REPORT TITLE: **TECHNICAL REQUIREMENT SPECIFICATION OF SMART MULTI-FUNCTION DISPLAY FOR LCA-MK1A AIRCRAFT**

PROJECT: **LCA-MK1A**

CLASSIFICATION: **RESTRICTED**

REPORT NO.: **HAL/ARDC/LCA-MK1A/AVI/345**

Issue: B

Amendment No.: NIL **DATE: 30-05-2019**

AIRCRAFT RESEARCH & DESIGN CENTRE
DESIGN COMPLEX
HINDUSTAN AERONAUTICS LIMITED
BANGALORE 560037

CONTENTS PAGE NOS.

List of Figures

List of Tables

1. INTRODUCTION

/i Hindustan Aeronautics Limited (HAL) is currently involved in the development of LCA-Mk1A, an upgraded version of LCA-TEJAS. The upgrade includes integration of 5"X5" Smart Multifunctional displays (SMFD) in place of existing 5"X5" Multi-Functional Displays (MFD).

1.1. Purpose and Scope

/i The scope of this document is to describe technical requirement specifications of 5"x5" Smart Multi-Function displays for LCA-Mk1A aircraft.

1.2. Reference Documents and Standards

Table 1: Applicable documents and standards List

ARINC 818	Avionics Digital Video Bus – High Speed
IEEE 1588-2008	IEEE standard for a Precision Clock Synchronisation Protocol
MIL-C-14806	Standard for anti-reflection multilayer coating on displays
MIL-HDBK-217F (Notice 2)	Reliability prediction of Electronic Equipment
MIL-HDBK-87213	Electronically/Optically Generated airborne displays
MIL-STD-1553B (Notice 2)	Digital Time Division Command Response Multiplex Data bus
MIL-STD-3009	Lighting, Aircraft, Night Vision Imaging System(NVIS) Compatible
MIL-STD-461E	Requirements for the control of Electromagnetic Interference characteristics of sub systems and equipment
MIL-STD-464C	Electromagnetic environmental effects Requirements for systems
MIL-STD-704D	Aircraft electric power characteristics
MIL-STD-810F	Test Method Standard for Environmental engineering considerations and Laboratory Tests
MIL-STD-85762A	Lighting, Aircraft, Interior, Night Vision Imaging System (NVIS) Compatible
RTCA DO 178B	Software considerations in Airborne Systems and Equipment Certifications
RTCA DO 254	Hardware considerations in Airborne Systems and Equipment Certifications
STANAG 3350	Analogue video standard for Aircraft system applications

1.3. List of abbreviations

Table 2: Abbreviations

Abbreviations	Description
ABC	Automatic Brightness Control
AGC	Automatic Gain Control
AMLCD	Active Matrix Liquid Crystal Display
ANVIS	Aviator's Night Vision Imaging System
API	Application Programming Interface
ARDC	Aircraft Research and Design Centre
ARINC	Aeronautical Radio Incorporation
ATE	Automated Test Equipment
BIT	Built In Test
BOM	Bill Of Material
BSP	Board Support Package
CBIT	Continuous Built In Test
CEMILAC	Centre for Military Airworthiness and Certification
COC	Certificate of Conformance
COTS	Commercial Off The Shelf
CSMFD	Centre Smart Multi Function Display
DC	Direct Current
DGAQA	Director General of Aeronautical Quality Assurance
EMC	Electromagnetic Compatibility
EMI	Electro Magnetic Interference
ESS	Environmental Stress Screening
FMECA	Failure Modes, Effects and Criticality Analysis
FSP	Function Selection Panel
GUI	Graphical User Interface
HAL	Hindustan Aeronautics Limited
IBIT	Initiated Built-In Test
ICD	Interface Control Document
IDE	Integrated Development Environment
IO	Input/output
IV&V	Independent Verification and Validation
LCA	Light Combat Aircraft
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LRU	Line Replaceable Unit
LSMFD	Left Smart Multi Function Display
MC	Mission Computer
MFD	Multi Function Display
MF-UFCP	Multi-Function Up Front Control Panel

MIP	Main Instrument Panel
MMI	Man Machine Interface
MTBF	Mean Time Between Failure
NVG	Night Vision Goggle
NVRAM	Non Volatile Random Access Memory
OFP	Operational Flight Program
OLED	Organic Light Emitting Diode
OpenGL	Open Graphics Library
PB	Push Button
PBIT	Power on Built In Test
PCB	Printed Circuit Board
PIP	Picture In Picture
QT	Qualification Test
RCMA	Regional Centre for Military Airworthiness
RGB	Red Green Blue
RSMFD	Right Smart Multi Function Display
RT	Remote Terminal
RTCA	Radio Technical Commission for Aeronautics
RTOS	Real Time Operating System
SDRAM	Synchronous Dynamic Random Access Memory
SOFT	Safety Of Flight Test
SMFD	Smart Multi-Function Display
SSP	Sensor Selection Panel

1.4. Interpretations

/i Information paragraph

Shall A mandatory action

2. DETAILS OF LCA

2.1. Introduction to LCA

/i The Indian Light Combat Aircraft (LCA), Tejas is a single-engine multi-role fighter with both defensive and offensive capabilities. LCA aircraft is designed as an unstable aircraft and flight control software ensures stability and provides good handling qualities to the pilot. LCA has been designed with Avionics and Weapon System which are configured to cater for Air-to-Air (A/A), Air-to-Ground (A/G) and Air-to-Sea (A/S) missions.

2.2. LCA Avionics

/i LCA Avionics architecture is configured around Mission Computer (MC1 and MC2) that combines the functions of Mission processor and Video switching. Avionics architecture of LCA is centred on MIL-STD-1553B for which Mission Computer, MC1 is the bus controller. In event of MC1 failure, all functionalities of MC1 will switch over to MC2 and MC2 will act as the bus controller. MC is interfaced with three Smart-multifunction displays (LSMFD, RSMFD and CSMFD), MF-UFCP, FSP and SSP for MMI control and command operations for interacting with avionics and weapon systems.

2.3. Approach to SMFD Integration

/i. SMFD is proposed to be a form fit replacement of the existing 3 MFDs. All the three SMFDs will be integrated with LCA avionics system as RT on MIL-STD-1553B. MC will be the Bus controller. Symbology generation of display pages and overlays for key selection is the function of SMFD. MC will provide necessary data for the page generation through MIL-STD-1553B and Ethernet interface to SMFD. Based on the operator command, MC will also provide sensor video to SMFD through ARINC818 and RGB STANAG3350B interface for the display. The displayed SMFD page will be recorded in Video recording system. Interface of SMFD on MIL-STD-1553B bus is shown in Figure 1.

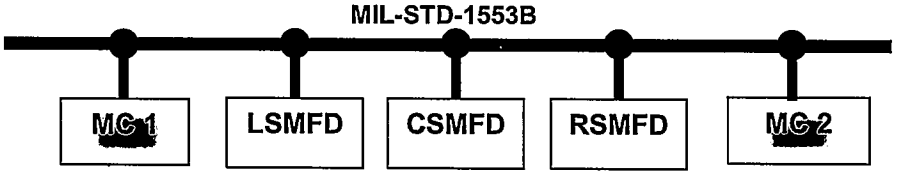

Figure 1: MIL-STD-1553B Bus Architecture of SMFD

3. TECHNICAL REQUIREMENTS

3.1. Functional Requirements

3.1.1. SMFD shall be a colour Active Matrix Liquid Crystal Display (AMLCD) with following features

a. Anti-reflection coating

b. Full sunlight readability

c. Night vision capability

3.1.2. SMFD shall combine a processing unit with a bright, sunlight readable Liquid Crystal Display with LED/OLED backlight.

3.1.3. SMFD shall have data processing and graphics processing capability with 2D & 3D display page generation features.

3.1.4. SMFD shall display the following based on the command:

3.1.4.1. Display of internally generated graphic symbology information

3.1.4.2. Display of internally generated graphic symbology information overlaid with external input video.

3.1.4.3. Display of only external video without any overlays.

3.1.4.4. Picture In Picture (PIP) display i.e. it shall be possible to resize the external video and place inside internally generated video.

3.1.5. SMFD shall have capability to generate snapshot of the displayed page on operator command and transmit the same in compressed/raw image format to Mission Computer through Ethernet interface.

3.1.6. SMFD shall have capability to read the image snapshot from the Mission Computer through Ethernet interface and display it on the screen based on operator command.

3.1.7. SMFD shall have Auto Brightness Control (ABC) of the display using Illumination sensors located on bezel.

3.1.8. SMFD shall have Option Selection Switches (Bezel Keys) for selection of various display parameters and pages.

3.1.9. SMFD shall have In-situ programming capability.

3.2. Display Requirements

3.2.1. The SMFD shall have a viewing area of 5" x 5".

3.2.2. The display resolution of SMFD shall be 600x600 RGB pixels or better. Vendor shall specify the proposed display resolution.

3.2.3. **Display Luminance:**

a. Minimum display luminance shall be 0.03fL or better

b. Maximum display luminance shall be 300fL or better

3.2.4. **Viewing Angle:** The display shall be clearly readable and the characteristics & performance of display shall be guaranteed for following viewing angles measured with respect to centre of display

a. Horizontal: ± 55° or better

b. Vertical: -15° to +40° or better.

/i Viewing eye above the display normal corresponds to a positive vertical angle. Viewing eye left of the display normal corresponds to a positive horizontal angle.

3.2.5. **Brightness Uniformity:** For a white pattern, the brightness shall not vary from the average by more than 25 % over the display surface, for any brightness level for the entire viewing envelope.

/i If Bmax is the maximum brightness and Bmin the minimum on the screen, brightness uniformity shall be defined by: Bmax – Bmin/Bmax + Bmin

3.2.6. **Contrast Ratio:**

3.2.6.1. The contrast ratio shall be 10:1 or better under 10,000 fc (Bright Ambient) and glare source of 2,000fL at the Design Eye Point or at Normal viewing angle.

3.2.6.2. The contrast ratio shall be 6:1 or better under 10,000 fc (Bright Ambient) and glare source of 2,000fL for the primary viewing angles of +0° to +25° in Vertical and -20° to +20° in Horizontal.The contrast ratio shall be 75:1 or better under Dark ambient for the primary viewing angles of +0° to +25° in Vertical and -20° to +20° in Horizontal.

3.2.6.3. The contrast ratio shall be 4:1 or better under 10,000 fc (Bright Ambient) & glare source of 2,000fL and 10:1 under dark ambient for extreme viewing angles specified in section 3.2.4.

3.2.6.4. Vendor shall specify contrast ratios for normal and other viewing angles in Bright and Dark ambient condition.

3.2.7. **Display Colours:** The display shall have 8 bit (256 levels) per colour component (greater than 16 million colours)

3.2.8. **Refresh Rate:** Refresh rate of the display screen shall be 50Hz or better. Vendor shall provide the proposed Refresh rate of the SMFD.

3.2.9. **Display Brightness Control:**

3.2.9.1. Display Brightness variation shall be limited according to the DAY, NIGHT/NVG or AUTO mode selection.

/i Command input for these modes will be provided by MC over MIL-STD-1553B interface.

3.2.9.2. AUTO mode: SMFD shall have an automatic brightness control to adjust the brightness of the display under ambient light condition.

3.2.9.3. Manual Mode: SMFD shall have a manual brightness control which shall override the brightness set in software set brightness.

i. In DAY mode, it shall be possible to vary the brightness manually from 0.1fL to 300fL using the Brightness Knob.

ii. In NIGHT mode, it shall be possible to vary the brightness manually from 0.03fL (or less) to the Maximum value of 15fL using the Brightness knob.

3.2.9.4. Vendor shall perform any modifications required in the Automatic brightness control law and Manual brightness range (Day and Night mode) of the SMFD based on the feedback of ground and flight test evaluation free of cost till Type approval certification.

3.2.10. **Input Video Control:**

3.2.10.1. SMFD shall have Automatic Gain Control (AGC) circuitry to compensate for any loss in video signal during transmission from MC.

3.2.10.2. SMFD shall have a Contrast control for changing the brightness of the input Video.

/i Contrast control will change the relative brightness of the background input video with respect to the overlaid symbology.

3.2.10.3. SMFD shall be capable to display video (RGB STANAG3350B and ARINC818) with the aspect ratio of 1:1 and 4:3 (without cropping and with side cropping) aligned at the centre of display surface as per external command received through MIL-STD-1553B interface.

3.2.10.4. SMFD shall support for Scaling and Cropping of the external video input as per the command received through MIL-STD-1553B interface.

3.2.10.5. Display symbol shape shall not be distorted on cropping / scaling function by SMFD i.e. a circle drawn shall not be distorted and get changed to oval shape.

3.2.11. **Display Response Time**

3.2.11.1. The display response time shall be 25ms or better at 25°C after Power-up time.

3.2.11.2. Vendor shall provide the details of the response time characteristics at other temperatures.

/i Response time is defined as the transition time for a pixel to change its level of luminance output between 10% and 90% of the maximum luminance level.

3.2.12. Night vision capability of the display shall be as per MIL-STD-3009 Class B for use with Gen III Night Vision Goggles.

3.2.13. Display shall have an anti-reflection multilayer coating as per MIL-C-14806 standard and incorporate anti-glare features to avoid glare / reflection when installed in the cockpit.

3.2.14. Display shall be free of smear, jitter, flicker, toggling and other artifacts such as noise, ripple and jerking.

3.2.15. SMFD shall incorporate antialiasing features to avoid jagged lines/ stair casing effect.

3.2.16. Display shall be stable under all operating conditions

3.2.17. Display freeze shall not happen under any condition.

3.2.18. Vendor shall demonstrate readability of SMFD at 10,000 fc to 0.1 fc light conditions in presence of glare source at all viewing angles.

3.3. Keypanel Requirements

3.3.1. The keypanel shall be integrally illuminated for the Bezel markings.

3.3.2. Bezel lighting shall be LED based and colour shall be ANVIS green A as per MIL-STD-3009 Class B.

3.3.3. SMFD shall have 2 illumination/light sensors placed on the bezel for Automatic brightness control function.

3.3.4. SMFD shall have 5 push buttons on top row and 5 push buttons on bottom row as shown in Figure 2.

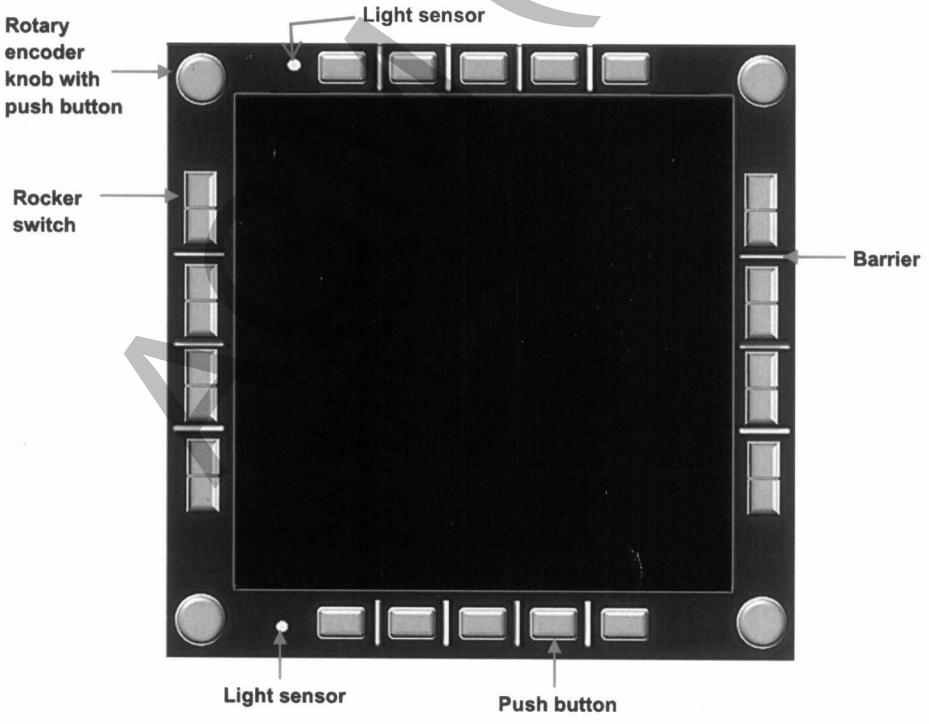

Figure 2: 5"X5" SMFD typical layout

3.3.5. SMFD shall have 4 rocker switches on left side and 4 rocker switches in right side (refer Figure 2).

3.3.6. SMFD shall have 4 rotary encoder knobs with push button function at all four corners.

/i Bottom two rotary encoder knobs may be replaced by rocker switches if required based on aircraft installation studies during design & development phase.

3.3.7. Rotary encoder knob shall have positive tactile feedback and shall have rims with suitable surfaces for secure grasp.

3.3.8. Rotary encoder knob with push button shall be used for following operations:

a. Brightness Control of the Display.

b. Internally generated symbology brightness control.

c. External video input contrast control as per section 3.2.10.2.

d. Symbology function selection and transmission of data to MC over MIL-STD-1553B.

3.3.9. Push buttons and rocker switches shall have the following characteristics:

3.3.9.1. It shall have Positive tactile feedback (click or snap) confirming key press operation.

3.3.9.2. It shall operate with a smooth action (i.e. no sticking or judder).

3.3.9.3. The depression resistance shall be uniform across the surface of the switch.

3.3.9.4. It shall have single press and long press capabilities.

3.3.9.5. It shall be separated by barriers as shown in Figure 2.

/i The exact location and type of Push button, Rocker switches, Rotary Knobs, and Display legends marking will be finalized during the design & development phase.

3.4. Interface Requirements

3.4.1. SMFD shall be interfaced with Mission computer and other on-board systems through various interfaces as shown in Figure 3.

/i The interface details will be finalized during the design and development phase.

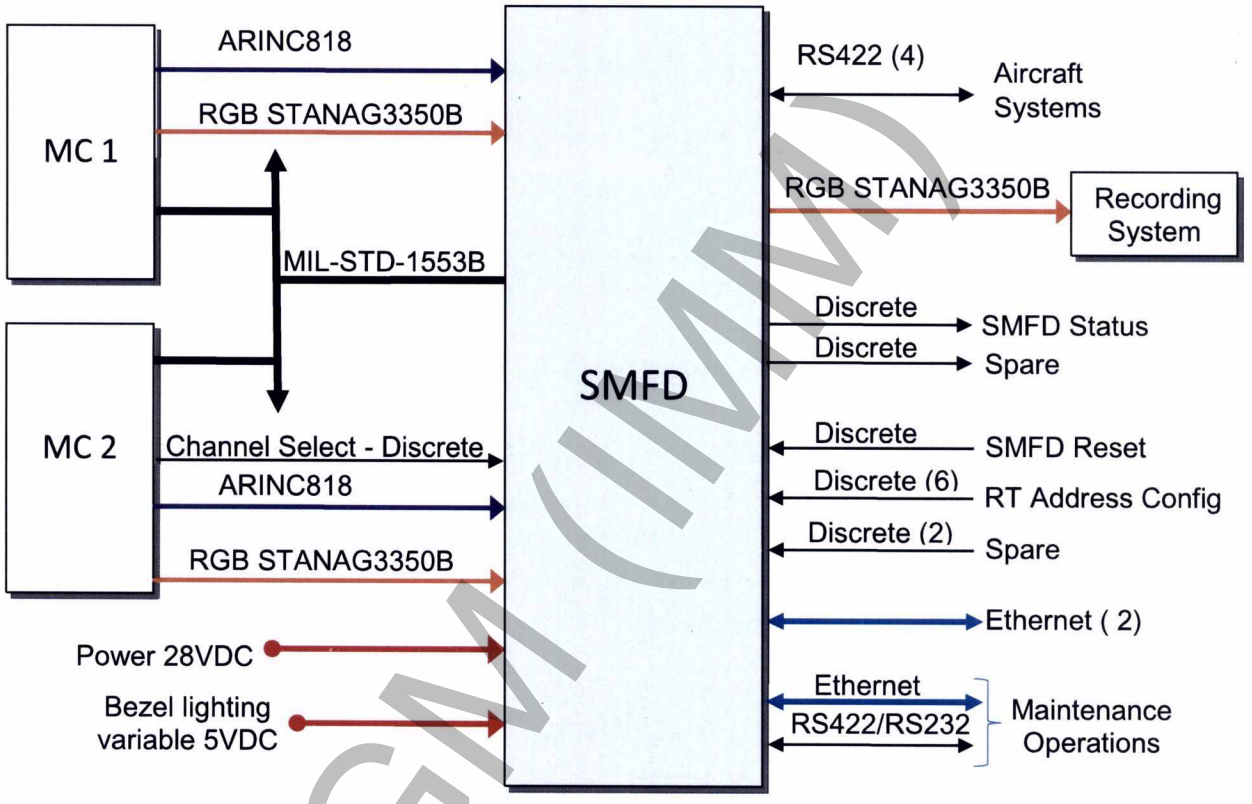

Figure 3: SMFD Interface details

3.4.2. SMFD interfaces and the quantities required for each interface type shall be as per Table 3.

Table 3: SMFD interface details

Sl. No	Interface Type	Quantity	Remarks
Functional Interfaces			
1	Bidirectional RS422 ports	4	Configurable Baud rate upto 1.5 Mbps.
2	ARINC818 video	2 input channels	• Link speed: 1x (1.0625 Gbps) • Transmission Media: Copper **Note :** ICD for ARINC818 video interface as per ARINC specification 818-1 will be finalised during design and development phase
3	RGB STANAG3350B	2 input channels	• Differential Red, Green with Sync and Blue • 2Vp-p without termination and 1Vp-p with 120Ω termination
		1 output channel	• Differential Red, Green with Sync and Blue • With 120Ω termination • For sending current display page for recording
4	Full duplex Ethernet	2	• Configurable to 10Mbps/100Mbps/1000Mbps. • Support for IEEE 1588-2008 for precision time synchronisation is preferred.
5	MIL-STD-1553B	1 dual redundant channel (i.e. with Bus A & Bus B)	• Link speed of 1Mbps • Shall work as RT on the bus
6	Discrete In (0V/OC)	10	1 - Channel Select 1- SMFD Reset 5 – RT Address 1 – Parity Control 2 - Spare
7	Discrete Out (0V/OC)	2	1 – SMFD Health Status 1 – Spare
8	5VDC variable bezel lighting	0-5V variable DC supply for bezel brightness control	-

9	28VDC	28V DC Power Supply	-
Maintenance Operation Interfaces			
10	Full duplex Ethernet	1	• For loading Application software
11	RS422/RS232	1	• For debugging software/firmware

3.4.3. By default, SMFD shall receive data and video from primary mission computer. In case of failure of primary MC, SMFD shall automatically switch over to standby MC to receive data and video based on the channel select discrete from the MC.

3.4.4. Based on the command from MC received through MIL-STD-1553B, SMFD shall display RGB STANAG3350B video or ARINC818 video from the active Mission Computer.

3.5. SMFD Hardware Requirements

3.5.1. SMFD design shall be based on Open System Architecture hardware.

3.5.2. The design of hardware shall be modular such that failure in one module does not result in failure of other modules. Modular design shall ensure replacement of only defective modules. Modular design shall also ensure card level interchangeability/replacement.

3.5.3. Data Processing module of the SMFD shall have minimum following capabilities:

a. Processor : Latest generation 32bit or better PowerPC
b. Frequency : > 650 MHz.
c. Memory (DDR2 or higher SDRAM) : 1 GB or more
d. Program Memory (FLASH) : 128MB or more
e. NVRAM : 128 KB or more
f. NAND Flash : 8 GB or more

3.5.4. Graphics generation module of the SMFD shall have following minimum capabilities :

a. Memory dedicated for graphics processing : 512 MB or more
b. Capability for Video overlay.
c. Support for minimum 8 graphics overlay layers.
d. Support for accelerated 2D and 3D APIs and OpenGL graphics drivers
e. Support for OpenGL ES version 2.0.
f. Support for texture mapping.

3.5.5. SMFD shall have hardware and software Watchdog timer. The hardware and software reset shall be possible from the OFP software. Vendor shall provide details of the Watchdog Timer.

3.5.6. SMFD shall have display backlight current monitoring capability.

3.5.7. SMFD hardware design shall be finalized in consultation with HAL during design and development stage.

3.5.8. SMFD Hardware design shall be carried out as per DO-254 recommendations or relevant RCMA/CEMILAC directives. The qualification standard shall conform to the mission critical standard.

3.6. Platform Software Requirements

3.6.1. The vendor shall be responsible for the development of platform software consisting of device driver software, BSP, BIT and associated libraries. Vendor shall supply the same for application software development.

/i Application(OFP) software of the SMFD will be developed by ARDC, HAL.

3.6.2. SMFD Platform software (board support packages, drivers, associated libraries including graphics libraries, BIT) shall be as per RTCADO178B or DDPMAS guidelines/recommendations. The qualification standard shall conform to the mission critical standard.

3.6.3. Certification of platform software from RCMA/CEMILAC shall be responsibility of the vendor.

3.6.4. The Vendor shall supply the Program flashing and boot loader software for loading application software and Boot loader from host computer to SMFD.

3.6.5. Device drivers, Board Support Package, and libraries supplied by vendor shall be compatible with airborne certifiable RTOS such as Windriver VxWorks /Greenhill's Integrity/DDC Deos.

3.6.6. RTOS and its version of SMFD shall be finalised in agreement with HAL during design phase.

3.6.7. Software tools required for the development of Test software, BSPs, device drivers etc. shall be Vendor's responsibility and shall be maintained by Vendor till Type approval certification. Vendor shall provide the details of the software tools to support application software development by HAL.

3.6.8. Graphics generation module shall support OpenGL ES 2.0 graphics library & drivers for Windriver VxWorks/Integrity/DDC Deos RTOS. Vendor shall supply all the graphics libraries and device drivers for the specified OpenGL version and RTOS.

3.6.9. The vendor shall supply Application Program Interfaces and associated libraries for accessing/ interfacing various hardware – ARINC818, RGB STANAG3350B, MIL-STD-1553B, Ethernet, RS422, Discrete, flash, mass

memory etc. and display features such as brightness, contrast and gain control.

3.6.10. Vendor shall perform necessary optimisation of the API execution timing if required to meet the application software execution cycle.

/i Execution cycle of the Data Processing and Graphics Processing Application software will be defined during design stage.

3.6.11. The vendor shall provide the required on-site support to HAL for carrying out the design, development, hardware–software integration, testing and certification of the application software of SMFD.

3.6.12. The vendor shall perform the necessary modifications to the platform software if required during integration and shall support till Type approval certification free of cost.

3.6.13. The vendor shall supply required debugging software for diagnostic and troubleshooting of SMFD.

3.6.14. Vendor shall supply sample applications for following display functionalities along with their source code for the specified RTOS and OpenGL libraries.

a. Generation of sample 2D & 3D-display page using MIL-STD-1553B and Ethernet data

b. Generation of sample display page using RS422 data

c. Display of sample external video received through ARINC818 and RGB STANAG3350B

d. Overlay of display symbology over external video received through ARINC818 and RGB STANAG3350B

e. Picture In Picture capability

f. Send display page as output on RGB STANAG3350B

g. Receiving and Sending of data through all interfaces

h. Transmit and Receive of snapshots through Ethernet interface

3.7. Software Loading Tool Requirements

3.7.1. A Rugged laptop based system for loading the SMFD application software and platform software in-situ on the aircraft shall be supplied along with the required accessories.

3.7.2. Rugged laptop shall be in compliance with MIL-STD-810 for environmental, MIL-STD-461 for EMC and IP-65 for ingress protection.

3.7.3. Laptop shall consist of Intel core i7 processor or better with following configuration:

a. Minimum 4 GB RAM

b. Minimum 256GB SSD

c. Windows 7/8/10 Operating System and Antivirus (minimum 1 year license).

3.7.4. Laptop shall consist of necessary add-on data cards required for loading the application and platform software to the SMFD.

3.7.5. Laptop shall operate on standard 230V 50Hz single-phase supply and also shall have provision to operate on 28VDC.

3.7.6. Laptop shall be supplied with following

a. Adaptor for operating laptop on 230 V AC

b. Adaptor for operating laptop on 28 V DC

c. Necessary cable/loom along with MIL standard mating connectors for interfacing with the aircraft.

d. Suitable Carry Case for laptop and accessories

e. CD/DVD containing software for application/platform software loading to SMFD, user manual, add-on cards device drivers and other required software.

3.8. Built In Test Requirements

3.8.1. SMFD shall perform following types of Built in test for health monitoring and reporting

a. Power On Built In Test (PBIT)
b. Continuous Built In Test (CBIT)
c. Initiated Built in Test (IBIT)

3.8.2. The scope and coverage of the above mentioned Built In Test shall be decided during the design phase and shall be finalized in consultation with HAL.

3.8.3. The result of each BIT shall be logged in the NVRAM.

3.8.4. PBIT shall be performed by the platform software.

3.8.5. All libraries shall be supplied to initiate CBIT & IBIT operation from the application software.

3.9. SMFD operational modes

SMFD shall have following Operational modes

3.9.1. Initialization mode

3.9.1.1. On power on, SMFD shall enter Initialization mode and perform Power On Built In test (PBIT).

3.9.1.2. After successful completion of tests, hardware and software versions along with checksums shall be displayed on SMFD (duration of which will be finalised during design stage) and SMFD shall subsequently enter into normal operation mode.

3.9.2. Normal operation mode

3.9.2.1. This mode shall be activated automatically after successful completion of initialization mode and when maintenance mode is not active.

3.9.2.2. In this mode SMFD shall generate the graphics and display external video with overlays based on received data.

3.9.2.3. It shall detect and process the Bezel key press as per the MMI requirements. The key press shall be processed within one software cycle.

3.9.2.4. It shall perform Continuous BIT (CBIT) periodically and send its health status to the MC over MIL-STD-1553B interface.

3.9.2.5. CBIT shall not interfere with the normal operation and shall not degrade the performance of the SMFD.

3.9.2.6. Initiated BIT

a. IBIT shall be initiated through a combination of SMFD keys which shall be finalized during design and development phase.

b. After successful completion of tests, SMFD shall enter into normal operation mode.

3.9.3. **Maintenance Mode**

3.9.3.1 SMFD shall enter to this mode through a deliberate action by enabling the mode selection discrete through debug connector when aircraft is on ground or when unit is kept in test rig.

3.9.3.2 In this mode operator shall be able to load application software including BSP & device drivers, download logged information from NVRAM, verify check sum of software and perform debugging.

3.9.3.3 All the relevant signals required for debugging shall be brought to the debug connector.

3.9.3.4 It shall be possible to calibrate brightness of LCD over complete range in DAY or NIGHT mode and fine tuning of the Automatic Brightness Control law through the Debug connector.

3.9.3.5 SMFD shall record Total number of hours operated in NVRAM and same shall be displayed on the maintenance page of the SMFD.

4. SMFD SYSTEM POWER UP TIME

4.1. The SMFD shall not require any pre-heating for functionality of its Electronics under normal operating condition. Under extreme low temperature, the Display Optics shall be automatically pre-heated and full display performance shall be attained.

4.2. SMFD shall be readable / useable (except for viewing angle, contrast ratio and response time which could be marginally lower) within 30 seconds of power on under normal operating conditions and within 2 minutes at Cold start (-40 degC).

4.3. SMFD shall achieve full performance (including full viewing angle, contrast ratio and response time) within 60 seconds under normal operating conditions and within 10 minutes at Cold start.

4.4. Vendor shall provide the temperature range for the normal operating conditions and operation with heater.

5. ELECTRICAL REQUIREMENTS

5.1. Power Supply

5.1.1. The SMFD shall function satisfactorily with nominal 28V DC aircraft power supply and shall be compliant to MIL-STD-704D.

5.1.2. SMFD shall be functional from 16V to 29V during aircraft emergency operation.

5.1.3. During engine start-up, the SMFD shall be functional at 12V for 15 minimum seconds.

5.1.4. No fuses or fusible links shall be used in the design.

5.1.5. SMFD shall have the reverse polarity protection against inadvertent reversal of power input.

5.1.6. The unit shall continue to perform normal operation for a power interruption of up to 50ms.

5.1.7. On restoration of power after power interruption of duration above 50ms, the SMFD shall resume its full functions without operator intervention within power up time duration.

5.2. Keypanel Integral Supply

5.2.1. The Keypanel brightness on the SMFD shall be controlled by 0 to +5V variable DC voltage from the aircraft.

5.3. Power Consumption

5.3.1. Power consumption of SMFD shall be less than 80W in normal operating condition.

5.3.2. Power consumption of SMFD shall be less than 110W in extremely low temperature condition (including heater).

5.3.3. Key Panel power consumption shall be less than 5 W.

5.4. Bonding

5.4.1. Chassis bonding shall be provided through mounting

5.4.2. Bonding resistance value (between any points on the body of the unit excluding connector points) shall be within 2.5mΩ as per MIL-STD-464C. Vendor shall specify a point on the unit where bonding value shall be measured.

5.5. Grounding Scheme

5.5.1. The internal grounds shall not be connected to the chassis of the equipment and shall be brought to a pin in the connector.

5.5.2. The internal supply returns shall be terminated to equipment sub star to which all ground lines (analog ground, digital ground) are terminated.

5.5.3. The sub star shall be brought to a pin on connector called SGRP (Single Ground Reference Point).

5.5.4. Primary power return shall not be connected to chassis of the equipment.

5.6. Electrical Insulation

5.6.1. The SMFD PCBs shall be electrically isolated with respect to chassis.

5.6.2. Insulation resistance shall be greater than 50Mega Ohms at 500V DC.

5.7. Circuit Isolation

5.7.1. The SMFD inputs & outputs shall be isolated and protected so that a fault in the components or interconnecting wires of one of the input or output interfaces does not affect the performance of the rest of the acquisition circuit.

5.7.2. Optical isolation shall be provided for all the Discrete Input and Output interfaces.

6. CONNECTORS

6.1. SMFD shall have circular connectors as per MIL-DTL-38999 connector series III for power & signals.

6.2. SMFD shall have Tri-axial MIL standard connectors for MIL-STD-1553B data bus interface.

6.3. A separate debug connector shall be provided for debugging, software loading, and other maintenance operations.

6.4. Debug connector shall be provided with a metal connector cap connected with a chain to the unit to close debug connector during normal operations.

6.5. There shall be unique identification for all connectors.

6.6. The distance between connectors shall be adequate for easy connection and removal.

6.7. All connectors shall be in the rear side of SMFD.

6.8. All connectors of the SMFD shall be of different part number to avoid any incorrect mating.

6.9. The electrical connectors shall have 20% spare pin contacts to meet the additional signal inputs/outputs to support future requirements. The spare pins shall be provided with dummy pins.

7. INTERCHANGEABILITY REQUIREMENT

7.1. SMFD shall be completely interchangeable with any other SMFD of the same part number.

8. PHYSICAL CHARACTERISTICS

8.1. Dimension

8.1.1. Overall dimensions of the SMFD shall be within 160(W) x 190(H) x 283(D) mm including mounting flanges, keypanel (rotary knobs, rocker keys and push buttons) and connectors as specified in Figure 4.

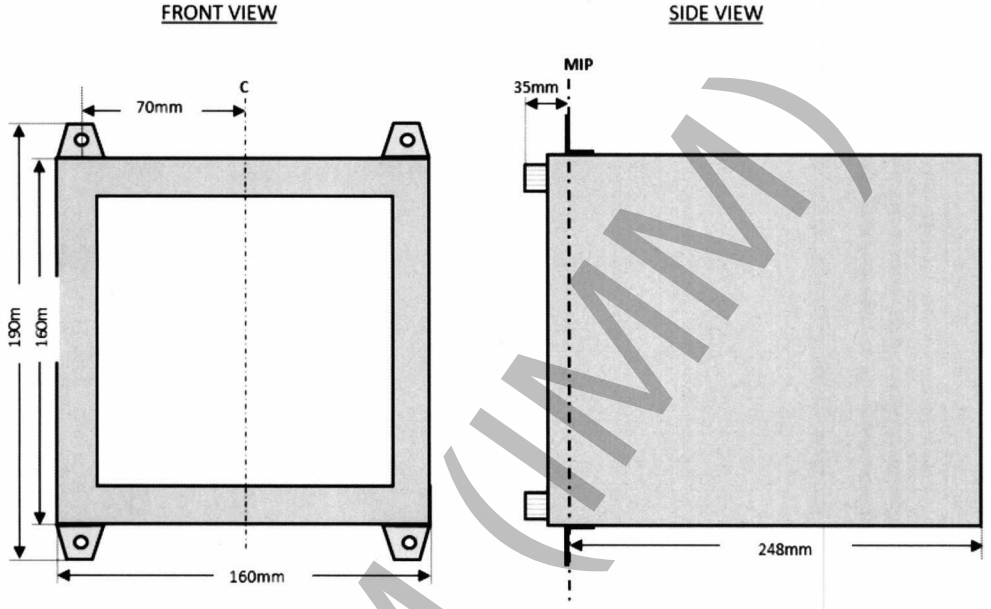

Figure 4: SMFD Dimension details

8.1.2. Based on the aircraft installation studies, if rocker switches are selected in place of rotary knobs on bottom corners (Refer information para on Page 17), then the Keypanel envelope including switches on bottom side shall not exceed 20.5 mm from the MIP.

8.1.3. The detail dimension and 3D model (Catia/step files or iges format file) shall be supplied by vendor for installation study.

8.2. Installation

8.2.1. SMFD shall be Panel mounted using mounting flanges on the aircraft MIP structure without any mounting trays or shock mounts.

8.3. Weight

8.3.1. The maximum allowable weight for SMFD shall be 5 Kg.

8.4. Materials, Process & Parts

8.4.1. **For Mechanical Parts:**

The following materials shall not be used in the design and construction of the unit:

a. Magnesium alloys
b. Beryllium and Beryllium based alloys.

Use of dissimilar metals (as defined by MIL-STD-889) in contact shall be limited to applications where similar metals cannot be used due to specific design requirements. When it is unavoidable to use dissimilar metals in contact, the metals shall be adequately protected against galvanic corrosion as per MIL-STD-889. Metals such as aluminium alloys that are prone to galvanic attack in contact with graphite composites shall also be protected as per MIL-STD-889.

8.4.2. **For Integrated Circuits / Electronics Components:** Electronics components with high reliability shall be chosen for the design of SMFD. For choosing the parts, given order of priority shall be followed:

a. Military Temperature with MIL-STD-883 screening
b. Military Temperature / Avionics Grade
c. Automotive Grade
d. Industrial Grade

8.4.3. If Automotive or Industrial Grade components are used, then the screening of the cards/ PCBs shall be in accordance with CEMILAC directive No.81/2003, Screening Procedure for COTS components and PCBs dated 10th Jan 2004."

8.5. Marking

8.5.1. SMFD shall have the label plate fastened to the chassis firmly.

8.5.2. The marking on label plate for SMFD may include the following details:

a. Unit Part Number
b. Serial Number
c. Hardware Mod
d. Software Version

e. Weight

f. Year of manufacture

g. Name of manufacturer

8.6. Surface Finish

8.6.1. SMFD shall be with mat black finish on all external surfaces and conductive chromate conversion coating on all inside surfaces.

8.6.2. Non-conductive finishes shall be removed from the contact area of all the surfaces only where shielding and bonding are required.

8.6.3. The joints and seals of cases of enclosure shall be cleaned and fitted to minimize the radio frequency interference.

8.7. Cooling

8.7.1. SMFD shall be conduction cooled (without fan) for the entire range of operating temperature.

9. REQUIREMENTS FOR STORAGE AND PACKING

9.1. A robust, strong and water resistant carry case shall be supplied with good foam for storing and transit of the unit.

9.2. Carry case shall be tested (Transit drop) with unit as per QT requirements (Sl No 11 d of Table 5). Same standard of carry case shall be delivered.

9.3. The external marking on the packing shall be done clearly with indelible paint/ink.

10. QUALIFICATION REQUIREMENTS

10.1. Vendor shall be responsible for SMFD hardware Qualification and obtaining Type Approval certification from RCMA/CEMILAC.

10.2. SOF and Qualification Test Procedure documents shall be discussed and agreed with RCMA/CEMILAC prior to commencement of testing. The testing will be witnessed by representatives of RCMA/CEMILAC, DGAQA and HAL.

10.3. The SMFD shall operate satisfactorily under all the limits specified in MIL-STD-704D for distortion, voltage transients, emergency and abnormal operating conditions. Test shall be performed as per MIL-HDBK-704/8.

10.4. Environmental requirements

10.4.1. SMFD shall meet the qualification requirements of MIL-STD-810F for environmental conditions and test procedures as specified in Annexure I.

10.5. EMI/EMC requirements

10.5.1. The SMFD shall operate satisfactorily in an Electromagnetic Environment to the extent specified in MIL-STD-461E for method and figures specified in Annexure II.

11. LIFE REQUIREMENTS

11.1. The SMFD shall be "on condition" maintenance type and no periodic servicing shall be required.

11.2. Vendor shall specify the total storage life (in calendar years) of the SMFD.

11.3. Mean Time Between Failure (MTBF) of SMFD shall be more than 5000hrs. Vendor shall provide MTBF evaluation parameters/procedure as per MIL-HDBK-217F Notice 2.

11.4. There shall not be any Time between overhaul (TBO) for SMFD.

12. DOCUMENTATION REQUIREMENTS

12.1. Vendor shall finalize technical specifications and qualification test procedures with RCMA/CEMILAC in coordination with HAL.

12.2. All ICDs shall be finalized in consultation with HAL.

12.3. Following documents in English (one soft copy and two hard copies) shall be delivered during the design and development phase of the SMFD:

a. Technical specifications of SMFD approved by RCMA/CEMILAC
b. LRU Design document covering both hardware and platform software features including Technical Description, design parameters and operational details.
c. Master Drawing index and Design drawings including Schematic diagrams with Mechanical and Electrical interface details.
d. Electrical ICD, Mechanical ICD and Software ICDs
e. Technical Description of the Software/ Firmware Loader, Debugging Tool, any other tool specific to the System proposed with details
f. Qualification test procedure (SOFT and Full QT) covering Environmental Tests and EMI/EMC Tests clearly bringing out test methods and other details and means of demonstration of the compliance to the specified requirements.
g. Qualification test reports including similarity/ analysis reports as applicable (SOFT and Full QT).
h. Software Requirements document and Design document for platform software.
i. Hardware - Software Interface documents for all the modules
j. Requirements and Design document for Built-in firmware
    i. Application Software Loader
    ii. Diagnostics Software
k. Software Compilation & Build Procedure (compilation, linking and generating the executable) using vendor's platform software for all the modules
l. Platform software related documents which are required for design and certification of the application software
m. Declaration of Design and Performance (DDP)
n. Power budget analysis document
o. Signal integrity analysis document
p. Thermal analysis document
q. Component derating analysis document as per MIL-STD-975.

r. Configuration Control document for hardware and software
s. Acceptance test procedure for the SMFD
t. Release notes/ Certificate of Conformance and serviceable tag and Acceptance Test Report with each unit
u. User's manual providing detailed operating procedures
v. Component Maintenance Manual (ATA 100 format)
w. Bill of Materials of the components used
x. Spare parts listing
y. Troubleshooting manual including details of test equipment or tools required for this purpose
z. Storage and preservation details
aa. FMECA, Fault Tree Analysis and Safety analysis report
bb. Reliability estimation and Maintainability aspects
cc. Vendors Quality Assurance Plan and documents
dd. Complete set of drawings and documents required for operation, maintenance, and calibration of Debugging tool, Software/firmware loading facility and ATE.
ee. Applicable Hardware documents as per RTCA-DO-254 or RCMA/CEMILAC Guidelines
ff. Applicable Software documents as per RTCA-DO-178B or DDPMAS guidelines
gg. Screening test Procedure at component /card/module level, if applicable (for electronic units)
hh. Environmental Stress Screening Procedure
ii. Type Approval Certificate from RCMA/CEMILAC and associated documents (after the flight trials).
jj. Any other required documents as per Certification agency requirements.

13. AUTOMATED TEST EQUIPMENT (TEST RIG) REQUIREMENT

13.1. Vendor shall supply Automated Test Equipment for performing the acceptance testing and standalone testing of SMFD along with the required hardware, software, necessary accessories, cables, mating connectors etc.

13.2. The ATE shall have the provision to load the platform software and application software in the SMFD and download fault log from the SMFD.

13.3. ATE shall have capability to generate all required signals and data for SMFD as per defined ICD.

13.4. ATE shall simulate Ethernet, RS422, Discrete I/Os signals and shall act as Bus controller (BC) for MIL-STD-1553B interface. ATE MIL-STD-1553B interface shall have capability to simulate multiple Remote Terminals (RT).

13.5. ATE shall generate video in Arinc818 & STANAG-3350B format for testing SMFD video i/p interface.

13.6. ATE shall have a video monitor to verify the SMFD o/p STANAG-3350B interface.

13.7. ATE shall consist of GUI based interactive software for setting the inputs of SMFD over entire range, testing and displaying the data received from SMFD.

13.8. A separate mechanical/ potentiometric controls may be provided to set those parameters which cannot be set through Rig software.

13.9. The ATE shall generate the Test report in printable form.

13.10. ATE shall consist of control rack with following requirements:

13.10.1. 19" standard width rack with casters with brakes and front & rear doors.

13.10.2. Industrial Computer with Intel core i7 processor (latest generation or better), minimum 4 GB RAM, 500GB or better Hard Disk, Windows 7/8/10 Operating System and Antivirus (minimum 1 year license).

13.10.3. Add on data cards for generating, acquiring and conditioning the required signals & data for SMFD

13.10.4. 19" rack mountable LED display.

13.10.5. Cut-outs/Installation space with screw arrangement on front face for installation of SMFD

13.10.6. Regulated 28V and 5V DC power supply for powering SMFD along with voltage and current indications on the power supply. It is preferred to have a combined 28V and 5V power supply.

13.10.7. Control and indicators to switch ON/OFF ATE, SMFD, Computer and other devices independently.

13.11. The electronic components, switches, indicators and other sub-assemblies used for the ATE shall be of Industrial grade quality.

13.12. Wiring/looming shall consists of MIL standard mating connectors for SMFD and aircraft standard wires with proper wire gauges.

13.13. ATE shall have automated Self-Test capability to monitor its health.

13.14. ATE shall operate on standard 230V 50Hz single-phase supply only.

13.15. Vendor shall carryout the upgrade / modification required for the Test rig during design and development phase and till Type Approval certification of SMFD.

13.16. Any standard lab equipment or other tools required for ATE operation shall be supplied by vendor. Necessary training for operation and maintenance of the ATE shall be provided.

13.17. ATE shall have necessary industry standard electrical/safety protections to protect its own electronic devices, SMFD and human operators using the ATE.

13.18. The ATE shall be operational at 0°C to +50°C and Relative Humidity (RH) up to 95%.

13.19. Vendor shall be responsible for Installation and commissioning of ATE at HAL.

13.20. Vendor shall be responsible for certification of ATE from Indian certification agency in accordance with relevant AQA guidelines.

13.21. All the necessary documents and drawings for operating and maintaining the ATE (including calibration) shall be supplied by vendor. The source for the modules/electronics used in the ATE shall be provided to HAL to aid in maintenance of ATE.

13.22. Vendor shall finalize technical specifications of ATE with RCMA/CEMILAC in coordination with HAL.

13.23. The following documents 2 sets (English) each in Hard copy and Soft copy (CD/DVD) shall be delivered along with the ATE:

a) Technical Specifications of the ATE
b) System Quality Assurance Plan of the ATE
c) Architecture Design Document of the ATE
d) Detailed Hardware & Software Design Document of the ATE
e) Software Requirement Specification of the ATE
f) Complete Source code of the ATE software in CD/DVD
g) Certified copy of the ATE software in CD/DVD
h) Software Test Plan of the ATE
i) Software Quality Assurance Plan
j) Version Description Document of ATE
k) User's Manual and Maintenance manual for the ATE
l) Acceptance Test Procedure for the ATE
m) Continuity and Megger test Schedule for the ATE
n) Qualification test reports of in-house developed boards
o) Software Test Report cleared by DGAQA rep
p) Acceptance Test Report cleared by DGAQA rep
q) ATE calibration procedure document
r) Electrical Grounding and earthing scheme
s) ATE bill of materials, applicable data sheets of hardware modules and COCs
t) ATE electrical and Mechanical drawings, circuits schematics, layout drawing and internal wiring diagram
u) Pre-dispatch inspection document of ATE
v) Other required documents as per Certification agency requirements.
w) ATE Clearance Certificate from DGAQA

14. 'I' LEVEL TESTER REQUIREMENTS

14.1. Vendor shall develop an 'I' level tester of SMFD for setting up support facility at HAL's customer bases.

14.2. Vendor shall finalize 'I' level tester technical specifications with RCMA/CEMILAC in coordination with HAL.

14.3. 'I' level tester shall be supplied along with the required hardware, software, necessary accessories, cables, mating connectors etc.

14.4. 'I' level tester shall consist of a GUI based interactive software for testing the SMFD.

14.5. 'I' level tester shall have short circuit and over load protection.

14.6. Vendor shall be responsible for qualification of 'I' level tester and certification from DGAQA as per the AQA directives. Exact testing requirements shall be finalized with DGAQA. The indicative test requirements for certification as per JSS 55555 are given below with procedure reference number:

- **i.** Vibration (28)
- **ii.** High Temperature (17)
- **iii.** Damp Heat (10)
- **iv.** Low Temperature (20)
- **v.** Tropical Exposure (27)
- **vi.** Toppling (26)
- **vii.** Bump (5)

14.7. Vendor shall be responsible for Installation, commissioning and training of 'I' level tester at HAL's customer bases.

14.8. Vendor shall supply the following documents (2 sets in English each in Hard copy and Soft copy):

a) Technical Specifications
b) Facility Requirement Document for the Tester
c) Electrical wiring and mechanical drawings
d) Bill of materials, applicable data sheets of hardware modules and COCs.
e) Acceptance Test Procedure

f) Acceptance Test Report

g) Calibration Procedure Document

h) Calibration Certificates for the applicable components, boards, standard test equipment etc.

i) Certified copy of Software (with Manuals) in CD

j) User Manual

k) Maintenance Manual

l) Any other relevant documents required by DGAQA to provide Rig Clearance Certificate

m) Rig Clearance Certificate from DGAQA

15. TECHNICAL SUPPORT

15.1. Vendor shall provide technical support during the Application Software development activity of HAL.

15.2. Vendor shall perform required modifications/changes in the SMFD units (including vendor supplied software) and ATE till Type Approval certification/warranty period whichever is later without any additional cost based on the feedback from HAL for problem rectifications/change requirements/product improvements during various stages like qualification / hardware-software integration / software testing/ verification & validation/ system integration / flight trials / certification.

15.3. Vendor shall provide special test equipment if any required during prototype testing.

Annexure I

1. Environmental Qualification Tests

1.1 SMFD shall meet the environmental tests as specified in Table 4 as part of Qualification requirements.

1.2 In case if the qualification tests are still under progress and the program needs to gather flight test performance of the units/system, the LRUs shall be subjected to Safety of Flight (SOF) Tests as specified in Table 7 of Annexure III. The full qualification tests shall be continued and any design related changes necessitated is to be addressed in the SOF Tested units.

Table 4: Environnemental Qualification tests

Sl. No.	Type of Tests	Severity	Duration	Remarks
1.	Altitude(Low Pressure) as per MIL–STD-810F, Method: 500.4, Procedure – II	Pressure corresponding to 60,000 ft (18 km) altitude (i.e. 7.172kPa). (Rate of change of altitude =150m/sec (or 12.5mm of Hg/s))	One hour soak (Non-Operating) followed by a single operational check.	**This test is not mandatory if CATH carried out**

Sl. No.	Type of Tests	Severity	Duration	Remarks
2.	Rapid Decompression test as per MIL–STD-810F, Method: 500.4, Procedure – III	From 23000ft (7 Km) to 60000ft (18 Km) within 15 seconds	Hold for 10 minutes at 60000ft.	NIL
3.	High Temperature–Storage cum operating	From 35 °C to 85 °C diurnal cycles (24 Hrs/cycle) as per *Figure* 5	7 Cycles	Carryout one operational check at the maximum temperature of 65 °C of the test item after allowing stabilization during 1st, 4th & 7th cycle.
4.	Low Temperature - Storage as per MIL–STD-810F, Method: 502.4, Procedure – I	Soak at -55°C	4 Hours	NIL

Sl. No.	Type of Tests	Severity	Duration	Remarks
5.	Low Temperature - Operating as per MIL–STD-810F, Method: 502.4, Procedure – II	Stabilize at -40°C	1 hour soak (Non-operating) followed by a single performance check at -40 deg C	SMFD should be capable of cold start at -40°C within warm up time of 2 minutes. **This test is not mandatory if CATH carried out**
6.	Random Vibration – Flight envelope as per MIL–STD-810F, Method: 514.5, Procedure – I	Random Vibration spectrum as per Figure 6	1 hour/axis in all three axes	The equipment shall be energized and operational during the test.
7.	Sinusoidal Vibration – Flight envelope as per MIL–STD-810F, Method: 514.5, Procedure – I	Displacement vs Frequency as per curve 3a of Figure 7 (Limited to 5g between 5-104Hz)	1½ Hr/axis (including resonance dwell and cycling)	Though the displacement Vs Frequency spectrum is given upto 2000Hz, it is adequate to subject the equipment upto 104Hz.

Sl. No.	Type of Tests	Severity	Duration	Remarks
8.	Acceleration – Functional as per MIL–STD-810F, Method: 513.5, Procedure – II	Fore : -4.0 'g' Aft : +8.71 'g' Left Lateral : -4.28 'g' Right Lateral : +4.28 'g' Down : -8.53 'g' Up : +11.41 'g' Directions is with respect to Aircraft Axis	1 min along each direction	The equipment shall be operational during this test.
9.	Acceleration – Structural as per MIL–STD-810F, Method: 513.5, Procedure – I	1.5 Times given in Sl No 8 above.	1 min along each direction	NIL
10.	Thermal Shock as per MIL–STD-810F, Method: 503.4 Procedure – II	Stabilize at -40°C soak for 1 hour. Transfer and stabilize at +65°C and soak it for 1 Hour. Transfer it to -40°C and soak for 1 hour. This constitutes 1 cycle.	3 cycles	Transfer from low to high temperature chamber and vice versa is to be effected within 5 min.

Sl. No.	Type of Tests	Severity	Duration	Remarks
11.	Shock as per MIL–STD-810F, Method: 516.5			
	a. Functional	20 g Saw Tooth (or 15 g Half sine) 11 ms	3 shocks in each of six directions	The equipment shall be operational during the test.
	b. Crash Hazard	40g sawtooth (or 30g half sine wave), 11 msec pulse	2 shocks in each of 6 directions	Mechanical equivalent mock up unit can be used.
	c. Bench Handling test	Edge rise by 10cm or 45° whichever is less	4 Drops in each face	Drop on the table with antistatic material
	d. Transit Drop test	Height of Drop 122cm	a) 26 Drops (1 Drop / each face, corner, edge) for equipment lighter than 45.4 kg b) 8 Drops (for equipment equal to or Heavier than 45.4 kg)	The equipment shall be in packed case during the test.

Sl. No.	Type of Tests	Severity	Duration	Remarks
12.	Salt fog as per MIL–STD-810F, Method: 509.4	Salt solution of 5±1% concentration 24 hrs exposure & 24 hrs drying constitutes one cycle.	Total 2 cycles	a.) Composition of salt for preparation of solution shall be with sodium chloride containing not >0.1% sodium iodide and not >0.5% impurities. b.) Drying shall be at prevailing ambient conditions.
13.	Fungus (Mould growth) Direct effect as per MIL–STD-810F, Method: 508.5	The spore suspension will be prepared using fungi specified in Table 5 or Alternatively fungi as per JSS55555 can be used.	Wet the entire surface of test item with spore suspension in 10 min. Incubation period 28 days at 30°C & 95% RH.	This test can be carried out on representative samples of parts used in the equipment. Alternatively, if material analysis reveals that none of the fungus nutrient material listed at Table 5 is used, then this test can be dispensed with.
14.	Humidity as per MIL–STD-810F, Method: 507.4	Temp 30 °C to 60 °C, RH 85 to 95% Temp. Humidity diurnal cycle as per *Figure 8*	10 Cycle	Conduct the operational check within 15 min after recovery to the ambient condition. Carryout operational check after 1st, 2nd & 10th cycle
15.	Rain-drip test as per MIL–STD-810F, Method: 506.4, Procedure – III	Volume flow rate of 250 to 280 lit / m² / hr. Dispenser should be approximately at 1 m above the test item.	15 min (configuration as installed on the aircraft)	NIL

Sl. No.	Type of Tests	Severity	Duration	Remarks
16.	Blowing Dust as per MIL–STD-810F, Method: 510.4, Procedure – I	Blowing Dust Air velocity 1.5 m/s to 8.9 m/s RH= 30%.	6 hrs at 23°C	Dust concentration: 10 ± 7 gm/m³ Material for dust : Silicon Dioxide or China Clay **Alternatively this test can be carried out as per JSS55555.**
17.	Fluid contamination (occasional contamination) as per MIL–STD-810F, Method: 504.1	Test temp: 65°C ± 3° C Test fluids: a. Fuel DERD 2494 b. Hydraulic fluid MIL-H-5606 E c. Lub oil mixtures to DERD 2497/MIL-L-7808 d. Soap water	7 days / test fluid	The test shall be conducted on all representative samples.

Sl. No.	Type of Tests	Severity	Duration	Remarks
18.	Combined Altitude Temperature and Humidity Test(CATH) as per MIL–STD-810F, Method: 520.2, Procedure – III	Refer *Figure 9*	10 cycles (electrical severity of 110%,100% & 90% have to be imposed for every 3 cycles)	If CATH carried out then Altitude & Low temperature test need not be carried out.
19.	Solar radiation (Actinic effect) as per MIL–STD-810F, Method: 505.4, Procedure – II	Accelerated intensity of heat flux @ 1120W/m2 ON time- 20 Hrs OFF time – 4 Hrs Constituting one cycle Occasional exposure – Continuous exposure-	 10 cycle 50 cycle	NIL
20.	Lightning Induced Transient Susceptibility As per Section 22.0 of RTCA/DO-160E	Indirect effects of lightning as per Waveform set B3K33	-	This test shall be carried out preferably

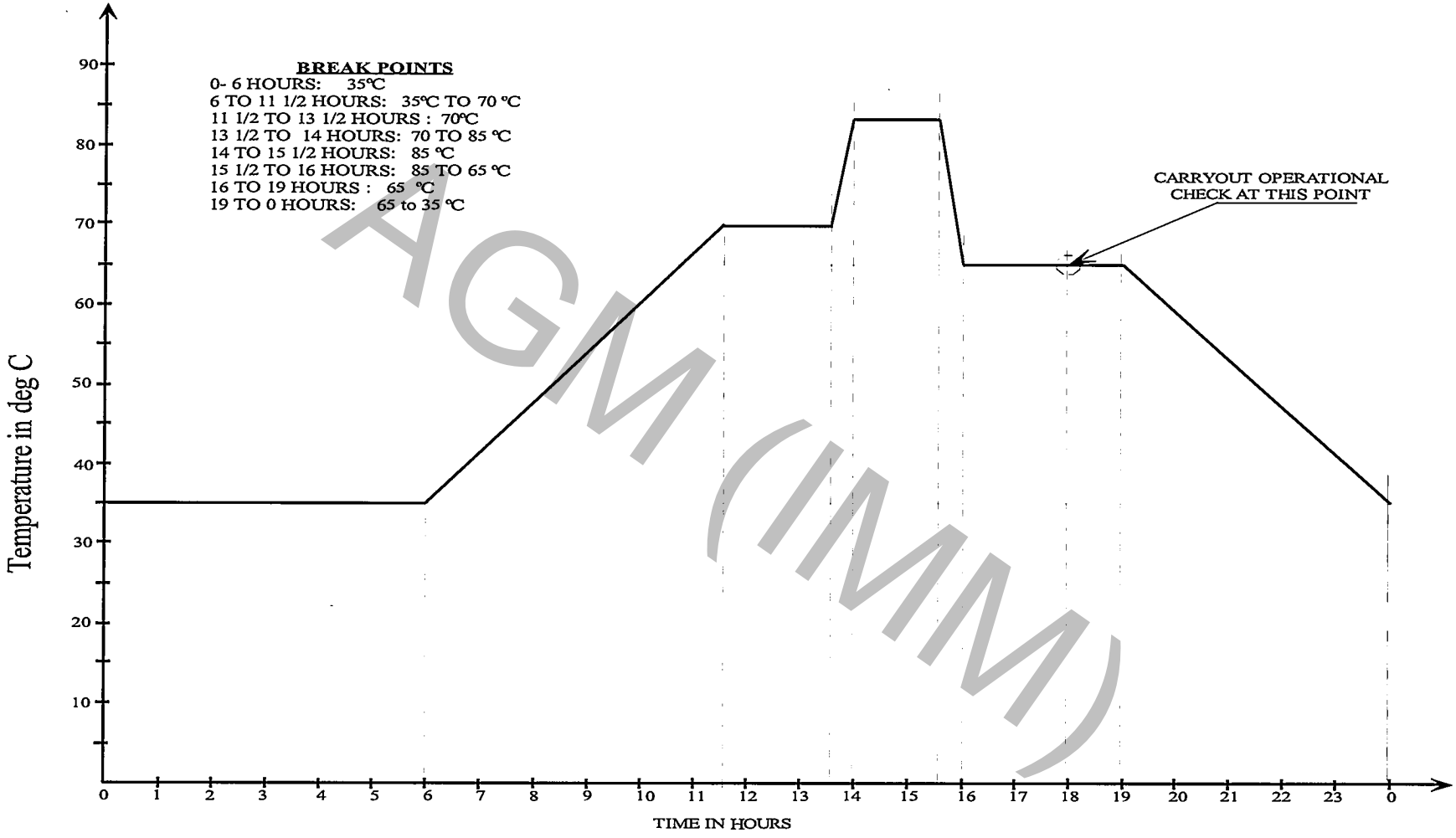

Figure 5: High Temperature – Storage cum Operating (Diurnal Cycle)

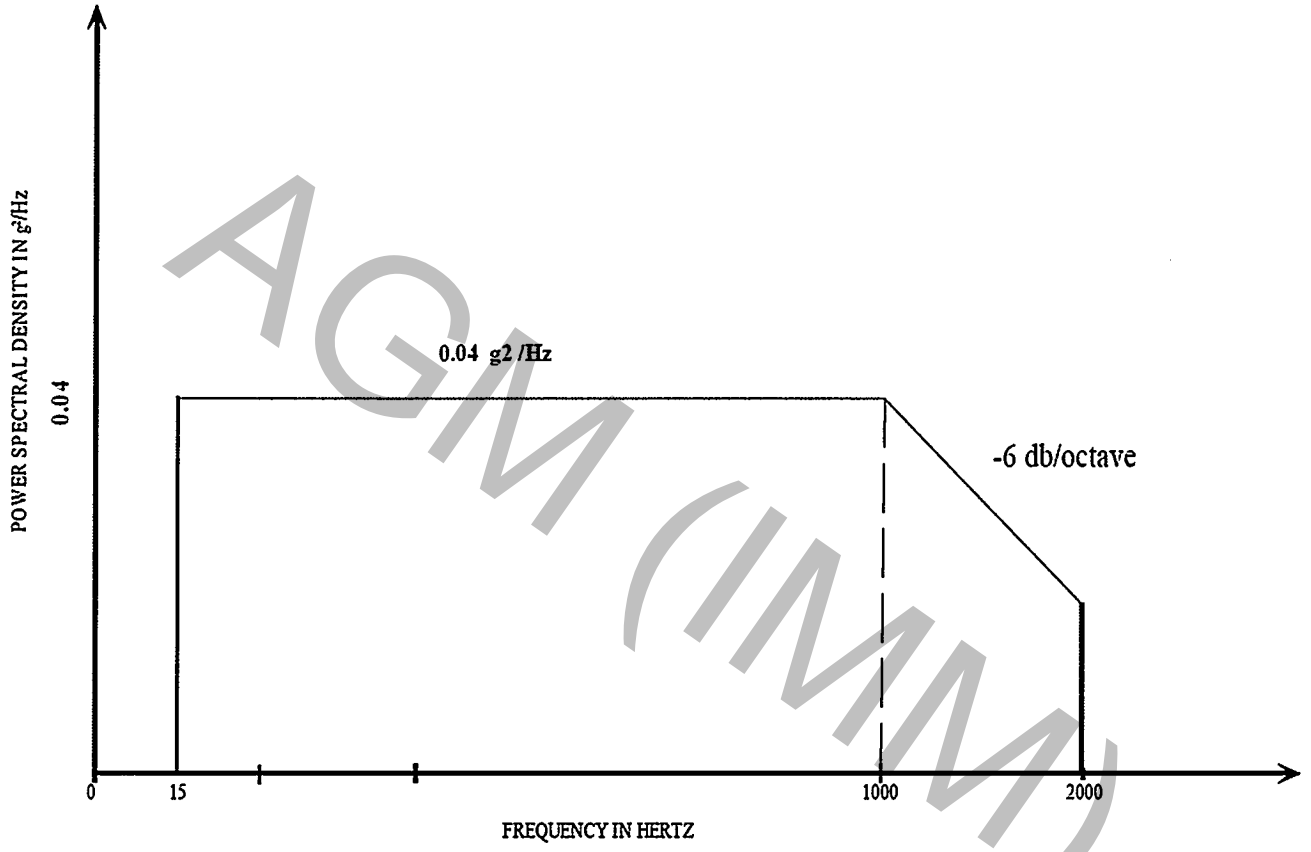

Figure 6: Random Vibration Spectrum Profile

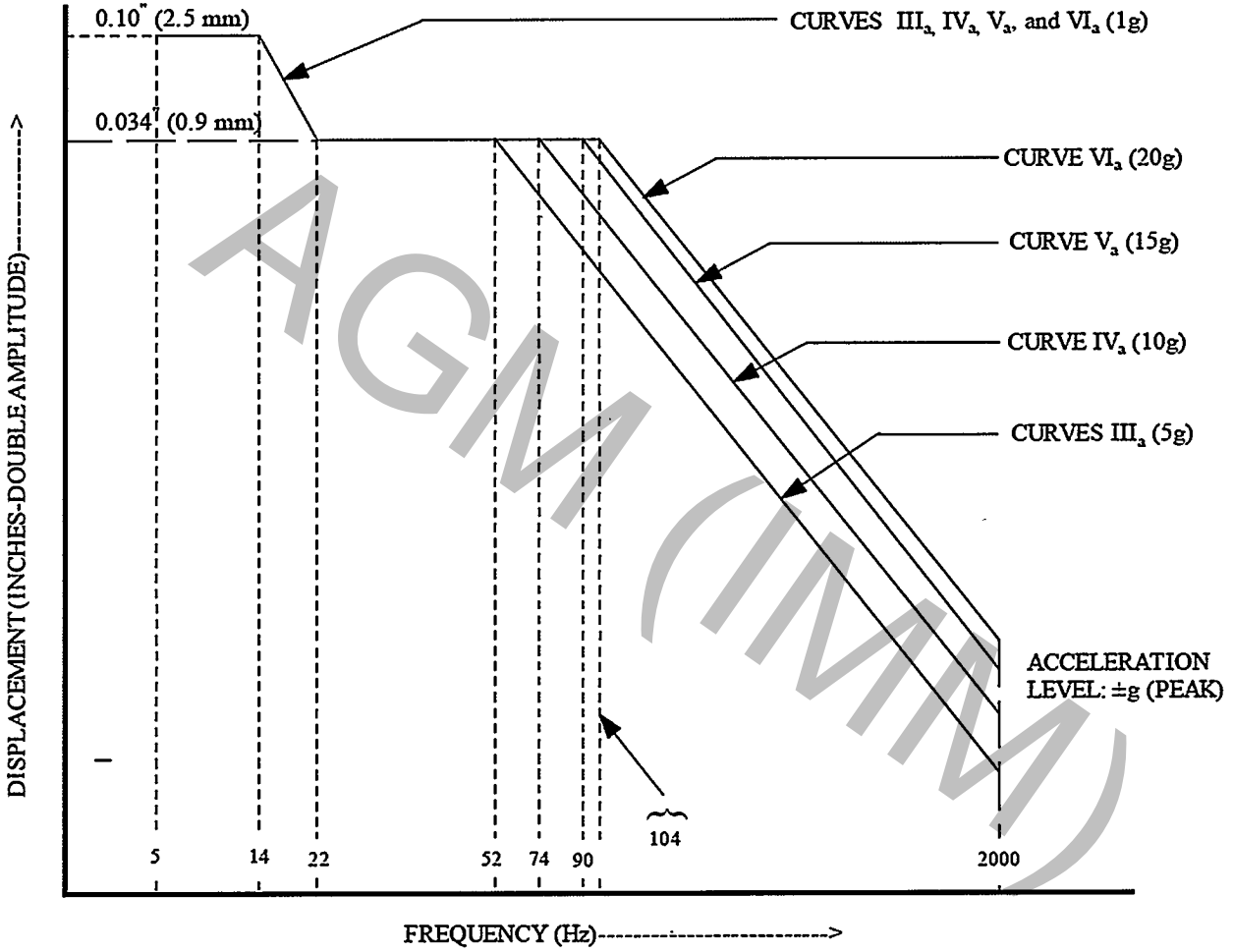

Figure 7: Sinusoidal Vibration Spectrum Severity level

Table 5: List of Fungi for Culture Preparation

SL.NO.	NAME OF CULTURE	STRAIN
1	Aspergillus Niger	V.Tieghem
2	Aspergillus terrens	Thom
3	Aureobasidium pullulans	(De Barry)Arnaud
4	Paecilomyces Varietal	Bainer
5	Pencillium Funiculosum	Thom
6	Pencillium Ochro-Chloran	Biourge
7	Scopulario psis Brevicaulis	Bain VarGlabra
8	Trichoderma Viride	Pers-ex Fr.

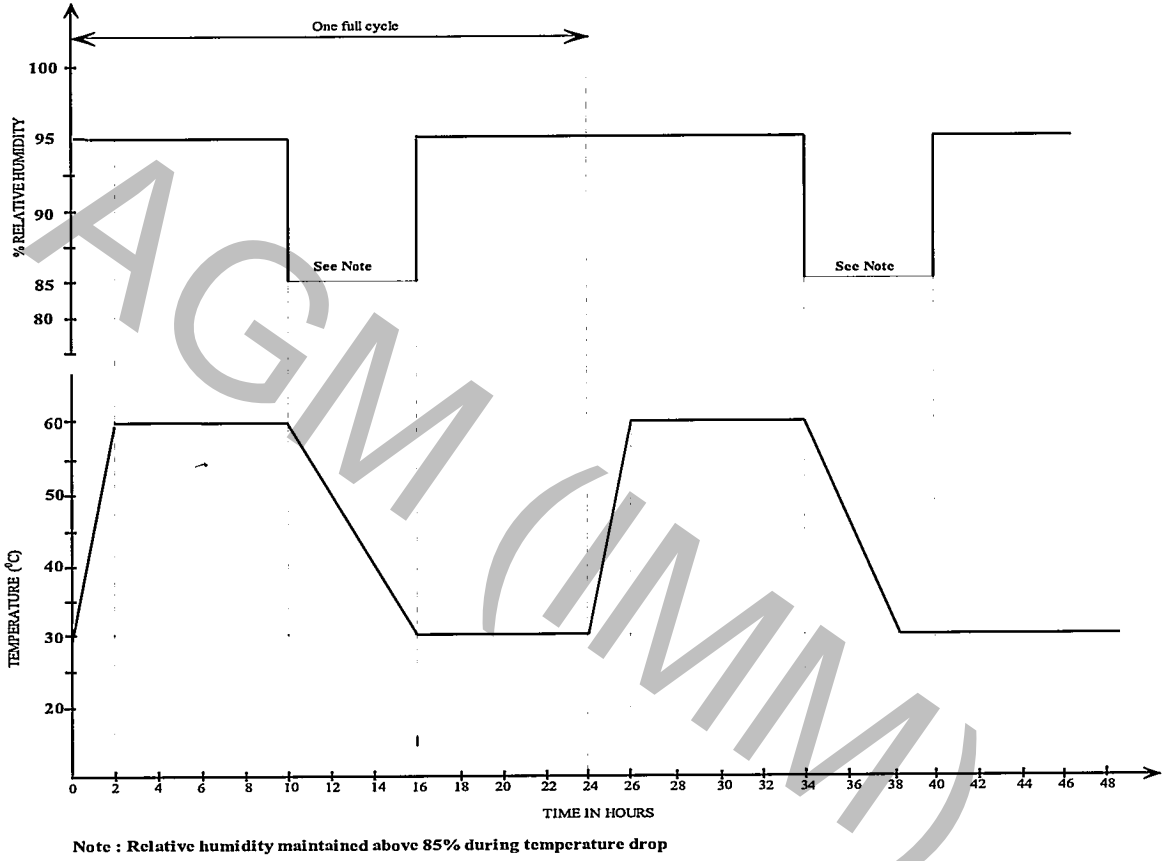

Figure 8: Diurnal Cycle for Temperature – Humidity

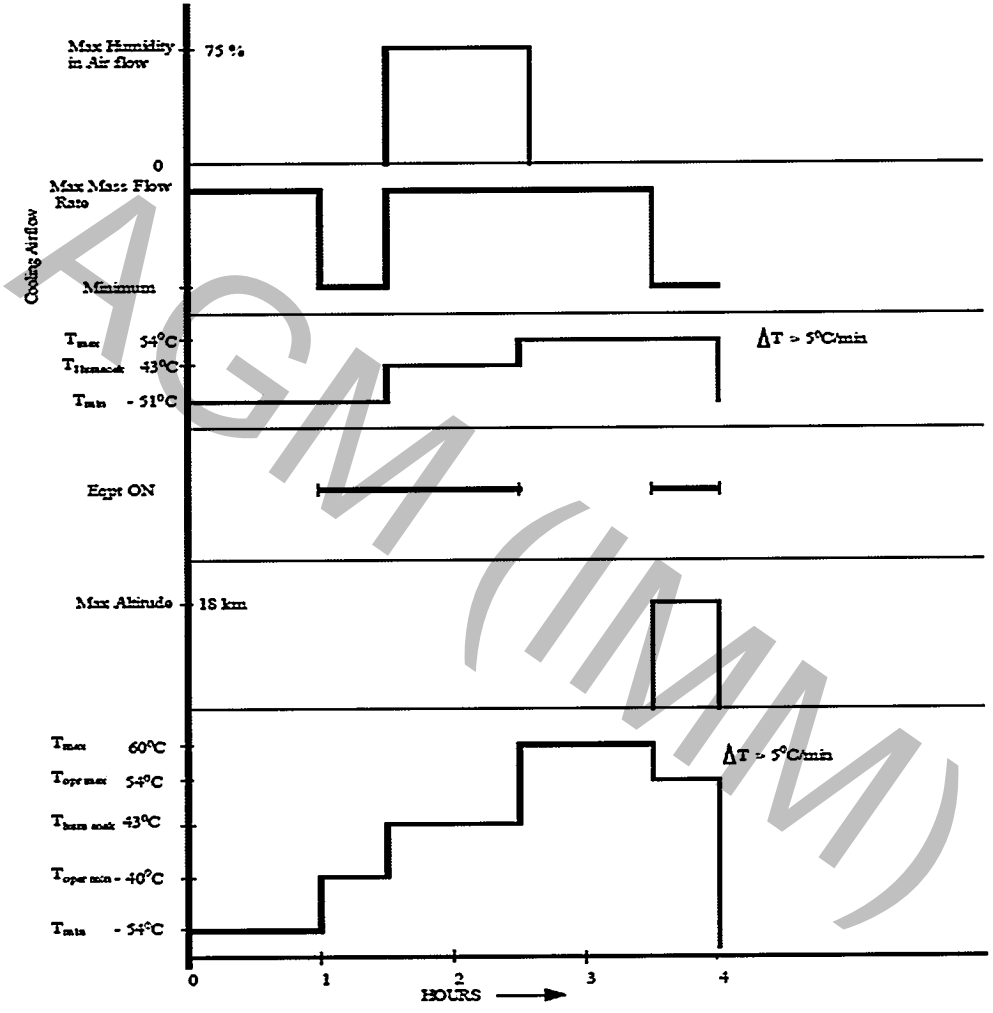

Figure 9: Combined Humidity, Temperature & Altitude test severity levels

Annexure II

1. EMI/EMC Tests

Table 6: EMI/EMC applicable tests for SMFD

Sl. No	Method of testing	Tests	Frequency / Range	Remarks
1.	CE-102	Conducted emission, power and interconnecting leads as per MIL–STD–461E	10K-10MHz	NIL
2.	CE-07	Conducted emission, transients, spikes, time domain Conducted switching spikes of less than 50 µsec in duration shall not exceed a. ±50 % of nominal RMS voltage in case of AC leads b. +50 %, -150 % of nominal line voltage in case of DC leads as applicable as per MIL–STD–461C	----	Spike limits to comply with MIL-STD-461C
3.	CS-101	Conducted Susceptibility, power leads as per MIL–STD–461E	30Hz-150kHz	NIL
4.	CS-114	Conducted Susceptibility, Bulk Cable Injection as per MIL–STD–461E	10kHz-200MHz	NIL
5.	CS-06	Conducted Susceptibility, spikes, power leads as per MIL–STD–461C	200V in magnitude with duration 0.15µs and 10µs	NIL
6.	RE-102	Radiated Emission, Electric Field@ 1 meter as per MIL–STD–461E	2MHz-18GHz	NIL
7.	RS-103	Radiated Susceptibility, Electric field as per MIL–STD–461E	2MHz-18GHz at 100V/m	NIL

Annexure III

1. Safety Of Flight (SOF) Test

1.1 SOF tests shall be carried out as mentioned in Table 7. These tests shall be applicable only for evaluation of SMFD in case full qualification tests are not completed.

1.2 Vendor shall submit all the SOF test reports.

Table 7: SOF Tests Description

Sl. No.	Test	Description
1.	Initial Visual Examination and measurement of weight and physical parameters	The equipment shall be inspected for type / part number, serial number etc. and to visually verify compliance to standard workmanship/ assembly practices and conformance to drawings. Also weight and physical dimensions shall be measured and recorded.
2.	Performance/ Functional Checks	The equipment shall be tested for complete performance / functional checks exercising the software residing in the equipment at nominal power supply voltages at ambient temperature.
3.	Burn-in	The equipment shall be kept powered 'ON' continuously for 4 hours at ambient temperature with nominal power supply voltage.
4.	Environmental Stress Screening (ESS)	ESS shall be carried out as per Table 8.
5.	Power Supply Tests	All the applicable tests under MIL-STD-704D shall be carried out.
6.	EMI/ EMC Tests	Compliance to all the applicable Conducted and Radiated Emission tests shall be carried out as per *Table 6.*

Sl. No.	Test	Description
7.	**Environmental tests:**	
7.1	Vibration	
	a. Initial Resonance Test	Resonance search at 0.5g from 5Hz to 2000Hz with equipment in OFF condition shall be carried out.
	b. Endurance Vibration Test	It shall be carried out as per Sl No 6 of Table 4 for 15 minutes per axis in all three axes.
	c. Final Resonance Test	Final resonance search (similar to the initial resonance search) shall be carried out after the endurance test, even if there was no resonance found during initial resonance search. If any resonance is found below 104Hz, dwell the unit for 15 minutes.
7.2	Combined Altitude Temperature and Humidity (CATH) test	CATH test shall be carried out as per Sl No.18 of Table 4. The equipment shall be subjected to this combined environment for 1 cycle. In case of non-availability of CATH facility, the temperature, altitude and humidity tests shall be carried out separately as following: a. High temperature test as per Sl no 3 of Table 4 for 3 cycles. b. Humidity test as per Sl no 14 of Table 4 for 3 cycles. c. Low temperature (Storage) test as per Sl no 4 of Table 4 for one cycle. d. Low temperature (Operating) test as per Sl no 5 of Table 4 for one cycle. e. Altitude test as per Sl no 1 of Table 4 for one cycle.

<table>
<tr><th>Sl. No.</th><th>Test</th><th>Description</th></tr>
<tr><td>8.</td><td>Shock Test (Functional)</td><td>This test shall be carried out as per Sl No 11.a of Table 4.</td></tr>
<tr><td>9.</td><td>Shock Test (Crash Safety)</td><td>The equipment shall be subjected to one shock each of 40g saw tooth I 30g half sine pulse of 11 milliseconds duration in all six directions in OFF condition.

A mock-up of the equipment may be used for this test.</td></tr>
<tr><td>10.</td><td>Rapid Decompression Test</td><td>As per SL No 2 of Table 4.

The equipment may be kept 'OFF' during the test.</td></tr>
<tr><td>11.</td><td>Acceleration Test (Structural)</td><td>
<table>
<tr><th>Direction</th><td>Fore</td><td>Aft</td><td>Up</td><td>Down</td><td>Lateral Left</td><td>Lateral Right</td></tr>
<tr><th>'g' levels</th><td>3.0</td><td>9.0</td><td>13.5</td><td>4.5</td><td>6.0</td><td>6.0</td></tr>
<tr><td colspan="7">Directions with respect to Aircraft Axis</td></tr>
</table>
</td></tr>
<tr><td>12.</td><td>Final Visual Examination and Performance/ Functional Checks.</td><td>At the end of all the Environmental Tests, final visual examination and performance checks shall be carried out.</td></tr>
</table>

1.3 ESS tests shall be carried out as per Table 8 for SMFD.

Table 8: Environmental Stress Screening (ESS) tests for all deliverables

Sl. No.	Test	Description
1.	Pre Thermal Vibration	This test shall be carried out as per Figure 10. The test shall be carried out in 'Power ON' condition for five minutes (5min) in all three perpendicular axes.
2.	Thermal cycling	The unit shall be subjected to 10 thermal cycles. The last three cycles shall be defect free. The temperature cycling profile shall be carried out as shown in Figure 11.
3.	Post Thermal Vibration	This test shall be carried out as per Figure 10. The test shall be carried out in 'Power ON' condition for five minutes (5min) in all three perpendicular axes.

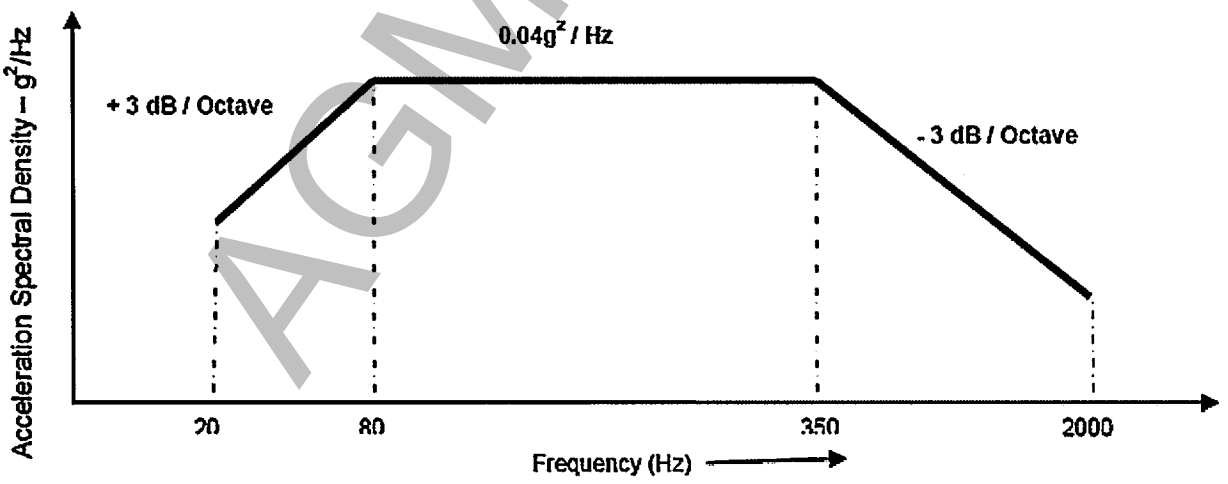

Figure 10: Vibration Test Profile for ESS

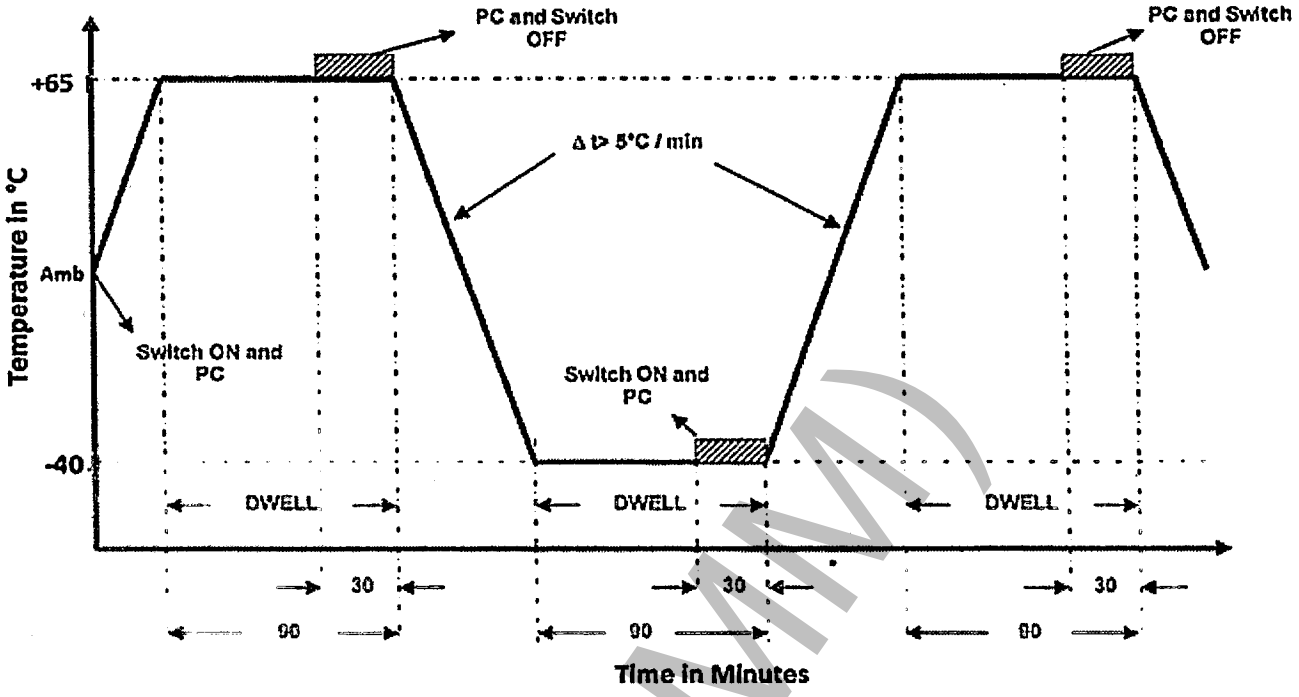

Figure 11: Thermal Cycling Profile