



System Description

Project: COMPASS-U Gyrotron HVPS
Proposal nr: 21-05479
Client: IPP Of Czech Academy of Science
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1. Introduction

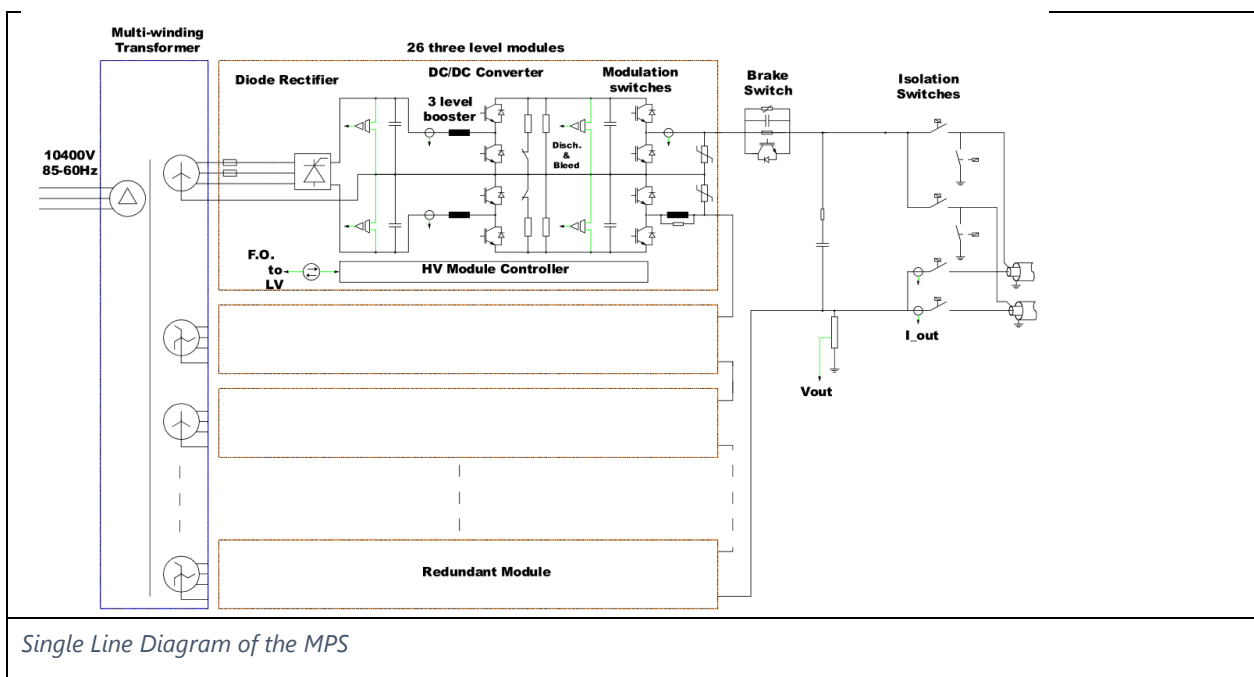
This is the overall description of the proposed HV PS system.

2. Description of the Power Supplies

2.1 Main Power Supply

The **strategy adopted by Jema** for addressing these requirements is summarized below:

- N identical modules with their outputs connected in series (HV modules).
- Each HV module is supplied from a secondary winding of a multi-winding transformer, operating at the specified frequency.
- Each HV module incorporates a high-frequency booster converter, which **very accurately stabilizes the internal DC link voltage**:
 - Accurate voltage stabilization is critical for ensuring overall power supply accuracy.
 - The booster is controlled by a local controller within the module. The DC link voltage is regulated according to an externally received reference (this value remains constant during the pulse).
 - **A booster topology has been selected because it can accommodate generator voltage variations.**
 - The booster also enables the MPS to follow the voltage references defined in the specification **without applying PWM modulation** at the output, thereby **improving ripple performance** without requiring an additional output filter.
- For earthing and discharging switches, normally-closed relays with spring return are used:
 - Passive return to the safe position simply by removing power from the coil (via a fail-safe safety ring).
 - Observable closed position of the switch.
 - The switch can be key-interlocked (opening the coil supply circuit).
- As required, two remotely controlled open and earthing relays will be included.

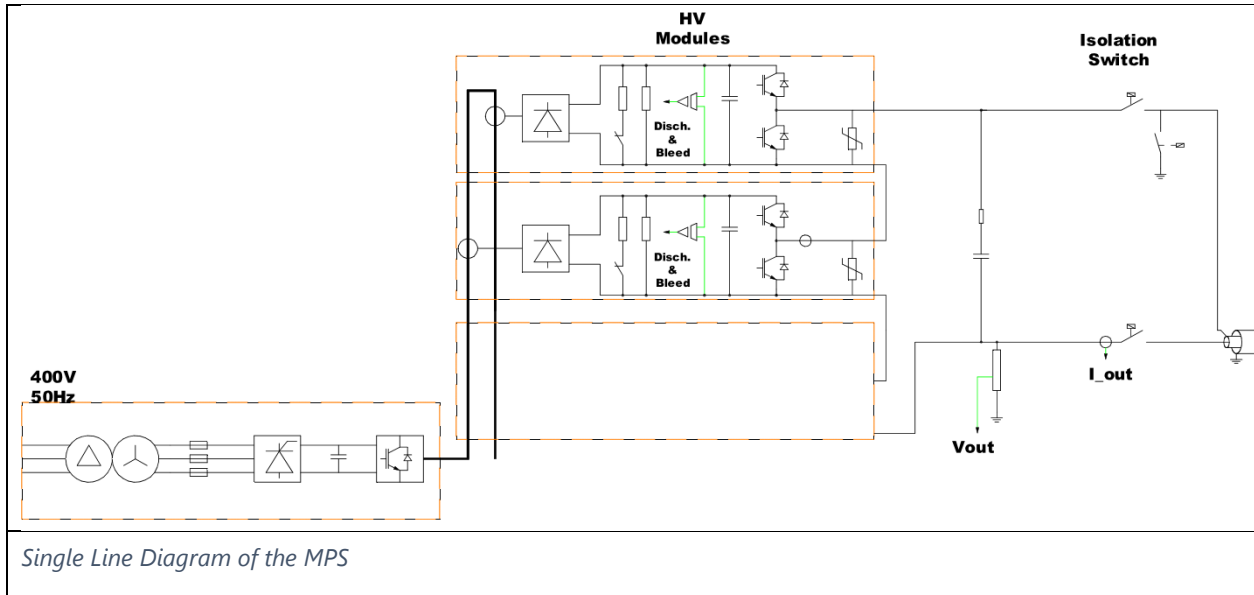


ID	Parameters	Value	Comments
	V _k nominal	-55 kV	
	I _k nominal	> 110 A	
	Power Supply: Gyrotron ratio	1:2	
	V _k coarse range	0 to -30 kV	
	V _k fine range	-30 kV to -55 kV	
	Switch on/Switch-off time	< 10 ms	
	Max overshoot/undershoot	≤ ±1100 V	
	V _k accuracy	≤ ±330 V	
	V _k reproducibility	≤ ±220 V	
	V _k setability	≤ ±220 V	
	V _k ripple	≤ ±220 V	
	Ramp speed	dV/dt > 1 kV/ms	
	Measurement accuracy of voltage / current @ DC	<0.1% / <0.2%	
	Measurement bandwidth (-3 dB)	2 MHz	
	Pulse Length (load)	15 sec	
	Pulse Length (load + no-load)	16 sec	
	Duty Cycle	up to 2%	
	Energy in an Arc event	< 10 J	
	Fast Shutdown time	< 10 μs	
	MPS efficiency	> 90%	
	Voltage Stability (no-load to load events & load to no-load events)	≤ ±1100 V	
	Voltage Settling time (no-load to load & load to no-load events)	< 50 μs	

2.2 Anode & Body Power Supply

The APS and BPS are fed from the 400 V three-phase grid. The single-line diagram of the proposed topology is shown in the following figure.

Note that the APS will be of a floating type without an ASM, according to REQ 14. The modulation is performed using the HV module output IGBTs.



APS main features

ID	Parameters	Value	Notes
	Va nominal	50 kV	Referenced to Cathode. Floating
	Ia nominal	10 mA	Current to Anode only
	Ia maximum	100 mA	Current to Anode only
	Switch on/Switch-off time	< 10 ms	
	Max overshoot/undershoot	$\leq \pm 500$ V	± 1 % @ 50 kV
	Va accuracy	$\leq \pm 150$ V	$\leq \pm 0.3$ % @ 50 kV
	Va reproducibility	$\leq \pm 150$ V	$\leq \pm 0.3$ % @ 50 kV
	Va setability	$\leq \pm 150$ V	$\leq \pm 0.3$ % @ 50 kV
	Va ripple	$\leq \pm 150$ V	$\leq \pm 0.3$ % @ 50 kV
	Ramp speed	$dV/dt > 1$ kV/ms	
	Measurement accuracy of voltage / current @ DC	0.1% / 0.2%	
	Measurement bandwidth (-3 dB)	2 MHz	The bandwidth is defined by -3 dB loss.
	Pulse Length (load)	15 sec	
	Pulse Length (load + no-load)	16 sec	

ID	Parameters	Value	Notes
	Duty Cycle	up to 2%	
	Energy in an Arc event	< 10 J	This assumes 100V arc voltage.
	APS efficiency	> 75%	
	Voltage Stability (no-load to load events & load to no-load events)	$\leq \pm 500$ V	± 1 % @ 50 kV
	Voltage Settling time (no-load to load events)	< 20 μ s	
	Voltage Settling time (load to no-load events)	< 50 μ s	

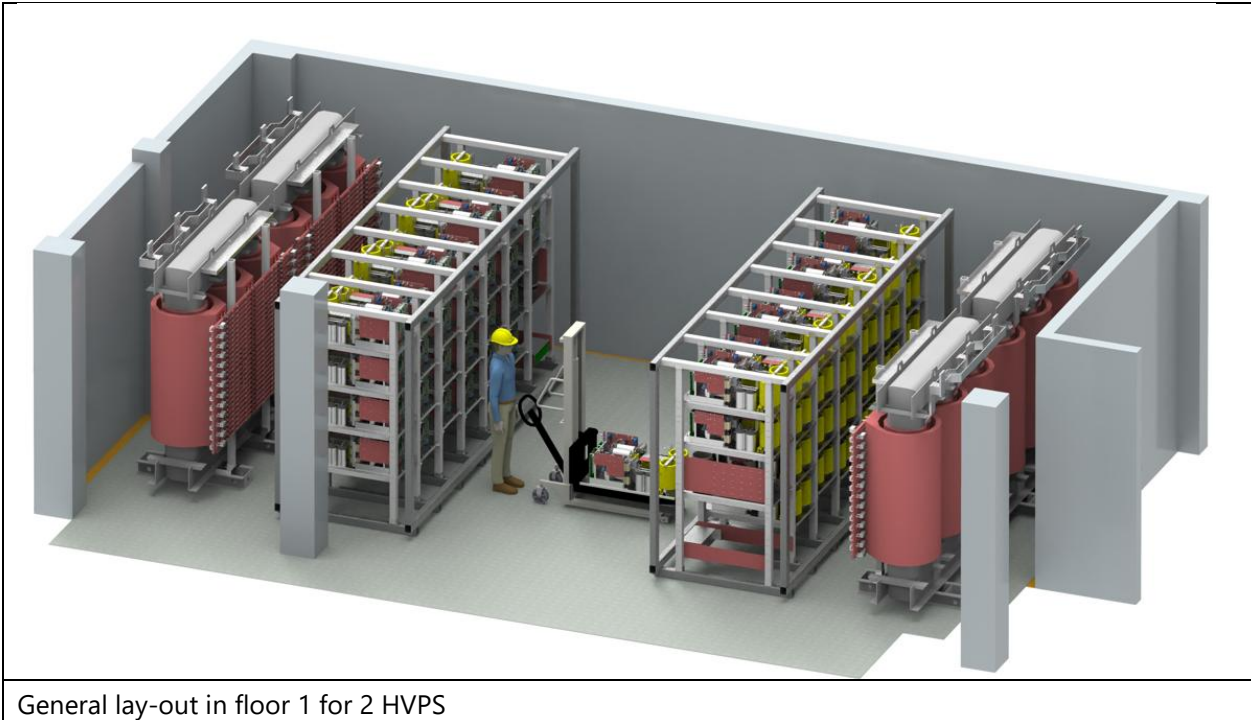
BPS main features

ID	Parameters	Value	Notes
	V_b nominal	33 kV	Referenced to ground
	I_b nominal	100 mA	
	I_b maximum	125 mA	
	Switch on/Switch-off time	< 10 ms	
	Max overshoot/undershoot	$\leq \pm 400$ V	$\leq \pm 1$ % @ 40 kV
	V_b accuracy	$\leq \pm 120$ V	$\leq \pm 0.3$ % @ 40 kV
	V_b reproducibility	$\leq \pm 120$ V	$\leq \pm 0.3$ % @ 40 kV
	V_b setability	$\leq \pm 120$ V	$\leq \pm 0.3$ % @ 40 kV
	V_b ripple	$\leq \pm 120$ V	$\leq \pm 0.3$ % @ 40 kV
	Ramp speed	$dV/dt > 1$ kV/ms	
	Measurement accuracy of voltage / current @ DC	0.1% / 0.2%	
	Measurement bandwidth (-3 dB)	2 MHz	The bandwidth is defined by -3 dB loss.
	Pulse Length (load)	15 sec	
	Pulse Length (load + no-load)	16 sec	
	Duty Cycle	up to 2%	
	Energy in an Arc event	< 10 J	This assumes 100 V arc voltage.
	BPS efficiency	> 75%	
	Voltage Stability (no-load to load events & load to no-load events)	$\leq \pm 400$ V	$\leq \pm 1$ % @ 40 kV
	Voltage Settling time (no-load to load & load to no-load events)	< 50 μ s	

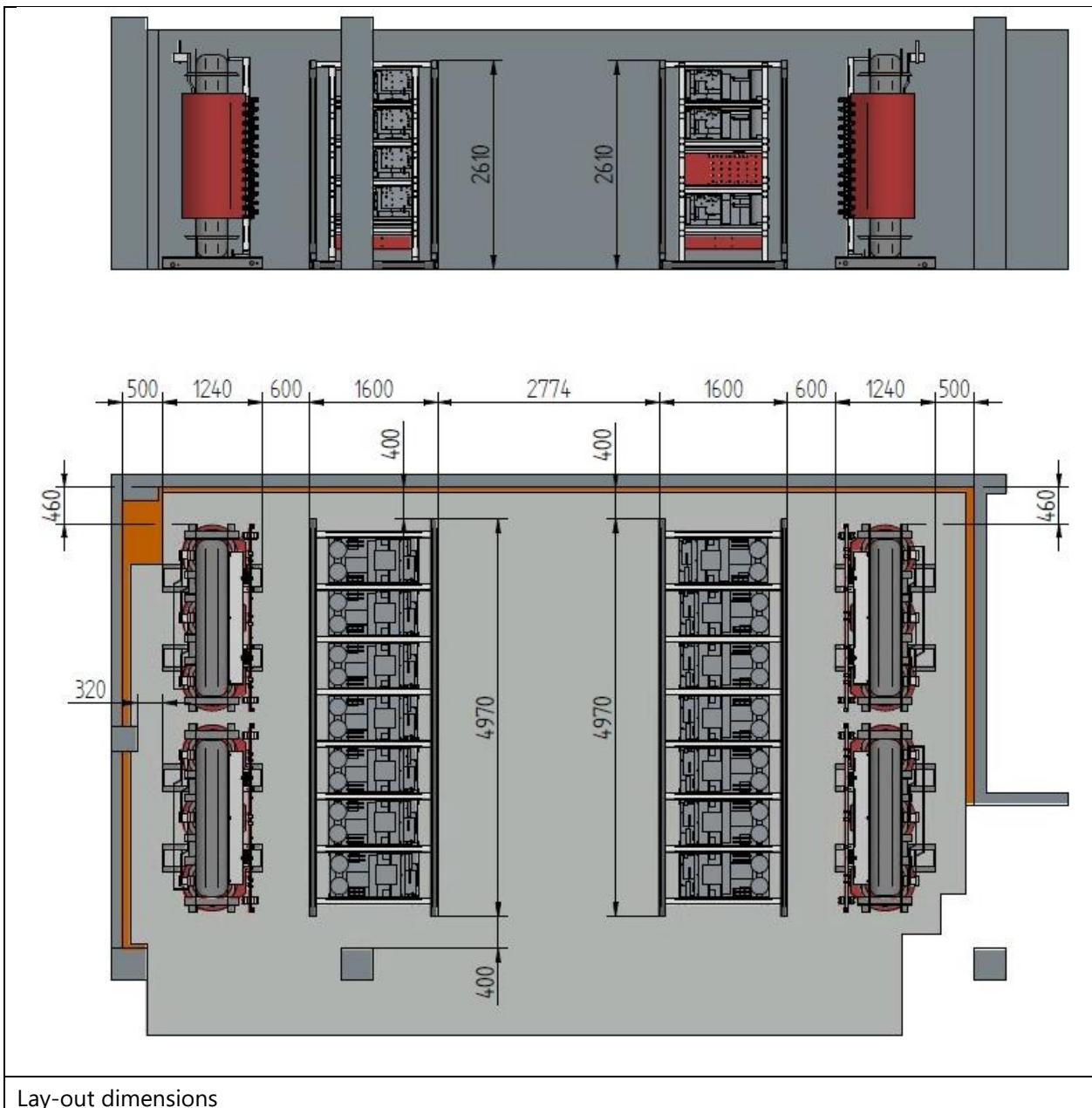
3. Lay-out

3.1 Floor 1

The following drawings show the proposed lay-out in floor 1 for 2 HVPS, this means, to feed up to 4 gyrotrons as per **REQ142**.



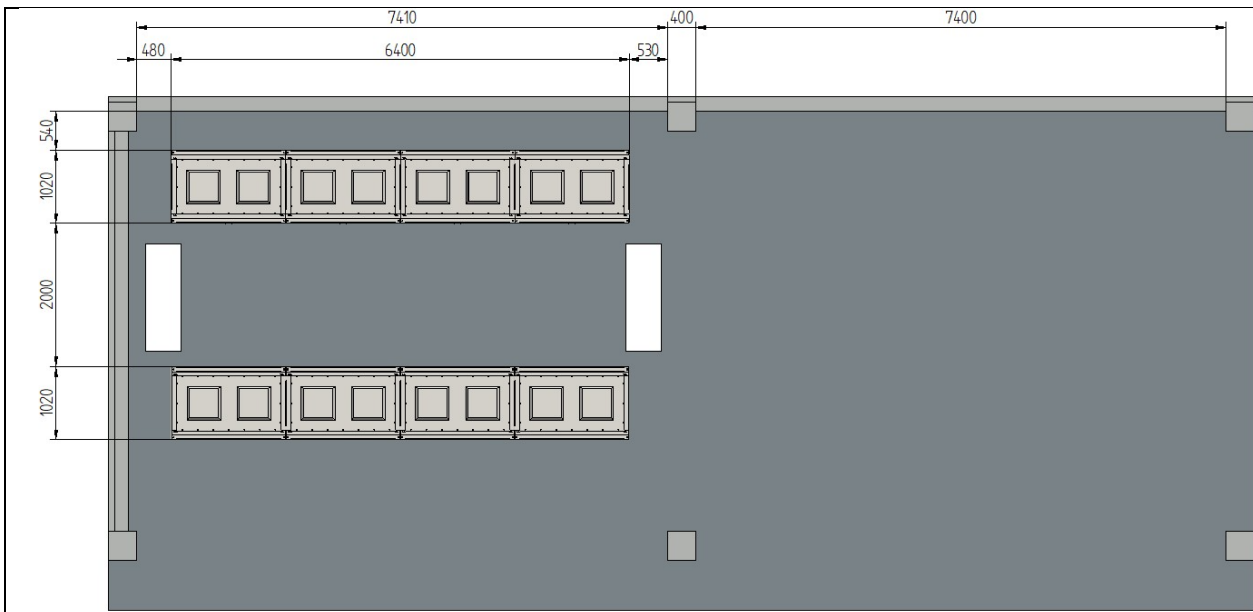
General lay-out in floor 1 for 2 HVPS



As can be seen in the drawing, the proposed lay-out allows good access for maintenance to all components. The dimensions are compatible with the door dimensions.

3.2 Floor 3

The following drawings show the proposed lay-out in floor 3 for 4 APS and 4 BPS, this means, to feed up to 4 gyrotrons as per **REQ142**. As can be seen in the drawings there is enough space to install 2 more stets for up to 6 gyrotrons.



2 APS and 2 BPS installed in the upper side of the drawing and 2 APS and 2 BPS in the bottom side

