



## Modbus Slave TCP/IP

### Implementation of Modbus Slave TCP/IP for Alfen NG9xx platform

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# 1 Introduction

This is a draft of the implementation of the Modbus slave functionality to the NG9xx charging stations of Alfen N.V. All information in this document might be subject to change in the future and should be used as an indication of which functionality will be supported.

There is an important difference between the master and slave roles in the Modbus communication protocol. This implementation covers the slave role that supports serving a Modbus master, these roles are also referred to server and client roles respectively when using Modbus over TCP/IP. The master initiates the connection to the slave and sends either read or write requests of certain Modbus registers.

The current Modbus implementation supports up to two simultaneously connected Modbus TCP/IP masters, UDP is not supported. There is a keep alive timeout of 60 seconds before the connection with a Modbus master is closed when no new read or write is received. The Modbus master should connect to the IP of the Modbus slave's wired Ethernet connection on port 502. Requests with certain slave addresses are accepted, where charging station related Modbus registers require slave address 200 and socket related Modbus registers require slave address 1 or 2, depending on the socket. All communication must be in the big endian format.

New values of received written registers by Modbus masters are logged in the charging station, only if this value is different than the current one.

This document is based on using:

- Firmware version 4.10
- Service Installer Application 3.4.10-130

## 1.1 Configuration options

Configuring the Modbus slave functionality can be done using the Alfen ACE Service Installer<sup>1</sup> with an administrator account or version 4.0 or higher with a service account. The charging station requires the license key for “Active load balancing” before the Modbus slave functionality can be enabled. The following configured settings are persistent and remain preserved when the charging station reboots.

Name	Function
<b>Allow reading</b>	Allow reading of Modbus registers via TCP/IP. By default this is turned off.
<b>Allow writing maximum currents</b>	Allow writing maximum current Modbus registers. By default this is turned off.
<b>Enable sockets</b>	This enables the charging station to take the written maximum current values for sockets into account when calculating the actual maximum current for all the sockets.
<b>Enable SCN</b>	This enables the charging station to take the written maximum current values for SCN into account when calculating the actual maximum current for all the SCN phases.
<b>Validity time</b>	The validity time is the time in seconds in which the charging station requires an updated maximum current from a Modbus master before falling back to the safe current. The validity time is equal for all maximum currents, however each maximum current has its own remaining valid time which is updated every time that maximum current is set via Modbus. The default validity time is 60 seconds. It is recommended that the polling time of a Modbus master is lower than the validity time.
<b>IP Address allocation</b>	DHCP or fixed IP
<b>Port</b>	502
<b>Modbus slave addresses</b>	1: measurements socket 1 2: measurements socket 2 (if available)
<b>Supported Modbus functions</b>	0x03: Read Holding Registers 0x06: Write Single Register 0x10: Write Multiple Registers

## 1.2 Reading registers

The Modbus slave implementation supports reading of holding registers with Modbus function code 3. Multiple registers can be requested within one Modbus request, as long as they are contiguous. Whenever a register is reserved or not available, the register reply is filled with Not a Number (NaN), which is set to 0xFFFF for a 16 bit register.

There are a Modbus registers that contain the datatype string. String registers contain strings where each 16-bit Modbus register contains two 8-bit ASCII chars. A string always contains a trailing zero.

**Note: Reading registers is done in network byte order.**

<sup>1</sup> Available at <https://alfen.com/downloads>

## 1.3 Writing registers

The Modbus slave implementation supports writing of holding registers. When writing a value with a datatype that contains multiple Modbus registers, then all registers should be written within one write request. For example when a variable is a 32 bit float, both consecutive 16 bit registers should be written in one Modbus request. When the Modbus write request does not write all registers, the request will be denied and a Modbus error will be returned.

**Note: Writing registers is done in network byte order.**

### 1.3.1 Maximum current

It is possible to set the maximum current via Modbus for a specific socket, or for a specific phase of the SCN network. Each maximum current has additional registers that are read only for the enabled property, actual maximum current, the configured safe current and the remaining validity time. Each time the maximum current is written via Modbus, the remaining valid time is updated with the validity time. For example, when the validity time is 60 seconds and the maximum current has been written most recently 10 seconds ago, then reading of the remaining valid time register will result in 50.

The maximum current and remaining valid time are not preserved during a reboot of the charging station. Since the enabled and safe current settings are persistent, the behaviour of the charging station will be such that it will first fall back to the safe current and waits for the Modbus master to rewrite the maximum current.

When a maximum current is enabled and the Modbus master did not update this for a certain time, the charging station will fall back to its safe current. The safe current has to be set before the maximum current can be set via Modbus. This value can also be configured by the back office.

Then internal handling of a newly written maximum current by the charging station can require some time. The time before the actual used current by the connected car is adapted to this relies on multiple factors, for starters by the response speed of the car itself.

## 1.4 Phase rotation

It must be noted that the naming of the phases depend on the installation and thus are for the charging station relative to the incoming phase rotation. This could potential result in confusion on the Modbus master side, especially when multiple Modbus slave charging stations are connected.

An example could be two charging stations of which the first is connected in order of the incoming phase connection L1-L2-L3, while the second charging station is wired in order L2-L3-L1. This could mean that if the Modbus master wants to read the current the current through phase L1, it should read the register of the phase L1 on the first charging station and the register of the phase L2 of the second charging station.

## 2 Enabling Modbus Slave in charging stations

Modbus Slave over TCP/IP is activated when the station is configured to communicate with an Energy Management System (EMS) and when Active Load Balancing is activated. Active Load Balancing is the functionality the currently implements Modbus Slave TCP/IP as a means of communication.

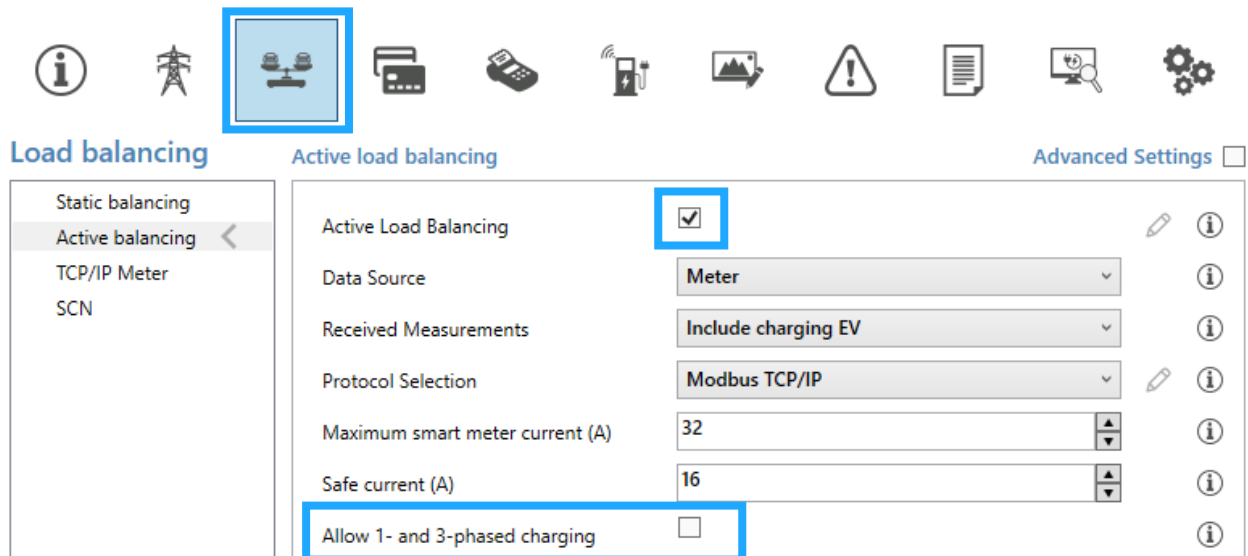
Note: Active Load Balancing is a locked feature of the charging station. It can only be unlocked after purchasing that feature. After the purchase, the unique license key of the charging station is updated.

This chapter displays the steps to take to enable Modbus Slave TCP/IP for e.g. testing purposes.

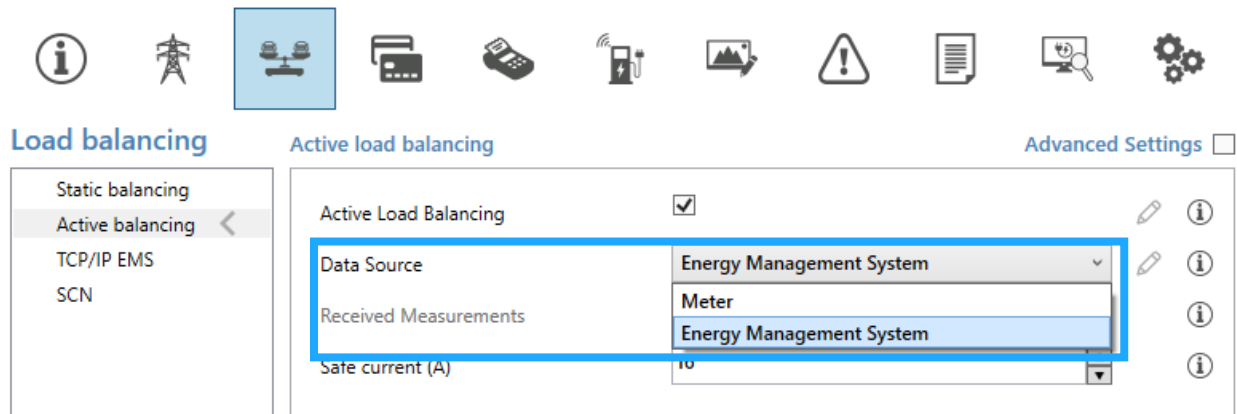
To configure the charging station on site, an account for Service Installer Application (SIA) is required. In case you do not have an account yet, please visit <https://support.alfen.com> to request an account.

### 2.1 Activate Active Load Balancing

Active Load Balancing can be activated using the selection box in the Section 'Load Balancing' of the Service Installer Application. In the menu on the left, select "Active balancing".



**Note:** the checkbox for 'Allow 1- and 3-phased charging'. This option must be active to allow an Energy Management System to control switching between single-phase and three-phases while charging. In the current implementation this option must be checked locally using the Service Installer Application.



In the Active Balancing menu, select your Data Source:

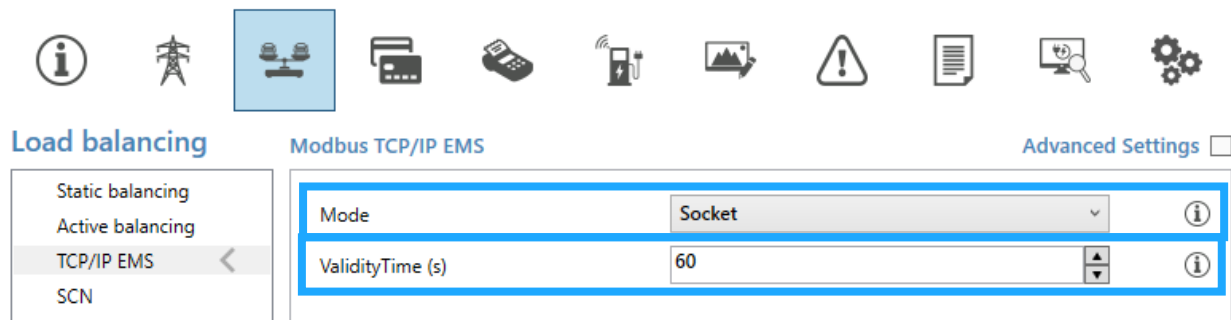
- **Meter**; This will activate 'Master' role for the charging station
- **Energy Management System**; This will activate 'Slave' role for the charging station

As a 'Master', the charging station calculates the available budget left for charging vehicles. Other consumers are considered of higher priority. Charging ramps up only if possible

As a 'Slave', the charging station responds to a command from an external device like an Energy Management System (EMS). The external device determines the priority of charging and acts accordingly. The charging station ramps up/down upon request.

## 2.2 Energy Management Systems

When Selecting 'EMS', the charging station will be configured as a 'Slave'. In the menu bar on the left, 'TCP/IP EMS' appears. Modbus TCP/IP is selected by default, no other protocol can be selected yet.



The following options are available:

### Mode;

- **Socket;** control each socket
- **SCN;** control the charging station as a complete station, or control a complete Smart Charging Network as one entity.

**Validity time (s);** After validity time, the station assumes that the Energy Management System (EMS) is not available anymore and reverts to safe current, configured in menu 'Active balancing'. Register values must be rewritten before validity time has expired.

### Configuring IP-address of the charging station

The charging station is by default configured to work with automatic IP allocation using DHCP. This can be used for Modbus Slave TCP/IP operation as well (station being the TCP server). To retrieve the station's identity use (for example) mDNS to retrieve its DNS name

- **Service type:** \_alfen.\_tcp.local
- **Assigned IP address**
- **Port:** 80
- **Modelname-serial number:** NG920-61001-ACE0012345 (example)
- **Station Identifier** ALF\_123 (example)
- **SCN name** (if applicable): ALF\_HBW (example)

As an alternative it is also possible to use a fixed IP address on the network to find the station.

- Navigate to tab 'Connectivity'
- Click 'Wired' in the menu on the left
- Select Fixed IP address
- Fill in the details

See figure below for the screen to configure a fixed IP address.





## Connectivity

### Wired

Advanced Settings ☒

General		
Wired		
Proxy		
Websocket		
Heartbeat		
Status notification		
Transaction data		
Meter value		
Central meter		
Nuvve		
Back office security		
Eichrecht		

Back office URL	<input type="text"/>	
Back office path	<input type="text"/>	
Fixed IP address	<input checked="" type="checkbox"/>	
IP address	<input type="text"/>	
Netmask	<input type="text"/>	
Gateway address	<input type="text"/>	
DNS 1	<input type="text"/>	
DNS 2	<input type="text"/>	
Ethernet MAC address	<input type="text"/>	

## 3 Modbus Register table

### 3.1 Product identification registers

The product identification registers can be reached using slave address 200.

Description	Start address	End address	Number of 16 bit registers	Read or Write	Data Type	Step size & Units	Additional info
<b>Name</b>	100	116	17	R	STRING	n.a.	"ALF_1000"
<b>Manufacturer</b>	117	121	5	R	STRING	n.a.	"Alfen NV"
<b>Modbus table version</b>	122	122	1	R	SIGNED16	n.a.	1
<b>Firmware version</b>	123	139	17	R	STRING	n.a.	"3.4.0-2990"
<b>Platform type</b>	140	156	17	R	STRING	n.a.	"NG910"
<b>Station serial number</b>	157	167	11	R	STRING	n.a.	"00000R000"
<b>Date year</b>	168	168	1	R	SIGNED16	1yr	2019
<b>Date month</b>	169	169	1	R	SIGNED16	1mon	03
<b>Date day</b>	170	170	1	R	SIGNED16	1d	11
<b>Time hour</b>	171	171	1	R	SIGNED16	1hr	12
<b>Time minute</b>	172	172	1	R	SIGNED16	1min	01
<b>Time second</b>	173	173	1	R	SIGNED16	1s	04
<b>Uptime</b>	174	177	4	R	UNSIGNED64	0.001s	100
<b>Time zone</b>	178	178	1	R	SIGNED16	1min	Time zone offset to UTC in minutes

## 3.2 Station status registers

The station status registers can be reached using slave address 200.

Description	Start address	End address	Number of 16 bit registers	Read or Write	Data Type	step size & Units	Additional info
<b>Station Active Max Current</b>	1100	1101	2	R	FLOAT32	1A	The actual max current
<b>Temperature</b>	1102	1103	2	R	FLOAT32	1°C	Board temperature, does not reflect environment temperature
<b>OCPP state</b>	1104	1104	1	R	UNSIGNED16	N.A.	To verify whether back office is connected
<b>Nr of sockets</b>	1105	1105	1	R	UNSIGNED16	N.A.	Number of sockets

### 3.3 SCN registers

The SCN registers can be reached using slave address 200.

Description	Start address	End address	Number of 16 bit registers	Read or Write	Data Type	step size & Units	Additional info
<b>SCN name</b>	1400	1403	4	R	STRING	n.a.	
<b>SCN Sockets</b>	1404	1404	1	R	UNSIGNED16	1A	Number of configured sockets
<b>SCN Total Consumption Phase L1</b>	1405	1406	2	R	FLOAT32	1A	
<b>SCN Total Consumption Phase L2</b>	1407	1408	2	R	FLOAT32	1A	
<b>SCN Total Consumption Phase L3</b>	1409	1410	2	R	FLOAT32	1A	
<b>SCN Actual Max Current Phase L1</b>	1411	1412	2	R	FLOAT32	1A	
<b>SCN Actual Max Current Phase L2</b>	1413	1414	2	R	FLOAT32	1A	
<b>SCN Actual Max Current Phase L3</b>	1415	1416	2	R	FLOAT32	1A	
<b>SCN Max Current per Phase L1</b>	1417	1418	2	R/W	FLOAT32	1A	
<b>SCN Max Current per Phase L2</b>	1419	1420	2	R/W	FLOAT32	1A	
<b>SCN Max Current per Phase L3</b>	1421	1422	2	R/W	FLOAT32	1A	
<b>Remaining valid time Max Current Phase L1</b>	1423	1424	2	R	UNSIGNED32	1s	Max current valid time
<b>Remaining valid time Max Current Phase L2</b>	1425	1426	2	R	UNSIGNED32	1s	Max current valid time
<b>Remaining valid time Max Current Phase L3</b>	1427	1428	2	R	UNSIGNED32	1s	Max current valid time
<b>SCN Safe current</b>	1429	1430	2	R	FLOAT32	1A	Configured SCN safe current
<b>SCN Modbus Slave Max Current enable</b>	1431	1431	1	R	UNSIGNED16	n.a.	1:Enabled, 0: Disabled.

### 3.4 Socket measurement registers

The socket measurements show information regarding the energy meter that is connected to the only socket in case of a single socket charging station, or the left socket in case of a dual socket charging station and can be reached using slave address 1. In case of a dual socket station, the right socket related energy measurements can be reached using slave address 2.

Description	Start address	End address	Number of 16 bit registers	Read or Write	Data Type	Step size & Units	Additional info
<b>Energy measurements</b>							
<b>Meter state</b>	300	300	1	R	UNSIGNED16	n.a.	Bitmask with state: Initialised: 0x01 Updated: 0x02 Warning: 0x04 Error: 0x08
<b>Meter last value timestamp</b>	301	304	4	R	UNSIGNED64	0.001s	Milliseconds since last received measurement
<b>Meter type</b>	305	305	1	R	UNSIGNED16	n.a.	0:RTU, 1:TCP/IP, 2:UDP, 3:P1, 4:other
<b>Voltage Phase V(L1-N)</b>	306	307	2	R	FLOAT32	1V	
<b>Voltage Phase V(L2-N)</b>	308	309	2	R	FLOAT32	1V	
<b>Voltage Phase V(L3-N)</b>	310	311	2	R	FLOAT32	1V	
<b>Voltage Phase V(L1-L2)</b>	312	313	2	R	FLOAT32	1V	
<b>Voltage Phase V(L2-L3)</b>	314	315	2	R	FLOAT32	1V	
<b>Voltage Phase V(L3-L1)</b>	316	317	2	R	FLOAT32	1V	
<b>Current N</b>	318	319	2	R	FLOAT32	1A	
<b>Current Phase L1</b>	320	321	2	R	FLOAT32	1A	
<b>Current Phase L2</b>	322	323	2	R	FLOAT32	1A	
<b>Current Phase L3</b>	324	325	2	R	FLOAT32	1A	
<b>Current Sum</b>	326	327	2	R	FLOAT32	1A	
<b>Power Factor Phase L1</b>	328	329	2	R	FLOAT32	N.A.	
<b>Power Factor Phase L2</b>	330	331	2	R	FLOAT32	N.A.	
<b>Power Factor Phase L3</b>	332	333	2	R	FLOAT32	N.A.	
<b>Power Factor Sum</b>	334	335	2	R	FLOAT32	N.A.	
<b>Frequency</b>	336	337	2	R	FLOAT32	1Hz	
<b>Real Power Phase L1</b>	338	339	2	R	FLOAT32	1W	
<b>Real Power Phase L2</b>	340	341	2	R	FLOAT32	1W	
<b>Real Power Phase L3</b>	342	343	2	R	FLOAT32	1W	
<b>Real Power Sum</b>	344	345	2	R	FLOAT32	1W	
<b>Apparent Power Phase L1</b>	346	347	2	R	FLOAT32	1VA	
<b>Apparent Power Phase L2</b>	348	349	2	R	FLOAT32	1VA	
<b>Apparent Power Phase L3</b>	350	351	2	R	FLOAT32	1VA	
<b>Apparent Power Sum</b>	352	353	2	R	FLOAT32	1VA	

Reactive Power Phase L1	354	355	2	R	FLOAT32	1VAr	
Reactive Power Phase L2	356	357	2	R	FLOAT32	1VAr	
Reactive Power Phase L3	358	359	2	R	FLOAT32	1VAr	
Reactive Power Sum	360	361	2	R	FLOAT32	1VAr	
Real Energy Delivered Phase L1	362	365	4	R	FLOAT64	1Wh	
Real Energy Delivered Phase L2	366	369	4	R	FLOAT64	1Wh	
Real Energy Delivered Phase L3	370	373	4	R	FLOAT64	1Wh	
Real Energy Delivered Sum	374	377	4	R	FLOAT64	1Wh	
Real Energy Consumed Phase L1	378	381	4	R	FLOAT64	1Wh	
Real Energy Consumed Phase L2	382	385	4	R	FLOAT64	1Wh	
Real Energy Consumed Phase L3	386	389	4	R	FLOAT64	1Wh	
Real Energy Consumed Sum	390	393	4	R	FLOAT64	1Wh	
Apparent Energy Phase L1	394	397	4	R	FLOAT64	1VAh	
Apparent Energy Phase L2	398	401	4	R	FLOAT64	1VAh	
Apparent Energy Phase L3	402	405	4	R	FLOAT64	1VAh	
Apparent Energy Sum	406	409	4	R	FLOAT64	1VAh	
Reactive Energy Phase L1	410	413	4	R	FLOAT64	1VArh	
Reactive Energy Phase L2	414	417	4	R	FLOAT64	1VArh	
Reactive Energy Phase L3	418	421	4	R	FLOAT64	1VArh	
Reactive Energy Sum	422	425	4	R	FLOAT64	1VArh	
<b>Status and transaction registers</b>							
Availability	1200	1200	1	R	UNSIGNED16	n.a.	1: Operative, 0: inoperative
Mode 3 state	1201	1205	5	R	STRING	n.a.	61851 states
Actual Applied Max Current	1206	1207	2	R	FLOAT32	1A	Actual Applied overall Max Current for socket
Modbus Slave Max Current valid time	1208	1209	2	R	UNSIGNED32	1s	Remaining time before fall back to safe current
Modbus Slave Max Current	1210	1211	2	R/W	FLOAT32	1A	
Active Load Balancing Safe Current	1212	1213	2	R	FLOAT32	1A	Active Load Balancing safe current
Modbus Slave received setpoint accounted for	1214	1214	1	R	UNSIGNED16	n.a.	1:Yes, 0: No
Charge using 1 or 3 phases	1215	1215	1	R/W	UNSIGNED16	phases	1: 1 phase, 3: 3 phase charging

**Note:** Register 1214 'Modbus Slave received setpoint accounted for' indicates whether the received Max Current (registers 1210-1211), also called a setpoint, is taken into account to determine the Actual

Applied Max Current (registers 1206-1207). Depending on other setpoints, registers 1206-1207 may read the settings requested by the external device (e.g. EMS).

### 3.4.1 Mode 3 state listing

State	Signal voltage (DC)	PWM signal applied	Vehicle connected	Charging
<b>A</b>	12V	No	No	No
<b>B1</b>	9V	No	Yes	No
<b>B2</b>	9V	Yes	Yes	No
<b>C1</b>	6V	No	Yes	No
<b>C2</b>	6V	Yes	Yes	Yes
<b>D1</b>	3V	No	Yes	No
<b>D2</b>	3V	Yes	Yes	Yes
<b>E</b>	0V	No	No	No
<b>F</b>	-12V	No	No	No

Note that State F is an error state.