



# CNC Communication Protocol

EtherCAT® Commands and RS-422 Serial / Discrete Signals  
for the XPR® Cutting System

Application Note

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## Before you begin

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You must connect the XPR plasma power supply to the CNC before programming. For instructions, refer to *Connect for communication* in the instruction manual that came with your cutting system.

## EtherCAT communication

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The cutting system is set up as an EtherCAT slave device. It is configured to use the CAN application protocol over EtherCAT (CoE).

The cutting system is configured for 1 millisecond cyclic data.

The mailbox communications were tested at 5 milliseconds.

Sync manager	Sync manager address	Name	PDO address	Object number
0	1000	Mailbox Out	–	3000
1	1100	Mailbox In	–	3000
2	1200	Outputs	(RxPDO) 1600	(Control) 7000: (sub-index 1 = 16-bit)
3	1600	Inputs	(TxPDO) 1A00	(Status) 6000: (sub-index 1 = 16-bit, sub-index 2 = 32-bit, sub-index 3 = 16-bit)

### Slave device – outputs

#### Object 6000, sub-index 1 (6000:01)

- Bit 0 = Machine motion
- Bit 1 = TBD
- Bit 2 = Ready for start
- Bit 4 = Error
- Bit 5 = Process ready
- Bit 6 = Error priority level = Info
- Bit 7 = Error priority level = Alert
- Bit 8 = Ohmic contact
- Bit 9 = Remote power status
- Bit 10 = Error priority level = Error
- Bit 11 = Error priority level = Failure

### **Object 6000, sub-index 2 (6000:02)**

- 32-bit value = Arc voltage



The plasma power supply calculates the arc voltage and updates it internally over the CAN bus every 2 milliseconds. The scale for the arc voltage value is: 1425 = 142.5 V direct current (DC).

### **Object 6000, sub-index 3 (6000:03)**

- 16-bit value = System information (current error code)

## **Slave device – inputs**

### **Object 7000, sub-index 1 (7000:01)**

- Bit 0 = Plasma Start (starts a torch ignition sequence)
- Bit 1 = Hold ignition (applied at the same time as the Plasma Start, used to keep the cutting system in the Preflow state and to synchronize multiple plasma power supplies)
- Bit 2 = Pierce (applies the Pierce Gas settings)
- Bit 3 = Request new process (clear the Process Ready and Ready-for-Start bits in 6000:01)

## **Mailbox data**

### **Object 3000**

- **Sub-index 1 (3000:01)**
  - Command ID
  - Size: 32 bits
- **Sub-index 2 (3000:02)**
  - [0..7] element array of 32-bit data (data from master)
  - Size: 32 X 8 = 256 bits
- **Sub-index 3 (3000:03)**
  - Array element [0] (same array that is in sub-index 2) (this field is to get access to an individual element in the array)
  - Size: 32 bits
- **Sub-index 4 (3000:04)**
  - Array element [1]
  - Size: 32 bits

- **Sub-index 5 (3000:05)**
  - Array element [2]
  - Size: 32 bits
- **Sub-index 6 (3000:06)**
  - Array element [3]
  - Size: 32 bits
- **Sub-index 7 (3000:07)**
  - Array element [4]
  - Size: 32 bits
- **Sub-index 8 (3000:08)**
  - Array element [5]
  - Size: 32 bits
- **Sub-index 9 (3000:09)**
  - Array element [6]
  - Size: 32 bits
- **Sub-index 10 (3000:0A)**
  - Array element [7]
  - Size: 32 bits
- **Sub-index 11 (3000:0B)**
  - Command status (a value of 1 signals the control board to accept the command data)
  - Size: 32 bits
- **Sub-index 12 (3000:0C)**
  - [0..7] element array of 32-bit data (data from cutting system)
  - Size: 32X 8 = 256 bits
- **Sub-index 13 (3000:0D)**
  - Array element [0] (same array that is in sub-index 12)
  - Size: 32 bits
- **Sub-index 14 (3000:0E)**
  - Array element [1]
  - Size: 32 bits
- **Sub-index 15 (3000:0F)**
  - Array element [2]
  - Size: 32 bits
- **Sub-index 16 (3000:10)**
  - Array element [3]
  - Size: 32 bits

- **Sub-index 17 (3000:11)**
  - Array element [4]
  - Size: 32 bits
- **Sub-index 18 (3000:12)**
  - Array element [5]
  - Size: 32 bits
- **Sub-index 19 (3000:13)**
  - Array element [6]
  - Size: 32 bits
- **Sub-index 20 (3000:14)**
  - Array element [7]
  - Size: 32 bits
- **Sub-index 21 (3000:15)**
  - EtherCAT error
  - Size: 32 bits
- **Sub-index 22 (3000:16)**
  - EtherCAT warning
  - Size: 32 bits

## Beckhoff™ EtherCAT master (example)

Object 3000 and the sub-indexes:

3000:0	Command Object	RO	> 22 <
3000:01	CommandNumber	RW	0x000003E8 (1000)
3000:02	Arguments	RW	
3000:03	Cmd Arg 0	RW	0x000003E8 (1000)
3000:04	Cmd Arg 1	RW	0x000003E8 (1000)
3000:05	Cmd Arg 2	RW	0x000003E8 (1000)
3000:06	Cmd Arg 3	RW	0x000003E8 (1000)
3000:07	Cmd Arg 4	RW	0x000003E8 (1000)
3000:08	Cmd Arg 5	RW	0x000003E8 (1000)
3000:09	Cmd Arg 6	RW	0x000003E8 (1000)
3000:0A	Cmd Arg 7	RW	0x000003E8 (1000)
3000:0B	CommandStatus	RW	0x000003E8 (1000)
3000:0C	ReturnVal	RW	

Object 3000, sub-index 1 (3000:01), CommandNumber 760:

Index	Name	Flags	Value
1C13:0	SM3 PDO Assignment	RO	> 1 <
3000:0	Command Object	RO	> 22 <
3000:01	CommandNumber	RW	0x000002F8 (760)
3000:02	Arguments	RW	
3000:03	Cmd Arg 0	RW	0x000003E8 (1000)
3000:04	Cmd Arg 1	RW	0x000003E8 (1000)
3000:05	Cmd Arg 2	RW	0x000003E8 (1000)
3000:06	Cmd Arg 3	RW	0x000003E8 (1000)
3000:07	Cmd Arg 4	RW	0x000003E8 (1000)
3000:08	Cmd Arg 5	RW	0x000003E8 (1000)
3000:09	Cmd Arg 6	RW	0x000003E8 (1000)
3000:0A	Cmd Arg 7	RW	0x000003E8 (1000)
3000:0B	CommandStatus	RW	0x000003E8 (1000)

Set Command Status (3000:0B) equal to 1 to signal the cutting system to execute the Command Number.

Data returned from the cutting system shows in 3000:0D – 3000:14.

Index	Name	Flags	Value
3000:09	Cmd Arg 6	RW	0x000003E8 (1000)
3000:0A	Cmd Arg 7	RW	0x000003E8 (1000)
3000:0B	CommandStatus	RW	0x00000000 (0)
3000:0C	ReturnVal	RW	
3000:0D	Ret Val 0	RW	0x00000043 (67)
3000:0E	Ret Val 1	RW	0x00000030 (48)
3000:0F	Ret Val 2	RW	0x00000030 (48)
3000:10	Ret Val 3	RW	0x00000030 (48)
3000:11	Ret Val 4	RW	0x00000030 (48)
3000:12	Ret Val 5	RW	0x00000000 (0)
3000:13	Ret Val 6	RW	0x00000000 (0)
3000:14	Ret Val 7	RW	0x00000000 (0)
3000:15	SysError	RW	0x00000000 (0)

Objects 6000 and 7000 with sub-indexes:

1C00:0	SM Communication Type	RO	> 4 <
1C12:0	SM2 PDO Assignment	RO	> 1 <
1C13:0	SM3 PDO Assignment	RO	> 1 <
3000:0	Command Object	RO	> 22 <
6000:0	PlasmaOutputs	RO	> 2 <
6000:01	Plasma_Out	RW	0x0026 (38)
6000:02	ArcVoltage	RW	0x00000000 (0)
7000:0	PlasmaInputs	RO	> 1 <
7000:01	Plasma_In	RW	0x0000 (0)

The Set Value Dialog screen shows the binary value of 3000:0C:

The screenshot displays a software interface with a 'Set Value Dialog' window open. The dialog contains the following fields and controls:

- Dec:** An empty text input field with an 'OK' button to its right.
- Hex:** An empty text input field with a 'Cancel' button to its right.
- Float:** An empty text input field.
- Bool:** Two radio buttons labeled '0' and '1', with a 'Hex Edit...' button to the right.
- Binary:** A text input field containing the binary sequence '81 04 00 00 00 00 00 00 00 00 00 00 00 00 00 00' and a '32' value to its right.
- Bit Size:** A set of radio buttons for '1', '8', '16', '32', '64', and '?', with '32' selected.

In the background, a table lists data points for '3000:0A' through '3000:16'. The table has columns for 'ex', 'Name', 'Flags', and 'Value'.

ex	Name	Flags	Value
3000:0A	Cmd Arg 7	RW	0x000003E8 (1000)
3000:0B	CommandStatus	RW	0x00000000 (0)
3000:0C	ReturnVal	RW	
3000:0D	Ret Val 0	RW	0x00000481 (1153)
3000:0E	Ret Val 1	RW	0x00000000 (0)
3000:0F	Ret Val 2	RW	0x00000000 (0)
3000:10	Ret Val 3	RW	0x00000000 (0)
3000:11	Ret Val 4	RW	0x00000000 (0)
3000:12	Ret Val 5	RW	0x00000000 (0)
3000:13	Ret Val 6	RW	0x00000000 (0)
3000:14	Ret Val 7	RW	0x00000000 (0)
3000:15	SysError	RW	0x00000000 (0)
3000:16	SysWam	RW	0x000003E8 (1000)

## Object dictionary

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### Write data

<b>Index 0x3100:</b>	<b>Set process</b>
<b>Sub-index:</b>	0x01 Process ID
	0x02 Current override (in amperage – A)
	0x03 Plasma cutflow override (psi)
	0x04 Shield cutflow override (psi)
	0x05 Shield pierceflow override (psi)
	0x06 H <sub>2</sub> override (slpm)
	0x07 Argon override (slpm)
	0x08 N <sub>2</sub> override (slpm)
<b>Index 0x3101:</b>	<b>System modes</b>
<b>Sub-index:</b>	0x01 Mode
	1 = Test pierceflow
	2 = Test cutflow
	3 = Test preflow
	4 = Leak check
	5 = Set pump timeout to 1440 minutes
	6 = Interface (RS-422, EtherCAT, or WiFi) will release control of system
	0x02 On/Off
	0 = Off
	1 = On
	0x03 Rampdown error protection enable
	0 = Off
	1 = On
	2 = No change
	0x04 Torch protection enable
	0 = Disable
	1 = Enable
<b>Index 0x3102:</b>	<b>Clear alerts</b>
<b>Sub-index:</b>	0x01 Clear
	0 = No change
	1 = Clear

## **Read data**

**Index 0x3200: Process data**

- Sub-index:**
- 0x01 Process ID
  - 0x02 Current override (in amperage – A)
  - 0x03 Plasma cutflow override (psi)
  - 0x04 Shield cutflow override (psi)
  - 0x05 Shield pierceflow override (psi)
  - 0x06 H<sub>2</sub> override (slpm)
  - 0x07 Argon override (slpm)
  - 0x08 N<sub>2</sub> override (slpm)

**Index 0x3201: Modes**

- Sub-index:**
- 0x01 Active mode
    - 1 = Test pierceflow
    - 2 = Test cutflow
    - 3 = Test preflow
    - 4 = Leak check
    - 5 = Set pump timeout to 1440 minutes
    - 6 = Interface (RS-422, EtherCAT, or WiFi) will release control of system
  - 0x02 RDE protection
    - 1 = Enabled
    - 0 = Disabled
  - 0x03 Torch protection
    - 1 = Enabled
    - 0 = Disabled

**Index 0x3202: Chopper 1 data**

- Sub-index:**
- 0x01 Setpoint (in amperage – A)
  - 0x02 Actual (in amperage – A)
  - 0x03 Temperature (X 10°C. Example: 253 = 25.3°C)
  - 0x04 Bus voltage (volts)
  - 0x05 Arc voltage (volts)

**Index 0x3203: Chopper 2 data**

- Sub-index:**
- 0x01 Setpoint (in amperage – A)
  - 0x02 Actual (in amperage – A)
  - 0x03 Temperature (X 10°C. Example: 253 = 25.3°C)

<b>Index 0x3210:</b>	<b>Torch connect console (TCC) data</b>
<b>Sub-index:</b>	0x01 Line A setpoint (psi)
	0x02 Line A actual (psi)
	0x03 Line A type (Refer to <a href="#">Gas type codes</a> on page 66.)
	0x04 Line A inlet (psi)
	0x05 Line A duty (% on)
	0x06 Line B setpoint (psi)
	0x07 Line B actual (psi)
	0x08 Line B type (Refer to <a href="#">Gas type codes</a> on page 66.)
	0x09 Line B inlet (psi)
	0x0a Line B duty (% on)
	0x0b Shield setpoint (psi)
	0x0c Shield actual (psi)
	0x0d Shield type (Refer to <a href="#">Gas type codes</a> on page 66.)
	0x0e Shield inlet (psi)
	0x0f Shield duty (% on)
	0x10 Valve states
	Bit 0: V1
	Bit 1: V2
	Bit 2: V3
	Bit 3: V4
	Bit 4: V5
	Bit 5: V6
	Bit 6: V7
	Bit 7: V8
	Bit 8: V9
	Bit 9: V10
	Bit 10: V11
	Bit 11: V12

<b>Index 0x3211:</b>	<b>Gas connect console (GCC) data</b>
<b>Sub-index:</b>	0x01 F5 setpoint (psi)
	0x02 F5 actual (psi)
	0x03 F5 inlet (psi)
	0x04 F5 duty (% on)
	0x05 H <sub>2</sub> O setpoint (psi)
	0x06 H <sub>2</sub> O actual (psi)
	0x07 H <sub>2</sub> O inlet (psi)
	0x08 H <sub>2</sub> O duty (% on)
	0x09 H <sub>2</sub> setpoint (psi)
	0x0a H <sub>2</sub> actual (psi)
	0x0b H <sub>2</sub> inlet (psi)
	0x0c H <sub>2</sub> duty cycle (% on)

- 0x0d Argon setpoint (psi)
- 0x0e Argon actual (psi)
- 0x0f Argon inlet (psi)
- 0x10 Argon duty cycle (% on)
- 0x11 N<sub>2</sub> setpoint (psi)
- 0x12 N<sub>2</sub> actual (psi)
- 0x13 N<sub>2</sub> inlet (psi)
- 0x14 N<sub>2</sub> duty cycle (% on)
- 0x15 Mix outlet pressure (psi)

**Index 0x3220:**

**Main control PCB data**

**Sub-index:**

- 0x01 Coolant flow (X 100 gal/min. Example: 183 = 1.83 gal/min)
- 0x02 Coolant temperature (X 10°C. Example: 253 = 25.3°C)
- 0x03 Coolant level (1 = level good)
- 0x04 Transformer temperature (X 10°C. Example: 253 = 25.3°C)
- 0x05 Inductor 1 temperature (X 10°C. Example: 253 = 25.3°C)
- 0x06 Inductor 2 temperature (X 10°C. Example: 253 = 25.3°C)
- 0x07 Inductor 3 temperature (X 10°C. Example: 253 = 25.3°C)
- 0x08 Inductor 4 temperature (X 10°C. Example: 253 = 25.3°C)
- 0x09 Fan tach 1 (rpm)
- 0x0a Fan tach 2 (rpm)
- 0x0b Fan tach 3 (rpm)
- 0x0c Fan tach 4 (rpm)
- 0x0d Fan tach 5 (rpm)
- 0x0e Fan tach 6 (rpm)
- 0x0f Discrete I/O
  - Bit 0: System On input
  - Bit 1: Start input
  - Bit 2: Hold input
  - Bit 3: Pierce input
  - Bit 4: Main Contactor output
  - Bit 5: Pump Enable output
  - Bit 6: Coolant Solenoid output
  - Bit 7: Fan output
  - Bit 8: Heat Exchanger Fan output
  - Bit 9: Ready-for-Start output
  - Bit 10: Auto-Pierce Detect output
  - Bit 11: Ohmic Contact output
  - Bit 12: CNC Motion output
  - Bit 13: CNC Hold output
  - Bit 14: CNC Error output
- 0x10 Process current (in amperage – A)
- 0x11 Display current (in amperage – A)

**Index 0x3230:****System status****Sub-index:**

0x01 System config

XPR 300 Core = 33

XPR 300 CorePlus = 40

XPR 300 VWI = 34

XPR 300 OptiMix = 36

0x02 System ID

XPR 300 Core = 33

XPR 300 CorePlus = 40

XPR 300 VWI = 34

XPR 300 OptiMix = 36

0x03 System state (Refer to [State codes](#) on page 65.)0x04 System error ID (Refer to [Code descriptions](#) on page 72.)

0x05 System error priority

Info = 0

Alert = 1

Error = 2

Failure = 3

0x06 System error data 1

0x07 System error data 2

0x08 Arc time (seconds)

0x09 On time (seconds)

0x0a MAC address (4 bytes) (each byte is an ASCII character)

0x0b IP address (4 bytes) (each byte is an integer)

0x0c Controlling source

No controlling source = 0

EtherCAT = 1

WiFi = 2

Internal control = 4

RS-422 = 5

Discrete control = 6

**Index 0x3231:****Revisions****Sub-index:**

0x01 Main control PCB revision (32-16: major ASCII character, 15-0 minor integer)

0x02 Torch connect revision (32-16: major ASCII character, 15-0 minor integer)

0x03 Gas connect revision (32-16: major ASCII character, 15-0 minor integer)

0x04 Chopper 1 revision (32-16: major ASCII character, 15-0 minor integer)

0x05 Chopper 2 revision (32-16: major ASCII character, 15-0 minor integer)

0x06 WiFi revision (32-0 major integer)

0x07 Database revision (32-0 major ASCII character)

<b>Index 0x3232:</b>	<b>Code count</b>
<b>Sub-index:</b>	0x01 Active count (integer) 0x02 Log count (integer)
<b>Index 0x3250-0x326f:</b>	<b>Active errors, up to 32</b>
<b>Sub-index:</b>	0x01 Class ID (32-16 Class, 15-0 ID) (Class: 0 = Info, 1 = Alert, 2 = Error, 3 = Failure) Refer to <a href="#">Code descriptions</a> on page 72 for ID. 0x02 Timestamp (time in seconds) 0x03 Data 1 0x04 Data 2
<b>Index 0x3280-0x329f:</b>	<b>Error log, up to 32</b>
<b>Sub-index:</b>	0x01 Class ID (32-16 Class, 15-0 ID) (Class: 0 = Info, 1 = Alert, 2 = Error, 3 = Failure) Refer to <a href="#">Code descriptions</a> on page 72 for ID. 0x02 Timestamp (time in seconds) 0x03 Data 1 0x04 Data 2

## CNC interface hardware

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The XPR plasma power supply uses a combination of the following signals and commands to communicate with the CNC:

- Discrete signals (Refer to [Discrete signals](#) on page 17.)
- RS-422 serial commands (Refer to [Serial RS-422 commands](#) on page 20.)

### Discrete signals

Signal name	Type	Description / meaning
Plasma Start	Input	Starts the plasma power supply, which causes ignition of the arc.
Machine Motion	Output	Identifies that the arc transferred to the workpiece.
Hold Ignition	Input	Keeps the plasma power supply in Preflow state and prevents torch ignition. Apply this signal at the same time as the Plasma Start signal. Used to keep multiple plasma power supplies synchronized.
System Error	Output	The plasma power supply has information available to read. Use serial commands to query for a specific code number.
Shield Pierce Gas	Input	Causes the plasma power supply to use shield pierce settings for piercing. When the Pierce Complete signal occurs, the plasma power supply changes to shield cutflow gases. Apply this signal at the same time as the Plasma Start signal. Remove this signal after the pierce delay time has elapsed. Refer to the XPR cut charts for the time value.
Remote Power	Input	Supplies power and removes power from the cutting system.
Ready for Start	Output	The plasma power supply is ready for the Plasma Start signal. This output has no effect during plasma power supply purges and in Test Gas mode.
Ohmic Contact	Output	The torch is touching the workpiece.
TX +	Serial	Transmitting from the plasma power supply. Connect to CNC RX + .
TX -	Serial	Transmitting from the plasma power supply. Connect to CNC RX - .
RX +	Serial	Receiving by the plasma power supply. Connect to CNC TX + .
RX -	Serial	Receiving by the plasma power supply. Connect to CNC TX - .

## Discrete signal hardware

- Inputs are optically isolated. They require 24 VDC at 12.5 mA or dry contact closure at 8 mA.
- Outputs are optically isolated, open collector transistors. The maximum rating is 24 VDC at 10 mA.
- The Hold signal is both an input and an output. It is usually used as an input. It can be used as an output to connect multiple plasma power supplies and make their operation synchronized.
- Serial RS-422 serial communication or the XPR web interface is required with discrete signal hardware to fully operate the cutting system.

## Serial RS-422 multi-drop (multi-system) addressing

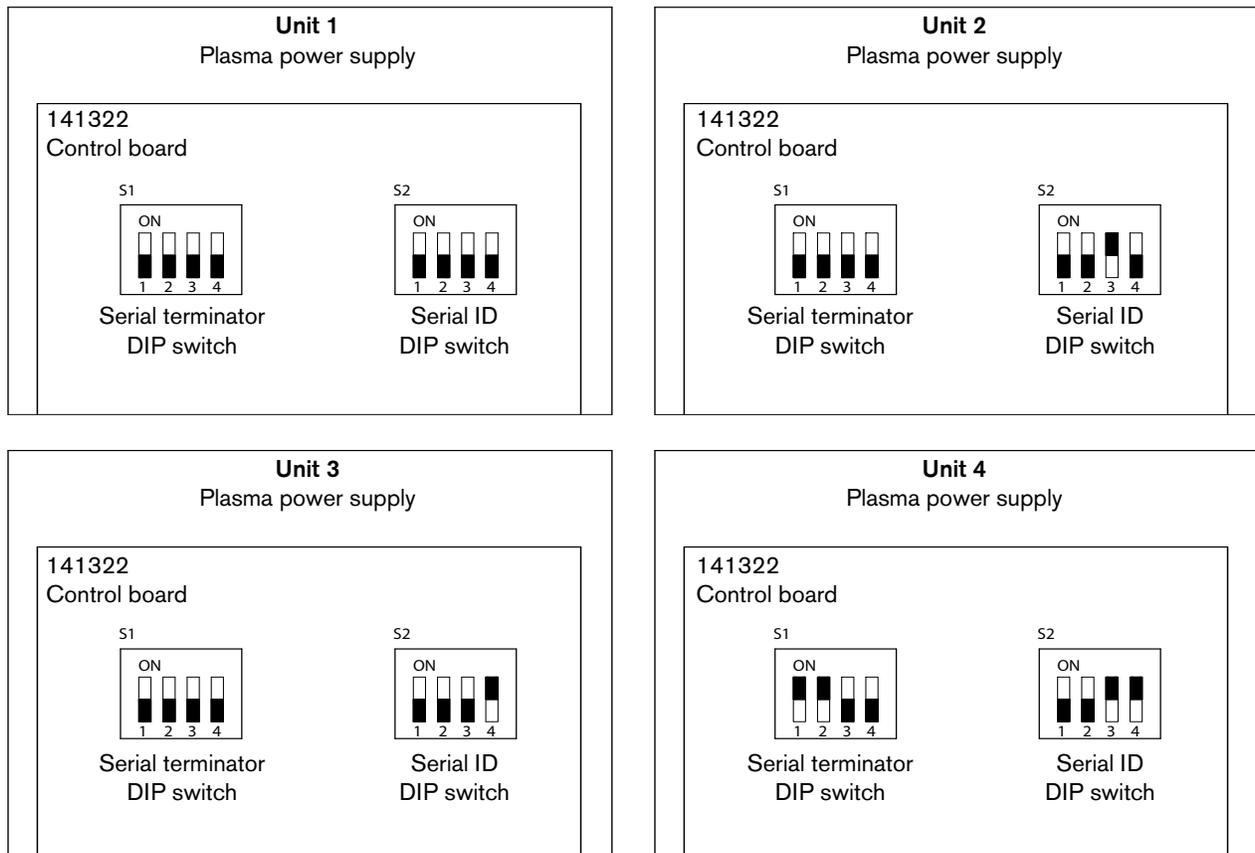
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- For single plasma power supply installations, set Serial terminators (S1) as shown in Unit 4 and Serial IDs (S2) as shown in Unit 1. Refer to [Figure 1](#) on page 19.
- For multi-plasma power supply installations, switch S1 position 1 and position 2 are OFF in all plasma power supplies except for the last one where they are set to ON. Refer to [Figure 1](#) on page 19.

Termination resistors (120  $\Omega$ ) or termination jumpers must be installed and set at the CNC for each of the RS-422 RX and TX signal pairs.

- If a Hypertherm CNC is used and there are intermittent communication failures (PS Link Failure), try reversing switch S1 position 1 and position 2 on the control board, and the termination jumper (J6 or J8) on the serial isolation board in the controller. Only remove the termination jumper on the serial isolation board that is connected to the plasma power supply.
- For complete wiring diagrams of the plasma power supply, refer to the *XPR170™ Instruction Manual* (810060) or the *XPR300™ Instruction Manual* (809480). Technical documentation is available at [www.hypertherm.com/docs](http://www.hypertherm.com/docs).

Figure 1 – Serial RS-422 multi-drop (multi-system) addressing



## Multi-drop (multi-system) interface

Use the multi-drop (multi-system) interface from the CNC to do the following:

1. Send the **sleep** command (758). This puts all the plasma power supplies into sleep mode.
2. Send the **wake** command (759) and the ID number for the plasma power supply that you want to use. The active plasma power supply can now receive any command.
3. Send the necessary or commands to the active plasma power supply.
4. After you send the last command to the active plasma power supply, return to step 1 to communicate with the next plasma power supply.

## Serial RS-422 communications

---

### Serial RS-422 signals

Signal name	Description / meaning
TX +	Transmitting from the plasma power supply. Connect to CNC RX + .
TX -	Transmitting from the plasma power supply. Connect to CNC RX - .
RX +	Receiving by the plasma power supply. Connect to CNC TX + .
RX -	Receiving by the plasma power supply. Connect to CNC TX - .

### Serial RS-422 commands

#### Command format

- ASCII-based protocol
- Baud 115200
- 8 data bits
- 1 stop bit
- No parity
- No flow control

#### Command framing

- > = Start of message
- 3-byte command ID
- Data (space following each data field [ASCII 0x20])
- c = end of data and start of checksum
- 2-byte checksum
- < = End of message

Example: >6091004 c84<

## Command results

The results to serial RS-422 commands include the ID for the command, unless there is an error in the command. If there is a command error, the result is an error response. Refer to the following command error results.

<b>Serial RS-422 bad checksum result</b>	
Return ID:	500
Description:	The serial command did not have the correct checksum.
Example:	Command: >000 cB1 < (in this example, the checksum should be B0, not B1)
	Result: >500c95< (command)
<b>Serial RS-422 bad command result</b>	
Return ID:	501
Description:	The serial command was not recognized.
Example:	Command: >999cCB< (unknown ID)
	Result: >501c96< (bad command)
<b>Bad command format</b>	
Return ID:	502
Description:	The > or < is missing from the serial command.
Example:	Command: 000 cB1 <
	Result: >502 c97<
<b>Access denied</b>	
Return ID:	503
Description:	Only 1 interface (RS-422, EtherCAT, or web interface) can control the system. Once a process is set by EtherCAT, the cutting system will not accept a process setting from an RS-422 interface or the web interface.
Example:	>503c98<
<b>Invalid data</b>	
Return ID:	504
Description:	The data in the serial command is not valid for that command (such as a bad process ID).
Example:	>504c99<

## How checksums are calculated for serial RS-422 commands

Checksum are only calculated for XPR serial RS-422 command IDs and command data. Refer to the following for examples.

HELLO command: >000 cB0<

- 0 = 0x30 (ASCII value for number 0)
- 0 = 0x30
- 0 = 0x30
- Space = 0x20
- Checksum = 0x30 + 0x30 + 0x30 + 0x20 = 0xB0

## Serial RS-422 guidelines

### Do a check of the checksum

The serial RS-422 cable between the plasma power supply and the CNC uses a communication protocol that contains a checksum for each message.

Do a check of the checksum for all messages to make sure that the information is not corrupt.

### Send an unacknowledged message again

High frequency can cause interference with serial RS-422 communications, especially when high-frequency is active.

If the plasma power supply does not acknowledge a message, resend the message when high frequency is inactive.

### Shield the serial RS-422 cable

Some plasma power supplies use metal shell (DB style) serial RS-422 interface cables. This type of cable has good electromagnetic interference (EMI) shielding capabilities.

For the best EMI shielding outcomes, use a serial RS-422 interface cable that has the following properties:

- Has 360° shield termination on both ends of the cable
- Is as short as possible
- No coils
- Metal shell



A drain-wire alone cannot give sufficient EMI shielding. Do regular maintenance to keep the integrity of the shielding.

## Serial RS-422 and EtherCAT commands

ID	Command	System	Description / meaning
000	<i>Hello</i>	XPR RS-422	Establishes communication with the plasma power supply. Use this command to identify the plasma power supply that you want to control.
			Data: none
			Return value: string identifying the plasma power supply
			RS-422 example: >000 cB0< >000XPR300 OptiMix c27< >000XPR170 OptiMix c2C<
602	<i>Read fault code (replaced with Command Number 780)</i>	XPR RS-422 EtherCAT	Gets the fault code for the latest system error.
			Data: none
			Return value: error code
			RS-422 example: >602 cB8< >602188 c59< (error code 188)
603	<i>Read state</i>	XPR RS-422 EtherCAT	Gets the current state of the plasma system.
			Data: none
			Return value: status code
			RS-422 example: >603 cB9< >6035 cEE< (status code 5)
			EtherCAT: X3000: 01 = 603 X3000: 0B = 1 (signal power source to act) X3000: 0D = 5 (status code)

ID	Command	System	Description / meaning
608	Read process ID	XPR	Reads the process ID number.
		RS-422	Data: none
		EtherCAT	Return value: process ID
			RS-422 example: (RS-422 does not return the offset values. Refer to command ID 795 to query for the offset values) >608 cBE< >6081005 c84< (process ID = 1005)
			EtherCAT: X3000: 01 = 608 X3000: 0B = 1 (signal power source to act) X3000: 0D = 1005 (process ID) X3000: 0E = 85 [Cut current overrides value. If no override is set, the value is (0)] X3000: 0F = 72 [Plasma cutflow psi overrides value. If no override is set, the value is (0)] X3000: 10 = 50 [Shield cutflow psi overrides value. If no override is set, the value is (0)] X3000: 11 = 6 [H <sub>2</sub> slpm overrides value. If no override is set, the value is (0)] X3000: 12 = 22 [N <sub>2</sub> slpm overrides value. If no override is set, the value is (0)] X3000: 13 = 10 [Argon (Ar) slpm overrides value. If no override is set, the value is (0)] X3000: 14 = 17 [Shield pierce psi overrides value. If no override is set, the value is (0)]
609	Write process ID	XPR	Writes the process ID.
		RS-422	Data: process ID
		EtherCAT	Return value:609 if accepted; 504 if not accepted (RS-422 only) (no Return value for EtherCAT)
			RS-422 example: >6091004 c84< (process ID 1004) >609c9F< (if successful) >504c99< (if not successful)
			EtherCAT: X3000: 01 = 609 X3000: 03 = 1004 (process ID) X3000: 0B = 1 (signal power source to act)

ID	Command	System	Description / meaning
611	<i>Read system type</i> (replaced with Command ID 777)	XPR RS-422 EtherCAT	Reads the system type code.
			Data: none
			Return value: System type code: Core = 33 CorePlus = 40 VWI = 34 OptiMix = 36
			RS-422 example: >611 cB8< >61134 c1F<
615	<i>Read Chopper 1 temperature</i>	XPR RS-422 EtherCAT	Reads the temperature for Chopper 1.
			Data: none
			Return value: temperature in degrees Celsius, scaled X 10
			RS-422 example: >615 cBC< >615246 c58< (24.6°C)
616	<i>Read Chopper 1 current</i>	XPR RS-422 EtherCAT	Reads the current for Chopper 1.
			Data: none
			Return value: current in amperage (A)
			RS-422 example: >616 cBD< >61685 c2A< (85 A)
619	<i>Read Chopper 2 temperature</i>	XPR RS-422 EtherCAT	Reads the temperature for Chopper 2.
			Data: none
			Return value: temperature in degrees Celsius, scaled X 10
			RS-422 example: >619 cC0< >619253 c5A< (25.3°C)
			EtherCAT: X3000: 01 = 619 X3000: 0B = 1 (signal power source to act) X3000: 0D = 253 (25.3°C)

<b>ID</b>	<b>Command</b>	<b>System</b>	<b>Description / meaning</b>
620	<i>Read Chopper 2 current</i>	XPR RS-422 EtherCAT	Reads the current for Chopper 2.
			Data: none
			Return value: current in amperage (A)
			RS-422 example: >620 cB8< >62010 c19< (10 A)
			EtherCAT: X3000: 01 = 620 X3000: 0B = 1 (signal power source to act) X3000: 0D = 10 (A)
624	<i>Read coolant flow rate</i>	XPR RS-422 EtherCAT	Reads the flow rate for the coolant.
			Data: none
			Return value: flow rate in U.S. gallons per minute (gal/min), scaled X 100 Example: 175 = 1.75 gal/min
			RS-422 example: >624 cBC< >624187 c5C< (1.87 gal/min)
			EtherCAT: X3000: 01 = 624 X3000: 0B = 1 (signal power source to act) X3000: 0D = 187 (1.87 gal/min)
625	<i>Read coolant temperature</i>	XPR RS-422 EtherCAT	Reads the coolant temperature.
			Data: none
			Return value: temperature in degrees Celsius, scaled X 10
			RS-422 example: >625 cBD< >625255 c59< (25.5°C)
			EtherCAT: X3000: 01 = 625 X3000: 0B = 1 (signal power source to act) X3000: 0D = 255 (25.5°C)

ID	Command	System	Description / meaning
626	<i>Read transformer temperature</i>	XPR RS-422 EtherCAT	Reads the temperature for the main transformer.
			Data: none
			Return value: temperature in degrees Celsius, scaled X 10
			RS-422 example: >626 cBE< >626226 c58< (22.6°C)
			EtherCAT: X3000: 01 = 626 X3000: 0B = 1 (signal power source to act) X3000: 0D = 226 (22.6°C)
627	<i>Read work lead current</i>	XPR RS-422 EtherCAT	Reads the current in the work lead (maximum value is 260 A).
			Data: none
			Return value: current in amperage (A)
			Example: >627 cBF< >6270 cEF< 0 (A)
			EtherCAT: X3000: 01 = 627 X3000: 0B = 1 (signal power source to act) X3000: 0D = 170 (A)
634	<i>Read actual Plasma A pressure</i>	XPR RS-422 EtherCAT	Reads the pressure in Plasma Line A.
			Data: none
			Return value: pressure in pounds/square inch (psi)
			Example: >634 cBD< >63415 c23< (15 psi)
			EtherCAT: X3000: 01 = 634 X3000: 0B = 1 (signal power source to act) X3000: 0D = 15 (psi)
635	<i>Read actual Plasma B pressure</i>	XPR RS-422 EtherCAT	Reads the pressure in Plasma Line B.
			Data: none
			Return value: pressure in pounds/square inch (psi)
			Example: >635 cBE< >63515 c24< 15 (psi)
			EtherCAT: X3000: 01 = 635 X3000: 0B = 1 (signal power source to act) X3000: 0D = 15 (psi)

<b>ID</b>	<b>Command</b>	<b>System</b>	<b>Description / meaning</b>
636	<i>Read actual shield pressure</i>	XPR RS-422 EtherCAT	Reads the shield gas pressure.
			Data (space delimited): none
			Returned value: pressure in pounds/square inch (psi)
			Example: >636 cBF< >6365 cF4< 5 (psi)
			EtherCAT: X3000: 01 = 636 X3000: 0B = 1 (signal power source to act) X3000: 0D = 5 (psi)
659	<i>Read Inductor 1 temperature</i>	XPR RS-422 EtherCAT	Reads the temperature of Inductor 1.
			Data: none
			Return value: temperature in degrees Celsius, scaled X 10
			Example: >659 cC4< >659226 c5E< (22.6°C)
			EtherCAT: X3000: 01 = 659 X3000: 0B = 1 (signal power source to act) X3000: 0D = 226 (22.6°C)
660	<i>Read Inductor 2 temperature</i>	XPR RS-422 EtherCAT	Reads the temperature for Inductor 2.
			Data: none
			Return value: temperature in degrees Celsius, scaled X 10
			Example: >660 cBC< >660225 c55< (22.5°C)
			EtherCAT: X3000: 01 = 660 X3000: 0B = 1 (signal power source to act) X3000: 0D = 225 (22.5°C)
661	<i>Read Inductor 3 temperature</i>	XPR RS-422 EtherCAT	Reads the temperature for Inductor 3.
			Data: none
			Return value: temperature in degrees Celsius, scaled X 10
			Example: >661 cBD< >661225 c56< (22.5°C)
			EtherCAT: X3000: 01 = 661 X3000: 0B = 1 (signal power source to act) X3000: 0D = 225 (22.5°C X 10)

ID	Command	System	Description / meaning
662	<i>Read Inductor 4 temperature</i>	XPR RS-422 EtherCAT	Reads the temperature for Inductor 4.
			Data: none
			Return value: temperature in degrees Celsius, scaled X 10
			Example: >662 cBE< >662225 c57< (22.5°C)
			EtherCAT: X3000: 01 = 662 X3000: 0B = 1 (signal power source to act) X3000: 0D = 225 (22.5°C X 10)
665	<i>Read bus voltage</i>	XPR RS-422 EtherCAT	Reads the direct current (DC) bus voltage.
			Data: none
			Return value: voltage in volts (V)
			Example: >665 cC1< >665352 c5B< (352 VDC)
			EtherCAT: X3000: 01 = 665 X3000: 0B = 1 (signal power source to act) X3000: 0D = 352 (VDC)
666	<i>Read Line A inlet</i>	XPR RS-422 EtherCAT	Reads the inlet pressure for Line A.
			Data: none
			Return value: pressure in pounds/square inch (psi)
			Example: >666 cC2< >66645 c5D< (45 psi)
			EtherCAT: X3000: 01 = 666 X3000: 0B = 1 (signal power source to act) X3000: 0D = 45 (psi)
667	<i>Read Line B inlet</i>	XPR RS-422 EtherCAT	Reads the inlet pressure for Line B.
			Data: none
			Return value: pressure in pounds/square inch (psi)
			Example: >667 cC3< >66745 c5D< (45 psi)
			EtherCAT: X3000: 01 = 667 X3000: 0B = 1 (signal power source to act) X3000: 0D = 45 (psi)

<b>ID</b>	<b>Command</b>	<b>System</b>	<b>Description / meaning</b>
668	<i>Read coolant level</i>	XPR RS-422 EtherCAT	Reads the sensor that monitors coolant level.
			Data: none
			Return value: 1 = level sufficient; 0 = level low
			Example: >668 cC4< >6681 cF5< (level sufficient)
			EtherCAT: X3000: 01 = 668 X3000: 0B = 1 (signal power source to act) X3000: 0D = 1 (level sufficient)
669	<i>Read WiFi MAC address</i>	XPR RS-422 EtherCAT	Reads the MAC address for the wireless module.
			Data: none
			Return value: hexadecimal address characters (ASCII), last 4 digits of the MAC address.
			Example: >669 cC5< >669aef6 c27< (aef6 = address)
			EtherCAT: X3000: 01 = 669 X3000: 0B = 1 (signal power source to act) X3000: 0D = 97d (a) X3000: 0E = 101d (e) X3000: 0F = 102d (f) X3000: 10 = 54d (6)
672	<i>Start test preflow</i>	XPR RS-422 EtherCAT	Starts the preflow gases.
			Data: 1 = start
			Return value: none
			Example: >6721 cF0< >672c9F<
			EtherCAT: X3000: 01 = 672 X3000: 03 = 1 X3000: 0B = 1 (signal power source to act)

ID	Command	System	Description / meaning
673	<i>Stop test preflow</i>	XPR RS-422 EtherCAT	Stops the preflow gases.
			Data: none
			Return value: none
			Example: >673 cC0< >673cA0<
			EtherCAT: X3000: 01 = 673 X3000: 0B = 1 (signal power source to act)
674	<i>Start test cutflow</i>	XPR RS-422 EtherCAT	Starts the cutflow gases.
			Data: 1 = start
			Return value: none
			Example: >6741 cF2< >674cA1<
			EtherCAT: X3000: 01 = 674 X3000: 03 = 1 X3000: 0B = 1 (signal power source to act)
675	<i>Stop test cutflow</i>	XPR RS-422 EtherCAT	Stops the cutflow gases.
			Data: none
			Return value: none
			Example: >675 cC2< >675cA2<
			EtherCAT: X3000: 01 = 675 X3000: 0B = 1 (signal power source to act)
676	<i>Leak check mode</i>	XPR RS-422 EtherCAT	Commands the system to do a leak check (results show in the error log).
			Data: 1 = start
			Return value: none
			Example: >6761 cF3< >676cA3<
			EtherCAT: X3000: 01 = 676 X3000: 03 = 1 X3000: 0B = 1 (signal power source to act)

ID	Command	System	Description / meaning
679	<i>Read console type</i>	XPR	Reads the console type.
		EtherCAT	Data: none
			Return value: console name in ASCII
			EtherCAT: X3000: 01 = 679 X3000: 0B = 1 (signal power source to act) X3000: 0D = 79d X3000: 0E = 112d X3000: 0F = 116d X3000: 10 = 105d X3000: 11 = 77d X3000: 12 = 105d X3000: 13 = 120d X3000: 14 = 0d (OptiMix)
686	<i>Read smart fault</i>	XPR	Reads the smart fault information.
		RS-422	Data: none
		EtherCAT	Return value: error code followed by the error description string
			Example: >686 cC4< >686520 Ignite_t/o arcv: 106V_busv:360V c8E<
			EtherCAT: X3000: 01 = 696 X3000: 0B = 1 (signal power source to act) X3000: 0D = 520 X3000: 0E = 106 (arc voltage) X3000: 0F = 360 (bus voltage)
			Note: refer to the faults.xls file to decode the data returned when using EtherCAT. X3000: 0D -> column A "id" X3000: 0E -> column E "Smart Data 1" X3000: 0F -> column F "Smart Data 2"

ID	Command	System	Description / meaning
687	<i>Read error log</i>	XPR RS-422 EtherCAT	Reads the error log.
			Data: none
			Return value: error code followed by the error description string.
			Example: >687 cC5< >687643 642 643 642 520 647 643 642 643 642 643 642 647 643 642 647 c75<
			EtherCAT: X3000: 01 = 687 X3000: 0B = 1 (signal power source to act) X3000: 0D = first error code X3000: 0E = second error code X3000: 0F = third error code
688	<i>Read gas types</i>	XPR RS-422 EtherCAT	Reads the gas type codes. Refer to <a href="#">Gas type codes</a> on page 66.
			Data: none
			Return value: Line A Gas Type Line B Gas Type Shield Type
			Space delimited
			Example: >688 cC6< >6881 6 6 cA3<
EtherCAT: X3000: 01 = 688 X3000: 0B = 1 (signal power source to act) X3000: 0D = 1 (Line A Gas Type) X3000: 0E = 6 (Line B Gas Type) X3000: 0F = 6 (Shield Type)			
689	<i>Read all process IDs</i>	XPR RS-422	Reads the available process IDs for the system (currently not available for EtherCAT).
			Data: none
			Return value: process IDs
			Example: >689 cC7< >68926 32 33 1000 1011 1012 1013 2000 2001 2002 2002 2010 2011 2012 2013 2014 2030 2031 2032 2033 2034 2040 2041 c1D<

ID	Command	System	Description / meaning
690	<i>Current setpoint increment</i>	XPR RS-422 EtherCAT	<p>Increases the current by the specified amperage value. (Limited up to +200% when current is less than 30 A, otherwise +100%.)</p> <p>Data: amount to change the current, in amperage (A)</p> <p>Return value: none</p> <p>Example: &gt;6905 cF4&lt; (increases the current by 5 A) &gt;690c9F&lt;</p> <p>EtherCAT: X3000: 01 = 690 X3000: 03 = 5 (A) X3000: 0B = 1 (signal power source to act)</p>
691	<i>Current setpoint Decrement</i>	XPR RS-422 EtherCAT	<p>-100%</p> <p>Data: amount to change the current by, in amperage (A)</p> <p>Return value: none</p> <p>Example: &gt;6915 cF5&lt; (decreases the current by 5 A) &gt;691cA0&lt;</p> <p>EtherCAT: X3000: 01 = 691 X3000: 03 = 5 (A) X3000: 0B = 1 (signal power source to act)</p>
692	<i>Plasma cutflow increment</i>	XPR RS-422 EtherCAT	<p>Increases the plasma cutflow pressure by up to +100%.</p> <p>Data: amount to change the cutflow pressure, in pounds/square inch (psi)</p> <p>Return value: none</p> <p>Example: &gt;6925 cF6&lt; (increases the pressure by 5 psi) &gt;692cA1&lt;</p> <p>EtherCAT: X3000: 01 = 692 X3000: 03 = 5 (psi) X3000: 0B = 1 (signal power source to act)</p>

ID	Command	System	Description / meaning
693	<i>Plasma cutflow decrement</i>	XPR RS-422 EtherCAT	Decreases the plasma cutflow pressure by up to -100%.
			Data: amount to change the cutflow pressure, in pounds/square inch (psi)
			Return value: none
			Example: >6935 cF7< (decreases the pressure by 5 psi) >693cA2<
			EtherCAT: X3000: 01 = 693 X3000: 03 = 5 (psi) X3000: 0B = 1 (signal power source to act)
694	<i>Shield cutflow increment</i>	XPR RS-422 EtherCAT	Increases the shield cutflow pressure by up to +100%.
			Data: amount to change the shield pressure, in pounds/square inch (psi)
			Return value: none
			Example: >6945 cF8< (increase the pressure by 5 psi) >694cA3<
			EtherCAT: X3000: 01 = 694 X3000: 03 = 5 (psi) X3000: 0B = 1 (signal power source to act)
695	<i>Shield cutflow decrement</i>	XPR RS-422 EtherCAT	Decreases the shield pressure by up to -100%.
			Data: amount to change the shield pressure, in pounds/square inch (psi)
			Return value: none
			Example: >6955 cF9< (decreases the pressure by 5 psi) >695cA4<
			EtherCAT: X3000: 01 = 695 X3000: 03 = 5 (psi) X3000: 0B = 1 (signal power source to act)

ID	Command	System	Description / meaning
696	<i>Mix H<sub>2</sub> setpoint increment</i>	XPR RS-422 EtherCAT	Increases the hydrogen (H <sub>2</sub> ) flow rate by up to +50%. (H <sub>2</sub> flow rate < Ar flow rate + N <sub>2</sub> flow rate).
			Data: amount to change the flow rate, in standard liters per minute (slpm)
			Return value: none
			Example: >6965 cFA< (increases the flow rate by 5 slpm) >696cA5<
			EtherCAT: X3000: 01 = 696 X3000: 03 = 5 (slpm) X3000: 0B = 1 (signal power source to act)
697	<i>Mix H<sub>2</sub> setpoint decrement</i>	XPR RS-422 EtherCAT	Decreases the hydrogen (H <sub>2</sub> ) flow rate by up to -50%.
			Data: amount to change the flow rate, in standard liters per minute (slpm)
			Return value: none
			Example: >6975 cFB< (decreases the flow rate by 5 slpm) >697cA6<
			EtherCAT: X3000: 01 = 697 X3000: 03 = 5 (slpm) X3000: 0B = 1 (signal power source to act)
716	<i>Mix N<sub>2</sub> setpoint increment</i>	XPR RS-422 EtherCAT	Increases the nitrogen (N <sub>2</sub> ) flow rate by up to +50%.
			Data: amount to change the flow rate, in standard liters per minute (slpm)
			Return value: none
			Example: >7165 cF3< (increase the flow rate by 5 slpm) >716c9E<
			EtherCAT: X3000: 01 = 716 X3000: 03 = 5 (slpm) X3000: 0B = 1 (signal power source to act)

ID	Command	System	Description / meaning
717	<i>Mix N<sub>2</sub> setpoint decrement</i>	XPR RS-422 EtherCAT	Decreases the nitrogen (N <sub>2</sub> ) flow rate by up to -50%.
			The hydrogen (H <sub>2</sub> ) flow rate cannot exceed the argon (Ar) flow rate plus the nitrogen (N <sub>2</sub> ) flow rate. (H <sub>2</sub> flow rate < Ar flow rate + N <sub>2</sub> flow rate)
			Data: amount to change the flow rate, in standard liters per minute (slpm)
			Return value: none
			Example: >7175 cF4< (decrease the flow rate by 5 slpm) >717c9F<
			EtherCAT: X3000: 01 = 717 X3000: 03 = 5 (slpm) X3000: 0B = 1 (signal power source to act)
718	<i>Mix argon setpoint increment</i>	XPR RS-422 EtherCAT	Increases the argon (Ar) flow rate by up to +50%.
			Data: amount to change the flow rate, in standard liters per minute (slpm)
			Return value: none
			Example: >7185 cF5< (increase the flow rate by 5 slpm) >718cA0<
			EtherCAT: X3000: 01 = 718 X3000: 03 = 5 (slpm) X3000: 0B = 1 (signal power source to act)
719	<i>Mix argon setpoint decrement</i>	XPR RS-422 EtherCAT	Decreases the argon (Ar) flow rate by up to -50%.
			The hydrogen (H <sub>2</sub> ) flow rate cannot exceed the argon (Ar) flow rate plus the nitrogen (N <sub>2</sub> ) flow rate. (H <sub>2</sub> flow rate < Ar flow rate + N <sub>2</sub> flow rate)
			Data: amount to change the flow rate, in standard liters per minute (slpm)
			Return value: none
			Example: >7195 cF6< (decreases the flow rate by 5 slpm) >719cA1<
			EtherCAT: X3000: 01 = 719 X3000: 03 = 5 (slpm) X3000: 0B = 1 (signal power source to act)

ID	Command	System	Description / meaning
750	<i>Fan #1 speed</i>	XPR RS-422 EtherCAT	Reads magnetics fan #1 speed in revolutions per minute (RPM).
			Data: none
			Return value: speed in revolutions per minute (RPM)
			Example: >750 cBC< >7502850 c8B< (2850 RPM)
			EtherCAT: X3000: 01 = 750 X3000: 0B = 1 (signal power source to act) X3000: 0D = 2850 (RPM)
751	<i>Fan #2 speed</i>	XPR RS-422 EtherCAT	Reads magnetics fan #2 speed in revolutions per minute (RPM).
			Data: none
			Return value: speed in revolutions per minute (RPM)
			Example: >751 cBD< >7512850 c8C< 2850 (2850 RPM)
			EtherCAT: X3000: 01 = 751 X3000: 0B = 1 (signal power source to act) X3000: 0D = 2850 (RPM)
752	<i>Fan #3 speed</i>	XPR RS-422 EtherCAT	Reads heat exchanger fan #3 speed in revolutions per minute (RPM).
			Data: none
			Return value: speed in RPM
			Example: >752 cBE< >7522850 c8D< (2850 RPM)
			EtherCAT: X3000: 01 = 752 X3000: 0B = 1 (signal power source to act) X3000: 0D = 2850 (RPM)
753	<i>Fan #4 speed</i>	XPR RS-422 EtherCAT	Reads heat exchanger fan #4 speed in revolutions per minute (RPM).
			Data: none
			Return value: speed in RPM
			Example: >753 cBF< >7532850 c8E< 2850 (2850 RPM)
			EtherCAT: X3000: 01 = 753 X3000: 0B = 1 (signal power source to act) X3000: 0D = 2850 (RPM)

ID	Command	System	Description / meaning
754	<i>Fan #5 speed</i>	XPR RS-422 EtherCAT	Reads chopper fan #5 speed in revolutions per minute (RPM).
			Data: none
			Return value: speed in RPM
			Example: >754 cC0< >7542850 c8F< 2850 (RPM)
			EtherCAT: X3000: 01 = 754 X3000: 0B = 1 (signal power source to act) X3000: 0D = 2850 (RPM)
755	<i>Fan #6 speed</i>	XPR RS-422 EtherCAT	Reads chopper fan #6 speed in revolutions per minute (RPM).
			Data: none
			Return value: speed in RPM
			Example: >755 cC1< >7552850 c90< (2850 RPM)
			EtherCAT: X3000: 01 = 755 X3000: 0B = 1 (signal power source to act) X3000: 0D = 2850 (RPM)
756	<i>Shield pierce increment</i>	XPR RS-422 EtherCAT	Increases the shield pierce pressure by up to +100%.
			Data: amount to change the pierce pressure, in pounds/square inch (psi)
			Return value: none
			Example: >7565 cF7< (increases the pressure by 5 psi) >756cA3<
			EtherCAT: X3000: 01 = 756 X3000: 03 = 5 (psi) X3000: 0B = 1 (signal power source to act)
757	<i>Shield pierce decrement</i>	XPR RS-422 EtherCAT	Decreases the shield pierce pressure by up to -100%.
			Data: amount to change the pierce pressure, in pounds/square inch (psi)
			Return value: none
			Example: >7575 cF8< (decreases the pressure by 5 psi) >757cA4<
			EtherCAT: X3000: 01 = 757 X3000: 03 = 5 (psi) X3000: 0B = 1 (signal power source to act)

ID	Command	System	Description / meaning
758	Sleep	XPR RS-422	Disables the RS-422 transmitter for multi-drop (multi-system) serial installations. All connected systems enter sleep mode (listen only).
			Data: none
			Return value: none
			Example: >758cA5< No response
759	Wake	XPR RS-422	Lets the RS-422 transmitter to do multi-drop (multi-system) serial installations. Note: only systems with matching system IDs will be-activated.
			Data: system ID (uses DIP switches to set the ID)
			Return value: none
			Example: >7591 cF6< (wake system ID #1) >759cA6<
760	Firmware versions	XPR RS-422 EtherCAT	Returns the firmware revisions for the following: <ul style="list-style-type: none"> <li>▪ Main control PCB</li> <li>▪ Torch connect console</li> <li>▪ Gas connect console</li> <li>▪ Chopper 1</li> <li>▪ Chopper 2</li> <li>▪ Wireless module</li> </ul>
			Data: none
			Example: >760 cBD< >760C 0 0 C C 18163 c89<
			Main control PCB = C Torch connect = 0 Gas connect = 0 Chopper 1 = C Chopper 2 = C Wireless module = 18163
			EtherCAT: X3000: 01 = 769 X3000: 0B = 1 (signal power source to act) X3000: 0D = x43 C X3000: 0E = x30 0 X3000: 0F = x30 0 X3000: 10 = x43 C X3000: 11 = x43 C X3000: 12 = x46F3 (18163d)

ID	Command	System	Description / meaning
761	<i>Read shield inlet</i>	XPR RS-422 EtherCAT	Reads the shield inlet pressure.
			Data: none
			Return value: shield pressure in pounds/square inch (psi)
			Example: >761 cBE<>76125 c25< 25 (psi)
			EtherCAT: X3000: 01 = 761 X3000: 0B = 1 (signal power source to act) X3000: 0D = 25 (psi)
762	<i>Read torch protection enable</i>	XPR RS-422 EtherCAT	Reads the enable/disable state of the Torch Protection Mode. When active, the system detects that the arc has become excessively unstable. When disabled, the system will not use this mode.
			Data: none
			Return value: 1 = enabled, 0 = disabled
			Example: >762 cBF< >7621 cF0< (enabled)
			EtherCAT: X3000: 01 = 762 X3000: 0B = 1 (signal power source to act) X3000: 0D = 1 (enabled)
763	<i>Write torch protection enable</i>	XPR RS-422 EtherCAT	Writes the enable/disable state of the Torch Protection Mode. When activated, the system detects that the arc has become excessively unstable.
			Data: 1 = enable, 0 = disable
			Return value: none
			Example: >7631 cF1< (enable) >763cA0<
			EtherCAT: X3000: 01 = 763 X3000: 03 = 1 (enable) X3000: 0B = 1 (signal power source to act)

ID	Command	System	Description / meaning
764	<i>Read rampdown error prevention</i>	XPR	Reads the enable/disable state of the Ramp-Down Error Prevention Mode.
		RS-422	When activated, the system detects that the arc is about to extinguish.
		EtherCAT	Data: none
			Return value: 1 = enabled, 0 = disabled
			Example: >764 cC1< >7641 cF2< (enabled)
		EtherCAT: X3000: 01 = 764 X3000: 0B = 1 (signal power source to act) X3000: 0D = 1 (enabled)	
765	<i>Write rampdown error prevention</i>	XPR	Writes the enable/disable state of the Ramp-Down Error Prevention Mode.
		RS-422	When enabled, each process ID can selectively activate this mode if the system detects that the arc is about to extinguish.
		EtherCAT	Data: 1 = enable, 0 = disable
			Return value: none
			Example: >7651 cF3< (enable) >765cA2<
		EtherCAT: X3000: 01 = 765 X3000: 03 = 1 (enable) X3000: 0B = 1 (signal power source to act)	
768	<i>Start test pierce flow</i>	XPR	Starts the pierce gas settings.
		RS-422	Data: 1 = start
		EtherCAT	Return value: none
			Example:>7681 cF6< >768cA5<
			EtherCAT: X3000: 01 = 768 X3000: 0B = 1 (signal power source to act)
769	<i>Stop test pierce flow</i>	XPR	Stops the pierce gas settings.
		RS-422	Data: none
		EtherCAT	Return value: none
			Example: >769 cC6< >769cA6<
			EtherCAT: X3000: 01 = 769 X3000: 0B = 1 (signal power source to act)

ID	Command	System	Description / meaning
770	<i>Current override</i>	XPR RS-422 EtherCAT	Overrides the current setpoint +200% / -100% if current is less than 30 A, otherwise +/- 100%. A value of 0 A is not allowed.
			Data: The desired current value in amperage (A)
			Return value: none
			Example: >770160 c55< (current setpoint = 160 A) >770c9E<
			EtherCAT: X3000: 01 = 770 X3000: 03 = 160 (A) X3000: 0B = 1 (signal power source to act)
771	<i>Plasma cutflow override</i>	XPR RS-422 EtherCAT	Overrides the plasma cutflow setpoint +/- 100%.
			Data: the desired plasma cutflow value in psi
			Return value: none
			Example:>77150 c24< (plasma cutflow = 50 psi) >771c9F<
			EtherCAT: X3000: 01 = 771 X3000: 03 = 50 (psi) X3000: 0B = 1 (signal power source to act)
772	<i>Shield cutflow override</i>	XPR RS-422 EtherCAT	Overrides the shield cutflow setpoint +/- 100%.
			Data: the desired shield cutflow value in psi
			Return value: none
			Example: >77250 c25< (shield cutflow = 50 psi) >772cA0<
			EtherCAT: X3000: 01 = 772 X3000: 03 = 50 (psi) X3000: 0B = 1 (signal power source to act)
773	<i>H<sub>2</sub> flow override</i>	XPR RS-422 EtherCAT	Overrides the hydrogen (H <sub>2</sub> ) flow setpoint +/- 50%.
			Data: the desired H <sub>2</sub> flow value in standard liters per minute (slpm)
			Return value: none
			Example: >77325 c28< (H <sub>2</sub> setpoint = 25 slpm) >773cA1<
			EtherCAT: X3000: 01 = 773 X3000: 03 = 25 (slpm) X3000: 0B = 1 (signal power source to act)

ID	Command	System	Description / meaning
774	<i>N<sub>2</sub> flow override</i>	XPR RS-422 EtherCAT	Overrides the nitrogen (N <sub>2</sub> ) flow setpoint +/- 50%.
			Data: the desired N <sub>2</sub> flow value in standard liters per minutes (slpm)
			Return value: none
			Example: >77425 c29< (N <sub>2</sub> setpoint = 25 slpm) >774cA2<
			EtherCAT: X3000: 01 = 774 X3000: 03 = 25 (slpm) X3000: 0B = 1 (signal power source to act)
775	<i>Argon flow override</i>	XPR RS-422 EtherCAT	Overrides the argon (Ar) flow setpoint +/- 50%.
			Data: the argon (Ar) flow value in standard liters per minute (slpm)
			Return value: none
			Example: >77525 c2A< (Ar setpoint = 25 slpm) >775cA3<
			EtherCAT: X3000: 01 = 775 X3000: 03 = 25 (25 slpm) X3000: 0B = 1 (signal power source to act)
776	<i>Shield pierce override</i>	XPR RS-422 EtherCAT	Overrides the pierce pressure setpoint +/- 100%.
			Data: the desired pierce pressure value in psi
			Return value: none
			Example: >77650 c29< (pierce pressure = 50 psi) >776cA5<
			EtherCAT: X3000: 01 = 776 X3000: 03 = 50 (psi) X3000: 0B = 1 (signal power source to act)

ID	Command	System	Description / meaning
777	<i>System Type ID</i>	XPR RS-422 EtherCAT	Reads the ID of the system type.
			Data: none
			Return value: system ID
			XPR 170 Core = 17 XPR 170 CorePlus = 24 XPR 170 VWI = 18 XPR 170 OptiMix = 20
			XPR 300 Core = 33 XPR 300 CorePlus = 40 XPR 300 VWI = 34 XPR 300 OptiMix = 36
			Example: >777 cC5< >77736 c2E<
			EtherCAT: X3000: 01 = 777 X3000: 0B = 1 (signal power source to act) X3000: 0D = 36
778	<i>System type description</i>	XPR RS-422	Reads the description of the system type.
			Data: none
			Return value: system type
			Example: >778 cC6< >778XPR OptiMix c3D<
780	<i>System error ID</i>	XPR RS-422 EtherCAT	Reads the ID of the system fault.
			Data: none
			Return value: system error
			Example: >780 cBF< >780759 c64<
			EtherCAT: X3000: 01 = 780 X3000: 0B = 1 (signal power source to act) X3000: 0D = 759

ID	Command	System	Description / meaning
781	<i>Arc time</i>	XPR RS-422 EtherCAT	Reads the arc time. Data: none Return value: arc time (in seconds) Example: >781 cC0< >7811896 c98< X3000: 01 = 781 X3000: 0B = 1 (signal power source to act) X3000: 0D = 1896 (seconds)
782	<i>Total current</i>	XPR RS-422 EtherCAT	Reads the total current output. Data: none Return value: current in amperage (A) Example: >782 cC1< >7820 cF1< EtherCAT: X3000: 01 = 782 X3000: 0B = 1 (signal power source to act) X3000: 0D = 300 (A)

ID	Command	System	Description / meaning
783	<i>Discrete I/O</i>	XPR	Reads the status of the system discrete I/O.
		RS-422	Data: none
		EtherCAT	Return value: I/O
			Bit 0: System On input Bit 1: Start input Bit 2: Hold input Bit 3: Pierce input Bit 4: Main Contactor output Bit 5: Pump Enable output Bit 6: Coolant Solenoid output Bit 7: Fan output Bit 8: Hx Fan output Bit 9: Ready-for-Start output Bit 10: Auto-Pierce Detect output Bit 11: Ohmic Contact output Bit 12: CNC Motion output Bit 13: CNC Hold output Bit 14: CNC Error output
			Example: >783 cC2< >783609 c61< (Convert the 609d to binary. Bit 0 and bit 14 are turned ON)
			EtherCAT: X3000: 01 = 783 X3000: 0B = 1 (signal power source to act) X3000: 0D = 609 (bit 0 and bit 14 are turned ON)
784	<i>Active errors</i>	XPR	Reads the IDs of the active errors.
		RS-422	Data: none
		EtherCAT	Return value: active error IDs
			Example: >784 cC3< >784643 759 c25<
			EtherCAT: X3000: 01 = 784 X3000: 0B = 1 (signal power source to act) X3000: 0D 643 X3000: 0E 759

ID	Command	System	Description / meaning
785	<i>Error history</i>	XPR RS-422	Reads the history of the system errors.
			Data: none
			Return value: error history information
			A_B_C_D_E_F A = ID B = Reserved C = Timestamp (on time) D = Data 1 E = Data 2 F = Timestamp (UTC)
			Example: >785 cC4< >785643_1_44221_0_0 759_1_44219_75_0 642_0_44217_0_0 646_0_44212_0_0 643_0_44123_0_0 759_0_44121_74_0 642_0_44121_0_0 cA3<
786	<i>Gas setpoints</i>	XPR RS-422 EtherCAT	Reads the gas setpoints from the torch connect console.
			Data: none
			Return value: setpoints in pounds/square inch (psi)
			Example: >786 cC5< >7860 0 0 c95<
			EtherCAT: X3000: 01 = 786 X3000: 0B = 1 (signal power source to act) X3000: 0D = 0 (Line A psi) X3000: 0E = 0 (Line B psi) X3000: 0F = 0 (Shield psi)
787	<i>Gas duty cycles</i>	XPR RS-422 EtherCAT	Reads the pulse width modulation (PWM) duty cycles of the gas control valves in the torch connect console (“percent on”).
			Data: none
			Return value: duty cycles (% PWM)
			Example: >787 cC6< >7870 0 0 c96<
			EtherCAT: X3000: 01 = 787 X3000: 0B = 1 (signal power source to act) X3000: 0D = 0 (Line A duty) X3000: 0E = 0 (Line B duty) X3000: 0F = 0 (Shield duty)

ID	Command	System	Description / meaning
788	<i>Chopper setpoints</i>	XPR RS-422 EtherCAT	Reads the current setpoints of the choppers.
			Data: none
			Return value: current in amperage (A)
			Example: >788 cC7< >7880 0 c47<
			EtherCAT: X3000: 01 = 788 X3000: 0B = 1 (signal power source to act) X3000: 0D = 0 (Chopper 1 set) X3000: 0F = 0 (Chopper 2 set)
794	<i>Read system on time</i>	XPR RS-422 EtherCAT	Reads the system on time in seconds
			Data: none
			Return value: seconds
			Example: >794 cC4< >7941000 cB5< (1000 seconds)
			EtherCAT: X3000: 01 = 794 X3000: 0B = 1 (signal power source to act) X3000: 0D = 1000 (seconds)
795	<i>Read process overrides</i>	XPR RS-422	Reads the process override values.
			Data: none
			Return value: cut current, plasma cutflow (psi), shield cutflow (psi), H <sub>2</sub> flow rate (slpm), N <sub>2</sub> flow rate (slpm), argon (Ar) flow rate (slpm), shield pierce (psi)
			Example: >795 cC5< >795165 75 50 6 18 12 22 c58< cut current = 165 in amperage (A) plasma cutflow = 75 (psi) shield cutflow = 50 (psi) H <sub>2</sub> flow = 6 slpm N <sub>2</sub> flow = 18 slpm Argon flow = 12 slpm Shield pierce = 22 (psi)

ID	Command	System	Description / meaning
850	<i>Outlet pressure mix</i>	XPR RS-422 EtherCAT	Reads the mixing module outlet pressure.
			Data: none
			Return value: pressure in pounds/square inch (psi)
			Example: >850 cBD< >85074 c28<
			EtherCAT: X3000: 01 = 850 X3000: 0B = 1 (signal power source to act) X3000: 13 = 74 (psi)
851	<i>Argon duty cycle</i>	XPR RS-422 EtherCAT	Reads the argon (Ar) duty cycle from the gas connect console.
			Data: none
			Return value: duty cycle (% on / PWM)
			Example: >851 cBE< >8510 cEE<
			EtherCAT: X3000: 01 = 851 X3000: 0B = 1 (signal power source to act) X3000: 0D = 0 (%)
852	<i>N<sub>2</sub> duty cycle</i>	XPR RS-422 EtherCAT	Reads the nitrogen (N <sub>2</sub> ) duty cycle from the gas connect console.
			Data: none
			Return value: duty cycle (% on / PWM)
			Example: >852 cBF< >8520 cEF<
			EtherCAT: X3000: 01 = 852 X3000: 0B = 1 (signal power source to act) X3000: 0D = 0 (%)
853	<i>H<sub>2</sub> duty cycle</i>	XPR RS-422 EtherCAT	Reads the hydrogen (H <sub>2</sub> ) duty cycle from the gas connect console.
			Data: none
			Return value: duty cycle (% PWM)
			Example: >853 cC0< >8530 cF0<
			EtherCAT: X3000: 01 = 853 X3000: 0B = 1 (signal power source to act) X3000: 0D = 0 (%)

ID	Command	System	Description / meaning
854	<i>Argon inlet pressure</i>	XPR RS-422 EtherCAT	Reads the argon (Ar) inlet pressure from the gas connect console.
			Data: none
			Return value: Pressure in pounds/square inch (psi)
			Example: >854 cC1< >854118 c5B< X3000: 01 = 854 X3000: 0B = 1 (signal power source to act) X3000: 0D = 119 (psi)
855	<i>N<sub>2</sub> inlet pressure</i>	XPR RS-422 EtherCAT	Reads the nitrogen (N <sub>2</sub> ) inlet pressure from the gas connect console.
			Data: none
			Return value: pressure in pounds/square inch (psi)
			Example: >855 cC2< >855119 c5D< EtherCAT:X3000: 01 = 855 X3000: 0B = 1 (signal power source to act) X3000: 0D = 119 (psi)
856	<i>H<sub>2</sub> inlet pressure</i>	XPR RS-422 EtherCAT	Reads the hydrogen (H <sub>2</sub> ) inlet pressure from the mixing console.
			Data: none
			Return value: pressure in pounds/square inch (psi)
			Example: >856 cC3< >856118 c5E< EtherCAT: X3000: 01 = 856 X3000: 0B = 1 (signal power source to act) X3000: 0D = 118 (psi)
857	<i>Argon outlet flow</i>	XPR RS-422 EtherCAT	Reads the argon (Ar) outlet flow from the gas connect console.
			Data: none
			Return value: flow in standard liters per minute (slpm)
			Example: >857 cC4< >8575 cF9< EtherCAT: X3000: 01 = 857 X3000: 0B = 1 (signal power source to act) X3000: 0D = 5 (slpm)

ID	Command	System	Description / meaning
858	<i>N<sub>2</sub> outlet flow</i>	XPR RS-422 EtherCAT	Reads the nitrogen (N <sub>2</sub> ) outlet flow from the gas connect console.
			Data: none
			Return value: flow in standard liters per minute (slpm)
			Example: >858 cC5< >8584 cF9<
			EtherCAT: X3000: 01 = 858 X3000: 0B = 1 (signal power source to act) X3000: 0D = 4 (slpm)
859	<i>H<sub>2</sub> outlet flow</i>	XPR RS-422 EtherCAT	Reads the hydrogen (H <sub>2</sub> ) outlet pressure from the gas connect console.
			Data: none
			Return value: flow in standard liters per minute (slpm)
			Example: >859 cC6< >8592 cF8<
			EtherCAT: X3000: 01 = 859 X3000: 0B = 1 (signal power source to act) X3000: 0D = 2 (slpm)
860	<i>Argon flow setpoint</i>	XPR RS-422 EtherCAT	Reads the argon (Ar) flow setpoint from the gas connect console.
			Data: none
			Return value: flow in standard liters per minute (slpm)
			Example: >860 cBE< >8601 cEF<
			EtherCAT: X3000: 01 = 860 X3000: 0B = 1 (signal power source to act) X3000: 0D = 1 (slpm)
861	<i>N<sub>2</sub> flow setpoint</i>	XPR RS-422 EtherCAT	Reads the nitrogen (N <sub>2</sub> ) flow setpoint from the gas connect console.
			Data: none
			Return value: flow in standard liters per minute (slpm)
			Example: >861 cBF< >8611 cF0<
			EtherCAT:X3000: 01 = 861 X3000: 0B = 1 (signal power source to act) X3000: 0D = 1 (slpm)

ID	Command	System	Description / meaning
862	<i>H<sub>2</sub> flow setpoint</i>	XPR RS-422 EtherCAT	Reads the hydrogen (H <sub>2</sub> ) flow setpoint from the gas connect console.
			Data: none
			Return value: flow in standard liters per minute (slpm)
			Example: >862 cC0< >8622 cF2<
			EtherCAT: X3000: 01 = 862 X3000: 0B = 1 (signal power source to act) X3000: 0D = 2 (slpm)
863	<i>F5 outlet pressure</i>	XPR RS-422 EtherCAT	Reads the F5 (nitrogen-hydrogen) outlet pressure from the VWI gas connect console.
			Data: none
			Return value: pressure in pounds/square inch (psi)
			Example: >863 cC1< >86369 c30<
			EtherCAT: X3000: 01 = 863 X3000: 0B = 1 (signal power source to act) X3000: 0D = 69 (psi)
864	<i>H<sub>2</sub>O outlet pressure</i>	XPR RS-422 EtherCAT	Reads the water (H <sub>2</sub> O) outlet pressure from the VWI gas connect console.
			Data: none
			Return value: pressure in pounds/square inch (psi)
			Example: >864 cC2< >8640 cF2<
			EtherCAT: X3000: 01 = 864 X3000: 0B = 1 (signal power source to act) X3000: 0D = 30 (psi)

ID	Command	System	Description / meaning
865	<i>F5 inlet pressure</i>	XPR RS-422 EtherCAT	Reads the F5 (nitrogen-hydrogen) inlet pressure from the VWI/OptiMix gas connect console.
			Data: none
			Return value: pressure in pounds/square inch (psi)
			Example: >865 cC3< >865121 c57<
			EtherCAT: X3000: 01 = 865 X3000: 0B = 1 (signal power source to act) X3000: 0D = 121 (psi)
866	<i>H<sub>2</sub>O inlet pressure</i>	XPR RS-422 EtherCAT	Reads the water (H <sub>2</sub> O) inlet pressure from the VWI/OptiMix gas connect console.
			Data: none
			Return value: pressure in pounds/square inch (psi)
			Example: >866 cC4< >86639 c30<
			EtherCAT: X3000: 01 = 866 X3000: 0B = 1 (signal power source to act) X3000: 0D = 39 (psi)
867	<i>F5 setpoint pressure</i>	XPR RS-422 EtherCAT	Reads the F5 setpoint pressure from the VWI/OptiMix gas connect console.
			Data: none
			Return value: pressure in pounds/square inch (psi)
			Example: >867 cC5< >8670 cF5<
			EtherCAT: X3000: 01 = 867 X3000: 0B = 1 (signal power source to act) X3000: 0D = 50 (psi)

ID	Command	System	Description / meaning
868	<i>H<sub>2</sub>O setpoint pressure</i>	XPR RS-422 EtherCAT	Reads the water (H <sub>2</sub> O) setpoint pressure from the VWI/OptiMix gas connect console.
			Data: none
			Return value: pressure in pounds/square inch (psi)
			Example: >868 cC6< >8684 cFA<
			EtherCAT: X3000: 01 = 868 X3000: 0B = 1 (signal power source to act) X3000: 0D = 4 (psi)
869	<i>F5 duty cycle</i>	XPR RS-422 EtherCAT	Reads the F5 duty cycle from the VWI/OptiMix gas connect console.
			Data: none
			Return value: duty (% on / PWM)
			Example: >869 cC7< >8693 cFA<
			EtherCAT: X3000: 01 = 869 X3000: 0B = 1 (signal power source to act) X3000: 0D = 3 (%)
870	<i>H<sub>2</sub>O duty cycle</i>	XPR RS-422 EtherCAT	Reads the water (H <sub>2</sub> O) duty cycle from the VWI/OptiMix console.
			Data: none
			Return value: duty (% on / PWM)
			Example: >870 cBF< >8702 cF1<
			EtherCAT: X3000: 01 = 870 X3000: 0B = 1 (signal power source to act) X3000: 0D = 2 (%)

ID	Command	System	Description / meaning
871	IP address	XPR RS-422 EtherCAT	<p>Reads the IP address of the wireless module.</p> <p>Data: none</p> <p>Return value: IP address</p> <p>Example: &gt;871 cC0&lt; &gt;871192.168.1.1 cE7&lt;</p> <p>EtherCAT: X3000: 01 = 871 X3000: 0B = 1 (signal power source to act) X3000: 0D = 192 X3000: 0E = 168 X3000: 0F = 1 X3000: 10 = 1</p> <p>(IP address = 192.168.1.1)</p>
872	Valve states	XPR RS-422 EtherCAT	<p>Reads the valve states of the torch connect console.</p> <p>Data: none</p> <p>Return value: valve states</p> <p>Bit 0: V1 Bit 1: V2 Bit 2: V3 Bit 3: V4 Bit 4: V5 Bit 5: V6 Bit 6: V7 Bit 7: V8 Bit 8: V9 Bit 9: V10 Bit 10: V11 Bit 11: V12</p> <p>Example: &gt;872 cC1&lt; &gt;8721 cF2&lt; (convert 1d to binary, v1 is on)</p> <p>EtherCAT: X3000: 01 = 872 X3000: 0B = 1 (signal power source to act) X3000: 0D = 1 (convert to binary, v1 is on)</p>

ID	Command	System	Description / meaning
873	<i>Process current</i>	XPR RS-422 EtherCAT	Reads the process current during cutting.
			Data: none
			Return value: current in amperage (A)
			Example: >873 cC2< >873300 c55<
			EtherCAT: X3000: 01 = 873 X3000: 0B = 1 (signal power source to act) X3000: 0D = 300 (A)
874	<i>Process plasma cutflow pressure</i>	XPR RS-422 EtherCAT	Reads the process plasma cutflow pressure during cutting.
			Data: none
			Return value: pressure in pounds/square inch (psi)
			Example: >874 cC3< >87490 c2C<
			EtherCAT: X3000: 01 = 874 X3000: 0B = 1 (signal power source to act) X3000: 0D = 90 (psi)
875	<i>Process shield cutflow pressure</i>	XPR RS-422 EtherCAT	Reads the process shield cutflow pressure during cutting.
			Data: none
			Return value: pressure in pounds/square inch (psi)
			Example: >875 cC4< >87553 c2C<
			EtherCAT: X3000: 01 = 875 X3000: 0B = 1 (signal power source to act) X3000: 0D = 53 (psi)
876	<i>Process shield pierce flow pressure</i>	XPR RS-422 EtherCAT	Reads the process shield pierce flow pressure during piercing.
			Data: none
			Return value: pressure in pounds/square inch (psi)
			Example: >876 cC5< >87653 c2D<
			EtherCAT: X3000: 01 = 876 X3000: 0B = 1 (signal power source to act) X3000: 0D = 53 (psi)

ID	Command	System	Description / meaning
877	<i>Process H<sub>2</sub> flow setpoint</i>	XPR RS-422 EtherCAT	Reads the process hydrogen (H <sub>2</sub> ) flow setpoint during cutting.
			Data: none
			Return value: flow, in standard liters per minute (slpm)
			Example: >877 cC6< >8776 cFC<
			EtherCAT: X3000: 01 = 877 X3000: 0B = 1 (signal power source to act) X3000: 0D = 6 (slpm)
878	<i>Process N<sub>2</sub> flow setpoint</i>	XPR RS-422 EtherCAT	Reads the process nitrogen (N <sub>2</sub> ) flow setpoint during cutting.
			Data: none
			Return value: flow, in standard liters per minute (slpm)
			Example: >878 cC7< >87824 c2D<
			EtherCAT: X3000: 01 = 878 X3000: 0B = 1 (signal power source to act) X3000: 0D = 24 (slpm)
879	<i>Process Argon (Ar) flow setpoint</i>	XPR RS-422 EtherCAT	Reads the process Argon (Ar) flow setpoint during cutting.
			Data: none
			Return value: flow in standard liters per minute (slpm)
			Example: >879 cC8< >87910 c29<
			EtherCAT: X3000: 01 = 879 X3000: 0B = 1 (signal power source to act) X3000: 0D = 10 (slpm)

ID	Command	System	Description / meaning
880	<i>Minor firmware revisions</i>	XPR RS-422 EtherCAT	<p>Reads minor revisions for the following printed circuit boards (PCBs):</p> <ul style="list-style-type: none"> <li>▪ Main control PCB</li> <li>▪ Chopper boards</li> <li>▪ Torch connect console board</li> <li>▪ Gas connect console board</li> </ul> <hr/> <p>Data: none</p> <hr/> <p>Return value: numeric revisions space delimited                      Main control PCB                      Torch connect console                      Gas connect console                      Chopper 1                      Chopper 2</p> <hr/> <p>Example:                      &gt;880 cC0&lt;                      &gt;880472 180 122 169 169 c4B&lt;</p> <hr/> <p>EtherCAT:                      X3000: 01 = 880                      X3000: 0B = 1 (signal power source to act)                      X3000: 0D = 472 (main control PCB)                      X3000: 0E = 180 (Torch connect console)                      X3000: 0F = 122 (Gas connect console)                      X3000: 10 = 169 (Chopper 1)                      X3000: 11 = 169 (Chopper 2)</p>
881	<i>Controlling source</i>	XPR RS-422 EtherCAT	<p>Identifies the interface that is in control of the power source.</p> <hr/> <p>Data: none</p> <hr/> <p>Return value: interface code number                      No controlling source = 0                      EtherCAT = 1                      WiFi = 2                      Internal control = 4                      RS-422 = 5                      Discrete control = 6</p> <hr/> <p>Example:                      &gt;881 cC1&lt;                      &gt;8815 cF6&lt; (RS-422)</p> <hr/> <p>EtherCAT:                      X3000: 01 = 881                      X3000: 0B = 1 (signal power source to act)                      X3000: 0D = 1 (EtherCAT)</p>

ID	Command	System	Description / meaning
882	<i>System code priority</i>	XPR	Reads the priority of the active power source code.
		RS-422	Data: none
		EtherCAT	Return value: priority-code number Info = 0 Alert = 1 Error = 2 Failure = 3
			Example: >882 cC2< >8822 CF4< (Error)
			EtherCAT: X3000: 01 = 882 X3000: 0B = 1 (signal power source to act) X3000: 0D = 1 (Alert)
883	<i>Set all overrides</i>	XPR	Sets all process override values.
		RS-422	Data: <ul style="list-style-type: none"> <li>▪ Current = +200% if current is less than 30 A, otherwise +100% and -100%</li> <li>▪ Plasma cutflow = +/- 100%</li> <li>▪ Shield cutflow = +/- 100%</li> <li>▪ Shield pierceflow = +/- 100%</li> <li>▪ Hydrogen (H2) flow rate = +/- 50%</li> <li>▪ Nitrogen (N2) flow rate = +/- 50%</li> <li>▪ Argon (Ar) flow rate = +/- 50%</li> </ul>
		EtherCAT	Return value: none
			Example: >883295 55 70 22 0 12 0 c1B< >883CA3<
			EtherCAT: X3000: 01 = 883 X3000: 03 = 295 (set to 295 A) X3000: 04 = 55 (set plasma outflow to 55 psi) X3000: 05 = 70 (set shield cutflow to 70 psi) X3000: 06 = 22 (set shield pierce flow to 22 psi) X3000: 07 = 0 (no override applied to hydrogen [H <sub>2</sub> ]) X3000: 08 = 12 (set nitrogen [N <sub>2</sub> ] flow rate to 12 slpm) X3000: 09 = 0 (no override applied to argon [Ar]) X3000: 0B = (signal power source to act)

ID	Command	System	Description / meaning
885	<i>Database revision</i>	XPR RS-422 EtherCAT	<p>Reads the plasma process database revision.</p> <p>Data: none</p> <p>Return value: database revision</p> <p>Example: &gt;885 cC5&lt; &gt;88500K C70&lt; (rev 'K')</p> <p>EtherCAT: X30000: 01 = 88 X30000: 0B = 1 (signal power source to act) X30000: 0D = 75 (ASCII 'K')</p>
886	Boot firmware versions	XPR RS-422 EtherCAT	<p>Returns the bootloader firmware revisions for the following:</p> <ul style="list-style-type: none"> <li>▪ Main control PCB</li> <li>▪ Torch connect console</li> <li>▪ Gas connect console</li> <li>▪ Chopper 1</li> <li>▪ Chopper 2</li> </ul> <p>Data: none</p> <p>Example: &gt;886 cC6&lt; &gt;886C 0 0 C C c72&lt;</p> <p>Main control PCB = C Torch connect console = 0 Gas connect console = 0 Chopper 1 = C Chopper 2 = C</p>

ID	Command	System	Description / meaning
887	<i>Boot minor firmware revision</i>	XPR RS-422 EtherCAT	Reads bootloader minor revisions for the following printed circuit boards (PCBs): <ul style="list-style-type: none"> <li>▪ Main control PCB</li> <li>▪ Chopper boards</li> <li>▪ Torch connect console board</li> <li>▪ Gas connect console board</li> </ul>
			Data: none
			Return value: numeric revisions spaces delimited Main control PCB Torch connect console Gas connect console Chopper 1 Chopper 2
			Data: none
			Example: >887 cC7< >887472 180 122 169 169 c52<
889	<i>File over serial open</i>	XPR RS-422	Prepares the cutting system to receive firmware file:
			Data: size of file in bytes
			Return value: none
			RS-422 example: >889443977 c0B< (443977 bytes) >889cA9<
			Causes the cutting system to erase some of its flash memory and temporarily interrupt EtherCAT or WiFi communications for short periods of time (1 – 10 seconds).
891	<i>File over serial close</i>	XPR RS-422	Instructs the cutting system to use the transmitted firmware-update file to update its firmware.
			Data: none
			Return value: none
			RS-422 example: >891cA2< >891cA2<

ID	Command	System	Description / meaning
892	Set source	XPR RS-422 EtherCAT	<p>Sets the controlling source of the system.</p> <p>Data:</p> <p>9: Set process with WiFi, use discrete for I/O            10 Set process with WiFi, use EtherCAT for I/O            11: Set process with EtherCAT, use EtherCAT for I/O            12: Set process with EtherCAT, use discrete for I/O            13: Set process with RS422, use discrete for I/O            14: Set process with RS422, use EtherCAT for I/O</p> <p>Return value: none</p> <p>RS-422 example:            &gt;89212 c26&lt; (12, set process with EtherCAT, use discrete for I/O)            &gt;892cA3&lt;</p> <p>EtherCAT:            X3000: 01 = 892            X3000: 03 = 12 (source)            X3000: 0B = 1 (signal power source to act)</p>
893	Get Active Error Log	XPR RS-422	<p>Reads the active error log with details.</p> <p>Data: none</p> <p>Return value:            A_B_C_D_E_F            A = ID            B = Reserved            C = Timestamp (on time)            D = Data 1            E = Data 2            F = Timestamp (UTC)</p> <p>Example:            &gt;893 cC4&lt;            &gt;893768_0_192895_18690_80_1559755408            542_0_193061_0_100_1559755578 c0B&lt;</p>
895	Set Pump Timeout XPR	RS-422 EtherCAT	<p>Sets the pump timeout (ordinarily 30 minutes).</p> <p>Data: time in minutes 20 = 20 minutes (maximum 4320 minutes)</p> <p>RS-422 example:            &gt;89520 c28&lt;            &gt;895cA6&lt;</p> <p>EtherCAT example:            X3000: 01 = 895            X3000: 03 = 20            X3000: 0B = 1 (signal power source to act)</p>

ID	Command	System	Description / meaning
896	<i>Read Pump Timeout XPR</i>	RS-422 EtherCAT	<p>Reads the pump timeout.</p> <p>Return value: timeout time in minutes 20 = 20 minutes</p> <p>RS-422 example: &gt;896 cC7&lt; &gt;89620 c29&lt;</p> <p>EtherCAT example: X3000: 01 = 896 X3000: 0B = 1 (signal power source to act) X3000: 0D = 20 (20 minutes)</p>
897	<i>Release system control XPR</i>	EtherCAT	<p>The controlling interface releases control of the cutting system, which makes it possible to do system updates over WiFi.</p> <p>Data: 1 (indicates intention to release control)</p> <p>Return value: none</p> <p>EtherCAT example: X3000: 01 = 897 X3000: 03 = 1 X3000: 0B = 1 (signal power source to act)</p>

# State codes

ID	XPR state
00	STANDBY
01	POWERUP
02	INITIAL CHECKS
03	GAS PURGE AND PUMP ON
04	INERT PURGE
05	WAIT FOR START
06	RESERVED
07	PREFLOW CHARGE DC
08	IGNITE
09	PILOT ARC
10	RESERVED
11	RAMPUP
12	STEADY STATE
13	RAMPDOWN
14	END OF CYCLE
15	SHUTDOWN
16	TEST PREFLOW
17	TEST CUTFLOW
18	TEST PIERCE FLOW
19	ALTERNATE RAMPDOWN
20	MANUAL LEAK TEST
21	H <sub>2</sub> O PURGE
22	AUTOMATIC GAS LEAK CHECK

## Gas type codes

ID	Gas Type
0	No Gas (invalid gas type)
1	Oxygen (O <sub>2</sub> )
2	Reserved
3	Hydrogen (H <sub>2</sub> )
4	Reserved
5	Air
6	Nitrogen (N <sub>2</sub> )
7	Argon (Ar)
8	Reserved
9	Reserved
10	Reserved
11	F5 (95% nitrogen, 5% hydrogen)
12	Water (H <sub>2</sub> O) (for water injection processes)
13	Reserved

## Set a process

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1. Use the CNC to set Bit 3 of Object 7000, sub-index 1 (Request New Process).
2. Make sure that Bit 2 and Bit 5 of Object 6000, sub-index 1 are both (0).
3. Use the CNC to send the process ID using Object 3000, sub-index 1 (Command Number 609) and sub-index 3 (Process ID) and set sub-index 11 to (1).
4. Use the CNC to send any process offset values. Use the following:
  - a. Object 3000, sub-index 1 (Command Number for the value to offset)
  - b. Sub-index 3 (offset data) and sub-index 11 (1)
5. Use the CNC to clear Bit 3 of Object 7000, sub-index 1.
6. The CNC waits for Bit 5 of Object 6000, sub-index 1 to be set (1).
7. The CNC verifies that the Process ID matches the desired value:
  - a. Use Object 3000, sub-index 1 (Command Number 608) and sub-index 11 (1).
  - b. Do a check of the Return value in Object 3000, sub-index 13 (this is the process ID that is active in the system).
8. Once Bit 2 of Object 6000, sub-index 1 is set (1), the cutting system will accept a Plasma Start signal.

## Purge sequences

XPR cutting system purges are automatic. The type of purge is based on the currently-active state of operation and on the type of gas connect console (OptiMix, VWI, CorePlus, or Core).

- OptiMix and VWI cutting systems do gas-change and process-setup purges.
- Core and CorePlus cutting systems only do process-setup purges.

The length of time necessary to complete a purge is based on the type of operator-selected process and if the active process is the first process sent after the Power-On state (State 01). (Refer to *Sequence of operation* in the instruction manual that came with your cutting system).

### Process setup purge – before doing an O<sub>2</sub> / air process (Core, CorePlus, VWI, and OptiMix) (example: setting process ID 1001)

1. If the previous process was a mixed-fuel gas process (VWI, OptiMix only), then 1 of the following purge sequences occur:
  - For an OptiMix cutting system, process ID 115 is active and the plasma power supply uses an inert gas to purge the cutting system for 16 seconds.
  - For a VWI cutting system, process ID 114 is active and the plasma power supply uses an inert gas to purge the cutting system for 15 seconds.
2. If the previous process was not a fuel-gas (or if the cutting system has a Core or CorePlus gas connect console), the following purge sequence occurs:
  - Process ID 1001 is active and the plasma power supply uses a purge gas to purge the cutting system for 10 seconds.
3. After the purge stops, the cutting system is ready to do an O<sub>2</sub>/Air process (process ID 1001).

### Process setup purge – before doing a mixed-fuel gas process (VWI, OptiMix only) (example: setting process ID 2059)

1. Process ID 116 is active and the plasma power supply does a gas-leak test for approximately 20 seconds.
2. Process ID 115 is active and the plasma power supply uses an inert gas to purge the cutting system for 16 seconds.
3. Process ID 2059 is active and the plasma power supply uses a purge gas to purge the cutting system for approximately 9 seconds.
4. After the purge stops, the cutting system is ready to do a mixed-fuel gas process (process ID 2059).

**Gas-change purge – from N<sub>2</sub> / H<sub>2</sub>O to any other process (VWI and OptiMix only)  
(example: changing from process ID 2011 to process ID 1001)**

1. Process ID 117 is active and the plasma power supply uses water to purge the cutting system for 14 seconds.
2. Process ID 1001 is active and the plasma power supply uses a purge gas to purge the cutting system for approximately 2 seconds.
3. After the purge stops, the cutting system is ready to do any other process (process ID 1001).

**Gas-change purge – from O<sub>2</sub> / air to mixed-fuel gas (VWI, OptiMix only) (example: changing from process ID 1001 to process ID 2059)**

1. Process ID 116 is active and the plasma power supply does a gas-leak test for approximately 20 seconds.
2. Process ID 115 is active and the plasma power supply uses inert gas to purge the cutting system for 16 seconds.
3. Process ID 2059 is active and the plasma power supply uses a purge gas to purge the cutting system for approximately 9 seconds.
4. After the purge stops, the cutting system is ready to do a mixed-fuel gas process (process ID 2059).

**Gas-change purge – from mixed-fuel gas to O<sub>2</sub> / air (VWI, OptiMix only) (example: changing from process ID 2059 to process ID 1001)**

1. Process ID 115 is active and the plasma power supply uses an inert gas to purge the cutting system for 16 seconds.
2. Process ID 1001 is active and the plasma power supply uses a purge gas to purge the cutting system for approximately 9 seconds.
3. After the purge stops, the cutting system is ready to do an O<sub>2</sub> / air process (process ID 1001).

**Gas-change purge – from O<sub>2</sub> / air to argon (Ar) marking to O<sub>2</sub> / air (Core, CorePlus, VWI, OptiMix)  
(example: changing from process ID 1001 to 9003 to 1001)**

1. Process ID 9003 is active and the plasma power supply uses a purge gas to purge the cutting system for approximately 2 seconds.
2. After the first purge stops, the cutting system is ready to do argon marking (process ID 9003).
3. After argon marking stops:
  - a. Process ID 1001 is active.
  - b. The plasma power supply uses purge gas to purge the cutting system for approximately 2 seconds.
4. After the second purge stops, the cutting system is ready to do an O<sub>2</sub> / air process (process ID 1001).

**Gas-change purge – from mixed-fuel gas to argon (Ar) marking to mixed-fuel gas (VWI, OptiMix only)  
(example: changing from process ID 2059 to 9003 to 2059)**

1. Process ID 9003 is active and the plasma power supply uses a purge gas to purge the cutting system for approximately 2 seconds.
2. After the first purge stops, the cutting system is ready to do argon marking (process ID 9003).
3. After argon marking stops:
  - a. Process ID 2059 is active.
  - b. The plasma power supply uses purge gas to purge the cutting system for approximately 2 seconds.
4. After the second purge stops, the cutting system is ready to do a mixed-fuel gas process (process ID 2059).

## Codes

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Codes have an ID number, priority level, and details that describe the conditions that caused the code.

For guidance about how to respond to codes, refer to *How to diagnose and troubleshoot diagnostic codes* in the instruction manual that came with your cutting system.

### Codes that have smart data

Depending on the conditions, codes can also include smart data measurements.

- Codes can have multiple smart data measurements. For example, a temperature-related error code can have 2 data:
  - Actual measured temperature
  - Temperature error limit
- Some codes have only 1 smart data element.
- Not all codes have smart data.

Codes can include the following abbreviations:

- GCC = Gas connect console
- CAN = Controller area network
- TCC = Torch connect console
- t/o = Time out
- HF = High frequency
- IGBT = Insulated-gate bipolar transistor
- Ch1 = Chopper 1
- Ch2 = Chopper 2
- DC = Direct current, current
- Ind = Inductor
- MagFan = Magnetics fan
- HxFan = Heat-exchanger fan

## **Codes in the web interface**

Information	These codes contain information about the current conditions. In many cases, operator action is <b>not</b> necessary for Information codes. If action is necessary, the steps are usually simple.
Alert	These codes describe conditions that can reduce productivity or quality. Resolve an Alert code as soon as possible.
Error	These codes describe or conditions that usually reduce productivity or quality, or cause damage to cutting system components. Resolve an Error code as soon as possible.
Failure	These codes describe conditions where you cannot start the arc until the condition is resolved. Failure mode protects the cutting system and system components from permanent damage.

## Code descriptions

ID	enum	Priority	Description	Details	Smart data 1	Smart data 2	Action	Clears with
500	11	Failure	GCC->Main CAN t/o	The gas connect console (Core, CorePlus, VWI, or OptiMix) cannot receive (at least once-per-second) main control PCB communications through the CAN.	Time since high frequency (milliseconds)	None	Shut down	Remote ON-OFF
501	12	Failure	Mix->Main CAN t/o	The mixing module in the gas connect console cannot receive (at least once-per-second) communications from the main control PCB through the CAN.	Time since high frequency (milliseconds)	None	Shut down	Remote ON-OFF
503	10	Failure	TCC->Main CAN t/o	The torch connect console cannot receive (at least once per second) main control PCB communications through the CAN.	Time since high frequency (milliseconds)	None	Shut down	Remote ON-OFF
504	13	Failure	Ch1->Main CAN t/o	Chopper 1 cannot receive (at least once-per-second) main control PCB communications through the CAN.	Time since high frequency (milliseconds)	None	Shut down	Remote ON-OFF
505	14	Failure	Ch2->Main CAN t/o	Chopper 2 cannot receive (at least once-per-second) main control PCB communications through the CAN.	Time since high frequency (milliseconds)	None	Shut down	Remote ON-OFF
507	8	Failure	Main no CAN	There is a problem with the CAN network when power is supplied to the cutting system.	None	None	None	Remote ON-OFF
508	16	Error	CAN Busy	The CAN bus is overloaded (for 10 milliseconds or more).	None	None	None	Remote ON-OFF
510	3	Failure	Main->GCC CAN t/o	The main control PCB cannot receive (at least once-per-second) communications from the gas connect console (Core, CorePlus, VWI, or OptiMix) through the CAN.	None	None	Ramp down	Remote ON-OFF

ID	enum	Priority	Description	Details	Smart data 1	Smart data 2	Action	Clears with
511	4	Failure	Main->Mix CAN t/o	The mixing module in the gas connect console cannot receive (at least once-per-second) communications from the main control PCB through the CAN.	None	None	Ramp down	Remote ON-OFF
513	2	Failure	Main->TCC CAN t/o	The main control PCB cannot receive (at least once-per-second) communications from the torch connect console through the CAN.	None	None	Ramp down	Remote ON-OFF
514	5	Failure	Main->Ch1 CAN t/o	The main control PCB cannot receive (at least once-per-second) Chopper 1 communications through the CAN.	None	None	None	Remote ON-OFF
515	6	Failure	Main->Ch2 CAN t/o	The main control PCB cannot receive (at least once-per-second) Chopper 2 communications through the CAN.	None	None	None	Remote ON-OFF
520	18	Alert	Ignite t/o	For at least 600 milliseconds, the current sensor in Chopper 1 is unable to measure current more than 75% of the pilot arc setpoint (of 3 milliseconds).	Most significant byte (MSB): Chopper 1 current (amperage: A) Least significant byte (LSB): arc voltage (volts: V)	Bus voltage (volts: V)	End of cycle	Start or set process or remote ON-OFF
521	17	Alert	Pilot arc t/o	For at least 500 milliseconds, the current sensor in the work lead is unable to measure current more than the transfer reference value (of 3 milliseconds).	Time without current (milliseconds)	Work lead current (amperage: A)	End of cycle	Start or set process or remote ON-OFF
522	19	Alert	Preflow t/o	The cutting system cannot complete the preflow routine within 30 seconds.	Time in preflow (milliseconds)	None	End of cycle	Start or set process or remote ON-OFF
523	123	Error	Preflow purge t/o	The preflow purge cannot get to the setpoint within 45 seconds.	Time in preflow (milliseconds)	Time limit (milliseconds)	None	Set process or remote ON-OFF

ID	enum	Priority	Description	Details	Smart data 1	Smart data 2	Action	Clears with
524	124	Error	Cutflow purge t/o	The cutflow purge cannot get to the setpoint within 45 seconds.	Time in cutflow (milliseconds)	Time limit (milliseconds)	None	Set process or remote ON-OFF
525	210	Error	Inert gas purge t/o	The nitrogen (N <sub>2</sub> ) purge cannot successfully complete.	Time in N <sub>2</sub> purge (milliseconds)	Time limit (milliseconds)	None	Set process or remote ON-OFF
530	56	Alert	Low psi-Line A	For a minimum of 200 milliseconds, Line A pressure is less than 75% of the pressure setpoint, and the pressure setpoint is greater than 0.	Actual pressure (psi)	Line A setpoint (psi)	Ramp down	Set process or remote ON-OFF
531	57	Alert	Low psi-Line B	For a minimum of 200 milliseconds, Line B pressure is less than 75% of the pressure setpoint, and the pressure setpoint is greater than 0.	Actual pressure (psi)	Line B setpoint (psi)	Ramp down	Set process or remote ON-OFF
532	59	Alert	Low psi-H <sub>2</sub> O	For a minimum of 200 milliseconds, water (H <sub>2</sub> O) pressure is less than 50% of the pressure setpoint, and the pressure setpoint is greater than 0.	Actual pressure (psi)	H <sub>2</sub> O setpoint (psi)	Ramp down	Set process or remote ON-OFF
533	60	Alert	Low psi-F5	For a minimum of 200 milliseconds, F5 pressure is less than 75% of the pressure setpoint, and the setpoint is more than 0.	Actual pressure (psi)	F5 setpoint (psi)	Ramp down	Set process or remote ON-OFF
534	58	Alert	Low psi-Shield	For a minimum of 600 milliseconds, shield pressure is less than 75% of the pressure setpoint, and the setpoint is more than 0.	Actual pressure (psi)	Shield setpoint (psi)	Ramp down	Set process or remote ON-OFF
540	61	Error	Low flow 1-Coolant	For a minimum of 40 seconds after the Plasma Start switch is turned ON, the coolant flow rate is less than 1.9 L/min (0.5 gal/min).	Coolant flow (gal/min)	Pump on time (milliseconds)	Shut down	Remote ON-OFF
541	62	Error	Low flow 2-Coolant	For a minimum of 10 seconds after the coolant flow rate gets to 1.9 L/min (0.5 gal/min), the flow rate stays less than 3.03 L/min (0.8 gal/min).	Coolant flow (gal/min)	Pump on time (milliseconds)	Shut down	Remote ON-OFF

ID	enum	Priority	Description	Details	Smart data 1	Smart data 2	Action	Clears with
542	63	Failure	Low flow–Coolant	The coolant flow is less than 3.79 L/min (1 gal/min) for a minimum of 1 second.	Coolant flow (gal/min)	Flow limit (gal/min)	Shut down	Remote ON-OFF
543	64	Error	High flow 1–Coolant	The coolant flow is more than 3.03 L/min (0.8 gal/min) for a minimum of 5 seconds after the coolant pump stops.	Coolant flow (gal/min)	Pump on time (milliseconds)	Shut down	Set process or remote ON-OFF
544	65	Failure	High flow–Coolant	The coolant flow is more than 11.36 L/min (3 gal/min) for a minimum of 1 second.	Coolant flow (gal/min)	Flow limit (gal/min)	Shut down	Remote ON-OFF
550	27	Alert	No plasma arc	For a minimum of 10 milliseconds during a Steady State, the total electric current decreases 50% below the electric current setpoint, and the setpoint is more than the setpoint for that process (setpoints vary by process type).	Work current (amperage: A)	Current setpoint (amperage: A)	End of cycle	Start or set process or remote ON-OFF
552	20	Alert	DC below limit Ch1	The Chopper 1 current decreases below 50% of the set for 50 milliseconds and the setpoint is more than 10 A.	Measured current (amperage: A)	Current limit (amperage: A)	End of cycle	Set process or remote ON-OFF
553	21	Alert	DC below limit Ch2	The Chopper 2 current decreases below 50% of the set for 50 milliseconds and the setpoint is more than 10 A.	Measured current (amperage: A)	Current limit (amperage: A)	End of cycle	Set process or remote ON-OFF
555	23	Failure	DC exceeds limit–Ch1	For at least 10 milliseconds, the electric current for Chopper 1 is more than 170 A.	Measured current (amperage: A)	Current limit (amperage: A)	Shut down	Remote ON-OFF
556	24	Failure	DC exceeds limit–Ch2	For a minimum of 10 milliseconds, the electric current for Chopper 2 is more than 170 A.	Measured current (amperage: A)	Current limit (amperage: A)	Shut down	Remote ON-OFF
560	29	Error	Over temp–Ch1	The insulated-gate bipolar transistor (IGBT) temperature sensor for Chopper 1 measures more than 75°C (167°F).	Chopper temperature (degrees Celsius: °C)	temperature limit (degrees Celsius: °C)	Ramp down	—
561	30	Error	Over temp–Ch2	The insulated-gate bipolar transistor (IGBT) temperature sensor for Chopper 2 measures more than 75°C (167°F).	Chopper temperature (degrees Celsius: °C)	temperature limit (degrees Celsius: °C)	Ramp down	—

ID	enum	Priority	Description	Details	Smart data 1	Smart data 2	Action	Clears with
570	70	Alert	Start on powerup	The Plasma Start switch is turned ON before the cutting system goes into Power-Up state.	None	None	None	Start or set process or remote ON-OFF
571	71	Alert	Start on wait-start	The Plasma Start switch is turned ON before the cutting system enters Wait-for-Start state.	None	None	None	Start or set process or remote ON-OFF
574	74	Info	Start removed preflow	The Plasma Start switch goes OFF during Preflow state.	Time in Preflow state (milliseconds)	None	End of cycle	Start or set process or remote ON-OFF
575	75	Info	Start removed ignite	The Plasma Start switch goes OFF during Ignite state.	Time in Ignite state (milliseconds)	None	End of cycle	Start or set process or remote ON-OFF
576	76	Info	Start removed pilot	The Plasma Start switch goes OFF during Pilot Arc state.	Time in Pilot Arc state (milliseconds)	None	End of cycle	Start or set process or remote ON-OFF
577	77	Info	Start removed ramp up	The Plasma Start switch goes OFF during Ramp-Up state.	Time in Ramp-Up state (milliseconds)	None	End of cycle	Start or set process or remote ON-OFF
580	88	Error	Over temp–Ind 1	The temperature for Inductor 1 is more than 160°C (320°F).	Temperature (degrees Celsius: °C)	Temperature limit (degrees Celsius: °C)	Ramp down	—
581	89	Error	Over temp–Ind 2	The temperature for Inductor 2 is more than 160°C (320°F).	Temperature (degrees Celsius: °C)	Temperature limit (degrees Celsius: °C)	Ramp down	—
582	90	Error	Over temp–Ind 3	The temperature for Inductor 3 is more than 160°C (320°F).	Temperature (degrees Celsius: °C)	Temperature limit (degrees Celsius: °C)	Ramp down	—

ID	enum	Priority	Description	Details	Smart data 1	Smart data 2	Action	Clears with
583	91	Error	Over temp–Ind 4	The temperature for Inductor 4 is more than 160°C (320°F).	Temperature (degrees Celsius: °C)	temperature limit (degrees Celsius: °C)	Ramp down	—
586	47	Error	Over temp–Xfmr	The temperature for the transformer is more than 160°C (320°F) for a minimum of 5 seconds.	Transformer temperature (degrees Celsius: °C)	Temperature limit (degrees Celsius: °C)	Ramp down	—
587	68	Error	Over temp–Coolant	The coolant temperature is more than 85°C (185°F).	Coolant temperature (degrees Celsius: °C)	Temperature limit (degrees Celsius: °C)	Ramp down	—
588	69	Failure	Fan timeout	The cooling system cannot cool the cutting system to the target temperature within 60 minutes.	None	None	Shut down	—
600	78	Error	No TCC found	The torch connect console does not identify itself to the main control PCB through the CAN for a minimum of 30 seconds after power is supplied to the cutting system.	None	None	Shut down	Remote ON-OFF
601	80	Error	No Chopper 1 found	Chopper 1 does not identify itself to the main control PCB through the CAN for a minimum of 30 seconds after power is supplied to the cutting system.	None	None	Shut down	Remote ON-OFF
602	83	Error	No GCC found	The gas connect console (Core, CorePlus, VWI, or OptiMix) does not identify itself to the main control PCB through the CAN for a minimum of 30 seconds after power is supplied to the cutting system.	None	None	Shut down	Remote ON-OFF
604	214	Alert	No Chopper 2 found	The main control PCB does not receive Chopper 2 communications through the CAN after power is supplied to the cutting system.	None	None	None	Start or set process or remote ON-OFF

ID	enum	Priority	Description	Details	Smart data 1	Smart data 2	Action	Clears with
610	110	Failure	Ch1 Torch Protect ChA	A catastrophic failure of a consumable part is found on the Channel A Chopper 1 current signature.	Measured blowout value (amperage seconds)	Blowout limit (amperage seconds)	Ramp down	Remote ON-OFF
611	113	Failure	Ch1 Torch Protect ChB	A catastrophic failure of a consumable part is found on the Channel B Chopper 1 current signature.	Measured blowout value (amperage seconds)	Blowout limit (amperage seconds)	Ramp down	Remote ON-OFF
612	111	Failure	Ch2 Torch Protect ChA	A catastrophic failure of a consumable part is found on the Channel A Chopper 2 current signature.	Measured blowout value (amperage seconds)	Blowout limit (amperage seconds)	Ramp down	Remote ON-OFF
613	114	Failure	Ch2 Torch Protect ChB	A catastrophic failure of a consumable part is found on the Channel B Chopper 2 current signature.	Measured blowout value (amperage seconds)	Blowout limit (amperage seconds)	Ramp down	Remote ON-OFF
620	26	Alert	Arc stretch detected	The chopper duty cycle exceeds the programmed limit.	Duty cycle (%)	Limit (%)	Ramp down	Start or set process or remote ON-OFF
621	118	Failure	Over voltage-DC bus	The DC bus voltage is more than 414 V.	Bus voltage (volts: V)	Voltage limit (volts: V)	Shut down	Remote ON-OFF
622	119	Failure	Under voltage-DC bus	The DC bus voltage is less than 280 V.	Bus voltage (volts: V)	Voltage limit (volts: V)	Shut down	Remote ON-OFF
623	191	Error	Ch1 DC at idle	Chopper 1 is in Idle state and the chopper current is more than 10 A.	Measured current (amperage: A)	Current limit (amperage: A)	None	Remote ON-OFF
624	192	Error	Ch2 DC at idle	Chopper 2 is in Idle state and the chopper current is more than 10 A.	Measured current (amperage: A)	Current limit (amperage: A)	None	Remote ON-OFF
626	44	Alert	No DC output-Ch1	Chopper 1 does not make current for a minimum of 250 milliseconds after Arc-On state starts.	Actual current (amperage: A)	Current setpoint (amperage: A)	End of cycle	Remote ON-OFF
627	45	Alert	No DC output-Ch2	No current is produced by Chopper 2 within 250 milliseconds after Arc-On state starts.	Actual current (amperage: A)	Current setpoint (amperage: A)	End of cycle	Remote ON-OFF

ID	enum	Priority	Description	Details	Smart data 1	Smart data 2	Action	Clears with
631	117	Failure	DC at wait-start	The voltage in the work lead is more than 5 V while the cutting system is in the Wait-For-Start state.	Work lead current (amperage: A)	Process current setpoint (amperage: A)	Shut down	Remote ON-OFF
642	53	Info	System powered	Power is supplied to the cutting system and the Power On-Off switch is set to the ON position.	None	None	Non	Start or set process or remote ON-OFF
643	54	Info	No process loaded	Power is supplied to the cutting system and no process is selected.	None	None	None	Start or set process or remote ON-OFF
645	109	Info	System is off	Power is supplied to the cutting system and the Power On-Off switch is set to the OFF position.	None	None	None	Start or set process or remote ON-OFF
646	125	Info	System turned off	Power is removed from the cutting system.	None	None	Shut down	Start or set process or remote ON-OFF
647	190	Info	Process selected	Shows the selected process.	Process ID	None	None	Start or set process or remote ON-OFF
652	106	Error	Block def over limit	During Ramp Up or Ramp Down state, the process block timer definition exceeds 1 second.	Process block type	Block duration (milliseconds)	Shut down	Remote ON-OFF
653	107	Error	Block time over limit	During Ramp Up or Ramp Down state, the process block timer exceeds 1 second.	Process block type	Time in block (milliseconds)	Shut down	Remote ON-OFF
654	108	Error	Ch1 ArcOn t/o	During Ignite state, Chopper 1 does not enter Arc-On State for at least 100 milliseconds.	Time in ignite state (milliseconds)	Chopper state	End of cycle	Remote ON-OFF

ID	enum	Priority	Description	Details	Smart data 1	Smart data 2	Action	Clears with
655	120	Alert	DC during preflow	During Preflow state, a chopper finds current.	BIT 0: Chopper 1 current detected BIT 1: Chopper 2 current detected BIT 3: Chopper 3 current detected	None	Shut down	Start or set process or remote ON-OFF
656	121	Error	Default case	A default case occurs unintentionally.	State	Sub state	Shut down	Remote ON-OFF
657	122	Error	Bad block type	The block type is incorrect.	Block type	Expected block type	Shut down	Remote ON-OFF
658	204	Alert	Block def under limit	The process block duration is less than the minimum value.	Process block type	Process block duration (milliseconds)	End of cycle	Start or set process or remote ON-OFF
659	205	Alert	State dur (duration) under limit	The state duration is less than the minimum value.	System state	Time in state (milliseconds)	End of cycle	Start or set process or remote ON-OFF
660	100	Error	Thermistor Fault-Ind 1	The main control PCB finds a shorted temperature sensor in Inductor 1.	Thermistor analog-to-digital converter (ADC) counts	None	Shut down	Remote ON-OFF
661	101	Error	Thermistor Fault-Ind 2	The main control PCB finds a shorted temperature sensor in Inductor 2.	Thermistor analog-to-digital converter (ADC) counts	None	Shut down	Remote ON-OFF
662	102	Error	Thermistor Fault-Ind 3	The main control PCB finds a shorted temperature sensor in Inductor 3.	Thermistor analog-to-digital converter (ADC) counts	None	Shut down	Remote ON-OFF
663	103	Error	Thermistor Fault-Ind 4	The main control PCB finds a shorted temperature sensor in Inductor 4.	Thermistor analog-to-digital converter (ADC) counts	None	Shut down	Remote ON-OFF

ID	enum	Priority	Description	Details	Smart data 1	Smart data 2	Action	Clears with
666	49	Error	Thermistor Fault–Xfmr	The main control PCB finds a shorted temperature sensor in the transformer.	Thermistor analog-to-digital converter (ADC) counts	None	Shut down	Remote ON-OFF
667	38	Error	Thermistor Fault–Ch1	Chopper 1 finds a shorted temperature sensor near the insulated-date bipolar transistor (IGBT).	Thermistor analog-to-digital converter (ADC) counts	None	Ramp down	Remote ON-OFF
668	39	Error	Thermistor Fault–Ch2	Chopper 2 finds a shorted temperature sensor near the insulated-date bipolar transistor (IGBT).	Thermistor analog-to-digital converter (ADC) counts	None	Ramp down	Remote ON-OFF
670	67	Error	Thermistor Fault–Coolant	The main control PCB finds a shorted coolant temperature sensor.	Thermistor analog-to-digital converter (ADC) counts	None	Shut down	Remote ON-OFF
671	94	Error	No Thermistor–Ind 1	The main control PCB cannot detect the temperature in Inductor 1.	Thermistor analog-to-digital converter (ADC) counts	None	Shut down	Remote ON-OFF
672	95	Error	No Thermistor–Ind 2	The main control PCB cannot detect the temperature in Inductor 2.	Thermistor analog-to-digital converter (ADC) counts	None	Shut down	Remote ON-OFF
673	96	Error	No Thermistor–Ind 3	The main control PCB cannot detect the temperature in Inductor 3.	Thermistor analog-to-digital converter (ADC) counts	None	Shut down	Remote ON-OFF
674	97	Error	No Thermistor–Ind 4	The main control PCB cannot detect the temperature in Inductor 4.	Thermistor analog-to-digital converter (ADC) counts	None	Shut down	Remote ON-OFF

ID	enum	Priority	Description	Details	Smart data 1	Smart data 2	Action	Clears with
677	48	Error	No Thermistor–Xfmr	The main control PCB cannot detect the temperature in the transformer.	Thermistor analog-to-digital converter (ADC) counts	None	Shut down	Remote ON-OFF
678	35	Error	No Thermistor–Ch1	The cutting system cannot detect the temperature sensor for Chopper 1.	Thermistor analog-to-digital converter (ADC) counts	None	Ramp down	Remote ON-OFF
679	36	Error	No Thermistor–Ch2	The cutting system cannot detect the temperature sensor for Chopper 2.	Thermistor analog-to-digital converter (ADC) counts	None	Ramp down	Remote ON-OFF
681	66	Error	No Thermistor–coolant	The main control PCB cannot detect coolant temperature.	Thermistor analog-to-digital converter (ADC) counts	None	Shut down	Remote ON-OFF
691	127	Error	Node reset	The main control PCB receives a “console-reset” message after power is supplied to the cutting system.	Reset info	Time since high frequency (milliseconds)	Shut down	Set process or remote ON-OFF
695	128	Alert	Low inlet H <sub>2</sub> -Mix (OptiMix only)	The hydrogen (H <sub>2</sub> ) inlet pressure for the mixing module in the gas connect console (only for OptiMix) is less than 7.24 bar (105 psi).	H <sub>2</sub> inlet pressure (psi)	Pressure limit (psi)	None	Set process or remote ON-OFF
696	129	Alert	Low inlet Ar-mix (OptiMix only)	The argon (Ar) inlet pressure for the mixing module in the gas connect console (Core, CorePlus, VWI, or OptiMix) is less than 7.24 bar (105 psi).	Argon (Ar) inlet pressure (psi)	Pressure limit (psi)	—	—
697	130	Alert	Low inlet N <sub>2</sub> -mix (OptiMix only)	The nitrogen (N <sub>2</sub> ) inlet pressure for the mixing module in the gas connect console (Core, CorePlus, VWI, or OptiMix) is less than 7.24 bar (105 psi).	N <sub>2</sub> inlet pressure (psi)	Pressure limit (psi)	None	Set process or remote ON-OFF
699	132	Error	Mix fault	The main control PCB finds a mixing module fault in the gas connect console (Core, CorePlus, VWI, or OptiMix).	Fault info	None	Ramp down	Set process or remote ON-OFF

ID	enum	Priority	Description	Details	Smart data 1	Smart data 2	Action	Clears with
700	133	Alert	Gas inlet F5–GCC	The F5 inlet pressure for P6 in the gas connect console (for VWI or OptiMix only) is less than 5.52 bar (80 psi) or more than 9.31 bar (135 psi).	F5 inlet pressure (psi)	Pressure limit (psi)	None	Set process or remote ON-OFF
701	134	Alert	Low inlet H <sub>2</sub> O–GCC	The water (H <sub>2</sub> O) inlet pressure for P8 in the gas connect console (for VWI and OptiMix only) is less than 2.07 bar (30 psi).	H <sub>2</sub> O inlet pressure (psi)	Pressure limit (psi)	None	Set process or remote ON-OFF
702	135	Alert	Shield gas inlet N <sub>2</sub> –TCC	For a minimum of 200 milliseconds, the N <sub>2</sub> inlet pressure in the torch connect console is less than 5.52 bar (80 psi) or greater than 9.31 bar (135 psi).	Most significant byte (MSB): N <sub>2</sub> inlet pressure (psi) Least significant byte (LSB): pressure sensor	Pressure limit (psi)	None	Set process or remote ON-OFF
703	136	Alert	Shield gas inlet O <sub>2</sub> –TCC	For a minimum of 200 milliseconds, the oxygen (O <sub>2</sub> ) inlet gas pressure in the torch connect console is less than 5.52 bar (80 psi) or more than 9.31 bar (135 psi).	Most significant byte (MSB): O <sub>2</sub> inlet pressure (psi) Least significant byte (LSB): pressure sensor	Pressure limit (psi)	None	Set process or remote ON-OFF
704	137	Alert	Shield gas inlet air–TCC	For a minimum of 200 milliseconds, the air inlet pressure in the torch connect console is less than 5.52 bar (80 psi) or more than 9.31 bar (135 psi).	Most significant byte (MSB): Air inlet pressure (psi) Least significant byte (LSB): pressure sensor	Pressure limit (psi)	None	Set process or remote ON-OFF
705	138	Alert	Shield gas inlet Ar–TCC	For a minimum of 200 milliseconds, the argon (Ar) inlet pressure in the torch connect console is less than 5.52 bar (80 psi) or more than 9.31 bar (135 psi).	Most significant byte (MSB): Argon (Ar) inlet pressure (psi) Least significant byte (LSB): pressure sensor	Pressure limit (psi)	None	Set process or remote ON-OFF

ID	enum	Priority	Description	Details	Smart data 1	Smart data 2	Action	Clears with
706	139	Error	No sensor P1–TCC	The P1 pressure in the torch connect console is not detected.	Sensor analog-to-digital converter (ADC) counts	Counts limit	Ramp down	Set process or remote ON-OFF
707	140	Error	No sensor P2–TCC	The P2 pressure in the torch connect console is not detected.	Sensor analog-to-digital converter (ADC) counts	Counts limit	Ramp down	Set process or remote ON-OFF
708	141	Error	No sensor P3–TCC	The P3 pressure in the torch connect console is not detected.	Sensor analog-to-digital converter (ADC) counts	Counts limit	Ramp down	Set process or remote ON-OFF
709	142	Error	No sensor P4–TCC	The P4 pressure in the torch connect console is not detected.	Sensor analog-to-digital converter (ADC) counts	Counts limit	Ramp down	Set process or remote ON-OFF
710	143	Error	No sensor P5–TCC	The P5 pressure in the torch connect console is not detected.	Sensor analog-to-digital converter (ADC) counts	Counts limit	Ramp down	Set process or remote ON-OFF
711	144	Error	No sensor P14–TCC	The P14 pressure in the torch connect console is not detected.	Sensor analog-to-digital converter (ADC) counts	Counts limit	Ramp down	Set process or remote ON-OFF
712	145	Error	No sensor P6–GCC	The P6 pressure in the gas connect console is not detected.	Sensor analog-to-digital converter (ADC) counts	Counts limit	Ramp down	Set process or remote ON-OFF
713	146	Error	No sensor P7–GCC	The P7 pressure in the gas connect console is not detected.	Sensor analog-to-digital converter (ADC) counts	Counts limit	Ramp down	Set process or remote ON-OFF

ID	enum	Priority	Description	Details	Smart data 1	Smart data 2	Action	Clears with
714	147	Error	No sensor P8–GCC	The P8 pressure in the gas connect console is not detected.	Sensor analog-to-digital converter (ADC) counts	Counts limit	Ramp down	Set process or remote ON-OFF
715	148	Error	No sensor P9–GCC	The P9 pressure in the gas connect console is not detected.	Sensor analog-to-digital converter (ADC) counts	Counts limit	Ramp down	Set process or remote ON-OFF
716	149	Error	Set process denied	The selected process is not supported by this cutting system.	1: PID invalid 2: invalid user 3: invalid user source 4: invalid PID 5: not allowed or system not ready 6: not supported	None	None	Set process or remote ON-OFF
717	150	Alert	Low voltage–mix	The supply voltage for the gas mixer in the gas connect console is less than 21 V.	System state	Time in state (milliseconds)	Ramp down	Set process or remote ON-OFF
718	151	Alert	High voltage–mix	The supply voltage for the gas mixer in the gas connect console is more than 27 V.	System state	Time in state (milliseconds)	Ramp down	Set process or remote ON-OFF
719	152	Alert	Mix pwm 100%	100% duty is reached on any line.	Most significant byte (MSB): H <sub>2</sub> duty cycle (%) Least significant byte (LSB): Ar duty cycle (%)	N <sub>2</sub> duty cycle (%)	None	Start or set process or remote ON-OFF

ID	enum	Priority	Description	Details	Smart data 1	Smart data 2	Action	Clears with
720	153	Alert	Mix P21 >Pin	Pressure out (P21) is more than pressure in (Pin) by at least 0.068 bar (1 psi).	Most significant byte (MSB): mixing console outlet pressure (psi) Least significant byte (LSB): H <sub>2</sub> inlet pressure (psi)	MSB: Ar inlet pressure (psi) LSB: N <sub>2</sub> inlet pressure (psi)	None	Start or set process or remote ON-OFF
721	154	Error	Mix checksum	There was a failure of the mixing parameter checksum.	None	None	Ramp down	Set process or remote ON-OFF
722	155	Error	Mix flow cal	There was a failure of the mixing flow calibration.	None	None	Ramp down	Set process or remote ON-OFF
723	156	Error	Mix pressure cal	There was a failure of the mixing pressure calibration.	None	None	Ramp down	Set process or remote ON-OFF
724	157	Error	Mix I2C1	There is a mixing communication error for I2C1.	System state	None	Ramp down	Set process or remote ON-OFF
725	158	Error	Mix I2C2	There is a mixing communication error for I2C2.	System state	None	Ramp down	Set process or remote ON-OFF
726	159	Error	Mix system clock	There is a problem with the mixing system clock.	None	None	Ramp down	Set process or remote ON-OFF
727	160	Info	Bad Temp Reading Ch1	Temperature samples taken one after the other vary by more than 2 degrees.	None	None	Ramp down	Start or set process or remote ON-OFF
728	161	Info	Bad Temp Reading Ch2	Temperature samples taken one after the other vary by more than 2 degrees.	None	None	Ramp down	Start or set process or remote ON-OFF

ID	enum	Priority	Description	Details	Smart data 1	Smart data 2	Action	Clears with
730	163	Alert	Solenoid error V1	There is a V1 error.	None	None	Ramp down	Set process or remote ON-OFF
733	166	Alert	Solenoid error V4	There is a V4 error.	None	None	Ramp down	Set process or remote ON-OFF
734	167	Alert	Solenoid error V5	There is a V5 error.	None	None	Ramp down	Set process or remote ON-OFF
735	168	Alert	Solenoid error V6	There is a V6 error.	None	None	Ramp down	Set process or remote ON-OFF
736	169	Alert	Solenoid error V7	There is a V7 error.	None	None	Ramp down	Set process or remote ON-OFF
737	170	Alert	Solenoid error V8	There is a V8 error.	None	None	Ramp down	Set process or remote ON-OFF
738	171	Alert	Solenoid error V9	There is a V9 error.	None	None	Ramp down	Set process or remote ON-OFF
739	172	Alert	Solenoid error V10	There is a V10 error.	None	None	Ramp down	Set process or remote ON-OFF
740	173	Alert	Solenoid error V11	There is a V11 error.	None	None	Ramp down	Set process or remote ON-OFF
741	174	Alert	Solenoid error V12	There is a V12 error.	None	None	Ramp down	Set process or remote ON-OFF
742	175	Alert	Mix I2C1 Alert	There is a mixing communication alert for I2C1.	System state	Time in state (milliseconds)	None	Set process or remote ON-OFF

ID	enum	Priority	Description	Details	Smart data 1	Smart data 2	Action	Clears with
743	176	Alert	Mix I2C2 Alert	There is a mixing communication alert for I2C2.	System state	Time in state (milliseconds)	None	Set process or remote ON-OFF
744	177	Alert	Low speed–mag (magnetics) Fan 1	Fan 1 speed is below the minimum acceptable RPM value.	Measured fan speed (RPM)	Fan speed limit (RPM)	None	Set process or remote ON-OFF
745	178	Alert	Low speed–mag (magnetics) Fan 2	Fan 2 speed is below the minimum acceptable RPM value.	Measured fan speed (RPM)	Fan speed limit (RPM)	None	Set process or remote ON-OFF
748	179	Alert	Low speed–Hx (heat exchanger) Fan 1	Fan 1 speed is below the minimum acceptable RPM value.	Measured fan speed (RPM)	Fan speed limit (RPM)	None	Set process or remote ON-OFF
749	180	Alert	Low speed–Hx (heat exchanger) Fan 2	Fan 2 speed is below the minimum acceptable RPM value.	Measured fan speed (RPM)	Fan speed limit (RPM)	None	Set process or remote ON-OFF
750	186	Alert	Low speed–Hx (heat exchanger) Fan 3	Fan speed is below the minimum acceptable RPM value.	Measured fan speed (RPM)	Fan speed limit (RPM)	None	Set process or remote ON-OFF
751	187	Alert	Low speed–Hx (heat exchanger) Fan 4	Fan speed is below the minimum acceptable RPM value.	Measured fan speed (RPM)	Fan speed limit (RPM)	None	Set process or remote ON-OFF
752	181	Error	Phase fault–Ch1	Chopper 1 detected a 3-phase error.	Minimum bus voltage (V)	Measured bus voltage frequency (Hz)	Shut down	Remote ON-OFF
753	182	Error	Phase fault–Ch2	Chopper 2 detected a 3-phase error.	Minimum bus voltage (V)	Measured bus voltage frequency (Hz)	Shut down	Remote ON-OFF
755	188	Alert	Low level–Coolant	The coolant level is low.	None	None	None	Set process or remote ON-OFF

ID	enum	Priority	Description	Details	Smart data 1	Smart data 2	Action	Clears with
756	189	Info	Leak test results	Reports the results of an automated gas leak test.	0: leak in v1 v12 or hose 1: leak in b1 2: leak in v1 or b1 3: leak in v1 Vv0 or hose 4: leak in b3); break; 5: leak in v10 or b3 6: manual leak test failed 7: manual leak test passed 8: leak in v4 v5 v6 or v7 9: leak in b2 10: leak in v10 or hose 11: no n2 inlet or v5 12: leak in p7 volume 13: leak in line A or v1 14: auto leak test failed 15: auto leak test passed 16: timeout	None	None	Start or set process or remote ON-OFF
757	194	Error	DC work exceeds limit	The work lead current exceeds the setpoint by 20 A for at least 10 milliseconds.	Actual current (amperage: A)	Limit (amperage: A)	End of cycle	Remote ON-OFF
758	198	Alert	Main 24V DIP	The 24 V DC bus decreases to less than 20 V on the main control PCB.	24 VDC bus voltage (V)	DIP duration (milliseconds)	None	Set process or remote ON-OFF
759	199	Alert	GCC 24V bus low	The 24 VDC bus decreases to less than 20 V on the gas connect console.	24 VDC bus voltage (V)	None	Ramp down	Set process or remote ON-OFF

ID	enum	Priority	Description	Details	Smart data 1	Smart data 2	Action	Clears with
763	126	Alert	Coolant solenoid fault	The coolant solenoid driver finds an over-current condition.	None	None	None	Set process or remote ON-OFF
764	195	Alert	Main contactor fault	The main contactor driver finds an over-current condition.	None	None	None	Set process or remote ON-OFF
765	196	Alert	Inrush contactor fault	The inrush contactor driver finds an over-current condition.	None	None	None	Set process or remote ON-OFF
766	197	Alert	Pump enable fault	The pump-enable driver finds an over-current condition.	None	None	None	Set process or remote ON-OFF
767	203	Alert	Remote relay fault	The Power On-Off relay driver detects an over-current condition.	None	None	None	Set process or remote ON-OFF
768	208	Alert	Gas Inlet-O <sub>2</sub> Line A	Line A O <sub>2</sub> inlet pressure is below 5.52 bar (80 psi) or above 9.31 bar (135 psi).	Line A inlet pressure (psi)	Most significant byte (MSB): pressure sensor Least significant byte (LSB): pressure limit (psi)	None	Set process or remote ON-OFF
769	209	Alert	Gas inlet-Argon Line B	Line B Argon (Ar) inlet pressure is below 5.52 bar (80 psi) or above 9.31 bar (135 psi).	Line B inlet pressure (psi)	Most significant byte (MSB): pressure sensor Least significant byte (LSB): pressure limit (psi)	None	Set process or remote ON-OFF

ID	enum	Priority	Description	Details	Smart data 1	Smart data 2	Action	Clears with
770	207	Alert	Gas Inlet–N <sub>2</sub> Line B	Line B N <sub>2</sub> inlet pressure is below 5.52 bar (80 psi) or above 9.31 bar (135 psi).	Line B inlet pressure (psi)	Most significant byte (MSB): pressure sensor Least significant byte (LSB): pressure limit (psi)	None	Set process or remote ON-OFF
771	206	Alert	Gas inlet–Air Line A	Line A Air inlet pressure is below 5.52 bar (80 psi) or above 9.31 bar (135 psi).	Line A inlet pressure (psi)	Most significant byte (MSB): pressure sensor Least significant byte (LSB): pressure limit (psi)	None	Set process or remote ON-OFF
772	211	Alert	High inlet line A	Line A inlet pressure is more than 9.65 bar (140 psi).	Line A inlet pressure (psi)	Pressure limit (psi)	Ramp down	Set process or remote ON-OFF
773	212	Info	System reverted to VWI	The system downgraded from OptiMix to VWI because of an error condition.	None	None	None	Start or set process or remote ON-OFF
774	213	Alert	P5 >= P2	Line A outlet pressure (P5) exceeds Air inlet pressure (P2) while V10 is active. Cutting system operation stops automatically when this occurs.	P2 pressure (psi)	P5 pressure (psi)	Ramp down	Set process or remote ON-OFF

ID	enum	Priority	Description	Details	Smart data 1	Smart data 2	Action	Clears with
775	215	Alert	Node update	The firmware on a node has been updated.	low byte: major rev high byte low nibble:result (0:success 1:boundary error 2:byte count error 3:checksum error 4:timeout error 5:target error) high byte high nibble:target (0:unknown 1:main control 2:tcc 3:gcc 4:ch1 5:ch1 ch2 6: ch1 ch2 ch3 7:boot main control 8:boot tcc 9:boot gcc 10:boot ch1 11:boot ch1 ch2 12:boot ch1 ch2 ch3)	Minor rev	None	Start or set process or remote ON-OFF
776	216	Alert	WiFi reset	The GS2011 wireless module is reset.	None	None	None	Start or set process or remote ON-OFF
777	217	Alert	Pilot relay fault	The pilot relay driver detects an over current.	None	None	None	Set process or remote ON-OFF

ID	enum	Priority	Description	Details	Smart data 1	Smart data 2	Action	Clears with
778	218	Alert	Hv (high voltage) relay fault	The high-voltage relay driver detects an over-current.	None	None	None	Set process or remote ON-OFF
779	219	Alert	Chopper 1 (15 VDC)	The 15 VDC for Chopper 1 is out of range.	Actual voltage	Reference voltage	None	Set process or remote ON-OFF
780	220	Alert	Chopper 2 (15 VDC)	The 15 VDC for Chopper 2 is out of range.	Actual voltage	Reference voltage	None	Set process or remote ON-OFF
781	221	Alert	Chopper 3 (15 VDC)	The 15 VDC for Chopper 3 is out of range.	Actual voltage	Reference voltage	None	Set process or remote ON-OFF
782	222	Alert	Low psi-P2	During mixed-gas flow, gas pressure for P2 is less than 7.58 bar (110 psi) for at least 200 milliseconds.	P2 pressure (psi)	P2 reference (psi)	None	Set process or remote ON-OFF
784	224	Error	Main 24V high	The 24 VDC bus is above 28 volts.	24 VDC bus voltage (V)	None	Ramp down	None

For guidance about how to respond to codes, refer to *How to diagnose and troubleshoot diagnostic codes* in the instruction manual that came with your XPR cutting system.

## How to get the best results from firmware updates

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### Firmware over EtherCAT (FoE) updates

Hypertherm OEMs without EDGE Connect CNCs can use standard File over EtherCAT (FOE) protocols to update firmware on any cutting systems that currently have firmware revision M or later.

For the best results do the following:

- Use hex passcode F0EACCEC. This gives the EtherCAT master permission to write to the XPR slave.
  - Use only firmware-update files from Hypertherm.
  - Before a firmware update begins:
    - Make sure that the remote ON-OFF switch for the cutting system is set to ON.
    - Make sure that the revision letter for the main control PCB is revision H or later and that the .esi file is revision 9.
    - If necessary, flash the latest .esi file onto the ASIC on the cutting system main control PCB. For example, it is necessary to support all new mailbox diagnostic data.
    - Set the cutting system to the EtherCAT Bootstrap state and then wait 1 – 2 seconds before sending a firmware-update file to the cutting system.
  - When sending a file to the cutting system:
    - Wait 1 – 2 seconds after the cutting system is set to the EtherCAT Bootstrap state before sending a firmware-update file to the cutting system.
    - Wait for the cutting system to return to the Initial Checks state (State 02) before sending the next firmware-update file. Not waiting can cause the cutting system to return an error and make it necessary to send the file again.
    - Send each firmware-update file **one-at-a-time**. Do not attempt to send or update multiple files simultaneously.
    - Send only the firmware-update files that are necessary for an update. The order for sending the files does **not** matter.
-  The maximum time for a single board to update is 3 minutes. If it takes longer, it can be necessary to send the file again.
- During the firmware update:
    - Wait 10 – 20 seconds after each firmware-update is complete before beginning the next update. After the firmware for the main control PCB is updated, no delays are necessary. However, a 10 – 20-second delay is a good practice.

## Firmware over serial (FoS) RS-422 updates

For the best results do the following:

- Use only firmware-update files from Hypertherm.
- Before the firmware update begins:
  - Make sure that the remote ON-OFF switch for the cutting system is set to ON.
  - Make sure that there is no process set or that the cutting system is in Initial Checks state (State 02).
- When sending a file to the cutting system:
  - Make sure that the CNC or other communication device determines the size of the firmware file in bytes. Refer to example below:
 

```
fileBytes = File.ReadAllBytes(openFileDialog1.FileName);
transmitXpr ("889", fileBytes.Length + " ");
```
- During the firmware update:
  - Make sure that the FoS Close command is sent to the cutting system within 10 seconds after the transmission of the firmware-update file is complete.

### Overview

1. The CNC, or other communication device, sends the FoS Open (889) command to the cutting system.
2. The CNC, or other communication device, sends the firmware-update files to the XPR cutting system, **one-at-a-time**, in 515-byte transmissions, and then waits for a FoS Write result (890) from the cutting system before continuing.
3. The CNC, or other communication device, sends the FOS Close (891) command to the cutting system.
4. The cutting system enters Updates Node state and begins the firmware update.

### FoS Open command

ID	Command	System	Description
889	File over serial open	XPR RS-422	Prepares the cutting system to receive the firmware file.  Data: size of the file in bytes  Return value: none  RS-422 example: >889443977 c0B< (443977 bytes) >889cA9<  The response to this command is sent only after the file transmission is complete.

ID	Command	System	Description
			<ul style="list-style-type: none"> <li>This command causes the cutting system to erase some of its flash memory and temporarily interrupt EtherCAT or WiFi communications for short periods of time (1 – 10 seconds).</li> </ul>
			<ul style="list-style-type: none"> <li>After the FOS Open command is sent the XPR treats all incoming RS-422 data as part of the firmware file. It also begins a 10-second timeout. If the cutting system does not receive a character at least once every 10 seconds, the XPR will exit firmware-update mode and normal serial communications will resume.</li> </ul>

EXAMPLE CODE:

```
fileBytes = File.ReadAllBytes(openFileDialog1.FileName);
transmitXpr ("889", fileBytes.Length + " ");
```

## Transmit files to the cutting system

Transmission of a firmware-update file to the cutting system begins after the FoS Open command is sent:

1. Send the first 512 bytes of the file.
2. Wait for FoS Write (890) result from the cutting system:  
>890cA1<
3. Send next 512 bytes of the file.
4. Wait for FoS Write (890) result from the cutting system:  
>890cA1<
5. Repeat *step 3* and *step 4* until there is less than 512 bytes remaining.



Until the total number of bytes is received, the cutting system considers all serial data that is transmitted as part of the firmware-update file.

6. Wait for FoS Write (890) result from the cutting system:  
>890cA1<



**Important:** The “890” result is **not** a command that is sent to the cutting system. It is a message from the cutting system that indicates that the bytes have been written to memory

**7. Transmission is now complete.**

```

EXAMPLE CODE:
for (i = 0; i < fileBytes.Length/512; i++)
{
    _serialPort.Write(fileBytes, i*512, 512); tmr1 = 0;
    while ((rx890 == false) && (tmr1 < 50)) ;
    rx890 = false;
}
_serialPort.Write(fileBytes, i * 512, fileBytes.Length % 5120);

```

In the example, the timer is used to separate each 512-byte transmission by at least 50 milliseconds and to wait for the “890” response before sending the next transmission.

**FoS Close command:**

ID	Command	System	Description
891	File over serial close	XPR RS-422	Instructs the cutting system to update firmware. Data: none Return value: none RS-422 example: >891cA2< >891cA2< If the update is for the main control PCB, the cutting system can become unresponsive during the firmware update. When the update is complete normal operation resumes automatically.
<ul style="list-style-type: none"> <li>The FoS Close command puts the cutting system into Node Update state (State 06) and instruct it to begin the firmware update.</li> </ul>			

After the firmware update, the cutting system automatically:

1. Uses a Node Update code (775) to report on firmware-update success or a failure.
2. Restarts the cutting system software.

To verify the current firmware version, use any cutting system interface to retrieve it.

## Firmware version descriptions

Firmware version	Released date	Updates
V	December 2022	<ul style="list-style-type: none"> <li>Add changes to support European idle-state power-consumption requirements specified in IEC 60974-1 Edition 6.0.</li> </ul>
U	May 2022	<ul style="list-style-type: none"> <li>Decrease EEPROM write cycles.</li> <li>Add "Reset Operator" button to webpage.</li> <li>Implement CorePlus.</li> <li>Add fix for Error 540.</li> <li>Add fix for incorrect reporting of smart error data on EtherCAT.</li> <li>Change webpage formatting.</li> <li>Increase reliability of uploads with USB drives.</li> <li>Enable gas leak test for Core and CorePlus gas consoles.</li> <li>Add process ID 2029 to improve start reliability for 80 A N<sub>2</sub>/H<sub>2</sub>O underwater cutting.</li> </ul>
T	July 2021	<ul style="list-style-type: none"> <li>Change how CAN-timeout codes are reported.</li> <li>Add Pump Timeout Time command to set a pump timeout value.</li> <li>Add Release Source command to improve firmware-update process.</li> <li>Remove Minor Revision information from the Other page in the web user interface (Minor Revision information remains available on the Update page).</li> </ul>
S	April 2021	<ul style="list-style-type: none"> <li>Improve chopper reliability.</li> </ul>
R	November 2020	<ul style="list-style-type: none"> <li>Release the 220 A process that includes 220 A True Hole™.</li> <li>Improve reliability for non-ferrous cutting. This includes aluminum 60 A N<sub>2</sub>/N<sub>2</sub>, stainless steel N<sub>2</sub>/H<sub>2</sub>O, and aluminum 170 A N<sub>2</sub>/N<sub>2</sub>.</li> <li>Improve gas-flow diagnostics for process control in the XPR web interface.</li> </ul>
P	June 2020	<ul style="list-style-type: none"> <li>Improve CAN bus error handling. Specifically, turn OFF all outputs if a CAN bus failure occurs to improve system control during hard faults.</li> <li>Increase process offset limits for most gas pressures. Increase process offset limits for marking and cutting currents for improved cutting and marking control optimization.</li> </ul>
N	April 2020	<ul style="list-style-type: none"> <li>Change Mix I2C diagnostic-code behavior to be a warning except with mixed-gas processes.</li> <li>Resolve false Node reset errors (691).</li> <li>Stop the cut on a lost current error.</li> <li>Add 784, Main 24 V high, for 24 VDC high voltage error.</li> <li>Stop the cut or prevent start on a 745, Low Speed-MagFan 2, alert.</li> <li>Resolve inductor 4 temperature scaling reporting error.</li> </ul>
M	June 2019	<ul style="list-style-type: none"> <li>Add FoE (firmware over EtherCAT) and FoS (firmware over serial).</li> <li>Change TorchConnect console solenoid valve duty cycle.</li> <li>Increase initialization time for USB memory sticks to support more USB memory sticks.</li> <li>Decrease XPR web interface refresh rate from 2 seconds to 0.5 seconds.</li> </ul>

Firmware version	Released date	Updates
L	March 2019	<ul style="list-style-type: none"> <li>▪ Add ohmic contact for vented water injection (VWI™) processes.</li> <li>▪ Eliminate false-failure messages that occur during XPR web interface firmware update.</li> </ul>
K	November 2018	<ul style="list-style-type: none"> <li>▪ Make sure that F5 HyDefinition™ (HDi) processes are enabled in VWI gas connect consoles.</li> <li>▪ Resolve issues from firmware version J.</li> </ul>
J	October 2018	<ul style="list-style-type: none"> <li>▪ Release 50 A True Hole processes.</li> <li>▪ Enable 170 A 0.75 inch and 130 A 0.25 inch True Hole processes.</li> <li>▪ Upgrade OptiMix gas connect console operation support.</li> <li>▪ Fix XPR web interface server crash and RS-422 multi-drop issues.</li> </ul>
H	June 2018	<ul style="list-style-type: none"> <li>▪ Enable wireless firmware updates.</li> <li>▪ Change the threshold for the coolant solenoid fault.</li> <li>▪ Improve gas system checks and error handling.</li> <li>▪ Enable fan speed error checks.</li> <li>▪ Improve error handling on chopper over-temp (560, 561) and main-control diagnostic codes.</li> </ul>
G	January 2018	<ul style="list-style-type: none"> <li>▪ Change CAN-message handling for solenoid valve (V11) functionality.</li> <li>▪ Improve CAN-message handling during rampup and rampdown.</li> <li>▪ Add a check of pierce gases during gas purge before the arc starts.</li> </ul>
F	August 2017	<ul style="list-style-type: none"> <li>▪ Improve 130 A O<sub>2</sub>/Air and 130 A True Hole process to reduce double arcing.</li> <li>▪ Improve when active gas lines are highlighted, add translations, and improve operate-menu filter setting stability in the XPR web interface.</li> <li>▪ Add multiple serial commands.</li> </ul>
E	June 2017	<ul style="list-style-type: none"> <li>▪ Add argon (Ar) marking processes.</li> <li>▪ Improve XPR web interface design.</li> <li>▪ Improve leak test and purge processes.</li> <li>▪ Change diagnostic code descriptions for clarity.</li> </ul>

## Notes

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