

Configuration Management and Documentation	Document Type Detailed Specification	Document Number F-DS-SFS-en-BD_0125	Date 12.08.2026
 			Page 1 of 12

Document Title	Detailed Specification of the CPS and UPS systems for the detectors and experimental equipment of the Super-FRS and for the experiments for ES
Description	Description of the content of PSP 2.14.16.3.1 and 2.14.16.4.1
Division/ Organization	SFS
Field of Application	FAIR GmbH and GSI GmbH

Document History

Version	Prepared/Checked by	Date	Date of Release	Comments
V1.0	S. Pietri	17/03/2021		First version to EDMS
V1.0b	S. Pietri	29/03/2021		Second version to EDMS
DV1	R. Knöbel	17.06.2026		
DV2	R. Knöbel	24.07.2026		
DV3	R. Knöbel	27.07.2026		
DV4	M. Winkler, R. Hettrich, R. Knöbel	29.07.2026		
DV5	M. Winkler, R. Hettrich, R. Knöbel	30.07.2026		
DV6	M. Winkler, R. Hettrich, R. Knöbel	30.07.2026		
DV7	M. Winkler, R. Hettrich, R. Knöbel	31.07.2026		
V002	M. Winkler, R. Hettrich, R. Knöbel	31.07.2026		For EDMS
DV8	R. Hettrich, R. Knöbel	11.08.2026		EDMS-comments included
V003	R. Hettrich, R. Knöbel	12.08.2026		For EDMS



Configuration Management and Documentation	Document Type Detailed Specification	Document Number F-DS-SFS-en-BD_0125	Date 12.08.2026
 			Page 2 of 12

Abstract

For certain FAIR experiments and for the Super-FRS, the electronics and the detectors are distributed along the beamline and mounted on or connected to racks. These racks are located in several buildings. To ensure high resolution and optimal response characteristics for this sensitive equipment, it is crucial to minimize random power fluctuations or interruptions. The detectors and electronic components are located on close proximity to equipment that is either susceptible to interference or a source of it such as pumps or high-current magnets. This detailed specification addresses cases in which an integrated rack-based solution for providing a “Clean Power Supply” (CPS) or an “Uninterruptable Power Supply” (UPS) was preferred over a more standard, building-wide infrastructure. This can be explained due to the complexities of planning across several buildings or simply the fact that a local solution allows for more flexible operation.

This document defines the requirements for the CPS and UPS for the Super-FRS and for the NUSTAR experiments part of the Early Science (ES) setup. The PSPs are 2.14.16.4.1 for CPS and 2.14.16.3.1 for UPS. The AIDs are AID:0000678 for the CPS modules and AID:0000679 for the UPS modules. The AID of the external battery expansion boxes is AID:0005396.

Configuration Management and Documentation	Document Type Detailed Specification	Document Number F-DS-SFS-en-BD_0125	Date 12.08.2026
 			Page 3 of 12

Table of Contents

1. Purpose and Classification of the Document.....	4
2. Abbreviations, Terms and Definitions	4
3. Scope of the Technical System.....	4
3.1. System Overview	4
3.2. Scope of Delivery	5
3.3. Spare Parts.....	5
4. System Specification	6
4.1. Technical Requirements for System Components.....	6
4.2. Functional Requirements (Parameter List)	7
4.3. Interfaces	8
4.4. System Environment and Constraints	8
5. Procedure.....	10
5.1. Design Phase	10
5.2. Production Phase.....	11
6. Quality Assurance, Tests and Acceptance.....	11
6.1. Quality Assurance System of the Contractor.....	11
6.2. Factory Acceptance Test (FAT)	11
6.3. Site Acceptance Test (SAT)	11
7. Documentation	12
8. Related Documents	12

List of Tables:

Table 1: Overview on the needed racks with the required maximum power and type of module (CPS or UPS). The UPS modules must ensure the operation of all connected systems for at least 15 minutes. The UPS modules in rack cupboards, which contain network components, have to buffer the accumulated rated power for all connected devices for 30 minutes. This corresponds to the Technical Guideline "Electrical Design Rules and Regulations" [2].....	5
Table 2: Overview of the interfaces at the CPS/UPS modules. See also section 4.3.	9
Table 3: Overview of the CIDs assigned to the CPS and UPS modules as well as to the external battery expansion boxes.....	10

Configuration Management and Documentation	Document Type Detailed Specification	Document Number F-DS-SFS-en-BD_0125	Date 12.08.2026
 			Page 4 of 12

1. Purpose and Classification of the Document

The purpose of this document is to specify the technical requirements of the component “CPS for Super-FRS and experiments” (PSP 2.14.16.4.1) and the component “UPS for Super-FRS and experiments” (PSP 2.14.16.3.1).

The document is the most detailed document in the hierarchy of the documentation to specify all rules and information for the planned realization of this system.

The general requirements related to the common rules and definitions for the FAIR project are specified in the General Specifications for the FAIR Accelerator Facility Project [1]. In this document, the FAIR GmbH is referred to as the “Company” and the supplier is referred to as the “Contractor”. This document only represents the technical part of the contract. All commercial and organisational conditions are not considered.

2. Abbreviations, Terms and Definitions

Abbreviation	Definition
AID	Article Identification Number
CDR	Conceptual Design Review
CID	Component Identification Number
CPS	Clean Power Supply
EPICS	Experimental Physics and Industrial Control System, Software
ES	Early Science
FAIR	Facility for Antiproton and Ion Research
FAT	Factory Acceptance Test
FDR	Final Design Review
NUSTAR	Nuclear Structure, Astrophysics and Reaction, FAIR collaboration
PSP	Project Structure Plan
SAT	Site Acceptance Test
Super-FRS	Superconducting Fragment Separator
UPS	Uninterruptable Power Supply

3. Scope of the Technical System

3.1. System Overview

The purpose of the CPS system is to provide a “Clean Power Supply” from the racks, in which it is installed, to the components connected to these racks or present in an experimental area.

The aim of the UPS system is to provide an “Uninterruptable Power Supply” for the components linked to the racks in addition to the above mentioned “Clean Power Supply” function, which filters out undesired disturbances from the power grid.

A CPS, as referred to in the present document, is just a UPS module without batteries. To ensure a proper separation of the output of the module from the mains supply of the grid, a line-interactive module shall be procured.

Configuration Management and Documentation	Document Type Detailed Specification	Document Number F-DS-SFS-en-BD_0125	Date 12.08.2026
 			Page 5 of 12

3.2. Scope of Delivery

The scope of delivery covers:

- 60 CPS modules
- 15 UPS modules
- 15 external battery expansion boxes

for the racks along the beamline of the Super-FRS and the NUSTAR experiments including the corresponding rack mount kits (pairs of adjustable rails per unit) and further accessories needed to comply with this specification (for example cards for additional interfaces or environmental sensors).

Table 1 gives an overview on the racks and their assigned functionality for the facility with their correspondingly necessary maximum power, the type of the needed power supply module (CPS or UPS) and the required amount. Table 1 covers all modules needed for the Super-FRS and related experiment setups belonging to the Early Science (ES) phase.

Type (internal nomenclature)	Function (not relevant for Contractor)	Max power (kVA) per rack	Power type	Number of racks
BD	Beam diagnostic	4	CPS	13
BD	Beam diagnostic	4	UPS	7
DAQ	Data AcQuisition	4	CPS	19
DEX	Experiment electronics	4	CPS	28
NEX	Network for experiments	7.5	UPS	8

Table 1: Overview on the needed racks with the required maximum power and type of module (CPS or UPS). The UPS modules must ensure the operation of all connected systems for at least 15 minutes. The UPS modules in rack cupboards, which contain network components, have to buffer the accumulated rated power for all connected devices for 30 minutes. This corresponds to the Technical Guideline "Electrical Design Rules and Regulations" [2].

The duration and power, needed to buffer an outage of the power grid at each single UPS is not determined yet. It has to be scaled later in the field. Therefore, the battery module should be the same for all devices and it should comprise all accessories to scale the power and buffer time by cascading the required amount of battery modules without a further purchase of cables and other accessories. In case the maximum buffered continuous power rating in a certain rack exceeds the 2.3 kVA, several CPS or UPS systems can be deployed. Although the required maximum power in table 1 exceeds the continuous power of 2.3 kVA, the power of a single system should be kept limited. This allows a fast and secure fuse at the power interfaces within the SFRS facility (man and machine protection).

3.3. Spare Parts

No spare parts are planned.

Configuration Management and Documentation	Document Type Detailed Specification	Document Number F-DS-SFS-en-BD_0125	Date 12.08.2026
 			Page 6 of 12

4. System Specification

4.1. Technical Requirements for System Components

The modules shall be 19-inch rack mountable and occupy a height between 2 to 4 U of the racks for the CPS and 4 to 12 U for the UPS including the necessary batteries. The weight of each module should be low enough to be supported by the rails inside a rack (< 50 kg). A UPS may consist of multiple modules (main module and additional batteries). Each rack can accommodate several modules.

The modules should be designed for the operation within the standard FAIR power grid (230 V, 50 Hz). The Total Harmonic Distortion (THD) of the input current at full load and the THD of the output voltage at linear load should be <5%. The rules for the electrical design and regulations [2] must be followed. The surge immunity, the safety standards, and the electromagnetic compatibility must comply to the industry standards. Audible noise emissions coming from the modules at full load should stay below 50 dBA at a distance of 1m.

The battery charging process after a complete discharge has to be complete in less than 4h.

The batteries should be easily replaceable in case of a failure.

Each module requires a minimum number of 6 standard power output connectors (C13). For single consumers with maximum power consumption a C19 output socket is also needed. The male input power connector must comply with the industry standards using either a C14 or a C20 connector.

The UPS modules shall be equipped with internal batteries and a dedicated connector to add external battery modules to extend capacity and offline time.

The operation parameters temperature and relative humidity should cover a range of 0° C to 40° C with relative humidity from 0% to 95% without condensation.

The UPS and CPS must ensure a clean power supply even during fluctuations in the sine-wave voltage or during brief interruptions (less than 1s). The principle of the desired working mode is called "on-line double conversion". It can be considered as a continuous rectification of an AC input current into an internal DC current, a smoothing process by a capacitor or a battery, followed by an electronic AC generation without possible disturbances from the sourcing power grid. A characteristic number to compare is the DOUBLE CONVERSION EFFICIENCY of this complete conversion procedure. Therefore, the efficiency of the online input to output conversion has to be given by the contractor as a percentage number. Another important size to compare is the Heat Dissipation with 100% load. This size has to be given by the contractor in Watts. Even though a bypass option between input and output can be chosen for many device types, it is not the preferred operating mode in Super-FRS. But it can help to ease service situations, for example when power is needed during a battery exchange procedure.

Due to The UPS and the CPS modules generate their output voltage from an internal voltage, there is the possibility to deliver the output voltage as a potential free output. The contractor should confirm or decline this potential free output property because it might be important for security reasons and is desirable for certain experiments.

In addition, both module types must be connectable to the emergency stop system of the buildings and be compatible with the according interlock-systems.

Configuration Management and Documentation 	Document Type Detailed Specification	Document Number F-DS-SFS-en-BD_0125	Date 12.08.2026
			Page 7 of 12

Both module types must be able to entirely disconnect the AC and DC sources to the load by an Emergency Power Off control (EPO, in German: Not-Aus=Not-/Schnellabschaltung), which evaluates a current transmission through a completely insulated external interlock loop. The interface at the module enclosure can be two pin-contacts with a bypass-jumper at the rear side as an example (see the row “EPO” in Table 2). Thus, several CPS/UPS-Systems shall be configured in a loop and connected to the corresponding Emergency Power Off-System of the building, which is expected as a larger number of Emergency-Stop buttons at places, where human beings are expected to sojourn. The EPO interface should allow to ignore a superior emergency power off request by simply bridging both interface pins at the desired module with a short cable or a jumper. This should prevent the modules from an instantaneous internal switch off, when the facility power has been switched off by a superior emergency power off command. This can be considered as a shutdown delay for the CPS in the magnitude order of seconds or for the UPS in the range of several minutes.

Further, two hardware pins for a DRY IN and another two pins for a DRY OUT function at the rear side are desirable. DRY IN evaluates its pins for a closed switch and triggers the switch on/off function of the entire Module. The DRY OUT pins are connected, when the input power is not there and the UPS works on battery.

4.2. Functional Requirements (Parameter List)

The CPS modules must provide a clean power supply for the racks, the electronics installed inside them and the connected components.

This also applies to the UPS modules. In addition, the UPS modules have to ensure the operation of all connected systems and components for at least 15 minutes after a shutdown of the main power supply.

In both cases, a line-interactive decoupling system must be used that delivers an online USV (a sinusoidal AC voltage of 230 V with a standard 50 Hz).

For compatibility reasons, the CPS and the UPS modules should be based on the same modules, with the battery connected directly to the UPS unit or being integrated into it.

A modularly, expandable battery capacity is desirable as well as batteries that are exchangeable during system operation (hot-swappable).

The system should be maintenance-free for a period of several, at least 3-5 years.

The modules are installed in locations that are not accessible during operation. Therefore, a remote connection to the modules, for monitoring as well as for switching on and off, must be possible via standard Ethernet interfaces. Concerning the interface hardware, the link layer and the basic high-level protocols, the Technical Guideline “Ethernet Network Connectivity” [3] must be followed (see the most important requirements, beginning from line 4 of the next chapter 4.3). On the remote site, a non-proprietary software, named EPICS, has to be used for this purpose (see at <http://epics-controls.org>). Therefore, on the CPS/UPS-device, an EPICS interface is desired. Alternatively, the required information can be exchanged via the common Simple Network Management Protocol (SNMP) too. The local CPS/UPS enclosures must provide information on the status of the module, the battery, the battery load and further necessary parameters as well as any alarms to a remote monitoring system via Ethernet network. An example for a representative list is:

Configuration Management and Documentation	Document Type Detailed Specification	Document Number F-DS-SFS-en-BD_0125	Date 12.08.2026
 			Page 8 of 12

- battery discharge / power grid outage
- low battery level I
- UPS fault
- overload
- overtemperature
- environmental temperature too high (desirable)
- ventilator outage
- required battery replacement
- battery failure
- grounding / power grid connection issues (desirable)
- inverter short at output (desirable)
- Emergency Power Off active (desirable)
- bypass status
- possibly further important information from the manufacturer.

For remote surveillance and servicing, a similar choice of alarms should be presented remotely via the Ethernet port of the device. If possible, the real time verification of the environmental temperature and maybe the relative humidity at each device via the above specified connection are desirable. If this implies additional hardware, this hardware should be offered as an option.

4.3. Interfaces

The modules must be connected to the network and the standard power grid of the buildings. They have to be network-controllable and shall be monitored via the network. Table 2 gives an overview of the interfaces needed at the CPS/UPS modules. The network interface has to comply with a modern choice of the rules in [3]. The network device at the CPS/UPS module must register itself on the accelerator network in the following way: After link layer setup the device has to send unrequested Ethernet packets. Unsolicited packets should presumably be DHCP. Further autosensing / autonegotiation (speed and duplex option) is mandatory during link layer setup. The most important supported connection standards are (the fast options can be looked up in [3]).

100BASE-TX, half or full duplex, IEEE 802.3u	Twisted Pair
1000Base-T, full duplex, IEEE 802.3af	Twisted Pair

The RS-232 or the USB port should give the possibility for UPS monitoring, control and firmware updates by the means of a local computer connection.

4.4. System Environment and Constraints

The modules will be mounted on racks inside the experimental hall, in the laboratories, and in the niche and the supply tunnel of the Super-FRS. Each module must fit into the racks and provide and deliver the maximum power of 3 kVA at 230V quite exactly. This corresponds to a long-term current of 10 A at a usual power receptable = 2.3 kVA multiplied by a factor of 1.3. Less power would not exploit the strength of the 230 V power grid. More power would probably throw out the external 230V/16A fast automatic fuse at switch on. The fast automatic 230V/16A fuse cannot be replaced or enhanced for systems with higher power without a loss of protection against fatal electrical shock.

The room conditions are 15°C – 35°C with a humidity between 30% and 70%. The repercussion from the CPS/UPS-Supply modules to the power grid must not exceed the limiting values given in

Configuration Management and Documentation	Document Type Detailed Specification	Document Number F-DS-SFS-en-BD_0125	Date 12.08.2026
 			Page 9 of 12

the electromagnetic compliance standard (EMC) DIN EN 61000-3-3 according to the Technical Guideline "Electrical Design Rules and Regulations" [2].

Furthermore, a serial RS232 interface or a USB interface (for on-site configuration of the CPS/UPS systems) are required/requested in order to read out the state of the device locally if the network transmission fails.

Interface	Connector	Amount	Purpose	Software/driver	necessity
Power input	C14	0	Connection to Power grid	None	Optional
Power input	C20	1	Connection to Power Grid	None	Mandatory
Power output	C13	6-8	Connection to consumer	None	Mandatory
Power output	C19	1	Connection to Power consumer.	None	Mandatory
Emergency Power Off (EPO)	Dual pin interlock	1	Connection to EPO-building	None	Mandatory
Dry In	Dual pin switch	1	Connection to external switch or loop of switches	None	Optional
Dry Out	Dual pin switch	1	Connection to external failure display	None	Optional
RS-232	D-Sub 9, pin 2 TxD, pin 3 RxD, pin 5 GND	1	Connection to local external computer	COM1-device, Terminal emulation software for serial data transmission (for example. Putty), CPS-Firmware	Mandatory
USB	USB-B or similar USB connector	1	Connection to local external computer	USB-to-serial driver	Optional
Network	RJ45/Cat 6	1	Connection to facility network	TCP/IP-Stack, SNMP, HTTP	Mandatory
External Battery Module	Device specific	1	Connection to external Batteries	None	Mandatory

Table 2: Overview of the interfaces at the CPS/UPS modules. See also section 4.3.

Configuration Management and Documentation	Document Type Detailed Specification	Document Number F-DS-SFS-en-BD_0125	Date 12.08.2026
 			Page 10 of 12

5. Procedure

5.1. Design Phase

A Conceptual Design Review (CDR) is not required, as the procurement covers only standard “off-the-shelf” products.

A Final Design Review (FDR) is mandatory and has to include an assembly layout and mounting scheme for the modules inside the racks as well as details regarding the number of modules needed per rack to fulfill the requirements. This holds as well for the number of batteries of the UPS required. In addition, the number of necessary connectors per rack must be specified.

Component	AID	CIDs		
CPS	AID:0000678	CID:06001261198, CID:06001261228, CID:06001261259, CID:06001261280, CID:06001261310, CID:06001261341, CID:06001261372, CID:06001261402, CID:06001261433, CID:06001261464, CID:06001261495, CID:06001261525, CID:06001261556, CID:06001261587, CID:06001261617, CID:06001261648, CID:06001261679, CID:06001261709, CID:06001261730, CID:06001261761,	CID:06001261204, CID:06001261235, CID:06001261266, CID:06001261297, CID:06001261327, CID:06001261358, CID:06001261389, CID:06001261419, CID:06001261440, CID:06001261471, CID:06001261501, CID:06001261532, CID:06001261563, CID:06001261594, CID:06001261624, CID:06001261655, CID:06001261686, CID:06001261716, CID:06001261747, CID:06001261778,	CID:06001261211, CID:06001261242, CID:06001261273, CID:06001261303, CID:06001261334, CID:06001261365, CID:06001261396, CID:06001261426, CID:06001261457, CID:06001261488, CID:06001261518, CID:06001261549, CID:06001261570, CID:06001261600, CID:06001261631, CID:06001261662, CID:06001261693, CID:06001261723, CID:06001261754, CID:06001261785
UPS	AID:0000679	CID:06001261792, CID:06001261822, CID:06001261853, CID:06001261884, CID:06001261914,	CID:06001261808, CID:06001261839, CID:06001261860, CID:06001261891, CID:06001261921,	CID:06001261815, CID:06001261846, CID:06001261877, CID:06001261907, CID:06001261938
External battery expansion boxes	AID:0005396	CID:06001261945, CID:06001261976, CID:06001262003, CID:06001262034, CID:06001262065,	CID:06001261952, CID:06001261983, CID:06001262010, CID:06001262041, CID:06001262072,	CID:06001261969, CID:06001261990, CID:06001262027, CID:06001262058, CID:06001262089

Table 3: Overview of the CIDs assigned to the CPS and UPS modules as well as to the external battery expansion boxes.

Configuration Management and Documentation	Document Type Detailed Specification	Document Number F-DS-SFS-en-BD_0125	Date 12.08.2026
 			Page 11 of 12

5.2. Production Phase

The Contractor agrees on delivery on call. Further details will be discussed and defined during the order processing.

During this phase the Company will provide a component ID (CID) for each CPS and UPS module with which each module can be exclusively identified. This holds as well for the external battery expansion boxes. Table 3 gives already an overview on the assigned CIDs.

Each module and box must be labelled with the CID and the interconnected AID. The CID tagging will be prepared and provided by FAIR in given time so that the CPS and UPS modules as well as the corresponding packaging can be labelled accordingly by the Contractor before the transport and delivery to FAIR.

6. Quality Assurance, Tests and Acceptance

6.1. Quality Assurance System of the Contractor

The modules must be tested on a rack test stand before being installed in the Super-FRS tunnel. A similar test procedure shall be applied to the CPS and the UPS modules. CPS test should ensure output sine wave has acceptable noise content (not a modified sine wave, for example). UPS test should include runtime on battery before shutdown.

6.2. Factory Acceptance Test (FAT)

For the electronic components procured as off-the-shelf products, the manufacturer-specific FAT-information and documents are requested.

6.3. Site Acceptance Test (SAT)

The Technical Guideline given in [4] has to be followed for the transport. Furthermore, the Site Acceptance Tests called “SAT Aa” and “SAT Ab” have to be carried out. All tests have to be applied to all modules.

SAT Aa comprises a visual inspection to ensure that no damage occurred during the transport to the Company.

SAT Ab involves the mounting of the CPS and UPS modules in a rack and verifying that the output power fulfills the specifications. In this process and tests, there must be no occurrence of any baseline fluctuation for the CPS modules. An additional test of continuous power generation for the UPS modules has to be performed as well.

Configuration Management and Documentation	Document Type Detailed Specification	Document Number F-DS-SFS-en-BD_0125	Date 12.08.2026
 			Page 12 of 12

7. Documentation

Following the FAIR General Specification [1] the following list of documents shall be provided by the Contractor:

- the manuals and documents of the hardware bought off-the-shelf
- component list
- instructions for the assembly, mounting, and the operation of the modules specifying the operating parameters (e.g., bias, operating point, connections, etc. ...)
- environmental conditions for operation
- CE-Declaration of Conformity for all modules

The documentation of the tests during SAT and FAT has to be included as well.

8. Related Documents

MANDATORY:

- [1] F-GS-PMO-en, General Specification, EDMS-ID: 1365092
- [2] F-TG-ET-01e, "Electrical Design Rules and Regulations" EDMS-ID: 1172862
- [3] F-TG-C-01e, "Ethernet Network Connectivity" EDMS-ID: 1171993
- [4] F-TG-T-01e, "Transport - Transport" EDMS-ID: 1172866