INSTITUTE FOR PLASMA RESEARCH

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NOTICE FOR EXPRESSION OF INTEREST AND

SELECTION OF VENDOR FOR

DESIGN, MANUFACTURE, SUPPLY, TESTING, INSTALLATION, TESTING AND COMMISSIONING OF DSP BASED CONTROLLERS AND ASSOCIATED HARDWARE AND SOFTWARE WITH ELECTRONICS INTERFACES FOR THE UPGRADE WORK OF EXISTING POWER SUPPLIES OF ADITYA TOKAMAK

EOI No.EOI/IPR/16-17/2 DATED 13-7-2016

"Expression of Interest" (EOI) is invited from reputed parties for design, manufacture, testing, inspection, delivery, installation and commissioning of DSP based Controllers and associated hardware and software with electronics interfaces for the upgrade of existing Power Supplies of AdityaTokamakat Institute for Plasma Research, Bhat, Gandhinagar.

The EOI document containing eligibility requirements, technical descriptions, scope of work and terms & conditions will be available in the official website of IPR, i.e. **http://www.ipr.res.in/documents/ tenders.html.** Interested vendors can download the EOI document from IPR Website, from 14-07-2016 onwards. Alternatively, vendors can obtain the EOI document from the Purchase Officer, IPR, Bhat, Gandhinagar up to 12-08-2017.

The vendors who are satisfying the eligibility criteria as mentioned in the EOI document may submit their EOI proposal to the Purchase Officer, Institute for Plasma Research at the above address latest by 1.00 p.m. on **17th August, 2016** superscribing the envelope with **EOI/IPR/16-17/2 dated 13-7-2016** for "UPGRADE OF EXISTING POWER SUPPLIES OF ADITYA TOKAMAK AT IPR, BHAT, GANDHINAGAR".

INSTITUTE FOR PLASMA RESEARCH
NEAR INDIRA BRIDGE, BHAT,
GANDHINAGAR 382 428
GUJARAT STATE (INDIA)

NOTICE FOR EXPRESSION OF INTEREST AND

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"DESIGN, MANUFACTURE, SUPPLY, TESTING, INSTALLATION, TESTING AND COMMISSIONING OF DSP BASED CONTROLLERS AND ASSOCIATED HARDWARE ANDSOFTWARE WITH ELECTRONICS INTERFACES FOR THE UPGRADE WORK OF EXISTING POWER SUPPLIES OF ADITYA TOKAMAK"

DUE DATE FOR SUBMISSION OF EOI PROPOSAL	**17-08-2016 BY 1.00 P.M.**

Expression of interest (EOI)

1.0 Eligibility criteria

Expression of Interest (EOI) is invited from the reputed vendors having experience in design and manufacturing DSP based controllers for high current dc power supplies for upgradation of existing Aditya Tokamak power supply system. The controls and interfaces of the present Power Supply system to be fitted with custom designed hardware and software including Digital Signal Processor (DSP) and Programmable Logic Controller (PLC) as per specifications provided in this document at Institute for Plasma Research, Bhat, Gandhinagar. The upgradation work includes design, manufacturing, factory tests, supply, and installation and commissioning of the custom designed hardware and software at site. Interested vendors should meetthe following criteria:

1.1. Bidder shall have proven experience of over 5 years in design and manufacture of control systems for high power of high current dc power supplies or dc/ac drives or inverters.Bidder shall be regular vendor for power control products to government bodies such as Railways, Smelter, Cement manufacturers, Research Institutes under DAE, DST etc. and/or PSUs and/or MNCs. Documentary evidence should be provided in the form of successfully executed purchase order copies along with completion certificates.

1.2. Bidder shall have manufactured, delivered, installed and executed successfully at least three systems of DSP and PLC based controls and interface hardware & software, preferably as apart/subsystem of 6, 12 or higher pulse high power DC supply equal to or more than 1000A or as a full/part/subsystem of AC/ DC drives / choppers using 32/64 bit DSP of capacities more than 1000 KW/ **1000A.** Copy of Purchase Order and successful completion certificates shall be provided.

1.3. Bidder shall have in house facility for designing and manufacturing Thyristor/IGBT based power supplies exclusively having digital controls and/or firing pulse generators using DSP and/or firing amplifiers and analogue circuits/ electronics circuit designs. Bidder shall be into designing and manufacturing of the above mentioned systems for at least last 5 years and possess appropriate certified infrastructure of their own. Documentary proof such as R&D activity, components developed and R&D, number of experienced engineer working etc.

1.4. Bidder shall have sufficient in-house experience of handling EMI/EMC preferably some products designed and manufactured by them should have qualified for compliance to IEC 61000–X series/ **MIL-STD-461 or equivalent standard** in tests by 3rd party laboratory.Third party tests done in past 5 year.

1.5. Bidder must be an ISO 9001-20XX (latest) certified company for the said type of activities. Issuing authority and type of activities

1.6. Bidder shall have executed single order of any project using DSP embedded controllers of value of Rs.60 lacs or more in **last 3 years & having average annual sales of more than Rs.6 crore for the last 3 years with profit making in any 3 years of last 5 years. Purchase Order copy with completion** certificate and audited financial statement of accounts for the last 5 years to be submitted.

2. 0 Evaluation procedure

2.1. First level of scrutiny of responders will be the compliance of vendors for the tender eligibility criteria. Bidders are required to submit all the supporting documents as proof for all the criteria as mentioned in Annexure I. Only those bidders who are eligible shall be considered for further evaluation.

2.2. The eligible bidders shall be invited for a detailed presentation on the proposal for the scope of the tender. The broad guideline for the presentation and evaluation parameters is provided in Annexure II.

Brief Description of Existing Power Supplies

The Institute for PlasmaResearch (IPR) has Aditya tokamak, which produces and confines plasma using magnetic fields for controlled thermonuclear fusion research. The Aditya tokamak has several coils for generating different kinds of magnetic fields. These coils are powered by power supplies, known as APPS, which were supplied by AEG Germany in the year 1986-87. These power supplies are designed for high current pulsed DC outputs having thyristor based rectifier's using analogue controls with computer interfaces. The 12 pulse generators and regulator protections are all based on analogue cards. There are 4 Power supplies and one wave shaping unit which all are fully operational. All power supplies are pulsed with3 secondsON and 5 minutes OFF duty cycle.

1. Toroidal Field Power Supply (TF): 400 V and 50 kA DC
2. OhmicTransformer Power Supply (OT): +/- 2.2 kV (bipolar) and +/- 20 kA
3. Vertical Field Power Supply (VF):2.2 kV and 12.5 kA DC
4. Auxiliary Power Supply (AUX):
5. Wave Shapingcontroller and Central control interfaces using remote PC and retrofit connections

Existing System Details

11 kV input is derived from upstream power transformer of 37.5 MVA 132 kV / 11.2 kV impedance 11% (at 37.5 MVA base) , delta / star n 11 (neutral earthed) with short time loading upto 60 MVA, installed at 132 KV switchyard in IPR premises. Fault level at 11 kV is 350 MVA. The S1 (APPS) bus gets power at 11 kV in the APPS power supply and 11 kV VCB feeders are used to switch each set of converter transformer (6 numbers) for TF, OT &VF, having one secondary in delta and other in star configuration. These set of transformers feedsdirectly the rectifier panels making 12 pulse output..All the rectifier panels are having thyristor stack of AEG/ Infineon make (rated ~2000 A) with air cooled heat sinkinstalled in converter room ground floor. For TF- 8 numbers, for OT- 4 numbers,forVF -3 numbers of devices are connected in parallel in each arm, and for the circulating converter single unit is used. In case of OT two antiparallel bridge is used for the dual polarity conversion, which has zero current crossing interlocks. There exists freewheeling Thyristors for each bridge, which are fired in case of overvoltage. Each device has series semiconductor fuses, temperature switches and pulse transformers. Firing circuits and controls are analogue based cards which are placed at first floor just above the rectifier panels. AC side protections are taken from the 11 kV panels, DC side protections are taken from DC current transformer,earthing shunts etc. In the rectifier panel protections against fuse / temperature failures, devices failures, over voltage, pulse failure are provided. AC damper in used with Diode Bridge and RC snubbers on AC line side. DC isolators / earthing switches are provided on DC side.11 kV bus pulse transformers (PTs)are used to obtain 110 V, 3 phases, 50 Hz (R Y B) to be used for the pulse synchronization. For the interlocks and control monitoring 96 IN /96 out (3 X 32 set) PLC's are used with relays.

Scope of work

(TFPS, OTPS, VF, AUX PS power supply controller upgrades and Wave shaping control unit controller upgrade)

Scope of work include design , supply , testing , commissioning controllers, interfaces electronics , pulse amplifier , control protections PLC's and complete replacement for the existing three power supplies, and wave shaping control unit. In each power supply, all the analogue controller Thyristor protections shall be replaced by completely new DSP based electronic boards and new digital 12 pulse generation system using latest DSP should be installed. This controller shall have required many numbers of channels for the analog in / out signals as well as digital in /out signals. Timer in and out is to be provided for switching. The reference value shall be set or passed by communication link. Maser trigger facility shall be installed. Hard wired timing and interrupt shall be given from one PS to other or vice versa. The monitoring analogue signal shall have proper input isolations amplifier like for dc current dc voltage shunt output currents, ac ct currents to the input to controllers. The bidder shall have designing and working experience for the 12 pulse digital controls and designing analogue circuits with EMI/ EMC. Each thyristor is having individual pulse transformer mounted on the same panel. The gating pulses are amplified by suitable pulse amplifiers to ensure simultaneous firing of all the parallel devices. The pulse amplifier is common for the all the thyristors connected in parallel of 8 units per arm. First pulse shall be approximately 80 V, followed by 35 V dc coupled by diode in final stage of the amplifier. There are two primaries and two secondary on the present pulse transformer. Each winding is fed by amplifier in compliment mode. And secondary's are connected in parallel which is pure DC (because primary inputs are complimented) each thyristor gating pulses are approximately 2 to 4 Amp. New Dc back supply shall be used to drive the pulse amplifier circuits. Firing pulses through pulse amplifiers are to be designed such that to ensure firing to all the thyristors connected in parallel. Existing circuit is to be given for the reference. Fuse / temp failure shall be derived from the current loading method. Each arm devices anode to cathode voltage shall be monitored by resistance divider and isolation to ensure correct firing and device failure or commutation failures. Over current shall be taken form ac side and dc side. Internal failure shall be derived from diff. in ac to dc side currents. Earth faults to be sensed from earthing shunts current by using isolation amp. Zero currents are to be measured by shunt currents. Over voltage is sensed from the ct's connected in MOV path, using isolation amp. Pulse firing auxiliary supply shall have 3 sec back up in case of power supply failure to keep firing to ramp down inductive currents on magnets. Ac side damper unit need to be retrofitted by new components such as new fast diodes , Fuse units , R-C components. New set of PLc's of 96 digital in /96 digital out channels are to be used toControl /interlock/ monitoring in each unit. Wave shaping controller shall have capacitor charging for Ohmic and VF. VCB opening closing, fast make resistor switching, Timing system to fire capacitors, switches and interface to present ignitron / switches firing. It shall have breaker, fast make switches, ignitron switches, capacitors, and diodes. Times and Digital out shall have fiber optic transmission for firing devices and adaptor shall be made. For the fast make switches and ignitrons new trigger circuits are to be made. Data's are to be set on computer for each shot it will be sent to respective controller and store in memories of the controllers, master trigger shall be giving from the remote computer to fire the shots. Data's are to be stored in individual comptroller unit and transfer to the main pc / server.DSP based controller shall have required facility like digital PID, local mode, remote mode, start / stop. Sequence operations reference control switch over fault monitoring, etc. Auxiliary power of +/- 5 V, +/- 15 V , 24V , or 35 V , or 80 V shall be derived from 230 V/ 415 Ac.

The lists of major protections are to be incorporated in new controllers

The new controller shall have sufficient number of analog channels, with signal conditioning which shall be used for the controls and protections .the input signals are shown as per the drawings, in which it is shown that the inputs are derived in the power supplies(one side is shown as existing and other side shall be connected to signal input to new controllers. The following protections shall be developed and given.

1. Phase failure, (it shall be derived from the 12 pulse output voltage of the converter the percent increase on ac ripple to dc).
2. Fuse failure /over temperature (fuse and temp switch is having isolated load current by transformer. Ac CT current is monitored drop in current indicating failures.)
3. Over current, over current time, (Ac ct's are already provided on 11 kv side same shall be used with signal conditions for the over current protections.)
4. over current, over current time, (Dc side ct signal shall be used)
5. Internal short circuit (difference on ac side current and dc side current is to be taken)
6. Commutation failure (V ak anode to cathode voltage shall be taken with isolation for each thyristor arm of the bridge. 12 voltages for the converter during firing voltage becomes zero for 1/3 of a cycle, after the commutations voltage builds up this sequence is used to find out commutations. In case of failures voltage builds up fails to be detected. Only resistance divider shall be given)
7. Ground fault detections, (earthing shunt mv output shall be taken with the isolations)
8. Over voltage detections (MOV / break over diode path is having pulse ct , output of the ct shall be amplified and detected only freewheeling shall be fired.)
9. Pulses Amplifier failures (final stage of the Pulse amplifier current shall be taken and use for the pulses failures.)
10. Synchronizing voltage failures, and control voltage failures all auxiliary supply shall be directly monitored also in alarm and trip circuits
11. AC side damper shall be retrofitted with new fuse units of similar make, new fast diodes of similar type in same circuits and RC components, fuses shall be monitored.
12. External fault. There shall be external faults on controllers coming from other units.
13. Hard ware interlock link to PLC's.
14. Some of the monitoring is external to controller those shall also be linked to PLC / controllers.
15. Electronic hardware circuit for zero current monitoring in Ohmic positive side and negative side converter interlocks, shall give signal for the negative pulse after a delay. This shall be done outside the controller.
16. In OT PS circulating current rectifier (1800 V dc/ 2800 A , 0.1 sec) firing controller, pulse amplifier start/ stop, fuse / temp monitoring , ac dampers, ac side and dc side current monitoring and regulations are to be added as per the main converters.

Common hardware for TF, OT, VF PS and WSC shall be newly built and supplied

DSP controller and interfaces, to meet fast control high end 4 core 200 Mhz 32 bit controller (preferably by Texas instrument) shall be used
12 Pulse generations output for the bridge converter 0 degree to 360 degree 30 degree spacing each in a cycle and pulse Amplifier to drive upto 8 devices
Thyristor protections by monitoring Anode to cathode voltage fuse failures, Over current fro ac and dc side,
New PLC's96 in/96 out with relays shall be used in each power supply unit and 48 in /48 out for the wave shaping control unit. Breaker positions , common tripping / breaker interlocks,

transformer faults, isolators positions / interlocks, rectifier ON/ OFF interlocks, auxiliary voltage failures indications/ interlocks, some parallel faults (to controllers) etc shall be built in PLC programming. Input shall have auxiliary relays. These shall be interconnected to controller by hardwired as well as link.
ADC must have 16 bit resolutions.
Each Analog signals shall be isolated , like dc current, ac side currents, dc voltage, shunt currents, V_{ak} (anode to cathode voltages) , fuse monitoring currents , over voltage circuit, wave shaping's voltages/ currents shall have suitable isolation amplifier, and all the analogue channel signals shall be calibrated before the input to controller digitizer. Digital control channels are also to be isolated. There shall be extra analog & digital channels for the user. There should be extra analog output channels/ digital out, timer out channels, digital in / out for the user.
New wiring connections to the controls like opto couplers, fiber optic cables, terminals, relays, auxiliary PS, 11 kv ct's are to be done.
Master trigger facility for synchronizations.
Local / manual control for testing at lower or higher currents with predefined wave shape in each power supply
Complete remote control with data link to remote system including remote PC.
Intergraded shots with preprogrammed current profile in all the power supply and wave shaping's form remote unit.
Wave shaping timers shall have fiber optic for ignitrons firing and for fast make switches also new adaptor triggering circuits.
Ethernet/ LAN/ mod bus or acceptable connectivity protocol shall be used.
All the control equipments shall be fitted in new panel.
Line diagram for the OT,VF, configuration for the TF, VF and typical controller scheme are given here.
TF and VF power supply is unidirectional 12 pulse converters (rectifying mode and inverting mode both) operating firing range shall be 0 to 150 degree.

Control interlocks for OT positive and negative

In case of OT converter it has anti parallel bridge for dual polarity operations From +20 to – 20 KA (shown in fig.1).OT power supply power converters are shown in fig,1 part 1. It has three converters. Positive converter(+20 KA) , circulating converter (-2.5 KA) , and negative converter (-20 KA), first pulses are given to positive and reference is given to drive required current (circulating and negative is in off mode) wave shaping breaker is opened at the same time timer is triggered and positive converter is brought in inverting mode , firing angle shifted to 150 to 90 degree., current is allowed to fall . at the falling of 2 ka circulating is given a reference to drive required current ,
For the smooth transitions – 2ka circulating converter is added comes in the operations during falling of positive current near to zero and operated in to negative directions. Once zero current is detected on positive converter negative is switched on with the gap of 30 ms, to avoid simultaneous gating of positive and negative converters. Extra interlock shall be built for the firing of circulating converter, positive and negative converter operations, and zero current detection on OT power supply. We are also proposing that there should be hard ware electronic circuits using discrete components shall monitored OT positive current comes to zero by zero detection high gain amplifier. Positive pulses monitoring, voltage on positive converter (Vak) , controller output shall be in inverting mode during circulating , circulating current shall be more than some limit and after zero detections 30 ms timer shall give transfer the pulses to negative converter. Similarly negative to positive interlocks shall be built. It should be highly reliable circuit otherwise any failure will lead to short circuit if both positive

and negative fired together. Bidder shall have good knowledge of electronics circuit designing.

There is timers circuit makes for the OT operations with wave shaping. VF power supply has capacitor addon voltage during starting is pre charged and fired at the time of plasma breakdown (shown in fig 1 part 2). Recently booster power supply is added similar way it will operate in new controller. (The main controller difference error output shall drive booster) analog out channel shall be used to integrate booster PS.

Project completion period:

The full system as per the scope shall be delivered and commissioned at site within 12-18 months from the date of LOI/Purchase order or 9-12 months from the date of drawing approval. Regarding delivery of material in full or partial may be decided mutually at the time of finalization of contract/order

Annexure I

Sr. no.	Criteria	Documents' to be submitted by the bidder
1	Bidder shall have proven experience of over 5 years in design and manufacture of control systems for high power of high current dc power supplies or dc/ ac drives or inverters. Bidder shall be regular vendor for power control products to government bodies such as Railways, Cement manufacturers, Research Institutes under DAE, DST etc. and/or PSUs and/or MNCs.	Company profile, main activities shall be given. Documentary evidence should be provided in the form of successfully executed purchase order copies.
2	Bidder shall have manufactured, delivered, installed and executed successfully at least three systems of DSP and PLC based controls and interface hardware & software, preferably as apart/subsystem of 6, 12 or higher pulse high power DC supply equal to or more than 1000A or as a full/part/subsystem of AC/ DC drives / choppers using 32/64 bit DSP of capacities more than 1000 KW/ **1000A.** Copy of Purchase Order and successful completion certificates shall be provided	PO copies, description of items falls under completion report shall be given. these are minimum criteria higher capacity shall be ranked more in grading system
3	Bidder shall have in house facility for designing and manufacturing Thyristor/IGBT based power supplies exclusively having digital controls and/or firing pulse generators using DSP and/or firing amplifiers and analogue circuits/ electronics circuit designs. Bidder shall be into designing and manufacturing of the above mentioned systems for at least last 5 years and possess appropriate certified infrastructure of their own	Details of R &D activities for the new development of similar items, number of engineers working support documents shall be given. Any new R&D product developed
4	Bidder shall have sufficient in-house experience of handling EMI/EMC preferably some products designed and manufactured by them should have qualified for compliance to IEC 61000–X series/ **MIL-STD-461 or equivalent standard** in tests by 3rd party laboratory.Third party tests done in past 5 year.	EMI/EMC tested certificate from third party for their parts/ similar products
5	Bidder must be an ISO 9001-20XX (latest) certified company for the said type of activities. Issuing authority and type of activities	Issuing authority for ISO certifications, category and items to carry out works
6	Bidder shall have executed single order of any project using DSP embedded controllers of value of Rs.60 lacs or more in **last 3 years & having average annual sales of more than Rs.6 crore for the last 3 years with profit making in any 3 years of last 5 years.** **Purchase Order copy with completion** certificate and audited financial statement of accounts for the last 5 years to be submitted	Copy of Purchase order with completion certificate report of customers not more than 5 years and audited finance statements for last 5 years from 2010-11, 2011-12, 2012-13, 2013-14, and 2014-15.

Annexure II

EOI evaluation/ grading and final selection guidelines

The vendors satisfying the above criteria shall be asked to present a detailed proposal based on the information attached with this document to an IPR committee. The proposal submitted by the vendor and corresponding presentations with understanding the scope shall be evaluated by the committee as per following grade points [Point(f) has weightage of 25 % and rest of the points shall be contributed to 75 % each having weightage of 15 %].

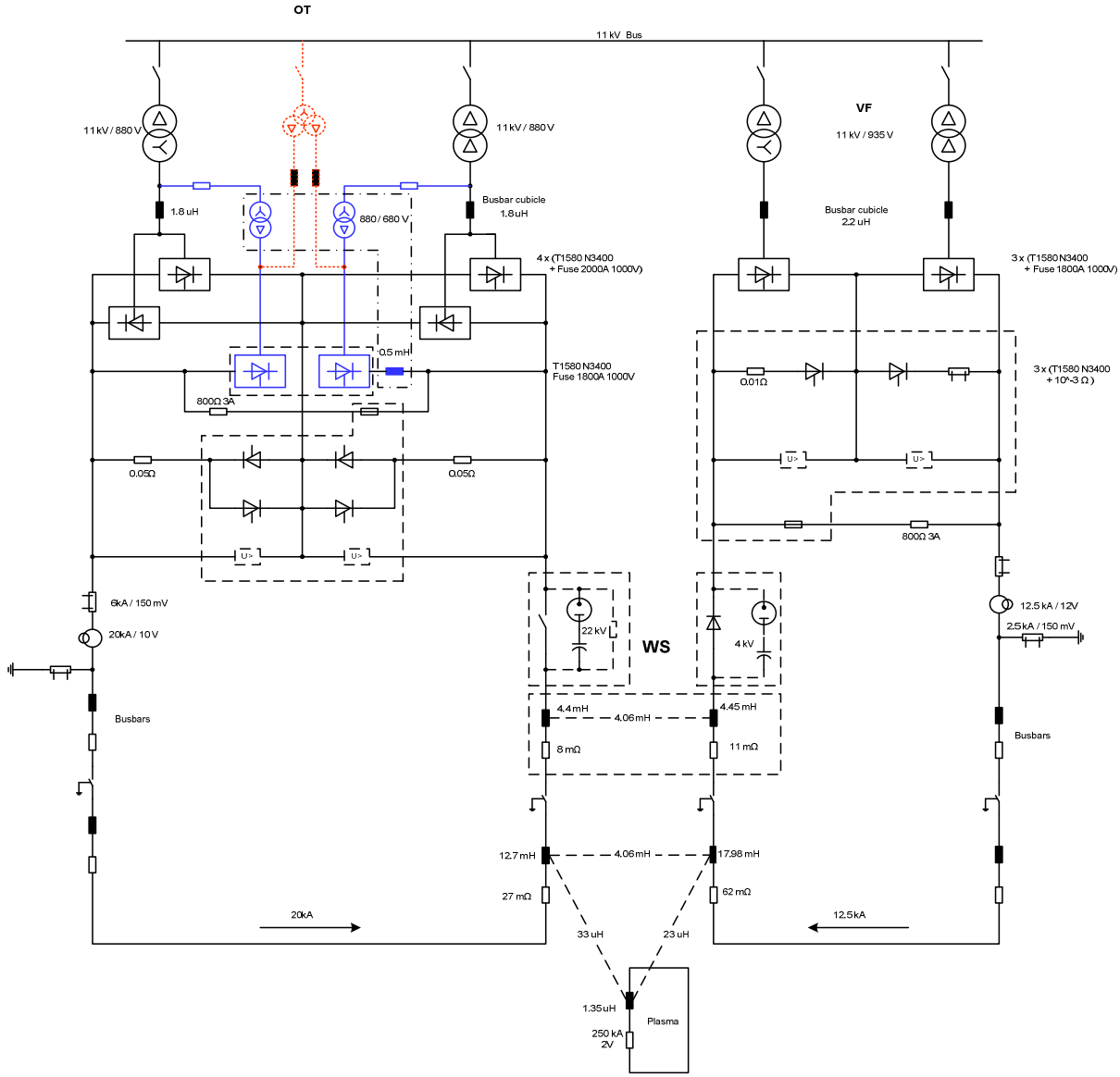
(a) In house R & D set up and associated manpower. Engineering working knowledge number of man power employed and experience shall be graded
(b) Number of years experience in working with DSP controller, similar experience. Higher number of years shall be graded higher.
(c) Number of similar or unique project completed in last 3 years,
(d) Experience in using PLCs for systems solutions ,knowledge in hardware and programming, based on successfully completed projects.

(e) Yearly turnoverRs.6crore is minimum requirements, higher turnovers (> 6Crore) shall attract more points.
(f) Clarity on the proposal presentation, vendor shall cover the design aspect of the scope and cover their design, layout, electronic interfaces, and pulse amplifier design and most importantly the acceptance test plans in the presentations.

The bidder who scores minimum of 50% in each category and overall 70% shall be considered qualified for the issue of the tender document.

Annexure III: details of circuit drawings

Fig 1: OT and VF power circuit details are given as above.
Fig 2 shows the typical system details of existing and new system
Fig. 3 12 pulse power and control scheme new and old
Fig 4. Shows the input signals voltage divider, fuse monitoring shunt output, all the signals are to be used for the controls.
Fig5: Gating circuit amplifier for individual phase, for one phase single amplifier shall be used. Pulse transformers are individually for each device. Single Amplifier shall be suitable to drive 8 units. Down it is shown fuse monitoring system and voltage divider for each Vak (anode cathode voltage) measurements.
Fig 6 A typical control scheme is shown with PC.
Fig 7 block diagram showing all three rectifiers
Fig 8 wave shaping waveforms
Fig 9: wave shaping circuits with VCB, safety switch, firing ignitrons, commutating resistors in steps, capacitors (charging separate not shown).



OT power circuit positive converter, negative Converter and circulating with intermediate Transformer, free wheeler FWT, and Load (part 1)

VF Power circuit and add on capacitor FIG 1 part 2

Fig. 1: OT(part 1) and VF Electrical Circuit (part2)

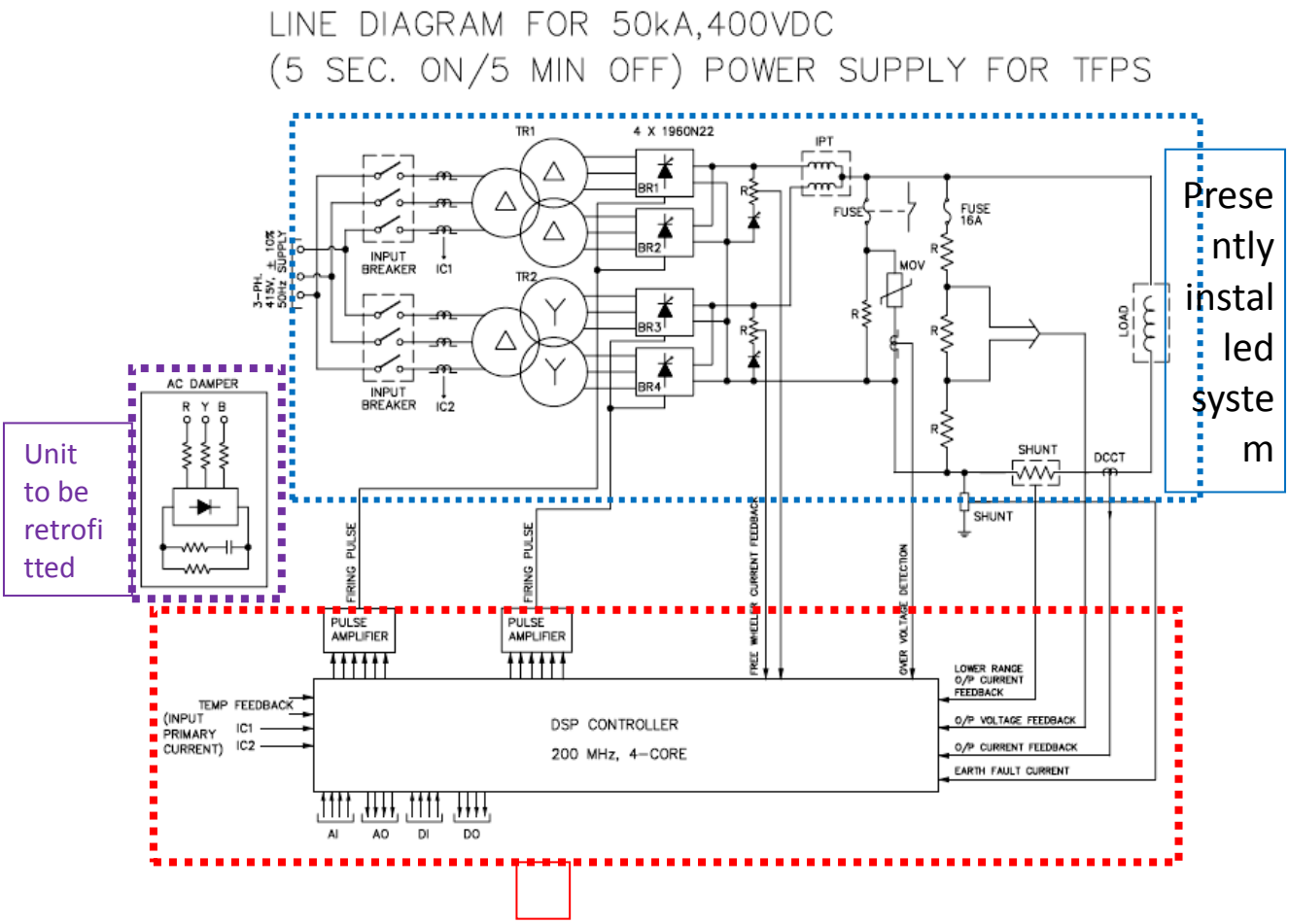


Fig. 2: Typical control and power scheme from existing and new system for 12 pulse parallel rectifiers

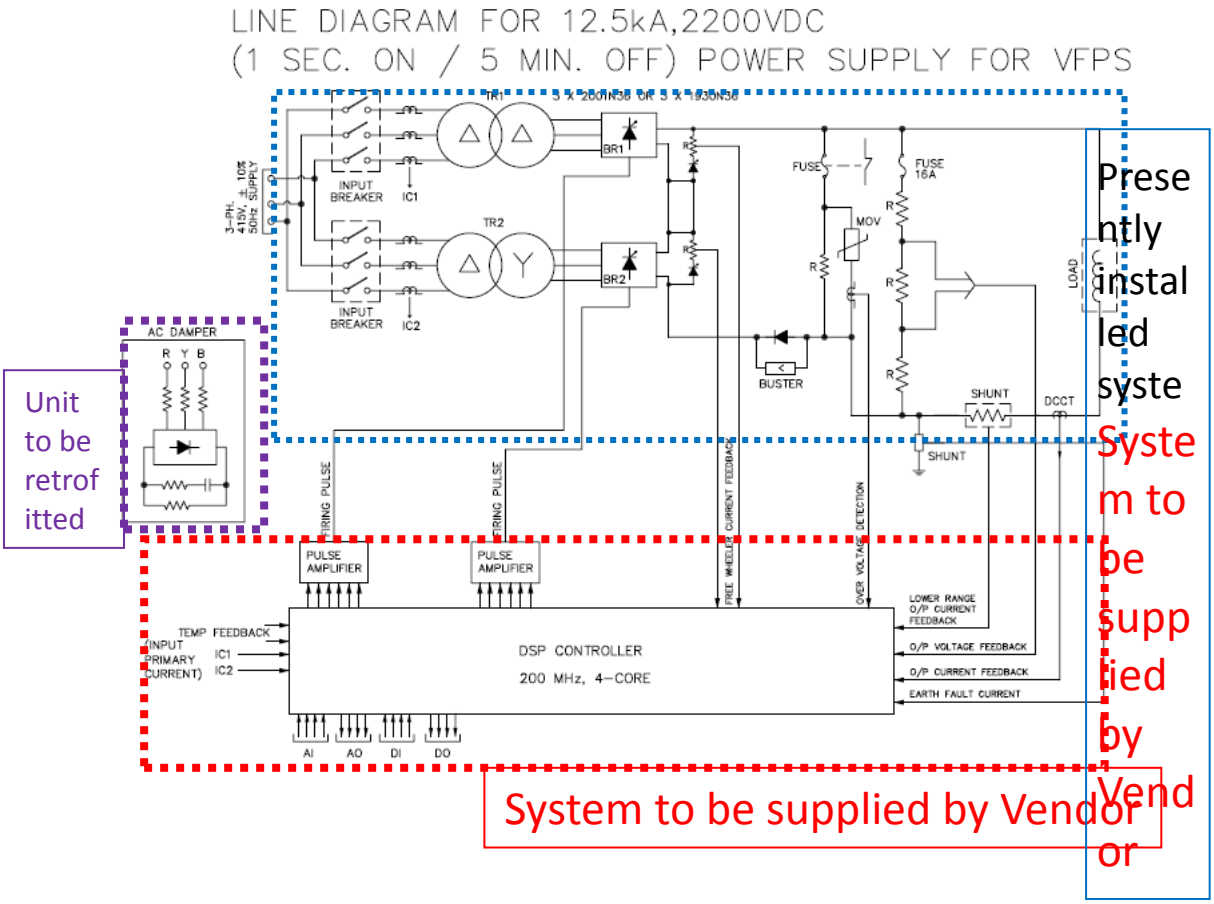


Fig. 3: Typical control and power scheme from existing and new system for 12 pulse series rectifiers

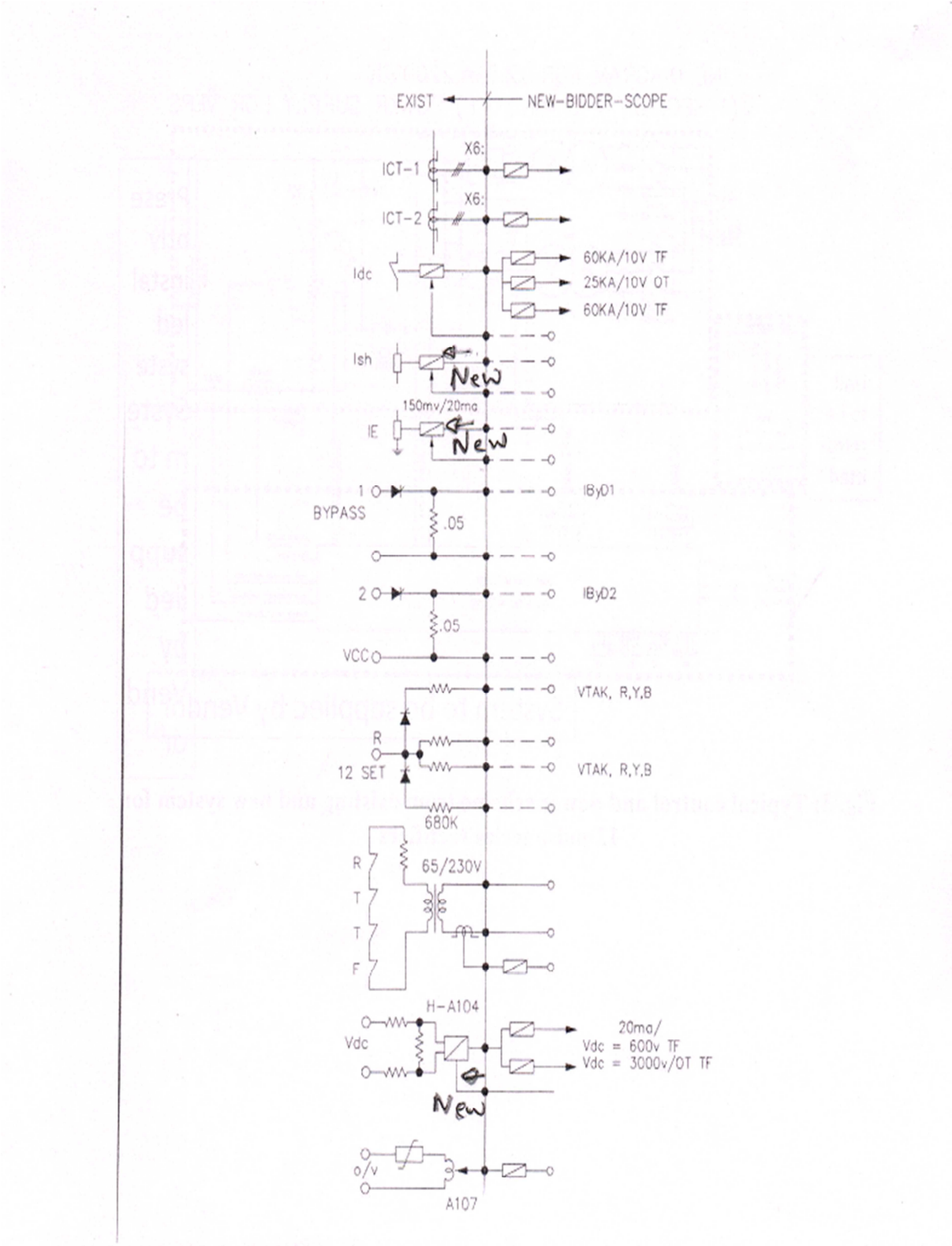


Fig. 4: control signal as connected form the existing system and new controller to be used

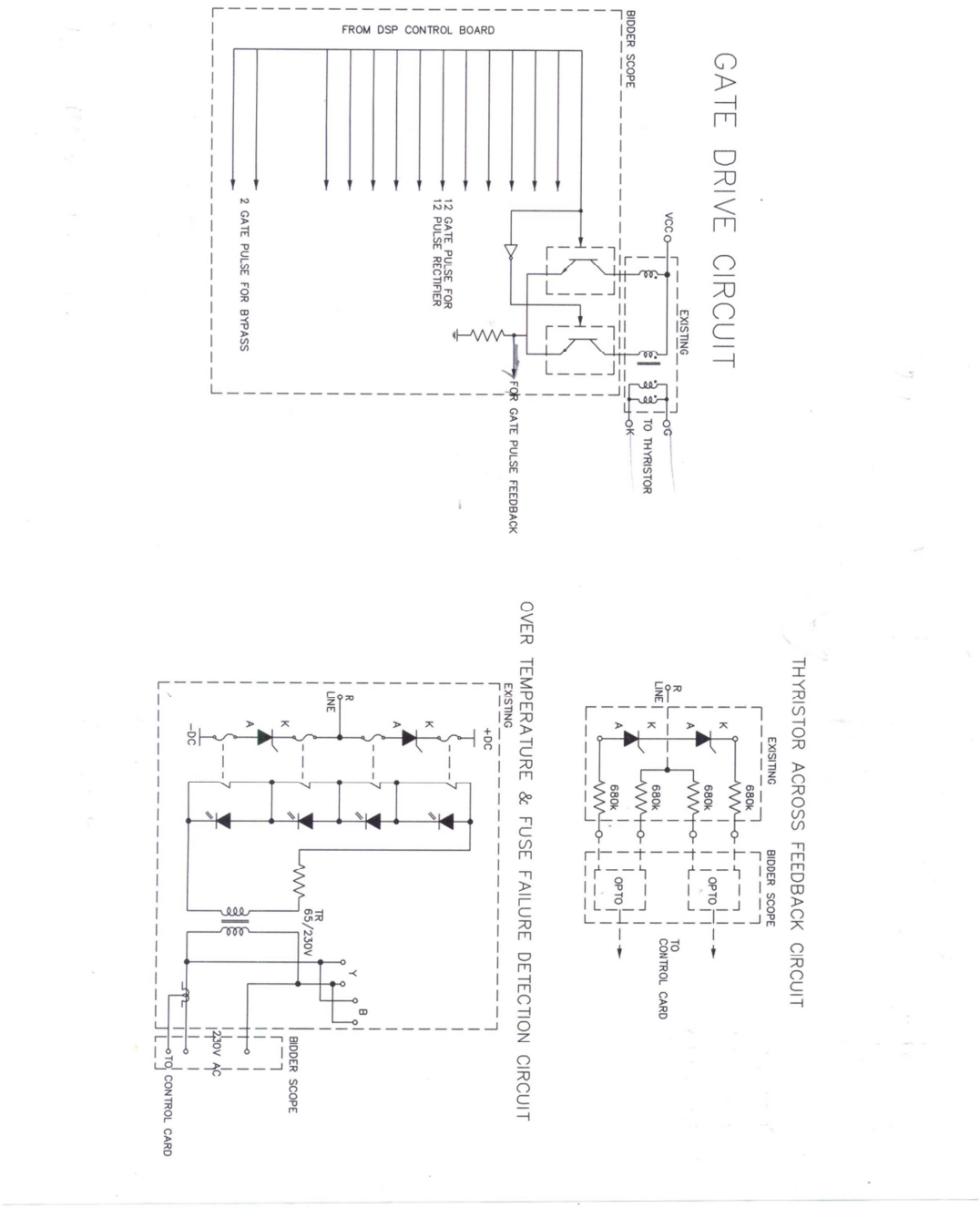


Fig. 5: gating pulses to be amplified as shown and fuse monitoring / measurements of Vak shown down.

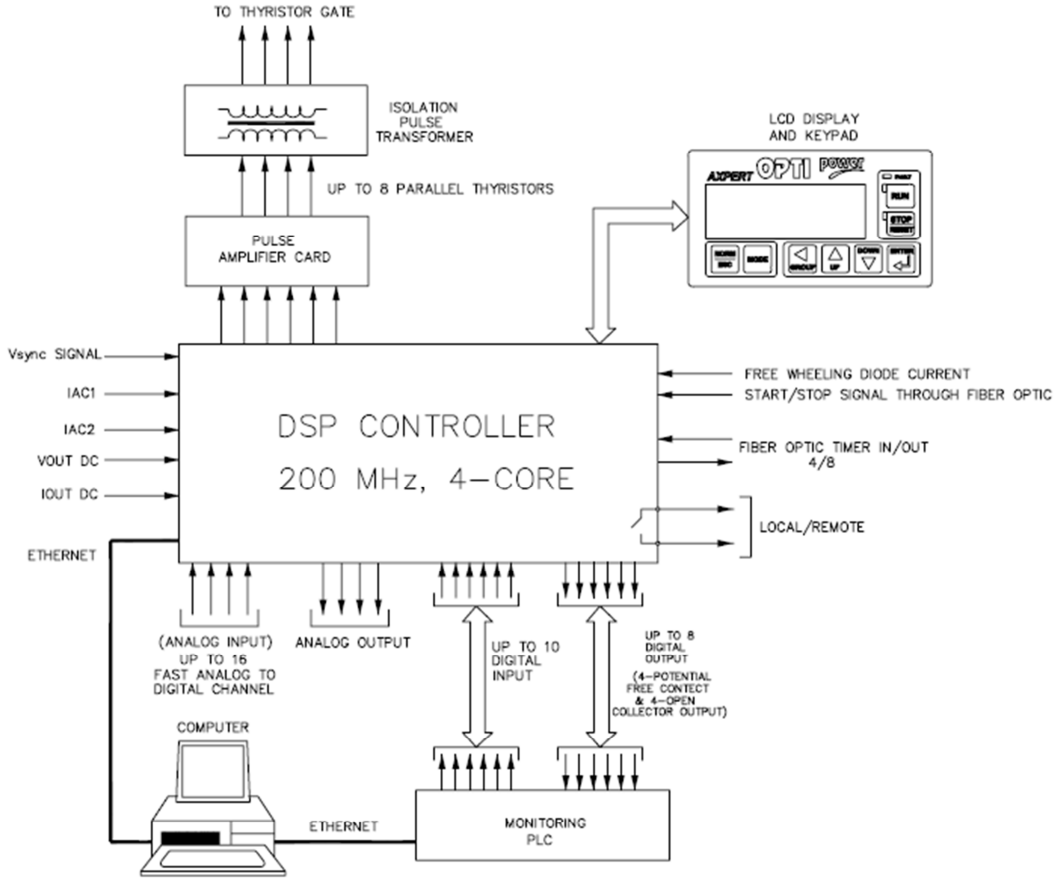


Fig. 6:Typical Control Scheme

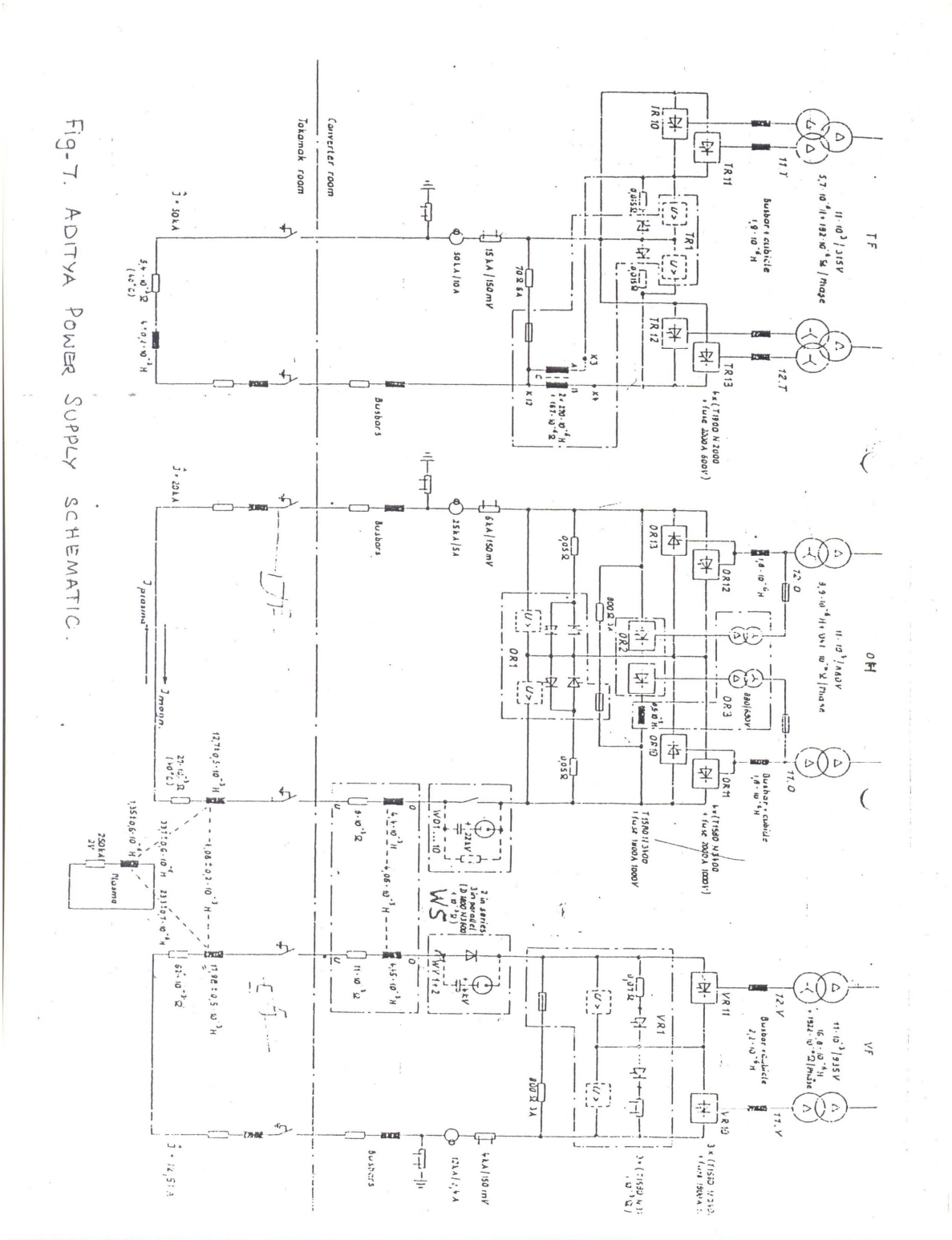
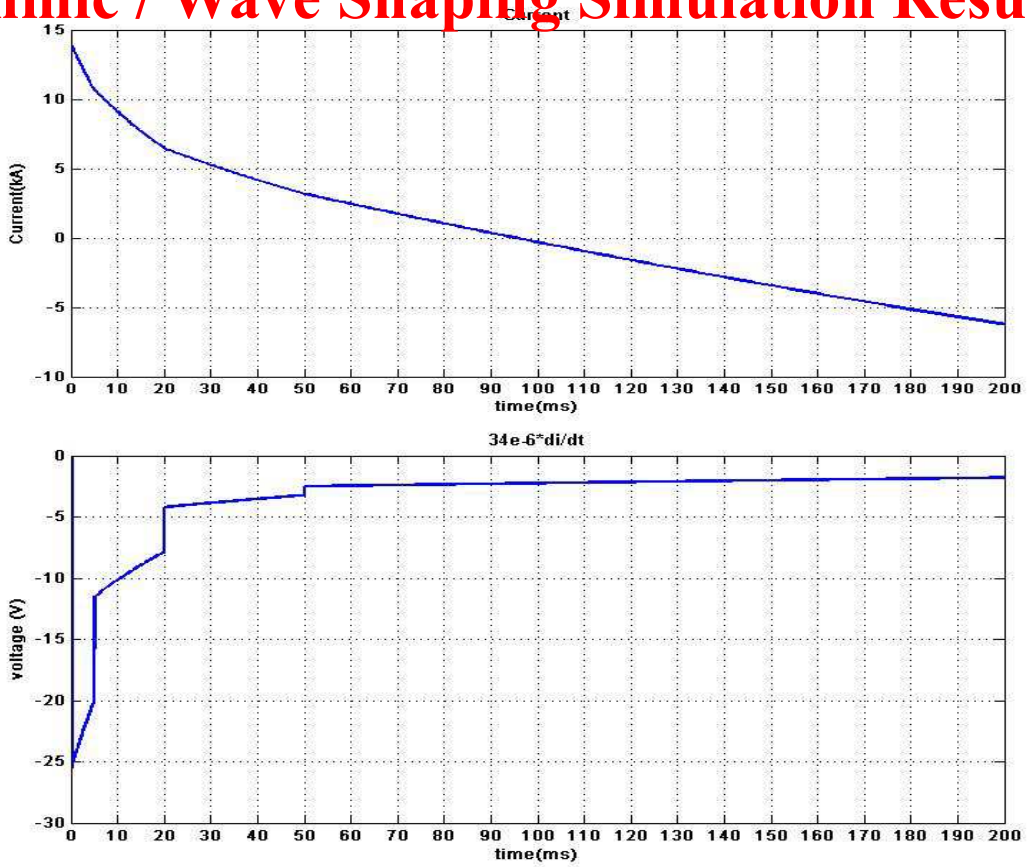


FIG-7. ADITYA POWER SUPPLY SCHEMATIC.

Fig. 7: all three rectifiers are shown here with devices and load

Ohmic / Wave Shaping Simulation Result



Effect of R, R1, R2, R3 switch in wave shaping , Ohmic current commutated to Resistors

Fig. 8:Ohmic current waveforms and wave shaping voltages as resistors were switched. Peak voltage in minus is shown.

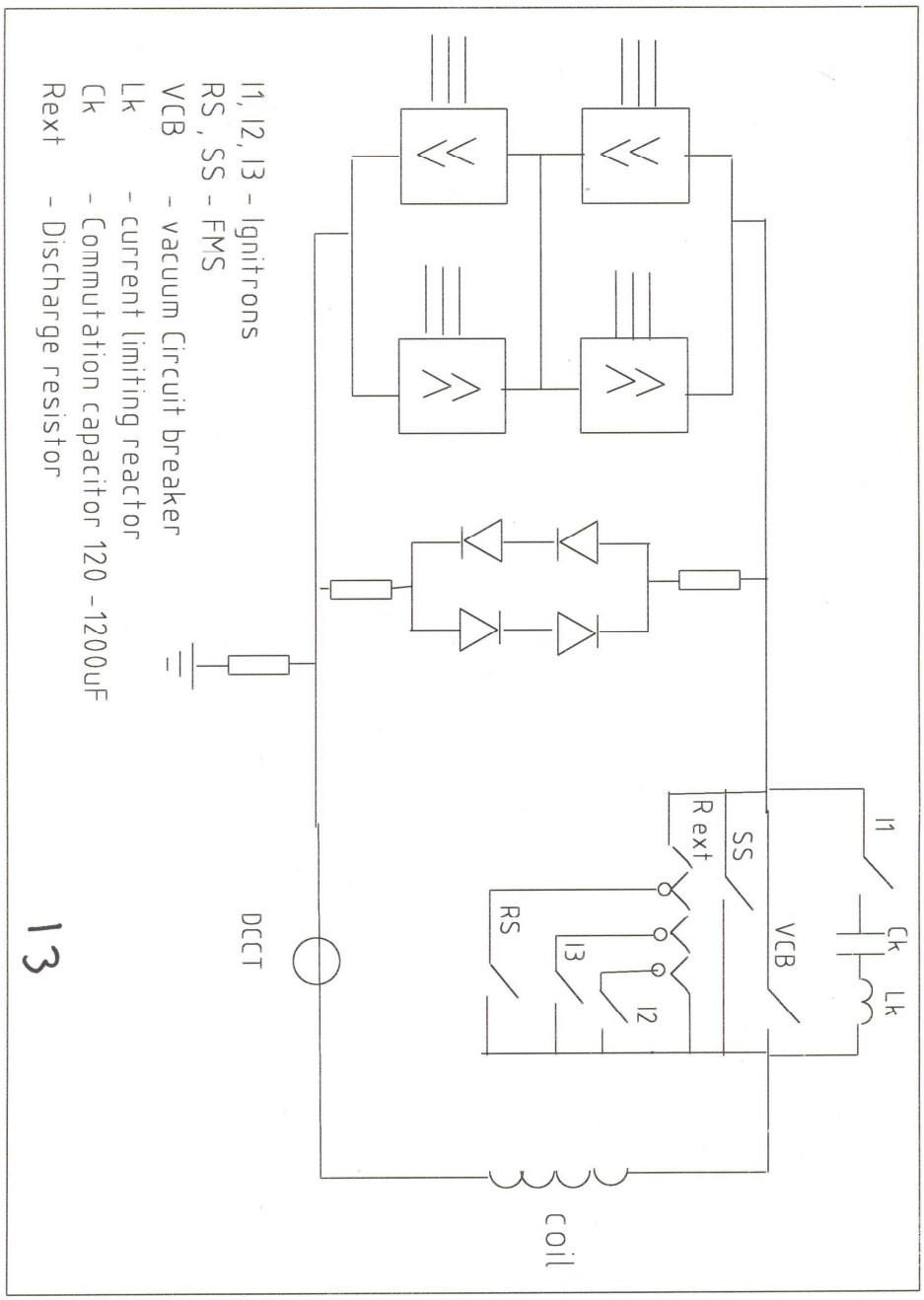


Fig. 9: wave shaping circuit with resistors