

Manual | EN

# TF3500

TwinCAT 3 Analytics Logger





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# 1 Foreword

## 1.1 Notes on the documentation

This description is only intended for the use of trained specialists in control and automation engineering who are familiar with applicable national standards.

It is essential that the documentation and the following notes and explanations are followed when installing and commissioning the components.

It is the duty of the technical personnel to use the documentation published at the respective time of each installation and commissioning.

The responsible staff must ensure that the application or use of the products described satisfy all the requirements for safety, including all the relevant laws, regulations, guidelines and standards.

### Disclaimer

The documentation has been prepared with care. The products described are, however, constantly under development.

We reserve the right to revise and change the documentation at any time and without prior announcement. No claims for the modification of products that have already been supplied may be made on the basis of the data, diagrams and descriptions in this documentation.

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The EtherCAT Technology is covered, including but not limited to the following patent applications and patents:

EP1590927, EP1789857, EP1456722, EP2137893, DE102015105702  
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## 1.2 Safety instructions

### Safety regulations

Please note the following safety instructions and explanations!  
Product-specific safety instructions can be found on following pages or in the areas mounting, wiring, commissioning etc.

### Exclusion of liability

All the components are supplied in particular hardware and software configurations appropriate for the application. Modifications to hardware or software configurations other than those described in the documentation are not permitted, and nullify the liability of Beckhoff Automation GmbH & Co. KG.

### Personnel qualification

This description is only intended for trained specialists in control, automation and drive engineering who are familiar with the applicable national standards.

### Description of symbols

In this documentation the following symbols are used with an accompanying safety instruction or note. The safety instructions must be read carefully and followed without fail!

#### **DANGER**

##### **Serious risk of injury!**

Failure to follow the safety instructions associated with this symbol directly endangers the life and health of persons.

#### **WARNING**

##### **Risk of injury!**

Failure to follow the safety instructions associated with this symbol endangers the life and health of persons.

#### **CAUTION**

##### **Personal injuries!**

Failure to follow the safety instructions associated with this symbol can lead to injuries to persons.

#### **NOTE**

##### **Damage to the environment or devices**

Failure to follow the instructions associated with this symbol can lead to damage to the environment or equipment.



##### **Tip or pointer**

This symbol indicates information that contributes to better understanding.

## 2 Overview

The TwinCAT Analytics Logger records process and application data of the machine controller in synchronization with task cycles. The logger is characterized by its high performance as it operates directly in the real-time context of the TwinCAT controller.

The TwinCAT Analytics Logger may either act as an MQTT client and transmit the data to a MQTT message broker on a regular basis (called MQTT-mode) or store the data locally in a file on the hard disk of the machine controller (called file-mode). The configuration required is performed in Microsoft Visual Studio®. All variables of the process image and the PLC application can be added easily to the configuration via check boxes without the need for programming.

When used as an MQTT Client the Logger is able to bypass short disconnects to the Message Broker using a ring buffer functionality to prevent loss of data temporarily. Used in file-mode, a ring buffer can also be configured, which may be useful in case of limited storage capacity or if there is no need for data to be recorded (henceforth referred to as logged) permanently, instead focusing on a fixed time interval.

The logged data may be used in various ways but its main intention is data analysis with TwinCAT Analytics as well as data visualization with TwinCAT Scope.

### Components

- Configuration surface in TwinCAT project tree
- Description files TcAnalytics.tmc and TcIotBase.tmc
- Drivers TcAnalytics.sys and TcIotDrivers.sys

### List of key features

Functionality	TC3 Analytics Logger as MQTT Client	TC3 Analytics Logger for local storage
Programable record control	Yes	Yes
Configuration Interface	Yes	Yes
RT Context	Yes	Yes
MQTT	Yes	No
Analytics Binary Format	Yes	Yes
JSON Format	No	No
File Storage	No	Yes
Ring Buffer	Yes	Yes
Authentication	Yes	No
Encryption	Yes	Yes
Compression	Yes	Yes

## 3 Installation

The TwinCAT Analytics Logger is installed with TwinCAT XAE and XAR. Therefore, the Logger should always be available but in order to use it, one “TC3 Analytics Logger” license per target device is needed which may either be a permanent or a 7-day trial license.

For general information about licensing, please refer to the licensing paragraph below.

### 3.1 System requirements

Technical Data	TF3500 TC3 Analytics Logger
Operating System	Windows 7, Windows 8, Windows 10, WinCE PC (x86, x64 und ARM)
Min. TwinCAT Version	3.1.4022.31
Min. TwinCAT Level	TC1100 TC3   I/O

### 3.2 Licensing

The TwinCAT 3 function can be activated as a full version or as a 7-day test version. Both license types can be activated via the TwinCAT 3 development environment (XAE).

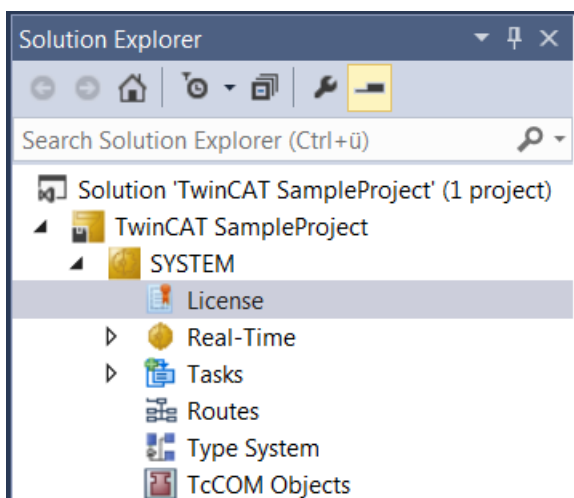
#### Licensing the full version of a TwinCAT 3 Function

A description of the procedure to license a full version can be found in the Beckhoff Information System in the documentation "[TwinCAT 3 Licensing](#)".

#### Licensing the 7-day test version of a TwinCAT 3 Function

Note: A 7-day test version cannot be enabled for a TwinCAT 3 license dongle.

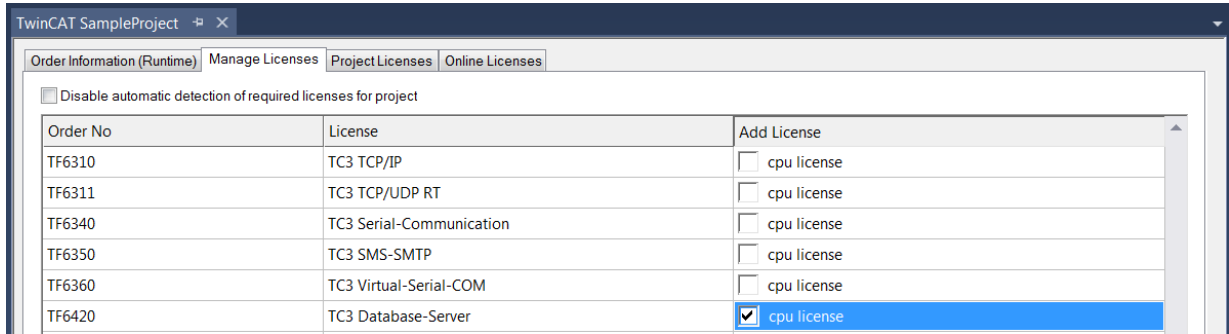
1. Start the TwinCAT 3 development environment (XAE).
2. Open an existing TwinCAT 3 project or create a new project.
3. If you want to activate the license for a remote device, set the desired target system. To do this, select the target system from the **Choose Target System** drop-down list in the toolbar.
  - ⇒ The licensing settings always refer to the selected target system. When the project is activated on the target system, the corresponding TwinCAT 3 licenses are automatically copied to this system.
4. In the **Solution Explorer**, double-click **License** in the **SYSTEM** subtree.



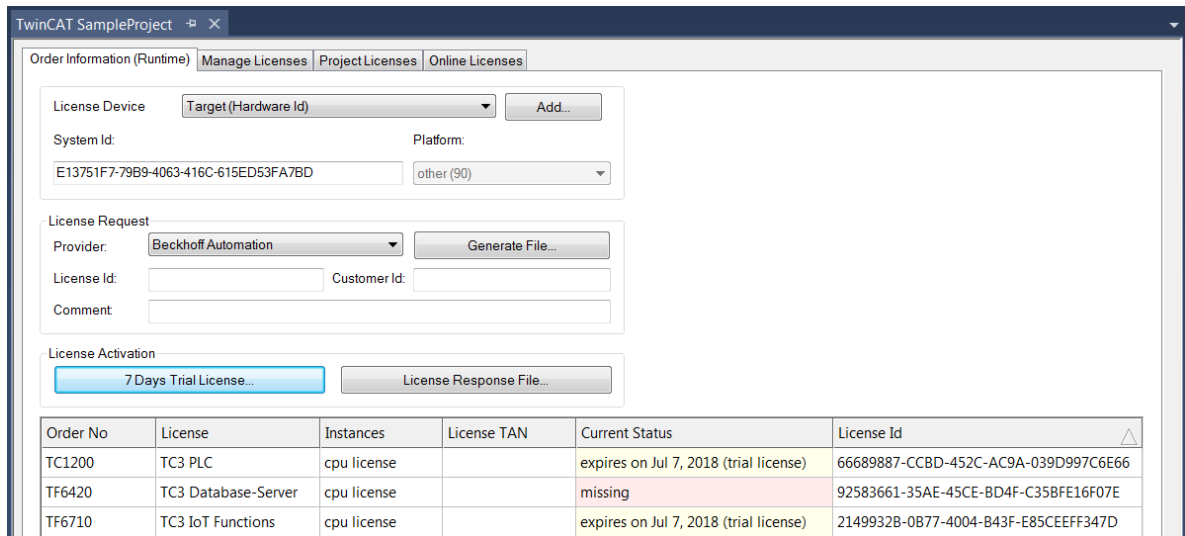
⇒ The TwinCAT 3 license manager opens.



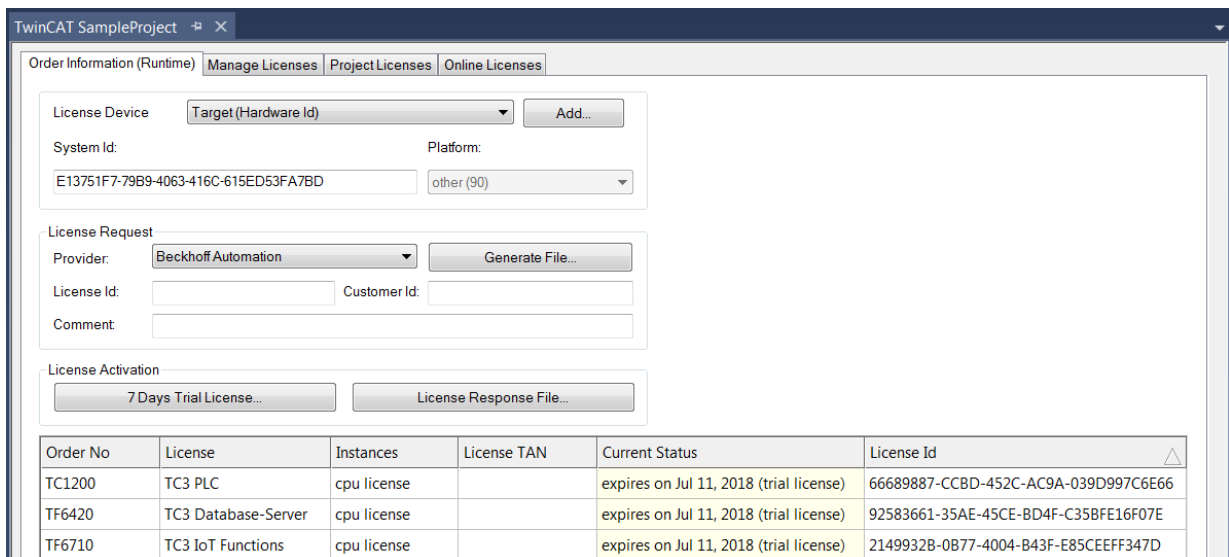
- Open the **Manage Licenses** tab. In the **Add License** column, check the check box for the license you want to add to your project (e.g. "TF6420: TC3 Database Server").



- Open the **Order Information (Runtime)** tab.
  - ⇒ In the tabular overview of licenses, the previously selected license is displayed with the status "missing".



- Click **7-Day Trial License...** to activate the 7-day trial license.



⇒ A dialog box opens, prompting you to enter the security code displayed in the dialog.

- Enter the code exactly as it appears, confirm it and acknowledge the subsequent dialog indicating successful activation.

⇒ In the tabular overview of licenses, the license status now indicates the expiry date of the license.

- Restart the TwinCAT system.

⇒ The 7-day trial version is enabled.

## 4 Analytics Workflow - First Steps

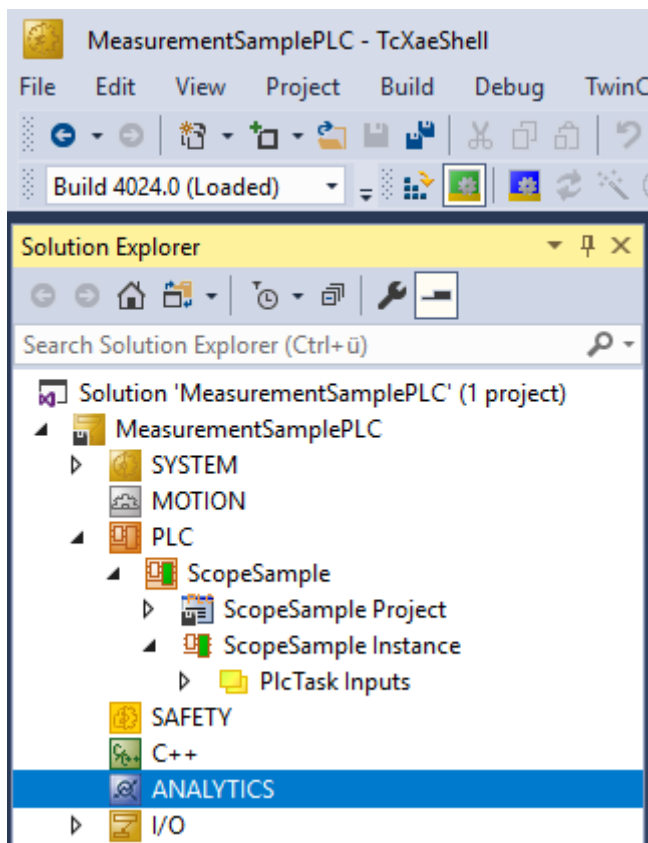
This step by step documentation presents the complete TwinCAT Analytics workflow. From the data acquisition over the communication and historizing up to the evaluation and analysis of the data and to the presentation of the data in web-based dashboard.

### 4.1 Recording data from the machine

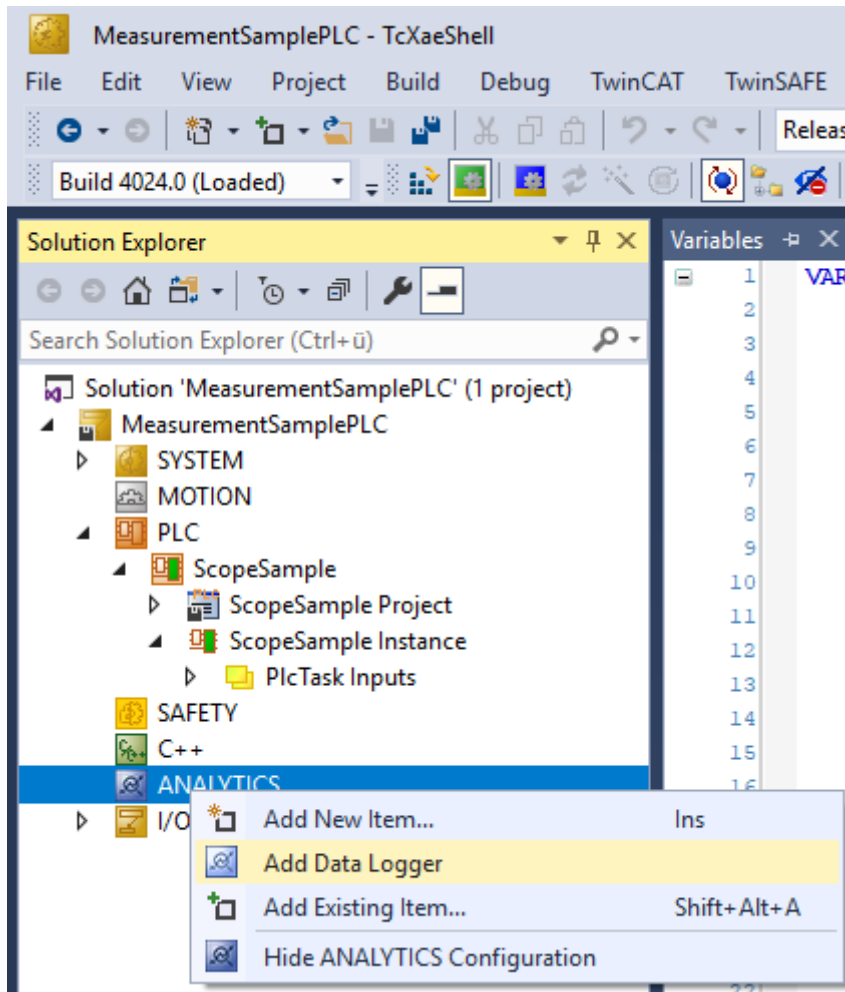
On the machine side is the Analytics Logger the recorder of process data from the machine image, PLC, NC and so on. The Logger is working in the real-time context of TwinCAT.

The TwinCAT Analytics Logger is installed with TwinCAT XAE and XAR. The Logger can act as MQTT Client to communicate the recorded data to a native MQTT Message Broker or store the data in the same data format in a local binary file. By the usage as MQTT Client the Logger is able to bypass short disconnects to the Message Broker with a ring buffer functionality. You can configure a ring buffer as well for the local binary file storage.

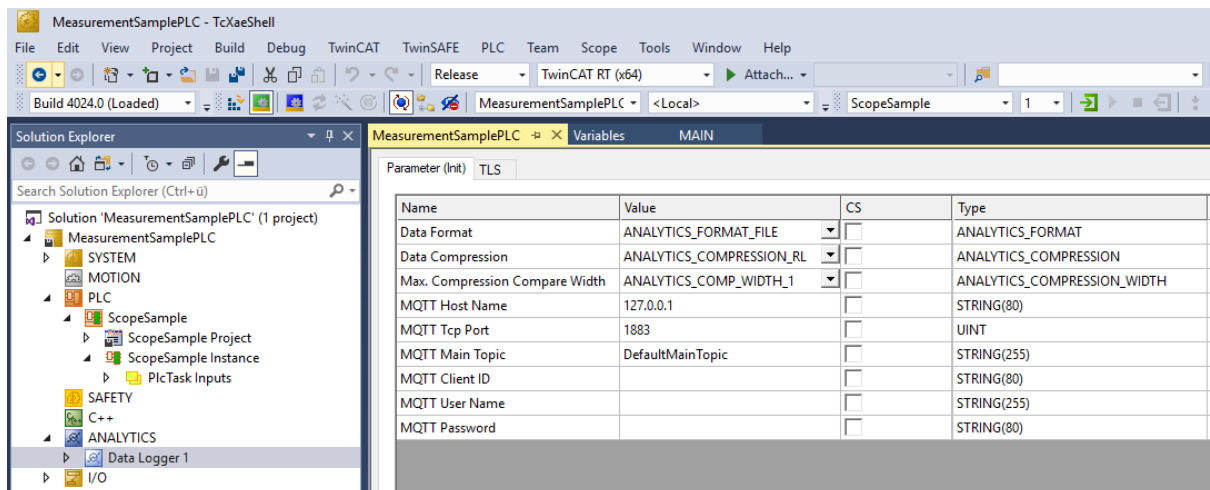
- To configure the Analytics Logger you have to navigate in your existing TwinCAT Project to the Analytics tree node



- Right click on this node and click on “Add Data Logger” to add one new instance to your configuration



- For configuring the base settings, please double click on the new tree item



You can make your specific Analytics Logger settings

-Data Format: Binary file or MQTT stream

-FILE format: Analytics Logger stores the data in local binary files and all other settings are not necessary anymore. The files will be stored in C:\TwinCAT\3.1\Boot\Analytics.

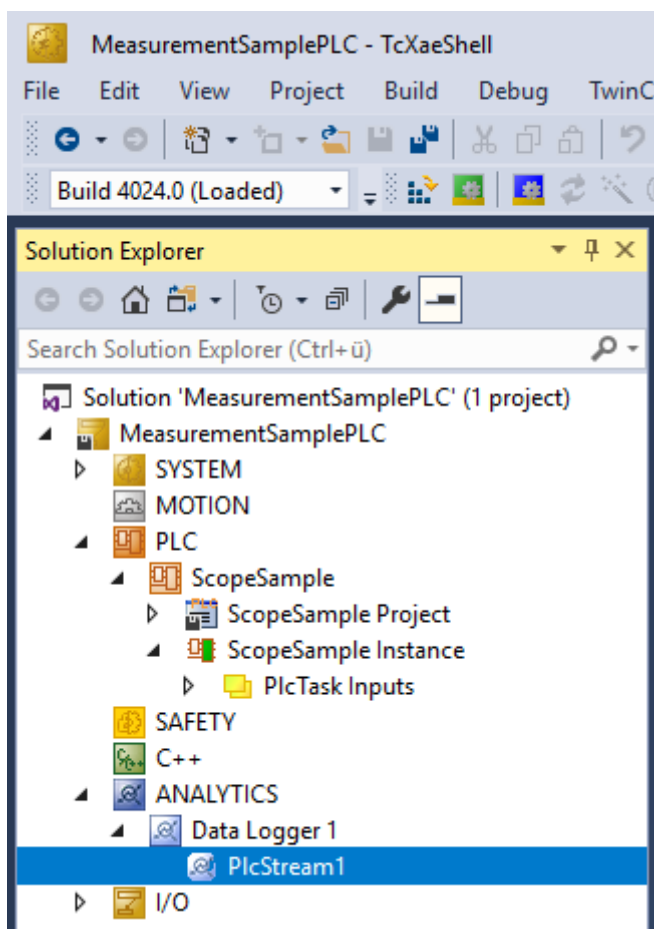
-BINARY: Data will be sent to the configured MQTT Message Broker. You can have multiple Logger in one TwinCAT project to communicate data to different MQTT Message Broker.

-Data Compression: on (default) or off

- Max Compression: mode of the compression
- MQTT host name
- MQTT Tcp port
- MQTT main topic for own hierarchical levels to keep the identification easy
- MQTT Client ID should be unique in the network
- MQTT username
- MQTT password to make authentication at the message broker

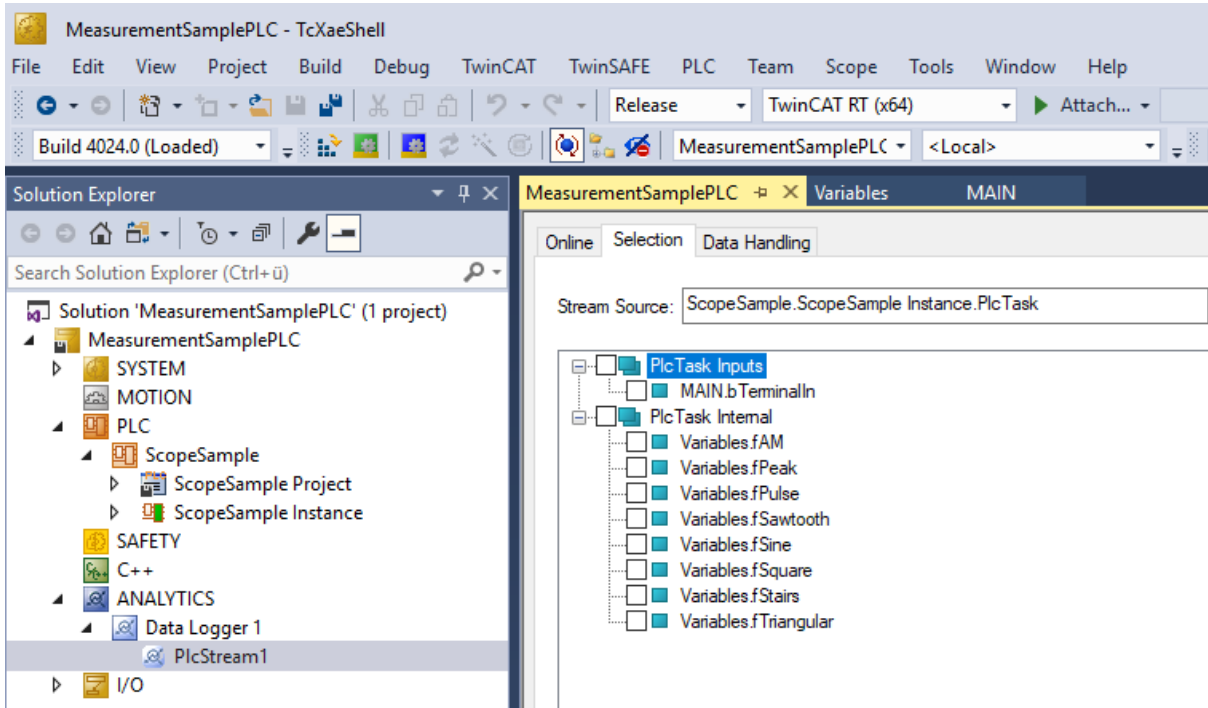
-At the TLS (Transport Layer Security) tab, security settings can be configured. TLS is a secure communication channel between client and server. By the usage of certificates, the TCP port 8883 is exclusively reserved for MQTT over TLS. Analytics Logger is supporting the modes CA Certificates, CA Certificates & Client Certificate and Preshared Key (PSK) mode.

- If variables in your PLC application are marked in the declaration with the attribute {attribute 'TcAnalytics'} they will be shown automatically as a stream below the Data Logger tree node.

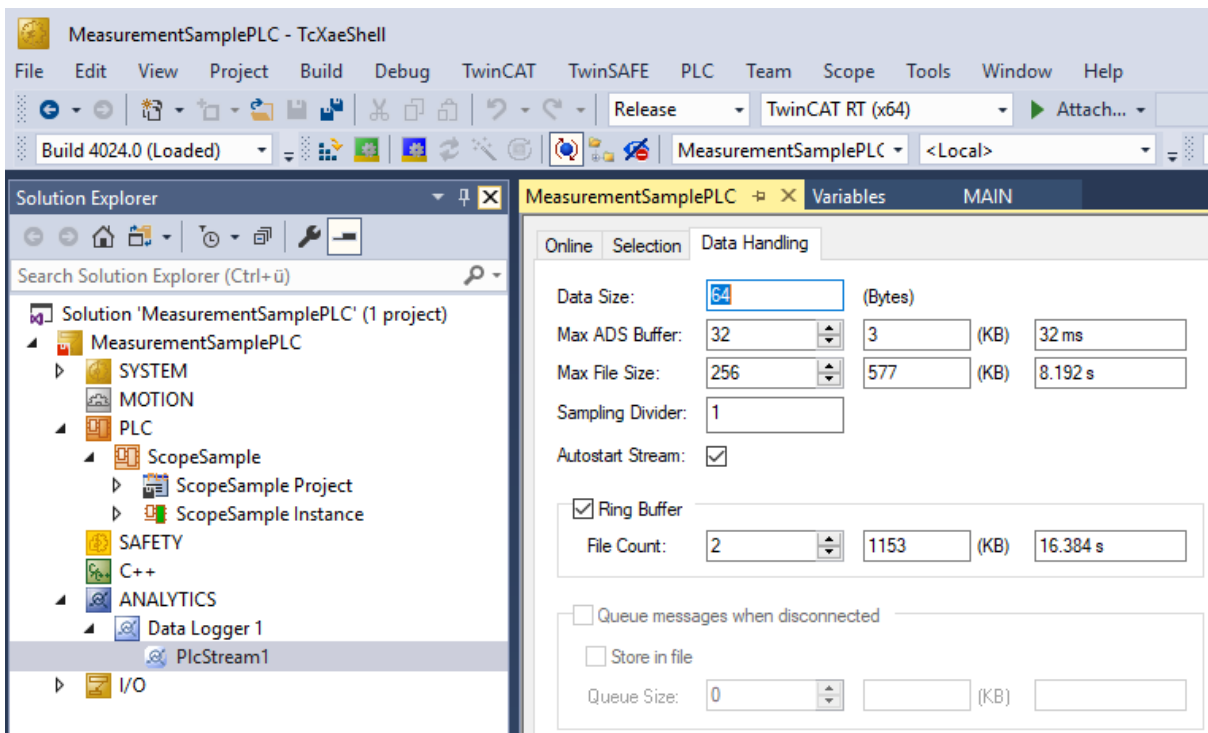


An additional device stream will be shown if your configuration provides an EtherCAT Process Image.

- In the stream a Selection tab is available to choose the variables that should be recorded

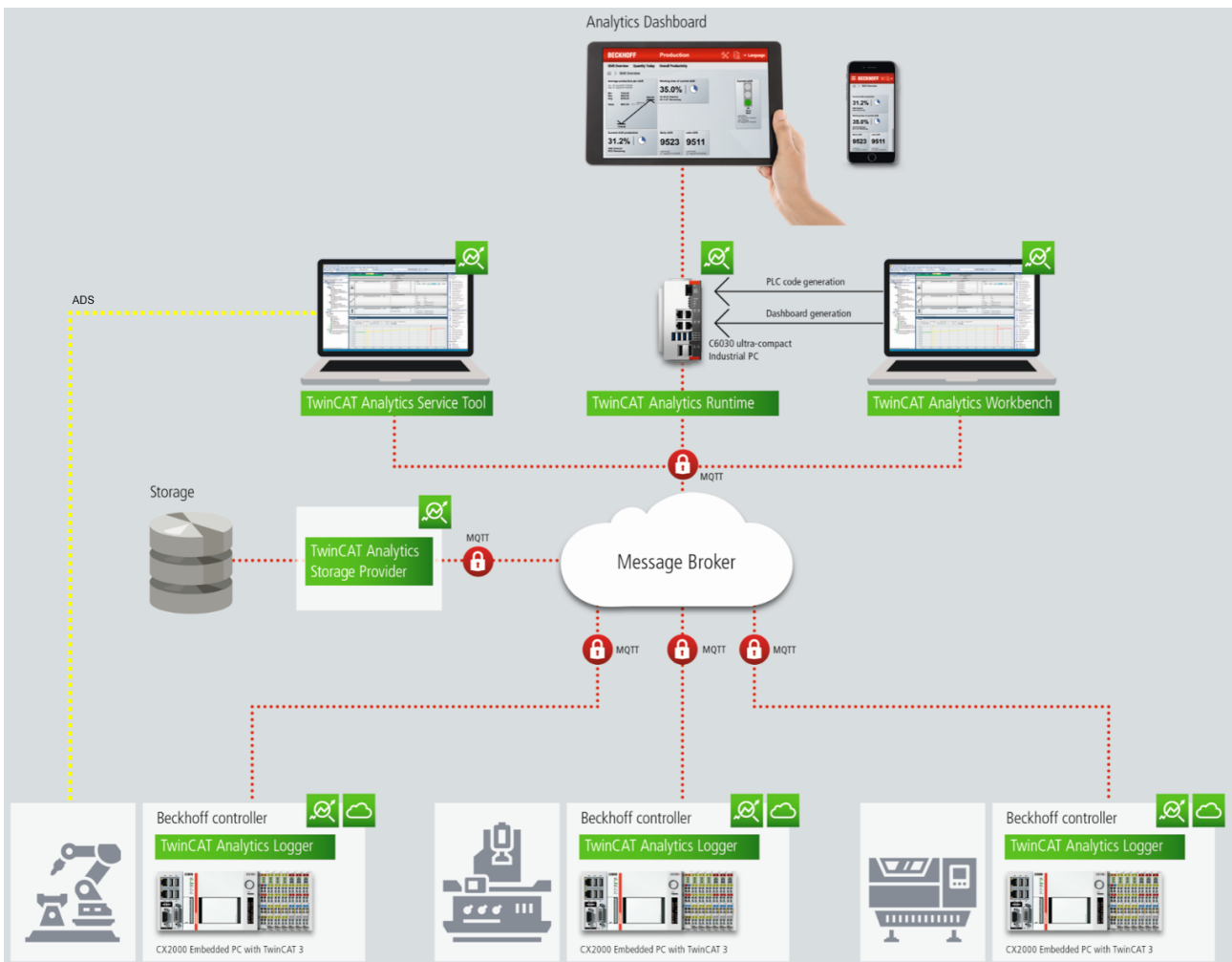


- Finally it is possible to change the package size for the frames or to configure the ring buffer for disconnects and file in the Data Handling tab.



## 4.2 Communication

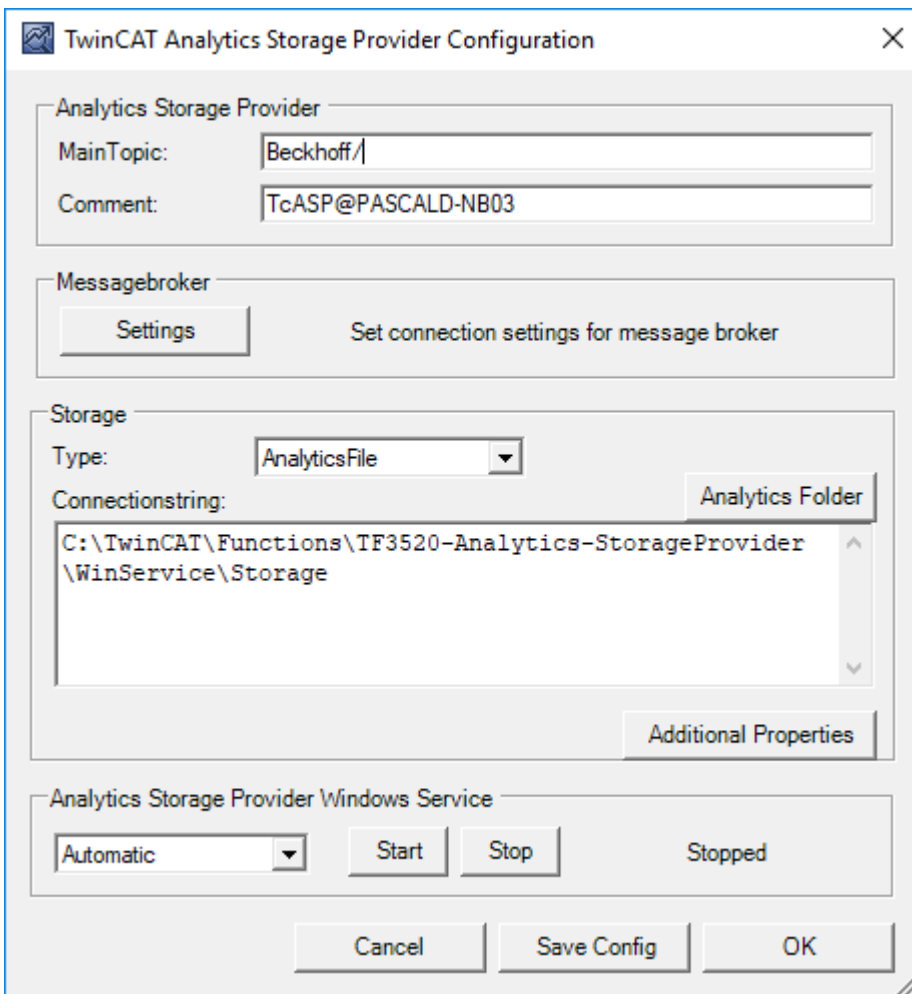
Currently, the Analytics workflow is fully mappable via MQTT. The engineering tools can also access the data of the machines via ADS and carry out analyzes.



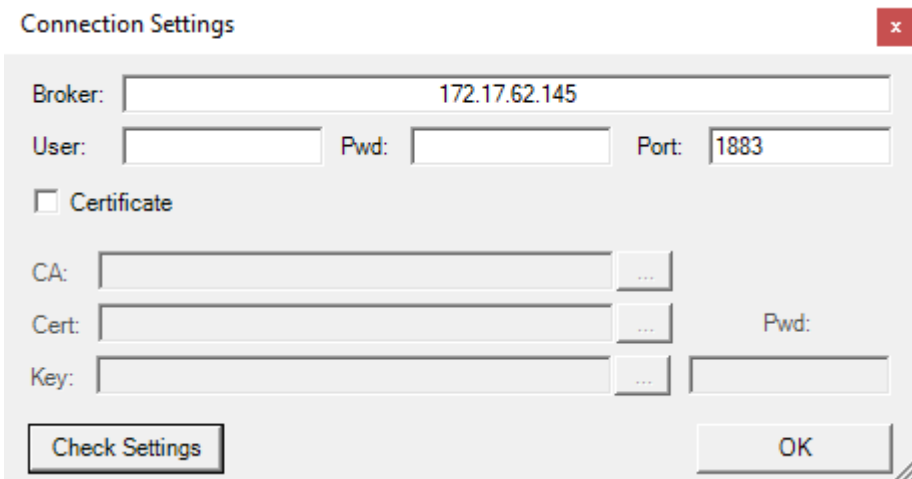
If you choose for the IoT communication protocol MQTT you have to setup a native MQTT Message Broker somewhere in the network (VM in a cloud system is also possible). This Message Broker provides a decoupling of the different applications in the Analytics Workflow.

### 4.3 Historicize data

After installation of the TwinCAT Analytics Storage Provider you are able to configure the service running in the background. You will find therefore the TcAnalyticsStorageProvider\_Config application in the folder C:\TwinCAT\Functions\TF3520-Analytics-StorageProvider\WinService.



The main part of the topic can be set in the configuration as well as the comment which will be used for identification if more than one Storage Provider is registered at the Message Broker.

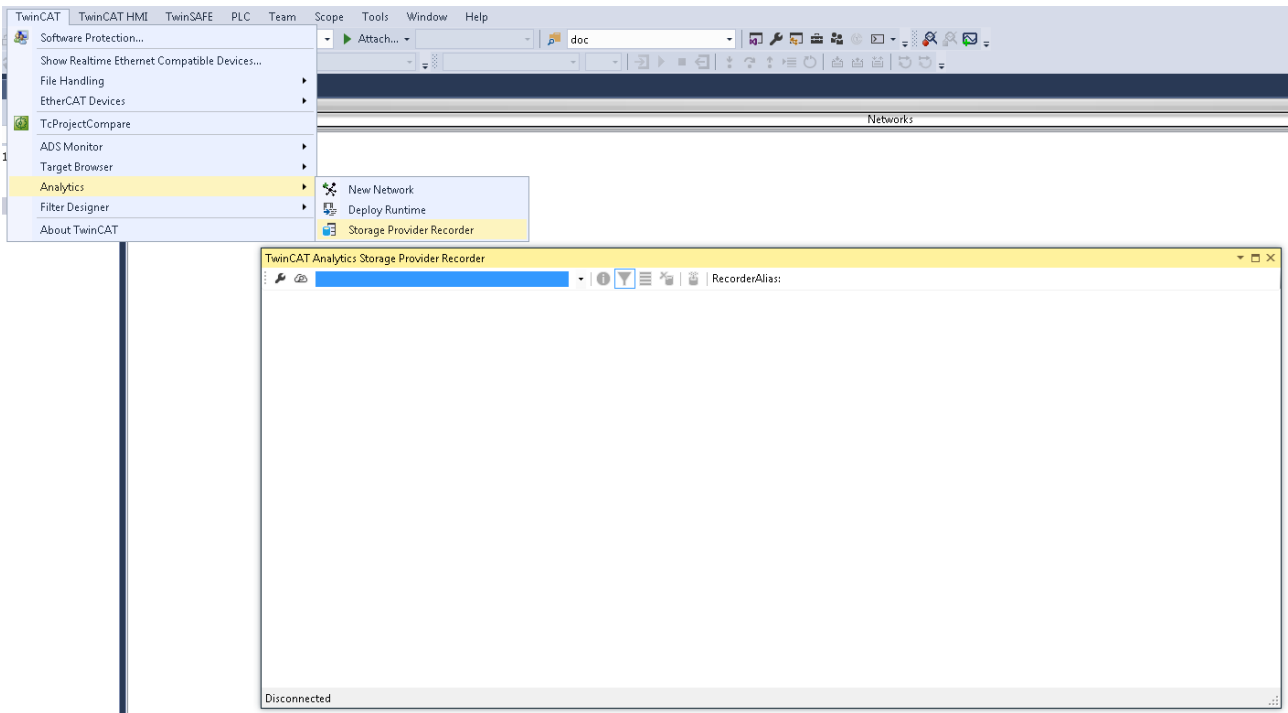


You are able to provide the Message Broker settings and to decide for storage type:

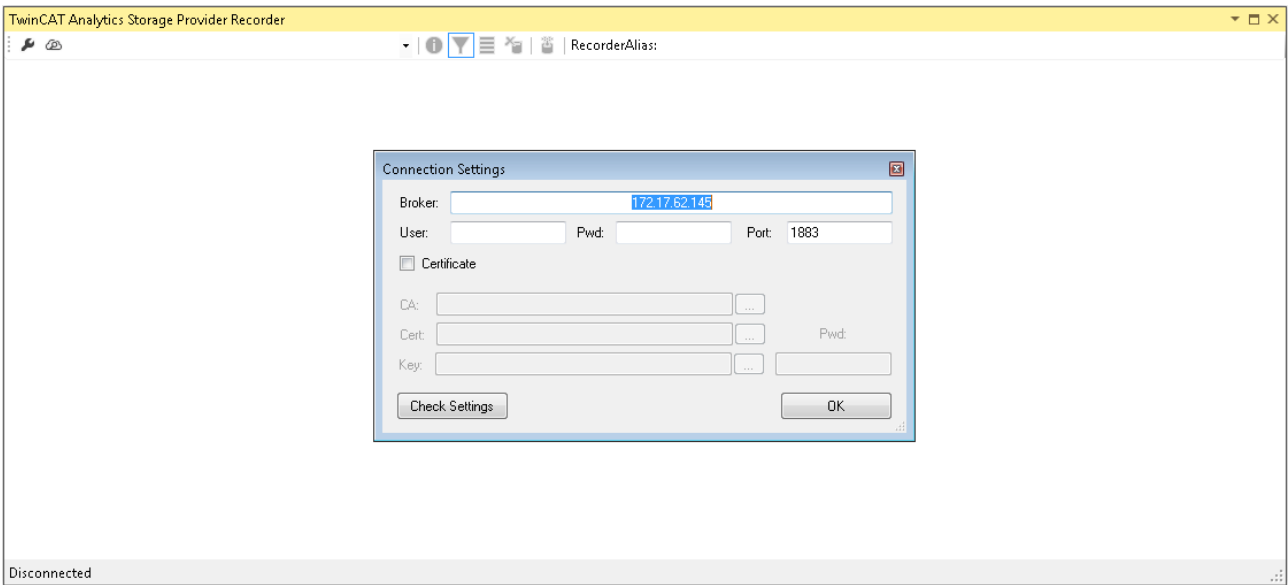
- Analytics File (binary file)
- Microsoft SQL
- Microsoft Azure Blob (Azure Cloud necessary)

Finally, you can save the config and start the service. The next step is the configuration of the specific record. Therefore you should choose in your development environment the Storage Provider Recorder.

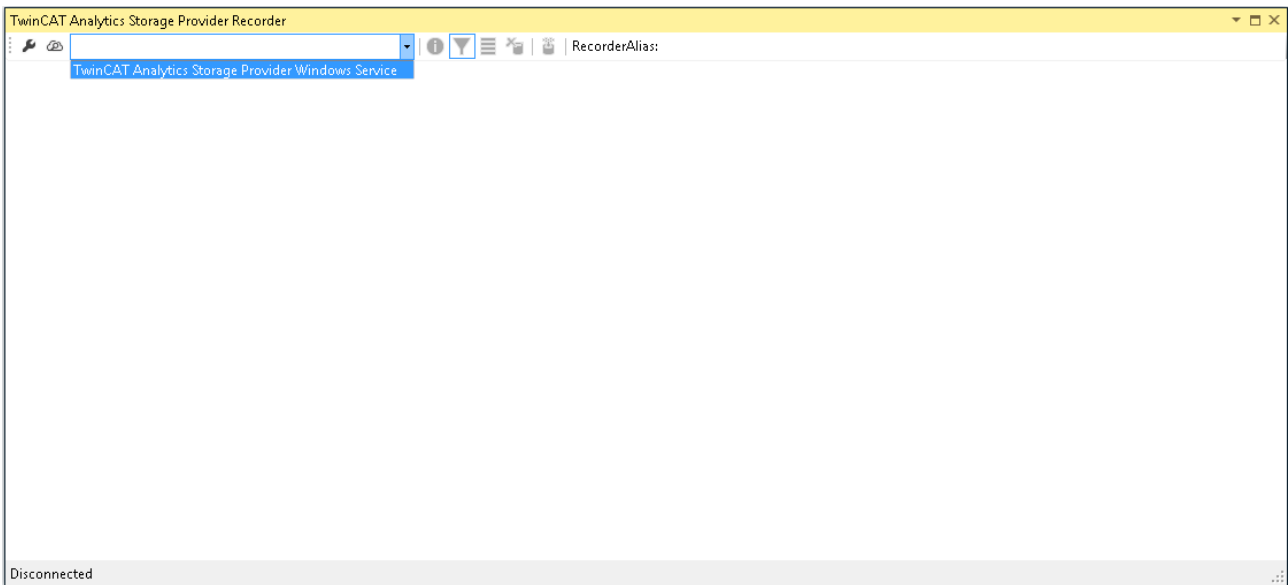




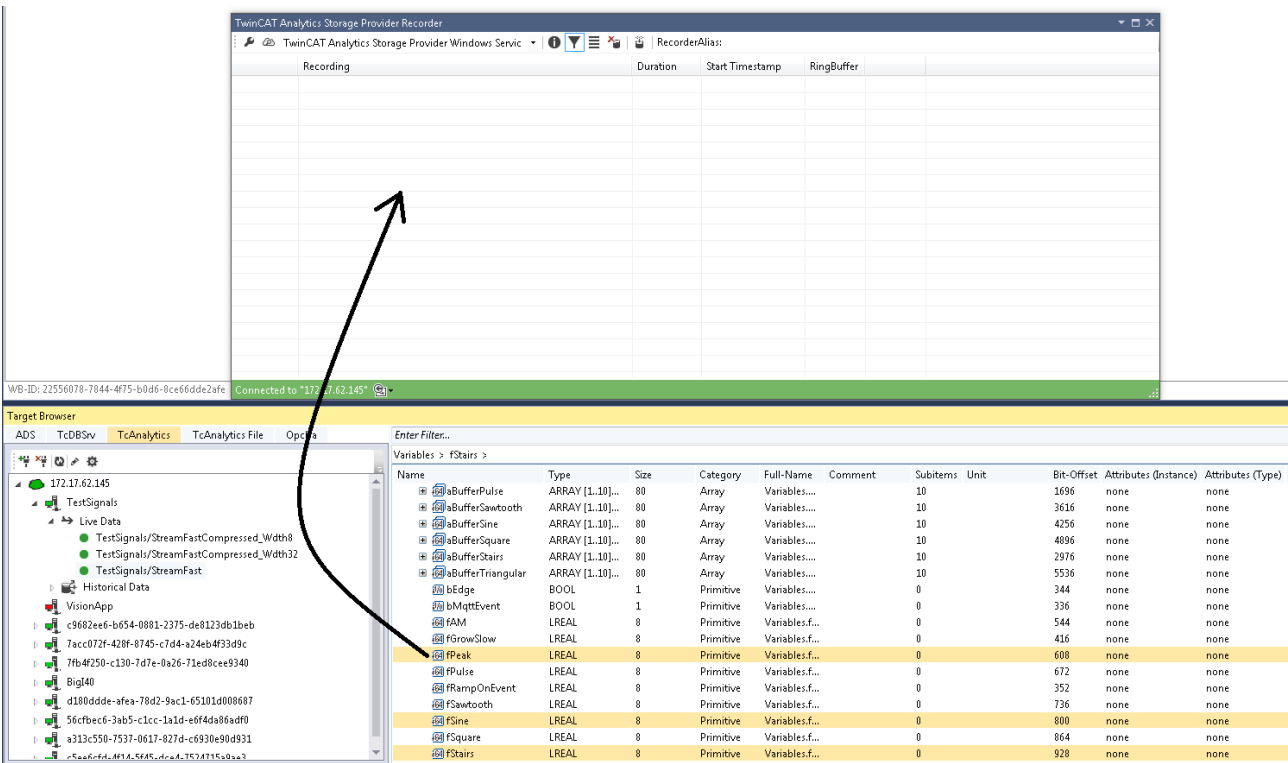
The recorder has also to connect to the Message Broker. So you have to provide the same settings as for the background service.



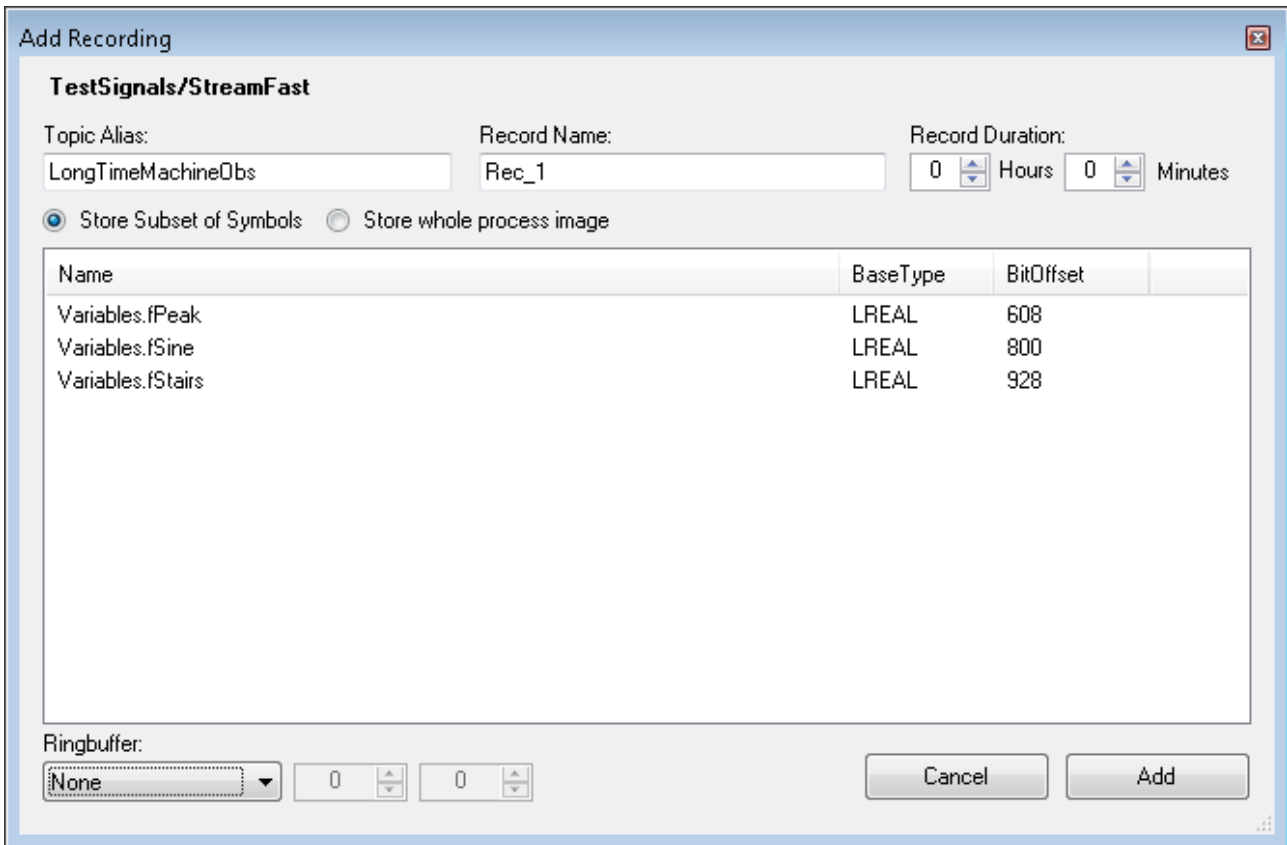
After this you can click to icon with the small cloud to search Storage Providers at the configured Message Broker. Here you will find also the comment you gave already by the service configuration to identify your Storage Provider.



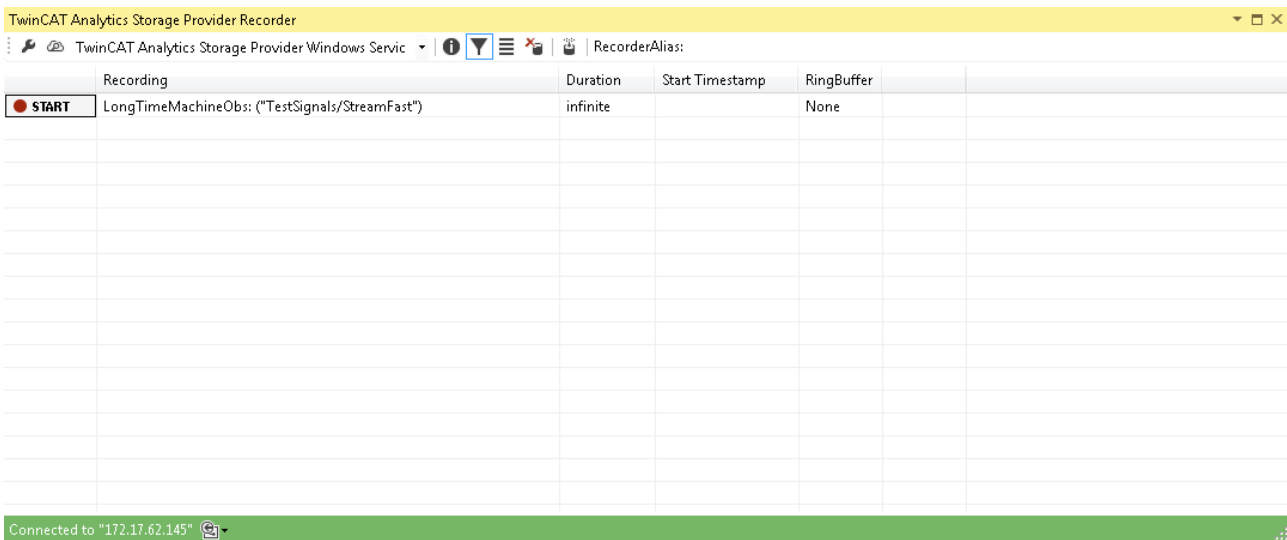
The configuration of the record is very easy. You have just to choose your target in the Target Browser. Click on Live data and choose one or more variables by multiselect and put them by drag and drop to the recorder window.



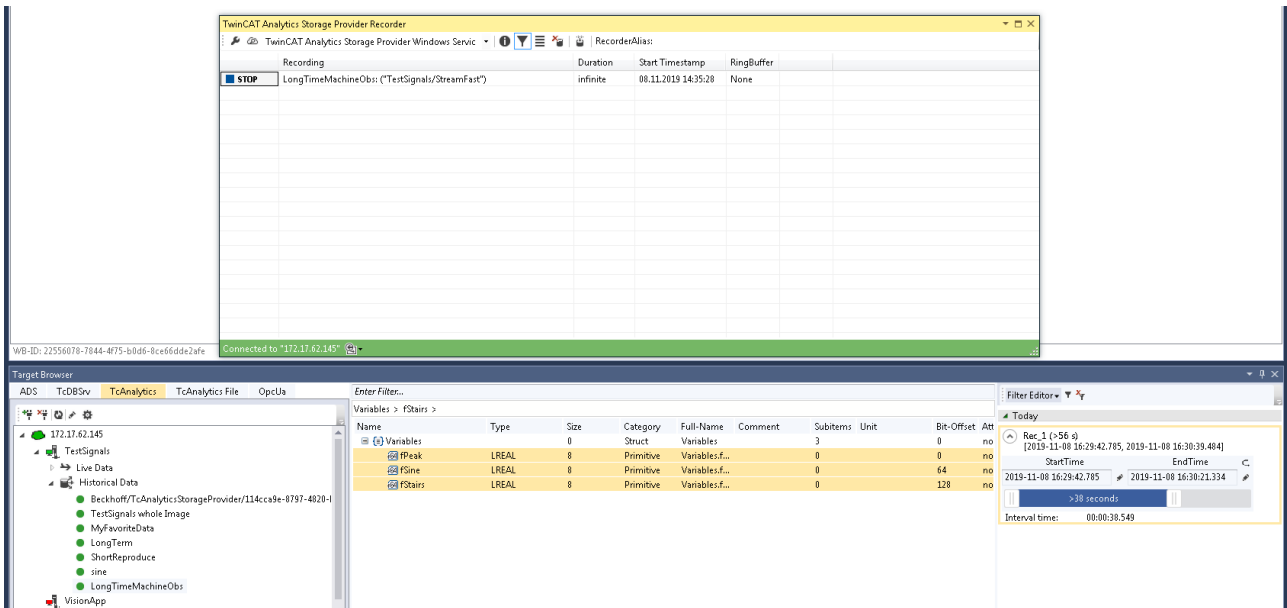
The recorder will ask you if you like to add just the chose variables or the complete source process image of the variables.



You can also configure record names and a duration (otherwise endless until manual stop). A ringbuffer can be set by memory or time.



Click the Start button to start the record. After this you can also disconnect the recorder, because the background service do the work. It is also possible that someone else connect to this Storage Provider service and control the running record.



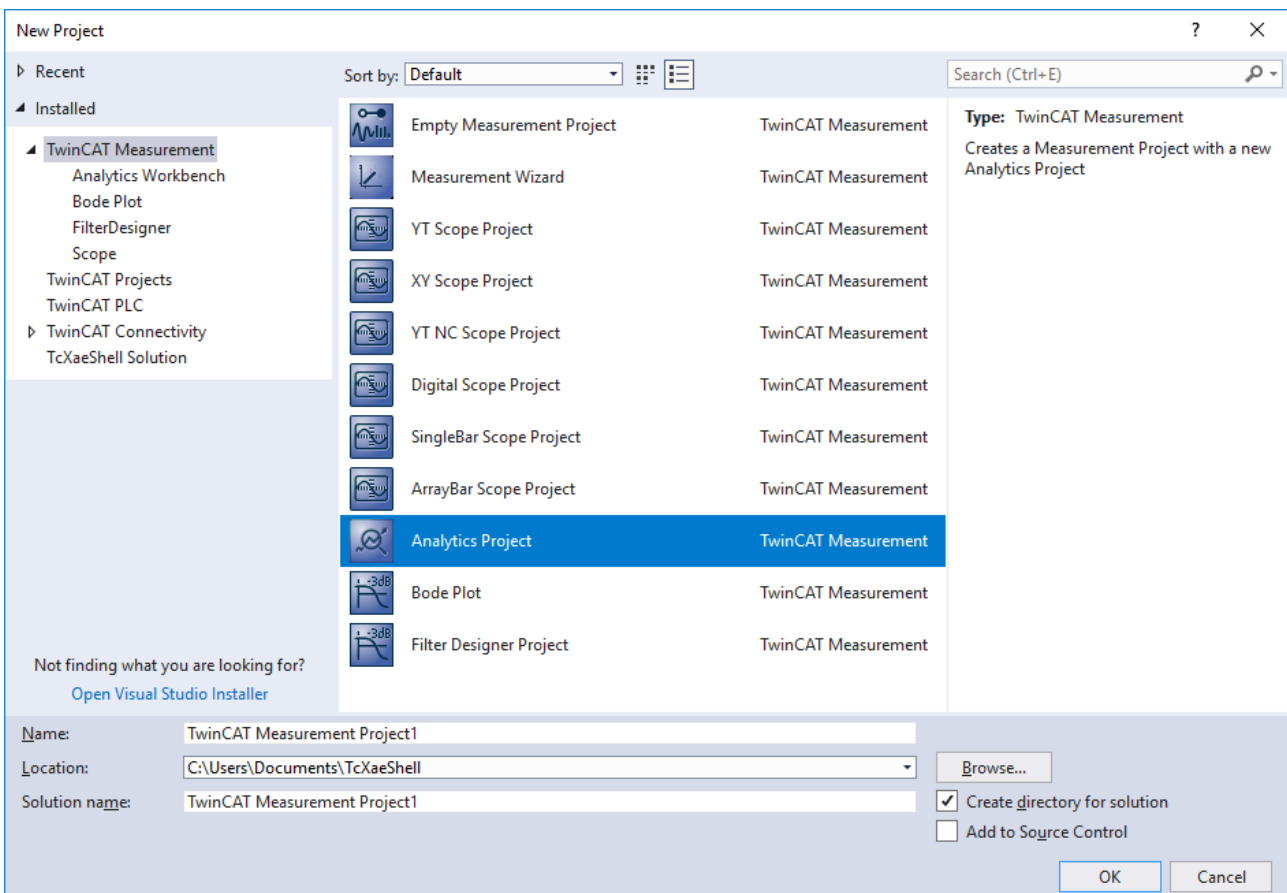
After and also during the record you can choose the historical data as input for your analysis in the Target Browser. In the Target Browser you will find for historical data a new control on the right hand side. There you can choose the time span for your data.

## 4.4 Analyse data

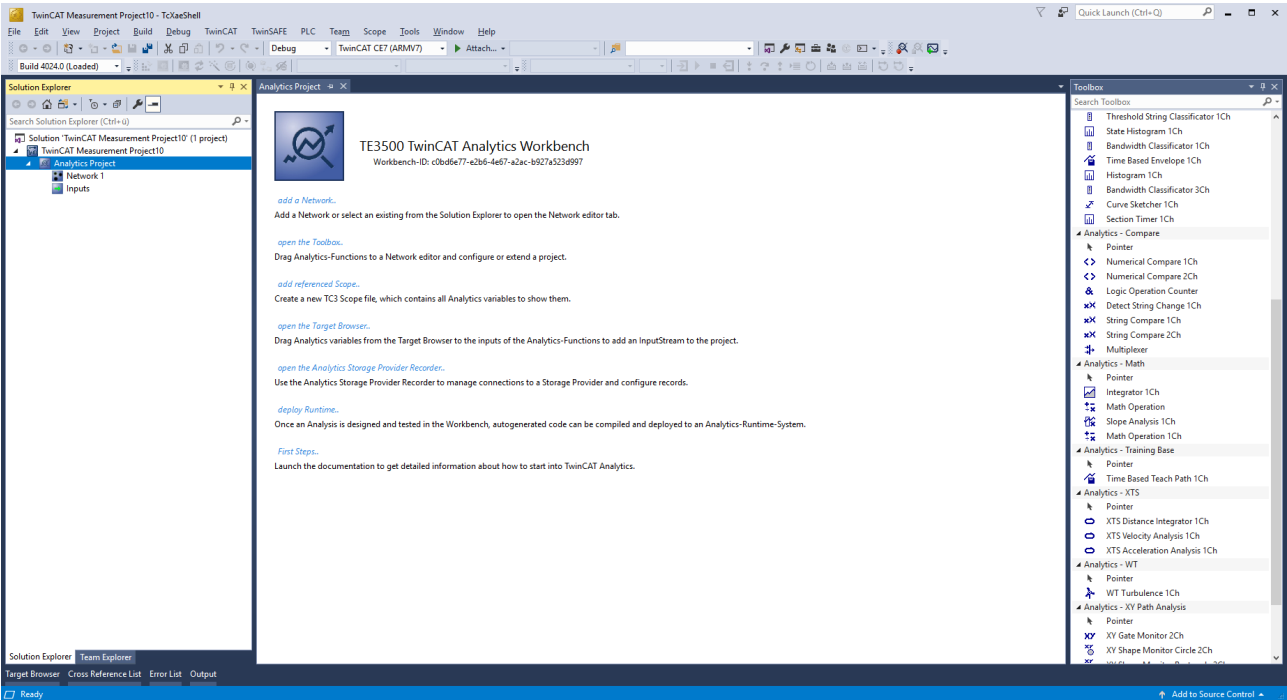
Open your TwinCAT engineering environment to start the analysis of the data.

Open Visual Studio® >> File >> New >> Project...

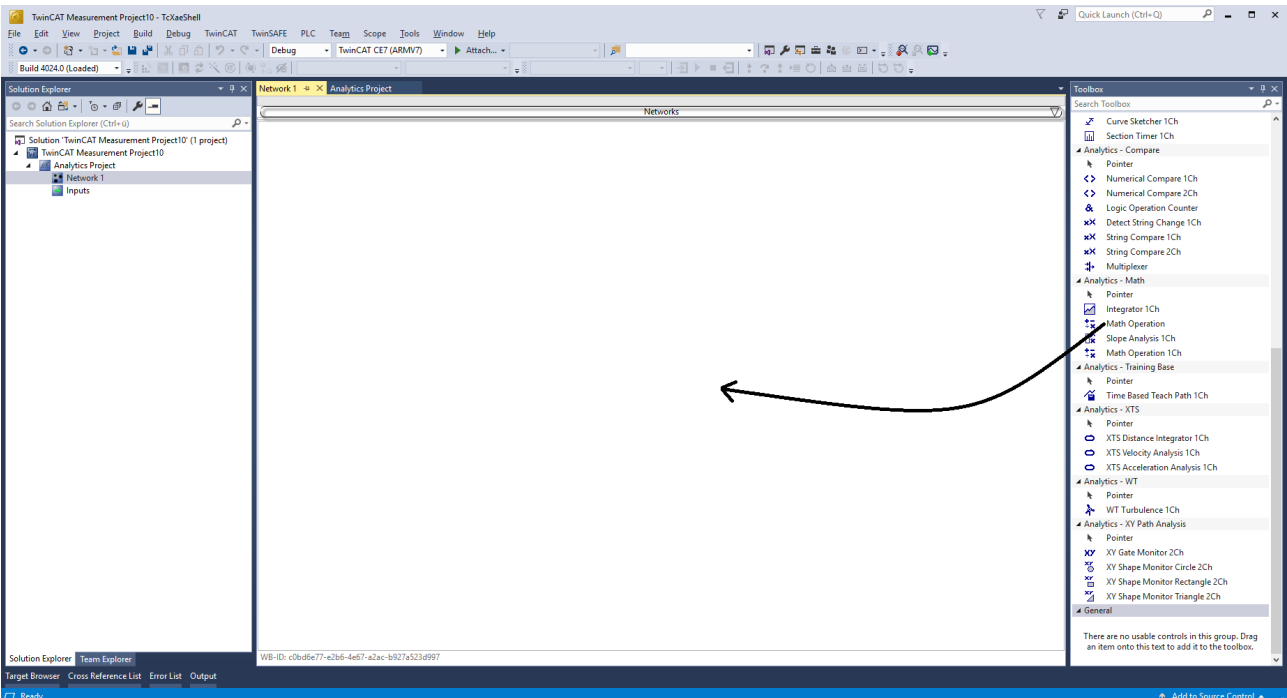
Choose from TwinCAT Measurement the Analytics project template.



The new project will be shown in the Solution Explorer. After a click on the Analytics Project tree node item a start window opens where you can select your first action. From here, you can add a Network, open the Toolbox, open the Target Browser or open the Analytics Storage Provider Recorder. You will do all these actions in the following steps.

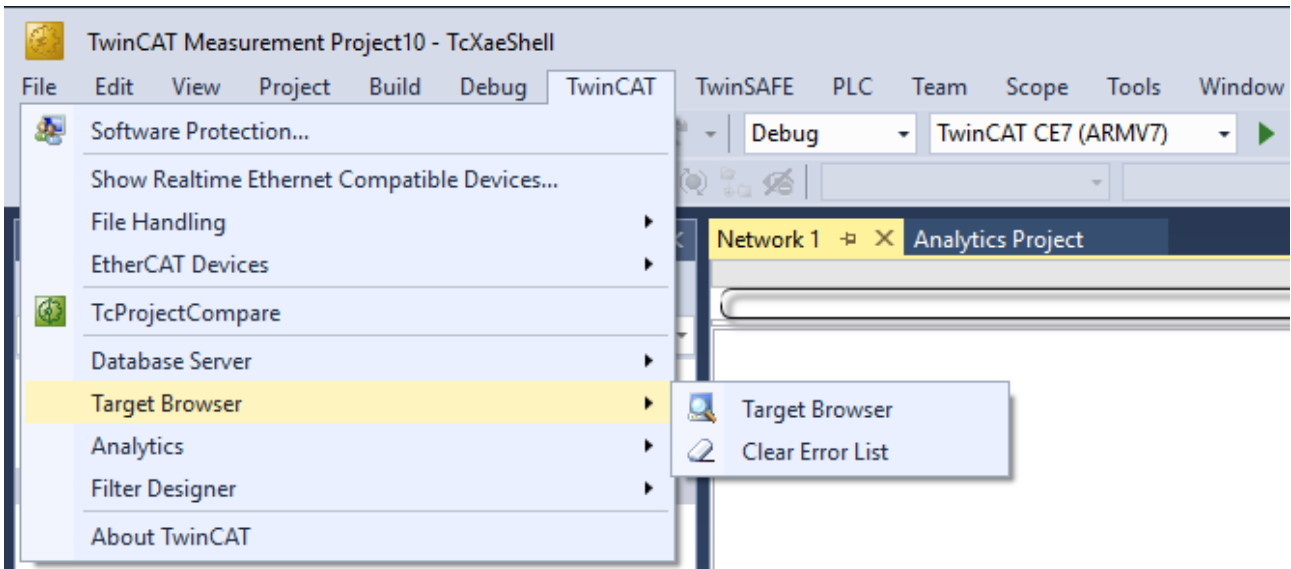


It makes sense to open in a first step the Toolbox of Visual Studio®. There you will find all the supported algorithm of TwinCAT Analytics. Algorithm must be organized and grouped into networks. Right click on the Analytics Project to add a new Network or add a Network using the start page. The first Network is always generated by default.

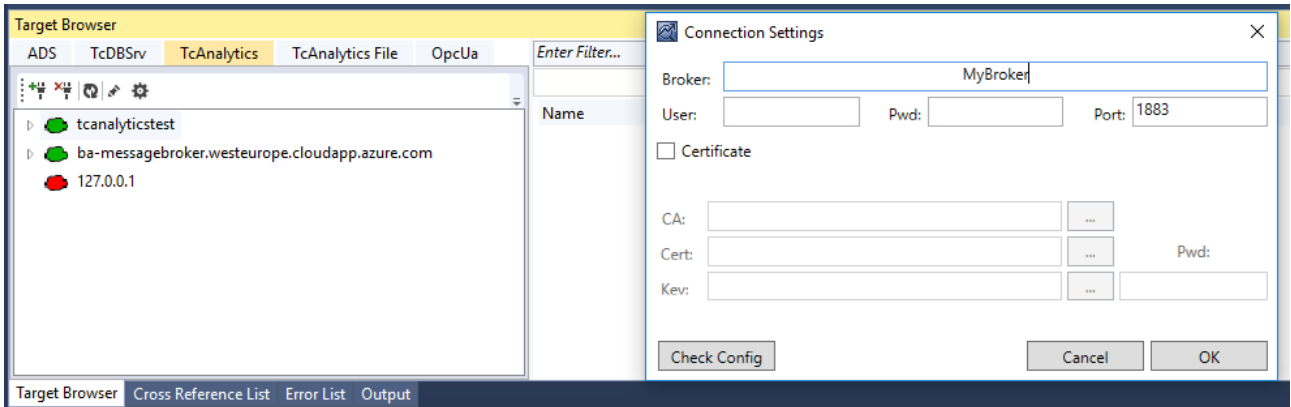


If you click on the Network an editor will be open. Now you can take the algorithm you like by drag and drop into the editor surface. After choosing the algorithm you need to connect input variables to the modules (algorithm). Therefor open the Target Browser.

TwinCAT >> Target Browser >> Target Browser



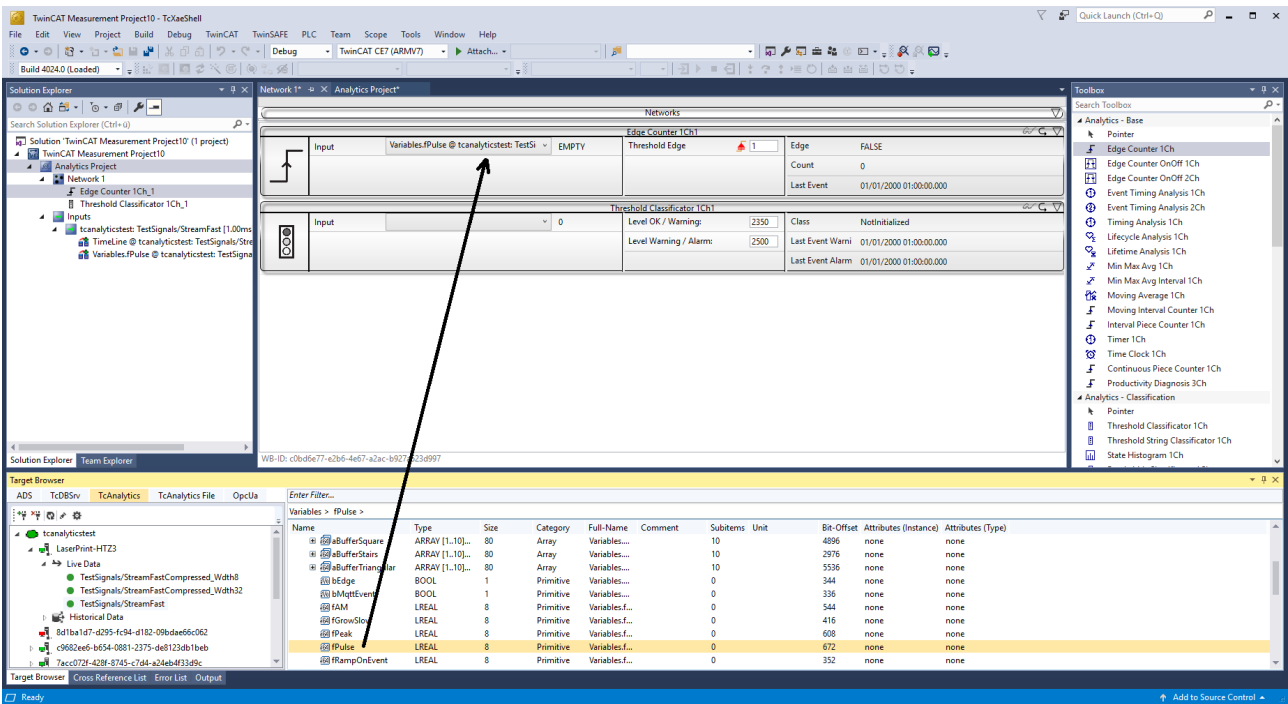
Choose now the TcAnalytics or TcAnalyticsFile tab in the Target Browser. We go ahead with the TcAnalytics tab (MQTT). Click on the green marked icon in the toolbar of this Analytics extension. A window will be open where you can provide your Message Broker connectivity data.



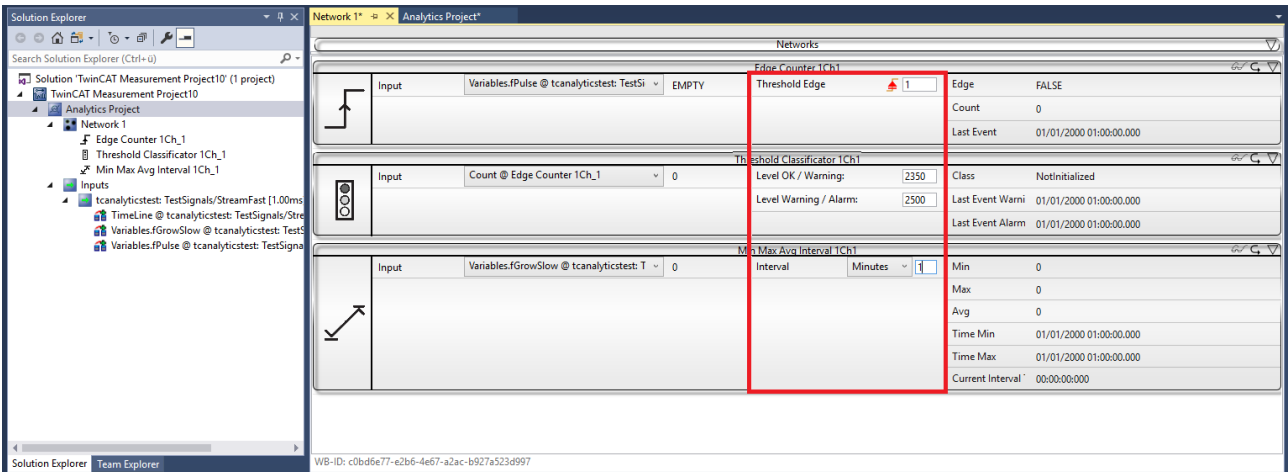
Choose your MQTT Analytics client (TwinCAT Analytics Logger, TwinCAT IoT Data Agent or Beckhoff EK9160). For each controller you have a unique ID. This ID is shown in the Target Browser. Not very legible, of course. Therefore, click on the icon with the gear to get to the machine administration page. Here you can provide a System Alias name which is shown in the Target Browser instead of the GUID.

Source	Customer	SystemID	System Alias	Online	Position	Topic Alias	Description
172.17.62.145							
TwinCAT Analytics Logger	MA Laser	3db95703-29fb-d99e-eb13-017b54677bb0	LaserPrintZG15	True			
TwinCAT Analytics Logger	MA Laser	3db95703-29fb-d99e-eb13-017b54677bb0	LaserPrintZG15	True	Laserstr. 13, 40597 Düsseldorf		MP4 Steel Laser Data
TwinCAT Analytics Logger	MA Laser	3db95703-29fb-d99e-eb13-017b54677bb0	LaserPrintZG15	True			
TwinCAT Analytics Logger	Fertig Motors	8d1ba1d7-d295-fc94-d182-09bdae66c062		False			
TwinCAT Analytics Logger	Fertig Motors	8d1ba1d7-d295-fc94-d182-09bdae66c062		False			
TwinCAT Analytics PLC DataLogger		7acc072f-428f-8745-c7d4-a24eb4f33d9c		False			
TwinCAT Analytics TEST Logger	Beckhoff	91c6eab3-1abb-5593-3651-1426874cf91f		True	Hülshorstweg 20, 33415 Verl		
TwinCAT Analytics Storage Provider		c9682ee6-b654-0881-2375-de8123db1beb		True			RetroFit
TwinCAT Analytics Storage Provider		7acc072f-428f-8745-c7d4-a24eb4f33d9c		True			AnalyticsSolution Results 1
TwinCAT Analytics Storage Provider		7fb4f250-c130-7d7e-0a26-71ed8cee9340		True			CloudControl
TwinCAT Analytics Storage Provider		3db95703-29fb-d99e-eb13-017b54677bb0	LaserPrintZG15	True			
TwinCAT Analytics Storage Provider		3db95703-29fb-d99e-eb13-017b54677bb0	LaserPrintZG15	True			TestSignals whole Image
TwinCAT Analytics Storage Provider		c5ee6cfd-4f14-5f45-dce4-7524715a9ae3		True			DataAgent Test
TwinCAT Analytics Storage Provider		3f8a342a-6fac-3e76-6172-e7b5f62c0eb0		True			Big40 FavValues
TwinCAT Analytics Storage Provider		a313c550-7537-0617-827d-c6930e90d931		True			EK_Test2
TwinCAT Analytics Storage Provider		d180ddde-afea-78d2-9ac1-65101d008f67		True			NewMachineApp
TwinCAT Analytics Storage Provider		3db95703-29fb-d99e-eb13-017b54677bb0	LaserPrintZG15	True			LongTerm
TwinCAT Analytics Storage Provider		3db95703-29fb-d99e-eb13-017b54677bb0	LaserPrintZG15	True			MyFavoriteData
TwinCAT Analytics Storage Provider		56cfbec6-3ab5-c1cc-1a1d-e6f4da86adf0		True			EdgeComputingTc2
TwinCAT Analytics Storage Provider		56cfbec6-3ab5-c1cc-1a1d-e6f4da86adf0		True			EdgeComputingTc3

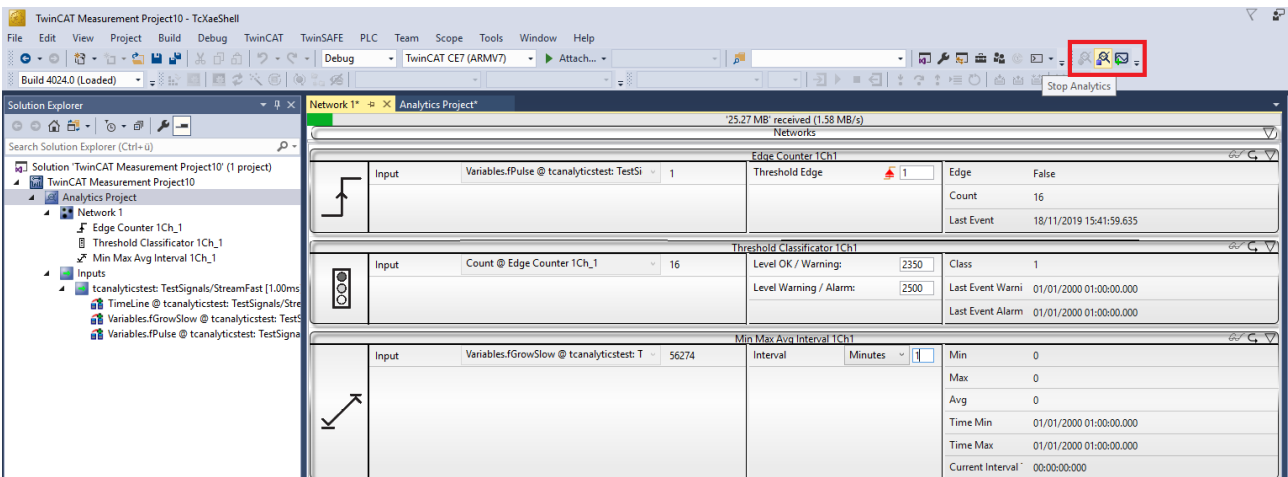
In the next step you can choose between Live Data and Historical Data for each MQTT Analytics client. Historical Data are only provided by the TwinCAT Analytics Storage Provider.



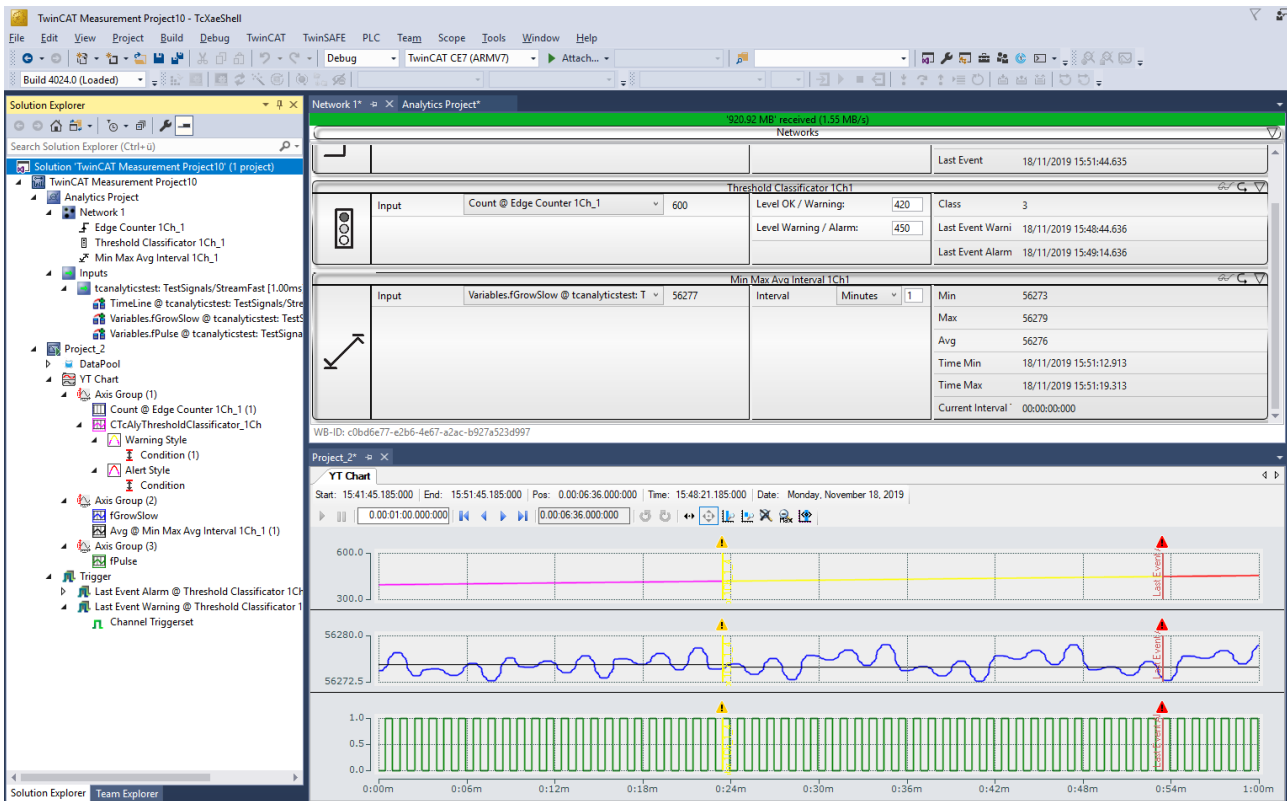
You can take the variables by drag and drop into the inputs of the specific algorithm. For the most algorithm it is possible to set conditions like thresholds, time intervals, logic operators and so on. You can do these settings in the middle of each module.



Finally, your first Analytics Project is finished. To start the analysis, click on “Start Analytics”. To stop the analysis, click on “Stop Analytics”.



Before starting Analytics or also during the runtime you can click on the button “Add Reference Scope”. A Scope configuration is automatically built to fit your Analytics project.



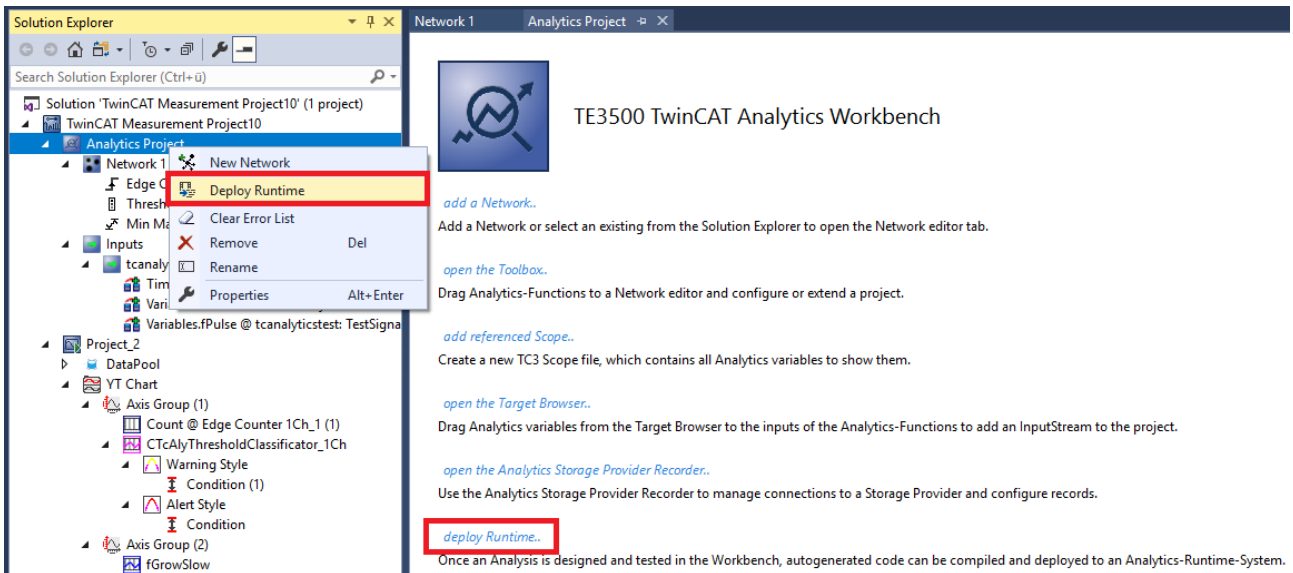
Results of the analysis can be shown in the Scope View charts by drag and drop. For example, an average value can be shown as new channel in the view. Timestamps as Marker at the x-axes to show significant values.

## 4.5 24h Analytics application

The last big step in the TwinCAT Analytics workflow is the continuous 24h machine analysis. It runs parallel to the machine applications in the field. To do this in a very easy way the TwinCAT Analytics Workbench is able to generate automatically a PLC code and a HTML5-based Dashboard of your Analytics configuration. Both can be downloaded to a TwinCAT Analytics Runtime (TC3 PLC and HMI Server) and provide the same analysis results as the configurator tool in engineering environment.

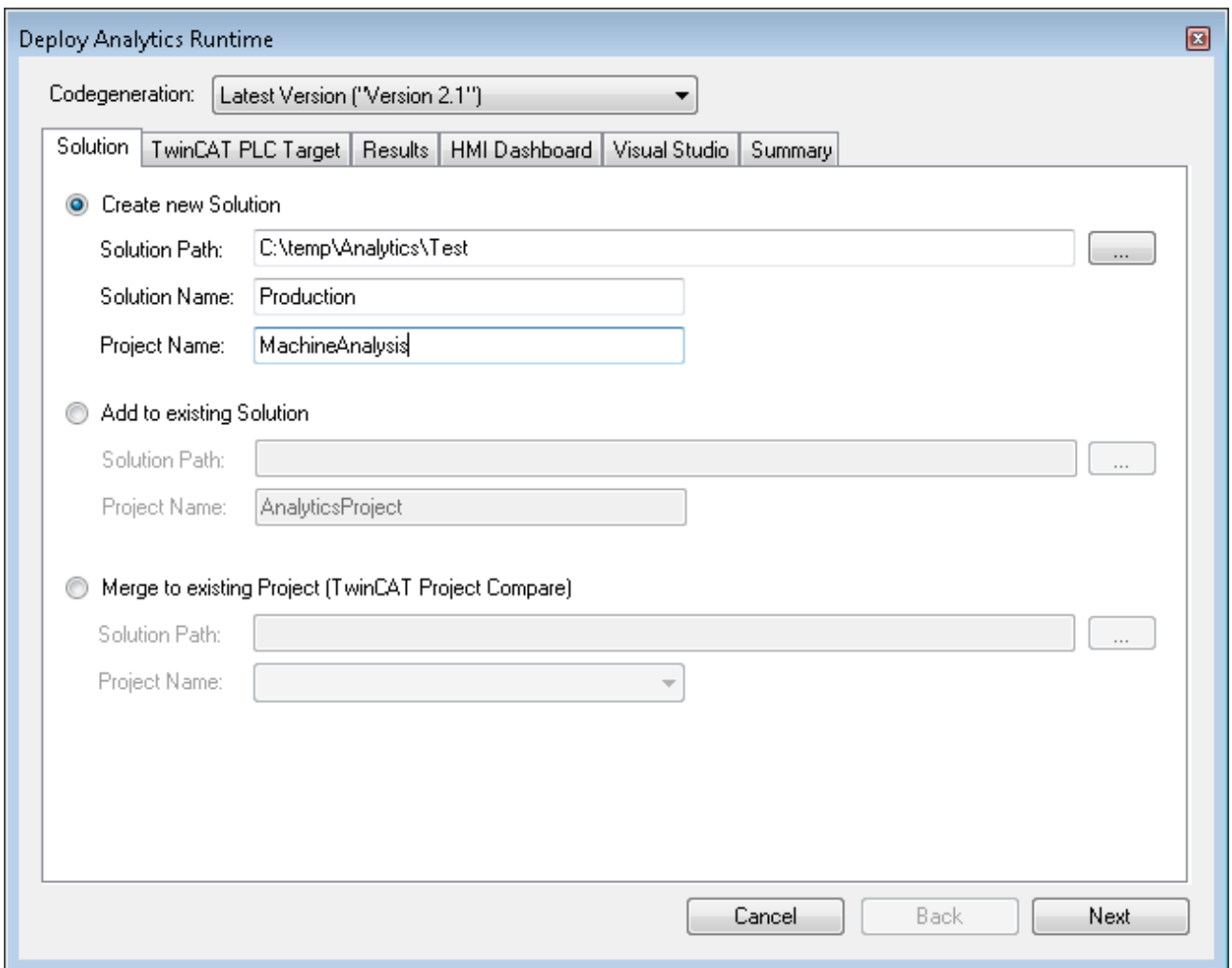
At first save your configuration and open the Analytics Deploy Runtime wizard. You can do this via the context menu at the Analytics Project tree item or by the Start Page.



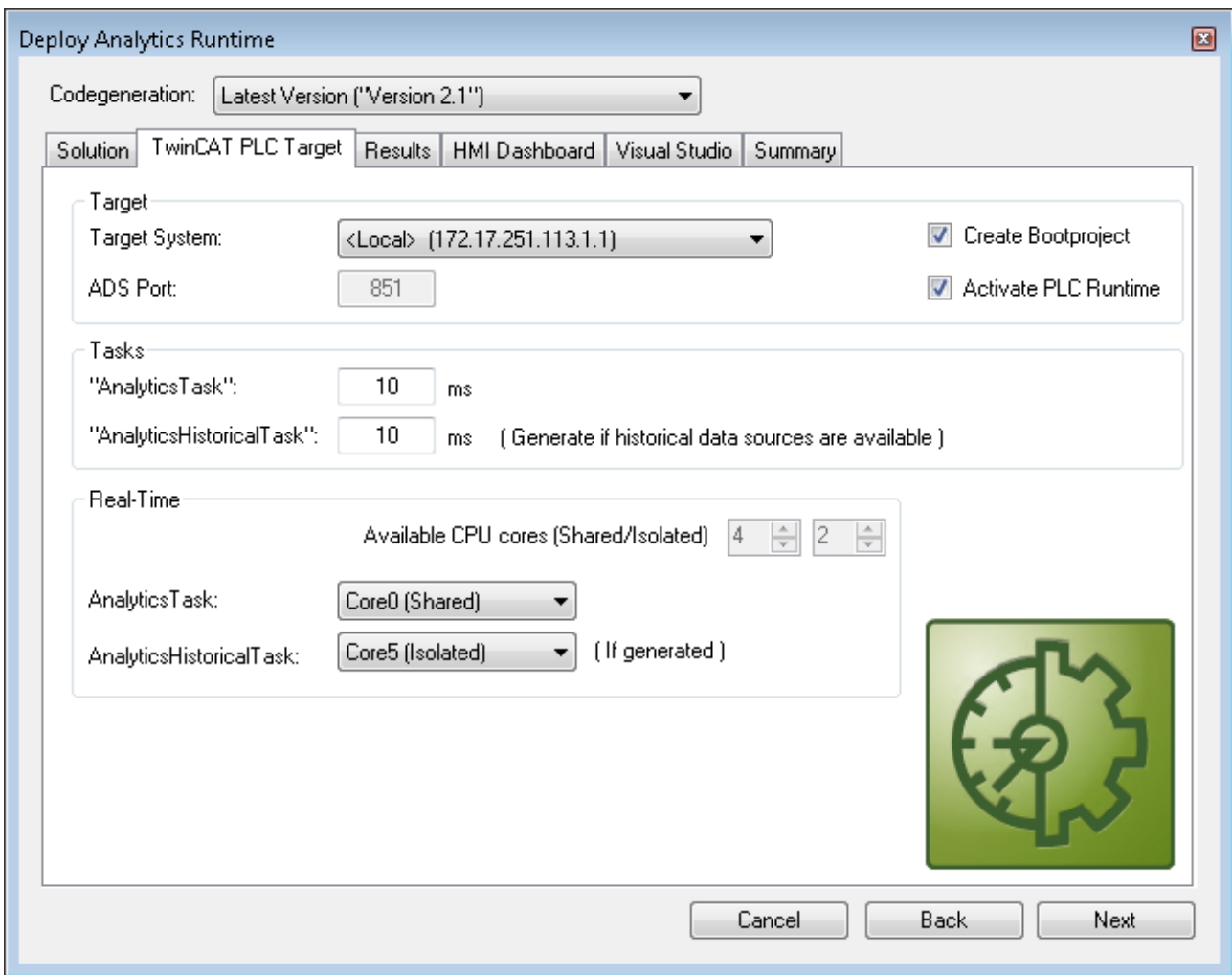


When the wizard is open, there are some tabs available for you to click through. First one is called Solution. Here it is possible to decide how you like to use your Analytics project in PLC code: As...

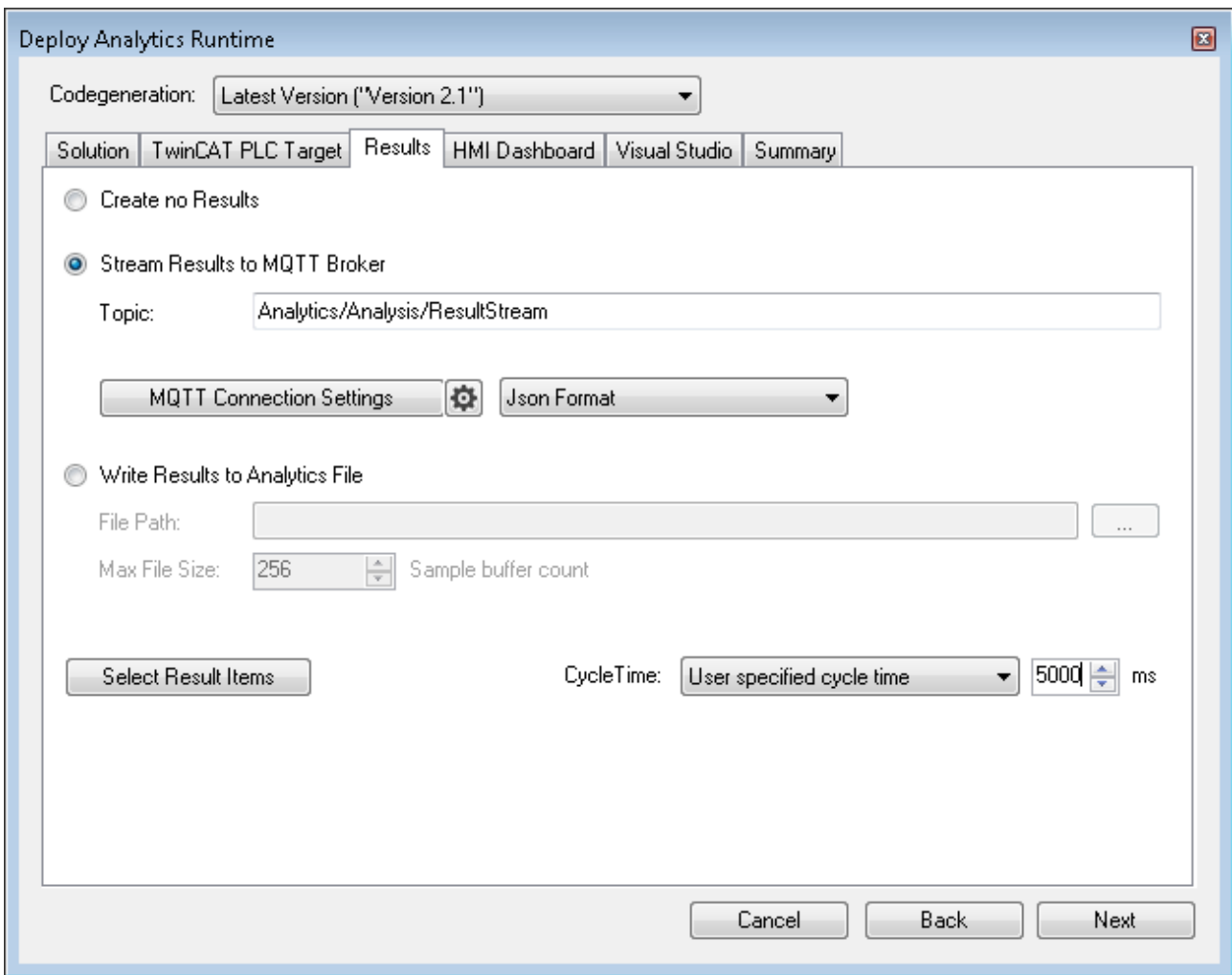
- completely new solution
- part of an existing solution
- update of an existing Analytics solution



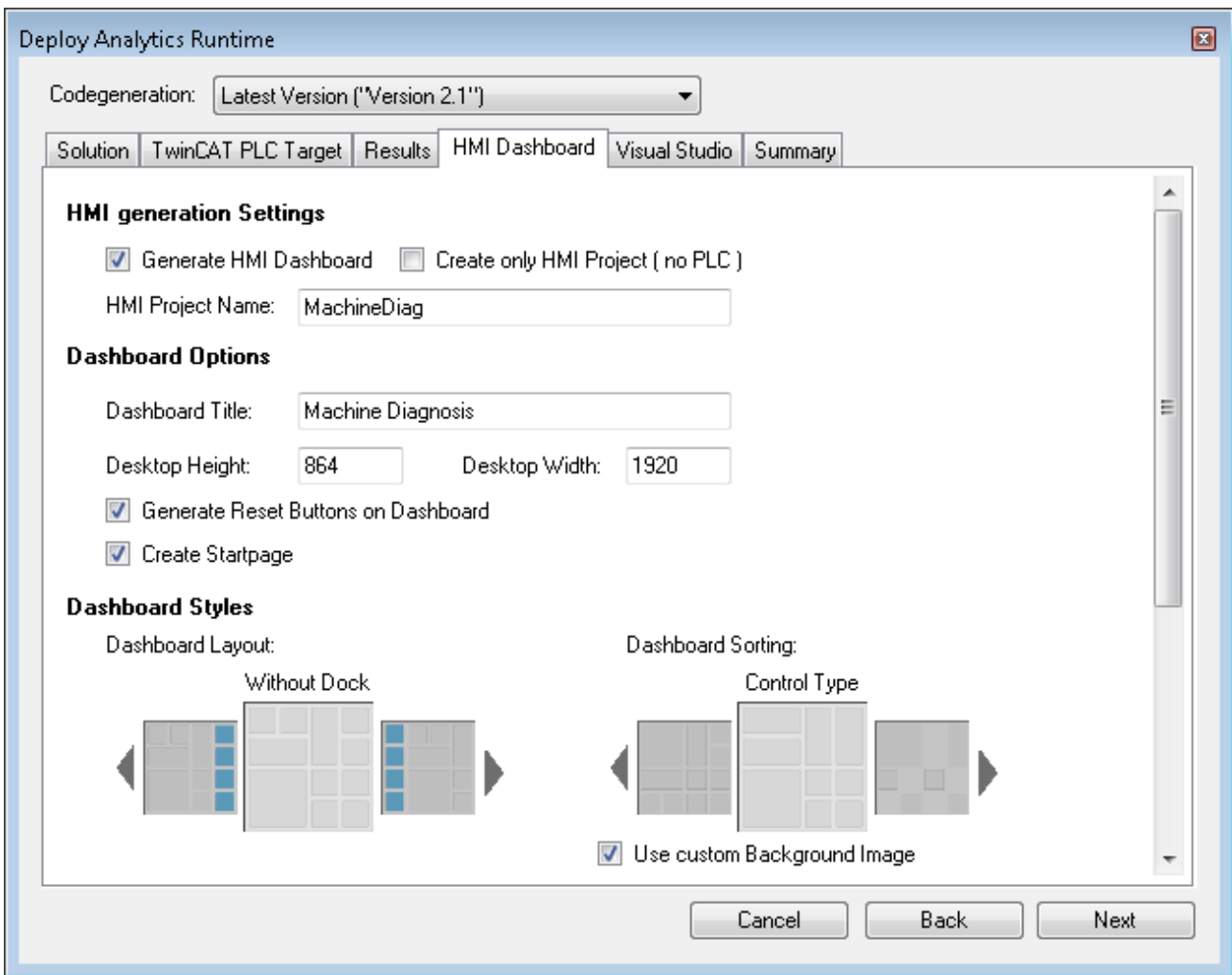
In the TwinCAT PLC Target tab you can choose the ADS target system which runs the TwinCAT Analytics Runtime (TF3550). The generated project is immediately executable. Therefore, you can set the option Activate PLC Runtime. Also, that directly a boot project is created.



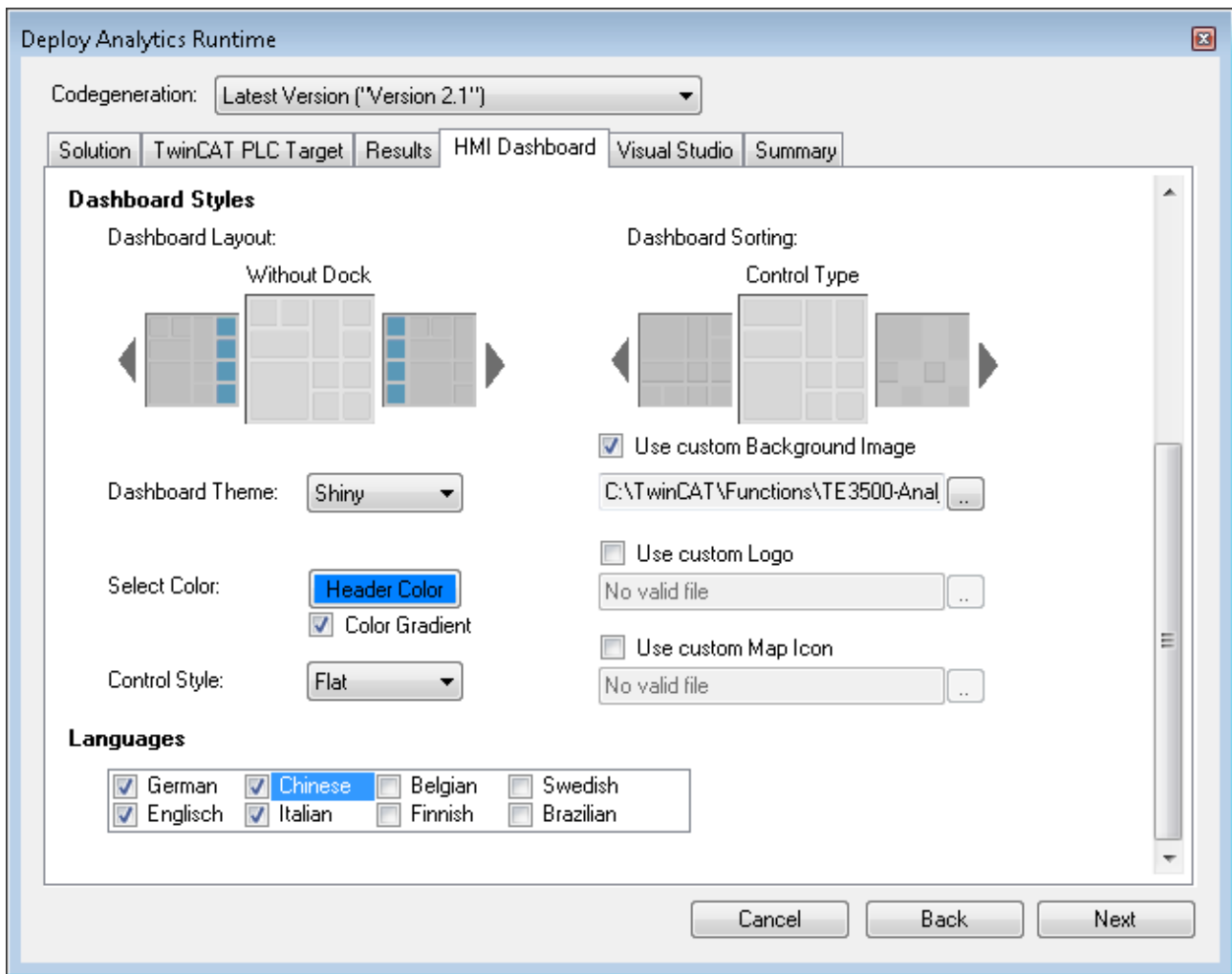
Specially for Virtual Machines it is important to run the project on isolated cores. Also, an option in this tab. The next tab Results is only necessary if you have chosen the Stream Results option in the algorithm properties. If you like to send results you can decide here in which way (local in a file/ by MQTT) and format (binary/JSON). Also, this is generated automatically and starts running after activation.



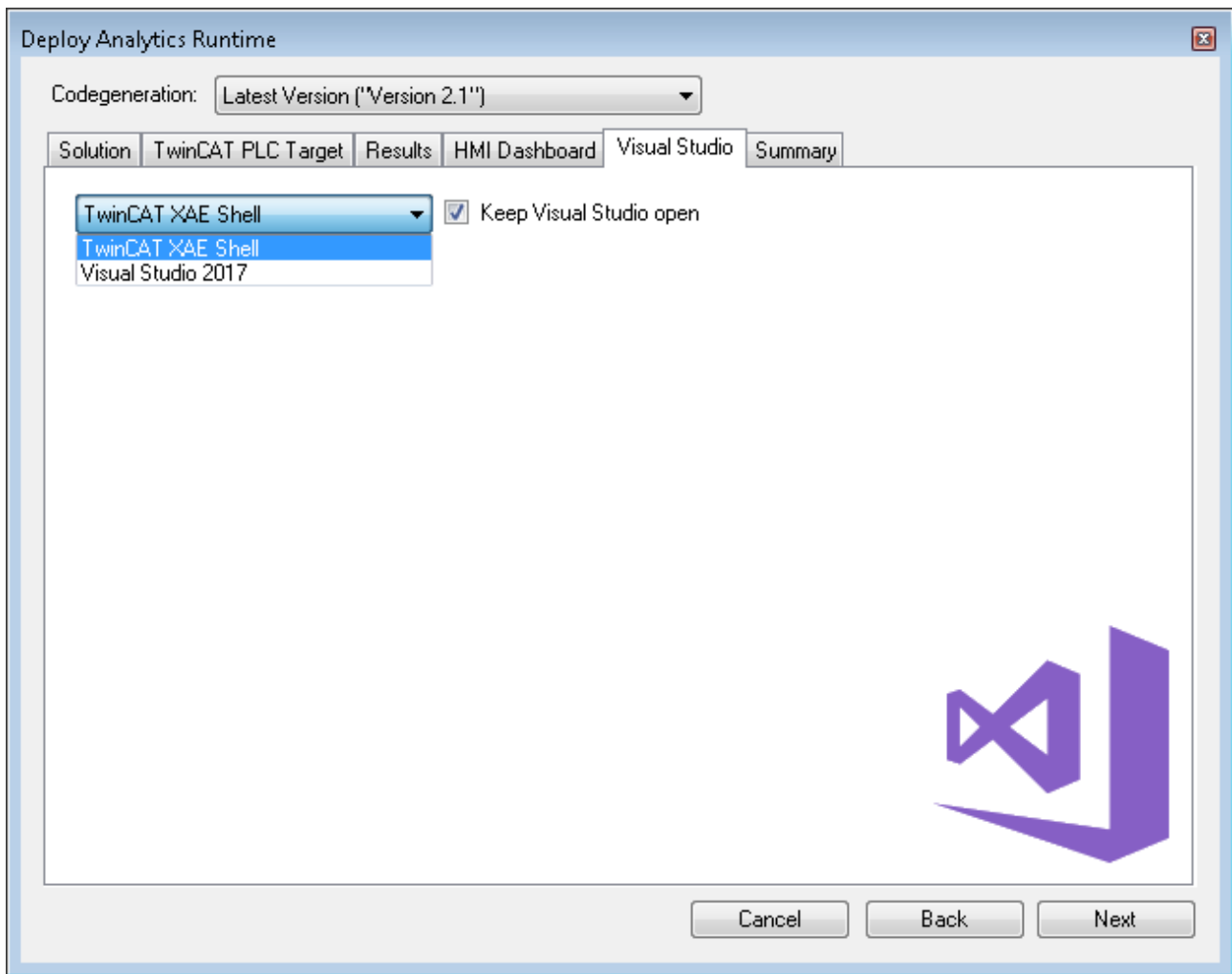
A down sampling of the results is possible by setting a cycle time. The next tab is reserved for the HMI Dashboard. The prerequisite for the automatic Dashboard generation is the selection of HMI controls for the corresponding algorithms whose results are to be displayed in the dashboard.



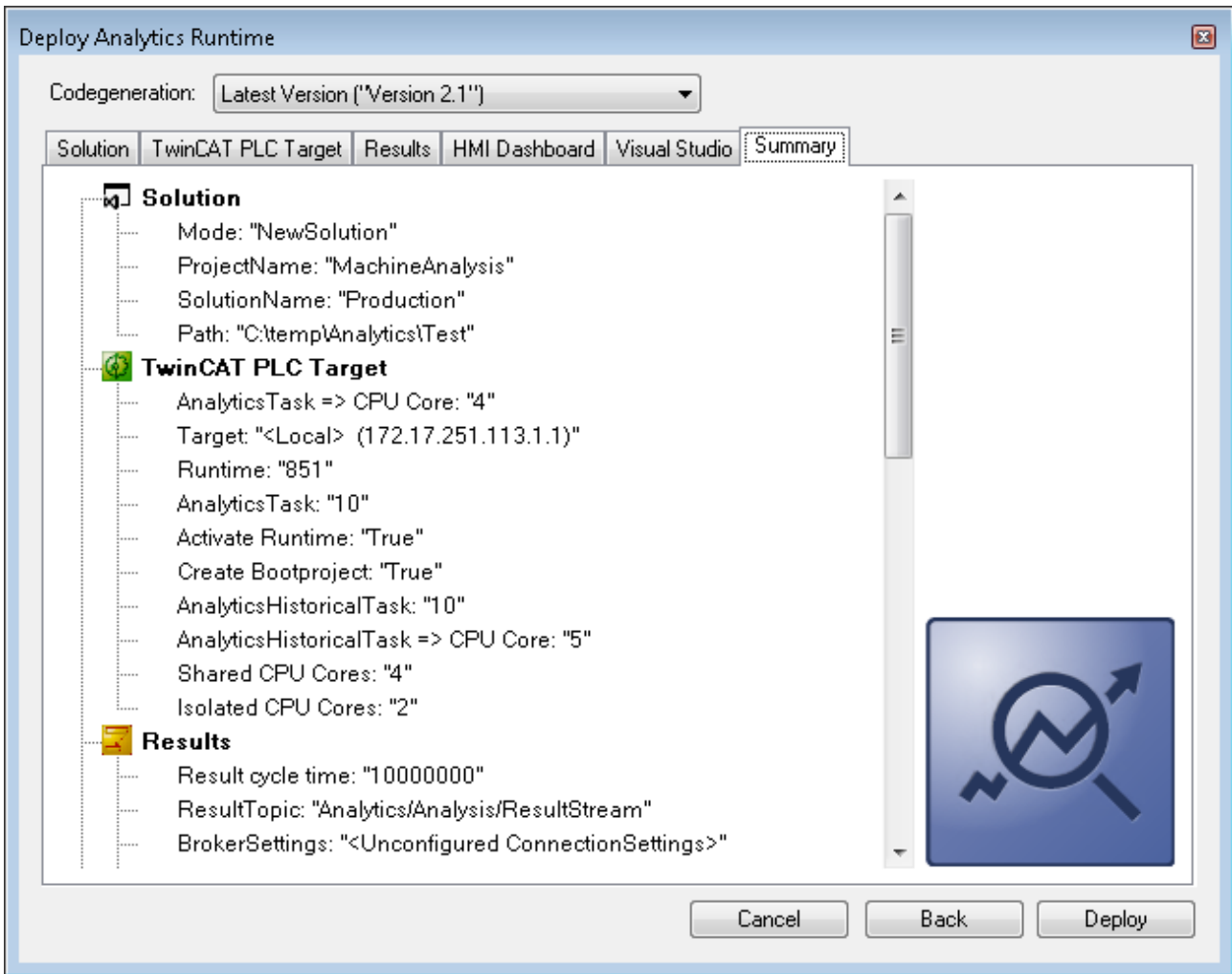
You can choose for your Analytics Dashboard different options like start page with a map, layouts, sorting algorithm, own colors and logos. If you choose more languages for the Analytics controls a language switch menu will be generated as well.



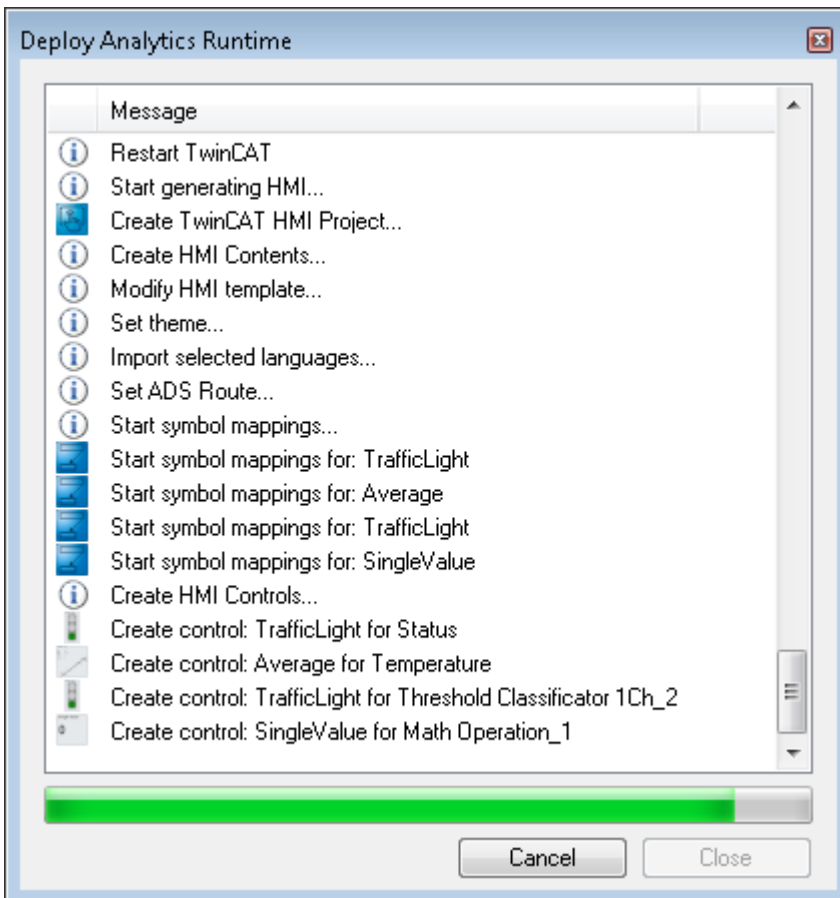
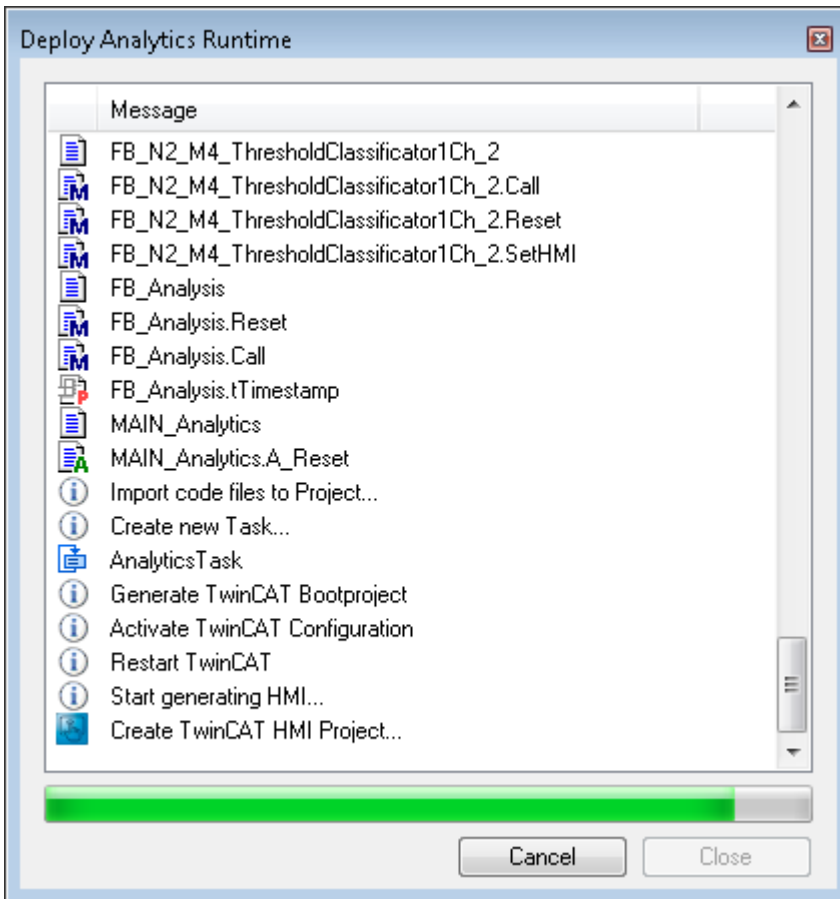
Choose one of the installed Visual Studio versions. And whether the generation should start the instance visibly or whether it should only be set up and activated in the background.



Finally you find a summary.

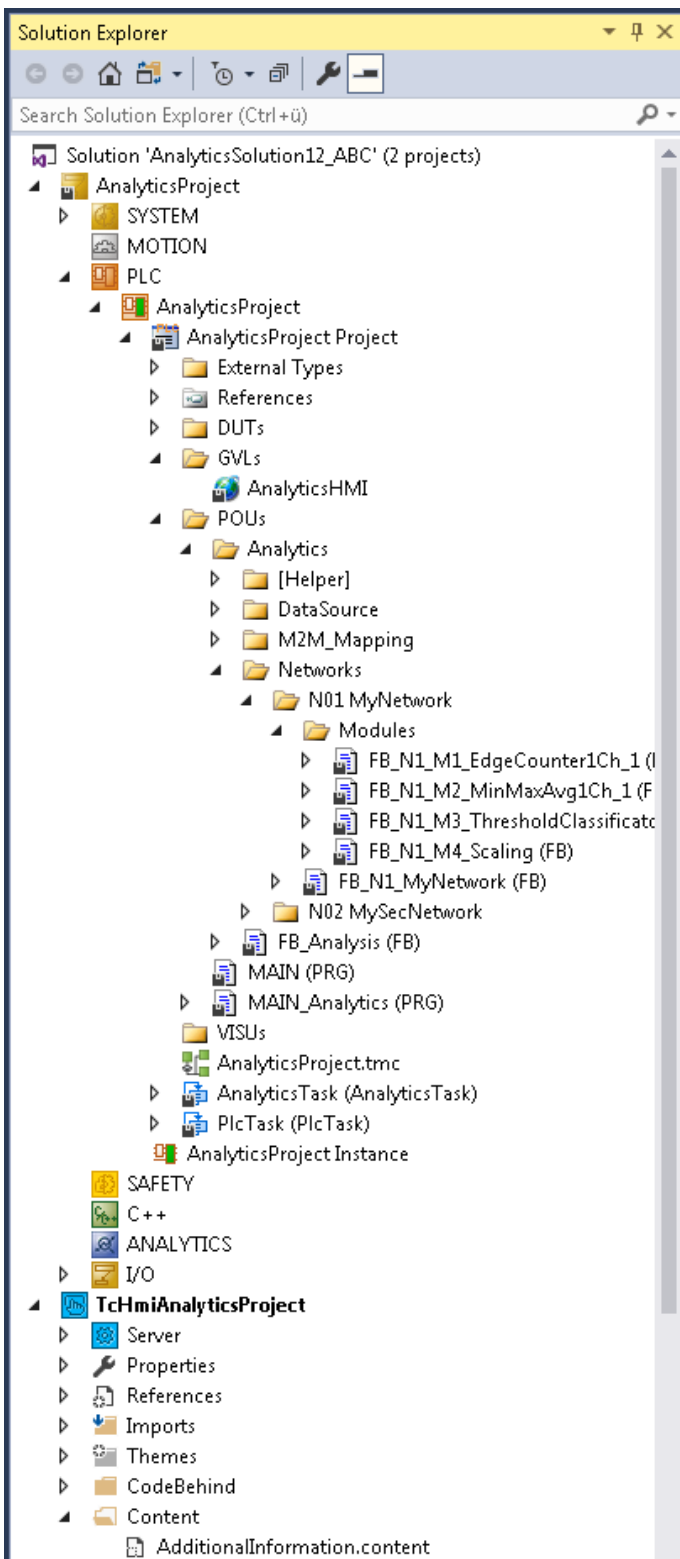


Now you can click the Deploy button to start the generation process. The PLC project and the HMI Dashboard will be generated now.



After the message Deploy Runtime succeeded you can find a new Visual Studio®/XAE Shell instance on your desktop. The new Solution and both Projects are generated.





# 5 Technical introduction

## 5.1 Basic Concepts

### Variables and Datatypes

There are several types of variables that can be logged. Variables that are part of:

- PLC or NC process images
- PLC programs
- process images of devices e.g. an EtherCAT master and
- data areas of generic TcCom objects.

Moreover, they may be of any datatype defined in IEC 61131 or the C++ standard in case of generic TcCom-objects.

Structured datatypes may recursively contain other structured datatypes and may be logged as a whole or partially. For more information on this topic, refer to the Configuration section.

### Modes of Operation

This documentation makes use of the terminology and concepts described in the MQTT-section. Please refer to that section for general information about the protocol.

A key concept of TwinCAT Analytics are streams, which form the basic unit of transaction between a data source and destination. One data logger can control several streams.

A stream may comprise four components:

- stream description
- stream Tx-description
- symbol info
- and stream data.

In **MQTT-mode**, Analytics participants coordinate by means of the first three components using an MQTT broker and a specific MQTT topic for each component. The **topics** are generally structured as illustrated in the following table, whereat <>-brackets indicate variables as opposed to the other parts that are fixed.

Component	Topic Structure	Format	Purpose
Description	<MainTopic>/<StreamTopic>/Desc	JSON	Informs if there is a stream source online or offline. Includes timestamp of info.
Tx-Description	<MainTopic>/<StreamTopic>/Bin/Tx/Desc	JSON	Informs about the transmission parameters when a stream source is active transmitting data.
Symbol Info	<MainTopic>/<StreamTopic>/Bin/Tx/Symbols	Binary	Contains meta information about the variables i.e. excluding the actual value.
Data	<MainTopic>/<StreamTopic>/Bin/Tx/Data	Binary	Contains the plain variable values.

The main topic is the only subtopic that can freely be set by the user.

A stream can be **started** and **stopped**. The system manager configuration allows a stream to be started by default as soon as TwinCAT starts in run-mode. Additionally, streams can be started and stopped from PLC code.

When connected to a broker, the logger first sends the stream description followed by the Tx-description and symbol info as soon as the stream starts. This enables recipients to take all measures that are needed before data arrives. Finally, data is sent cyclically.

For the **file-mode**, the TwinCAT Boot directory on the target device is used as a base for a dedicated Analytics directory, which in turn contains one subdirectory per stream as soon as the respective TwinCAT project has been activated. Inside the stream's directory, a dedicated .tas-file holds the symbol info whereas .tay-files, which are created cyclically, contain the stream data.

### Relation of Logger and Streams

One data logger can control several streams. As will be described more detailed in the Configuration section a user can add one or more data loggers to the Analytics configuration. Streams then are added automatically, depending on what variables are available to be logged. To understand how streams are assigned to a logger it is useful to understand that every stream has specific characteristics. One characteristic, the **cycle time**, comes from the fact that every variable that is acted upon cyclically is subject to a cyclic task; therefore, cycle times that underlie different variables can vary. Since a stream has a fixed cycle time by definition and to decouple tasks with the same cycle time, one stream is created for every task that drives relevant variables. Additionally, it is purposeful to further divide streams depending on the **stream source**, meaning the origin PLC instance or TcCom object. This enables users to send variables of different sources to different MQTT topics and start/stop the transmission independently. Eventually it all comes down to the following scheme:

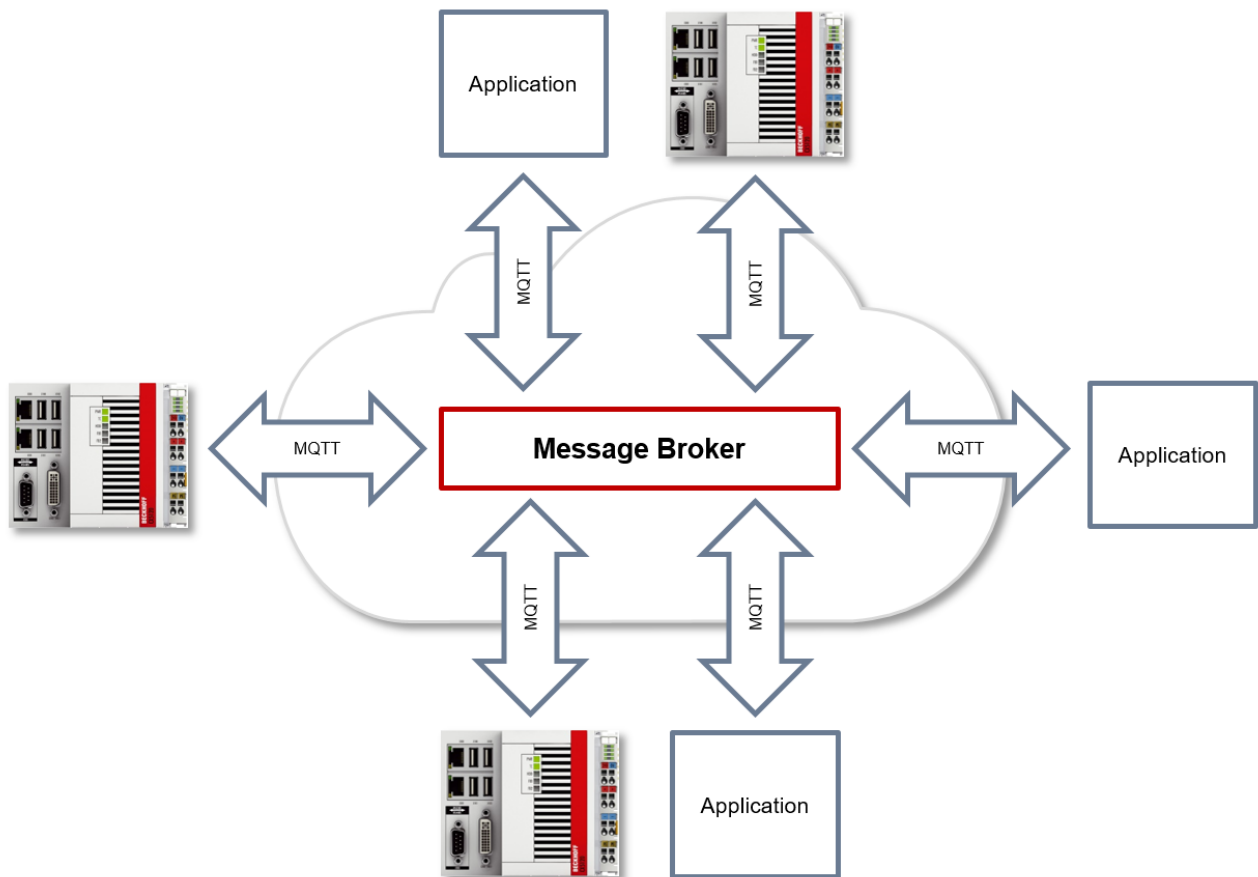
- 
- i** For every stream source and every task that drives variables of that source, a stream is created.
- 

When configuring the data logger, there are configuration parameters that all streams have in common and those that are stream specific. The logger specifies the destination, the compression method, MQTT credentials etc. whereas e.g. the data size and start/stop-functionality are stream specific.

In most cases it might not be necessary to send or write data every task cycle, so the data of a stream recorded in a cycle, a so-called **sample**, can be buffered before sending it to the broker or writing it to file. The number of samples in a buffer and thus the cycle time of a **buffer** being sent/written can be configured. Moreover, the number of buffers in a file and thus the **file size** can be configured.

## 5.2 MQTT

MQTT(Message Queueing Telemetry Transport) is a publisher/subscriber-based communication protocol, which enables message-based transfer between applications. A central component of this transfer type is the so-called message broker, which distributes messages between the individual applications or the sender and receiver of a message. The message broker decouples the sender and receiver, so that it is not necessary for the sender and receiver to know their respective address information. During sending and receiving all communication devices contact the message broker, which handles the distribution of the messages.



**Payload**

The content of an MQTT message is referred to as payload. Data of any type can be transferred, e.g. text, individual numerical values or a whole information structure.

**i Message payload formatting**

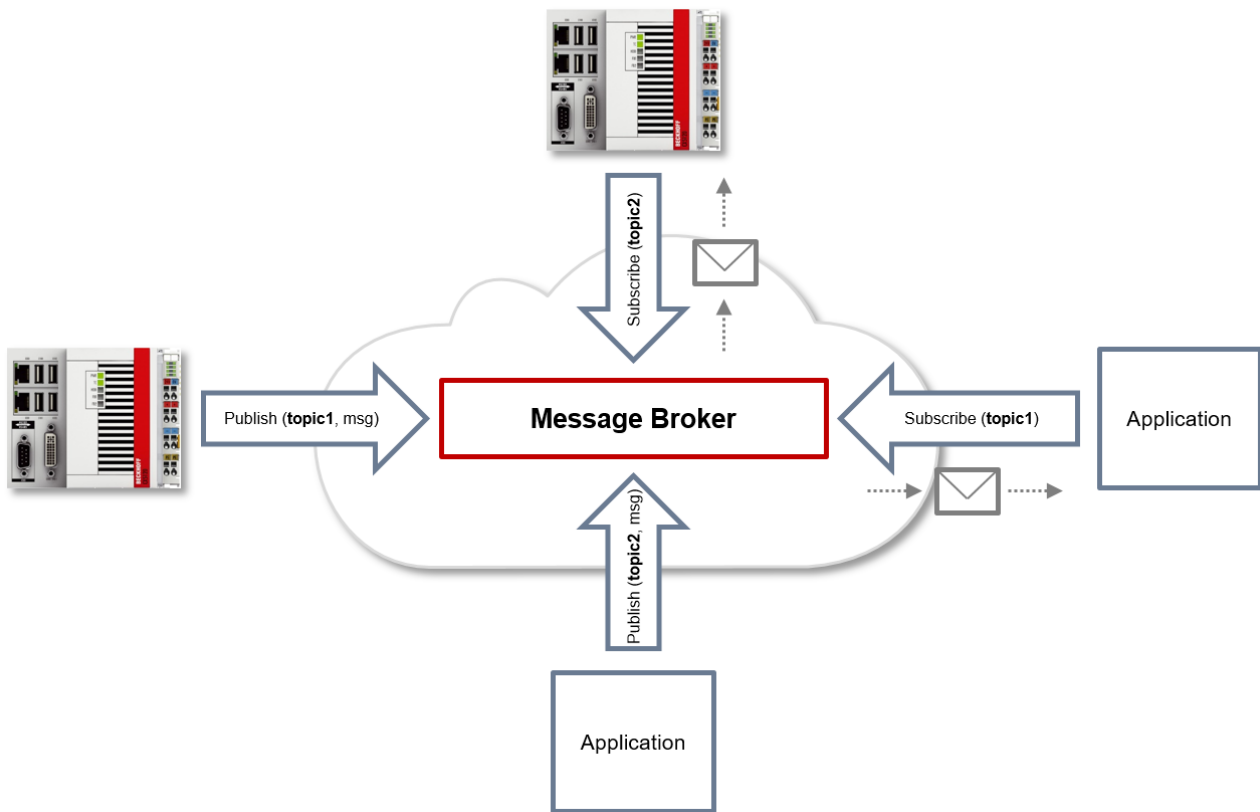
Note that the data type and the formatting of the content must be known to the sender and receiver side, particularly when binary information (alignment) or strings (with or without zero termination) are sent.

**Topics**

If a message broker is used that is based on the MQTT protocol, sending (publish mode) and subscribing (subscribe mode) of messages is organized with the aid of so-called topics. The message broker filters incoming messages based on these topics for each connected client. A topic may consist of several levels; the individual levels are separated by “/”.

Example: Campus / Building1 / Floor2 / Room3 / Temperature

When a publisher sends a message, it always specifies for which topic it is intended. A subscriber indicates which topic it is interested in. The message broker forwards the message accordingly.



Communication example 1 from the diagram above:

- An application subscribes to “topic1”.
- A controller publishes a message to “topic1”.
- The message broker forwards the message to the application accordingly.

Communication example 2 from the diagram above:

- A controller subscribes to “topic2”.
- An application publishes a message to “topic2”.
- The message broker forwards the message to the controller accordingly.

**Wildcards**

It is possible to use wildcards in conjunction with topics. A wildcard is used to represent part of the topic. In this case a subscriber may receive messages from several topics. A distinction is made between two types of wildcards:

- Single-level wildcards
- Multi-level wildcards

Example for single-level wildcard:

The + symbol describes a single-level wildcard. If it is used by the subscriber as described below, for example, corresponding messages to the topics are either received by the subscriber or not.

- The receiver subscribes to Campus/Building1/Floor2/+ /Temperature
- The publisher sends to Campus/Building1/Floor2/Room1/Temperature - OK
- The publisher sends to Campus/Building1/Floor2/Room2/Temperature - OK
- The publisher sends to Campus/Building42/Floor1/Room1/Temperature - NOK
- The publisher sends to Campus/Building1/Floor2/Room1/Fridge/Temperature - NOK

Example for multi-level wildcard:

The # symbol describes a multi-level wildcard. If it is used by the subscriber as described below, for example, corresponding messages to the topics are either received by the subscriber or not. The # symbol must always be the last symbol in a topic string.

- The receiver subscribes to Campus/Building1/Floor2/#
- The publisher sends to Campus/Building1/Floor2/Room1/Temperature - OK
- The publisher sends to Campus/Building1/Floor2/Room2/Temperature - OK
- The publisher sends to Campus/Building42/Floor1/Room1/Temperature - NOK
- The publisher sends to Campus/Building1/Floor2/Room1/Fridge/Temperature - OK
- The publisher sends to Campus/Building1/Floor2/Room1/Humidity - OK

**QoS (Quality of Service)**

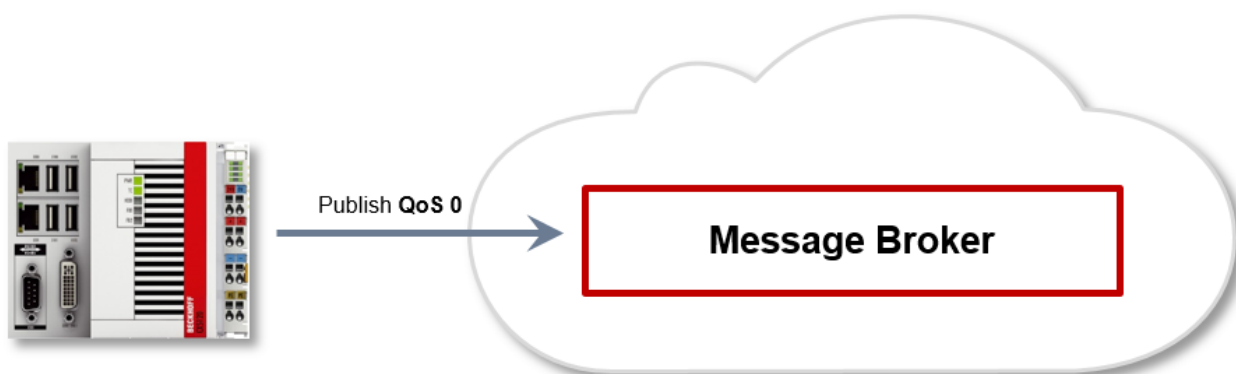
QoS is an arrangement between the sender and receiver of a message with regard to guaranteeing of the message transfer. MQTT features three different levels:

- 0 – not more than once
- 1 – at least once
- 2 – exactly once

Both types of communication (publish/subscribe) with the message broker must be taken into account and considered separately. The QoS level that a client uses for publishing a message is set by the respective client. When the broker forwards the message to client that has subscribed to the topic, the subscriber uses the QoS level that was specified when the subscription was established. This means that a QoS level that may have been specified as 2 by the publisher can be “overwritten” with 0 by the subscriber.

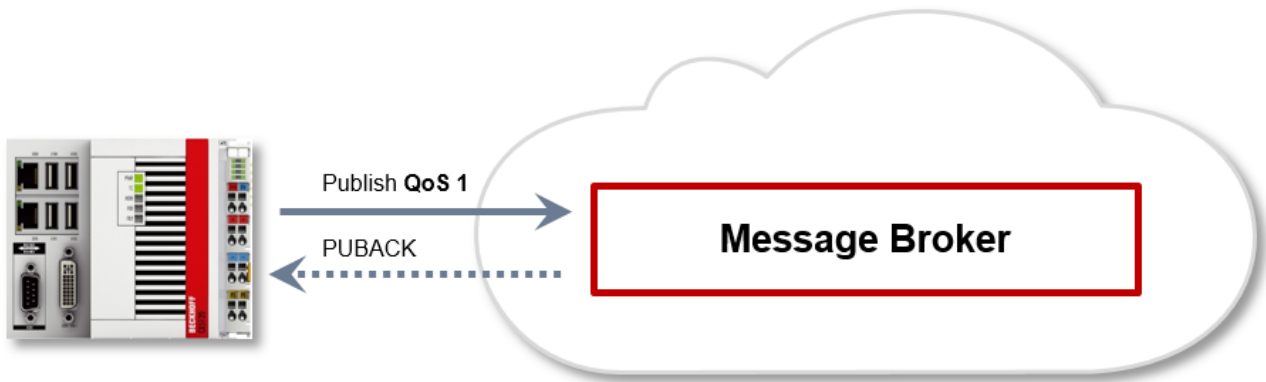
**QoS-Level 0**

At this QoS level the receiver does not acknowledge receipt. The message is not sent a second time.



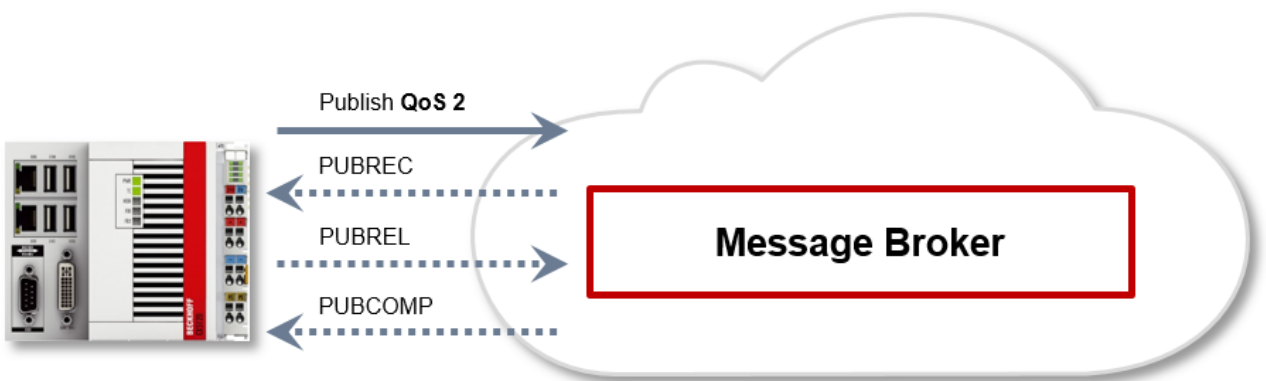
**QoS-Level 1**

At this QoS level the system guarantees that the message arrives at the receiver at least once, although the message may arrive more than once. The sender stores the message internally until it has received an acknowledgement from the receiver in the form of a PUBACK message. If the PUBACK message fails to arrive within a certain time, the message is resent.



**QoS-Level 2**

At this QoS level the system guarantees that the message arrives at the receiver no more than once. On the MQTT side this is realized through a handshake mechanism. QoS level 2 is the safest level (from a message transfer perspective), but also the slowest. When a receiver receives a message with QoS level 2, it acknowledges the message with a PUBREC. The sender of the message remembers it internally until it has received a PUBCOMP. This additional handshake (compared with QoS 1) is important for avoiding duplicate transfer of the message. Once the sender of the message receives a PUBREC, it can discard the initial publish information, since it knows that the message was received once by the receiver. In other words, it remembers the PUBREC internally and sends a PUBREL. Once the receiver has received a PUBREL, it can discard the previously remembered states and respond with a PUBCOMP, and vice versa. Whenever a package is lost, the respective communication device is responsible for resending the last message after a certain time.



**Security**

When a connection to the message broker is established, it is possible to use security mechanisms such as TLS, in order to encrypt the communication link or to realize authentication between client and message broker.

**Sources**

For further and more detailed information about MQTT we recommend the following blog series:

HiveMq blog: <http://www.hivemq.com/blog/mqtt-essentials/> (the main basis for this article)

**5.3 Data Compression**

In order to reduce the amount of data to be sent without reducing the amount of information and thus enhance the performance, a compression method derived from the Run Length Encoding method can be used. It utilizes the fact, that data of two consecutive samples in a buffer may not vary in parts. Thus knowing what parts of a previously sent buffer are equal in conjunction with the varying data, a recipient can reconstruct the next buffer without the need to receive the whole buffer. After sending the first buffer uncompressed, the logger constructs the compressed buffer by comparing user-specified units of data (e.g.

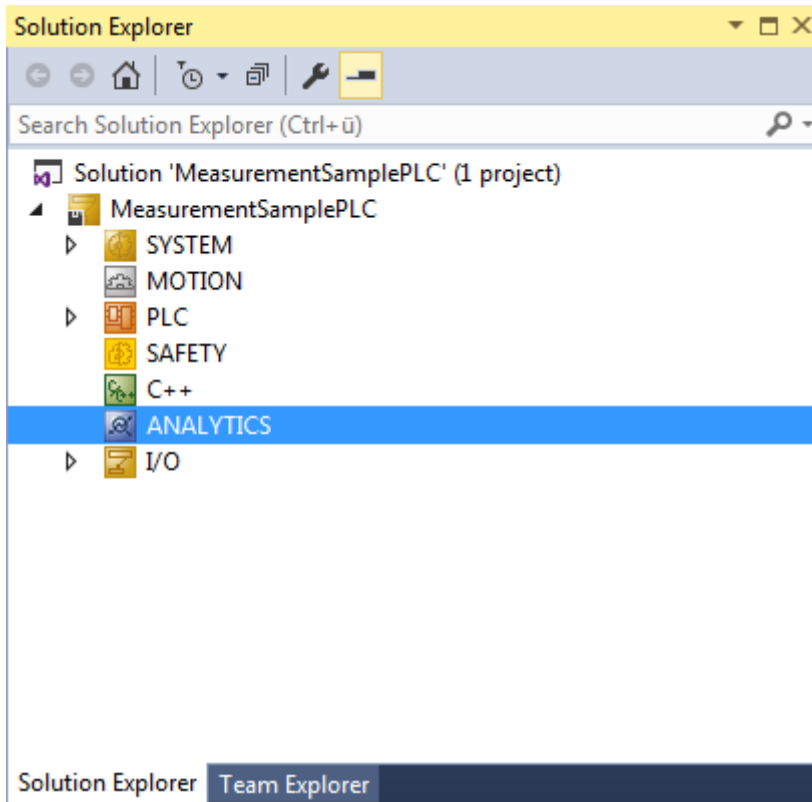
every byte, every 8 byte etc.) one after another. The logger counts the amount of data units (called Compression Compare Width) that are equal and places this information in the buffer instead of the data. Dependent on the kind of data this can lead to a data saving or overhead. To decide whether a compression is purposeful or not the user is provided with a data compression saving value, which can be found on the Online-tab of every stream dialog window. A positive value indicates saving and a negative value indicates overhead.



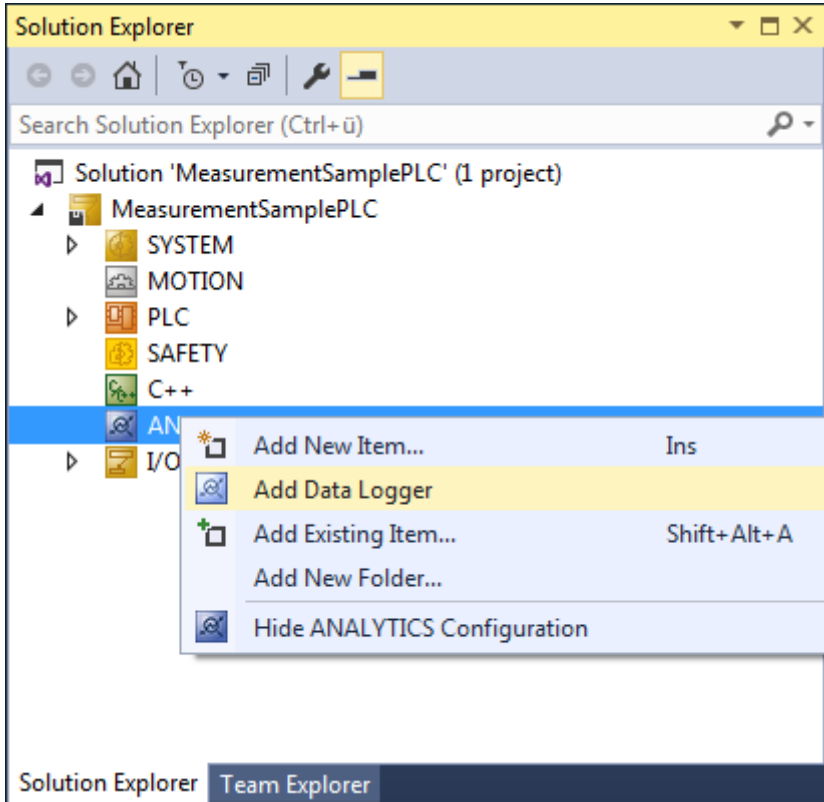
## 6 Configuration

### 6.1 Basic settings

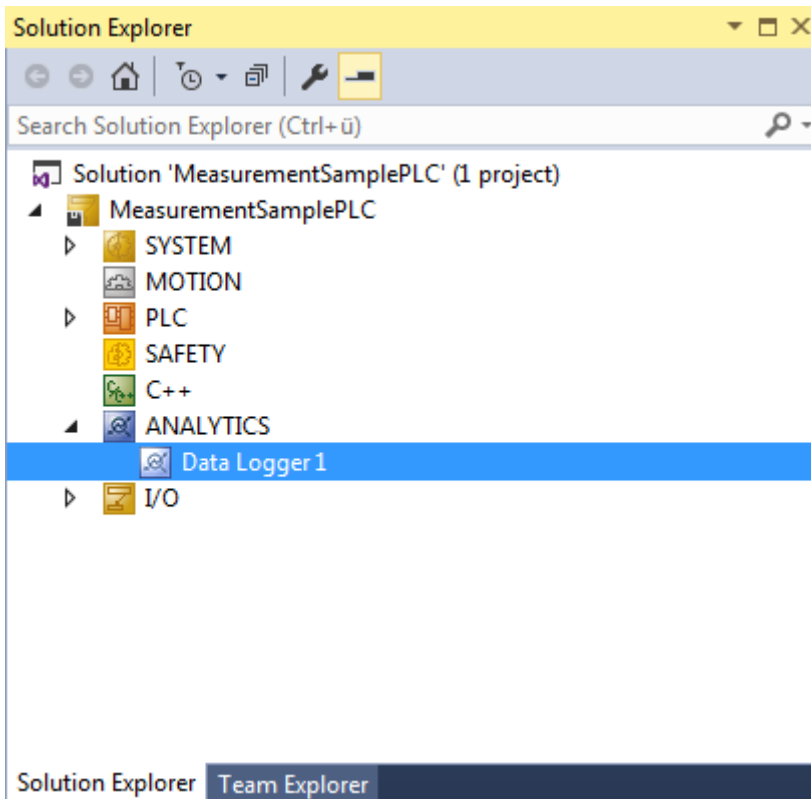
To configure the TwinCAT Analytics Logger the user is provided with a dedicated Analytics configuration inside of a XAE project.



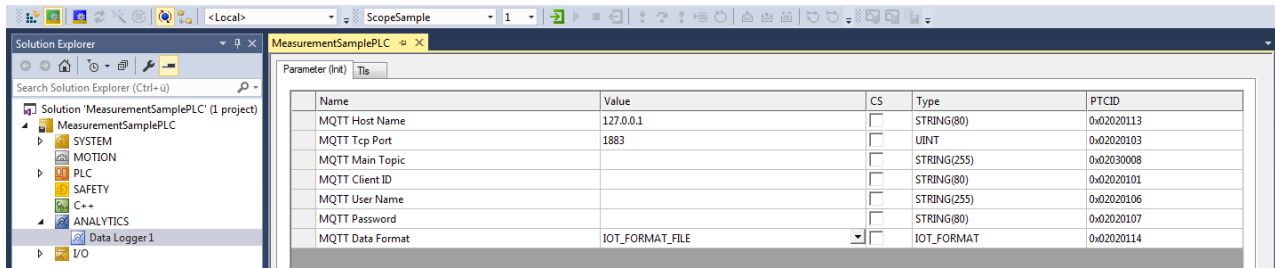
To add a data logger choose the respective item in the context menu of this configuration node.



This may either result in the additional Data Logger node alone or subordinate stream nodes in case there already are variables that can be logged.



By double clicking the new Data Logger node the editor window will be open. In the Parameter tab you can make your specific Analytics Logger settings.



- **MQTT Host Name:** Provide here the host name or IP address of your native MQTT Message Broker
- **MQTT Tcp Port:** Here set the Tcp port for the communication. Default MQTT port: 1883
- **MQTT Main Topic:** It is possible to provide an own and individual main topic. Sample: Beckhoff/Verl/ Production/Drives/Machine5 – the Analytics Logger will add automatically his own specific subtopics: Beckhoff/Verl/Production/Drives/Machine5/**Bin/Tx/Data**
- **MQTT Client ID:** The client identifier is an identifier of each MQTT client connecting to a native MQTT Message Broker. It should be unique per Broker.
- **MQTT User Name:** MQTT allows to send a username for authenticating the client.
- **MQTT Password:** MQTT also allows to send a password for authenticating the client and authorization.
- **Data Format:** Here the user can choose between *IOT\_FORMAT\_FILE* and *IOT\_FORMAT\_BINARY*. By using the *FILE* format the Analytics Logger store the data in local binary files and all settings above are not necessary anymore. The files will be stored in C:\TwinCAT\3.1\Boot\Analytics. By using *BINARY* the data will send to the configured MQTT Message Broker.

It is possible to have multiple Logger in one TwinCAT project to communicate data to different MQTT Message Broker or to have partly a storage in a local binary file.

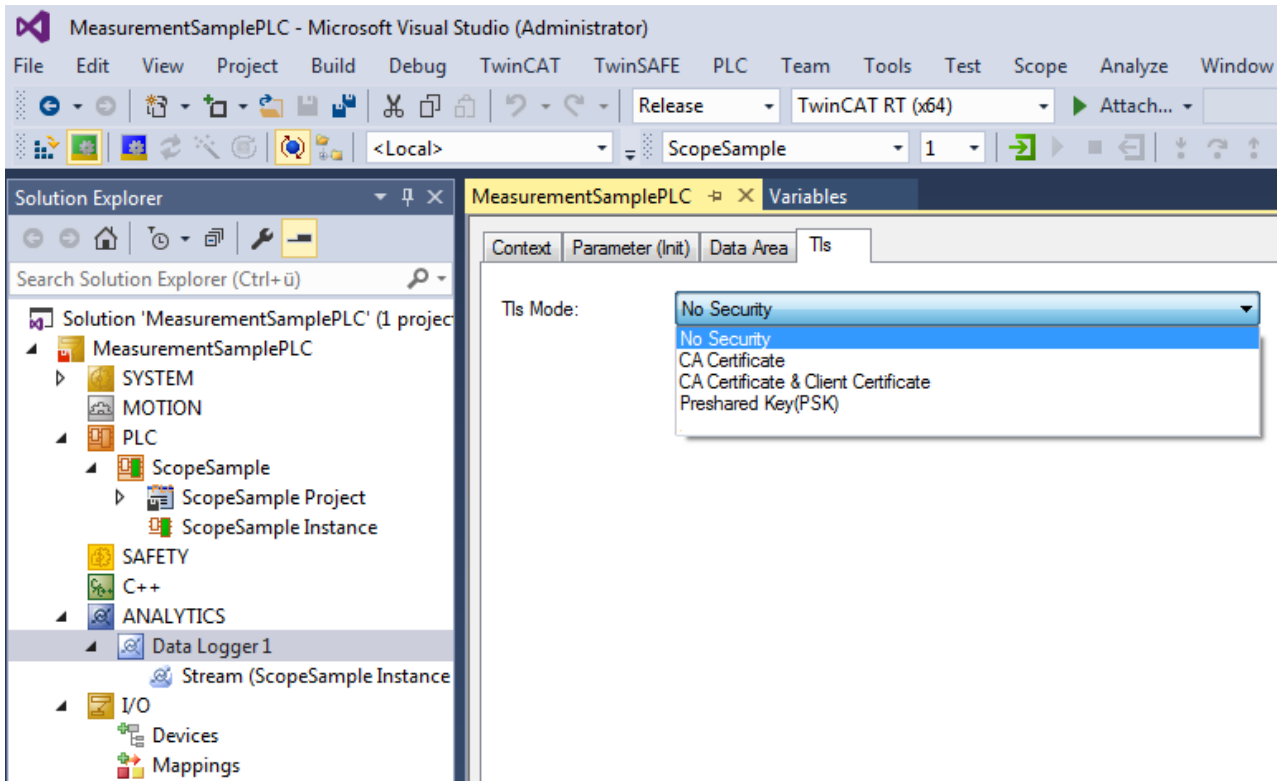
### 6.1.1 TLS

TLS (Transport Layer Security) provide a secure communication channel between a client and a server. At its core, TLS is cryptographic protocols which use a handshake mechanism to negotiate various parameters to create a secure connection between the client and the server. The TwinCAT Analytics Logger is supporting TLS version 1.2.

#### ● MQTT communication with TLS

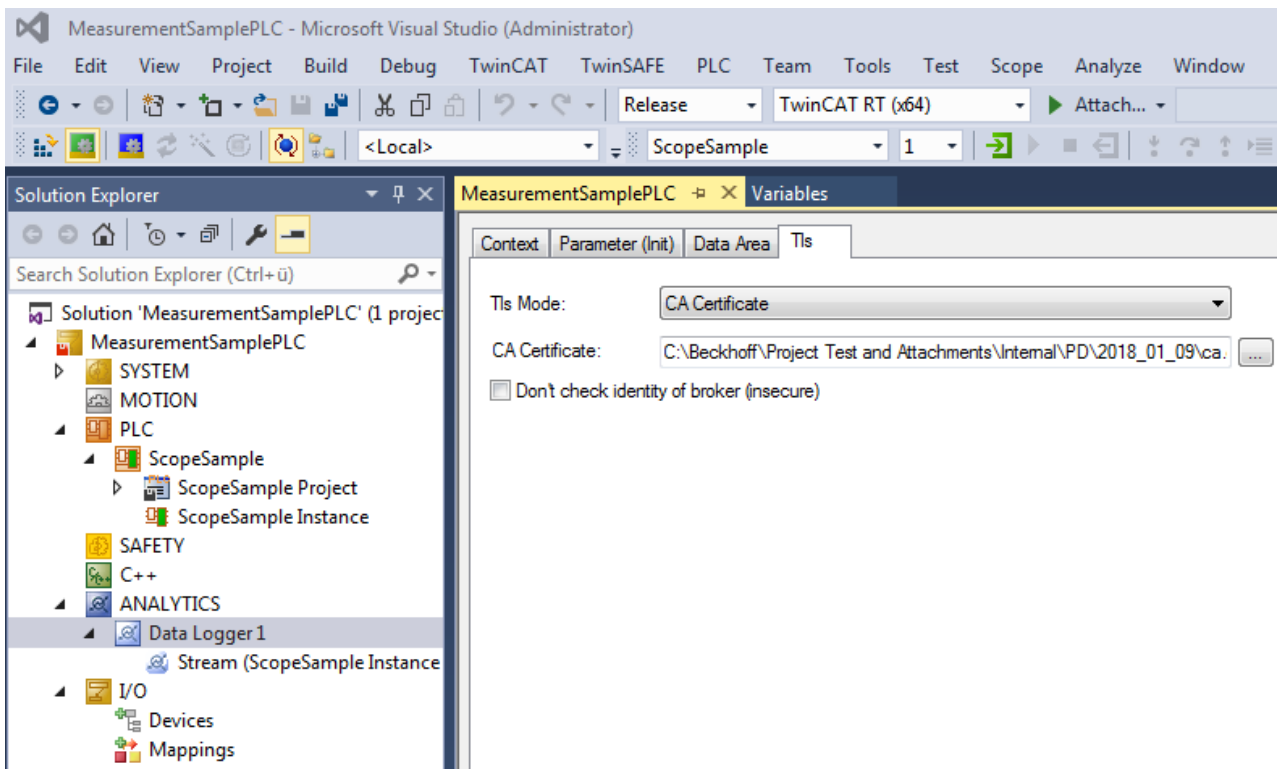
**i** By the usage of certificates the TCP port 8883 is exclusively reserved for MQTT over TLS!

On the TLS tab of the Data Logger your first choice is the TLS Mode in a drop down box. Depending on the Message Broker it is possible to use different TLS mechanism/modes. The Analytics Logger is supporting the modes CA Certificates, CA Certificates & Client Certificate and the Preshared Key (PSK) mode.



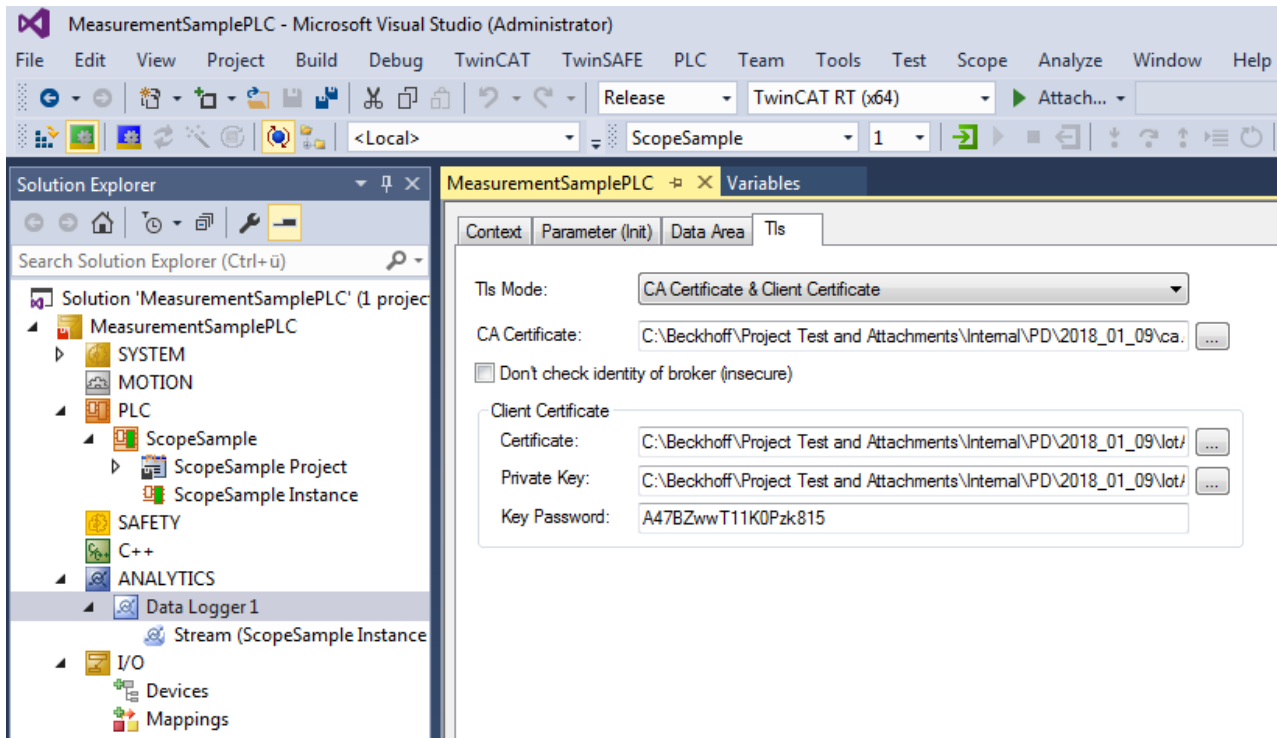
**CA Certificate**

Encryption and authentication via TLS can also be accomplished through a certificate authority (CA). The CA provides a signature via the public key for all communication clients. In this case an MQTT client connect to a Message Broker without a dedicated client certificate.



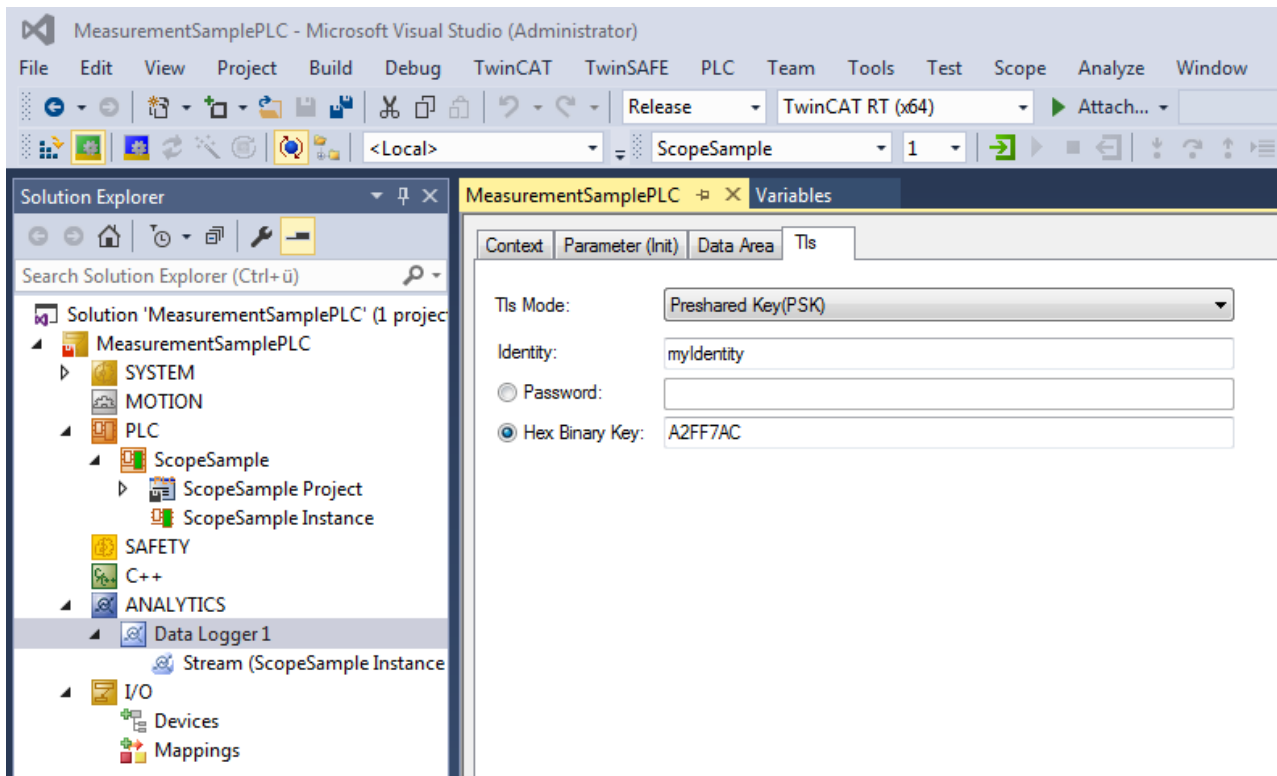
### CA Certificate & Client Certificate

Encryption and authentication via TLS can also be accomplished through a certificate authority (CA). The CA provides a signature via the public key for the message broker (the so-called server key) and usually also for all connecting clients. All communication devices can then trust each other, because the issuing certificate authority is trusted.



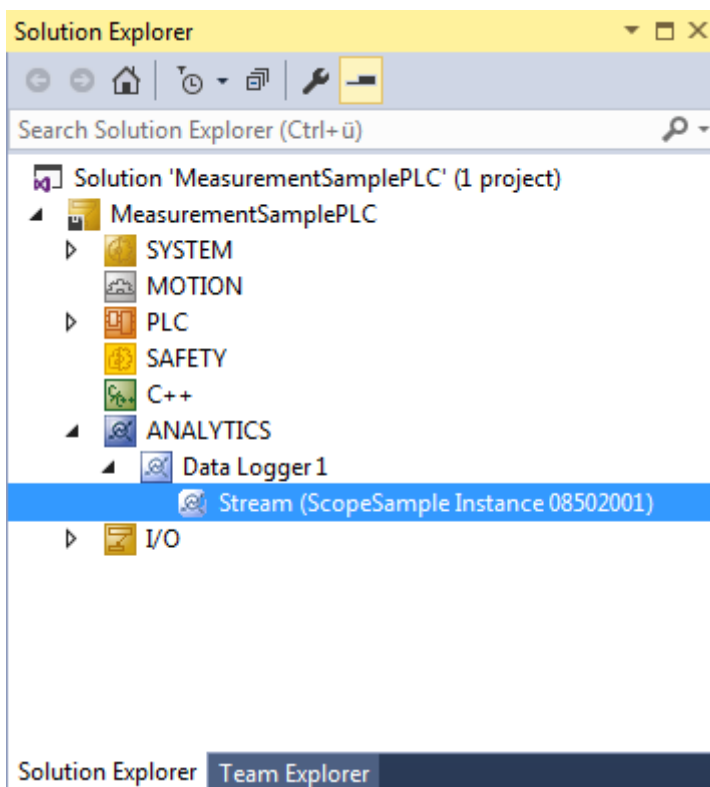
### Preshared Key (PSK)

The TLS PreSharedKey (PSK) method offers a simple option for realizing encryption between client and message broker. Client and broker recognize a common password, which is used to encrypt and decrypt the packages.



## 6.2 Data Streams

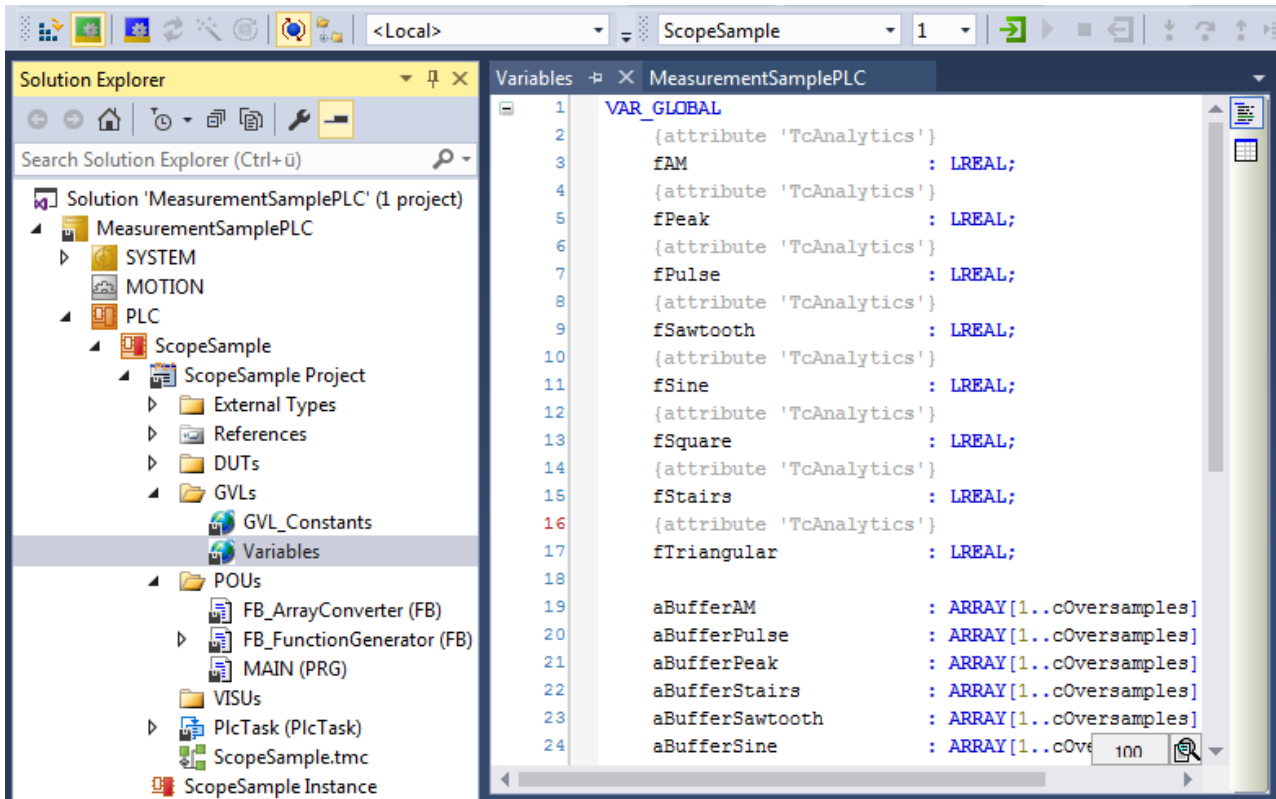
If variables are available for recording they will be shown automatically as a so called Stream. At the moment it is possible to record data directly from the EtherCAT process image or from the PLC application.



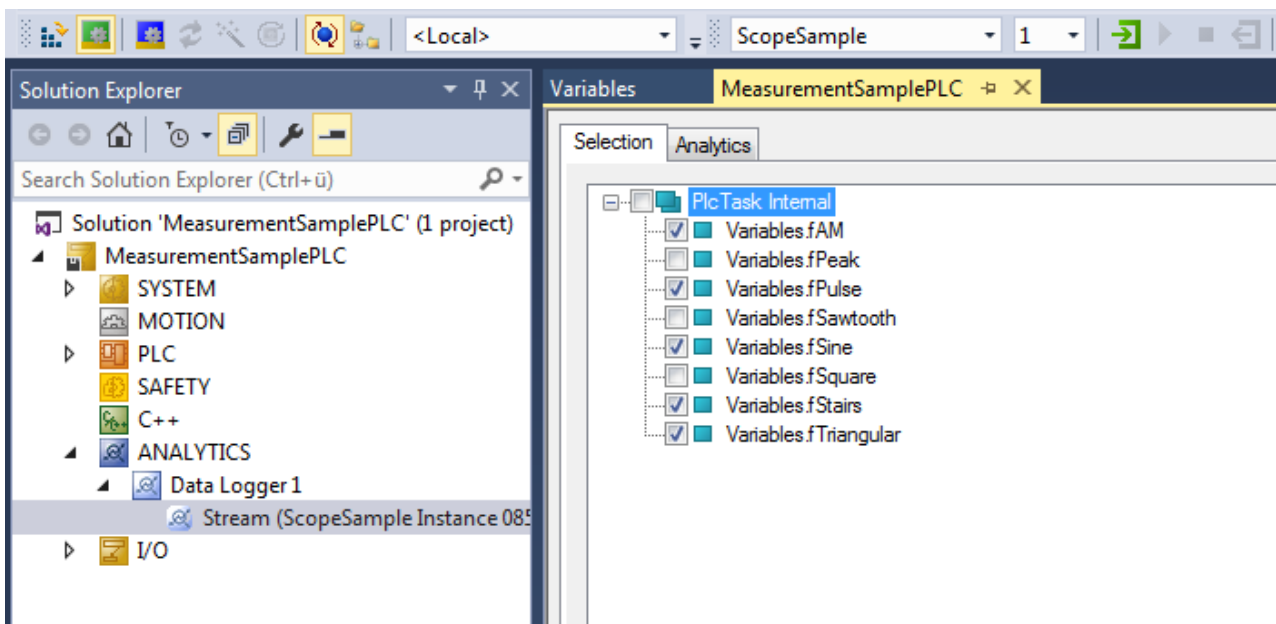
**PLC Application:**

If variables from PLC should be recorded by the Analytics Logger, the user must set an attribute in front of each variable in the variable declaration.

The attribute syntax is: {attribute 'TcAnalytics'}

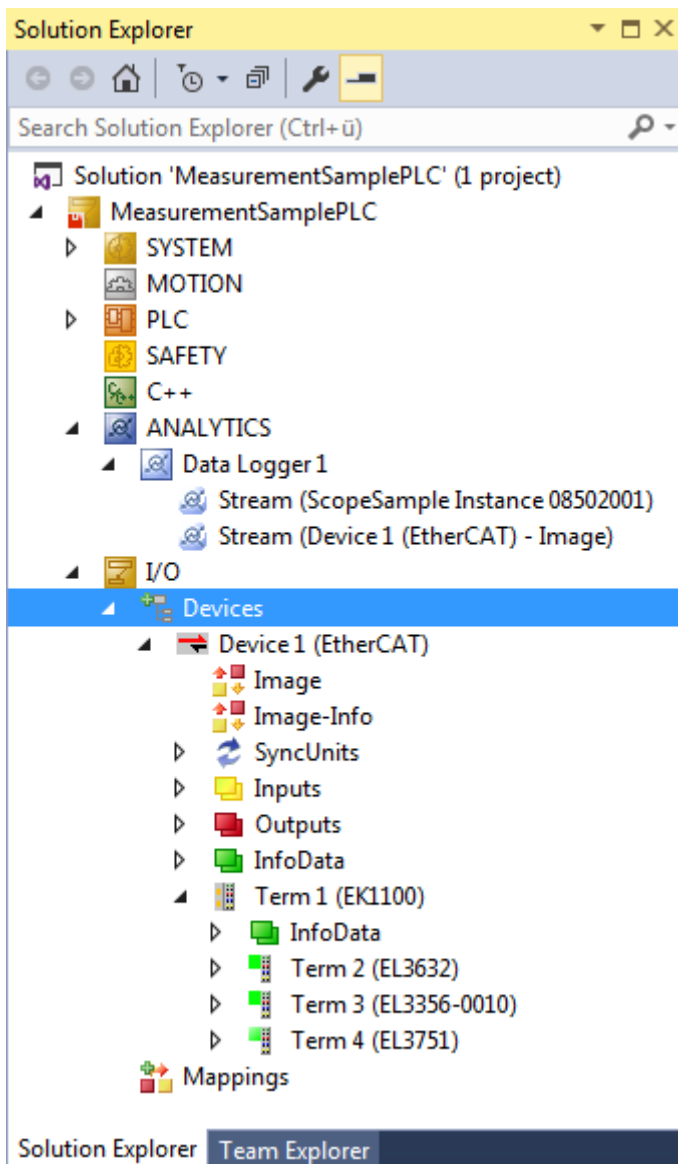


As already described a new stream is automatically added to the Analytics Logger configuration **after rebuild** of the PLC project. In the stream a *Selection* tab is available to choose finally the variables by checkboxes who should be recorded.



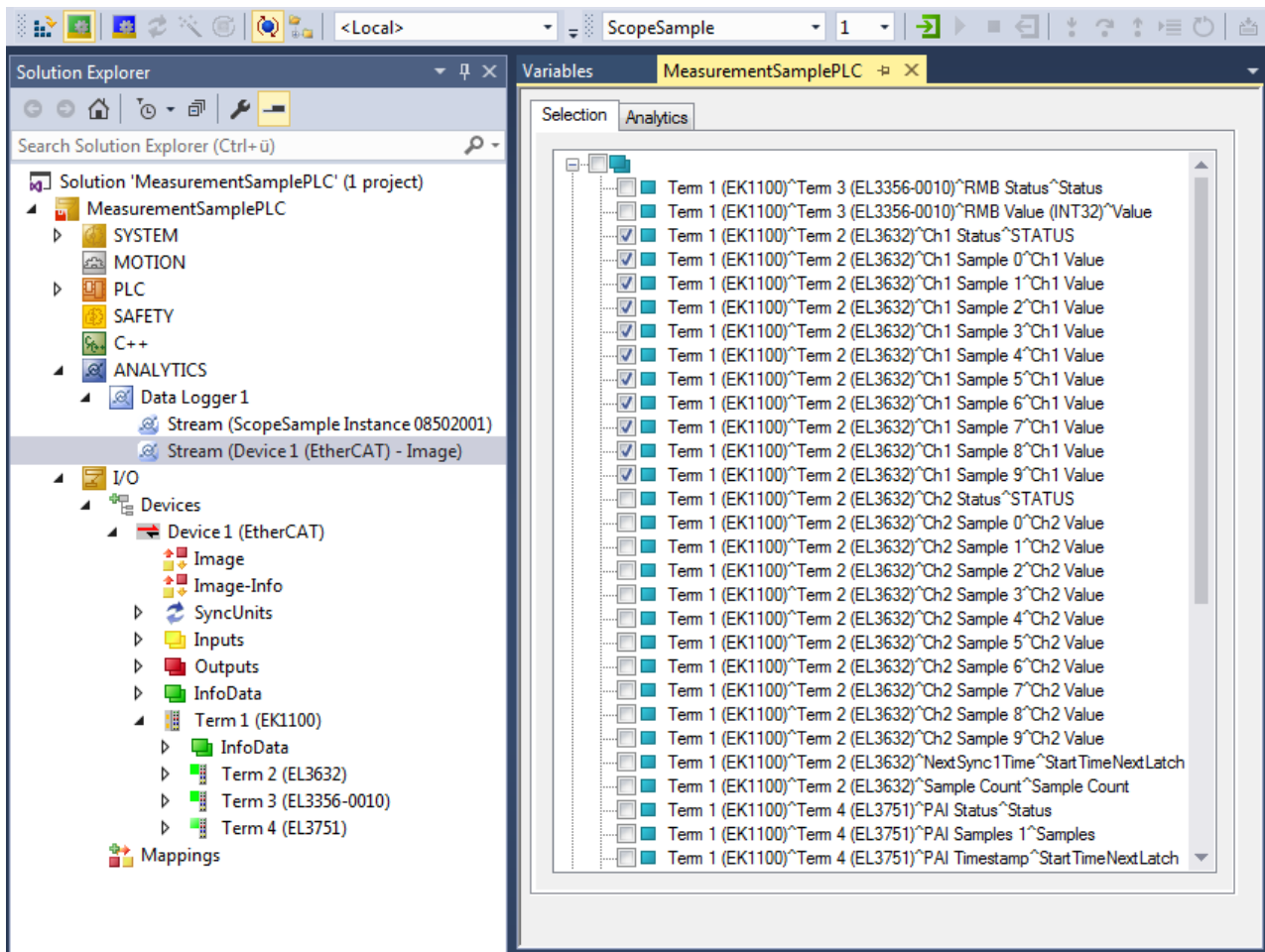
**Process Image:**

If an EtherCAT process image is available in the given configuration, an additional stream will be shown under the Data Logger tree node.



On the *Selection* tab the user can choose again the values who should be recorded by the Analytics Logger.



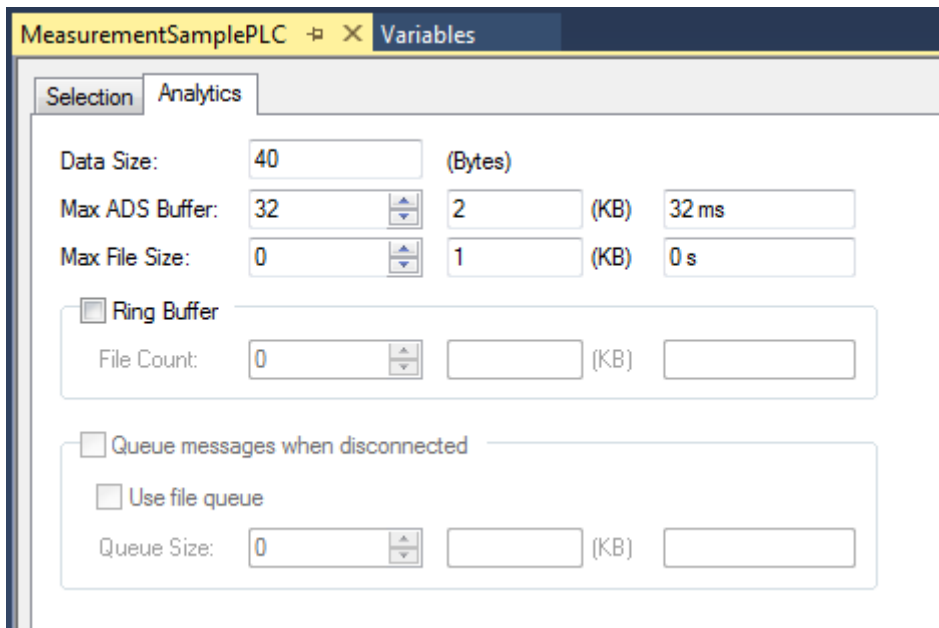


**Start Record**

With the activation of the TwinCAT configuration the Analytics Logger starts logging. Depending on the basic settings to a MQTT Message Broker or into a local binary file. By the given format there are different settings possibilities on the Data Handling tab of each Stream. See therefore the following chapter.

**6.2.1 Data Handling**

In the Data Handling tab you can make general settings for the package size of the recorded data. Depending on the given data format it gives additional settings.



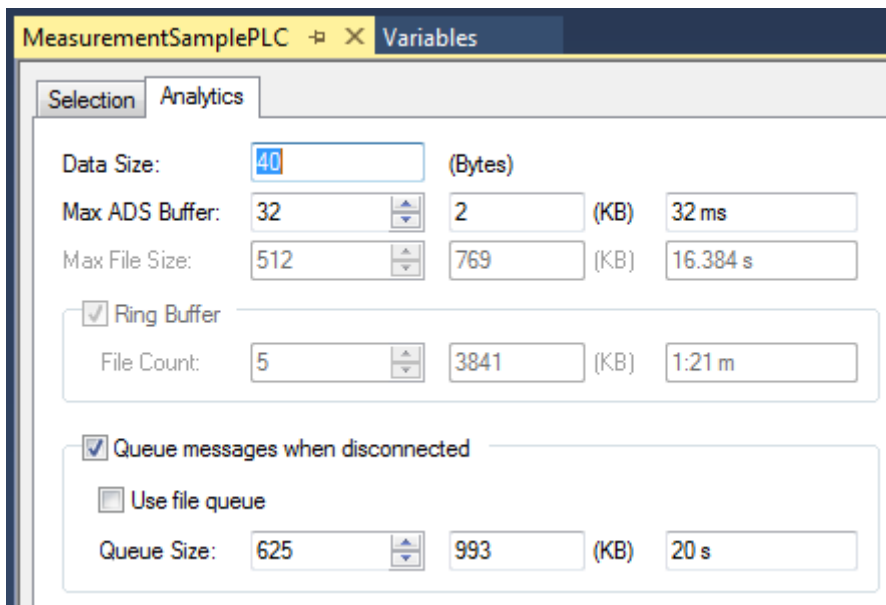
**Data Size:** This is a read-only value and provide the size of the given variable selection for this stream.

**Max ADS Buffer:** Here you can set the number of buffered cycles before write to file or send to Message Broker. By 1ms cycle time and 32 buffers the Analytics Logger buffered 32ms before operated. It is an individual setting depending on the system resources.

**Max File Size:** Only available by *IOT\_FORMAT\_FILE*. You can give the maximum file size before starting with a new file. The files will be stored under C:\TwinCAT\3.1\Boot\Analytics.

**Data format: MQTT**

If the data format is *IOT\_FORMAT\_BINARY* it is possible to activate an additional checkbox for queuing messages by disconnect.

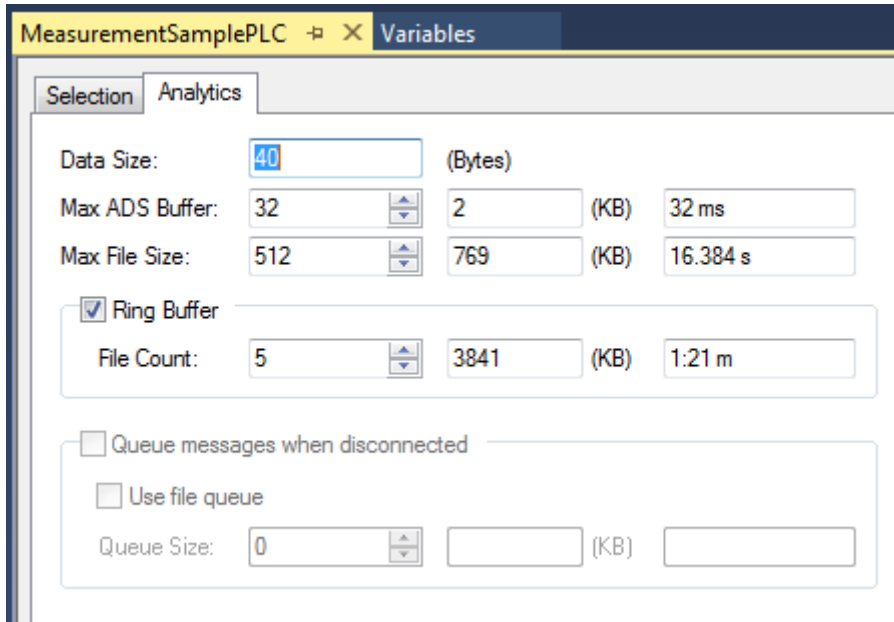


**File Store:** If this option is activated the queued messages will stored in a temporary file at the hard disk. Otherwise the data will be stored in the RAM when connection to the Message Broker is disconnected.

**Queue Size:** Is the number of configured ADS Buffer which should be stored in the case of a lost connection.

**Data format: File**

If the data format is *IOT\_FORMAT\_FILE* it is possible to activate an additional checkbox for a ring buffer.



**File Count:** You can set up a ring buffer system for the binary files. With the File Count parameter you can give a number of files who should be part of the ring buffer. The ring buffer time depends on the given Max File Size.

### 6.3 Using the Programming Interface

As described in the Technical Introduction a stream can be started and stopped from PLC code using Structured Text. For that, the streams of a data logger, themselves being TcCom-objects provide an interface called *ITcAnalyticsStream* comprising two methods, *StartAnalyticsStream()* and *StopAnalyticsStream()*. Follow the following steps to use the interface, the code samples may be useful, too:

Declare a variable of the type *ITcAnalyticsStream* and another one of the type *OTCID* for the object ID of the correspondent stream. For diagnostic purposes, an *HRESULT* variable is advisable.

```
HR : HRESULT := S_OK;
{attribute 'tcinitsymbol'}
oidPlcStream1 : OTCID;
ipPlcStream1 : ITcAnalyticsStream;
```

Next, add the attribute 'tcinitsymbol' above the OTCID variable. This way, it doesn't need to be initialized statically in the source code, instead it be initialized at configuration time by double clicking the PLC instance node in the project tree and selecting the relevant stream in the combo box as illustrated in the following picture.

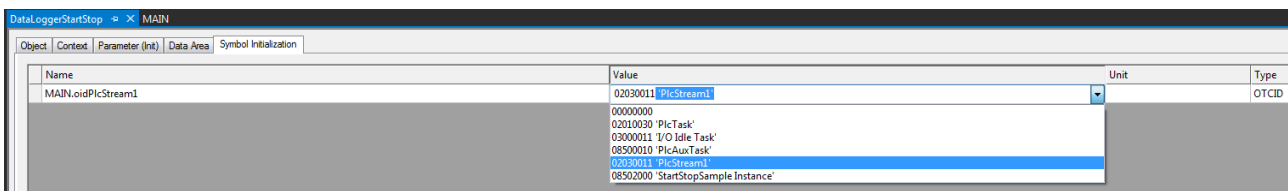


Fig. 1:

After that, get an interface pointer using following the TcCom-object server method and the interface's IID.

```
IF ipPlcStream1 = 0 AND oidPlcStream1 <> 0 THEN
    HR := FW_ObjMgr_GetObjectInstance(oidPlcStream1, IID_ITcAnalyticsStream, ADR(ipPlcStream1));
END_IF
```

Now you can use the interface pointer to call interface's methods. As shown in the following example:

```
IF ipPlcStream1 <> 0 THEN
  IF bStartPlcStream1 THEN
    ipPlcStream1.StartAnalyticsStream();
    bStartPlcStream1 := FALSE;
  END_IF
  IF bStopPlcStream1 THEN
    ipPlcStream1.StopAnalyticsStream();
    bStopPlcStream1 := FALSE;
  END_IF
END_IF
```

The stream is started in the same cycle `StartAnalyticsStream()` is called and will include the logged variable values. The stream is stopped in the same cycle `StopAnalyticsStream()` is called but *will not* include the variable values of this cycle.

In the Samples section of this documentation you can find a sample program that includes the here presented code snippets.

## 7 Samples

Data Logger Start/Stop stream from PLC code sample:

[https://infosys.beckhoff.com/content/1033/tf3500\\_tc3\\_analytics\\_logger/Resources/zip/6904617099.zip](https://infosys.beckhoff.com/content/1033/tf3500_tc3_analytics_logger/Resources/zip/6904617099.zip)

## 8 Appendix

### 8.1 FAQ - frequently asked questions and answers

In this section frequently asked questions are answered in order to make your work with TwinCAT Analytics Logger easier. If you have further questions, please contact our support team [support@beckhoff.com](mailto:support@beckhoff.com).

Should I always use TLS with MQTT? [▶ 54]

Is it possible to have multiple connections? [▶ 54]

Is it possible to control the Analytics Logger by a PLC function block? [▶ 54]

#### **?Should I always use TLS with MQTT?**

!Yes, you should if you can. If you can afford the overhead in CPU and bandwidth, then a secure communication channel is invaluable. Depending on the general CPU performance it could be possible to have a noticeable reduction of communication performance.

#### **?Is it possible to have multiple connections?**

!Yes, you can connect the Analytics Logger at the same time to different Message Broker just by adding a new instance of the Logger. Also it is possible to have one instance of the Logger for an MQTT communication to a Message Broker and at the same time one instance for writing data into Analytics File to the local system.

#### **?Is it possible to control the Analytics Logger by a PLC function block?**

!There is no special function block to control the Analytics Logger. But you can use an interface of the Analytics Logger to control him with easy commands like start and stop from the PLC. How to do see [this \[▶ 51\]](#) cheapter.



More Information:  
[www.beckhoff.com/tf3500/](http://www.beckhoff.com/tf3500/)

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