Powermax45 XP/65/85/105/125® Serial Communication Protocol

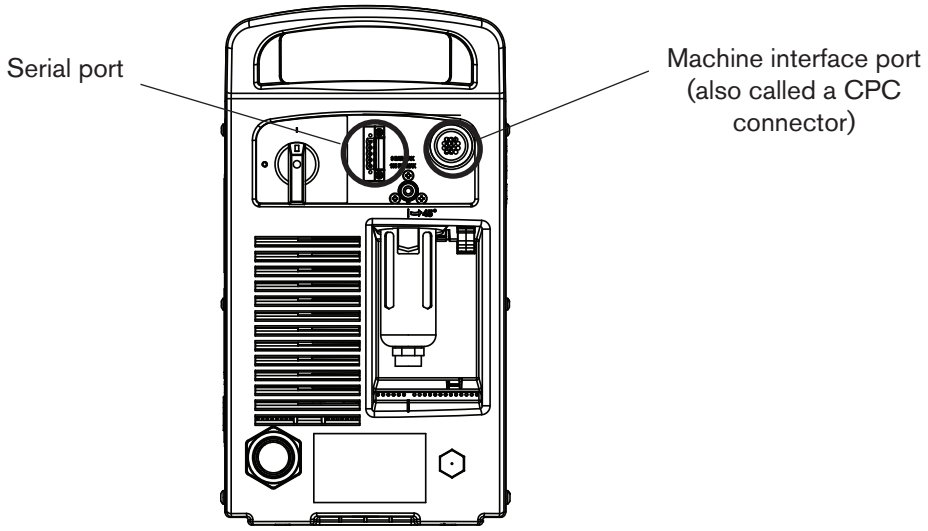
Application Note

807220 – Revision 4 – September 2016

Hypertherm®

Overview

The Powermax45 XP®, Powermax65®, Powermax85®, Powermax105®, and Powermax125® can support serial communications with a CNC. A five-pin serial port sends and receives the signals over an RS-485 connection using the ModBus ASCII serial protocol in a Master/Slave configuration. The power supplies require both the serial port and the machine interface port (CPC connector) to be installed to provide full communications capability. Both ports are located on the rear panel of the plasma supply:



Power supply hardware requirements

Machine torch

Using the Powermax in a mechanized application requires a machine torch. Either the full-length machine torch, the mini machine torch, or a robotic torch can be mounted to an X-Y table or other platform. (The Powermax45 XP does not have a mini machine torch or a robotic torch.) See the *Powermax45 XP Operator Manual* (809240), *Powermax65/ Powermax85 Operator Manual* (806650), the *Powermax105 Operator Manual* (807390), or the *Powermax125 Operator Manual* (808080) for more information on mounting a machine torch.

Communication ports

The serial port or machine interface port may not have been installed at the factory.

Serial port

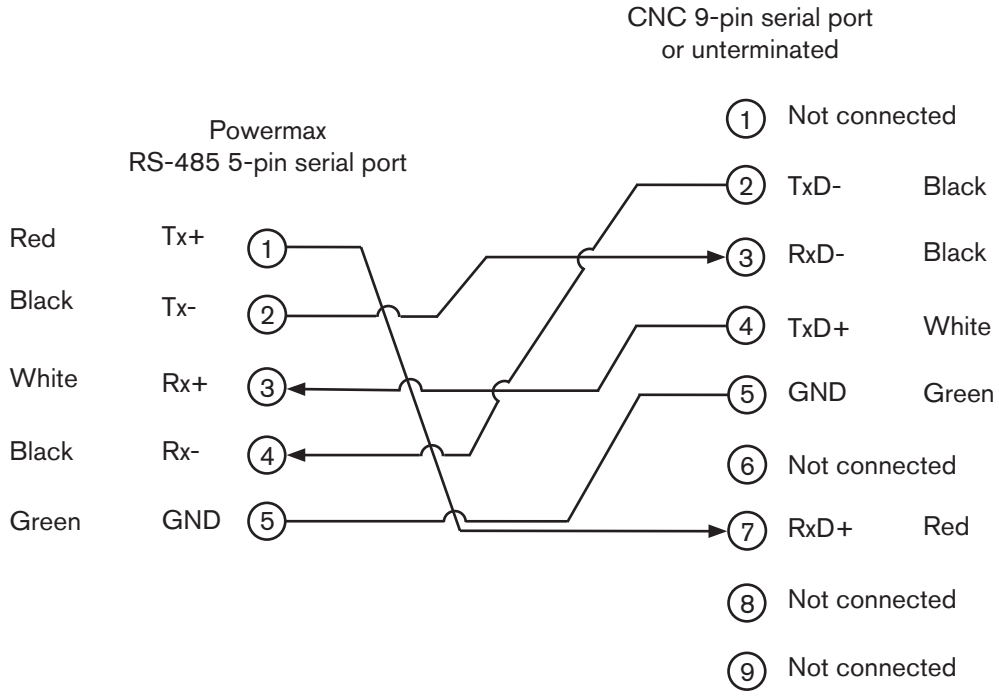
To upgrade a power supply for serial communication, order one of the following upgrade kits and cables:

- 428654 – Powermax45 XP: Serial interface port, internal cables, and RS-485 board.
- 228539 – Powermax65/85/105/125: Serial interface port, internal cables, and RS-485 board.
- Serial cables:
  - 223236 – RS-485 cable, unterminated, 25 ft / 7.6 m
  - 223237 – RS-485 cable, unterminated, 50 ft / 15 m
  - 223239 – RS-485 cable, 9-pin D-sub connector for Hypertherm controls, 25 ft / 7.6 m
  - 223240 – RS-485 cable, 9-pin D-sub connector for Hypertherm controls, 50 ft / 15 m

Serial port pin assignments

The serial port on the Powermax is a 5-pin male connector (also called a Phoenix connector). The wiring diagram below shows the signals and how they would connect to a 9-pin connector on the CNC. The 9-pin connector shown below is used on Hypertherm EDGE® Pro CNCs. Be sure to check the serial port on your CNC for the correct pin assignments.

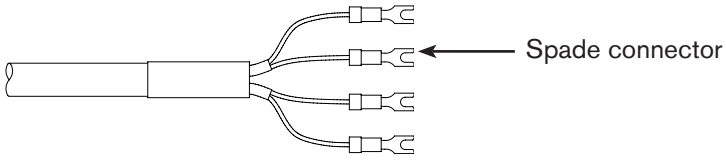
If you will be using one of the unterminated serial cables (223236 or 223237) the diagram below shows the wire colors and the signals carried on each of the wires.



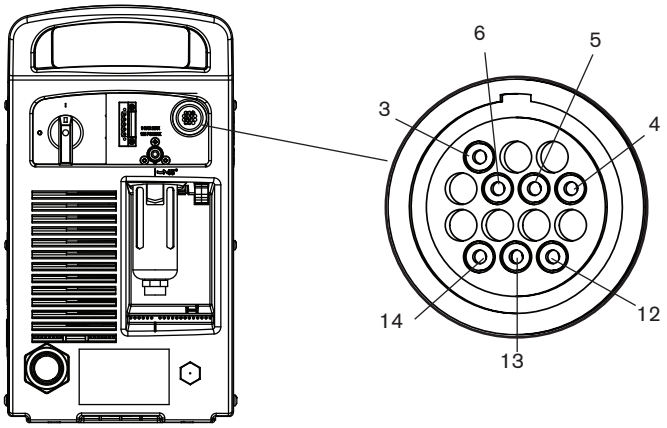
Machine interface port

The machine interface port (also called a CPC connector) gives the CNC access to arc start and transfer, and to the voltage divider. To add the machine interface port to the Powermax, order one of the following upgrade kits and cables:

- 428653 – Powermax45 XP: Machine interface port, internal cables, and voltage divider board.
- 228697 – Powermax65/85: Machine interface port, internal cables, and voltage divider board.
- 228884 – Powermax105/125: Machine interface port, internal cables, and voltage divider board.
- Cables:
  - To use the built-in voltage divider that provides an isolated, scaled down arc voltage, in addition to signals for arc transfer and plasma start:
    - 228350 – terminated with spade (fork) connectors, 25 ft / 7.6 m
    - 228351 – terminated with spade (fork) connectors, 50 ft / 15 m
    - 223354 – terminated with D-sub connector (compatible with Hypertherm's controls), 10 ft / 3.0 m
    - 223355 – terminated with D-sub connector (compatible with Hypertherm's controls), 20 ft / 6.1 m
    - 223048 – terminated with D-sub connector (compatible with Hypertherm's controls), 25 ft / 7.6 m
    - 223356 – terminated with D-sub connector (compatible with Hypertherm's controls), 35 ft / 10.7 m
    - 123896 – terminated with D-sub connector (compatible with Hypertherm's controls), 50 ft / 15 m
  - To use signals for arc transfer and plasma start only:
    - 023206 – terminated with spade (fork) connectors, 25 ft / 7.6 m
    - 023279 – terminated with spade (fork) connectors. 50 ft / 15 m



Refer to the following diagram and table when connecting the Powermax to a CNC with a machine interface cable.



Signal	Type	Notes	Connector sockets	Cable wires
Start (start plasma)	Input	Normally open. 15 VDC (Powermax45 XP) or 18 VDC (Powermax65/85/105/125) open circuit voltage at START terminals. Requires dry contact closure to activate.	3, 4	Green, black
Transfer (start machine motion)	Output	Normally open. Dry contact closure when the arc transfers. 120 VAC/1 A maximum at the machine interface relay or switching device (supplied by the customer).	12, 14	Red, black
Ground	Ground		13	
Voltage divider	Output	Divided arc signal of 20:1, 21.1:1, 30:1, 40:1, 50:1 (provides a maximum of 18 V [Powermax65/85], 15 V [Powermax105], or 16 V [Powermax45 XP, Powermax125]).	5 (-), 6 (+)	Black (-), white (+)

Serial communications with ModBus ASCII

For information on the ModBus ASCII serial protocol, please see the following documents:

- http://www.modbus.org/docs/Modbus_Application_Protocol_V1_1b.pdf
- http://www.modbus.org/docs/Modbus_over_serial_line_V1_02.pdf

The ModBus ASCII standard defines the serial frame as:

- 19200 baud
- 8 data bits
- even parity
- 1start bit
- 1 stop bit

The most significant bit is the first bit and the least significant bit is the last bit.

The ModBus data envelope is:

Start	Address	Function	Data	LRC	End
1 character	2 characters	2 characters	0 up to 2x252 characters	2 characters	2 characters
Colon :					*<CR><LF>*

Address The power supply address is set by the first valid ModBus message it receives from the CNC. The power supply uses this address until it is powered down. When it is powered up again, the power supply will not have retained the address, and will again take its address from the first valid ModBus message it receives.

Function Functions are defined in the ModBus ASCII documents referenced earlier. Examples include 04 for register read and 06 for a single register write.

Data Includes the register location, and the data being requested from the Powermax or sent to the CNC.

LRC Longitudinal Redundancy Check, a method for performing a checksum on the message.

<CR><LF> Carriage return (CR) and line feed (LF) in hexadecimal: 0x0D and 0x0A. The end characters are typically removed on incoming messages by the CNC.

ModBus Protocol The ModBus communication works in a Master/Slave configuration, where the CNC works as the Master and the Powermax system works as the Slave. The CNC must initiate a request to the Powermax. When the CNC sends a request command to the Powermax, the CNC goes into the “waiting for reply” state and starts a “response time-out.” (Hypertherm recommends a “response time-out” of 60 – 100 ms.)

If the CNC receives a reply from an unexpected slave, the “response time-out” timer keeps running. If the CNC detects an error in the received reply, it may perform a retry.

If the CNC does not receive a reply, the “response time-out” timer expires. The CNC then goes into the “idle” state and retries the request command.

The CNC can control the following Powermax operations by writing to specific input registers, also called force registers.

- Cut mode (normal, continuous pilot arc [CPA], gouge [Powermax65/85/105/125] or gouge/marking [Powermax45 XP])
- Amperage
- Gas pressure and control mode

To put the power supply into remote control mode, the CNC needs to write to the following force registers with a valid string (see the sample command string tables later in this document):

- **cut_mode_force**
- **current_set_force**
- **pressure_set_force**

While writing these registers, be aware of the following:

- You may get 0-11-*n* faults while writing these registers. These faults will clear once all the registers are set.
- The **pressure_set_force** can be zero when **cut_mode_force** and **current_set_force** are set to valid (non-zero) values. In this case, the system automatically adjusts the gas pressure based on the torch type, the length of the torch lead, and the selected cut mode.

After the CNC takes control of the power supply, the front panel controls are disabled until you exit remote mode. For the Powermax65/85/105/125, the LCD displays the remote control icon. For the Powermax45 XP, the 2-digit display shows “r.c.”

Powermax65/85/105/125

Powermax45 XP

Do either of the following to exit remote mode and return the power supply to manual control:

- Set all force registers to zero: **cut_mode_force**, **current_set_force**, and **pressure_set_force**.
- Disconnect the power supply from its power source for approximately 30 seconds. When you power the system back ON, it will no longer be in remote mode.

In remote mode, the CNC can update the force registers as needed.

Real-time updates are not recommended because system response times vary based on the application being performed and the commands being issued. Powermax systems enable you to update some control settings – such as cutting current and gas pressure – even while the torch is cutting. However, testing should be performed to make sure that system response times are adequate for your applications.

Note: You can update cut mode from the CNC but not while the torch is cutting (torch start to postflow).

The power supply responds to commands with either the ModBus function code and data, or with a ModBus exception function code followed by an error code. For a list of the ModBus function and exception codes, see http://www.modbus.org/docs/Modbus_Application_Protocol_V1_1b.pdf.

Calculating the checksum (LRC)

ModBus ASCII requires a **longitudinal redundancy check** (LRC, also called a checksum) on each message.

Note: In the example below, and throughout this document, when you see **0x**, the characters following the 0x are **hexadecimal (hex) numbers**.

To calculate the LRC:

Example: :010108080001ED*<CR><LF>* – the LRC is 0xED

Add the hex values of the message but exclude the start (:) and end characters (*<CR><LF>*) and the LRC itself:

0x01 + 0x01 + 0x08 + 0x08 + 0x00 + 0x01 = 0x13

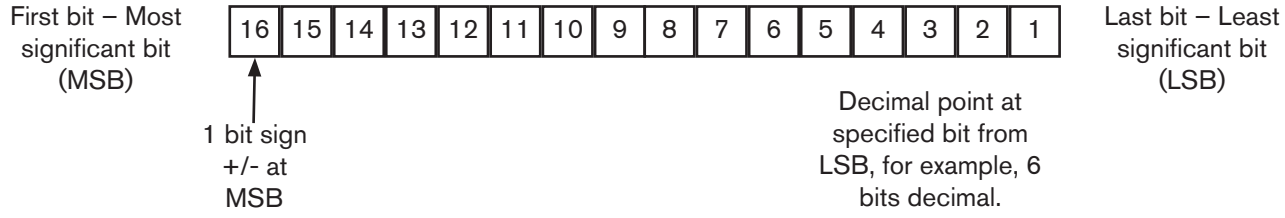
Subtract from 0xFF. When the value is less than FF, subtract the entire value: 0xFF - 0x13 = 0xEC

Add 1: 0xEC + 0x01 = 0xED

Note: When the value is more than FF, subtract the last two digits from FF. For example, when the message values equal 0x110, subtract 0x10 from FF to result in 0xEF. Complete the calculation by adding 1.

Variable scaling

In addition, Hypertherm uses variable scaling on some of the values as defined below:



Sample ModBus command string tables

The following tables show sample command strings that could be sent from the CNC and the responses from the power supply. The sample command strings show a single register write function. While the ModBus protocol allows you to write to and read multiple registers, these functions are not shown in the samples.

Command Name	Register (Hex)	Description
cut_mode_force Scaling is 16-bit, fixed-point binary with 1-bit sign at MSB and 0-bit decimal at LSB.	0x2093	Sets the cut mode to one of these values: Normal = 1 CPA = 2 Gouge = 3 Powermax45 XP: Normal mode does not apply. If you select Normal mode, the system automatically defaults to CPA mode. For Marking applications, use Gouge mode. cut_mode_force *value* :01062093xxxxcc where xxxx equals the cut mode value cc equals LRC (checksum) Samples: **Normal** :01062093000145*<CR><LF>* Response: :01062093000145 **CPA** :01062093000244*<CR><LF>* Response: :01062093000244 **Gouge** :01062093000343*<CR><LF>* Response: :01062093000343

Command Name	Register (Hex)	Description
current_set_force Scaling is 16-bit, fixed-point binary with 1-bit sign at MSB and 6 bit decimal at LSB.	0x2094	Changes the amperage setting. current_set_force *value* :01062094xxxxcc where xxxx equals the hex value of the amperage decimal multiplied by 64. cc equals LRC (checksum) Samples: **40 A** :010620940A003B*<CR><LF>* 40 A × 64 = 2560 = 0xA00 Response: :010620940A003B **45 A** :0106209400B40FA*<CR><LF>* 45 A × 64 = 2880 = 0x0B40 Response: :0106209400B40FA **65 A** :010620941040F5*<CR><LF>* 65 A × 64 = 4160 = 0x1040 Response: :010620941040F5 **85 A** :010620941540F0*<CR><LF>* 85 A ×64 = 5440 = 0x1540 Response: :010620941540F0 **105 A** :010620941A40EB*<CR><LF>* 105 A x 64 = 6720 = 0x1A40 Response: :010620941A40EB **125 A** :010620941F40E6*<CR><LF>* 125 A x 64 = 8000 = 0x1F40 Response: :010620941F40E6 Note: Assigning a value to current such as 55.5 follows the same equation: **55.5 A** :010620940DE058*<CR><LF>* 55.5 A x 64 = 3552 = 0x0DE0 Response: :010620940DE058

Command Name	Register (hex)	Description
pressure_set_force Scaling is 16-bit, fixed-point binary with 1-bit sign at MSB and 7-bit decimal at LSB.	0x2096	When pressure_set_force = 0, the gas mode is set to Automatic mode at the power supply. When pressure_set_force > 0, the CNC controls the gas pressure and the pressure controls on the power supply are disabled. pressure_set_force *value* :01062096xxxxcc Where xxxx equals the hex value of the PSI decimal value multiplied by 128 cc equals LRC (checksum) Samples: **45 PSI** :010620961680AD*<CR><LF>* 45 PSI × 128 = 5760 = 0x1680 Response: :010620961680AD **70 PSI** :01062096230020*<CR><LF>* 70 PSI × 128 = 8960 = 0x2300 Response: :01062096230020
fault_code	0x2098	Reads the fault condition. Sample: :01042098000142*<CR><LF>* Response: :010402006F8A fault_code *value* :010402xxxxcc where xxxx equals the hex value of the decimal fault code cc equals LRC (checksum) 0x006F = 111 Fault code 0-11-1 Current setting value is out of range The full set of fault codes is shown on page 11.

Command Name	Register (hex)	Description
current_set min Scaling is 16-bit, fixed-point binary with 1-bit sign at MSB and 6 bit decimal at LSB.	0x2099	Reads the minimum current setting limit for the power supply. Sample: :01042099000141*<CR><LF>* Response: :0104020500F4 current_set_min *value* :010402xxxxcc Where xxxx equals the hex value of a decimal value. Divide by 64 to get the amperage. cc equals LRC (checksum) 0x0500 = 1280 ÷ 64 = 20 The minimum current setting limit in this example = 20 A
current_set_max Scaling is 16-bit, fixed-point binary with 1-bit sign at MSB and 6 bit decimal at LSB.	0x209A	Reads the maximum current setting limit for the power supply. Sample: :0104209A000140*<CR><LF>* Response: :0104021040A9 :010402xxxxcc Where xxxx equals the hex value of a decimal value. Divide by 64 to get the amperage. cc equals LRC (checksum) 0x1040 = 4160 decimal÷ 64 = 65 The maximum current setting limit in this example = 65 A
pressure_set_min Scaling is 16-bit, fixed-point binary with 1-bit sign at MSB and 7-bit decimal at LSB.	0x209C	Reads the minimum pressure setting limit for the power supply. Sample: :0104209C00013E*<CR><LF>* Response: :0104021F805A :010402xxxxcc Where xxxx equals the hex value of the decimal value. Divide by 128 to get the PSI. cc equals LRC (checksum) 0x1F80 = 8064 decimal ÷ 128 = 63 The minimum pressure setting in this example = 63 PSI

Command Name	Register (hex)	Description
pressure_set_max Scaling is 16-bit, fixed-point binary with 1-bit sign at MSB and 7-bit decimal at LSB.	0x209D	Reads the maximum pressure setting limit for the power supply. Sample: :0104209D00013D*<CR><LF>* Response: :0104022700D2 pressure_set_max *value* :010402xxxxcc Where xxxx equals the hex value of a decimal value. Divide by 128 to get the PSI. cc equals LRC (checksum) 0x2700 = 9984 decimal ÷ 128 = 78 In this example, the maximum pressure setting limit for the power supply is 78 PSI.
arc_time_low **arc_time_high**	0x209E 0x209F	Reads the amount of time the arc has been on in seconds. The commands work together to read the upper and lower 16 bits of the 32-bit unsigned integer. Sample: :0104209E00023B*<CR><LF>* Response: 010404llllhhhhcc llll = ARC time lower 16 bits hhhh – ARC time higher 16 bits cc equals LRC (checksum) Sample responses: 1 second – :01040400010000F6 60 seconds (1 minute) - :010404003C0000BB 3600 seconds (1 hour) - :0104040E100000D9 360000 seconds (100 hour) - :0104047E40000534

<table>
<tr><th>Command Name</th><th>Register (Hex)</th><th>Description</th></tr>
<tr><td>torch_index</td><td>0x0808
0x0809

(Coils)</td><td>Reads the torch lead length. Hypertherm controls use this command to set gas pressure and load the correct cut charts.

The sample below reads the two coils.

Sample: :010108080002EC<CR><LF>

Response: :010101xxcc

Where xx equals torch length

cc equals LRC (checksum)

Torch lead length is contained in the last 2 bits of the 8-bit response value.

<table>
<tr><th>Bit 1</th><th>Bit 0</th><th>Length</th></tr>
<tr><td>0</td><td>0</td><td>15 – 25 ft (≤7.6 m)</td></tr>
<tr><td>0</td><td>1</td><td>35 – 50 ft (≤15 m)</td></tr>
<tr><td>1</td><td>0</td><td>75 ft (≤23 m)</td></tr>
</table>
Responses:

:01010100FD 15 – 25 ft (≤7.6 m)

:01010101FC 35 – 50 ft (≤15 m)

:01010102FB 75 ft (≤23 m)</td></tr>
</table>

Fault codes

The chart below summarizes some fault codes that could be returned by the power supply. For a complete list of fault codes, see the *Powermax45 XP Service Manual* (809230), *Powermax65 and Powermax85 Service Manual* (807120), the *Powermax105 Service Manual* (807580), or the *Powermax125 Service Manual* (808070). All values are decimal without the symbol "-".

Fault code	Description
0-11-0	Invalid cut mode setting
0-11-1	Current setting value is out of range
0-11-2	Gas pressure setting value is out of range
0-12-0*	Low input gas pressure
0-12-1†	Output gas pressure low
0-12-2†	Output gas pressure high
0-12-3†	Output gas pressure unstable
0-13-0	AC input unstable warning
0-19-0*	Power board hardware protection
0-19-9	Power board hardware protection (Powermax45 XP only)
0-20-0	Low gas pressure
0-21-0*	Powermax65/Powermax85: Gas flow lost while cutting Powermax105/Powermax125: Excessive arc voltage change: check consumables, gas flow
0-22-0	No gas input
0-30-0	Torch consumables stuck open
0-30-1	Torch consumables stuck closed
0-32-0*	End of consumable life (Powermax105/Powermax125 only)
0-40-0	PFC under temperature
0-40-1	PFC over temperature
0-40-2	Inverter under temperature
0-40-3	Inverter over temperature
0-50-0	Retaining cap off
0-51-0	Start/trigger signal on at power-up
0-52-0*	No torch connected to the power supply.
0-60-0	AC input voltage error – phase loss
0-60-1	AC input voltage error – voltage too low
0-60-2	AC input voltage error – voltage too high
0-61-0	AC input unstable, shutdown
0-98-0*	Internal communication error
0-99-0*	System hardware fault – service required

* Fault code does not apply for the Powermax45 XP.

† Powermax45 XP only: These 0-12-*n* fault codes display only on the CNC. They do not display on the system's front panel.

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