Agenzia nazionale per le nuove tecnologie,
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MINISTERO DELLO SVILUPPO ECONOMICO

Ricerca di Sistema elettrico

Disegni di fabbrica e layout definitivi dei sistemi di alimentazione elettrica delle bobine del Tokamak JT-60SA

P. Zito, A. Lampasi, G. Maffia, F. Starace

Report RdS/PAR2013/205

DISEGNI DI FABBRICA E LAYOUT DEFINITIVI DEI SISTEMI DI ALIMENTAZIONE ELETTRICA DELLE BOBINE DEL TOKAMAK JT-60SA

P. Zito, A. Lampasi, G. Maffia, F. Starace (ENEA)

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Report Ricerca di Sistema Elettrico
Accordo di Programma Ministero dello Sviluppo Economico – ENEA
Piano Annuale di Realizzazione 2013
Area: Produzione di Energia Elettrica e Protezione dell'Ambiente
Progetto: Attività di fisica della Fusione complementari a ITER
Obiettivo: Metodi per verifiche di sostenibilità
Responsabile del Progetto: Aldo Pizzuto, ENEA

Index

Sommario

Nell'ambito del Broader Approach (che è un accordo di cooperazione internazionale tra Unione Europea Euratom e Giappone avente lo scopo di integrare il progetto ITER ed accelerare i tempi per la realizzazione dell'energia da fusione, attraverso attività di R&S relative a tecnologie avanzate per i futuri reattori dimostrativi), l'ENEA deve fornire parte delle alimentazioni elettriche del sistema magnetico di JT-60SA, per un totale di 8 alimentatori ad alta corrente (6 alimentatori per le bobine poloidali CS1, CS2, CS3, CS4, EF1 e EF6, 2 alimentatori per le bobine FPPC Fast Plasma Position Control con relativi interruttori e trasformatori).
L'ENEA ha condotto gli studi e la progettazione per la realizzazione di alimentatori AC/DC e relativi trasformatori, per gli avvolgimenti poloidali e di controllo della macchina JT60SA. Le alimentazioni elettriche degli avvolgimenti devono fornire una corrente continua regolabile in grado di riprodurre gli scenari di corrente desiderati. Gli scenari di corrente di un tokamak prevedono una prima fase caratterizzata da una lenta salita (ramp-up) della corrente prodotta dal convertitore a tiristori, fino a un massimo valore prestabilito (20 kA nel caso dei CS). Le specifiche tecniche elaborate definiscono i parametri funzionali del sistema, la modalità di funzionamento e i limiti di esercizio.
Il contratto per la fornitura di otto Alimentatori e sei Trasformatori per JT- 60SA PFC PS (CS1 , CS2 , CS3 , CS4 , EF1 e EF6 PS e le due FPPC PS) è stato assegnato da ENEA al fornitore industriale POSEICO - JEMA in Joint Venture il 01/agosto/2013.
Il contratto di appalto è basato su specifiche tecniche e di gestione della qualità sviluppate da ENEA con la stretta collaborazione di F4E e JAEA. Le caratteristiche del sistema e i documenti di specifica tecnica e di gestione della qualità sono stati accuratamente analizzati e discussi, durante i design meeting organizzati.

Il documento descrive le attività svolte correlate alla fase del contratto 2A "lo sviluppo dei disegni di fabbrica e layout, disegni meccanici e funzionali schemi elettrici di potenza, protezione, misure comando e controllo dei sistemi di alimentazione" delle bobine del Tokamak JT-60SA. A tal uopo, si riporta una breve relazione dei componenti utilizzati, i disegni di fabbrica e i layout definitivi. Inoltre, poiché tutta la documentazione fornita è in lingua inglese, i prossimi paragrafi sono riportati in inglese.

1 Introduction

The Design Report and layout and drawing are a detailed description of the activity done during the phase 2A of POSEICO/JEMA procurement to provide 8 new Power Supplies (EF1, EF6, CS1, CS2, CS3, CS4, FPPC1, FPPC2) for part of the JT-60SA Poloidal Field and Plasma Position Control Coils power supplies. Power supplies will provide a bipolar DC current, adequate to achieve the required scenarios on the superconducting coils.

2 Description of activities

2.1 Power assembies

In order to obtain the maximum modularity for all the different Power Supplies all the PS configurations have been designed using only 4 types of different power assemblies. Only 2 types of thyristors, having the same outline, one type of gate drive board and one type of water cooled heatsink will be used. The types of different fuses are reduced to the minimum.
In Table 1 are summarized the main characteristics of the different Power Assemblies.

Power assembly type	Type	Thyristor type	Thyristor blocking voltage VDRM/VRRM	Thyristor diameter	Power Assembly Dimensions (W x L x H) (mm)	PSs
Type A	Bidirectional (4 thyristors)	AT940P29	2900 V	100 mm	600 x 292 x 585	CS1 – CS4 EF1 –EF6
Type B	Bidirectional (4 thyristors)	AT970P34	3400 V	100 mm	600 x 292 x 585	CS2 – CS3
Type C	Unidirectional (2 thyristors)	AT940P29	2900 V	100 mm	600 x 292 x 458	EF1 - EF6 FFPPC1 – FPPC2
Type D	Unidirectional (2 thyristors)	AT940P29	2900 V	100 mm	600 x 292 x 458	FPPC1 – FPPC2

Table 1 - Main characteristics of the FPPC Power assemblies (the other assembly types are reported for the purpose to show the modularity used in all configurations).

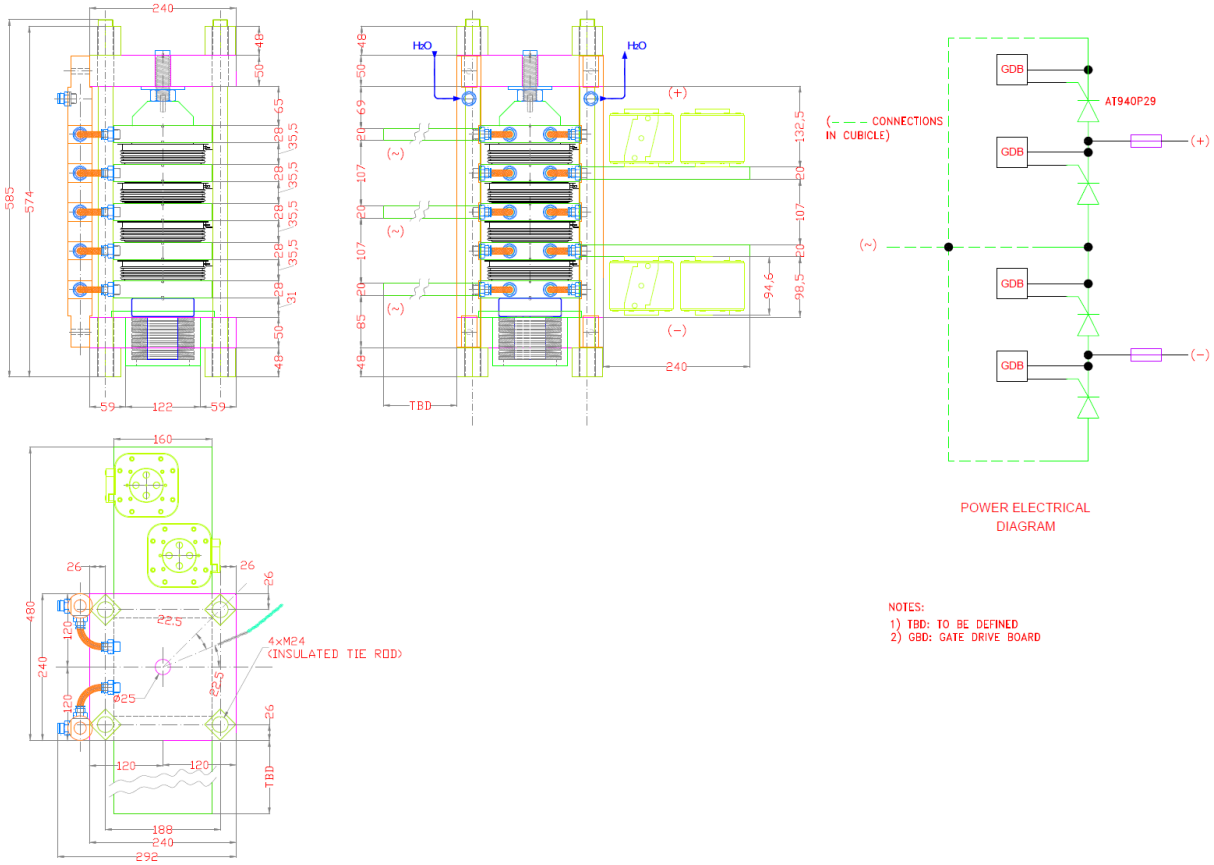

Figure 1 – Power Assembly Type A

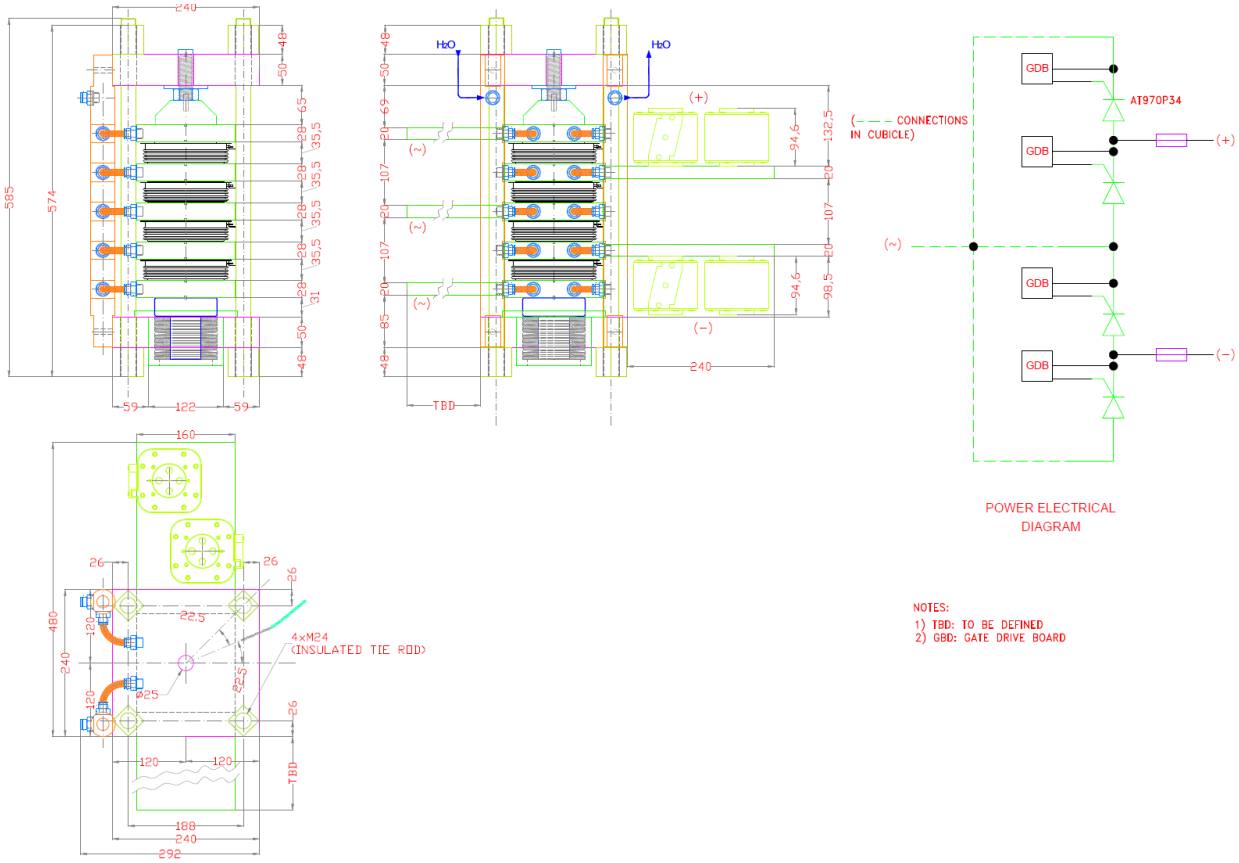

Figure 2 - Power Assembly Type B

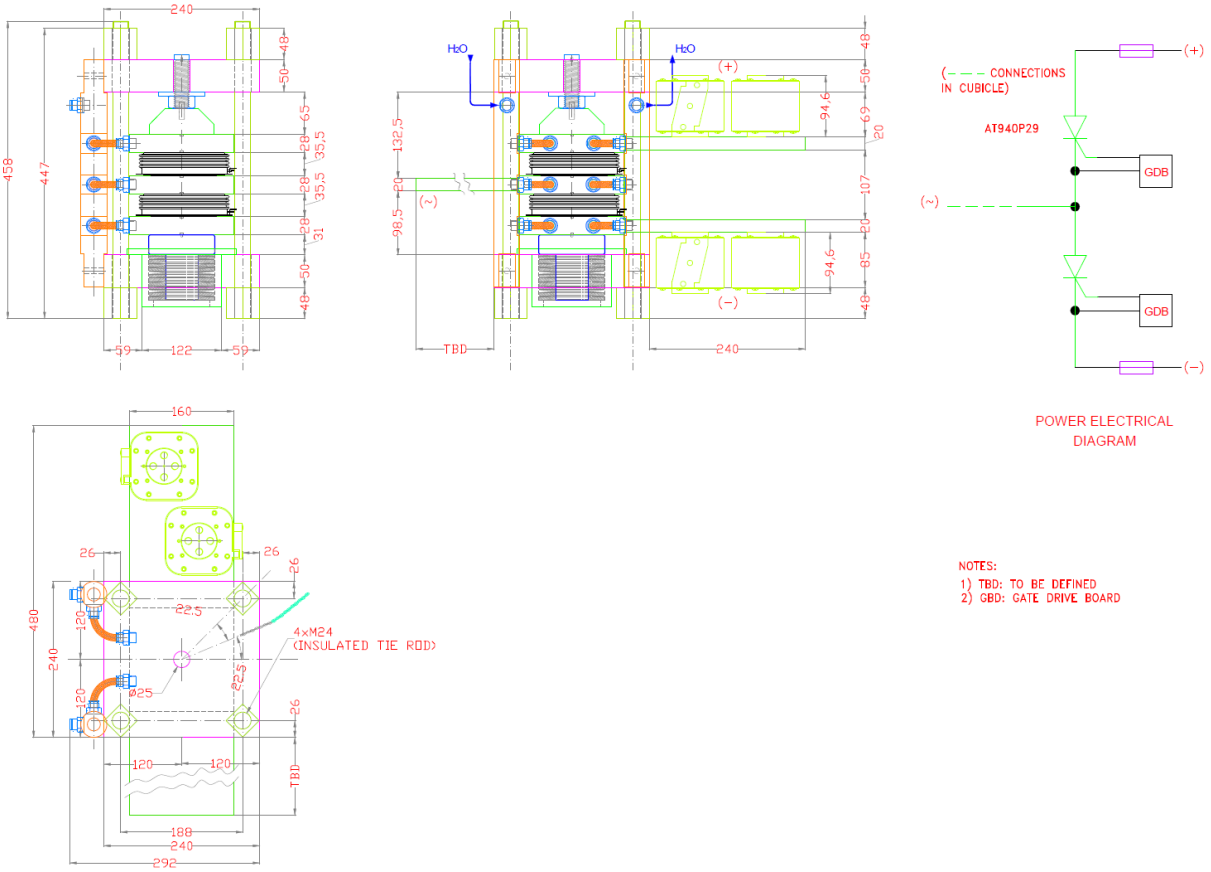

Figure 3 – Power Assembly Type C

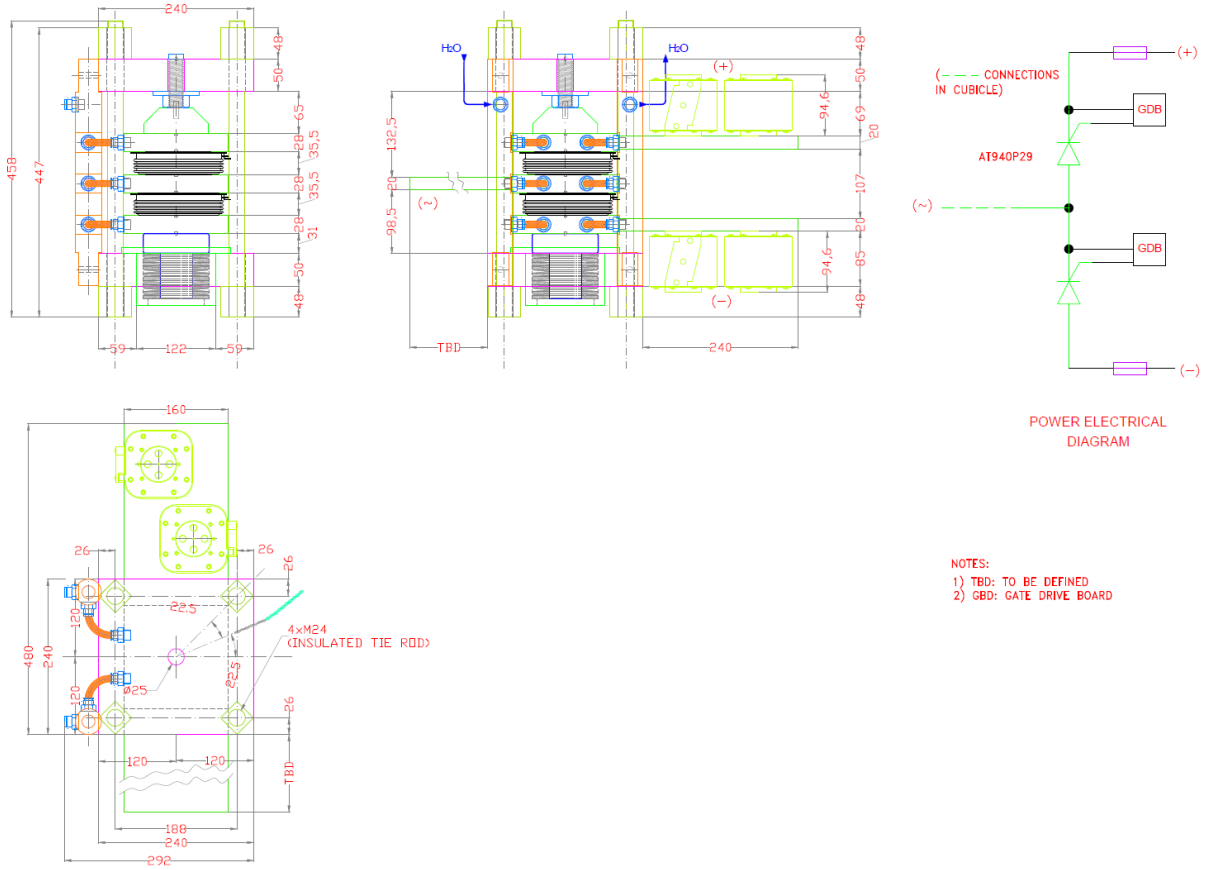

Figure 4 – Power Assembly Type D

All the Power Supplies object of the contract are designed using only 2 types of 100 mm thyristors, with different blocking voltage, in order to obtain the maximum of modularity and to reduce cost of the spare parts and maintenance management.
In the following table (Table 2) are reported the types of thyristor used in FPPC PSs and in the other Power Supplies.
The FPPC configuration has been confirmed as series connection configuration with 1 Thyristor for leg and direction. The series configuration ensure a fast voltage response of the FPPC PSs.

Power Supply	Thyristor code	VDRM, VRRM (V)	ITSM (KA)	Total Quantity (for 1 PS)	Data sheet Code /Issue
CS1	AT940P29	2900 V	75	72	AT940 issue 05A
CS2	AT970P34	3400 V	68	72	AT970 issue 00
CS3	AT970P34	3400 V	68	72	AT970 issue 00
CS4	AT940P29	2900 V	75	72	AT940 issue 05A
EF1	AT940P29	2900 V	75	54	AT940 issue 05A
EF6	AT940P29	2900 V	75	54	AT940 issue 05A
FPPC1 upper	AT940P29	2900 V	75	24	AT940 issue 05A
FPPC2 lower	AT940P29	2900 V	75	24	AT940 issue 05A

Table 2 - Type of POSEICO Thyristor used for FPPC SCR Rectifier Units (the other thyristor type is reported for the purpose to show the modularity used in all configurations)

- All the thyristors are designed and manufactured by POSEICO
- The symbol “S” or “P” in the Thyristor code means:
    - S= single operation mode
    - P = parallel operation mode.

Figure 5 and 6 show FPPC PS1 and 2 single line drawings.

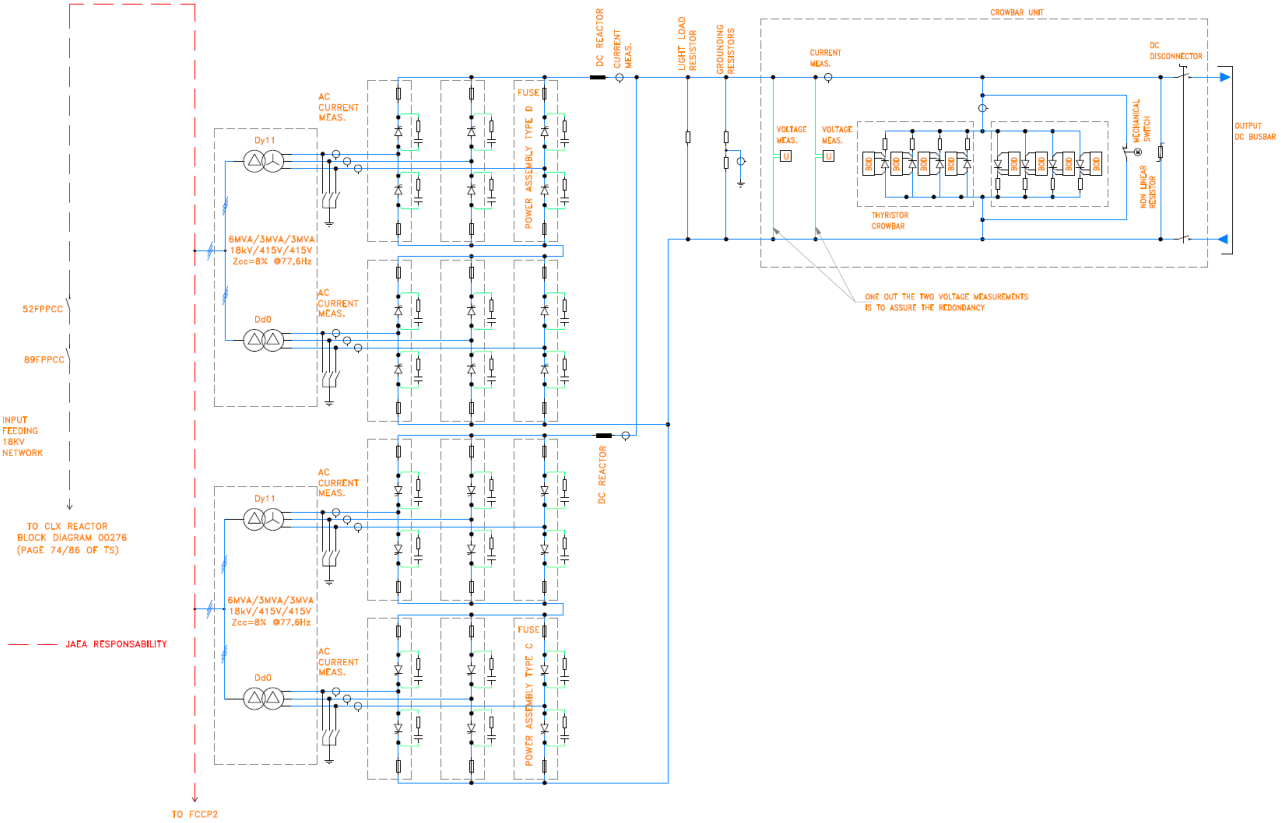

Figure 5 – FPPC Power Supply Single line Drawings

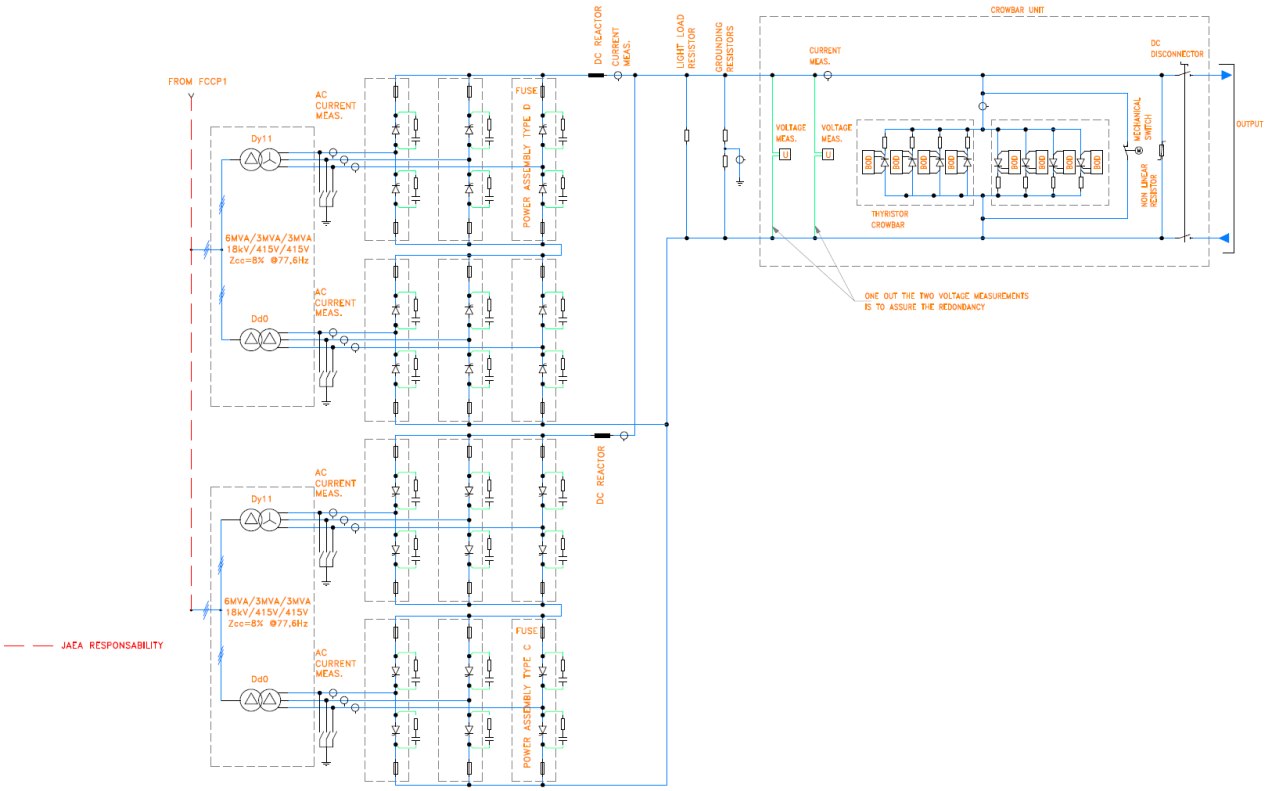

Figure 6 - FPPC Power Supply Single line Drawings

2.2 Crow Bar Thyristors

In the following Table 3 are reported the type of thyristors used in the Crow Bar.

Power Supply	Crow Bar Thyristor code	VDRM, VRRM (V)	ITSM (KA)	Quantity of parallel devices for 1 Crow Bar	Data sheet Code /Issue
CS1	AT940P29	2900V	75	2 x 4	AT940 issue 05A
CS2	AT940P29	2900V	75	2 x 4	AT940 issue 05A
CS3	AT940P29	2900V	75	2 x 4	AT940 issue 05A
CS4	AT940P29	2900V	75	2 x 4	AT940 issue 05A
EF1	AT940P29	2900V	75	2 x 4	AT940 issue 05A
EF6	AT940P29	2900V	75	2 x 4	AT940 issue 05A
FPPC1 upper	**AT940P29**	**2900V**	**75**	**2 x 4**	**AT940 issue 05A**
FPPC2 lower	**AT940P29**	**2900V**	**75**	**2 x 4**	**AT940 issue 05A**

Table 3 - POSEICO Thyristors used in the Crow Bar.

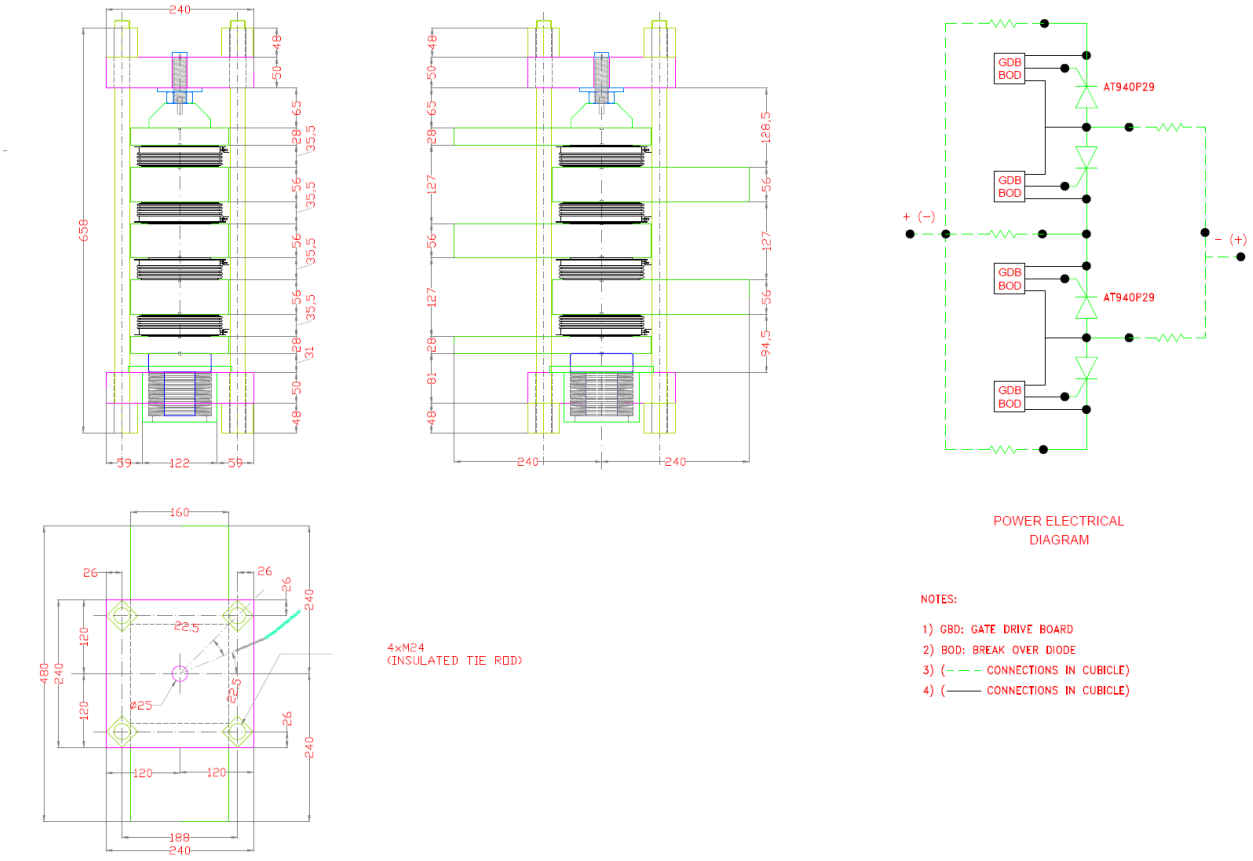

Figure 7 – Crowbar Power Assembly

Next figures show the plant layout CS PSs and FPPC PSs.

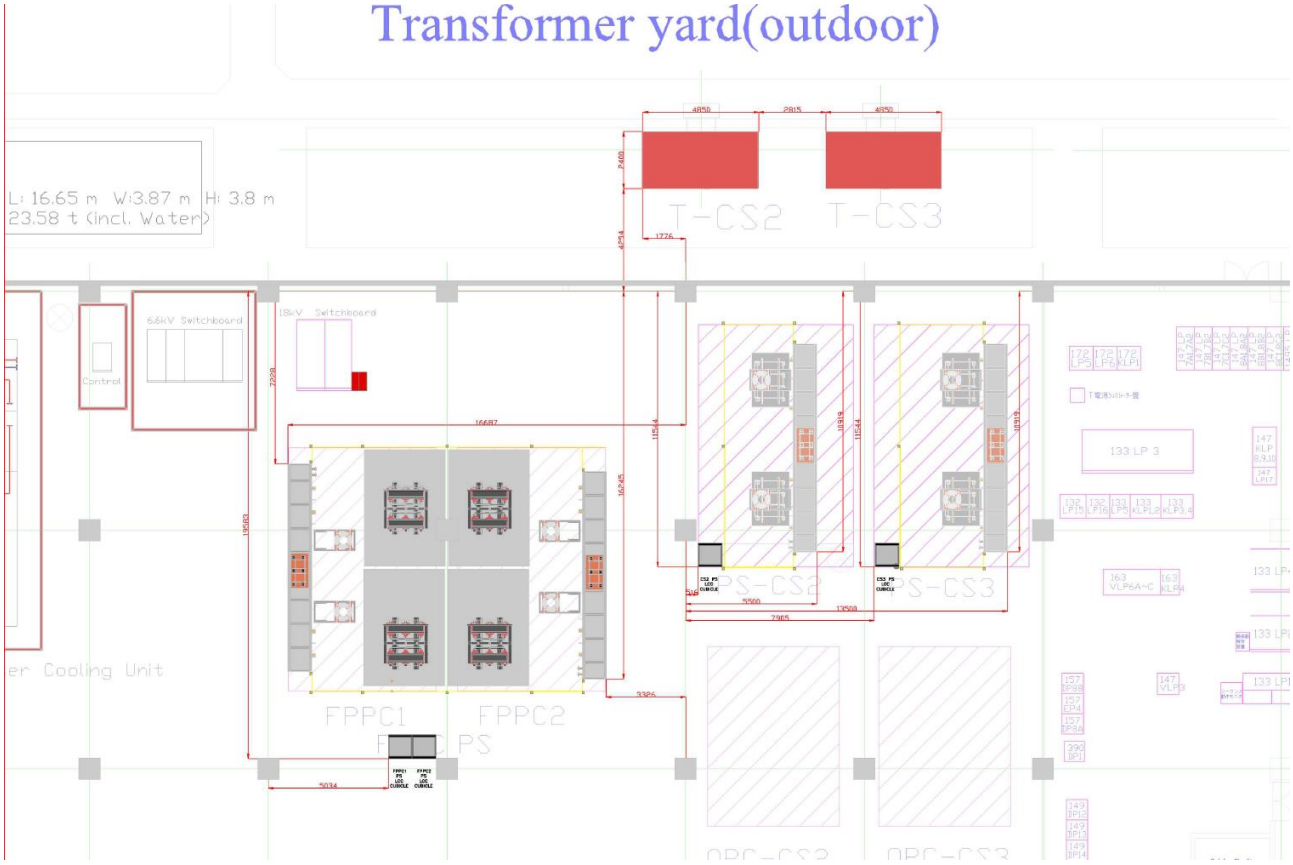

Figure 8 – CS2, CS3 FPPC1 and FPPC2 Plant layout

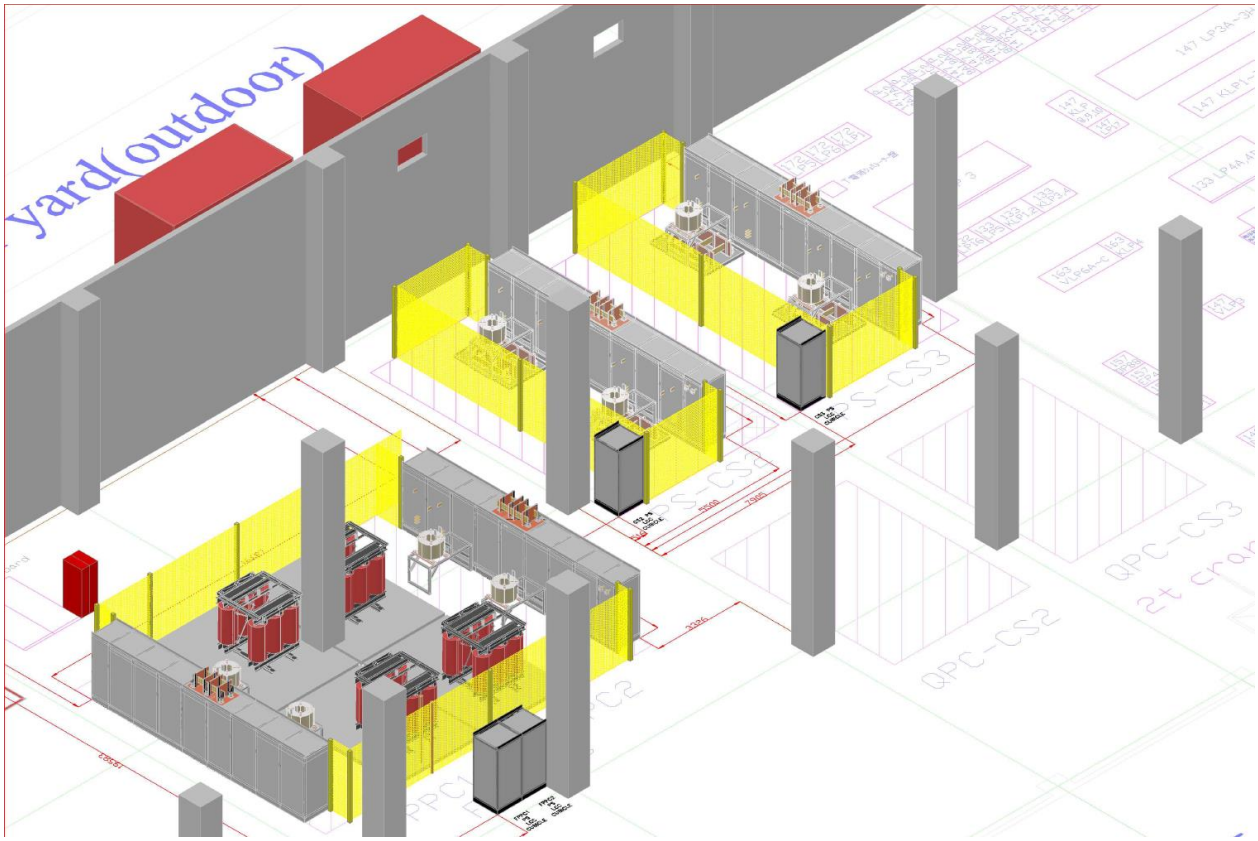

Figure 9 – Axonometric view

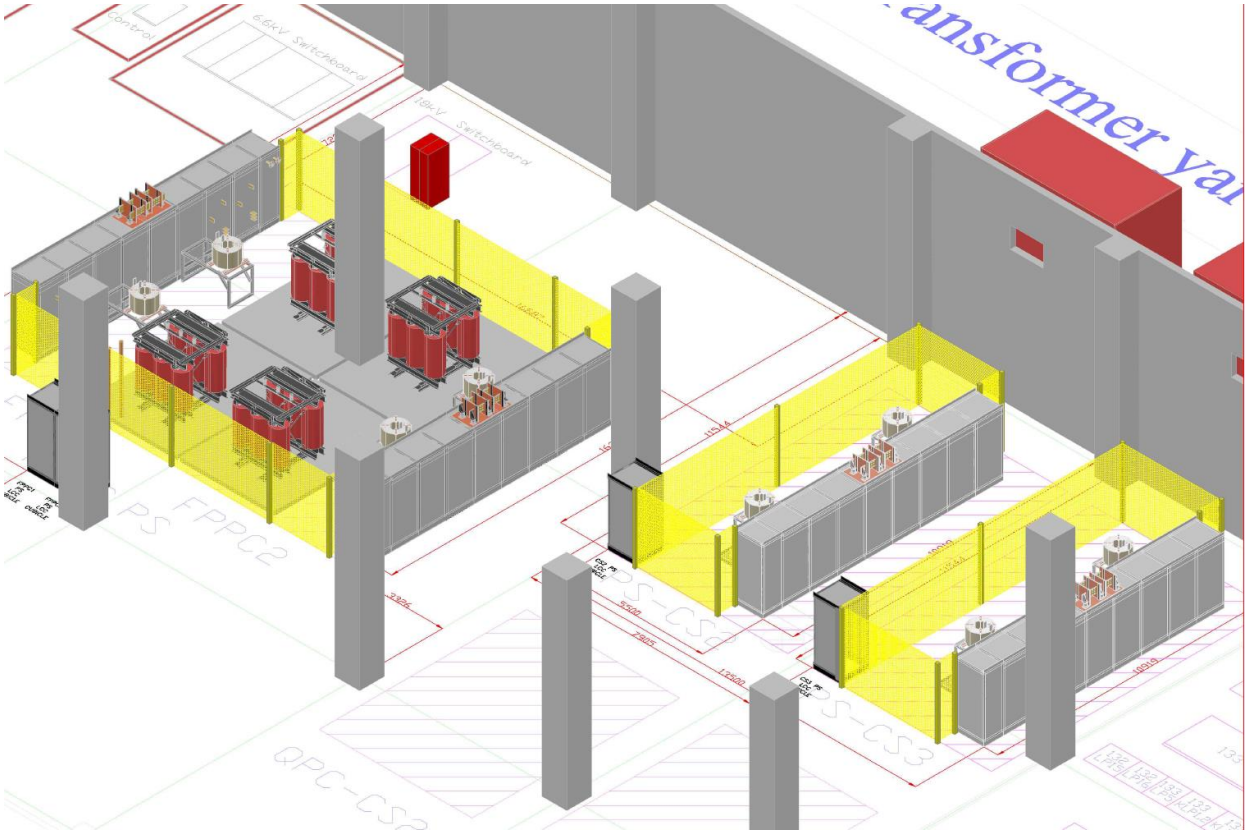

Figure 10 - Axonometric view

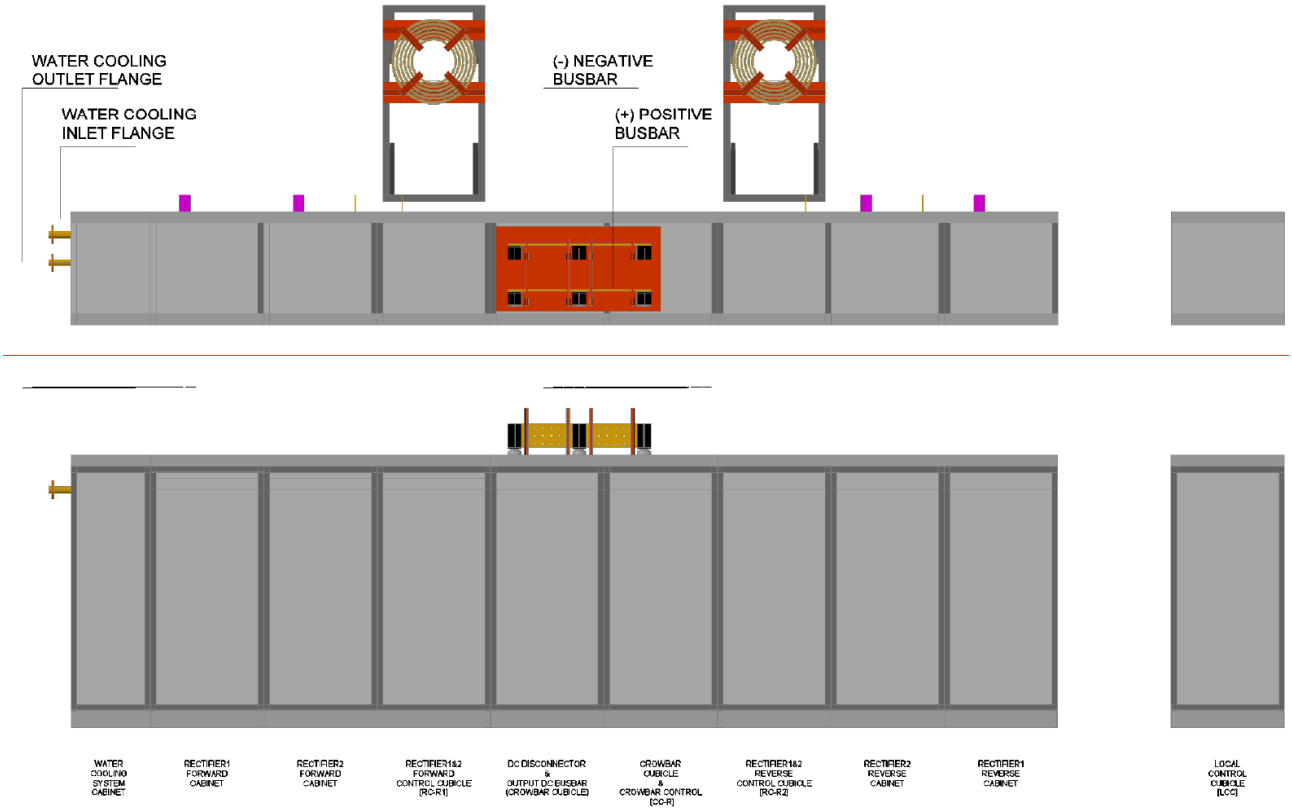

Figure 11 – FPPC PS Layout

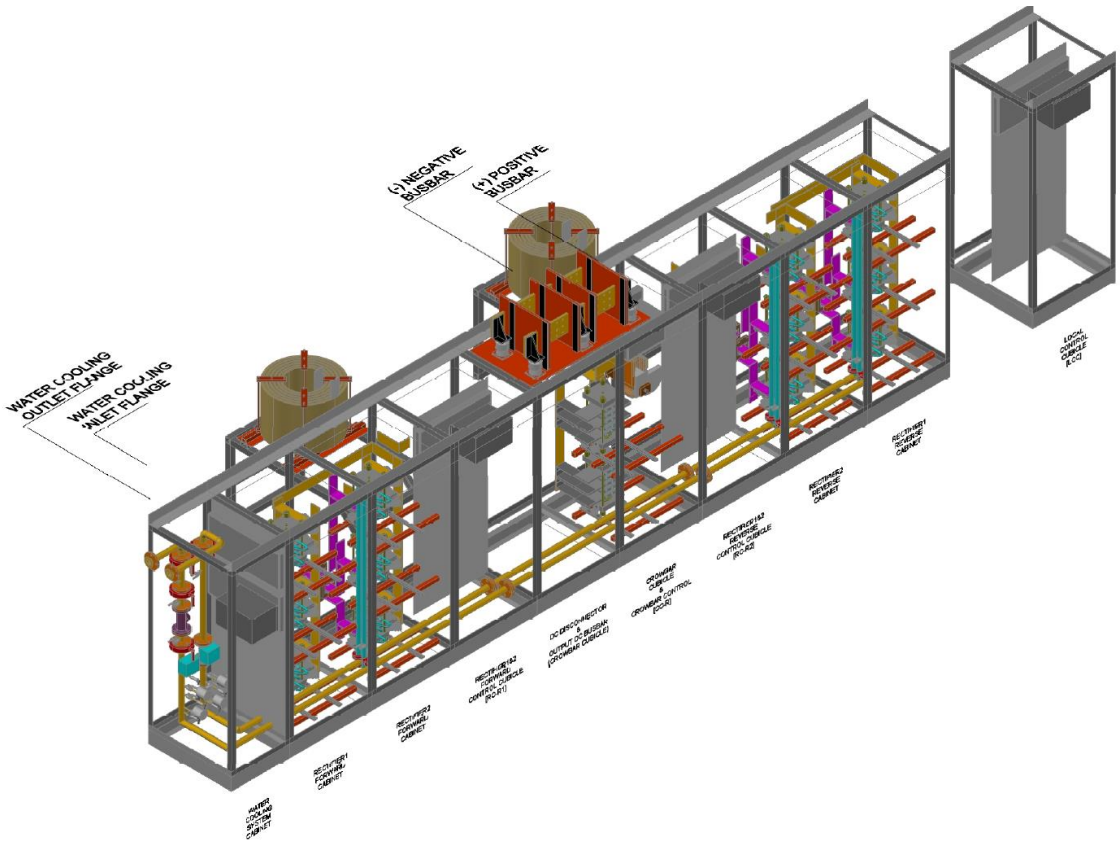

Figure 12 - FPPC PS Layout

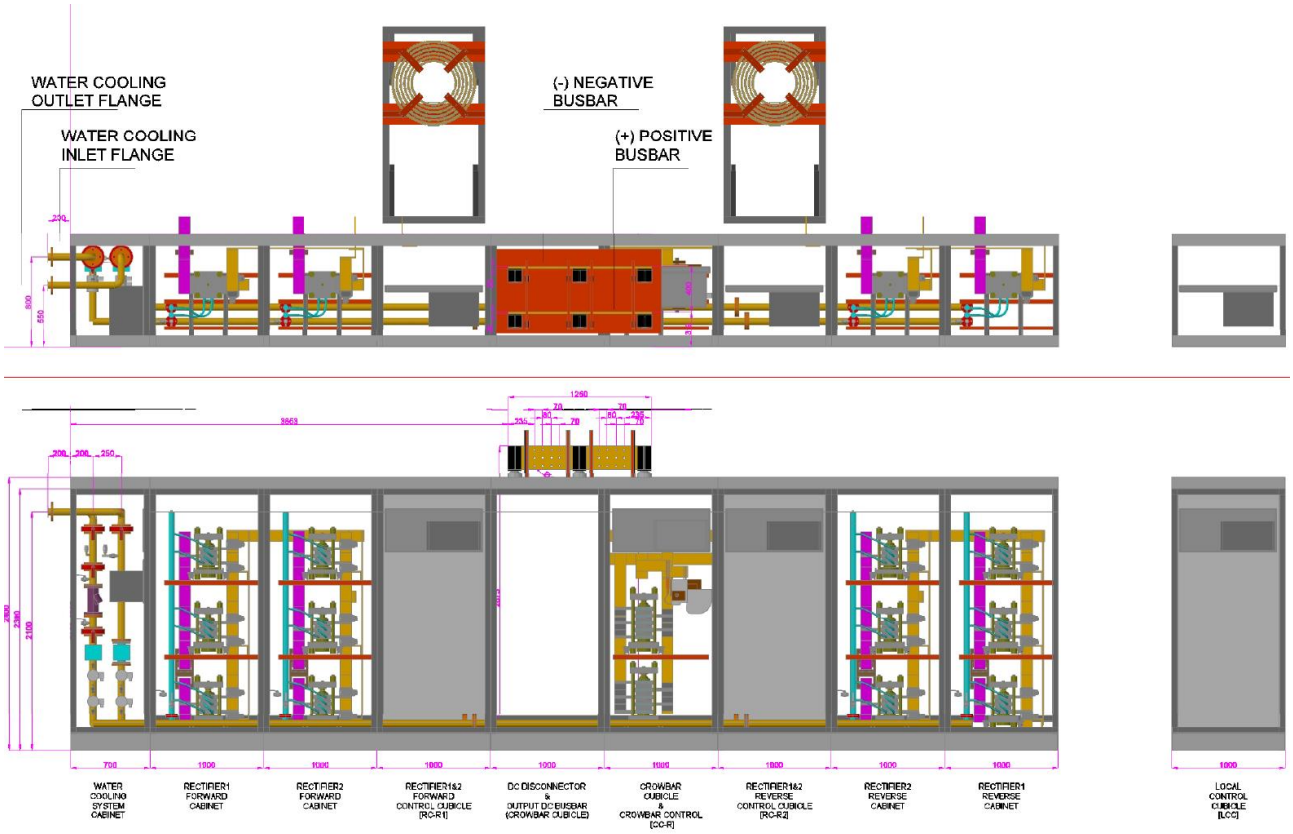

Figure 13 - FPPC PS Layout (frontal e vertical view)

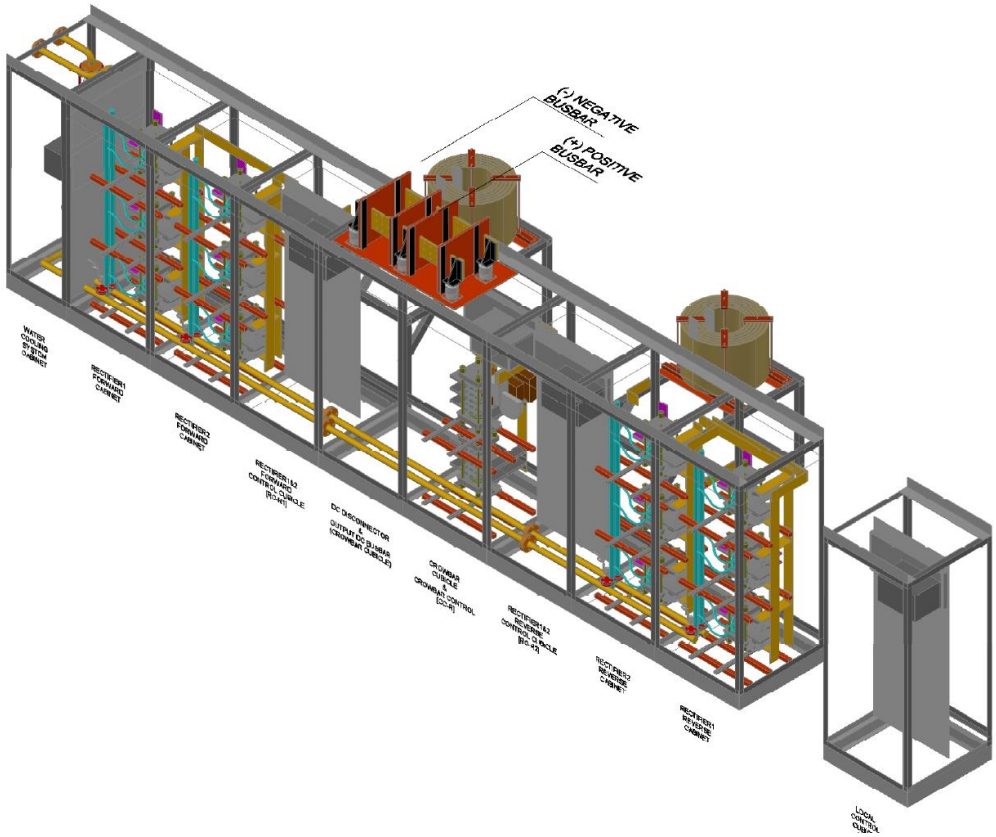

Figure 14 - FPPC PS Layout

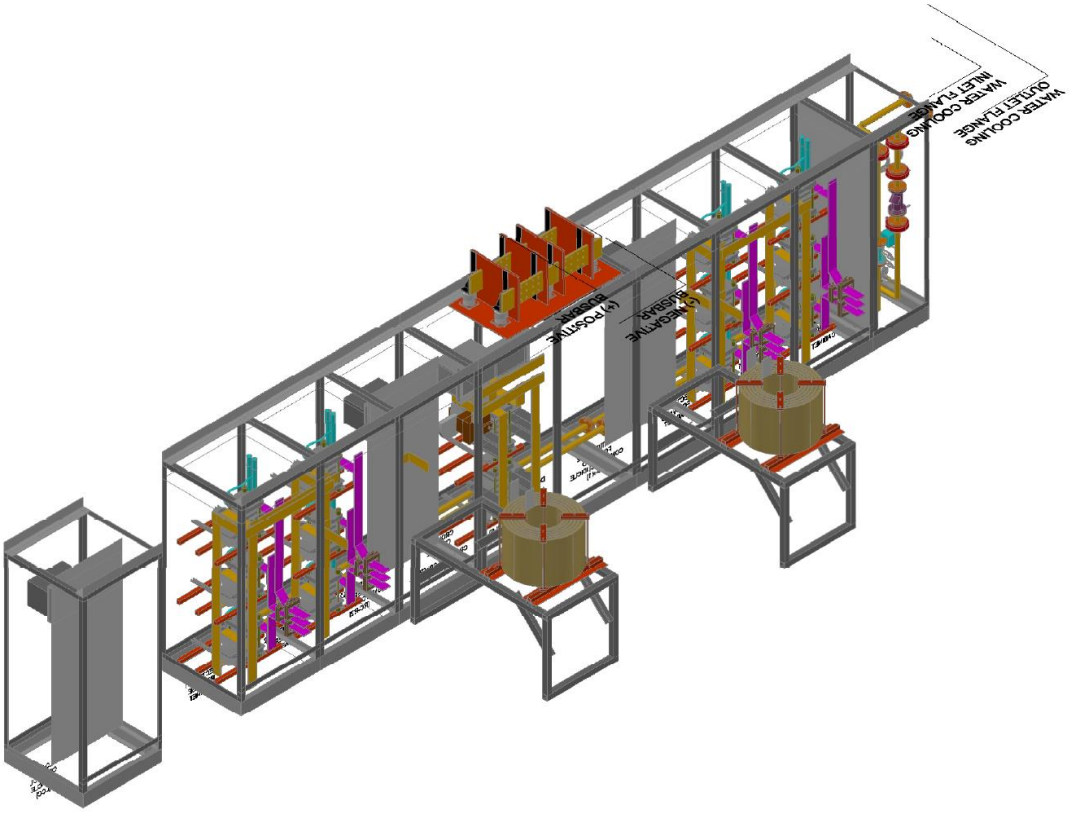

Figure 15 - FPPC PS Layout

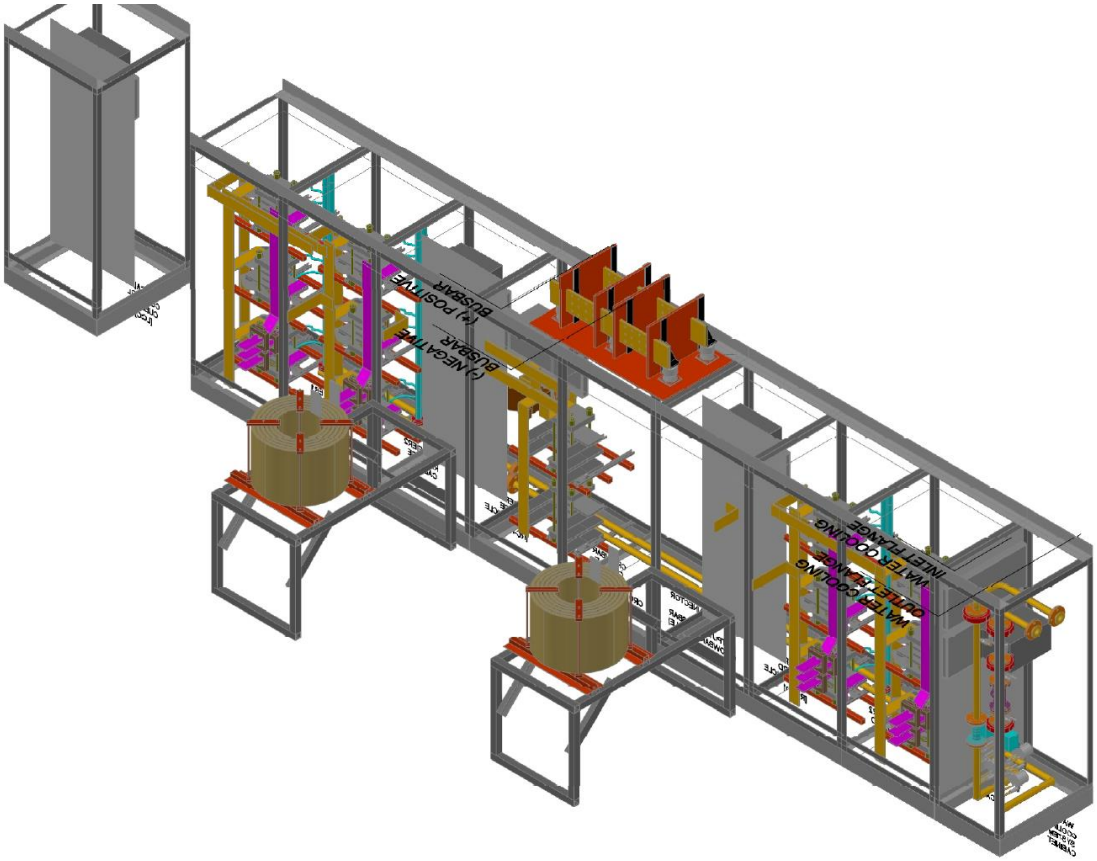

Figure 16 - FPPC PS Layout

3 Conclusions

La relazione riporta una sintesi delle attività svolte correlate alla fase del contratto 2A “lo sviluppo dei disegni di fabbrica e layout, disegni meccanici e funzionali schemi elettrici di potenza, protezione, misure comando e controllo dei sistemi di alimentazione”, delle bobine del Tokamak JT-60SA.

4 Abbreviations and acronyms

Acronym	Term	Definition
AC	Alternating Current	–
AI	Analog Input	
AoC	Agreement of Collaboration	Framework between F4E and VC-DI to reinsure its commitments towards JAEA under the Procurement Arrangements
BA	Broader Approach	Agreement between Japan Government and the European Atomic Energy Community for the joint implementation of the activities in the field of fusion energy research
CB, CBU	Crowbar (Unit)	Electrical circuit used to prevent an overvoltage of a power supply
CC-R	Crowbar Control Rack	Fires, controls and protects the crowbar thyristors, measuring current, DC voltage and status monitoring, apart from communicating with the MC-R.
CPU	Central Processing Unit	
CS	Central Solenoid	Nb_3Sn conductor consisting of 4 independent modules
–	Customer	VC-DI responsible for handling financially and legally the Procurement of its in-kind contributions: for this Procurement, the Customer is ENEA
DC	Direct Current	–
DDP	Detailed Design Phase	In this phase, the IS shall detail the technical solutions selected to comply with the requirements
DSP	Digital Signal Processor	
EU	Europe	
EM	Electromagnetic	
EMC	Electromagnetic Compatibility	Correct operation of different objects in the same electromagnetic environment
ENEA	ENEA	Italian National Agency for New Technologies, Energy and Sustainable Economic Development
F4E	Fusion for Energy	European joint undertaking for ITER and the Development of Fusion Energy: integral part of the JT-60SA Project EU Home Team ensuring the coordination of implementation of the PA and its interfaces with other PAs in BA activities
FPPC FPPC(u,l) FPPC(1,2)	Fast Plasma Position Control	Coils used to control the plasma position (classified as upper/lower or 1/2)

HV	High Voltage	
HVCB	High Voltage Circuit Breaker	
IAs	Implementing Agencies	F4E and JAEA
IDC	Identification Code	Code used for identification and traceability of JT-60SA components
IPC	Inter-Process Communication	
IS	Industrial Supplier	The company selected by ENEA to provide the supplies, services or works described in these Technical Specifications, according to a Procurement Contract
JT-60SA	JT-60SA	JT-60 Super Advanced tokamak, the construction and exploitation of which shall be conducted under the Satellite Tokamak Programme and the Japanese national programme
LV	Low Voltage	–
MC-R	Main Control Rack	MC-R is in charge of the regulation and firing of thyristor rectifiers and at the same time communicating all data/signals to with JT-60SA supervising system PS-SC. It shares data with both RC-R and CC-R.
PF, PFC	Poloidal Field (Coil)	In a tokamak, the poloidal field travels in circles orthogonal to the toroidal field
PID	Plant Integration Document	Document defining the technical basis of the JT-60SA Project [ANX1]
PA	Procurement Arrangement	Framework between F4E and JAEA for the main governing, financial and collaborative requirements for the supply of a procurement package
PS	Power Supply	–
PS SC	Power Supply Supervising Computer	Computer provided by JAEA that communicates with SCSDAS, GPS and SIS and includes an IPS
RCM	Remote Control Mode	Remote Control Mode of the operations
RC-R	Rectifier Control Rack	Measures rectifier input and output currents, over temperature and monitors fuse melting status so as to communicate all this data to MC-R through optic fiber links.
RM	Reflective Memory	Real-time Local Area Network in which each computer always has an up-to-date local copy of the shared memory set
SCADA	Supervisory Control And Data Acquisition	
SCB	Static Circuit Breaker	Switch system based on static devices that supports the BPS to satisfy the SNU time specifications
SCMPS	Superconducting Magnet Power Supply	Power systems, electrical and electronic devices to feed the coils of JT-60SA
SCR	Silicon Controlled Rectifier	
SCSDAS	Supervisory Control System and Data Acquisition System	JT-60SA system
STP	Satellite Tokamak Programme	One of the three projects in the BA activities with the purpose to develop JT-60SA

TCS	Transformer for Central Solenoid	
TF, TFC	Toroidal Field (Coil)	In a tokamak, the toroidal field travels around the torus in circles
TFPPC	Transformer for Fast Plasma Position Control	
–	Tokamak	Device using a magnetic field to confine a plasma in the shape of a torus
TS	Technical Specifications	The present document
UPS	Uninterruptible Power Supply	APS provided by JAEA
VC-DI	Voluntary Contributor Designated Institution	Institution appointed by the Government of the countries (Voluntary Contributors) that give voluntary contributions to Euratom for the implementation of the BA activities