

APPLICATION NOTE: AN-0344

AC500 MQTT & MS AZURE FIRST STEPS AND CONFIGURATION



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1 Abbreviations

AJAXAsynchronous JavaScript and XMLCETCentral European TimeCMSCondition Monitoring SystemDTUDatabase Throughput Unit1JSONJavaScript Object NotationKPIKey Performance IndicatorMQTTMessage Queuing Telemetry TransportMSMicrosoftMVCProgrammable Logic ControllerRMSShared Access SignatureSQLStandardized Query LanguageSMSSQL Server Management StudioTTLTime-to-liveUTCCoordinated Universal Time	AB	Automation Builder
CMSCondition Monitoring SystemDTUDatabase Throughput Unit1JSONJavaScript Object NotationKPIKey Performance IndicatorMQTTMessage Queuing Telemetry TransportMSMicrosoftMVCModel-Viewer-ControllerPLCProgrammable Logic ControllerRMSShared Access SignatureSQLStandardized Query LanguageSSMSSQL Server Management StudioTTLTime-to-live	AJAX	Asynchronous JavaScript and XML
DTUDatabase Throughput Unit1JSONJavaScript Object NotationKPIKey Performance IndicatorMQTTMessage Queuing Telemetry TransportMSMicrosoftMVCModel-Viewer-ControllerPLCProgrammable Logic ControllerRMSRoot Mean SquareSASShared Access SignatureSQLStandardized Query LanguageSSMSSQL Server Management StudioTTLTime-to-live	CET	Central European Time
JSONJavaScript Object NotationKPIKey Performance IndicatorMQTTMessage Queuing Telemetry TransportMSMicrosoftMVCModel-Viewer-ControllerPLCProgrammable Logic ControllerRMSRoot Mean SquareSASShared Access SignatureSQLStandardized Query LanguageSSMSSQL Server Management StudioTTLTime-to-live	CMS	Condition Monitoring System
KPIKey Performance IndicatorMQTTMessage Queuing Telemetry TransportMSMicrosoftMVCModel-Viewer-ControllerPLCProgrammable Logic ControllerRMSRoot Mean SquareSASShared Access SignatureSQLStandardized Query LanguageSMSSQL Server Management StudioTTLTime-to-live	DTU	Database Throughput Unit ¹
MQTTMessage Queuing Telemetry TransportMSMicrosoftMVCModel-Viewer-ControllerPLCProgrammable Logic ControllerRMSRoot Mean SquareSASShared Access SignatureSQLStandardized Query LanguageSSMSSQL Server Management StudioTTLTime-to-live	JSON	JavaScript Object Notation
MSMicrosoftMVCModel-Viewer-ControllerPLCProgrammable Logic ControllerRMSRoot Mean SquareSASShared Access SignatureSQLStandardized Query LanguageSSMSSQL Server Management StudioTTLTime-to-live	KPI	Key Performance Indicator
MVCModel-Viewer-ControllerPLCProgrammable Logic ControllerRMSRoot Mean SquareSASShared Access SignatureSQLStandardized Query LanguageSSMSSQL Server Management StudioTTLTime-to-live	MQTT	Message Queuing Telemetry Transport
PLCProgrammable Logic ControllerRMSRoot Mean SquareSASShared Access SignatureSQLStandardized Query LanguageSSMSSQL Server Management StudioTTLTime-to-live	MS	Microsoft
RMSRoot Mean SquareSASShared Access SignatureSQLStandardized Query LanguageSSMSSQL Server Management StudioTTLTime-to-live	MVC	Model-Viewer-Controller
SASShared Access SignatureSQLStandardized Query LanguageSSMSSQL Server Management StudioTTLTime-to-live	PLC	Programmable Logic Controller
SQLStandardized Query LanguageSSMSSQL Server Management StudioTTLTime-to-live	RMS	Root Mean Square
SSMSSQL Server Management StudioTTLTime-to-live	SAS	Shared Access Signature
TTL Time-to-live	SQL	Standardized Query Language
	SSMS	SQL Server Management Studio
UTC Coordinated Universal Time	TTL	Time-to-live
	UTC	Coordinated Universal Time

¹ Measure of performance for databases in MS Azure

2 Introduction

2.1 Scope of the document

This manual gives a first introduction into setting up a cloud-based condition monitoring system with the AC500 PLC & the MS Azure cloud. It provides a step-by-step description of cloud configuration for a demo application.

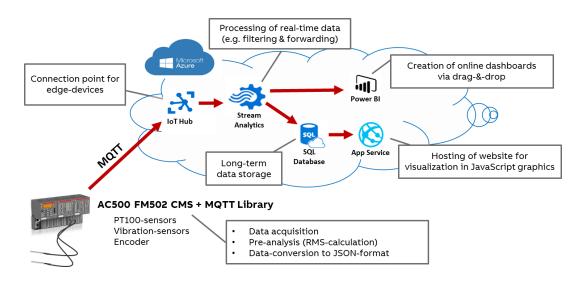
Capabilities of demo application

The demo application is able to store and visualize locally gathered data (temperature, speed, vibration velocity RMS and alarms) in the MS Azure cloud. Therefore, it enables global monitoring of KPIs and alarms.

2.2 Compatibility

The application note explained in this document is using functionalities and screenshots from the MS Azure portal. In future versions the naming or look and feel might be different. Check the azure documentation from Microsoft for further details.

2.3 Overview



Component	Function	
AC500 FM502 CMS	Collects data from local sensors (temperature, vibration & speed), processes them (calculation of vibration RMS & alarms, conversion to JSON-format) and sends them to the IoT Hub using MQTT-library	
loT Hub	Manages connection of Edge-devices, receives messages sent from AC500 and makes them accessible for other Azure-services	
Stream Analytics	Processes incoming messages in real-time: selects relevant data and for- wards them to other Azure services	
SQL Database	Receives data from Stream Analytics and stores them	
App Service	Hosts website to visualize the data from the database	
Power Bl	Enables easy creation of online dashboards	

For the visualization, two variants will be mentioned:

1. Visualization with a self-created website built inside App Service in MS Azure. The website is created using Asynchronous JavaScript and XML (AJAX) and is based on Model-Viewer-Controller (MVC).

It is a more sophisticated solution for user who want full control and flexibility of dashboard design and updating intervals. Furthermore, the website can be accessed by anyone who has the link. It does not require special MS licenses. However, it requires additional knowledge and effort of programming the website.

2. Visualization with Power BI, a MS-owned Business Intelligence service. It enables fast creation of dashboards & visuals via drag-and-drop and does not require any programming for visualization. Power BI can be used for free using an MS account. However, to access Power BI dashboards from others or to share own dashboards, users need a Power BI license (Power Bi Pro or Premium).

Power BI is a good way to get started with cloud visualization as it is easy to use and enables fast creation of dashboards without any programming. However, users are bound to MS and need to have licenses for more advanced functionality.

3 Cloud setup & configuration

3.1 Creation of MS Azure services

To get started, create the following Azure-services:

- IoT Hub
- Stream Analytics
- SQL Database (including server, database and table)
- App Service (For variant 1)

For the second approach, replace App Service by Power BI. This is an additional MS service, but not part of the MS Azure platform.

For further information on how to create and get these services, please follow the links below:

- How to create an IoT Hub
- How to create a Stream Analytics job
- How to create a SQL Database
- App Service overview
- What is Power BI?
- Get started with Power BI



Note: The selection of pricing & scaling models in Azure is depending on the actual requirements for the project

For the **demo application** following is chosen:

IoT Hub

.

•	Subscription:	Choose the Azure subscription

- Resource group: Create new group (Here: "DemoHD")
- Region: West Europe
 - IoT Hub name: Name the IoT Hub (Here: "DemoHD-IoT-Hub")
 - S1: Standard tier
- No. of IoT Hub units:

Pricing tier:

Stream Analytics Job

•	Job name:	Name the Stream Analytics job
		(Here: "DemoHD-StreamingAnalytics")
•	Subscription:	Choose the Azure subscription
•	Resource group:	Choose resource group created in IoT Hub
		(Here: "DemoHD")
•	Location:	West Europe
•	Hosting environment:	Cloud
•	Streaming Units:	3

SQL-Database

•	Database name:		Name the database				
•	Select source:		blank database				
•	Server:		Create a new server				
	 Server name 	:	Name the server				
	 Server admin 	n login:	Name the admin login				
	Password:		Define the password				
	 Server locati 	on:	West Europe				
•	Elastic pool:		No elastic pool				
•	Pricing tier:		Standard S0: 10 DTUs, 250 GB				
•	Collation:		SQL_Latin1_General_CP1_CI_AS				
•	Location:		West Europe				



Note: For the demo application, the standard pricing tier to have access to the most common functionality (e.g. to enable bidirectional communication with the IoT Hub) is used.

For the scaling (e.g. streaming/ IoT Hub units), the lowest scaling was chosen. Only one device is connecting and no complex data processing on cloud level is done.

3.2 Creation of SQL database tables

After creation of the SQL Server, "SQL Server Management Studio (SSMS)" can be used to create and modify the SQL databases and tables.

Start the SSMS software:

- Add the server name (will be selected when creating the SQL server in Azure)
- Username
- Password

🖵 Connect to Server		×						
	SQL Server							
Server type:	Database Engine	~						
Server name:	ac500sqlserver.database.windows.net	~						
Authentication:	SQL Server Authentication	\sim						
Login:	ac500	~						
Password:	•••••							
	Remember password							
	Connect Cancel Help Option	Connect Cancel Help Options >>						

Once logged the defined database, here: "DemoHD-Database" is visible. This database has already two tables. By default, there are no tables visible. We will focus only on table "dbo.PM592" in this example.

Reference in the second	er <u>T</u> ools <u>W</u> indow <u>H</u> elp					Launch (Ctrl+Q)	۹ – ۵
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😑 📑 ac500sqlserver.database.windows.net (SQL Server		datetime				11 24 ×	
😑 📕 Databases	PartitionId	int				🗆 (Identity)	
System Databases DemoHD-Database	EventEnqueuedUtcTime	datetime				(Name)	PM592
Demond-Database Database Diagrams	loTHub	text				Database Name	DemoHD-Database
🖂 🗰 Tables	device	text				Description	
🗉 🗰 System Tables	temp1	real				Schema Server Name	dbo ac500sglserver
🗉 🛑 External Tables	temp2	real				Table Designer	acousqiserver
🗉 📕 GraphTables	plctime	text				Identity Column	id
dbo.PM566 dbo.PM592	alarm1	text				Indexable	Yes
Hill dbo.PM092 Hill dbo.PM092 Hill dbo.PM092						Lock Escalation	Table
External Resources	alarm2	text				🗷 Regular Data Space	e PRIMARY
🗉 🗰 Synonyms	rms1	real				Replicated	No
🕀 💼 Programmability	rms2	real				Row GUID Colum	
🕀 📕 Query Store	😵 id	int				Text/Image Filegr	PRIMARY
Extended Events Storage	EventProcessedCetTime	datetime					
storage Security	EventEngueuedCetTime	datetime					
MesseAC500							
B Security	Column Properties			EvenProcessedUcTime Yes dateline			
4	✓ Table Designer (General)					(Identity)	

If no table like "PM592" is created yet, this can be done by right click - choose New →Table...

ac500sqlserver.DemoHD-Database - dbo.Table_1 - N File Edit View Project Debug Table Designe		itudio (Administrator)				Quick Launch (Ctr	+Q) 👂 🗕	□ ×
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External Resources		_				🕀 Regula	r Data Space PRIMARY	
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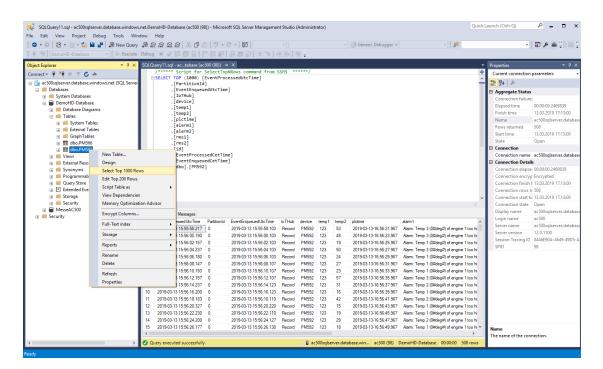
The table structure is the following:

Column Name	Data Type	Allows Nulls
EventProcessedUtcTime	datetime	NULL
PartitionId	int	NULL
EventEnqueuedUtcTime	datetime	NULL
IoTHub	text	NULL
device	text	NULL
temp1	real	NULL
temp2	real	NULL
plctime	text	NULL
alarm1	text	NULL
alarm2	text	NULL
rms1	real	NULL
rms2	real	NULL
id	int	IDENTITY(1,1) NOT NULL
EventProcessedCetTime	datetime	NULL
EventEnqueuedCetTime	datetime	NULL

id has PRIMARY KEY

The result will be the creation of the table "PM592".

Right click on the table PM592 and choose: "Select Top 1000 Rows". The result will be the following screen, with the data inside, if the PLC is already running.



3.3 Configuration of MS Azure services

After creation of Azure services and database, the configuration can be done.

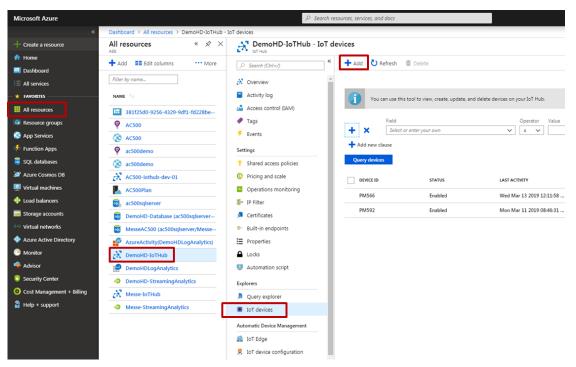
3.3.1 IoT Hub & device configuration

To enable communication between local devices (e.g. PM592) and the cloud, they need to be registered in the IoT Hub and a shared signature containing username and password for authentication has to be created.

This is how to proceed:

1) Add devices to the IoT Hub

- Go to All resources
- Select the IoT Hub
- Select IoT devices
- Click Add



- Name the device (Device Id)
 - use unique Ids
 - do not use underscores _
- Click Save

Microsoft Azure		res, and docs		>_ 67		> ti⊋ ∟ @ ? co torsten.rular) 日子 口 徳 ? ① torsten.ruland@de		> ti⊋ _ @ ? ⊙ torsten.ruland@de.ab		
*	Home > All resources > DemoHD-IoTHub - IoT devices > Create a device		-							A88	A58
+ Create a resource	Create a device										
🛧 Home	200										
🛄 Dashboard											
E All services	Find Certified for Azure IoT devices in the Device Catalog	12									
+ FAVORITES											
III resources	* Device ID PM592	~									
Stream Analytics jobs		¥									
💦 IoT Hub	Authentication type Symmetric key X.509 Self-Signed X.509 CA Signed										
📦 Resource groups	* Primary key 🖲										
🔕 App Services	Enter your primary key										
🥫 SQL databases	 Secondary key										
Storage accounts	Enter your secondary key										
Azure Active Directory	Auto-generate keys 👩										
Monitor											
🔶 Advisor	Connect this device to an IoT hub Enable Disable										
Security Center	Parent device (preview) 0										
O Cost Management + Billing	No parent device										
° Subscriptions	Set a parent device										
🕒 Recent											
dification Hubs											
📒 Activity log											
Log Analytics workspaces											
	Save										
	3470										

2) Generate Username + Password with Azure IoT Explorer

For authentication of local devices, username and password must be configured using MS Azure credentials and the Azure IoT Explorer.

• Open the IoT Hub in Microsoft Azure Portal

• Select Security settings > Shared access policies

Hub settings	Connect using shared access policies							
Built-in endpoints	🗟 Save 🏷 Discard change							
🔀 Message routing	Allow							
🕒 File upload	O Deny							
🐣 Failover	Manage shared access policies							
O Pricing and scale	+ Add shared access policy 🕐 Refresh 🛍 Delete							
Properties		m Delete						
🔒 Locks	Policy Name	Permissions						
Security settings	iothubowner	Registry Read, Registry Write, Service Connect, Device Connect						
🚷 Identity	service	Service Connect						
📍 Shared access policies	service	Service Connect						
↔ Networking	device	Device Connect						

• Click iothubowner and copy the Primary connection string

- Download and install / open Azure IoT Explorer or any similar software
- Select IoT hubs and click "Connect via IoT Hub connection string"

Azure IoT Explorer (preview)			
Home			
=			
윰 IoT hubs	Welcome to Azure IoT Explorer, a cross-		
${\mathscr S}^{\!$			
Q Notification Center	Choose an authentication method and connect to based on functionality. Learn more		
	Connect via IoT Hub		
	La Contraction de la Contracti		

• Click Add connection and parse the copied primary connection string



• Click View devices in this hub

DemoHD-IoTHub		
Host name		
DemoHD-IoTHub.azure-devices.net		D
shared access policy name		
iothubowner		D
shared access policy key		-
•••••	0	D
Connection String		-
	•••••••••••••••••••••••••••••••••••••••	D

• Select the required device (Here "PM592")

• Expand Connection string with SAS token

PM592			1
PM592			J 4
rimary key 💿			
		0	1
econdary key 🛈			
		۲] (
rimary connection string 💿			
		٥] [
econdary connection string			
		0] (
			1
Connection string with SA	AS token 💿		
Symmetric key *			
Primary key			
Expiration (minutes)			
60	\$ \$		
SAS token connection string			
HostName=DemoHD-IoTHu	b.azure-devices.net;DeviceId=PM592;SharedAccessSignature=SharedAccessSignature sr=DemoHD-IoTHub.azure-devices.net%2Fdevices%	-	D
Generate			
onnect this device to IoT hub			
Enable			

• Select Primary key as Symmetric key

• Define the **Expiration** time for the Shared Access signature in minutes. The table below gives some standard times in minutes:

Time	1 hour	1 day	1 week	1 month	1 year	5 years	10 years
In minutes	60	1440	10080	43200	525600	2628000	525600

Note: Once the validation time is expired the device is no longer able to connect to Azure IoT hub.

• Click Generate to generate a SAS token. This is looking like shown below:

HostName=DemoHD-IoTHub.azure-devices.net;DeviceId=PM592; SharedAccessSignature=SharedAccessSignature sr=DemoHD-IoTHub.azure-devices.net%2Fdevices%2FPM592&sig=0sqfp08OMiEfuezLqjv%2FcM3GsHgZt3pZGFfR 7JFN%2B%2B0%3D&se=17060xxxxx

In the PLC programming, Hostname, ClientID, Username and Password are required. These can be found inside the SAS token:

Hostname	DemoHD-IoTHub.azure-devices.net
ClientID	PM592
Username	DemoHD-IoTHub.azure-devices.net/PM592
Password	SharedAccessSignature sr=DemoHD-IoTHub.azure- de- vices.net%2Fdevices%2FPM592&sig=0sqfp08OMiEfuezLqjv %2FcM3GsHgZt3pZGFfR7JFN%2B%2B0%3D&se=17060xxxxx

Following IEC code snippet can be used to get Hostname, ClientID, Username and Password from the SAS token.

```
(*Maximum SAS length: 254 chars. If longer String Utils library must be used*)
FUNCTION AzureSASParser : BOOL
VAR INPUT
      SasTokenConnectionString: STRING(255) := 'HostName=<AzureHostName>;De-
viceId=<AzureClientId>;SharedAccessSignature=<SASContainingDevicePathAndSignature>';
END VAR
VAR OUTPUT
       sHostname: STRING(255);
       sClientID: STRING(255);
       sUsername: STRING(255);
       sPassword: STRING (255);
END_VAR
VAR
       iFindPos: INT := 0;
       iStartPos: INT;
END VAR
(* Hostname*)
iFindPos := iFindPos := FIND(SasTokenConnectionString, 'HostName=');
IF iFindPos = 0 THEN RETURN; END IF
iStartPos := iFindPos + 9; (* HostName= are 9 chars*)
iFindPos := FIND(SasTokenConnectionString, ';DeviceId');
IF iFindPos = 0 THEN RETURN; END_IF
sHostname := MID(SasTokenConnectionString, iFindPos-iStartPos, iStartPos);
(* DeviceId*)
iFindPos := FIND(SasTokenConnectionString, 'DeviceId=');
IF iFindPos = 0 THEN RETURN; END_IF
iStartPos := iFindPos + 9; (* DeviceId= are 9 chars*)
iFindPos := FIND(SasTokenConnectionString, ';Shared');
IF iFindPos = 0 THEN RETURN; END IF
sClientID := MID(SasTokenConnectionString, iFindPos-iStartPos, iStartPos);
(* SharedAccessSignature*)
iFindPos := FIND(SasTokenConnectionString, 'SharedAccessSignature=');
IF iFindPos = 0 THEN RETURN; END_IF
iStartPos := iFindPos + 22; (* SharedAccessSignature= are 22 chars*)
iFindPos := LEN(SasTokenConnectionString)+1; (* Last entry --> Stringlength *)
IF iFindPos = 0 THEN RETURN; END IF
sPassword := MID(SasTokenConnectionString, iFindPos-iStartPos, iStartPos);
(* Username *)
sUsername := CONCAT(sHostname, '/');
sUsername := CONCAT(sUsername, sClientID);
```

AzureSASParser := TRUE;

3.3.2 Stream Analytics Configuration

To process the content of messages sent to Azure, the Stream Analytics service is required. Using SQL-like queries, specific parameters from the message can be selected and modified and forwarded to the desired outputs (e.g. a SQL-database).

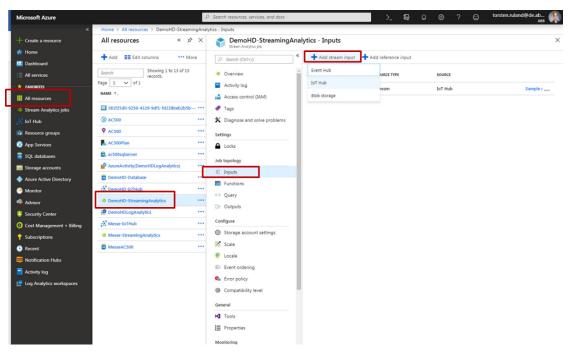
In Stream Analytics, inputs & outputs must be created.

The input is indicating the source of information (here: the IoT Hub, where the messages arrive).

The output is indicating, where the data should be sent to (here: SQL-Database for data storage and Power BI for real-time monitoring & visualization).

1) Create an IoT Hub input in Azure Stream Analytics

- Go to All resources
- Select the Stream Analytics Job
- Select Inputs
- Select Add stream input
- Select IoT Hub



Name the input (any name)

Choose the IoT Hub created before

Choose the subscription

Messaging

iothubowner

- Enter the following information:
 - Input alias:
 - Subscription:
 - IoT Hub:

•

- Endpoint:
- Shared access policy name:
- Consumer group:
 \$Default
- Event serial. Format: JSON
- Encoding: UTF-8
- Event compression type: None

Aicrosoft Azure		𝒫 Search resources, services, and docs	>_ 17	, C ⊗ ? ⊙ torsten.ruland@de.ab A88
	Home > All resources > DemoHD-StreamingA	nalytics - Inputs		Input details
Create a resource	All resources « 🖈 >	DemoHD-JoTHub		
🕈 Home	Add EE Edit columns ···· More	Stream Analytics job	+ Add stream input	
Dashboard			Add stream input	* Input alias
All services	Search Showing 1 to 13 of 13 records.	 Overview 	NAME SOURCE TYPE	DemoHD-IoTHub
FAVORITES	Page 1 V of 1	Activity log	DemoHD-IoTHub Stream	Provide IoT Hub settings manually
All resources	NAME 1.	Access control (IAM)		Select IoT Hub from your subscriptions
Stream Analytics jobs	1 381f25d0-9256-4329-9df1-fd228beb2b5b •	• 🛷 Tags		Subscription Subscription information not neede
🕻 loT Hub	@ AC500	X Diagnose and solve problems		subscription mornation not neede
Resource groups		• Settings		* IoT Hub O DemoHD-IoTHub
App Services	AC500Plan ••	Locks		
SQL databases	ac500sqlserver	Job topology		Endpoint Messaging
Storage accounts	AzureActivity(DemoHDLogAnalytics)	E Inputs		* Shared access policy name 🙃
Azure Active Directory	DemoHD-Database			snared access policy name iothubowner
Monitor	R DemoHD-IoTHub			Shared access policy key 🚯
Advisor	DemoHD-StreamingAnalytics	Query Outputs		=
Security Center	DemoHDLogAnalytics	. Outputs		Consumer group 🕚
Cost Management + Billing	🕅 Messe-IoTHub	. Configure		SDefault
Subscriptions	Messe-StreamingAnalytics			* Event serialization format ()
Recent	MesseAC500	Scale		V NO2L
Notification Hubs		👳 Locale		Encoding 🛛
Activity log		Event ordering		UTF-8
Log Analytics workspaces		💁 Error policy		Event compression type None
		Compatibility level		- Total
		General		
		M Tools		Save If the chosen resource and the stream
		Properties		analytics job are located in different regions, you will be billed to move data between regions.
		Monitoring		

2) Create a SQL-Database output in Azure Stream Analytics

- Select Outputs
- Select Add
- Select SQL-Database
- Enter the following information
 - Output alias:
 - Subscription:
 - Database:
 - Server name:
 - Username:
 - Password:
 - Table:

- Name the output (any name)
- Choose the subscription
 - Choose the SQL-Database created before

Choose the SQL-server created before

Enter "Server admin login" of SQL-server created in Creation of MS Azure services 3.1

Enter the "**Password**" of SQL-server created in Creation of MS Azure services 3.1

Name the table for storing the data (table must exist in the database)

• Press Save

osoft Azure		P Search resources, service	s, and docs	>_ 67	Q @ ? ☺ torsten.ruland@de.ab
•	Dashboard > Stream Analytics jobs > DemoHD-St				Output details
reate a resource	Stream Analytics jobs « 🖈 🗙	DemoHD-StreamingAna	lytics - Outputs		DemoriD-Database-PM592
lome	+ Add III Edit columns ···· More	Search (Ctrl+/)	+ Add		igz Jest Desete
Jashboard		,D' search (Ctn+/)			Output alias
Il services	Filter by name	 Overview 	NAME	SINK	Demon-D-Database-PM592
WORLTES	NAME T	Activity log	DemoHD-Database-PM566	SQL Database	Provide SQL Database settings manually
resources	DemoHD-StreamingAnalytics	Access control (IAM)	DemoHD-Database-PM592	SQL Database	Select SQL Database from your subscriptions
ream Analytics jobs	Messe-StreamingAnalytics	🖉 Tags			Subscription Subscription information not needed
l Hub		X Diagnose and solve problems			subscription information not needed
source groups		Settings			* Database DemoHD-Database
op Services		Locks			
QL databases		-			Server name ac500splserver.database.windows.net
orage accounts		Job topology			
ure Active Directory		E Inputs			* Username ac500
onitor		E Functions			Password
dvisor		Query			Password
curity Center		Outputs			* Table
st Management + Billing		Configure			Measurement
bscriptions		Storage account settings			Merge all input partitions into a single writer
scent		🔀 Scale			Inherit partition scheme of previous query step or input
otification Hubs		Locale			Max batch count.
tivity log		Event ordering			10000
		C Error policy			
g Analytics workspaces		Compatibility level			
		General			
		M Tools			
		E Properties			5ave If the chosen resource and the stream analytics job are located in different
		Monitoring			regions, you will be billed to move data between regions.
		fili Metrics			

- 3) Create a Power BI output in Azure Stream Analytics
 - Select Outputs
 - Select Add
 - Select Power BI
 - Enter the following information:
 - Output alias:
 - Group Workspace:

Name the output (any name)

Define to which workspace data should be sent

- Default is "My workspace":
 - only accessible for the authorized user
 - can be used without Power BI license
- Group workspaces
 - Enable sharing dashboards & reports with several users
 - Can only be used with Power BI Pro / Premium license
- Additional information on workspaces
- Dataset name: Name the dataset in Power BI
- Table name:Name the table in Power BI
- Press Authorize
- Enter e-mail-address of authorized user
- Press Save

•

Microsoft Azure		${\cal P}$ Search resources, services, and docs	>_ \$	🗧 📮 🔞 ? 😳 torsten.ruland@dc.ab 🥀
*	Home > DemoHD-StreamingAnalytics - O	lutputs		Power BI ×
+ Create a resource	DemoHD-StreamingAnaly	ytics - Outputs		New output
슈 Home		+ Add	Workspace:	Output alias
📕 Dashboard	, Search (Ctrl+/)	- Auu	Default is "My Workspace" >	DemoHD-PowerBI 🗸
E All services	Overview	NAME	only accessible for the - authorized user.	Group workspace
+ FAVORITES	Activity log	DemoHD-Database-PM566	Group workspaces can be	AcSoo - rest Area
All resources	Access control (IAM)	DemoHD-Database-PM592	created within the Power BI	DemoHD-Power8I-Stream 🗸
Stream Analytics jobs	🛷 Tags		website.	* Table name
💦 IoT Hub	X Diagnose and solve problems		Treporte.	DemoHD-Power8I-Table
😯 Resource groups	Settings			Currently authorized as Torsten Ruland (torsten ruland@de.abb.com)
🔇 App Services	Locks			Authorize connection
🥫 SQL databases	Job topology			You'll need to authorize with Power BI to configure your output settings.
Storage accounts	€ Inputs			Authorize
Azure Active Directory	Functions			Note: You are granting this output permanent access to
Monitor	<> Query			your Power BI dashboard. Should you need to revoke this access in the future you can do one of the following:
🔷 Advisor	⊒- Outputs			1. Change the user account password. 2. Delete this output.
Security Center				3. Delete this job.
Ost Management + Billing	© Storage account settings			
? Subscriptions	Scale			
🕒 Recent	🔮 Scale			
Rotification Hubs	Event ordering			
Activity log	Error policy			
Log Analytics workspaces	Compatibility level			
	General			
	Tools			
	Properties			
	Monitoring			
	iii Metrics			Save
	• • • • • • • • • • • • • • • • • • •			

4) Program query

After having created all the inputs & outputs, the query can be written. **Stream Analytics queries** are written with **SQL-like syntax**.

The basic elements of the query are the following:
--

Query element	Explanation
SELECT	Defines which values should be selected from the incoming data stream.
	Default is " * " which means that all data is taken and forwarded.
	Note 1: for writing data into the SQL-Database, a specific selection of parameters is recommended as precise names & IDs for each column inside the database-table must be defined. As the IoT Hub is adding parameters to the messages, there could arise issues otherwise.
	Also, a modification of parameters is possible. (e.g. adding hours to the timestamps given by the IoT Hub)
	Note 2: the order of selection is relevant as well. Therefore, please check with the structure of the message.
	Data that has been added by Azure IoT Hub will be on top of the mes-
	sage.
ΙΝΤΟ	Defines to which outputs selected data should be forwarded.
FROM	Defines from which inputs data should be processed.

For more complex queries, there are **additional elements** available.

Please check MS Azure for additional information.

Stream Analytics query in demo application

For every output, a separate query must be used.

In the demo application, the query looks like this:

Query 1 for SQL-Database output

Microsoft Azure	₽ Search resources, services, and docs
+ Create a resource	Home > DemoHD-StreamingAndytics > Query Query DemoHD-StreamingAndytics
■ Dashboard E All services	Enputs (1) Need help with your query? Check out some of the most common Stream Analytics query patterns here.
FAVORITES All resources	DemoHD-doTHub 1 Azure Stream Analytics jobs will only send data to one table per output. 2 Take the data from the ToT Hub and forward all this data to the SQL database> PMS92
🐼 Resource groups	Output Selection & modification SELECT Of parameters Demot
 Function Apps SQL databases 	B IoThib, GDemoHD-PowerBI 9 device, 10 temp2, 11
Azure Cosmos D8	12 plctime, 13 alarni, 14 alarn2,
Load balancers Storage accounts Virtual networks	15 rms1, 16 rms2 17 INTO 18 [Denok0-Database-PH592] (Dutput (SQL-Database)
Virtual networks Azure Active Directory Monitor Advisor	Specification for input (Device Id "PM592)

- SELECT
 - Takes the above-mentioned parameters from the message
 - Uses function Dateadd (+ 2 hrs) to change timestamp from UTC to CET-time
- INTO
 - Defines **SQL-Database** as output.
- FROM
 - Defines IoT-Hub as input.
- WHERE
 - Specifies that only data from device "PM592" should be taken from input. This "device" string is coming from the PLC JSON payload. In this example it is required that each message has the member "device": "PM592".

For further information check the application examples AC500 MQTT library and AC500 V3 JSON library.

Query 2 for Power Bl output

- SELECT
 - Takes the above-mentioned parameters from the message
 - Uses function Dateadd (+ 2 hrs) to change timestamp from UTC to CET-time
- INTO
 - Defines **Power BI** as output.
- FROM
 - Defines IoT-Hub as input.

```
48
    -- Azure Stream Analytics jobs will only send data to one table per output.
     -- Take the data from the IoT Hub and forward all this data to
49
    -- the PowerBI
50
51 SELECT
52
        EventProcessedUtcTime, Dateadd(hour , 2 , EventProcessedUtcTime) AS EventProcessedCetTime,
53
        PartitionId.
54
        EventEnqueuedUtcTime, Dateadd(hour, 2, EventEnqueuedUtcTime) AS EventEnqueuedCetTime,
55
         IoTHub,
56
        device.
57
         temp1,
58
         temp2,
59
         plctime.
         alarm1,
60
61
         alarm2,
62
         rms1,
63
         rms2
    INTO
64
        [DemoHD-PowerBI]
65
    FROM
66
67
      [DemoHD-IoTHub]
       ########### ENDE #############
68
```

3.3.3 Service App Configuration

This part will not be covered by the documentation. Please refer to the MS Azure documentation for more information.

3.3.4 Power BI Configuration

The easiest and fastest way to achieve cloud visualization is done by using Power BI, a MS product for Business Intelligence. It enables creation of dashboards, reports and other elements.

It can be used for free under the following conditions:

- A MS account (e.g. through corporate e-mail-address) is required
- You are the authorized user mentioned in 3.3.2 and use "My workspace"

(It means that only you have access to the data and nobody else can see reports created in Power BI)

The free version, however, only offers limited functionality (e.g. creation of reports).

With **the Power BI Pro** or **Power BI Premium license**, the **full functionality** can be used to share data, dashboards, reports, etc. with others.

To find out more about Power BI licenses, please check Power BI.

Creation of dashboards

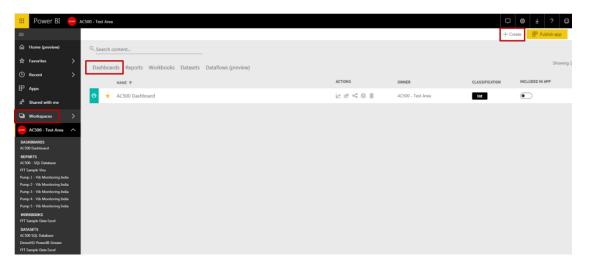
This documentation will describe how a dashboard can be created in Power BI. A dashboard is a canvas where graphics & data from streaming datasets (e.g. the dataset created in 3.3.2) can be implemented. Dashboards are temporary and update automatically – as long as the chosen data stream is sending data.

For the creation of dashboards, a **Power BI license** is **required**.

Please check the MS documentation for further information on dashboards.

To create a dashboard, proceed like this:

- Log in to Power BI
- Press Workspaces
- Select the Workspace chosen in 3.3.2 (Here the group workspace: "AC500 – Test Area" is choosen)
- Press Dashboards
- Press Create



- Press Add tile
- Select Custom Streaming Dataset
- Press Next

🗰 Power BI 🗧	ACS00 - Test Area > DemoHD Dashboard			2 🛛 🕲	? 🕒 🥷
=		+ Add tile 💬 Comments 🔄 Usage metrics 🕬 Usage View relation	Add tile		
A Home (preview)			Select source		
🛱 Favorites			MEDIA		
C Recent			HLUM .		
🕀 Apps			[]		AA
g ^R Shared with me			Web content	Image	Text box
Workspaces					
AC500 - Test Area 🗸	× .				
DASHBOARDS AC500 Dashboard DemoHD Dashboard			Video		
REPORTS AC500 - SQL Database					
FFT Sample Visu					
			REAL-TIME DATA		
			((0))		
Pump 4 - Vib Monitoring India Pump 5 - Vib Monitoring India			((0))		
WORKBOOKS			Custom Streaming		
FFT Sample Data Excel			Data		
FFT Sample Data Excel Pump 1 - Vib Monitoring India					
DATAFLOWS You have no dataflaws				Next	Cancel
-					

 Select the dataset created in 3.3.2 Here: "Demo-HD-PowerBI-Stream"

					2	\Box	8	₹	?	ę.
+ Add tile	Comments	Usage metrics	¤⊂ <mark>¤</mark> View relati	Add a custom		eami	ng d	lata	tile	
				-	+ Add	streamir	ng datas	et		
				YOUR DATASETS						
					DemoHl	D-Power	BI-Strea	m		

Enter following information

- Visualization Type
- Axis:
- Values:
- Time window to display:

Line Chart

Choose the timestamp for the x-axis Here: EventProcessedUtcTime Choose the parameters that should be show Here: temp1, temp2 Choose the desired time window Here: Last 1 min

POWER BI 🔤 ACS00 - Test Area > 1	DemoHD Dashboard				▶ ♥ ♥ ♥ ₹ ? €	• (
=		+ Add tile	Comments 🗠 C	Usage metrics α_0^0 View relation	Add a custom streaming data tile	
Home (preview)	np2				Choose a streaming dataset > Visualization design	
Favorites Favorites Favorites	OCESSEDUTCTIME					
⊙ Recent >					Visualization Type	
EP Apps				L	Line chart.	
gR Shared with me	AAAAAAAAAAAAAAAAAAAAAA			l l	Ans	
Workspaces					EventProcessedUtcTime	* =
AC500 - Test Area				L L	* Add volue	
DASHBOARDS ACSIO Dashboard	M 101015 AM 101230 AM 101045 AM				Legend	
DemoHD Dashboard ····					+ Add value	
REPORTS AC500 - SQL Database						_
FFT Sample Visu					Values	
Pump 1 - Vib Monitoring India Pump 2 - Vib Monitoring India					temp1	• 🗄
Pump 3 - Vib Monitoring India						
Pump 4 - Vib Monitoring India					temp2	* 8.
Pump 5 - Vib Monitoring India					+ Add value	
WORKBOOKS				L	- Plate Velice	
FFT Sample Data Escel						
DATASETS AC500 SQL Database					Time window to display	
DemoHD-Powerfil-Stream					Last 1 * Minutes *	
FFT Sample Data Escel						
Pump 1 - Vib Monitoring India						
Pump 2 - Vib Monitoring India						
Pump 3 - Vib Monitoring India						
Pump 4 - Vib Monitoring India Pump 5 - Vib Monitoring India					Manage datasets	
DATAFLOWS						
DATAFLOWS You have no dataflows					Back Next Can	ncel

- Press Next
- Name the tile
- **Optional**: set a link to
 - An external website
 - Another Power BI document in the chosen workspace (e.g. report or another dashboard)
- Press Apply

Now a dashboard for real-time monitoring of the temperature values is created. More features (e.g. alerts) can be added to this dashboard.

To find out more, please check the Power BI documentation.

4 PLC Configuration

The settings how to connect from an AC500 PLC to an MQTT broker are explained in the application example AC500 MQTT library. Details about the JSON format and how to use this in the AC500 V3 PLC are explained in the application example AC500 V3 JSON library.

4.1 Publish and subscribe topics

In this MS Azure example the topics to send and subscribe data are:

- devices/{device_id}/messages/events/ (here: devices/PM592/messages/events/)
- devices/{device_id}/messages/devicebound/# (not used in this example)

4.2 Certificate for Azure

4.2.1 DigiCert

Azure IoT Hub is using the "DigiCert Global Root G2" root certificate for signing. This can be extracted from Windows CertMgr. (Run "certmgr.msc")

🚟 certlm - [Certificates - Local Comp	outer\Trusted Root Certification Author	ities\Certificates]					
File Action View Help							
🔶 🐟 🖄 📰 🕹 📰] 📑 🛛 🖬						
💭 Certificates - Local Computer	Issued To	Issued By	Expiration Date	Intended Purposes	Friendly Name	Status	Certificate Tem
> 📔 Personal	AAA Certificate Services	AAA Certificate Services	01.01.2029	Client Authenticati	Sectigo (AAA)		
Trusted Root Certification Au	ABB Ability(tm) Root CA	ABB Ability(tm) Root CA	12.06.2048	<all></all>	<none></none>		
Certificates	ABB ECC Root CA	ABB ECC Root CA	04.08.2036	<all></all>	<none></none>		
> 📔 Enterprise Trust	ABB Ltd - Master	ABB Ltd - Master	23.06.2021	<all></all>	<none></none>		
> Intermediate Certification Au > Trusted Publishers	ABB Root CA	ABB Root CA	27.02.2028	<all></all>	<none></none>		
Inusted Publishers Inusted Certificates	ABB SWG iBoss CA 00	ABB Root CA	23.03.2025	Client Authenticati	<none></none>		
> Third-Party Root Certification	Baltimore CyberTrust Root	Baltimore CyberTrust Root	13.05.2025	Client Authenticati	DigiCert Baltimore		
> Trusted People	Certum CA	Certum CA	11.06.2027	Client Authenticati	Certum		
Client Authentication Issuers	Certum Trusted Network CA	Certum Trusted Network CA	31.12.2029	Client Authenticati	Certum Trusted Net		
> Preview Build Roots	Class 3 Public Primary Certificat	Class 3 Public Primary Certificatio	02.08.2028	Client Authenticati	VeriSign Class 3 Pu		
> Test Roots	Copyright (c) 1997 Microsoft C	Copyright (c) 1997 Microsoft Corp.	31.12.1999	Time Stamping	Microsoft Timesta		
> 📋 AAD Token Issuer	DigiCert Assured ID Root CA	DigiCert Assured ID Root CA	10.11.2031	<all></all>	<none></none>		
> 📔 Other People	GigiCert Assured ID Root CA	DigiCert Assured ID Root CA	10.11.2031	Client Authenticati	DigiCert		
> 🧾 eSIM Certification Authorities		DigiCert CS RSA4096 Root G5	15.01.2046	Code Signing, Time	DigiCert CS RSA409		
> 📔 Homegroup Machine Certific	GigiCert Global Root CA	DigiCert Global Root CA	10.11.2031	Client Authenticati	DigiCert		
> 🧮 Remote Desktop	DigiCert Global Root G2	DigiCert Global Root G2	15.01.2038	Client Authenticati	DigiCert Global Roo		
> 📔 Certificate Enrollment Reque:	DigiCert Global Root G3	DigiCert Global Root G3	15.01.2038	Client Authenticati	DigiCert Global Roo		
> 📔 Smart Card Trusted Roots	DigiCert High Assurance EV Ro	DigiCert High Assurance EV Root	10.11.2031	<all></all>	<none></none>		
> 📔 SMS	DigiCert High Assurance EV Ro	DigiCert High Assurance EV Root	10.11.2031	Client Authenticati	DigiCert		
> Install	DigiCert Trusted Root G4	DigiCert Trusted Root G4	15.01.2038	Client Authenticati	DigiCert Trusted Ro		
> 🧾 Trusted Devices	DST Root CA X3	DST Root CA X3	30.09.2021	Client Authenticati	DST Root CA X3		
> 🧾 Windows Live ID Token Issuer	D-TRUST Root Class 3 CA 2 EV 2	D-TRUST Root Class 3 CA 2 EV 2009	05.11.2029	Client Authenticati	D-TRUST Root Class		
> WindowsServerUpdateService	Entrust Root Certification Auth	Entrust Root Certification Authority	27.11.2026	Client Authenticati	Entrust		

Right click \rightarrow All Tasks \rightarrow Export

Please be sure, that you extract the file as "Base-64" encoded:

Ex	port File Format	
	Certificates can be exported in a variety of file formats.	
	Select the format you want to use:	
	O DER encoded binary X.509 (.CER)	
	Base-64 encoded X.509 (.CER)	
	Cryptographic Message Syntax Standard - PKCS #7 Certificates (.P7B)	
	Include all certificates in the certification path if possible	
	 Personal Information Exchange - PKCS #12 (.PFX) 	
	Include all certificates in the certification path if possible	
	Delete the private key if the export is successful	
	Export all extended properties	
	Enable certificate privacy	
	 Microsoft Serialized Certificate Store (.SST) 	

4.2.2 How to change from Baltimore to DigiCert?

"Starting in February 2023, all IoT hubs in the global Azure cloud will migrate to a new TLS certificate issued by the DigiCert Global Root G2." https://learn.microsoft.com/en-us/az-ure/iot-hub/migrate-tls-certificate?tabs=portal

To change the root certificate steps in the AC500 and the Azure portal are necessary.

Attention not only the root certificate but also the IP address is changing. A DNS resolve inside the program is required. If missing, please add before trying to connect.

- 1. Export the **DigiCert Global Root G2 as described in chapter** Error! Reference source not found.
- 2. Connect to the PLC and open the Security Screen
- 3. Open Devices, select Trusted Certificates and install the new certificate

User	Ф	Information		Information	Issued for	Issued by	Valid from	Valid until
	-	PLC_AC500_V3	×	B	Baltimore CyberTrust Root	Baltimore CyberTrust Root	12.05.2000 20:46:00	13.05.2025 01:59:00 (> 1 year)
Project		Own Certificates	4073	10	DigiCert Global Root G2	DigiCert Global Root G2	01.08.2013 14:00:00	15.01.2038 13:00:00 (> 1 year)
Devices	_	Trusted Certificates	1					
Devices		Untrusted Certificates						
		Quarantined Certificates	6*					
			(*)					

If using "AC500_MQTT" library, continue here.
 If using "MQTT Client SL" library, continue with step 8.

Please use only one of both libraries.

🖪 Add Library 🔀 Delete Library 🔄 Properties 🐻 Details 🛛 🖾 Placeholders 🔮 Library Parame	Library Kepos	itory of icon Legend E Summar
Libraries used in application 'PLC_AC500_V3.Application'		
Name	Namespace	Effective Version
🖲 🚺 3SLicense = 3SLicense, 3.5. 19. 10 (3S - Smart Software Solutions GmbH)	_3S_LICENSE	3.5.19.10
🗷 - 🚺 AC500_DiagCpu = DiagCpu, 1.2.3.1 (ABB)	AC500_DiagCpu	1.2.3.1
🖲 🔝 AC500_DiagIoBus = DiagIoBus, 1.2.3.2 (ABB)	AC500_DiagIoBus	1.2.3.2
AC500_DiagTypes = DiagTypes, 1.2.7.2 (ABB)	AC500_DiagTypes	1.2.7.2
🕮 🔝 AC500_Ethernet = Ethernet, 1.5.0.5 (AB8)	AC500_Ethernet	1.5.0.5
🖲 💟 AC500_Io = Io, 1.2.4.1 (ABB)	AC500_Io	1.2.4.1
🖲 🔝 AC500_IoDrvEthernet = IoDrvEthernet, I.O.3.1 (ABB)	AC500_IoDrvEthernet	1.0.3.1
AC500_Mqtt = Mqtt, 1.1.3.1 (ABB)	AC500_Mqtt	1.1.3.1
AC500_Pm = Pm, 1.2.8.10 (ABB)	AC500_Pm	1.2.8.10
🖲 🔟 BreakpointLogging = Breakpoint Logging Functions, 3.5.17.0 (3S - Smart Software Solutions GmbH)	BPLog	3.5.17.0
🕮 🕕 [1] IoStandard = IoStandard, 3.5.17.0 (System)	IoStandard	3.5.17.0
MQTT_Client_SL = MQTT Client SL, 1.9.0.0 (CODESYS)	MQTT	1.9.0.0
Standard = Standard, 3.5.18.0 (System)	Standard	3.5.18.0

5. Copy the thumbprint of the certificate

eneral	Details	Certification	Path	
show:	<al></al>		~	
Field			Value	^
Su	bject		DigiCert Global Root G2, www	
Pu	blic key		RSA (2048 Bits)	
		arameters	05 00	
		Identifier	4e2254201895e6e36ee60ffaf	
	sic Constr	aints	Subject Type=CA, Path Lengt	
	y Usage		Digital Signature, Certificate Si	
	24f9bf	d666761b	df3c24f9bfd666761b268073fe 268073fe06d1cc8d4f82a4	×
		d666761b		v

6. In the code, where the connect fb is called, change the ServerCert

7. Login to the PLC via online change and create a boot project

The existing MQTT connection will remain only new connections will be done via the new certificate.

- 8. Login to azure portal
- Open the IoT hub and click "Migrate to DigiCert Global G2"
 Certificates —

Certificate Hub root certificate
This resource uses a certificate on the soon-to-expire Baltimore CyberTrust Root and must be updated to the DigiCert Global G2 root. All devices that connect to this resource must be updated to trust the DigiCert Global G2 root to avoid disruption due to this change. Learn more
This resource uses a TLS certificate that by default is on a public chain of trust and provided by Azure. All devices connecting to this resource require the public portion of this certificate. Learn more
Certificate root Baltimore CyberTrust root (expiring soon)
Minrate to Dini/Cert Global G2

10. Check all boxes and click Update

nected Devices				
08				Γ
0.6				
0.4				
0.2				
0				
12 PM	6 PM	Jan 12	6 AM	
Connected devices (Mar)				
Connected devices (Max)				
Connected devices (Max)				
earn more about IoT Hub migration	root.			
earn more about IoT Hub migration have updated my devices to trust the DigiCert Global G2 r understand that any devices not updated will not be able		es to reconnect.		

Please be patient. The update might take some time

11. After the update check if the PLC is still connected. Trigger a new connect to check if the connection with the new certificate is working properly.

5 FAQs

5.1 Which QoS does Azure support?

Please check:

https://docs.microsoft.com/de-de/azure/iot-hub/iot-hub-mqtt-support

Azure IoT Hub does not support QoS 2 messages.

When a device app publishes a message with QoS 2, IoT Hub closes the network connection.

5.2 Does Azure support multiple connections with the same device?

Please check:

https://docs.microsoft.com/de-de/azure/iot-hub/iot-hub-mqtt-support

Azure IoT Hub only supports one active MQTT connection per device. Each new MQTT connection for the same device ID causes the IoT Hub to disconnect the existing connection.

5.3 Does Azure support Retain flag?

Please have a look at this link:

https://docs.microsoft.com/de-de/azure/iot-hub/iot-hub-mqtt-support

IoT Hub does not persist retention messages. When a device sends a message with the RETAIN flag set to 1, IoT Hub adds the application property x-opt-retain to the message. In this case, IoT Hub does not persist the retention message, but passes it on to the back-end app.

5.4 What are the costs for sending and storing data on Azure?

It depends on the amount of data that will be send. Each data they will be send to Azure, will be received by a generic broker, called IoT Hub on Azure side. This data will be stored in the broker database until the Streaming Analytics job from Azure access the data and forward them, for example to a SQL database. This means, as more data they will be send to Azure, as more you must pay.



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