18 Excel Configuration

Protocol HUB uses the configuration in excel file format. Each sheet represents a specific part of the configuration: Devices contain device lists and protocol-related configurations. Signals contain a list of signals and their options. First-line on each sheet is a header row that contains the parameter name for each column. Header order determines parameter names for each following row. Every line after the header is a new entry. An empty row is interpreted as the end of the sheet. Any rows after empty row are discarded.

18.1 Devices sheet

The device sheet contains all devices to be configured on the gateway. Each row represents one device and its settings. The following options are required for each device:

- **name** - Name of the device. Used for representation only.
- **description** - A short description of the device. Used for representation only.
- **device_alias** - A unique short name for the device. It is used for linking signals to a device.

> ⚠ An alias can only contain alphanumeric characters and dashes (- and _). The alias must be unique for each device.

- **protocol** - Protocol type to use on the device. The exact values of protocols are written in every protocol documentation. Please look into the range of supported protocols:

IEC 61850 MMS:

– IEC 61850 Client (since FW 1.5.0)

– IEC 61850 Server (since FW 1.5.0)

IEC 60870-5:

– IEC 60870-5-101 master

– IEC 60870-5-101 slave

– IEC 60870-5-103 master

– IEC 60870-5-104 master

- IEC 60870-5-104 slave

DNP 3.0 Serial/LAN/WAN:

- DNP3 Master

– DNP3 Slave

Modbus Serial/TCP:

- Modbus RTU/ASCII

– Modbus TCP

Metering protocols:

- DLMS/COSEM (since FW 1.3.0)

– IEC 62056-21 (since FW 1.2.13)

– MBus Serial

– MBus TCP

– Elgama (Meters based on IEC 62056-21 / 31 protocols)

Industrial IOT protocols:

- MQTT

- RESTful API

Specific protocols:

– Aurora (ABB PV inverters protocol)

– PowerOne (ABB PV inverters protocol)

– SMA Net (SMA PV inverters protocol)

– Kaco (Kaco PV inverters protocol)

– Ginlong (Ginlong PV inverters protocol)

– Solplus (Solutronic AG PV inverters protocol)

– ComLynx (Danfoss PV inverters protocol)

– Delta (Delta PV inverters protocol)

– Windlog (Wind sensors from RainWise Inc.)

– Vestas (Wind turbines protocol)

– Internal data

– VBus.

Although device name rules aren't strictly enforced, it is highly advised to give a unique name to every new device. Identical device names might introduce confusion while searching for signals in the Imported Signals tab.

Optional settings

- **enable** - Flag to enable or disable a device on the system. Can contain values 0 or 1.
- **event_history_size** - Maximum number of signal events to save on the device for later review. Older records will be erased. This feature is only available on cloud firmware.

Serial port settings

Required for any protocol that uses serial line communication.

- **device** - Serial port for communication **(PORT1/PORT2)**
- **baudrate** - Serial port speed. Valid values: **300**; **600**; **1200**; **2400**; **4800**; **9600**; **19200**; **38400**; **57600**; **115200**
- **databits** - Number of data bits (6-9)
- **stopbits** - Number of stop bits (1-2)
- **parity** - Parity mode (none/even/odd)
- **flowcontrol** - Flow control method (none/hardware/software)

TCP/IP settings

Settings for any protocol that uses communication over TCP/IP. Note that all TLS certificates and keys are stored in a single folder therefore only the name and not the path should be filled in respective fields.

TLS fields are only supported for IEC 61850 Client and Server, IEC-60870-5-104 Slave, and DNP3 Master and Slave, MQTT.

- **ip** - IP address for a master protocol to connect to;
- **bind_address** - one of the local IP addresses to bind the server to. Connections through other network devices will be ignored;
- **host** - space-separated host IP addresses of master devices;
- **port** - TCP port to listen for incoming connections;
- **tls_local_certificate** - the name of the local TLS certificate;
- **tls_peer_certificate** - the name of a certificate authority (CA) TLS certificate;
- **tls_private_key** - the name of a private key for making TLS connections.

18.2 Optional parameters for signals

The signals sheet contains all signals linked to devices. Each signal is defined in a single row. The Signal list can be split into multiple sheets. Each sheet name may start as Signals.

Required attributes

These attributes are mandatory for every configured signal. Every Excel configuration should have specified them in the first row of the Signals sheet:

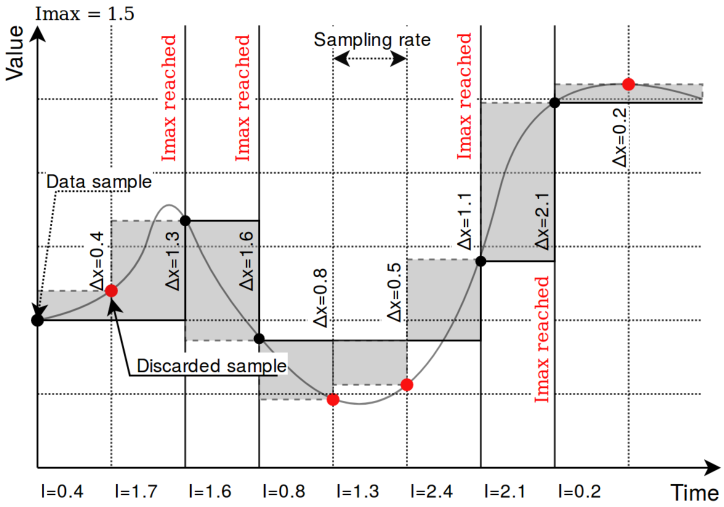
- **signal_name** - Name of the signal. Used for representation only.
- **device_alias** - Alias of a device defined in the Devices sheet. A signal is linked to a matching device.
- **signal_alias** - A unique short name for the signal. It is used for linking signals to other signals. The alias can only contain alphanumeric characters and dashes (- and _). The device and signal alias combination must be unique.

Optional attributes

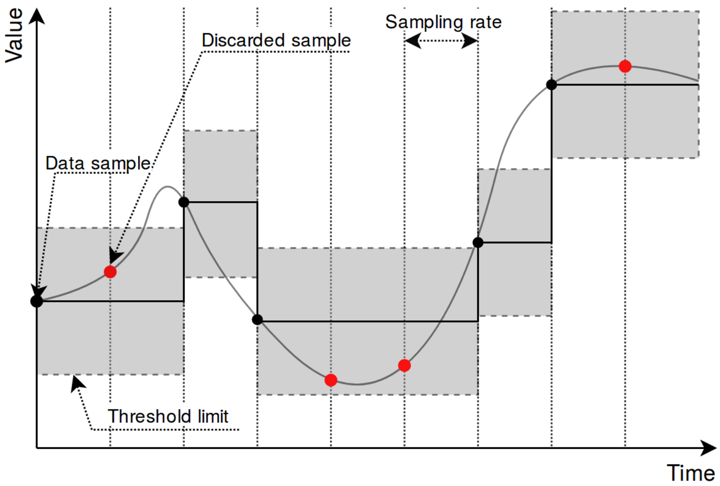
Optional attributes are required depending on the protocol in use and they can be used to extend protocol functionality:

- **source_device_alias** - Alias of a source device defined in the Devices sheet. If a user intends to use several signals and combine them via mathematical or logical function, every alias should be separated by a newline symbol (in the same cell). An operation used must also be defined in an operation column.
- **source_signal_alias** - Alias of a source signal defined in the Signals sheet. If a user intends to use several signals and combine them via mathematical or logical function, every alias should be separated by a **separator** symbol (in the same cell). An operation used must also be defined in an operation column. Each `source_signal_alias` should be posted in the same line as its respective`source_device_alias`. Aliases can only contain alphanumeric characters and dashes (- and _). The device and signal alias combination must be unique.
- **enable** - Flag to enable or disable signal on the system. Can contain values 0 or 1.
- **tag_type** - Tag type. Simple signals are polled from the device. Virtual signals are computed internally.
- **units** - Signal value measurement units.
- **multiply** - Multiply the value by this number.
- **add** - Add this number to a value.
- **min_value** - Minimum expected value. If the result is lower than this value, the overflow flag is raised.
- **max_value** - Maximum expected value. If the result is higher than this value, the overflow flag is raised.
- **absolute_threshold** - Absolute threshold level.
- **integral_threshold** - Integral threshold level.
- **threshold_units** - Units used in threshold level fields (percent/real).
- **log** - Maximum number of records for this tag to keep in the events log.
- **suppression_values** - Space-separated numeric values to be used in suppression.
- **suppression_time_ms** - Suppression time in milliseconds.
- **operation** - Mathematical or logical operation to be used for signals defined in source_signal_alias column which are separated using **separators**. The following mathematical operations for source signal values can be used: average (average of all values), min (lowest value), max (highest value), median (median value), and sum (all values accumulated to a single number). An internal threshold is used to reduce value updates when the value doesn't change. Logical operations are intended for unsigned integers only.
- **bit_select** - selecting an individual bit of an integer number; bit numeration starts from zero.
- **math_expression** - a mathematical expression for master protocol monitor direction or slave command direction signals to be evaluated against. Explained in detail in the **Mathematical expression document.**
- **source_math_expression** - a mathematical expression for master protocol command direction or slave monitor direction signals to be evaluated against. Explained in detail in the **Mathematical expression document.**
- **periodic_update_ms –** time set for specific signal, that updates the signal state even if the value hasn't changed.

Picture. Result of using an absolute threshold:



Picture. Result of using an integral threshold:



Signal recalculation operation priority

A value generated by some protocol usually has to be recalculated in one way or another. This might mean changing the value of an argument as well as adding flags needed for other protocols to correctly interpret results. As recalculation is a sequential process, some actions are done before others. The sequence of operations done to a value is as follows:

- *Edition of attributes*. Attributes for further interpretation are added. This might, for example, include a flag to show that a signal resembles an answer to a command;
- *Mathematical calculations*. **multiply**, **add**, **bit_select,** and **math_expression** columns are evaluated here;
- *Usage of last value*. The decision if the last value for a signal should be used if a new value of a signal is not a number (NaN) or contains a non-topical (NT) flag;
- *Limiting of values*. If a value exceeds a lower or higher configured limit, the value is approximated not to be lower (or higher) than the limit. An additional overflow (OV) flag is added as frequently used in IEC-60870-5 protocols;
- *Suppression of values*. As electrical circuits can be noisy, protocols may generate multiple values in a short amount of time. What is more, some values are considered intermediaries and ideally should not be sent to SCADA unless they stay in the same state for some amount of time. **suppression_values** and **suppression_time_ms** are used to configure this functionality;
- *Threshold* checking. If a new signal doesn't cross a threshold target value, the value is suppressed and not used in further stages. **absolute_threshold, integral_threshold and threshold_units** columns are used to configure this functionality.

> Not all of the elements in this sequence have to be configured, missing operations are skipped and values are fed to a further stage of signal recalculation.

`number_type` field

This field is required for some protocols to determine a method to retrieve a signal value from the hexadecimal form. Available values:

- **FLOAT** - 32-bit single precision floating point value according to IEEE 754 standard
- **DOUBLE** - 64-bit double precision floating point value according to IEEE 754 standard
- **DIGITAL** - 1-bit boolean value
- **UNSIGNED8** - 8-bit unsigned integer (0 - 255)
- **SIGNED8** - 8-bit signed integer (-128 - 127)
- **UNSIGNED16** - 16-bit unsigned integer (0 - 65535)
- **SIGNED16** - 16-bit signed integer (-32768 - 32767)
- **UNSIGNED32** - 32-bit unsigned integer (0 - 4294967295)
- **SIGNED32** - 32-bit signed integer (-2147483648 - 2147483647)

Number conversion uses **big-endian** byte order by default. Converted data will be invalid if the byte order on the connected device side is different. In such a case, byte swap operations can be used. Adding swap prefixes to number types will set different byte orders while converting values. The following swap operations are available:

- **SW8** - Swap every pair of bytes (8 bits) (e.g.,**0xAABBCCDD** is translated to **0xBBAADDCC**);
- **SW16** - Swap every pair of words (16 bits) (e.g.,**0xAABBCCDD** is translated to **0xCCDDAABB**);
- **SW32** - Swap every pair of two words (32 bits) (e.g.,**0x1122334455667788** is translated to **0x5566778811223344**);

Table. Example of using different swapping functions:

Address	7	6	5	4	3	2	1	0
Original number	Byte 7	Byte 6	Byte 5	Byte 4	Byte 3	Byte 2	Byte 1	Byte 0
SW8	Byte 6	Byte 7	Byte 4	Byte 5	Byte 2	Byte 3	Byte 0	Byte 1
SW16	Byte 5	Byte 4	Byte 7	Byte 6	Byte 1	Byte 0	Byte 3	Byte 2
SW32	Byte 3	Byte 2	Byte 1	Byte 0	Byte 7	Byte 6	Byte 5	Byte 4
SW8.SW16	Byte 4	Byte 5	Byte 6	Byte 7	Byte 0	Byte 1	Byte 2	Byte 3
SW8.SW32	Byte 2	Byte 3	Byte 0	Byte 1	Byte 6	Byte 7	Byte 4	Byte 5
SW8.SW16.SW32	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7

Where Byte x, means bit x position in the byte.

Add a dot-separated prefix to the number format to use byte swapping. Multiple swap operations can be used simultaneously. For example, use `SW8.SW16.SIGNED32` it to correctly parse a 32-bit signed integer in a little-endian format. The table shows in detail how bytes, words, or double words can be swapped and how swapping functions can be combined to make different swapping patterns. The table shows how byte swap is done for 64-bit (8-byte) numbers. It doesn't matter if it is an unsigned/signed integer or double, byte swapping is considered a bit-level operation. If a number is shorter than 64 bits, the same logic applies, the only difference is the unavailability of some swapping operations (`SW32` for 32-bit and smaller numbers). Using such an unavailable operation might lead to undefined behaviour.

Linking signals

Signals can be linked together to achieve data transfer between several protocols. If a signal source is defined, all output from that source will be routed to the input of the target signal. This way events polled from a Modbus device (e.g., Modbus, IEC 60870-5, etc.) can be delivered to an external station over a different protocol. A signal source is required if a signal is created on a slave protocol configuration to link events between protocols.

Example 1:

To read a coil state from a Modbus device and transfer it to the IEC 60870-5-104 station, the following steps may be taken:

1. Create a Modbus master configuration in the Devices sheet.
2. Create an IEC 60870-5-104 slave configuration in the Devices sheet.
3. Create a signal on the master device to read coil status (function 1).

4. Create a signal on the slave device with a single point type (data_type = 1).
5. Set **source_device_alias** and **source_signal_alias** fields on the slave device signal to match**device_alias** and **signal_alias** on the master device's coil signal.

Example 2

To write a coil state to a Modbus device on a command fromIEC 60870-5-104 station, the following steps may be taken:

1. Follow steps 1-3 from example 1.
2. Create a signal on the slave device with a single command type (data_type = 45).
3. Set source_device_alias and source_signal_alias fields on the master configuration coil signal to match device_alias and signal_alias on the slave device's command signal. Coil will be written to a value received by a command.
4. Set source_device_alias and source_signal_alias fields on the command signal to match device_alias and signal_alias on the master device's coil signal. A command termination signal will be reported to the station on the coil to write the result.

For additional information regarding the configuration of IEC 60870-5-101/103/104 protocols, please refer to "IEC 60780-5-101/103/104 PID interoperability for WCC Lite devices", accordingly.

Separators

These operators can be used when defining two or more values in a single cell. For example, source_signal_alias and source_device_alias from different signals have to be written in the same cell but separated by the separators listed below. This is useful when using the operation parameter when trying to do mathematical operations on more than one signal.

- " "
- (newline)
- ";"
- ","

18.3 Mathematical functions

The signal value might require some recalculation or signal update before being sent. Understandably, existing columns in Excel configuration like `multiply`, `add`, `bit_select` might not be flexible enough. To overcome these limitations, symbolic mathematical expressions can be configured to do calculations automatically on every update of a signal.

Feature list:

- Optimized for speed
  - High parsing performance
  - if-then-else operator with lazy evaluation
- Default implementation with many features
  - 25 predefined functions
  - 18 predefined operators
- Unit support
  - Use postfix operators as unit multipliers (3m -> 0.003)

Mathematical functions

Table. Supported mathematical functions:

Name	Argument count	Explanation
sin	1	sine function (rad)
cos	1	cosine function (rad)
tan	1	tangent function (rad)
asin	1	arcus sine function (rad)
acos	1	arcus cosine function (rad)
atan	1	arcus tangent function (rad)
sinh	1	hyperbolic sine function
cosh	1	hyperbolic cosine
tanh	1	hyperbolic tangent function
asinh	1	hyperbolic arcus sine function
acosh	1	hyperbolic arcus tangent function
atanh	1	hyperbolic arcus tangent function
log2	1	logarithm to the base 2
log10	1	logarithm to the base 10
log	1	logarithm to base e (2.71828...)
ln	1	logarithm to base e (2.71828...)

exp	1	e raised to the power of x
sqrt	1	square root of a value
sign	1	sign function -1 if x<0; 1 if x>0
rint	1	round to the nearest integer
abs	1	absolute value
min	variable	min of all arguments
max	variable	max of all arguments
sum	variable	the sum of all arguments
avg	variable	the mean value of all arguments
floor	1	round down to the nearest integer
mod	variable	modulo operation

It should be noted that trigonometric functions (excluding hyperbolic functions) only support arguments in radians. This means that arguments for this function have to be recalculated if the angle is defined in degrees.

Value recalculation is only triggered on signal change of the preconfigured signal. That means that using other signals (via TagValue() call) does not trigger a value update.

Some mathematical expressions cannot be mathematically evaluated in some conditions, for example, a square root cannot be found for negative numbers. As complex numbers are not supported, the result is then equal to Not a Number (NaN). These results are marked with an invalid (IV) flag.

Binary operations

Table. Supported binary operators:

Operator	Description	Priority
=	assignment	-1
»	right shift	0
«	left shift	0
&	bitwise and	0
|	bitwise or	0
&&	logical and	1
||	logical or	2
<=	less or equal	4

>=	greater or equal	4
!=	not equal	4
==	equal	4
>	greater than	4
<	less than	4
+	addition	5
-	subtraction	5
*	multiplication	6
/	division	6
^	raise x to the power of y	7

Ternary operators can be used. This expression can be compared to the operator supported by C/C++ language (Table 39). Condition is written before a question (?) sign. If the condition is true, the result after the question sign is selected. If the condition is false, the result after colon (:) is selected.

Ternary operations

Table. Supported ternary operators

Operator	Description	Remarks
?:	if then else operator	C++ style syntax

Examples

Users can construct their equations by using the aforementioned operators and functions. These examples can be seen in the Table below.

Table. Example expressions

Expression	Description
value * 0.0001	Multiply the tag by a constant.
value + TagValue(”tag/dev_alias/sig_alias/out”)	Add value of tag/dev_alias/sig_alias/out to the current tag.
sin(value)	Return a predefined sine function value of the tag.
(value>5)? 1: 0	If the value is greater than 5, the result should be equal to 1, otherwise - equal to 0

A variable called "value" is generated or updated on every signal change and represents the signals being configured. If another value from the tag list is intended to be used, one should use `TagValue()` function to retrieve its last value.

The inner argument of `TagValue()` function has to be described in a Redis topic structure of WCC Lite. That means that it has to be constructed in a certain way. Quotes should be used to feed the topic name value, otherwise expression evaluation will fail.

Every Redis topic name is constructed as tag/[device_alias]/[signal_alias]/[direction]. Prefix tag/ is always used before the rest of the argument. `device_alias` and `signal_alias` represent columns in Excel configuration. Direction can have one of four possible values - rout, out, in, rin; all of which depend on the direction data is sent or acquired device-wise. For example, the "out" keyword marks data sent out of the WCC Lite device, whereas the "in" direction represents data that WCC Lite is waiting to receive, for example, commands. Additional "r" before either direction means that data is raw, it is presented the way it was read by an individual protocol.

Signal mathematics

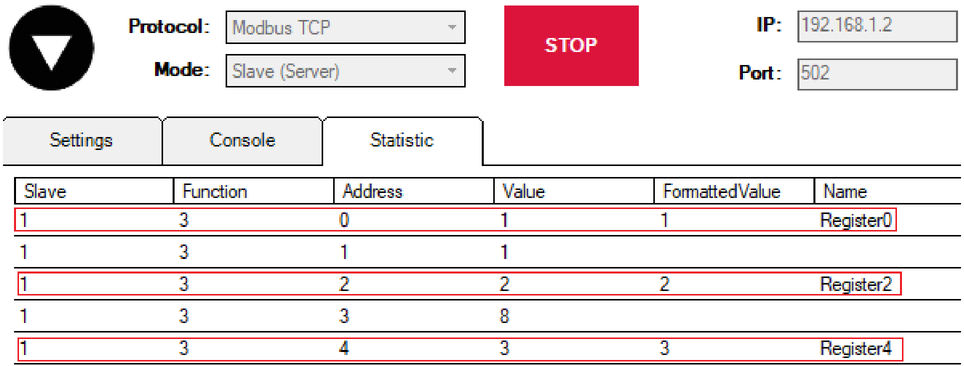
In this section, you will be shown how "math_expression" and other mathematical functions can be used in case of common signals. You can download the configuration to follow along here. Signals which we are concerned with in this section are highlighted in green colour.

Let us analyze what mathematical functions are configured for the signals. For both the second and third signals the same expression will be used: "**value + TagValue(”tag/Master/RHR0/out”)** ". The only difference is that for the second signal scale function "add" was used.

signal_name	device_alias	signal_alias	source_device_alias	source_signal_alias	enable	job_todo	tag_job_todo	number_type	multiply	add	bit_select	source_math_expression	math_expression
Read Holding Register 0	Master	RHR0			1	3;0;36	3;0;1	SIGNED16					
Write Single Register 1	Master	WSR1	Master	RHR0	1	6;0;36	6;1;1	SIGNED16					
Read Holding Register 2	Master	RHR2			1	3;0;36	3;2;1	SIGNED16		5			value + TagValue(”tag/Master/RHR0/out”)
Write Single Register 3	Master	WSR3	Master	RHR2	1	6;0;36	6;3;1	SIGNED16					
Read Holding Register 4	Master	RHR4			1	3;0;36	3;4;1	UNSIGNED16					value + TagValue(”tag/Master/RHR0/out”)

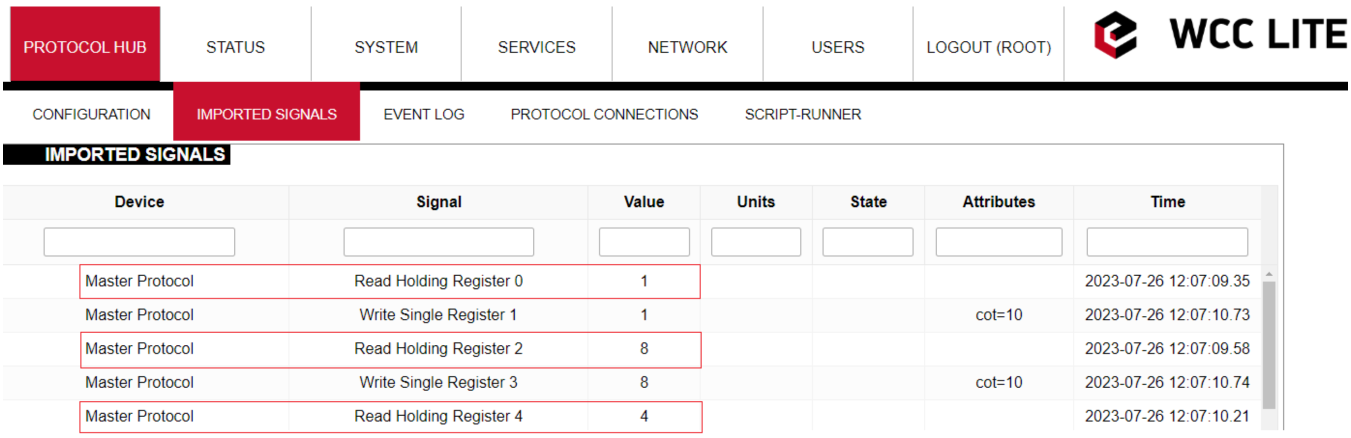
In this signal configuration, the value of the second signal is calculated by adding the current value of the second signal to the value of the first signal. Then the sum of two signals is going to be increased by 5. The third signal is going to be calculated in the same way except that 5 is not going to be added.

To see how it works let us start Modbus TCP Slave simulation in Vinci application. You can download the simulation here.



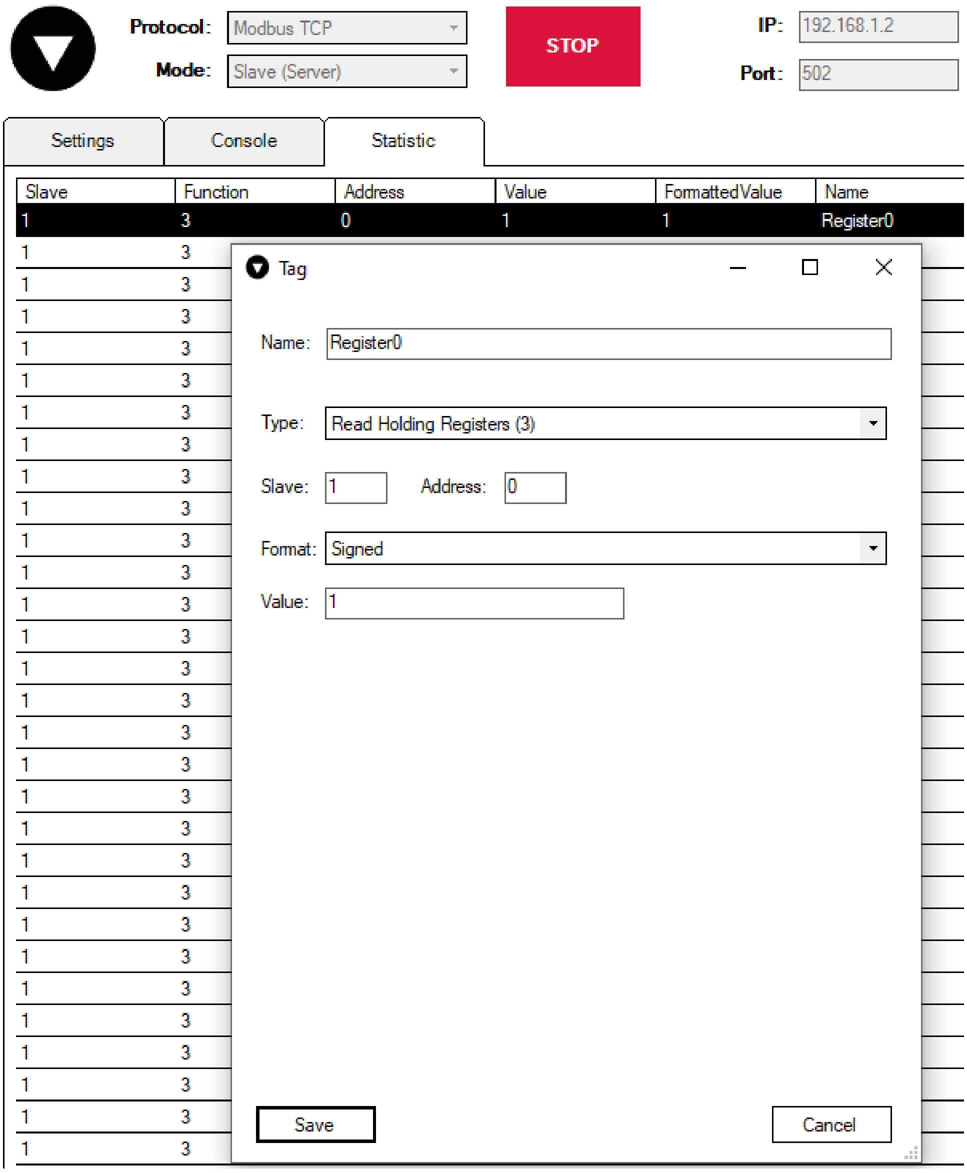
In the picture above you can see 6 registers. However, our main focus is null, second and fourth registers (Register0, Register2, Register4) since the first three signals of Modbus Master protocol (RHR0, RHR2 and RHR4) are reading the values of those registers (accordingly).

Let us go to the WCC Lite web interface to see how these signals are displayed there:

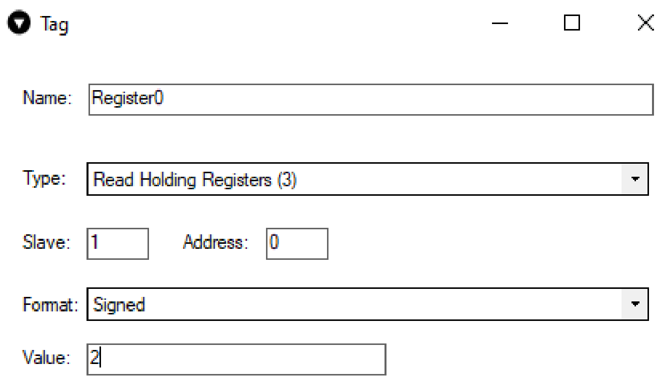


As we can see the values of the third and fifth signals have been modified (RHR2 = 2+1+5 = 8; RHR3 = 3+1 = 4). However, the values of the signals that are displayed in the web interface are intermediate so to speak. All the math is done in the protocol services (Modbus TCP Master in this case). Then those values are transmitted to the REDIS service. The values that are displayed in the web interface are REDIS values. We are going to see why it is important in another example.

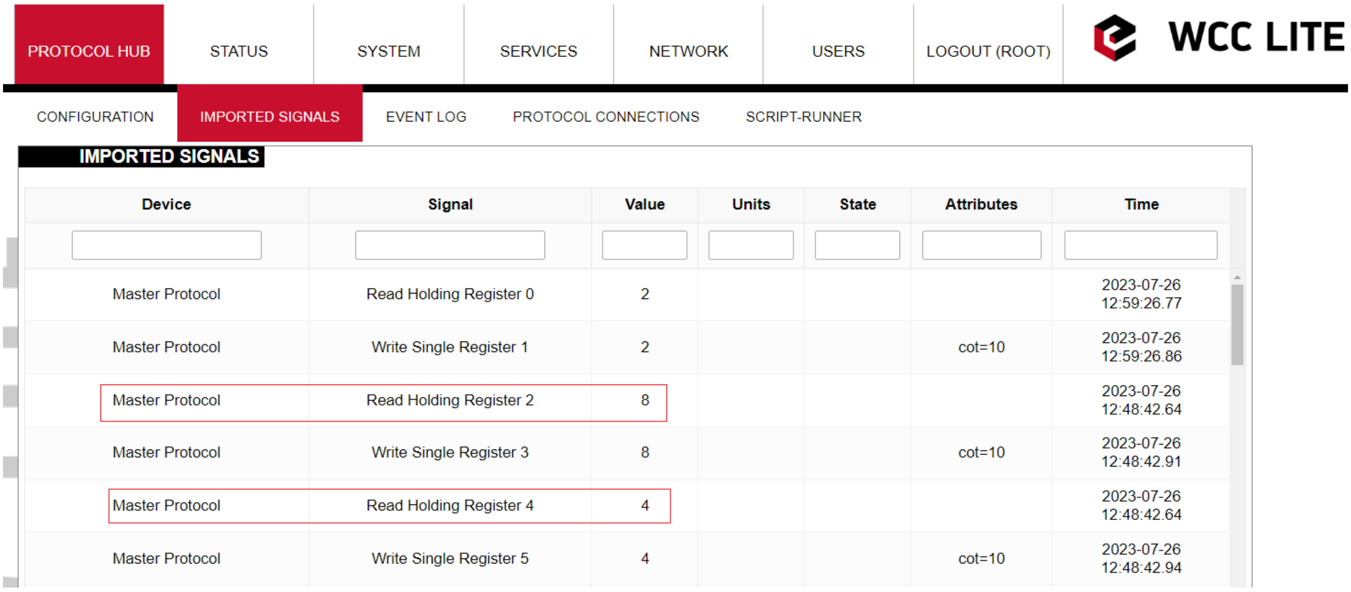
Now it was mentioned that the values of the third and fifth signals depend on the value of the first one. Let us see what will happen if we change the value of the Register 0. To do so we need to return to the VINCI application. Locate Register 0 and double-click on it. A menu with the register parameters will appear.



Now let us change the value of the register to 2:

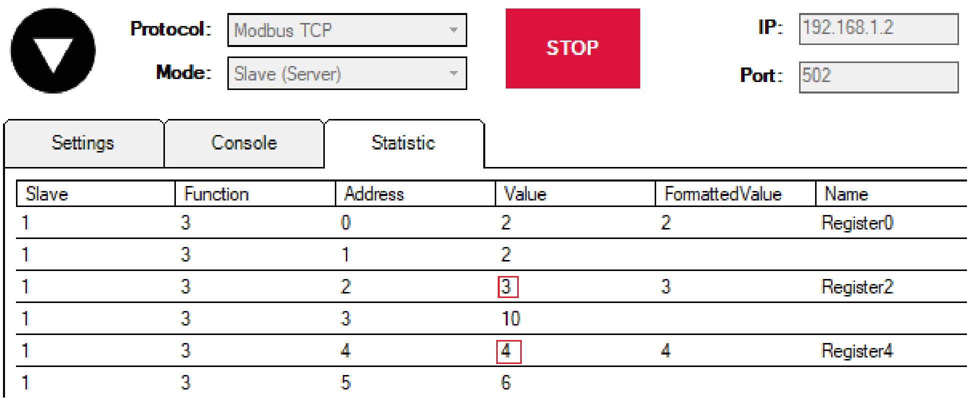


Now it would be expected that the value of the second and third signals would become 9 and 5 accordingly (RHR2 = 2+2+5 = 9; RHR3 = 3+2 = 5). However if one checks the WCC Lite web interface right after that, one could notice that the second and third signals remained unchanged:

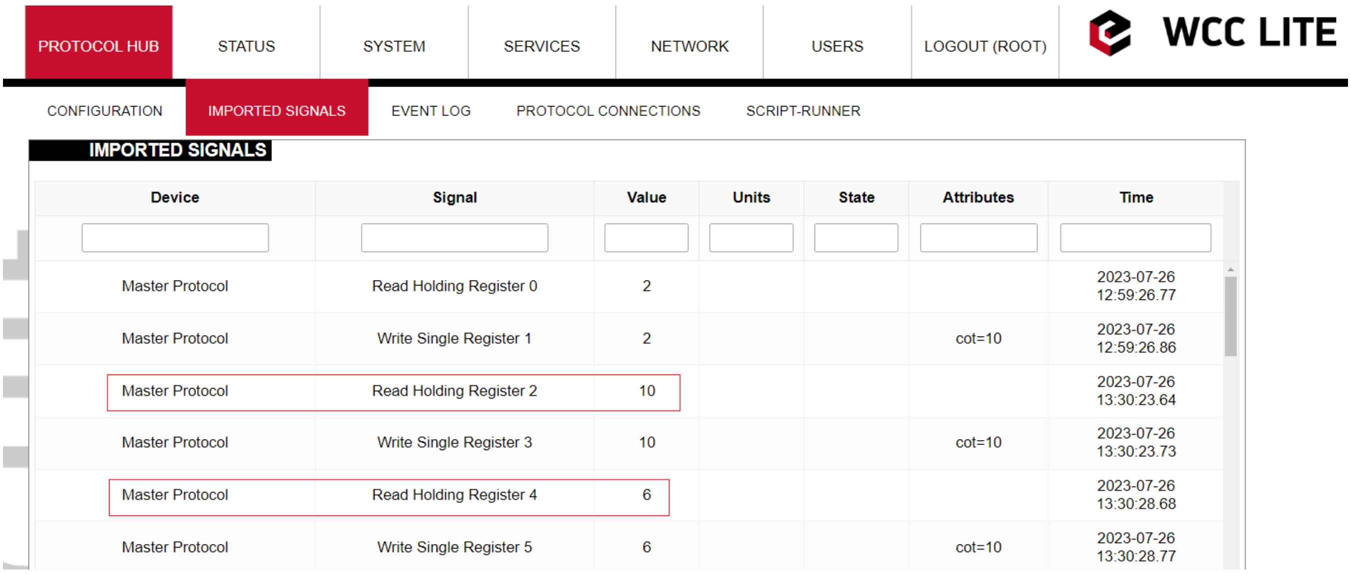


Device	Signal	Value	Units	State	Attributes	Time
Master Protocol	Read Holding Register 0	2				2023-07-26 12:59:26.77
Master Protocol	Write Single Register 1	2			cot=10	2023-07-26 12:59:26.86
Master Protocol	Read Holding Register 2	8				2023-07-26 12:48:42.64
Master Protocol	Write Single Register 3	8			cot=10	2023-07-26 12:48:42.91
Master Protocol	Read Holding Register 4	4				2023-07-26 12:48:42.64
Master Protocol	Write Single Register 5	4			cot=10	2023-07-26 12:48:42.94

To explain this let us look again at the math expression of these signals. The equation (**value + TagValue("tag/Master/RHR0/out")**) consists of two operands "value" and "TagValue("tag/Master/RHR0/out")". Currently, the system is designed in such a way that only if the "value" operand has changed, only then there is going to be a change in a signal's value. So if the values of the second and fourth registers are changed (increased by one in this example) then the values of the third and fifth signals are going to change taking into account the previous change in the value of Register 0 (RHR2 = 2+3+5 = 10; RHR3 = 2+4 = 6).



Slave	Function	Address	Value	FormattedValue	Name
1	3	0	2	2	Register0
1	3	1	2		
1	3	2	3	3	Register2
1	3	3	10		
1	3	4	4	4	Register4
1	3	5	6		



Device	Signal	Value	Units	State	Attributes	Time
Master Protocol	Read Holding Register 0	2				2023-07-26 12:59:26.77
Master Protocol	Write Single Register 1	2			cot=10	2023-07-26 12:59:26.86
Master Protocol	Read Holding Register 2	10				2023-07-26 13:30:23.64
Master Protocol	Write Single Register 3	10			cot=10	2023-07-26 13:30:23.73
Master Protocol	Read Holding Register 4	6				2023-07-26 13:30:28.68
Master Protocol	Write Single Register 5	6			cot=10	2023-07-26 13:30:28.77

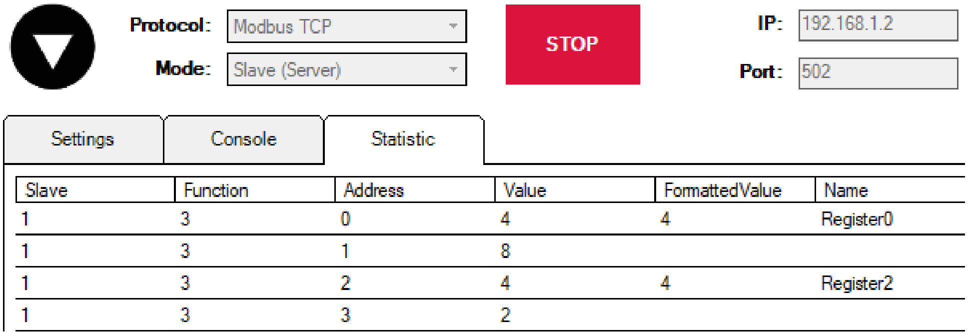
Command mathematics

In this section, you will be shown how "math_expression", and other mathematical functions can be used in case of command signals. You can download the configuration to follow along here. Signals which we are concerned with in this section are highlighted in blue colour.

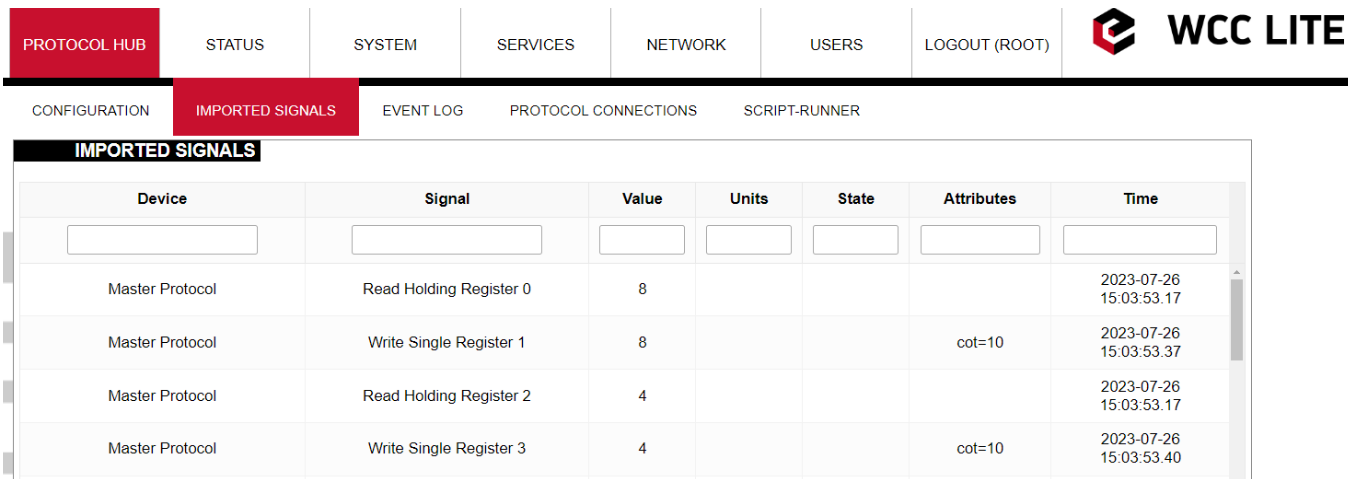
Let us analyze what mathematical functions are configured for the signals.

signal_name	device_alias	signal_alias	source_device_alias	source_signal_alias	enable	job_todo	tag_job_todo	number_type	multiply	add	bit_select	source_math_expression	math_expression
Read Holding Register 0	Master	RHR0			1	3;0;36	3;0;1	SIGNED16	2				
Write Single Register 1	Master	WSR1	Master	RHR0	1	6;0;36	6;1;1	SIGNED16					
Read Holding Register 2	Master	RHR2			1	3;0;36	3;2;1	SIGNED16					
Write Single Register 3	Master	WSR3	Master	RHR2	1	6;0;36	6;3;1	SIGNED16	2				
Read Holding Register 4	Master	RHR4			1	3;0;36	3;4;1	SIGNED16					
Write Single Register 5	Master	WSR5	Master	RHR4	1	6;0;36	6;5;1	SIGNED16				value - TagValue("tag/Master/RHR0/out")	value + TagValue("tag/Master/RHR0/out")
Read Holding Register 6	Master	RHR6			1	3;0;36	3;6;1	SIGNED16					
Write Single Register 7	Master	WSR7	Master	RHR6	1	6;0;36	6;7;1	SIGNED16			3		

The first four signals are going to be used for scale function analysis. To see how it works let us start Modbus TCP Slave simulation in Vinci application. You can download the simulation here.



Let us go to the WCC Lite web interface to see how these signals are displayed there:



As one can notice the values displayed in the Vinci application differ from the values displayed in the web interface. To better understand the results let us see step by step how signals are modified.

The first signal RHR0 reads the value of Register 0 which is equal to 4. After the read operation, the value is multiplied by two in the master protocol service. Then the signal is transmitted to the REDIS service. REDIS value is presented in the web interface. Then the same value 8 is written to Register 1 by sending a WSR1 command signal. Finally, the value of the WSR1 signal is displayed in the Vinci simulation.

The third signal RHR2 behaves quite the same as the first RHR0 signal. It reads the value of Register 2 and without performing any scaling operations transmits value to REDIS. It again can be seen in the web interface. While still in REDIS service the value of Register 2 is passed to WSR3 signal. Then command signal WSR3 is transmitted back to the Modbus Master protocol service where the value of the signal is scaled. One could expect that the value of the signal would be multiplied by two but it is divided by two. Then the value of 2 is displayed in the Vinci Slave simulation. After changing the value of Register 3 WSR3 signal is sent back from the Master Protocol service to REDIS. On its way, the signal again passes the signal scaling place where it is again multiplied by two. This is why we see in the web interface that the value of the fourth signal WSR3 is 4.

All the moments when a signal passes a place where its value is scaled can be seen by turning on a debugger session. To do so one should connect to WCC Lite via Ubuntu terminal in Terminal application. Then Modbus Master protocol needs to be stopped by sending "**/etc/init.d/modbus-master stop**". Then Modbus Master protocol needs to be started again with the -m flag (m for math) "**modbus-master -d7 -m -c /etc/modbus-master/modbus-tcp.json**".

```
root@wcc-lite:~# /etc/init.d/modbus-master stop
root@wcc-lite:~# modbus-master -d7 -m -c /etc/modbus-master/modbus-tcp.json
```

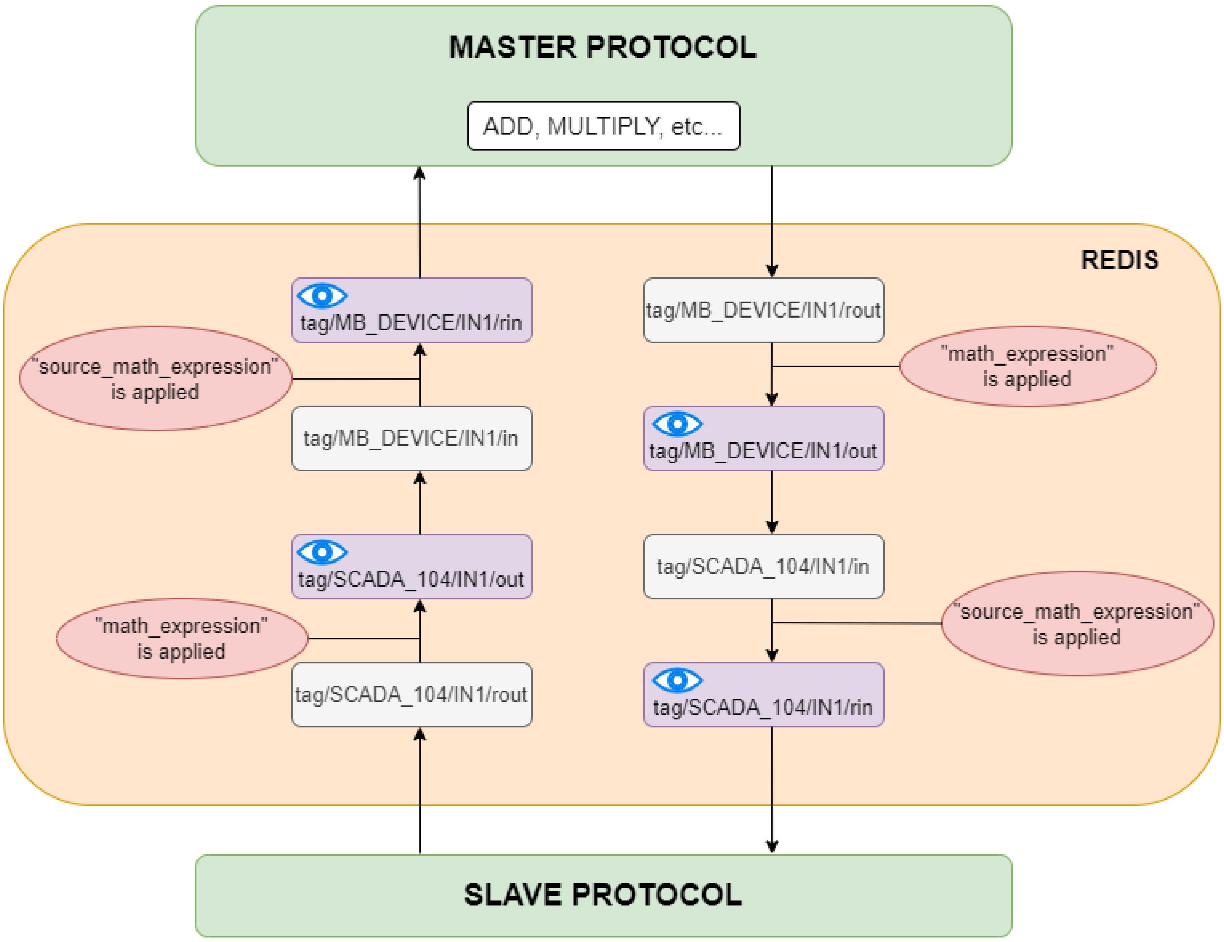
If you scroll up after starting the session you will be able to find how both RHR0 and WSR3 signals are scaled after passing the signal scaling place.

```
[DEBUG]  SERVICE_MATH: Signal: tag/Master/RHR0/rout
[DEBUG]  SERVICE_MATH: Value: 4
[DEBUG]  SERVICE_MATH: value * 2 = 8
```

```
[DEBUG]  SERVICE_MATH: Signal: tag/Master/WSR3/rin
[DEBUG]  SERVICE_MATH: Value: 4
[DEBUG]  SERVICE_MATH: (value) / 2 = 2
[DEBUG]  SERVICE_MATH: Signal: tag/Master/WSR3/rout
[DEBUG]  SERVICE_MATH: Value: 2
[DEBUG]  SERVICE_MATH: value * 2 = 4
```

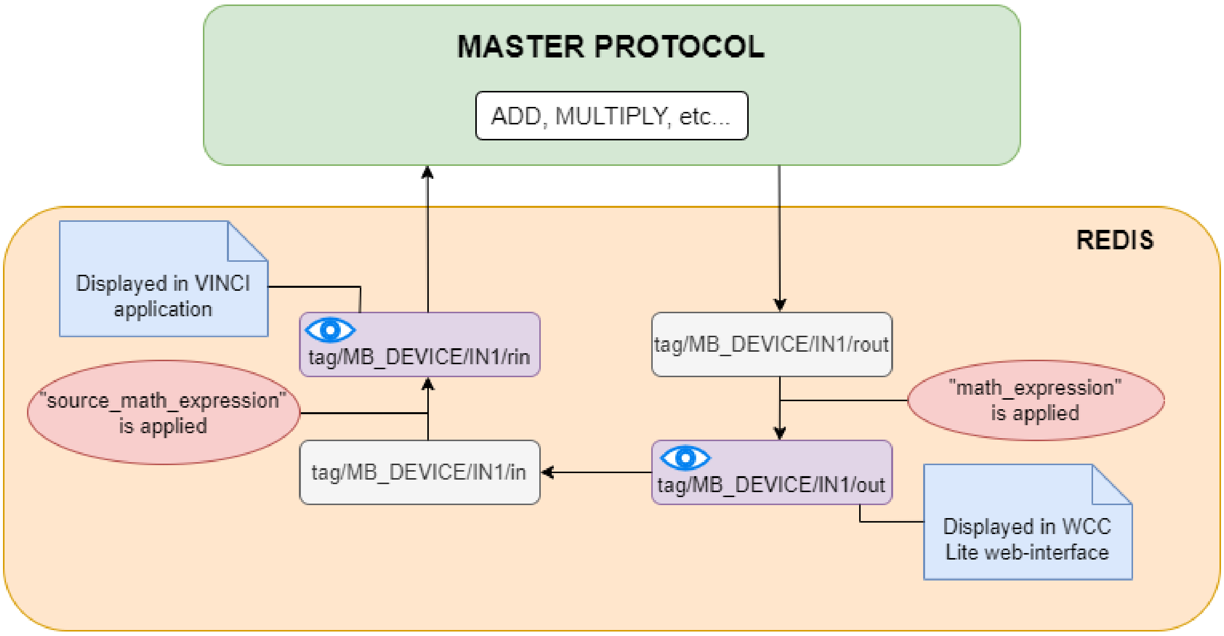
Why is it the case that the signal is divided instead of being multiplied by two? The answer to this question is that the scaling factor depends on the direction of the signal. When the RHR0 signal was travelling from Master Protocol to REDIS service and was passing the place where signals are scaled the signal was multiplied by a scaling factor. On the other hand, when the WSR3 signal was travelling from REDIS service to Master Protocol and was passing the same signal scaling place the signal was divided by the scaling factor.

Now let us analyze how "math_expression" and "source_math_expression" are applied to the WSR5 signal. To get a better insight let us look at how signals are transmitted and transformed inside WCC Lite and when mathematical expressions are applied.

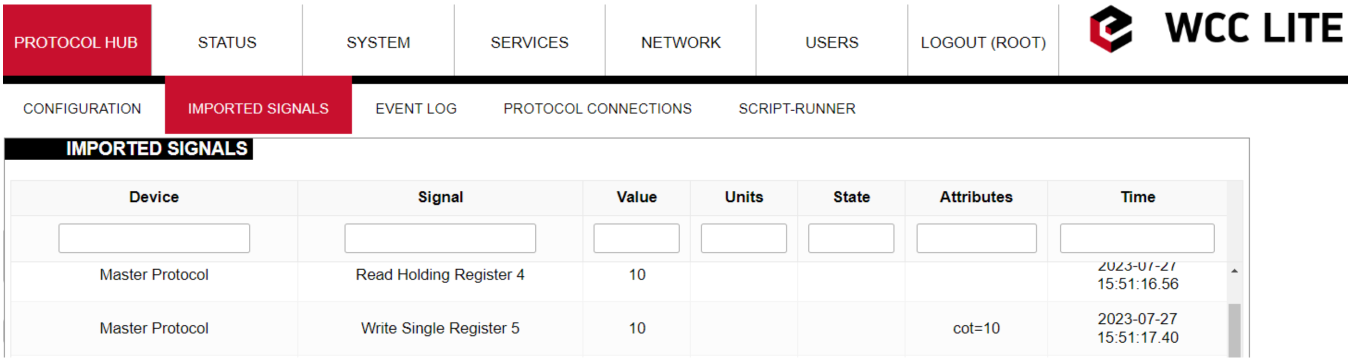


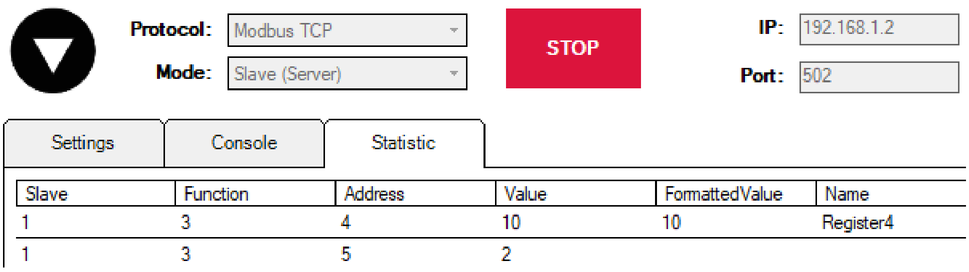
Let us analyze the diagram above. As we can see all basic mathematical operations (such as add, multiply, etc.) are performed inside a Master protocol service. When signals are transmitted between protocols they travel through REDIS service. The period of existence of a signal inside the REDIS service can be divided into four stages. They can be denoted by their endings, namely: "rout", "out", "in" and "rin". At the "out" and "rin" stages signal values can be seen through certain interfaces which is why they are displayed in a purple colour with blue eyes on them. At the "out" stage a signal is displayed on the WCC Lite web interface, at the "rin" stage signal value can be seen through the Vinci application. As one can notice "math_expression" is applied before the "out" stage and "source_math_expression" is performed before the "rin" stage.

However, in our particular example, we did not configure any Slave device. In this situation signal transportation inside REDIS service can be depicted as follows:

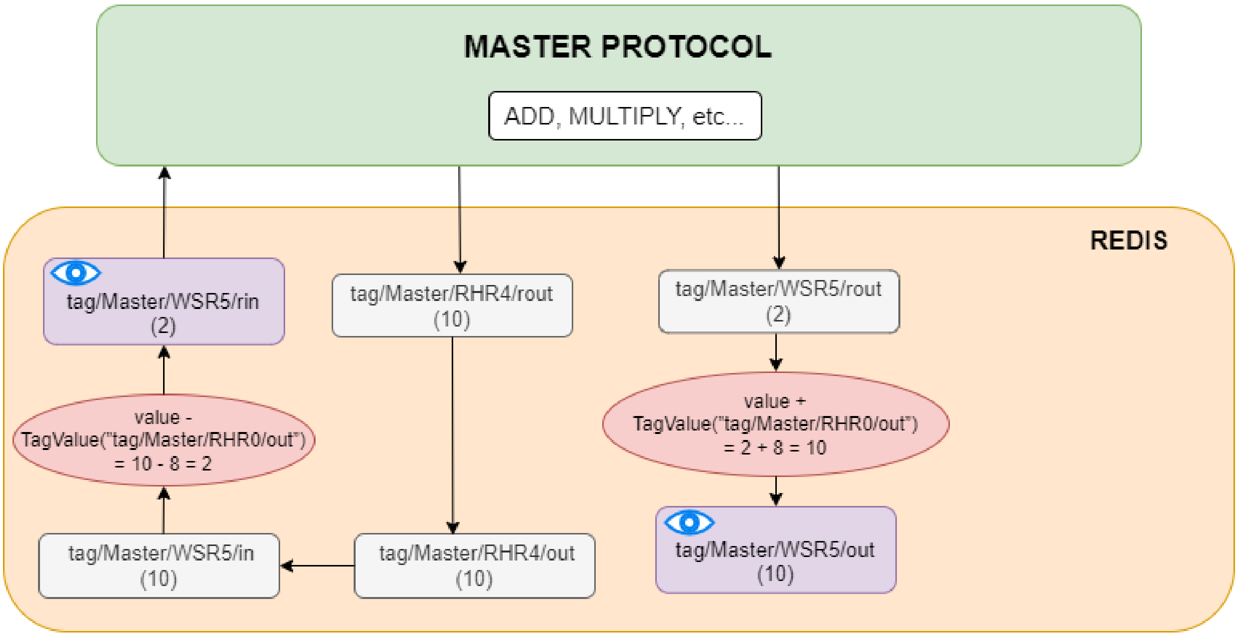


Let us return to our example and let us see what are the values of the WSR5 signal in the WCC Lite web interface and Vinci Slave simulation.





The diagram below explains how these values were calculated.



Extra functions

Several functions are defined to make tag operations possible:

- `TagValue(key)` - returns the last known value of the tag identified by the Redis key;
- `TagFlag(key)` - returns 1 if the tag flag exists. The name format is: ”key flag”. For example, to check if the tag is non-topical, the name would be ”tag/19xxxxxxx/x/x nt”;
- `TagAttribute(key)` - similar to TagFlag, but returns a numeric value of a tag attribute;
- `TagTime(key)` - returns the UNIX timestamp in milliseconds of the last known tag value.

18.4 Uploading configuration

As of WCC Lite version v1.4.0, there are three separate ways to import the configuration: import an Excel file via the web interface, generate compressed configuration files and later upload them via the web interface; or generate compressed configuration files and upload them via utility application.

For WCC Lite version v1.4.0, the name of the file is shown in Protocol Hub -->Configuration. Older versions only allow configuration files to be stored in a file called phub.xlsx and later downloaded with a custom-built name reflecting the date of a download. The upgrade process from older versions to versions v1.4.0 and above when preserving configuration files automatically makes the necessary changes to enable this new functionality of WCC Lite.

If a user intends to **downgrade** the firmware to versions older than version v1.4.0 from newer versions, they must first download the configuration files and later re-upload the configuration after finishing the upgrade process.

Importing an Excel file

Excel files can be imported without any external tools. This option can be used where there is no internet connection or only minor change has to be applied. This way of importing is not suitable for the validation of Excel configuration files.

Generating configuration is a resource-intensive task. It might take up to 10 minutes depending on the configuration complexity

Supported types of an Excel configuration: .xlsx, .xlsm, .xltm, .xltx

To upload an Excel file, open Protocol Hub -->Configuration screen in the Web interface, select Configuration file, and press Import configuration.

Generating .zip file

To accelerate the task of generating configuration a computer can be used. For this users should download the WCC Excel Utility application. Upon opening an application, the user should search for a field called Excel file which lets to choose an Excel file for which a conversion should be made. The output file should be filled out automatically, however, this value can be edited.

To make a conversion press Convert. If there are no errors found in the configuration, the output file should contain the generated configuration, otherwise, an error message is shown to a user.

This .zip file can be uploaded via the Web interface, using the same tools used for the import of an Excel file.

Uploading configuration remotely

As of the WCC Lite version, v1.4.0 generated configuration files can be uploaded with a click of a button in the Excel Utility. There are four parameters (not counting the configuration file itself) that have to be filled in before starting upload:

- *Hostname*: an IP address for the device to connect to. This field conforms to hostname rules, therefore, if an invalid value is selected, it is reset to default (192.168.1.1);
- *Port*: a PORT number to which an SSH connection can be made; valid values fall into a range between 1 and 65535; if an invalid value is selected, it is reset to default (22);
- *Username*: a username which is used to make an SSH connection; make sure this user has enough rights, preferably root;
- *Password*: a password of a user used for establishing an SSH connection;

Configuration can only be uploaded if a port used for SSH connection is open for the IP address filled in the hostname entry field. Please check WCC Lite firewall settings in case of connection failure.

To upload a configuration remotely, press Upload Configuration. If no errors occur, you should finally be met with text output mentioning configuration has been applied. During the upload process, the aforementioned button is disabled to prevent spanning multiple concurrent processes.

18.5 Virtual device

General

The virtual device is a device that you can use to calculate additional math or keep a counter. It doesn't bind to any protocol and only works when its math expression is used.

Virtual device functionality is only available since firmware version v1.6.3, of WCC Lite.

Configuring Virtual device

To configure WCC Lite to use the virtual device you must configure the device and signal sheets.

Virtual device parameters for Device tab:

Parameter	**Type**	**Description**	**Required**	**Default value** (when not specified)	**Range**	
					Min	Max
name	string	User-friendly device name	Yes			
description	string	Description of the device	No			
device_alias	string	Device alias to be used in the configuration	Yes			
protocol	string	Selection of protocol	Yes		**Virtual device**	

Virtual device parameters for the Signals tab:

Parameter	**Type**	**Description**	**Required**	**Default value** (when not specified)	**Range**	
					Min	Max
signal_name	string	User-friendly signal name	Yes			
device_alias	string	Device alias from a Devices tab	Yes			
signal_alias	string	Unique signal name to be used	Yes			
math_expression	string	Field to calculate specific math. You must enter the signal you want to use.	Yes			

The only field that is a must to use the virtual device is the*math_expression* field. Here you need to enter the signal which you want to associate it with. Some examples of what it can do:

- Hold a specific tag value.
- Calculate a specific math function with many signals, that you can, later on, pass to another device.
- Add tag value to the current value, to create a counter.