Atacama
Large
Millimeter
Array

ALMA Back End IPT IFP
Highpass Filter

SPECIFICATION

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Change Record

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A	2007-03-23	All		Initial Release

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1 PURPOSE

This document defines all specifications of the IF Processor highpass filter (IFP HPF). The low band edge of the first IF and high band edge of the second IF are both 4 GHz. Any first IF signal in the 3-4 GHz range makes its way to the second IF output as a leakage signal without frequency translation and is therefore a spurious signal. The IFP HPF specifications are written with the intent to suppress this spurious signal to an acceptable level without introducing undue passband insertion loss and ripple.

2 SCOPE

This specification establishes the performance, design, manufacture, quality assurance, qualification, and acceptance criteria for the Back End IFP highpass filter. The IFP HPF shall be referred to herein as the *unit* or the *filter*.

3 APPLICABLE DOCUMENTS

3.1 Compliance Documents

The Vendor shall comply with the requirements of the following documents of the exact issue shown to the extent specified herein. In the event of conflict between the documents listed and the contents of this specification, this specification shall be the superseding document.

BEND-52.00.02.00-001-A-SOW, ALMA Back End IPT IF Processor Production Highpass Filter Statement of Work

3.2 Reference Documents

The following documents are listed as reference documents and shall be used for guidance only. This specification does not require compliance to the requirements of these documents. Vendors should note instances where internal specifications and standards are substituted for these reference documents.

ANSI/ASQC Z1.4-1993 Sampling Procedures and Tables for Inspection by Attributes

4 ACROYNMS

°C	Degrees Celsius
dB	decibel, 10log (ratio)

dBm	decibel with respect to a milliwatt (e.g., 20 dBm = 100 mW)
ESD	Electrostatic Discharge
ESO	European Southern Observatory
FMEA	Failure Modes and Effects Analysis
g	9.8 m/s^2, a measure of acceleration
GHz	Giga-Hertz (10E9 Cycles per Second)
HPF	High Pass Filter
IF	Intermediate Frequency
IFP	IF Processor
ISO 9001	The International Standardization Organization quality standard
m	Meter
mb	Millibar, a unit for expressing atmospheric pressure
MHz	Mega Hertz (10E6 Cycles per Second)
MTBF	Mean Time between Failures
NRAO	National Radio Astronomy Observatory
ppm	parts per million
RF	Radio Frequency
SMA	Sub-Miniature version A connector, a coaxial RF connector
SOW	Statement of Work

5 REQUIREMENTS

5.1 Item Description

The unit shall consist of a highpass filter. The goal is to reject signals at 4 GHz and below while maximizing the available frequency range of 4-12 GHz. Figure 1 illustrates the basic functionality of the highpass filter.

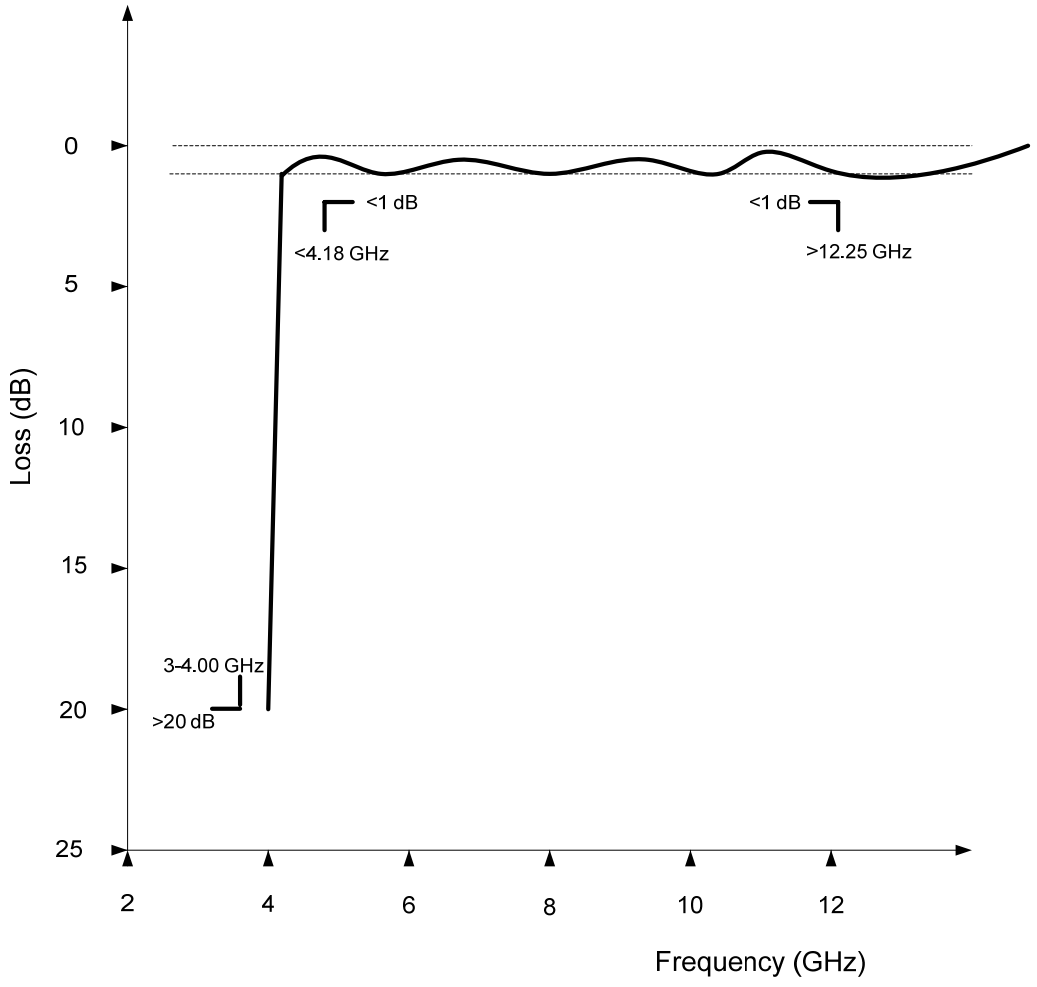

Figure 1: IFP Highpass Filter Mask

5.2 Specifications

The following subsections detail the RF, physical, interface, lifetime, environmental and safety specifications that the IFP Highpass filter must satisfy.

5.2.1 RF Performance Summary

The high pass filter will be used at the input to second down conversion in ALMA receivers. The input frequency range of the down converter is 4-12 GHz. The output frequency range is approximately 2-4 GHz. Input signals at 3 to 4 GHz pass straight through the down converter attenuated only by the down converter mixer RF to IF isolation, which causes erroneous total power detector readings at any frequency. Additionally, when the LO is near 8 GHz, the leakage corrupts the ~4 GHz signal that is being down converted, also to ~4 GHz.

The highpass filter will provide additional input to output isolation at 4 GHz and below. At the same time, it is desired that the passband edge should remain as close to 4 GHz as possible to maximize the usable instantaneous input bandwidth.

The filter may be a highpass, pseudo-highpass, or notch filter as the Vendor sees fit. The Vendor shall propose the actual filter type.

Example

For 20 dB rejection at 3-4 GHz, the equal-ripple band edge of the pseudo-elliptic highpass filter would be at 4.18 GHz. There is a total loss of 180 MHz from the 4-12 GHz band. A filter with more sections and less lost bandwidth would be the preferred choice as long as all other requirements such as insertion loss, loss ripple and loss slope are met.

5.2.1.1 Characteristic Impedance

The characteristic impedance of both ports shall be 50 Ohms.

5.2.1.2 Passband Frequency Range

The filter shall have a passband over the range of ~4 GHz to 12.25 GHz, minimum, as outlined in paragraph 5.2.1.

The exact highpass filter cutoff frequency shall be proposed by the Vendor; preferably the cutoff frequency shall be stated as the equal-ripple cutoff frequency. The Vendor shall present the proposed filter band edges for approval.

5.2.1.3 Stop Band

The filter will provide rejection of 20 dB minimum over a range of 3 to 4.00 GHz.

As described in 5.2.1, after meeting the 20 dB rejection requirement, the next most important parameter is maximizing the 1 dB equal-ripple passband between 4 and 12.25 GHz.

5.2.1.4 Return Loss

The return loss shall be 17 dB minimum over the passband frequency range defined in Section 5.2.1.12.

5.2.1.5 Phase Matching

Filter to filter phase matching is required to within ± 4 degrees over the passband frequency range of ~4-12.25 GHz (Vendor to specify the lower band edge over which the phase matching shall be realized).

Phase matching is for a fixed room ambient temperature only to be specified by the Vendor, NOT over the full operating temperature range.

The requirement allows removal of the least squares best fit straight line phase slope across the equal-ripple passband, defined in paragraph 5.2.1.2. That is, the requirement will be for phase variation after the phase slope is removed.

A "golden" unit may be kept by the Vendor and used as a reference for matching all the filters to that one. (It can be one of the filters on order, and it can be the last filter delivered on our last production order.)

5.2.1.6 Power Handling

The unit shall be capable of receiving an input RF power of +20 dBm with no degradation to any performance specification. The unit shall not electrically breakdown (corona discharge) at the specified operating altitude given in paragraph 5.2.5.2. The unit shall not use hermetic sealing to meet the power handling requirement without the approval of the Buyer.

5.2.1.7 Insertion Loss

The unit insertion loss goal shall be 1.0 dB maximum over the frequency range defined in Section 5.2.1.12.

The unit insertion loss variation shall be 0.8 dB maximum, over all environmental conditions and the frequency range defined in Section 5.2.1.12.

Insertion loss can be a trade-off parameter for maximum equal-ripple passband. The 1 dB insertion loss is desired, but is not a hard requirement. A ripple of <0.8 dB is highly desired, but the total insertion loss can be higher than 1 dB. The Vendor should propose a trade value for insertion loss, if greater than 1 dB, that will provide more usable 0.8 dB equal-ripple bandwidth; i.e., a low frequency corner closer to 4 GHz.

5.2.2 Lifetime Requirements

5.2.2.1 Reliability

The unit shall have a minimum calculated MTBF of 150,000 hours (17 years), goal of 300,000 hours (34 years).

5.2.2.2 Failure Modes and Effects Analysis (FMEA)

The Vendor shall perform a Failure Modes and Effects Analysis (FMEA) and provide the results to the Buyer.

5.2.2.3 Root Cause Analyses

For each device failure within the warranty period, the Vendor shall perform a root cause analysis on the failed unit. The results of the failure analysis shall be provided to the Buyer. For unit failure beyond the warranty period, the Buyer may request a root cause analysis to be performed at the Buyer's expense.

5.2.2.4 Maintainability

The Vendor shall design the unit such that there is no need for scheduled or preventive maintenance.

The Vendor shall identify repair turnaround times for failed units.

5.2.2.5 Operating Life

The unit is used in a large scale scientific application with an expected operational life of 30 years. Vendor should provide feedback in regards to this level of operating life requirement.

5.2.2.6 Storage Life

The unit shall meet the operational life requirements following a storage life of up to three years. The Vendor shall identify any procedures that are necessary to meet this requirement.

5.2.2.7 Age Sensitivity

The Vendor shall identify age sensitive parts including criteria for age sensitivity and procedures for periodic servicing and/or life extension as applicable. Each unit shall include a list of age sensitive items, date of manufacture, and schedule date for maintenance or replacement action.

5.2.3 Interface Definition

The unit shall comply with the following interface definitions.

5.2.3.1 Physical Mounting Interface

The unit shall be capable of being mounted from the top either through the body of the filter itself or through outboard mounting feet with through holes. In either case, the through holes must provide clearance for M3 screws (metric). Vendor shall provide an outline drawing.

5.2.3.2 RF Signal Interface

The RF input signal interface shall have a straight, SMA Plug (Male) coaxial connector. The connector shall be similar to an Astrolab type:

29049, SMA jack, flanged.

This is a two-hole flange; a four-hole flange is also acceptable.

The RF output signal interface shall have a right angle or swept right angle SMA Jack (Female) coaxial connector. The orientation of the right angle bend shall be in the same direction for all filters (i.e., to the top or bottom or one of the sides). The connector shall be similar to an Astrolab type:

29214, right angle SMA jack, flanged,

or 29501, 90° sweep SMA jack, flanged,

or 29522, 90° sweep SMA jack, flanged,

or 29521, 90° sweep SMA jack, flanged.

Two-hole or four-hole flanges are acceptable.

5.2.4 Physical Characteristics

The unit shall meet the following physical requirements.

5.2.4.1 Envelope

The highpass filter shall be no larger than 1.5 x 1.5 x 5.0 inches, including connectors and mounting feet. The Vendor shall propose the actual filter size. The Vendor is encouraged to define the smallest envelope within the above size restriction that will result in best performance and/or reduced cost.

One surface shall be designated the mounting surface, preferably one of the sides if the filter has a rectangular cross section.

If the filter cannot be made to meet performance and fit the maximum envelope restriction, size exception should be stated in the proposal.

5.2.4.2 Weight

There is no weight limit. The Vendor shall propose the maximum weight.

5.2.4.3 Mounting Surface

The mounting surface of the unit shall be machined with a surface finish of 12.5 μm or better. Mounting surface scratches are acceptable with the provision that no material protrude outward from the mounting surface (in order to maintain base plate flatness). The unit mounting surface shall be flat within 0.1 mm.

5.2.5 Environmental Conditions

The unit shall meet the requirements of this specification during and after exposure to any combination of the following environments.

5.2.5.1 Temperature

5.2.5.1.1 Operating Range

The unit shall meet all performance requirements of this specification, except for phase matching, when operating over the temperature range of 10 °C minimum to +50 °C maximum.

5.2.5.1.2 Stability

The filter shall be designed to minimize frequency drift with temperature variation of the low end equal-ripple corner and 20 dB rejection point at 4.00 GHz. The maximum allowable temperature drift is 10 ppm/°C over the operating temperature range.

5.2.5.1.3 Storage Range

The unit shall be capable of meeting all performance requirements of this specification after it has been stored for extended periods of time over the temperature range of -40 °C minimum to +75 °C maximum.

5.2.5.2 Altitude

The unit shall be capable of meeting all performance requirements when operating from sea level barometric pressure level through to the barometric pressure level of approximately 5000 m (on average, 557 mb ±3 mb).

5.2.5.3 Acceleration

The unit shall be capable of meeting all performance requirements after being exposed to a constant acceleration of 1 g around any axis.

5.2.5.4 Humidity

The unit shall be capable of meeting all performance requirements when the relative humidity is in the range of 1% to 95%. Vendor shall inform Buyer if the unit can not meet, or has any sensitivity to, low relative humidity levels.

5.3 Design and Construction

The design process shall consider material, tolerances, processes, methods, and techniques that will achieve the lowest cost consistent with acceptable performance.

5.3.1 Parts, Materials and Processes

The Vendor shall utilize a control system for parts, materials, and processes consistent with the requirements of ISO 9001.

5.3.1.1 Cleanliness

All internal and external surfaces of the unit shall be clean. The surfaces shall be free of oil and other contaminants.

5.3.2 Workmanship

The unit will be built using workmanship standards that meet or exceed MIL-STD-454 Guideline 9.

5.3.3 Interchangeability

All parts having the same manufacturer's part number shall be functionally and dimensionally interchangeable and replaceable. Units shall be uniformly characterized to accommodate interchangeability without re-characterization or adjustment in the subsystem or system.

5.3.4 Safety

5.3.4.1 Environmental, Health, and Disposal

The Vendor shall comply with the safety, environmental, health and disposal requirements established in federal rules and regulations.

5.3.4.2 Electrostatic Discharge Sensitive Devices

The unit shall include the proper protection of any ESD sensitive electronics. The unit will have an ESD warning label if it is ESD sensitive.

Tests in addition to other Vendor suggested and Buyer approved tests. It is highly recommended parts be tested in an altitude simulation chamber to verify performance at 5000m altitude. Vendor may substitute or provide altitude data on similar devices to satisfy this requirement, with the approval of the Buyer.