000 hex to FFFF hex is valid.
The Validation Code feature is not available for Modbus/TCP due to the great number of Industrial devices supporting this protocol, which makes impractical to establish a general way to implement such feature.		

Validation codes are entered in the relevant field of your HMI Editor' connector. Note that HMI Editor will always perform this security check. There is no way to disable or prevent it, however you can set a custom *Validation Tag*:

7.8.7 Setting a Custom Validation Tag

If the default validation tag interferes with your project you can set a custom one with the *Validation Tag* parameter.

When using a custom Validation Tag you must be aware of the following rules:

- It is explicitly forbidden to use 0 (zero) for the Validation Code when you set a custom Validation Tag. If you do so validation check will always fail.
- If you explicitly set the *Validation Tag* property to the same as the default one, you will still have to explicitly set a non zero value for the validation code, as using 0 will always fail the validation check.
- To return to the Default Validation Tag, and thus remove the restriction on a value of 0 for the Validation Code, simply leave the Validation Tag field empty.

7.8.8 International Languages Support and String Encodings

The HMI Editor app fully supports International Characters and Strings in any language. Integrators can therefore chose to present their project interface in any language.

To represent strings the concept of *String Encodings* is used. String Encodings are international conventions that determine how characters representing particular languages are stored into files and device memory.

By default HMI Editor assumes project files and Strings to conform to the **UTF-8 Encoding**. This is specially adequate for English and relatively compact for most Western European languages such as German, French, Spanish, Portuguese, and many others. UTF-8 is still designed to work for virtually any international language including Asian languages (Chinese, Japanese, Korean) and the rest of languages that are not based on Latin derived characters. It does not require any particular setting.

The UTF-8 encoding is backward compatible with old plain ASCII, meaning that ASCII characters share the same codes when represented in UTF-8 encoding.

International languages can be represented with encodings other than UTF-8 which are generally more efficient for a particular language. This is presented on the next section.

The default string encoding for String storage in PLCs is **WindowsLatin1**. Like UTF-8 the WindowsLatin1 encoding is backward compatible with ASCII, but contrary to UTF-8, it uses one single byte per character for representing most Western European languages like German, French, Spanish, or Portuguese.

7.8.8.1 String Encoding for International Languages.

The following explicit *string encodings* are supported on HMI Editor:

EXPLICIT ENCODING	Description
WindowsLatin1	Identifies the ISO Latin 1 encoding (ISO 8859-1). This is the default.
UTF-8	Identifies the Unicode UTF 8 encoding.
UTF-16	Identifies the Unicode UTF 16 encoding.
MacRoman	Identifies the Mac Roman encoding. Used on western localizations of Mac OS. Useful when you use diacritic characters (Spanish, French, German, the degree ° simbol...) but you do not want to export your file as csv-windows.
Cyrillic/Mac	Identifies the Mac Cyrillic encoding
Cyrillic/Win	Identifies the Windows Code page 1251 Slavic Cyrillic encoding
Cyrillic/ISO	Identifies the ISO 8859-5 Cyrillic encoding
Japanese/Mac	Identifies the Mac Japanese encoding
Japanese/Win	Identifies the Windows Code page 932 Japanese encoding
Japanese/JIS	Identifies the Shift-JIS format encoding of JIS X0213
Chinese/Mac	Identifies the Mac Simplified Chinese encoding
Chinese/Win	Identifies the Windows Simplified Chinese encoding
Chinese/GB2312	Identifies the GB_2312 Chinese encoding

The UTF-8 encoding is a multibyte character encoding derived from UTF-16. Like UTF-16 it can represent every character of all languages, but unlike UTF-16, it is backward compatible with ASCII, using only one byte for representing ASCII characters.

Only UTF-16 or UTF-8 is supported on project files. Project files with the UTF-16 encoding will be converted automatically to UTF-8.

7.8.8.2 Use of International Characters in PLC Strings

You can store international Strings in PLCs with HMI Editor just as easily as you do ASCII strings. HMI Editor will use the string encoding specified for the Connector to decode/encode strings onto raw bytes in the PLC.

When storing international Strings into PLCs you must expect the number of bytes used, and thus the PLC string length, to be larger than the number of characters the string actually contains. This is particularly notorious when storing Chinese or Japanese strings in PLCs.

The UTF-8 encoding, for instance, can use up to 6 bytes per character in a PLC. However, this does not affect how strings are allocated in HMI Editor or the behavior of String methods and operators in expressions, since these always refer to actual characters and actual character lengths regardless of encoding.

Of couse, if you only use English or ASCII characters with an encoding that is backward compatible with ASCII, or you use the default **WindowsLatin1** encoding, only one byte per character will be allocated in your PLC to store strings.

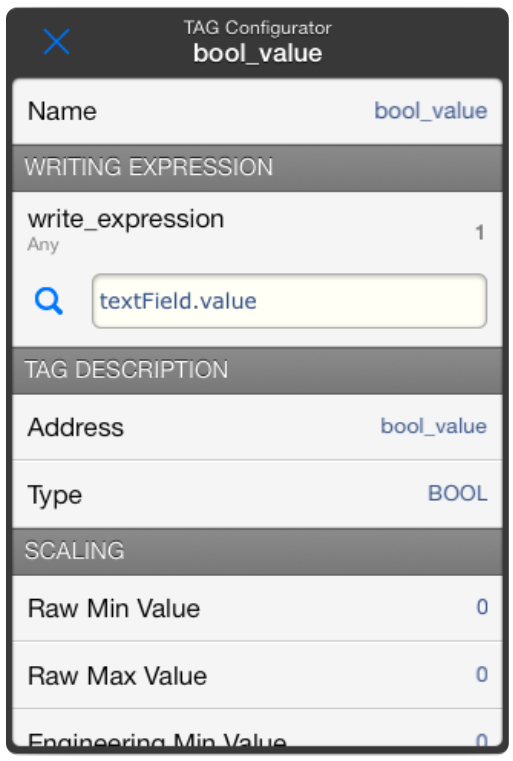
7.9 PLC Tags

PLC Tags are associated with PLC Connectors through Properties that are dynamically created upon addition of PLC Tags. This makes possible to access them as any regular Object Property. PLC Tags are accessible as Properties of PLC Connectors

The syntax for accessing a tag named *tagName* of a PLC Connector named *source* is the following:

source.tagName

PLC Tags have in turn their own configuration panel. The following parameters are available:



PLC TAG PARAME-TERS	MEANING
write_expression	Enter an expression here to write values to PLC Tags The execution of the expression causes a write to the PLC Tag. See sections below for more information.
Address	Memory location or Variable Name in the PLC for this PLC Tag. See sections below for more information.
Type	Native Data Type in the PLC for this PLC Tag. See sections below for more information.

PLC TAG PARAME-TERS	MEANING
Raw Min Value **Raw Max Value** **Engineering Min Value** **Engineering Max Value**	These four parameters determine the scaling to be applied upon reading and writing of scalar numeric types. *Raw Min Value*, *Raw Max Value* represent a pair of numeric values in raw units as present in the PLC. *Engineering Min Value*, *Engineering Max Value* represent a pair of corresponding values in engineering units they as will be treated on HMI Editor. By setting these parameters, raw values are converted (scaled) to engineering values on by applying a linear transformation on read, and engineering values are converted back to raw values upon writing. Example: by setting 0,100,0,1 respectively to these parameters any PLC raw value will be divided by 100 upon read, and multiplied by 100 upon write. Or in other words, 100 units on the PLC will correspond to 1 unit on HMI Editor.

7.9.1 Specification of Variable Types ('Type' Parameter)

Type determine the native data type of variables in PLCs. A Type may refer to a simple scalar value such as an INT or FLOAT or to an array of values.To indicate that you access a PLC Variable as an array you append [n] to its data type. In the table below, 'n' indicates the total number of elements that the array must hold.

The following types are supported.

TYPE	REMARKS
BOOL*[n]*	Value that can adopt one of two states.
SINT*[n]*	8 bits signed integer value (-128 ... +127)
INT*[n]*	16 bits, signed integer value (-32768 ... +32767)
UINT*[n]*	16 bits unsigned integer value (0 ... 65535).
UINT_BCD*[n]*	4 digit BCD value stored in a 16 bit register using 4 bits per digit (0 ... 9999)
DINT*[n]*	32 bits signed integer value (-2147483648 ... +2147483647)
UDINT*[n]*	32 bits unsigned integer value (0 ... 4294967295)
UDINT_BCD*[n]*	8 digit BCD value stored in two 16 bit register using 4 bits per digit (0 ... 99999999)
REAL*[n]*	32 bits floating point value (IEEE 754) (aprox -1e38 ... +1e38)
CHANNEL*[n]*	Same as UINT
WORD*[n]*	Same as UINT
DWORD*[n]*	Same as UDINT
STRING*[n]* **STRING(size)*[n]***	Type containing a characters string. Actual representation depends on protocol, for example Allen Bradley controllers can hold up to 82 character bytes. Siemens S7 controllers require a *size* specification for strings. Notice that *size* is given between parentheses, NOT square brackets. Note that STRING[n] does not indicate a string containing *n* characters but an array containing *n* strings of default capacity. Particularly do not confuse with CHAR(n) or STRING(n) which refers to a single string with a capacity of *n* bytes. By default, Strings on controllers are interpreted as per the WINDOWS-LATIN1 encoding, but other encodings are possible if specified on the Connections Object.(See International Languages Support) The STRING type should be used with the appropriate string memory area or string tag type in controllers supporting them. The use of the STRING data type is not limited to controllers with explicit support for strings. See section Representation of Character Strings in PLCs below for further information.

TYPE	REMARKS
CHAR(size)*[n]* **CHAR[size]**	Similar to STRING except that it is meant for NULL terminated strings and it does not insert a leading length word. It can be used on protocols with no specific support for strings such as Modbus. In this case *size* indicates the string buffer length, i.e. the number of character bytes that should be allocated in the PLC for the string, starting from the address specified in the Address Parameter. Note that CHAR[20] would technically mean an array of 20 character bytes, however in this case it will be treated as a single string with a capacity of 20 bytes. Keep in mind that if you use a string encoding other that the default, you must require an increased *size* to give more capacity to fit all the characters. This is because on some encodings a single character may require multiple bytes to be represented. It is possible to have arrays of char strings. For example CHAR(size)[n] will represent an array of *n* strings with a capacity of *size* bytes each. See also section Representation of Character Strings in PLCs below

When entering a Type, you can optionally specify an array size for it as shown above in italics. When you do so, the related PLC Variable is interpreted as an array of values of the relevant type instead of a single value. See PLC Memory Arrays and Access Types for more information.

Size definition is obligatory for CHAR types.

Reading a PLC Variable provides a value to the Expressions Engine with a Data Type as defined in section "Data Types in Expressions" that depends on the PLC DataType.

For STRING and CHAR(n) you will get a **String**, for the scalar types such as BOOL, INT, DINT, FLOAT etc you get a **Number**. For PLC Arrays you will get an **Array of Strings** or an **Array of Numbers** depending on the base PLC Type.

7.9.1.1 Representation of Character Strings in PLCs

Strings in PLCs are stored in several ways depending on PLC brand or family. HMI Editor uses a homogeneous way to indicate PLC tag Types that in some cases differ slightly from the PLC manufacturer way.

In general, you do not need to worry about which particular representation a particular PLC uses. HMI Pad handles it all automatically for you.

Not all PLCs share the same fields for representing a string. For example Allen Bradley controller strings are fixed capacity and can hold up to 82 character bytes. Siemens S7 controllers, on the other hand, require a size specification for strings.

For **Allen Bradley Controllers** you can simply use STRING to indicate a single string, or STRING[*n*] to indicate an array of *n* strings. The actual representation of a single string on the PLC consists on a UINT or UDINT field followed by a 82 bytes long buffer.

AB MICROLOGIX STRING REPRESENTATION (STRING):

Length (2 bytes)	Characters (fixed size, 82 bytes)

AB LOGIX STRING REPRESENTATION (STRING):

Length (4 bytes)	Characters (fixed size, 82 bytes)

The same criteria apply for **Opto22 PAC controllers** as they represent STRINGs with a variable length structure starting with a field containing a value for both size and length followed by the same number of raw characters after the length field.

OPTO22 STRING REPRESENTATION (STRING):

Size and Length (4 bytes)	Characters (variable size)

For **Siemens S7 Controllers** you must use STRING(*size*) where *size* is the total number of byte characters that the string can hold, or STRING(*size*)[*n*] to indicate an array of *n* strings of *size* character capacity. The actual representation of a STRING(size) in the PLC consists on the following pattern.

SIEMENS SIMATIC S7 STRING REPRESENTATION (STRING(size)):

Size (1 byte)	Length (1 byte)	Characters (variable size)

Although the above representations are the default ones for the mentioned controller brands, HMI Editor will still attempt to chose one of the above for use on controllers with no explicit STRING specification. The choice will depend on whether you used a *size* specifier.

On controllers with no explicit STRING representation you will want to use the raw char string representation CHAR(n)

RAW CHAR STRING REPRESENTATION (CHAR(size)):

Characters (variable size)

For raw char string reads, HMI Editor will understand a NULL character or the total buffer size as the termination of the string. For writes, HMI Editor will pad all unused bytes with NULL characters. This is the usual convention for raw character string representations.

Important note about Strings with Siemens Simatic S7 controllers.

The size field for STRINGS in S7 must be generally specified. This is usually done in Siemens software by appending the size in square brackets just after 'STRING'. For example STRING[20].However, HMI Editor already uses square brackets to identify arrays so this notation conflicts with S7 notation.

To work around this we chose to use normal parentheses to indicate size.

Thus, STRING sizes must be indicated in the Type parameter using round parentheses. The square notation is still reserved for arrays, so when you use them you will be referring to ARRAYs. Consider the following cases:

STRING(20) This refers to a STRING with a capacity of 20 characters and should not be confused by STRING[20]

STRING(20)[3] This is an ARRAY of 3 elements, each element is a string with a capacity of 20 characters

STRING[20] This is an ARRAY of 20 STRINGs. This is **not** a string of 20 characters!. Since the default string size for S7 is 254 (256 bytes including the size and length fields) you will end having an array of 20 STRINGs with a capacity of 254 characters each. Actually you will end reading (or writing) a range of 20*256 = 5120 bytes on your PLC for this tag and your PLC will most probably reply with an out of range error.

7.9.2 Specification of Variable Addresses ('Address' Parameter)

A Variable Address represents a memory location, a register or a Tag in a PLC to which a Variable refers. Addresses are specified in different ways depending on the particular communications protocol.

For protocols based on registers or memory areas, Addresses are specified by a prefix referring to the memory area followed by a numeric value indicating the position in that area. For Allen Bradley's Logix controllers and Opto 22 PAC controllers Addresses are based on symbolic names.

The following memory areas and prefixes are supported.

PROTOCOL	ADDRESS	REMARKS
EIP/Native (AB Logix Controllers)	***<symbolic-name>*** : Access by name	Actual symbolic PLC tag name. See Note on EIP/Native Communication Protocol below.
EIP/PCCC (AB Micrologix and SLC 5)	**O0**: Outputs **I1**: Inputs **S2**: Status **B3**: Binary **T4**: Timer **C5**: Counter **R6**: Control **N*n***: Integer File (*n* is file number) **F*n***: Floating Point File (*n* is file number) **ST*n***: String File (*n* is file number)	Tags are specified by File type, File number and Offset in the regular way. Individual bits in words can be accessed to using the usual slash notation for SCL and Micrologix controllers. Examples: B3:5 would access word 5 on file 3 of type 'B' N7:0 would access value at position 0 in N7 File. N7:0/3 would access bit 3 in N7:0
Fins/TCP (Omron)	**W**: Work area **D**: Data Memory Area (DM) **T**: Tim/Counter Area (T/C) **H**: Holding Register Area (HR) **A**: System Area (AR) Area **E**: Extra Memory (EM) Area (no prefix) : I/O Area	Individual bits are specified by following a dot (.) and a number from 0 to 15. For example: W10.5 refers to bit 5 of W10
Melsec/TCP	**D**: Data Register (word) **R**: File Register (word) **TN**: Timer Current Value (word) **TS**: Timer Contact (bit) **CN**: Counter Current Value (word) **CS**: Counter Contact (bit) **X**: Input (bit) **Y**: Output (bit) **M**: Internal Relay (bit) **S**: State Relay (bit)	Bits or Words are specified by appending the number address to the device area: For example: M4 is bit 4 of M area, D8 is word 8 of D area Individual bits on 16 bit device areas can be accessed by appending a dot (.) and a number from 0 to 15. For example: D8.5 refers to bit 5 of D8

PROTOCOL	ADDRESS	REMARKS
Modbus/TCP **Modbus over TCP**	**I**: Input Discrete (read only) **C**: Coil **IR**: Input Register (read only) **HR**: Holding Register	To access Coil number 10, specify C10. To access Holding register 1 specify HR1. Individual bits in HRs can be accessed for reading or writing using a dot notation. For example, HR1.3 would refer to bit 3 in HR1
Opto22/Native **(Opto22 PAC)**	***<symbolic-name>*** : Access by name	Actual symbolic PAC control tag name for accessing Strategy Variables, Timers, Tables, i/O.and Charts. In some cases suffixes or element specifiers are applied to identify variable attributes and special functions. Data type and array index provided in *Type* are also relevant for the actual read/write command used to access PAC Charts or Timers. See Note on Opto22/Native Communication Protocol below and the included example files.
Siemens/ISO_TCP **(Siemens S7)**	Area Prefixes: **E**: Inputs **I**: same as E **A**: Outputs **Q**: Same as A **M**: Internal Flags **DB*n*.DB**: Data block Valid Size Modifiers (after Area Prefix): **X**: Any size or 1 bit size **B**: byte (8 bits) **W**: word (16 bits) **D**: double word (32 bits) (none): 1 bit size	Tags are addressed by Area and Size in the usual way for S7 controllers. Examples: E2.3 accesses bit 3 of input address 2 I2.3 same as above (English notation) MB14 accesses address 14 on the flags area as a 8 bit value MW14 accesses address 14 on the flags area as a 16 bits value MD14 accesses address 14 on the flags area as a 32 bits value DB2.DBW6 accesses address 6 on Data Block number 2 area as a 16 bits value DB4.DBX8 accesses address 8 on Data Block number 4 area. Size depends on actual type specified type on column B

Accessing data types longer than one register.

For data types requiring more than one register or memory location, the lower address in their range must be specified. For example, a variable of type DINT addressed by HR100 will use HR100 and HR101 because 2 Modbus registers (16 bits) are required to accommodate the complete variable (32 bits). Integrators must be aware of it to avoid overlapping tag values. This applies to all protocols except EIP/Native and Opto22/Native.

Accessing a Register as a BOOL.

Generally, it is possible to specify a BOOL type for a register or memory location even if it is not meant to hold a BOOL. You can for example specify that HR1 is a BOOL. In such case, HMI Editor will apply the usual convention of true non zero values

EIP/Native does not allow a non BOOL PLC Tag to be treated as BOOL due to the strict type checking that this protocol encourages.

Siemens/ISO_TCP enforces size identification along with memory area, thus some restrictions apply for use of BOOL type on larger sizes.

The Opto22/Native protocol does not add type information to tags so you can use BOOL as Type to display values as per the general rule.

Accessing individual bits in a Register.

Individual bits on registers can be accessed by using the BOOL type and by specifying a bit address using the dot (.) or slash (/) notation depending on protocol (see table above). When writing, HMI Editor will use the appropriate protocol command to avoid overwriting undesired bits on the register.

On EIP/Native you can still use the dot notation to access individual bits on variables, but due to strict type checking you must set the correct variable Type.

With the Opto22/Native protocol the general rule still works for reads and therefore you can use the dot and bit number notation to obtain the corresponding bit value, for example ‘myIntTag.3’ will return the value of bit 3.

Note on EIP/Native communications protocol (AB Logix controllers).

EIP/Native communications do not rely on particular memory locations or positions, but on symbolic names. With this protocol the user is relieved from the responsibility to assign memory addresses or registers and from the need to take tag sizes into account for storage. Additionally, EIP/Native tags carry data information such as type and size, which HMI Editor uses to check against type mismatches on PLC returned values. As a result, it is not possible to store values that differ in type or size from the values that are uniquely defined in the PLC. Any attempt to so so will result in a ‘type mismatch’ error on the offending tag.

For **EIP/Native** any valid reference to an existing scalar or array type tag including structure members or array elements is supported. For example “myStructData[2,3].intMember” may refer to an integer value referenced by the intMember member of element (2,3) of an array of structures.

As a general rule, any Tag name path referring to an existing scalar value (BOOL, SINT, INT, DINT, REAL, STRING) or array of such elements in a Logix Controller can be accessed.

To access arrays as a whole you need to set the array size on *Type*, as discussed on the previous and following sections.

You can also access program tags by using the following syntax

Program:<program_name>.<tag_name>

Note that ‘Program’ is literal. *<program_name>* and *<tag_name>* identify just what they suggest.

Note also that HMI Editor performs a Validation Code security check before any other attempt to access other tags is made, therefore, it is mandatory to have a tag named “SMValidationCode” of type INT in your PLC for communications to work. (see The Default Validation Tag)

Note on Opto22/Native communications protocol (Opto22 PAC).

The **Opto22/Native** is a symbolic communications protocol that uses PAC control symbolic tag names to access variables in Opto22 PAC controllers. Integer, Float and String data types and Tables are fully supported for read and write. Additionally, HMI Editor provides ways to perform particular operations on timers and chars and to access fields of digital and analog I/O points. The way you use HMI Editor for accessing to these features is described in continuation.

DataTypes: Supported types for Opto22 are DINT, REAL and STRING (*Type* Parameter). Other data types in HMI Editor can be used as well but they may trim results depending on the actual values in the controller.

Tables: Tables are fully supported. Tables can be of DINTs, REALs or STRINGs. To access tables you define the number of elements to read or write from a table as an array subscript on Type. For example REAL[8] will refer to 8 elements of a table of floats. Similarly, on *Address* you specify the starting element, for example myRealTable[3]. These two entries combined will cause reads or writes of 8 values from the table myRealTable starting at element 3 and continuing through element 10 inclusive.

DIgital and Analog I/O Points: I/O points in Opto22 are represented by data structures which HMI Editor can read and provide access to some of its members. In order to access I/O point structure members a dot notation using particular names is used. The following member access names are available:

digital_IO_point.state	read access to a BOOL value corresponding to the actual state of any Digital I/O point
digital_I_point.on_latch	read access to a BOOL with the On Latch attribute of a Digital Input point
digital_I_point.off_latch	read access to a BOOL with the Off Latch attribute of a Digital Input point
digital_I_point.counter	read access to a DINT value with the Counter value of a Digital Input point
analog_IO_point.value	read access to a REAL with the actual value of any Analog I/O point
analog_I_point.min	read access to a REAL with the min value of an Analog Input point
analog_I_point.max	read access to a REAL with the min value of an Analog Input point
IO_Point.enabled	read access to an an 8 bit value register associated with an I/O point to check if its I/O Unit and I/O Point Communication flags are enabled.

Note that these member access names are not available on the expressions engine but only as an extension for point variable definitions as entered in *Address*. In other words, a point variable data structure cannot be read as a single object but only through its members.

Timers:. Timer values are accessed as any regular float variable. Additionally, some actions can be performed on timers when operated in write mode. In such case particular commands are sent to the PAC controller as opposed to a data value. To cause commands for appropriate actions to be sent you must set the *write_expression* parameter on the PLC Tag. Actions are specified using the dot notation with particular names as follows:

timer	Actual value, a REAL with the value of the Timer variable *timer*.
timer.start_timer	when written to sends the command StartTimer to the Timer *timer*
timer.stop_timer	when written to sends the command StopTimer to the Timer *timer*
timer.pause_timer	when written to sends the command PauseTimer to the Timer *timer*
timer.continue_timer	when written to sends the command ContinueTimer to the Timer *timer*

Charts:. It is possible to read Chart Status and to perform Start and Stop operations. This is provided by means of structure member access names. The Start and Stop commands work with writable tags. The same recommendations given for Timer commands apply for Chart commands.

chart.chart_status	provides read access to the 32 bit BitStat value of Chart *chart* as a UDINT value
chart.start_chart	when written to sends a Start command to the Chart *chart*
chart.stop_chart	when written to sends a Stop command to the Chart *chart*

7.9.3 PLC Memory Arrays and Access Patterns

It is possible to read or write consecutive memory locations in the PLC as memory arrays and use them as single property values. In order to do so you define the array size for the PLC Tag *Type*. HMI Editor will read the specified number of values and will make them available as an Array through the Property associated to the PLC Tag.

To deal with PLC arrays HMI Editor uses several **access patterns** depending on the specified *Type* and actual size of data in the PLC. We will use examples based on the modbus protocol to discuss each possible case. The same patters will work on all protocols for similar types and data sizes. For the examples we assume PLC Tags belong to a Connector named *source*.

The following access patterns are possible:

1 - Accessing 1 bit data size memory areas as single values (modbus coils).

• BOOL, SINT, INT, DINT, in *Type*
• Cx in *Address*

The tag property gets the value of Cx (0 or 1) regardless of *Type*

Example: get value at C1 as INT

testTag INT C1
source.testTag will contain 0 or 1 depending on the value in *C1*.

2 - Accessing 1 bit data size memory areas as an array (modbus coils)

• BOOL[n], SINT[n], INT[n], DINT[n] in *Type*
• Cx in *Address*

The tag property will be an array containing *n* elements of the specified type. Bits in each element will be taken from the PLC memory from the less significative to the most significative.

Example: get array of 2 INTs starting at C1

testTag INT[2] C1
Array element 0 (*source. testTag[0]*) will contain bits from *C1* to *C16*.
Array element 1 (*source. testTag[1]*) will contain bits from *C17* to *C32*.

Example: array of 10 BOOLs starting at C1

testTag BOOL[10] C1
Array element 0 (*source.testTag[0]*) will contain *C1*
Array element 1 (*source.testTag[1]*) will contain *C2*
...
Array element 9 (*source.testTag[9]*) will contain *C10*

3 - Accessing regular PLC memory as single values (valid on all protocols).

• BOOL, SINT, INT, DINT, REAL, STRING, CHAR[n] in *Type*
• HRx in *Address*

The tag property gets the value of HRx taking either the full register or the necessary following registers to hold the complete value. For types that are shorter than the actual register size the value in the PLC register is taken as a whole rather than trimmed to a shorter type.

Example: get DINT at HR1

testTag DINT HR1
source.testTag will contain the DINT value contained in *HR1,HR2*. (this is because DINT is 32 bits long and HRs hold 16 bits each)

Example: get HR1 as a BOOL

testTag BOOL HR1
source.testTag will contain 1 (true) if *HR1* is not zero, or 0 (false) otherwise. *HR1* raw value is therefore interpreted as boolean.

4 - Accessing regular PLC memory as an array of values (valid on all protocols).

• SINT[n], INT[n], DINT[n], REAL[n], STRING[n] in *Type*
• HRx in *Address*

The tag property will be an array containing *n* elements of the specified type. The array gets its values starting from HRx taking the necessary following registers to complete all its data according to data type size. Data is packed as it is found in PLC memory for types that are shorter than the actual PLC register size and taking into account the native endianness of the protocol.

Example 1: get array of 2 REALs starting at HR1

testTag REAL[2] HR1
Array element 0 (*source.testTag[0]*) will contain the REAL value at *HR1,HR2*.
Array element 1 (*source.testTag[1]*) will contain the REAL value at *HR3,HR4*.

Example 2: get array of 4 SINTs starting at HR1

testSTag SINT[4] HR1
Array element 0 (*source.testSTag[0]*) will contain the first byte of *HR1*.
Array element 1 (*source.testSTag[1]*) will contain the second byte or *HR1*
Array element 2 (*source.testSTag[2]*) will contain the first byte of *HR2*
Array element 3 (*source.testSTag[3]*) will contain the second byte of *HR2*

5 - Accessing individual bits of regular PLC memory (valid on all protocols).

• BOOL, SINT, INT, DINT, REAL in *Type*
• HRx.y in *Address*

The tag property gets the value of bit *y* (0 or 1) of *HRx* regardless of its type

For writes, using this pattern guarantees that writes of individual bits on registers will not affect or overlap other bits in the same or other registers.

Example: get HR1.0 as DINT

testTag DINT HR1.0
source.testTag will contain 0 or 1 depending on the value in *HR1.0*

6 - Accessing individual bits of PLC memory as an array of boolean values (valid on all protocols).

• BOOL[n], in *Type*
• HRx in *Address*

The tag property will be an array containing *n* elements of type BOOL. The array gets its values starting from Bit zero of HRx taking the necessary following registers to complete all its data.

Note that writing BOOL arrays with a size that is not a multiple of the raw register size on PLC memory will cause the exceeding bits to be set to zero.

Example: array of 32 BOOL starting at HR1

testTag BOOL[32] HR1
Array element 0 (*source.testTag[0]*) will contain bit 0 of *HR1*
Array element 1 (*source.testTag[1]*) will contain bit 1 of *HR1*.
...
Array element 16 (*source.testTag[16]*) will contain bit 0 of *HR2*
...
Array element 31 (*source.testTag[31]*) will contain bit 15 of *HR2*

Note on EIP/Native communication protocol (AB Logix controllers).

Since **EIP/Native** communications rely on symbolic names and type checking is performed on returned data, type matching must be observed. Basically, most of the above patters are applicable in the general way as far as the data type specified in column B matches the actual type on the PLC tag. This includes strings and arrays of any type.

From your perspective as integrator you do not need to treat Logix BOOL arrays in a special way as HMI Editor handles them automatically for you, in essence you can access individual elements by just entering BOOL on *Type* and the particular array element on *Address* (pattern 3), or you can get the complete (or part of the) array by specifying BOOL[n] on *Type* (pattern 6)

Note on Opto22/Native communication protocol (Opto22 PAC controllers).

The **Opto22/Native** protocol is symbolic but it does not always carry type information. Therefore, all the above accessing patters (except 1 and 2) are applicable and will work as described in most cases, specially for Integer and Float data values. The availability of access patters allows for advanced ways to get partial information from Opto22 strategy variables

Pattern 4 is especially relevant to be considered when used with Integer or Float Tables as it will prioritize the specified element size (for example 2 bytes for INT[n]) as opposed to the actual table element size (always 4 for Opto) and will still produce the effects described for that pattern (so when reading integer elements from OPTO into INT arrays, each OPTO table element will consume 2 HMI Editor array-elements).

Of course, if you always use DINT[n] or REAL[n] for accessing tables (strongly recommended), each table element will correctly fit in one element both in the Opto22 PAC controller and HMI Editor.

7.9.4 Writing to PLC Variables ('write_expression' Parameter)

You can configure writes to PLC Variables by entering an expression into the *write_expression*. The *write_expression* property is designed to perform writes on the PLC as the expression changes (receives a change event).

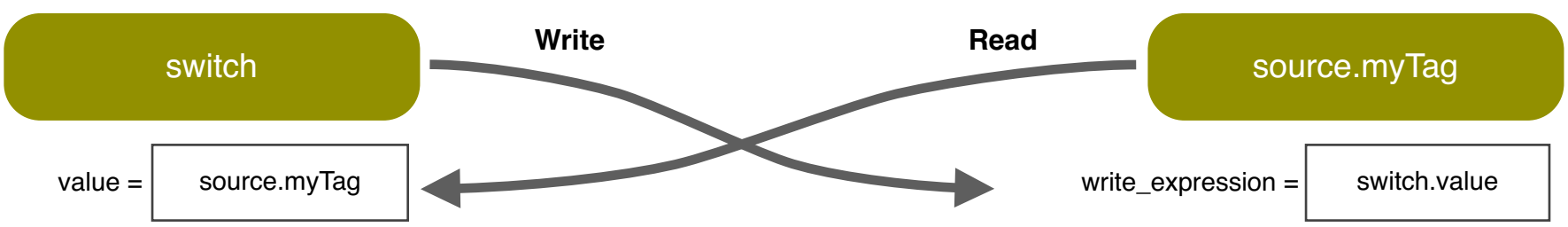
Example 1

For example if you enter button1.value on the *write_expression* property of a BOOL Tag, HMI Editor will send the button action (1 or 0) to the PLC when an user taps on the button.

Example 2

Consider that we have a *switch* on screen we want to link both ways with a PLC Tag named *source.myTag.* We want the *switch* to track changes of *source.myTag* and we want *source.myTag* to update when the *switch* changes.

Therefore we need to connect both sides of the required actions through expressions as schematized below:



1:- On the *value* property of the switch we enter: source.myTag. (This will update the *switch* when *source.myTag* changes)
2:- On the *write_expression* of the *myTag* we enter: *switch.value* (This will update *source.myTag* when the *switch* changes)

It is worth observing that you can enter whatever expression on each side of the link. This allows for achieving complex things such as updating interface elements that depend on several PLC values (or other interface elements) and perform writes to PLC tags that depend (or are linked) to disparate elements on the interface.

Use of the Expression List Operator (comma operator) to differentiate writes

The Expression List Operator ',' (comma operator) can be used to easily configure writes that should trigger on separate conditions without affecting each other.

For example we may have a *numberField* and a *knob* control on the interface and we want to update a PLC Tag for changes on any of the two. In this case you can enter the following on the *write_expression* property of said PLC Tag :

```
numberField.value, knob.value
```

this will write a value to the PLC Tag when either *numberField.value* changes or *knob.value* changes. Of course to keep both controls updated on the opposite direction you need to enter *source.tag* in the value fields of both controls..

Document Revision History

Refer to this section to look at changes on this document over different versions.

Version 2.2.1

- Description for *rand* function
- Updated description for *$UsersManager*

Version 2.2

- Added description for *$System.pulseOnce* property
- New section covering the *$Scanner* object
- Update of the image object properties for inclusion of the *animationDuration* property, animated sequencing of images, and mention of 'gif' file support.
- New section describing the *$UsersManager* object.
- New section describing the 'User' object.
- Description of new system methods, *SM.allFonts*, *SM.allColors*, *SM.encrypt*, *SM.decrypt*, *SM.mktime*.
- New sections for describing *Data Loggers* and *Data Presenters*.
- Added the *element* property and replaced *value* by *index* properties on the Array Picker object
- Description of new *Recipe Sheet* object
- Description of new *Data Snap* object
- Description of *$Project.allowedOrientationPhone* property
- Added note on the ab-use of the 'if-then-else' clause

Version 2.1

- Additional methods for Numbers (*floor*, *cel*), Arrays (*min*, *max*) and Ranges (*begin*, *end*)
- Deprecation note for the *Math.floor()* and *Math.ceil()* methods

Version 2.0

- Description of available options on the Editing Tools menu.
- Added the *enabledInterfaceIdiom* property to Page
- Added *LinkToPage* and *LinkToPages* properties to Button, Slider Control and Array Picker
- Description of *$System.interfaceIdiom* property
- Description of *$Project.allowedOrientation* property

Version 1.2

- Description for the *group* object.
- Updated *page* object with new properties.
- Updated *alarm* object with new properties related to sound and alerts.
- Added the Register Grouping Limit parameter to the modbus protocol parameters.

Version 1.0

- Initial Release.

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