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ELECTROSTATIC DISCHARGE PROTECTION PROCEDURES

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1.0 PURPOSE

The purpose of ESD protection procedures is to protect the susceptible electrical and electronic items comprising the MIPS Ge:Ga focal plane arrays from damage or degradation due to electrostatic discharge.

2.0 SCOPE

This specification describes methods and procedures for the protection of sensitive electrical and electronic parts. In addition it establishes the requirements and procedures used for ESD protection during the development, manufacture and test of MIPS Ge:Ga focal plane arrays (FPAs). The methods, procedures and requirements contained herein support the requirements of MIL-STD-1686, Electrostatic Discharge Control Program for the Protection of Electric and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices) and provide for ESD protective area design, selection and use of protective materials and equipment, documentation and quality control.

3.0 APPLICABLE DOCUMENTS

The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the referenced documents shall be of the issue or revision in effect on the date of use of this specification.

3.1 Government Documents

Standards, Military

MIL-STD-129	Marking for Shipment and Storage
MIL-STD-1686A	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)

Handbook, Military

DOD-HDBK-263	Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)

3.2 Non-Government Documents

University of Arizona, Steward Observatory, IR Group

MIPS-0033	Ge:Ga Focal Plane Array Quality Assurance Plan

4.0 CLASSIFICATION OF ESDS PARTS, ASSEMBLIES, AND EQUIPMENT

The MIPS focal plane arrays are critical to the SIRTF mission and, as such, will be appropriately classified and handled with respect to ESD susceptibility. The classification of parts, assemblies and equipment will be in accordance the following classifications as defined in MIL-STD-1686.

> Class 1: Susceptible to damage from ESD voltages greater than 0 to 1,999 volts as determined in accordance with MIL-STD-1686 5.2.1.1.
>
> Class 2: Susceptible to damage from ESD voltages of 2,000 to 3,999 volts as determined in accordance with MIL-STD-1686 5.2.1.1.
>
> Class 3: Susceptible to damage from ESD voltages of 4,000 to 15,999 volts as determined in accordance with MIL-STD-1686 5.2.1.1.

For the purposes of this plan, parts, assemblies, and equipment susceptible to ESD voltages of 16,000 volts or higher will be considered non-ESD sensitive.

Assemblies and equipment will be designed to provide ESD protection for the most sensitive ESDS part of the focal plane array design, the electrical readouts, designated Class 1. As all other detail parts utilized in the FPAs are not susceptible to ESD damage, precautions shall only be required for the readouts and any assemblies containing the readouts. Although protective circuitry is an integral part of the design of the CMOS electrical readouts, due consideration and appropriate measures will be provided to protect against ESD caused by strong electrostatic fields or by contact of electrical connections or paths with a charged object. ESD classifications will be specified in the engineering drawings or on applicable process and procedural documentation and will serve to alert personnel to precautionary action to be taken.

4.1 Control Plan Responsibilities

Although ultimate responsibility for protection of the focal plane arrays from ESD damage resides with the Project Manager, it is the Deputy Principal Investigator who will determine the ESD classification of the focal plane arrays, subassemblies, parts, and equipment. The MIPS Development/Test Lead Engineer will be responsible for ensuring that the requirements of this control plan are implemented and sustained. A member of the MIPS team will be delegated by the Project Office the responsibility and authority to ensure quality control. To this end, monitoring of written records, conformance inspections and surveillance will be conducted to verify compliance with the requirements specified herein.

5.0 PROTECTED AREAS

ESD sensitive parts, assemblies and equipment shall be handled within protected areas and in accordance with detailed ESD protective handling procedures, unless the items are packaged and sealed in approved protective materials and containers. When outside of protective packaging, means will be provided to maintain electrostatic voltages below the lowest voltage sensitivity level of the ESDS items.

5.1 Design of Protected Areas

The design and construction of each ESD protected area shall ensure that all external parts, surfaces, and shields in electronic test equipment and power tools are at a common ground potential at all times during normal operation. The design of the ESD protected areas will take into consideration the type of work to be conducted and the physical limitations of the work area. For example, protected areas within which FPA assembly operations are conducted will include humidity monitoring, grounded work benches made of ESD protective material, conductive flooring, personnel wrist ground straps, and grounded tools and test equipment. The use of prime static electricity generators (varnished or painted work surfaces, common plastics, spray cleaners, etc.) will be prohibited from use in the construction of static protected areas.

Identifying signs will be posted at the entry to static protected areas and at static protected work benches. The signs will typically read: "ESD Protected Area: Use Precautions When Handling ESDS Items Outside of Their Protective Wrappings."

Access to protected area will be limited to people who are properly trained and equipped, or who are escorted, cautioned in protective procedures, and restricted from contacting ESDS items.

5.2 Handling Requirements

ESD protective handling procedures will protect the readout die in both wafer and discrete die form, and all assemblies containing it.

- Cleanroom procedures

  Fabrication of all assemblies, including wire-bonding operations, for the MIPS FPAs shall be conducted in the cleanroom (which has conductive flooring and humidity monitoring), using grounded work benches made of ESD protective material, personnel wrist ground straps, grounded foot protectors, and grounded tools and test equipment.

- Storage procedures

  Assemblies shall be stored in ESD-protective boxes with appropriate ESD caution stickers in the cleanroom desiccated storage cabinet. Assemblies shall not be handled without protective gloves and personnel grounding straps.

- Testing procedures

  Transport of the assemblies outside of the cleanroom shall be in ESD-protective storage boxes or ESD-protective bags, marked with the appropriate ESD caution sticker. Assemblies will not be handled or removed from storage containers without protective gloves and personnel grounding straps. Loading and unloading hardware into test fixtures shall be conducted only with grounding safeguards in place.

5.3 ESD Protective Materials

Primary protective properties of ESD protective materials include (1) protection from electrostatic fields and (2) protection against direct discharge from contact with charged people or a charged object. ESD protective materials to be used in accordance with this plan shall have a resistivity of not greater than 10^{14} ohms per square when measured at approximately 30% relative humidity. Appropriate selection of an ESD protective material for each specific

application will be based on the following classifications of ESD-protective materials and the ESD sensitivity level of the item(s) to be protected.

Type 1: Conductive - surface resistivity less than 10^5 ohms per square

Type 2: Static Dissipative - surface resistivity between 10^5 and 10^9 ohms per square

Type 3: Antistatic - surface resistivity greater than, or equal to 10^9 ohms per square, but less than, or equal to 10^{14} ohms per square

ESD-protective materials will be used in a variety of applications including work bench tops, floors, floor mats, formed parts trays, storage and transport containers, personnel apparel (smocks, shoes or shoe covers, finger cots, ground strap cables), shorting bars for electrical shorting of the connector leads on the ESDS FPAs and readout assemblies, and packaging material (bags or containers to enclose the ESDS hardware). To prevent potential contamination of the devices, carbon-based materials shall be excluded from use to short or to bag cleaned parts and assemblies prior to, and including final packaging.

5.4 ESD Protective Equipment

5.4.1 Air Ionizers and Ionizing Air Grids

Air ionizers and air ionizing grids may be used to dissipate electrostatic charges from ESDS parts and assemblies when grounding is not sufficiently effective to bleed off static charge or to dissipate charge on insulators. Air from the ionizers should contain nearly equally amounts of positive ions and negative ions to dissipate both negative and positive charges produced when static electricity is generated, and shall be regularly monitored for ion balance. The ionizers will be located overhead or directly on the work bench and will be of the type appropriate for the specific application. The voltage sensitivity level of the ESDS items being handled will be a prime factor in selection of the ionizers. Operationally, the ionized airflow will be directed at the operator and the ESDS parts, assemblies, tools, equipment and all required non-conductors will be within the flow of the ionized air. Bench type ionizers shall be positioned no closer than 24 inches of the ESD sensitive hardware and should be activated a minimum of 60 seconds prior to unpacking of ESDS items. The blowers shall remain operating until repackaging of the ESD items has been completed. Laminar flow benches having an ionizing air grid shall be equipped with a Faraday cage attached to the bench frame and grounded. Gas guns with pressure greater than 10 psi used on ESDS items shall have the gas jets equipped with an active ionizing element to prevent electrostatic charge buildup. Discharge point-of-use ionizing equipment shall be capable of discharging the isolated plate charge from ± 1000 volts to ± 100 volts or less in less than 15 seconds. Room air ionizing equipment shall be capable of discharging the isolated plate from ± 1000 volts to ± volts or less in less than 3 minutes.

5.4.2 Protective Flooring

ESD protective flooring will be used for all cleanroom assembly operations. When wired to ground, conductive floor tile will contain a suitable resistance to limit current to a safe level. In work areas where conductive floor tile is used, conductive shoes or shoe covers will be worn to discharge personnel. Grounded conductive work stools will be used in areas having conductive flooring. This will maximize the benefits of the flooring in the event that personnel sitting at workbenches in an ESD protected area lift their feet from the floor to the work stool.

ESD protective floor mats may be used to cover non-ESD protective flooring areas of traffic flow and at workbenches. Wax or synthetic floor finish shall never be used on conductive tile or floor mats. The use of cleaning agents, which can cause a build up of an insulating film on the flooring or floor mats, will likewise be prohibited.

5.4.3 Personnel Ground Straps

Personnel handling ESDS items shall a wear wrist, leg or ground strap to rapidly dissipate personnel static charges safely to ground and to equalize personnel static levels with that of the work surfaces. The ground straps shall make direct contact with the skin and should have a minimum resistance needed to prevent these grounds from posing a safety hazard to the personnel. The strap grounding leads shall be firmly connected to ground.

Additional personnel grounding methods may be used, including the use of conductive shoes, heel grounders or conductive chairs used in conjunction with ESD protective flooring, and wrist straps.

5.4.4 Personnel Apparel

Personnel handling electrostatic sensitive items shall wear long-sleeved protective smocks or close fitting, short-sleeved shirts or blouses. ESD protective gauntlets that are banded to the bare wrist and extent toward the elbow should be used to cover long-sleeved apparel that is not made of ESD protective material. Should working situations require the use of additional protection, such as the use of an apron, the additional protective apparel shall be made of protective materials. Gloves or finger cots required for handling electrostatic sensitive items shall be made of conductive materials. Protective material shall be checked frequently, particularly after having been cleaned, to monitor for damage.

5.4.5 Grounded Work Benches

Work benches which contact ESDS items and personnel shall have ESD protective work surfaces over the areas where ESDS items are placed. Personnel ground straps shall be an integral component of the workbenches. The work bench surfaces should be connected to ground through a ground cable. The resistance in the bench top ground cable should be located at or near the point of contact with the work bench top. This resistance should be high enough to limit any leakage current to 5 milliamperes or less considering the highest voltage source within reach of grounded personnel and all parallel resistances to ground such as wrist ground straps, table tops and conductive floors. Figure 1 shows a typical ESD protective work bench, while Figure 2 shows a typical ESD protective laminar flow bench. At a minimum, all

assembly operations involving Class 1 devices shall be conducted at a work bench similar to that shown in Figure 1.

Figure 1. ESD Protected Work Bench –Typical

5.4.6 Shunting Bars, Clips and Conductive Foams

The terminals of ESDS items shall be shorted together using metal shunting bars, metal clips or non-corrosive conducting foam. The resistance of the shunt shall be orders of magnitude below the minimum impedance between any two pins of the ESDS part. For parts with metal cases, the shunt should also contact the case. For parts with non-conductive cases and for ESDS assemblies, the shunting material should be wrapped around the ESD item.

Figure 2. Laminar Flow Bench with Ionizing Grid and Faraday Cage - Typical

5.4.7 Electrical Equipment and Tools

Electrical power equipment that comes into contact with ESDS items shall be hard grounded. Where practical, the grounding shall be made through ground fault interrupter equipment. Electrical equipment that contacts any ungrounded pads of the electrical readouts shall have less than 1 volt to equipment ground. This requirement shall apply only to those parts of the equipment which contact the readouts and shall apply for both ac and dc voltage. AC plugs shall have provisions for automatically grounding the equipment when plugged in. ESDS parts and assemblies shall not be handled at a distance closer than 18 inches from a cathode ray tube unless the CRT is protected by a conductive screen.

5.4.8 Non-Electrical Equipment and Tools

All non-electrical tools, including tweezers, and equipment used in handling or processing where the leads or pads of a static sensitive device may be touched shall be grounded. Hand tools that do not have an insulated handle shall be considered grounded when used by an operator wearing a grounded wrist strap. Hand tools that have an insulated handle shall be brought in contact with a grounded dissipative or conductive work surface to discharge static prior to contacting a static sensitive device. Insulated handles of hand tools shall be periodically wiped down with detergent solutions.

5.4.9 Test Equipment

Test equipment shall have all exposed metallic surfaces electrically connected by means of a grounded plug to the test equipment power system or other hard ground. For personnel safety from electrical shock, test equipment shall not be placed on conductive work bench surfaces as this could result in hard grounding the surface. As an added safety precaution, ground fault interrupters, as practicable, will be used in electrical receptacles used for powering test equipment. Test fixtures with exposed terminals or leads connected to circuits that contain ESDS items shall be shorted to chassis ground whenever operations other than test are being performed.

Test equipment shall be turned off and power shall be removed from ESDS assembly or focal plane array connections prior to insertion and removal of these items into or from the test equipment. Test equipment that contains capacitors between an input terminal and ground shall be labeled and the capacitors discharged to ground prior to connection in the event that all available discharge paths have a resistance greater than 10 Mohm.

5.4.10 Bake, Cleaning and Storage Chambers

Chambers into which ESDS parts and assemblies are placed during manufacture and storage operations shall be grounded. As appropriate, the chambers will have grounded baffles to dissipate charges in circulated air, ionized air to dissipate static charges caused by air flow, or shields to divert the charged air away from the ESDS items in the chamber. The ESDS items will be placed in EDS protective trays on grounded metal racks with the chambers.

5.4.11 Relative Humidity

To facilitate dissipation of electrostatic charges, the relative humidity in ESD protective areas shall be monitored. Work on ESDS items shall cease when the relative humidity falls below 25 percent in ESD protective areas that do not have an operating ionized air system. Work on the ESDS items shall not be resumed until the relative humidity reaches a minimum of 25 percent or until air ionizers are in operation.

6.0 ESDS MARKING OF HARDWARE, EQUIPMENT AND DOCUMENTATION

6.1 Hardware Marking

Storage boxes and containers for parts and assemblies shall be marked with either the MIL-STD-129 sensitive electronic device symbol, the EIA RS-471 symbol as illustrated in Figure 3, or other appropriate ESD caution label. The label shall be located in a position readily visible to personnel when the part or assembly is incorporated into the next higher level assembly. The following ESD caution statement, or similar, should be placed adjacent to the ESDS symbol:

CAUTION
CONTAINS PARTS AND ASSEMBLIES
SUSCEPTIBLE TO DAMAGE BY
ELECTROSTATIC DISCHARGE (ESD)

6.2 Equipment Marking

Equipment, including storage cabinets, which contain ESDS parts and assemblies, shall be marked with either the sensitive electronic device symbol, the RS-471 symbol, or other appropriate ESD caution sticker. The symbol shall be located on the exterior surface of the equipment and shall be readily visible to personnel prior to gaining access to the ESDS parts and assemblies within the equipment. A caution statement similar to the following should be placed in close proximity to the symbol:

CAUTION
THIS EQUIPMENT CONTAINS PARTS
SENSITIVE TO DAMAGE BY ELECTROSTATIC
DISCHARGE (ESD). USE ESD PRECAUTIONARY
PROCEDURES WHEN TOUCHING, REMOVING
OR INSERTING PARTS OR ASSEMBLIES

(a) MIL-STD 129 Symbol

(b) RS-471 Symbol

Figure 3. Electrostatic Discharge Symbols

6.3 Documentation Marking

Parts and assembly drawings, and assembly, test, inspection, packaging and handling documentation shall contain ESD precautions and handling procedures, or reference this document, as appropriate. The front sheet of production logs, test documents, and planning paperwork which process ESDS parts shall be identified with an appropriately sized warning label, or similar marking, or the MIL-STD-129 sensitive electronic device symbol.

ESDS acquisition documentation shall include the appropriate ESD program requirements.

7.0 PERSONNEL AWARENESS

Information pertaining to ESD awareness will be provided, to the necessary extent, to all personnel prior to their handling ESDS items, including a thorough review of the provisions provided in this document. Grounding safety precautions will be an integral component of the information. Only cognizant personnel will be allowed to inspect, process, assemble, test, package or in any other way handle ESDS items. Personnel handling ESDS items will be responsible for their personal wrist straps and other grounding devices for proper operation prior to such handling.

8.0 QUALITY ASSURANCE

Conformance inspections and surveillance will be conducted to verify compliance with the requirements specified herein. Specific QA responsibilities include:

a. Establish the status for the ESD protected areas and grounded work benches.

b. Monitor the use of protective personnel clothing and proper personnel grounding at all necessary points where ESDS items are handled outside of protective packaging.

c. Ensure personnel handling ESDS items are proficient, and have received the appropriate ESD protection information.

d. Conduct monthly audits to assure the integrity of ESD protected areas and ESD grounded work benches, personnel grounding facilities, grounding of tools and test equipment, and the implementation of handling, packaging and labeling procedures.

e. Verify that all pertinent documents contain ESD markings, precautions and handling procedures, as appropriate.

f. Inspect ESDS items, storage containers and equipment for proper ESD markings.

9.0 ACRONYMS

CMOS	Complementary MOS
CRT	Cathode Ray Tube
EIA	Electronic Industries Association
ESD	Electro-Static Discharge
ESDS	Electro-Static Discharge Sensitive
FPA	Focal Plane Array
Ge:Ga	Gallium-doped Germanium
MIPS	Multi-band Imaging Photometers for SIRTF
MOS	Metal Oxide Semiconductor
SIRTF	Space Infrared Telescope Facility

MIPS ESD Protection Requirements

	Protective Materials	Air ionizers	Protective Flooring	Personnel Ground Strap	Personnel Apparel	Grounded Work Bench	Shunting bar or Clip	Protective Work Surface	Faraday Cage, Ionized Grid	Hard Grounded Tools	Grounded Test Equipment	Grounded Storage Chambers	Hardware/Equipment Marking
Detector Wafer MIPSD-065	X		X	X	X	X		X		X		X	X
Detector Die MIPSD-067	X		X	X	X	X		X		X		X	X
Readout Wafer MIPSD-025	X		X	X	X	X		X		X		X	X
Readout Die MIPSD-027	X		X	X	X	X		X		X		X	X
Fanout MIPS-060	X				X			X				X	
Reflector Bar MIPSD-069	X				X			X				X	
Side Bar MIPSD-068	X				X			X				X	
Optical Concentrator MIPSD-066	X				X			X				X	
Cable Assembly MIPSD-040	X		X	X	X	X	X	X		X	X	X	X
Frame Clamp MIPSD-048	X				X			X				X	
Frame MIPSD-049	X			X	X			X				X	
Resistors MST-35AN-20K-01-E	X			X	X	X		X				X	X
Capacitors 700A102MC	X			X	X	X		X				X	X
Detector Block MIPSD-070-(-1,-2,-3,-4)	X		X	X	X	X		X		X	X	X	X
4x32 Block Assembly (Front End) MIPSD-080	X		X	X	X	X		X		X	X	X	X
Module Frame Block (Back End) MIPSD-085	X		X	X	X	X	X	X		X	X	X	X
4x32 Module Assembly MIPSD-089	X		X	X	X	X	X	X		X	X	X	X
Higher Assemblies	X		X	X	X	X	X	X		X	X	X	X