Brief Technical Specification

Development of Ultra low pitch, High format Detector Based Technologies (UHDT)

INSTRUMENTS RESEARCH AND DEVELOPMENT ESTABLISHMENT
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Document Control and Data Sheet

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5.	**Sponsoring Agency and Address**	DRDO
6.	**Abstract**	This document contains the broad technical specifications, acceptance criterion and scope of work for theUltra low pitch, High Format Detector Based Technologies (UHDT)
7.	**Key words**	HOT MWIR detector, VGA,HD Detector, Surveillance, FOV, Infra-Red, Focal Plane Array, Low SWaP,

CONTENTS

1. INTRODUCTION:

Ultra low pitch, High Format Detector Based Technologies (UHDT) is centered around a HOT MWIR detector (CRANE) with 2560×2048 format and 5µm pitch. An Electro optical system based on this detector will have very wide FOV, compact and low weight configuration which will open the way for new applications such as persistent surveillance. To provide situational awareness, a MWIR zoom camera along with a zoom CCD camera is integrated in the system. In addition to these imaging sensor the configuration will also have eye safe Laser Range Finder (LRF), Global Positioning System (GPS) and Digital Magnetic Compass (DMC) which will enable the technology not only for target ranging but also provide target geo-location capabilities.

2. SYSTEM SPECIFICATIONS:

The UHDT system assembly comprise of the different sub modules. It consists of Optics module, 5MPixel IR Detector and the Video processing electronics. Following are the Specification along with its Range requirements:

Parameters	**Value**
Detector type and format	2560 X 2048pixels, XBn Hot detector
Pixelpitch	5 µm
Wavelength Band	3.6-4.2µm
F#	1.6
FOV	2.3^{o} x 1.8^{o} (Version 1); 4.6^{o} x 3.7^{o}(Version 2)
Video format	Digital (HDMI)
Power	24 VDC (18-36V), ≤ 120 W
Weight	≤ 5.0 kg
Communication	RS 422 (Communication)
Video format	HDMI

HD Color CCD Day camera Specification (COTS)	
Wavelength Band	0.4-0.7µm
Format	2560 X 1440
FOV	2.3º (H) x 1.3º (V)
Zoom	30X
Video format	Digital (HDMI)
Power	7V to 12 VDC
Operating Temperature	-5 º C to +60 º C
Laser Range Finder specifications (COTS)	
Type	Laser Diode (Eye safe)
Laser safety class	1/1M
Range	32 Km
Wavelength	1.54um
Precision	0.01m to 0.5m
Operating Temperature	-32 º C to +60 º C
OTHER SENSORS	
GPS (COTS)	GNSS: NavIC/IRNSS,GPS,GLONASS,GAGAN Position Accuracy: ≤ 3 m
DMC (COTS)	Accuracy: 0.25º Elevation: -45 º to 45 º

3. SYSTEM ELECTRONICS CONFIGURATION:

Block diagram representation of electrical interface of various modules of Thermal imager is shown in the Figure 1.

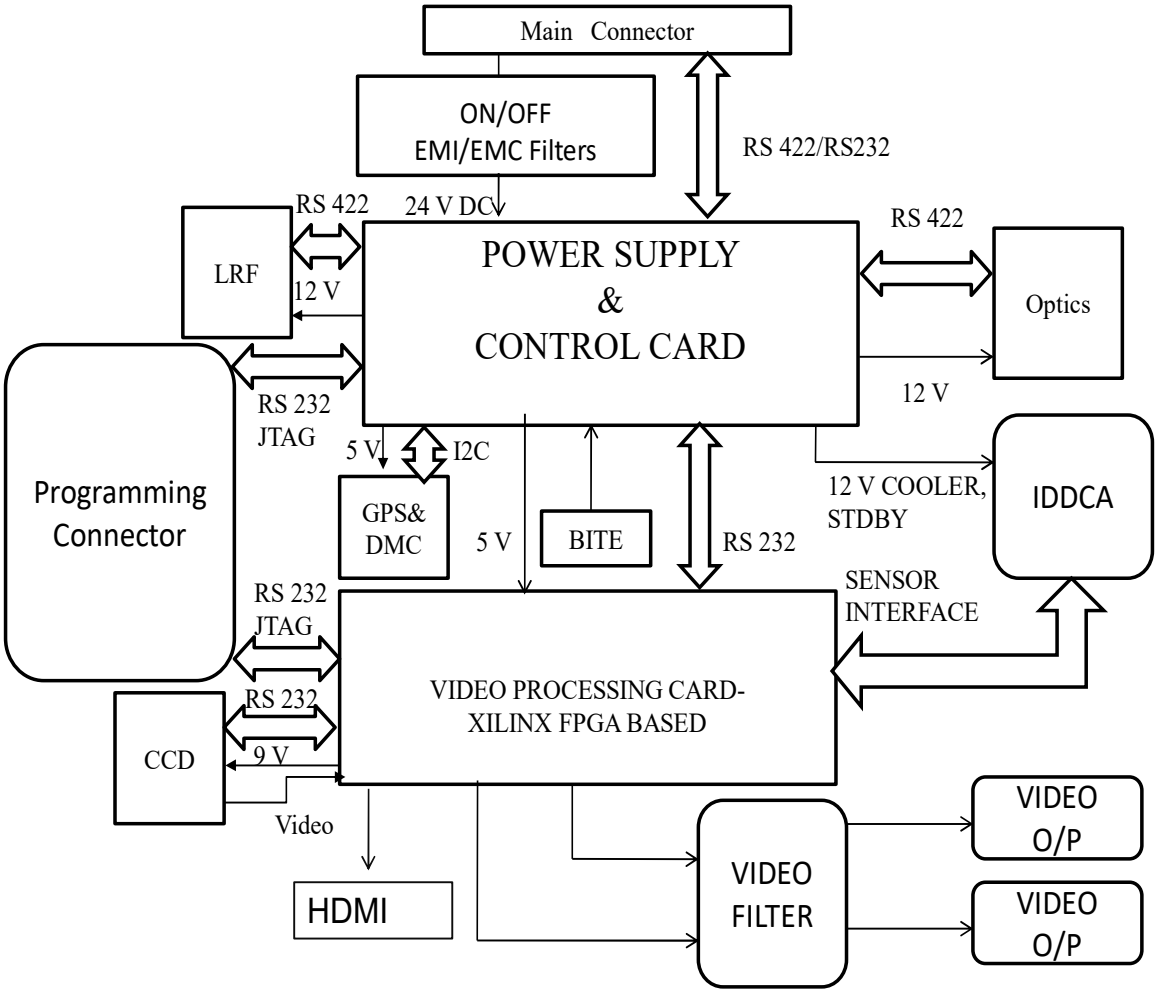

***Figure 1**: Block diagram of Sighting Unit for UHDT*

UHDT will consist of 2560X2048 , 5 µm pitch FPA based MWIR (3.6 -4.2 µm) sighting system to make surveillance during night as well as in day, a Day camera to enhance surveillance capability during day, an eye-safe Laser Range Finder to find range of the target, a GPS module to get GPS co-ordinate of the system and a DMC which helps in finding a GPS coordinate of the target. Block diagram shows the various electrical interface requirements of UHDT. The

electrical interface is consist of interfaces of communication signals between power supply and control card, Video Processing Electronics (VPE) and other sub-systems.

3.1 Video Processing Electronics (VPE)

VPE will be centred around Xilinx FPGA.The power supply and the synchronization signals are delivered to the Proximity Electronics through the same interface (power over CoaXPress). The system controls the detector through standard protocols on CoaXPress. A hardware and software will be developed around FPGA to form image from Crane detector for various applications. The same will be fine-tuned for the application. The indicative Video Processing Architecture is shown in Fig. 2.

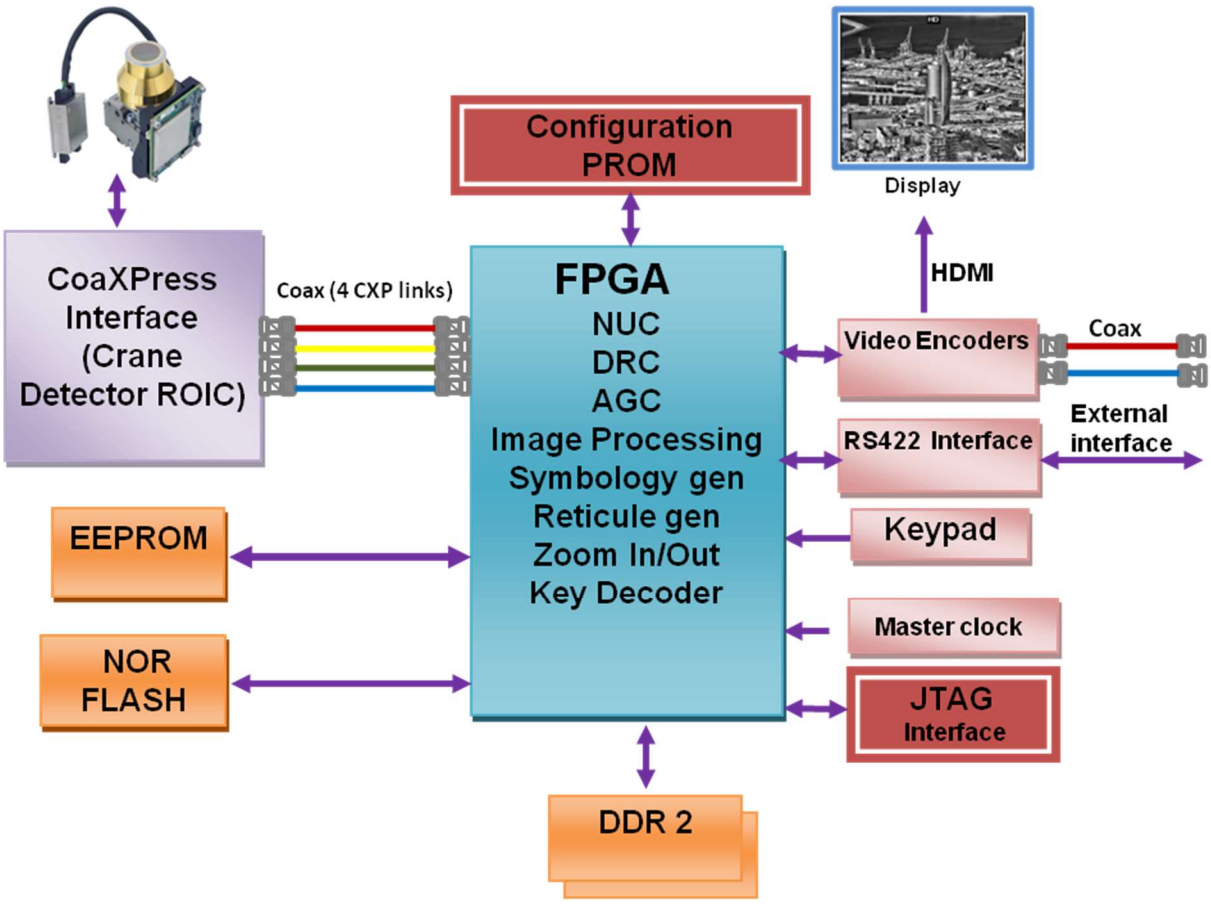

Figure 2: *Video Processing Architecture*

Video processing electronics cater for following functions:

- Detector Interface
- Non-Uniformity Correction (NUC) & calibration
- Bad Pixel Replacement
- Automatic Gain Control (AGC)
- Image Processing: Dynamic Range Compression (DRC) with plateau control
- E-Zoom with user selectable magnification(2X, 4X, 8x)
- Built In Test
- Video Control Generation
- Image manipulation
- Symbology Generation
- Video Mixing
- HMI (Human Machine Interface) Controller

3.2 Power Supply & Control Card (PSCC)

PSCC will be catered around a microcontroller. Main function of PSCC is to provide power to various modules and function as an interface between various modules like optics module, Day camera, LRF module, GPS, DMC and IDDCA. It will also generate serial communication commands using RS 232 link to Video Processing card of Thermal Imager for appropriate action. It also interface with Main computer of Electro-optical payload through RS 422 serial link and control various operations of the Thermal Imager.

3.3 Optical System:

Property	**Value** (version 1)	Value (version 2)
F/#	1.6	1.6
Spectral Range	3.6 - 4.2 μm	3.6 - 4.2 μm
Aperture	200mm	100mm
EFL	320mm	160mm

FOV (Single FOV)	(2.3° X 1.83°) ±5%	(4.6° X 3.7°) ±5%
Electrical		
Lens Control	Designated lens controller	
Drive Voltage	12VDC	
Communication Interface	RS422	

Table 1. Optics Specifications

3.4 Detector and Cryogenics:

It converts infrared radiation collected by IR optical module into electrical signal. The 5Mega-pixel (2560×2048format) "Crane" detector which combines a 5µm pixel array based on the mature High Operating Temperature (HOT) MWIR XBn-InAsSb technology with a new ROIC design utilizing advanced CMOS technology. This allows for dense layout of devices to maintain high level of functionality. These technologies enable outstanding FPA electro-optical performance at temperatures as high as 150K, and high readout speed of digital signal at reduced power consumption.

Figure 2.5M-pixel Crane Detector

ROIC supports several operation modes – Integrate While Read / Integrate Then Read (IWR / ITR), low gain with a capacitor of 0.6Me- and high gain with a capacitor of 0.25 Me-. The2×2-pixel Binning mode, enables SXGA (1280×1024) format which is useful when a higher signal-to-noise ratio and / or higher frame rate (increased by a factor of 4) are needed. The main features of the ROIC are:

- 5 M Pixel, 5 µm pitch
- Multiple operation modes – IWR, ITR, Binning
- Standard serial interface (E2PROM compatible)
- Above 140Hz maximum frame rate
- 11–13-bit resolution

Detector type	XBn-InAsSb barrier device arrays
Spectral Response	3.6 - 4.2 µm
Array format	2560 x 2048 elements (SXGA)
Pitch	5 µm x 5 µm
ROIC output	Digital
Integration mode	Integrate–while-Read, Integrate-then-read
Quantum Efficiency	≥ 70 %
Dark Current	200 fA at 150K
Data resolution	11,12,13 bit (Programmable)
NETD	47mK at 70% WF
Cooler Type	Sterling rotary cooler optimized to 150K
Cooler power consumption	4W at 23ºC
Modes of operation	Normal & 2X2 binning
Maximum Frame Rate	100 Hz (13 bit) 140 Hz (11, 12 bit)
Size	88mm X 71mm X 68mm
Weight	360 grams

Table 2 Detector *Specifications*

4. Software Features:

- Integrated video and control GUI
- Northing of the system using Astronomical North Finder / Known Target/ known anchor/ DMC.
- Control of Day Camera – Selection of CCD operations like Optical Zoom, Focus Adjustment, and other CCD functions.
- Control of Thermal Imager – Selection of TI operations like Optical Zoom, Focus Adjustment, and other TI functions.
- Eye safe LRF module Control
- Pan and Tilt Control
- Generation of Target Co-ordinates
- Image Enhancement

5. Scope of Work

The scope of the work includes the following:

5.1 System Design and Development:

Comprehensives development of the system includes:

i. Development of all the sub-module as per the IRDE specifications/drawings.
ii. Integration of the system in the IRDE premises under the supervision of IRDE team.
iii. Complete testing of the system as per the acceptance criterion.
iv. Milestone wise document and report generation.

5.2 Development of the sub-module as per the IRDE specifications/drawings.

I. Optical Module

i. Optical module of UHDT will be a single field of view (FOV) module and it will be designed by IRDE. There will be two versions of the optics module and the Vendor will develop these optical module as per the IRDE design.

ii. IRDE will provide all the opto-mechanical design to the vendor and accordingly vendor will realise the module.

iii. Vendor will develop a microntroller/DSP/FPGA based motor driver card to control dc motor with encoder as per the IRDE specification.

iv. Vendor will develop the software module for focus by implementing a PID controller.

v. Vendor will calibrate the system for focus retention and active athermalisation.

vi. Vendor can make the minor changes in the design in consultation with the IRDE team.

II. IR Detector Module

i. UHDT is centred around a 5MP, HOT IR detector, which is selected considering the system performance, weight & space constraints and low power consumption.

ii. Vendor will purchase the specified detectors from the targeted vendor.

III. Electronics Module

System, primarily will have two electronics card viz. Power Supply and Control card(PS&CC), FPGA Based Video processing Card.

A. Micro-controller based power supply and control card

i. Vendor will develop PS&CC, which will be centred around a Pic/Atmel microcontroller. Vendor will design & develop this card& associated software as per specifications provided by the IRDE.

ii. Card should be developed considering IRDE acceptance criterion.

B. FPGA based video Processing card

The work encompasses design and development of 03 Sets of Video Processing Electronics for interfacing and video signal processing of sensor data. The Video Processing Electronics will comprise of a Video Processing Card (VPC). The VPC will be interfaced with the sensor through a CoaXPress interface and will provide the necessary power, clocks and control signals for its operation. VPC will be designed around a Xilinx FPGA. Vendor will also develop detector interfacing module and basic image processing modules in VHDL. A PC based test software compatible with Windows 10 Pro Operating System incorporating a Graphical User Interface (GUI) for health check of the components of the VPC is to be developed.

IV. Mechanical Components/Housing

Vendor will develop the mechanical components/housing as per the vetted mechanical design from the IRDE.

V. LRF Module

Eye safe LRF will integrated as a COTS item from NOPTEL(LRX-42A)/BEL Pune/Vectronix or equivalent specifications.

VI. CCD Module

CCD will be integrated as a COTS item from SONY(FCB-EW9500H)/HikVision/Axis or equivalent.

VII. Integrated GPS and DMC Module

a. GPS will be integrated as a COTS item having compatibility with Indian regional Navigation Satellite System(IRNSS OR NavIC) from Elena(Part no: ELNNC4A)

b. DMC will be integrated as a COTS item from Safran Vectronics(DMC-pico)/Honeywell Digital Compass/KVH industries Digital Compass or equivalent .

VIII. Software Module

A. Vendor should develop hardware project in VHDL and PC based application. PC based graphical user interface should be developed for providing various commands to the system and also for controlling the sensor parameters. Vendor should develop hardware project in VHDL to interface CRANE MWIR detector and implement following image processing features/calibration:

i. Real time implementation using FPGA.

ii. IR Sensor control & interface.

iii. Digital scan conversion.

iv. Non-uniformity corrections and PC based calibration software.

v. One point NUC.

vi. Reticle/Symbology generation.

vii. Bad pixel replacement

viii. Polarity inversion

ix. Electronic Zoom

x. Dynamic range compression for automatics image adjustment.

xi. Manual brightness and contrast adjustment.

xii. Contrast improvement.

xiii. Edge enhancement and noise removal.

xiv. Image Enhancement Algorithm (Histogram Based).

xv. Real time Bad Pixels Identification and Replacement with moving cursor.

xix. PC based interface & control.

xx. ROIC

xxii. Gathering and display of data from LRF, GPS,DMC and target co-ordinate finding.

B. Vendor should develop HDL test codes and PC based software with Graphical User Interface (GUI) for testing of all the components/interfaces on board.

C. The testing software is to be developed for the PC based hardware platform compatible with Windows 10 Pro Operating System and to be supplied with the video processing electronics and rigi-flex cable on a memory stick.

D. The vendor should test the PCB for full functionality by integrating with the sensor system in presence of IRDE scientists at IRDE.

IX. Multifunction Display

It will display the video output from the system and at the same time it will send command to the system via a serial interface.

X. Platform for system mounting

A pan and tilt unit i.e. A High Accuracy 12' 2-Axes Gimbal Mount (Item No.GM-12E-090090) from Newmark Systems with controller or equivalent platform to be used for mounting of UHDT system

XI. Vendor will provide all the detail updated design, gerber data, technical documents, programming codes, GUI in a Toughbook Panasonic FZ-G2 (10810U) or better.

6. Inspection and Acceptance Tests

6.1 Environmental Stress Screening (ESS)

Limited ESS to be performed as per Appendix A

6.2 Integration of the system at IRDE

a) Vendor will carry out the final integration of the system at IRDE under the supervision of IRDE scientist

b) Vendor will depute 04 nos. of engineer at IRDE upto 6 months for integration of system during the complete cycle of the development.

6.3 Complete testing of the system

Vendor will carry out testing of the system as per the acceptance criterion laid down by IRDE and accordingly submit the test report to the IRDE.

6.4 Milestone wise document and report generation

Vendor should prepare following documents and submit a copy of the same in both softcopy and hardcopy to the IRDE. These document should be handover to IRDE in the phase wise manner during the development of the system.

Sr. No.	Document
1.	System Design documents
2.	User Manual
3.	Technical description manual
4.	System Acceptance Test Reportas per ATP
5.	Manufacturer's Recommended List of Spares (MRLS)
6.	Illustrated Spare Parts List (ISPL)
7.	ESS /QUALIFICATION Test Reports
8.	Sub modules Acceptance Test Results (ATR) as per ATP
9.	Complete Wiring layout
10.	Electrical and mechanical ICD
11.	Mechanical documents: 1. Assembly procedure document 2. Material inspection report, 3. Component & assembly level inspection report **4.** Mechanical drawings (Part Drawings, Sub-Assembly Drawings and Assembly Drawings in DWG format of Solid Works)
12.	Electronics Hardware documents: **1.** Design document with memory mapping details **2.** BOM **3.** Schematics, Circuit Diagrams, PCB layouts and connectors details

	4. Data sheets of all components **5.** Acceptance Test Report **6.** Signal Integrity & Thermal Analysis Report of Electronics Cards
13.	Software Documents **1.** Software Requirement Specifications (SRS) **2.** Interface Requirement Specifications (IRS) **3.** Software Design Documents (SDD) **4.** Device Driver Document **5.** Software Configuration Management (SCM) **6.** Software Version Description (SVD) **7.** Software Test Plan (STP) **8.** Software IV&VReport **9.** Acceptance Test Report (ATR)

The above list is indicative and any activity towards the Development and Delivery which is necessary but not part of the list above will be deemed to be in the scope of work.

7. Intellectual Property Rights

The rights of Intellectual Property, developed under the contract, will be property of IRDE (DRDO), Govt. of India. The development Partner will have to give complete technical know-how & design data to IRDE.Development partner is also required to sign a Non-disclosure Agreement with DRDO.Development partner is also required to sign a Non-disclosure Agreement with DRDO.

8. Realization Time

First unit to be realized in 18 months and 2nd unit to be delivered by 21 months after signing of contract

9. Deliverables

The work package envisages the following deliverables.

1. **UHDT** : **02set** (Details as per table 9.1)
2. **Spares** : **01set** (Details as per table 9.2)

9.1 List of deliverables items for 01 set of UHDT:

Deliverables	Quantity	Remarks
UHDT with Harness	01 No	-
Multifunction Display	01 No	
Rugged controller for VHDL . programming and upload	01 No	
Platform for system mounting	01 No	

9.2 List of deliverables items for 01 set of Spares:

Nomenclature of Item	Quantity
IR Detector	01 No
Single FOV Optics	01 No
HD CCD Block camera	01 No
Video Processing Electronics	01 No
Interface Electronics	01 No
Laser Range Finder	01 No
Multifunction Display	01 No
Light weight gimbal	01 No
DMC and GPS Module	01 No
Documentation	01 No

Along with above mentioned deliverables the following are also to be supplied:

1. *CAD model of complete systems and their subsystems*
2. *System Assembly Tools - 01 Sets for each system*
3. *Fasteners Used in System - 01 Sets for each system*
4. *Electronics Unit Assembly Tools - 01 Set for each system*
5. *Packing case for Transportation of system- 01 for each unit*
6. *Board Support Package for all electronics boards & Application Software*

Appendix A

Limited Environmental Test

1. VISUAL

All the developed units will undergo visual testing. The sight shall be checked visually and must be free from the following defects:

a. Missing, loose or damaged screws and other components.
b. Broken or chipped optical windows / lenses.
c. Dirt, dust, filming or fungus on optical surfaces.
d. Defective polishing and thin film coatings.
e. Faulty electrical connections/hardware.

2. Environmental Tests

2.1 Dry Heat(storage):

Place the prototype unit inside the temperature chamber in switch off condition. Raise the temperature of the chamber to +70°C ± 3oC and maintain for 8 hrs. Switch off the chamber and allow the temperature to come down to room temperature and open the heat chamber. Switch on the system and Check all the function and controls of system.

2.2 Dry Heat (Operation):

Connect the prototype unit to 24 Volts power supply and place it inside the temperature chamber. Raise the temperature of the chamber to +55°C ± 3°C and maintain for 8 hrs. Switch on the sight for last 1 Hrs. Switch off the chamber and allow the temperature to come down to room temperature and open the heat chamber. Check all the function and controls of system.

2.3 Low Temperature

Connect the prototype unit to 12 Volts power supply and place it inside the temperature chamber. Lower the temperature of chamber to -20°C ± 3°C and maintain for 8 hrs. Switch ON

the system for last half an hour and system should display normal image. Switch off the chamber and allow the temperature to come down to room temperature and open the heat chamber. Check all the function and controls of the system.

2.4 Vibration Test:

Mount the system using a suitable fixture on the vibration machine and subject to the vibration test in following sequence keeping switch off condition.

a. 20- 30 Hz at 2g for 30 min.
b. 10- 40 Hz with amplitude of vibration displacement of 0.16 mm.
c. 40 – 120 Hz with and vibration accuracy of 1g for 10 min.

Power on system and check the function and controls of system.