
	Technical specification for the procurement of the HV power supply system for the MDT detector of the ATLAS experiment	Technical responsible of the specification: Dr. A. Lanza agostino.lanza@pv.infn.it
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Technical specification for the procurement of the HV power supply system for the MDT detector of the ATLAS experiment

The present document defines the technical specification of the HV power supply system for the MDT chambers of the ATLAS experiment, which will be operational from 2006 on the proton-proton beam of the new LHC accelerator at CERN.

The present specification requires the supply of:

- 1- **768 HV channels**, 0 to 4kV, 0 to 1mA full scale each, working in radiation and magnetic field environment, grouped in modules of 12 or 16 channels each and based on DC-DC converters;
- 2- For the above mentioned modules, **13 standard 19"/6U crates**, if module is composed of 12 channels, or **12 standard 19"/6U crates**, if module is composed of 16 channels, working in radiation and magnetic field environment. Each crate must host up to 10 modules and the interface to the remote controller. For **7 crates**, depth cannot exceed 460 mm, while for the other **6 (5 for modularity 16)** depth can reach up to 700 mm. All crates can be of the same depth (< 460 mm);
- 3- **1 mainframe**, hosting all remote controllers, working in non-hostile environment and able to control and monitor all channels;
- 4- All remote controllers necessary to control and monitor **12 crates**, or **64 (48) HV distributor modules**;
- 5- optionally, **1 primary generator system** for supplying all modules, working in non-hostile environment and able to provide a total output power of 5 kW.

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1. Introduction

1.1 The CERN

The CERN (European Centre for Nuclear Research) is a European organization of 20 member states. Its seat is in Switzerland, in Geneva, but a part of it also extends beyond the French border. Its aim is to offer the most up-to-date particle accelerators and their experimental zones to the international community of physicists .

At present, its laboratories and installations are used by more than 5000 physicists of research institutes of all continents .

1.2 The LHC accelerator


The Large Hadron Collider (LHC) is the accelerator under construction at CERN. It will accelerate and collide two proton beams of 7 TeV energy. The LHC is now in the installation phase in the 27 km long tunnel, 100 m underground, which hosted the LEP (Large Electron Positron) accelerator until 2000. The very big collision energy reached by protons is possible thanks to the use of superconducting magnets, working at the liquid Helium temperature.

The LHC will be operational from end 2007.

1.3 The ATLAS experiment

The ATLAS (A Toroidal Lhc ApparatuS) experiment aims to study the particle interactions produced by collisions in the LHC accelerator, measuring the momentum and energy of the particles produced by the above-mentioned collisions. It is formed by an international collaboration of roughly 2000 physicists, belonging to research centers of 34 countries of the five continents.

The experiment is composed of many detectors, and has a cylindrical shape, as shown in Fig. 1. It is placed in a cavern and surrounded by scaffolding (partially shown in Fig. 1),

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which host all electronics and gas racks and allow access to the detectors by means of platforms.

The most external part of the experiment is the muon apparatus, composed of four different detectors. The HV system, specified in the present document, is used to supply high voltage to the MDT (Monitored Drift Tube chambers) detector, which with its 5000 m² of drift tubes is able to measure the position of a particle with a precision of 50 microns.

Each MDT chamber is composed of aluminum tubes with a diameter of 30 mm, and length from 1 m up to 6 m, with a Tungsten wire of 50 micron diameter, stretched on the central axis. From 12 up to 72 tubes are glued one to each other to forming plane layers, which, glued together by three or four, form a structure called multilayer.


One MDT chamber is composed of two multilayers, separated by an aluminum spacer.

1.4 Subject of the procurement

The present document is intended for procurement of part of the MDT HV system. What needed in order to complete the procurement will be ordered separately by another Funding Agency, on the basis of the official documentation approved by I.N.F.N. for this tender.

Subject of this technical specification are the following components:

- 1 - **768 HV channels**, 0 to 4kV, 0 to 1mA full scale each, working in radiation and magnetic field environment and based on DC-DC converters. Modularity can be either 12 channels per module, totaling **64 modules**, or 16 channels per module, totaling **48 modules**;
- 2 - For the above mentioned modules, **13 standard 19"/6U crates**, if module has modularity of 12 channels, or **12 standard 19"/6U crates**, if module has modularity of 16 channels, working in radiation and magnetic field environment. Each crate must host up to 10 modules and the interface to the remote controller. For **7 crates**, depth

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cannot exceed 460 mm, while for the other **6** (**5** for modularity 16) depth can reach up to 700 mm. All crates can be of the same depth (< 460 mm);

3 - **1 mainframe**, hosting all remote controllers, working in non-hostile environment and able to control and monitor all channels;

4 - All remote controllers necessary to control and monitor **12 crates**, or **64 (48) HV distributor modules**;

5 - Optionally, **1 primary generator system** for supplying all modules, working in non-hostile environment and able to provide a total output power of 5 kW;


As described in the following section, the above reported components are not sufficient for fully equipping the MDT detector. Missed components will be ordered by another Funding Agency, different from I.N.F.N., on the basis of the documentation received by I.N.F.N. for this procurement. Details can be found in section 7.

2 - The MDT detector

2.1 Detector layout

The MDT detector, shown in Fig. 1, is composed of three parts: the central, called Barrel and represented in turquoise in Fig. 1, and the external ones, called Endcaps, represented in red and blue in the same picture. Endcaps are in turn composed of three “wheels”, of which the most internal, called Small Wheel, is the smaller (not visible in Fig. 1), and the most external, called External or Outer Wheel, is the bigger (shown in red in Fig. 1). The wheel shown in blue in Fig. 1 is called Big Wheel.

Barrel MDTs are of rectangular shape, while the Endcap ones are of trapezoidal shape. The main general parameters of the detector are summarized in Table 1.

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MDT chambers are composed of a variable number of proportional tubes, according to the type. They are built with aluminum tubes of 30 mm diameter and 0.4 mm wall thickness, on the central axis of which a W/Re of 0.05 mm diameter is stretched. They are filled in with a gas mixture of Ar and CO₂, in proportion of 93 to 7, at 3.0 absolute bar, and are flown at a rate of 1 volume exchange per day.

	Barrel	Endcap	Total
Chambers	656	516	1.172
Tubes	191.904	162.240	354.144
Total area (m ²)	3.122	2.391	5.513
Total weight (kg)	129.060	84.728	213.788
HV channels	656	516	1.172
HV distributors with modularity 12	55	42	97
HV distributors with modularity 16	41	32	83
HV distributor crates (modularity 12)	6	12	18
External splitter crates (modularity 12)	6	0	6
HV distributor crates (modularity 16)	5	12	17
External splitter crates (modularity 16)	5	0	5

Tab. 1 – Summary of main parameters of the MDT detector

Wires are polarized at 3.08 kV positive with respect to tubes, which are the chamber electrical ground. The average tube currents are of the order of 0.2 nA/m, corresponding to roughly 500 nA for the biggest chambers when operated without beam.

Under ATLAS environmental conditions, currents significantly increase. The calculated estimations are reported in Table 2, where three correction factors are used. Taking in account all of them, the current per tube for the hottest chambers in the Endcap region closest to the interaction point reaches 2.5 μ A, so the total current per chamber ranges from 0.5 and 0.75 mA, and the power consumption per chamber is more than 2 W.

The estimated MDT total power consumption is 2.6 kW.

MDT chambers

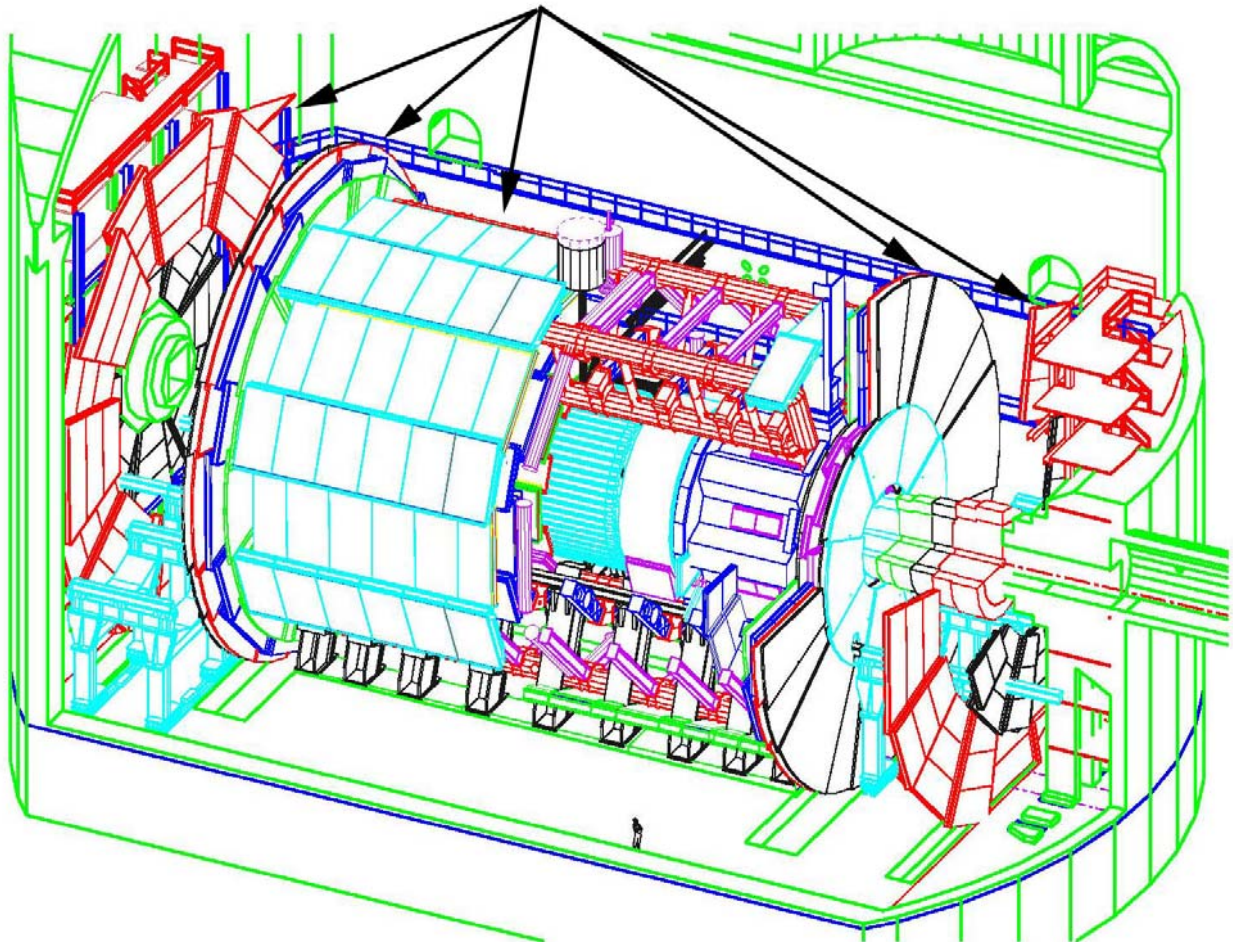



Fig. 1 - MDT detector layout in ATLAS. Part of the chambers are removed, in order to show the internal detectors. The man is on scale.

Spatial resolution essentially depends on the chamber working point, in terms of pressure, electrical polarization and temperature. Particularly, it worsens of about $10 \mu\text{m}$ for a gas gain variation of 5%, corresponding to a polarization change of 9 V.

Each chamber is connected to the HV system by means of an on-chamber splitter box, which distributes HV to each layer. Every splitter box has two inputs, one for each multilayer, equipped with SHV connectors. So, from the point of view of the HV system, each chamber is seen as two SHV connectors, separately supplying the two multilayers.

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In order to reduce the HV channels to one per chamber (for budget reasons), another out-of-chamber splitter is needed. These external HV splitters, which split one HV channel in two, are assembled in electronics modules hosted in 6U Europa crates, placed in the same racks used by the HV distributor crates, except for Endcap, where they are hosted in the same crates hosting the HV distributors.

		Nominal conditions		Fluctuation	Option
		Background from MC	Safety factor from MC	Peak luminosity at start-of-fill	2 x nominal luminosity
Correction factor		1	5	1,6	2
Cumulative factor		1	5	8	16
Current/tube	μA	0,16	0,81	1,30	2,59
Current/chamber	mA	0,05	0,23	0,37	0,75
Power/chamber	W	0,14	0,70	1,12	2,24
Total MDT power	W	164	820	1312	2624

Tab. 2 – Estimated MDT currents and powers

Table 1 summarizes the needed quantities, without spares, of HV distributors and crates, in both hypotheses of 12 and 16 modularity. It has to be remarked that for Endcap the number of crates is fixed, 4 each Wheel placed at the 4 corners, while for Barrel it depends on the number of distributor modules.

Out-of-chamber splitters are not discussed in this document, the only important point to underline is that one HV channel supplies one MDT chamber, so two multilayers.

2.2 Environmental operating requirements

The HV system is composed of three main blocks, called distributors, remote controllers and primary generators, which functionality and performance will be detailed in the following.

Distributors are placed in racks situated on the scaffolding surrounding ATLAS, as shown in Fig. 2, with the exception of the two Big Wheels and the two External Wheels (the blue and red chambers in Fig. 1), for which they are placed on the rim of the wheels.

For Barrel and Small Wheels, the height of electronics racks is 41U. For the Big and the External Wheels, each rack has to host only two crates and the cooling system, so their height is limited to 19U. Table 3 summarized the number of available racks for the detector subsystems.

The distance between electronics racks and the interaction point is 12 meters on average. At this position there is a not negligible radiation. Simulations show up that the most intense dose is between the end of the Barrel and the Big Wheels, where the interposed material is thinner.

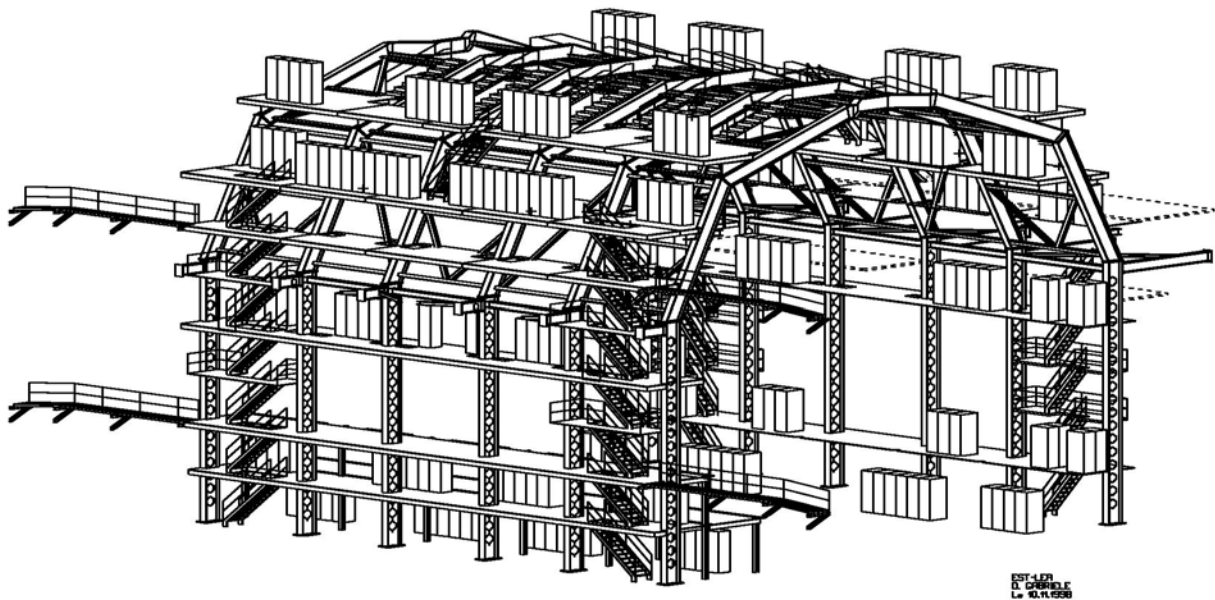


Fig. 2 – Electronics rack positions around the detector

Estimations of radiation take in account three different safety factors: one for simulation uncertainties, one for the low dose rate correction and one for the spread of different production lots of used integrated circuits.

	Available racks	Rack height	Crates/rack	Total
Barrel	7	41U	4	9
Small Wheels	2	41U	4	
Big Wheels	8	19U	2	16
External Wheels	8	19U	2	

Tab. 3 – Summary of available racks


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Table 4 summarizes the maximum radiation levels predicted for the rack positions, and the safety factors used. All HV distributors must be able to work at worst values without any damage.

Because of the toroidal magnet embedded in the MDT detector (the red coils in Fig. 1), electronics racks are also immersed in a quite intense magnetic field. The simulated upper limit is 0.1 T, as reported in Table 4. All HV distributors and the related crates must be able to cope with such environment. In particular, crate cooling systems cannot be based on standard fan units, due to the presence of high magnetic field.

Two options are feasible:

- crates are cooled by means of water, circulating in pipes properly embedded in them;
- crates are cooled by means of the mixed air-water system developed by a CERN group, a description of which is available at

<http://documents.cern.ch/archive/electronic/cern/groupdoc/epess/public/epess-2003-014.pdf>,


and

https://edms.cern.ch/file/336025/1/racks_tests_magnetiques.pdf.

This last option is the preferred one. It will be detailed in section 3.3.

	TID (Gray/10 years)	NIEL (1 MeV equivalent neutrons/(cm ² *10 years))	SEE (>20 MeV hadrons/(cm ² *10 years))	B field (Tesla)
Safety factor simulation	3,5	5	5	
Safety factor low dose rate	5	1	1	
Safety factor production lot	4	4	4	
Total safety factors	70	20	20	
Barrel and Small Wheel	186	1,2*10¹²	2,7*10¹¹	0,1
Big Wheel	63	8,8*10¹¹	2,2*10¹¹	0,1

Tab. 4 – Summary of radiation and B field requirements for HV distributors

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3 - System specification

3.1 General description

The logic diagram of the HV system is illustrated in Fig. 3. It is composed of three blocks:

- HV distributors and hosting crates
- Remote controllers in a mainframe
- Primary VDC generators

HV distributors are electronics modules hosted in crates placed around the detector. Their function is to generate the DC HV from the DC LV supplied by the primary generators, and each channel must be able to provide 4kV at 1mA current. The distributor design must be based on DC-DC conversion, in order to reduce the power dissipated in them to less than 20% of the total power delivered to chambers.

External splitters are modules with the same width than HV distributors, and are allocated in crates placed immediately below the distributor ones, so each distributor output can be connected to the external splitter input in the shortest possible way.

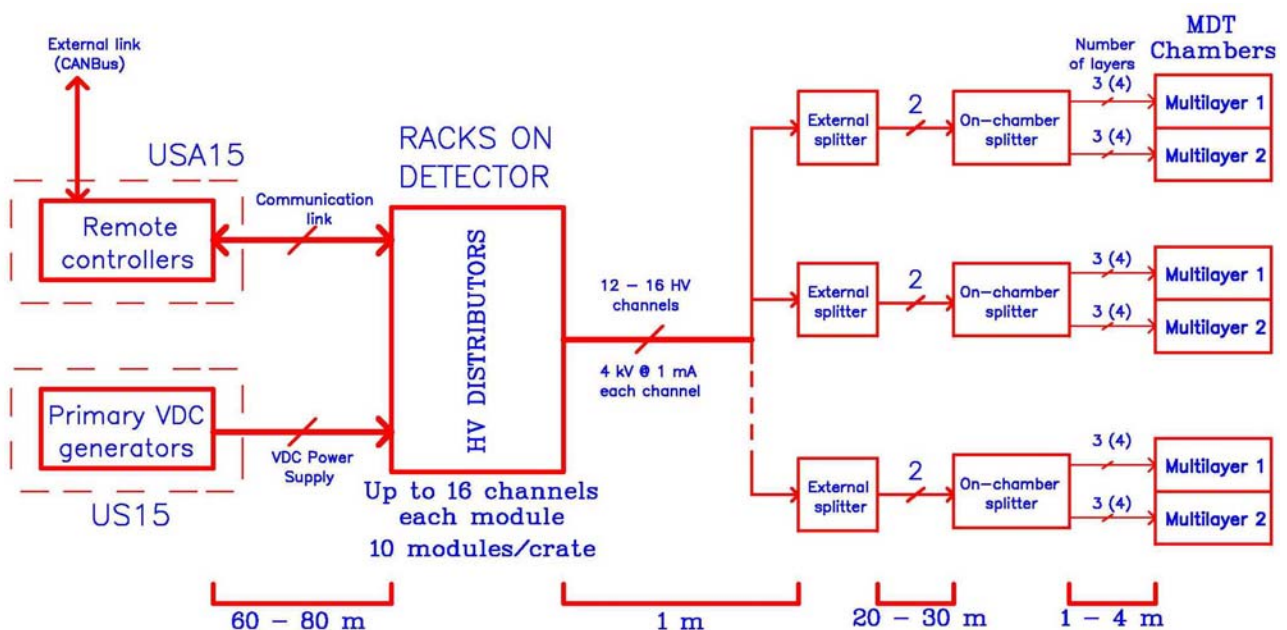



Fig. 3 - Logic diagram of the HV system

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HV distributors are controlled by remote controllers, placed in a mainframe in the ATLAS electronics hall, USA15, where there are no radiation and magnetic field issues. Controllers must initialize, set and monitor the distributors. They are linked to distributors by means of screened copper cables, from 60 to 80 meters long. Controllers are linked to the ATLAS central Detector Control System (DCS) via an Ethernet connection, which must be available on the mainframe.

Primary VDC generators provide the DC current necessary to supply the electronics of the HV distributors, and to feed them the power for generating HV. They must be based on switching DC-DC converters, in order to reduce dimensions, weight and costs. Primary generators are accommodated in a hall (US15) on the other side of the experiment with respect to the electronics hall USA15, where the environmental conditions are the same as USA15. The distance between them and the distributors is the same, 60 to 80 meters.

3.2 HV distributor

3.2.1 Functionality

HV distributors generate and supply HV to MDT chambers. So, they have to be fully programmable from remote mainframe. The main functionality requirements are listed in Table 5, and illustrated in the following.


Voltage and current settings must be done remotely via software, while local hardware regulation is not required. Exception is the maximum voltage limit, V_{max} , both remotely programmable via software and locally regulated via trimmer.

Trip logic must be implemented, in order to safely protect the detector against malfunctioning and accidents. In particular, when an overvoltage or an overcurrent event is detected, HV distributors must be switched off after a time set by the trip value.

Because of the negligible voltage drop on cables connecting distributors to chambers, no sense wires, or hardware compensation of cable impedance are required.

All set and output voltages and currents have to be monitored, together with the other main functional parameters. Exception is V_{max} , which doesn't need to be monitored.

Ramp up and ramp down parameters must be remotely programmable, in order to slowly increase and decrease HV on wires.

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Local hardware V_{set}	No
Remote software V_{set}	Yes
Local hardware I_{set}	No
Remote software I_{set}	Yes
Local hardware V_{max}	Yes
Remote software V_{max}	Yes
Trip logic	Yes
Overcurrent reaction	Channel is switched off
Overvoltage reaction	Channel is switched off
Sense wires	No
Impedance local adjustment	No
V_{set} monitoring	Yes
V_{out} monitoring	Yes
I_{set} monitoring	Yes
I_{out} monitoring	Yes
V_{max} monitoring	No
Programmable ramp up/down	Yes
Radiation performance	See section 2.2
B field performance	See section 2.2


Table 5 – HV distributor functionality

Distributors must be operational in radiation and magnetic field environment, as already described in detail in section 2.2.

3.2.2 Mechanical requirements

The HV distributor is an electronic module placed in a crate. Due to the requirement of hosting at least 10 of them in a standard 19" crate, each module must not be larger than 8 HP (40.64 mm). Module height is the standard double Europa (6U), so to allow up to 4 crates to be put in a 41U rack. Because of the available rack depth of 700 mm, its maximum depth must not exceed 430 mm, in order to leave enough space for backplanes and possible auxiliary electronics on the back of crates.

Channel modularity must be either 12 or 16. Crates are unaccessible from rear, so all connection should be put on the front panel. In particular, the HV connectors must be of SHV type, and must be available on the front panel. Other connectors, used for

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monitoring/control and for LV power supply, can be on the back side, if buses are used for them, but master connectors must be available on the front side at crate level.

Maximum height	6 U
Maximum width	8 HP
Maximum depth	430 mm
Channels/module	12 or 16
HV output connector	SHV on front panel
Monitoring/control and LV connectors	No requirements
"HV ON" signaling	One/channel on front panel
HV interlock	On front panel

Tab. 6 - HV distributor mechanical requirements

Close to each SHV connector on the front panel, there must be a LED indicating that the channel is ON.

For each module, it has to be available on the front panel an interlock switch, in order to hardware enable the module. Other features, like hardware limitation for HV and module current, can be implemented, but are not expressly required.

Table 6 summarizes the HV distributor mechanical requirements.

3.2.3 Electrical requirements

HV distributors are required to continuously operate at 3080 V, supplying currents ranging from some tens μA up to 700 μA . For this, their maximum voltage and current must be respectively 4000 V and 1000 μA .

Output voltage and current accuracies are intended as the difference between the monitored and the real values. In order to avoid gas gain variation greater than 5%, as explained in section 2.1, output voltage accuracy must be contained within 0.3% Full Scale (FS), while output current accuracy can be within 2% FS.

Maximum ripple in all the bandwidth of interest, 40 MHz, must be lower than 50 mV in common mode, while differential ripple, referred as the ripple measured between the positive pole and the ground pole of each channel, must be lower than 20 mV.

V_{out} range	0 - 4000 V positive
I_{out} output range	0 - 1000 μ A
V_{out} accuracy	\pm 0.3% FS
I_{out} accuracy	\pm 2% FS
Differential ripple	< 20 mVpp from 0 to 40 MHz
Common mode ripple	< 50 mVpp from 0 to 40 MHz
V_{set} range	0 - 4000 V
V_{set} resolution	1 V
I_{set} range	0 - 1000 μ A
I_{set} resolution	100 nA
V_{mon} resolution	1 V
I_{mon} resolution	100 nA
Ramp up/down range	10 - 500 V/s
Ramp up/down resolution	10 V/s
Trip resolution	0.1 s
Ground	Connected to earth. Floating is not required
Communications line decoupling	Optical, with $V_{breakdown} > 100$ V
Temperature stability	1000 ppm/ $^{\circ}$ C
Long term stability	1000 ppm/month
Conversion efficiency	> 70% at full load and 0.1 T B field
Power/module	< 70 W at full load and 0.1 T B field

Tab. 7 – HV distributor electrical requirements

Voltage and current sets must include all range, from 0 up to the maximum programmable value. Their resolution must be of 1V for voltage and 100 nA for current.

Ramp up and ramp down range must be within 10 and 500 V/s, programmable at least with 10 V/s steps. Trip feature must be programmable in steps of 0.1 s.


It is not required for each channel ground to be floating, all grounds can be connected to earth directly at module level.

All communications links must be optically decoupled from HV ground, in order to avoid ground loops. The breakdown voltage of the optocouplers must be at least 100 V.

Channel stability in temperature and over long term must not exceed 1000 ppm/ $^{\circ}$ C and 1000 ppm/month.

Power consumption of whole module must be less than 70 W all included, at full load and in operating conditions of 0.1 T magnetic field.

Table 7 illustrates the HV distributor electrical requirements.

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3.3 Crate requirements

Crates are based on the standard Europa chassis, 19" large and 6U high. Maximum depth depends on their position, as shown in Table 8. Crate depth on External and Big Wheels is limited by the available space. Barrel and Small Wheel crates can be up to 700 mm deep, but there is no constraint for getting them of the same depth as for the two wheels.

No ventilation unit must be embedded in crates. Their cooling must be done using one of the two following options:

A – water cooling by means of copper pipes embedded in crates. If this option is used, the total crate height, including cooling pipes, must not exceed 8U. Pipes must be terminated with 1/2" nuts. Cooling water circuit is available at each rack position, and it must be taken in account that pressure of circulating water will be kept below 1 bar for safety reasons;


	Needed crates	Maximum crate depth (mm)
External Wheel	4	460
Big Wheel	4	460
Small Wheel	4	700
Barrel	6	700

Tab. 8 – Maximum crate depth in Barrel and Endcap

B – mixed water-air cooling developed by CERN. It is composed of one 4U turbine unit, placed at the top of a rack, which flows air from bottom to top and dissipates up to 3kW power, four 1U heat exchangers, placed under each crate, which are cooled by water, and one 2U deflector unit, placed at the bottom of a rack, which deflects the air to the turbine unit. Total space occupied by the cooling system is 10U.

The second option was standardized by CERN and is available at the Store. All electronics racks of the LHC experiments placed in magnetic field greater than 50 Gauss will use this cooling system.

Crate power supply and communications connectors should be placed in front, using the slot out of 21 not occupied by the HV distributors.

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3.4 Remote controller and mainframe requirements

All remote controllers necessary to operate the HV distributors must reside in one mainframe. One remote controller controls at least one distributor crate, so from Table 1 the maximum number of controllers are 18. Therefore, they can be hosted in only one mainframe.

Remote controllers are placed in a non-hostile environment, USA15, and are linked to distributor crates by means of control cables, each one 60 - 80 meters long. The implemented hardware protocol must be able to communicate without errors using cables of at least 100 meters long.


The mainframe must be equipped with an Ethernet port, and optionally with a CANBus port. It can operate the system either standalone, by means of embedded display and keyboard, or with the aid of a PC.

The mainframe is cooled by means of a standard ventilation unit. Its dimensions must not exceed 19" (width) by 6U (height) by 700 mm (depth). Ventilation unit height must not exceed 4U.

3.5 Primary VDC generator system requirements

HV distributors are fed by an AC-DC generator system. It must be composed of more than one unit, in order to increase system granularity and avoid higher currents on connecting cables, so big voltage drop on them. Primary generators are connected to each distributor crate by means of screened cables with a section of 12 mm². Referring to the maximum power consumption per module, as detailed in section 3.2.3, and considering a standard generator output voltage of 48V, the maximum current for a full load crate is of the order of 15A, which leads to a voltage drop of about 2V for the present cable estimated length.

Primary generator chassis must be of rack type, 19" large. Its dimensions must not exceed 6U in height and 700 mm in depth. Cooling unit (ventilation fans) is requested, if not embedded in the generator unit. In such case, the height limitation of 6U includes the cooling unit.

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Output voltage must be compatible with the requirements of the HV distributors.

Chassis	Rack type, 19"
Unit max dimensions	6U (height) x 700 mm (depth)
Cooling	Embedded or external fan unit
Output voltage	Compatible with the HV distributor input
Unit output power	From 2kW to 3kW
Output connectors	Screw and nuts (preferred)
AC input voltage	240/415 VAC 50 Hz 2P+N+E
AC mains plug	IEC 309 standard
Load/line regulation and stability in time	Compatible with the HV distributor technical specifications

Tab. 9 – Requirements of primary VDC generator system

Output connectors should be made of screw and nuts, so cable connectors can be simple cable lugs.

Preferred AC input voltage is three phases 240/415 VAC, 50 Hz, plus Neutral and Earth, for which mains plug should be of IEC 309 standard. Single phase units, if available, can be quoted as well.


All electrical specification must comply with the HV distributor specification. Table 9 summarizes the primary generator requirements.

4 - Documentation and Quality Control

4.1 Conformities and documentation provided by the Supplier

Components subject of the present document must conform to all specified requirements and to CERN safety instructions IS N. 23 (electrical cables), IS N. 28 (dangers due to electricity) and IS N. 41 (plastic materials), available at

<http://safety-commission.web.cern.ch/safety-commission/TIS-site/index.html>.

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The Supplier must certificate its capability of producing radiation and magnetic field tolerant electronics, by means of any reference documenting radiation and magnetic field tests performed on HV system components, and particularly on the HV distributor model subject of the offer. Such documents must be attached to the offer documentation. Also links to public documentation available on web are accepted.

The Supplier must declare, under its responsibility, that the HV distributor model quoted in the offer is radiation and magnetic field tolerant, and satisfies the requirements reported in section 2.2. The declaration must be attached to the offer documentation.


The Supplier must provide the Quality Assurance Plan (QAP), reporting all tests performed by it on the blocks composing the system, test methodology and conformity to International Standards (ISO, IEC, etc.), within two months from notification of contract. The QAP must be approved or rejected by I.N.F.N. by written notification within four weeks from its reception. Rejected QAP must be changed by the Supplier in agreement with I.N.F.N. until the agreed final version is approved by I.N.F.N. by written notification. Final approval of QAP must happen in any case before the pre-series delivery.

For each component block of the system (HV distributors, crates, remote controllers, primary VDC generators and mainframe), the Supplier must provide at the delivery time a fully detailed datasheet and a Users' manual.

For each single component of the system, the Supplier must provide at the delivery time a properly signed Certification sheet of compliance, reporting the component type, its serial number and the global result of the tests performed on it, according to the QAP.

4.2 Radiation and magnetic field policy

ATLAS defined a specific policy for designing, producing and testing electronics that must be operational in radiation environment, but, for reasons of cost, designed with standard commercial components (the so-called COTS, Components-Off-The-Shelf) that are not certified to be radiation resistant by their producers. It is available at <http://atlas.web.cern.ch/Atlas/GROUPS/FRONTEND/radhard.htm>, "ATLAS policy on radiation tolerant electronics".

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HV distributors, which have to be operational in radiation environment, must comply with the criteria established in the above mentioned policy, in particular they have to be tested following the methods there defined.

The Supplier accepts the responsibility of offering a HV distributor model that complies with the ATLAS policy and with the requirements written in section 2.2, and of declaring, that all HV distributor modules will comply with the requirements written in section 2.2.

I.N.F.N. has the responsibility of carefully testing HV distributor samples under both radiation and magnetic field environments, following the ATLAS policy, and of certifying their performance suitable for use in the MDT detector.


Minimum number of HV channels to be tested by I.N.F.N. is 3% of the total (1,172). They will be picked up from the pre-series production. Test results will be sent by written notification to the Supplier, and will lead to acceptance or rejection of the pre-series, together with the other tests detailed in section 4.3.2.

I.N.F.N. reserves the rights of testing any other HV distributor belonging to the series production.

The Supplier has the obligation of replacing any HV distributor module or part of it that will fail working in the ATLAS real environment without any additional charge to I.N.F.N., even after the full delivery of the system, if demonstrated by I.N.F.N. that the requirements written in section 2.2 are not exceeded.

4.3 Tests and acceptance criteria

All components subject of this document must be tested and certified by the Supplier, as stated in section 4.1. I.N.F.N. will perform other tests at CERN and in other available accelerator facilities, and components will be accepted only if they pass all tests, as described in the following sections. Rejected components must be fixed or replaced by the Supplier without any additional charge to I.N.F.N., transportation from and to CERN included.

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4.3.1 Tests to be performed by the Supplier

All mechanical, electrical and functional tests necessary to declare component compliance to the requirements stated in the present document must be performed by the Supplier. All tests must comply with the approved QAP.

All equipment necessary to perform the above mentioned tests, including software, must be procured by the Supplier.


4.3.2 Tests to be performed by I.N.F.N.

I.N.F.N. will perform the following tests:

- Radiation test on three HV distributors for TID, NIEL and SEE certification;
- Magnetic field test on three HV distributors (they could be different from the ones used for previous test);
- Mechanical and electrical tests on HV distributors (dimensions, electrical performance);
- Mechanical tests on crates (dimensions, insertion/extraction of modules, insertion of power and control connectors);
- Mechanical and electrical tests on primary VDC generators (dimensions, delivered power);
- Functional tests on mainframe and remote controllers, connected to HV distributors using cables of final length;
- Global test of all components connected together.

The Supplier will be informed in advance of dates and places where the tests will be done. Supplier personnel can participate to the tests in agreement with I.N.F.N., but without any additional charge to I.N.F.N..

Components that fail one or more tests will be declared non-compliant to the technical specification, and rejected with a written notification to the Supplier. The Supplier has the obligation of repairing or replacing non-compliant components or part of them without any additional charge to I.N.F.N..

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4.4 Maintenance at CERN during operation

The ATLAS experiment will last at least for 10 years starting from 2008. The HV system will be operational for more than 50% of this time at nominal voltage, and for the rest of the time at a reduced voltage.

The Supplier is required to software update, repair and maintain in good working conditions directly at CERN all the supplied components subject of this document, including the ones ordered by other Funding Agencies, up to 2018.

In order to provide maintenance, the Supplier is required to purchase in due time on the market all necessary estimated critical components needed up to 2018, especially the ones working in hostile environment.

In case of replacement of critical components with other ones of different producers or different types, the Supplier must guarantee the same performance of the system as it was before the replacement. Modules no more working in hostile environment after component replacements must be fully replaced by the Supplier without any additional charge for I.N.F.N..

The above mentioned requirements are intended as implicitly accepted by the Supplier by acceptance of the present document, if not expressly rejected in the offer documentation.


5 - Pre-series and series productions

In order to evaluate the compliance of the requested components to the present document, they must be produced in two steps, the pre-series and the series production.

5.1 Pre-series production quantities

Pre-series production includes:

- **5 HV distributor modules;**
- **2 crates**, of which at least one with depth less than 460 mm;
- **1 remote controller;**
- **1 mainframe;**

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- **1 primary generator VDC unit.**

5.2 Series production quantities

Series production includes all the rest, which is:

- **59 HV distributor modules** (if modularity 12) or **43 HV distributor modules** (if modularity 16)
- **11 crates** (if modularity 12), or **10 crates** (if modularity 16), with depth specified in section 1.4;
- **All other remote controllers**, as specified in section 1.4;
- **All others primary generator VDC units**, as specified in section 1.4.

6 - Shipment and delivery schedule

6.1 Shipment address

All components must be delivered duty unpaid (DDU) at CERN Laboratory, Switzerland, at the following address:

CERN, Meyrin site


CH - 1211 Geneve 23, Switzerland

The reference person for reception of components will be indicated later.

6.2 Delivery time schedule

The requested delivery time schedule is the following:

- Pre-series production within 120 solar days from notification of contract;
- Series production:
 - 1 - 50% of components (approximately) within 90 solar days from written notification of Provisional Acceptance of the pre-series production;
 - 2 - All remaining components within 90 solar days from first series delivery.

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The Supplier can propose in the offer a different delivery schedule, but it must be accepted by I.N.F.N. with a written notification in order to be valid.

6.3 Provisional Acceptance

Series production must not start until Provisional Acceptance notification of the pre-series production has been given in writing to the Supplier by I.N.F.N.

Provisional Acceptance for series production will be granted for each individual component. If rejection of single component of series production is not notified in writing to the Supplier within 90 solar days from its reception at CERN, Provisional Acceptance is implicitly notified, with the exception of what required in the last sentence of section 4.2.

7 - Offer

Offer is composed of the following documentation:

1 – Price quotation for:


- A – **64 (or 48) HV distributor modules**, as explained in section 1.4;
- B – **13 (or 12) crates**, as explained in section 1.4;
- C – **1 mainframe**;
- D – **As many remote controllers as needed for driving 12 crates**.

2 – Price quotation for the following option:

- A - **As many primary VDC generator units as needed for getting available 5 kW power**, as explained in section 1.4, with possibly both three phases and single phase AC input quoted.

3 – Price quotation for an order issued later, covering the remaining components needed for the MDT HV system, including:

- A – **36 (if modularity 12) or 38 (if modularity 16) HV distributor modules** as quoted in point 1A, taking 3 as spare with respect to the total number reported in 2.1;

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B - **7 crates**, same as quoted in point 1B, of which at least **5** with depth not greater than 460 mm, as explained in 1.4;

C - **As many remote controllers as needed for driving 7 crates, or 36 (38) HV distributor modules** (the least between the two choices), as quoted in point 1D.

4 - Price quotation for the following option of the order issued later:

A - **As many primary VDC generator units as needed for getting between 2 and 3 kW**, as quoted in point 2A.

The order issued later, for which the quotations of points 3 and 4 are valid, will be issued by another Funding Agency, different from I.N.F.N., and will be based on this offer documentation. Validity of offer for points 3 and 4 must not be less than 6 months. The Funding Agency financing this order will issue a pledge for it after the I.N.F.N. approval of the tender.

5 - Price quotation for the following option:

A - Additional purchase of up to **10 other HV distributor modules**. The validity of the offer for this option must last for at least 12 months.

All quotations in points 1, 2, 3, 4 and 5 must include cost transportation to CERN. They must be separated from component cost.

6 - Documentation proving that the Supplier has experience in designing radiation and magnetic field tolerant power supplies, and in particular all tests performed on the proposed HV distributor, as explained in section 4.1.

7 - Declaration that the proposed HV distributor model comply with the environment requirements listed in section 2.2.

8 - Acceptance document of the requirements listed in sections 4.2, 4.4 and 6.2. Any disagreement must be reported in writing on this document. I.N.F.N. reserves the rights of excluding from tender Suppliers not accepting the requirements of sections 4.2 and 4.4.