Solar Direct Drive SDD1.5kW-425V

Solar in Motion – driving industrial motors by the power of sun

The Solar Direct Drive “SDD” has been developed to operate standard industrial 3 phase electrical motors from a few hundred Watts up to several horse powers (hp) where mains grid is not available. Its robust case structure is designed to meet a protection degree of IP54 (IP65) permitting installation outdoor. Optional GSM based remote controllability has become available for this small member of the Solar Direct Drive product range as well as a PayGo option. The EMPO-NI Solar Direct Drive is designed to operate with almost every manufacturer's PV panels and driving any standard industrial 3 phase induction motor up to 3-phase 230V in typical applications like pumping and ventilation. The Solar Direct Drive SDD1.5kW-425V incorporates extra setups for non-standard 1,1kW/160V, 750W/110V, 550W/85V and 375W/65V 3-phase induction motors for highly cost optimized systems. Those motors are available at EMPO-NI for submersible pumps and industrial (standfoot/flange) for productive use applications. Versatile sensor and digital interfaces along with the integrated software incorporate adaptability to systems and can take over system control functions.
This application manual provides a comprehensive overview of the SDD’s functions and safety requirements, the interfaces and the menu structure etc. Please read this document carefully before starting to install or operate the SDD.

Figure 1: SDD1.5kW-425V (model 2020/21)

Table of contents:

Figures and tables

List of Abbreviations

A	Ampere
AM	Air Mass
DIN	Deutsche Industrie Norm
Fo	Output frequency [Hz]
Hz	Hertz [1/sec]
IP	Ingress Protection Rating
I/O	Input / Output
LC(D)	Liquid Crystal (Display)
MMI	Man Machine Interface
MPP	Maximum Power Point
MPPT	Maximum Power Point Tracking
NOCT	Normal Operating Conditions
PayGo	Pay-as-you-go
PV	Photo voltaic
Voc	Open circuit voltage
(R)	Read only
(R/W)	Read and write access
SDD	Solar Direct Drive
SPD	Surge Protective Device
STC	Standard Test Conditions
Tc	Cell Temperature of the solar panel in °C
V	Volt
W	Watt

Safety advice:

General information

The Solar Direct Drive (SDD) should be installed in accordance with the local code authority having jurisdiction and this installation manual.
This manual has been prepared to acquaint you with the installation, operation and maintenance of the SDD and to provide important safety information in these areas.
We urge you to read all of the instructions thoroughly before attempting the installation or operation of this SDD. This manual should be kept for future reference.
The manufacturer of this Solar Direct Drive will not be liable for any damages caused by failure to comply with the installation and operating instructions outlined in this manual.
If you lack the necessary skills required to properly install this SDD or you have difficulty following the directions, you should not proceed but have a qualified person perform the installation of this SDD.
Examples of a qualified person include: licensed electricians, authorized electric company personnel and authorized service personnel.
Retain your original receipt as proof of purchase in case warranty within the applicable warranty period might be in place.

IMPORTANT: Do not remove, cover or deface any permanent instructions, labels, or the data label from either the outside of the SDD or on the inside of the SDD.

The SDD must NOT be placed on its cover (plastic) side. It should be transported and stored in a way that is avoiding mechanical stress on the plastic cover.
• Remove exterior packaging and place installation components aside.
• Inspect all parts for damage prior to installation and start-up.
• Completely read all instructions before attempting to assemble and install this product.
• Our product is saving environmental resources, please dispose of/recycle all packaging materials after installation.

Installation location requirements

- Select a location that is avoiding direct sunlight exposure ideally bellow the PV- panel array and in vicinity to the electrical motor, e.g. the application that is driven.

- The site location must be free from any corrosive elements in the atmosphere such as sulfur, fluorine, and chlorine.
- Excessive dust or sand, e.g. any pollution that might stick on the case or the part dedicated to the cooling of the SDD might deteriorate the performance the drive and lead to over temperature protection events that stop the operation of the unit.
- The unit must be installed in a vertical position on a level surface or a suitable pole construction
- The Solar Direct Drive's metal part's (heatsink) temperatures might reach a level of 90°C even at partial load. Suitable protection against touching this part shall be foreseen by the installer.

IMPORTANT: The Solar Direct Drive must have unrestricted airflow and must be mounted in a way that air can flow vertically through the fins of the heatsink.

NOTE: To ensure optimal performance and efficiency a minimum clearance of 35cm from the back, left and right sides and 40cm from the bottom and 60cm from the top side of SDD's case must be maintained. A minimum of 25cm from the front of the unit should be maintained for control access.

Ambient temperature range

The ambient air temperature must also be considered when installing this unit. The ambient air temperature must be above 0°C and below 45°C for the SDD1.5kW-425V. If the ambient air temperature is outside of those upper and lower limits the Solar Direct Drive's operability might be deteriorated or even not be available. Besides others this may take such negative effect especially on the accuracy of the internal control and the LC- display's operability.

Electrical requirements

If you lack the necessary skills required to properly install the electrical wiring to this Solar Direct Drive, do not proceed but have a qualified electrician perform the installation.
When making the electrical connections, always make sure:

• That the entire installation is compliant to the safety standard DIN VDE 0100-600 and the equipment grounding conductor is connected to the metal part of the Solar Direct Drive, e.g. to the heatsink. Not complying with this requirement will create danger for life in case of isolation failure.
• That the open loop voltage of the considered PV array under no circumstances exceeds a voltage of 425V.

IMPORTANT:
Most PV array's maximum open loop voltage is reached at minimum PV panel temperature. PV panels and the number of PV- panels put in serial connection in the PV array string shall be selected for this worst-case operation point, e.g. at the minimum ambient temperature that can be expected at the installation location. Further details and examples of a proper PV- panel selection are given in a dedicated chapter.

• Never disconnect the PV-array when the Solar Power Drive is powered and the motor is running

IMPORTANT:
Disconnecting any cable of the PV-array while current is flowing will create high voltages and arcs are dangerous for life. Arcs create high temperature and result in fire. Ensure and verify the following:

• Wire sizes and connections must comply with all applicable codes and follow safety standards as covered by DIN VDE 0298-4 (if applicable for buildings) or in conjunction with electrical machines by DIN EN 60204-1 (VDE 0113-1)

• That the electrical load is equipped with an overload fuse or breaker protection and / or a thermal overload protection.

• That the safety of the installation is regularly checked at least once per year provided that harsh circumstances or environment do not endorse a more frequently check of the entire installation.

• That the Solar Direct Drive is not sufficiently protected against lightning. Lightning protection depending on the location and probability of a lightning event shall be assessed by the installer and the required protection systems shall be installed in vicinity and in between the PV-array and the SDD, e.g. between the SDD and the driven motor. Lightning devices tent to be most efficient when located close to the PV-panel array and the SDD. Carefully check your requirement and consult an expert for your specific installation conditions.

Operation:

System topology:

The SDD is the core element of an off-grid solar drive system that is built out of standard 3~ motors and pumps and PV- panels. Figure 1 indicates a typical system in which the SDD is utilized:

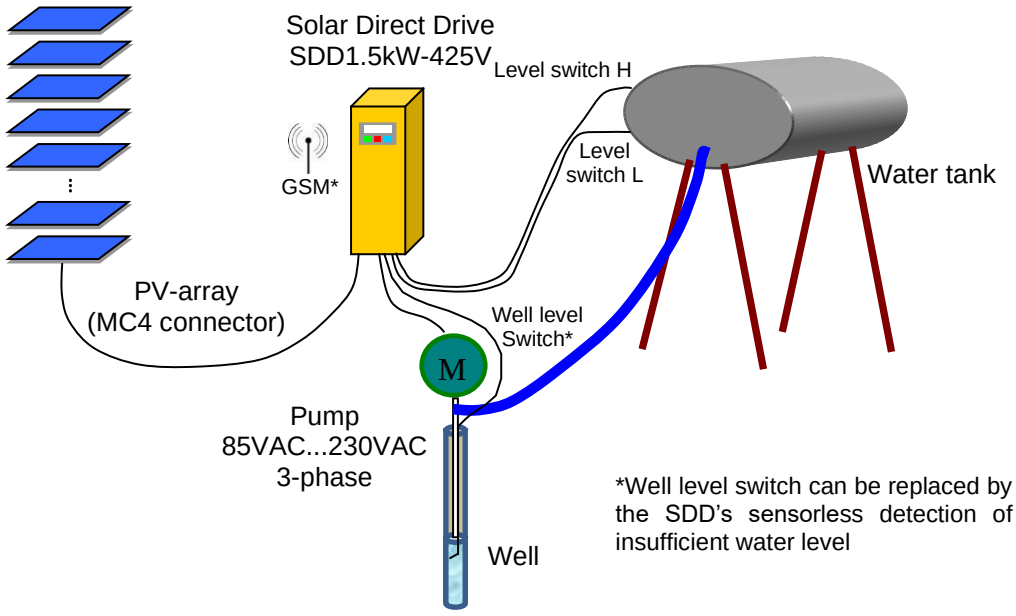


Figure 2: Principle of a water pumping / water storage application controlled by the SDD (optional: Built-in GSM)

Figure 1 shows a typical system to automatically fill a tank with water. In this example two levels are sensed by simple digital (mechanical) level switches. The SDD controls the Maximum Power Point (MPP) of the connected PV-array delivering the best calculated system efficiency during pump operation. The SDD stops the operation of the pump when the level switch "H" indicates a high water level. A more precise volumetric sensor interface and any extended (custom) functionality of the SDD is available on request. Please contact the EMPO-NI office for your requirements (engineering@empo-ni.de).

Connections to the Solar Direct Drive

All high voltage connections can be easily accessed from outside through industry standard connectors. The versatile low voltage interface is accessed inside the housing through standard 2,54mm connectors. An IP65 specified cable gland shall be used in such case to ensure sealing of the inside case. An overview of all connector types used in the SDD including their supplier's references is indicated in Figure 3:

Function	Connector (supplier's reference)	Manufacturer	delivered
PV (+) (from PV-array)	32.0014P0001-UR (2,5mm²…4mm²); 32.0034P0001 (10mm²)	http://www.multi-contact.com	No
PV (-) (from PV-array)	32.0015P0001-UR (2,5mm²…4mm²), 32.0035P0001 (10mm²)	http://www.multi-contact.com	No
Connector to motor	ZE RST16i15 SW (46.0524553.1)	www.wieland-electric.com	Yes
Digital inputs	For wire 0,2mm²…0,5mm²	WAGO 250; www.wago.de	On board

Table 1: Connectors utilized for the SDD's physical interfaces

Selection of PV- modules and motor star / delta connection

The selection of suitable PV-modules their technology and the number to connect in series in one string depends on environmental conditions as well as the power that is consumed by the application. Since the DC input voltage of the SDD must not exceed 425V at any time the maximum number of PV- panels is well limited for a certain range of ambient temperature, e.g. above a certain minimum temperature. On the other hand also PV- panel technology differs and the achievable MPP voltage and current differs between manufacturers and certainly heavily depend on the utilized PV panel technology itself, e.g. for mono- crystalline, poly- crystalline and several thin film based PV-panel technologies. The following selection has been done for a few example panels to clarify the way the suitability of any PV- panel (technology) can be assessed. The commonly available PV- panel technologies have been considered for the design of the SDD, e.g. the SDD is dedicated to operate from only a single string that always should be in the range of 380V…425V to be able to drive up to 230VAC 3~ motors over the entire frequency range. This maximum voltage conditions should be calculated at the PV- panel's open loop voltage and coldest condition which might appear in the location of the PV- panel array. In case of other 3~ AC motor's voltages the minimum requirement of DC-link voltage at the MPP under customer's specific environmental conditions can be calculated as VDC,min = 1,42 * Vrms (of the 3-phase motor). In general stator windings can be connected in delta (Δ) connection, too. For any operation the maximum current that the SDD can provide shall not exceed the limits referred to in the datasheet of the corresponding SDD model. Figure 4 provides an indicative overview for the three asynchronous / induction motors available in the SDD1.5kW-425V and one example PV panel module. This list is not complete. If you have any specific request to your selected PV-panel module, kindly provide the datasheet and get in touch with our technical support team:

		Tc=25°C (STC)			Tc=45°C	number in series	Tc=25°C	Tc=45°C
Typical 3-phase motor	Typical PV-panel type	Voc [V]	V(MPP) [V]	I(MPP)	V(MPP) [A]		MPP [W]	
1.5kW 230V	60cells min. 250Wp	37,6	30,2	8,28	28,2	11	2750	2570
1,1kW 160V	60cells min. 250Wp	37,6	30,2	8,28	28,2	8	2000	1870
0,75kW 110V	60cells min. 250Wp	37,6	30,2	8,28	28,2	5	1250	1167
0,55kW 85V	60 cells min. 250Wp	37,6	30,2	8,28	28,2	4	1000	934
0,37kW 65V	60 cells min. 250Wp	37,6	30,2	8,28	28,2	3	750	700

Table 2: PV- array setup for different motor power rating and voltages based on an example PV-module type (www data)

Figure 2 is a table that proposes a (minimum) number of PV-panels forming an array connected to the SDD for classic motor ratings of 1,5kW, 1,1kW, 0,75kW. The low-cost system solution based on EMPO-NI 550W/85V and 375W/63V 4" submersible motor / industrial motor set require non-standard 3-phase induction motors. The latter 375W/65V motor solution requires only 3 PV-panels (60-cell) forming the PV-array. Please contact EMPO-NI for such motors with non-standard voltages. Besides the referred low cost crystalline 60cell full wafer based solar panels there are suitable solutions based on 72 cell modules, too. Thin-film technology based PV-modules can be used alternatively, however the string length = number of PV-modules in series connection needs to be observed for the maximum applicable open circuit voltage (Voc) as well as probably two strings in parallel connection might be required to provide the required power. All these considerations are influenced by actual environmental conditions. Hence, figure 2 serves as a first indication and the individual conditions at the installation location and the application's requirements as well as the installation, operating conditions and limitations as indicated by the manufacturer of the PV-panels used in the connected PV-array shall carefully be checked.

Typical pump operation

Sizing a solar pumping application means to provide a certain volume of water per day whereas average conditions shall be assumed for the relevant period of the year, e.g. for the irrigation period. The matching between PV-array size and the motor rating plays an essential role to provide satisfactory results for the irrigation task. Bellows figure is intended to provide an aid to find a suitable sizing of the PV-array. Moreover water availability requirements in certain seasons or at certain times of the year besides the annual average based selection may lead to oversizing from those minimum requirements.

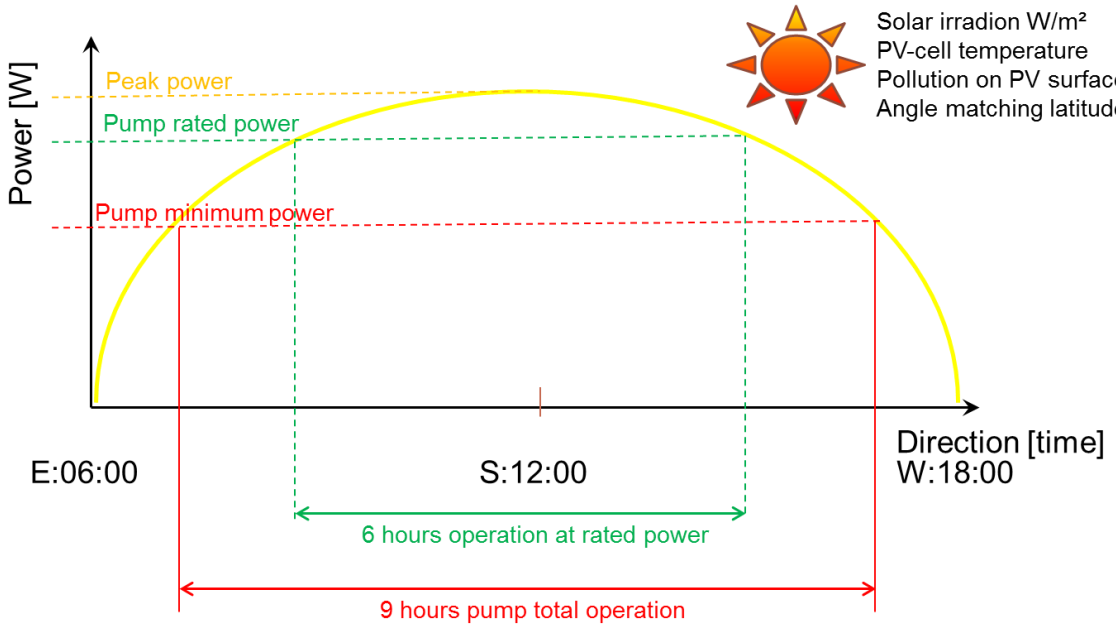


Figure 3 indicates a simplified view on the power availability (yellow curve) over a day of the northern hemisphere starting in the morning at East side and ending in the evening at West side with a sunset. This power availability curve being a sinus function basically depends on the size of the PV-array as well as on environmental conditions (PV-panel orientation, sun position and intensity, cell temperature etc.) and the pollution of the PV-array. Once the PV-array as a result of a concatenation of those conditions provides sufficient power the pump application starts at the shown red line “Pump minimum power” delivering a first small amount of water. This amount of water gradually increases to the rated flow rate of the pump when the power availability curve intersects with the green line. The power delivered in excess of this green line, e.g. when the yellow power availability line is located above the green line of rated power of the application can provide the margin required for clouds and non-optimum environmental conditions.

In a first rough approach the sizing of the PV-array could be selected to deliver the desired amount of water during the rated power operation period only, e.g. to consider the partial power operation inside the red curve as margin.

Interface (MMI)

The SDD has several interfaces to run, to set up and to control the SDD. The 2 lines 16 character LC-Display along with three keys are used to configure and to read the most important operation parameter of the Solar Direct Drive (SDD) directly at the case. Figure 5 shows a photo of this keypad.

Keypad

Three keys are integrated into the keypad to ensure waterproofness of the entire construction. Depending on the menu these keys have two different functions:

- The “START” key also acts as “up” or “increment”, while
- The “STOP” key has a double function as “down” or “decrement”. A long activation brings the user directly to the start menu from any menu.
- The “MENU” key is also used as cursor shift right function. The “MENU” key distinguishes between a long or a short activation in some menus.

Figure 3: Keypad with LC-

A simple menu structure allows setting up the desired function easily. Furthermore the SDD has got an isolated electrical interface that is accessible below the plastic cover. The interface provides totally 2 outputs and 3 inputs. The available inputs and one output can be used to control external applications such as sensor inputs, e.g. for water level sensing etc. A dedicated menu will assign the function, e.g. START or STOP to the input level of this interface etc.

CAUTION: Use only shielded cabling to the digital inputs/outputs

LC-Display

The SDD employs a 16 character 2 row LC-display whose contrast is adjustable in a dedicated menu. Menus shown in this chapter are either (R) read only menus or (R/W) read and write menus, e.g. they are used to indicate the currently selected parameter and to configure the SDD.

Menu “Default” (R)

At startup after a system check and welcome messages the LC- display enters the default menu showing the “default screen” that provides a survey about the most essential operation parameter:

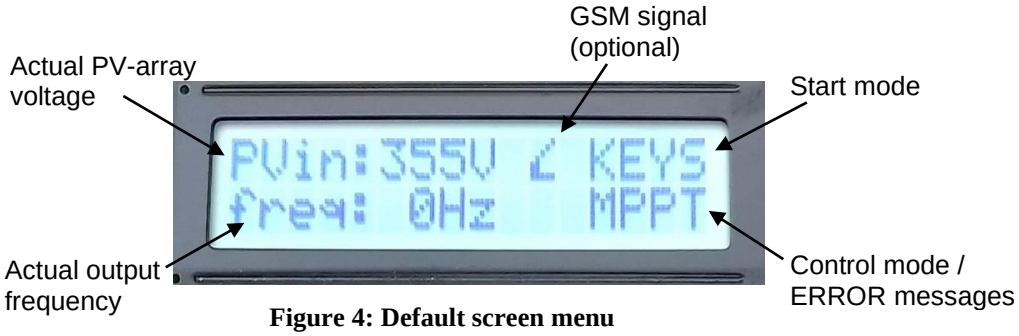


Figure 4: Default screen menu

Figure 5: Default LCD screen

Menu “Operation overview” (R)

P	V	i	n		C	U	R	i	n		P	O	W	E	R
_	_	_	V		_	.	_	_	A		_	_	_	_	W

One click on the “MENU” key switches the “default” menu to the menu “Operation overview” that is indicating the actual PV-array voltage, the DC current of the PV-array and the power that is currently delivered / consumed. This menu allows monitoring the PV-panel array’s performance, e.g. the PV-array’s voltage, current and power.

Menu “Energy” (R)

The “Energy” menu informs the totally harvested energy since the first moment of operation as well as the energy that has been converted since the last start of the motor. Whenever the output of he Solar Direct Drive is stopped this most recently harvested energy is added on to the totally harvested energy counter and restarts counting at the next start of the output. Bellows LCD screens appear alternatively every 2,5 seconds.

	E	N	E	R	G	Y		S	A	V	I	N	G	S	
T	o	d	a	y	:	_	_	_	,	_	_	k	W	h	

	E	N	E	R	G	Y		S	A	V	I	N	G	S	
T	o	t	a	l	:	_	_	_	_	_	_	_	k	W	h

Menu “Drive condition” (R)

The “drive condition” menu provides all essential parameter of the power stage on to the screen. This data is the actual output frequency, the temperature of the power stage and the actual switching frequency of the system

f	o	u	t		T	E	M	P			f	(	s	w	)
_	_	H	z		_	_	_	°	C		_	_	k	H	Z

Menu “Pay-as-you-go (PayGo)” (R/W)

The “PayGo” menu is available from SW version 2.17 and provides the interface in case the Solar Direct Drive is used in conjunction with lease business models. Once activated by a suitable Token the Solar Direct drive is operable for a specific utilization period depending on the value that is crypted in the TOKEN. Modern Token cryptography prevents to a very high degree from abuse of Tokens.

P	a	y	G	o		c	r	e	d	i	t	:	*	*	*
T	o	k	e	n	*	_	_	_	_	_	_	_	_	_	#

In the start screen of the PayGo menu the actual credit is shown in the top right corner “***”. In case the credit is more than “999”, the display will show “>1k”.

The “***” indicated in the display of this example however indicates the deactivated PayGo which then allows the free utilization of theSolar Direct Drive without requiring further payments through PayGo.

The PayGo function is based on a 9-digit Token always starting with "*" and ending with "#" and following the the EnAccess foundation's guidelines for PayGo Tokens and implementations.

With this standard Token compliance, the Solar Direct Drive's PayGo implementation is compatible with most of "Last Mile Management System" platforms presently used for those business models.

The "MENU" key in this menu will move right the cursor to each digit of the Token to be entered while the "UP" and "DOWN" keys would increase or decreased the digit of the PayGo Token that is actually selected by the cursor.

Moving the cursor to the last position of the 2nd row of the display, e.g. to the "#", a next screen will be invoked on the display to initiate the submission of the entered Token:

P	a	y	G	o		c	r	e	d	i	t	:	*	*	*
A	c	t	i	v	a	t	e		=		S	T	A	R	T

Pressing "START" in this screen would submit the Token entered on the previous screen for verification and execution inside the Solar Direct Drive and automatically return to the initial PayGo screen. To return to the previous screen without submitting the Token please use the "MENU"- key.

The Solar Direct Drive will respond to the entered Token with a 2,5sec lasting message on the screen and then return to the inititial PayGo menu screen then. The display will show one of the following "PayGo – messages":

In case the submitted Token was valid the following messages depending on the Token's content will appear for 2,5secs bellow the first row "PayGo – message:"

P	a	y	G	o		-		m	e	s	s	a	g	e	:
	P	a	y	G	o		d	i	s	a	b	l	e	d	
	C	r	e	d	i	t		u	p	d	a	t	e	d	
c	o	u	n	t	e	r		s	y	n	c	h	r	o	n

In case the Token was not entered correctly or not valid or already used, the following message will appear on the screen:

	P	a	y	G	o		-		E	R	R	O	R	:	
		w	r	o	n	g		T	o	k	e	n			

It is possible to check the correct Token entry and to retry. However, starting from the 2nd erroneous submission the entry of subsequent Tokens is delayed and the following screen will appear:

P	a	y	G	o		c	r	e	d	i	t	:	*	*	*
T	o	k	e	n		w	a	i	t	:				6	0

This example shown that the next entry of a Token is possible in 60sec. The number on the display will count down when time passes. Further wrong attempts will substantially increase the waiting time until a next entry of a Token will be possible and block the Token entry screen.

A long activation of the "MENU" key will leave the PayGo menu and proceed to the next one.

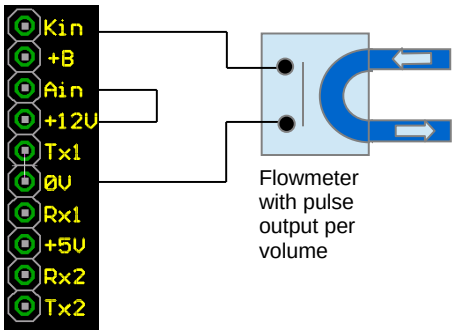
GSM based PayGo utilization

The Solar Direct Drive is optionally available with integrated GSM modem as used for remote controlling and monitoring functions. It is easily possible to use a text (SMS) message to submit the Token directly. Just the Token in its correct format needs to be sent as text message "*??????????#" where each "?" represents one digit of the Token. Further explanations and response messages of the Solar Direct Drive please find in chapter "Wireless GSM (optional)".

Menu "Flowmeter / Volume" (R/W)

The volume measurement is a feature that permits to log the water amount in [m³] that has passed a flowmeter sensor. The feature incorporates a measurement of the volume from the

last start of the SDD to the actual moment as well as a memory that stores the totally measured volume in [m³] that has flown through the sensor. Whenever the SDD is stopped the actual volume is added to the total volume and the actual volume counter is reset. The potential free contact of the flowmeter is connected to the SDD that also provides the required supply and input pins.



Flowmeter type setting menu:

"number of pulses" per 100liter

Various adaptations for typical flowmeters on request:
engineering@empo-ni.de

The initial screen of the Flowmeter / Volume menu toggles every 2,5 seconds between the total volume and the volume measured since the last start of the SDD and the actual flowrate:

		V	o	l	u	m	e		T	O	T	A	L		
							.			c	b	m			

		V	o	l	u	m	e		T	O	D	A	Y		
							.			c	b	m			

	A	c	t	u	a	l		f	l	o	w	r	a	t	e
							.			c	b	m	/	h	

The "MENU" key would switch to the next menu while the above indicated screens are shown on the LCD. For a setting of the suitable flowmeter parameter [pulse/m³] either the "UP" or the "DOWN key should be pressed. In this case the next flowrate setting submenu is indicated on the LCD whereas the actual set flowrate is blinking:

F	L	O	W	R	A	T	E		S	E	T	T	I	N	G
P	u	l	s	e	/	1	0	0	l	=	_	_	_	_	_

The "MENU" key will move right the cursor to each digit of the "Pulse per 100liter" setting while the "UP" and "DOWN" keys would increase or decreased the digit that is selected by the cursor.

The actual setting will be stored when both keys "UP" and "DOWN" are pressed simultaneously and "WRITE EEPROM" pops up on the screen for about 0,5 seconds.
Clicking the "MENU" key will resume back to the Volume indication menu.

Menu "Motor" (R/W)

In the "Motor" menu the parameter of the attached motor is set. The activation of the menu is initiated after the "UP" or "DOWN" key is pressed. The parameter to change starts blinking and can be altered by the "UP" or "DOWN" key.

The "MENU" key changes the parameter that can be modified. The SDD1.5kW-425V currently provides matching output for 3-phase 230V, 3-phase 160V, 3-phase 110V, 3-phase 85V and 3-phase 65V motors. The stainless steel submersible and industrial standard foot/flange motors of 160V, 110V,

85V and 65V are available through EMPO-NI. Please contact sales@empo-ni.de for further enquiries. Special motor voltages and frequencies on request.

The parameter “fmax:” sets the maximum output frequency of the Solar Direct Drive. In operation the SDD’s output frequency will never exceed this value.

The parameter “f:” corresponds with the rated frequency of the pump, e.g. if the motor’s voltage is rated at 50Hz or 60Hz nominal motor input frequency.

Clicking simultaneously the “UP” and “DOWN” key stores the selection into an E²PROM. A long activation of the “MENU” key will switch to the next menu.

Please note that the newly stored setting is getting active only after repowering the SDD, e.g. after removal of the PV-array supply and reconnecting to the PV-array.

M	O	T	O	R	:		V	r	m	s	:	_	_	_	V
f	m	a	x	:	_	_	H	z		f	:	_	_	H	z

Menu “Minimum Startup Voltage” (R/W)

This setting directly influences the PV-array under voltage detection level, the appearance of the corresponding ERROR message that is issued on screen of the “Default menu”. The set value represents the threshold voltage that needs to be reached to automatically start the drive once after sunrise if “AUTO”, e.g. the automatic start function has been selected.

M	i	n		S	t	a	r	t	u	p		P	V	i	n
						_	_	_	V						

The “UP” and “DOWN” key increments and decrements the displayed minimum startup voltage level in steps of 10V. Pressing simultaneously the “UP” and “DOWN” key stores the selection into an E²PROM.

Menu “Start Stop Mode” (R/W)

The “Start Stop Mode” menu selects the method of starting the SDD. This menu can select the control method to start and stop function of the SDD, e.g. the automatic start function “autostart” or the keyboard or digital inputs.

S	T	A	R	T	/	S	T	O	P		M	O	D	E	:
	1	)	S	T	A	R	T	/	S	T	O	P	K	E	Y
	2	)	A	U	T	O	S	T	A	R	T				
	3	)	D	I	G	I	T	A	L		I	N	P	U	T

In case the SDD shall be started by digital inputs please ensure that the corresponding digital inputs are indeed activated in the corresponding menu. Options are selected through the “UP” and “DOWN” keys. The actual selection is marked with “*” at the beginning of the line. Pressing simultaneously the “UP” and “DOWN” key stores the selection into an E²PROM. Pressing “MODE” switches to the next menu.

Menu “Speed Input selection” (R/W)

The “Speed Input selection” menu selects how the Solar Direct Drive generates the output frequency. While the motor menu provides certain boundaries for the safe operation of the connected motor, this menu allows to select the control mode of the motor. The operation with constant speed and the speed control through Maximum Power Point algorithms are the available options

	S	P	E	E	D		I	N	P	U	T		S	E	L
	M	P	P	T		C	O	N	T	R	O	L	L	E	D
	K	E	Y	B	O	A	R	D		I	N	P	U	T	

While for the “MPPT CONTROLLED” operation mode the parameter setting is done automatically and adaptive the “KEYBOARD INPUT” mode requires a subsequent menu, where the target frequency is preset. Note: The target frequency can only be reached if the externally connected PV-panel array provides sufficient voltage and power.

	F	i	x	e	d		s	p	e	e	d		i	n	
							_	_	H	z					

The actual selection is marked with “*” at the beginning of the line. Pressing simultaneously the “UP” and “DOWN” key stores the selection into an E²PROM. Pressing “MODE” switches to the next menu.

Menu “LCD contrast” (R/W)

The display contrast is set in this menu in 10 steps. Please use the “UP” and “DOWN” key to modify the contrast to your requirements.

		L	C	D	-	c	o	n	t	r	a	s	t		
			-	O	O	O	✶	O	O	O	O	O	+		

The actual setting is marked with “✶” within the scale of the line. Pressing simultaneously the “UP” and “DOWN” key stores the selection into an E²PROM. A long activation of the “MODE” key switches to the next menu.

Menu “Communication” (R/W)

The functionality of the optionally built-in GSM modem is selected through this menu.

	C	O	M	M	U	N	I	C	A	T	I	O	N		
	0	)	N	O		G	S	M		C	O	M			
	1	)	G	L	8	6	5		G	S	M				
	2	)	S	I	M	8	0	0		G	S	M			

This function is set to “0) NO GSM COM” from factory side. In case the optional GSM modem has been implemented for remote controlling / setting of the Solar Direct Drive (SDD), the option can be set according to the utilized modem type. The actual selection is marked with “*” at the beginning of the line. Pressing simultaneously the “UP” and “DOWN” key stores the selection into an E²PROM. Pressing “MODE” switches to the next menu.

Menu “T1/R1 communication” (R/W)

The functionality of the serial communication or alternative function of the T1/R1 terminals is selected through this menu.

	T	1	/	R	1		P	R	O	T	O	C	O	L	
	N	o	t		a	c	t	i	v	a	t	e	d		
		2	k	4		8	N	1		B	I	K	O	M	
		4	k	8		8	N	2		M	O	D	B	U	S
	E	x	t	.	E	R	R	O	R		0	s	e	c	

	E	x	t	.	E	R	R	O	R		3	0	s	e	c

The T1/R1 communication menu provides an isolated asynchronous interface to remotely control and set-up parameters of the Solar Direct Drive. The shown “BIKOM” protocol is for service purposes while the MODBUS protocol is intended for public use in automation systems. The “UP” or “DOWN” key selects the desired option or simply deactivated the serial communication option. The actually set option is marked with an “*” at the first column. Pressing simultaneously the “UP” and “DOWN” key stores the selection into an E²PROM. Pressing “MODE” switches to the next menu.

In case the MODBUS has been selected one additional menu will be available after pressing “MENU” to select the slave address in the MODBUS network ID of this SDD

Please note that the MODBUS communication speed is fixed to 4800 Baud and 8 data bits no parity and 2 stop bits.

	M	O	D	B	U	S		A	D	D	R	E	S	S	
						_	_	_							

The cursor is activated in this menu and the digits of the ID can be altered by “UP” and “DOWN” individually while the “MODE” key shifts the cursor right. A blinking ID on the display indicates that the actual ID assigned to the SDD is different from the one shown on the display. Pressing simultaneously the “UP” and “DOWN” key selects the actually indicated ID and stores the selected MODBUS ID into an E²PROM. Pressing “MODE” long switches to the next menu.

Other than for serial communication the Rx1 input can be used to detect external error conditions and generate an error message on the LCD while stopping the drive. Two modes have been implemented:

1.) The reaction on the external error conditions as fast as possible within a few tens of milliseconds only

2.) The reaction on the external error condition with a preset delay of 30 seconds. In this 30-second mode the time is count down in the two last digits of the second row of the LC-Display.

In both latter cases the fault condition must be removed and the error condition must be quit by clicking “STOP” in the main menu.

Menu “DIGOUT” (R/W)

The operation of the digital output is selected through this menu and the existing isolated digital output “T2” is controlled by either the PV-array input voltage, the output frequency „speed“ or the processed power. Alternative the function of the DIGOUT can be set to indicate if any error situation is pending. Depending on the source for the activation of the digital output the following screens can appear on the LC-display:

Power depending output – the output will get active „on“ if the actual power exceeds the set value.

D	I	G	O	U	T	=	f	(	P	O	W	E	R	)	
P	>	_	_	0	0	W		D	I	G	O	U	T	=	p

PV-array voltage depending: The digital output turns on, when the max limit is exceeded and reset to passive level, when the actual PV- voltage falls below the indicated minimum value.

D	I	G	O	U	T	=	f	(	P	V	O	L	T	)	
M	a	x	_	_	0	V			M	I	N	_	_	0	V

Speed depending output: The digital output turns on, when the max limit is exceeded and reset to passive level, when the the actual output frequency of the SDD falls below the indicated minimum value.

D	I	G	O	U	T	=	f	(	S	P	E	E	D	)	
M	a	x	_	_	H	z			M	I	N	_	_	H	z

In the two latter menus a cursor pops up and parameter will blink indicating that it is possible to set those threshold values. In this operation mode the “MENU” key would shift the cursor one position to the right and the keys “UP” or “DOWN” would alter the digit accordingly.

Alternatively, the digital output can be used to indicate any error condition (detailed errors please check the corresponding chapter in this document). The signal is active low if there’s no error present

and in case any error has been detected it will go Hi-Z. Please observe electrical limits of this output.

D	I	G	O	U	T	=	f	(	E	R	R	O	R	)	
	S	u	m		o	f		E	r	r	o	r	s		

Pressing simultaneously the “UP” and “DOWN” key would store the selected parameter. The storage process is indicated by a short pop-up of “WRITE EEPROM” on the LC-display.

This function allows the SDD to be used in cooperation with other sources of energy. Through the keyboard a power threshold is set as shown in the LCD. The keys “UP” and “DOWN” increment / decrement the value in steps of 100W or 1000W, while “MODE” shifts the cursor right. Is the actually delivered power of the SDD higher than this set level, the digital output will turn-on, e.g. the digital output is turned on. This function is used to control simple transfer switches like contactors (through a relay driver) to operate motors from other sources or to start a conventional generator in hybrid systems. For further information and options please get in touch with EMPO-NI engineering team (engineering@empo-ni.de). Clicking simultaneously the “UP” and “DOWN” key stores the selection into an E²PROM. Pressing “MODE” switches to the next menu.

Menu “Pump protector” (R/W) (low speed protection)

An optional protection for pumps stopping the operation below a defined minimum mechanical speed is activated and parameterized through this menu.

	P	U	M	P		P	R	O	T	E	C	T	O	R	
I	f		f	<	_	_	H	z		_	_	_	m	i	n

This function can protect pumps from being operated at too low speed. In case the selected speed cannot be reached with the current output of the PV-array’s power as a result from the actual insolation, the SDD will stop the output and will restart after the time [minutes] set in the display will have elapsed. The “MODE” key shifts the cursor right and “UP” / “DOWN” increment / decrement the selected digit. Clicking simultaneously the “UP” and “DOWN” key stores the selected parameter set into an E²PROM. Pressing “MODE” long switches to the next menu.

Menu “Pump dry protection” (R/W)

A low water level of the well will lead to a dangerous condition for the pump that can be damaged because of insufficient cooling or lubrication through the water. Hence, the “Pump dry protection” menu provides this essential protection and offers two options to protect the system from such a dangerous situation. Besides the classical level switch detection option through the SDD’s digital inputs (ref. section digital inputs) the pump’s abnormal operation at insufficient water level can be sensed to a certain extent by an operation parameter analysis such as a combination of speed and the consumed current at this specific speed. In case a set speed is exceeded and at the same time a set current is not reached an indication of a dry-running pump could be given.

The “Pump dry protection” menu and its options appear on the LCD like this:

P	U	M	P		D	R	Y		P	R	O	T	E	C	T
	1	)	N	o		p	r	o	t	e	c	t	i	o	n
	2	)	L	e	v	e	l		s	w	i	t	c	h	
*	3	)	S	e	n	s	o	r	l	e	s	s			

For either option 2) or 3) The SDD will stop and issue an ERROR message indicating a dry running pump. The “STOP” function resets this situation and the drive can be restarted with a “START”.

In case the sensor less detection method has been chosen, two additional menus are activated to set the desired protection parameter and the number of retry attemps as well as :

P	U	M	P		D	R	Y		P	R	O	T	E	C	T
I	f		f	>	_	_	H	z	&	I	<	_	,	_	A

This function can protect pumps to be run when no water is present. In order to efficiently use this protection function the parameter of this menu must be well adjusted. Information from the pump supplier / manufacturer or a test in case this is permitted from pump manufacturer side will deliver valuable hints of optimized settings for both parameters. As a starting point to find suitable parameter for the sensor less protection mode the SDD might be operated for a test at a fixed speed of 40Hz (Speed → “KEYS” and fixed speed set to 40Hz) provided that there is enough power of the PV-array available during this test and that sufficient water is present in the well. The SDD provides a menu that indicates the current consumed at this operation point. The consumed current shall be used as a first rough indication to set the sensor less protection to 40Hz and about 80% of this measured current. A verification is definitely necessary to prove the effectiveness of the setting or to provide further improvement of the found parameter. A clear warning shall be given here, since only a water level switch can provide an immediate protection with less stress on the pump. The sensor less approach always is based on a rotating pump – with or without water.

Since some well's capacity to provide the required flow rate of water might be insufficient and consequently the SDD might detect a dry well when such case occurs when the well cannot provide sufficient water it can make sense to provide some time to the well to recover / refill until a next start attempt can be made. To foresee this possibility the SDD has got a retry counter and a delay time to provide a restart attempt after the delay time has elapsed for a max. number of retry attempts

	R	e	t	r	y				D	e	l	a	y	
		#	*	*				*	*	*	m	i	n	

The “MODE” key shifts the cursor right and “UP” / “DOWN” increment / decrement the selected digit. Pressing simultaneously the “UP” and “DOWN” key stores the selection into an E²PROM. Pressing “MODE” for a longer time switches to the next menu.

Menu “Service” (R/W)

R	e	s	t	r	i	c	t	e	d		a	r	e	a	:
P	a	s	s	c	o	d	e	:	_	_	_	_			

The access to this menu area is reserved to service personnel only. Several menus are in this service section to modify internal settings of the SDD or to show internal parameter of the SDD. Altering parameter in this section can damage the SDD and in worst case destroy the SDD.

Input / Output functions

The SDD provides several input and one output function that communicate with the built-in microprocessor control through a safety isolated interface. In the corresponding LCD menu to set up the digital I/O function the functions can be assigned to these digital I/Os or as serial communication port.
The digital I/O interface is located under the top cover and shall be accessed by a suitable cable through the cable gland foreseen in the housing to ensure at least IP54 protection degree against humidity and dust. After mounting of the cable the cover shall be closed carefully by moderately evenly tightening the 8 M4 x 6 screws to ensure a stress free and well-sealed housing.

Physical Interface assignment

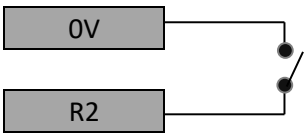
The cover protects the interface from dust and humidity and needs to be removed to access the digital interface. A suitable shielded and well isolated cable shall be used to connect with the terminal clamp block and shall be guided through the cable glands to ensure that no humidity can creep in. The following table indicates the pin terminal assignment:

Terminal (as on PCB)	Description	Utilization
T1	Transmit output (open collector) serial interface	Active LOW, internally linked to 0V/12V
R2	Receive input 1 (active LOW) serial interface, alternatively used for external error detection	Drive with open collector, internally connected to 0V/12V supply
12V	unstabilized 12V SELV supply	12V supply of this interface
R2	Digital input (active LOW)	Drive with open collector, internally connected to 0V/12V supply
0V	Reference ground of this interface	Reference for all Rx/Tx terminals
T2	Digital output (open collector)	Active LOW, internally linked to 0V/12V
Ain	Positive Digital input (differential with Kin)	Max. 12V input, no reverse polarity allowed
Kin	Negative Digital input (differential with Ain)	

Table 3: Interface terminal description

Using the digital inputs for pump level switches

The digital interface provides an input that can be used to start the SDD provided that this has been activated when no fault condition like PV under voltage or over temperature or short circuit is present. The following table summarizes the required conditions at the two digital inputs to start the drive if no fault condition is present:



Starting the SDD when „Digital Input“ has been selected to start the SDD when input “R2” is tied to „0V“.
CAUTION – the input is only read when the SDD is in the default menu.

Proposed connection of level switches and / or emergency switches:

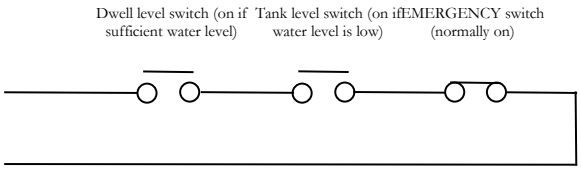


Figure 6: Preferred interface connection for pump applications

The preferred solution brings the SDD into a safe off state, e.g. stopping the motor in case the cable connection is interrupted.

Digital output function

The equivalent circuit of the output whose function is determined by the setting in the menu DIG_out is shown as follow:

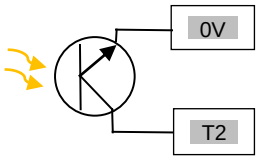


Figure 7: Equivalent output circuit for the digital output (T2)

The output stage of the internally implemented photocoupler is getting into high resistive stage when the condition has been met according to the selected parameter and its threshold levels. The output stage is not suitable to switch directly inductive loads. For detailed specification of current / voltage limits of this digital output please refer to the detailed output specification of the SDD and the menu “DIGOUT”.

For detailed electrical specifications please refer to the datasheet.

Error messages

The Solar Direct Drive provides certain information on active error conditions in the start screen of the LCD. Figure 11 shows all possible error messages in the orange marked part of the LCD

P	V	i	n	:	_	_	_	V		S		K	E	Y	S
f	r	e	q	:	_	_	H	z			E	R	R	S	C
f	r	e	q	:	_	_	H	z			E	I	s	p	d
f	r	e	q	:	_	_	H	z			E	R	H	2	O
f	r	e	q	:	_	_	H	z			E	R	R	P	V
f	r	e	q	:	_	_	H	z			E	T	E	M	P
f	r	e	q	:	_	_	H	z			E	R	R	O	L
f	r	e	q	:	_	_	H	z			E	R	e	x	t
f	r	e	q	:	_	_	H	z			E	X	T	_	_

Figure 8: Error messages

The error messages are shown according to an internally fixed priority, e.g. only the error of the highest internal priority is shown on the LCD screen. When this current most important error is removed the display would show the next less important error on display until all errors are cleared and the display resumes to normal display mode. The error message is only present in the default menu and changing “blinking” with the information of the start menu that is normally indicated on the LCD in the orange marked part. Errors, depending on their severity require different handling. Some errors need a confirmation to be quit in order to re-start the drive, some automatically reset when the failure condition disappeared. The following table provides details:

ERROR	Description / origin	Countermeasure	RESUME
ERRSC	A short circuit or a very heavy overload has occurred at the output terminals connected to the motor. This ERROR is severe and counted. Warranty expires if more than 10	If this happens at the first commissioning check cabling and motor for short circuit of wiring and motor windings. Ensure correct settings of the motor rated voltage. If	STOP and re- START

	short circuit events have been logged.	this happens after successful commissioning consult your EMPO-NI dealer or installer	
Elspd	The output frequency of the SDD has been lower than the set limit of the corresponding menu for more than 20 seconds	Adjust the minimum speed limit value to the desired value. Setting 00Hz deactivates this function. The timeout until the output restarts can be changed in the corresponding menu.	AUTO after time elapsed
ERRH_2O	The Pump low water protection is activated and the failure condition level switch or sensorless have been met	Check well water level, mechanical well level sensor or adjust the sensorless parameter of this protection function	AUTO after failure condition ends
ERRPV	The actual PV-array voltage is less than the set PV voltage minimum to run the drive.	Ensure a properly selected string length (ref chapter module selection). Early /late this error normally may occur	AUTO resets at higher voltage
ETEMP	The maximum permitted temperature of the drive has been reached and the drive shuts down for self protection and to avoid a severe damage.	Check if mounting conditions are vertical and heat dissipator is not blocked and the ambient temperature limit is not exceeded. Check motor currents if they comply with limits given in the datasheet of the SDD	AUTO user needs to restart at lower temperature
ERROL	An unsuitable PV array is connected to the SDD. The max. input current rating is exceeded	Check if the PV-array's short circuit current is exceeding the specified limit of your SDD	STOP and re- START
ERext	The external error input (physical terminal Rx1) was drawn to "0V"	Remove the error condition that creates the "0V" at the input of the SDD	Quit clicking "STOP"
EXT__	The external error input (physical terminal Rx1) was drawn to "0V" for 30 seconds duration. Time elapsed to generate the error is indicated in the LCD at placeholders "__"	Remove the error condition that creates the "0V" at the input of the SDD	Quit clicking "STOP"
"S" instead of field strength symbol)	There's no valid SIM card detected from the modem when the modem function has been activated	Unpower the Solar Direct Drive and check / insert a correct SIM card if GSM modem connectivity is required. Otherwise deactivate modem in the corresponding menu	AUTO after error condition has ended.

Table 4: Error messages, potential root cause and countermeasures

MODBUS RTU

A derivate product of the SDD1.5KW-425V can be used as slave in MODBUS protocol controlled applications. The communication utilizes the insulated serial communication through the Rx1, Tx1 and the 0V terminal of the interface and requires an interface circuit for the required MODBUS physical layer, e.g. RS-485. The serial interface data settings are fixed to 4800Bd, 8 data bits, no parity and 2 stop bits.

Protocol implementation

The following commands have been implemented. For any deviating command or a violation of the permitted data range a corresponding error message will be issued.

Function	ADR	DATA	Reply will contain this information	Interpretation
1	0x0000	0x0001	reads if SDD is running	standard
2	not implemented			n/a
3	0x0000	0x0001	DC-bus voltage measurement	x 0,1V
3	0x0001	0x0001	DC-bus current measurement	x 0,01A
3	0x0002	0x0001	Temperature of the power stage	x 0,01°C
3	0x0003	0x0001	speed of the drive	x 1Hz
4	not implemented			n/a
5	0x0000	0xFF00	starts the SDD	n/a
5	0x0000	0x0000	stops the SDD	n/a
6	0x0003	0x00??	sets the speed of the drive *	x 1Hz (<88Hz)
7	n/a	n/a	Bit 0: Short circuit motor output	protection
			Bit 1: Low DC-bus voltage	protection
			Bit 2: High temperature fault	protection
			Bit 3: Overload DC-input	protection
			Bit 4: Specific Error (sensor)	protection
			Bit 5: Low speed Error	protection

*) please use only in SDD stop mode

Table 5: MODBUS protocol implementation

Wireless GSM (optional)

The GSM option of the SDD1.5kW-425V (if SDD model name contains a –M suffix) allows a remote control of the SDD and provides analysis functionality to the operator wherever GSM network coverage exists. The required modem pcb can be inserted into the SDD1.5kW-425V later as service upgrade.

SIM card

As prerequisite a standard “micro” SIM card needs to be installed and the corresponding modem option “SIM800 GSM” or “GL865 GSM” option in the “communication menu” shall be activated to make the modem function operable. As anti-theft precaution the SIM card holder is located under the top cover. Caution - the SIM card shall be installed after removal of the cap only when it was assured beforehand that there is no voltage / power source connected to the SDD. Besides danger for life the SIM card and /or the modem might be damaged if this precaution is not respected. After insertion of the SIM card the cover shall be closed carefully by moderately and evenly tightening the 6 pieces of M3 x 8 screws to ensure a stress free and well-sealed housing. The suggested mounting procedure is explained in a later chapter.

Menu “SIM” (R/W)

This menu is only available when a modem mode has been selected and the SIM card PIN is required. Usually the menu is hidden if the SIM card’s PIN has been deactivated. The menu also would not appear if the PIN was stored previously in the Solar Direct Drive. In case the PIN is required the following menu would be available:

			S	I	M		m	e	n	u	e				
P	I	N	1	:	_	_	_	_						O	K

The PIN is entered digit by digit underlined by the cursor. “MENU” shifts the cursor to the next digit. Pressing simultaneously the “UP” and “DOWN” key stores the entered PIN into an E²PROM and submits it to the connected MODEM for verification. This stored PIN1 is used automatically by the SDD to sign in the modem. In case an error occurs during the automatic submission the SIM menu

automatically pops up requesting a manual interaction. A long activation of the “MODE” key switches to the next menu.

Communication: Command set

The communication is initiated by a short message (SMS) received that is containing a command and – for some commands – additionally setting parameter. After reception of the command the modem replies back to the received GSM number confirming the reception of the command and to provide the requested data (if applicable). Selectable emergency situations like motor short circuit or power stage over temperature or system overvoltage can generate a user unsolicited SMS. For standard operation a wide set of commands has been installed already from factory. The following table provides an overview about these standard functions. Commands are case sensitive.

Command	description
FIR	SDD sends its firmware version
ALR	SDD sends current status of alarms
MSR1	SDD sends group 1 measured values
PON	Start SDD motor operation
INFO	PV, I, fo, FIR, ALARM, °C, Timer “R”/”S” status, Error counter
HOURS	SDD sends operation hours along with other parameter
OFF	Stop SDD motor drive output
R%%%%	Run SDD and stop after %%%% minutes (timer mode “R”)
S%%%%	Stop SDD and start after %%%% minutes (timer mode “S”)
POSITION	(only SIM800) the SDD delivers the actual approximate position provided by the GSM network (note: the precision of the returned latitude and longitude is a few hundred meters usually and can differ depending on network availability)
*123456789#	PayGo Token *123456789# entry: SDD will respond with an update message indicating the Token content or Error.
CREDIT	SDD sends the actual credit of the PayGo service

Table 6: SDD / modem control set overview

The GSM modem will respond to the sending phone number and provide the requested information. The reply is in ASCII format and max. 160 characters will be responded. For efficient metering or performance analysis the compound commands “INFO” and “HOURS” have been implemented.

GSM for PayGo applications

The SolarDirect Drive with GSM modem option will respond to the entered Token. The following Text SMS messages are created depending on the validity and content of the received Token:

a.) “**SYNC-message received”** (PayGo service message)
b.) “**Valid Token PayGo Credit Top-Up:+???**” (where ??? represents the amount added to the credit)
c.) “**Valid Token PayGo Credit:?????**” (Where ????? represents the stored credit in this Solar Direct Drive)
d.) “**Wrong or used Token-Retry in ?????sec**” (where ????? represents the waiting time to retry)
e.) “**No Token format**” (In case the *123456789# format was not correctly used – formal error)

Non-public commands

Non-public commands allow to change all menu settings and to change operational parameter and specific E²PROM settings. These commands are reserved to the EMPO-NI technical team. Please contact engineering@empo-ni.de in case such field support is required, e.g. at a first commissioning of the Solar Direct Drive.

GSM for custom control functions

The SDD with GSM function can take over more sophisticated control functions based on analogue and digital in- and outputs in customized version. Complex process automation can be realized on request. Please contact engineering@empo-ni.de in case you would need a customized Solar Direct Drive with GSM function.

Handling after use (end of life)

The Solar Direct Drive is a technical good which requires after use handling according to the applicable local legislation. Under no circumstances it shall be disposed with household litter.

Technical data (preliminary)

DATASHEET status Security status	preliminary				EMPO-NI (EUROPE) Wernigeroder Strasse 102 D-40595 Düsseldorf
general specifi-cation or custom specification	prepared	W. Schröder	REV B	R.Zeimentz	
	checked	M. Heyer		W.Schröder	
	approved	R. P. Honsberg		M.Honsberg	
general	DATE	14.07.2015		05.08.2020	

1. **Type** **Solar Direct Drive SDD1.5kW-425V**

2. **Description** **MPPT Solar Direct Drive for up to 1,5kW induction motors**

3. **Ratings and specifications**

Electrical ratings (25°C unless otherwise noted)

ITEM	Description	min	typ	max	unit	REV
V_{start}	startup voltage (internal supply)	65		425	V	A
V_{op}	operation voltage after startup	85		425	V	A
V_{MPP}	Maximum Power Point Tracking range	80		400	V	A
f_c	switching frequency		4		kHz	
I_{PV}	Input current through PV plugs	0,05		10	A	
T_{amb}	Operating ambient temperature range	-10		50	°C	
T_{fin}	Heatsink temperature			90	°C	
P_{out}	Motor rating (f_o=50Hz, V_{DC}≥325V, V_{out}=230V_{rms})	0		1500	W	
I_{out}	output current (Ta < 45°C)	0		8,50	Arms	A
V_{out}	Rated output voltage 3 phase system	65		230	Vrms	A
f_{out}	output frequency range	0		87	Hz	
η	Efficiency (600VDC, fc=4kHz,P=Pmax, PF=1)	96			%	
Alt	altitude without derating			1000	m	
V_{iso}	Isolation to PE (heatsink) 1minute 50Hz		1500		Vrms	

Interface (digital in/outputs)

V_{SELV1}	Isolated supply unstabilized	10		18	V	
I_{SELV1}	current available from V_{SELV2}			85	mA	
V_{thH}	Threshold (to 0V) digital inputs passive	4,5			V	
V_{thL}	Threshold (to 0V) digital inputs active			1	V	
I_{DIGin}	Digital input current (Ain/Kin or 0V referred)			12	mA	
V_{DoutH}	Digital output passive level *option	4,6		5,4	V	
V_{DoutL}	Digital output active level			1	V	
I_{DIGout}	Digital output current (open collector)			10	mA	
V_{DIGout}	Open loop voltage open Collector (ext.)			30	V	
P_{under}	Digital output is passive below P_{under}	0		2200	W	

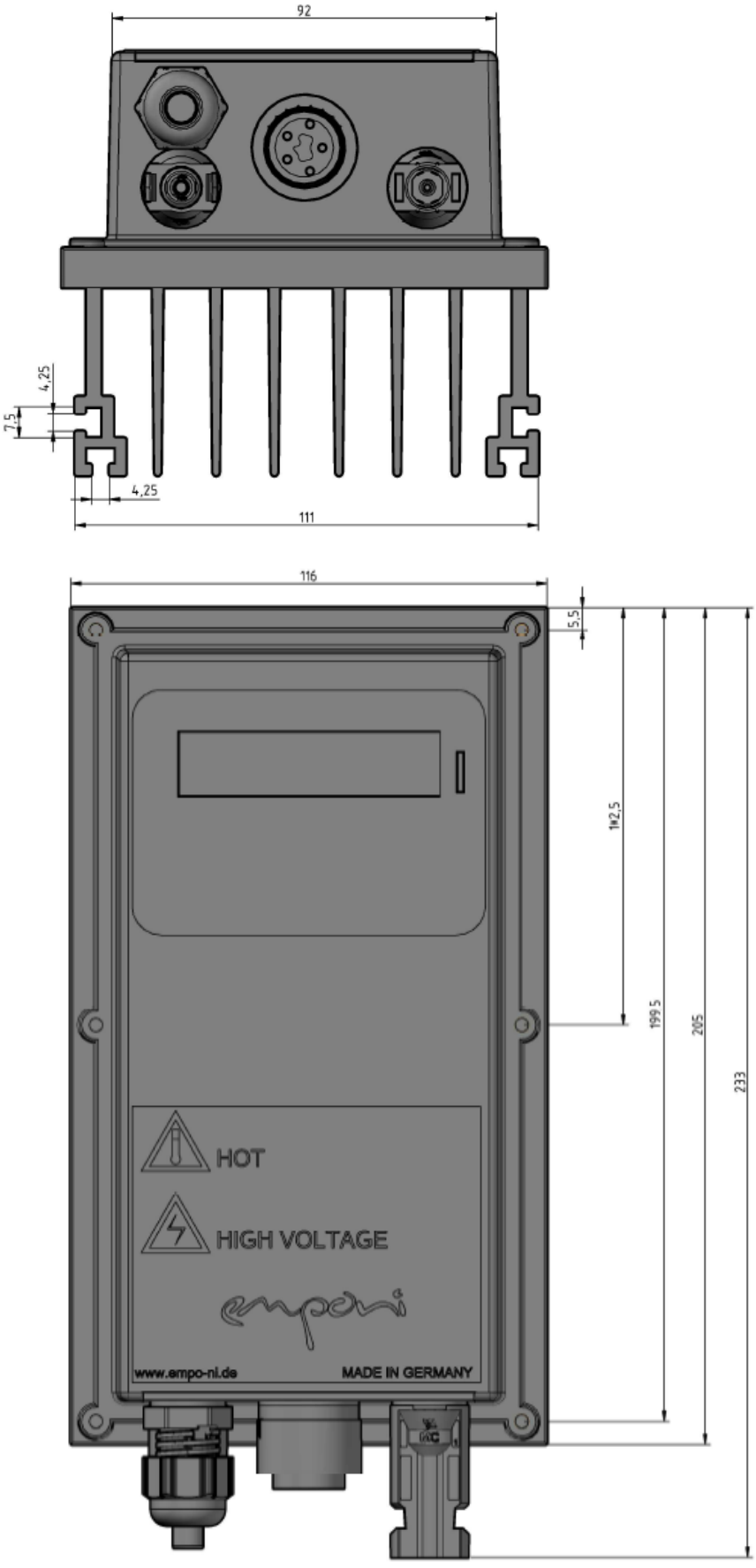
Mechanical

DIM	dimensions width x length x height (max.)	116	233	105	mm	B
m	mass (net weight)		1,3		kg	B
IP	Protection degree		54		--	

Errors and omissions excepted

©2020	Solar Direct Drive 1.5kW-425V	Document no. 20150714-2b	page 1/1

Dimensional drawing



History of changes

Rev.	Item	Date
Prel.	First edition of preliminary document	01.05.2014
0.1	“Selection of PV- modules and motor star / delta connection” added to the description. Further module type implemented SOLARWATT BLUE 60P 250Wp. Example for ∆-connected 3 x 230VAC calculated	12.06.2016
0.2	Layout adjustments, photo update	22.09.2018
0.3	Added 3-phase 160V motor (1.1kW), removed Solarwatt as manufacturer. Supply of 3-phase industrial and submersible motors of non-standard motor voltages by EMPO-NI possible (ref.: Panel selection). Change from “Pay-as-you-use” to “Pay-as-you-go” wording. Some typo correction.	08.08.2019
1.01	Updated version with new heat sink and extended power specification. New GSM modem description for optionally available integrated modem. Re-assignment of interface terminals.	02.01.2020
1.02	External error input description T1/T2 menu description added, GSM command section added “POSITION” command, typos removed, Error message for missing SIM card updated. Speed input menu description added. Photo of SDD1.5kW-425V with new heatsink updated. Corrected dimensions and weight in datasheet, added dimensional drawing	05.08.2020
1.03prel	PAY-AS-YOU-GO (PayGo) implementation for EnAccess compliant Token handling added (section description). PayGo utilization with GSM and response messages added. Flow meter functionality and description updated	22.03.2021