KACO new energy.

Battery inverter BG50.0 TL3-S

Setup instruction EMS communication

Application note

for system integrators

NOTE
This documentation is valid for all versions of BG50.0 TL3-S (options B / M: without internal precharge unit; options L / XL: with internal precharge unit) with Software Version V5.22

Contents

1 General

Refer to the operating instructions and further documentation for general information and steps necessary to connect the inverter.

NOTE

Please refer to the following documents which are provided with this Application note:

- "**Operating Instructions blueplanet gridsave 50.0 TL3-S**"
- **"Application Note Remote access via web user interface**"
- **"Application Note for Modbus Protocol"**

1.1 BG50.0TL3-S Option B / M (without precharge unit):

CAUTION

Before fully energizing the DC input, make sure that the DC input is precharged with a maximum current of 100A until the DC-Link capacitors are charged.

The DC input capacity per inverter is 2mF.

Devices without precharge unit do not limit the DC inrush current. The DC inrush current must be externally limited to a maximum current of 100A. Exceeding the maximum allowed inrush current may damage device.

2 External interface

The battery inverter uses an Ethernet interface for configuration and control.

The default IP configuration is:

- DHCP

IP settings can be changed either from the inverter menu or from the internal webserver.

3 Communication and Control

3.1 General

The inverter is controlled externally by a ModbusTCP interface which is based on SunSpec. See the documents “SunSpec_Information_Model_Reference.xls” and “SunSpec_Information_Model_Reference_KACO.xls” which are provided together with this Application note and the general SunSpec documentation for further information.

Modbus registers are numbered from 1 to n. The data address in the Modbus protocol data unit (PDU, data on the wire) start from zero. For further information see Modbus Application Protocol V1.1b (http://www.modbus.org/docs/Modbus_Application_Protocol_V1_1b.pdf).

You can use the following Modbus function codes for all registers:

- FC03 (`0x03`) Read holding registers
- FC06 (`0x06`) Write single holding register
- FC16 (`0x10`) Write multiple holding registers

Write access (FC06 and FC16) to registers with access mode “R” (read-only) is possible and will not raise an error. The written value is ignored.

The number of Modbus requests has to be limited to max. 5 requests per second with a time of more than 200ms between each request.

The inverter allows only one concurrent Modbus connection.

3.2 Minimum Required Registers

At least the following control values are required for operation:

- Inverter connection state
  `64201.RequestedState` and `64201.CurrentState`
- Battery limits
  `64202.DisMinV`, `64202.DisMaxA`, `64202.ChaMaxV`, `64202.ChaMaxA` and `64202.EnLimit`
- External power set point
  `64201.WSetPct`
- Watchdog control
  `64201.Watchdog`

The following control value must be sent periodically (e.g. once every 1 second):

- Watchdog control
  `64201.Watchdog`

It is recommended that the following registers are sent periodically as well:

- Power set point
  `64201.WSetPct`
- Battery limits
  `64202.DisMinV`, `64202.DisMaxA`, `64202.ChaMaxV`, `64202.ChaMaxA` and `64202.EnLimit`

3.3 Inverter states

The following diagram shows the states and transitions of the inverter.

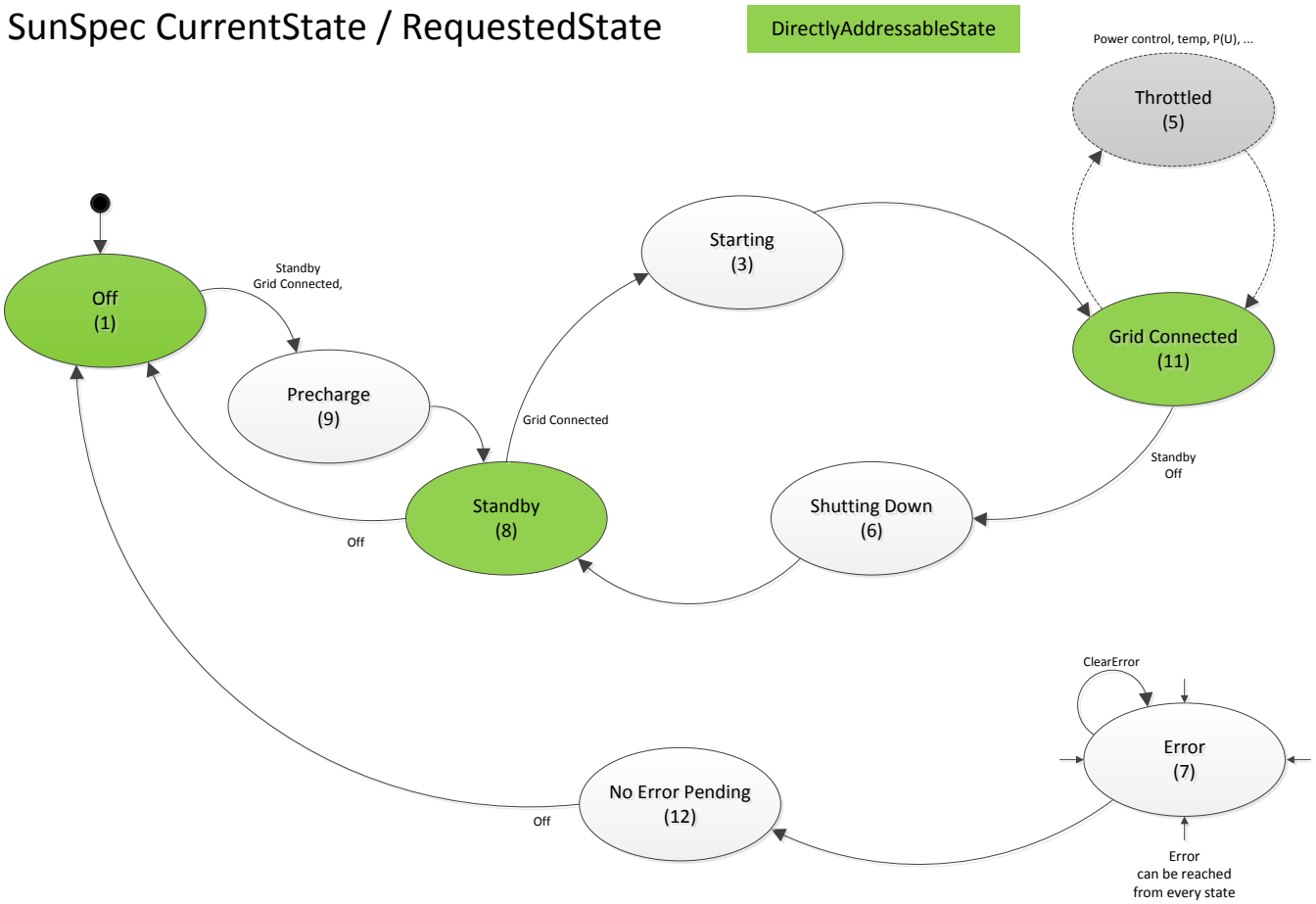

Figure 1. Inverter states

3.3.1 Description

3.3.1.1 Directly Addressable states

Possible target states for register `64201.RequestedState`

State Off (1), *AC-Relays and DC-Relay(s) (Version L/XL) disconnected*
State is reached when AC is applied. The boot up time of the front end (HMI) takes about 75 seconds. The Modbus communication requires that AC is applied and that the front end (HMI) is booted. Modbus registers that contain measurement data will not contain meaningful values in this state (a read request will return 0).
The battery limits must be sent at least once while in state Off (1) before starting the system. However it is recommend sending the battery limits cyclically. The data point `64202.DisMinV` and `64202.ChaMaxV` must not be zero.

State Standby (8), *AC-Relays disconnected, DC-Relay(s) (Version L/XL) connected*
Power electronics controller is running, AC-grid and DC parameters are monitored (e.g. voltage, frequency).

State GridConnected (11), *AC-Relays and DC-Relay(s) (Version L/XL) connected*
Inverter is connected to the AC grid. Active power can now be set.

3.3.1.2 Other states

Cannot be reached directly, no possible target states for register `64201.RequestedState`

State Precharge (9), *AC Relays disconnected, Precharge in progress*
Transitional state in which the intermediate circuit is precharged and the controller of the power electronics is booting. After boot up state (8) is reached automatically. The precharge and boot time takes about 60 seconds. Modbus registers that contain measurement data will contain meaningful values after state (9) is left.

State Starting (3), *AC-Relays disconnected, DC-Relay(s) (Version L/XL) connected*
Transitional state in which the inverter waits for all values to be within its valid ranges and a stable AC grid is detected. Before connecting to the grid, a system self-test is invoked.
The startup time depends on the country specific grid code (e.g. 300s for South Korean country setting).

State Throttled (5), *AC-Relays and DC-Relay(s) (Version L/XL) connected*
Inverter is connected to the AC grid. Output power is limited due to grid support functions or internal limitations (eg. temperature derating).

State ShuttingDown (6), *AC-Relays and DC-Relay(s) (Version L/XL) connected*
Transitional state in which the inverter is disconnecting from the AC grid.

State Error (7), *AC-Relays and DC-Relay(s) (Version L/XL) disconnected*
State can be reached from any other state in case an error is detected.

State NoErrorPending (12), *AC-Relays and DC-Relay(s) (Version L/XL) disconnected*
State is reached when the Inverter has switched off in case of an error and the error is not present any more. The error condition must be reset by requesting State Off (1).

3.4 Recommended operation procedure

This chapter describes the recommended communication operation. The following steps should be performed in order to guarantee a working communication. AC must be applied and the boot up of the user interface must be completed in order to be able to establish a Modbus connection.

Step	Description
1	Find the existing Modbus models and corresponding start addresses: • Probe the well-known base addresses for the well-known 32 bit “SunS”-Identifier • Find all available SunSpec models and start addresses • Calculate the absolute addresses of the registers that are used (see chapter 3.6) For details see document SunSpec Information Model Specification.
2	Check that all required models and data points are available. For storage inverters at least the following models are required: • 1 (optional) • 121 • 64201 • 64202 The scale factors of all used data points must be read at least once. The data points must be scaled with the corresponding scale factors. Scale factors are not going to change during operation.
3	Recommended communication procedure: The following models should be read once at the beginning (initial read sequence): • Read model 1 (optional) • Read model 121 The following models should be written at least once after startup: • Write model 64202 The following models should be read / written cyclically. • Read / write model 64201 • Read / write model 64202 (optional) Do not send more than 5 requests per second. The time between each request must be >= 200ms and should be equal.
4	Startup preparation: • Apply DC • Send valid battery limits: o Write model 64202 data point `DisMinV`, `DisMaxA`, `ChaMaxV`, `ChaMaxA`, `EnLimit` o `64202.DisMinV` and `64202.ChaMaxV` must not be zero o When `64202.EnLimit` is set to 1 the values are activated.

Step	Description	
	Version B and M (without precharge unit)	**Version L and XL (with precharge unit)**
5	Start the inverter: We assume that step 4 was processed and AC and DC are applied.	

	• 64201.`CurrentState` is (8)
	• In order to start the inverter
	  ○ set 64201.`RequestedState` register t0 11
	  ○ `64201.CurrentState` will change to (3).
	• Selftest and checking for a stable grid
	  ○ `64201.CurrentState` will change from (3) to (11).
	• The inverter is connected to the grid
	• In case of an error
	  ○ Contactors are opened
	  ○ `64201.CurrentState` will change to (7).
	  ○ Read 64201.`StVnd` for further information. The meaning of this data point can be found in the user manual of the device.
		• 64201.`CurrentState` is (1)
		• In order to start the inverter
		  ○ set 64201 `RequestedState` register t0 11
		• The intermediate circuit is precharged.
		  ○ `64201.CurrentState` will change to (9).
		• After approx. 60s the
		  ○ `64201.CurrentState` will change from (9) over (8) to (3).
		• Selftest and checking for a stable grid
		  ○ `64201.CurrentState` will change from (3) to (11).
		• The inverter is connected to the grid
		• In case of an error
		  ○ Contactors are opened
		  ○ `64201.CurrentState` will change to (7).
		  ○ Read 64201.`StVnd`, `64201.ErrPcu` for further information. The meaning of these data points can be found in the user manual of the device.

6	Send power set points: Register `64201.WSetPct` is used for power set points. • `64201.WSetPct` should be 0 when `64201.CurrentState` is not (11) or (5) • `64201.WSetPct` should be 0 before `64201.RequestedState` is set to (1) or (8) • `64201.WSetPct` can be set as desired when `64201.CurrentState` is (11) or (5)	
7	Stop the inverter:	

	• In order to stop the inverter
	  ○ set `64201.RequestedState` register t0 1
	• Contactors are opened.
	  ○ `64201.CurrentState` will change over (1) to (8).
	Note: (1) might not be visible
		• In order to stop the inverter
		  ○ set `64201.RequestedState` register t0 1
		• Contactors are opened.
		  ○ `64201.CurrentState` will change to (1).

8	Clear error: Error is not pending anymore and `64201.CurrentState` is (12).	

	• In order to clear error condition
	  ○ Set 64201 `RequestedState` register t0 1
	  ○ `64201.CurrentState` will change over (1) to (8).
	Note: (1) might not be visible
		• In order to clear error condition
		  ○ Set 64201 `RequestedState` register t0 1
		  ○ `64201.CurrentState` will change to (1).

3.5 SunSpec register description

The following paragraphs describe the most common registers used to control the inverter. For a complete list of all registers please refer to the enclosed documentation ("SunSpec_Information_Model_Reference.xls", "SunSpec_Information_Model_Reference_KACO.xls" and the general SunSpec documentation).

3.5.1 Model 121 – Basic settings

The following registers of Model 121 are needed to calculate the power setpoint (`64201.WSetPct`) based on an absolute value.

SunSpec model 121 – Basic Settings						
Name	**Address Offset**	**Acc. Mode**	**Type**	**Unit**	**Scale factor**	**Description**
`WMax`	2	R	uint16	W	`WMax_SF`	maximum power output
`WMax_SF`	22	R	int16	-	-	scale factor active power

3.5.2 Model 64201 – bidirectional inverter control

The following registers in SunSpec model 64201 are used to control the inverter:

SunSpec model 64201 – Bidirectional inverter control						
Name	**Address Offset**	**Acc. Mode**	**Type**	**Unit**	**Scale factor**	**Description**
`RequestedState`	4	R/W	uint16	-	-	connection control 1 Off 8 Standby 11 Grid Connected
`CurrentState`	5	R	uint16	-	-	current state of the inverter
`Watchdog`	8	R/W	unit16	Sec	-	enable Watchdog timer. Register must be written with the desired watchdog timeout in seconds. 0 means watchdog is disabled.
`WSetPct`	9	R/W	int16	% Wmax	`WSetPct_SF`	power setpoint in % of WMax See model 121 data point WMax
`WSetPct_SF`	46	R	int16	-	-	active power scaling

3.5.2.1 Connection control

Register `64201.CurrentState` contains the current state of the inverter. The number read from the register corresponds to the state shown in Figure 1 above.

The inverter state can be changed by writing the desired target state to register `64201.RequestedState`.

3.5.2.2 Watchdog

Once the Power electronis controller has started (`64201.CurrentState` not (1) or not (9)) a watchdog timer is started with a default value of 30s to monitor the communication to the EMS/PMS.
The watchdog timer is reset to the value written into the register `64201.Watchdog` every time a write access to the register is observed. The watchdog timer can be disabled by writing a value of 0.

In case of a communication timeout, which means that the watchdog register was not written for more than the configured value, the inverter will stop operating and the HMI will show (196) *External communication error* on the display.
This error (like all other errors) can be cleared by sending `64201.RequestedState=1`.

3.5.2.3 Setpoints – power control

Register `64201.WSetPct` is used to control the power set point. The value needs to be scaled with the corresponding scaling factor. Positive values of active power means discharging.

Example to calculate the register 64201.WSetPct **in order to set the desired active power setpoint** WSet_inWatt **given in watt:**

$$64201.WSetPct = \frac{WSet_{inWatt} * 100}{121.WMax * 10^{121.WMax\_SF} * 10^{64201.WSetPct\_SF}}$$

3.5.3 Model 64202 – Battery limits

All voltage and all current values must be scaled with the corresponding scaling factor V_SF or A_SF.

SunSpec model 64202 – Battery Charge Discharge Characteristic						
Name	**Address Offset**	**Acc. Mode**	**Type**	**Unit**	**Scale factor**	**Description**
`V_SF`	6	R	int16	-	-	voltage scaling
`A_SF`	7	R	int16	-	-	current scaling
`DisMinV`	8	R/W	unit16	V	`V_SF`	min. discharge voltage
`DisMaxA`	9	R/W	unit16	A	`A_SF`	max. discharge current
`ChaMaxV`	11	R/W	unit16	V	`V_SF`	max. charge voltage
`ChaMaxA`	12	R/W	unit16	A	`A_SF`	max. charge current
`EnLimit`	15	R/W	unit16	-	-	new battery limits are activated when EnLimit is 1

For increased efficiency it is recommended to write the registers `DisMinV` up to `EnLimit` in a single Modbus request (function code 16).

3.5.4 Model 64203 – Display of Battery information

The following values can be set optionally in model 64203. This model allows the EMS/PMS to display certain battery parameters on the display of the inverter. The values do not influence the behaviour of the inverter in any way.

SunSpec model 64203 – Batterysystem Information						
Name	**Address Offset**	**Acc. Mode**	**Type**	**Unit**	**Scale factor**	**Description**
SoC_SF	5	R	int16	-	-	scale factor SoC
SoH_SF	6	R	int16	-	-	scale factor SoH
Temp_SF	7	R	int16	-	-	scale factor temperature
BatSOC	16	R/W	uint16	%	SoC_SF	SoC of battery 0% to 100%
BatSOH	17	R/W	uint16	%	SoH_SF	SoH of battery 0% to 100%
BatTemp	18	R/W	int16	°C	Temp_SF	avg. temperature of battery -50°C to 100°C

The SOC of the battery (64203.BatSOC) is visualized on the home screen of the inverter in 6 steps. If no information is written by the EMS/PMS for more than 30s, an empty Battery symbol is displayed.

SOC range 64203.BatSOC	**Description**	**Symbol**
0 <= SOC <= 19%	empty battery symbol	
19 < SOC <= 39%	one bar visible	
39 < SOC <= 59%	two bars visible	
59 < SOC <= 79%	three bars visible	
79 < SOC <=95%	four bars visible	
SOC >95%	filled battery symbol (five bars)	

3.5.5 Model 64302 – Generic commands

SunSpec model 64302 – Generic commands						
Name	**Address Offset**	**Acc. Mode**	**Type**	**Unit**	**Scale factor**	**Description**
CommandIdReq	12	R/W	int16	-	-	ID of the command to execute 0 no command 1 Reset System
ReqParam0	13	R/W	uint32	-	-	first Parameter
CommandIdReqEna	29	R/W	unit16	-	-	writing a “1” triggers execution of command
CommandIdRes	30	R	int16	-	-	command ID response
ReturnCode	31	R	int16	-	-	status and result of command execution 0 Success 1 Processing 2 unknown command 3 error 4 invalid parameter

To initiate a manual system reset perform the following steps::

- stop the inverter
  - set `64201.RequestedState` t0 `1`
  - Version B / M
    - `64201.CurrentState` will change over (1) to (8).
  - Version L / XL
    - `64201.CurrentState` will change to (1).
- prepare reset command
  - set `64302.CommandIdReq` to `1` (“Reset System”)
  - set `64302.ReqParam0` to `0` (“Reset complete system”)
- execute command
  - set `64302.CommandIdReqEna` to `1`
- optionally check result by reading `64302.CommandIdRes` and `64302.ReturnCode`

3.6 Available SunSpec data models

The following table shows the available SunSpec models with start address as implemented in software package 5.22.

NOTE
Start Addresses in the following table are only valid for software package 5.22 and are subject to change in future software versions without further notice. It is strongly recommended to calculate the model start addresses during each system start as described in the SunSpec protocol description.

SunSpec Model	Length	Start Address
1	66	40003
121	30	40213
64201	52	40823
64202	14	40877
64203	26	40893
64302	46	40931

Example to access data point `64201.RequestedState` in model 64201:

SunSpec model 64202 – Bidirectional inverter control						
Name	**Address Offset**	**Acc. Mode**	**Type**	**Unit**	**Scale factor**	**Description**
`RequestedState`	4	R/W	uint16	-	-	connection control

Absolute register address of `64201.RequestedState`: <Model start address> + <register offset> = 40823 + 4 = 40827

4 Document Revision History

Revision	Dated	Author	Status and Description
1.0	171102	Jochen Bender(TR)	First draft version
1.1	171107	Mathias, Diebold	Added additional information
2.0	180326	Diebold	Changed description and operating procedures for devices with internal precharge unit and Software V5.10
2.1	180627	Diebold	Changed description and operating procedures for all devices and Software V5.22. Restructured all chapters.

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