

En2ra[®] RPS **Remote Plasma System**

Specification & Installation **(Rev.1)**

Product number: A120ID-01

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1. Introduction and Specifications

1.1 Introduction

The EN2CORE technology EN2RA[®] RPS is self-contained atomic plasma generator.

1.2 Specifications

Table 1 EN2RA[®] RPS, Technical Specifications

EN2RA[®] RPS, Technical Specifications	
<i>item</i>	<i>Specification</i>
Electrical Service Requirements	
AC power input	Nominal: 200/208VAC, 50/60Hz, 30A _{rms}
Receptacle	MS Connector Panel mount MS Connector Male inserts, 22-22
Mating Connector (Not Provided)	MS Connector, Female inserts, 22-22 MS Connector Hood
Pin A,B,C	Phases A-R, B-S,C-T respectively
Pin D	Earth ground
Cooling Requirements	
Ambient Air Temperature of Operation	5-40°C.
Minimum Water Flow during operation	8 lpm (min.)
Maximum Water Inlet Temperature	30°C
External Water Connections	3/8" A-LOK TYPE UNION
Process Compatibility	
Process Gas Feed	<ul style="list-style-type: none"> • 1/4 VCR Male inlet connection.(2EA. See Figure 1) • O-ring seal outlet connection. (sealing area $\Phi 55\text{mm} \sim \Phi 70\text{mm}$ see Figure 1) • External transport tube > 54mm ID recommended
Exposed Material Surfaces	<ul style="list-style-type: none"> • KALREZ O-ring • Ceramic Tube • 6061-T6 aluminum
Operating Performance	
Max.Power	7kW
Control Interface	Rs-232, Analog
Ignition Gas	100% Ar, CGA Grade D 99.998% or higher
Operation Gas	Ar, H ₂ , O ₂ , N ₂ , NF ₃
Ignition Pressure and Flow	1 – 5 Torr, Ar: 0.5 – 5 slm
Operating Pressure and Flow (Contact customer support division for different operating window)	< 10 Torr, @Ar 2 slm, H ₂ 10slm
	< 10 Torr, @Ar 2 slm, O ₂ 8slm
	< 10 Torr, @Ar 2 slm, N ₂ 8slm
	< 10 Torr, @Ar 2 slm, NF ₃ 6slm
Physical Characteristics	
Overall Chassis Size	378 Deep x 300 Wide x 351 High (mm)
Weight (Dry)	Approximately 26.5 kg
Optional	
Analog Power control	Accuracy: $\leq \pm 1\%$ of Max.Power
Additional gas nozzle	1/4 VCR Male inlet connection

1.3 Dimensional Drawings

Dimensional drawings for the EN2RA[®] RPS are shown in Figure 1 below

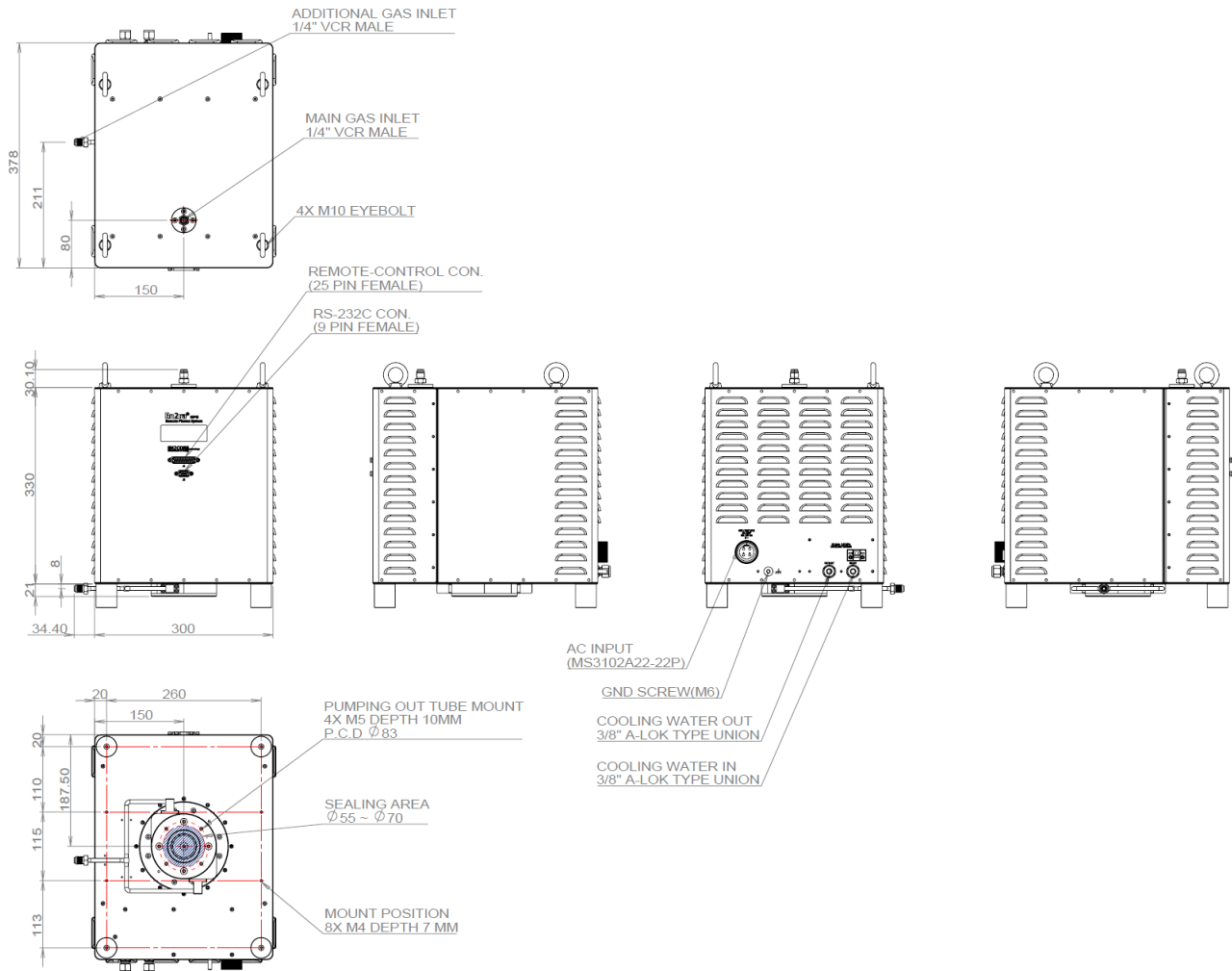


Figure 1 Dimensional drawings

Note: All the dimensions are in mm scale.

Note: Mounting Features: Tapped holes M4 by 7 deep, 8 locations.

Note: For proper operation, water inlet / outlet protocol must be adhered to.

1.4 Center of Gravity Drawings

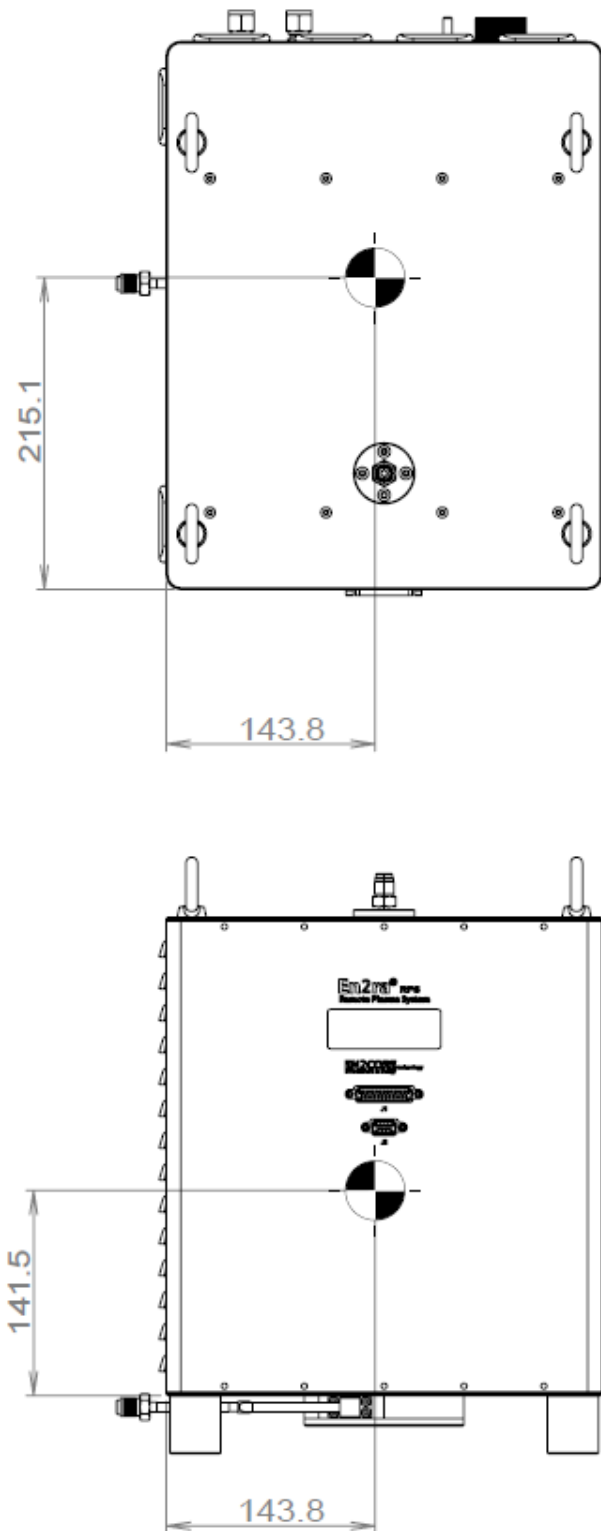


Figure 2 Center of Gravity

2. System Integration

2.1 Water Connection

The EN2RA[®] RPS equipment is cooled by recirculating water according to the specifications provided in Table 1 on page 3.

WARNING

Installation of an external water flow switch is required to protect the unit from permanent damage in the event of a low water flow condition.

- Securely connect a water line to the input 3/8" A-LOK type union water connector. This water line will carry cooling water to the EN2RA[®] RPS equipment. Refer to Table 1 on page 3 for the cooling water temperature requirements.
- Securely connect a water line to the output 3/8" A-LOK type union water connector. This water line will carry heated water away from the EN2RA[®] RPS equipment. The cooling water system must be capable of dissipating the maximum cooling load listed in Table 1 on page 3 while provided a maximum inlet temperature of 30°C.

WARNING

To avoid damage to the equipment, it is extremely important that the circulating water is filtered to 20 microns or better condition.

2.2 Power Connection

Refer to the technical specifications provided in Table 1 on page 3 for the power requirements.

Table 2 208 V_{AC} Input Cable Lead Out

208 V_{AC} Input Cable Pinouts	
Type: MS Connector Panel mount MS Connector Male inserts, 22-22	
<i>Pin No.</i>	<i>Name</i>
A	200 - 208 VAC
B	200 - 208 VAC
C	200 - 208 VAC
D	Power Ground



- Make sure the facility power cable circuit breaker is in the OFF position.
- Follow local guidelines for wire size and type.

2.3 Remote-Control Connection

The EN2RA[®] RPS equipment is operated with a remote control by means of a 25-pin cable terminating in a male DB-25 connector. The inputs and outputs are configured for externally sourced 24V logic. Attach the 25-pin connector to the 25pin female D connector on the front panel. Refer to Table 3 for cable pinouts and Figure 3 and 4 for the internal circuit interface and an example of a remote-control interface, respectively.

Table 3 Remote control cable pinouts

Remote control cable pinout					
Pin no.	Name	Type	Active state	In-active state	Remark
2	+24V return for input				use with 4
14	+24V return for output				use with 15,16,17,20,21,22
4	POR(Plasma On Request)	input	plasma on request	plasma off request/reset	
15	READY	output	ready	not ready	
16	Plasma OK	output	plasma ok	plasma off	
17	AC ON	output	AC supply on	AC supply malfunction	
18	Power Set Input(+)	input			
3	Power Set Input(-)	input			
19	Power monitor Output(+)	output			
11	Power monitor Output(-)	output			
20	Fault bit 0	output	Lo	Pulled Hi	
21	Fault bit 1	output	Lo	Pulled Hi	
13	Interlock	output			Connected to pin 25.
25	Interlock return	input			Connected to pin 13.

Active state : current flows through the semiconductor (diode for inputs, transistors for outputs)

Table 4 *Hardwire Interlock Definitions*

<i>Hardwire Interlock</i>	
Fault name	Remark
Insufficient Cooling Water	Operated when cooling water flow is lower than 5.6 slm (1.5 gal/min)
Over Heat at RF MOSFET	Operated when temperature at RF MOSFET exceeds 70°C
Over Heat at RF Capacitor	Operated when temperature at RF capacitor exceeds 80°C

Hardwire interlocks are not linked to the internal digital controller, thus independently operates with the software interlock. See Figure 4.

The EN2RA[®] RPS unit provides a system interlock through its Analog control port. Closing the interlock(13 pin to pin 25) energizes the DC bus through. Integrate this interlock into your control system so the unit functions only when FET temp and cooling water flow specifications are satisfied.

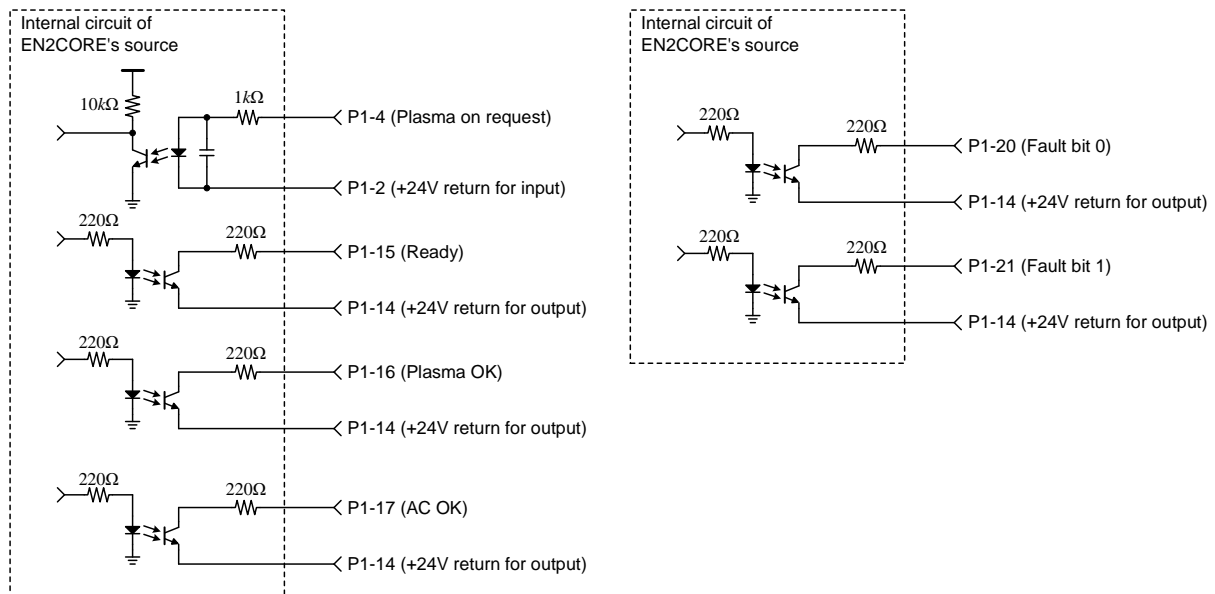


Figure 3 Internal I/O interface diagram

Note: 25pin D Connector, Control I/O

1. Maximum current allowed on the input pin = 20mA
2. Maximum current allowed on the output pin = 20mA
3. Maximum operating voltage for I/O = 24V_{DC}

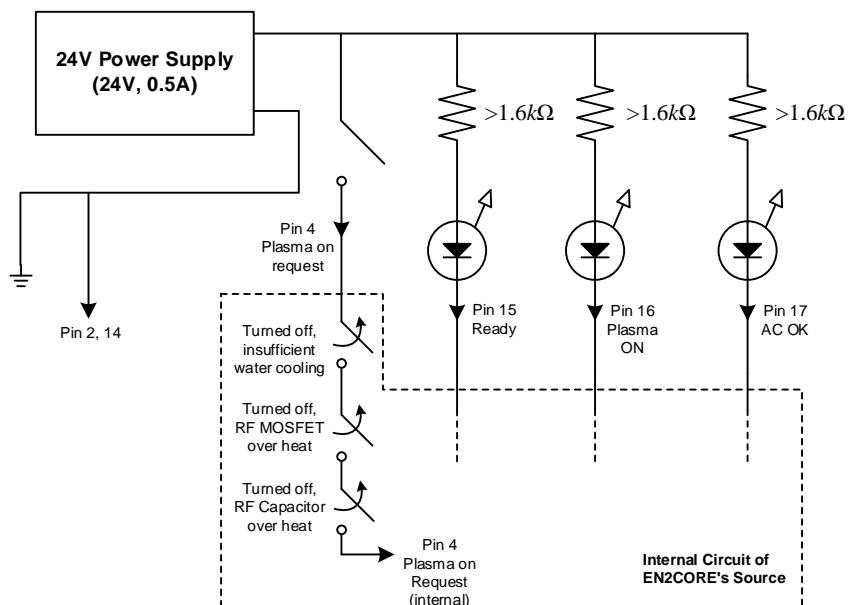


Figure 4 Interface schematic diagram example

2.4 Digital-Control Connection

The RPS equipment provides digital control for setting and reading the RF power in real-time. Attach the RS-232 9-pin connector to the 9pin female D connector on the front panel. Refer to Table 1.2.1 for cable pinouts and RS-232 serial communication protocol.

Table 1.2.1 *Digital control cable pinouts*

Remote control cable pinout (Host)			
Pin no.	Name (RPS Unit)	Name (Host)	Remark (Host)
2	TXD	RXD	Receive Data
3	RXD	TXD	Transmit Data
5	GND	GND	Ground
Others	RESERVED	RESERVED	RESERVED

1. Serial Interface Setting

- Baud rate : 9600
- Data bit : 8
- Parity : none
- Stop bit : 1
- Flow control : none
- All command and response packet is ASCII code.
- Transmit delay : 10msec/char, 60msec/line
- It is Recommended to use an electrically separated(isolated) cable for RS232 cable.

2. Serial Command Scheme

- Carriage return : {CR}, Line feed : {LF}
- Basic Operation

If the command doesn't exist or doesn't fit the rules, A question mark (?) will be returned at the terminal.
Response Packet : ?{CR}{LF}

A question mark (?) is returned, check the following

1. Set the character transmission delay.
2. Invalid command input.

All commands are case-insensitive. (Don't care Uppercase and Lowercase letters.)
Add {CR} or {LF} or {CR}{LF} after the command.

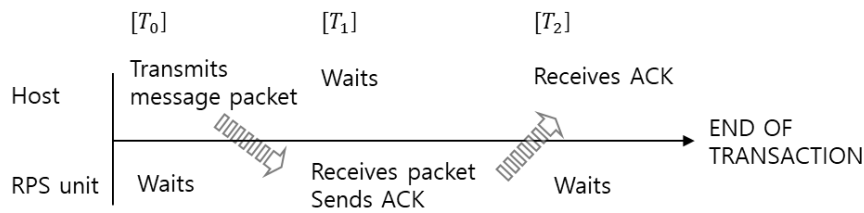


Figure 1.2.1 RPS Communications transaction

- T_0 : Host Transmits Message Packet

The host computer sends a message packet to the RPS unit. The packet contains one of the following:

- A command that requests data or status information
- A command and data that change a parameter setting
- An executable command
- Transmit delays between command characters must be respected.
- if Tx 'CMD' command :

```
char *data = "CMD{CR}";
for i=0 to data.length do
    Serial.print(*data) // Tx 1 character of data
    delay(10)           // delay 10 milliseconds between characters of data
    data++              // to the next character of data
end for
```

- T_1 : Unit Verifies Host Transmission Packet

Once the RPS unit receives the host computer transmission message packet, It analyzes the message and sends an ACK message if it is a valid message.

If the message packet is different from the specified rule, the ACK message will be returned with A question mark (?).

ACK consists of Command, Response packet and EOP({CR}{LF}).

- Start of packet detection : Tx command
- End of packet detection : {CR}{LF}

- T_2 : Host Acknowledges Unit Response

When the host receives the message, the RPS returns to its normal standby state. In the case of monitoring parameters, the parameter values are transmitted continuously.

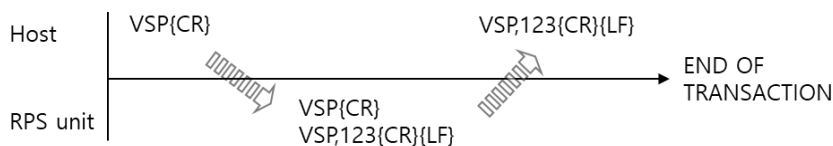


Figure 1.2.2 Communications transaction example

The command transmission/reception rule is as follows

if Tx, VPO Command, Tx Packet : VPO1{CR} and
Rx Packet : VPO,on{CR}{LF}

```
[TX] - VPO<CR><LF>
[RX] - VPO,0<CR><LF>
[TX] - VSP1<CR><LF>
[RX] - VSP,on<CR><LF>
```

Figure 1.2.3 VSP Command test example of terminal program

if Tx, VSP Command, Tx Packet : VSP=15{CR} and
Rx Packet : VSP,15{CR}{LF}

```
[TX] - VSP=15<CR><LF>
[RX] - VSP,15<CR><LF>
[TX] - VSP<CR><LF>
[RX] - VSP,15<CR><LF>
[TX] - VSP1<CR><LF>
[RX] - VSP,on<CR><LF>
```

Figure 1.2.4 VSP Command test example of terminal program

if Tx CMD Command, Tx Packet : CMD{CR} and
Rx Packet : CMD,response packet{CR}{LF}

```
[TX] - CMD<CR>
[RX] - CMD,9,10,2.7,3.4,3.0,0.2,0.0,2830000,1.0,0.8,0.0,4,0,1,1,1,10<CR><LF>
[TX] - CMD<LF>
[RX] - CMD,9,10,2.7,3.4,3.0,0.2,0.0,2830000,1.0,0.8,0.0,4,0,1,1,1,10<CR><LF>
[TX] - CMD<CR><LF>
[RX] - CMD,9,10,2.7,3.4,3.0,0.2,0.0,2830000,1.0,0.8,0.0,4,0,1,1,1,10<CR><LF>
```

Figure 1.2.6 CMD Command test example of terminal program

3. Command List

3.1 Set Power Command

- VSP : Print the value stored in Digital Set Power
- VSPn : Turn Digital Set Power on (n = 1) or off (n = 0)
Be sure to turn it off(n = 0) when setting power through analog 25 pins.
- VSP=z : Set to Digital Set Power (z in watt)

An example of using the command is as follows.

- if set 'Digital Set Power On'

Tx command : VSP1 , response packet : VSP,on

- if set 'Digital Set Power to 3500W'

Tx command : VSP=3500 , response packet : VSP,3500

- if print 'the value stored in Digital Set Power'

Tx command : VSP , response packet : VSP,3500

- if set 'Digital Set Power Off'

Tx command : VSP0 , response packet : VSP,off

3.2 Plasma On Enable Command

- VPO : Print the value stored in Digital Plasma On Enable
- VPOn : Turn Plasma On Enable on (n = 1) or off (n = 0)
Be sure to turn it off(n = 0) when setting plasma on enable through analog 25 pins.
- VPO=z : Set to Plasma On Enable Output High(z = 1) or Low(z = 0)

An example of using the command is as follows.

- if set 'Turn Plasma On Enable on'

Tx command : VPO1 , response packet : VPO,on

- if set to 'Plasma On Enable Output High'

Tx command : VPO=1 , response packet : VPO,1

- if print 'the value stored in Digital Set Power'

Tx command : VPO , response packet : VPO,1

- if set 'Turn Plasma On Enable off'

Tx command : VPO0 , response packet : VPO,off

3.3 Monitor Command

-CMD : Print all Parameters Readbacks

The number of bytes of one data can range from 1 to 10 bytes. It depends on the output value. The ASCII code '.' of the decimal point that separates integers and decimals is also included in the data.(Except for integer type)

When data is a negative value, ASCII code '-' is appended to the front of the data.

Response packet configuration of CMD command :

“CMD,offset00,offset01,offset02,offset03,offset04,offset05,offset06,offset07,
offset08,offset09,offset0a, offset0b, offset0c, offset0d, offset0e, offset0f, offset10”

Address offset	Description	Data type (ASCII code)
00	delivered power in Watt	integer
01	set power in Watt	integer
02	RF voltage in Volt	one decimal places
03	RF current in Ampere	one decimal places
04	DC voltage in Volt	one decimal places
05	DC current in Ampere	one decimal places
06	RF phase in degree	one decimal places
07	Frequency in Hz	integer
08	QFR in no unit	one decimal places
09	Plasma Impedance, real part, in Ohm	one decimal places
0a	Plasma Impedance, imaginary part, in Ohm	one decimal places
0b	Run Mode State 1 = Ignition ready 2 = Ignition start 3 = Ignition failed 4 = Normal operation 5 = User off 6 = Interlock 7 = DC discharging	integer
0c	Interlock 0 = None	integer

		1 = Over power 2 = Over operation time 3 = Current fault 4 = fan fault 5 = Hardware fault		
	0d	VPOn : 1 : Turn Plasma On Enable on 0 : Turn Plasma On Enable off	integer	
	0e	VPO=z : 1 : Set to Plasma On Enable Output High 0 : Set to Plasma On Enable Output Low	integer	
	0f	VSPn : 1 : Turn Digital Set Power on 0 : Turn Digital Set Power off	integer	
	10	VSP=z : Set to Digital Set Power in watt	integer	

3. Operation Quick Manual

3.1 Front Panel Indicator

Table 4 below shows the front panel liquid crystal display used to record the power-up status of the EN2RA[®] RPS equipment. It is also used to indicate the status of plasma ignition and as a troubleshooting device.

Table 6 LCD Display Indications

Display	Description
Ignition Ready	Indicates that EN2RA [®] RPS is ready to ignite plasma
Ignition Start	Ignition Start
Normal Operation	Indicates that plasma is successfully running
Ignition Fail	Ignition Fail
User Off	User Plasma Off
Interlock Locked	Indicates that a Interlock has occurred
DC Discharging	Waits for EN2RA [®] RPS to be available for the next ignition (30 sec)

3.2 Pre-Operational Checkout

Before operating the EN2RA[®] RPS equipment for the first time, perform the following procedure to assure operational readiness:

- 1) Perform a leak check using a helium leak detector, or a rate of rise method prior to operation.
- 2) Turn on facility water supply and allow water to circulate through En2ra-RPS equipment. Check for any visible leaks. Verify flow is as specified in Table 1 on page 3, or greater than 8 lpm(min.).
- 3) Check that all electrical and the remote-control connector is firmly seated.
- 4) Place facility dedicated circuit breaker to ON position.
- 5) Apply facility gas EN2RA[®] RPS equipment.

3.3 Operational Procedure

Use the following procedure to apply power to the EN2RA[®] RPS equipment and to produce plasma:

- 1) Upon power up the front panel indicator should **Ignition READY**
- 2) Pump EN2RA[®] RPS and feed gas lines to base pressure.
- 3) Introduce Argon; assure pressure is within the ignition pressure specification as shown in Table 1 on page 3.
- 4) Activate remote plasma on request.
- 5) Front panel indicator should then indicate **Ignition Start**
- 6) Front panel indicator should then indicate **Normal Operation**
- 7) Introduce H₂, O₂, N₂, and NF₃ at the desired flow rate. Assured pressure is within the operating pressure specification listed in Table 1 on page 3.