Digital Interface Protocol for HQC Plasma Systems

PROFIBUS

Contents

Introduction

This reference manual targets system integrators. It provides complete information on how to implement a proper interfacing for HQC Plasma Systems by using the *PROFIBUS DPV1* protocol.

This manual refers to power sources art.**948.41**, **949.41**, **960.41**, **968.41** and **969.41** with firmware release **07** or higher.

Related documents

All instruction manuals and cutting charts are available from CEBORA website http://welding.cebora.it

PROFIBUS interface

Overview

The PROFIBUS interface between a plasma power source (*slave*) and a CNC/robot (*master*) is used for:

- transmit I/O signals and setpoint to the power source
- receive measures and I/O status from the power source.

The power source must be connected to the CNC/robot by using the specific shielded cable. Depending on the fieldbus network (type of the network, topology, number of nodes, baud-rate, etc.) the terminating resistors must be properly connected at the ends of the cables. In a basic network with two nodes only (the CNC and the power source) both the ends must be terminated.

PROFIBUS network configuration

The *Slave Address* is the only network parameter that must be configured in the power source by software using the manual gas console panel (art.470 or art.480) or the user panel (art.460) – see the Settings section in the related manual cod.3.300.045. The *Slave Address* can be fixed to a specific value from 0 to 125.

Alternatively (value 126) it can be set at runtime by the Master with the SSA (Set Slave Address) function.

The baud rate is determined automatically at runtime.

Signals handshaking

The following figure shows the correct signals handshaking between the power source and the CNC. For the description of each signals see the following paragraphs.

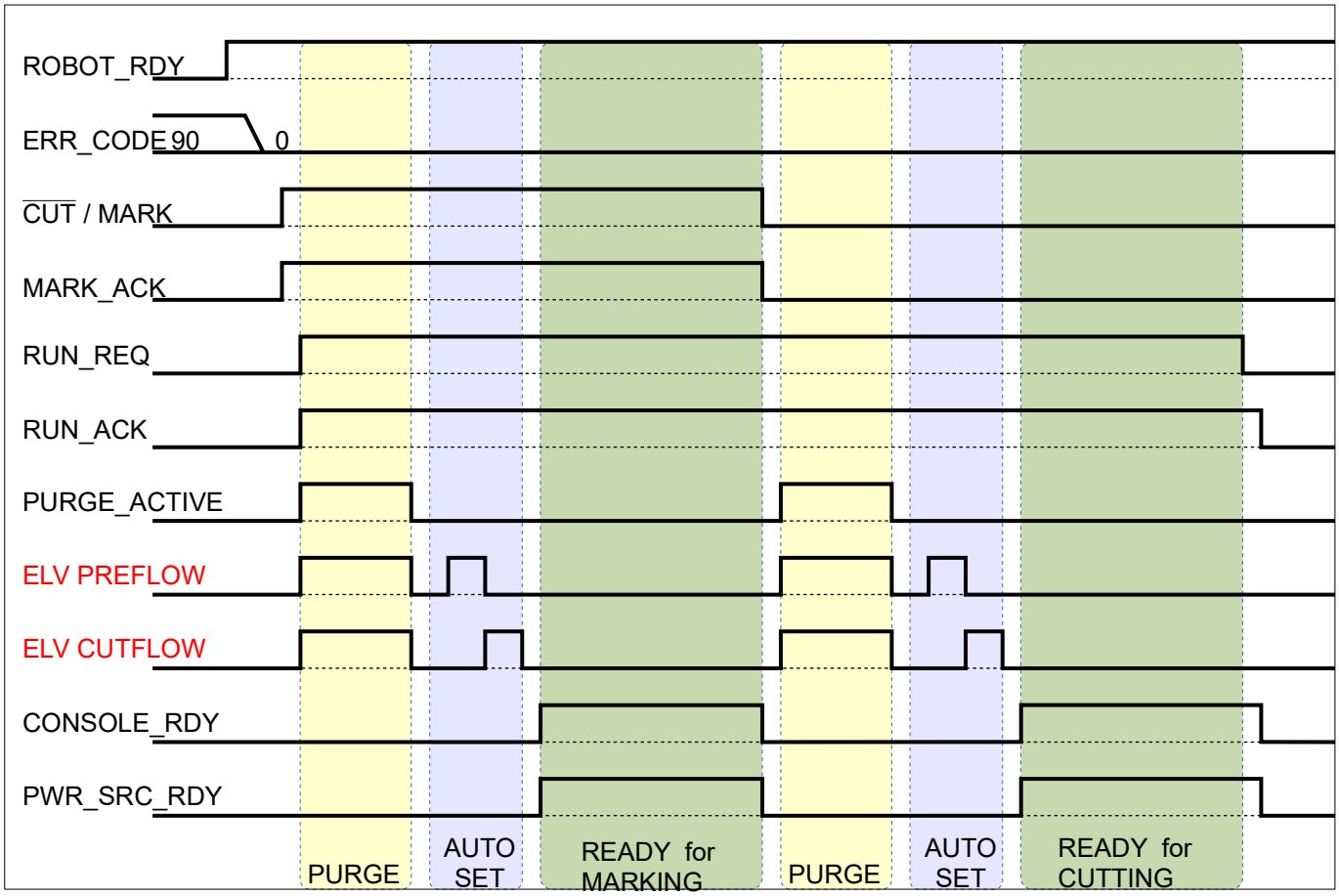

Figure 1: General interfacing protocol.

Some notes:

- the *Robot Ready* and *Run (Request)* signals should not be toggled simultaneously;
- the *Run (Request)* and *Mark (Request)* signals should not be toggled simultaneously;
- the *Mark (Request)* and *Run (Request)* should be toggled when the Robot Ready is stable active;
- the *Mark (Request)* must be toggled when the *Run (Request)* is stable (active or inactive);
- during the purging and auto-set phases the *Mark (Request)* should not be toggled.

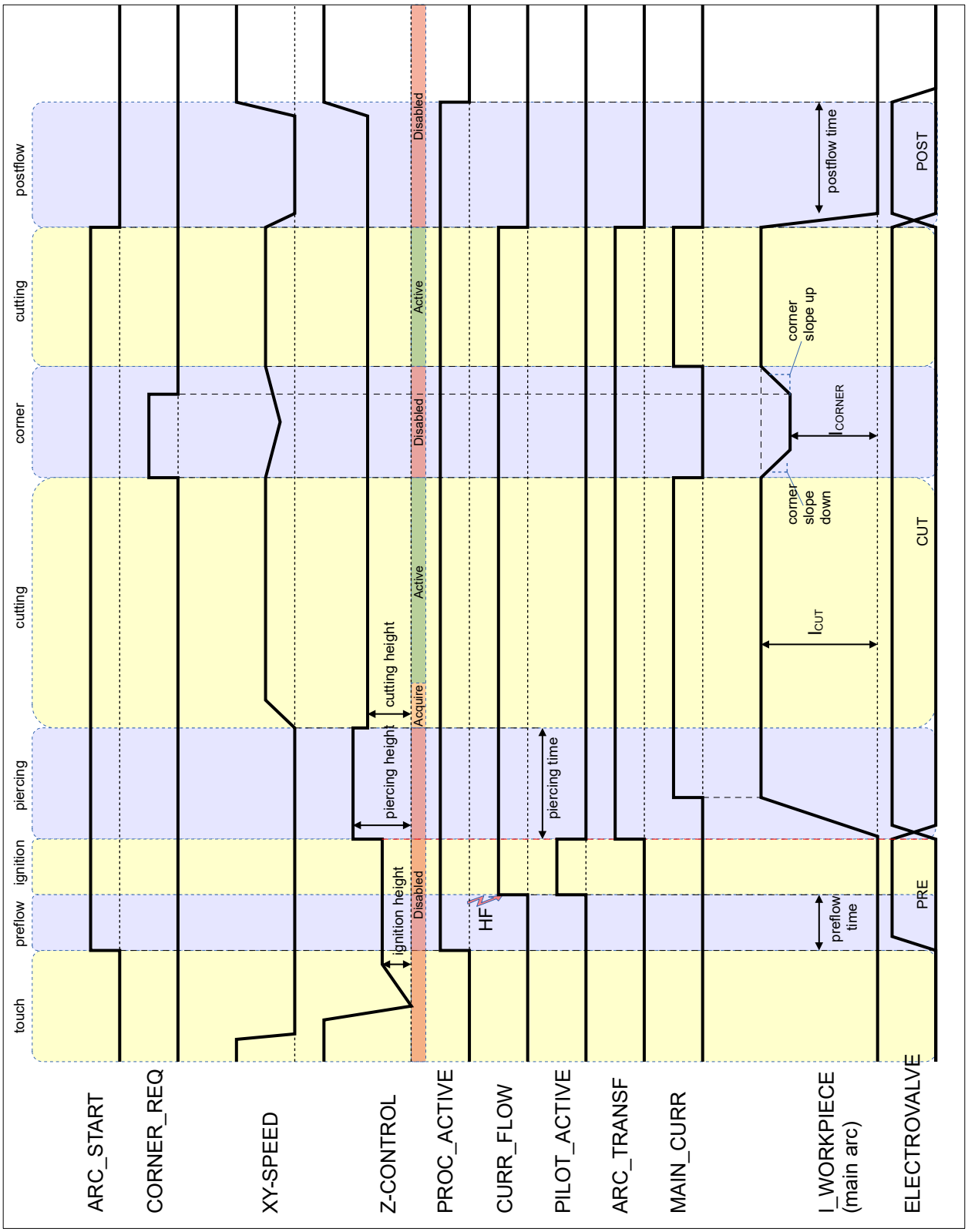

Figure 2: Process signals.

Data Process Image

With the digital interface, a lot of control signals can be exchanged between the power source (slave) and the CNC (master). Some signals are mandatory, some are optional.

- **input** (24-bytes / 192-bits) – from CNC to PS
  - **digital input** (8-bytes / 64-bits)
  - **analog input** (8-words / 128-bits)
- **output** (20-bytes / 160-bits) – from PS to CNC
  - **one digital output** (8-bytes / 32-bits)
  - **two analog output** (8-words / 128-bits)

In the following tables are listed the bit numbering. By comparison between the digital interface and the analog interface, two columns are shown on the right.

Inputs

Bit	Name	Analog Interface	Digital Interface
0	Start Arc	X	X
1	Robot Ready	X	X
2	Run Request	-	X
3	-	-	-
4	-	-	-
5	-	-	-
6	-	-	-
7	Protocol Mode	0	X
8	Preflow	X	X
9	-	-	-
10	Gas Test Auxiliary	-	X
11	Source Error Reset	-	X
12	Gas Test Plasma Preflow	-	X
13	Gas Test Plasma Cutflow	-	X
14	Gas Test Secondary Preflow	-	X
15	Gas Test Secondary Cutflow	-	X
23:16	Job Number (8-bit)	-	X
31:24	-	-	-
32	Analog Setpoint Disable 0	X	X
33	Analog Setpoint Disable 1	X	X
55:34	-	-	-

56	Corner Request	X	X
57	Spot Request	X	X
58	Mark Request	X	X
63:59	-	-	-
79:64	Current Fine Regulation	X	X
95:80	Corner Current Regulation	X	X
111:96	-	-	X
127:112	-	-	X
143:128	-	-	X
159:144	-	-	X
175:160	-	-	X
191:176	-	-	X

Digital Inputs – bit [63:0]

Digital inputs are implemented with 8 data bytes for a total of 64 inputs. The transmission of this message is usually event-driven and it is sampled by the power source every [10ms]. Some bits are mandatory because they are required for the cutting process control, others are optional.

Conventions about the bit state:

Bit value	Description
0	Inactive state (reset state)
1	Active state (set state)
0 → 1	Inactive to active transition (set event)
1 → 0	Active to inactive transition (reset event)

Start Arc – bit [0]

Turn on/off request of the plasma arc.

Start Arc	Description
1 → 0	Trigger the turn-off sequence of the plasma arc and starts the post-flow
0 → 1	Trigger an arc ignition. This command is accepted only if the *Power Source Ready* bit is asserted.

Robot Ready – bit [1]

Indication of the robot control status to the power source. Once the communication is established the CNC sets this bit enabling the power source to accept other control signals. If it is not set, the power source remain in an error state (error number 90) and all outputs signals are set to the inactive state. This bit directly controls even the state of the cooling pump, so it is not advisable to toggle it if not strictly needed.

Robot Ready	Description

0	The robot control is not ready or in alarm state. The cooling pump is stopped.
1	The robot control is ready for the signal handshaking. The cooling pump is running.

Run (Request) – bit [2]

Request for enabling the plasma cutting process. This bit must be toggle from inactive to active when the *Robot Ready* bit is set. If this request is accepted the *Run Acknowledge* bit is set and, if needed, the power source execute a purging phase followed by an auto-set of the gasses. At the end of the procedure the *Power Source Ready* bit goes to active state. NOTE: this bit is valid only with automatic gas console (art.466).

Run (Request)	Description
0	The power source is requested for disabling the plasma process.
1	The power source is requested for enabling the plasma process.

Protocol Mode – bit [7]

Selection of the data representation for all 16-bit analog values, both measures and setpoints. If inactive (analog mode) each value must be rescaled from the minimum value to the maximum value in order to fully fit in a 16-bit unsigned variable. If active (digital mode) all values are handled as standard signed binary values and no rescaling is needed.

Protocol Mode	Description
0	Values are 16-bit *unsigned* rescaled with range `0x0000` (min) – `0xFFFF` (max).
1	Values are 16-bit *signed* binary with no rescaling.

Preflow – bit [8]

Trigger the preflow process phase (plasma and secondary preflow channel are both open) without igniting the pilot arc. This bit is sampled only when the *Power Source Ready* bit is active and the *Arc Start* bit is not set. Use this command for extending the preflow phase or for saving time (up to 0.5s) between successive ignitions of the arc.

Preflow	Description
0	User preflow not requested (automatic preflow).
1	User request for entering in the preflow phase.

Source Error Reset – bit [11]

Request for resetting an error condition in the power source. A typical gas low alarm *(ERR.78)* can be reset from the master. Others cannot be reset and the power source remains in alarm state until the error condition disappears or the system is rebooted.

Source Error Reset	Description
0, 1, 1 → 0	No operation.
0 → 1	Request for resetting the error condition in the power source.

Gas Test (Set) – bit [15:12]

Each of these bits triggers the activation of the corresponding gas channel. It is useful for testing the gas flow. These bits are sampled only when the *Run (Request)* is not active.

Gas Test	Description
0	No operation
1	Request for opening one of the gas channels (manual gas set)

Job Number – bit [23:16]

These bits are used for addressing a job from the power-souce memory. Jobs must be previously stored by the art.460 panel and the *Internal* flag must be deactivated.

Gas Test	Description
0	Normal mode – no job is selected from CNC
1 - 99	Valid job number
100 - 255	Invalid job number – value 99 is used

Analog Input Disable – bit [33:32]

These bits enable or disable the sampling of an external setpoint received in the analog input message. Each bit is related to a 16-bit bit field in the analog input message AI[1].

Analog Input Dis.	Description
0	The analog input *n* must be read.
1	The analog input *n* must be ignored.

Corner (Request) – bit [56]

This bit is used for the synchronization of the cutting current and the torch speed at a corner. It is sampled only in the standard cut process when the *Main Current* bit is active. An inactive to active transition begins a reduction of the cutting current with a fixed ratio (see object *Corner slope-down*) until the *Corner Current* value is reached. An active to inactive transition begins an increase of the cutting current with a fixed ratio (see object *Corner slope-up*) until the *Main Current* value is reached.

Corner	Description
0	Standard cut process.
0 → 1	Request for starting the corner phase.
1	Corner phase.
1 → 0	Request for ending the corner phase.

Spot (Request) – bit [57]

This bit selects the spot marking process. It is sampled only when the *Power Source Ready* bit is active but it is ignored when the *Mark (Request)* bit is active.

Spot	Description
0	Standard cut process request.
1	Spot marking request.

Mark (Request) – bit [58]

Process type selection between standard cutting (or spot marking) and marking. If this bit is toggled when the *Power Source Ready* bit is set, a purging phase followed by an auto-set of the gas regulators is performed. If the *Mark* bit is active, the *Spot* bit is ignored.

Mark	Description
0	Cut (or spot marking) process request.
1	Marking process request.

Analog Inputs – bit [191:64]

The power source accepts a single PDO message of 8-data byte for handling setpoint adjustment runtime. The data are organized as 4 analog setpoint values named AI1[3:0] of 16-bit each. Inputs are sampled within [10ms] since the receive event. The format of 16-bit data fields depends on the *Protocol Mode* bit. The order of bytes in these fields is BigEndian (MSB first).

Current Fine Regulation – AI[0], bit [79:64]

This field (I_{CFR}) is used for adjusting runtime the actual cutting current within the range admitted by the selected consumable parts of the torch. It is expressed in [0.1 A] from -25.0A to +25.0A.

$$I_{ARC} = I_{SET} + I_{CFR}$$

This field is ignored if the *Analog Setpoint Disable 0* bit is set.

Description	Value	Protocol Mode = 0	Protocol Mode = 1
Minimum	-25.0A	0x0000	0xFF06
Default	0.0A	0x8000	0x0000
Maximum	25.0A	0xFFFF	0x00FA

Corner Current Regulation – AI[1], bit [95:80]

This field (CCR) is used for setting the corner current value runtime from the CNC. It is expressed as percentage of the main current value from 100% (no current reduction) down to 50% (lowest accepted value). See also *Corner Req* and *Corner Ack* bits.

$$I_{CORNER} = I_{ARC} * CCR / 100$$

This field is ignored if the *Analog Setpoint Disable 1* bit is set.

Description	Value	Protocol Mode = 0	Protocol Mode = 1
Minimum	20%	0x0000	0x0014
Maximum	100%	0xFFFF	0x0064

Outputs

Bit	Name	Analog Interface	Digital Interface
0	Current Flow	-	X
1	Run Acknowledge	-	X
2	Process Active	X	X
3	Main Current	-	X
4	-	-	-
5	Power Source Ready	X	X
6	Communication Ready	-	1
7	Protocol Mode	-	X
15:8	Error Code (8-bit)	-	X
16	Plasma Preflow Active	-	X
17	Plasma Cutflow Active	-	X
18	Secondary Preflow Active	-	X
19	Secondary Cutflow Active	-	X
20	Purge Active	-	X
21	Console Ready	-	X
22	Arc Transfer	X	X
23	Pilot Arc	X	X
24	Corner Acknowledge	-	X
25	Spot Acknowledge	-	X
26	Mark Acknowledge	-	X
30:27	-	-	-
31	Hard Fault	-	X
47:32	Arc Voltage Measure	X	X
63:48	Arc Current Measure	X	X
79:64	Coolant Temperature Measure	-	X
95:80	Coolant Flow Measure	-	X
111:96	Pressure Measure Plasma Preflow	-	X
127:112	Pressure Measure Plasma Cutflow	-	X
143:128	Pressure Measure Secondary Preflow	-	X
159:144	Pressure Measure Secondary Cutflow	-	X

Digital Outputs – bit [31:0]

Digital outputs reflects the status of the power source and the plasma process. They are implemented with 4 data bytes for a total of 32 outputs. Outputs are updated every [10ms] and the transmission of the message is triggered by a status change.

Current Flow – bit [0]

Indicates if the power source is generating current. It is active when the pilot-arc or the main-arc are on.

Current Flow	Description
0	The power source is not generating current.
1	The power source is generating current.

Process Active – bit [2]

Indicates that the power source accepted a start command and the plasma process is running. This bit is active from the preflow phase to the end of the postflow phase.

Process Active	Description
0	The plasma process is not running.
1	The plasma process is running.

Main Current – bit [3]

Indicates that the output current of the plasma arc is equal to the main current setpoint. This bit goes inactive during a corner phase.

Main Current	Description
0	The output current is lower than the main current setpoint.
1	The output current has reached the main current setpoint.

Power Source Ready – bit [5]

This bit goes active after a *Run (Request)* command, indicating that the power source is not in alarm status and all gasses are prepared for the plasma arc ignition. If this bit does not go active within a timeout of about 1 minutes from the *Run (Request)* command, some errors are occurred, and the *Run (Request)* bit must be released. See also the *Purge Active* and *Console Ready* bits.

Power Source Ready	Description
0	The power source is in stand-by or in alarm state.
1	The power source is ready for the plasma process.

Communication Ready – bit [6]

Status of the signals communication. This bit goes to the active state after the boot-up sequence of the power source and becomes immediately inactive when a power-down event occurs. Signals handshaking is enabled only when this bit is active.

Comm. Ready	Description
0	The power source is not ready for the signal handshaking (boot-up sequence, ...).
1	The power source is ready for the signal handshaking.

(Power Source) Protocol Mode – bit [7]

This bit reflects the state of the *Protocol Mode* input bit, indicating that the power source has accepted or not the configuration requested by the master.

(P.S.) Prot. Mode	Description
0	Values are 16-bit unsigned rescaled with range `0x0000` (min) – `0xFFFF` (max).
1	Values are 16-bit signed binary with no rescaling.

Error Number – bit [15:8]

Error code number referring the error code table of the specific power source model. Some error conditions require a reboot of the system (*fatal errors*) others can be reset runtime (*warnings*) using the *Source Error Reset* bit. See also the *Hard Fault* bit.

Error Number	Description
0	The machine is operating.
1 – 99	The machine is in error state with all outputs inactive (see the error code table).

Flow Active – bit [19:16]

Each bit is active when the corresponding gas channel is active.

Flow Active	Description
0	The gas channel is closed.
1	The gas channel is open.

Purge Active – bit [20]

A gas purging is running. When this bit is active the power source is not enabled for the arc ignition.

Purge Active	Description
0	The gas console is not purging.
1	The gas console is purging.

Console Ready – bit [21]

This bit indicates that the automatic gas console is set and ready for starting the plasma process. This bit goes active after a *Run Request* command, usually followed by the purging and auto-set phases.

Console Ready	Description
0	Some gas are not ready for the plasma process.
1	All gasses are ready for starting the plasma process.

Arc Transfer – bit [22]

Status of the plasma arc. This bit goes active after the *Pilot Arc* bit.

Arc Transfer	Description
0	The arc is not transferred to the workpiece.
1	The arc is on and transferred to the workpiece.

Pilot Arc – bit [23]

Status of the pilot arc. This bit goes active after an arc ignition indicating that the pilot arc is on and goes inactive when the arc is transferred on the workpiece.

Pilot Arc	Description
0	The pilot arc is off.
1	The pilot arc is on.

Corner Acknowledge – bit [24]

The power source is executing a corner. This signal goes active after a C*orner Request* during the main current phase.

Corner Ack.	Description
0	The power source is not executing the corner current.
1	The power source is executing the corner current.

Spot Acknowledge – bit [25]

This bit goes active when the *Spot Marking* process is selected. This bit goes active after the *Power Source Ready* bit is active.

Spot Ack.	Description
0	The spot marking process is not selected.
1	The spot marking process is selected.

Mark Acknowledge – bit [26]

This bit is the current process indication. When this bit is active, *Corner* and *Spot* commands are ignored.

Mark Ack.	Description
0	Cut (or spot marking) process selected.
1	Marking process selected.

Hard Fault – bit [31]

This bit goes active when a fatal error occurs and the plasma system must be shut down. See also *Error number*.

Hard Fault	Description

0	No fatal errors occurred.
1	A fatal error occurred.

Analog Outputs – bit [159:32]

The plasma power source produces 8 analog measures of 16-bit values AO[7:0]. The format of 16-bit data fields is dependent on the *Protocol Mode* bit. The order of bytes in these fields is BigEndian (MSB first).

AO[3:0] are updated every [10ms] and are related to the state of the power source and the cooling system.

AO[7:4] are updated every [100ms] and are related to the pressure of the gas in the gas console. These values should match the actual setpoints only when the corresponding valve is open.

Arc Voltage Measure – AO[0], bit [47:32]

The plasma arc voltage measured with [0.1 V] of resolution.

Description	Value	Protocol Mode = 0	Protocol Mode = 1
Minimum	0.0V	0x0000	0x0000
Maximum	250.0V	0xFFFF	0x09C4

Arc Current Measure – AO[1], bit [63:48]

The plasma arc current measured with [1 A] of resolution.

Description	Value	Protocol Mode = 0	Protocol Mode = 1
Minimum	0A	0x0000	0x0000
Maximum (other models)	300A	0xFFFF	0x012C
Maximum (for art.960 only)	500A	0xFFFF	0x01FA

Coolant Temperature Measure – AO[2], bit [79:64]

The temperature of the cooling liquid with [0.1°C] of resolution.

Description	Value	Protocol Mode = 0	Protocol Mode = 1
Minimum	-50.0°C	0x0000	0xFE0C
Maximum	100.0°C	0xFFFF	0x03E8

Coolant Flow Measure – AO[3], bit [95:80]

The mass flow of the cooling liquid with [0.1 l/min] of resolution.

Description	Value	Protocol Mode = 0	Protocol Mode = 1
Minimum	0.0 l/min	0x0000	0x0000
Maximum	10.0 l/min	0xFFFF	0x0064

Plasma Preflow Pressure Measure – AO[4], bit [111:96]

The pressure of the gas in the plasma preflow channel with [0.1bar] of resolution.

Description	Value	Protocol Mode = 0	Protocol Mode = 1
Minimum	0.0 bar	0x0000	0x0000
Maximum	10.0 bar	0xFFFF	0x0064

Plasma Cutflow Pressure Measure – AO[5], bit [127:112]

The pressure of the gas in the plasma cutflow channel with [0.1bar] of resolution.

Secondary Preflow Pressure Measure – AO[6], bit [143:128]

The pressure of the gas in the secondary preflow channel with [0.1bar] of resolution.

Secondary Cutlow Pressure Measure – AO[7], bit [159:144]

The pressure of the gas in the secondary cutflow channel with [0.1bar] of resolution or the water flow [0.1l/min] when water secondary console (art.485) is used.

Document revision history

Rev.	Date	Author	Description
0	30/08/2021	C.C.	Preliminary.