Fracsun Modbus Documentation

Introduction

ARES and Wash Extension

The Fracsun soiling monitoring solution often encompasses two separate devices: ARES and the Wash Extension. Both devices are configurable as Modbus Slaves to transfer data into the onsite SCADA system via a Modbus RTU RS-485 connection.

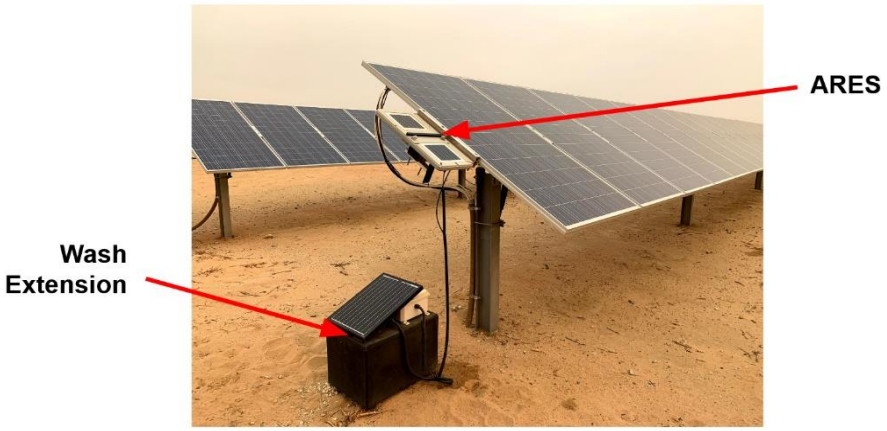


Figure 1: ARES and Wash Extension devices

A note on Modbus: If a cellular network is not available, ARES and Wash Extension devices can function as Modbus RS-485 slave devices and stream data to a master device. However, a Modbus-only communication is not recommended because of the *loss of additional processing* performed in the Fracsun cloud (like daily soiling/insolation calculations, wash optimization schedules, and financials). The most flexible option to have data in your DAS platform and the Fracsun cloud, is to use our RESTful API. Please contact us to learn more.

Modbus commands

These commands are all according to the Modbus RTU protocols described in: 'Modbus® over serial line V1.02' and 'MODBUS application protocol V1.1b' available from the Modbus® organization (www.modbus.org). These commands can be tested using software tools, such as 'Modbus Poll' from www.modbustools.com.

The following commands are implemented:

Function	Description
0x03	Read Holding Register (Single or Multiple)
0x06	Write Single Register
0x16	Write Multiple Registers

Key Modbus Notes

- The address field uses the Protocol address with base 0, not the PLC Address with base 1.
- Treat all data types using Big-Endian format.
- The data type column refers to the target data type. For example, if the Wash Power parameter reads 7521 in a Poll, after the scalar (100) is accounted for, the target FLOAT value would be 75.21 (7521 / 100 = 75.21).

Wiring to a RS-485 Master Device

In its simplest form, ARES and Wash Extension devices are connected in parallel to the RS-485 master device. Internal 120Ω termination resistors are already installed in Fracsun devices, therefore are not required.

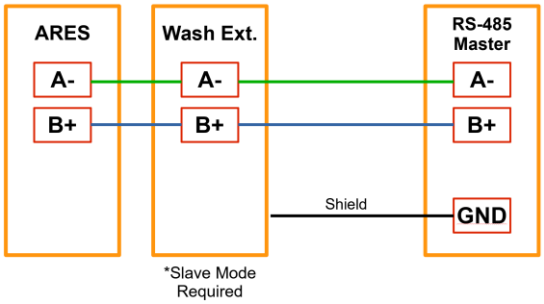


Figure 2: RS-485 connection diagram

Some minor modification of either the ARES or Wash Extension enclosure is required to create a new parallel RS-485 connection that is routed to the RS-485 master device. ARES modifications should only be performed in the factory, whereas Wash Extension modifications can be performed in the field using a direct wire-to-screw-terminal parallel connection. Some examples of a factory ARES modification and Wash Extension modification are seen below. Contact Fracsun for one of these setups.

Figure 3: ARES additional RS-485 connection (factory)

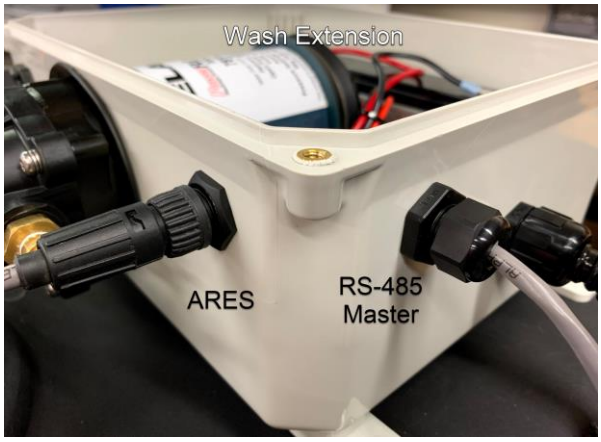


Figure 4: Wash Extension additional RS-485 connection

ARES Device Cellular/Modbus Modes

Three different modes are available in the ARES device. Change the mode by writing to ARES Modbus register 44.

Cellular mode (default)

By default, the ARES device is configured as a self-powered IoT cellular device, without any external Modbus RTU connection required. The device turns on, takes a few measurements, sends the data to the cloud, and then goes into a low-power sleep state to maintain optimal battery voltage. Any Modbus polling attempts during measurement or sleep states will almost always result in a timeout or missed poll. There is a very short 3 second window in which a *single* poll attempt could be successful. Depending on the parameters, the window approximately occurs once every 5 minutes.

- Internal battery power is sufficient in this mode.

Modbus-only mode

When a more robust Modbus connection is required, a different mode (Modbus-only mode) can be enabled, but with the loss of the default cloud functions. Modbus-only mode will bypass the low-power sleep state and cellular cloud functions, but the microcontroller will always remain ON to be available for constant Modbus polling.

This mode is recommended for dataloggers, SCADA systems, and PV plants with NERC requirements.

- External power is required in this mode. The internal battery may not be sufficient in this mode.

Modbus+Cellular mode (experimental)

This is an experimental mode only. In this mode, the device will attempt to connect to a cellular tower at a predetermined time interval. During this connection, some data will be uploaded to the Fracsun cloud and will check for OTA firmware updates. The data can be used for Fracsun cloud processing.

- External power is required in this mode.

Changing the modes

Modes can be changed in a variety of ways:

- Write to the appropriate registers (see Modbus Mode and Apply Code parameters). *ARES must be connected to a Modbus Master device (or a PC with Modbus Poll software).*
- Over-the-air (OTA) parameter change by Fracsun support team. *ARES must be connected to cloud.*
- Shipped preconfigured with a particular mode.
- Button press pattern on ARES main control PCB. *Not recommended, device must be opened.*
- USB serial console command accessible from ARES PCB. *Not recommended, device must be opened.*

External power requirements in Modbus-only and Cellular modes

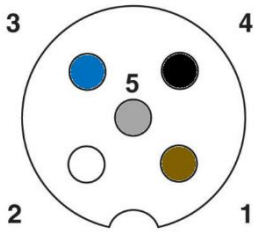
Depending on the available sunlight at the ARES install location and night-sleep mode selection, a dedicated power connection is often required in Modbus-only mode. Power is absolutely required for downward facing ARES devices in Bifacial systems. Use the table below to select the appropriate power source for your ARES device:

Parameter	Min	Typical	Max	Unit	Mode
Input Voltage	7.5	12	16	V	All
Avg. Input Current @ **12 Vdc**	18	21	30	mA	Modbus-only
Peak Input Current @ **12 Vdc**	280	--	600	mA	Cellular (2G/3G)
Avg. Input Current @ **7.5 Vdc**	28	35	50	mA	Modbus-only
Peak Input Current @ **7.5 Vdc**	450	--	1000	mA	Cellular (2G/3G)

ARES M12 connection diagram (ARES devices built 2021 and later)

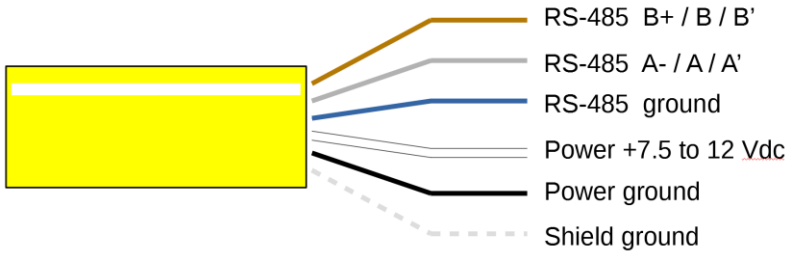
For installations utilizing Modbus-only mode (an external Modbus RTU connection) or Modbus + Cellular mode, use the M12 pinout diagram below to connect ARES to the Modbus Master.

Wire		Connection description
1	Brown	Modbus RS-485 B+ / B / B'
5	Gray	Modbus RS-485 A- / A / A'
3	Blue	Modbus common / ground *
2	White	Power +7.5 to +12Vdc **
4	Black	Power common / ground
	Shield	Housing *



* Not a required connection.

** Absolute maximum Power input voltage is 16 Vdc. *Do not exceed*.



M12 automation cable with loose-end wires purchased separately. Various lengths available.

ARES Modbus Map

The default SLAVE ID/address is: **42**. This address can be changed by writing to the slave address register.

Parameter Name	Address	R/W	Data type	Scalar	Description
Irradiance (Clean)	0	R	UINT_16		Irradiance in W/m2 of the **Clean** reference cell. Is a temperature-compensated and post-calibrated value.
Irradiance (Soiled)	1	R	UINT_16		Irradiance in W/m2 of the **Soiled** reference cell. Is a temperature-compensated and post-calibrated value.
Shunt current (Clean)	2	R	FLOAT	100	Shunt (short-circuit) current of the **Clean** reference cell. Is not a temperature-compensated value.
Shunt current (Soiled)	3	R	FLOAT		Shunt (short-circuit) current of the **Soiled** reference cell. Is not a temperature-compensated value.
Soiling Loss	4	R	FLOAT	100	Instantaneous Soiling Loss value in %. Computed as the percent difference between the Clean vs. Soiled irradiance (temp compensated).
Soiling Ratio	5	R	FLOAT	1000	Instantaneous Soiling Ratio value (no units). Computed per IEC 61724-1.
Calibration (Clean)	6	R+W	INT_16		Calibration value of the **Clean** reference cell. Range is -30 to 30.
Calibration (Soiled)	7	R+W	INT_16		Calibration value of the **Soiled** reference cell. Range is -30 to 30.
Temperature (cell)	8	R	FLOAT	100	Temperature in degrees Celsius of the reference cell backsheet.
Temperature (interior)	9	R	FLOAT		Temperature in degrees Celsius of the ARES interior (main PCB).
Battery Voltage	10	R	FLOAT	100	LTO battery voltage in Volts.
Soiling Loss Avg. (yesterday)	11	R	FLOAT		Future update (2021) – not available yet. The daily average soiling loss value (%) from the previous day.
Cellular RSSI	12	R	INT_16		Received Signal Strength Indicator in dBm from the last cell connection.
Slave address	40	R+W	UINT_16		Modbus slave address (1 – 255). Default is 42.
Baud Rate	41	R+W	UINT_16		Modbus baud rate. Acceptable rates are 1200, 2400, 4800, 9600, 14400, 19200, and 38400. Default is 19200.
Frame Config	42	R+W	UINT_16		Modbus frame configuration. Acceptable values are 0 and 4. 0 = 8 Databits, None Parity, 1 Stop Bit 4 = 8 Databits, Even Parity, 1 Stop Bit (default)
Modbus Mode	43	R+W	UINT_16		Modbus mode selection. Use the table below to select a mode: 1 = Cellular mode / intermittent Modbus (default mode) 100 = Modbus-only mode (cellular modem off) 200 = Modbus + Cellular mode (experimental)
Apply Code	44	R+W	UINT_16		Apply code that must be written *prior* to modifying Calibration values, Modbus config, or Modbus mode registers. 321 = Enable auto-calibration (recommended) 123 = Enable manual-calibration 456 = Enable Modbus configuration (Slave address, baud, frame) 789 = Enable Cellular/Modbus mode change This register automatically resets to 0 after any write operation to registers 6, 7, or 40-43.
Reset	45	R+W	UINT_16		Resets the device. Write 255 once to enable. Register is automatically reset to 0 upon reset.
Auto-Calibrate Result	46	R	UINT_16		The result of the auto-calibration process. 1 = Success, 2 = Failed during testing, 3 = Not enough sunlight to calibrate, 4 = No calibration reqd.
Night-Sleep Mode	48	R+W	UINT_16		Enables/disables night-sleep mode. When enabled, ARES will enter a deep sleep state during darkness. Acceptable values are: 0 = Disabled, 1 = Enabled

Wash Extension Device

Modbus modes – Master/Slave

In the default mode, the Wash Extension functions as a Modbus Master (for a Fracsun-only connection). If connecting the Fracsun soiling monitoring system to an external Modbus RTU connection, the Wash Extension Modbus mode must be changed to function as a Modbus Slave. Changing this mode ensures that two Modbus Masters are not on the same RS-485 network.

Changing the Modbus Mode to SLAVE via USB

The mode, and other Modbus configurations, can be changed by interfacing a computer to the Wash Extension controller via the micro-USB connection on the board labeled "Xenon". With a few keypresses inside a serial console, the configuration is configurable. Follow the instructions below to change the Wash Extension to SLAVE-mode:

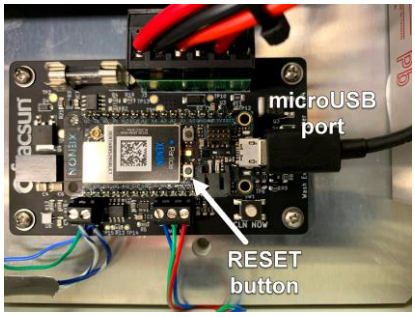


Figure 5: Xenon microUSB and RESET

1. Connect a microUSB cable between the Fracsun "Xenon" board and a Windows 10+ computer.
2. Open a serial terminal program, such as Tera Term VT or Putty and begin a New Connection to the COM port associated with the Xenon board. Often, it's displayed as "Xenon Serial (COM#)". If not COM port is visible, the Windows USB Drivers might have to be installed. The default USB COM settings are: 9600 baud rate, 8 databits, NONE parity, and 1 stop bits.
3. Once connected, the terminal will show all of logging information.
4. Press "m" once on your keyboard, wait up (up to 2 minutes) to access the Modbus menu in the console.
5. Press "2" and then "y" to enable SLAVE mode.

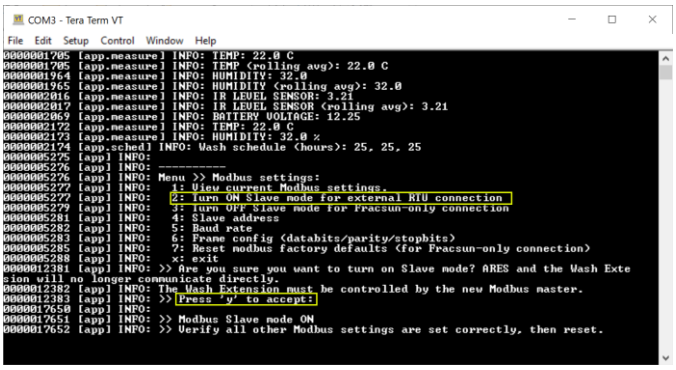


Figure 6: Wash Extension serial console - changing Modbus mode

6. Reset the device by pressing the RESET button on the Xenon board to use Slave Mode.

Through this same menu system, you can also change the slave address, baud rate, and frame configuration. The default values are: 43 slave address, 19200 baud rate, 8 databits, EVEN parity, and 1 stop bit.

Wash Extension Modbus Map (SLAVE mode only)

The default SLAVE ID/address is: **43**. The address can be changed via the microUSB cable. See instructions above.

Parameter Name	Address	R/W	Data type	Scalar	Description
Timezone	13	R+W	INT_16		Current timezone (*required* for proper wash schedule). If negative, convert to an unsigned number. (**ex**: -7 timezone would convert to 65529). *This value is retained in flash memory. It only needs to be set once – new installs, during DST time changes, or changing station locations.*
Unix Time	20-21	R+W	UINT_32		The number of seconds that have elapsed since January 1, 1970 (midnight UTC/GMT). *Value is not retained in flash memory.* *Recommended to write every 3 hours for proper time keeping.*
Last Wash Time	40-41	R	UINT_32		Unix time value of the last wash event
Wash Power	42	R	FLOAT	100	Pump motor power (in watts) of the last wash event. Values between 50 – 80 W indicate a successful wash.
Temperature	43	R	FLOAT	100	Temperature in degrees Celsius inside the Wash Extension enclosure.
Relative Humidity	44	R	FLOAT	100	Relative humidity (%) inside the Wash Extension enclosure. Can often detect rain events in dry/arid climates.
Battery Voltage	45	R	FLOAT	100	Lead-acid battery voltage in Volts.
Tank Level	46	R	UINT_16		Liquid level sensor output in Volts. 0 = presence of water, 3 = absence of water *When the output value switches from 0 to 3, this indicates approximately 8-10 weeks before the reservoir is completely empty.
Wash Hour 1	50	R+W	UINT_16		Hour to initiate a wash event #1 (0-23). Default is 25 (no wash).
Wash Hour 2	51	R+W	UINT_16		Hour to initiate a wash event #2 (0-23). Default is 25 (no wash).
Wash Hour 3	52	R+W	UINT_16		Hour to initiate a wash event #3 (0-23). Default is 25 (no wash).
Wash Now	53	R+W	UINT_16		Initiate a wash now. Write 255 once to enable. Register is automatically reset to 0 upon wash.

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