Sealed quotations are invited on behalf of President of India by Head, CSDD/ BARC for the following work from contractors having adequate experience and capabilities to execute such magnitude and quality of similar works and who have similar experience with different units of Department of Atomic Energy (DAE).

**Name of Work:** Development, optimization, fabrication and supply of 1kVA High frequency Inverter drive (As per Annexure-I)

1. Period of completion: 60 days from the date of issue of work order.
2. The vendors may contact on Telephone No. 25591764 for submission of application for tender/issuance of enquiry.
3. The bidder shall quote on original letterhead signed with company seal, quoting GST number, PAN number. Basic cost, GST and packing & forwarding shall be quoted separately.
4. The quotation shall reach Head, Control Measurement & Drives Section by 15-09-2020 and must be sent in sealed envelope super-scribed with the above reference number and due date given above. Also name of the work shall be displayed on the envelope.
5. Sealed Quotations should be submitted only through registered post/speed post through Indian Postal Service. Address on the envelope shall read

   The Head, Control Measurement & Drives Section,
   Bhabha Atomic Research Centre,
   CEL-5, Trombay, Mumbai-400085
   Attn: Munendra Singh, Scientific Officer-I
   Tel. No. 022-25591764

6. The party shall stand guarantee for the materials supplied & workmanship for this work for a period of 12 months from the date of supply.
7. The fabrication or repair work shall be subject to inspection by our engineer. The finished component/equipment shall not be dispatched prior to approval by our engineer, at bidder’s works. Necessary inspection facilities shall be provided to our engineers during fabrication/repairs at bidder’s premises.
8. The bidder shall deliver finished components/equipment after approval of our engineer within 60 days from the date of firm purchase order issued to the bidder. The finished components/equipment shall be delivered by the bidder at CTD Stores, Bhabha Atomic Research Centre, Trombay, Mumbai-85
9. Sealed quotations will be received up to 14:00 hrs on 15/09/2020 will be opened on 15/09/2020 at 14:30hrs
10. The Head, Control Measurement & Drives Section, B.A.R.C. reserves the right to accept or reject any or all quotations without assigning any reason.
Annexure-1

Technical specification

1. Description: This specification covers the design, fabrication, assembly, wiring/cabling and inspection, delivery and performance guarantee of 1kVA, DSP controlled Pulse Amplitude Modulation (PAM) based Variable Frequency Drive (VFD). This also involves the testing, and demonstration of all features and functioning of VFDs at supplier's end at rated load. The bidder shall be thorough with the specified requirements, high quality in engineering and workmanship for satisfactory operation throughout the lifetime of the VFD.

2. Introduction:
Scope of work: Nature of the work involved is procurement of components, sub-systems from approved vendors and integration of the VFD. Scope of work involved in this tender is as follows:
(a) Conceptualization and finalization of the system.
(b) Circuit Design, Bill of Material, PCB Layout Design.
(c) Transformer concepts, Metglas Transformer Design calculations.
(d) Fabrication and testing of all the PCBs like DSP controller, chopper ckt.s, Inverter bridge, etc.
   The bidder shall fabricate the cards as per the approved drawings by purchaser.
(e) Design & fabrication of suitable enclosure, maximum care shall be taken while designing enclosure and PCB design to reduce the EMI susceptibility of the instrument. For enclosure design supplier has to follow the guideline mentioned in IEC 610101 (Safety requirements for electrical equipment for measurement, control, and laboratory use) Section6 wherever applicable. Final design of the enclosure need to be reviewed and approved by purchaser before fabrication of the enclosure.
(f) Assembly of components on all PCBs and testing. Bidder shall used suitable types of Hall sensors instead of CT & PT, wherever required.
(g) Development of DSP application software for PAM drive application, details are given in 3(b) in this document. Supplier has to make detailed Software requirement specification with the help of end user/purchaser, reviewed and approved, before starting the software development work.
(h) Testing of complete system as per test procedure mentioned in section 5 in this document.
(i) Supply of PCB Design/schematic document and source code/Flash file of software developed in softcopy.
(j) The bidder shall submit all technical details like detailed catalogs, circuit diagrams, make, model no and datasheets of all components while submitting the quotation.
(k) Technical document shall consist of at least following information:
   i. The bidder shall submit all technical details like detailed catalogs, circuit diagrams, make, model no and datasheets of all components while submitting the quotation.
   ii. The bidder shall submit the detailed drawings indicating the layout of components, mounting arrangement, connector arrangement, circuit diagrams with suitable legends and catalogs of components
   iii. Interconnection details between the boards.
   iv. JTAG interface details.
   v. Power supply connection details.
   vi. Flow chart and source code of software developed.
   vii. PCB design details: Gerber files of all the PCBs designed.
   viii. Standard Operating Procedures (SOP) of VFD.
   ix. Bill Of Materials all component datasheets/catalogues.
x. Source code of application program.

(l) All necessary accessories related to the system required for complete functionality of the system shall be supplied.

(m) The specifications define the minimum requirements. However, the bidder is expected to work out the finer details & quote for standard field proven system.

(n) Performance of the supplied VFDs shall be guaranteed for one year from the date of delivery.

3. DSP based Variable Frequency Drive (VFD)

(a) **Description:** This DSP based VFD will be used for mission critical application running 24x7 at 40°C ambient temperature to drive three phase motor.

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Description</th>
<th>Requirements</th>
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<tbody>
<tr>
<td>1.</td>
<td>Input supply</td>
<td>1phase, 230V +10%, 50Hz</td>
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</table>
| 2.    | Output      | - 3phase Variable frequency Variable Voltage  
- 300V RMS line to line voltage  
- 50Hz to 1000Hz frequency  
- Pulse Amplitude Modulation (PAM) six step waveform.  
- Transformer isolated with v/f of 0.35 |
| 3.    | Output Current | 2 Amp Max. Continuous current |
| 4.    | Rated Load   | 1KVA         |
| 5.    | Communication Interface | RS485, up to 38Kbps MODBUS RTU protocol with dip switch baud rate selection |
| 6.    | Local Display | Two lines of Seven Segment 8 digit display for Power, Output voltage and frequency. Separate LCD may be provided to display other parameters like RYB currents or trip conditions. |
| 7.    | Local/Remote mode selection | There shall be separate push button for selection of Local/Remote operation. On every press and release Operation of push button, the mode of operation shall toggle between Local and Remote. |
| 8.    | Parameter settings in Local mode | Only output Voltage & Frequency shall be available to change from VFD, locally. Single optical encoder for output Voltage and Frequency. |
| 9.    | Parameter settings in Remote mode | Through Serial RS485 interface all the parameters like Frequency, Voltage and protection settings, etc. shall be able to change. |
| 10.   | Protections  | - Inverter output short circuit  
- V/F trip  
- Overload (Iac over current)  
- Over temperature  
- Single phasing  
- DC Over voltage/chopper device failure  
- Inverter bridge device failure |
<p>| 11.   | Starting Method | Output frequency is soft started to set frequency every time there is new set value from Communication interface/Local optical encoder |</p>
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<th></th>
<th></th>
<th>and every time output voltage shall start from zero. Output voltage shall ramp upward to set voltage if set value is higher than current voltage but no ramping is required if set value is lesser than current value.</th>
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</thead>
<tbody>
<tr>
<td>13.</td>
<td>Status/Fault Indication</td>
<td>Through Serial Communication and LEDs on local interface indications list is as per point No. 11 in this table</td>
</tr>
<tr>
<td>14.</td>
<td>Input/Output terminal blocks</td>
<td>2.5 sqmm, screw type terminal blocks shall be provided for input and output terminals of VFD.</td>
</tr>
<tr>
<td>15.</td>
<td>Mounting arrangement</td>
<td>Suitable mounting arrangements shall be provided for mounting the VFDs inside 19&quot; rack with side handle.</td>
</tr>
<tr>
<td>16.</td>
<td>Heat removal</td>
<td>Efficient heat removal mechanism shall be planned like air ducts, cooling fans, etc. Case temperature of the switching device shall not increase more than 25°C above ambient temperature (40°C) Transformer core temperature shall not increase more than 50°C above ambient temperature (40°C). Suitable winding insulation (Class H) shall be used for transformer.</td>
</tr>
<tr>
<td>17.</td>
<td>Warranty</td>
<td>1 years from date of delivery at BARC Mumbai</td>
</tr>
<tr>
<td>18.</td>
<td>Quantity</td>
<td>05 Nos.</td>
</tr>
</tbody>
</table>

This panel mount Variable Freq. Drive shall consist of following components:

i. DSP Controller
ii. Uncontrolled Diode bridge rectifier.
iii. Variable voltage chopper circuit.
iv. Three phase IGBT bridge.
v. Output transformer.

**i. DSP Controller:** This VFD controller is heart of the system, which controls the operation of 3 phase Inverter bridge entire drive unit. This is required for PAM generation based on 150° pulse conduction technique of Pulse Amplitude Modulation (PAM) technique. Output voltage and frequency can be varied by varying optical encoder provided on front side of the enclosure. VFD shall provide RS485 communication interface with baud rate of at least 38 kbps to communicate with standard MODBUS RTU Master/server. Stability of clock used for DSP chip shall be of 40 ppm at 40°C or better. For the entire internal wiring suitable size Teflon Insulated 1100 volts grade different color wires shall be used. Function of this board also includes voltage/current PI controller, protection, control and monitoring of various VFD parameters and for implementing various features of VFD. This board provides interfaces mainly to following items:

A. Pulse output to drive Inverter IGBT bridge
B. ADC input from power circuits.
C. Fault inputs.
D. RS485 interface
E. 7segment LED display with optional LCD display
F. Single optical encoder for Output Voltage & Frequency control.
ii. Uncontrolled Diode bridge rectifier: Input of VFD is given to uncontrolled diode bridge of suitable ratings. Main function of this rectifier is to convert 1 phase, 230V, 50Hz ac input to DC output. This DC output shall be fed to the Variable voltage DC to Variable DC chopper circuitry. Electrical ratings of the diode shall be selected such that these shall be operated at 50% of max rating in normal operation of the VFD.

iii. Variable voltage Chopper circuit: Purpose of the Variable voltage chopper is to supply the variable DC voltage to Inverter Bridge, in order to generate desired/set output voltage from the VFD. Switching device shall be selected such that the losses incurred by chopper shall be minimum.

iv. Threephase IGBT bridge: This bridge circuit consists of six numbers of IGBTs along with freewheeling diodes and their gate drive cards, etc. Input for this bridge comes from chopper circuit and output of this is given to output transformer. Gate pulses to drive these IGBTs are comes from DSP controller cards.

v. Output transformer: Transformer shall be of Metglas type, with suitable ratings. Inverter output shall be connected to primary of output transformer. The secondary of Transformer shall be brought out to output terminal of VFD. Output transformer shall be carefully design for suitable output rating and minimum power losses in transformer. Care should be taken for efficiently removal of heat generated by transformer.

Following procedure shall be followed while designing of Variable Frequency Drive hardware:

- All the components including ICs shall be of Industrial grade for withstanding wide range of temperatures (40°C to +85°C). Wherever possible ICs shall be in DIP package. Suitable IC bases shall be provided to facilitate easy replacement of ICs.
- Circuit boards shall be made up of Multilayer, wherever possible including power supply and ground layer separately to give better noise immunity. Necessary care shall be taken while connecting the analog and digital grounds for better coupling and noise immunity.
- Suitable filtering components for ripple rejection, decoupling, EMI compatibility shall be used for proper functioning of board in high frequency power switching environment.
- Necessary care shall be taken for operating the card at an ambient temperature of 40°C and 83% humidity.
- Suitable insulating coating shall be applied on PCB to avoid problems with static discharge, moisture, dust etc.
- All the components of DSP controller card shall be identified with suitable legends, which shall be clearly visible.
- The placement of connectors shall be such that it shall be easy to plug-in the DSP controller card on application card.
- The supplier shall take the approval of DSP controller card layout before initiating manufacturing.
- Supplier should give the complete set of manual, circuit diagrams indicating all connection details of the board and components.
• The potential free contacts as inputs shall be interfaced to DSP through opto-couplers, gain adjusting circuits and buffers.
• All the PAM signals from DSP board shall be taken through suitable high-speed buffers to the terminal block.
• The placement of connectors shall be such that it shall be easy to plug-in the DSP controller card on application card.
• All the terminals of components of application card shall be accessible even after plugging the DSP controller card.
• Suitable terminal blocks of Phoenix/Molex make (Male and female type) for connecting the wire with pin type lugs shall be provided on application board for connecting and taking out various signals.

(b) Development of DSP application software: The bidder has to develop the application software for DSP based Pulse Amplitude Modulated (PAM) drive application. The bidder shall note that the code shall be developed to the purchaser’s satisfaction for proper functioning of the system. The supplier shall do the modifications in the application program at any stage till the VFDs are commissioned successfully in the purchaser’s premises. The detailed requirements will be given to the successful bidder, however the major requirements are given below.

i. Generation of IGBT gate pulses for IGBT bridge, to generate PAM output.
ii. Suitable dead band compensation shall be provided to overcome the adverse impact of the dead band on the output wave.
iii. Implementation of PI controller for closed loop operation: The Voltage PI controller shall be used to regulate the output voltage. The voltage shall be maintained according to set voltage values by controlling the amplitude of PAM pulses.
iv. Transient response of controller: During the input variation, the inverter output voltage shall not vary more than 4% of the set value.
v. Open loop operation: Option shall be provided to adjust the output voltage to the set value by varying the width of the pulses in open loop operation.
vi. Soft start feature: When the VFD is started, the frequency of inverter shall be increased from minimum to SET value, gradually according to set ramp rate (soft start feature). Voltage shall ramp upward but rampdown feature is not required thus voltage can to set to zero or lower values immediately. The drive start command to DSP will be given through a potential free contact.
vii. Protection: The drive shall be protected against various faults mentioned previously. On the occurrence of any fault, the PAM pulses shall be stopped immediately and corresponding indication along with one potential free contact shall be provided.
viii. Retention of various set values and protection values: In case of failure of power supply to DSP controller, the previous settings of all parameters of DSP shall be retained in remote as well as local mode (in external memory). When the power supply to the DSP controller is resumed, the functioning of the DSP controller shall be based on previous set values except output voltage which will start from zero.
ix. Local Mode Operation: The adjustment of fundamental frequency, voltage/power settings will be carried out in local mode through optical encoder. There shall be single optical encoder for either setting Voltage/Power or Frequency. Remote mode operation: The DSP software shall be developed for sending various inverter control, protection values and status parameters like Voltage, Frequency,
Power, over voltage, over current, etc. In remote mode, facility shall be provided to switch ON and switch OFF the VFD from MODBUS master/server software. *Note: Supply of MODBUS master/server software is in purchaser’s scope.*

**x.** Communication: The DSP software shall be developed for MODBUS slave operation. MODBUSRTU protocol shall be used for communication with master. All the standard MODBUS functions required for smooth functioning of VFD shall be developed by the supplier including Diagnostic function.

**xi.** Remote/Local mode selection: for selection of either remote or local mode for the operation of VFD, there shall be one push button switch, on pressing of it, operation mode shall be changed from current status to other one.