Request for Proposal (RFP)

FOR

RATE CONTRACT OF

FABRICATION, ASSEMBLY, TESTING AND DELIVERY

OF

SPACE QUALIFIED HIGH POWER Ka-BAND WAVEGUIDE CIRCULATORS

DOC. NO: SAC/PPCD/April/2024

GOVERNMENT OF INDIA
DEPARTMENT OF SPACE
SPACE APPLICATIONS CENTRE, ISRO
AHMDEDABAD - 380 015

INDEX

EXHIBIT-A: Technical Requirements & General Terms & Conditions

Sr No		Vendor's Compliance
1.0	**INTRODUCTION:** Space Applications Centre is a unit of ISRO involved in design and development of various communication, navigation and remote sensing payloads of the satellites for the Indian space program. It is intended that an Indian industry having in-house or support through Indian facility, capability and experience shall offer bid in carrying out the above job in response.	
2.0	Vendor by their own facility /other SAC/ISRO approved fabrication, plating, painting & test facilities with appropriate calibration and validation certificates will carry out of all activities (like machining, plating, Thermal Painting/Tape, assembly, testing, tuning etc.)	
2.1	The Rate Contract is being established to cater to future workload, which will be exercised, based on Project need.	
2.2	The Vendor is requested to examine this RFP thoroughly and offer compliance or non-compliance, Para by Para as given in this document. In case of non-compliances against any parameter, the vendor is required to specify the same in detail for review by SAC for acceptance. The vendor can seek clarifications if required, for any part of this document before submitting the quotation. Provisional Drawings, fabrication sequence etc. for the cost estimation will be provided to the vendors	
2.3	Work Order will be issued along with Final Drawing, Fabrication Sequence, & Specifications after signing Non-Disclosure Agreement (NDA)	
3.0	**Scope of Work:** The vendor is required to fabricate, test and deliver the circulators for space flight usage as per SAC design and specifications. Major activities are:	
a)	Over all planning of activity along with time schedule to complete different activities to meet delivery of units in time by vendor	
b)	Realization of DVM, QM, & LAT/FM Units with compliance to electrical & environmental specifications	
c)	Procurement of materials as per the requirements given in this document	
d)	Incoming inspection of mechanical parts and materials as per ISRO standard	
e)	Screening of passive parts (wherever applicable)	
f)	Fabrication of mechanical parts as per approved drawings and processes	
g)	Ultrasonic cleaning of silver-plated parts	
h)	Assembly and integration to meet the required specifications	
i)	Final visual inspection	
J)	Audit inspection by SAC	
k)	Final production test of units	
l)	Interim Test report generation by vendor, review and approval by SAC	
m)	Environmental Testing of units as per the requirements	
n)	Test report generation by vendor & review and approval by SAC	
o)	Delivery of unit with final test report after shipment clearance by SAC	
p)	Vendor should have ISRO qualified fabrication facility, storage facility and test facility as well as necessary ISRO certified fabricator / inspector & technical expertise to build, optimize, test and deliver the high reliability product.	
q)	All the above-mentioned activities are to be carried out by vendor as per ISRO qualified processes, with quality control at each step, as per the SAC approved fabrication and test documents.	
3.1	**Realization activities:**	

Sr No		Vendor's Compliance
	A) Fabrication: Fabrication of units to be carried out as per the approved drawings supplied by SAC. It includes mechanical fabrication, electronics fabrication, plating, & thermal coating on the unit. **Post-fabrication** compatibility check is to be performed in Class 1,00,000 or better clean room area by the vendor to ensure the mechanical compatibility of package with all components. After successful completion of this activity, unit can proceed to next stage of production.	
	B) ASSEMBLY: a. Mounting of passive components as per SAC approved drawing : b. Assembly work is to be performed in Class 1,00,000 or better clean room area. c. Plated components may be required to undergo Re-tapping and De-burring. d. Mechanical Components prior to assembly are to be cleaned by Ultrasonic cleaning in Iso-Propyl alcohol. e. Fasteners are to be torque with calibrated torque screwdrivers & suitable adaptors. f. Vendor should be equipped with basic metrology instruments to facilitate measurement and inspection. g. Thermal tape/paint application at applicable places on the package as per approved masking drawing.	
	C) FUNCTIONAL TESTING: Unit testing is carried out as per following: 1) Testing: Unit is tested and optimized for various parameters to meet specifications of the subsystem. 2) Thermal Testing (only DVM): Unit is tested for rated performance over the operating temperature range in a thermal chamber. Unit should meet performance specifications at ambient as well as over operating temperature range.	
3.2	**Realization Phases:**	
	A) DVM Phase: Units are to be fabricated, assembled and tested as per section 3.1 A), B) and C) for various parameters to meet specifications of the subsystem. Units shall undergo the test as per R&QA requirement in para 2.2.1 of Exhibit B. Only after review and clearance of successful completion and delivery of DVM units at SAC, Qualification phase can be started.	
	B) Qualification Phase: Units are to be fabricated, assembled and tested as per section 3.1 A), B) and C) and Annexures in Exhibit D for various parameters to meet specifications of the subsystem. The units are subjected to Process qualification and Product qualification as per the following: **1) Process qualification**: A number of samples will undergo process qualification level tests as per para 2.1 of R&QA requirement in Exhibit B. All these qualification samples shall be structurally and electrically identical, manufactured on the same production line using the same production processes. **2) Product qualification**: Once the process qualification is successfully completed, new units will undergo product qualification level tests as per Table-2 of R&QA requirement in Exhibit B. All these qualification samples shall be structurally and electrically identical, manufactured on the same production line using the same production processes.	

<table>
<tr><th>Sr No</th><th></th><th>Vendor's Compliance</th></tr>
<tr><td></td><td colspan="2">C)FM/Screening and LAT Phase:
Units are to be fabricated, assembled and tested as per section 3.1 A), B) and C) and Annexures in Exhibit D for various parameters to meet specifications of the subsystem.
The FM assemblies shall go through their corresponding acceptance level test as per Table-4 of R&QA requirement in Exhibit B. Acceptance testing is a set of tests carried out on each unit to verify the workmanship and performance of the unit under given operating conditions. It includes various tests such as EMI/EMC tests, vibration test and thermal vacuum test etc as per list and details included in R&QA section of this RFP. The units are required to undergo the above tests successfully, meeting all the specifications, before delivery to SAC.

LAT testing: The periodicity of LAT shall be ONE out of every TWENTY-FIVE (25) FM units fabricated and successfully screened, drawn randomly from screened lot, excluding the samples subjected to high power tests during Screening. This will be decided by SAC at the time of work order/project requirements. SAC will ensure that maximum LAT sample Quantity should not exceed 7 Nos.

Vendor shall start acceptance test on LAT/FM units only after review & clearance of Qualification test results from SAC.</td><td></td></tr>
<tr><td>4.0</td><td colspan="2">Requirements of Test Equipments, Facilities and Accessories:
Vendor to provide list of available instrument along with quote. (This will be subjected to physical verification by SAC during evaluation of technical bids.)
<table>
<tr><th>A) Mandatory Test Equipments, Facilities and Accessories etc availability at vendor's site at the time of bid as per RFP requirements</th><th>Compliance (wherever applicable)</th></tr>
<tr><td>• Test Equipments</td><td></td></tr>
<tr><td>Vector Network Analyzer</td><td>(Make, Model No.)</td></tr>
<tr><td>Automatic RF- data logging System (Desktop/Laptop with Software)</td><td>(Make, Model No.)</td></tr>
<tr><td>• Facilities</td><td></td></tr>
<tr><td>Ultrasonic Cleaning Machine</td><td>(Make, Model No.)</td></tr>
<tr><td>Class 1,00,000 or better clean room facility</td><td></td></tr>
<tr><td>Mechanical Facility - Tapping and Helicoil fixing tools</td><td></td></tr>
<tr><td>Humidity Chamber</td><td>(Make, Model No.)</td></tr>
<tr><td>Climatic Test Chambers (Thermal cycle and Thermal shock)</td><td>(Make, Model No.)</td></tr>
<tr><td>Thermo-VAC Test Chamber</td><td>(Make, Model No.)</td></tr>
<tr><td>• Accessories</td><td></td></tr>
<tr><td>Surface Plate</td><td></td></tr>
<tr><td>Microscope</td><td>(Make, Model No.)</td></tr>
<tr><td>SMA torque wrench (calibrated)</td><td></td></tr>
<tr><td>SMA flexible RF cables (Vacuum Compatible)</td><td></td></tr>
<tr><td>Controlled environment storage chamber/area (bonded store)</td><td></td></tr>
<tr><td>B) Other Test Equipments, Facilities and Accessories required at Vendor's or Sub-contractors' site for execution of work order:</td><td></td></tr>
<tr><td>• Test Equipments</td><td>(Make, Model No.)</td></tr>
<tr><td>Spectrum Analyzer</td><td></td></tr>
<tr><td>• Facilities</td><td></td></tr>
</table></td></tr>
</table>

Sr No		Vendor's Compliance
	Vibration Test Facility	
	EMI/EMC Test measurement Facility	
	Chemical facilities – Silver plating	
	Chemical facilities – Thermal painting	
	• **Accessories**	
	Digital Vernier calipers, Micrometer,	(Make, Model No.)
	WG to Coaxial adapters (Waveguide (WR51 to SMA-F)	
	WG Calibration Kit W/G(WR51), SMA Calibration Kits	
	W/G (WR51) & Coaxial (SMA) terminations	
	Waveguide short plates, Transitions and Handling Plates	
	Lint free tissue/cloth, Silver saver papers, Kapton tape	
	EL-Grade Isopropyl alcohol, Araldite, RTV-3145, Conductive Epoxy (CHO BOND 1075, Make: M/s Parker Chomerics), DC 93500 epoxy, Dow Corning 1200 OS Primer	
	General purpose tools like knife, needle, wire-brush	
	Calibrated Torque wrench for socket head screws (M2,M2.5, M3, M4)	
	Allen keys, spanners (M2,M2.5, M3, M4)	
	Socket head screws (M2,M2.5, M3, M4) with plain and spring washers and nuts	
4.1	**VENDOR DETAILS: Vendor has to provide the following details at the time of bid submission:**	
	A) Certified manpower: Vendor must have ISRO certified fabricators and inspectors as per ISRO-PAX-300 for tinning, soldering and epoxy and thermal tape application and QC inspection. It is mandatory that these manpower are available with the vendor at the time of bid.	
	B) Fabrication Facility Qualifications/Certification: 1. ISRO certified fabrication and assembly facility & processes as per ISRO-PAX-300. 2. Controlled environment storage facility to store parts, material & assemblies for Hi-Rel fabrication of space-hardware.	
	C) Experienced Indian Company:	
	1. The vendor should meet the following criteria: a) An Indian company with all facilities located in India. b) Have proven heritage in making flight worthy Hi-Rel hardware for spacecraft of ISRO. c) Experience of successfully delivering space qualified subsystems within given schedule in last 5 years.	
	D) Guidelines to vendors:	
	1. The vendor shall provide the list of activities carried out by their sub-contractors along with the qualification status of the processes involved.	
	2. Vendor must maintain their infrastructure facility like Clean room, fabrication tools, machineries and equipment. SAC may audit these periodically.	
	3. Certification of manpower, fabrication facilities and qualified processes should be valid throughout the contract period. In case of expiry of certification within contract tenure, it will be vendor's responsibility to recertify without proceeding for further work and without hampering the execution of ongoing work order.	

Sr No		Vendor's Compliance
	4. Vendor should furnish the copies of past purchase orders / contracts which they have successfully executed within given timeline, ISRO/SAC certificated infrastructure (holding valid certificate on the date of offer), ISRO / SAC certified fabricator(s) and inspector(s) (Holding valid certificate on the date of offer) etc. for the Hi Rel hardware assembly, packaging and integration work carried out by them along with the offer. Vendor should provide all contact information like address, landline phone, fax, mobile numbers, etc.	
	5. Vendor should have sufficient test engineers having technical experience in the field of RF & Microwave testing & optimization. Details of current RF engineers to be provided.	
	6. The technical information, drawings and other related documents, disclosed by SAC/ISRO to the vendor and forming part of the order, are property of Government of India, Department of Space and shall not be used for any other purpose except for execution of this order.	
	7. All rights, including rights in the event of grant of patent and registration of designs are reserved.	
	8. The technical information, drawings, specifications, records and other documents shall not be copied, transcribed, traced or reproduced in any other forms or otherwise in whole and/or duplicated, modified divulged and/or disclosed to a third party nor misused in any other form whatsoever without SAC/ISRO's consent in writing except to the extent required for the execution of this order.	
	9. The technical information, drawings, specifications and other related documents shall be returned to SAC/ISRO with all approved copies and duplicates, if any, immediately after they have been used for the agreed purpose.	
	10. Non-Disclosure Undertaking as given in Exhibit-D must be signed after PO placement.	
5.0	**General Terms:**	
a)	The Vendor is requested to examine this RFP thoroughly and offer compliance or non-compliance, Para by Para with respect to test specifications, test parameters and test methods including commercial and other requirements as given in this document. In case of non-compliances against any parameter, the vendor is required to specify the same in detail for review by SAC for acceptance.	
b)	Vendor may seek any clarification in the proposal within one week of publishing of tender, so that RFP requirements are met correctly and adequately.	
c)	Circulators are required in the frequency band of 17.7 GHz to 21.5 GHz.	
d)	Estimated Work-load for the Rate Contract period (May change based on actual requirement at the time of establishing PO): 1. Ka Band WG Circulators (FM) – 98 Nos. 2. Ka Band WG Circulators (LAT) – 7 Nos. 3. Ka Band WG Circulators (DVM) – 1 Nos. 4. Ka Band WG Circulators (QM - Process Qualification - 08 Nos. + Product Qualification – 10 Nos.) – 18 Nos.	
e)	The quantity requirement of circulators will be distributed across the awarded period of 3 years. Validity of the Purchase Order – 3 years. The prices shall be firm and fixed during the awarded Purchase Order period.	

Sr No		Vendor's Compliance
f)	Vendor to confirm that, in case the maximum quantity mentioned in the Rate Contract is consumed within the contractual period, the prices quoted by the vendor will be valid for additional Work order quantity within the validity of the Rate Contract.	
g)	To fulfill the project's requirement the said contract may be extended for a period of one year, with same rates, terms and conditions, based on satisfactory performance and mutual agreement between SAC & Vendor.	
h)	Quantities indicated are only to define the maximum envelope of PO. There is no minimum work order commitment from SAC/ISRO.	
i)	SAC may modify the sample size and addition or deletion of test requirements during FM or qualification testing, if required, in consultation with the vendor. SAC reserves the right to modify any part of the design as per project requirements.	
j)	Vendor shall identify one or more focal point/s for interaction with SAC and for execution of the work. The Vendor's identified focal point should preferably be a senior person who will be able to provide any clarification and take decision as required. SAC will also identify one or more focal point/s for day-to-day interaction with the vendor and for execution of the work. SAC identified focal point will be also a senior person who will be able to provide any clarification and take decision as required.	
k)	Costly parts are not involved in Fabrication, Testing-Tuning and Test & Evaluation of the tendered items. Hence, No Advance payment at the time of PO. Payment to be done on pro-rata basis.	
6.0	**Technical terms:**	
a)	Final approved fabrication document and Test Document shall be supplied to the vendor after the PO is placed. All documents supplied by SAC shall be the exclusive property of SAC (Non-disclosure and IPR) and shall not be used for any purpose other than agreed upon with written approval. Any changes carried out in the design, drawings or documents during the PO period, done by vendor shall be exclusive property of SAC. Vendor shall take written approval from SAC prior to third party outsourcing (All the clauses, Terms & Conditions and R&QA requirements will be applicable to third party also).	
b)	For the Rate Contract of DVM/QM/FM/LAT units, Vendor is responsible to procure material like; Silver Saver paper, RTV-3145, Thermal Tape, Epoxy, EL-Grade Isopropyl Alcohol, Aluminum alloy 6061-T6, Teflon, Fasteners, Helicoil, assembly tools etc. and procurement of materials used in various facilities like Silver Plating, Thermal Painting, Ultrasonic Cleaning etc. Vendor has to take SAC QA approval for material procurement specifications before placing order.	
c)	The operating temperature range mentioned in R&QA document are typical. Final specifications to be given with work order.	
d)	SAC will provide High Power Test (Power Handling, Multipaction & PIMP Product Test) facility free of cost so vendor should not add its cost in their quote. However, vendor shall be responsible for co-ordination with SAC to conduct the test.	
e)	Free Issue Material guidelines: 1) SAC will supply ferrites and magnets, as Free Issue Material (FIM) for DVM, QM, LAT and FM Units. Vendor shall procure all consumable materials & accessories to carry out the Fabrication, Assembly, and Testing of units as per requirement given in the RFP. 2) Collection of FIMs & other details from SAC will be the responsibility of vendor.	

Sr No		Vendor's Compliance
	3) The vendor should maintain all records of inventory of FIM received, utilized, balance etc., and update them continuously. 4) The Vendor shall be responsible for proper storage & security of FIM 5) The Vendor shall be responsible for any mishandling and loss of FIM held under their custody. 6) The Vendor shall return the unused / excess / spoiled FIM, if any, to Purchaser on the advice of the Focal Point at SAC. 7) In case of rejection, a request letter from vendor clearly indicating reasons for rejections, preventive action thereof should be submitted to SAC. 8) A maximum of 10% Failures/Rejection will be acceptable for FIMs. 9) In the event of failures of FIM beyond the permissible limits, SAC will provide replacement FIM for completion of jobs. However, the cost of such FIM issued by SAC beyond permissible limits has to be borne by the vendor. 10) If it is revealed that the cause for the rejection in FIM is due to material defect, then the same shall be replaced free of cost by SAC.	
f)	To complete the scope of the work, SAC will issue the material free of cost to the vendor on submission of Bank Guarantee of equivalent amount of FIM for each work order as per purchase terms and conditions.	
g)	In case the Rate Contract is terminated due to unsatisfactory execution, progress or performance, vendor shall be responsible to return the unused FIM components to SAC as per purchase procedure.	
h)	It is mandatory that vendor shall follow the test sequence and methods as given in the document. In case of any modification or change suggested by vendor, the approval for the same shall be obtained from SAC before implementation.	
i)	All mechanical & interface drawings of waveguide circulators will be provided to the vendor by SAC along with work order. SAC reserves the right to change and modify to suit the requirement, if necessary.	
j)	Calibrated Test & measuring instruments shall be used during the tests. Calibration certificates of all test equipment used shall be made available for SAC audit at any stage. Details of Instrument shall be logged in proper formats for traceability point of view.	
k)	Handling during test as well as before and after storage shall be done with utmost care. In case damage is detected due to handling or storage at any stage of testing, the same shall be recorded with reason and shall be reported to SAC at the earliest. Damaged samples shall not be subjected to further tests. Replacement of damaged samples shall be done by the vendor with proper priority so that test schedule shall not get affected.	
l)	Only after the acceptance of DVM units by SAC, go ahead for the commencement of Process Qualification samples and Product Qualification samples will be given. After successful qualification of Ka band waveguide circulator, work for FM/LAT shall be started.	
m)	The prices shall be firm, fixed and no additional amount OR any types of charges will be paid during the entire PO period.	

Table 1. Typical Value of Free Issue Material FIM:

S.No.	Item Description	Qty (Nos)	Value Rs.
1.	Ferrite	1	2000
2.	Magnet	1	2000

EXHIBIT-B

R & QA REQUIREMENTS OF RATE CONTRACT FOR FABRICATION, ASSEMBLY AND TESTING OF HIGH POWER S-BAND W/G CIRCULATORS

1 R & QA Requirements

1.1 *Scope*

This section, together with qualification and Screening test program is described in next section, describes the R & QA requirement to be met by the vendor during the realization of circulators.

1.2 *Mandatory Requirements*

It is mandatory that ISRO qualified fabrication line as per ISRO-PAX-300 should be used for fabrication, including ISRO Hi-Rel certified manpower. All fabrication activity shall be carried out in Class 1,00,000 clean room. Necessary certificate should be attached along-with the quote. Vendor should have capabilities in terms of fabrication facility, storage facility and test facility as well as necessary technical expertise to build, optimize, test and deliver the high reliability product.

1.3 *Applicable Documents*

ISRO-PAS-100: Nonconformance control requirements for ISRO projects
ISRO-PAS-201: Failure Reporting, Analysis and corrective Action procedures
MIL-STD-202: Test Method Standard for Electronic and Electrical Component Parts
ISRO-PAS-207: Storage handling and transportation requirements for electronic hardware
ISRO-PAX-300: Workmanship standards for fabrication of electronic packages
MIL-STD-461E: Requirements for the control of electromagnetic interference characteristics of subsystems and equipment

1.4 *Reliability*

Life: The unit shall be fabricated so as to meet all the requirements for its use in onboard geostationary spacecraft, for a minimum period as specified below

- Operating life of 18 years in orbit after
    - 3 years' storage and operations at various levels of spacecraft assembly
    - 5 years' storage in controlled environmental conditions.

Vendor shall specify the exact method of storage.

1.5 *Typical Environmental Specifications*

1.5.1 Non-Operating Environment

The units shall be capable of withstanding following environmental conditions:

i. **Temp. range**: -55 Deg C to +85 Deg C
ii. **Pressure**: Ambient and vacuum better than 10^{-5} torr.
iii. **Relative humidity:** Up to 95% without condensation of water at +40 Deg. C (Applicable for storage on ground only)

1.5.2 Operating Environment

The unit shall meet all the performance requirements as given in electrical specifications under the following environmental conditions:

i. **Temperature range**: All temperatures are referred to as the base plate. If there is no base plate, then it is the DUT body temperature.

    1. Qualification (QM)/LAT: -25 Deg. C to +75 Deg C
    2. Flight Acceptance (FM): -20 Deg C to +70 Deg C

    Temperatures specified are tentative and will be as per applicable ETLS.

ii. **Pressure:** The unit shall be capable of operating and compliant to the specifications at ambient pressure as well as vacuum level of 10^{-5} torr.
iii. **Relative humidity**: Up to 70% of RH at + 35 Deg. C without condensation of water (applicable for environment during ground testing only)

1.6 *Mechanical Parts / Materials*

Vendor shall ensure to use ISRO approved / qualified materials. Procurement of all the mechanical and electronic fabrication materials shall be done as per SAC Approved Materials List (DML). Vendor shall review & clear Material Test Report (MTR) & CoC of the manufacturer. Non-metallic materials shall have a Total Mass Loss (TML) of less than 1% and Collectable Volatile Condensable Materials (CVCM) of less than 0.1% when subjected to a test condition of +125ºC and 1x10E-06 torr pressure for 24 hours. If CoC contains outgassing parameters, then separate test not required. All inspection and clearance records for the materials shall be maintained by the vendor and send to SAC for review & acceptance.

Ferrous and non-ferrous material used shall be of corrosion resistance type or suitably treated to resist corrosion caused by atmospheric conditions existent in storage or normal operational conditions. Materials, which are nutrients for fungus, shall not be used.

Any other materials, which are not available in SAC DML, shall first be qualified as per SAC test plan & cleared by SAC prior to their use.
Materials list consisting of the name of vendor, shelf life, qualifying agency, location of application in the sub-systems shall be submitted to SAC for approval.

All the materials shall be used within their shelf life.

1.6.1 Inspection

All the materials procured by the vendor shall undergo Incoming inspection / testing including measurement of, **Critical physical/ chemical and mechanical properties and out gassing properties of specified materials.**

Proper traceability of all the materials shall be maintained; back to the level of approved / tested batch. Wherever the test results with the compliance certificate are supplied by the vendor along with material batch, out-gassing test is not required

1.7 *Processes*

The unit shall be built to the standards normally associated with long life satellite hardware. ISRO-PAX-300 workmanship standard for fabrication of packages shall be followed for the fabrication work. Mechanical fabrication processes including surface treatment on the box, i.e., plating and coating, in realizing the hardware shall be SAC/ ISRO qualified. All the processes shall be carried out in accordance with PIDs reviewed & approved by SAC.

The vendor shall provide a list of SAC / ISRO qualified processes available at their facility along with valid certificate at the time of bid. Ferrite and magnet attachment to Silver-plated Aluminum may need increment or full qualification as per SAC test plan. Also, in case of processes qualified by other agencies, process qualification reports shall be submitted to SAC for review. After review of previous qualification plan, SAC will decide for requirement of full qualification / delta qualification of such processes. However, right for decision on feasibility of such a qualification activity will be retained by SAC.
The following fabrication processes are likely to be used for fabrication of unit and should be carried out on ISRO qualified fabrication line.

- Machining / Fabrication of mechanical hardware
- Plating / painting of mechanical hardware
- Ferrite attachment to Silver-plated Aluminum package of by using epoxy
- Magnet attachment to Silver-plated Aluminum package of by using epoxy
- Assembly

Fabrication work shall be carried out using ISRO qualified processes & fabrication line by ISRO certified operators & inspectors.

1.8 *Fabrication Documentation*

For the fabrication activity, a fabrication traveler / fabrication history sheet shall be maintained for each unit, where-in all the fabrication steps and QC inspection comments are logged by Vendor QC on-line. This shall include any non-conformance reported by QC and its close out. This shall also include the specific serial nos. of mechanical parts used for fabrication of units

1.9 *Facilities*

Vendor / sub-vendor shall have in-house or access to ISRO qualified facilities & for fabrication, assembly and testing of Units, like:
Fabrication, assembly & inspection of fabricated packages
Instrumentation for electrical testing
Environmental test facilities
Storage area as per the requirements of ISRO standard
Apart from environmental controls of temperature and humidity, the electronic fabrication and storage area shall meet class 100,000 cleanliness requirements as a minimum and shall have all the ESD safety precautions implemented.
The work area shall meet the requirements of ISRO-PAX-300

1.10 *Process Identification Document (PID)*

All the activities involved for realisation of space FM units shall be addressed in the PID. Vendor shall prepare a PID, identifying all the activities, methods / procedures & inspection check points that will be followed for fabrication of the units. The PID shall include detailed manufacturing process flow chart indicating critical process parameters, inspection checks points, instruments used in manufacturing these unit including parameter setting etc. for all stages of fabrication, assembly and testing. It also includes the BoM, parts & materials test parameter details, source of procurement, etc. The copy of PID shall be sent to SAC for review & approval.

This approved PID shall be adhered by the vendor for manufacturing deliverable product. Only SAC approved PIDs shall be followed for production of subsequent flight hardware units.

1.11 *Fabrication Sequence*

A generalized fabrication sequence detailing each step of fabrication and QC inspection shall be worked out and provided to SAC before start of fabrication. SAC approved fabrication sequence shall only be implemented. This is to ensure smooth flow of the assembly activity and avoiding rework / rejection. This shall be clearly understood and agreed upon. The assembly flowchart shall include the following:

a) Flow of fabrication activities
b) Approved drawing nos.
c) Name of processes and PID numbers.

d) Intermediate electrical testing
e) Handling instructions
f) Permanent/Temporary torque values.
g) Specific instructions, caution notes etc.
h) Any environmental test which is a part of fabrication process or for electrical performance check
i) Marking & Identification of unit.

1.12 *Quality Control (QC) And Verification of Process Quality (VoPQ)*

An in house Quality Control (QC) group shall carry out 100% inspection of all the fabricated / processed items as well as on-line inspection during the fabrication activity. Mechanical inspection includes dimensional compliance, finish and surface quality on a 100% basis.

All fabrication and inspection work shall be carried out by ISRO certified fabricators / inspectors of vendor. Online inspection of all the fabricated hardware and witness samples shall be carried out by QC of the vendor. These data can be used to monitor the process health. Required process control documents are to be generated and maintained by the vendor, which will be reviewed by SAC during QA audit.

Regarding the verification of process quality, for all applicable mechanical fabrication processes, test coupons shall be fabricated along with the FM hardware. These test coupons shall be subjected to VOPQ (Verification of Process Quality). Any deviations observed on these samples shall be a cause for rejection of the lot fabricated and a final disposition shall be taken after discussion with ISRO regarding their impact on unit functioning and reliability. Corrective action shall be taken to ensure quality.

1.13 *Quality Audit*

The purpose of the QA audit is to ensure that all planned Product Assurance activities are complied with the identified procedures and to determine effectiveness of quality systems at vendor's place. The QA audit shall be carried by SAC from both electronic & mechanical point of view. The audit may be conducted without prior intimation to vendor. As a general guideline, facility audit shall be carried out during fabrication of Qualification model/LAT and once at every three months during fabrication of FM units. However, based on the fabrication activity schedule the final audit plan shall be decided. Following may be noted.

a) All the fabricated units shall be first inspected and accepted by QC/QA of the vendor with proper records. Then these units shall further be audited by SAC prior to final cover closing. Functional testing shall commence only after the clearance from SAC.
b) The frequency for QA audit shall be decided on mutual agreement between SAC and the Vendor and accordingly Audit plan shall be jointly worked out. The auditor shall be free to audit/ inspect all related facilities, activities, which the vendor will carryout to realize hardware. Fabrication processes, cleanliness records, QC inspected hardware, process log books/history records, overall documentation, parts & material evaluation/test reports, facilities, procedures followed etc. are in the audit list.

c) The audit report shall be generated by SAC and shall be circulated to all concerned. The Vendor shall generate close outs on the audit discrepancies by taking appropriate corrective actions and submit the same to SAC for review and acceptance.
d) The disposition on the non-conformances on actual hardware, if any, which cannot be closed by the auditee, shall be closed through vendor's NCRB, with approval from SAC, after reviewing the impact of the non-conformance on reliability of the non-conformed hardware for intended use.
e) The corrective actions implemented by the vendor shall be documented after necessary review and approval by SAC.

1.14 *Marking and Identification*

The units shall be identified by assigning unique serial number on the exterior surface by a suitable process applicable for space use. Marking shall not degrade the performance and quality of the unit. In addition to functional markings like input / output, frequency etc. following marking shall appear on each unit as minimum.

Unit Name : Frequency Band
Specification Number / Contract Number : Serial Number
Name of the Manufacturer : Date of Manufacture in YYWW format (YY=last two digits of year of fabrication, WW=week number of the fabrication year)

SAC to approve final marking to be put on FM units before beginning of screening tests.

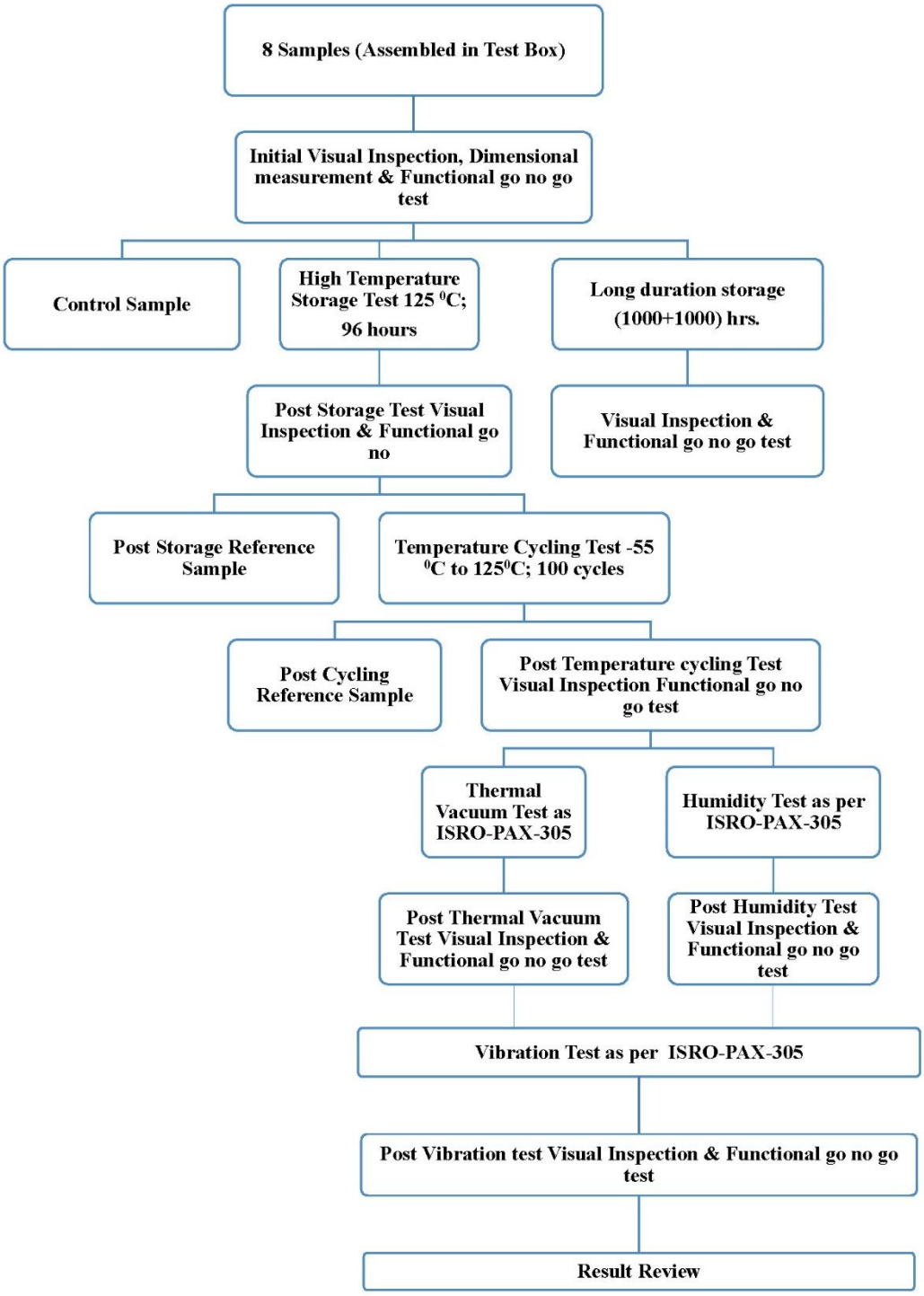
The permanency of the marking shall be sufficient to withstand the specified environmental conditions and normal cleaning operations using Isopropyl Alcohol and other cleaning solvents. The marking method to demonstrate the same shall be specified by the manufacturer.

2 Qualification and Screening Test Program

This section describes the qualification and screening test details.

2.1 *Process Qualification*

Qualification Test Plan is given in Flowchart-1. Total 8 nos. of qualification samples (assembled in test box) will be required for qualification testing. These samples shall be fabricated and subjected to the specified tests. The test methods and conditions are given in subsequent paragraphs.



Flowchart: Qualification test plan for attachment of ferrite and magnet using epoxy

Note:

1. Functional GO – NO-GO test will be decided mainly based on confidence level.
2. Visual inspection & other test methods will be provided at the time of realization.

2.2 *Product Qualification and Screening*

2.2.1 Phase-I: DVM Phase

Design Verification Model (DVM) is made to verify the technicalities of design, fabrication and processes.

ONE unit shall be subjected to prototype tests as below.

Table 1: Tests on Prototype units

Sr. No.	Test	Test conditions
1.	Initial Bench Tests	As per specifications
2.	Temperature Operational	@ +25 deg C; Initial measurement @ lowest oper. temp (qual); after one hour stabilisation Electrical Test; As per electrical specifications; @ highest oper. temp (qual); after one hour stabilisation Electrical Test; As per electrical specifications @ +25 deg C; after one hour stabilisation
3.	Vibration test	18.2grms (TBD)
4.	EMI/EMC	RE102, MIL 461E at center frequency of the band
5.	Report Generation	

Only after the acceptance of DVM unit by SAC, go ahead for the commencement of qualification phase will be provided.

2.2.2 Phase-II: Qualification Phase

The qualification units shall be initially screened as per Table-4 for Screening.

All the qualification devices shall be structurally (conforming to defined ICD) and electrically identical device types manufactured on the same production line using the same fabrication processes.

Two batches of circulators (fabrication batch codes exceeding one-month interval) shall be fabricated and samples shall be drawn from each batch as below. -TBD

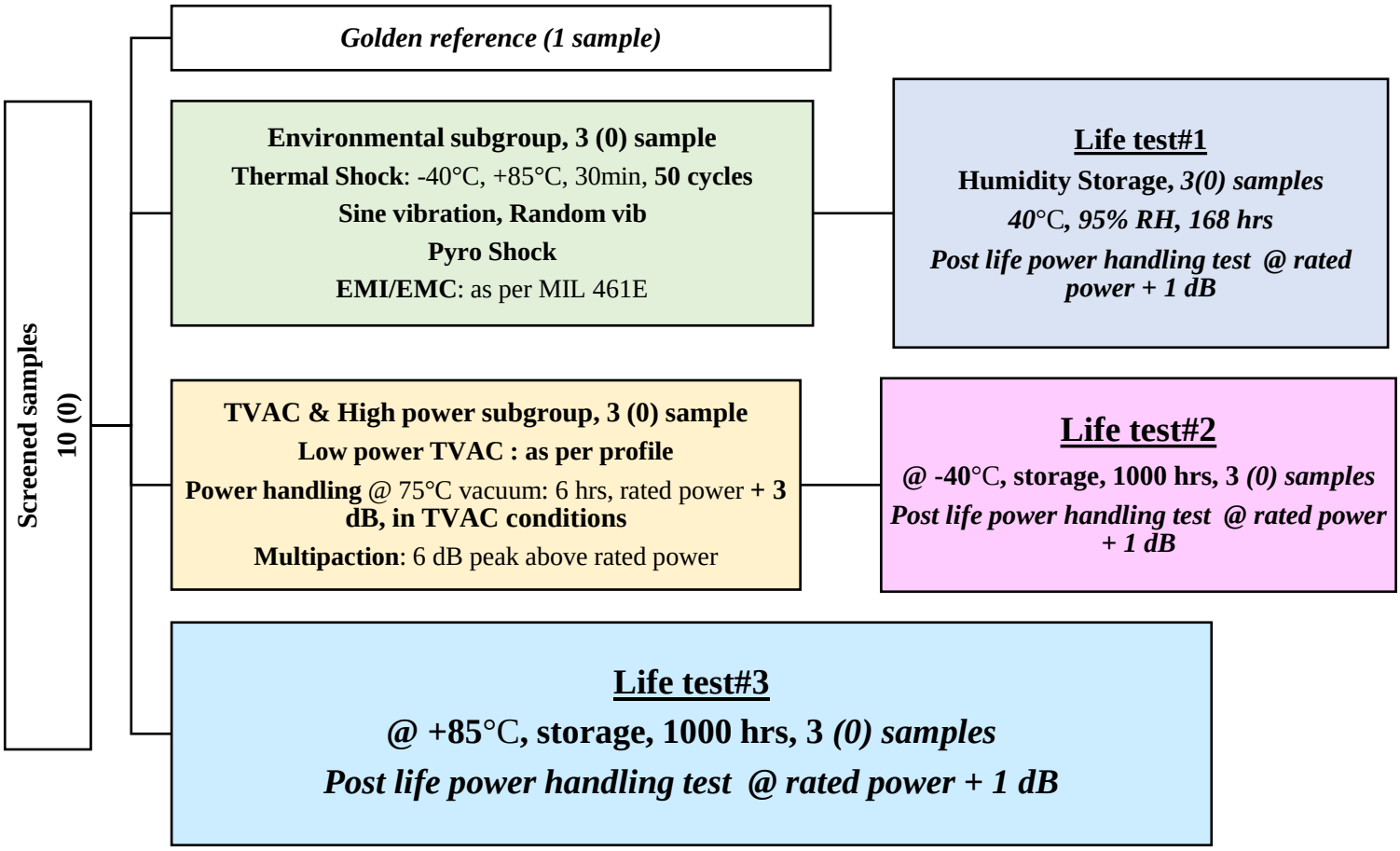
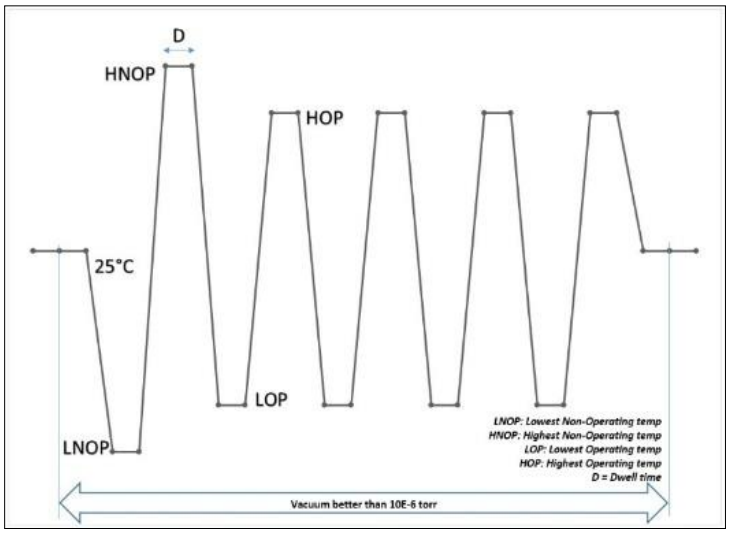


Figure: Sample distribution among qualification subgroups

Table 2: Tests on Qualification units

<table>
<tr><th>Sr. No.</th><th>Test</th><th>Test conditions</th></tr>
<tr><td>1.</td><td>Screening of Qual units</td><td>As per Table: Screening</td></tr>
<tr><td colspan="3">Subgroup-1: Environmental tests</td></tr>
<tr><td>2.</td><td>Thermal Shock</td><td>Non-Operating temp limits; 30 min dwell; 50 Cycles</td></tr>
<tr><td>3.</td><td>Post thermal Shock</td><td>Visual inspection @ 10 X
Electrical Test; As per electrical specifications</td></tr>
<tr><td>4.</td><td>Temperature Operational</td><td>@ lowest oper. temp (qual); after stabilisation
Electrical Test; As per electrical specifications;
@ highest oper. temp (qual); after stabilisation
Electrical Test; As per electrical specifications
@ +25 deg C; after stabilisation</td></tr>
<tr><td>5.</td><td>Sine Vibration</td><td>• Pre-sine vibration resonance search ---
10 to 2000 Hz to 10 Hz, 30 G peak., X, Y, Z
Sweep Rate: 2 Octave / Min.
No. of sweeps: 36 (12 per axis) ---
• Post-sine vibration resonance search
• Visual inspection
• Electrical verification</td></tr>
<tr><td>6.</td><td>Random Vibration</td><td><table><tr><th>Frequency (Hz)</th><th>Levels</th></tr><tr><td>20-50</td><td>+ 6 dB/Octave</td></tr><tr><td>50-1200</td><td>0.45 g^2/Hz</td></tr><tr><td>1200-2000</td><td>- 6 dB/Octave</td></tr><tr><td>Overall Level</td><td>27.2 g_{rms}</td></tr><tr><td>Duration</td><td>2 minute/axis</td></tr></table></td></tr>
<tr><td>7.</td><td>Post Vibration</td><td>Visual inspection @ 10 X
Electrical Test; As per electrical specifications</td></tr>
</table>

<table>
<tr><th>Sr. No.</th><th>Test</th><th>Test conditions</th></tr>
<tr><td>8.</td><td>Mechanical Shock</td><td>Parallel to mounting plane
<table><tr><th>Frequency (Hz)</th><th>SRS</th></tr><tr><td>100 – 300</td><td>15 dB / octave</td></tr><tr><td>300 – 1000</td><td>9 dB / octave</td></tr><tr><td>1000 – 5000</td><td>400 g</td></tr><tr><td>5000 – 10000</td><td>- 6 dB / octave</td></tr></table>Normal to mounting plane
<table><tr><th>Frequency (Hz)</th><th>SRS</th></tr><tr><td>100 – 300</td><td>15 dB / octave</td></tr><tr><td>300 – 1000</td><td>9 dB / octave</td></tr><tr><td>1000 – 5000</td><td>700 g</td></tr><tr><td>5000 – 10000</td><td>- 6 dB / octave</td></tr></table></td></tr>
<tr><td>9.</td><td>Post Shock</td><td>Visual inspection @ 10 X
Electrical Test; As per electrical specifications</td></tr>
<tr><td>10.</td><td>EMI/EMC</td><td>RE102, MIL 461E
at center frequency of the band</td></tr>
<tr><td colspan="3">TVAC and High power tests subgroup</td></tr>
<tr><td>11.</td><td>Thermal Vacuum</td><td> 
</td></tr>
</table>

Sr. No.	Test	Test conditions
12.	Power handling test	At rated (forward + reflected) power; Thermo-vacuum condition; @ max. operating temperature (base plate temp); 24 hours min.; At 1dB above rated (forward + reflected) power; additional 3 hours min. Monitor: • Forward, reflected and output power; calculated Insertion loss & return loss from measured power levels • Temperatures of mounting surface, Device body, Input and output interfaces, termination
13.	Multipactor test	i. Shall be tested at rated peak power with 6 dB margin; ii. Multipaction breakdown levels to be established by test (TBD) Record of global sensors and temperature monitors
Life test#1		
14.	Humidity Storage life	RH 90-95%; temperature 40°C; 168 hours
15.	Post storage life	Electrical Test; As per electrical specifications Visual inspection @ 10 X Power handling test: rated power + 1 dB
Life test#2		
16.	Storage life @ cold	@ Lowest non-op. temp (-40°C), 1000 hrs. Electrical measurements every 250 hrs. interval
17.	Post storage life @ cold	Electrical Test; As per electrical specifications Visual inspection @ 10 X Power handling test: rated power + 1 dB
Life test#3		
18.	Storage life @ hot	@ Highest non-op. temp (+85°C), 1000 hrs. Electrical measurements every 250 hrs. interval
19.	Post storage life @ hot	Electrical Test; As per electrical specifications Visual inspection @ 10 X Power handling test: rated power + 1 dB

Sr. No.	Test	Test conditions
20.	Conclusion and Report generation	

Table 3: Parameters to be measured during qualification tests

PERFORMANCE MEASUREMENTS / TESTS	Visual Inspection	Insertion Loss	I/P AND O/P VSWR	Isolation	Variation over Temperature	RF leakage / Shielding Effectiveness	Forward, reflected and output power	Test Monitoring sensors, Temp. at mounting surface, Device body, I/P and O/P interfaces, termination
Initial Performance	X	X	X	X	-	-	-	-
Post Thermal Shock	X	X	X	X	-	-	-	-
Post Temp. Storage (Cold)	X	X	X	X	-	-	-	-
Post Temp. Storage (Hot)	X	X	X	X	-	-	-	-
Temp. Operational	-	X	-	X	X	-	-	-
Post Vibration	X	X	X	X	-	-	-	-
Post Pyro Shock	X	X	X	X	-	-	-	-
Thermo-vacuum	-	X	-	X	X	-	-	-
High Power Tests (power handling test; multipaction test)	-	-	-	-	-	-	X	X
Post high power test	X	X	X	X	-	-	-	-
EMI / EMC	-	-	-	X	-	X	-	-
Humidity Storage Test	X	-	-	-	-	-	-	-
Final Performance	X	X	X	X	-	-	-	-
Resistance to Solvent test (if applicable)	X	-	-	-	-	-	-	-

Note: Only after the acceptance of qualification units and test results by SAC, go ahead for the commencement of flight model (FM phase) will be provided.

2.2.3 Phase-III: FM/Screening Phase

On successful completion of qualification phase, the units (other than qualification samples) shall undergo Screening as per plan below.

Table 4: Screening Tests

<table>
<tr><th>Sr. No.</th><th>TEST</th><th>Test details</th></tr>
<tr><td>1.</td><td>Physical/dimensional Measurements</td><td>All dimensions as identified;
Particularly for critical dimensions, if any
Report to include measured values</td></tr>
<tr><td>2.</td><td>Initial Performance</td><td>As per specifications
Visual Inspection @ 10 X</td></tr>
<tr><td>3.</td><td>Thermal Shock</td><td>-40°C, +85°C, 30min, 10 cycles</td></tr>
<tr><td>4.</td><td>Temperature Storage</td><td>@ -40°C, 6 hrs, post storage measurement
@ +85°C, 6 hrs, post storage measurement
ambient measurement</td></tr>
<tr><td>5.</td><td>Temperature Operational</td><td>Lowest operating temp, after stabilisation
Highest operating temp, after stabilisation</td></tr>
<tr><td>6.</td><td>Random Vibration</td><td><table><tr><th>Frequency (Hz)</th><th>Screening</th></tr><tr><td>20-50</td><td>+ 6 dB/Octave</td></tr><tr><td>50-1200</td><td>0.20 g^2/Hz</td></tr><tr><td>1200-2000</td><td>- 6 dB/Octave</td></tr><tr><td>Overall Level</td><td>18.2 g_{rms}</td></tr><tr><td>Duration</td><td>1 minute/axis</td></tr></table></td></tr>
<tr><td>7.</td><td>Power Handling tests</td><td>Power handling test @Rated RF power (forward+reverse), 6 hrs, specified base plate temp.
(Excluding the units to be subjected to LAT; refer LAT philosophy)</td></tr>
<tr><td>8.</td><td>Final Performance Test</td><td>As per specifications
Visual Inspection @ 10 X</td></tr>
<tr><td>9.</td><td>Analysis of results</td><td>• Screen accept
• Screen reject</td></tr>
</table>

Table 5: Parameters to be measured During Screening

PERFORMANCE MEASUREMENTS / TESTS	Visual Inspection	Insertion Loss	I/P AND O/P VSWR	Isolation	Variation over Temperature	RF leakage / Shielding Effectiveness	Forward, reflected and output power	Test Monitoring sensors, Temp. at mounting surface, Device body, I/P and O/P interfaces, termination
Initial Performance	X	X	X	X	-	-	-	-
Post Thermal Shock	X	X	X	X	-	-	-	-
Post Temp. Storage (Cold)	X	X	X	X	-	-	-	-
Post Temp. Storage (Hot)	X	X	X	X	-	-	-	-
Temp. Operational	-	X	-	X	X	-	-	-
Post Random Vibration	X	X	X	X	-	-	-	-
High Power Tests (power handling test; multipaction test)	-	-	-	-	-	-	X	X
Post high power test	X	X	X	X	-	-	-	-
Final Performance	X	X	X	X	-	-	-	-

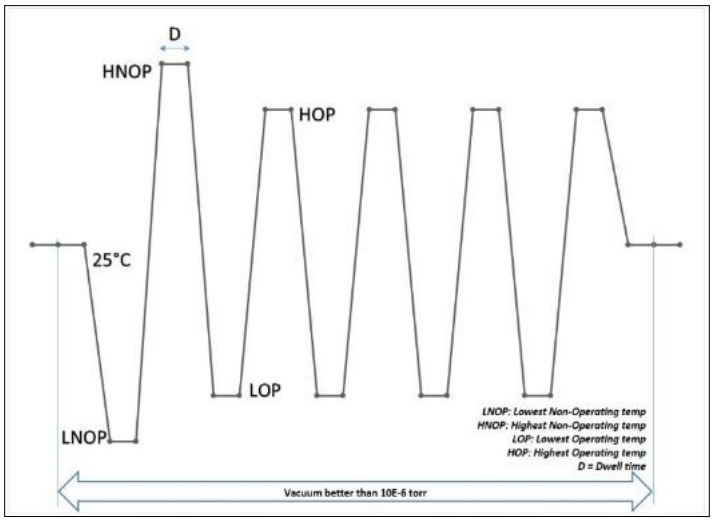
2.2.4 Phase-IV: Lot Acceptance Testing Phase (LAT)
Applicability and periodicity

i) Lot Acceptance Test (LAT) shall be applicable on all batches subsequent to device qualification. LAT **need not be performed** on the batch from which qualification samples are taken, and successfully undergone the qualification tests.

ii) **The periodicity of LAT shall be ONE out of every TWENTY-FIVE (25) FM units fabricated and successfully screened,** drawn randomly from screened lot, excluding the samples subjected to high power tests during Screening. This will be decided by SAC at the time of work order/project requirements. **SAC will ensure that maximum LAT sample Quantity should not exceed 7 Nos.**

Table 6: Lot Acceptance Testing

Sr. No.	Test	Test conditions
1.	Initial Bench tests	As per specifications
2.	Thermal Shock	Non Oper temp limits; 30 mins dwell; 25 Cycles
3.	Post thermal Shock	Visual inspection @ 10 X Electrical Test; As per electrical specifications
4.	Temperature Operational	@ lowest oper. temp (LAT); after stabilisation Electrical Test; As per electrical specifications; @ highest oper. temp (LAT); after stabilisation Electrical Test; As per electrical specifications @ +25 deg C; after stabilisation
5.	Sine Vibration	• Pre-sine vibration resonance search --- 10 to 2000 Hz to 10 Hz, 30 G peak., X, Y, Z Sweep Rate: 2 Octave / Min. No. of sweeps: 12(4 per axis) --- • Post-sine vibration resonance search • Visual inspection • Electrical verification

<table>
<tr><th>Sr. No.</th><th>Test</th><th>Test conditions</th></tr>
<tr><td>6.</td><td>Random Vibration</td><td>
<table>
<tr><th>Frequency (Hz)</th><th>Levels</th></tr>
<tr><td>20-50</td><td>+ 6 dB/Octave</td></tr>
<tr><td>50-1200</td><td>0.45 g^2/Hz</td></tr>
<tr><td>1200-2000</td><td>- 6 dB/Octave</td></tr>
<tr><td>Overall Level</td><td>27.2 g rms</td></tr>
<tr><td>Duration</td><td>2 minute/axis</td></tr>
</table>
</td></tr>
<tr><td>7.</td><td>Post Vib</td><td>Visual inspection @ 10 X
Electrical Test; As per electrical specifications</td></tr>
<tr><td>8.</td><td>EMI/EMC</td><td>RE102, MIL 461E
at center frequency of the band</td></tr>
<tr><td>9.</td><td>Thermal Vacuum</td><td> 
</td></tr>
<tr><td>10.</td><td>Power handling test</td><td>At 1dB above rated (forward + reflected) power
Thermo-vacuum condition; @ max. operating temperature (base plate temp); 3 hours min.;
Monitor:
• Forward, reflected and output power; calculated Insertion loss & return loss from measured power levels
• Temperatures of mounting surface, Device body, Input and output interfaces, termination</td></tr>
</table>

<table>
<tr><th>Sr. No.</th><th>Test</th><th>Test conditions</th></tr>
<tr><td>11.</td><td>Multipactor test</td><td>Shall be tested at rated peak power with 6 dB margin; record of global sensors and temperature monitors</td></tr>
<tr><td>12.</td><td>Humidity Storage</td><td>RH 90-95%; temperature 40°C; 240 hours;</td></tr>
<tr><td>13.</td><td>Post humidity storage</td><td>Electrical Test; As per electrical specifications
Visual inspection @ 10 X</td></tr>
<tr><td>14.</td><td>Mechanical Shock</td><td>
<table>
<tr><th>Frequency (Hz)</th><th>SRS</th></tr>
<tr><td>100 – 300</td><td>15 dB / octave</td></tr>
<tr><td>300 – 1000</td><td>9 dB / octave</td></tr>
<tr><td>1000 – 5000</td><td>700 g</td></tr>
<tr><td>5000 – 10000</td><td>- 6 dB / octave</td></tr>
</table>
Normal to mounting plane
<table>
<tr><th>Frequency (Hz)</th><th>SRS</th></tr>
<tr><td>100 – 300</td><td>15 dB / octave</td></tr>
<tr><td>300 – 1000</td><td>9 dB / octave</td></tr>
<tr><td>1000 – 5000</td><td>400 g</td></tr>
<tr><td>5000 – 10000</td><td>- 6 dB / octave</td></tr>
</table>
Parallel to mounting plane
</td></tr>
<tr><td>15.</td><td>Post Shock</td><td>Visual inspection @ 10 X
Electrical Test; As per electrical specifications</td></tr>
<tr><td>16.</td><td colspan="2">Analysis of data and report generation</td></tr>
</table>

Table 7: Parameters to be Measured During LAT

TESTS \ PERFORMANCE MEASUREMENTS	Visual Inspection	Insertion Loss	I/P AND O/P VSWR	Isolation	Variation over Temperature	RF leakage / Shielding Effectiveness	Forward, reflected and output power	Test Monitoring sensors, Temp. at mounting surface, Device body, I/P and O/P interfaces, termination

Initial Performance	X	X	X	X	-	-	-	-
Post Thermal Shock	X	X	X	X	-	-	-	-
Post Temp. Storage (Cold)	X	X	X	X	-	-	-	-
Post Temp. Storage (Hot)	X	X	X	X	-	-	-	-
Temp. Operational	-	X	-	X	X	-	-	-
Post Vibration	X	X	X	X	-	-	-	-
Post Pyro Shock	X	X	X	X	-	-	-	-
Thermo-vacuum	-	X	-	X	X	-	-	-
High Power Tests (Power handling test, multipaction test)	-	-	-	-	-	-	X	X
Post high power test	X	X	X	X	-	-	-	-
EMI / EMC	-	-	-	X	-	X	-	-
Humidity Storage Test	X	-	-	-	-	-	-	-
Final Performance	X	X	X	X	-	-	-	-
Resistance to Solvent test (if applicable)	X	-	-	-	-	-	-	-

3 Non-conformance Management

Effective non-conformance management mechanism shall be established by the vendor. Major non-conformance at any stage, which affects the quality & reliability or the fabrication process of entire lot, shall be reported with photographs to SAC immediately. This shall be followed by detailed failure analysis clearly identifying the cause of failure. Based on the failure analysis, a retest plan / modified test plan shall be decided and implemented after approval by ISRO. This may include re-qualification of process or the unit. Further action shall be taken only after clearance from SAC.

However, for all the minor non-conformances, approval from SAC is not mandatory, and shall be reviewed and discussed by the vendor's NCR board. Non-conformance report shall be generated by the concerned agency and shall be reviewed and disposed-off by the NCR board.

Storage & packaging of the units during handling and transportation conditions shall be done in accordance with ISRO-PAS-207 to protect the units from contamination, environmental conditions including humidity, vibration & shock experienced during transportation.

All fabricated units shall be stored in controlled environmental conditions, standard for passive FM units. Any specific recommendation for storage made, as a result of qualification exercise, shall be implemented.

Each individual unit should be packaged and handled in separate container. This package shall protect the unit from environmental conditions during transportation like heat, humidity, dust, shock, vibration and ESD. This individual container shall then be placed in a transportation container. Transportation container shall be capable to protect the units from heat, humidity, dust, mechanical shock & vibrations during transportation.

Suitable packaging shall be provided for the transportation of the units by air, ship or road without any degradation / damage. The transportation package shall suitably be made to protect the unit from rough handling. Wherever required the transportation container shall have nitrogen purging facility so that the unit before shipment is purged with dry nitrogen to prevent contamination and corrosion.

The package and transportation container shall be clearly marked with following instructions, along with other mandatory markings,

"**TO BE OPENED UNDER CLEAN ENVIRONMENT ONLY** "
"**HIGH RELIABILITY SPACE USAGE PARTS**"

Annexure-1

QA Check List

Vendor to provide complete details of following with relevant certificates.

Sr. No	Details of information required	Vendor response
1	Point by Point compliance provided ?	Yes / No
2	List each applicable process (ISRO qualified) at your / sub-vendor's facility, their qualification status & attach qualification certificate.	
	Process Name	**At Facility**
	a) Mechanical package fabrication facility	
	b) Plating / Surface treatment on package	
	c) Details of other ISRO qualified processes available in-house	
3	List of ISRO certified fabricator and Inspector attached ?	Yes / No
4.	Attach details of Test engineer available in-house	Yes / No
5.	Attach details of test & measuring instrument available in-house	Yes / No
6.	Attach details of environmental test facility available in-house	Yes / No
7.	**Location of test facilities likely to be used for following tests shall be provided. (whichever applicable)**	**Location**
	a) Final production test	
	b) Visual Inspection (internal & external)	
	c) Electrical measurements	
	d) Temperature tests : Storage temperature test, Humidity e) Storage and Temp. operational test	
	f) EMI / EMC & ESD	
	g) Vibration test (sine & Random)	
	h) Thermo-Vacuum	
	i) Power handling test	
	j) Multipaction test	
	k) Mechanical Shock	
	l) Life Test	

Annexure-2

VIBRATION TEST REPORT FORMAT

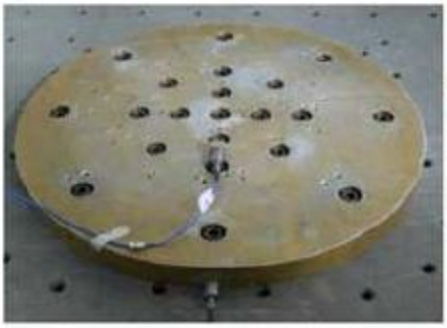
Company Logo	Name & Address of Company/Industry
REPORT No.	DATE

STANDARD FORMAT OF VIBRATION & SRS TEST REPORT FOR ISRO-SAC UNIT

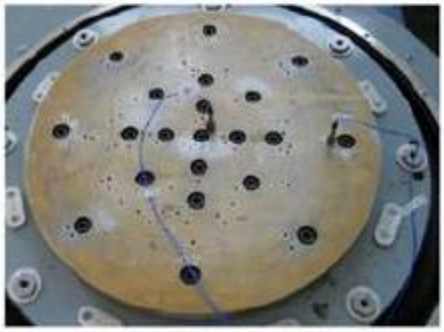
ISRO Specification Number
Subsystem
Sub Assembly details
Customer Part No
Model No
Serial No
Model
Weight
Test start date &Test End date
Drawing No. and T & E clearance certificate no with date :
Vibration Test Equipment & calibration details:

Sample of Photo graphs showing test set-up of Subsystem with control & measurement accelerometer location with Axis definition.

Fixture Characterization in LLS

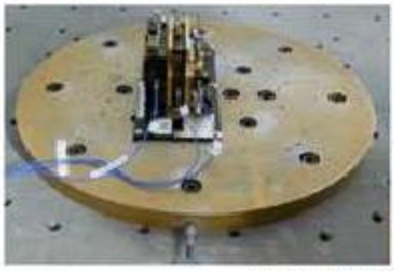
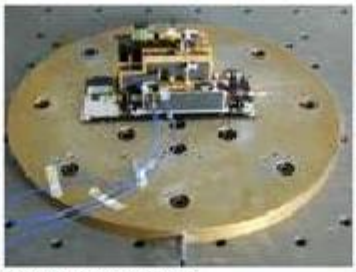


Parallel to mounting plane

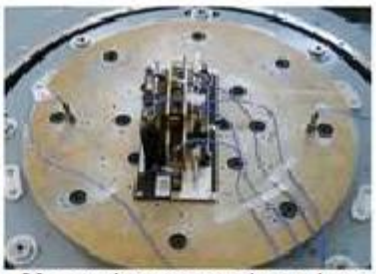


Normal to mounting plane

Subsystem during Vibration test in each Axis

Parallel to mounting plane



Normal to mounting plane

Test Description:

1. Vibration Test Set-up:

1.1 Fixture details [size, Material, No of mounting fasteners & torque details to shaker]

1.2 Mounting Torque: Fixture to subsystem: Size & -No. of Fastener

1.3 Torque Wrench Calibration details

1.4 Accelerometer details with calibration

1.4. Axis Definition with photo graph/sketch [Parallel to Mounting Plane, Perpendicular to Mounting Plane]

2. TEST SPECIFICATIONS:

2.1 Resonance Test [LLS]

Axis	(Frequency-Hz)	Amplitude	Sweep Rate Oct/Min.
X, Y & Z	10 to 2000 Hz	0.5 g	2

2.2 Sample of Sine & Random Test Levels:

Axis	SINE TEST (Frequency-Hz)	Amplitude	Sweep Rate Oct/Min.
X,Y			
Z			
Axis	**RANDOM TEST (Frequency-Hz)**	**PSD (g^2/Hz)**	**OVERALL g.r.m.s.**
X & Y			
Z			

2.3 Sample of SRS Test Levels:

Axis	SRS TEST (Frequency-Hz)	Amplitude	No. of Pulses
X,Y,Z			

3. Response of Random/SRS & Resonance search tests: Frequency (Hz) / Amplitude (g):

Axis	Measurement Accelerometer Ch. No	Measurement Accelerometer location	Pre-Sine/SRS Resonance Hz/g	Post-Sine Resonance Hz/g	Random response grms	Post Random/SRS Resonance Hz/g
X						
Y						
Z						

4. TEST SEQUENCE: For Vibration testing of QM

QM 1.[LLS-SINE-LLS-FUNCTION-TEST-LLS-RANDOM-LLS] in X, Y, Z Axis
PFM 2.[LLS-SINE-LLS-RANDOM-LLS] in X, Y, Z Axis
FM 3.[LLS-RANDOM-LLS] in X, Y, Z Axis
For SRS testing of QM[LLS-SRS-LLS] in X, Y, Z Axis

5. PASS/FAILURE CRITERIA:

Pass Criteria:

- Full functionality and structural integrity of subsystem following vibration testing as verified by visual inspection during and after test.
- Structural integrity is defined as no loose components (bolts backing out), cracking of structure, excessive buckling, or excessive displacements. Functionality is defined as full electrical and mechanical characteristics.
- First natural frequency greater than 100 Hz.
- "Before" and "After" Sine Survey Sweeps match each other within 10% of frequency & 20 % of Amplitude.

6. OBSERVATION/ ANALYSIS:

- Natural frequency of the package in each Axis above 120Hz.
- No apparent structural damage observed after & during vibration test. Pre & Post resonance signatures are matching within acceptable criteria.
- No loosening or damage found during or after Vibration test.
- Annexure should be attached for vibration test plots.

7. CONCLUSION

Sub-system withstood the specified severities of vibration / SRS tests successfully and hence, cleared for further activities.

Test carried out by

Test surveillance by

Vendor Compliance:

EXHIBIT-C

DELIVERABLE, SCHEDULE, LD CLAUSE, ORDERING METHODOLOGY, LOWEST BIDDER EVALUATION CRITERIA & WARRANTY

1. DELIVERABLE & MAXIMUM TOTAL QUANTITY:

Table-1

SR.NO	ITEM/ACTIVITY	Unit	Maximum Quantity	Unit Price (in INR)	Total Cost (in INR)
1.	Delivery of DVM of High power Ka band waveguide circulators as per Annexure in Exhibit D and R&QA requirement	**No.**	**1**		
2.	Delivery of process qualification completed QM units of High power Ka band waveguide circulators as per Annexures in Exhibit D and R&QA requirement*	**No.**	**8**		
3.	Delivery of product qualification completed QM units of High power Ka band waveguide circulators as per Annexures in Exhibit D and R&QA requirement*	**No.**	**10**		
4.	Delivery of Screened FM and LAT units of High-power Ka band waveguide circulators as per Annexures in Exhibit D and R&QA requirement*	**No.**	**105**		
5.	QM (Process qualification) level Test Charges for High Power Ka band waveguide circulators as per R&QA requirement	**Lot$**	**1**		
6.	QM (Product qualification) level Test Charges for High Power Ka band waveguide circulators as per R&QA requirement	**Lot@**	**1**		
7.	FM level Screening Charges for one batch (5 nos.) of High Power Ka band waveguide circulators as per R&QA requirement	**Lot#**	**23**		
8.	LAT level Test Charges of High Power Ka band waveguide circulators as per R&QA requirement	**No.**	**7**		

*** - Excluding screening/qualification Charges**

$ - One Lot consists of 8 nos. of circulators to undergo tests as per R&QA requirement

@ - One Lot consists of 10 nos. of circulators to undergo tests as per R&QA requirement

 # - One Lot consists of 5 nos. of circulators to undergo tests as per R&QA requirement

Note: -

- Price bid shall be submitted as per above format.
- It is mandatory to quote for all the items of above Table-1 in order to qualify for this Rate Contract.
- For Sr. No. 2 to 5, quoted price should not include T&E charges.

2. DELIVERY SCHEDULES

SAC may allow shipment of FM prior to completion of QM/LAT testing; however final acceptance of FM is subject to successful completion of QM/ LAT.

Table-2

Item	Description	Duration
1.	Fabrication, assembly, Testing, optimization and delivery of DVM of High power Ka band waveguide circulators as per Annexures in Exhibit D	T1= 3 Months
2.	Hi-Rel Fabrication, assembly, Testing and optimization of QM/LAT/FM of High power Ka band waveguide circulators with and without adapters as per Annexures in Exhibit D	T2= 3 Months
3.	Process Qualification of High Power Ka band waveguide circulators as per R&QA requirement*	T3= 2 Months
4.	Product Qualification of High Power Ka band waveguide circulators as per R&QA requirement*	T4 = 4 months
5.	FM level Screening of High Power Ka band waveguide circulators as per R&QA requirement*	T5 = 2 Months
6.	LAT level Testing of High Power Ka band waveguide circulators as per R&QA requirement*	T6 = 1 Month

*Excluding High power test (for QM/FM/LAT) and mechanical shock (for QM and LAT only) at SAC.

3. For LD calculation following guidelines will be followed:

T0 is date of placement of work order and will be referred for LD calculation

- Vendor has to submit bank guarantee within 15 days from the date of placement of work order (T0) by SAC.
- SAC will issue FIMs within 15 days of submission of Bank Guarantee by vendor to SAC.
- Any delay beyond stipulated time in issuance of FIMs will be exempted from LD calculation.

4. ORDERING METHODOLOGY

1. Ordering Examples:

Case-1: For delivery of **(1 no.)** DVM, the work order format will be: -

Sr. No.	**ITEM / Activity**	**Unit**	**QTY.**	**UNIT COST (in Rs.)**	**Cost (in Rs.)**	**Schedule**
1	Delivery of DVM of High power Ka band waveguide circulators as per Annexure in Exhibit D and R&QA requirements	No.	1	A	1 X A	T1= 3 months
	List of Deliverables: - 1 DVM units	Nos.	**1**	A	Total cost = **1A**	Delivery Schedule = $T1+T0^{*}$ = 3 months

	(Fabrication History and lab test data)					

*Date of placement of work order.

Case-2: For delivery of QM units which includes **(8 nos.)** Process Qualification units+ **(10 nos.)** Product Qualification units of Ka Band circulators, the work order format will be:

Sr. No.	**ITEM / Activity**	**Unit**	**QTY.**	**UNIT COST (in Rs.)**	**Cost (in Rs.)**	**Schedule**
1	Delivery of process qualification completed QM units of High power Ka band waveguide circulators as per Annexures in Exhibit D and R&QA requirement (**Excluding screening/qualification)**	No.	8	A	8 X A	T2= 3 months
2	QM (Process qualification) level Test Charges for High Power Ka band waveguide circulators (without adapters) as per R&QA requirement	Lot$	1	B	1 X B	T3= 2 months
3	Delivery of product qualification completed QM units of High power Ka band waveguide circulators as per Annexures in Exhibit D and R&QA requirement **(Excluding screening/qualification)**	Nos.	10	C	10XC	T2=3 months
4	QM (Product qualification) level Test Charges for High Power Ka band waveguide circulators as per R&QA requirement	Lot@	1	D	1 X D	T4= 4 months#
	List of Deliverables: - 18 Qualification completed QM units (08 nos. of Process & 10 nos. of Product Qualification) of Ka Band Circulators , Fabrication History (including inspection reports, MRB details,	Nos.	**18**	-	Total cost = **8A+1B+10C+1D**	Delivery Schedule = T2+T2+T3+T4= T0*+ 9 months#

	clearance certificates etc.) + lab test data + T&E Reports					

$ - One Lot consists of 8 nos. of circulators to undergo tests as per R&QA requirement
@ - One Lot consists of 10 nos. of circulators to undergo tests as per R&QA requirement
*Date of placement of work order.
Excluding High power test at SAC.

Case-3 : For delivery of **24 nos. FM + 1 LAT** units of Ka Band Circulators, the work order format will be:-

Sr. No.	ITEM / Activity	Unit	QTY.	UNIT COST (in Rs.)	Cost (in Rs.)	Delivery Schedule
1	Delivery of Screened FM units of High power Ka band waveguide circulators as per Annexures in Exhibit D and R&QA requirement*	Nos.	25	A	25 X A	T2= 3 months$
2	FM level Screening Charges for one batch (5 nos.) of High-Power Ka band waveguide circulators as per R&QA requirement	Lot.	5	B	5 X B	T5= 2 months$
3	LAT level Test Charges of High Power Ka band waveguide circulators as per R&QA requirement	Nos.	1	C	1XC	T6=1 month$
	List of Deliverables: - 24 FM +1 LAT testing completed units + Fabrication History of each (including inspection reports, MRB details, clearance certificates etc.) + lab test data + T&E Report	Nos.	25	-	Total cost = **25A+5B+ 1C**	T2+ T5+T6= T0* + 6 months$

*Date of placement of work order
$ Excluding High power test at SAC.

2. Final Drawings (complete drawing set, connector shims, short plates, transitions, ferrite bonding Jig etc.), Fabrication Sequence & Specifications will be issued with Work Order. FIM may be given in batches.
3. The Work order will be placed as per requirements of project.
4. List of Deliverables will be clearly spelt out in Work Order.

5. Delivery Schedule & unit cost mentioned against each item is applicable to that particular item or activity. In case of work order consisting of cascaded activities, cost & delivery schedule will also be cascaded.
6. Above mentioned schedule for FM units is valid for work order which contains maximum 25 individual circulators. For a work order containing more than 25 Individual circulators, Delivery schedule of first 25 units will be as mentioned above in Table-2 (excluding High Power Test) & will be 25 units/2 months for remaining units.

5. LOWEST BIDDER EVALUATION CRITERIA:

The bidder with the lowest cumulative unit price of all the items listed in Table 1 above and also meeting all technical and general requirements will be considered as L1.

6. WARRANTY:

"The units supplied here upon shall be free from any defects in material or workmanship and in accordance with the applicable specifications and drawings". This warranty shall run for period of one year from the date of final acceptance by SAC/ISRO and shall be in addition to any other rights available to SAC/ISRO. Within warranty period, vendor should provide post fabrication support, if required. This warranty shall continue to be valid for corrected or replaced units until one year after the date of final acceptance by SAC/ISRO of the corrected or replaced Unit. Under warranty period, unit will be stored in controlled environment. Within warranty period, vendor should provide post fabrication support, if required.

EXHIBIT-D:

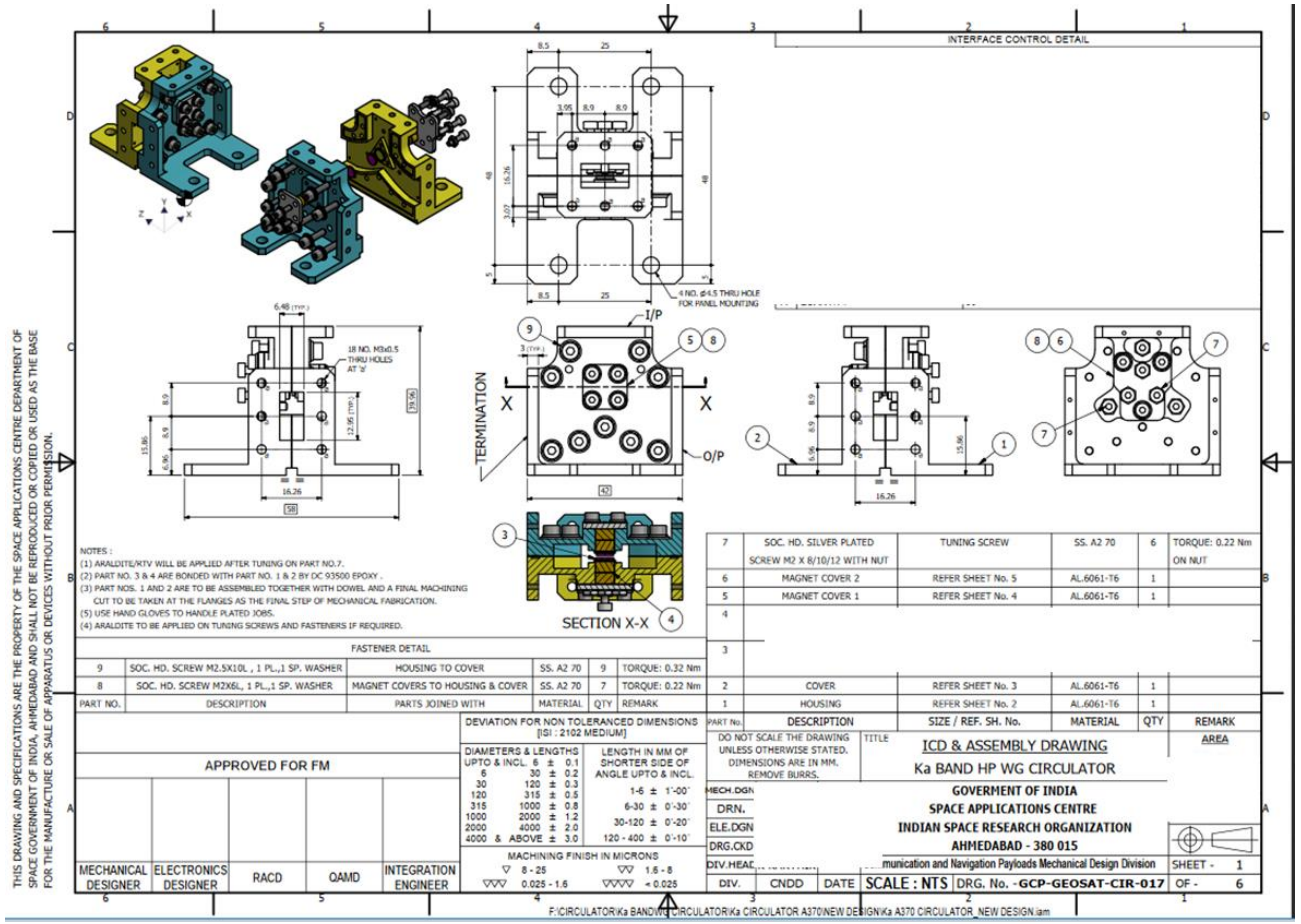
ANNEXURE -1: Specifications

Tentative Technical Specifications of Ka Band High Power Waveguide Circulators

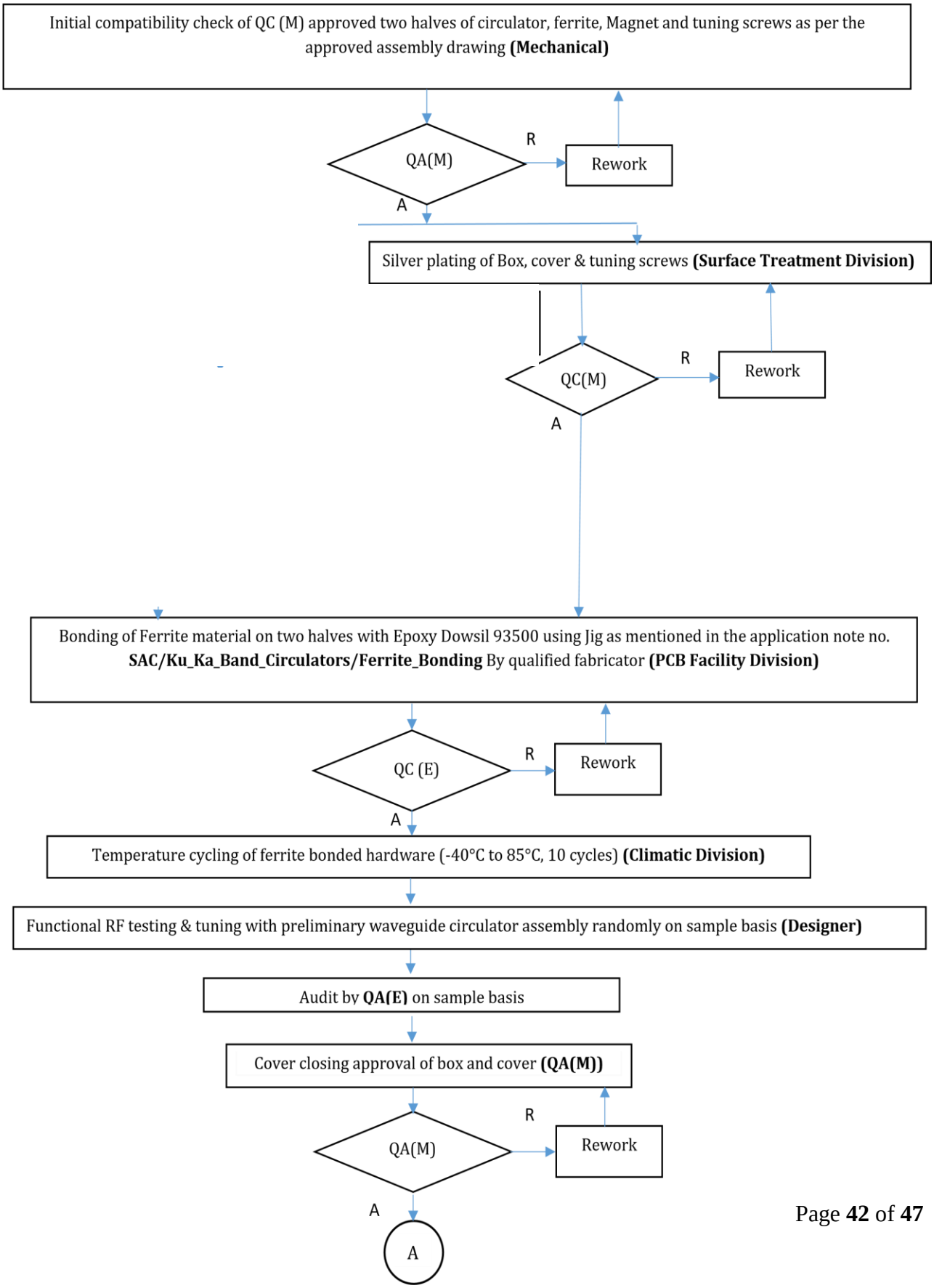
S. No.	Parameter	Units	Specifications
1	Frequency Band	GHz	17.7-21.5
2	Insertion Loss (over the band)	dB	< 0.2
3	Insertion loss variation over any 250 MHz	dB p-p	< 0.05
4	Return Loss at all ports	dB	> 20
5	Isolation	dB	> 20
6	Average Power Handling	W	Forward: 120W Reverse: 120W
7	Multipaction Threshold (Peak Power)	W	480
8	Input, Output, Isolated ports	-	WR 51
9	Temperature Range	-	As per R&QA requirement of EXHIBIT-B

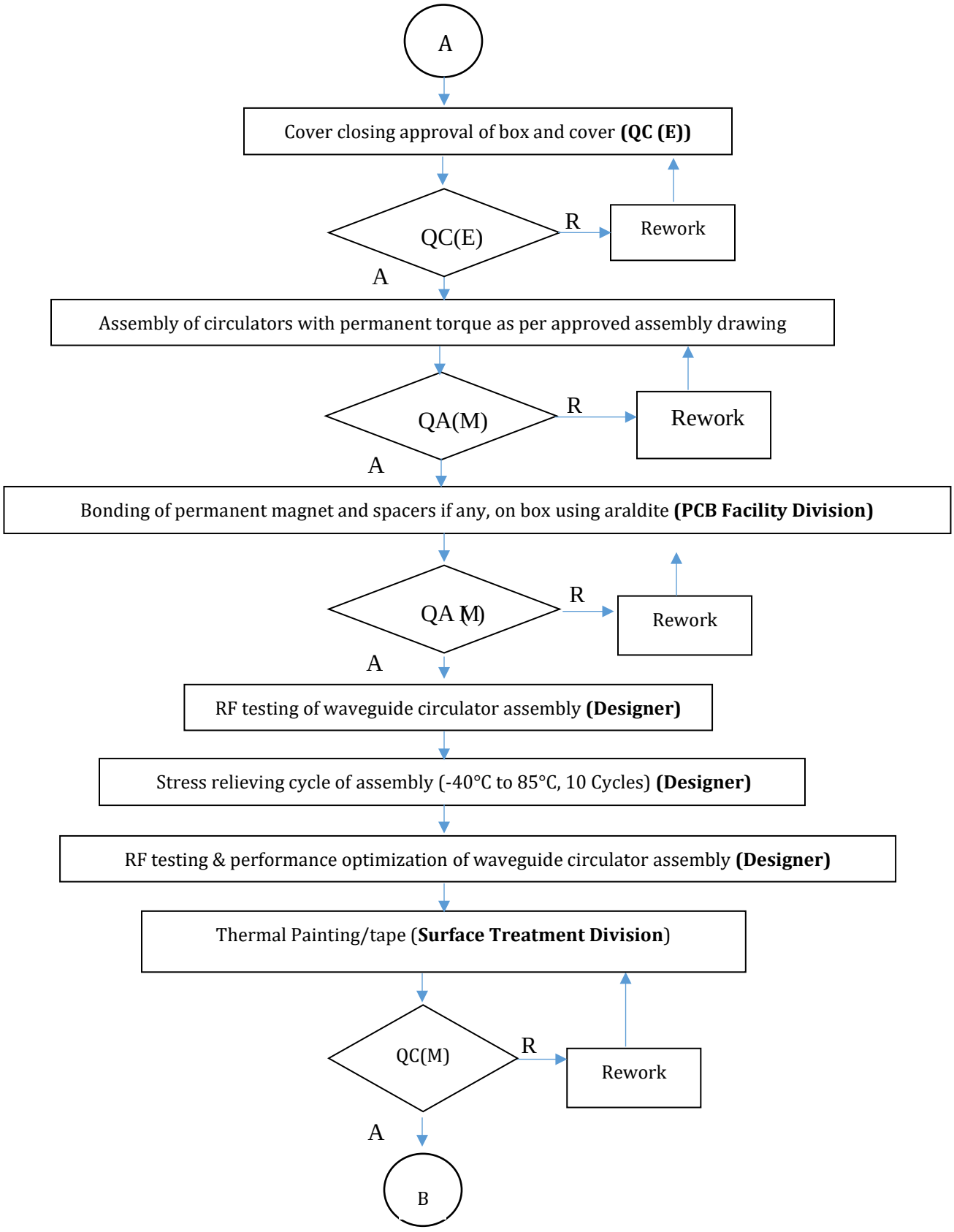
ANNEXURE -2: Interface control Drawing

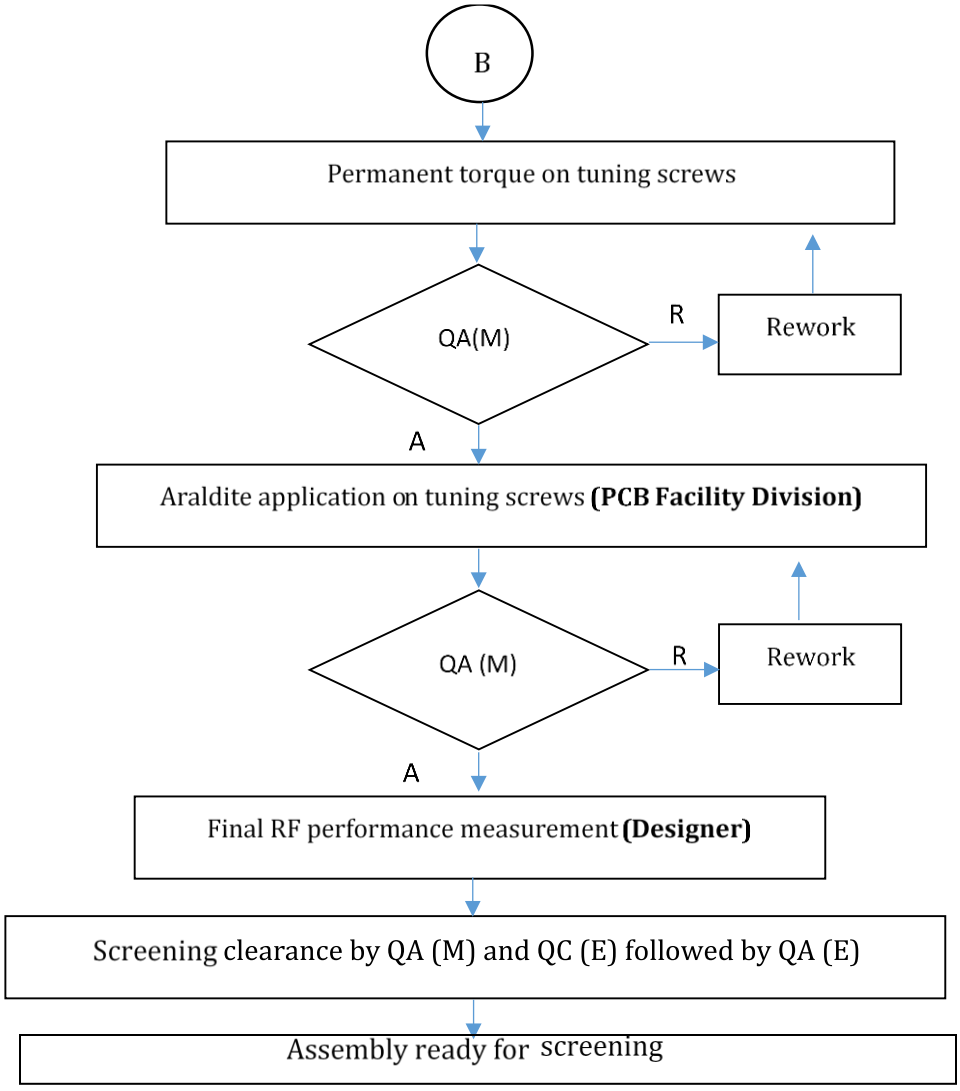
Interface control drawing of Ka Band High Power Waveguide Circulators:



ANNEXURE -3: Fabrication Sequence Ka Band High Power Waveguide Circulators




A
Cover closing approval of box and cover (QC (E))
QC(E)
R
Rework
A
Assembly of circulators with permanent torque as per approved assembly drawing
QA(M)
R
Rework
A
Bonding of permanent magnet and spacers if any, on box using araldite (PCB Facility Division)
QA(M)
R
Rework
A
RF testing of waveguide circulator assembly (Designer)
Stress relieving cycle of assembly (-40°C to 85°C, 10 Cycles) (Designer)
RF testing & performance optimization of waveguide circulator assembly (Designer)
Thermal Painting/tape (Surface Treatment Division)
QC(M)
R
Rework
A
B



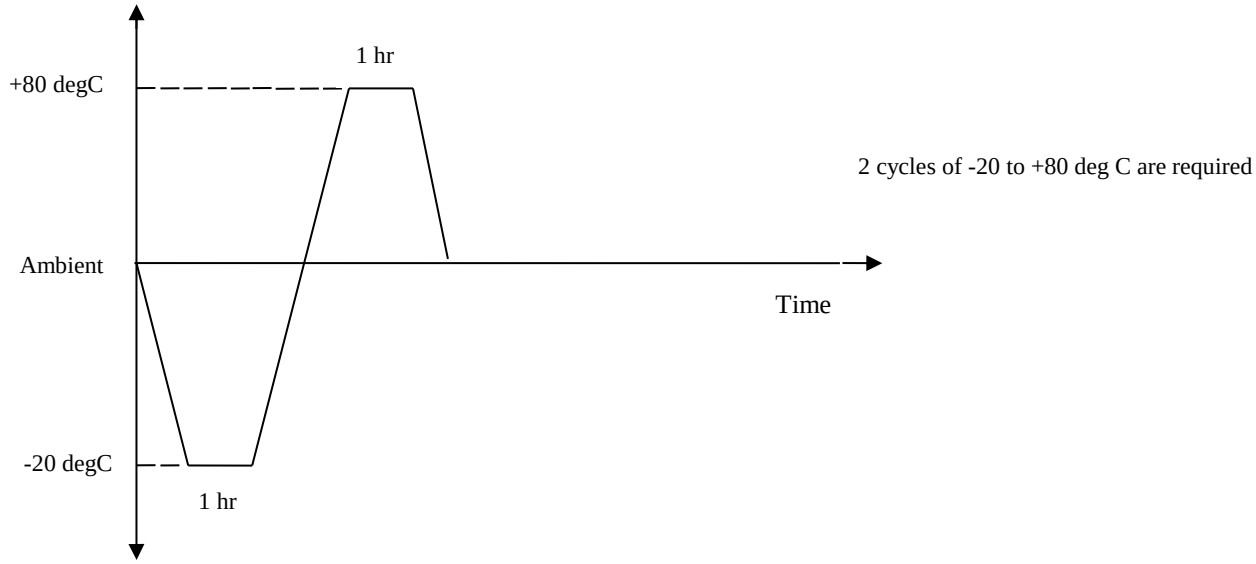
Note:
A- Accept, R - Reject

Annexure-4: Surface Area for silver plating of Hardware:

Sr. No.	Hardware	Approx. silver Plating area (in sq mm)
01.	Ka-Band WG circulator Housing	7907
02.	Ka-Band WG circulator Cover	7588

Annexure-5: Operational cycle of Ka Band High Power Waveguide Circulators (DVM)

The tentative cycle to follow is as shown below:



Note:

- The operation cycle to be done for the tentative temperature of -20 degC to 80degC in RF ON condition.
- The measurement at ambient, cold and hot condition to be saved and compared.
- The cycle to be repeated twice.
- The dwell time at hot and cold condition is 1 Hr for thermal and RF stabilization.
- Transition Rate: 2°C/Min

Annexure-4: NON-DISCLOSURE UNDERTAKING

NON-DISCLOSURE UNDERTAKING

This affidavit is to be made on Judiciary/ Non-Judiciary Stamp paper of Rs. _____ and to be attested by 1st class Magistrate etc.

We, (M/S _____), hereinafter called the Vendor, fully understand and accept that Document No. : DOC. NO: SAC/PPCD/AUGUST/2023/02 - **"Request for Proposal (RFP) of RATE CONTRACT FOR FABRICATION, ASSEMBLY, TESTING AND DELIVERY OF SPACE QUALIFIED HIGH POWER Ka BAND WAVEGUIDE CIRCULATORS"** consisting of technical information and drawings related to fabrication and testing of electronic hardware, is the exclusive property and Copyright of "Space Applications Centre (ISRO), Ahmedabad-380015, Department of Space, Government of India", hereinafter called SAC.

We, the Vendor, further undertake and guarantee that the contents of the said "Request for Proposal" (RFP) or any part thereof, including documents and drawings appertaining thereto, shall not be used for any purpose other than the sole purpose of preparation and submission to SAC of technical and commercial proposals in response to the said "Request for Proposal". In the event of our proposal being accepted and an order being awarded by SAC to us, we undertake to use the said RFP and associated documents and drawings, strictly in compliance with the terms and conditions of such Rate Contract.

We further accept and agree that any changes carried out in the design, drawings or documents, whether by us, M/s _____ or by SAC at any time, shall be the exclusive property and copyright of SAC.

We further undertake and assure that we shall not make the RFP or any part thereof, available to any third party for any reason, without first obtaining written permission from SAC. All the above clauses, terms & conditions applicable to the Vendor M/s _____, will be equally applicable to any such third party, and we (Vendor) hereby undertake responsibility for compliance with the same.

(Authorised Signatory)
Designation