Getting Started – Sparkplug B

Revision History		
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Designed, Manufactured and Distributed by EZAutomation
4140 Utica Ridge Rd. Bettendorf, IA 52722-1327
P**hone: 1-877-774-3279 (EASY)**
**Fax: 1-877-775-3279**
www.EZAutomation.net

Getting Started – Sparkplug B

This setup guide is for using the EZRack PLC with Inductive Automation's Ignition platform. Using this guide, the EZRack PLC will be setup to communicate over MQTT to the Ignition platform using the Sparkplug B specification. This allows the EZRack PLC's tag to automatically show up in the Ignition software. Please follow the instructions below to create a basic project that will communicate to Ignition.

Note: This MQTT communication is for use with the Inductive Automation's Ignition Platform with the Cirrus-Link IIoT Modules. For more information please visit https://inductiveautomation.com/ and http://www.cirrus-link.com/. There is a quick setup guide for the needed Ignition modules included at the end.

EZRack Sparkplug B Setup

1. Launch the EZRack PLC Designer Pro version 2.1.0 or higher. *Note: You will need EZRack PLC firmware version A.0.297 or higher.*
2. On the Project Information screen click the button option "**Open / New Project**".
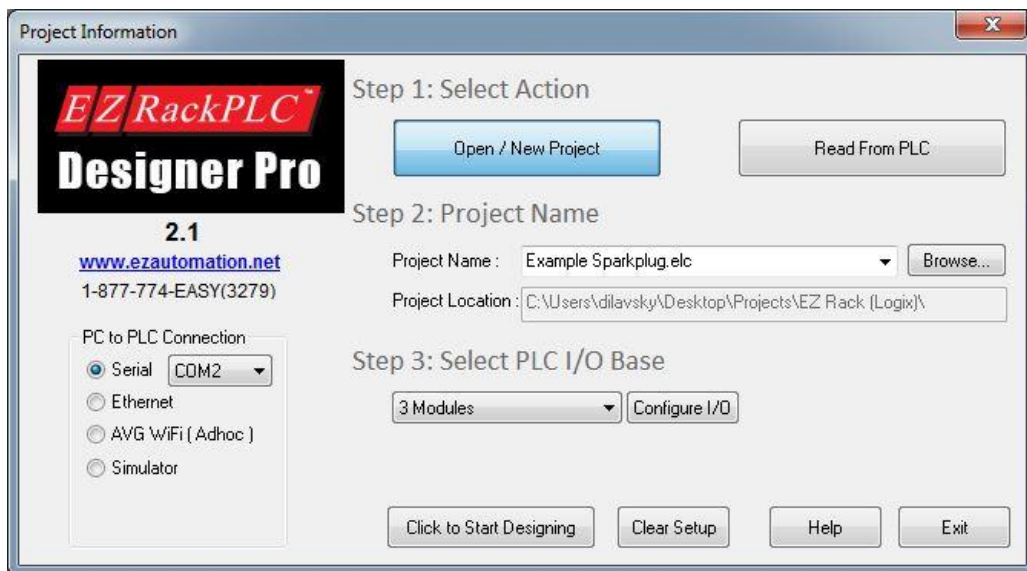
3. Select a project or enter a project name (new project names will create a new project). You can also configure your I/O if you would like, but it is not needed. Then click the button "**Click to Start Designing**".
4. Once the project is open, we will add a contact and coil. In the right side bar click on the Normally Open Contact and place it down anywhere in the Main Logic area. Next select a Normally Open Coil and place it down as well.

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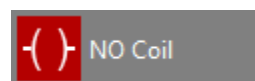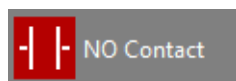
5. Next double click on the NO Contact and in the next dialogue enter a tag name, for example OPEN CONTACT. Then click OK.
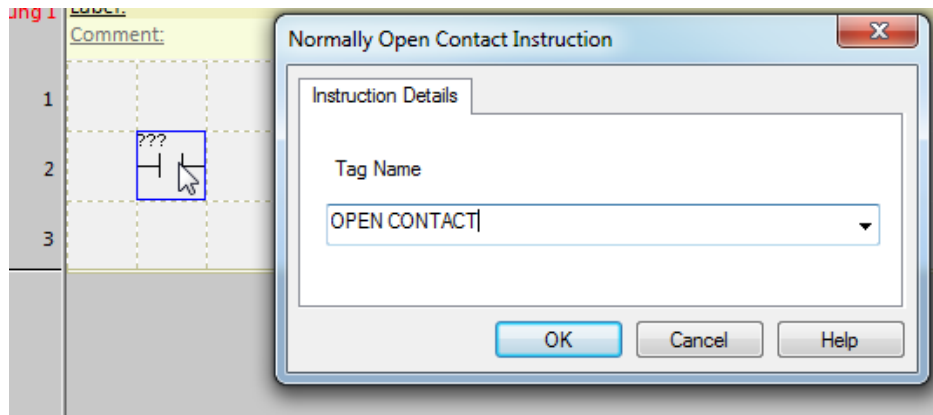
6. Next do the same for the NO Coil, giving it a different name, for example OPEN COIL.
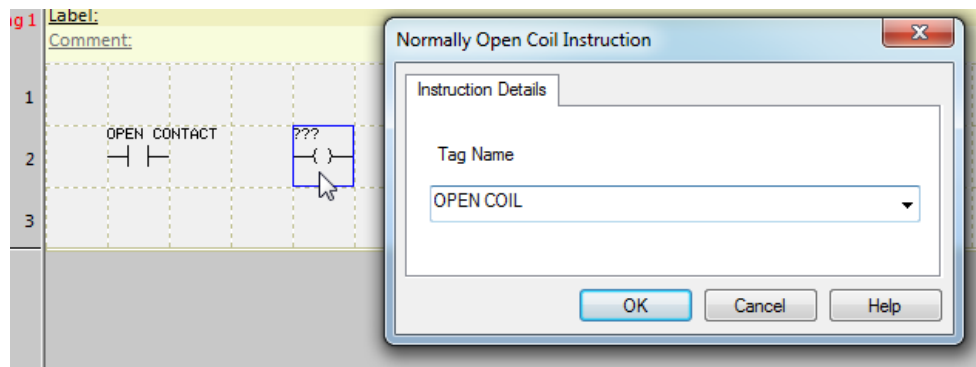
7. Finally make sure that the contacts are connected. If need be use the line option (in top toolbar) to connect the left side to the NO Contact and the NO Coil. You can also double click in the ladder logic. *Note: You do not need to connect the line all the way to the right side power rail.*
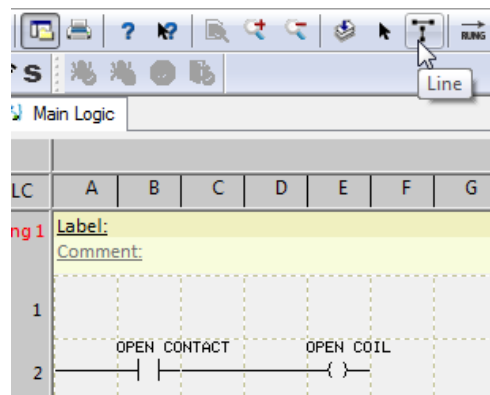
8. Now you will need to setup the sparkplug to communicate to the broker. Please make sure you have the following information from the Ignition Broker.

Information Type	Example Information
User Name to Connect to Broker	admin
Password to Connect to Broker	changeme
Domain Name (Server URI) or IP Address of Broker	10.1.200.12
Port Number (TLS or non-TLS)	1883 (TLS 8883)

9. Next open the Sparkplug Setup. It is on the Navigation window / project tree on the left side. It is also under **Setup > Sparkplug Setup ….**
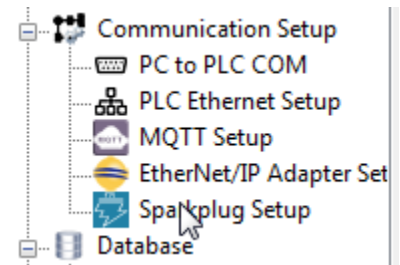
10. In the Sparkplug dialogue box please enter a Client ID. *Note: The Primary Host ID is used for Redundant Ignition Environment, please see the section on Redundancy for more information.*

11. Next you can change the Group ID, Node ID, and Device ID. The final options in the first tab, if selected, will have the PLC provide some basic info about the CPU and USB to the Ignition platform.

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12. In the Brokers tab please enter the IP address of the Broker or use the Domain Name Lookup to find the IP address. For the Domain Name Lookup just enter the Domain Name and it will input the needed IP address.

13. Please enter the Port and set the Keep Alive Interval. Finally enter the Username and Password for the Broker.

    Note: Please refer to the security section to setup TLS security.

    Note: The EZRack supports up to 4 different brokers. Please see the redundancy section for more information.

14. Finally in the Publish Tags section add the Open Contact and Open Coil tags. Then select the Open Contact and make it Read/Write. Please see next page for button descriptions.

    Note: You can also set the tag to be stored in case of Broker connection loss. Please see the Store and Forward section for more information.

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Button descriptions:

a. Add Topic: Use this to add a topic from the Available Tags list (Table on left). If no tag select then can add a folder (topic).
b. Rename Topic / Metric: Can rename either a topic or even a tag. Note: The name change does not affect the tag database name of the tag.
c. Remove Topic / Tags: Removes selected topic or tag. If topic removed, it will also remove any subtopics and tags in the topic.
d. Make Tag(s) Read Only: Makes the tag read only, this means that cannot use external means to change this tag.
e. Make Tag(s) Read Write: Allows tags to be changed externally. For example Ignition could now use the open coil tag as a button, instead of just an indicator.
f. Enable Tag(s) Store: Allows redundancy to work with that tag.
g. Disable Tag(s) Store: Disables redundancy to work with that tag.

15. Now go to **File > Transfer to PLC.** Please make sure you are connected to the PLC and have the correct PC to PLC Connection.

16. Once the project has been transferred and the PLC is running you will now see the tags in your Ignition Designer software in the tag browser. After enabling Read/Write you will be able to use the OPEN_CONTACT to turn ON/OFF the OPEN_COIL.
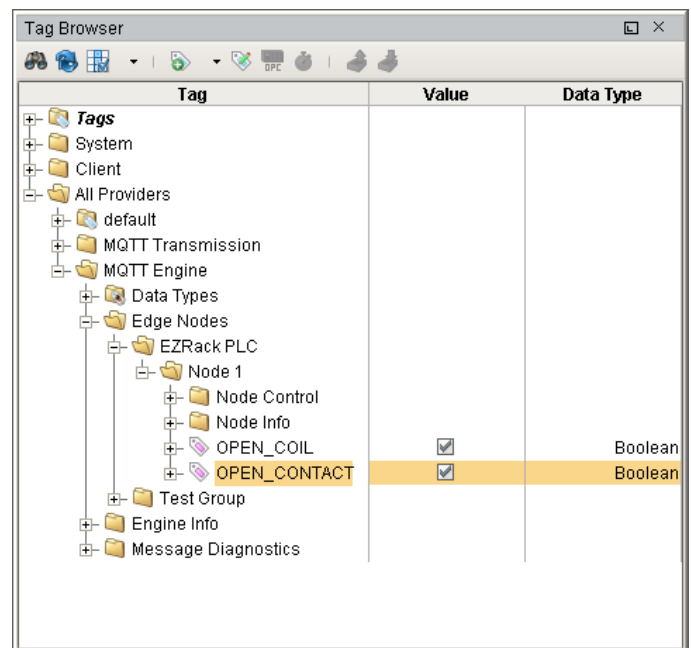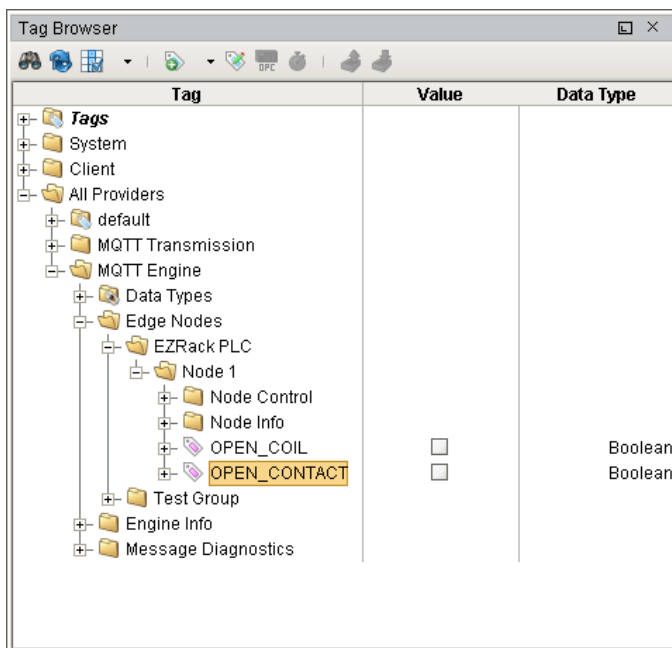
Note: For basic Ignition setup instructions you can see the next section of this Getting Started Guide or you can visit https://inductiveautomation.com/ and http://www.cirrus-link.com/ for more information.

For more help on creating logic in the EZRack Designer Pro and other functionality please refer to the Software Manual or the Software Help File.

Basic Ignition MQTT Modules Setup

This section briefly explores how to add to Ignition the Cirrus-Link MQTT modules and where to find the needed information to setup the EZRack PLC. Please visit https://inductiveautomation.com/ and http://www.cirrus-link.com/ for more information.

Cirrus Link Needed Modules

Please download the following modules from https://inductiveautomation.com/downloads/ignition.

- MQTT Distributor Module
- MQTT Engine Module
- MQTT Transmission Module

Adding Needed Modules

1. Go to localhost:8088 and Log into your Ignition Software. *Note: This assumes you have already setup the Ignition platform.*
2. Go to the Configure tab and select **System > Modules.**
3. Scroll all the way down to the bottom of the page and click Install or Upgrade Module.
4. Select the wanted module and click Install. The module will be installed and Ignition will restart.
5. Repeat for all 3 needed modules.

Cirrus-Link Guide to Using the 3 Modules

https://docs.chariot.io/display/CLD/Getting+Started%253A+Single+Ignition+Architecture

EZRack PLC Information

The above Cirrus-Link Guides explains how to use the 3 Modules and make changes to their setup. If no changes are made then the default information needed to use with the EZRack PLC is listed below. This information is changed and modified in the MQTT distributor Module. Note: If you do modify it then both the MQTT Engine and MQTT Transmission will also need to be modified.

Information Type	Example Information
User Name to Connect to Broker	admin
Password to Connect to Broker	changeme
Domain Name (Server URI) or IP Address of Broker	IP address of the computer with Ignition Running
Port Number (TLS or non-TLS)	1883 (TLS 8883)

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### Advanced Sparkplug Setup (Security and Encryption)

The EZRack PLC supports Encryption and Certificate security. Encryption is used to make sure that no one can listen to the data the EZRack PLC is sending out to the Broker. The certificate authentication is used to make sure that the Broker is the one you want. The EZRack PLC will also support client certificate authentication in the future, where the Broker will be able to tell that the EZRack PLC is the correct Client.

Encryption and Certificate Basics

When the EZRack PLC attempts to communicate with a Broker over a secure SSL connection, the PLC and the Broker establish the SSL connection using a process called an "SSL Handshake" (see diagram below). Note that the SSL Handshake is invisible to the user and happens instantaneously.

Essentially, three keys are used to set up the SSL connection: the public, private, and session keys. Anything encrypted with the public key can only be decrypted with the private key, and vice versa.

Because encrypting and decrypting with private and public key take a lot of processing power, they are only used during the SSL Handshake to create a symmetric session key. After the secure connection is made, the session key is used to encrypt all transmitted data.
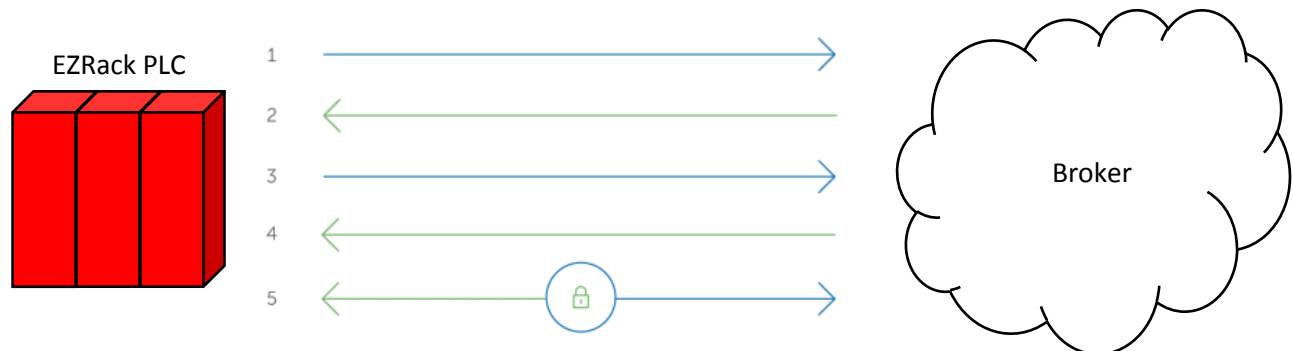
When using security the process is as follows:

1. The EZRack PLC contacts the Broker and requests it identifies itself.
2. The Broker sends a copy of its SSL Certificate including the Broker's public key.
3. The EZRack PLC checks the certificate against a list of trusted CAs and that the certificate is unexpired. If the EZRack PLC trusts the certificate, it creates, encrypts, and sends back a symmetric session key using the Broker's public key.
4. The Broker decrypts the symmetric session key using its private key and sends back an acknowledgement encrypted with the session key to start the encrypted session.
5. The EZRack PLC and Broker now encrypt all transmitted data with the session key.

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Example of how keys work and protect from spying on your connection:
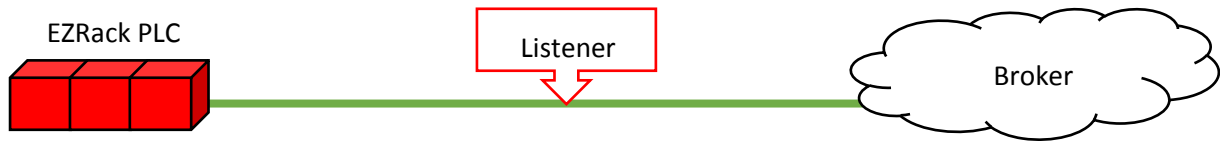
Diffie–Hellman Key Exchange is the concept that explains how keys work without a Listener being able to decrypt the message. The following examples are commonly used to explain this concept.

Cryptographic Example:

The simplest and the original implementation of the protocol uses the multiplicative group of integers modulo p, where p is prime, and g is a primitive root modulo p. These two values are chosen in this way to ensure that the resulting shared secret can take on any value from 1 to p − 1.

EZRack PLC and Broker agree to use a modulus p = 23 and base g = 5 (which is a primitive root modulo 23).

EZRack PLC chooses a secret integer a = 4, then sends Broker A = g^a mod p

$$A = 5^4 \bmod 23 = 4$$

Broker chooses a secret integer b = 3, then sends EZRack PLC B = g^b mod p

$$B = 5^3 \bmod 23 = 10$$

EZRack PLC computes s = B^a mod p

$$s = 10^4 \bmod 23 = 18$$

Broker computes s = A^b mod p

$$s = 4^3 \bmod 23 = 18$$

EZRack PLC and Broker now share a secret (the number 18).

Both EZRack PLC and Broke have arrived at the same value s, because, under mod p,

$$A^b \bmod p \ = \ g^{ab} \bmod p \ = \ g^{ba} \bmod p \ = \ B^a \bmod p$$

More specifically,

$$(g^a \bmod p)^{\ b} \bmod p \ = \ (g^b \bmod p)^{\ a} \bmod p$$

Note that only a, b, and (g^{ab} mod p = g^{ba} mod p) are kept secret. All the other values – p, g, g^a mod p, and g^b mod p – are sent in the clear. Once EZRack PLC and Broke compute the shared secret they can use it as an encryption key, known only to them, for sending messages across the same open communications channel.
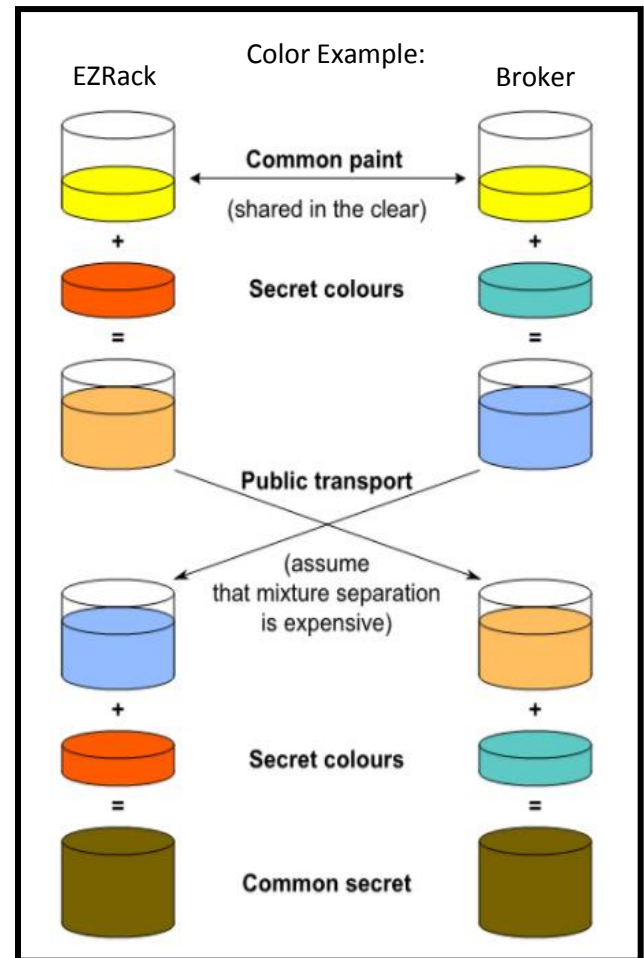
EZRack PLC Encryption and Certificate Authority Setup:

To setup the EZRack to use encryption follow the directions below:
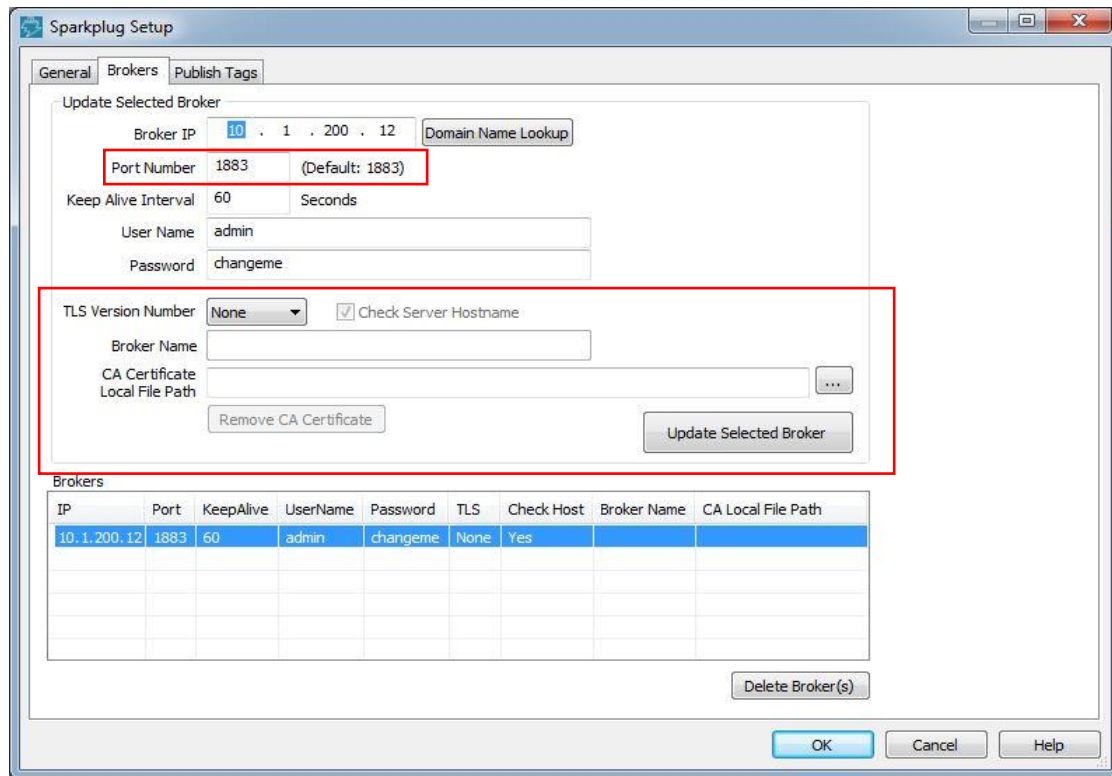
1. To setup encryption you will need to go to the Sparkplug Setup (**Setup > Sparkplug Setup…**) and then to the Brokers tab.

2. Now add a new broker or edit the current broker.

3. In the Port Number you will need to change it to the port used for SSL security. The Ignition SSL secure port is 8883.

4. For TLS Version Number select the newest that is supported by your broker. Most brokers should be able to use TLS version 1.2.

5. Next in the Certificate Authority (provided by broker), find and select the file in your local directory.
   a. You can also select the checkbox next to Check Server Hostname. If you do check this make sure to enter your hostname in Broker Name field. With this box checked the Server Certificate will be checked to make sure that the hostname matches.

6. Finally click the Update Selected Broker button.

7. The EZRack will now use TLS (SSL) secure communication and check the Certificate of the broker.

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Ignition Encryption and Keystore Setup

To setup the Ignition MQTT Distributor Module to use encryption follow the directions below:

1. Go to localhost:8088 and Log into your Ignition Software. *Note: This assumes you have already setup the Ignition platform and MQTT Modules setup.*
2. Go to the Configure tab and select **MQTT Distributor > Settings.**
3. Under General the TLS Configuration will need to be enabled. You can also at this point change the secure MQTT port if you want.

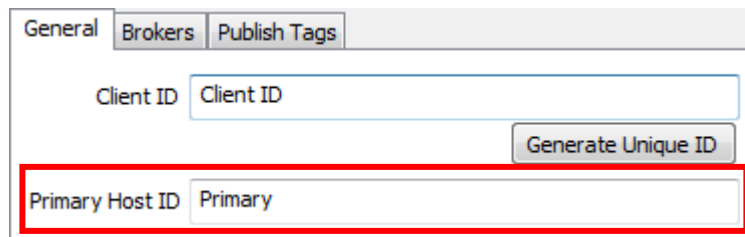| **TLS Configuration**		
Enable TLS	☑ Enable or Disable TLS for the MQTT Server	
Secure MQTT Port	8883	
	TLS enabled MQTT Server port	
Secure Websocket Port	9443	
	TLS enabled MQTT Server Websocket port	
Keystore Password		
	Java keystore password	
Java Keystore File	Choose File No file chosen	
	Java Keystore File to upload for SSL enabled MQTT	

4. Next you will need to provide a Java Keystore file to the Distributor. This Keysore will include the Certificate for the Broker and the Key pair of public and private key for the Broker. Use the Choose File option and navigate to the Keystore to select it.

5. You also need to enter the Keystore Password in the field above the File.

6. Finally click the button to Save Changes. The MQTT distributor will now have TLS (SSL) Security and Authentication Enabled.

The EZRack and MQTT Distributor should now be able to communicate over the secure MQTT port.

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Redundancy Setup (EZRack PLC and Ignition):

The EZRack PLC supports a redundancy backup system of Brokers. What this means is that the Broker tab allows the user to input up to 4 different Brokers. If more than one broker is setup and the EZRack cannot connect to the first Broker it will cycle through the rest of Brokers and try to connect to them. This makes sure that the EZRack will be connect even if a Broker fails.

The EZRack also supports the Redundant Ignition Environment. To learn more about the Ignition Redundant Environment you can visit Cirrus Link website and their help documentation. This environment is setup to have a failover backup for the primary/master ignition instance. It also lets the EZRack know that it has moved to the backup through the Primary Host ID.
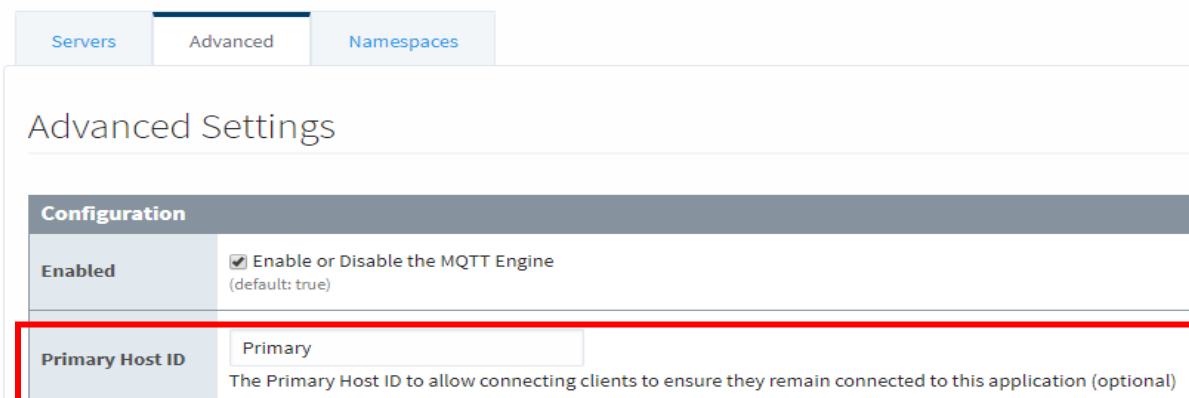

To setup the Redundant Ignition Environment on the EZRack you will only need to input the Primary Host ID from the MQTT Engine Settings. The Primary Host ID which is used to ensure client to client communications. The only requirement is that it match exactly on both the MQTT Engine and EZRack configurations. Also you will need to ensure that both the Master and Backup Brokers are listed in the Brokers tab.

Cirrus Link Documentation: https://docs.chariot.io/display/CLD/Advanced%3A+MQTT+Modules+in+Redundant+Ignition+Environment

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Store and Forward Setup:

The EZRack PLC supports "store & forward" for approximately 500 past historical values in a First In, First Out (FIFO) format. This is used in conjunction with the Ignition Historian databases. If the EZRack ever were to lose connection with all the Brokers it will retain all the needed Sparkplug Ignition MQTT information that can be later forwarded to the Ignition Software after connection is reestablished. This information is battery backed up so that it can be retained over a power cycle as well.

Store and Forward works with a GMT (UTC) to make sure that information is slotted into the right location. Therefore please use the _SR_TIME_ZONE system register to set the time zone you are in. Please see the next paged on how to do this correctly. *Note: System Registers are not retentive over a power cycle.*

To setup Store and Forward for tags please follow the directions below:

1. Please go to your **Sparkplug Setup > Publish Tags** tab.

2. For any tag you can select it and click the Enable Store option.
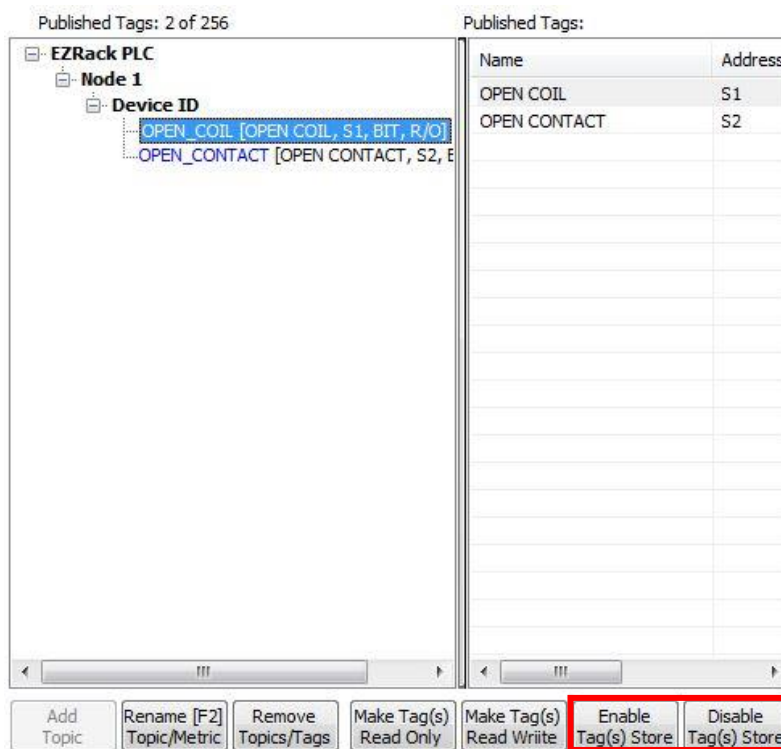
3. After this option is clicked the EZRack will store tag data if the Broker connection is lost. When the Broker reestablished all the changed information with time and date stamp, the data will be sent to the Ignition software.

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Store and Forward Time Zone Setup

When the EZRack PLC has to store and then forward the information, the time stamp used with the Ignition software needs to be in GMT (UTC). The EZRack Time and Date is setup to be used in your current time zone and therefore for the Store and Forward to work correctly the different from GMT needs to inputted into the System Register _SR_TIME_ZONE (SR29). Please see directions below about setting this up correctly.

1. To setup the Time Zone, please first go to a website like https://www.timetemperature.com/ to figure out your time zone. Some basic time zones are mentioned below.

2. Convert the hour time zone difference to minutes. For example if for Central time of -6 hours, please use -360 minutes.

Time Zone	GMT time offset (UTC)	Number to Enter into _SR_TIME_ZONE (SR29)
Eastern Standard Time (EST)	- 5 hours	-300
Central Standard Time (CST)	- 6 hours	-360
Mountain Standard Time (MST)	- 7 hours	-420
Pacific Standard Time (PST)	- 8 hours	-480
Middle European Time (MET)	+ 1	60
Indian Standard Time (IST)	+ 5.5	330
China Standard Time (CST)	+ 8	480
Australian Eastern Standard Time (AEST)	+ 10	600

3. Next create a first scan rung with a Move Data instruction.
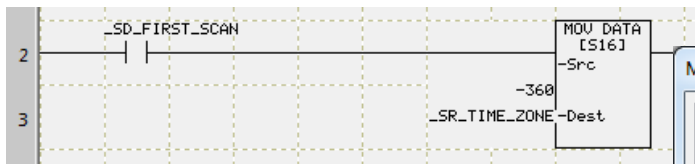
4. If you do not need to set this external (ex: from HMI) then you can set the Move Data Instruction to move the constant value selected above to the System Register. *Note: System registers are not retentive over a power cycle.*

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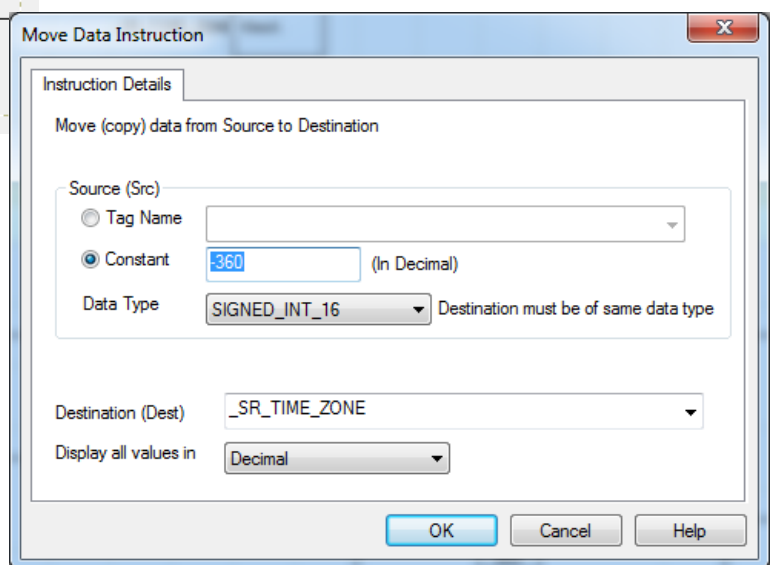
5. If you need to set it externally, please use a Register tag to store the value and move this value into the _SR_TIME ZONE upon power up. Please note that you should set the System Register from the HMI and then have an instruction to store the value into a register like below.
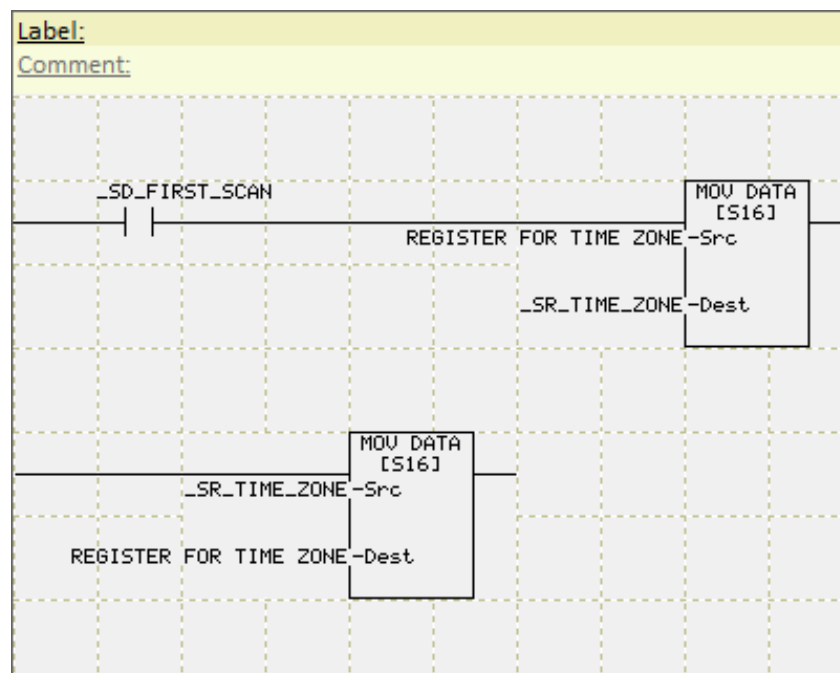
Troubleshooting Sparkplug B Setup:

This section will outline some basic EZRack PLC Sparkplug B troubleshooting tips. The EZRack PLC has some System Discretes and System Registers to help figure what might be causing your problem.

System Discretes

System Discretes Name	System Discretes	Description	Read/Write
_SD_SPARKPLUG_CONFIG_ERROR	SD29	This bit will turn on if the Sparkplug configuration has an error.	Read Only
_SD_SPARKPLUG_PUBLISH_ERROR	SD30	This bit indicates if the EZRack PLC is not able to publish a message to the broker.	Read Only
_SD_SPARKPLUG_RUNNING_STATUS	SD31	This bit is ON if the Sparkplug MQTT is connected to the Broker and publishing correctly.	Read Only

System Registers

System Register Names	System Registers	Description	Read/Write	Data Type
_SR_TIME_ZONE	SR29	This register is used to set the timestamp of messages to correspond to GMT (UTC).	Read/Write	SIGNED_INT_16
_SR_SPARKPLUG_CURRENT_BROKER_INDEX	SR30	If multiple Brokers are defined this register will indicate which broker is connected (0-3)	Read Only	UNSIGNED_INT_16
_SR_SPARKPLUG_STORE_FORWARD_FIFO_COUNT	SR31	When Store and Forward is enabled this will indicate how many tag updates are stored	Read Only	UNSIGNED_INT_16
_SR_SPARKPLUG_TASK_COUNTER	SR32	Each time that Sparkplug communication is initiated this counter will increment.	Read Only	UNSIGNED_INT_16

Troubleshoot Tips

Error	Suggested Solution
Configuration Error (SD29 is ON)	This suggested that your configuration on the Sparkplug setup is incorrect. Recommend creating a simple Sparkplug program and seeing if that works. Then work up to the project that caused this error.
Publish Error (SD30 is ON)	This suggest that broker is refusing EZRack MQTT messages. I would check that the EZRack has permission to publish to those topics. Also I would check the username and password of the EZRack PLC Broker sign in. Also check that Client ID is unique.
Sparkplug Not Running (SD31 is ON)	Please make sure that the Broker is accessible from the network the EZRack PLC is on. Further check the username and password of the EZRack PLC sign in. Also check that Client ID is unique. Finally if using TLS security I would make sure that the CA is current and that the PLC time makes the CA valid.
Store and Forward Not Working	Please make sure that the tags you would like to store are set to store configuration. Also please make sure that you are setting the time zone correctly so that store forward slots the information in the right time slot. Note that ignition works of GMT (UTC) and not the current time zone you are in.

Error	Suggested Solution
EZRack connected to Broker but Ignition is not seeing connection	Please make sure that the EZRack is connected to the correct Broker that the Ignition software is connected to. Also please make sure that both EZRack and Ignition have correct permissions with Broker (ACLs).
Non-TLS connection works but TLS does not	Please make sure that the for TLS security you have included a valid Certificate Authority and that the Time on the EZRack PLC has been set so the CA is valid.

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Contact Information:

Technical Support: If you still need assistance, please call our technical support at 1-877-774-3279 or email us at techsupport@ezautomation.net

Customer Service: 1-877-774-3279 or email us at sales@ezautomation.net

Website: www.EZAutomation.net

Address:
EZAutomation, division of AVG
4140 Utica Ridge Rd.
Bettendorf, IA 52722

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