



QE Framework - QEGui and User Interface Design

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Introduction

This document describes how to use the QE Framework to develop ‘code free’ Control GUI systems. It explains how features of the QE Framework widgets can be exploited, and how the QE Framework widgets interact with each other and with the QEGui application typically used to present the user interface.

While widget properties are referenced, a definitive list of the available properties is available in document QEReferenceManual.pdf.

This document is not intended to be a general style guide, or a guide on using Qt’s user interface development tool, Designer. Style issues should be resolved using facility based style guidelines, EPICS community standards, and general user interface style guides. Consult Qt documentation regarding Designer.

License

The QE Framework is distributed under the GNU General Public License version 3, distributed with the framework in the file COPYING. It may also be obtained from here:

<http://www.gnu.org/licenses/gpl-3.0-standalone.html>

Overview

In a typical configuration, Qt’s Designer is used to produce a set of Qt user interface files (.ui files) that implement an integrated GUI system. The QE Framework application QEGui is then used to present the set of .ui files to users. The set of .ui files may include custom and generic template forms, and forms can include nested sub forms. Other applications can also be integrated.

<image of a set of GUIs>

Qt Designer

Designer is used to create Qt User Interfaces containing Qt Plugin widgets. The QE Framework contains a set of Qt Plugin widgets that enable the design of Control System GUIs. These are used, along with standard Qt widgets and other third party widgets.

<image of designer>

QEGui

QEGui is an application use to display Qt User Interface files (.ui files). Almost all of the functionality of a Control System GUI based on the QE Framework is implemented by the widgets in the user interface files. QEGui simply presents these user interface files in new windows, or new tabs, and provides support such as a window menu and application wide logging.

Simple but effective integration with Qt Designer is achieved with the option of launching Designer from the QEGui ‘Edit’ Menu. The user interface being viewed can then be modified, with the changes being automatically reloaded by QEGui.

Refer to 'QEGui' (page 6) for documentation on using QEGui.

QE widgets

QE widgets are self contained. The application loading a user interface file – typically QEGui – does not have to be aware the user interface file even contains QE widgets. The Qt library locates the appropriate Plugin libraries that implement the widgets it finds in a user interface file.

While QE widgets need no support from the application which is loading the user interface containing them, some QE widgets are capable of interacting with the application, and other widgets. For example, a QEPushButton widget can request that whatever application has loaded it open another user interface in a new window.

QE widgets fall into two categories:

- **Standard widgets.** These widgets are based on a standard Qt widget and generally allow the widget to write and read data to a control system. For example, QELabel is based on QLabel and displays data updates as text.
- **Control System Specific widgets.** These widgets are not readily identifiable as a single standard Qt widget and implement functionality specific to Control systems. For example, QEPlot displays waveforms.

QEGui

Command format:

<code>QEGui [-s] [-e] [-b] [-h] [v] [-m <i>macros</i>] [-p <i>path-list</i>] [<i>filename</i>]</code>

Command switches and parameters are as follows:

- **-s Single application.**
QEGui will attempt to pass all parameters to an existing instance of QEGui. When one instance of QEGui managing all QEGui windows, all windows will appear in the window menu. A typical use is when a QEGui window is started by a button in EDM.
An existing instance of QEGui will only be used if it uses the same macro substitutions (see -m switch)
- **-e Enable edit menu option.**
When the edit menu is enabled Designer can be launched from QEGui, typically to edit the current GUI.
- **-b Disable the menu bar.**
- **-p *path-list* Search paths.**
When opening a file, this list of paths may be used when searching for the file. Refer to 'File location rules' (page 5) for the rules QEGui uses when searching for a file.
- **-h Display help text explaining these options and exit.**
- **-v Display version information and exit.**

- **[-m *macros*] Macro substitutions applied to GUIs.**

Macro substitutions are in the form:

keyword=substitution,keyword=substitution,... and should be enclosed in quotes if there are any spaces.

Typically substitutions are used to specify specific variable names when loading generic template forms. Substitutions are not limited to template forms, and some QEWidgets use macro substitutions for purposes other than variable names.

- *filename* GUI filename to open.
If no filename is supplied, the 'File Open' dialog is presented. Refer to 'File location rules' (page 5) for the rules QEGui uses when searching for a file.

Switches may be separate or grouped.

Switches that precede a parameter (-p, -m) may be grouped. Associated parameters are then expected in the order the switches were specified. For example:

```
QEGui -e -p /home
QEGui -epm /home PUMP=02
```

File location rules

If a user interface file path is absolute, QEGui will simply attempt to open it as is. If the file path is not absolute, QEGui looks for it in the following locations in order:

1. If the filename is for a sub-form, look in the directory of the parent form.
2. Look in the directories specified by the -p switch.
3. Look in the directories specified by the QE_UI_PATH environment variable.
4. Look in the current directory.

<Are macro substitutions applied to filenames??>

QEGui uses file location rules defined by the QE framework. Refer to Finding files (page 12) for more details.

Tricks and tips (FAQ)

GUI titles

The QEGui application reads the windowTitle property of the top level widget in a user interface file. It then applies any macro substitutions to the name and uses it as the GUI title. Figure 1 shows a windowTitle property that includes macros being edited in Designer, with the same user interface being displayed by QEGui with the appropriate macro substitution.

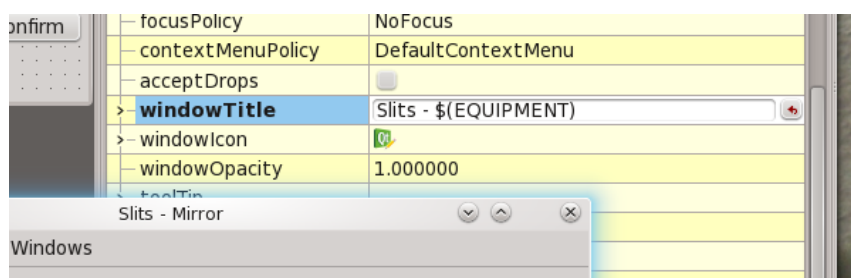


Figure 1 windowTitle Property in designer with actual translated window title on form in foreground

User levels

The QE framework manages three application wide user levels. These are independent of the operating system user accounts.

Within an application using the QE framework (such as the QEGui application), one of three user levels can be set. The three user levels are:

- **User**
- **Scientist**
- **Engineer**

User levels allow the most appropriate view of the system to be presented to different user groups. In Figure 2 for example, while in User mode operational information (beam current) is large. In Scientist mode a 'maintenance' panel appears but a maintenance control is not enabled. In Engineer mode, the maintenance control is enabled.

To avoid the annoyance of widgets disappearing while you are trying to design a GUI, widgets will not become 'not visible' due to user level while being edited in Qt Designer. This also applies to Designer's 'preview' mode. To check if a widget's visibility is changes correctly according to user level, open the GUI using the QEGui application.

While the user level can be set and read programmatically using the ContainerProfile class, it is intended to be set using the QELogin widget and acted on by other QE widgets. The QELogin widget imposes a hierarchy to the user levels, requesting passwords when increasing user levels but allowing the user level to be reduced without authority.

The user levels are used to control individual QE widget behaviour. Most commonly, user level is used to determine if a QE widget is visible or enabled for a given user level through the 'userLevelVisibility' and 'userLevelEnabled' properties respectively. The 'userLevelUserStyle', 'userLevelScientistStyle' and 'userLevelEngineerStyle' properties, however, allow any style string to be applied for each user level. While user level based style strings allow many simple and convenient user interface changes beyond visibility and enabled state, they can also allow obscure and bizarre behaviour changes. For example, a style string may simply set a QEPushButton background to red in user mode, alternatively a style string could be used to move a QEPushButton to a different location on a form.

The syntax for all Style Sheet strings used by this class is the standard Qt Style Sheet syntax. For example, 'background-color: red'. Refer to Qt Style Sheets Reference for full details. The style sheet syntax includes a 'qproperty' keyword allowing any property to be altered using the style string. For example, 'qproperty-geometry:rect(10 10 100 100);' would move a widget to position 10,10 and give it a size of 100,100.

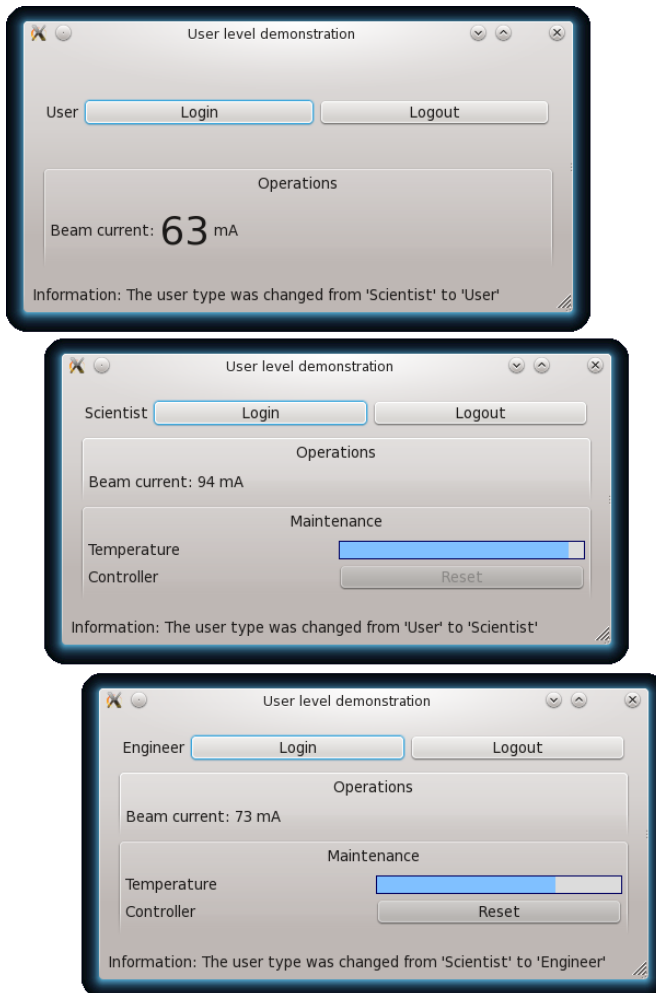


Figure 2 User level example

Logging

Several QE widgets generate log messages. These can be caught and displayed by a QELog widget, or a user application. This section describes the overall QE framework message logging system. Refer to 'QELog' (page 25) for a description of the QELog widget.

Log messages have three attributes:

1. the message text itself;
2. its severity (information, warning or error); and
3. the message kind, which defines the class or type of message. It may be set to one, one or both of:
 - a. event – used of significant system events. These can be displayed by the QELog widget as described below; and/or
 - b. status – used for transient status information, such the time/value coordinates associated with the cursor when moving over the plot area of the QESTripChart widget. When running within in QEGui, this class of message are displayed on the form's status bar.

Simplest use:

The simplest use of this system is to drop a QELog widget onto a form. That's it. Any log messages generated by any QE widgets within the application (for example, the QEGui application) will be caught and displayed provided that the message kind specifies the event attribute. Figure 3 shows a form containing a QELogin widget and a QELog widget. When the user logs in using the QELogin widget, messages generated by the QELogin widget are automatically logged by the QELog widget.

The messages generated by the QELogin widget are denoted as both status and event, and so also shown on the status bar at the bottom of the form.

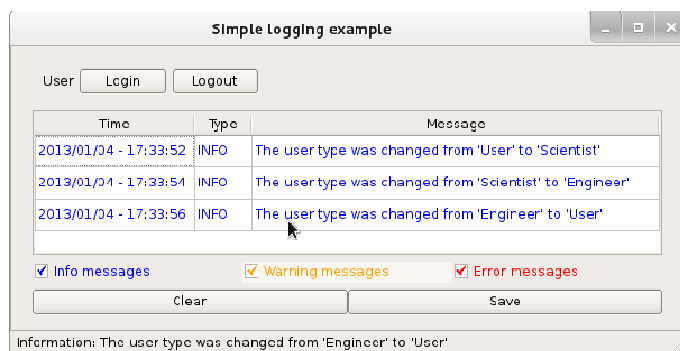


Figure 3 Simple logging example

Complex use:

By default, QELog widgets catch and display any message, but messages can be filtered to display only messages from a specific sets of QE widgets or a to display messages originating from QE widgets within the same QEForm containing the QELog widget.

A form may contain QEForm widgets acting as sub forms. A QELog widget in the same form as a QEForm widget can catch and display messages from widgets in the QEForm if the QEForm is set up to catch and re-broadcast these messages. QEForm widgets can catch and filter messages exactly like QELog widgets, but selected messages are not displayed, rather they are simply re-broadcast as originating from themselves. When a QELog widget is selecting messages only from QE widgets in the same form it is in it will catch these re-broadcast messages

The messageFormFilter, messageSourceFilter, and messageSourceId properties are used to manage message filtering as follows:

Any QE widget that generates messages has a messageSourceId property. QELog and QEForm widgets with the messageSourceId property set to the same value can then use the messageSourceFilter property to filter messages based on the message source ID as follows:

- **Any** A message will always be accepted. (messages source ID is irrelevant)
- **Match** A message will be accepted if it comes from a QEWidget with a matching message source ID.
- **None** The message will not be matched based on the message source ID. (It may still be accepted based on the message form ID.)

All generated messages are also given a message form ID. The message form ID is supplied by the QEForm the QE widget is located in (or zero if not contained within a QEForm widget). QELog and QEForm widgets with a matching message form ID can then use the messageFormFilter property to filter messages based on the message form ID as follows:

- **Any** A message will always be accepted.
- **Match** A message will be accepted if it comes from a QE widget on the same form.
- **None** The message will not be matched based on the form the message comes from. (It may still be accepted based on the message source ID.)

Note: The internal archive access manager object also generates log messages. As this object is not a widget, the value of its messageSourceId is not modifiable as a property and has been hard-coded as 9,001. The range 9,001 to 10,000 is reserved for internal framework use, and while one is not prohibited from allocating these numbers to widgets within, it is not recommended.

Figure 4 shows a complex logging example. The main form contains two sub forms and a QELog widget. The right hand sub form looks after its own messages. It has a QELog widget with filtering set to catch any messages generated on the same form. The left hand sub form does not display its own messages, but the form is set up to re-broadcast any messages generated by QE widgets it contains, so the QELog widget on the main form can be set up to catch and display these messages. Note, the QEGui application itself also uses a UserMessage class to catch and present the same messages on its status bar.

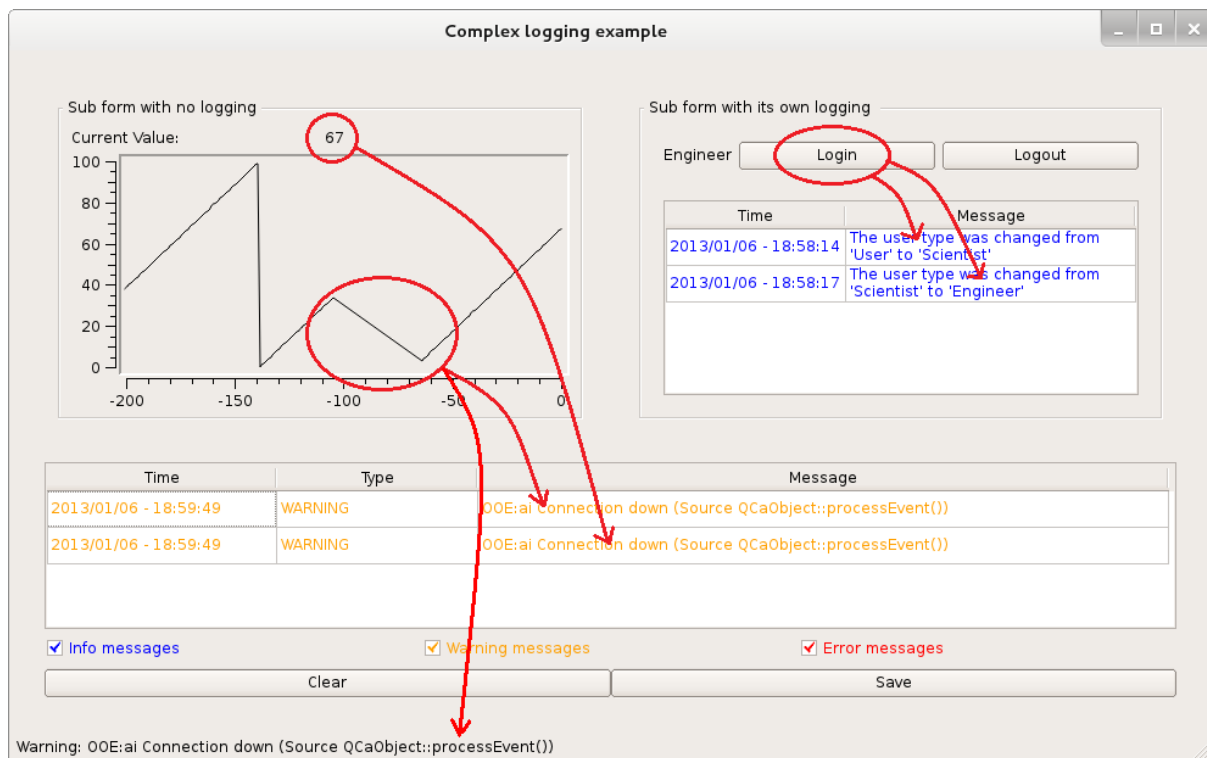


Figure 4 Complex logging example

Note, Application developers can catch messages from any QE widgets in the same way the QELog and QEForm widgets do, by implementing a class based on the UserMessage class. See the UserMessage class documentation for details.

Finding files

The QE widgets uses a consistent set of rules when locates files. File names can be absolute, relative to the path of the QEform in which the QE widget is located, relative to the any path in the path list published in the ContainerProfile class or in the QE_UI_PATH environment variable, or relative to the current path.

See QEWidget:: findQEFile() in QEWidget.cpp for details on how the rules are implemented.

In the GEQui application, the `-p` switch is used to specify a path list which is published in the ContainerProfile class.

Sub form file names

Absolute names simplify locating forms, but make a set of related GUI forms and sub forms less portable. The following rules will help make a set of forms and sub forms more portable.

- No path should be specified for sub forms in the same directory as the parent form.
- A relative path should be given for sub forms in a directory under the parent form directory.
- Paths to directories containing generic sub forms can be added to the `-p` switch.

Refer to 'File location rules' (page 5) details on how QEGui searches for a user interface file given absolute and relative file paths.

Sub form resizing

QForm widgets are used to embed sub forms in a user interface by loading a Qt user interface (.ui) file into itself at run time. Each QForm widget has a set of properties (inherited from QWidget) that define how resizing is managed including geometry, size policy, maximum, minimum, and base sizes, size increments and margins. The top level widget in the .ui file loaded by a QForm also contains these properties. A conflict may exist if the size related properties of the QForm are not the same as the size related properties of the top level widget in the .ui file the QForm is loading.

This conflict can be resolved with the `resizeContents` property of the QForm. If `resizeContents` is true, the size related properties of the top level widget in the .ui file are adjusted to match the QForm. If `resizeContents` is false, the size related properties of the QForm are adjusted to match the top level widget in the .ui file.

Refer to 'QForm' (page 43) for complete details about the QForm widget

Ensuring QERadioButton and QCheckBox is checked if it matches the current data value

When a data update matches the `checkText` property, the Radio Button or Check Box will be checked.

If the 'format' property is set to 'Default' (which happens to be the default!), and the data has enumeration strings then the `checkText` property must match any enumeration string.

This can cause confusion if the values written are numerical – the click text (the value written) can end up different to the clickCheck text. Also, if the enumeration strings are dynamic, it is not possible to specify at GUI design time what enumeration strings to match.

To solve this problem, set the 'format' property to 'Integer' and set the 'checkText' property to the appropriate integer value. Remember, the `checkText` property is a text field that will be matched against the data formatted as text, so the `checkText` property must match the integer formatting. For example, a `checkText` property of ' 2' (includes spaces) will not match '2' (no spaces)

What top level form to use

If you are using Qt's Designer to lay out user interfaces as part of an application you are developing, then the top level form you start with will depend on your application, but if you are creating a user interface file for use in QEGui the following guidelines apply:

QEGui can load a user interface file with any sort of top level widget, but the most appropriate is likely to be one of the simpler containers such as QWidget as QEGui is already managing most aspects more complex containers such as are designer to manage.

You select the top level widget when you create a new user interface in Designer. It is recommended that you choose QWidget, but if there is functionality you require provided by other widgets, then feel free to use any other widget.

QEGui opens all user interface files using a QEForm widget. If the user interface file it is opening does not have a layout, the top level widget in the user interface file is resized to match the QEForm.

If it does have a layout, then the QEForm will also have given itself a layout to ensure layout requests are propagated and the top level widget is not resized.

How does a user interact with an updating QE widget

Most QE widgets that a user can use to write to an EPICS database can also be set to subscribe to the variable it controls and display its current value. In fact this is generally the default. Updating of the widget is stopped, however, whenever a widget has focus. This means updates will not cause the widget to change what it is displaying while the user is interacting with it.

If a separate readback value is preferred, the control widget's 'subscribe' property can be cleared and a read only widget such as a QELabel can be added beside the control widget.

QE widgets

QE widgets enable the design of control system user interfaces.

This document describes what the widgets are designed to do, what features they have and how they should be used. For a comprehensive list of properties, refer to the widget class documentation in QE_ReferenceManual.pdf

EPICS enabled standard Qt widgets:

Many QE widgets are simply standard Qt widgets that can generally read and write to EPICS variables. For example, a QELabel widget is basically a QLabel widget with a variable name property. When a variable name is supplied, text representing the variable is displayed in the label.

The QE Framework also manages variable status using colour, provides properties to control formatting, etc

Control System widgets

Other QE widgets implement a specific requirement of a Control System. For example QEPlot presents waveforms. These widgets are still based on standard low level Qt widgets so still benefit from common Qt widget properties for managing common properties such as geometry.

Common QE Widget properties

Properties of base Qt widgets are not documented here – refer to Qt documentation for details.

variableName and variableSubstitutions

All EPICS aware widgets have one or more variable name properties. The variable names may contain macro substitutions that will be translated when a user interface is opened. The same variable name macro substitutions are used by many widgets for translating macros in other text based properties as well. For example, QEPushbutton uses the macro substitutions in the GUIFile property.

Generally the macro substitutions will be supplied from QEGui application command line parameters, and from parent forms when a user interface is acting as a sub form. The widget itself may have default macro substitutions defined in the 'variableSubstitutions' property. Default macro substitutions are very useful when designing user interface forms as they allow live data to be viewed when designing generic user interfaces. For example, a QLabel in a generic sub form may be given the variable name `SEC${SECTOR}:PMP${PUMP}` and default substitutions of 'SECTOR=12 PUMP=03'. When used as a sub form valid macro substitutions will be supplied that override the default substitutions. At design time, however, the QLabel will connect to and display data for `SEC12:PMP03`. Note, default substitutions can be dangerous if they are never overridden.

The following example describes a scenario where macro substitutions required for a valid variable name are defined at several levels, and in one case multiple levels.

Figure 5 shows a form containing a QLabel. The variable name includes macros SECTOR, DEVICE and MONITOR. Default substitutions are provided for MONITOR. This is not adequate to derive a complete variable name.

Figure 6 shows a form using the form from Figure 5 as a sub form. Additional macro definitions for SECTOR and DEVICE are provided with the sub-form file name. When the sub form is loaded, the QLabel in the sub form can now derive a complete variable name (`SR01BCM01:CURRENT_MONITOR`). While complete, this is not actually functional – the correct sector is SR11.

Figure 7 shows the form from Figure 6 opened by the QEGui application with the following parameters:

```
QEGui -m "SECTOR=11" example.ui
```

The MONITOR macro has been overwritten, so the QLabel in the sub form now derives the correct variable name `SR11BCM01:CURRENT_MONITOR`.

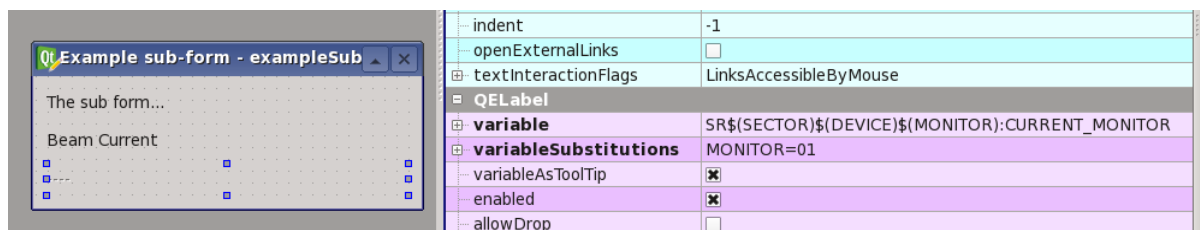


Figure 5 Sub form with macro substitution for part of the variable name

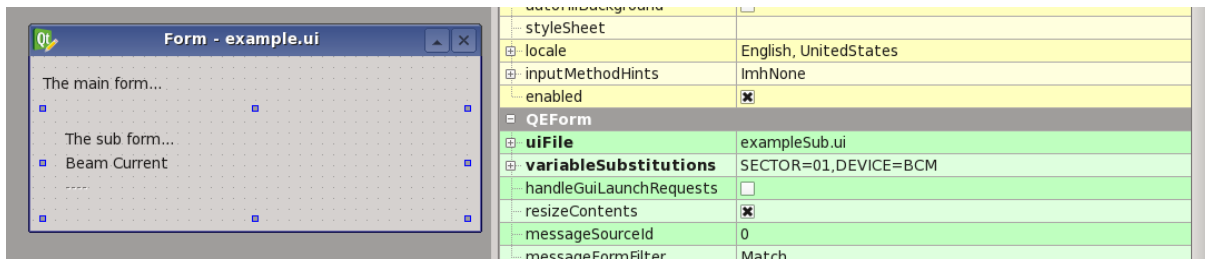


Figure 6 Main form containing sub form with all macro substitutions satisfied (but one is incorrect)

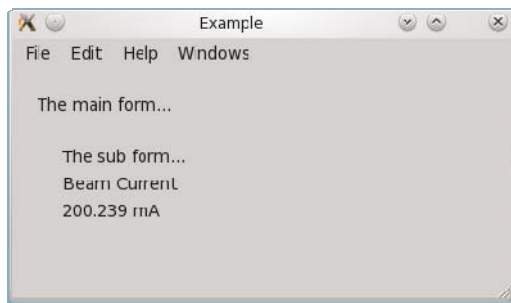
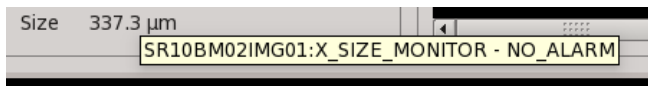


Figure 7 QEGui displaying form and sub forms with all macro substitutions satisfied correctly

variableAsToolTip

If checked, the ToolTip is generated dynamically from the variable name or names and status.



subscribe

If checked, the widget will subscribe for data updates and display them. This is true by default for display QE widgets as QELabel. For control widgets it may be false by default. For example it is false by default for QEPushButtons since it is more common to have static text in the button label, but it can be set to true if the button text should be a readback value, or if the button icon is to be updated by a readback value.

enabled

Set the preferred 'enabled' state. Default is true.

The standard Qt 'enabled' property is set false by many QE widgets to indicate if the data displayed is invalid (disabled). When the data displayed is valid, the QE widget will reset standard Qt 'enabled' property to the value of this 'enabled' property. Users wanting to enable or disable a QE widget for other purposes should use this property. This property will be used to set the standard Qt 'enabled' property except when data is invalid.

allowDrop

Allow drag/drops operations to this widget. Default is false. Any dropped text will be used as a new variable name.

visible

Display the widget. Default is true. Setting this property false is useful if widget is only used to provide a signal - for example, when supplying data to a QELink widget.

Note, when false the widget will still be visible in Qt Designer.

messageSourceId

Set the ID used by the message filtering system. Default is zero.

Widgets or applications that use messages from the framework have the option of filtering on this ID.

For example, by using a unique message source ID a QELog widget may be set up to only log messages from a select set of widgets.

Refer to Logging (page 10) for further details.

userLevelUserStyle, userLevelScientistStyle, userLevelEngineerStyle

Style Sheet strings to be applied when the widget is displayed in 'User', 'Scientist', or 'Engineer' mode. Default is an empty string.

The syntax is the standard Qt Style Sheet syntax. For example, 'background-color: red'

This style strings will be safely merged with any existing style string supplied by the application environment for this widget, or any style string generated for the presentation of data.

Refer to User levels (page 8) for details regarding user levels.

userLevelVisibility

Lowest user level at which the widget is visible. Default is 'User'.

Used when designing GUIs that display more detail according to the user mode.

The user mode is set application wide through the QELogin widget, or programmatically through `setUserLevel()`.

Widgets that are always visible should be visible at 'User'.

Widgets that are only used by scientists managing the facility should be visible at 'Scientist'.

Widgets that are only used by engineers maintaining the facility should be visible at 'Engineer'.

Refer to User levels (page 8) for details regarding user levels.

userLevelEnabled

Lowest user level at which the widget is enabled. Default is 'User'.

Used when designing GUIs that allows access to more detail according to the user mode.

The user mode is set application wide through the QELogin widget, or programmatically through `setUserLevel()`

Widgets that are always accessible should be visible at 'User'.

Widgets that are only accessible to scientists managing the facility should be visible at 'Scientist'.

Widgets that are only accessible to engineers maintaining the facility should be visible at 'Engineer'.

Refer to User levels (page 8) for details regarding user levels.

displayAlarmState

If true (default) the widget will indicate the alarm state of any variable data is displaying. Typically the background colour is set to indicate the alarm state.

Note, this property is included in the set of standard properties as it applies to most widgets. It will do nothing for widgets that don't display data.

String formatting properties

Many QE widgets present data as text, or interpret text and write data accordingly. Examples are QELabel and QELineEdit.

Common formatting properties are used for all these widgets where possible. Not all are relevant for all data types.

precision

Precision used when formatting floating point numbers. The default is 4.

This is only used if the 'useDbPrecision' property is false.

useDbPrecision

If true (default), format floating point numbers using the precision supplied with the data.

If false, the 'precision' property is used.

leadingZero

If true (default), always add a leading zero when formatting numbers.

trailingZeros

If true (default), always remove any trailing zeros when formatting numbers.

addUnits

If true (default), add engineering units supplied with the data.

localEnumeration

An enumeration list used to data values. Used only when the 'format' property set to 'local enumeration'.

The data value is converted to an integer which is used to select a string from this list.

Format is:

```
[[<|<=|=|!=|>|=|>]value1|*] : string1 , [[<|<=|=|!=|>|=|>]value2|*] : string2 , [[<|<=|=|!=|>|=|>]value3|*] : string3 , ...
```

Where:

- < Less than
- <= Less than or equal
- = Equal (default if no operator specified)
- >= Greater than or equal
- > Greater than
- * Always match (used to specify default text)

Rules are:

- Values may be numeric or textual
- Values do not have to be in any order, but first match wins
- Values may be quoted
- Strings may be quoted
- Consecutive values do not have to be present.
- Operator is assumed to be equality if not present.
- White space is ignored except within quoted strings.
- \n may be included in a string to indicate a line break

Examples:

- 0:Off,1:On
- 0 : "Pump Running", 1 : "Pump not running"
- 0:"", 1:"Warning!\nAlarm"
- <2:"Value is less than two", =2:"Value is equal to two", >2:"Value is greater than 2"
- 3:"Beamline Available", *:""
- "Pump Off": "OH NO!, the pump is OFF!", "Pump On": "It's OK, the pump is on"

The data value is converted to a string if no enumeration for that value is available.

For example, if the local enumeration is '0:off,1:on', and a value of 10 is processed, the text generated is '10'.

If a blank string is required, this should be explicit. for example, '0:off,1:on,10:""

A range of numbers can be covered by a pair of values as in the following example:

- `>=4:"Between 4 and 8",<=8:"Between 4 and 8"`

format

This property indicates how non textual data is to be converted to text:

- **Default** Format as best appropriate for the data type.
- **Floating** Format as a floating point number
- **Integer** Format as an integer
- **UnsignedInteger** Format as an unsigned integer
- **Time** Format as a time, source value interpreted as seconds.
- **LocalEnumeration** Format as a selection from the 'localEnumeration' property

radix

Base used for when formatting integers. Default is 10 (duh!)

notation

Notation to use when formatting data as a floating point number. Default is Fixed. Options are:

- **Fixed** Standard floating point. For example: 123456.789
- **Scientific** Scientific representation. For example: 1.23456789e6
- **Automatic** Automatic choice of standard or scientific notation

arrayAction

This property defines how array data is formatted as text. Default is ASCII. Options are:

- **Append** Interpret each element in the array as an unsigned integer and append string representations of each element from the array with a space in between each. For example, an array of three numbers 10, 11 and 12 will be formatted as '10 11 12'.
- **Ascii** Interpret each element from the array as a character in a string. Translate all non printing characters to '?' except for trailing zeros (ignore them). For example an array of three characters 'a' 'b' 'c' will be formatted as 'abc'.
- **Index** Interpret the element selected by `setArrayIndex()` as an unsigned integer. For example, if `arrayIndex` property is 1, an array of three numbers 10, 11 and 12 will be formatted as '11'.

arrayIndex

Index used to select a single item of data for formatting from an array of data. Default is 0.

Only used when the `arrayAction` property is INDEX. Refer to the 'arrayAction' property for more details.

QEAAnalogIndicator and QEAAnalogProgressBar

The QEAAnalogIndicator widget is used to simulate an analog indicator such as a bar indicator or dial. It is not EPICS aware.

The QEAnalogProgressBar is based on the QEAnalogIndicator and is EPICS aware.

Features include:

- Logarithmic or linear scale
- Optional units
- Same widget used for multiple analog indicators including dial and bar.
- Based on QEAnalogIndicator which is available for non EPICS aware uses.
- Alarm Limits are represented on the scale if required

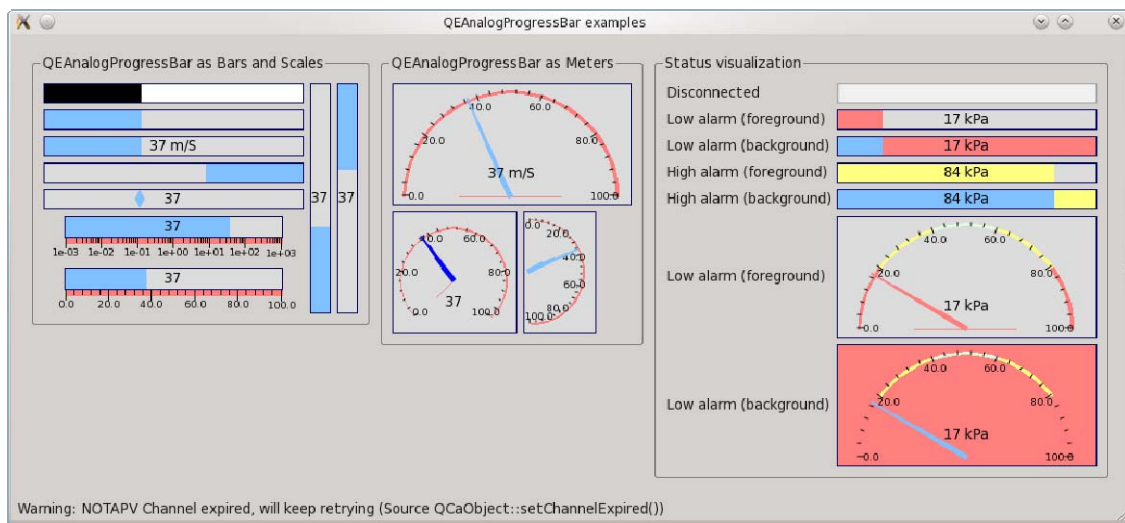


Figure 8 QEAnalogProgressBar examples

QBitStatus and QEBitStatus

The QBitStatus widget is used to present a selected set of bits from a data word. It is not EPICS aware. The QEBitStatus widget is based on QBitStatus and is EPICS aware.

Bits are presented as an array of rectangles or circles with presentation properties to control shape, size, orientation, spacing and colour. Other properties allow bit by bit selection of what values display as 'on' and 'off' and if bits are rendered when 'on' or 'off'.

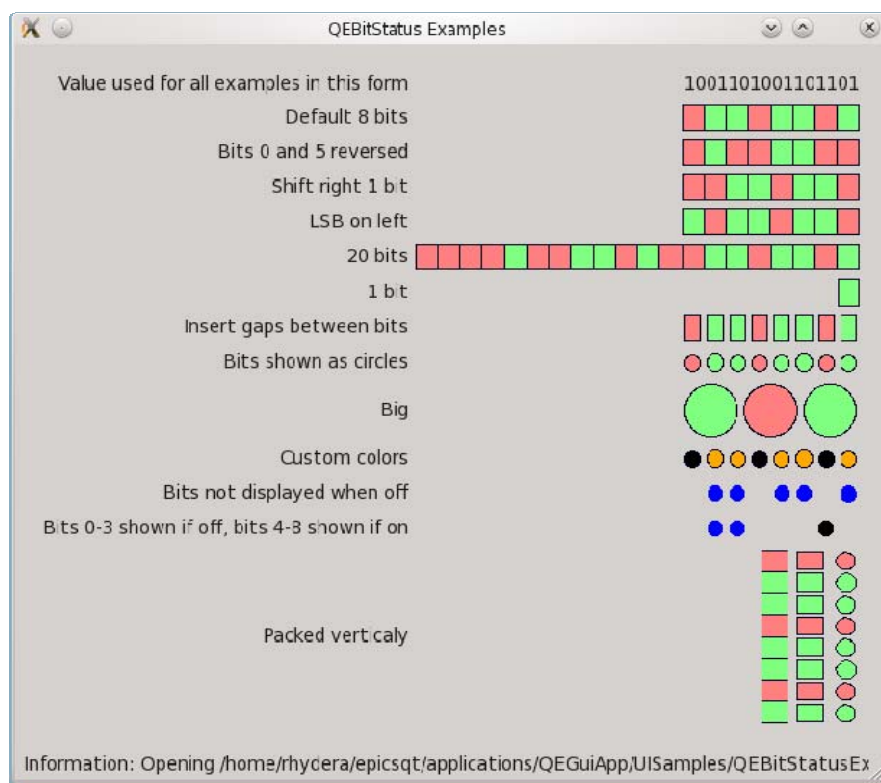


Figure 9 QEBitStatus widget examples

QEConfiguredLayout

The QEConfiguredLayout presents a tabular layout of QE widgets, including button, combo box, label and line edit widgets based on an xml definition stored within the widget, or in a file that can be shared by multiple widgets. It provides similar functionality to a sub form without the need to design and maintain a suitable tabular sub form. The XML defining the layout contains the definition for the rows and columns. Since a change to the row definition affects all columns and a change to a column definition affects all rows, the layout of widgets in a QEConfiguredLayout is always consistent.

<example of xml to be included>

<image of QEConfiguredLayout example to be included>

QEFileBrowser

The QEFileBrowser widget is currently under development. <General description to be added>

QELabel

The QELabel widget provides a simple textual display of EPICS data. It is based on the QLabel widget and so shares QLabel properties such as justification.

The QLabel widget provides many options for formatting the EPICS data as text. These formatting options are common to all QE widgets that display EPICS data as text. Most of these options do not presume any specific EPICS data type. Refer to ‘String formatting properties’ (page 18) for details about the standard text formatting.

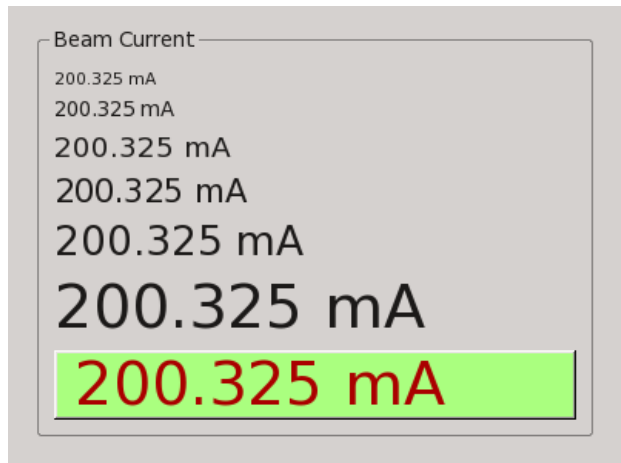


Figure 10 QLabel examples with variations to QLabel properties



Figure 11 QLabel used to display a pump failure

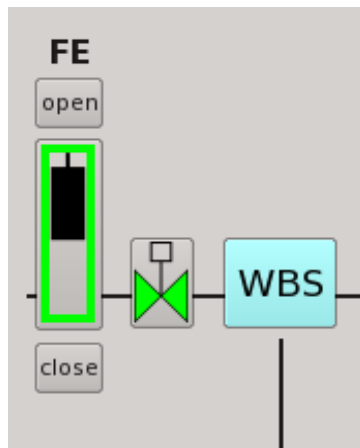


Figure 12 QLabels used icons to represent states

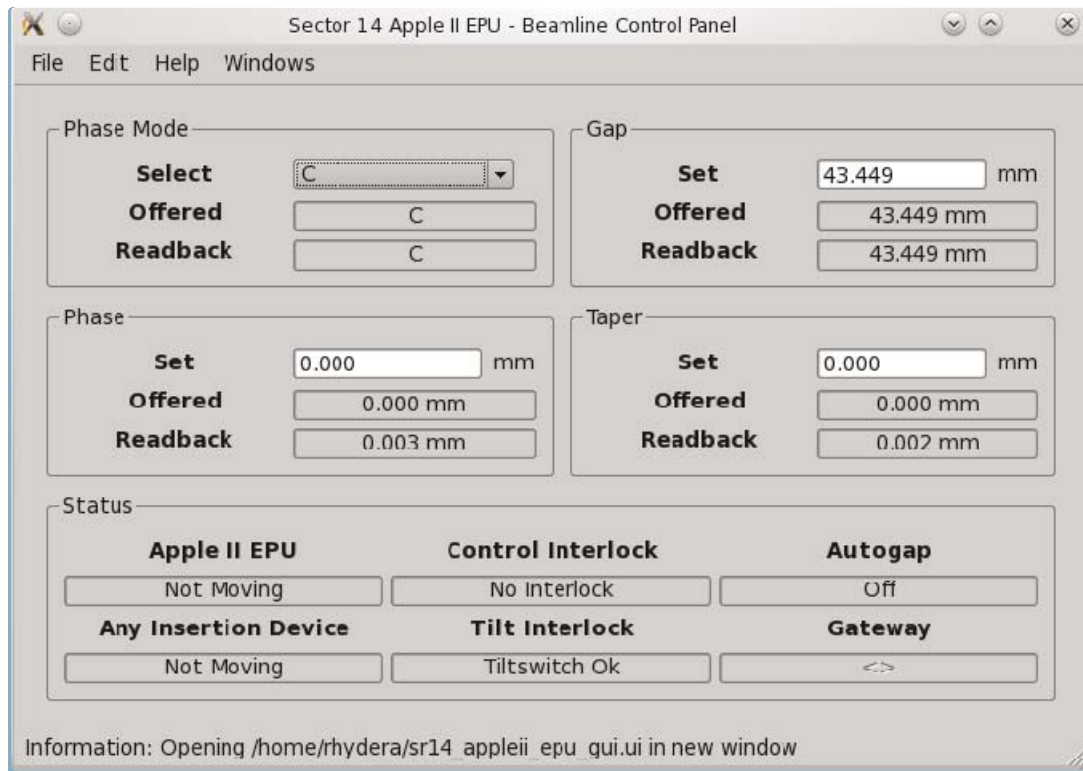


Figure 13 GUI using mostly QLabels to represent numeric and textual data

The text displayed in a QLabel reflects the value of the variable. How that text is presented reflects the state of the variable as follows:

- **Invalid** (not connected) – The QLabel is displayed not-enabled, or ‘greyed out’.
- **In alarm condition** – The QLabel is optionally displayed with an appropriate background colour.

In common with any Qt widget, many aspects of the presentation can be set by the GUI designer, or modified by an imposed ‘style’. It is important that any changes to the presentation of the QLabel is compatible with the display of the variable state.

Display of alarm state is optional – Display of alarm state is on by default. It may be appropriate to turn display of alarm state off if the alarm state is displayed elsewhere, or the alarm state is the actual field being displayed.

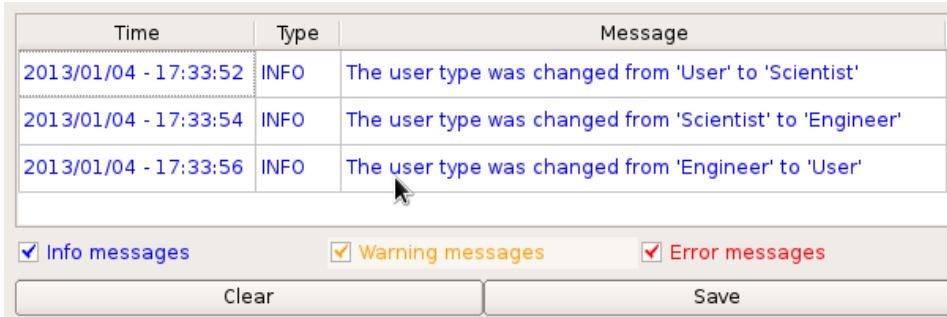
QELogin

QELog

The QELog widget provides a destination for messages generated by other QE widgets, or other widgets and applications using the QE framework. Messages may be generated due to user actions such as changing user level, data issues such as an invalid variable name, and application errors.

The QELog widget receives and displays messages from the QE framework message system. Any application or widget can generate or consume these messages. For example, the QEGui application displays QE messages in its status bar.

Refer to 'Logging' (page 10) for a more general discussion on how the QELog widget is used as part of the QE framework message logging system.



Time	Type	Message
2013/01/04 - 17:33:52	INFO	The user type was changed from 'User' to 'Scientist'
2013/01/04 - 17:33:54	INFO	The user type was changed from 'Scientist' to 'Engineer'
2013/01/04 - 17:33:56	INFO	The user type was changed from 'Engineer' to 'User'

☒ Info messages ☒ Warning messages ☒ Error messages

Clear Save

Figure 14 QELog example

The QELog widget is designed to be dropped on a form and automatically catch messages from QE widgets on the same form, or in sub forms. Alternately, it can be used to filter messages from specific sets of QE widgets and forms.

The logged messages can be saved or cleared by the user. The user can also select the type of messages logged from a message filter. Note, the message filter viewed by the user is used by the user to filter message content. For example, the user can select only information messages. Filter properties are also available to filter messages based on the source of the message, rather than content.

Properties of the QELog widget allow:

- Selective display of message time, type and content.
- Presentation of the 'Clear' and 'Save' buttons and the message filter.
- Message type colour selection.
- Selection of the message filtering based on the source of the message. Note, this is different to the message filter presented to the user which allows the user to filter based on message type.

Each QE widget can be given a message source ID (the `messageSourceId` property). The GUI designer is free to allocate any ID to any widget. IDs do not need to be unique, so a set of widgets might have the same message source ID if required.

Each QEForm widget also has a unique message form ID allocated by the QE framework.

QELog widgets can be set up to filter messages based on the message source ID (the QE widget or set of widgets it came from) and the QEForm that widget generating the message is in. The filtering is as follows:

- **Form filtering:**
 - **None** - Never match based on the form ID
 - **Match** – Use the message if message came from a widget in the same form as the QELog widget, or from a sub form. Note, Messages are accepted from sub forms because QEForms themselves filter messages and rebroadcast them as their own.
 - **Any** – Always use the message. When this option is selected, message source filtering, below, is irrelevant.
- **Message source filtering:**
 - **None** – Never match based on message source ID
 - **Match** – Use the message if the message came from a widget with the same message source ID.
 - **Any** - Always use the message. When this option is selected, form filtering, above, is irrelevant.

By default a QELog widget form filter is set to 'Match' and the message source filter is set to 'None'. These are the settings required to allow a QELog widget to be dropped onto a form to display all messages from widgets on the form, including those within sub forms.

QEPvProperties

QERecipe

The QERecipe widget is currently under development. It will allow a user to define, save and restore a named set of variables and values. This would typically be used by a user to restore a system to a state previously identified and named by the user.

QEScript

The QERecipe widget is currently under development. It will allow a user to specify a list of scripts to be run when requested. This widget will be useful for running a simple series of user scripts. For example, user scripts before and after a scan. Script interaction will be minimal and be limited to the ability to abort or continue with the next script in the event of a script returning an error code.

QEStripChart

QEPeiodic

QESubstitutedLabel

A QESubstitutedLabel adds macro substitution capability to a standard QLabel widget. A QESubstitutedLabel widget with macros in the text is typically used in a form to produce varying text depending on the macro substitutions used on the form. For example, a form may include a QESubstitutedLabel with the text 'Pump \$(NUM)' as a title. If the macro substitutions applied to one instance of the form include 'NUM=1' and 'NUM=2' for another, the form title labels will be 'Pump 1' and 'Pump 2' respectively. Another example of using a QESubstitutedLabel to vary a title in multiple instances of a sub form is shown in Figure 15

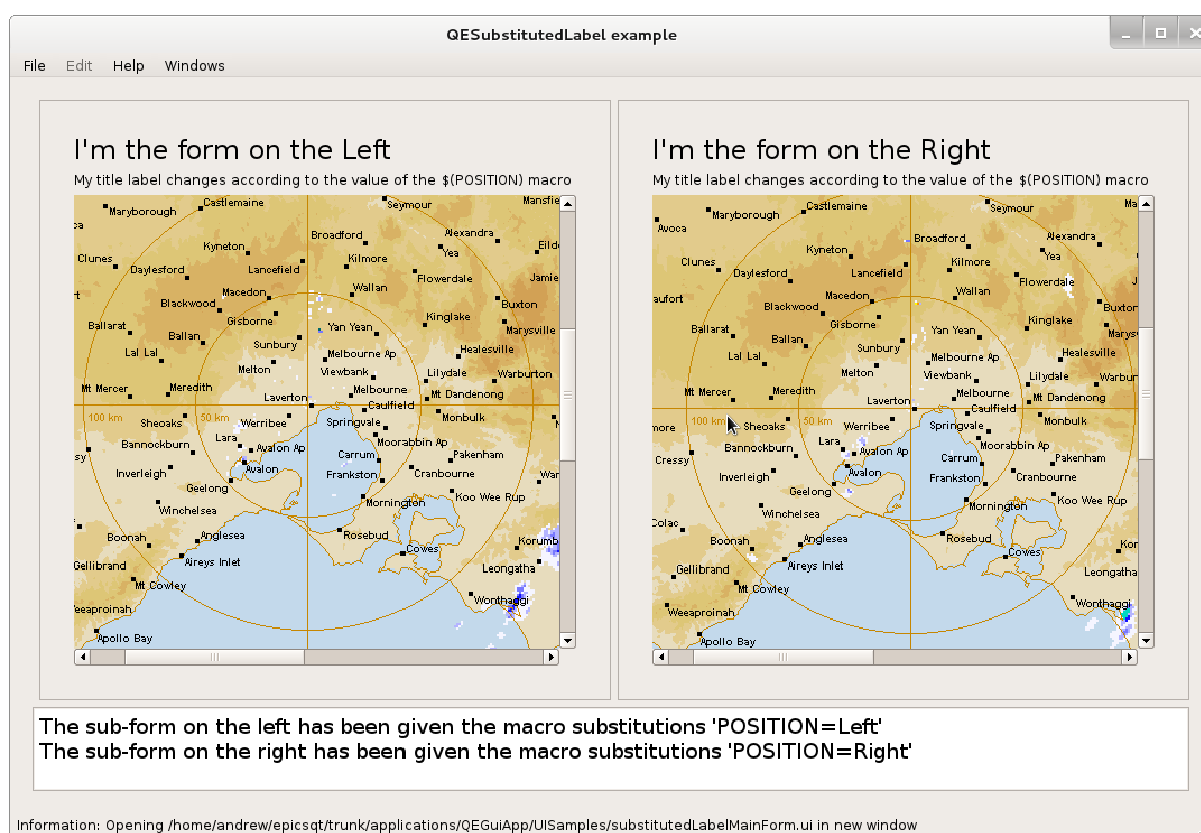


Figure 15 QESubstitutedLabel used to vary title in sub forms

QELineEdit

The QELineEdit widget provides the ability to textually modify the value of a single PV. This widget is (indirectly) derived from QLineEdit. The example in Figure 16 shows a QELineEdit widget connected to an ao record. While this widget is primarily intended for writing to string PVs, it can also be used with numerical PVs as in this example. However in this case, a QENumericEdit or a QESpinBox widget may be more appropriate.

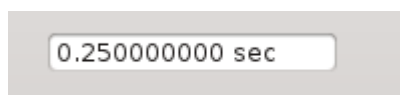


Figure 16 QLineEdit example

The behaviour of the widget is defined by the widget specific properties as shown in Figure 17.

Property	Value
> QObject	
> QWidget	
> QLineEdit	
▼ QEGenericEdit	
> variable	TS02EVR01:TTL01_TIME_DELAY_SP
> variableSubstitutions	
— subscribe	<input checked="" type="checkbox"/>
— writeOnLoseFocus	<input type="checkbox"/>
— writeOnEnter	<input checked="" type="checkbox"/>
— writeOnFinish	<input checked="" type="checkbox"/>
— confirmWrite	<input type="checkbox"/>
— variableAsToolTip	<input checked="" type="checkbox"/>
— enabled	<input checked="" type="checkbox"/>
— allowDrop	<input type="checkbox"/>
— visible	<input checked="" type="checkbox"/>
— messageSourceId	0
> userLevelUserStyle	
> userLevelScientistStyle	
> userLevelEngineerStyle	
— userLevelVisibility	User
— userLevelEnabled	User
— displayAlarmState	<input checked="" type="checkbox"/>
▼ QLineEdit	
— precision	4
— useDbPrecision	<input checked="" type="checkbox"/>
— leadingZero	<input checked="" type="checkbox"/>
— trailingZeros	<input checked="" type="checkbox"/>
— addUnits	<input checked="" type="checkbox"/>
> localEnumeration	
— format	Default
— radix	10
— notation	Fixed
— arrayAction	Ascii
— arrayIndex	0

Figure 17 QLineEdit properties

As well as the usual PV variable name, substitutions, display format, user level etc. properties, the widget has additional properties to control its mode of operation:

- a) subscribe (default true): determines if the widget subscribes for data updates and displays current data;
- b) writeOnLoseFocus (default false): when true this widget automatically writes any changes when it loses focus;
- c) writeOnEnter (default true): when true writes when the user presses 'enter'. Note, the current value will be written even if the user has not changed it;
- d) writeOnFinish (default true): when true writes any changes when the user finished editing (the QLineEdit 'editingFinished' signal is emitted). No writing occurs if no changes were made; and
- e) confirmWrite (default false): when true this widget will ask for confirmation (using a dialog box) prior to writing data.

QENumericEdit

The QENumericEdit widget provides the ability to modify the value of a single numeric, either integer or floating point, PV. This widget is (indirectly) derived from QLineEdit. Figure 18 shows examples of the widget in several configurations, and in each case the widget is connected to the same PV.



Figure 18 QENumericEdit examples

The first example shows a QENumericEdit in its default configuration, and in appearance at least, looks very much like its QLineEdit counterpart. The second example shows the appearance with the separator property set to “comma”. The 3rd, 4th and 5th show the same with the radix property set to Hexadecimal, Octal and Binary respectively. The widgets tool tip will be annotated accordingly.

Unlike the QLineEdit, the user may only enter valid radix digits and if a sign is present enter a plus/minus (“+”, “-”). A sign is displayed if and only if the allowed range of values encompasses negative values. The user may also use the left and right keys to navigate sideways to select a digit and use the up and down keys to increment or decrement the overall value by an amount corresponding

to the unit value of the selected digit. An example sequence is shown below (using an approximate representation of the widget appearance):

0.2589 Amps	
0.2589 Amps	- widget gets focus – the current selected digit is after the first decimal point
0.2589 Amps	- left key – first digit selected – note: the decimal point skipped
0.2589 Amps	- right key three times – third digit after point selected
0.2599 Amps	- up key – increment value by 0.001
0.2609 Amps	- up key – increment value by 0.001, second digit has changed from 5 to 6.

Like the QELineEdit widget, the subscribe, writeOnLoseFocus, writeOnEnter, writeOnFinish and confirmWrite properties modify the behaviour is exactly the same manor. The widget specific properties are shown in Figure 19. These are described below:

- autoScale (default true): when true the number of leading zeros, precision, minimum and maximum values will be determined from the PV's associated meta. When false (or when not connected), the precision, leadingZeros, minimum and maximum properties are used;
- precision (default 4): specifies the number digits after the decimal point for display and editing;
- leadingZeros (default 3): specified the number of digits before the decimal point;
- minimum: specifies the minimum value allowed to be entered;
- maximum: specifies the maximum value allowed to be entered;
- addUnits (default true): the widget displays includes any engineering units;
- radix (default Decimal): allows the selection of display/editing radix. Unlike other widgets, this is restricted to just four options: Decimal, Hexadecimal, Octal and Binary.
Note: the widget assumes that the precision/leading zeros , manual or automatic, are appropriate for the selected radix; and
- separator (default None): allows the use of a character to break up the string. This may be one of None, Comma, Underscore or space. For Decimal and Octal, this is between every third digits, whereas for Hexadecimal and Binary, this is every 4th digit.

Note: the widget ensures that items (b), (c), (d) and (e) are consistent. For example: the maximum value is always greater than or equal to the minimum value. When in decimal mode, the sum of (b) and (c) is never greater than 15 which is approximately the maximum significance of an IEEE 64 bit float which is used to hold the underlying widget value (and indeed is the “best” significance

supported by Channel Access).

Property	Value
> QObject	
> QWidget	
> QLineEdit	
▼ QEGenericEdit	
> variable	TS02EVR01:TTL01_TIME_DELAY_SP
> variableSubstitutions	
— subscribe	<input checked="" type="checkbox"/>
— writeOnLoseFocus	<input type="checkbox"/>
— writeOnEnter	<input checked="" type="checkbox"/>
— writeOnFinish	<input checked="" type="checkbox"/>
— confirmWrite	<input type="checkbox"/>
— variableAsToolTip	<input checked="" type="checkbox"/>
— enabled	<input checked="" type="checkbox"/>
— allowDrop	<input type="checkbox"/>
— visible	<input checked="" type="checkbox"/>
— messageSourceId	0
> userLevelUserStyle	
> userLevelScientistStyle	
> userLevelEngineerStyle	
— userLevelVisibility	User
— userLevelEnabled	User
— displayAlarmState	<input checked="" type="checkbox"/>
▼ QENumericEdit	
— autoScale	<input checked="" type="checkbox"/>
— precision	4
— leadingZeros	3
— minimum	-999.999900
— maximum	999.999900
— addUnits	<input checked="" type="checkbox"/>
— radix	Decimal
— separator	None

Figure 19 QENumericEdit properties

QEPushButton, QERadioButton and QECheckBox

General description:

The QEPushButton, QERadioButton and QECheckBox widgets provide the following non exclusive functions:

- Write to a variable
- Read from a variable

- Issue a command to the operating system
- Open a new GUI form.
- Emit a signal

If the properties used to define any or all of these functions are set up, the functions will be carried out.

All QE button like widget types are based on QGenericButton and on QAbstractButton (through QPushButton, QRadioButton and QCheckBox). QPushButton, QERadioButton and QECheckBox widgets share most properties and it is mainly the way the buttons are presented that differentiates them.

Generally, QERadioButton and QECheckBox widgets will be shown as checkable, and properties related to the checked state are more likely to be used for QERadioButton and QECheckBox widgets.

Various data values can be written on any or all or the following button actions:

- Press A mouse press with the pointer over the button
- Release A mouse release with the pointer over the button
- Click A press and release while over the button

By default, values are written on a button click. A click will be accompanied with a press and release.

Writing values on Press and Release typically allows a value to be set momentary, while the button is held down. In this case, no data would be written on the click.

Use of enumerated values:

QE buttons can display variable data in the button label and, like many QE widgets, QE buttons may construct a list of enumerated values for this purpose. The same list of enumerations, if present, is used to validate values written by the button.

If a list of enumerated values has been constructed for the variable being written to, then any value written must match a value from the enumeration list. The enumeration list may have originated from the database or be stored locally in the GUI file. The 'pressText', 'releaseText' and 'clickText' properties must all match one of the enumeration values or an error will be displayed when a write is attempted. If an enumeration list was build from the database then the following error will be displayed:

```
Write failed. String not written was 'your string'. Value does
not match an enumeration value from the database.
```

If an enumeration list was stored in the GUI file then the following error will be displayed:

```
Write failed. String not written was 'your string'. Value does
not match a local enumeration value.
```


Enumeration lists will be present and used to check any string written in the following scenarios:

- The 'format' property is set to 'LocalEnumeration' and 'localEnumeration' property is defined.
- The 'subscribe' property is set to true (checked), the 'format' property is set to 'Default' and enumeration values were successfully read from the database for the variable.

Conversely, enumeration lists will not present and string will be written without validation by the button in the following scenarios:

- The 'format' property is set to 'LocalEnumeration' but no 'localEnumeration' property is defined.
- The 'subscribe' property is set to false (unchecked), the 'format' property is not set to 'Default' or enumeration values were not successfully read from the database for the variable.

In these scenarios any string in the pressText', 'releaseText' and 'clickText' properties is written as is and it is up to the database to accept or reject the string.

Signals on user action:

The same value that would be written to a variable is also interpreted as an integer and emitted as a 'pressed', 'released' or 'clicked' signal. This is useful, for example, for selecting a tab in a tab widget or a page in a toolbox widget.

Why QE buttons can open a new GUI form:

While QEPushButton, QERadioButton and QECheckBox widgets can open a new GUI form when set up correctly without any action on the part of the application that created them, this functionality is mainly so the button functionality can be tested from the Designer 'preview' window. Applications using QEPushButton, QERadioButton and QECheckBox widgets should provide a slot to create new windows through the ContainerProfile class. The application can then respect the creation options set up with the new button and manage the window better – for example it may wish to add the window to its window menu. The QEGui application provides such a slot through the ContainerProfile class. Refer to the QEGui application and the Container Profile class for more details.

To write to a variable, the following properties are used:

- **variable**
If present, a value will be written to the variable when the button is operated.
The value of this variable can also be used to update the button text or image.
- **variable Substitutions**
Macro substitutions to apply to 'variable' and 'altReadbackVariable' properties. Note, the variableSubstitutions property is also applied to pressText, releaseText, and clickText

properties prior to writing, is applied to the labelText property if present, and is used in any GUI filename and passed on to any new GUI launched by the QE button.

- **password**
Password user will need to enter before any action is taken.
- **confirmAction**
If true, a dialog will be presented asking the user to confirm if the button action should be carried out
- **writeOnPress**
If true, the 'pressText' property is written when the button is pressed. Default is false.
- **writeOnRelease**
If true, the 'releaseText' property is written when the button is released. Default is false
- **writeOnClick**
If true, the 'clickText' property is written when the button is clicked. Default is true
- **pressText**
Value written when user presses button if 'writeOnPress' property is true.
This property is also interpreted as an integer and used in the 'pressed' signal.
Note, the variableSubstitutions property is also applied to this property before writing. For example, if the property contains MY\$(ITEM) and the variable substitutions contains ITEM=CAR, MYCAR will be written.
Note, for variables with enumerated values in the database, the text must match one of the enumerated values. So if a variable is set up to display 'Off' and 'On' instead of 0 or 1, then the press text must be 'Off' or 'On', not 0 or 1.
- **releaseText**
Value written when user releases button if 'writeOnRelease' property is true.
This property is also interpreted as an integer and used in the 'released' signal.
Note, the variableSubstitutions property is also applied to this property before writing. For example, if the property contains MY\$(ITEM) and the variable substitutions contains ITEM=CAR, MYCAR will be written.
Note, for variables with enumerated values in the database, the text must match one of the enumerated values. So if a variable is set up to display 'Off' and 'On' instead of 0 or 1, then the press text must be 'Off' or 'On', not 0 or 1.
- **clickText**
Value written when user clicks button if 'writeOnClick' property is true and the button is unchecked.
This property is also interpreted as an integer and used in the 'clicked' signal when the button is unchecked.
Note, the variableSubstitutions property is also applied to this property before writing. For example, if the property contains MY\$(ITEM) and the variable substitutions contains ITEM=CAR, MYCAR will be written.
Note, for variables with enumerated values in the database, the text must match one of the enumerated values. So if a variable is set up to display 'Off' and 'On' instead of 0 or 1, then the press text must be 'Off' or 'On', not 0 or 1.

The default 'clickText' varies to suit the default 'checkable' property of the QEButton type. For QEPushButton the default 'clickText' is "1" which suits the default 'checkable' property which is 'false'. For QERadioButton and QECheckBox the default is 'clickText' is "0" which suits the default 'checkable' property which is 'true'. If the 'checkable' property is changed the default 'clickText' property is likely to be inappropriate.

- **clickCheckedText**

Text used to compare with text written or read to determine if push button should be marked as checked.

Note, must be an exact match following formatting of data updates.

When writing values, the 'pressText', 'ReleaseText', or 'clickedtext' must match this property to cause the button to be checked when the write occurs.

- **Good example:** formatting set to display a data value of '1' as 'On', clickCheckedText is 'On', clickText is 'On'. In this example, the push button will be checked when a data update occurs with a value of 1 or when the button is clicked.
- **Bad example:** formatting set to display a data value of '1' as 'On', clickCheckedText is 'On', clickText is '1'. In this example, the push button will be checked when a data update occurs with a value of 1 but, although a valid value will be written when clicked, the button will not be checked when clicked as '1' is not the same as 'On'.

This property is also interpreted as an integer and used in the 'clicked' signal when the button is checked.

Note, the variableSubstitutions property is also applied to this property before writing. For example, if the property contains MY\$(ITEM) and the variable substitutions contains ITEM=CAR, MYCAR will be written.

The default 'clickCheckText' varies to suit the default 'checkable' property of the QEButton type. For QEPushButton the default 'clickCheckText' is "0" which suits the default 'checkable' property which is 'false'. For QERadioButton and QECheckBox the default is 'clickText' is "1" which suits the default 'checkable' property which is 'true'. If the 'checkable' property is changed the default 'clickCheckText' property is likely to be inappropriate.

To read from a variable, the following properties are used:

- **subscribe**

If checked, the button will read and present the current value defined by the 'variable' property. If the 'altReadbackVariable' property is define, it is used in preference to the 'variable' property

- **variable**

If present, a value will be written to the variable when the button is operated. The value of this variable can also be used to update the button text or image.

- **altReadbackVariable**

If present, the value of this variable will be used to update the button text or image if required.

- **variable Substitutions**

Macro substitutions to apply to 'variable' and 'altReadbackVariable' properties. Note, the variableSubstitutions property is also applied to pressText, releaseText, and clickText properties prior to writing, is applied to the labelText property if present, and is , and is used in any GUI filename and passed on to any new GUI launched by the QE button.

- **updateOption**

Used to determine if the data is presented textually using the button's 'text' property, or graphically using the button's 'icon' property, both textually and graphically, or if the data updates the buttons checked state.

Options are:

- Text Data updates will update the button text
- Icon Data updates will update the button icon
- TextAndIcon Data updates will update the button text and icon
- State Data updates will update the button state (checked or unchecked)

- **Pixmap0 to pixmap7**

Pixmap to display if updateOption is Icon or TextAndIcon and data value translates to an index between 0 and 7.

- **alignment**

Set the buttons text alignment.

Left justification is particularly useful when displaying quickly changing numeric data updates.

General presentation:

- **labelText**

Button label text (prior to substitution).

Macro substitutions from the variableSubstitutions property will be applied to this text and the result will be set as the button text.

Used when data updates are not being represented in the button text.

For example, a button in a sub form may have a 'labelText' property of 'Turn Pump \$(PUMPNUM) On'.

When the sub form is used twice in a main form with substitutions PUMPNUM=1 and PUMPNUM=2 respectively, the two identical buttons in the sub forms will have the labels 'Turn Pump 1 On' and 'Turn Pump 2 On' respectively.

A system command can be issued on a button click using the following properties:

- **program**

Program to run when the button is clicked.

No attempt to run a program is made if this property is empty.

Example:

```
firefox
```

- **arguments**

Arguments for program specified in the 'program' property.

A new GUI can be started on a button click using the following properties:

- **guiFile**

File name of GUI to be presented on button click.

QEWidgets use a common set of rules for locating a file. Refer to Finding files (page 12) for details.

- **creationOption**

Creation options when opening a new GUI. Open a new window, open a new tab, or replace the current window.

The creation option is supplied when the button generates a newGui signal.

Application code connected to this signal should honour this request if possible.

When used within the QEGui application, the QEGui application creates a new window, new tab, or replaces the current window as appropriate.

Options are:

- Open Replace the current GUI with the new GUI
- NewTab Open new GUI in a new tab
- NewWindow Open new GUI in a new window

- **variableSubstitutions**

The variableSubstitutions property is applied to the GUI file name and added to the list of macro substitutions provided to the new form being opened by the QE button. The macro substitutions present in the variableSubstitutions property **do not** take precedence over any other macro substitutions already defined by any QEForm containing the button, or by the application. Note, the variableSubstitutions property is also used to provide default substitutions for the variable names, is applied to pressText, releaseText, and clickText properties prior to writing, and is applied to the labelText property if present.

- **prioritySubstitutions**

The prioritySubstitutions property is added to the list of macro substitutions provided to the new form being opened by the QE button. The macro substitutions present in the prioritySubstitutions property **do** take precedence over any other macro substitutions already defined by any QEForm containing the button, or by the application. Unlike the variableSubstitutions property, the prioritySubstitutions property is only added to the list of macro substitutions provided to a new GUI being launched by the QE button.

The prioritySubstitutions property is particularly useful when re-opening the form containing the QE button, but with different macro substitutions. The variableSubstitutions property can't be used for this since the macro substitutions it contains do not take precedence over existing macro substitutions.

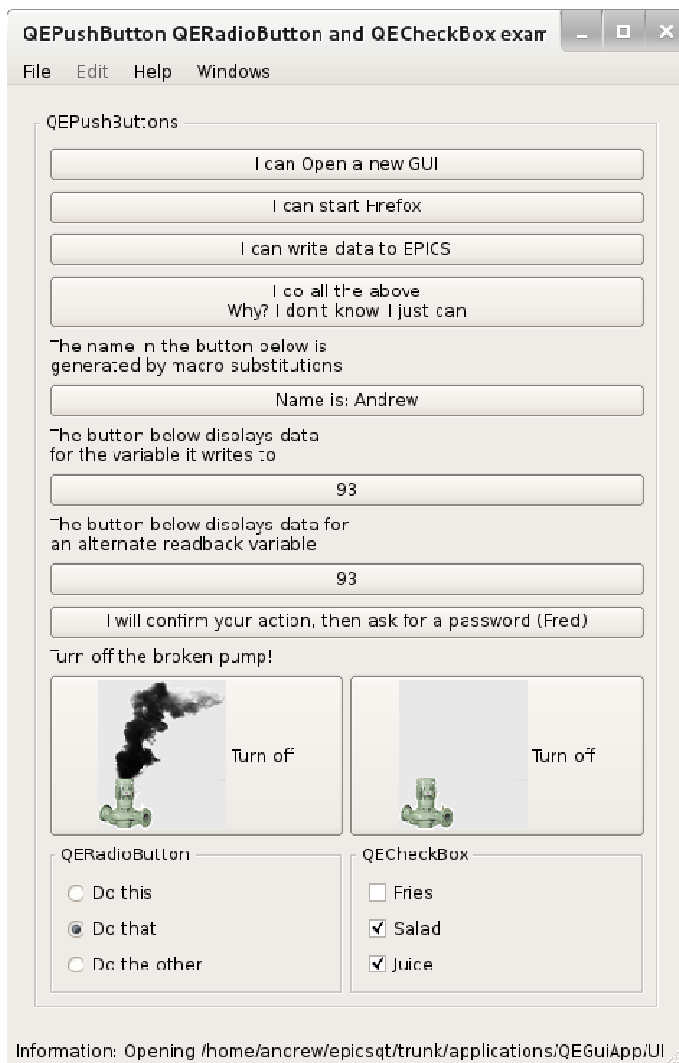


Figure 20 QEPushButton, QERadioButton and QECheckBox examples

QEShape

QESimpleShape

The QESimpleShape widget is an EPICS aware widget which uses either the alarm state or the value of a single PV to determine the colour of the shape. The shape itself is determined by the widget's shape property, and may be one of: circle, ellipse, rectangle, roundRectangle, roundSquare, square, triangleUp, triangleDown, triangleLeft, triangleRight, diamond, or equalDiamond. The size of the shape is maximised to just fit within the geometry of the widget. For circle, square, roundSquare and equalDiamond the size is determined by the lesser of the widget's width and height.

When the displayAlarmState (above) property is set true (the default), the colour of the widget is determined by the alarm state of the PV. Standard framework alarm colours are used, i.e. green for no alarm, yellow for minor alarm, red for major alarm and white for invalid alarm.

When the `displayAlarmState` property is set false, the value of the PV is used to select a colour from a set of 16 colour properties, i.e. `color0`, `colour1`, and so on to `colour15`. The value of the PV must be capable of being interpreted as an integer. Modulo 16 arithmetic is used to ensure the PV value yields a number in the range 0 to 15. The selection of the number of colours properties was somewhat arbitrary. 16 was chosen so that a colour could be associated with each value of an `mbbi/mbbo` record.

Figure 21 below shows examples of this widget. All the `QESimpleShape` widgets are monitoring the same PV and have geometries which all have a width of 40 and a height of 20. The first row of widgets all have `displayAlarmState` set to false, and are blue because the value of the PV is 2 and `color2` property has been set to blue. The second row of widgets all have `displayAlarmState` set to true, and are green because the PV's severity is no alarm (the third row contains a `QLabel` which shows the actual value of the PV).

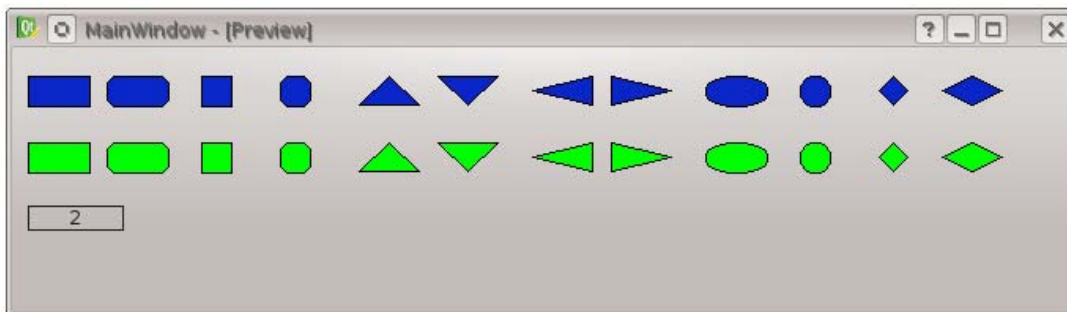


Figure 21 `QESimpleShape` examples

When disconnected the `QESimpleShape` is displayed as washed-out gray with a light gray boarder.

Figure 22 below shows the properties values selected for the second row of widgets.

















QESimpleShape	
> variable	SR00IE01:INPUT_TRIGGER_COUNT
> variableSubstitutions	
— variableAsToolTip	<input checked="" type="checkbox"/>
— enabled	<input checked="" type="checkbox"/>
— allowDrop	<input type="checkbox"/>
— visible	<input checked="" type="checkbox"/>
— messageSourceId	0
> userLevelUserStyle	
> userLevelScientistStyle	
> userLevelEngineerStyle	
— userLevelVisibility	User
— userLevelEnabled	User
— displayAlarmState	<input type="checkbox"/>
— shape	diamond
> colour0	 [200, 44, 17] (255)
> colour1	 [8, 200, 8] (255)
> colour2	 [10, 38, 200] (255)
> colour3	 [200, 43, 85] (255)
> colour4	 [200, 133, 61] (255)
> colour5	 [57, 200, 196] (255)
> colour6	 [255, 255, 0] (255)
> colour7	 [255, 255, 255] (255)
> colour8	 [58, 58, 58] (255)
> colour9	 [169, 83, 200] (255)
> colour10	 [200, 198, 75] (255)
> colour11	 [75, 134, 70] (255)
> colour12	 [200, 64, 23] (129)
> colour13	 [11, 200, 17] (97)
> colour14	 [14, 14, 200] (102)
> colour15	 [255, 0, 255] (255)

Figure 22 QESimpleShape properties

QESlider

The QESlider widget provides the ability to display and modify the value of a single PV using a slider. This widget is derived from QSlider. The example in Figure 23 shows several QESlider widgets connected a variable. The QESlider subscribes to the variable by default (subscribe property set by default).

For many variables, the standard QSlider ‘minimum’ and ‘maximum’ properties can be used to set the range of the slider to match the variable data. This is not adequate for some variables. For example an appropriate integer maximum and minimum cannot be set if the variable is a floating point type with a range of 0.0 to 1.0. In cases like this the QESlider ‘scale’ and ‘offset’ properties can be used to prescale the variable to allow sensible QSlider ‘maximum’ and ‘minimum’ values. For example a scale of 1000 and a maximum of 1000 would allow a floating point value of 0.0 to 1.0 to be set with a precision of 0.1 (as long as the slider had a range of at least 1000 pixels).

Scale and offset properties

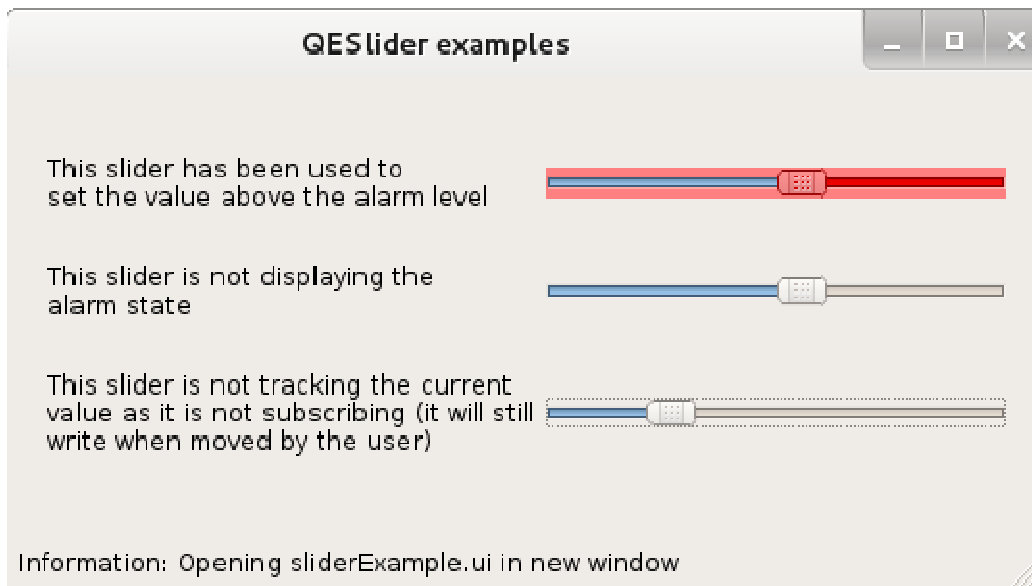


Figure 23 QESlider examples

QESpinBox

The QESpinBox widget provides the ability to display and modify the value of a single PV using a spin box. This widget is derived from QDoubleSpinBox. For variables with a large range, QESpinBox may not be the best choice as the step size is set at design time. In these instances, a QENumericEdit widget may be more appropriate. The example in Figure 24 shows several QESpinBox widgets, some appropriate for the variable range and some not so appropriate

The 'addUnits' property will set the 'suffix' property to the engineering units read for the variable from the database. Alternately the 'suffix' property can be set directly. When set directly 'addUnits' must be cleared or 'suffix' will be overwritten with the database value.

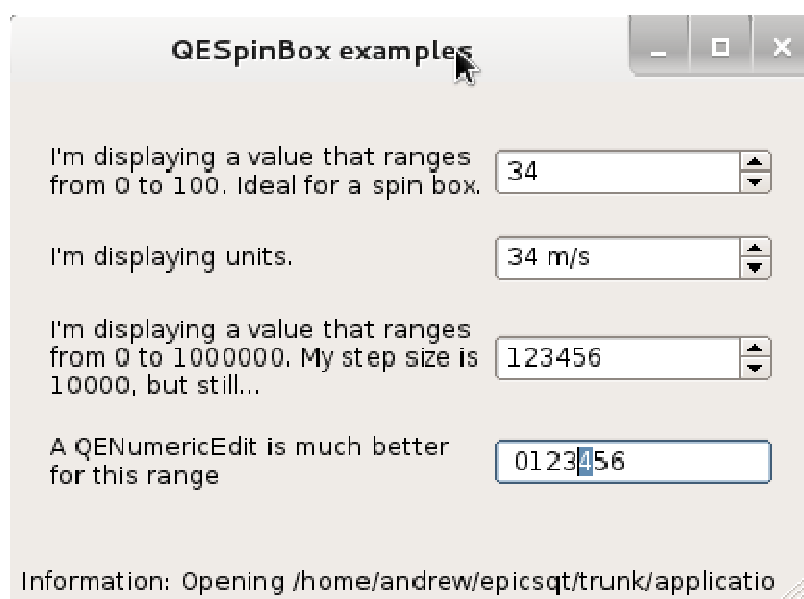


Figure 24 QESpinBox examples with a QENumericEdit where more appropriate

QEComboBox

The QEComboBox widget provides the ability to display and modify the value of a single PV using a combo box. This widget is derived from QComboBox. The example in Figure 25 shows QEComboBox widgets connected to an mbbi record. This widget is primarily intended for presenting a variable with enumeration strings defined for each value. Typically, the enumeration strings are defined in the database and will be used by the QEComboBox if the 'useDbEnumerations' property is set (the default). If the 'useDbEnumerations' property is not set, then the strings used by the combo box for each variable value must be set up in the QEComboBox at design time. If using Qt's designer you can right click over a QEComboBox and select 'Add Items' to add the combo box strings.

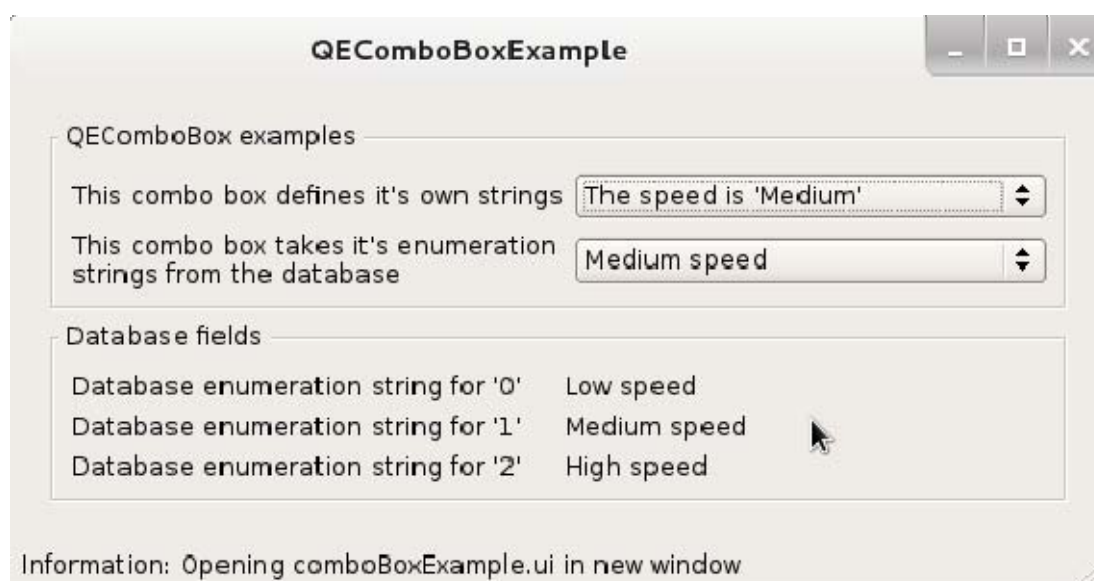


Figure 25 QEComboBox example showing local and database defined enumeration strings

QEForm

The QEForm widget is used to present a Qt user interface (.ui) file. While an application can programmatically achieve this by opening a .ui file with a QFile class and loading the contents using the QUiLoader, the QEForm widget adds the following functionality:

- The QEForm uses consistent rules for locating the file common to all QE widgets that access files. Refer to Finding files (page 12) for details.
- The contents of a QEForm is dynamic and can be changed by changing the 'uiFile' property.
- The .ui file used to generate the contents of a QEForm is monitored and re-loaded if it changes.
- The QEForm can be used as a sub form. Forms can share common sub forms. Sub forms can be nested.
- The QEForm uses macro substitutions. This means a form can contain multiple instances of the same sub form, each with a different set of macro substitutions. For example, a form displaying a set of slits could use an identical sub form for each motor.

QEForms help manage messages emitted by QE widgets. Messages can be filtered and displayed based on the QEform they reside in. Refer to

- Logging (page 10) for details.
- The .ui file loaded by a QForm widget will have a top level widget with size and layout policies that may differ to those of the QForm. To minimise any confusion, the QForm widget ensures the top level widget loaded and itself share the same size and layout policies. By default the QForm widget sets the top level widget loaded to match itself, but this behaviour can be reversed. The 'resizeContents' property controls this behaviour. If true, the top level widget loaded is set to match the QForm. If false, the QForm is set to match the top level widget loaded.
- QEPushButton, QERadioButton and QECheckBox widgets look in the ContainerProfile class to see if a slot they can use to create new GUI windows is available. Applications like QEGui publish a slot to open new GUIs using this mechanism. If the 'handleGuiLaunchRequests' property is true, the QForm widget publishes its own slot for launching new GUIs and so all QE widgets within it will use the QForm's mechanism for launching new GUIs.

The following properties are specific to the QForm widget:

- uiFile
File name of the user interface file to be presented. Refer to Finding files (page 12) for details on how this file is located.
- handleGuiLaunch
If set the QForm will supply the slot used by any QE widgets it creates to launch new GUIs. (Typically it is QE buttons that will use this slot.)
Generally this should be left unset when used within QEGui, allowing the QEGui application to supply the slot used to launch new GUI windows.
- resizeContents
If set, the QForm will resize the top level widget of the .ui file it opens (and set other size and border related properties) to match itself. This is useful if the QForm is used as a sub form within a main form (possibly another QForm) and you want to control the size of the QForm being used as a sub form.
If clear, the QForm will resize itself (and set other size and border related properties) to match the top level widget of the .ui file it opens. This is useful if the QForm is used as a sub form within a main form (possibly another QForm) and you want the main form to resize to match the size of the QForm being used as a sub form, or you want the sub form border decorations (such as frame shape and shadow) to be displayed.

In Figure 26, the QEGui application is displaying a user interface (.ui) file. QEGui uses QForms to present .ui files. In the example given, the .ui file itself includes three QForm widgets, each referencing the same sub form, but with different macro substitutions, resulting in a different title and the display of data from different variables. In this example the top level widget in the sub form is a QFrame with a border. To ensure the border is displayed, the QForm widgets in the main form have their 'resizeContents' property set to false so the contents (the top level QFrame in the sub form) copies its border properties to the QFrame, rather than the other way around.

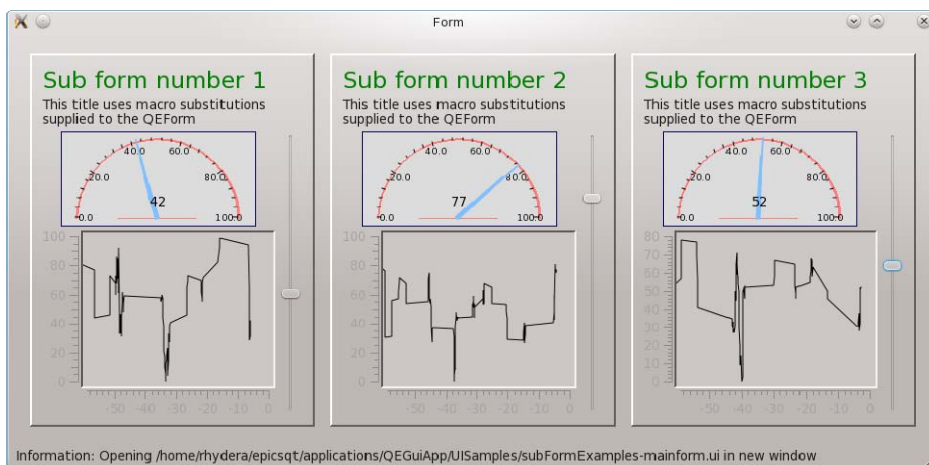


Figure 26 QEForm examples

QEPlot

QEImage

The QEImage widget is used to present an EPICS waveform (typically from areaDetector) as an image. It provides local analysis tools, such as displaying pixel profiles of slices through the image, and interacts with central analysis tools, such as areaDetector's Region of Interest plugin.





Images can be zoomed, panned, and scrolled. Images views can be captured to a local file.


The image has functionality to support sample positioning.

An image input for the QEImage is defined using the following properties:

- **imageVariable** An EPICS waveform record (typically from areaDetector)
- **widthVariable** An EPICS record (typically from areaDetector)
- **heightVariable** An EPICS record (typically from areaDetector)
- **formatOption** The expected pixel format (unrelated to the data type of the waveform record, except that the pixel format must fit in the waveform record data type)

QEImage user interaction is as follows:

- To pause image updating, press  if the Button Bar is displayed, or select 'Pause' from the Right Click menu. To resume image updating, press  if the Button Bar is displayed, or select 'Play' from the Right Click menu.
- To save the current image to a local file, press  if the Button Bar is displayed, or select 'Save...' from the Right Click menu.
- To move the target position into the beam, mark the target and beam positions and press  on the Button Bar. To mark the target and beam, select 'Mark Target' and 'Mark Beam' from the select menu (available on the button bar and in the right click menu) and mark the

target and beam positions on the image with the mouse. When  is pressed, the EPICS variables representing the target and beam will be updated with pixel coordinates and the target trigger variable will be updated. (Note, the coordinates represent coordinates in the original image and are not affected by how the image is zoomed.) Two EPICS calc records can then be used to perform the required move in each dimension. Each calc record subtracts the target position from the beam position, applies a scaling factor to convert pixels to distance, adds this to the current position of the target and writes the result to the target positioned.

Target and Beam markers can be seen selected in Figure 27.

The EPICS variables written to when marking the beam and target are defined by the following properties:

- targetXVariable
 - targetYVariable
 - beamXVariable
 - beamYVariable
 - targetTriggerVariable
- To zoom, either:
 - Select the required zoom percentage from the 'Zoom' menu on the button bar or in the right click menu.
 - Select 'Fit' from the 'Zoom' menu on the button bar or in the right click menu to zoom to a percentage that will fit the image in the current window. The image will be resized if the window size changes.
 - Choose 'Select Area 1' (Region 1) from the Mode menu on the button bar or from the right click menu, select an area within the image, then select 'Selected Area' from the 'Zoom' menu on the button bar or in the right click menu.

The image may be zoomed and set to an initial scroll position by default using the following properties:

- resizeMode
 - zoom
 - initialHosScrollPos
 - initialVertScrollPos
- To rotate an image by 90 degrees clockwise or anticlockwise, or 180 degrees, select the appropriate option from the Flip/Rotate menu. Refer to Figure 30 for an example of rotated images.

The image may be rotated by default using the following property:

- rotation
- To flip image vertically or horizontally, select the appropriate options from the Flip/Rotate menu. Refer to Figure 30 for an example of flipped images.

The image may be flipped by default using the following properties:

- verticalFlip
 - horizontalFlip

- To apply contrast reversal to an image (present a negative view), select the 'Contract Reversal' from the right click menu. Refer to Figure 30 for an example of contrast reversal. The image contrast may be reversed by default using the following property:
 - `contrastReversal`
- To display a timestamp in the top left corner of the image, select 'Show Time' from the right click menu. The timestamp may be shown by default using the following property:
 - `showTime`

- To present a profile of pixel values on a vertical 'Horizontal Slice Profile', 'Vertical Slice Profile', or 'Line Profile' from the Mode menu and mark a vertical slice, a horizontal slice, or mark an arbitrary line on the image with the mouse. After the markup is drawn, the mouse can be used to drag the markup to a new location or, in the case of the arbitrary line, can also be used to drag either end of the line to a new location. The mark-ups can be cleared by right clicking over the outline and selecting 'Clear'

Figure 27 shows an image with Vertical, Horizontal and arbitrary profiles selected.

The profile thickness can be changed from a single line by grabbing the square handle in the middle of the line and moving the line boundary as required. The line boundary lines (dashed) can be grabbed anywhere and dragged to change the line thickness. When dragged back to the centre line the dashed boundary lines disappear, the thickness reverts to a single pixel, and the square handle used to set the thickness reappears in the centre of the line.

The line thickness can also be returned to single line thickness from the line's context menu. The profile plots are simple indicative plots of the profile data. For more detailed analysis, the profile data presented in the plot can be copied by selecting 'Copy Plot Data' from the plot context menu. This can then be pasted into another program such as Excel. Note the data displayed and copied is generated from the most recent image update using the full original image data. It is unaffected by the current zoom level. The current zoom level will affect how accurately the lines can be positioned.

- To set the area in up to 4 areaDetector Region of Interest plugins, select 'Select Area 1', 'Select Area 2', 'Select Area 3' or 'Select Area 4' from the Mode menu on the button bar or in the right click menu, and mark the area in the image using the mouse. When marked, the four EPICS areaDetector variables representing the Region of Interest area position and size will be updated. Figure 29 shows an example of this.

After the area mark-ups are drawn, the mouse can be used to drag the markups to a new location to drag individual sides or corners to a new location. The area can be cleared by right clicking over the outline and selecting 'Clear'

The four EPICS areaDetector variables for each area are defined by the following properties:

- `regionOfInterest1XVariable`
- `regionOfInterest1YVariable`
- `regionOfInterest1WVariable` (width)
- `regionOfInterest1HVariable` (height)
- `regionOfInterest2XVariable`
- `regionOfInterest2YVariable`

- regionOfInterest2WVariable (width)
 - regionOfInterest2HVariable (height)
 - regionOfInterest3XVariable
 - regionOfInterest3YVariable
 - regionOfInterest3WVariable (width)
 - regionOfInterest3HVariable (height)
 - regionOfInterest4XVariable
 - regionOfInterest4YVariable
 - regionOfInterest4WVariable (width)
 - regionOfInterest4HVariable (height)
- Image clipping can be achieved by defining clipping variables with the following properties:
 - clippingLowVariable
 - clippingHighVariable
 - clippingOnOffVariable
- To simplify the user interfaces, some options can be disabled by default using the following properties:
 - enableVertSliceSelection
 - enableHozSliceSelection
 - enableProfileSliceSelection
 - enableAreaSliceSelection (for all area and region selection)
 - enableTargetSliceSelection (for beam and target selection)
- Markup colors can be altered using the following properties:
 - vertSliceColor
 - hozSliceColor
 - profilecolor
 - areaColor
 - beamColor
 - targetColor
 - timeColor
- Local brightness and contrast controls can be enabled by setting the enableBrightnessContrast property, or by checking 'Display local brightness and contrast controls' from the widget's context menu. Brightness and contrast can then be set by moving the brightness and contrast sliders as required. Local brightness and contrast are independant of areaDetector brightness and contrast settings. If 'auto brightness and contrast' is checked then selecting any area or region of interest will cause the brightness and contrast to be adjusted so match the range of pixel in the selected area. The reset button above the brightness and contrast sliders can be pressed to reset the controls to 'normal'.

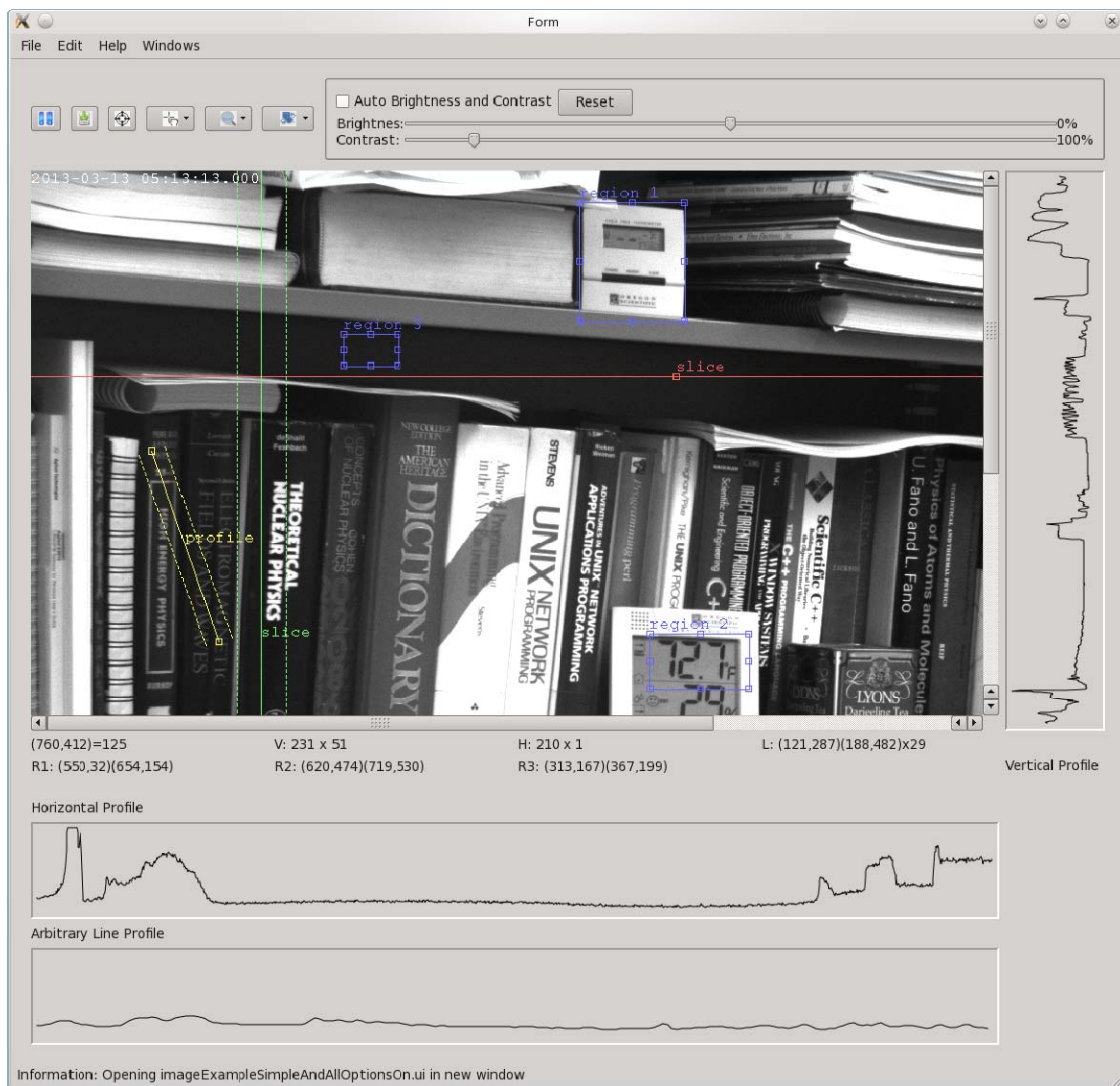


Figure 27 QEImage with most options activated



Figure 28 Minimal use of QEImage

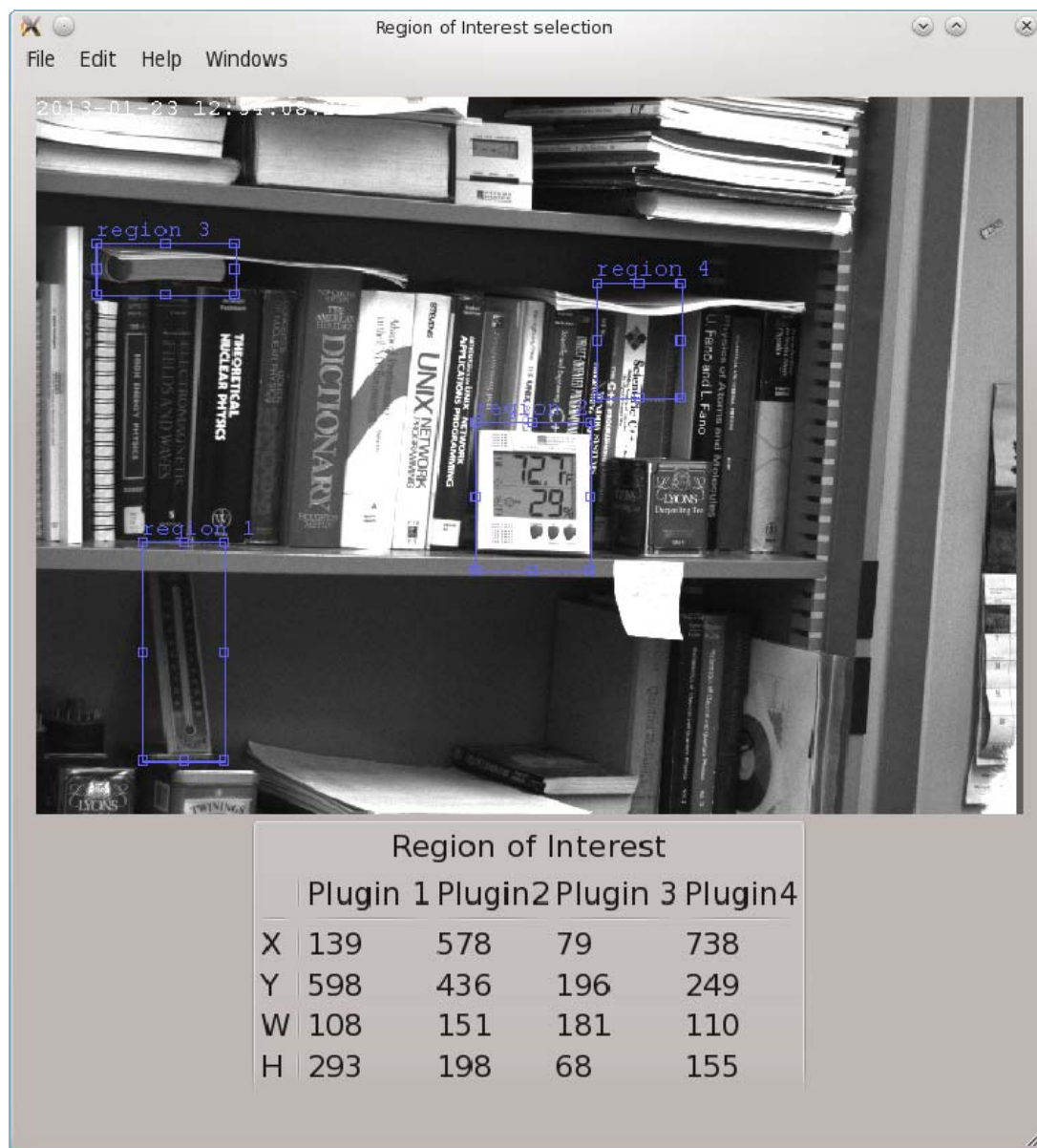


Figure 29 QEImage specifying areaDetector Region of Interest

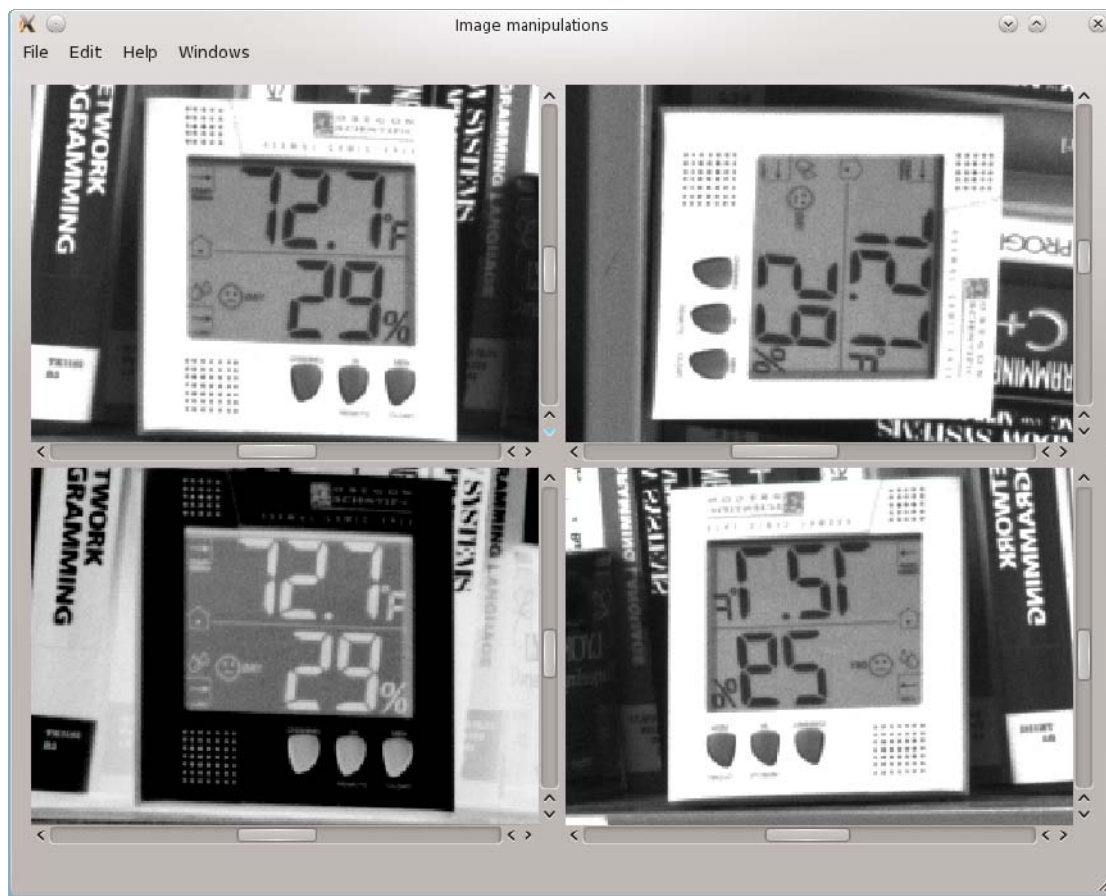


Figure 30 Some QEImage image manipulation options

QEFrame and QEGroupBox

The QEFrame and QEGroupBox widgets provide a minimalist extension to the QFrame and QGroupBox widgets respectively. It provides user level enabled and user level visibility control to the frame or group box but more significantly to all the widgets enclosed within the QEFrame or QEGroupBox container also. The User Level example in Figure 2 (page 9) shows a QEGroupBox only visible in 'Engineer' mode.

QELink

The QELink widget is part of a general mechanism to allow a GUI to be modified by data changes. For example, to disable a GroupBox if a variable is equal to a nominated value.

QELink widgets are only visible while in Designer. After placing them in a GUI the appropriate signals/slots connections and properties are defined to configure the GUI behaviour based on PV values. Then when opened in QEGui (or in any application except Designer) the functionality remains, but the QELink widget itself is hidden.

Typically, a QE widget sends data update signals to a QELink widget which makes a comparison and signals a value to another widget depending on the comparison result. The output signal can be used to set a widget invisible, or enabled, or click a button, or set focus, or raise, or...

In Figure 31, A QELink widget (circled) is configured to receive data update signals from a QELabel displaying beam current. It compares this to 205 (mA) and if greater sends a signal to enable the group box on the right. The signals used and the relevant QELink Properties are shown in the figure. Figure 32 shows this GUI in use by the QEGui display application. The QELink widget is not visible. The 'Shutdown' group box on the right is not enabled as the beam current is less than 205 mA.

The QELink widget can be made visible at all times by setting the 'visible' property.

Traditionally, the type of GUI functionality QELink widgets support has been effected by using EPICS database variables (often CALC records) to determine the state of GUI items. Where the variable is primarily a part of the control system this is appropriate. Where the variable is only present to support the GUI, then this functionality should be embedded in the GUI.

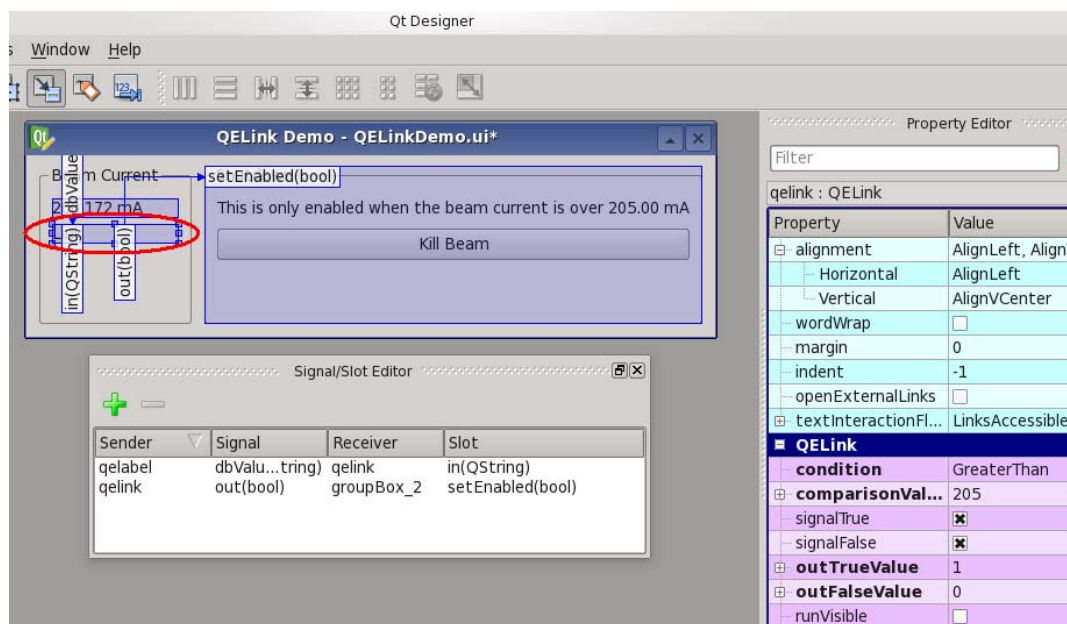


Figure 31 QELink being configured

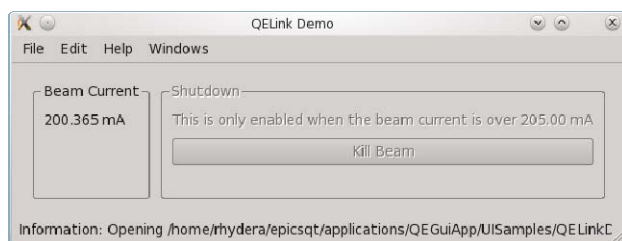


Figure 32 QELink in use

Appendix A

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