



## SINGLE PIXEL FEED CONTROLLER DEVELOPMENT SPECIFICATION

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## LIST OF ABBREVIATIONS

CFI	Client Furnished Item
COTS	Commercial off the Shelf
DFN	Dish Fibre Network
DS	Dish Structure
FMECA	Failure Mode, Effects and Criticality Analysis
FP	Feed Package
FPC	Feed Package Controller
ILS	Integrated Logistic Support
LMC	Local Monitoring and Control
LNA	Low Noise Amplifier
OLM	Organisational Level Maintenance
PDU	Power Distribution Unit
POST	Power-On Self-Test
RFI	Radio Frequency Interference
SCP	Secure Copy
SFTP	SSH File Transfer Protocol
SKA	Square Kilometre Array
SKADC	SKA Dish Consortium
SKAO	SKA Project Office
SPF	Single Pixel Feed
SPFC	Single Pixel Feed Controller
SPFHe	Single Pixel Feed Helium Service
SPFVac	Single Pixel Feed Vacuum Service
SPF1	Single Pixel Feed Band 1
SPF2	Single Pixel Feed Band 2
SPF345	Single Pixel Feed Band 345
SSH	Secure Shell
TE	Test Equipment

For items written in ***Bold Italic***, see the Glossary in [AD1].

# 1 SCOPE

## 1.1 Identification

This specification establishes the performance, design, development and test requirements for the SKA single pixel feed controller (SPFC).

## 1.2 Intended use of Document

This development specification:

- Forms part of the SPF sub-element engineering baseline.
- Defines functional, performance, interface, environmental, physical, services, safety, logistic support, regulatory (legal), special design, construction and commissioning requirements which are an input to the engineering and development of the item.
- Describes the methods that will be used to verify that these requirements have been met when the item is submitted for acceptance.

## 1.3 System Description

### 1.3.1 System Overview

The Square Kilometre Array (SKA) dish structure will house up to three single pixel feed packages (FP), each functioning in a different frequency band. In order to obtain optimum sensitivity, two of the feed packages utilise cryostats to cryogenically cool the signal chain. The cryostats need vacuum for thermal isolation and the cryocoolers require high pressure helium. The supply of high pressure helium and the creation of a vacuum are defined as the SPF helium service (SPFHe) and SPF vacuum service (SPFVac) respectively.

The SPFC is responsible for controlling the SPFHe and SPFVac as well as the respective FPs and for providing an interface to the local monitoring and control (LMC) sub-element. The SPFC is a microprocessor-based design, located inside the RFI shielded area of the pedestal and uses slow serial communication over fibre to the different feed packages. It monitors the health status of each SPF cryostat, receiver control and monitoring electronics and also controls the active components inside each receiver cryostat. All monitored parameters are independently logged per FP and sent to the end user when requested.

The SPFC communicates to the LMC sub-element via the Tango protocol over an optic fibre Ethernet interface. ON/OFF control of the low noise amplifiers (LNAs), temperature control set points, and the cool down and vacuum procedures are accomplished via the network interface. To obtain the required switching times, the calibration sources in the feed packages are controlled by the receiver. The SPFC can, however, override this signal and turn the noise diode on. Secure shell (SSH) connections to the SPFC are possible in order to change initialization files and update software, while internal log files can be downloaded with an SSH file transfer protocol (SFTP) connection.

Once initialized, the SPFC shall automatically control each connected feed package to enter into the user defined default start-up-mode.



### 1.3.2 Context

Figure 1 shows the SPFC in context of the other SPF major components, as well as the interface types present between them. The SPF sub-element interfaces only with other components of the dish element, hence all external interfaces are internal to the SKA Dish Consortium (SKADC).

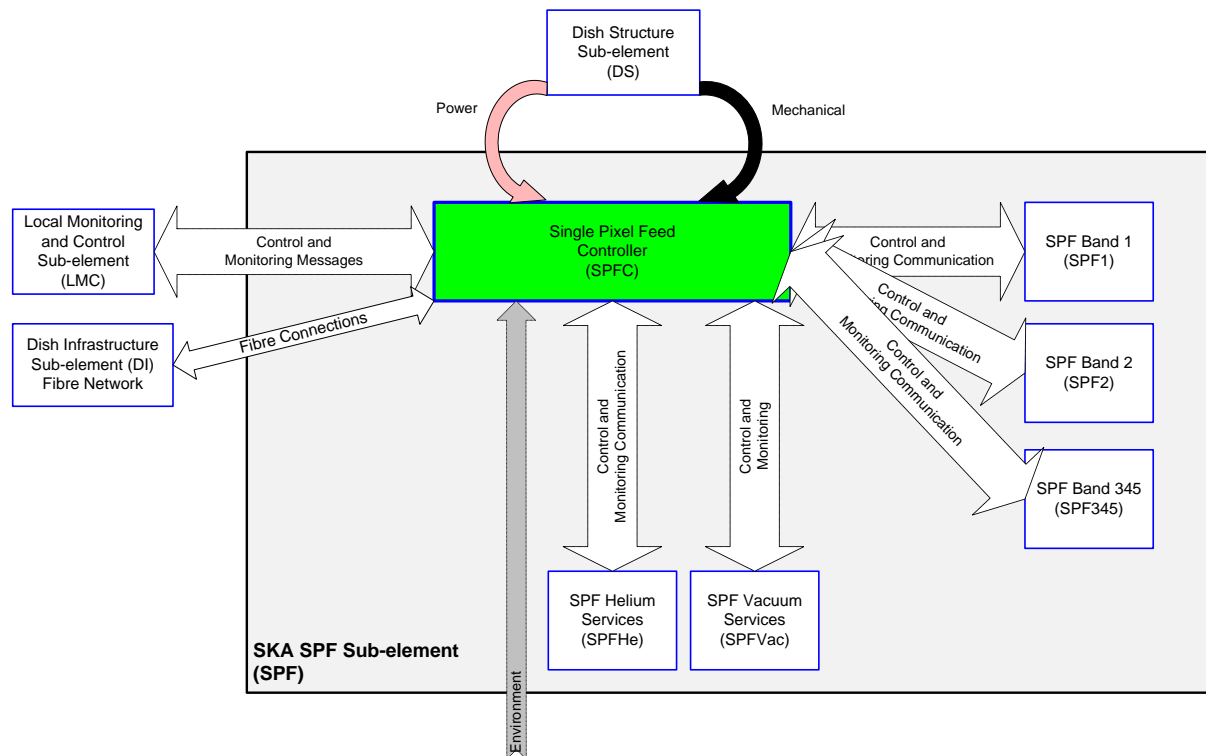


Figure 1: SPFC context diagram.

### 1.4 Document Overview

This document is organized into the following major sections.

Section 2 is a list of applicable documents.

Section 3 addresses the requirements with respect to modes, capabilities, interfaces, data, and adaptation, safety, operating environment, quality factors and design constraints.

Section 4 contains the quality assurance provisions. It defines a set of qualification methods and specifies a test method to be used for each requirement in Section 3.

Section 5 contains the requirement provisions for the delivery of the system in its entirety.

Section 6 provides non-contractual notes for clarification of the specification.

The intended audience for this document is:

- a. SKADC system engineering personnel involved with the establishment and approval of this development specification.
- b. SKADC SPF as engineering personnel involved in the development of the SPF major components.

## 2 DOCUMENTS

### 2.1 Applicable Documents

The following documents are applicable to the extent stated herein. In the event of conflict between the contents of the applicable documents and this document, **the applicable documents** shall take precedence.

- [AD1] A. Peens-Hough, et al., "Single Pixel Feed (SPF) Requirements Specification", SKA-TEL-DSH-0000012, Rev. 5, 2017-06-01.
- [AD2] G. Smit , et al., "SKA1 Dishes Element Power Management", SKA-TEL-DSH-0000041, Rev. 2, 2017-03-03.
- [AD3] G. Smit, et al., "Data Exchange Interface between the Dish LMC and the SPF Controller", SKA-TEL-DSH-0000055, Rev. 2, 2018-02-01.
- [AD4] P.C. van Niekerk, "SPF Controller to SPF Band 1 Data Exchange ICD", SKA-TEL-DSH-0000093, Rev. 3, 2018-01-31.
- [AD5] P.C. van Niekerk, "SPF Controller to SPF Band 2 Data Exchange ICD", SKA-TEL-DSH-0000094, Rev. 2, 2017-11-03.
- [AD6] T. Steyn, "SPF Controller to SPF Band 345 Data Exchange ICD", SKA-TEL-DSH-0000095, Draft A.
- [AD7] T. Steyn, "SPF Controller to SPF Vacuum ICD", SKA-TEL-DSH-0000096, Rev. 1, 2016-11-30.
- [AD8] T. Steyn, "SPF Controller to SPF Helium Data Exchange ICD", SKA-TEL-DSH-0000097, Rev. 1, 2016-11-30.
- [AD9] G. Smit , "Physical Interface Control Document between the SPF Controller and Dish Structure", SKA-TEL-DSH-0000063, Rev. 2, 2017-06-14.
- [AD10] G. Smit, et al., "Physical Interface Control Document between the Dish Fibre Network and the Single Pixel Feeds", SKA-TEL-DSH-0000066, Rev. 4, 2018-07-03.
- [AD11] I. P. Theron, et al., "Single Pixel Feed (SPF) Sub-element Design Document", SKA-TEL-DSH-0000020, Rev. 6, 2018-07-18.

### 2.2 Reference Documents

The following documents are referenced in this document. In the event of conflict between the contents of the referenced documents and this document, this document shall take precedence.

- [RD1] Environmental conditions and environmental tests for telecommunications equipment; Part 1-2: Classification of environmental conditions; Transportation, ETSI EN 300 019-1-2 V2.1.4

### 3 REQUIREMENTS

#### 3.1 Functional and Performance Requirements

##### 3.1.1 States and Modes

[SPFC-0001] The SPFC shall have the following modes (Refines: R.SPF.SM.1):

- a) OFF
- b) STARTUP
- c) STANDBY\_LP
- d) OPERATE
- e) MAINTENANCE
- f) ERROR

[SPFC-0002] The SPFC shall have the following power states (Refines: R.SPF.SM.11):

- a) LOW\_POWER
- b) FULL\_POWER

[SPFC-0003] The SPFC shall report its modes and power states to the LMC (Refines: R.SPF.SM.3).

**Table 1: SPFC Modes**

Mode	Description and Transition requirements
OFF	[SPFC-0004] The SPFC shall switch off when in STANDBY_LP mode and a system reset is requested by the LMC.
STARTUP	[SPFC-0005] The SPFC shall, after a successful start-up procedure, automatically transition to the STANDBY_LP mode and remain there until commanded by the LMC to transition to a new mode (Refines: R.SPF.SM.13).
STANDBY_LP	[SPFC-0006] The SPFC shall ensure the helium compressor, vacuum pump and FPs are OFF in the STANDBY_LP mode. [SPFC-0007] The SPFC shall transition to the STANDBY_LP mode from any other mode if so requested by the LMC.
OPERATE	[SPFC-0008] When in the operate mode, the SPFC shall continuously try to achieve full performance state (Refines: R.SPF.SM.7). [SPFC-0009] When in the FULL performance state, the SPFC shall comply with all its performance requirements (Refines: R.SPF.SM.6).
MAINTENANCE	When in the maintenance mode: [SPFC-0011] The SPFC shall either be in FULL_POWER or LOW_POWER states (Refines: R.SPF.SM.12). [SPFC-0012] The SPFC shall configure its receivers to be safe for maintenance (Refines: R.SPF.SM.8).

Mode	Description and Transition requirements
	<p>[SPFC-0013] The SPFC shall make the engineering interface available (Refines: R.SPF.SM.9).</p> <p>[SPFC-0014] The SPFC shall make it possible to update SPF firmware and software (Refines: R.SPF.SM.10).</p>
ERROR	<p>[SPFC-0015] The SPFC shall transition to the error state in the case when a critical functional error occurs (Refines: R.SPF.SM.5).</p> <p><i>Note: a critical function error refers to a condition where the captured data cannot be used for astronomical observation.</i></p>

### 3.1.2 Capability Requirements

The major system functions of the SPFC are indicated in Figure 2.

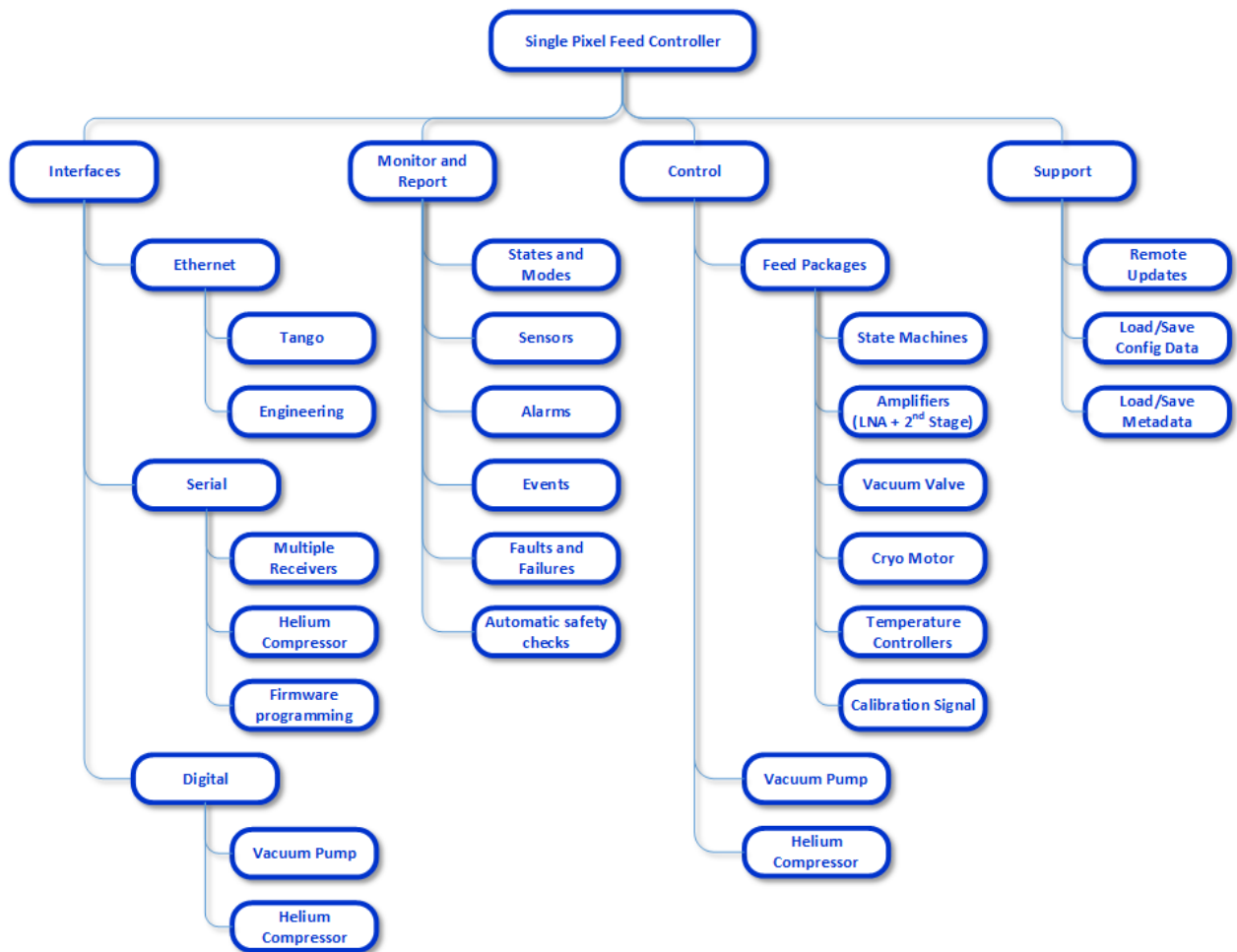


Figure 2: Functional breakdown of the SPFC.

### 3.1.2.1 Control

#### 3.1.2.1.1 States and Modes

[SPFC-0021] The SPFC shall control the states and modes of the FPs, SPFHe and SPFVac based on the commands received from the LMC (Refines: R.SPF.CCC.1).

[SPFC-0201] To limit the overall peak inrush current, the SPFC shall ensure that the SPFHe and SPFVac services are not switched on simultaneously (Refines: R.SPF.PW.1).

#### 3.1.2.1.2 Control Services

[SPFC-0022] The SPFC shall set its internal states, modes and configuration data and traverse the necessary configuration data to the FPs, SPFHe and SPFVac, based on the commands received from the LMC (Refines: R.SPF.CCC.1).

### 3.1.2.2 Monitor and Report

[SPFC-0023] The SPFC shall report monitoring information in a hierarchical structure based on the product breakdown structure (Refines: R.SPF.M.14).

#### 3.1.2.2.1 States and Modes

[SPFC-0024] The SPFC shall report to the LMC the availability of the following capabilities<sup>1</sup> (Refines: R.SPF.M.4):

- a) MID band 1 capability,
- b) MID band 2 capability,
- c) MID band 3 capability,
- d) MID band 4 capability, and
- e) MID band 5 capability.

[SPFC-0025] The SPFC shall report its health status to the LMC (Refines: R.SPF.M.11).

[SPFC-0026] The SPFC shall identify and report missing sub-elements to the LMC (Refines: R.SPF.M.13). A missing component refers to a component which is not available, either being not installed or being in an error state.

[SPFC-0016] The SPFC shall have the following aggregated capability states (Refines: R.SPF.SM.20):

- a) UNAVAILABLE
- b) STANDBY
- c) OPERATE\_DEGRADED
- d) OPERATE\_FULL.

The SPFC reports to the LMC the state of the SPF system.

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<sup>1</sup> Availability of a capability shall be defined as the complete end-to-end functional availability of all components that are required to observe the applicable frequency band.

**Table 2: SPFC Capability States**

State	Description and Transition requirements
UNAVAILABLE	[SPFC-0017] The SPFC shall set frequency Band_X to unavailable if no communication to the Band_X feed package can be established or if there are errors that render Band_X not fully functional (Refines: R.SPF.SM.21).
STANDBY	[SPFC-0018] The SPFC shall set a frequency Band_X to standby, if it is ready to fully function, and its cooling system is turned off (Refines: R.SPF.SM.22).
OPERATE_DEGRADED	[SPFC-0019] The SPFC shall set a frequency Band_X to operate_degraded if it is fully functional, but its performance is not within its specifications (Refines: R.SPF.SM.24).
OPERATE_FULL	[SPFC-0020] The SPFC shall set a frequency Band_X to operate_full if it is fully functional and its performance is within specifications (Refines: R.SPF.SM.25).

### 3.1.2.2.2 Alarms

[SPFC-0027] The SPFC shall configure the level of reporting over the SPF\_LMC control interface for alarms based on the request from the LMC (Refines: R.SPF.CCC.2).

[SPFC-0028] The SPFC shall send the following information for each alarm (Refines: R.SPF.M.1):

- 1) Time of detection of the condition;
- 2) Description of the condition;
- 3) Alarm justification:
  - a) Conditional data
  - b) Source identification
  - c) The limit logic used to evaluate the data.

[SPFC-0029] The latency of reporting the alarm to the LMC shall not exceed 3 seconds (Refines: R.SPF.M.2).

[SPFC-0030] The SPFC shall report alarms to the LMC for conditions and failures that (Refines: R.SPF.M.5):

- a) Pose hazards to equipment and personnel
- b) Reduce the effectiveness of the dishes element (DSH) to perform its prime functions or provide capabilities due to a degraded health status as a result of SPF sub-elements being unavailable or in an error state.

[SPFC-0031] The SPFC shall generate no alarms of missing FPs (Refines: R.SPF.M.13).

### 3.1.2.2.3 Events

[SPFC-0032] The SPFC shall configure the level of reporting over the LMC interface for events based on the request from the LMC (Refines: R.SPF.CCC.2).

[SPFC-0033] The SPFC shall report the following events to the LMC (Refines: R.SPF.M.6):

- a) Changes in states and modes
- b) Changes in health status

[SPFC-0034] The SPFC shall report no event information of missing FPs (Refines: R.SPF.M.13).

#### 3.1.2.2.4 Logs

[SPFC-0035] The SPFC shall configure the level of reporting over the LMC interface for logs based on the request from the LMC (Refines: R.SPF.CCC.2).

[SPFC-0036] The SPFC shall report log messages to the LMC on request (Refines: R.SPF.M.8).

[SPFC-0037] The SPFC shall report no log information of missing FPs (Refines: R.SPF.M.13).

#### 3.1.2.2.5 Sensors

[SPFC-0038] The SPFC shall configure the level of reporting over the LMC interface for sensors based on the request from the LMC (Refines: R.SPF.CCC.2).

[SPFC-0039] The SPFC shall report drill down monitoring points to the LMC to enable fault diagnostics of the SPF sub-element (Refines: R.SPF.M.10). Drill-down refers to providing more low-level sensor parameters of consolidated sensor parameters. An example will be where the SPFC reports total power consumption and it can be broken down into the power consumption of its individual sub-elements.

#### 3.1.2.2.6 Faults and Failures

[SPFC-0040] The SPFC shall report failures and the identification thereof based on the product structure and the Failure Mode, Effects and Criticality Analysis (FMECA) analysis to the LMC (Refines: R.SPF.M.7).

[SPFC-0041] The SPFC shall identify faulty line replaceable units (LRU) where applicable (Refines: R.SPF.M.7).

[SPFC-0042] The SPFC shall report to the LMC monitoring points that are required for preventative maintenance or for predicting failures as identified in the FMECA analysis (Refines: R.SPF.M.9).

[SPFC-0043] The SPFC shall report no faults of missing SPFs (Refines: R.SPF.M.13).

#### 3.1.2.2.7 Automatic Safety Checks

This is detailed in paragraph 3.7.3.

### 3.1.2.3 Support

#### 3.1.2.3.1 Remote Updates

[SPFC-0044] The SPFC shall facilitate remote software updates to its application software (Refines: R.SPF.CRS.1).

[SPFC-0045] The SPFC shall facilitate the remote updates of the firmware of its connected SPFs (Refines: R.SPF.CRS.1).

#### 3.1.2.3.2 Load and Save Configuration and Meta Data

[SPFC-0046] The SPFC shall report to the LMC upon request its serial number (Refines: R.SPF.CRS.3).

[SPFC-0047] The SPFC shall report to the LMC upon request the installed software and firmware versions (Refines: R.SPF.M.12).

[SPFC-0048] The SPFC shall report to the LMC upon request the software and firmware versions of the available sub-elements (Refines: R.SPF.M.12).

[SPFC-0049] The SPFC shall incorporate an elapsed time counter (ETC).

[SPFC-0050] The elapsed time shall be made available via the LMC communication interface and the SPFC debug port.

#### 3.1.2.4 *Engineering Interface*

[SPFC-0051] The SPFC shall provide an engineering interface that can be accessed remotely for detailed diagnostics and low level control (Refines: R.SPF.CRS.2).

### **3.1.3 Performance Requirements**

#### 3.1.3.1 *System Start up Time*

[SPFC-0052] The SPFC shall perform its POST, operating system start-up and application initialisation in less than 5 minutes.

[SPFC-0054] The SPFC, while in STANDBY\_LP and OPERATE\_DEGRADED modes shall estimate the time to full performance and report this value to the LMC (Refines: R.SPF.SM.4).

#### 3.1.3.2 *Processing Resources*

[SPFC-0055] The processing load on the SPFC CPU shall not exceed 80% of the available processing time.

[SPFC-0056] The SPFC shall be capable of maintaining all FPs in the fully powered up state for extended durations (Refines: R.SPF.P.15).

#### 3.1.3.3 *System Built-In Test (BIT) Operations*

[SPFC-0057] During normal operation, the SPFC shall perform automated on-line health monitoring (OLHM) to the greatest extent possible without interfering with the normal operation of the SPFC. Only the following SPFC parameters shall be monitored:

- a) Device status – Individual devices and overall health status
- b) SPFC voltage
- c) SPFC current
- d) SPFC temperature
- e) SPFC operational time

[SPFC-0058] The SPFC shall not start its application software if a POST error is present.

[SPFC-0059] The SPFC shall provide a self-test capability appropriate to the level-of-repair analysis needed (Refines: R.SPF.LSE.3).

#### 3.1.3.4 *Data Rate*

[SPFC-0060] The SPFC shall report monitoring information to the LMC at a data rate of less than 200 kbps (Refines: R.SPF.M.15).

#### 3.1.3.5 *Data Latency*

[SPFC-0061] The latency introduced by the SPFC because of processing and hardware specific delays shall be less than 5s.

#### 3.1.3.6 *Mode Transition Times*

[SPFC-0062] The SPFC shall comply with the mode transition times as specified in Table 3.



**Table 3: SPFC mode transition times**

From Mode	To Mode	Transition Time [s]
Off	Initialise	< 1
Initialise	Operational	< 10
Operational	Off	< 60

#### 3.1.3.7 System Time-outs

[SPFC-0063] The SPFC application software shall be restarted if the system is unresponsive for more than 10 seconds.

[SPFC-0064] The SPFC shall comply with the communication time-outs stipulated in the respective interface ICDs.

#### 3.1.3.8 System Memory

[SPFC-0066] The microprocessor module shall provide non-volatile memory for logging all system sensor data for a period of 30 days.

[SPFC-0067] The microprocessor module shall have at least 30% spare non-volatile memory for future logging expansion.

### 3.1.4 Control and Processing Logic

[SPFC-0068] The control and monitoring functions of the SPFC shall be performed by a CPU.

[SPFC-0069] A commercial-off-the-shelf (COTS) microprocessor module shall be used for control and monitoring.

[SPFC-0070] The temperature of the microprocessor board shall be monitored with an on-board temperature sensor.

[SPFC-0071] The on-board temperature sensor shall be located in an appropriate location to monitor the temperature as accurately as possible.

[SPFC-0072] The total operational time of the SPFC shall be monitored with the ETC.

[SPFC-0073] The SPFC shall adhere to all control commands from the LMC. These commands include the setting of internal states, modes and configuration data based on the external state, mode, configuration and capability commands received from the LMC.

## 3.2 Interface Requirements

### 3.2.1 Client Furnished Item (CFI) Interface Requirements

This section is not applicable.

### 3.2.2 External Interfaces

The SPFC external interfaces of the SPFC are shown in Figure 3.

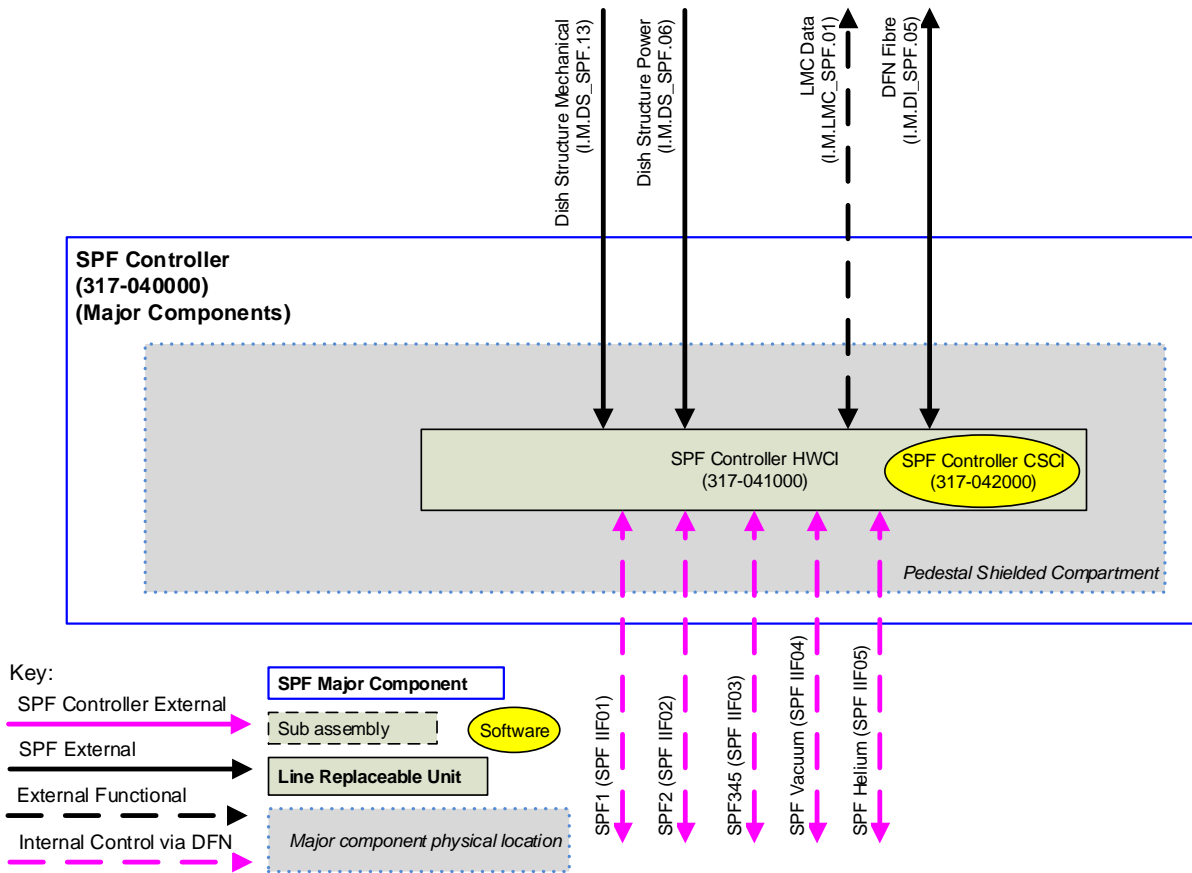


Figure 3: SPFC external interfaces.

Table 4: SPFC external interfaces

Interface Number	External To	Interface Type	Component A	Component B
I.M.DS_SPF.06	SPF	Conductive (Power)	DS power distribution unit (DS PDU)	SPFC
I.M.DS_SPF.13	SPF	Mechanical	SPFC	DS
I.M.LMC_SPF.01	SPF	Data over fibre	SPFC	LMC
I.M.DI_SPF.05	SPF	Fibre	SPFC	DFN
SPF IIF01	SPFC	Data over fibre	SPFC	SPF1
SPF IIF02	SPFC	Data over fibre	SPFC	SPF2
SPF IIF03	SPFC	Data over fibre	SPFC	SPF345
SPF IIF04	SPFC	Data over fibre	SPFC	Vacuum pump
SPF IIF05	SPFC	Data over fibre	SPFC	Helium compressor

### 3.2.2.1 Interface [I.M.DS\_SPF.06] Shielded Compartment DB – SPFC

See sections 3.4.1 and 3.8.1

### 3.2.2.2 Interface [I.M.DS\_SPF.13] SPFC – Dish Structure

See section 3.4.1

### 3.2.2.3 Interface [I.M.LMC\_SPF.01] SPFC – LMC

[SPFC-0074] The SPFC shall use the protocol defined in [AD3] to communicate with the LMC (Refines: R.SPF.CCC.3).

[SPFC-0075] The SPFC shall provide a self-description of the SPFC\_LMC interface as detailed in [AD3] (Refines: R.SPF.CCC.4).

[SPFC-0076] The SPFC shall connect to the LMC with an Ethernet over fibre connection.

[SPFC-0077] A multimode transceiver shall be used for the 100BASE-FX interface.

### 3.2.2.4 Interface [I.M.DI\_SPF.05] SPFC – Dish Fibre Network

See section 3.4.1

### 3.2.2.5 Interface [SPF IIF01] SPFC – SPF1

[SPFC-0078] The SPFC shall connect to the SPF1 with a serial over fibre connection and conform to the requirements of [AD4].

### 3.2.2.6 Interface [SPF IIF02] SPFC – SPF2

[SPFC-0079] The SPFC shall connect to the SPF2 with a serial over fibre connection and conform to the requirements of [AD5].

### 3.2.2.7 Interface [SPF IIF03] SPFC – SPF345

[SPFC-0080] The SPFC shall connect to the SPF345 with a serial over fibre connection and conform to the requirements of [AD6].

### 3.2.2.8 Interface [SPF IIF04] SPFC – SPFVac

[SPFC-0081] The SPFC shall connect to the vacuum pump controller with a discrete fibre connection and conform to the requirements of [AD7].

### 3.2.2.9 Interface [SPF IIF05] SPFC – SPFHe

[SPFC-0082] The SPFC shall connect to the helium compressor controller with a serial over fibre as well as a discrete fibre connection and conform to the requirements of [AD8].

## 3.3 Environmental Conditions

[SPFC-0083] The SPFC shall be compliant with all local, state and national environmental protection legislation and regulations of South Africa as well as the country where it is manufactured / assembled (Refines: R.SPF.EL.1).

### **3.3.1 Operational**

#### *3.3.1.1 Climatic Conditions*

##### *3.3.1.1.1 Air Temperature*

[SPFC-0084] The SPFC shall be capable to operate in a temperature range of 0 °C to 50 °C (Refines: R.SPF.ED.2, R.SPF.ED.3, R.SPF.ED.4).

##### *3.3.1.1.2 Solar Radiation*

None.

#### *3.3.1.2 Earthquake Conditions*

[SPFC-0085] The SPFC shall be capable to operate at levels of seismic zone 1 as defined in IEC 60721-2-6 (Refines: R.SPF.ED.2, R.SPF.ED.3, R.SPF.ED.4).

#### *3.3.1.3 Lightning*

[SPFC-0086] The SPFC shall be capable to operate with a lightning ground flash density of 1-3 strikes per square kilometre per year (Refines: R.SPF.ED.2, R.SPF.ED.3, R.SPF.ED.4).

#### *3.3.1.4 Height above sea level*

[SPFC-0087] The SPFC shall be capable to operate at a height above sea level between 900m and 1100m (Refines: R.SPF.ED.2, R.SPF.ED.3, R.SPF.ED.4).

#### *3.3.1.5 Condensation*

[SPFC-0088] Electronic equipment shall be safe and withstand, without damage or degradation or additional maintenance tasks, the presence of condensation (Refines: R.SPF.ED.1).

### **3.3.2 Non-operational**

The non-operational conditions of the SPFC shall be the same as the operational conditions, except for the differences presented in this subsection. The SPFC is in a non-operational state when it is installed in the dish pedestal, but switched off.

#### *3.3.2.1 Climatic Conditions*

##### *3.3.2.1.1 Air Temperature*

[SPFC-0089] The SPFC shall be capable to withstand an air temperature range of -15 °C to 60 °C (Refines: R.SPF.ED.2, R.SPF.ED.5).

##### *3.3.2.1.2 Humidity*

[SPFC-0090] The SPFC shall be capable to withstand a relative humidity according to IEC 60721-3-3 Class 3K4 (Refines: R.SPF.ED.2, R.SPF.ED.5).

### **3.3.3 Electromagnetic Compatibility**

[SPFC-0094] Custom made SPFC components shall comply with IEC 61000-6-4 and IEC 61000-6-2 (Refines: R.SPF.RFI.8).

[SPFC-0095] COTS components of the SPFC shall comply with the applicable harmonised standards in the European Commission EMD Directive 2004/108/EC, or the SABS equivalent thereof (Refines: R.SPF.RFI.8).

### **3.3.4 Radio Frequency Interference**

[SPFC-0096] The SPFC shall adhere to the radio frequency interference (RFI) requirements as specified in [AD1] paragraph 3.3.3 (Refines: R.SPF.RFI.3, R.SPF.RFI.6).

### **3.3.5 Transportation**

[SPFC-0097] The SPFC shall be packaged for careful transportation conditions to prevent incurring any residual damage TBC.2 (Refines: R.SPF.ET.1).

#### *3.3.5.1 Climatic Conditions*

##### *3.3.5.1.1 Air Temperature*

[SPFC-0098] The SPFC shall be capable of withstanding a temperature range of -25 °C to 70 °C (unventilated) and -25 °C to 50 °C (ventilated) during transportation.

#### *3.3.5.2 Mechanical*

[SPFC-0099] The SPFC shall be capable of withstanding free fall drop based on IEC 60721-3-2 class 2M1.

#### *3.3.5.3 Vibration*

[SPFC-0100] The SPFC shall be capable to withstand normal class 2.1 public transport vibration as specified in [RD1].

#### *3.3.5.4 Canting, Rolling and Pitching*

Not applicable.

### **3.3.6 Storage**

[SPFC-0101] The SPFC shall be packaged for storage conditions, without incurring any damage, for a period of at least 2 years (Refines: R.SPF.ES.1).

#### *3.3.6.1 Climatic Conditions*

##### *3.3.6.1.1 Air Temperature*

[SPFC-0102] The SPFC shall be able to withstand a storage temperature range of -5 °C to 45 °C.

## **3.4 Physical**

### **3.4.1 Interconnections**

[SPFC-0103] The SPFC shall adhere to the fibre interconnection characteristics as is defined in [AD10] (Refines: R.SPF.I.1).

[SPFC-0104] The SPFC shall have the mechanical mounting characteristics as defined in [AD9] (Refines: R.SPF.I.2).

[SPFC-0105] The SPFC shall have the power and ground characteristics as defined in [AD9] (Refines: R.SPF.I.3).

### **3.4.2 Mass**

[SPFC-0106] The SPFC shall weigh less than 3kg.

### **3.4.3 Dimensions**

[SPFC-0107] The SPFC shall fit into a 1U slot in a 19" rack.

### **3.4.4 Finishing**

[SPFC-0108] The SPFC enclosure shall have Alodining treatment in order to protect its surface as well as to provide an electrically conductive surface for grounding to the 19" rack in which it shall be installed.

## **3.5 Human Factors**

[SPFC-0109] The SPFC shall be ergonomically compliant with MIL-STD-1472G (Refines: R.SPF.HF.1).

### **3.5.1 Ingress and Egress**

This section is not applicable.

## **3.6 Integrated Logistics Support**

### **3.6.1 Reliability, Availability and Maintainability**

Basic reliability is defined as the duration or probability of failure free performance under stated conditions, given that a failure of the unit is considered a failure of the system.

[SPFC-0110] The SPFC shall have a minimum deployed lifetime of 10 years (Refines: R.SPF.LRA.1).

[SPFC-0111] The SPFC shall be able to be online 24 hours a day, 365 days a year.

[SPFC-0112] The SPFC shall have a mean maintenance downtime (MMDT) of less than 2.5 hours (Refines: R.SPF.LRA.2).

[SPFC-0113] The SPFC shall have a mean time between maintenance of more than 35 000 hours (Refines: R.SPF.LRA.3).

### **3.6.2 Repair and Replacement**

[SPFC-0114] The SPFC shall be replaceable making use of standard manufacturing tools (Refines: R.SPF.LRR.1, R.SPF.LSF.1, R.SPF.PD.1).

[SPFC-0115] The mean time to replace the SPFC or any of its sub elements shall not exceed 30 minutes.

[SPFC-0116] Time taken to change external cables shall be less than 5 minutes.

[SPFC-0117] Hardware components in the SPFC shall be easily accessible and component stacking shall be kept to a minimum (Refines: R.SPF.LRR.3).

[SPFC-0118] Internal interfaces shall have terminal blocks or plugs and sockets to ease the swopping out of components, i.e. a modular approach shall be followed.

[SPFC-0119] Items identified as ILM Spare items shall require a minimum of tuning, calibration, aligning and other actions (Refines: R.SPF.LRR.4).

[SPFC-0120] Where alignment, calibration or tuning is required, a deterministic procedure for such actions shall be contained in the support publications (Refines: R.SPF.LRR.4).

[SPFC-0121] Reparable items shall include maintenance provisions such as test points, accessibility and plug-in components (Refines: R.SPF.LRR.5).

[SPFC-0122] The SPFC shall have a modular design to enable easy removal and replacement of faulty LRUs (Refines: R.SPF.LRR.6).

[SPFC-0123] Mounting guides and location pins shall be provided to facilitate module mounting (Refines: R.SPF.LRR.7).

[SPFC-0124] Provisions for the preclusion of mounting the wrong module shall be provided (Refines: R.SPF.LRR.8).

[SPFC-0125] Items identified as organisational level maintenance (OLM) Spare items shall be interchangeable with items of the same part number and version with no calibration, tuning or special alignment (Refines: R.SPF.LRR.9).

[SPFC-0126] Modules shall be securely mounted with the minimum number of fasteners (Refines: R.SPF.LRR.10).

[SPFC-0127] Stand-offs and handles shall be used to protect system components from damage during shop maintenance (Refines: R.SPF.LRR.11).

### **3.6.3 Nameplates and Product Marking**

[SPFC-0128] All cables and harnesses and their connectors shall be labelled in the English language to allow identification while the cables and harnesses are installed (Refines: R.SPF.LPM.1).

[SPFC-0129] All component mounted connectors shall be labelled in the English language to allow identification during installation and maintenance of the SPFC (Refines: R.SPF.LPM.2).

[SPFC-0130] The SPFC shall have clear markings and labels in the English language for all switches and controls used by operators or technical personnel (Refines: R.SPF.LPM.3).

[SPFC-0131] Disposable modules shall be marked as such (Refines: R.SPF.LPM.4).

[SPFC-0132] The SPFC shall be clearly marked with warning labels in the English language where special handling is required to prevent damage to items (Refines: R.SPF.LPM.5).

[SPFC-0133] The SPFC shall have clear markings to indicate equipment which may jeopardise the safety of personnel or result in a hazardous situation if improperly operated or handled (Refines: R.SPF.LPM.6).

[SPFC-0134] The labels on the SPFC shall withstand all environments and conditions to which it is subjected (Refines: R.SPF.LPM.8).

[SPFC-0135] Product markings shall not become detached or unreadable with repeated handling (Refines: R.SPF.LPM.9).

[SPFC-0136] The product markings on the SPFC shall be clearly visible when it is installed (Refines: R.SPF.LPM.9).

[SPFC-0137] The SPFC shall be labelled in the English language with the following information (Refines: R.SPF.LPM.7):

- a) Supplier name
- b) Product name
- c) Part number
- d) Version
- e) Serial number
- f) Barcode containing the above information

### **3.6.4 ILS Publication**

#### *3.6.4.1 Manufacturing Data Packs*

[SPFC-0138] As-built data shall be provided as part of the manufacturing data pack (Refines: R.SPF.LDM.1).

[SPFC-0139] As-designed data shall be provided as part of the manufacturing data pack (Refines: R.SPF.LDM.2).

[SPFC-0140] The SPFC shall have an assembly and installation manual.

[SPFC-0141] A qualification test procedure and a qualification test report shall be defined for the SPFC to define the tests and record the results thereof.

[SPFC-0142] The SPFC shall have an acceptance test procedure and an acceptance test report that define and record the acceptance tests conducted on the main components and the installed system.

[SPFC-0143] The SPFC shall have a single, dual purpose operators and maintenance manual which covers all lines of user maintenance.

#### *3.6.4.2 Support Publications*

This section is not applicable

### **3.6.5 Personnel and Training**

#### *3.6.5.1 Operating personnel*

[SPFC-0144] No operating personnel shall be required to operate the SPFC, however personnel shall be required to maintain the SPFC.

#### *3.6.5.2 Training*

[SPFC-0145] Training shall be required for maintaining the SPFC. Although the maintenance required by the SPFC is very basic, a procedure shall be provided as required.

### **3.6.6 Supply Concept**

This section is not applicable.



### **3.6.7 Packaging Handling and Transportation**

[SPFC-0146] The package labelling of the SPFC shall have the following information (Refines: R.SPF.LPA.3):

- a) Item name
- b) Part number
- c) Version
- d) Serial number
- e) Supplier part number (where applicable)
- f) Supplier identification (where applicable)
- g) Barcode
- h) Packaged weight
- i) Container stackability (where applicable)
- j) Preservation data (where applicable)
- k) Shelf life (where applicable)

[SPFC-0147] The SPFC, when packaged, shall have the following markings securely attached to the outside of the packaging container (Refines: R.SPF.LPA.4, R.SPF.SAF.2):

- a) Mode of transport "Careful transportation"
- b) "This side up" label
- c) Packaged item identification plate with data completed as per package labelling requirement.
- d) ESD warnings where applicable.

[SPFC-0148] The SPFC shall be packaged such that standard transportation vehicle and entry constraints are adhered to (Refines: R.SPF.LPA.8).

[SPFC-0149] Packaging of spare SPFCs shall be supplied by the supplier of the SPFC (Refines: R.SPF.LPA.9).

### **3.6.8 Equipment**

Not applicable.

### **3.6.9 Facilities**

[SPFC-0150] The SPFC shall be supplied by the 1<sup>st</sup> line maintainer.

## **3.7 Product Assurance**

### **3.7.1 Standardisation**

[SPFC-0151] Fasteners shall be standardised as far as possible to minimize the use of different types and sizes (Refines: R.SPF.PD.2).

### **3.7.2 Workmanship**

For workmanship requirements refer to [AD1] section 3.7.2.

### **3.7.3 Safety and Security**

[SPFC-0152] Safety features shall be incorporated to provide safety, protection of personal, and equipment during use, maintenance, transportation and storage.

[SPFC-0153] The SPFC shall be locally fail-safe and not be dependent on any external inputs for safety (Refines: R.SPF.SAF.1).

The SPFC shall implement the following safety checks:

- [SPFC-0154] Switch off temperature controllers if the temperature exceeds 320K.
- [SPFC-0155] Close the vacuum valve if the cryostat or manifold pressure suddenly increases.
- [SPFC-0156] Perform a valve safety check by confirming pressures before the vacuum valve is opened.

#### *3.7.3.1 Electric Shock*

[SPFC-0157] The equipment shall incorporate protective elements to prevent inadvertent contact with voltages capable of producing shock hazards in accordance to the applicable sections of SANS 60950-1 (Refines: R.SPF.SAF.4).

[SPFC-0158] The SPFC shall ensure galvanic connection in accordance to IEC62305 LPL III and with resistance of less than 10 milliohms between the chassis and the lightning protection earth interface provided by the DS (Refines: R.SPF.LPS.2).

#### *3.7.3.2 Lightning Safety*

[SPFC-0159] The SPFC shall maintain its lightning protection zone in accordance to IEC62305 LPL III as specified in [AD9] (Refines: R.SPF.LPS.4).

[SPFC-0160] The SPFC shall extend its lightning protection zone on all power interfaces in accordance to IEC62305 LPL III as specified in [AD9] (Refines: R.SPF.LPS.5).

#### *3.7.3.3 Mechanical Safety*

[SPFC-0161] Sharp corners, edges, projectors and hot surfaces of which personnel can be exposed shall be avoided or shielded with protective covers or coatings (Refines: R.SPF.SAF.3).

#### *3.7.3.4 Electrical Safety*

[SPFC-0162] Connectors shall be wired as such to avoid the exposure of hot points.

### **3.7.4 Design Methods**

[SPFC-0163] A risk assessment shall be conducted for each item of machinery in accordance with BS EN ISO 12100 (Refines: R.SPF.PR.6).

## 3.8 Design Constraints

### 3.8.1 System Power Consumption

[SPFC-0164] The SPFC shall operate from a single-phase supply voltage of 204-253 VAC and 49-51 Hz.

[SPFC-0165] The average power consumption shall not exceed, with power factor less than, the allocated values as defined in [AD2] when operating at full performance under the **Precision, Standard and Degraded Operating conditions** (Refines: R.SPF.PW.1).

[SPFC-0166] The SPFC power consumption surge shall not exceed the allocated values as defined in [AD2] when operating at full performance under the **Precision, Standard and Degraded Operating conditions** (Refines: R.SPF.PW.1).

[SPFC-0167] The SPFC shall not induce total harmonic distortion (current) onto the electrical supply that exceeds the levels defined in [AD2] for single phase equipment (Refines: R.SPF.PW.3).

[SPFC-0168] The SPFC shall estimate the power consumption for the individual SPF equipment as the function of their current state and report it to the LMC upon request (Refines: R.SPF.CCC.5).

### 3.8.2 Induced Heat Loads

[SPFC-0169] The SPFC shall not induce heat loads that exceed the levels as defined in [AD2] (Refines: R.SPF.PW.5).

### 3.8.3 Grounding Strategy

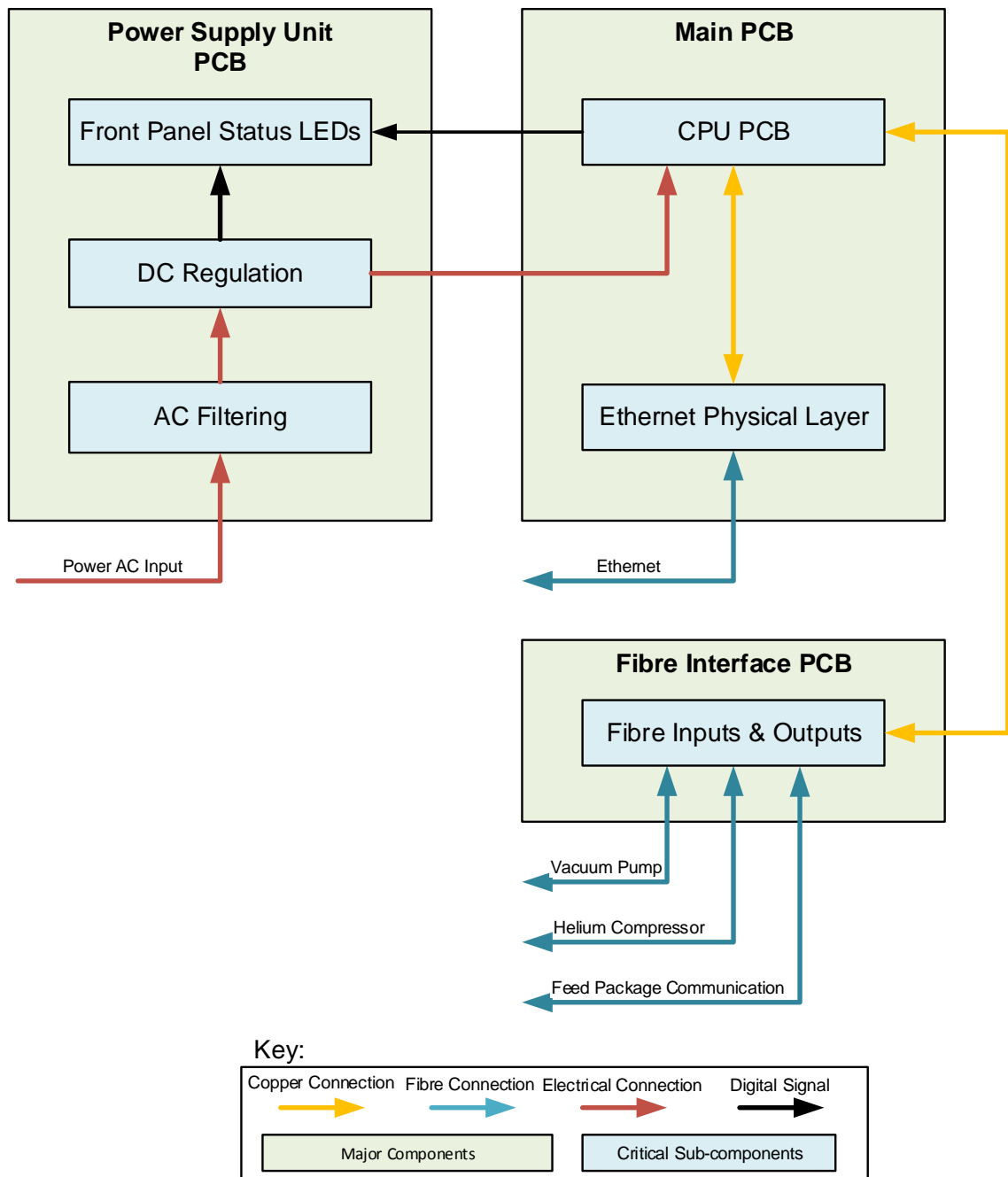
[SPFC-0170] The grounding shall be in accordance of the dish structure grounding requirements (Refines: R.SPF.I.3).

## 3.9 Precedence and Criticality of Requirements

None applicable.

## 3.10 Major Component Characteristics

The main components of the SPFC are illustrated in Figure 4.



**Figure 4: SPFC main components.**

[SPFC-0171] The SPFC shall consist of the following major components:

1. SPFC enclosure
2. SPFC CPU PCB assembly
3. Fibre interface assembly
4. Power supply unit with front panel LED display

### **3.10.1 SPFC Enclosure**

#### *3.10.1.1 Item Definition*

[SPFC-0172] All electronic parts and sub-assemblies of the SPFC shall reside within the SPFC enclosure.

#### *3.10.1.2 Characteristics*

The SPFC enclosure shall have the following characteristics:

- a. [SPFC-0173] The enclosure shall house and protect the electronic modules of the SPFC against the specified environment.
- b. [SPFC-0174] The enclosure shall be RFI shielded.
- c. [SPFC-0175] The enclosure shall be able to fit into a 1U space of a 19" rack.
- d. [SPFC-0176] The enclosure shall have distinct cavities for the major SPFC components.
- e. [SPFC-0177] The power supply cavity shall house the panel status LEDs with light pipes through the wall of the enclosure.
- f. [SPFC-0178] The fibre cavities shall provide space for the fibre adaptors and connectors.
- g. [SPFC-0179] The enclosure shall have fibre routing slots between the cavities where needed.
- h. [SPFC-0180] Each of the cavities of the enclosure shall be RFI shielded using RF gaskets/pads and filtered connectors.
- i. [SPFC-0181] Panels and lids of the enclosure shall be easily removable to allow easy access for test and maintenance purposes.

### **3.10.2 SPFC CPU PCB Assembly**

#### *3.10.2.1 Item Definition*

The function of the SPFC CPU PCB is to control the operation of the SPFC by executing the main application.

#### *3.10.2.2 Characteristics*

The CPU PCB assembly shall have the following characteristics:

- a. [SPFC-0182] The CPU shall be a modern microprocessor with at least 200 MIPS.
- b. [SPFC-0183] The CPU module shall have at least the following memory capabilities:
  - 64 MB SDRAM
  - 128 MB NAND Flash
  - 128 byte EEPROM
- c. [SPFC-0184] The CPU module shall have the following minimum communication interfaces:
  - 6x UART modules
  - 1x Fibre Ethernet MAC
  - 1x SPI
  - 16 digital IO ports
  - 1x SD card interface

- d. [SPFC-0185] The application software shall be externally downloadable without removing components.
- e. [SPFC-0186] The CPU shall provide a watchdog function.
- f. [SPFC-0187] The CPU shall provide an elapsed time counter (ETC).
- g. [SPFC-0188] The CPU shall be capable of monitoring on-board temperature, supply voltage and supply current.

### **3.10.3 Fibre Interface Assembly**

#### *3.10.3.1 Item Definition*

The fibre interface assembly is used to convert between conductive and fibre optic mediums.

#### *3.10.3.2 Characteristics*

[SPFC-0189] The fibre interface assembly shall have the following characteristics:

- a. Provide at least 8x individual transmitters
- b. Provide at least 8x individual receivers.

### **3.10.4 Power Supply Unit**

#### *3.10.4.1 Item Definition*

[SPFC-0190] The SPFC PSU shall provide the SPFC sub-assemblies with regulated and conditioned electrical power.

#### *3.10.4.2 Characteristics*

The power supply shall have the following characteristics:

- a. [SPFC-0191] The PSU shall be capable of operating from a 204-253 VAC and 49-51 Hz AC power source.
- b. [SPFC-0192] The PSU shall be a linear power supply as to reduce the RFI.
- c. [SPFC-0193] The output of the PSU shall be 5.0 VDC, 2 A.
- d. [SPFC-0194] The PSU shall provide thermal overload and over voltage protection.
- e. [SPFC-0195] The PSU shall provide inrush current limiting.
- f. [SPFC-0196] The PSU shall have soft-start functionality.
- g. [SPFC-0197] All PSU outputs shall be electrically isolated from the inputs.
- h. [SPFC-0198] The power efficiency shall be greater than 60%.
- i. [SPFC-0199] The PSU shall provide a minimum output power of 10W.

[SPFC-0200] The front panel LED display shall provide system status as per Table 5 below.

**Table 5: SPFC LED status**

Status	On	Off
Band 1	Band 1 feed package online	Band 1 feed package offline
Band 2	Band 2 feed package online	Band 2 feed package offline
Band 3,4,5	Band 3,4,5 feed package online	Band3,4,5 feed package offline
Helium compressor error	Helium compressor error detected	Helium compressor no error detected
Helium compressor running	Helium compressor running	Helium compressor not running
Vacuum pump ready	Vacuum pump ready	Vacuum pump not ready
Vacuum pump running	Vacuum pump running	Vacuum pump not running

## 4 VERIFICATION

### 4.1 Verification Definitions

The requirements of section 3 of this document shall be verified by one of the test categories detailed in Table 6.

**Table 6: Verification methods applicable to the system**

Term	Abbreviation	Description
Formal Test	FT	The measurement of either mechanical or electrical characteristic using standard measuring equipment. If the measurement technique or equipment needed for the measurement is non-standard, it is described under the appropriate test paragraph number.
Inspection	I	The inspection of a characteristic either visually or by simple measurement and compared against a drawing, standard or data sheet. Verification by inspection implies that the measurement technique is elementary enough to obviate a formal test procedure.
Demonstration	D	Verifying a functional characteristic by means of actual demonstration using the hardware itself.
Analysis	A	Verification of a characteristic by means of analysis using appropriate theoretical models.

The applicable test classes are given in Table 7.

**Table 7: Test classes applicable to the system**

Abbreviation	Description
N/A	Not applicable
DT	Tested/verified during the development phase (first prototypes)
QT	Tested/verified during qualification
AT	Acceptance test during integration and manufacturing



## 4.2 Requirements Cross Reference

The verification cross-reference matrix in Table 8 lists the SPFC requirements and the methods by which they shall be verified.

**Table 8: SPFC requirements verification matrix**

Requirement number & description	Test Phase			Test Description (& responsible party)
	DT	QT	AT	(Note: These test definitions given here serve as framework for more detailed test instructions)
[SPFC-0001] The SPFC shall have the following modes (Refines: R.SPF.SM.1): a) OFF b) STARTUP c) STANDBY_LP d) OPERATE e) MAINTENANCE f) ERROR	I			Inspect and confirm in CSCI source code
[SPFC-0002] The SPFC shall have the following power states (Refines: R.SPF.SM.11): a) LOW_POWER b) FULL_POWER	I			Inspect and confirm in CSCI source code
[SPFC-0003] The SPFC shall report its modes and power states to the LMC (Refines: R.SPF.SM.3).	D			Demonstrate that the modes are reported to the LMC using an interface simulator or actual hardware.
[SPFC-0004] The SPFC shall switch off when in STANDBY_LP mode and a system reset is requested by the LMC.	D			Demonstrate functionality when command is sent
[SPFC-0005] The SPFC shall, after a successful start-up procedure, automatically transition to the STANDBY_LP mode and remain there until commanded by the LMC to transition to a new mode (Refines: R.SPF.SM.13).	D			Demonstrate functionality when command is sent
[SPFC-0006] The SPFC shall ensure the helium compressor, vacuum pump and FPs are OFF in the STANDBY_LP mode.	D			Demonstrate that when the mode is entered, the services are switched off and remains off.
[SPFC-0007] The SPFC shall transition to the STANDBY_LP mode from any other mode if so requested by the LMC.	D			Demonstrate functionality when command is sent
[SPFC-0008] When in the operate mode, the SPFC shall continuously try to achieve full performance state (Refines: R.SPF.SM.7).		FT		Test functionality by verifying that the SPFC performs the necessary actions to achieve full performance
[SPFC-0009] When in the FULL performance state, the SPFC shall comply with all its performance requirements (Refines: R.SPF.SM.6).		FT	D	Test functionality
[SPFC-0011] The SPFC shall either be in FULL_POWER or LOW_POWER states (Refines: R.SPF.SM.12).	I			Inspect and confirm in CSCI source code

Requirement number & description	Test Phase			Test Description (& responsible party)
	DT	QT	AT	(Note: These test definitions given here serve as framework for more detailed test instructions)
[SPFC-0012] The SPFC shall configure its receivers to be safe for maintenance (Refines: R.SPF.SM.8).	D			Demonstrate functionality
[SPFC-0013] The SPFC shall make the engineering interface available (Refines: R.SPF.SM.9).	I			Inspect in system configuration
[SPFC-0014] The SPFC shall make it possible to update SPF firmware and software (Refines: R.SPF.SM.10).	D	D		Demonstrate and functionality
[SPFC-0015] The SPFC shall transition to the error state in the case when a critical functional error occurs (Refines: R.SPF.SM.5).	D	FT	FT	Demonstrate functionality and perform specific tests by generating operational failure scenarios
[SPFC-0021] The SPFC shall control the states and modes of the FPs, SPFHe and SPFVac based on the commands received from the LMC (Refines: R.SPF.CCC.1).	I			Inspect and confirm in CSCI source code
[SPFC-0022] The SPFC shall set its internal states, modes and configuration data and traverse the necessary configuration data to the FPs, SPFHe and SPFVac, based on the commands received from the LMC (Refines: R.SPF.CCC.1).	D	FT		Simulate communication loss Simulate errors
[SPFC-0023] The SPFC shall report monitoring information in a hierarchical structure based on the product breakdown structure (Refines: R.SPF.M.14).	D	FT		Simulate states
[SPFC-0024] The SPFC shall report to the LMC the availability of the following capabilities (Refines: R.SPF.M.4): a) MID band 1 capability, b) MID band 2 capability, c) MID band 3 capability, d) MID band 4 capability, and e) MID band 5 capability.	D	FT		Simulate states
[SPFC-0025] The SPFC shall report its health status to the LMC (Refines: R.SPF.M.11).	D	FT		Simulate states
[SPFC-0026] The SPFC shall identify and report missing sub-elements to the LMC (Refines: R.SPF.M.13).	D	FT		Demonstrate and verify functionality
[SPFC-0016] The SPFC shall have the following aggregated capability states (Refines: R.SPF.SM.20): a) UNAVAILABLE b) STANDBY c) OPERATE_DEGRADED d) OPERATE_FULL.	D			Demonstrate functionality when command is sent

Requirement number & description	Test Phase			Test Description (& responsible party)
	DT	QT	AT	(Note: These test definitions given here serve as framework for more detailed test instructions)
[SPFC-0017] The SPFC shall set frequency Band_X to unavailable if no communication to the Band_X feed package can be established or if there are errors that render Band_X not fully functional (Refines: R.SPF.SM.21).	D			Demonstrate functionality
[SPFC-0018] The SPFC shall set a frequency Band_X to standby, if it is ready to fully function, and its cooling system is turned off (Refines: R.SPF.SM.22).	D			Demonstrate functionality
[SPFC-0019] The SPFC shall set a frequency Band_X to operate_degraded if it is fully functional, but its performance is not within its specifications (Refines: R.SPF.SM.24).	D			Demonstrate functionality
[SPFC-0020] The SPFC shall set a frequency Band_X to operate_full if it is fully functional and its performance is within specifications (Refines: R.SPF.SM.25).	D	FT		Simulate conditions
[SPFC-0027] The SPFC shall configure the level of reporting over the SPF_LMC control interface for alarms based on the request from the LMC (Refines: R.SPF.CCC.2).	D			Demonstrate functionality
[SPFC-0028] The SPFC shall send the following information for each alarm (Refines: R.SPF.M.1): 1) Time of detection of the condition; 2) Description of the condition; 3) Alarm justification: a) Conditional data b) Source identification c) The limit logic used to evaluate the data.	I			Inspect in CSCI source code
[SPFC-0029] The latency of reporting the alarm to the LMC shall not exceed 3 seconds (Refines: R.SPF.M.2).	FT	FT		Simulate faults and measure response times
[SPFC-0030] The SPFC shall report alarms to the LMC for conditions and failures that (Refines: R.SPF.M.5): a) Pose hazards to equipment and personnel b) Reduce the effectiveness of the dishes element (DSH) to perform its prime functions or provide capabilities due to a degraded health status as a result of SPF sub-elements being unavailable or in an error state.	I			Inspect in CSCI source code
[SPFC-0031] The SPFC shall generate no alarms of missing FPs (Refines: R.SPF.M.13).	I	D		Inspect in CSCI source code and demonstrate during qualification
[SPFC-0032] The SPFC shall configure the level of reporting over the LMC interface for events based on the request from the LMC (Refines: R.SPF.CCC.2).	D			Demonstrate functionality

Requirement number & description	Test Phase			Test Description (& responsible party)
	DT	QT	AT	(Note: These test definitions given here serve as framework for more detailed test instructions)
[SPFC-0033] The SPFC shall report the following events to the LMC (Refines: R.SPF.M.6): a) Changes in states and modes b) Changes in health status	D	FT		Simulate conditions
[SPFC-0034] The SPFC shall report no event information of missing FPs (Refines: R.SPF.M.13).	I	D		Inspect in CSCI source code and demonstrate during qualification
[SPFC-0035] The SPFC shall configure the level of reporting over the LMC interface for logs based on the request from the LMC (Refines: R.SPF.CCC.2).	D			Demonstrate functionality
[SPFC-0036] The SPFC shall report log messages to the LMC on request (Refines: R.SPF.M.8).	D			Demonstrate functionality
[SPFC-0037] The SPFC shall report no log information of missing FPs (Refines: R.SPF.M.13).	I	D		Inspect in CSCI source code and demonstrate during qualification
[SPFC-0038] The SPFC shall configure the level of reporting over the LMC interface for sensors based on the request from the LMC (Refines: R.SPF.CCC.2).	D			Demonstrate functionality
[SPFC-0039] The SPFC shall report drill down monitoring points to the LMC to enable fault diagnostics of the SPF sub-element (Refines: R.SPF.M.10).	D			Demonstrate functionality
[SPFC-0040] The SPFC shall report failures and the identification thereof based on the product structure and the Failure Mode, Effects and Criticality Analysis (FMECA) analysis to the LMC (Refines: R.SPF.M.7).	D	D		Demonstrate functionality by simulating faults
[SPFC-0041] The SPFC shall identify faulty line replaceable units (LRU) where applicable (Refines: R.SPF.M.7).	D	D		Demonstrate functionality by simulating faults
[SPFC-0042] The SPFC shall report to the LMC monitoring points that are required for preventative maintenance or for predicting failures as identified in the FMECA analysis (Refines: R.SPF.M.9).	I			Inspect CSCI source code
[SPFC-0043] The SPFC shall report no faults of missing SPFs (Refines: R.SPF.M.13).	I	D		Inspect in CSCI source code and demonstrate during qualification
[SPFC-0044] The SPFC shall facilitate remote software updates to its application software (Refines: R.SPF.CRS.1).	FT	FT		Test functionality
[SPFC-0045] The SPFC shall facilitate the remote updates of the firmware of its connected SPFs (Refines: R.SPF.CRS.1).	FT	FT		Test functionality
[SPFC-0046] The SPFC shall report to the LMC upon request its serial number (Refines: R.SPF.CRS.3).	D			Demonstrate functionality

Requirement number & description	Test Phase			Test Description (& responsible party)
	DT	QT	AT	(Note: These test definitions given here serve as framework for more detailed test instructions)
[SPFC-0047] The SPFC shall report to the LMC upon request the installed software and firmware versions (Refines: R.SPF.M.12).	D			Demonstrate functionality
[SPFC-0048] The SPFC shall report to the LMC upon request the software and firmware versions of the available sub-elements (Refines: R.SPF.M.12).	D			Demonstrate functionality
[SPFC-0049] The SPFC shall incorporate an elapsed time counter (ETC).	D			Demonstrate functionality
[SPFC-0050] The elapsed time shall be made available via the LMC communication interface and the SPFC debug port.	D			Demonstrate functionality
[SPFC-0051] The SPFC shall provide an engineering interface that can be accessed remotely for detailed diagnostics and low level control (Refines: R.SPF.CRS.2).	D			Demonstrate functionality
[SPFC-0052] The SPFC shall perform its POST, operating system start-up and application initialisation in less than 5 minutes.		FT		Test functionality
[SPFC-0054] The SPFC, while in STANDBY_LP and OPERATE_DEGRADED modes shall estimate the time to full performance and report this value to the LMC (Refines: R.SPF.SM.4).		FT		Test functionality
[SPFC-0055] The processing load on the SPFC CPU shall not exceed 80% of the available processing time.		FT		Test functionality
[SPFC-0056] The SPFC shall be capable of maintaining all FPs in the fully powered up state for extended durations (Refines: R.SPF.P.15).		FT		Test functionality
[SPFC-0057] During normal operation, the SPFC shall perform automated on-line health monitoring (OLHM) to the greatest extent possible without interfering with the normal operation of the SPFC.	I			Inspect CSCI source code
[SPFC-0058] The SPFC shall not start its application software if a POST error is present.	I			Verify system configuration
[SPFC-0059] The SPFC shall provide a self-test capability appropriate to the level-of-repair analysis needed (Refines: R.SPF.LSE.3).	D			Demonstrate functionality
[SPFC-0060] The SPFC shall report monitoring information to the LMC at a data rate of less than 200 kbps (Refines: R.SPF.M.15).	A	FT		Test functionality
[SPFC-0061] The latency introduced by the SPFC because of processing and hardware specific delays shall be less than 5s.		FT		Test functionality

Requirement number & description	Test Phase			Test Description (& responsible party)
	DT	QT	AT	(Note: These test definitions given here serve as framework for more detailed test instructions)
[SPFC-0062] The SPFC shall comply with the mode transition times as specified in Table 3.		FT		Test functionality
[SPFC-0063] The SPFC application software shall be restarted if the system is unresponsive for more than 10 seconds.		FT		Test functionality
[SPFC-0064] The SPFC shall comply with the communication time-outs stipulated in the respective interface ICDs.		FT		Test functionality
[SPFC-0066] The microprocessor module shall provide non-volatile memory for logging all system sensor data for a period of 30 days.	I			Inspect CSCI source code calculations
[SPFC-0067] The microprocessor module shall have at least 30% spare non-volatile memory for future logging expansion.	I			Inspect CSCI source code calculations
[SPFC-0068] The control and monitoring functions of the SPFC shall be performed by a CPU.	I			Inspect system
[SPFC-0069] A commercial-off-the-shelf (COTS) microprocessor module shall be used for control and monitoring.	I			Inspect system
[SPFC-0070] The temperature of the microprocessor board shall be monitored with an on-board temperature sensor.	I			Inspect system and CSCI source code
[SPFC-0071] The on-board temperature sensor shall be located in an appropriate location to monitor the temperature as accurately as possible.	I			Inspect system
[SPFC-0072] The total operational time of the SPFC shall be monitored with the ETC.	I			Inspect CSCI source code
[SPFC-0073] The SPFC shall adhere to all control commands from the LMC.	D	FT		Demonstrate and qualify that all commands are implemented and the expected behaviour is seen
[SPFC-0074] The SPFC shall use the protocol defined in [AD3] to communicate with the LMC (Refines: R.SPF.CCC.3).	I	FT		Qualify that the implementation adhered to the specification
[SPFC-0075] The SPFC shall provide a self-description of the SPFC_LMC interface as detailed in [AD3] (Refines: R.SPF.CCC.4).	I			The Tango interface provides this functionality out of the box
[SPFC-0076] The SPFC shall connect to the LMC with an Ethernet over fibre connection.	I			Inspect system
[SPFC-0077] A multimode transceiver shall be used for the 100BASE-FX interface.	I			Inspect system as well as product datasheets
[SPFC-0078] The SPFC shall connect to the SPF1 with a serial over fibre connection and conform to the requirements of [AD4].	I			Inspect system

Requirement number & description	Test Phase			Test Description (& responsible party)
	DT	QT	AT	(Note: These test definitions given here serve as framework for more detailed test instructions)
[SPFC-0079] The SPFC shall connect to the SPF2 with a serial over fibre connection and conform to the requirements of [AD5].	I			Inspect system
[SPFC-0080] The SPFC shall connect to the SPF345 with a serial over fibre connection and conform to the requirements of [AD6].	I			Inspect system
[SPFC-0081] The SPFC shall connect to the vacuum pump controller with a discrete fibre connection and conform to the requirements of [AD7].	I			Inspect system
[SPFC-0082] The SPFC shall connect to the helium compressor controller with a serial over fibre as well as a discrete fibre connection and conform to the requirements of [AD8].	I			Inspect system
[SPFC-0083] The SPFC shall be compliant with all local, state and national environmental protection legislation and regulations of South Africa as well as the country where it is manufactured / assembled (Refines: R.SPF.EL.1).	I			Inspect system
[SPFC-0084] The SPFC shall be capable to operate in a temperature range of 0 °C to 50 °C (Refines: R.SPF.ED.2, R.SPF.ED.3, R.SPF.ED.4).		FT		Test capability
[SPFC-0085] The SPFC shall be capable to operate at levels of seismic zone 1 as defined in IEC 60721-2-6 (Refines: R.SPF.ED.2, R.SPF.ED.3, R.SPF.ED.4).		FT		Test capability
[SPFC-0086] The SPFC shall be capable to operate with a lightning ground flash density of 1-3 strikes per square kilometre per year (Refines: R.SPF.ED.2, R.SPF.ED.3, R.SPF.ED.4).		FT		Test capability
[SPFC-0087] The SPFC shall be capable to operate at a height above sea level between 900m and 1100m (Refines: R.SPF.ED.2, R.SPF.ED.3, R.SPF.ED.4).		FT		Test capability
[SPFC-0088] Electronic equipment shall be safe and withstand, without damage or degradation or additional maintenance tasks, the presence of condensation (Refines: R.SPF.ED.1).		FT		Test capability
[SPFC-0089] The SPFC shall be capable to withstand an air temperature range of -15 °C to 60 °C (Refines: R.SPF.ED.2, R.SPF.ED.5).		FT		Test capability
[SPFC-0090] The SPFC shall be capable to withstand a relative humidity according to IEC 60721-3-3 Class 3K4 (Refines: R.SPF.ED.2, R.SPF.ED.5).		FT		Test capability
[SPFC-0094] Custom made SPFC components shall comply with IEC 61000-6-4 and IEC 61000-6-2 (Refines: R.SPF.RFI.8).	I			Inspect system and product datasheets

Requirement number & description	Test Phase			Test Description (& responsible party)
	DT	QT	AT	(Note: These test definitions given here serve as framework for more detailed test instructions)
[SPFC-0095] COTS components of the SPFC shall comply with the applicable harmonised standards in the European Commission EMD Directive 2004/108/EC, or the SABS equivalent thereof (Refines: R.SPF.RFI.8).	I			Inspect system and product datasheets
[SPFC-0096] The SPFC shall adhere to the radio frequency interference (RFI) requirements as specified in [AD1] paragraph 3.3.3 (Refines: R.SPF.RFI.3, R.SPF.RFI.6).		FT		Test capability
[SPFC-0097] The SPFC shall be packaged for careful transportation conditions to prevent incurring any residual damage TBC.2 (Refines: R.SPF.ET.1).	I			Inspect system
[SPFC-0098] The SPFC shall be capable of withstanding a temperature range of -25 °C to 70 °C (unventilated) and -25 °C to 50 °C (ventilated) during transportation.		FT		Test capability
[SPFC-0099] The SPFC shall be capable of withstanding free fall drop based on IEC 60721-3-2 class 2M1.		FT		Test capability
[SPFC-0100] The SPFC shall be capable to withstand normal class 2.1 public transport vibration as specified in [RD1].		FT		Test capability
[SPFC-0101] The SPFC shall be packaged for storage conditions, without incurring any damage, for a period of at least 2 years (Refines: R.SPF.ES.1).		I or FT		This test will take a long time. If good practice is adhered to, this test can be completed with detailed inspection.
[SPFC-0102] The SPFC shall be able to withstand a storage temperature range of -5 °C to 45 °C.		FT		Test capability
[SPFC-0103] The SPFC shall adhere to the fibre interconnection characteristics as is defined in [AD10] (Refines: R.SPF.I.1).	I			Inspect product datasheets
[SPFC-0104] The SPFC shall have the mechanical mounting characteristics as defined in [AD9] (Refines: R.SPF.I.2).	I			Inspect system
[SPFC-0105] The SPFC shall have the power and ground characteristics as defined in [AD9] (Refines: R.SPF.I.3).	I			Inspect system
[SPFC-0106] The SPFC shall weigh less than 3kg.	I			Inspect system
[SPFC-0107] The SPFC shall fit into a 1U slot in a 19" rack.	I			Inspect system
[SPFC-0108] The SPFC enclosure shall have Alodining treatment in order to protect its surface as well as to provide an electrically conductive surface for grounding to the 19" rack in which it shall be installed.	I			Inspect system



Requirement number & description	Test Phase			Test Description (& responsible party)
	DT	QT	AT	(Note: These test definitions given here serve as framework for more detailed test instructions)
[SPFC-0109] The SPFC shall be ergonomically compliant with MIL-STD-1472G (Refines: R.SPF.HF.1).	I			Inspect system
[SPFC-0110] The SPFC shall have a minimum deployed lifetime of 10 years (Refines: R.SPF.LRA.1).		I or FT		This test will take a long time. If good practice is adhered to, this test can be completed with detailed inspection.
[SPFC-0111] The SPFC shall be able to be online 24 hours a day, 365 days a year.		I or FT		This test will take a long time. If good practice is adhered to, this test can be completed with detailed inspection.
[SPFC-0112] The SPFC shall have a mean maintenance downtime (MMDT) of less than 2.5 hours (Refines: R.SPF.LRA.2).	D			This can be demonstrated by evaluating production assembly time
[SPFC-0113] The SPFC shall have a mean time between maintenance of more than 35 000 hours (Refines: R.SPF.LRA.3).		I or FT		This test will take a long time. If good practice is adhered to, this test can be completed with detailed inspection.
[SPFC-0114] The SPFC shall be replaceable making use of standard manufacturing tools (Refines: R.SPF.LRR.1, R.SPF.LSF.1, R.SPF.PD.1).	I			Inspect production assembly tools needed
[SPFC-0115] The mean time to replace the SPFC or any of its sub elements shall not exceed 30 minutes.		D		Demonstrate capability
[SPFC-0116] Time taken to change external cables shall be less than 5 minutes.	D			Demonstrate capability
[SPFC-0117] Hardware components in the SPFC shall be easily accessible and component stacking shall be kept to a minimum (Refines: R.SPF.LRR.3).	I			Inspect system design
[SPFC-0118] Internal interfaces shall have terminal blocks or plugs and sockets to ease the swapping out of components	I			Inspect system
[SPFC-0119] Items identified as ILM Spare items shall require a minimum of tuning, calibration, aligning and other actions (Refines: R.SPF.LRR.4).	I			Inspect system
[SPFC-0120] Where alignment, calibration or tuning is required, a deterministic procedure for such actions shall be contained in the support publications (Refines: R.SPF.LRR.4).	I			Inspect documentation and/or procedures
[SPFC-0121] Repairable items shall include maintenance provisions such as test points, accessibility and plug-in components (Refines: R.SPF.LRR.5).	I			Inspect system design
[SPFC-0122] The SPFC shall have a modular design to enable easy removal and replacement of faulty LRUs (Refines: R.SPF.LRR.6).	I			Inspect system design

Requirement number & description	Test Phase			Test Description (& responsible party)
	DT	QT	AT	(Note: These test definitions given here serve as framework for more detailed test instructions)
[SPFC-0123] Mounting guides and location pins shall be provided to facilitate module mounting (Refines: R.SPF.LRR.7).	I			Inspect system design
[SPFC-0124] Provisions for the preclusion of mounting the wrong module shall be provided (Refines: R.SPF.LRR.8).	I			Inspect system design
[SPFC-0125] Items identified as organisational level maintenance (OLM) Spare items shall be interchangeable with items of the same part number and version with no calibration, tuning or special alignment (Refines: R.SPF.LRR.9).	I			Inspect system design
[SPFC-0126] Modules shall be securely mounted with the minimum number of fasteners (Refines: R.SPF.LRR.10).	I			Inspect system design
[SPFC-0127] Stand-offs and handles shall be used to protect system components from damage during shop maintenance (Refines: R.SPF.LRR.11).	I			Inspect system design
[SPFC-0128] All cables and harnesses and their connectors shall be labelled in the English language to allow identification while the cables and harnesses are installed (Refines: R.SPF.LPM.1).	I		I	Inspect system
[SPFC-0129] All component mounted connectors shall be labelled in the English language to allow identification during installation and maintenance of the SPFC (Refines: R.SPF.LPM.2).	I		I	Inspect system
[SPFC-0130] The SPFC shall have clear markings and labels in the English language for all switches and controls used by operators or technical personnel (Refines: R.SPF.LPM.3).	I		I	Inspect system
[SPFC-0131] Disposable modules shall be marked as such (Refines: R.SPF.LPM.4).	I		I	Inspect system
[SPFC-0132] The SPFC shall be clearly marked with warning labels in the English language where special handling is required to prevent damage to items (Refines: R.SPF.LPM.5).	I		I	Inspect system
[SPFC-0133] The SPFC shall have clear markings to indicate equipment which may jeopardise the safety of personnel or result in a hazardous situation if improperly operated or handled (Refines: R.SPF.LPM.6).	I		I	Inspect system
[SPFC-0134] The labels on the SPFC shall withstand all environments and conditions to which it is subjected (Refines: R.SPF.LPM.8).	I	FT	I	Inspect system
[SPFC-0135] Product markings shall not become detached or unreadable with repeated handling (Refines: R.SPF.LPM.9).	I	FT	I	Inspect system

Requirement number & description	Test Phase			Test Description (& responsible party)
	DT	QT	AT	(Note: These test definitions given here serve as framework for more detailed test instructions)
[SPFC-0136] The product markings on the SPFC shall be clearly visible when it is installed (Refines: R.SPF.LPM.9).	I		I	Inspect system
[SPFC-0137] The SPFC shall be labelled in the English language with the following information (Refines: R.SPF.LPM.7): g) Supplier name h) Product name i) Part number j) Version k) Serial number l) Barcode containing the above information	I		I	Inspect system
[SPFC-0138] As-built data shall be provided as part of the manufacturing data pack (Refines: R.SPF.LDM.1).			I	Inspect data pack
[SPFC-0139] As-designed data shall be provided as part of the manufacturing data pack (Refines: R.SPF.LDM.2).			I	Inspect data pack
[SPFC-0140] The SPFC shall have an assembly and installation manual.		I	I	Inspect data pack
[SPFC-0141] A qualification test procedure and a qualification test report shall be defined for the SPFC to define the tests and record the results thereof.		I		Inspect data pack
[SPFC-0142] The SPFC shall have an acceptance test procedure and an acceptance test report that define and record the acceptance tests conducted on the main components and the installed system.		I	I	Inspect data pack
[SPFC-0143] The SPFC shall have a single, dual purpose operators and maintenance manual which covers all lines of user maintenance.		I		Inspect data pack
[SPFC-0144] No operating personnel shall be required to operate the SPFC, however personnel shall be required to maintain the SPFC.		I		
[SPFC-0145] Training shall be required for maintaining the SPFC. Although the maintenance required by the SPFC is very basic, a procedure shall be provided as required.		I		

Requirement number & description	Test Phase			Test Description (& responsible party)
	DT	QT	AT	(Note: These test definitions given here serve as framework for more detailed test instructions)
[SPFC-0146] The package labelling of the SPFC shall have the following information (Refines: R.SPF.LPA.3): a) Item name b) Part number c) Version d) Serial number e) Supplier part number (where applicable) f) Supplier identification (where applicable) g) Barcode h) Packaged weight i) Container stackability (where applicable) j) Preservation data (where applicable) k) Shelf life (where applicable)			I	Inspect system
[SPFC-0147] The SPFC, when packaged, shall have the following markings securely attached to the outside of the packaging container (Refines: R.SPF.LPA.4, R.SPF.SAF.2): a) Mode of transport "Careful transportation" b) "This side up" label c) Packaged item identification plate with data completed as per package labelling requirement. d) ESD warnings where applicable.			I	Inspect system
[SPFC-0148] The SPFC shall be packaged such that standard transportation vehicle and entry constraints are adhered to (Refines: R.SPF.LPA.8).			I	Inspect system
[SPFC-0149] Packaging of spare SPFCs shall be supplied by the supplier of the SPFC (Refines: R.SPF.LPA.9).			I	Inspect system
[SPFC-0150] The SPFC shall be supplied by the 1st line maintainer.			I	Inspect system
[SPFC-0151] Fasteners shall be standardised as far as possible to minimize the use of different types and sizes (Refines: R.SPF.PD.2).	I			Inspect system
[SPFC-0152] Safety features shall be incorporated to provide safety, protection of personal, and equipment during use, maintenance, transportation and storage.	I	I	I	Inspect system and/or documentation and/or procedures
[SPFC-0153] The SPFC shall be locally fail-safe and not be dependent on any external inputs for safety (Refines: R.SPF.SAF.1).	I			Inspect system
[SPFC-0154] Switch off temperature controllers if the temperature exceeds 320K.		FT		Simulate temperature increase
[SPFC-0155] Close the vacuum valve if the cryostat or manifold pressure suddenly increases.		FT		Simulate pressure increase

Requirement number & description	Test Phase			Test Description (& responsible party)
	DT	QT	AT	(Note: These test definitions given here serve as framework for more detailed test instructions)
[SPFC-0156] Perform a valve safety check by confirming pressures before the vacuum valve is opened.		FT		Simulate edge conditions
[SPFC-0157] The equipment shall incorporate protective elements to prevent inadvertent contact with voltages capable of producing shock hazards in accordance to the applicable sections of SANS 60950-1 (Refines: R.SPF.SAF.4).	I			Inspect system design
[SPFC-0158] The SPFC shall ensure galvanic connection in accordance to IEC62305 LPL III and with resistance of less than 10 milliohms between the chassis and the lightning protection earth interface provided by the DS (Refines: R.SPF.LPS.2).	I			Inspect system design
[SPFC-0159] The SPFC shall maintain its lightning protection zone in accordance to IEC62305 LPL III as specified in [AD9] (Refines: R.SPF.LPS.4).	I			Inspect system design
[SPFC-0160] The SPFC shall extend its lightning protection zone on all power interfaces in accordance to IEC62305 LPL III as specified in [AD9] (Refines: R.SPF.LPS.5).	I			Inspect system design
[SPFC-0161] Sharp corners, edges, projectors and hot surfaces of which personnel can be exposed shall be avoided or shielded with protective covers or coatings (Refines: R.SPF.SAF.3).	I			Inspect system design
[SPFC-0162] Connectors shall be wired as such to avoid the exposure of hot points.	I			Inspect system design
[SPFC-0163] A risk assessment shall be conducted for each item of machinery in accordance with BS EN ISO 12100 (Refines: R.SPF.PR.6).		A		Analyse system
[SPFC-0164] The SPFC shall operate from a single-phase supply voltage of 204-253 VAC and 49-51 Hz.	FT			Test system with different power inputs
[SPFC-0165] The average power consumption shall not exceed, with power factor less than, the allocated values as defined in [AD2] when operating at full performance under the <b>Precision, Standard and Degraded Operating conditions</b> (Refines: R.SPF.PW.1).	A	FT		Analyse system component datasheets
[SPFC-0166] The SPFC power consumption surge shall not exceed the allocated values as defined in [AD2] when operating at full performance under the <b>Precision, Standard and Degraded Operating conditions</b> (Refines: R.SPF.PW.1).	A	FT		Analyse system component datasheets
[SPFC-0167] The SPFC shall not induce total harmonic distortion (current) onto the electrical supply that exceeds the levels defined in [AD2] for single phase equipment (Refines: R.SPF.PW.3).	A	FT		Analyse system component datasheets

Requirement number & description	Test Phase			Test Description (& responsible party)
	DT	QT	AT	(Note: These test definitions given here serve as framework for more detailed test instructions)
[SPFC-0168] The SPFC shall estimate the power consumption for the individual SPF equipment as the function of their current state and report it to the LMC upon request (Refines: R.SPF.CCC.5).	D	A		Demonstrate the estimates power consumption functionality and analyse the estimated power result.
[SPFC-0169] The SPFC shall not induce heat loads that exceed the levels as defined in [AD2] (Refines: R.SPF.PW.5).	A	FT		Analyse system component datasheets
[SPFC-0170] The grounding shall be in accordance of the dish structure grounding requirements (Refines: R.SPF.I.3).	I			Inspect design
[SPFC-0171] The SPFC shall consist of the following major components: <ol style="list-style-type: none"> <li>1. SPFC enclosure</li> <li>2. SPFC CPU PCB assembly</li> <li>3. Fibre interface assembly</li> <li>4. Power supply unit with front panel LED display</li> </ol>	I			Inspect design
[SPFC-0172] All electronic parts and sub-assemblies of the SPFC shall reside within the SPFC enclosure.	I			Inspect design
[SPFC-0173] The enclosure shall house and protect the electronic modules of the SPFC against the specified environment.	I			Inspect design
[SPFC-0174] The enclosure shall be RFI shielded.	I	FT		Inspect design
[SPFC-0175] The enclosure shall be able to fit into a 1U space of a 19" rack.	I			Inspect design
[SPFC-0176] The enclosure shall have distinct cavities for the major SPFC components.	I			Inspect design
[SPFC-0177] The power supply cavity shall house the panel status LEDs with light pipes through the wall of the enclosure.	I			Inspect design
[SPFC-0178] The fibre cavities shall provide space for the fibre adaptors and connectors.	I			Inspect design
[SPFC-0179] The enclosure shall have fibre routing slots between the cavities where needed.	I			Inspect design
[SPFC-0180] Each of the cavities of the enclosure shall be RFI shielded using RF gaskets/pads and filtered connectors.	I			Inspect design
[SPFC-0181] Panels and lids of the enclosure shall be easily removable to allow easy access for test and maintenance purposes.	I			Inspect design

Requirement number & description	Test Phase			Test Description (& responsible party)
	DT	QT	AT	(Note: These test definitions given here serve as framework for more detailed test instructions)
[SPFC-0182] The CPU shall be a modern microprocessor with at least 200 MIPS.	I			Inspect design
[SPFC-0183] The CPU module shall have at least the following memory capabilities: <ul style="list-style-type: none"> <li>• 64 MB SDRAM</li> <li>• 128 MB NAND Flash</li> <li>• 128 byte EEPROM</li> </ul>	I			Inspect design
[SPFC-0184] The CPU module shall have the following minimum communication interfaces: <ul style="list-style-type: none"> <li>• 6x UART modules</li> <li>• 1x Fibre Ethernet MAC</li> <li>• 1x SPI</li> <li>• 16 digital IO ports</li> <li>• 1x SD card interface</li> </ul>	I			Inspect design
[SPFC-0185] The application software shall be externally downloadable without removing components.	I			Inspect design
[SPFC-0186] The CPU shall provide a watchdog function.	I			Inspect design
[SPFC-0187] The CPU shall provide an elapsed time counter (ETC).	I			Inspect design
[SPFC-0188] The CPU shall be capable of monitoring on-board temperature, supply voltage and supply current.	I			Inspect design
[SPFC-0189] The fibre interface assembly shall have the following characteristics: <ol style="list-style-type: none"> <li>Provide at least 8x individual transmitters</li> <li>Provide at least 8x individual receivers.</li> </ol>	I			Inspect design
[SPFC-0190] The SPFC PSU shall provide the SPFC sub-assemblies with regulated and conditioned electrical power.	I			Inspect design
[SPFC-0191] The PSU shall be capable of operating from a 204-253 VAC and 49-51 Hz AC power source.	I			Inspect design
[SPFC-0192] The PSU shall be a linear power supply as to reduce the RFI.	I			Inspect design
[SPFC-0193] The output of the PSU shall be 5.0 VDC, 2 A.	I	FT		Inspect and test design
[SPFC-0194] The PSU shall provide thermal overload and over voltage protection.	I			Inspect design

Requirement number & description	Test Phase			Test Description (& responsible party)
	DT	QT	AT	(Note: These test definitions given here serve as framework for more detailed test instructions)
[SPFC-0195] The PSU shall provide inrush current limiting.	I			Inspect design
[SPFC-0196] The PSU shall have soft-start functionality.	I			Inspect design
[SPFC-0197] All PSU outputs shall be electrically isolated from the inputs.	I			Inspect design
[SPFC-0198] The power efficiency shall be greater than 60%.	FT			Test
[SPFC-0199] The PSU shall provide a minimum output power of 10W.	FT			Test
[SPFC-0200] The front panel LED display shall provide system status	I			Inspect design
[SPFC-0201] To limit the overall peak inrush current, the SPFC shall ensure that the SPFHe and SPFVac services are not switched on simultaneously (Refines: R.SPF.PW.1).	I			Inspect and confirm in CSCI source code



## 5 PACKAGING

Not applicable.

## 6 NOTES

### 6.1 Explanatory Notes

None.

### 6.2 List of Unresolved Items

This section summarises all TBD and TBC statements within this specification.

**Table 9: TBD and TBC control list**

No	Topic	Reference
TBC.2	Very careful transportation can be requested (TBC.4 in [AD1]), but only if required to achieve specification.	3.3.5

## 7 REQUIREMENTS TRACEABILITY

Traceability of the SPF sub-element level requirements to the major SPF components will be added to the DHS requirements in Core. It can also be checked manually by considering the “Refines” entries in the first column of Table 8.



**SINGLE PIXEL FEED CONTROLLER DEVELOPMENT SPECIFICATION**

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