INS 23 122469 - HES_PMS_EMS_Communication

Date : 24/2/2023	From : ESS/EIS	Verified by :
To :		
Copy to :		

Document revisions

Revision	Date	Author	Evolution/Change
1.07	24/02/2023	TOJ	Add Drying process information
1.06	03/01/2023	GAS	Change name of file, change name of Modbus mapping file
1.05	02/12/2022	TOJ	Update alarm reset steps
1.04	24/03/2022	GAS	Rework of initial version : new state machine & explanations
1.03	4/10/2021	LCV	
1.02	12/05/2021	SYK	Add description for OFF Grid mode and transitions
1.01	06/04/2021	LCV	New chapters : Active/Reactive power setpoint
1.00	18/3/2021	LCV	Initial version

Definitions

BMS	Battery Management System
EMS	Energy Management System
ESS	Energy Storage System (includes PCS and Battery System)
HMI	Human Machine Interface
PCS	Power Conversion System
PMS	Power Management System
PV	Photovoltaic System
GE	Electric Power Generator
SOC	State of Charge
SOH	State of Health
IC	Islanding Controller

Index

1. Foreword

The scope of this document is the definition of the communication interface with the SOCOMEC Power Management System (PMS from here on) to be implemented by an external controller.

The reference to an Energy Management System (EMS from here on) refers to this same external controller which can be any client communicating with the PMS to monitor/operate the Energy Storage System (ESS from here on).

2. Protocol overview and definitions

The communication protocol supported by SOCOMEC PMS is the standard Modbus application-layer protocol over standard Ethernet connection (Modbus TCP, port 502, SlaveID 255).
SOCOMEC PMS acts as a Modbus server.

Refer to the Modbus protocol specifications for the description of the frame formats and protocol details (available on www.modbus.org).

Modbus Function Codes

Only the following FC (Function-Codes) are supported:

Modbus FC	Description
3	Read registers
6	Write Single register
16	Write Multiple registers

Registers addressing mode

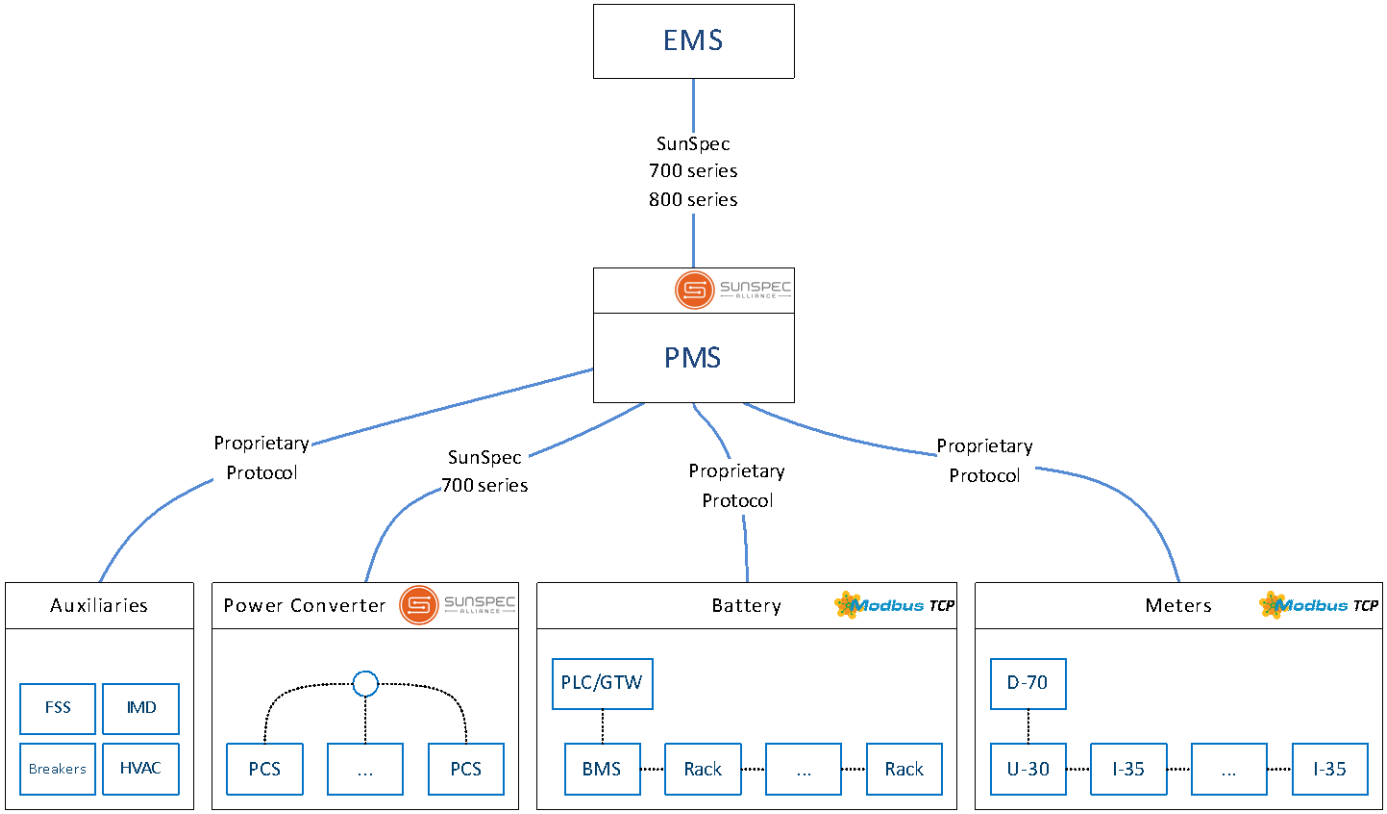
A “base 0 address” format has to be used to access data.
This means that the “Modbus Address” field in the data mapping tables of this document shall be considered as the Modbus PDU address (no -1 offset has to be applied to get the PDU address).

3. Modbus register mapping

Modbus mapping is based on the SunSpec Information Model, which can be found in the following document:

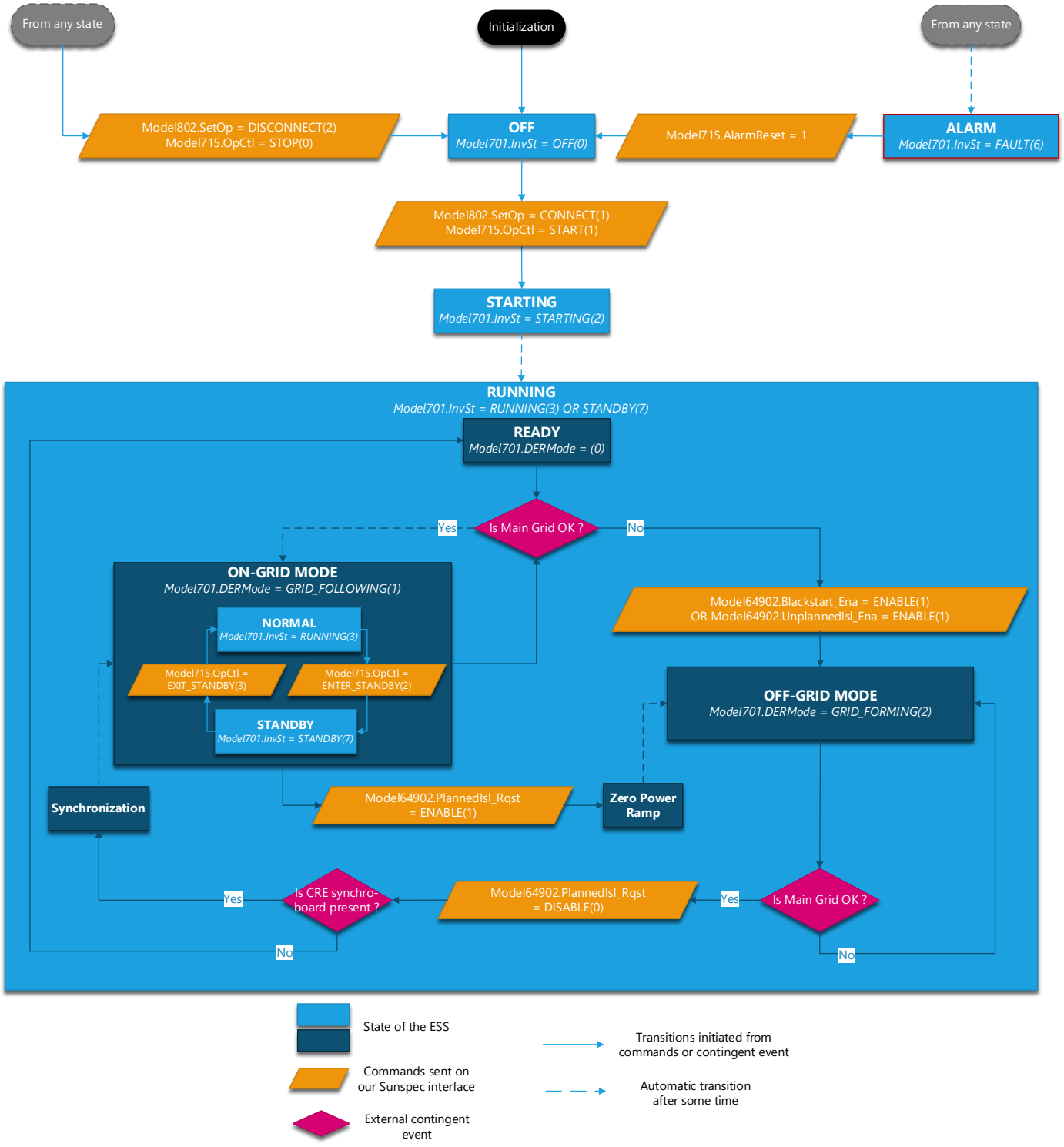
INS 23 122470 - HES_PMS_Sunspec_Information_Model_Reference.xlsx

4. Communication architecture



5. State-machine

Zoom in to get a higher definition



6. User Manual

6.1. The starting sequence

6.1.1. Initialization to OFF

When the auxiliaries of the ESS power up, the PMS initializes and automatically enters the **OFF** state. The AC and DC switches of the ESS are open and the PMS awaits commands.

NOTE:
It is likely that the ESS enter the **ALARM** state when the PMS powers up: in this case, follow the instructions in the ALARM management section.

6.1.2. OFF to STARTING

After receiving the "Model802.SetOp = CONNECT(1)" and "Mode715.OpCtl = START(1)" commands, the PMS enters the **STARTING** state with its associated sequence : the DC switch between the batteries and the inverter get closed, the converter get energized by the DC bus and starts up.
During the starting sequence, the "Model701.InvSt" is "STARTING(2)".

6.1.3. STARTING to RUNNING

The starting sequence is performed automatically after the PMS gets the two commands above.

NOTE:
If the ESS has just been switched off and immediately requested to start again, the starting sequence might take up to 5 minutes.

As soon as the ESS is ready to operate, the ESS enters the **RUNNING** state, and the "Model701.InvSt" is "RUNNING(3)".
At that moment:

- If the main grid is present, the ESS immediately closes its AC switch and enters the ON-GRID MODE. (grid-following, current generator)
- If the main grid is not present, the ESS checks that either "Mode64902.UnplannedIsl_Ena = ENABLE(1)" or "Mode64902.Blackstart_Ena = ENABLE(1)", then closes its AC switch and enters the OFF-GRID MODE (grid-forming, voltage generator)

6.2. The ON-GRID MODE

While in **ON-GRID-MODE**, "Model701.DERMode" is "GRID-FOLLOWING(1)" : the ESS can be operated with active power and reactive power setpoints, or can be set in standby.

NOTE:
In On-Grid mode, in case of loss of communication with the EMS, the PMS can be configured as follow:

- An alarm is activated and the ESS consequently goes in **ALARM** state (PCS and battery are disconnected).
- A warning is activated and P and Q setpoints are forced to zero until recovering communication.

The choice between those two behaviors must be selected during system commissioning.

6.2.1. The Active Power Setpoint

In order to enable active power setpoint, register "Model704.WSetEna" must be set to ENABLED(1).
Then, register "Model704.WSetMod" can be set with:

- W_MAX_PCT(0) (*Active Power As Max Percent*) : in this case the register "Model704.WSetPct" is used as setpoint.
- WATTS(1) (*Active Power As Watts*) : in this case the register "Model704.WSet" is used as setpoint.

If the value is negative the system will draw power and charge.
If the value is positive the system will give power and discharge.

NOTE :
"Model704.WSetPct" has a scale factor "Model704.WSetPct_SF" and "Model704.WSet" has a scale factor "Model704.WSet_SF" that need to be considered. The value to send in these registers is the value before getting scaled by the factor. (For instance : in W_MAX_PCT mode, if the scale factor "Model704. WSetPct _SF" = -3, "Model704.WSetPct" = 50000 will result in a setpoint of 50% of the maximum active power).

6.2.2. The Reactive Power Setpoint

In order to enable reactive power setpoint, register "Model704.VarSetEna" must be set to ENABLED(1).
Then, register "Model704.VarSetMod" can be set with:

- VAR_MAX_PCT(1) (*Reactive Power As Var Max Pct*) : in this case the register "Model704.VarSetPct" is used as setpoint.
- VARS(4) (*Reactive Power As Vars*) : in this case the register "Model704.VarSet" is used as setpoint.
- Any other mode will result in a 0 reactive setpoint

The default value for reactive power priority "Model704.VarSetPri" is ACTIVE(0), it means the reactive power setpoint can be limited if there is no enough apparent power.

NOTE :
Similarly to active power, "Model704.VarSetPct" has a scale factor "Model704.VarSetPct_SF" and "Model704.VarSet" has a scale factor "Model704.VarSet_SF". The value to send in these registers is the value before getting scaled by the factor.

6.2.3. The Standby Mode

The Standby Mode is a particular mode when the ESS is in **ON-GRID MODE**. While in Standby Mode, the ESS works with a 0-power setpoint, and the PCS will limit the power exchange with the batteries as much as possible. The ESS enters the Standby Mode by receiving "Mode715.OpCtl = ENTER_STANDBY(2)", the "Model701.InvSt" is "STANDBY(7)".
The ESS exits the Standby Mode by receiving "Mode715.OpCtl = EXIT_STANDBY(3)" , the "Model701.InvSt" gets back to "RUNNING(3)".
After exiting the Standby Mode, the ESS resumes the power setpoints normally.

6.3. The OFF-GRID MODE

While in **OFF-GRID MODE**, "Model701.DERMode" is "GRID-FORMING(2)" : the power output of the ESS is self-regulated according to the loads and other DERs connected to it.

NOTES:

- The **OFF-GRID MODE** can be forced with "Mode64902.PlannedIsl_Rqst = ENABLE(1)" even if the main grid is back within acceptable conditions. This command has to be sent before the grid is back.
- The **OFF-GRID MODE** is only permitted if the value of Battery SOC and PCS capabilities are inside defined ranges (can be modified from PMS parameters).
- In **OFF-GRID MODE**, in case of loss of communication with the EMS, the PMS can be configured as follow:
    - an alarm is activated and the ESS consequently goes in **ALARM** state (PCS and battery are disconnected).
    - a warning is activated and the ESS keep last received commands until recovering communication. So, if "Mode64902.PlannedIsl_Rqst = ENABLE(1)" , the ESS will stay in **OFF-GRID MODE** as long as possible. If "Mode64902.PlannedIsl_Rqst = DISABLE(0)", the ESS will perform a transition to **ON-GRID MODE** as soon as the main grid is back within acceptable conditions.

  The choice between those two behaviors must be selected during system commissioning.

6.4. The ON-GRID MODE to OFF-GRID MODE transitions

6.4.1. The Unplanned Transition (Open Transition)

When the ESS is in **ON-GRID MODE** and an unplanned outage occurs on the main grid or the main grid is out of acceptable conditions, the breaker from the mains will be opened by a relay controller.
In this case, the ESS will be able to restart if "Mode64902.UnplannedIsl_Ena = ENABLE(1)" OR "Mode64902.Blackstart_Ena = ENABLE(1)" and if the ESS has the capabilities to support the loads.

NOTES :

- The unplanned islanding authorized by "Mode64902.UnplannedIsl_Ena = ENABLE(1)" is slightly faster than the blackstart authorized by "Mode64902.Blackstart_Ena = ENABLE(1)", but is proceeded with less regulations. If both are activated, the ESS will prioritize the unplanned islanding.
- To perform the unplanned islanding transition, the PMS must have the information of the position for the breaker from the mains. Discuss with Socomec to further specify the sequence of the transition.

6.4.2. The Planned Transition (Close Transition)

When the ESS is in **ON-GRID MODE**, the EMS can intentionally request to get into **OFF-GRID MODE** with "Mode64902.PlannedIsl_Rqst = ENABLE(1)" even if the mains is still present.
After receiving the command, the PMS will use the ESS to perform a zero-power ramp where the breaker is to be opened: the ESS is still in **ON-GRID MODE**, but the control of active and reactive power setpoints is temporarily disabled. The EMS can still cancel the procedure by sending "Mode64902.PlannedIsl_Rqst = DISABLE(0)".
When the zero-power ramp is completed or the time for the zero-power ramp is elapsed the breaker will open with no exchange of power and the ESS seamlessly enters **OFF-GRID MODE**.

Conditions to enter back in **ON-GRID MODE** are described in the next section.

NOTES :

- The power ramp can be configured with two settings: a power threshold can be used to do a x-power ramp where x is the threshold. The maximum time of power ramp can also be configured.
- To perform the planned transition, the PMS must be correctly connected to power measurement devices as specified by Socomec.
- The grid former to get disconnected from is not necessarily the main grid, it can also be a genset. Discuss with Socomec to further specify this use case.

NOTE :

Transitions to **OFF-GRID MODE** are only permitted if the values of Battery SOC and PCS capabilities are inside defined ranges (can be modified from PMS parameters).

6.5. The OFF-GRID MODE to ON-GRID MODE transitions

If the main grid is within acceptable conditions, the ESS can swap from **OFF-GRID MODE** to **ON-GRID MODE** if "Mode64902.PlannedIsl_Rqst = DISABLE(0)".
In this case, the transition sequence relies on the presence or not of a CRE synchro-phasor board:

- If the CRE board is present, the swap can happen in close-transition: the ESS will start a phase and frequency synchronization with the main grid. When the main grid and the ESS are synchronized, the CRE board will raise a signal standing for the authorization for closing the breaker from the mains. When the breaker gets closed, the ESS will seamlessly go in **ON-GRID MODE**.
- If the CRE board is not present, the swap will happen in open-transition: the ESS opens its AC switch resulting in the shutdown of the Micro Grid, then the ESS waits for the breaker from the mains to get closed before reconnecting to the grid in **ON-GRID MODE**.

NOTES :

- To perform the synchronization, the PMS must be correctly connected to a CRE board. Discuss with Socomec for further specifications.
- If "Mode64902.PlannedIsl_Rqst = ENABLE(1)" and the main grid is within acceptable condition, the ESS remains in **OFF-GRID MODE** until the values of Battery SOC and the PCS capabilities are no more in defined ranges (can be modified from PMS parameters), then the PMS autonomously starts the transition to **ON-GRID MODE**, ignoring the command "Mode64902.PlannedIsl_Rqst = ENABLE(1)".

6.6. ALARM management

In case of faulty condition, the ESS enters the **ALARM** state and "Model701.InvSt" is "ALARM(6)".
The PMS enters a safe state by opening both DC and AC switches of the system. This can happen from any state.
The ESS will stay in this state until the PMS receives the reset command "Model715.AlarmReset = 1".
When a reset command is received, the PMS will acknowledge its alarms and you must wait 30seconds before checking the state of the PMS.
If the command gets through, no alarm condition is present and the ESS goes to **OFF** state. The starting sequence can be executed.
If the PMS is still in **ALARM** you can perform the reset steps two more times.
If after 3 reset command, the PMS is still in **ALARM**, you must contact your maintenance team or SOCOMEC in order to troubleshoot and repair the system, and you must stop sending commands until the technical team confirm the system availability.

On start-up of the system or on environmental conditions the system can go in a drying phase.
During this drying process the system will be in alarm and will stay in alarm until it is finished.
You can monitor this process by reading "Model64901.SW2 bit 14" .
If it is at 1 you must not send reset alarm. If it is at 0 you can perform the reset alarm sequence.

6.7. SUMMARY

LOGIC STATE	MAIN GRID BREAKER POSITION	MODE	POWER CONTROL MODE
OFF	Any	---	---
STARTING	Any	---	---
READY	Any	---	---
ON-GRID MODE NORMAL	Closed	Grid Following	P and Q setpoints from EMS
ON-GRID MODE STANDBY	Closed	Grid Following	P=0 and Q=0
OFF-GRID MODE	Open	Grid Forming	P and Q depend on the loads
ZERO POWER RAMP	Closed ➡Open	Grid Following➡ Grid Forming	P and Q setpoints from PMS
SYNCHRONIZATION	Open ➡Close	Grid Forming➡ Grid Following	P and Q depend on the loads
UNPLANNED ISLANDING	Open	--- ➡Grid Forming	---
BLACK START	Open	--- ➡Grid Forming	---
ALARM	Any	---	---