INOMAX

Medium and Low-Voltage drives Servo drives
Solar pump inverters Soft starters solution provider

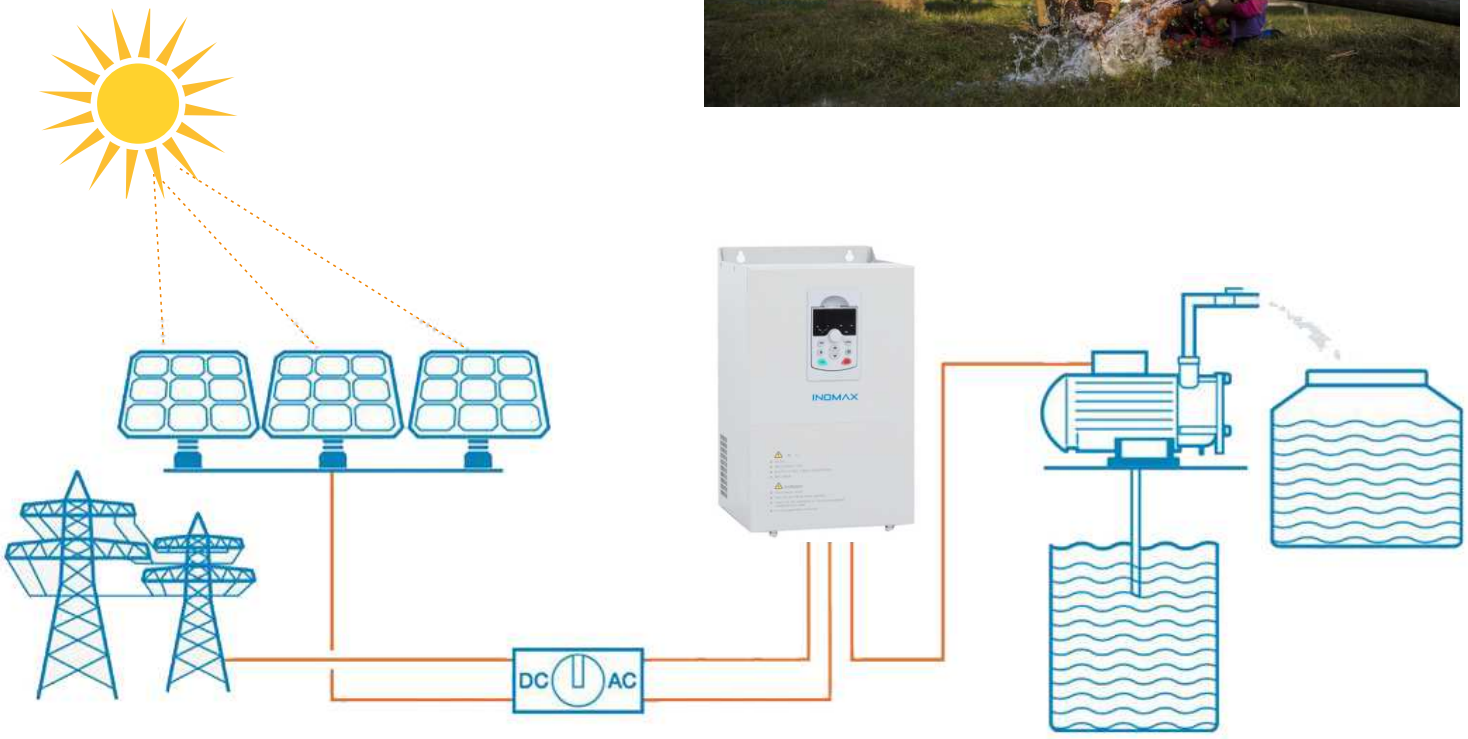
MAX500-PV series solar pump inverter with MPPT >99%

0.75KW-250KW

User manual

16111002

REV: V218
Jun.2021



SHENZHEN INOMAX TECHNOLOGY CO.LTD

www.inomaxtechnology.com

Quick Start

Model	MAX500-PV-1	MAX500-PV-2	MAX500-PV-3	MAX500-PV-4
Input DC Range(V)	170-800			270-800
MPPT Range(V)	170-800			270-800
Recommended Input DC(V)	330-800	330-800	330-800	540-800
Input AC(V)	220	220	220	380
Input AC Connect	Single Phase	Single Phase	Three Phases	Three Phases
Output AC(V)	220	220	220	380
Output AC Connect	Single Phase	Three Phases	Three Phases	Three Phases
Power Range(kW)	0.75 - 5.5	0.75 - 5.5	0.75 - 7.5	0.75 - 250
Recommended Configuration	Inverter power one level higher than pump power Solar panel power 2.0 times of pump power when pump power below 4kW Solar panel power 1.3 times of pump power when pump power over 2.2kW			
Terminal For AC Input	Please connect X4 and COM terminal when inverter get AC power input. Do not input AC power and DC power (from solar panel) at the same time to inverter, unless install optional device.			
Failure Signal Lamp	Terminal (TA, TB, TC, 24V, COM) can light the lamp (green running and red alarm signal) automatically and easily in control system.			
Wirin g	Please do not connect terminals (R S T U V W + -) directly because short circuit will damage inverter.			
Start Automatically	When inverter start working automatically with weak sunshine, inverter will start and stop frequently too many times. It will reduce inverter working life. Please set parameter P28.03 to protect inverter.			

1 Operation

1.1 Button

1. When P28.01=1 (default setting), inverter start working automatically once it getpower. When P28.01=0, please press "**RUN**" button to start inverter.
2. Keypad will show data in turn. If you press ▶ button, it will always shows same data.

1.2 Data

When inverter is in standby model, keypad will show the specification in turn

Solar panel DC voltage
Maximum output frequency
Output current

When inverter is outputting power, keypad will show the specification in turn

Solar panel DC voltage
Output frequency
Output current

2 Protection

Minimum frequency	If output frequency is lower than 35Hz for 60s, inverter will stop working for 300s and restart automatically.
Dry running	If output current smaller than the value (parameter 28.13) for 60s, inverter will stop working for 300s and restart automatically.
Over voltage	If DC voltage from solar panel is over 800V, inverter will stop working.
Tank full	If float switch sensor reach high position, sensor connect X2 and COM terminal. After sensor disconnect X2 and COM terminal, inverter will wait for 900s more and restart automatically.
Well empty	If floating switch sensor reach low position, sensor connect inverter X3 and COM terminal. After sensor disconnect X3 and COM terminal, inverter will wait for 900s more and restart automatically.

3 Parameter

No	Name	Detail	Range	Default
P28.01	Run command	0.Keypad； 1.Run automatically when power on 2.Control board terminal； 3.Communication channel.	0-3	1
P28.03	Waiting time in automatic model	0.10s； 1.30s； 2.60s； 3.90s； 4.180s； 5.300s； 6.600s； 7.1200s； 8.1800s； If set P28.01=1 and power on, inverter will wait for some time and start working automatically.	0-8	0
P28.04	Maximum output frequency	0.60Hz； 1.50Hz； 2.45Hz； 3.40Hz； 4.35Hz； 5.30Hz； 6.25Hz； 7.20Hz.	0-7	1
P28.05	Minimum output frequency	0.45Hz； 1.40Hz； 2.35Hz； 3.30Hz； 4.25Hz； 5.20Hz； 6.15Hz； 7.10Hz. Output frequency drops below 35Hz for 60s, inverter show alarm signal “111” and stop working 35Hz depends on P28.05. 60s depends on P28.06.	0-7	2

P28.06	Delay time of minimum frequency	Output frequency drops below 35Hz for 60s, inverter show alarm signal “111” and stop working 35Hz depends on P28.05. 60s depends on P28.06.	0-65535	60
P28.07	Restart time after minimum frequency	After alarm signal “111” last for 300s, inverter will restart automatically.	0-65535	300
P28.12	Dry running protection	0 Invalid; 1 Enable.	0-1	0
P28.13	Current of dry running	If inverter output current less than P28.13 value (Unit:Ampere) for 60s, inverter will show alarm signal “222” and stop. 60s depends on P28.14.	0-6553.5	/
P28.14	Protection time of dry running	If inverter output current less than P28.13 value (Unit:Ampere) for 60s, inverter will show alarm signal “222” and stop. 60s depends on P28.14.	0-6553.5	60
P28.15	Interval time of dry running restart	After alarm signal “222” last for 300s, inverter will restart automatically.	0-65535	300
P28.18	Motor rated power	Unit: kW	/	/
P28.19	Motor rated voltage	Unit: V	/	/
P28.20	Motor rated current	Unit: A	/	/
P28.21	Motor rated speed	Unit: rpm	/	/
P28.22	Parameter reset	0 Invalid； 1 Enable.	0-1	0
P28.30	Delay time of full water level signal	Inverter will show “555” alarm signal if full water signal last 5s.	0-1000	5
P28.31	Restart time after 555 alarm signal	If inverter don’t receive full water signal any more, inverter will wait for 900s and restart working.	0-1000	900

P28.32	Delay time of low water level signal	Inverter will show “777” alarm signal if low water signal last 5s.	0-1000	5
P28.33	Restart time after 777 alarm signal	If inverter don’t receive low water signal any more, inverter will wait for 900s and restart working.	0-1000	900
P28.39	Single phase model	0 Invalid； 1 Enable. Take out capacity in pump and set P28.39=1, inverter will start pump easier.	0-1	0

4 Specification

4.1 Designation

MAX500-PV-X-XRX

① ② ③

Sign	Identification	Description	Content
①	MAX500-PV	Series name	Solar pumping series
②	X	Voltage degree	4: 380V/three phase input/ three phase output 3: 220V/three phase input/ three phase output 2: 220V/single phase input/ three phase output 1: 220V/single phase input/single phase output
③	XRX	Output power	0R7: 0.75kW 1R5: 1.5kW 002: 2.2kW 004: 4kW …… 250: 250kW

4.2 Specification

Voltage Degree	220V	380V
Maximum Input DC Voltage	800V	
Minimum Input DC Voltage	170V	270V
MPPT Voltage	170-660V	270-660V
Recommended DC Voltage	330-750V	540-750V

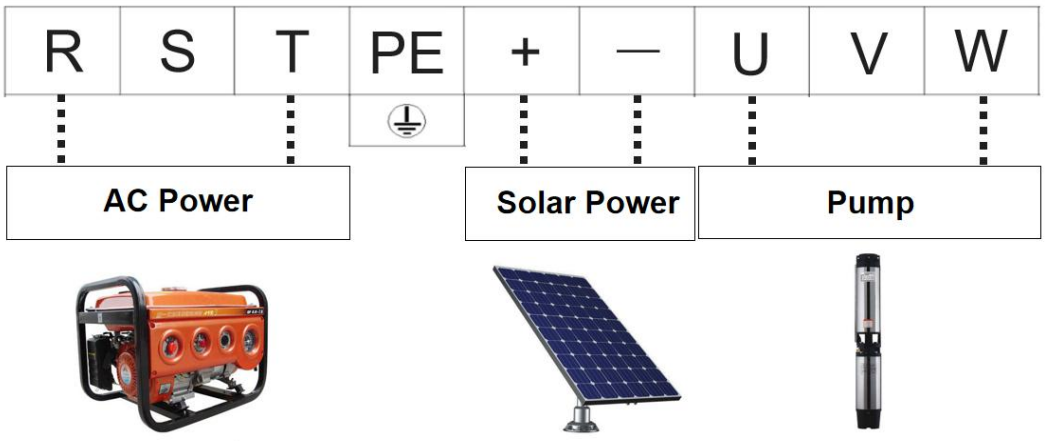
Model	Input AC Voltage(V)	Input AC current (A)	Output AC current (A)	Panel power (kW)	Pump power (kW)
MAX500-PV-10R7	220	9	7	0.8	0.4
MAX500-PV-11R5	220	16	9	1.4	0.7
MAX500-PV-1002	220	24	14	3.0	1.5
MAX500-PV-1004	220	27	17	4.4	2.2
MAX500-PV-1005	220	30	25	5.2	4.0
MAX500-PV-20R7	220	9	4	0.8	0.4
MAX500-PV-21R5	220	16	7	1.4	0.7
MAX500-PV-2002	220	24	9	3.0	1.5
MAX500-PV-2004	220	30	17	4.4	2.2
MAX500-PV-2005	220	35	25	5.2	4.0
MAX500-PV-30R7	220	5	4	0.8	0.4
MAX500-PV-31R5	220	8	7	1.4	0.7
MAX500-PV-3002	220	11	10	3.0	1.5
MAX500-PV-3004	220	15	13	4.4	2.2
MAX500-PV-3005	220	26	25	5.2	4.0
MAX500-PV-3007	220	35	32	7.2	5.5
MAX500-PV-40R7	380	4	3	0.8	0.4
MAX500-PV-41R5	380	5	4	1.4	0.7
MAX500-PV-4002	380	6	5	3.0	1.5
MAX500-PV-4004	380	14	9	4.4	2.2
MAX500-PV-4005	380	20	13	5.2	4.0
MAX500-PV-4007	380	25	17	7.2	5.5
MAX500-PV-4011	380	32	25	10	7
MAX500-PV-4015	380	40	32	14	11
MAX500-PV-4018	380	47	38	20	15
MAX500-PV-4022	380	56	45	23	18
MAX500-PV-4030	380	70	60	29	22
MAX500-PV-4037	380	80	75	39	30
MAX500-PV-4045	380	92	90	48	37

MAX500-PV-4055	380	115	110	59	45
MAX500-PV-4075	380	160	150	72	55
MAX500-PV-4090	380	190	180	98	75
MAX500-PV-4110	380	225	215	117	90
MAX500-PV-4132	380	265	260	143	110
MAX500-PV-4160	380	307	304	172	132
MAX500-PV-4200	380	385	377	208	160
MAX500-PV-4220	380	430	426	260	200
MAX500-PV-4250	380	468	465	286	220

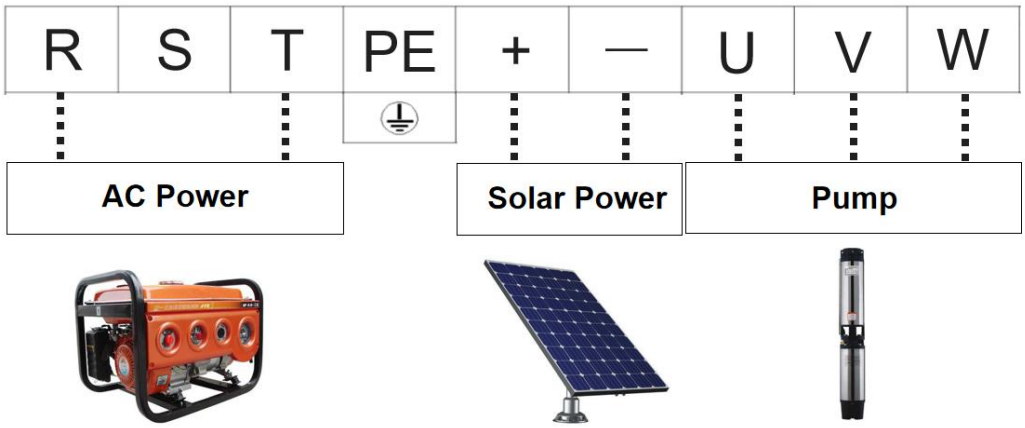
5 Installation

5.1 Main Circuit Terminals

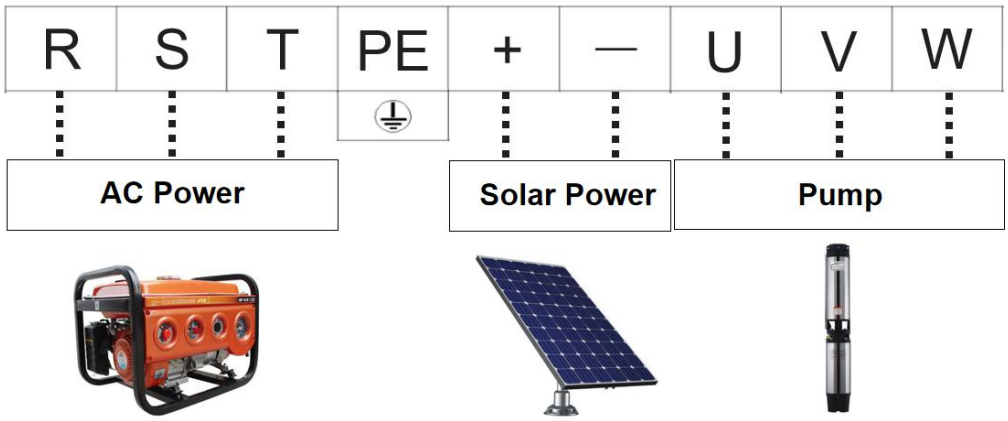
MAX500-PV-1 (220 V single phase input and single phase output)



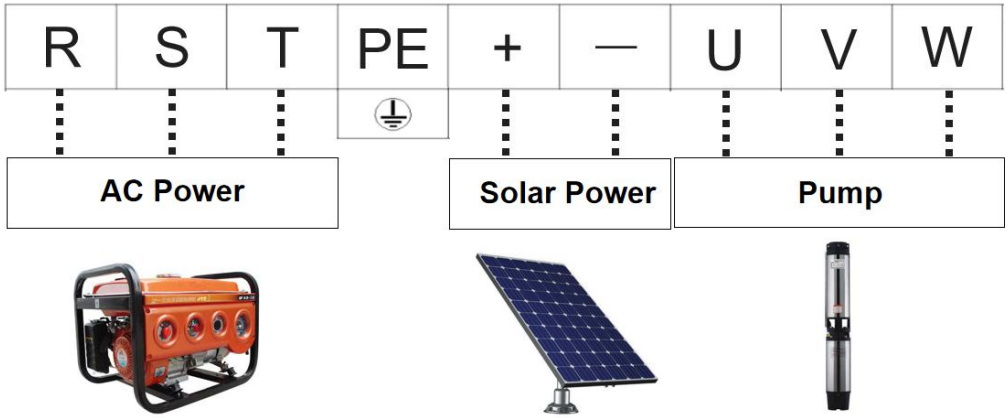
MAX500-PV-2 (220 V single phase input and 3 phase output)



MAX500-PV-3 (220 V single phase input and 3 phase output)

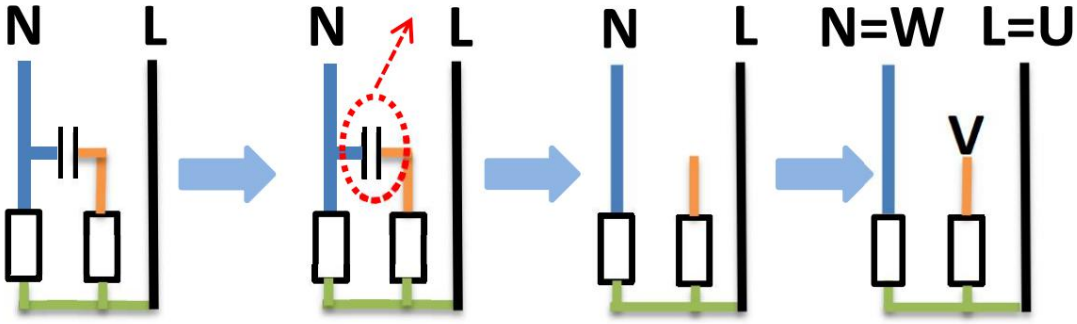


MAX500-PV-4 (380 V single phase input and 3 phase output)

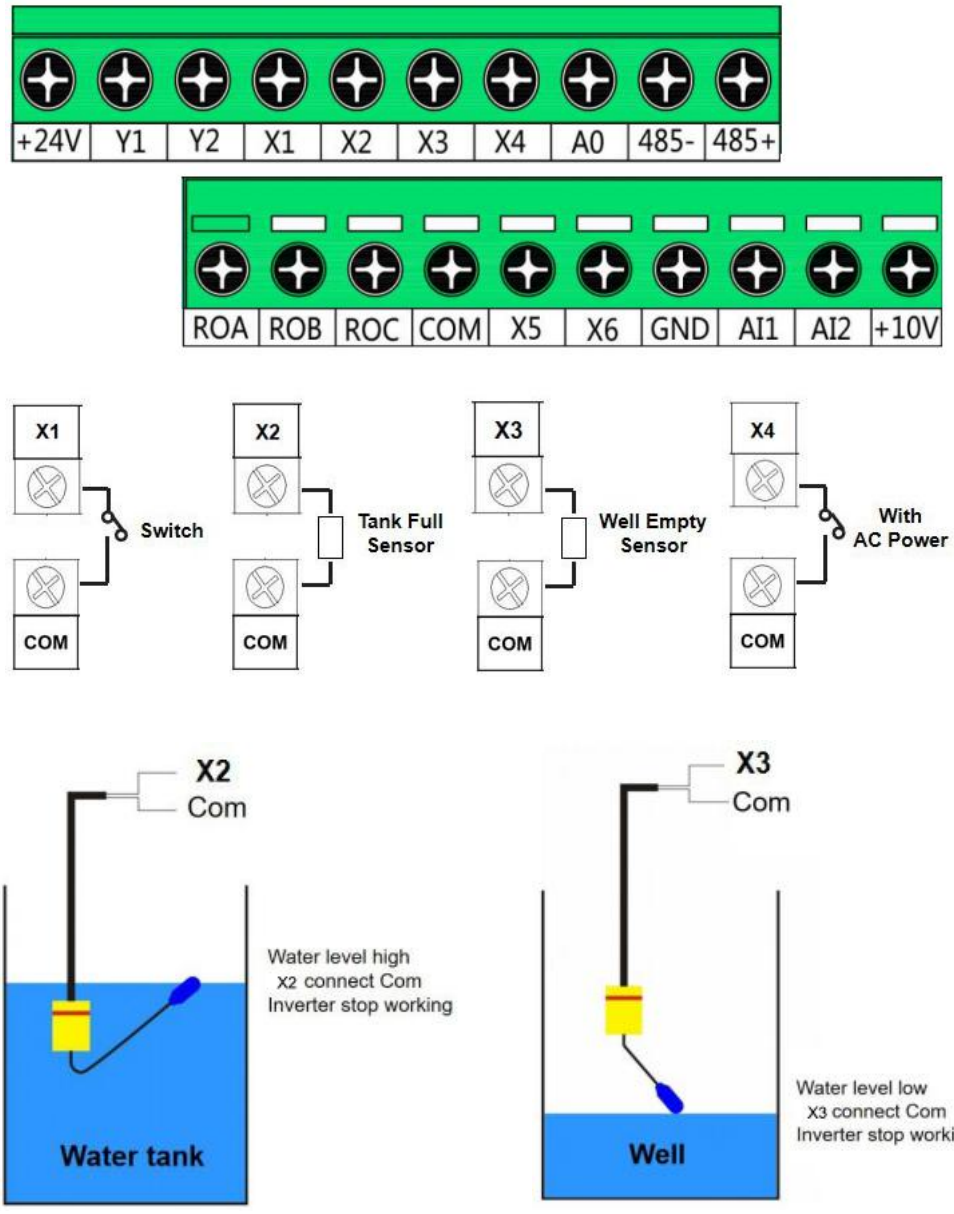


Terminal symbol	Terminal wiring
R S T	AC power input terminals for three phases
R T	AC power input terminals for single phases
+ -	DC input terminals for solar DC power(Do not charge inverter by generator and solar panel at the same time unless you add optional device)
PE	Grounding terminal
U V W	AC power output terminals for three phases
U W	AC power output terminals for single phases, if can not start single phase pump please take out capacity, change the wiring as photo below, and set P28.39=1.
PB	Invalid terminal

4.3 Pump connection:



4.4 Control board Terminal



Terminal	Terminal function description
X1	Set Parameter P28.01=2 for terminal control, connect X1 and COM terminal together, inverter will run.
COM	
X2	Tank full sensor, connect X2 and COM terminal for full water signal, inverter will stop in 5s, show alarm signal “555”, and restart automatically in 900s.
COM	
X3	Well empty sensor, connect X3 and COM terminal for empty water signal, inverter will stop in 5s, show alarm signal “777”, and restart automatically in 900s.
COM	
X4	When inverter get AC power input from RST terminal, please connect X4 and COM terminal.
COM	

5 Alarm signal

When inverter show alarm signal with software default setting, keypad will show number as below

111	When inverter output frequency is lower than 35Hz for 60s, inverter shows alarm signal “111”.
222	When pump are dry running for 60s and output current is smaller than P28.13 value, inverter shows alarm signal “222”.
333	When solar panel voltage is lower than 170V (220V inverter) or 270V(380V inverter), inverter shows alarm signal “333”.
444	When solar panel voltage higher than 800V, inverter shows alarm signal “444”.
555	Inverter will show “555” alarm signal if full water signal last 5s. After inverter shows alarm signal “555” and stop receiving full water signal, inverter will wait for 900s and restart.
777	Inverter will show “777” alarm signal if low water signal last 5s. After inverter shows alarm signal “777” and stop receiving low water signal, inverter will wait for 900s and restart.
888	When inverter output current is too big and may damage pump, inverter shows alarm signal “888”.
999	When inverter output power is too big and may damage pump, inverter shows alarm signal “999”.

6 General function parameters

"○": means the set value of the parameter can be modified on stop and running state;

"◎": means the set value of the parameter cannot be modified on the running state;

"●": means the value of the parameter is the real detection value which cannot be modified;

Note: The inverter implements auto checking and restriction on the parameter modification property. This prevents users from modifying parameters by misoperation.

6.1 Common function parameters for solar pumping inverter control

Function code	Name	Detailed illustration of parameters	Default	Modify
P00 Group Basic function group				
P00.00	Speed control mode	0: SVC 0 No need to install encoders. Suitable in applications which need low frequency, big torque for high accuracy of rotating speed and torque control. Relative to mode 1, it is more suitable for the applications which need small power. 1: SVC 1 1 is suitable in high performance cases with the advantage of high accuracy of rotating speed and torque. It does not need to install pulse encoder. 2: SVPWM control 2 is suitable in applications which do not need high control accuracy, such as the load of fan and pump, and suitable when one inverter drives multiple motors. **Note:** In vector control, the inverter must autotune motor parameters first.	2	◎
P00.01	Run command channel	Select the run command channel of the inverter. The control command of the inverter includes: start, stop, forward/reverse	1	○

Function code	Name	Detailed illustration of parameters	Default	Modify
		rotating, jogging and fault reset. 0: Keypad running command channe ("LOCAL/REMOT" light off) Carry out the command control by RUN, STOP/RST on the keypad. Set the multi-function key QUICK/JOG to FWD/REV shifting function (P07.02=3) to change the running direction; press RUN and STOP/RST simultaneously in running state to make the inverter coast to stop. 1: Terminal running command channe ("LOCAL/REMOT" flickering) Carry out the running command contro by the forward rotation, reverse rotation and forward jogging and reverse jogging of the multi-function terminals. 2: Communication running command channel ("LOCAL/REMOT" on); The running command is controlled by the upper monitor via communication.		
P00.03	Max. output frequency	This parameter is used to set the maximum output frequency of the inverter. Users need to pay attention to this parameter because it is the foundation of the frequency setting and the speed of acceleration and deceleration. Setting range: P00.04–400.00Hz	50.00Hz	◎
P00.04	Upper limit of the	The upper limit of the running frequency is	50.00Hz	◎

Function code	Name	Detailed illustration of parameters	Default	Modify
	running frequency	the upper limit of the output frequency of the inverter which is lower than or equal to the maximum frequency. Setting range: P00.05–P00.03 (Max. output frequency)		
P00.05	Lower limit of the running frequency	The lower limit of the running frequency is that of the output frequency of the inverter. The inverter runs at the lower limit frequency if the set frequency is lower than the lower limit. **Note:** Max. output frequency ≥ Upper limit frequency ≥ Lower limit frequency Setting range: 0.00Hz–P00.04 (Upper limit of the running frequency)	0.00Hz	◎
P00.11	ACC time 1	ACC time means the time needed if the inverter speeds up from 0Hz to the Max. output frequency (P00.03). DEC time means the time needed if the inverter speeds down from the Max. output frequency to 0Hz (P00.03). MAX500-PV series inverters have four groups of ACC/DEC time which can be selected by P05. The factory default ACC/DEC time of the inverter is the first group. Setting range of P00.11 and P00.12: 0.0–3600.0s	Depend on mode	○
P00.12	DEC time 1		Depend on mode	○
P00.13	Running direction	0: Runs at the default direction. The	0	○

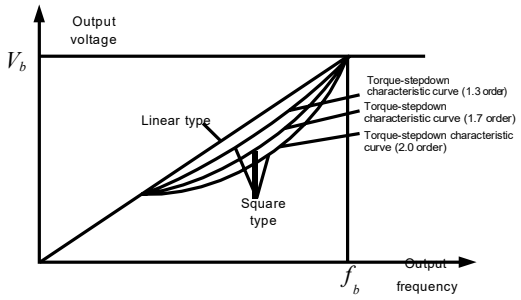
Function code	Name	Detailed illustration of parameters	Default	Modify
	selection	inverter runs in the forward direction. FWD/REV indicator is off. 1: Runs at the opposite direction. The inverter runs in the reverse direction. FWD/REV indicator is on. Modify the function code to shift the rotation direction of the motor. This effect equals to the shifting the rotation direction by adjusting either two of the motor lines (U, V and W). The motor rotation direction can be changed by QUICK/JOG on the keypad. Refer to parameter P07.02. **Note:** When the function parameter comes back to the default value, the motor's running direction will come back to the factory default state, too. In pump application scenarios, the inverter cannot run in the reverse direction. This function code cannot be modified. 2: Forbid to run in reverse direction: It can be used in some special cases if the reverse running is disabled.		
P00.15	Motor parameter autotuning	0: No operation 1: Rotation autotuning Comprehensive motor parameter autotune.	0	◎

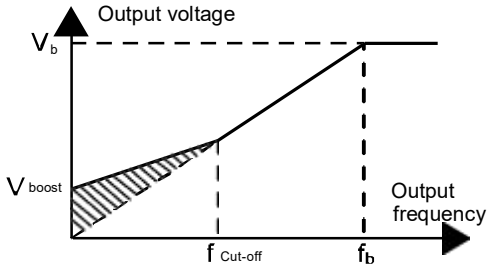
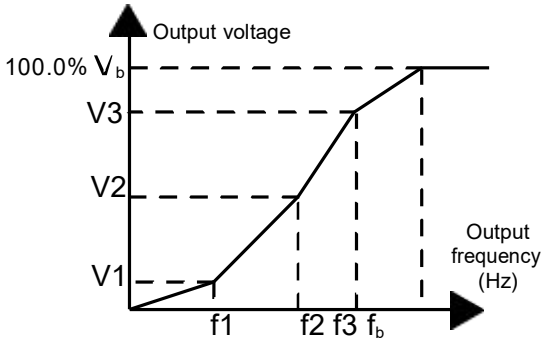
Function code	Name	Detailed illustration of parameters	Default	Modify
		It is recommended to use rotation autotuning when high control accuracy is needed. 2: Static autotuning It is suitable in the cases when the motor cannot de-couple form the load. The autotuning for the motor parameter will impact the control accuracy. 3: Static autotuning 2 (No autotuning for non-load current and mutual inductance)		
P00.18	Function restore parameter	0: No operation 1: Restore the default value 2: Clear fault records **Note:** The function code will restore to 0 after finishing the operation of the selected function code. Restoring to the default value will cancel the user password. Use this function with caution.	0	◎
P01 Group Start-up and stop control				
P01.08	Stop mode	0: Decelerate to stop. After the stop command becomes valid, the inverter decelerates to reduce the output frequency during the set time. When the frequency decreases to 0Hz, the inverter stops. 1: Coast to stop. After the stop command	0	○

Function code	Name	Detailed illustration of parameters		Default	Modify
		becomes valid, the inverter ceases the output immediately. And the load coasts to stop at the mechanical inertia.			
P01.18	Operation protection	0: The terminal running command is invalid when powering on. 1: The terminal running command is valid when powering on.		1	○
P01.21	Restart after power off	0: Disabled 1: Enabled		1	○
P02 Group Motor 1 parameters					
P02.00	Motor type	0: Asynchronous motor 1: Reserved		0	◎
P02.01	Rated power of asynchronous motor	0.1–3000.0kW	Set the parameter of the asynchronous motor. In order to ensure the controlling performance, set the P02.01–P02.05 according to the name plate of the synchronous motor. MAX500-PV series inverters provide the function of parameter autotuning.Correct	Depend on model	◎
P02.02	Rated frequency of asynchronous motor	0.01Hz–P00.03		50.00 Hz	◎
P02.03	Rated rotating speed of asynchronous motor	1–36000rpm		Depend on model	◎
P02.04	Rated voltage of asynchronous motor	0–1200V		Depend on model	◎

Function code	Name	Detailed illustration of parameters		Default	Modify
P02.05	Rated current of asynchronous motor	0.8–6000.0A	parameter autotuning comes from the correct setting of the motor name plate. In order to ensure the controlling performance, please configure the motor according to the standard principles, if the gap between the motor and the standard one is huge, the features of the inverter will decrease. **Note:** Resetting the rated power (P02.01) of the motor can initialize the motor parameters P02.02–P02.10.	Depend on model	◎
P02.06	Stator resistor of asynchronous motor	0.001–65.535Ω	After the motor parameter autotuning finishes, the set values of P02.06–P02.10 will be updated automatically. These parameters are basic parameters controlled	Depend on model	○
P02.07	Rotor resistor of asynchronous motor	0.001–65.535Ω		Depend on model	○
P02.08	Leakage inductance of asynchronous	0.1–6553.5mH		Depend on model	○

Function code	Name	Detailed illustration of parameters		Default	Modify
	motor		by vectors which directly impact the features. **Note:** Users cannot modify the parameters freely.		
P02.09	Mutual inductance of asynchronous motor	0.1–6553.5mH		Depend on model	○
P02.10	Non-load current of asynchronous motor	0.1–6553.5A		Depend on model	○
P04 Group SVPWM control					
P04.00	V/F curve setting	These function codes define the V/F curve of MAX500-PV series motor 1 to meet the need of different loads. 0: Straight line V/F curve; applying to the constant torque load 1: Multi-dots V/F curve 2: Torque-stepdown characteristic curve (1.3 order) 3: Torque-stepdown characteristic curve (1.7 order) 4: Torque-stepdown characteristic curve (2.0 order) Curves 2–4 apply to the torque loads such as fans and water pumps. Users can adjust according to the features of the loads to get the best performance. 5: Customized V/F(V/F separation); in this mode, V can be separated from f and f can be adjusted through the frequency given channel set by P00.06 or the voltage given channel set by P04.27 to		4	◎

Function code	Name	Detailed illustration of parameters	Default	Modify
		change the feature of the curve. **Note:** V_b in the below picture is the motor rated voltage and f_b is the motor rated frequency. 		
P04.01	Torque boost	Torque boost to the output voltage for the features of low frequency torque. P04.01 is for the Max. output voltage Vb. P04.02 defines the percentage of closing frequency of manual torque to fb. Torque boost should be selected according to the load. The bigger the load is, the bigger the torque is. Too big torque boost is inappropriate because the motor will run with over magnetic, and the current of the inverter will increase to add the temperature of the inverter and decrease the efficiency. When the torque boost is set to 0.0%, the inverter is automatic torque boost. Torque boost threshold: below this frequency point, the torque boost is valid, but over this frequency point, the torque boost is invalid.	0.0%	○
P04.02	Torque boost close		20.0%	○

Function code	Name	Detailed illustration of parameters	Default	Modify
		 Setting range of P04.01: 0.0%: (automatic) 0.1%–10.0% Setting range of P04.02: 0.0%–50.0%		
P04.03	V/F frequency point 1 of motor 1	If P04.00 =1, the user can set V//F curve by P04.03–P04.08. V/F is set to the motor load. **Note:** V1 ＜V2 ＜V3; f1 ＜f2 ＜ f3. If the low-frequency voltage is high, overtemperature and burning may occur and the overcurrent stall and protection may occur to the inverter.  Setting range of P04.03: 0.00Hz–P04.05 Setting range of P04.04: 0.0%–110.0% (rated voltage of motor1) Setting range of P04.05: P04.03–P04.07 Setting range of P04.06: 0.0%–110.0% (rated voltage of motor1) Setting range of P04.07: P04.05–P02.02	0.00Hz	○
P04.04	V/F voltage point 1 of motor 1		00.0%	○
P04.05	V/F frequency point 2 of motor 1		00.00 Hz	○
P04.06	V/F voltage point 2 of motor 1		00.0%	○
P04.07	V/F frequency point 3 of motor 1		00.00 Hz	○
P04.08	V/F voltage point 3 of motor 1		00.0%	○

Function code	Name	Detailed illustration of parameters	Default	Modify
		(rated frequency of motor1) or P04.05–P02.16 (rated frequency of motor1) Setting range of P04.08: 0.0%–110.0% (rated voltage of motor1)		
P04.09	V/F slip compensation gain	This function code is used to compensate the change of the rotation speed caused by load during compensation SVPWM control to improve the rigidity of the motor. It can be set to the rated slip frequency of the motor which is counted as below: $\triangle f=f_b-n*p/60$ Of which, fb is the rated frequency of the motor, its function code is P02.01; n is the rated rotating speed of the motor and its function code is P02.02; p is the pole pair of the motor. 100.0% corresponds to the rated slip frequency△ f. Setting range: 0.0–200.0%	0.0%	○
P04.34	Two phase control selection of single-phase motor	Ones: Reserved Tens: Voltage of the secondary winding (V phase) reverse 0: Not reversed; 1: Reversed Setting range: 0–0x11	0x00	◎
P04.35	Voltage ratio of V and U	0.00–2.00	1.40	○
P05 Group Inputterminals				
P05.00	HDI input type	0: High-speed pulse input. See P05.49–P05.54.	1	◎

Function code	Name	Detailed illustration of parameters	Default	Modify
		1: HDI switch input		
P05.01	X1 terminals function selection	0: No function 1: Forward rotation operation 2: Reverse rotation operation 3: 3-wire control operation 4: Forward jogging 5: Reverse jogging 6: Coast to stop 7: Fault reset 8: Operation pause 9: External fault input 10: Increasing frequency setting (UP) 11: Decreasing frequency setting (DOWN) 12: Cancel the frequency change setting 13: Shift between A setting and B setting 14: Shift between combination setting and A setting 15: Shift between combination setting and B setting 16: Multi-step speed terminal 1 17: Multi-step speed terminal 2 18: Multi-step speed terminal 3 19: Multi-step speed terminal 4 20: Multi-step speed pause 21: ACC/DEC time 1 22: ACC/DEC time 2 23: Simple PLC stop reset 24: Simple PLC pause	42	◎
P05.02	X2 terminals function selection		43	◎
P05.03	X3 terminals function selection		44	◎
P05.04	X4 terminals function selection		45	◎
P05.05	X5 terminals function selection		1	
P05.09	HDI terminals function selection		46	◎

Function code	Name	Detailed illustration of parameters	Default	Modify
		25: PID control pause 26: Traverse pause (stop at the current frequency) 27: Traverse reset (return to the center frequency) 28: Counter reset 29: Torque control prohibition 30: ACC/DEC prohibition 31: Counter trigger 32: Reserved 33: Cancel the frequency change setting 34: DC brake 35: Reserved 36: Shift the command to the keypad 37: Shift the command to terminals 38: Shift the command to communication 39: Pre-magnetized command 40: Clear the power 41: Keep the power 42: Forced switch to power frequency input (Switching-on indicates switching to power frequency input; switching-off indicates the input mode is controlled by the keypad.) 43: Full water signal 44: Non-water signal 45: Two-phase control mode of the single-phase motor		

<table>
<tr><th>Function code</th><th>Name</th><th>Detailed illustration of parameters</th><th>Default</th><th>Modify</th></tr>
<tr><td></td><td></td><td>46: PV voltage digital input when no boost module is applied (in auto switching mode)
47–63: Reserved</td><td></td><td></td></tr>
<tr><td>P05.10</td><td>Polarity selection of the input terminals</td><td>0x000–0x10F<table><tr><th>BIT8</th><th>BIT3</th><th>BIT2</th><th>BIT1</th><th>BIT0</th></tr><tr><td>HDI</td><td>X4</td><td>X3</td><td>X2</td><td>X1</td></tr></table></td><td>0x000</td><td>◎</td></tr>
<tr><td>P06 Group</td><td>Output terminals</td><td></td><td></td><td></td></tr>
<tr><td>P06.03</td><td>Relay RO1 output selection</td><td>0: Invalid
1: In operation
2: Forward rotation operation
3: Reverse rotation operation
4: Jogging operation
5: Inverter fault
6: Frequency degree test FDT1
7: Frequency degree test FDT2
8: Frequency arrival
9: Zero speed running
10: Upper limit frequency arrival
11: Lower limit frequency arrival
12: Ready for operation
13: Pre-magnetizing
14: Overload alarm
15: Underload alarm
16: Completion of simple PLC stage
17: Completion of simple PLC cycle
18: Setting count value arrival
19: Defined count value arrival</td><td>30</td><td>○</td></tr>
<tr><td>P06.04</td><td>Relay RO2 output selection</td><td></td><td>5</td><td>○</td></tr>
</table>

<table>
<tr><th>Function code</th><th>Name</th><th>Detailed illustration of parameters</th><th>Default</th><th>Modify</th></tr>
<tr><td></td><td></td><td>20: External fault valid
21: Reserved
22: Running time arrival
23: Modbus communication virtual terminals output
24–26: Reserved
27: Weak light
28–29: Reserved
30: Shift to PV mode (If the system works in PV mode, relay output is high.)</td><td></td><td></td></tr>
<tr><td>P06.05</td><td>Polarity selection of output terminals</td><td>The function code is used to set the pole of the output terminal.
When the current bit is set to 0, output terminal is positive.
When the current bit is set to 1, output terminal is negative.
<table><tr><td>BIT1</td><td>BIT0</td></tr><tr><td>RO2</td><td>RO1</td></tr></table>Setting range: 0–F</td><td>0</td><td>○</td></tr>
<tr><td>P06.10</td><td>Switch on delay of RO1</td><td>0.000–50.000s</td><td>10.000s</td><td>○</td></tr>
<tr><td>P06.11</td><td>Switch off delay of RO1</td><td>0.000–50.000s</td><td>10.000s</td><td>○</td></tr>
<tr><td>P06.12</td><td>Switch on delay of RO2</td><td>0.000–50.000s</td><td>0.000s</td><td>○</td></tr>
<tr><td>P06.13</td><td>Switch off delay of RO2</td><td>0.000–50.000s</td><td>0.000s</td><td>○</td></tr>
</table>

Function code	Name	Detailed illustration of parameters	Default	Modify
P07 Group Human-Machine Interface				
P07.02	QUICK/JOG function selection	0: No function 1: Jogging running. Press QUICK/JOG to begin the jogging running. 2: Shift the display state by the shifting key. Press QUICK/JOG to shift the displayed function code from right to left. 3: Shift between forward rotations and reverse rotations. Press QUICK/JOG to shift the direction of the frequency commands. This function is only valid in the keypad commands channels. 4: Clear UP/DOWN settings. Press QUICK/JOG to clear the set value of UP/DOWN. 5: Coast to stop. Press QUICK/JOG to coast to stop. 6: Shift the running commands source. Press QUICK/JOG to shift the running commands source. 7: Quick commissioning mode (based on non-factory parameters) **Note:** Press QUICK/JOG to shift between forward rotation and reverse rotation, the inverter does not record the state after shifting during powering off. The inverter will run according to parameter P00.13 during next powering on.	6	◎

Function code	Name	Detailed illustration of parameters	Default	Modify
P07.03	QUICK/JOG the shifting sequence of running command	When P07.02=6, set the shifting sequence of running command channels. 0: Keypad control→terminal control →communication control 1: Keypad control←→terminals control 2: Keypad control←→communication control 3: Terminals control←→communication control	1	○
P07.04	STOP/RST stop function	Select the stop function by STOP/RST. STOP/RST is effective in any state for the keypad reset. 0: Only valid for the keypad control 1: Both valid for keypad and terminals control 2: Both valid for keypad and communication control 3: Valid for all control modes	1	○
P07.11	Boost module temperature	When the inverter is configured with the boost module, this function code displays the temperature of this module. This function code is valid only in the AC mode. This function code is invalid in the PV mode. -20.0–120.0°		●
P07.12	Converter module temperature	-20.0–120.0°		●
P07.15	MSB of inverter	Display the power used by the inverter.		●

Function code	Name	Detailed illustration of parameters	Default	Modify
	power consumption	Inverter power consumption = P07.15*1000 + P07.16		
P07.16	LSB of inverter power consumption	Setting range of P07.15: 0–65535 (*1000) Setting range of P07.16: 0.0–999.9 Unit: kWh		●
P07.27	Current fault type	0: No fault 1: IGBT U phase protection (OUt1) 2: IGBT V phase protection (OUt2) 3: IGBT W phase protection (OUt3) 4: OC1 5: OC2 6: OC3 7: OV1 8: OV2 9: OV3 10: UV 11: Motor overload (OL1) 12: The inverter overload (OL2) 13: Input side phase loss (SPI) 14: Output side phase loss (SPO) 15: Overheat of the boost module (OH1) 16: Overheat fault of the inverter module (OH2) 17: External fault (EF) 18: 485 communication fault (CE) 19: Current detection fault (ItE) 20: Motor antotune fault (tE) 21: EEPROM operation fault (EEP)		●
P07.28	Previous fault type			●
P07.29	Previous 2 fault type			●
P07.30	Previous 3 fault type			●
P07.31	Previous 4 fault type			●
P07.32	Previous 5 fault type			●
P07.57	Previous 6 fault type			●
P07.58	Previous 7 fault type			●
P07.59	Previous 8 fault type			●
P07.60	Previous 9 fault type			●
P07.61	Previous 10 fault type			●
P07.62	Previous 11 fault type			●

Function code	Name	Detailed illustration of parameters	Default	Modify
P07.63	Previous 12 fault type	22: PID response offline fault (PIDE) 23: Braking unit fault (bCE) 24: Running time arrival (END) 25: Electrical overload (OL3) 26 – 31:Reserved 32: Grounding short circuit fault 1 (ETH1) 33: Grounding short circuit fault 2 (ETH2) 34: Speed deviation fault (dEu) 35: Maladjustment (STo) 36:Underload fault (LL) 37: Hydraulic probe damage (tSF) 38: PV reverse connection fault (PINV) 39: PV overcurrent (PVOC) 40: PV overvoltage (PVOV) 41: PV undervoltage (PVLV) 42: Fault on communication with the boost module (E-422) 43: Bus overvoltage detected on the boost module (OV) Note: Faults 38 – 40 can be detected in boost. The boost module stops working once after detecting a fault. The boost module sends back the fault information to the inverter module in the next data send back. Alarms: Weak light alarm (A-LS) Underload alarm (A-LL)		●
P07.64	Previous 13 fault type			●
P07.65	Previous 14 fault type			●
P07.66	Previous 15 fault type			●
P07.67	Previous 16 fault type			●
P07.68	Previous 17 fault type			●
P07.69	Previous 18 fault type			●
P07.70	Previous 19 fault type			●
P07.71	Previous 20 fault type			●

Function code	Name	Detailed illustration of parameters	Default	Modify
		Full water alarm (A-tF) Water-empty alarm (A-tL)		
P08 Group Enhanced functions				
P08.28	Times of fault reset	0–10	5	○
P08.29	Interval time of automatic fault reset	0.1–3600.0s	10.0s	○

6.2 Parameters of special functions

Function code	Name	Detailed illustration of parameters	Default	Modify
P11 Group Protective parameters				
P11.00	Phase loss protection	0x000–0x011 LED ones: 0: Input phase loss software protection disabled 1: Input phase loss software protection enabled LED tens: 0: Output phase loss software protection disabled 1: Output phase loss software protection enabled LED hundreds: Reserved 000–111	Depend on model	○
P11.01	Frequency decrease at	0: Disable 1: Enable	0	○

<table>
<tr><th>Function code</th><th>Name</th><th>Detailed illustration of parameters</th><th>Default</th><th>Modify</th></tr>
<tr><td></td><td>sudden power loss</td><td></td><td></td><td></td></tr>
<tr><td>P11.02</td><td>Frequency decrease ratio at sudden power loss</td><td>Setting range: 0.00Hz–P00.03/s
After the power loss of the grid, the bus voltage drops to the sudden frequency decrease point, the inverter begin to decrease the running frequency at P11.02, to make the inverter generate power again. The returning power can maintain the bus voltage to ensure a rated running of the inverter until the recovery of power.
<table><tr><td>Voltage degree</td><td>220V</td><td>400V</td></tr><tr><td>Frequency decrease point</td><td>260V</td><td>460V</td></tr></table></td><td>0.00Hz/s</td><td>○</td></tr>
<tr><td colspan="5">P15 Group Special functions for PV inverters</td></tr>
<tr><td>P15.00</td><td>PV inverter selection</td><td>0: Invalid
1: Enable
0 means the function is invalid and the group of parameters cannot be used
1 means the function is enabled, and P15 parameters can be adjusted</td><td>1</td><td>◎</td></tr>
<tr><td>P15.01</td><td>Vmpp voltage reference</td><td>0: Voltage reference
1: Max. power tracking
0 means to apply voltage reference mode. The reference is a fixed value and given by P15.02.
1 means to apply the reference voltage of Max. power tracking. The voltage is</td><td>1</td><td>◎</td></tr>
</table>

Function code	Name	Detailed illustration of parameters	Default	Modify
		changing until the system is stable. Note: If terminal 43 is valid, the function is invalid.		
P15.02	Vmpp voltage keypad reference	0.0–6553.5 V DC If P15.01 is 0, the reference voltage is given by P15.02. (During test, reference voltage should be lower than PV input voltage; otherwise, the system will run at lower limit of frequency).	250.0V	○
P15.03	PI control deviation	0.0–100.0% (100.0% corresponds to P15.02) If the ratio percentage of real voltage to reference voltage, which is abs(bus voltage-reference voltage)*100.0%/ reference voltage, exceeds the deviation limit of P15.03, PI adjustment is available; otherwise, there is no PI adjustment and the value is defaulted to be 0.0%. abs: absolute value	0.0%	○
P15.04	Upper frequency of PI output	P15.05–100.0% (100.0% corresponds to P00.03) P15.04 is used to limit the Max. value of target frequency, and 100.0% corresponds to P00.03. After PI adjustment, the target frequency cannot exceed the upper limit.	100.0%	○
P15.05	Lower frequency	0.0%–P15.04 (100.0% corresponds to	20.0%	○

Function code	Name	Detailed illustration of parameters	Default	Modify
	of PI output	P00.03) P15.05 is used to limit the Min. value of target frequency, and 100.0% corresponds to P00.03. After PI adjustment, the target frequency cannot be less than the lower limit.		
P15.06	KP1	0.00–100.00 Proportion coefficient 1 of the target frequency The bigger the value is, the stronger the effect and faster the adjustment is.	5.00	○
P15.07	KI1	0.00–100.00 Integral coefficient 1 of the target frequency The bigger the value is, the stronger the effect and faster the adjustment is.	5.00	○
P15.08	KP2	0.00–100.00 Proportion coefficient 2 of the target frequency The bigger the value is, the stronger the effect and faster the adjustment is.	35.00	○
P15.09	KI2	0.00–100.00 Integral coefficient 2 of the target frequency The bigger the value is, the stronger the effect and faster the adjustment is.	35.00	○
P15.10	PI switching point	0.0–6553.5Vdc If the absolute value of bus voltage	20.0V	◎

Function code	Name	Detailed illustration of parameters	Default	Modify
		minus the reference value is bigger than P15.10, it will switch to P15.08 and P15.09; otherwise it is P15.06 and P15.07.		
P15.11	Water level control	0: Digital input of the water-level control 1: AI1(the water-level signal is input through AI1, not supported currently) 2: AI2 (the water-level signal is input through AI2, not supported currently) 3: AI3 (the water-level signal is input through AI3, not supported currently) If the function code is 0, the water-level signal is controlled by the digital input. See 43 and 44 functions of S terminals in group P05 for detailed information. If the full-water signal is valid, the system will report the alarm (A-tF) and sleep after the time of P15.14. During the alarm, the full-water signal is invalid and the system will clear the alarm after the time of P15.15. If the empty-water signal is valid, the system will report the alarm (A-tL) and sleep after the time of P15.16. During the alarm, the empty -water signal is invalid and the system will clear the alarm after the time of P15.17. If the function code is 1–3, it is the reference of water-level control analog	0	◎

Function code	Name	Detailed illustration of parameters	Default	Modify
		signal. For details, see P15.12 and P12.13.		
P15.12	Full-water level threshold	0.0–100.0% This code is valid when P15.11 water level control is based on analog input. If the detected water level control analog signal is less than the water level threshold P15.12 and keeps in the state after the delay time P15.14, the system reports A-tF and sleeps. If the delay time is not reached, the signal is bigger than the water level threshold, the time will be cleared automatically. When the measured water level control analog signal is less than the water level threshold, the delay time will be counted again. 0 is full water and 1 is no water. During the full-water alarm, if the detected water level signal is higher than the threshold of P15.12 and the delay counts, the alarm is cleared after the time set by P15.15 is reached in this continuous state continues. During the non-continuous application, the delay timing will clear automatically.	25.0%	○
P15.13	Empty-water level threshold	0.0–100.0% This code is valid when P15.11 water	75.0%	○

Function code	Name	Detailed illustration of parameters	Default	Modify
		level control is based on analog input. If the detected water level control analog signal is greater than the water level threshold P15.13 and keeps in the state after the delay time P15.16, the system reports A- tLand sleeps. If the delay time is not reached (that means non-continuous), the delay time is automatically cleared. When the detected water level control analog signal is less than the water level threshold, the delay counts. During the empty-water alarm, if the detected water level control analog signal is less than the water level threshold P15.13 and delay counts, the empty-water alarm is cleared after the delay time set by P15.17 in this continuous state. In the non-continuous state, the delay time is automatically cleared.		
P15.14	Full water delay	0–10000s Time setting of full water delay (This function code is still valid when the digita indicates the full-water signal.)	5s	○
P15.15	Wake-up delay in full water state	0–10000s Time setting of wake-up delay in full-water state (This function code is still	20s	○

Function code	Name	Detailed illustration of parameters	Default	Modify
		valid when the digital indicates the full-water signal.)		
P15.16	Empty-water delay	0–10000s Time setting of empty-water delay (This function code is still valid when the digita indicates the empty-water signal.)	5s	○
P15.17	Wake-up delay in empty-water state	0–10000s Time setting of wake-up delay in empty-water state (This function code is still valid when the digital indicates the empty-water signal.)	20s	○
P15.18	Hydraulic probe damage	0.0–100.0% 0.0%: Invalid. If it is not 0.0%, when the signal is longer than P15.18, it will report tSF fault directly and stop.	0.0%	◎
P15.19	Operation time of water pump underload	0.0–1000.0s This parameter is used to set the operation time of water pump underload. Under the continuous underload operation, underload prealarm (A-LL) will be reported if the operation time is reached.	60.0s	○
P15.20	Current detection value of underload operation	0.0%: Automatic underload detection 0.1–100.0% If it is 0.0%, it is determined by the underload detection of the water pump inverter. If it is not 0.0%, it is determined by	00.00%	○

Function code	Name	Detailed illustration of parameters	Default	Modify
		P15.20. 100.0% corresponds to therated current of the motor. If the target frequency and the absolute value of the ramp frequency is less than or equal to P15.22, and the current is less than P15.20, after the time set by P15.19, underload fault is reported. Otherwise, it will be operated normally. If the state is not continuous, the delay counting will be cleared automatically.		
P15.21	Underload reset delay	0.0–1000.0s This parameter is used to set the underload reset delay. The operation time and reset time are counted at the same time during underload, and it is generally bigger than P15.19 so as to ensure underload prealarm is reported after underload delay operation time is reached. After the time set by P15.21-P15.19, it is reset. If the value is the same as P15.19, it is automatically reset when underload prealarm is reported.	120.0s	○
P15.22	Lag frequency threshold	0.00–200.00Hz P15.22 is the lag frequency threshold for the analysis of underload operation. If the target frequency and the absolute value of the ramp frequency is less than	0.30Hz	○

Function code	Name	Detailed illustration of parameters	Default	Modify
		or equal to P15.22, the current will be compared.		
P15.23	Delay time of weak light	0.0–3600.0s Delay time of weak light If the output frequency is less than or equal to the lower limit of PI output frequency and the state lasts for the set value, it will report A-LS and sleep. If the state is not continuous, the delay counting will be cleared automatically. **Note:** If the bus voltage is lower than the undervoltage point or the PV voltage is lower than 70V, it will report the weak light alarm without any delay time. If P15.32=0, the system will switch to the power frequency input when the light is weak.	100.0s	○
P15.24	Delay time of wake-up at weak light	0.0–3600.0s Delay time of wake-up at weak light If the weak light alarm is reported, after the delay time of wake-up, the alarm will be cleared and it will run again. When P15.32=0, if the PV voltage is higher than P15.34, after the delay time, it will switch to PV input mode.	300.0s	○
P15.25	Initial reference voltage display	0.0–2000.0V	0	●
P15.26	Min. voltage	0.00 – 1.00	0.70	○

Function code	Name	Detailed illustration of parameters	Default	Modify
		Initial reference voltage =PV voltage-P15.28		
P15.29	Adjustment of upper and lower limit time of Vmppt	0.0–10.0s When P15.29 is set to 0.0, the automatic adjustment is invalid. If it is not 0.0, the upper and lower limits of Vmppt will be adjusted automatically at the inveral set by P15.29. The medium value is the current PV voltage and the limit is P15.30: Maximum/Minimum reference voltage=Current PV voltge±P15.30 and it will update to P15.26 and P15.27 at the same time.	1.0s	○
P15.30	Adjustment of upper and lower limits of Vmppt	5.0–100.0V Adjustment of the upper and lower limits	30.0V	○
P15.31	Max. value of Vmppt	P15.27–6553.5V During the maximum power tracking, the upper limit of the solar cell panel reference voltage will not exceed the value set by P15.31. The factory value depends on the model. By default, the value for the -4 models is 750V and the value for other models is 400V.	400.0V	○
P15.32	PV input and power frequency input selection	0: Automatic shift 1: Power frequency input 2: PV input	2	◎

Function code	Name	Detailed illustration of parameters	Default	Modify
		If the value is 0, the system will switch between PV input and power frequency input according to the detected PV voltage and threshold; If the value is 1, the system will force to switch to power frequency input; If the value is 2, the system will force to switch to PV input. **Note:** When the terminal input 42 is valid, the function code will be invalid.		
P15.33	Threshold to switch to power frequency input	0.0V–P15.34 If PV voltage is lower than the threshold or the light is weak, it can switch to power frequency input through the relay output. If the value is 0, it is invalid. For inverters without the boost module, the switching point voltage is determined by the external voltage detection circuit. For inverters with the boost module, the switching point voltage is 70V.	70.0V	○
P15.34	Threshold to switch to PV input	P15.33–400.0V If PV voltage is greater than the threshold, it can switch to PV input through the relay output after the time set by P15.24. To prevent frequent switching, this threshold must be greater than P15.33.	100.0V	○

Function code	Name	Detailed illustration of parameters	Default	Modify
		If the value is 0.0, it is invalid. The default value depends on model.		
P15.35	Rated pump flow	The pump flow is Q_N if the pump runs at the rated pump frequency and rated lift. Unit: cubic meter/hour.	0.0	○
P15.36	Rated pump lift	The pump lift is H_N if the pump runs at the rated frequency and rated current. Unit: meter	0.0	○
P15.37	Voltage setting at PV undervoltage point	When the PV voltage is less than the preset voltage, the system reports the PV undervoltage (UV) fault. The default value depends on the model.	70.0	○
P15.39	Model	This function code is provided for users to change models. For example, if the user wants to use model -4 (default after factory delivery) as model -2, P15.39 must be set to 2. 0: MAX500-PV-1 220V; single-phase input; single-phase output	0	◎

Function code	Name	Detailed illustration of parameters	Default	Modify
		1: MAX500-PV-2; 220V single-phase input; three-phase output 2: MAX500-PV-3; 220V three-phase input; three-phase output 3: MAX500-PV-4; 400V three-phase input; three-phase output Setting range: 0–3		

7 Communication protocol

7.1 Brief instruction to Modbus protocol

Modbus protocol is a software protocol and common language which is applied in the electrical controller. With this protocol, the controller can communicate with other devices via network (the channel of signal transmission or the physical layer, such as RS485). And with this industrial standard, the controlling devices of different manufacturers can be connected to an industrial network for the convenient of being monitored.

There are two transmission modes for Modbus protocol: ASCII mode and RTU (Remote Terminal Units) mode. On one Modbus network, all devices should select same transmission mode and their basic parameters, such as baud rate, digital bit, check bit, and stopping bit should have no difference.

Modbus network is a controlling network with single-master and multiple slaves, which means that there is only one device performs as the master and the others are the slaves on one Modbus network. The master means the device which has active talking right to sent message to Modbus network for the controlling and inquiring to other devices. The slave means the passive device which sends data message to the Modbus network only after receiving the controlling or inquiring message (command) form the master (response). After the master sends message, there is a period of time left for the controlled or inquired slaves to response, which ensure there is only one slave sends message to the master at a time for the avoidance of singles impact.

Generally, the user can set PC, PLC, IPC and HMI as the masters to realize central control. Setting certain device as the master is a promise other than setting by a bottom or a switch or the device has a special message format. For example, when the upper monitor is running, if the operator clicks sending command bottom, the upper monitor can send command message actively even it can not receive the message form other devices. In this case, the upper monitor is the master. And if the designer makes the inverter send the data only after receiving the command, then the inverter is the slave.

The master can communicate with any single slave or with all slaves. For the single-visiting command, the slave should feedback a response message; for the broadcasting message from the master, the slave does not need to feedback the response message.

7.2 Application of the inverter

The Modbus protocol of the inverter is RTU mode and the physical layer is 2-wire RS485.

7.2.1 2-wire RS485

The interface of 2-wire RS485 works on semiduplex and its data signal applies differential transmission which is called balance transmission, too. It uses twisted pairs, one of which is defined as A (+) and the other is defined as B (-). Generally, if the positive electrical level between sending drive A and B is among +2~+6V, it is logic“1”,if the electrical level is among -2V~-6V, it is logic“0”.

485+ on the terminal board corresponds to A and 485- to B.

Communication baud rate means the binary bit number in one second. The unit is bit/s (bps). The higher the baud rate is, the quicker the transmission speed is and the weaker the anti-interference is. If the twisted pairs of 0.56mm（24AWG）is applied as the communication cables, the Max. Transmission distance is as below:

Baud rate	Max.transmission distance	Baud rate	Max.transmission distance	Baud rate	Max.transmission distance	Baud rate	Max.transmission distance

2400BPS	1800m	4800BPS	1200m	9600BPS	800m	19200BPS	600m

It is recommended to use shield cables and make the shield layer as the grounding wires during RS485 remote communication.

In the cases with less devices and shorter distance, it is recommended to use 120Ω terminal resistor as the performance will be weakened if the distance increase even though the network can perform well without load resistor.

7.2.1.1 Single application

Figure 1 is the site Modbus connection figure of single inverter and PC. Generally, the computer does not have RS485 interface, the RS232 or USB interface of the computer should be converted into RS485 by converter. Connect the A terminal of RS485 to the 485+ terminal of the inverter and B to the 485- terminal. It is recommended to use the shield twisted pairs. When applying RS232-RS485 converter, if the RS232 interface of the computer is connected to the RS232 interface of the converter, the wire length should be as short as possible within the length of 15m. It is recommended to connect the RS232-RS485 converter to the computer directly. If using USB-RS485 converter, the wire should be as short as possible, too.

Select a right interface to the upper monitor of the computer (select the interface of RS232-RS485 converter, such as COM1) after the wiring and set the basic parameters such as communication baud rate and digital check bit to the same as the inverter.

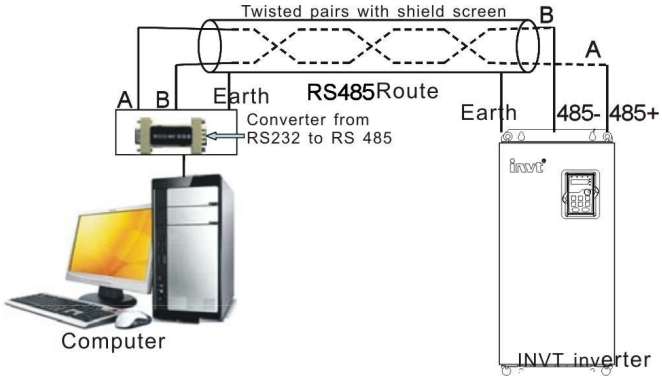


Figure 1 RS485 physical connection in single application

7.2.1.2 Multi-applicationIn the real multi-application, the chrysanthemum connection and star connection are commonly used.

Chrysanthemum chain connection is required in the RS485 industrial fieldbus standards. The two ends are connected to terminal resistors of 120Ω which is shown as figure 2. Figure 3 is the simply connection figure and figure 4 is the real application figure.

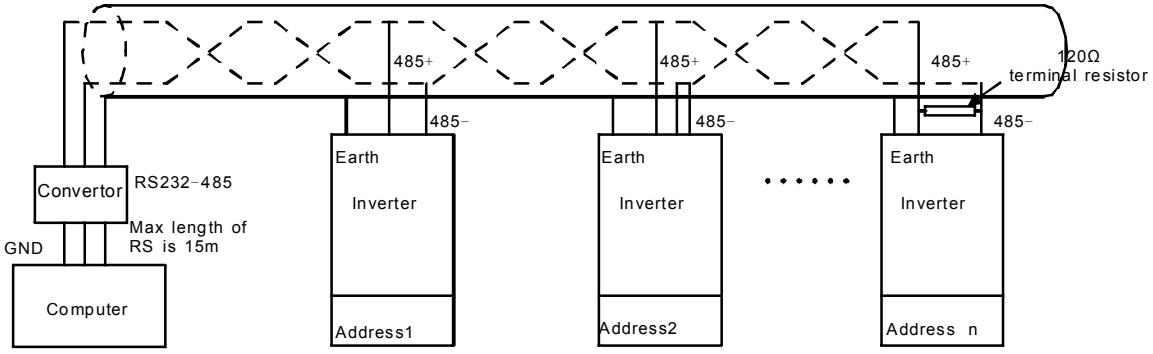


Figure 2 Chrysanthemum connection

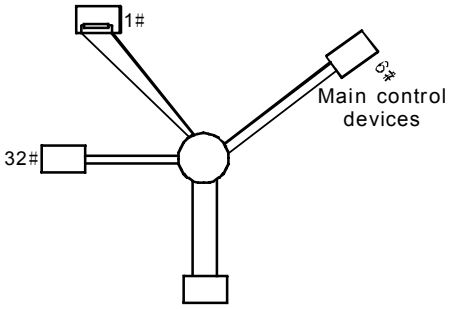


Figure 3 Chrysanthemum connection

It is recommended to use shield cables in multiple connection. The basic parameter of the devices, such as baud rate and digital check bit in RS485 should be the same and there should be no repeated address.

7.2.2 RTU mode

7.2.2.1 RTU communication frame format

If the controller is set to communicate by RTU mode in Modbus network every 8bit byte in the message includes two 4Bit hex characters. Compared with ACSII mode, this mode can send more data at the same baud rate.

Code system

- 1 start bit
- 7 or 8 digital bit, the minimum valid bit can be sent firstly. Every 8 bit frame includes two hex characters (0...9, A...F)
- 1 even/odd check bit . If there is no checkout, the even/odd check bit is inexistent.
- 1 end bit (with checkout), 2 Bit(no checkout)

Error detection field

- CRC

The data format is illustrated as below:

11-bit character frame (BIT1~BIT8 are the digital bits)

Start bit	BIT1	BIT2	BIT3	BIT4	BIT5	BIT6	BIT7	BIT8	Check bit	End bit

10-bit character frame (BIT1~BIT7 are the digital bits)

Start bit	BIT1	BIT2	BIT3	BIT4	BIT5	BIT6	BIT7	Check bit	End bit

In one character frame, the digital bit takes effect. The start bit, check bit and end bit is used to send the digital bit right to the other device. The digital bit, even/odd checkout and end bit should be set as the same in real application.

The Modbus minimum idle time between frames should be no less than 3.5 bytes. The network device is detecting, even during the interval time, the network bus. When the first field (the address field) is received, the corresponding device decodes next transmitting character. When the interval time is at least 3.5 byte, the message ends.

The whole message frame in RTU mode is a continuous transmitting flow. If there is an interval time (more than 1.5 bytes) before the completion of the frame, the receiving device will renew the uncompleted message and suppose the next byte as the address field of the new message. As such, if the new message follows the previous one within the interval time of 3.5 bytes, the receiving device will deal with it as the same with the previous message. If these two phenomena all happen during the transmission, the CRC will generate a fault message to respond to the sending devices.

The standard structure of RTU frame:

START	T1-T2-T3-T4(transmission time of 3.5 bytes)
ADDR	Communication address: 0~247(decimal system)(0 is the broadcast address)
CMD	03H:read slave parameters 06H:write slave parameters
DATA (N-1) ... DATA (0)	The data of 2*N bytes are the main content of the communication as well as the core of data exchanging
CRC CHK low bit	Detection value:CRC (16BIT)
CRC CHK high bit	
END	T1-T2-T3-T4(transmission time of 3.5 bytes)

7.2.2.1 RTU communication frame error checkout

Various factors (such as electromagnetic interference) may cause error in the data transmission. For example, if the sending message is a logic "1",A-B potential difference on RS485 should be 6V, but in reality, it may be -6V because of electromagnetic interference, and then the other devices take the sent message as logic "0". If there is no error checkout, the receiving devices will not find the message is wrong and they may give incorrect response which cause serious result. So the checkout is essential to the message.

The theme of checkout is that: the sender calculate the sending data according to a fixed formula, and then send the result with the message. When the receiver gets this message, they will calculate anther result according to the same method and compare it with the sending one. If two results are the same, the message is correct. If not, the message is incorrect.

The error checkout of the frame can be divided into two parts: the bit checkout of the byte and the whole data checkout of the frame (CRC check).

Bit checkout of the byte

The user can select different bit checkouts or non-checkout, which impacts the check bit setting of each byte.

The definition of even checkout: add an even check bit before the data transmission to illustrate the number of "1" in the data transmission is odd number or even number. When it is even, the check byte is "0", otherwise, the check byte is"1". This method is used to stabilize the parity of the data.

The definition of odd checkout: add an odd check bit before the data transmission to illustrate the number of "1" in the data transmission is odd number or even number. When it is odd, the check byte is "0", otherwise, the check byte is"1". This method is used to stabilize the parity of the data.

For example, when transmitting "11001110", there are five "1" in the data. If the even checkout is applied, the even check bit is "1"; if the odd checkout is applied; the odd check bit is "0". The even and odd check bit is calculated on the check bit position of the frame. And the receiving devices also carry out even and odd checkout. If the parity of the receiving data is different from the setting value, there is an error in the communication.

CRC check

The checkout uses RTU frame format. The frame includes the frame error detection field which is based on the CRC calculation method. The CRC field is two bytes, including 16 figure binary values. It is added into the frame after calculated by transmitting device. The receiving device recalculates the CRC of the received frame and compares them with the value in the received CRC field. If the two CRC values are different, there is an error in the communication.

During CRC, 0*FFFF will be stored. And then, deal with the continuous 6-above bytes in the frame and the value in the register. Only the 8Bit data in every character is effective to CRC, while the start bit, the end and the odd and even check bit is ineffective.

The calculation of CRC applies the international standard CRC checkout principles. When the user is editing CRC calculation, he can refer to the relative standard CRC calculation to write the required CRC calculation program.

Here provided a simple function of CRC calculation for the reference (programmed with C language):

```
unsigned int crc_cal_value(unsigned char *data_value,unsigned char data_length)
{
int i;
unsigned int crc_value=0xffff;
while(data_length--)
{    crc_value^=*data_value++;
                    for(i=0;i<8;i++)
                    {
if(crc_value&0x0001)crc_value=(crc_value>>1)^0xa001;
                    else crc_value=crc_value>>1;
                    }       }
return(crc_value);
}
```

In ladder logic, CKSM calculated the CRC value according to the frame with the table inquiry. The method is advanced with easy program and quick calculation speed. But the ROM space the program occupied is huge. So use it with caution according to the program required space.

7.3 RTU command code and communication data illustration

7.3.1 command code:03H

03H（correspond to binary 0000 0011）,read N words（Word）(the Max. continuous reading is 16 words)

Command code 03H means that if the master read data form the inverter, the reading number depends on the "data number" in the command code. The Max. continuous reading number is 16 and the parameter address should be continuous. The byte length of every data is 2 (one word). The following command format is illustrated by hex (a number with "H" means hex) and one hex occupies one byte.

The command code is used to read the working stage of the inverter.

For example, read continuous 2 data content from0004H from the inverter with the address of 01H (read the content of data address of 0004H and 0005H), the frame structure is as below:

RTU master command message (from the master to the inverter)

START	T1-T2-T3-T4 (transmission time of 3.5 bytes)
ADDR	01H
CMD	03H
High bit of the start bit	00H
Low bit of the start bit	04H
High bit of data number	00H

Low bit of data number	02H
CRC low bit	85H
CRC high bit	CAH
END	T1-T2-T3-T4 (transmission time of 3.5 bytes)

T1-T2-T3-T4 between START and END is to provide at least the time of 3.5 bytes as the leisure time and distinguish two messages for the avoidance of taking two messages as one message.

ADDR = 01H means the command message is sent to the inverter with the address of 01H and ADDR occupies one byte

CMD=03H means the command message is sent to read data form the inverter and CMD occupies one byte

"Start address" means reading data form the address and it occupies 2 bytes with the fact that the high bit is in the front and the low bit is in the behind.

"Data number" means the reading data number with the unit of word. If the "start address' is 0004H and the "data number" is 0002H, the data of 0004H and 0005H will be read.

CRC occupies 2 bytes with the fact that the high bit is in the front and the low bit is in the behind.

RTU slave response message (from the inverter to the master)

START	T1-T2-T3-T4 (transmission time of 3.5 bytes)
ADDR	01H
CMD	03H
Byte number	04H
Data high bit of address 0004H	13H
Data low bit of address 0004H	88H
Data high bit of address 0005H	00H
Data low bit of address 0005H	00H
CRC CHK low bit	7EH
CRC CHK high bit	9DH
END	T1-T2-T3-T4 (transmission time of 3.5 bytes)

The meaning of the response is that:

ADDR = 01H means the command message is sent to the inverter with the address of 01H and ADDR occupies one byte

CMD=03H means the message is receiced from the inverter to the master for the response of reading command and CMD occupies one byte

"Byte number" means all byte number from the byte(excluding the byte) to CRC byte(excluding the byte). 04 means there are 4 byte of data from the "byte number" to "CRC CHK low bit", which are "digital address 0004H high bit", "digital address 0004H low bit", "digital address 0005H high bit" and "digital address 0005H low bit".

There are 2 bytes stored in one data with the fact that the high bit is in the front and the low bit is in the behind of the message, the data of data address 0004H is 1388H,and the data of data address 0005H is 0000H.

CRC occupies 2 bytes with the fact that the high bit is in the front and the low bit is in the behind.

7.3.2 Command code:06H

06H(correspond to binary 0000 0110), write one word(Word)

The command means that the master write data to the inverter and one command can write one data other than multiple dates. The effect is to change the working mode of the inverter.

For example, write 5000 (1388H) to 0004H from the inverter with the address of 02H, the frame structure is as below:

RTU master command message (from the master to the inverter)

START	T1-T2-T3-T4 (transmission time of 3.5 bytes)
ADDR	02H
CMD	06H
High bit of writing data address	00H
Low bit of writing data address	04H
data content	13H
data content	88H
CRC CHK low bit	C5H
CRC CHK high bit	6EH
END	T1-T2-T3-T4 (transmission time of 3.5 bytes)

RTU slave response message (from the inverter to the master)

START	T1-T2-T3-T4 (transmission time of 3.5 bytes)
ADDR	02H
CMD	06H
High bit of writing data address	00H
Low bit of writing data address	04H
High bit of data content	13H
Low bit of data content	88H
CRC CHK low bit	C5H
CRC CHK high bit	6EH
END	T1-T2-T3-T4 (transmission time of 3.5 bytes)

Note: section 10.2 and 10.3 mainly describe the command format, and the detailed application will be mentioned in 10.8 with examples.

7.3.3 Command code 08H for diagnosis

Meaning of sub-function codes

Sub-function Code	Description
0000	Return to inquire information data

For example: The inquiry information string is same as the response information string when the loop detection to address 01H of driver is carried out.

The RTU request command is:

START	T1-T2-T3-T4 (transmission time of 3.5 bytes)
ADDR	01H
CMD	08H
High byte of sub-function code	00H
Low byte of sub-function code	00H
High byte of data content	12H
Low byte of data content	ABH
Low byte of CRC	ADH
High byte of CRC	14H
END	T1-T2-T3-T4 (transmission time of 3.5 bytes)

The RTU response command is:

START	T1-T2-T3-T4 (transmission time of 3.5 bytes)
ADDR	01H
CMD	08H
High byte of sub-function code	00H
Low byte of sub-function code	00H
High byte of data content	12H
Low byte of data content	ABH
Low byte of CRC	ADH
High byte of CRC	14H
END	T1-T2-T3-T4 (transmission time of 3.5 bytes)

7.3.4 The definition of data address

The address definition of the communication data in this part is to control the running of the inverter and get the state information and relative function parameters of the inverter.

7.3.4.1 The rules of parameter address of the function codes

The parameter address occupies 2 bytes with the fact that the high bit is in the front and the low bit is in the behind. The range of high and low byte are: high byte—00~ffH; low byte—00~ffH. The high byte is the group number before the radix point of the function code and the low byte is the number after the radix point. But both the high byte and the low byte should be changed into hex. For example P05.05, the group number before the radix point of the function code is 05, then the high bit of the parameter is 05, the number after the radix point 05, then the low bit of the parameter is 05, then the function code address is 0505H and the parameter address of P10.01 is 0A01H.

Note: PE group is the factory parameter which can not be read or changed. Some parameters can not be changed when the inverter is in the running state and some parameters can not be changed in any state. The setting range, unit and relative instructions should be paid attention to when modifying the function code parameters.

Besides, EEPROM is stocked frequently, which may shorten the usage time of EEPROM. For users, some functions are not necessary to be stocked on the communication mode. The needs can be met on by changing the value in RAM. Changing the high bit of the function code form 0 to 1 can also realize the function. For example, the function code P00.07 is not stocked into EEPROM. Only by changing the value in RAM can set the address to 8007H. This address can only be used in writing RAM other than reading. If it is used to read, it is an invalid address.

7.3.4.2 The address instruction of other function in Modbus

The master can operate on the parameters of the inverter as well as control the inverter, such as running or stopping and monitoring the working state of the inverter.

Below is the parameter list of other functions

Function instruction	Address definition	Data meaning instruction	R/W characteristics
Communication control command	2000H	0001H:forward running	W
		0002H:reverse running	
		0003H:forward jogging	
		0004H:reverse jogging	
		0005H:stop	
		0006H:coast to stop (emergency stop)	
		0007H:fault reset	
		0008H:jogging stop	
		0009H:pre-exciting	
The address of the communication n setting value	2001H	Communication setting frequency(0~Fmax(unit: 0.01Hz))	W
	2002H	PID given, range(0~1000, 1000 corresponds to100.0%)	
	2003H	PID feedback, range(0~1000, 1000 corresponds to100.0%)	W
	2004H	Torque setting value (-3000~3000, 1000 corresponds to the 100.0% of the rated current of the motor)	W
	2005H	The upper limit frequency setting during forward rotation(0~Fmax(unit: 0.01Hz))	W
	2006H	The upper limit frequency setting during reverse rotation(0~Fmax(unit: 0.01Hz))	W
	2007H	The upper limit torque of electromotion torque (0~3000, 1000 corresponds to the 100.0% of the rated current of the motor)	W
	2008H	The upper limit torque of braking torque (0~3000, 1000 corresponds to the 100.0% of the rated current of the motor)	W

Function instruction	Address definition	Data meaning instruction	R/W characteristics
	2009H	Special control command word Bit0~1:=00:motor 1 =01:motor 2 =10:motor 3 =11:motor 4 Bit2:=1 torque control =0:speed control	W
	200AH	Virtual input terminal command , range: 0x000~0x1FF	W
	200BH	Virtual input terminal command , range: 0x00~0x0F	W
	200CH	Voltage setting value(special for V/F separation) (0~1000, 1000 corresponds to the 100.0% of the rated voltage of the motor)	W
	200DH	AO output setting 1(-1000~1000, 1000 corresponds to 100.0%)	W
	200EH	AO output setting 2(-1000~1000, 1000 corresponds to 100.0%)	W
SW 1 of the inverter	2100H	0001H:forward running	R
		0002H:forward running	
		0003H:stop	
		0004H:fault	
		0005H: POFF state	
SW 1 of the inverter	2101H	Bit0: =0:bus voltage is not established =1:bus voltage is established Bi1~2:=00:motor 1 =01:motor 2 =10:motor 3 =11:motor 4 Bit3: =0:asynchronous motor =1:synchronous motor Bit4:=0:pre-alarm without overload =1:overload pre-alarm Bit5:=0:the motor without exciting =1:the motor with exciting	R
Fault code of the inverter	2102H	See the fault type instruction	R
Identifying code of the inverter	2103H	Goodrive100---0x0110	R

R/W characteristics means the function is with read and write characteristics. For example, "communication control command" is writing chrematistics and control the inverter with writing command (06H). R characteristic can only read other than write and W characteristic can only write other than read.

Note: when operate on the inverter with the table above, it is necessary to enable some parameters. For example, the operation of running and stopping, it is necessary to set P00.01 to communication running command channel and set P00.02 to MODBUS communication channel. And when operate on "PID given", it

is necessary to set P09.00 to "MODBUS communication setting".

The encoding rules for device codes (corresponds to identifying code 2103H of the inverter)

Code high 8bit	Meaning	Code low 8 position	Meaning
01	Goodrive	10	Goodrive300 Vector inverter
		11	Goodrive100 Vector inverter

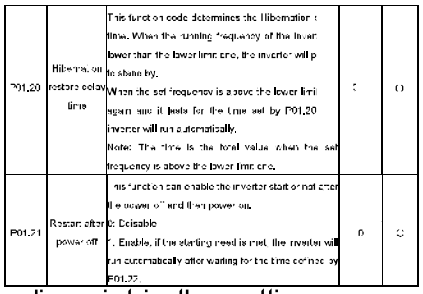
Note: the code is consisted of 16 bit which is high 8 bits and low 8 bits. High 8 bits mean the motor type series and low 8 bits mean the derived motor types of the series. For example, 0110H means Goodrive100 vector inverters.

7.3.5 Fieldbus ratio values

The communication data is expressed by hex in actual application and there is no radix point in hex. For example, 50.12Hz can not be expressed by hex so 50.12 can be magnified by 100 times into 5012, so hex 1394H can be used to express 50.12.

A non-integer can be timed by a multiple to get an integer and the integer can be called fieldbus ratio values. The fieldbus ratio values are refered to the radix point of the setting range or default value in the function parameter list. If there are figures behind the radix point (n=1), then the fieldbus ratio value m is 10^n.

Take the table as the example:



P01.20	Hibernation restore delay time	This function code determines the hibernation time. When the running frequency of the inverter is lower than the lower limit one, the inverter will pause to shut down. When the set frequency is above the lower limit again and it lasts for the time set by P01.20, the inverter will run automatically. Note: The time is the total value when the set frequency is above the lower limit one.	0.0	0.0
P01.21	Restart after power off	This function can enable the inverter start or not after the power off and then power on. 0: Disable 1: Enable, if the starting need is met, the inverter will run automatically after waiting for the time set by P01.20	0	0

If there is one figure behind the radix point in the setting range or the default value, then the fieldbus ratio value is 10. if the data received by the upper monitor is 50, then the "hibernation restore delay time" is 5.0 (5.0=50÷10). If Modbus communication is used to control the hibernation restore delay time as 5.0s. Firstly, 5.0 can be magnified by 10 times to integer 50 (32H) and then this data can be sent.

01	06	01 14	00 32	49 E7
Inverter address	Read command	Parameters address	Data number	CRC check

After the inverter receives the command, it will change 50 into 5 according to the fieldbus ratio value and then set the hibernation restore delay time as 5s. Another example, after the upper monitor sends the command of reading the parameter of hibernation restore delay time ,if the response message of the inverter is as following:

01	03	02	00 32	39 91
Inverter address	Read command	2-byte data	Parameters data	CRC check

Because the parameter data is 0032H (50) and 50 divided by 10 is 5, then the hibernation restore delay time is 5s.

7.3.6 Fault message response

There may be fault in the communication control. For example, some parameter can only be read. If a writing message is sent, the inverter will return a fault response message.

The fault message is from the inverter to the master, its code and meaning is as below:

Code	Name	Meaning
01H	Illegal command	The command from master can not be executed. The reason maybe: 1. This command is only for new version and this version can not realize. 2. Slave is in fault state and can not execute it.
02H	Illegal data address	Some of the operation addresses are invalid or not allowed to access. Especially the combination of the register and the transmitting bytes are invalid.
03H	Illegal value	When there are invalid data in the message framed received by slave. **Note:** This error code does not indicate the data value to write exceed the range, but indicate the message frame is an illegal frame.
04H	Operation failed	The parameter setting in parameter writing is invalid. For example, the function input terminal can not be set repeatedly.
05H	Password error	The password written to the password check address is not same as the password set by P7.00.
06H	Data frame error	In the frame message sent by the upper monitor, the length of the digital frame is incorrect or the counting of CRC check bit in RTU is different from the lower monitor.
07H	Written not allowed.	It only happen in write command, the reason maybe: 1. The written data exceeds the parameter range. 2. The parameter should not be modified now. 3. The terminal has already been used.
08H	The parameter can not be changed during running	The modified parameter in the writing of the upper monitor can not be modified during running.
09H	Password protection	When the upper monitor is writing or reading and the user password is set without password unlocking, it will report that the system is locked.

The slave uses functional code fields and fault addresses to indicate it is a normal response or some error occurs (named as objection response). For normal responses, the slave shows corresponding function codes, digital address or sub-function codes as the response. For objection responses, the slave returns a code which equals the normal code, but the first byte is logic 1.

For example: when the master sends a message to the slave, requiring it to read a group of address data of the inverter function codes, there will be following function codes:

0 0 0 0 0 0 1 1 (Hex 03H)

For normal responses, the slave responds the same codes, while for objection responses, it will return:

1 0 0 0 0 0 1 1 (Hex 83H)

Besides the function codes modification for the objection fault, the slave will respond a byte of abnormal code which defines the error reason.

When the master receives the response for the objection, in a typical processing, it will send the message again or modify the corresponding order.

For example, set the “running command channel” of the inverter (P00.01, parameter address is 0001H) with the address of 01H to 03, the command is as following:

01	06	00 01	00 03	98 0B
Inverter address	Read command	Parameters address	Parameters data	CRC check

But the setting range of "running command channel" is 0~2, if it is set to 3, because the number is beyond the range, the inverter will return fault response message as below:

01	86	04	43 A3
Inverter address	Abnormal response code	Fault code	CRC check

Abnormal response code 86H means the abnormal response to writing command 06H; the fault code is 04H. In the table above, its name is operation failed and its meaning is that the parameter setting in parameter writing is invalid. For example, the function input terminal can not be set repeatedly.

7.3.7 Example of writing and reading

Refer to 10.4.1 and 10.4.2 for the command format.

7.3.7.1 Example of reading command 03H

Read the state word 1 of the inverter with the address of 01H (refer to table 1). From the table 1, the parameter address of the state word 1 of the inverter is 2100H.

The command sent to the inverter:

01	03	21 00	00 01	8E 36
Inverter address	Read command	Parameters address	Data number	CRC check

If the response message is as below:

01	03	02	00 03	F8 45
Inverter address	Read command	Parameters address	Data number	CRC check

The data content is 0003H. From the table 1, the inverter stops.

Watch "the current fault type" to "the previous 5 times fault type" of the inverter through commands, the corresponding function code is P07.27~P07.32 and corresponding parameter address is 071BH~0720H(there are 6 from 071BH).

The command sent to the inverter:

03	03	07 1B	00 06	B5 59
Inverter address	Read command	Starting address	6 parameters	CRC check

If the response message is as below:

03	03	0C	00 23	00 23	00 23	00 23	00 23	00 23	5F D2
Inverter address	Read command	Byte number	Current fault type	Previous fault type	Previous 2 fault type	Previous 3 fault type	Previous 4 fault type	Previous 5 fault type	CRC check

See from the returned data, all fault types are 0023H (decimal 35) with the meaning of maladjustment (STo).

7.3.7.2 Example of writing command 06H

Make the inverter with the address of 03H to run forward. See table 1, the address of "communication control command" is 2000H and forward running is 0001. See the table below.

Function instruction	Address definition	Data meaning instruction	R/W characteristics
Communication control command	2000H	0001H:forward running	W
		0002H:reverse running	
		0003H:forward jogging	
		0004H:reverse jogging	
		0005H:stop	
		0006H:coast to stop (emergency stop)	
		0007H:fault reset	
		0008H:jogging stop	
		0009H:pre-exciting	

The command sent by the master:

03	06	20 00	00 01	42 28
Inverter address	Write command	Parameters address	Forward running	CRC check

If the operation is successful, the response may be as below (the same with the command sent by the master):

03	06	20 00	00 01	42 28
Inverter address	Write command	Parameters address	Forward running	CRC check

Set the Max. Output frequency of the inverter with the address of 03H as100Hz.

P00.03	Max. output frequency	This parameter is used to set the maximum output frequency of the inverter. Users should pay attention to this parameter because it is the foundation of the frequency setting and the speed of acceleration and deceleration. Setting range: P00.04~400.00Hz	50.00Hz	☆

See the figures behind the radix point, the fieldbus ratio value of the Max. output frequency (P00.03) is 100. 100Hz timed by 100 is 10000 and the corresponding hex is 2710H.

The command sent by the master:

03	06	00 03	27 10	62 14
Inverter address	Write command	Parameters address	Parameters data	CRC check

If the operation is successful, the response may be as below (the same with the command sent by the master):

03	06	00 03	27 10	62 14
Inverter address	Write command	Parameters address	Parameters data	CRC check

Note: the blank in the above command is for illustration. The blank can not be added in the actual application unless the upper monitor can remove the blank by themselves.

INOMAX

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