

Real Time Control of Morningstar Products using Open Protocol MODBUS and MSView Software

Abstract

System integrators and project engineers often design systems that require external control over one or more Morningstar products during operation. Many Morningstar products include open protocol MODBUS which is well suited to provide external control. This is a simple but powerful software solution. This document provides the information needed to implement external control of Morningstar equipment.

Target Audience: System integrators, designers, and engineers

The System Controller may be a PC, Linux box, PLC, or other computing device. The physical MODBUS network may be RS-232, EIA-485 (RS-485), Ethernet, or USB (or a combination of these).



Figure 1: RS-232 Serial Interface with PC or PLC to a TriStar controller

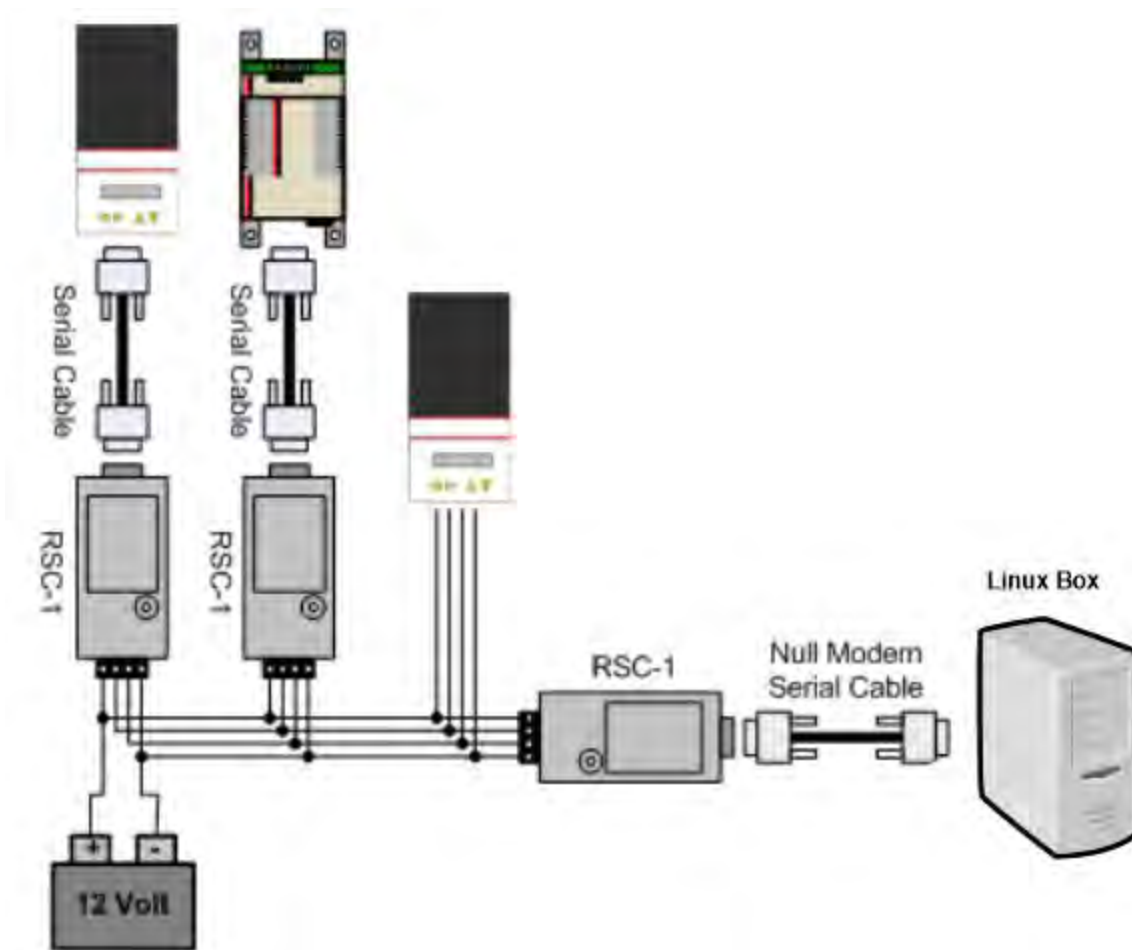


Figure 2: EIA-485 Serial Interface with TriStar , Relay Driver and TriStar MPPT to a Linux Box

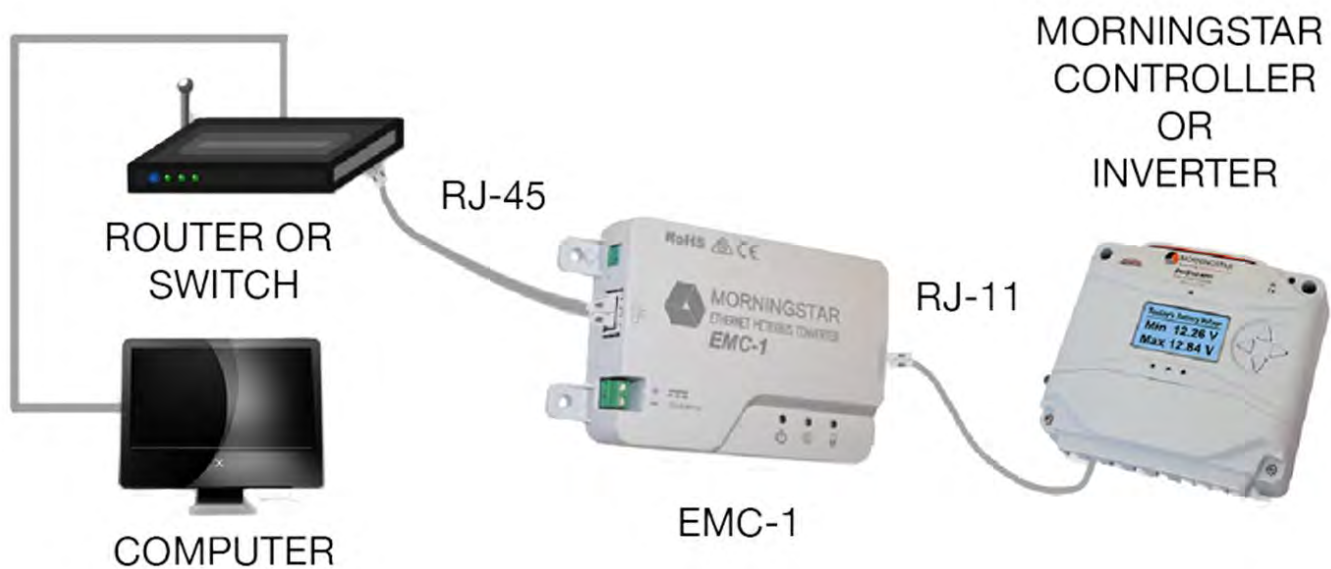


Figure 3: Ethernet Interface with Morningstar Ethernet Meterbus Adapter (EMC-1) for a ProStar MPPT with a Computer.

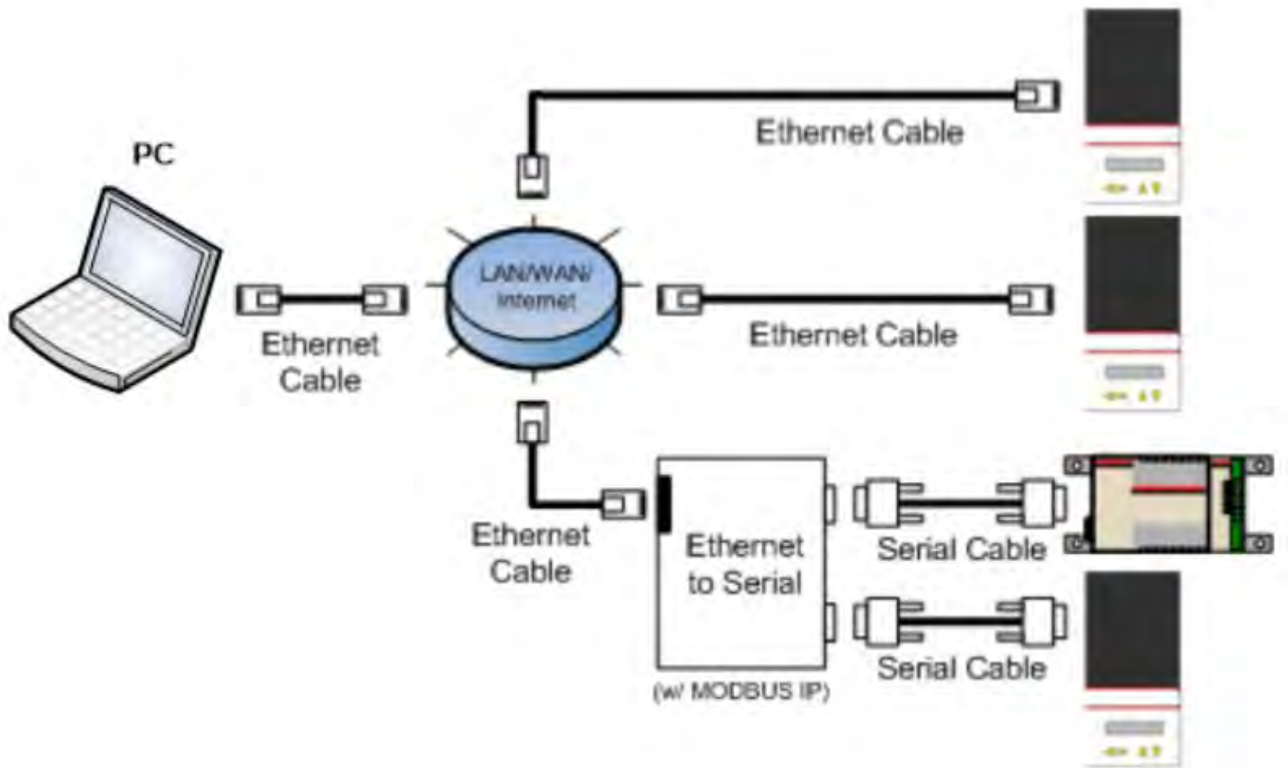


Figure 4: Ethernet Interface with PC to (2) TriStar MPPT's, a Relay Driver and a TriStar

There are two types of software control available for Morningstar products. The first type is to use **Device Control Coils** and the other is to use **Slave Control**. Implementation of this control is achieved by writing to Coil MODBUS registers and Slave MODBUS registers respectively. The use of either of these methods will depend on the type of parameters that need to be controlled and the level of control needed.

Morningstar Product	Control Coils	Slave Mode (Vb_ref_slave)	Slave Mode (Ib_ref_slave)
TriStar MPPT 600V	●	●	●
TriStar MPPT (150V)	●	●	●
TriStar (PWM)	●	○	○
ProStar MPPT	●	●	○
ProStar Gen 3 (PWM)	●	○	○
SunSaver MPPT	●	○	○
SunSaver Duo	●	○	○
Relay Driver	●	○	○

Table: Morningstar Device Types of Control

Applications where external control can be used

Manual Control

Users who have a local or remote data connection to a Morningstar device are able to initiate a Coil Command for various purposes. These commands provide control using one write command at a time to trigger an operational function, device reset or clear resettable data parameters.

Operational functions include:

- turn loads off and on,
- disabling and enabling charging,
- triggering an equalize charging stage or
- overriding a low voltage disconnect (LVD)

ON/OFF control of loads and charging would otherwise require the use of a breaker switch.

It's recommended to disable charging before programming the controller with new custom settings. Then, after programming the device, a reset coil command can be used to restart the controller with the new settings. The reset coil command is also useful if there is a critical fault that requires a power cycle to clear. Counters, faults and alarms can also be reset with control coils.

Automated Control

Automated control of Morningstar products requires MODBUS automation control software. Automation control can be used for control coils or slave modes of operation. This gives an external processor the ability to control various aspects of the system including both Morningstar and third-party devices.

Automation software can be used to control the operation of multiple Morningstar devices in a system. This is useful for coordinating charge stages, prioritizing loads and other operational parameters. Integration with parameters from third-party equipment including charging sources, meters, loads and advanced battery management systems (BMS) is also possible with digital automation.

Coil Commands

Coil commands are write commands implemented with MODBUS software. Morningstar [MSView software](#) includes the ability to force a Coil off and on. 3rd party MODBUS software programs can also be used for Coil commands as it can with MSView. However, in addition to the user being able to select a Coil manually one at a time, a software program can trigger a Coil Command automatically.

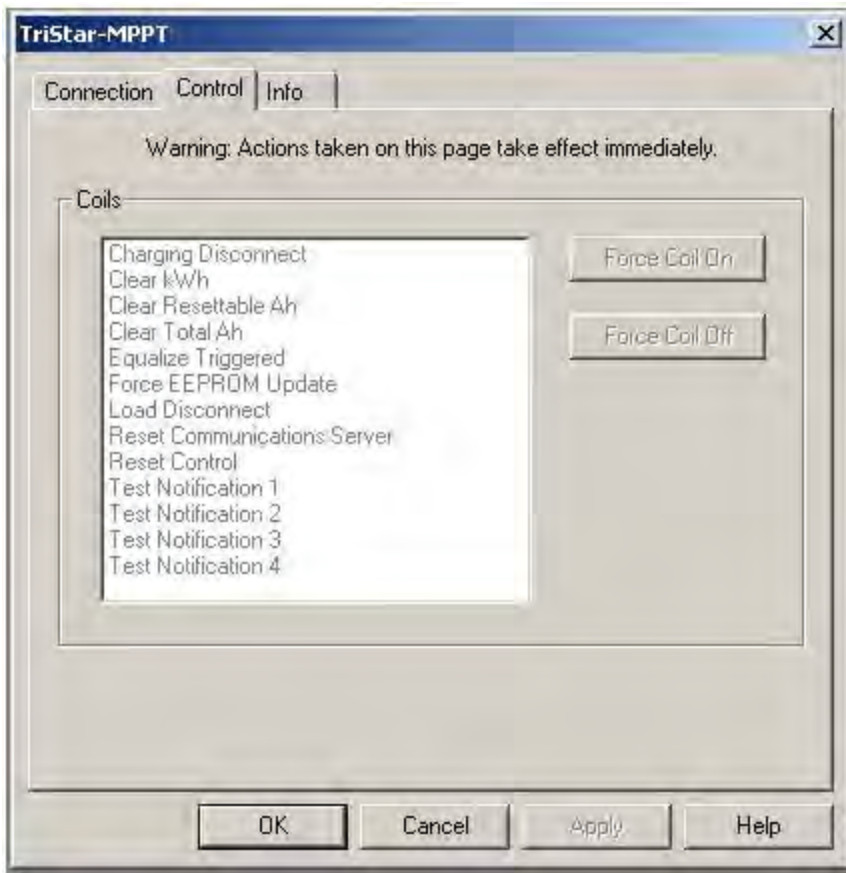


Figure 5: MSView TriStar MPPT Coil Commands

Morningstar products that include control coils are shown in the Morningstar Device Types of Control Table above. These products will include the following types of Control Coils.

Solar Controllers

- Disable and enable charging (Force Coil OFF/ON).
- Disable and enable loads (Force Coil OFF/ON).
- Override Low Voltage Disconnect (LVD) (set only, turns on load for LVD warning duration)
- Trigger an Equalize Cycle (set only)
- Reset/reboot the processor software (set only)
- Clear faults and alarms (set only)
- Clear kWh and Ah Counters (set only)
- EEPROM Update (set only)

Relay Driver - Channel control requires the Channel Function set for "MODBUS Slave"

- Channel X OFF/ON (Force Coil OFF/ON).
- Clear faults and alarms (set only)
- Reset/reboot the processor software (set only)
- EEPROM Update (set only)

MultiWave Inverter/Charger (future release product)

For more info about Device Control Coils please see the Reference/Device Control Coils section of the Help Topics in MSView.

MODBUS Specification documents for Morningstar products include descriptions of each of the Coil Registers as well as MODBUS addresses.

[TriStar MPPT \(150V\) MODBUS Specs doc](#)

[TriStar MPPT 600V MODBUS Specs doc](#)

[TriStar \(PWM\) MODBUS Specs doc](#)

[ProStar MPPT MODBUS Specs doc](#)

[ProStar Gen3 \(PWM\) MODBUS Specs doc](#)

[SunSaver MPPT MODBUS Specs doc](#)

[SunSaver Duo MODBUS Specs doc](#)

[Relay Driver MODBUS Specs doc](#)

Slave Control

Morningstar's Slave Control is different from Control Coils in the following ways.

- Instead of simple ON/OFF or clear/reset controls, slave control takes over operational settings.
- Continuous control is required during slave operation to prevent possible issues with loss of communications.
- Slave control cannot be implemented with MSView. This requires third-party MODBUS automation control software which can send periodic write commands.

A Modbus Master device will send write commands to Morningstar controllers which include slave modes of operation. Writing to the slave control registers overrides the charge control parameters in real-time. As indicated in the Morningstar Device Types of Control Table ProStar MPPT models include one Slave MODBUS register for battery voltage regulation override and all TriStar MPPT controllers include two Slave MODBUS registers, one for battery voltage regulation override and one for battery current limit.

Download the MODBUS specifications document associated with the Morningstar controller in use to use as a reference for this section.

[TriStar MPPT \(150V\) MODBUS Specs doc](#)

[TriStar MPPT 600V MODBUS Specs doc](#)

[ProStar MPPT MODBUS Specs doc](#)

Look up the MODBUS PDU register(s) for Slave Control in the MODBUS spec docs. When a non-zero value is written to a slave control register address, the controller will automatically enter slave mode and adjust the associated operational variable to the value written to the register.

Vb_ref_slave is the variable name of the slave control register for **battery voltage regulation override**. This will override the "target voltage" which is the voltage that the controller attempts to be charged to at any given time. When not in slave mode the target voltage is based on the charge settings, current charge stage and it will be temperature compensated. Vb_ref_slave will not be temperature compensated.

Ib_ref_slave is the variable name for the slave control register for **battery current regulation override**. It acts as a battery current limit which is an absolute limit on battery charging current allowed by the controller. The TriStar MPPT controller will limit the battery charge current to its current rating unless it is programmed with custom settings with Battery Current Limit enabled.

Note that other current regulators may set a lower current reference over-riding the desired current output (e.g. heatsink hot temperature current limit). The controller will regulate current to the minimum current reference of all regulator inputs.

Once in SLAVE mode, controller operation requires the slave control register to be updated at least once per minute. If a value is not written to the register within 1 minute, the controller will fault and charging will cease until a new value is written.

The value written to the Slave Control registers must be:

- scaled correctly
- the exact regulation value (already temperature compensated if needed)
- updated at least once per minute while in slave mode

In SLAVE mode the controller surrenders the battery charging logic, including battery temperature compensation, to the system controller. However, all other functions including:

- Maximum power point tracking
- Real time diagnostics reporting (faults & alarms)
- Hardware and software protections
- Day / Night detection and transition
- data logging

are still operational and automatic, requiring no action from the system controller.

Slave control registers

Variable name	Variable description	PDU Addr	Logical Addr	Scaling
TriStar MPPT (150)				
vb_ref_slave	Battery voltage regulation override	0x0059	90	$n \cdot V_PU \cdot 2^{-15}$
lb_ref_slave	Battery current regulation override	0x0058	89	$n \cdot 80 \cdot 2^{-15}$
TriStar MPPT - 600V				
vb_ref_slave	Battery voltage regulation override	0x0059	90	Float 16
lb_ref_slave	Battery current regulation override	0x0058	105	Float 16
ProStar MPPT				
vb_ref_slave	Battery voltage regulation override	0x0025	38	Float 16

Example:

Controller: TriStar MPPT (150V)

Set the battery voltage regulation override voltage to 14.34 Volts.

Set the battery current regulation override current to 32 Amps.

Step 1: Determine scaling values

Slave control registers - TS-MPPT (150V)

TSPPT150 - Vb_ref_slave

PDU address 0x0059

Scaling $n \cdot V_PU \cdot 2^{-15} = n \cdot 180 \cdot 2^{-15}$

TSPPT150 - Ib_ref_slave PDU address 0x0058
Scaling n·80·2⁻¹⁵

Voltage Scaling Calculations:

V_PU hi register 0x0000 = 0x00B4 (180 decimal)

V_PU lo register 0x0001 = 0x0000 (0 decimal)

Voltage scaling value = V_PU hi + (V_PU lo / 2¹⁶) = 180

Current Scaling Value = 80

Note: The scaling values stored in the controller may change in future firmware versions, but they are static values that only need to be read once.

Step 2: Compute the scaled values that must be written to the Slave Control register

Target Voltage value = n·180·2⁻¹⁵ for Vb_ref_slave

Solving for [n] gives the scaled value.

Scaled Target Voltage Value = (Target Voltage x 2¹⁵) / (Voltage Scaling Value)

Scaled Target Voltage Value = (14.34 V x 32768) / 180

Scaled Target Voltage Value = 2610.51 rounded up to 2611

Scaled Target Voltage Value (hex) = 0x0A33

Target value = n·80·2⁻¹⁵ for Ib_ref_slave

Solving for [n] gives the scaled value.

Scaled Value = (Target Voltage x 2¹⁵) / (Voltage Scaling Value)

Scaled Value = (32 V x 32768) / 80

Scaled Value = 13,107.2 rounded down to 13,107

Scaled Value (hex) = 0x3333

Step 3. Send the MODBUS write command

Write the scaled value to the Slave Control register. Per the MODBUS specification, a confirmation or error response will be returned for each write command sent.

All controllers will now have a battery voltage regulation override of 14.34 Volts and a battery current regulation override of 32 Amps.