外部委託業者の募集

References: IO/25/OT/10030889/JPK

“Design, Manufacturing, Delivery, Site Installation and Acceptance Testing of High Voltage Power Supply (HVPS) for Ion Cyclotron (IC) System."

（イオンサイクロトロンシステム（IC）用高圧電源の設計、製造、搬入、サイト据え付けと受入れ試験）

IO 締め切り 2025 年 3 月 21 日(金)

〇はじめに

本事前情報通知（PIN）は、作業契約の入札授与および実行につながる公開入札調達プロセスの最初のステップです。

本文書の目的は作業範囲と入札プロセスに関する技術的な内容の基本的な要約を提供することです。

国内機関は、次回の入札に先立って、これらのサービス/工事を提供することができる企業、機関またはその他の団体が入札の詳細を事前に通知する前に、この情報を公表するよう求められます。

〇背景

ITER は平和利用の核融合発電の科学的および技術的な実現可能性の実証を目的とした、国際共同研究開発プロジェクトです。ITER 機構の 7 つのメンバーは、;欧州連合（EURATOM が代表）、日本、中華人民共和国、インド、大韓民国、ロシア連邦、および米国です。

ITER の敷地はフランス南東部のブーシュデュローヌ地区にあり、ITER 本社（HQ）もあるフランス CEA サン・ポール・レ・デュランス に近いところに位置しています。詳細については、ITER のウェブサイト http://www.iter.org を参照して下さい。

〇作業範囲

現在の入札プロセスは、イオンサイクロトロン（IC）システム用の高圧電源供給（HVPS）の設計、製造、納品、現地設置、および受入試験に関連するサービスおよび供給契約の確立を目的としています。

高圧電源、試験装置、DCケーブル、予備品の納品が求められ、それらはインコタームズDAP（デリバリー地点：ITERサイト）に基づいてITERサイトへそれぞれ出荷されます。

この契約の範囲には、PICおよび/またはPIAおよび/またはPE/NPEコンポーネントは含まれていません。

本契約の品質クラスはQC2です。

作業は現地外および/または現地で実施されます。

〇調達プロセスと目的

目的は、競争入札プロセスを通じて供給契約を落札することです。
この入札のために選択された調達手続きは<u>**公開入札**</u>手続きと呼ばれます。
オープン入札手順は、次の 4 つの主要なステップで構成されています。

- ステップ 1-事前情報通知（PIN）
  事前情報通知は公開入札プロセスの第一段階です。IO は、関心のある候補企業に対し、以下の概略日程に示された期日までに担当調達担当官に添付の関心表明フォームで以下の情報を提出し、競争プロセスへの関心を示すよう正式に要請します。

  <u>**特に注意:**</u>
  <u>**関心のある候補企業は、IO Ariba の電子調達ツール 「IPROC」 に登録してください（まだ登録していない場合）。手順については、**</u>
  <u>**https://www.iter.org/fr/proc/overview**</u>
  <u>**を参照してください。**</u>

  <u>**Ariba (IPROC) に登録する際には、お取引先様に最低 1 名の担当者の登録をお願いします。この連絡担当者は、提案依頼書の発行通知を受け取り、必要と思われる場合は入札書類を同僚に転送することができます。**</u>

- <u>ステップ 2-入札への招待</u>
  PIN の発行から締切日の後、提案依頼書（RFP）を 「IPROC」 に掲載します。この段階では、担当の調達担当者に関心を示し、かつ IPROC に登録している関心のある候補企業は、RFP が公表された旨の通知を受けることができます。その後、RFP に詳述されている入札説明書に従って提案書を作成し、提出します。

  <u>**このツールに登録されている企業のみが入札に招待されます。**</u>

- <u>ステップ 3-入札評価プロセス</u>
  入札者の提案は、IO の公平な評価委員会によって評価されます。入札者は、技術的範囲に沿って、かつ、RFP に記載された特定の基準に従って作業を実施するために、技術的遵守を証明する詳細を提供しなければなりません。

- <u>ステップ 4-落札</u>
  認定は、公開されている RFP に記載されている、コストに見合った最適な価格または技術的に準拠した最低価格に基づいて行われます。

〇概略日程

概略日程は以下の通りです：

マイルストーン	暫定日程

事前指示書（PIN）の発行	2025 年 2 月 28 日
関心表明フォームの提出	2025 年 3 月 21 日
入札への招待（ITT）の発行	2025 年 4 月 3 日
明確化のための質問（もしあれば）	2025 年 5 月 7 日
入札提出	2025 年 5 月 15 日
入札評価と契約授与	2025 年 5/6 月
契約調印	2025 年 6 月

〇契約期間と実行

ITER機構は2025年6月ごろに授与する予定です。予想される契約期間は21か月の予定です。

〇経験

入札者は付属書 I に詳述された作業範囲に関連する技術的および産業上の経験を実証する必要があります。

ITERでの作業に使われる言語は英語です。プロレベルの流暢さが求められます（話す、書く両方)。

〇候補

参加は、個人またはグループ/コンソーシアムに参加するすべての法人に開放されます。法人とは、法的権利及び義務を有し、ITER 加盟国内に設立された個人、企業又は機構をいいます。ITER 加盟国は欧州連合(EURATOM メンバー)、日本、中華人民共和国、インド共和国、大韓民国、ロシア連邦、アメリカ合衆国です。

法人は、単独で、またはコンソーシアムパートナーとして、同じ契約の複数の申請または入札に参加することはできません。共同事業体は、恒久的な、法的に確立されたグループ又は特定の入札手続のために非公式に構成されたグループとすることができます。

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どのコンソーシアムメンバーも IPROC に登録する必要があります。
【※　詳しくは添付の英語版技術仕様書「**Design, Manufacturing, Delivery, Site Installation and Acceptance Testing of High Voltage Power Supply (HVPS) for Ion Cyclotron (IC) System**」をご参照ください。】
ITER 公式ウェブ　http://www.iter.org/org/team/adm/proc/overview からもアクセスが可能です。

「核融合エネルギー研究開発部門」の HP：　http://www.fusion.qst.go.jp/ITER/index.html
では ITER 機構からの各募集（IO 職員募集、IO 外部委託、IO エキスパート募集）を逐次更新しています。ぜひご確認ください。

イーター国際核融合エネルギー機構からの外部委託
に関心ある企業及び研究機関の募集について

＜ITER 機構から参加極へのレター＞

以下に、外部委託の概要と要求事項が示されています。参加極には、提案された業務に要求される能力を有し、入札すべきと考える企業及び研究機関の連絡先の情報を ITER 機構へ伝えることが求められています。このため、本研究・業務に関心を持たれる企業及び研究機関におかれましては、応募書類の提出要領にしたがって連絡先情報をご提出下さい。

28 February 2025

To: Domestic Agencies (DAs)

IO Tender Reference: IO/25/OT/10030889/JPK

Title: Design, supply, installation, and commissioning of High Voltage Power Supply to support Antenna Test Facility

Subject: Prior Indicative Notice (PIN)

Dear colleagues,

The ITER Organization intends to launch an Open Tender process in the coming weeks as indicated above and in accordance with the details in the attached Prior Indicative Notice (PIN). In this regard, and to provide some introductory information about the forthcoming tender, we kindly request the attached PIN to be published on your DA website with immediate effect for a period of 15 working days.

The advance notification is to alert companies, institutions, or other eligible entities to the forthcoming tender, and provide information to promote healthy competition, allowing interested parties time to decide whether to participate in the tender or not.

Please could you kindly acknowledge receipt of this e-mail and confirm once the PIN is published on your website.

Yours sincerely

JunHyung PARK
Procurement Officer
Procurement Division

Route de Vinon-sur-Verdon - CS 90 046 - 13067 St Paul Lez Durance Cedex - France

PRIOR INDICATIVE NOTICE (PIN)

OPEN TENDER SUMMARY

IO/25/OT/10030889/JPK

For

Design, Manufacturing, Delivery, Site Installation and Acceptance Testing of High Voltage Power Supply (HVPS) for Ion Cyclotron (IC) System.

Annexes
Annex I– Expression of Interest Form
Annex II – Technical Specifications

Abstract

The purpose of this summary is to provide prior notification of the IO's intention to launch a competitive Open Tender process in the coming weeks. This summary provides some basic information about the ITER Organisation, the technical scope for this tender, and details of the tender process for the procurement of the

supplies and services related to the Design, Manufacturing, Delivery, Site Installation and Acceptance Testing of High Voltage Power Supply (HVPS) for Ion Cyclotron (IC) System.

1 Introduction

This Prior Indicative Notice (PIN) is the first step of an Open Tender (OT) Procurement Process leading to the award and execution of a Contract.

The purpose of this document is to provide a basic summary of the technical content in terms of the scope of work, and the tendering process.

2 Background

The ITER project is an international research and development project jointly funded by its seven Members being, the European Union (represented by EURATOM), Japan, the People's Republic of China, India, the Republic of Korea, the Russian Federation and the USA. ITER is being constructed in Europe at St. Paul–Lez-Durance in southern France, which is also the location of the headquarters (HQ) of the ITER Organization (IO).

For a complete description of the ITER Project, covering both organizational and technical aspects of the Project, visit www.iter.org.

3 Scope of Work

The present tender process aims to establish a Service and Supply Contract related to the Design, Manufacturing, Delivery, Site Installation and Acceptance Testing of High Voltage Power Supply (HVPS) for Ion Cyclotron (IC) System.

The delivery of the High voltage Power Supply, Testing Devices, DC cable, and Spares. Those shall be shipped to the ITER site respectively based on the Incoterms DAP ITER site.

The scope under this contract does not cover PIC and/or PIA and/or PE/NPE components.

The Quality class under this contract is QC2.

The work shall be performed off-site and/or on-site.

4 Procurement Process & Objective

The objective is to award a Supply Contract through a competitive bidding process.

The Procurement Procedure selected for this tender is called the **Open Tender** procedure.

The Open Tender procedure is comprised of the following four main steps:

- Step 1- Prior Information Notice (PIN)

  The Prior Information Notice is the first stage of the Open Tender process. The IO formally invites interested Suppliers to indicate their interest in the competitive process by returning to the Procurement officer in charge the attached “Expression of Interest and PIN Acknowledgement” by the date indicated under the procurement timetable.

Special attention:

Interested tenderers are kindly requested to register in the IO Ariba e-procurement tool called "IPROC". You can find all links to proceed along with instruction going to: https://www.iter.org/fr/proc/overview.

When registering in Ariba (IPROC), suppliers are kindly requested to nominate at least one contact person. This contact person will be receiving the notification of publication of the Request for Proposal and will then be able to forward the tender documents to colleagues if deemed necessary.

- Step 2 - Invitation to Tender

After at least 15 working days of the publication of the PIN, normally the Request for Proposals (RFP) will be published on our digital tool "Iproc". This stage allows interested bidders who have indicated their interest to the Procurement Officer in charge AND who have registered in IPROC to receive the notification that the RFP is published. They will then prepare and submit their proposals in accordance with the tender instructions detailed in the RFP.

Only companies registered in this tool will be invited to the tender.

- Step 3 – Tender Evaluation Process

Tenderers proposals will be evaluated by an impartial evaluation committee of the IO. Tenderers must provide details demonstrating their technical compliance to perform the work in line with the technical scope and in accordance with the particular criteria listed in the RFP.

- Step 4 – Contract Award

A Service contract will be awarded on the basis of the Best Value For Money methodology according to the evaluation criteria and methodology described in the RFP.

Procurement Timetable

The tentative timetable is as follows:

Milestone	Date
Publication of the Prior Indicative Notice (PIN)	28 February 2025
Submission of expression of interest form	21 March 2025
Invitation to Tender (ITT) advertisement	3 April 2025
Clarification Questions (if any) and Answers	7 May 2025
Tender Submission	15 May 2025
Tender Evaluation & Contract Award	May/June 2025
Contract Signature	June 2025

5 Quality Assurance Requirements

Prior to the commencement of any work under this Contract, a “Quality Plan” shall be produced by the Supplier and submitted to the IO for approval, describing how they will implement the ITER Procurement Quality Requirements.

6 Contract Duration and Execution

The ITER Organization shall award the Service Contract around June 2025. The estimated contract duration shall be 21 months.

7 Cost Range

This scope of work is identified at Cost Range **A,** which is a range from 300 000 to 2 000 000 EUR.

8 Experience

The tenderer shall demonstrate their technical and industrial experience related to the scope of work as detailed in Annex I.

The working language of ITER is English, and a fluent professional level is required (spoken and written).

9 Candidature

Participation is open to all legal entities participating either individually or in a grouping/consortium. A legal entity is an individual, company, or organization that has legal rights and obligations and is established within an ITER Member State, being, the European Union (represented by EURATOM), Japan, the People’s Republic of China, India, the Republic of Korea, the Russian Federation and the USA.

Legal entities cannot participate individually or as a consortium partner in more than one application or tender of the same contract. A consortium may be a permanent, legally established grouping, or a grouping which has been constituted informally for a specific tender procedure. All members of a consortium (i.e. the leader and all other members) are jointly and severally liable to the ITER Organization.

In order for a consortium to be acceptable, the individual legal entities included therein shall have nominated a consortium leader with authority to bind each member of the consortium, and this leader shall be authorised to incur liabilities and receive instructions for and on behalf of each member of the consortium.

It is expected that the designated consortium leader will explain the composition of the consortium members in its offer. Following this, the Candidate’s composition must not be modified without notifying the ITER Organization of any change. Evidence of any such authorisation to represent and bind each consortium member shall be submitted to the IO in due course in the form of a power of attorney signed by legally authorised signatories of all the consortium members.

Any consortium member shall be registered in IPROC.

10 Sub-contracting Rules

All sub-contractors who will be taken on by the Contractor shall be declared together with the tender submission. Each sub-contractor will be required to complete and sign forms including technical and administrative information which shall be submitted to the IO by the tenderer as part of its tender.
The IO reserves the right to approve any sub-contractor which was not notified in the tender and request a copy of the sub-contracting agreement between the tenderer and its sub-contractor(s).
Sub-contracting is allowed but it is limited to one level and its cumulated volume is limited to 30% of the total Contract value.

EXPRESSION OF INTEREST & PIN ACKNOWLEDGEMENT

To be returned by e-mail to: Junhyung.park@iter.org copy to Andrew.Brown@iter.org

Company Name:___________________________________

TENDER No.	**IO/25/OT/10030899/JPK**
DESIGNATION of SERVICES:	**Design, Manufacturing, Delivery, Site Installation and Acceptance Testing of High Voltage Power Supply (HVPS) for Ion Cyclotron (IC) System**
OFFICER IN CHARGE:	**JunHyung PARK – Procurement Division ITER Organization**

☐ WE ACKNOWLEDGE HAVING READ THE PIN NOTICE FOR THE ABOVE MENTIONED TENDER

☐ WE INTEND TO SUBMIT A TENDER

Are you registered in Iproc (only entities registered in iPROC will be invited to tender)?:

☐ YES

Please indicate your registration number: ………………

☐ NO, but we shall register before the indicated tender launch date

………

Signature:

COMPANY STAMP

Contact person: ....

Position: ....

Tel: ....

E-mail...

Date: ....

IDM UID
B8XKDJ

VERSION CREATED ON / VERSION / STATUS
14 Jan 2025 / 1.2 / Approved

EXTERNAL REFERENCE / VERSION

Technical Specifications (In-Cash Procurement)

Technical Specifications for HVPS to support Antenna Test Facility

HVPS Specifications.

SUPPLY

Table of Contents

SUPPLY

SUPPLY

1 Preamble

This technical specification is to be read in combination with the General Management Specification for Service and Supply (GM3S) – [AD1] that constitutes a full part of the technical requirements.

In case of conflict, the content of the technical specification supersedes the content [AD1].

2 Purpose

The scope of this contract is for the Design, Manufacturing, Delivery, Site Installation and Acceptance Testing of High Voltage Power Supply (HVPS) for Ion Cyclotron (IC) System. In present technical specifications, “HVPS unit” shall be recognized as a functional group supplying DC electrical power to Tetrode based Radio Frequency (RF) Amplifier.

2.1 Background

2.1.1 ITER

ITER is an international experiment with the aim of demonstrating the scientific and technical feasibility of fusion as an energy source. ITER is designed to generate 500MW of fusion power for periods of 300s to 500s with a fusion power multiplication factor, Q, of at least 10 ($Q \geq 10$). The device is also intended to demonstrate non-inductive steady-state operation with a fusion power multiplication factor of 5 and, ultimately, pulse lengths of up to several thousand of seconds.

One of the main requirements for achieving fusion is to heat the plasma particles to very high temperatures. In ITER, several heating methods will work concurrently to bring the plasma in the core of the machine to a temperature of about 150 million °C. Ohmic heating is the basic mechanism exploited to reach such level of temperature. Two families of external heating methods will complement ohmic heating to bring the ITER plasma to such temperatures: neutral beam injection and high-frequency electromagnetic (EM) waves.

The energy carried by high-frequency EM waves introduced into the plasma is transferred to the charged particles, increasing the velocity of their motion and, at the same time, their temperature. The heat transfer is maximized when the frequency of the EM waves matches a resonant frequency of plasma ions or electrons in the interior of the machine. Two frequency ranges will be employed in ITER: Ion Cyclotron (IC) and Electron Cyclotron (EC).

2.1.2 Ion Cyclotron Heating & Current Drive System (IC H&CD)

The Ion Cyclotron Heating & Current Drive (IC H&CD) system have the capability to accommodate long pulse operational modes with up to 3600s of burn with additional heating power of up to 10 MW to the plasma. The IC H&CD System shall provide ITER with the following functions: access to H mode and heating to ignition, central current drive and assistance in controlled plasma shutdown. Plasma control functions, such as sawtooth control and burn control by direct ion heating, current profile control, and auxiliary functions such as plasma breakdown, wall cleaning, conditioning and coating are also within the IC H&CD System capabilities.

The typical RF Power Amplifier layout consists of three amplifier stages: A solid-state amplifier cascaded to a two-tube based tuned amplifier: a pre-driver, followed by a driver stage and an end stage. Since no high-power tube exists as per ITER requirement, it is necessary to implement two parallel chains of amplifiers, with a combiner circuit on the output side to achieve the required performances. In this case the 2 chains (≈1.5MW each) and the combiner form a single unit referred to as 1 RF Amplifier of 2.5MW capability on Voltage Standing Wave Ratio (VSWR) =2 all phases.

SUPPLY

Figure 1 shows a typical scheme of the RF Amplifier (on this scheme, RHVPS represents the HVPS):

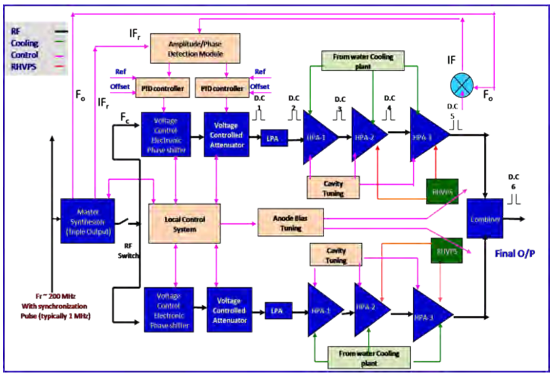

Figure 1: Block Diagram of RF Amplifier System

The antennas for IC H&CD are the subcomponents close to the plasma. One antenna will couple the power generated by the RF Amplifiers the ITER plasmas. The antenna is part of the ITER first confinement system and contribute to nuclear shielding.

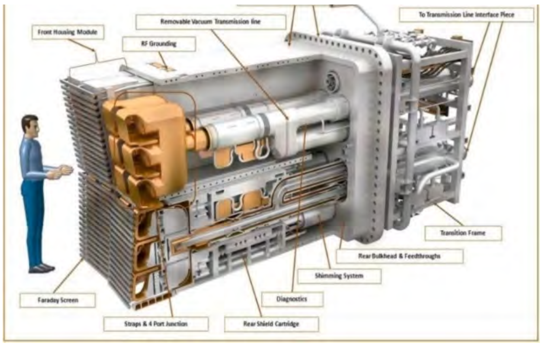

Figure 2 : Antenna to couple IC Power to Plasma

A typical sketch for Antenna is shown in Figure 2. These components will measure 1.8 x 3.5 x 2.5 metres and weigh 45 tons (dry weight).

2.1.3 Antenna Test Facility

As an Antenna for IC H&CD system is unique in its type and application, Quarter Antenna Prototype development is under progress at various facilities. Presently ITER Organization is developing a facility to test it at rated operating conditions. A generic block diagram for test facility is as shown in Figure 3.

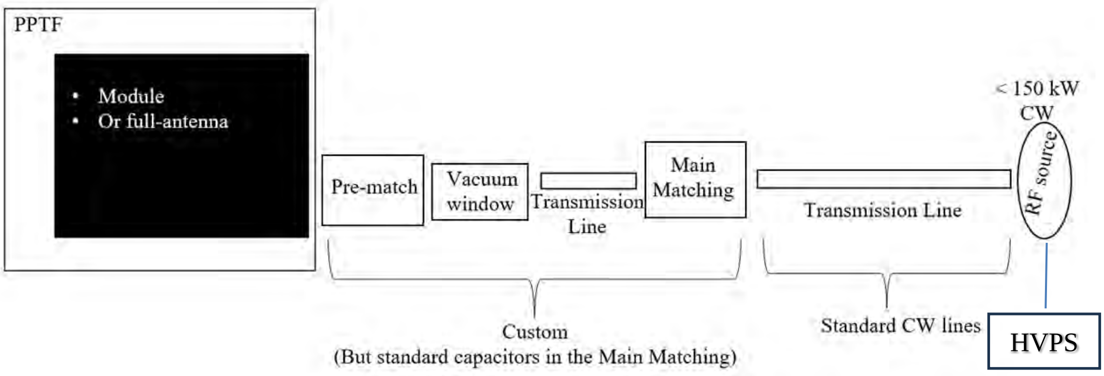

Figure 3 : Block Diagram of Antenna Test Facility

SUPPLY

2.1.4 HVPS for Antenna Test Facility

As indicated in Figure 3 above, HVPS is required to provide DC anode bias voltage to 150kW RF Amplifier System. Present technical specifications are intended to procure same. Detailed specifications and requirements are discussed in subsequent sections.

2.2 Summary of the Contract Scope

2.2.1 Scope of Supply

Following system/components are to be supplied under the scope of present contract.

Table 1:Scope of Supply and Work

Sr. No.	Description	Quantity
1	High Voltage Power Supply consisting of, • 400V, 3L+N Copper Cable from feeding point (~100m) to HVPS including termination at both sides. • 400V input switchgear with earthing switch • Power Converter consisting of converter transformer, rectifier, capacitor bus, semiconductor converter, local control unit, housing/enclosure etc. These are for indication only however according to opted topology, it may vary. • Output side dc disconnector with earthing switch	1 No.
2	Testing Devices a. Dummy Load (10 second over 10 Minutes) b. Short-circuit Switch	1 No.
3	DC Cable	50m
4	Spares (as per list prepared in 5.6)	Option

Supplier is solely responsible for following activities along with the supply of above listed items. IO will help to conduct SAT as well as Training,

1. Engineering activities for the Final Design of the supply
2. Inspections and quality records
3. Documentation
4. Factory testing
5. Packaging and Transportation to the ITER site
6. Assembly, installation at ITER site
7. Final Acceptance Tests on ITER Site
8. Training (Basic operation – 1 Day)

The supply of above-mentioned items shall be executed in following Stages. Each stage lists the responsibility of either IO, supplier/contractor or both.

Table 2:Responsibilities Summary

Sr. No.	Particulars	IO	Supplier
Stage 1	Engineering activities for the Final Design of the HVPS in compliance to present specifications and IO quality norms.	A	R
Stage 2	Documentation as various Stages mentioned in Section 5.10	A	R
Stage 3	Manufacturing		R

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Stage 4	Factory Acceptance Testing	A	R
Stage 5	Packaging and Transportation to the ITER site	A	R
Stage 6	Assembly, installation at ITER site according to ITER Safety Rules and Regulations	A	R
Stage 7	Final Acceptance Tests on ITER Site	R, A	R
Stage 8	Training (Basic operation - 1 Day)	R, A	R
Stage 9	On-site support after acceptance (OPTION)	A	R

R = Responsible for organizing, performing and for the content

A = Review/Comment/Accept/Approve

2.2.2 Contract Execution

The overall procurement cycle is divided into following phases,

Table 3:Contract Schedule

Sr. No.	Execution Phase	Timeline
1	Contract Signature	T0
2	Kick off Meeting	< T0+ 1 Month
3	Final Design Phase	< T0 + 4 Months
4	Final Design Documentation Review and Approval by IO (HP)	< T0 + 5 Months
5	Manufacturing	< T0 + 15 Months
6	Factory Acceptance Test and its approval by IO (WP)	< T0 + 16 Months
7	Packing, Shipment, Installation and commissioning	< T0 + 18 Months
8	Installation and commissioning	< T0 + 20 Months
9	Site Acceptances Test, Handover to IO and Training	< T0 + 21 Months

Note: *IO must to review final design documents in 1 month. Delay in approval will add delay in next step of manufacturing.*

3 Acronyms & Definitions

3.1 Acronyms

The following acronyms are the main one relevant to this document.

Table 4:Acronyms

Abbreviation	Description
CRO	Contract Responsible Officer
GM3S	General Management Specification for Service and Supply
PRO	Procurement Responsible Officer
HVPS	High Voltage Power Supplies
COTS	Commercial Off the shelf
AC	Alternating Current
BOM	Bill of Materials
CAD	Computer-Aided Design
DC	Direct Current

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DL	Dummy Load
EM	Electromagnetic
EMC	Electromagnetic Compatibility
FAT	Factory Acceptance Test
FDP	Final Design Phase
FDR	Final Design Review
FO	Fiber Optics
H&CD	Heating and Current Drive
HMI/GUI	Human Machine Interface / Graphical User Interface
HP	Hold Point
HV	High Voltage
HVAC	Heating, Ventilation and Air Conditioning
HVPS	High Voltage Power Supply
I/O	Input/Output
I&C	Instrumentation and Control
IC	Ion Cyclotron
ID	Identifier
IEC	International Electrotechnical Commission
IGBT	Insulated Gate Bipolar Transistor
IO	ITER Organization
IP	Ingress Protection Rating (IEC60529)
LCU	Local Control Unit
MESH-CBN	Meshed Common Bonding Network
MIP	Manufacturing and Inspection Plans
MRR	Manufacturing Readiness Review
MV – LV	Medium Voltage (6.6-22kV) – Low Voltage
QA	Quality Assurance
QP	Quality Plan
RF	Radio Frequency
SSEN	Steady State Electrical Network
TBD	To Be Defined
SIC	Safety Important Class
SLD	Single Line Diagram
OC	Over Current
OV	Over Voltage
NSC	Non-Seismic Category
HSPC	Health and Safety Project Coordinator
IRR	Integration Readiness Review
CC	Construction Completion
ITP	Inspection and Test Plan (ITP) for works
PPTF	Port Plug Test Facility

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4 Applicable Documents & Codes and standards

4.1 Applicable Documents

This is the responsibility of the Supplier to identify and request for any documents that would not have been transmitted by IO, including the below list of reference documents.

This Technical Specification takes precedence over the referenced documents. In case of conflicting information, this is the responsibility of the Supplier to seek clarification from IO.

Upon notification of any revision of the applicable document transmitted officially to the Supplier, the Supplier shall advise within 4 weeks of any impact on the execution of the contract. Without any response after this period, no impact will be considered.

Table 5: Applicable Documents (AD) and Referred Documents (RD)

Ref	Title	IDM ID	Ver.
AD1	General Management Specification for Service and Supply (GM3S)	82MXQK	1.4
AD2	IO Cabling Rules	335VF9	3.3
AD3	General Management Specification for Executing Entities at the ITER Site	YX55YY	2.3
AD4	ITER Quality Assurance Program	22K4QX	8.5
AD5	Requirements for Producing a Quality Plan	22MFMW	4.0
AD6	Procedure for the management of Deviation Request	2LZJHB	8.1
AD7	Procedure for management of Nonconformities	22F53X	9.1
RD1	Requirements for Producing an Inspection Plan	22MDZD	3.7
RD2	Inspection Plan (IP) Template	QV7GQF	1.3
RD3	Specification for Labelling of Equipment on ITER Project	TL25DK	3.3
RD4	Bill of Material templates	YRPWTW	NA
RD5	IO / In-Cash Contractor Documentation Exchange and Storage Working Instruction	G8UMB3	6.0
RD6	Contractor Safety Management Procedure	Q2GBJF	1.4
RD7	ITER Site Master Plan	27X5FM	3.11
RD8	ITER Seismic Nuclear Safety Approach	2DRVPE	1.6
RD9	B55 Civil Drawings (Password: Test@1234)	Link	
RD10	Draka CLP50 - Coaxial High Voltage Cable datasheet	YKQFBS	1.0

4.2 Applicable Codes and Standards

This is the responsibility of the Supplier to procure the relevant Codes and Standards applicable to that scope of work.

Table 6 : Applicable Codes and Standards

Ref	Title
CS1	IEC60146-1-1: General requirements and line commutated converters - Part 1-1 : specification of basic requirements
CS2	NFC13-200: High voltage electrical installations for electrical energy production sites, industrial, commercial and agricultural site
CS3	NFC15-100: Low-voltage electrical installations
CS4	IEC60060-1: High-voltage test techniques. Part 1: general definitions and test requirements
CS5	IEC61936-2: Power installations exceeding 1 kV AC and 1,5 kV DC. DC

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CS6	IEC61378-1: Converter transformers - Part 1: transformers for industrial applications
CS7	IEC61000-6-2: Electromagnetic compatibility (EMC) - Part 6-2: generic standards - Immunity standard for industrial environments
CS8	IEC61000-6-4: Electromagnetic compatibility (EMC) - Part 6-4: generic standards - Emission standard for industrial environments
CS9	IEC 61439-1: Low-voltage switchgear and controlgear assemblies - Part 1: general rule
CS10	IEC 60947-1: Low-voltage switchgear and controlgear - Part 1: General rules
CS11	IEC62271-200: High-voltage switchgear and controlgear - Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV
CS12	IEC60071-1: Insulation co-ordination - Part 1: definitions, principles and rules
CS13	IEC60071-5: Insulation co-ordination - Part 5: procedures for high-voltage direct current (HVDC) converter stations
CS14	IEC61000-2-4: Electromagnetic compatibility (EMC) - Part 2-4: Environment - Compatibility levels in power distribution systems in industrial locations for low-frequency conducted disturbances
CS15	IEC60529: Degrees of protection provided by enclosures (IP Code)
CS16	IEC62262: Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)

5 Scope of Work

This section defines the specific scope of work, in addition to the contract execution requirement as defined in [AD1].

5.1 Technical Specifications for HVPS

5.1.1 Description

The basic block diagram of HVPS under scope of present contract is depicted in Figure 4. Diagram is for indication only, listing major components. As per selected power architecture, components may be different. Detailed requirements are listed in subsequent section. The utilization of COTS Products is preferred wherever feasible.

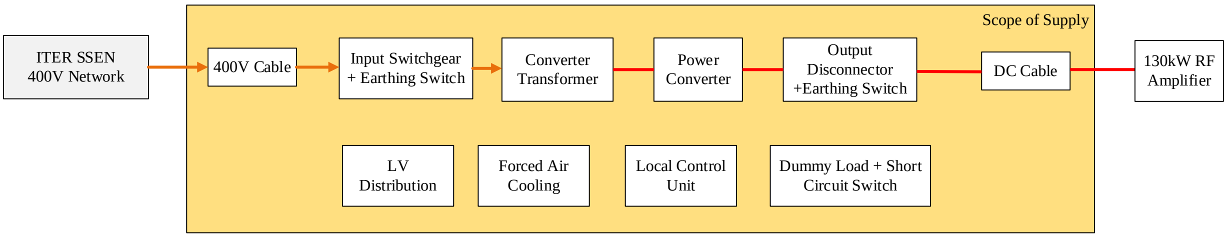

Figure 4: HVPS Block Diagram

The HVPS is treated as indoor equipment within controlled ambience. IO will provide 400V input and required space only so internal LV distribution, forced air Cooling, illumination inside HVPS etc. shall be responsibility of supplier.

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5.1.2 Detailed Specifications

Detailed specifications are as per Table 7 with additional notes for clarifications on same.

Table 7: HVPS Specifications

	Parameter	Value
Input	Voltage	400 V ± 10%
	Distribution System	3L+N+PE
	Earthing	TN-S
	Frequency	50Hz
	VTHD	< 5 % as per IEC 61000-2-4
	PF Requirements	> 0.92 at rated load (True PF)
	ITHD	To be controlled as per IEC61000-3-4
	Short Circuit Current	45kA
	Efficiency	>95 % (3.7.12 of IEC60146-1-1)
Output	Design Voltage	0 - 15kV DC
	Operating Voltage	3 - 14 kV DC [1]
	Maximum Current	20A [2]
	Output Power	250kW
	Rise Time	500μs, 1ms, 2ms, 5ms- Selectable [10]
	Fall Time	500μs, 1ms, 2ms, 5ms- Selectable [10]
	Resolution	100V [3]
	Ripple	+ 1 % of maximum voltage (± 150V) [4]
	Accuracy	+ 1 % of maximum voltage (± 150V) [5]
	Transient Response	<1mS [6]
	Fast Switch-off time	<10μs [7]
	Energy delivered to load in case of fault	<10 Joule [8]
	Time for restart	<200ms [9]

Note* [1] *: *HVPS must be able to achieve performance parameter of mean value in operating voltage range at certain load current. Deviation shall be accepted for parameters of ripple, accuracy for set voltage <3kV at current mentioned in Note [4] – [5].*

Note* [2] *: *HVPS must be able to provide 20A current in operating voltage range (feasible up to 12.5kV). All components shall be selected accordingly.*

Note* [3] *: *HVPS Control System (Local & Remote) should provide feasibility to set voltage in step of 100V i.e. 3.0kV,3.1kV,3.2kV etc . Output must comply set voltage achieving specified accuracy.*

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Note *(4)* ***:*** *HVPS must able to provide output voltage with specified ripple for the load current range of >4A. Estimates for voltage ripple at lower current range shall be submitted at design stage.*

Note *(5)* ***:*** *HVPS must able to provide output voltage with specified accuracy for the load current range of >4A.*

Note *(6)* ***:*** *HVPS must be able to achieve step response behaviour in specified transient response time. i.e. HVPS able to rise to 12kV from previous set voltage of 2kV within 1ms of lower. These may be for any values.*

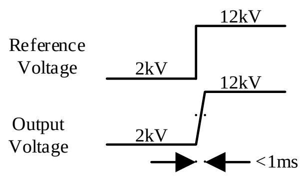

Figure 5 : Definition of Step response

Note *(7)* ***:*** *HVPS must be able to switch-off in less than 10µs in case of any fault defined under load protection. Here switch-off is meant for disconnection from energy source. Defined time of 10µs shall be demonstrated at rated load resistance; fast switch time may appear higher at open terminals/high resistance value as per time constant.*

Note *(8)* ***:*** *Energy delivered to load in case of arc/fault shall be measured by assuming arc as a 100V . Energy is being computed using* $\int \mathbf{100} * \boldsymbol{i}\, \boldsymbol{dt}$ *where current is considered as a "current passed through shorted path "and arc as a 100V.*

Note *(9)* ***:*** *In case of certain load faults , HVPS must be switched off in <10µs followed by restart in <200ms. All semiconductors shall be selected in such a way. Controller also support same by keeping capacitors charged to facilitate replication. In the event of fault within HVPS, HVPS may discharge all capacitor declaring "HVPS Fault".*

Note *(10)* ***:*** *Selectable rise/fall time are meant for 0 % to 100 % of Voltage at rated load. Further information is available in I&C requirements.*

Note *(11)* *: IO will share CANECO Analysis file. HVPS supplier must amend same with additional installed 400V network and perform study with approved French regulator prior to connection on ITER network.*

5.1.3 Operating requirements

HVPS shall be used to feed 130kW, 36-60MHz Radio Frequency Amplifier for anode bias. The amplifier is based on Tetrode vacuum tube and load is mostly treated as resistive. Some of the operating requirements are as per following,

Table 8 : HVPS Operating Requirements

Sr. No.	Requirement
1	The maximum pulse duration of single HV Pulse is up to 3600 seconds. The duty cycle of pulse is 25 % so it's being converged that 1 hour on period followed by 3 hours off time. In case of shorter pulses, next pulse after a duration not exceeding three times the duration of the previous pulse or 1800 s whichever is longer to be followed. There would be 8 hours operation every day.

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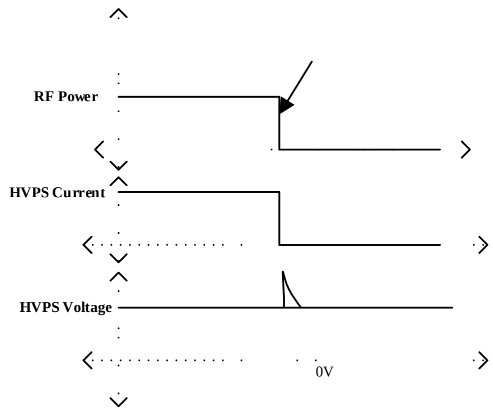
2	RF Amplifier with vacuum tube demands a scenario of HVPS operation with very low current initially. During the energization phase of RF Amplifier, HVPS may operate at rated voltage but current drawn from it might be few milliamperes. For such conditions, parameters of ripple and accuracy may not be achievable but must remain in known safe and controllable regime.
3	For one of the operating modes, only RF Power will be switched off while HVPS remain on. In such case, HVPS current transit to no-load and transition time is in order of 10µs which cause an overshoot. The maximum absolute voltage must not increase above 20kV in such event.  *Figure 6 : Possible operating mode during RF Arc*
4	RF Amplifier may see a mismatched load conditions with VSWR 1.3:1. In such case, load-line for HVPS appear with negative slope. In such condition, HVPS may draw a higher current at lower voltage and lower current at Higher voltage. Maximum Voltage and Current remain same as defined in Table 7.
5	HVPS must support the operating life of 20 Years.

5.1.4 Electrical Requirements

5.1.4.1 Insulation Requirements

As per operation requirements, a connection to ground shall be made at RF Amplifier side so HVPS remain isolated. Both positive and negative terminal must be having isolation from ground. As per IEC60071-1 and IEC60071-5, AC side insulation refer to standard voltage class however DC sides are rounded up for practical values.

- Insulation Level for HVPS: 7.2 kV as per IEC 60071-1:2019, Table 2
- Power Frequency Withstand Test :20kV$_{RMS}$ corresponds to DC Value of 28kV$_{DC}$

Further details about insulation test are discussed in Section 5.9.2 and Appendix. I – Factory Acceptance Test Details.

5.1.4.2 Protection Function

HVPS must be having self-protection function as well as load protection function as per Table 9. The listed faults are indicative only, suppliers are advised to list more as per selected power architecture.

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Table 9: List of Protection Functions

Protection	Fault List	Possible Action
Self-Protection	Loss of input power	HVPS may be transit to disconnection from 400V supply or disable the output voltage. This may be defined according to severity of fault. In the event of self-protection faults, HVPS must convey status to RF Amplifier about “HVPS Internal Fault”.
	Input over voltage	
	Input over current	
	Input under voltage	
	Over temperature (converter / transformer / enclosure etc.)	
	Output over voltage	
	Output over current	
	Overload	
	Earth Fault	
	Controller malfunction	
	Measurement system failure/error	
Load Protection	Instantaneous over voltage measurement	HVPS switches-off in <10µs. There may be restart in <200ms so input disconnection is not recommended.
	Instantaneous over current measurement. This flag represents arcing inside amplifier and HVPS must be fast switched off in such case.	

5.1.4.3 Earthing / Grounding

All buildings in IO adapts a meshed common bonding network (Meshed CBN). HVPS earthing design is to be done in accordance with NF C13-200 and NF C15-100 and NF C18-510. Wherever IEC/NF C13-200 recommends installing a ring conductor around HVPS, it must be done. The supplier shall provide all internal earthing connections with copper conductors having sections adequate to carry the fault current without voltage rises dangerous for the human safety. All the earth conductors shall be easily accessible.

List of required earthing points number shall be conveyed to IO for necessary arrangements during the design phase as a part of Design Report as listed in Section 5.10.3.

5.1.4.4 Electrical Safety

HVPS access control and occupational safety must be designed as per NF C15-100 and NF C13-200 by suitable obstacles, enclosure, fence etc. The HVPS components are to be accessible only under top safety conditions. The connection points (terminals), both ac and dc must be protected from direct access.

It must be equipped with disconnectors and earthing switches connected to input and output terminals as shown in Figure 7. This allows connection/isolation of the HVPS to the RF Amplifier while doing maintenance within HVPS. HVPS dc side disconnector would not contribute to cable discharge. Manual earthing rod shall be provided to discharge cable, in case of cable disconnection.

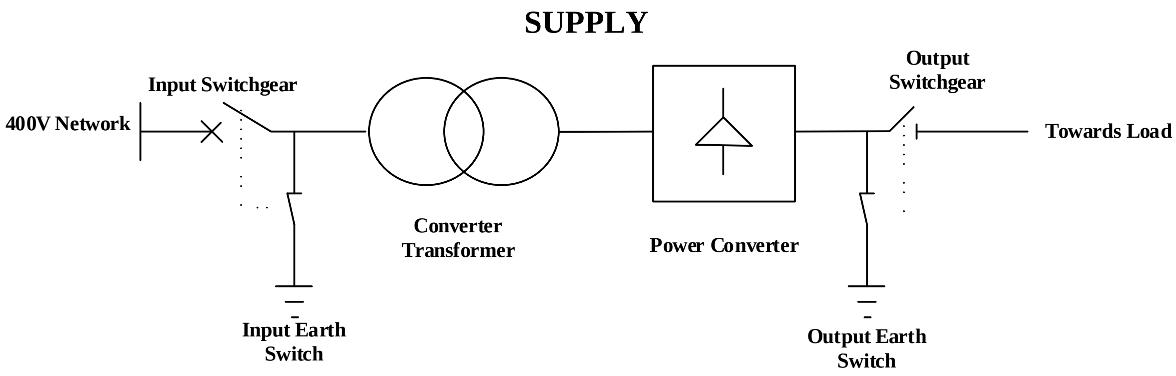

Figure 7: Indication of Electrical Safety by Earth Switches

The opening of the HVPS enclosure doors (or of any other high-voltage area access) shall be allowed only after the earthing switches have been closed (earthed). Similarly, the opening of the earthing switches shall be possible only after the enclosure doors have been closed.

For safe access to the HVPS, which may include DC charged capacitors, NF C13-200 must be applied. A visible indication is required prior to approaching such devices for no electrical potential. Capacitor must be having discharge resistor which discharge it to safe voltage level after disconnecting from supply.

The status of these switches and disconnector, as any other safety device shall be properly monitored from the HVPS local control system. The corresponding signals will be used in the safety control functions of whole plant (not included in this procurement). The operations on the earthing switches and enclosure doors shall be constrained to a mechanical key-interlock system connected with the LV sources upstream and downstream the HVPSs. DC output earthing shall release keys so as to safely open RF Amplifier enclosure. Enclosure will be equipped with red and green lights that indicate the status of the earthing switches and safe access to the related enclosure. All safety function must produce fail safe condition in case of LV power failure. If required, local Uninterruptible Power Supply (UPS) shall be used to monitor safety related signals.

5.1.4.5 Reliability and Maintainability

There is not restriction on selection of power architecture, so supplier is free to select any scheme complying with the requirements. In view of improved system availability and maintainability, modular architecture is preferred availing quick replacement of faulty converter stack without requiring supplier intervention. The design and construction of the equipment shall conform to the best current engineering practice

5.1.4.6 Component Selection

- Appropriate design margins are to be used while selecting components, supporting normal operation as well as operation in case of fault.
- Component selection (viz. Semiconductors, capacitors etc.) must support the desired life of 20 years based on duty given in section 5.1.3. It is recommended to use capacitor with 90ºC class.
- For insulation, oil and other combustible materials are not allowed. Transformer/Reactor insulations are selected accordingly.
- Components containing mercury is not accepted by the IO.
- For the long lead components (viz. Transformer etc.), appropriate protection should be applied to avoid failure (use of arrestors, fuse etc.)

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5.1.4.7 EMC Compatibility

Appropriate design consideration should be applied for EMI/EMC. HVPS must having traceability to certain EMC standards viz. IEC 61000-6-2, IEC61000-6-4 or equivalent. Further details are available in Section 5.7.3 and 5.9.2.

5.1.5 Mechanical Requirements

HVPS shall be installed in indoor environment. Details of indoor ambience is provided in Section 5.3.1.

All live parts must be prohibited for access by suitable enclosure, fence or obstacles. The IEC60529 shall be followed with minimum IP class of IP3X as defined in NF C13-200. For indoor installation, the minimum impact level shall be IK07 according to IEC 62262.Enclosures shall have sufficient mechanical strength, robustness and durability to maintain the specified degree of protection, taking all external influences into account. For design of enclosure, guidelines given in section 6.102 of IEC62271-200 are to be followed. All access doors are to include locks and comply with the safety procedures described in NF C13-200 with appropriate signage. Enclosure is treated as an important step in occupational safety. All intervention must be done in absence of voltage and appropriate steps should be followed prior to approach. Appropriate graphics/signage is to be followed. The mechanical enclosure must be connected to the earth grid of the site. Regarding creepage/clearance, IEC 60071/NF C13-200 Table 32b/equivalent standard shall be followed.

The supplier shall perform the design of the HVPS including the anchorage and supports compatible with seismic requirement. A seismic spectrum is given in 5.1.7. HVPS structure must sustain it i.e. not collapse on nearby object. HVPS shall be designed to restart and operate after this event without special maintenance or test.

5.1.6 Instrumentation & Control Requirements (I&C)

5.1.6.1 Functional Requirements

1. The HVPS should be designed to be an independent sub-system with the complete I&C infrastructure to support stand-alone operation and remote operation within its designated limits. Said HVPS I&C system is referred as a Local Control Unit (LCU) in present document.
2. HVPS I&C system shall be self-sufficient while conducting factory acceptance test, site acceptance test (HVPS tests on dummy load) and HVPS operation on RF amplifier.
3. The main function of the Local Control Unit (LCU) is to control HVPS in real time and generate required DC voltage complying all technical requirement. LCU must provide deterministic power on time response, upon receiving trigger and/or command based on reference voltage and enable from RF Amplifier.
4. LCU must support HVPS self-protection in case of internal fault. It also facilitates load protection which adapt fast switch-off of HVPS (<10µs).
5. HMI/GUI of LCU must provide all facilities to operate HVPS as per requirements.
6. It is recommended that LCU offer data acquisition facility for certain operational parameters viz. Output Voltage, Current, Alarms, Trips etc.
7. LCU must use two level protection system providing redundancy for critical fault of short-circuit /arcing inside RF Amplifier i.e. implementation of current measurement by two same or different types of sensors.
8. LCU must ensure all human safety functions with fail-safe provision.
9. It shall be designed to measure, register and transmit internal parameters. It shall provide detailed information and status updates for remote or local operation. The principle of “no hidden data” is applicable for this system. The data rate, number of signals and

communication protocol to the upper-layer controller shall be designed by the supplier taking into account the nature of the measurement.

10. ITER Organization supports, maintains and enforces the use of well-established industrial standards, commercial off-the-shelf (COTS) and open-source products, while custom-built solutions are strongly discouraged.
11. The HVPS is envisaged to be controlled by a hybrid architecture containing process control devices like Siemens S7 PLCs, FPGA-based fast controllers for protections, fast data acquisition and control and Linux-based controllers interfacing EPICS, the ITER Scada-like control system.
12. The bidder shall promote the use of reliable interfaces and if necessary, point-to-point interfaces based on optical fibre.

5.1.6.2 Operational Requirements

The HVPS shall be operated locally via an embedded HMI or remotely. In local mode, user can set various parameters on HMI and operate it with load bank.

1. It shall implement a local/remote switching mechanism in order not to be controlled both locally and remotely at the same time.
2. In remote mode, HVPS unit is interfaced with the test bed Plant System Controller and follows commands as a slave. HVPS must generate output voltage as per reference received from Plant System Controller. Connection with Plant System Controller is in optical form only for better EMC immunity. LCU must ensure that such interface do not compromise the integrity of protection and control functions.
3. The HMI shall provide facility to check all performance specifications viz. set voltage with resolution requirements, rise/fall time, power on/off, duration, threshold for protection, indication of present state etc. Supplier is free to suggest as per selected topology.
4. In remote mode, the HVPS shall generate the output voltage in a deterministic manner whether as per external signals or by a pre-programmed power profile.
5. LCU shall be able to follow state transition commands (like Safe, Ready, Standby, Power-On, Fault/Trip, etc.). Further details shall be discussed during KOM and design phase.
6. The HVPS shall be designed to ensure personal safety and to prevent access to HV parts prior to grounding.

5.1.6.3 Software Specifications

1. The system shall be able to autonomously maintain safe operation in case of loss of external operation.
2. The central I&C can provide time reference for the HVPS like NTP or IEEE1588 PTP v2 protocol though dedicated networks.
3. Remote control functions shall be available (i.e. reboot, configure, start, stop) through dedicated interfaces to be defined by the supplier.
4. The plant system I&C events shall be reported in the logging and alarms. This information shall also be propagated externally.
5. The local HMI shall include restriction policies for un-authorised personnel.

5.1.6.4 Cubicle

Present section indicates requirements of LCU cubicles/enclosure whether its integrated part of HVPS cubicle or separated.

1. The cubicles must be connected to the earth grid of the site; all their metallic parts shall be linked to the earth point.

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2. 230 V AC mains plug are to be available inside each cabinet and shall be protected by a 30mA differential circuit breaker (as specified in NF C15-100).
3. A holder for documents shall be on the cabinet door, containing the detailed wiring diagram of the cabinet.
4. The wiring channels shall be halogen-free and flame retardant, fitted with a cover and secured by screws.
5. The signals terminal blocks and the command/control boards are to be separated by a protection shield from the hazardous parts.
6. Adequate test points, with easy access, shall be included in the equipment to enable maintenance and troubleshooting to be carried out as quickly as possible.
7. All the cables shall be clearly identified with a label of an approved type and this label shall be clearly visible within the cubicle.
8. The cabinet shall be separately tagged and have the appropriate safety signage displayed.

5.1.6.5 Signal Transmission and Insulation

- For signal exchange between high voltage and low voltage parts, appropriate galvanic/optical isolation is to be selected.
- Cable laying should be done according to good EMC practises.
- Cable trays for signalling must be having sufficient vacant space.
- A fail-safe logic shall be adopted for all the alarm/fault signals both for their elaboration and for their transmission.
- All cables shall be selected, sized and laid according to applicable NF/IEC standards. All cables and optical fibres shall have appropriate mechanical support to minimize strains on the connectors and to respect manufacture requirements on bending radius.
- All cables shall be marked with an appropriate label, which is clearly visible and identifies connection points. Where possible cables between common connection points shall be grouped.
- Analogue signals shall be routed separately (using different cables) from digital signals. Twisted pair cables shall be used to reduce interferences to control, protection and monitoring signals.

5.1.6.6 Signals / Data Acquisition

Current Measurement

- Arc inside the RF Amplifier is being detected by HVPS current. High bandwidth DC current transducers should be used. Hall effect based closed loop sensors are recommended for current measurement.
- As per technical specifications to limit 10J energy dumped to load in case of arc, fault detection must be done in 3-4μs, so appropriate current comparison is to be designed. Current threshold should be adjustable to tune during FAT/SAT only.
- To provide redundancy, backup protection is also required with current coordination between them.
- One passive protection (fuse) is also advised as a backup (to be discussed during design phase)
- LCU must log the current at rate of 10KHz. Same also being transmitted to RF Amplifier LCU. After each operation phase of 1 hour, logged data shall be transferred to storage. Defined 10KHz bandwidth is for data transmission however sensor must be having high bandwidth to detect overshoot and respond in 3-4μs.

Voltage Measurements

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- As RF Amplifiers are sensitive to over voltage (OV), voltage measurement and over voltage protection must be implemented. Threshold setting for OV should be either programmable or hardware settable.
- HV probes or dividers shall be used for voltage measurement. Bandwidth of same shall be determined based on HVPS design however voltage value must be transmitted at rate of 10KHz. After each operation phase of 1 hour, logged data shall be transferred to storage.
- As indicated in Section 5.3.3 that ground/common connection shall be made at RF Amplifier end, HVPS return conductor potential may lift above the ground. Spark gaps are recommended between return and earth.

Othe Measurements

- As per selected technology, certain temperature sensors as well as smoke sensor shall be deployed within HVPS. Data of same remain limited up to HMI only.

5.1.7 Seismic Requirements

The HVPS is classified NSC (Non-Seismic Category) according to "ITER Seismic Nuclear Safety Approach [RD8]".

The supplier shall perform the design of the HVPS including the anchoring and supports compatible with seismic requirement. Analysis report or manual calculation notes should be submitted for selected anchor-fastener. Eurocode - 8 spectra is as per following Table 10 for horizontal direction. Vertical seismic acceleration (spectrum) is not considered for NSC environment.

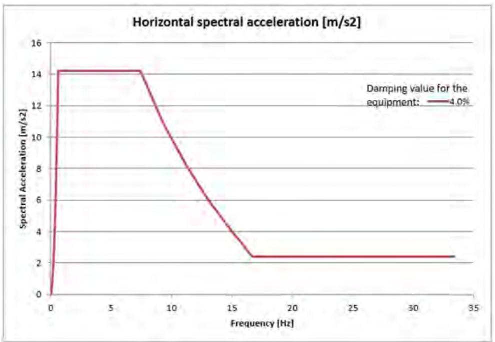

Figure 8 - Horizontal design spectra for HVPS

Table 10:Seismic Spectra

Floor response spectra (horizontal directions)	
Damping value for equipment =	4.0%
Frequency [Hz]	Spectral acceleration [m/s2]
0.000	0.000000
0.058	0.142311
0.117	0.569244
0.175	1.280800
0.234	2.276977
0.292	3.557777
0.350	5.123199
0.409	6.973243
0.467	9.107909
0.526	11.527198
0.584	14.231108
3.994	14.231108
7.404	14.231108
9.263	10.976659
11.122	8.319522
12.982	6.074072
14.841	4.129688
16.700	2.415099
33.400	2.415099

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As per Eurocode -8 requirements, human safety must be ensured considering the seismic events.

5.2 Specification for other equipments/accessories

As discussed in 2.2.1, the specification for Dummy Load is as per following.

Table 11 : Dummy Load Specifications

Sr. No.	Parameter	Value
1	Voltage	15 kV
2	Insulation Voltage	20kV, Test 28kV DC
3	Tapings[1]	Facilitate following HV Test conditions, (1) 15kV, 15A, 225kW (~1000Ω) (2) 12kV, 20A, 240kW (~600Ω) (3) 8kV, ~13A, 106kW (~600Ω) (4) 4kV, ~10A, 40kW (~400Ω)
4	Maximum Power	250kW
5	Duty	10 second over 10 Minutes
6	Type	Resistive
7	Cooling	Natural / Forced Air
8	Others	Mounted on wheels, movable
9	IP Class	Above IP2X
10	Usage	Indoor environment

As discussed in 2.2.1, the specification for short-circuit switch are as per following.

Table 12: Specifications for Short-Circuit switch

Sr. No.	Parameter	Value
1	Voltage	15kV
2	Insulation Voltage	20kV, Test 28kV DC
3	Maximum Current	100 A (for <10μs)
4	Type of Moving Element	Vacuum Relay / Vacuum Contactor
5	Duty	1 Second over 300 seconds
7	Cooling	Natural / Forced Air
8	Suggested Product	Jennings Vacuum Relay / North Star HV Relays
9	Usage	Indoor environment
10	IP Class	Above IP2X

As discussed in 2.2.1, the specification for dc coaxial cable is as per following.

Table 13:Specifications for dc co-axial cable

Sr. No.	Parameter	Value
1	Voltage	$15kV_{DC}$

[1] Optimization according to available components and modularity is acceptable provided most of HVPS Test scenario are covered.

SUPPLY

2	Test Voltage	$20kV_{RMS}$ or $28kV_{DC}$
3	Current	20A
4	Construction	Coaxial or Tri-Axial (Armour to be used as ground)
5	Others	Low Smoke, Zero Halogen, Flame Retardant
6	Length	50m
7	Short Circuit Current	To be selected as per HVPS current cut-off time during fault
8	Conductor	Copper
9	IO Recommendation	As per [RD10]

5.3 Interfaces Requirements

5.3.1 Building Interface

5.3.1.1 Installation Location

HVPS shall be installed inside Building 55. A detailed ITER site map is available at [RD7] while civil work of B55 available at [RD9]. The space allocated for HVPS is on ground level.

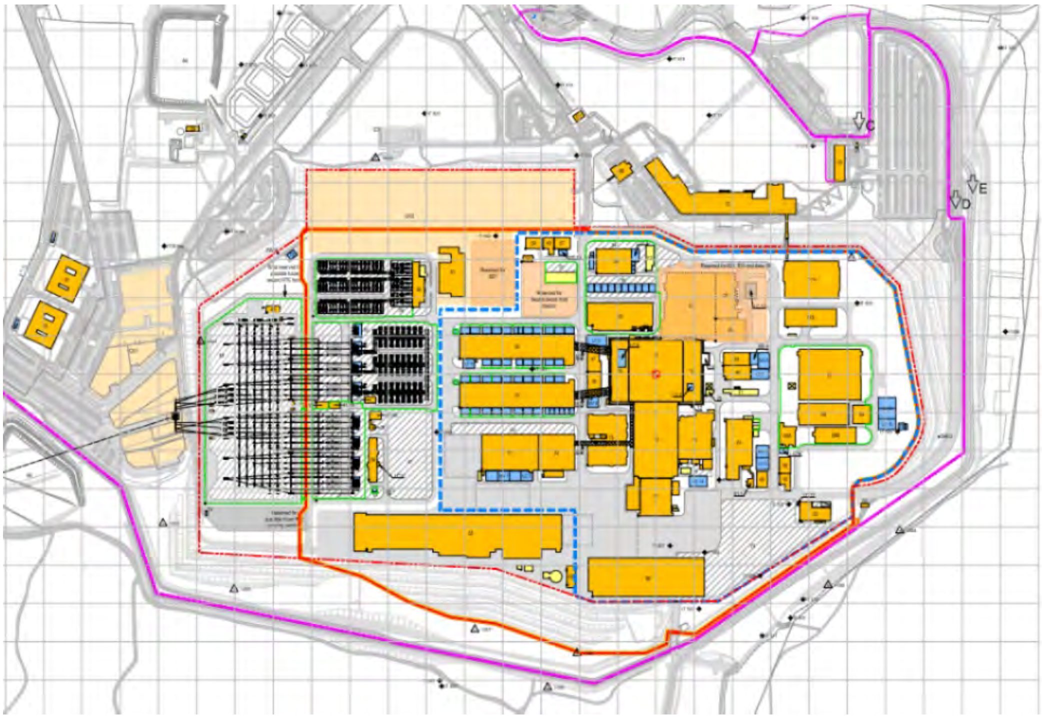

Figure 9 : ITER Site Map

Within Building 55, various facilities will come named as Port Plug Test Facility (PPTF). For Antenna Test, PPTF TS4 shall be used as shown in Figure 10 (left side). Within TS4, proposed space for HVPS is indicated in Figure 10 (right side). In same image, 400V cable path is also indicated. In the current layout assumption by the IO, the HVPS has a footprint of 1 x 4.4m. It’s considered height is ~2.4m. 1m is provided on 3 of the 4 sides for maintenance workstation. The final layout will be provided at the kick off meeting. The area for dummy load is excluded from above footprint. (considered temporary).

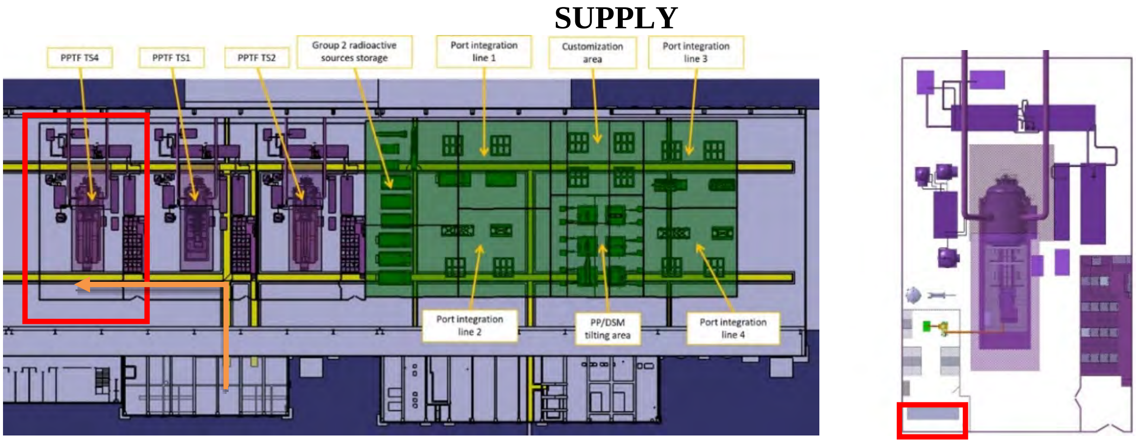

Figure 10 : Layout within Building 55

Supplier may propose different dimensions with sufficient justification and general arrangements drawings describing a different layout. Any such proposal shall be assessed prior to the Kick-Off meeting or be part of a deviation request subject to validation. The input power cable is expected to be routed from below close to the HVPS (trench), while the output power cable shall be routed at the upper right corner. The I&C cables will be routed between the Plant System Controller (PSC) and HVPS for remote mode of operation.

Additional details such as position of the position of earthing connection and power cable routing to the HVPS will be made available to the supplier at the Kick Off meeting. The supplier is responsible for all the assembly and installation actions on site. The supplier shall submit a site installation plan during the design phase.

5.3.1.2 Ambient Conditions

Table 14: Ambient Conditions

Parameters	**Value**
Internal temperature conditions	19°C < T °C ambient < 26°C (EN 15251)
Air Filtration	F6-GF-F9 (IDA-2, ODA-5; standard EN13779)
Pressure conditions	Overpressure held at > 0 Pa
Make up flow rate	≥ 0,9 vol/h o 1,25 vol/h of fresh air. o 1,75 vol/h of recirculated air.
Relative Hygrometry rate maintained in the interval [25% - 85%].	
High degree of cleanliness with slight overpressure inside as per ISO 8;	
Ventilation time slot regulation (IDA C3);	
HVAC Requirement: Supplier must provide estimation for heat load dumped into building HVAC system, for all the mode i.e. 1 Hour on-3 Hour off. As per Table, HVPS efficiency requirement is asked at 96 % so around 4 % of power to be dissipated in air. On above, ac and dc cable losses are additional.	

Note:

The IO is responsible not to degrade the above conditions by:

- Managing of all type of air contamination as fumes, gas or dust coming from its works (vehicle, welding, grinding, cleaning…);
- Limit as much as possible the use of the main motorized doors;
- For any activity creating some atmosphere pollution inside B55, the Supplier shall erect at its expense a temporary airlock around the source generating the contamination. The

air inside the airlock shall be managed properly and shall not be released in the building atmosphere. In addition, the noise exposition of the workers and the surrounded areas shall be carefully managed to be compliant with the French labour code. All the associated preventive measures necessary shall be provided by the supplier at its expense.

5.3.1.3 Working area specifications

The conditions listed below will be provided in B55 to the supplier for their works:

I. Floor characteristics inside B55:
   A. Anti-dust painting applied on the top of the concrete slab composed of 25cm of reinforced concrete (2 layers of HA14 gird, e = 20 cm),
   B. Distributed loadings: 100 kN/m^2 (10 t/m^2),
   C. Flatness of the slab: the slab is flat without slope gradient; and there are several galleries crossing the area with removable covers on all their lengths.

II. Usable volume in B55 for the activities:
   A. Maximum usable height for the working area: 7 m for fix elements, up to 13 m for specific temporary operation (less than half day) upon specific request which shall be assessed in case by case by building owner, HSPC and coordination officer,
   B. Minimum distance to be kept from the North and south façade of B55: 3 m,
   C. No storage outside the allocated area.

A required footprint for HVPS shall be conveyed during the bidding phase. A site install plan shall list the necessary work to be performed on floor viz. anchorage, earthing strip laying etc.

5.3.1.4 Electricity provision

The supplier will be authorised to use the LV electrical network available in B55 for the Works at ITER's expense, under condition that its consumption is considered as normal (no abusive use by the Supplier).
All around B55, fixed on the supports, several existing connection points are potentially available, below a standard electrical cabinet in the building is composed of:
- 4x 16 A 1L+N+PE outlets;
- 2x 32 A 3L+N+PE outlets;
- 2x 63 A 3L+N+PE outlets.

Depending on the location of the Supplier working area and the supplier needs, the Supplier can select the most appropriate connection points.

However, in the case it is not feasible for the IO to provide the expected electrical power supply to the Supplier's working area, the Supplier shall forecast its installation at its own expense. In principle, any additional electrical network installation shall be foreseen in the scope of the Supplier taking into account the existing.

5.3.1.5 Gantry crane of B55

An auxiliary gantry crane is available for works in B55. It is running in translation in the direction East – West. Working load on a single hook is 25 t. The maximum Crane Hook height is 11.4 m.

Upon request and in accordance to the ITER rules and condition of use, the Supplier can use the crane for its activity inside B55. In any case, this crane will be share between several users and slot of use will be booked during the coordination meetings of the building.

For all the external lifting, the supplier shall forecast its own material in accordance to the elements to be lifted and the site constraints.

SUPPLY

5.3.2 Interface with ITER 400V SSEN

The power required for HVPS systems shall be provided from the low voltage AC network with characteristics in Table 15.

Table 15:SSEN Parameters

Parameters	Values
Voltage operating range	400 V ± 10 %
Frequency range	50 Hz ± 1 %
Distribution system	3L+N+PE
Short circuit current at the interface point	< 45 kA
Total Harmonic distortion THDV	≤ 5 %
Earthing system	TN-S

The interface point shall be conveyed by ITER organization however it is recommended to consider 100m cable length. The selection of LV cable, cable trays and laying should be done in compliance with IEC/NF C standards and IO Cabling Rules [AD2].

In case of need of uninterruptible control power, supplier must manage by in housed UPS. There is not any separate connection point for control power so it must be tapped from main 400V network. Further information shall be made available during Kick-off meeting. During the design phase, supplier has to convey precise power requirement and breakdown.

5.3.3 Interface with RF Amplifier

Scope of present contract covers the supply of HVPS with co-axial cable up to RF Amplifier. Cable termination at HVPS side should be done by HVPS supplier while at RF Amplifier side should be done by RF Amplifier supplier. It is to be noted that HVPS must remain isolated and have connection to ground at RF Amplifier side only as shown in Figure 11.

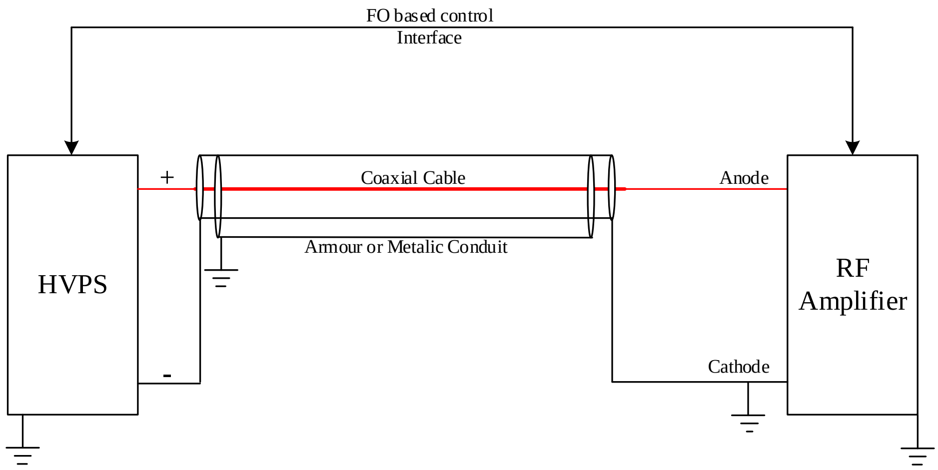

Figure 11: HVPS -RFPS Interface

5.4 Cabling

For SSEN connection to HVPS, supplier is responsible for design, supply and install cable (with cable tray, support etc.) from feeding point onwards, up to HVPS. Tentative layout for 400V cable is indicated in Figure 10 while final layout shall be supplied during design stage however presently it is assumed to be 100m.

As mentioned in the scope of supply, supplier is responsible to supply DC cable as per specification given in Section 5.2. The power connections from the HVPSs to the RF Amplifiers shall be realized, as a rule, by coaxial (or triaxial, better) cables of due section and insulation supporting 14kV DC (test 28kV DC). A suitable termination is to be supplied for HVPS side.

SUPPLY

Termination at RF Amplifier is not covered in present contract however connection to dummy load shall be made during the FAT & SAT.

The supplier shall select cables as per NF/IEC standards. All power, measurement, control and auxiliary cables shall be made of copper. IO Cabling rules [AD2] are applicable for cable and cable tray selection, cable colour code, layout, cable tag and EMC practises. As mentioned in Section 5.7, IO will support to generate cable tags.

All cables shall be compatible to NF C320-70 C1 or the equivalent IEC, having specifications of low smoke, zero halogen, flame retardant and non-toxic. From EMC point of view, power cable and signal cables are routed with some spacing. Cable ends shall be adequately identified with ferrules. Identification using adhesive tape is not permitted. The internal power connections and terminations shall be mechanically strong and thermally adequate.

Supplier is responsible to generate cabling diagram (as indicated in 5.10.3) indicating cable between different system viz. SSEN feeding point, HVPS, RF Amplifier (including I&C).

5.5 Packing, preservation & shipping

The Supplier is responsible for the shipment of the system to the ITER site and management of administrative procedures (customs, export control…). The supplier must follow the requirements defined in section 10 of [AD1].

5.6 Spare Parts

The Supplier shall finalise the spare part list, with the following principle:

- Consumable electronic devices (including high power electronic device): 10 % spare.

The price for spares should be provided separately. IO may order same as an Option.

5.7 Coding and Marking requirements

5.7.1 *Coding*

The Supplier shall liaise with the IO CRO to determine the applicable IO Part Numbers. The IO CRO shall provide to the supplier a list of pre-assigned functional references (FR) to HVPS unit, and load bank unit during design phase.

The Supplier shall manage a material take-off list completed with their serial number / batch number or any relevant contractual identification.

5.7.2 *Labelling*

According to [AD1] Section 9.2, all components supplied by the Supplier shall be physically labelled with the minimum contents of the “Product Label” as specified in below table:

Table 16:Labelling Requirements

Label	By whom	When	Life cycle	Mandatory contents	Additional information may be specified in Tech. Spec., etc.	Note
Product	Supplier	After production	Permanent	1) Title of Product, 2) Manufacture Part Number, MN, 3) PNI,	1) Other Ref. Num., 2) Dimensions, 3) Weight, 4) Supplier,	PNI to be provided by IO.

SUPPLY

				4) SN, 5) Safety Classification, e.g. PIC/SIC, ESPN, 6) Quality Class.	5) Production Date (MM/YYYY), 6) CE marking	
Shipping	Supplier	After packaging	Temp.	1) Title of crate, 2) Purchase Order, PO, Contract Number, PA code, etc., 3) Shipping/Crate Num., 4) Supplier Ref. Num., 5) MN, 6) PNI, 7) SN, 8) Safety Classification, e.g. PIC/SIC, ESPN, 9) From (CON-M) / To, 10) Net / gross weight, 11) Responsibility, 12) Packing Date (MM/YYYY).	1) Dimensions, 2) Other Ref. Num., 3) Quantity in the crate	For PNI as mentioned above. Accompanying signs, e.g. sign of handling precaution during transportation.

5.7.3 *CE Marking*

CE Markings shall be implemented in accordance with European and French legislation. The list of products for which the CE marking may be applicable is available on the following web-site: https://ec.europa.eu/growth/single-market/ce-marking/manufacturers_en.

Comprehensive guidance on the implementation of EU product rules can be found in the so-called Blue Guide: https://ec.europa.eu/docsroom/documents/18027/

5.8 Assembly and Installation Requirement

The Supplier is responsible to assemble and install the components on ITER worksite. Before the installation, an IRR shall be organized to check the readiness of the installation (drawings and procedures) and approve the installation activities. After the installation, a Construction Completion and SAT Readiness Review (CC and SAT RR) shall be organized to approve the installation and allow the SAT activities.

5.8.1 *Installation design*

The supplier shall minimize the installation effort needed on site by design the system in a way that most of the components are pre-assembled (and tested) in the factory.

In the design stage, the supplier shall perform the installation design to identify the installation activities on site, the required workflow and the duration. The installation design must be approved by the IO before going to the manufacturing stage.

5.8.2 *Site installation*

Section 13 of [AD1] applies to the site installation activities in the scope of this contract.

5.9 Inspection & Factory Acceptance Tests Requirements

5.9.1 *General requirements*

- HVPS must undergo Factory Acceptance Test (FAT) and Site Acceptance Test (SAT). The test shall be conducted in accordance with IEC60146-1 or equivalent standard. A dedicated compliance with NF C13-200 is also mandatory assuming an installation. Further details about tests are available in subsequent sections.

SUPPLY

- As advised to use maximum COTs while developing HVPS, test certificates from OEM shall be submitted (for transformers, converter stack, control cubicles, enclosure etc.). If in case, while HVPS belongs to COTs of supplier catalogue, type test report shall be submitted while routine test shall be conducted.
- The supplier will notify IO at least four weeks in advance of all Factory tests. The IO reserves the right to participate in all the type and routine factory tests.
- The supplier shall prepare and submit to the IO the factory test report within 25 calendar days of the successful completion of the type and routine tests. The report shall include all records, certificates, test conditions and performance curves concerning the testing procedures. These test records, certificates and performance curves shall be supplied for all tests, whether or not the tests have been witnessed by the IO.
- The factory tests must be fully completed and accepted by the IO prior to any equipment is packed and dispatched from the site of the factory tests, unless otherwise agreed with IO in advance.
- Site acceptance tests shall be performed on HVPS as a single entity with aim to verifying its performances and the equipment insulation.
- The supplier shall provide all the test equipment, auxiliaries (power grid connections, protections, etc.), monitoring, control, and measurements systems as required to successfully perform the FAT and SAT.
- Any item of equipment or component that fails to comply with the specification requirements in any respect or at any stage of manufacture or testing, shall be rejected by the IO either in whole or in part as the IO considers necessary. The supplier shall provide either a replacement or revised product, at the supplier own charge, to fulfil the failed requirements.
- IO reserves the right to repeat the entire set of tests depending on the scope of the failed component or assembly.

5.9.2 *Acceptance Test*

The HVPS shall be connected to the dummy loads with the same cable type and length (typically 20-50m) that will connect the PS to the RF Amplifiers. Whenever it is not specified, the pulses have a length of 10s and a cycle time of 600s. Pulse timings and duty shall be varied according to best optimum conditions.

All I&C components in the procurement shall be powered and tested during FAT/SAT. The FAT/SAT scenario for I&C will be adjusted depending on configuration of the I&C procurement with the policy to test as much as possible.

The results of FAT shall be recorded and retained in the lifetime records of the ITER plant. Any failures during FAT shall be investigated and the cause and rectification of the failure documented in the FAT report. A complete bug report (problems and fixes) must be provided and maintained during all life-cycle phases

In case of any deviation, supplier must indicate during the bidding process as well as during the design phase. For FAT, following test shall be performed. Supplier has to submit detailed test procedures during the design phase.

Table 17:FAT and SAT Test

Sr. No.	Test	FAT	SAT
1	Visual inspection[6]	√	√
2	Insulation test[4]	√	√

SUPPLY

3	Functional Tests 1. Communication test 2. Simulated field interlock test 3. Earth switch verification and safety test 4. State transition demonstration 5. Voltage accuracy and resolution 6. Measurement of voltage regulation and ripple 7. Rise and fall time 8. Step response test 9. Fast-turn off test 10. Wire-burn test 11. No-load test 12. Full power test 13. Reapplication capability test 14. No-load long pulse test 15. Overshoot verification[7]	√	√
4	Measurement of 400V Harmonics (current)	√	-
5	Temperature Rise Test[3]	√	-
6	Power Factor and Efficiency Measurements[2]	√	-
7	EMC Test[1] 1. Immunity Test as per IEC61000-6-2 2. Emission Test as per IEC61000-6-4	√	-
8	Measurement of Audible Noise	√	-

Note [1] : In case of COTs, type test certificates are accepted for EMC Test. If any deviation, then supplier must propose during the bidding phase as well as during design phase.

Note [2] : In case of unavailability of long duty load bank, calculation is also accepted.

Note [3] : In case of unavailability of long duty load bank, calculation is also accepted.

Note [4] : As same test shall be done as a SAT also, withstand voltage shall be derated at 80%.

Note [6] : Visual inspection also consist enclosure continuity verification and bonding test.

Note [7] : During the design phase , simulation outcome to be submitted as such test need special setup to remove load in <10μs.

5.10 Documentation Requirements

5.10.1 *Documents during Bidding Phase*

Following documents shall be submitted during the bidding phase.

- Compliance to technical specifications
- Non-conformity / deviation, if foreseen
- Preliminary design report on selected topology consisting major components, control scheme etc.
- Contract execution plan
- General Arrangement Drawings
- Catalogue /leaflet/Datasheet of previously developed HVPS above 10kV, above 200kW with having fast-turn off feature (<10μs).

5.10.2 *Documents for Kick-off meeting*

Following documents shall be delivered at the Kick off meeting:

SUPPLY

- Schedule
- Quality Plan
- Manufacturing and Inspection Plan

5.10.3 *Documents during Final Design Phase (including Manufacturing)*

- Schedule (if any change than KoM)
- Quality Plan (if any change than KoM)
- Manufacturing and Inspection Plan (if any change than KoM)
- **Design Report**
- Electrical Single Line Diagram
- Draft Test procedures
- CAD data (2D as well 3D Drawings)
- Draft Installation and Assembly procedure
- Cabling Diagram and Cable List
- Design Change Requests and Non-Conformity / Deviation Reports.
- Bill of Materials
- Manufacturing Drawings
- I&C Dossier (Appendix. II)
- Datasheets

Content of ***Design report*** is as per following,

- Detailed design description of the power section and the selection of rating and type of the major components and data sheets (for standard components). The selection of component must include the normal operation mode as well as fault case. For semiconductors, junction temperature estimates are to be given. In particular, the report shall describe the calculations used to estimate the transient voltages and currents during various modes of operations.
- Layout drawings shall be provided showing the location of the various components inside each enclosure/cabinet. The layout shall comprise all the dimensions and weights and a description of the enclosures.
- Design description of the LCU, with block diagrams showing the main functional blocks, the signal flow, the data of the main components used in the control (Appendix II & Appendix III)
- The supplier shall provide a table of fault conditions listing faults, detection strategies, related protections, related alarms and monitoring. An analysis of the stresses on the components shall be provided for every severe fault and shall include all the related calculations and simulations. The effectiveness of the protective actions shall be demonstrated.
- Detailed description on Occupational Health and Safety system (OHS) to demonstrate the proper conditions are ensured.
- Interface description with interface tables listing interface parameters and consistency with interface boundaries from the specification.
- A list of reference standards used for the design of the system.

5.10.4 *Documents during the Dispatch*

- Factory acceptance test report
- CE compliance certifications
- Legal inspection certificate with CANECO analysis files

SUPPLY

- Calibration factors for each sensor-actuator-conditioner-I/O board and procedures for recalibration of these components
- Specifications for handling and transportation
- Release note
- Bill of Materials (BOM)[RD4]
- Packing List.
- *I&C Dossier (Appendix II & Appendix III)*

5.10.5 *Final Documents*

- Operation and maintenance manuals
- Site acceptance test report
- Final design report
- CAD Data and diagram, in the "as Built" maturity.
- Source Code or Executable File to reinstall (in case of restore required)
- *I&C Dossier (Appendix II & Appendix III)*

6 Location for Scope of Work Execution

The supplier has to design and manufacture HVPS at their premise however installation location is at ITER Site. For executing activities at ITER Site, following document is applicable "General Management Specification for Executing Entities at the ITER Site [AD3]".

7 IO Documents & IO Free issue items

7.1 IO Documents

All the referenced IDM documents in section 4.1will be provided to the supplier upon request.

7.2 Free issue items

Listed in the site available facilities, section 5.3.1.

8 Deliverables and Schedule Milestones

8.1.1 *Schedule for delivery*

Contract delivery schedules is available in Section 2.2.2

8.1.2 List of deliverable documentation

Section 5.10 provides the detailed list of required documents at various stages.

9 Quality Assurance requirements

The Quality class under this contract is QC-2, [AD1] GM3S section 8 applies in line with the defined Quality Class. The Supplier shall have an ISO 9001 certified quality system or alternatively a QA Program approved by QARO.

The supplier shall produce a Quality Plan in accordance with [AD4] and transmit the document at minimum 2 weeks prior to the KOM. If some of the required topics of the Quality plan are covered in the Contract Management Plan, the Supplier to organise cross reference between those plans. The quality plan shall cover all critical quality activities as well as any activity identified with risk to quality, cost or schedule. As such, CRO and QARO reserve the right to request for update of the Quality Plan to cover for any quality issue and/or risk arising at any time of the Contract execution.

SUPPLY

The supplier shall also produce inspection plans to monitor quality control and acceptance tests during the implementation of the Contract: Manufacturing and Inspection Plan (MIP) for manufacturing activities, Inspection and Test Plan (ITP) for works [RD1]-[RD2].

All requirements of this Technical Specification and subsequent changes proposed by the Supplier during the course of execution of this Contract are subject to the Deviation Request and non-conformity processes described in [AD4] and [AD6].

Documentation developed as the result of this Contract shall be retained by the Supplier for a minimum of 5 years and then may be discarded at the direction of the IO.

10 Safety requirements

The scope under this contract does not cover PIC and/or PIA and/or PE/NPE components.

10.1 Nuclear Safety class

N.A.

10.2 Seismic class

The seismic requirements are given in Section 5.1.7.

11 Special Management requirements

Requirement for [AD1] GM3S section 6 applies, amended with the below specific requirements.

Table 18 : Various Section of GM3S and its applicability

<table>
<tr><th>Section of [AD1]</th><th>Subsection</th><th>Coverage</th></tr>
<tr><td rowspan="7">6.1</td><td>6.1.1</td><td>Fully Applicable</td></tr>
<tr><td>6.1.2</td><td>Fully Applicable</td></tr>
<tr><td>6.1.3</td><td>Fully Applicable</td></tr>
<tr><td>6.1.4</td><td>Fully Applicable</td></tr>
<tr><td>6.1.5</td><td>Partial. 2 gate reviews are applicable
• Design Review (FDR and Simplified MRR)
• FAT
• Delivery Readiness Review
• SAT</td></tr>
<tr><td>6.1.6</td><td>Fully Applicable</td></tr>
<tr><td>6.1.7</td><td>NA</td></tr>
<tr><td rowspan="3">6.2</td><td>6.2.1</td><td>Fully Applicable</td></tr>
<tr><td>6.2.2</td><td>Fully Applicable</td></tr>
<tr><td>6.2.3</td><td>Fully Applicable</td></tr>
<tr><td>6.3</td><td colspan="2">Fully Applicable</td></tr>
<tr><td>6.4</td><td colspan="2">Fully Applicable</td></tr>
<tr><td>6.5</td><td colspan="2">Fully Applicable</td></tr>
</table>

Appendix. I – Factory Acceptance Test Details

Sr. No.	Test	Details over the requirements listed in IEC60146-1-1.
1	Visual Inspection	• Verification of assembly as per General Arrangement Drawings. • Check for mechanical damages and aesthetics. • Verification of enclosure as defined in Section 5.1.5. • Electrical continuity verification as defined in IEC62271/IEC60947. • Verifications for cabling as specified in Section 5.1.6.6 and Section 5.4. • Verification of electrical occupational safety in view of access to live parts.
2	Insulation test	• Insulation Resistance Test at $500V_{DC.}$ • Voltage Withstand Test. • Repeat of Insulation Resistance Test.
3	Functional Tests	
3.1	Communication Test	• Verification of communication signals viz. within HVPS as well as higher level controller. • Test shall be conducted on LCU without powering power circuit. • All possible I&C connectivity verification.
3.2	Simulated field interlock test	• Simulation of major faults signal viz. over voltage, over current, over temperature etc. • Test shall be conducted on LCU without powering power circuit.
3.3	Earth Switch Verification and Safety Test	• Interlock verification of earth switch with disconnector. • Simulation related to occupational safety and operation of switchgears. • Test shall be conducted on LCU without powering power circuit.
3.4	Control system local and remote mode demonstration	• Verification of states and associated actions. • Verification of backward state transition • Simulation of fault and its effect on state machine. • Test shall be done at no-load or light load whichever is supporting longer duty
3.5	Voltage Accuracy and Resolution	• Verification of accuracy with requirements in Section 5.1.2. • Test shall be done at all available 4 options with load bank as per Section 5.2. • Measurements also to be repeated at No-Load condition (for verification purpose)

3.6	Measurement of voltage regulation and ripple	• Verification of ripple with requirements in Section 5.1.2. • Test shall be done at all available 4 options with load bank as per Section 5.2 • For regulation, online load variation may not be feasible so possible scheme shall be worked out as per facility available at factory i.e. changing the input voltage to +10% and -10% by autotransformer etc. Test parameters shall be altered as per available facility.
3.7	Rise and Fall time	• Verification shall be done at maximum voltage i.e. 15kV for all selectable rise & fall time. • 15A current tap of load bank shall be used
3.8	Step Response test	• Test shall be done at rated load. • Predefined voltage reference signal shall be given, and response time shall be measure. Further details on test procedures for same will be discussed in design phase.
3.9	Fast-turn off test and Residual Voltage Measurement	• HVPS shall be connected at load bank with 20A current tap. Fast turn off simulated by any external trip and voltage turn-off time shall be measured. • Residual voltage also to be measured by disconnecting load bank (open terminal) and output voltage disabled. The loading to HVPS is caused by measurement probe impedance only. Residual voltage must be vanished at certain current i.e.1mA, if any.
3.10	Wire-burn test	• Test shall be demonstrated while HVPS connected to load bank and delivering rated current. • HVPS output shall be shorted with Short Circuit Switch with 30AWG 6' Inches copper wire series connection. • Wire must remain intact and Energy values must remain below 10J.
3.11	No-Load test	• This test is intended to check HVPS behaviour at no-load and very light load. • HVPS output voltage (mean value as well ripple) shall be measured by applying set voltage of 3kV and 5kV. As there is not any limitation on load bank, online reference voltage value is to be changed, and output is observed. • Same shall be repeated by connecting load bank with 1000Ω tap.
3.12	Full Power test	This test is to verify behaviour at rated load. HVPS shall be operated at best possible condition with available load bank to verify behaviour. Test duration shall be 1second, as supported by load bank.
3.13	Reapplication capability test	In case of external trip command, HVPS must be switched off in <10µs and support reapplication in 200mS. Same shall be verified where external trip command shall be simulated, and reapplication shall be observed. No reapplication is foreseen if HVPS observe a fault viz. load over current, load over voltage etc.

3.14	No-Load long pulse test	Test setup is same as listed in Sr. No. 3.11 however test duration shall be 1 hour.
3.15	Overshoot verification	As per Section 5.1.3, HVPS may see fast removal of load. In case, overshoot value must be remain as specified in 5.1.2. As such test need special setup, may not feasible so must be proved by simulation/analysis during the design phase.
4	Measurement of 400V Harmonics (current)	If possible, current harmonics shall be measured along with Full Power Test (Sr.No.3.12). Limitation is imposed because of 1 second duty of load bank. In other case, simulation verification is also accepted.
5	Temperature Rise Test	As this test is not possible with 1second load bank, temperatures of various parts shall be observed during no-load long pulse test (Sr.No.3.14). For rated load condition, analysis/calculation estimates shall be accepted.
6	Power Factor and Efficiency Measurements[2]	If possible, Power Factor and Efficiency shall be measured along with Full Power Test (Sr.No.3.12). Limitation is imposed because of 1 second duty of load bank. In other case, analytical justification is also accepted.
7	EMC Test 1. Immunity Test as per IEC61000-6-2 2. Emission Test as per IEC61000-6-4	Both of standard list various tests on input port, output port and enclosure. Based on available facility with 3rd party test facilities, it should be performed. LCU of HVPS must undergo all immunity test as per IEC61000-6-2, if in case not possible to apply same on whole HVPS. For emission as per IEC61000-6-4, HVPS unit as whole shall be operated at no-load and emission shall be measured. Such test is possible at factory by various test agencies. In case of HVPS or LCU as a catalogue item, type test certificates and reports shall be submitted.
8	Measurement of Audible Noise	Test shall be done at as per IEC60164-1-1.

Appendix. II: I&C Dossier

- The following deliverables are expected for description of the I&C during the Final design phase:
    - System architecture, detailed functional breakdown and characterization of control functions, and physical architecture
    - Specifications for the controller types and interfaces configuration
    - List of signals connected to the I&C system, including name, type, sampling rate and allocation for internal and external interfaces
    - Hardware configuration of the controllers
    - Cabling documents for systems connection with I/O cabinets, networks, earth and power supplies.
    - Schematic diagrams of the full signal path from the sensors/actuators to the I/O boards of the controllers including powering and conditioning, with identification of test points for fault analysis or calibration and identification of the terminal blocks.
    - Operation manuals, description of state machines with transitions and state variables.
    - Any document required for cubicle mounting, air conditioning, assembly, external and internal wiring, earthing and powering.
    - Inventory of any equipment or component used for cubicle manufacturing (including I&C equipment), with supplier identification and a supplier procurement reference.
    - A proactive management plan for obsolescence describing the strategies for identification and mitigation of the effects of obsolescence throughout all stages of I&C life cycle. This document shall be produced during design phase and maintained through all phases
- The following deliverables are expected for description of the I&C after completion of FAT:
    - The I&C supplier shall provide all necessary hardware and software tools and configuration files for FAT
    - A single report collecting all I&C FAT results related to I&C. The report shall include tracing to all requirements from the approved design which are fulfilled, not fulfilled and not testable
    - Certificates of conformity for I&C procurement to any regulation applicable on ITER site and proof of compliance to ITER I&C standards.
- The following deliverables are expected for description of the I&C prior to the dispatch:
    - As-built cabling & wiring documents for cubicle connection with I/O cabinets, I&C Networks, earth and power supplies.
    - Procedure of installation, configuration, starting up and software and hardware completeness checks for the system.
    - Technical documentation for each piece of equipment or component (including software) used to manufacture the systems in an I&C cubicle.
    - Technical documents, manuals and procedures required for maintenance of any I&C component.
    - Maintenance plan: detailed warranty and/or maintenance periods and their possible extensions, licensing requirements. Trouble shooting procedures and functions.
    - Tools required for maintenance of any I&C component.

- The following deliverables are expected for description of the Final I&C documents:
    - A single report collecting all SAT results related to I&C will be issued. The results of SAT shall be recorded and retained in the lifetime records of the ITER plant. Any failures during SAT shall be investigated and the cause and rectification of the failure documented in the SAT report

Appendix. III: References for I&C Design

Following information is treated for references purpose only. Supplier may choose as per their prior experience and expertise.

Block Diagram

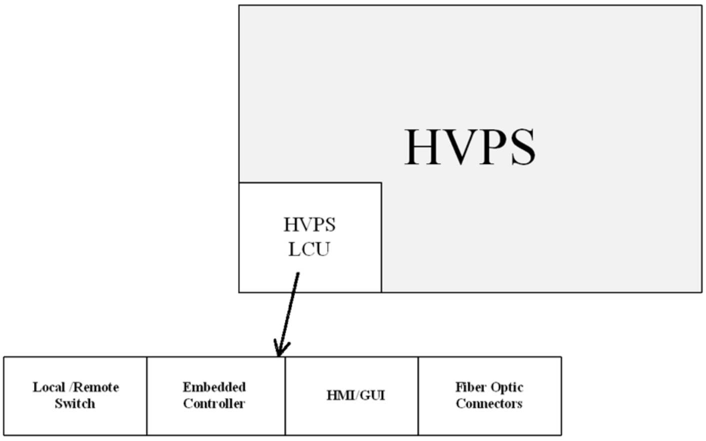

Figure 12: Block Diagram of I&C System

- Embedded Controller is core part of LCU. Supplier is free to choose any technology meeting the performance requirements with enhanced reliability and functionality counting its intended use in vicinity of RF Amplifiers.
- Human Machine Interface (HMI) / Graphical User Interface (GUI) should be designed in such a way that operator can access it during the local operation viz. operation on load bank, troubleshoot etc. It must provide facility to check all performance specifications viz. set voltage with resolution requirements, rise/fall time, power on/off, duration, threshold for protection, indication of present state etc. Supplier is free to suggest as per selected topology.
- Local-Remote change over switch is key part of the system which disable the operating states on HMI once selected in “remote”. In remote mode, HVPS must generate the output voltage as per received external signals. In remote mode, HVPS must follow reference voltage, on-off command, trip command from external fibre optic signals however rise/fall time and other settable parameters remain same as per HMI. Mapping of external signals with state machine and detailed design of LCU shall be submitted during design phase.
- External connection with LCU shall be made in form of fibre optic only. HFBR 1521-2521 type connector shall be used to transmit/receive signals to HMI. External wired connections are to be avoided. List of signals provided in Section 5.1.6.5.

State Machine

To synchronise HVPS operation with RF Amplifiers as well as overall Antenna Test Facility, State Machine is proposed as per following. A proposed states are as per Table 10 however it may be tuned during the design stage.

During the local mode of operation, HMI facilitates following states. During the remote mode, listed signals in Table 10 is to be mapped with states. Further details shall be implemented during the design phase in accordance with opted topology.

Table 19: Operating States

STATE	Description

Safe:	Everything is switched off. All earth switches are connected to ground.
Off / PAS (Parameters Setting):	Only Control Power in on (LCU). User can set parameters in GUI/HMI. A remote mode transition is allowed in this state only.
Ready:	On attempting READY, HVPS shall energise power part and charge DC bus. On achieving same, it will declare READY. In READY State, HVPS can't generate output even if command is received.
Standby:	On transiting STANDBY, HVPS can generate dc voltage on reception of command whether Local or Remote.
Power-On:	Power-On is a status. HVPS remain in POWER-ON state while generating voltage. On termination of voltage enable command, it will transit back to STANDBY.
Fault Category – I	For certain faults, Power-On terminated but HVPS will go to STANDBY State.
Fault Category - II	For some major faults, HVPS transit to PAS state by disconnecting 400V. Only control power remains there.

Interface

Following signals shall be directly interfaced with RF Amplifier LCU (named RFPS in Table Table 20) and are in form of FO. On HVPS LCU appropriate FO connectors to be used viz. Transmitter HFBR1521 and Receiver HFBR 2521(TBD at design phase). Supplier must fabricate some simulator PCB (General Purpose Board) to demonstrate same during FAT.

Table 20:Signal exchange between HVPS-RFPS

Signal Name	From	To	Signal type	Logic
PS Request (command)	RFPS	HVPS	Boolean	Active High
PS Ready (status)	HVPS	RFPS	Boolean	Active High
Reference Voltage	RFPS	HVPS	PWM Pulse (1)	
Enable / Disable (command)	RFPS	HVPS	Boolean	Active High
HVPS On (status)	HVPS	RFPS	Boolean	Active High
HVPS Fault 1(status)	HVPS	RFPS	Boolean	Active Low
HVPS Fault 2	HVPS	RFPS	Boolean	Active Low
HVPS Fault 3	HVPS	RFPS	Boolean	Active Low
Voltage Monitor	HVPS	RFPS	PWM Pulse (1)	
Current Monitor	HVPS	RFPS	PWM Pulse (1)	
External Trip (command)	RFPS	HVPS	Boolean	Active Low