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TECHNICAL SPECIFICATION FOR SUBRACKS FOR LHC EXPERIMENTS

ABSTRACT

This document describes 6U and 9U subracks[1] for use by the four LHC experiments, ALICE, ATLAS, CMS and LHCb. The subracks shall be constructed according to the IEEE 1101.1, 1101.10 and 1101.11 mechanical standards and will be equipped with backplanes either application-specific, or conforming to VME64x. The card-cages, power supplies, cooling systems and control and monitoring are described in this document.

The subracks will be used in a number of different applications within the experiments as well as in laboratory tests. The different applications will require subracks to have specific mechanical layouts involving different backplane configurations, power supply locations and power requirements.

[1] Subracks - also referred to as "crates".

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INTRODUCTION

1. CERN

The European Organization for Nuclear Research (CERN) is an intergovernmental organisation with 20 Member States[2] located on the Franco-Swiss border with its seat in Geneva, Switzerland. Its objective is to provide for collaboration among its Member States and associated countries in the field of particle physics research, and to this end it designs, constructs and runs the necessary particle accelerators and the associated experimental areas.

At present, more than 5000 physicists from research institutes worldwide use the CERN installations for their experiments.

2. LARGE HADRON COLLIDER & ITS EXPERIMENTS

The Large Hadron Collider (LHC) is the next accelerator being constructed on the CERN site. It will be installed about 100m underground in the existing 27km circumference tunnel, presently housing the Large Electron Positron Collider (LEP). The LHC machine will mainly accelerate and collide 7 TeV protons, but will also work with heavier ions up to the atomic weight of lead. This machine is scheduled to come into operation in 2005.

The LHC will support four major experiments (ALICE, ATLAS, CMS and LHCb) each of which is organised as an international collaboration of many hundreds of institutes from CERN's member states and the rest of the world. The four experiments are being constructed in separate underground caverns on the LEP/LHC tunnel and will commence data-taking operations in 2005.

3. THIS SPECIFICATION

The four LHC experiments will house a large quantity of modular electronics in subracks[3], which will be used in a number of different applications within the experiments as well as in laboratory tests. The different applications will require subracks to have specific mechanical configurations involving different backplane configurations, power supply locations and power requirements. The subracks will be constructed from mechanical and electrical components in a modular fashion to be able to be assembled, mechanically and electrically into these configurations. The mechanical configuration will not be changed after initial construction.

The subrack comprises the card-cages (front and rear), backplane, power supply and fan-tray, including the local and remote monitoring and control. Heat exchangers used in the cooling of a complete subrack installation do not form part of this specification.

[2] CERN Member States are: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, The Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland and the United Kingdom.

[3] Subracks - also referred to as "crates".

TECHNICAL SPECIFICATION

1. INTRODUCTION

This specification describes a set of subracks with a number of different arrangements in mechanical layout, backplane type and configuration, and power supply characteristics. These variants shall be constructed using the maximum of common mechanical and electrical components.

1.1 Standards nomenclature

In this specification, the ANSI VITA 1-1994 VME64 standard will be referred to as "VME64" and the ANSI VITA 1.1-1997 VME64 Extensions standard will be referred to as "VME64x". Other specifications will be named in full.

1.2 Other information

The description herein contains the essential elements specific to this invitation for tender. The bidder's attention is drawn to the ANSI VITA 23-1998 VME64 Extensions for Physics and Other Applications - "VME64xP" and its accompanying "Designer & User Guide", for more complete and background information on some of the functions and functionality described in this document. (The subracks described in this document are not intended to conform to either of these documents and this specification takes precedence in all cases).

2. MECHANICS

2.1 General

2.1.1 Applicable Standards

The subracks shall be constructed according to the requirements of the IEEE1101.1[4], IEEE1101.11[5] and ANSI VITA 1.3-1997[6] specifications. The front module and rear transition module card-cages shall be equipped with EMC gaskets, ESD protection, injector/ejector/locking handle engagements, pre-alignment pin and keying chambers according to IEEE1101.10[7].

The subracks will be mounted in racks conforming to the IEC 297- series of specifications.

2.1.2 Number of Slots

All subracks shall have 21 slots on the 20.32mm (0.8") pitch defined in VME64 and associated specifications.

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[4] IEEE Standard for Mechanical Core Specifications for Microcomputers Using IEC 603-2 Connectors

[5] IEEE Standard for Mechanical Rear Plug-in Units Specifications for Microcomputers Using the IEEE 1101.1 and the IEEE 1101.10 Equipment Practice

[6] ANSI VITA 1.3-1997 VME64x 9U x 400mm Form Factor

[7] IEEE Standard for additional Mechanical Specifications for Microcomputers using the IEEE 1101.1 Equipment Practice

2.1.3 Transition Module Card-Cage

When specified, the 9U subracks shall be able to house 9U and 6U transition modules, and the 6U subracks, 6U transition modules. When 9U transition modules are specified, free, unimpeded access is required to the entire height of the transition module space to the rear of the backplane.

The transition module card-cage shall accommodate modules with a depth of 220mm for 9U subracks and for 6U subracks. Provision shall be made for the insertion of shorter modules in a limited number of cases; typically 160 or 80mm for 9U subracks and 80mm for 6U subracks.

Note: the recommended depths for transition modules in the VME64x (6U) and ANSI/VITA 1.3 (9U) specifications are 80mm and 120mm, respectively. This document refers to the base IEEE1101.11 specification for the choice of the 160mm and 220mm depths.

2.1.4 Mechanical Rigidity

The card guides for each slot in both card-cages shall be capable of carrying fully loaded modules, and the subrack of carrying a full load of such modules without significant mechanical distortion.

Note: a 9U x 400mm module will have a maximum weight of 2000g and a 9U x 220mm transition module a maximum weight of 730g.

2.1.5 EMC Gaskets

The IEEE1101.10 EMC gaskets mounted on the sidewalls of the card-cage shall be straightforward to replace in case of damage, and without the use of special tools.

2.1.6 Mechanical Envelope

In order to provide a measure of protection, the sidewalls shall extend beyond the front-panels of fully inserted cards, a distance slightly greater than the length of an injector/extractor handles.

2.1.7 J5/J6 Backplane Space

The space below the J2 connector row in a 9U subrack shall be entirely free of obstructions in order to allow a custom J5/J6 backplane to occupy the full space (apart from that space required for the mechanical support required by the backplane configuration).

If necessary, the cabling of power to a custom J5/J6 backplane in the case of variants 1 and 1a shall be routed to the rear of slot 21. Refer to Figure 1.

Note: if the transition module slot 21 space is used for cabling, the number of transition modules will be restricted to 20.

2.1.8 6U Modules in 9U Subracks

Mechanical supports shall be provided to allow groups of 1, 2, 3 or 4 unmodified, standard 6U modules to be inserted directly into the backplane at the left of the card-cage.

The mechanical arrangement for the support and guiding of the 6U modules shall not obstruct adjacent slots.

The number of 6U slots shall be field modifiable. The installation or dismounting of the mechanical support shall not require special tools.

6U VMEbus card-cages are not required to have specific mechanical adapters for 3U modules.

Note: the interspersion of 6U modules within a group of 9U modules other than at the left of the backplane will require the use of 6U to 9U active adapter modules (refer to Section 10).

2.1.9 Protection Against Falling Objects

Perforated covers shall be provided on the top of the subrack to limit the ingress of foreign objects, within the limits imposed by the assurance of an adequate flow of cooling air. These covers shall be straightforward to remove and replace without the need for special tools.

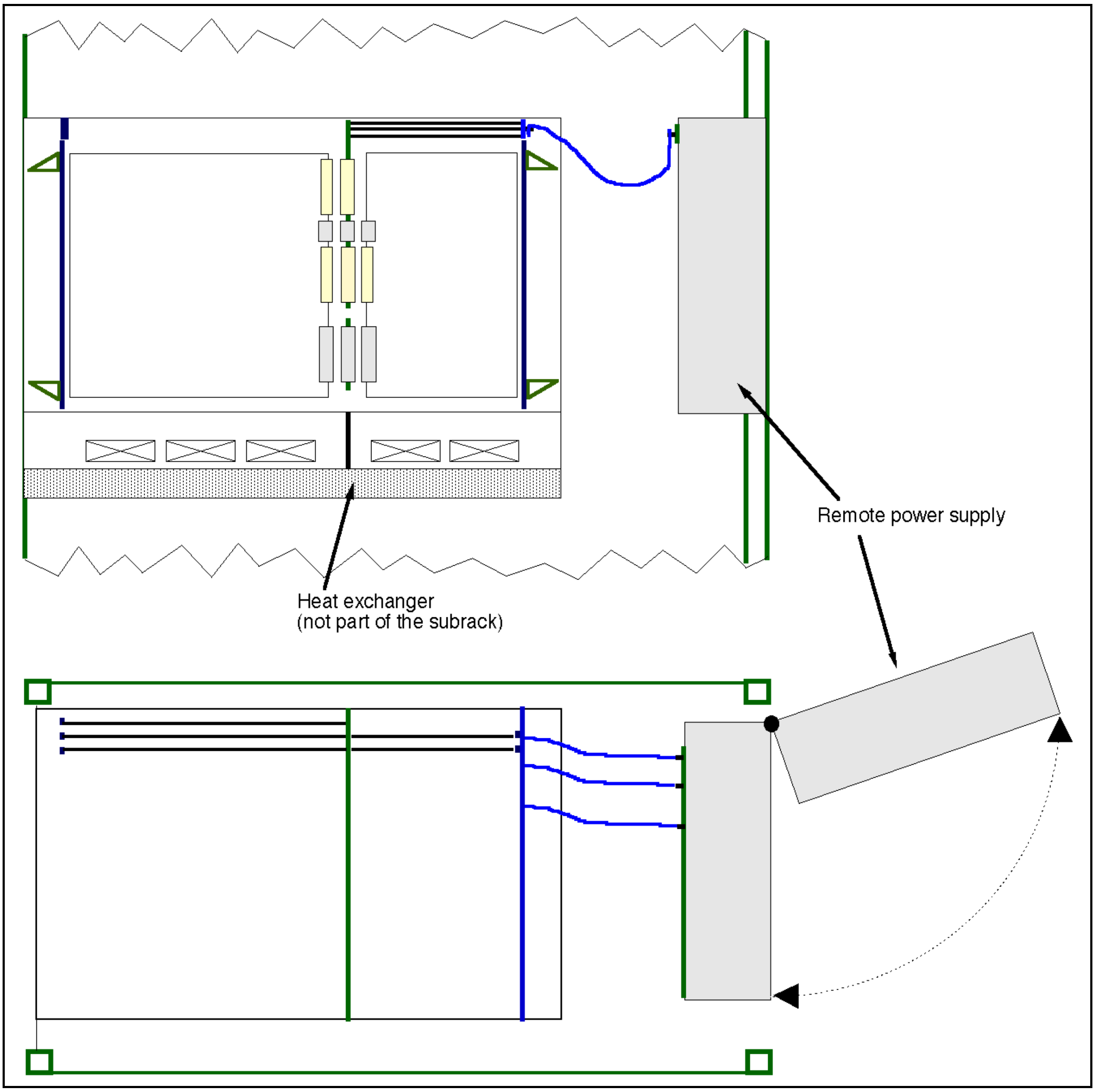

Figure 1. Rear view of a Variant 1/1a subrack (diagrammatic)

3. BACKPLANES

3.1 General

According to the variant, the subracks shall be fitted as standard with a VME64x backplane, or shall be delivered ready for the installation of a custom backplane to be furnished by CERN.

Note: attention is drawn to the end dimensions of VME64x backplanes with respect to VME64 backplanes. Refer to VME64x Section 4.2.7. This will be equally true for subracks not installed with a VME64x backplane.

3.1.1 Power Connection

3.1.1.1 Local

The power, sense and logical connections from local power supplies shall be connected directly to the backplane by means of suitable connectors and short cables or busbars. Refer to Section 4.4.1.

3.1.1.2 Remote

When the power supply is mounted remote from the card-cage, as in 9U layout variants 1 and 1a, the power connections to the subrack shall be made by means screw lugs or suitable connectors mounted on a bulkhead at the top rear of the subrack. Sense and logical connections shall be made by means of suitable connectors. Cables shall be used for low current connections and bus-bars for the high power connections from this power bulkhead to the backplane. (Two busbars each for the +5V and +3.3V supplies, and eventually the 48V, for the voltage and its return).

The length of the cables from the power supply terminals to the power bulkhead shall be as short as possible and shall not exceed 50cm.

Note: this arrangement implies a vertical extension of the backplane to provide space for the power connections to be made to the backplane without compromising free access to the rear of the backplanes for 9U high transition modules. Refer to Figure 3 and Section 9.2.6 of VME64x. The vertical extension to the backplane implies a total height of 10U for a "9U" variant 1 subrack and 7U for a "6U" variant 1 subrack. See Section 5.

Note: the power supply housing in a remote power installation will be attached to the rear of the rack behind the subrack, inside the rear door. Since the electrical characteristics specified in Section 4 are to be maintained over a maximum of some 75cm of cable, the use of low impedance (specifically low-inductance) cable is to be anticipated. Refer to Figure 2.

Note: the contractor is responsible for the performance to specification of the entire subrack assembly, including card-cage, backplane and power supply and any inter-connecting cables whether the power supply is mounted locally or remotely.

3.1.2 Ground Connection

An easily accessible and clearly visible means to connect and disconnect the mains earth to and from the DC 0V shall be provided. No special tools shall be required to change the ground connection.

3.2 VME64x Backplane

3.2.1 Backplane Connectors

The backplane signal connectors are specified in Chapter 3 of VME64x.

3.2.2 Backplane Electrical Specification

The backplane power and other, electrical requirements are specified in Chapter 6 of VME64 and Chapter 3 of VME64x. Refer also to Table 3.

3.2.3 Backplane Termination

The backplane terminators shall be powered from either +5V or +3.3V. In either case, the backplane shall carry a prominent, easily visible label: "Backplane Terminators Powered from +5V" (or +3.3V as appropriate). See VME64x Section 3.2.9.

3.2.4 J0 Connectors

The backplane shall be equipped with J0 and RJ0 connectors according to Chapter 4 of the VME64x specification.

3.2.5 VPC (Pre-Charge Voltage)

Three pins on the P1/J1 and P2/J2 connectors collectively implement VPC. These three pins mate a minimum of 1.5 mm before the other pins during live insertion. They are required to support the hot swap capability defined in the VITA 1.4-199x VME64x Live Insertion Draft Standard. The VPC voltage pins shall be connected directly to the backplane's +5V power plane. Refer to Section 3.2.7 and Chapter 3 of VME64x.

3.2.6 Transition Module Power

All power and GND pins shall be available to transition modules at the rear of the J2 connector (RJ2).

Note: only +5V and GND connections are available from J2.

3.2.7 Live Insertion and Extraction

Support is required for the live insertion and extraction of VMEbus modules according to ANSI/VITA 3-1995 "Board Level Live Insertion for VMEbus", with compatible, automatic daisy chain line jumpering.

3.2.8 Power Rating

Tables 1 and 2 give the maximum power dissipation per slot.

Table 1. Maximum front (VMEbus) module power dissipation

VMEbus module size		**Power (W)**
Height	**Depth (mm)**	
9U	400	110
6U	160	30

Table 2. Maximum transition module power dissipation

Transition module size		Power (W)
Height	Depth (mm)	
9U	220	39
	160	28
6U	160	18
	80	9

Note: Each VME64x module has 6 +5V pins, 1 +5VSTDBY pin, 3 VPC (+5V) pins, 10 +3.3V pins, 1 +12V pin, 1 -12V pin and 1(2) pins at V1 and V2 (48V). The pin power rating curve given in VME64 allows approximately 1.5A per pin at 20°C. Thus each board has potentially 15A at +5V (75W), 15A at 3.3V (49.5W), 1.5A at ±12V (18W each) and 1.5A at V1 and V2 (72W each). The maximum power values given in Tables 1 and 2 are derived from acceptable power densities in the specified cooling environment.

3.2.9 Ripple and Allowed Variations

Table 3 gives the maximum allowed ripple and variations as measured on the backplane. Refer to VME64 Table 6.1.

Table 3. Bus Voltage Specification

Voltage	Allowed Variation	Peak to Peak Ripple and Noise (<10MHz)
+5V	+0.25V / -0.125V	50mV
+3.3V	+0.165V / -0.085V	50mV
+12V	+0.60V / -0.36V	50mV
-12V	+0.60V / -0.36V	50mV
48V	+2.5V / -1.25V	100mV

3.2.10 Data Transfer Rates

The VME64x backplane shall be able to support data transfer frequencies of at least 20MHz between suitably designed VMEbus modules in worse case conditions on a 21-slot backplane. This corresponds to a data rate of 160 Mbyte/s for 64 bit transfers.

3.3 Custom Backplanes

3.3.1 General

Suppliers shall furnish all the information and mechanical drawings necessary for the installation of custom backplanes in all variants.

4. POWER SUPPLIES

4.1 General

This specification describes an integrated power supply consisting of individual power modules mounted in a single unit containing all the wiring and components necessary for its operation. The removal and replacement of the entire power supply unit as well as individual power modules within the unit shall be straightforward, and shall not require any special tools or additional circuitry.

When considered necessary, bidders are encouraged to offer alternative proposals to the detailed power supply specifications, Refer to Section 1.2 of the Tender Form.

4.2 Electrical Characteristics

4.2.1 Electrical Input

The power supply shall operate on a single-phase input of 92 to 264V AC, 50 to 60Hz. The line power factor shall be better than 0.95. The power supply shall be connected to the AC mains by means of a relay or solid-state relay which may be actuated either manually, by the local protection circuits, or remotely by the remote control system (refer to Section 7). Each power supply shall be supplied with a correctly rated three-wire power cord of minimum length 1.5 metres. On switch-on, the maximum instantaneous value of the input current to the power supply shall be limited to a value no greater than the nominal input current.

4.2.2 Electrical Insulation

The power supply shall conform to the CE (industrial environment) standards in respect of the electrical insulation of the input and output.

4.2.3 Electromagnetic Compatibility

4.2.3.1 Emission

The power supply shall conform to the EN50081-1 standard.

4.2.3.2 Immunity

The power supply shall conform to the EN50082-1 or -2 standards.

4.2.4 Noise and Ripple

Noise and ripple as measured on an oscilloscope having a bandwidth limit of 50MHz shall not exceed 10mV peak-to-peak.

4.2.5 Static Regulation

The output voltages shall vary by less than 0.5% when the load is varied from 0 to 100%, and the mains input voltage by ±15%.

4.2.6 Dynamic Regulation

Under worst case conditions the output voltages shall deviate less than 100mV from their nominal values for a ±25% output load step, with a recovery to ±1% of the nominal values within 0.5ms.

4.2.7 Output Voltage Adjustment

The output voltages shall be adjustable within a range of ±10% of their nominal values by means of an easily accessible screwdriver adjustment, safe from accidental manoeuvre.

4.2.8 Output Voltage Sensing

Each pair of supply terminals shall have a corresponding pair of remote sense lines for connection to the appropriate points on the backplanes. The sense circuit shall compensate for a deviation of no less than 500mV from the nominal voltage outputs.

4.2.9 Efficiency

At nominal input and output voltages, the power supplies shall have an overall efficiency of greater than 80%, auxiliary circuits and cooling system included. The individual, modular power units shall have conversion efficiencies of greater than 85% for voltages of 5V and above, and greater than 75% for voltages below 3V.

4.2.10 Stability

The nominal values of the output voltages shall vary less than 0.3% in any 24 hour period and less than 1% in any period of six months at constant temperature.

4.2.11 Over Current Protection

All outputs shall be protected by an electronic circuit, which shall limit the output current to the specified maximum under all conditions. A continuous short circuit current shall not damage the supply.

4.2.12 Over Voltage Protection

Limiting circuits shall protect the output voltages such that they shall never exceed their nominal rated values by more than 10%. These limits shall apply even if the remote sense inputs are not connected.

4.2.13 DC Trip Off

All output voltages shall be reduced to a maximum of approximately 20% of their nominal values within 5ms if they deviate more than 2% from their rated values, or if the power supply detects overload or over-temperature conditions.

4.2.14 Over Temperature Protection

Thermal switches shall protect the power supply from abnormal temperature increase. If an over-temperature condition occurs, the power supply shall be latched in the off state until the mains switch has been recycled, or a remote signal has been given (refer to Section 7.2).

4.2.15 Operating Temperature and Temperature Coefficient

The power supply shall operate between 0 and 50°C ambient temperature without de-rating of any characteristic and output voltages shall deviate less than 0.02%/°C in that range. See also Section 6.4.

4.3 Monitoring and Control

Refer to Section 7.

4.4 Mechanical Mounting

Two mechanical layouts are specified:

1. "Local" where the power supply is mechanically attached to the card-cage, with direct, or very short, connections to the backplane and fan-tray,
2. "Remote" where the power supply is mechanically attached to the rack[8] in which the card-cage is mounted, with short cables connecting the power supply to a power bulkhead in the rear of the subrack.

4.4.1 Local Power Supply

A system of connectors shall be used to connect the power supplies to the subrack with short connections to the backplane. These connectors shall permit the transmission of currents up

[8] Rack or cabinet.

to 150% of the rated maximum current with low electrical resistance and mechanical insertion force. See also Section 3.1.1.1. Suitable connectors shall be used for the transmission of sense lines and logical signals.

The power supply shall be mounted behind the J1 connector position in the upper part of the subrack (see Figure 4 and Figure 6). The power supply shall be coupled and uncoupled to the subrack by means of a suitable mechanical injector/extractor mechanism which shall ensure the correct mechanical location of the power supply, and of the power connectors. The installation and removal of the power supply shall not require the removal the subrack from the rack nor the use of special tools.

In order to allow access to the rear of the lower part of the backplane (J2 and J5/J6), the power supply shall not exceed 3U in height. The width of the power supply shall be such that it can be mounted between a rearward extension of the subrack's sidewalls.

4.4.2 Remote Power Supply Housing

Remote power supply installations, as in 9U layout variants 1 and 1a (see Section 5), require the power supply to be mounted in a separate, individually cooled housing. This housing shall be hinged to the rear of the rack in such a manner that it may be swung out of the rack to allow unimpeded access to the rear of the subrack. In its closed position, he housing shall be as close to the inside of the rack's rear door as is practicable.

The power supply shall be straightforward to change mechanically and electrically. Its installation into, and removal from, the rack shall not require the use of special tools.

Note: the housing may be dismounted mechanically by the use of "lift-off" hinges.

The housing shall not exceed the height of the card-cage in vertical extent. Its depth shall be the minimum possible and shall not in any case exceed 200mm. Its width shall be such as to allow the housing to swing clear of the rack. A means shall be provided for the free edge of the housing to be rapidly attached to or released from the rack upright (hand-operated catch). Refer to Figure 2.

All electrical connections shall be made on the hinged side of the housing to minimise power cable length. The electrical connection of a remote power supply to the backplane(s) is described in Section 3.1.1.2.

4.5 Cooling

4.5.1 Local Power Supplies

Local power supplies shall be provided with an adequate air-cooling system. Since the cooling air will be taken from, and exhausted to, the cooled air stream rising vertically through the rack, the cooling air shall flow vertically upwards through the power supply.

4.5.2 Remote Power Supplies

Two options shall be offered by the bidder: air cooling and water cooling.

4.5.2.1 Air cooling

The power supply shall be cooled by air in a similar manner to the local power supply as specified in Section 4.5.1.

4.5.2.2 Water cooling

The power supply shall be cooled by water with no heat being rejected into the local environment.

The mounting and dismounting of water connections to the power supply shall be straightforward and shall require no special tools.

Note: the power supply will be provided with demineralised water at a maximum temperature of 16°C and a minimum flow rate of 0.05 litres/s. A rise in temperature of approximately 5°C is anticipated at full load.

4.6 Power Output

4.6.1 Voltages

The power supplies shall deliver the standard VME64x voltages (+5V, +3.3V, ±12V, 48V). Two variants are defined, one for 9U and one for 6U subracks.

4.6.2 Current Ratings

Maximum current ratings are defined in Tables 3 and 4, below. The power supply shall be designed in a modular fashion to allow the maximum current available at each voltage to be altered to suit specific applications.

All the output voltages shall be available simultaneously. However, the output power available at each voltage shall be chosen according to the requirements of the application by selection of power modules.

Note: The integrated maximum output power will be limited by the capability of the input circuits: mains connector, fuse, power factor correction circuit, etc., as well as the limitations imposed by the physical dimensions of the power supply housing and its cooling capacity. The power ratings given in Tables 3 and 4 are intended to show the maximum that shall be available at each voltage, if so specified. It is NOT intended that they shall all be available simultaneously.

4.6.3 Turn-0n and Turn-Off Transients

When connected to a resistive load, the output voltages shall rise to within 5% of their final value within 100ms for any current up to the full rated current.

The output circuits of the power supply shall be discharged after switch-off within a specified time.

Note: no particular sequencing of the voltages at switch-on of -off is required. Any requirement for particular power sequencing will be met by on-board circuits.

Table 4. 9U power supply - maximum ratings

Supply (V)	Current (A)	Power (W)	Comments
+3.3	200	660	
+5	300	1,500	
+12	20	240	
-12	20	240	
+V1	20		-V1 return
+V2	20		-V2 return
-V1	30	1,440	48V
-V2	30	1,440	48V
+5 STDBY	Connected to +5V on VME64x backplane		

Table 5. 6U VME64x power supply - maximum ratings

Supply (V)	Current (A)	Power (W)	Comments
+3.3	100	330	
+5	100	500	
+12	5	60	
-12	5	60	
+V1	5		-V1 return
+V2	5		-V2 return
-V1	5	240	48V
-V2	5	240	48V
+5 STDBY	Connected to +5V on VME64x backplane		

4.7 Signal Outputs

The VME64x power supply shall generate the VMEbus ACFAIL* and SYSRESET* signals as required by the VME64 and VME64x specifications.

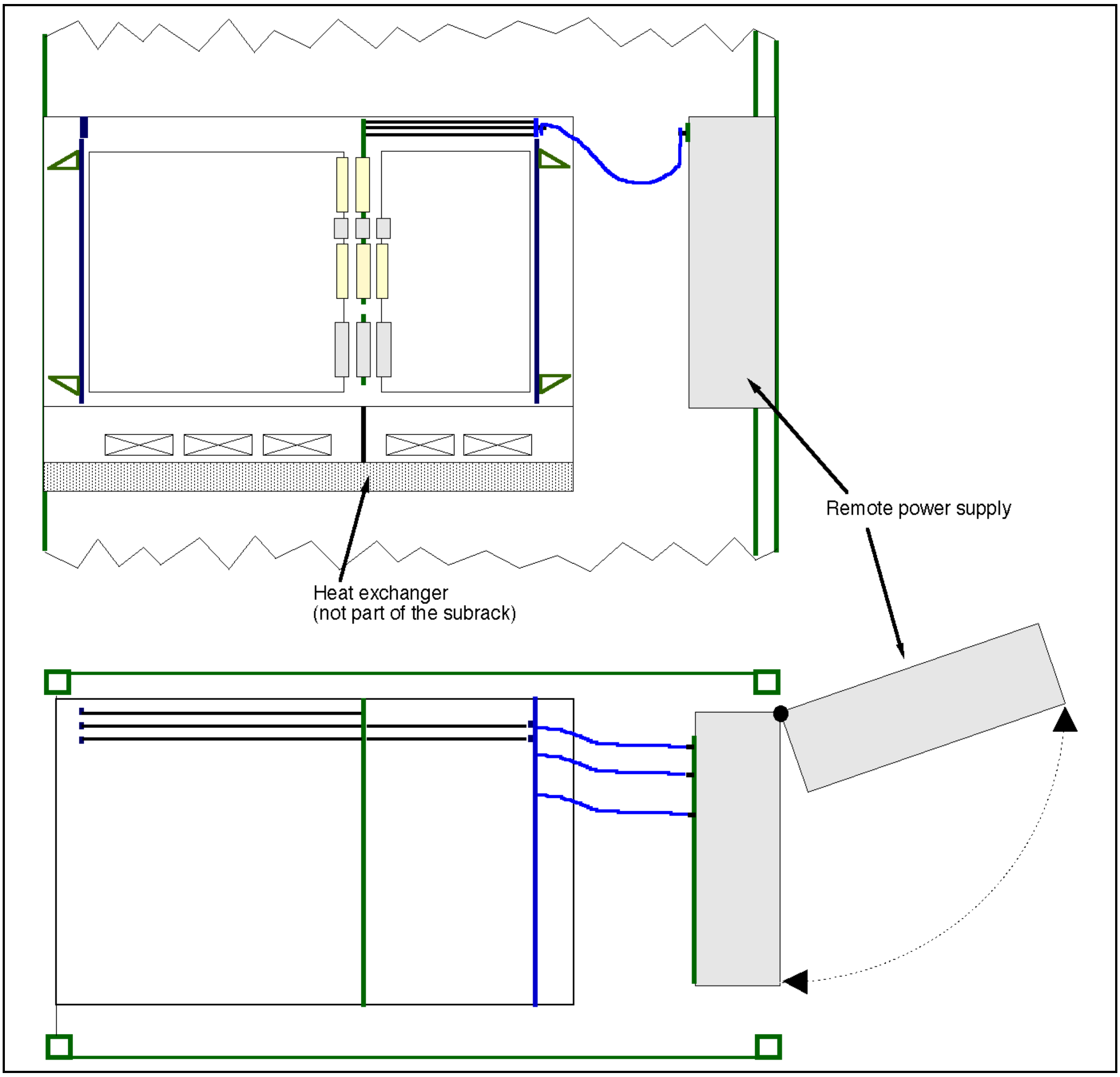

Figure 2. 9U subrack with remote power supply showing the hinging of the power supply clear of the rear of the subrack (incomplete, diagrammatic view)

5. CONFIGURATIONS

Table 6 and Table 7 summarise the different subrack configuration variants in terms of mechanical layout, backplane type and configuration, and power supply location.

Table 6. 9U Subrack Variants

9U Variant	Backplane		Power Supply		Transition Modules	
	VME64x	Custom	Remote	Local	9U/6U	6U only
1	✓		✓		✓	
1a		✓	✓		✓	
2	✓			✓		✓
2a		✓		✓		✓

Table 7. 6U Subrack Variants

6U Variant	Backplane		Power Supply		Transition Modules	
	VME64x	Custom	Remote	Local	6U	None
1	✓		✓		✓	
1a		✓	✓		✓	
2	✓			✓		✓
2a		✓		✓		✓

Figures 3-6 show diagrammatic views of the layout configuration variants.

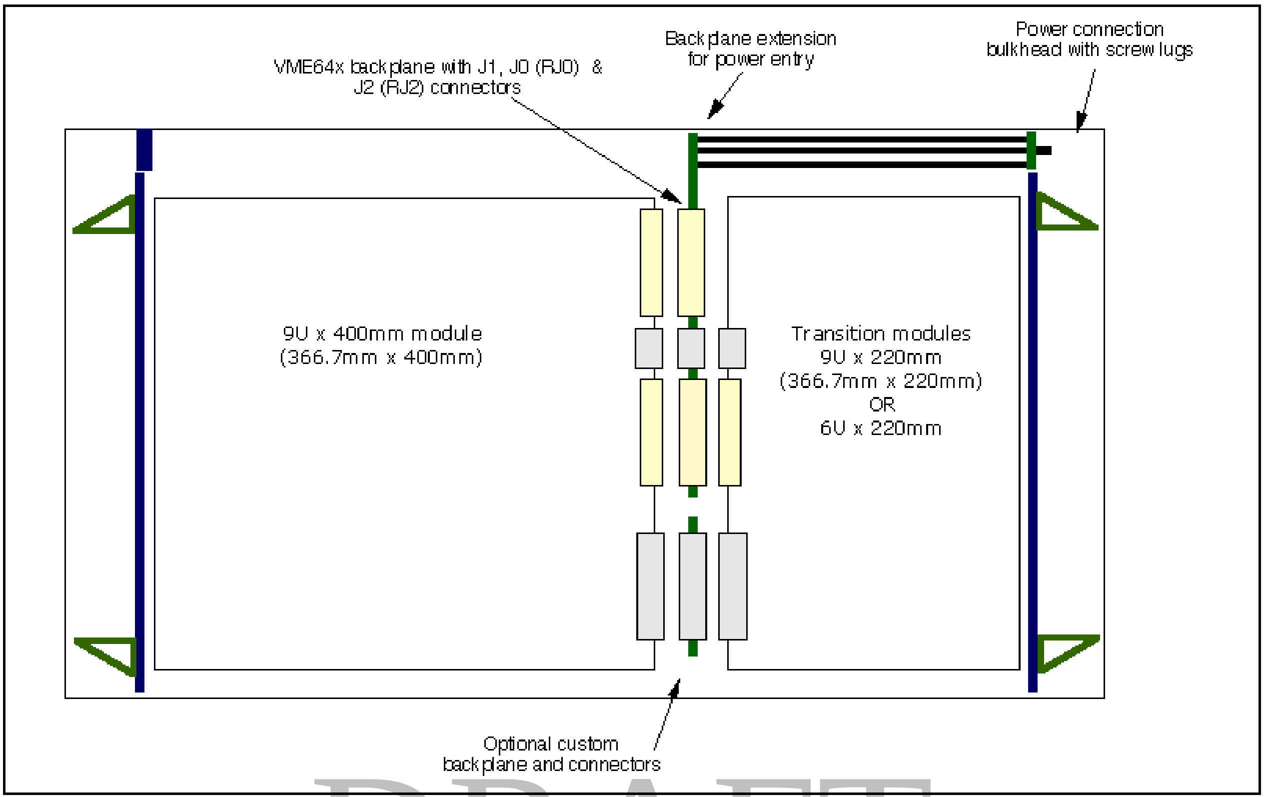

Figure 3. 9U Subrack Variant 1 (Variant 1a with custom J1/J0/J2 backplane)

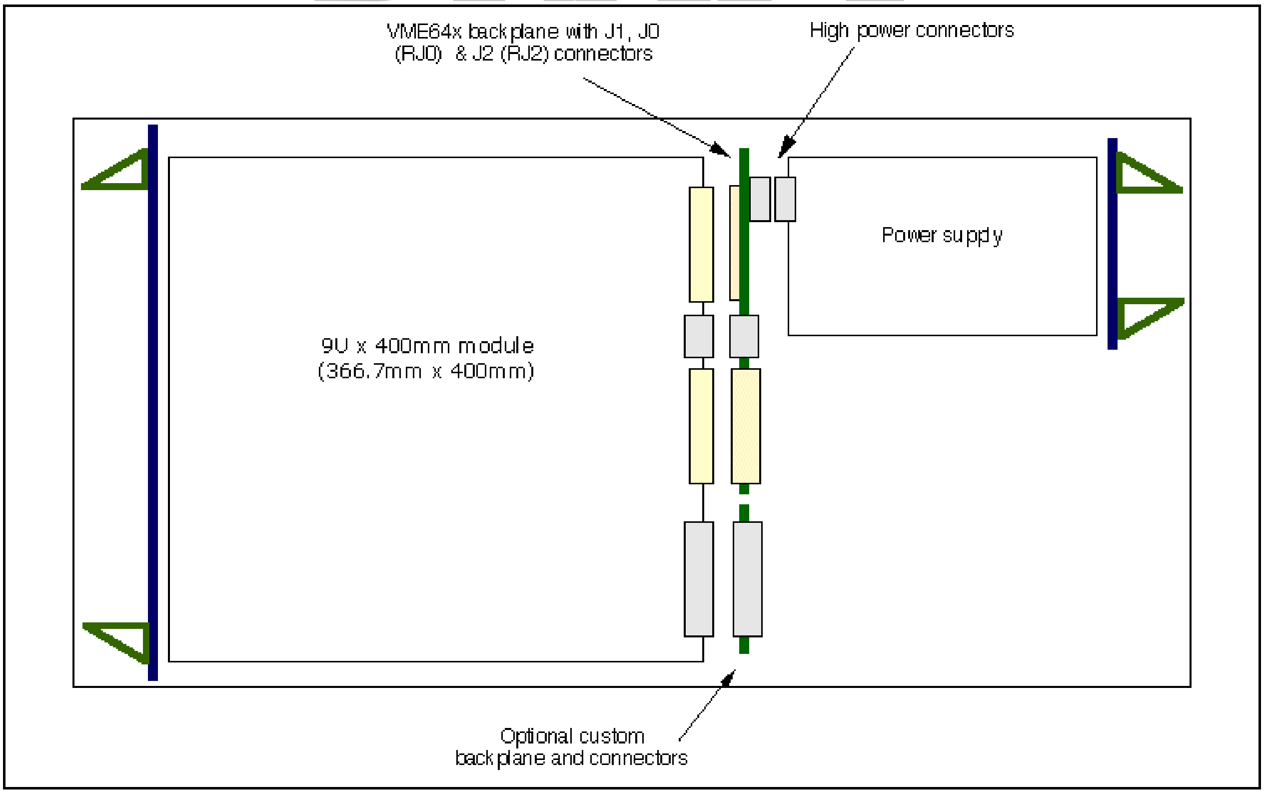

Figure 4. 9U Subrack Variant 2 (2a with custom backplane)

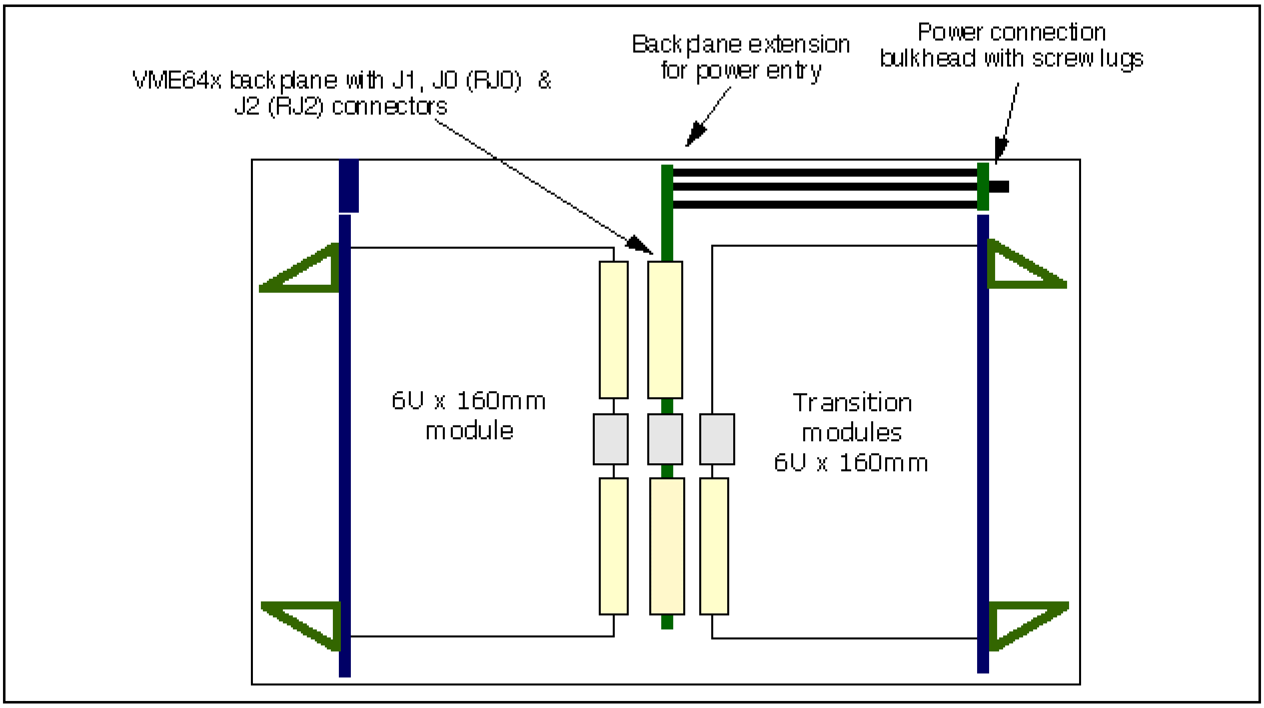

Figure 5. 6U Subrack Variant 1 (1a with custom backplane)

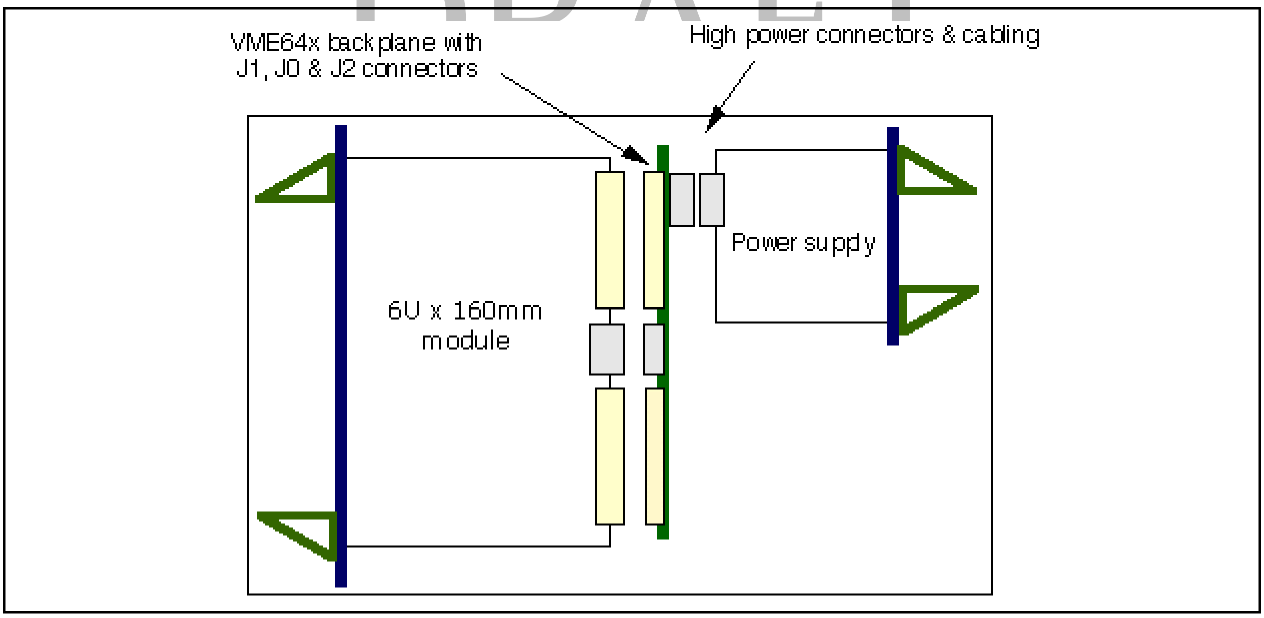

Figure 6. 6U Subrack Variant 2 (2a with custom backplane)

5.1 Other Configurations

In addition to the variants described in Section 5, the subracks shall be able to accommodate different backplane configurations including:

3. A custom monolithic backplane covering the full height of the 9U subrack,
4. Individual, custom backplanes in the J1, J2 and J5/J6 positions in a 9U subrack.

6. ENVIRONMENTAL CONSIDERATIONS

6.1 Halogen Free Construction

All components of the subrack shall be halogen free.

6.2 Subrack Cooling

6.2.1 General

The subracks and their power supplies will be installed in racks having a temperature and humidity controlled environment. These racks have a forced, re-circulating, vertical air flow upwards through air/water heat exchangers interspersed between subracks by means of individual fan-trays below each subrack. In addition to which a centrifugal blower assures the return airflow though vertical channels in the sides of the rack. The heat exchangers do not form part of this specification.

Note: in test applications, the subracks will be used in a normal laboratory environment often without the benefit of a cooled airflow, as described above. This mode of operation shall be considered as exceptional, and the subrack may have to be operated in a degraded manner with reduced power.

6.2.2 Fan Trays

The LHC rack cooling system foresees a 2U high modular, removable fan-tray beneath the subrack card-cage(s). The fan-trays shall provide a uniform airflow over the whole area of the card-cage, with particular attention being shown to slot one.

The card-cages shall be constructed so as to minimise obstruction to the flow of cooling air for modules, and such that the airflow through the module and transition module areas are independent of each other, with no shunting from front to back.

Three versions of the fan-tray shall be offered to suit the different mechanical configurations:

1. 6U without rear transition modules,
2. 6U with rear transition modules (160mm deep),
3. 9U with rear transition modules (220mm deep).

6.3 Radiation and Magnetic Fields

The subracks shall be used in environments with no magnetic field and no ionising radiation.

6.4 Temperature

6.4.1 Operation

The subracks shall operate within specification at ambient temperatures between 0°C and 50°C.

6.4.2 Storage

The subracks shall not suffer any deterioration when stored indefinitely at ambient temperatures between -30°C and +85°C.

7. SUBRACK MONITORING AND CONTROL

7.1 General

The subrack shall be equipped with a minimum set of control and monitor functions which shall be available locally on the subrack, and remotely via a CERN approved fieldbus (CAN with CAN Open, Profibus or WorldFIP).

Table 8 summarises the required minimum monitoring and control parameters.

7.2 Remote Monitoring and Control

The remote control and monitoring of the subrack and power supply shall be made by means of a CERN approved fieldbus with a controller integrated in the subrack. A commercially available OPC server shall give access to all the monitoring and control functions (see Table 8).

The remote control and monitoring shall be available to the detector control system at all times, and thus shall not be powered from the power supply itself, (it may be powered from the fieldbus, if so allowed).

For test purposes, a remote power supply shall be able to operate without connection to the rest of the subrack, and have sufficient built-in control and monitoring to allow independent operation.

Any additional sensor inputs and control outputs shall be made available on suitable connectors mounted at the rear of the subrack.

Table 8. Control and monitoring - minimum functionality

Parameter /Function	Remote		Local			Notes
	Monitor	Control	Monitor	Control	Readout /Control	
Voltages	✓		✓	✓	Single meter with switch selection (accuracy ±2% at FSD)	Local adjustment (see Section 4.2.7)
Currents	✓		✓			
Slot 1 temperature	✓		✓			Probe in exhaust air above slot 1.
Floating temperature probe 1	✓		✓			Probes which may be used to measure temperatures of concern within the card-cages (front and rear).
Floating temperature probe 2	✓		✓			
Card-cage fan status	✓		✓		Individual LED indicators.	Warns that the fans are not working within normal limits.
Power supply over-voltage	✓		✓			Over-voltage situation on one of the output voltages.
Power supply over-current	✓		✓			Over-current situation on one of the outputs.
Power supply over temperature	✓		✓			Excessive temperature within the power supply.
Power supply DC trip off	✓		✓			The power supply has tripped off.
Reset trip off		✓		✓		Resets the trip off.
Subrack "health"	✓		✓			Indicates that the whole subrack is operating within normal limits.
Power supply AC on/off	✓	✓	✓	✓	Switch	A local action to switch the power supply off shall override any remote control action to switch the power supply on.
Local monitor test				✓	Push button	Lights the LEDs and sets the meter to full-scale deflection.
Local control	✓		✓	✓	Switch	When actuated, the remote control locked out. Remote monitoring remains enabled.
Subrack reset		✓		✓	Push button[9]	System reset[10].

[9] The push-button shall be protected against accidental actuation.

[10] In VME64x subracks this function shall assert the VMEbus SYSRESET* line in accordance with the VME64 specification. In non-VMEbus subracks it should provide a pulse identical to SYSRESET* for connection to the custom backplane or other appropriate point within the card-cages.

8. SAFETY REGULATIONS

The subracks shall be CE certified with proven record of compliance comprising a test certificate for one subrack with a quality assurance of the conformity of the series.

9. RELIABILITY

The VME64x specification describes the minimum acceptable backplane connector performance level (Rules 3.3 and 4.4.).

The subracks and their power supplies will be in continuous service for more than ten years (approximately 90,000 hours). Components shall be chosen to minimise the likelihood of maintenance or adjustment being required during that period. Where significant cost penalties are likely owing to the choice of a very long lifetime component, the bidder shall clearly indicate the possible alternatives.

10. 6U TO 9U ADAPTERS

The subrack system shall include 6U to 9U active adapters to be used to insert 6U boards into the 9U card-cage with their front panels flush with the front-edge of the card-cage. The electrical buffering circuits shall ensure that the requirements of VME64 for backplane signal stub length are respected. Refer to VME64 Rule 6.24.