



Atacama Large Millimeter Array

Interface Control Document *Between:* Site (AOS Technical Building) *And:* ACA Correlator


ALMA-20.01.02.00-62.00.00.00-C-ICD

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Change Record


Version	Date	Affected Section(s)	Change Request #	Reason/Initiation/Remarks
A	2005-04-28	All	Draft A	First release
A	2005-06-03	minor	Draft A2	Revised after the ACA Correlator PDR
A	2005-09-30	3.2	Draft A3	Deleted the communication switch power requirement.
A	2005-11-21	3.1.1, 3.3, 3.4.2, 5.2	Draft A4	Revised after the ACA Correlator CDR
A	2007-01-12	3.1.1 Table, 3.3 5.2 2.1 3.2.1 3.2, 3.4 3.4.2 3.4.2	Draft A5	Modified the footprint size of rack, and the floor loading. Revised by the improvement of RD 06. RD 03 ICD between Site and computing ALMA-20.01.02.00-70.00.00.00-A-ICD, The latest version letter is now B. Revised ALMA-20.01.02.00-70.00.00.00-A-ICD. Modified the number of electrical connectors Changed the power consumption for the ACA Correlator Included the effect of computing Recalculated with new AHU specs
A	2007-03-19	3.1.1 3.4.2	Draft A6	Revised the height of rack. Removed the inlet room temperature of 14°C.
B	2010-03-06	2.1 3.2 3.4.2	Draft A	Revised the power consumption.
B	2010-05-15	Cover page	Draft A	Correct the name of CCB Approval and delete SE Approval
C.1	2018-08-29	Cover page Header and text body of all pages 2.1 3.1.1 3.2 3.2.1	Draft	RD07 was added to Reference Documents table. The number of racks was fixed from 14 to 12. M&C computers and data processing computers for ACA Correlator and those for ACA Spectrometer are considered in specifying the electricity, cooling capability and total mass on the computing racks. The temperature difference, dt2, in the calculation of air flow was changed to 10 from 10.9 for consistency.



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		3.3 3.4.2 3.5.1		
C.2	2018-09-12	3.4.2	Draft	Removed unnecessary “putative specific heat” term from a formula in calorific value calculation.
C.3	2018-10-22	3.4.2	Draft	Added Table 4 which indicated the maximum calorific power consumption at full capacity. The maximum calorific power consumption is used in calculation of required cooling capacity. RD08 and RD09 are added to the REFERENCE DOCUMENTS.
C.4	2018-11-28	5.1	Draft	The last statement of section 5.1 is removed because no illumination and fire protection issue are identified for the optical data receiver.
C.5	2019-06-12	3.4.2	Draft	The details of cooling efficiency are removed and only the inlet air temperature and the increase of the air temperature are specified in this section. The details are described in [RD10].
C.6	2019-10-16	2.1	Draft	Update [RD 10]
C.7	2020-07-23	2.1 5.2	Draft	Added 2.1 Applicable Documents section newly. Corrected [RD07] to [RD06].
C.8	2020-08-05	Signature Matrix, Date	Draft	Updated the signature matrix at the suggestion of Bernhard.
C.9	2020-08-14	1.2 2.2 3.1.1 3.2 3.2.1 3.2.2	Draft	Added a statement to the scope section. Added an explanation why this ICD covers electricity and floor loading of the ACA Spectrometer. Added ALMA-20.01.02.07-0015-A-REP and “Initial Assessment on Power Installation Upgrade for ACA Spectrometer” to the reference documents. Added a foot note of Table 1 for G9XE8. Added the altitude derating discussion. Added the reference document number to the apparent power of correlator racks. Added a foot note of Table 2 for G9XE8. Ampere capacity of sockets for COMP. Set #X was changed from “32 A” to “25 A or more” in the table 3. Changed the description about the UPS to be clearer.
C	2020-08-14	Status	Released	Edit for Release

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C	2020-08-18	1.2, 2.3		Fixed typos
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1 DESCRIPTION


1.1 PURPOSE

This document defines the interface between the ACA Correlator and the AOS Technical Building.

1.2 SCOPE

This ICD covers the requirements for the electrical and mechanical interface between ACA Correlator and AOS Technical Building. The electricity and floor loading of the ACA Spectrometer are also in the scope of this ICD because the ACA Spectrometer modules and the control servers are installed in the blank space of the existing Computing racks in the ACA Correlator room, and the ACA Spectrometer modules and the control servers share the PDUs on the Computing racks and electricity accordingly with the ACA Correlator Computers.

The version C of this ICD has been updated for the purpose of documenting the most current configuration of the ACA Correlator, and therefore it does not constitute an obligation for the Site IPT to provide additional deliverables.

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2 RELATED DOCUMENTS AND DRAWING

2.1 APPLICABLE DOCUMENTS


No	Document Title	Reference
AD 01	Earthing, Bonding and Protection against Lightning and LEMP of ALMA Buildings and Structures	SITE-20.00.00.00-024-A-SPE

2.2 REFERENCE DOCUMENTS


No	Document Title	Reference
RD 01	AOS Technical Building Completion Program	SITE-20.01.02.03-007-B-DWG
RD 02	ICD <i>Between</i> Site (AOS Technical Building) <i>and</i> Baseline Correlator	ALMA-20.01.02.00-60.00.00.00-A-ICD
RD 03	ICD <i>Between</i> AOS Technical Building <i>and</i> Computing	ALMA-20.01.02.00-70.00.00.00-B-ICD
RD 04	Standard for Plugs, Socked-outlets, and Couplers	ALMA-80.05.00.00-004-B-STD
RD 05	ALMA Environmental Specification	ALMA-80.05.02.00-001-B-SPE
RD 06	ICD <i>Between</i> Site (AOS Technical Building) <i>and</i> Backend (Central Equipment)	ALMA-20.01.02.00-50.00.00.00-A-ICD
RD 07	ACA Correlator Structural Analysis Report (including Seismic Support Structure)	NF-ACACOR-2006-0055
RD 08	ICD between ACA Correlator and ACA Spectrometer	ALMA-62.00.00.00-64.00.00.00-A-ICD
RD 09	Measurements of power consumption of ACA Correlator at AOS Technical Building	ALMAJ-CORR-09023-A
RD 10	Study Report on Cooling Capacity of ACA Correlator Room for ACA Spectrometer	CORL-64.00.00.00-0013-A-REP
RD 11	Technical Investigation Report NCR-44 – "Power Socket burned of the ACA Correlator" and new design proposal	ALMA-20.01.02.07-0015-A-REP
RD 12	Initial Assessment on Power Installation Upgrade for ACA Spectrometer	Not an ALMA document

2.3 ABBREVIATIONS AND ACRONYMS

ACA	Atacama Compact Array
ALMA	Atacama Large Millimeter/submillimeter Array
ASC	ACA Spectrometer Computer

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ASM	ACA Spectrometer Module
AUATC	Raritan ASCII Terminal Converter
BE	Back-End
CCC	Correlator Control Computer
CDP	Correlator Data Processor
CEE	Commission internationale de réglementation en vue de l'approbation de l'équipement électrique (International Commission on Rules for the Approval of Electrical Equipment) currently IECCEE (http://www.iecee.org/)
CIP	Correlation and Integration Processor
DFP	DTS Receiver and FFT Processor
DMC	DTS-R Monitor & Control Computer
DTS-R	Data Transmission System (DTS) Receiver
HVAC	Heating Ventilation and Air Conditioning
ICD	Interface Control Document
IEC	International Electrotechnical Commission
IPT	Integration Product Team
ISO	International Organization for Standardization
JAO	Joint ALMA Observatory
KASI	Korea Astronomy and Space Science Institute
M&C	Monitor and Control
MCI	Monitor and Control Interface
NAOJ	National Astronomical Observatory of Japan
PDU	Power Distributor Unit
RD	Reference Document
RSD	Reference Signal Distributor
UPS	Uninterruptible Power Supply

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3 PHYSICAL SYSTEM INTERFACES

3.1 MECHANICAL INTERFACE

3.1.1 ACA Correlator Room Space

There are 12 racks in the ACA Correlator Room. They are divided into four sets, one of which consists of two ACA Correlator racks and one computing rack. The ACA Correlator racks contain the modules of the ACA Correlator. The computing racks contain ACA Correlator M&C computers, ACA Correlator data processing computers, ACA Spectrometer modules, ACA Spectrometer M&C computers and other network, power distribution and optical signal distribution equipment. The ACA Correlator floor space is described in RD 01, which is delivered by ALMA Site IPT. The floor space required to house the ACA Correlator is about 67.32 m², for instance, in a 10.2 m by 6.6 m configuration (see 'CORRELATOR 2' in Figure 1). The ceiling height should be 3 m that is the same as that of ALMA 12-Array Correlator (RD 02). Also, the underfloor space area of 0.5 m to 0.6 m in depth will be allowed beneath the computer floor as an *air plenum* and for under-floor cabling.



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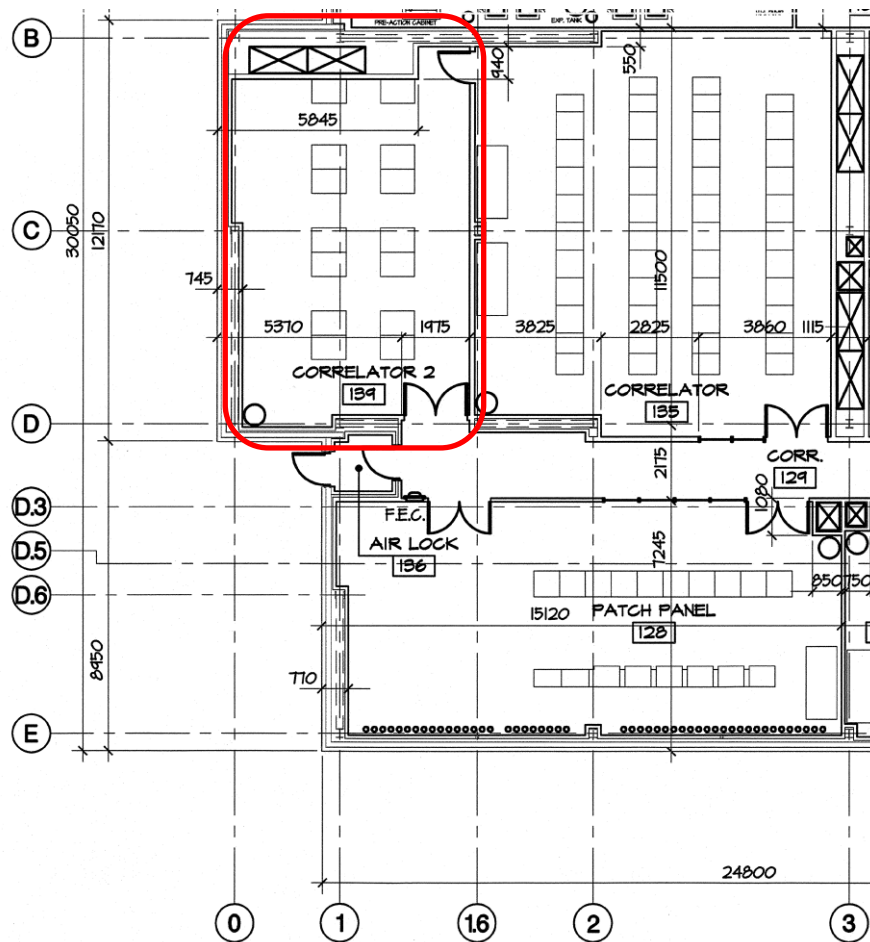


Figure 1: AOS Technical Building Floor.

ACA Correlator, ACA Correlator Computer System and ACA Spectrometer are housed in the 12 racks as shown in Table 1:


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Table 1. Racks of ACA Correlator, Spectrometer and Computers.

Rack name	Qty	Height (H) x Footprint size [(W)x(D)]	Comments
ACA Corr. Set #0	2	(H)1.8 x (W)0.7 x (D)0.95 m (Equivalent to 19-inch rack)	Including DFP, CIP, MCI, RSD, and PDU modules, and Switching Hub.
ACA Corr Set #1	2	(H)1.8 x (W)0.7 x (D)0.95 m (Equivalent to 19-inch rack)	Including DFP, CIP, MCI, and PDU modules, and Switching Hub.
ACA Corr. Set #2	2	(H)1.8 x (W)0.7 x (D)0.95 m (Equivalent to 19-inch rack)	Including DFP, CIP, MCI, and PDU modules, and Switching Hub.
ACA Corr. Set #3	2	(H)1.8 x (W)0.7 x (D)0.95 m (Equivalent to 19-inch rack)	Including DFP, CIP, MCI, and PDU modules, and Switching Hub.
COMP. Set #0	1	(H)1.8 x (W)0.7 x (D)0.95 m (Equivalent to 19-inch rack)	Including ACA-CCC, ACA-CCC (standby), ACA-CDP Nodes, G9XE8 ^{*1} , ASM, ASM (standby), ASC, ASC (standby)
COMP. Set #1	1	(H)1.8 x (W)0.7 x (D)0.95 m (Equivalent to 19-inch rack)	Including ACA-CDP Master, ACA-CDP Master (standby), ACA-CDP Nodes, G9XE8 ^{*1} , ASM, Network Switch
COMP. Set #2	1	(H)1.8 x (W)0.7 x (D)0.95 m (Equivalent to 19-inch rack)	Including ACA-DMC, ACA-CDP Nodes, G9XE8 ^{*1} , ASM, Paragon User, Service Drawer
COMP. Set #3	1	(H)1.8 x (W)0.7 x (D)0.95 m (Equivalent to 19-inch rack)	Including ACA-DMC (standby), ACA-CDP Nodes, Network Switch, Paragon Switch, AUATC, G9XE8 ^{*1} , ASM

(*1) G9XE8 is a box which converts 8 PCI-X interfaces to 8 PCI Express interfaces.



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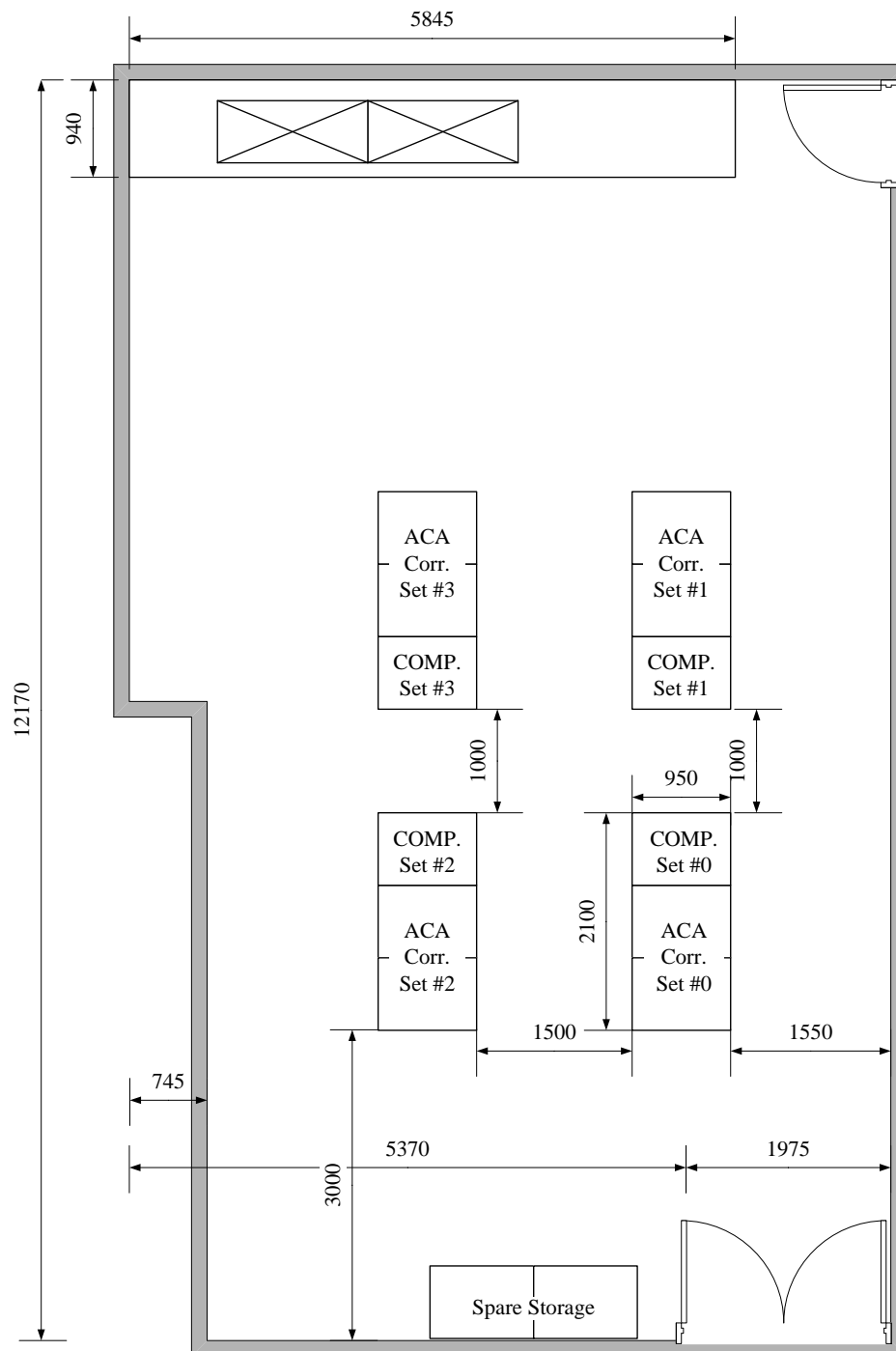



Figure 2. ACA Correlator room layout (This shows the floor space regarding to the footprint size of the ACA Correlator and ACA Correlator Computing racks).

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3.2 ELECTRICAL POWER INTERFACE

230 VAC, 50 Hz single-phase power shall be provided. Each power line shall be separately connected with 15A circuit breakers for 8 racks of ACA Correlator and nine 25A circuit breakers for 4 racks of ACA Correlator computers and Spectrometer.

The altitude derating needs to be considered for the power cables and the circuit breakers in the ACA Correlator room. We use the discussions in [RD 11]. There are three correction factors in [RD 11]:

- K1: Correction factor for ambient temperature
- K2: Correction factor for grouping of cables
- K3: Correction factor for geographic altitude

According to [RD 11], we should put K1 as 1.08 assuming the ambient temperature is 20 degree Celsius and K3 as 0.9 to compensate for the lower air density for cooling. The two correction factors, K1 and K3 give us the total correction factor 0.972, $K1 \times K3 = 0.972$. Therefore,

- Each of the nine single-phase 25A circuit breakers supports 24.3A ($=25A \times 0.972$) under the current environment assumption, and is enough because 19.8A is the maximum estimated current.
- The main three-phase 60A circuit breaker supports 58.3A ($=60A \times 0.972$) under the current environment assumption for each phase, and is enough because 52.95A is the maximum estimated current in [RD 12].

The derated cable capacity should be 24.3A at least or more so the standard rating of the cable should be 25A or more before derating depending on the grouping factor of cables, K2.

3.2.1 Electricity Demand

The total apparent power shall be equal to or less than 90.4 kVA. The total ampere corresponds to the total capacity of circuit breakers at 230V shall be equal to or less than 393.2 A. The breakdown is shown in Table 2. Detailed breakdown of electricity for computing racks are described in [RD 08].


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Table 2. Power breakdown

Rack	Ampere	Apparent Power	Comments
ACA Corr. Set #x-0	35.8 A	8.23 kVA ^[RD09]	DFP, CIP
ACA Corr. Set #x-1	36.6 A	8.42 kVA ^[RD 09]	DFP, CIP, MCI, RSD and Switching HUB
Subtotal of 4 Sets	289.6 A	66.6 kVA	The total ampere and apparent power for ACA Corr. Set#0-0, #0-1, #1-0, #1-1, #2-0, #2-1, #3-0, #3-1.
COMP. Set #0	36.1 A	8.3 kVA	ACA-CCC, ACA-CCC (standby), ACA-CDP Nodes, G9XE8 ^{*1} , ASM, ASM (standby), ASC, ASC (standby)
COMP. Set #1	19.8 A	4.6 kVA	ACA-CDP Master, ACA-CDP Master (standby), ACA-CDP Nodes, G9XE8 ^{*1} , ASM, Network Switch
COMP. Set #2	23.1 A	5.3 kVA	ACA-DMC, ACA-CDP Nodes, G9XE8 ^{*1} , ASM, Paragon User, Service Drawer
COMP. Set #3	24.6 A	5.7 kVA	ACA-DMC (standby), ACA-CDP Nodes, Network Switch, Paragon Switch, AUATC, G9XE8 ^{*1} , ASM
Total	393.2 A	90.4 kVA	

(*1) See the foot note of Table 1.

3.2.2 Electrical Connectors

Electrical connectors shall comply with the standard of AC plugs and socket [RD04]. DFP module, CIP module and Emergency switch have CEE 7/4 (Schuko type) plug. Every 2 correlator racks have 8 DFP modules, 4 CIP modules and Emergency switch. 52 CEE 7/3 sockets shall be provided for 8 correlator racks in total.

The computing racks house Correlator computers, Spectrometer computers, Spectrometer modules, and all other computer equipment. 9 PDUs distribute electric power to all devices on the computing racks. Each PDU has IEC309 32A 2P+E plug for power input. The nine IEC309 2P+E sockets shall be provided for 4 computing racks. There is an UPS behind the panel "UPS PK-ACA" which supplies 3 x 60A. 3 x 60A is enough for all servers and electrical equipment on four ACA Correlator Computing racks and no additional UPSs are needed.


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Table 3. Electricity socket

Rack	Socket	Qty	Ampere-capacity	Comments
ACA Corr. Set #x-0	CEE 7/3 (Schuko)	6	15 A per 2 sockets	6.6 A x 4 + 4.7 A x 2. No UPS.
ACA Corr. Set #x-1	CEE 7/3 (Schuko)	7	15 A per 2 sockets	6.6 A x 4 + 4.7 A x 2 + 0.8 A. No UPS.
Subtotal of 4 Sets		52		
COMP. Set #0	IEC309 2P+E	3	25 A or more	3 PDUs. No UPS.
COMP. Set #1	IEC309 2P+E	2	25 A or more	2 PDUs. No UPS.
COMP. Set #2	IEC309 2P+E	2	25 A or more	2 PDUs. No UPS.
COMP. Set #3	IEC309 2P+E	2	25 A or more	2 PDUs. No UPS.
Subtotal of 4 COMP. Sets		9		9 PDUs

3.3 FLOOR LOADING

The floor loading of the correlator system excluding the seismic support structure is 1033 kg/m² at maximum corresponding to 687kg per rack including the weight of a rack which is used in the structural analysis report [RD 07]. The floor space of the ACA Correlator racks is 5.32 m² for 8 racks and that of the ACA Correlator computing rack is 2.66 m² for 4 racks.


The weight of ACA Correlator computer racks is assumed as 687 kg in the structural analysis report. The weight of the rack itself is 140 kg. The total weight of ACA Correlator computers, the ACA Spectrometer modules and related computing equipment shall be less than 547 kg per rack (see 5 of [RD 08] for details).

3.4 AIR CONDITIONING

The air conditioning of ACA Correlator room shall comply with the specifications in [RD05]. The room to house the ALMA Correlator must have a computer floor *for forced air cooling system*. A minimum height of 0.5 m to 0.6 m will be allowed beneath the computer floor as an *air plenum* and for under-floor cabling. The racks should be bolted to frames which are rigidly attached to the underlying foundation floor rather than to the computer floor. The ACA Correlator consists of four sets of racks (2 racks per set or total 8 racks). Racks shall be bolted together per set. The running cables between sets will be laid under the floor.

3.4.1 Air Quality

The ceiling should be made of dust-free acoustic lay-in tile.

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The air shall be filtered so that the airborne dust concentration meets the ISO clean room specification of class 8 (Fed. Std. 209D class 100,000), or better.


Static control should be maintained by keeping the relative humidity between 30 % and 50 %.

3.4.2 Cooling Requirement

Sufficient cooling air must be supplied to the ACA Correlator and computing racks to suppress the temperature rise. The inlet air temperature into the room shall be between 6 to 16 degree Celsius. And the temperature increase of the outlet air from the room shall not exceed 13 degree Celsius. The air flow rate into / from the room shall be between 600 to 680 m³/min. More details are in [RD10].

4 SOFTWARE/CONTROL FUNCTION INTERFACE

There is no software or control interface between the ACA Correlator and the AOS Technical Building.

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5 SAFETY INTERFACE

5.1 ILLUMINATION AND FIRE PROTECTION

The ACA Correlator protection requirements will be same as those of the ALMA 12-Array Correlator (see section 5.2 in RD 03). The ACA Spectrometer protection requirements shall be the same as those of Computing system because the ACA Spectrometer module is a commercial computer server.

5.2 SEISMIC SUPPORT

The floor shall be provided with adequate support for the ACA Correlator and ACA Correlator Computer System racks. The rack anchors shall be strong enough to withstand seismic accelerations.

These racks also require a seismically rated steel support structure beneath the racks (see 5 of [RD 07]). The top of this structure will be bolted to the bottom of the racks and the bottom of this structure will be bolted to the concrete slab at the true floor level. The top of the structure will be even with the top of the computer floor. The ACA Correlator team will develop seismic analysis and support structure fabrication drawing for the ACA Correlator and ACA Correlator Computer System racks. The ACA Correlator team will furnish the fabrication drawings to the Site IPT for fabrication and installation by the Site IPT at the AOS Technical Building.

Apportionment of responsibilities between the Site IPT and ACA Correlator team will be identical/similar with those of the BE (see 4.5 of [RD 06]).