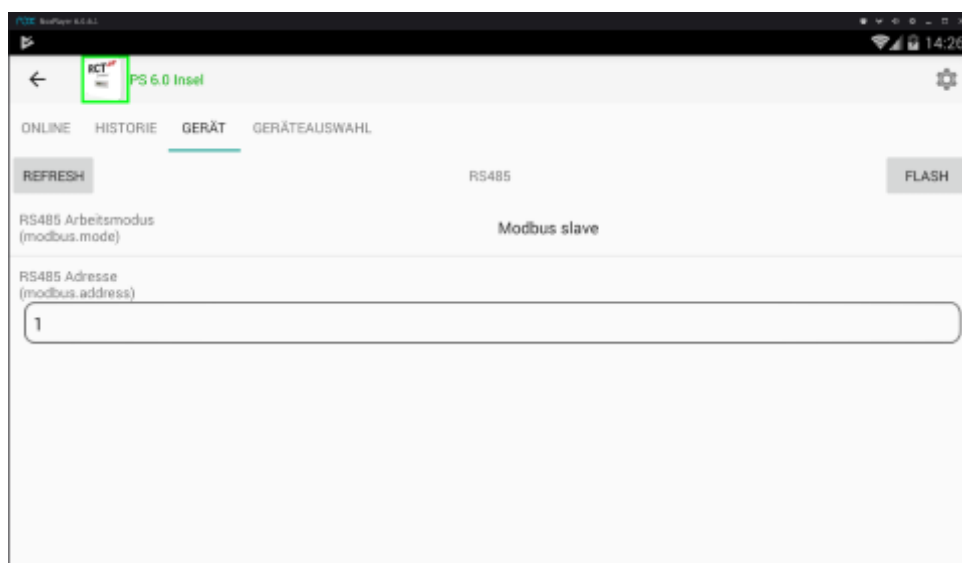


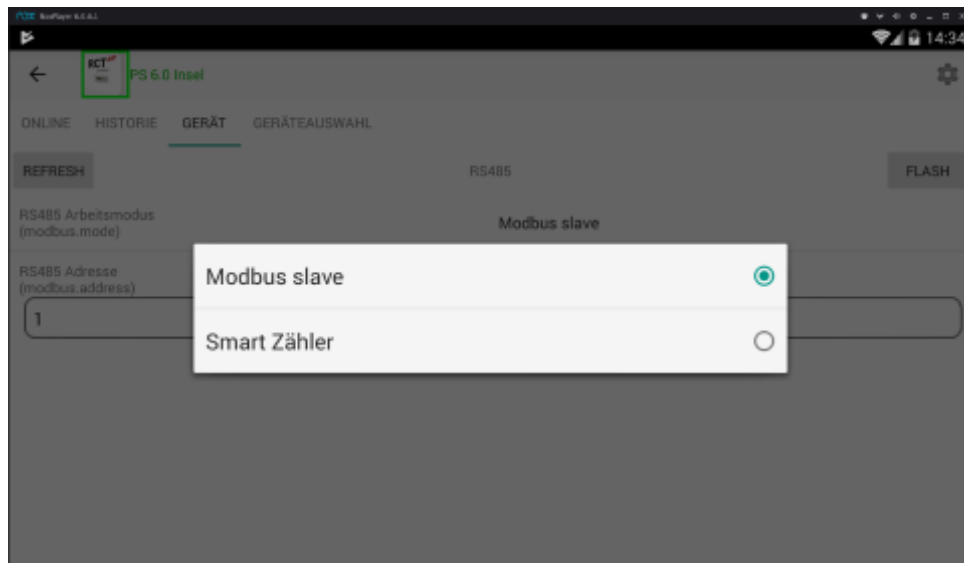
# RS485 Communication with external devices v.1.2

## Changes

| Version | Date       | Author           | Description                                                         |
|---------|------------|------------------|---------------------------------------------------------------------|
| 1.1     | 11.04.2019 | Dmitry Podobedov | Added registers:<br><br>40080 Battery power<br><br>40081 Grid Power |
| 1.2     | 29.04.2020 | Dmitry Podobedov | Faults description chapter added. Table with inverter states added. |

RS485 interface can be configured as MODBUS slave or master over the App (Device -> Settings -> Interfaces -> RS485):





If "Modbus slave" selected, the RS485 interface can be used by external devices for serial communication with Inverter using MODBUS V1.1 RTU standard protocol. The RS485 address should be appropriately choosed - this will be the MODBUS slave address of the inverter.

RS485 port settings are follow:

baudrate: 9600

coding system: 8-bit binary

bits per byte: 1 start bit, 8 data bits (least significant bit sent first), no parity, 1 stop bit

For CRC calculation the polynom 0xA001 is used, initialization value is 0xFFFF.

Broadcast address "0" is supported.

Exception response by wrong requests is supported.

Supported function codes:

0x03 - read holding registers

0x10 - write multiple registers

The table of the available registers is follow:

| Register Address | Description | Format            | Scale |
|------------------|-------------|-------------------|-------|
| 40000            | Model       | String (32 bytes) |       |
| 40016            | Version     | String (16 bytes) |       |

| Register Address | Description                       | Format            | Scale    |
|------------------|-----------------------------------|-------------------|----------|
| 40024            | Serial Number                     | String (16 bytes) |          |
| 40032            | AC Current (Sum of active phases) | int16             | 0.01 A   |
| 40033            | Phase A Current                   | int16             | 0.01 A   |
| 40034            | Phase B Current                   | int16             | 0.01 A   |
| 40035            | Phase C Current                   | int16             | 0.01 A   |
| 40036            | Phase Voltage AB                  | int16             | 0.1 V    |
| 40037            | Phase Voltage BC                  | int16             | 0.1 V    |
| 40038            | Phase Voltage CA                  | int16             | 0.1 V    |
| 40039            | Phase Voltage AN                  | int16             | 0.1 V    |
| 40040            | Phase Voltage BN                  | int16             | 0.1 V    |
| 40041            | Phase Voltage CN                  | int16             | 0.1 V    |
| 40042            | AC Power                          | int16             | 1 W      |
| 40043            | Line Frequency                    | uint16            | 0.001 Hz |
| 40044            | AC Apparent Power                 | int16             | 1 VA     |
| 40045            | AC Reactive Power                 | int16             | 1 VAr    |
| 40046            | AC Power Factor                   | uint16            |          |
| 40047            | AC Energy (day)                   | uint16            | 10 Wh    |
| 40048            | Current on PV input A             | uint16            | 0.01 A   |
| 40049            | Current on PV input B             | uint16            | 0.01 A   |

| Register Address | Description                           | Format | Scale  |
|------------------|---------------------------------------|--------|--------|
| 40050            | Voltage on PV input A                 | uint16 | 0.1 V  |
| 40051            | Voltage on PV input B                 | uint16 | 0.1 V  |
| 40052            | DC Power                              | uint16 | 1 W    |
| 40053            | Heat Sink Temperature                 | uint16 | 0.1 °C |
| 40054            | Heat Sink Temperature (battery conv.) | uint16 | 0.1 °C |
| 40055            | Core Temperature                      | uint16 | 0.1 °C |
| 40056            | Operating State                       | uint16 |        |
| 40057            | Bitmask value. Event fields.          | uint32 |        |
| 40059            | AC Energy (year)                      | uint16 | 1 kWh  |
| 40060            | AC Energy (total)                     | uint32 | 1 kWh  |
| 40062            | Power Reduction (Power Control)       | uint16 | 0.01 % |
| 40063            | Insulation                            | uint16 | 1 kOhm |
| 40064            | Power on PV input A                   | uint16 | 1 W    |
| 40065            | Power on PV input B                   | uint16 | 1 W    |
| 40066            | Bitmask value. Event fields.          | uint32 |        |
| 40068            | Bitmask value. Event fields.          | uint32 |        |
| 40070            | Bitmask value. Event fields.          | uint32 |        |
| 40072            | Time stamp (UNIX)                     | uint32 | 1 s    |
| 40074            | Number of installed battery units     | uint16 |        |
| 40075            | State of Charge (SOC)                 | uint16 | 0.1 %  |

| Register Address | Description                                             | Format | Scale  |
|------------------|---------------------------------------------------------|--------|--------|
| 40076            | Loaded energy                                           | uint16 | 100 Wh |
| 40077            | Battery capacity                                        | uint16 | 100 Wh |
| 40078            | Max discharge power                                     | uint16 | 1 W    |
| 40079            | Max charge power                                        | uint16 | 1 W    |
| 40080            | Battery power (positive = discharge)                    | int16  | 1 W    |
| 40081            | Grid Power: Negative - feed-in, positive - consumption. | int16  | 10 W   |

**Table 1**

## Faults

There are two classes of the faults

- Inverter faults
- Battery (BMS) faults

The faults are bit-coded in four 32-bit variables, where each bit is reserved for one fault, so there are 4 x 32 faults at all. Bit 0 of the „fault[0].flt“ variable corresponds fault index 0.

| Variable     | Fault indexes | Register |
|--------------|---------------|----------|
| fault[0].flt | 0..31         | 40057    |
| fault[1].flt | 32..63        | 40066    |
| fault[2].flt | 64..95        | 40068    |
| fault[3].flt | 96..127       | 40070    |

**Table 2**

The following table presents all available faults

| Fault index | Description   |
|-------------|---------------|
| 0           | TRAP occurred |

|    |                                             |
|----|---------------------------------------------|
| 1  | RTC can't be configured                     |
| 2  | RTC 1Hz signal timeout                      |
| 3  | Hardware Stop by 3.3V fault                 |
| 4  | Hardware Stop by PWM Logic                  |
| 5  | Hardware Stop by Uzk overvoltage            |
| 6  | Uzk+ is over limit                          |
| 7  | Uzk- is over limit                          |
| 8  | Throttle Phase L1 overcurrent               |
| 9  | Throttle Phase L2 overcurrent               |
| 10 | Throttle Phase L3 overcurrent               |
| 11 | Buffer capacitor voltage                    |
| 12 | Quartz fault                                |
| 13 | Grid under_voltage phase 1                  |
| 14 | Grid under_voltage phase 2                  |
| 15 | Grid under_voltage phase 3                  |
| 16 | Battery overcurrent                         |
| 17 | Relays Test failed                          |
| 18 | Board Over Temperature                      |
| 19 | Core Over Temperature                       |
| 20 | Sink 1 Over Temperature                     |
| 21 | Sink 2 Over Temperature                     |
| 22 | Error by I2C communication with Power Board |
| 23 | Power Board Error                           |
| 24 | PWM output ports defect                     |

|    |                                                                  |
|----|------------------------------------------------------------------|
| 25 | Insulation is too small or not plausible                         |
| 26 | I DC Component Max (1 A)                                         |
| 27 | I DC Component Max Slow (47 mA)                                  |
| 28 | One of the DSD channels possibly defect (too big current offset) |
| 29 | Error by RS485 communication with Relays Box IGBT L1 BH defect   |
| 30 | Phase to phase over voltage                                      |
| 31 | IGBT L1 BH defect                                                |
| 32 | IGBT L1 BL defect                                                |
| 33 | IGBT L2 BH defect                                                |
| 34 | IGBT L2 BL defect                                                |
| 35 | IGBT L3 BH defect                                                |
| 36 | IGBT L3 BL defect                                                |
| 37 | Long Term over voltage phase 1                                   |
| 38 | Long Term over voltage phase 2                                   |
| 39 | Long Term over voltage phase 3                                   |
| 40 | Over voltage phase 1, level 1                                    |
| 41 | Over voltage phase 1, level 2                                    |
| 42 | Over voltage phase 2, level 1                                    |
| 43 | Over voltage phase 2, level 2                                    |
| 44 | Over voltage phase 3, level 1                                    |
| 45 | Over voltage phase 3, level 2                                    |
| 46 | Over frequency, level 1                                          |
| 47 | Over frequency, level 2                                          |
| 48 | Under voltage phase 1, level 1                                   |

|    |                                                |
|----|------------------------------------------------|
| 49 | Under voltage phase 1, level 2                 |
| 50 | Under voltage phase 2, level 1                 |
| 51 | Under voltage phase 2, level 2                 |
| 52 | Under voltage phase 3, level 1                 |
| 53 | Under voltage phase 3, level 2                 |
| 54 | Under frequency, level 1                       |
| 55 | Under frequency, level 2                       |
| 56 | CPU Exception NMI                              |
| 57 | CPU Exception HardFault                        |
| 58 | CPU Exception MemManage                        |
| 59 | CPU Exception BusFault                         |
| 60 | CPU Exception UsageFault                       |
| 61 | RTC Power on reset                             |
| 62 | RTC Oscillation stops                          |
| 63 | RTC Supply voltage drop                        |
| 64 | Jump of RCD current DC + AC > 30mA was noticed |
| 65 | Jump of RCD current DC > 60mA was noticed      |
| 66 | Jump of RCD current AC > 150mA was noticed     |
| 67 | RCD current > 300mA was noticed                |
| 68 | incorrect 5V was noticed                       |
| 69 | incorrect -9V was noticed                      |
| 70 | incorrect 9V was noticed                       |
| 71 | incorrect 3V3 was noticed                      |
| 72 | failure of RDC calibration was noticed         |

|    |                                                                                     |
|----|-------------------------------------------------------------------------------------|
| 73 | failure of I2C was noticed                                                          |
| 74 | afi frequency generator failure                                                     |
| 75 | sink temperature too high                                                           |
| 76 | Uzk is over limit                                                                   |
| 77 | Usg A is over limit                                                                 |
| 78 | Usg B is over limit                                                                 |
| 79 | Switching On Conditions Umin phase 1                                                |
| 80 | Switching On Conditions Umax phase 1                                                |
| 81 | Switching On Conditions Fmin phase 1                                                |
| 82 | Switching On Conditions Fmax phase 1                                                |
| 83 | Switching On Conditions Umin phase 2                                                |
| 84 | Switching On Conditions Umax phase 2                                                |
| 85 | Battery current sensor defect                                                       |
| 86 | Battery booster damaged                                                             |
| 87 | Switching On Conditions Umin phase 3                                                |
| 88 | Switching On Conditions Umax phase 3                                                |
| 89 | Voltage surge or average offset is too big on AC-terminals (phase failure detected) |
| 90 | Inverter is disconnected from the household grid                                    |
| 91 | Difference of the measured +9V between DSP and PIC is too big                       |
| 92 | 1.5V error                                                                          |
| 93 | 2.5V error                                                                          |
| 94 | 1.5V measurement difference                                                         |
| 95 | 2.5V measurement difference                                                         |
| 96 | The battery voltage is outside of the expected range                                |

|     |                                                                                      |
|-----|--------------------------------------------------------------------------------------|
| 97  | Unable to start the main PIC software                                                |
| 98  | PIC bootloader detected unexpectedly                                                 |
| 99  | Phase position error (not 120° as expected)                                          |
| 100 | Battery overvoltage                                                                  |
| 101 | Throttle current is unstable                                                         |
| 102 | Difference between internal and external measured grid voltage is too big in phase 1 |
| 103 | Difference between internal and external measured grid voltage is too big in phase 2 |
| 104 | Difference between internal and external measured grid voltage is too big in phase 3 |
| 105 | External emergency turn off signal is active                                         |
| 106 | Battery is empty, not more energy for standby                                        |
| 107 | CAN communication timeout with battery                                               |
| 108 | Timing problem                                                                       |
| 109 | Battery IGBT's Heat Sink Over Temperature                                            |
| 110 | Battery heat sink temperature too high                                               |
| 111 | Internal Relays Box error                                                            |
| 112 | Relays Box PE off error                                                              |
| 113 | Relays Box PE on error                                                               |
| 114 | Internal battery error                                                               |
| 115 | Parameter changed                                                                    |
| 116 | 3 attempts of island building are failed                                             |
| 117 | Phase to phase under voltage                                                         |
| 118 | System reset detected                                                                |
| 119 | Update detected                                                                      |

|     |                                                                            |
|-----|----------------------------------------------------------------------------|
| 120 | FRT over-voltage                                                           |
| 121 | FRT under-voltage                                                          |
| 122 | IGBT L1 free wheeling diode defect                                         |
| 123 | IGBT L2 free wheeling diode defect                                         |
| 124 | IGBT L3 free wheeling diode defect                                         |
| 125 | 1 phase mode is activated but not allowed for this device class (e.g. 10K) |
| 126 | Island detected                                                            |

**Table 3**

The fault “Internal battery error” (index 114) is a BMS class fault and must be interpreted as follow:

### **Error Code**

32-Bit Error Code.

Bit-Mask

0xF8000000 Subsystem

0x00000001 active

**Subsystem:** Master (16), UI/Power(15)

Bit-Mask

0x07FFFE00 Code

0x000001E0 Information

0x0000001E Severity

**Subsystem:** Stack/Slave (0..14)

Bit-Mask

0x07FFC000 Code

0x00003C00 Information

0x000003C0 Severity

0x0000003E Cell

## Severity

| Severity | Description   | Action                                                                                                           |
|----------|---------------|------------------------------------------------------------------------------------------------------------------|
| 1        | Info          | -                                                                                                                |
| 2        | Warning       | Continue normal operation, LED is flashing.                                                                      |
| 3        | Error Class 1 | Wait until error is resolved.<br />Shutdown after 2 hours.<br />Shutdown after 5 minutes if cell voltage is low. |
| 4        | Error Class 2 | Shutdown after 5 minutes.<br />Try to resolve after restart.                                                     |
| 5        | Error Class 3 | Shutdown after 5 minutes.<br />Can not be resolved without technician.                                           |

## Master

| Type   | Severity | Limit       | Description                       |
|--------|----------|-------------|-----------------------------------|
| 0x0100 | 3        | -           | BMSERRORMASTERVCCADC_TIMEOUT      |
| 0x0210 | 3        | 11.4V (5%)  | BMSERRORMASTERVCC12V_MIN          |
| 0x0220 | 3        | 12.6V (5%)  | BMSERRORMASTERVCC12V_MAX          |
| 0x0310 | 3        | 3.135V (5%) | BMSERRORMASTERVCC3V3_MIN          |
| 0x0320 | 3        | 3.465V (5%) | BMSERRORMASTERVCC3V3_MAX          |
| 0x1100 | 4        | 610V        | BMSERRORMASTERUMAXSYSTEM          |
| 0x1200 | 4        | 6           | BMSERRORMASTERINCORRECTNROFSLAVES |
| 0x1300 | 4        | 1h          | BMSERRORMASTERDEVICENOT_AVAILABLE |
| 0x1400 | 4        | 2h          | BMSERRORMASTERDEVICENOT_CONNECTED |
| 0x2100 | 4        |             | BMSERRORMASTERCONNECTLSOPENCLAMP  |
| 0x2200 | 4        |             | BMSERRORMASTERCONNECTHSOPENCLAMP  |
| 0x2300 | 4        |             | BMSERRORMASTERCONNECTLS_STUCK     |
| 0x2400 | 4        |             | BMSERRORMASTERCONNECTHS_STUCK     |
| 0x2500 | 4        |             | BMSERRORMASTERCONNECTLSSTUCKOPEN  |
| 0x2600 | 4        |             | BMSERRORMASTERCONNECTHSSTUCKOPEN  |
| 0x2710 | 4        | Ubat -5%    | BMSERRORMASTERCONNECTVOLTAGE_LOW  |
| 0x2720 | 4        | Ubat +5%    | BMSERRORMASTERCONNECTVOLTAGE_HIGH |
| 0x2800 | 4        | 1h          | BMSERRORMASTERCONNECTTIMEOUT      |
| 0x3100 | 3        | 10s         | BMSERRORMASTEREXTERNCAN_ERROR     |

## UI/Power

| Type   | Severity | Limit | Description        |
|--------|----------|-------|--------------------|
| 0x0100 | 5        | 40A   | BMSERRORUI_CURRENT |

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|        |   |                |                     |                            |
|--------|---|----------------|---------------------|----------------------------|
| 0x0110 | 3 | <br />4<br />5 | *<br />25A<br />40A | BMSERRORUICURRENTDISCHARGE |
| 0x0120 | 3 | <br />4<br />5 | *<br />25A<br />40A | BMSERRORUICURRENTCHARGE    |
| 0x0400 | 4 |                | 1A                  | BMSERRORUICURRENTOFFSET    |
| 0x0500 | 3 |                |                     | BMSERRORUIRELAYSOPEN       |
| 0x0600 | 3 |                |                     | BMSERRORUI_SLAVE           |
| 0x0700 | 3 |                | 5%                  | BMSERRORUISUPPLYVOLTAGE    |
| 0x0800 | 4 |                | 1s                  | BMSERRORUI_CAN             |
| 0x1100 | 3 |                | 5%                  | BMSERRORUICURRENTDIFF      |
| 0x1200 | 3 |                | 5%                  | BMSERRORUIVOLTAGEDIFF      |

\* Temperature dependent characteristic  $I(T)$ .

### ***Slave***

| Type   | Severity        | Limit                      | Description                 |
|--------|-----------------|----------------------------|-----------------------------|
| 0x0100 | 5               | 2.8V / 3.6V                | BMSERRORSLAVE_CELLVOLTAGE   |
| 0x0110 | 3<br />4<br />5 | 2.975V<br />2.9V<br />2.8V | BMSERRORSLAVECELLVOLTAGEMIN |
| 0x0120 | 4<br />5        | 3.55V<br />3.6V            | BMSERRORSLAVECELLVOLTAGEMAX |
| 0x0200 | 5               | -25°C / 65°C               | BMSERRORSLAVE_CELLTEMP      |
| 0x0210 | 5               | -25°C                      | BMSERRORSLAVECELLTEMPMIN    |
| 0x0220 | 5               | 65°C                       | BMSERRORSLAVECELLTEMPMAX    |
| 0x0300 | 4               | -20°C / 60°C               | BMSERRORSLAVE_BOARDTEMP     |
| 0x0400 | 4               |                            | BMSERRORSLAVE_HARDWARE      |
| 0x0500 | 3               | 1x                         | BMSERRORSLAVE_TIMING        |
| 0x0600 | 3               | 1x                         | BMSERRORSLAVE_SPI           |
| 0x0700 | 3               | 10%                        | BMSERRORSLAVE_SUPPLYVOLTAGE |
| 0x0800 | 4               | 1s                         | BMSERRORSLAVE_CAN           |

### ***Faults storing in the internal flash memory***

#### **All faults (see Table 3)**

) can occur simultaneously. After one of the faults is gone – the appropriate record will be immediately written into internal flash memory. This record contains the following information about the fault:

#### **Index (see Table 3)**

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- )
- Begin time stamp
- End time stamp
- Extra information bytes

All records are sorted by the faults end time. Requesting of the faults includes the time stamp (e.g. Treq), the answer will contain all the faults whose end time is equals or smaller as Treq. For example the request time stamp is 12:00 08.11.2018, then the answer list can include the faults like this (the latest faults are first):

```
11:33:07 08.11.2018   ERR_UNSTABLE_CURRENT
9:01:15 08.11.2018   ERR_UZK_OVERVOLTAGE
3:45:50 08.11.2018   ERR_UZK_OVERVOLTAGE
23:59:00 07.11.2018   ERR_RTC
20:44:05 07.11.2018   ERR_OVERCURRENT_L1
```

## Table of inverter states

The state number is in the variable `prim_sm.state` (see " Operating State" (40056) register)

| State # | Description                                                    |
|---------|----------------------------------------------------------------|
| 0       | Standby                                                        |
| 1       | Initialization                                                 |
| 2       | Standby                                                        |
| 3       | Efficiency (debug state for development purposes)              |
| 4       | Insulation check                                               |
| 5       | Island check (decision where to go - grid connected or island) |
| 6       | Power check (decision if enough energy to start or not)        |
| 7       | Symmetry (DC-link alignment)                                   |
| 8       | Relays test                                                    |

|    |                                                                              |
|----|------------------------------------------------------------------------------|
| 9  | Grid Passive (inverter get power from grid without bridge clocking)          |
| 10 | Prepare Bat Passive                                                          |
| 11 | Battery Passive (inverter disconnected from grid and get power from battery) |
| 12 | H/W check (prepare to start)                                                 |
| 13 | Feed in                                                                      |

**Table 4**