

RHINO MOTION CONTROLS

RMCS-1120

Hybrid Servo Driver with Modbus RTU communication
(Max. 40Vdc and 7A per phase)



Installation Manual and Datasheet

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Page 1

Hybrid AC Driver [RMCS-1120]

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RMCS-1120

Hybrid Servo Driver with Modbus RTU communication
(Max. 40Vdc and 7A per phase)



Key Features

- Smooth and quiet operation at all speeds and extremely low motor heating
- Industrial grade performance for an alternating current servo motor
- Field oriented control based low voltage servo loop
- Fully configurable position and velocity loop
- Input supply voltage from 12VDC to 40VDC
- Delivers up to 7amps of continuous current
- Selectable gear-ratio for encoder with counts from 4000 to 10000 per revolution
- PULSE, DIRECTION and ENABLE inputs with opto-isolated interface
- Short-circuit protection for the motor outputs, over-voltage and under-voltage protection
- LED indication for power and error states

Description

Thank you for purchasing RMCS-1120, Hybrid AC Driver. RMCS-1120 is Rhino Motion Controls introductory hybrid low voltage AC drive designed for smooth and quiet operation without compromising on torque and control at higher speeds. It has short-circuit protection for the motor outputs, over-voltage and under-voltage protection and will survive accidental motor disconnects while powered-up.

The RMCS-1120 delivers a low-voltage servo performance using a field oriented control (FOC) current loop for two-phase hybrid PMSM motors. It also provides a fully configurable position and velocity loop with feed-forward variables to achieve close to zero lag in servo performance.

Two phase PMSM servo systems give an advantage of higher speed, faster response and very low motor heating.

The RMCS-1120's FOC control gains are calibrated on start-up based on motor characteristics and also adjusted dynamically while the motor is in motion. This control algorithm makes it capable of achieving better torque at higher speeds in comparison to comparable drives in its range.

The PULSE/STEP, DIRECTION and ENABLE inputs are optically isolated. Both inputs work with 2.5V, 3.3V or 5V logic drive signals. The input drive current is 5mA at 2.5V so almost all logic family (74LS, 74HC, etc.) can be used to drive these inputs.

The RMCS-1120 hybrid AC drive is warranted to be free of manufacturing defects for six months from the date of purchase. Please see the section on service, support and warranty at the end of this document.

<http://www.rhinomc.com>

Page 2

Hybrid AC Driver [RMCS-1120]

RHINO MOTION CONTROLS

RMCS-1120

Hybrid Servo Driver with Modbus RTU communication
(Max. 40Vdc and 7A per phase)



Technical Specifications

Specification	Min	Max	Units	Comments
Supply Voltage	12	40	Volts DC	Between +Ve and GND
Phase Current	0.5	7	Amps	As demanded by load
Servo Loop Speed	500	1000	Hz	
Power Dissipation	0	15	Watts	—
Short-Circuit Current	7	10	Amps	In case of motor terminal short
PUL and DIR Voltage	2.5	7	Volts DC	Between + and – input pins
Ambient Temp.	0	70	Celsius	
Humidity	0	95%		Non condensing
Step Frequency	—	200	kHz	
Direction Setup time	500	—	ns	Steps is clocked on positive edge

Mechanical Specifications

Specification	Details
Dimensions (L * W * H)	110mm * 77mm * 33mm
Weight	155gms
Heat Sink	Anodized Aluminum 3mm thickness
Mounting Screw Holes	3.6mm minimum diameter

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RHINO MOTION CONTROLS

RMCS-1120

Hybrid Servo Driver with Modbus RTU communication
(Max. 40Vdc and 7A per phase)



Caution

- Read this document carefully before installing and using you drive
- Inputs voltage to the drive must not exceed the maximum of 40VDC or it may damage the drive
- Reversing polarity power supplied to the drive will damage the drive or power supply
- Connecting the power supply wires to the terminals outputs of the motor coils will damage the drive
- Short-circuiting the motor terminals to +Ve power or to each other or to GND may damage the drive
- Excess humidity or condensation on the drive may damage the drive
- Voltage in excess of 7V between the PULSE+ and PULSE- or DIR+ and DIR- or ENA+ and ENA- input terminals may damage the opto-isolators
- Reverse voltage in excess of 7V between the PULSE- and PULSE+ or DIR- and DIR+ or ENA+ and ENA- input terminals may damage the opto-isolators
- Heat sink is designed to dissipate heat from the drive circuitry as long as the ambient temperature is less that 70 degrees Celsius. Ambient temperature in excess of that may damage the drive
- Do not un-plug the terminals of the motor while the drive is powered up and running

Power and Motor Terminal Assignments

Terminal No.	Terminal Name	Description
Terminal 1	A+	Motor Coil Phase A+
Terminal 2	A-	Motor Coil Phase A-
Terminal 3	B+	Motor Coil Phase B+
Terminal 4	B-	Motor Coil Phase B-
Terminal 5	+V	Power +Ve (12VDC to 50VDC Max wrt. GND)
Terminal 6	GND	Power Ground or Power -Ve

RHINO MOTION CONTROLS

RMCS-1120

Hybrid Servo Driver with Modbus RTU communication
(Max. 40Vdc and 7A per phase)



Encoder Terminal Assignments

Terminal No.	Terminal Name	Wire Colour	Description
Terminal 1	GND	BLACK	Power Ground or Power -Ve
Terminal 2	+V	RED	Power +Ve (5VDC wrt. GND)
Terminal 3	A-	GREEN	Motor Coil Phase A-
Terminal 4	A+	YELLOW	Motor Coil Phase A+
Terminal 5	B-	WHITE	Motor Coil Phase B-
Terminal 6	B+	BLUE	Motor Coil Phase B+

Pulse and Direction Input Assignments

Terminal No.	Terminal Name	Description
Terminal 1	ENA-	Enable (Motor Free) -Ve optically isolated input
Terminal 2	ENA+	Enable (Motor Free) +Ve optically isolated input
Terminal 3	DIR-	Direction -Ve optically isolated input
Terminal 4	DIR+	Direction +Ve optically isolated input
Terminal 5	PUL-	Pulse -Ve optically isolated input
Terminal 6	PUL+	Pulse +Ve optically isolated input

RHINO MOTION CONTROLS

RMCS-1120

Hybrid Servo Driver with Modbus RTU communication
(Max. 40Vdc and 7A per phase)



Switch Selection Table for Step Selection

Resolution	SW1	SW2
1/4	ON	ON
1/5	OFF	ON
1/2	ON	OFF
1x	OFF	OFF

1x = Encoder Counts Per Revolution (CPR)

Switch (3): Sets EEPROM permissions

SW3 ON – EEPROM Data Locked

SW3 OFF – EEPROM Data Unlocked

Switch (4): Sets Direction

SW4 ON – Forward Direction

SW4 OFF – Reverse Direction

RS-485 Command Port

A 2pin command port is available on the drive for debug and tuning routines. The communication is based on Modbus RTU, the drive works as Modbus Slave and its register map is given in the Modbus Register Table.

When connected it to a computer the drive parameters can be accessed by simple commands using any Modbus Master Poll Software. An additional hardware to execute this process would be a USB to RS485 Converter. The baud rate of 115200 bps is default with 8 bit data, 1 stop bit and no parity.

The Modbus RTU Functions 03 (Read Multiple Registers), 05 (Write Single Coil) and 06 (Preset Single Register) are used to control the drive.

<http://www.rhinomc.com>

Page 6

Hybrid AC Driver [RMCS-1120]

RHINO MOTION CONTROLS

RMCS-1120

Hybrid Servo Driver with Modbus RTU communication
(Max. 40Vdc and 7A per phase)



For example, some valid Control Query Frames for Drive would be like:

1. 0x01, 0x03, 0x00, 0x00, 0x00, 0x0F, CRC16 – This Query will expect a read of 15 Slave Registers starting from address 0x0000 as a response from Drive with Slave Address 0x01.
2. 0x00, 0x05, 0x00, 0x00, 0x00, 0x00, CRC16 – This Query will set all the Slave Drives' Parameters to their default values.
3. 0x01, 0x06, 0x20, 0x04, 0x00, 0x00, CRC16 – This Query will Set Value 0x0000 to the Register at address 0x2004 of Drive, that will start the Motor.

Modbus Register Table

Parameter	Description	Address	Decimal Address	Data Type	Default	Max
PP_GAIN	Position P Gain	0X0000	0	Signed	256	30000
PFF_GAIN	Feed Forward Gain	0X0001	1	signed	50	30000
PD_GAIN	Position D Gain	0X0002	2	signed	300	30000
PV_GAIN	Velocity P Gain	0X0003	3	signed	600	30000
IV_GAIN	Velocity I Gain	0x0004	4	signed	80	1000
DV_GAIN	Velocity D Gain	0X0005	5	signed	300	30000
C_LIMIT	Current Limit	0X0006	6	signed	2400	4000
CP_GAIN	Current P Gain	0X0007	7	signed	100	1000
CI_GAIN	Current I Gain	0X0008	8	signed	100	1000
C_TRIGGER	Current Trigger Level	0X0009	9	signed	1200	4000
FLT_TIME_CN ST	Input Filter Time	0X000A	10	signed	0	100
PFA_GAIN	Acceleration FeedF	0X000B	11	byte	7	100
I_MUL	Input Multiplier	0X000B	11	byte	1	8
SLVADDR	Modbus Slave Address	0X000C	12	byte	1	247
ENC_PPR	Encoder CPR	0X000D	13	signed	4000	10000
M_POLES	Motor Poles Count	0X000E	14	byte	50	100

RHINO MOTION CONTROLS

RMCS-1120

Hybrid Servo Driver with Modbus RTU communication
(Max. 40Vdc and 7A per phase)



Where,

PP_GAIN	Position Error Proportional Gain in Position Control Loop
PFF_GAIN	Input Velocity Feedforward Gain in Position Control Loop
PD_GAIN	Position Error (Derivative) Damping Gain in Position Control Loop
PV_GAIN	Velocity Error Proportional Gain in Velocity Control Loop
IV_GAIN	Velocity Error Integral Gain in Velocity Control Loop
DV_GAIN	Velocity Error (Derivative) Damping Gain in Velocity Control Loop
C_LIMIT	Current Command Limit Variable to reduce overheating in specific applications
CP_GAIN	Current Error Proportional Gain in Current Control Loop
CI_GAIN	Current Error Integral Gain in Current Control Loop
C_TRIGGER	Overload Current Trigger Level setting for LED Display
FLT_TIME_CNST	Input Pulse Train IIR filter Time Constant setting
PFA_GAIN	Input Acceleration Feedforward Gain In Position Loop
I_MUL	Input Pulse Train Multiplier to reduce Output Speed
SLVADDR	Slave Address of Device for Modbus RTU Communication
ENC_PPR	The Encoder CPR setting for the Motor
M_POLES	The Number of Poles in the Motor

Note: The Current Limit and the Current Trigger Level are application specific parameters.

Additional Commands

Parameter	Description	Address	Decimal Address	Data Type	Default	Max
V_COMD	Velocity Command	0X2000	8192	Signed	0	200
A_COMD	Acceleration Command	0X2001	8193	signed	25	1000
M_COMD	Motion Command	0X2002	8194	signed long	0	-
M_STATE	Motion Status	0X2004	8196	signed	4	-
P_ERROR	Position Error	0x2005	8197	signed	-	-
C_POS	Current 32bit POS	0X2006	8198	Signed long	-	-
C_Angle	Current Angle	0X2008	8200	signed	-	-

<http://www.rhinomc.com>

RHINO MOTION CONTROLS

RMCS-1120

Hybrid Servo Driver with Modbus RTU communication
(Max. 40Vdc and 7A per phase)



	(CPR)					
C_Speed	Current Speed	0X2009	8201	signed	-	-
C_Current	Current Input Current	0X200A	8202	signed	-	-
C_Calibrate	Current loop calibrated level	0X200B	8203	signed	-	-
C_Error	Realtime error status	0X200C	8204	Signed	0	

Where,

V_COMD	The maximum Velocity setting for Trapezoidal Motion Profile (15rpm / unit)
A_COMD	The Acceleration Slope setting for Trapezoidal Motion Profile (30rpm/s ² / unit)
M_COMD	The Displacement required for the Motion Profile in Encoder Steps (32bit signed)
M_STATE	The state of the Motion Profile State Machine
P_ERROR	The Position Error between Commanded and Current Position (Realtime)
C_POS	The Current Encoder Position (16 bit) (Realtime)
C_Angle	The Commutation Angle of the Shaft (Encoder CPR) (Realtime)
C_Speed	The Speed of the Motor (30rpm/step) (Realtime)
C_Current	The Current Command Given to Current Loop (Realtime)
C_Calibrate	The Startup Current Loop Calibration Value
C_Error	Gives the status of the error when motor is automatically disabled due to fault

Note: The motion command value 4000 corresponds to one full rotation of motor. The programmer can have multiples of 4000 to achieve specific number of rotations. For example, if 8 rotations are required, this value would be 32000 (4000 multiplied by 8). If the motion command value is negative, it will run the motor in opposite direction.

RHINO MOTION CONTROLS

RMCS-1120

Hybrid Servo Driver with Modbus RTU communication
(Max. 40Vdc and 7A per phase)



RS-485 Connection Setting.

Baud Rate : 115200 bps (Bits per second)

Data bits : 8

Parity : None

Stop Bits : 1

Motion Profiler Status : 8196		Supported Functions:
0 : Motor Start [Start Operation]		03 : Read Single / Multiple Registers
1: Running [Command Running, Read Only]		06 : Write Single Register
2 : Stop Motor [Deceleration]		05 : Write Coil [Slave ID 0x00 (Default)]
3 : Emergency STOP [Disable]		
4 : Idle [Enabled and Locked]		
5 : Current Gains Auto Tuning		
6 : Motor Start [Absolute Operation]		
7: Reset Position Resistors to Zero		

RHINO MOTION CONTROLS

RMCS-1120

Hybrid Servo Driver with Modbus RTU communication
(Max. 40Vdc and 7A per phase)



Modbus RTU Master's Command List for Setting Motion Profile

For setting any Command's value, the Modbus Master Queries with the RTU Function 0x06. The query frame contains 8 bytes. Some Right Shift (" \gg ") and "&" operations on the input value are required in order to tackle the data type issues.

Note: SDA stands for Slave Drive Address

Caution: The Motion Status must be IDLE before sending Motion Profiler Status Commands except 2 and 3.

Command Modbus Master Query Frame

Velocity	SDA, 0x06, 0x20, 0x00, (Value \gg 8), (Value & 0xFF), CRC16
Acceleration	SDA, 0x06, 0x20, 0x01, (Value \gg 8), (Value & 0xFF), CRC16
Motion	SDA, 0x06, 0x20, 0x02, ((Value & 0xFFFF) \gg 8), (Value & 0xFF), CRC16
	SDA, 0x06, 0x20, 0x03, (Value \gg 24), ((Value & 0xFFFFFFF) \gg 16), CRC16
Motion Status	SDA, 0x06, 0x20, 0x04, (Value \gg 8), (Value & 0xFF), CRC16

Power Supply Selection

The general rule of thumb to get the most out of the motor is to drive it with a supply voltage that is at least 3 to 4 times its rated supply voltage. A DC regulated power supply with good low-ESR decoupling capacitors on its output is recommended for best performance of this drive.

LED Status and Error Codes

There is a single LED on this drive for power and error status messages. In case the LED is blinking or flickering please check all connections and powered-down, wait for 5 seconds and then power-up the drive once again.

LED State	Message
Green LED ON and steady	Powered up and calibrated
Red LED Flickering randomly	Current Trigger Level Achieved
Red LED blinking	Short circuit on motor terminals or drive message to connection error

<http://www.rhinomc.com>

RHINO MOTION CONTROLS

RMCS-1120

Hybrid Servo Driver with Modbus RTU communication
(Max. 40Vdc and 7A per phase)



Guide to General Problems

Problem Symptom	Possible Reasons and Solutions
Motor is not rotating	Drive is not powered up Motor is not connected properly to the drive Drive is in an error state, check LED status Pulse and Direction inputs are not connected properly or are not supplying enough current
Motor rotates in the wrong direction	Motor Phase connections may be reversed
LED is blinking	Check LED status messages in this document and check connections and voltages accordingly Drive might be damaged due to incorrect installation or handling
Drive is not powering up (no LED)	Check that the connectors to the drive are tightly plugged in Check the supply voltage is adequate and in correct polarity Drive might be damaged due to incorrect installation or handling
Erratic Motion on Motor	Power supply voltage not stable or regulated Motor Coil damaged or not connected to the drive correctly Current setting on the motor too high Control signals of Pulse or Direction are not connected properly or not supplying enough voltage and current Control signal interference due to power supply or environmental noise
Motor stalls during accelerating	Motor load is too high Acceleration is too high Gain settings is too low of the Motor Power Supply is too low for Motor or Speed
Excessive Motor or Drive Heating	Drive is damaged Power supply voltage is too high Not enough cooling or ventilation for motor or drive

RHINO MOTION CONTROLS

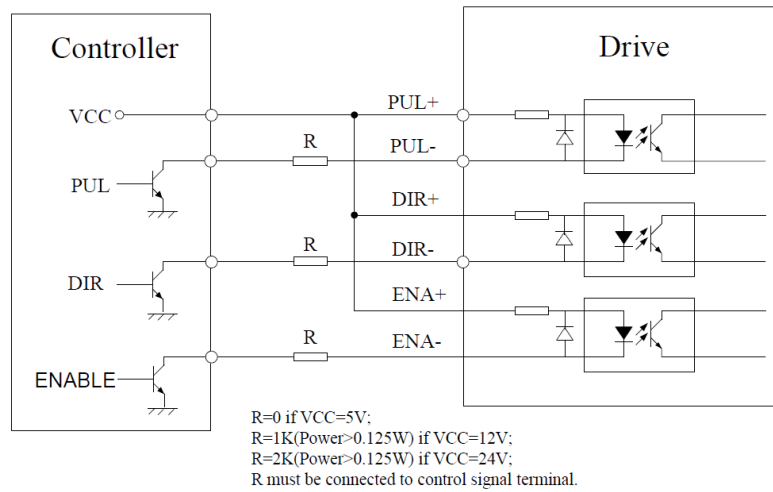
RMCS-1120

Hybrid Servo Driver with Modbus RTU communication
(Max. 40Vdc and 7A per phase)



Control Signal Connection NPN pull-down

In this connection technique all the signal +ve inputs are connected to a common high voltage VCC. The opto-isolators LED is turned-on by a pull-down on the -ve terminals by an NPN-transistor output



RHINO MOTION CONTROLS

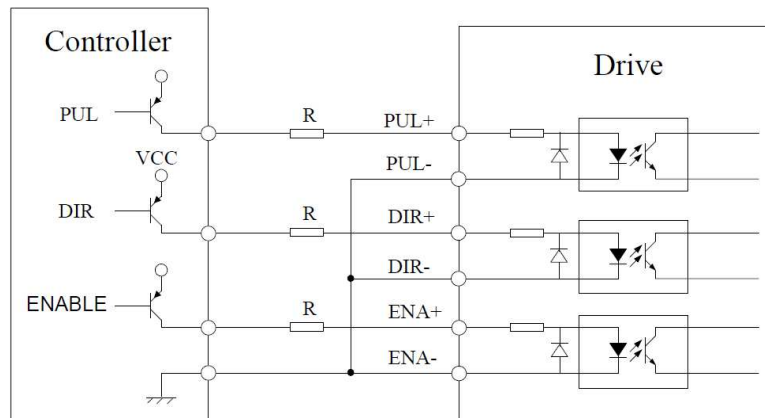
RMCS-1120

Hybrid Servo Driver with Modbus RTU communication
(Max. 40Vdc and 7A per phase)



Control Signal Connection PNP pull-up

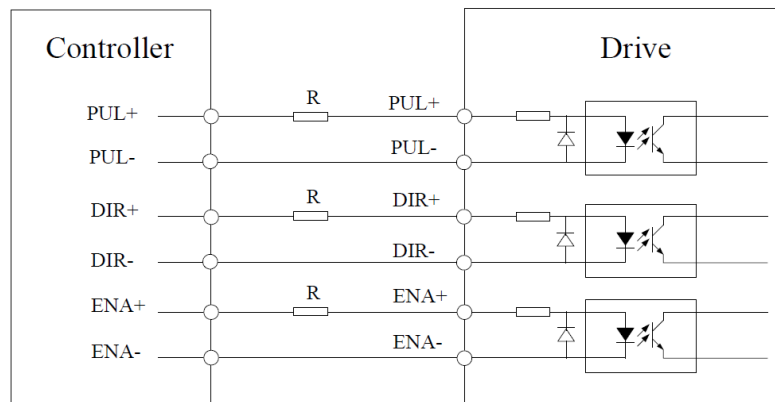
In this connection technique all the signal -ve inputs are connected to a common low voltage GND. The opto-isolators LED is turned-on by a pull-up on the +Ve terminals by an PNP-transistor output



R=0 if VCC=5V;
R=1K(Power>0.125W) if VCC=12V;
R=2K(Power>0.125W) if VCC=24V;
R must be connected to control signal terminal.

Control Signal Connection Differential

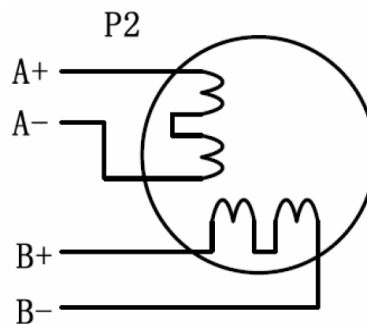
In this connection technique each input is differential controlled and no necessity for a common voltage



R=0 if VCC=5V;
R=1K(Power>0.125W) if VCC=12V;
R=2K(Power>0.125W) if VCC=24V;
R must be connected to control signal terminal.

2-phase, 4-lead Motors Connections

4 lead motors are the least flexible but easiest to wire. Speed and torque will depend on winding inductance. In setting the drive output current, multiply the specified phase current by 1.4 to determine the peak output current.



RHINO MOTION CONTROLS

RMCS-1120

Hybrid Servo Driver with Modbus RTU communication
(Max. 40Vdc and 7A per phase)

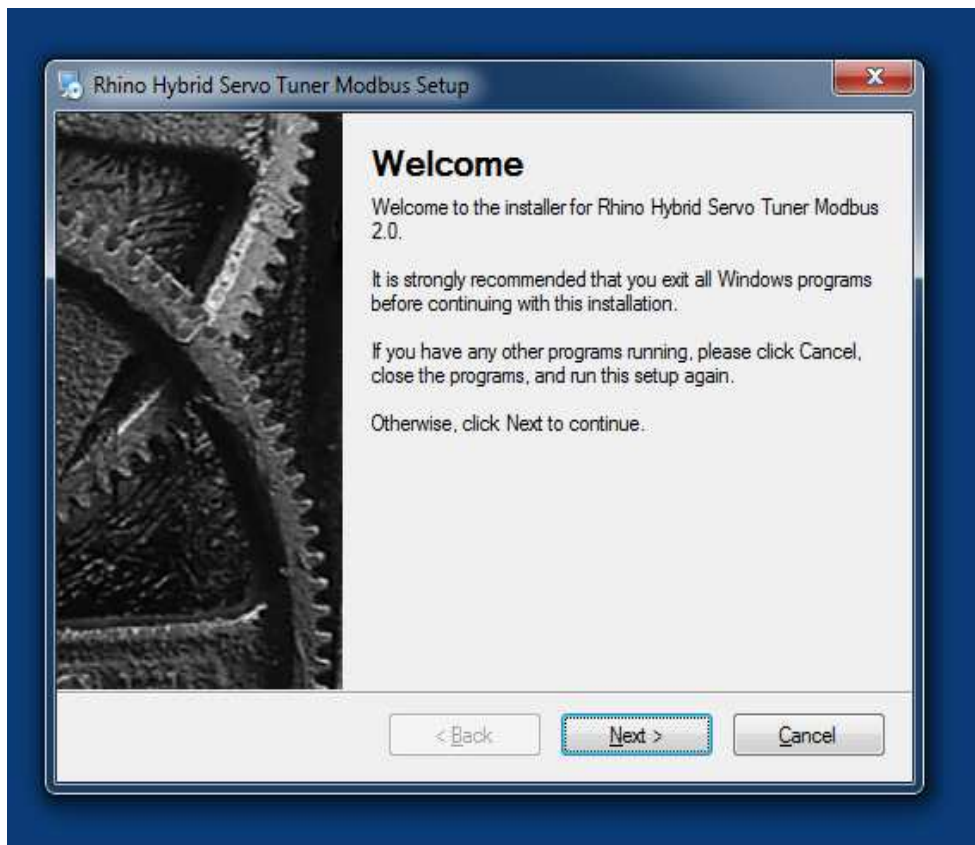


Configuration through PC software

To configure the drive easily a Windows software is available here

http://rhinomc.com/downloads/Hybrid_Servo_Tuner_Setup_Modbus.exe

The software is compatible with Windows XP and later operating systems including Windows 7, 8 and 10. Both 32 bit and 64 bit versions are supported. Software must be installed with Admin rights, however after installing it can be used normally without Admin rights. Software will be installed for all users by default.



After running the setup you will get the welcome screen. Click Next.

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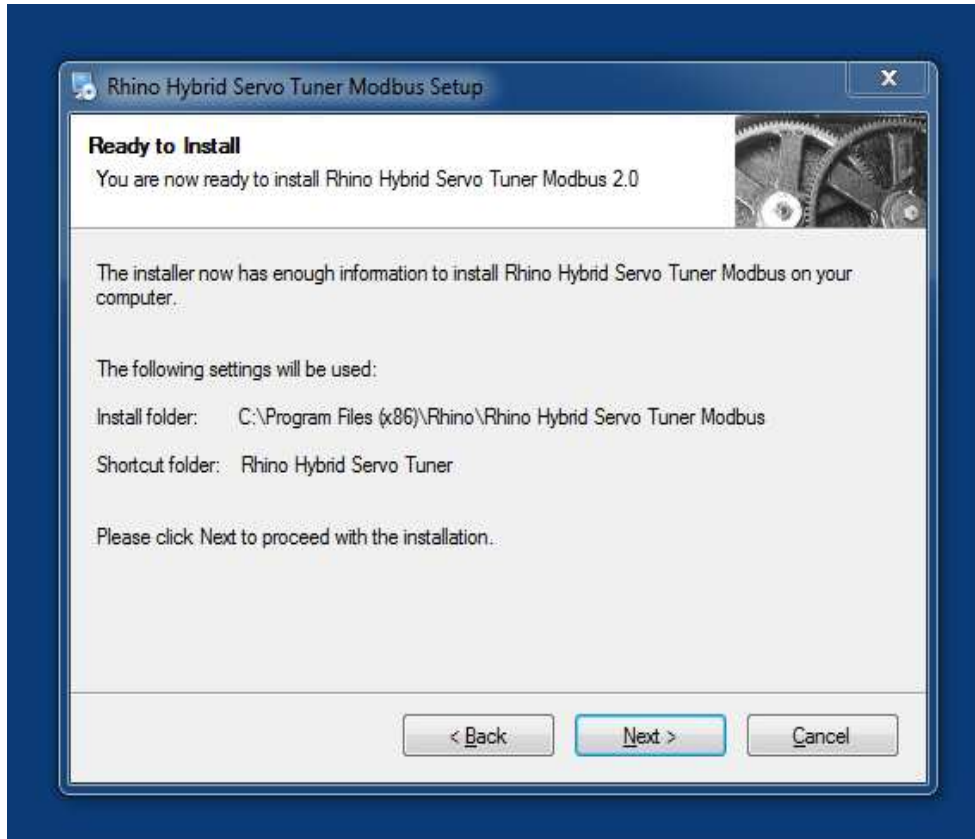
Page 16

Hybrid AC Driver [RMCS-1120]

RHINO MOTION CONTROLS

RMCS-1120

Hybrid Servo Driver with Modbus RTU communication
(Max. 40Vdc and 7A per phase)



Then it will show the install path and shortcut folder in start menu. Click next and then finish on the next screen to finish the installation.

To start the software you can go to Start Menu - Rhino Hybrid Servo Tuner Modbus

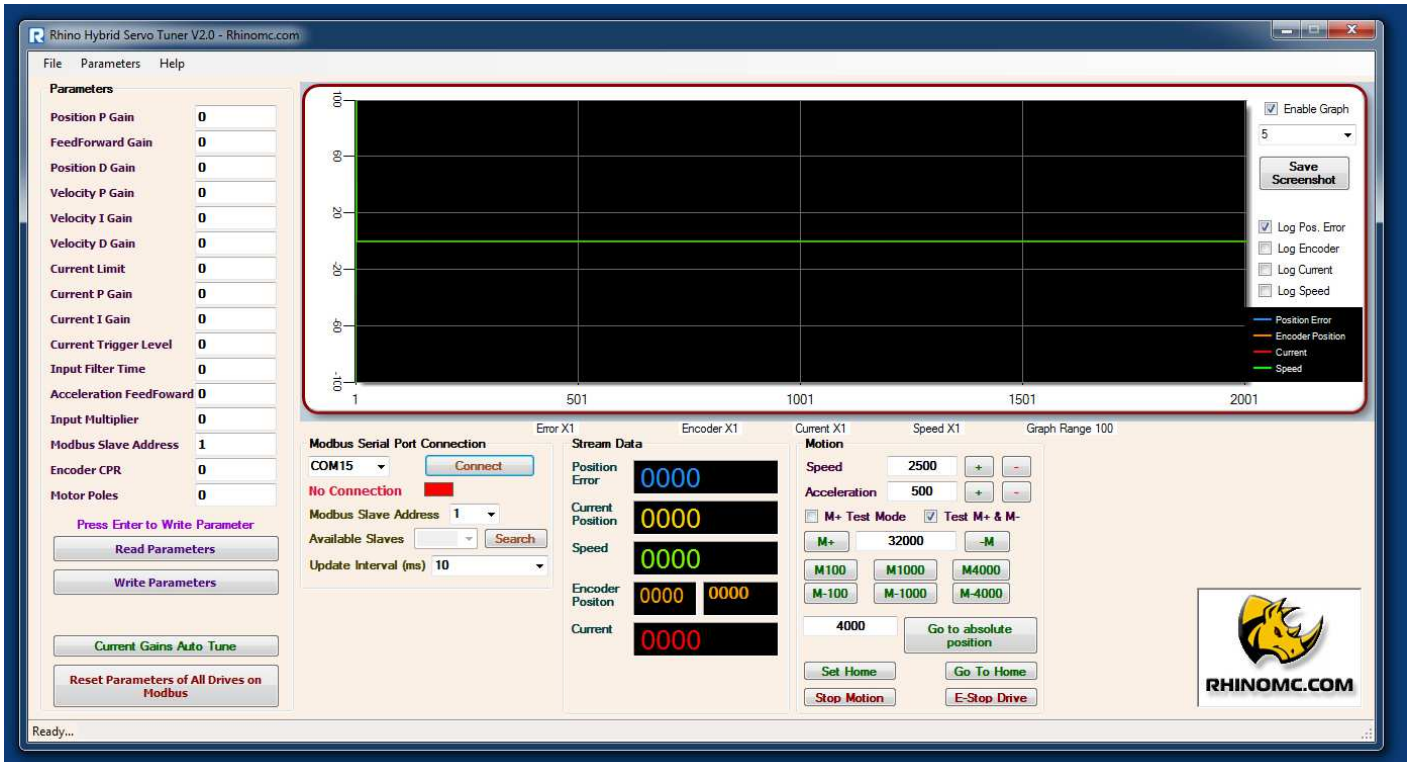
Alternatively you can also start from the shortcut created on your desktop.

After opening you will see the following screen

RHINO MOTION CONTROLS

RMCS-1120

Hybrid Servo Driver with Modbus RTU communication
(Max. 40Vdc and 7A per phase)



To connect this software to drive you will need a USB to RS485 or Serial to RS485 converter as shown in image below.

D+ and D- Lines needs to be connected between drive and converter. After connecting and installing the driver you need to make sure that hardware or virtual Com port is between the range of Com1 to Com32. Com Port beyond this range are incompatible with the software. You may change the COM port from device manager.

You may connect multiple drives on same paralleled connection to D+ and D- lines.

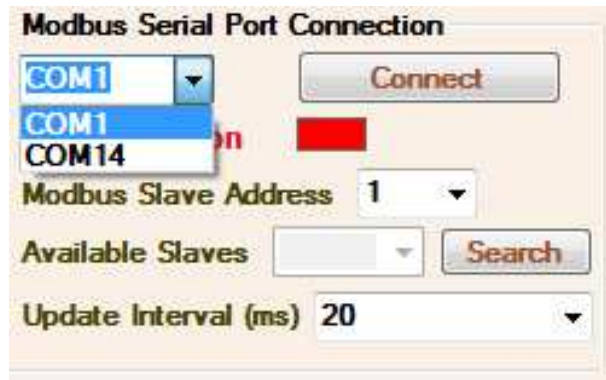
RHINO MOTION CONTROLS

RMCS-1120

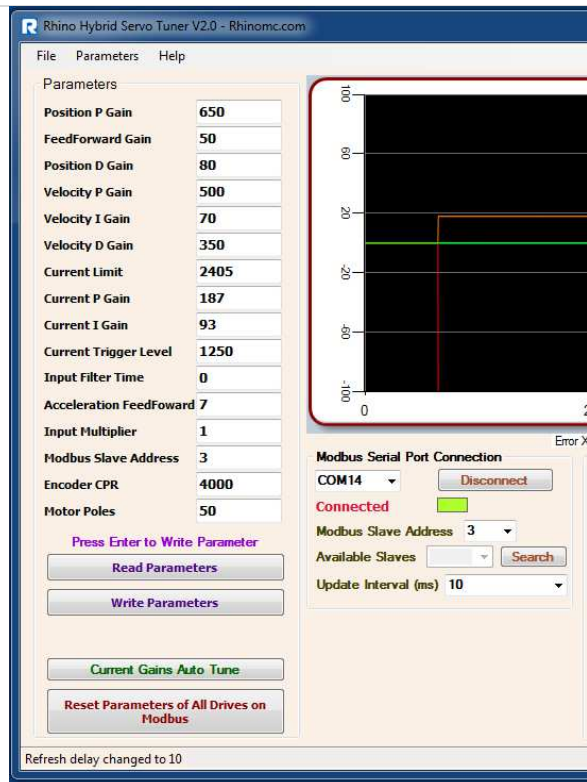
Hybrid Servo Driver with Modbus RTU communication
(Max. 40Vdc and 7A per phase)



Once the drive is connected through converter and drivers are installed there should be a COM port for the connection. It should be selected in the software in the 'Modbus Serial Port Connection' section.



If the Com port for your connection is not visible, clicking on the dropdown will refresh the list of available ports. Click Connect button to connect to the specified com port.



Once the connection is done, you will also need to select the slave address to communicate with drive. Slave address can be from 1 to 247.

If you don't know the slave addresses for connected drives you may click the Search button for Available Slaves. It will search from 1 to 247 slaves for response. If it gets a response the slave will be added in drop down. You can see the progress in status bar. It will take a lot of time to scan all devices. You may press cancel when all connected devices are found. Once the process is finished you can select any slave address from the drop down of Available Slaves to communicate to it.

Once a valid slave address is selected the drive will start communicating to software and the connection status indicator will turn green. It will also change colors between green and yellow-green to indicate communication. Also the software will load all the parameters stored in drive.

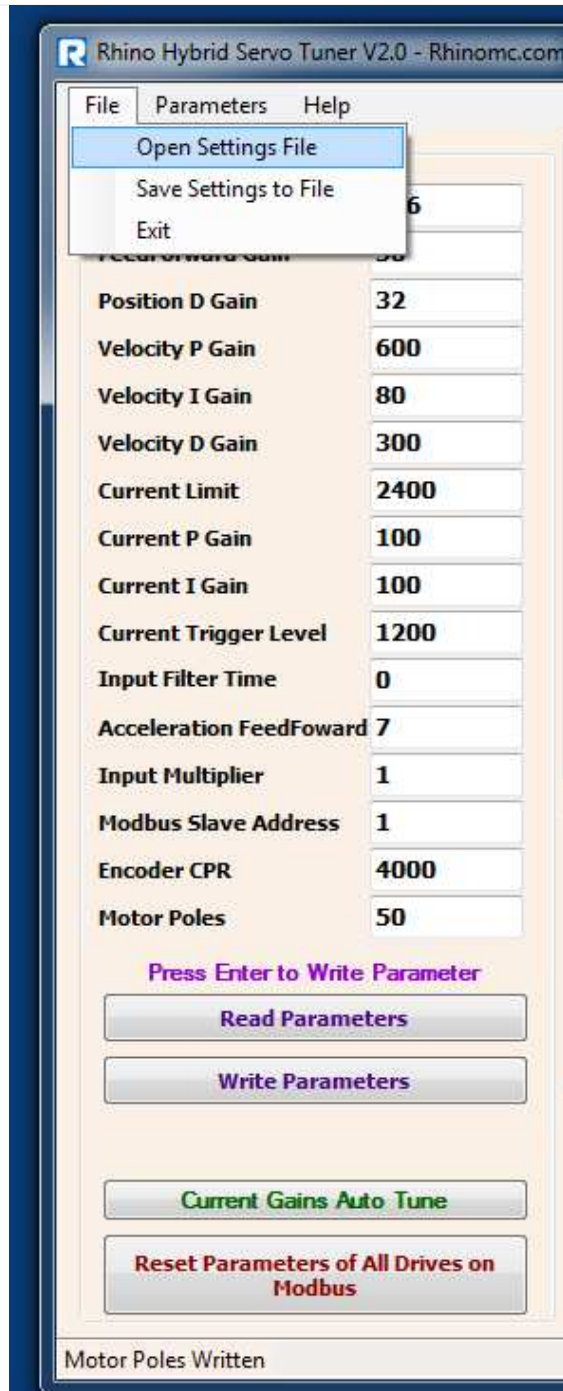
You may also change the update interval through drop down. Lower the interval - faster the communication will be. However it will also consume more CPU. If you are running a slow PC or the software slows down your PC you may increase it. Ideally 10 to 50 ms interval will suite most PCs.

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RHINO MOTION CONTROLS

RMCS-1120

Hybrid Servo Driver with Modbus RTU communication
(Max. 40Vdc and 7A per phase)



On the Parameters section you can see all the parameters loaded from the currently connected drive. If you change the slave address, the parameters will be loaded for the new slave.

You may also click 'Read Parameters' button at any point to read the parameters from drive.

Description of each parameter can be seen by hovering the mouse cursor over it. If it isn't showing the tooltip you can enable it from Help menu.

You may change the parameters by typing into the textbox. You can save it to the drive by pressing enter. You may also change multiple parameters and click 'Write Parameters' button to save all parameters. Only the parameters which are changed will be written.

You can save all the parameters for a particular drive to a file and load it when required. On opening such saved file all the parameters will be written to the drive and drive will immediately start responding according to the new parameters.

In case you have set the parameters wrongly and you want to reset it, you may click the 'Reset Parameters of All Drives on Modbus' button. This will reset all the drives connected on modbus. Its recommended that you do this only when one drive is connected because otherwise it will **reset the slave address of each connected drive to 1**, this will make all the drive communicating simultaneously to the software and it may show wrong values or misbehave. Ideally you should connect drives one by one and change their slave addresses to greater than 1 value. After all your drive are programmed with different slave addresses you may connect them all to the modbus lines and configure through the software.

After connecting a new motor or resetting the parameters its recommended to click the 'Current Gains Auto Tune' button once. This will set the current gains according to the motor characteristics.

RHINO MOTION CONTROLS

RMCS-1120

Hybrid Servo Driver with Modbus RTU communication
(Max. 40Vdc and 7A per phase)



Stream Data

Position Error: 1
Current Position: -118802
Speed: 2517
Encoder Position: 1198 257.85°
Current: 2023

Motor Running

When the drive is connected the motion data is polled every few milliseconds which are specified in Update Interval drop down box. This data is shown in then 'Stream Data' Section. It shows realtime information about motor's data like 1. Actual Position error between given command and current position, 2. Actual 32 bit position of encoder (from startup or set position) 3. Approximate speed in RPM 4. Exact angular positon of encoder in counts and degrees 5. Approximate current.

This data is also shown in graph if the graph is enabled. In graph you can set the multiplier of each parameter and range to get all the logged data visible properly. The graph also shows number of readings taken. Each section on X axis of graph shows 500 readings. If the graph is slowing down your system you may change the number of reading to log per refresh. Ideally 10 to 50 readings per refresh will be fine for most PCs.

Graph can be a very useful tool when tuning the PIDs for drive and motor.



RHINO MOTION CONTROLS

RMCS-1120

Hybrid Servo Driver with Modbus RTU communication
(Max. 40Vdc and 7A per phase)



You may also control the motor motion by giving Speed, Acceleration, Direction and Position inputs. These can be set from Motion section in the software.

Speed is in RPM which can be set from 15 to 4000 RPM. The set speed works only when motion commands through modbus are passed. It doesn't affect the operation when motion is done through Step-Direction input. Depending on motor and PID settings it may or may not be able to run at the speed which is set. If it can't reach the speed which is set the drive will give error and E-stop the system - motor and all other operations will stop. The actual RPM of motor may be different than set as it also depends on parameters and gains set. Using + and - buttons the speed can be changed. You may also type the speed in the text box. Speed will change immediately if you press button or enter when in textbox. Speed will change even when motor is running.

Acceleration can be set same as speed. This acceleration works only when motion commands through modbus are passed. It doesn't affect the operation when motion is done through Step-Direction input.

M+ button will run the motor at the specified speed, acceleration and relative position to current position of motor. Number of counts is a 32 bit number and has a range of -2147483648 to +2147483647. Speed and acceleration can be changed when the motor is running through this command. The motor can be stopped if 'Stop Motion' button is pressed. No other motion command will work if the motor is not in idle state.

There are 2 checkboxes in the motion section named "M+ Test Mode" and "Test M+ & M-". If M+ Test Mode checkbox is checked when pressing M+ button or during motion after pressing M+ Button, at the end of the motion (When motor goes to idle state) the same command is given again. This will result in continuous motion of motor for number of steps given in text box. When you want to stop sending the

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RHINO MOTION CONTROLS

RMCS-1120

Hybrid Servo Driver with Modbus RTU communication
(Max. 40Vdc and 7A per phase)



commands just uncheck the checkbox. If "Test M+ & M-" checkbox is checked motion will be in both directions. All the commands for movement send 32 bit position to modbus registers which are actually two 16 bit registers. Sending any motion commands from software will show this 32 bit value divided in to two 16 bit values in status bar in decimal and hex format.

```
M 320000 : -7680,4 -- E200,4
```

M- button work same as M+ but the motion will be in reverse direction.

M100, M-100, M1000, M-1000, M4000 and M-4000 commands will work same as M+ but with fixed number of steps.

The RMCS-1120 drive supports absolute 32 bit position output on modbus. This means that the drive can show the absolute position of 2147483648 counts in both directions after startup. This range is enough for most applications as its about 536870 revolutions or 214 minutes (3 Hours and 34 minutes) of running at 2500 RPM in each direction. The software can show this position and also set it to zero(Home).

"Set Home" button can be used to set current position to absolute 0 or home position. "Go To Home" button will send the command to move the motor at the 0 position. "Go to absolute position" button will send the command to move the motor to absolute position given in text box.

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Service and Support

Service and support for this product are available from the Rhino Motion Controls Web site (<http://www.rhinomc.com>) and our customer service email: info@rhinomc.com

Six-Month Warranty

Rhino Motion Controls (rhinomc.com) warrants its products against defects in materials and workmanship for a period of 6 months from shipment delivery. During the warranty period, Rhino Motion Controls will either, at its option, repair or replace products which proved to be defective.

Exclusions

The above warranty does not extend to any product damaged by reasons of improper or inadequate handlings by customer, improper or inadequate customer wirings, unauthorized modification or misuse, or operation beyond the electrical specifications of the product and/or operation beyond environmental specifications for the product.

Obtaining Warranty Service

To obtain warranty service, please contact our customer service department at info@rhinomc.com before returning product for service. Please make sure that you have gone through this entire installation manual and datasheet before deciding that your product is liable for replacement or repair under this 6-month warranty. Customer shall prepay shipping charges for products returned to Rhino Motion Controls for warranty service, and Rhino Motion Controls shall pay for return of products to customer.

Warranty Limitations

Rhino Motion Controls makes no other warranty, either expressed or implied, with respect to the product. Rhino Motion Controls specifically disclaims the implied warranties of merchantability and fitness for a particular purpose. Some jurisdictions do not allow limitations on how long and implied warranty lasts, so the above limitation or exclusion may not apply to you. However, any implied warranty of merchantability or fitness is limited to the 6-month duration of this written warranty.

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Page 24

Hybrid AC Driver [RMCS-1120]