

## Specifications of IGBT based Pulsed DC Power Source with auxiliary DC power supply

| Sr. No.  | Parameter                                       | Specification  |
|----------|---|--|
| <b>A</b> | <b>Specifications of Pulsed DC power supply</b> |  |
| <b>1</b> | <b>Input Parameters</b>                         |  |
|          | Input Voltage                                   | 3-Phase, 415V $\pm$ 10% AC, 50Hz   |
|          | Input connections                               | 5 wire (R, Y, B, N and Earth)  |
| <b>2</b> | <b>Output Parameters</b>                        |  |
|          | <b>Voltage</b>                                  |  |
|          | Output voltage polarity                         | Pulsed DC negative output (pulsed between zero and negative peak).<br>Important: The positive terminal of the power supply should be grounded.   |
|          | Peak output voltage                             | -800 V max.<br>Settable between 0V to -800V<br>[Voltage control via HMI or potentiometer mounted on front panel through selector switch]   |
|          | Voltage setting resolution                      | Better than 1V   |
|          | Voltage ripple                                  | 0.5% or better (at maximum rated values)   |
|          | Voltage regulation                              | 0.1% or better (at maximum rated values)   |
|          | <b>Current</b>                                  |  |
|          | Output current                                  | 60A [Peak] at 90% Duty Cycle   |
|          | <b>Frequency</b>                                |  |
|          | Pulse frequency                                 | Settable between 10KHz to 30KHz through HMI [in the step of 1KHz or better]  |
|          | <b>Duty cycle</b>                               |  |
|          | Pulse duty cycle                                | Settable between 10% to 90% through HMI [in the step of 1% or better]  |
|          | <b>Output Waveforms</b>                         | As per Annexure 3  |
| <b>3</b> | <b>Protections</b>                              |  |
|          | Over current protection                         | Whenever over current [i.e. 150% of maximum rated value] or short circuit is detected then the power supply should respond as per following: <ul style="list-style-type: none"> <li>• Overcurrent Sensing Time - Within 5<math>\mu</math>s</li> <li>• Inhibit of the IGBT Gate Pulses - Within 20 <math>\mu</math>s</li> <li>• Blocking Time : 200ms</li> <li>• Auto restarts the IGBT gate pulses after blocking time.</li> <li>• If the over current occurs 10 times within a minute the power supply should shut down by giving OC Trip indication and it can be restarted</li> </ul> |

|          |   |  |
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|          |   | <p>by pressing the Reset push button only</p> <ul style="list-style-type: none"> <li>If the rate of over current events is less than 10 per minute, then the overcurrent counter must be reset to zero and restart to count again.</li> </ul>  |
|          | Short circuit protection                    | 10 consecutive overcurrent trips may be considered as short circuit and the power supply may be tripped  |
|          | Output over voltage                         | Power supply must trip if output voltage exceeds maximum rated voltage. Indication should be on front panel.   |
| <b>4</b> | <b>Output load</b>                          | The final negative pulsed DC output will be connected to a resistive (plasma) load and positive terminal will be connected to ground.  |
| <b>5</b> | <b>Front Panel Indications and Controls</b> |  |
|          | Mains on/off                                | Suitable MCCB must be provided.  |
|          | Start/stop                                  | Push button switches for power supply start/stop   |
|          | Emergency switch                            | To turn off the supply in the event of emergency   |
|          | Trip display                                | Indication Lamps (For all different trips)   |
|          | Trip reset                                  | Via HMI or front panel push button through selector switch   |
|          | Selector switch                             | Selector switch should be provided to select the control from HMI or Front panel   |
|          | Output voltage control                      | Through HMI in the step of 1V or potentiometer on Front panel  |
|          | Output peak voltage display                 | Voltage should be displayed in HMI with $\pm 1V$ accuracy  |
|          | Output peak current display                 | Peak pulsed current should be displayed in HMI with $\pm 1A$   |
|          | Output frequency control                    | Through HMI in the step of 1KHz  |
|          | Output frequency display                    | Frequency should be displayed in HMI with $\pm 0.2KHz$ for full range of duty cycle i.e. 10% to 90%  |
|          | Output duty cycle control                   | Through HMI in the step of 1% from 10% to 90%  |
|          | Output duty cycle display                   | Duty cycle should be displayed in HMI provided on front panel with $\pm 1%$ accuracy   |
|          | Timer display(digital)                      | Set time duration and Remaining time display   |
|          | Temperature measurement display             | <ol style="list-style-type: none"> <li>The Nickel-Chromium (K) type grounded thermocouple will be used for the temperature measurement which will be connected with negative pulsed DC voltage (0 to -800VDC).</li> <li>Temperature should be displayed in HMI in Degree Centigrade, corresponding to mv produced at the junction of "K" type thermocouple and in addition with actual room temperature.</li> <li>Error should be less than <math>\pm 5^{\circ}C</math>.</li> <li>Total three identical temperature measurement units required for measurement at three different</li> </ol> |

|           |                                     |   |
|-----------|-------------------------------------|---|
|           |                                     | locations.  |
| <b>6</b>  | <b>Duty of operation</b>            | Continuous duty (24 x 7 continuous operation)   |
| <b>7</b>  | <b>HMI Display and Data logging</b> | <ol style="list-style-type: none"> <li>1. Standard HMI for display and storage of, <ol style="list-style-type: none"> <li>a) Output Frequency with graph</li> <li>b) Output Duty cycle with graph</li> <li>c) Output peak pulsed current display with graph</li> <li>d) Output pulsed DC Voltage display with graph</li> <li>e) Temperature display with graph for all three locations</li> </ol> </li> <li>2. Storage capacity: Must be capable of storing all the above parameters at an interval of 1s for 500 hours at internal devices.</li> <li>3. Ports : USB as active, RS232, RS485</li> <li>4. TCP/IP Communication port for data logging facility of following parameters. <ol style="list-style-type: none"> <li>a) Output Frequency</li> <li>b) Output Duty Cycle</li> <li>c) Output peak pulsed current</li> <li>d) Pulsed DC Voltage</li> <li>e) Temperature-1, 2 and 3</li> </ol> </li> <li>5. Necessary graphs and parameters should be displayed through graphical user interface (GUI). For reference see annexure-1 and 2.</li> <li>6. Connectivity with HMI Module for Remote monitoring of all above parameters and controls of following parameters with pre-defined IP Address <ol style="list-style-type: none"> <li>a) Duty cycle</li> <li>b) Pulsed Voltage</li> <li>c) Pulse frequency</li> </ol> </li> </ol> |
| <b>8</b>  | <b>Interlocks</b>                   |   |
|           | Timer                               | Time format should be hh:mm which can be fixed up to 99:59 hours as per process time duration. This timer will also display set and remaining time in the same format. At initial both set time and remaining time will be same, after achieving temperature equal to set parameter (temperature-1) remaining time counting should be start. On completion of time duration applied voltage should be reduced to 0V.  |
| <b>9</b>  | <b>Input/output Terminations</b>    |   |
|           | Terminations                        | Input and Output – Screw terminal blocks with proper nomenclature   |
| <b>10</b> | <b>Environment</b>                  |   |
|           | Ambient Temperature                 | Up to 50°C  |

|          |  |  |
|----------|--|--|
|          | Humidity   | Up to 95% RH   |
| <b>B</b> | <b>Specifications of auxiliary DC power supply</b> |  |
|          | <b>Input voltage</b>                               | 230VAC, 50Hz   |
|          | <b>Output voltage</b>                              | -700V DC   |
|          | <b>Output current</b>                              | 500 mA. (Suitable current limiting resistance should be provided)  |
|          | <b>Display</b>                                     | Auxiliary On/Off indication should be provided on HMI and on front panel also.   |
|          | <b>Control</b>                                     | ON/OFF control should be provided through HMI  |
|          | <b>Output polarity</b>                             | Negative DC output. The positive output of this power supply to be grounded  |
| <b>C</b> | <b>Acceptance Criteria</b>                         |  |
|          | <b>Factory acceptance test</b>                     | The performance of the pulsed DC power supply has to be demonstrated on resistive load at the vendor's premises. The list of parameter to be tested at vendor site is provided in annexure 4.<br>Vendor has to make all necessary arrangements for pre-dispatch inspection and testing at full rated values. The cost of all these arrangements has to be borne by the vendor. |
|          | <b>Site acceptance</b>                             | Vendor has to demonstrate the performance of the pulsed DC power supply on plasma load or resistive load (as per site condition) for 24 hour at FCIPT.   |
| <b>D</b> | <b>Installation and commissioning</b>              | To be done by vendor at FCIPT, Gandhinagar   |
| <b>E</b> | <b>Manuals</b>                                     | Both hard & soft copies of the operational and maintenance manual and firmware must be provided. Manuals must contain all electrical drawings and circuits. Schematic wiring diagram must be provided.   |
| <b>F</b> | <b>Training</b>                                    | Should be imparted after installation and commissioning of the power supply at FCIPT.  |
| <b>G</b> | <b>Warranty</b>                                    | The supplier has to provide 12 months warranty from the date of acceptance at FCIPT.   |

## Annexure-1 GUI page

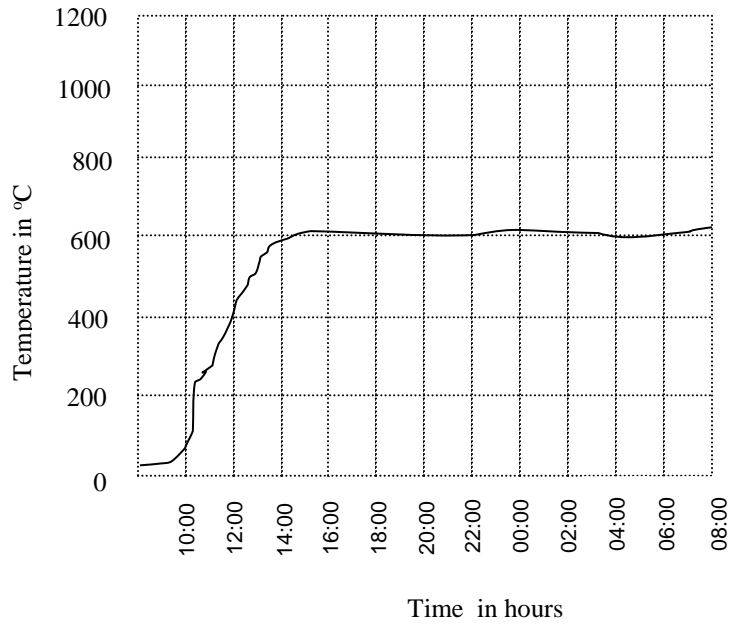
| <i>Plasma Nitriding Process Parameters</i> |        |                  |         |               |                       |
|--|--------|------------------|---------|---------------|-----------------------|
| Set Parameter                              |        | Actual Parameter |         | Trends        | PS Trip<br>&<br>Reset |
| Voltage                                    | -0 V   | Voltage          | -601.5  | Voltage       |                       |
| Frequency                                  | 30 KHz | Frequency        | 30 KHz  | Peak Current  |                       |
| Duty Cycle                                 | 30%    | Duty Cycle       | 80.2%   | Temperatur-1  |                       |
| Auxiliary PS                               | OFF    | Peak Current     | 55.7 A  | Temperature-2 |                       |
| Temperature-1                              | 25°C   | Temperature-1    | 590.6°C | Temperature-3 |                       |
| Temperature-2                              | 25°C   | Temperature-2    | 590.6°C | Duty Cycle    |                       |
| Temperature-3                              | 25°C   | Temperature-3    | 590.6°C |               |                       |
| Duration                                   | 00:00  | Remaining Time   | 00:00   |               |                       |
|  |        | Arc Counter      | 10      |               |                       |

- 1) Yellow coloured value indicated variable where we can add value as per our requirement in a given range. (Voltage: 0 to -800, in the step of 1 volt; Frequency: 10 to 30KHz, in the step of 1 KHz; Duty cycle: 10 to 90% in the step of 1%; Duration: 00:00 to 99:59; Temperature: 0 to 999°C)
- 2) Parameter values under actual parameter column are measured value and resolution for them should be up to first decimal number for voltage, peak current, duty cycle and temperature.
- 3) Tab under trends column will show the trend page of respective parameter while being pressed and a home button tab should be given on each trend page to come back on this home page.
- 4) Default values under set parameter for all the parameter are listed below,
  - a. Voltage: 0V
  - b. Frequency: 30KHz
  - c. Duty Cycle: 30%
  - d. Duration: 00:00
  - e. Temperature: 0°C
  - f. Auxiliary PS: OFF in red coloured tab,

- 5) Auxiliary tab will be **green** while auxiliary power supply is ON otherwise should be **red**.
- 6) All trends must be plotted with respect to time.  
Whole screen of trend should be divided in 24:00 hours scale on horizontal axis and other parameter like, voltage, peak current, temperature, and duty cycle should be on vertical axis. Each trend should be plotted for both set and actual parameters.  
Provision should be provided to save all the trends individually after completion of process with appropriate file name. Trend of temperature is attached as annexure-2 for reference purpose.
- 7) PS trip/reset: While we are working with plasma load many arcs occurs on the electrode and therefore power supply trips, one indication for the power supply tripping should be on front panel and one tab should be provided in HMI which will become **red** while power supply trips and same tab should be used to reset the power supply by touching the same tab. The tab color should be **green** while power supply resets.
- 8) Initial value of remaining time under actual parameter should be same as duration under set parameter, later when actual temperatures-1 reaches to the set temperature-1, counting of remaining time must start. Remaining time should be display under actual parameter.  
Voltage of the power supply must reduce to 0 Volt on completion of process duration or when remaining time goes to 00:00.

# Annexure-2

## Temperature trend:

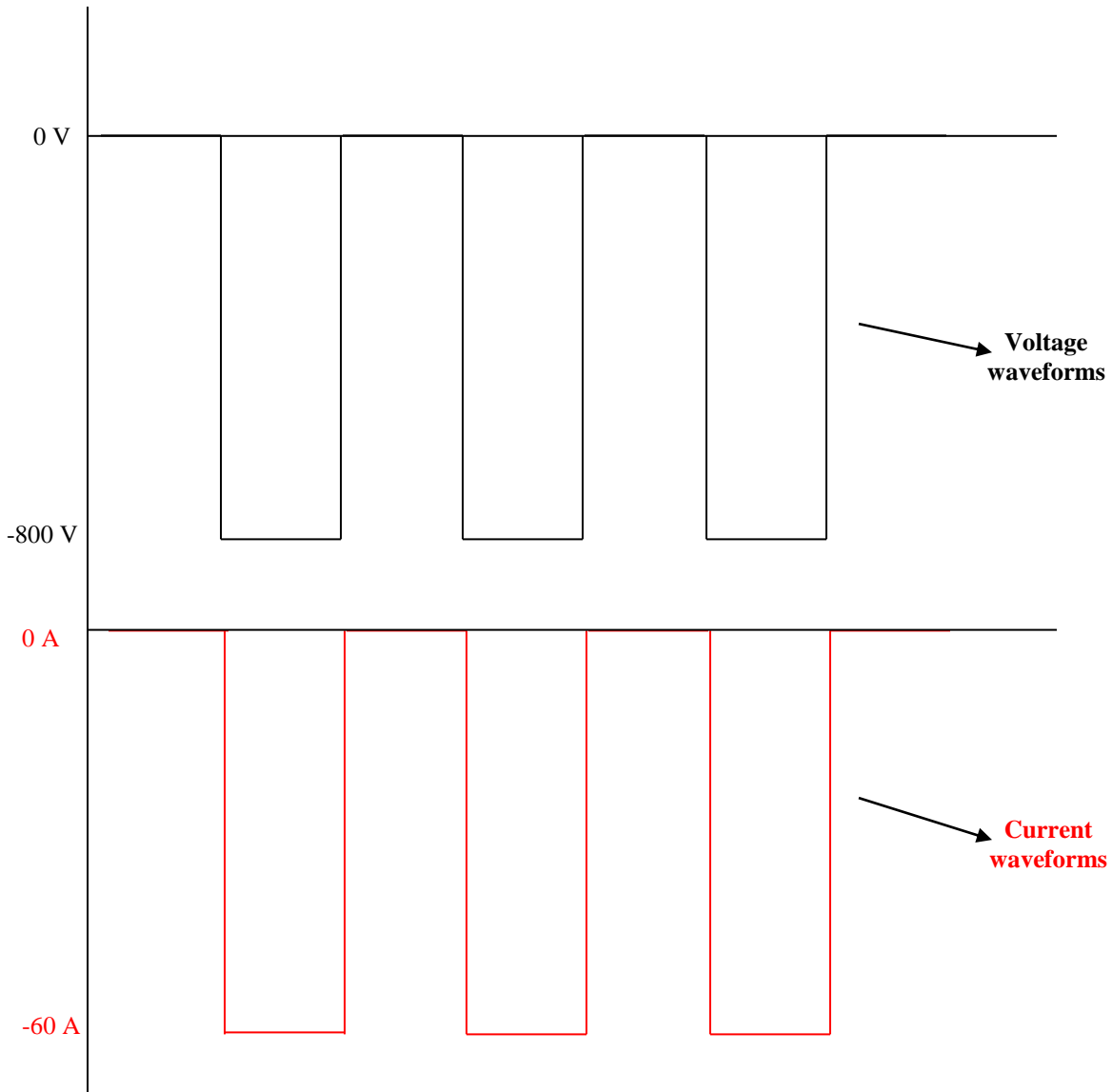


## Annexure-3

### Output waveforms

The IGBT based pulsed DC power source of 60A with auxiliary power supply will be used to generate plasma in the plasma nitriding system

Representative voltage and current waveforms are as shown below:





**Annexure 4**  
**List of test to be performed at vendor site**

Following tests will be carried out at vendor site during the pre-dispatch inspection

| <b>Sr. No.</b> | <b>Test of parameter</b>   | <b>IPR Requirements</b>  |
|----------------|--|--|
| 1              | Output voltage with polarity   | -800V<br>(while positive output terminal grounded)   |
| 2.             | Voltage setting resolution<br>(Via HMI or Potentiometer through selector switch) | 0 to -800V<br>(1V setting will be checked randomly in between specified range of voltage in two conditions,<br>a) with no load and<br>b) with load.)   |
| 3              | Voltage ripple   | 0.5% or better (at maximum rated voltage and current)  |
| 4              | Voltage regulation   | 0.1% or better (at maximum rated values)   |
| 5              | Output current   | 60A [Peak] at 90% Duty Cycle   |
| 6              | Pulse frequency  | Settable between 10KHz to 30KHz through HMI [in the step of 1KHz or better]  |
| 7              | Pulse duty cycle   | Settable between 10% to 90% through HMI [in the step of 1% or better]  |
| 8              | Over current protection  | As described in the specifications at Sl.No: A-3 of the specification, the over current detection and protection circuit performance will be tested. Suitable simulated/actual over current signals have to be provided for the test.  |
| 9              | Short circuit protection   | 10 consecutive overcurrent trips i.e in ~2 seconds will be considered as short circuit and the power supply must trip. (Test by simulation or actual application of short circuit)   |
| 10             | Output over voltage protection   | Power supply must trip if output voltage is more than 800V   |
| 11             | Temperature measurement display  | All Temperature measurement units will be tested for room temperature measurement as well as by applying the output of K type thermocouple floated at -800V. The results will be compared with its standards of mv Vs. temperature chart with an accuracy of $\pm 5^{\circ}\text{C}$ . The test will be carried out by random selection temperatures in its range. |
| 12             | Timer  | Process time will be set for particular  |

|    |        |   |
|----|--------|---|
|    |        | duration at certain temperature in the set parameter. On completion of this duration the output voltage should be reduced to 0V. During this test, set time and remaining time clock performance will be tested as mentioned in timer section at SI No: A-8 of the specification. |
| 13 | Trends | Trends for voltage, peak current, temperatures-1, 2, 3 and duty cycle will be observed for a time period selected for timer test.   |