Prode

Industrial Process Interface

User's Manual rel. 1.3

Contents

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Prode, via Spalato 2 Milano 20124 Italia

How to obtain technical support

we welcome your comments or suggestions about our program. On request we will also provide information on the internal methods used. While the program has been tested carefully to ensure proper operation, it still may be possible for an unusual situation to result in an error. We will have a much greater chance of fixing or assisting with errors and problems if they are provided to us in a form that is repeatable.

In reporting a problem to us, the following information should be given:

• customer reference
• the version of the software
• a copy of the procedure you are running and if possible the input data
• a detailed description of what you were doing (sequence of operations) when the problem occurred
• any additional information you think may describe the problem

Introduction

OPC
OPC stands for OLE for Process Controls, it is a industry wide standard that allows connectivity between different devices, software applications, control systems. In OPC the servers provide methods which other software packages, the clients, can access to exchange data, each control device, such as a PLC or DCS and instruments can exchange data.

MODBUS
MODBUS is an application-layer messaging protocol, it provides client-server communication between devices connected on different types of buses or networks,a industrial serial standard since 1979 MODBUS enables millions of automation devices to communicate.

PRODE PROPERTIES
Prode Properties is the thermodynamic framework created by Prode, it solves problems such as physical properties data, process simulation, optimization and realtime control.

PRODE INDUSTRIAL PROCESS INTERFACE
Available in different versions since 1995 Prode industrial interface works as a bridge between the world of industrial applications and the specialized software required for calculating thermodynamic properties. Many industrial applications need access to rigorous thermodynamic calculations and Prode interface in union with Prode Properties allows this at effective cost and in a very simple way.

Prode Interface includes a OPC server, a OPC client and a MODBUS device, it can receive data from inline devices or DCS systems and returns in realtime a series of calculated values, standard version has more than 30 predefined properties (see the list below), custom versions are available for expanding the list of properties and providing a flexible data communication according OPC UA (Unified Architecture) specifications.

Critical pressure
Critical temperature
CricondenBar pressure
CricondenBar temperaure
CricondenTherm pressure
CricondenTherm temperature
Liquid Fraction
Dew point temperature
Bubble point temperature
Gas heating value
Gas Joule Thomson coefficient
Gas Wobbe index
Gas specific entropy
Gas specific enthalpy
Gas specific heat at constant pressure (cp)
Gas specific heat at constant volume (cv)
Gas speed of sound
Gas compressibility
Gas specific gravity
Gas compressibility
Gas specific gravity
Gas density
Gas viscosity
Gas thermal conductivity
Liquid specific entropy
Liquid specific enthalpy
Liquid specific heat at constant pressure (cp)
Liquid specific heat at constant volume (cv)
Liquid speed of sound
Liquid viscosity
Liquid thermal conductivity
Liquid surface tension

ADDITIONAL PROPERTIES
Custom versions can extend the features by including additional properties such as

Hydrate formation pressure and temperature
Wax formation
Water dew point (in Hydrocarbons)

or procedures for real time simulation of equipments as distillation columns etc.

How Prode Industrial Process Interface Works

Introduction

A generic plant can include one or more equipments and each equipment can have one (or more) lines entering (influents) and lines exiting (effluents). For purposes of process simulation each line constitutes a process stream, defined in terms of mixture composition and operating conditions (pressure,temperature) , when energy and mass balance calculations are required the flow is the additional specification. Different properties can require different specifications, for example the calculation of gas densitiy requires as specifications composition, operating temperature and pressure while gas heating value (which is related to standard conditions) requires only composition. Prode interface permits to set each specification (composition, pressure, temperature) directly from external providers as in-line instruments, DCS systems or other devices and get immediately the calculated values. The standard version can manage up to 20 different streams and more than 30 different properties per stream, with Prode Interface it becomes very easy to add sophisticated process calculations to your applications.

How it works

Once the data provider (OPC or MODBUS) is connected the software detects changes in inputs (specifications) and calls Prode Properties to calculate output values (or, in case of errors, generate reports), the outputs are then available as external connection. The different timing cycles doesn't affect the execution time of Prode Properties internal procedures but permits to reduce the number of calls when process inputs are not updated frequently, for example with gas-chromatographs a typical interval would be about 10 minutes.

Features

- Fully customizable list for inputs (specifications) and outputs (properties to be calculated)
- Support for up to 20 components per stream and up to 100 streams,
  each stream supports a different list of components, pseudo components, thermodynamic models etc.
- Capability to relay each input to OPC and MODBUS ports
- Customizable parameters for OPC and MODBUS ports
- Automatic diagnostic and error reporting

Operating

Once started the program shows two windows which have different purposes:
- on the window above the program shows errors and warnings which occurred during operations
- on the window below the program creates the list of ports, the connections state, the values read/written etc.
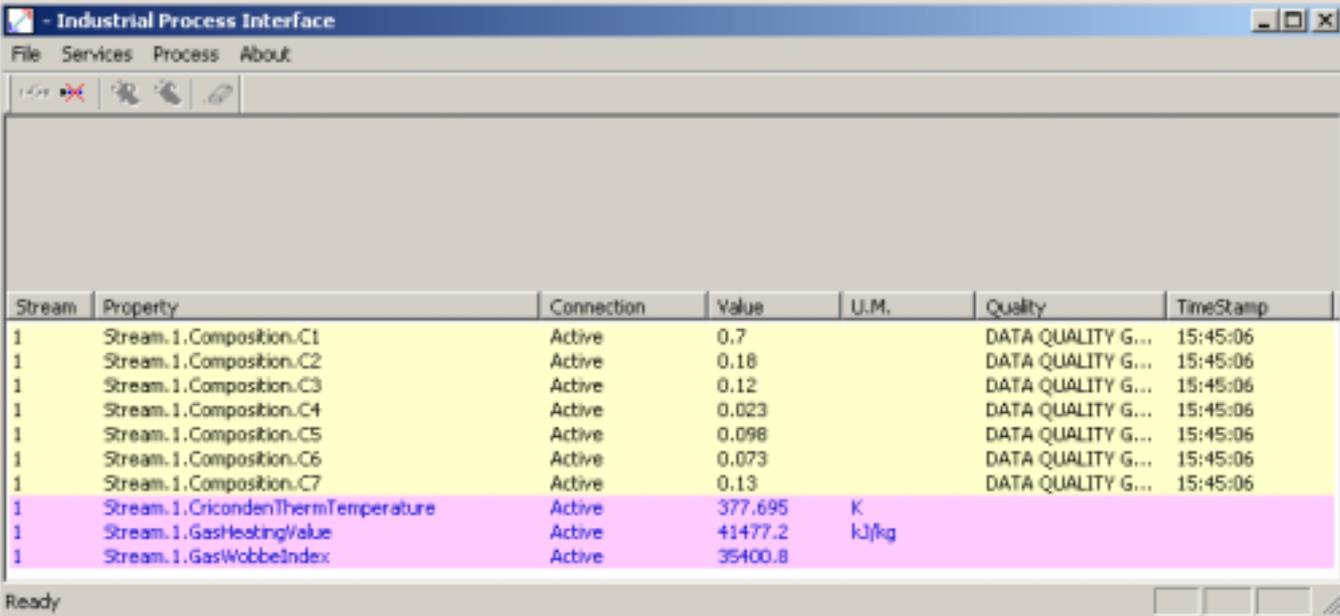
Stream	Property	Connection	Value	U.M.	Quality	TimeStamp
1	Stream.1.Composition.C1	Active	0.7		DATA QUALITY G...	15:45:06
1	Stream.1.Composition.C2	Active	0.18		DATA QUALITY G...	15:45:06
1	Stream.1.Composition.C3	Active	0.12		DATA QUALITY G...	15:45:06
1	Stream.1.Composition.C4	Active	0.023		DATA QUALITY G...	15:45:06
1	Stream.1.Composition.C5	Active	0.098		DATA QUALITY G...	15:45:06
1	Stream.1.Composition.C6	Active	0.073		DATA QUALITY G...	15:45:06
1	Stream.1.Composition.C7	Active	0.13		DATA QUALITY G...	15:45:06
1	Stream.1.CricondenThermTemperature	Active	377.695	K		
1	Stream.1.GasHeatingValue	Active	41477.2	kJ/kg		
1	Stream.1.GasWobbeIndex	Active	35400.8			

Diagnostics

During the operations of the interface different events may occur. Prode interface includes procedures for validating data by utilizing filters and generating error / warning messages when the program detects a possible problem. When the problem is related to one (or more) ports the program can use different colors to emphasize the row (in the list of ports) which is related with the detected problem.

Installing Prode Industrial Process Interface

Prode Industrial Process Interface is distributed in form of executable which installs automatically in your operating system.

IMPORTANT

For OPC Server and Client services (if not already available in your system) you may need to install the OPC Core Components freely available from OPC Software Foundation

Configuring the Interface

Configuring Prode Industrial Process Interface is easy, only a few steps are required
- defining the inputs
- define and set up connection devices (OPC Server, OPC Client, MODBUS)
- define and set up connecting ports

IMPORTANT

For configuring the interface must not be connected to external devices

Once you have completed each step you can save the configuration with the command File->Save config

The program automatically loads the configuration file at startup.

First step, define the Inputs

To execute the calculations the procedure needs for each property a suitable set of specifications, these inputs (usually provided by external devices via MODBUS or OPC protocols) can be the operating conditions (temperature, pressure) at which the process takes place and/or the composition of the mixture (the molar percentage of each component in the stream), the table below shows the list of required specifications per each property.
The user is allowed to force fixed values for compositions, temperatures and pressures (from Prode Properties Editor) as alternative to obtain these value at regular intervals from a data provider , in any case the procedure does require a consistent set of inputs (specifications) to solve the calculations.

Property	Main specifications	Additional specification
Critical pressure	Composition	
Critical temperature	Composition	
CricondenBar pressure	Composition	
CricondenBar temperaure	Composition	
CricondenTherm pressure	Composition	
CricondenTherm temperature	Composition	
Liquid Fraction	Operating temperature, pressure	Composition
Dew point temperature	Operating pressure	Composition
Bubble point temperature	Operating pressure	Composition
Gas heating value	Composition	
Joule Thomson coefficient	Operating temperature, pressure	Composition
Gas Wobbe index	Composition	
Gas specific entropy	Operating temperature, pressure	Composition
Gas specific enthalpy	Operating temperature, pressure	Composition
Gas specific heat (cp)	Operating temperature, pressure	Composition
Gas specific heat (cv)	Operating temperature, pressure	Composition
Gas speed of sound	Operating temperature, pressure	Composition
Gas compressibility	Operating temperature, pressure	Composition
Gas specific gravity	Composition	
Gas compressibility	Operating temperature, pressure	Composition
Gas specific gravity	Composition	
Gas density	Operating temperature, pressure	Composition
Gas viscosity	Operating temperature, pressure	Composition
Gas thermal conductivity	Operating temperature, pressure	Composition
Liquid specific entropy	Operating temperature, pressure	Composition
Liquid specific enthalpy	Operating temperature, pressure	Composition
Liquid specific heat (cp)	Operating temperature, pressure	Composition
Liquid specific heat (cv)	Operating temperature, pressure	Composition
Liquid speed of sound	Operating temperature, pressure	Composition
Liquid viscosity	Operating temperature, pressure	Composition
Liquid thermal conductivity	Operating temperature, pressure	Composition
Liquid surface tension	Operating temperature, pressure	Composition

From Prode Interface application, menu Process->General to activate the dialog where to define the required properties and input specifications.
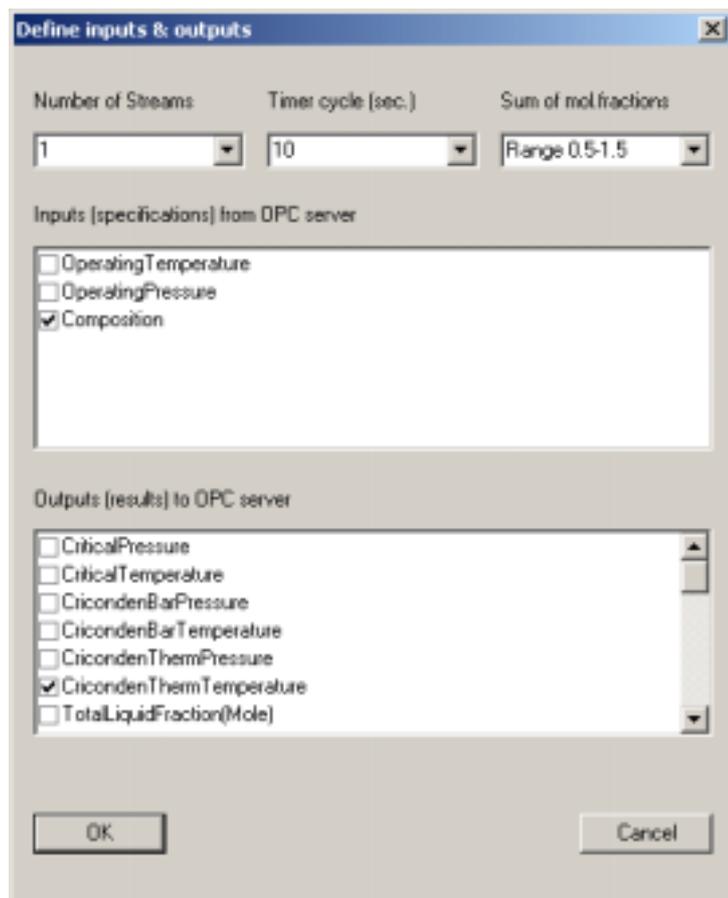
Number of Streams	the procedure calculates the properties per each stream in the list
Timer Cycle	the procedure recalculates the properties at regular intervals of time
Sum of Mol.Fractions	acceptable range of values for the sum of molar frations in compositions
Inputs (Specifications)	inputs from external devices
Outputs (Results)	required properties, outputs to external devices

From Prode Interface application, menu Process->Process Data to activate the Prode Properties Editor

Prode Properties Editor

Stream	Select / edit stream	1 Test Case 1	Test Case 1		Save
— Operating	Operating Conditions		K		Pa.a		kg/s

Feed and Operation	1 Test Case 1	T-P VL		Compute
Specifications	288.15	K	101327	Pa.a	1	kg/s
Specifications (OUT)		Pa.a		kW	

Tree (left panel):
- Stream
  - Operating
  - Components
  - Models
  - BIPs
- Config
- Chemicals
- BIPs
- Licence

Phase	Feed	Not present	Not present	Not present	Not present	Not present
Mol.fraction	0	0	0	0	0	0
C2H6	0.528701	0	0	0	0	0
C3H8	0.135952	0	0	0	0	0
C4H10	0.0906344	0	0	0	0	0
C4H10	0.0173716	0	0	0	0	0
C6H14	0.0740181	0	0	0	0	0
CH4	0.055136	0	0	0	0	0
CO2	0.0981873	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0

OK   Cancel   Apply

Use this editor to define
- List of components for all streams
- Thermodynamic models and options
- Units of measurement

To define the list of components, thermodynamic models and options for a stream select the stream in the list then in components page define the list of components

Prode Properties Editor

Tree (left panel):
- Stream
  - Operating
  - Components
  - Models
  - BIPs
- Config
- Chemicals
- BIPs
- Licence

ACETONE

Sort by first name

Molar fractions

Add   Remove   Clear

| Component	Fraction (0-1)
ETHANE	0.528701
PROPANE	0.135952
ISOBUTANE	0.0906344
n-BUTANE	0.0173716
n-HEXANE	0.0740181
METHANE	0.055136
CARBON DIOXIDE	0.0981873
	0
	0
	0
	0
	0
	0
	0

OK   Cancel   Apply

IMPORTANT

in stream's editor make sure to save your edited stream's data (button save) before to select a different stream, differently all changes will be discharged

In Models page define the models and options for this stream
in BIPS page enter the relevant binary interaction pairs, see Prode Properties manual for additional informations on these parameters , then back to page Operating, Select Save for saving this stream before selecting a different stream or leaving the dialog.
To define a set of Units of Measurement go to the page Units
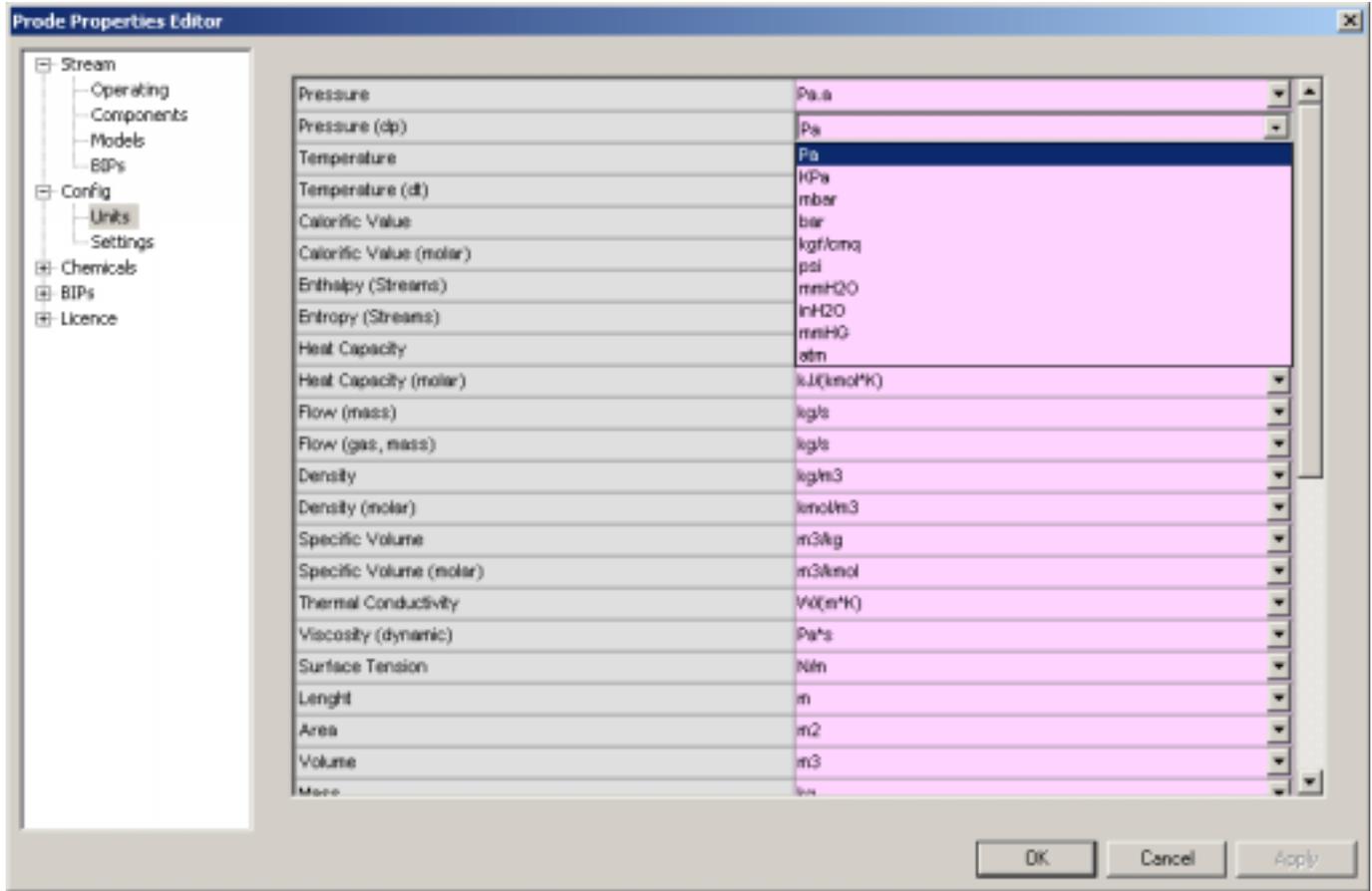
Once all process parameters have been defined select Ok to leave the dialog

Define calculated fractions

Before to configure the connection devices take care to define the information about the calculated fractions, calculated fractions permit to get accurate results by extending the set of measured values with the information from laboratory analysis, supposing we know (from laboratory analysis) the composition of a stream

C1	CH4	0.7
C2	C2H6	0.11
C3	C3H8	0.05
C4	C4H10	0.03
C5	C5H12	0.02
C6	C6H14	0.03
C7	C8H14	0.02
C8	C9H20	0.02
C9	C10H22	0.02

if the in field analyzer can measure only C1-C5 returning a total value (sum) for all the remaining C6-C9 components, we can configure the interface for calculating C6-C9 as fractions of measured (total) value:

total (C6+C7+C8+C9)   0.09

relative fractions	C6	0.3333
	C7	0.2222
	C8	0.2222
	C9	0.2222

From Prode Interface application, menu Process->Pseudo Components to activate the dialog.

Define Pseudo Components

Edit Stream	Component to split
Stream 1	C6

Into components	Molar fraction
C6	0.33333
C7	0.22222
C8	0.22222
C9	0.22222
Not included	0
Not included	0
Not included	0

Ok   Cancel

In the dialog select "Do not split" if you do not require calculated fractions, differntly define in each stream the input component from which the software calculates the components not provided as inputs. Note that the interface will show only the input values (in this case C1-C6 from analyzer)


- Industrial Process Interface

File   Services   Process   About

Stream	Property	Connection	Value	U.M	Quality	TimeStamp
1	Stream.1.Composition.C1	Active	0.7		DATA QUALITY G...	23:50:50
1	Stream.1.Composition.C2	Active	0.11		DATA QUALITY G...	23:50:50
1	Stream.1.Composition.C3	Active	0.05		DATA QUALITY G...	23:50:50
1	Stream.1.Composition.C4	Active	0.03		DATA QUALITY G...	23:50:50
1	Stream.1.Composition.C5	Active	0.02		DATA QUALITY G...	23:50:50
1	Stream.1.Composition.C6	Active	0.09		DATA QUALITY G...	23:50:50

but if you stop the connection and access the Process Editor you can verify how the procedure calculates the fractions for all the remaining components (C6-C9) before to call the thermodynamic package.

Prode Properties Editor

- Stream
  - Operating
  - Components
  - Models
  - BIPs
- Config
- Chemicals
- BIPs
- Licence

Select / edit stream	1 Test Case 1		Test Case 1		Save	
Operating Conditions		K		Pa.a		kg/s

Feed and Operation	1 Test Case 1		T-P VL		Compute	
Specifications	288.15	K	101 327	Pa.a	1	kg/s
Specifications (OUT)		Pa.a		kW		

Phase	Feed	Not present	Not present	Not present	Not present	Not present
Mol.fraction	0	0	0	0	0	0
CH4	0.7	0	0	0	0	0
C2H6	0.11	0	0	0	0	0
C3H8	0.05	0	0	0	0	0
C4H10	0.03	0	0	0	0	0
C5H12	0.02	0	0	0	0	0
C6H14	0.03	0	0	0	0	0
C7H16	0.02	0	0	0	0	0
C9H20	0.02	0	0	0	0	0
C10H22	0.02	0	0	0	0	0

Second step, setting up connection devices

Prode interface can act as OPC client, OPC server and MODBUS device, each connection can get data from external providers (input port) or working as output port, in addition each connection can relay data (expose a copy) from a different connection. From Prode Interface application, menu Services->Settings to activate the Connection Settings dialog.
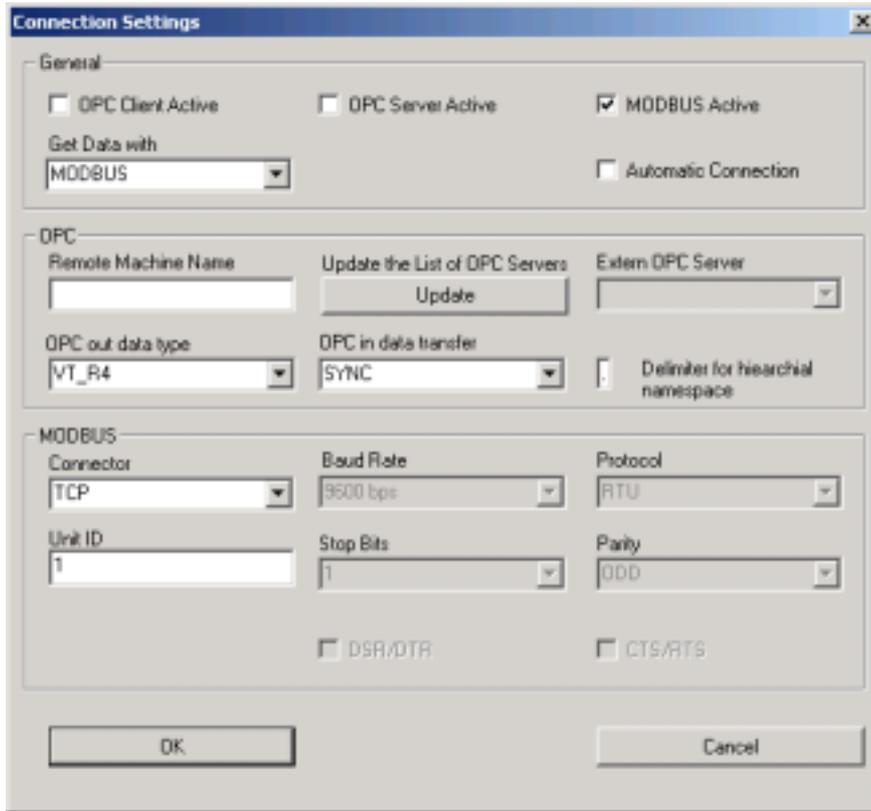
General
In this section define
the required connections (OPC client, OPC server, MODBUS)
the service which provides the input data
automatic connection at application's startup, required when OPC server is activated

OPC Connection
In this section define
the extern OPC server in case of OPC client active, with OPC Client active select the button "Update" to see the list of OPC Servers available, then select one
OPC out data type, calculated values are of real types, COM provides two compatible types
OPC in data transfer, SYNC forces reading at each cycle
OPC delimiter, must be compatible with external OPC devices
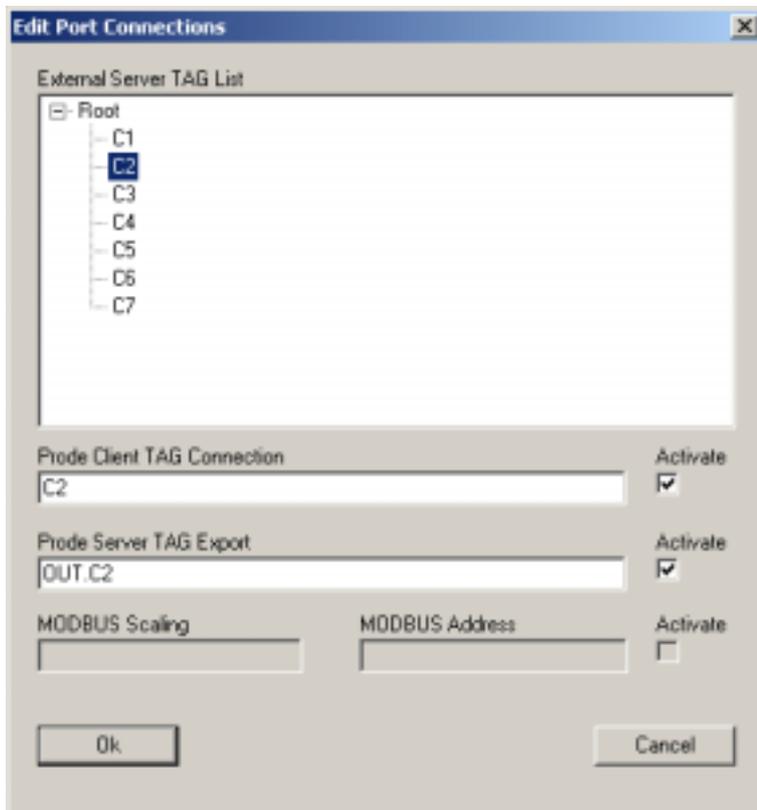
MODBUS Connection
In this section define
Connector, TCP or computer's COM port
Device ID, the address to access this MODBUS device
Baud Rate, port speed
Protocol, MODBUS protocol
Stop Bits, Parity, MODBUS connection settings

Third step, setting up connection ports

Each position in the list represents a port, select the connection to edit
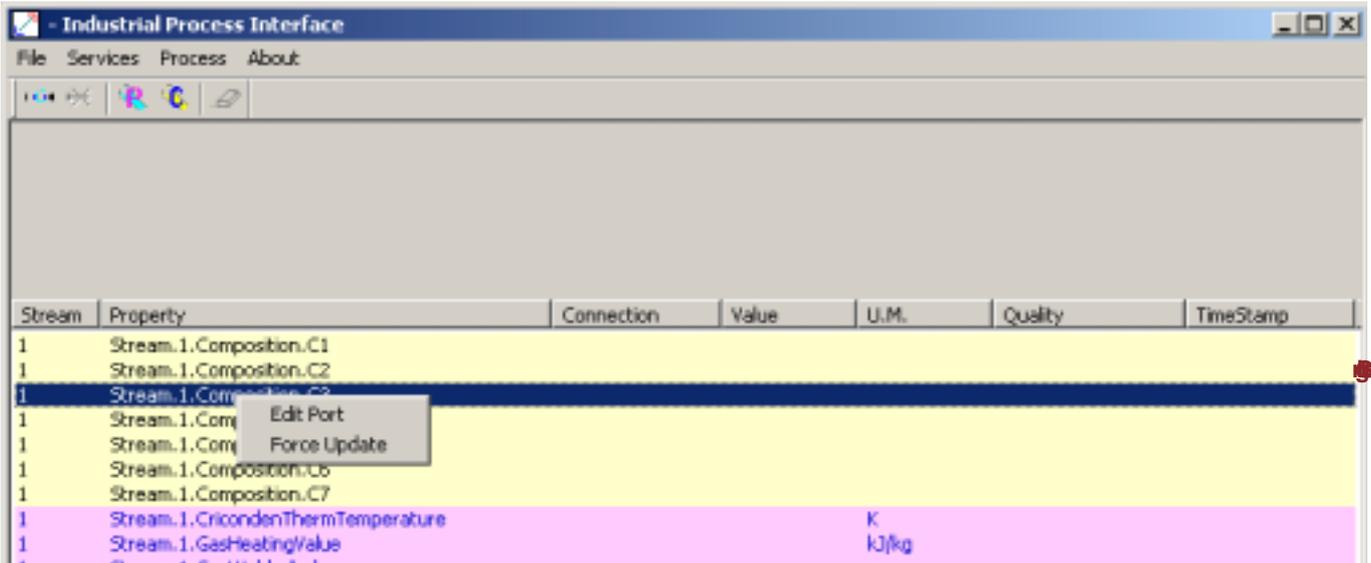
Then for activating the Connection Settings dialog use the right buttom in the mouse or the application menu Services->Edit Port

the different sections of the dialog are editable when the related service (OPC client, OPC server, MODBUS) has been activated in Connection Settings dialog.

The external Server TAG List shows the connections exposed by the external OPCserver (which connects with the OPC client in Prode interface)

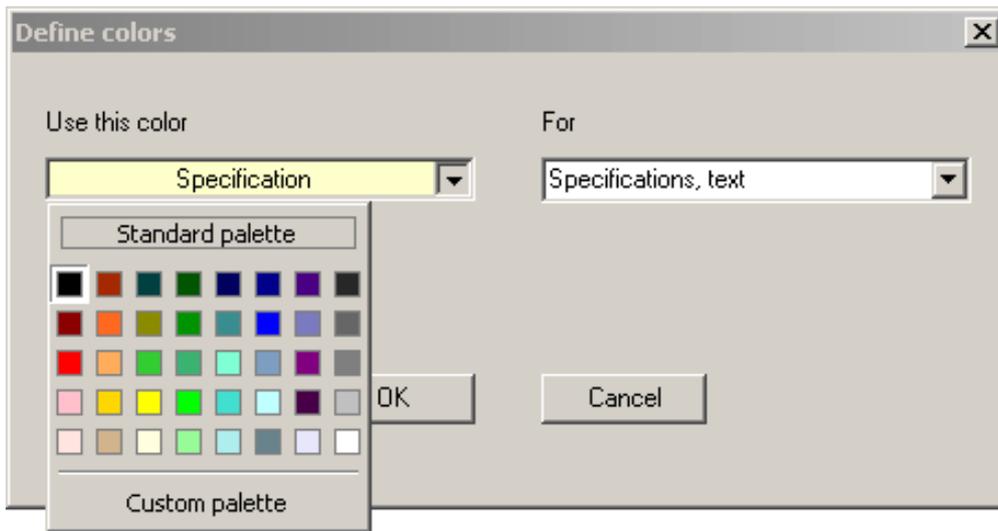The TAG names are those exposed by OPC ports

MODBUS Scaling defines a multiplier (a real which defines the full scale) for extending the MODBUS range.

MODBUS address defines the address.

To activate a service set the related box

Define Colors

Select Process->File in menu, then Set colors.

From this dialog you can set the different colors (text and background) associated to each operating condition :

- Normal condition, the connection is working as expected
- Warning condition, the connection doesn't receive data
- Error condition, the port isn't connected

Connect the Services

To connect the external services select Services->Connect

For disconnecting Services->Disconnect

Once onnected at regular intervals the procedure reads the inputs (specifications), calls Prode Properties to calculate output values and show the results (or, in case of errors, generate reports) , outputs are then available to external connections.

MODBUS Interface

MODBUS standard offers two types of analog registers, the Holding Register which permits read/write operations and theInput Register for read only operations. Each register has a size of 16 bits and can store unsigned integers with values between 0 and 65535, each register has a address, Input Registers in range 30000-30999 and Holding Registers in range 40000-49999. Prode interface maps the inputs (compositions, temperature, pressure) in Holding Registers and the outputs (calculated values) in Input Registers, the interface accepts values for address in range 1-9999

MODBUS Scaling	Input Register Number	Activate
500	1	☑

| Ok | | Cancel |

In this example the address 1 for calculated Cricondentherm will be translated by MODBUS to 30001 which is the first position in Input Registers area.

Standard MODBUS registers have 65536 possible values and a proper scaling is important , the MODBUS Scaling factor is the full range value, in the example for Cricondentherm the range is 0 to 500 Kelvins, a MODBUS register value of 0 means 0 K and a value of 65535 the value 500 K

```
40001:  <43483>
40002:  <02134>
40003:  <07896>
40004:  <03876>
40005:  <02345>
40006:  <03456>
40007:  <02345>
```

```
30001:  <47499>
30002:  <29333>
30003:  <25835>
```

In the example there are 7 input values (the molar fractions of each component in mixture) and 3 output values (Crciondentherm, Gas Heating Value and Gas Wobbe Index)

Stream	Property	Connection	Value	U.M.	Quality	TimeStamp
1	Stream.1.Composition.C1	Active	0.663508		DATA QUALITY G...	08:49:02
1	Stream.1.Composition.C2	Active	0.0325628		DATA QUALITY G...	08:49:02
1	Stream.1.Composition.C3	Active	0.120485		DATA QUALITY G...	08:49:02
1	Stream.1.Composition.C4	Active	0.059144		DATA QUALITY G...	08:49:02
1	Stream.1.Composition.C5	Active	0.0357824		DATA QUALITY G...	08:49:02
1	Stream.1.Composition.C6	Active	0.0527352		DATA QUALITY G...	08:49:02
1	Stream.1.Composition.C7	Active	0.0357824		DATA QUALITY G...	08:49:02
1	Stream.1.CricondenThermTemperature	Active	362.398	K		
1	Stream.1.GasHeatingValue	Active	44760.6	kJ/kg		
1	Stream.1.GasWobbeIndex	Active	39423.2			

To obtain the value in Kelvins for Cricondentherm from MODBUS internal value of 47499 (address 30001) use the formulation

Value = Scaling factor * MODBUS value / 65535

or   500 * 47499 / 65535

OPC Interface

The standard OPC interface, based on Microsoft Variant objects, support several data types including

VT_R4   32-bit floating-point value
VT_R8   64-bit floating-point value

Prode interface recognizes automatically the different types and the user can define the format for outputs.

Data files folder

When running Prode Interface requires to access several files, these are placed in a directory \Prode\ in user space to avoid possible conflicts with code reserved areas, the exact path depends from Windows version and settings, for example in Windows XP they could be placed in C:\Documents and Settings\All Users\Application Data, the list of files includes

proind.lan
proind.ppp
proind.cfg

do not remove or rename these files

Translate resources to different languages

A large part of the resources are stored in the file proind.lan, this is a text file, easily editable by the user.

Example

in English language
PID_LABEL_14 = "Automatic connection";

in French language
PID_LABEL_14 = "Connecter automatiquement";

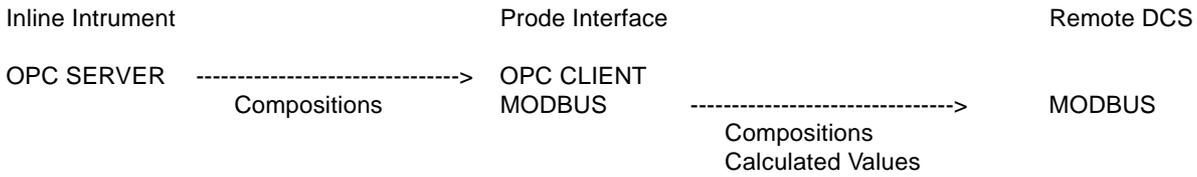in Italian language
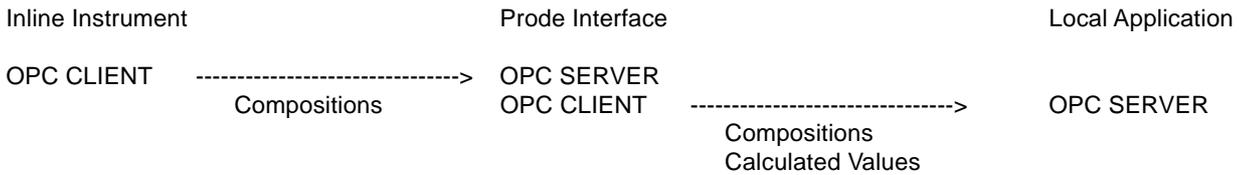PID_LABEL_14 = "Connessione automatica";

IMPORTANT

When editing a string take care to modify only the parts enclosed within the braces "" and do not alter/modify the data structures composed by special characters
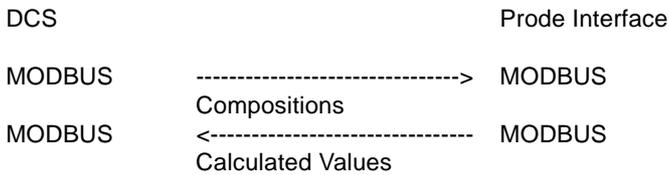
Application Examples

A inline Instrument includes a OPC Server to export compositions data, the OPC Client in Prode Interface reads the data, the package calculates several properties then exports both compositions and calculated properties via MODBUS

```
Inline Intrument                         Prode Interface                        Remote DCS

OPC SERVER   -------------------------->  OPC CLIENT
                    Compositions          MODBUS
                                                  -------------------------->    MODBUS
                                                        Compositions
                                                        Calculated Values
```
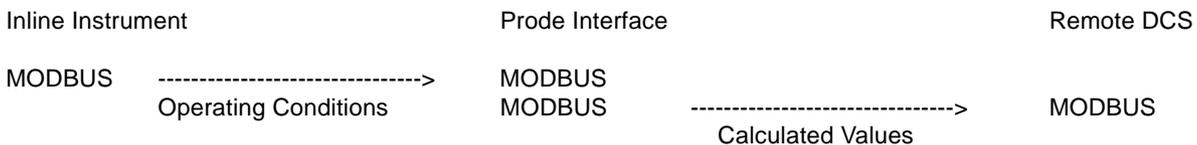
A inline instrument includes a OPC Client to export compositions data, the OPC Server in Prode Interface reads the data, the package calculates several properties then exports both compositions and calculated properties via OPC Client

```
Inline Instrument                        Prode Interface                        Local Application

OPC CLIENT   -------------------------->  OPC SERVER
                    Compositions          OPC CLIENT
                                                  -------------------------->    OPC SERVER
                                                        Compositions
                                                        Calculated Values
```

A DCS provides compositions to Prode Interface for calculating several properties which are then exported via MODBUS interface

```
DCS                                      Prode Interface

MODBUS       -------------------------->  MODBUS
                    Compositions
MODBUS       <--------------------------  MODBUS
                    Calculated Values
```

A inline intrument with MODBUS provides operating conditions, Prode Interface calculates several properties which are then exported to a remote DCS via MODBUS

```
Inline Instrument                        Prode Interface                        Remote DCS

MODBUS       -------------------------->  MODBUS
              Operating Conditions        MODBUS
                                                  -------------------------->    MODBUS
                                                        Calculated Values
```

Custom solutions

On request Prode software is available preinstalled and tested in different types of industrial grade computers, these can be very small with rugged metal case, splash/dust resistant.