Technical Specification

ALMA Back End Fibre Optic Patch Panel for Technical Building

ALMA-54.00.00.00-012-B-SPE
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Revision History

Version	Date	Affected Section(s)	Author	Reason/Initiation/Remarks
A	2007-08-08	All	H. Kurlandczyk	Initial Version
B	2016-10-18	Numbered all requirements. Added requirements for Auxiliary rack (section 5.3)	G. Fischer, S. Rossi	ALMA-54.10.02.00-0008-A-CRE

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1 Purpose

This document specifies the patch panel as part of the Internal Fibre Management (IFM) within the Technical Building located at the Array Operating Site (AOS) of the ALMA project.

2 Scope

The document provides a general description of the IFM and details the technical requirements for fibre optics Patch Panel.

3 Applicable and Reference Documents

3.1 Definition of Terms and Abbreviations

Term/Abbreviation	Definition
AD	Applicable Document(s)
ADR	Acceptance Discrepancy Report
ALMA	Atacama Large Millimetre Array
AOS	Array Operations Site
BE	Back End
ESO	European Southern Observatory
F	(Optical) Fibre
FE	Front End
HW	Hardware
IF	Intermediate Frequency
IET	Integrated Engineering Team
JAO	Joint ALMA Office
LO	Local Oscillator
OSF	Operations Support Facility
Patchcord	1 or 2 fibre cable with connectors on both ends
Pigtail	1 or 2 fibre cable with connectors on one end only
Rack	Any framework that can accommodate equipment
RD	Reference Document(s)
SOW	Statement of Work
SW	Software
TB	Technical Building

3.2 Reference Documents

The following documents contain additional information. The latest issue of the document is valid.

	Document Title	ALMA Doc. Number
RD 01	Back End Patch Panel Upgrade	ALMA-54.10.02.00-0008-A-CRE

3.3 Requirements numbering

The requirements within the present document are numbered with the following code:

[ALMA-54.00.00.00-012-XXXX-YY / Z(ZZ)]

Where:

ALMA-54.00.00.00-012 identifies the Document Number;

XXXX is a consecutive number 0010, 0020, (the nine intermediate numbers remaining available for future revisions of this document);

YY describes the requirement revision. It starts with 00 and is incremented by one with every requirement revision;

Z(ZZ) describes the requirement verification method(s). Where T stands for Test, I for Inspection, R for Review of design and A for Analysis.

4 General

ALMA consists of 66 microwave antennas, built at Chajnantor, 5000 metres above sea level in one of the most inhospitable parts of the Atacama Desert of northern Chile.

The antennas are grouped in two arrays: the ALMA-B (bilateral project between North America and Europe) composed of 50 Antennas, and the ACA (Atacama Compact Array build by Japan) composed of 16 Antennas. Each ALMA-B antenna can be located on any of 177 fixed locations (antenna stations), while each ACA antenna can be located in any of 22 fixed locations.

Each antenna station is connected by means of optical fibres to the Technical Building, where control and signal processing electronics is located. The scope of this document is limited to the optical fibre cabling inside the Technical Building.

The optical fibre cable carries four signals to/from each antenna station:

- Data Transmission System (DTS): the scientific data, from Antenna to Technical Building
- Local Oscillator (LO): an accurate time reference, from Technical Building to Antenna
- Monitor and Control (M&C): Ethernet LAN, 2 signals, bi-directional

The main components of the Internal Fibre Management are:

- Patch Panel, whose purpose is to route the signals from the external cables to the internal destination. This is the scope of this document.
- Patch Cables that connect the Patch Panel to the destination equipment. This is NOT the scope of this document.

The room of the Technical Building in which the Patch Panel is installed is the Patch Panel room. The DTS as well as the M&C destinations are located in the Patch Panel, while the LO destinations are in a separate room, the LO room.

5 Specifications

The sketch in Figure 1 shows a block diagram of the connectivity requirements of the patch panel room and is the basis for the design. To note the presence of the Auxiliary Patch Panel Rack which is a consequence of [RD 01].

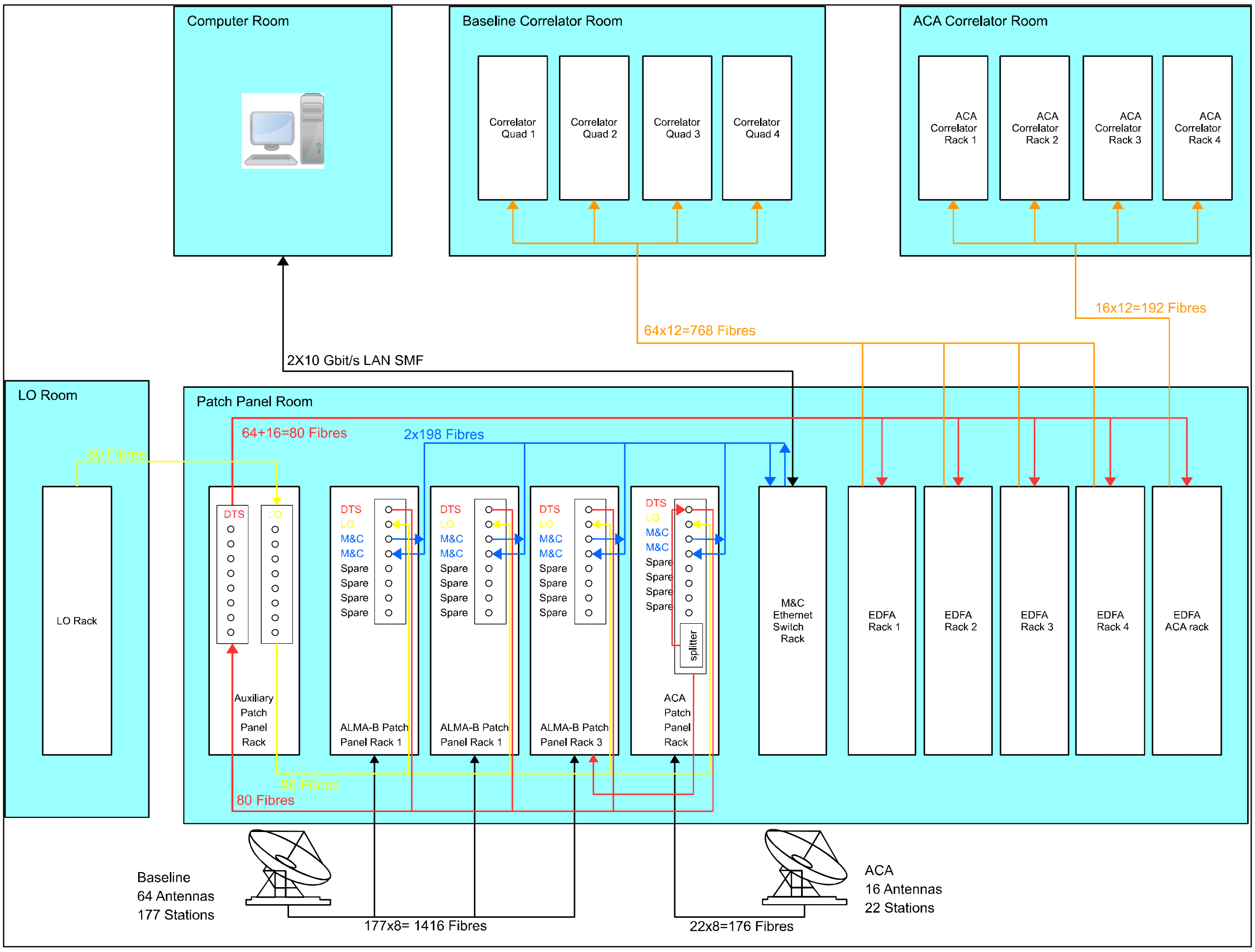

Figure 1 ALMA Back End Connectivity Block Diagram

The Patch Panel consists of 5 racks: three for handling the ALMA-B cables, one for the ACA cables and one Auxiliary meant to prevent the user patching DTS and LO fibres routed to distant cabinets. The aim is to provide a clear layout for easy and safe operation. The use of the Auxiliary rack as requested in [RD 01] aims at improving the maintainability of the system versus the original design described in the issue A of this document.

The functions the M&C, DTS and LO connectors are colour coded and also keyed to prevent incorrect connection.

The external cables are terminated directly at the rear of the ALMA-B/ACA Patch Panel Racks. In order to allow the simultaneous correlation of the scientific data generated by the ACA antennas in the ALMA-B correlator and in the ACA correlator, the DTS signals coming from the ACA stations are optically split and routed to both the ACA Patch Panel and the ALMA-B Patch Panel. The splitters are located in the ACA Patch Panel Rack. The other signals (LO and M&C) are not split.

80 duplex patch cords connect the DTS and LO signals between the Auxiliary Patch Panel rack ALMA-B/ACA Patch Panel Racks.

Table 1 is an overview of the different hardware items that will be described in more detail in the following paragraphs.

Table 1 Project deliverables detail

	ALMA-B	Qty
Item 1	Patch Panel Rack equipped with:	3
	connector modules with 8 connectors each	195
	connector module for ACA – ALMA-B correlation	1
	ACA	
Item 2	Patch Panel Rack equipped with:	1
	connector modules with 8 connectors each, including Splitter and pigtail	25
	AUXILIARY	
Item 3	Patch Panel Rack equipped with:	1
	connector modules with 12 connectors each	20

5.1 Safety

ALMA-54.00.00.00-012-0010-00/I
Laser Safety

All laser hazards shall be indicated with the appropriate safety labelling and be fully compliant with ANSI Z136.2 and /or IEC 60825-2.
The patch panel racks should have laser safety labels. The labels should be written both in English and Spanish.

5.2 ALMA-B and ACA Patch Panels Requirements

The following requirements apply to the ALMA-B and ACA Patch Panel Racks shown in Figure 1.

ALMA-54.00.00.00-012-0020-00/I
Build

The Patch Panel shall handle a total of 66 antennas, 50 of which are capable of being positioned on any of the 177 baseline stations (ALMA-B) and the remaining 16 antennas distributed over 22 ACA stations.
Provision for spare connection modules can be considered if room within the Patch Panel racks allows, in order to accommodate future extensions of the Array.
The DTS signal coming from the ACA stations shall be split within the ACA Patch Panel and brought both to the ACA and the ALMA-B from panel.
Only the DTS connections from the ACA stations will be split to feed both ACA and the ALMA-B systems.

ALMA-54.00.00.00-012-0030-00/I
Number of module connections

Each connection module on the ALMA-B and ACA Patch Panel shall provide 8 connections, including the 4 spare fibres.

ALMA-54.00.00.00-012-0040-00/R
Fibre Layout

After entrance through the cable ducts, the external cables pass under the suspended floor and enter the ALMA-B and ACA Patch Panel racks from below.
The Patch Panel shall be assembled in order to allow an easy installation of those cables.
The internal fibre management is an indoor application with controlled, stable environment, although the air pressure is about 60% the pressure at sea level due to the elevation.
Therefore, regulations for indoor environment shall apply, like ICEA S-83-596, Fiber Optic Premises Distribution Cable, is the industry standard that defines the requirements for inside plant cables. Additionally, the cables shall meet the requirements of the National Electrical Code® (NEC®) and local building codes based upon their installed location (general purpose, riser, and plenum).
The front of the racks is used for patching in the fibres to and from the LO, DTS and M&C. These cables enter and exit the racks through the top panel.

ALMA-54.00.00.00-012-0050-00/R Electrical

The Patch Panel racks shall include only passive components and do not require power or forced ventilation.

ALMA-54.00.00.00-012-0060-00/R Optical Attenuators

In order to equalize the strength of the signals coming from different stations, it is foreseen that attenuators can be used for the DTS and the M&C links, while for the LO no attenuators are envisaged.

The ALMA-B and ACA Patch panel shall give the possibility to place removable inline attenuator on the back side of the patch panel according to Figure 2.

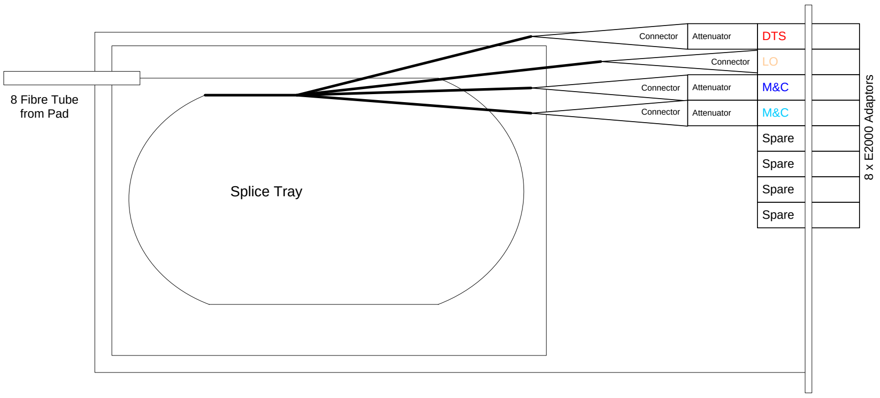

Figure 2 Diagram indicating section through main patch module, showing recommended position of attenuators

ALMA-54.00.00.00-012-0070-00/R Patch Panel Rack

The rack shall be the Optical Distribution Rack 900F from the manufacturer Huber und Suhner. The racks shall be rated seismic Zone 4.

Figure 3 Optical Distribution Rack 900F

It shall have the following characteristics:

- Composed of one base rack 600 and one base rack 300
- Arrangement of the patchcord management on the left side of the subracks
- Receiving of 10 subracks 900 with one patchcord routing channel or 11 subracks 900 without patchcord routing channel
- Telescopic mounting angle with cable bracket for fixing at the grid
- C rack without front rail
- 30 cage nut M6 for mounting of components to the rails
- Levelling by height adjustable feet
- Sideways and backside mounting of further racks incl. mounting material
- Hammer head stampings for mounting cables at each head and floor frame right- and left-aligned
- Grounding bolt M6 at top and bottom of the rack
- Door with look and handle
- Mounting of the door and side walls without tools
- Cut-out for socket
- Dimensions: 900x300x2200mm (WxDxH)
- Material: steel powder coated
- Colour: light grey (RAL 7035)
- Optional: back and side wall, front door, socket

ALMA-54.00.00.00-012-0080-00/R
Fibre Bending Radius

Fiber bends shall be controlled by the system hardware. Typical examples are shown in Figure 4.

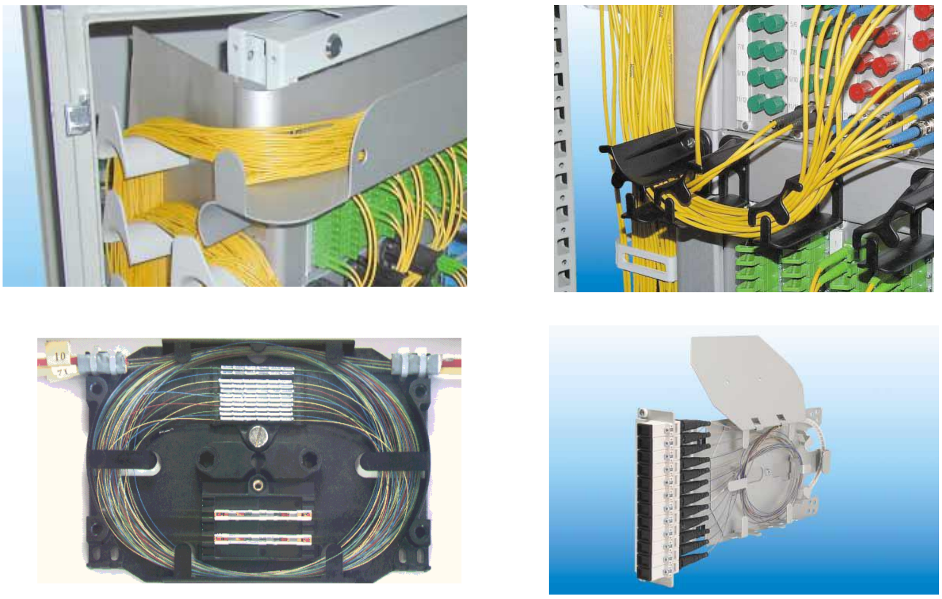

Figure 4 Cable and Fibre Management

The minimum bend radius shall be 30 mm with most guides providing a minimum bend of 40 mm. It is recommended that no hardware is used that allows a bend radius of less than 40mm.

Cables positioned on the overhead trays between cabinets will be installed to provide the maximum possible bend radius at changes in direction. These will typically be greater than 150 mm radius, and we anticipate up to a total of 8 bends per cable.

ALMA-54.00.00.00-012-0090-00/I
Fibre Connector Modules

Connector modules are used for terminating both indoor and outdoor cables. Buffer tubes or indoor cables can be secured, inserted and terminated in the fiber connector modules.

Figure 5 Fibre Connector modules

Connector modules are used for terminating both indoor and outdoor cables. Buffer tubes or indoor cables can be secured, inserted and terminated in the fibre connector modules.

- For the ALMA-B 177 antenna stations need to be connected to 177 connector modules. The modules shall be distributed on the 3 racks where each rack contains 59 modules + 6 spare modules. Therefore 65 connector module shall be in each rack.
- For the ACA 22 antenna stations need to be connected to 22 connector modules. 3 spare connector modules should be included. The ACA rack will therefore have 25 connector module.

ALMA-B Patch Panels			ACA Patch Panel
Rack 1	Rack 2	Rack 3	ACA Rack
65 Modules	65 Modules	65 Modules 1 Connector Module for ACA-ALMA-B correlator	25 Modules

ALMA-54.00.00.00-012-0100-00/I
Fibre Connector Modules characteristics

The pre-assembled connector module comprises the following parts:
- Limitation of bending radius minimal 35mm
- 8 splice connections with heat shrink splice protectors
- Cross over field with bending limitation for fibres
- Fibre and loose tube entry possibilities at all four sides
- Splice cassettes fixing with crews or central bolt
- Cassette stack and lid secured against rotation
- Snap-on lid incl. laser safety sign and labelling areas
- Splice cassette dimensions: 210x104x8mm (LxWxH)
- Material: ABS/PC, thermoplastic, flame-retardant, halogen free, UL94 V-0
- Optional: “book system” with hinge at all four sides, Pigtail strain relief for fixing of Pigtails, lid for covering the top cassette, splice holder
- The connector modules should be able to accommodate attenuators as described in ALMA-54.00.00.00-012-0060-00/R

ALMA-54.00.00.00-012-0100-00/I
ACA Connector Modules characteristics

ACA connector modules shall meet the requirement ALMA-54.00.00.00-012-0100-00/I. Additionally, the 25 (22 + 3 spares) ACA connector modules shall have an additional optical splitter having the characteristics described in ALMA-54.00.00.00-012-0110-00/I.

ALMA-54.00.00.00-012-0110-00/I Optical Splitter

The DTS signals for the ACA shall be split before they are routed back to the EDFA cabinets. This is done by adding an optical coupler into the circuit of the connector modules in the ACA distribution cabinet.

The coupler will perform an equal two way split of the signal and will consist of a metal tube similar in size to a splice protection sleeve. The input of the coupler shall be spliced to the incoming DTS Fibre from the antenna station. This operation can only be done on site at the AOS. The outputs of the coupler are spliced to the DTS pigtail mounted on the front panel of the connector module and to a 4 metre ruggedized pigtail which will be cable tied to the entry / exit point of the splice tray.

The splicing of both pigtails will be done by the manufacturer before shipment to the AOS. The ruggedized pigtail shall be coiled into protective packaging and secured in the bottom of the cabinet during shipment. Once installed on site they will be un-packed and routed to cabinet 2 where they will be installed into the bottom sub-frame.

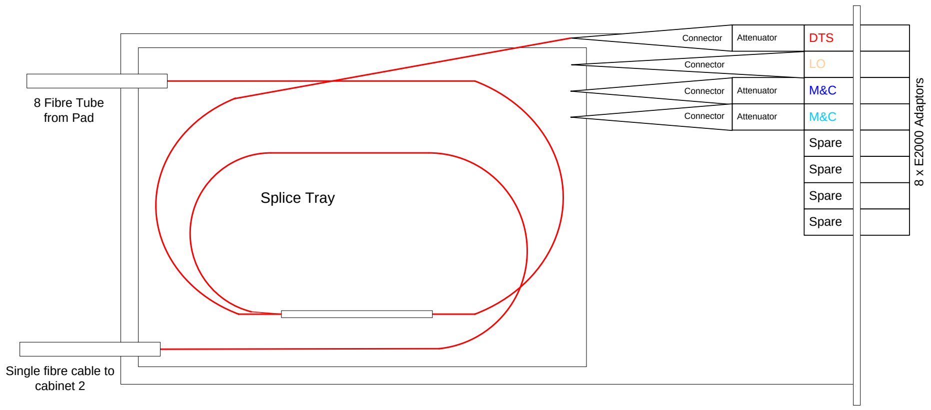

Figure 6 Splitter arrangement for the ACA DTS Signal.

The splitter devices used in the splitter modules shall have the following optical characteristics:

Split Ratio	1 x 2
Operating Wavelengths	1310 & 1550nm
Insertion Loss	≤3.6dB
Uniformity	≤0.7dB
Return Loss	≥55dB
Polarization Dependent Loss	≤0.15dB
Temperature Dependent Loss	0.2dB (-10°C to +75°C)
Packaging Dimensions	55mm x 3mm diameter
Fibre Leg Lengths	1 m

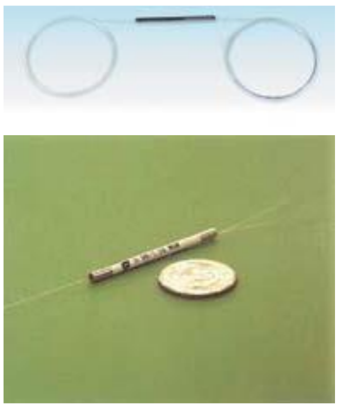

Figure 7 Examples of optical splitters

ALMA-54.00.00.00-012-0120-00/I ACA/ALMA-B correlation connector module

After the DTS signals have been split in the 25 ACA connector modules, all pigtails are routed inside the patch panel rack and spliced to a connector module. This module should be able to accommodate 25 connectors. The last one can be considered as unconnected spare.

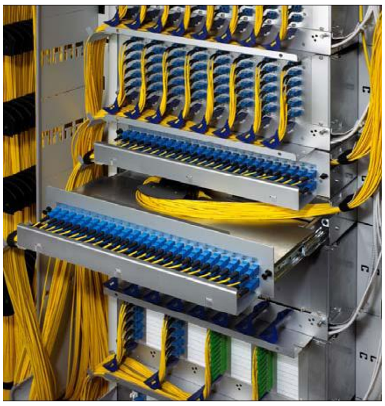

Figure 8 Examples of possible Connector module for the ACA - ALMA-B correlation

ALMA-54.00.00.00-012-0130-00/I Labelling

The labelling of the connector modules shall be as shown in Figure 9 and Figure 10:

ALMA-B module
DTS 1
LO 1
M&C 1
M&C 1
Spare
Spare
Spare
Spare

ACA Module
ACA DTS 1
ACA LO 1
ACA M&C 1
ACA M&C 1
Spare
Spare
Spare
Spare

Figure 9 Labelling of connector modules

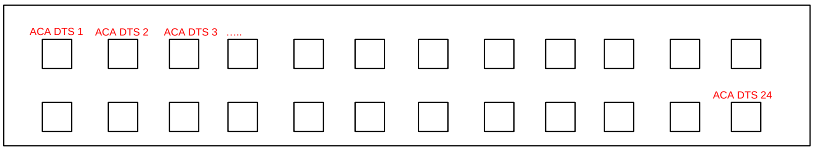

Figure 10 Labelling of connector modules for the ACA - ALMA-B correlation

ALMA-54.00.00.00-012-0140-00/R
Fibre Requirement

The fibre included in the system shall be G.652 and meet all attributes within G.652 tables A, B, C and D as identified in the ITU -T G.652 standard “Characteristics of a single-mode optical fibre and cable”.

Mode field diameter nominal value (1550 nm): 10 – 11 µm
Mode field diameter tolerance (1550 nm): 0.5 µm
Cladding diameter: (125 ± 0.7) µm
Mode field concentricity error: 0.5 µm
Cladding non circularity: 1%
Refractive index profile: step
Design: matched cladding
Effective group index of refraction Neff (at 1310nm): 1.4677
Effective group index of refraction Neff (at 1550nm): 1.4682
Attenuation at 1550 nm: ≤0.20 dB/km typical ≤ 0.22 dB/km max
Attenuation at 1625 nm: ≤ 0.22 dB/km typical ≤ 0.25 dB/km max
Dispersion in the range 1288 to 1339 nm: ≤ 3.5 ps/nm x km
Dispersion at 1550 nm: ≤ 18 ps/nm x km
Polarisation Mode Dispersion (PMD)
at 1550nm <0.2 ps/rtkm all 8 fibres
<0.05 ps/rtkm at least 4 fibres per bundle

ALMA-54.00.00.00-012-0150-00/R
Connectors

All connectors included in the system shall be E2000 APC (8º) SM with system performance of 0.1 dB maximum insertion loss with random mating.

Figure 11 E2000 Connector

The connector modules described in requirement ALMA-54.00.00.00-012-0120-00/I shall be E2000 feed-through couplers.

Figure 12 E2000 feed-through coupler

These connectors and couplers shall be fitted with colour coded sleeves as well as mechanical key. This will prevent the connection of cables to the wrong service function (for example LO into M&C). The following Colour scheme shall be followed:

DTS → Red
LO → Yellow
M&C (in) → Dark blue
M&C (out) → Light Blue

5.3 Auxiliary Patch Panel Requirements

The following requirements apply to the Auxiliary Patch Panel Rack shown in Figure 1.

ALMA-54.00.00.00-012-0160-00/I
Build

The Patch Panel shall serve a total of 240 connections split in 20 modules.
A maximum 8 connection modules shall be fitted in a sub rack.
A maximum of 4 sub racks (2 for 120 DTS fibres and 2 for 120 LO fibres) shall be installed in the Auxiliary Patch Panel.

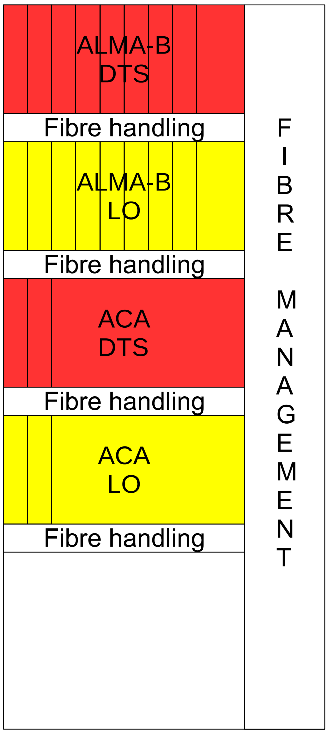

Figure 13 Auxiliary Patch Panel Build Layout

ALMA-54.00.00.00-012-0170-00/I
Fibre Connector Module Characteristics

Connector modules are used for terminating fibres to EDFA / LO racks and duplex patchcords. Buffer tubes or indoor cables can be secured, inserted and terminated in the fibre connector modules.

Figure 14 Fibre Connector modules

Each connection module in the Auxiliary Patch Panel shall provide 12 connections.

ALMA-54.00.00.00-012-0180-00/I Labelling

The labelling of the connector modules for the ALMA-B and ACA signals shall be as shown in Figure 15:

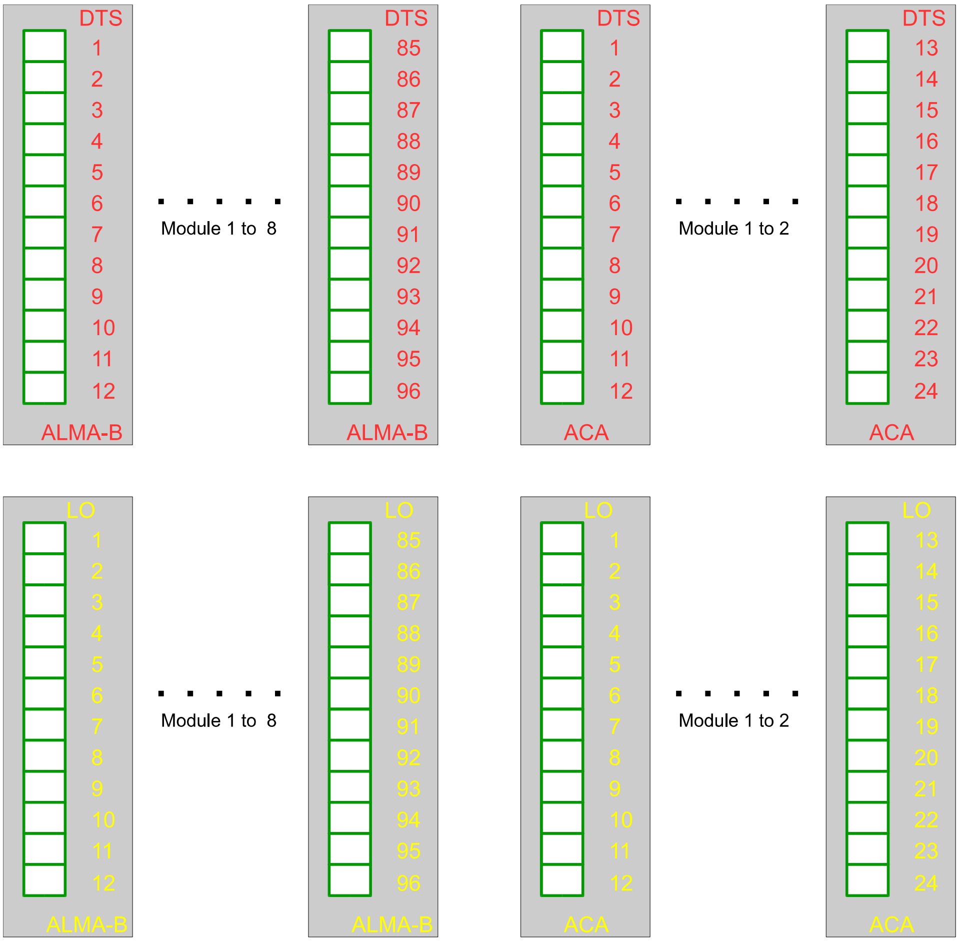

Figure 15 Labelling of connector modules

ALMA-54.00.00.00-012-0190-00/R Fibre Layout

The cables form destinations (EDFA racks and LO racks) shall be routed from the top, reach each module form the back side and be connected to the back of the E2000 couplers.

The Patch Panel shall be assembled in order to allow an easy installation of those cables.

The internal fibre management is an indoor application with controlled, stable environment, although the air pressure is about 60% the pressure at sea level due to the elevation.

Therefore, regulations for indoor environment shall apply, like ICEA S-83-596, Fibre Optic Premises Distribution Cable, is the industry standard that defines the requirements for inside plant cables. Additionally, the cables shall meet the requirements of the National Electrical Code® (NEC®) and local building codes based upon their installed location (general purpose, riser, and plenum).

The front of the racks is used for connecting the DTS and LO duplex patch cords.

ALMA-54.00.00.00-012-0200-00/R Electrical

The Auxiliary Patch Panel rack shall include only passive components and do not require power or forced ventilation.

ALMA-54.00.00.00-012-0210-00/R
Patch Panel Rack

The rack shall have the following characteristics:

- Composed of one base rack 600 and one base rack 300
- Arrangement of the patchcord management on the right side of the subracks
- Receiving of 4 subracks 900 with one patchcord routing channel or 4 subracks 900 without patchcord routing channel
- Telescopic mounting angle with cable bracket for fixing at the grid
- C rack without front rail
- 30 cage nut M6 for mounting of components to the rails
- Levelling by height adjustable feet
- Sideways and backside mounting of further racks incl. mounting material
- Hammer head stampings for mounting cables at each head and floor frame right- and left-aligned
- Grounding bolt M6 at top and bottom of the rack
- Mounting of the side walls without tools
- Cut-out for socket
- Dimensions: 900x300x2200mm (WxDxH)
- Material: steel powder coated
- Colour: light grey (RAL 7035)
- Optional: back and side wall, front door, socket

ALMA-54.00.00.00-012-0220-00/R
Fibre Bending Radius

Fibre bends shall be controlled by the system hardware.

The minimum bend radius shall be 30 mm with most guides providing a minimum bend of 40 mm. It is recommended that no hardware is used that allows a bend radius of less than 40mm.

Cables positioned on the overhead trays between cabinets will be installed to provide the maximum possible bend radius at changes in direction. These will typically be greater than 150 mm radius, and we anticipate up to a total of 8 bends per cable.

5.4 Environmental Constraints

ALMA-54.00.00.00-012-0230-00/R Operational Temperature Range: [-20°C … +40°C]

ALMA-54.00.00.00-012-0240-00/R Operational Range of pressure: from sea level down to 550mb ± 50mb which corresponds to an air density of 0.7214 kg/m^3 (typical)

ALMA-54.00.00.00-012-0250-00/R Operational Relative Humidity: Min. 0% Max. 95%

5.5 Mechanical Constraints

ALMA-54.00.00.00-012-0260-00/R Seismic stresses (peak horizontal ground acceleration): 0.28g

5.6 Store and Transport conditions

ALMA-54.00.00.00-012-0270-00/R Storage Temperature: [-40°C.. +85°C]

ALMA-54.00.00.00-012-0280-00/R Storage Relative humidity: Min. 0% Max. 95%

ALMA-54.00.00.00-012-0290-00/R The boxes of all deliverables should be suitable for intercontinental shipment