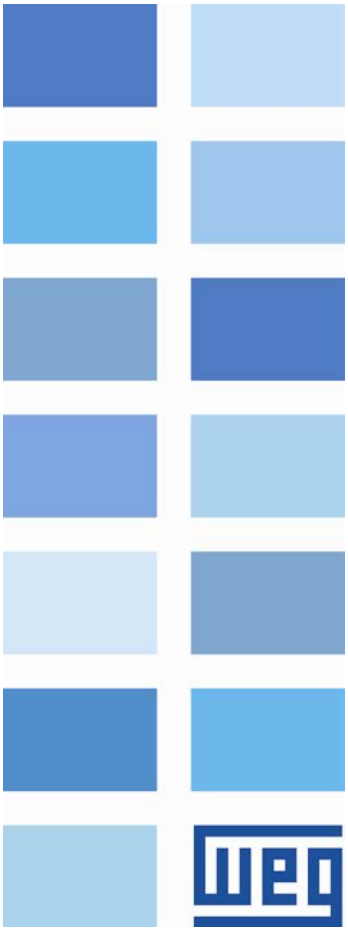
SOLAR PUMP DRIVE

CFW500

Application Manual

Language: English
Document: 10005553220 / 03



Application Manual
Solar Pump Drive

Series: CFW500

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CONTENTS

ABOUT THE MANUAL

This manual provides the necessary information for the configuration of Solar Pump Drive application developed with the CFW500 inverter SoftPLC function. This application manual must be used together with the CFW500 user's manual, the SoftPLC function manual and the WLP software manual.

ABBREVIATIONS AND DEFINITIONS

PLC	Programmable Logic Controller
CRC	Cycling Redundancy Check
RAM	Random Access Memory
USB	Universal Serial Bus
WLP	Ladder Language Programming Software

NUMERICAL REPRESENTATION

Decimal numbers are represented by means of digits without suffix. Hexadecimal numbers are represented with the letter 'h' after the number.

QUICK PARAMETER REFERENCE

Parameter	Description	Adjustable Range	Application Default: 60Hz (50Hz)	User Setting	Properties	Groups	Page
P0100	Acceleration Time	0.1 to 999.0 s	5.0 s			BASIC	-
P0101	Deceleration Time	0.1 to 999.0 s	5.0 s			BASIC	-
P0133	Minimum Speed	0.0 to 500.0 Hz	40.0 (30.0) Hz			BASIC	-
P0134	Maximum Speed	0.0 to 500.0 Hz	60.0 (50.0) Hz			BASIC	-
P0136	Manual Torque Boost	0.0 to 30.0 %	According to inverter model		V/F	MOTOR, BASIC	-
P0142	Maximum Output Voltage	0.0 to 100.0 %	100.0 %		cfg V/F		-
P0143	Intermediate Output Voltage	0.0 to 100.0 %	60.0 %		cfg V/F		-
P0144	Minimum Output Voltage	0.0 to 100.0 %	28.0 %		cfg V/F		-
P0202	Type of Control	0 to 5	0 = V/F		cfg	STARTUP	-
P0203	Special Function Sel.	0 to 3	0 = None		cfg		-
P0204	Load/Save Parameters	0 to 10	0 = Not Used		cfg		-
P0205	Main Display Parameter	0 to 1500	4 = DC Link Voltage			HMI	-
P0206	Secondary Display Parameter	0 to 1500	5 = Output Freq.			HMI	-
P0207	Parameter for Bar	0 to 1500	3 = Motor Current			HMI	-
P0209	Ref. Eng. Unit	0 to 19	1 = Volts			HMI	-
P0216	HMI Backlight	0 to 1	0 = Off		cfg	HMI	-
P0220	LOC/REM Selection Source	0 to 11	1 = Always Remote		cfg	I/O	-
P0222	REM Reference Sel.	0 to 17	12 = SoftPLC		cfg	I/O	-
P0226	REM Rotation Selection	0 to 12	0 = Clockwise		cfg	I/O	-
P0227	REM Run/Stop Selection	0 to 5	5 = SoftPLC		cfg	I/O	-
P0228	REM JOG Selection	0 to 6	0 = Disable		cfg	I/O	-
P0230	Dead Zone (AIs)	0 to 1	1 = Active		cfg	I/O	-
P0231	AI1 Signal Function	0 to 15	1 = Not Used			I/O	22
P0233	AI1 Input Signal	0 = 0 to10V 1 = 4 to 20 mA	0 = 0 to10V			I/O	-
P0235	AI1 Input Filter	0.00 to 16,00	0,30			I/O	-
P0236	AI2 Signal Function	0 to 15	1 = Not Used		cfg	I/O	21
P0238	AI2 Input Signal	0 to 3	0 = 0 to 10 V		cfg	I/O	-
P0263	DI1 Input Function	0 to 46	1 = Run / Stop		cfg	I/O	-
P0264	DI2 Input Function	0 to 46 40 = Pressure Control 42 = Power by Group or Network	40 = Pressure Control		cfg	I/O	-
P0265	DI3 Input Function	0 to 46 41 = 1st DI for Control Setpoint Selection 42 = Power by Group or Network	41 = 1st DI for Control Setpoint Selection		cfg	I/O	-
P0266	DI4 Input Function	0 to 46 41 = 2nd DI for Control Setpoint Selection 42 = Power by Group or Network	41 = 2nd DI for Control Setpoint Selection		cfg	I/O	-
P0275	DO1 Output Function	37 = Triggers External Power	11 = Run			I/O	-
P0296	Line Rated Voltage	0 to 7	According to inverter model		ro, cfg	READ	
P0320	Flying Start/Ride-Through	0 to 3	3 = Ride-Through		cfg		-
P0331	Voltage Ramp	0.2 to 60.0 s	10.0 s				-
P0340	Auto-Reset Time	0 to 255 s	255 s				-
P0400	Motor Rated Voltage	200 to 600 V	According to inverter model		cfg VVW	MOTOR, STARTUP	-
P0401	Motor Rated Current	0.0 to 200.0 A	According to inverter model		cfg	MOTOR, STARTUP	-
P0402	Motor Rated Speed	0 to 30000 rpm	According to inverter model		cfg	MOTOR, STARTUP	-
P0403	Motor Rated Frequency	0 to 500.0 Hz	(60.0 Hz) 50.0 Hz		cfg	MOTOR, STARTUP	-
P0510	SoftPLC Eng. Unit 1	0 = None 13 = Hz	13 = Hz			HMI, SPLC	-
P1001	Command for SoftPLC	0 to 2	1 = Run Program			SPLC	-

Parameter	Description	Adjustable Range	Application Default: 60Hz (50Hz)	User Setting	Properties	Groups	Page
P1010	Solar Pump Drive Application Version	0.00 to 10.00			ro	SPLC	27
P1011	Current Tracking Setpoint	0 to 1000 V			ro	SPLC	28
P1012	Actual Pression Setpoint / Speed	0.0 to 300.0 [Eng. Un.1]			ro	SPLC	28
P1013	Output Pressure	0.0 to 300.0			ro	SPLC	28
P1014	Operating Time CFW500	0 to 65535 h			ro	SPLC	28
P1015	Counter kWh	0 to 65535 kWh			ro	SPLC	29
P1019	Increment Rate MPPT	1 to 20	5			SPLC	18
P1020	Maximum Power Voltage (Vmpp)	0 to 1000 V	302 V			SPLC	18
P1021	Open Circuit Voltage (Voc)	0 to 1000 V	370 V			SPLC	18
P1022	Minimum Setpoint Vdc	0 to 1000 V	250 V			SPLC	19
P1023	Maximum Setpoint Vdc	0 to 1000 V	410 V			SPLC	19
P1024	PID Proportional Gain Vdc	0.000 to 32.000	1.000			SPLC	19
P1025	PID Integral Gain Vdc	0.00 to 32.00	20.00			SPLC	19
P1026	PID Integral Gain Vdc	0.000 to 32.000	0.00			SPLC	20
P1027	Starting Time	0 to 30000 s	0 s			SPLC	20
P1028	Starting Value of AI2	0.0 to 100.0 %	0.0 %			SPLC	21
P1029	Actuation Value DOx	0.0 to 100.0 %	0.0 %			SPLC	21
P1030	Pressure Control	0 = Disabled 1 = Enabled 2 = Enabled via DI2	0			SPLC	22
P1031	Pressure Sensor Scale	0.0 to 300.0	10.0			SPLC	22
P1032	PID Proportional Gain Pressure	0.000 to 32.000	1.000			SPLC	23
P1033	PID Integral Gain Pressure	0.00 to 320.00	10.00			SPLC	23
P1034	PID Integral Gain Pressure	0.000 to 32.000	0.000			SPLC	23
P1035	Pump Motor Speed below which Solar Pump Drive goes to Sleep Mode	0.0 to 300.0 Hz	0.0 Hz			SPLC	23
P1036	Time Delay for Solar Pump Drive goes to Sleep Mode	1 to 65000 s	10 s			SPLC	23
P1037	Control Process Variable Deviation for Solar Pump Drive to Wake Up	0.0 to 300.0	0.0			SPLC	24
P1038	Vdc Start Level	0 to 1000 V	0 V			SPLC	24
P1040	Time Delay for Dry Pump Fault (F781)	0 to 65000 s	0 s			SPLC	24
P1041	Motor Speed for Dry Pump	0.0 to 300.0 Hz	59.0 (49.0) Hz			SPLC	24
P1042	Motor Torque for Dry Pump	0.1 to 100.0 %	20.0 %			SPLC	25
P1043	Time Reset Fault for Dry Pump	0 to 6500 min	0 min			SPLC	25
P1044	Minimum Output Pressure	0.0 to 300.0	0.0			SPLC	25
P1045	Minimum Fault Pressure Time	0 to 65000 s	0 s			SPLC	25
P1046	Maximum Output Pressure	0.0 to 300.0	10.0			SPLC	26
P1047	Maximum Fault Pressure Time	0 to 65000 s	0 s			SPLC	26
P1049	Actuation Time DOx	0 to 65000 s	0 s			SPLC	20
P1051	Control Setpoint 1	0.0 to 300.0 [Eng. Un.1]	60.0			SPLC	26
P1052	Control Setpoint 2	0.0 to 300.0 [Eng. Un.1]	1.5			SPLC	26
P1053	Control Setpoint 3	0.0 to 300.0 [Eng. Un.1]	1.5			SPLC	26
P1054	Control Setpoint 4	0.0 to 300.0 [Eng. Un.1]	1.5			SPLC	26
P1059	Operation (P1014) time and kWh (P1015) Reset	0 = Not Used 1 = Resets Time Counter 2 = Reset kWh	0			SPLC	27

NOTE!
To load the factory default set parameter P0204 to "7".

FAULTS AND ALARMS

Fault / Alarm	Description	Possible Causes
F021: Undervoltage on the DC Link	Undervoltage fault on the intermediate circuit.	Low voltage supply; check if the data on the inverter label comply with the power supply and parameter P0296. Supply voltage too low (AC generator or DC Solar Panel), producing voltage on the DC Link (P0004) below the minimum value: Ud < 200 Vdc in 200-240 Vac (P0296 = 0). Ud < 360 Vdc in 380-480 Vac (P0296 = 1, 2, 3 or 4). Ud < 500 Vdc in 500-600 Vac (P0296 = 5, 6 or 7). Phase fault in the input. Fault in the pre-charge circuit.
A0163: Signal Fault AIx 4..20 mA	Analog input signal AIx at 4 to 20 mA or 20 to 4 mA is below 2 mA.	Current signal on the analog input AIx interrupted or null. Error in the parameterization of analog input AIx
A750: Sleep Mode Active	It indicates that the Solar Pump Drive is in the sleep mode	Value of the pump motor speed is below the threshold programmed in P1035 during the time programmed in P1036
A752: Starting Time	It indicates that the time between start attempts has elapsed	Starting Time was due to lack of Solar Drive power
F761: Minimum Pressure	Minimum system pressure failure	The system pressure is below the value of P1044 for the time programmed in P1045
F763: Maximum Pressure	Maximum system pressure failure	The system pressure is above the value of P1046 for the time programmed in P1047
F781: Dry Pump	It indicates that the pump was stopped due to dry pump protection	During a time (P1040) the value of the pump motor speed remains above of the threshold programmed in P1041 and motor torque remains below the threshold programmed in P1042

1 SAFETY INSTRUCTIONS

This manual contains the information necessary for the correct use of the frequency inverter CFW500 applied to photovoltaic systems for water pumping.

It was developed to be operated by people with proper technical training or qualification to handle this kind of equipment.

1.1 SAFETY WARNINGS IN THIS MANUAL

DANGER!
The procedures recommended in this warning aim at protecting the user against death, serious injuries and considerable material damages.

ATTENTION!
The procedures recommended in this warning aim at preventing material damages.

NOTE!
The information mentioned in this warning is important for the proper understanding and good operation of the product.

ATTENTION!
The voltage Voc should not be higher than 410 V for equipments with nominal voltage 200 – 240 Vac and 810 V for equipments with nominal voltage 380 – 480 Vac to avoid damaging the frequency inverter.

1.2 SAFETY WARNING IN THE PRODUCT

The following symbols are attached to the products as a safety warning:

High voltages present

Components sensitive to electrostatic discharges. Do not touch them.

Connection of the shield to the grounding.

1.3 PRELIMINARY RECOMMENDATIONS

DANGER!
Only persons with adequate technical training or qualification to operate this type of equipment. These people should follow the safety instructions defined by a local regulations. Failure to follow the safety instructions could result in death and/or equipment damage.

NOTE!
For the purposes of this manual, qualified persons are those trained and are therefore suitable for:
1. Install, ground, energize and operate the CFW500 in accordance with these manual and legal safety procedures.
2. Wear protective equipment in accordance with established local standards.
3. Provide first aid.

DANGER!
Always open switch Q1 to disconnect the DC side of photovoltaic modules, before touching any electrical components connected to the product. Wait for at least ten minutes in order to guarantee the full discharge of the capacitors. Always connect the grounding point of the inverter to the protection grounding.

ATTENTION!
The electronic cards have components sensitive to electrostatic discharges. Do not touch the components or connectors directly. If necessary, first touch the grounding point of the inverter which must be connected to the protection ground or use a proper grounding strap

NOTE!
Read this manual thoroughly before installing or connecting the CFW500.

2 PHOTOVOLTAIC WATER PUMPING SYSTEM

This document presents information necessary to configure all the functions of the frequency inverter CFW500. Applied to photovoltaic water pumping systems. For more detailed information on the function of expansion and communications accessories, refer to the following manuals:

- CFW500 Frequency Inverter Documentation;
- Solar Pump Drive Installation Guide;
- CFW500 SoftPLC Manual;
- CFW500 Programming Manual;
- CFW500-CRS485 - Plug-in Module Input/Output.

These files are available on the WEG's website - www.weg.net.

2.1 OVERVIEW OF THE CFW500 IN PHOTOVOLTAIC SYSTEMS

The frequency inverter CFW500 is a high-performance converter AC/DC and AC/DC that allows a speed and torque control of induction three-phase motors. The frequency inverter CFW500 also features PLC (Programmable Logic Controller) through the SoftPLC feature (integrated).

The function of the CFW500 in photovoltaic water pumping systems is to convert energy generated by photovoltaic modules into alternating form, and to apply this energy in the activation of water pumps, according to Figure 2.1.

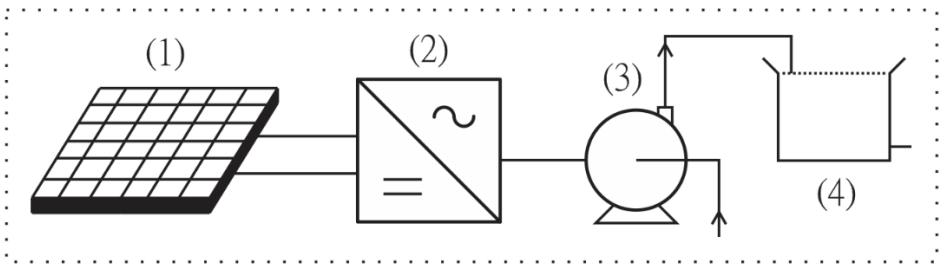

Figure 2.1 – Block Diagram of a photovoltaic pumping system

Where:

(1) Solar photovoltaic plant
(2) Frequency Inverter CFW500 WEG
(3) Water pump
(4) Water tank

2.2 GENERAL CHARACTERISTICS OF THE SOLAR PUMP

The main characteristic of the Solar Pump Drive developed for the CFW500 inverter SoftPLC function is the control of one pump using for this a frequency inverter using the power supply by a photovoltaic system, thus allowing control of the speed of the pump.

Each is notable for the following characteristics:

- Acceleration and deceleration ramps for the pump driven by inverter;
- Maximum and minimum speed limits for the pump driven by inverter;
- Selection the manual control mode, automatic or via digital input. If the control is in manual mode the control setpoint will be speed, if it is in automatic the control setpoint will be pressure;
- Selection of the control setpoint via logical combination of the two digital inputs (maximum of 4 setpoints);
- Selection of the control process variable via analog input AI1;
- Selection of the engineering unit and range of the control process variable sensor via CFW500 parameters;
- Voltage setpoint Vdc minimum and maximum;
- Gain, offset and filter adjustments for the control signals via analog inputs;
- PID controller gains setting of the pressure control;

- PID controller gains setting of the voltage control;
- Enable or not of the sleep mode with the PID controller enabled;
- Wake up/Start level mode to activate the pump;
- Minimum output pressure protection;
- Maximum output pressure protection;
- Dry pump protection through evaluation of motor torque and pump speed;
- Counter hours of operation and energy produced by the solar modules and consumed by the pump.

NOTE!
For applications where the cable between motor and inverter is greater than 100 meters, consult the WEG for sizing.

3 INSTALLATION

3.1 SIZING OF PHOTOVOLTAICS SOLAR MODULES

To install/dimension solar photovoltaic modules must accomplish its 3 main characteristics:

- **Peak Power (W_p)** Is the maximum measured power that the solar photovoltaic module establishes for the STC condition.
- **Open Circuit Voltage (V_{oc})** is the voltage measured at the terminals of the module when it is uncharged, for the STC condition.
- **Maximum Power Voltage (V_{mpp})** is a specific value of the voltage which it is multiplied by the output current, it will give the maximum output power, for the STC condition.

The Standard Test Conditions (STC) is the values presented were measured by standard tests under irradiation conditions of 1000 W/m² with an air mass (PM) of 1,5 and a cell temperature of 25 ºC.

In the plant where such modules are installed, the climatic conditions may be different, it being necessary to calculate a new open circuit voltage value for the scaling of the photovoltaic water pumping system. The main factor that will affect the operation of the system will be the temperature, since the low temperatures will raise the voltage of the open circuit (V_{oc}).

The equation that considers all variables is complex, as well as knowing the exact values of these variables, for this reason is presented below a simple equation that approaches the value to reality:

$$V_{oc} = N_p \cdot V_{oc(STC)} \cdot \left(1 + \left(T_{mínima} - T_{(STC)}\right) \cdot \frac{\beta}{100}\right)$$

Where:

- **V_{oc}:** Open circuit voltage of the photovoltaic solar module at the installation local (V);
- **N_p:** Number of photovoltaic solar modules connected in series;
- **$V_{oc\ (STC)}$:** Open circuit voltage of photovoltaic solar module in STC condition;
- **$T_{mínima}$:** Minimum operating temperature of the module at the operating local (ºC);
- **$T_{(STC)}$:** Standard panel test temperature, 25 °C;
- **β:** Temperature Coefficient you specified by the module data.

With this information calculates the number of solar modules that must be connected in series to operate in the operating voltage range of the inverter. This serial connection, in turn, shall be replicated in parallel as many times as necessary to meet the operating power of the system.

The operating voltage of the inverter varies according to the model, being 250-380 Vdc for 220 Vac single phase and three phase, and 450-760 Vdc for 380-440 Vac models. Particular attention should be paid to the open-circuit voltage (V_{oc}), which should not exceed the inverter's overvoltage protection voltage. In case of voltage you are higher, this will end up damaging the equipment.

The frequency inverters operate with undervoltage and overvoltage protection, so that if the voltage reaches these limit values, the inverter will interrupt its operation. Table 3.1 shows the inverter operating voltage information, as well as the overvoltage and undervoltage limits.

Table 3.1 – Voltage levels of the CFW500

P0296	200-240 Vac		380 Vac	480 Vac
Number of power phases	1	3	3	3
Operating Voltage (Vdc)	250~380	250~380	450~760	450~760
Undervoltage Protection (Vdc)	200	200	360	360
Overvoltage Protection (Vdc)	410	410	810	810

To facilitate the understanding of sizing, we use the following system as an example:

- CFW500 Single Phase / Three-Phase 220 V;
- 2 CV Three-Phase Pump;
- Solar modules model GCL-P6/72 from the manufacturer GCL.

The photovoltaic solar panel model GCL-P6/72 of the manufacturer GCL has the following characteristics (STC):

Table 3.2 – Technical characteristics of the Photovoltaic Solar Module Polycrystalline

Electrical Characteristics	
Nominal Power Output (P_{mpp})	330 W_p
Voltage at Pm Point (V_{mpp})	37,8 V
Current at Pm Point (I_{mpp})	8,73 A
Open Circuit Voltage (V_{oc})	46,2 V
Short Circuit Current (I_{sc})	9,33 A
Module Efficiency	17 %

For example, is defined the serial connection of four photovoltaic solar modules, generating for the standard test condition (STC) a maximum power voltage of 302,4 Vdc, with an open circuit voltage (V_{oc}) of 369,6 Vdc.

NOTE!
The dimensioning values are according to the table 3.1 (within the limits of CFW500).

By choosing to connect eight solar modules in series, we are inserting power steps for the sizing of the system, being it of 2640 W. To comply with a 2 CV pump, it is recommended a power of 1471 W, as a minimum peak power.

Table 3.3 – Technical information for serial connection of eight solar modules GCL-P6/72

Specific Information PV Installation (STC) 25 °C x PV Quantity	
Nominal Power Output (P_{mpp})	2640 W_p
Voltage at Pm Point (V_{mpp})	302,4 V
Current at Pm Point (I_{mpp})	8,73 A
Open Circuit Voltage (V_{oc})	369,6 V
Short Circuit Current (I_{sc})	9,33 A

The connection of the eight solar modules must be carried out according to the diagram in figure 3.1.

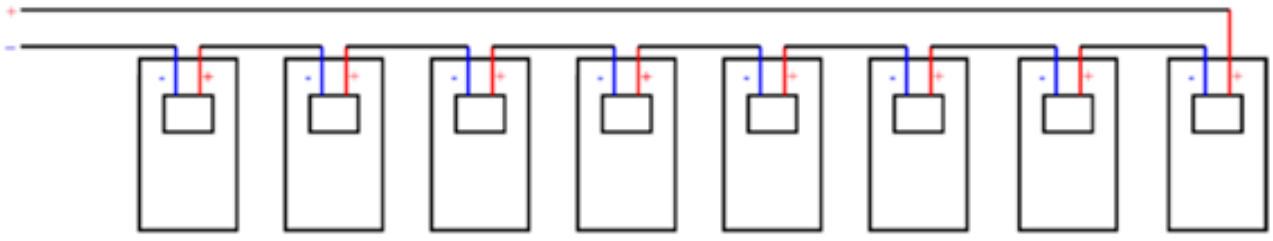

Figure 3.1 – Connection of solar modules

3.2 CONNECTIONS

The type of connection to be used will be determined by the voltage of the equipment, below are presented the typical connections for each CFW500 Frame, for more details about the connections of the solar panels consult the “Solar Pump Drive Installation Guide”

3.2.1 Frame A

For inverters CFW500 and Frame "A", models without access to the Link DC terminals, the following connection is recommended:

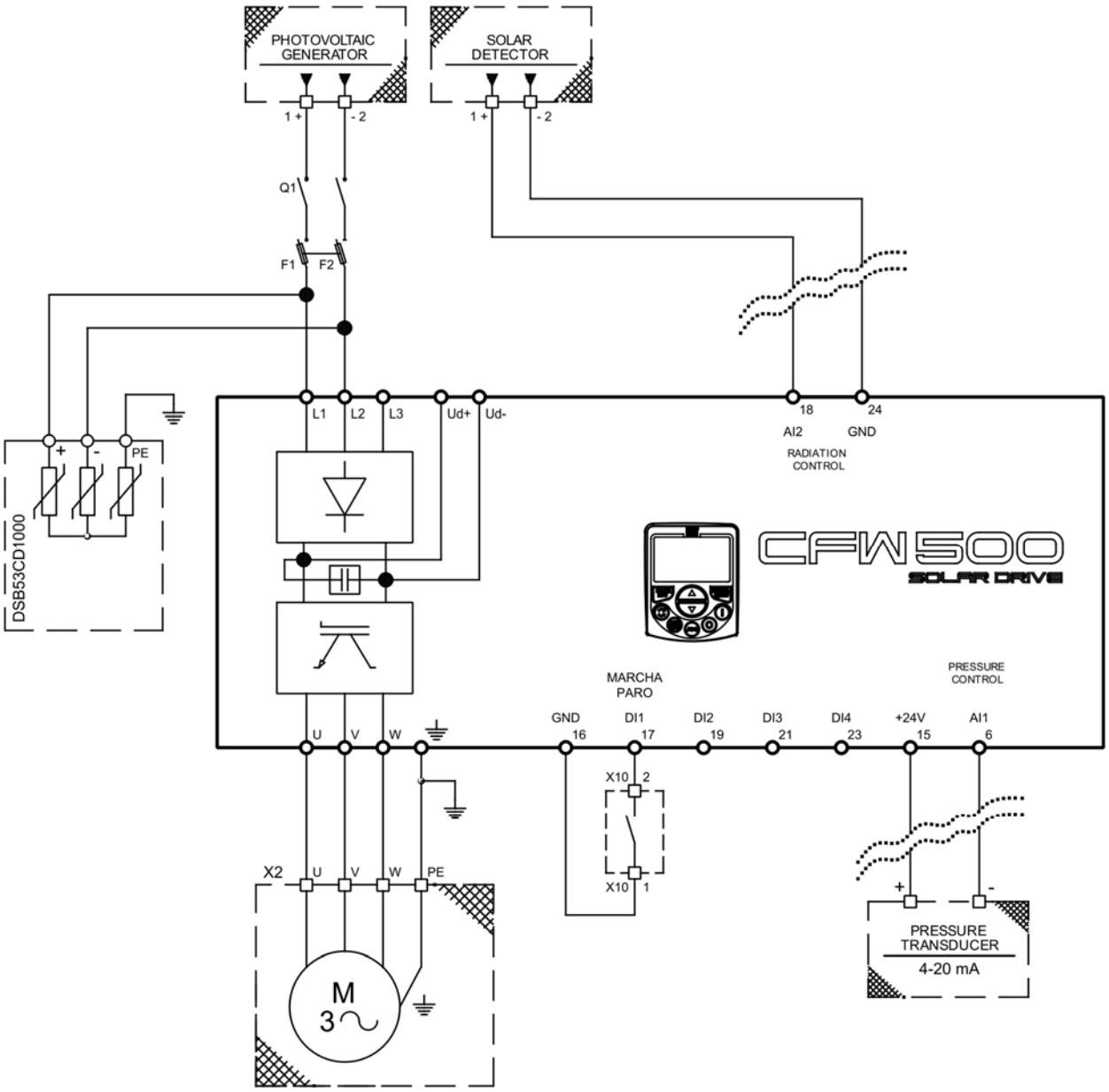

Figure 3.2 – Connection diagram of the water pumping photovoltaic system for inverter frame A

NOTE!
Take care to don't reverse the positive and negative voltage connections from the solar modules.

NOTE!
The inputs/outputs connections may be different from what is indicated in this diagram, depending on the needs of the application.

3.2.2 Frames B, C, D, E and F

For CFW500 frequency inverters of frames B, C, D and E, models with access to the Link DC (Ud + and Ud-) the following connection is recommended.

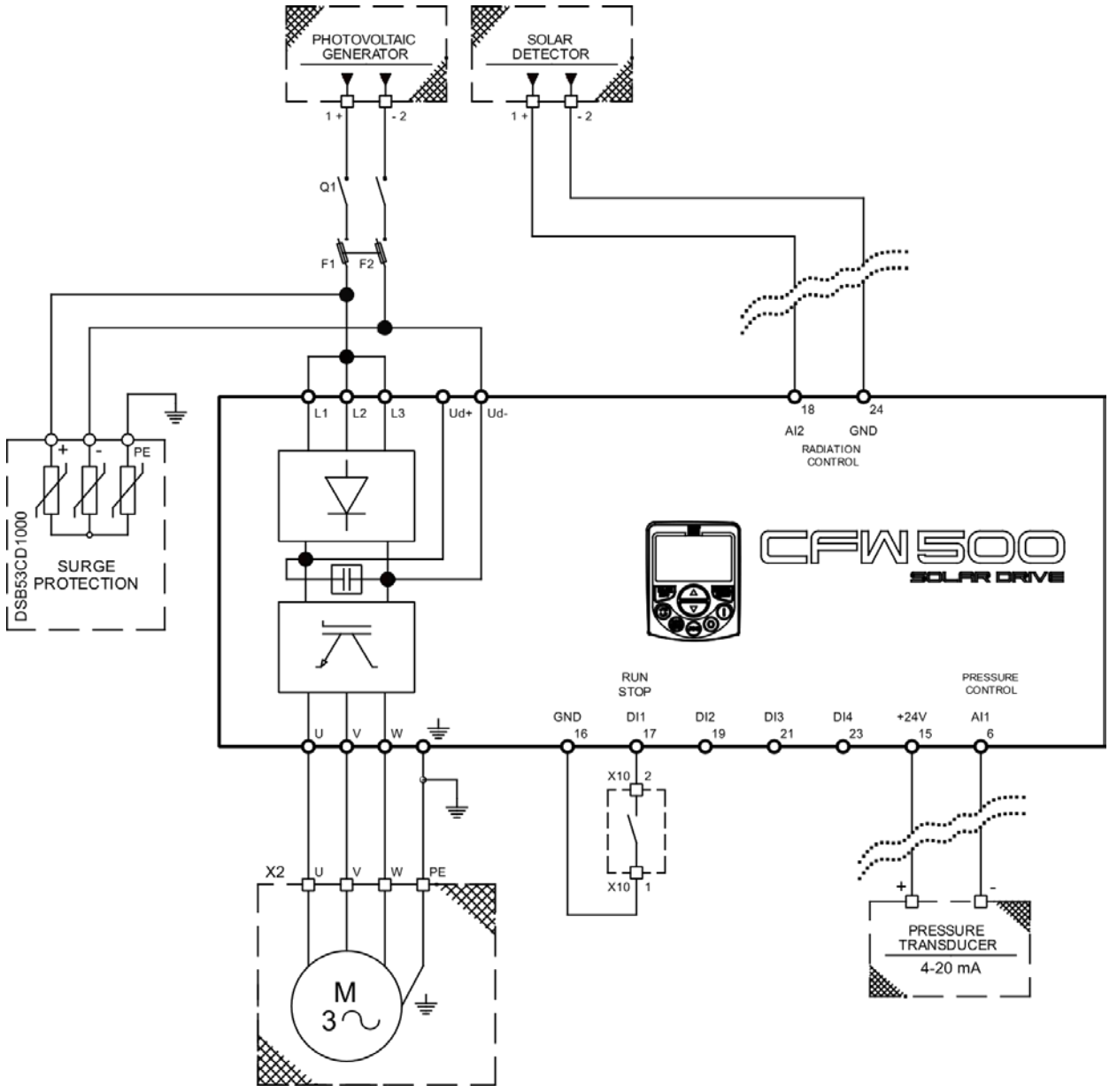

Figure 3.3 – Connection diagram of the water pumping photovoltaic system for inverter frames B, C, D, E and F

NOTE!
Take care to don't reverse the positive and negative voltage connections from the solar modules.

NOTE!
The inputs/outputs connections may be different from what is indicated in this diagram, depending on the needs of the application.

3.2.3 Frames B, C, D, E and F with Hybrid Power

For CFW500 frequency inverters of frames B, C, D, E and F, models with access to the Link DC (Ud + and Ud-) and require hybrid power, the following connection is recommended.

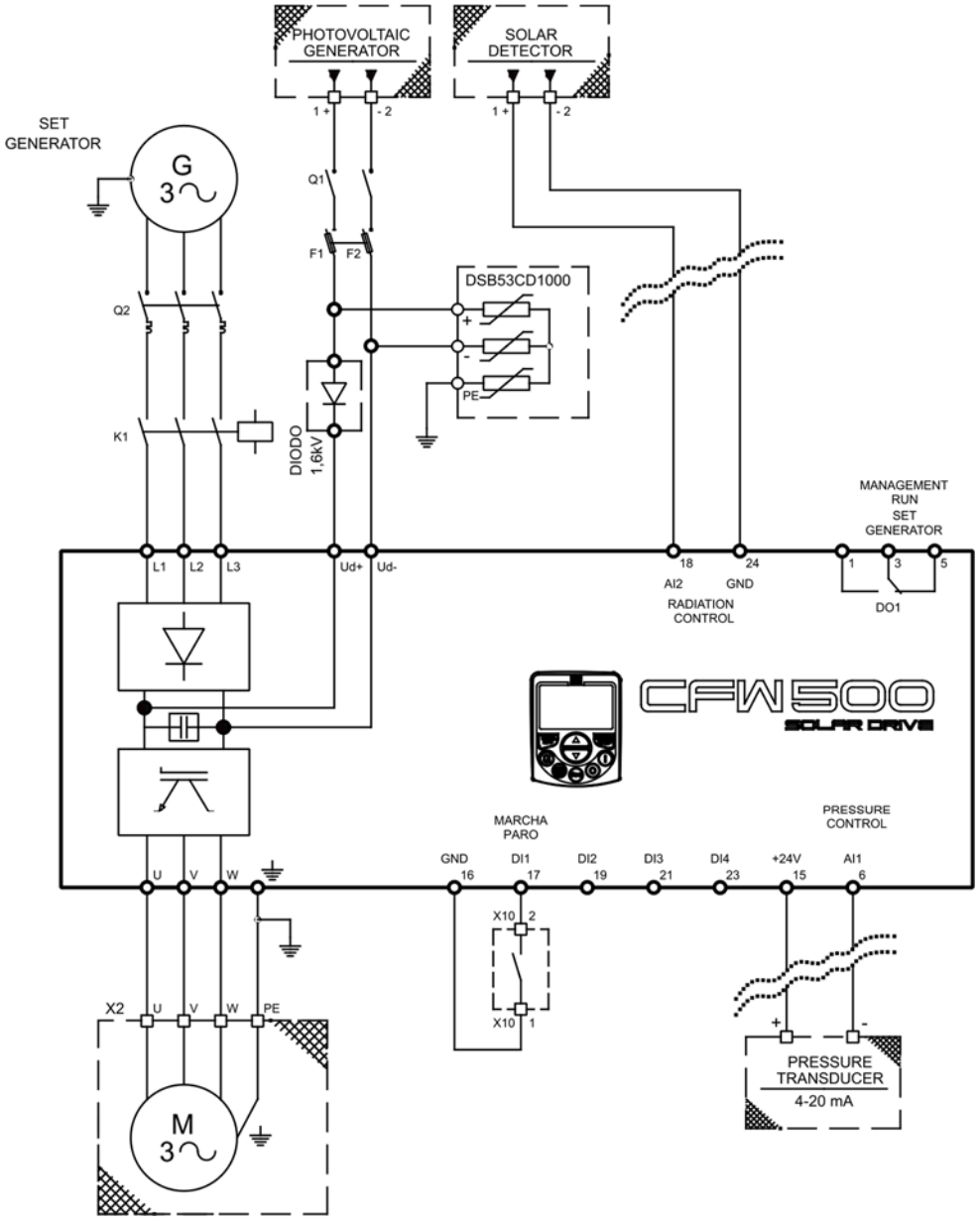

Figure 3.4 – Connection diagram of the water pumping photovoltaic system for inverter frames B, C, D, E and F with hybrid power

NOTE!
Take care to don't reverse the positive and negative voltage connections from the solar modules.

NOTE!
When closing the contactor K1 it must be timed to avoid that the starting peak of the generator reaches the voltage input of the frequency inverter.

NOTE!
The inputs/outputs connections may be different from what is indicated in this diagram, depending on the needs of the application.

4 CONTROL METHOD BY MAXIMUM POWER POINT TRACKING

The strategy of control method of variable reference is constantly tracking the maximum power point of the system (MPPT).

The maximum power point of a solar module changes according to the solar irradiance incident on the solar cell, as well as the temperature, wind velocity, inclination of the solar photovoltaic module, passing of clouds, thus generating the need of the constant search for maximum power of the system. Compared to the fixed-point method, MPPT provides a higher system efficiency, which can reach 20 %.

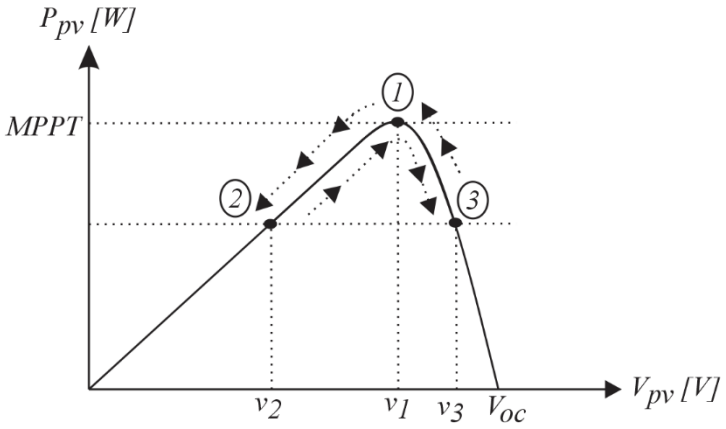

Figure 4.1 – Maximum Power Point Tracking

Where:

(1) Automatic Proportional Voltage Value at Maximum System Power
(2) Minimum Control Setpoint Level per MPPT (P1022)
(3) Maximum Control Setpoint Level per MPPT (P1023)
(← →) Increment Rate MPPT (P1019)

5 PARAMETERS DESCRIPTION

The CFW500 inverter parameters (P0000 to P0999) and the SoftPLC function parameters (P1000 to P1059) for the Solar Pump Drive application will be presented next.

NOTE!
The Solar Pump Drive application only works on CFW500 inverter with firmware version over V2.06. So, upgrading the CFW500 inverter firmware to the working of this application is required.

NOTE!
The adjustable range of the CFW500 parameters has been customized for Solar Pump Drive application. Refer to the CFW500 programming manual for more details on the parameters.

Symbols for property description:

CFG	Configuration parameter, value can be programmed only with motor stopped
RO	Read-only parameter
RW	Read and write parameter

5.1 VOLTAGE REGULATOR

This group of parameters allows the user to configure the operating conditions of the voltage regulator for operation by the photovoltaic modules, both for direct pumping and pressure regulation.

P1019 – Increment Rate MPPT

Adjustable Range:	1 to 20	**Application Default Setting:**	5
Properties:			
Access groups via HMI:	SPLC		

Description:
This parameter defines the variation rate of voltage setpoint for maximum power point tracking. Initially leave this parameter with the defect value “5” and in case of Setpoint variation it is not fast enough to gradually increase until the optimum operating result is achieved.

5.1.1 Photovoltaic Generator Data

P1020 – Maximum Power Point Voltage (Vmpp)

Adjustable Range:	0 to 1000 V	**Application Default Setting:**	302 V
Properties:			
Access groups via HMI:	SPLC		

Description:
This parameter defines the maximum power point the installed photovoltaic module system. This data will appear on each of installed photovoltaic panels and will be named Vmpp under the STC test conditions. Thus, in the case presented above, the value to be configured would be 302 Vdc (8 modules in series x 37,8 Vdc at maximum power point).

P1021 – Open Circuit Voltage (Voc)

Adjustable Range:	0 to 1000 V	**Application Default Setting:**	370 V
Properties:			
Access groups via HMI:	SPLC		

Description:
This parameter defines the value of open circuit voltage of the installed PV panels. This data will appear on each of the installed photovoltaic panels and will be named V_{oc} under the STC test conditions. Thus, in the case presented above, the value to configure would be 369,6 Vdc (8 modules in series x 46,2 Vdc of open circuit).

5.1.2 Voltage Setpoint Limits

P1022 – Minimum Setpoint Vdc

Adjustable Range:	0 to 1000 V	**Application Default Setting:**	250 V
Properties:			
Access groups via HMI:	SPLC		

Description:
This parameter defines the minimum value of the voltage setpoint that the system must use during the process of maximum power point search.

P1023 – Maximum Setpoint Vdc

Adjustable Range:	0 to 1000 V	**Application Default Setting:**	410 V
Properties:			
Access groups via HMI:	SPLC		

Description:
This parameter defines the maximum value of the voltage setpoint that the system must use during the process of maximum power point search.

5.1.3 Voltage PID Controller

This group of parameters allows the user to configure the PID controller gains for the DC voltage control supplied by the photovoltaic modules. The PID controller always will attempt to search the work point defined by Tracking Setpoint and for this will act on the output frequency of the motor.

P1024 – Voltage PID Proportional Gain

Adjustable Range:	0.000 to 32.000	**Application Default Setting:**	1.000
Properties:			
Access groups via HMI:	SPLC		

Description:
This parameter defines the proportional gain value of the PID controller for the DC voltage control.

P1025 – Voltage PID Integral Gain

Adjustable Range:	0.00 a 320.00	**Application Default Setting:**	20.00
Properties:			
Access groups via HMI:	SPLC		

Description:
This parameter defines the integral gain value of the PID controller for the DC voltage control.

P1026 – Voltage PID Derivative Gain

Adjustable Range:	0.000 to 32.000	**Application Default Setting:**	0.000
Properties:			
Access groups via HMI:	SPLC		

Description:
This parameter defines the derivative gain value of the PID controller for the DC voltage control.

5.1.3.1 PID Controller Gain Adjustment

In controlling pumping systems, a Proportional-Integral (PI) velocity regulator is sufficient to achieve good control performance. The proportional gain K_P (P1024) and integral K_I (P1025) must be changed if the controller response is not satisfactory, ie if there are oscillations in the output pressure around the setpoint, very slow response time or constant error in relation to the setpoint. Here are some suggestions for regulator adjustment:

■ Output pressure oscillation: In most cases this is due to excessive gain of the PID controller, reduce the K_P and K_I gains gradually and observe the response;

■ Very slow response time: Increasing the K_P gain the system must respond faster, however from a limit the system may have surges;

■ Constant error in the output: In this case, increasing the gain K_I eliminates the constant error of the output, ie when the output cannot reach the setpoint. Excessive K_I gain can generate oscillations at the output, then decrease the gain K_P so that the total gain is reduced while maintaining gain K_I.

5.1.4 System Start Configuration

This group of parameters allows the user to configure system start options.

NOTE!
See also parameter P1038 as a condition for starting the system autonomously.

P1027 – Time Between Starts

Adjustable Range:	0 to 30000 s	**Application Default Setting:**	0 s
Properties:			
Access groups via HMI:	SPLC		

Description:
This parameter defines the time between starts, when the system is stopped by power failure or when it reaches the limit set in the parameter P1029. This delay is to avoid continuous starts and stops, and in the case of submersible pumps, preventing the restart of the pump before the empty pipe.

NOTE!
If the run command is removed from the system, the time will be reset and once go back to operate the run command the start will be realized immediately without consider any time.

P1049 – DO Actuation Time

Adjustable Range:	0 to 65000 s	**Application Default Setting:**	0 s
Properties:			
Access groups via HMI:	SPLC		

Description:
This parameter defines the DO actuation condition of DO for the digital output be trigged.

5.1.5 Solar Detector

The Solar Photovoltaic Detector consists of a photovoltaic module with a small power properly dimensioned to be connected to the analog input 2 (AI2) of the CFW500, whose function is to inform the solar radiation available at all times. The use of this device is optional but will increase the efficiency of solar pumping by allowing system starts to occur only when available solar radiation is sufficient to drive the pump at a predetermined minimum speed.
The settings of these parameters must be carried out at the first or last hour of the day, when the solar radiation is lower, to verify in which radiation conditions the pump operates at the lowest permissible speed. Under these conditions you should check the value of parameter P0019 to determine the available radiation value. Once this value is known, it must be set equal to or slightly higher in parameter P1028.
The Solar Detector can also be used to automate the external power supply. The parameter P1029 is used to drive the digital output DO1 configured in 37 or 38 that can connect an external power supply.

NOTE!
The use of the Solar Detector is optional, but its use is recommended if a more autonomous system is desired.

P0236 – AI2 Signal Function

Adjustable Range:	0 a 15 -> 1 = No Function -> 9 = Function 2 Application (Solar Detection)	**Application Default Setting:**	1
Propriedades:	CFG		
Grupos de acesso via HMI:	I/O		

Description:
This parameter defines the function of the analogic Input AI2. To enable the Solar Detection Function, select the corresponding value.

P1028 – Solar Detector Value for System Starts

Adjustable Range:	0.00 to 100.0 %	**Application Default Setting:**	0.0 %
Properties:	CFG		
Access groups via HMI:	SPLC		

Description:
This parameter defines the radiation value, in % of analogic input AI2, which will allow the system to start.

P1029 – Solar Detector Value for Digital Output Actuation (External Power)

Adjustable Range:	0.00 to 100.0 %	**Application Default Setting:**	0.0 %
Properties:	CFG		
Access groups via HMI:	SPLC		

Description:
This parameter defines the value of the radiation, in% of the analogic input AI2, which will allow the activation of the digital output 1 configured with value 37 or 38 for the activation of an external power supply that will complement the photovoltaic generator.

Table 5.1 – Value for Digital Output Drive

P0275 = 37	The output DO1 will switch when the solar radiation shown at P0019 is less than the value set at P1029, during the time set at P1049. The output DO1 will return to its idle state when the radiation read in P0019 exceeds at least 5 % of the value set in P1029 during the time set in P1049. In this option, the actuation of the external power supply requires the presence of minimum solar radiation that allows the energization of the equipment.
P0275 = 38	The output DO1 will not switch until the solar radiation read at P0019 exceeds at least 5 % of the value set at P1029 for the time set at P1049. The output DO1 will return to its idle state when the radiation read in P0019 is lower than the value set in P1029 during the time set in P1049. This option is valid when it is necessary to automate the input of the external power supply in the absence of solar radiation and its disconnection when the solar radiation is sufficient to drive the pump without external support. For this option the NC contact of the DO1 must be used and involve with the commissioning of the system.

5.2 PRESSURE CONTROLLER

This group of parameters allows the user to configure the conditions of operation of the pressure controller. The pressure controller should receive the pressure return of the system by connecting a pressure transducer to the analogic input (AI1) and perform the pump speed control, when the user defined pressure is reached and the solar radiation conditions allow it.

P0231 – AI1 Signal Function

Adjustable Range:	0 a 15 -> 1 = No Function -> 8 = Function 1 Application (Read Pressure)	**Application Default Setting:**	1
Propriedades:	CFG		
Grupos de acesso via HMI:	I/O		

Description:
This parameter defines the function of the analogic Input AI1. To enable Read the Pressure, select the corresponding value.

P1030 – Pressure Control

Adjustable Range:	0 = Disabled 1 = Enabled 2 = Enabled via DI2	**Application Default Setting:**	0
Properties:	CFG		
Access groups via HMI:	SPLC		

Description:
This parameter defines the enabling or not the pressure control, so that the system operates through the DC voltage control and when the solar radiation allows, regulate the voltage of the pipeline, changing only the DC voltage, causing the pump to run at maximum speed possible.

P1031 – Pressure Sensor Scale

Adjustable Range:	0.0 to 300.0	**Application Default Setting:**	10.0
Properties:	CFG		
Access groups via HMI:	SPLC		

Description:
This parameter defines the full-scale value of the pressure sensor connected to the analog input 1 (AI1).

5.2.1 Pressure PID Controller

This group of parameters allows the user to configure the PID controller gains for the pressure control.

P1032 – Pressure PID Proportional Gain

Adjustable Range:	0.000 to 32.000	**Application Default Setting:**	1.000
Properties:			
Access groups via HMI:	SPLC		

Description:
This parameter defines the proportional gain value of the PID controller for the pressure control.

P1033 – Pressure PID Integral Gain

Adjustable Range:	0.00 to 320.00	**Application Default Setting:**	10.00
Properties:			
Access groups via HMI:	SPLC		

Description:
This parameter defines the integral gain value of the PID controller for the pressure control.

P1034 – Pressure PID Derivative Gain

Adjustable Range:	0.000 to 32.000	**Application Default Setting:**	0.000
Properties:			
Access groups via HMI:	SPLC		

Description:
This parameter defines the derivative gain value of the PID controller for the pressure control.

5.2.2 Sleep Mode

This group of parameters allows the user to configure the system to stop the pump when the pump motor speed drops below a programmed threshold (low control demand). Even though apparently the pumping control is off, the output pressure (control process variable) is still monitored for wake up and/or start level conditions by voltage level.

P1035 – Pump Motor Speed below which Solar Pump Drive goes to Sleep Mode

Adjustable Range:	0.0 to 300.0 Hz	**Factory Setting:**	0.0 Hz
Properties:			
Access groups via HMI:	SPLC		

Description:
This parameter defines the value of the pump motor speed below which the system will stop the pump keeping the control active, i.e., will sleep.

P1036 – Time Delay for Solar Pump Drive goes to Sleep Mode

Adjustable Range:	1 to 65000 s	**Application Default Setting:**	10 s
Properties:			
Access groups via HMI:	SPLC		

Description:
This parameter defines the waiting time with the value of the pump motor speed should remain below the value set in P1035 in order for sleep mode to be activated and the pump to be stopped.

P1037 – Control Process Variable Deviation for Solar Pump Drive to Wake Up

Adjustable Range:	0.0 to 300.0	**Application Default Setting:**	0.0
Properties:			
Access groups via HMI:	SPLC		

Description:
This parameter defines the value to be reduced (direct PID) to the control setpoint for starting the pump and resuming control of the pumping. Becoming this value is compared with the control process variable and, if the value of the control process variable is less than this value, the condition to wake up is enabled.

P1038 – Vdc Start Level

Adjustable Range:	0 to 1000 V	**Application Default Setting:**	0 V
Properties:			
Access groups via HMI:	SPLC		

Description:
This parameter defines the control process variable level for starting the pump and resuming control of the pumping. With a Direct Mode PID controller, the pumping control will be enabling to start when the control process variable drops lower than P1038.

5.3 PROTECTIONS

This group of parameters allows the user to configure the protections as dry pump, maximum pressure and minimum pressure as dry pump protections, maximum pressure and minimum pressure. If the system activates pumping without pressure control, the time parameter P1045 and P1047 must be set to "0" so that as pipe pressure protection functions remain disabled.

5.3.1 Dry Pump

This group of parameters allows the user to configure dry pump detection, to protect the inverter driven pump.

P1040 – Time Delay for Dry Pump Fault (F781)

Adjustable Range:	0 to 65000 s	**Application Default Setting:**	0 s
Properties:			
Access groups via HMI:	SPLC		

Description:
This parameter defines the waiting time with the dry pump condition active, before the dry pump fault “F781: Dry Pump” is generated.

P1041 – Motor Speed for Dry Pump

Adjustable Range:	0.0 to 300.0 Hz	**Application Default Setting:**	59.0 Hz
Properties:			
Access groups via HMI:	SPLC		

Description:
This parameter defines the pump motor speed threshold value, above which evaluation of actual motor torque to detect the dry pump condition (P1042) is enabled.

P1042 – Motor Torque for Dry Pump

Adjustable Range:	0.0 to 100.0 %	**Application Default Setting:**	20.0 %
Properties:			
Access groups via HMI:	SPLC		

Description:
This parameter defines the pump motor torque threshold value, below which the dry pump condition is detected.

P1043 – Reset Dry Pump Time

Adjustable Range:	0 to 6500 min	**Application Default Setting:**	0 min
Properties:			
Access groups via HMI:	SPLC		

Description:
This parameter defines the time in minutes the reset time of the drive time when the dry pump was detected to the time the drive is reset.

If this parameter is set to "0", the automatic reset of the Dry Pump condition is disabled.

NOTE!
This parameter may interfere with the automatic auto-reset programmed in parameter P0340, so if it is necessary to activate the fault reset by Dry Pump, you must deactivate auto-reset by setting P0340 to "0".

5.3.2 Minimum Output Pressure

This parameter group allows the user to configure the minimum output pressure detection for pump protection activated by the CFW500 frequency inverter.

P1044 – Minimum Output Pressure

Adjustable Range:	0.0 to 300.0	**Factory Setting:**	0.0
Properties:	CFG		
Access groups via HMI:	SPLC		

Description:
This parameter defines the minimum pressure value of the system to enter the minimum pressure condition. In addition to the pressure, to enter a minimum pressure condition, the pump speed must be equal the maximum speed. This condition is to avoid the interference of the voltage control, which can cause the system pressure not to reach the minimum marked, because the solar radiation will not be enough to reach this value, without involving a fault.

P1045 – Minimum Fault Pressure Time (F761)

Adjustable Range:	0 to 65000 s	**Factory Setting:**	0 s
Properties:	CFG		
Access groups via HMI:	SPLC		

Description:
This parameter defines the time with the active minimal pressure condition, to generate the minimum pressure fault (F761).

NOTE!
The system will stop if a fault message is generated. The value of this parameter at "0" disables the fault.

5.3.3 Maximum Output Pressure

This parameter group allows the user to configure the maximum output pressure detection for pump protection activated by the CFW500 frequency inverter.

P1046 – Maximum Output Pressure

Adjustable Range:	0.0 to 300.0	**Factory Setting:**	10.0
Properties:	CFG		
Access groups via HMI:	SPLC		

Description:
This parameter defines the minimum pressure value of the system to enter the maximum pressure condition.

P1047 – Maximum Fault Pressure Time (F763)

Adjustable Range:	0 to 65000 s	**Factory Setting:**	0 s
Properties:	CFG		
Access groups via HMI:	SPLC		

Description:
This parameter defines the time with the active maximal pressure condition, to generate the minimum pressure fault (F763).

NOTE!
The system will stop if a fault message is generated. The value of this parameter at "0" disables the fault.

5.4 CONTROL SETPOINT

This group of parameters allows the user to adjust the speed or pressure setpoint required for the system to function. The setpoint will have the speed function in Hz when the system is in idle pressure control mode, and will have the Pressure Setpoint function when the system is in active control mode.

The communication between a Setpoint or another will be via digital inputs configured for the function.

P1051 – Control Setpoint 1

P1052 – Control Setpoint 2

P1053 – Control Setpoint 3

P1054 – Control Setpoint 4

Adjustable Range:	0.0 to 300.0 [Eng. Un. 1]	**Application Default Setting:**	P1051 = 60.0 P1052 = 1.5 P1053 = 1.5 P1054 = 1.5
Properties:			
Access groups via HMI:	SPLC		

Description:
These parameters define the value of the setpoint in pressure mode active (bar) or pressure mode inactive (Hz) when control setpoint source was programmed to be via logical combination of digital inputs DI3 and DI4 according the table 5.2.

Table 5.2 – Truth table for control setpoint via logical combination of the digital inputs DI3 and DI4

Digital Input	P1051 – Control Setpoint 1	P1052 – Control Setpoint 2	P1053 – Control Setpoint 3	P1054 – Control Setpoint 4
Digital Input DI3	0	1	0	1
Digital Input DI4	0	0	1	1

NOTE!
This parameter will be displayed according to the parameter selection for engineering unit 1 (P0510) in 0 (without unit) or 13 (Hz). This selection is made automatically by the application.

NOTE!
The Control Setpoint function operated by digital inputs is configured by setting the parameters P0265 and P0266 to 26.

5.4.1 Reset of P1014 and P1015

P1059 – Reset P1014 and P1015

Adjustable Range:	0 = No function 1 = Reset Time Operation (P1014) 2 = Reset kWh (P1015)	**Application Default Setting:**	0
Properties:	CFG		
Access groups via HMI:	SPLC		

Description:
This parameter allows to reset the parameters P1014 (operating time of the CFW500) and P1015 (kWh counter).

These parameters can be useful for counting the number of monthly or weekly hours that the system is operating and the kWh generated.

Once parameter P1014 or P1015 is reset, parameter P1059 returns to value "0" automatically.

5.5 HMI MONITORING

This parameter group allows the user to configure which parameters will be shown on the HMI display in the monitoring mode.

P0205 – Main Display Parameter Selection

P0206 – Secondary Display Parameter Selection

P0207 – Bar Graph Parameter Selection

NOTE!
Refer to the CFW500 frequency inverter programming manual for further information about the HMI parameters.

5.6 READING PARAMETERS

P1010 – Application Version

Adjustable Range:	0.00 to 10.00	**Application Default Setting:**	-
Properties:	RO		
Access groups via HMI:	SPLC		

Description:
This parameter indicates the version of the ladder application software developed for the Solar Pump Drive.

P1011 – Current Tracking Setpoint

Adjustable Range:	0 to 1000 V	**Application Default Setting:**	-
Properties:	RO		
Access groups via HMI:	SPLC		

Description:
This parameter shows the current value of the DC voltage setpoint that will be modified by the system in search of the maximum reference point.

P1012 – Actual Pressure Setpoint / Speed

Adjustable Range:	0.0 to 300.0 [Eng. Un. 1]	**Application Default Setting:**	-
Properties:	RO		
Access groups via HMI:	SPLC		

Description:
This parameter displays the current value of the pressure setpoint or speed in function of the system configuration and can be presented in two ways:

- Pressure control enabled: the value shown here will correspond to the system pressure setpoint that the pressure controller will attempt to maintain;
- Pressure control disabled: The value shown here will correspond to the speed in Hz the drive will attempt to reach.

NOTE!
For more details about the pressure control refer to parameter P1030.

NOTE!
This parameter will be displayed according to the parameter selection for engineering unit 1 (P0510) in 0 (without unit) or 13 (Hz). This selection is made automatically by the application.

P1013 – Output Pressure

Adjustable Range:	0.0 to 300.0	**Application Default Setting:**	-
Properties:	RO		
Access groups via HMI:	SPLC		

Description:
This parameter displays the value of the system output pressure read via the connection of a pressure transducer in the analog input 1.

P1014 – Operating Time CFW500

Adjustable Range:	0 to 65000 h	**Application Default Setting:**	-
Properties:	RO		
Access groups via HMI:	SPLC		

Description:
This parameter displays the operating time of the pump powered by the CFW500.

P1015 – kWh Counter

Adjustable Range:	0 a 65000 kWh	**Application Default Setting:**	-
Properties:	RO		
Access groups via HMI:	SPLC		

Description:
This parameter displays the kWh value produced by the CFW500 and consumed by the pump. Until it reaches the value of 1000 kWh, the data will be presented with one decimal point, that is, XXX.X kWh. From 1000 kWh, the parameter format will be without decimal point, XXXX kWh.

6 POWER UP AND START UP

Shown below is a step-by-step guide for the commissioning of a water pumping photovoltaic system using a WEG CFW500 frequency inverter:

1. Verify that the connections of power, ground, and control are correct and secure;
2. Faça a medição da tensão proveniente dos módulos solares, e verifique se está dentro da faixa permitida;
3. Mechanically disengage the load motor. If the engine cannot be uncoupled, make sure that turning in either direction (clockwise or counterclockwise) will not cause damage to the machine or risk of accidents;
4. Energize input;
5. Enter the general parameters in the CFW500, report according to the technical characteristics of the water pump and the inverter;
6. Switch to remote mode, and restart the CFW500.
7. With the system running, configure the Proportional (P1024) and Integrals (P1025) gains of the controller, can be done by the HMI, or WLP, through the monitoring dialogs;
8. When running with the fixed voltage method, change the optimal voltage value (P1022 and P1023), searching the best system performance.

NOTE!
The inverter performs some routines related to loading or downloading data (parameter settings and/or SoftPLC). The indication of these routines is displayed in the bar for variable monitoring. After these routines, if there is no problem, the display will show the monitoring mode

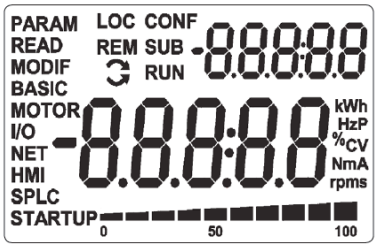

Figure 6.1 – HMI display when powering the drive