

ELECTRICAL NETWORK AND POWER ELECTRONICS AT CERN: BUSINESS OPPORTUNITIES

BSBF 2022 / PARALLEL SESSION A1

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Outline

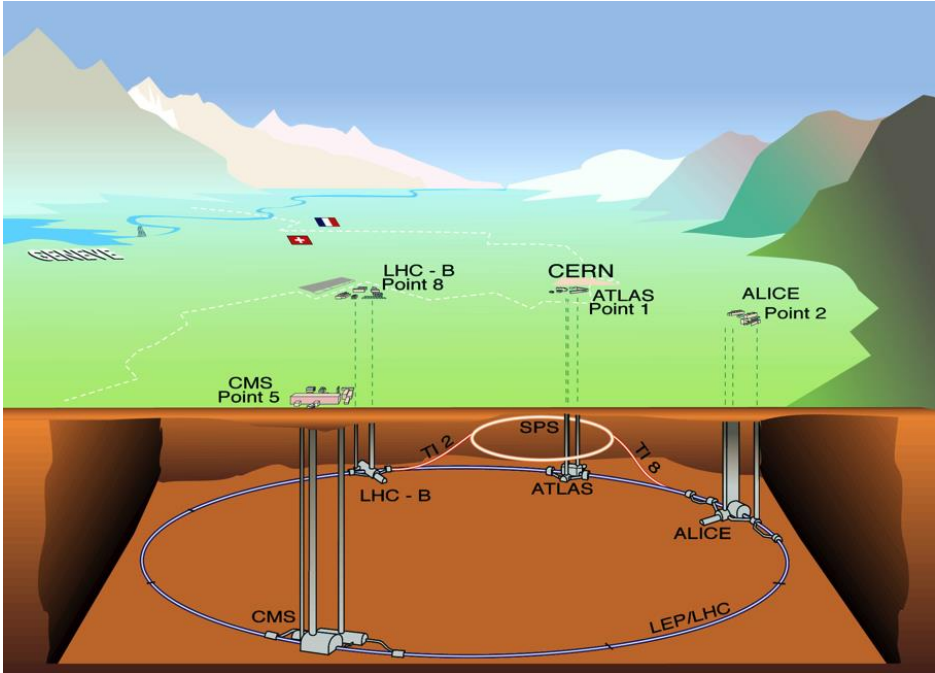
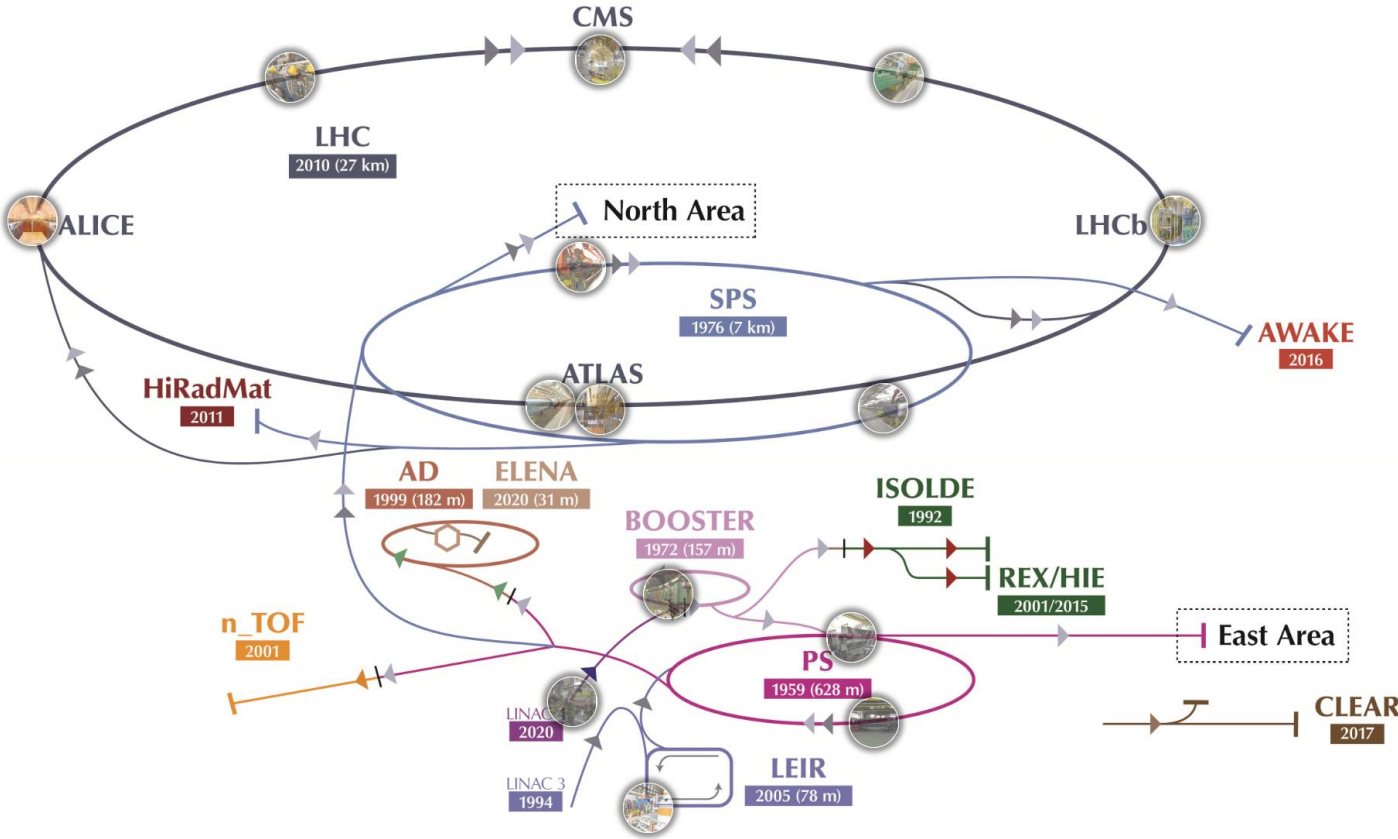
- **Introduction to CERN**
- **Electrical network**
- **Power converters**
- **Cables**
- **Conclusions**

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Introduction to CERN

The CERN accelerator complex

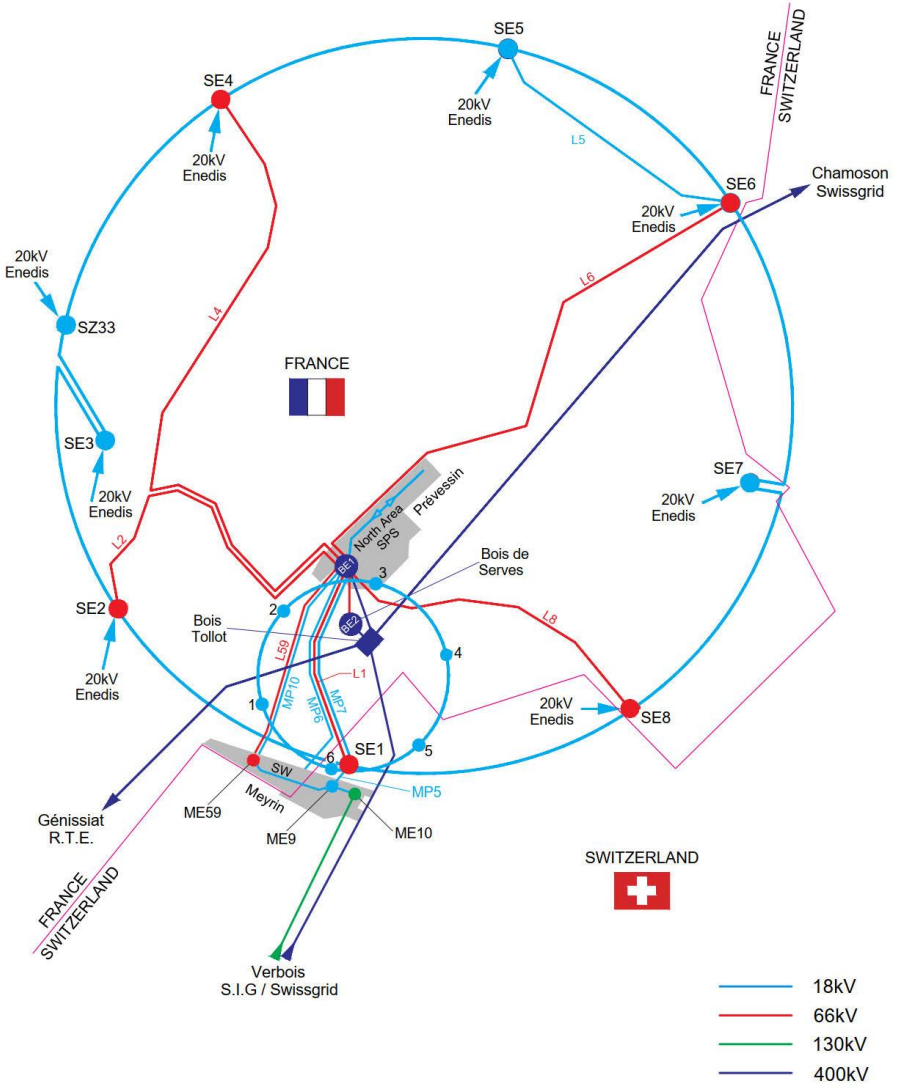


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Electrical transmission and distribution network

- Electrical equipment from 400 kV to 230/400 V
- Operation & Maintenance
- Projects: consolidation, upgrade and extension
- Electricity supply



Electrical transmission and distribution network

- Voltage levels

- 400 kV – 130 kV – 66 kV
- 20 kV – 18 kV – 3.3 kV
- 400 V – 230 V
- 48 V DC



- Main types of networks

- General services
- Machine
- Secured
- UPS distribution
- DC distribution



- Equipment quantities

- HV power transformers – 14
- Distribution transformers – 400
- MV switchgear – 1380
- LV switchboards – 760
- UPS systems – 330
- Monobloc batteries – 27 000
- 48 V DC systems – 100
- Diesel generators – 16
- Optical Fibre – 45 000 km

➔ **700 MVA installed at 400 kV level**

➔ **>350 MCHF of installed assets**

Supply and service contracts

- **Blanket contracts for the supply of equipment**
 - 12 currently in place (Transformers, LV Switchboards, MV Switchgear, UPS, 48 V systems, Optical fibres, etc.)
 - 5 years typical duration
- **Service contracts**
 - 8 contracts currently in place
 - 2 for installation (cabling & electrical equipment, fibre optics)
 - 6 for maintenance (General maintenance, LV Switchboards, MV Switchgear, Diesel Generators, UPS, etc.)
 - 3 years typical duration
- **One-time supply purchase orders**

Upcoming industrial opportunities: SUPPLY

Ref	Contract description	Contract type	Market Survey	Invitation to Tender	Estimated volume
→	Supply & installation of primary equipment for 66 kV substation	Purchase order	Q3 2022	Q4 2022	-
	Supply & installation of a 66/18 kV 38 MVA power transformer	Purchase order	Q4 2022	Q1 2023	1 unit
	Supply of 24 kV compact switchgear	Blanket contract	2023		TBD
	Supply of 2 emergency gensets rated 1.5 and 2.5 MVA	Purchase order	Q2 2023	Q4 2023	2 units
→	Supply of UPS units from 20 to 200 kVA	Blanket contract	Q1 2023	Q2 2023	100 units
	Supply of UPS installations from 300 to 2000 kVA	Purchase order	Q3 2024	Q4 2024	4 installations
	Supply of lead acid batteries for UPS	Purchase order	2023		2300 monoblocs
	IT-4749	Supply of LV switchboards	Blanket contract	Q1 2022 Ongoing	Q4 2022
IT-4643	Supply of water-cooled cables	Blanket contract	Ongoing	Q4 2022	120 cables – 2.5 km

Upcoming industrial opportunities: SERVICE

Ref.	Contract description	Comments	MS	IT
IT-4717	Maintenance of Borri UPS systems	Existing contract with Borri	Q2 2022 Ongoing	Q4 2022
	Maintenance of 400 kV and 66 kV transformers	New contract	2022	
IT-4740	Maintenance of diesel generator sets	Existing contract with 2H Energy	Q2 2022 Ongoing	Q4 2022
IT-4766	General maintenance services	Existing contract with COMSA	Q3 2022 Ongoing	Q4 2022

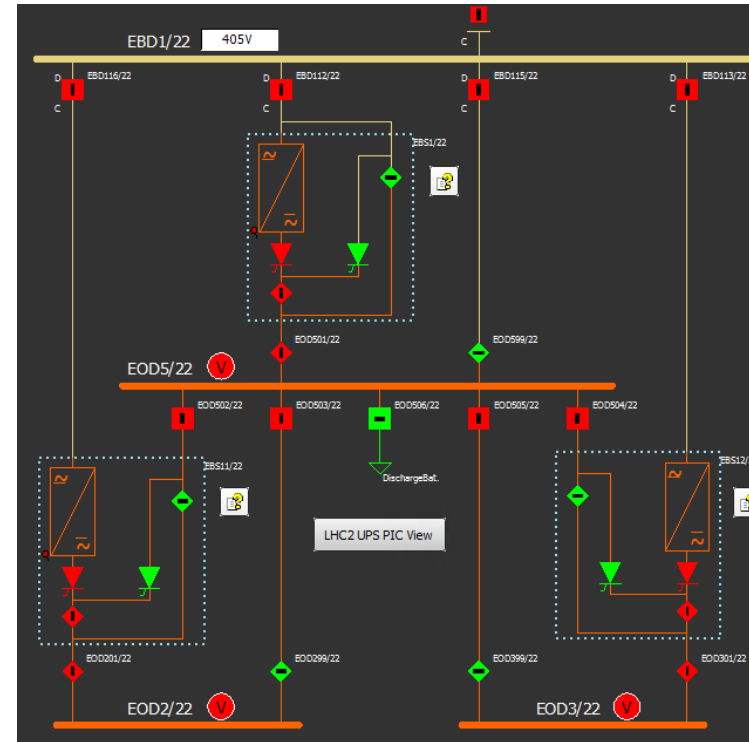
Example 1: 66 kV substation

- New 66 kVA substation for LHC point 5
- Purchase order for the **Primary equipment**
 - Beginning of procurement process in September 2022 (Market Survey)
 - Scope: Detailed Design, Supply, Installation and Commissioning
 - Equipment: Breaker, Current Transformers, Voltage Transformers, etc.
 - Installation during 2025
- Purchase order for the 66/18 kV **38 MVA Power Transformer**
 - Beginning of procurement process in Q4 2022 (Market Survey)
 - Scope: Supply, Installation and Commissioning
- Separate tender for Engineering and Civil works



Example 2: UPS

- More than 330 UPS installed, operated and maintained by CERN Electrical Group (36 MVA)
 - Accelerator protection
 - Experiments
 - IT Data centre
- UPS
 - Unitary power rating ranging from 10 to 600 kVA
 - Monolithic UPS
 - Double conversion
 - Single / Cascade / Parallel configurations
- Battery
 - Valve Regulated Lead Acid batteries (VRLA)
 - 10 min typical autonomy
 - Installed in cabinet or on rack



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Electrical power converters: introduction

- Power converters for all accelerators, transfer lines, experimental areas and tests facilities at CERN:
 - Solid-state modulators for RF klystrons;
 - High-voltage power converters for RF amplifiers and particle sources;
 - Power converters from 100W to 100MW for DC, cycling or pulsed magnets;
 - Static VAR compensators and harmonic filters.



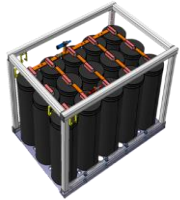
Electrical power converters: challenges

- Converters with efficient energy management including magnet energy recovery
- High-precision and fast-pulsed power converters (ms range)
- Advanced regulation & real time control
- Availability
- Capital and operational cost
- Radiation effects on electronics



Electrical Power Converters: opportunities

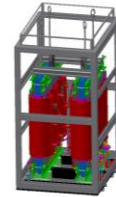
Energy storage modules



Power Stacks



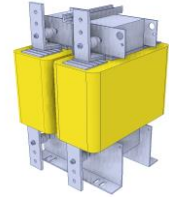
MV transformers



Power Resistors



LV Magnetics



Integration / Cabling



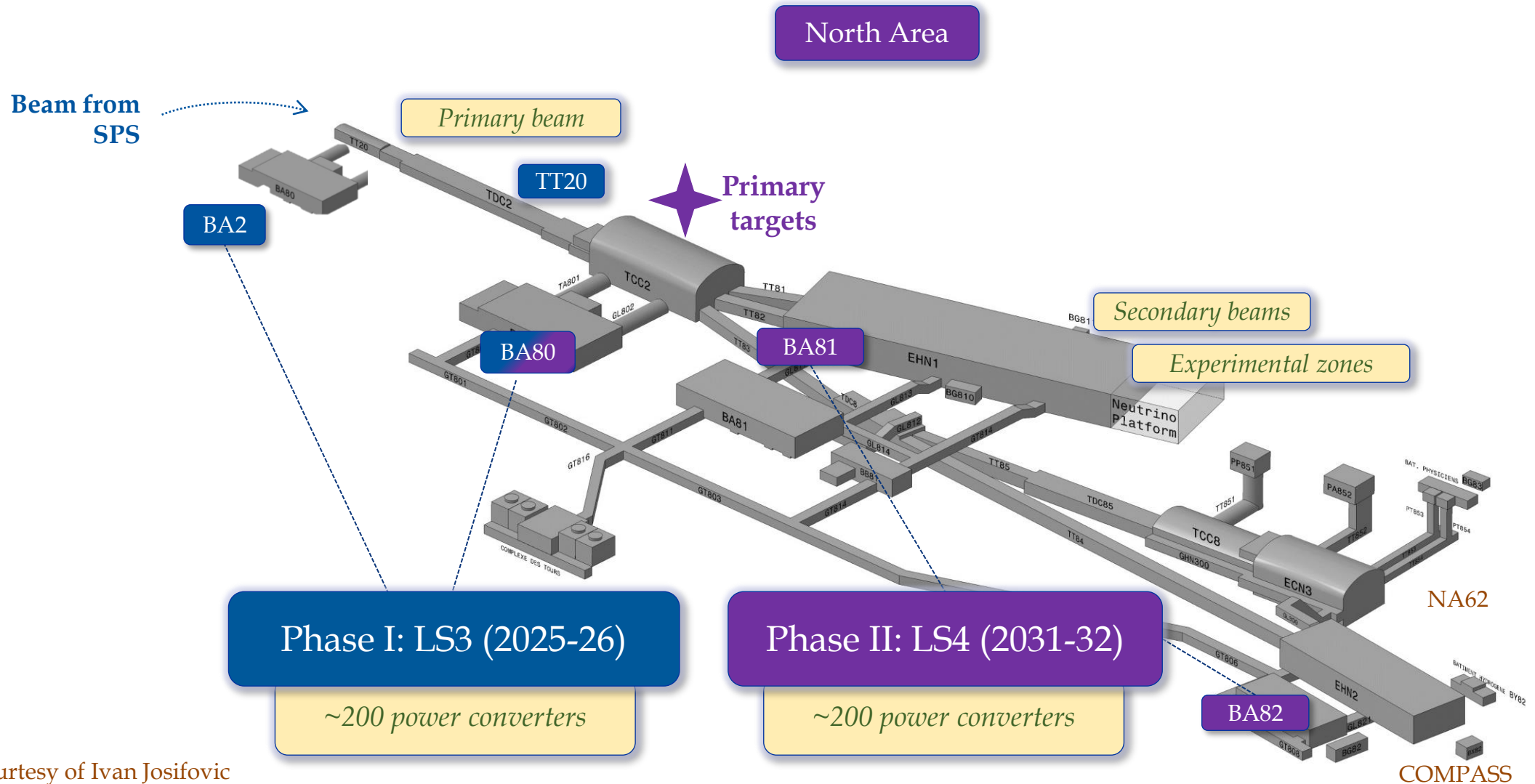
Be part of CERN consolidation and upgrade projects

Power Module Production



Design, manufacture, test
build-to-spec equipment's

Example 3: North Area consolidation 1/2

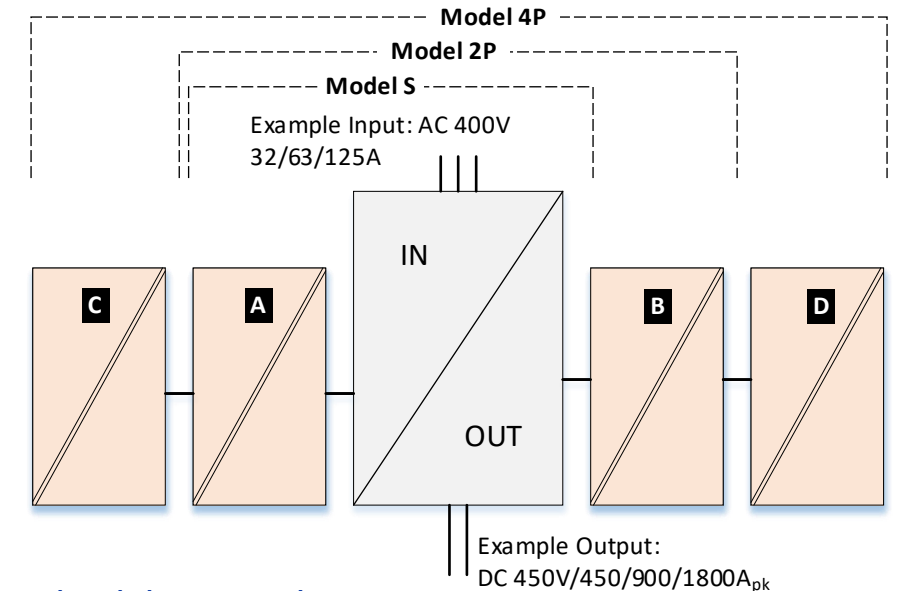


Courtesy of Ivan Josifovic

Example 3: North Area consolidation 2/2

Typical requirements

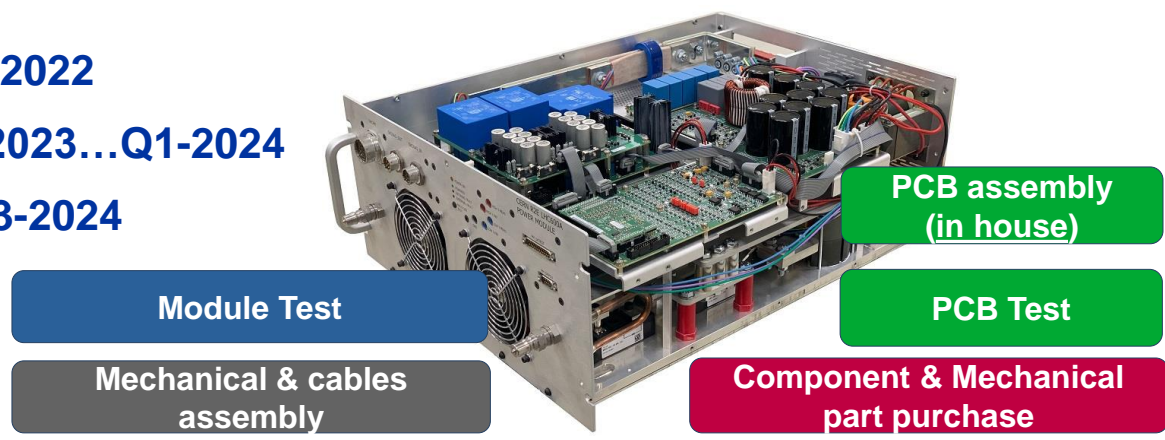
- ➔ Power converters cabinets manufacturing (built-to-print)
- ➔ Typical contract duration is 5 years (+2 option)
- ➔ Approximate quantities are 200 to 400 systems/7years
- ➔ The cabinet voltage level is 1000Vdc and supply voltage is 400Vac
- ➔ Typically integrated in 19inch racks (<5 racks per system)
- ➔ The scope of the supply includes:
 - the procurement of off-the-shelf parts
 - manufacturing or purchase of enclosures (cabinets)
 - Sheet metal works (cutting, drilling, bending, welding, surface treatment) for aluminium, steel.
 - copper busbar manufacturing (cutting, drilling, bending, surface treatment/insulation)
 - cooling water distribution circuit (<1inch pipework, inox + flexible hoses)
 - assembly, cabling, testing of subassemblies and complete cabinets
 - storage and delivery
- ➔ Outsourcing is permitted for parts of the



Example 4: High Luminosity LHC

- Four main types of Power Converters entirely designed by CERN (built-to-print)
- For each type: a housing rack + several Power Modules
- Approximate quantities
 - HL-LHC18kA-10V 5 converters / 220 power modules
 - HL-LHC14kA-08V 9 converters / 250 power modules
 - HL-LHC600A-10V ~20 converters / 70 power modules
 - R2E-HL-LHC120A-10V ~120 converters } 1200 power modules
 - R2E-HL-LHC60A-10V ~150 converters }

Power Modules MS Q4-2022
 Power Modules IT Q2-2023...Q1-2024
 Power Racks MS/IT2023-2024



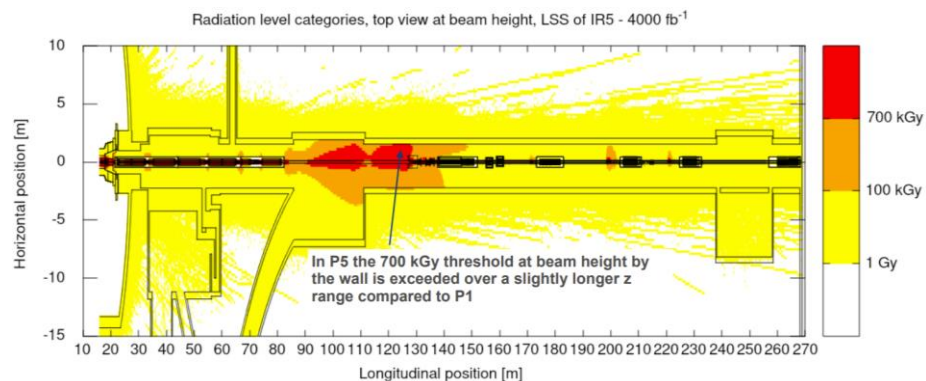
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Example 5: cables for HL-LHC



- New installations related to HL-LHC will require approximately 1300 km of signal and AC cables (and 700 km for other projects)
- Radiation levels are being assessed and rad-hard cables might be required, in addition to normal and fire-resistant cables
- Timeline
 - MS Q4/2022
 - Cables qualification at MS level (i.e. radiation, thermal aging)
 - Multiple ITs foreseen in 2024, after testing campaign
 - Manufacturing from Q4 2024 for approx. 3 years



- **Standard cables**, qualified up to 500 kGy (to be used up to 100 kGy)
- **Intermediate cables**, ideally qualified at least up to 3.5 MGy (i.e. ok up to 700 kGy in operation)
- **Rad-hard cables**, qualified up to 10 MGy (ok up to 2 MGy)

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Conclusions

CERN applications in the field of electrical network, power converters and cabling are interesting for the industry, and many opportunities are foreseen in the next year in the context of new projects (HL-LHC) or consolidations.

A list of forthcoming tenders can be found at this link

<https://forthcoming-ms.app.cern.ch/#/>

Register at the supplier portal

<https://procurement.web.cern.ch/home/supplier-portal>

Forthcoming Tendering Procedures

Forthcoming tendering procedures expected to exceed 200k CHF are listed below. Except if specified otherwise, the firms that have the right to reply to the Market Survey are only the ones which country of origin of supplies and services is one of CERN Member States.

If you would like to know more about a specific procedure, please, click on one of the following procedures. In case you are interested in a specific Market Survey, you will find the related document under "Available action". However, if the Market Survey documents have not been released yet, you are invited to express your interest by sending an email to the email address depicted in the same section.

Firms may reply as long as the tendering procedures are still on this page. Therefore, in case the deadline for replies indicated in the Market Survey cover letter is over, disregard the date on the cover letter but please send your reply to the Market Survey as soon as you can.

If you have any questions, please address them to procurement.service@cern.ch or to the procurement or technical officers in charge of the corresponding market survey.

Finally, we invite you to consult this page frequently as the status of each procedure is regularly updated.

Type keywords e.g. Magnets, Software, Civil Engineering, ...

200k 750k 5M 10M ∞
Cost Range (CHF)

More Filters Share Search Results Reset Filters

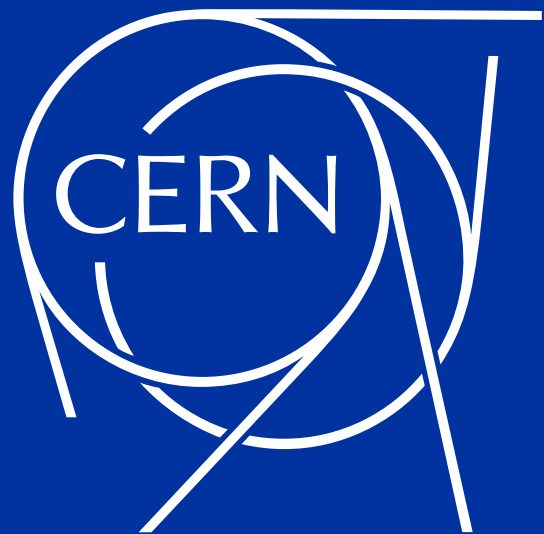
Publication date	Type of contract	Reference	Description	Cost Range (CHF)	Status	Next step
23/09/2022	Supply	IT-4821/SY	Supply of around forty-five 18 kV cast-resin rectifier power transformers with a rated power of 0.62 MVA.	750k - 5M	Announcement	Invitation to Tender 03/2023
23/09/2022	Supply	IT-4820/SY	Supply of around twenty 18 kV/1 kV @ 2 MVA/ cast-resin rectifier power transformer with a rated power	750k - 5M	Announcement	Invitation to Tender 12/2022



Thank you for your attention

For questions: stefano.bertolasi@cern.ch

Thanks to all the colleagues who contributed to this presentation, in particular
J. Emonds-Alt (EN-EL), H. Garcia (ATS-DO), V. Montabonnet (SY-EPC)



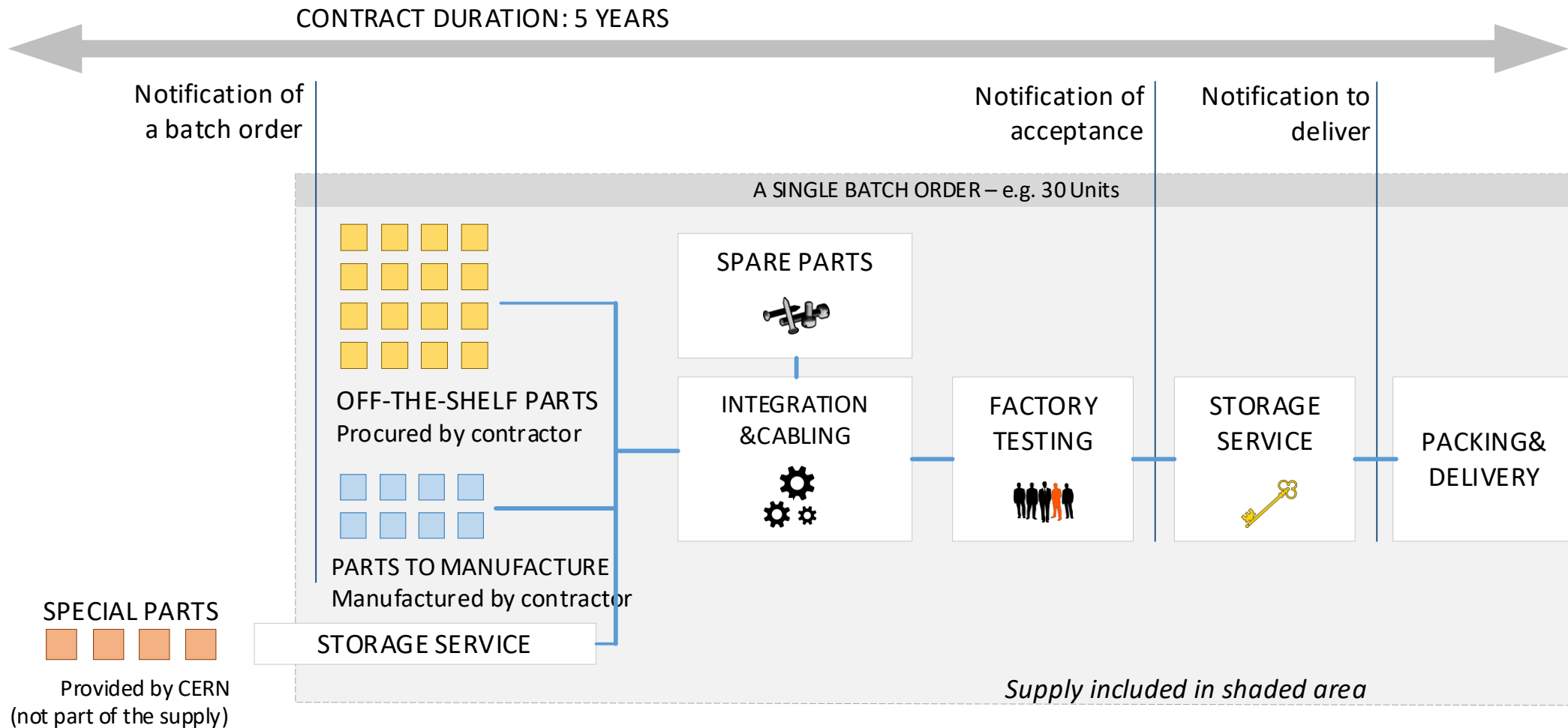
UPS 20 to 200 kVA: opportunities

- Contract: Blanket purchase contract, 5 years
- Scope: Supply of UPS and associated batteries (...maybe UPS only)
- Schedule: Market survey Q1 2023, Invitation to Tender Q3 2023
- Estimated volume
 - Up to 60 kVA – 50 units
 - 60 to 120 kVA – 30 units
 - 120 to 200 kVA – 20 units
- UPS
 - 3x400V+N, TN-S, 50 Hz
 - Modular UPS, N+1 redundancy
 - Static bypass / Manual Bypass included
 - Compliant with IEC 62040 (+ NF C 58 311)
 - max. 400 V DC battery
 - Front and rear access

UPS installations above 200 kVA: opportunities

- Contract: One-time supply purchase order(s)
- Scope: Supply of UPS and associated batteries, Commissioning and Maintenance
- UPS installation needs
 - 300 kVA (N+1)
 - 800 kVA (N+1)
 - 1200 kVA (N+1)
 - 2000 kVA (N+1)
- UPS requirements
 - Monolithic UPS (unitary power rating above 200 kVA)
 - Parallel operation with N+1 redundancy
 - Industrial application (high THDi, inrush current, etc.)
 - Particular loads (physic experiments)
 - Alternative solution envisaged: Static switch(es) + Inverter(s)
- Battery requirements – Same as 20 to 200 kVA UPS supply contract

Typical order roll-out

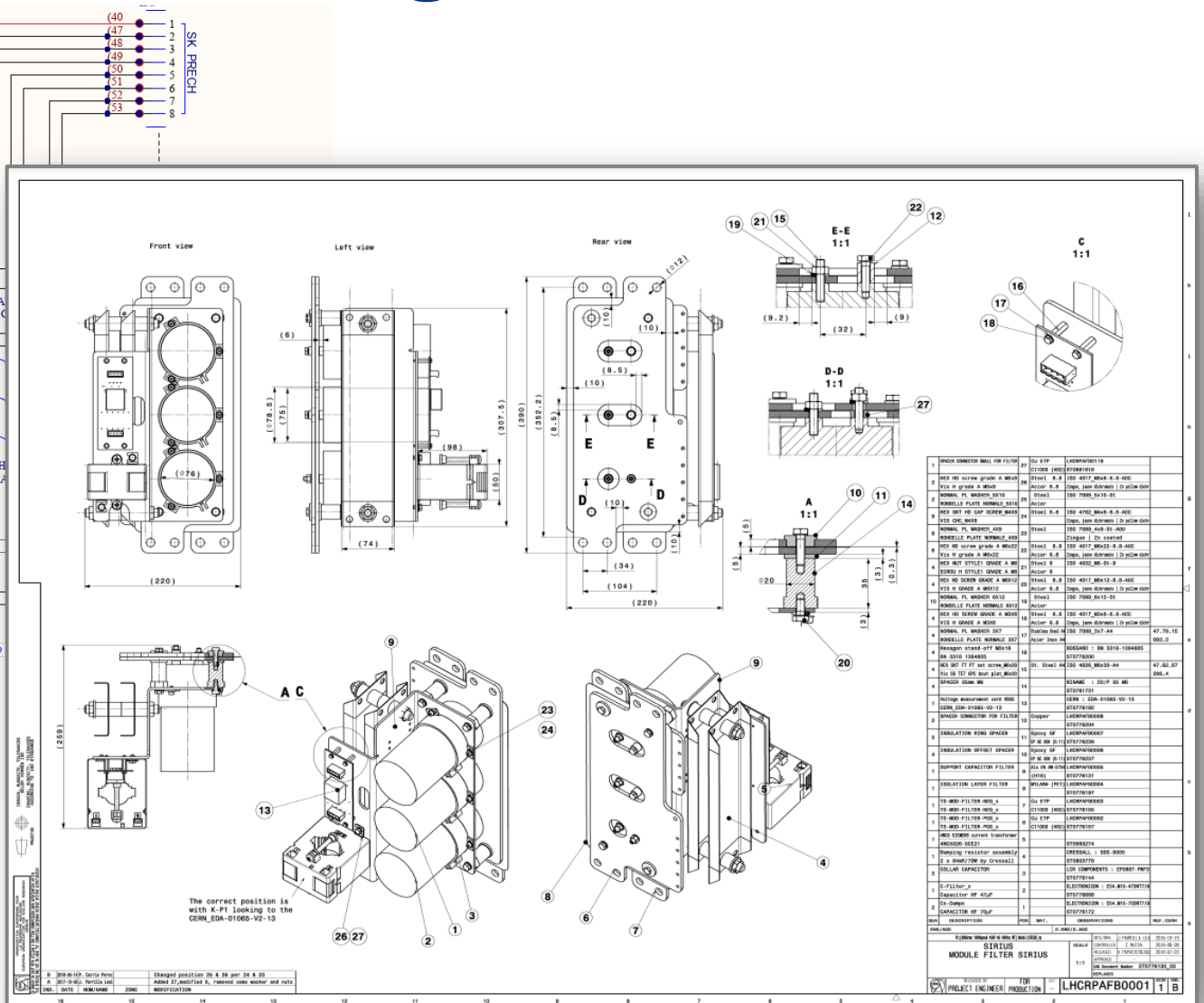
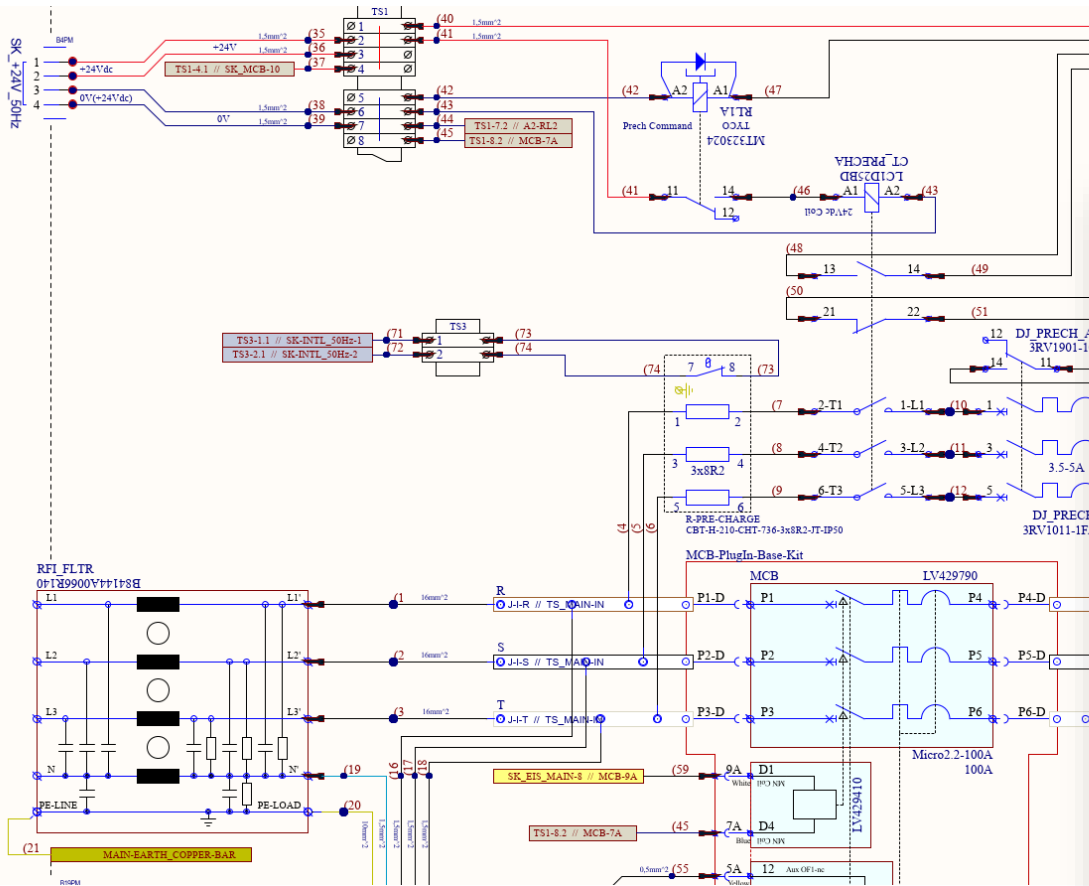


Built-to-print

CERN manufacturing folder includes:

- Electrical diagrams
 - ~10 A3 pages organised per sub-assembly
- Bill of materials
 - ~ 300 part numbers per model
- Drawings of parts & assemblies
 - ~ 120 2d and assembly drawings/converter model
- 3d step files
- Cabling lists
 - ~ 160 cables per converter model
- Auxiliaries (stickers, labels)

Electrical and mechanical drawings



Bill of materials

Bill of materials

ITEMS and documents												
Type	ST number	Revision	Definition	Nomenclature	Index	total qty	Make or Buy	Mass	Supplier	Supplier Ref	Document type	Material
48	ITEM	ISO 4762 M4x8-8.8-A0C	HEX SKT HD CAP SCREW_M4X8			20	Normalized					Steel 8.8
50	ITEM	ISO 7089 3x7-A4	NORMAL PL WASHER 3X7			4	Normalized					Stainless Steel A4 Acier Inox
52	ITEM	ISO 7089 4x9-St-A0U	NORMAL PL WASHER 4X9			13	Normalized					Steel
54	ITEM	ISO 7089 5x10-St	NORMAL PL WASHER 5X10			20	Normalized					Steel Acier
56	ITEM	ST0776131	SUPPORT CAPACITOR FILTER	LHCRPAFB0005		1	CERN Design					Alu EN AW-6060 (T6)
59	ITEM	ST0776144	COLLAR CAPACITOR			3	Commercial Item		LCR	COMPOI	EP0887-PNF3	
62	ITEM	ST0776155	TS-MOD-FILTER-NEG_x	LHCRPAFB0003		1	CERN Design					Cu ETP C11000 (H02)
65	ITEM	ST0776157	TS-MOD-FILTER-POS_x	LHCRPAFB0002		1	CERN Design					Cu ETP C11000 (H02)
68	ITEM	ST0776172	Cx-Dampx			2	Commercial Item		ELECTRONICO	E54.M15-703NT/9		
71	ITEM	ST0776192	Voltage measurement card VBUS			2	Commercial Item		CERN	EDA-01065-V2-10		
74	ITEM	ST0776195	TI TRANSFO 500/1A 4N53			1	Commercial Item		SIEMENS	4NCS326-OCE20		
77	ITEM	ST0776197	ISOLATION LAYER FILTER	LHCRPAFB0004		1	CERN Design					Polyethylene (PE)
80	ITEM	ST0776200	Hexagon stand-off M3x16			4	Commercial Item		BOSSARD	BN 3318-1384805		
83	ITEM	ST0776204	SPACER CONNECTOR FOR FILTER	LHCRPAFB0008		2	CERN Design					Copper
86	ITEM	ST0776237	INSULATION OFFSET SPACER	LHCRPAFB0006		4	CERN Design					Epoxy GF EP GC 308 (G-11)
89	ITEM	ST0776239	INSULATION RING SPACER	LHCRPAFB0007		2	CERN Design					Epoxy GF EP GC 308 (G-11)
93	ITEM	ST0776668	C-Filter			1	Commercial Item		ELECTRONICO	E54.M15-473NT/9		

Cables list

Cable name	Cable label	END 1				CABLE	END 2				
		terminal 1	termination reference 1	terminal 2	termination reference 2						
158											
159											
160	CA_+24V-50Hz	Main	24VAuxPow SK_+24V_OUT1	PLUG-ROUND-CABLE-4C-TY-UT	2x1.5mm2-CERN	200	Main	50HzSwBrd;-SK_+24V_50Hz	SOCKET-ROUND-CABLE-4C-TY-UT		
161				PIN-BURNDY-MAL-1.5mm2					PIN-BURNDY-FEM-1.5mm2		
162				PIN-BURNDY-MAL-1.5mm2					PIN-BURNDY-FEM-1.5mm2		
163											
164	CA_POWER-24V	Main	24VAuxPow SK_POWER-24V	PLUG-ROUND-CABLE-12C-TY-UT	12x0.5mm2-SHIELDED-CABLE	200	Main	CtrlCrate SK_POWER	SOCKET-ROUND-CABLE-12C-TY-UT		
177											
178	CA_M+24VOUT2 // J21-VSCOND	Main	24VAuxPow SK_+24V_OUT2	PLUG-ROUND-CABLE-4C-TY-UT	2x1.5mm2-CERN	150	Pow-A	VSCOND J21-VSCOND	SOCKET-WEID-2WAY		
181											
182											
183	CA_M+24VOUT3 // J24V-INTF	Main	24VAuxPow SK_+24V_OUT3	PLUG-ROUND-CABLE-4C-TY-UT	2x1.5mm2-CERN	150	Pow-A	PStack J24V-INTF			
186											
187											
188	CA_INTF // FG3-PULSES_A	Main	CtrlCrate SK_PULSES_A	PLUG-ROUND-CABLE-19C-TY-UT	24x0.22mm2-SHIELDED-CABLE	150	Pow-A	PStack SK_PULSE	SOCKET-ROUND-CABLE-19C-TY-UT		
208											

Example: SIRIUS converter

